

# CNS Cerebrum

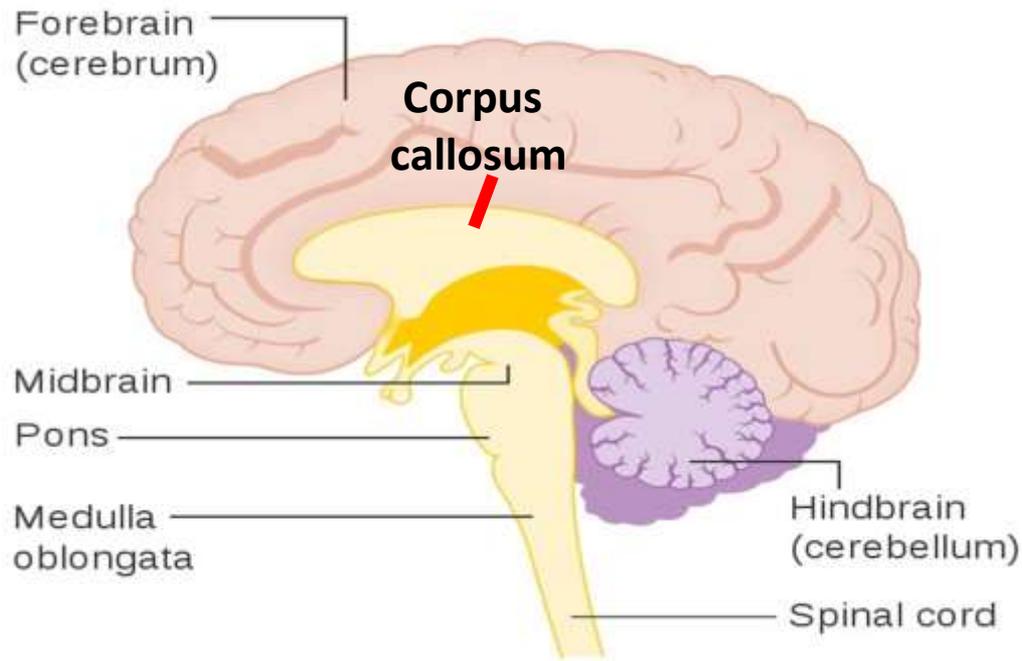
**Ass. Prof Dr. Heba Hassan Abd El-Gawad**

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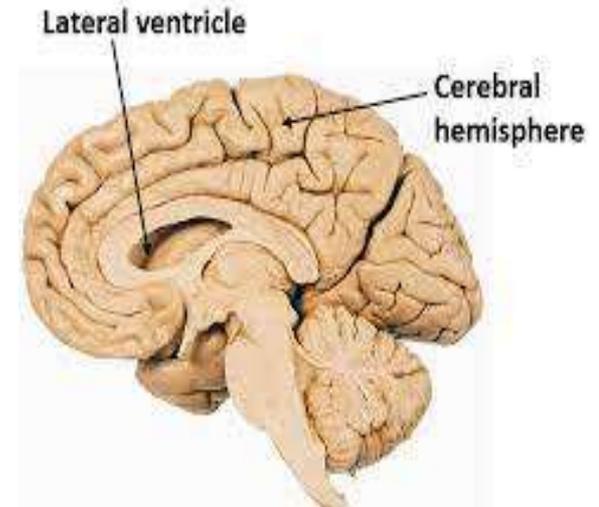
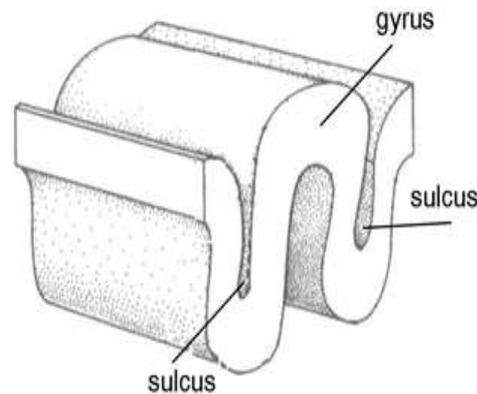


# CEREBRUM

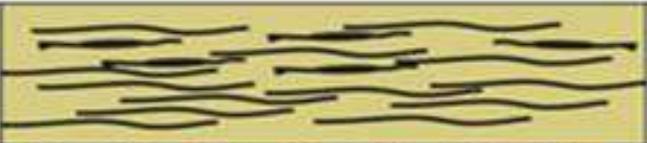
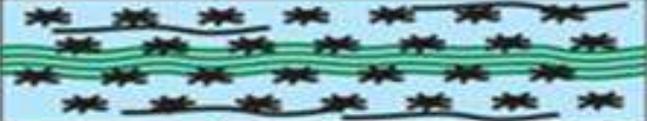
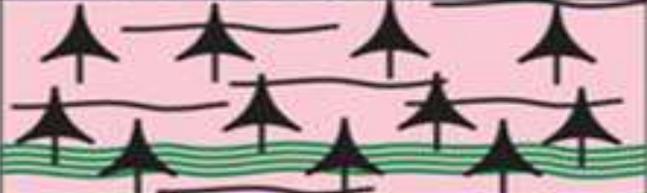
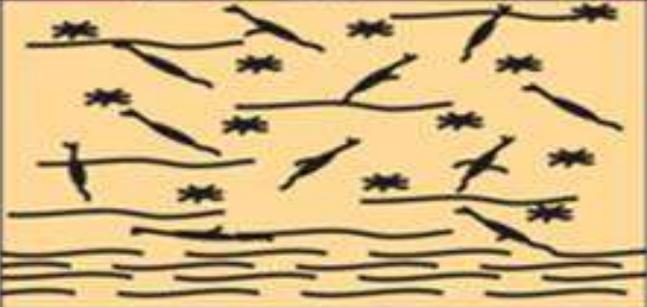
- Cerebrum consists of two hemispheres which are connected by a mass of white matter called the corpus callosum.
- Each hemisphere has an outer cortex (grey matter) & an inner medulla (white matter). Within the white matter of each hemisphere there are several large masses of grey matter; the basal ganglia.



