

Cellular & Subcellular Components of the Nervous System

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Learning Objectives

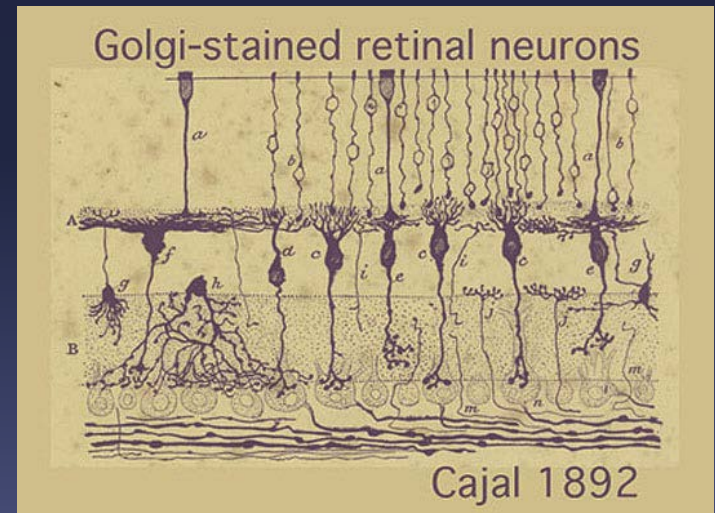
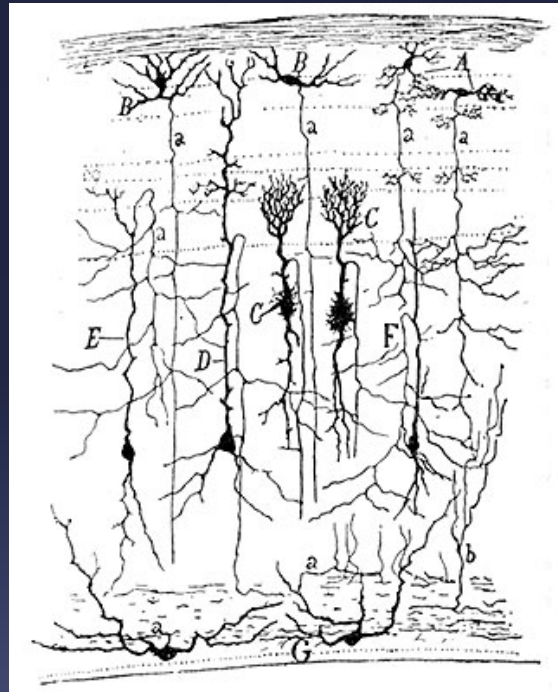
- Understand the differences between neurons & glia
- Understand neuronal morphology and subcellular components
- Understand the classifications of neurons
- Understand the different types of glia and their function
- Understand the histology methods used to label different cell types

History: Santiago Ramon y Cajal



(1852-1934)

**Established the Neuron Doctrine:
the nervous system is made up of discrete
individual cells**



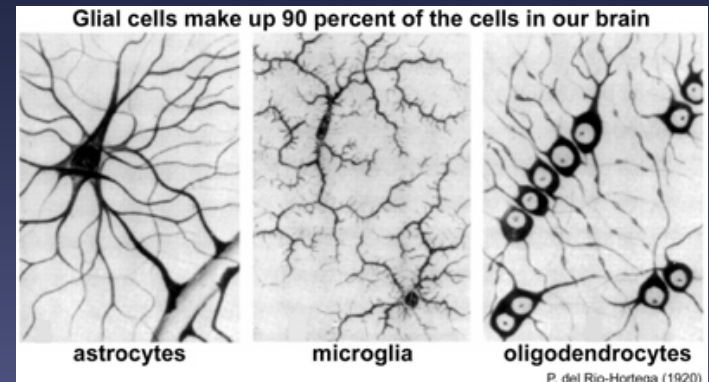
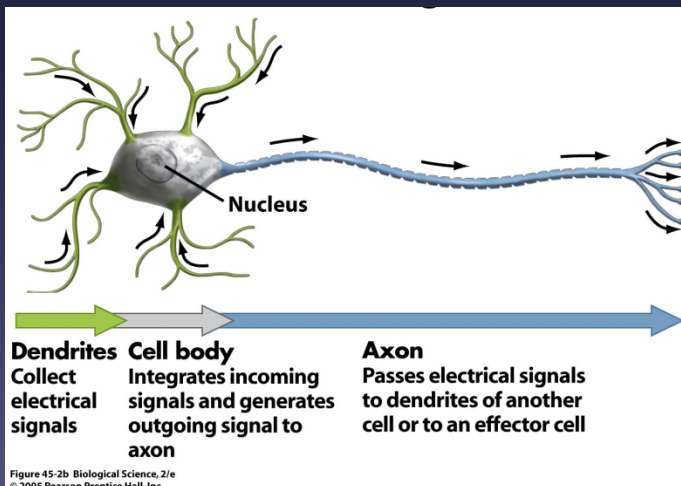
Cell Types in the Nervous System

Neurons

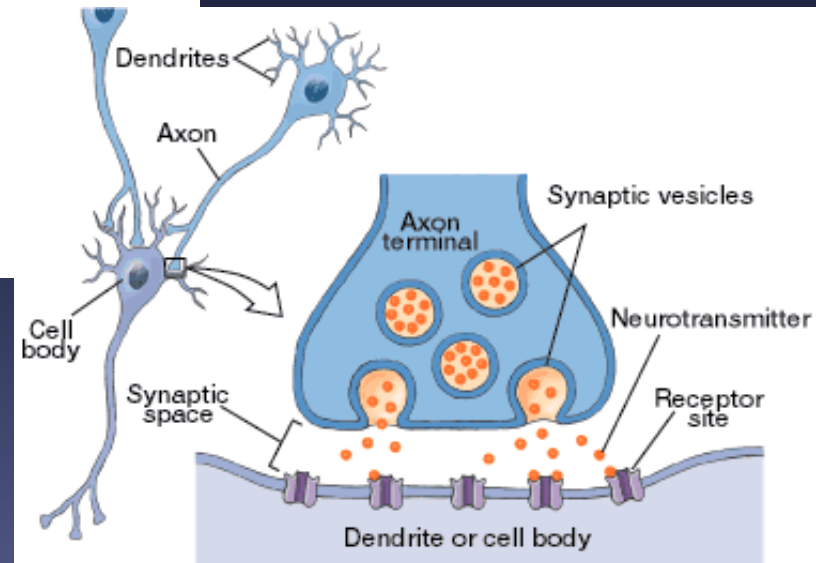
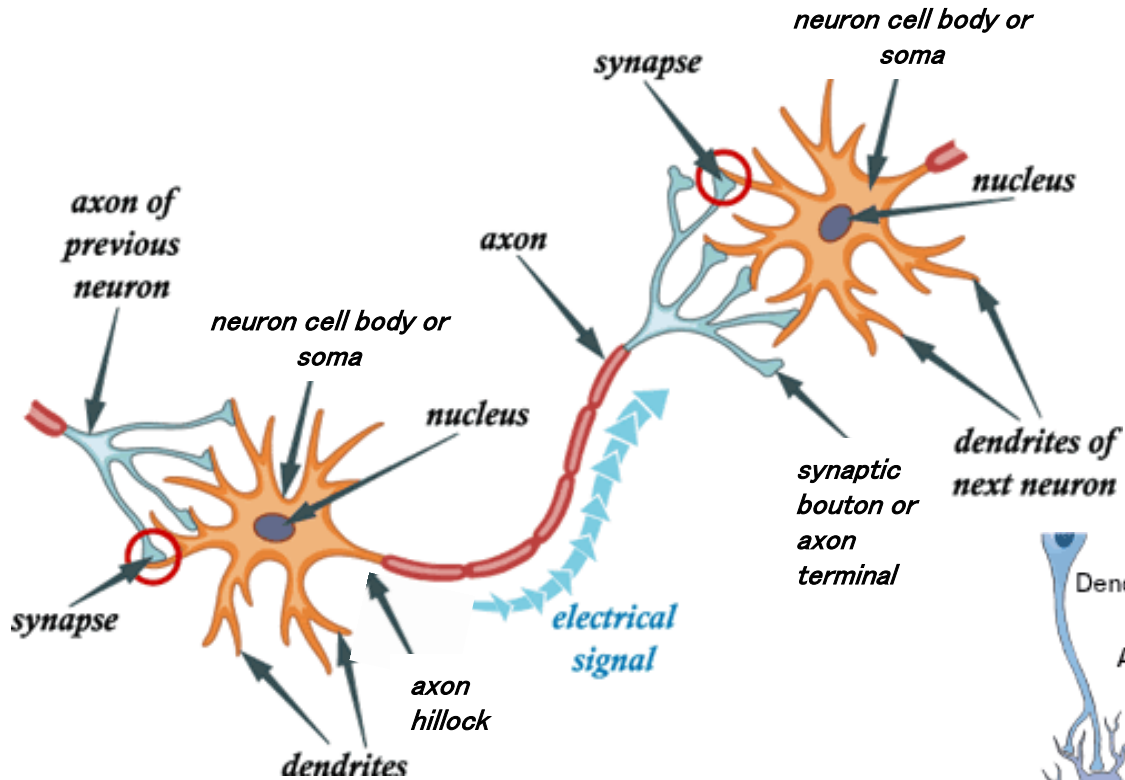
- Are excitable (produce action potentials)
- Sense environmental changes
- Process information
- Control muscles & organs
- Form circuits/networks
- Do not divide

Glia

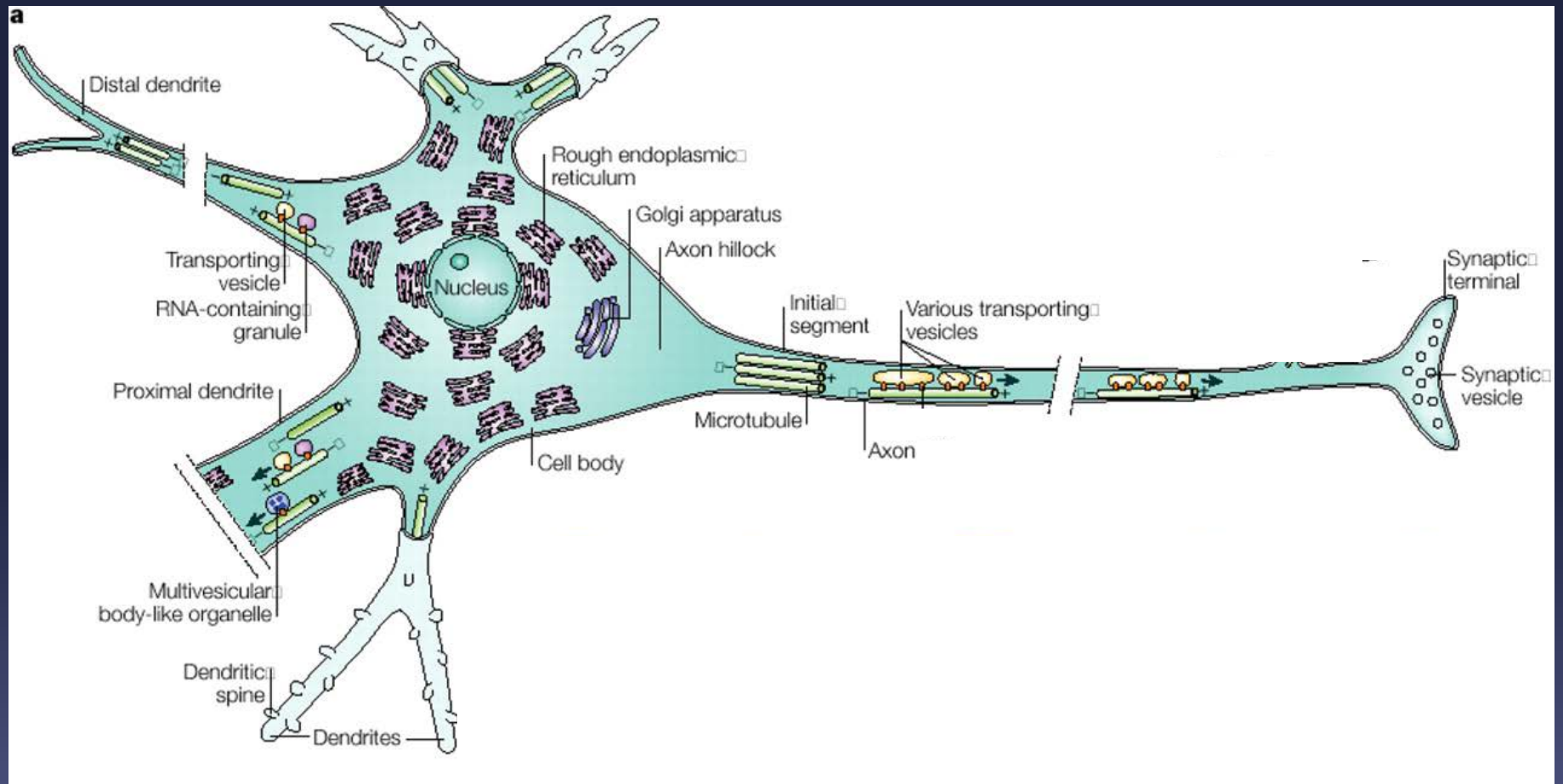
- Provide structural support
- Take up neurotransmitters & ions from extracellular space
- Myelinate neuronal processes
- Secrete trophic factors, cytokines & transmitters
- Phagocytose cellular debris
- Are part of the blood-brain barrier
- Promote movement of CSF
- Direct migration of neurons



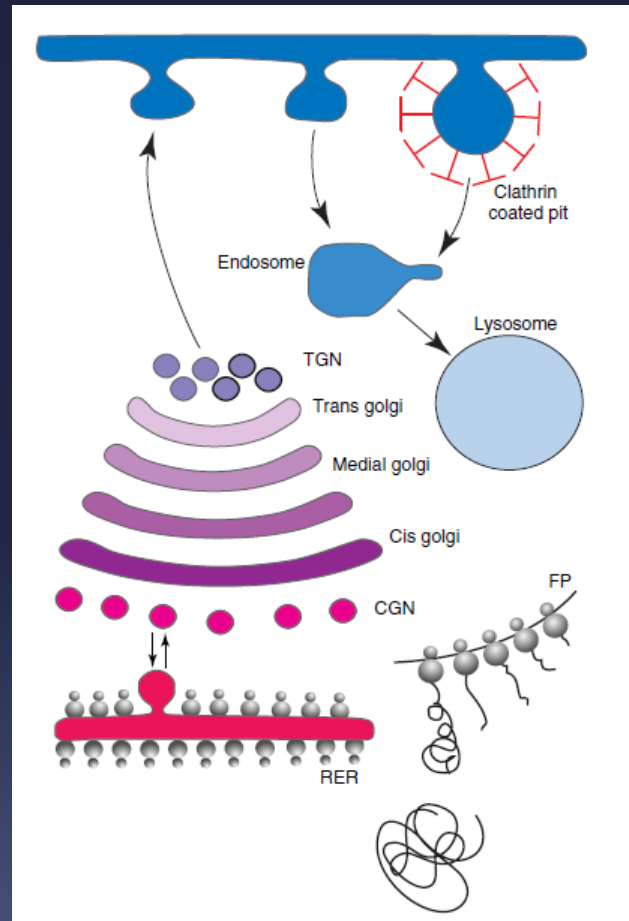
Neuronal Morphology



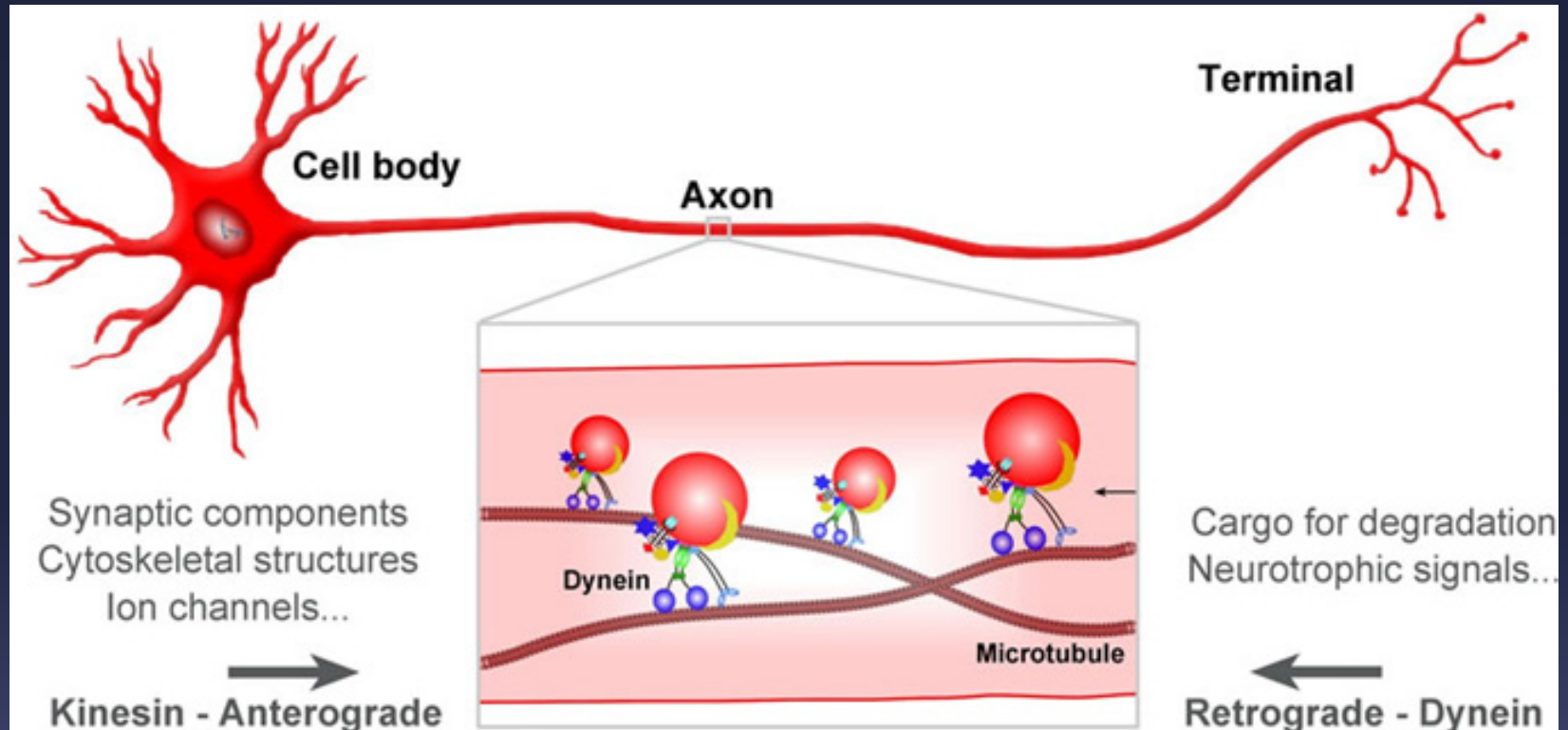
Subcellular Components of Neurons



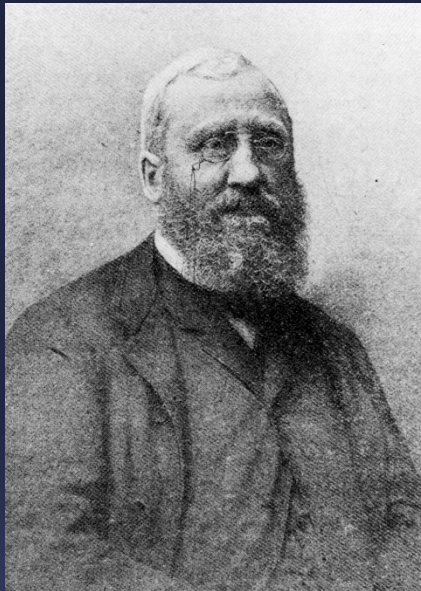
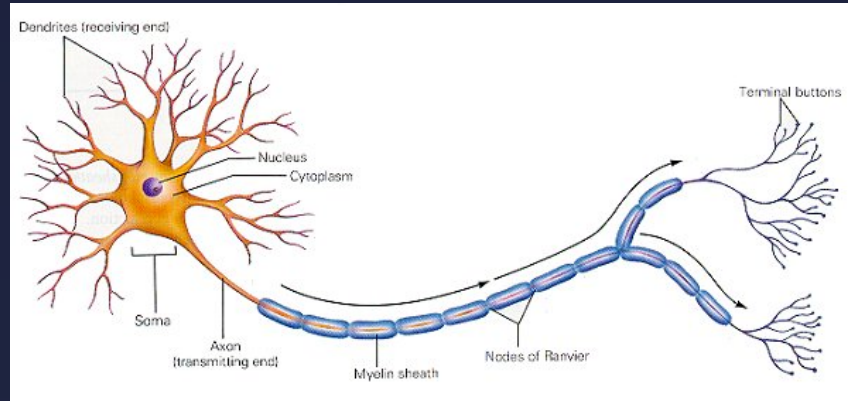
Pathway for Secreted Proteins



