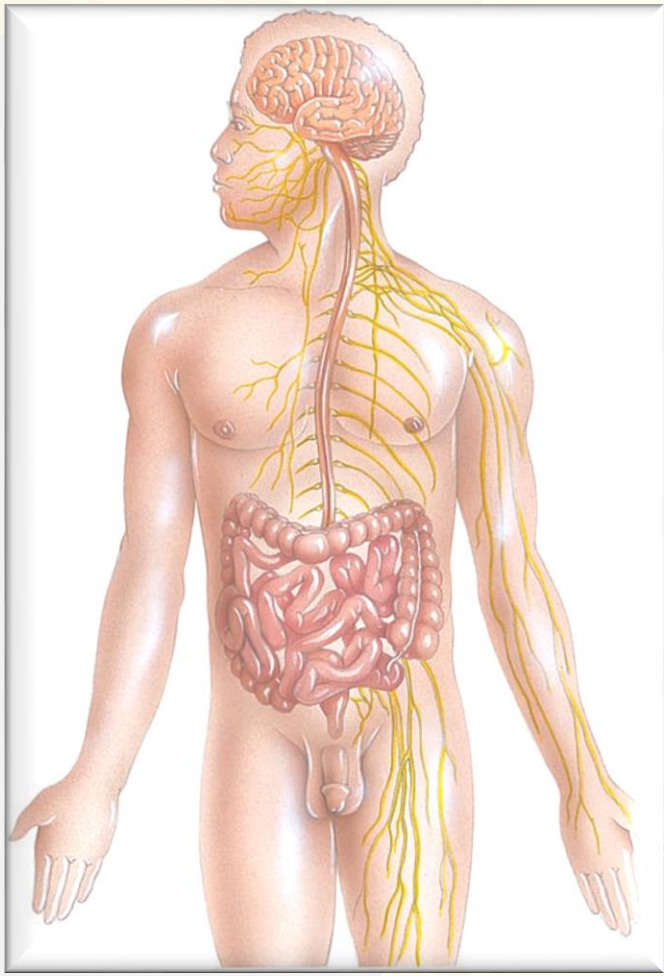
# Human Anatomy & Physiology

## Communication

- The blood
- The cardiovascular system
- The lymphatic system
- **The nervous system**
- **The special senses**
- **The endocrine system**



L.Ayora

# Objectives.

- By the end of the lesson, learners will be able to:

i. State the functional components of Nervous system

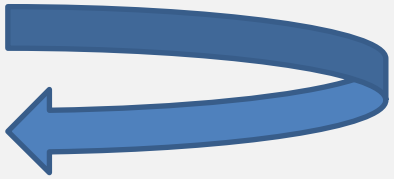
ii. Describe the structure of a neurone

iii. Describe the process of impulse generation & propagation

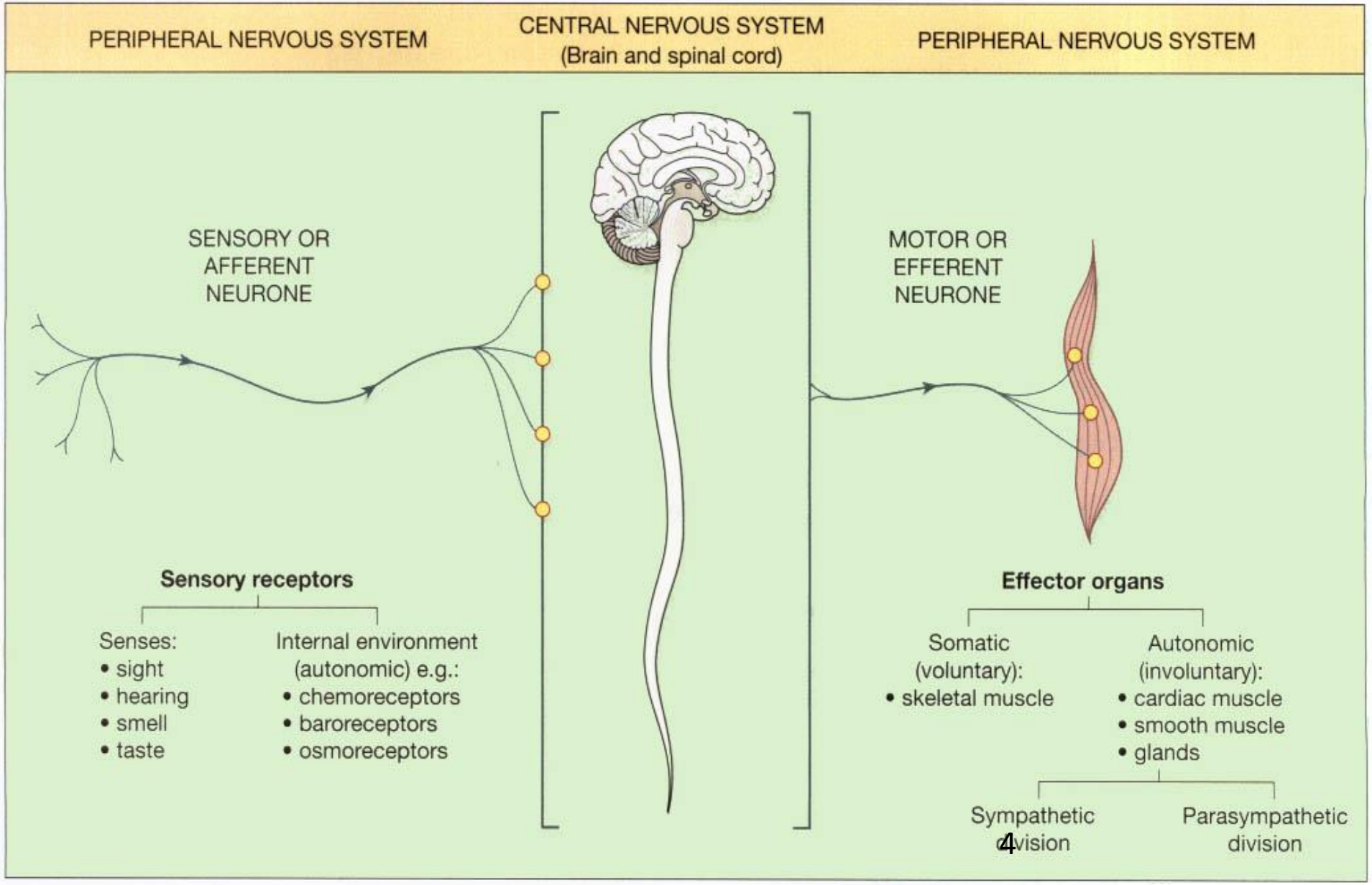
iv. Identify types of nerves

# Nervous System Introduction

- Excitability
  - Impulses [action potential/impulse]
- **Functions**:
  - Communication
  - Perceptions, behaviors, memory
  - Initiates all voluntary movements.
  - Homeostasis [ plus endocrine system]
    - Internal environment
    - External environment



# Functional components of the nervous system.



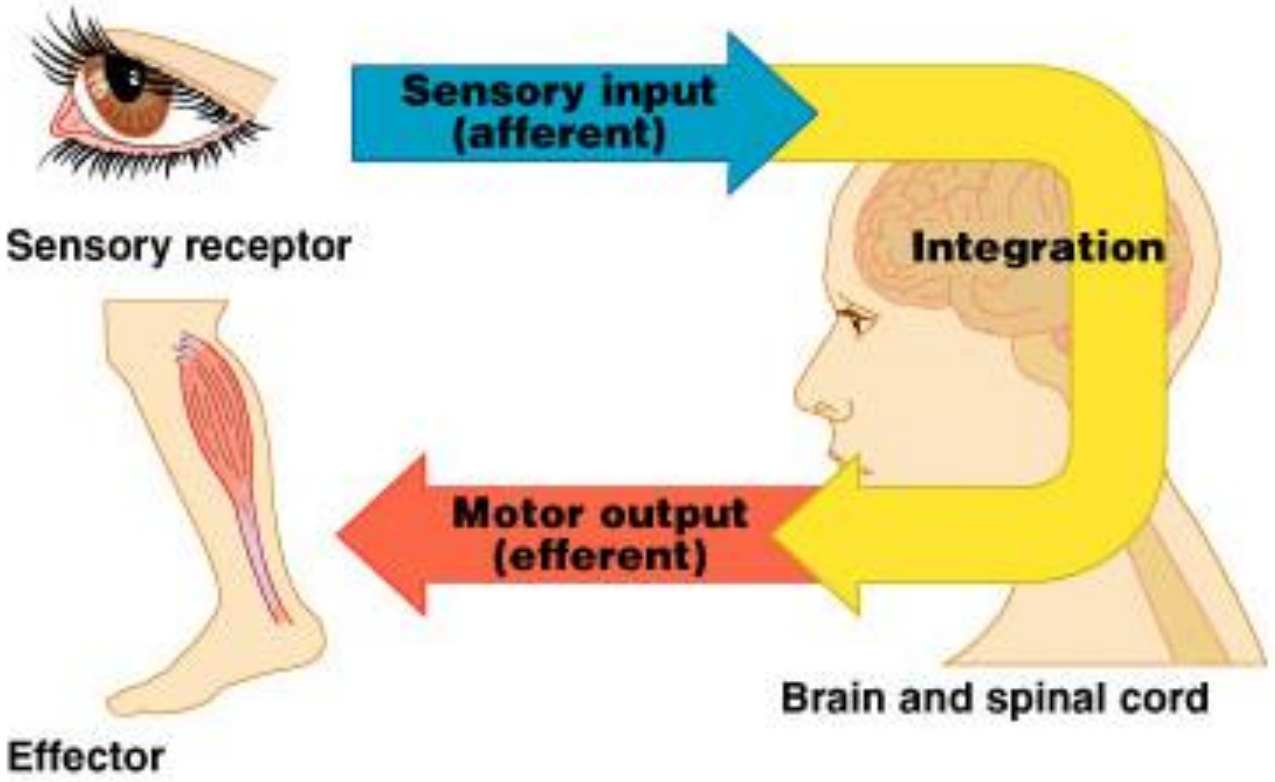
# Basic division of the Nervous System

- Central nervous system ("CNS") – occupies cranium and vertebral column
  - Brain
  - Spinal cord
- Peripheral nervous system ("PNS")
  - Cranial nerves
  - Spinal nerves
  - Ganglia (clusters of cell bodies)

