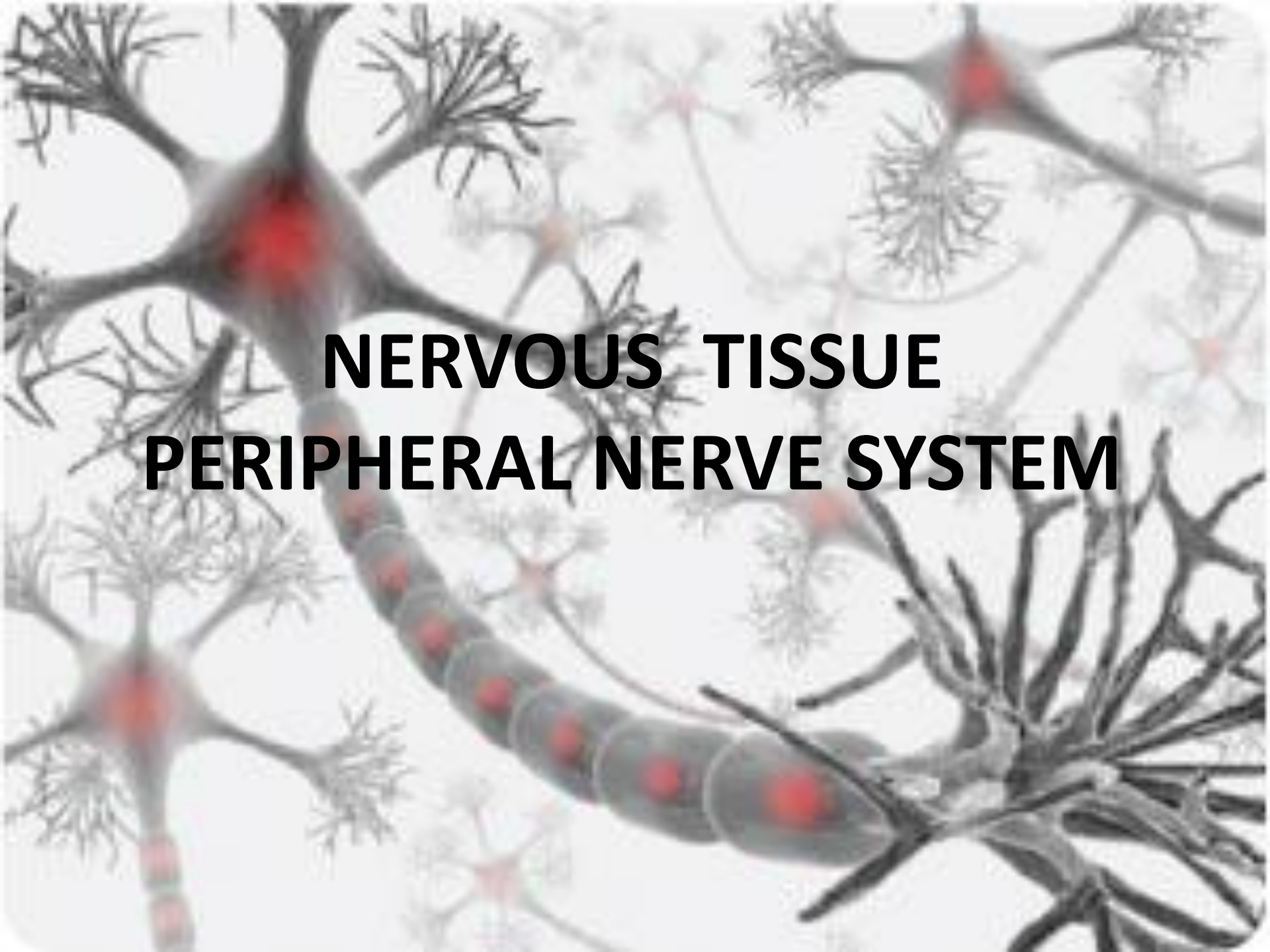


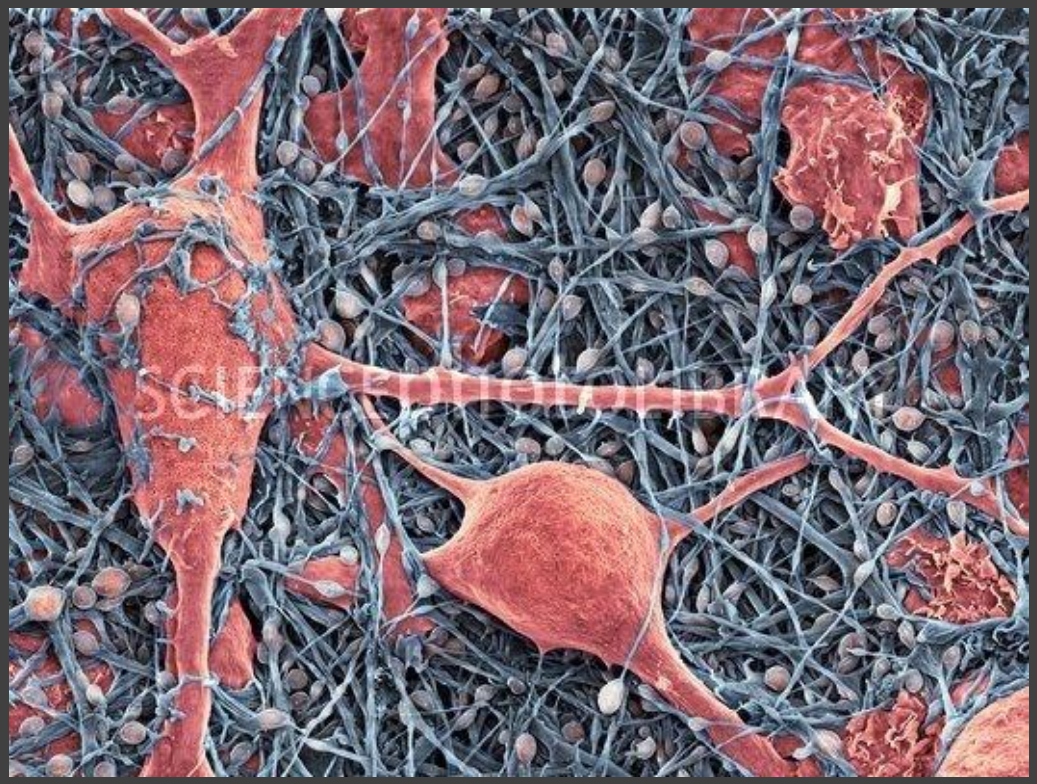
NERVOUS TISSUE
PERIPHERAL NERVE SYSTEM

NERVOUS TISSUE

develops from ectoderm

neurons (red)

nerve cells



glial cells (blue)

support and protect neurons

FUNCTIONS:

- organization and coordination of organism activity (intellect, consciousness, sub consciousness, motion, visceral and gland activity)
- receiving, conducting, processing and transmission impulses about organism condition and environment.

ORIGIN OF NERVOUS TISSUE (Ectoderm)

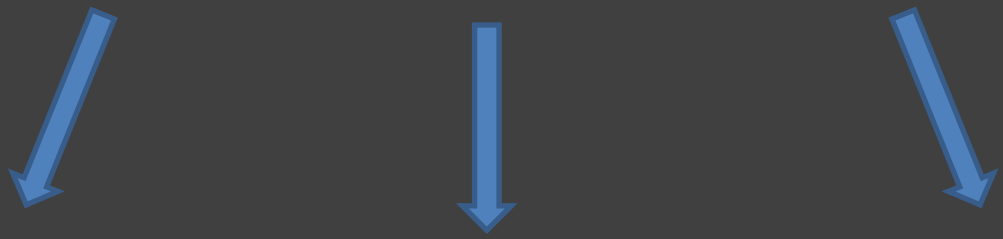
Neural tube

anterior end
brain

neuroglia, ependyma
neurons

caudal end
spinal cord

Neural crest cells



PNS
sensory components

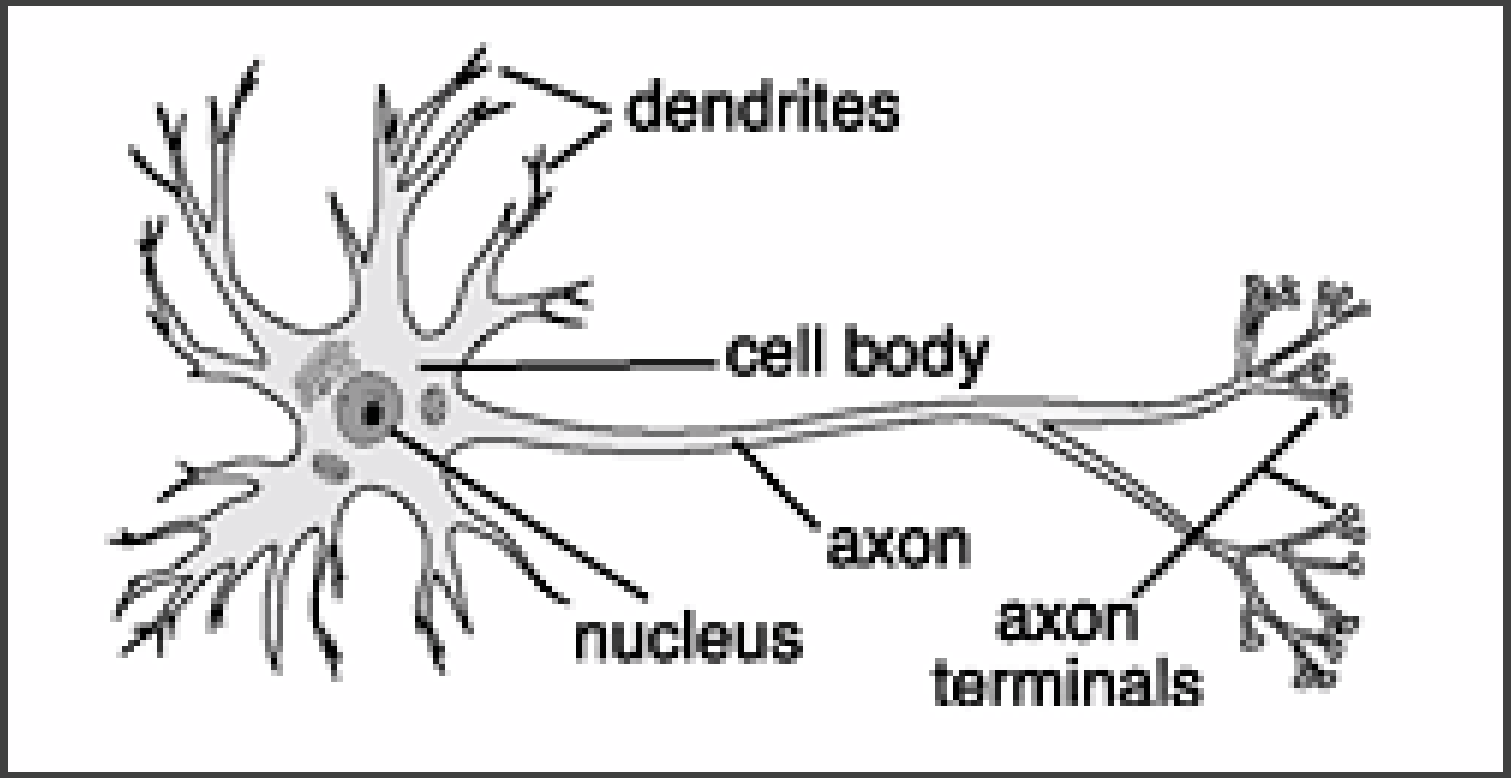
ganglia

satellite cells
Schwann cells

NEURON

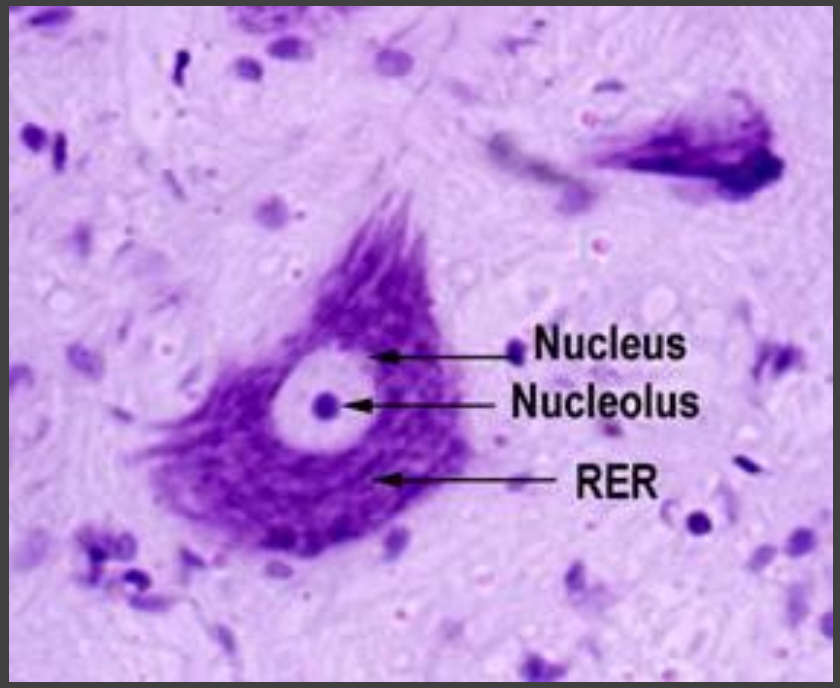
cell body
(perikaryon)

processes
(axon and dendrites)



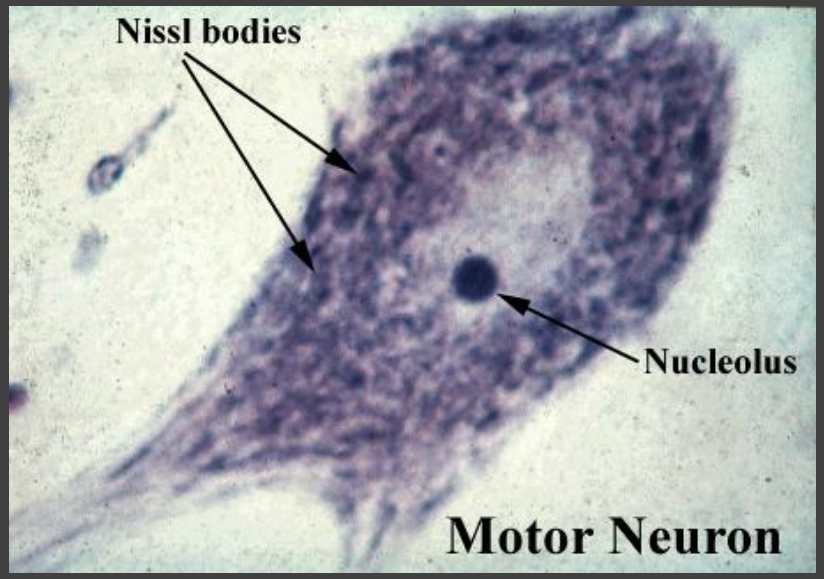
PERIKARYON (cell body)

