CNS
Cerebellum

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CEREBELLUM (little brain)

- The cerebellum consists of two hemispheres joined by narrow median vermis. It is made up of:

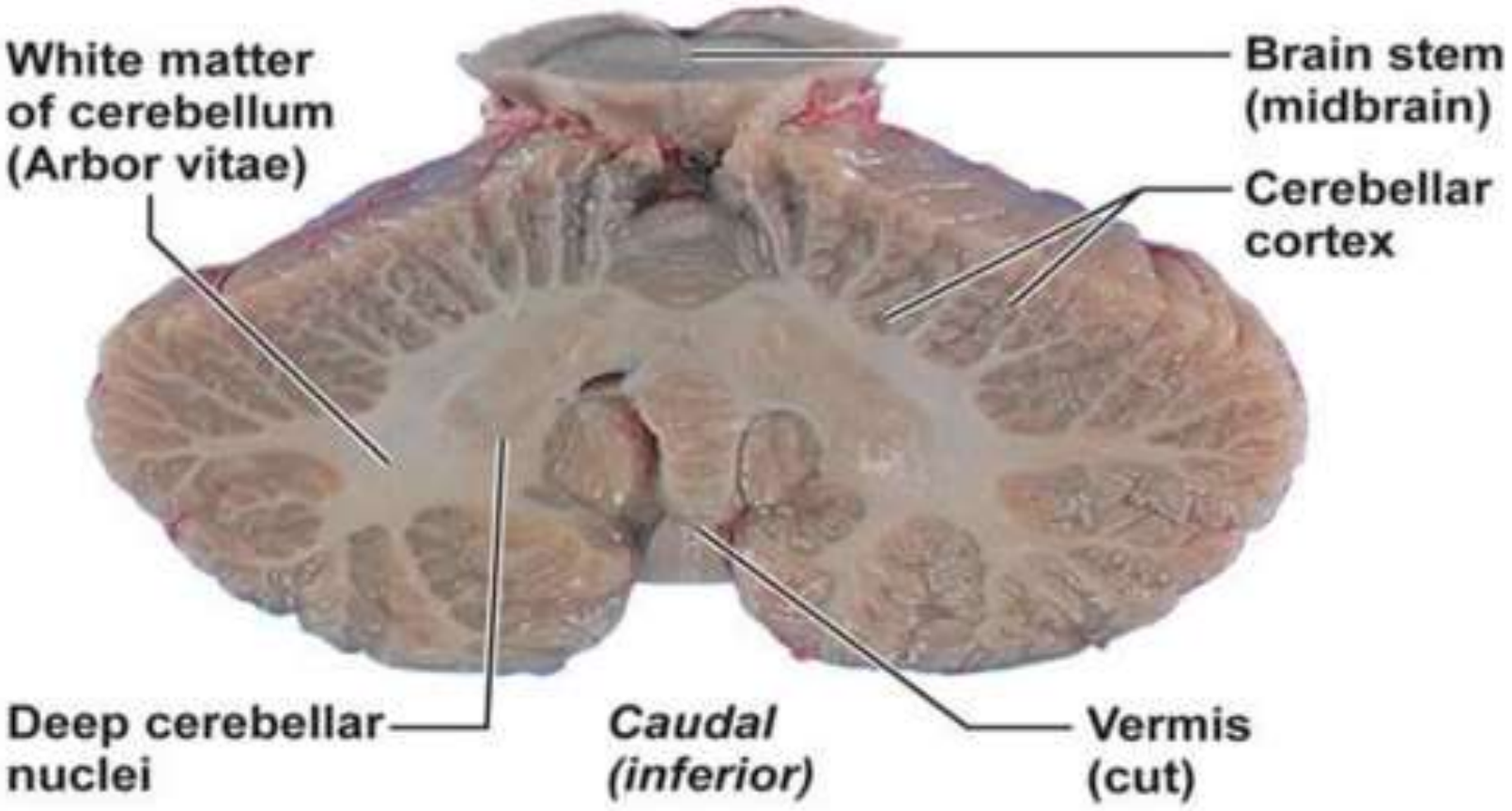
1.Outer gray matter (cerebellar cortex).

2.Inner white matter which contains small aggregation of gray matter (intracerebellar nuclei).

