

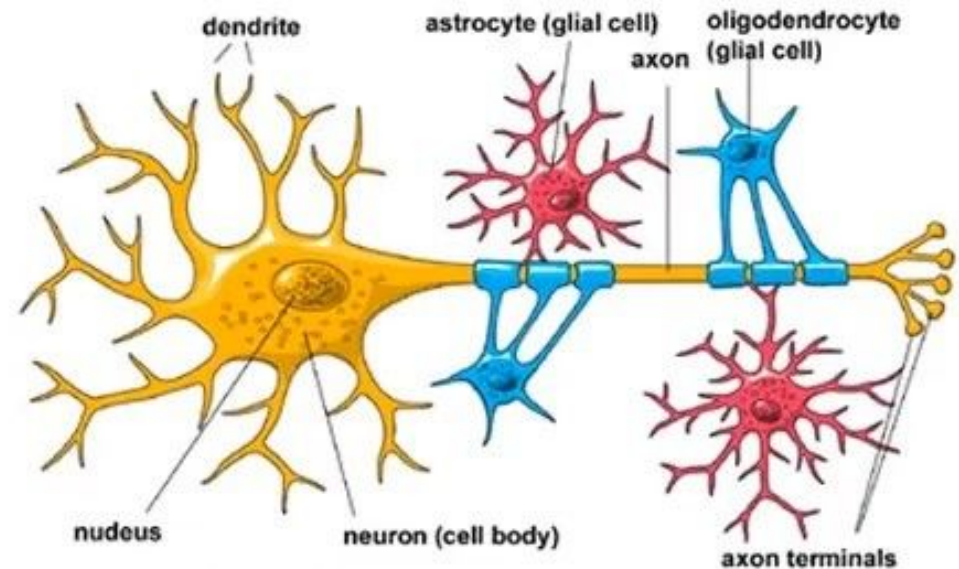
Histology of Nervous System

CONACyT - CONAHCYT - CONACYT

HISTOPHYSIOLOGY (AND BLOOD IRRIGATION)

Nervous System

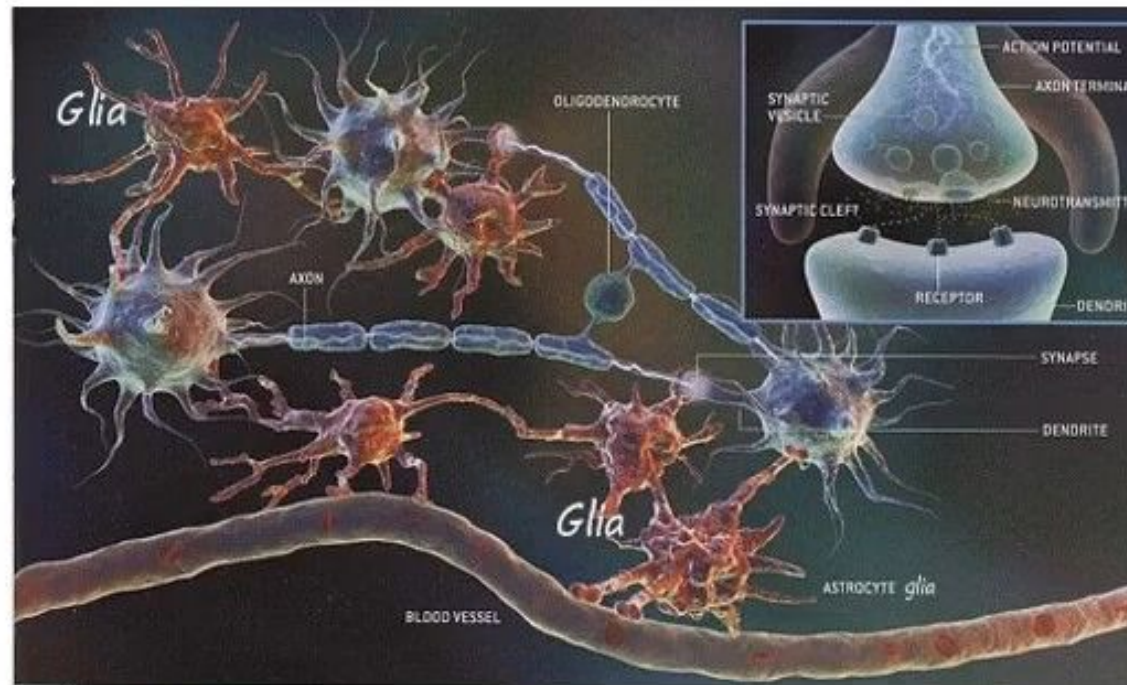
- The nervous system is composed mainly of two types of cells:
 - **Neurons** – responsible for information transmission
 - **Glial cells** or **neuroglia** – responsible for homeostasis and protection
 - Glial cells are more numerous than neurons.



Glial cells

- Glial cells responsibilities:
 - Provide physical support for neurons
 - Supply of nutrition and essential oxygen for the neurons
 - Cooling (Acting as an insulator between different neurons via a myelin sheath)
 - Protection (formation of myelin) for the neurons
 - Clearance of neurotransmitters from the synaptic clefts
 - Repair of neurons after brain injury
 - Remover of dead neurons
 - Destroyers of pathogens

Glial cells

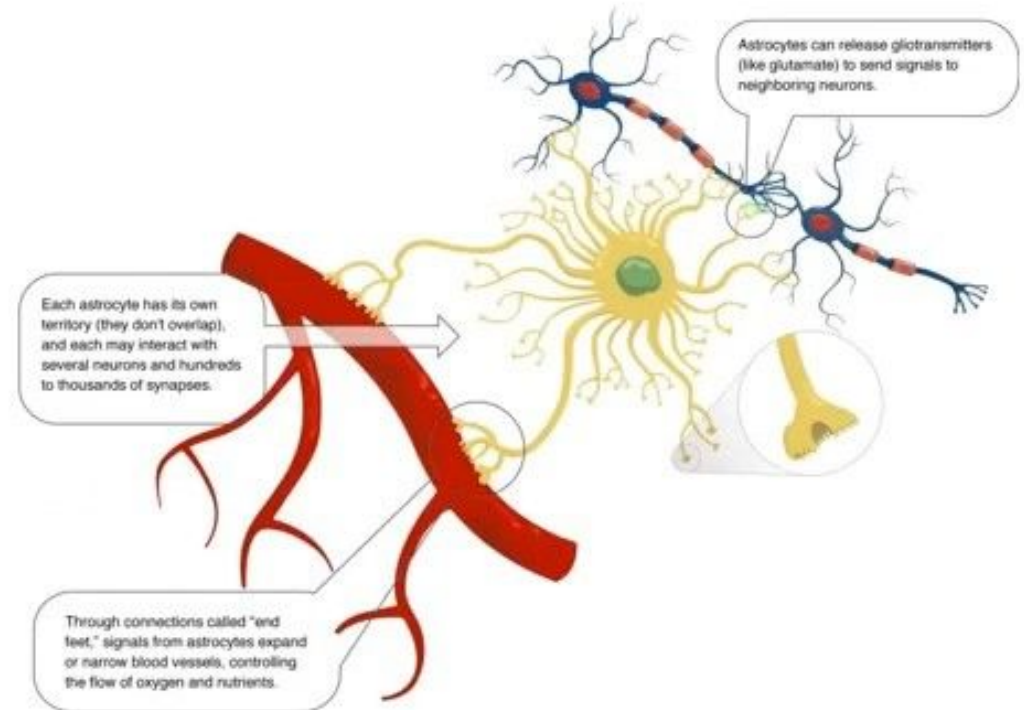


- There are different types of glial cells exist within the nervous system:
 - Macroglía:
 - Astrocytes
 - Oligodendrocytes
 - Microglia
 - Ependymocytes or ependymal cells

