

NERVOUS SYSTEM

Cells of the Nervous System

Peripheral Nervous System

Impulse Conduction

Nerve Circuit

Ch48 p1023-1026, 1040-1041

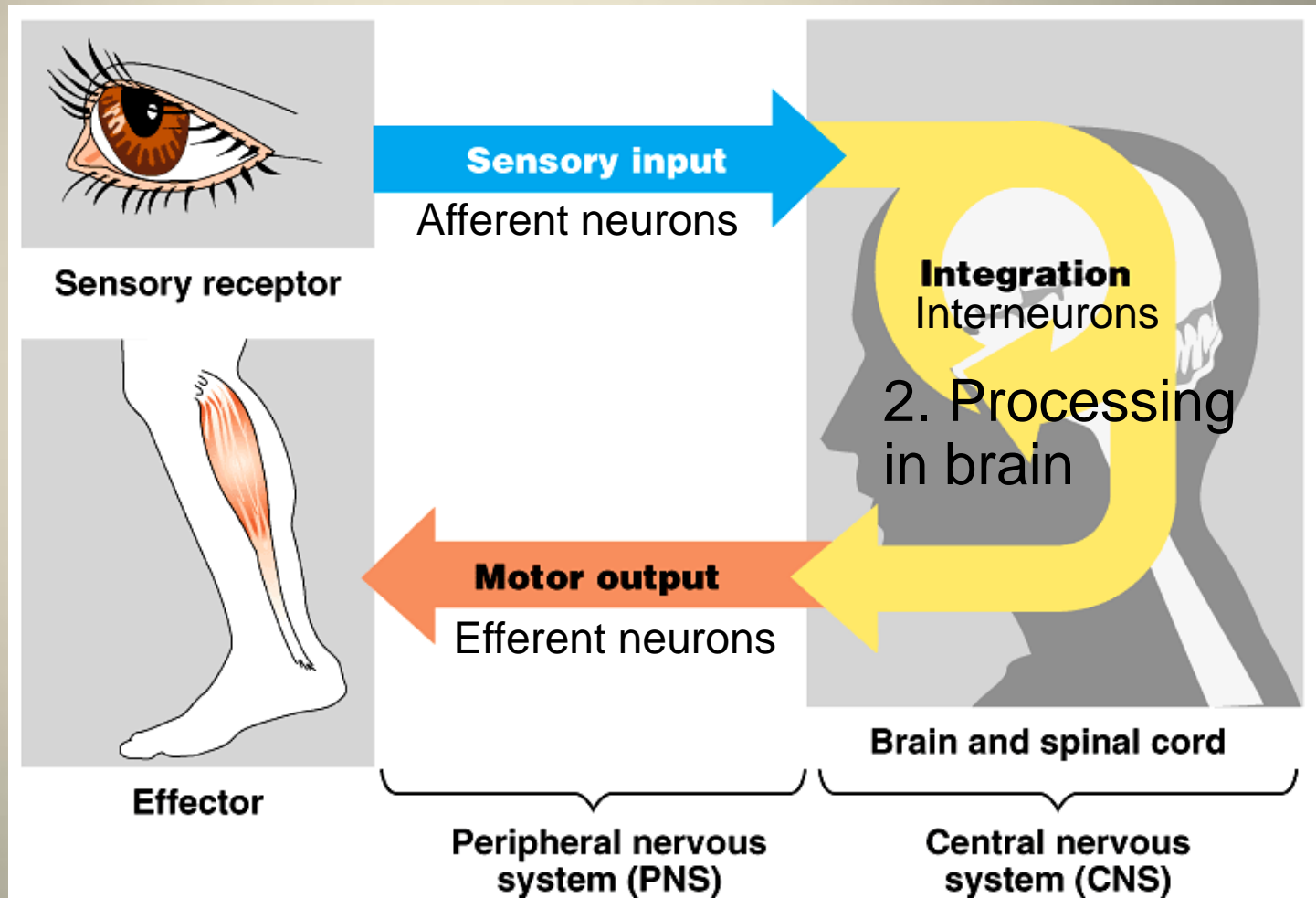
Role of nervous system

- To transmit information rapidly
- The brain receives information about the environment and responds accordingly

How the nervous system works

1. Detection of stimulus

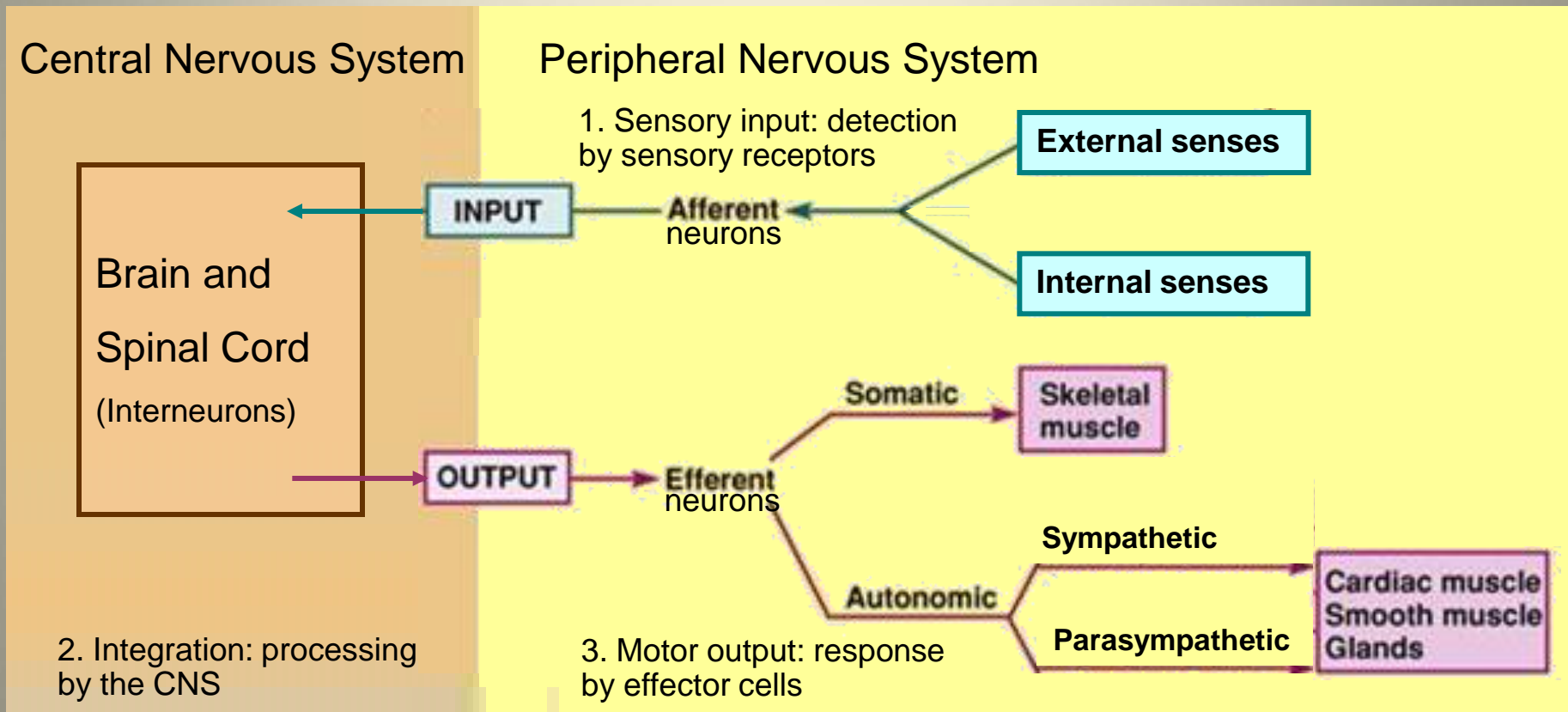
3. Response in other part of body



How the nervous system works

Function	Description	Components
1. Sensory Input	Detection of stimulus	a. Sensory receptor b. Afferent / sensory neurons
2. Integration	Processing in the brain	c. Central Nervous system (brain & spinal cord interneurons)
3. Motor Output	Response in other body part	d. Efferent / motor neurons e. Effector cells (muscle cells or glands)

Overview of the nervous system



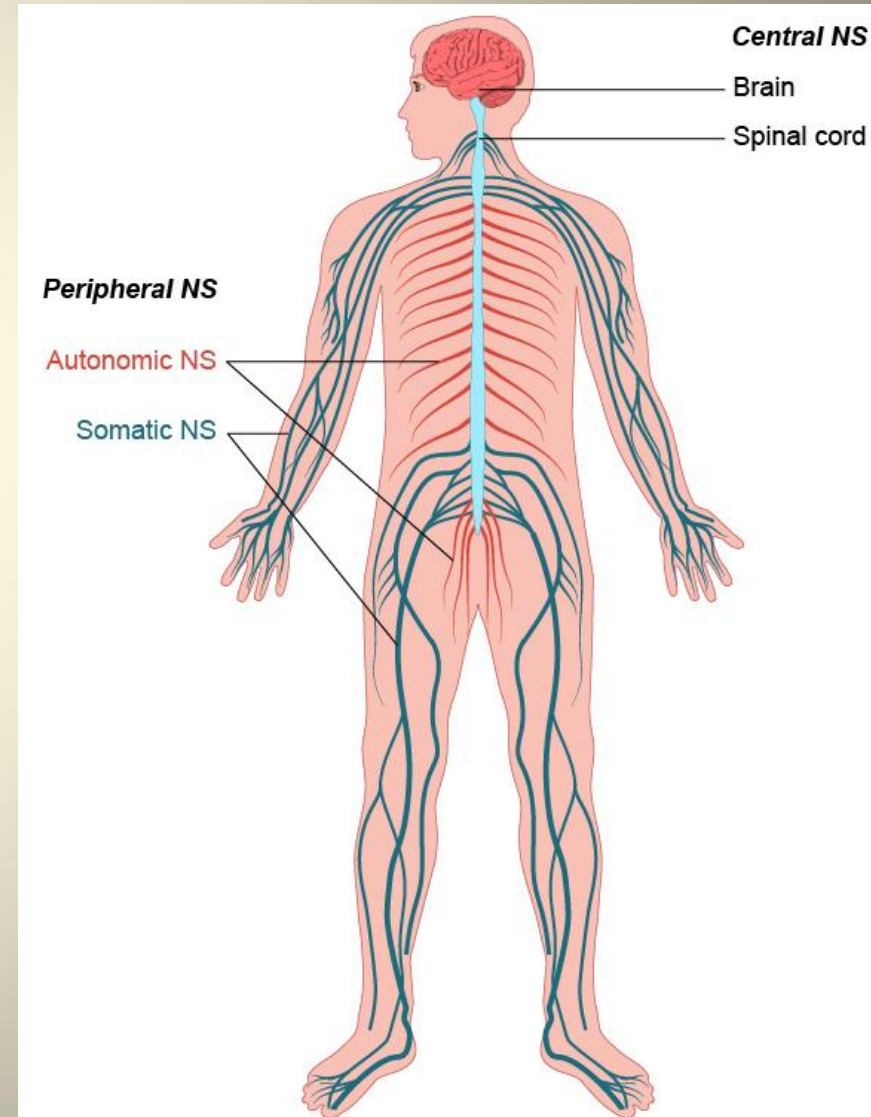
Central and Peripheral Nervous System

Central Nervous System (CNS)

