

**HISTOLOGICAL
EXAMINATION OF THE
NERVOUS TISSUE**

LECTURE OUTLINE

- *Cells* of the Nervous System: Structure and Function
- *CNS Organization* and *Correlation with Histology*
- *Blood-Brain Barrier*
- *Meninges*
- Peripheral Nervous System (*PNS*) Histology: *Nerves* and *Ganglia*

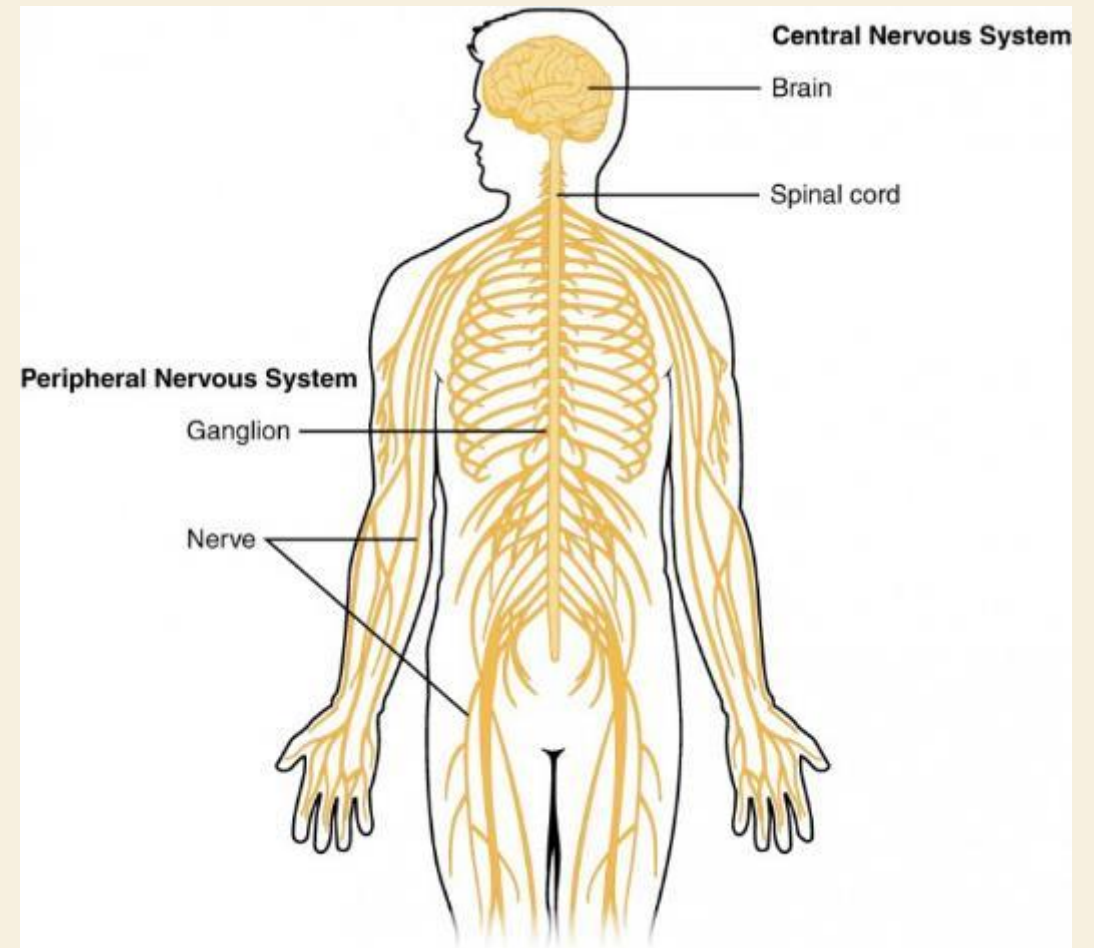
CELLS OF THE NERVOUS SYSTEM: WHERE ARE THEY LOCATED?

- **Central Nervous System (CNS)**

- ✓ Brain
- ✓ Spinal Cord

- **Peripheral Nervous System (PNS)**

- ✓ Nerves (Cranial + Spinal)
- ✓ Ganglia (groups of nervous Cell Bodies outside the CNS)



CELLS OF THE NERVOUS SYSTEM: ONLY 2 TYPES!!!

1. ***Neurons***

2. ***Glial Cells*** (or ***Supporting Cells***)

- ✓ Astrocytes (CNS)
- ✓ Oligodendrocytes (CNS)
- ✓ Ependymal Cells (CNS)
- ✓ Microglial Cells (CNS)
- ✓ Schwann Cells (PNS)
- ✓ Satellite Cells (PNS)

NEURONS: THE DUDE OF THE NERVOUS SYSTEM

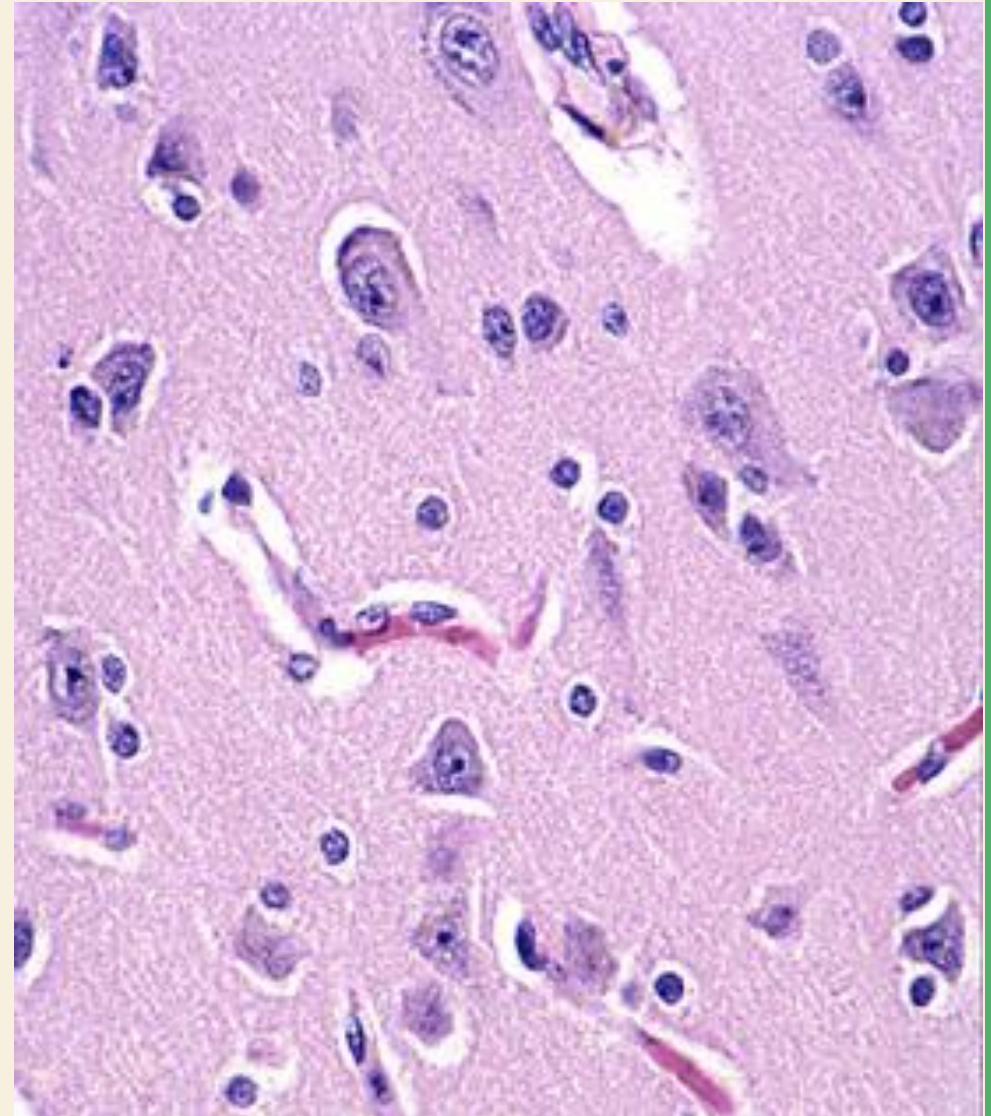


CELLS OF THE NERVOUS SYSTEM: ONLY 2 TYPES!!!

Neurons: big cells

Glial Cells: small cells

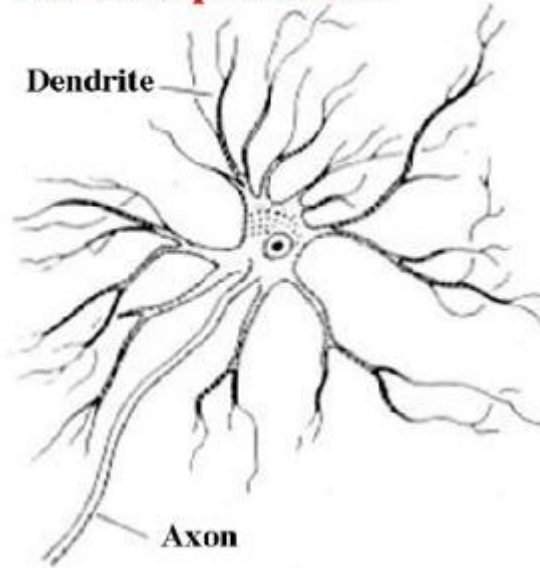
Glial cells about **10 times more abundant**
than Neurons in Brain!!!



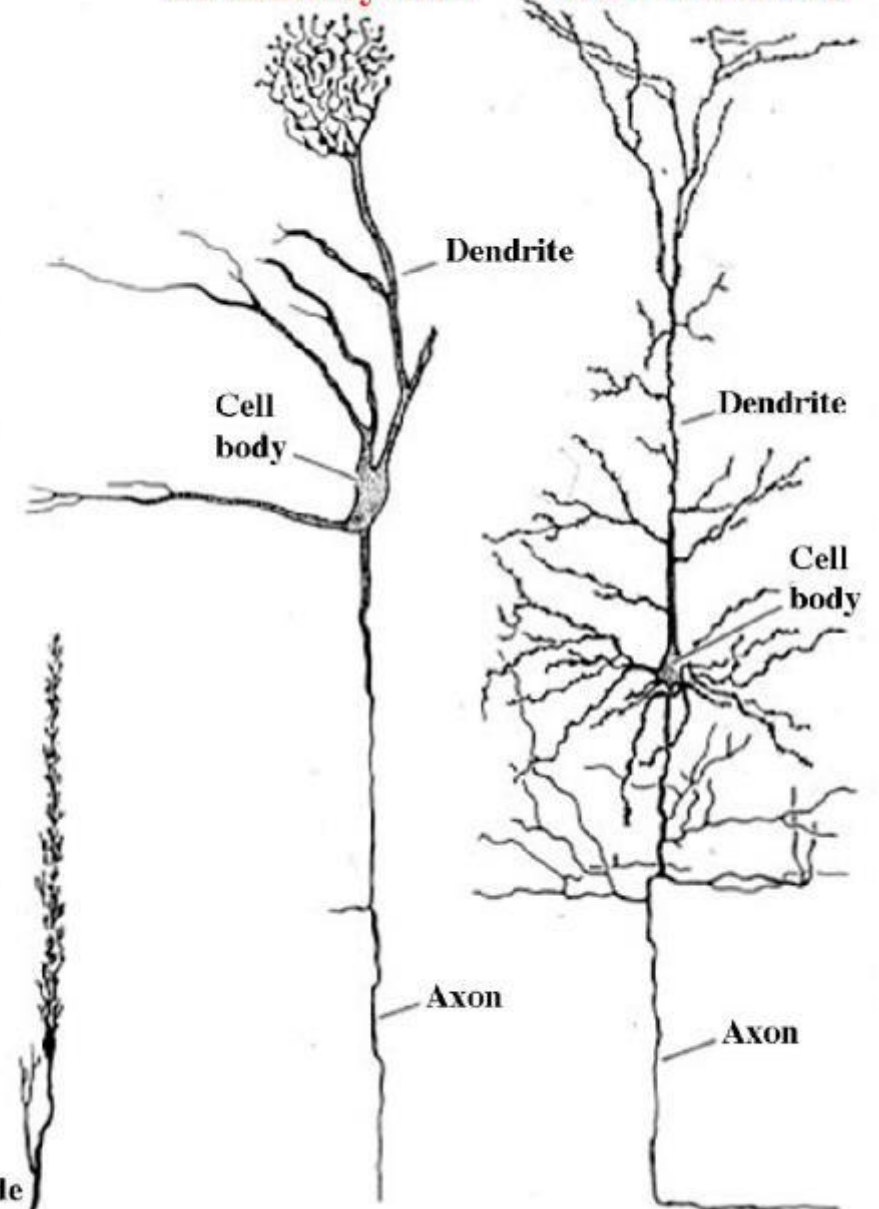
CELLS OF THE NERVOUS SYSTEM: **NEURONS**

Various Cell Structures to serve
different Functions

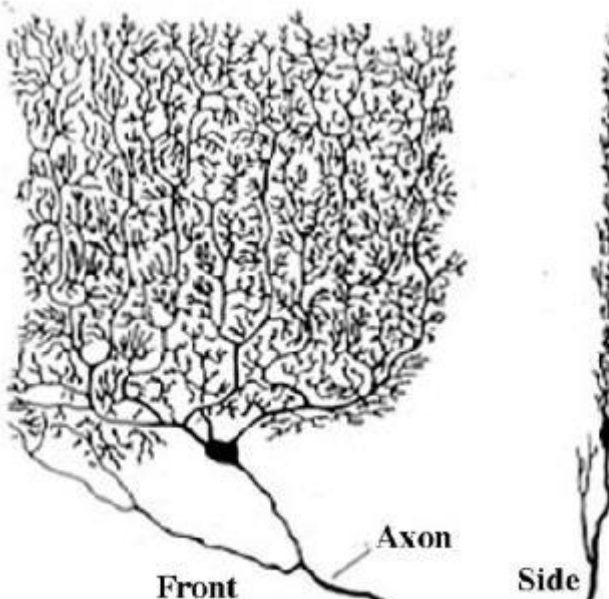
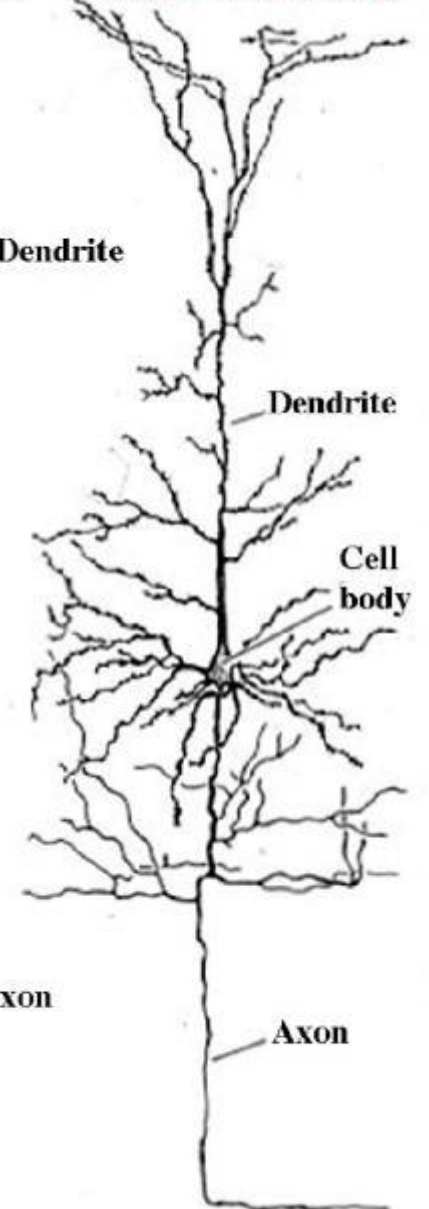
**Motor neuron
from the spinal cord**



