

Nervous System I

Chapter 10
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10
Unit Three

Refer to the following URLs. It is a good idea to print them and bring them to class. Be sure to study these along with your book.

<http://www.sirinet.net/~jgjohnso/nervous.html>

<http://faculty.washington.edu/chudler/ap.html>

<http://faculty.washington.edu/chudler/synapse.html>

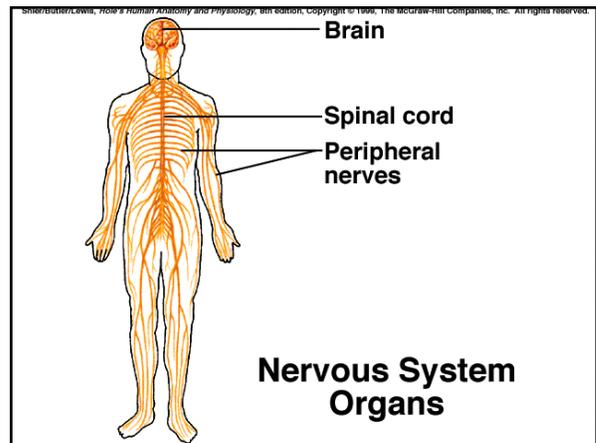
<http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookNERV.html>

I. General Functions of the Nervous System

A. The nervous system is composed of neurons and neuroglia. (neuroglia nourish neurons & possibly send & receive messages; neurons are the structural & functional units of the nervous system)

B. Synapses are spaces that exist between neurons where neurotransmitters transmit information from one neuron to the next. Neurotransmitters are biological messenger molecules. (chemicals)

C. Organs of the nervous system can be divided into the central nervous system (CNS), made up of the brain and spinal cord, and the peripheral nervous system (PNS), made up of peripheral nerves that connect the CNS to the rest of the body.



I. General Functions of the Nervous System

D. The nervous system provides sensory, integrative, and motor functions to the body.

*sensory receptors – gather information & detect changes in internal & external body conditions; they convert their information into nerve impulses which are transmitted over the PNS to the CNS where they are integrated, this leads to making decisions & then acting by means of motor functions

*motor impulses stimulate effectors to respond (muscles to contract & glands to secrete when stimulated)

*the nervous system helps maintain homeostasis

The motor portions of the PNS can be subdivided into the somatic nervous system and the autonomic nervous system.

Somatic nervous system – involved in conscious (voluntary) control such as skeletal muscle contraction

Autonomic nervous system – involved in subconscious (involuntary) control such as the heart & various glands.

E. Neuron Structure

*neurons vary in size & shape but they have some similarities = **cell body, cell processes, & organelles**

cell body – in every neuron, contains granular cytoplasm, mitochondria, lysosomes, Golgi apparatus, & many microtubules

neurofibrils – network of fine threads (fibers) that extends into nerve fibers & supports them

chromatophilic substance (Nissl bodies) – spread throughout cytoplasm & are membranous packets which consist of rough endoplasmic reticulum

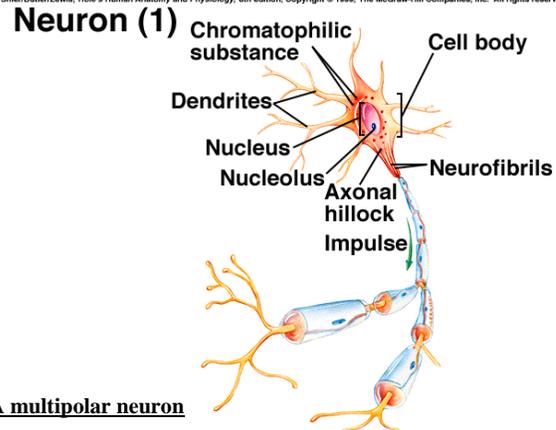
*mature neurons generally do not reproduce

2 kinds of nerve fibers: *(1) **dendrites** – nerve fibers (many extend from the neuron; highly branched, can have **dendritic spines** = that can contact other neurons *dendrites provide the main receptive surfaces for neurons

*(2) **axon** – a single nerve fiber extension; arises from axonal hillock; **can conduct electrical signals & carries impulses away from the cell body of the neuron (cont.)**



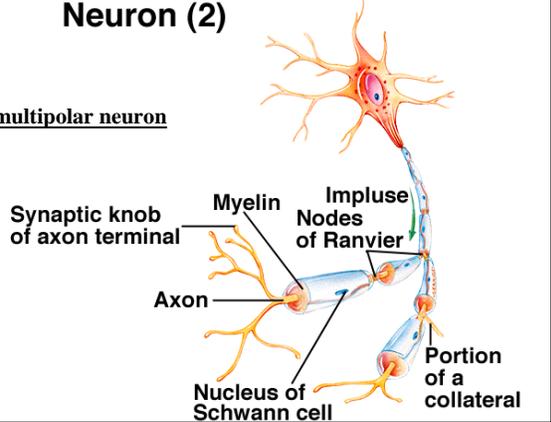
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Neuron (2)

A multipolar neuron



(axon continued)

***synaptic cleft** – space which separates neurons at axons

***axons** = (1) conduct nerve impulses away from cell body & (2) convey biochemicals that are produced in the neuron cell body

***Schwann cells** – neuroglial cells that enclose axons of peripheral nerves forming **myelin sheaths**

***myelin** – fatty material that forms a covering around nerve fibers

***neurilemma** – another sheath that surrounds the myelin sheath; it contains the nuclei from the Schwann cells

***myelinated fibers** – fibers that have myelin sheaths (appear white in white matter in brain & spinal cord)

***unmyelinated fibers** - appear gray = form gray matter in brain & spinal cord

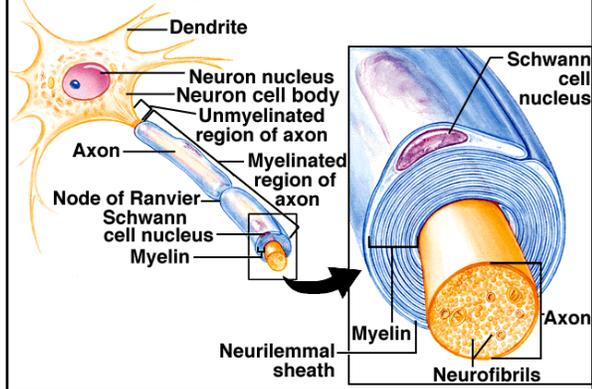
***nodes of Ranvier** – narrow gaps in myelin sheaths between Schwann cells

Read about **multiple sclerosis**.