- There is a lateral ventricle inside each hemisphere. The surface of the cortex has gyri (convolutions) which are separated by sulci (fissures)
- The grey matter consists of nerve cells, nerve fibers, neuroglia and blood vessels. The white matter contains nerve fibers which may be afferent or efferent.



# Layers of the neocortex

1	Plexiform or molecular layer		Predominantly transverse fibres and some scattered horizontal cells
2	External granular layer		Densely packed cells
3	External pyramidal layer		Small and medium sized pyramidal cells
4	Internal granular layer		Closely packed stellate cells Outer band of Baillarger
5	Internal pyramidal (ganglionic) layer		Large pyramidal cells of Betz Inner band of Baillarger
6	Multiform or polymorphic layer		Cells of multiple forms merge with white matter

# Cells present in cerebral cortex

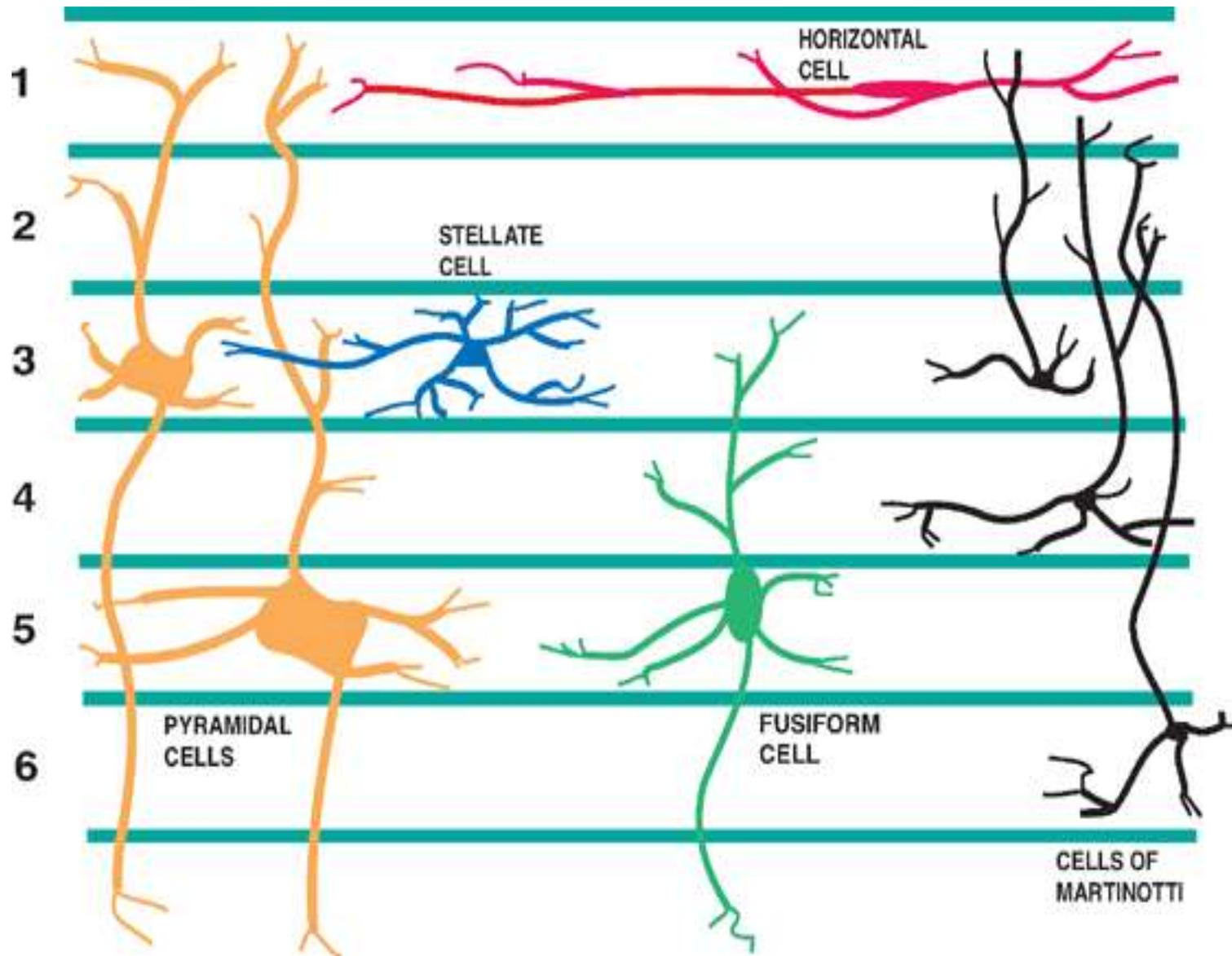
**I- Interneurons:** They are present only intracortically (their processes don't leave the cortex). All are inhibitory except excitatory spiny stellate cells, they include:

**a) Horizontal cells of Cajal** (Retzius cajal cells) are few and present in L1 and parallel to the surface. Spindle shaped neurons, their axons pass laterally to synapse with dendrites of pyramidal cells. Prominent during development and disappear after birth

**b) Stellate (granule cells)** (6-8  $\mu\text{m}$ ) are most numerous in layer IV and layer II. They have multipolar triangular cell bodies, dark condensed nuclei and several dendrites which radiate for variable distances.

**c) Martinotti cells** are large multipolar neurons present mainly in deepest layers. They have very short few dendrites and their axons extend towards the surface and bifurcate to run horizontally superficially forming synapse with pyramidal cells. They are related to a cortical dampening; when the pyramidal neuron is overexcited, they send inhibitory signals.