**Mitral cell from
the olfactory bulb**



**Pyramidal cell
from the cortex**



Purkinje cell from the cerebellum

CELLS OF THE NERVOUS SYSTEM: ***NEURONS: BIG AND SMALL***

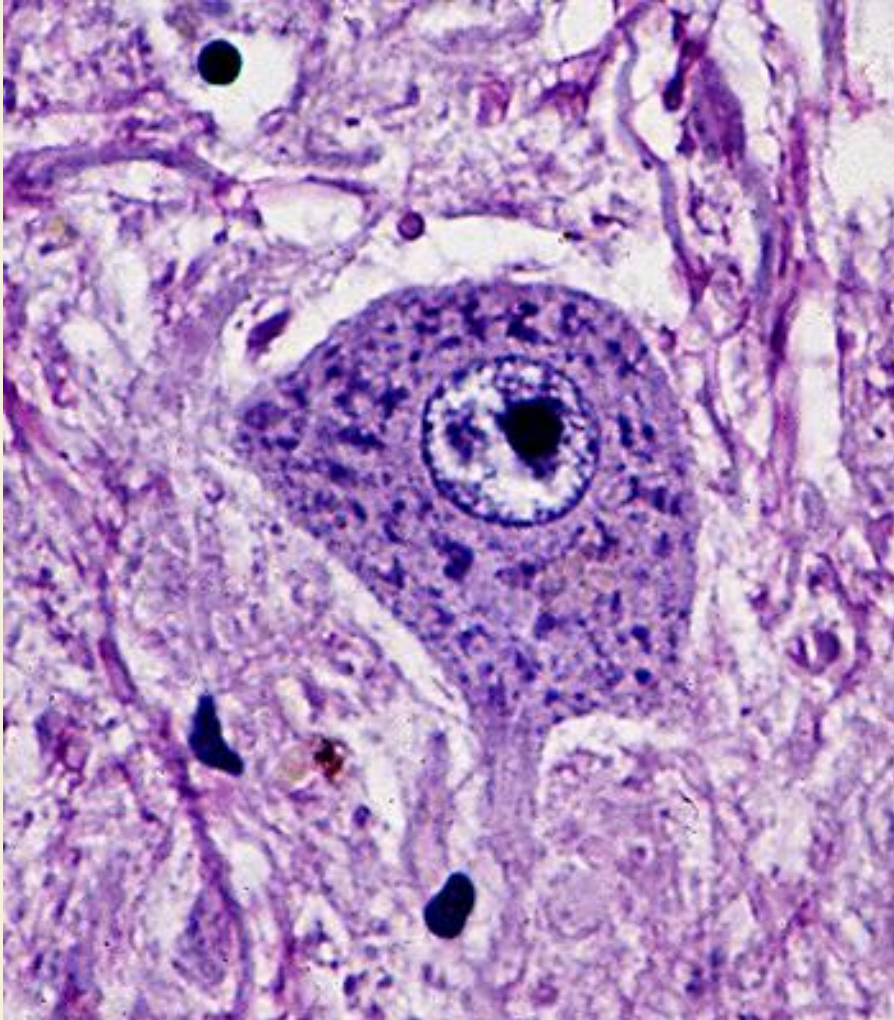


Image from: <http://neuropathology-web.org/chapter1/chapter1aNeurons.html>

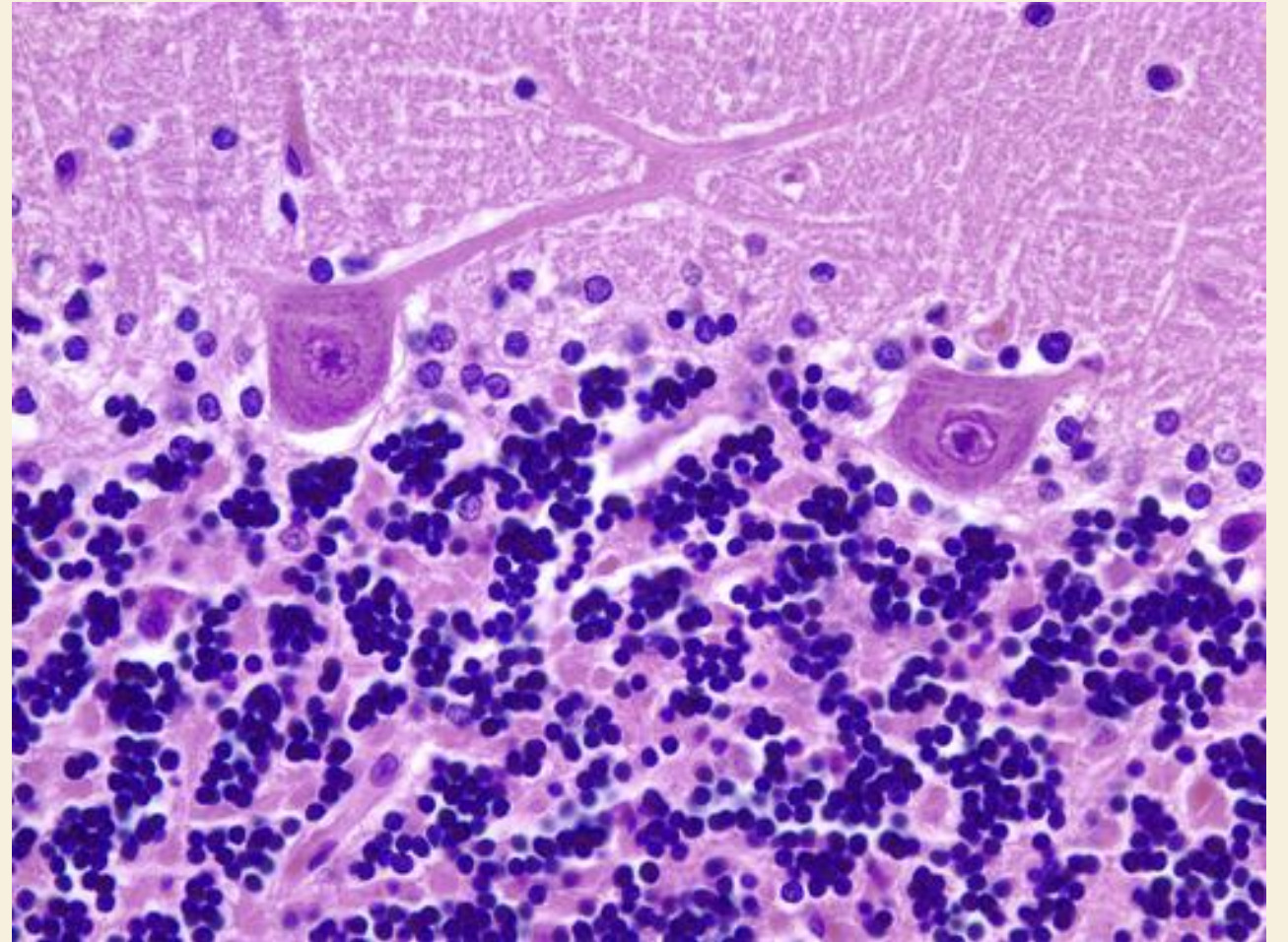
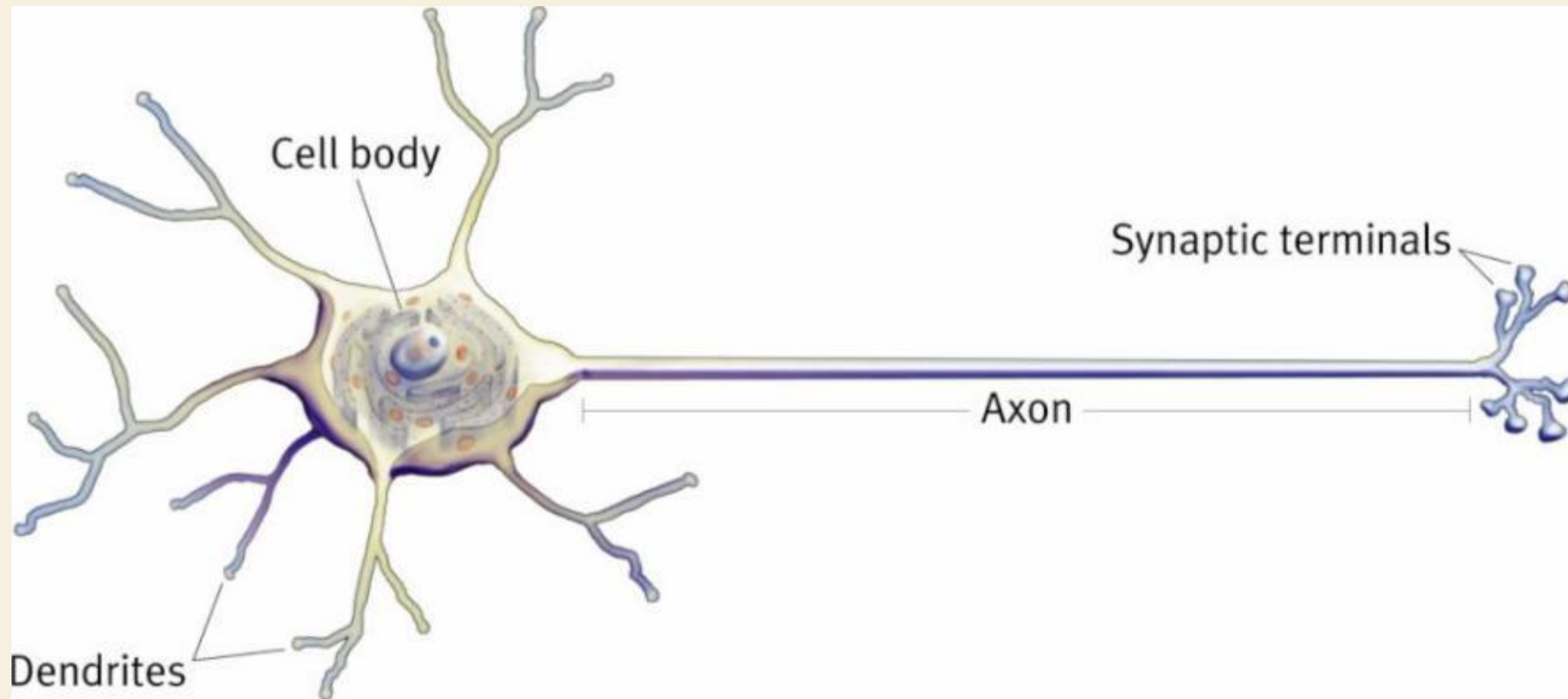


Image from: <http://neuropathology-web.org/chapter1/chapter1aNeurons.html>

CELLS OF THE NERVOUS SYSTEM: ***NEURONS***

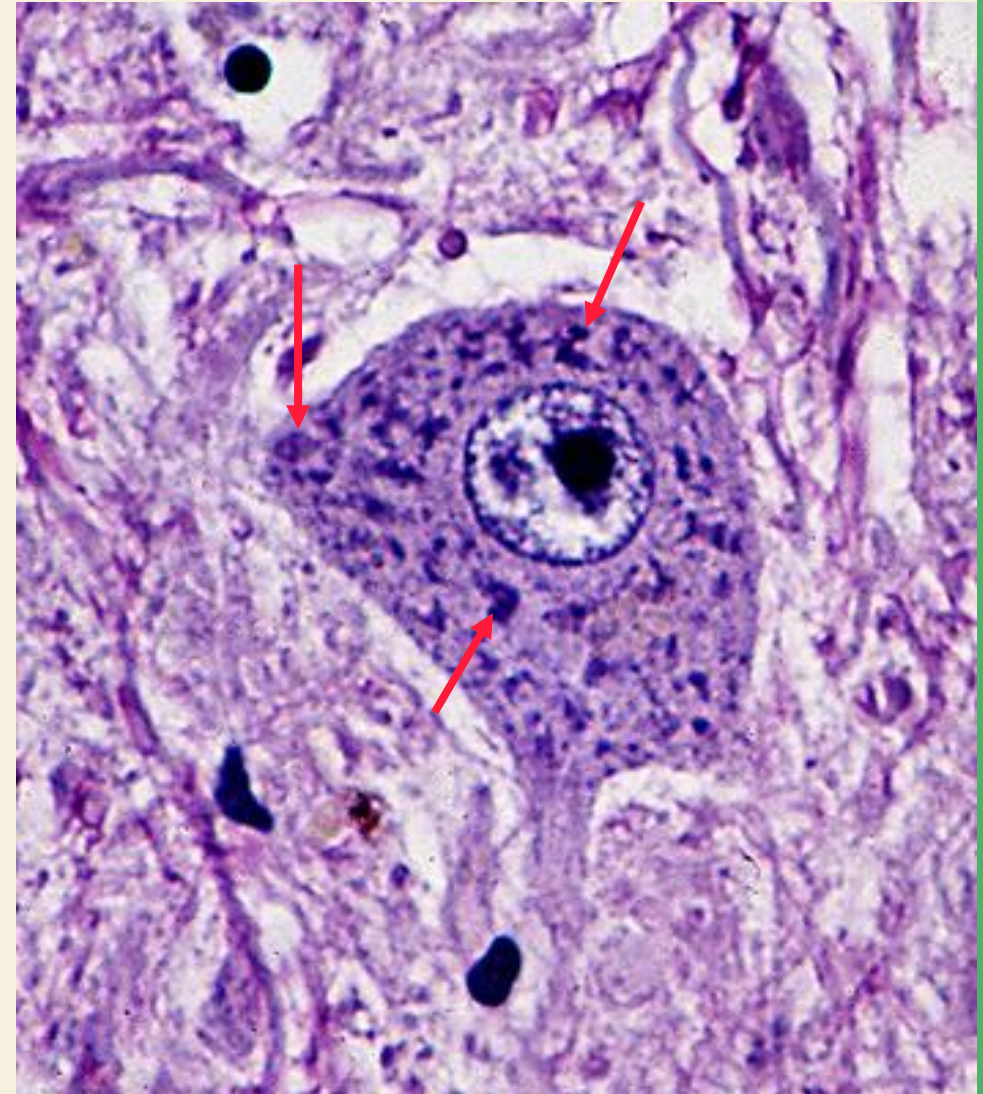
- **Cell Body** (or Perikaryon)
- **Axon**
- **Dendrites**



CELLS OF THE NERVOUS SYSTEM: ***NEURONS***

Nissl Substance (red arrows)

