BAU-Medicine

Sheet no. 8
Lecture title : Histology of CNS
Lecture date :24/2/2021
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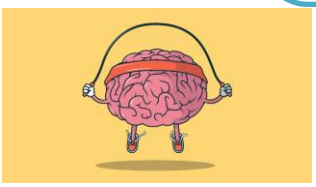
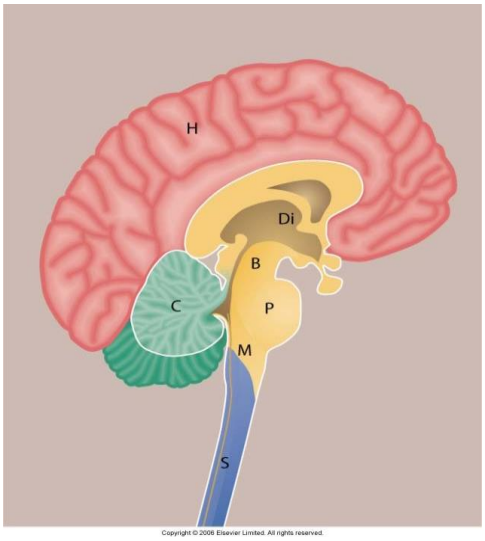
دعاء إلى فقيدنا وأخينا رشيد الهواملة :

اللهم اني اسالك له الدرجات العلى من الجنة، وادخله الجنة، وأسألك له خلاصًا من النار، ربنا لا تؤاخذنا إن نسينا أو أخطأنا، ربنا ولا تحمل علينا إصرًا كما حملته على الذين من قبلنا، سبحانك ربي واليك المصير.



The central nervous system:

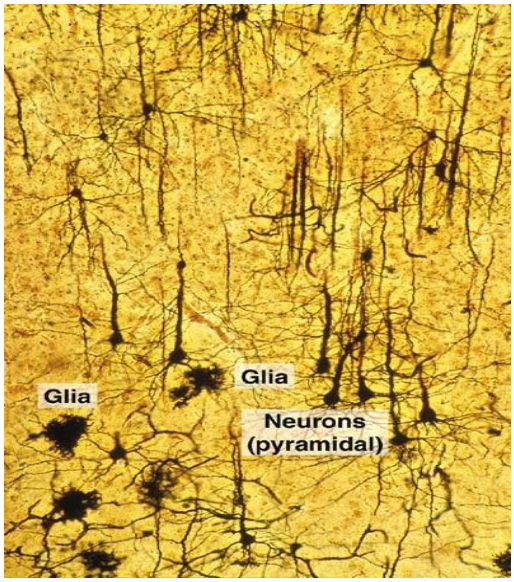
- Major parts
  - Cerebrum
    - Cerebral cortex
    - Basal ganglia
  - Diencephalon
    - Thalamus
    - Hypothalamus
    - Epithalamus
  - Brainstem
    - Medulla
    - Pons
    - Midbrain
  - Cerebellum
  - Spinal cord



Nervous system is composed of cells mainly, and almost no connective tissue, therefore it is relatively soft gel-like organ.

Cerebral Cortex

- Cerebral cortex is gray mater overlying white mater.
  – 2-4 mm thick containing billions of cells.
- Generally, it has six layers of cells with different forms and sizes (according to the function).
  But you don't see these six layers all over the cerebrum, for example in hippocampus and dentate there are three layers only.



Neuronal Cells in cerebral cortex: (Types of Neurons - Interneurons):

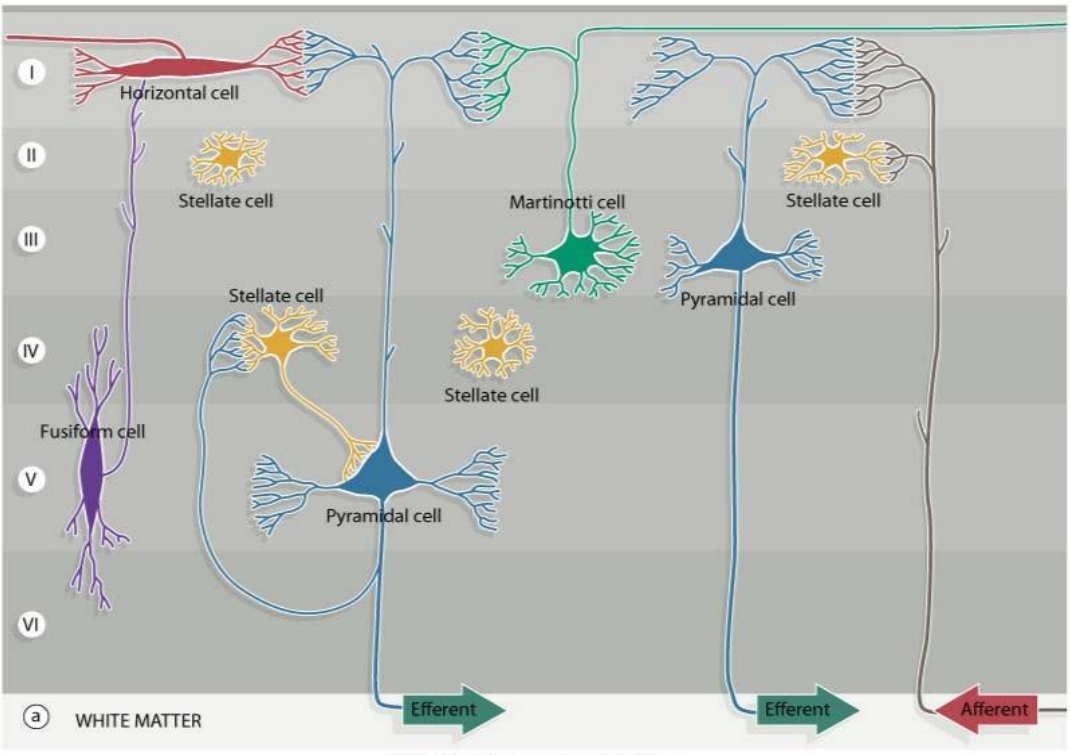
- Pyramidal cells.
  - These cells are indication for Efferent fibers of cerebral cortex.
    Efferent fibers are found in 1ry motor area, because it gives the projection fibers that give the corticospinal tract.
  - Cell body can be small, and these cells are more superficial.
    Or Large – Betz cells (motor cells), as in Corticospinal tracts, they have large pyramidal cells, may be called Ganglionic cells too. The longer the axon the larger the cell body.
- Stellate (granule) cells.
  - Small cells, Star shape with branches.
  - They connect the adjacent in the surrounding area together.
  - These cells are very important (in cerebral & cerebellar cortex) for the modulation and analysis of data (action potential).
    (you will find these cells scattered in 2 different layers in cortex because of their importance).

