Hole's Human
Anatomy and Physiology

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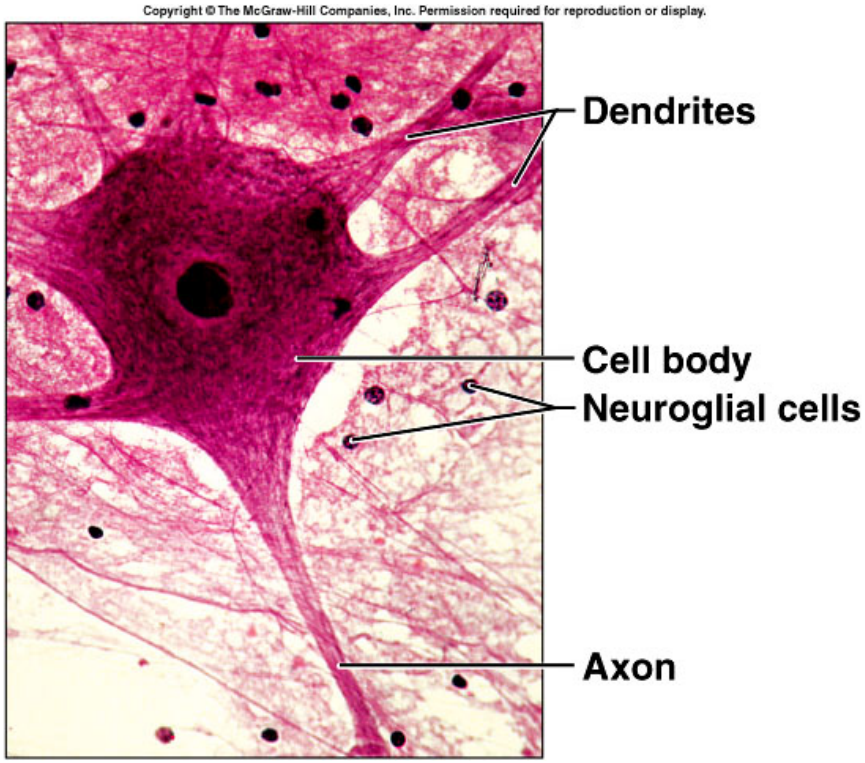
Chapter 10
Nervous System I

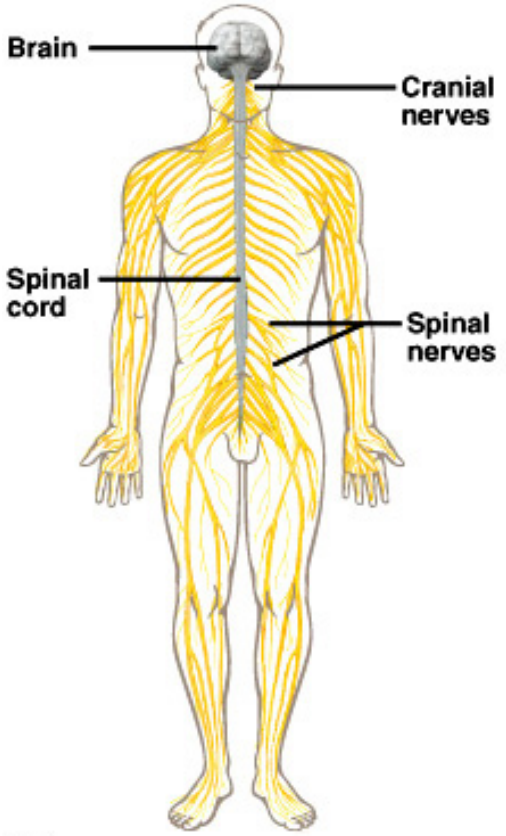
Cell Types of Neural Tissue

- **neurons**
- **neuroglial cells**



Divisions of the Nervous System

- Central Nervous System
  - brain
  - spinal cord
- Peripheral Nervous System
  - nerves
    - cranial nerves
    - spinal nerves



Divisions of Peripheral Nervous System

Sensory Division

- **picks up sensory information and delivers it to the CNS**

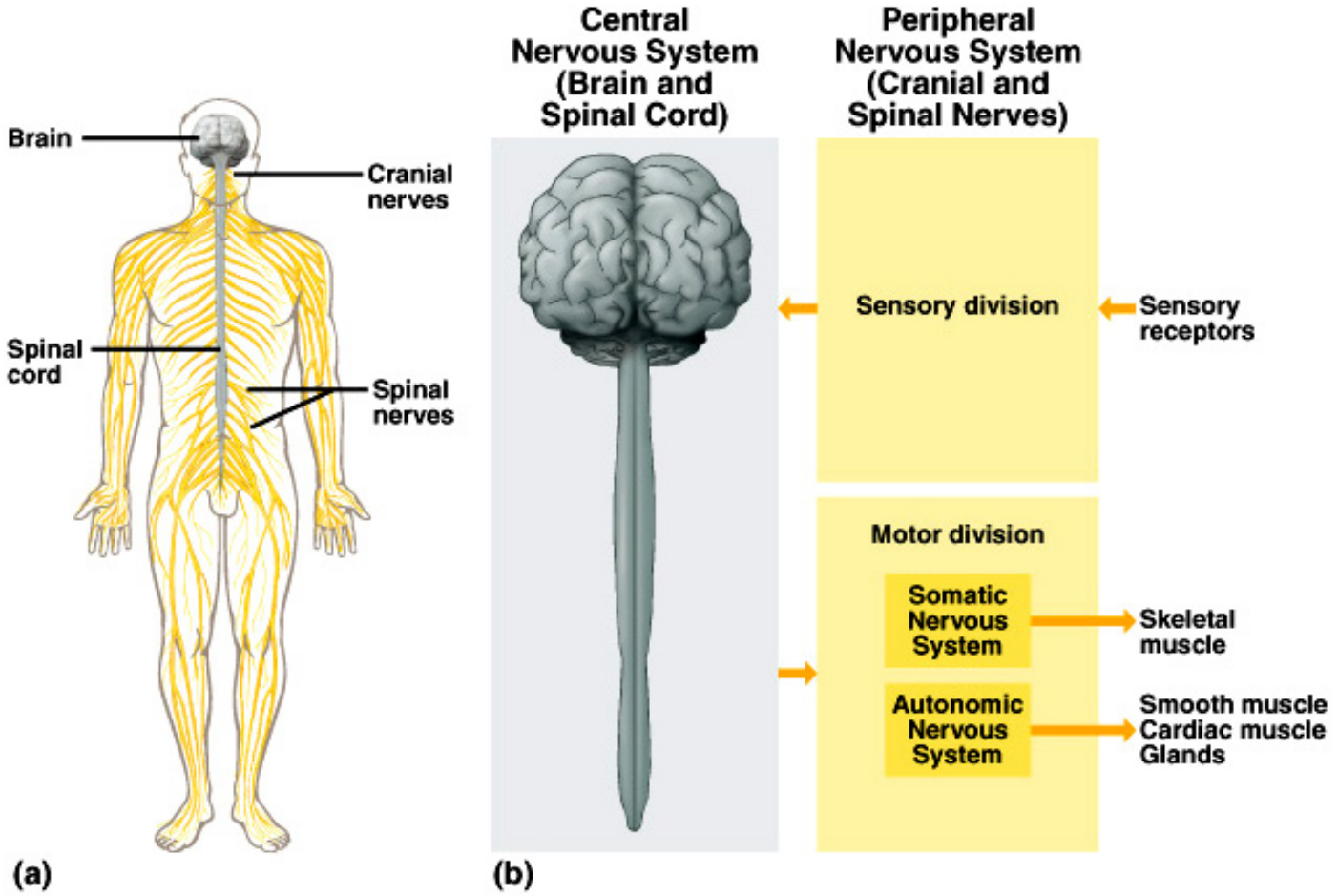
Motor Division

- **carries information to muscles and glands**

Divisions of the Motor Division

- **Somatic – carries information to skeletal muscle**
- **Autonomic – carries information to smooth muscle, cardiac muscle, and glands**