# Terminology

- Input: sensory = ***sensory input***
  - Receptors monitor changes
  - Changes called "stimuli" (sing., stimulus)
  - Information sent by **"afferent"** nerves
- Integration
  - Info processed
  - Decision made about what should be done
- Output: motor = ***motor output***
  - Effector organs (muscles or glands) activated
  - Effected by **"efferent"** nerves

# Simplified…


Sensory input
(afferent)
Sensory receptor
Integration
Motor output
(efferent)
Brain and spinal cord
Effector

# Nervous tissue: 2 types of cells

1. ***Neurons***
   - Excitable nerve cells
   - Transmit electrical signals

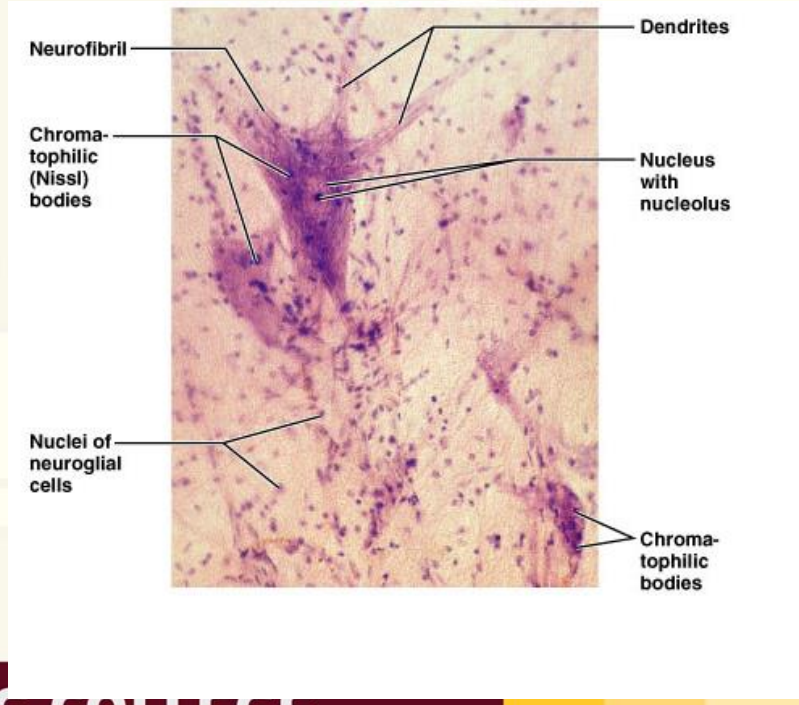
2. Supporting cells: ***neuroglia*** or just ***glia***
   - Means “nerve glue”

# Neurons

- All have a cell body: with nucleus and cytoplasm

- Cell bodies are in clusters
  - CNS: clusters called ***nuclei***
  - PNS: clusters are called ***ganglia***

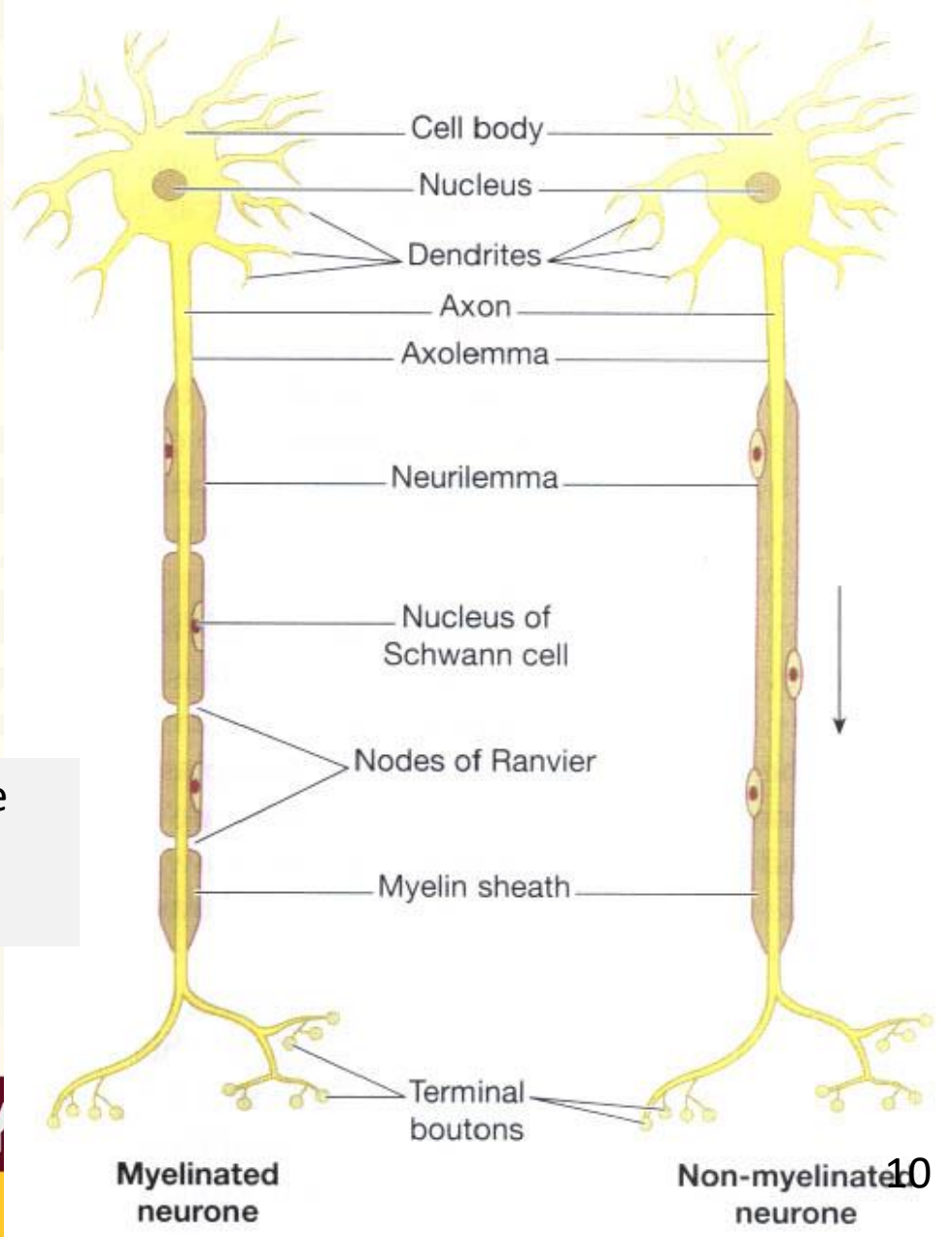
    (are *outside* the CNS)

