NEUROHISTOLOGY IV: CEREBRUM & CEREBELLUM

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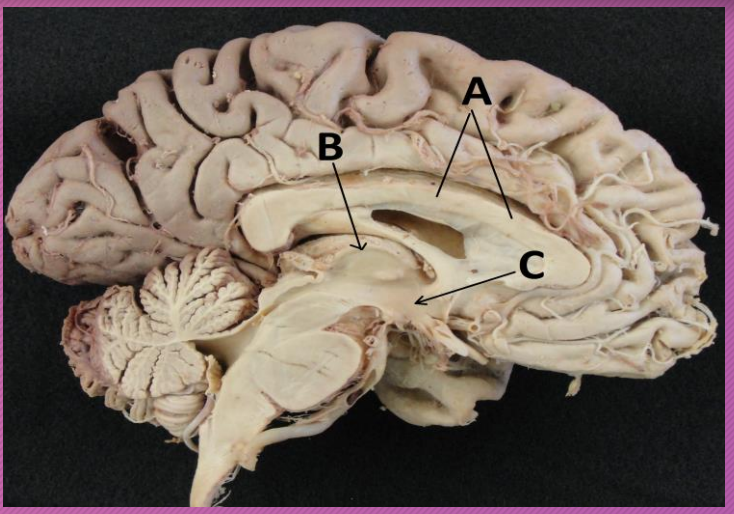
DEPARTMENT OF HUMAN ANATOMY

UNIVERSITY OF NAIROBI

CEREBRUM – EXPECTED LEARNING OUTCOMES

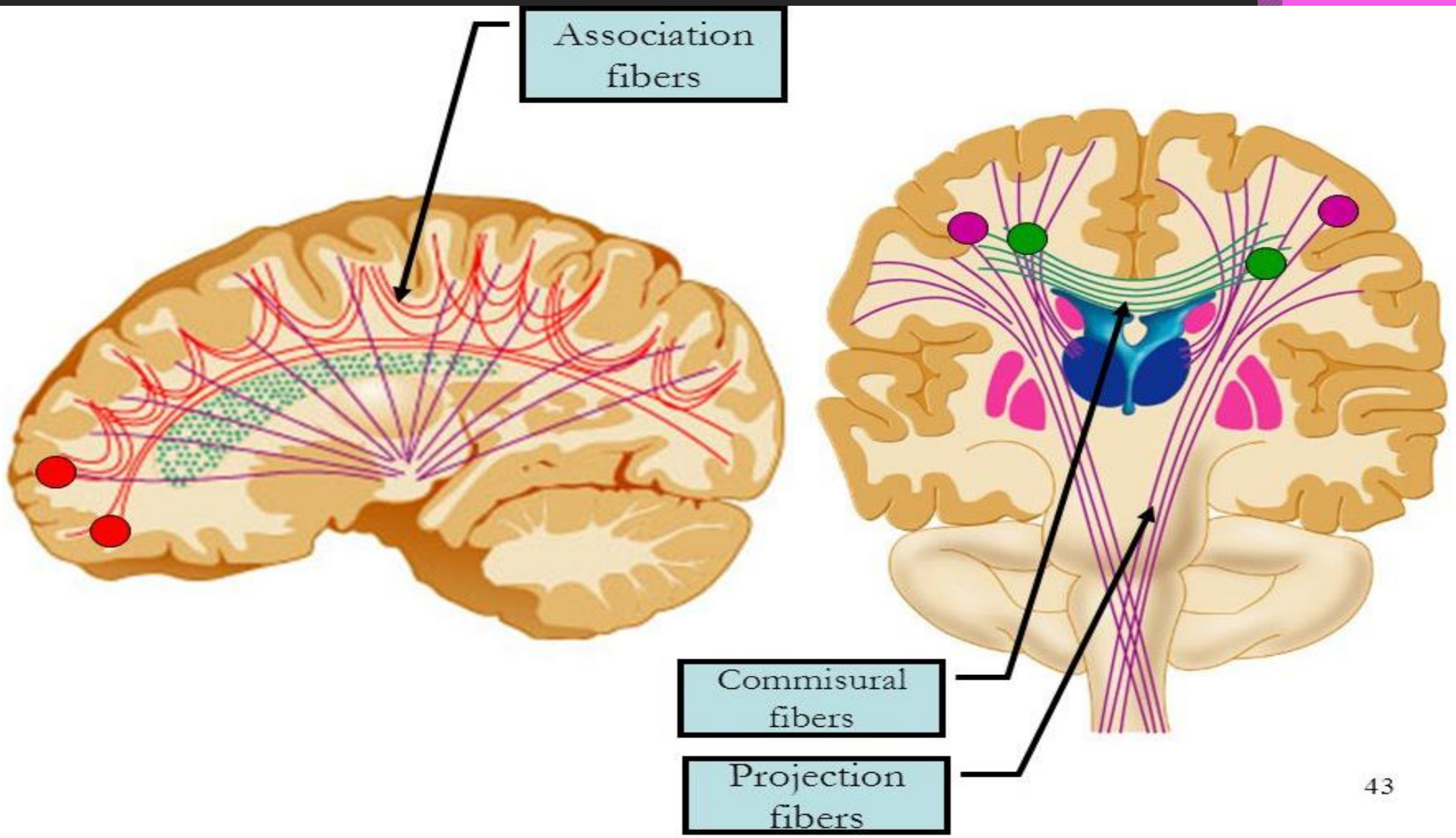
1. Name the parts and subparts of the cerebrum
2. Outline the fiber types of the cerebral white matter, with examples
3. State the components and function of the basal ganglia*
4. Name the cell types and layers of the cerebral cortex
5. Familiarize with the phylogenetic classification of the cortex
6. State the characteristics of a “Cortical module”

