

## CONCEPTS OF NEUROANATOMY

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## **Cells of the nervous system:**

- Neurons, supporting cells (Schwann and satellite in the PNS and astroglia, oligodendroglia and microglia in CNS), ependymal, meninges, Perineural cells (in PNS), blood vessels.

### Satellite cells:

- Surround nerve cell bodies in PNS and are similar to astroglia

### Astrocytes:

- Prominent in gray matter but also found in white matter. Their processes found near blood vessels, pia, ependymal and neurons including near synapses. Function, mechanical support, metabolic, maintain homeostasis of extracellular fluid, form scar tissue.

### Ependyma:

- Line the ventricles and along with the pia and capillaries form the choroid plexus, which secretes cerebrospinal fluid (CSF).

### Perineural Cells:

- Are found in peripheral nerves where they form the perineurium. The perineurium defines the fascicular substructure of peripheral nerves.

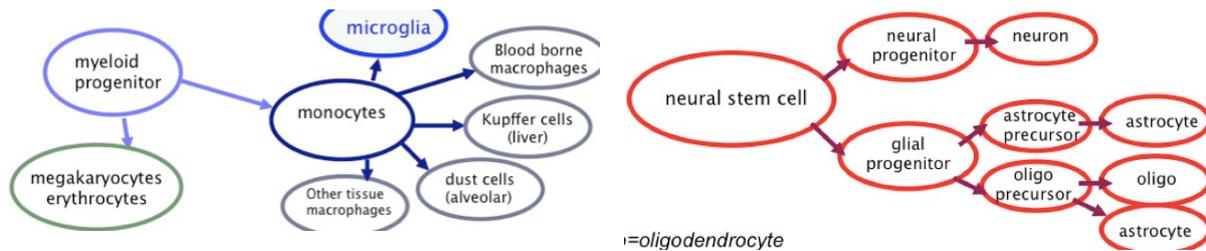
### Pericytes:

- Contractile cells around blood vessels with immune functions.

## **Glia= glue**

- More than 50% of the brain is made up of glia, 10x more glia than neurons
- Each astrocyte may enclose 2 million synapses
- Neuronal energy supply relies on astrocytic interface with capillaries. Blood flow through muscular vessels (arterioles) and non-muscular capillaries are modulated by astrocytes and pericytes
- White matter is highly enriched in lipids- oligodendrocyte membranes comprise most of this volume

Categories of glia: macroglia (astrocytes and Oligodendrocytes) and microglia.



## Macroglial cell lineage

- Astrocytes, Oligodendrocytes and neurons share a common stem cell.

## Microglial cell lineage

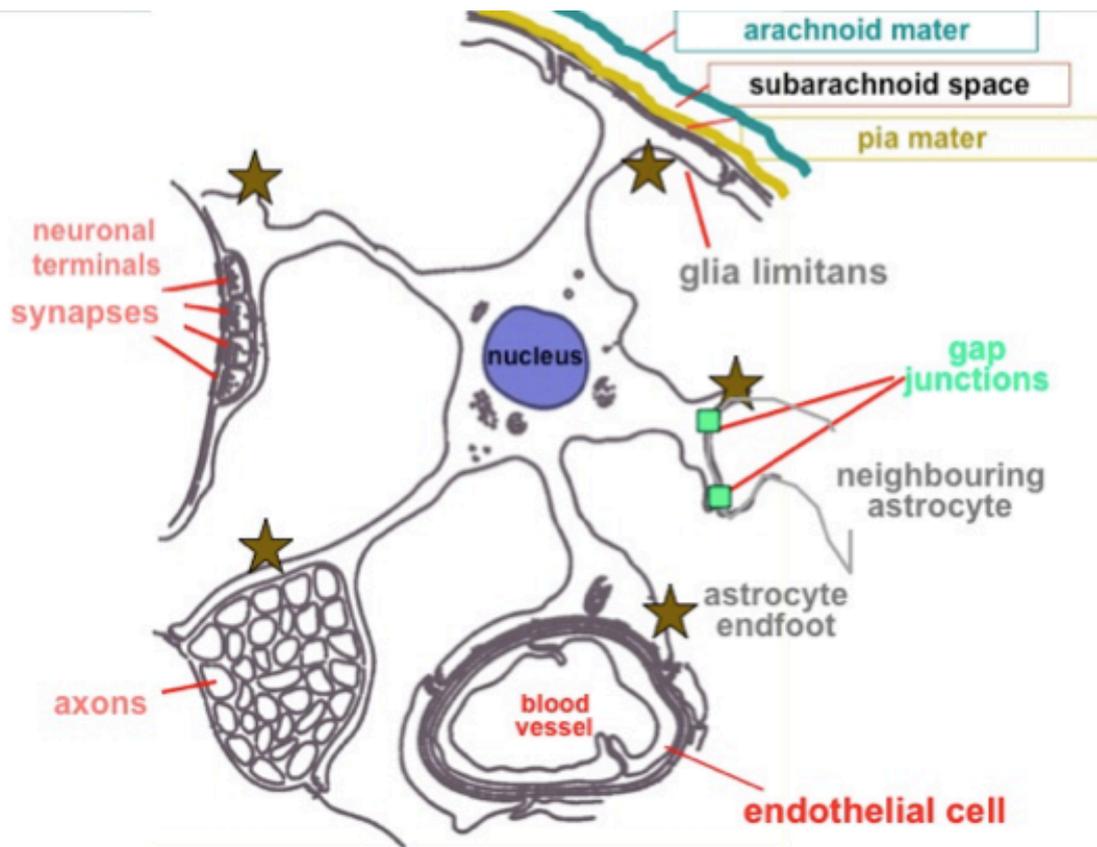
- Microglia are macrophages and have a monocyte (bone marrow derived) lineage.