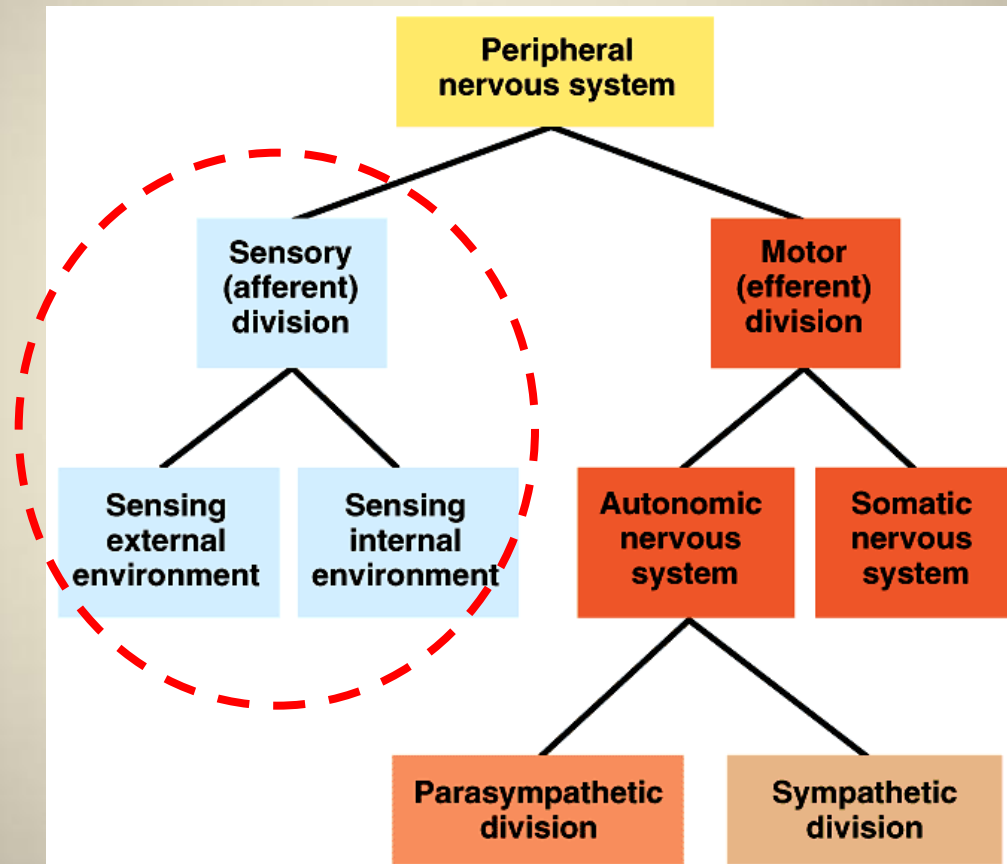
- Brain
- Spinal cord

Peripheral Nervous System (PNS)

- Afferent (sensory) neurons
- efferent (motor) neurons
- All neurons outside of CNS is PNS

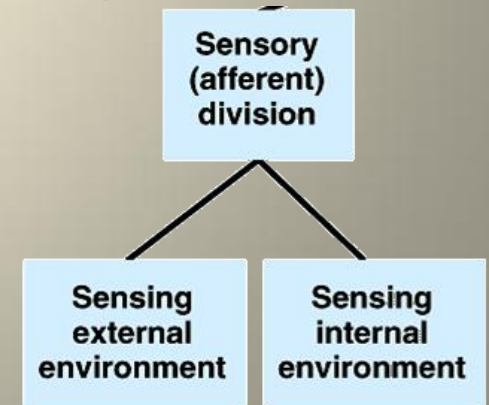


Organization of the PNS



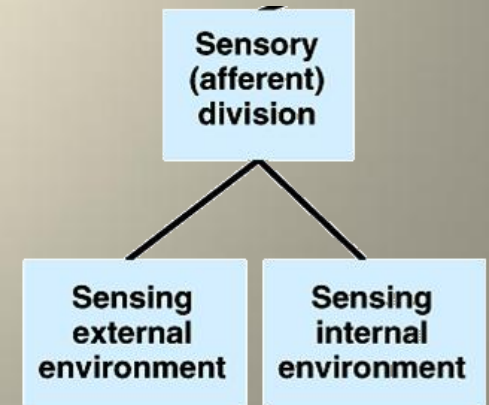
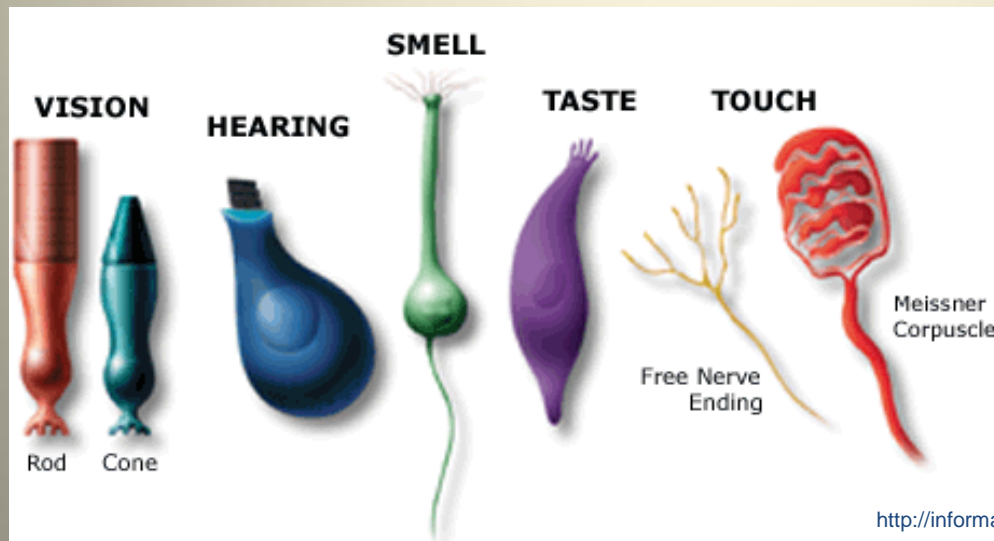
Types of senses

- Sensing the external environment
 - **Somatic** senses: skin, muscle, joints
 - **Special** senses: vision, hearing, smell, taste, equilibrium
- Sensing the internal environment
 - **Visceral** senses
 - e.g. fullness of stomach, blood pressure, blood volume, oxygen levels



Sensory Receptors by Location

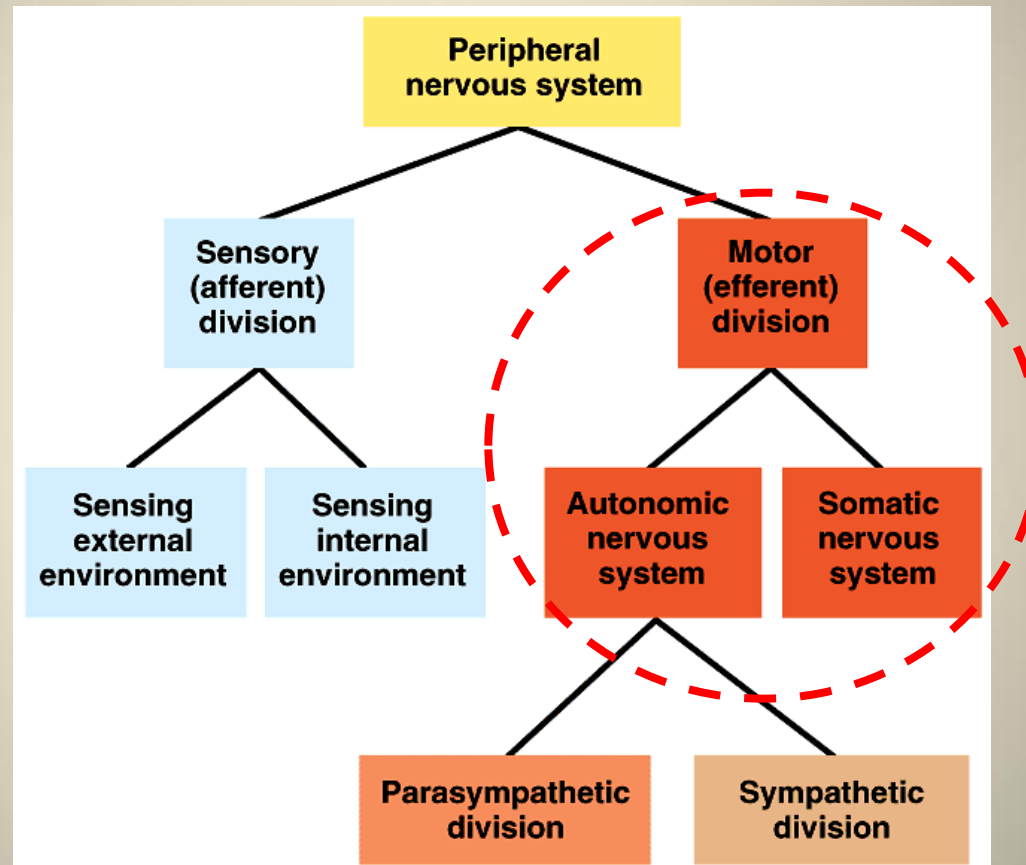
- Detect a specific type of stimulus
- **Exteroreceptors**: detect stimuli outside the body
- **Interoreceptors**: detect stimuli within the body (visceral senses)



Sensory Receptors by Stimulus

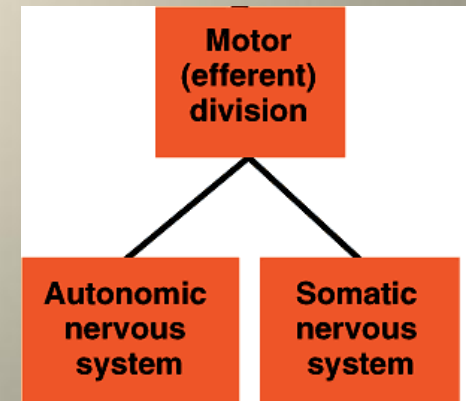
Examples	Stimuli	External location	Internal location
Mechanoreceptor	Pressure, movement, stretch	Skin, muscles, ears	Blood vessels, stomach, lungs, bladder
Photoreceptor	Light	Eyes	
Chemoreceptor	Chemicals	Nose, mouth	Aorta, arteries, brain
Thermoreceptor (heat, cold)	Temperature	Skin	Organs
Nociceptor	Pain	Skin	Organs, glands, blood vessels

Organization of the PNS



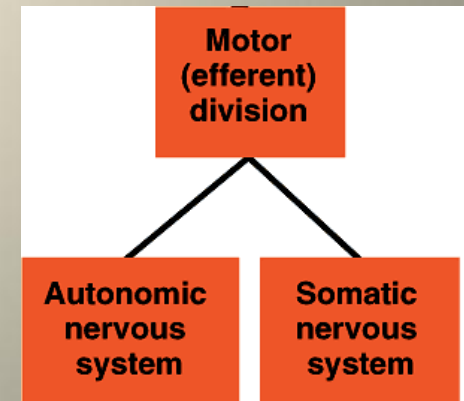
Motor output

- The conduction of signals from integration centers to effector cells.
- **Effector cells**: carry out the body's response to a stimulus.

