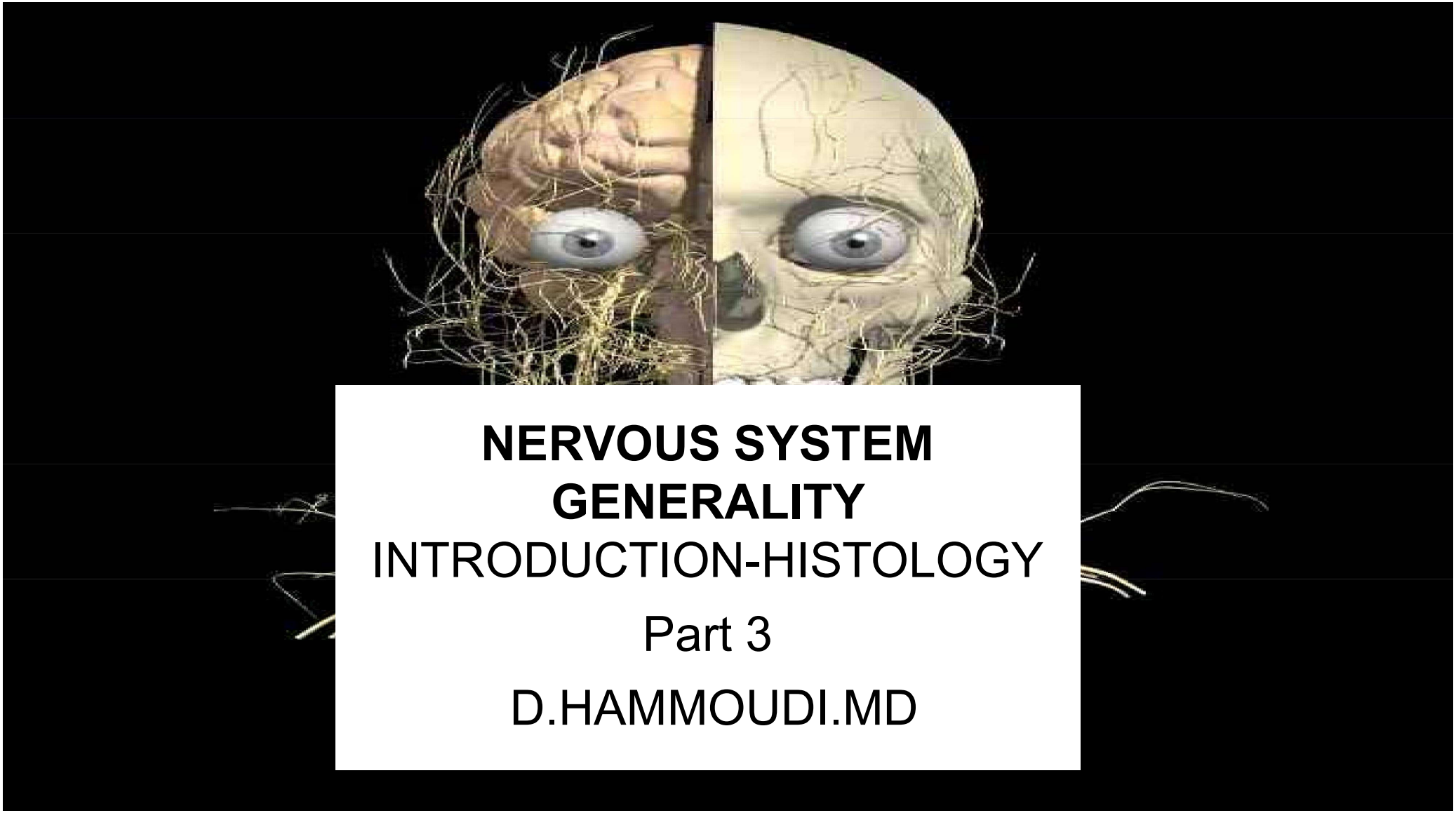


NERVOUS SYSTEM GENERALITY

INTRODUCTION-HISTOLOGY

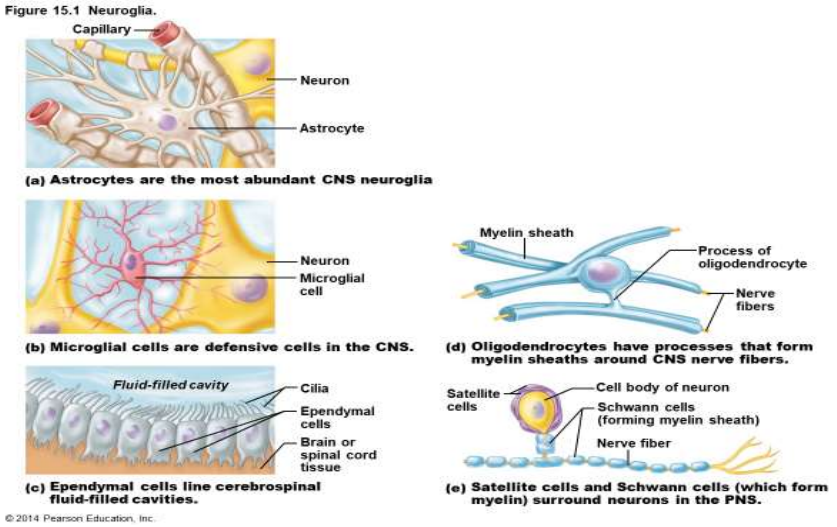
Part 3

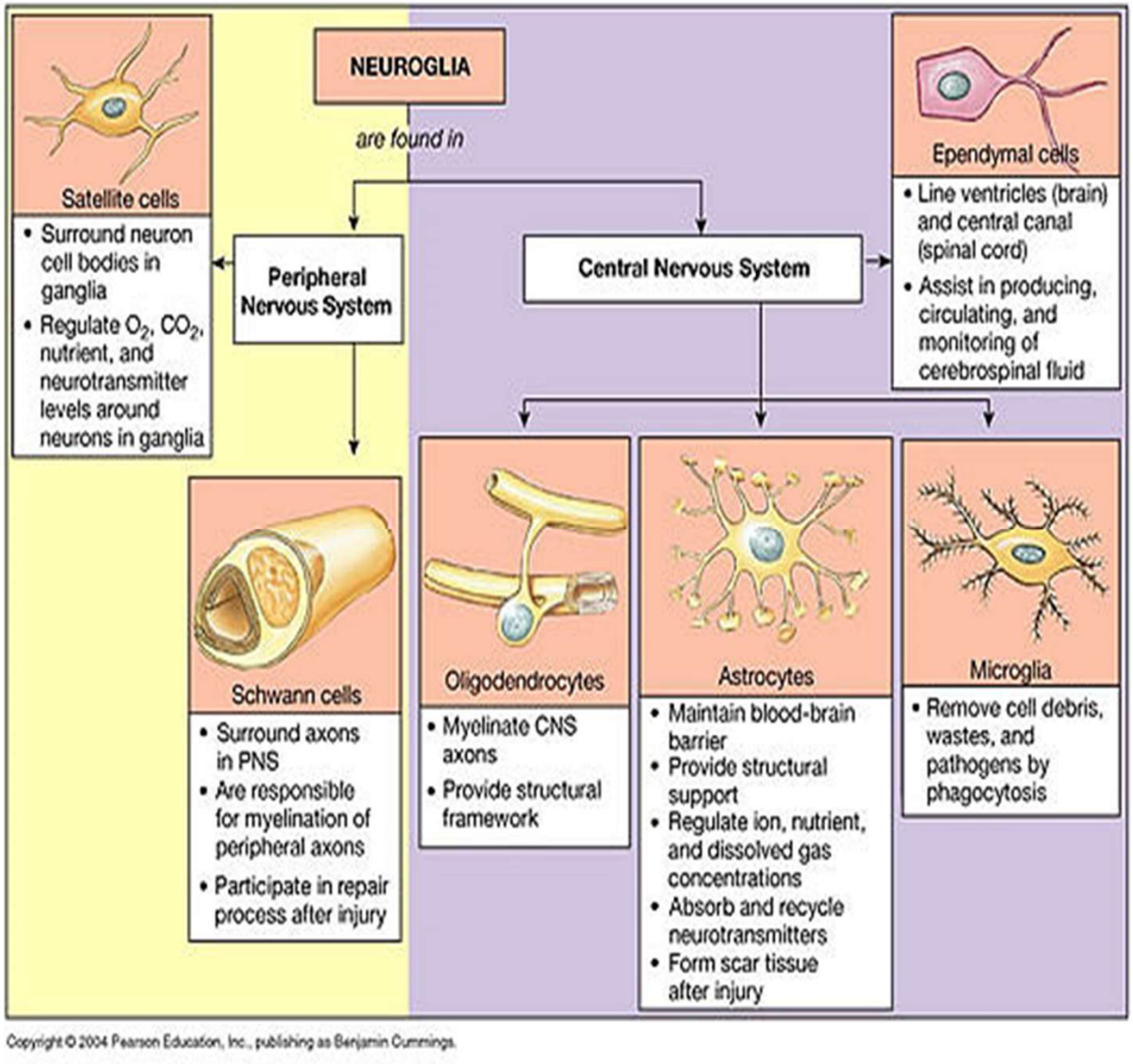
D.HAMMOUDI.MD

PART 2
NEURO GLIA OR GLIAL CELLS

nonneuronal cells of the CNS and the PNS.

- arise from the neural tube and neural crest.
- capable of cell division throughout life.
- best revealed with gold and silver impregnation stains.





NERVOUS TISSUE: GLIAL CELLS or Ne

Neuroglia comprise over 90 % of the cells of the nervous system.

- **Outnumber neurons by about 10 to 1 (the guy on the right had an inordinate amount of them).**
- **6 types of supporting cells**

Glial cells are relatively small.

Their function is

- **to provide structural support and nutrition**
- **form the CNS boundary**
- **ensheath and insulate axons by forming myelin sheath**
- **maintain the ionic homeostasis of the extracellular space**
- **phagocyte cell debris**
- **produce scar tissue**
- **participate in signal transmission**

Classification of neuroglia:

- **in the central nervous system (CNS): ependyma**
  astrocytes
  oligodendrocytes
  microglial cells
- **peripheral nervous system (PNS): neurolemmocytes: Schwann cells**

•Neurons perform all communication, information processing, and control functions of the nervous system.

• Neuroglia preserve the physical and biochemical structure of neural tissue, and are essential to the

Many glial cells do express neurotransmitter receptors, but they do not form synapses with neurones.

•Neuronal activity may regulate glial function by a spillover of transmitter from synaptic sites, which are typically surrounded by fine processes of glial cells.

•Glial cells may also communicate with each other via

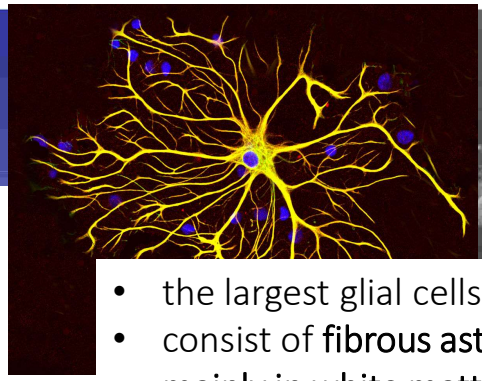
TYPE OF NEUROGLIA

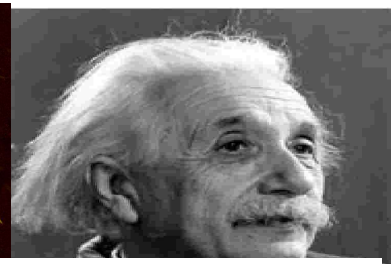
- **Microglia [Microglia are specialized macrophages capable of phagocytosis that protect neurons of the CNS.]**

- **Macroglia FOR CNS**
  - » **Astrocytes: The most abundant type of glial cell, astrocytes (also called *astroglia*)**
  - » **Oligodendrocytes**
  - » **Ependymal cells**
  - » **Radial glia**

- **FOR PNS [PERIPHERIC NERVOUS SYSTEM**
  - » **Schwann cells = (neurilemmacytes)**
  - » **Satellite cells = (amphicytes)**

Astrocytes





1. • Star-shaped, abundant, and versatile
   - Guide the migration of developing neurons
   - **Act as K+ and NT buffers**
   - Involved in the formation of the blood brain barrier = filtration
   - Function in nutrient transfer

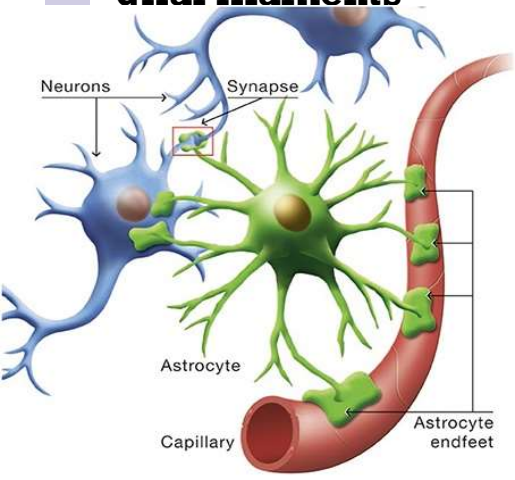
- the largest glial cells.
- consist of fibrous astrocytes that are found mainly in white matter and protoplasmic astrocytes

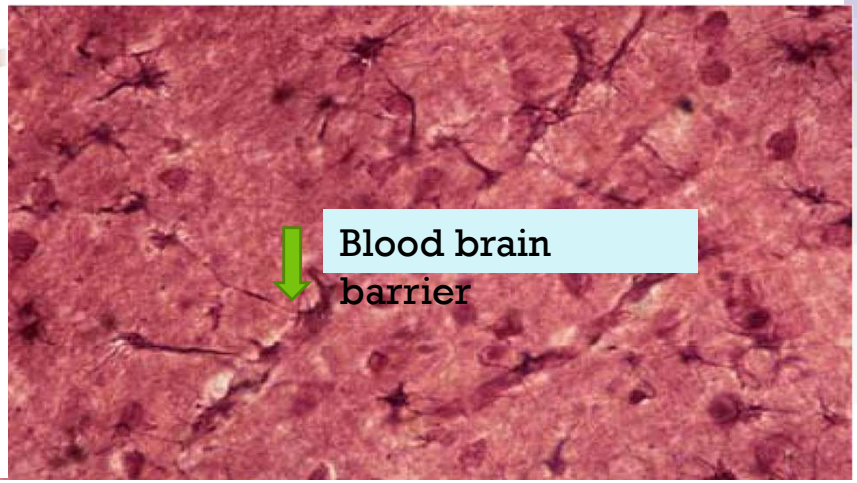
that are found mainly in gray matter.