***** DO NOT MIX!!!!!!
These stellate cells here are Neurons have action potentials! NOT a neuroglia that covers and supports the cell body of neurons.
(Keep in your mind that Satellite neuroglial cells are found in PNS only while here stellate cells are neurons in CNS)

Remember: Action potential can stimulate or inhibit a cell, depend on the DNA of it.
Which lead to toning or modulation and analysis of data (by interneurons) that gives at the end a memory, decision, skill, order, emotion and so on.

- Cells of Martinotti.
  - Their axons reach the superficial layers and connect the cells there and may connect them for long distances.
- Fusiform cells.
  - Spindle shape.
  - Vertical orientation (since there are also some horizontal fusiform spindle cells in the superficial layers).
  - In deep layers.
- Horizontal cells of Cajal.
  - Spindle shape.
  - Horizontal orientation.
  - In superficial layers.
  - Connect pyramidal cells.

All these cells EXCEPT pyramidal cells, connect different cells together, so action potential of pyramidal cells can be modulated (inhibition or excitation regarding their own function) and analyzed in order to become a decision and leave by the efferent fibers of pyramidal cells.



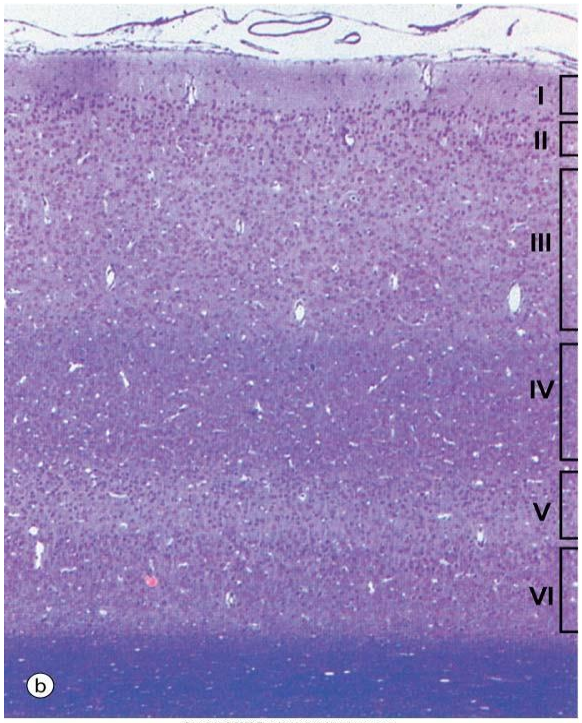
Layers of cerebral cortex:

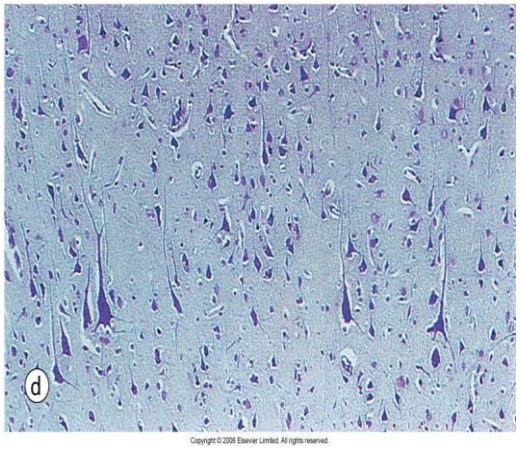
- Molecular layer (Most superficial).
  - Area of connection between different cells.
- Outer granular layer.
  - Small pyramidal & stellate cells.
- Pyramidal cell layer.
  - Medium pyramidal cells & martinotti cells.
    These pyramidal cells in this layer are responsible for the formation of commissural and association fibers.
- Inner granular layer.
  - Stellate cells.
    AGAIN: Note that stellate (granular) cells are scattered in 2 different layers because these are the cells that modulate and analyse data, so they need to be connected with all other cells.
- Ganglionic layer.
  - Large pyramidal cells.
    This layer is found mainly in motor areas.
- Multiform cell layer (Most internal).
  - Mix of different cells.
  - Only for support.

Under microscope:

You roughly can differentiate the layers.

- I – Molecular layer.
  This layer is mainly for connections between cells, so you find little number of nuclei.
- II – Outer granular layer.
  Here you can find a lot of nuclei because stellate cells are small cells, so the layer can contain too many cells.
- III – Pyramidal cell layer.
  You can find nuclei but less than the granular layer because pyramidal cells may by large cells (Betz cells), so they take more space and the layer contain less cells.
- IV – Inner granular layer.
  A lot of nuclei
- V – Ganglionic layer.
  Small number of pyramidal cells same as the third layer.
- VI – Multiform cell layer.
  Same as the first layer.

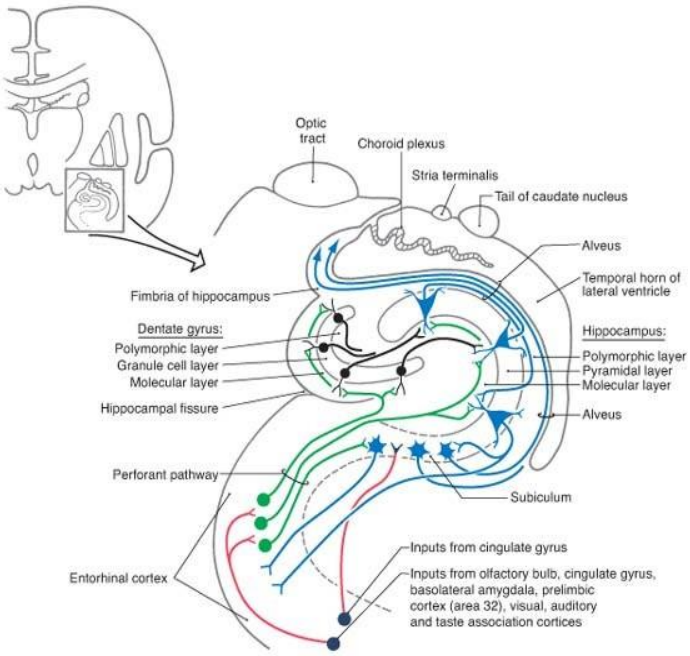


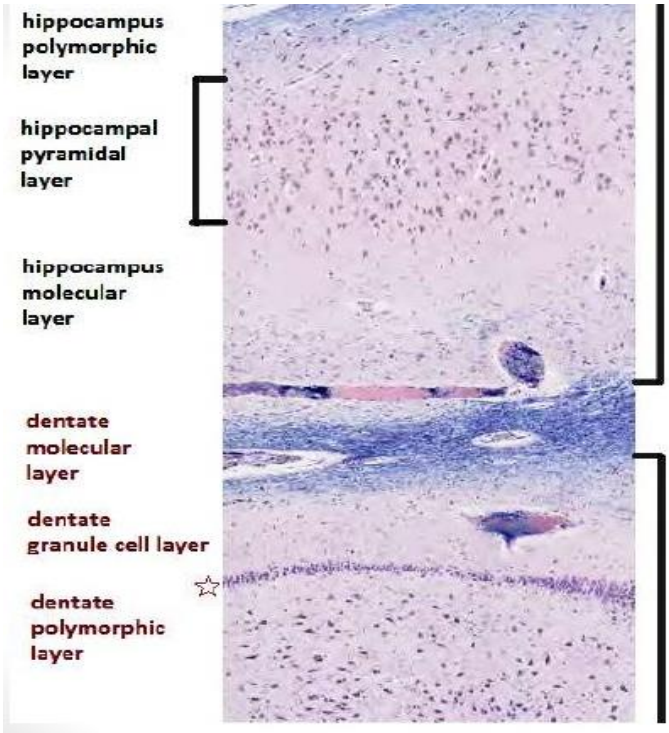


The only cells that can be differentiate is the Betz cells (large pyramidal cells)
Especially under light microscope.