Divisions Nervous System



Functions of Nervous System

Sensory Function

- sensory receptors gather information
- information is carried to the CNS

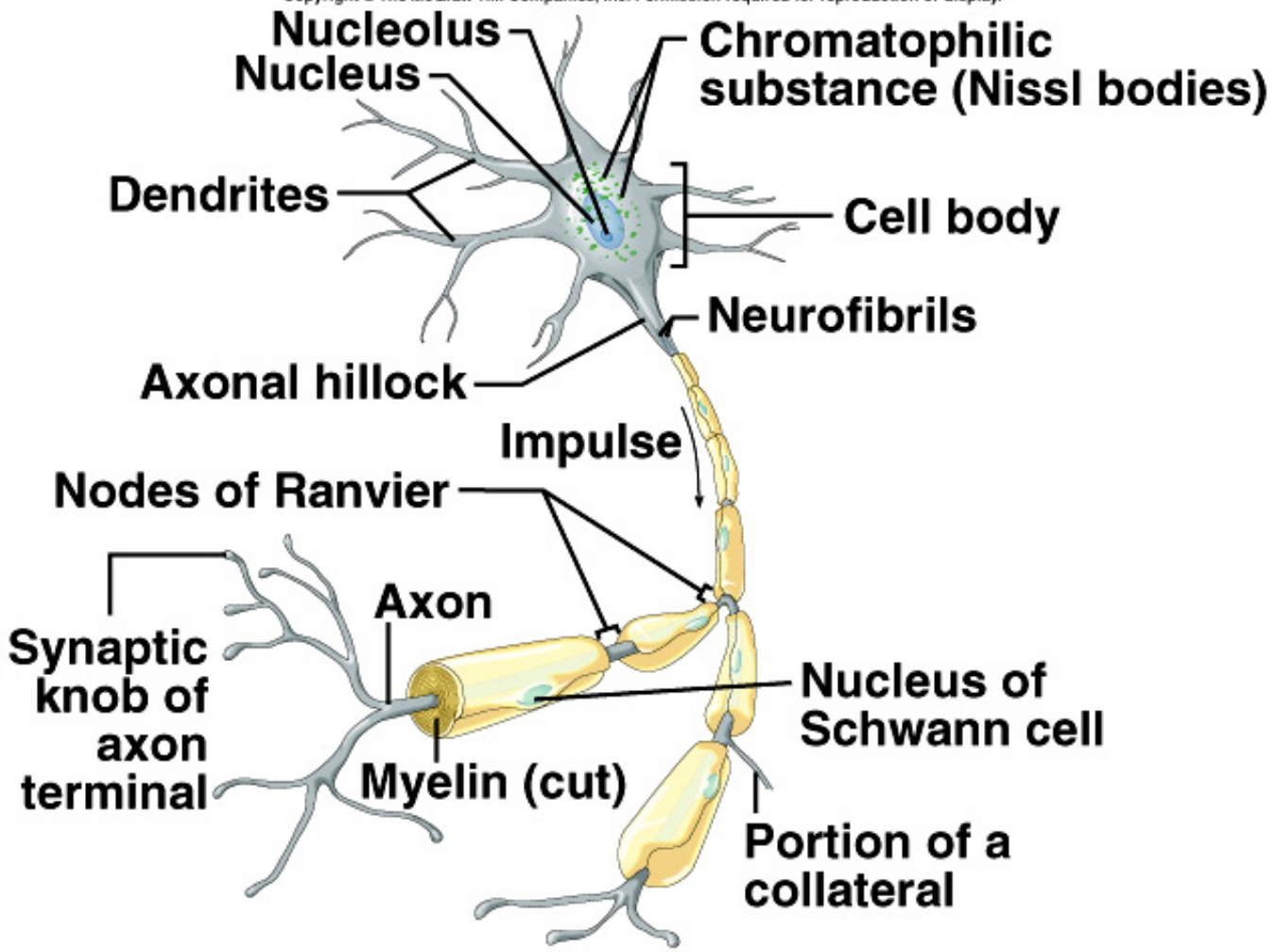
Integrative Function

- sensory information used to create
  - sensations
  - memory
  - thoughts
  - decisions

