

Injury, Degeneration and Regeneration in the Peripheral (PNS) and Central (CNS) Nervous System

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The cellular composition and anatomical organization of nervous system into distinct functional pathways

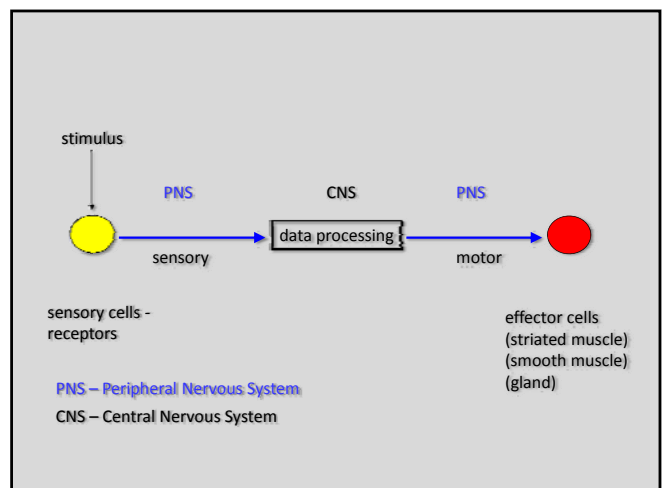
become familiar with the

- types of neuronal and non-neuronal cells that compose the nervous system
 - *all cells are involved development, normal function, and in injury and disease*
- principles that underlie the anatomical organization of nervous system into distinct functional pathways
 - *understand some aspects of normal function, what functions are lost in injury and disease, and how function may be restored*

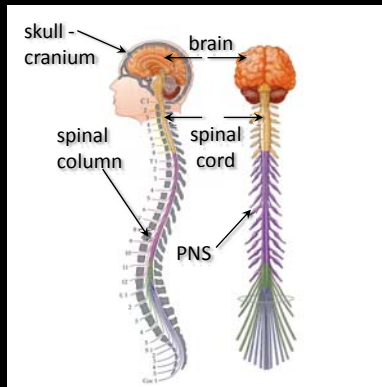
Functions of the Nervous System

- Communication with the world outside of us
- Communication with our inner world
- Higher brain functions / cognitive functions

The pentatonic scale - Bobby McFerrin



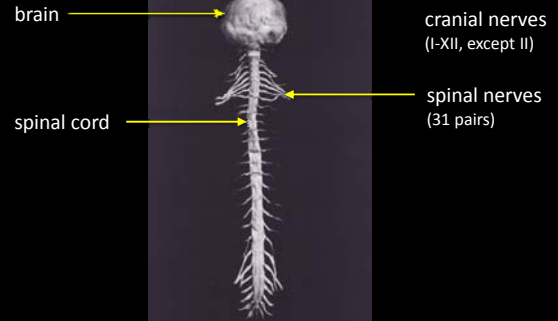
The Nervous System: CNS & PNS



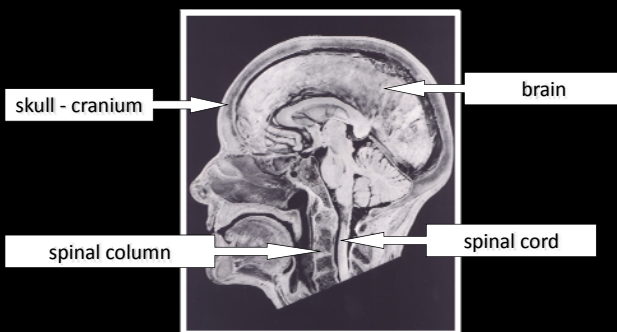
The Nervous System

CNS

PNS



CNS – within bony structures



The cellular composition of the nervous system the three elements:

1st - neurons, 2nd - neuroglia, 3rd - microglia

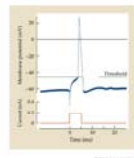


Santiago Ramon Y Cajal

The cellular composition of the Nervous System

Nerve cells – Neurons

- excitable cells (Action Potential – AP)
- encode, transfer and process data



Glia cells

- non-neuronal cells that are unique to the nervous system
- perform diverse functions in normal neuronal function, injury and disease