HISTOLOGICAL ORGANIZATION OF THE CEREBRUM

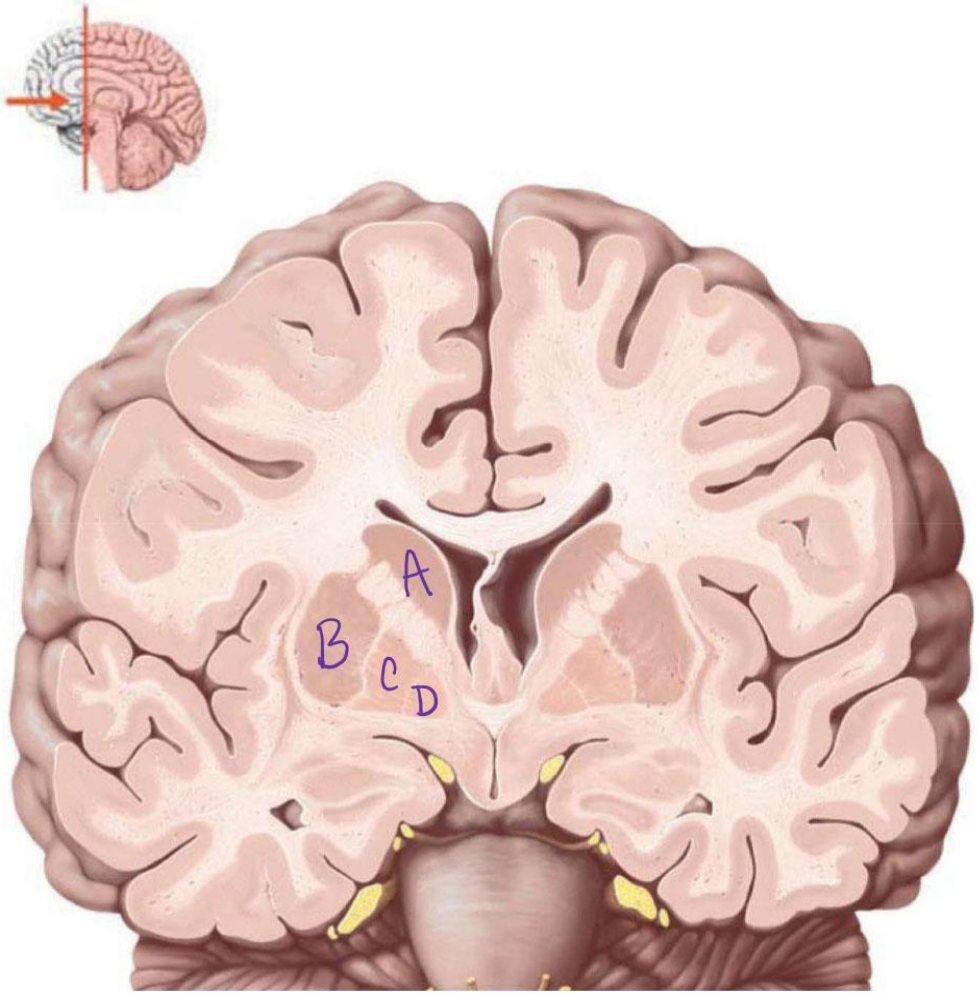


- Has the cerebral hemispheres and the diencephalon
- Components of diencephalon?
- The hemispheres consist of cortex, white matter and the basal nuclei

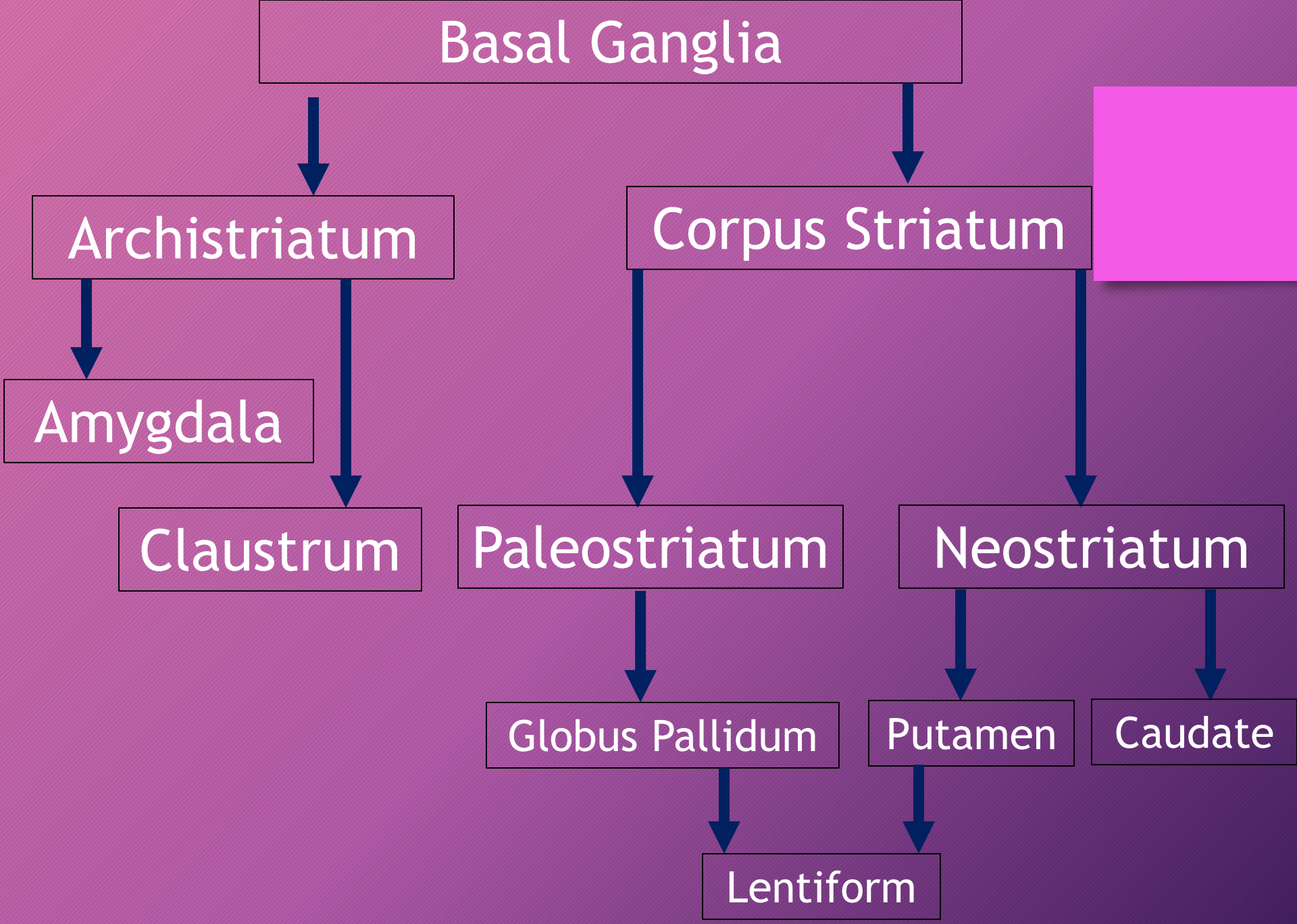
CEREBRAL WHITE MATTER



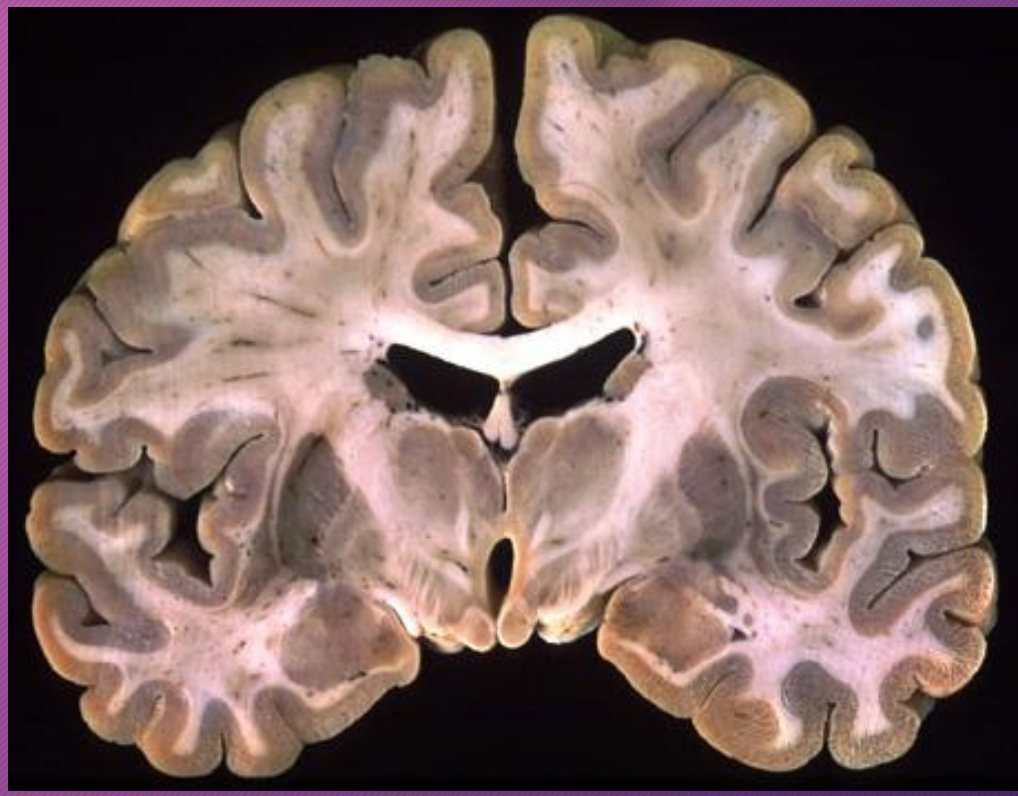
BASAL NUCLEI (BASAL GANGLIA)

