CNS
Cerebrum

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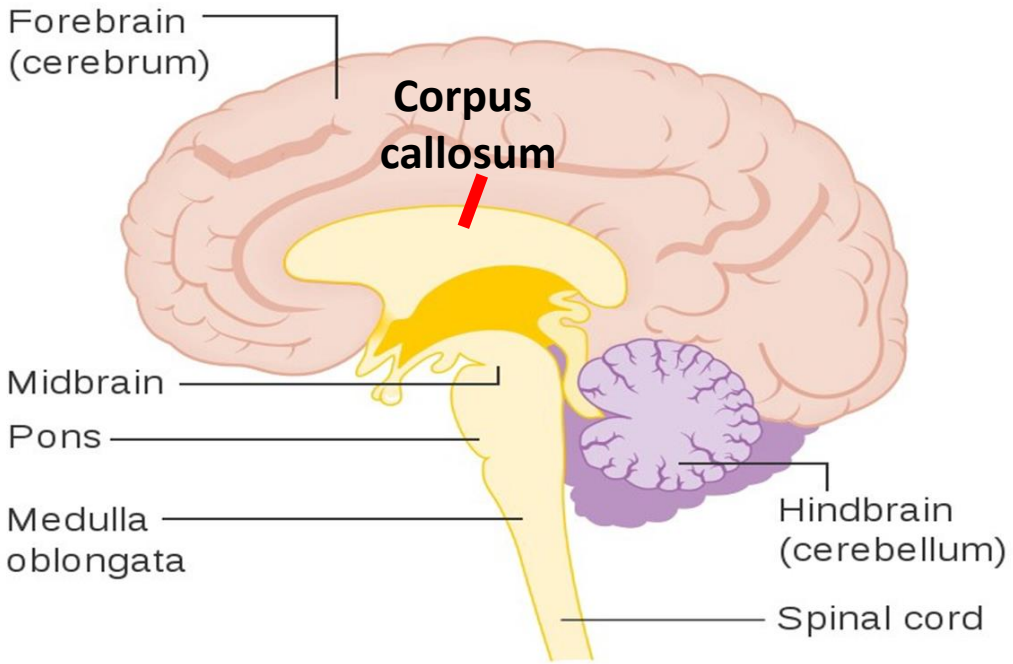
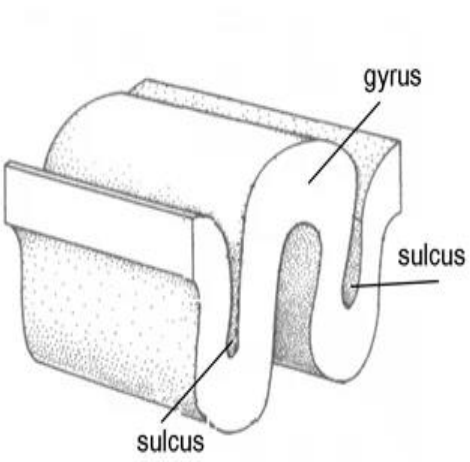
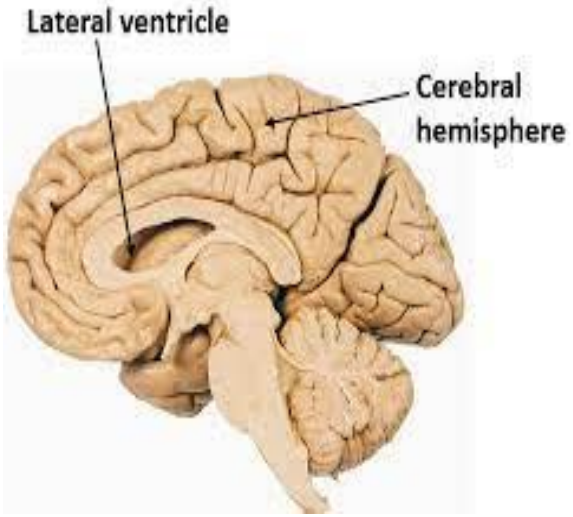
CEREBRUM

- 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.