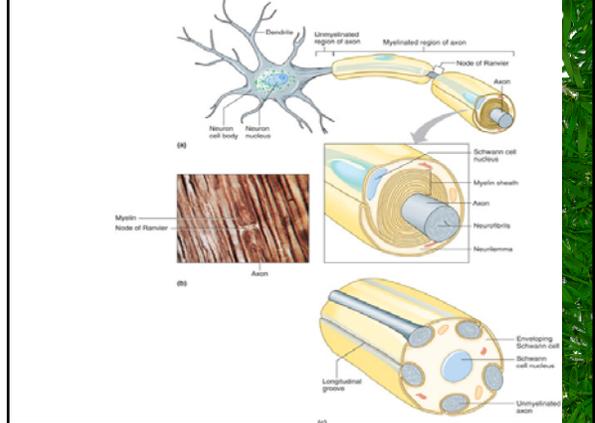


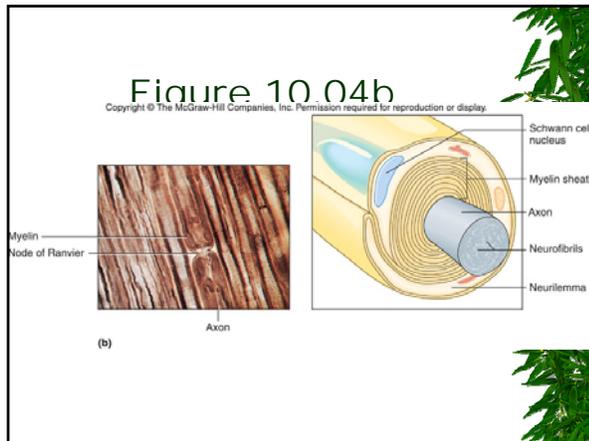
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Schwann Cell



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II. Classification of Neurons and Neuroglia

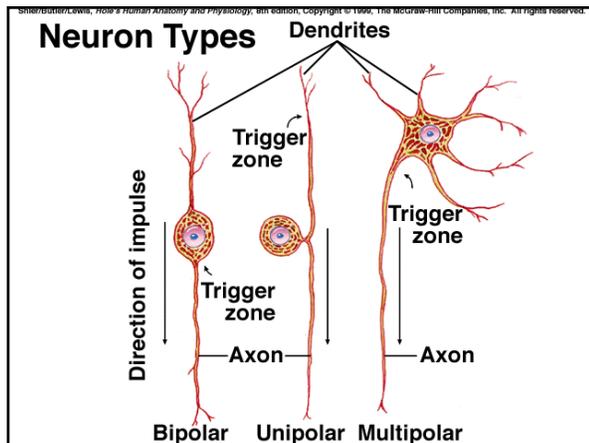
A. Neurons can be classified in two ways: on the basis of structural differences (bipolar, unipolar, and multipolar neurons), each specialized to send an impulse originating at a unique trigger zone, and by functional differences (sensory neurons, interneurons, and motor neurons).

B. Classification of Neurons

***Each type of neuron is specialized to send a nerve impulse in one direction.

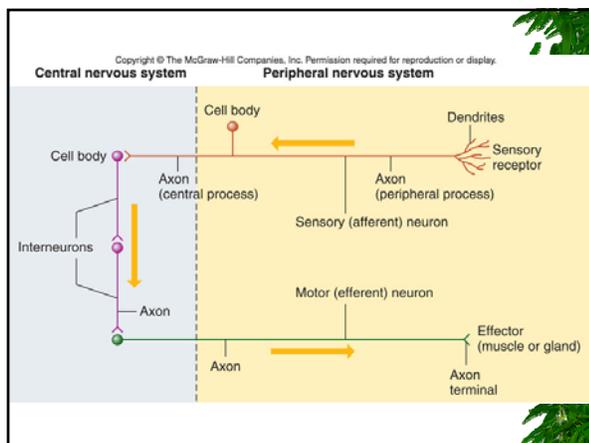
Neuron classification by structural differences:

- 1) bipolar – has only 2 nerve fibers = eyes, ears, & nose
- 2) unipolar – has a single nerve fiber extending from the cell body which divides into 2 branches; locate in ganglia (masses of nerve tissue) which are located outside the brain & spinal cord
- 3) multipolar – many nerve fibers arise from cell body; only one fiber is an axon & the rest are dendrites = found in brain & spinal cord & in PNS (continued)



Neuron classification by functional differences:

- 1) sensory neurons – carry nerve impulses from peripheral body parts into the brain; changes that occur inside or outside the body stimulate sensory receptors in the skin or body; they send impulses to the brain/spinal cord; most unipolar & a few bipolar
- 2) interneurons – lie within the brain or spinal cord; transfer impulses from one part of the brain or spinal cord to another = they direct incoming sensory impulses to appropriate regions for processing and interpreting; are multipolar
- 3) motor neurons – carry nerve impulses out of the brain/spinal cord to effectors = structures that respond i.e. muscles or glands; are multipolar



C. Classification of Neuroglia

*neurons & neuroglial cells descend from the same neural stem cells

*in the embryo neuroglial cells guide neurons to their positions & help them specialize