Hippocampus:

- The hippocampal cortex has 3 layers.
  - Molecular layer. (DEEPEST)
    At the centre.
    Consists of interacting axons & dendrites.
  - Prominent pyramidal cell layer.
    Of large neurons gives the efferent fibers of cortex (CA3).
    The axons of pyramidal cells form the alveus then fimbria and at the end the fornix which considered the efferent fiber of hippocampus.
  - Polymorphic layer. (MOST SUPERFICIAL)
    containing axons, dendrites & interneurons.





But keep in your mind that hippocampus is continuation of subiculum which turn a full roll so the layers will be completely upside down (the most superficial (molecular) will be deep here)

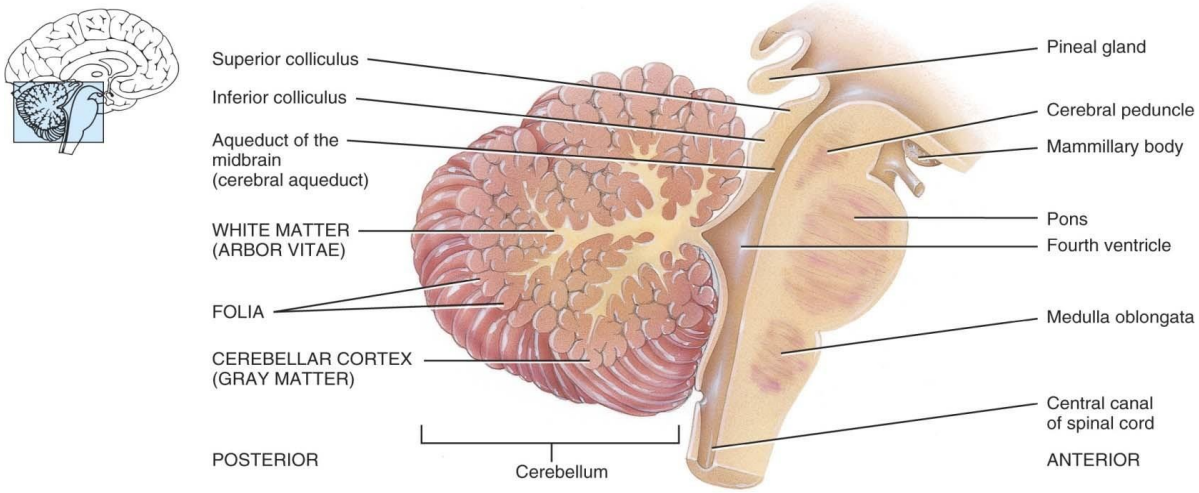
*** This is an EXTRA pic from google to show you the layers arrangement.

The dentate gyrus:

Has 3 layers like hippocampus but the pyramidal cell layer is replaced by granule cell layer (that contain stellate cells that modulate the action potential).

Remember that dentate gyrus is the first part that receive information from entorhinal cortex (that modulate information), that's why the pyramidal cell layer is replaced by granular.
Dentate gyrus does not need efferent fibers to go outside the brain, its efferent is directly to hippocampus, that's why it doesn't have pyramidal cell layer.

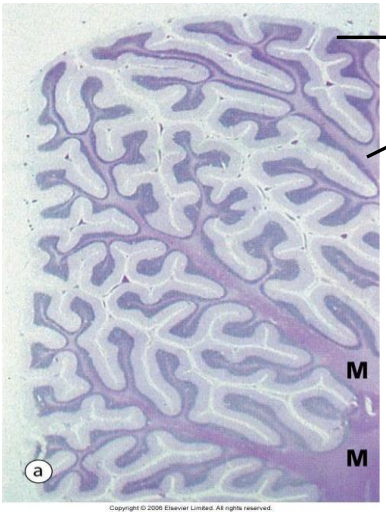
Cerebellum



(c) Midsagittal section of cerebellum and brain stem

Grossly, Similar to cerebral structure, has convulsion called folia, which contain cerebellar cortex (grey mater), and the Arbor vitae (white mater).
Inside Arbor vitae there are cerebellar central nuclei.

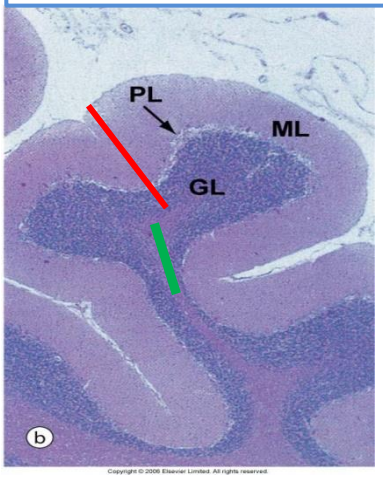
Histologically:

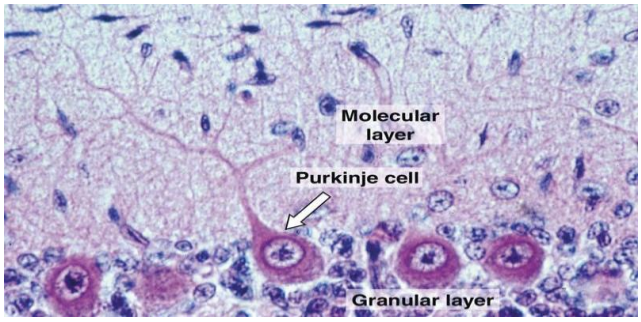


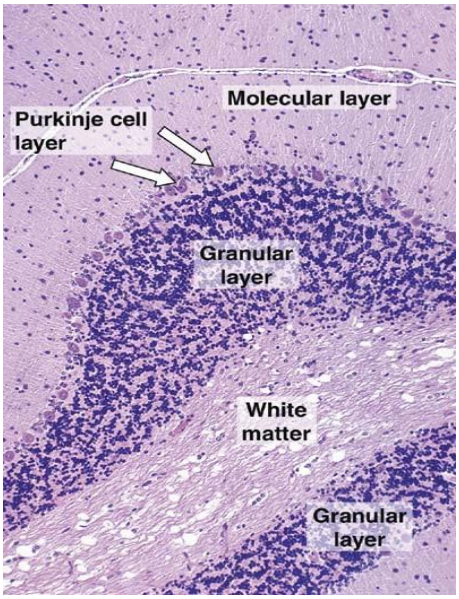
Cerebellar cortex.
White mater (medulla).