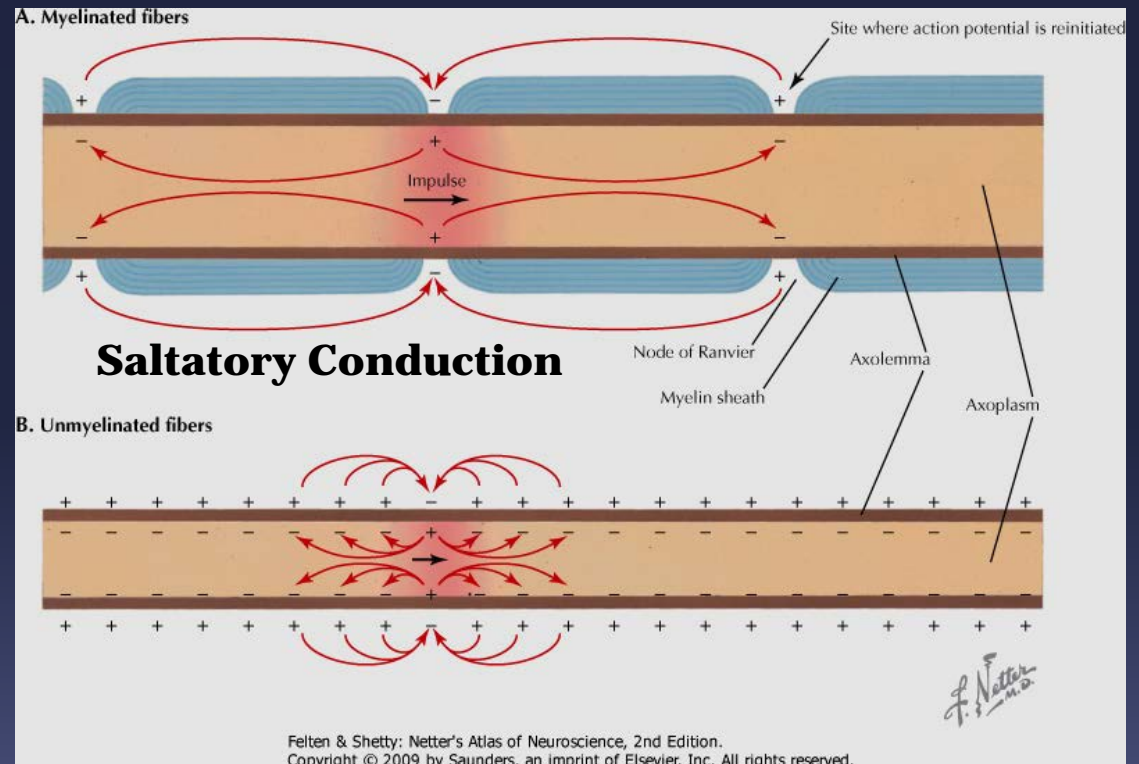
Axonal Transport



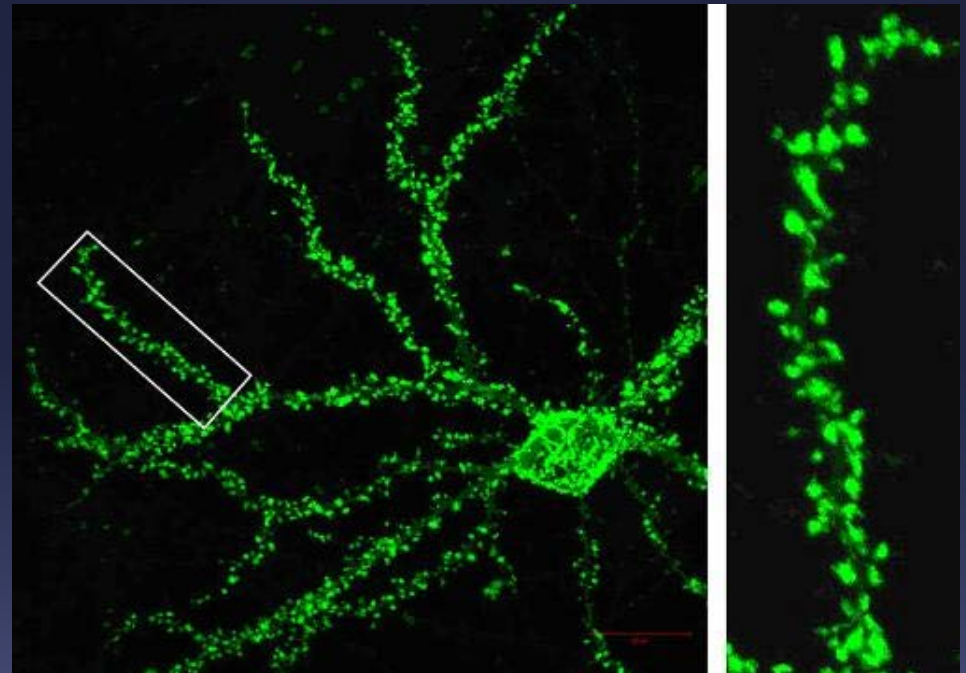
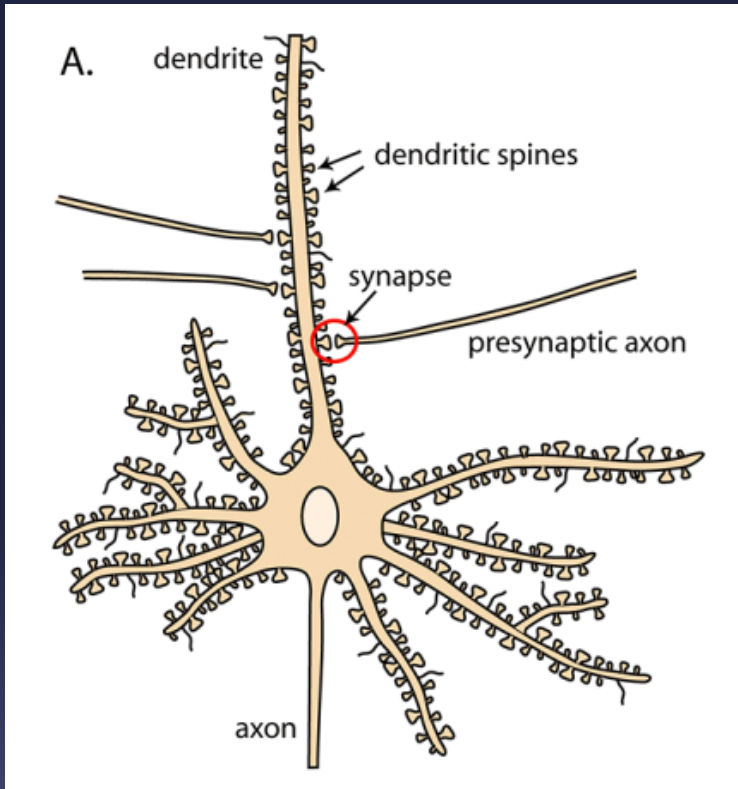
Axons



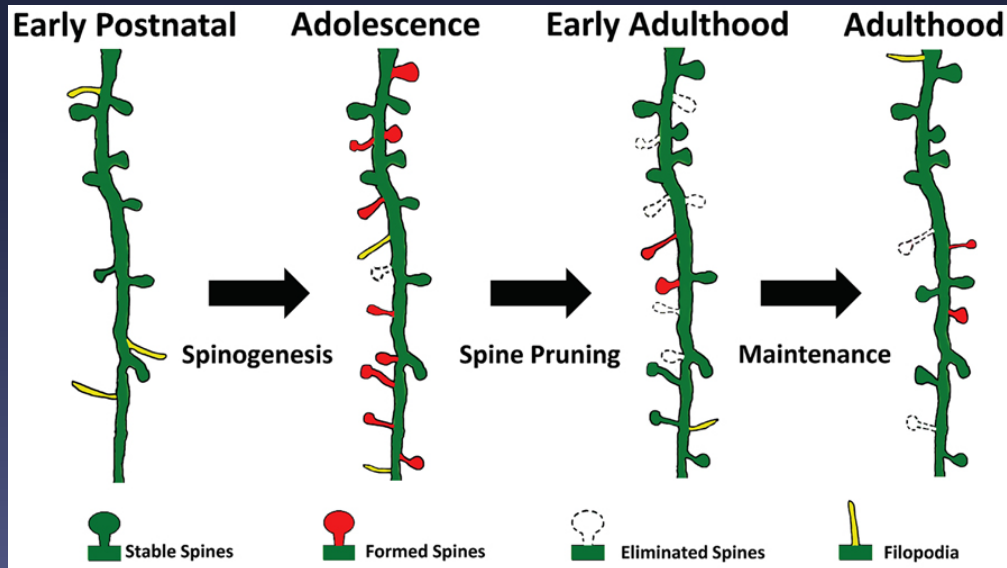
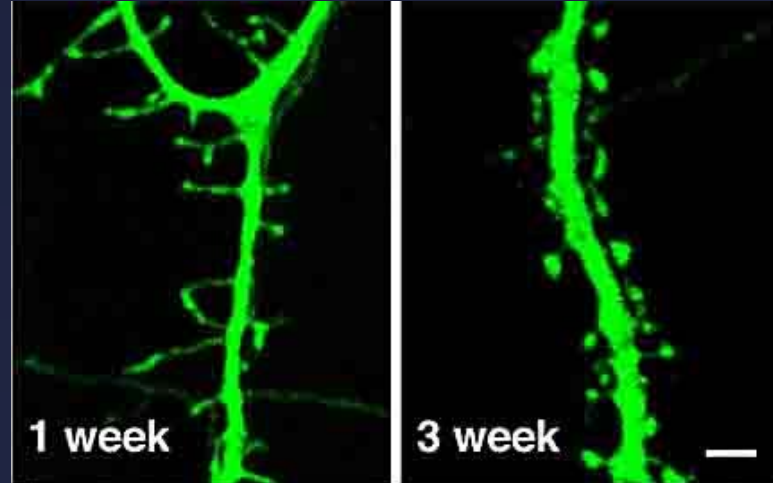
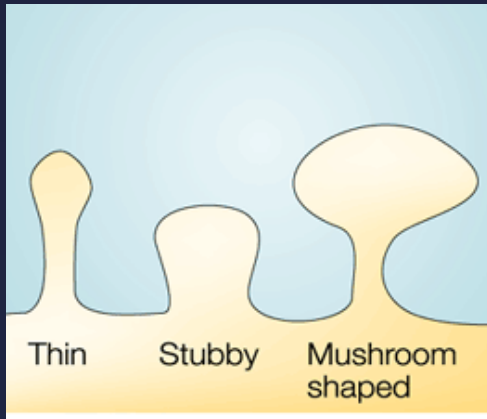
Louis Antoine Ranvier
(1835-1922)