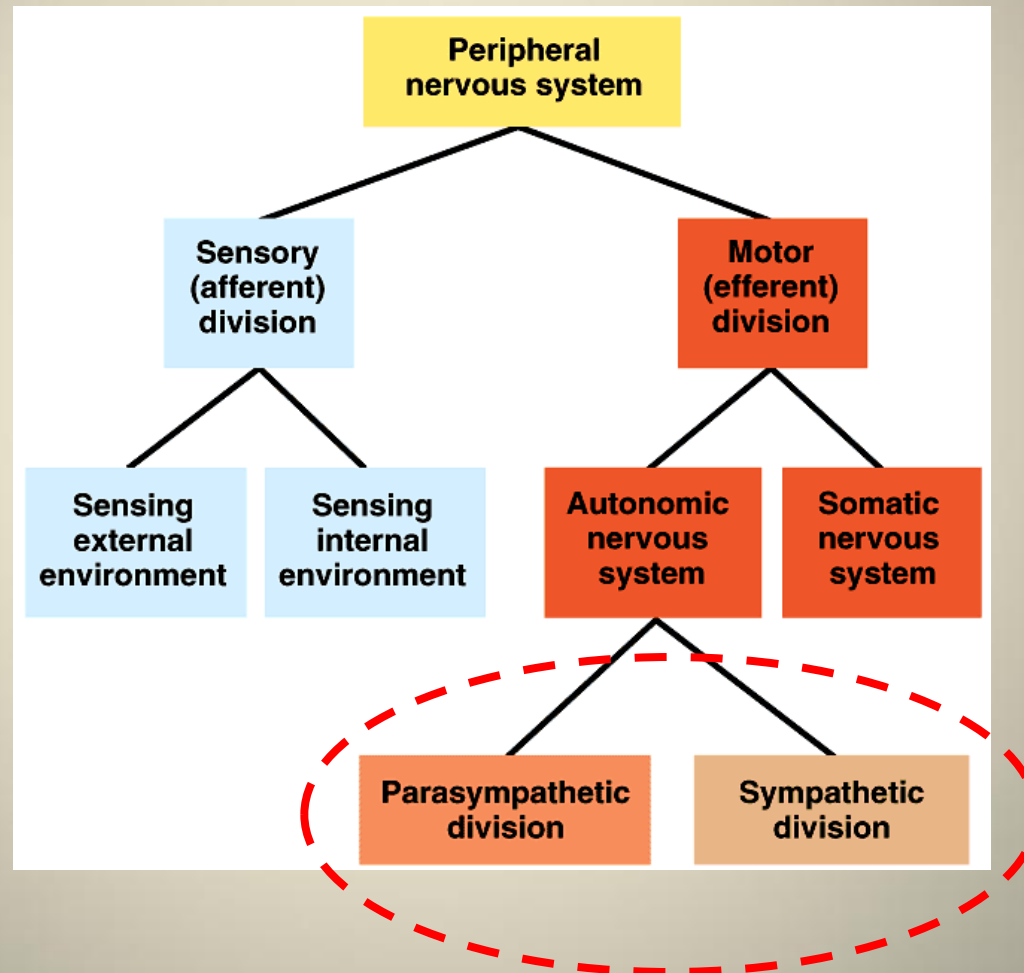


Organization of the PNS

- **Somatic nervous system:** responds to external and internal stimuli by sending signals to skeletal muscles (voluntary)
- **Autonomic nervous system:** respond to stimuli by sending signals to smooth muscle, cardiac muscle and organs of the body (involuntary)

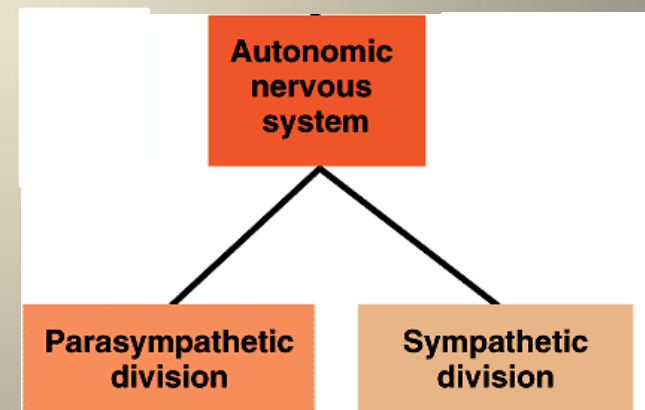


Organization of the PNS



Sympathetic and Parasympathetic

- **Sympathetic** nervous system
 - prepares body for stress
 - affected by epinephrine / norepinephrine
- **Parasympathetic** nervous system
 - restores body to normal balance
 - affected by acetylcholine



Sympathetic and Parasympathetic

- Often have antagonistic effects (but not

Sympathetic	Parasympathetic
Arousal and energy generation	Calming
Increase stress responses (increase heart rate, rate of gas exchange, glucose metabolism)	Decrease heart rate and rate of gas exchange in lungs
Inhibit digestive and excretory systems	Stimulate digestive and excretory systems (salivary glands, stomach, intestine, pancreas, bladder)

Sympathetic and Parasympathetic

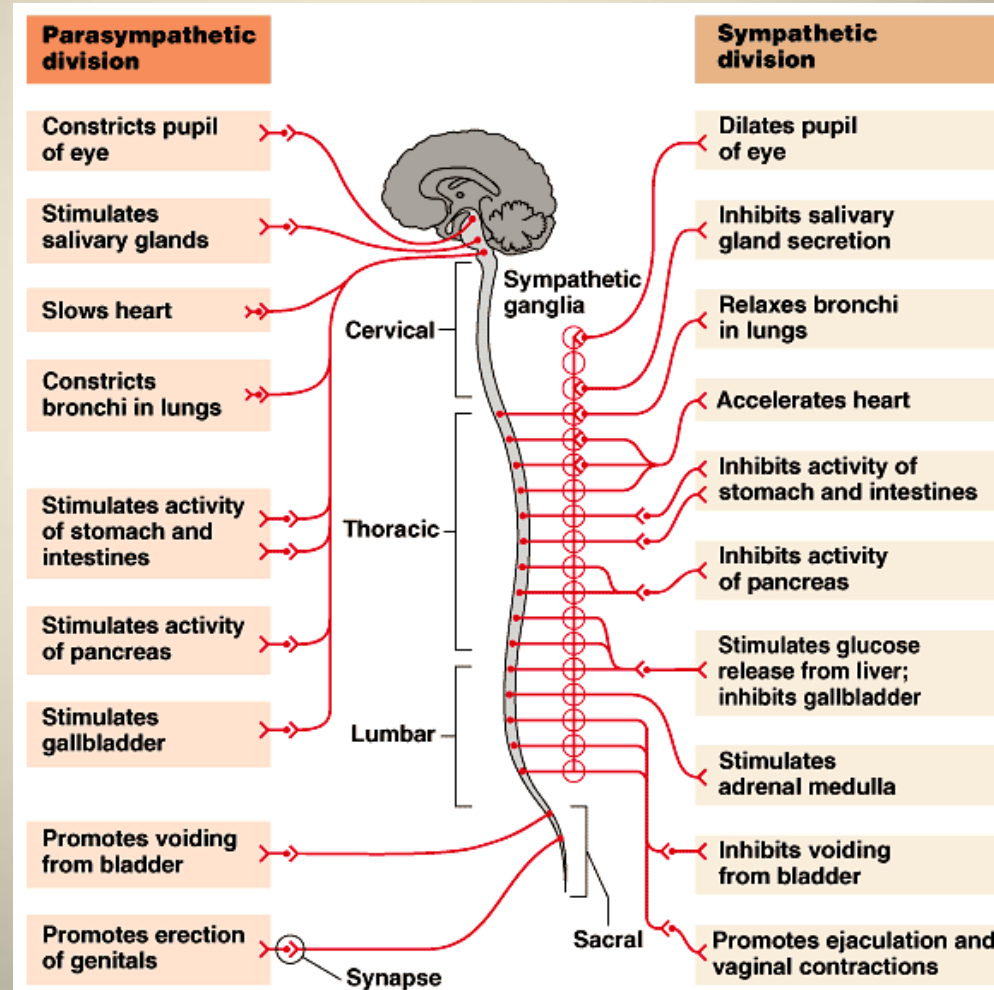
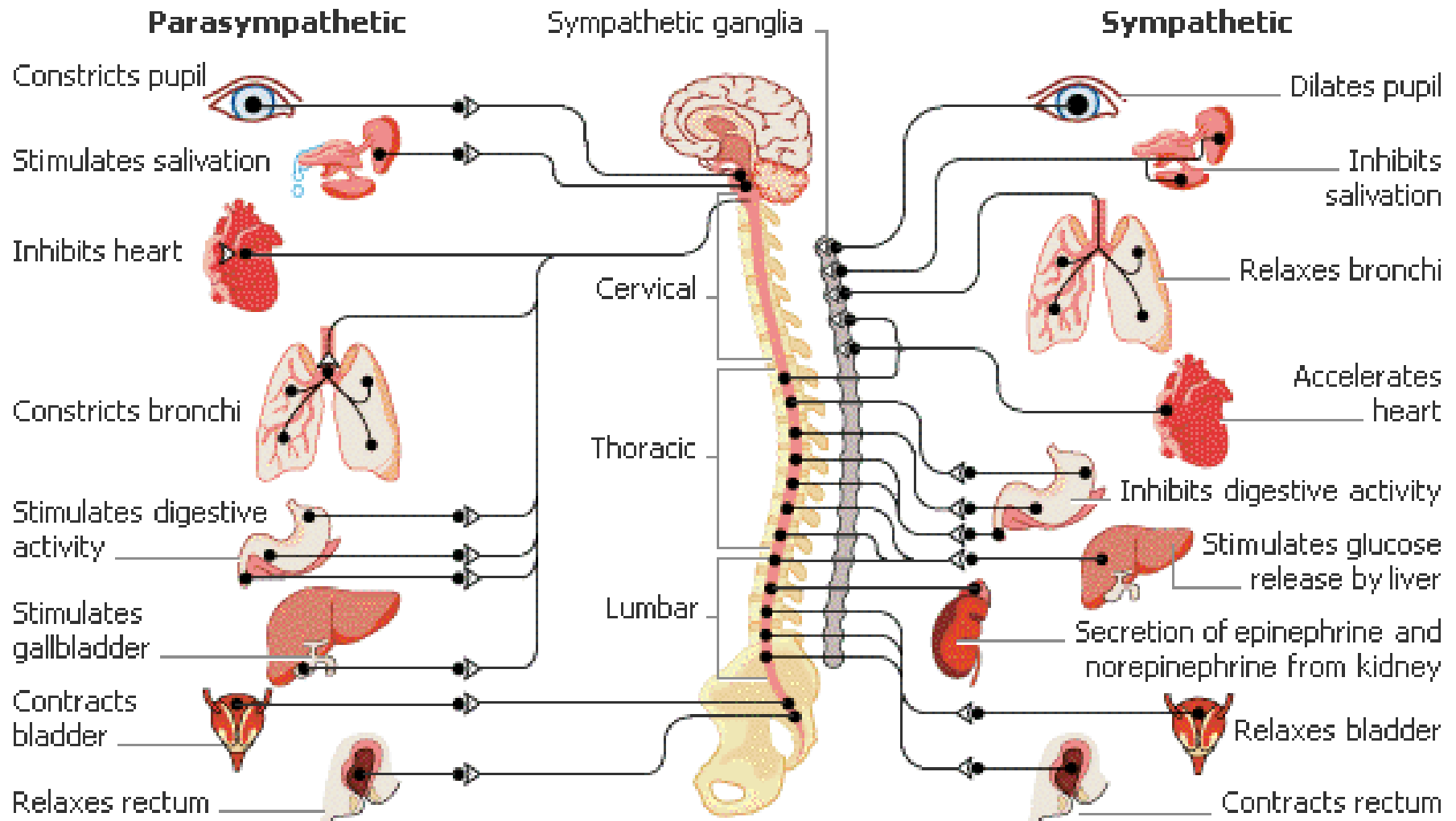