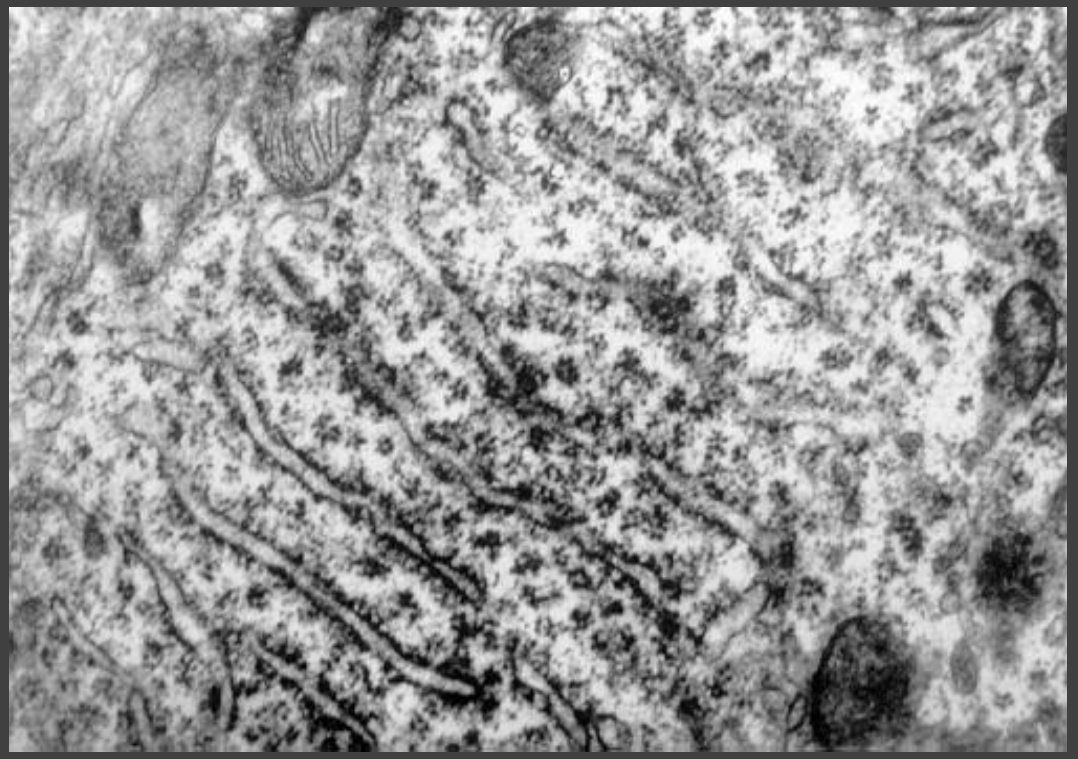
Contains:
- nucleus (1 or 2) with dispersed chromatin
- abundant RER and polyribosomes (Nissl bodies or tigroid)
- neurofilaments (type IV),
- microtubules + MAP-2



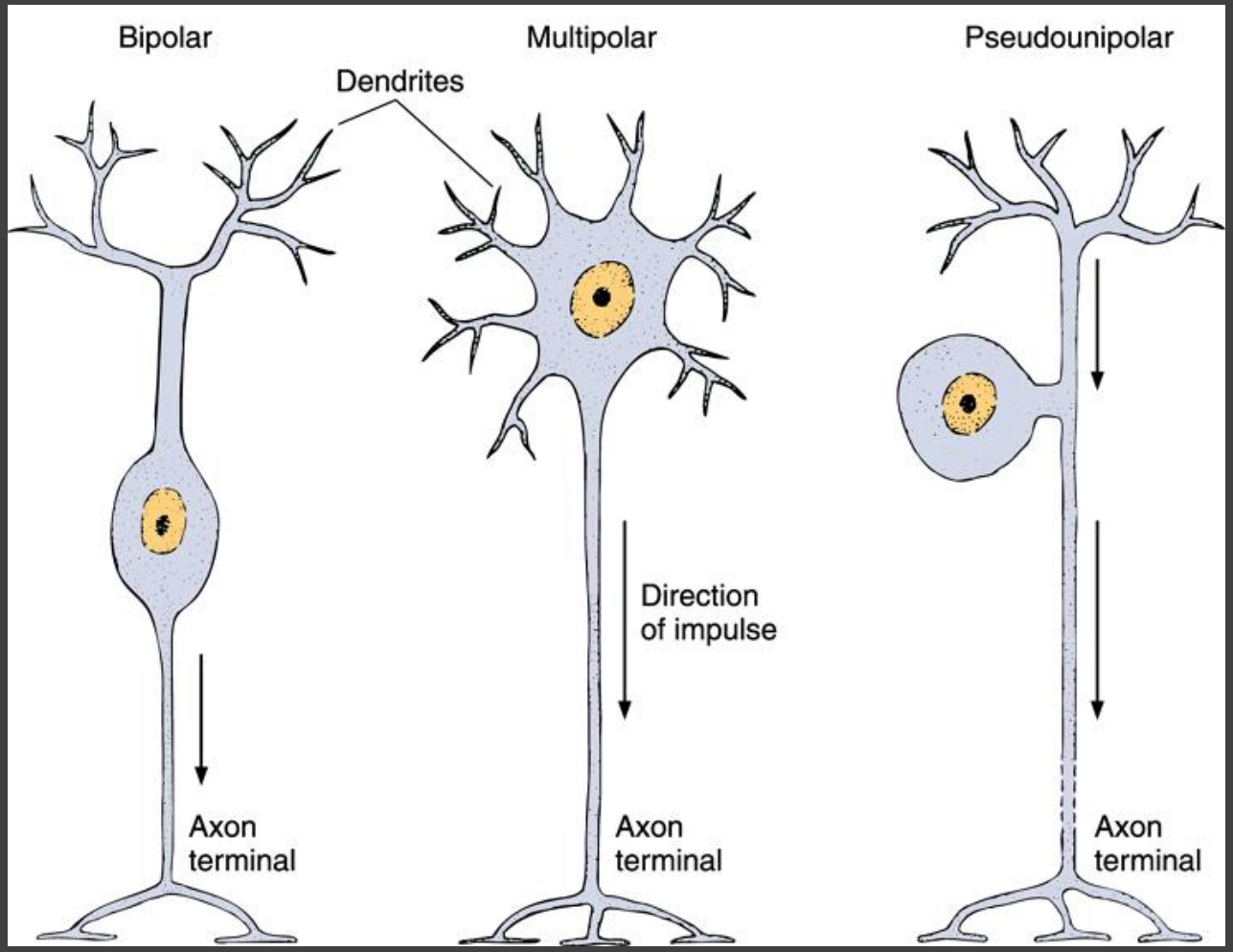
FUNCTIONS:
- synthesis of macromolecules
- control of the distribution of proteins throughout the cell
- Speed control of the impulse, impulse generation

NISSL BODIES





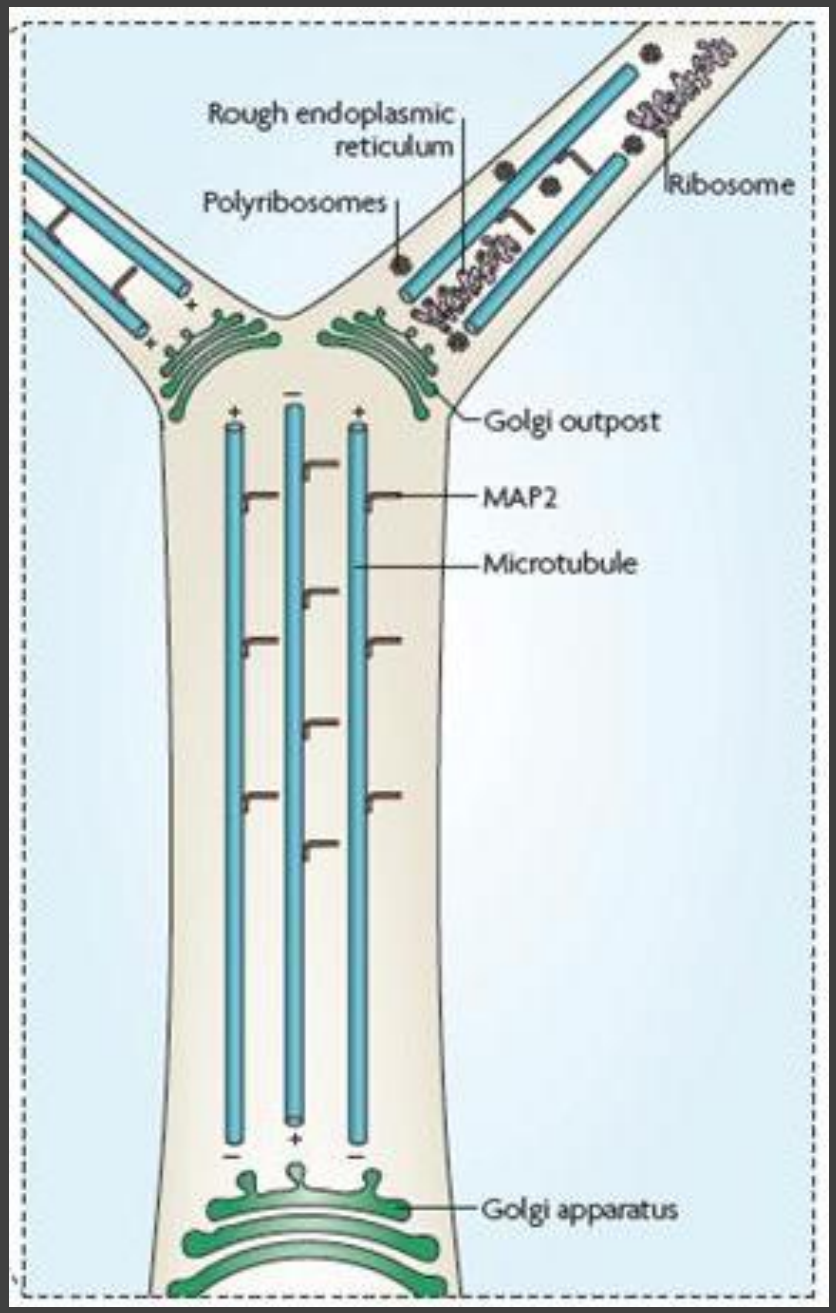
MAIN TYPES OF NEURONS



Dendrites

Contain:
- Microtubules + MAP-2
- small bundles of neurofilaments,
- RER and ribosomes (Nissl bodies) only in region nearest to cell body

Dendrites - functions:
- receiving stimuli
- transmission of nerve impulses
- integration multiple impulses - numerous synapses
- anterograde and retrograde transport of macromolecules

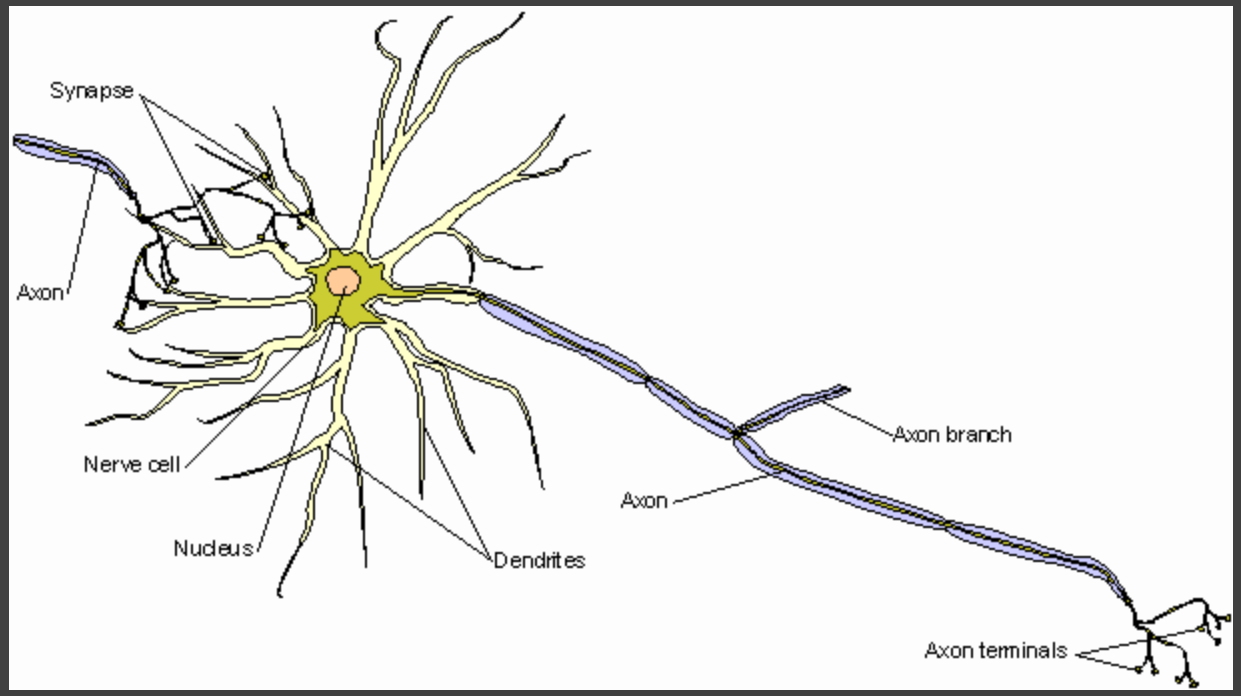


AXON

- length up to 1m, constant diameter, axon hillock without Nissl bodies

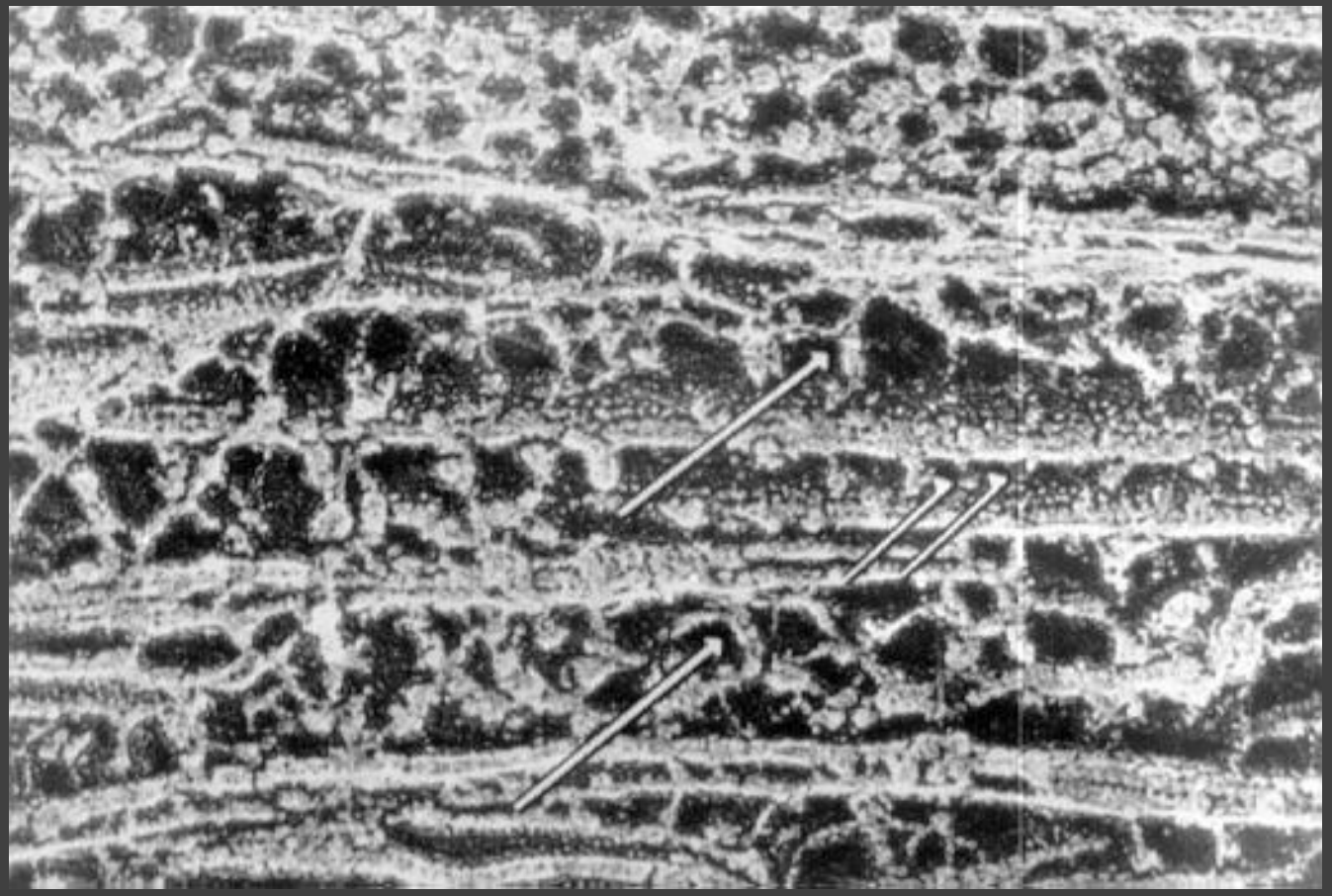
- collateral axons (lateral branches), terminal arbor

