

The Nervous Tissue



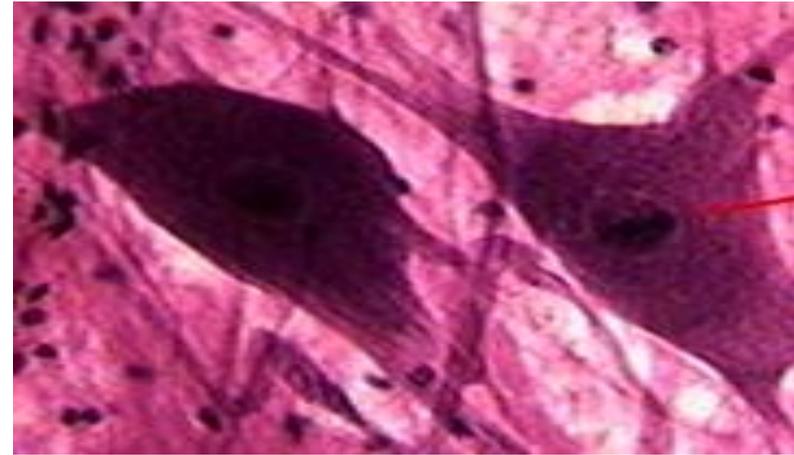
Categories of Tissue

1. Epithelial Tissue

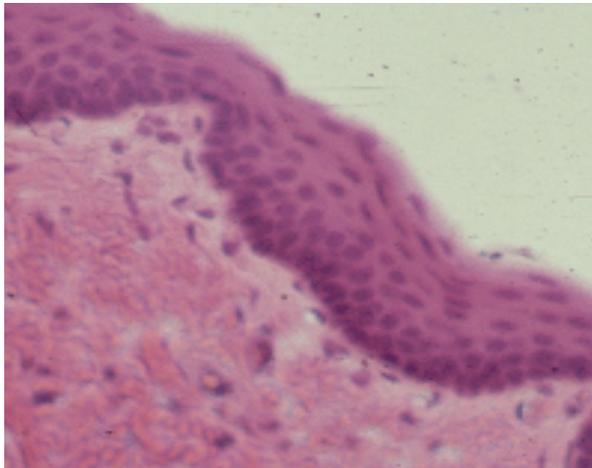
2. Connective Tissue

3. Nervous Tissue

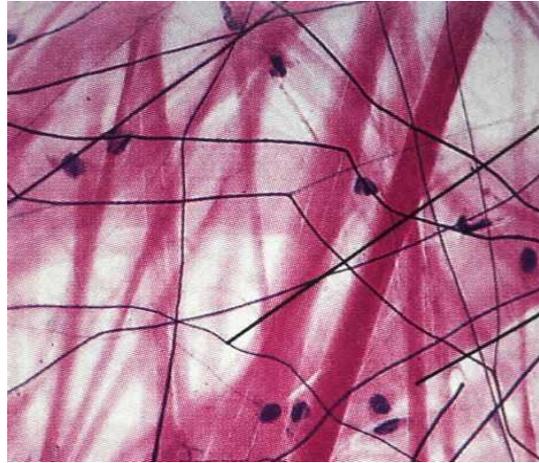
4. Muscle Tissue



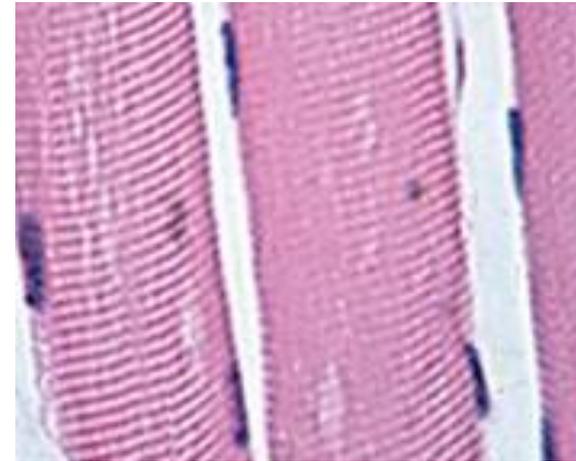
Nervous tissue



Epithelial tissue



Connective tissue



Muscular tissue

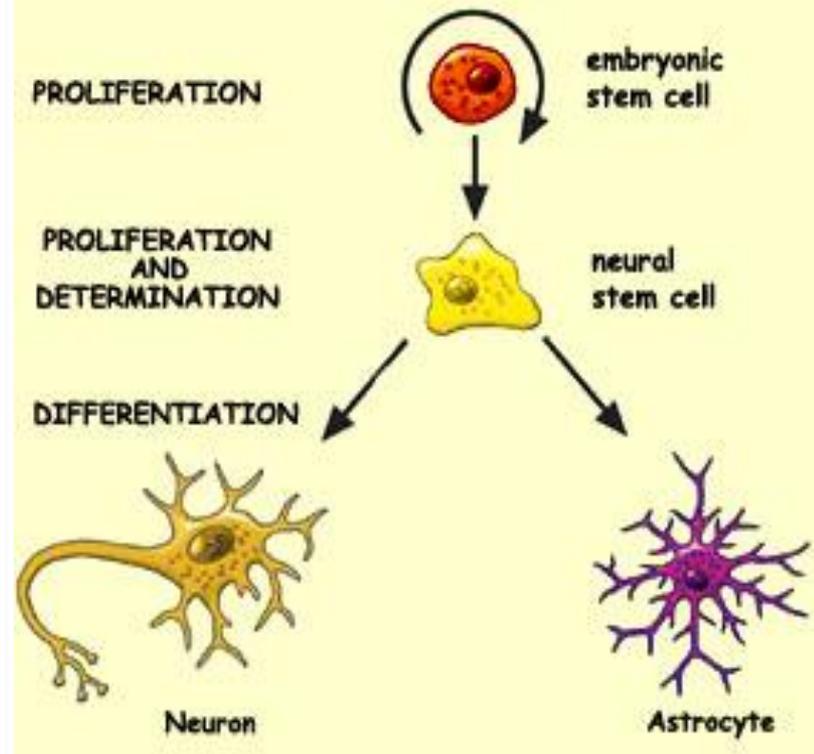
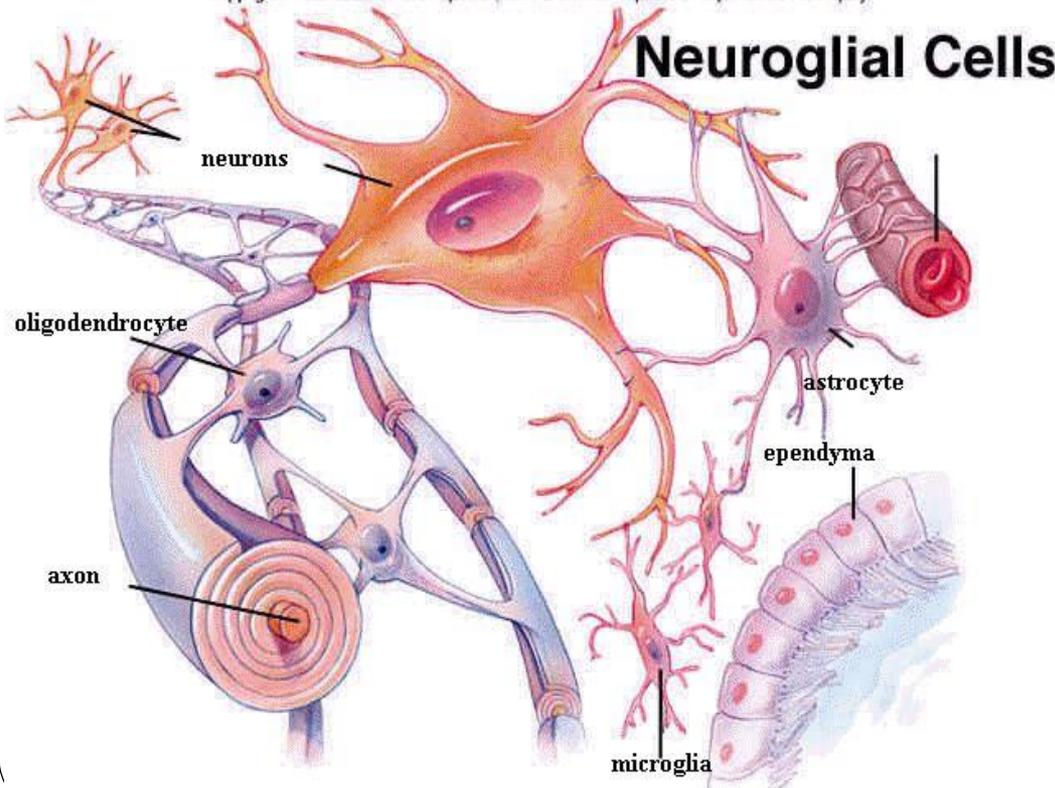
The Nervous Tissue

Contains **two different** varieties of cells

1. **Neurons** = nerve cell
2. **Neuroglia** = supporting cells

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Neuroglial Cells



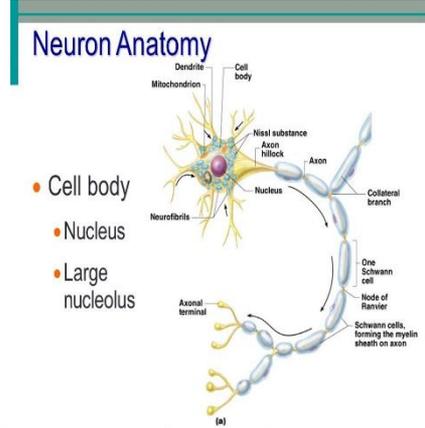
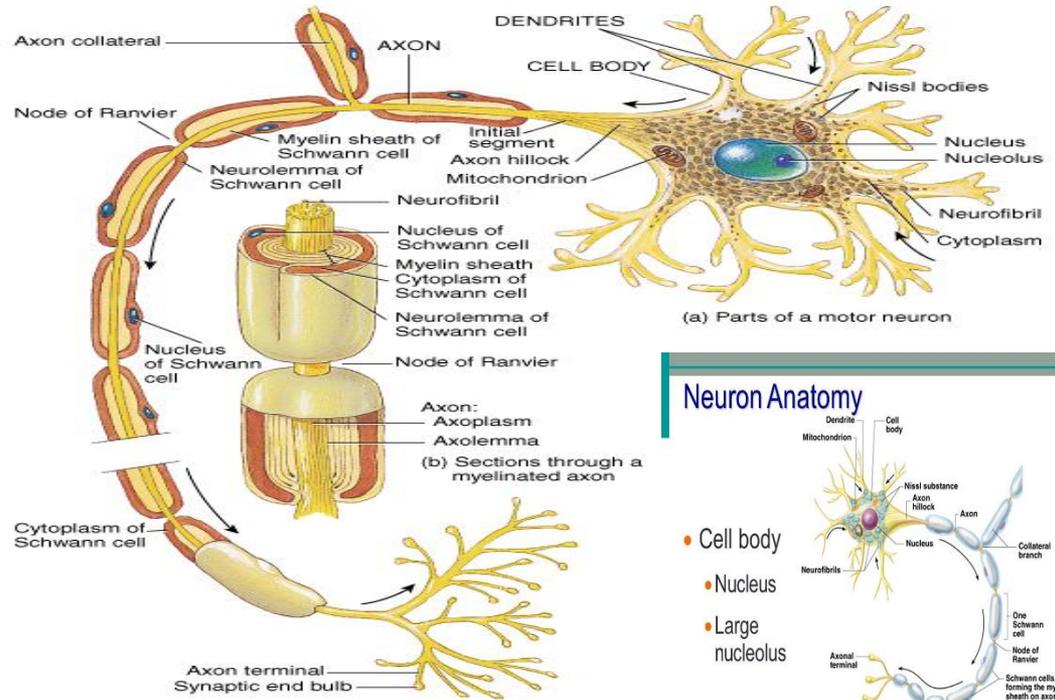
NEURON

- Also called **nerve cells**
- Structural unit of nervous system

Character:

- **Excitability**
- **conductivity**

Conduct messages in the form of nerve impulses from one part of the body to another = synapse



Structure of neuron

1- Cell body

= Soma

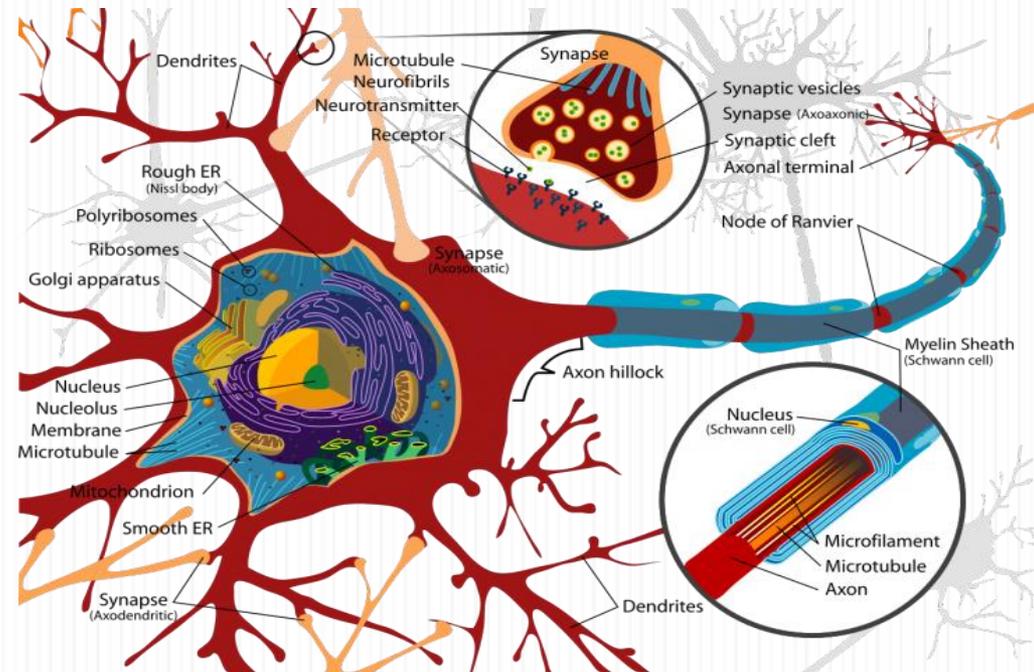
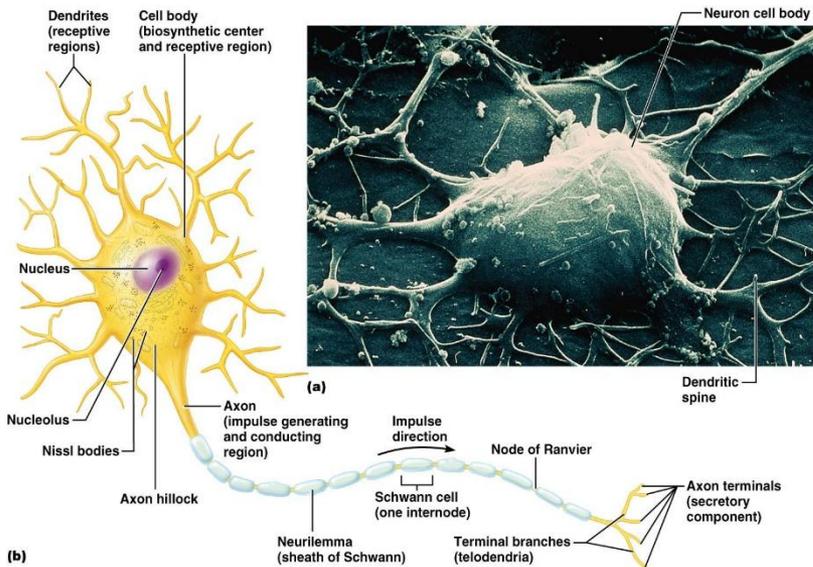
around nucleus

perikaryon

2-Cell processes

axon

dendrites



■ Perikaryon = nerve cell body contains

❑ **Nucleus** : large, central, active & prominent nucleolus

❑ **Rough endoplasmic reticulum (rER)**

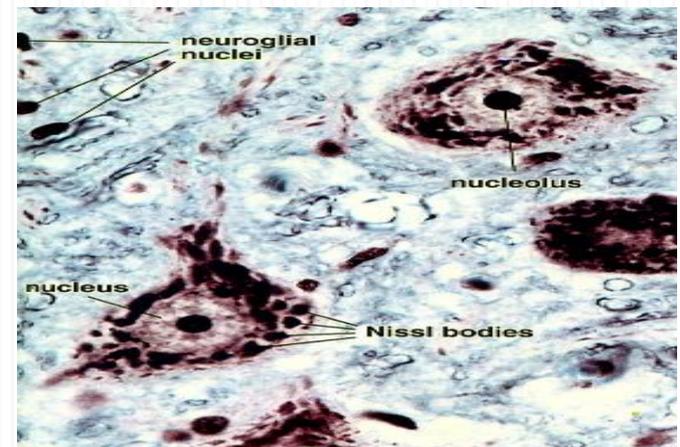
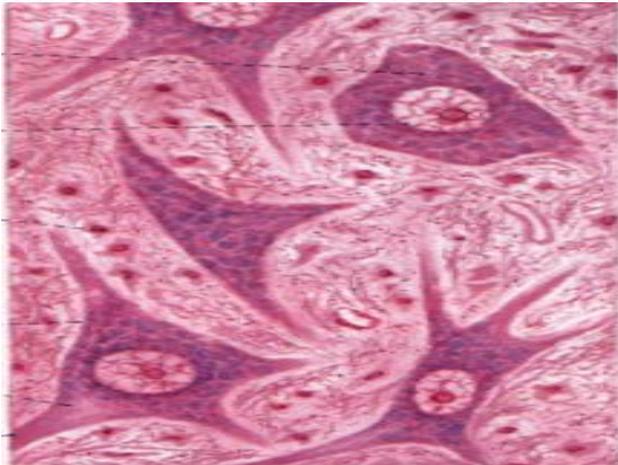
Nissl bodies are condensations of **rER** and **free ribosomes**.

for synthesis of structural and transport proteins (neurotransmitters)

❑ **Golgi apparatus** : near to the nucleus .