- Three layers
  - Outer molecular layer (ML)
  - Central layer of large Purkinje cells (PL)
    Thin layer
  - Inner granule layer (GL)

Red line = cerebellar cortex
Green line = white meter



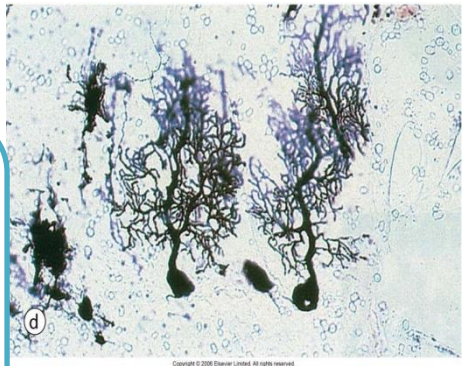




- Outer molecular layer.
  - Few neurons.
  - Mostly unmyelinated fibers.
  - Dendrites of purkinje cells.
- Central layer of large Purkinje cells.
  - One layer of large cells.
  - Efferent for cerebellar cortex which enters the white mater.
  - Resembles pyramidal cells in the cerebral cortex.
- Inner granule layer.
  - Very small neurons (smallest in the body) that is compactly disposed like stellate cells in the cerebral cortex.
  - They are responsible for modulation and analysis data in cerebellum.
  - Connect with the afferent fibers.
  - Connect with the dendrites of purkinje cells (in molecular layer) to modulate the afferent action potential that then leave from the axon of purkinje cells forming efferent fibers either (mainly) to the central cerebellar nuclei or to the outside.

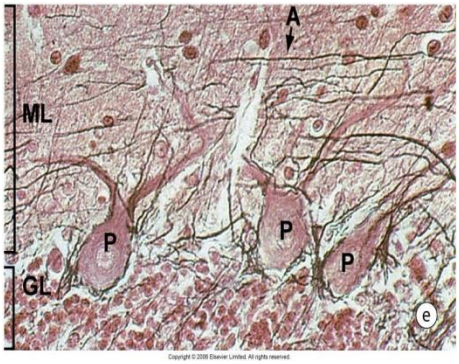
Purkinje cells:

Purkinje cells resemble the pyramidal cells of cerebral cortex, as they are the efferent part of cerebellar cortex.



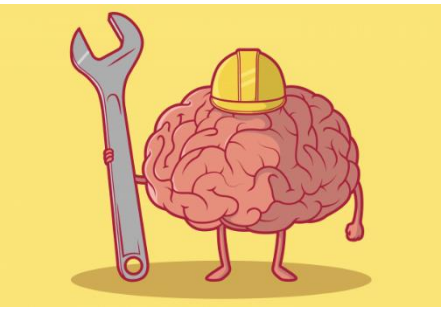
Axon of purkinjie cells are efferent fibers of cerebellar CORTEX, NOT cerebellum itself.
DO NOT MIX!
The efferent fiber of the cerebellum is formed by the axons of neurons in the central nuclei.

- Purkinje cells has highly developed dendrites.
  - Dendrites occupy most of the molecular layer.
  - Axons (Efferent) traverse the granular layer to the central nuclei of the cerebellum (White matter) mainly.



NOW THE NEXT 4 PAGES ABOUT SPINAL CORD EITHER HAS BEEN DISCUSED IN PREVIOUS LECTURES OR WILL BE DISCUSED IN DETAILS IN THE LAB,
BUT DO NOT SKIP!

Spinal cord



- Anterior median fissure.
- Posterior median sulcus.
- Gray and white commissures.
- Central canal.
- Anterior, posterior & lateral gray horns.
  - Anterior horns contain motor neurons.
  - Posterior horns receive sensory fibers from neurons in the spinal ganglia.
- Anterior, posterior & lateral white columns.

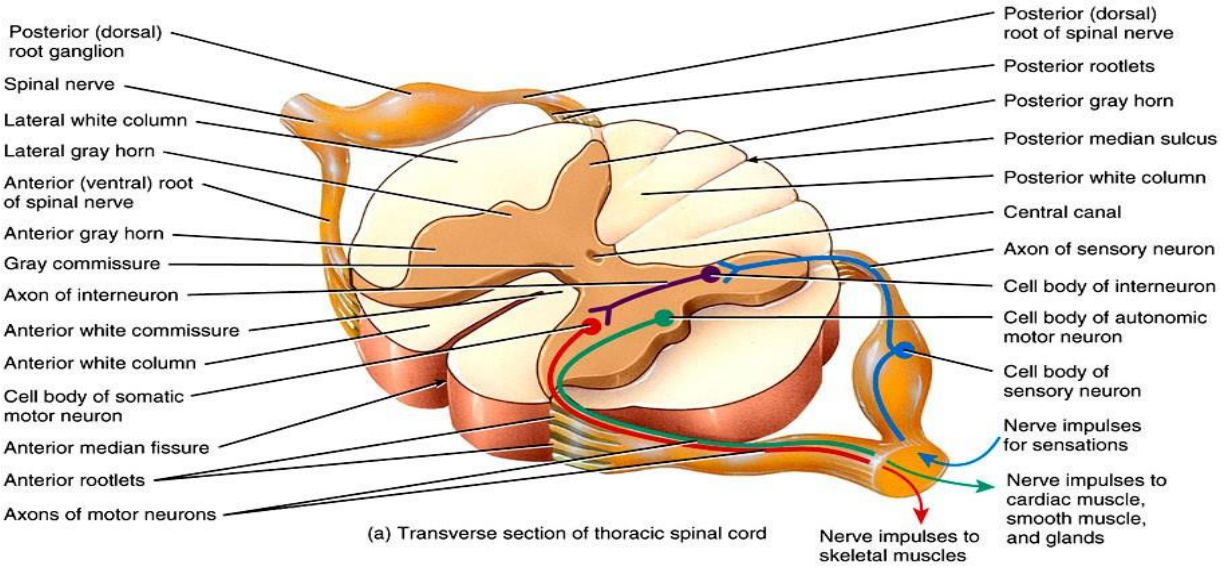
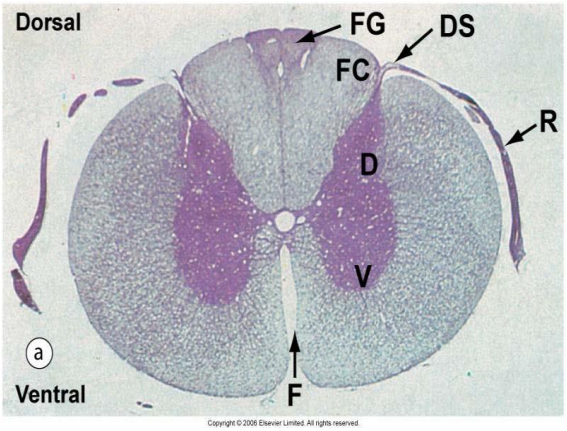
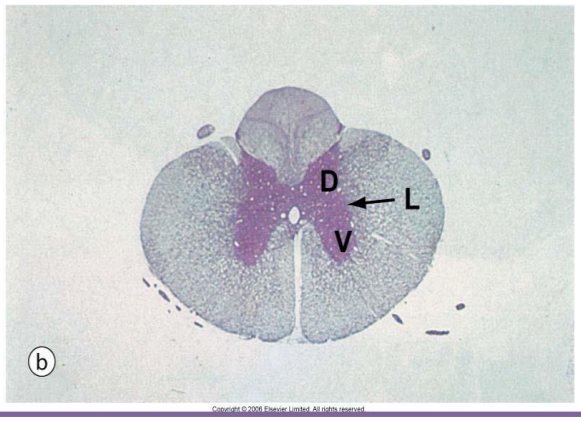