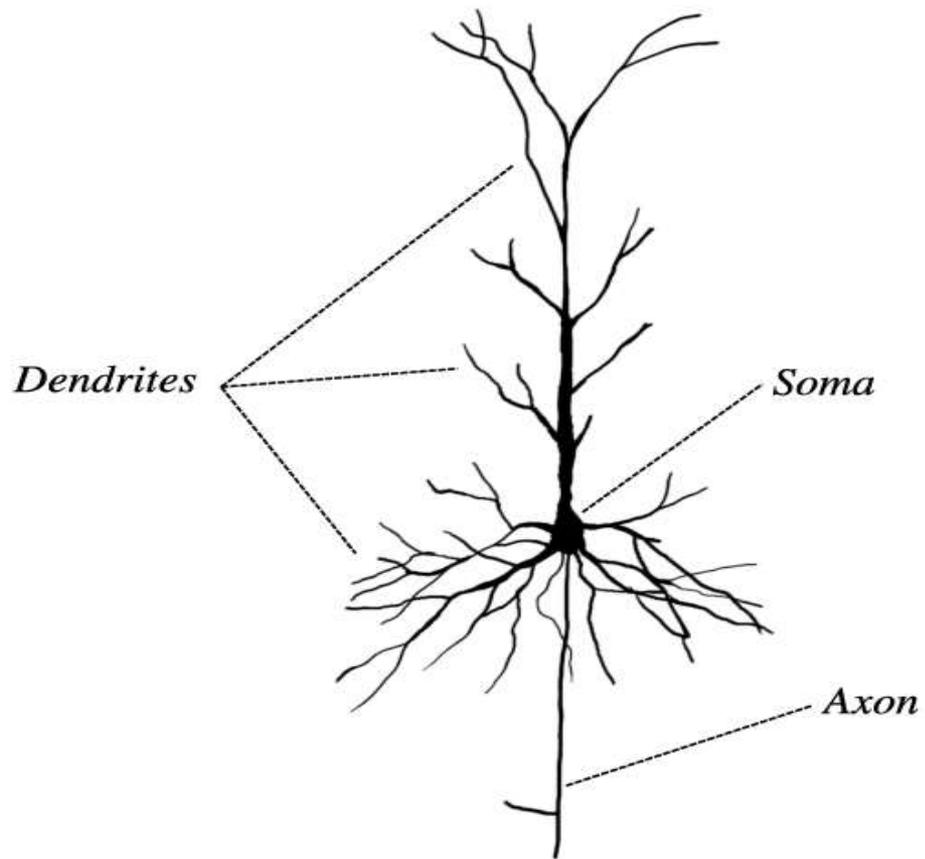
# Cells present in cerebral cortex



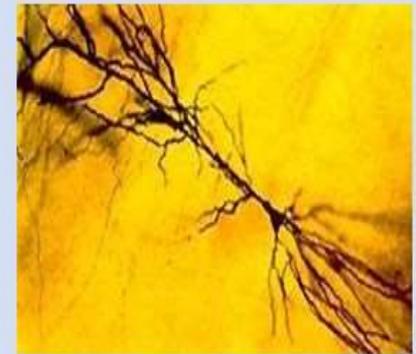
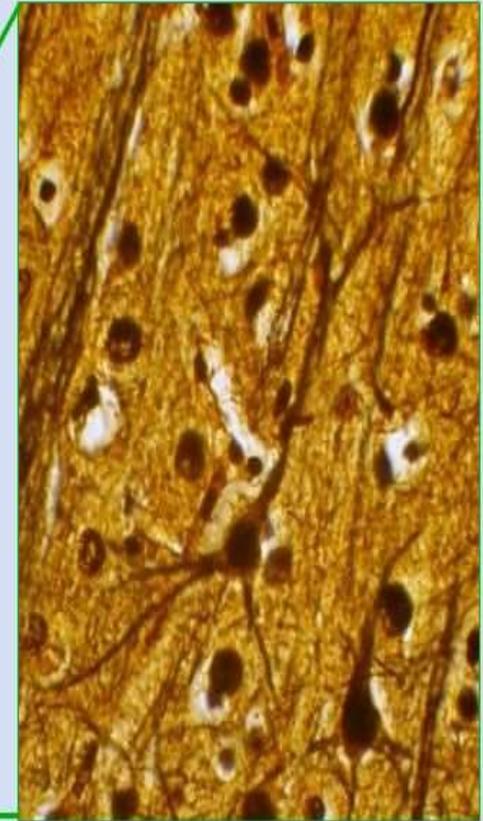
**II-Projection neurons:** the processes of projection cells leave the cortex, they include:

- a) **The pyramidal cells** are present in all layers except layer I. Each has a flask shaped or triangular soma (10-80  $\mu\text{m}$  in diameter), but the Betz cells measure 120  $\mu\text{m}$ . The soma gives dendrites from 3 angles; thick apical that penetrate up to molecular layer and multiple basal that spread horizontally. They are studded with dendritic spines (numerous small projections that are special site of synaptic contact). Its axon emerges from the base of soma and penetrates deeper projecting to the white matter.
- b) **The fusiform cells** are spindle shaped cells oriented at right angles to the cortex. Each has numerous dendrites branching into superficial layers and one axon arises from the lower part of the soma, projecting to the white matter.

# Pyramidal cell



(Low Power - Cerebrum)