- abundant microtubules + *tau* and neurofilaments (regulation of the axon's diameter)



Axoplasm of nerve fiber from rat ischiadic nerve

Tau proteins bind microtubules (arrows)

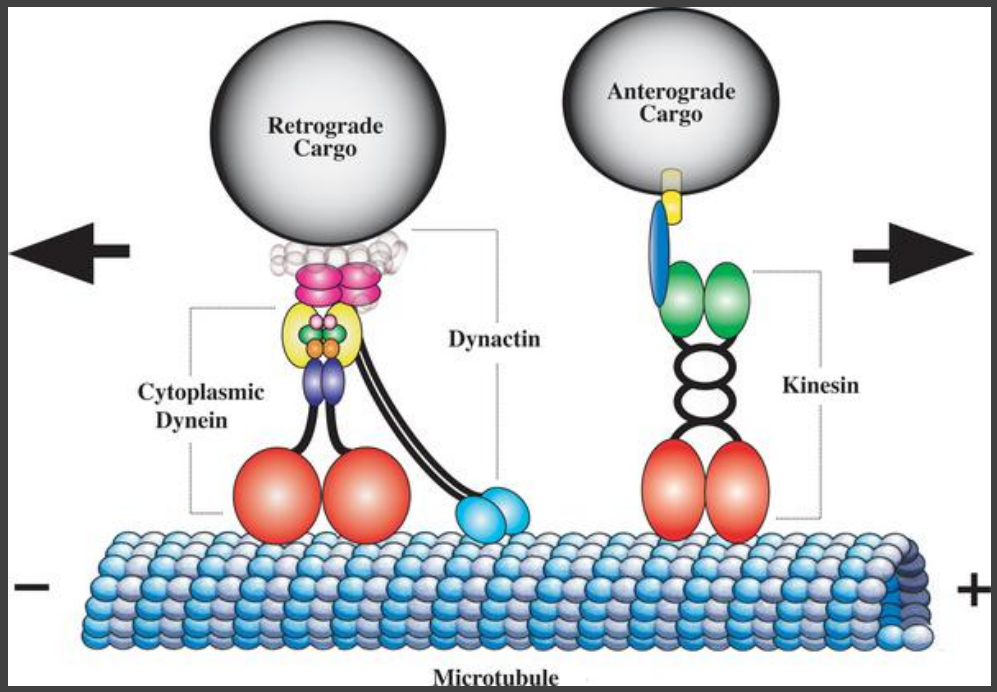


AXON - FUNCTIONS:

- conduction of impulses **from cell body toward the synapses** and transmission them to other neurons, muscle cells or glands.

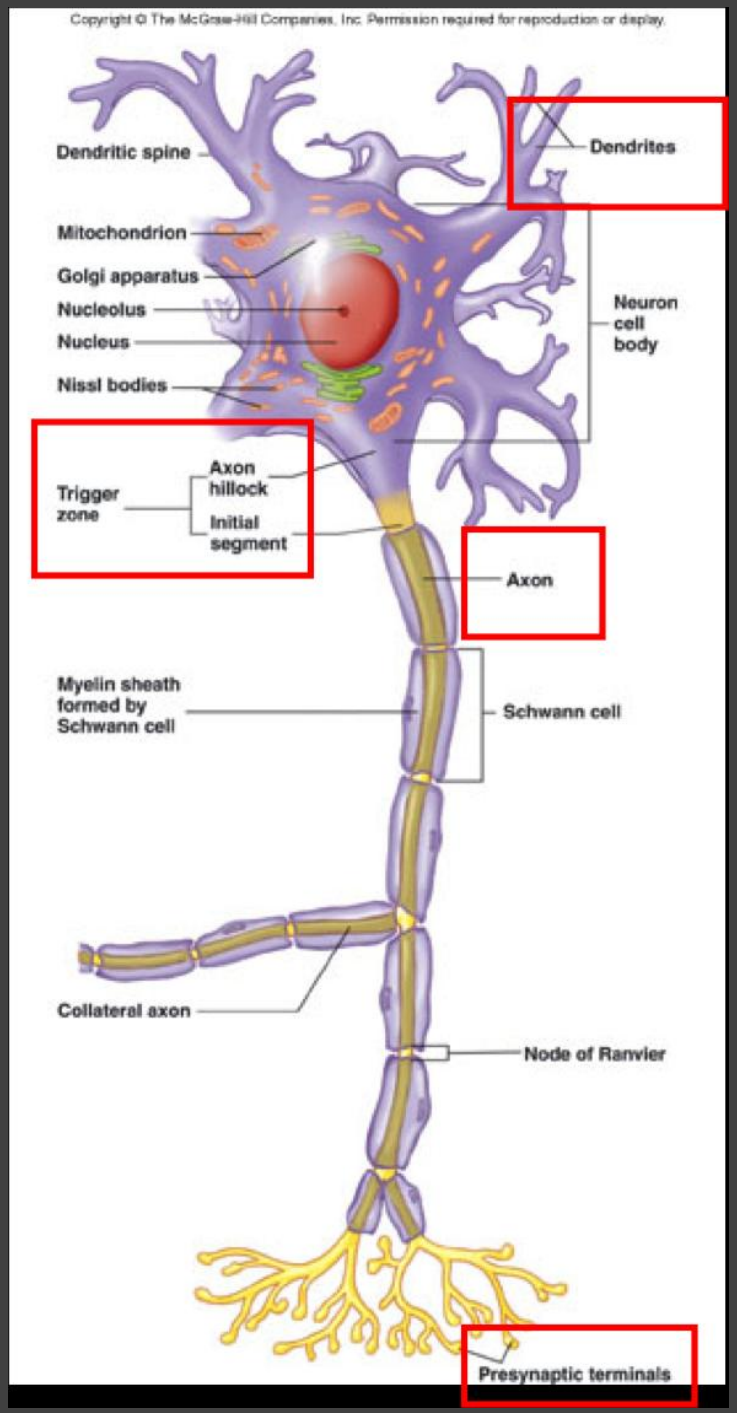
- **anterograde** transport (organelles, vesicles, macromolecules)

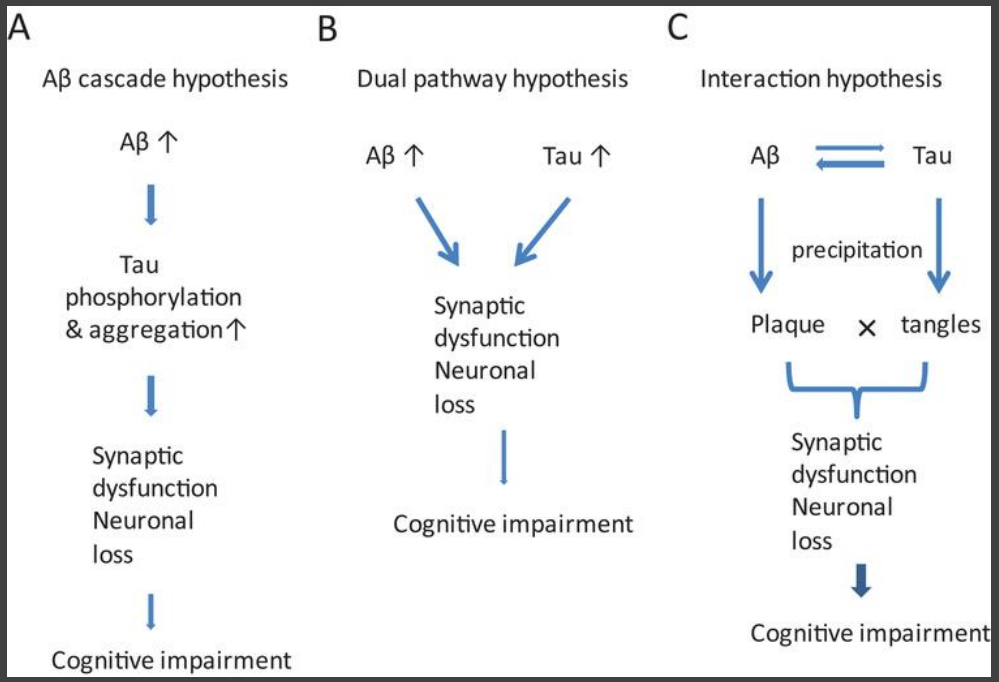
- **retrograde** transport (neurofilament proteins, subunits of microtubules, macromolecules and endocytic material)



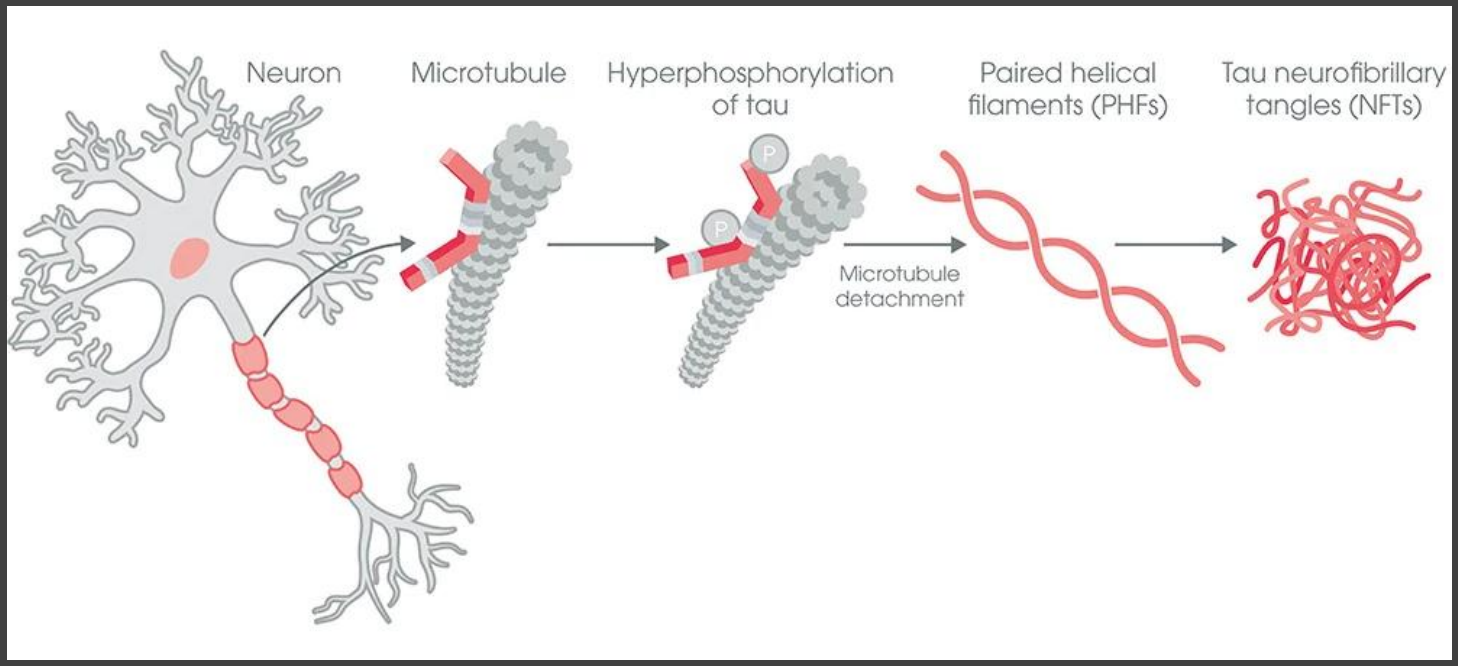
-initial segment –the portion of axon emanating immediately from axon hillock to the beginning of first myelin sheath

-spike trigger zone is the place, where excitatory and inhibitory impulses are summed to determine whether propagation of action potential is to occur.





Neurodegenerative disorders – Alzheimer's Disease



GENERATION AND CONDUCTION OF NERVE IMPULSES

Resting potential (-90mV)– arises because of two mechanisms.

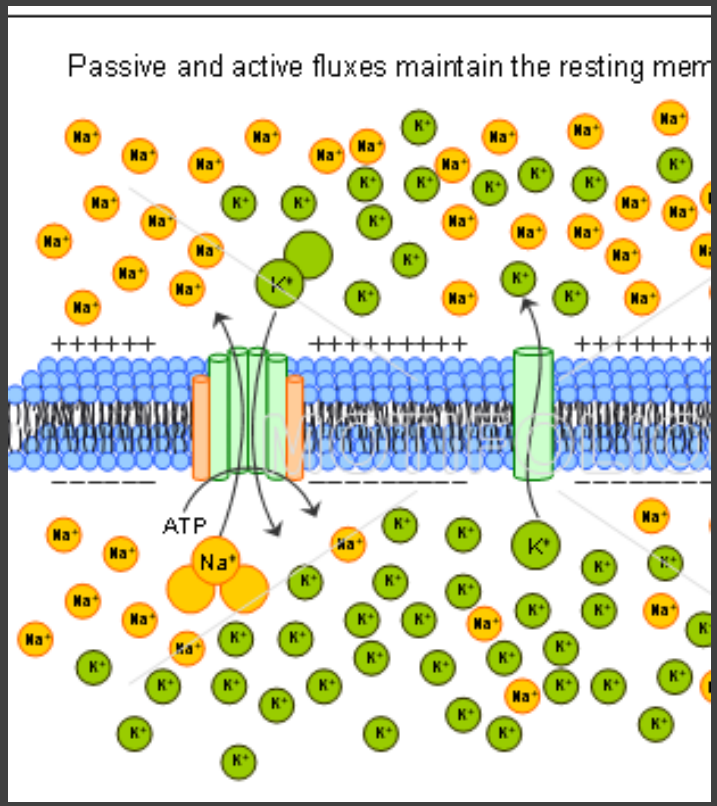
1. Na^+ /K^+ pumps

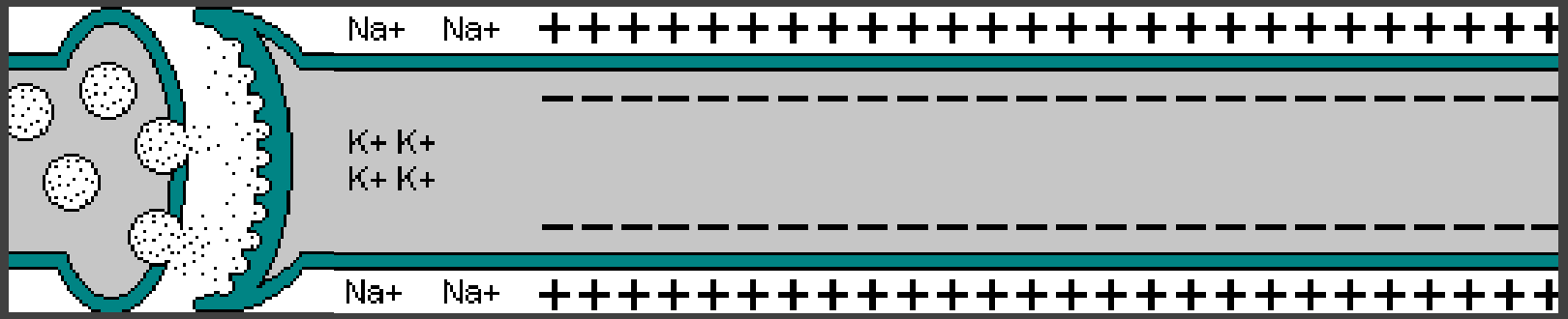
-pump Na^+ out of the cell, and K^+ into the cell in ratio 3 : 2 (for every 3 sodium ions pumped out, 2 potassium ions enter the cell)

2. K^+ leak channels

-permit free flow of K^+ out of the cell (Na^+ can enter to the cell but in ratio K^+: Na^+ 100:1).