Glia cells: classification and location

CNS

PNS

- Oligodendrocyte
- Astrocyte
- Ependyma
- Microglia

- Schwann cell

Neurons: classification

(i) number of processes leaving the cell body

pseudo unipolar



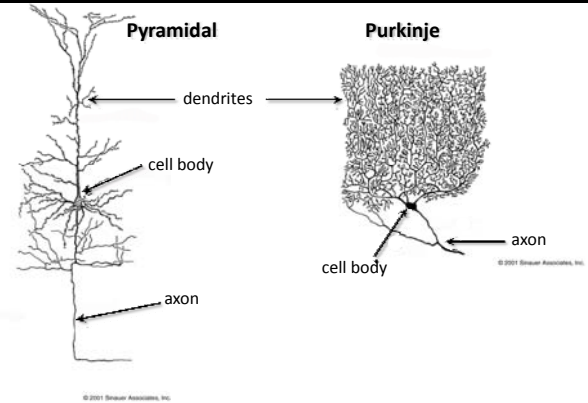
bipolar



multipolar



Multipolar cells differ in shape

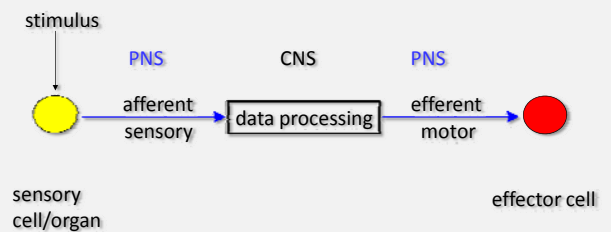


Neurons: classification

(i) number of processes (ii) direction - function

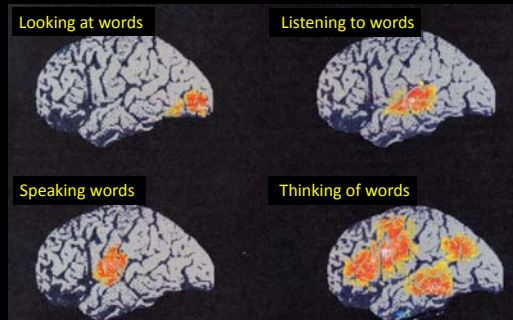
- | | |
|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • pseudo unipolar • bipolar | <ul style="list-style-type: none"> • afferent – sensory |
| <ul style="list-style-type: none"> • multipolar | <ul style="list-style-type: none"> • efferent – motor • interneuron |

function depends on the anatomical organization of the nervous system into distinct pathways which enable transfer of information along distance from distinct origins to distinct destinations