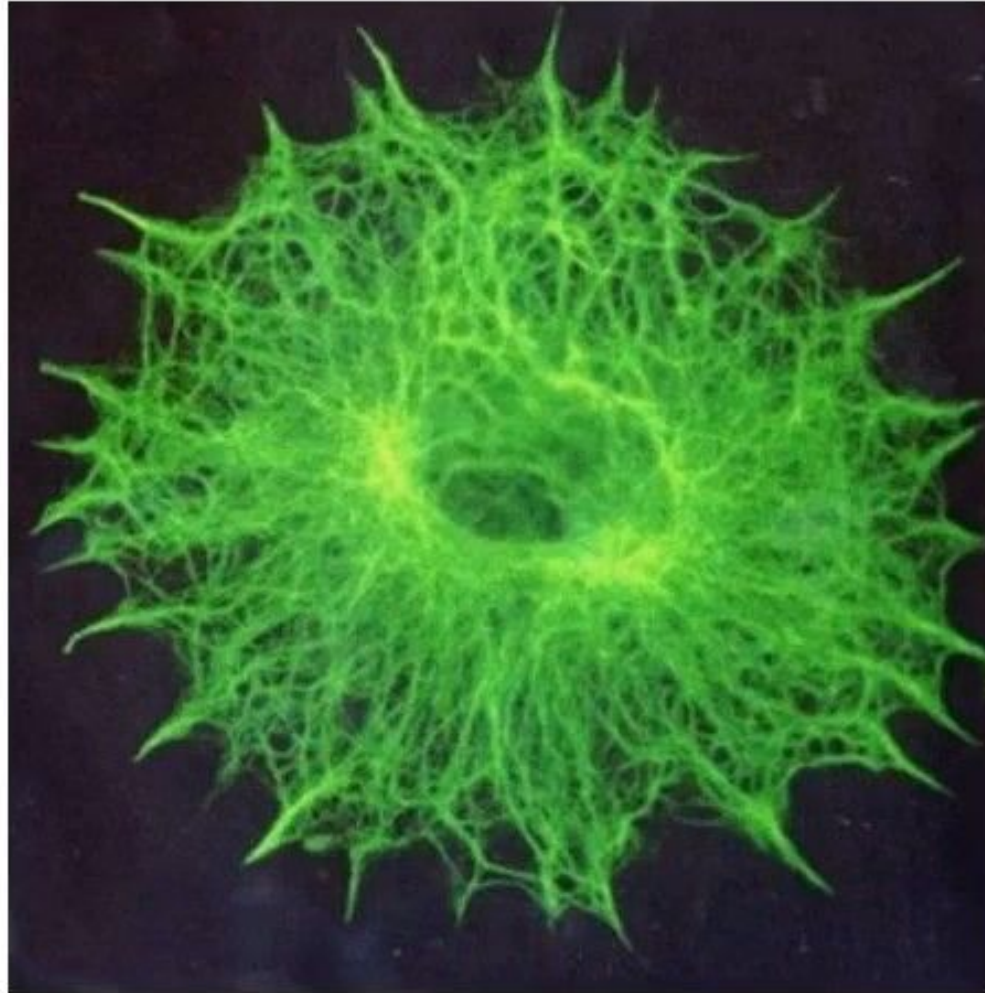
Glial cells

■ Astrocytes

- Star-shaped cells
- Responsible for:
 - nutrition of neurons
 - Digesting dead neurons
 - Communicate with neurons and modify the signals they send and receive.
 - Controlling flow of oxygen
 - Maintenance of the integrity of the blood-brain barrier
- Cannot generate action potentials
- If communication with neurons is break:
 - Alzheimer's disease, brain cancer, and ALS (amyotrophic lateral sclerosis)



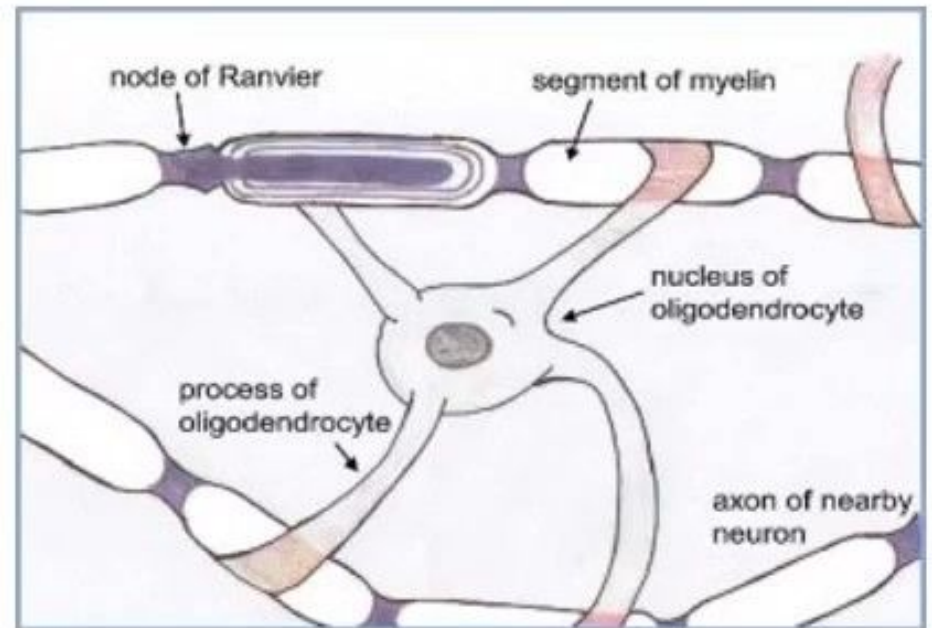
Glial cells



An astrocyte stained with green fluorescent proteins Figure from: [Wikimedia Commons]

Glial cells

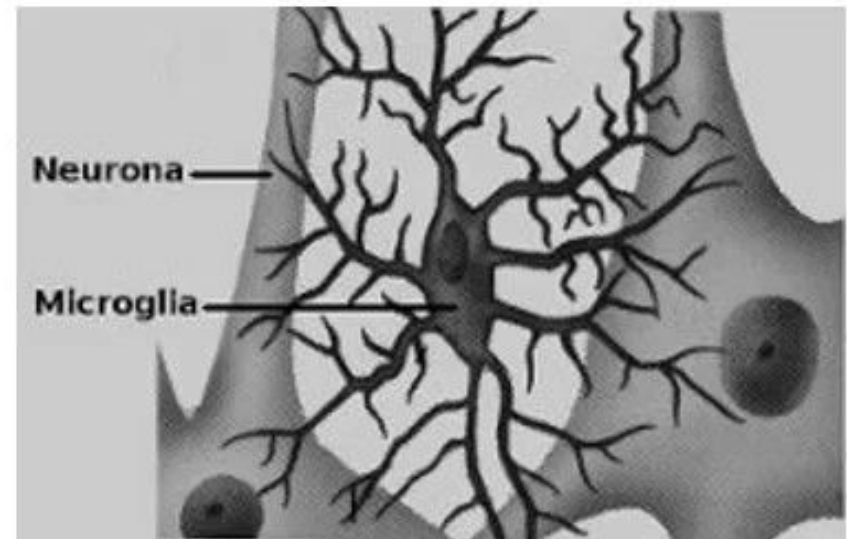
- **Oligodendrocytes.**
 - Provide the brain with structural integrity.
 - Responsible for:
 - Creating the myelin sheath around the neurons (speeding up electrical signals)
 - Without oligodendrocytes, an action potential would travel down an axon 30 times slower!



Glial cells

- **Microglia**

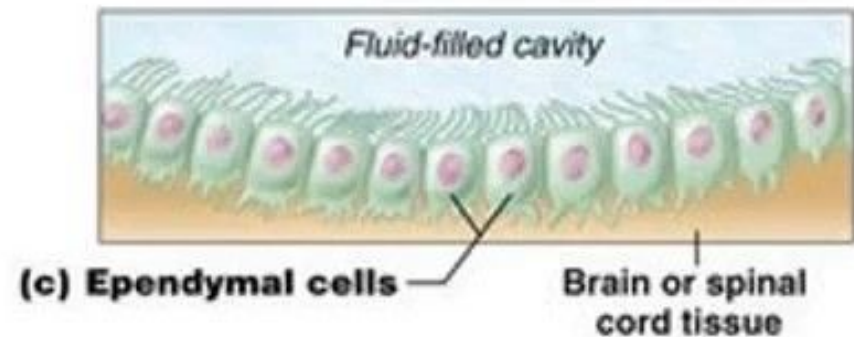
- special immune cells found only in the brain
- Responsible for:
 - Destroying pathogens (bacteria and viruses).
 - Engulfing cellular debris
 - Synaptic plasticity



Glial cells

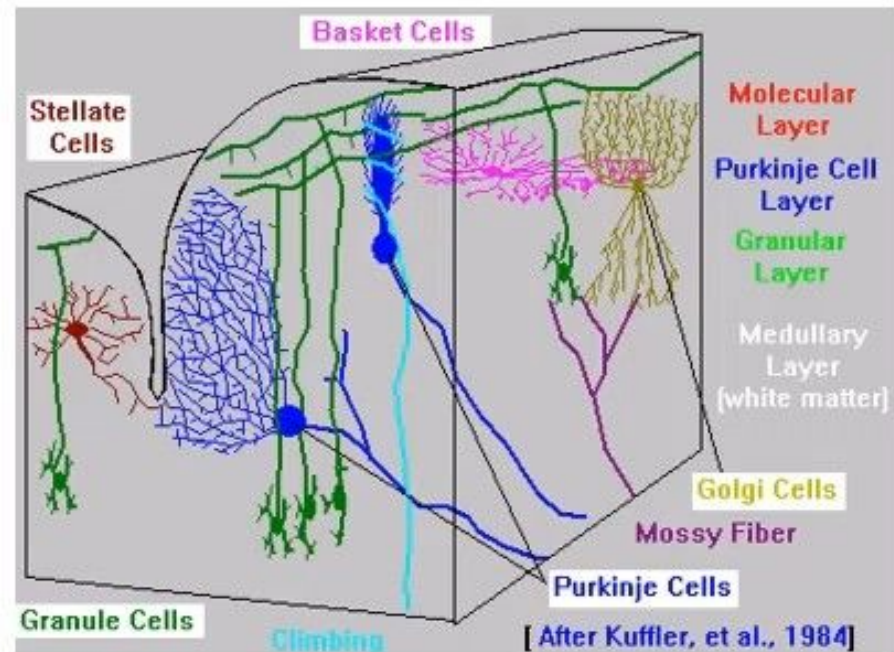
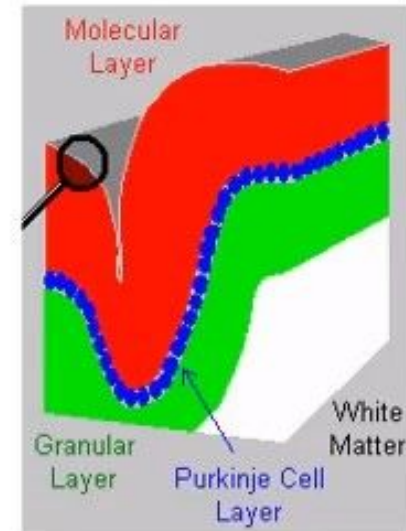
■ Ependymocytes