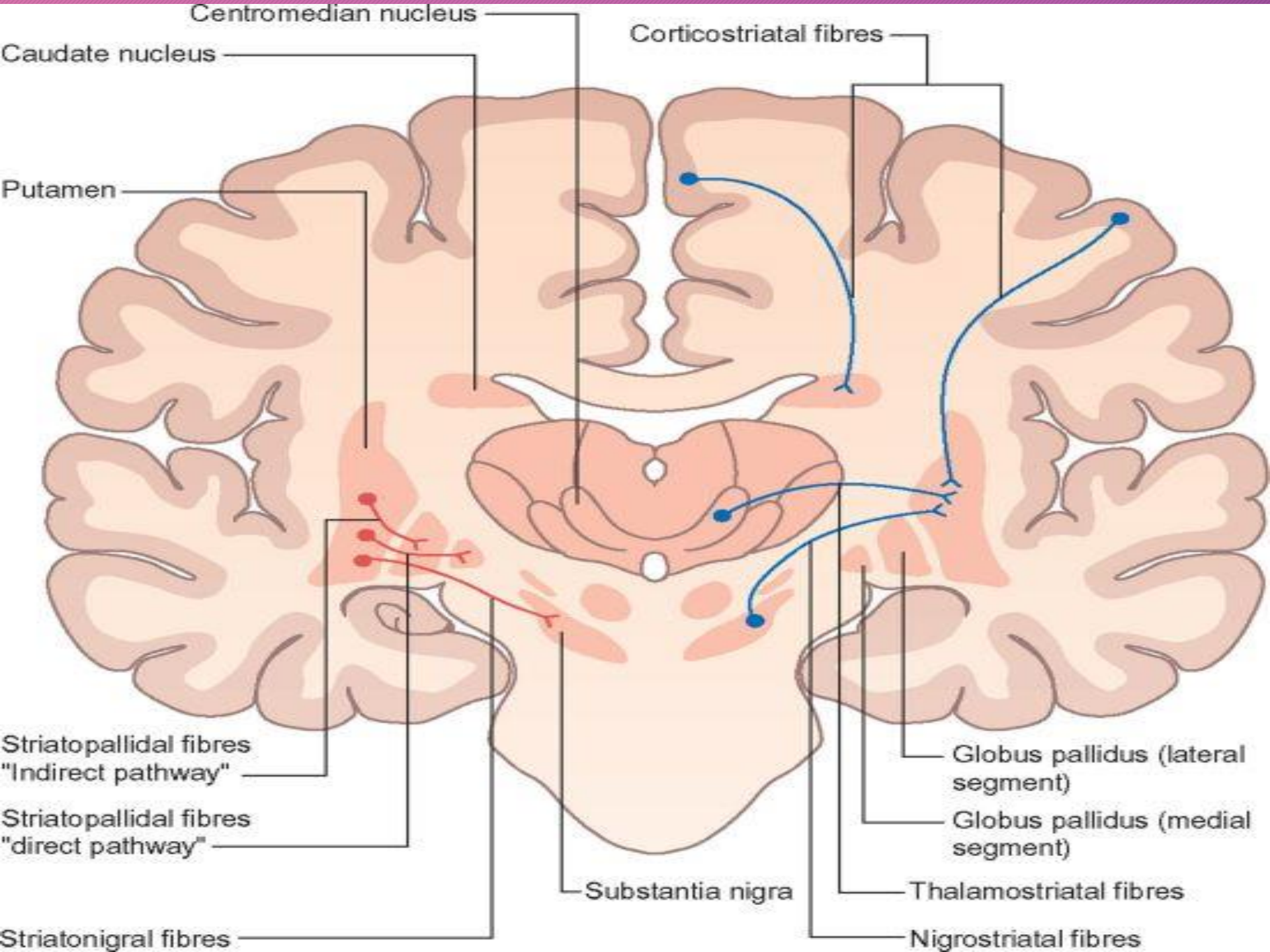


- Subcortical nuclear masses that lie in the inferior part of the cerebral hemisphere
- Associated with diencephalon and midbrain
- Control of movement


Basal Ganglia
Archistriatum
Corpus Striatum
Amygdala
Claustrum
Paleostriatum
Neostriatum
Globus Pallidum
Putamen
Caudate
Lentiform

SECTIONS OF THE CEREBRUM




Centromedian nucleus
Caudate nucleus
Corticostriatal fibres
Putamen
Striatopallidal fibres
"Indirect pathway"
Striatopallidal fibres
"direct pathway"
Striatonigral fibres
Substantia nigra
Globus pallidus (lateral segment)
Globus pallidus (medial segment)
Thalamostriatal fibres
Nigrostriatal fibres