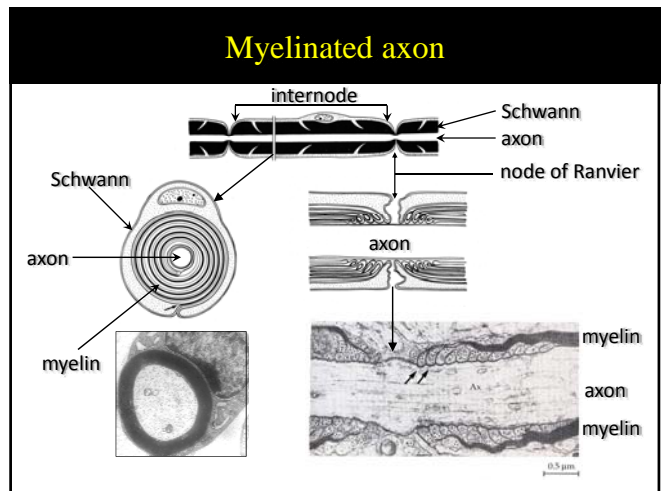
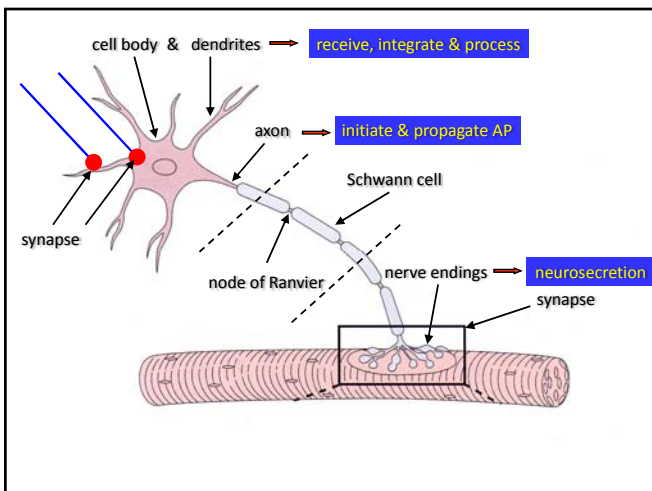
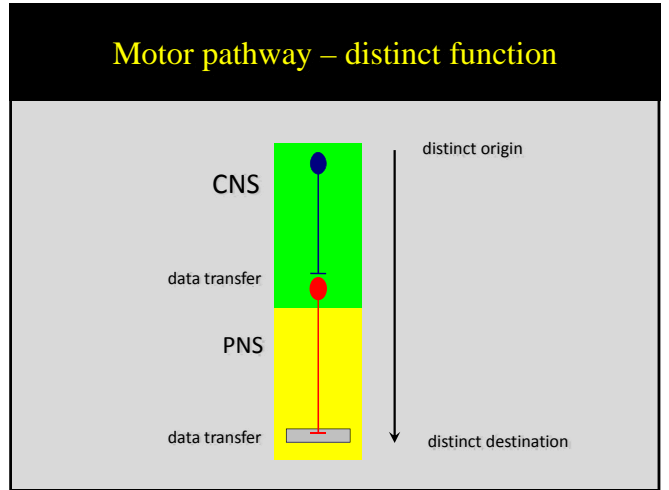
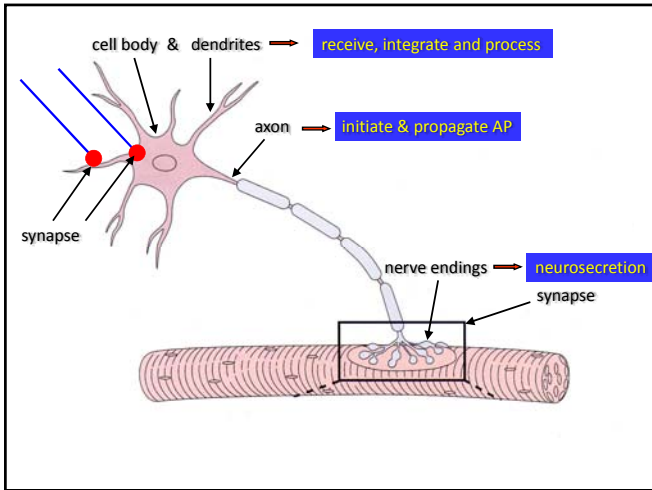
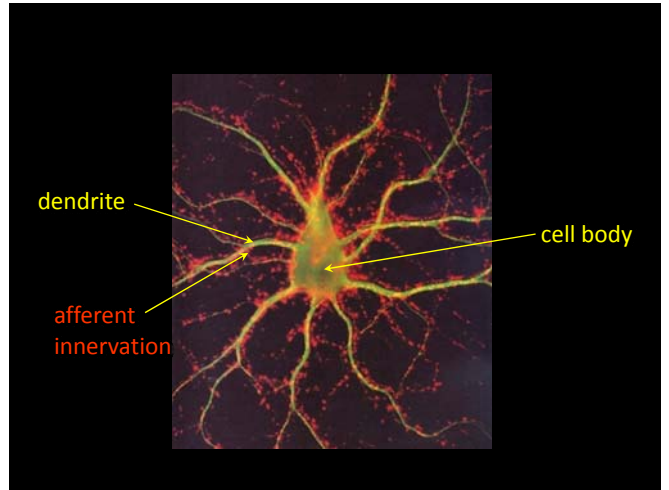
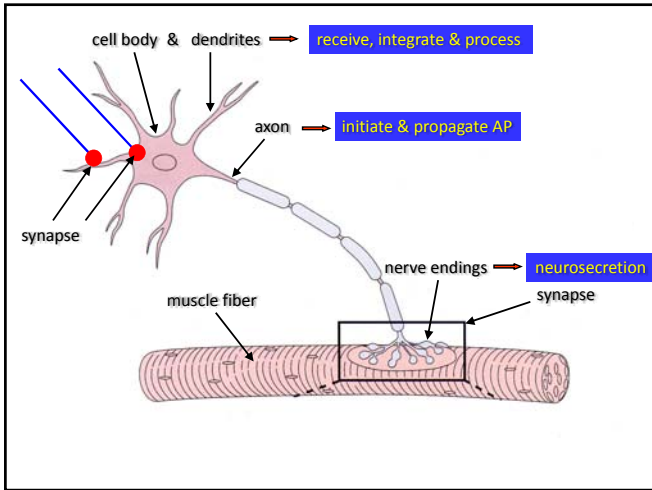
Functional localization by PET