Motor Function

- decisions are acted upon
- impulses are carried to effectors

Neuron Structure



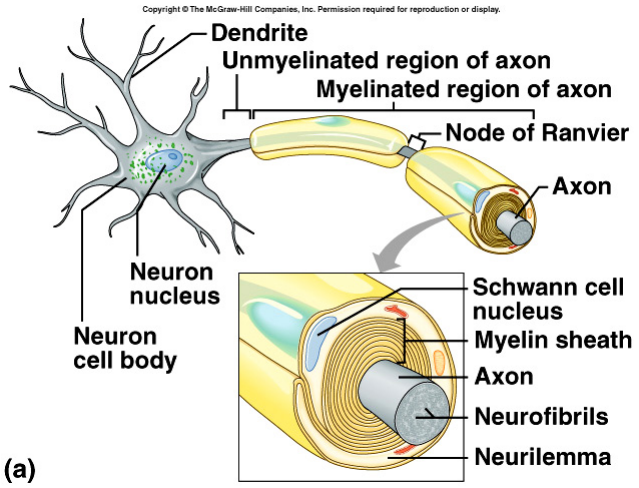
Myelination of Axons

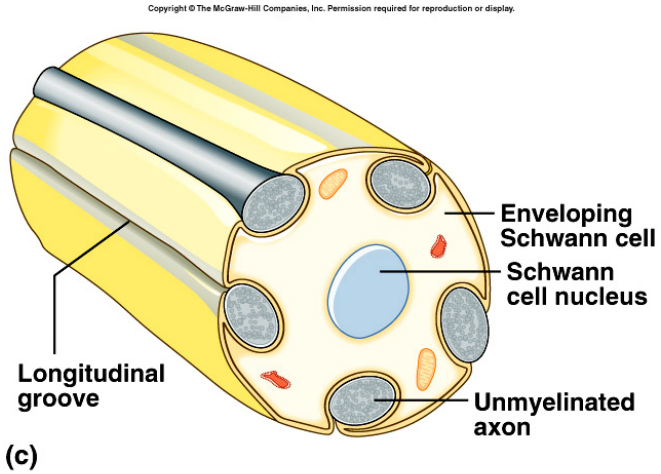
White Matter

- contains myelinated axons

Gray Matter

- contains unmyelinated structures
- cell bodies, dendrites





Classification of Neurons – Structural Differences

Bipolar

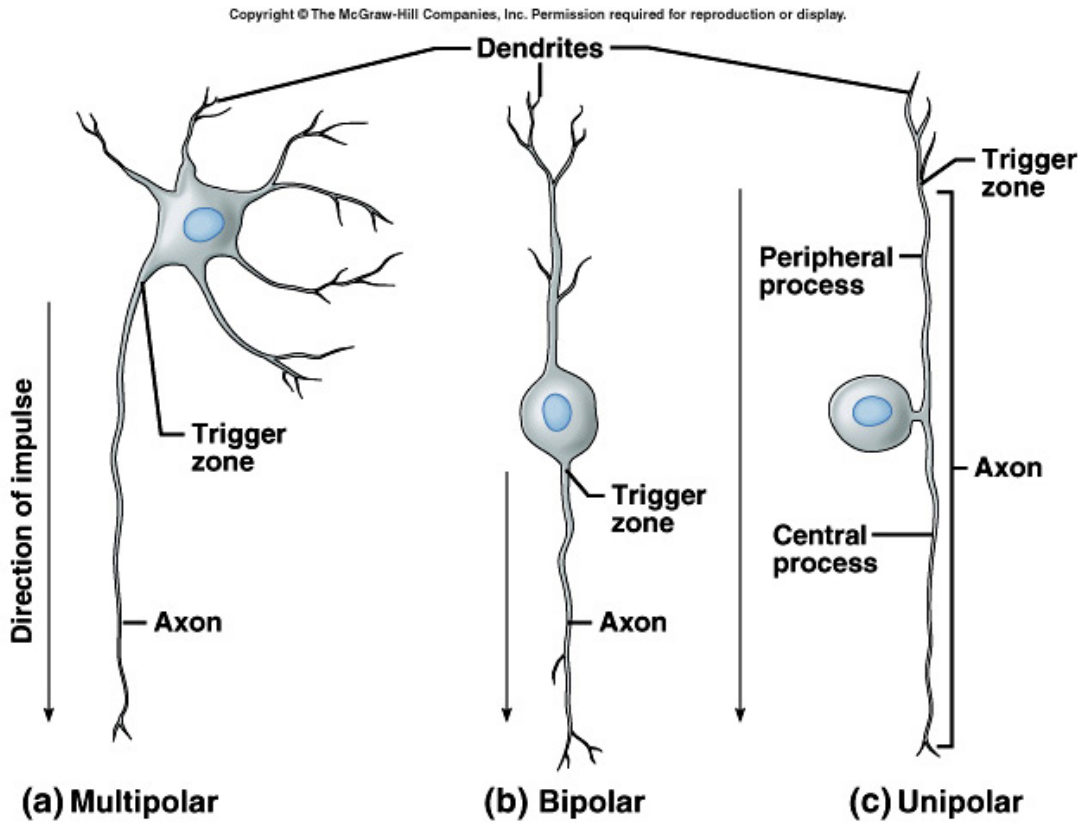
- two processes
- eyes, ears, nose

Unipolar

- one process
- ganglia

Multipolar

- many processes
- most neurons of CNS



Classification of Neurons – Functional Differences

Sensory Neurons

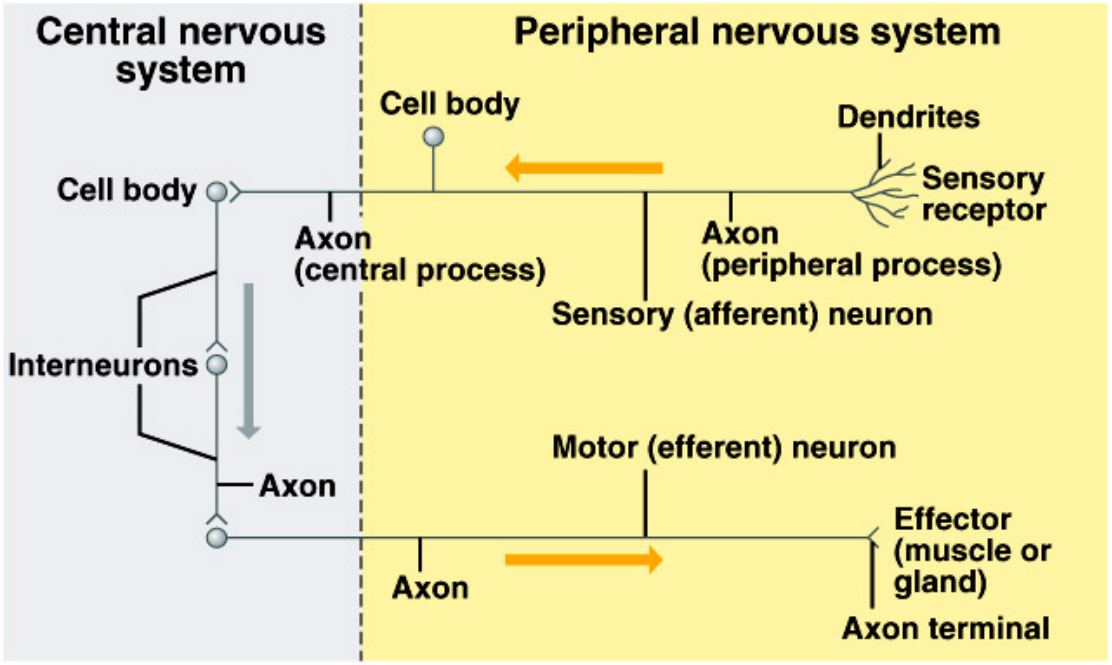
- afferent
- carry impulse to CNS
- most are unipolar
- some are bipolar

Interneurons

- link neurons
- multipolar
- in CNS

Motor Neurons

- multipolar
- carry impulses away from CNS
- carry impulses to effectors



Types of Neuroglial Cells in the PNS

Schwann Cells

- **produce myelin found on peripheral myelinated neurons**
- **speed neurotransmission**

Satellite Cells

- **support clusters of neuron cell bodies (ganglia)**

Types of Neuroglial Cells in the CNS

Astrocytes

- CNS
- scar tissue
- mop up excess ions, etc
- induce synapse formation
- connect neurons to blood vessels