- Make up the blood brain barrier
- Ciliated (not to move themselves but to help with circulation of CSF)
- Responsible for:
 - Creation, secretion and circulation of the cerebrospinal fluid (CSF)
 - also thought to act as neural stem cells



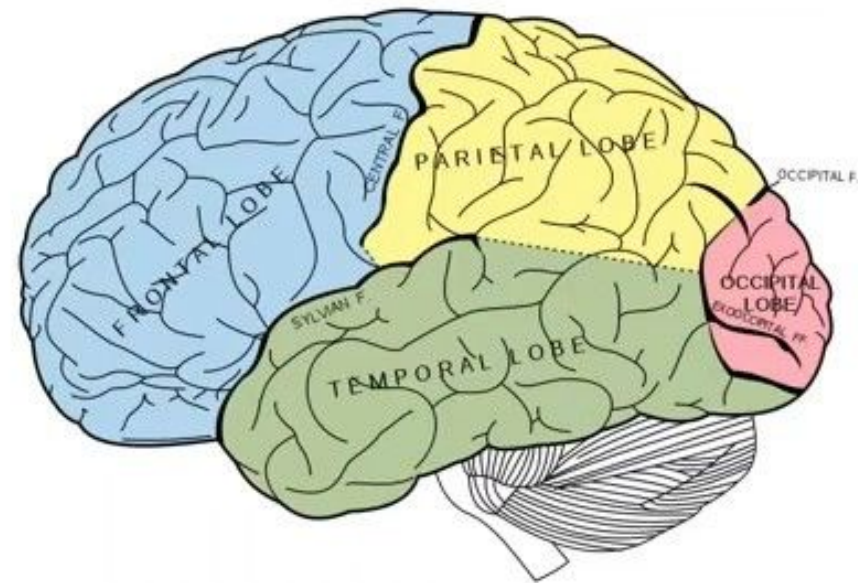
Cerebellum

- The cerebellum consists of:
 - **white matter**, containing pairs of relay neurons that connect the cerebellum to other parts of the nervous system
 - The WM surrounded by a thin layer or mantle of **gray matter**.
 - Within the gray matter are three layers:
 - an **outer molecular layer**,
 - an **inner granular layer**, and
 - a thin layer of large **Purkinje cells** between the two.
 - There are five types of neurons in the cerebellum:
 - Purkinje cells
 - Stellate cells
 - Basket cells
 - Golgi cells
 - Granule cells

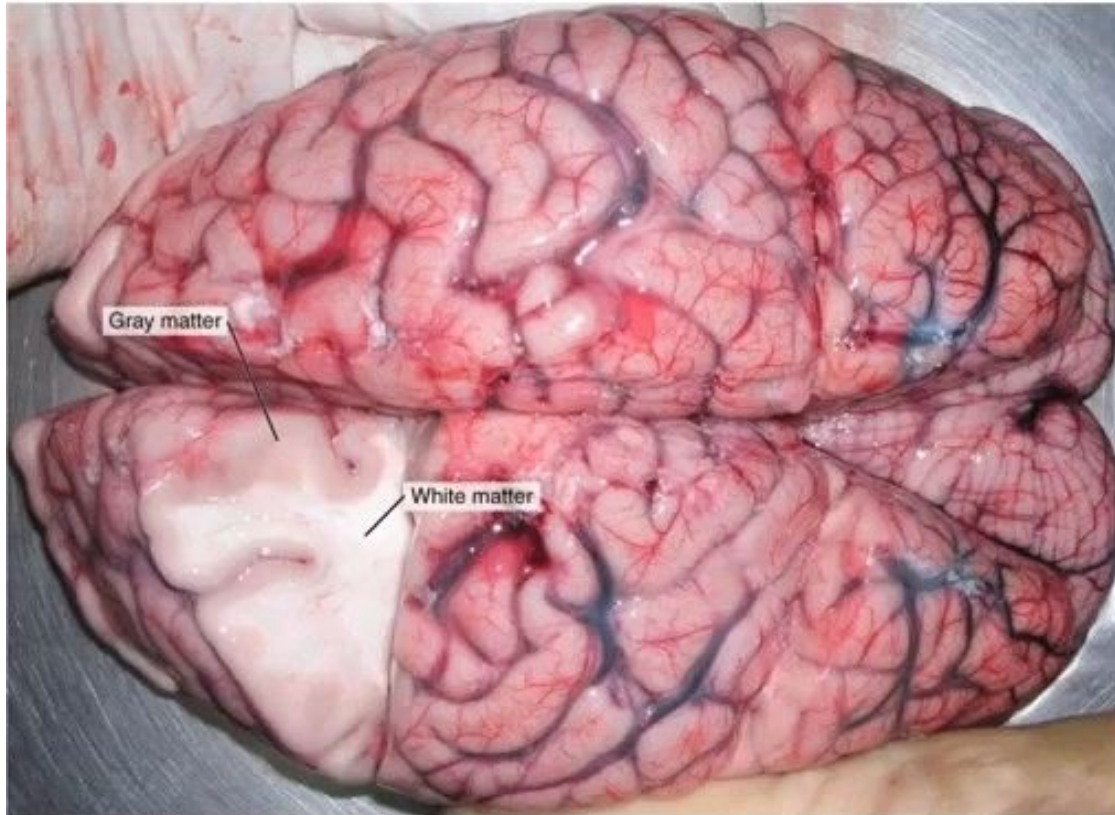


Brain

- Cerebrum or telencephalon
 - Divided into 2 hemispheres
 - It has 4 lobes



Brain

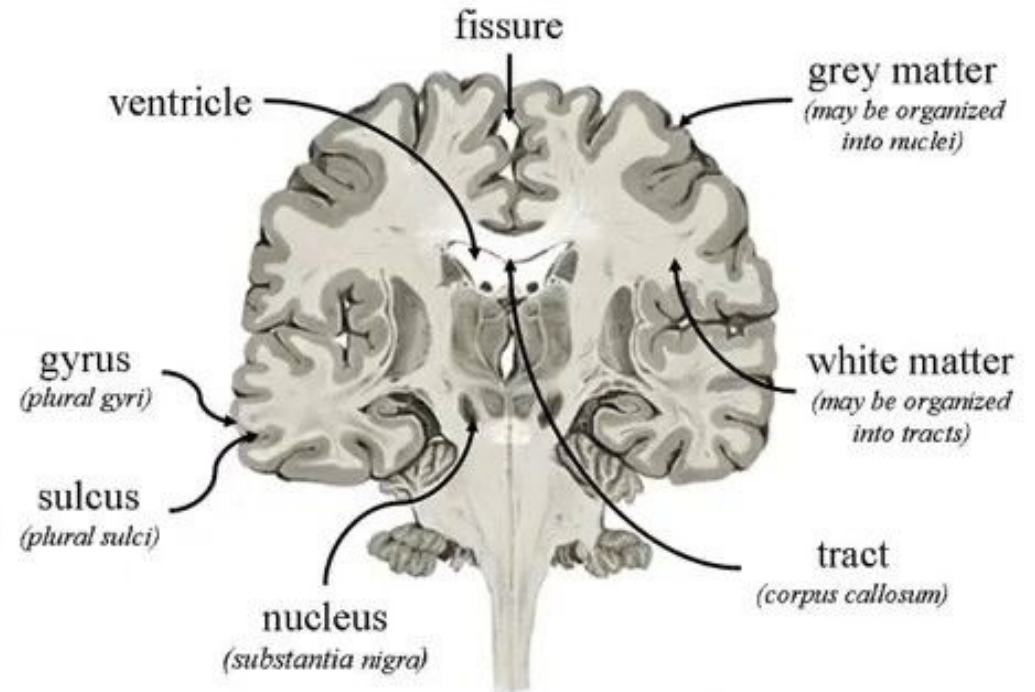


- The cerebrum has two major layers:
 - **White matter** : Mostly axons and oligodendrocytes
 - In turn it has 6 horizontal layers
 - **Grey Matter** a.k.a. **cortex***: Mostly neurons soma with astrocytes.
 - Both layers include glial cells

* Well, not really; cortex is a anatomical term, whereas grey matter is a histological term