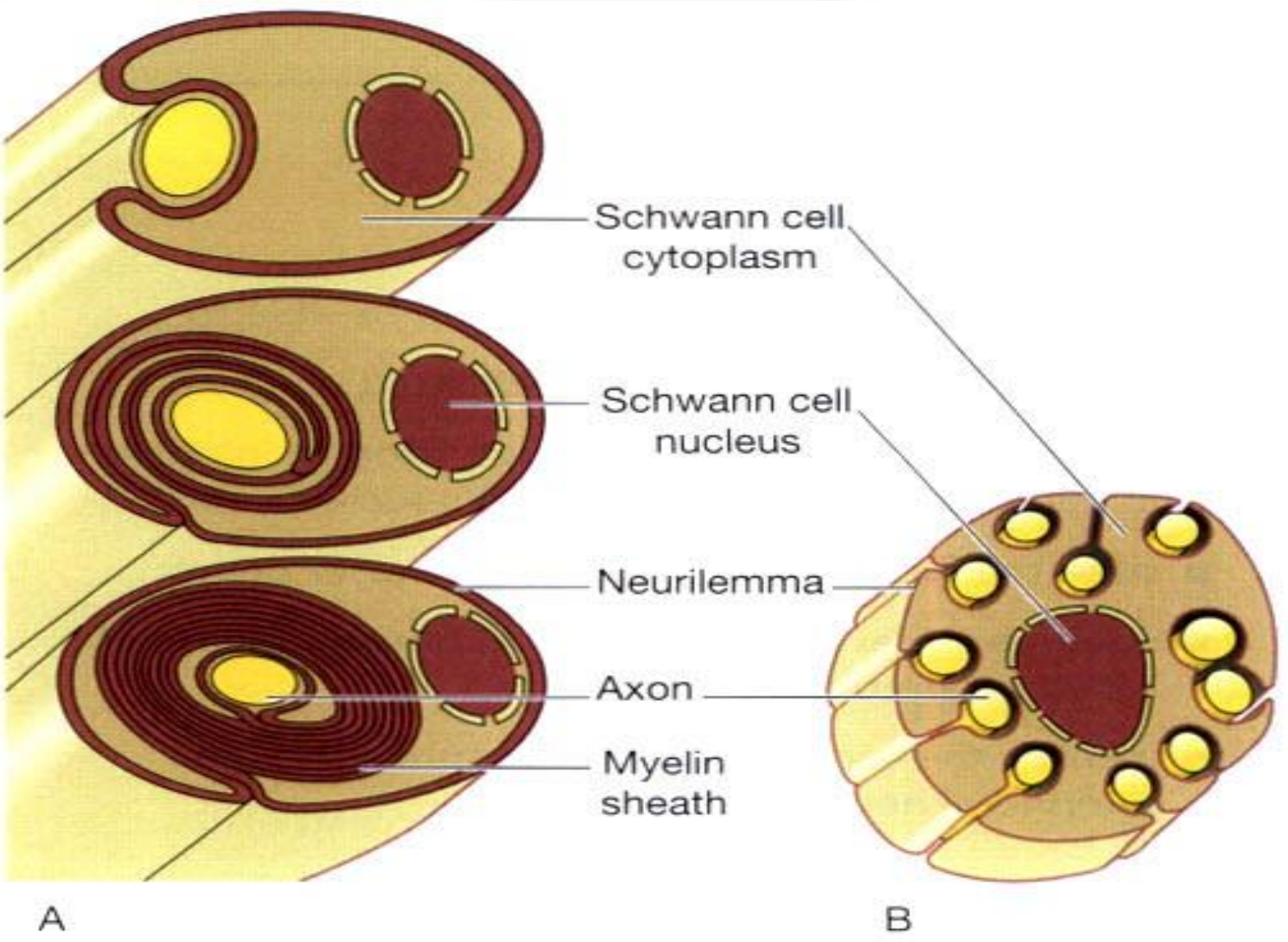


# The structure of neurones

***Irritability*** is the ability to initiate nerve impulses in response to stimuli

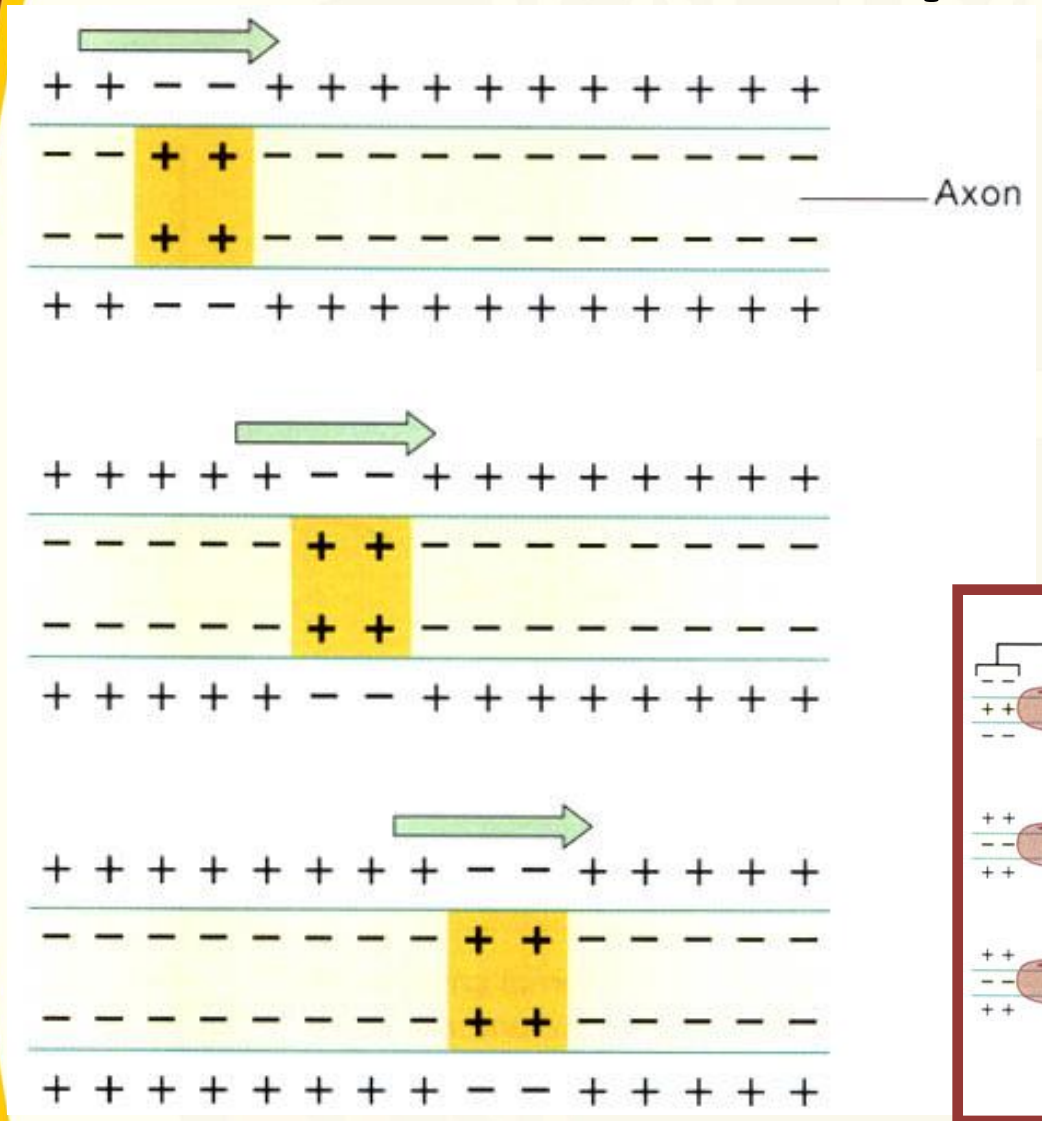
***Conductivity*** means the ability to transmit an impulse.



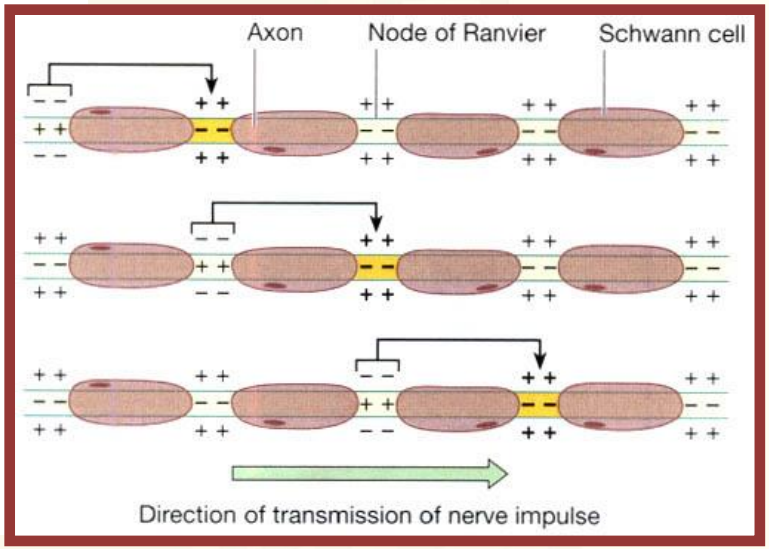



**Nerve fibres: A. Myelinated.** **B. Non-myelinated.**

# Nerve impulse




**Generation & propagation**




**Simple**

**Saltatory**

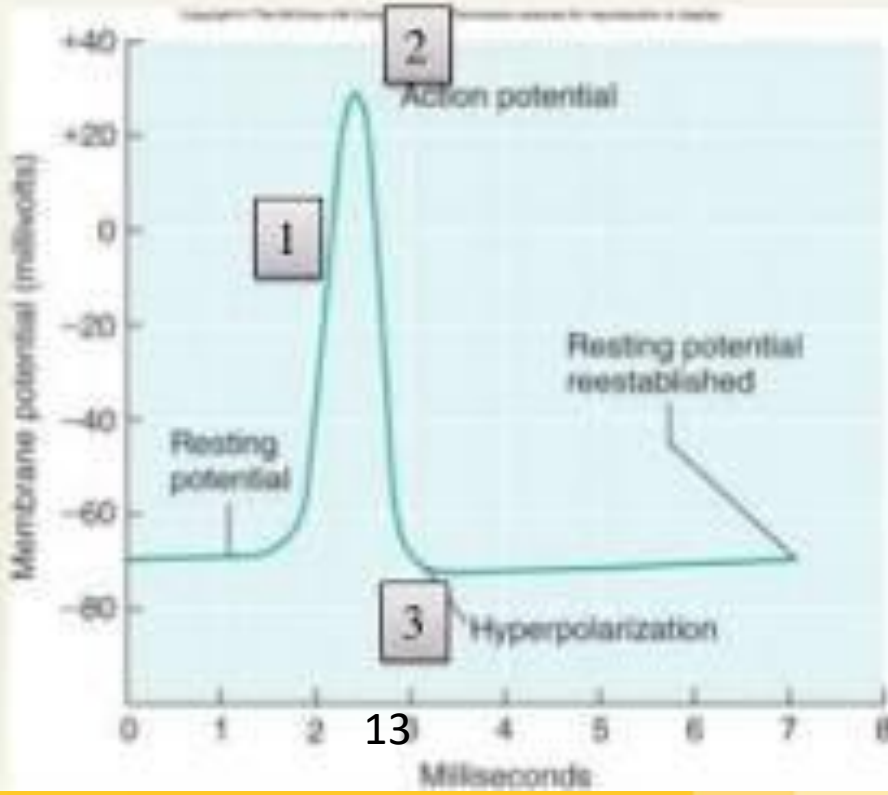
# There are 3 phases of an Action Potential