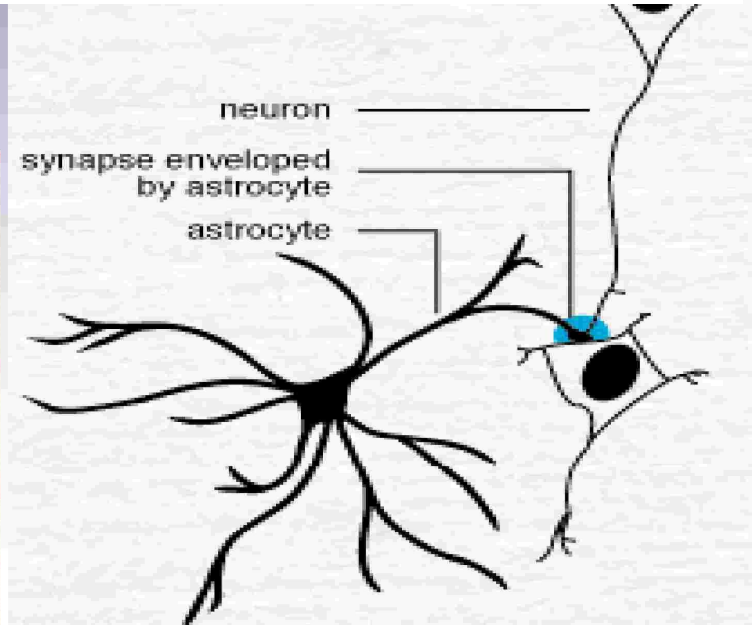
•in the white matter: long slender processes: fibrous astrocytes

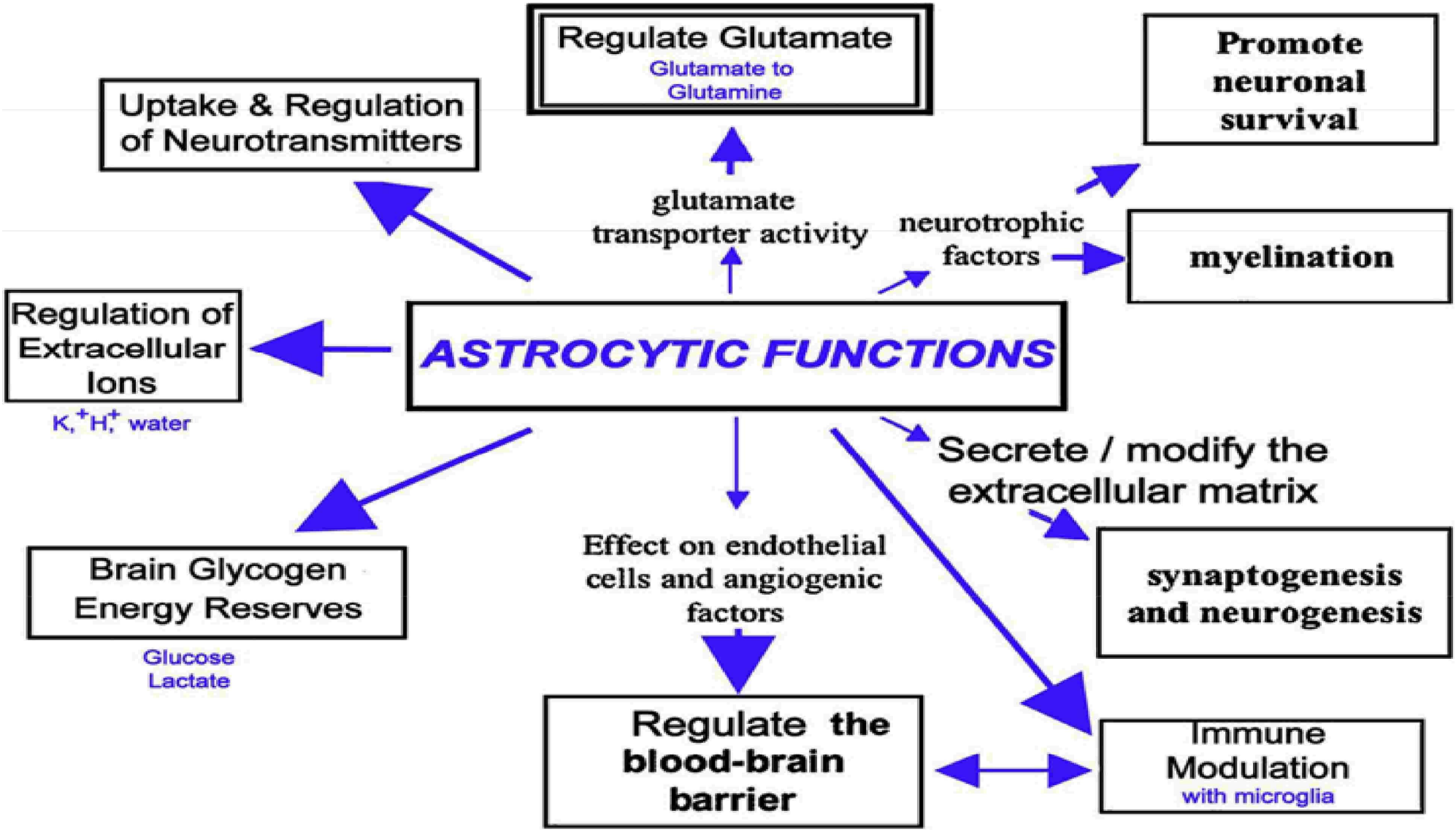
• in the gray matter: shorter branching processes: protoplasmic astrocytes.

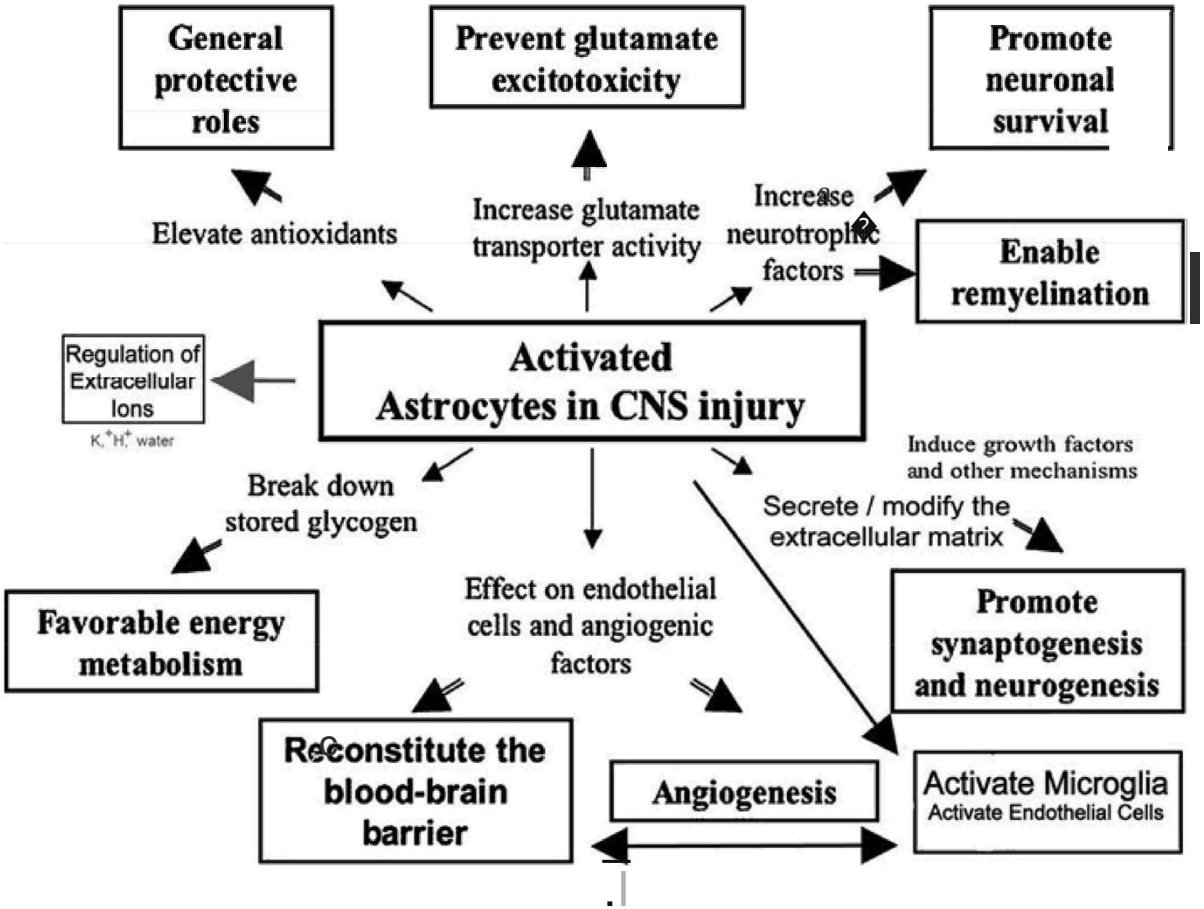
They contain glial fibrillary acidic protein (GFAP) forming glial filaments



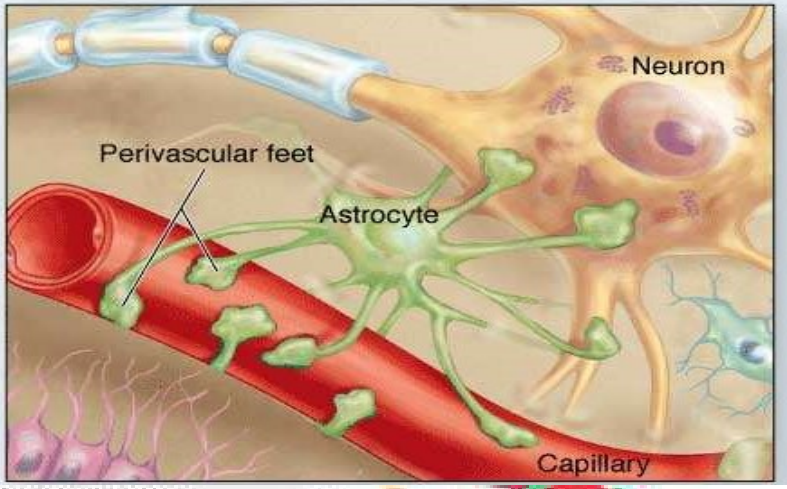


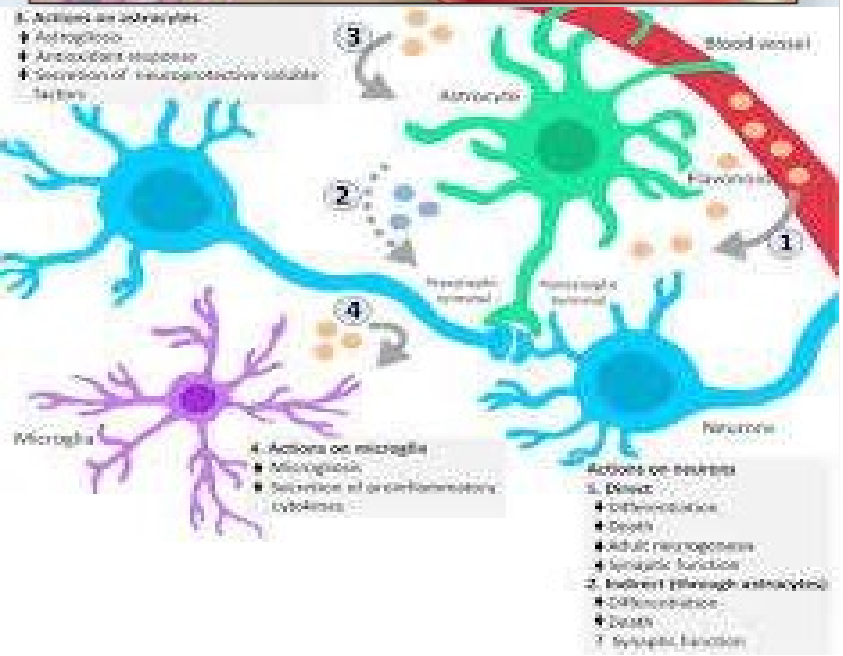


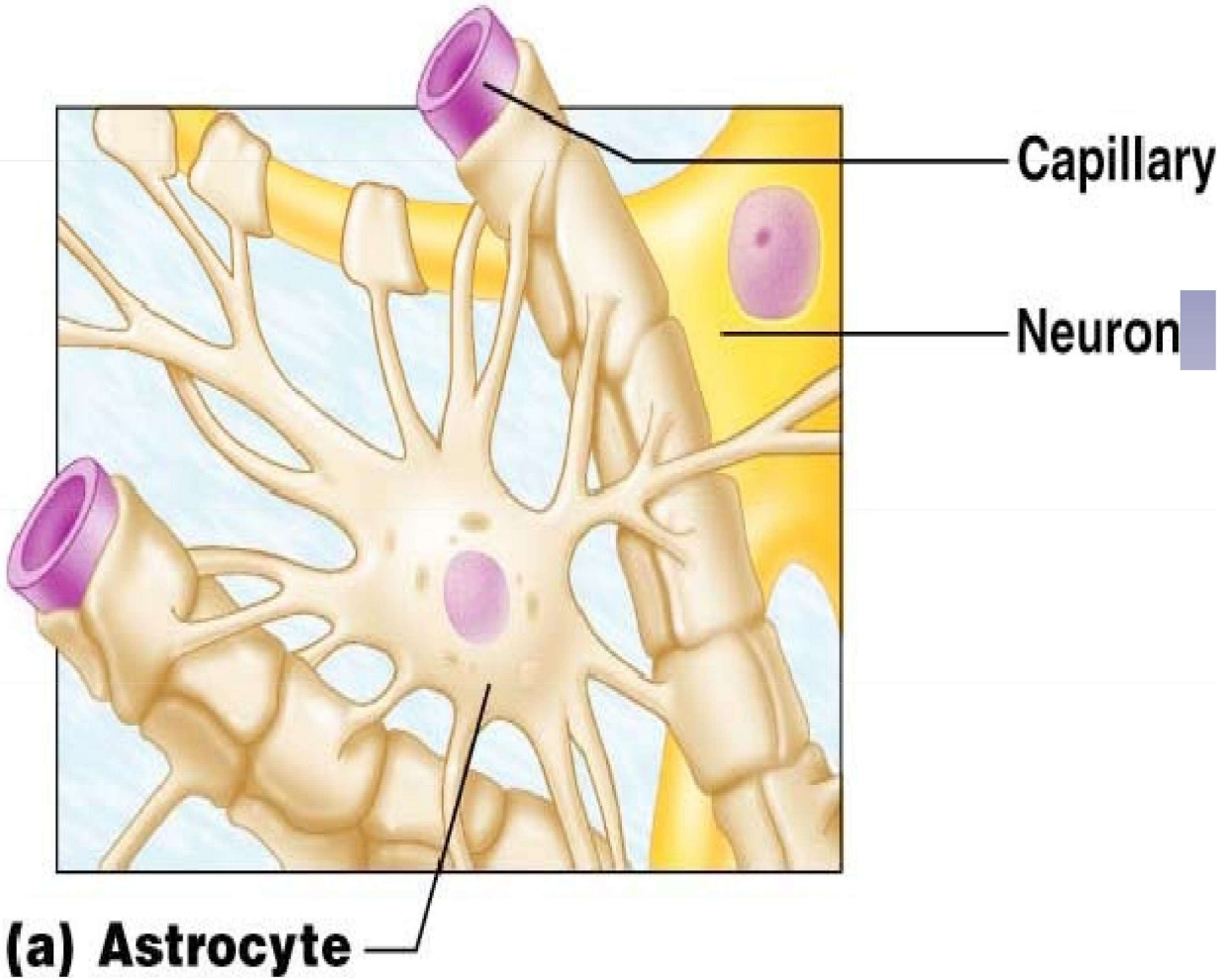

Regulate Glutamate
Glutamate to Glutamine
Uptake & Regulation of Neurotransmitters
Promote neuronal survival
glutamate transporter activity
neurotrophic factors
myelination
Regulation of Extracellular Ions
K,+H,+ water
ASTROCYTIC FUNCTIONS
Secrete / modify the extracellular matrix
Brain Glycogen Energy Reserves
Glucose Lactate
Effect on endothelial cells and angiogenic factors
synaptogenesis and neurogenesis
Regulate the blood-brain barrier
Immune Modulation
with microglia