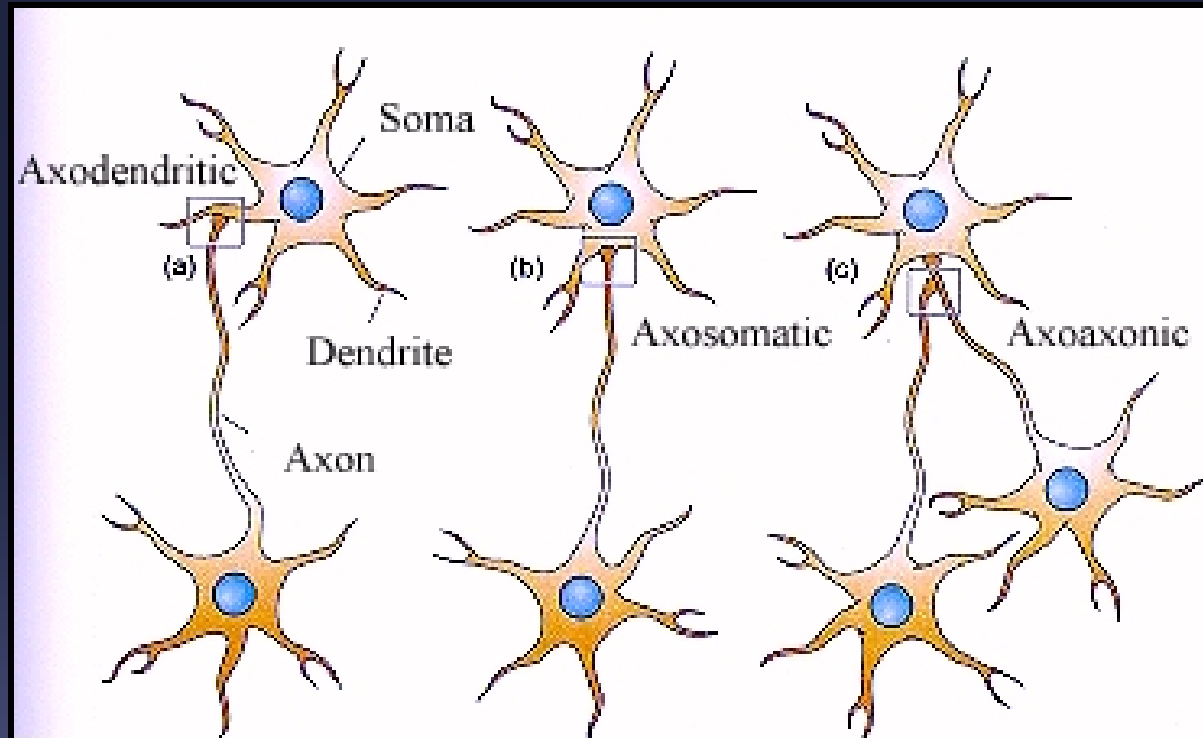
Dendrites and Spines



Spines are Dynamic

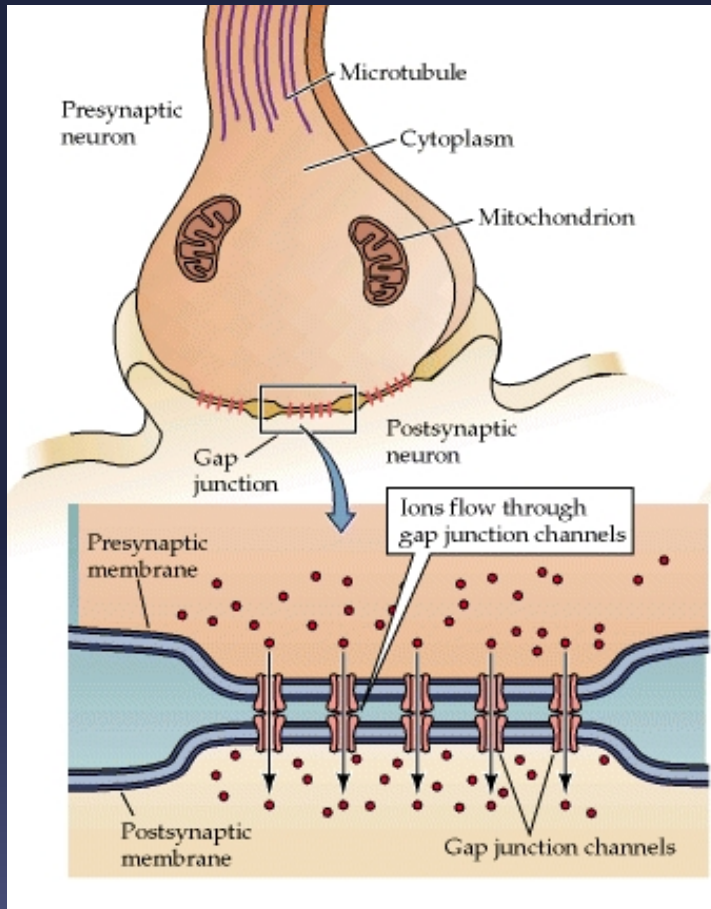


Types of Synapses

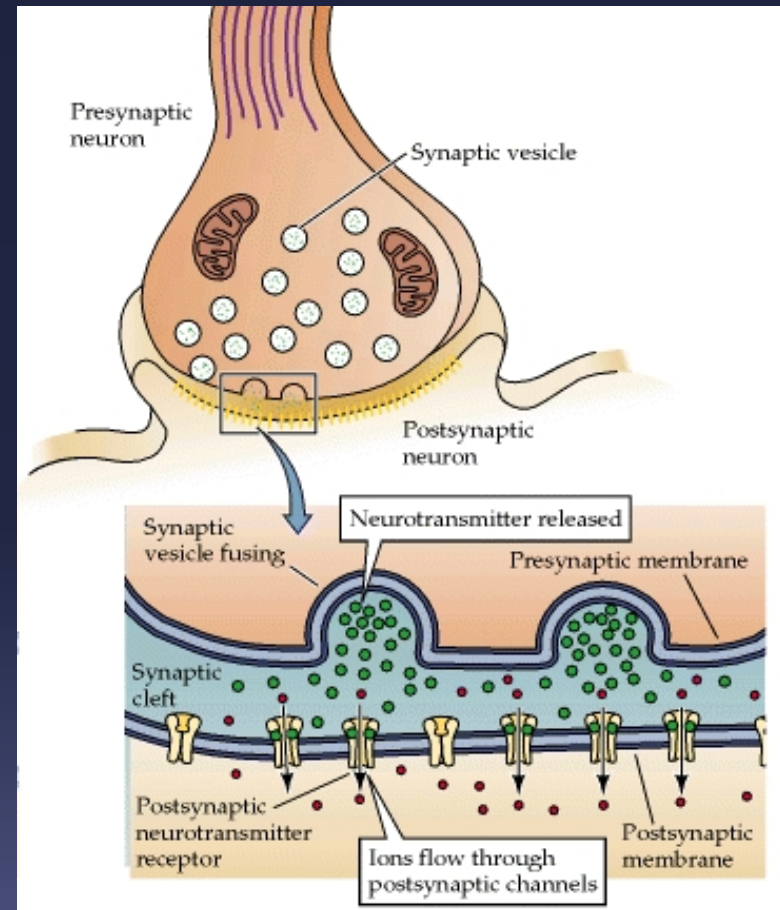


Types of Synapses

Electrical Synapse

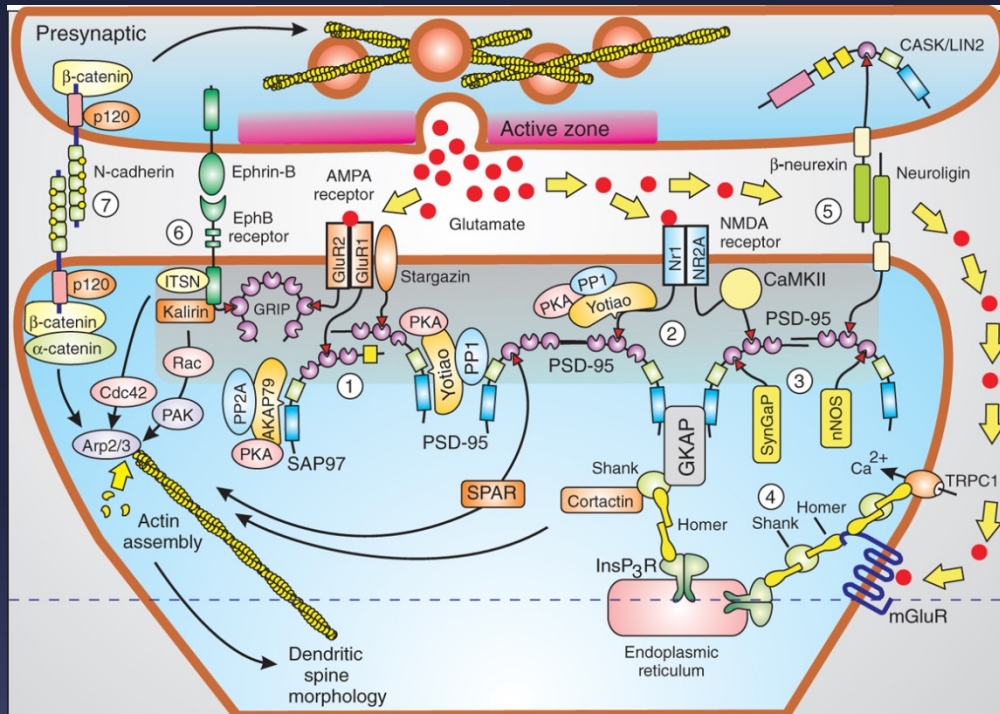


Chemical Synapse

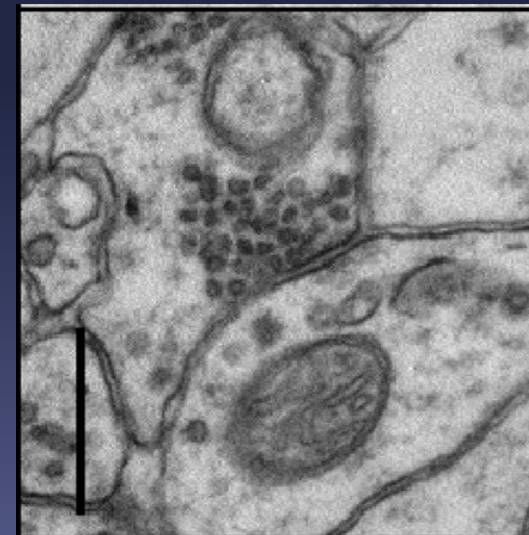


Postsynaptic Density

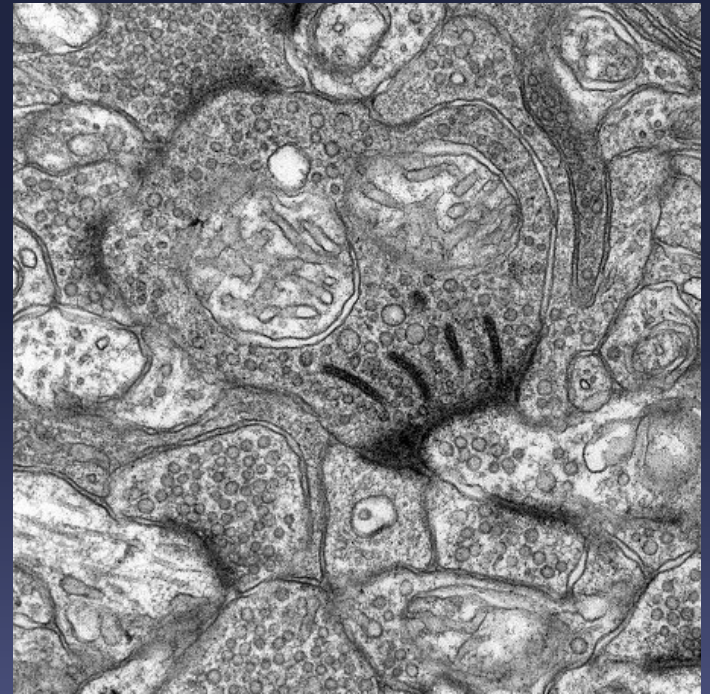
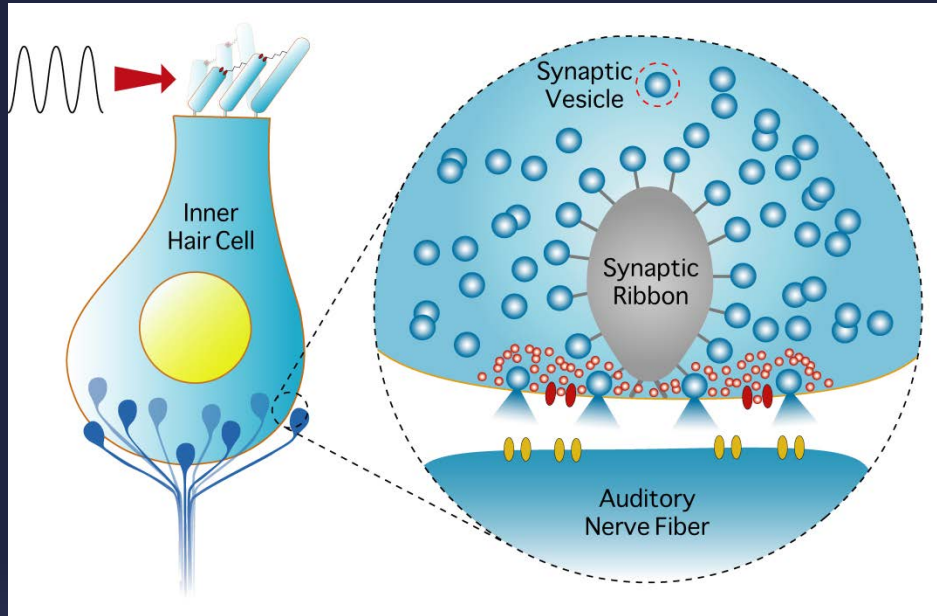
**Asymmetrical synapse
= Excitatory**



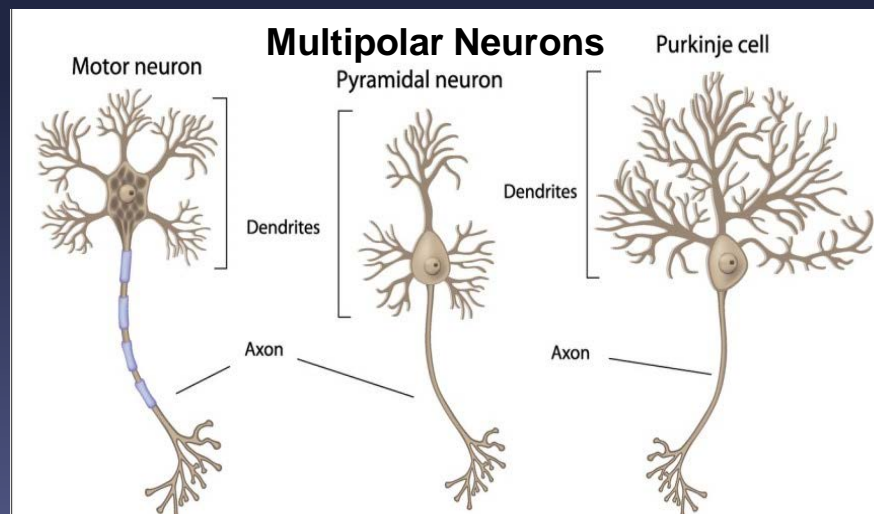
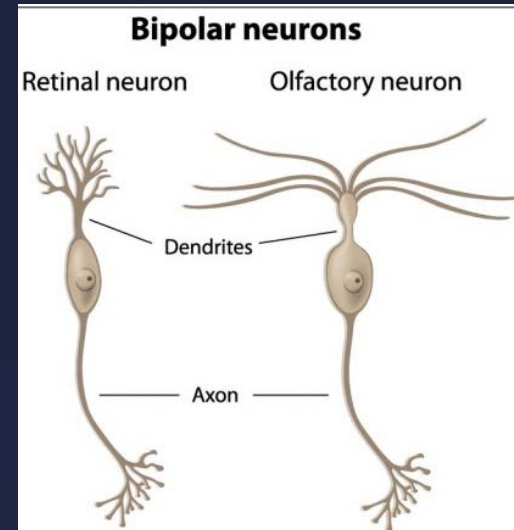
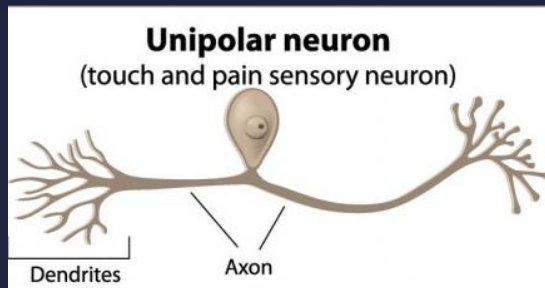
**Symmetrical synapse
= Inhibitory**



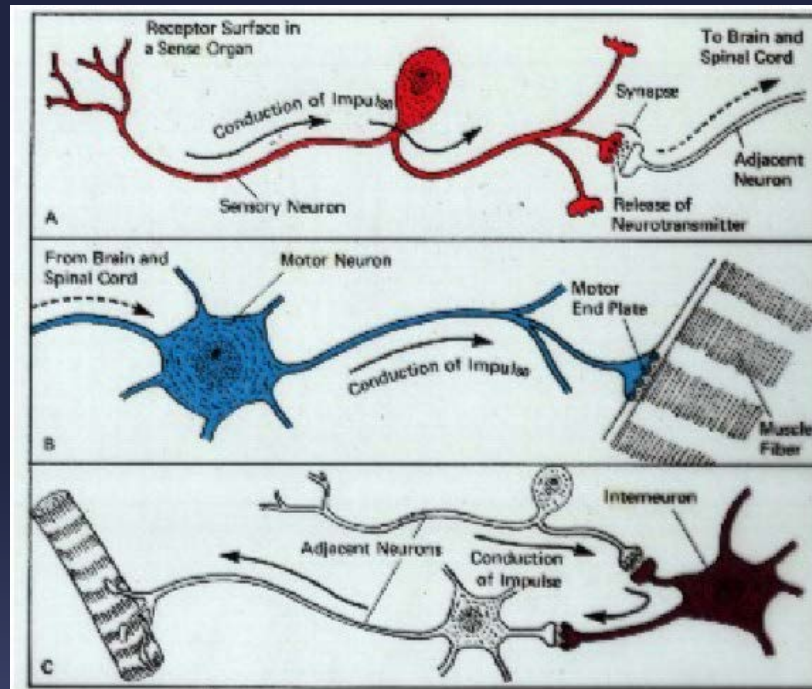
Ribbon Synapse



Classification of Neurons: by Morphology

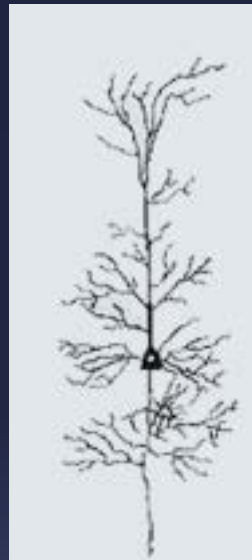


Classification of Neurons: by Function/Connectivity



Efferent neuron = projects FROM CNS
Afferent neuron = projects TO CNS

Classification of Neurons: by Dendrite Structure



Pyramidal neuron



Stellate neuron



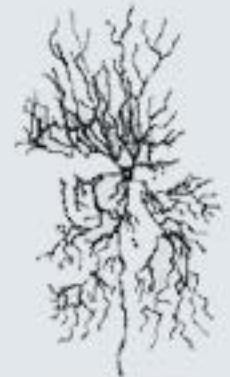
Purkinje cell



Granule neuron



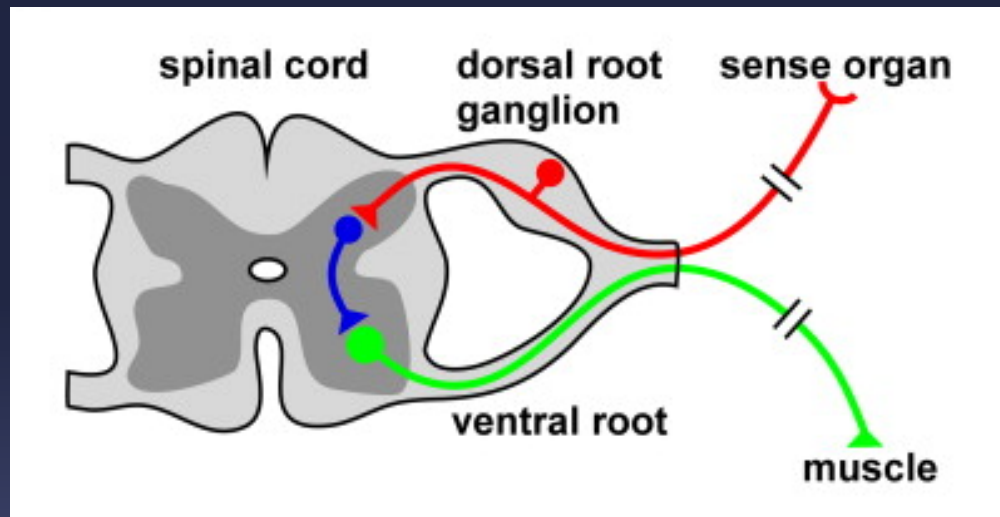
Basket neuron



Chandelier neuron

Classification of Neurons by Axon Length

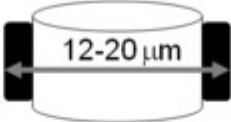
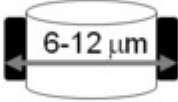
Golgi Type I vs. Golgi Type II



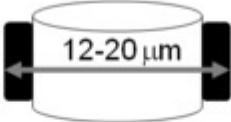
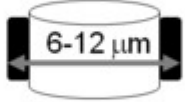

Classification of Neurons by Axon Diameter

<i>Fibre Type</i>	<i>Diameter</i>	<i>Conduction velocity</i>	<i>Myelinated</i>	<i>Function</i>
A alpha	I 	72-120 m/s	Yes	Muscle control. Stretch

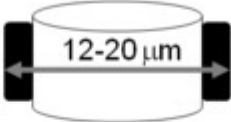
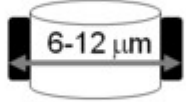


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A alpha	I 	72-120 m/s	Yes	Muscle control, Stretch
A beta	II 	36-72 m/s	Yes	Touch, pressure

Classification of Neurons by Axon Diameter

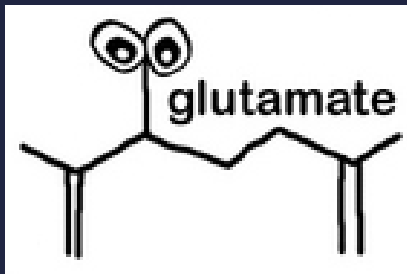
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A delta	III 	4-36 m/s	Thinly	Pain, Cold temperature

Classification of Neurons by Axon Diameter

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A beta	II 	36-72 m/s	Yes	Touch, pressure
A delta	III 	4-36 m/s	Thinly	Pain, Cold temperature
C	IV  0.2-1.5 μm	0.4-2 m/s	No	Pain, Itch, Warm temperature, heart rate, blood pressure, Gut function