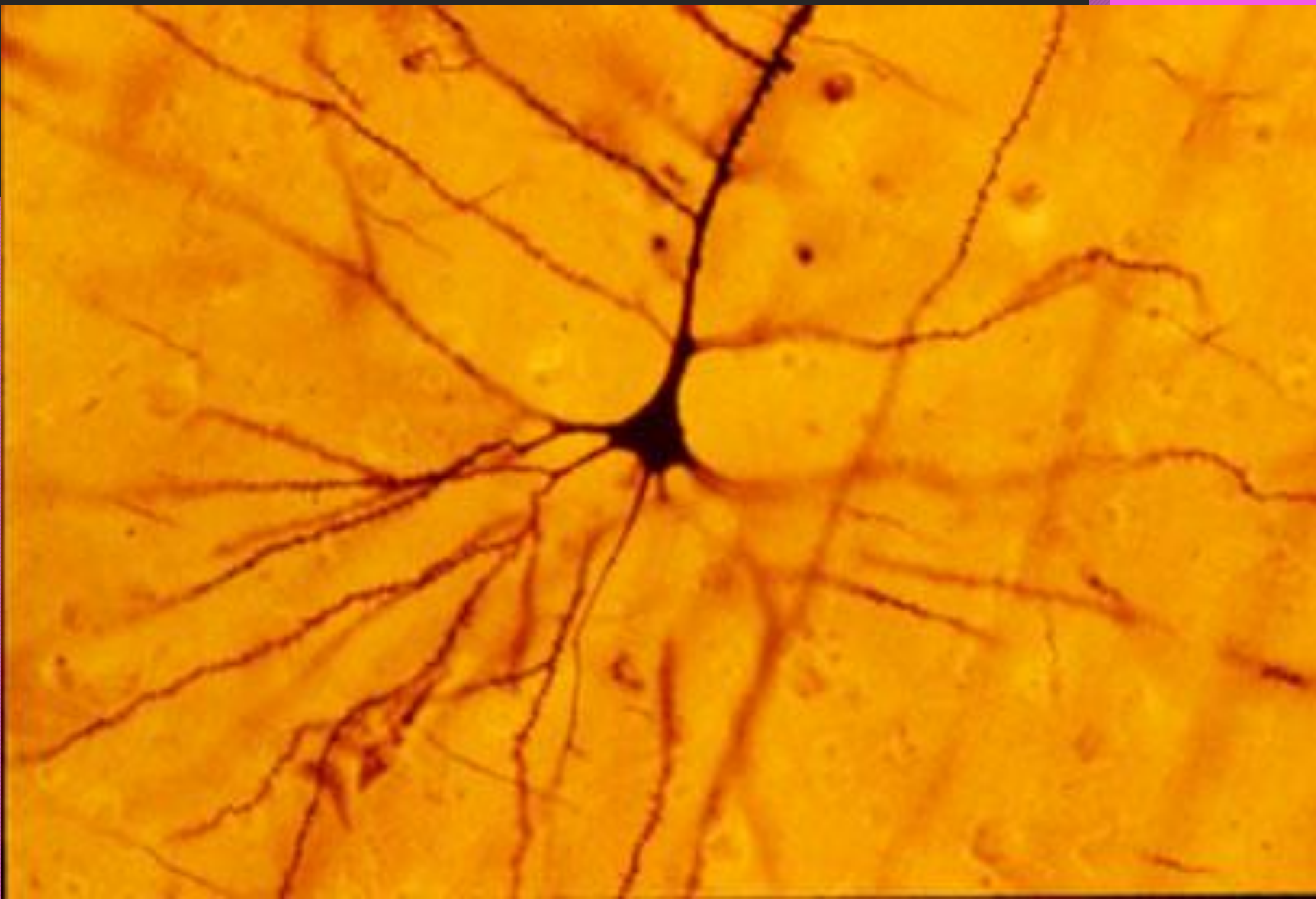
THE CEREBRAL CORTEX

- About 2.4mm-2.8mm thick in humans
- Outer layer of the grey matter of the cerebral hemisphere
- Sophisticated composite of nerve cell bodies, nerve fibers, neuroglia and blood vessels

CELL TYPES OF THE CEREBRAL CORTEX

- Neuronal and neuroglial cell types
- Neuroglial cells
- Neuronal cell types
  - ✓Pyramidal cells
  - ✓Non-pyramidal cells – stellate/granule cells

PYRAMIDAL CELLS



NON-PYRAMIDAL CELLS

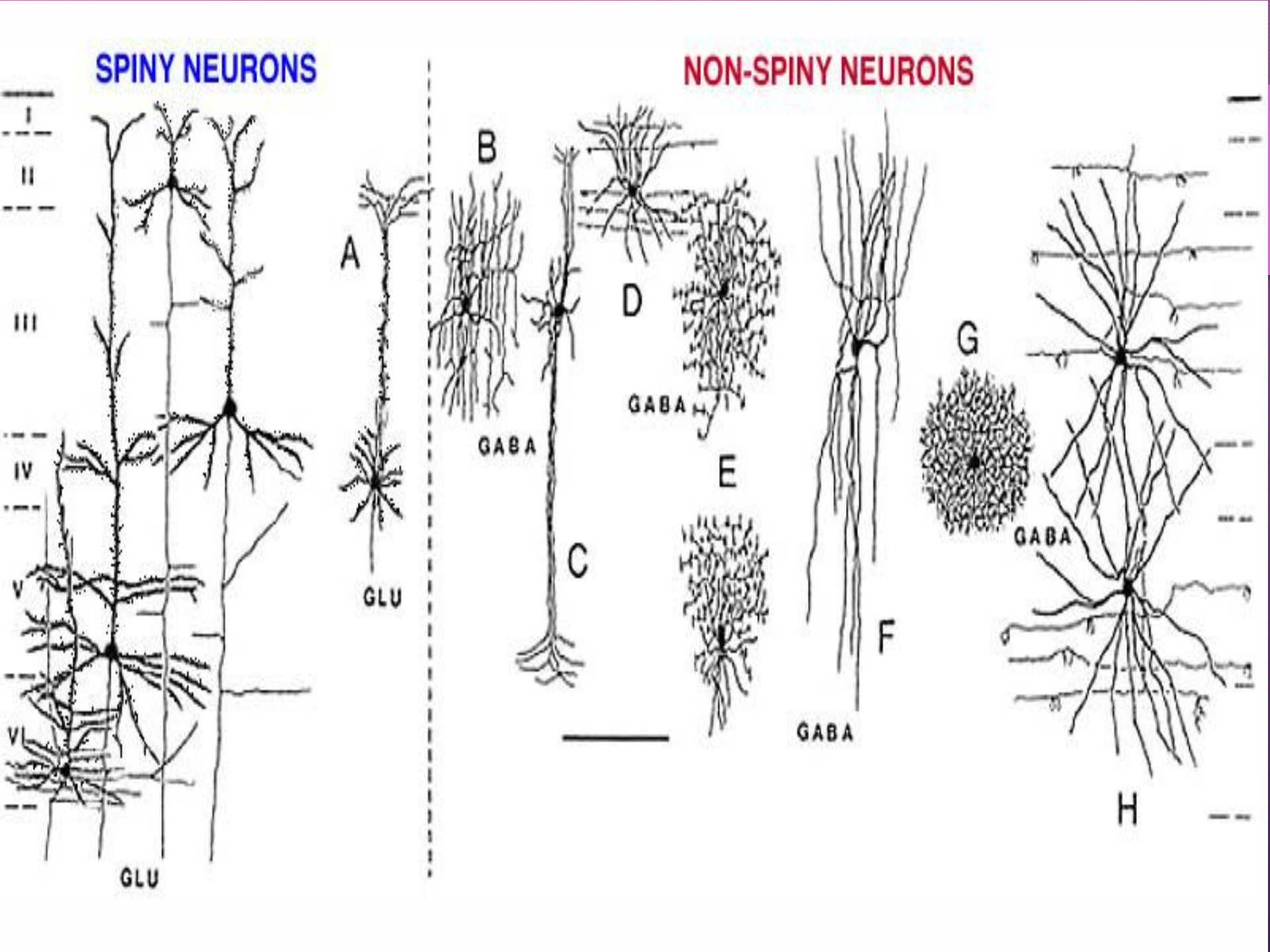
- Stellate or granule cells
- Divided into spiny and non-spiny neurons

SPINY STELLATE CELLS

- Have small multipolar cell bodies
- Have several primary dendrites, profusely covered in spines
- Axons ramify within the grey matter predominantly in the vertical plane