*produce growth factors that nourish neurons

*remove ions & neurotransmitters that accumulate between neurons

*they can communicate with neurons

D. Neuroglia of the PNS - Schwann cells & satellite cells

*Schwann cells – produce myelin & encase large axons

*satellite cells – support cluster of neuron cell bodies called ganglia

***CNS contains 4 types of neuroglia:**

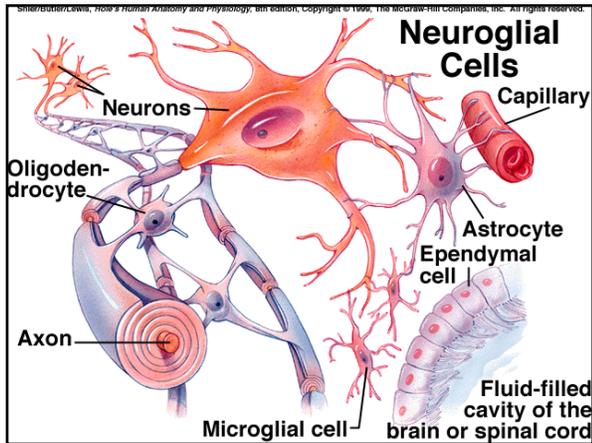
1) **astrocytes** – star-shaped; found between neurons & blood vessels; aid metabolism of substances like glucose; help regulate concentrations of ions like K; respond to injury of brain tissue; also help move substances from blood vessels to neurons that bathe them in growth factors; are linked by gap junctions that help Ca ions travel from neuron to another

2) **oligodendrocytes** – small & have few processes; occur in rows along myelinated nerve fibers; form myelin in the brain & spinal cord; can provide myelin for many axons (continued)

3) **microglia** – small with fewer processes; help support neurons & phagocytize bacterial cells & cellular debris; they can increase in number when the brain or spinal cord is inflamed because of injury or disease; are scattered through CNS

4) **ependyma** – are cuboidal or columnar in shape & have cilia; form the inner lining of the central canal through the spinal cord; form a membrane that covers the inside of the brain's ventricles (spaces in the brain); they form a porous layer in which substances can diffuse; they help regulate the composition of the cerebrospinal fluid

***Neuroglia form more than half of the volume of the brain; abnormal neuroglial cells can cause brain tumors

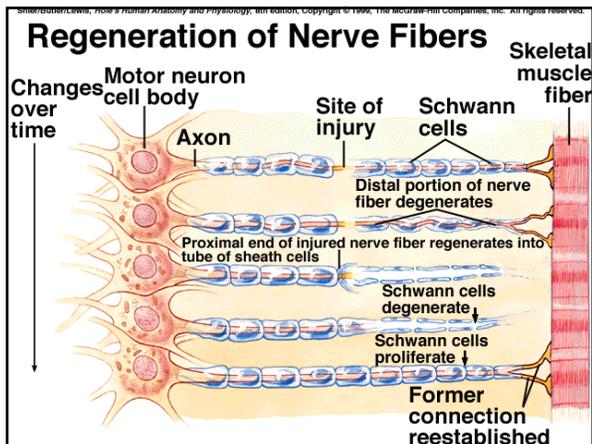


E. Regeneration of Nerve Fibers

*injured neuron cell bodies are likely to die unless neural stem cells become stimulated to divide

*if a peripheral nerve fiber is severed, its distal portion will die, but under the influence of nerve growth factors the proximal portion may regenerate & reestablish former connections, only if a tube of connective tissue guides it

*significant regeneration is not likely in the central nervous system



THE SYNAPSE

A **synapse** is a junction between 2 cells. A **synaptic cleft** is the gap between parts of 2 cells at a synapse. Synapses can occur between 2 neurons, a receptor cell & a neuron, or a neuron & an effector.

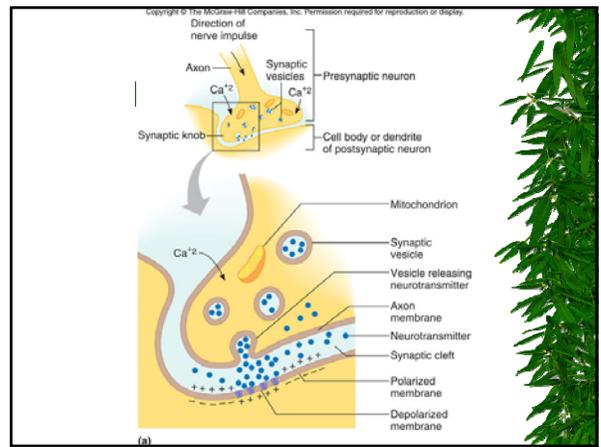
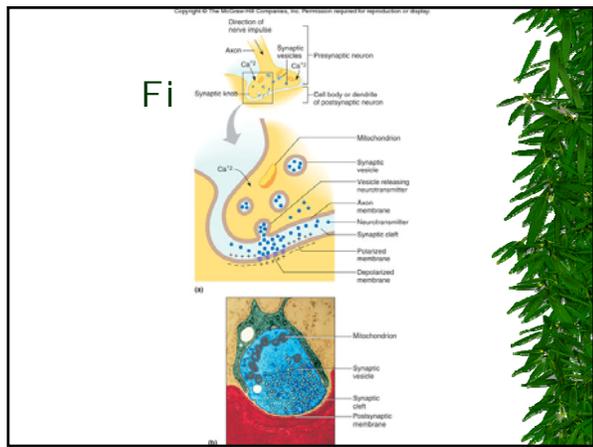
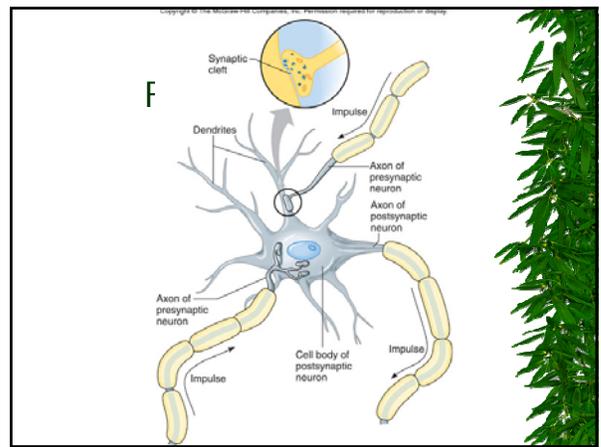
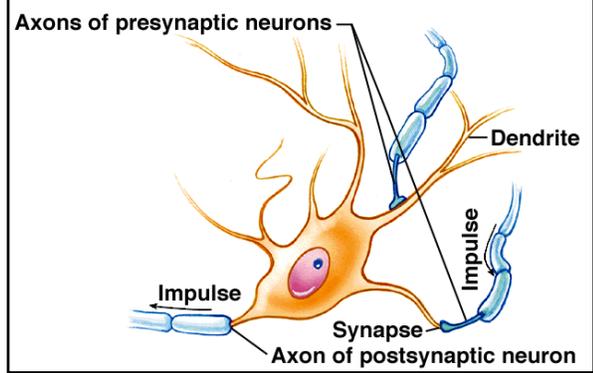
presynaptic neuron – brings the impulse to the synapse which stimulates or inhibits the **postsynaptic neuron** (or a muscle or gland)