PET – positron emission tomography

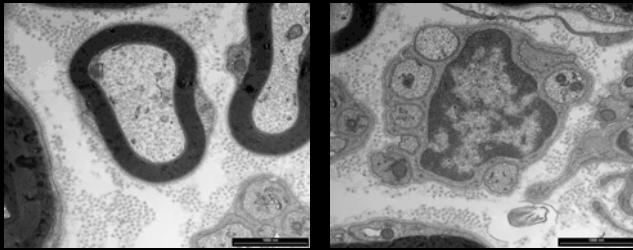


Principles that underlie the formation of distinct anatomical-functional pathways

- The geometry – shape – of individual nerve cells
- The ability to move information along the length of individual neurons
- The ability to transfer information from one nerve cell to another



Myelinated & unmyelinated axons



Myelinated

Unmyelinated

Cytoskeleton

the cytoskeleton is made of a system of filaments

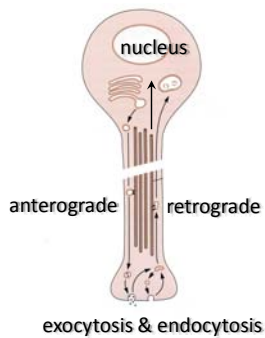


- actin

Axonal Transport (AT)

fast AT

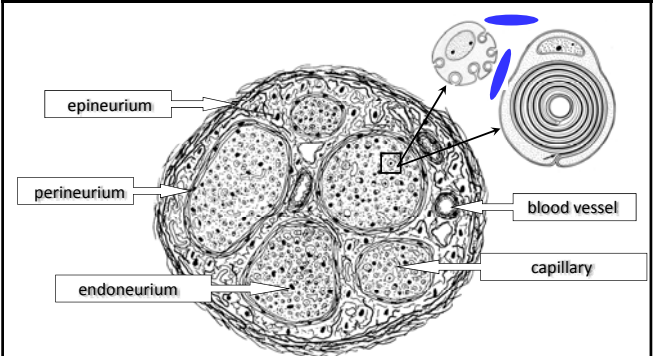
Organelles
anterograde
400 mm/24h
retrograde
300 mm/24h