Expected, since intense synthetic activity of neurotransmitters that must be packaged in vesicles.

❑ **Mitochondria** : abundant for high energy requirements



❑ Cytoskeleton (neurofilaments , microtubules)

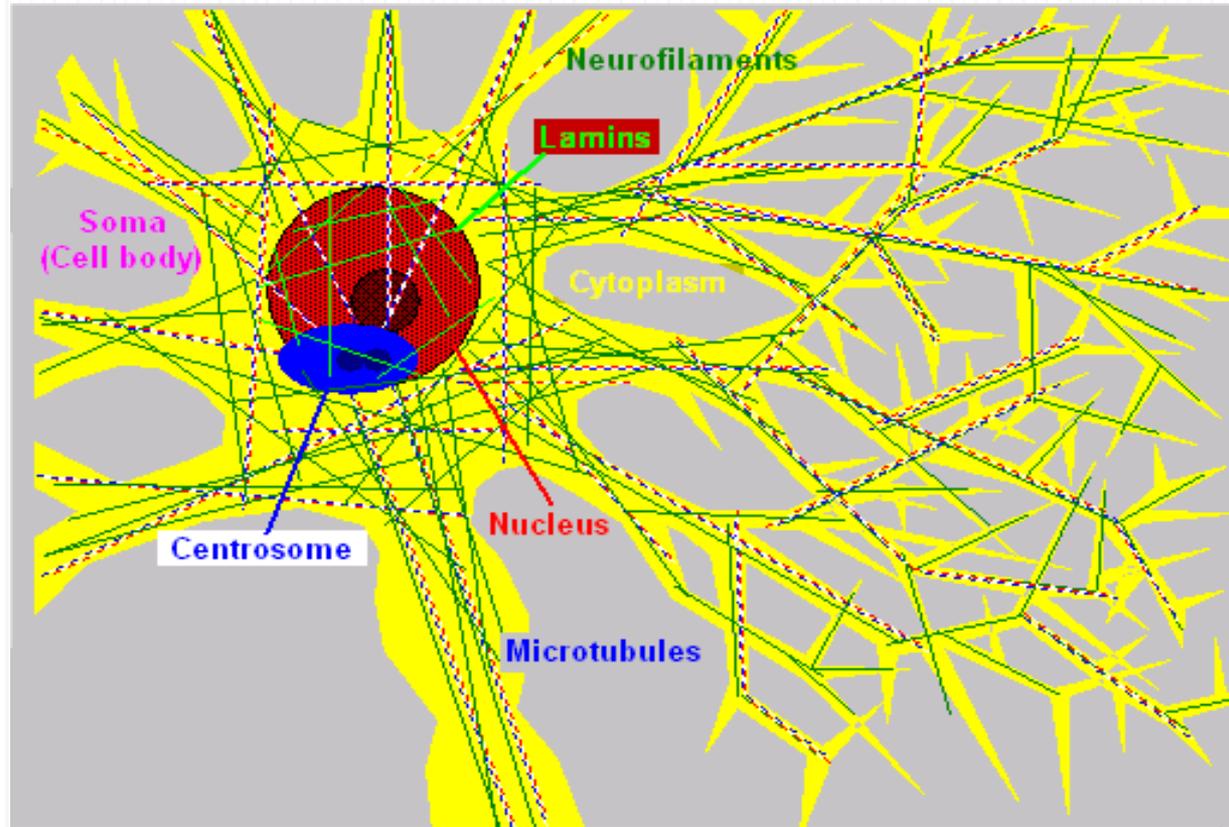
Two of the known roles of cytoskeletal components include maintaining the link structure or the physical form of neurons and transporting cell components from the **soma** to the synapses.

❑ Inclusions :

➤ **Pigment**

➤ Residual bodies

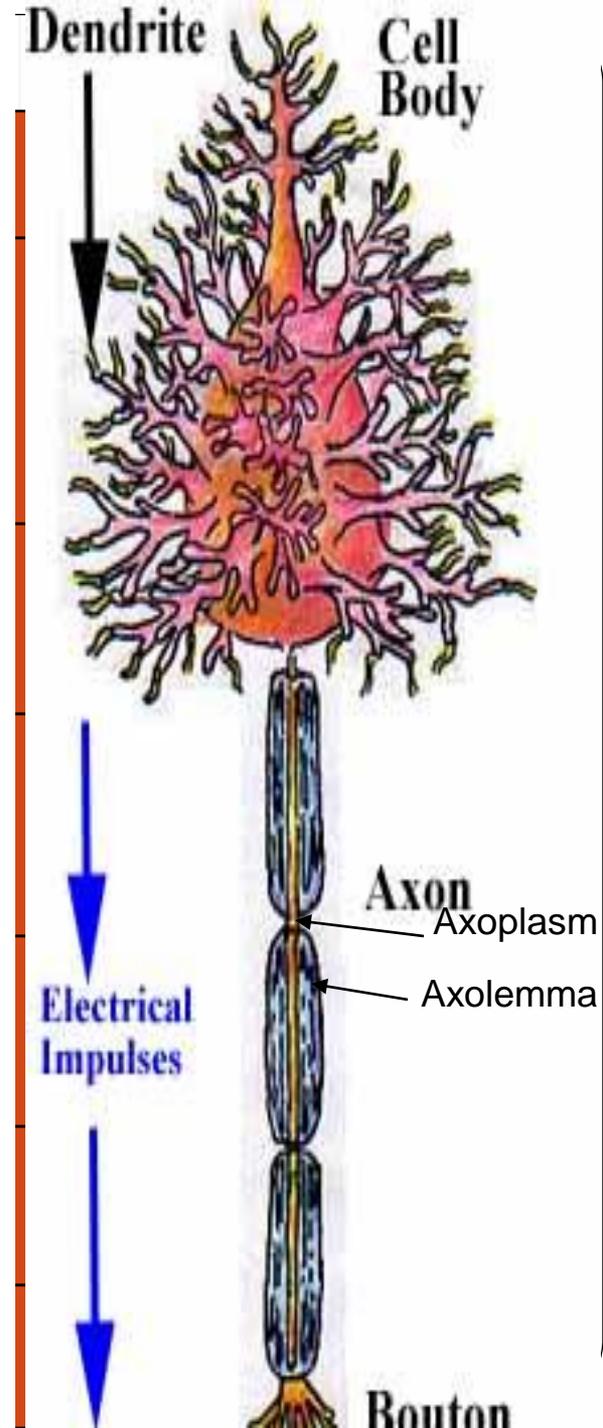
increase with age.



AXON

Dendrite

| | | |
|-----------------------------------|--|--|
| Origin | From axon hillock | From any part of cell |
| Number | Always single | Usually multiple |
| length | long | Short |
| Thickness | Thin uniform | Thick near cell then tapers away |
| Branching | Does not branch except at its termination | Many branches. |
| Organelles | Few No Nissl bodies No golgi | Contains most of organelles Contain golgi + Nissl |
| Surrounding structures | Surrounded with sheaths | Not surrounded with sheaths |
| Direction of | Away | Towards |



Classification of neurons

❑ **Functionally**

- Sensory
- Motor
- Interneurons
- Neuro-secretory

❑ **Morphologically**

❖ **Size**

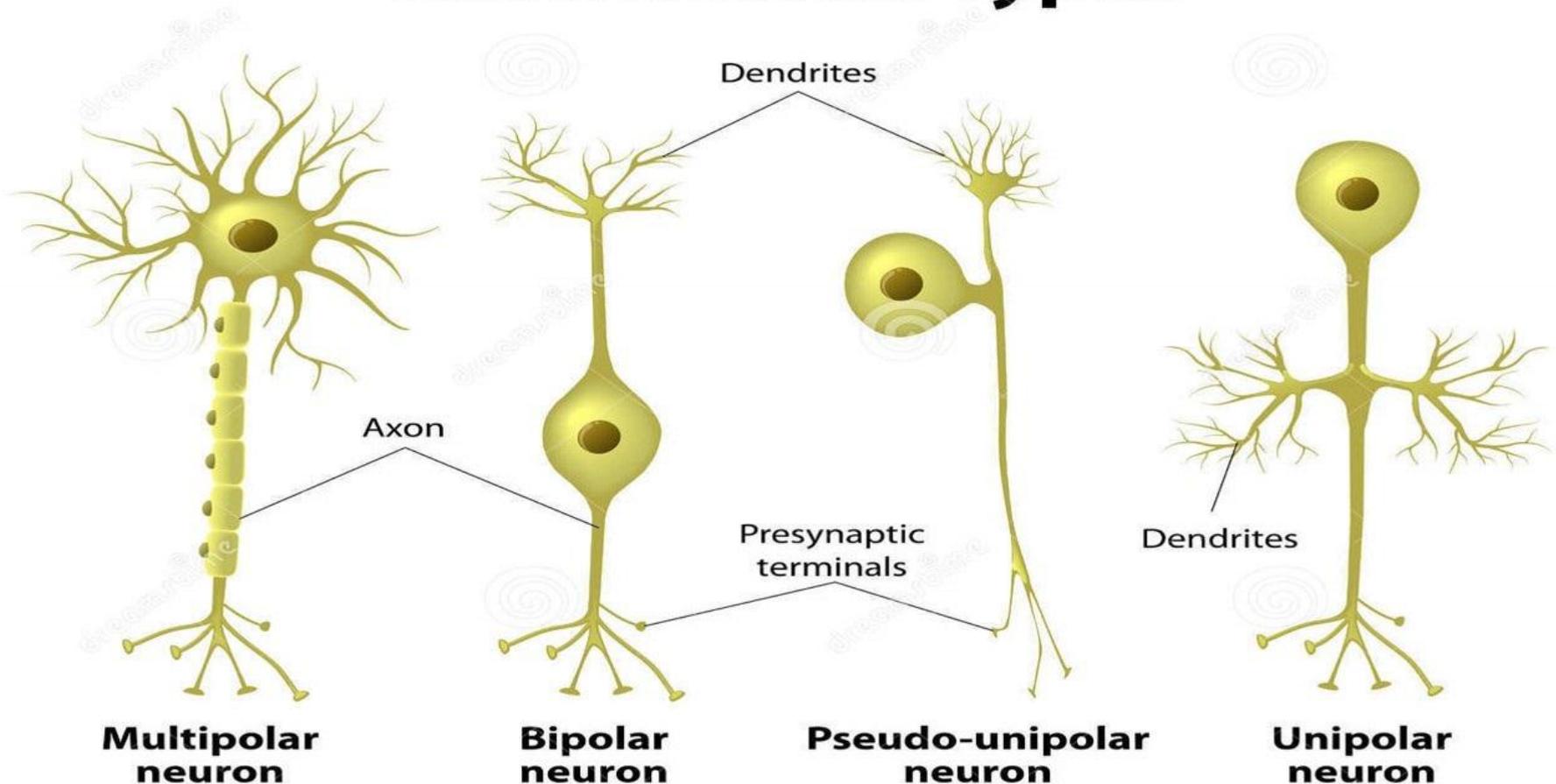
1. Golgi I (long axon)
2. Golgi II (short axon)

❖ **No of Processes**

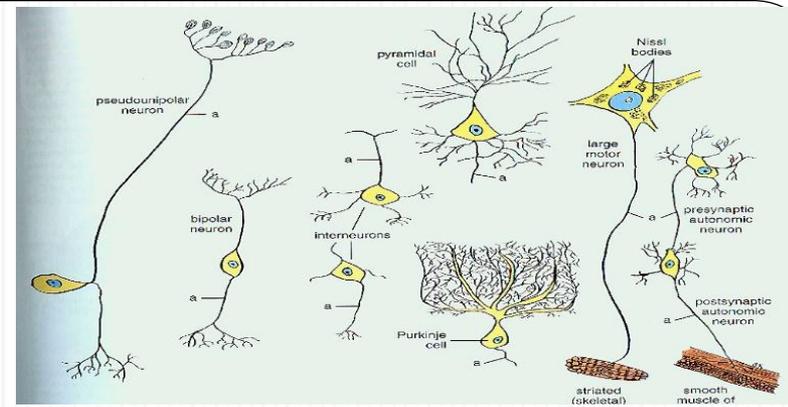
1. one Process
2. two Processes
3. more Processes