Fig 48.18

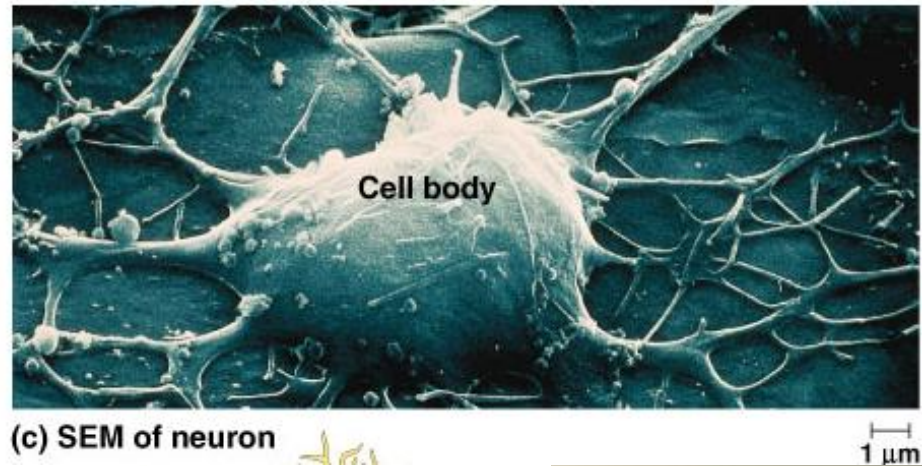
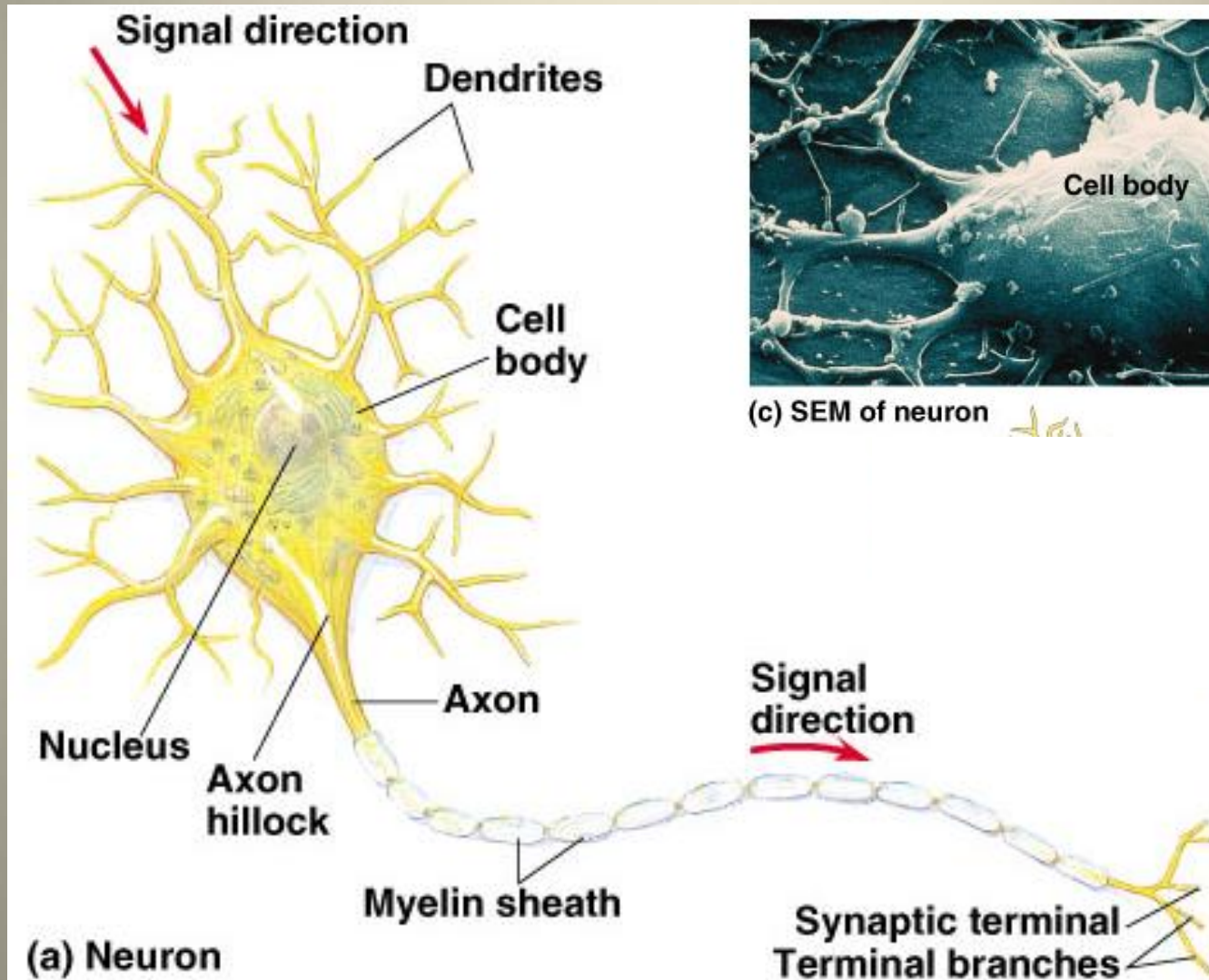
Sympathetic and Parasympathetic



Neuron

- Nerve: a group of neurons bundled together
- Nerve cell = neuron
- Neuron: the structural and functional unit of the nervous system
- Excitable cell:
 - cell capable of producing large, rapid electrical signals (changes in membrane potential)
 - Neurons & muscle cells
- Mature neurons lose ability to undergo cell division

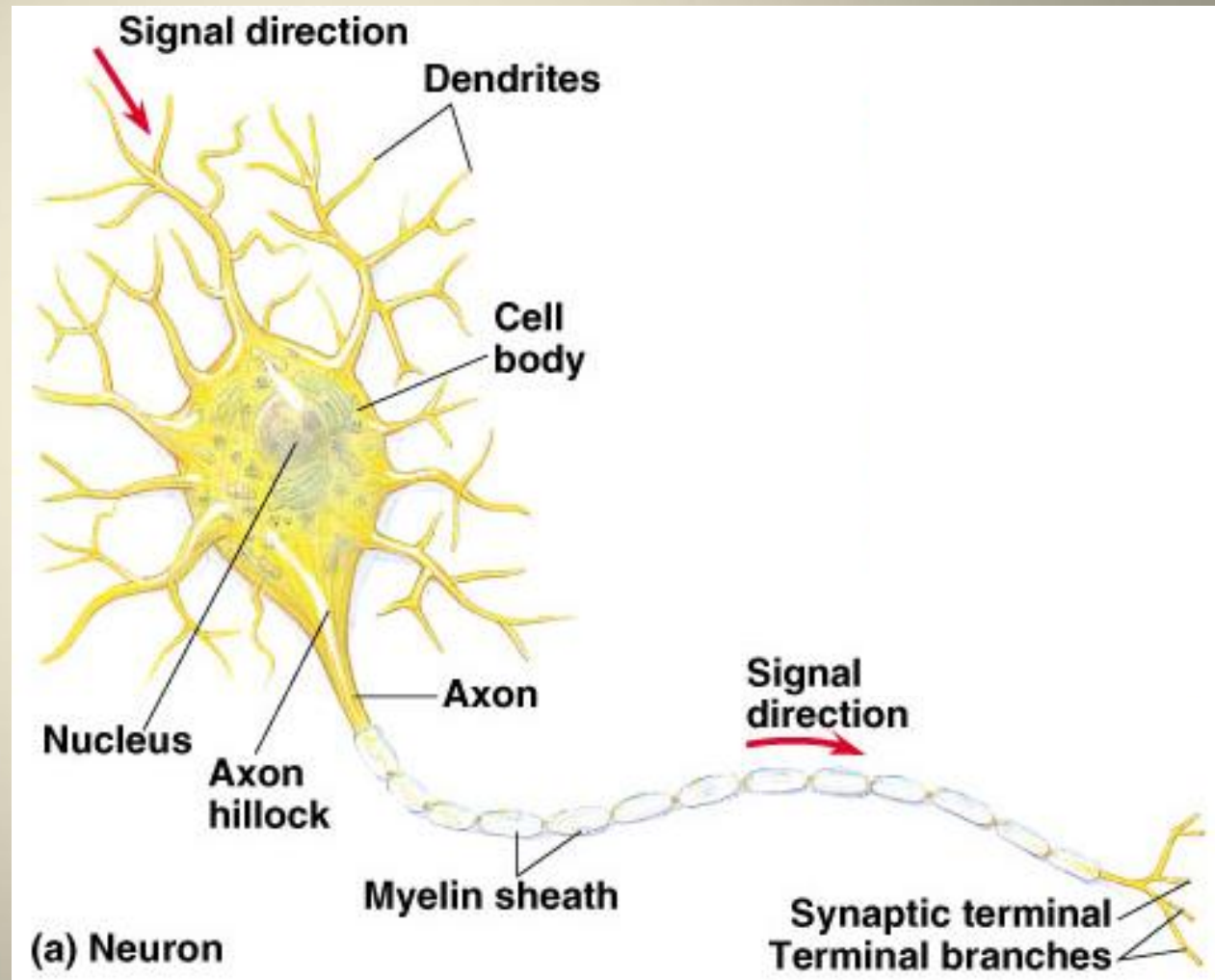
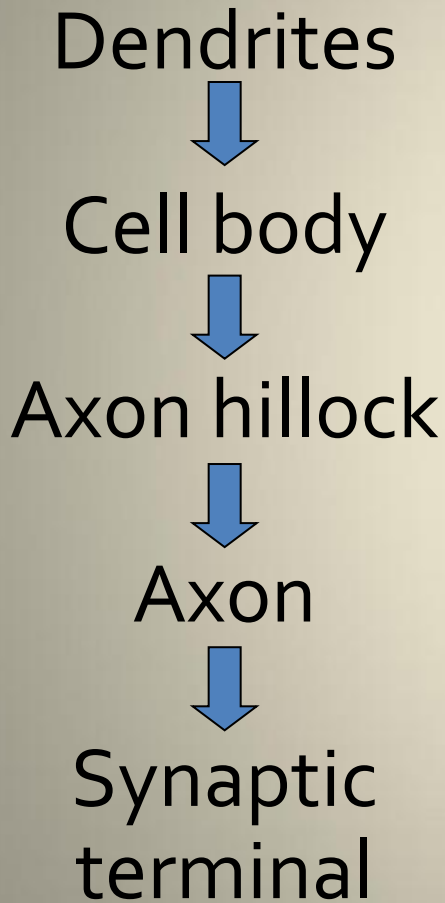
Components of a neuron