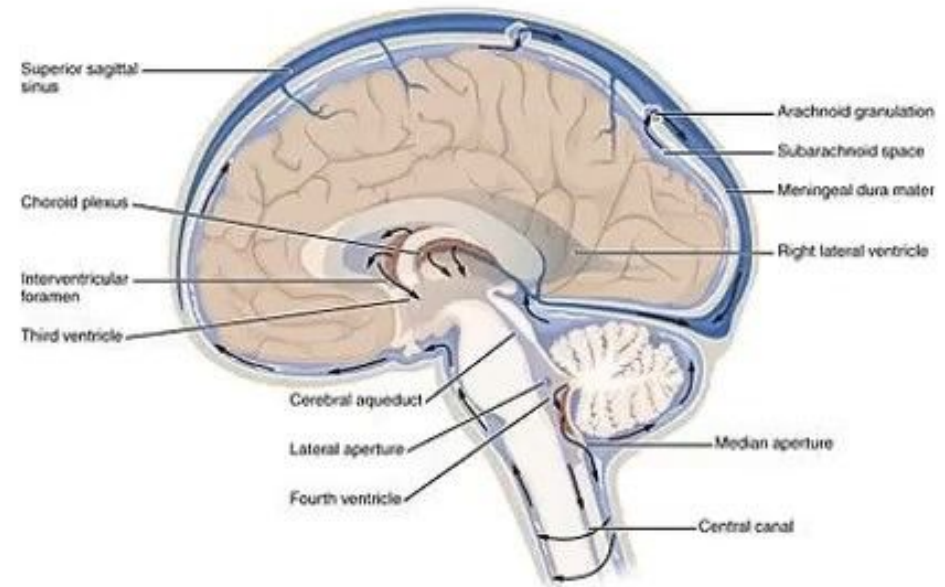
Brain

- In terms of evolution, the **cortex** is folded giving greater surface
 - ...but the mechanical reason is tension [SpornsO2010]
- A fold or ridge in the cortex is termed a **gyrus** (plural **gyri**)
- A groove or fissure is termed a **sulcus** (plural **sulci**)



Brain

- The **ventricular system** is a set of four interconnected cavities (**ventricles**) in the brain, where the cerebrospinal fluid (CSF) is produced (within the choroid plexus).
- The **cerebrospinal fluid (CSF)** is a fluid that acts as a cushion for the brain's cortex, providing basic mechanical and immunological protection to the brain inside the skull.



Brain



MRI showing the circulation of CSF within the ventricular system Figure from: [Wikipedia:Cerebrospinal_fluid]

Spinal Cord

In cross sections of the spinal cord:

- ◉ White matter is peripheral.
- ◉ Gray matter is internal and has the general shape of the letter (H).
 - In the center is an opening, the **central canal**, which develops from the lumen of the embryonic neural tube.
 - The canal is continuous with the ventricles of the brain, contains CSF, and is lined by ependymal cells.
 - The gray matter forms the **anterior horns**, which contain motor neurons whose axons make up the ventral roots of spinal nerves, and the **posterior horns**, which receive sensory fibers from neurons in the spinal (dorsal root) ganglia.
- ◉ **Spinal cord neurons are large and multipolar**, especially the motor neurons in the anterior horns.

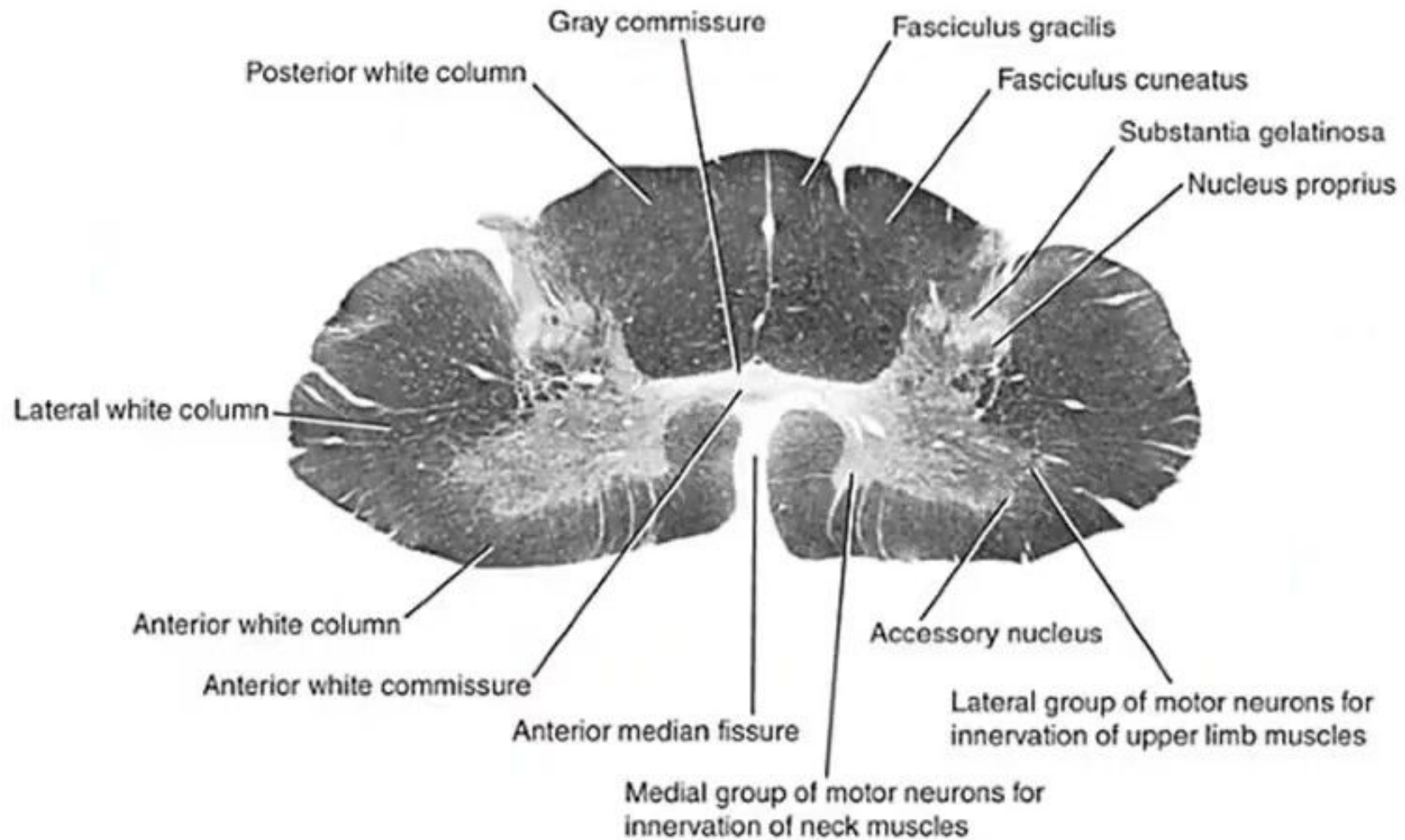
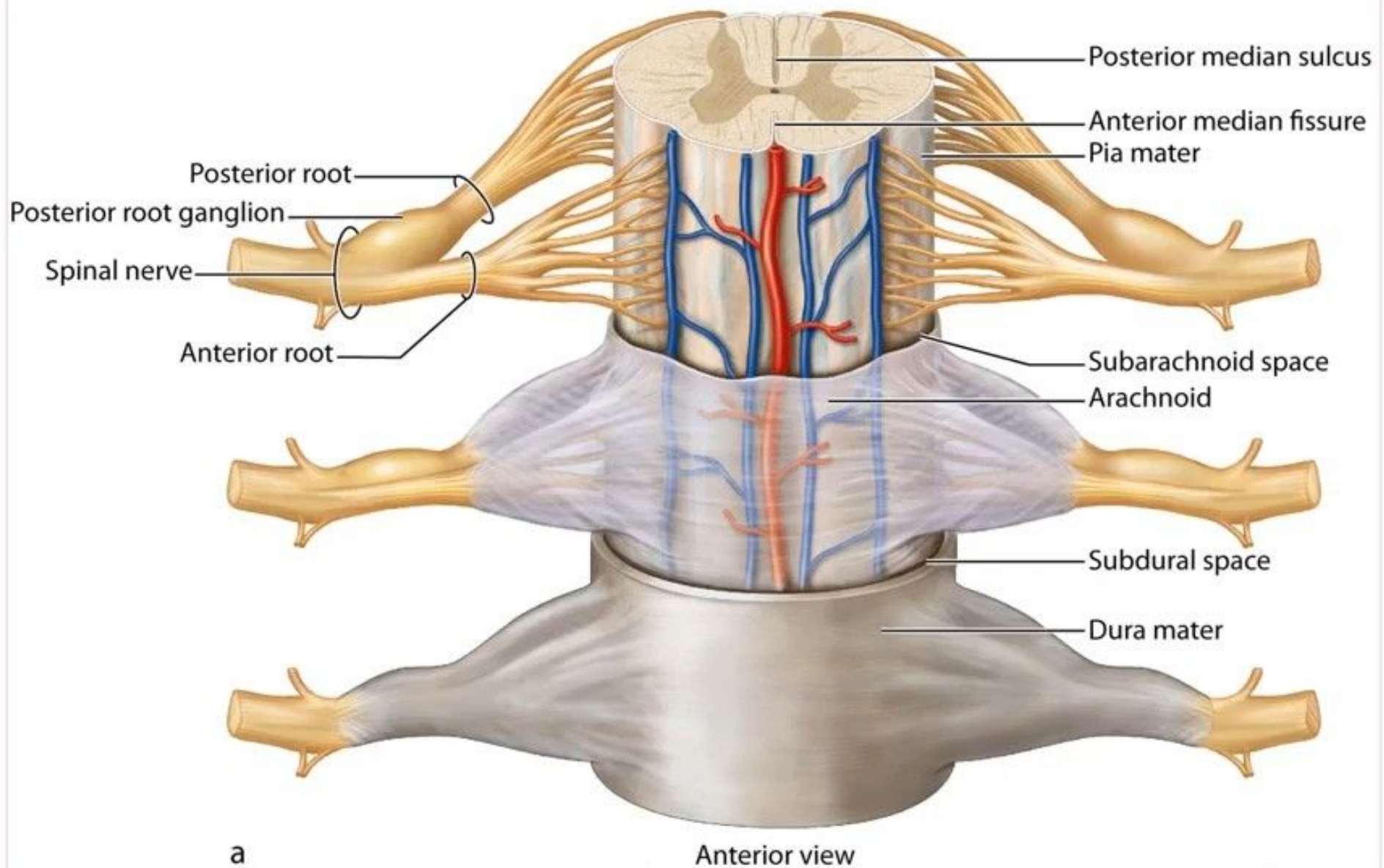


Figure 4-7 Transverse section of the spinal cord at the level of the fifth cervical segment. (Weigert stain.)