The concentration of K^+ ions is higher inside the cell, whereas Na^+ ions outside the cell.





Membrane depolarization

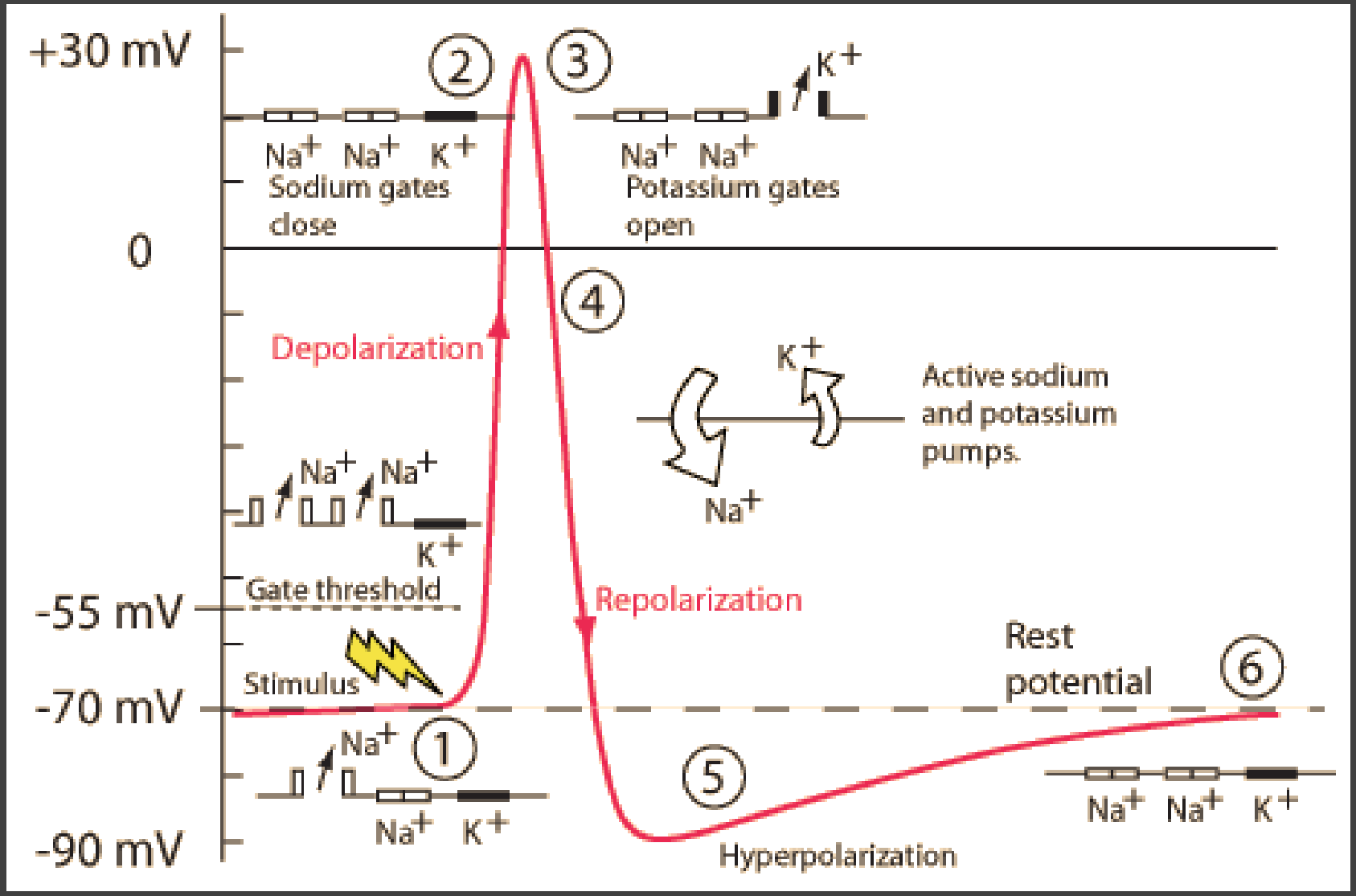
- opening Na^+ channels and Na^+ flow into the cell - **reversal of the resting potential**

- **refractory period** - Na^+ channels become inactivated for 1-2 msec

-**and Hyperpolarization - voltage-gated K^+ channels** open - the efflux of K^+ out, **Na^+/K^+ pumps** activate and **pump Na^+** outside

- **Resting potential -** voltage-gated K^+ channels and Na^+ channels close

The cycle of membrane depolarization, hyperpolarization and return to the resting potential – **action potential**

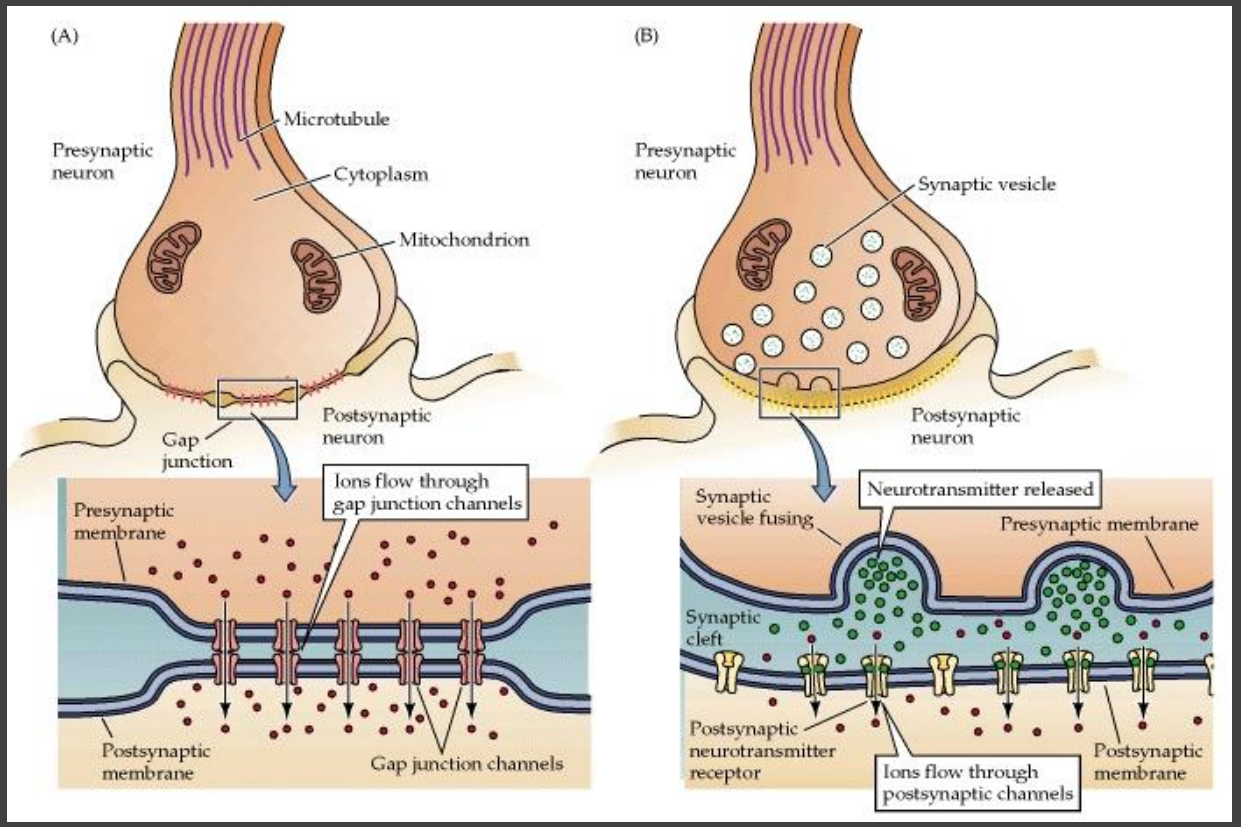

+30 mV
0
-55 mV
-70 mV
-90 mV
2
3
Na+ Na+ K+
Sodium gates close
K+
Na+ Na+
Potassium gates open
4
Depolarization
K+
Active sodium and potassium pumps.
Na+
Na+ Na+
K+
Gate threshold
Repolarization
Stimulus
Rest potential
6
1
Na+
Na+ K+
5
Hyperpolarization
Na+ Na+ K+

SYNAPSE

the site of impulse transmission
from the neuron to another neuron, muscle cell or cell of gland.

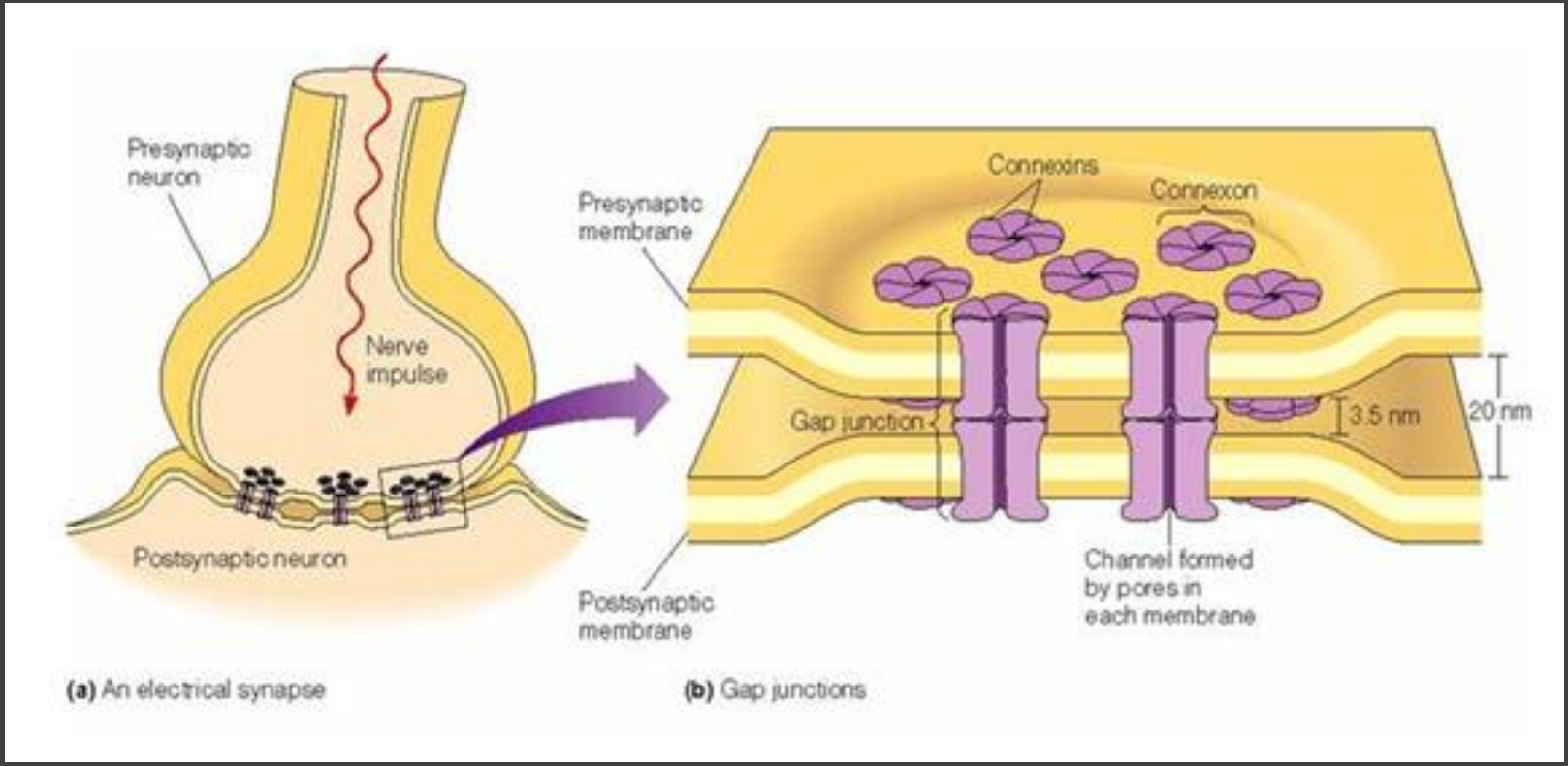
ELECTRICAL SYNAPSES
- present in brain stem, retina and cerebral cortex.
- contain gap junctions

CHEMICAL SYNAPSES are the most common manner of communication between nerve cells.



ELECTRICAL SYNAPSE

- **nexus (gap junction)**
-Cell-cell adhesion
-Formed from connexins

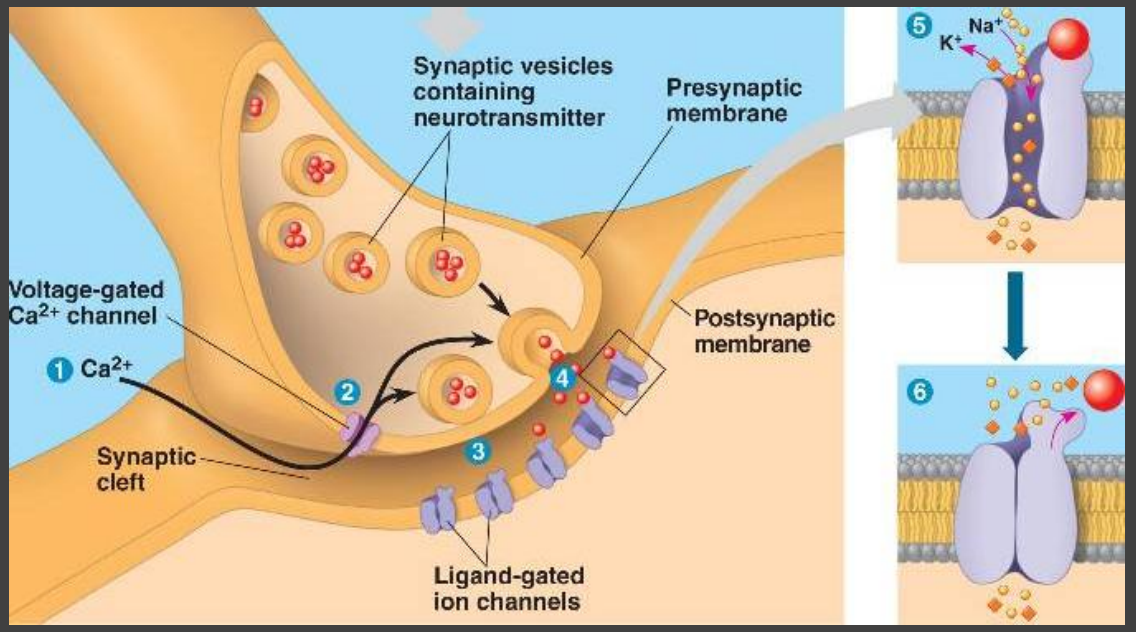


CHEMICAL SYNAPSE

-**Presynaptic membrane** (transmitting cell) with synaptic vesicles with neurotransmitters

-**Synaptic cleft**

-**Postsynaptic membrane** (receiving cell) with gated ion-channel receptors for neurotransmitters. Binding of neurotransmitters causes opening of ion channels, which permits the passage of ions, altering the membrane permeability and reverse its membrane potential.