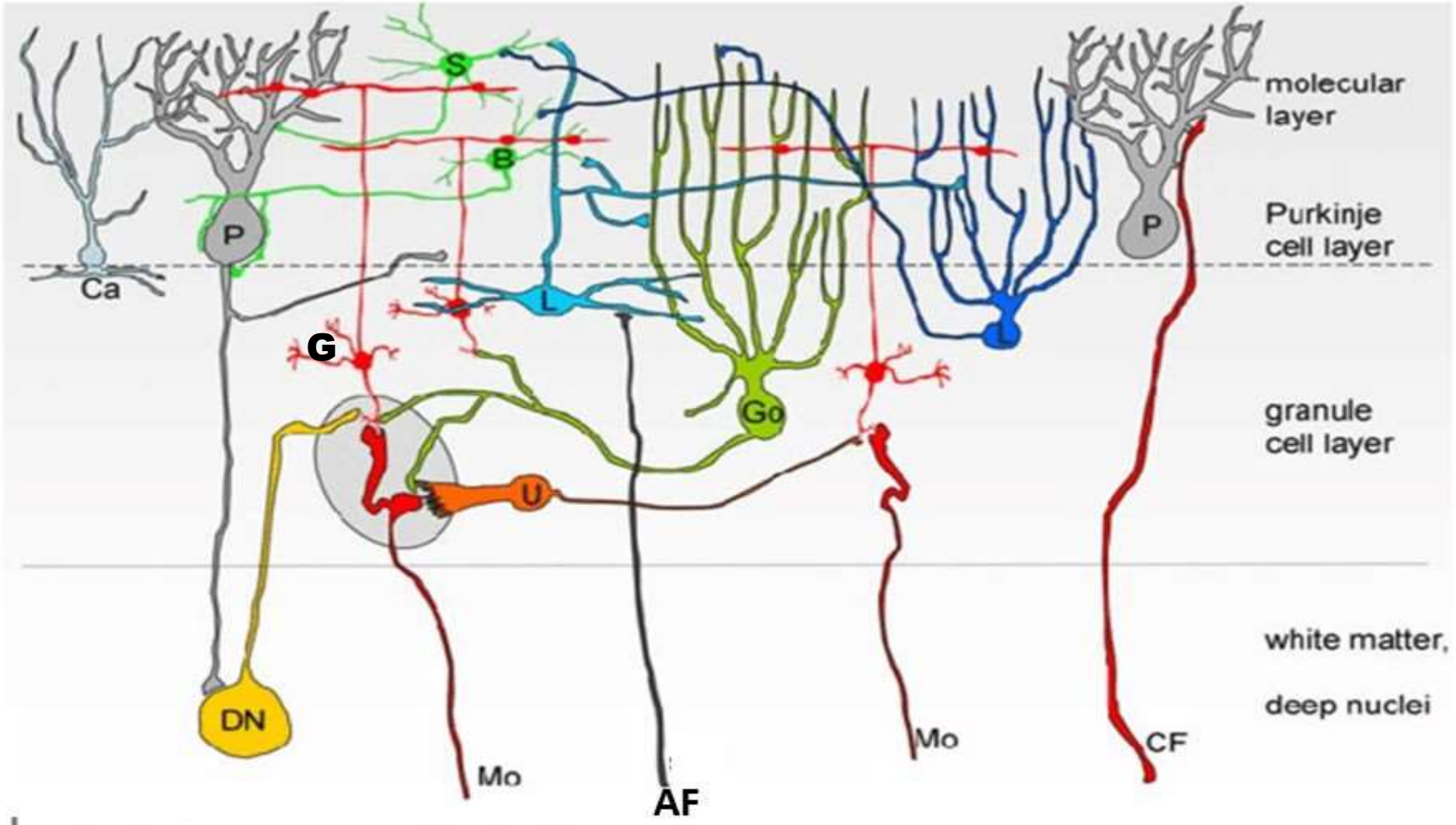
- The cerebellum contains more than half of neurons in brain. The thickness of cerebellar cortex is the same everywhere 0.6 mm.
- Weight of cerebellum 150 gm (10% of cerebrum)

- Surface area of cerebellum is 40% of cerebrum (about 800 cm)

The Cerebellum – White and Gray Matter



(d) Coronal section, posterior view



Projecting neurons: P= Purkinje cell

Interneurons: S= stellate, B= basket, Ca= candelabrum, L= Lugaro cells, U= unipolar brush cells, G= granule cells, Go= Golgi type II

Fibers: CF=Climbing fibers, Mo=mossy fibers, AF= Afferent fibers

Cells present in cerebellar cortex

I- Interneurons: They are present only intracortically (their processes don`t leave the cortex). They include

1) Stellate cells (12 million): They are inhibitory interneurons present in the molecular layer. They have star-like shape soma and many radiating dendritic processes.