Components of a neuron

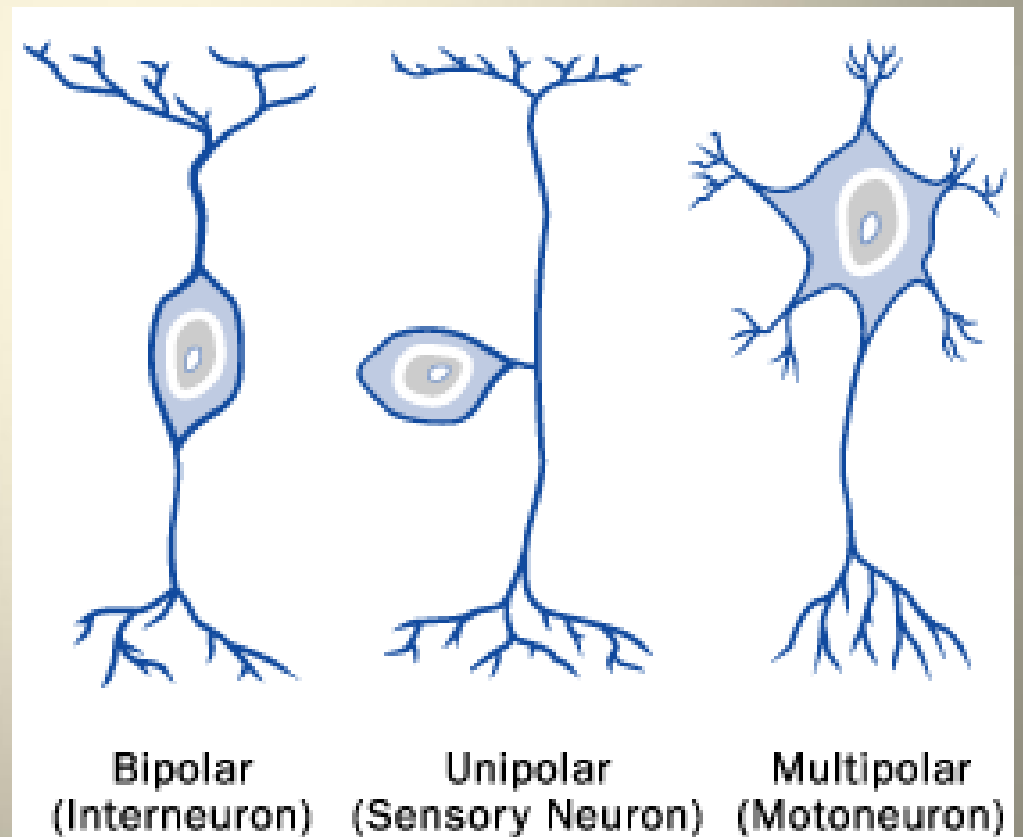
Components	Description	Function
Cell body (soma)	Main part of cell Contain nucleus & organelles	Carries out basic cell functions (i.e. protein synthesis, metabolism)
Dendrites	Short, branched extensions	Receives input from other neurons
Axon (nerve fiber)	one per neuron, long extension, can branch	Sends information
Axon hillock	Site where axon originates	Where action potential initiates
Synaptic terminal	Ends of axons	Contains & releases neurotransmitters (NT)

Direction of impulse conduction

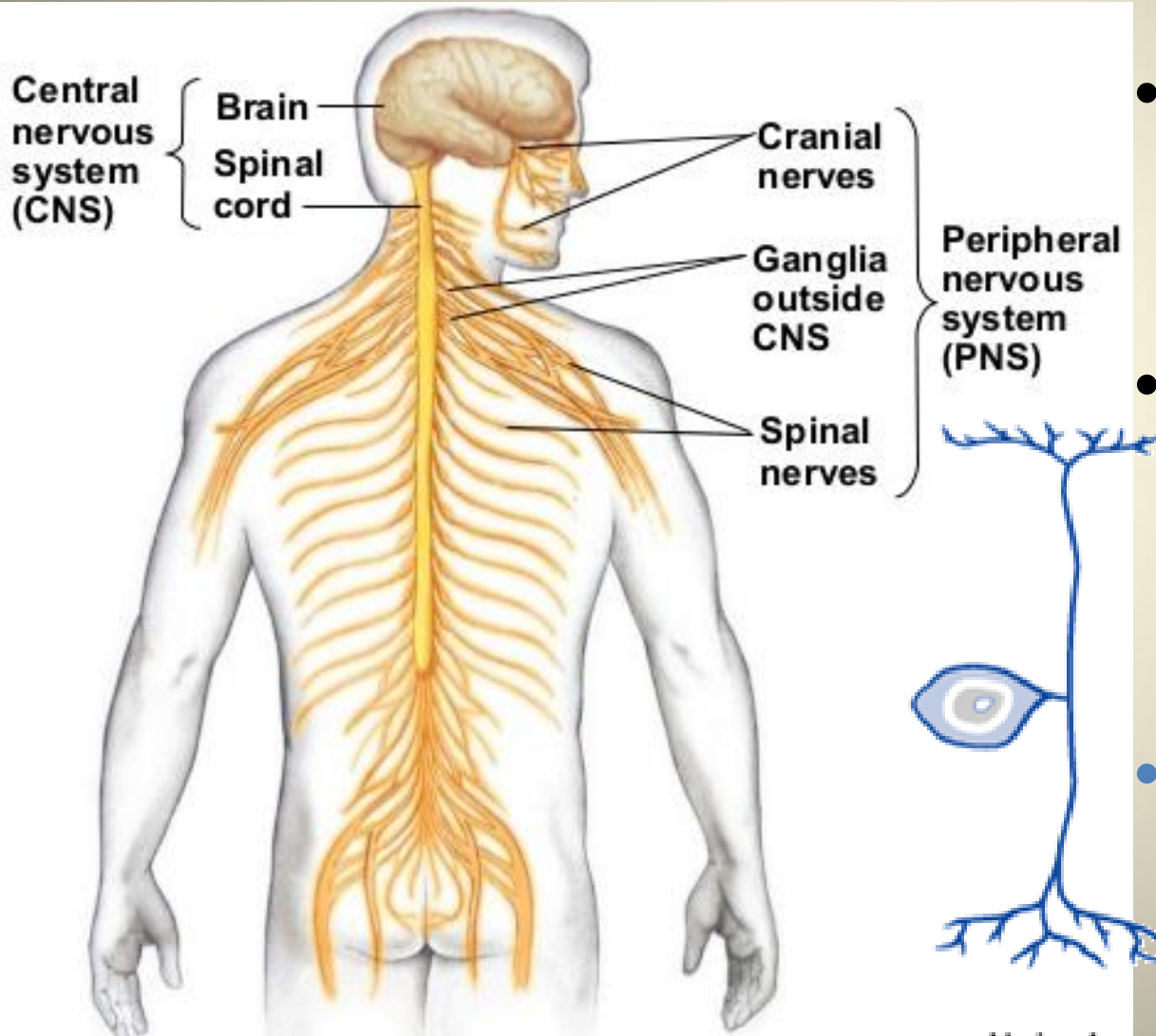


Types of neurons

- Sensory neurons
- Interneurons (CNS)
- Motor neurons



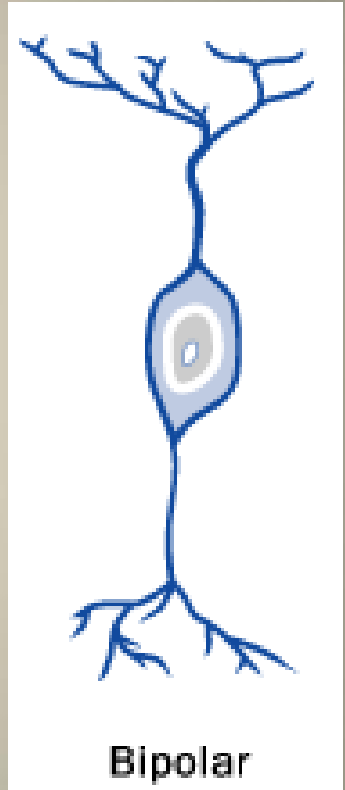
Sensory Neuron



- Also known as **afferent neurons**
- Direction: carries signals from sensory receptors to CNS
- **Ganglia**: clusters of neurons

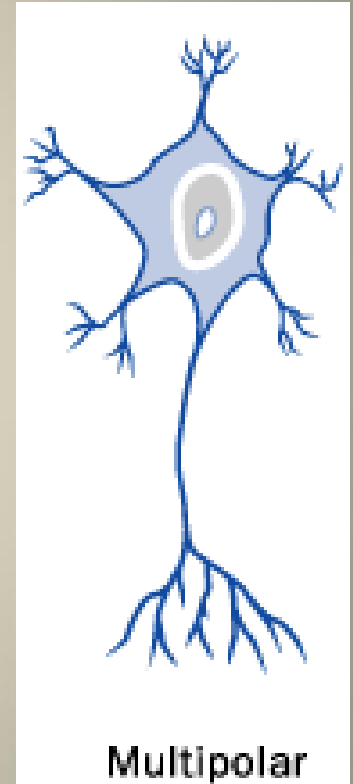
Interneuron

- Also known as **association neurons**
- Direction:
 - receives incoming signals from sensory neurons
 - delivers outgoing signals to neurons responsible for responses
- Can be **excitatory** or **inhibitory**



Motor Neuron

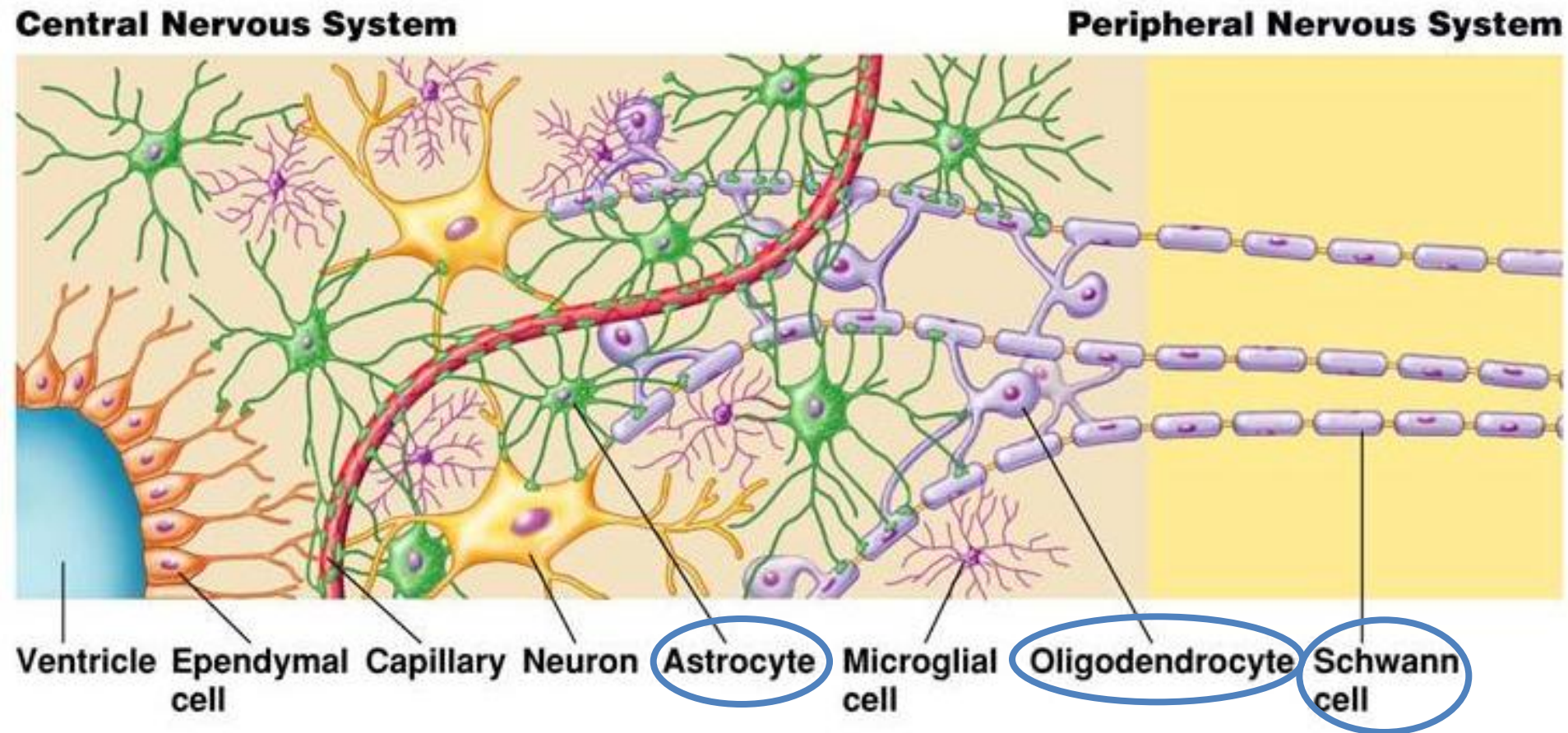
- Also known as **efferent neurons**
- Direction: carries signals from CNS to effector cells
- Effector cells: tissues that respond according to what was detected
 - Examples:
 - muscle contraction
 - gland secretion of hormones