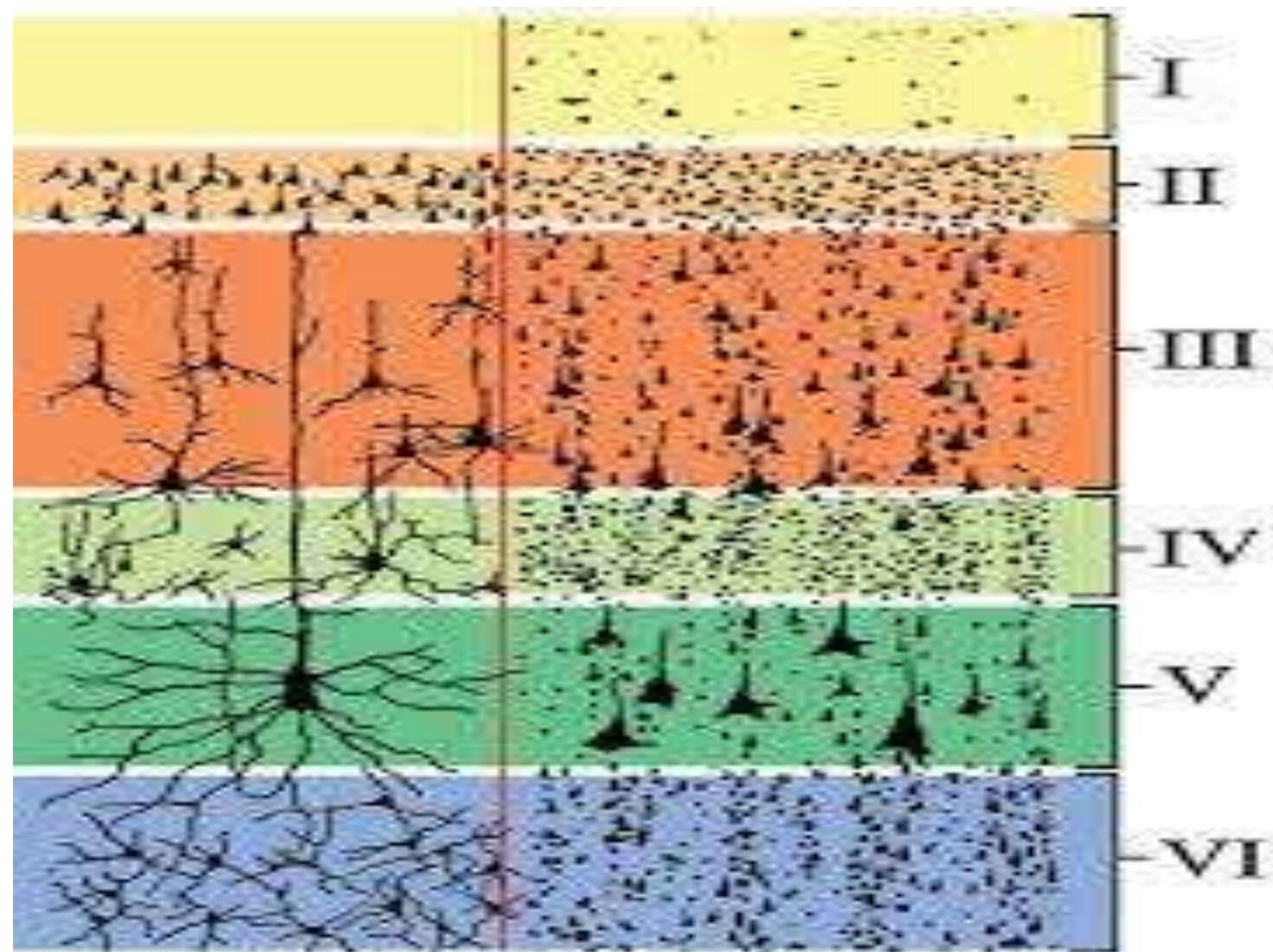
# Histological structure (layers) of the neocortex (grey matter)

- consists of ill-defined six layers from outside to inner, clear demarcation between these layers is not possible. They vary somewhat from one region of the cortex to another depending on cortical thickness and function. These layers are:
- **1- Molecular or plexiform layer (LI):** most superficial layer, directly under the pia matter. It consists mainly of parallel nerve fibers from cells of other deeper layers. It also contains few scattered horizontal cells of Cajal and some neuroglia. This layer is called molecular because in cross section, the delicate fibers are stained as tiny dots giving a molecular appearance. Also called plexiform because it is an important synaptic area (many dendrites & axons appear as a plexuses)

- **2-External granular layer (LII):** it contains
- **I) Cells:** a) Predominate Stellate (granule) cells; they are 2 types; i) Spiny: have spiny dendrites and are excitatory ii) Smooth: have non spiny dendrites and are inhibitory. b) Small pyramidal cells: projecting to deeper layers.
- **II) Fibers:** a) Axons of pyramidal cells traverse this layer projecting to the internal layers. b) Dendrites of stellate cells terminate in this layer or ascend into the molecular layer

- **3- External pyramidal layer (LIII):** it contains medium sized pyramidal cells project to same and opposite hemispheres as association and commissural fibers. Some stellate cells and Martinotti cells are also present. The pyramidal cells increasing in size deeper in this layer. Their apical dendrites extend into the molecular layer
- **4- Internal granular layer (L IV):** it has the greatest cell density of the cortex. It contains closely packed small granule (stellate) cells, neuroglia and outer band of Baillarger. Granule cells are especially numerous in somatic, visual and auditory cortex; so, the term granular cortex is applied to these areas. In contrast, the motor cortex contains relatively few stellate cells and is called agranular cortex

- **5- Internal pyramidal layer (LV):** It has the lowest cell density of the cortex. It contains pyramidal cells of different size, neuroglia and Martinotti cells. Betz cells are the largest (120  $\mu\text{m}$ ) project to superficial layers and to subcortical centers as corpus striatum, pons, brain stem nuclei and spinal cord. It also contains inner band of Baillarger.
- **6- Polymorphic cell layer (LVI):** The deepest layer of cortex close to the white matter. It contains nerve cells of different shapes (fusiform or spindle shaped) project to thalamus and cells of Martinotti. Many nerve fibers (axons) are entering or leaving the underlying white matter