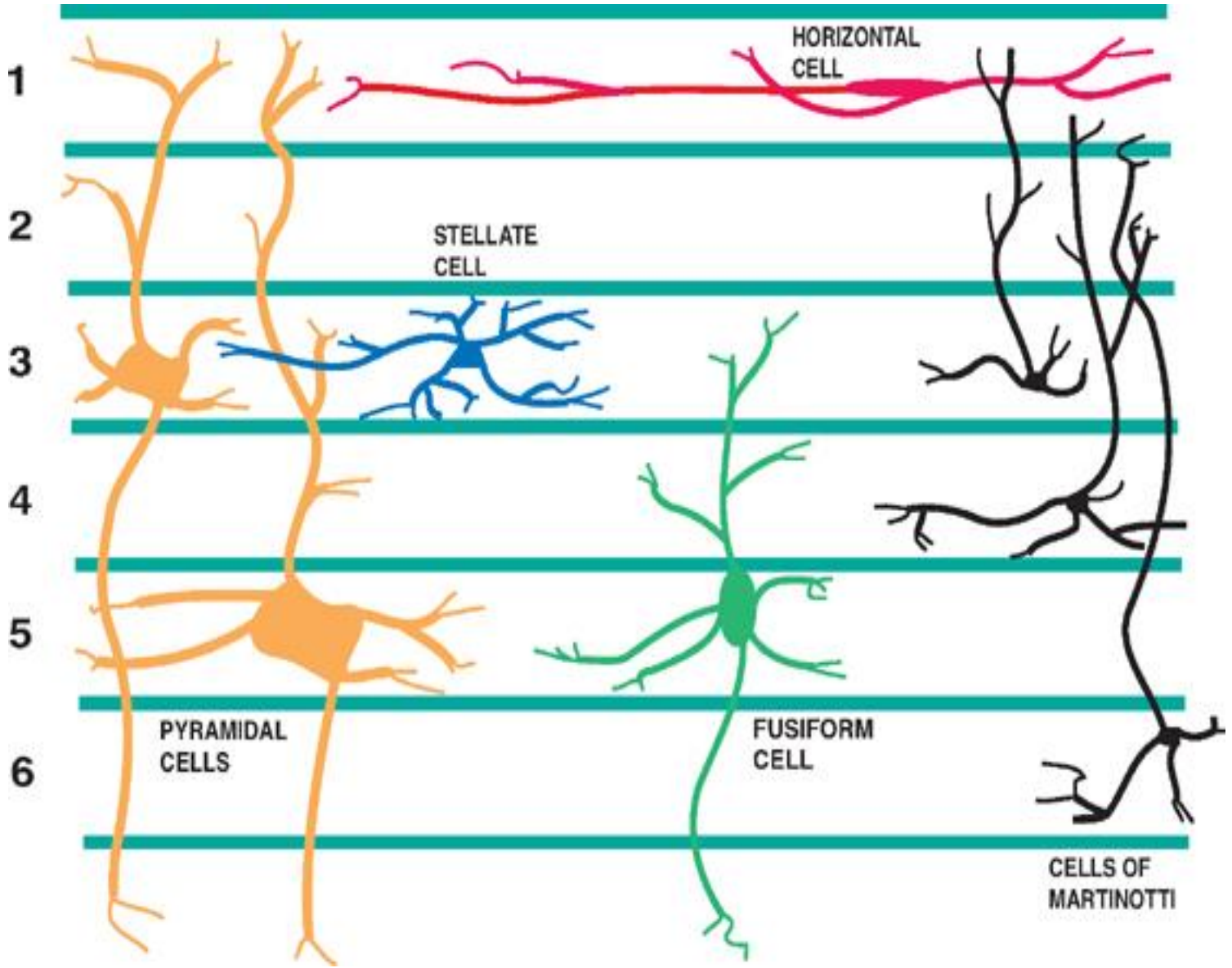


- There is a lateral ventricle inside each hemisphere. The surface of the cortex has gyri (convolutions) which are separated by sulci (fissures)





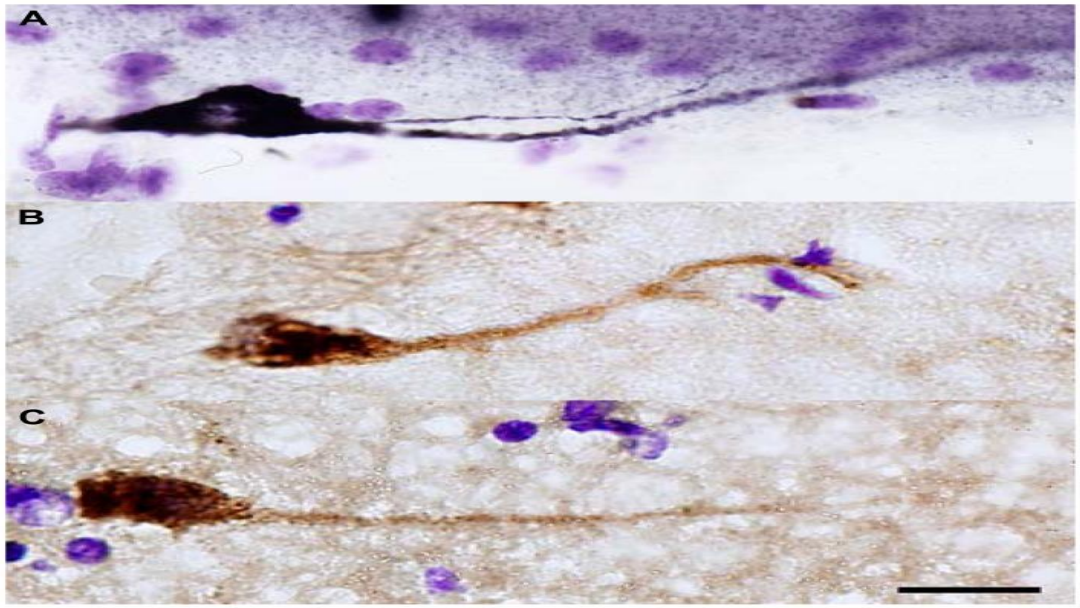
Cells present in cerebral cortex



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



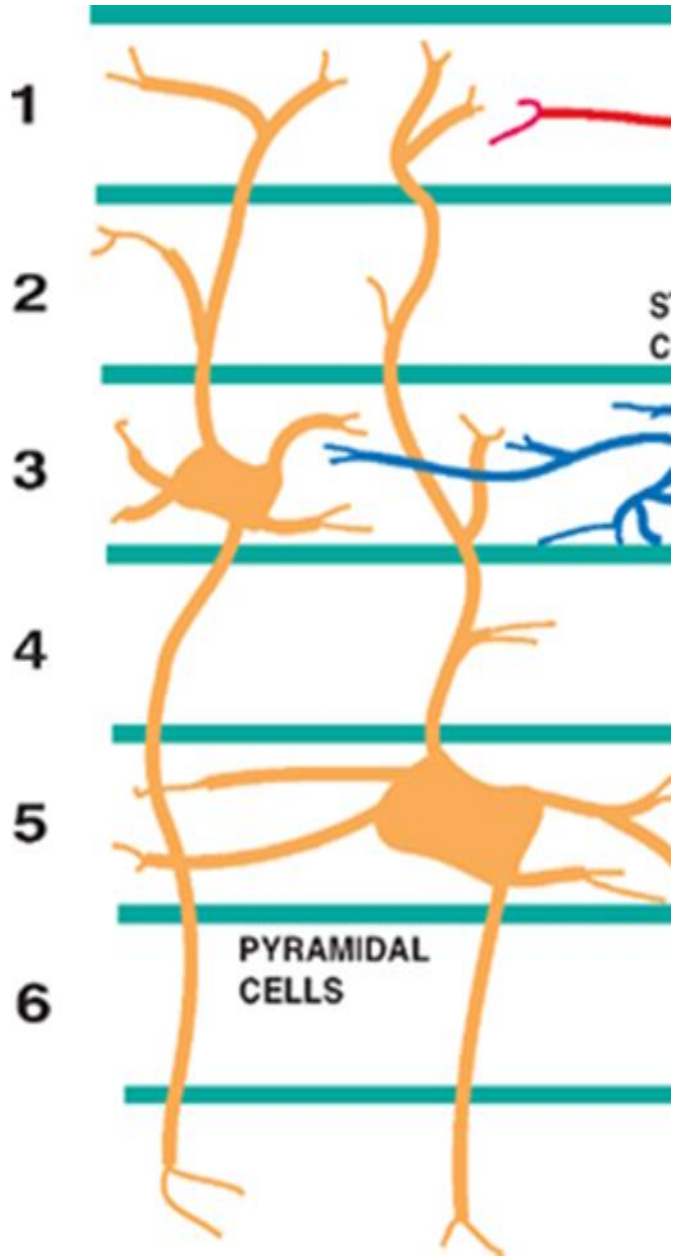
b) Stellate (granule cells) are most numerous in layer IV and layer II. They have multipolar triangular cell bodies, dark condensed nuclei and several dendrites which radiate for variable distances.