According to the number of processes

Basic Neuron Types

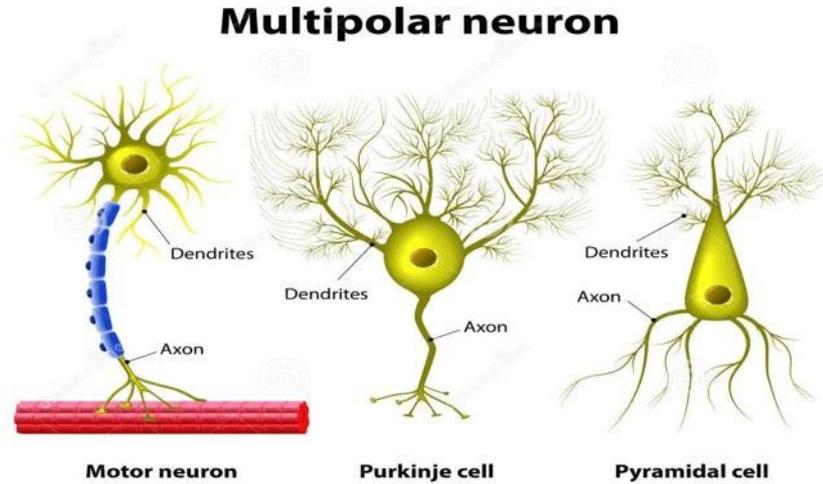


Multipolar Neurons



According to the shape of the cell body

Stellate



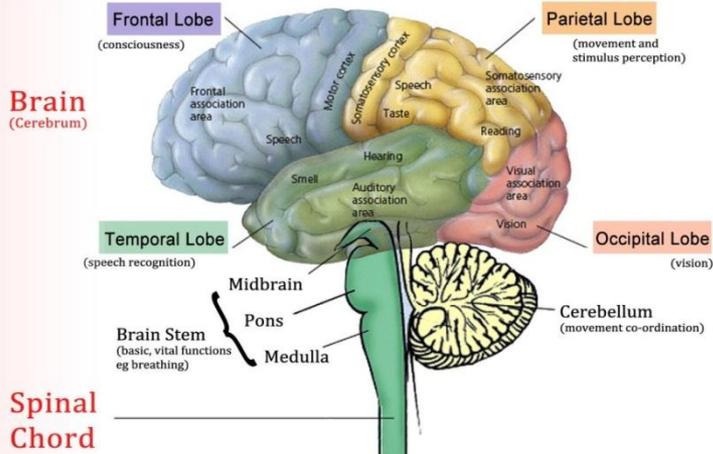
Pyramidal

Pyriform

Granule

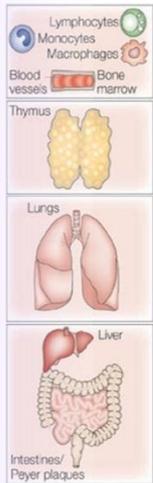
The Nervous System

Central Nervous System



Peripheral Nervous System

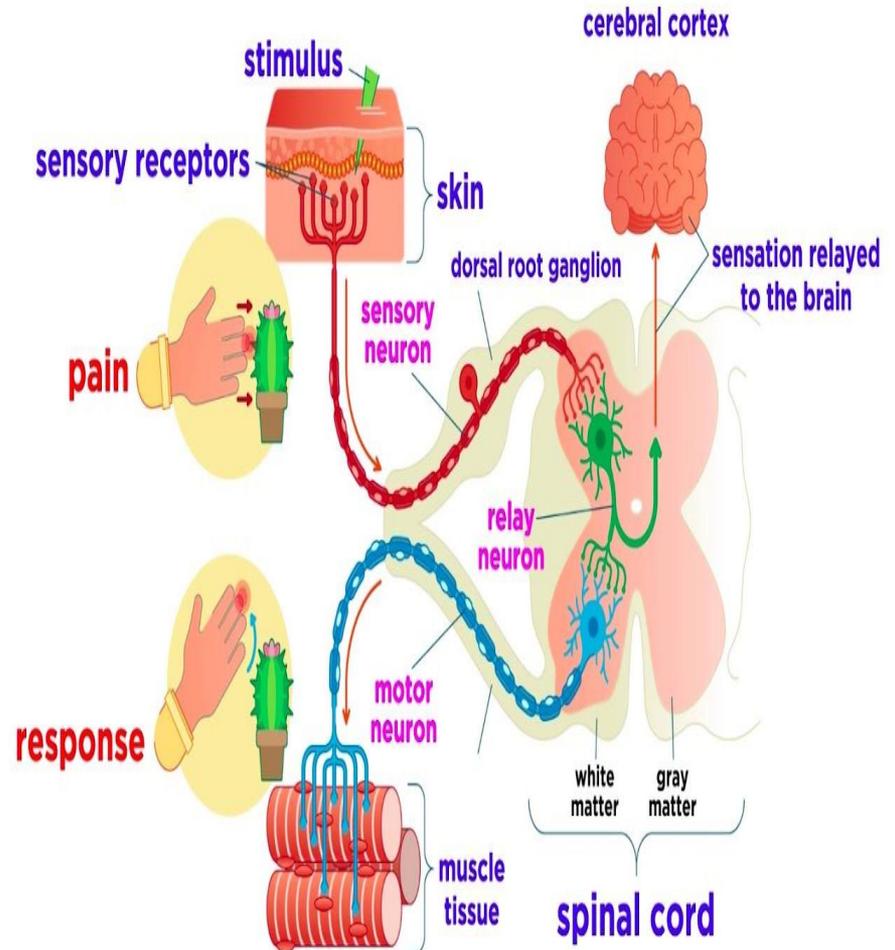
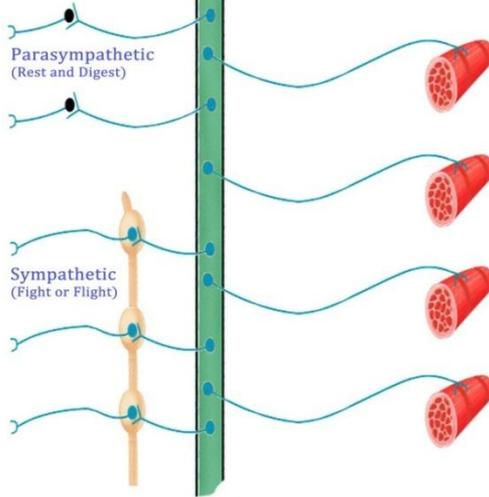
Autonomic (Subconscious, control systems)



Parasympathetic (Rest and Digest)

Sympathetic (Fight or Flight)

Somatic (Voluntary, muscle movement)



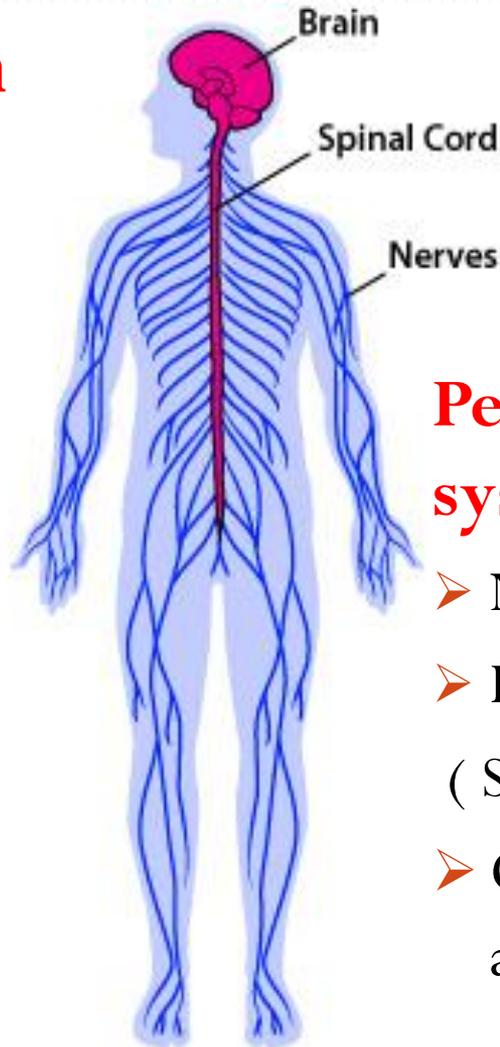
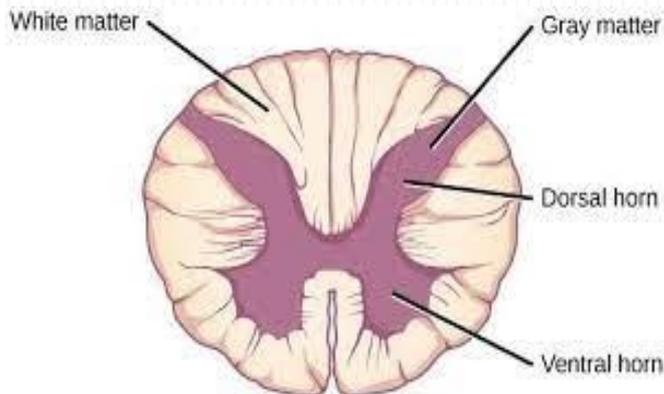
Nervous system

Central nervous system (CNS)

□ Brain

□ Spinal cord

- Cell body in grey matter
- Processes in white matter



Peripheral nervous system (PNS)

- Nerve ending
- Peripheral nerves
(Somatic + autonomic)
- Ganglia (cranio- spinal & autonomic ganglia)

■ Central Nervous System (CNS)

■ Peripheral Nervous System (PNS)

Neuroglia

Definition :

Supporting cells of the nervous system

Stain :

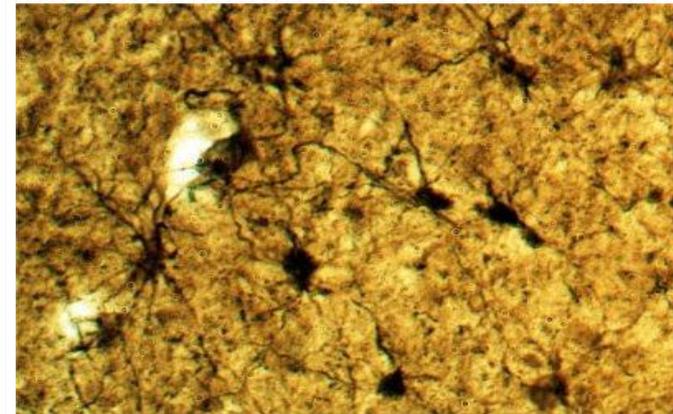
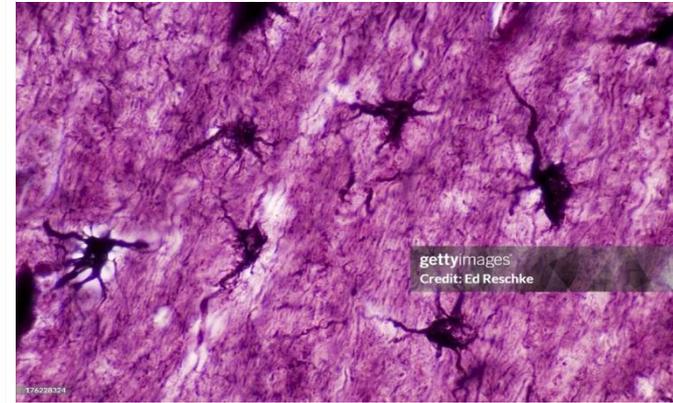
- Gold chloride
- Silver stain
- Immuno-histochemical

Shape :

- Branching cells

Origin :

- All ectodermal in origin except **microglia** derived from blood monocytes = mesodermal in origin



Site :

❑ Inside CNS

macroglia = astrocytes, microglia, ependymal cell ,
oligodendroglia

❑ Outside CNS = peripheral NS

Schwann cell, satellite cells in ganglia

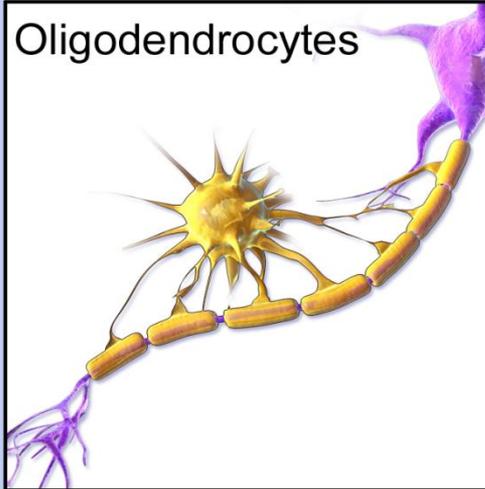
Types of Neuroglia

Central Nervous System

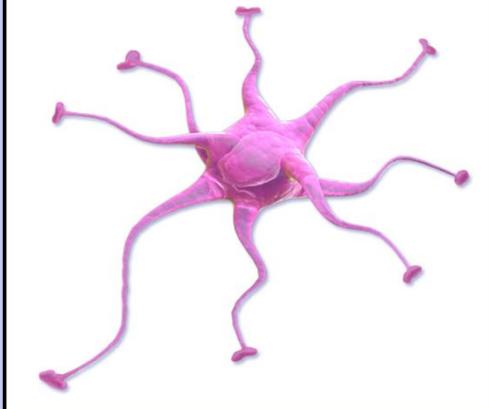
Ependymal cells



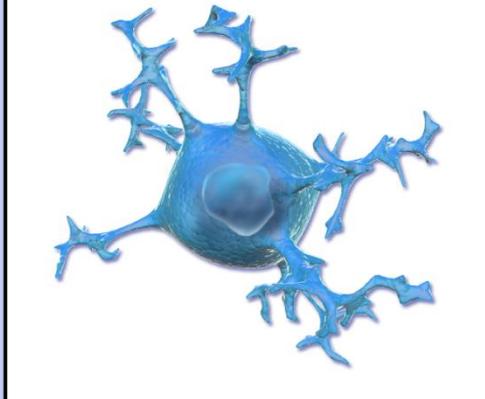
Oligodendrocytes



Astrocytes

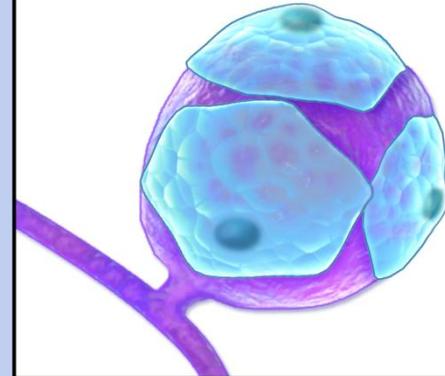


Microglia

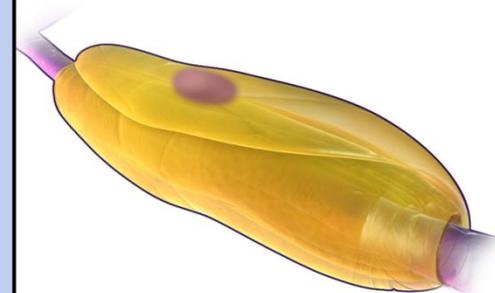


Peripheral Nervous System

Satellite cells



Schwann cells



Types of neuroglia

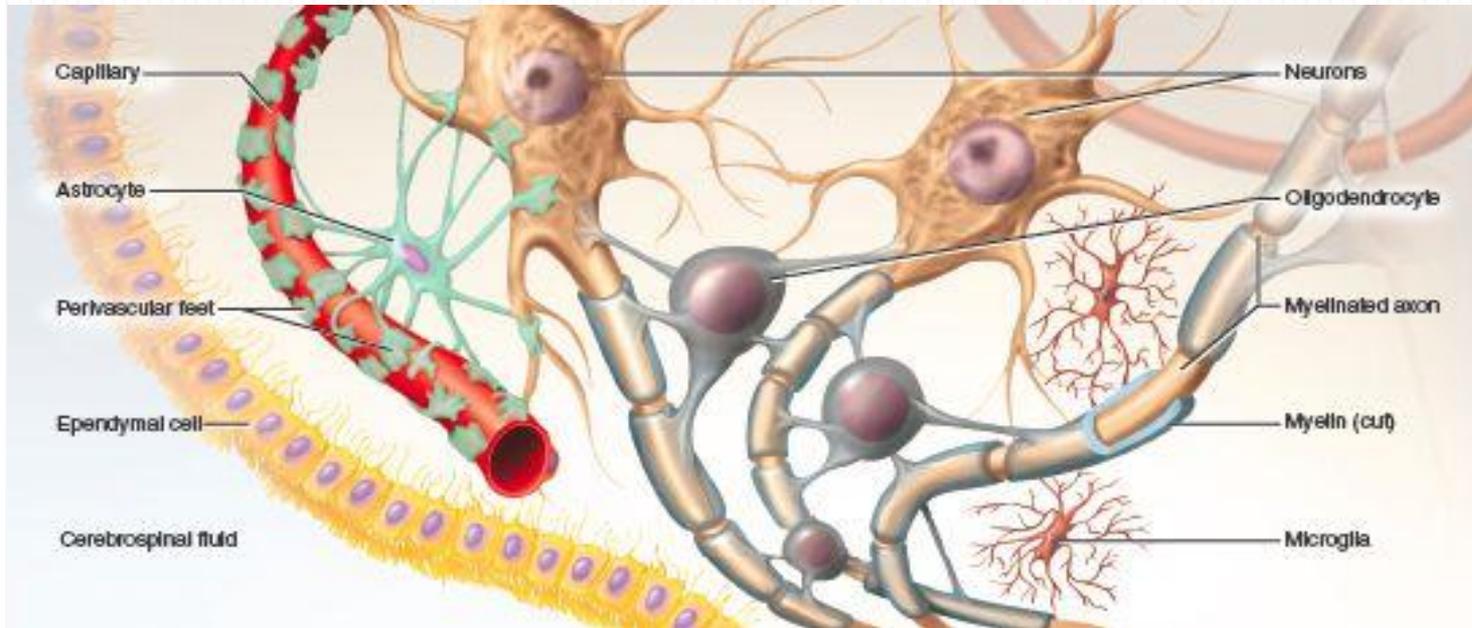
| Name of the cell | Location | Function |
|--------------------|--|--|
| ❖ Astrocytes | CNS Grey & white matter | Regulate microenvironment B.B.B |
| ❖ Oligodendrocytes | CNS White & grey matter | Myelination of axon in CNS |
| ❖ Microglia | CNS Grey & white matter Mesodermal in origin | Phagocytic |
| ❖ Ependymal cell | CNS Ventricle & central canal of spinal cord-----with a ciliated simple columnar shape | Assist in producing & controlling composition of CSF |
| ❖ Schwann cell | PNS | Myelination of axon Structural support |
| ❖ Satellite cell | PNS In ganglia | Regulate microenvironment of |