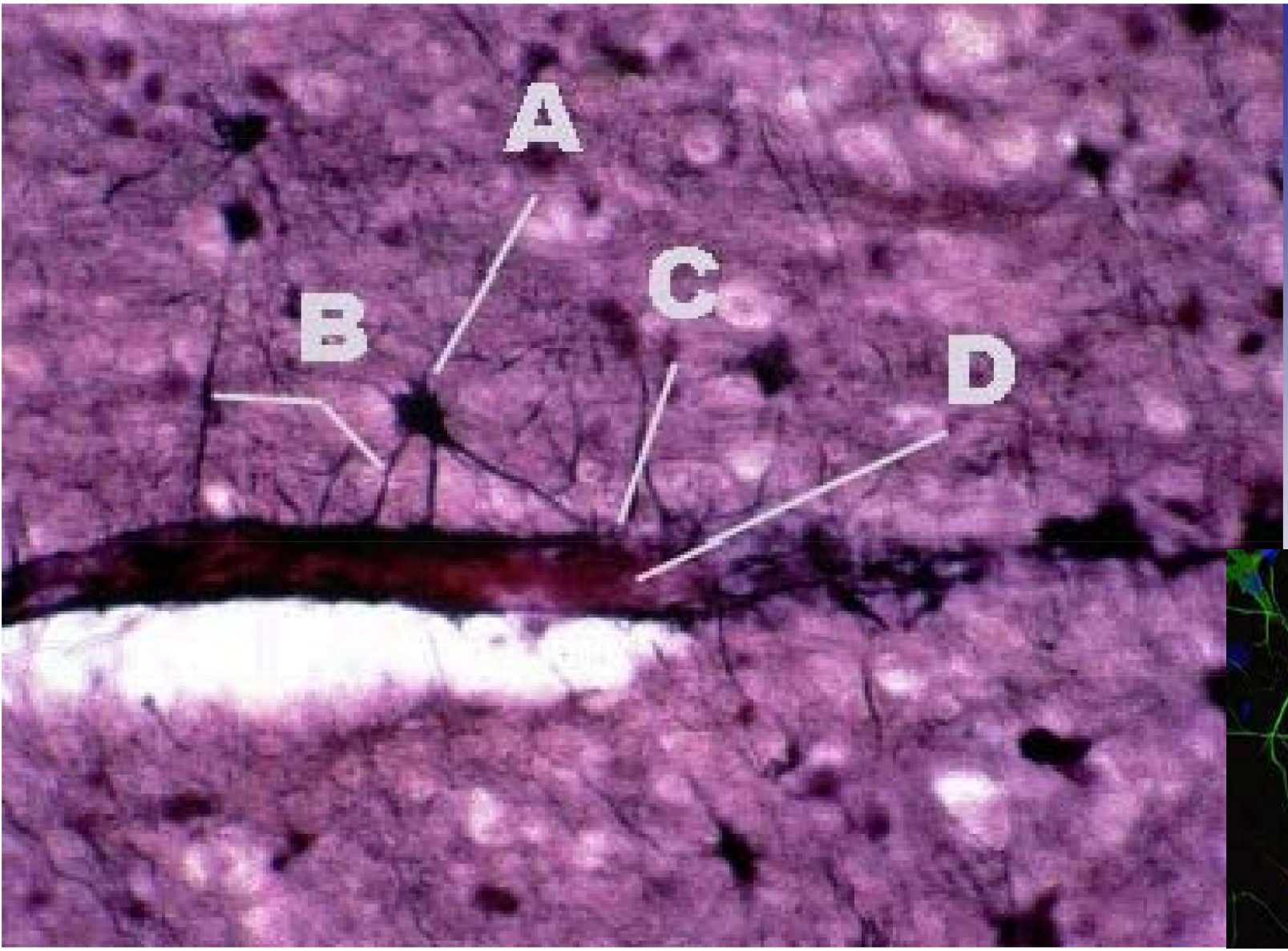

General protective roles
Prevent glutamate excitotoxicity
Promote neuronal survival
Elevate antioxidants
Increase glutamate transporter activity
Increase neurotrophic factors
Enable remyelination
Regulation of Extracellular Ions
K,+H,+ water
Activated Astrocytes in CNS injury
Induce growth factors and other mechanisms
Break down stored glycogen
Secrete / modify the extracellular matrix
Favorable energy metabolism
Effect on endothelial cells and angiogenic factors
Promote synaptogenesis and neurogenesis
Reconstitute the blood-brain barrier
Angiogenesis
Activate Microglia
Activate Endothelial Cells

Astrocytes


Neuron
Perivascular feet
Astrocyte
Capillary

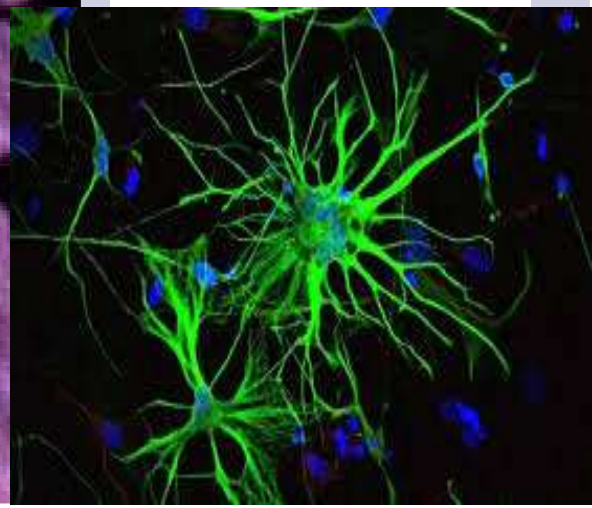

3
2
1
4
Blood vessel
Astrocyte
Neuron
Microglia
4. Actions on microglia
Actions on neurons

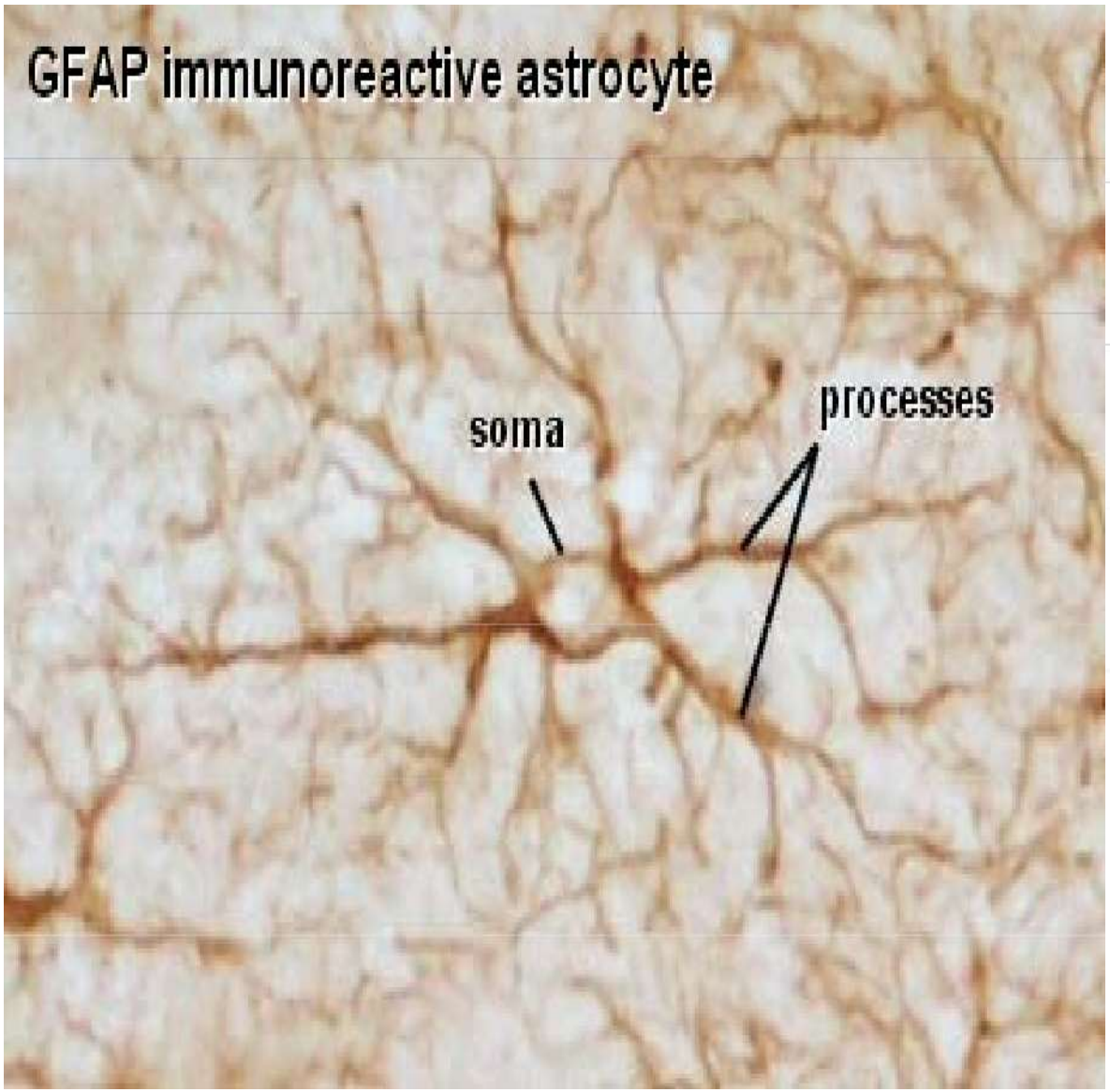

Capillary
Neuron
(a) Astrocyte

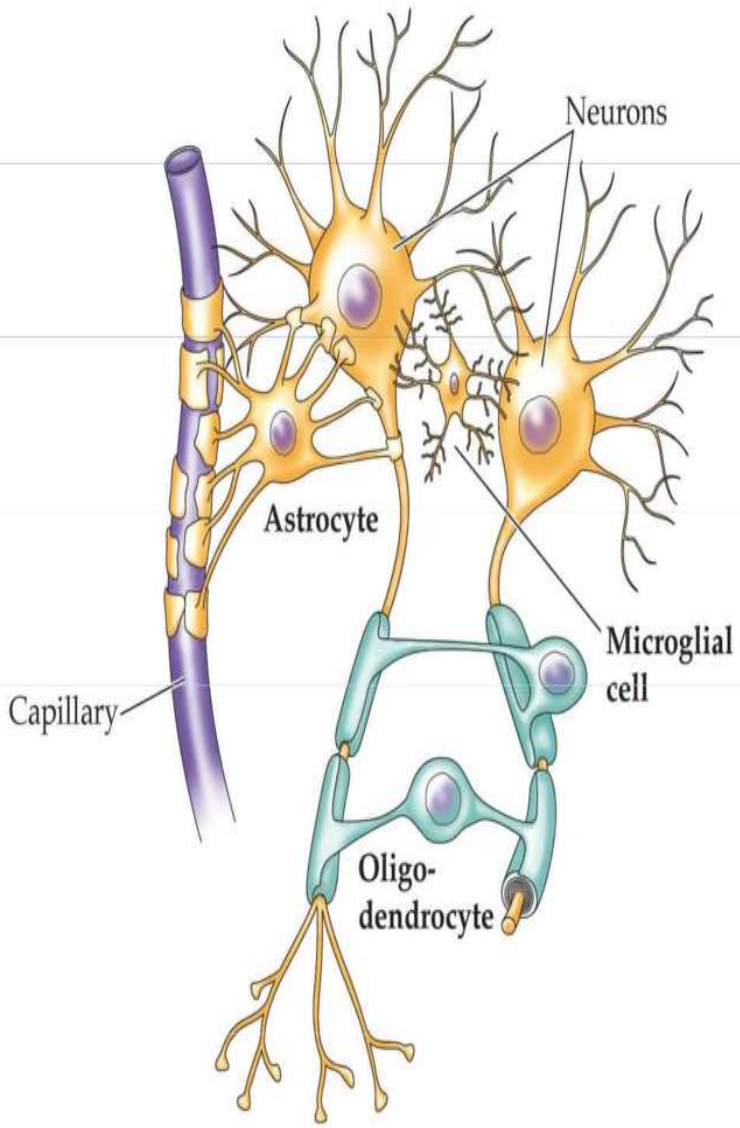


A:ASTROCYT ES numerous processes (B), some astrocytic processes are in contact with nerve fibers.

Other astrocytic processes surround capillaries (D) forming perivascular end-feet (C).