Classification of Neurons by Neurotransmitter Released

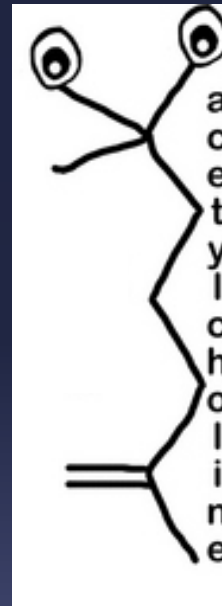
glutamatergic



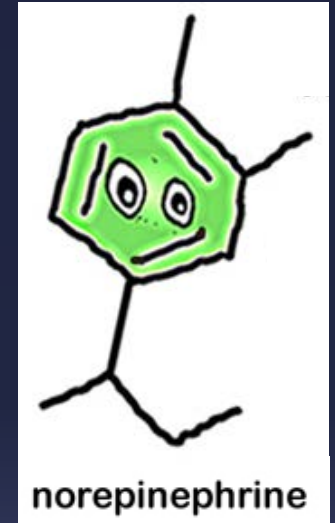
GABAergic



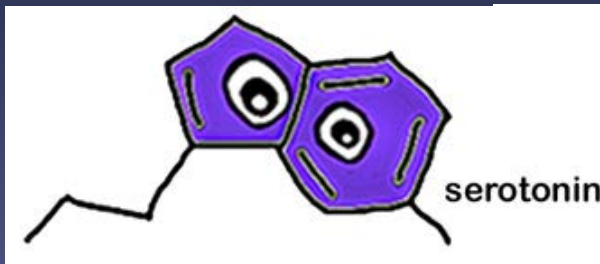
cholinergic



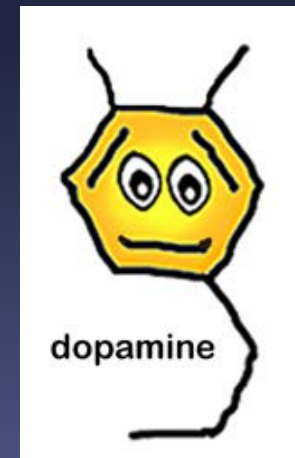
norepinephrinergetic



serotonergic

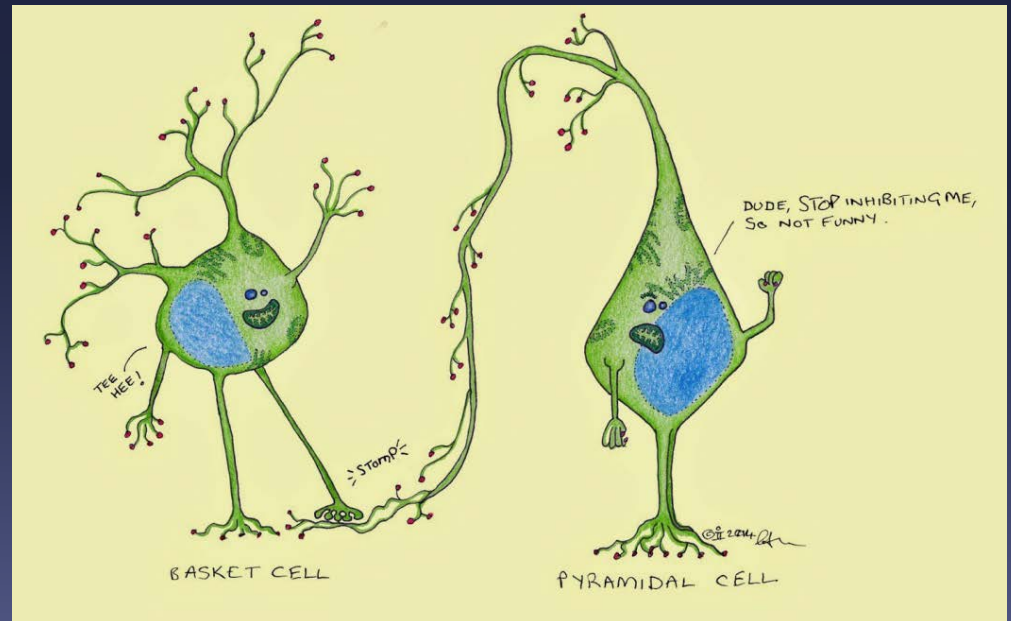


dopaminergic

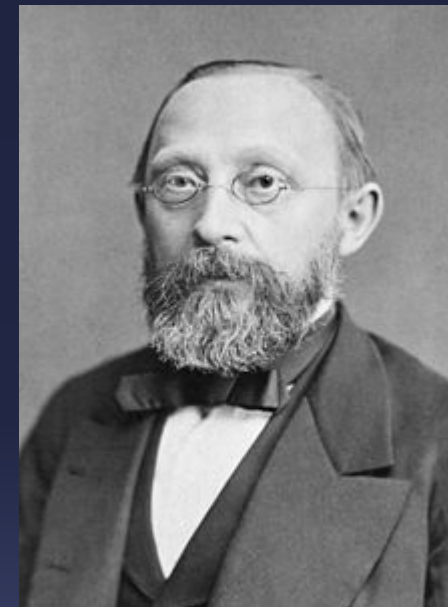
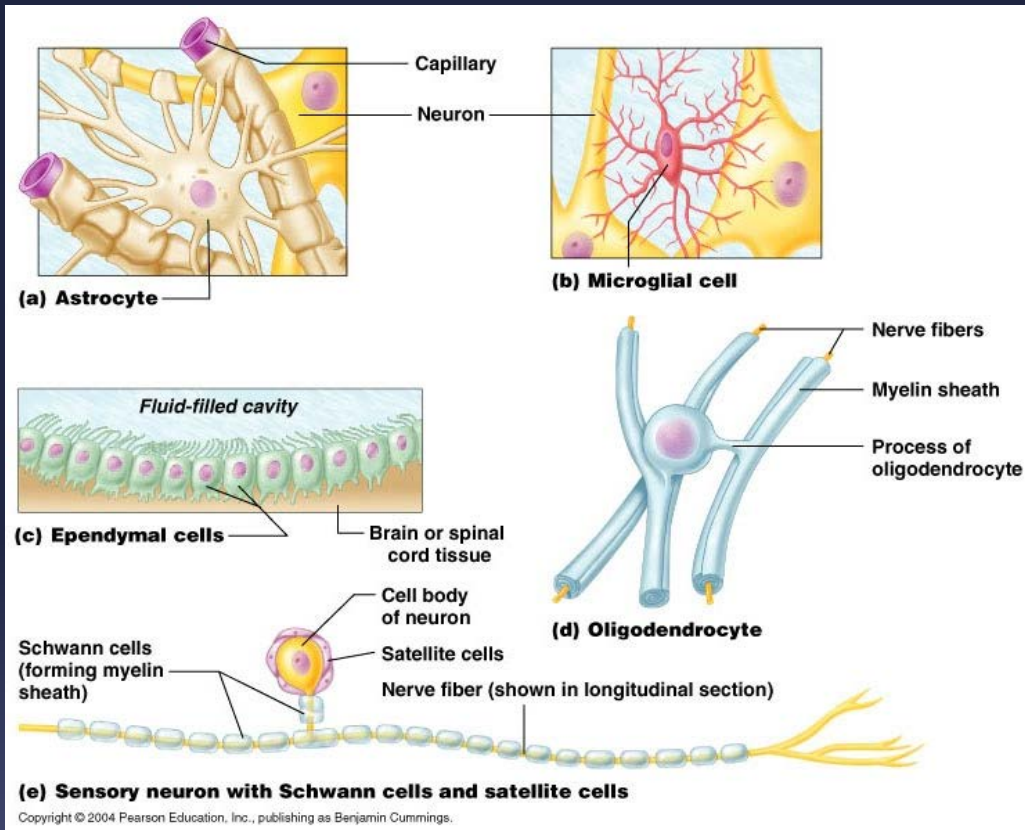


Summary

- Differences between Neurons & Glia
- Neuronal morphology:
 - Axons vs. Dendrites
 - Spines
 - Synapses: Excitatory vs. Inhibitory
- Classifications of neurons:
 - By morphology
 - By function
 - By dendrite structure
 - By axon length
 - By axon diameter
 - By Neurotransmitter



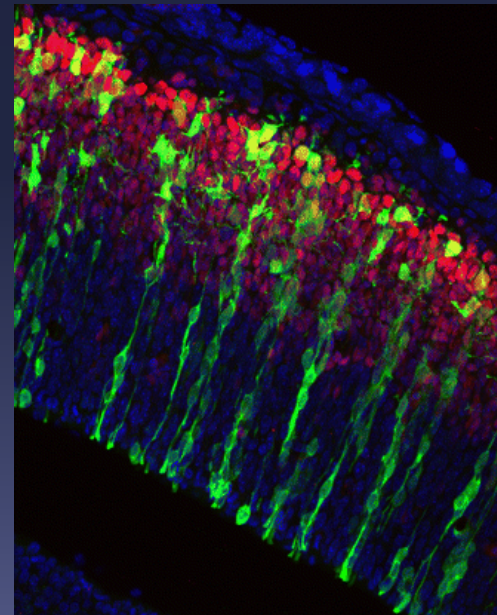
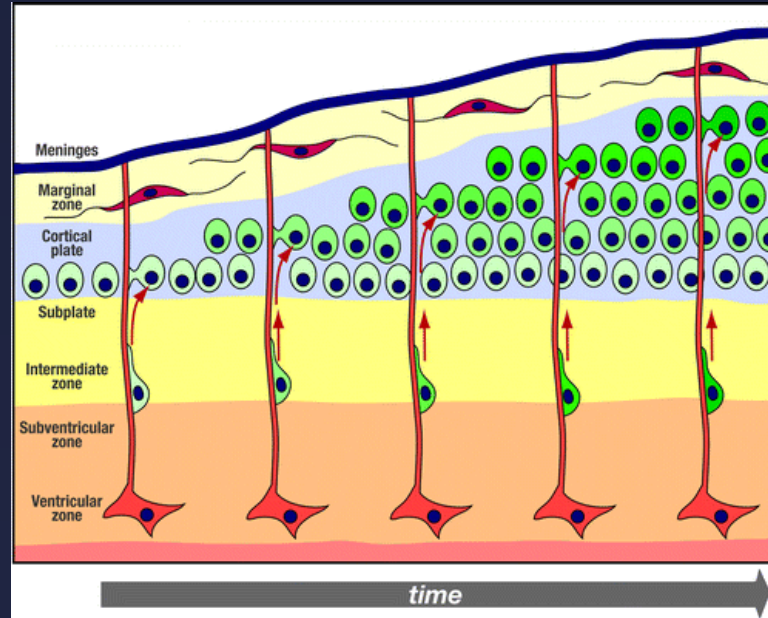
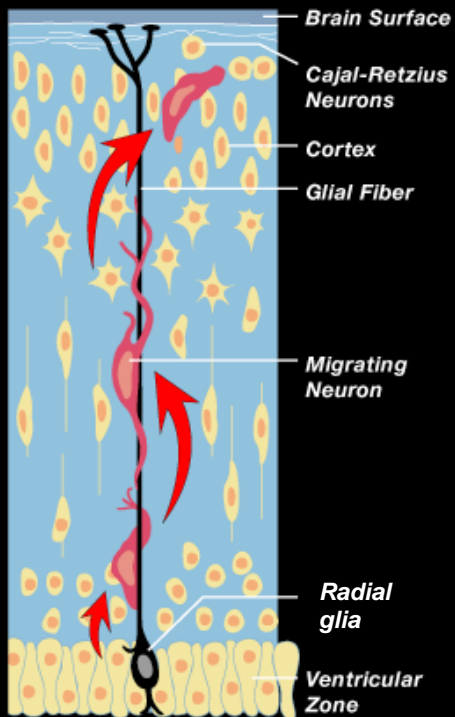
Neuroglia or just Glia



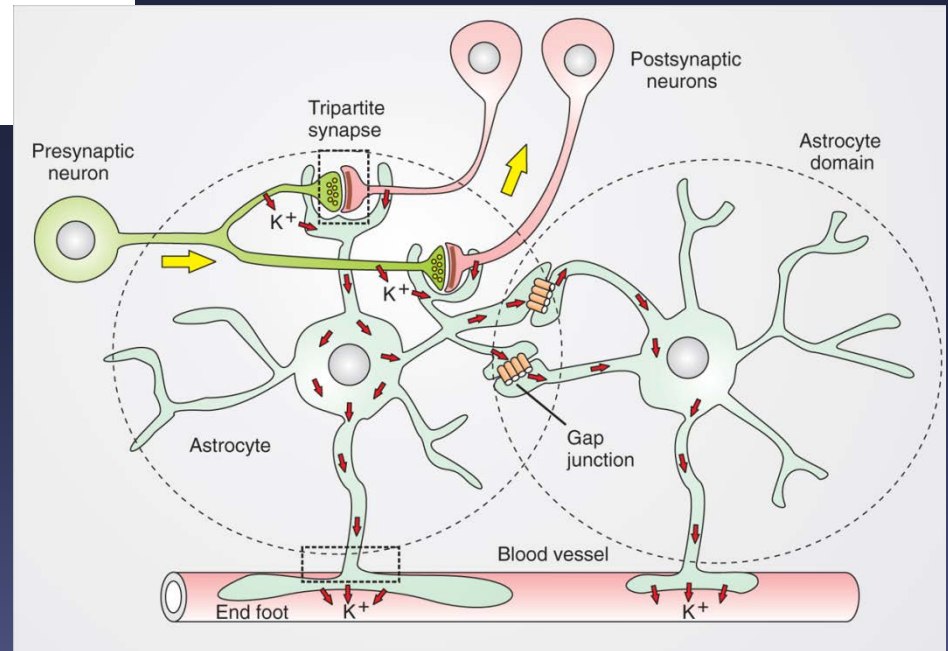
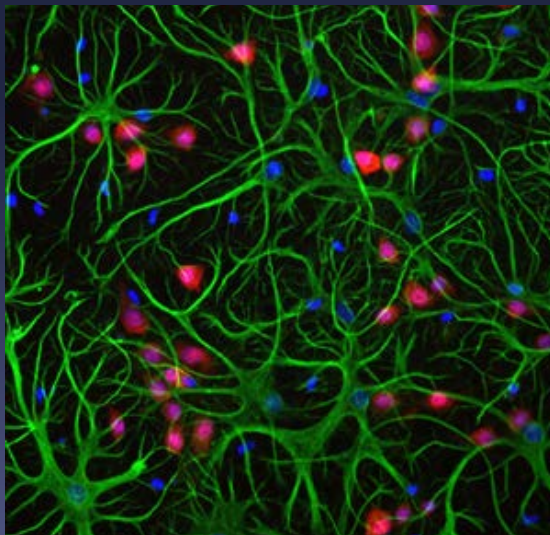
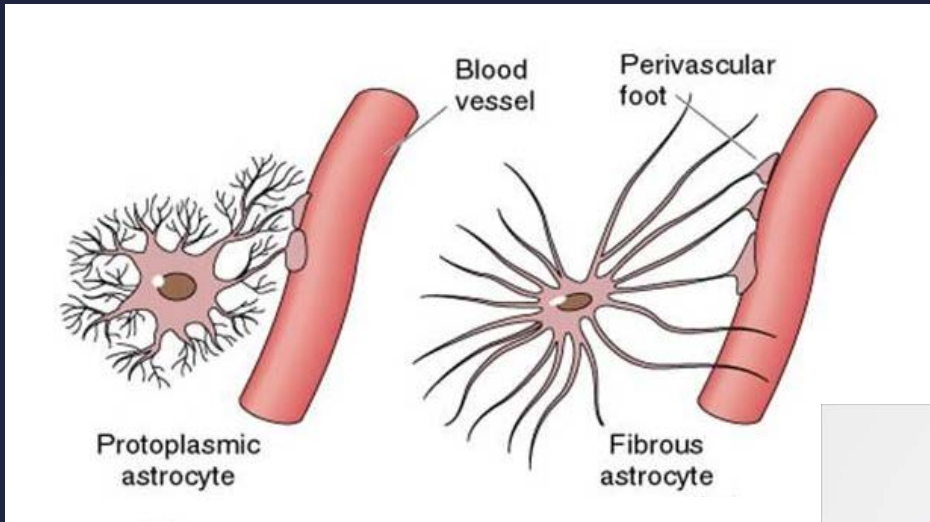
Rudolf Virchow
(1821-1902)

Radial Glia

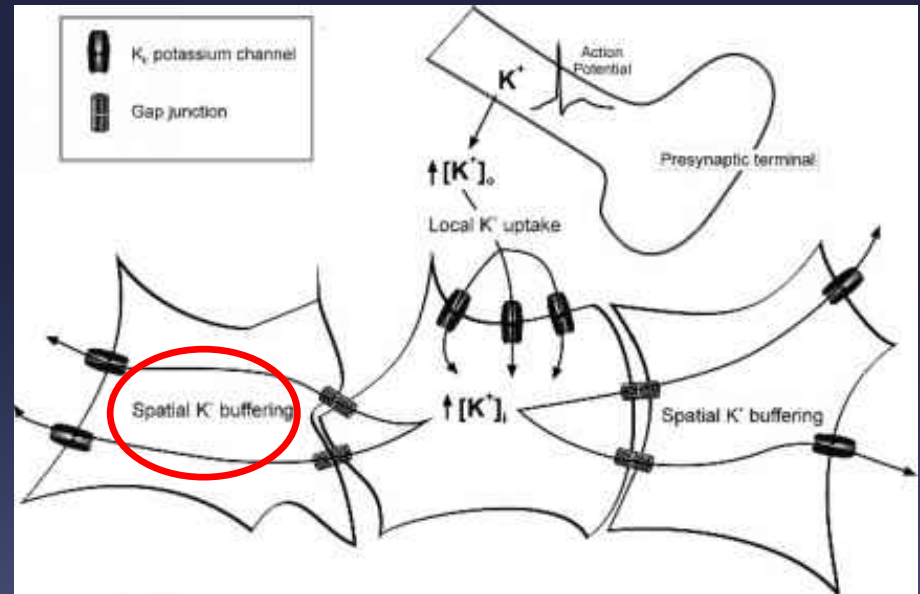
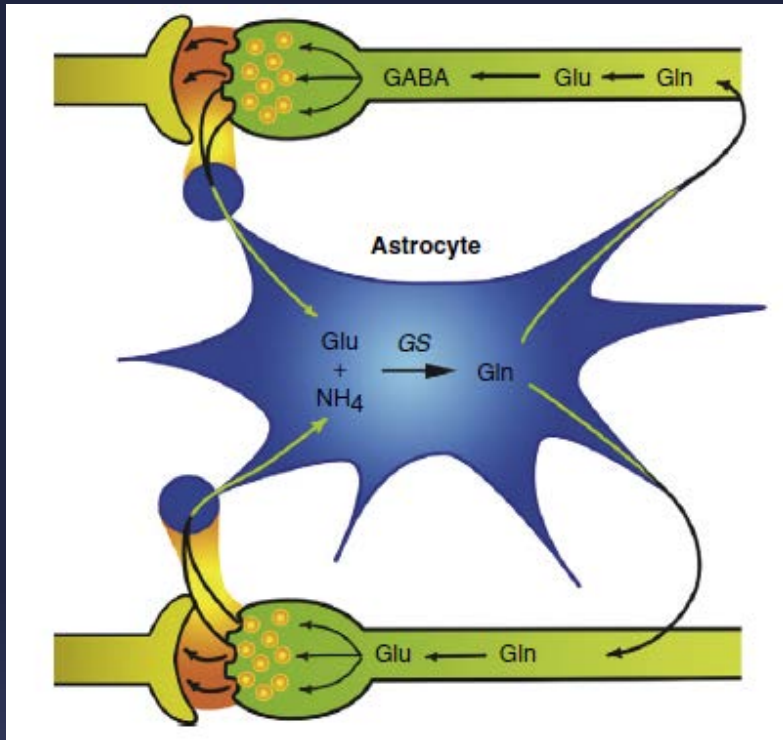
Formation of Cortical Layers by Neuronal Migration Along Radial Glial Guidance Fibers