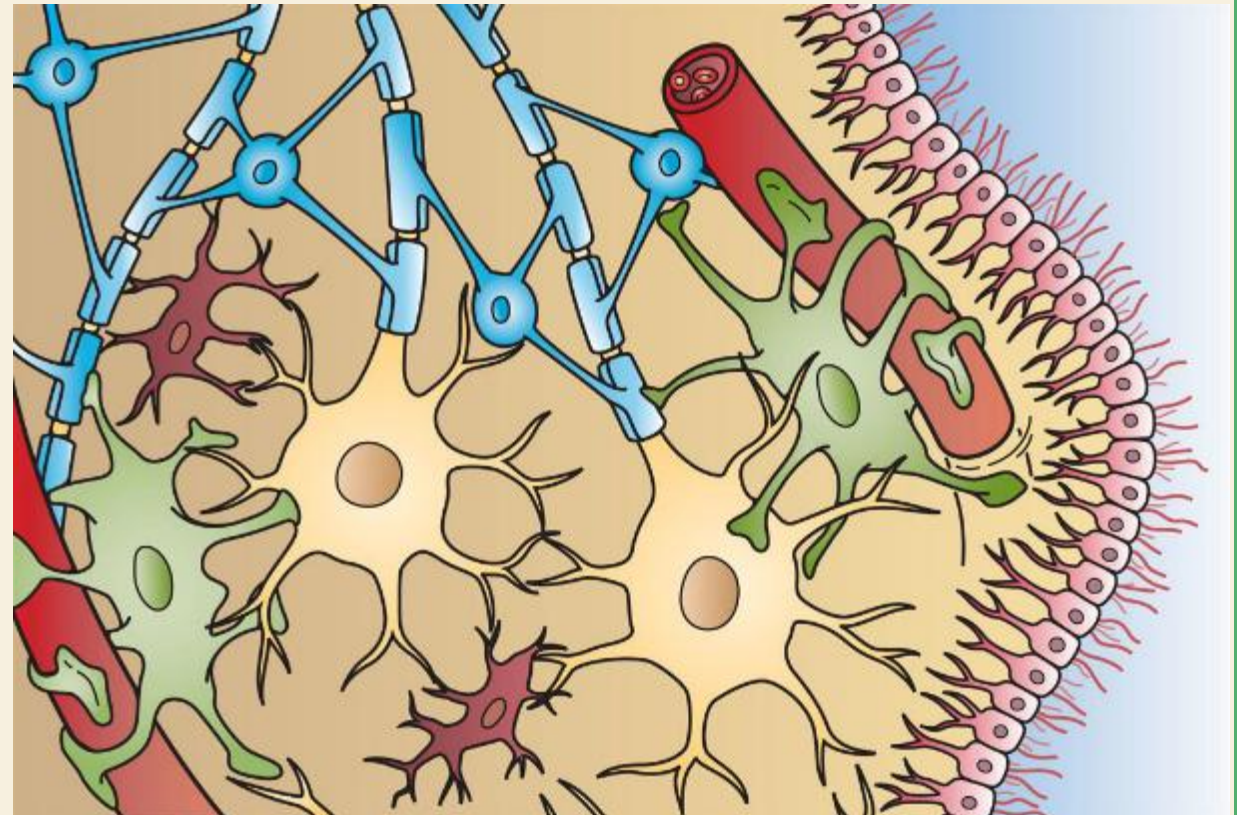
- It is the **Rough Endoplasmic Reticulum** (RER)
- Role in **Protein Synthesis**
- Found in Cell Body and Dendrites
- **NOT Found** (or rarely found) **in Axon**; Axon depends on the Cell Body for its viability



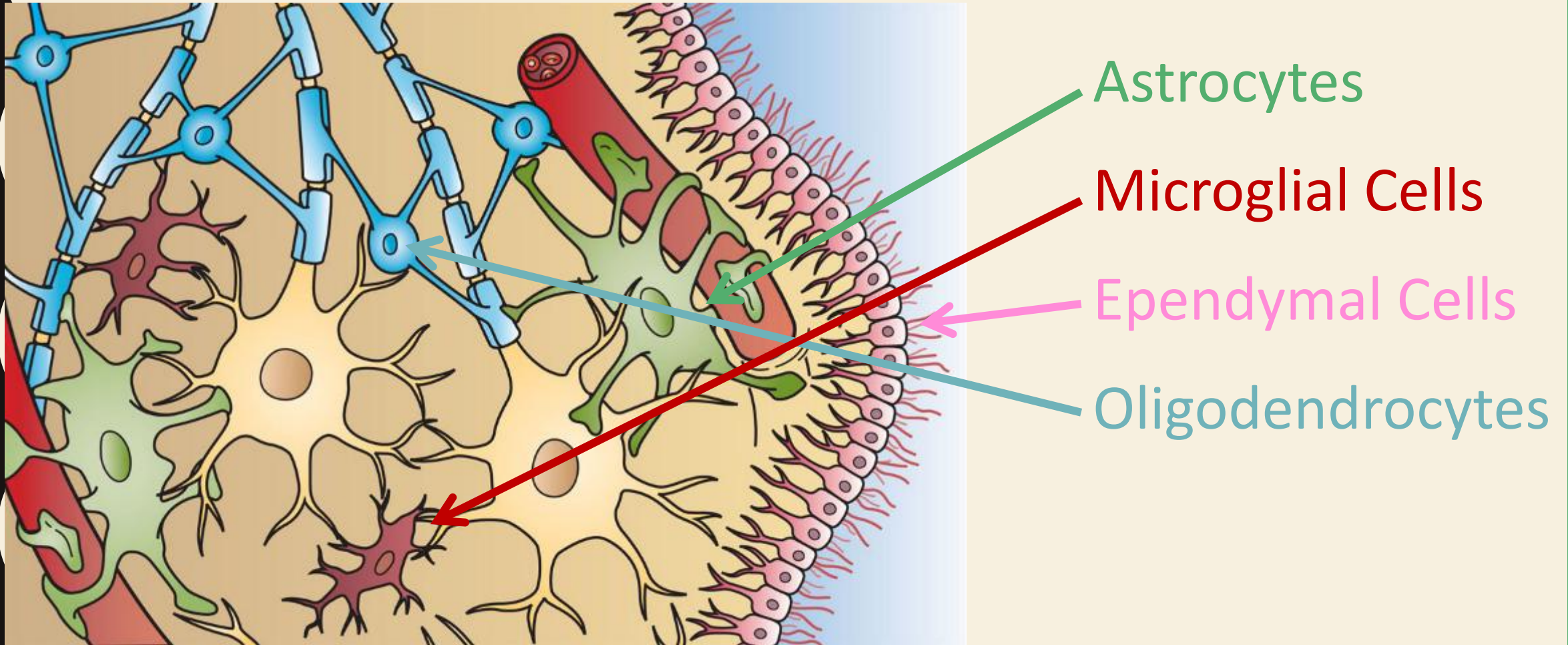
CELLS OF THE NERVOUS SYSTEM: GLIAL (SUPPORTING) CELLS

- **10 times** more abundant than Neurons in Brain
- Each with a different **Structure** than serves a unique **Function**
- Generally **Support** and **Protect** Neurons

- Astrocytes
- Oligodendrocytes
- Ependymal Cells
- Microglial Cells
- Schwann Cells (PNS)
- Satellite Cells (PNS)



GLIAL (SUPPORTING) CELLS OF THE CNS



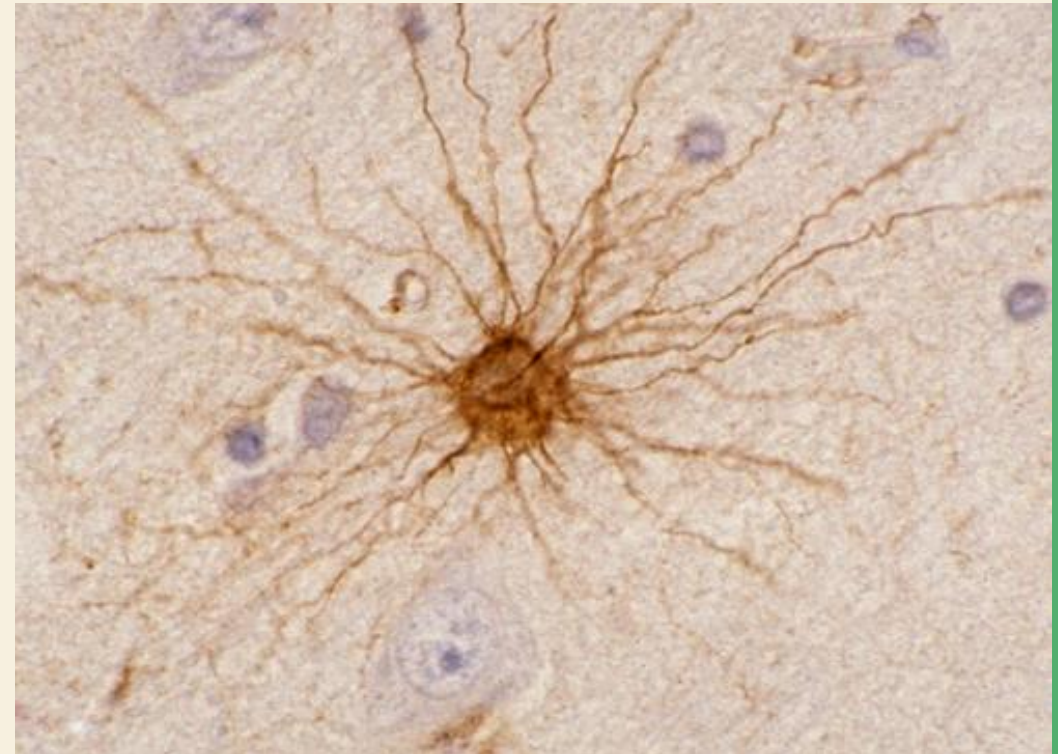
Artwork by Holly Fischer, ©Regents of the University of Michigan

GLIAL (SUPPORTING) CELLS OF THE CNS: ***ASTROCYTES***

- **Most numerous** of the Glial Cells
- Provide general **Structural Support**
- **Bind Neurons to Capillaries** (transfer of molecules from blood to neurons e.g. glucose; **Metabolic Support**)
- Are part of the **Blood Brain Barrier**
- Form the **glial limiting membrane** (astrocytic processes), that surrounds the CNS

Astrocytes: Star-Shaped

GFAP (Glial Fibrillary Acidic Protein)
Immunohistochemistry



Astrocytes bind Neurons to Capillaries

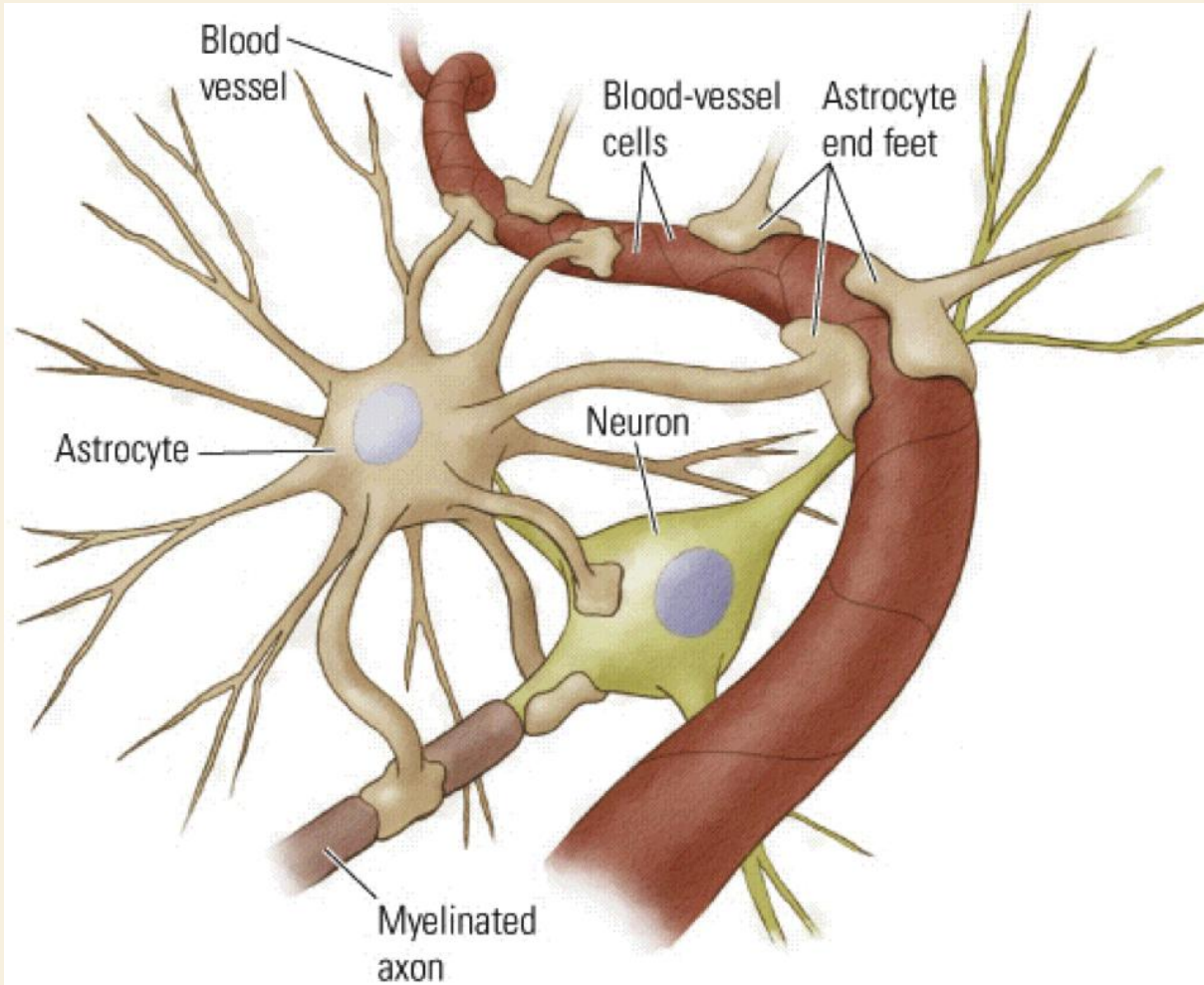


Image from: <http://www.quasargroupconsulting.com/Encyclopedia/anatomy/brain.php>

Astrocytes: Star-Shaped

GFAP (Glial Fibrillary Acidic Protein)
Immunohistochemistry)