The process by which the impulse in the **presynaptic neuron** is transmitted across the synaptic cleft to the **postsynaptic neuron** is called **synaptic transmission**.

When nerve impulse reaches the synaptic knob, voltage sensitive Ca channels open, & Ca diffuses in to initiate events that cause the synaptic vesicles to fuse with the cell membrane, releasing their neurotransmitter by exocytosis. This is excitatory or inhibitory to the postsynaptic neuron.

-can be caused by 1-100,000 presynaptic neurons

Synapse between Axon and Dendrite

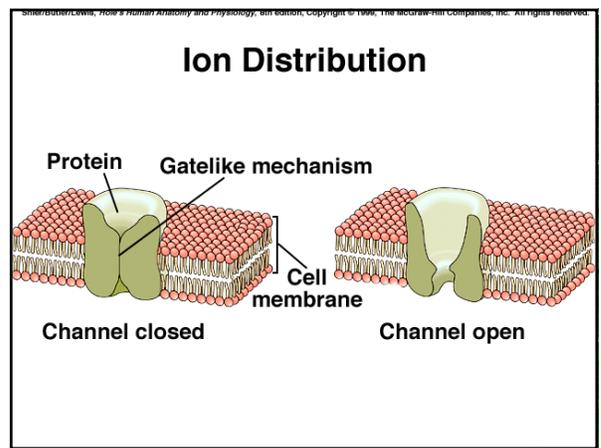


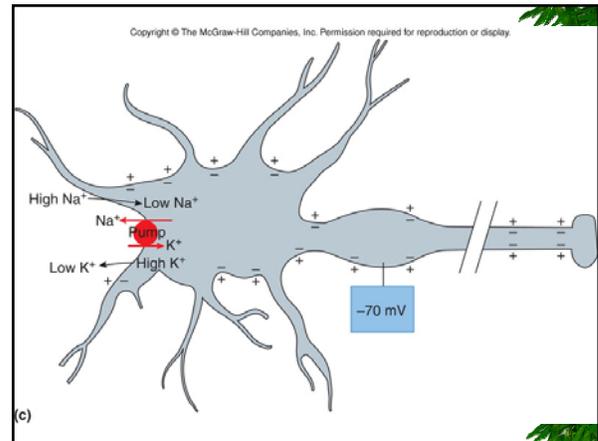
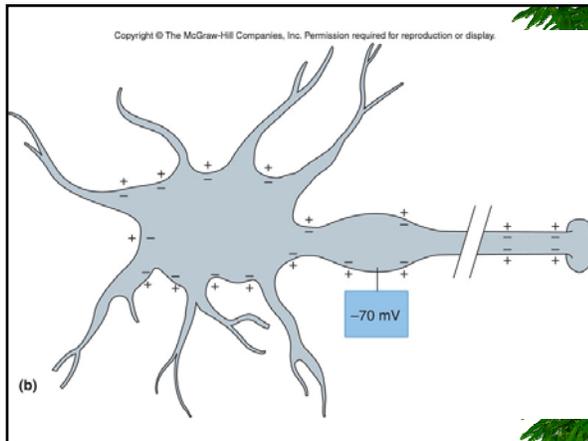
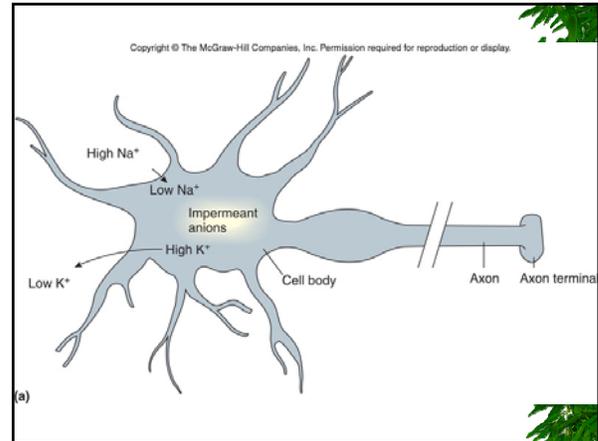
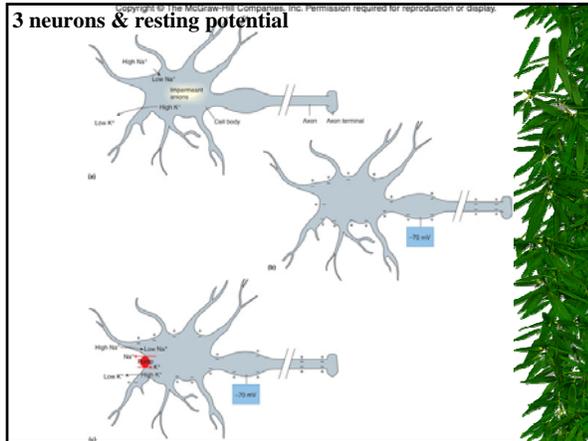
Cell Membrane Potential

A. A cell membrane is usually polarized (electrically charged), with an excess of negative charges on the inside of the membrane; polarization is due to an unequal distribution of + and - ions on either side of the membrane; polarization is important to the conduction of nerve & muscle impulses.