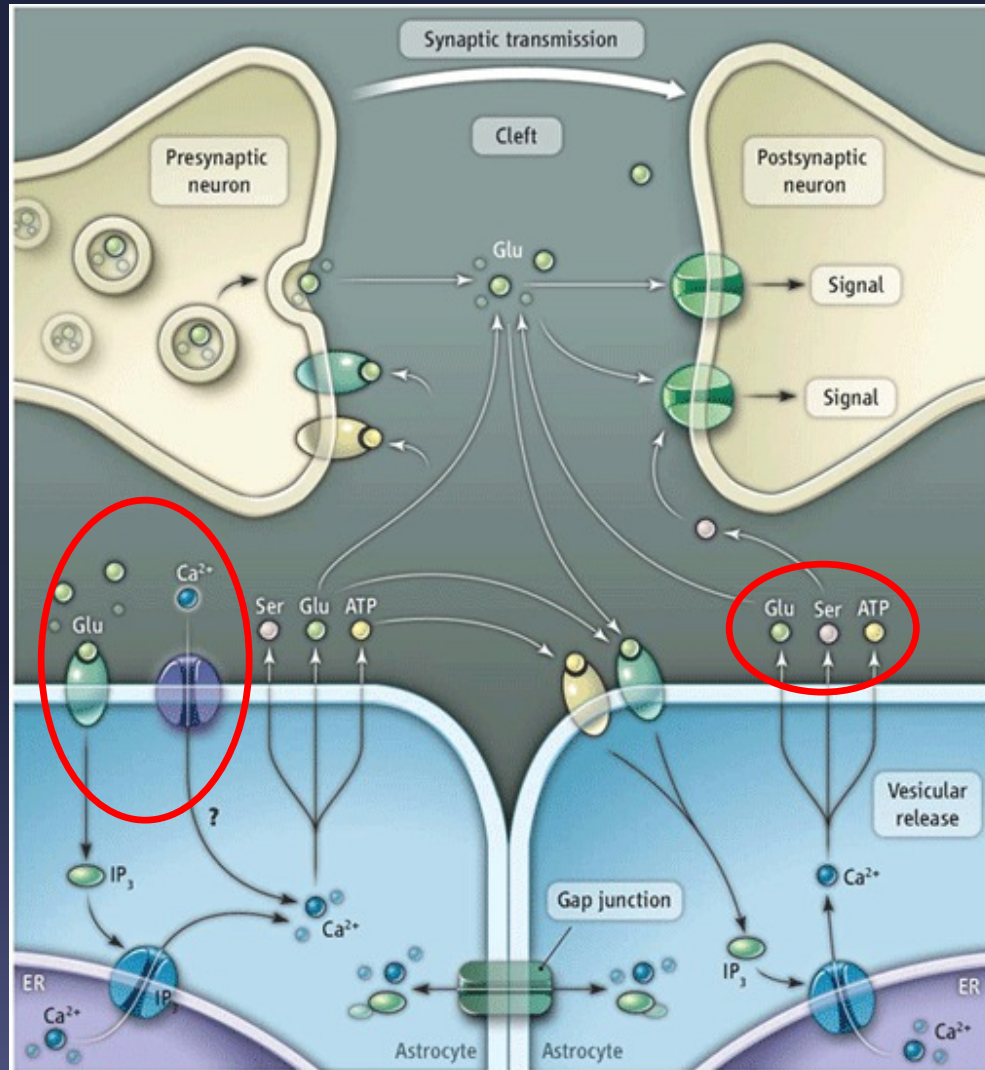
Astrocytes



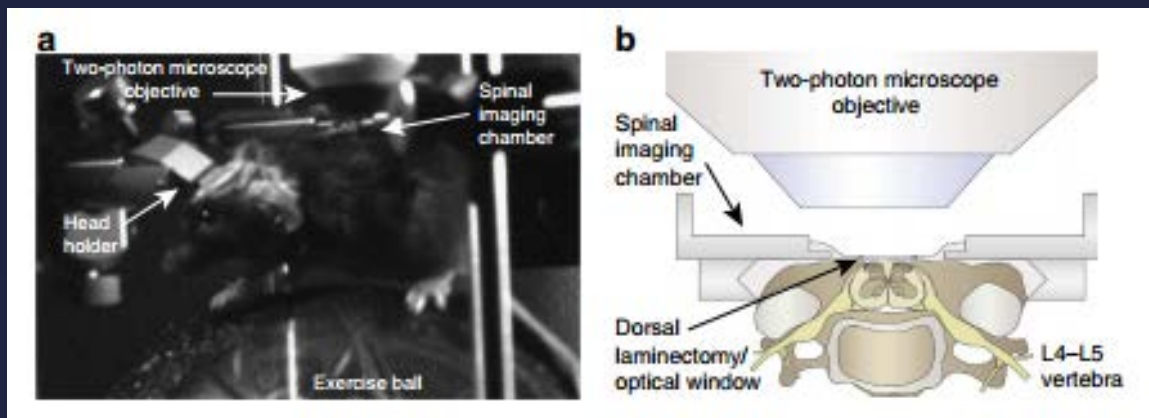
Astrocyte Role in Synaptic Transmission



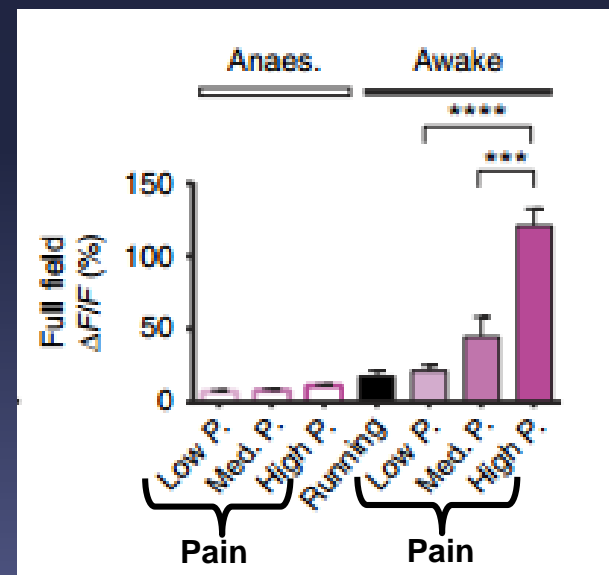
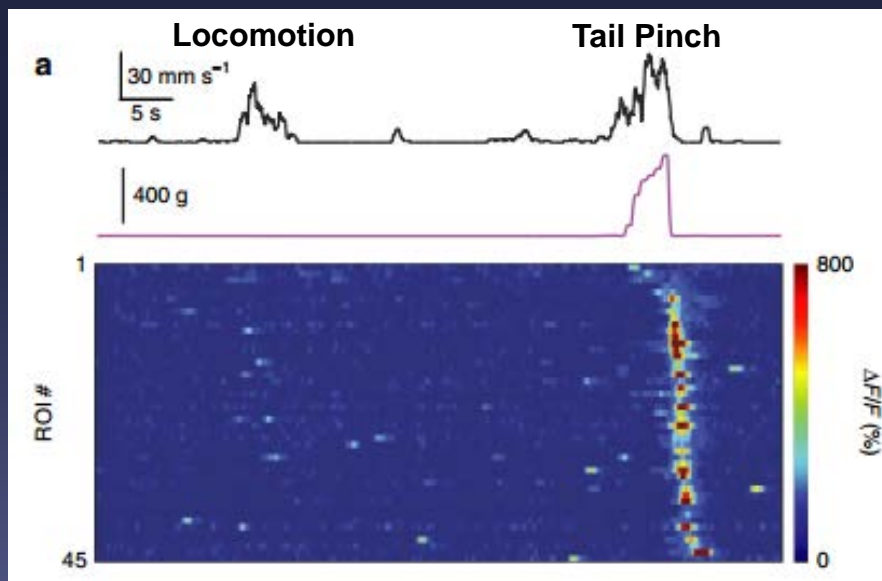
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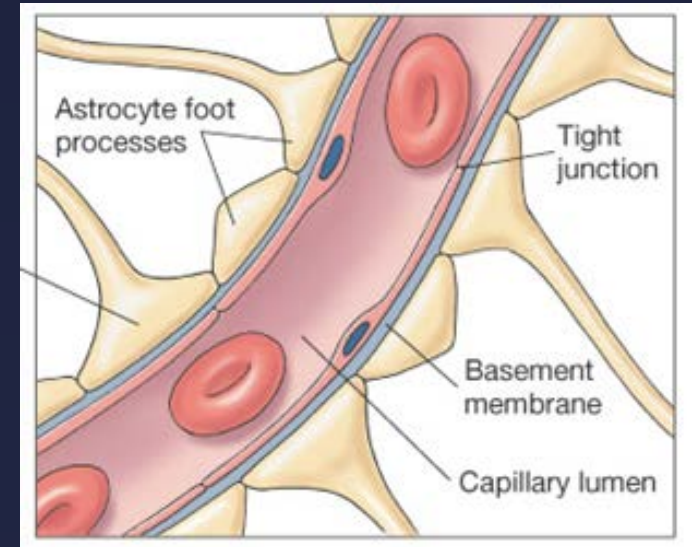
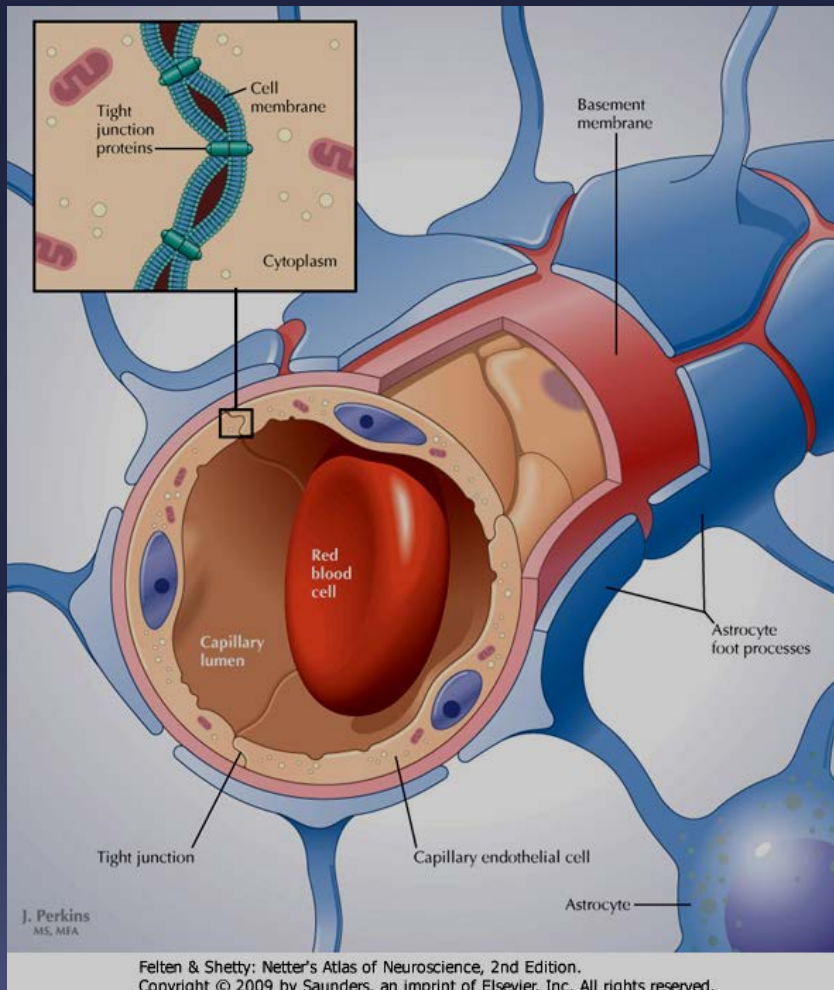
Astrocytes Respond to Painful Stimuli