Neuron

1. **Large**
2. **Transmit nerve impulse**
3. **Not** able to divide
4. **Form synapse**

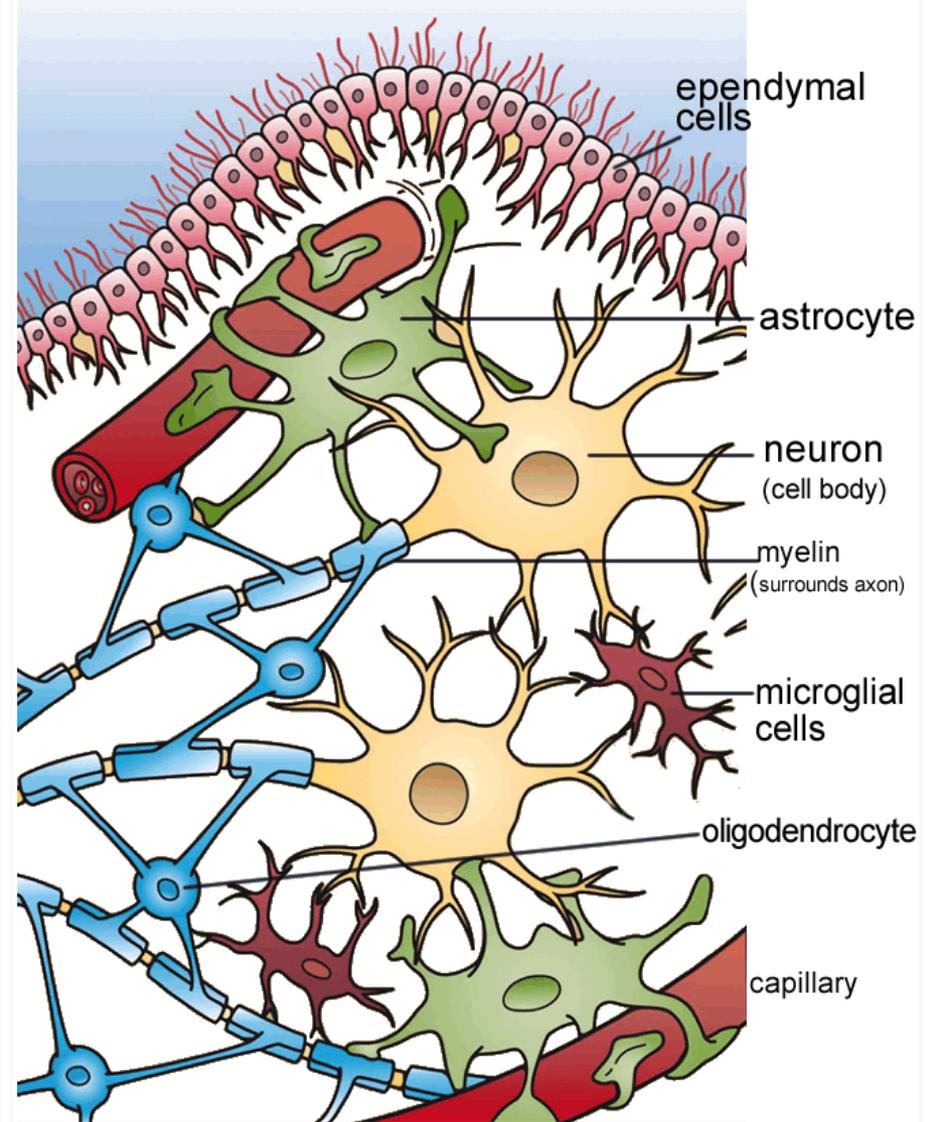
Neuroglia

1. **Small**
2. **Not** transmit nerve impulse
3. **Able to divide**
4. **Not** form synapse



Function of neuroglia

1. Supportive
2. Nutritive
3. Electrical insulation= formation of myelin sheath
4. Formation of blood brain barrier
5. Formation of CSF
6. Phagocytosis



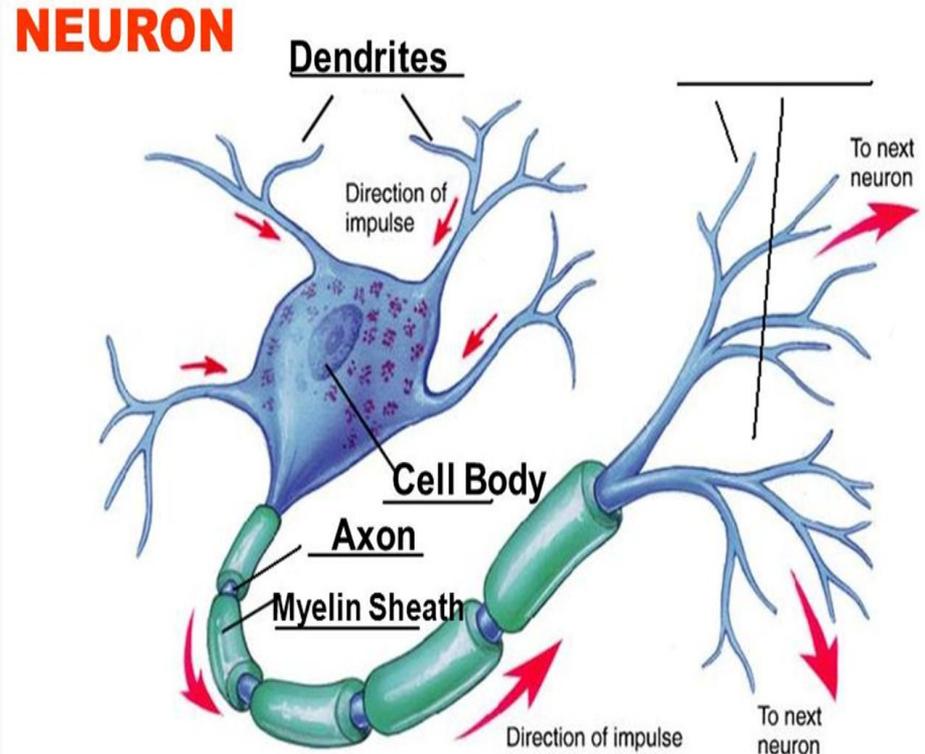
Myelin Sheath

Def :

Segmented protein-lipoid sheath around most long or large-diameter axons

Functions :

1. Protect and electrically insulate the axon
2. Increase speed of nerve impulse transmission



Myelin Sheath – a layer of fatty cells covering the axon, helps speed neural impulses

Myelin Sheaths in the **PNS**

Schwann cells wraps many times around the axon

□ **Myelin sheath** —concentric layers of Schwann cell membrane

Nodes of Ranvier ---????

- **Myelin sheath** gaps between adjacent Schwann cells **Myelinated** nerve are separated by nodes of Ranvier, at these points , the axons are bare. Impulses jump from one node to the next

Unmyelinated Axons. Thin nerve fibers are unmyelinated. One Schwann cell may incompletely enclose **15 or more** unmyelinated axons. **Conduction in unmyelinated nerve is slower**

❖ Schwann cell plasma membrane

❖ Schwann cell Cytoplasm

❖ Axon

A Schwann cell envelopes an axon.

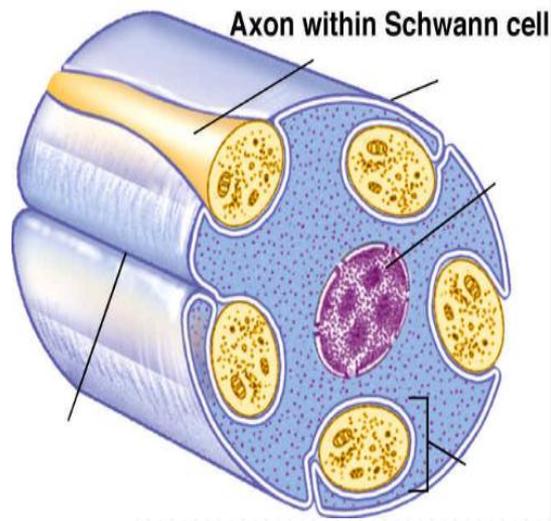
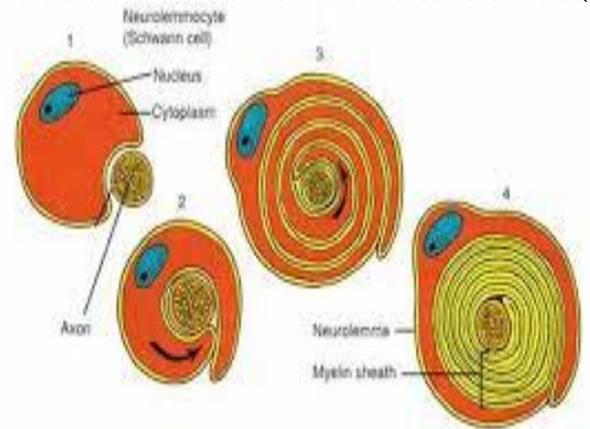
Schwann cell nucleus

Neurilemma

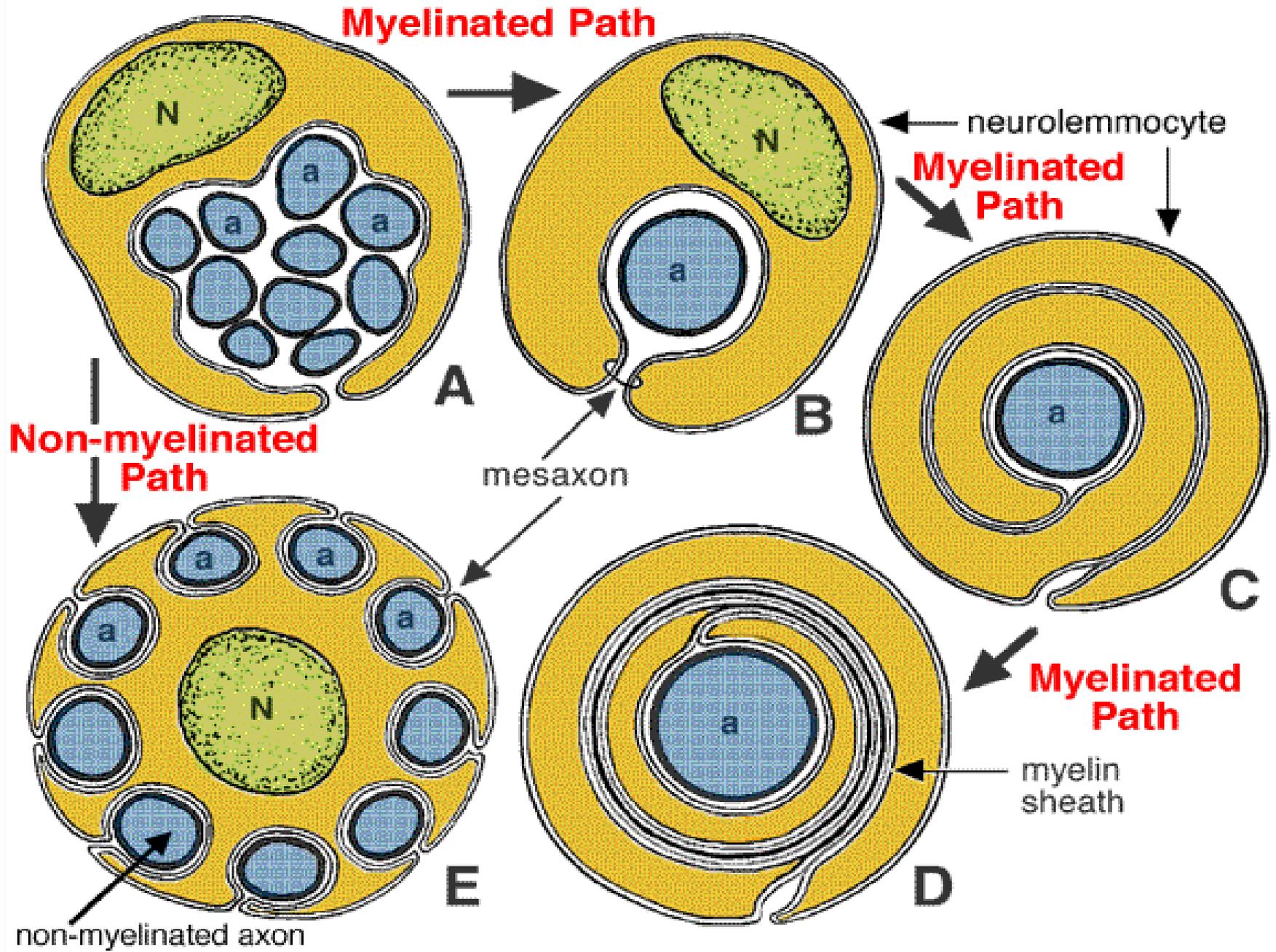
The Schwann cell then rotates around the axon, wrapping its plasma membrane loosely around it in successive layers.

Myelin sheath

Myelination of a nerve fiber (axon)-----????



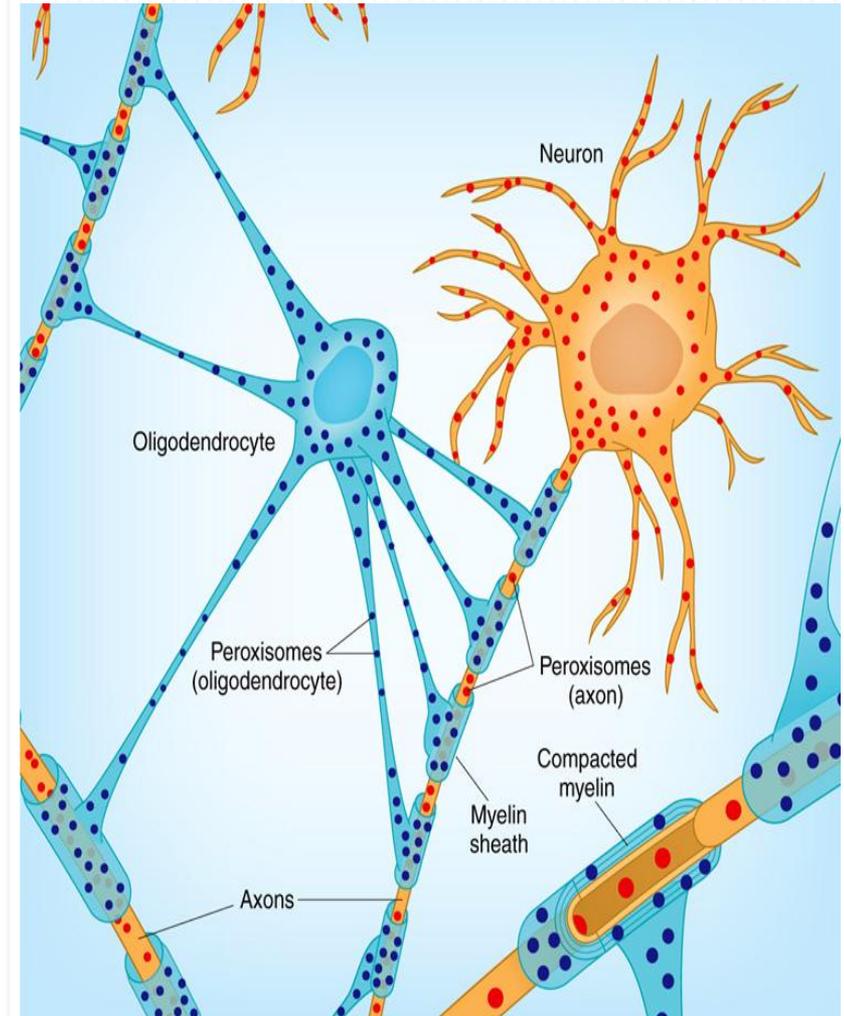
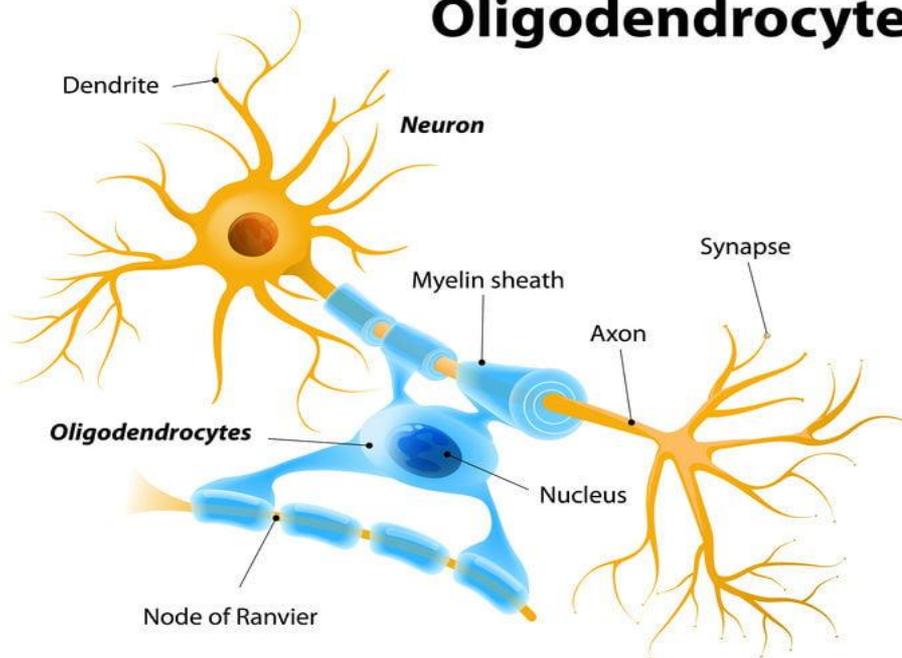
Unmyelinated nerve fiber (axon)