Oligodendrocytes

- CNS
- myelinating cell

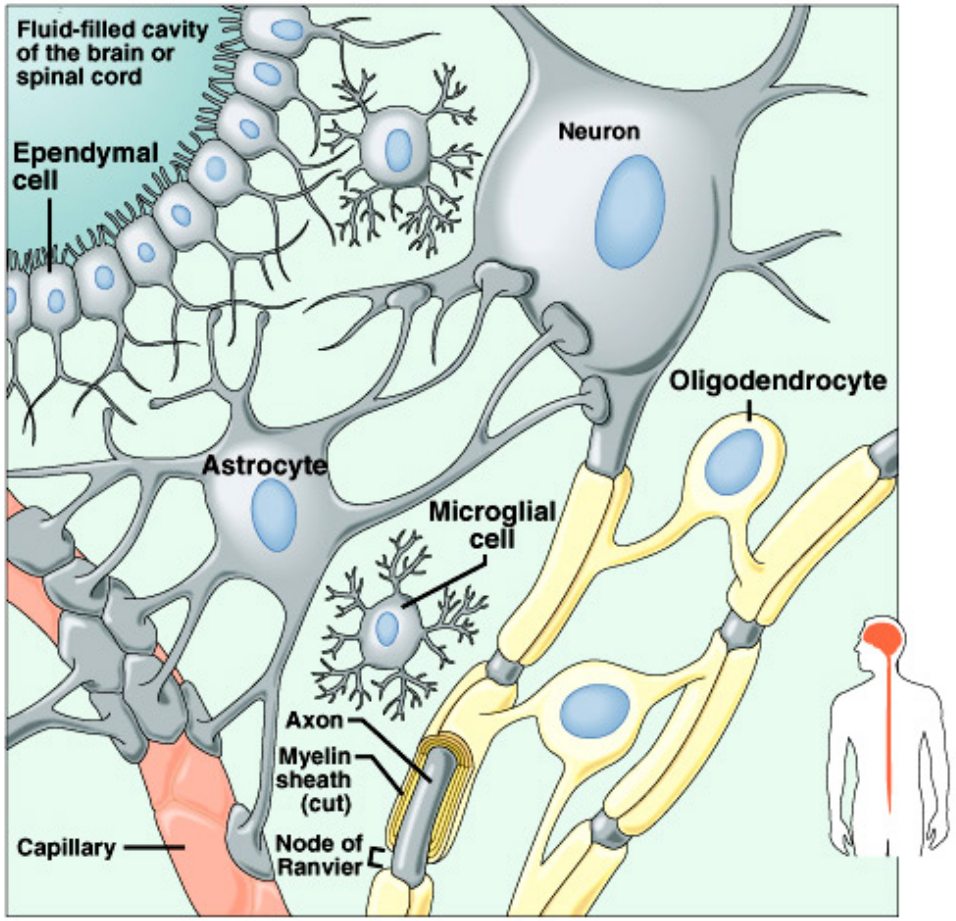
Microglia

- CNS
- phagocytic cell

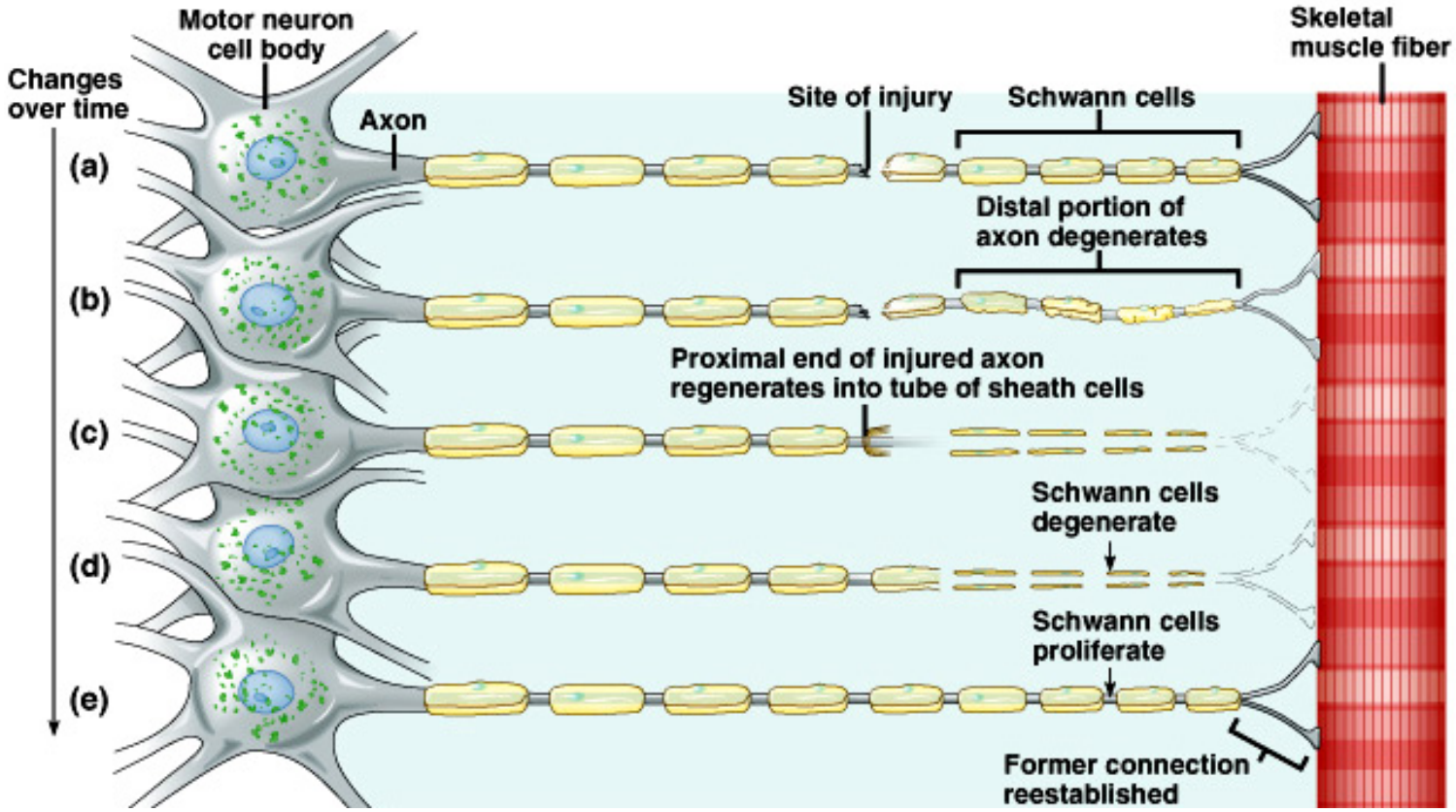
Ependyma

- CNS
- ciliated
- line central canal of spinal cord
- line ventricles of brain

Types of Neuroglial Cells

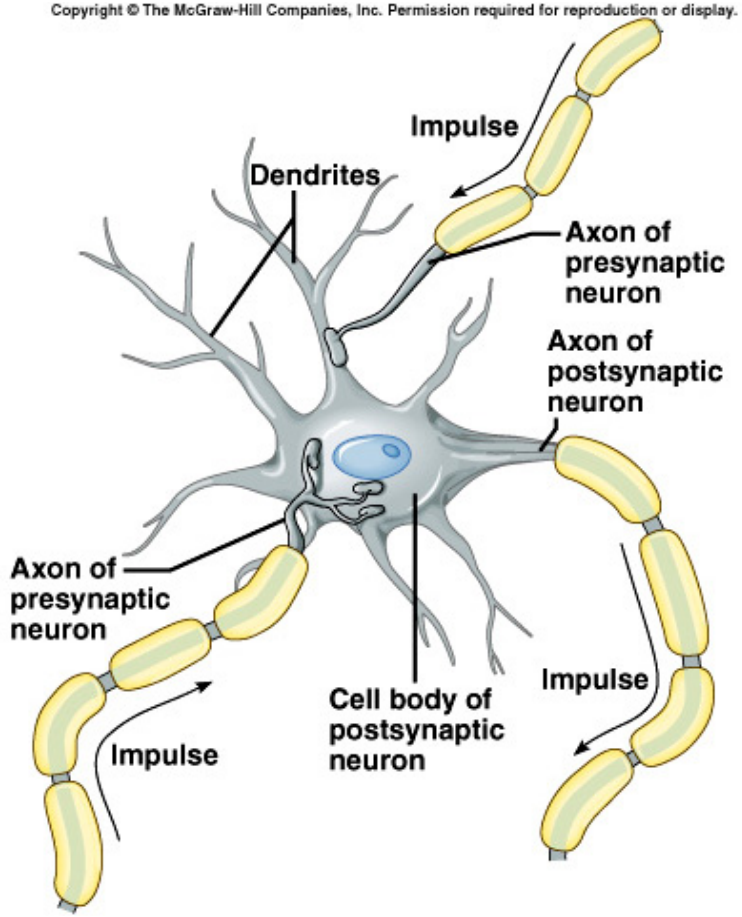


Regeneration of A Nerve Axon



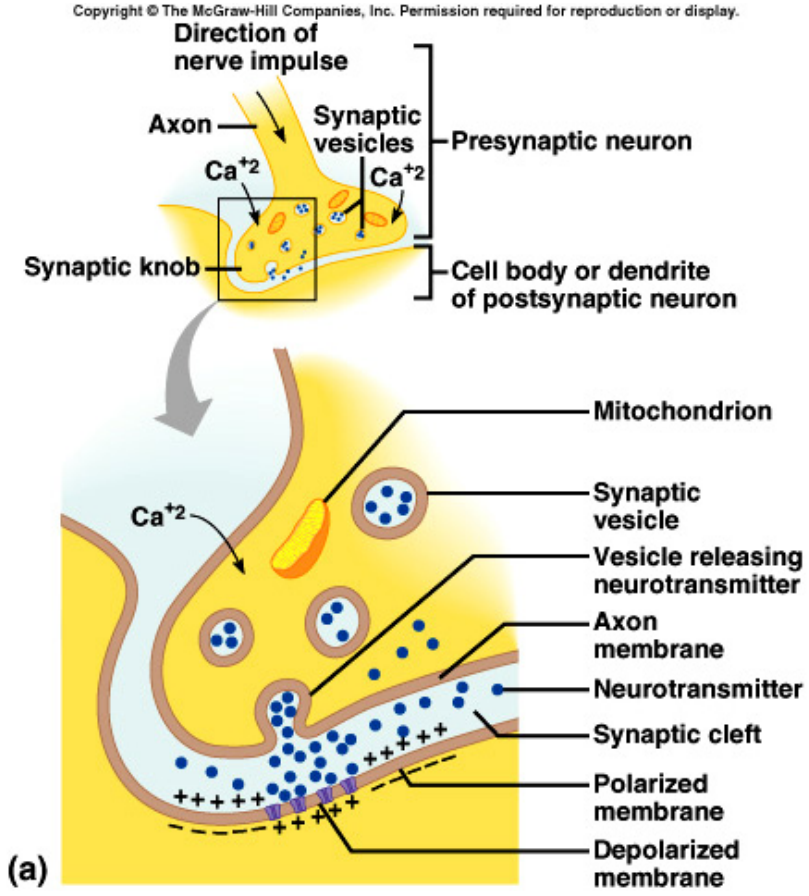
The Synapse

Nerve impulses pass from neuron to neuron at synapses



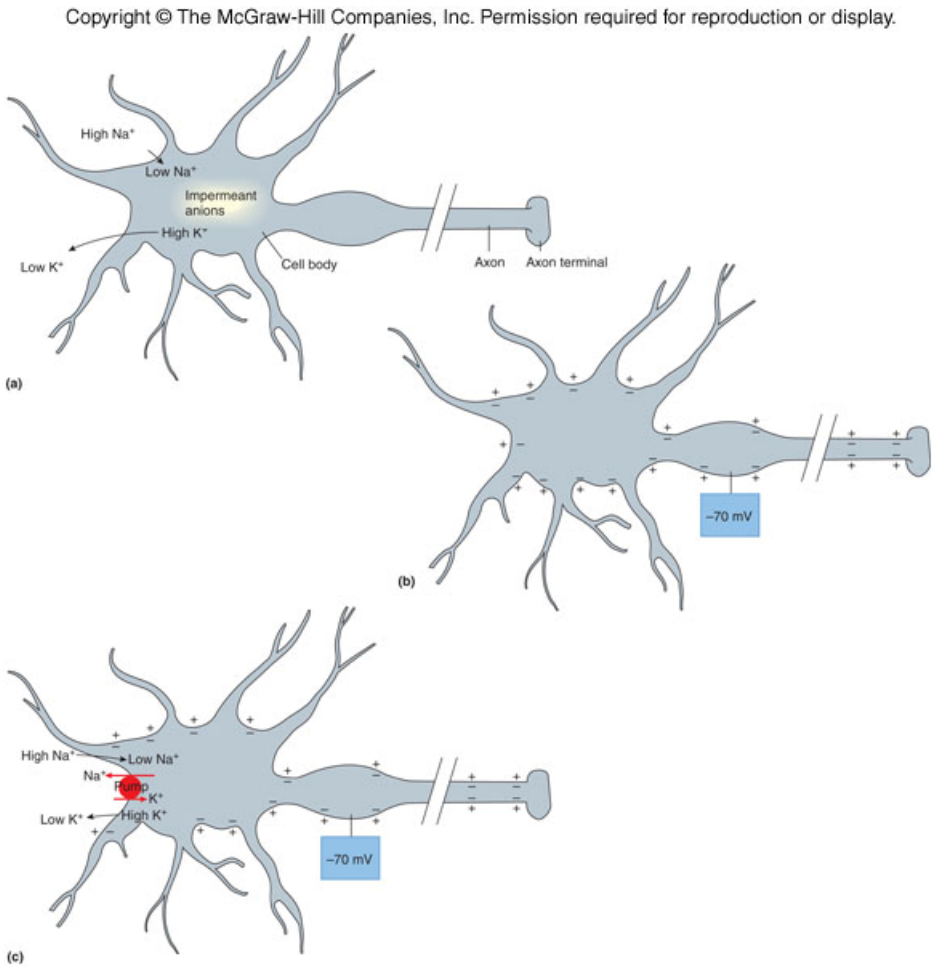
Synaptic Transmission

Neurotransmitters are released when impulse reaches synaptic knob