White Matter

- **NB:**

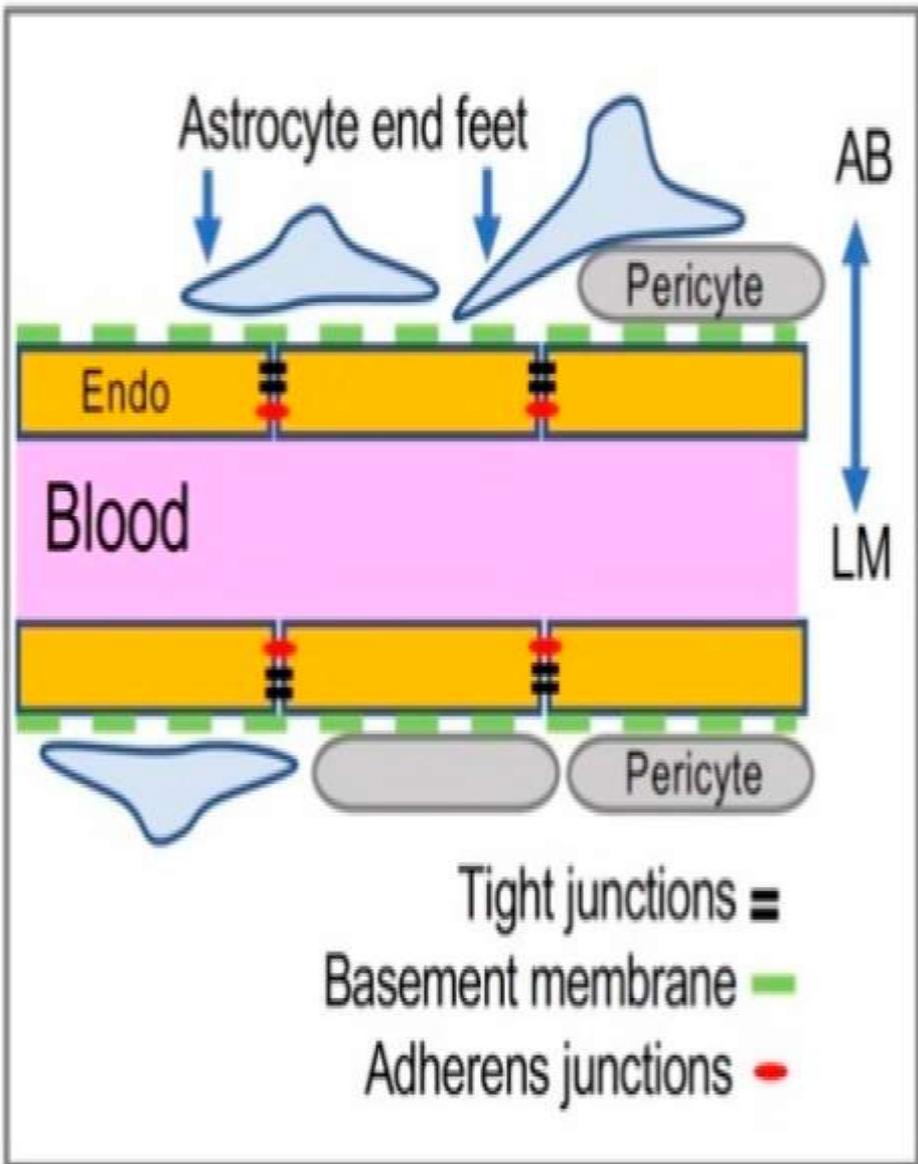
- Number of nerve cells in the brain is 10-20 billion, each nerve cell is associated with 10 neuroglia. 1% of neurons are motor & sensory and 99% are interneurons.
- Layer IV shows the greatest cell packing density in all cortical layers and called granular.
- Layers I, II, III are called supragranular layers and layers V, VI are infragranular layers.
- Layer IV receives thalamocortical specific sensory afferent fibers from (geniculate nuclei) that form a well evident transverse white band called outer **band of Baillarger or stripe of Gennari** which can be seen by naked eye in the primary visual cortex (striate cortex).

- Weight of cerebrum is 1.5 Kg - Surface area of cerebrum is 0.2 m<sup>2</sup> , one third of this area is exposed to surface and 2/3 are hidden in the sulci. Thickness of cerebral cortex is 1.5 mm in visual to 4.5 mm in primary motor cortex.
- 20% of cerebral cortex is motor and sensory and 80% is associative for cognition, language, planning, calculation, abstract and integration activity.