Myelin Sheaths in the CNS

- Formed by processes of **oligodendrocytes**, not the whole cells
- Nodes of Ranvier are present
- **No neurilemma**
- Thinnest fibers are unmyelinated

Oligodendrocyte



Structure of Peripheral Nerve

Group of nerve fibers (NF)

★ **NF = Axon + myelin sheath**

★ **Structure :**

Connective Tissue of the Nerve

★ **Epineurium:-** external layer of dense irregular CT covering the nerve

★ **Perineurium:-** layers of flat cells with tight junctions & basal lamina around each bundle of axons

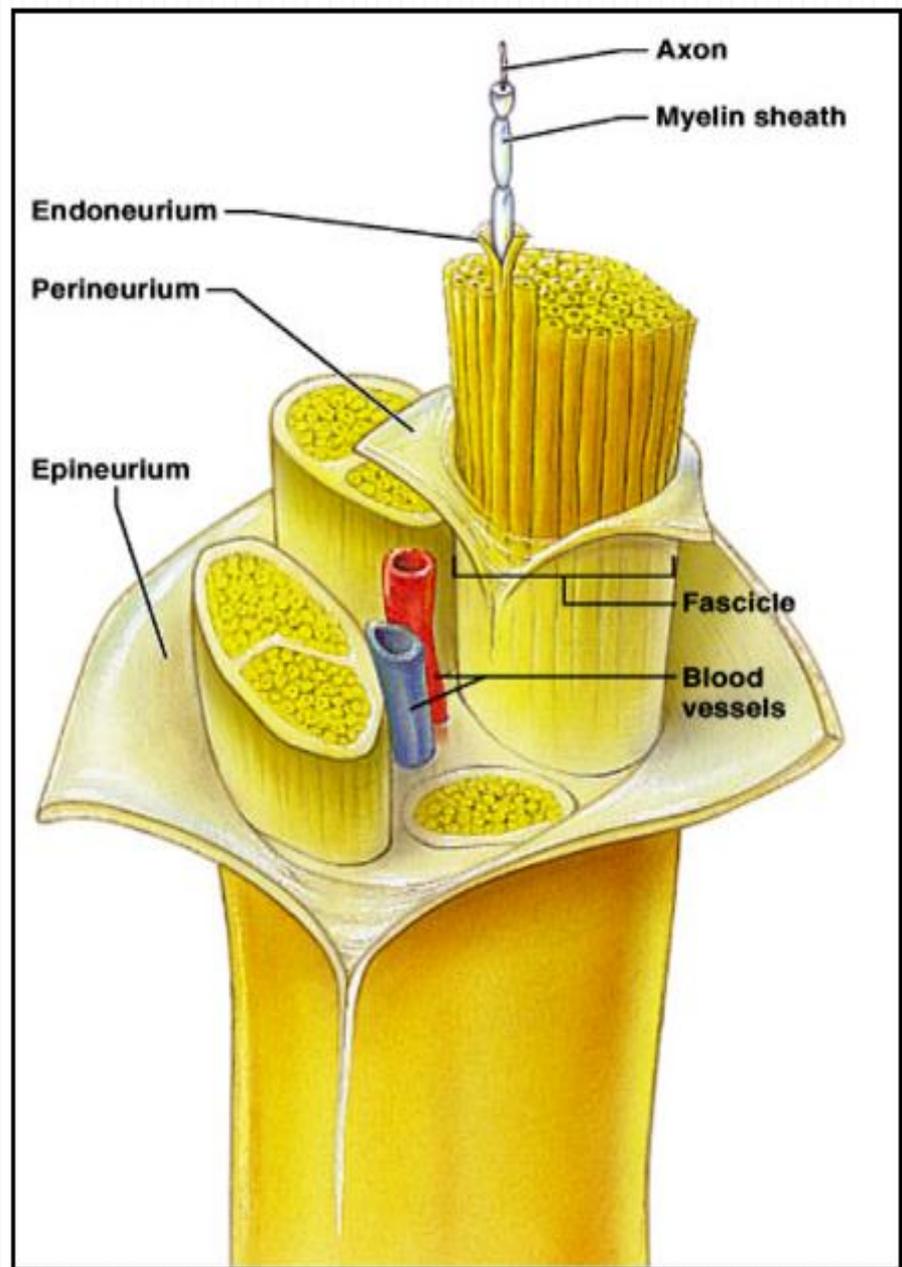
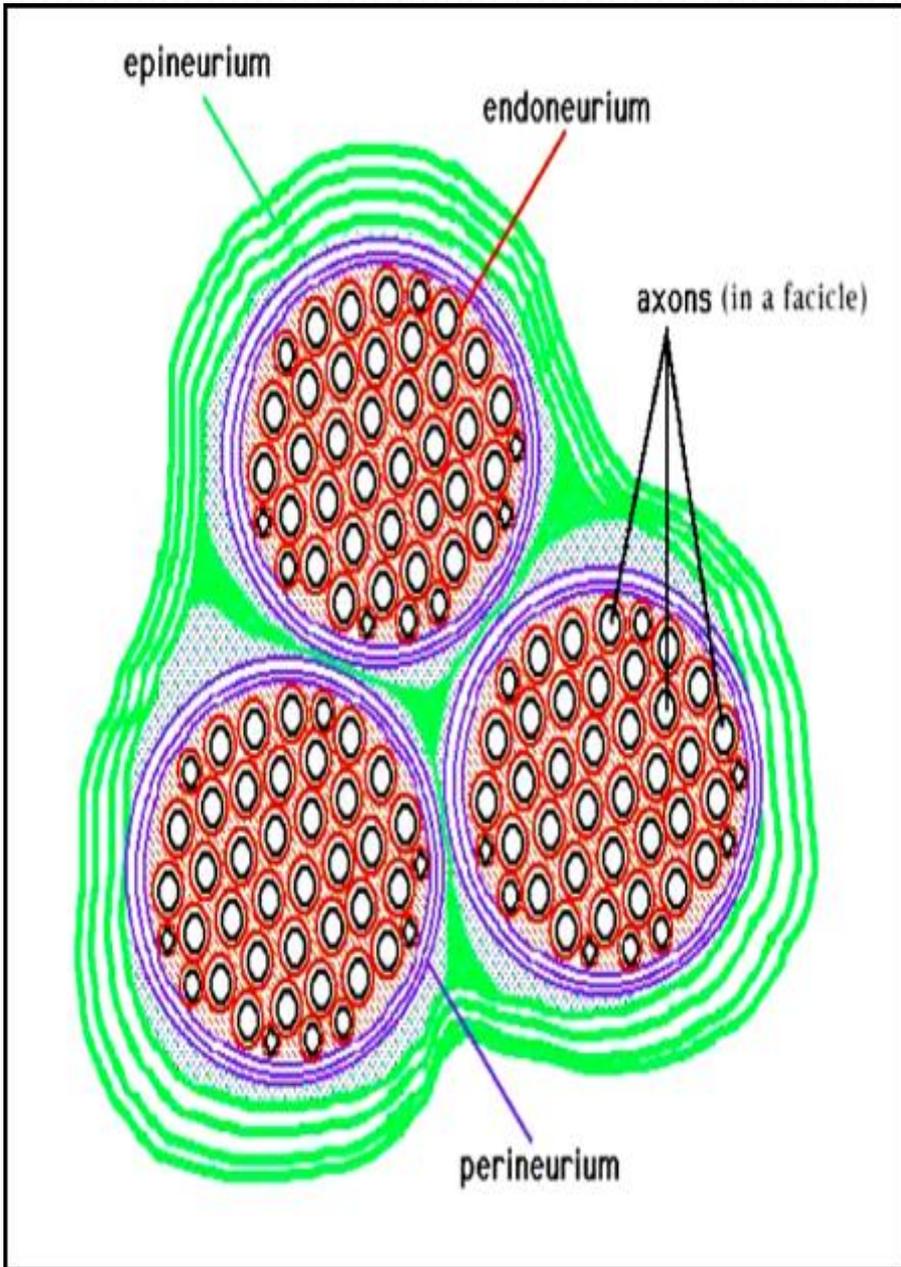
★ **Endoneurium:-** innermost layer of reticular CT around each Schwann cell covering the axon

★ Contains parallel bundles of axons

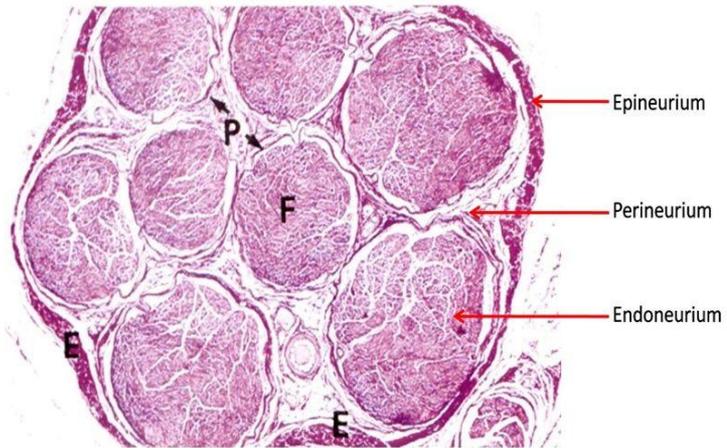
★ Each bundle contains myelinated & unmyelinated axons

★ Contains motor & sensory axons

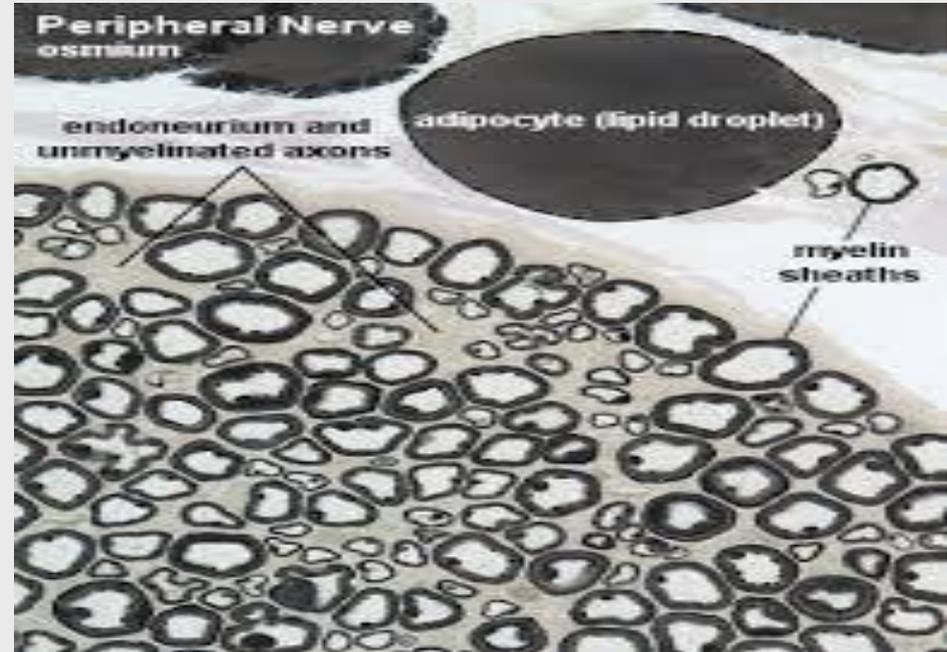
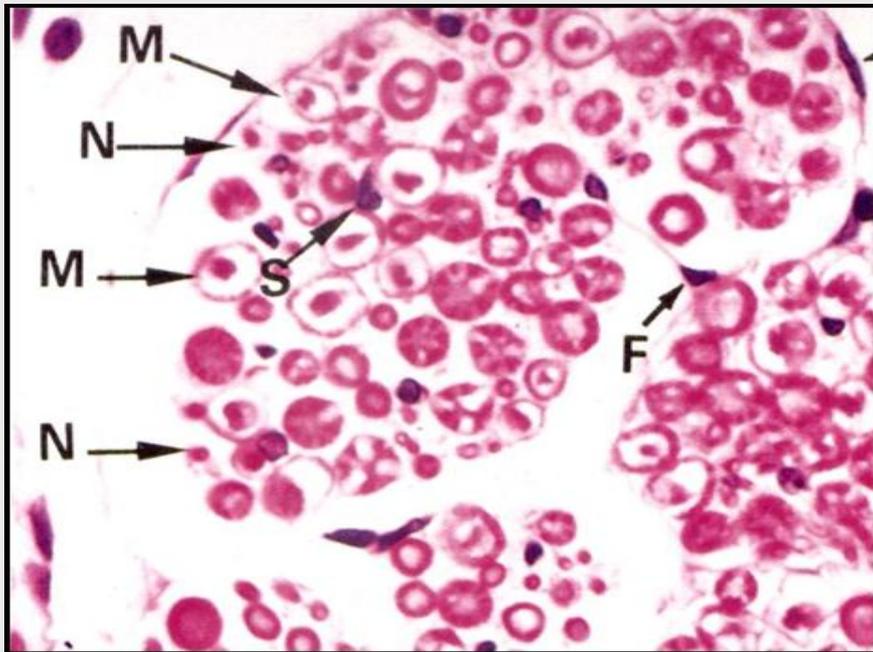
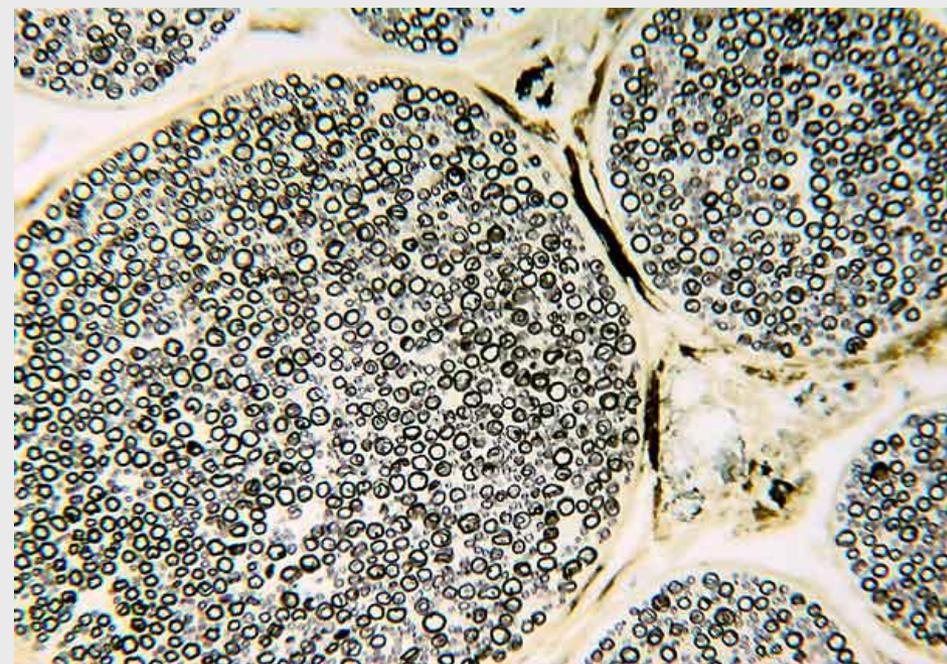
★ No nerve cell bodies