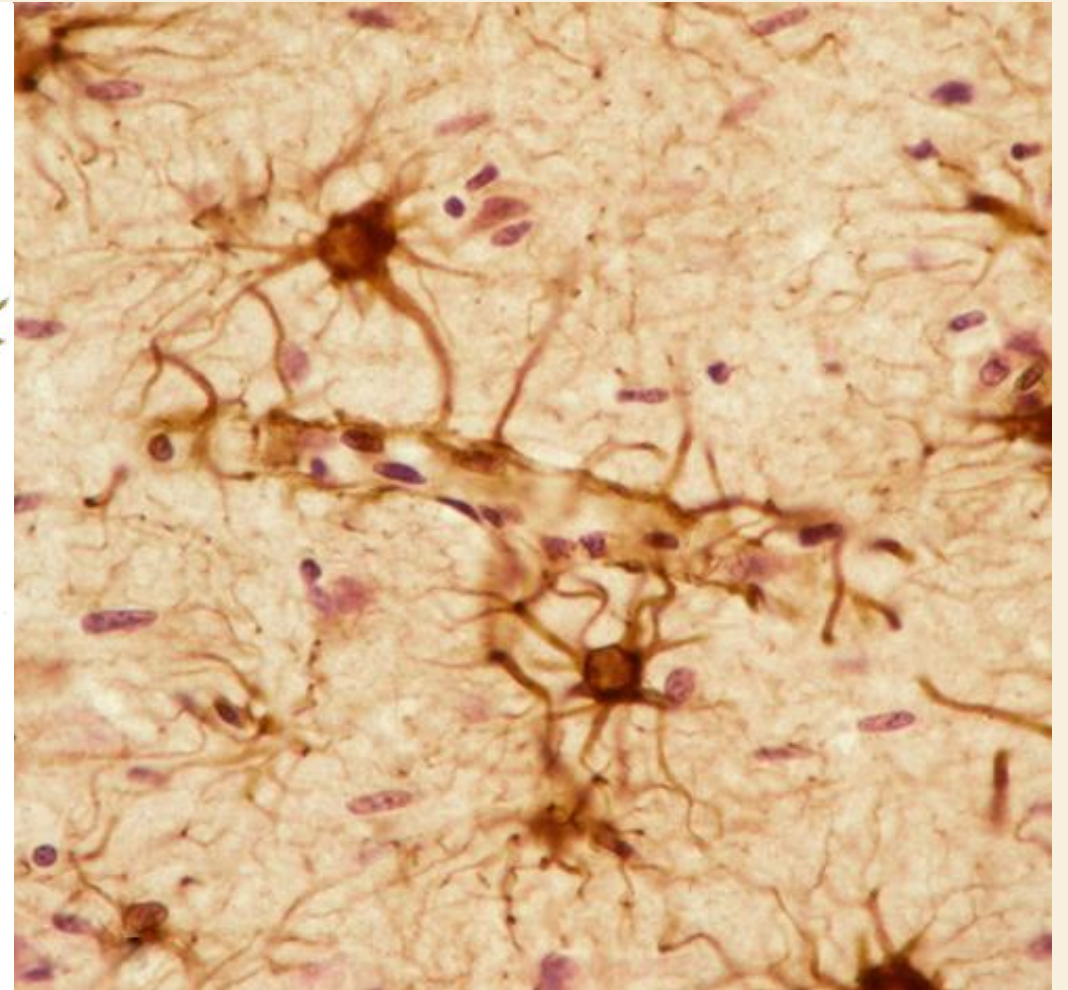
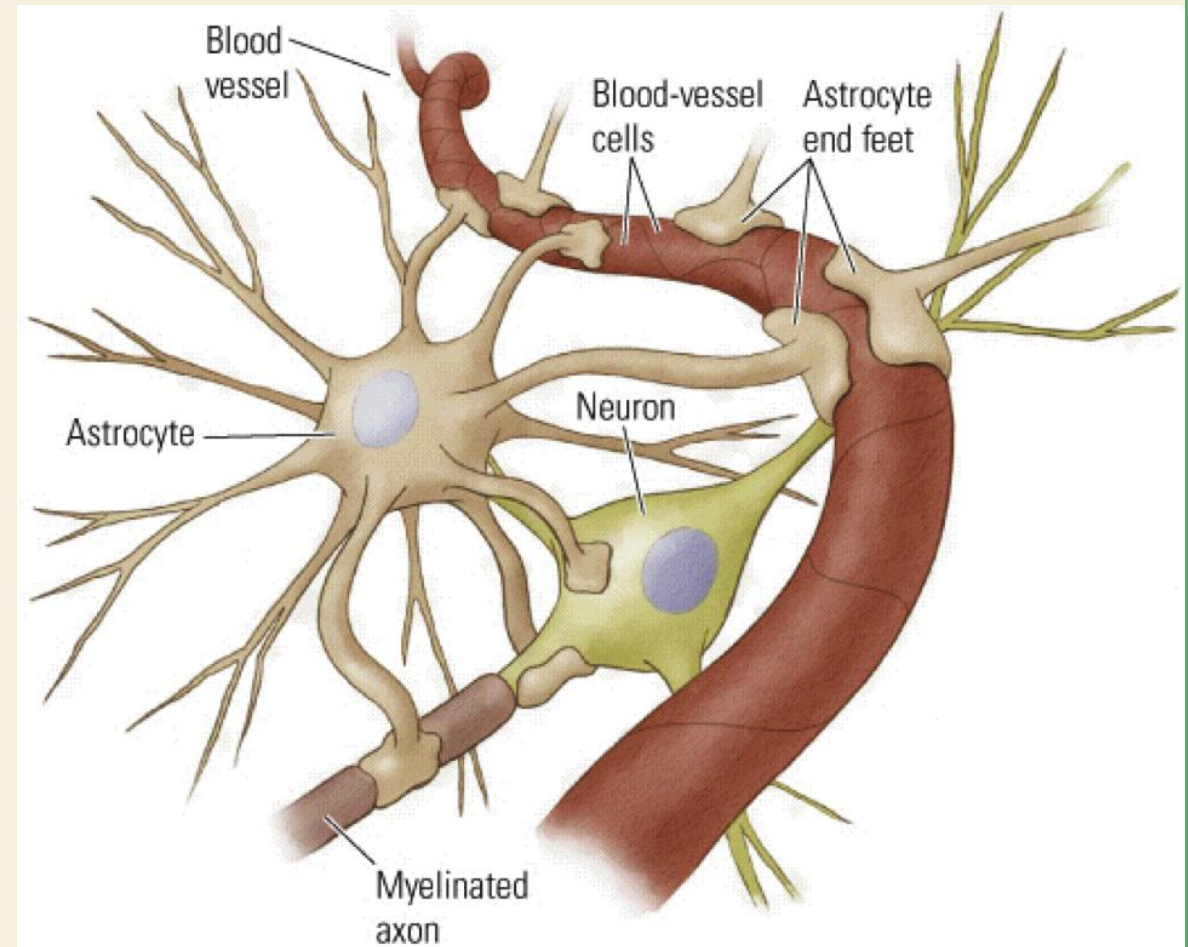


Image from: <http://neuropathology-web.org/chapter1/chapter1bAstrocytes.html>

GLIAL (SUPPORTING) CELLS OF THE CNS: ***ASTROCYTES***

Astrocytes: other Functions

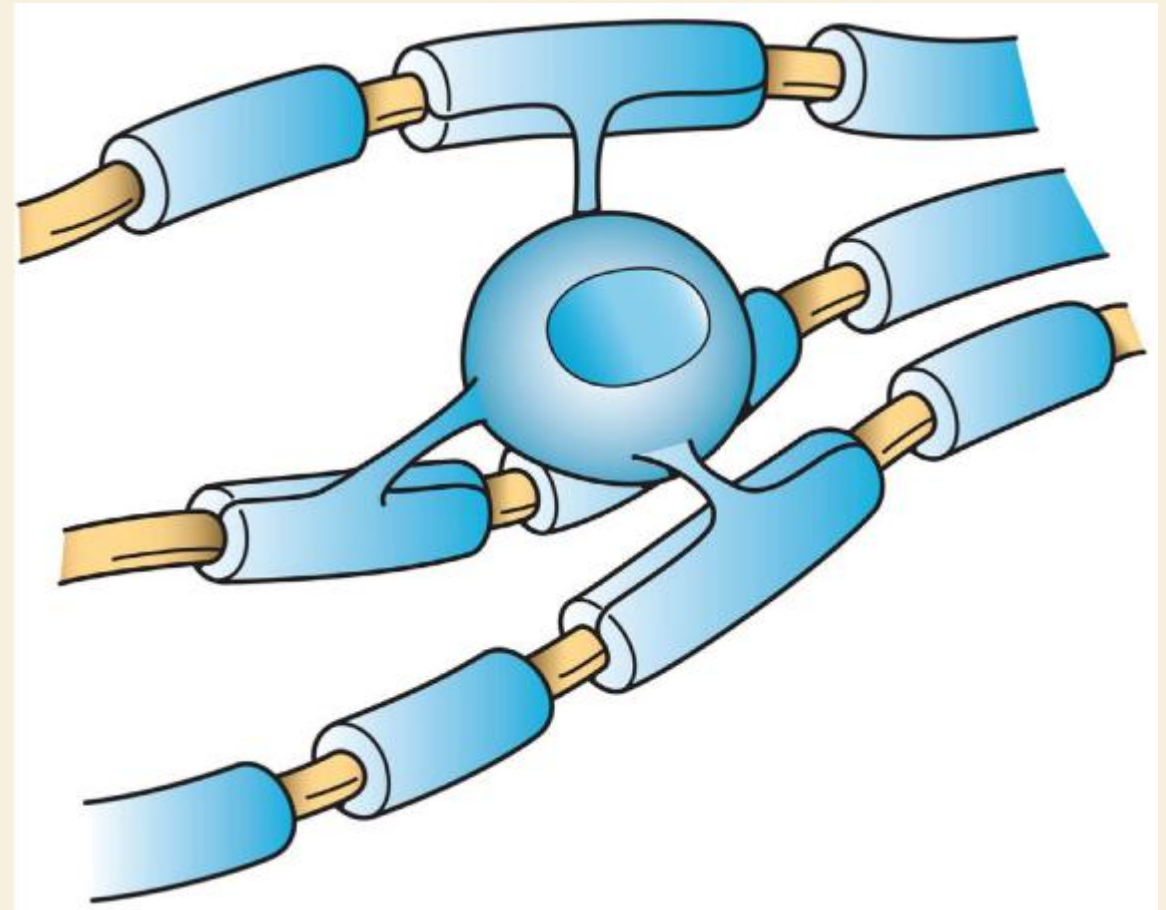
- Take up and ***Recycle*** released ***Neurotransmitters*** (e.g. GABA, Glutamate)
- Communicate with other glial cells (***e.g. stimulate Oligodendrocytes*** to initiate ***Myelination*** in the CNS)
- Compose the ***Glial Scar*** after CNS damage



GLIAL (SUPPORTING) CELLS OF THE CNS: ***OLIGODENDROCYTES***

One Oligodendrocyte can myelinate multiple Axons

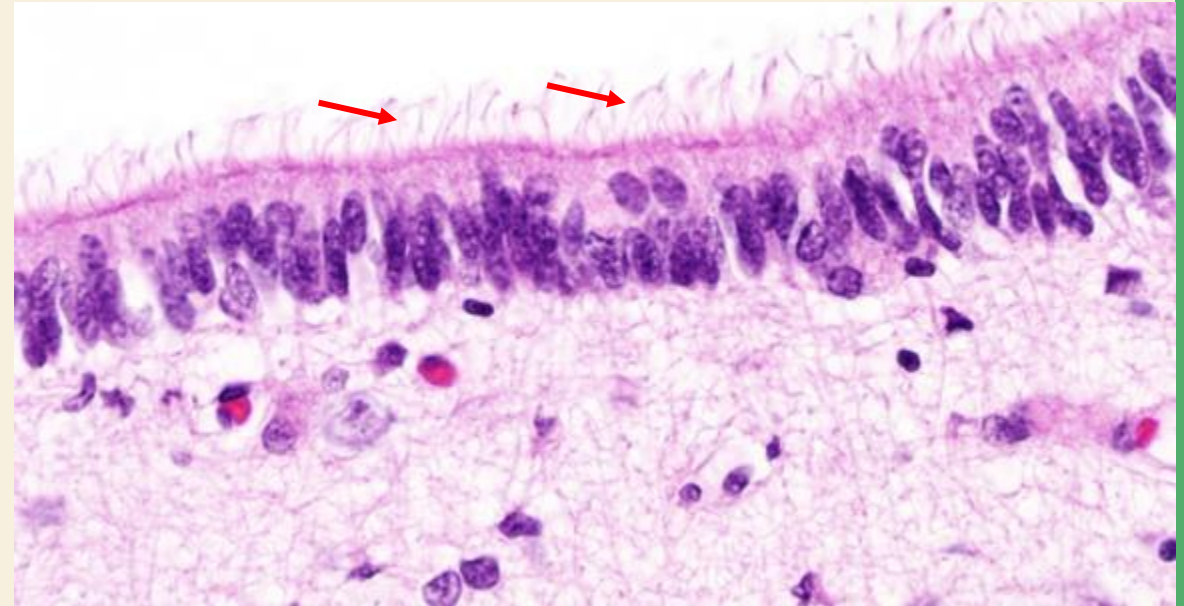
- ***Myelination in the CNS*** (insulation of Axons)
- Predominant Glial Cell in the White Matter
- ***Astrocytes*** stimulate Oligodendrocytes to initiate Myelination in the CNS
- ***One Oligodendrocyte can myelinate multiple Axons***



GLIAL (SUPPORTING) CELLS OF THE CNS: ***Ependymal Cells***

- Line CNS cavities (*Ventricles* of the Brain and the *Spinal Canal*)
- In the roof of Ventricles they form the *Choroid Plexus*
- *Ependymal cells of the Choroid Plexus* produce the *Cerebrospinal Fluid (CSF)* by transporting and secreting materials derived from adjacent capillaries
- *Cilia* on their surface: move the CSF

Ependymal cells with *Cilia* (red arrows) on their surface



GLIAL (SUPPORTING) CELLS OF THE CNS: ***MICROGLIAL CELLS***

- Originate from blood ***Monocytes***, that migrate to Nervous Tissue
- ***Phagocytes*** (eat infectious agents, dead tissue etc.), part of the mononuclear phagocyte system
- Role in ***Immune Defense***