NON-SPINY STELLATE CELLS

- Interneurons, axons confined to grey matter
- Multitude of different cells – basket, chandelier, double bouquet, horizontal cells (of Cajal) etc
- Horizontally, vertically or radially ramifying axons
- Predominantly GABAergic

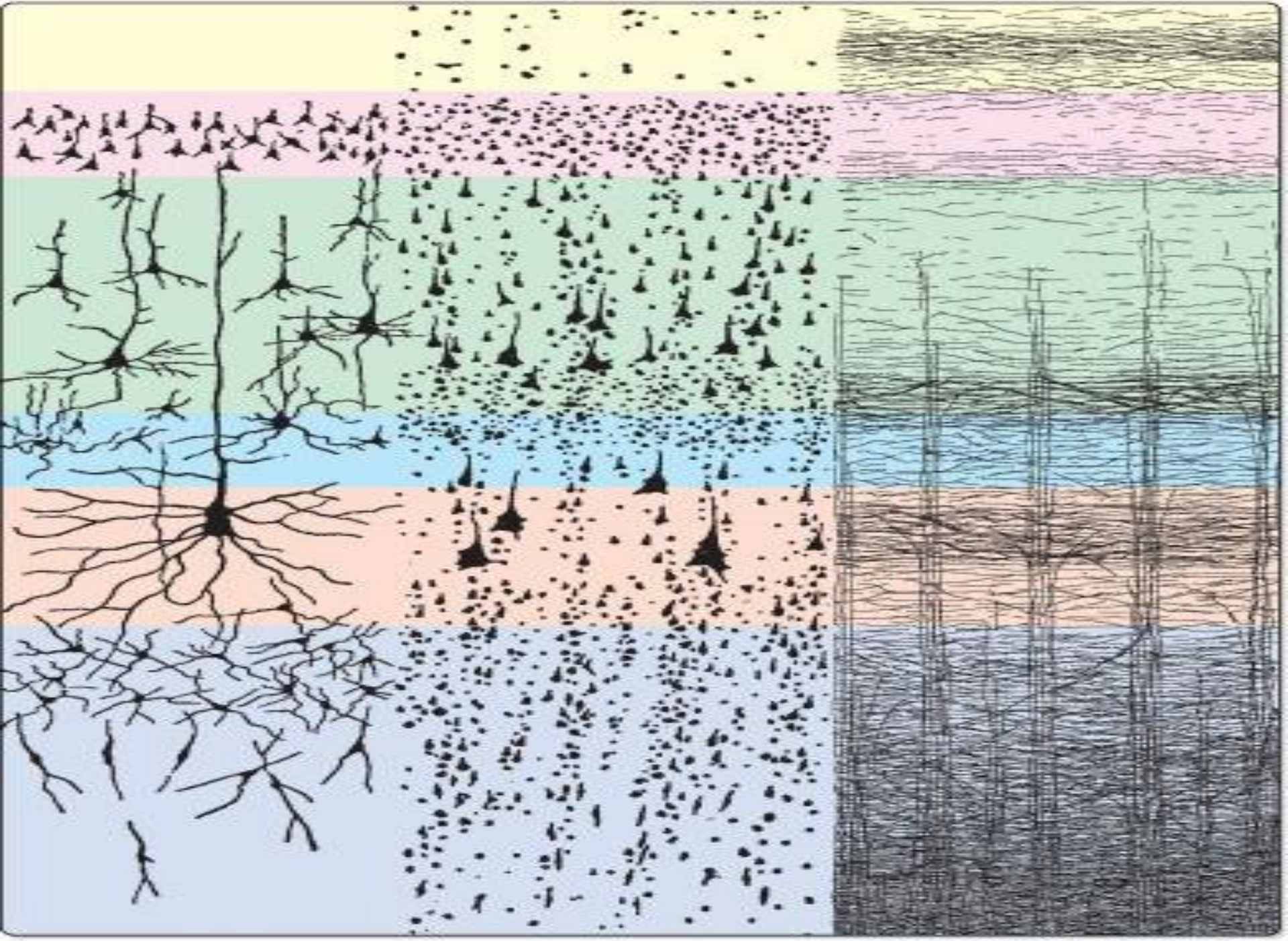

SPINY NEURONS
NON-SPINY NEURONS
I
II
III
IV
V
VI
A
B