NEUROTRANSMITTERS

<table>
<tr><th colspan="2">SMALL-MOLECULE TRANSMITTERS</th><th>PEPTIDES</th><th>GASES</th></tr>
<tr><td colspan="2">1. Acetylcholine
2. Amino acids: glutamate, glycine, GABA
3. Biogenic amines – monoamines i catecholamines: serotonine, dopamine, noradrenaline, adrenaline</td><td rowspan="3">Motyline, substance P, neuropeptyde Y, neurotensin, VIP, oksytocin</td><td rowspan="3">NO, CO</td></tr>
<tr><th>EXCITATORY</th><th>INHIBITORY</th></tr>
<tr><td>Glutamate, acetylocholine, dopamine, noradrenaline</td><td>GABA, glycine</td></tr>
</table>

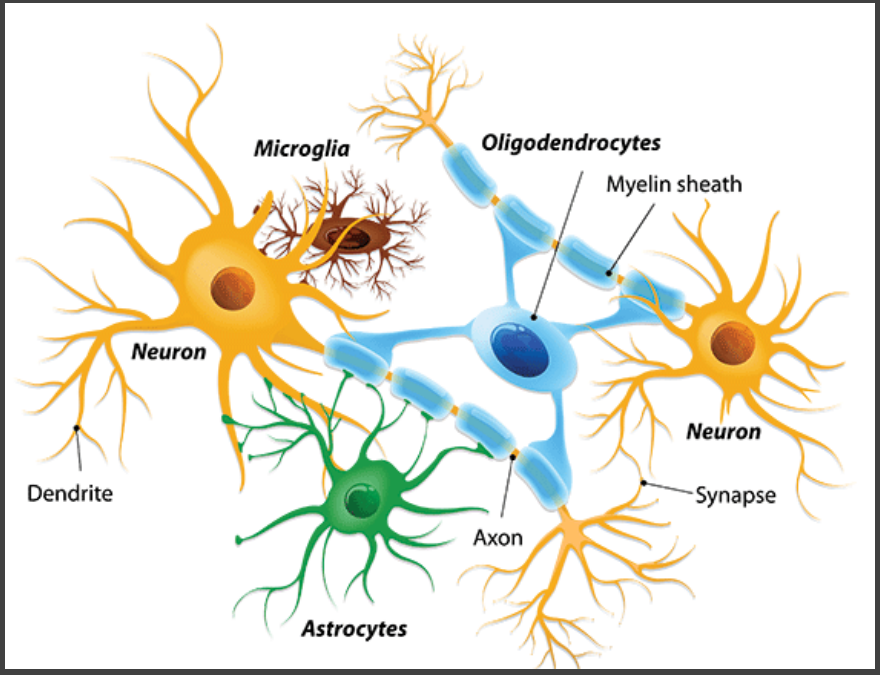
OTHERS – adenosine, anandamide

NEUROGLIAL CELLS

- physical support for neurons
- supply nutrients and oxygen to neurons
- destroy pathogens and remove dead neurons
- **Neuroglial cells undergo mitosis**

Types of glial cells

- Ependymal cells
- Astrocytes
- Oligodendrocytes
- Microglial cells
- Schwann cells (located in PNS)

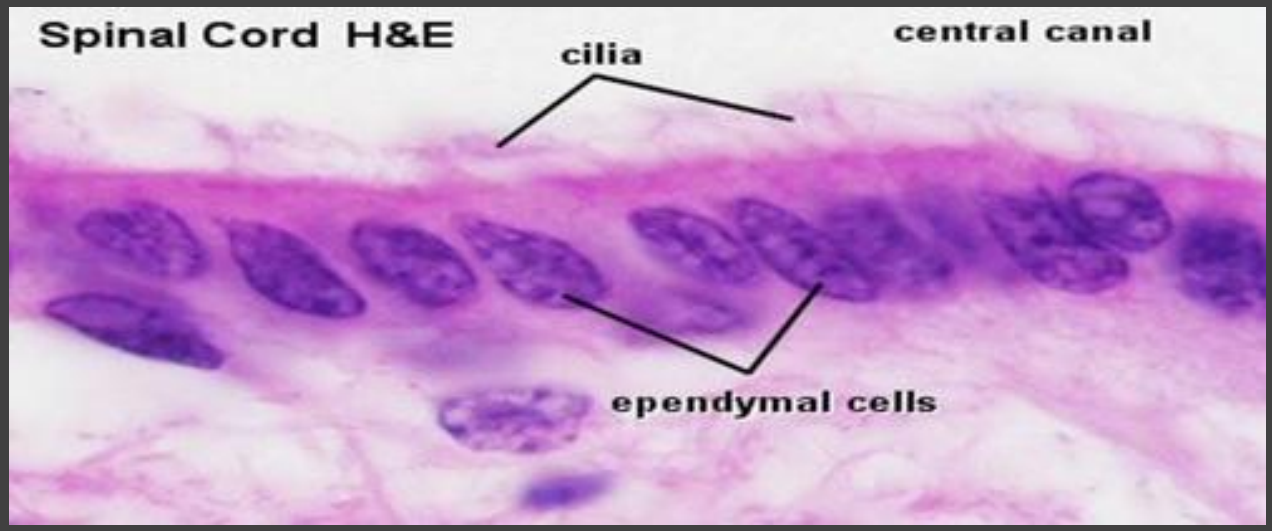


EPENDYMOCYTES

– cuboidal epithelial cells lining ventricles of the brain and central canal of the spinal cord forming ependyma.

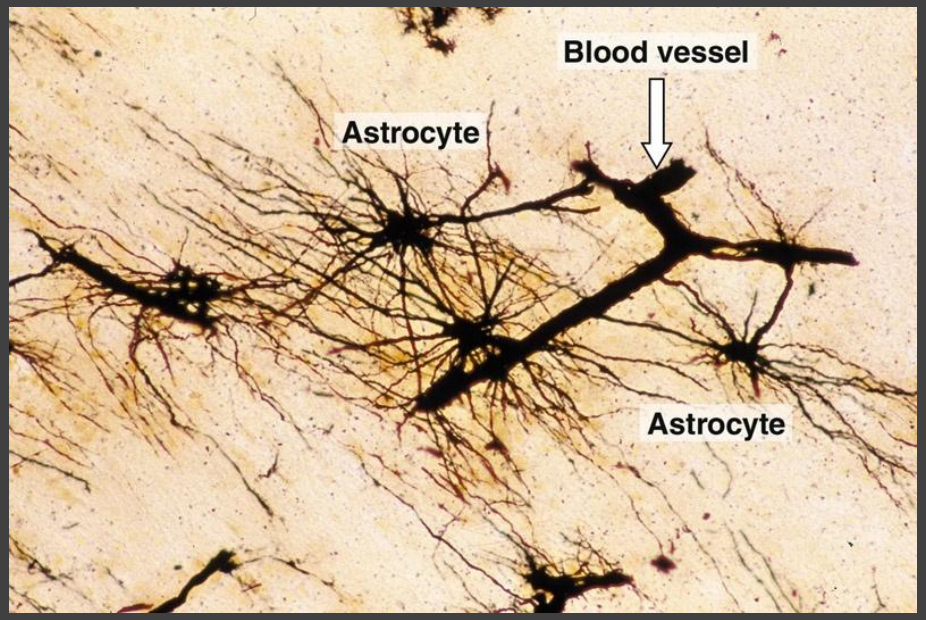
- contain cilia or microvilli.
- create and secrete cerebrospinal fluid (CSF)
- contain stem cells ???

TANYCYTES – III brain chamber



ASTROCYTES

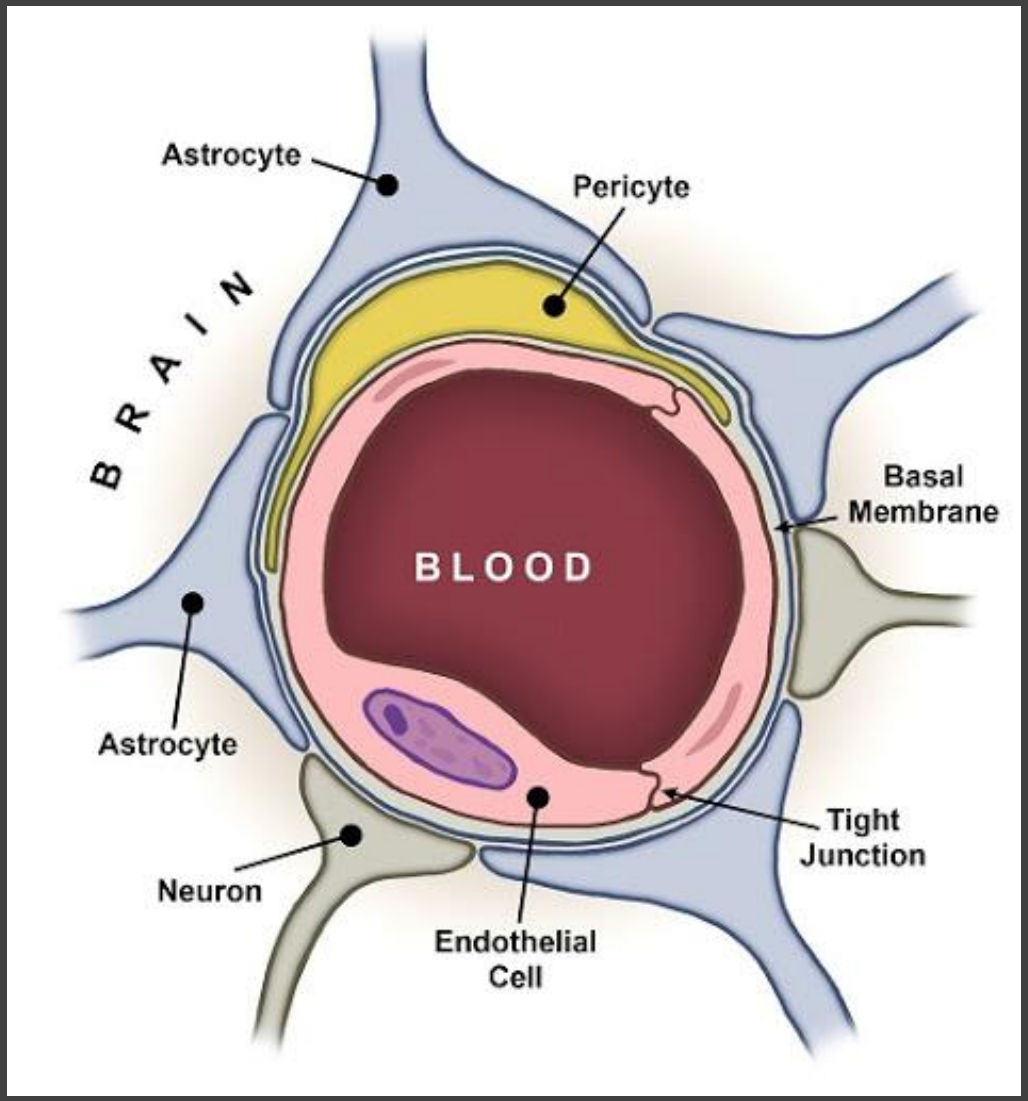
- The largest of the neuroglial cells
- Protoplasmic astrocytes (grey matter of CNS)
- Fibrous astrocytes (white matter of CNS)

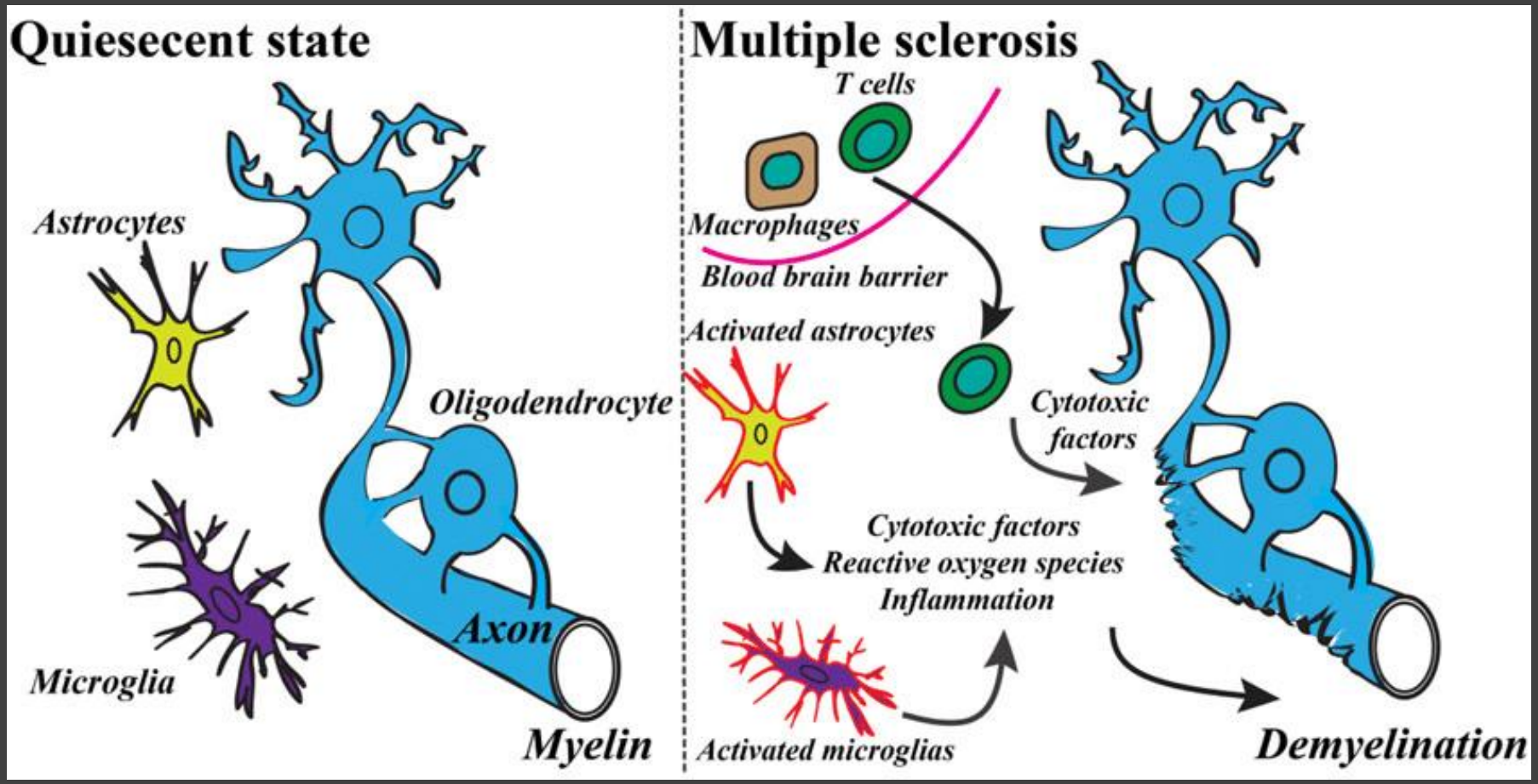


Function of astrocytes

- separation of blood vessels from direct contact with nerve tissue **(blood-brain barrier)**
- transport nutrients to neurons by transcytosis (***Transcytosis*** is the process by which various macromolecules are transported across the interior of a cell)
- maintenance of extracellular **ion balance (**express potassium channels)
- production, storage and secretion **neurotransmitters** and enzymes inactivating them
- regulate the transmission of electrical impulses within the brain.