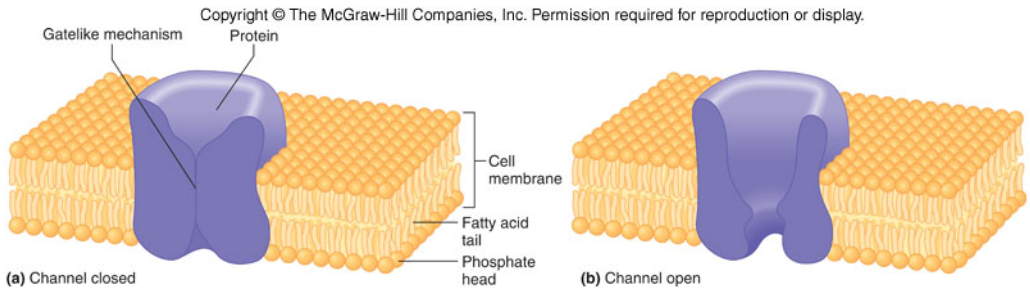
Resting Membrane Potential

- **inside is negative relative to the outside**
- **polarized membrane**
- **due to distribution of ions**
- **Na^+/K^+ pump**



Local Potential Changes

- **caused by various stimuli**
  - **temperature changes**
  - **light**
  - **pressure**



- **environmental changes affect the membrane potential by opening a gated ion channel**

Local Potential Changes

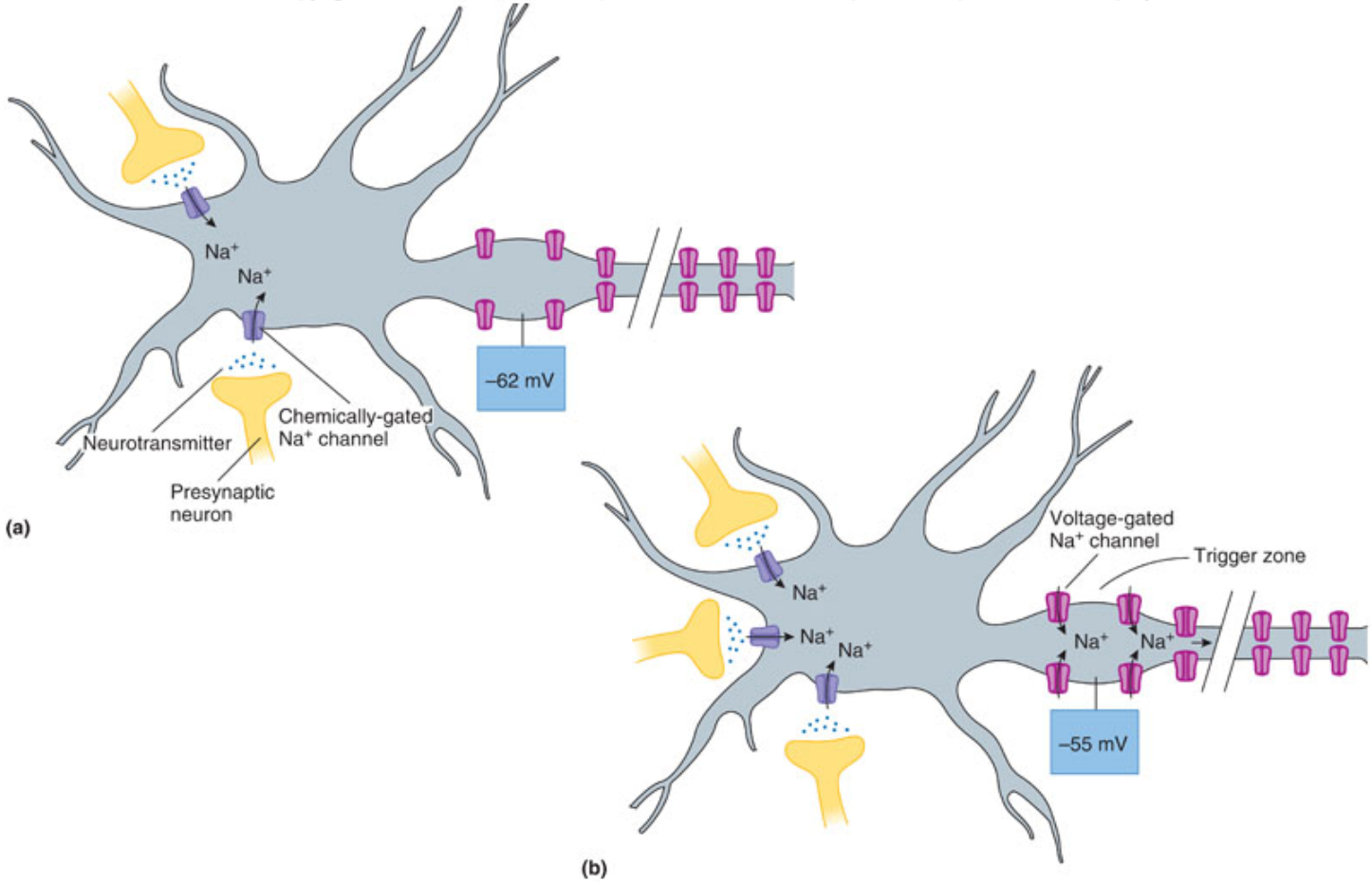
•**if membrane potential becomes more negative, it has hyperpolarized**