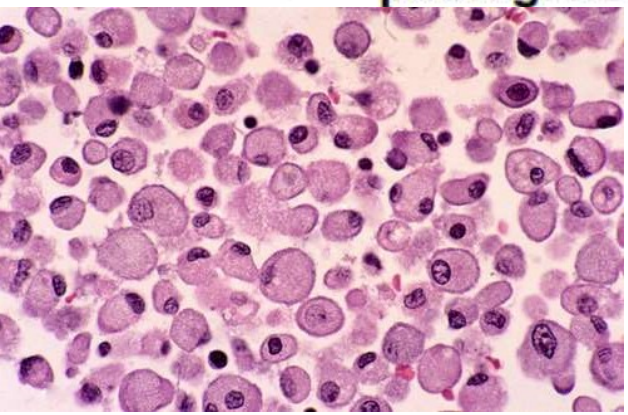

GFAP immunoreactive astrocyte
soma
processes

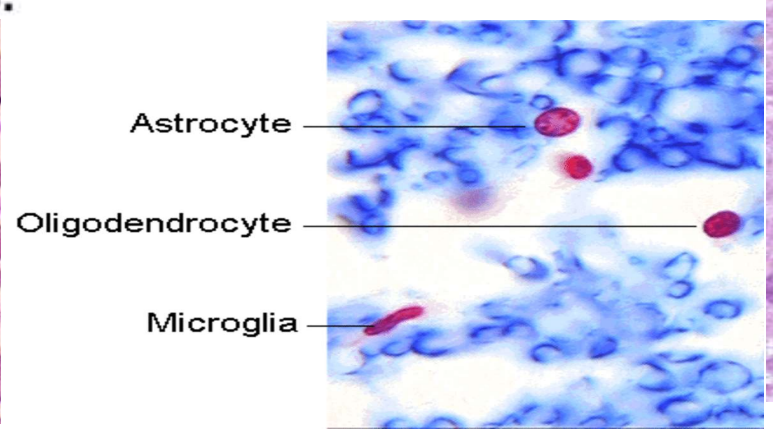

Neurons
Astrocyte
Microglial cell
Capillary
Oligo-dendrocyte

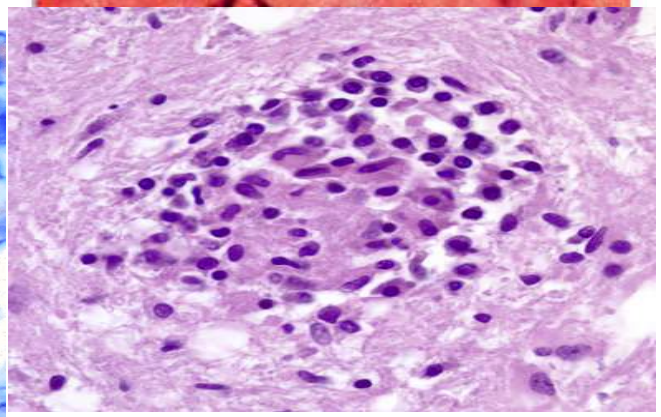
Neuroglia

2. **Microglia = Macrophage**

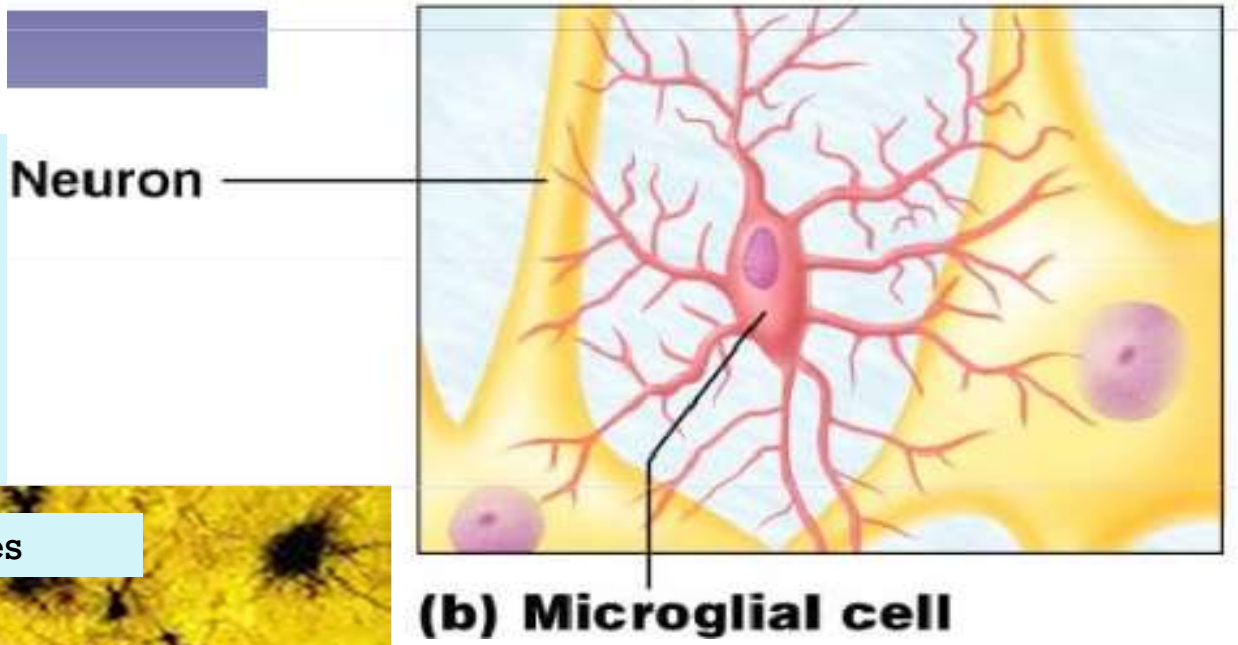
- **Specialized immune cells that act as the macrophages of the CNS**
- Why is it important for the CNS to have its own army of immune cells? Microglia
- - Microglia are small, with many fine-branched processes. They migrate
- through neural tissue, cleaning up cellular debris, waste products and
- pathogens.

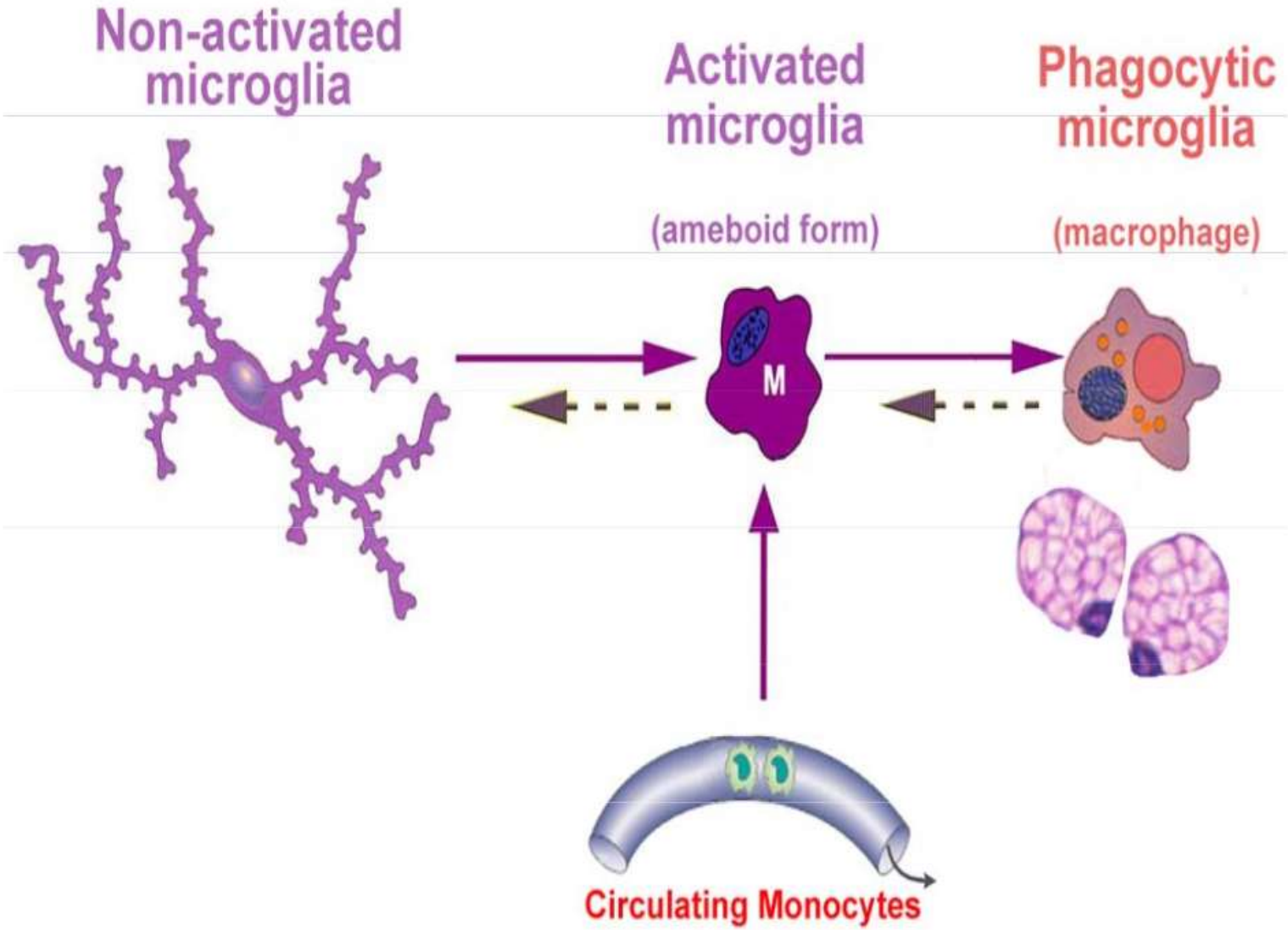






- **Microglia are cells of mesodermal origin that invade the CNS**
- **when it is vascularized.**
- **They have antigen presenting and phagocytic abilities.**
- **They have small elongated chromophilic nuclei.**



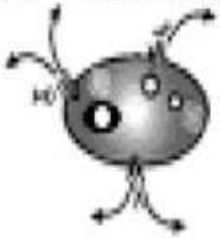

Non-activated microglia
Activated microglia
(ameboid form)
Phagocytic microglia
(macrophage)
M
Circulating Monocytes

MICROGLIA STIMULATORS

viruses

bacteria

dead cells/debris



CNS toxins

ABeta40/42

damaged neurons

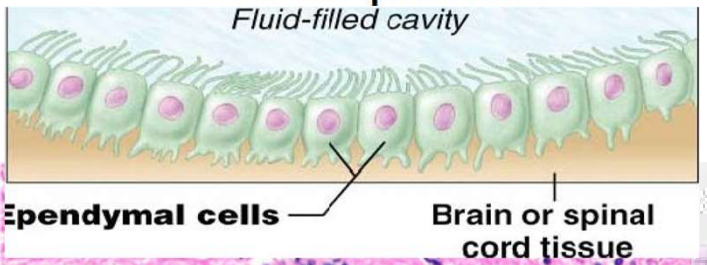
ischemia

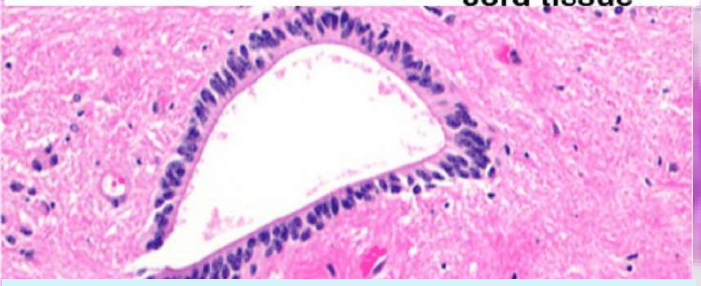
neuronal degeneration

activated astrocytes

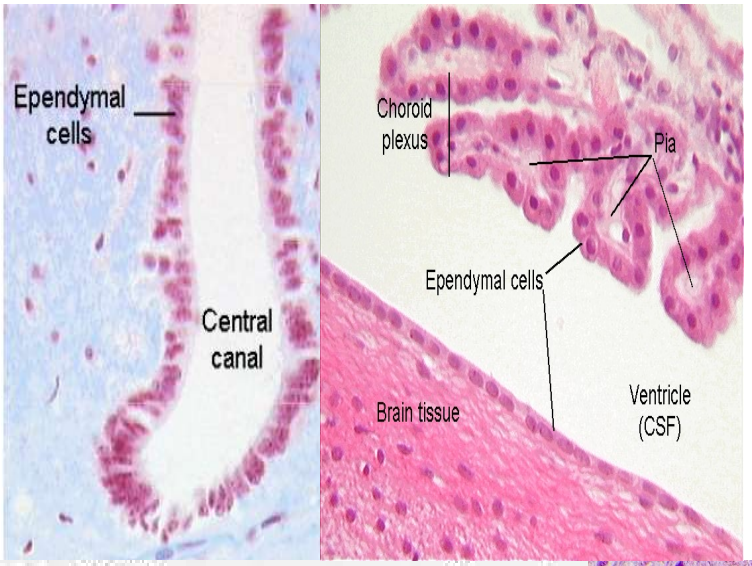
3. **Ependymal Cells**

- Low columnar epithelial-esque cells that line the ventricles of the brain and the central canal of the spinal cord
- Some are ciliated which facilitates the movement of cerebrospinal fluid

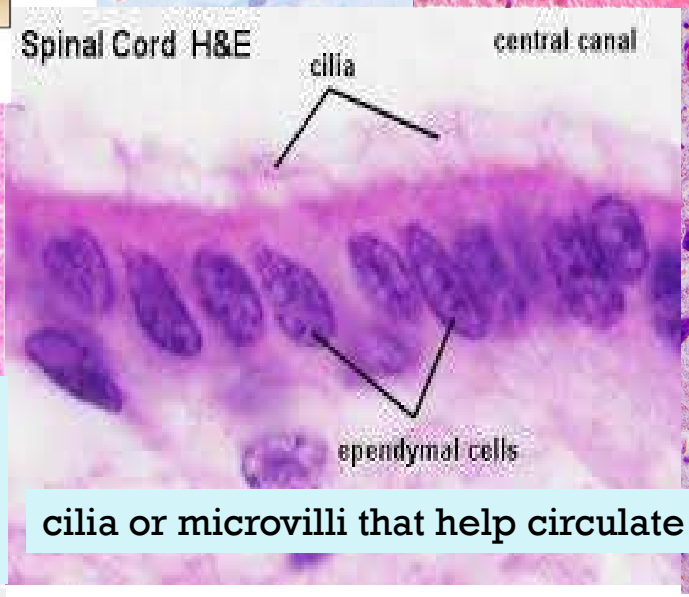




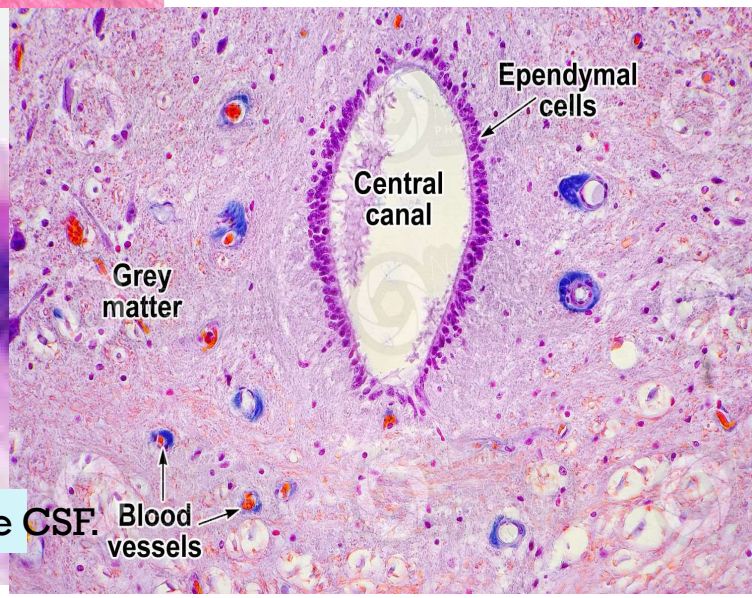
Others monitor the CSF or contain stem cells for repair. Processes of ependymal cells are highly branched and contact neuroglia directly