C
D
E
F
G
H
GLU
GLU
GABA
GABA
GABA
GABA

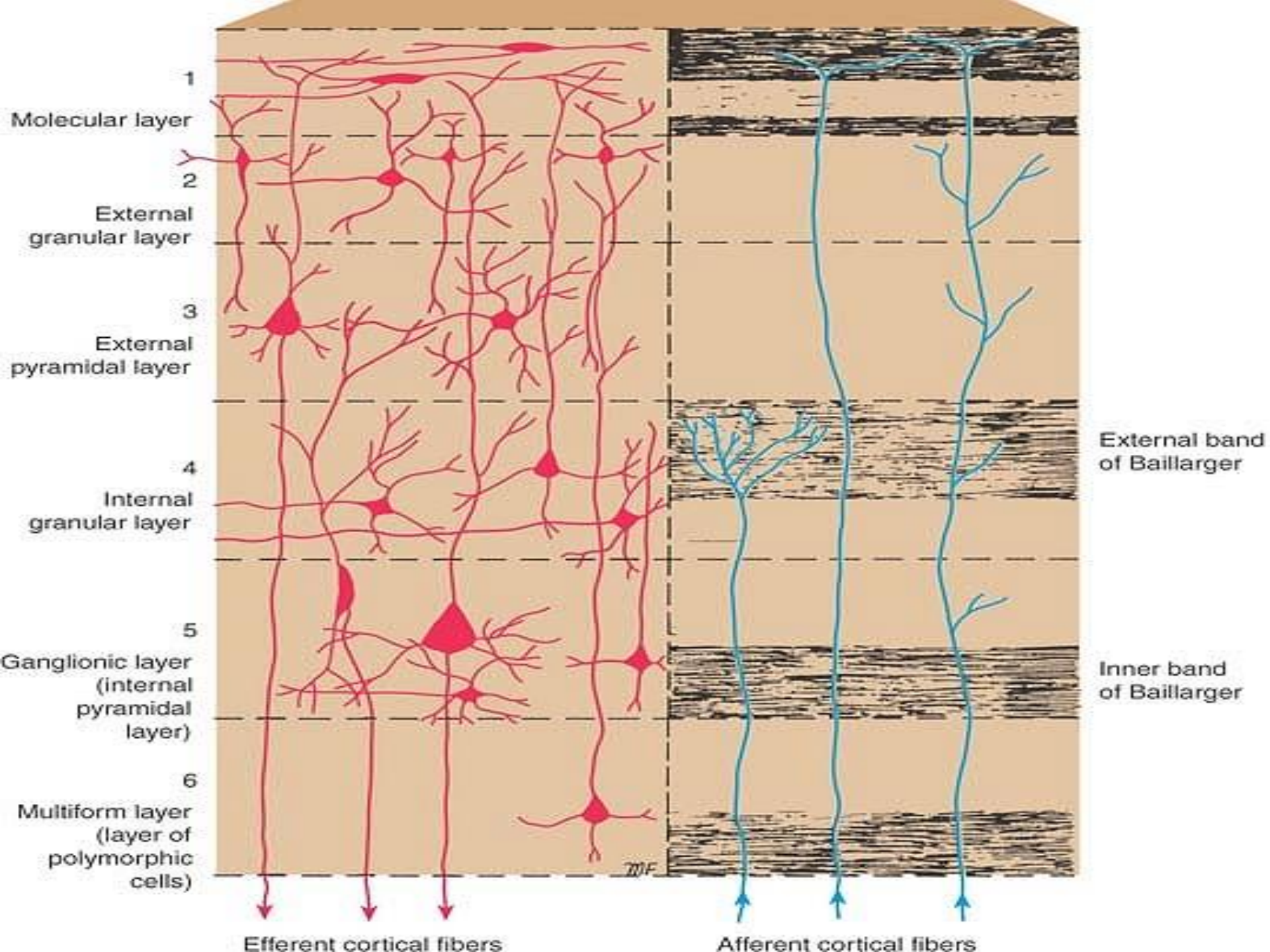
PHYLOGENETIC CLASSIFICATION OF THE CEREBRAL CORTEX

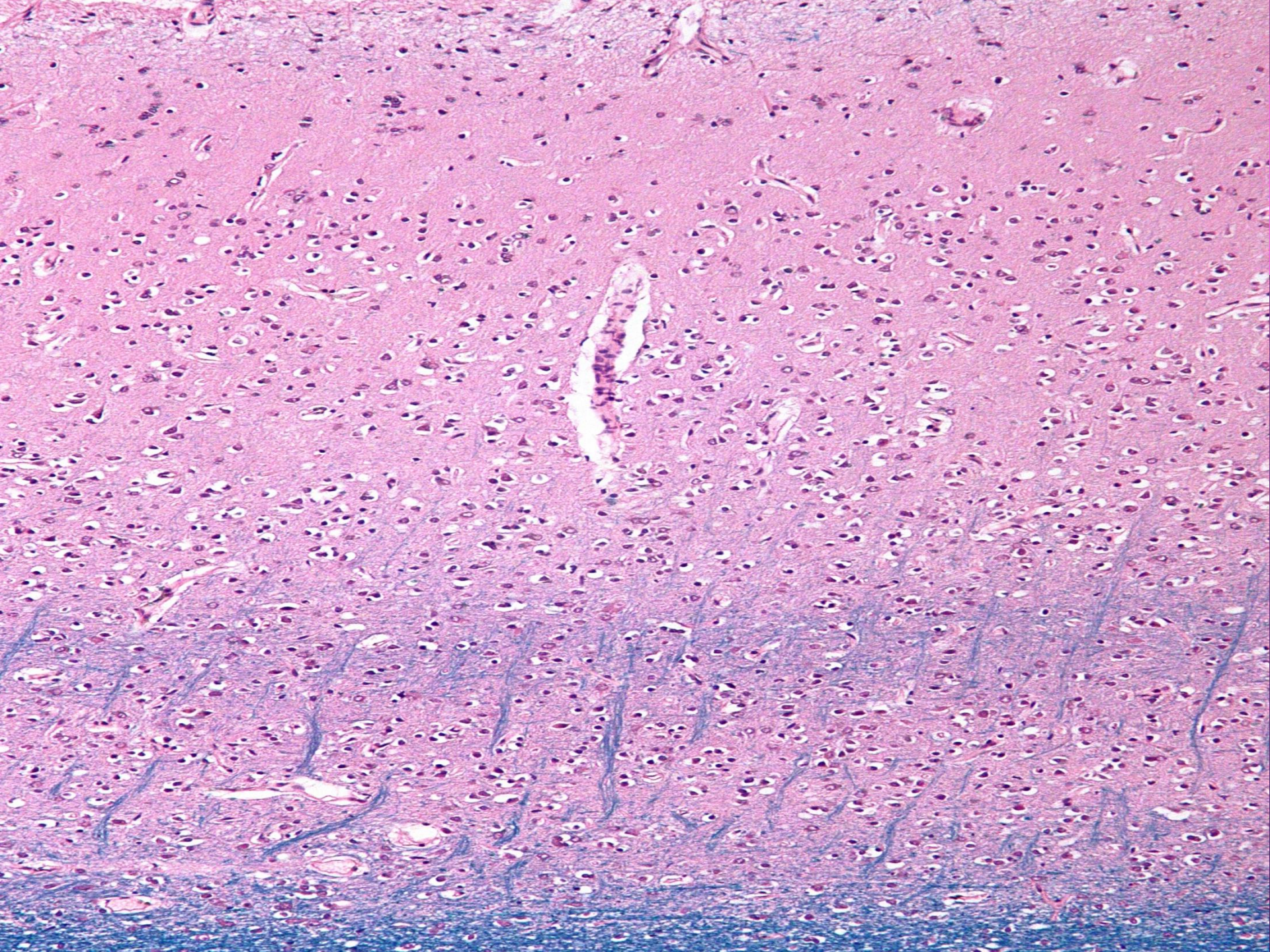
- Older cortex – Allocortex
  - ✓Archicortex
  - ✓Palaeocortex
- Newer cortex – Neocortex

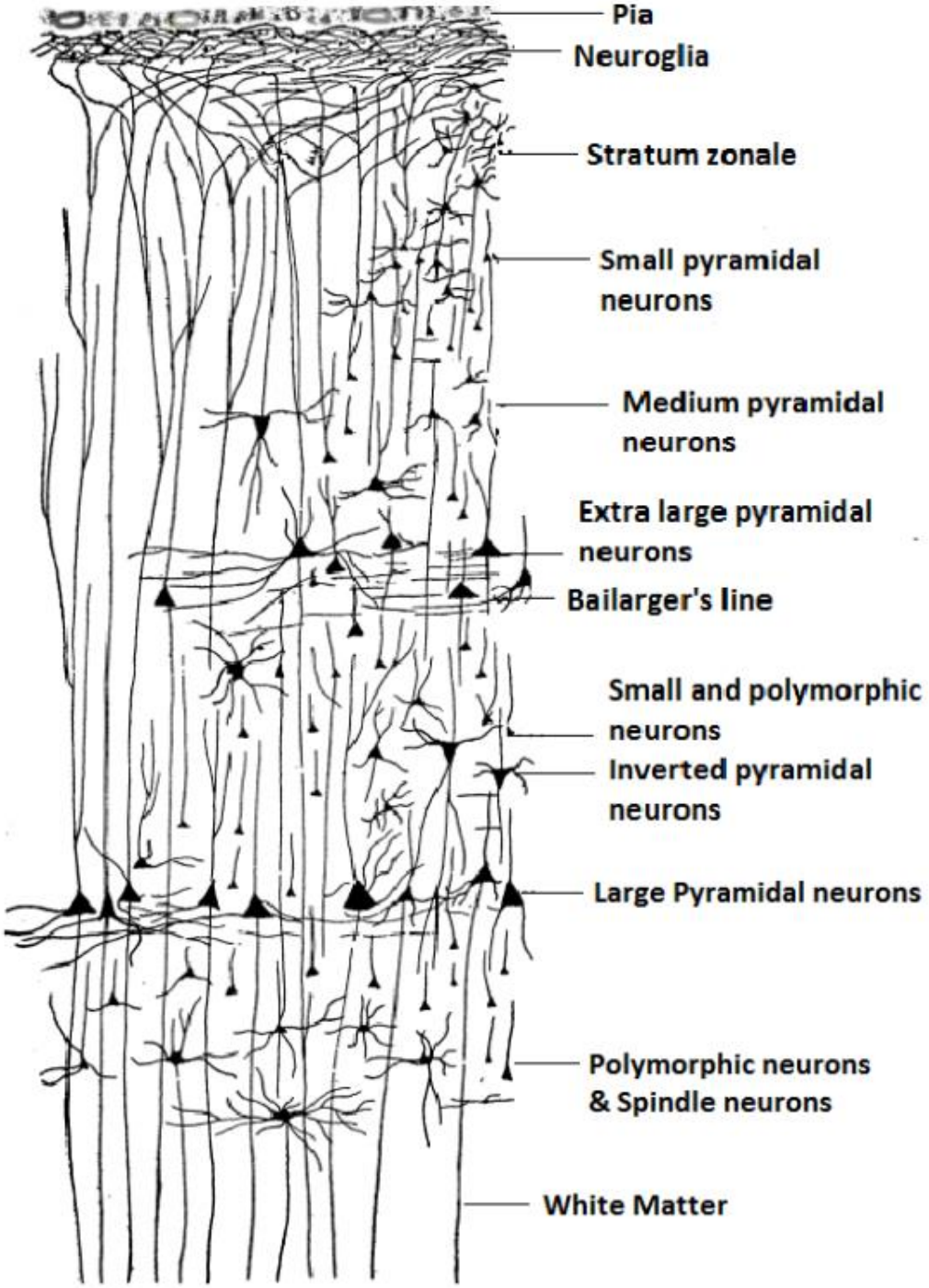
LAMINAR ORGANIZATION OF THE CEREBRAL CORTEX