Cross Section of a Nerve



5



Ganglia

★ Ganglia are groups of neuron cell bodies **outside** the CNS

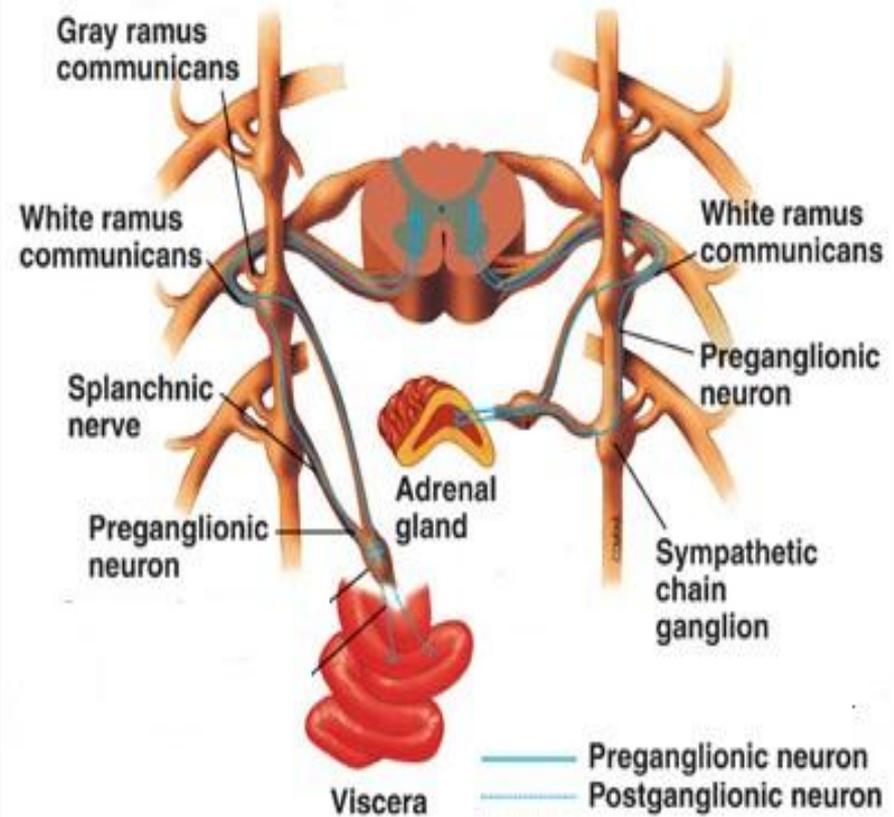
★ **Inside** CNS called nucleus

★ **Types of ganglia:-**

1. Dorsal root (spinal)
ganglia = sensory

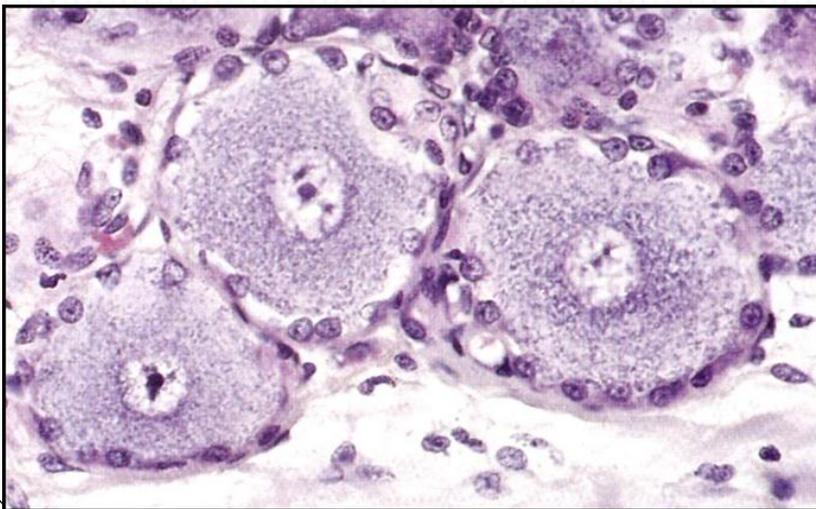
2. Autonomic ganglia

(e.g. Sympathetic ganglia) =
motor



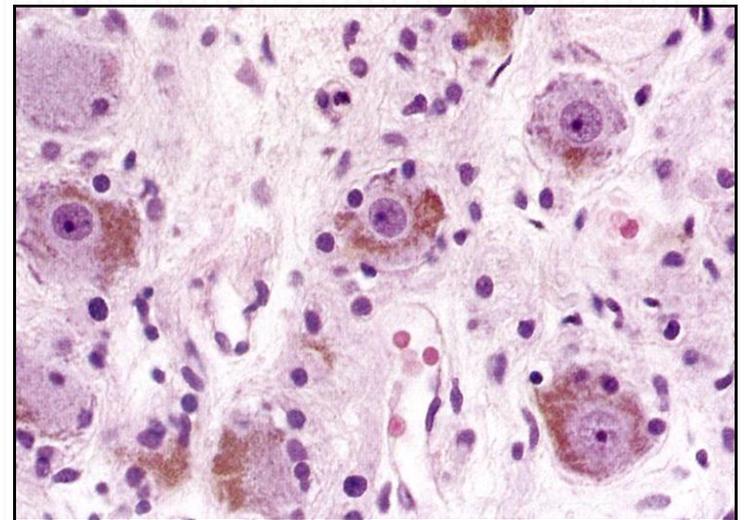
- **Dorsal Root Ganglion (Spinal Ganglion)**

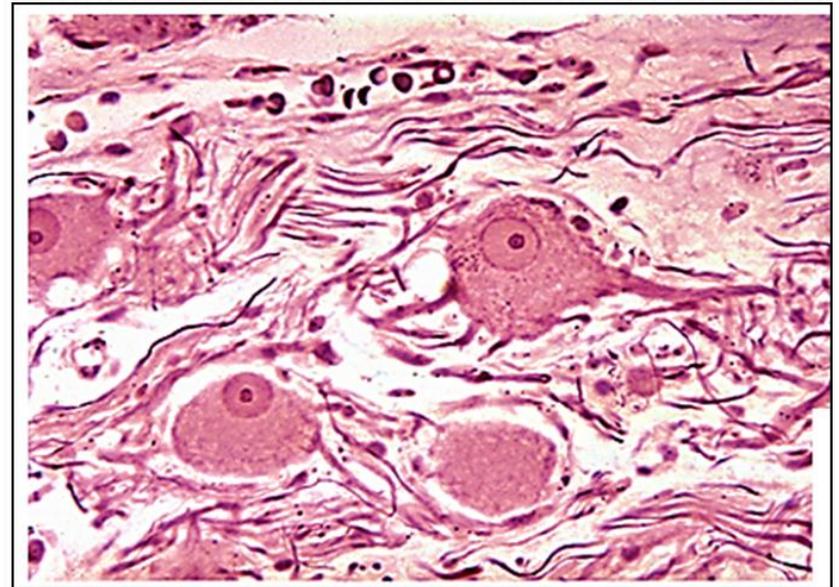
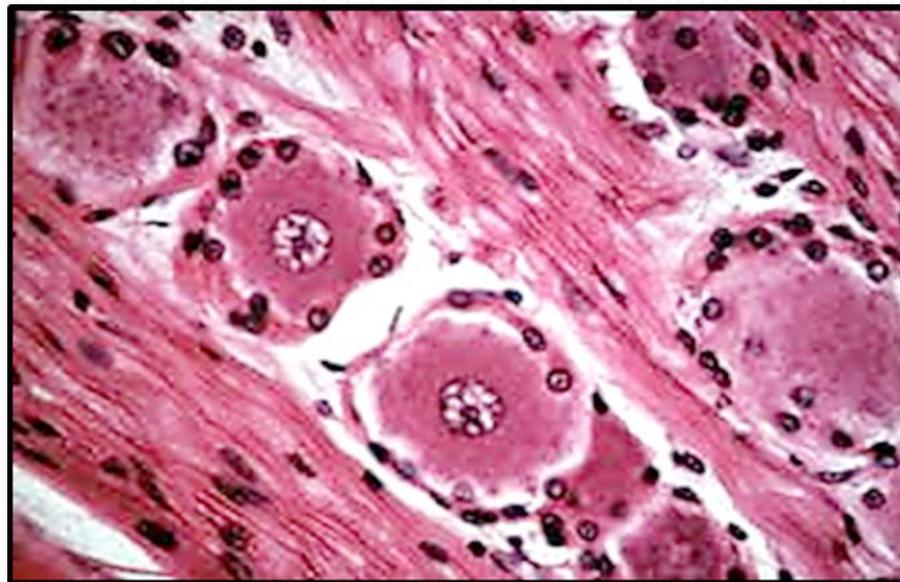
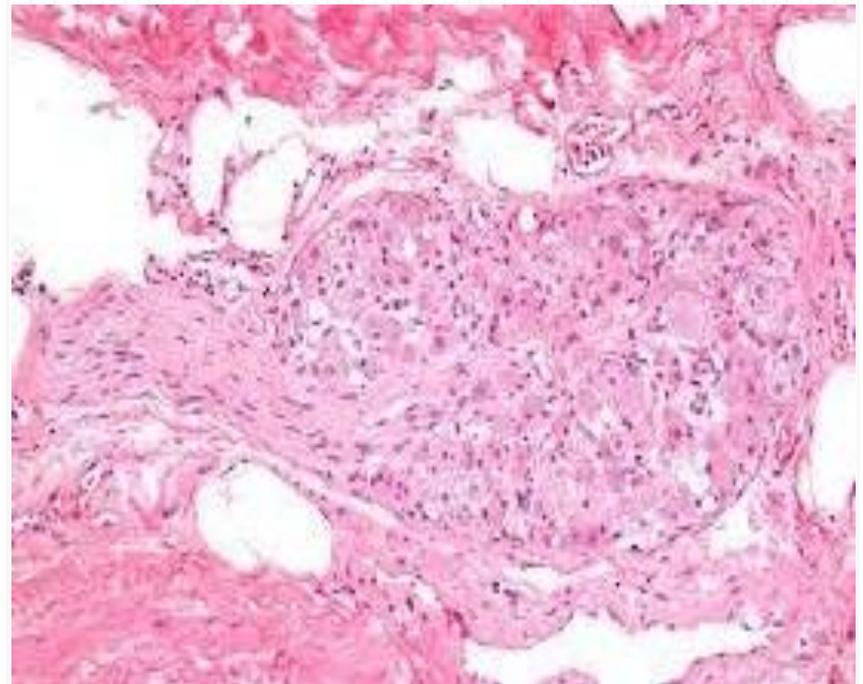
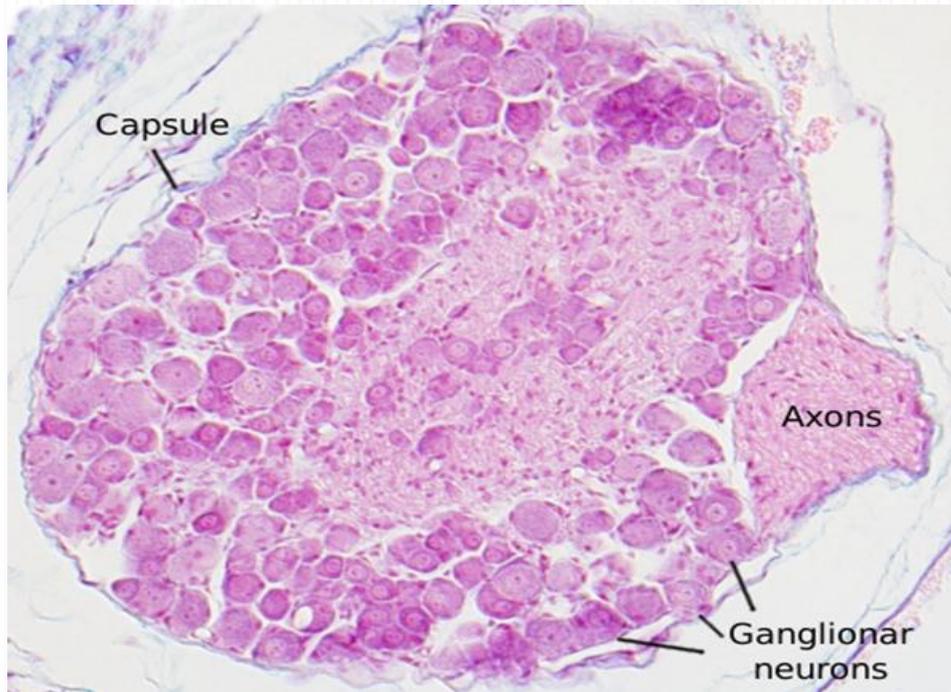
- ★ Contains pseudounipolar neurons in groups
- ★ Each neuron is surrounded by a capsule of supporting cells called **satellite cells**
- ★ Contains myelinated axons
- ★ Sensory ganglion



- **Sympathetic Ganglion**

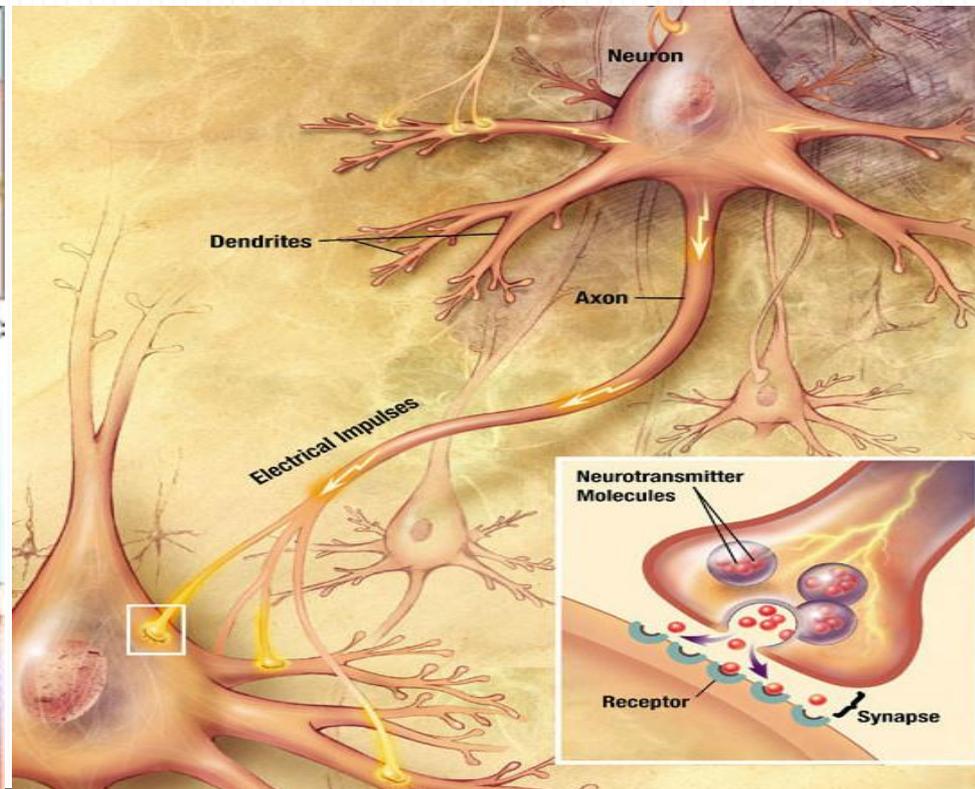
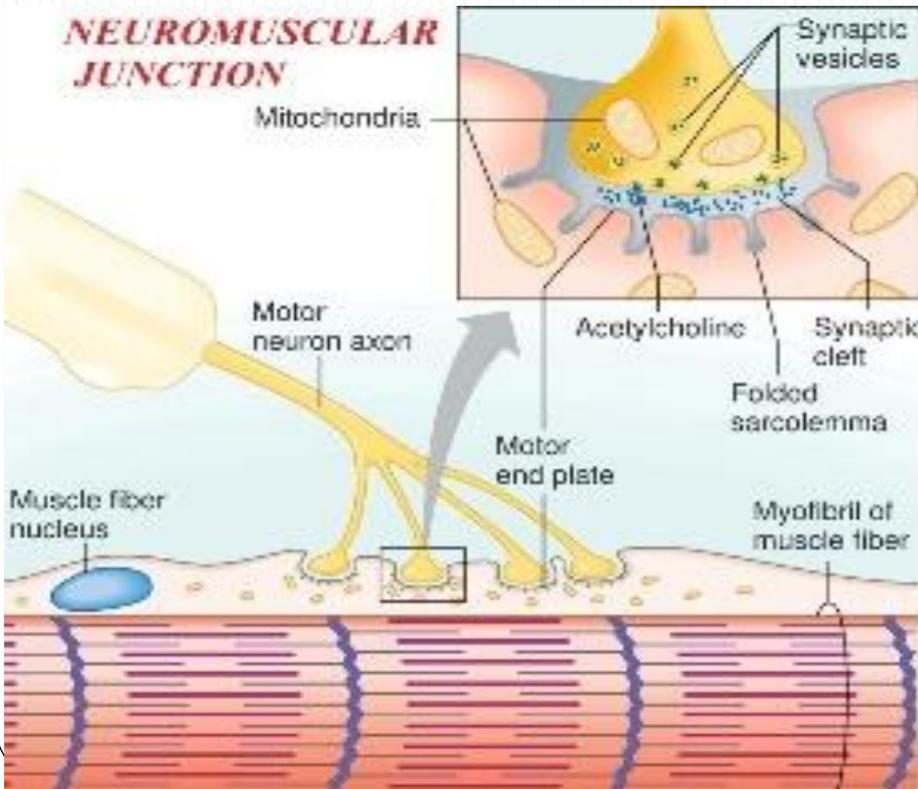
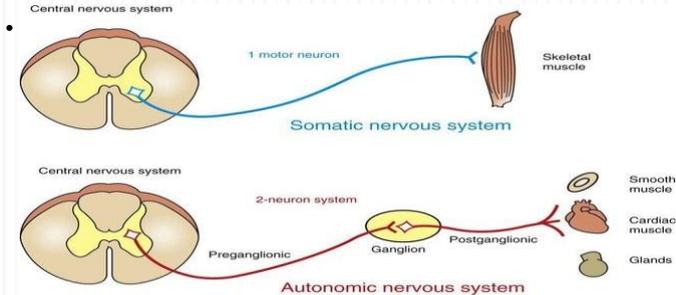
- ★ Contains multipolar neurons separated by spaces containing unmyelinated axons
- ★ Capsule of **satellite cells** is not prominent
- ★ It is a motor ganglion
- ★ Contains synapses