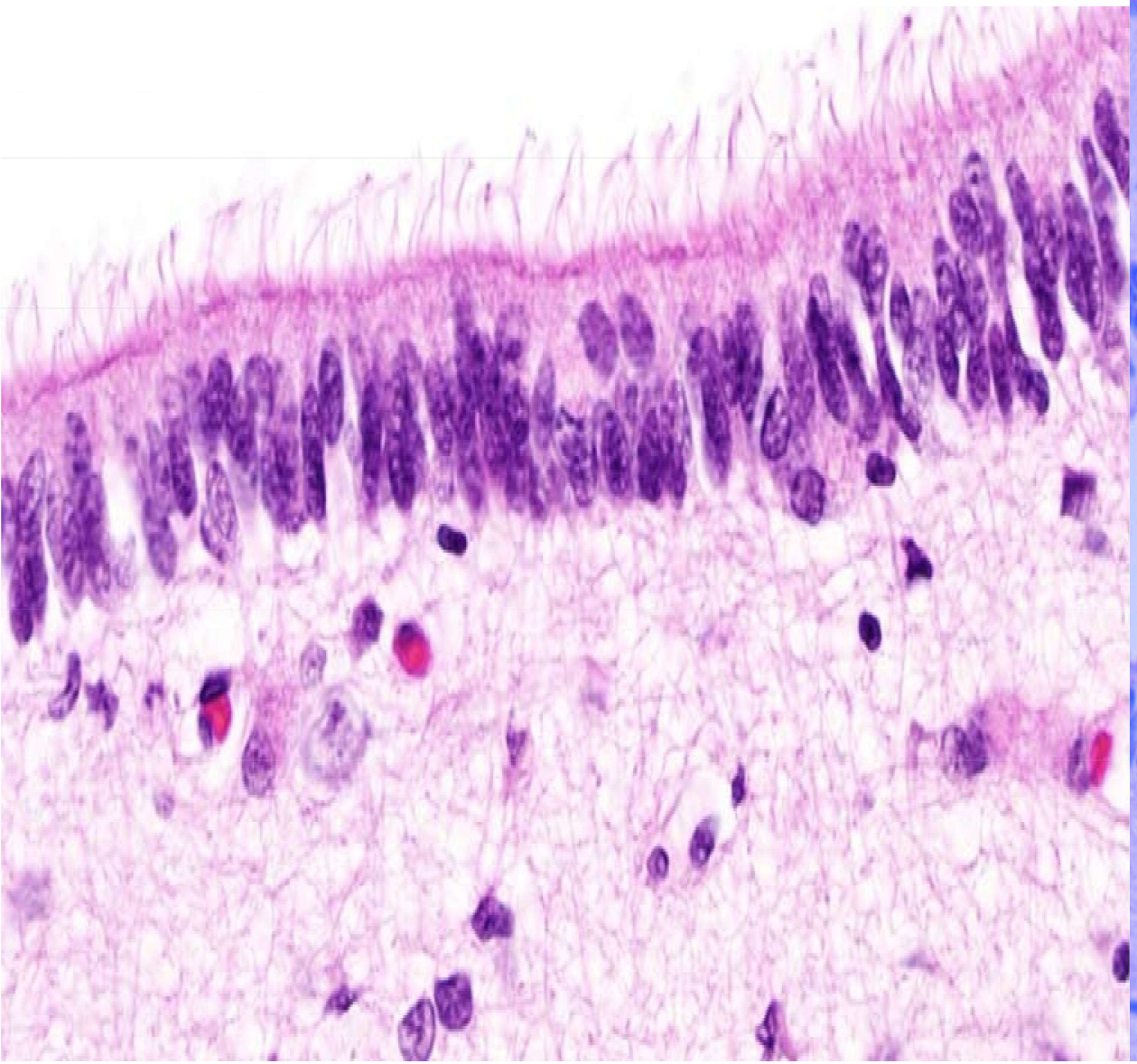


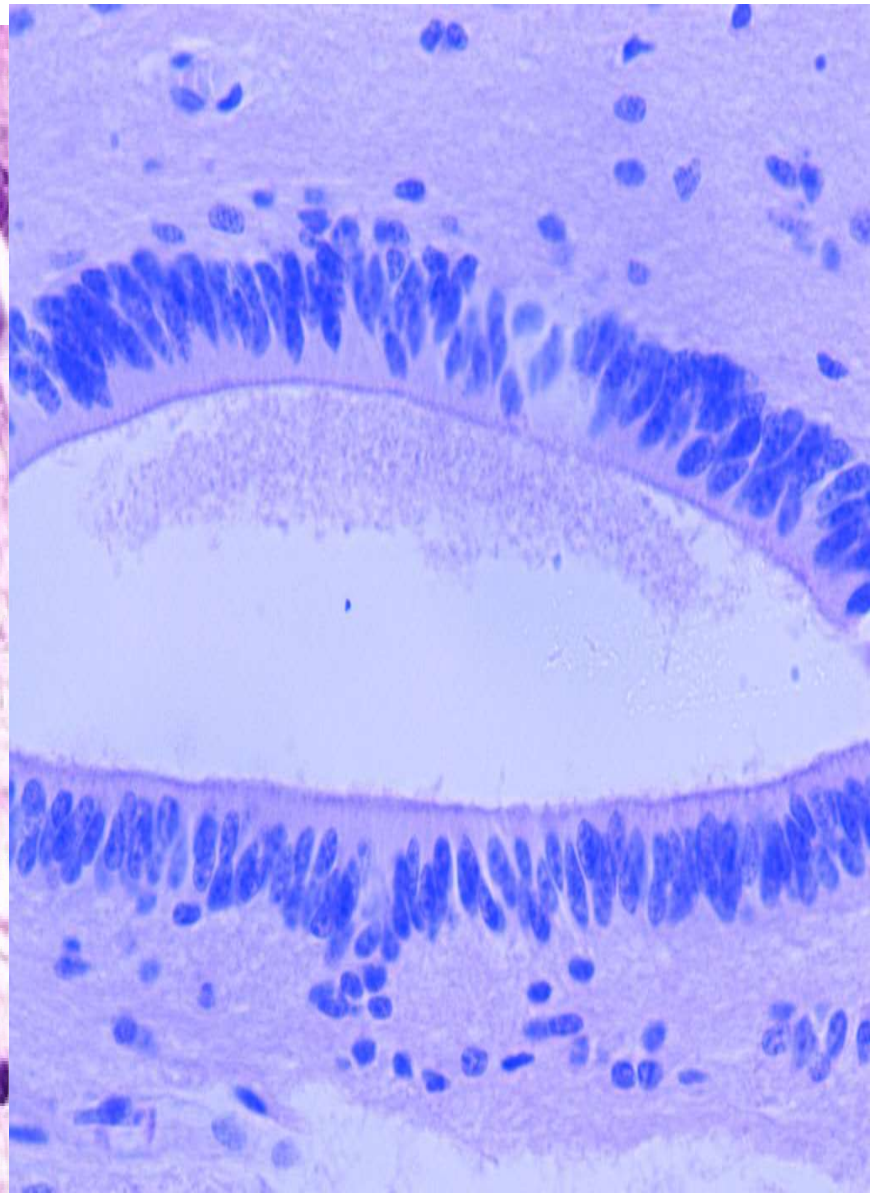
- **In the brain it form the choroid plexus that produces the CSF.**
- **Location, the ventricle in the brain**



cilia or microvilli that help circulate CSF.



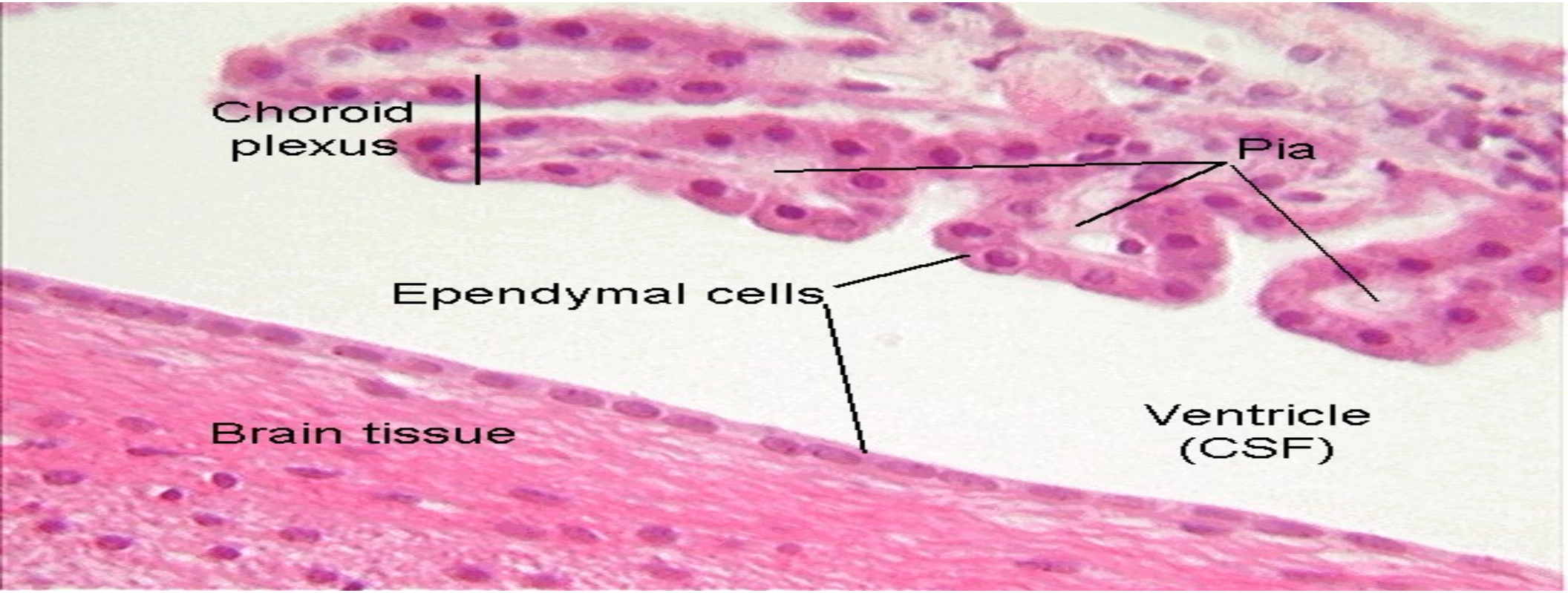




•The ventricles of the brain and the central canal of the spinal cord are lined with ependymal cells.

•The cells are often cilated and form a simple cuboidal or low columnar epithelium.

•The lack of tight junctions between ependymal cells allows a free exchange between cerebrospinal fluid and nervous tissue.

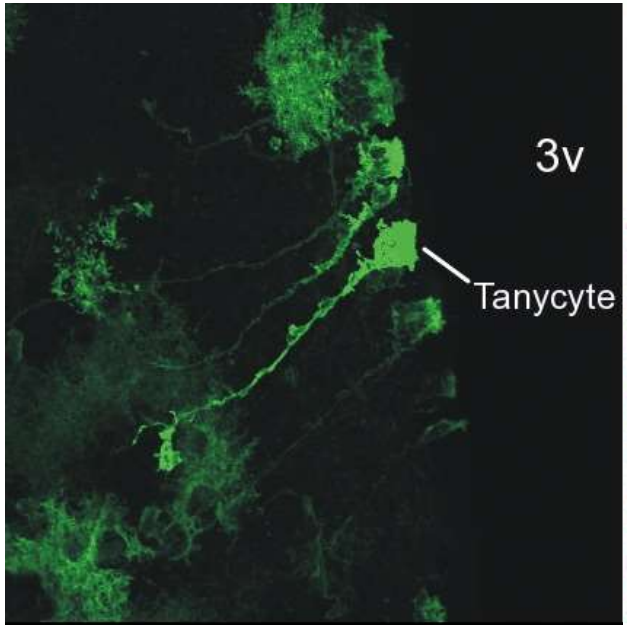


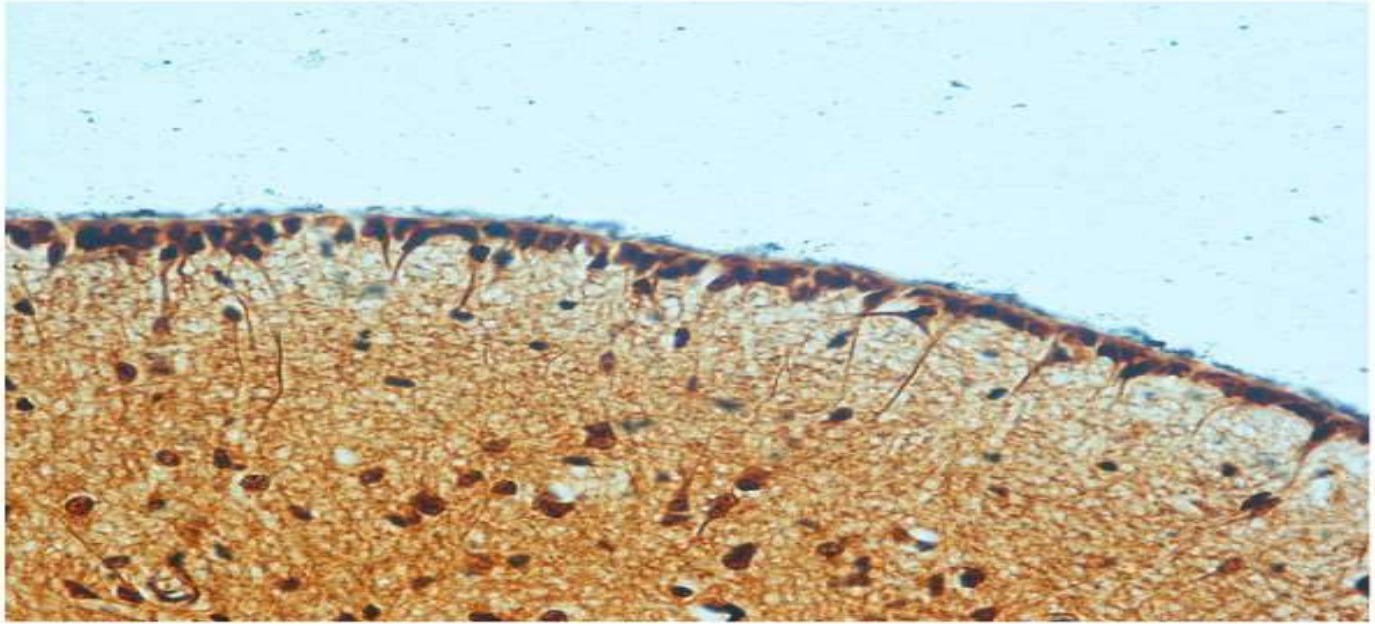
•**Tanycytes are special ependymal cells** located in the floor of the third ventricle having processes extending deep into the hypothalamus. It is possible that their function is to transfer chemical signals from CSF to CNS.