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.

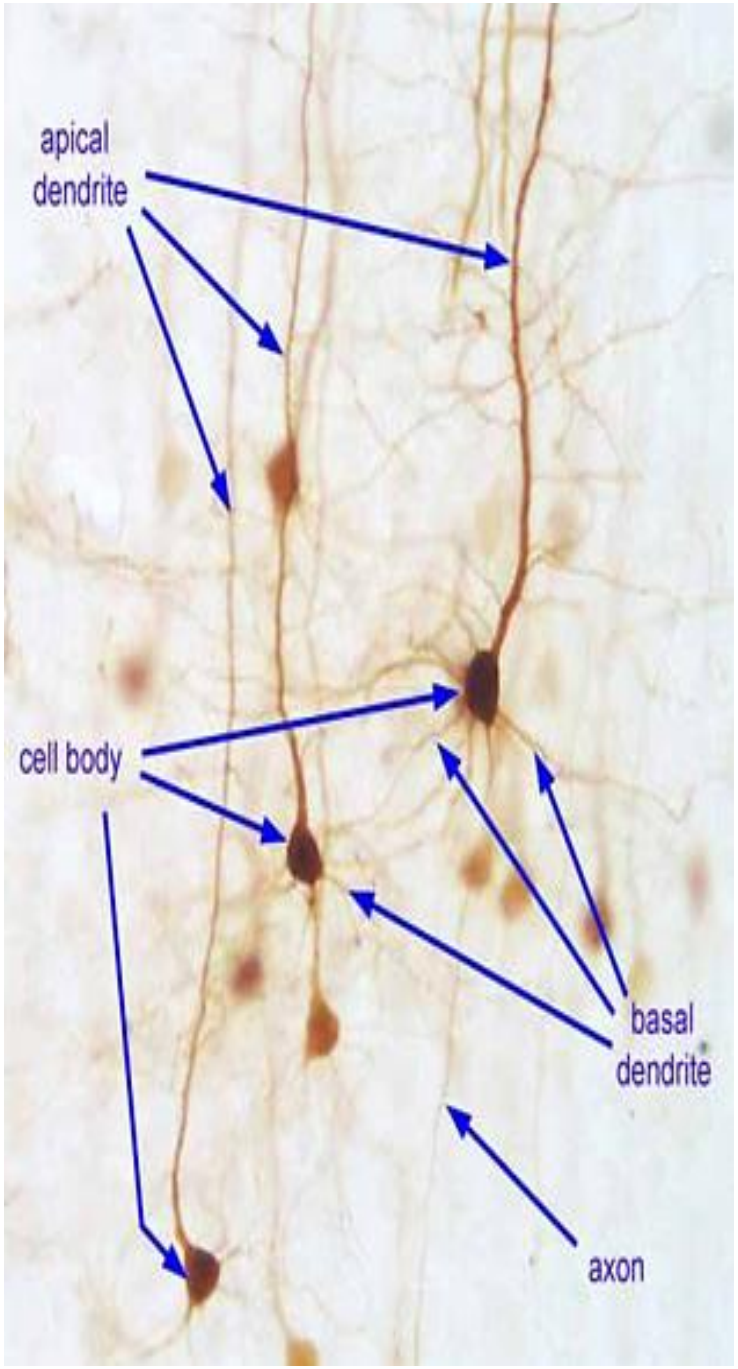
II-Projection neurons:

the processes of projection cells leave the cortex, they include:

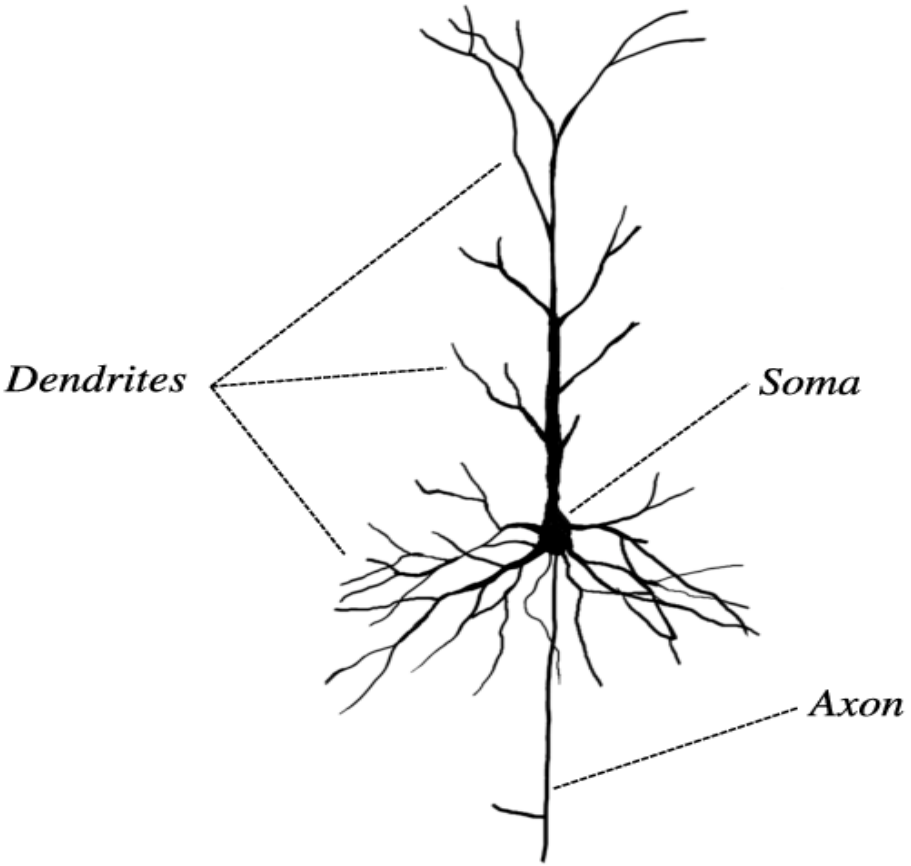
a) **The pyramidal cells** are present in all layers except layer I. Each has a flask shaped or triangular soma (10-80 µm in diameter), but the **Betz cells (giant pyramidal cell)** measure 120 µm.

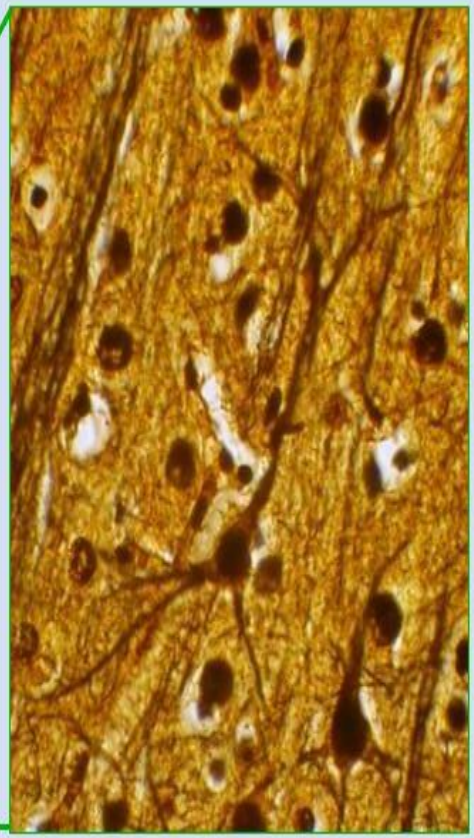


- The soma of pyramidal cells gives multiple dendrites; **thick apical** that penetrate up to molecular layer (1) and **multiple basal** that spread horizontally. They are studded with dendritic spines (numerous small projections that are special site of synaptic contact). Its axon emerges from the base of soma and penetrates deeper projecting to the white matter.