1. **Depolarization Phase**
   - Voltage-gated $Na^+$ channels open at -55mV (threshold stimulus)
   - $Na^+$ diffuses into cell

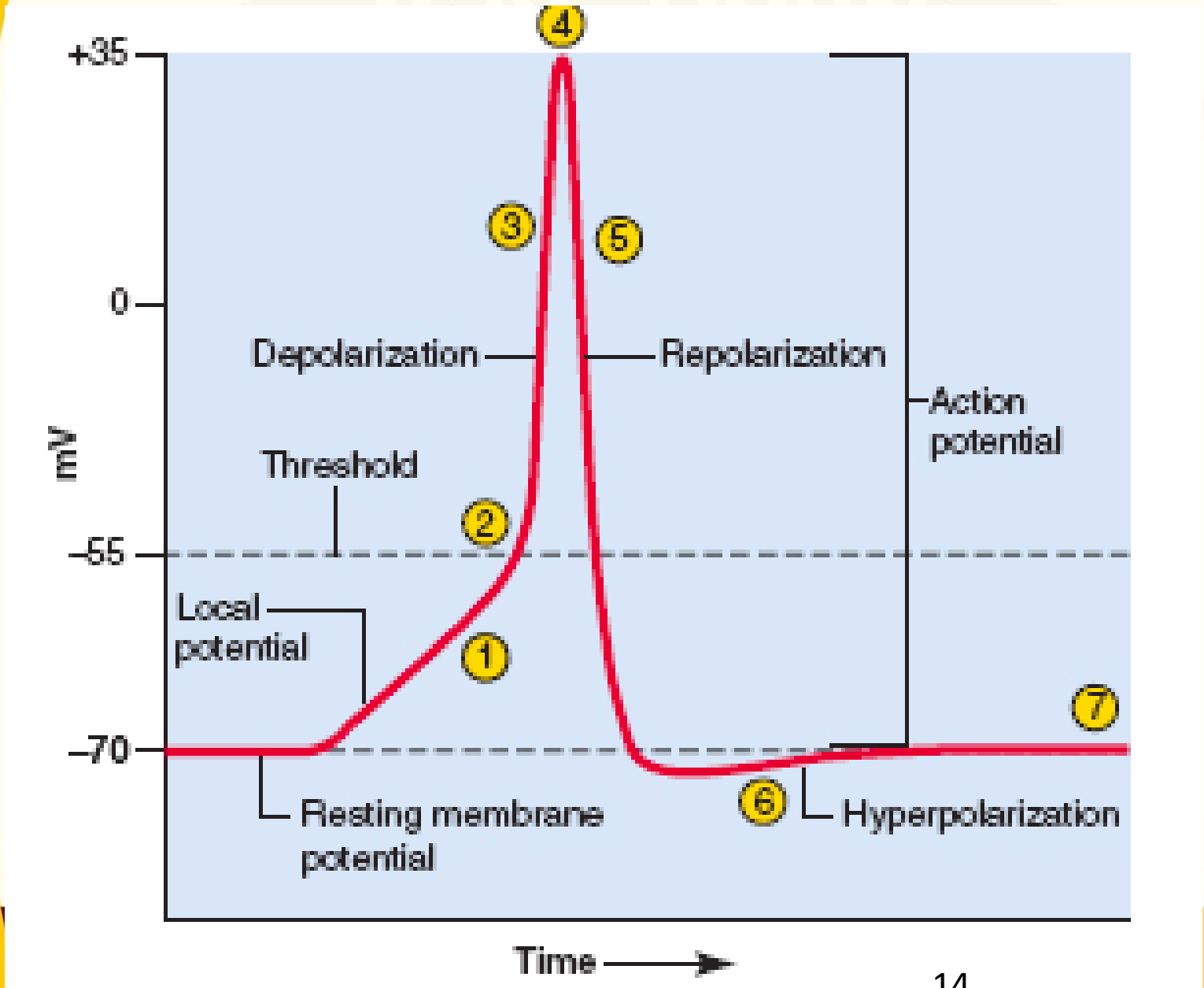
2. **Repolarization Phase**
   - Voltage-gated $K^+$ channels open at +30mV
   - $K^+$ rushes out of the cell repolarizing the membrane
   - $Na^+$ channels close

3. **Hyperpolarization Phase**
   - The slower voltage-gated $K^+$ channels remain open briefly, resulting in a slight hyperpolarization (-90mV).