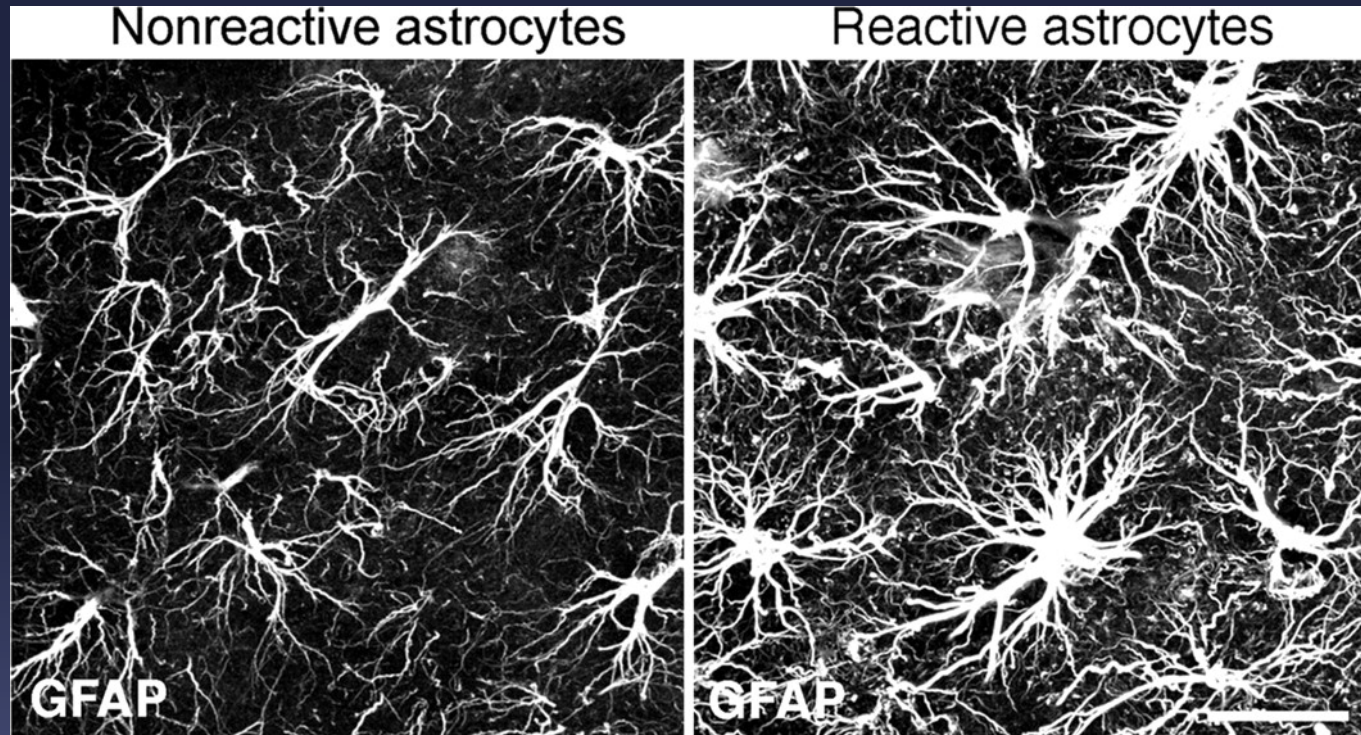
Calcium Signaling in Astrocytes



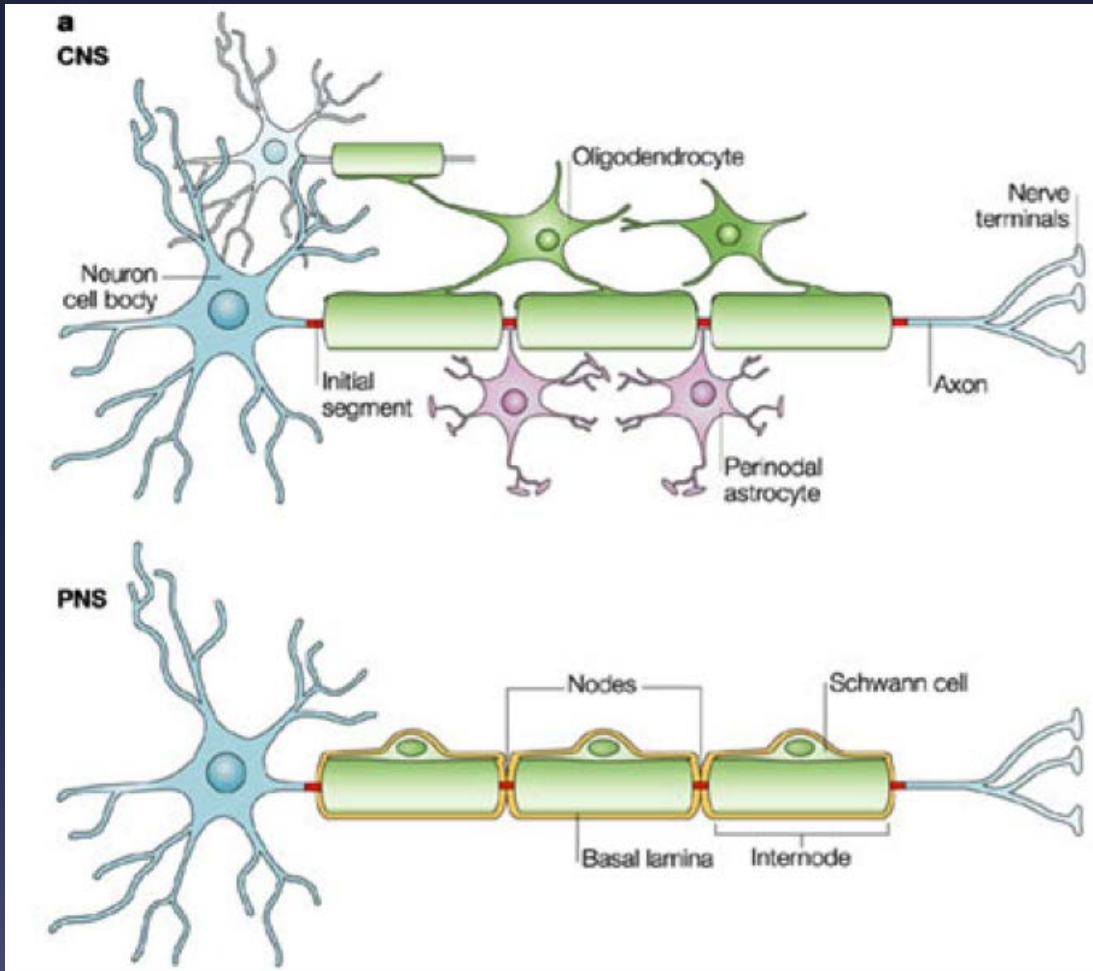
Blood Brain Barrier



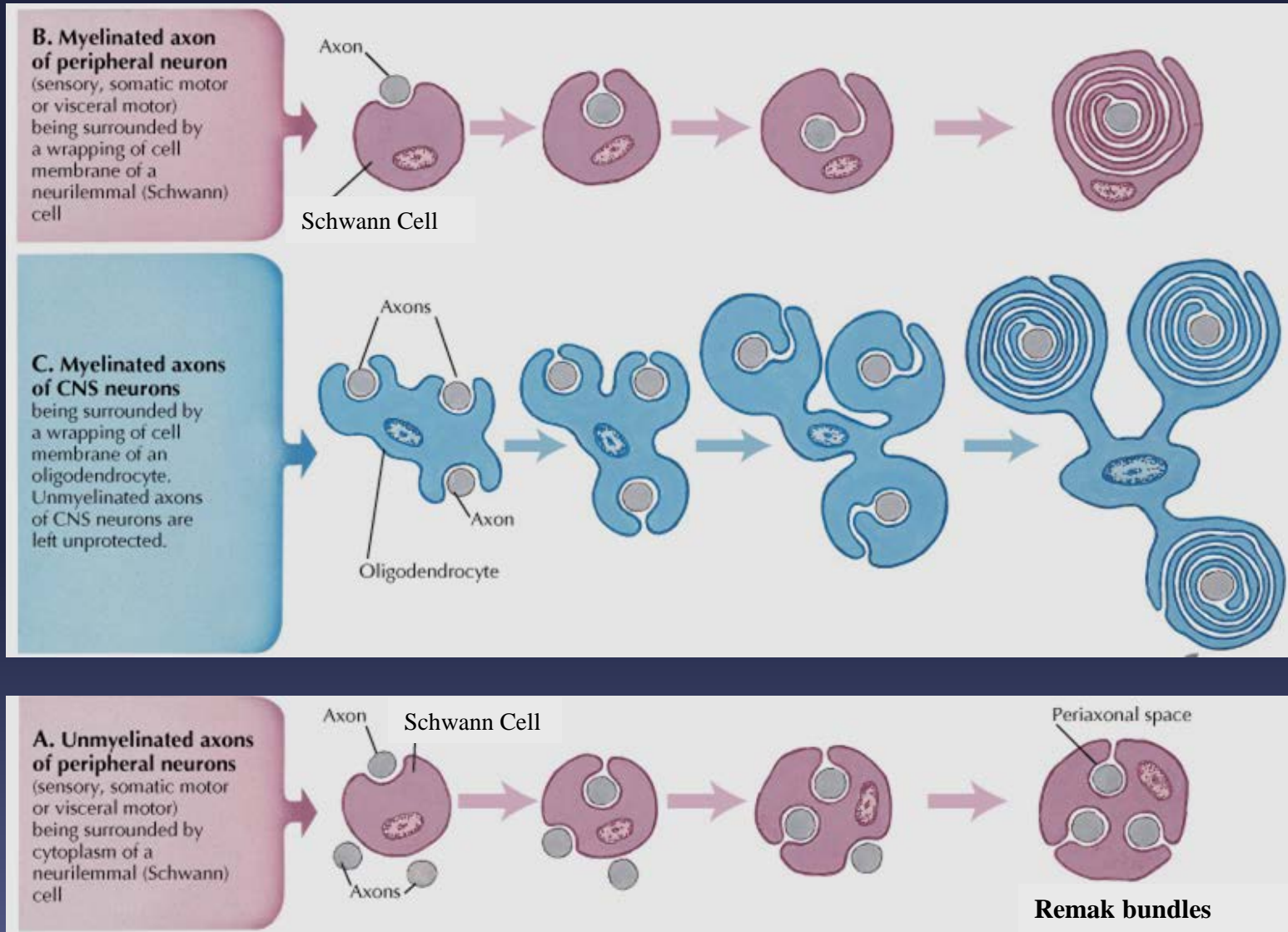
Reactive Astrocytes



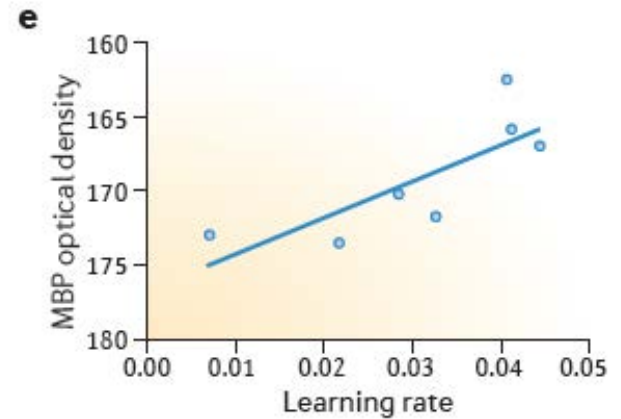
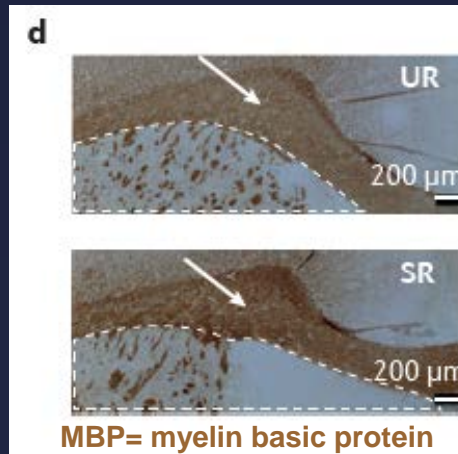
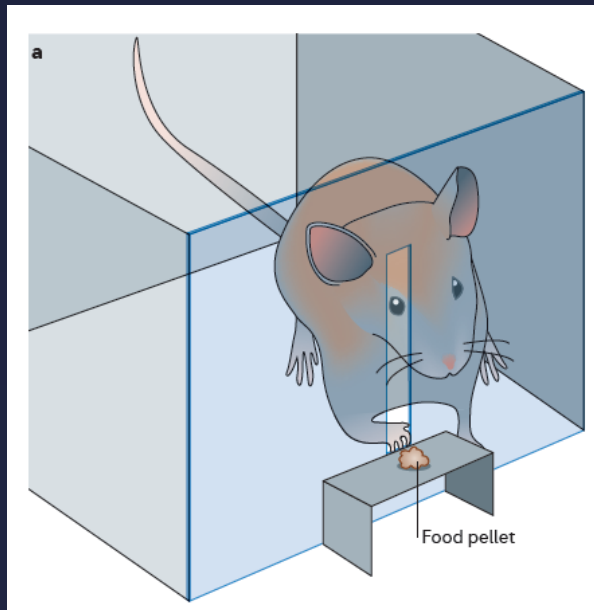
Oligodendrocytes & Schwann Cells



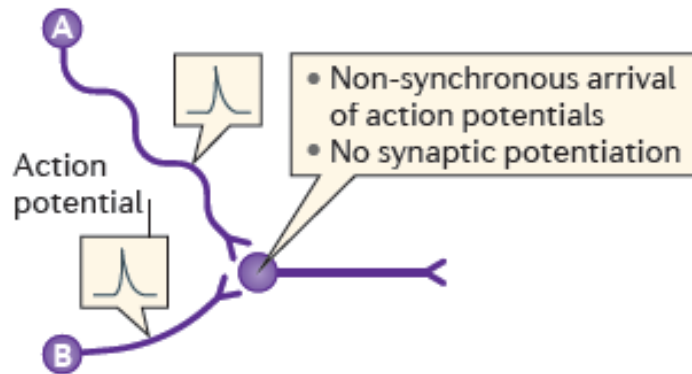
Oligodendrocytes & Schwann Cells



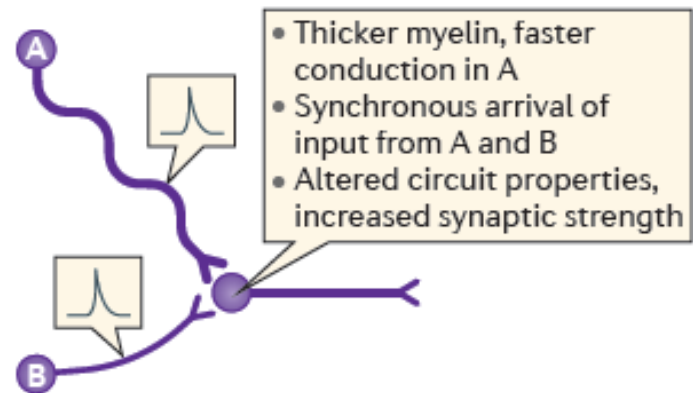
Learning Increases Myelination



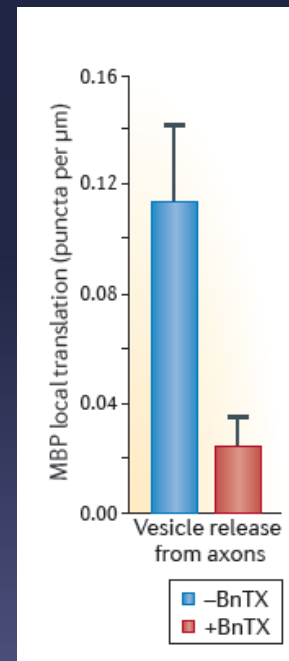
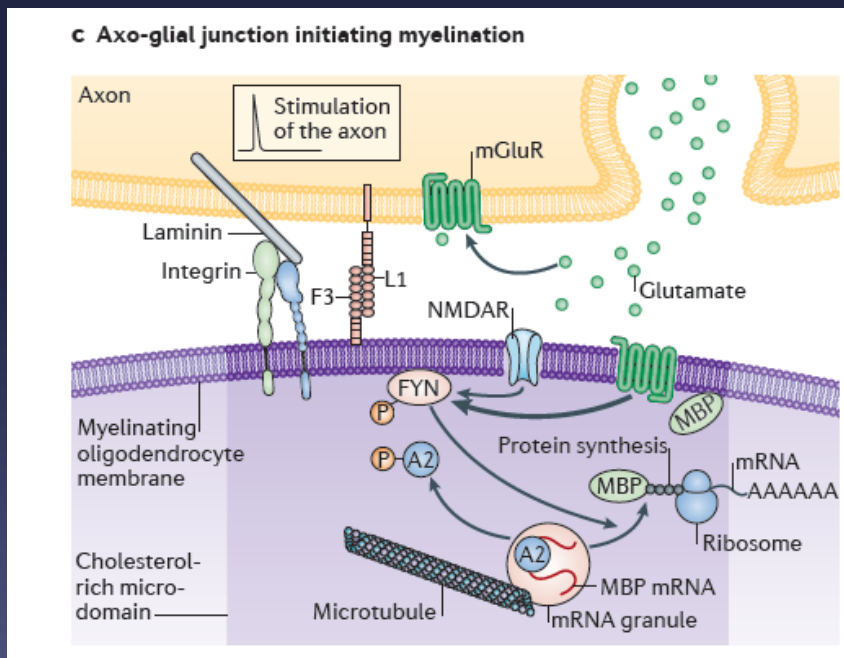
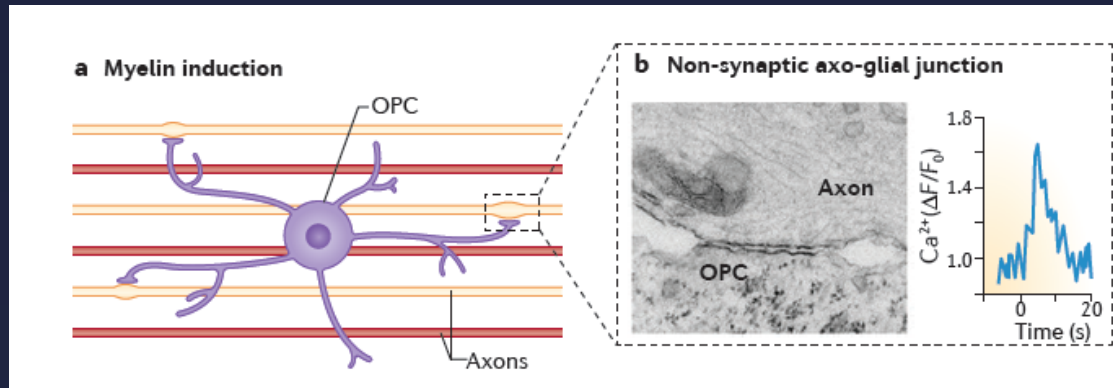
b Before learning



c After learning



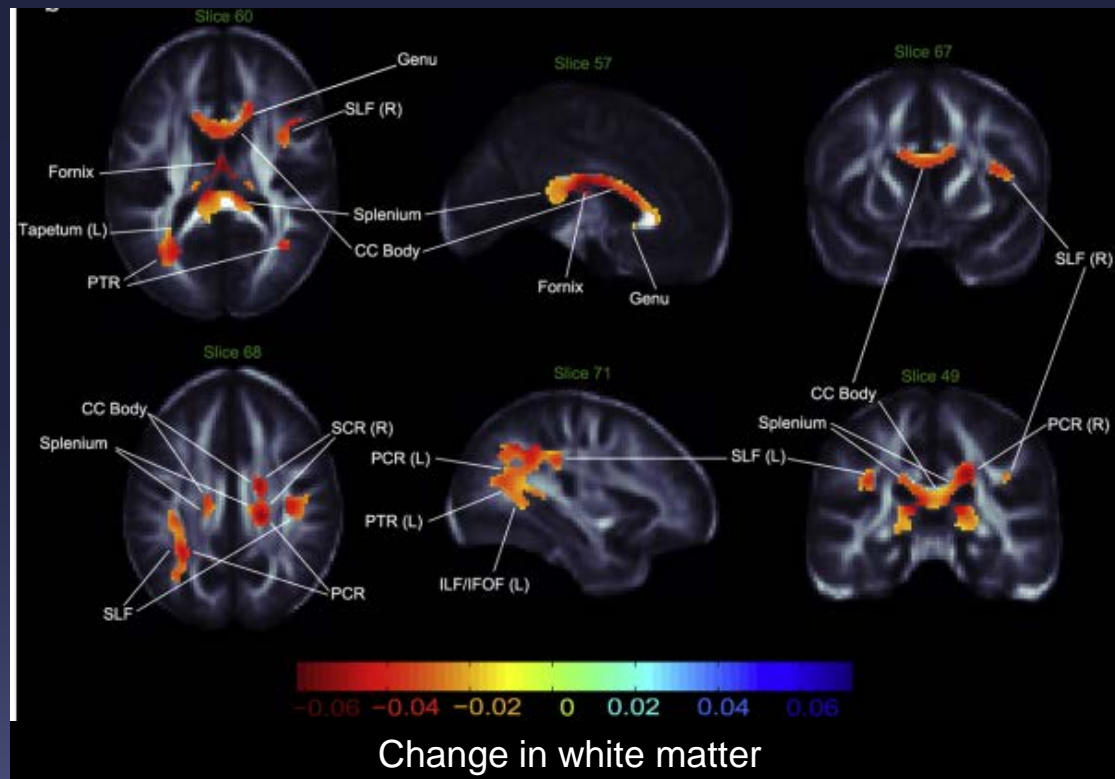
Initiation of Myelination Induced by Neuronal Activity



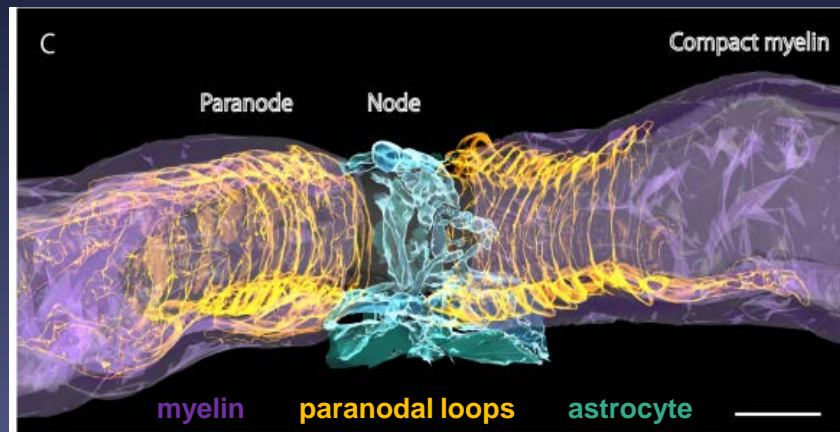
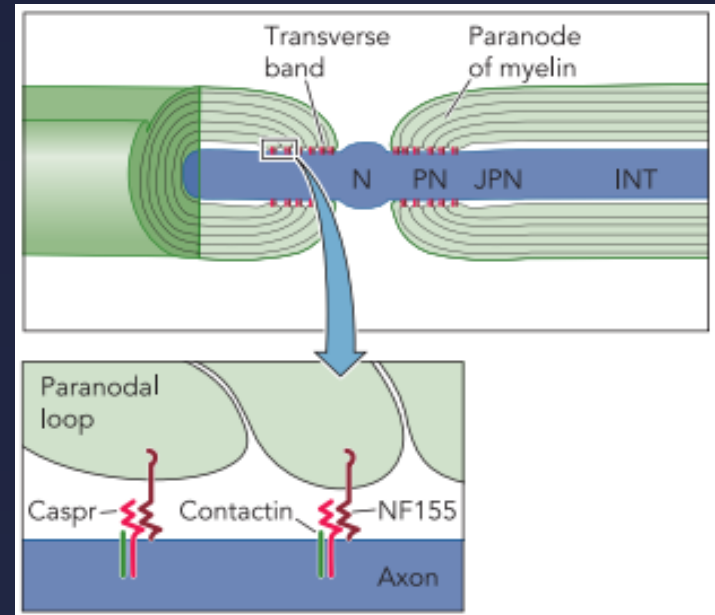
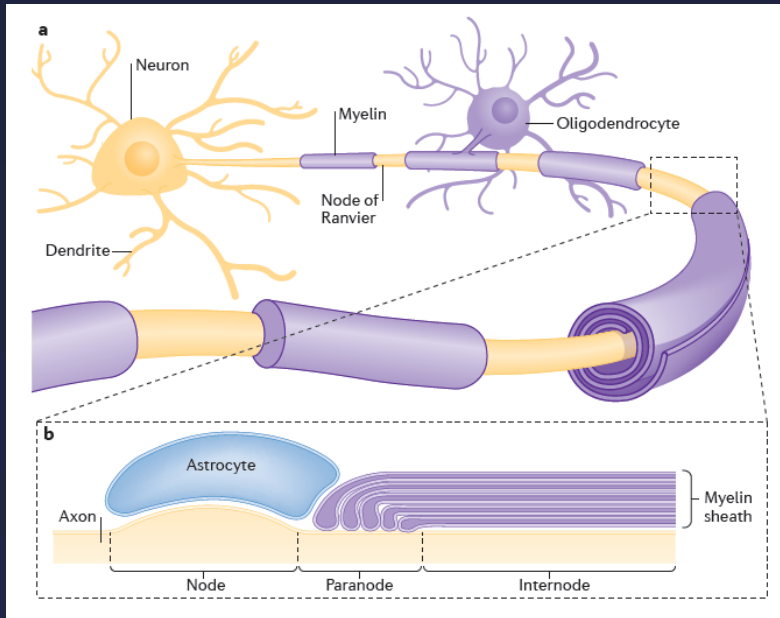
MBP= myelin basic protein