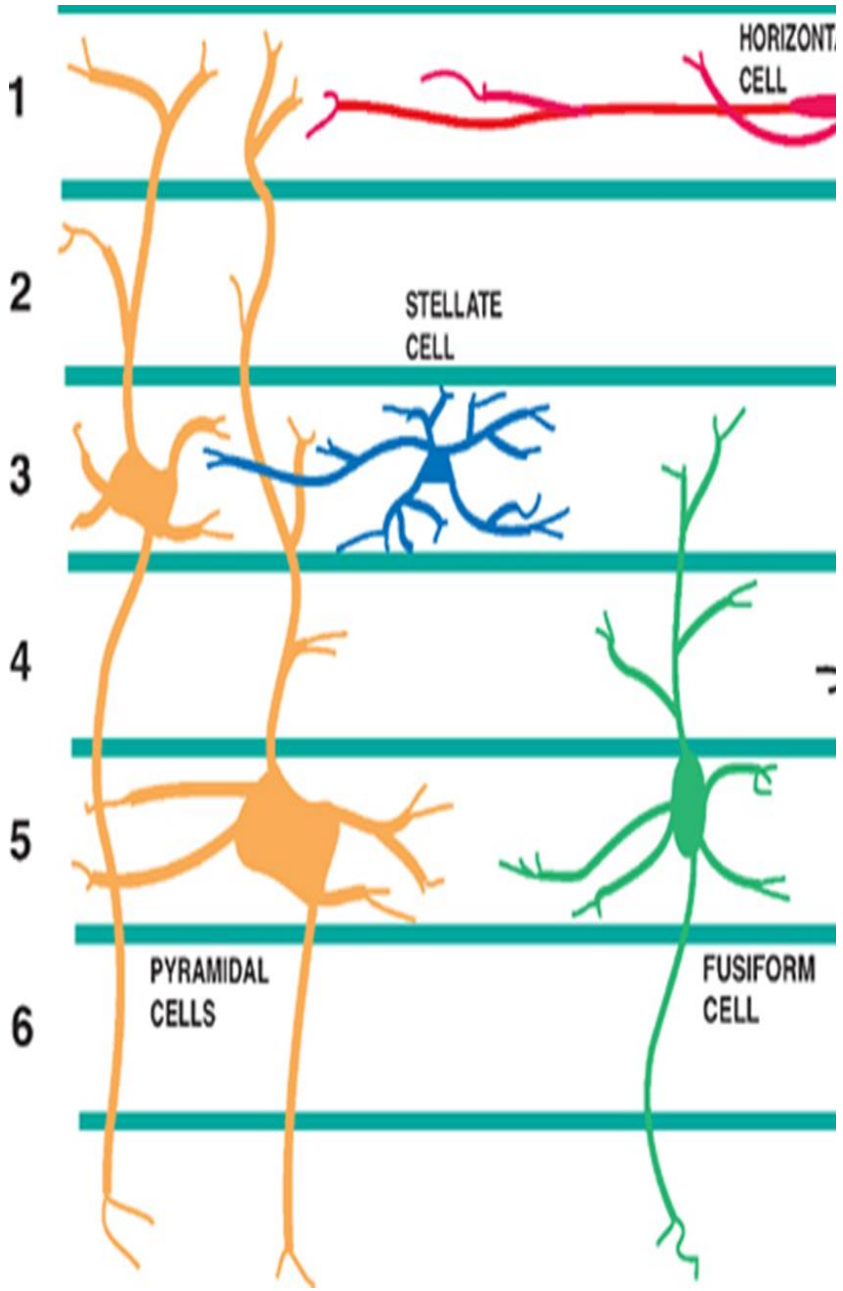


Pyramidal cell

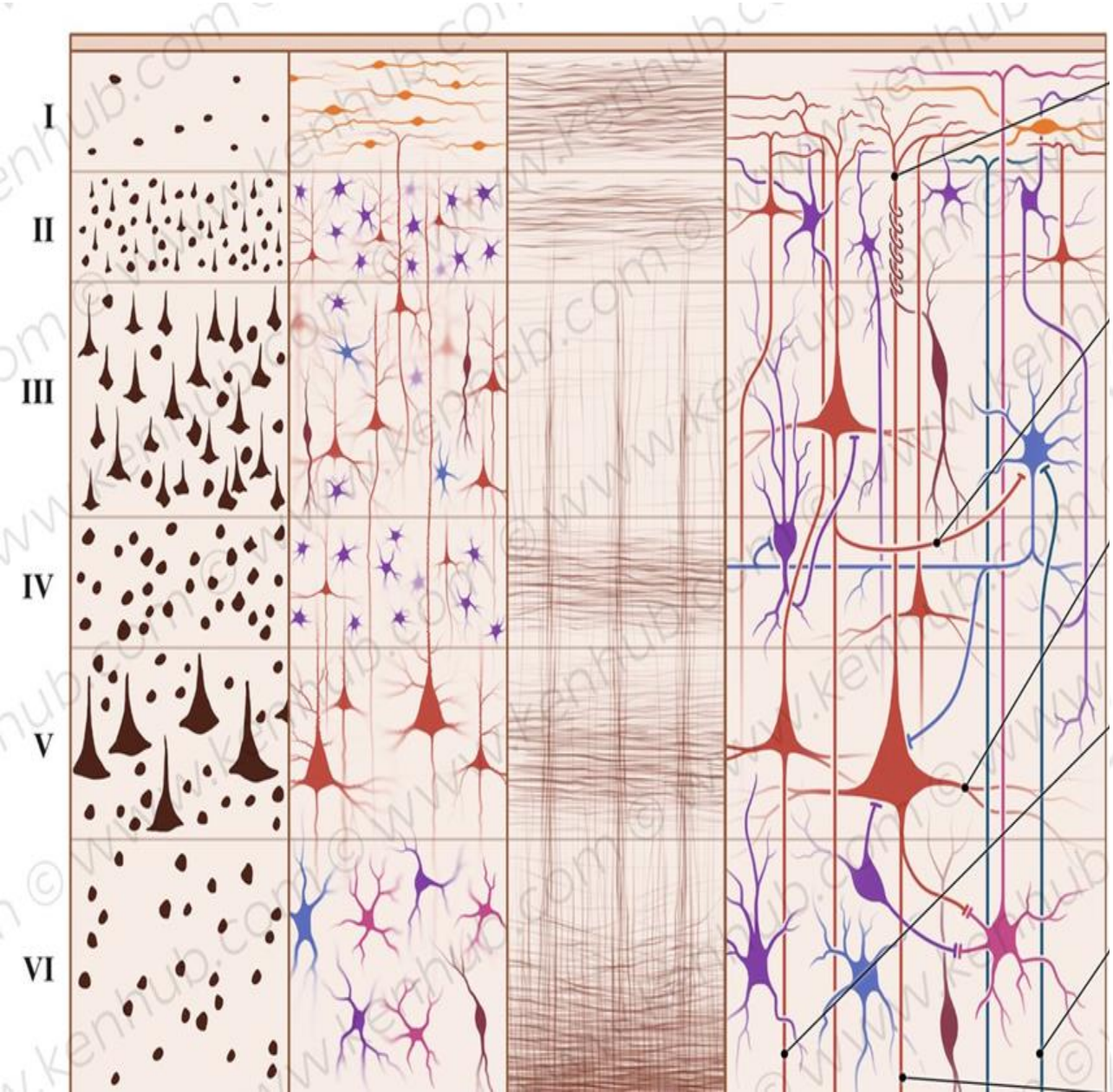




b) **The fusiform cells** are spindle shaped cells oriented at right angles to the cortex. Each has numerous dendrites branching into superficial layers and one axon arises from the lower part of the soma, projecting to the white matter.



Layers of the neocortex



I Molecular layer

II External granular layer

III External pyramidal layer

IV Internal granular layer

V Internal pyramidal layer

VI Multiform layer

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 sensory, visual and auditory cortex; so, the term granular cortex is applied to these areas. In contrast, the motor cortex contains relatively few granule 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 µm) project to superficial layers and to subcortical centers, 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