Supporting cells (glial cells)

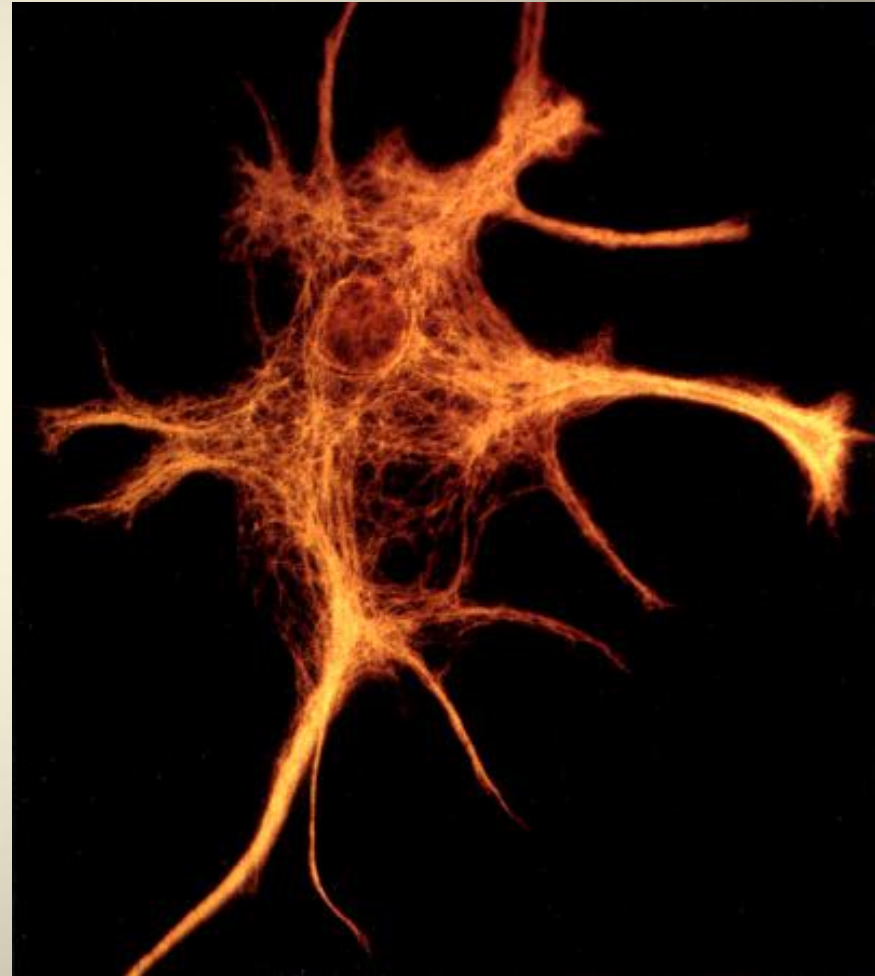
- Consists of 90% of the cells in the nervous system
- Provide structural and metabolic support to neurons
- Types:
 - Astrocytes (CNS)
 - Oligodendrocytes (CNS)
 - Schwann cells (PNS)

Glial Cells



Astrocytes

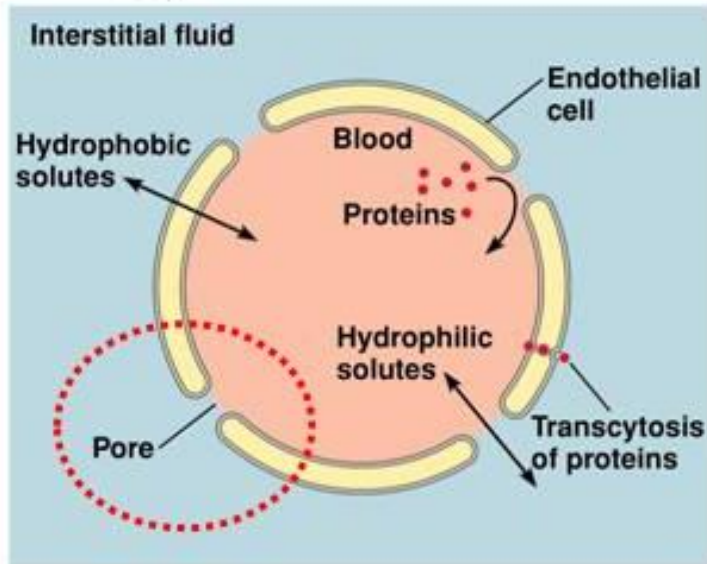
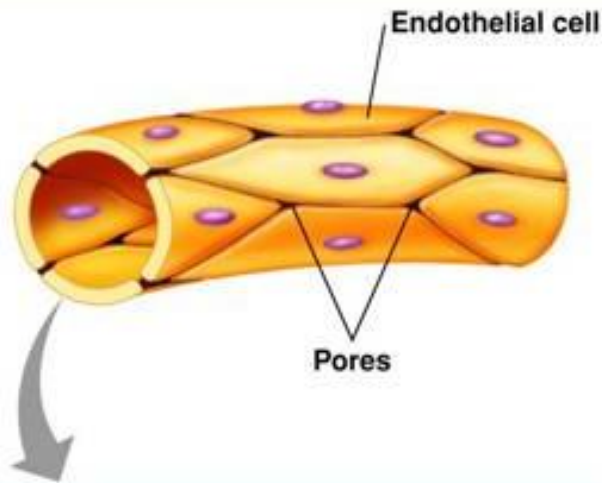
- Star-shaped cell
- Provide structural and metabolic support for neuron
- Communicate with neurons
- No electrical conduction



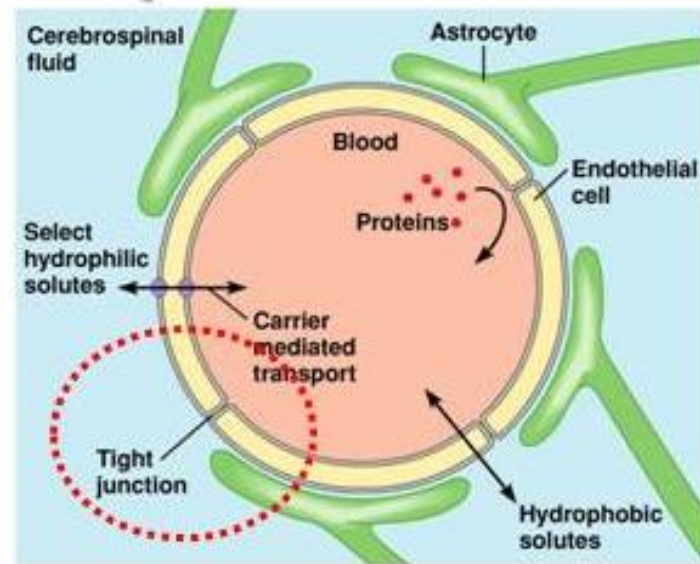
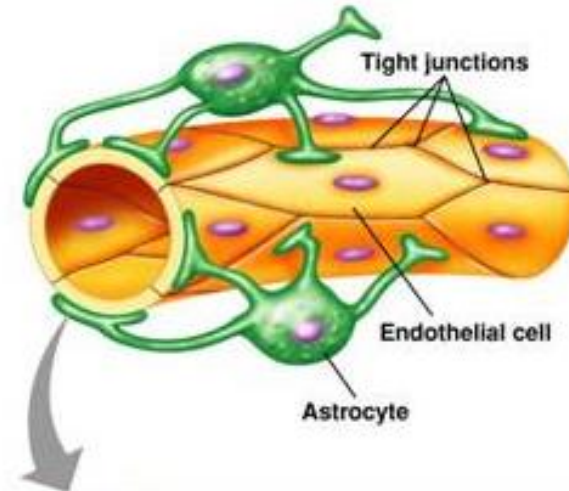
Blood-Brain Barrier

- Blood vessels in the brain are completely sealed off with the help of astrocytes
- This contributes to the barrier between blood and brain.

Blood-Brain barrier



(a) Typical capillary

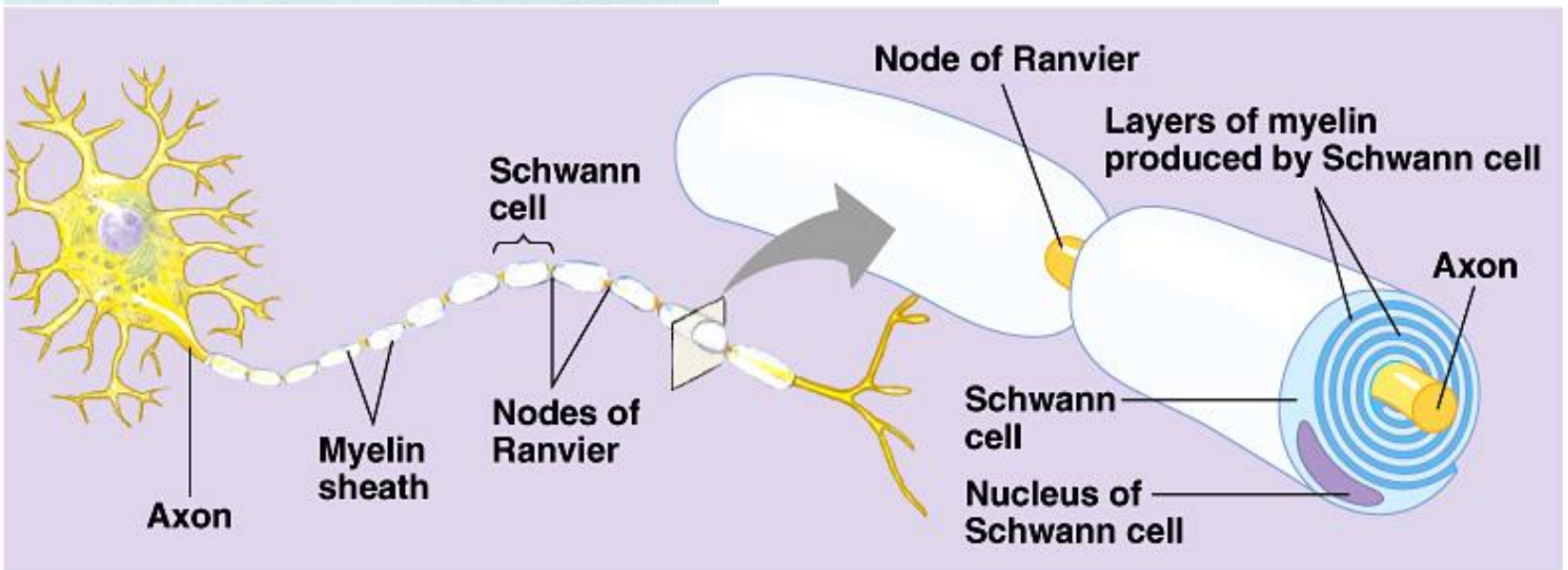
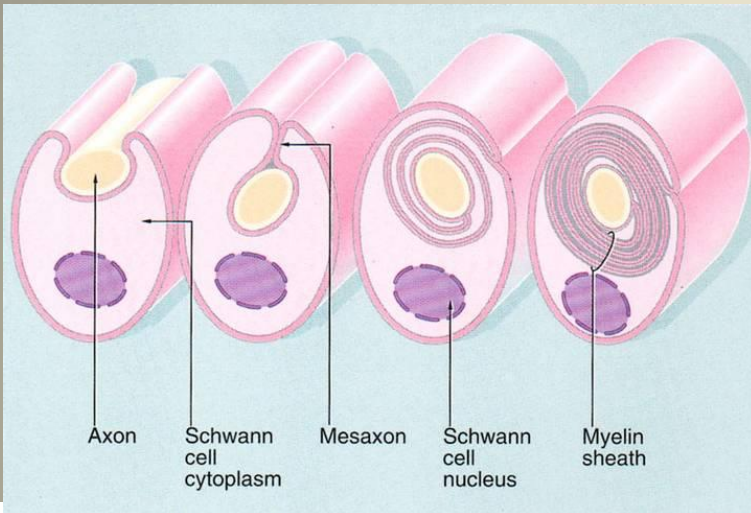