• **if membrane potential becomes less negative, it has depolarized**

• **graded**

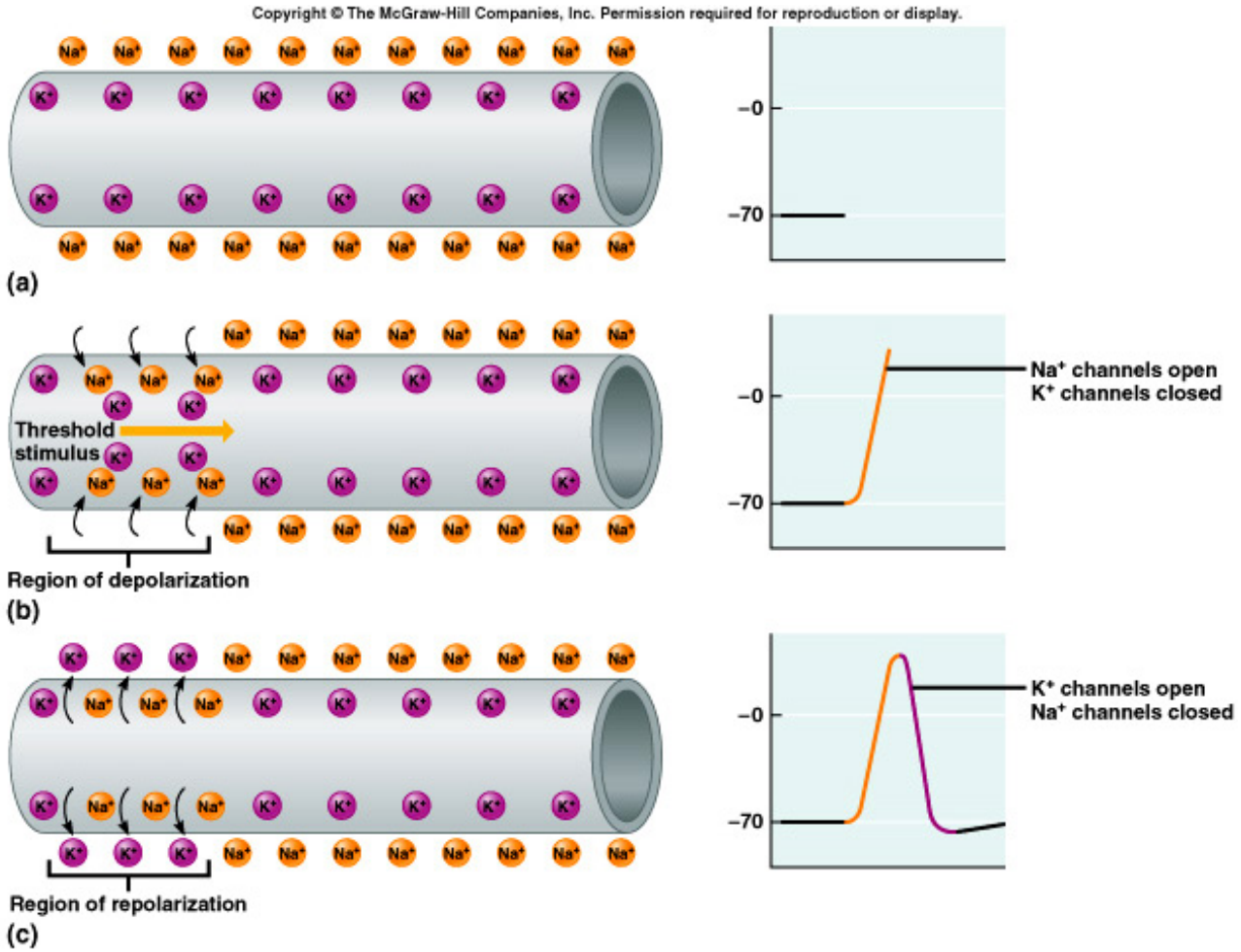
• **summation can lead to threshold stimulus that starts an action potential**