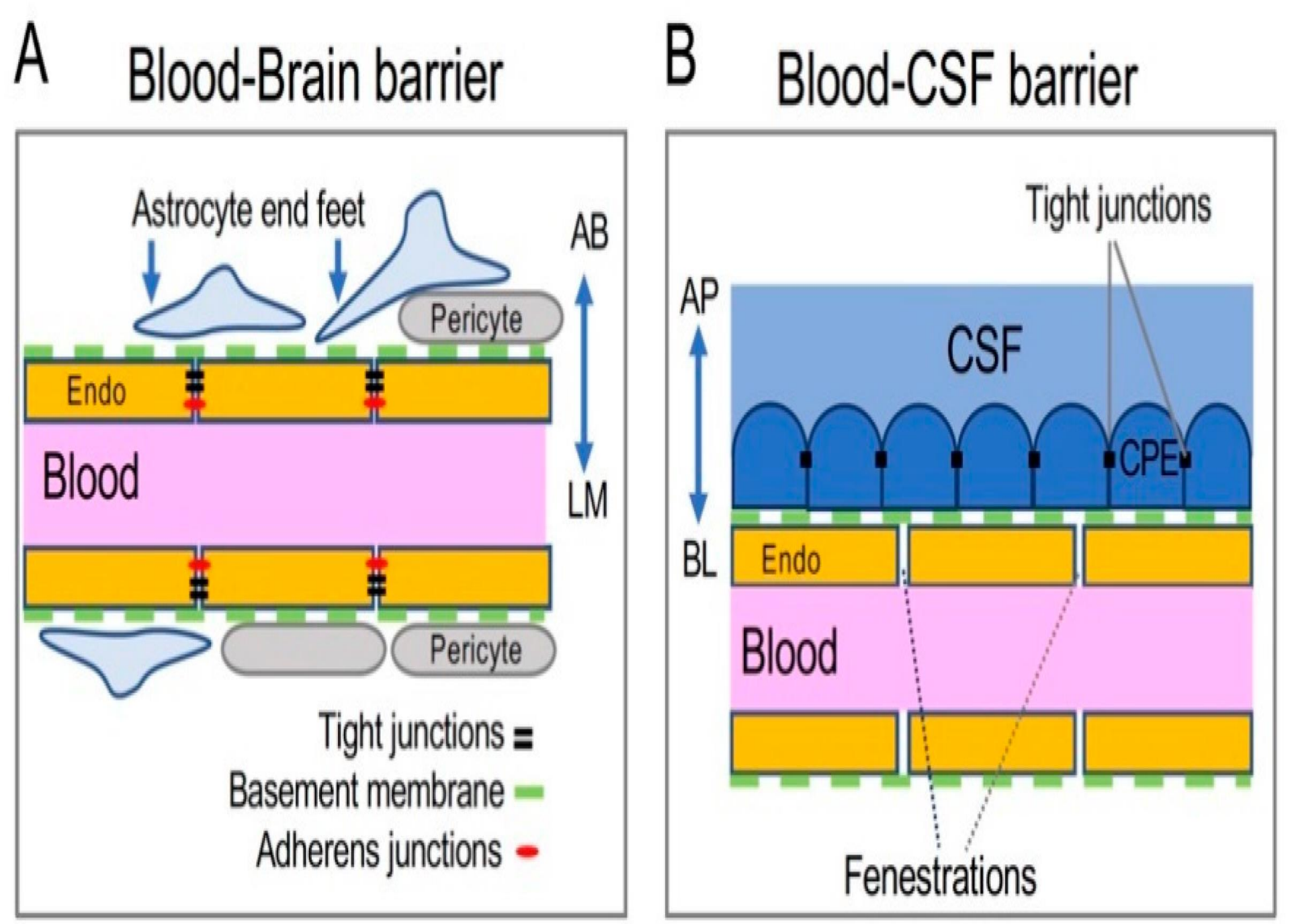
NB:

- 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 myleinated fibers from (geniculate nuclei) that form a well evident transverse white band called outer **band of Baillarger** in sensory cortex **or stripe of Gennari** which can be seen by naked eye in the primary visual cortex.

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
Astrocyte end feet
AB
Pericyte
Endo
Blood
LM
Pericyte
Tight junctions
Basement membrane
Adherens junctions
B
Blood-CSF barrier
Tight junctions
AP
CSF
CPE
BL
Endo
Blood
Fenestrations

- **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:

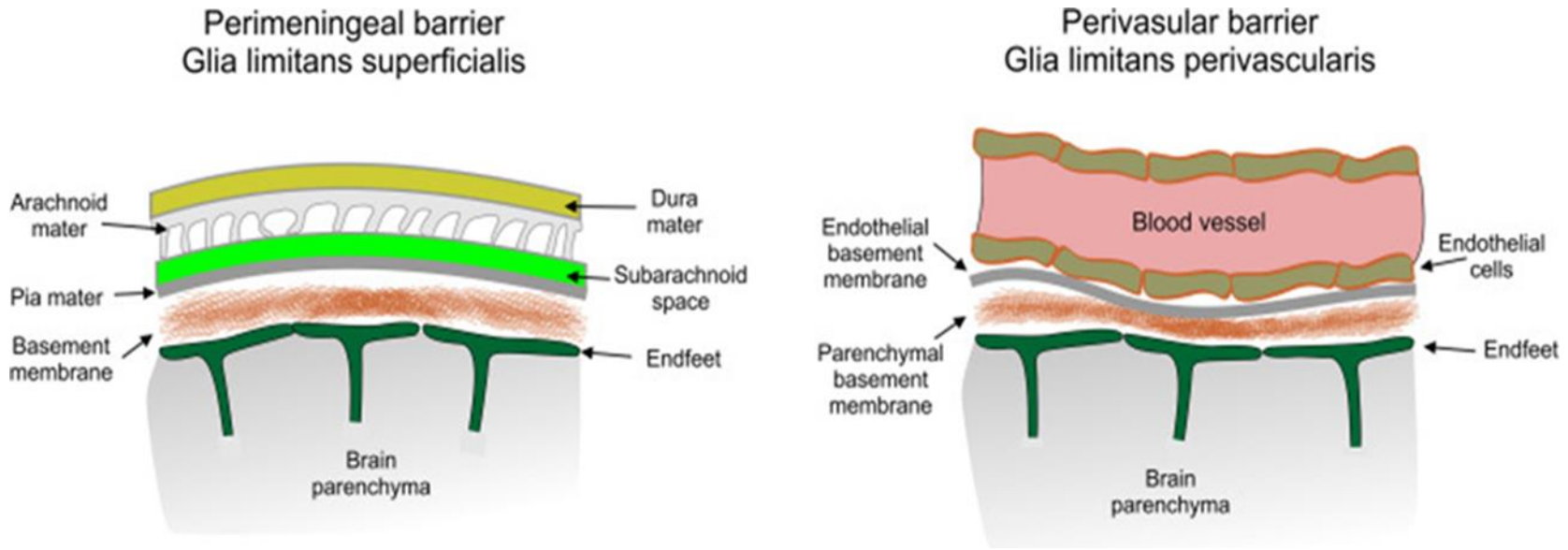
1. Continuous non-fenestrated endothelial cells of brain capillaries with tight junctions between these endothelial cells which represent the main structural component of the barrier. They are impermeable to large molecules.