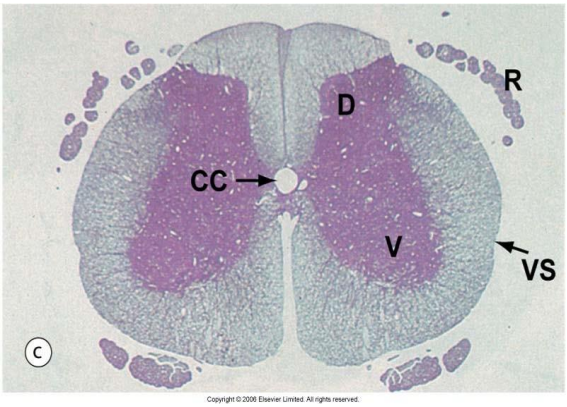
Figure 13.03 Tortora - PAP 12/e

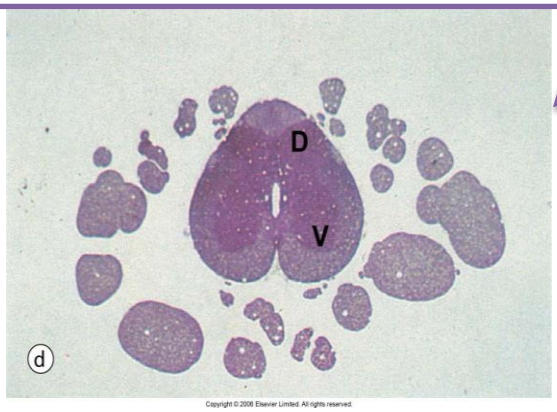
Section for the lab:



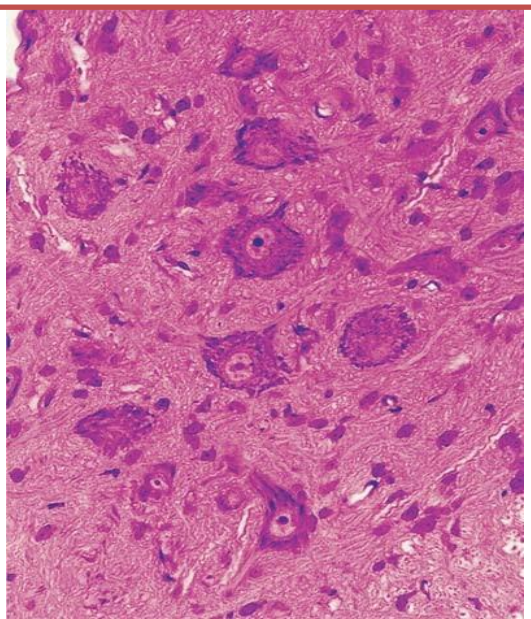


Roughly you can tell that the section below is from lower part of spinal cord because of the small amount of white matter and you can see that cauda equine starts to appear.

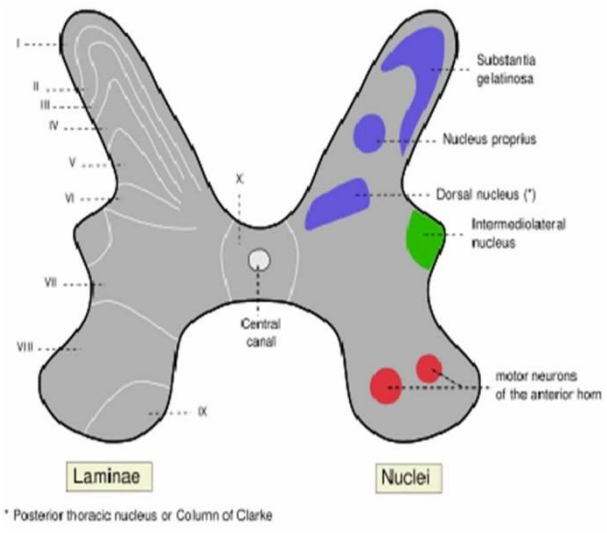




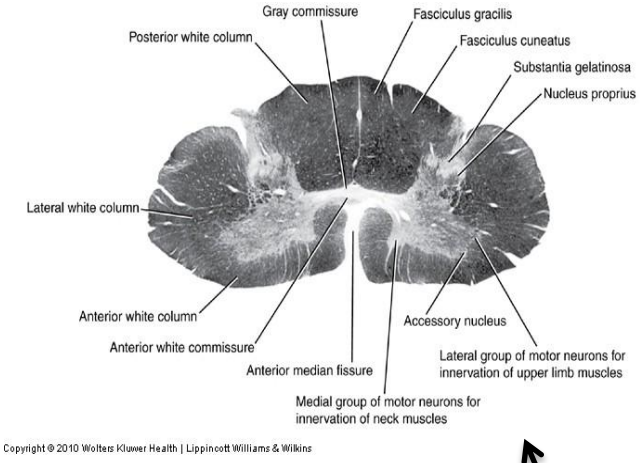
The section below is a gray mater of spinal cord from ventral horn and you can see lower motor neurons (Multipolar neurons)