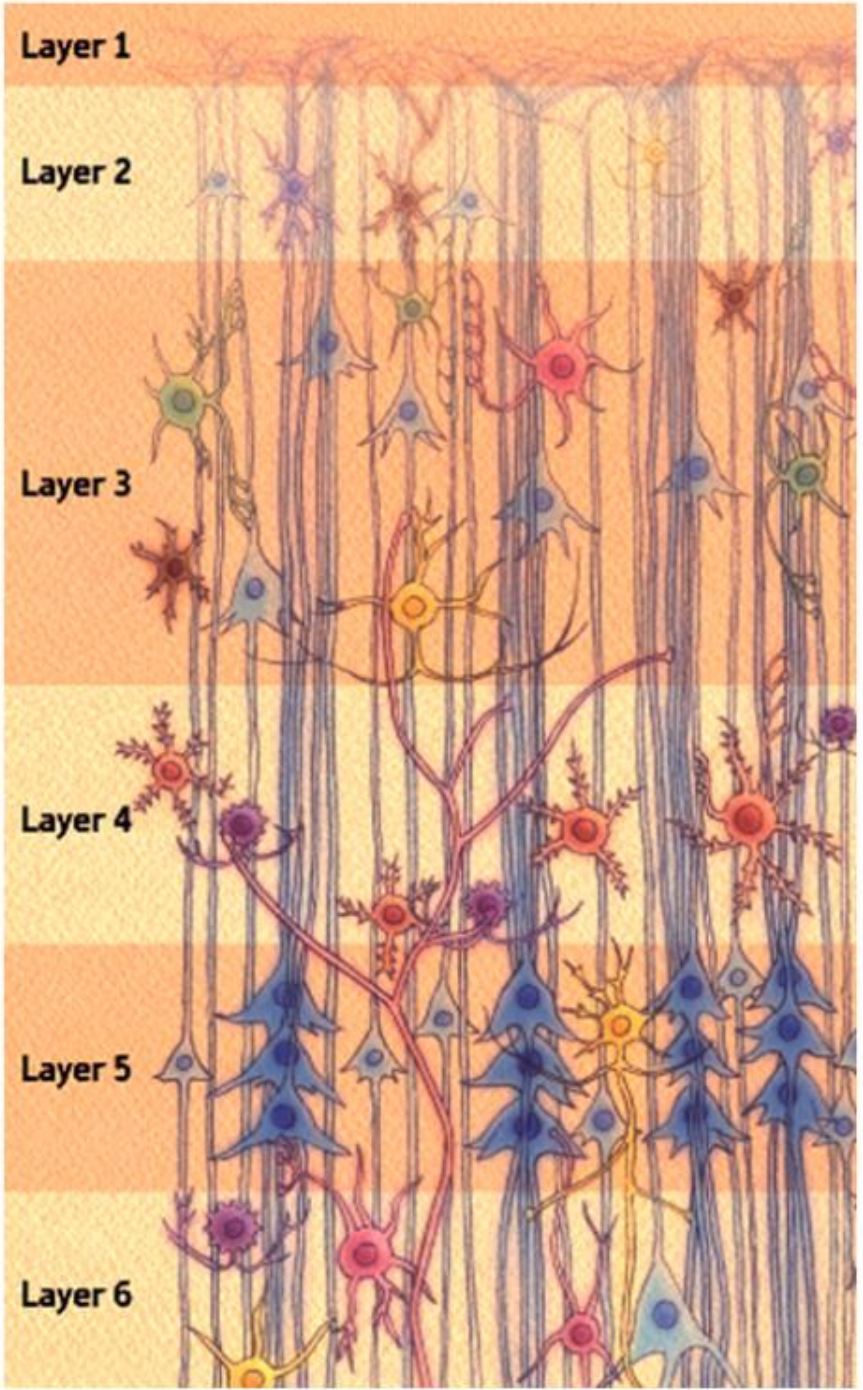
- Typical neocortex is described as having six layers or laminae lying parallel to the surface


Golgi
Nissl
Weigert


1
Molecular layer
2
External granular layer
3
External pyramidal layer
4
Internal granular layer
5
Ganglionic layer (internal pyramidal layer)
6
Multiform layer (layer of polymorphic cells)
External band of Baillarger
Inner band of Baillarger
Efferent cortical fibers
Afferent cortical fibers