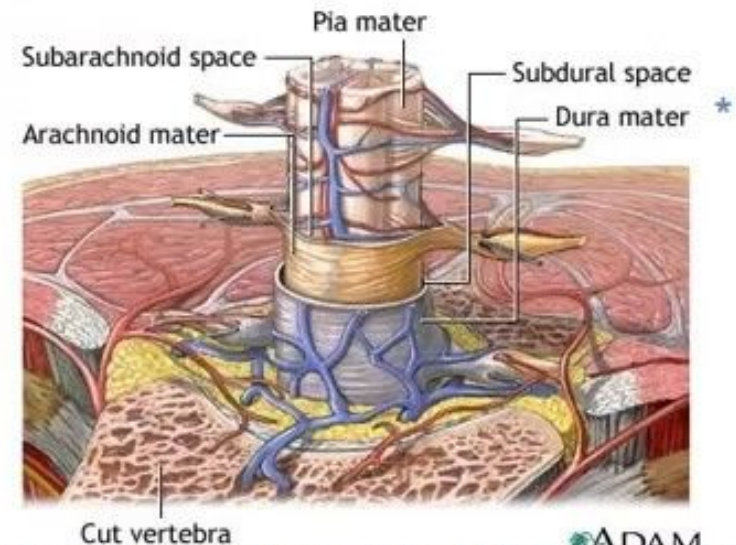
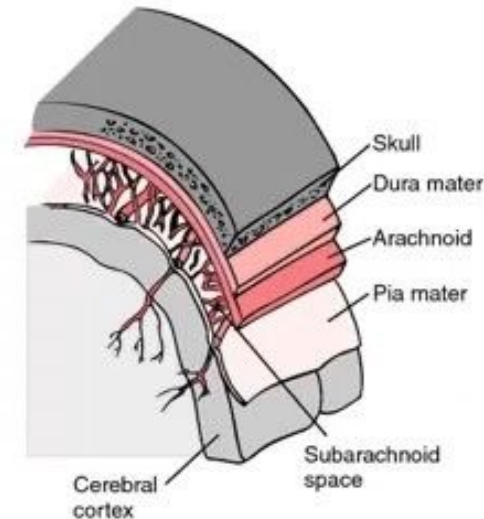


The meninges and protective tissues

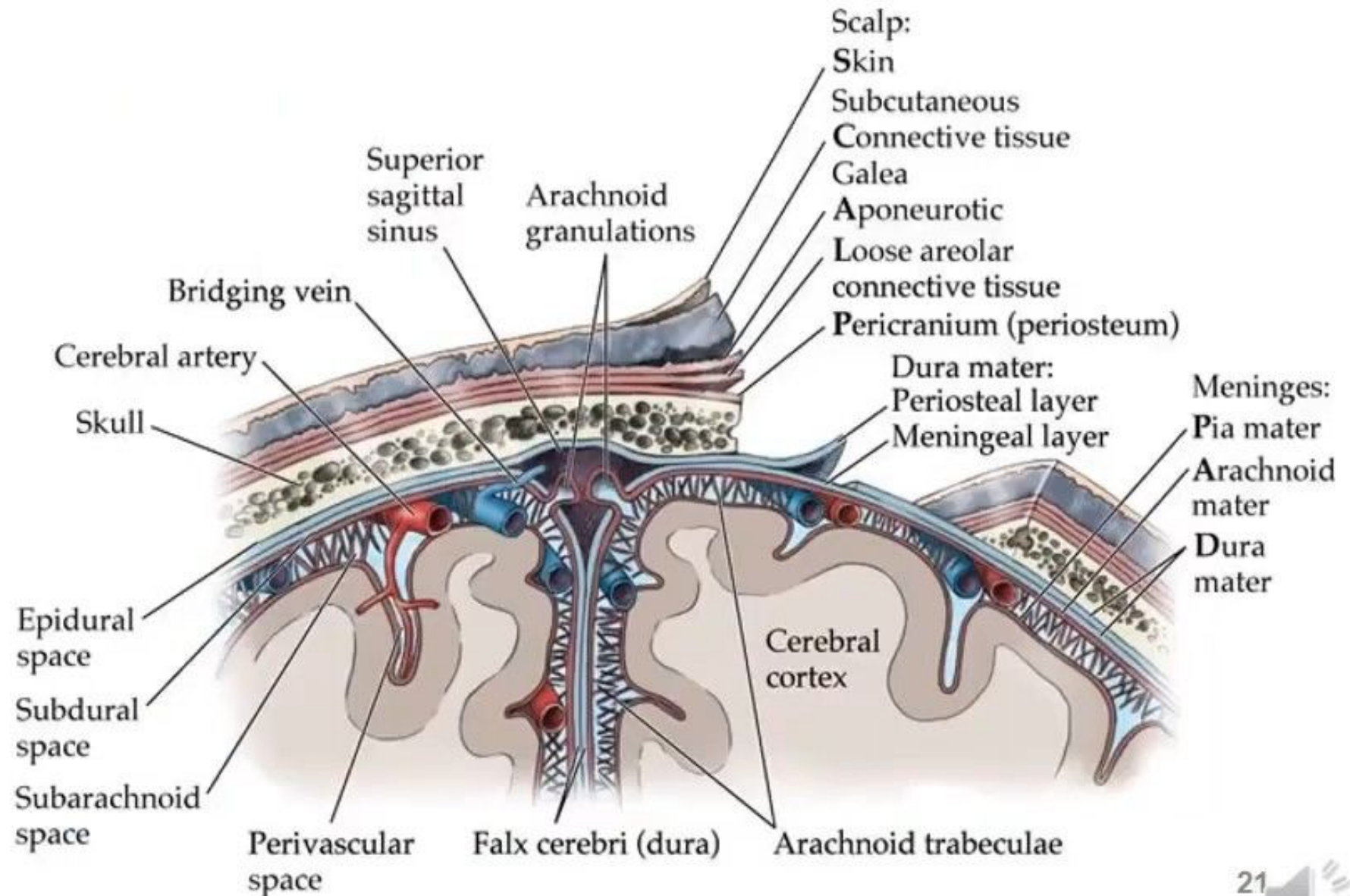
■ Meninges

- The meninges is the connective tissue covering the whole central nervous system (CNS)
 - It protects the brain as well as the spine.
- It consists of several layers
 - the **dura mater**,
 - the **arachnoid**
 - the **subarachnoid space**, and
 - the **pia mater**

*NOTE: The subdural space occurs following trauma. It is NOT part of the meninges



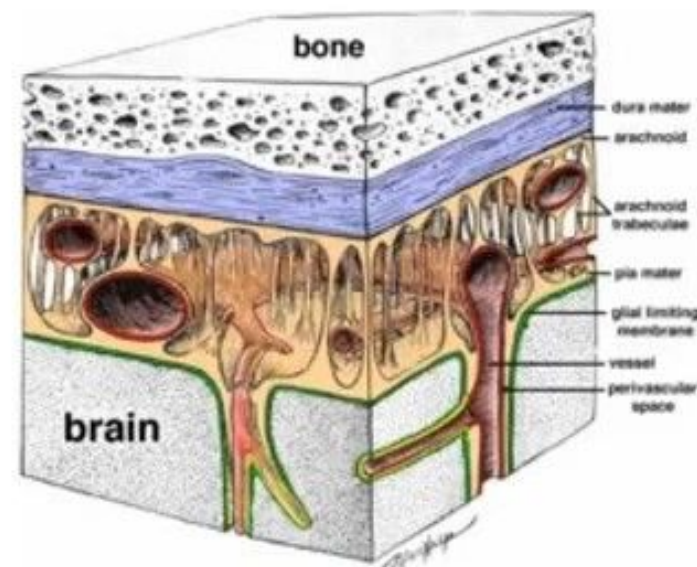
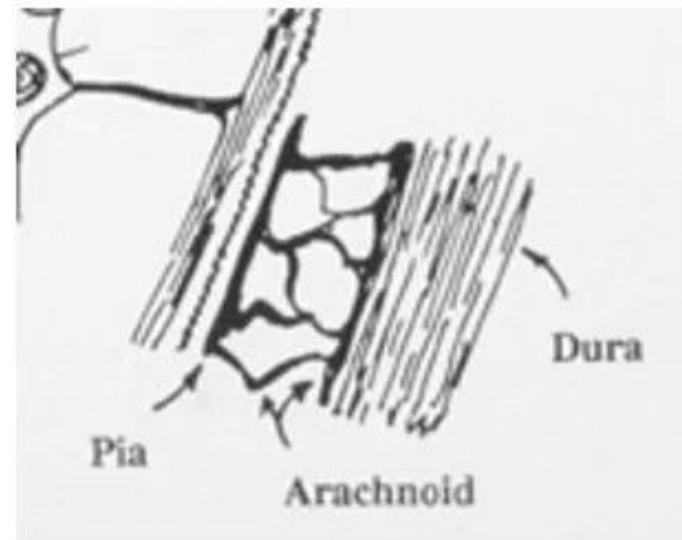
The meninges and protective tissues