Blood-brain barrier



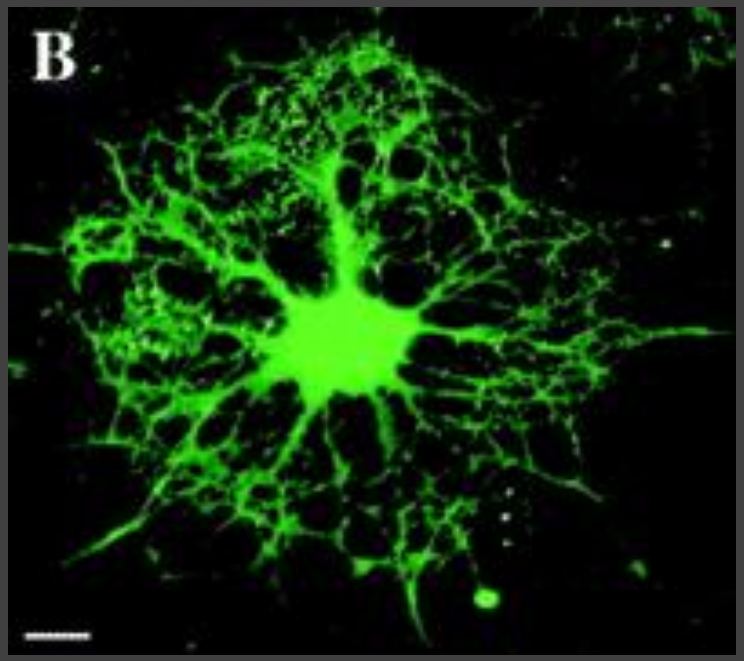

Quiesecent state
Astrocytes
Oligodendrocyte
Axon
Microglia
Myelin
Multiple sclerosis
T cells
Macrophages
Blood brain barrier
Activated astrocytes
Cytotoxic factors
Cytotoxic factors
Reactive oxygen species
Inflammation
Activated microglias
Demyelination

OLIGODENDROCYTES

- located in white and gray matter of CNS

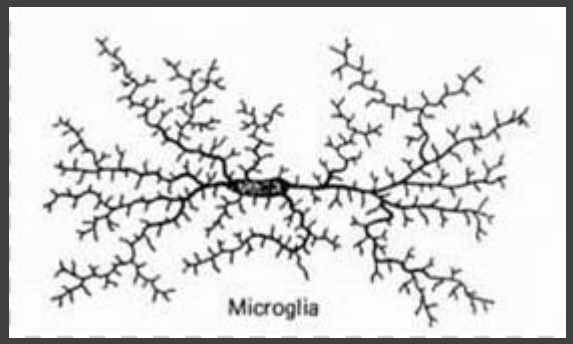
- posses a few processes with sparse branching.

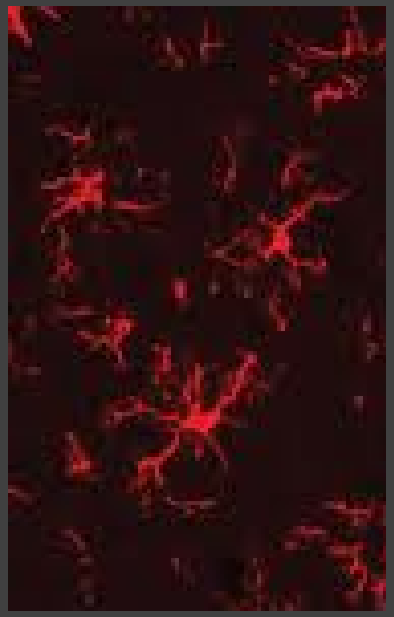
- **Interfascicular oligodendrocytes** produce the myelin sheath around the axons in CNS.
- **Satellite oligodendrocytes** are located close to cell bodies of large neurons; their function is not clear.

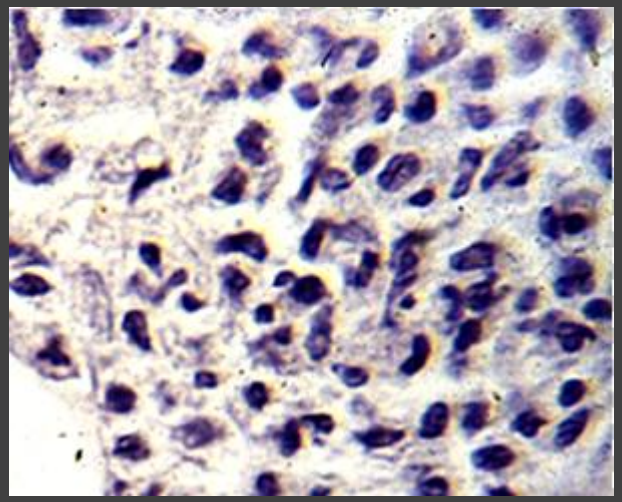


MICROGLIAL CELLS

- belong to mononuclear phagocyte system and derived from mesoderm
- exhibit irregular short processes, and spines on the cell body and processes
- function as phagocytes in clearing debris in CNS and in protecting nerve cells from pathogens and tumor formation



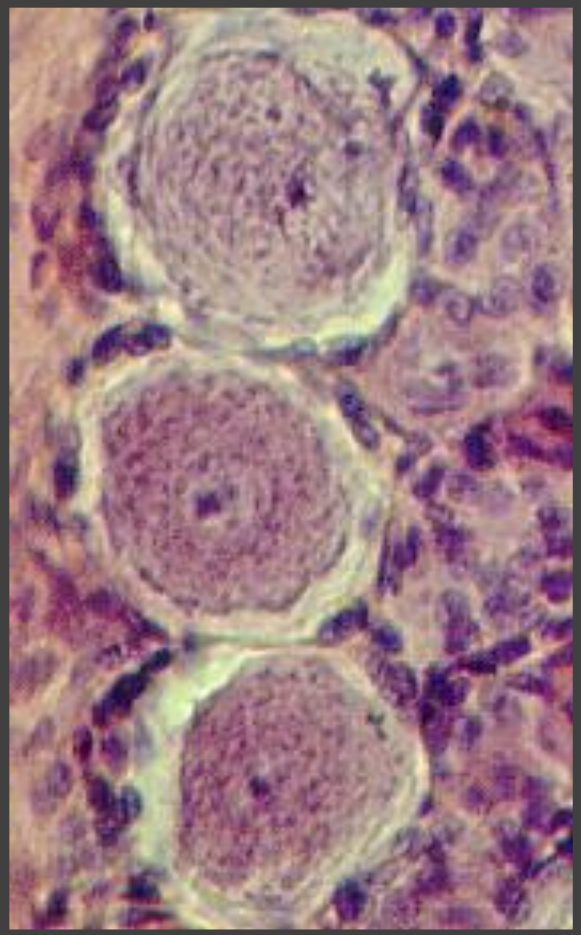




GLIAL CELLS OF PERIPHERAL NERVOUS SYSTEM (PNS)

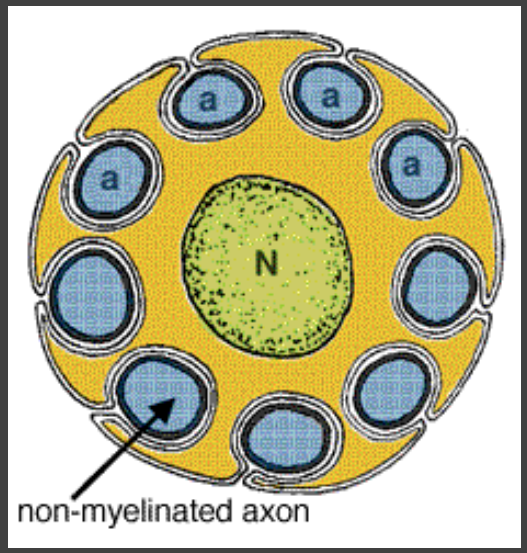
SATELLITE CELLS – envelop the cell bodies of unipolar neurons of sensory ganglia

LEMMOCYTES –Schwann cells – form both myelinated and unmyelinated coverings over axons in PNS

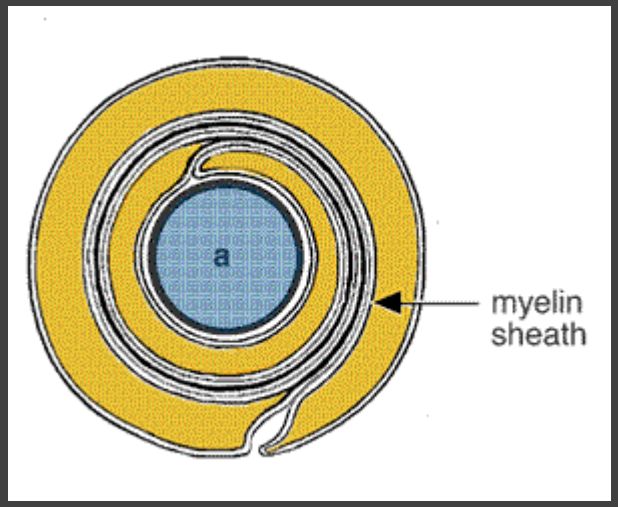


Axon sheath

1. Unmyelated axons



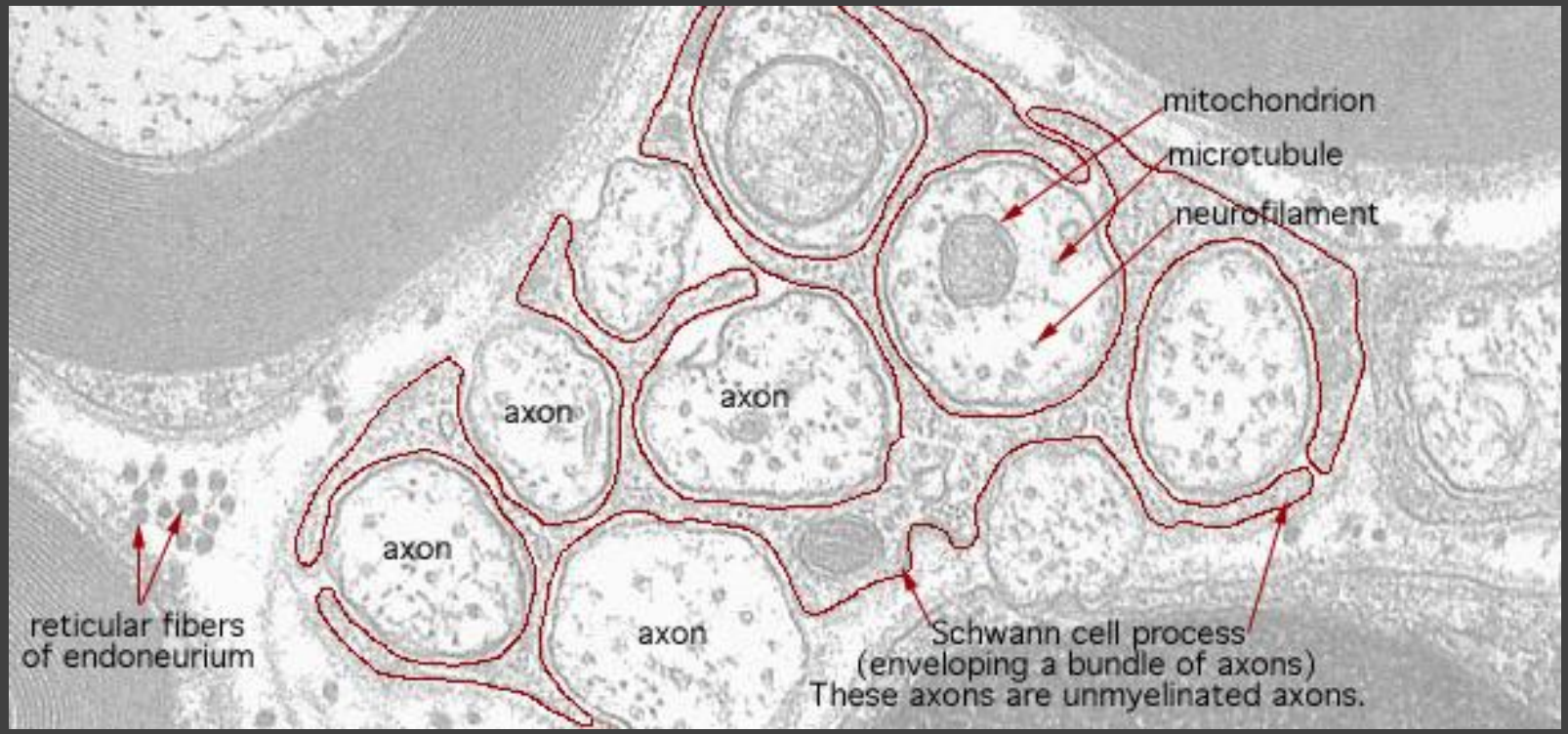
3. Myelated axons



NEUROLEMMA

Unmyelinated axons – surrounded by a single layer of Schwann cell plasma membrane and cytoplasm of the Schwann cell