•**Tanycytes form the ventricular lining over the few CNS regions in which the blood-brain barrier is incomplete.**

•**They do form tight junctions and control the exchange of substances between these regions and surrounding nervous tissue or cerebrospinal fluid.**

•tanycytes participate in the release of gonadotropic hormone-releasing hormone (Gn-RH).

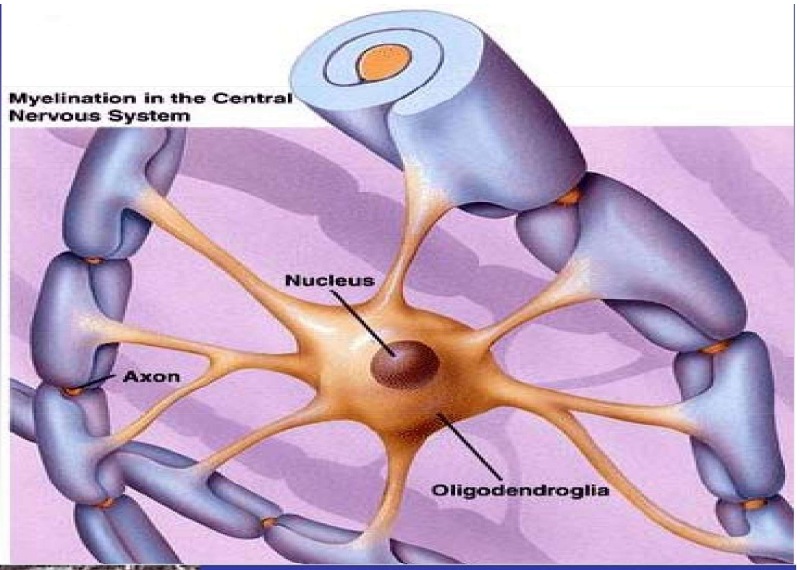


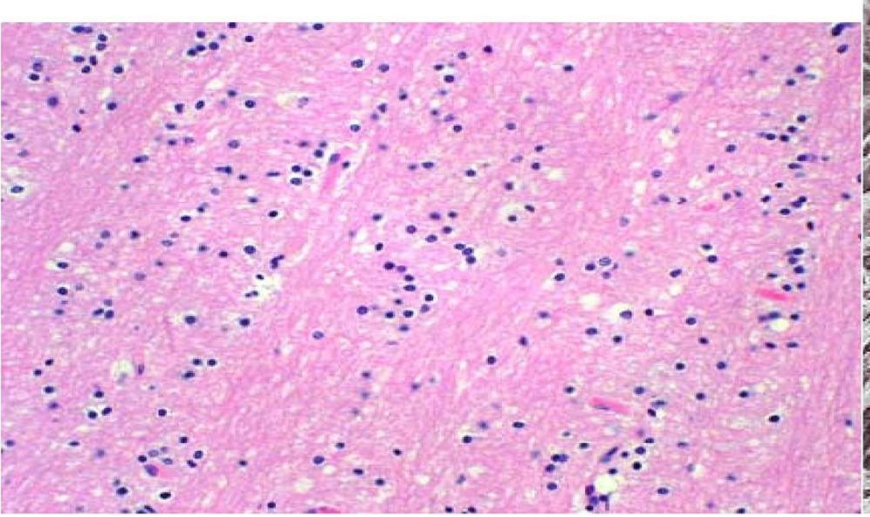


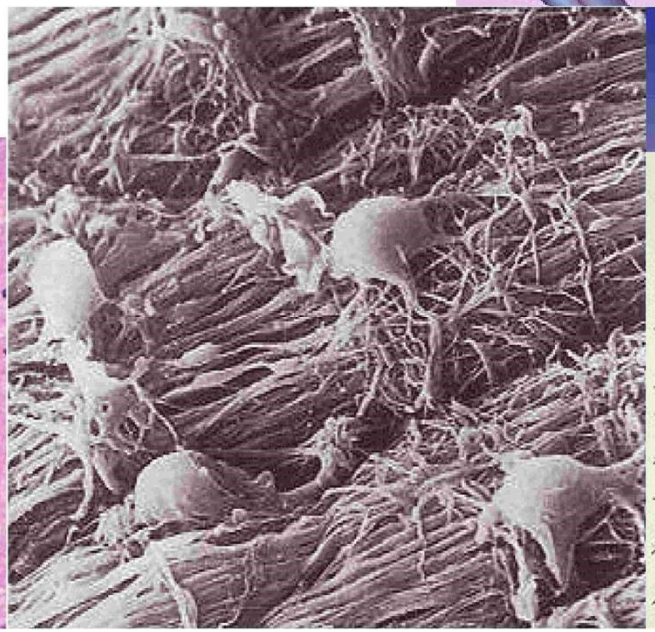
Neuroglia

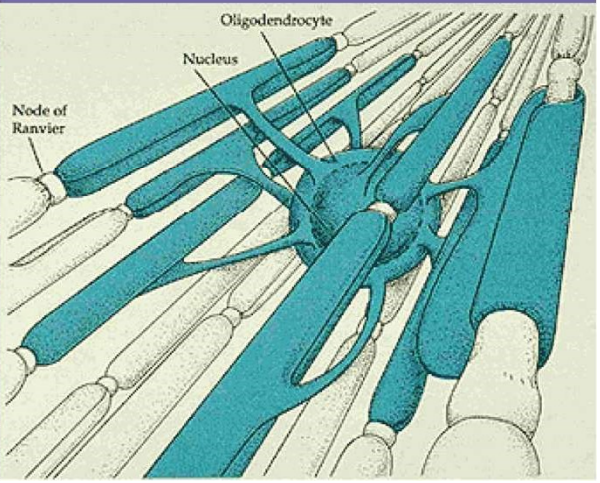
4.Oligodendrocytes

- Produce the myelin sheath which provides the electrical insulation for certain neurons in the CNS



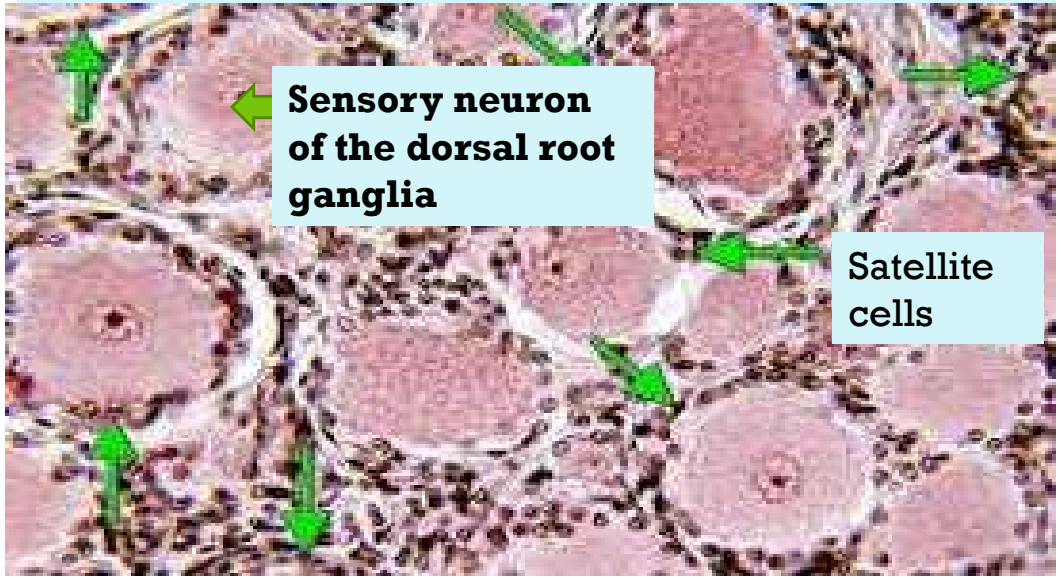


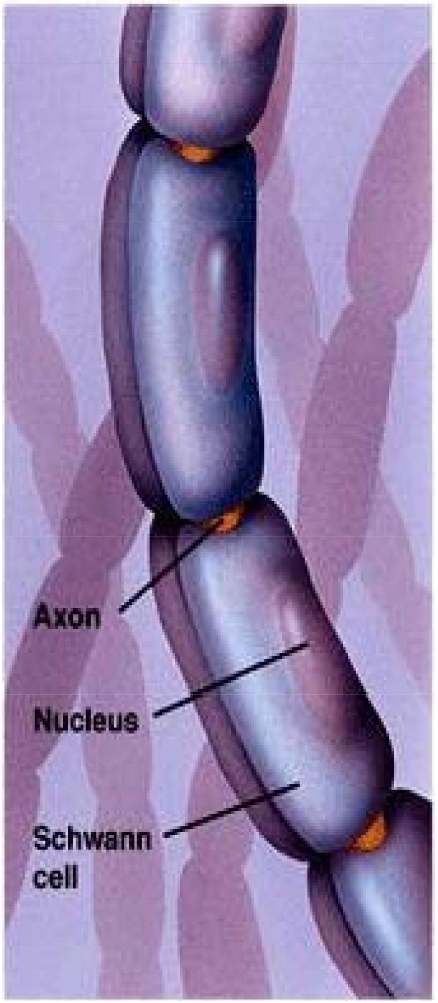


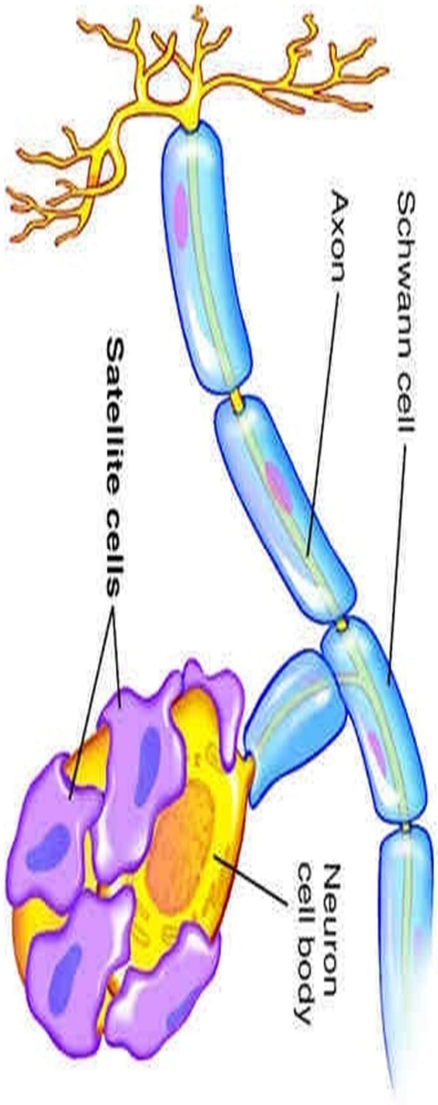


- 2 types of glia in the PNS

1. **Satellite glial cells**
   - Surround clusters of neuronal cell bodies in the PNS
   - Unknown function
2. **Schwann cells**
   - Form myelin sheaths around the larger nerve fibers in the PNS.
   - Vital to neuronal regeneration



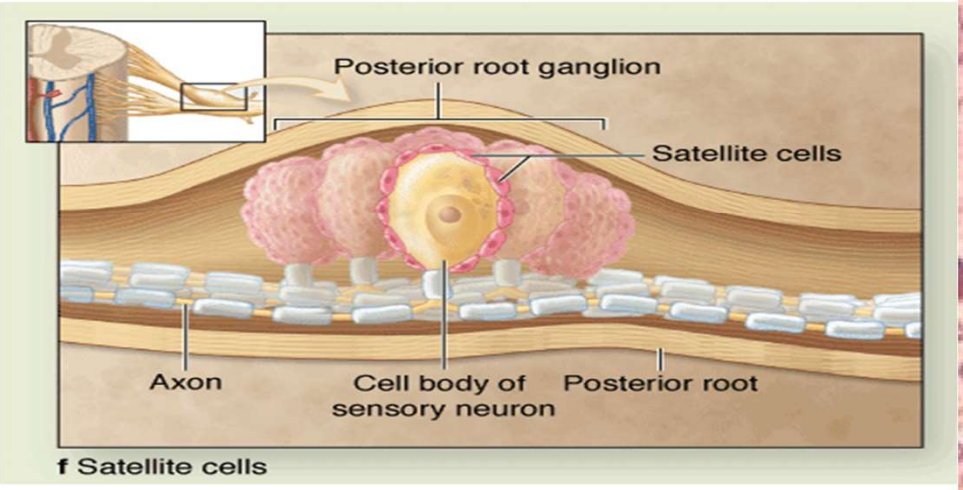




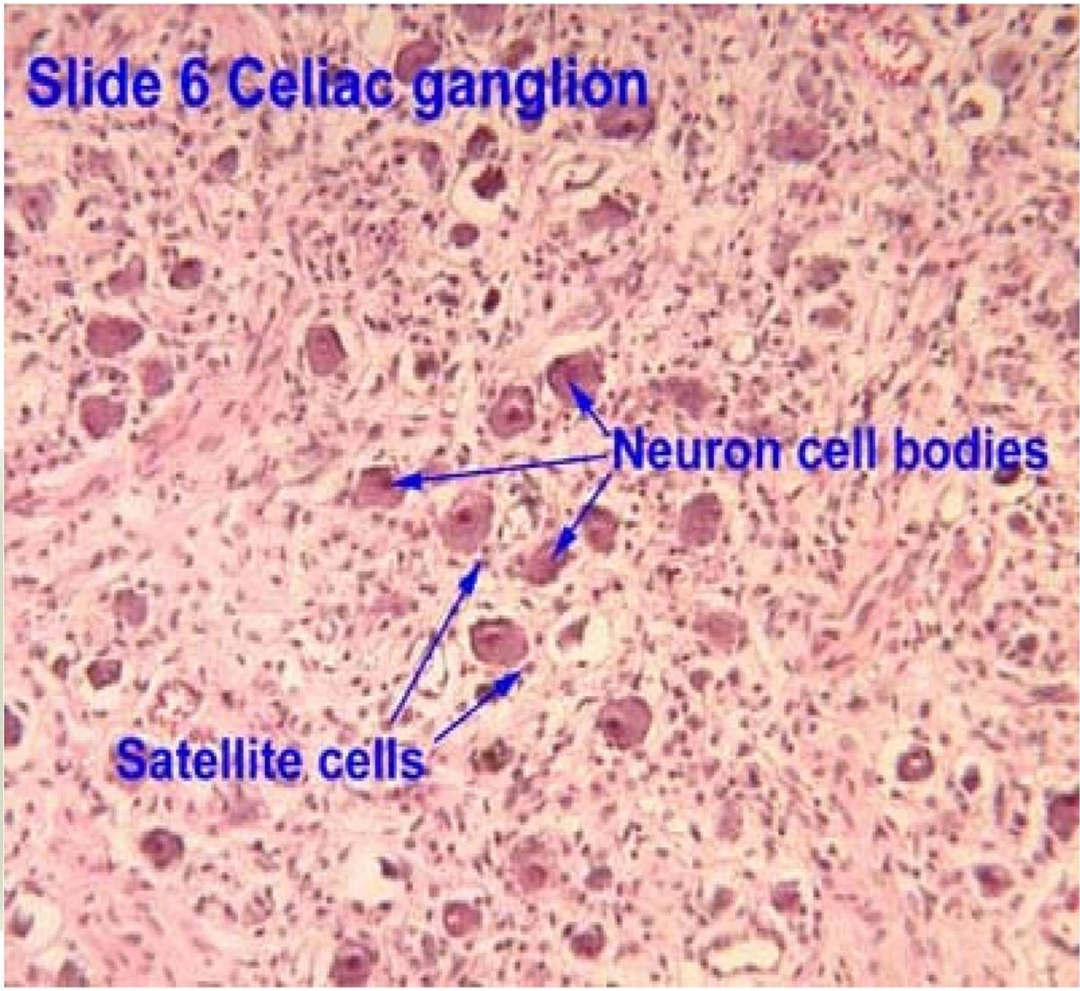
Satellite glial cells are the principle glial cells found in the peripheral nervous system,