The meninges and protective tissues

■ Meninges

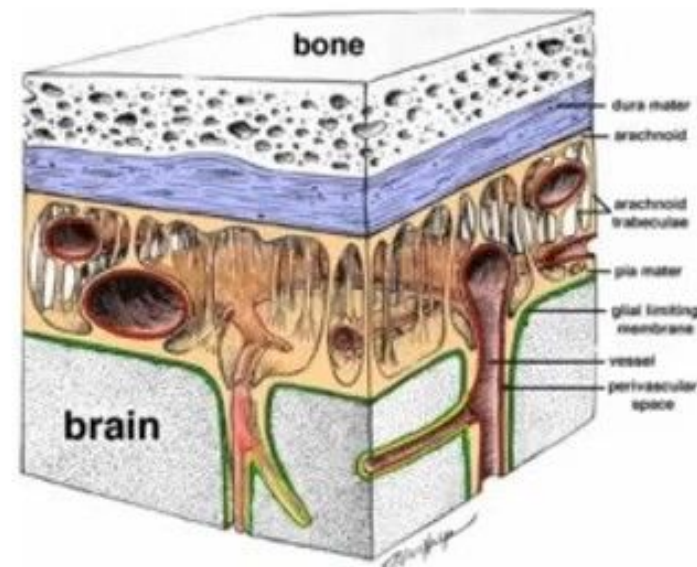
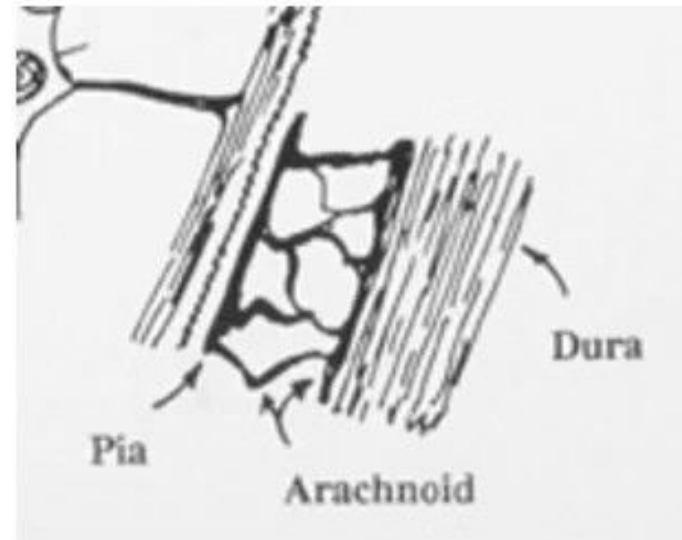
- the **dura mater**, made up of thick fibrous connective tissue (outer periosteal + inner meningeal) Inside the skull.
- Around the spinal cord, the dura mater is separated from the periosteum of the vertebrae by the epidural space, which contains a plexus of thin-walled veins and loose connective tissue
- the **arachnoid**, has two components: a continuous membrane adherent to the inner surface of the dura and trabeculae which bridge through the subarachnoid space to attach to the pia mater.



The meninges and protective tissues

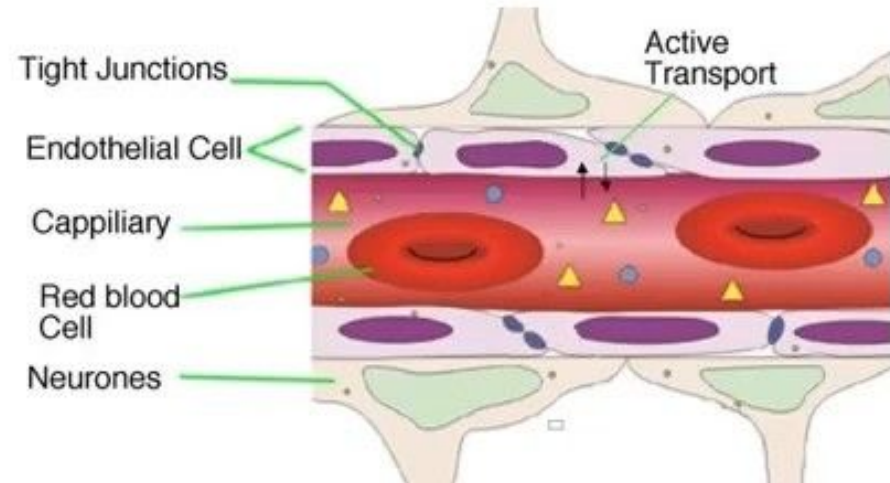
■ Meninges

- the **subarachnoid** space, contains blood vessels and the fibrous trabeculae. The CSF runs within this space
- the **pia mater**, a thin membrane (a monolayer of cells) that is adherent directly to the surface of the brain



Blood brain barrier

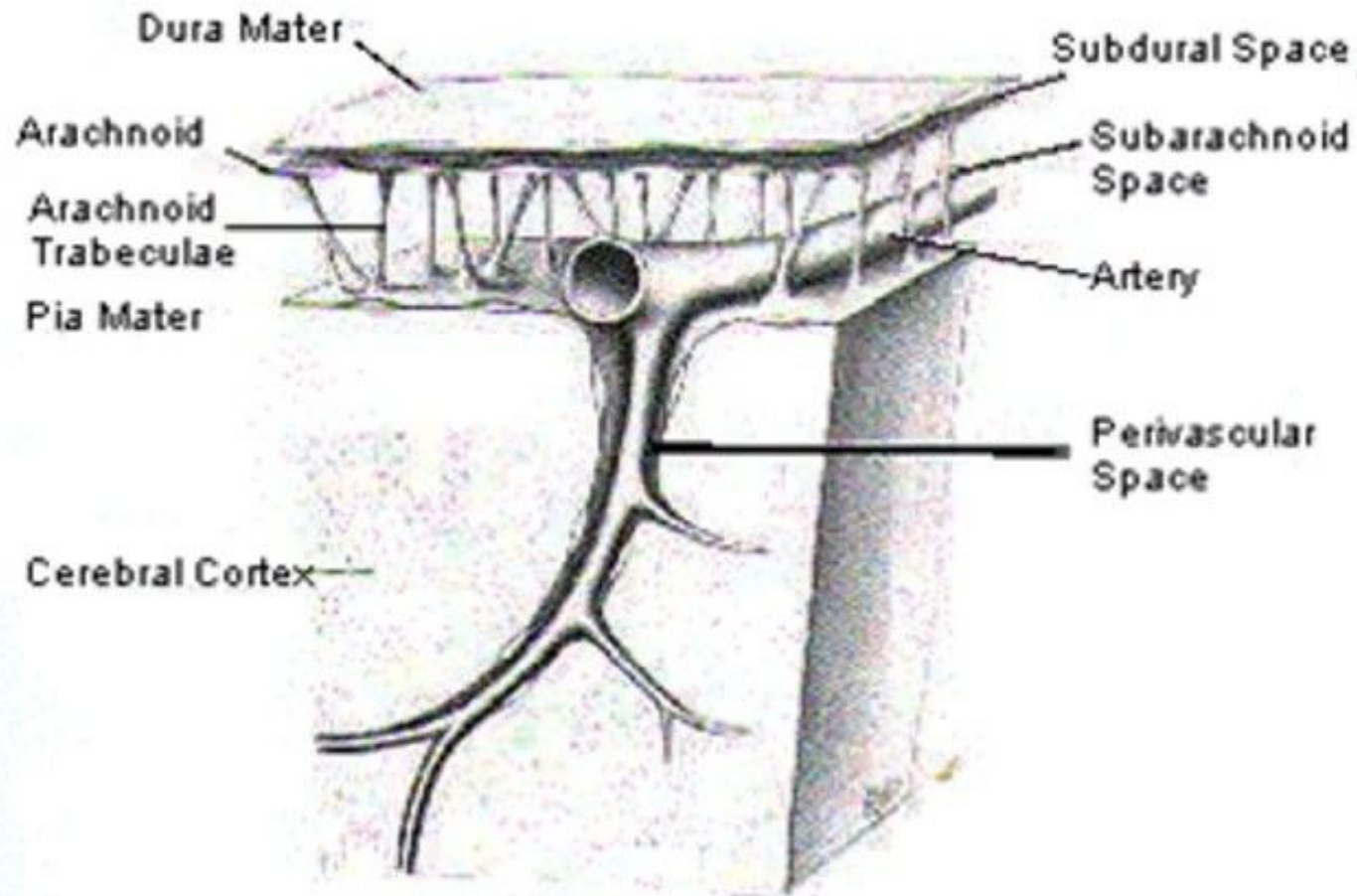
- The **blood-brain barrier** is a physical barrier composed of an endothelial layer or a thin layer of cells which separates the blood in the circulation from the cells in the brain.
 - Unlike in normal circulation, the arteries within the brain contain tight junctions which prevent bacteria and hydrophilic molecules from crossing the blood vessels into the extracellular fluid where the brain cells are located.