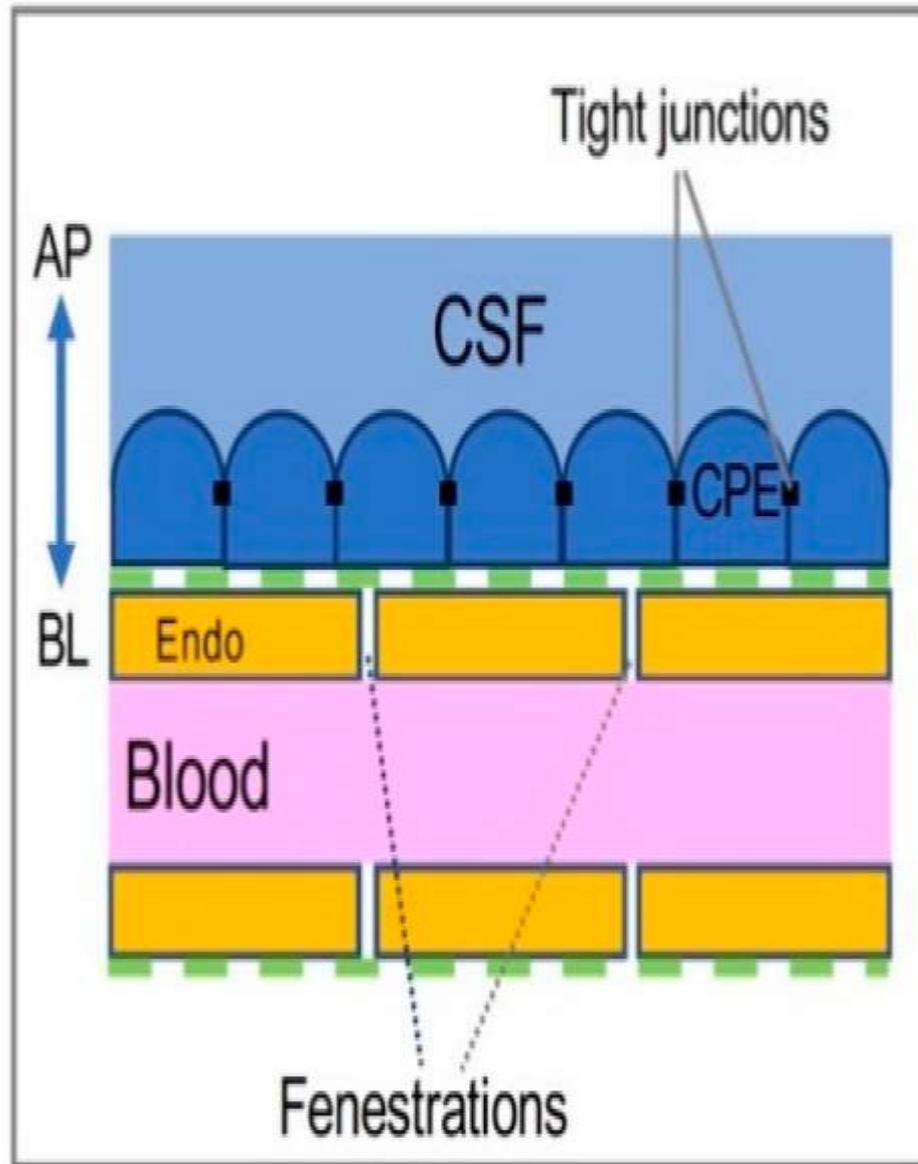
# CNS Barriers

- The absence of any lymphatic capillaries in the brain substance will protect the brain from any antigen that may be present in lymph.
- The nervous system is isolated from the blood by a barrier system that provides a stable environment for neurons and neuroglia.
- This barrier system is a functional barrier that prevents the passage of some substances e.g. antibiotics, chemicals and bacterial toxins from the blood to nervous tissue of the brain.
- There are two types of barriers; blood- CSF and blood brain barrier.

# A Blood-Brain barrier



# B Blood-CSF barrier



- **1- Blood-CSF barrier:** between choroid capillaries and CSF. It is formed by tight junctions between the apices of choroidal epithelium
- **2- Blood brain barrier:** between blood capillaries and the extracellular (interstitial) fluid. At EM level it is formed of:
  1. Continuous non-fenestrated endothelial cells of brain capillaries with tight junctions between these endothelial cells which represent the main structural component of the barrier. They are impermeable to large molecules.
  - 2- A very substantial continuous basement membrane of the endothelial cells of these capillaries.
  - 3- The foot-like expansions of the neuroglial (astrocytes) cellular processes that envelop the capillaries.

**2+3 = Glia limitans perivascularis**

## Common functions of blood brain barrier and blood-CSF barrier:

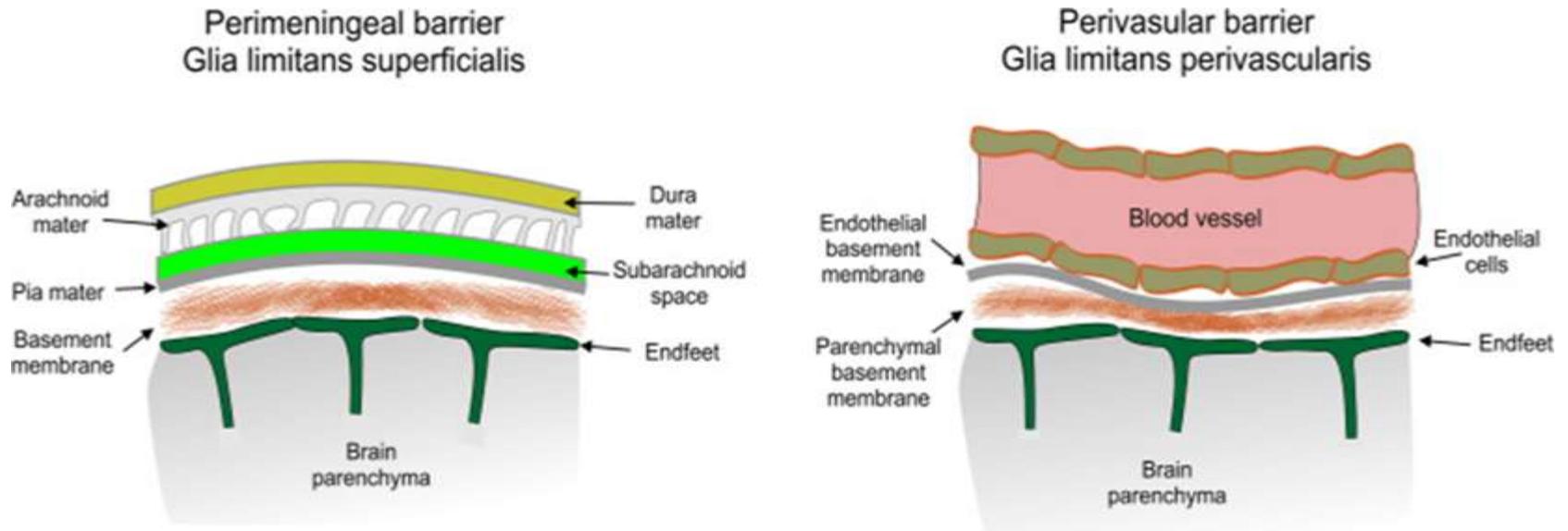
1- Prevents:

- a) Proteins (more than 60.000 molecular weight).
- b) Lipid soluble substance bound to proteins.
- c) Dyes bound to proteins.
- d) Hexoses except glucose.
- e) Dopamine, norepinephrine and serotonin but allows their precursor L-DOPA.

2- Allows a) Water and gases. b) Lipid soluble substances and narcotics. c) Some drugs as L- DOPA, sulfides, tetracyclines and little of penicillin

# Choroid Plexus

- It composed of folds of pia mater within the ventricles of the brain, produces CSF that fills the brain ventricles, central canal of spinal cord and subarachnoid space.
- The pia mater itself contains collagen fibres, fine elastin fibres and occasional fibroblasts separated from the processes of underlying astrocytes by a basement membrane. The basement membrane is completely invested by astrocytic processes, the two layers forming the impermeable glia limitans.