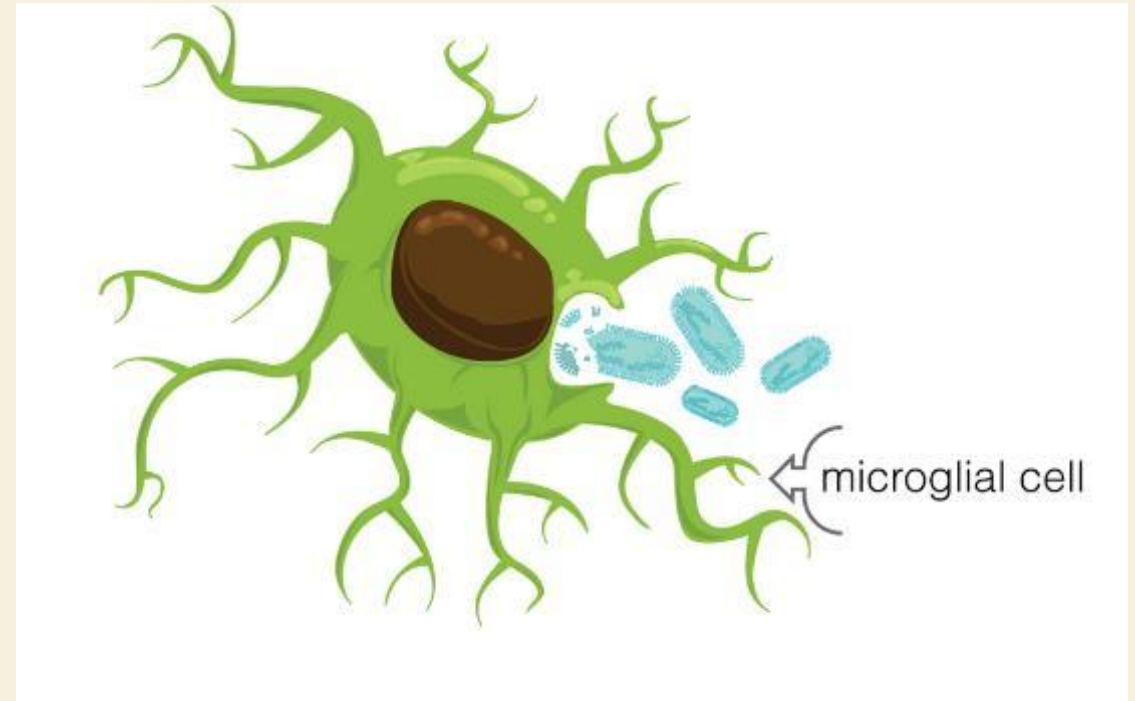
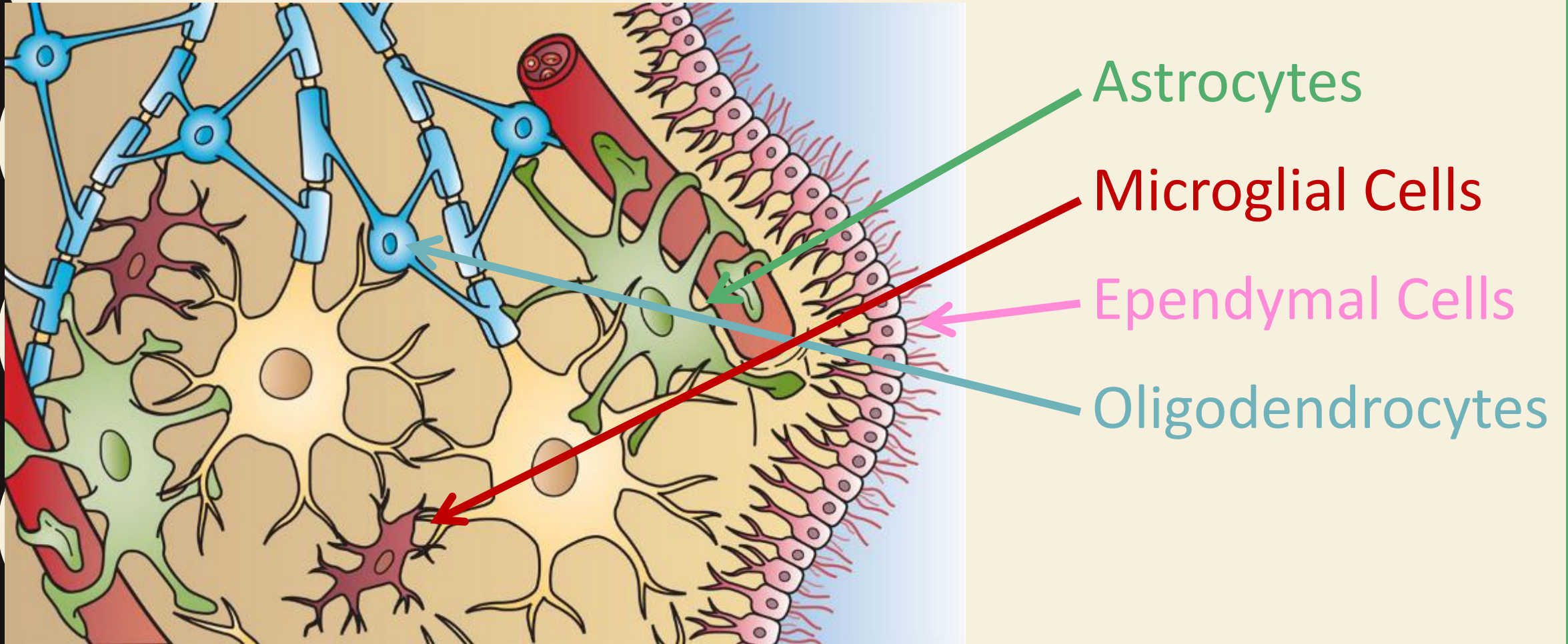


Image from: <http://learn.genetics.utah.edu/content/neuroscience/braincells/>

GLIAL (SUPPORTING) CELLS OF THE CNS



Artwork by Holly Fischer, ©Regents of the University of Michigan

GLIAL (SUPPORTING) CELLS OF THE PNS: ***SCHWANN CELLS***

- ***Myelination in the PNS*** (insulation of Axons)
- ***One Schwann Cell can myelinate one Axon***



GLIAL (SUPPORTING) CELLS OF THE PNS: ***SATELLITE CELLS***



Image from <http://histologyguide.com/slide-view/MH-047-spinal-cord/06-slide-3.html?x=12376&y=12121&z=88&page=1>

ANY QUESTIONS SO FAR?

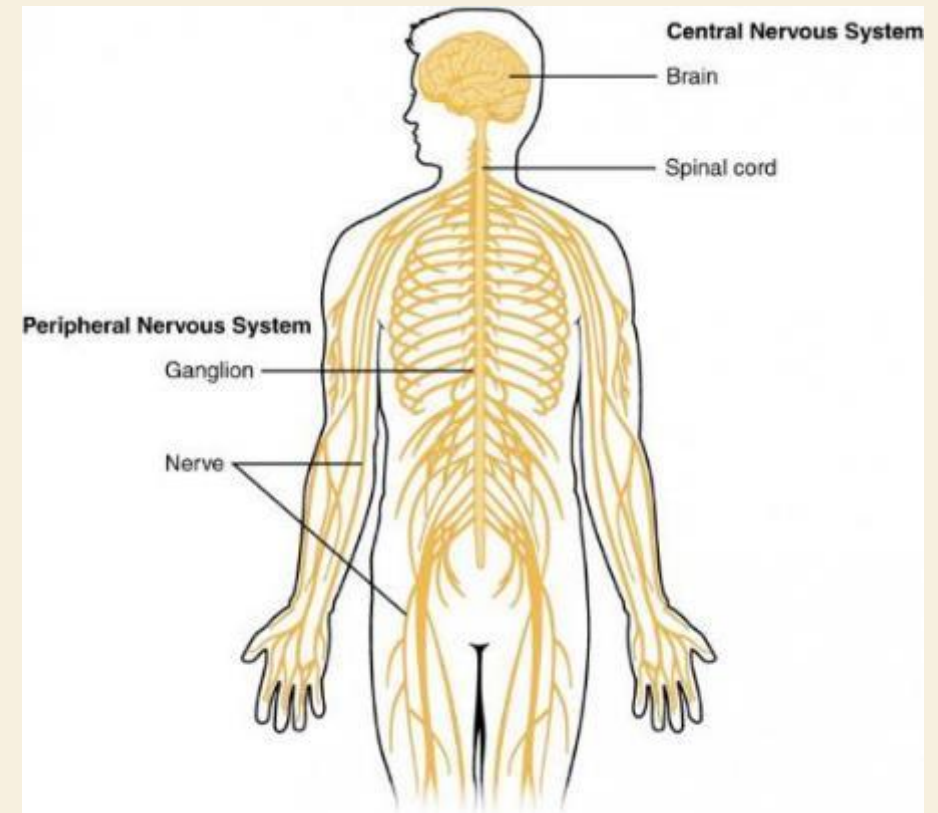


LECTURE OUTLINE

- Cells of the Nervous System: Structure and Function
- **CNS Organization** and **Correlation with Histology**
- Blood-Brain Barrier
- Meninges
- Peripheral Nervous System (PNS): Nerves and Ganglia

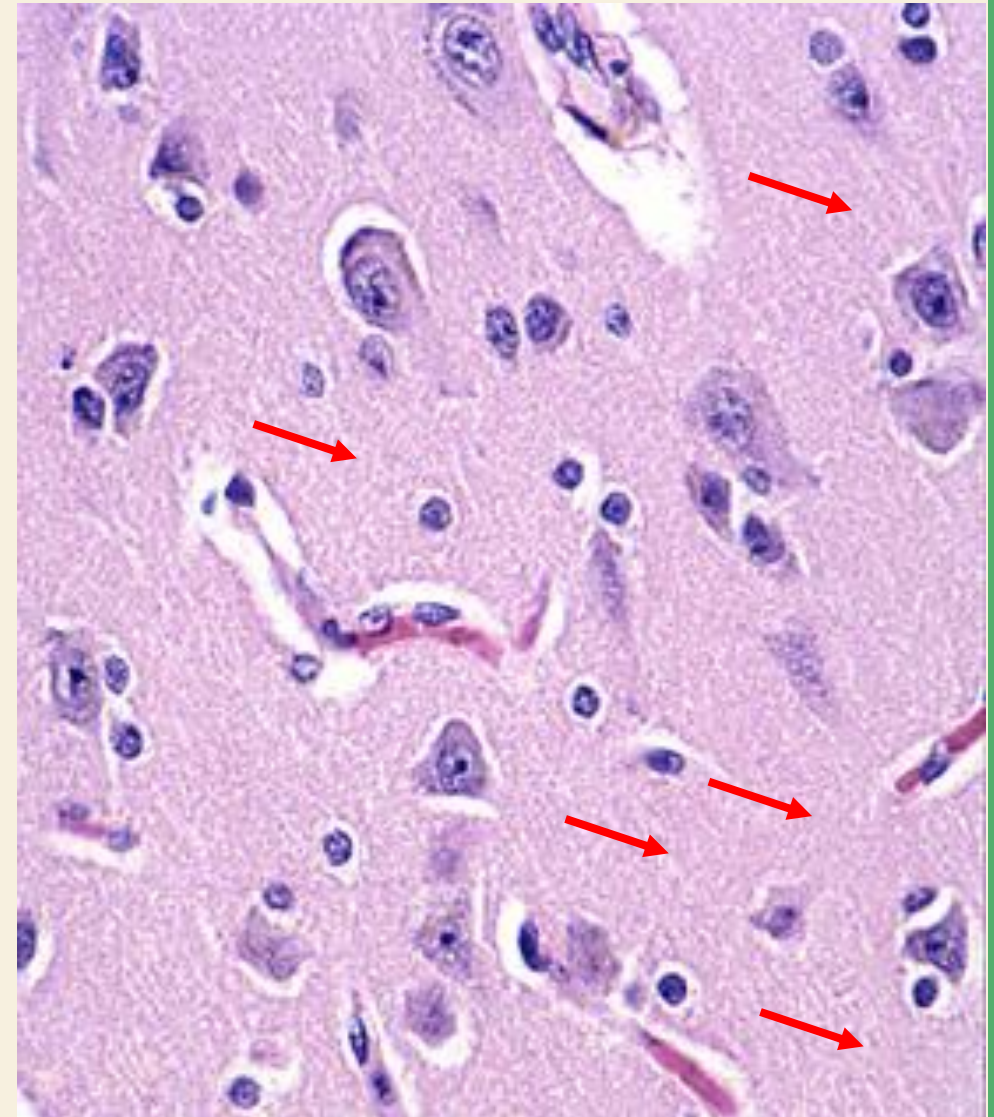
ORGANIZATION OF THE CENTRAL NERVOUS SYSTEM (CNS): CORRELATION WITH ***HISTOLOGY***

- **CNS**: Brain + Spinal Cord
- Regions within CNS
- ✓ **Gray Matter**: contains neuron cell bodies, dendrites, axons and glial cells
- ✓ **White Matter**: contains mainly axons and oligodendrocytes



ORGANIZATION OF THE CENTRAL NERVOUS SYSTEM (CNS): CORRELATION WITH ***HISTOLOGY***

- **Neurons**: big cells
- **Glial Cells**: small cells
- **Neuropil** (red arrow): dense network of **glial fibers** (especially those of astrocytes), **axons**, and **dendrites** in the Gray Matter
- **Gray Matter Regions of the CNS** are usually arranged in multiple unique **layers**



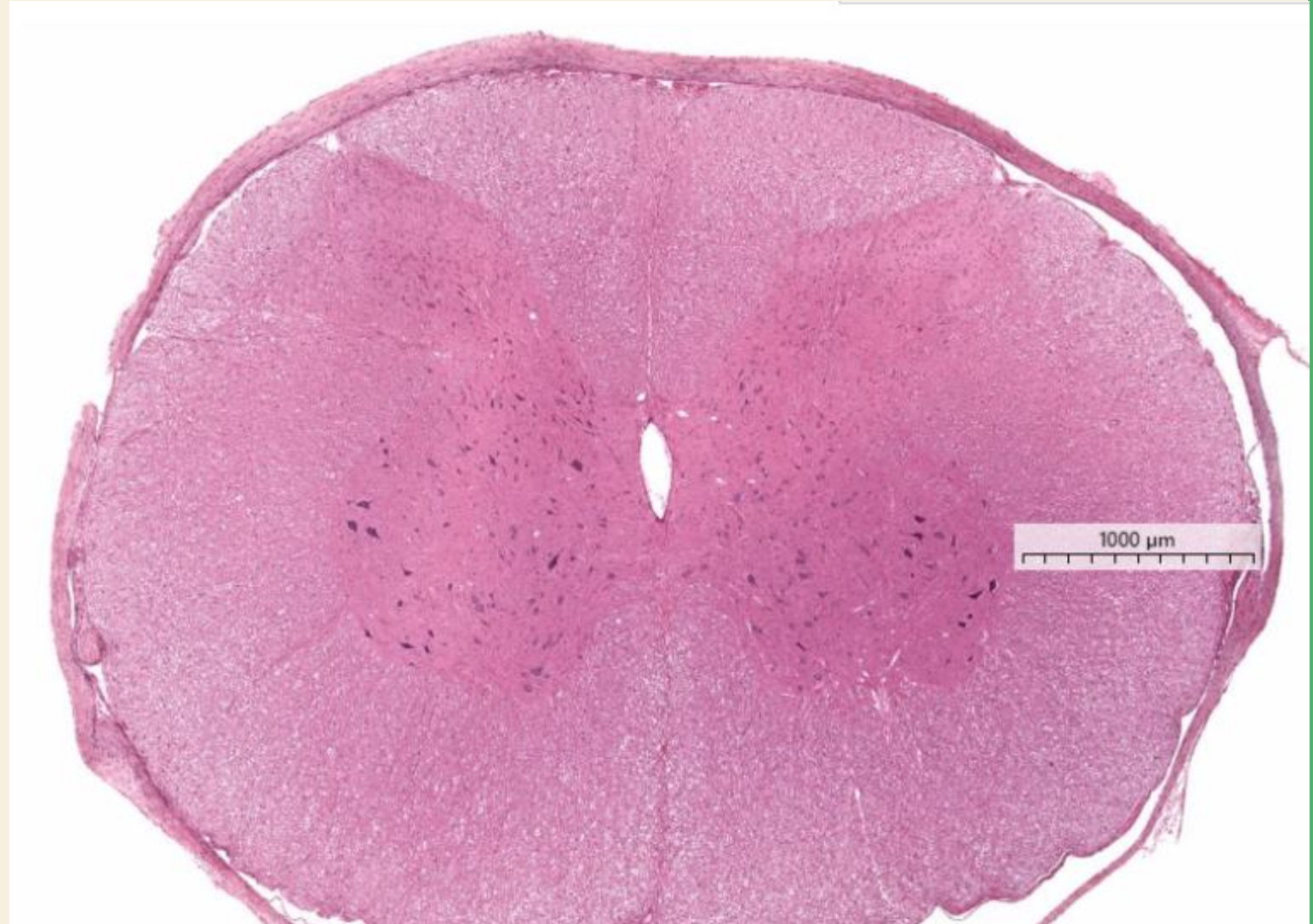
ORGANIZATION OF THE CENTRAL NERVOUS SYSTEM (CNS): CORRELATION WITH ***HISTOLOGY***