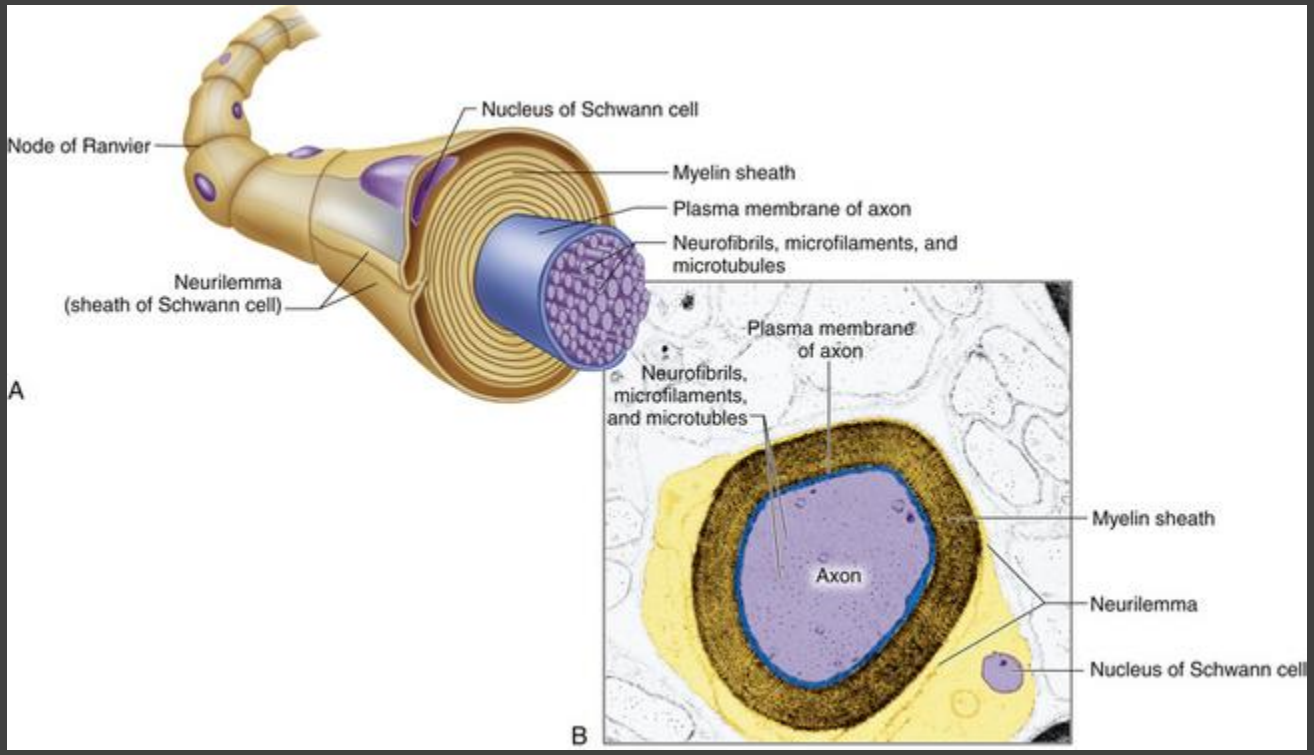
- several unmyelinated axons may be enveloped by a single Schwann cell
- the outermost cytoplasmic layer of Schwann cells that surrounds the axon of the neuron forms **neurolemma**



FORMATION OF MYELIN SHEATH IN PNS

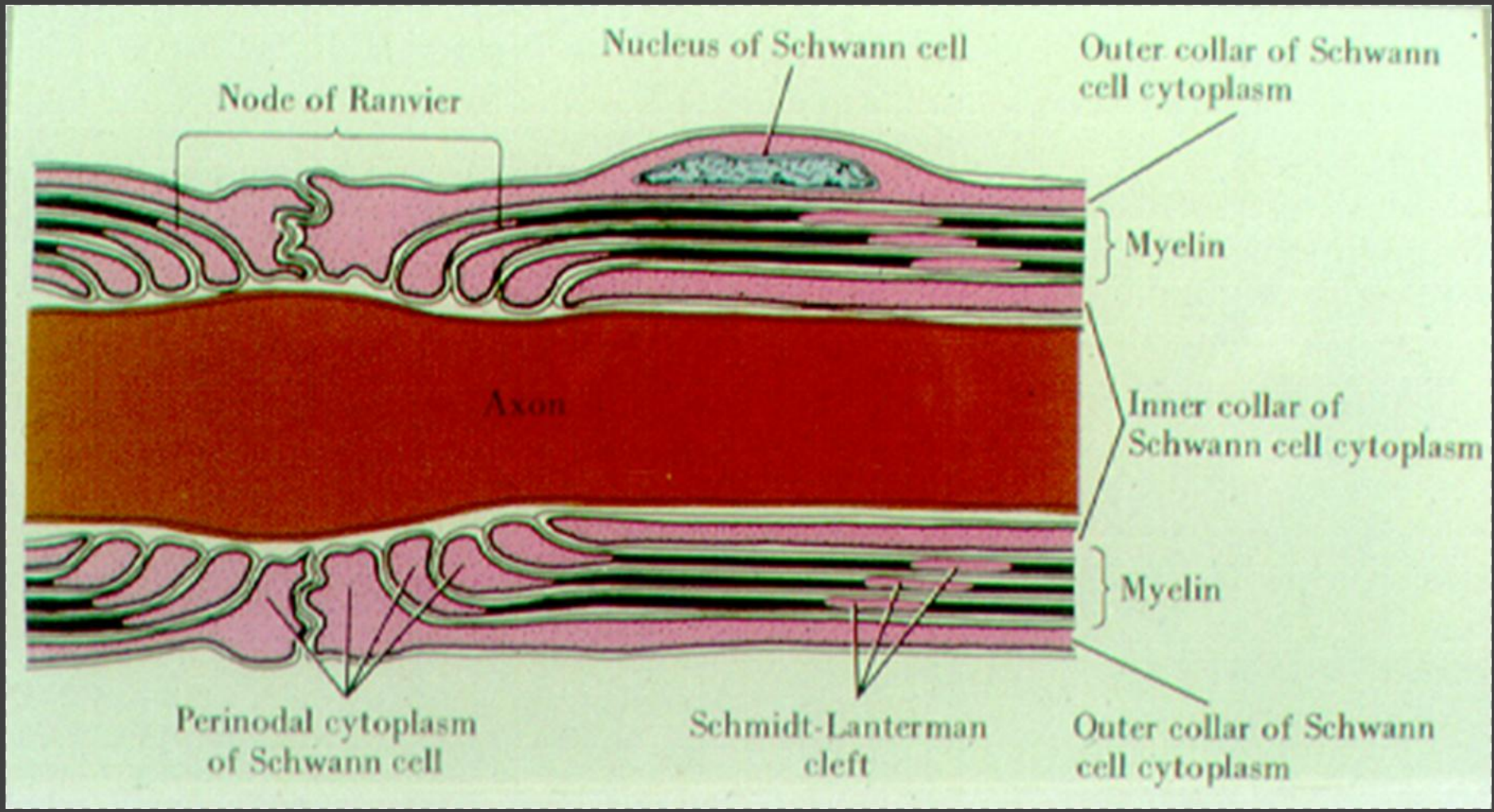
- whole Schwann cell wraps its membrane around the axon and forms one internodal segment

- the cytoplasm is squeezed into the body of Schwann cell

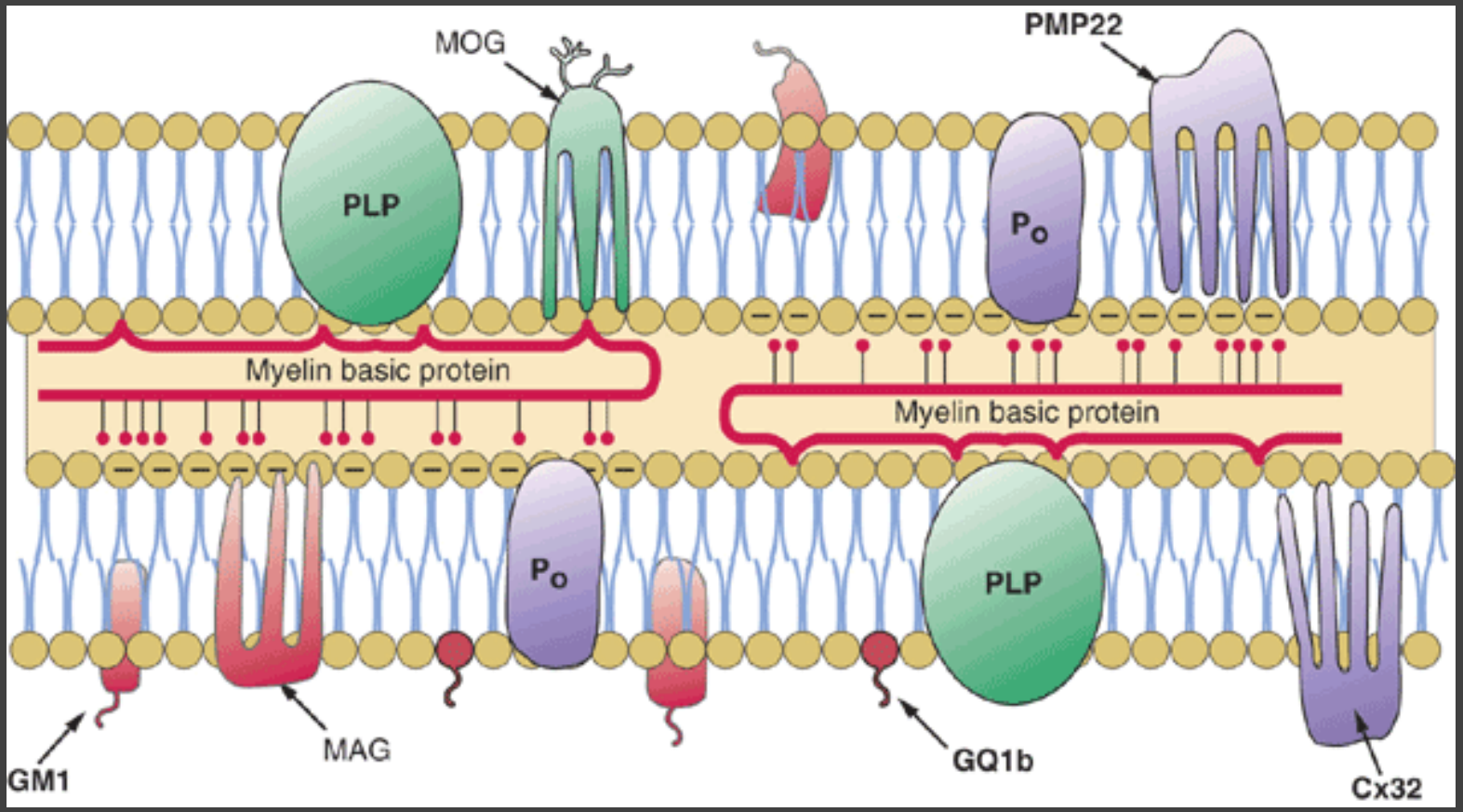


Schematic structure of nerve fiber

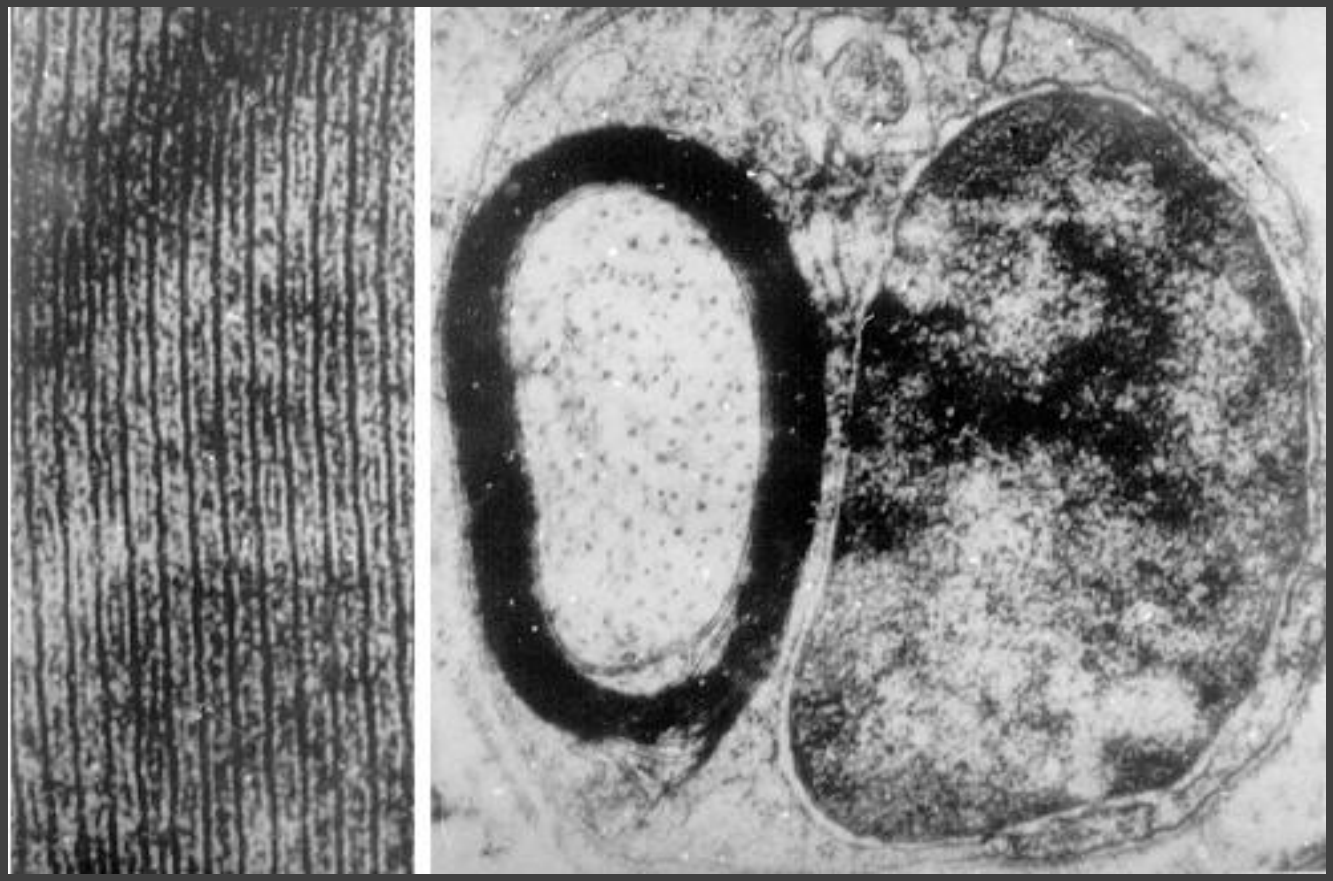
Schwann cell produces basal lamina, which covers the outer portion of this cell, adjacent node of Ranvier and overlapped area of adjacent Schwann cell. Thus whole axon is covered by a basal lamina.