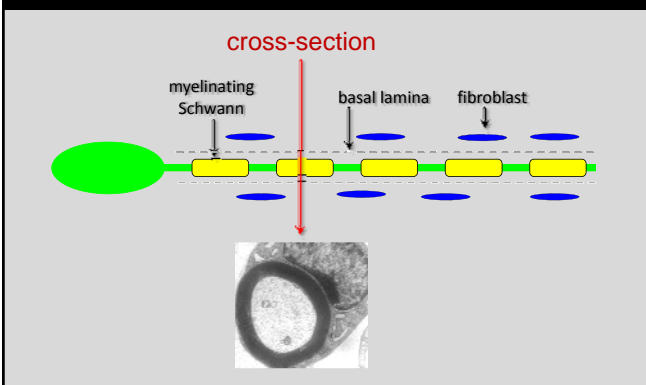
slow AT

soluble proteins
anterograde
0.2-2.5 mm/24h
3-5 mm/24h

The peripheral nerve



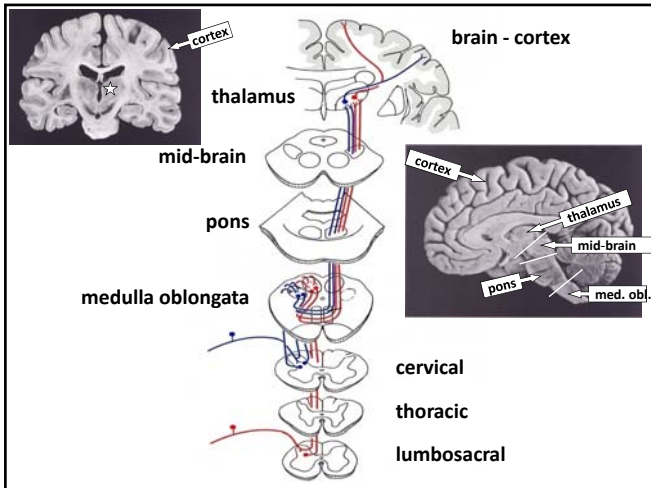
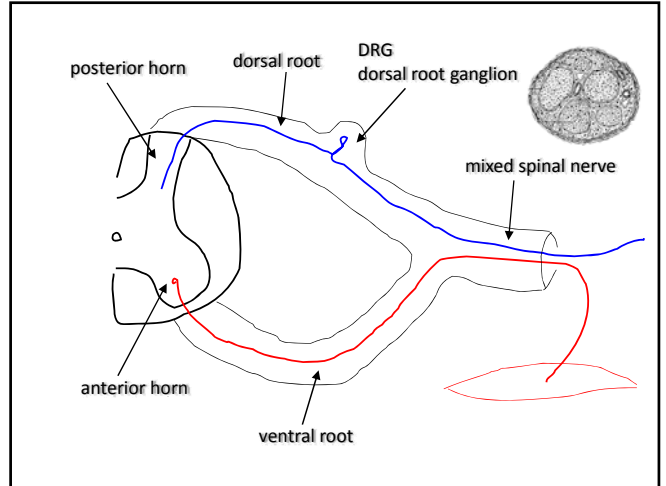
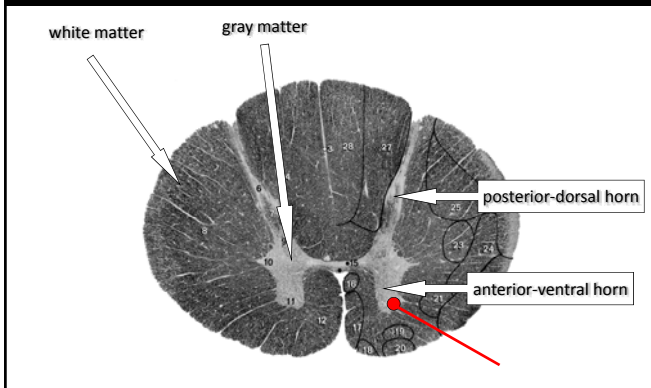
PNS: intact axon



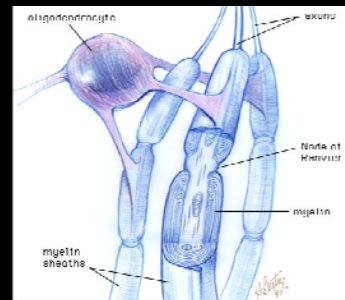
Spinal cord segments



Spinal cord: cross section

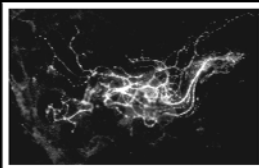


Myelinated CNS axons



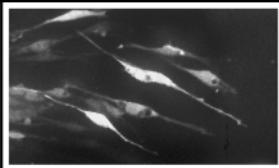
Oligodendrocytes have many branches
Schwann cells have few (mostly bipolar)

oligodendrocyte



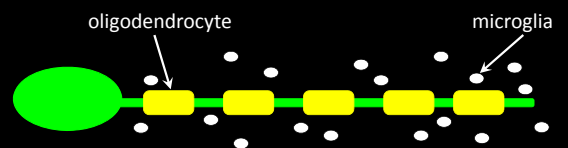
ensheathes several axons
forms several internodes