2) Basket cells (7 million): They are present in the molecular layer and have inhibitory function. They have multipolar cell body, free branching dendrites containing smooth spines, highly branched axon that arborized in the form of basket surrounding the soma of target cell.

3) Candelabrum cells: They are present in Purkinje cell layer, having small elongated, vertically oriented soma. Each has one or two long branched dendrites, ascending vertically into the molecular layer, and several (3–5) short dendrites which project into the granule cell layer, where they run in the horizontal plane. Both types of dendrites are covered with spines.

4) Granule cells: They are present in the granular cell layer and have excitatory function. They are numerous (2.2 billion), very small (6-9µm), spherical neurons with dense nuclei and scanty cytoplasm. **Their axons** pass into molecular layer where it divides into two parts at right angles to the parent axon (T-junction).

- These branches are abundant, fill the molecular layer and called parallel fibers. They run at right angles to the planes of the dendritic trees of Purkinje cells (make synapses with each other). They also synapse with Golgi II, basket and stellate cells. Each cell gives off three to five **short dendrites** that end in the glomeruli (cerebellar islands).

5) Golgi cells (Type II) (4 million): They are large, stellate inhibitory neurons, scattered in the superficial part of granular cell layer. **Their dendrites** enter the molecular layer, where they branch profusely and synapse with parallel fibers and dendrites of Purkinje cells. Some dendrites ramify in the granular layer. **Their axons** also branch profusely, share in the formation of cerebellar glomeruli.

6) Unipolar Brush cells: They are excitatory interneurons situated in the granule cell layer, mostly in areas with vestibular functions. Each cell has a round or oval small cell body and a single short dendrite that ends in a brush-like cluster.

By EM, the brush dendrites emit numerous, cytoplasmic projections called filopodia.

-These cells share in integration of signals involving the orientation of the head, as they amplify inputs from the vestibular ganglia and nuclei by spreading and prolonging excitation within the granular layer. UBCs have been implicated in the dysfunction of balance and motor coordination present in some condition as Down syndrome

7) Lugaro cells: they are located in the granule cell layer just beneath the Purkinje cell layer.

- They are two types;

1-The classical one have spindle shaped body, tapering at each end and give thick principal dendrites from opposite poles of their bodies that travel to contact Purkinje cells in a horizontal direction.

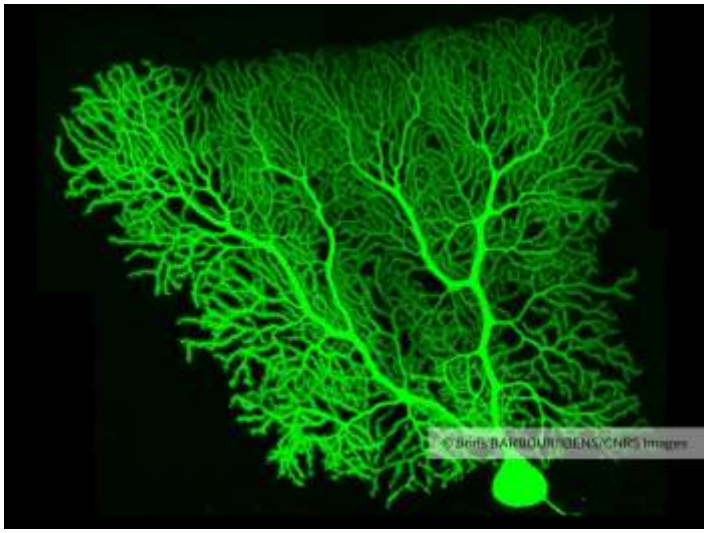
2-The second type of Lugaro cells occupy a deeper position within the granule cell layer, and have a globular soma.