Figure 10.17. An oscilloscope records and action potential



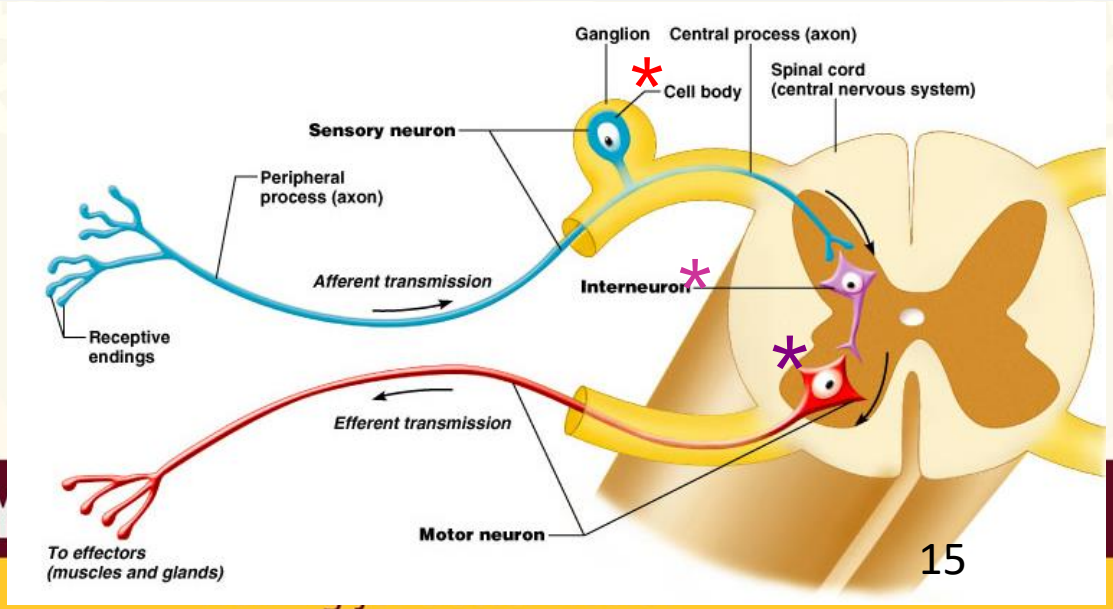
# Action potential



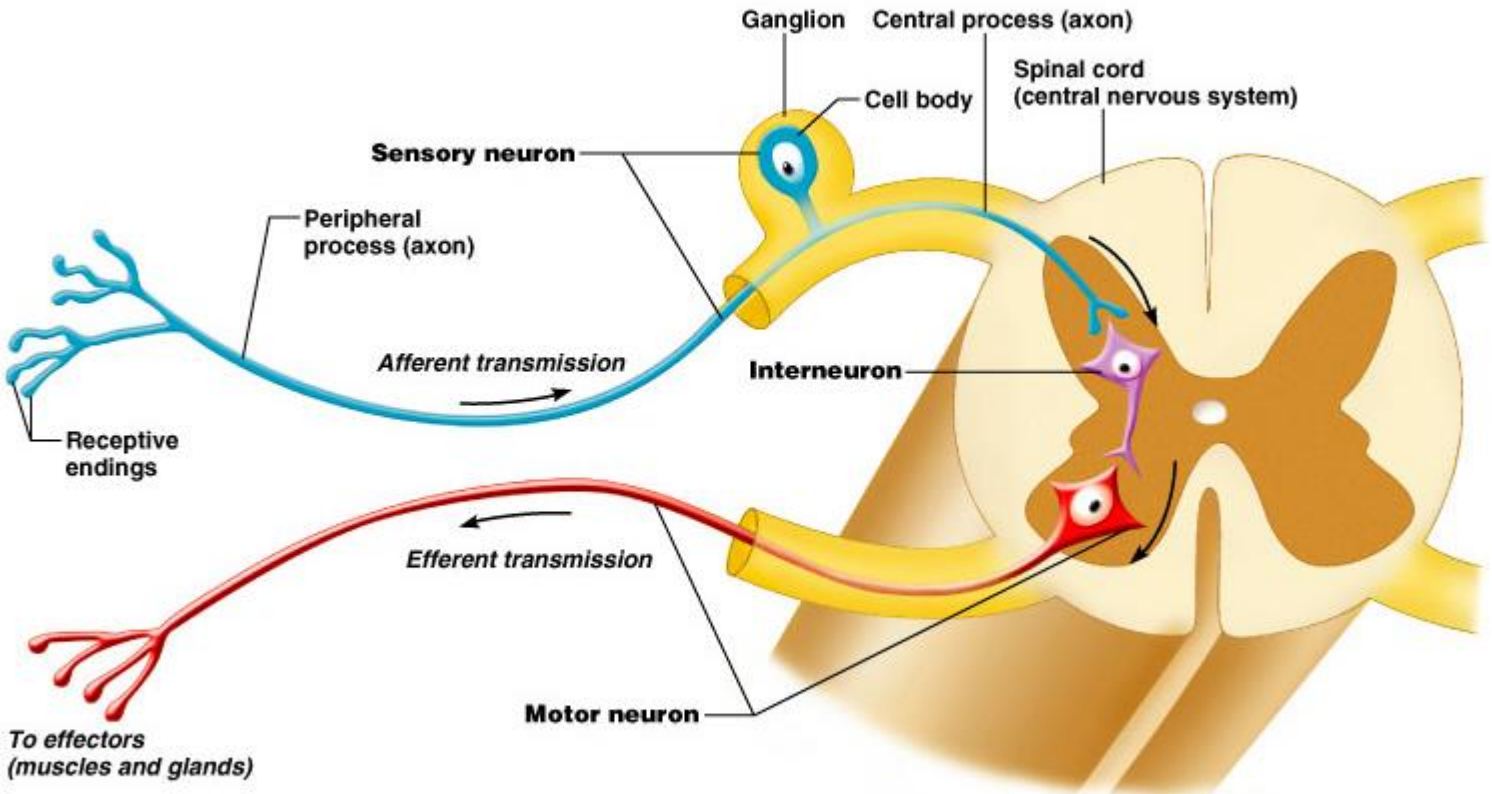
# Types of Neurons by function/direction

- Sensory or afferent (toward CNS from sensory receptor in PNS)
  - Dendrites with specialized sensory receptors (in skin, muscles, viscera, etc)
  - Cell bodies **always** in ganglion* outside CNS
- Motor or efferent
  - From CNS to muscles, glands or viscera
  - Cell bodies almost always in CNS*
- Interneurons*: 99.98% of neurons (within CNS; can be long, e.g. travel down the spinal cord)

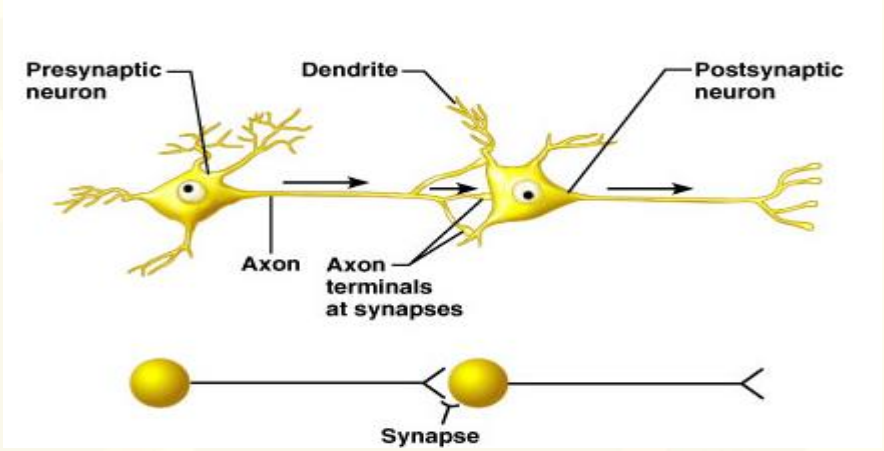
- **MIXED NERVES**



# Note…

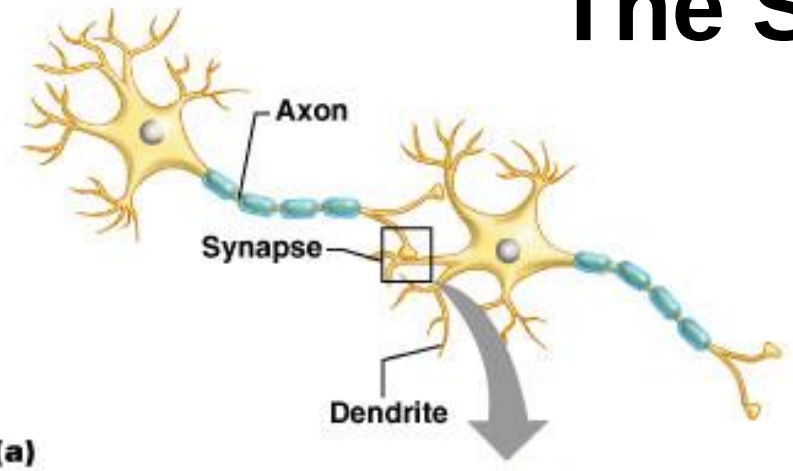


# Synapses

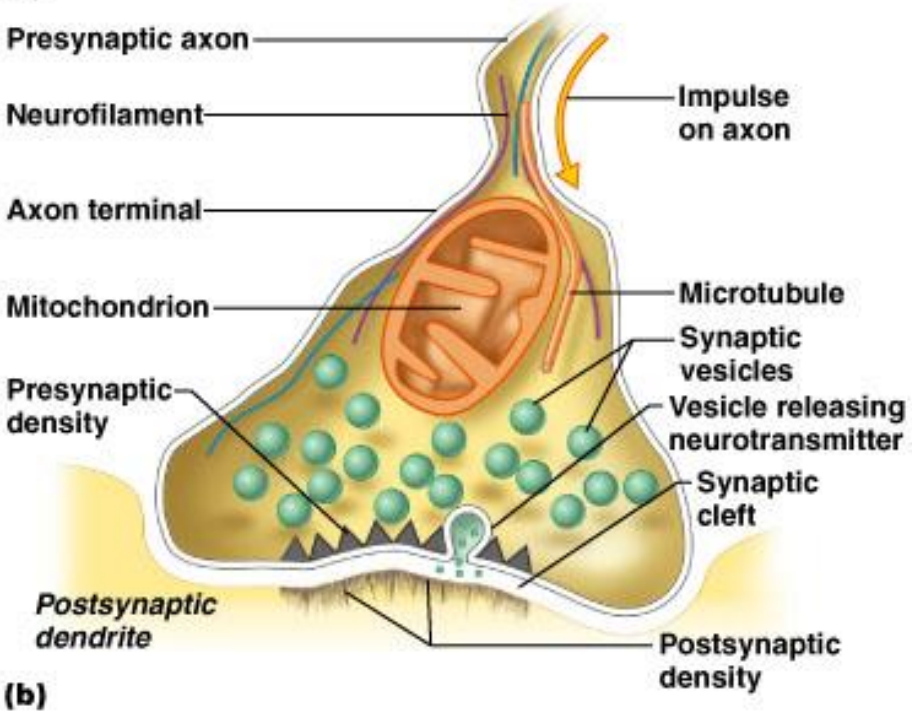



- Junctions between neurons
- Information is passed (usually chemically)
- Unidirectional
- Presynaptic (*toward* synapse) vs postsynaptic (*away from* synapse): most neurons function as both
- Synaptic cleft (tiny gap)

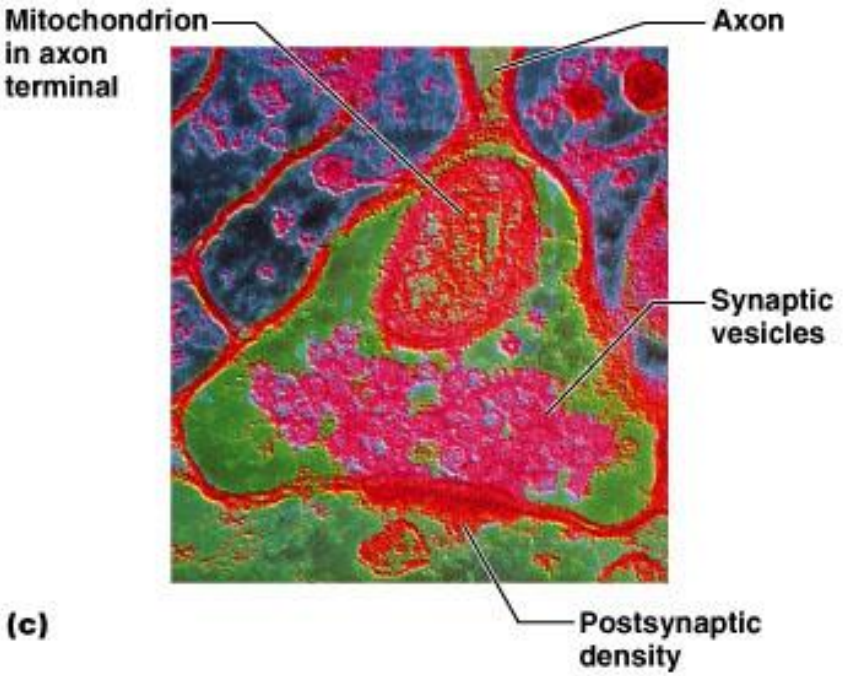
# The Synapse




(a)