Blood brain barrier

- The blood-brain barrier protects the brain from unwanted chemicals in the blood.
 - This is crucial because neuron signalling in the brain relies on electrical signals and fine chemical signals, which require a precisely regulated microenvironment.
- ☞ This is a curse for pharmacology, as drugs have a hard time to get to the brain. Neuropharmacologists have to circumvent nature.

Blood supply of the central nervous system



Blood supply of the central nervous system

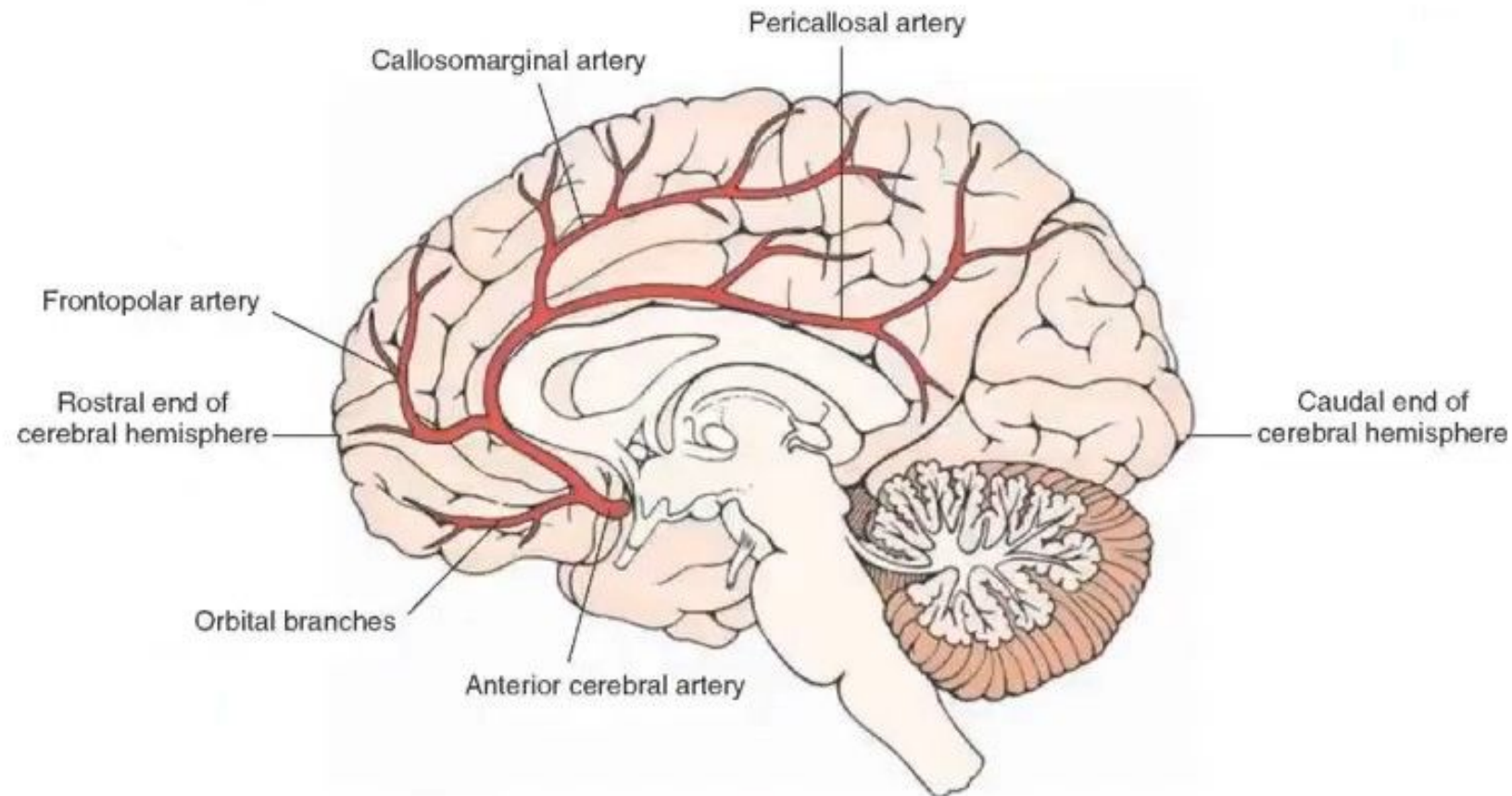
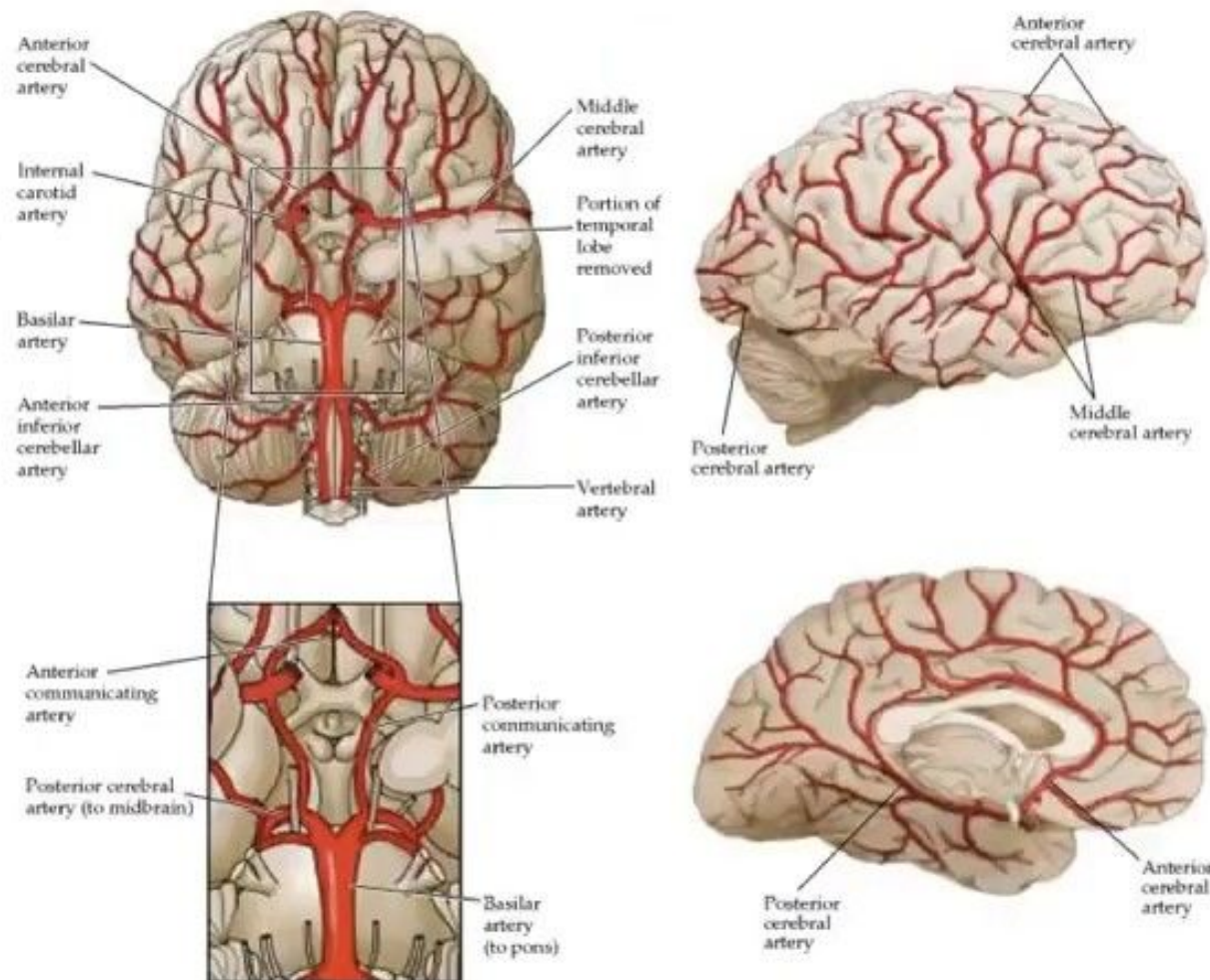


Figure from: [<http://what-when-how.com/neuroscience/blood-supply-of-the-central-nervous-system-gross-anatomy-of-the-brain-part-1/>]