SYNAPSE

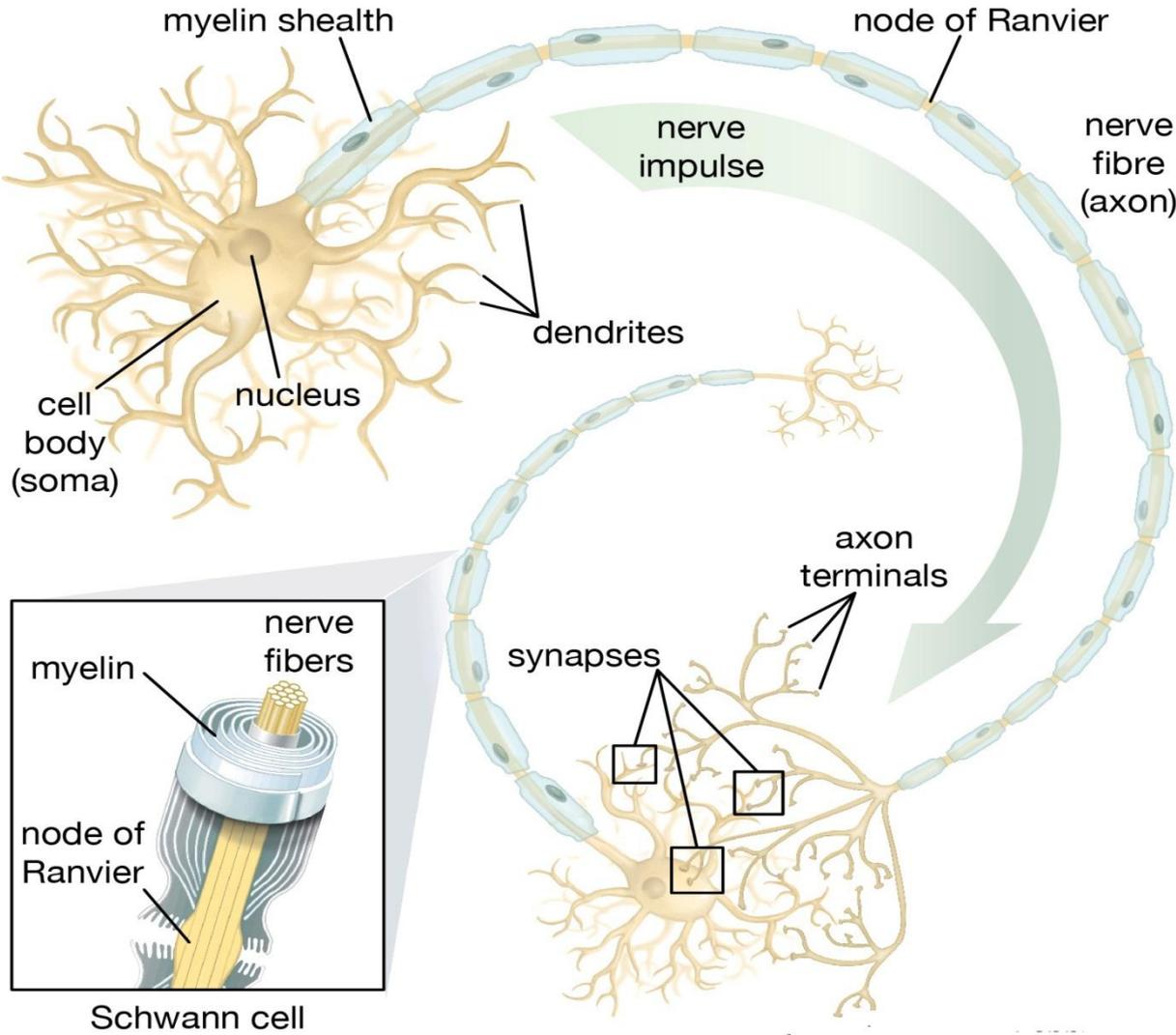
Def : Synapse is a specialized area of **functional contact**. Through synapses nerve impulses are transmitted from a presynaptic neuron to a postsynaptic cell (another neuron, muscle or gland).



Classification of synapse:

1- According to the effect on the target neuron, synapse could be:

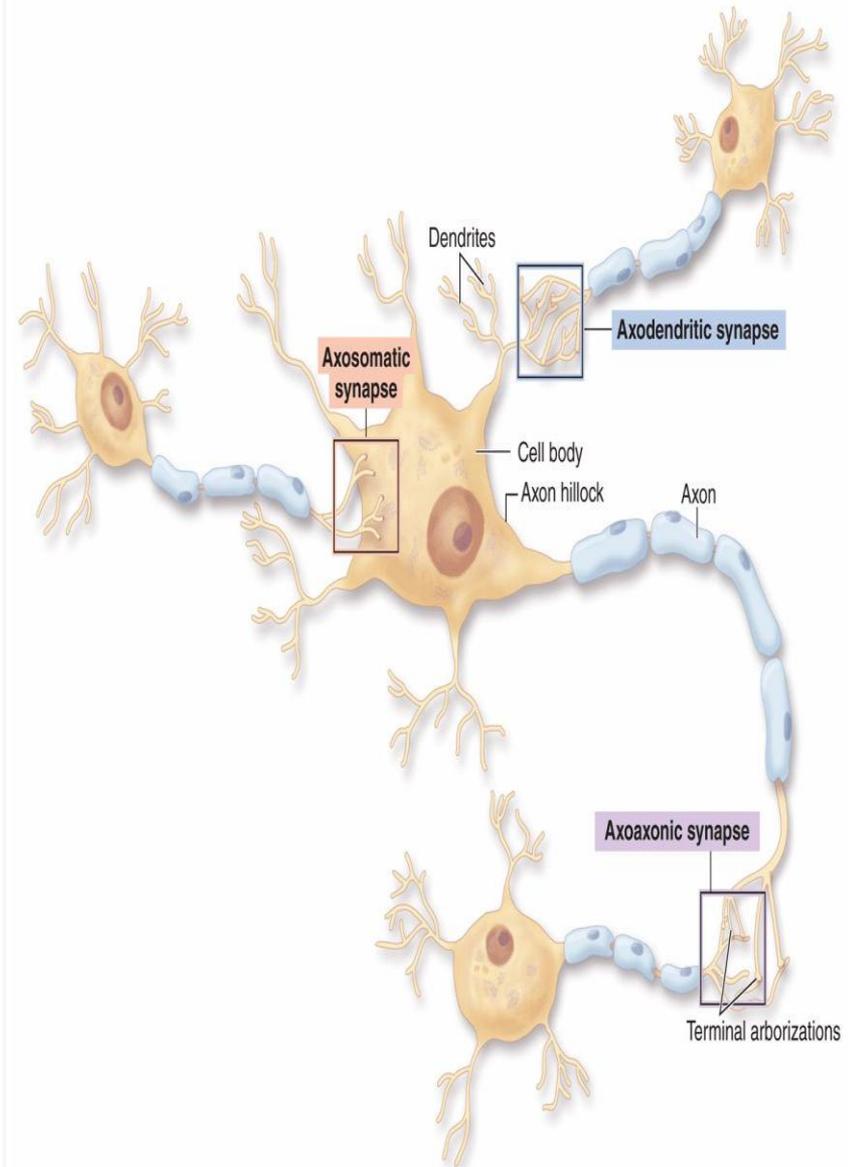
- Excitatory
- Inhibitory



2- According to the components:

- ❑ **Axodendritic:** between axon and dendrite
- ❑ **Axosomatic:** between axon and cell body.
- ❑ **Axo-axonic:** between two axons.
- ❑ **Dendrodendritic:** between two dendrites.

- Axodendritic and axosomatic synapses are **common**
- axoaxonic and dendrodendritic synapses are **rare.**

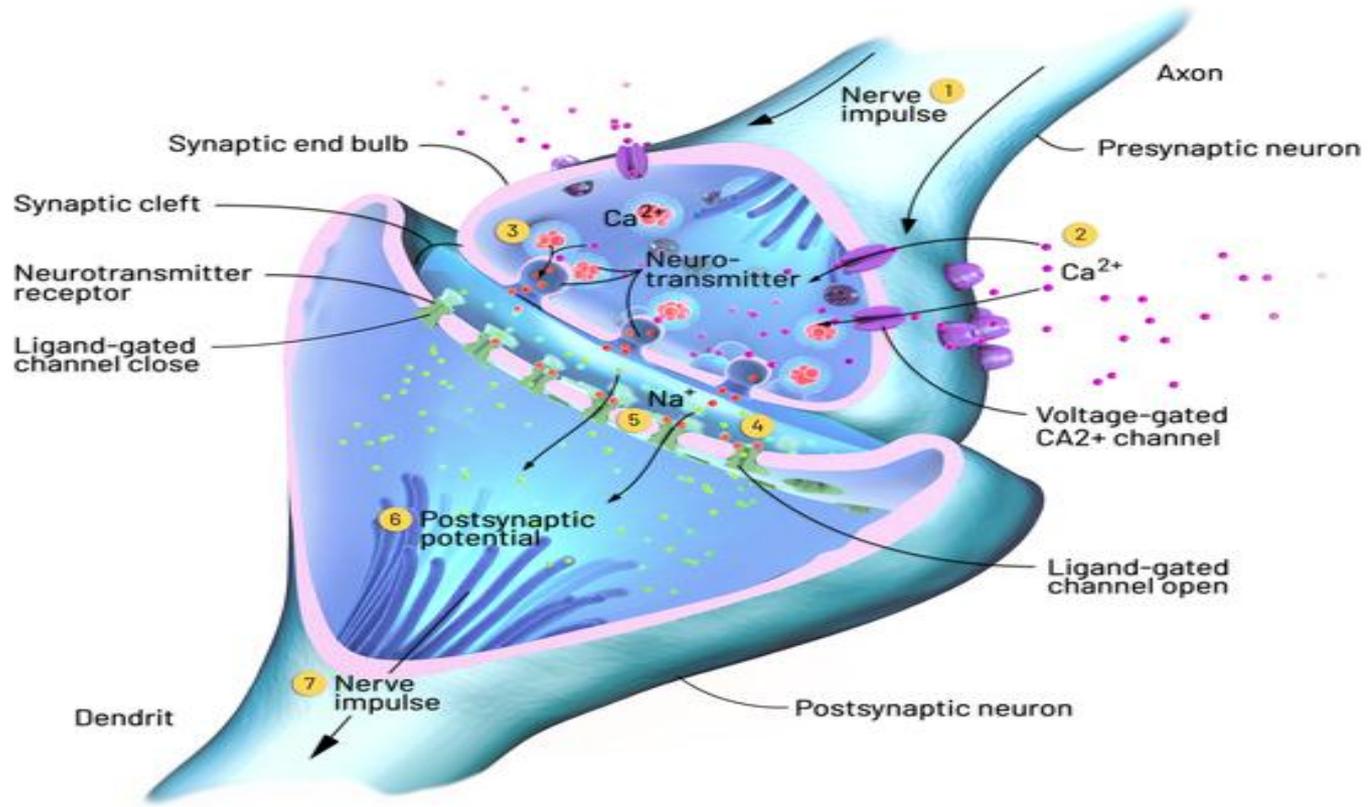


3- According to mode of transmission of nerve impulse:

1- Chemical synapse:

□ Number: The **most common** mode of communication between neurons.

□ Structure :With EM, chemical synapse is formed of:



□ Terminal bouton: It is a bulbous expansion "synaptic knob" found at the terminations of the axon.

It contains numerous mitochondria and many synaptic vesicles assembled around the presynaptic membrane. These membrane-bound synaptic vesicles are filled with the neurotransmitter e.g. acetylcholine and biogenic amines.

□ Presynaptic membrane:

it is the electron dense membrane of the axon terminal end at the site of synapse.

□ Synaptic cleft:

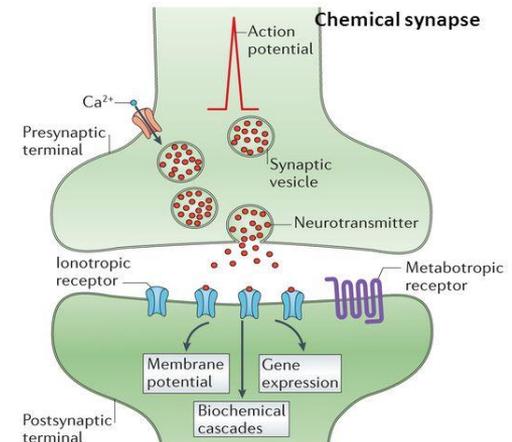
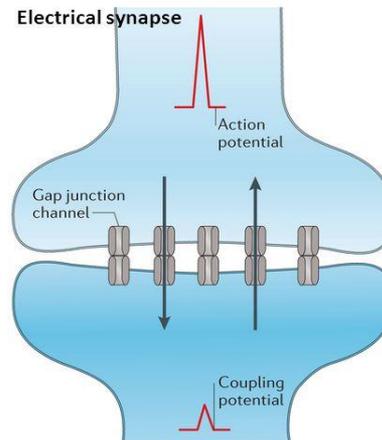
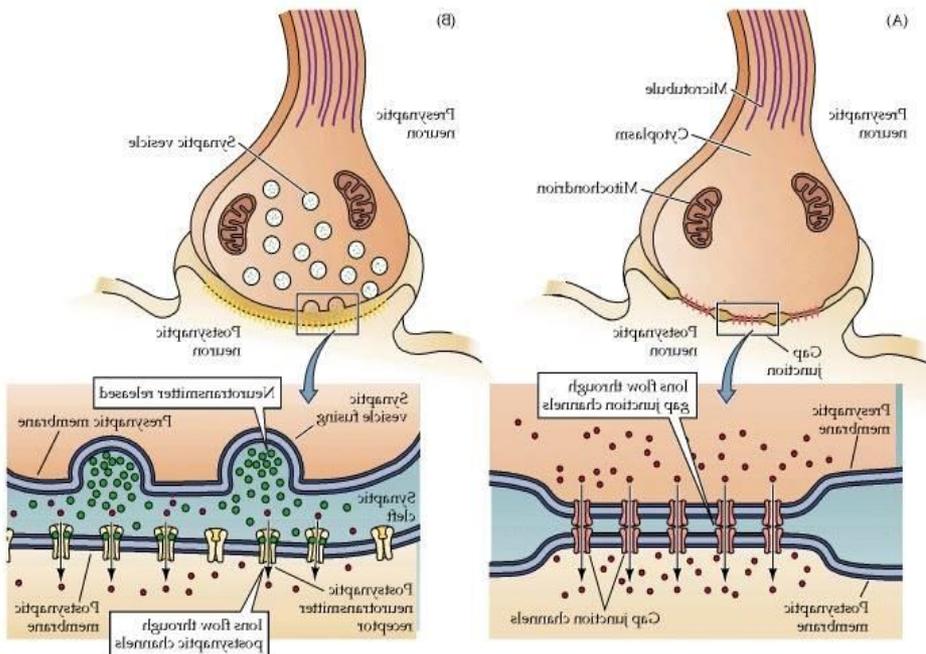
it is a gap of 20 nm between the pre and postsynaptic membranes. Into this gap the neurotransmitter is released by exocytosis.