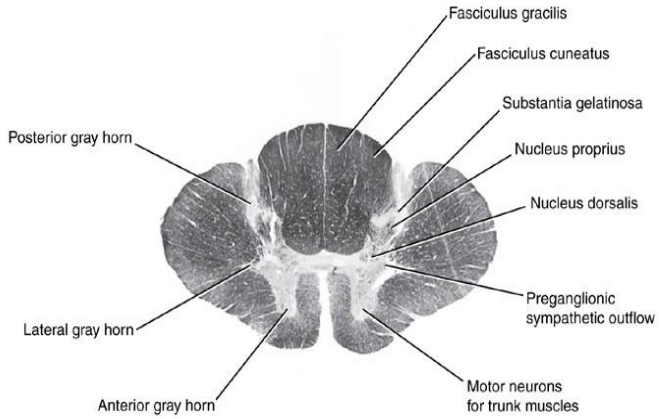


- Gray mater
  - Substantia gelatinosa (entire SC)
  - Nucleus proprius (entire SC)
  - Nucleus dorsalis (C8-L2)
  - Intermediolateral cell column (T1-L2, S2-S4)
  - Medial motor nucleus (entire SC)
  - Lateral motor nucleus (enlargements)
- White mater
  - Fasciculus gracilis (entire SC)
  - Fasciculus cuneatus (C1-T6)

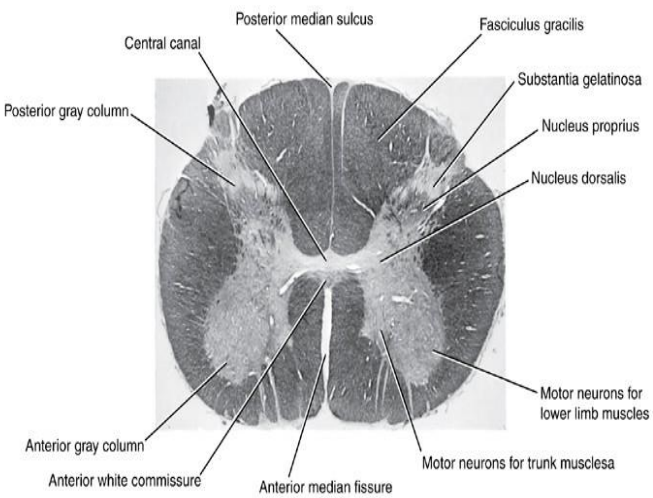


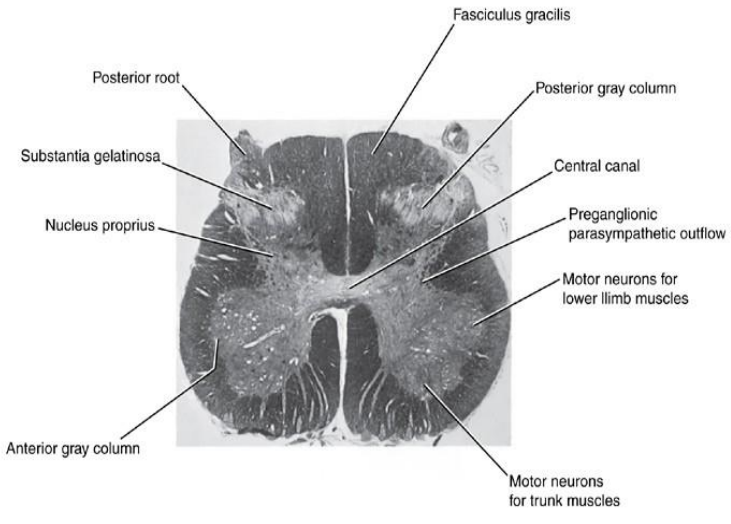
Lab sections:

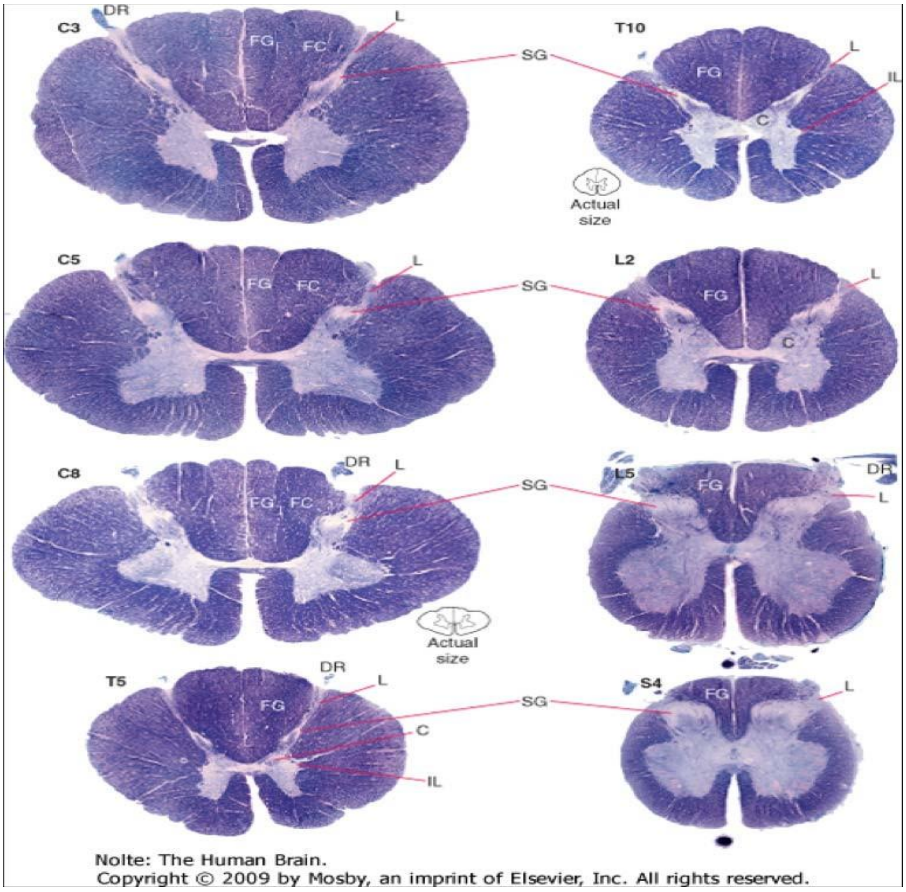


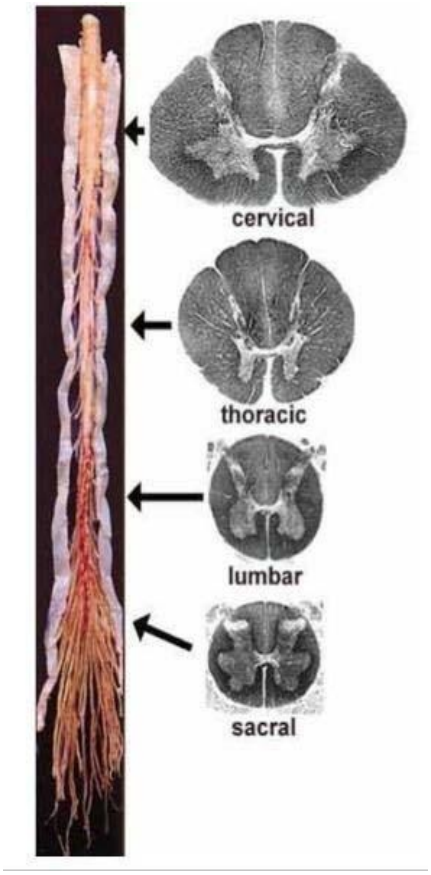


You can tell that the section above is from cervical enlargement region Because the white mater is huge and the ventral horns are huge too, the lateral side is mainly for upper limb nerves and brachial plexus.