White Matter is Decreased in Several Diseases

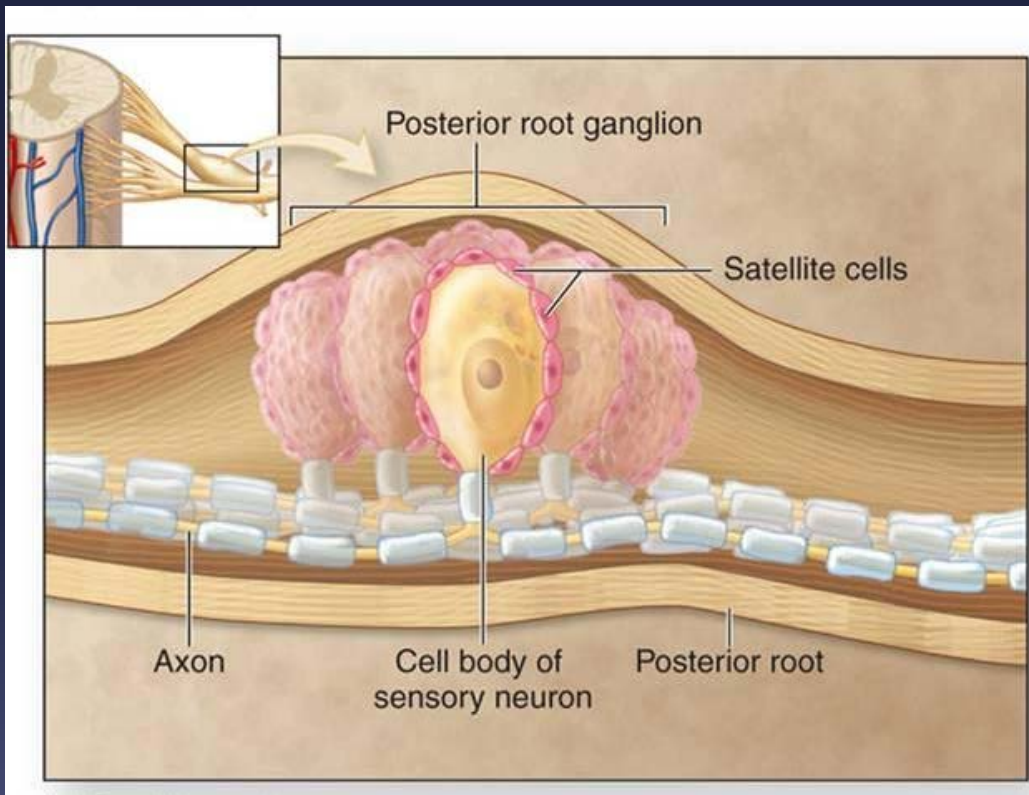
Bipolar Disorder



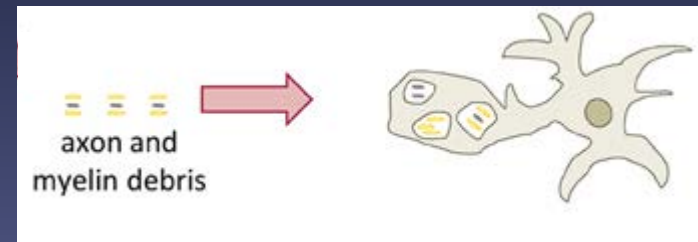
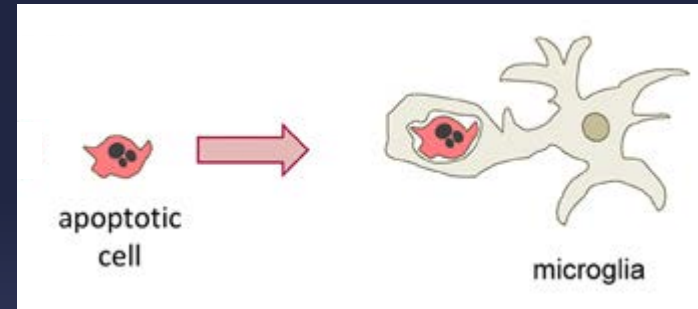
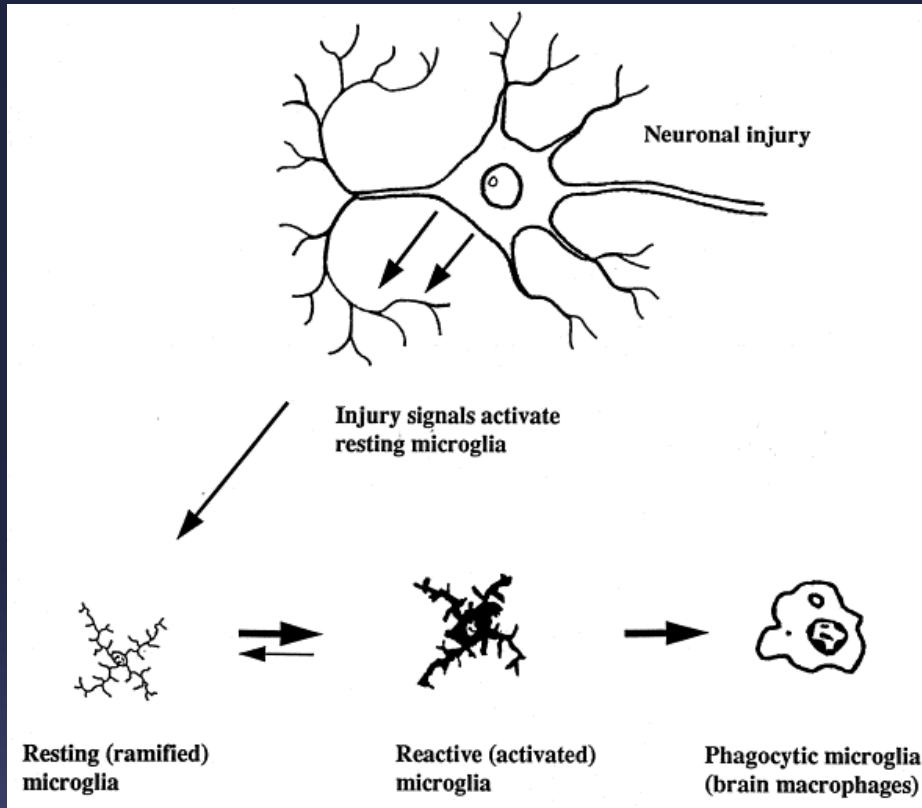
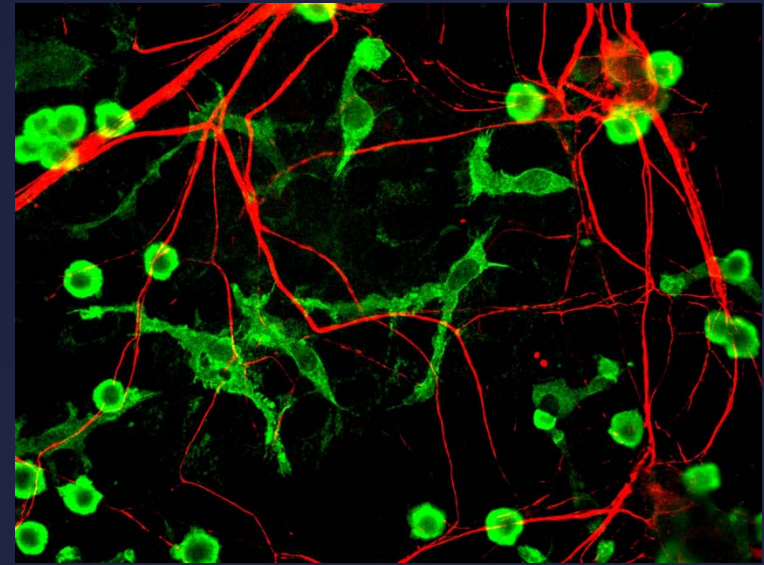
Astrocytes Regulate the Connection of Myelin to Axons



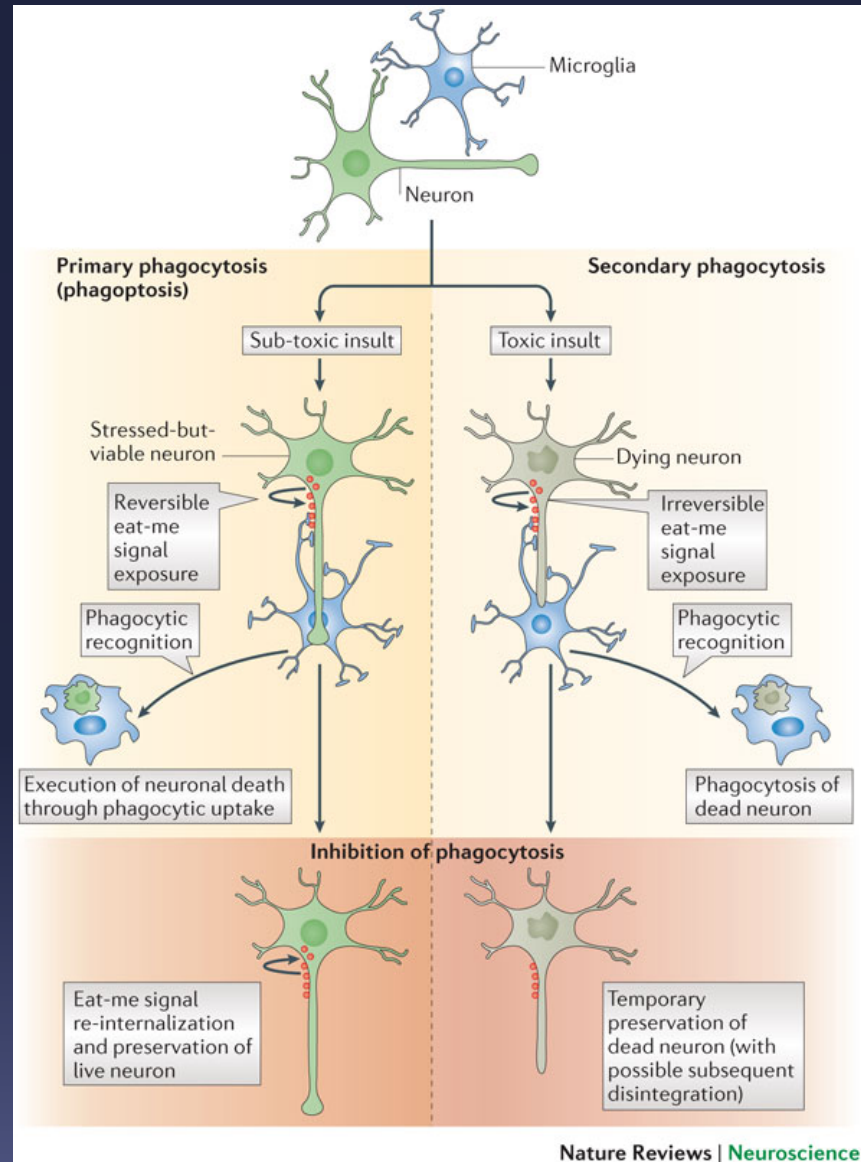
Satellite Glial Cells



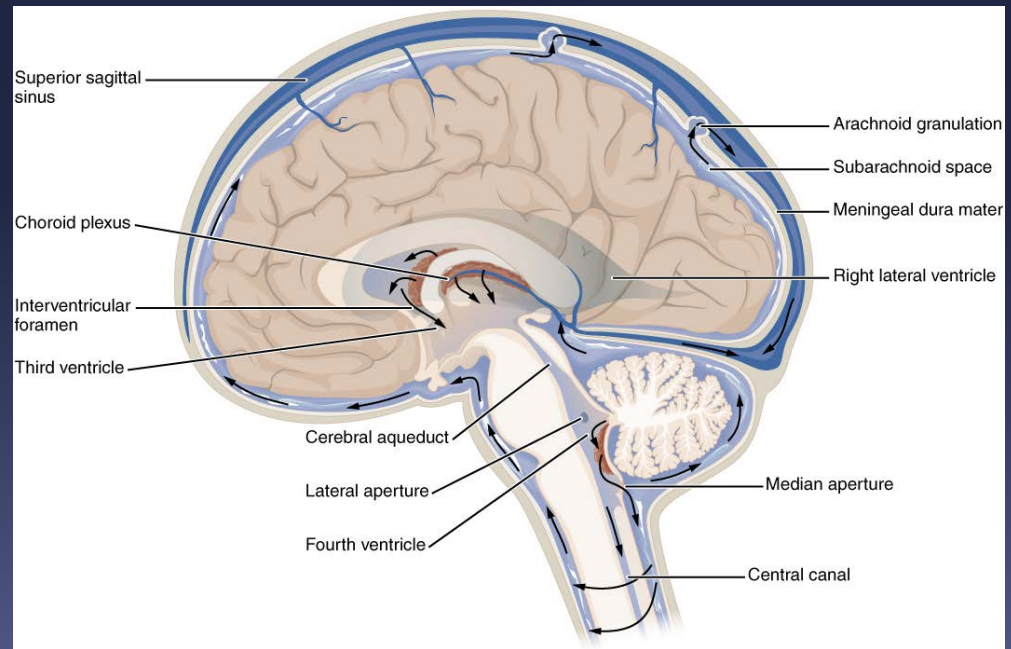
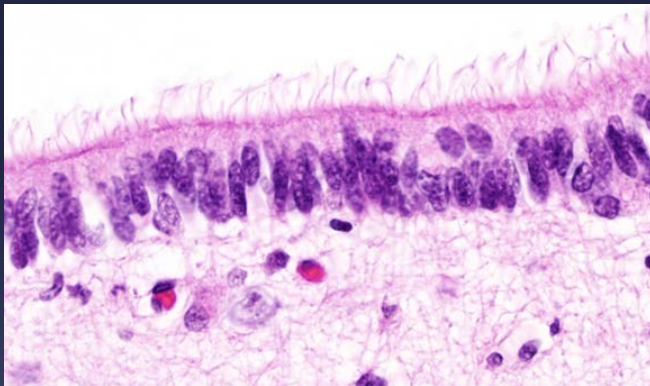
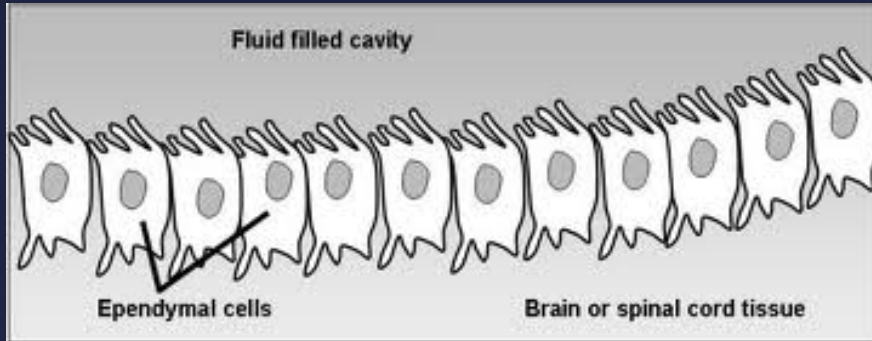
Microglia



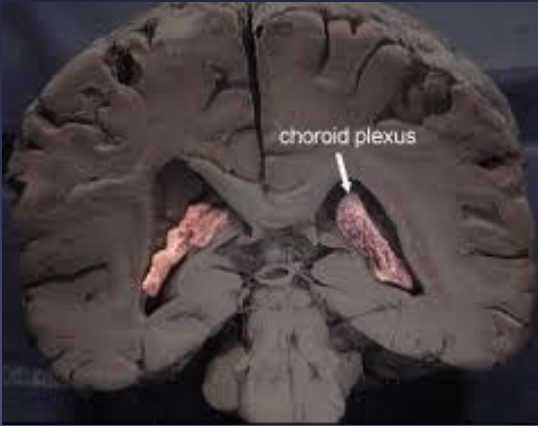
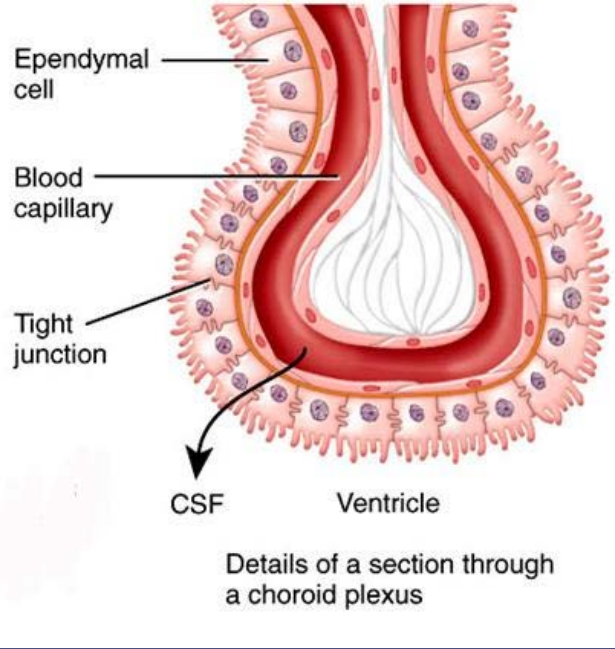
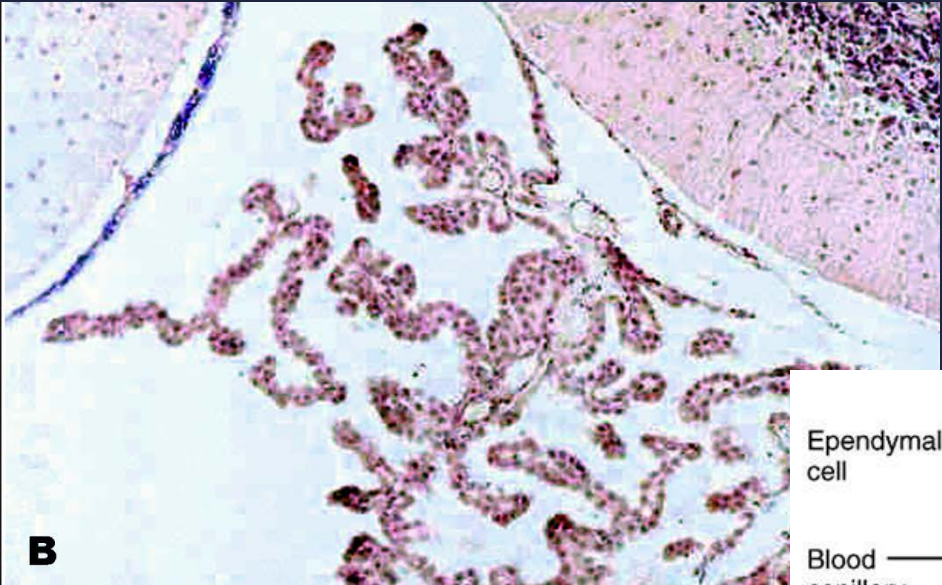
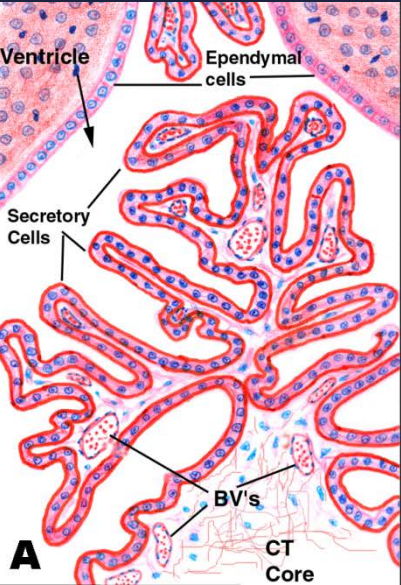
Primary vs. Secondary Phagocytosis