- **specifically in sensory,**
- **sympathetic,**
- **parasympathetic ganglia**

•Might have the same role as astrocytes



f Satellite cells

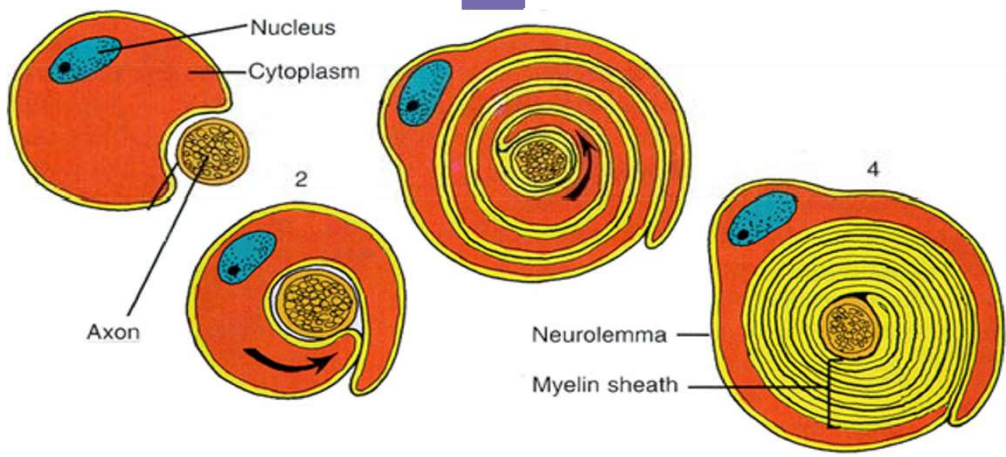


Do not confuse with :

Myosatellite cells or **satellite cells** are small mononuclear progenitor cells with virtually no cytoplasm found in mature muscle. hey are found sandwiched between the basement membrane and sarcolemma (cell membrane) of individual muscle fibers. These cells represent the oldest known adult stem cell niche, and are involved in the normal growth of muscle, as well as regeneration following injury or disease.

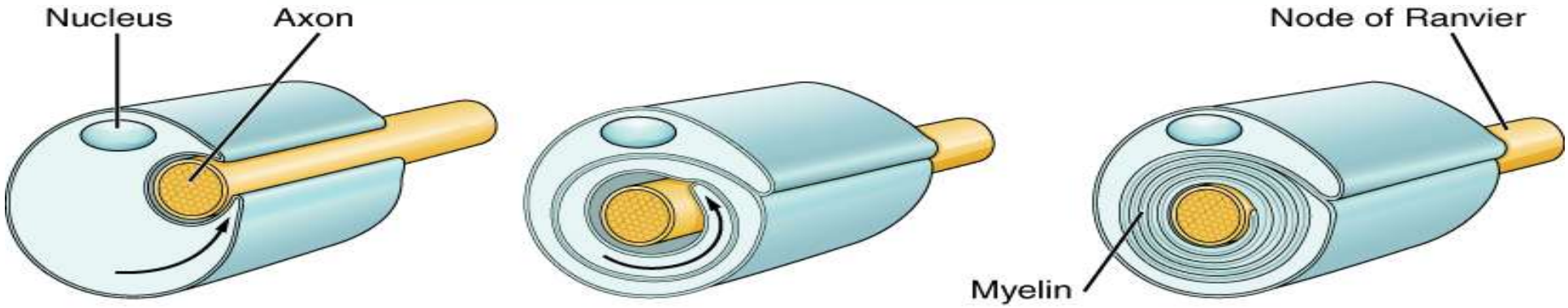
Myelin Sheath and Neurilemma: Formation

- Formed by Schwann cells in the PNS
- A Schwann cell:
  - Envelopes an axon in a trough
  - Encloses the axon with its plasma membrane
  - Has concentric layers of membrane that make up the myelin sheath
- Neurilemma – remaining nucleus and cytoplasm of a Schwann cell

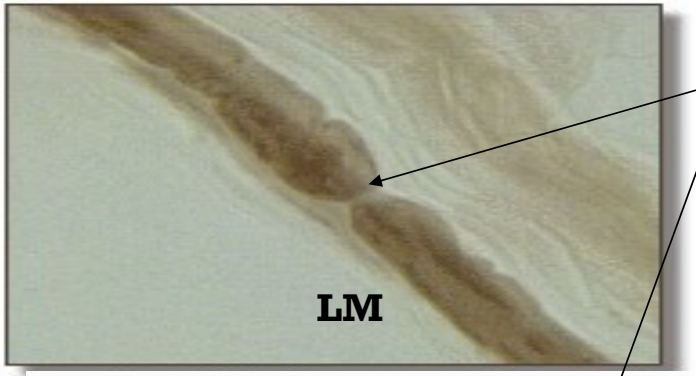


MYELIN SHEATH

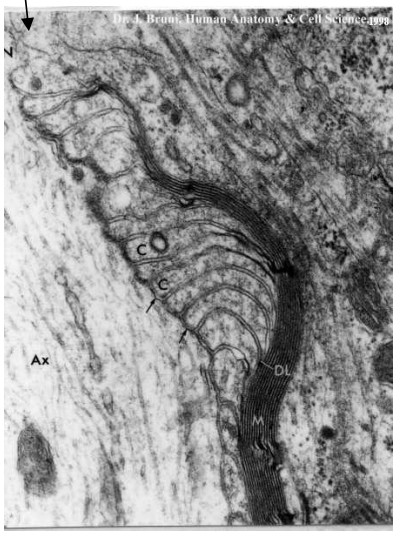
1. Myelin Sheaths greatly increase the speed of impulse along an axon.
2. Myelin is composed of 80% lipid and 20% protein.
3. Myelin is made of special cells called Schwann Cells that forms an insulated sheath, or wrapping around the axon.
4. There are **SMALL NODES or GAPS** called the **Nodes of Ranvier** between adjacent myelin sheath cells along the axon.
5. As an impulse moves down a myelinated (covered with myelin) axon, the impulse JUMPS form Node to Node instead of moving along the membrane.
6. This jumping from Node to Node greatly increase the speed of the impulse.
7. Some myelinated axons conduct impulses as rapid as 200 meters per second.
8. The formation of myelin around axons can be thought of as a crucial event in evolution of vertebrates.
9. Destruction of large patches of Myelin characterize a disease called **Multiple Sclerosis**. In multiple sclerosis, small, hard plaques appear throughout the myelin. Normal nerve function is impaired, causing symptoms such as double vision, muscular weakness, loss of memory, and paralysis.