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

Together, the pia mater and the layer of astrocytic end feet with its basement membrane form a physical barrier separating CNS tissue from CSF in the subarachnoid space



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.
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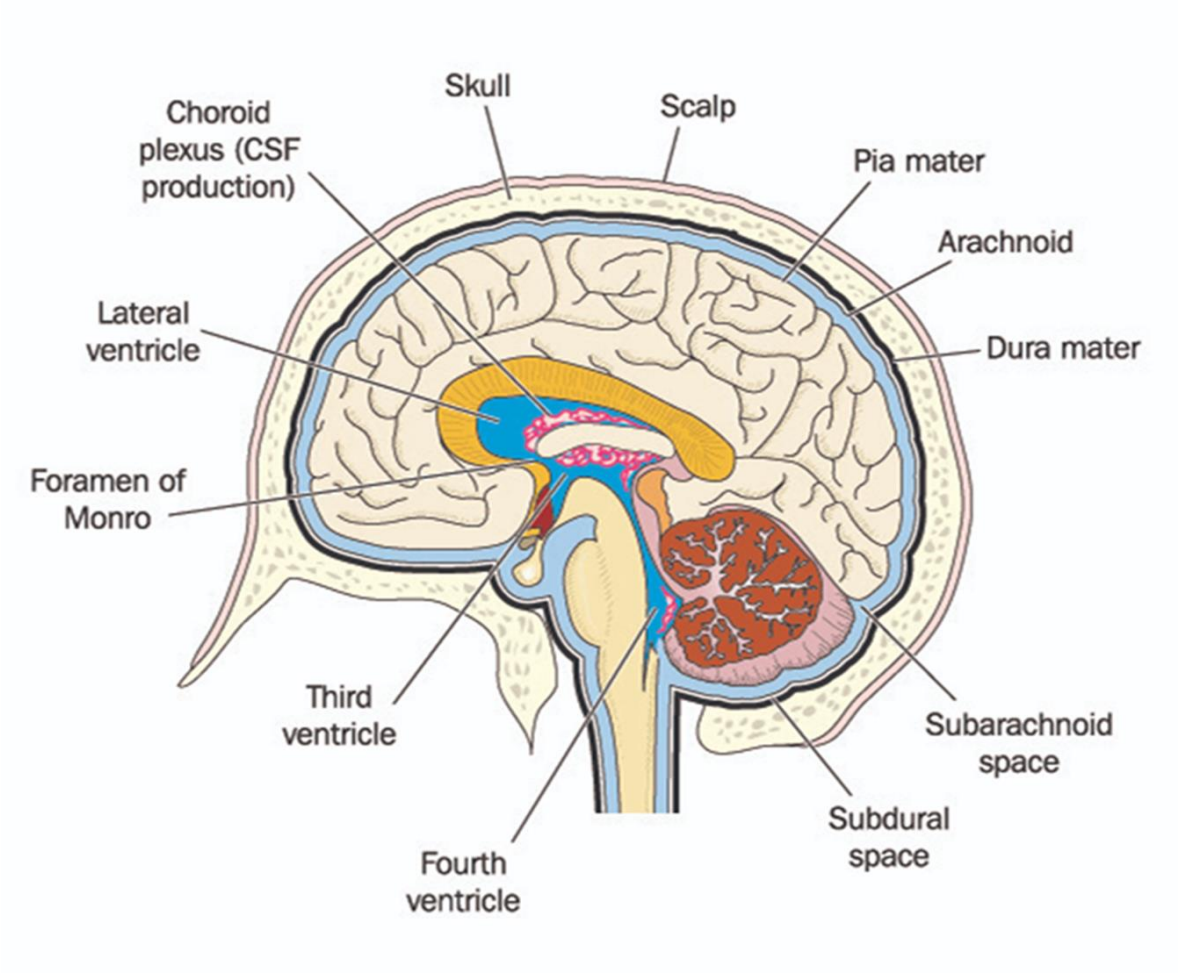
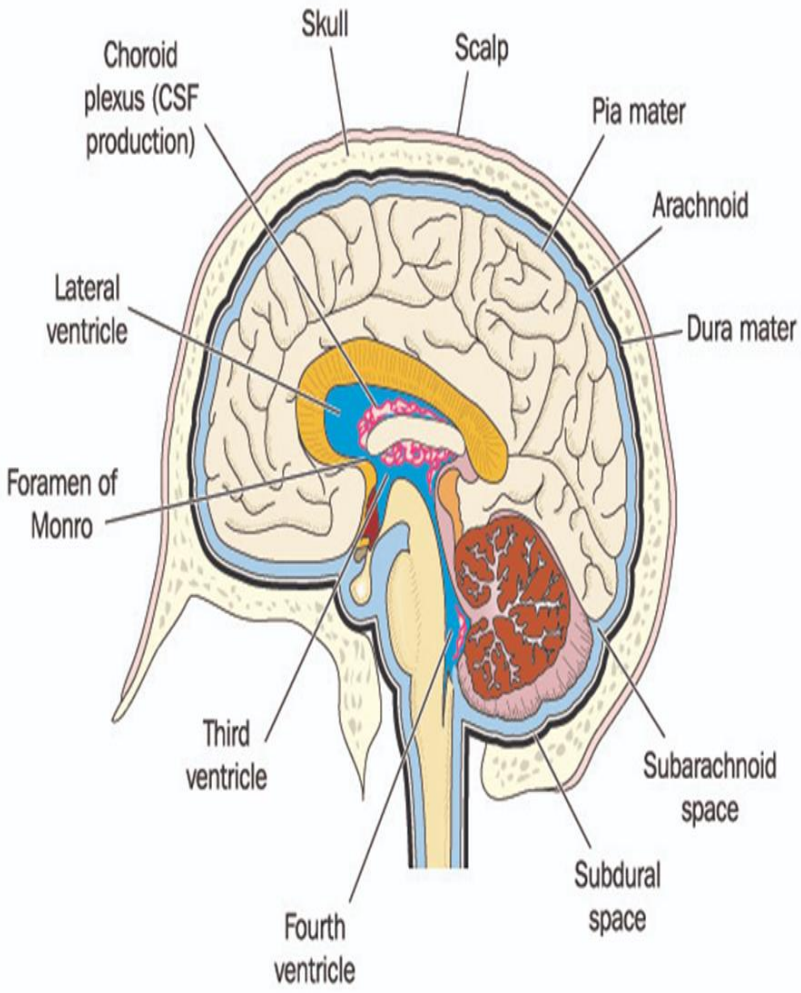