Ependymal Cells

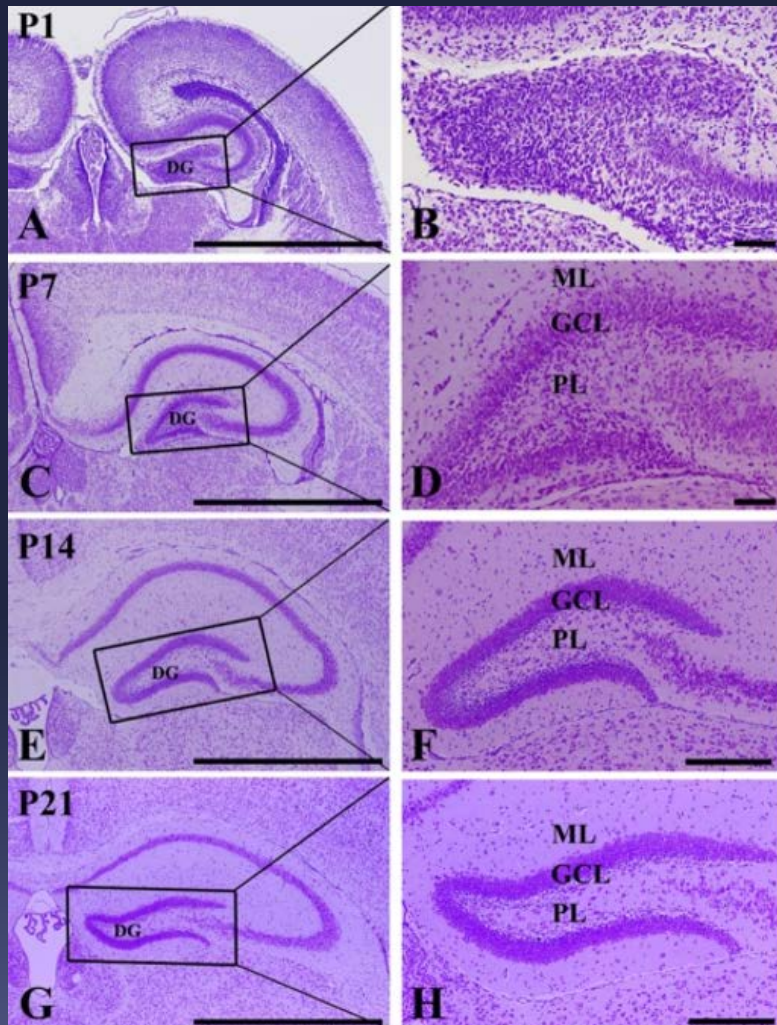


Choroid Plexus

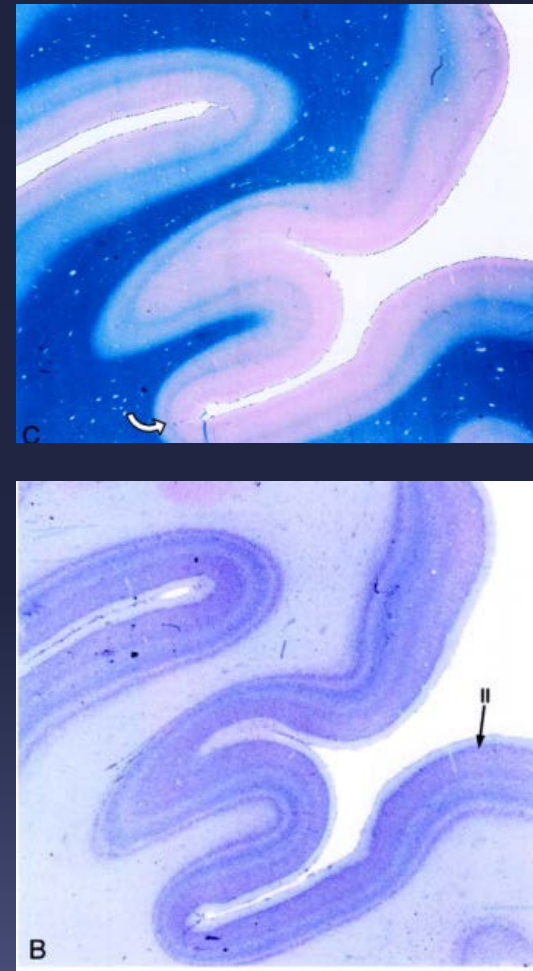


Neurohistological Techniques

Cresyl violet

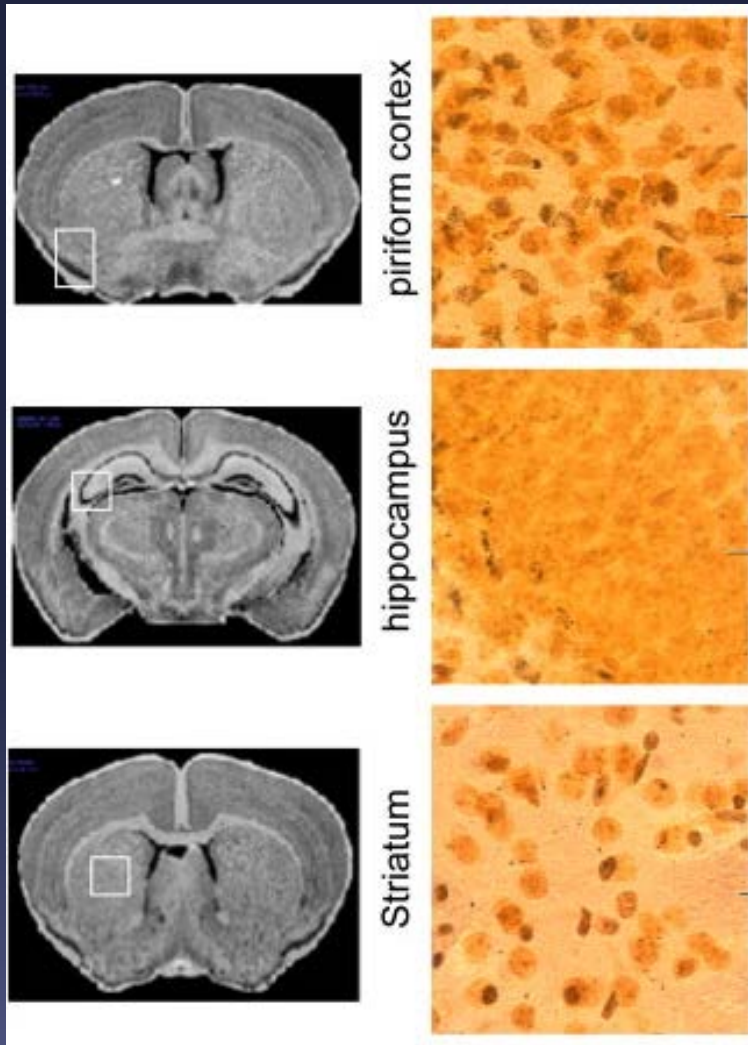


Klüver-Barrera (Luxol fast blue)

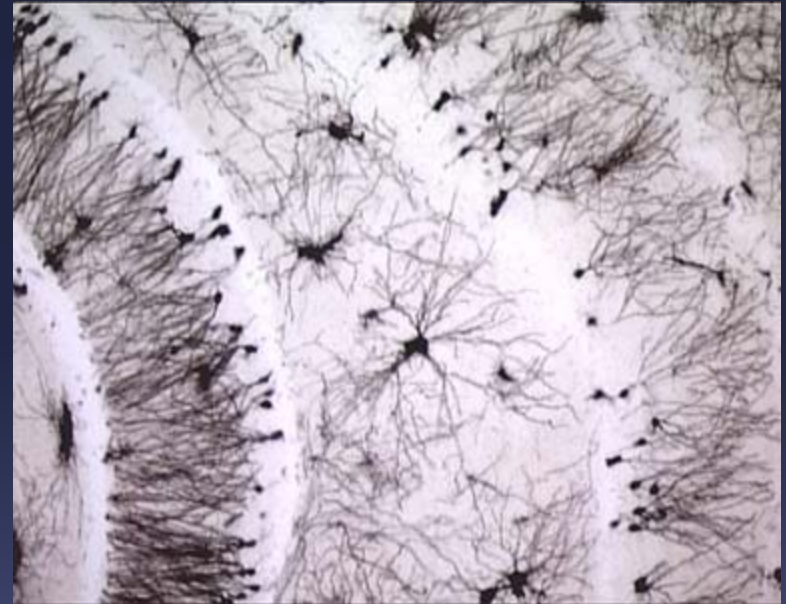


Neurohistological Techniques

Holmes silver stain

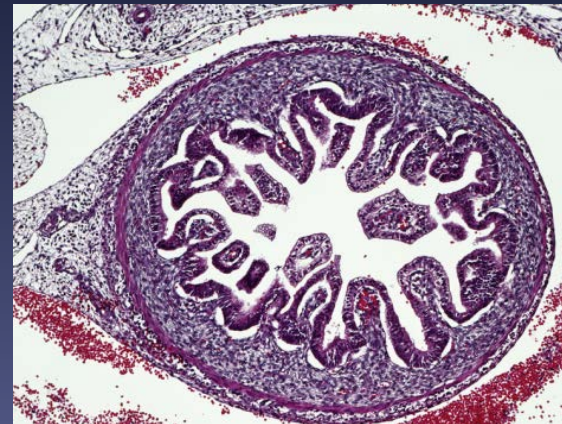
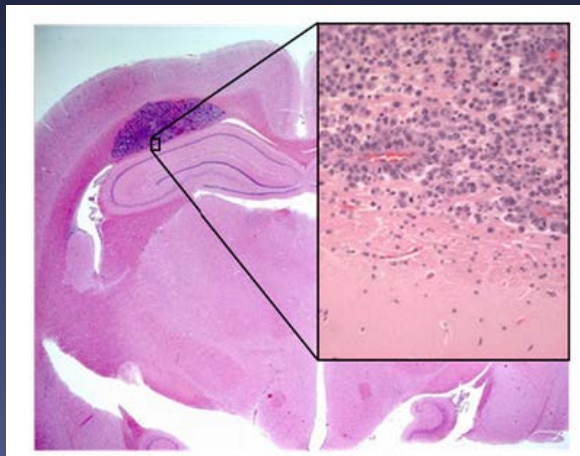
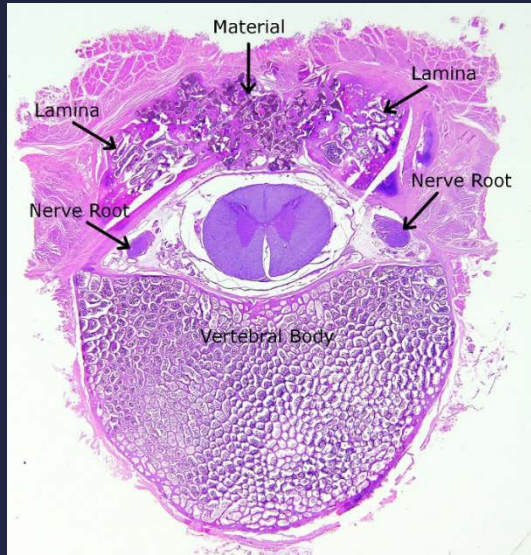


Golgi stain



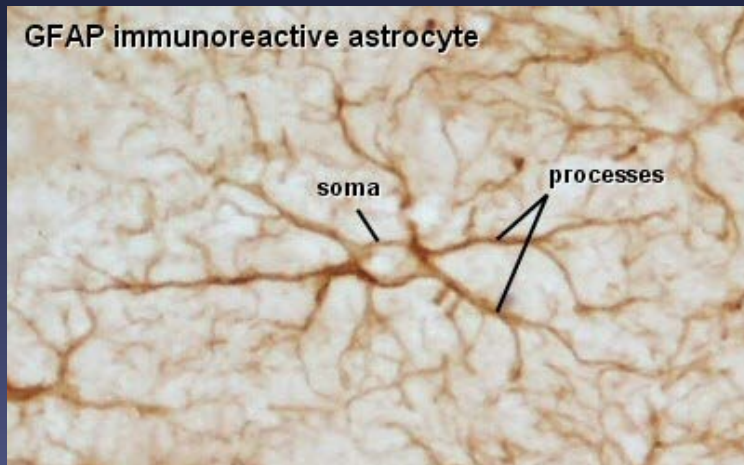
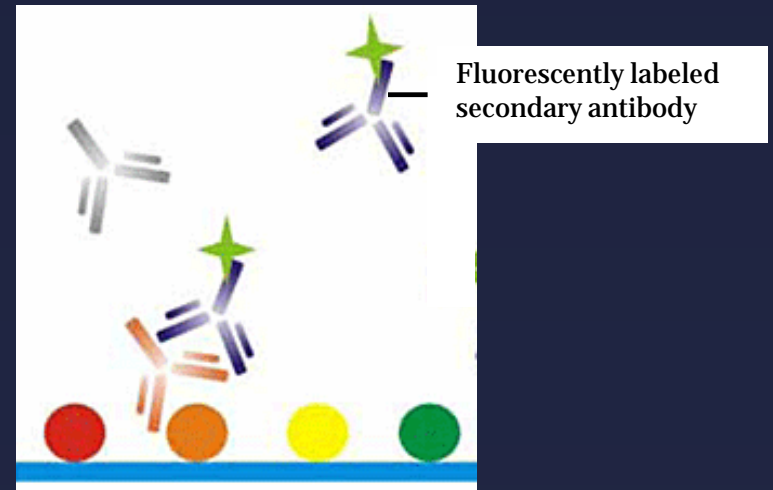
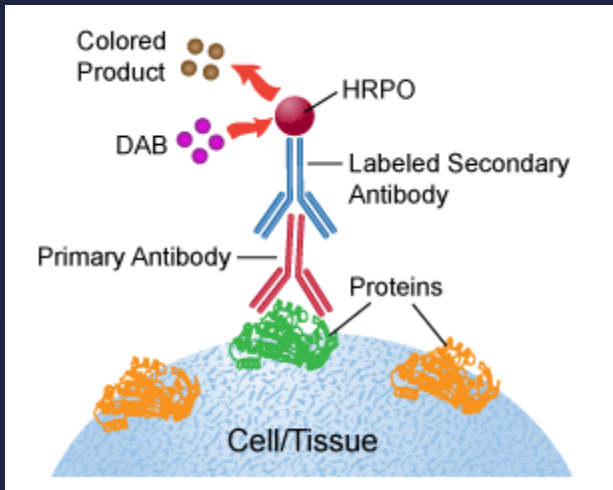
Neurohistological Techniques

Hematoxylin & Eosin (H&E)



Neurohistological Techniques

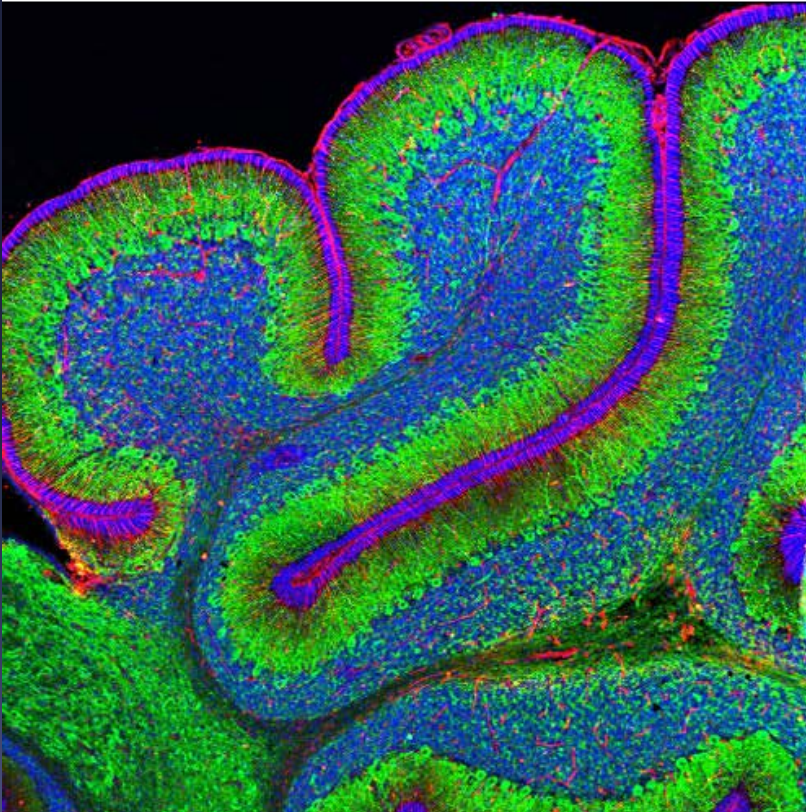
Immunohistochemistry/Immunofluorescence



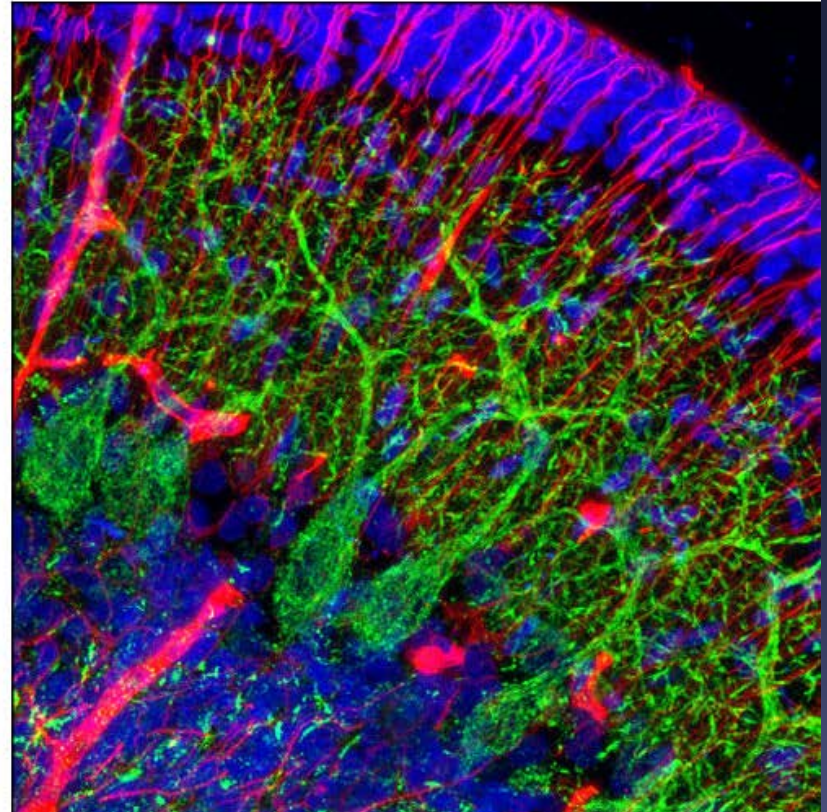
Neurohistological Techniques

Immunofluorescence

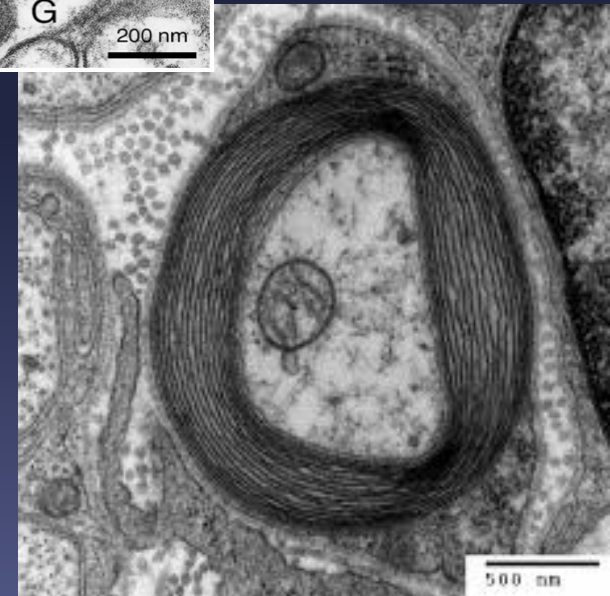
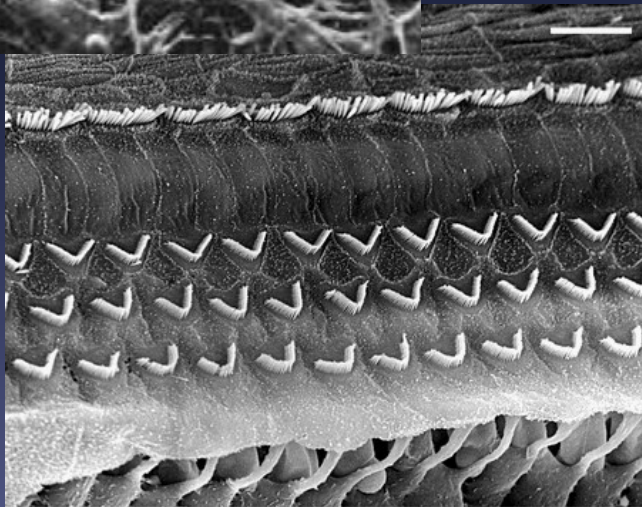
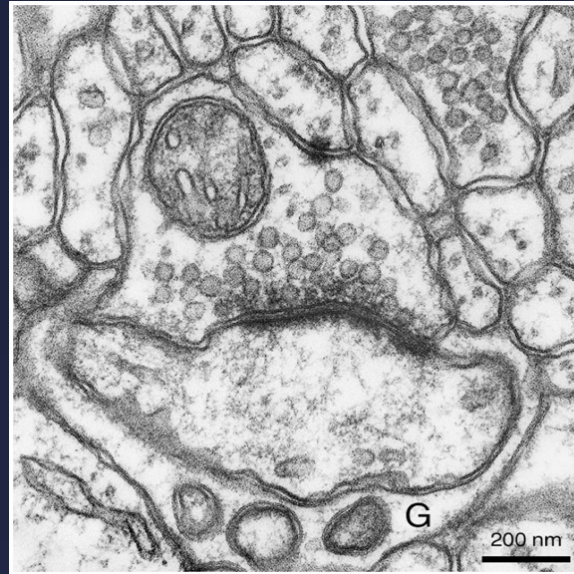
Rat Brain



Zoom



Electron Microscopy: SEM & TEM



Summary

- Function of Glial cells:
 - Radial Glia
 - Astrocytes
 - Oligodendrocytes
 - Schwann cells
 - Satellite glial cells
 - Microglia
 - Ependymal cells
- Neurohistological techniques
 - Cresyl violet
 - Luxol fast blue
 - Holmes silver stain
 - Golgi stain
 - H&E
 - Immunohistochemistry
 - SEM & TEM