- ***Cerebrum and Cerebellum***: gray matter outside, white matter inside



ORGANIZATION OF THE CENTRAL NERVOUS SYSTEM (CNS): CORRELATION WITH ***HISTOLOGY***

- ***Spinal Cord***: white matter outside, gray matter inside





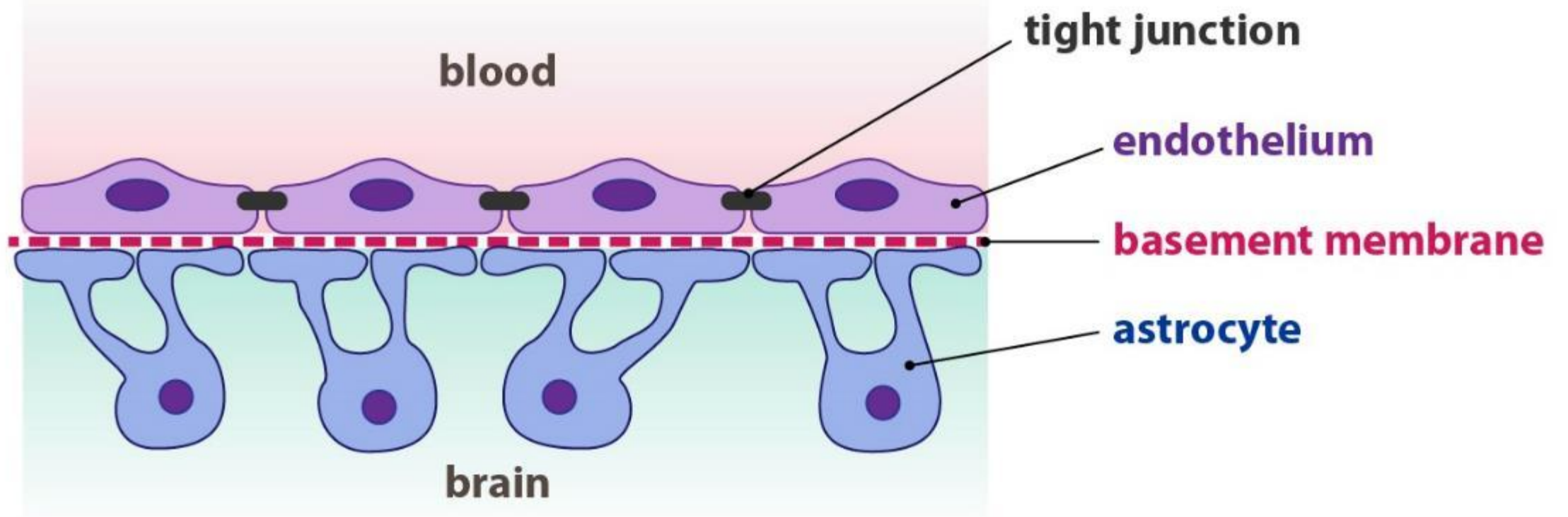
QUIZ TIME!!!



LECTURE OUTLINE

- Cells of the Nervous System: Structure and Function
- CNS Organization and Correlation with Histology
- **Blood-Brain Barrier**
- Meninges
- Peripheral Nervous System (PNS) Histology: Nerves and Ganglia

BLOOD BRAIN BARRIER



BLOOD BRAIN BARRIER

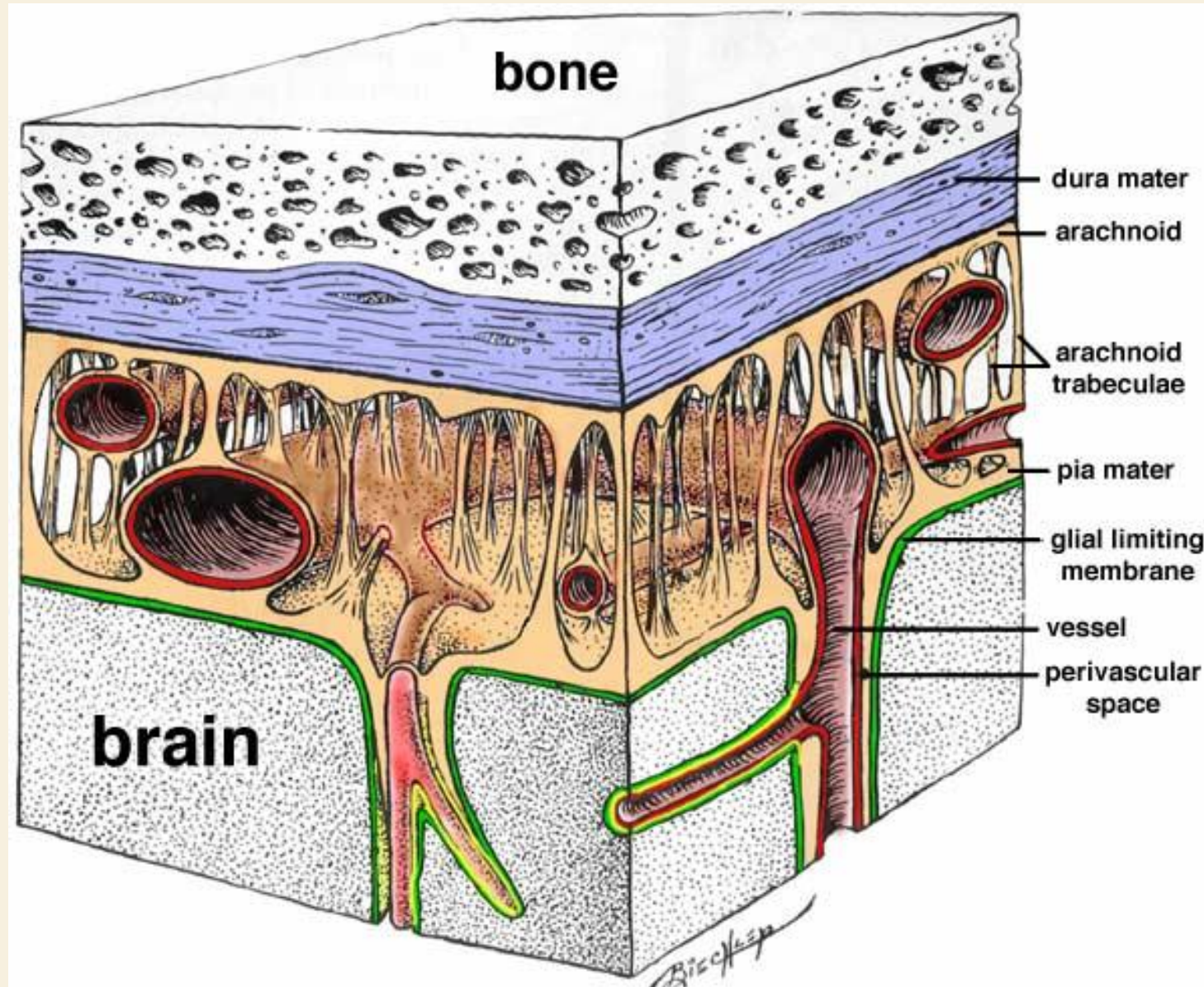
3 components:

1. Endothelial cells of the capillaries with their tight junctions
 2. Basement membrane of the capillary walls
 3. Astrocyte foot processes that surround capillaries
- Protective Function: Blood Brain Barrier prevents passage of some Germs and Toxins from Blood into CNS tissue; however, it prevents passage of some Drugs

LECTURE OUTLINE

- Cells of the Nervous System: Structure and Function
- CNS Organization and Correlation with Histology
- Blood-Brain Barrier
- Meninges
- Peripheral Nervous System (PNS) Histology: Nerves and Ganglia

MENINGES



MENINGES

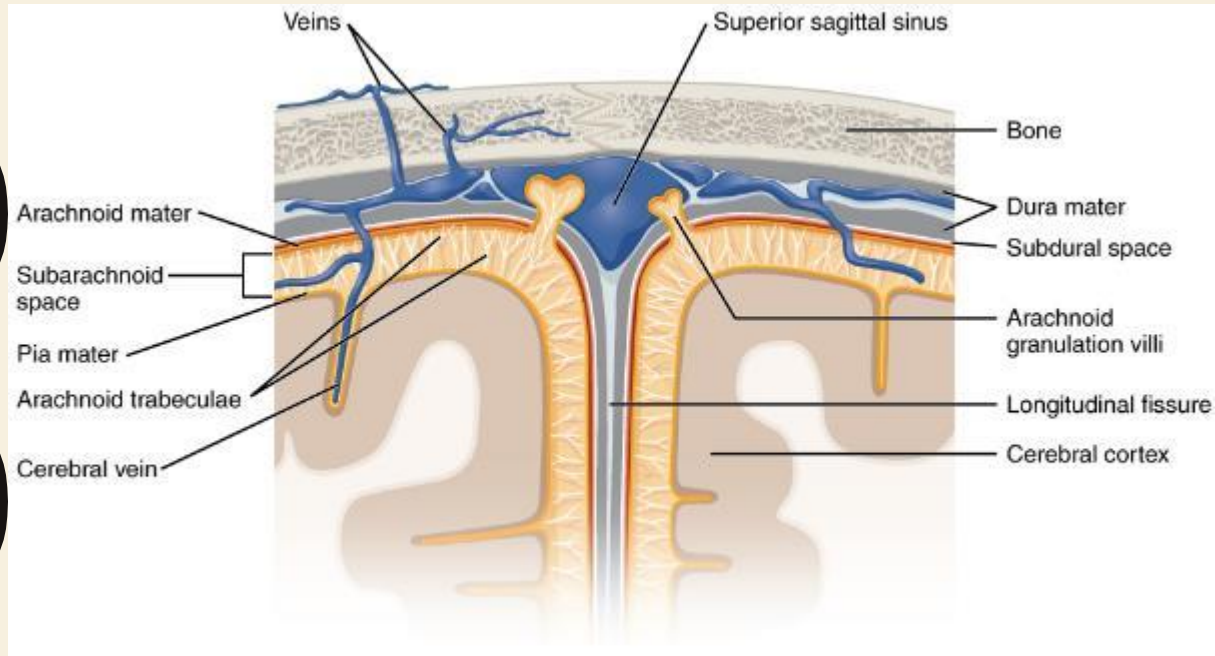


Image from: <https://cnx.org/contents/DcB5rjNc@3/Circulation-and-the-Central-Ne>

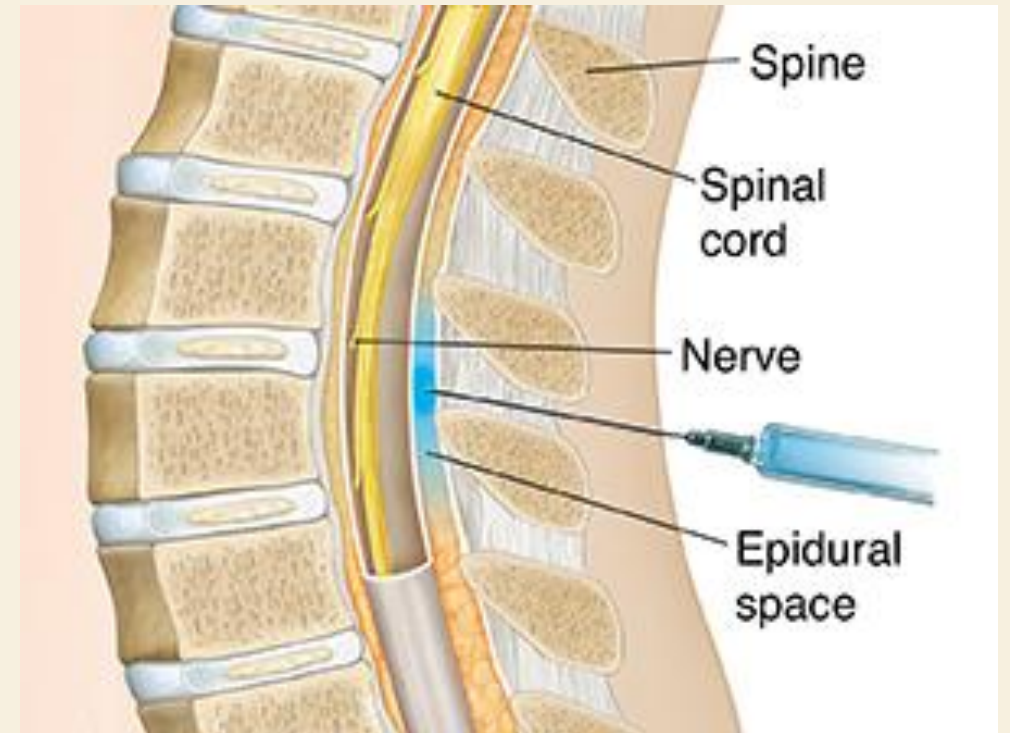


Image from: <https://www.sterlingcare.com/resources/resources/diseases-and-conditions-library/view/what-is-epidural-anesthesia/>

MENINGES

3 Meninges: surround the Brain and the Spinal Cord; composed of connective tissue

1. **Dura**: outermost layer; attaches to the skull
 2. **Arachnoid**: two parts (one in contact with the dura; the other one forms trabeculae that connect Arachnoid with Pia)
 3. **Pia**: innermost layer; lines the brain
- **Subarachnoid Space** (between Arachnoid and Pia): contains CSF