## MACROGLIA

- Central nervous system: Astrocytes and Oligodendrocytes
- Peripheral nervous system: Schwann cells

### **Astrocytes:** (the star cell)

- Can label with immunohistochemistry= antibodies against GFAP: glial fibrillary acidic protein. The cytoskeleton confers strength and shape of cell. GFAP is an intermediate filament protein (component of cytoskeleton). **GFAP is specific to astrocytes.**
- Astrocytes are big fat cells and they take up all the space, there is VERY little extracellular space between them, very close together. You cannot see this with GFAP label, but their complete cell volume is much larger (invisible cytoplasm)
- Brain evolution: the increase in number of astrocytes → increase in neuronal number in the brain. Human brain has way more astrocytes than a leech or frog or rat.



## Astrocyte Function

1. Provides structural support
2. Surrounds blood vessels (invests endothelium)
  - They invest 90% of brain capillary surface, induce endothelial cells to form the blood brain barrier tight junctions (tight junctions between endothelial cells by using their astrocytic endfeet- don't permit movement of cells and molecules across it). In the absence of astrocytes, endothelial cells do not form tight junctions.
3. Promote angiogenesis
  - Growth of new blood vessels.
  - Also pericytes (contractile cells) have a major role in forming and maintaining the BB
4. Astrocytes regulate blood flow
  - Produce vasoconstrictive/dilatory factors eg. Arachidonic acid, NO, prostaglandins.
5. Forms gap junctions with other astrocytes.
  - Propagate Calcium waves.
  - Propagation timescale- slow- seconds (astrocytes) vs milliseconds (neurons).

- Several potential functions in vivo- may prime activity over large distances, spread glial activation (such as in inflammation), regulate blood flow in local areas). Cell-cell communication.
6. Forms the glia limitans
    - The outside of the brain. Invests outer surfaces of the CNS and envelop blood vessels, forming the glia limitans.
  7. Provides support for synapse formation and maintenance.
    - Astrocytes isolate the neurons using their endfeet to ensure that receptive neuronal surfaces are protected from non-specific influences.
    - Support synaptic microanatomy: envelope neuronal terminals, astrocyte processes are especially dense in areas of intense synaptic activity. Synaptic remodeling: remove degenerating synapse
    - Astrocytes maintain brain water balance via aquaporin channels. Using these channels, astrocytic swelling can change synaptic distance, thus efficiency.
  8. Guides neuronal process growth and regulate neurogenesis/ guide brain development.
    - Radial astroglial processes guide immature, migrating neurons, form template for neuronal growth, produce neurotrophic factors such as nerve growth factor NGF, produce adhesion molecules for grip such as proteoglycans, determine neuronal polarity during development. Dendrite→ soma→ axon.
  9. Maintain biochemical balance around neurons
    - Sequester/ redistribute K<sup>+</sup> during neural transmission
    - Remove glutamate and GABA at synapse. Excess Glu can be neurotoxic so we need fine control of it.
    - Synthesise glutamate and GABA precursors (glutamine\_
    - Detoxify ammonia
    - Provide energy substrates (lactate) to neurons
  10. Form scars.

Activated astrocytes produce abundant GFAP and extracellular matrix (such as laminin, tenascin, fibronectin, collagens and proteoglycans). Astrocytic scars fill in around where neurons are injured or dying. They interfere with regrowth of neuronal processes in CNS. The downside= partly accounts for poor CNS regeneration, astroglial factors inhibit neuronal fibre regrowth after Lesioning.