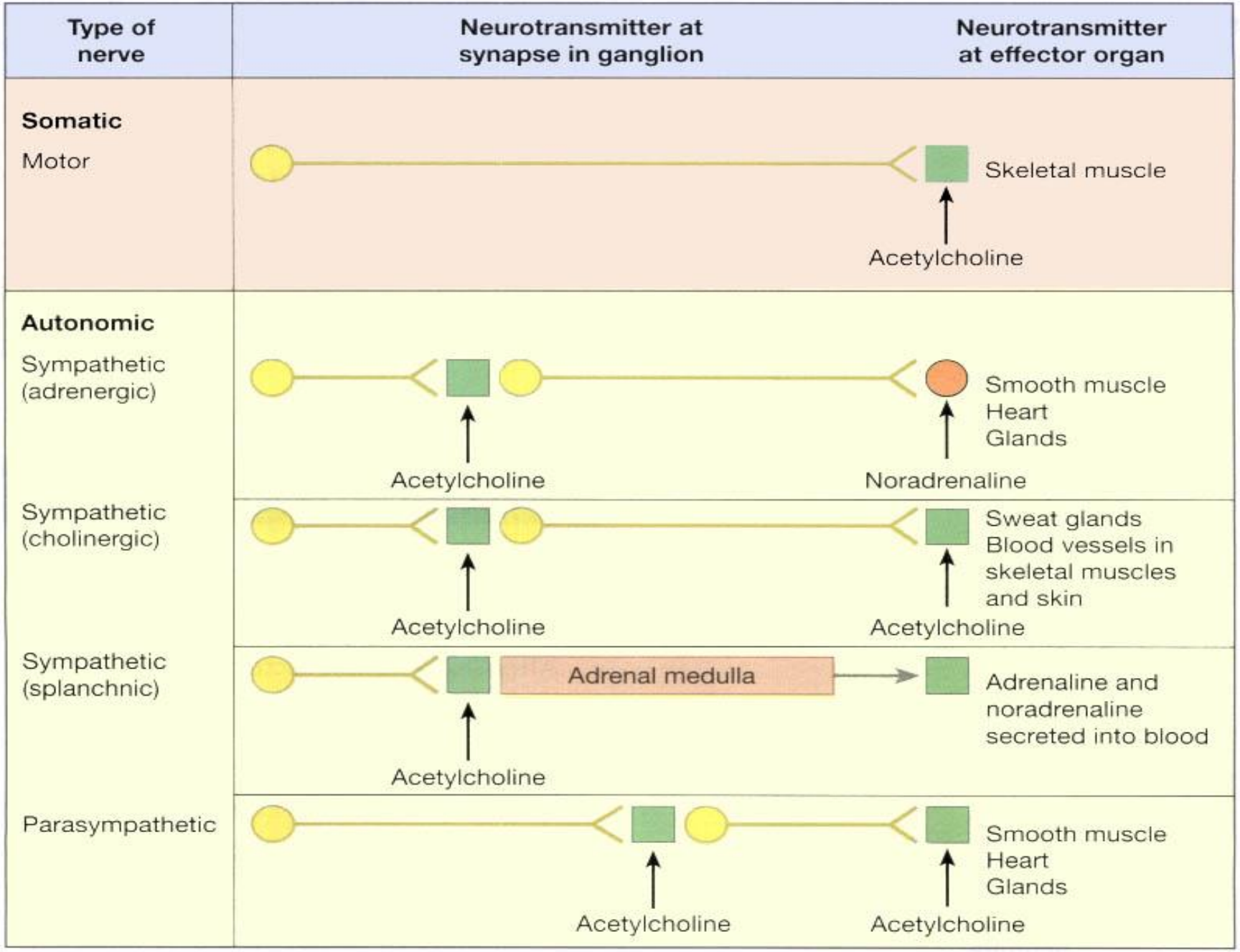



(b)




(c)

# Neurotransmitters at synapses in the peripheral nervous system.

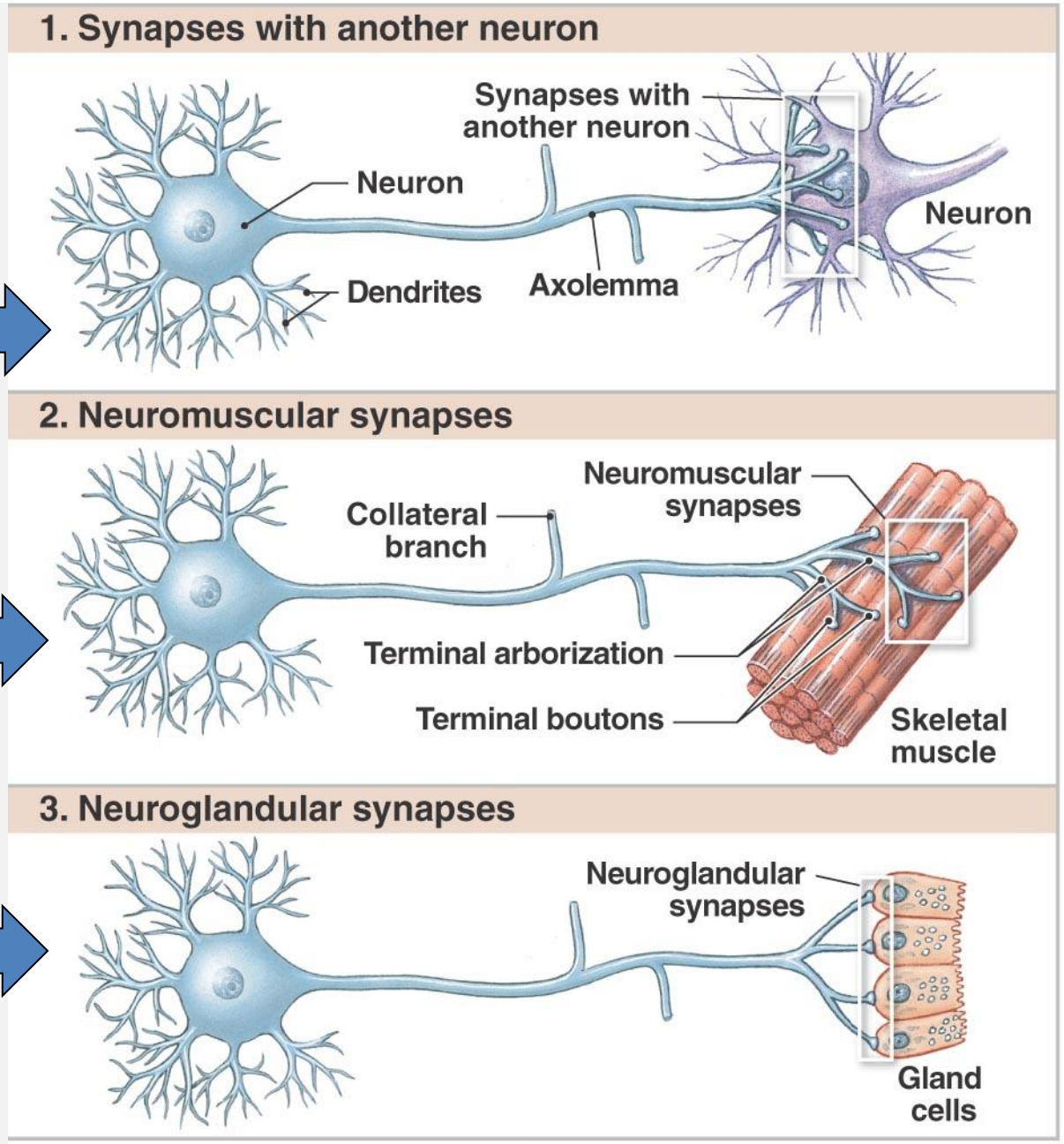


# Note…

- Info passed between neurons by chemicals
  - Can be **excitatory or inhibitory**
- Along the axons, the information passes electrically

# Neurons can synapse with:

1. Neurons
2. Muscle
3. Glands




(b)

REVIEW…

# Nervous tissue: 2 types of cells

1. **Neurons and their processes √**

2. Supporting cells = neuroglia or just glial cells
   - CNS
     - Astrocytes
     - Oligodendrocytes
     - Microglia
     - Ependymal cells
   - PNS
     - Schwann cells
     - Satellite cells

# Supporting cells

- Neuroglia usually refers to CNS ones
- Just “glia” to both
- Divide throughout life
- Smaller and darker than neurons
- Outnumber neurons 10 to 1

# Neuroglia (CNS glial cells)

- Astrocytes
  - Star shaped; the most numerous
  - Involved in metabolism & synapse formation
- Microglia
  - Phagocytes
- Ependymal cells
  - Line the cavities of CNS and spinal cord; cilia
- Oligodendrocytes
  - Produce myelin sheaths in CNS