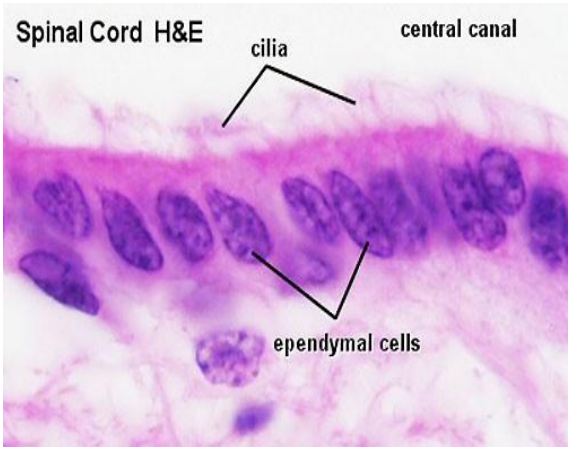


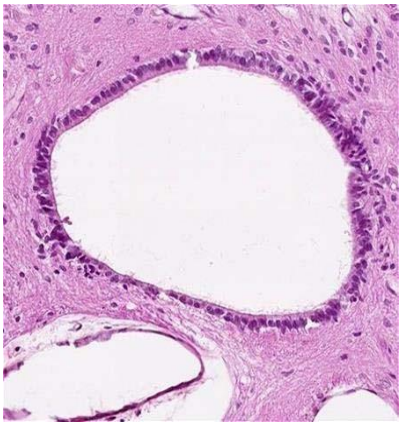






Central canal of spinal cord:



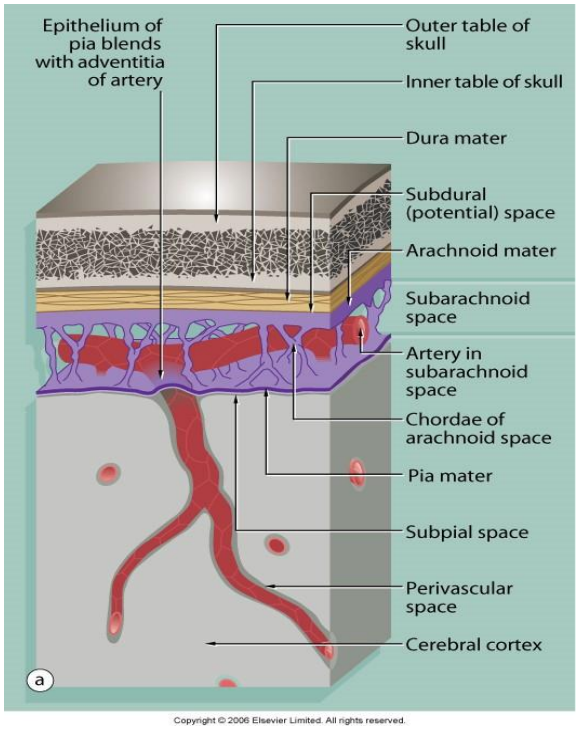


- All ventricles and spinal canal are lined by ependymal cells.
- Ependymal cells are neuroglia (glia matter).
    - Cuboidal to low columnar cells, have cilia.
    - Here in central canal ependymal cells do not produce CSF because there is no choroid plexus.

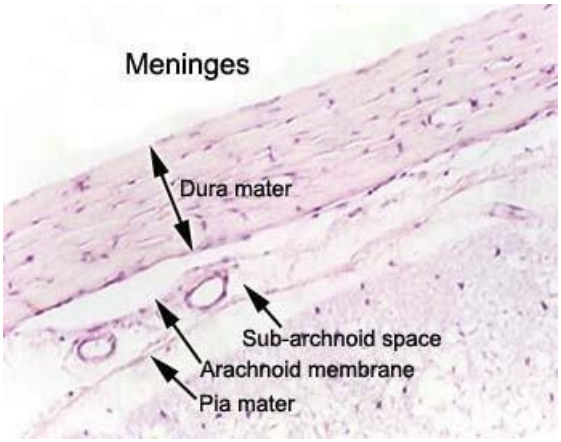
Meninges

Meninges:

- Dura mater
  - Dense fibroelastic tissue.
  - Lined with a layer of flat cells (squamous cells).
- Arachnoid mater
  - Fibrous layer.
  - Lined and covered by flat cells (squamous cells).
  - Fibrous strands connect it to pia mater.
- Pia mater
  - Loose Delicate layer.
  - Directly attached to the brain.
  - Covered by mesothelial layer (squamous cells).

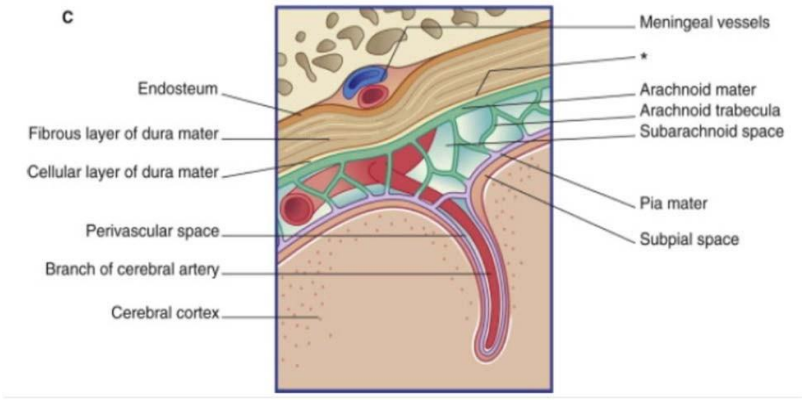


Arachnoid and pia matter are connected together physically because of they develop from the same origin, although subarachnoid space develops between them.



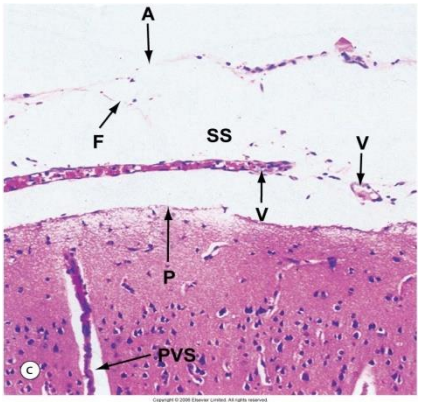
Spaces:

- Subdural space (Potential space).
- Subarachnoid space
  Contains blood vessels.