Local Potential Changes

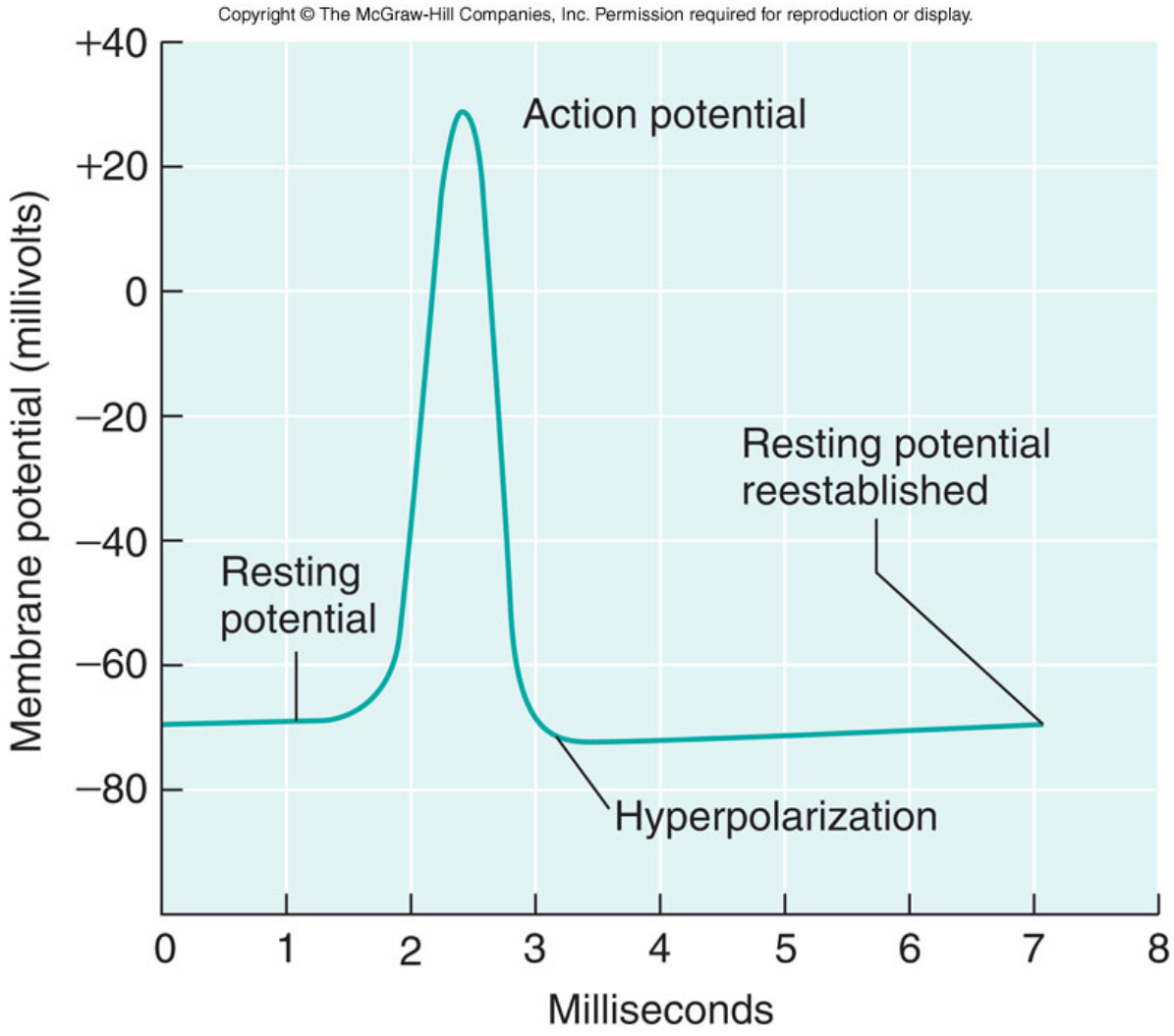


Action Potentials

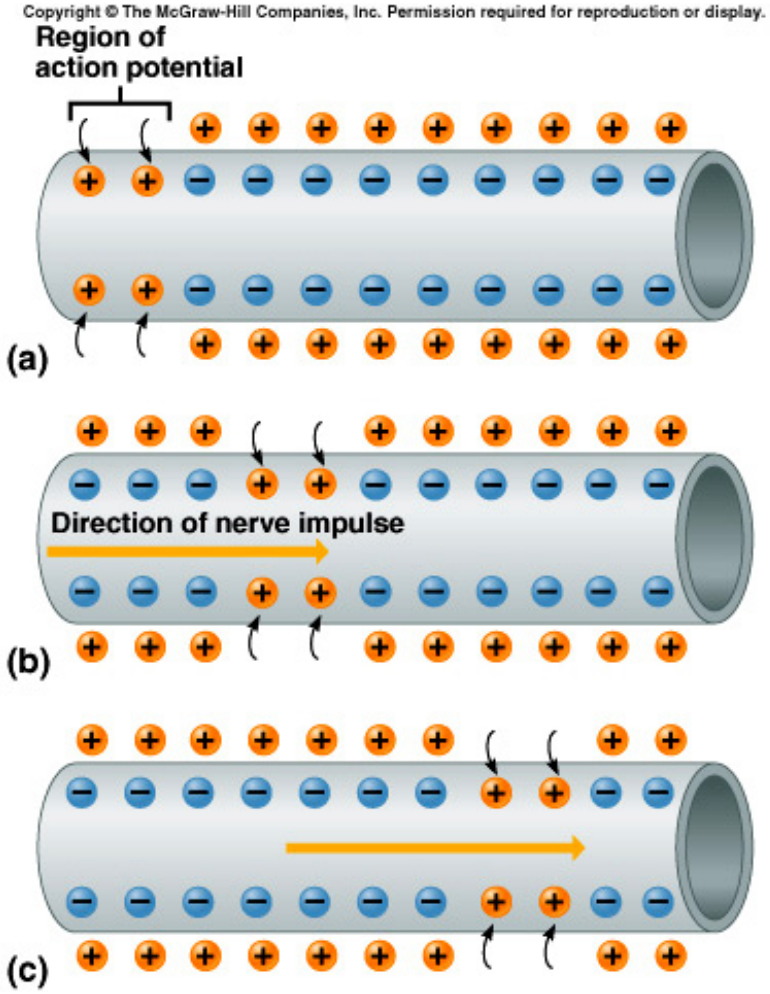
- at rest membrane is polarized
- threshold stimulus reached
- sodium channels open and membrane depolarizes
- potassium leaves cytoplasm and membrane repolarizes



Action Potentials



Action Potentials



All-or-None Response

- **if a neuron responds at all, it responds completely**

- **a nerve impulse is conducted whenever a stimulus of threshold intensity or above is applied to an axon**

- **all impulses carried on an axon are the same strength**

Refractory Period

- **absolute**

– time when threshold stimulus does not start another action potential

- **relative**

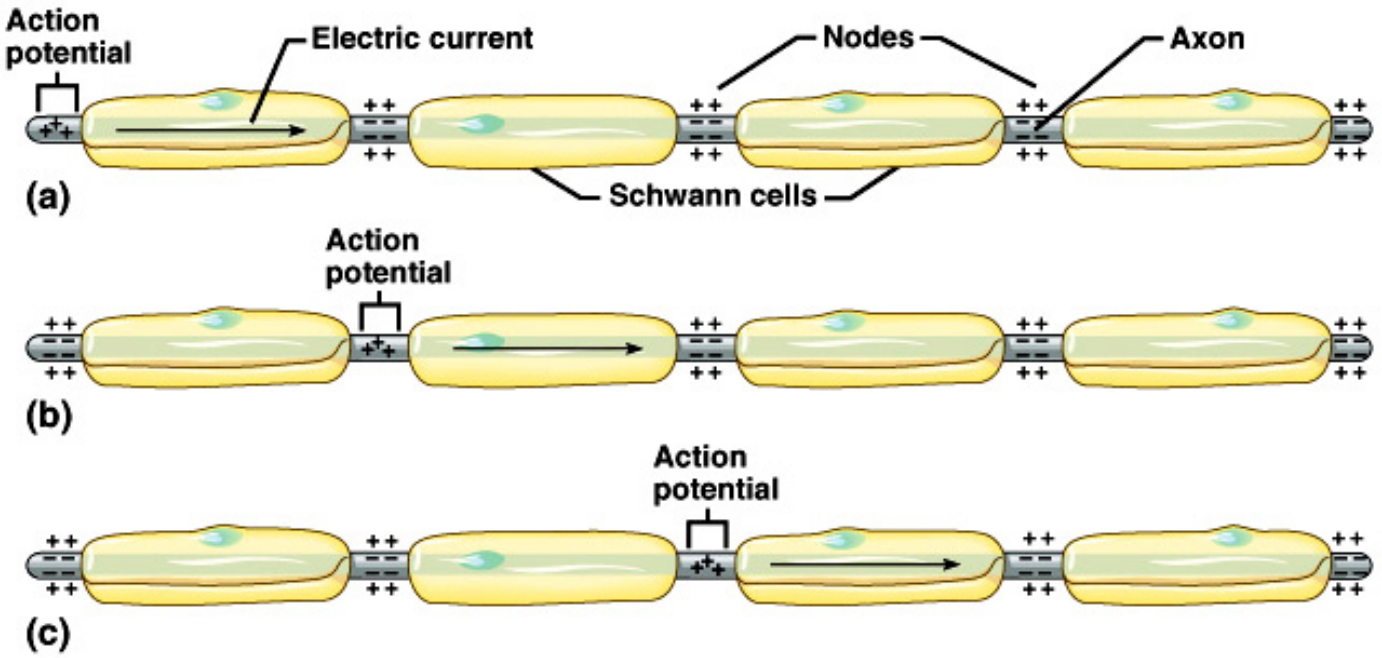
–time when stronger threshold stimulus can start another action potential

Impulse Conduction

TABLE 10.3 Events Leading to Nerve Impulse Conduction

1. Nerve cell membrane maintains resting potential by diffusion of Na^+ and K^+ down their concentration gradients as the cell pumps them up the gradients.
2. Neurons receive stimulation, causing local potentials, which may sum to reach threshold.
3. Sodium channels in a local region of the membrane open.
4. Sodium ions diffuse inward, depolarizing the membrane.
5. Potassium channels in the membrane open.
6. Potassium ions diffuse outward, repolarizing the membrane.
7. The resulting action potential causes an electric current that stimulates adjacent portions of the membrane.
8. Series of action potentials occurs sequentially along the length of the axon as a nerve impulse.

Saltatory Conduction



Synaptic Potentials

EPSP

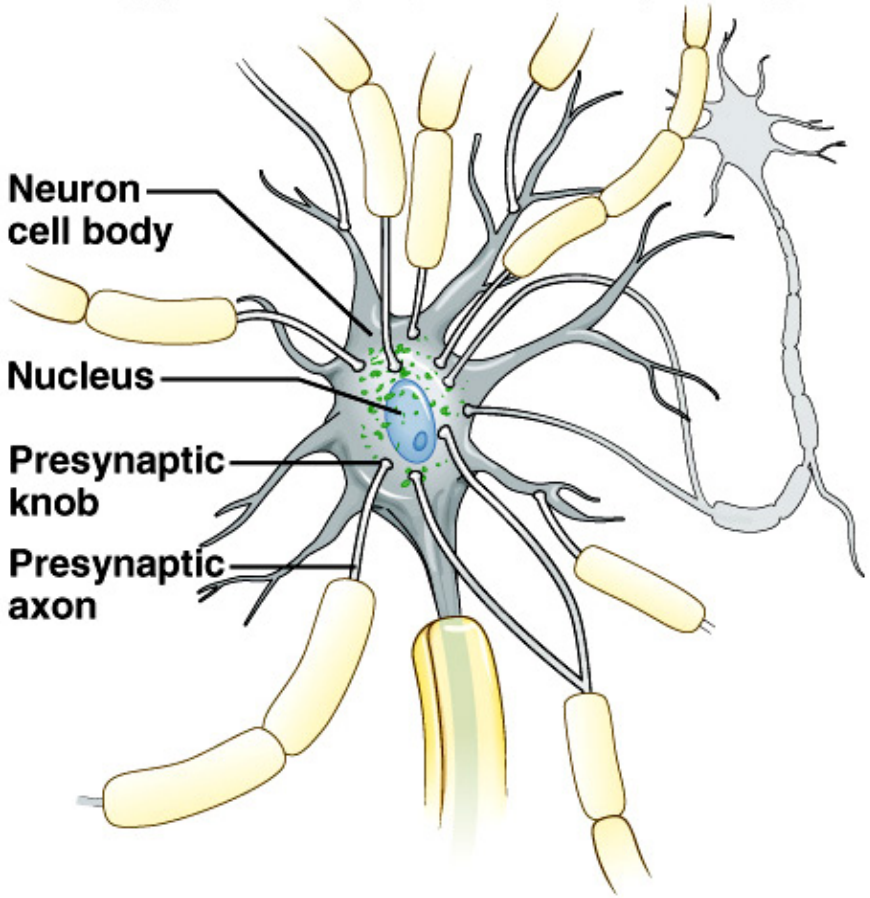
- **excitatory postsynaptic potential**
- **graded**
- **depolarizes membrane of postsynaptic neuron**
- **action potential of postsynaptic neuron becomes more likely**