□ Postsynaptic membrane:

It contains the specific receptors for the neurotransmitter.

2- Electrical synapse:

- **Number:** Few in the nervous system.
- **Structure:** It is formed of gap junctions.
- **Function:** It allows movement of ions between neurons "electrical coupling" thus permits the direct spread of electrical current from one cell to another.
- **Transmission of impulse:** **Direct, bidirectional** and do not require release of neurotransmitters.



- **Why wasn't evolution satisfied with electrical synapses?**
 - Gap junctions synaptic transmission is fast
 - They can be regulated
- **PROBLEM:** Gap junctions are straight forward transducers of electricity:
 - Pre depolarized → Post is depolarized;
 - Post depolarized → Pre depolarized
- It is impossible to build a highly compartmentalized system with just electrical synapses
- Evolution favored more complex systems. It is easier to build a complex system with chemical synapses:
 - cells are electrically isolated;
 - chemicals (neurotransmitters) are used to transmit signal between cells.
 - Some neurotransmitters depolarize the postsynaptic cell; some hyperpolarize
 - Some neurotransmitters have only transient effect (1ms); others long-lasting effect (100ms)

Response of neuron to injury

Damage to the cell body

- occurs as a result of injury or disease
- **degeneration** and permanent loss of neuron leading to **atrophy** of the innervated muscle
- The **perikaryon enlarges**, **eccentric nucleus** and **chromotolysis** (loss of Nissl substance)

Nerves can be injured by:

❖ ischaemia

❖ Compression

❖ traction

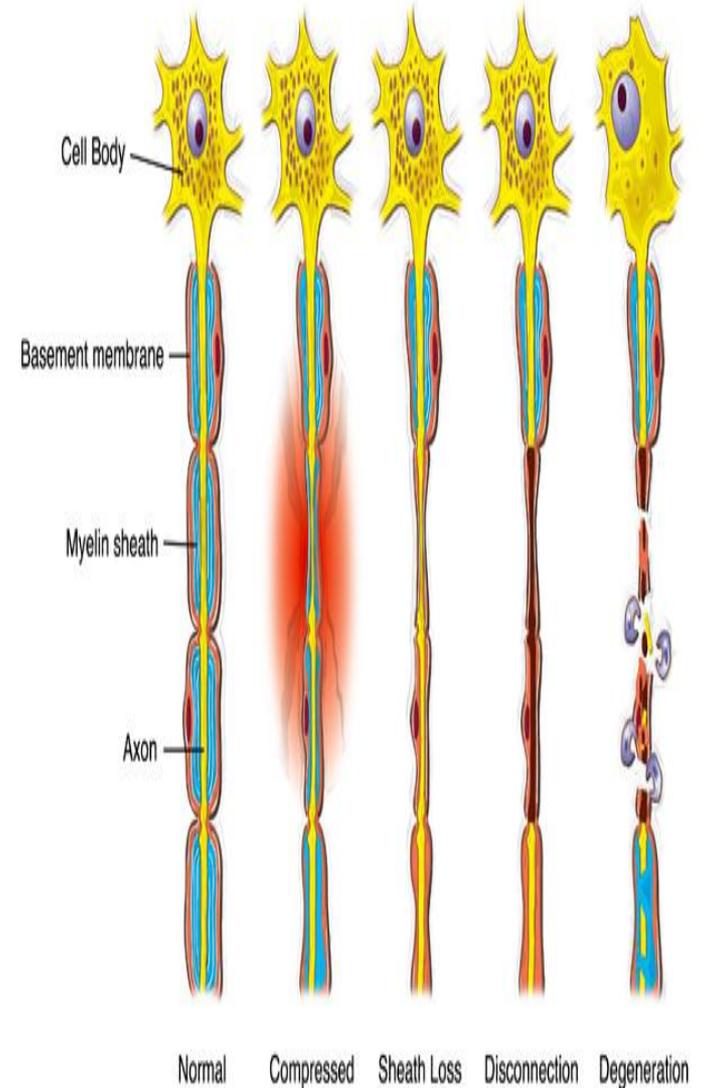
❖ laceration

❖ burning.

➤ Damage varies in severity from: transient and quickly recoverable loss of function

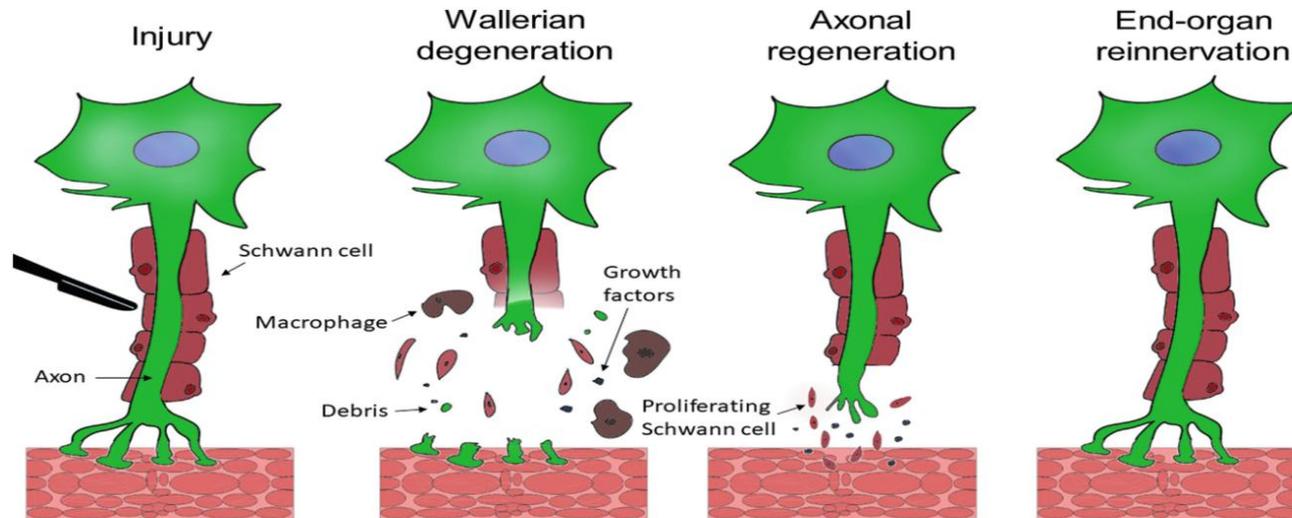
➤ to complete interruption and degeneration.

➤ There may be a mixture of types of damage in the various fascicles of a single nerve trunk.



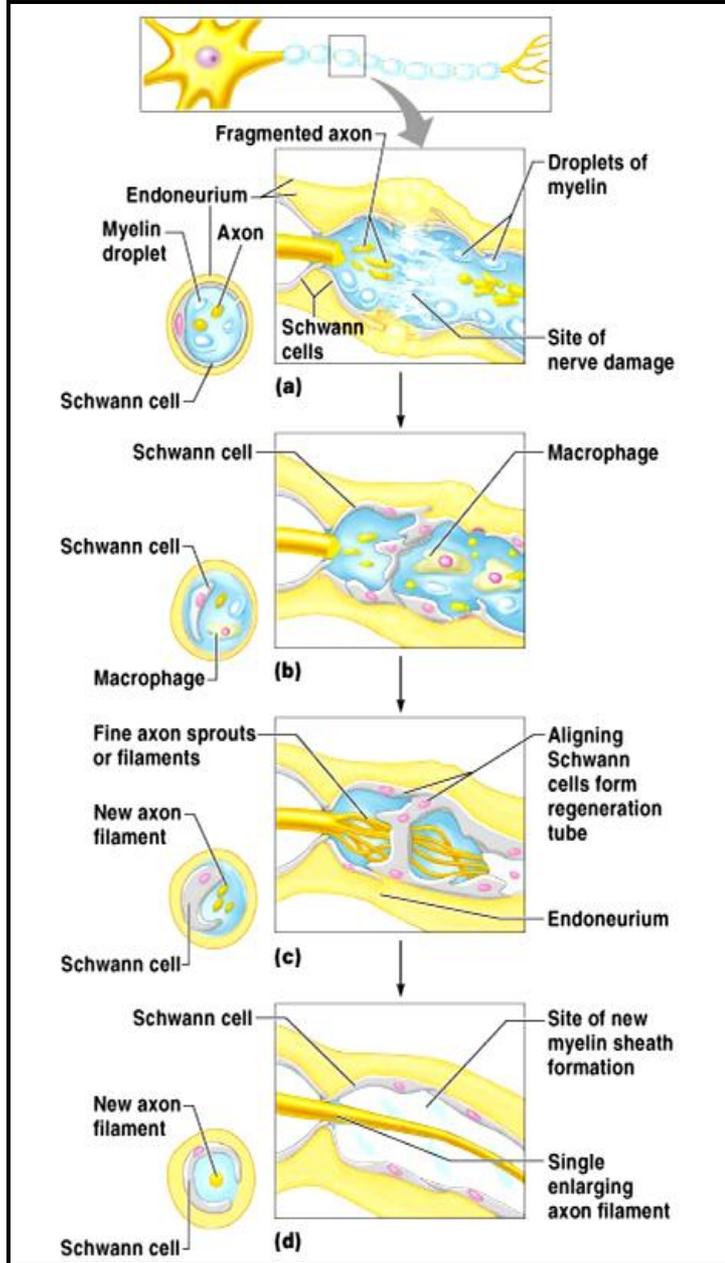
Damage to the axon

- ❑ degeneration occurs in the distal portion (**anterograde degeneration**) and the proximal portion (**retrograde degeneration**)
- ❑ **Anterograde (Wallerian) degeneration**, complete degeneration of the axon and myelin sheath, fragments phagocytosed by Schwann in PNS, microglia in CNS, and blood **monocytes**
- ❑ **Retrograde degeneration**, incomplete degeneration

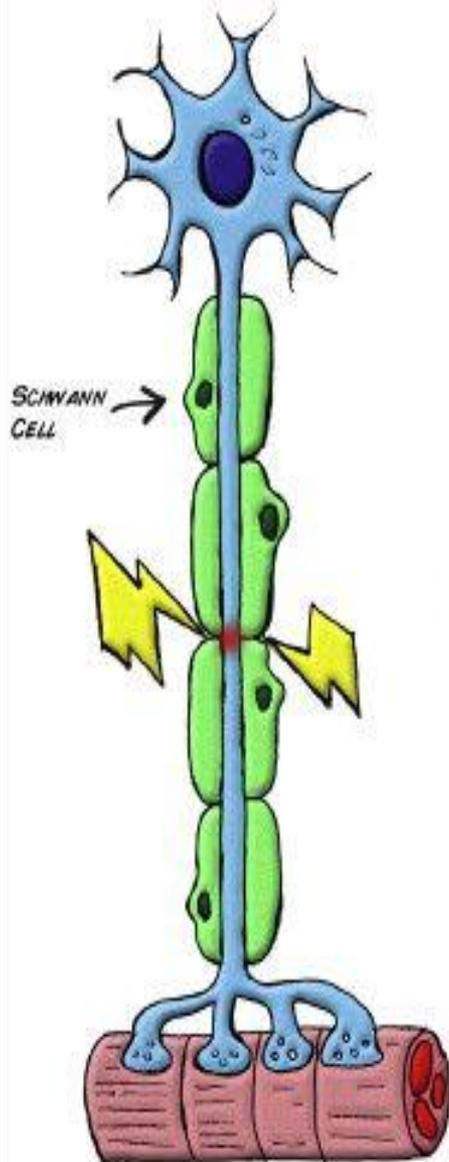


❑ Schwann cells start to **divide** and **bridge** the injured site forming large number of new nerve processes **sprouts, neurites**, from proximal portion

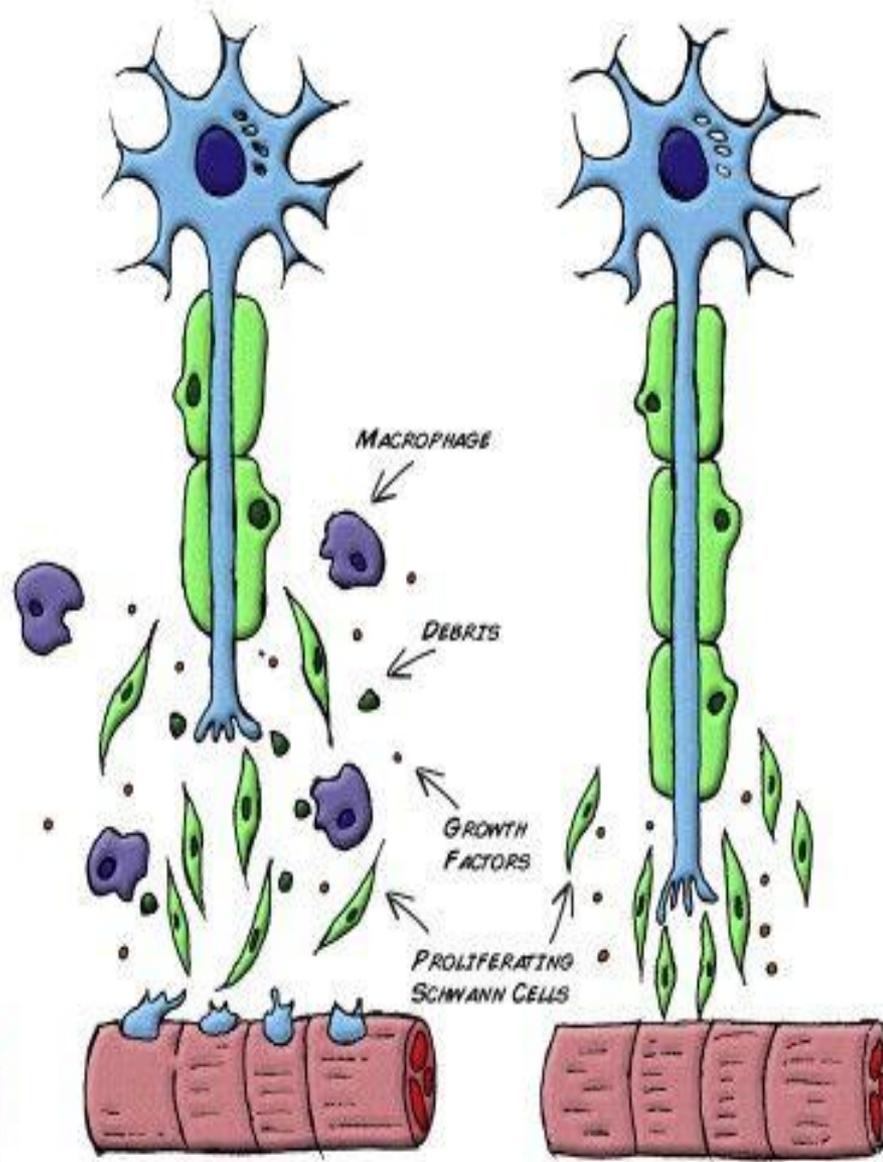
❑ if the gap is too wide or the sprouts do not reestablish contact, the sprouts grow in disorganized manner forming **neuroma** causing atrophy to end-organ



INJURY



DEGENERATION



REGENERATION