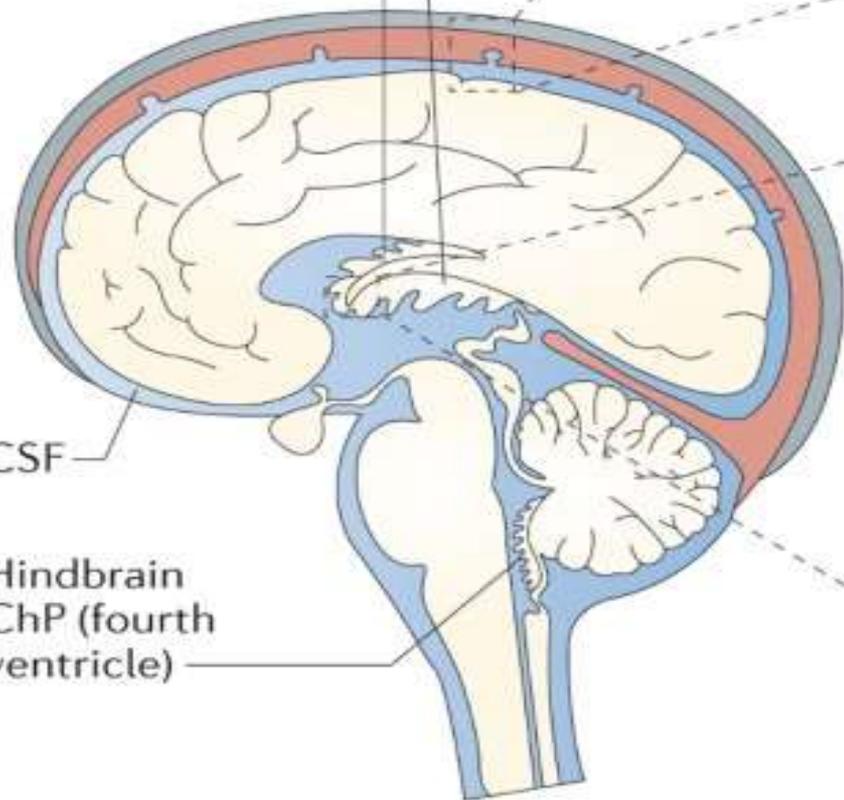


Diencephalic  
ChP (third  
ventricle)

Telencephalic  
ChP (lateral  
ventricle)

CSF

Hindbrain  
ChP (fourth  
ventricle)