B. Distribution of Ions
 *K ions are the major intracellular positive ion (cation)
 *Na ions are the major extracellular cation
 *Na/K pump transports Na ions out of the cell & K ions into the cell
 *membrane proteins form channels that may be selective to ions entering the cell

C. Resting Potential
 *a resting nerve cell is one that isn't being stimulated to send a nerve impulse or respond to other neurons
 *K ions pass more readily through resting neuron cell membranes than do Na ions; they follow the laws of diffusion





- *a high concentration of Na ions is on the outside of the cell membrane & a high concentration of K ions is on the inside
- *in a resting cell, more positive ions leave the cell than enter it, so the inside of the cell membrane develops a negative charge with respect to the outside; this takes ATP to occur
- *difference in electrical charge between 2 points is measured in volts – represents stored electrical energy
- *membrane potential – the potential difference across the cell membrane; measured in millivolts
- *resting potential – difference in charge between inside & outside of a resting neuron; equals -70 millivolts
- *How do neurons respond to signals called stimuli?
The negative membrane potential helps Na enter the cell membrane faster than K leaks out.
- *Na/K pump in turn balances these leaks

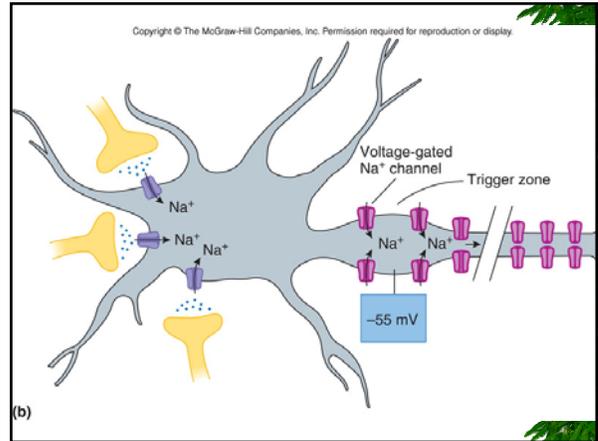
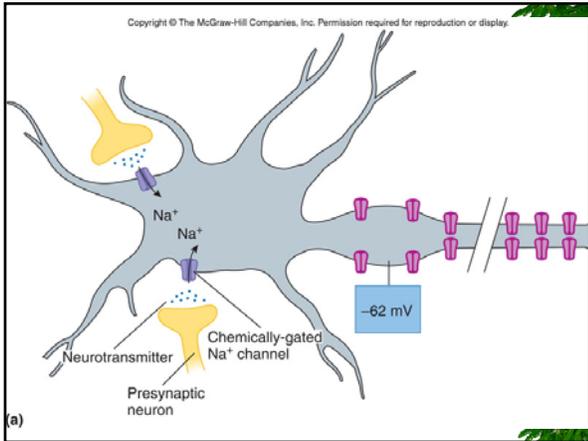
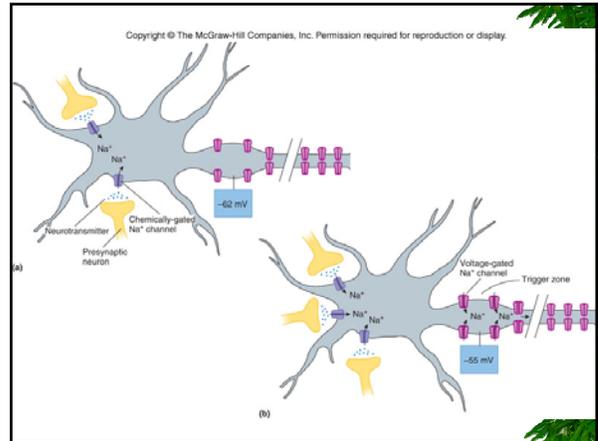
D. Local Potential Changes

- *neurons are excitable & respond to changes in their surroundings; *these changes affect the membrane potential in the region of the membrane exposed to the stimulus
- *environmental changes cause the gated ion channels to open
- *if the membrane potential becomes more negative than the resting potential, the membrane is hyperpolarized
- *if the membrane comes less negative (more positive) than the resting potential, the membrane is depolarized
- *the membrane is repolarized when it returns to resting potential
- *threshold potential – level of potential at which an action potential or nerve impulse is produced; = -55 millivolts
- *action potential – the nerve impulse – occurs when threshold is reached

Local Potential Changes (continued)

*sometimes the presynaptic neuron does not release enough neurotransmitter to open the gated Na channels just for a moment; then the depolarization that results may not be sufficient enough to reach threshold (this is a subthreshold depolarization & will not result in an action potential)

*sometimes the presynaptic neurons release more neurotransmitter so threshold can be reached & an action potential results



E. Action Potentials

*trigger zone – the first part of the axon (initial segment); contains many voltage-gated Na channels