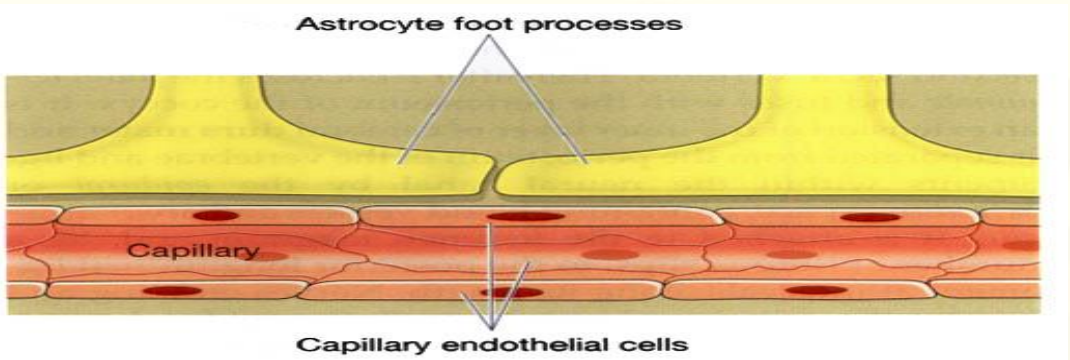
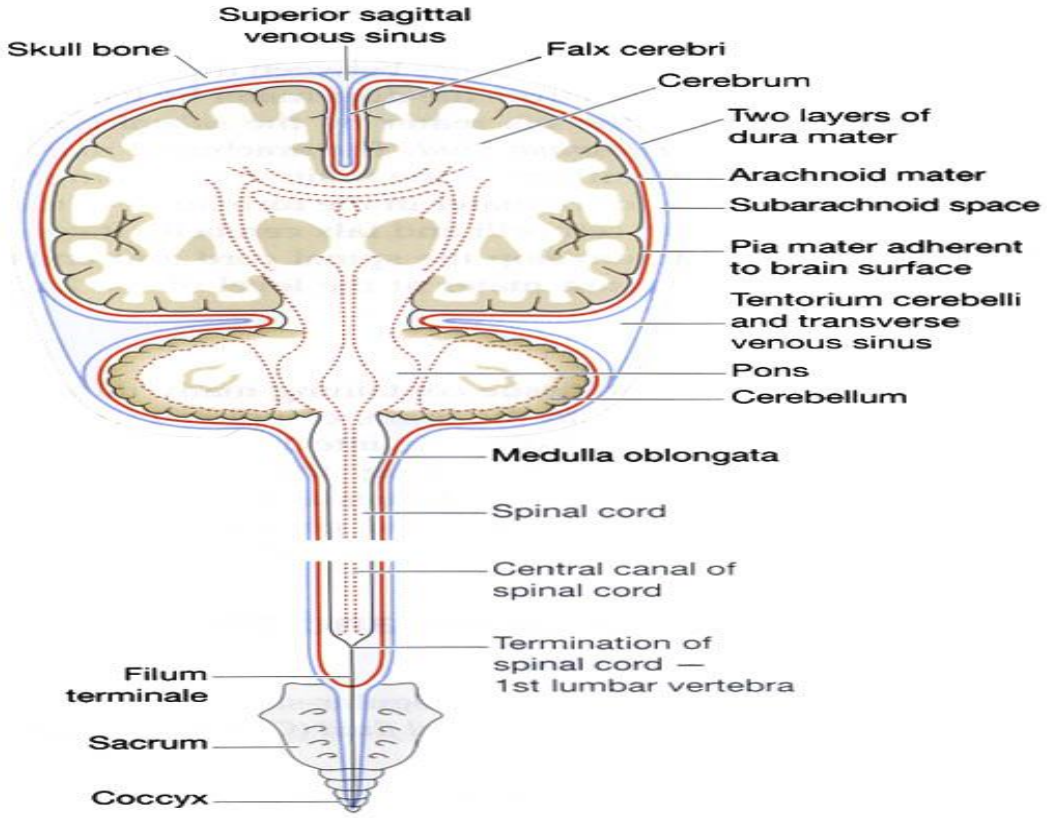


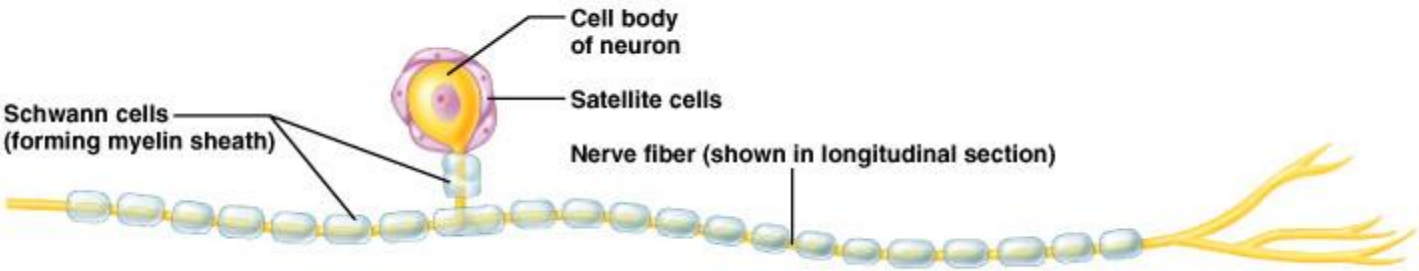

**Figure 7.11** Blood–brain barrier.




Blood brain barrier; [**BBB]**

# PNS supporting cells

- Satellite cells
  - Surround neuron cell body
- Schwann cells
  - Form myelin in PNS