IPSP

- **inhibitory postsynaptic potential**
- **graded**
- **hyperpolarizes membrane of postsynaptic neuron**
- **action potential of postsynaptic neuron becomes less likely**

Summation of EPSPs and IPSPs

- **EPSPs and IPSPs are added together in a process called summation**
- **More EPSPs lead to greater probability of action potential**



Neurotransmitters

TABLE 10.4 Some Neurotransmitters and Representative Actions

Neurotransmitter	Location	Major Actions
Acetylcholine	CNS	Controls skeletal muscle actions
	PNS	Stimulates skeletal muscle contraction at neuromuscular junctions. May excite or inhibit at autonomic nervous system synapses
Biogenic amines		
Norepinephrine	CNS	Creates a sense of well-being; low levels may lead to depression
	PNS	May excite or inhibit autonomic nervous system actions, depending on receptors
Dopamine	CNS	Creates a sense of well-being; deficiency in some brain areas associated with Parkinson disease
	PNS	Limited actions in autonomic nervous system; may excite or inhibit, depending on receptors
Serotonin	CNS	Primarily inhibitory; leads to sleepiness; action is blocked by LSD, enhanced by selective serotonin reuptake inhibitor antidepressant drugs
Histamine	CNS	Release in hypothalamus promotes alertness
Amino acids		
GABA	CNS	Generally inhibitory
Glutamate	CNS	Generally excitatory
Neuropeptides		
Enkephalins, endorphins	CNS	Generally inhibitory; reduce pain by inhibiting substance P release
Substance P	PNS	Excitatory; pain perception
Gases		
Nitric oxide	CNS	May play a role in memory
	PNS	Vasodilation

Neurotransmitters

TABLE 10.7 Events Leading to Neurotransmitter Release

1. Action potential passes along an axon and over the surface of its synaptic knob.
2. Synaptic knob membrane becomes more permeable to calcium ions, and they diffuse inward.
3. In the presence of calcium ions, synaptic vesicles fuse to synaptic knob membrane.
4. Synaptic vesicles release their neurotransmitter by exocytosis into the synaptic cleft.
5. Synaptic vesicles become part of the membrane.
6. The added membrane provides material for endocytotic vesicles.

Impulse Processing

- **way the NS processes nerve impulses and acts upon them**

- **Neuronal Pools**

- **Convergence**

- **Divergence**

Neuronal Pools

•groups of interneurons that make synaptic connections with each other

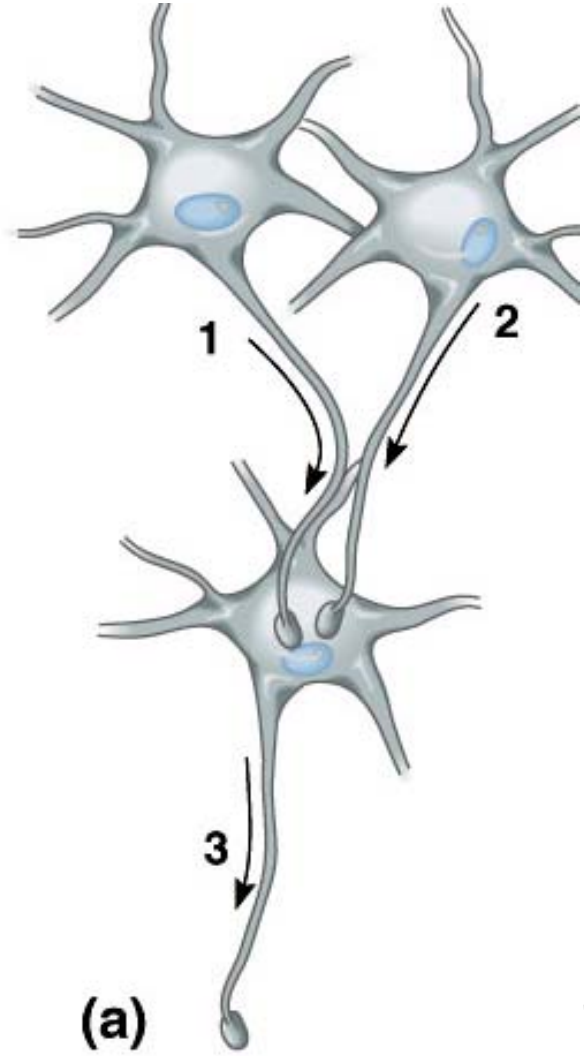
• interneurons work together to perform a common function

• each pool receives input from other neurons

• each pool generates output to other neurons

Convergence

- **neuron receives input from several neurons**
- **incoming impulses represent information from different types of sensory receptors**
- **allows nervous system to collect, process, and respond to information**
- **makes it possible for a neuron to sum impulses from different sources**

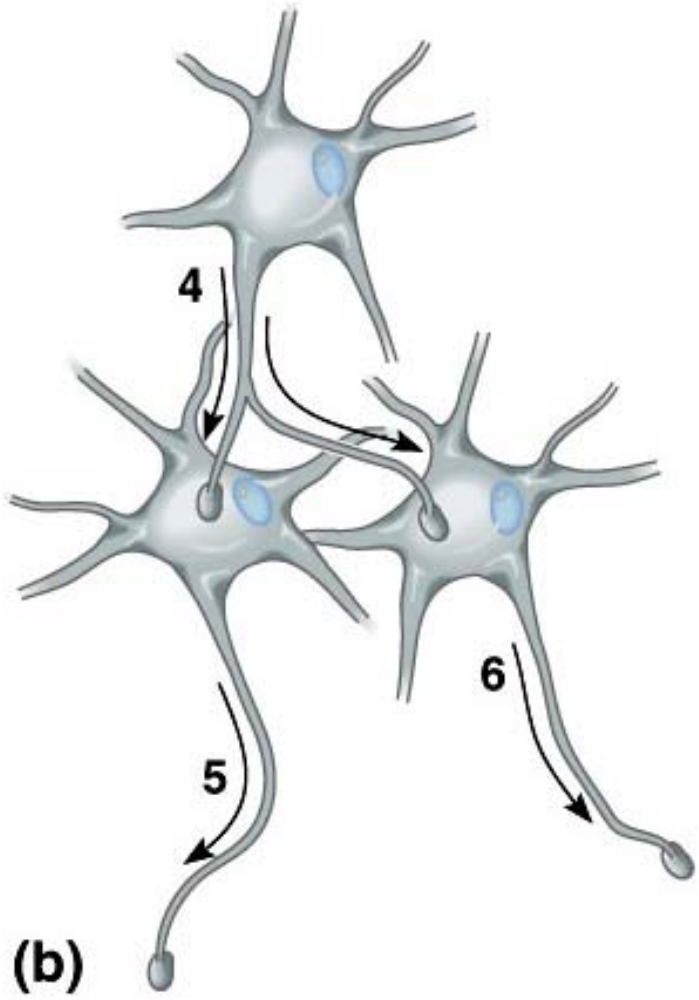


Divergence

- **one neuron sends impulses to several neurons**

- **can amplify an impulse**

- **impulse from a single neuron in CNS may be amplified to activate enough motor units needed for muscle contraction**



Clinical Application

Drug Addiction

- occurs because of the complex interaction of neurons, drugs, and individual behaviors
- understanding how neurotransmitters fit receptors can help explain the actions of certain drugs
- drugs have different mechanisms of action
- several questions remain about the biological effects of addiction, such as why some individuals become addicted and others do not