Schwann cells

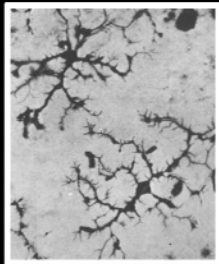


ensheathes a single axon
forms a single internode

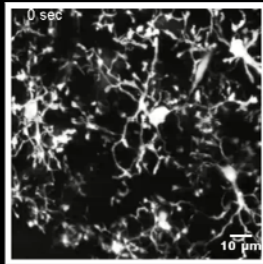
CNS: intact



Microglia are innate-immune cells that normally reside in CNS

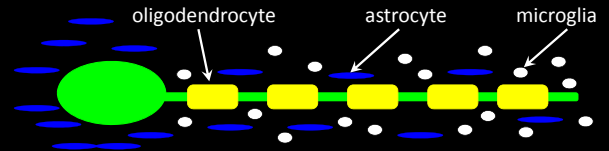


Pío del Río-Hortega, *Microglia*, in *Cytology & Cellular Pathology of the Nervous System*, 1932

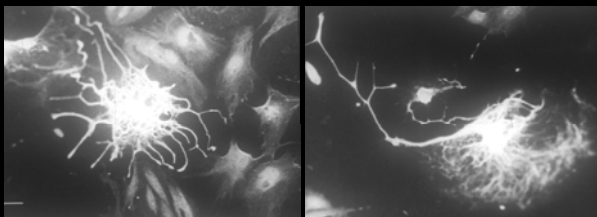


Davalos et al., *Nature Neuroscience*, 2005

CNS: intact

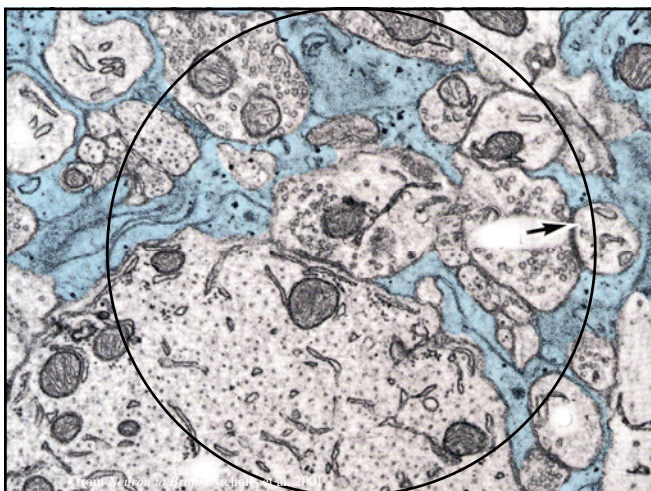
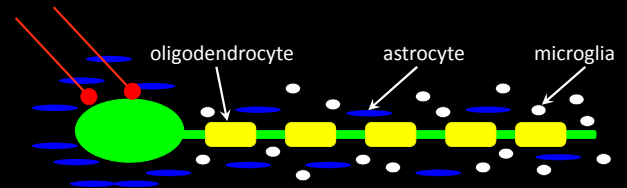


Astrocytes



Reichert & Rotshenker, *J. Neuroimmunology*, 2005

CNS: intact



- Nerve cells encode, transfer and process information
- Different regions of the nerve cell specialize in different functions
- Nerve cells' geometry and ability to transfer information from one to the other by specific synaptic connections enables the formation of distinct anatomical-functional pathways
- Glia and nerve cells communicate signals which result in the formation of special structures that are required for proper neuronal function