Skull

Sinus

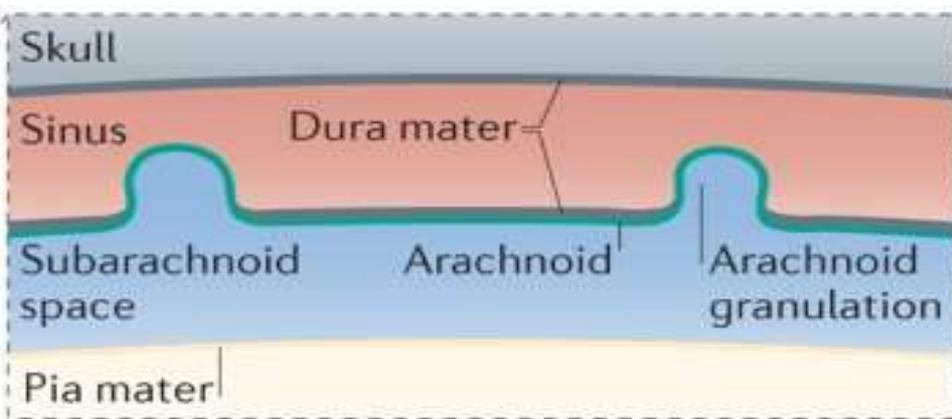
Dura mater

Subarachnoid  
space

Arachnoid

Arachnoid  
granulation

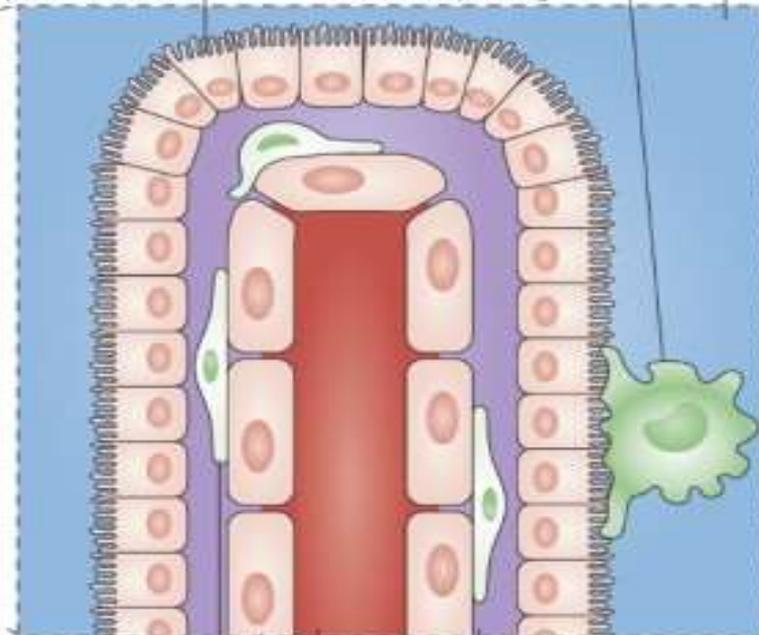
Pia mater



ChP epithelium

Ventricular space

Macrophage



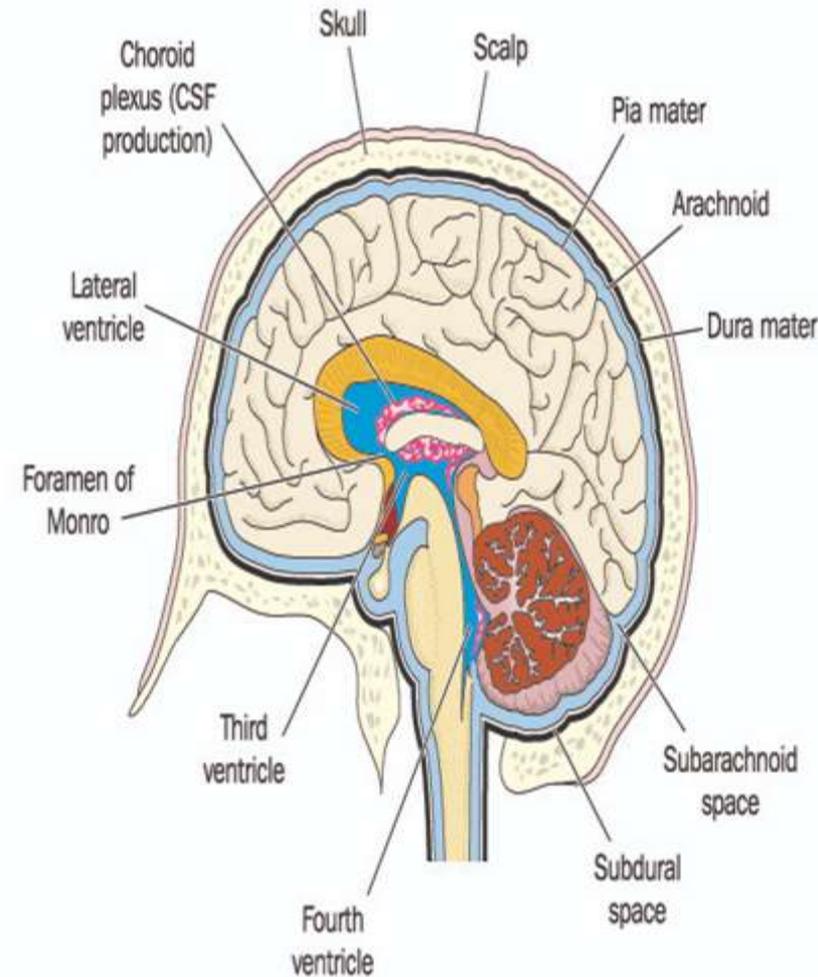
Pericyte

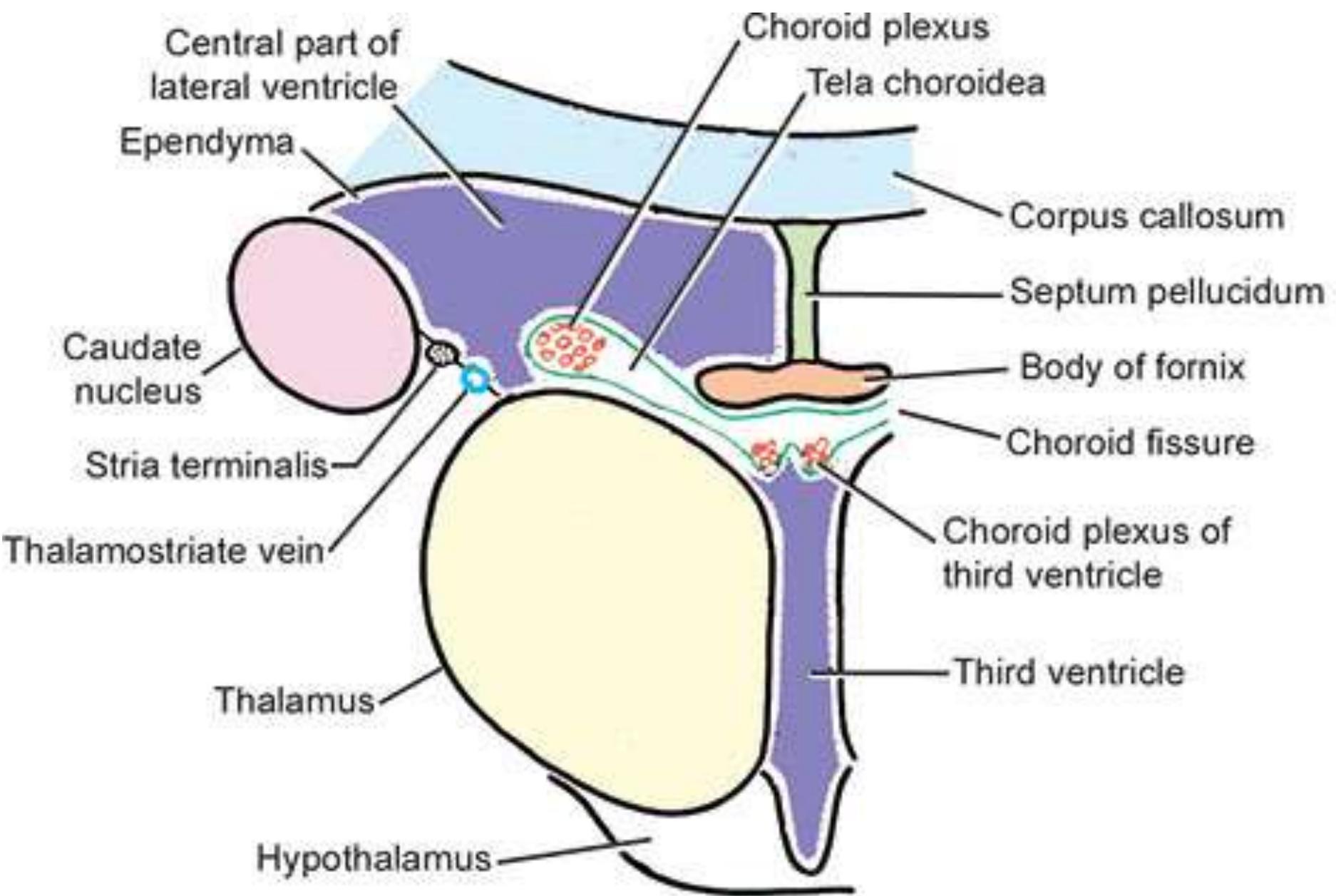
Endothelial cell

Fenestrated  
capillary

Stromal space

- The pia`folds that form choroid plexus housing an abundance of fenestrated capillaries and covered by the simple cuboidal or columnar (ependymal) cells extend into the 3 rd , 4 th, and lateral ventricles of the brain, forming the plexus.
- Tela Choroida (Tela =Web) (Choroida =membrane): It is a vascular 2 layered fold of pia from which arise choroid plexuses of ventricles.





- Choroid plexus of 4th ventricle is T-shaped having 3 openings in the subarachnoid space in the lower half of roof of 4th ventricle. Choroid plexus of 3rd ventricle is 11 shaped present in its roof, and that of lateral ventricle is nearly C shaped present in its body, antrum and inferior horn.
- **Subtypes of Ependyma:** 1. Ependymocytes: cover most of the ventricles and all spinal central canal.
- 2. Choroid epithelium is present in villi of choroid plexuses that form CSF.
- 3. Tanycytes present in some places in 3rd ventricle and have long processes that reach fenestrated blood capillaries in median eminence to transport regulatory hormones from CSF to pituitary portal circulation.

**THANK YOU**