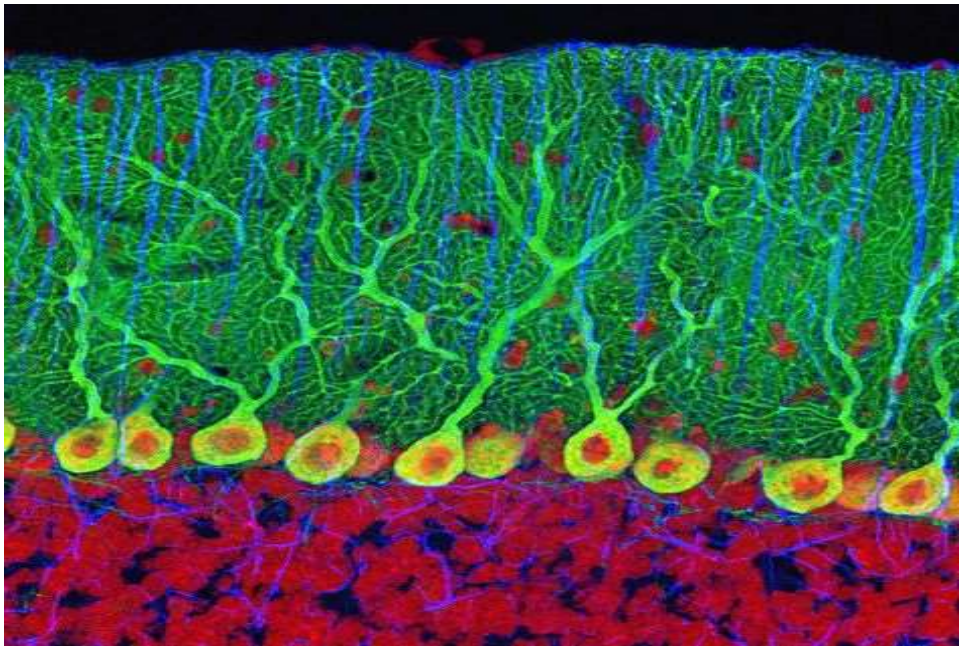
- Axons of both types target the stellate, basket and Golgi cells. They are interconnected many neurons located in all layers of the cortex (information from the Purkinje cell forwards to molecular and granular layers).

II- Projecting neuron:

Purkinje cells: (15 million, Golgi type I neuron)

- They are unique cells to the cerebellum. They are arranged in a single row at the Purkinje cell layer and have large pyriform soma (35 µm). Their dendrites project upward into the molecular layer where it branches extensively to form a dendritic tree and synapse with axons of granular cells. The dendritic tree lie in one plane and those of adjoining cells are parallel to each other. Their dendrites can relay with axons of the collateral branches of basket cells. Their axons pass through the granular layer projecting to white matter and terminate in cerebellar nuclei.





Histological structure (layers) of the Cerebellar cortex (grey matter)

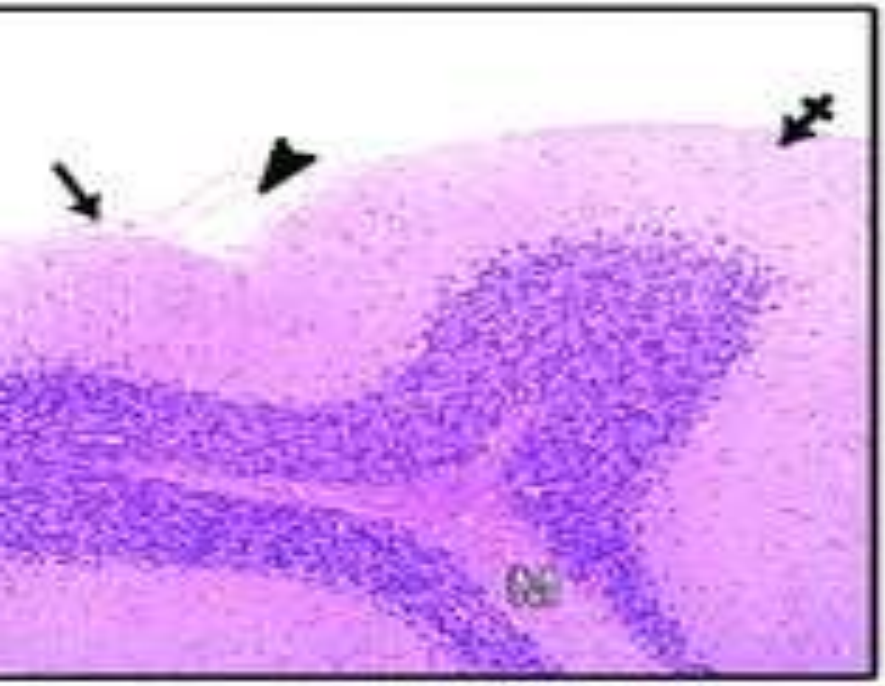
- The cerebellar cortex is much folded forming folia which are separated by transverse fissures.