- The pia`folds that form choroid plexus housing an abundance of fenestrated capillaries and covered by the simple cuboidal or columnar (ependymal) cells extend into the 3 rd , 4 th, and lateral ventricles of the brain, forming the plexus.

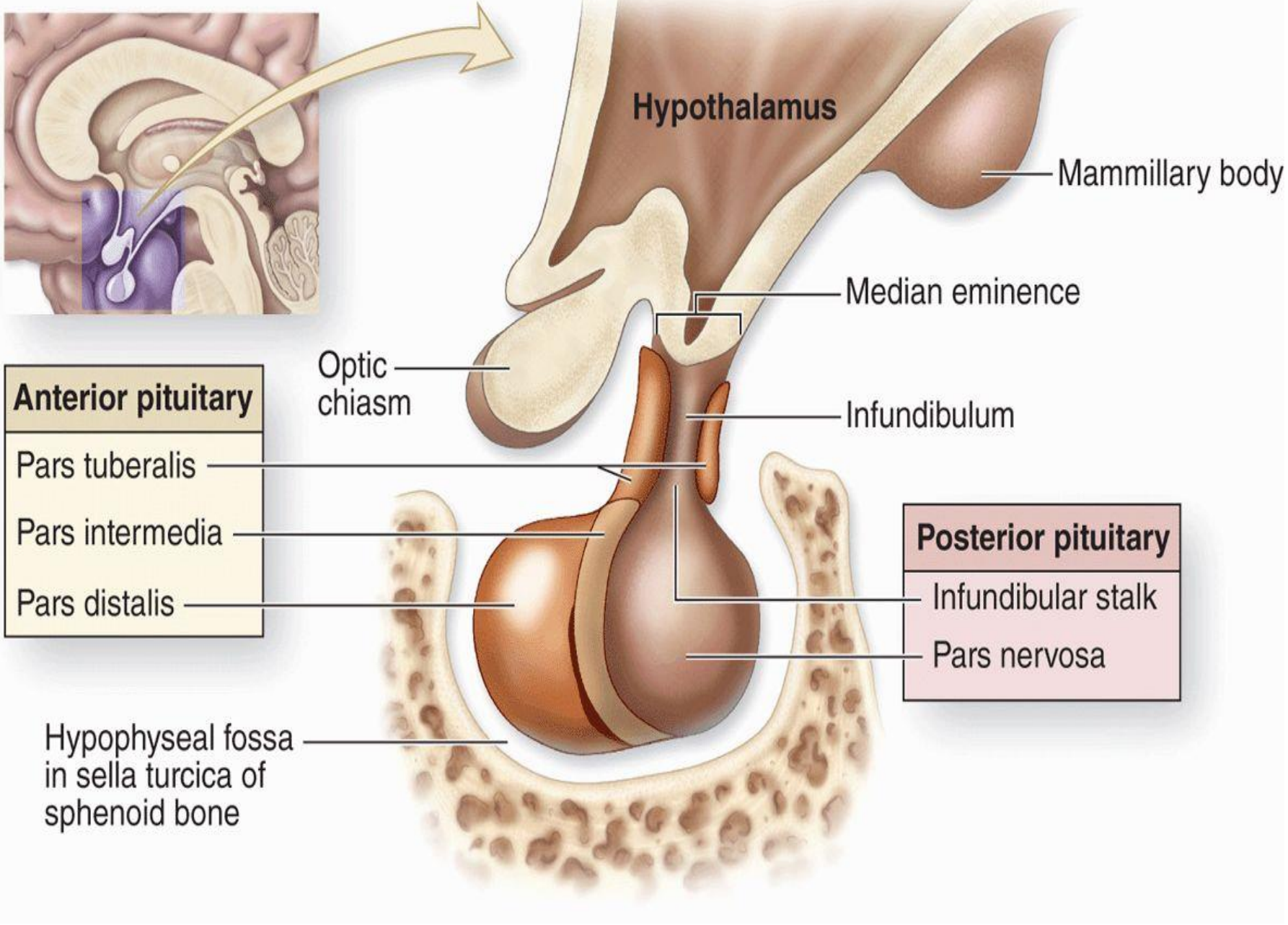


- **Subtypes of Ependyma:**

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.


Hypothalamus
Mammillary body
Median eminence
Optic chiasm
Infundibulum
Anterior pituitary
Pars tuberalis
Pars intermedia
Pars distalis
Posterior pituitary
Infundibular stalk
Pars nervosa
Hypophyseal fossa in sella turcica of sphenoid bone

THANK YOU