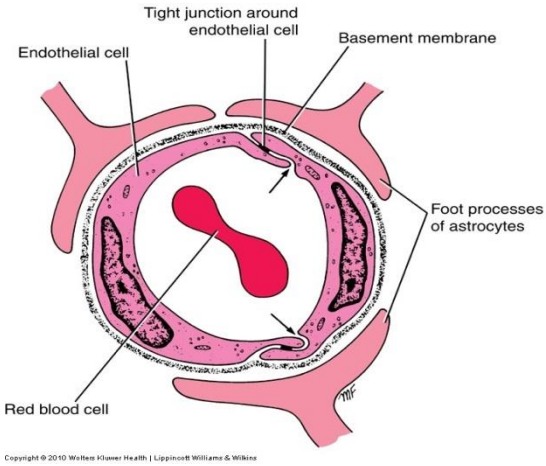
- Arteries are not directly connected to brain (nervous) tissue they penetrate the brain tissue and takes with it:
  - Arachnoid mesothelium.
  - Pia mater.
  - Perivascular space (continuous with subarachnoid space).

    » Arteries enter the brain tissue with all of the 3 above, but arachnoid mater and perivascular space disappear at the end while pia mater continues with the arteries forming a tunnel like structure in the brain proper preventing the artery from connecting with the brain tissue.

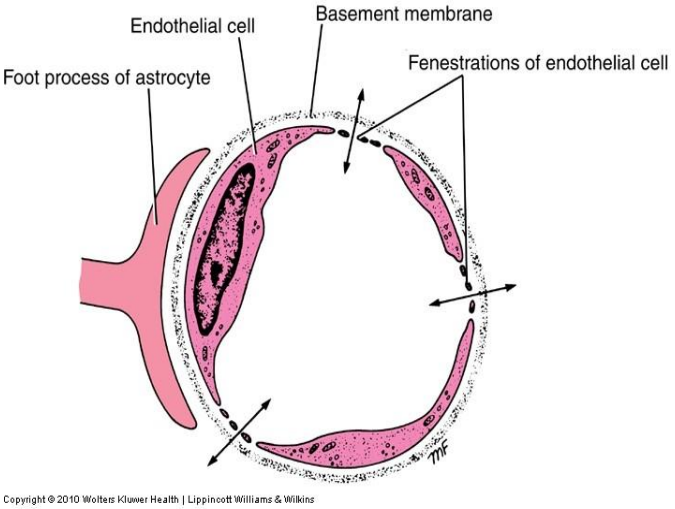


Blood Brain Barrier

- protects cells from some toxins and pathogens.
  - proteins & antibiotics cannot pass but alcohol & anaesthetics do.
- Structure
  - tight junctions seal together epithelial cells.
  - continuous basement membrane.
  - astrocyte processes covering capillaries.

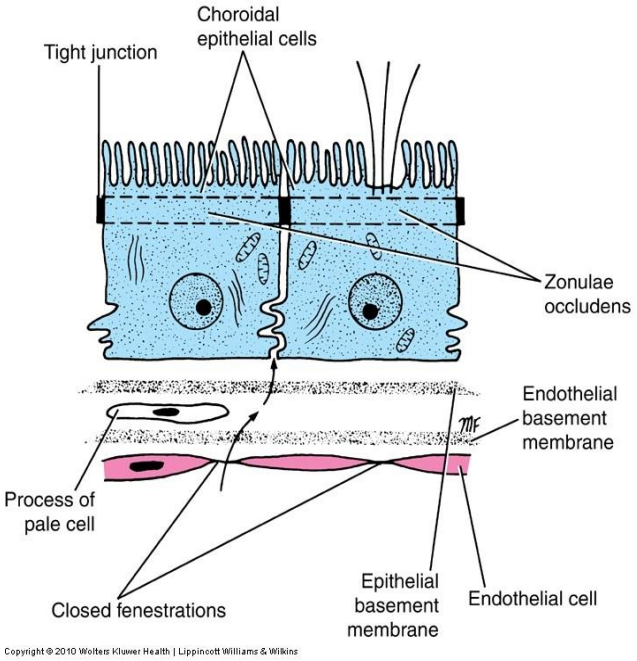


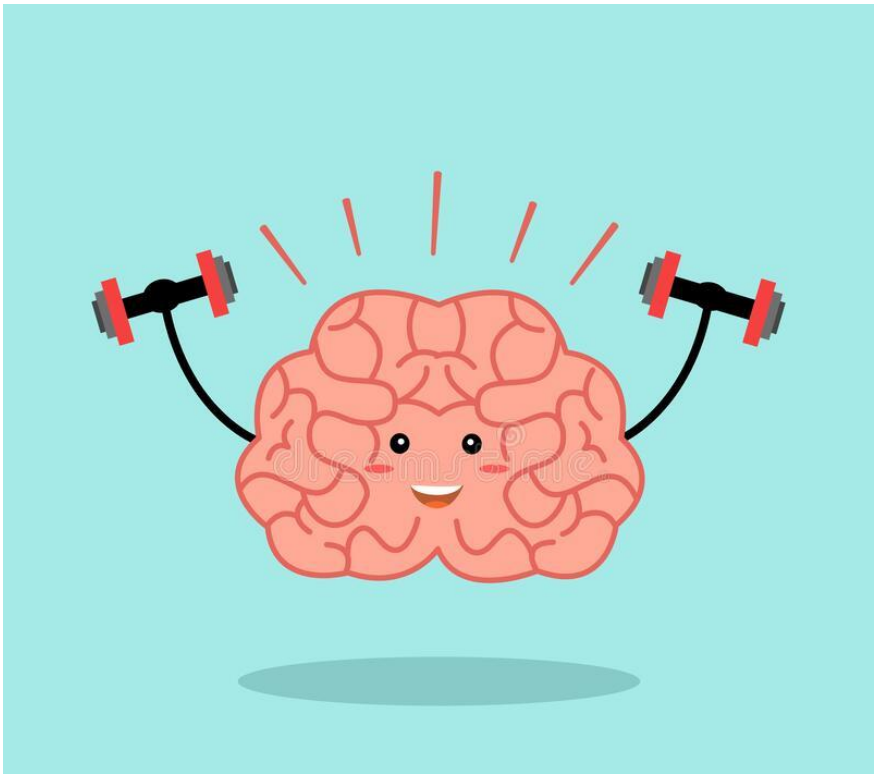
- Areas without BBB
  - Area postrema in the floor of the fourth ventricle.
  - Areas in the hypothalamus.
- Structure
  - Endothelial fenestrations.



Blood Cerebrospinal Fluid Barrier :

- Structure
  - Endothelial cells.
  - BM of endothelial cells.
  - Pale cells.
  - BM of choroidal epithelial cells.
  - Tight junctions seal the choroidal epithelial cells.





THANK YOU