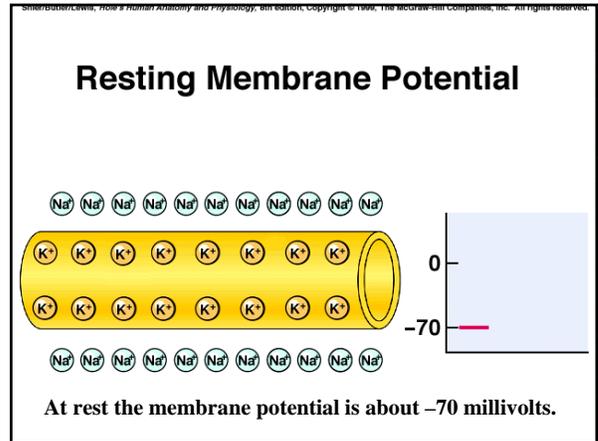
*at threshold, Na channels open & Na ions diffuse inward, depolarizing the membrane = -30 millivolts

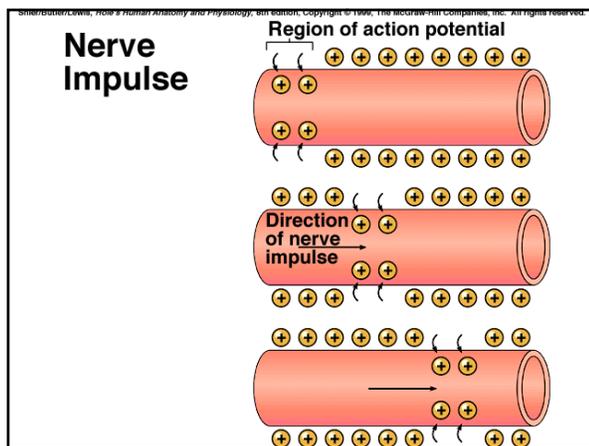
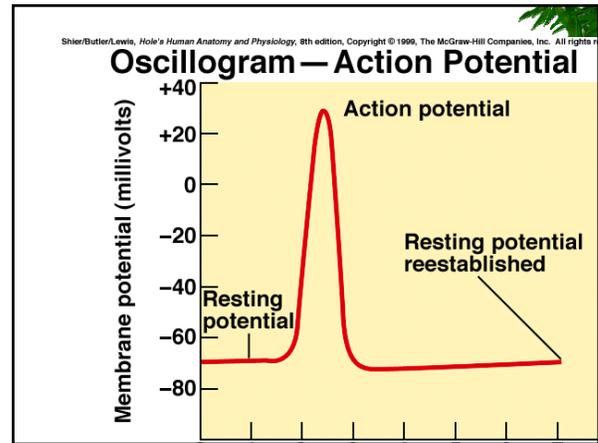
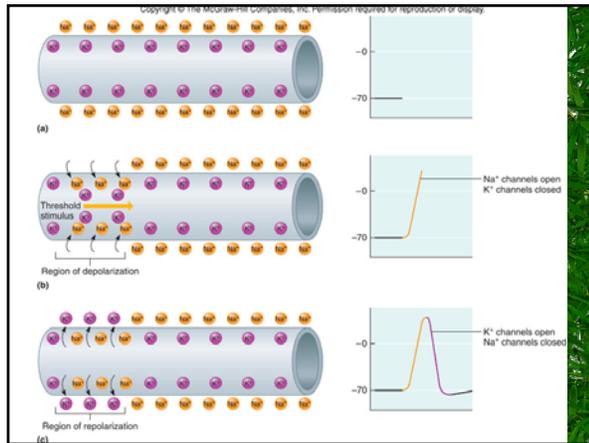
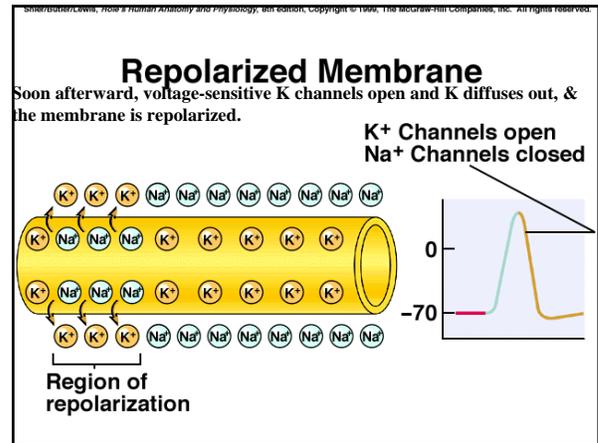
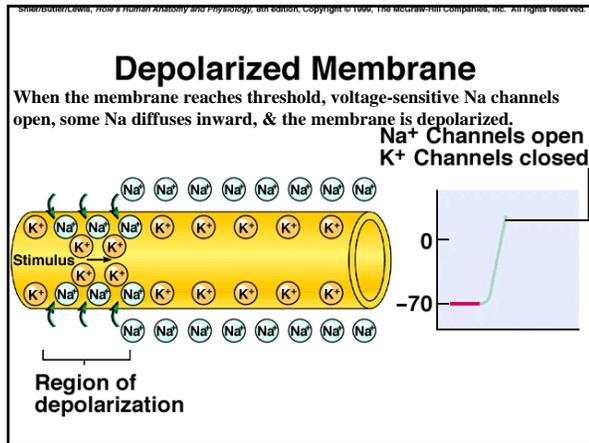
*about the same time, K channels open & K ions diffuse outward, repolarizing the membrane

*this rapid change in potential is an action potential

*many action potentials can occur before active transport reestablishes the original resting potential

*the propagation of action potentials along a nerve fiber is a nerve impulse (KNOW THIS)