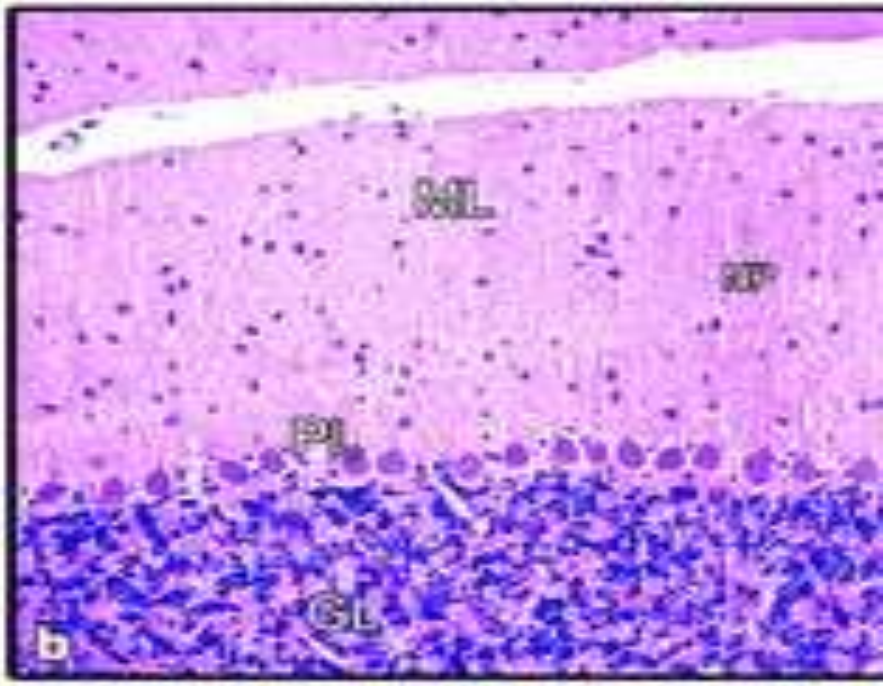
-It has a uniform structure in all parts of the cerebellum.

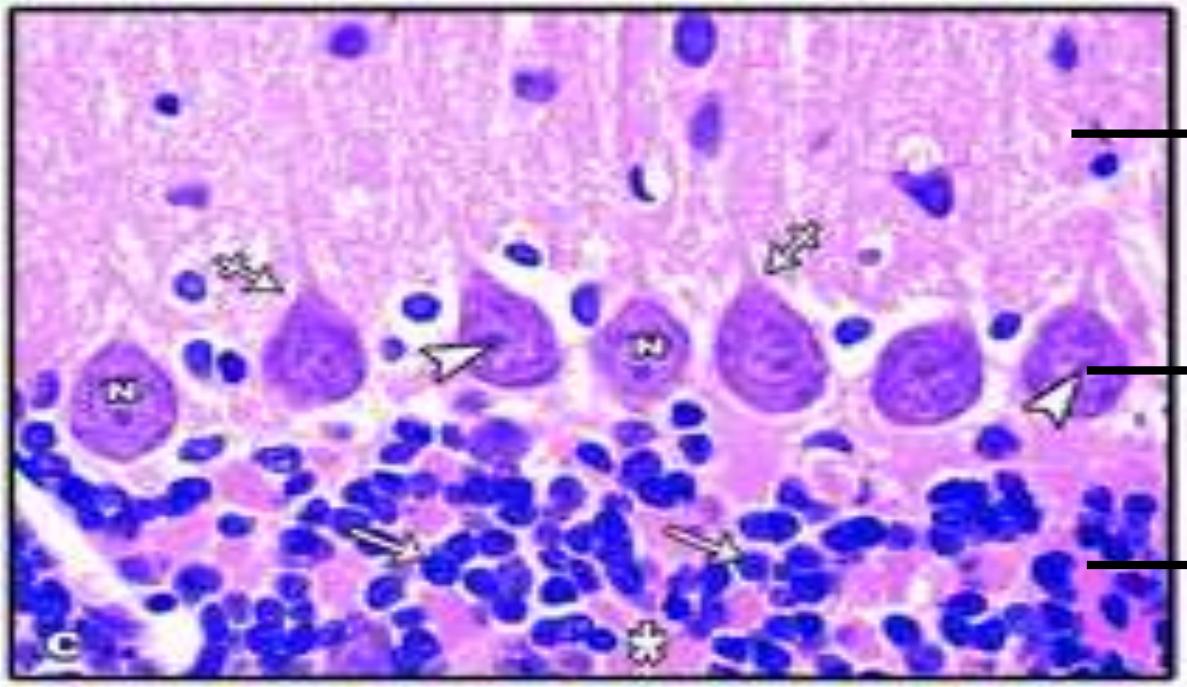
- Cerebellar cortex can be divided into three layers:

(1) Molecular layer (300µm): Most superficial layer, lies directly below the pia mater. It which contains: a) Two types of neurons: stellate cells and basket cells. b)Neuroglia cells c) Dendrites of Purkinje cells d) Axons of granular cells

(2) Purkinje cell layer (100µm): it contains two types of neurons: a) Purkinje cells: projecting neurons b) Candelabrum cells: interneurons







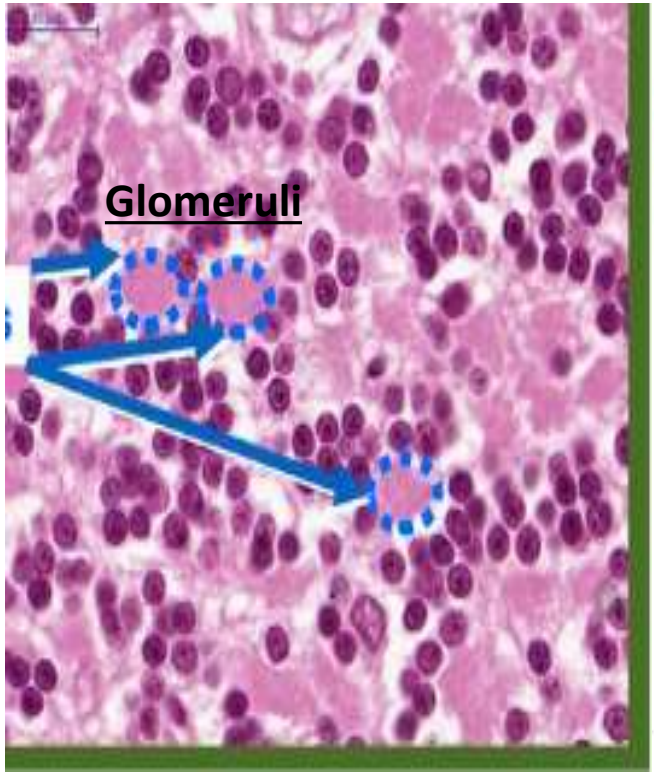
molecular

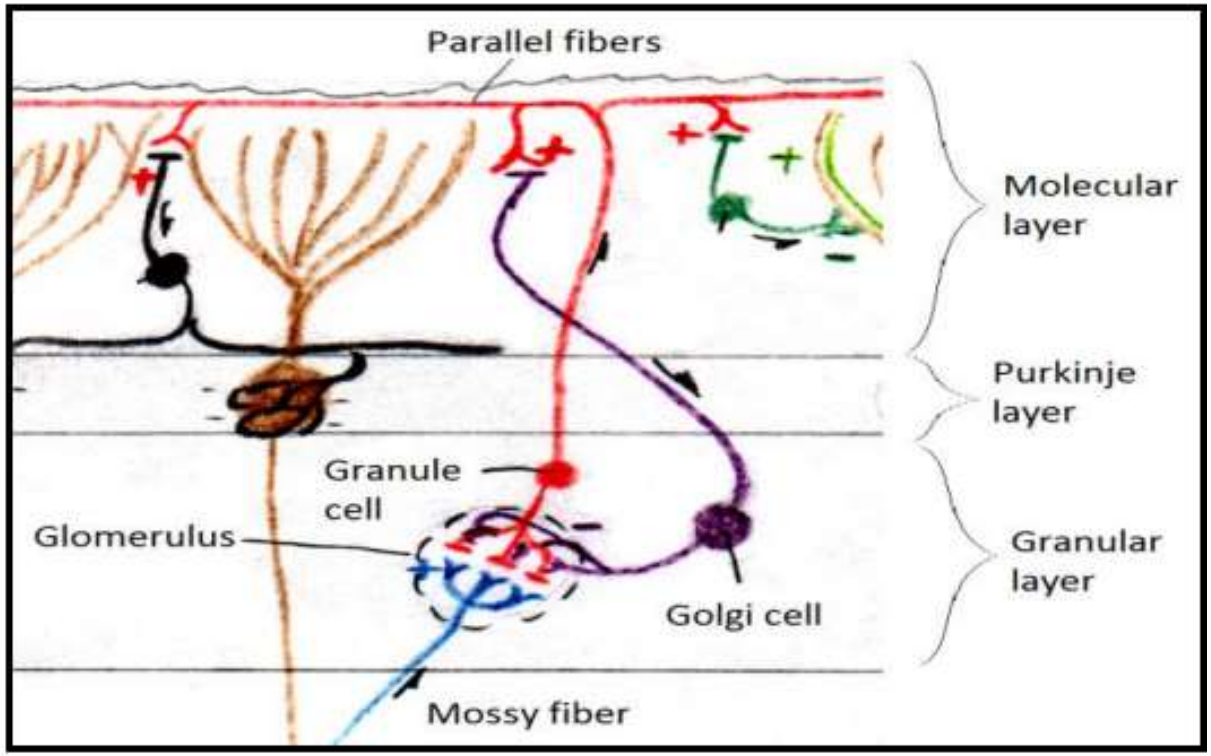
purkinje

granule

(3) Granular cell layer (200µm):

- The deepest layer rests on white matter. It is extremely cellular and contains: a) Granule cells b) Golgi cells (Type II) c) Unipolar Brush cells d) Lugaro cells e) Neurolgia f) Glomeruli (cerebellar islands)
- **Glomeruli :** These are the spaces which not occupied by cells, seen by LM as pale areas. They are occupied by special synaptic structures called glomeruli.





- They are small (2.5 um) in diameter, and each consists of synapse between:

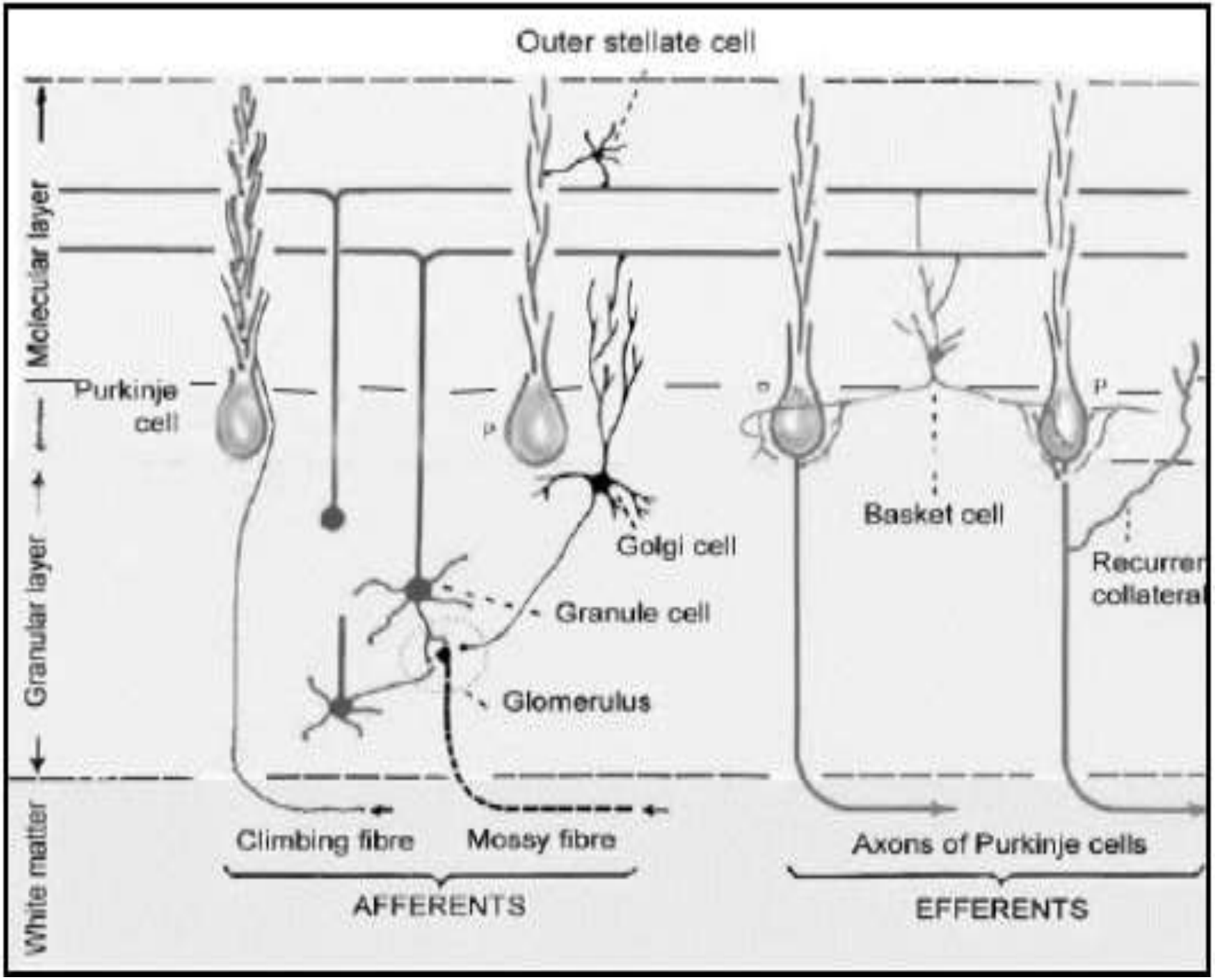
1- Granule cell dendrites (excitatory).

2-Terminals of mossy fibers forming a rosette located laterally (excitatory).

3-Golgi cell axon terminals, and proximal parts of Golgi dendrites (inhibitory).

- The cerebellar glomeruli has a glial sheath formed from protoplasmic astrocytes. This glial sheath has a role in support, insulation, chemical equilibrium. The cerebellar glomeruli are the first "processing station" for afferent fibers entering the cerebellum.

- **N.B.** Damage to Purkinje cells due to any cause (e.g. neurodegenerative disease, alcohol abuse, tumors, trauma or hypoxia) leads to the development of cerebellar ataxia in which there is poor co-ordination of voluntary movement.


Outer stellate cell
Molecular layer
Granular layer
White matter
Purkinje cell
Golgi cell
Granule cell
Glomerulus
Basket cell
Recurrent collateral
Climbing fibre
Mossy fibre
AFFERENTS
Axons of Purkinje cells
EFFERENTS

Cerebellar white matter

- It is made up of three groups of fibers:

(1) Intrinsic fibers: which connect different parts of the cerebellum.

(2) Afferent fibers (mainly enter through inferior & middle cerebellar peduncle).

A- Climbing fiber system: These fibers are olivocerebellar. They pass through granular and Purkinje layers, reaching the molecular layer to synapse and associate with dendritic tree of Purkinje.

B- Mossy fiber system: comes from nearly all the CNS except inferior olives. Each fiber ends by about 50 rosette like structures. Each rosette synapses with 20 granule cells in the cerebellar glomerulus. So each mossy fiber has connection with about 1000 granule cells.

C- Multilayered fiber system: Fibers originate from hypothalamus, locus ceruleus, substantia nigra and reticular formation .

(3) Efferent fibers (by SCP and ICP):

- Axons of Purkinje cells : most Purkinje axons end in deep cerebellar nuclei, little by pass these nuclei to end in vestibular nuclei.

- Efferents from deep cerebellar nuclei:

a) Dentate nuclei project mainly to thalamus.

b) Emboliform and Globose nuclei (interposed nucleus) project mainly to red nucleus and inferior olive. The fibers of these nuclei pass through superior cerebellar peduncle.

c) Fastigi nuclei projects mainly to vestibular nuclei (and RF). Fastigial fibers pass through inferior cerebellar peduncle.


Thank
you