Myelin Basic Protein - MBP



PERIPHERAL NERVE FIBER – ELECTRON MICROSCOPE



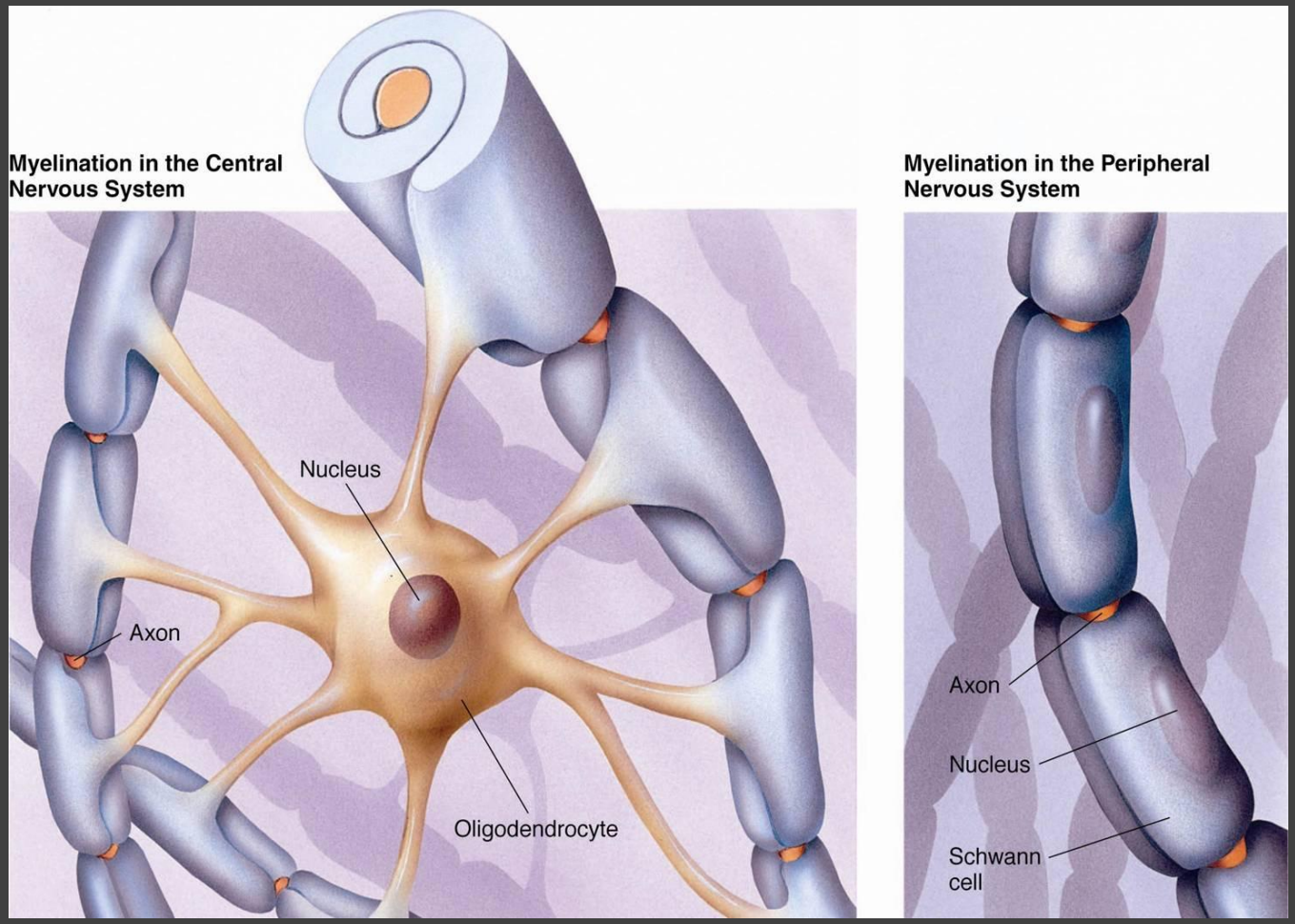
MYELINATION IN

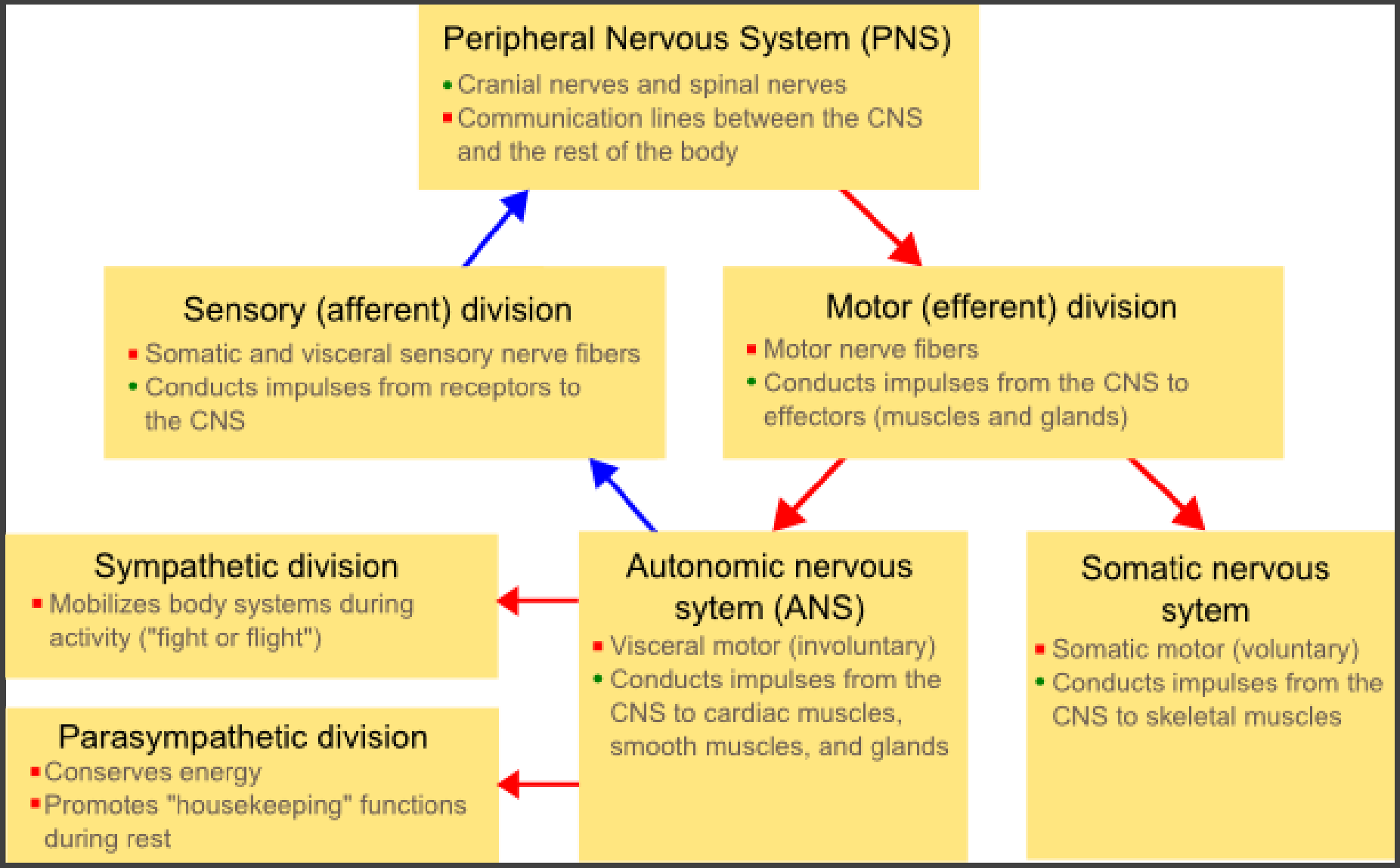
CNS

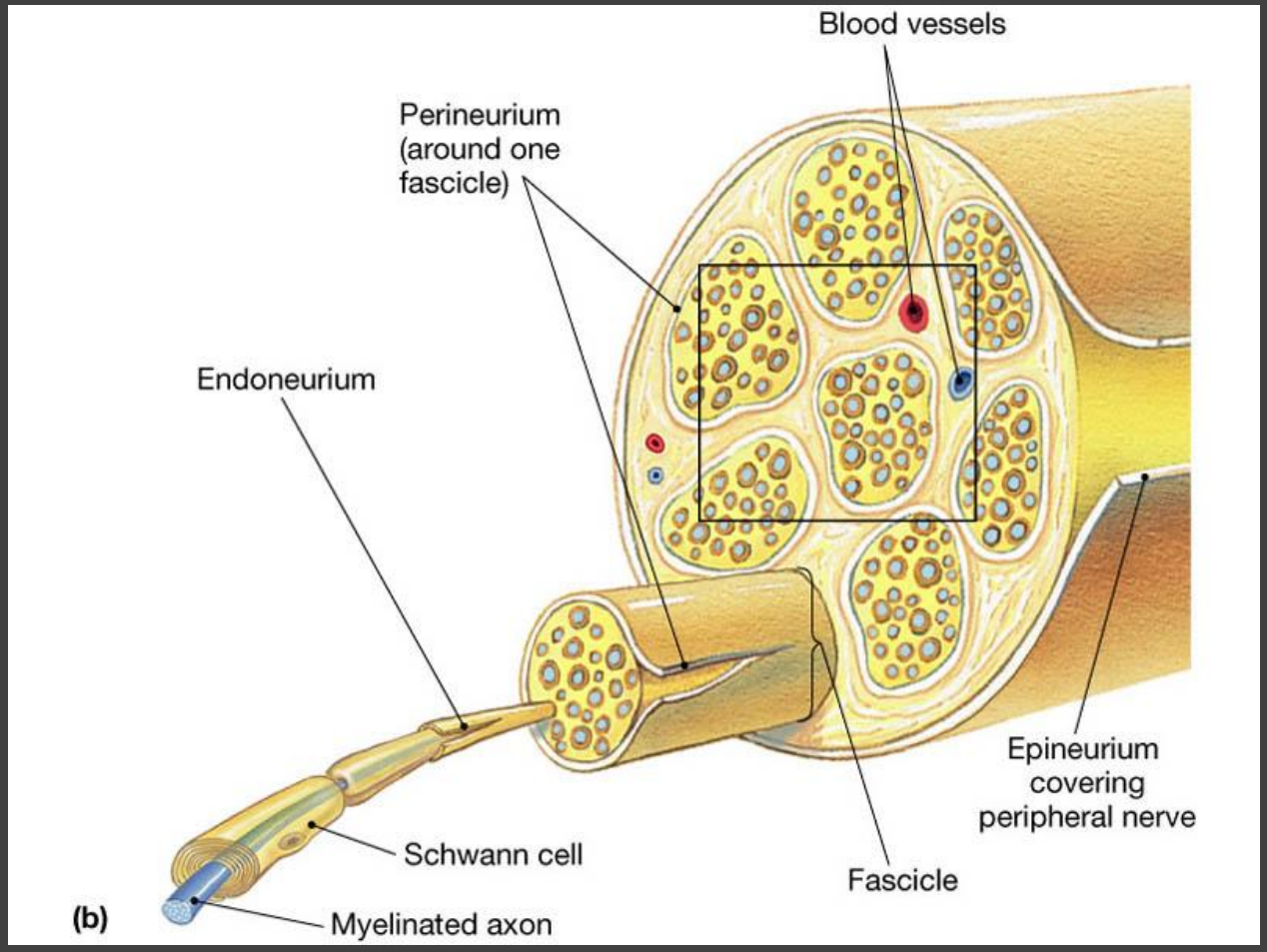
one oligodendrocyte- some internodal segments – some axons

PNS

one Schwann cell – one internodal segment - one axon




Peripheral Nervous System (PNS)
Cranial nerves and spinal nerves
Communication lines between the CNS and the rest of the body
Sensory (afferent) division
Somatic and visceral sensory nerve fibers
Conducts impulses from receptors to the CNS
Motor (efferent) division
Motor nerve fibers
Conducts impulses from the CNS to effectors (muscles and glands)
Sympathetic division
Mobilizes body systems during activity ("fight or flight")
Parasympathetic division
Conserves energy
Promotes "housekeeping" functions during rest
Autonomic nervous sytem (ANS)
Visceral motor (involuntary)
Conducts impulses from the CNS to cardiac muscles, smooth muscles, and glands
Somatic nervous sytem
Somatic motor (voluntary)
Conducts impulses from the CNS to skeletal muscles



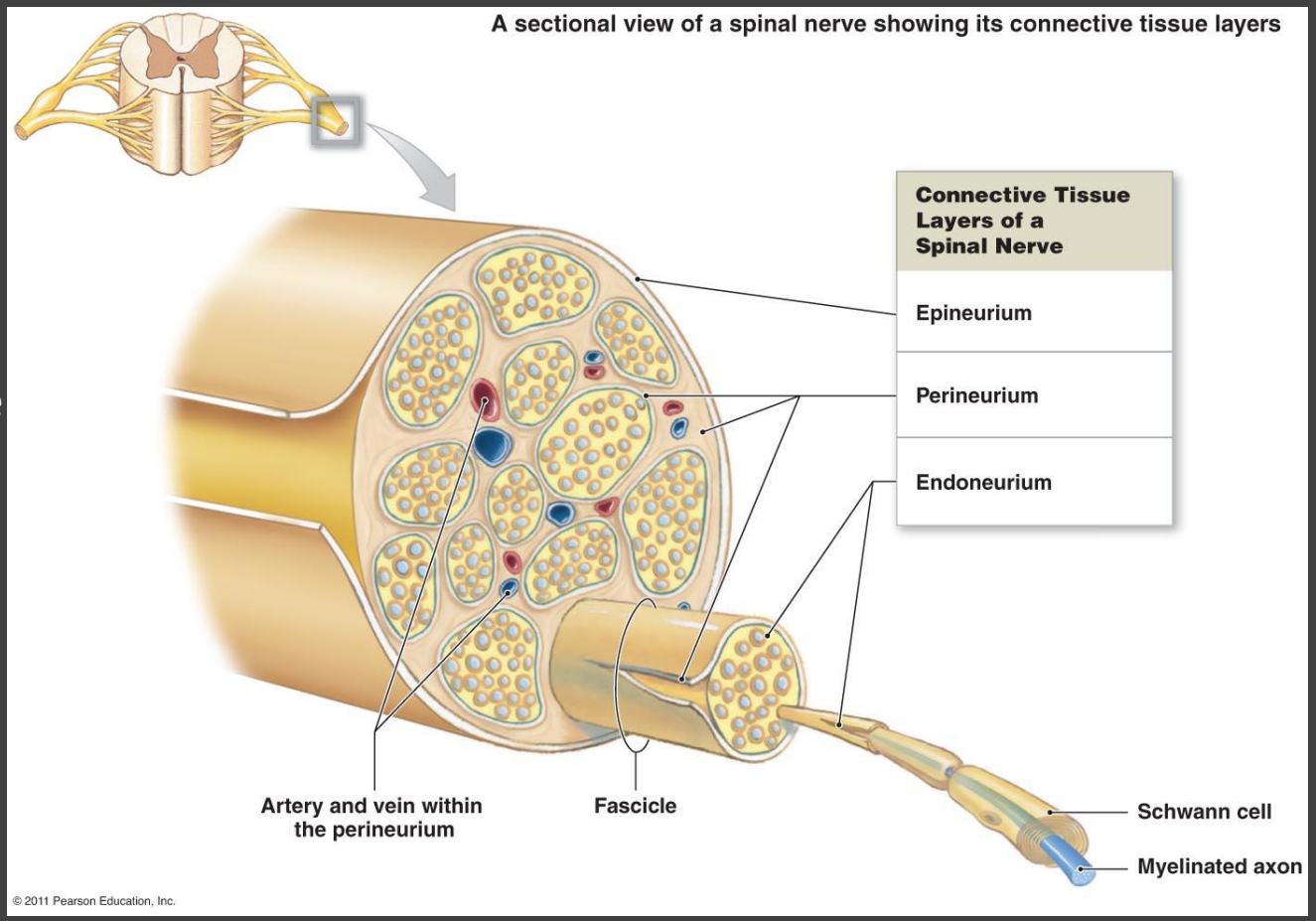
Peripheral nerve – collection of bundles of nerve fibers (axon with its sheats) with connective tissue investments.

PERIPHERAL NERVE – CONNECTIVE TISSUE INVESTMENTS

EPINEURIUM
Outermost layer, covers the nerve, dense, irregular connective tissue

PERINEURIUM
Middle layer, covers each bundle of nerve fibers, dense connective tissue (thinner than epineurium)

ENDONEURIUM
Innermost layer, surrounds the individual nerve fibers (axons), loose connective tissue



Ganglion

CAPSULE – dense connective tissue

STROMA – loose connective tissue proper with fibroblasts, fibers, macrophages, blood vessels