MENINGES

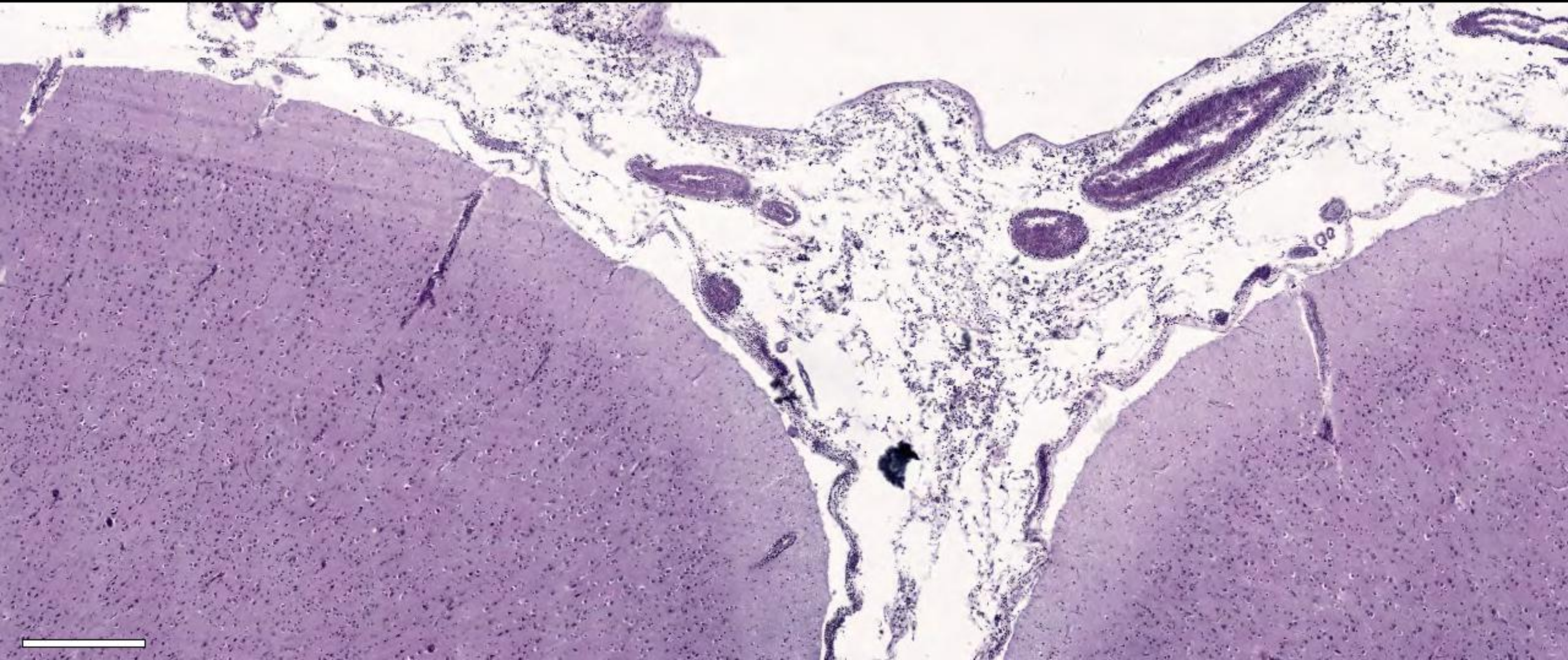
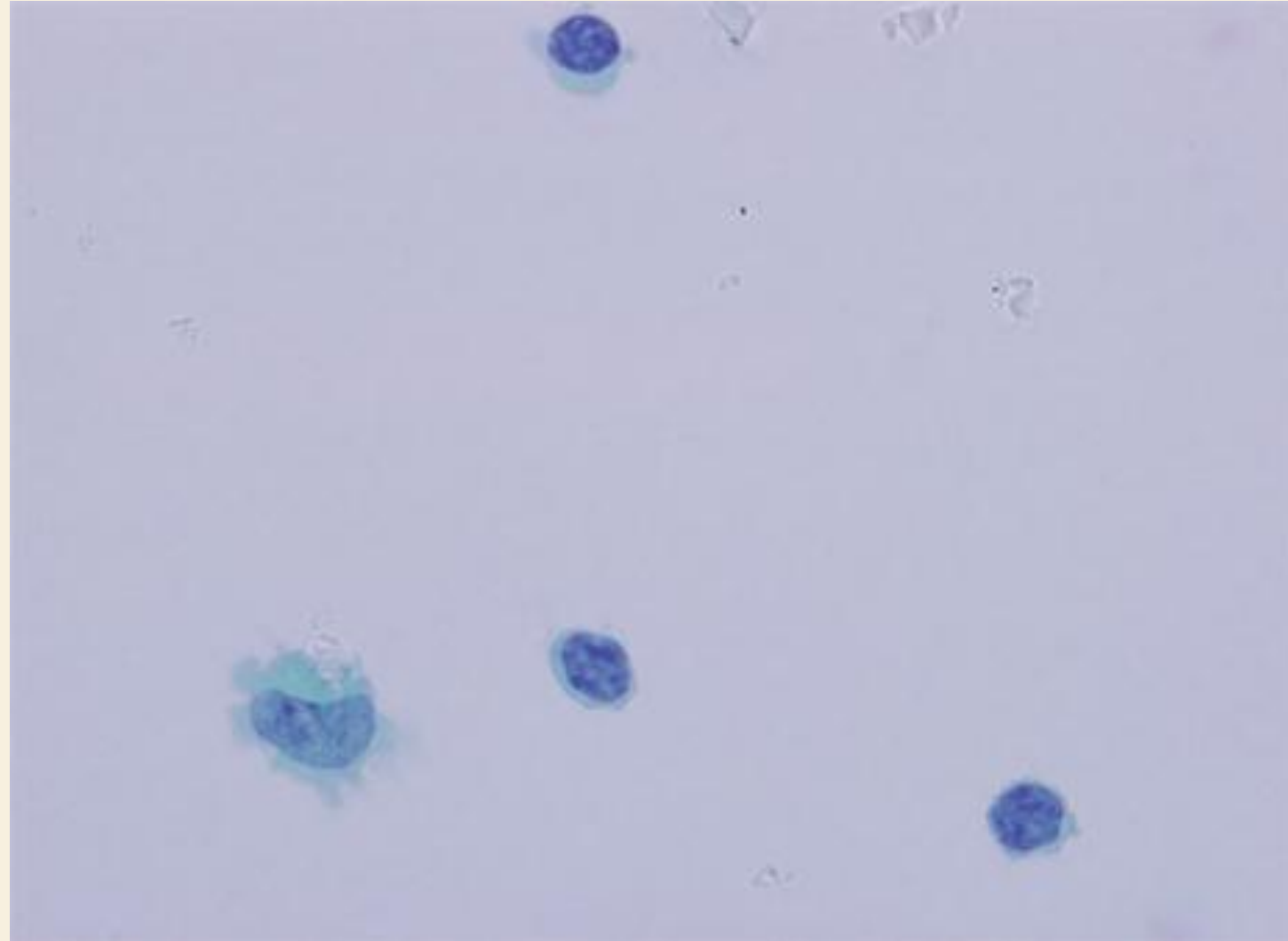


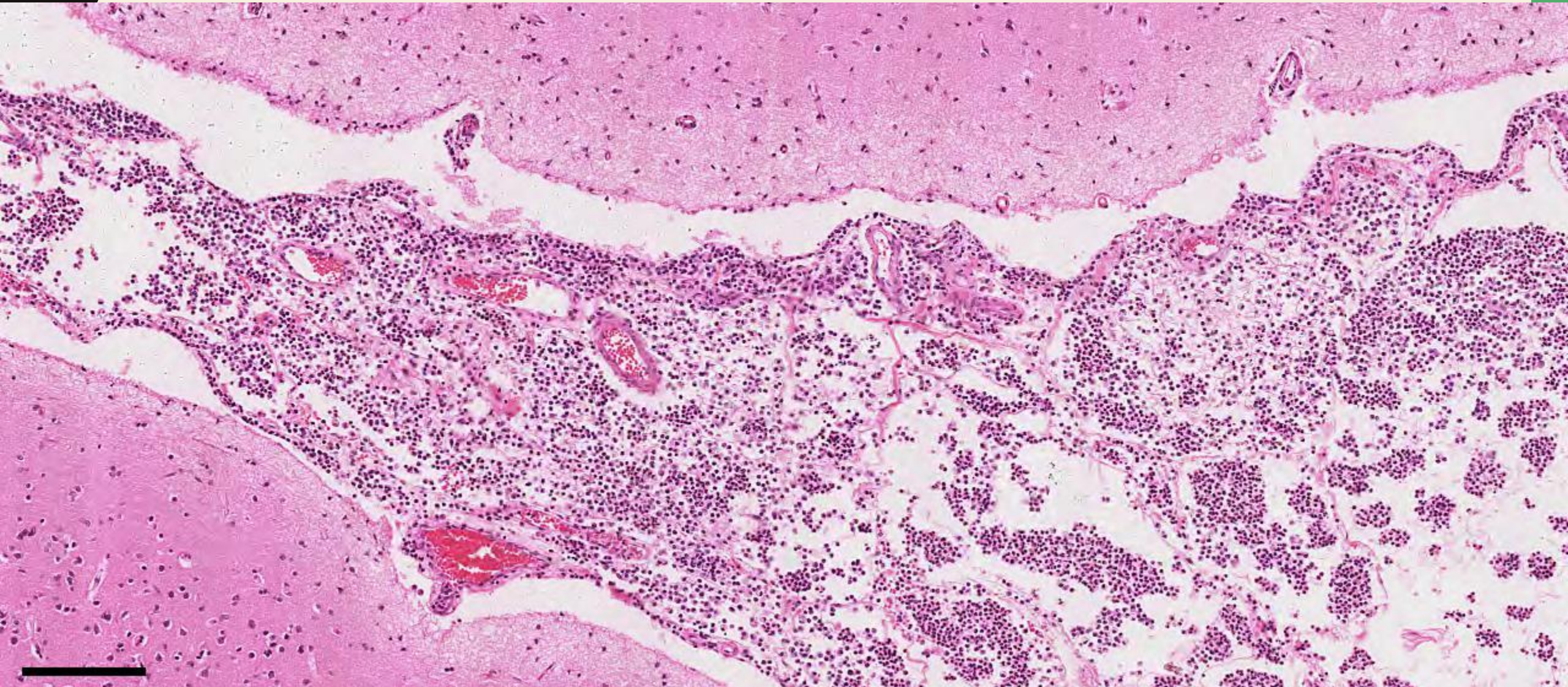
Image adapted, with permission, from the Iowa Virtual Slidebox (<http://www.mbfbioscience.com/iowavirtualslidebox>)

NORMAL CSF (CYTOLOGY)

Normal CSF contains Lymphocytes and Monocytes



ABNORMAL CSF: MENINGITIS

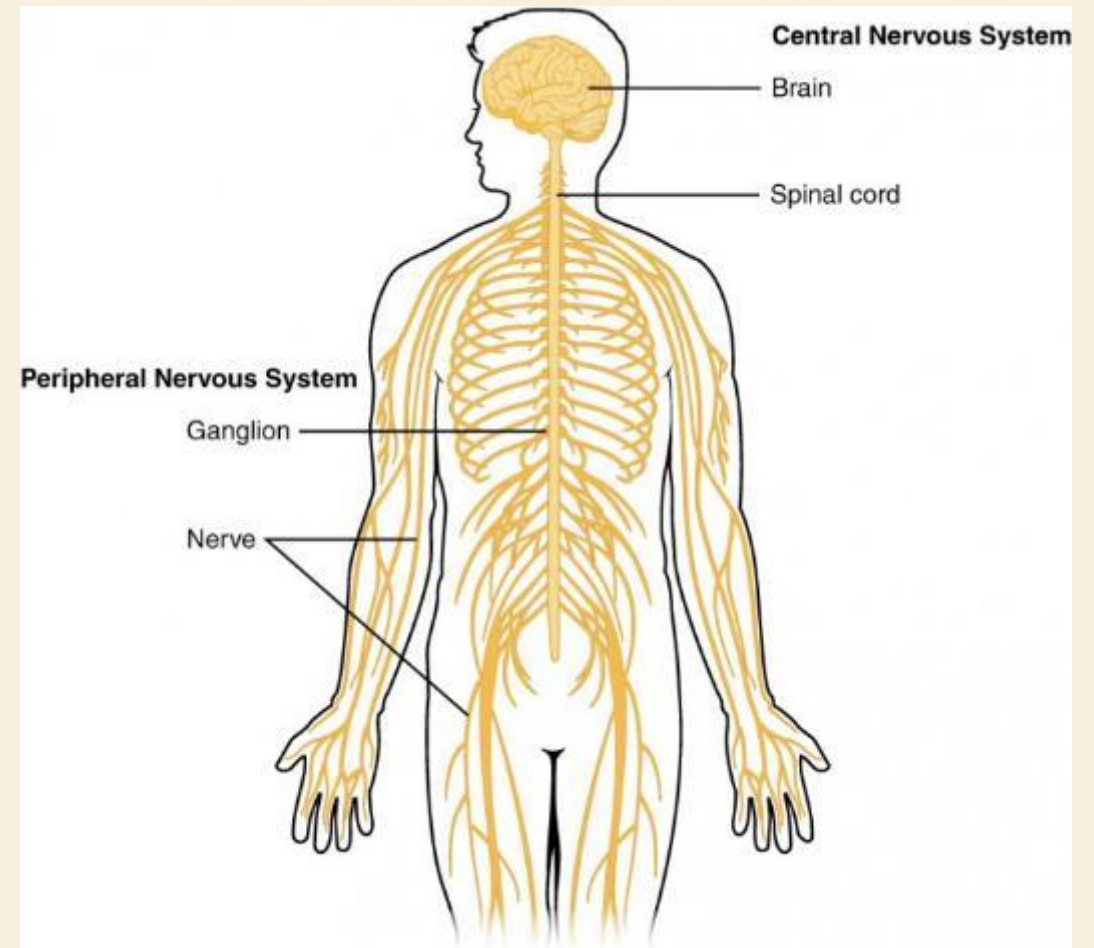


LECTURE OUTLINE

- Cells of the Nervous System: Structure and Function
- CNS Organization and Correlation with Histology
- Blood-Brain Barrier
- Meninges
- Peripheral Nervous System (PNS) Histology: Nerves and Ganglia

PERIPHERAL NERVOUS SYSTEM HISTOLOGY

- **Peripheral Nervous System (PNS)**
 - ✓ **Nerves** (Cranial + Spinal)
 - Nerves = collections of nerve fibers (axons) surrounded by Schwann cells and layers of connective tissue
 - ✓ **Ganglia** (groups of nervous Cell Bodies outside the CNS)