F. All-or-None Response

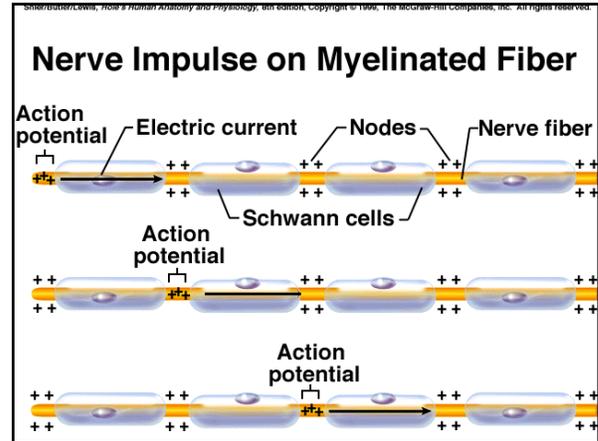
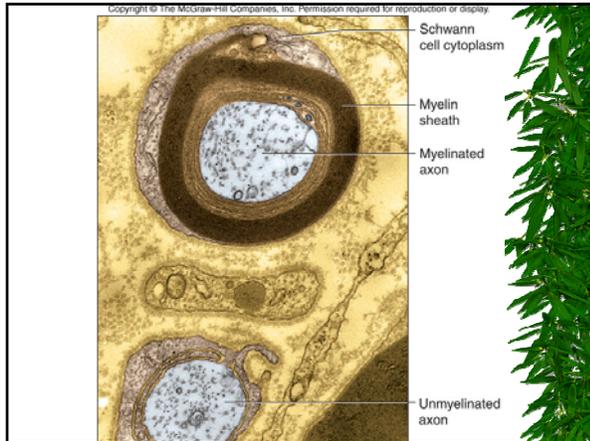
- *a nerve impulse is an **all-or-none** response to a stimulus of threshold intensity applied to a fiber
- *all the impulses conducted on a fiber are the same

G. Refractory Period – the brief amount of time following the passage of a nerve impulse (at threshold stimulus) when the membrane is unresponsive to another stimulus

- *because of the refractory period a nerve fiber cannot be continuously stimulated

H. Impulse Conduction

- *an **unmyelinated nerve fiber** conducts an impulse over its entire surface
- *myelin contains lipids which only allows impulses on **myelinated nerve fibers** to travel from node to node which is **saltatory conduction**
- *impulse conduction is more rapid on myelinated fibers with large diameters (KNOW THIS)

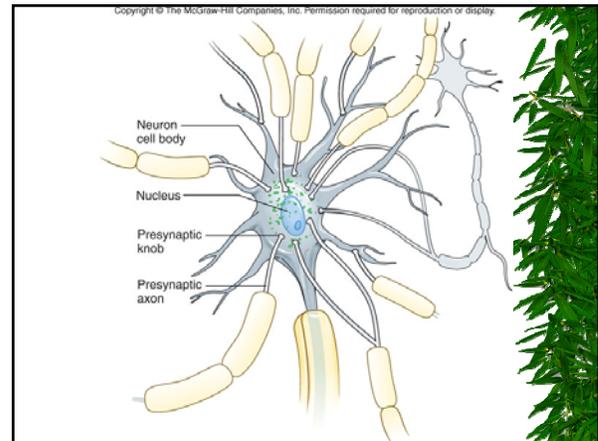


Synaptic Transmission

Neurotransmitter molecules diffuse across the synaptic cleft & react with receptors in the postsynaptic neuron membrane.

Synaptic Potentials

- *some neurotransmitters can depolarize postsynaptic membranes, triggering an action potential. This is an excitatory postsynaptic potential (EPSP).
- *others hyperpolarize the membranes, inhibiting action potentials. This is an inhibitory postsynaptic potential (IPSP).
- *EPSPs and IPSPs are summed in a trigger zone (initial segment of the axon) of the neuron

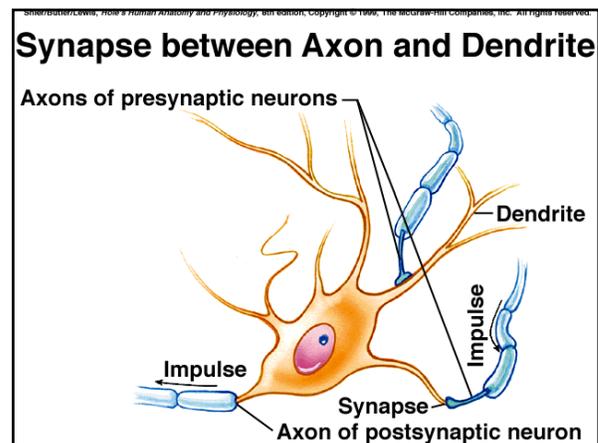


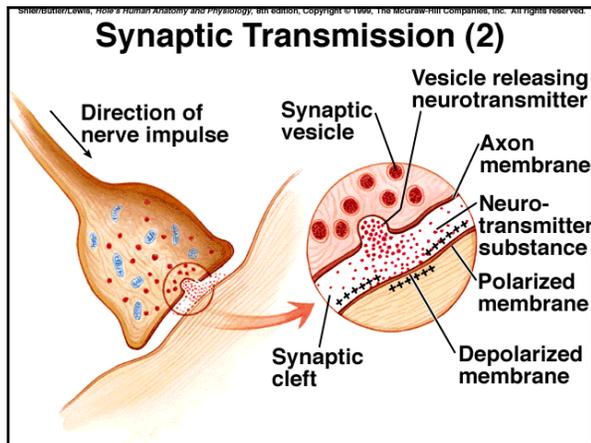
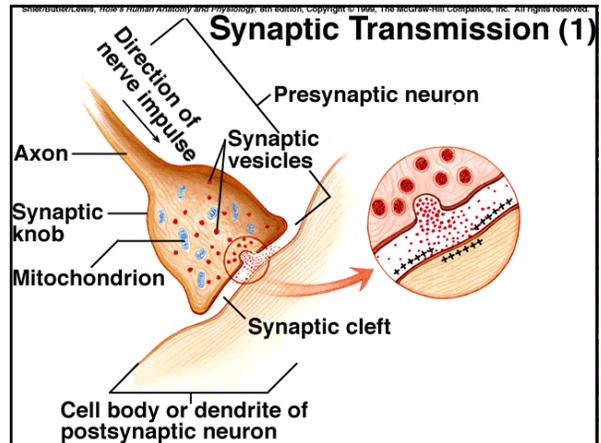
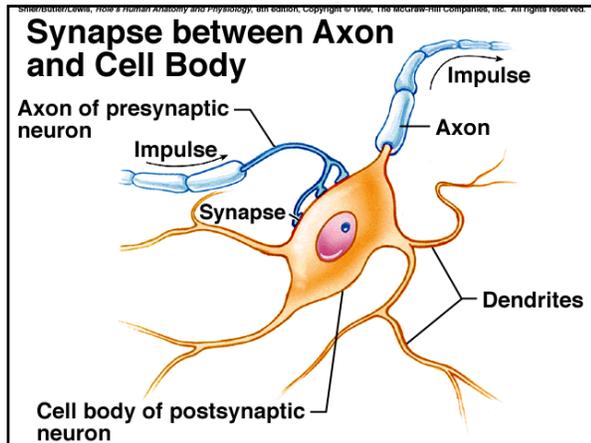
Neurotransmitters