Blood supply of the central nervous system

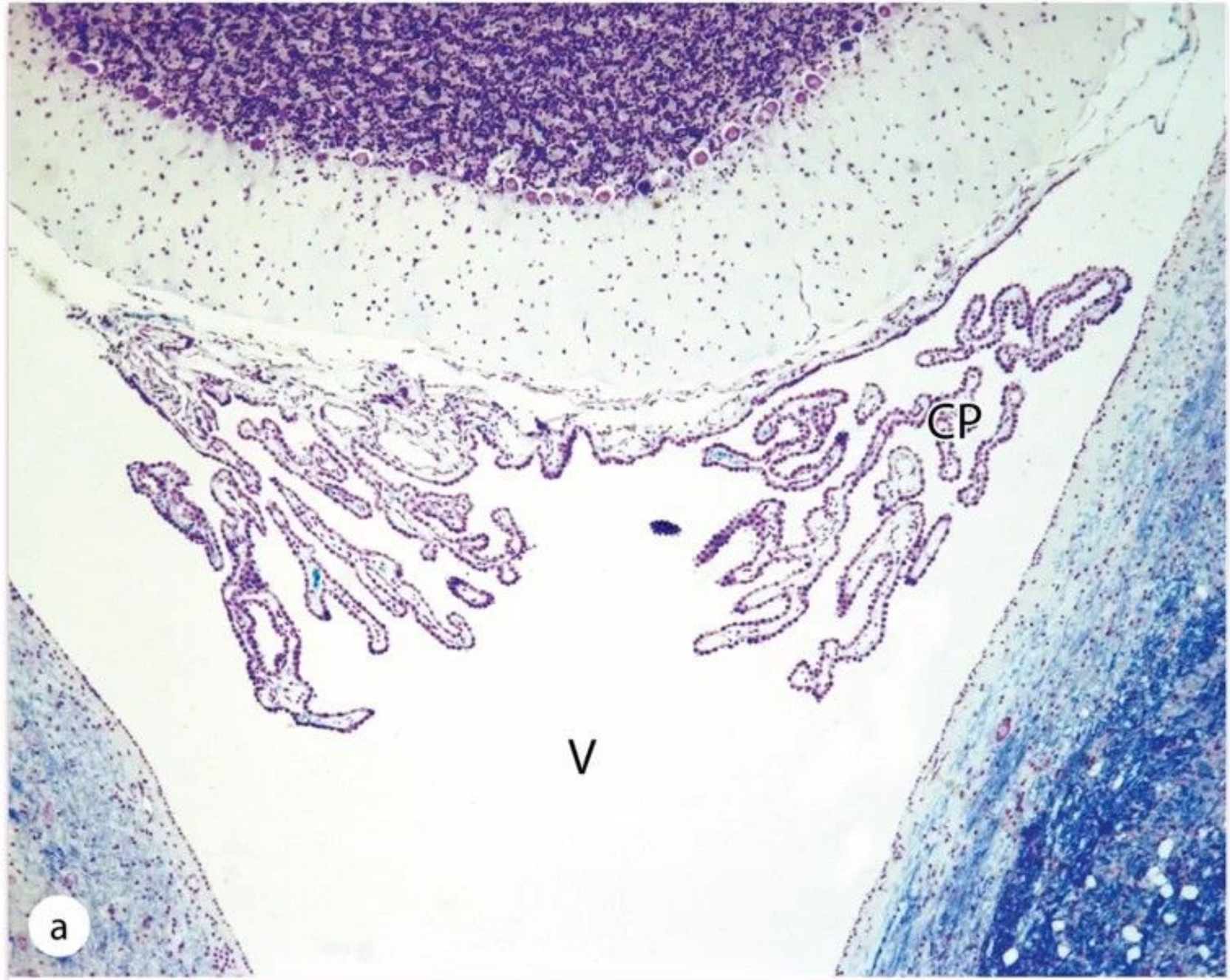
Brain's Blood Supply as Communication Network

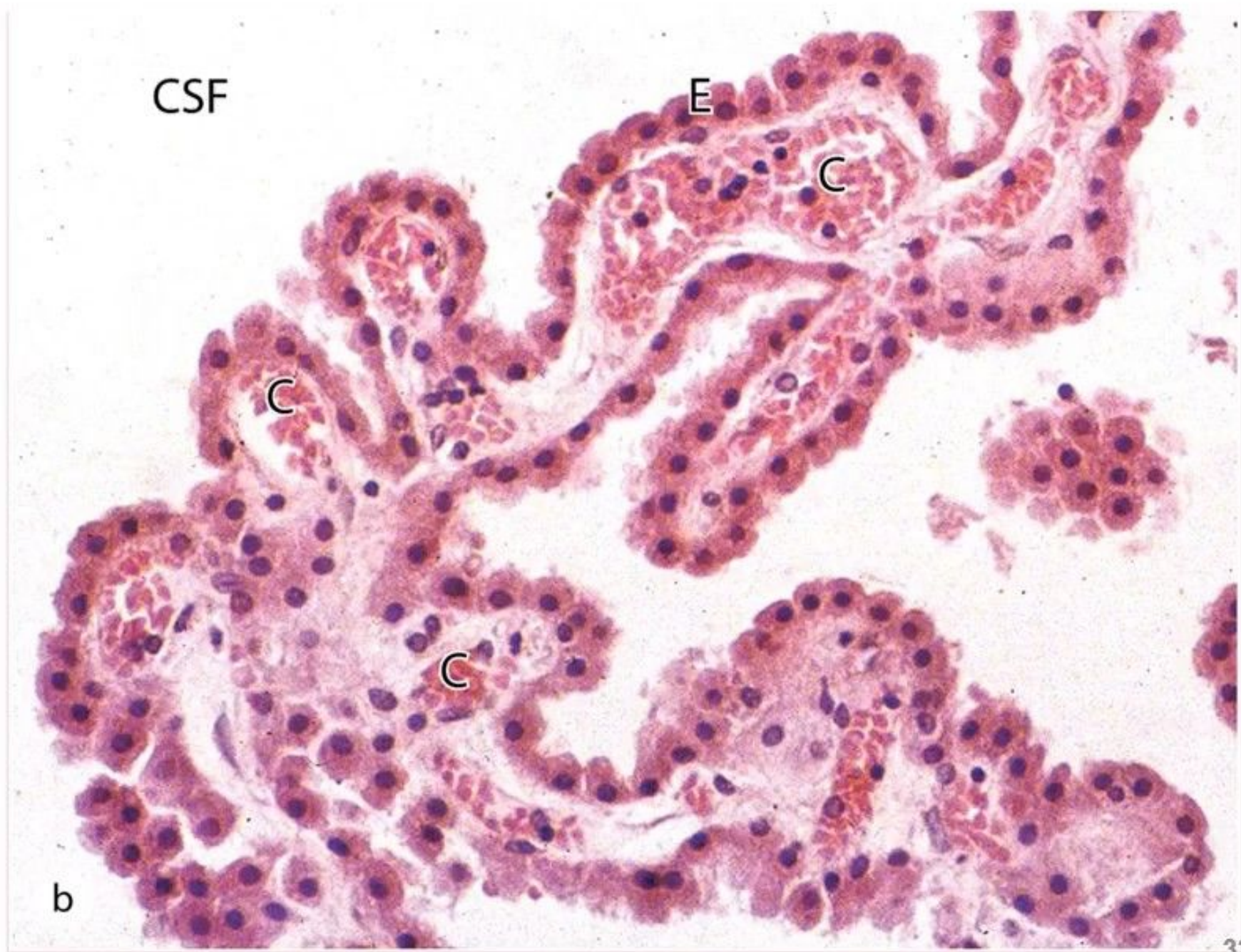


Choroid plexus

- ◉ The choroid plexus consists of highly vascular tissue with elaborate folds and many villi projecting into the four large ventricles of the brain.
- ◉ **It is found in** the roofs of the third and fourth ventricles and in parts of the two lateral ventricular walls.
- ◉ **Each villus** of the choroid plexus contains a thin layer of well-vascularized pia mater covered by cuboidal ependymal cells.

- ◉ The function of the choroid plexus is to remove water from blood and release it as the CSF.
- ◉ CSF is clear, contains Na^+ , K^+ , and Cl^- ions but very little protein, and its only cells are normally very sparse lymphocytes.
- ◉ It is produced continuously and it completely fills the ventricles, the central canal of the spinal cord, the subarachnoid and perivascular spaces.
- ◉ It provides the ions required for CNS neuronal activity and in the arachnoid serves to help absorb mechanical shocks.
- ◉ Arachnoid villi provide the main pathway for absorption of CSF back into the venous circulation.
- ◉ There are very few lymphatic vessels in CNS tissue.





Brain Plasticity

- Brain structure and connectivity is not static.
- **Brain plasticity** or **neuroplasticity** refers to the brain's ability to reorganise neural pathways
 - It may occur as a result of injury or stimulation –whether external (environment) or internal (thinking)-, or training
 - It occurs at cellular level whether by changing:
 - synaptic connections, dendritic arborization, neurogenesis (**synaptic plasticity**),
 - modification of ion channel function that results in specific changes in the integration of excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs) –(**non-synaptic plasticity**).
 - Morphological features or phagocytic activity (**microglial plasticity**)
- Plasticity is necessary for learning, memory, healing, etc

Brain Plasticity

- Plasticity is always present; it never stops but the “speed” of it changes with many factors:

- Age
- Injury
- Training
- Cognitive function

Synapse formation in the brain