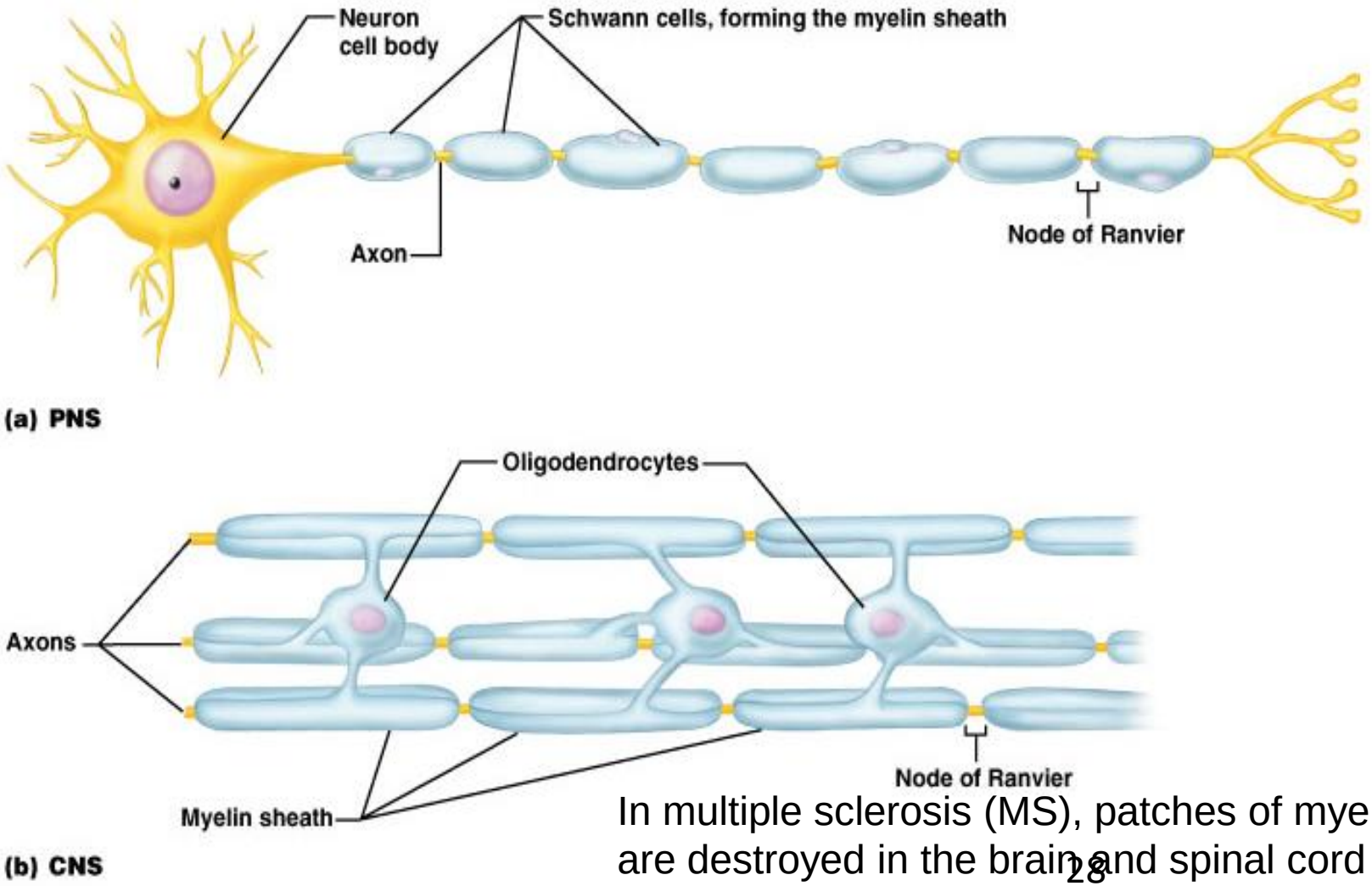



Sensory neuron with Schwann cells and satellite cells

# Myelin

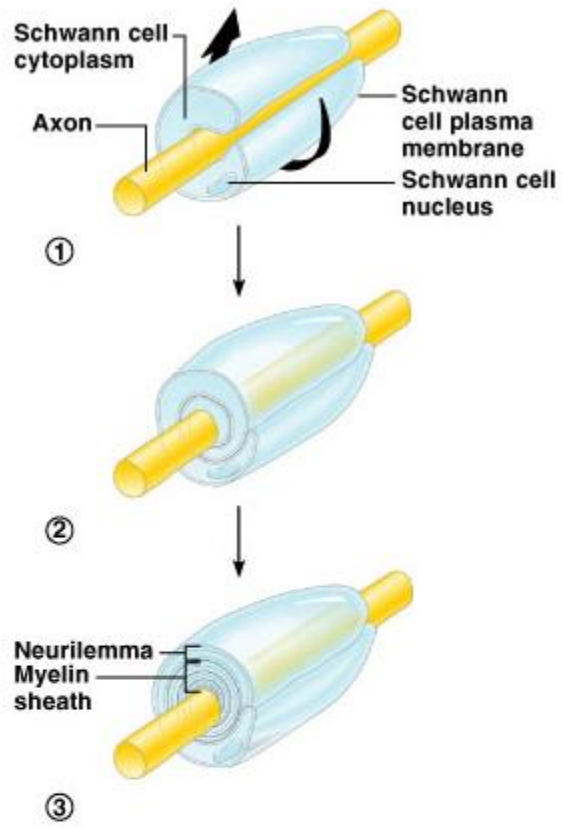
- Lipoprotein
- Increases speed of conduction, large axons
  - Insulation
  - Prevent leakage of electric current
- Layers with spaces (nodes of Ranvier) between cells
- Impulse “jumps” from node to node
- “Unmyelinated” axons – smaller, slower

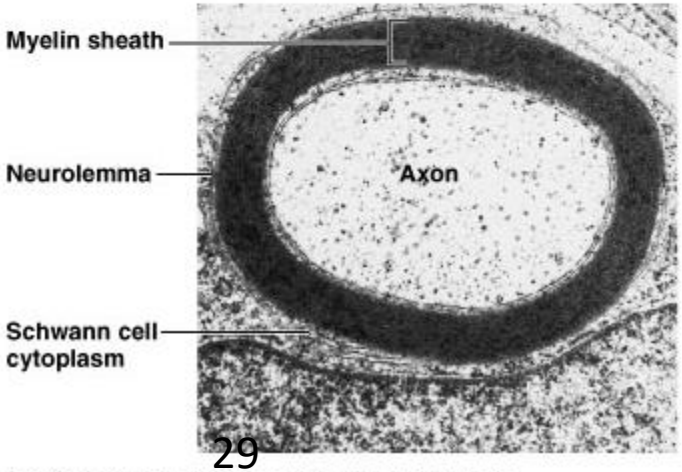
# Myelin in the Peripheral and Central Nervous Systems




In multiple sclerosis (MS), patches of myelin are destroyed in the brain and spinal cord

- Schwann cells
  - Myelin sheath



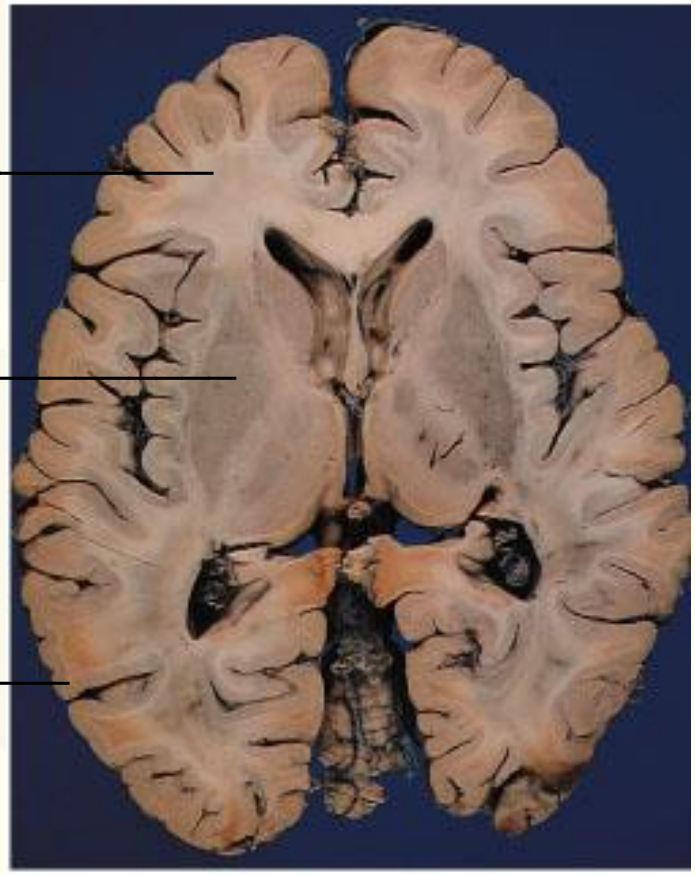

(a) Schwann cells on myelinated axon

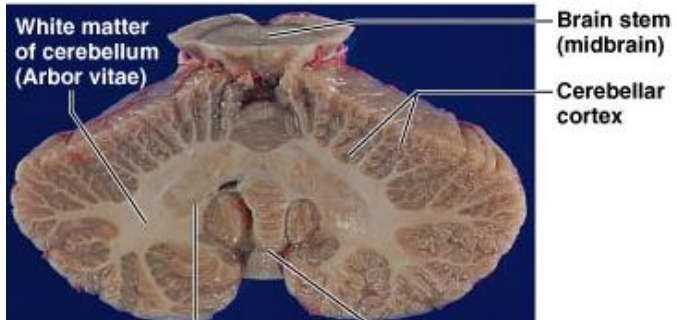
# Gray and White Matter of the CNS
## (GROSS ANATOMY OF THE CNS)

- Gray matter: gray-colored
  - Where neuron **cell bodies** are clustered
- White matter: white-colored
  - Where millions of **axons** are running between different part of CNS, in bundles of "tracts"
    - Remember, *tracts* are in CNS, vs *nerves* in PNS
  - White is from the myelin sheaths

# Usual pattern of gray/white in CNS

- White exterior to gray
- Gray surrounds hollow central cavity
- Two regions with additional gray called “cortex”
  - Cerebrum: “cerebral cortex”
  - Cerebellum: “cerebellar cortex”

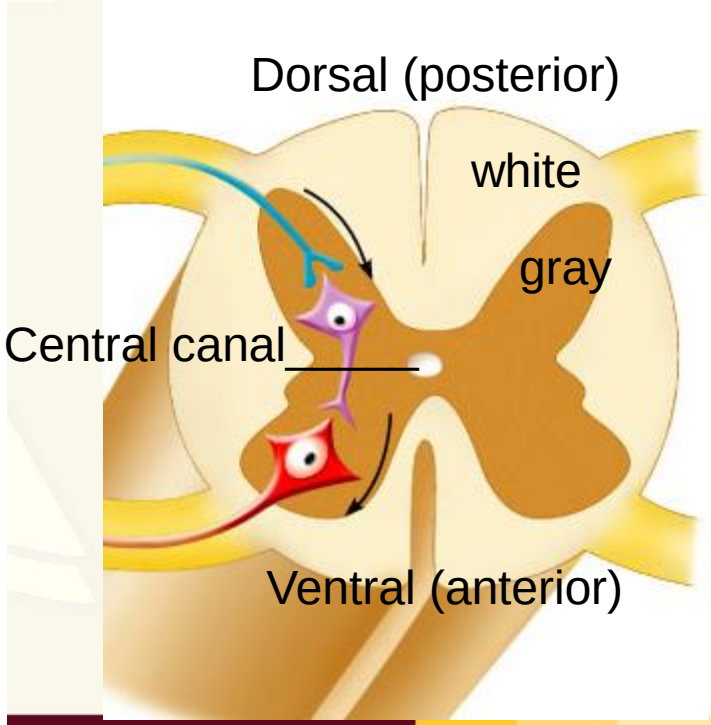




# Gray/White in spinal cord

- Hollow central cavity (“central canal”)
- Gray matter surrounds cavity
- White matter surrounds gray matter (white: ascending and descending tracts of axons)
- “H” shaped on cross section
- Dorsal half of “H”: cell bodies of interneurons
- Ventral half of “H”: cell bodies of motor neurons
- No cortex

***Same pattern***



# From earlier: neuron processes

- Run through CNS in ***tracts*** of white matter

- Run through the PNS forming peripheral ***nerves***

# Review these terminologies

- ***Neuron*** = nerve cell
- ***Neuroglia*** = supporting cell
- ***Nerve fiber*** = long axon
- ***Nerve*** = collection of nerve fibers (axons) in ***PNS***
- ***Tract*** = collections of nerve fibers (axons) in ***CNS***
- ***Nucleus*** = cluster of cell bodies in CNS
- ***Ganglia*** = cluster of cell bodies in PNS

**New:**

- ***Unilateral:*** on ***one*** side
- ***Ipsilateral:*** on the ***same*** side
- ***Contralateral:*** on the ***opposite*** side

**Remember also:**

- ***CNS vs PNS***
- ***Input: sensory: afferent: to brain***
- ***Output: motor : efferent: from brain***

# Assignment

- Describe the classes and functions of neurotransmitters