(b) Brain capillary

Oligodendrocytes (CNS) and Schwann cells (PNS)

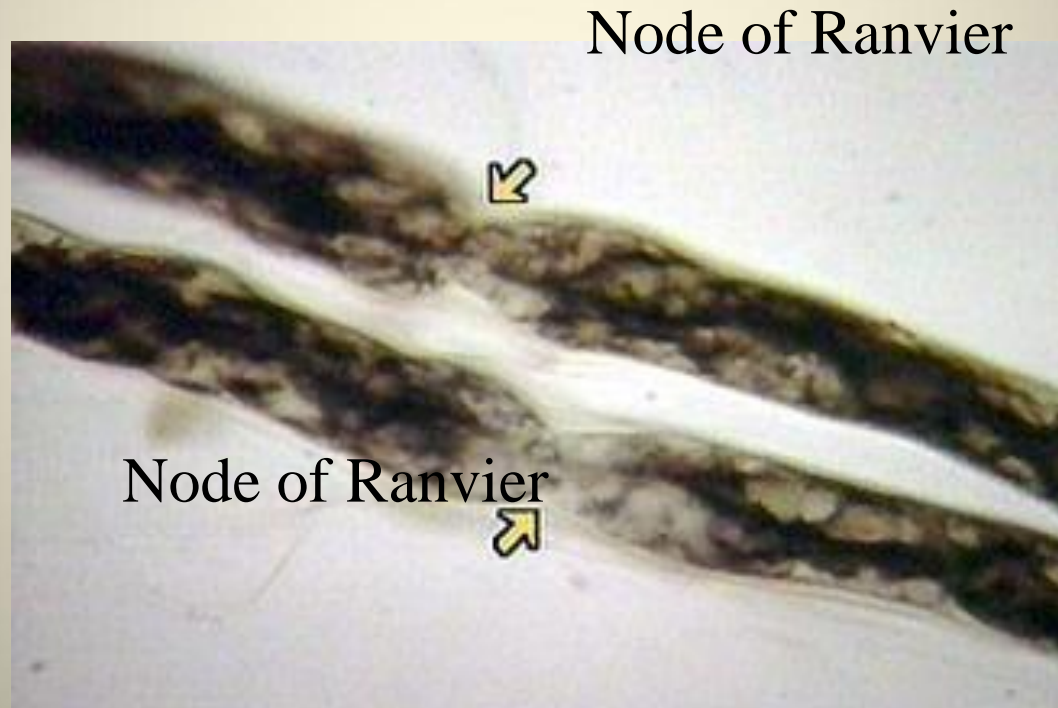
- Cells that wrap themselves around the axon of a neuron to provide insulation for electrical impulses passing through axon
- Cells form a layer called the myelin sheath
 - cell membrane have a lot of lipid molecules.
 - lipid molecules are poor electrical conductors
 - provides electrical insulation
- Neurilemma: myelin sheaths wrapped around each other
- Analogy: insulation around wires

Schwann cells: Fig. 48.5



Nodes of Ranvier

- **Nodes of Ranvier:** gaps between cells that wrap themselves around the neuron



Types of nerve circuits

- Divergent nerve circuit
- Convergent nerve circuit
- Circular nerve circuit

Direction of Impulse Conduction

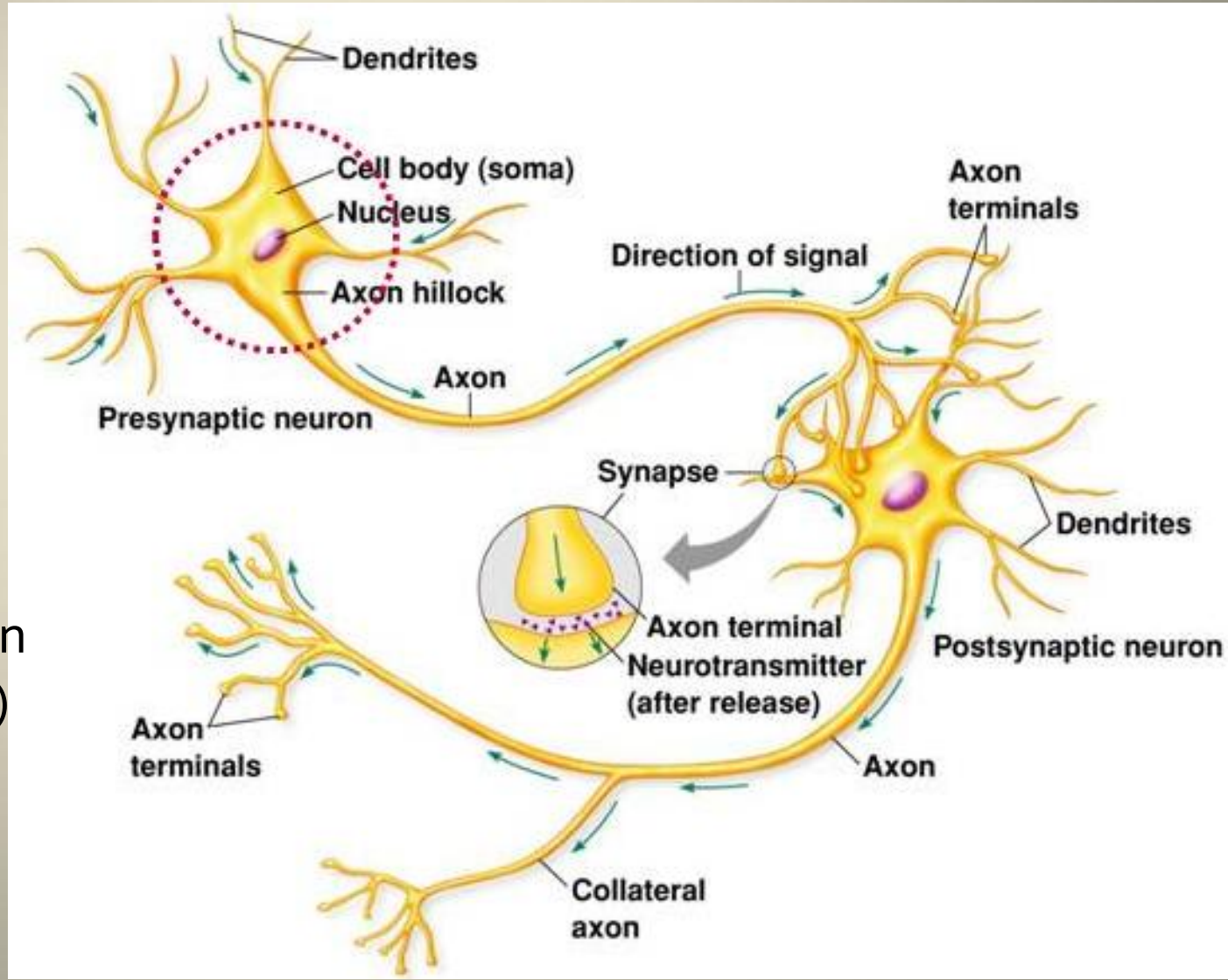
Transmitting cell
Presynaptic
(axon of neuron)



Synapse

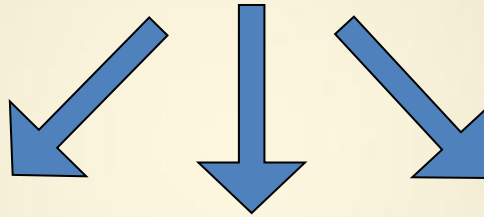


Target cell
Postsynaptic
(dendrite of neuron
or effector cell)



Divergent nerve circuit

Nerve impulse in **ONE**
presynaptic neuron

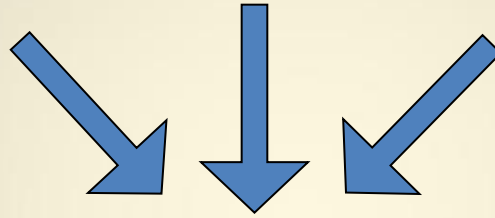


Nerve impulses in **SEVERAL**
postsynaptic neurons

- Example: visual information sensed by photoreceptors sent to several parts of the brain