- *nervous system produces about 30 types of neurotransmitters
- *Ca ions diffuse into synaptic knobs in response to action potentials, releasing neurotransmitters
- *neurotransmitters are quickly decomposed or removed from synaptic clefts

Neuropeptides – are chains of amino acids

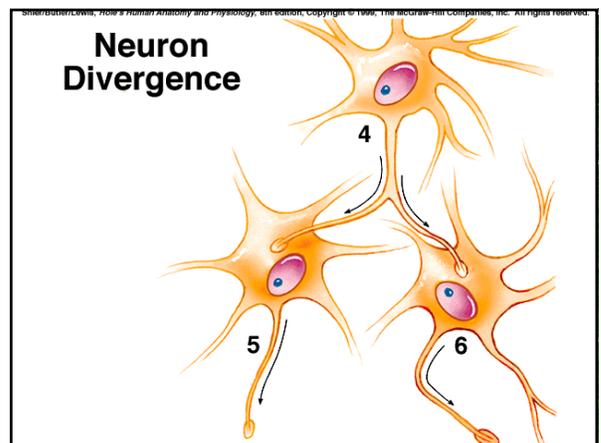
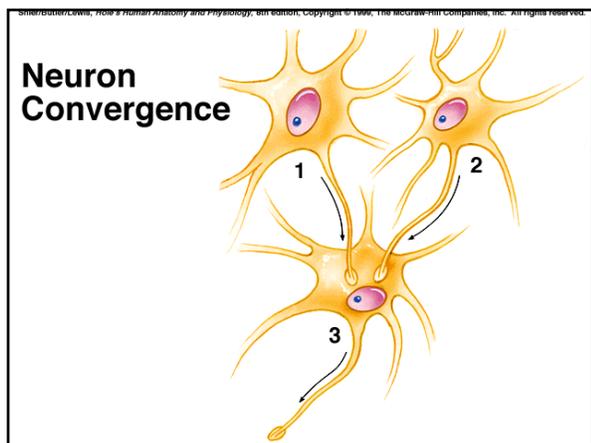
- *some neuropeptides are neurotransmitters or **neuromodulators** = enkephalins, endorphins, & substance P; they function to relieve pain sensations

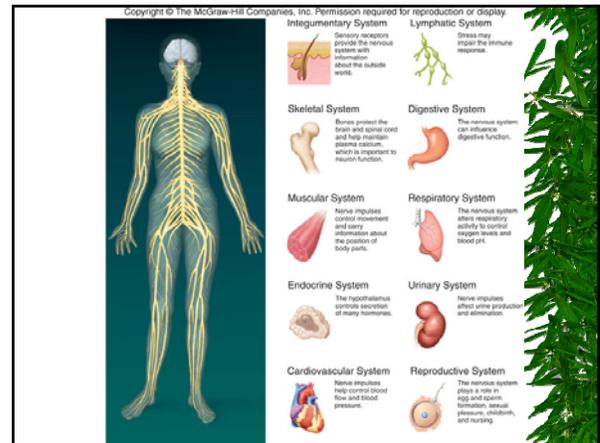
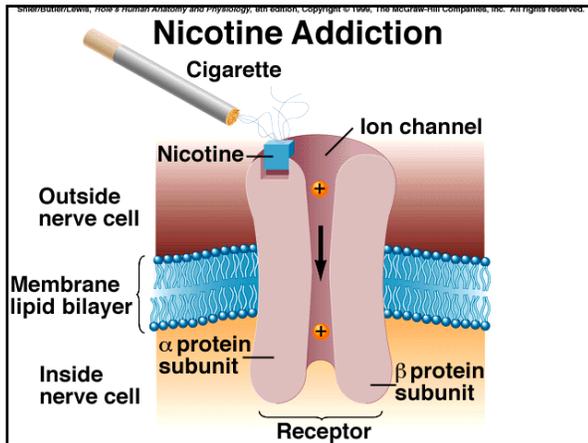




Impulse Processing

- How impulses are processed is dependent upon how neurons are organized in the brain and spinal cord.
- Neuronal Pools**
*neurons are organized into pools within the central nervous system; each pool receives, processes, & conducts away impulses
- Facilitation**
*each neuron in a pool may receive excitatory and inhibitory stimuli
*a neuron is **facilitated** when it receives subthreshold stimuli & becomes more excitable
- Convergence** – when impulses from 2 or more incoming fibers may converge on a single neuron
***convergence** enables a neuron to summate impulses from different sources
- Divergence** – impulses leaving a pool may diverge by passing onto several output fibers
***divergence** amplifies impulses





Time to STUDY!

Remember – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 10 test.