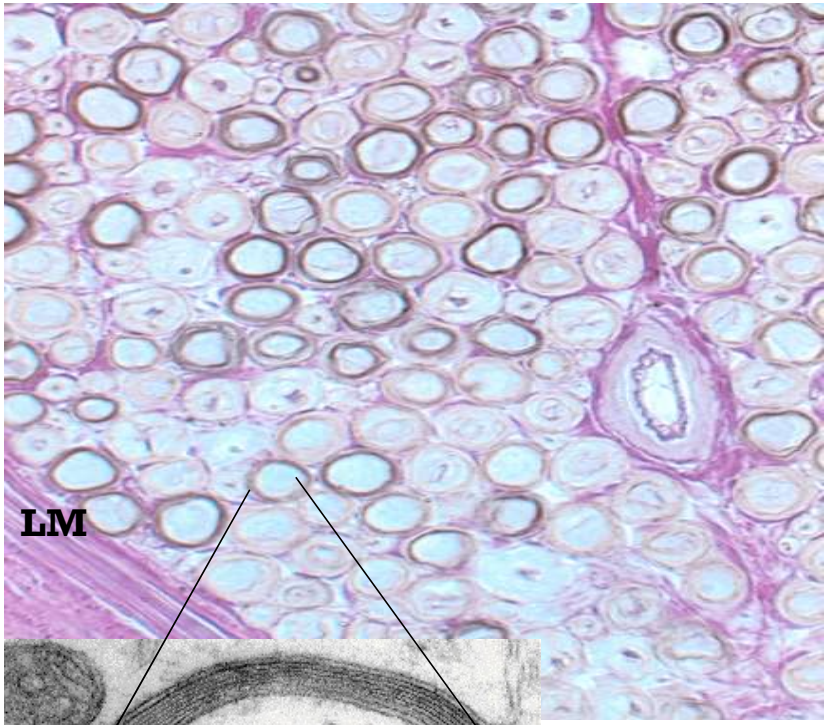


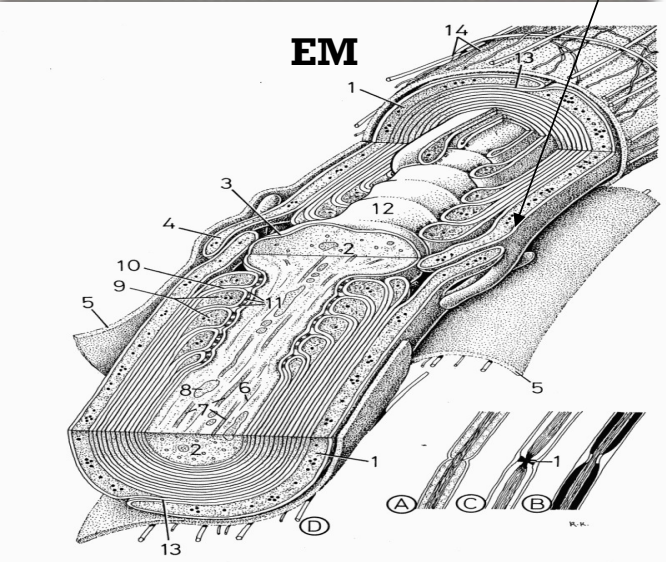
NERVE FIBERS: MYELINATED AXONS



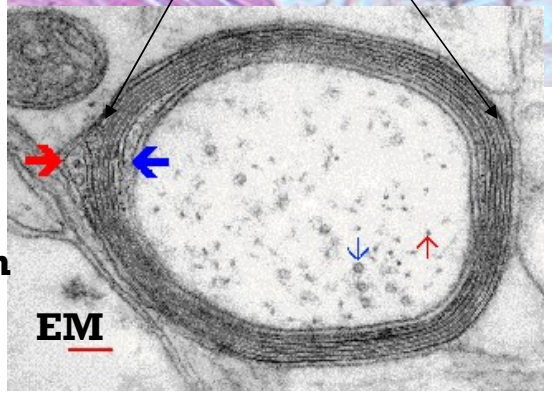
Node of Ranvier

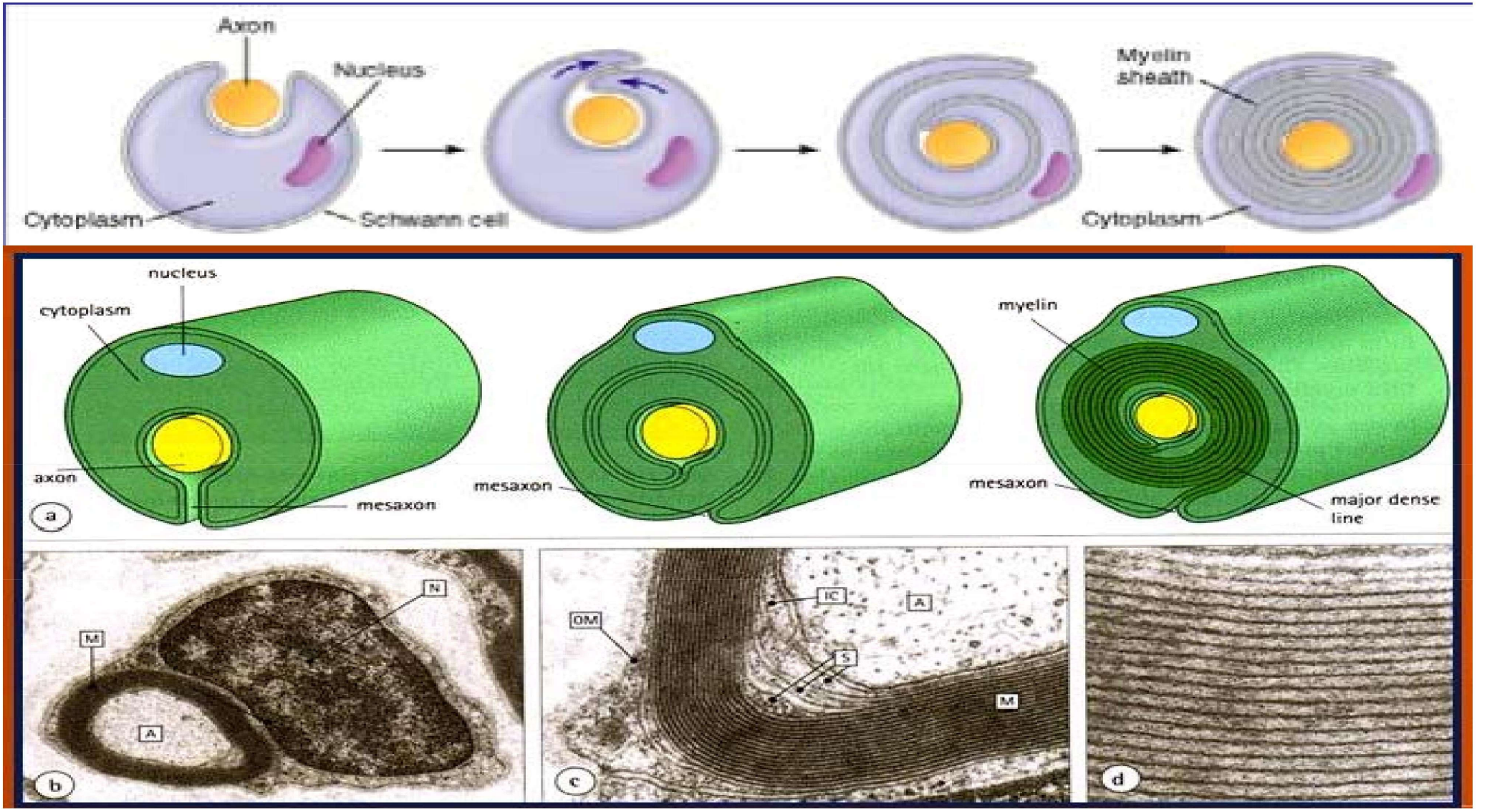


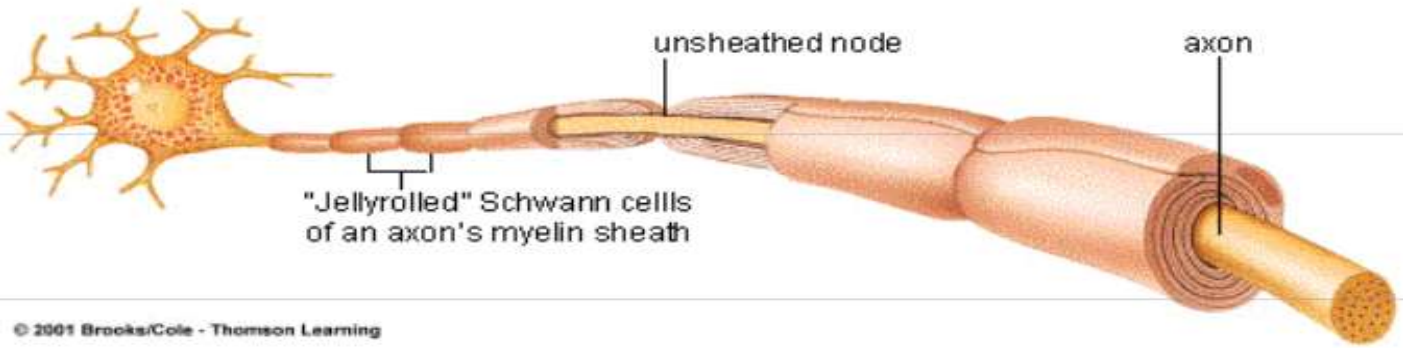




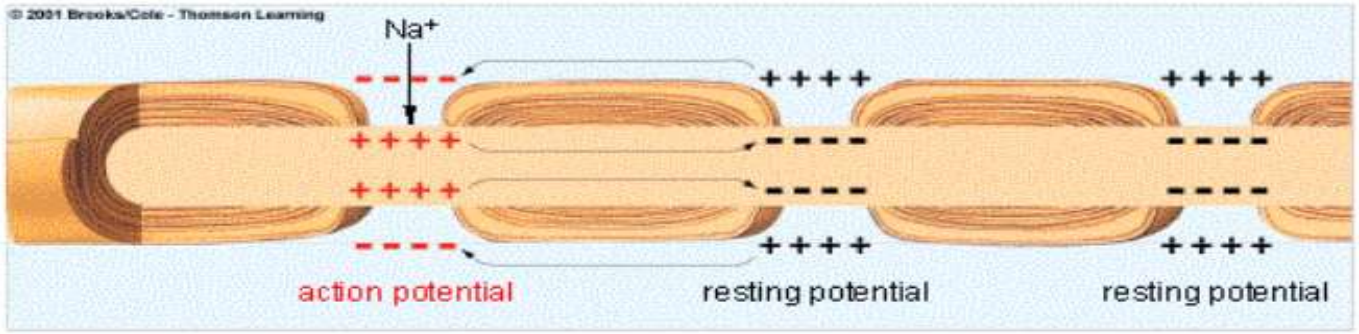
Red arrow: outer mesaxon
Blue arrow: inner mesaxon
Small red arrow: neuro-filament
Small blue arrow: micro-tubulus

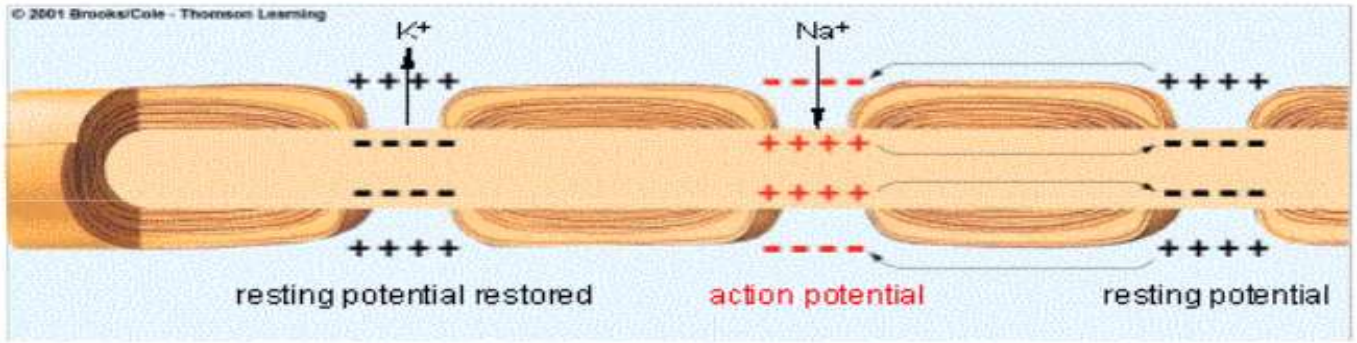



Axon
Nucleus
Cytoplasm
Schwann cell
Myelin sheath
Cytoplasm
nucleus
cytoplasm
axon
mesaxon
a
mesaxon
myelin
mesaxon
major dense line
N
M
A
b
OM
IC
A
S
M
c
d

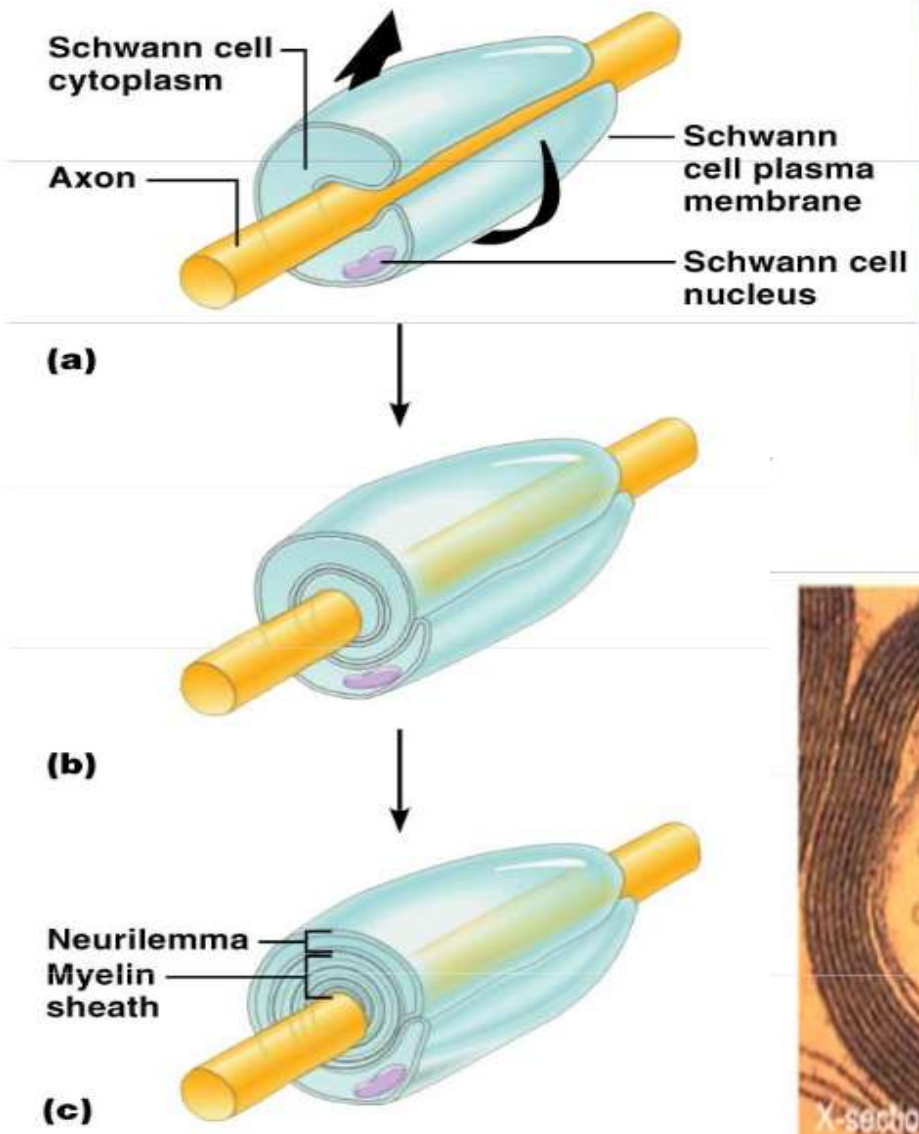


Myelin Sheath



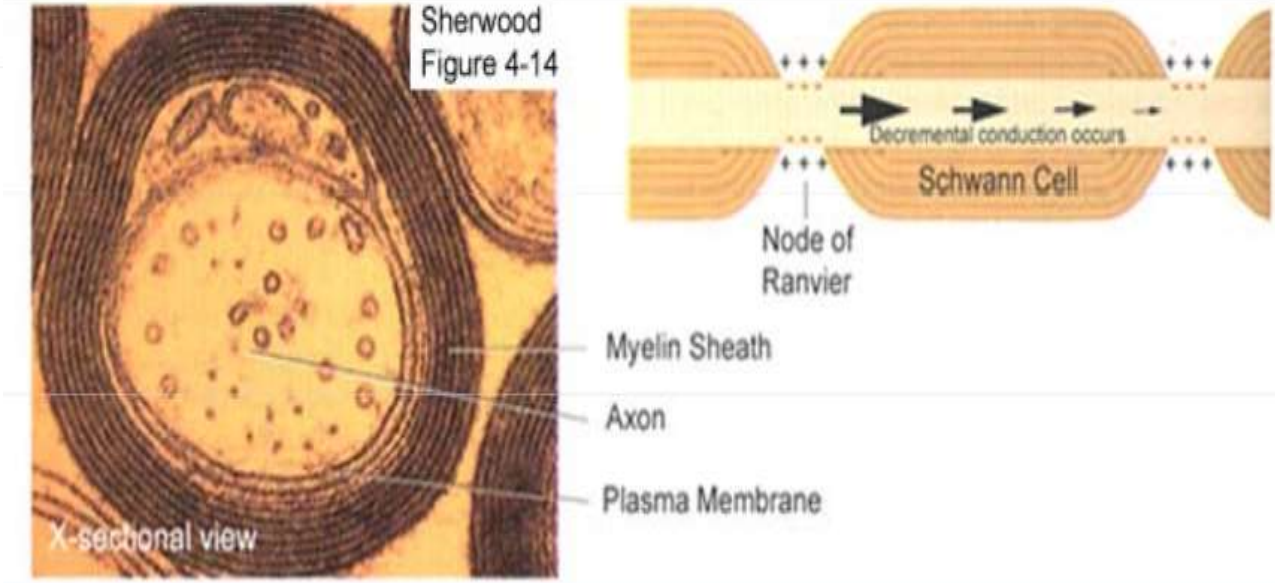


- A series of Schwann cells
- Sheath blocks ion movements
- Action potential must "jump" from node to node



The outer nucleated cytoplasmic layer of the neurolemmocyte, which encloses the myelin sheath, is called the neurolemma (sheath of Schwann). A neurolemma is found only around the axons in the PNS. When an axon is injured, the neurolemma aids in the regeneration by forming a regeneration tube that guides and stimulates regrowth of the axon. At intervals along an axon, the myelin sheath has gaps called neurofibral nodes (nodes of Ranvier).

Action Potential Leaps From Node of Ranvier to Node of Ranvier



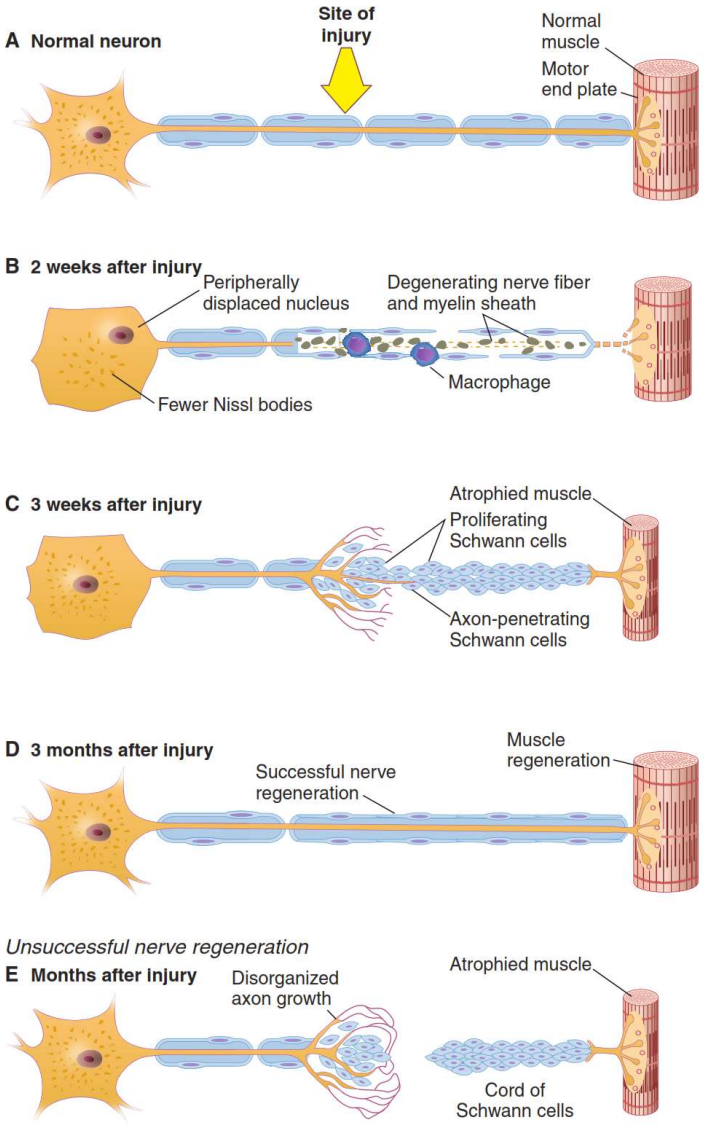


FIGURE 5.2. Wallerian (anterograde) degeneration and regeneration of a nerve fiber.