Convergent nerve circuit

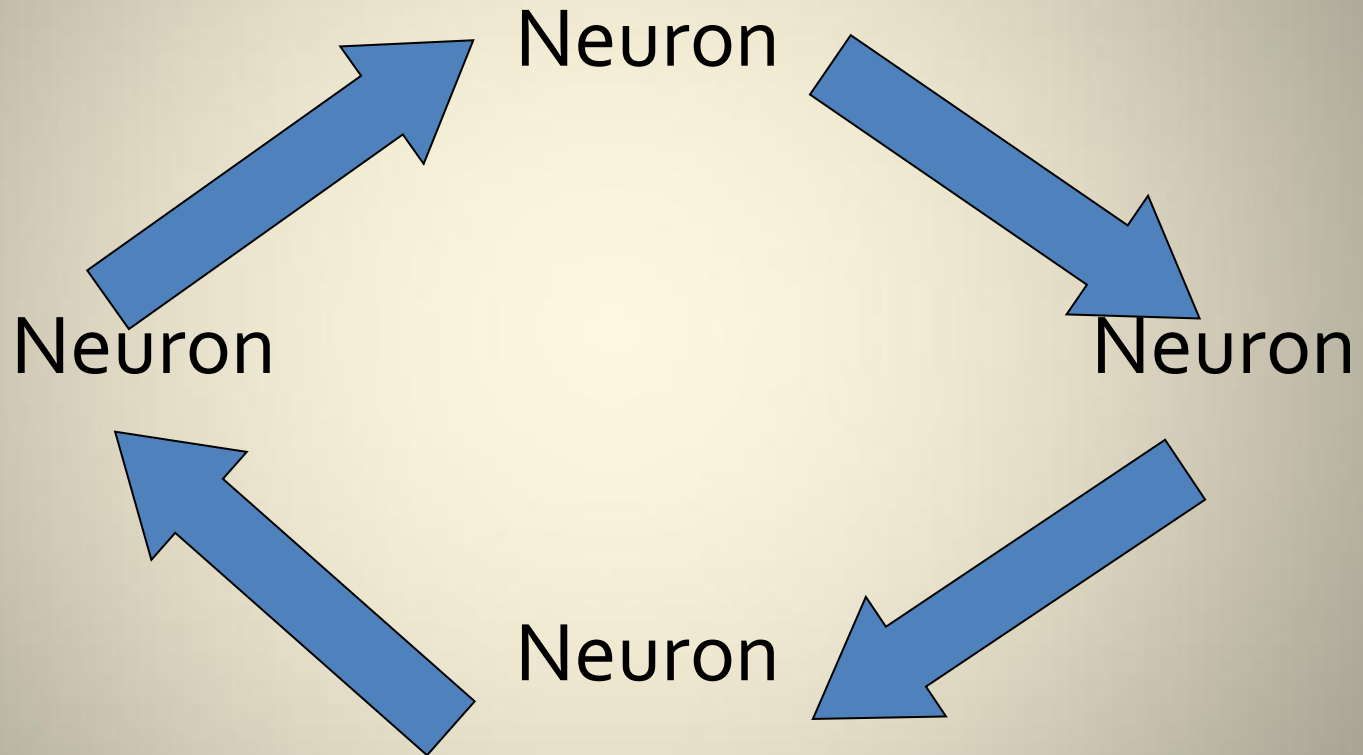
Nerve impulse in **SEVERAL** presynaptic neurons



Nerve impulse in **ONE** postsynaptic neuron

- Example: information from several sources like vision, touch and hearing is used to identify an object in the environment

Circular nerve circuit



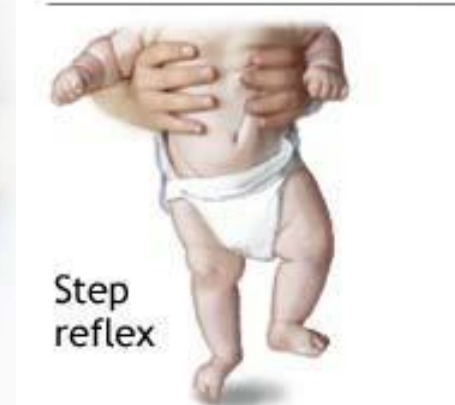
- Example: Processing and storing of memories

Simplest type of nerve circuit

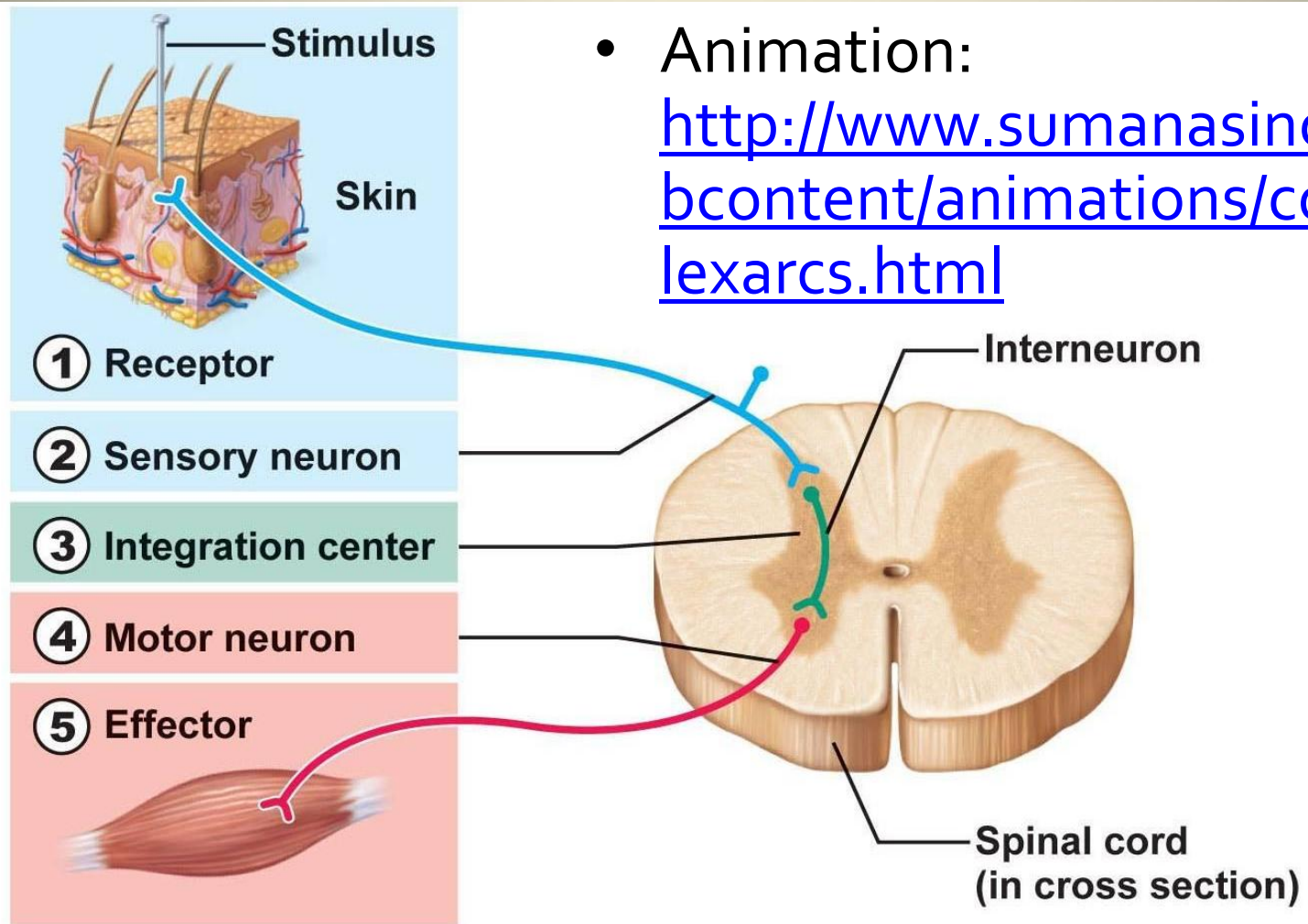
- Reflex arc: a type of nerve circuit that regulates the reflex
- Reflex: rapid, involuntary responses to stimuli
- Intergration occurs in the spinal cord rather than in the brain

Examples of reflexes

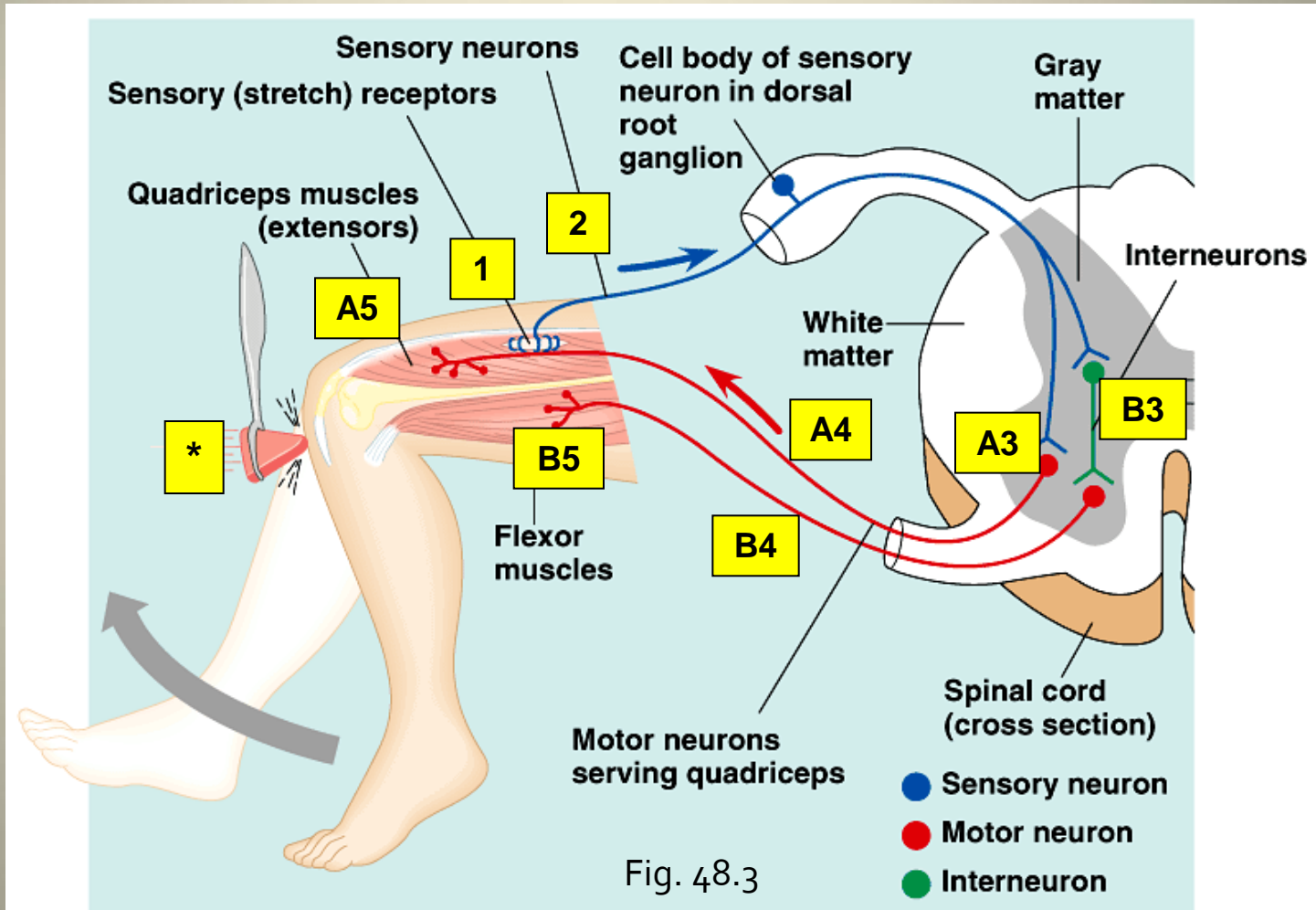
- Withdrawal (nociceptive) reflex
- Knee-jerk (patellar) reflex
- Gag (pharyngeal) reflex
- Blink (corneal) reflex
- Pupillary reflex



Reflex Arc



Knee-Jerk Reflex



Knee-Jerk Reflex

Step	Part	Description
*	Stimulus	Tapping of tendon
1	Sensory neuron	Stimulus detected by stretch receptors in sensory neuron. Conducts nerve impulse to spinal cord.
A3	Excitatory interneuron	Sensory neurons synapse with motor neurons in spinal cord.
A4	Motor neuron	Conducts nerve impulse to quadricep muscle.
A5	Effector	Quadricep muscle contracts.
B3	Inhibitory interneuron	Sensory neurons synapse with interneurons. Interneurons synapse with motor neurons.
B4	Motor neuron	Conducts nerve impulse to hamstring muscle.
B5	Effector	Inhibits contraction of hamstrings (relaxation).