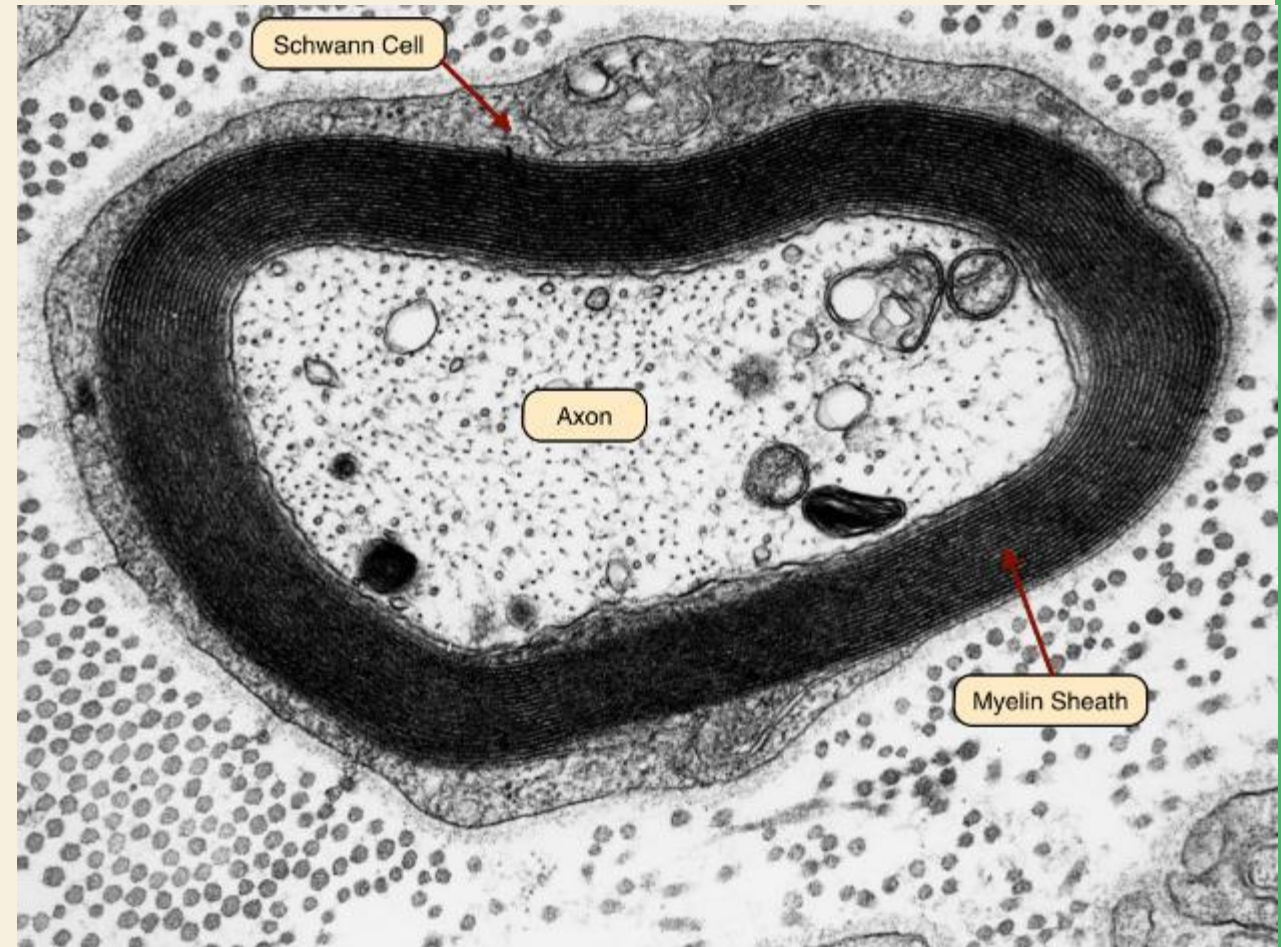


PERIPHERAL NERVOUS SYSTEM HISTOLOGY

One Schwann Cell Myelinates one Axon

(Transmission Electron Microscopy)

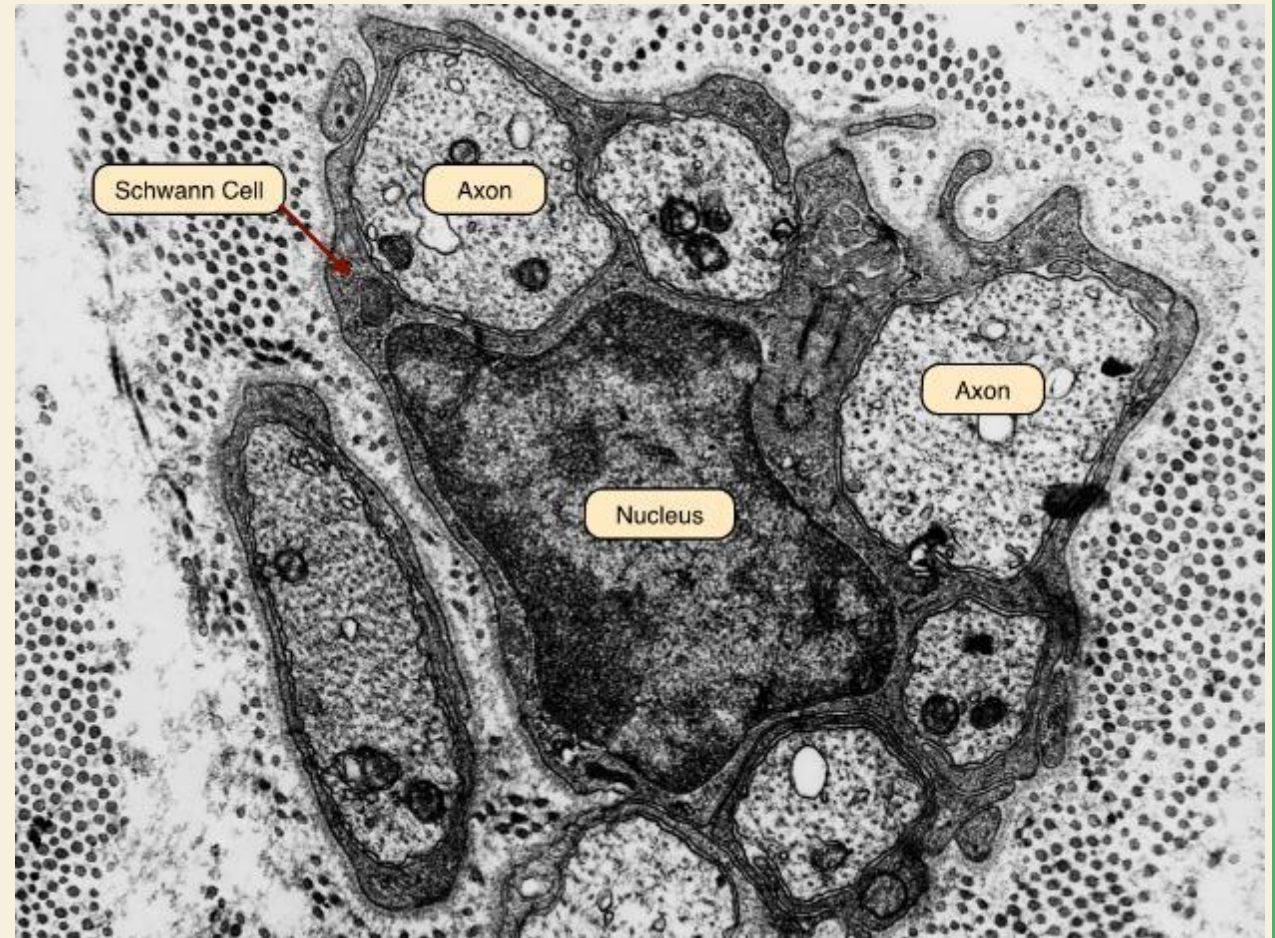
- Myelination in the PNS (insulation of Axons)
- Myelination: dynamic process (Schwann cell wraps around the axon multiple times!)
- Myelin: 80% lipid, 20% protein



PERIPHERAL NERVOUS SYSTEM HISTOLOGY

Unmyelinated Axons (Transmission Electron Microscopy)

- Schwann cells enclose all axons in nerves of the PNS
 - Large axons: myelinated
 - Small axons: not myelinated
(however, they are enclosed by Schwann Cells!!!)
- Schwann Cells also participate in the axonal regeneration



PERIPHERAL NERVOUS SYSTEM HISTOLOGY

Connective Tissue layers found in Nerves

- **Endoneurium**: around axons
- **Perineurium**: around axon fascicles
- **Epineurium**: around the entire nerve



PERIPHERAL NERVOUS SYSTEM HISTOLOGY

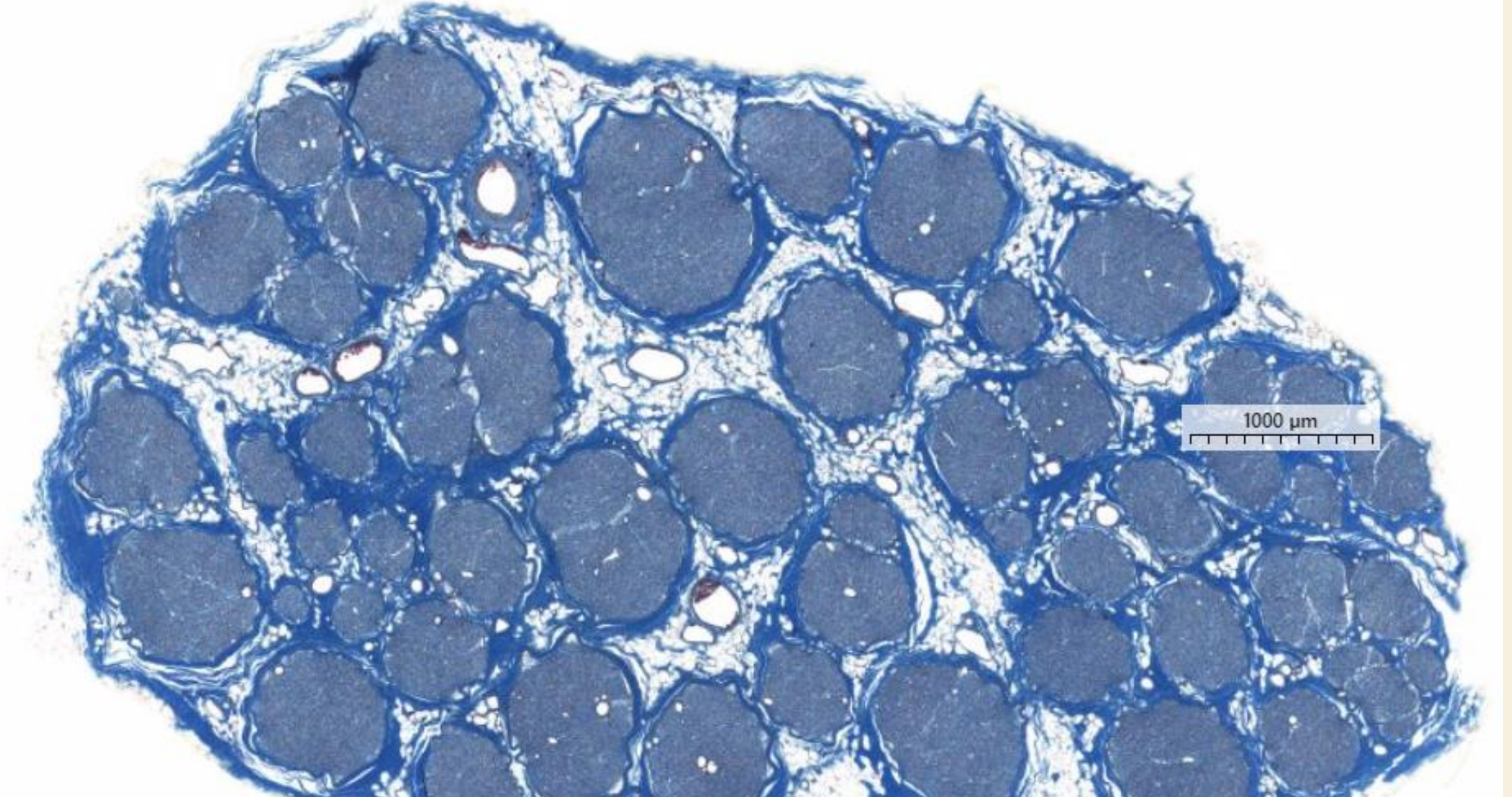
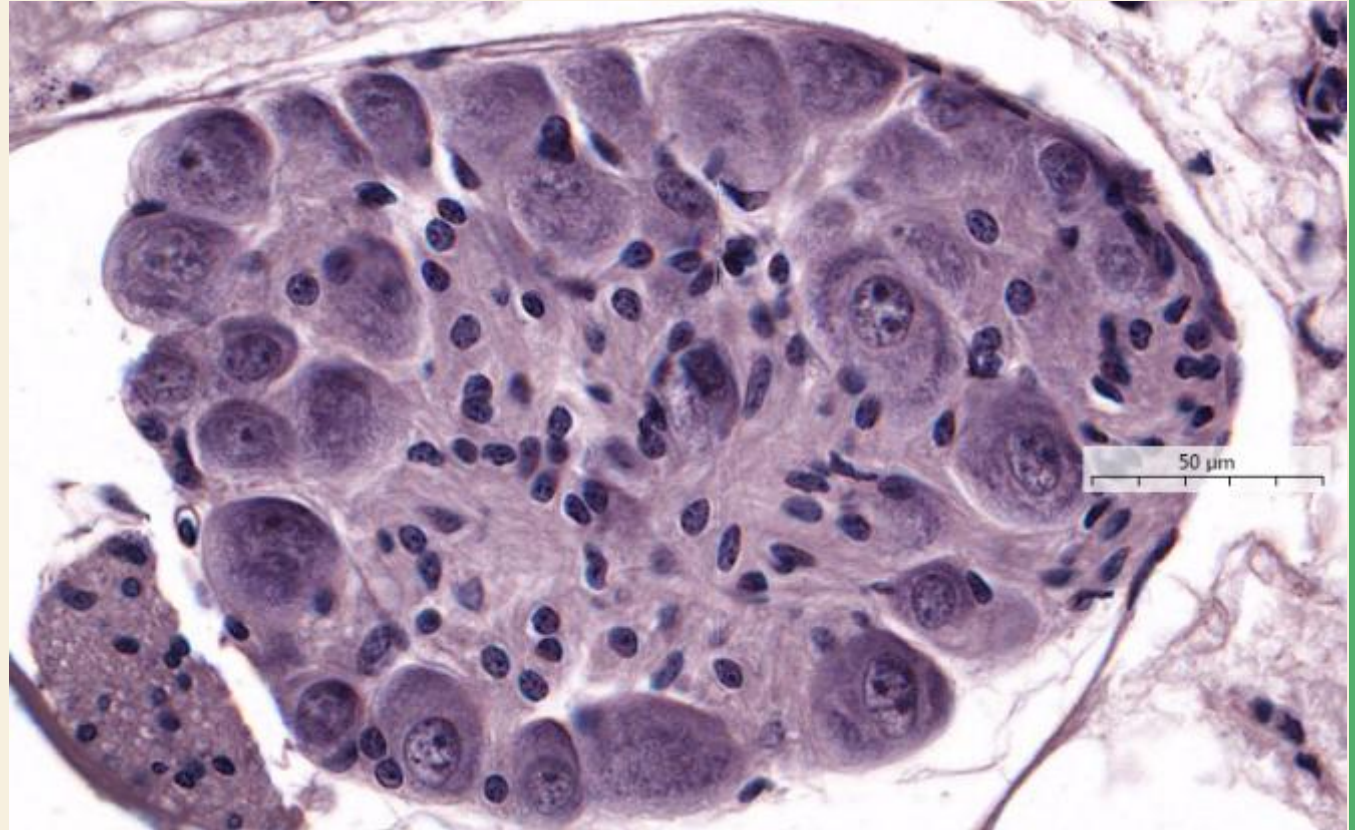


Image from: <http://histologyguide.com/slide-view/MHS-239-peripheral-nerve/06-slide-1.html?x=0&y=0&z=-1&page=1>

PERIPHERAL NERVOUS SYSTEM HISTOLOGY

- **Ganglia**
- ✓ Groups of nervous **Cell Bodies** **outside the CNS**
- ✓ Glial Cells: **Satellite Cells**



ANY QUESTIONS FROM THIS LECTURE?



Thank you for your attention!