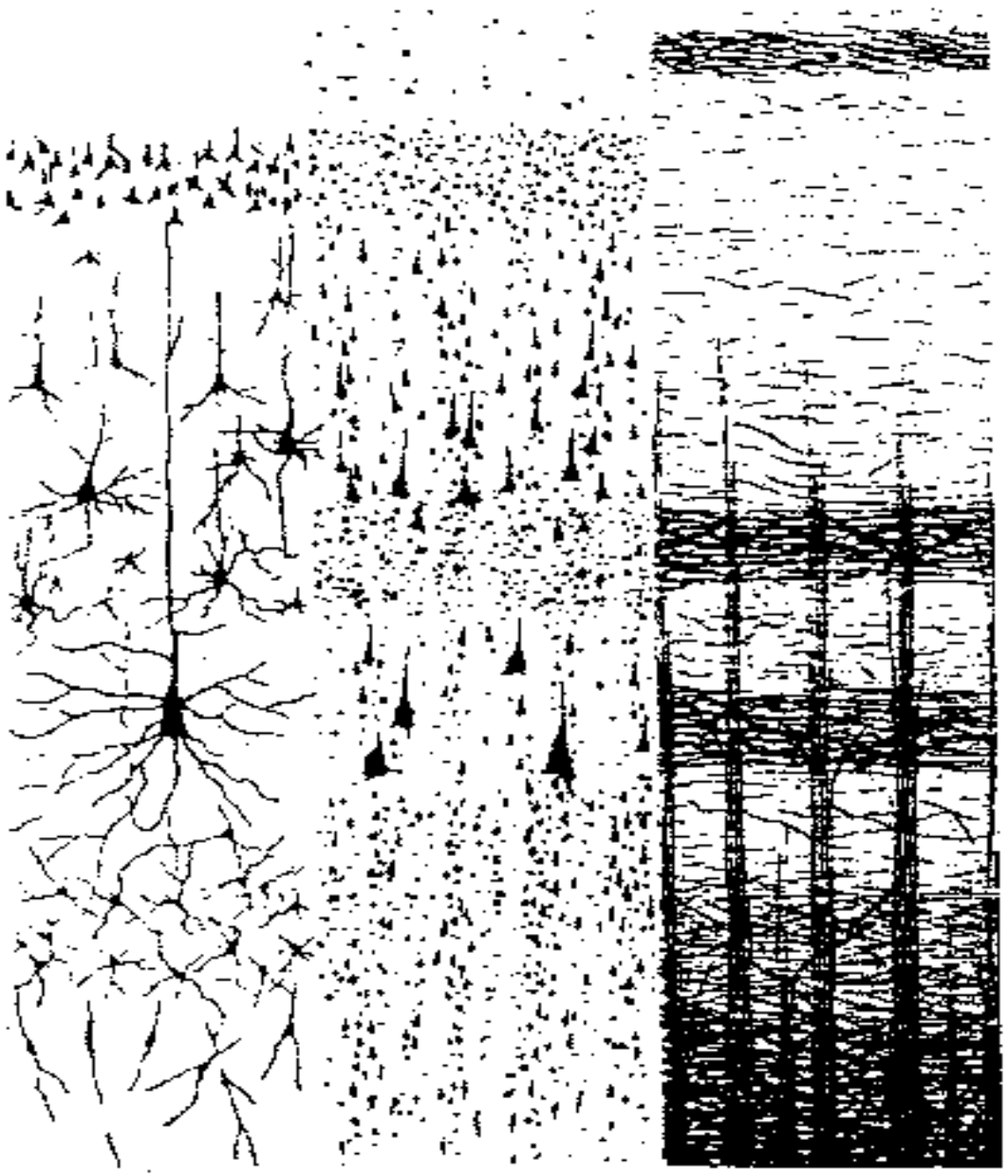



Pia
Neuroglia
Stratum zonale
Small pyramidal neurons
Medium pyramidal neurons
Extra large pyramidal neurons
Bailarger's line
Small and polymorphic neurons
Inverted pyramidal neurons
Large Pyramidal neurons
Polymorphic neurons & Spindle neurons
White Matter


Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Layer 6

CEREBRAL CORTEX

1. MOLECULAR LAYER
2. EXTERNAL GRANULAR LAYER
3. EXTERNAL PYRAMIDAL LAYER
4. INTERNAL GRANULAR LAYER
5. INTERNAL PYRAMIDAL LAYER
6. MULTIFORM LAYER



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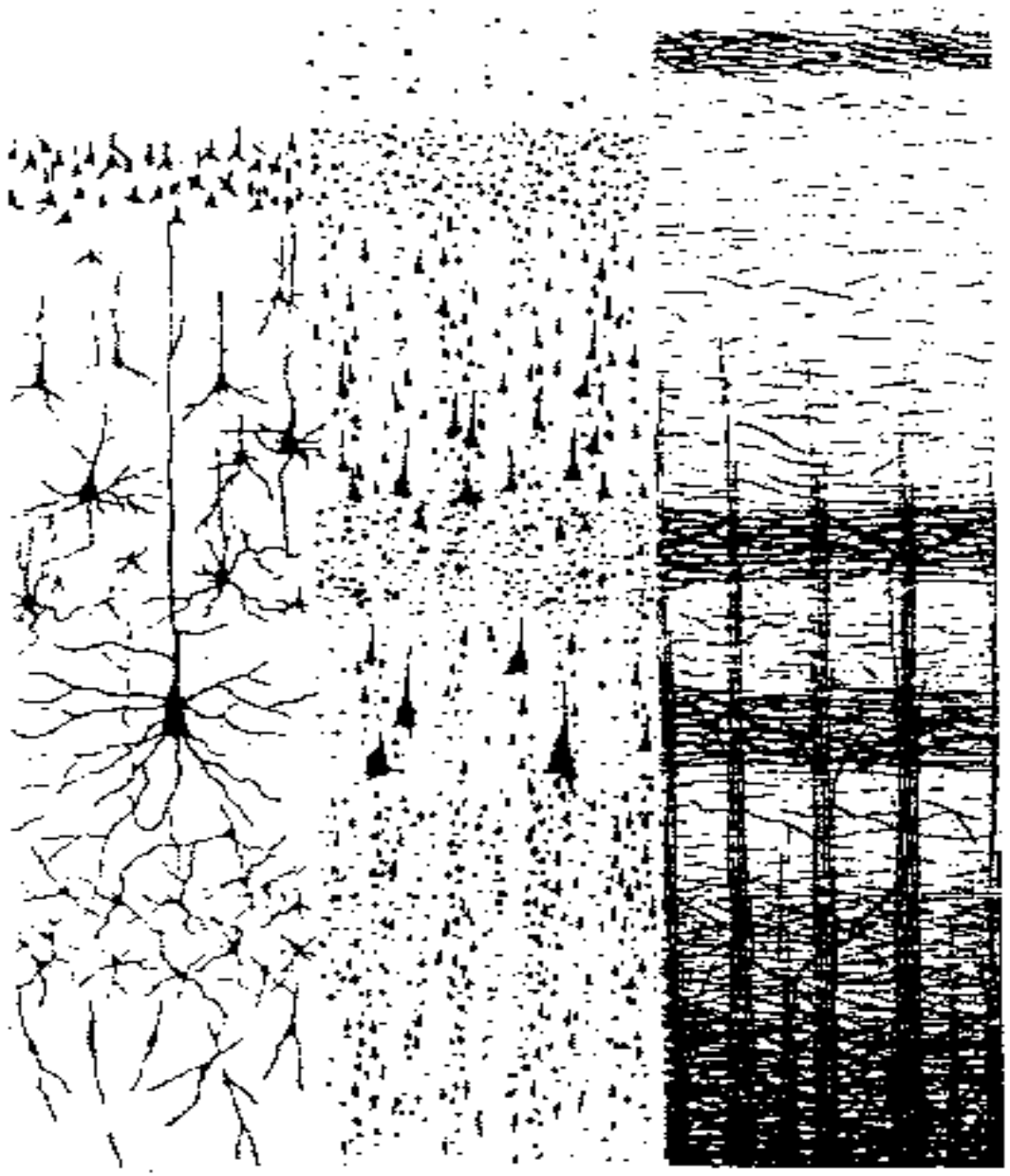

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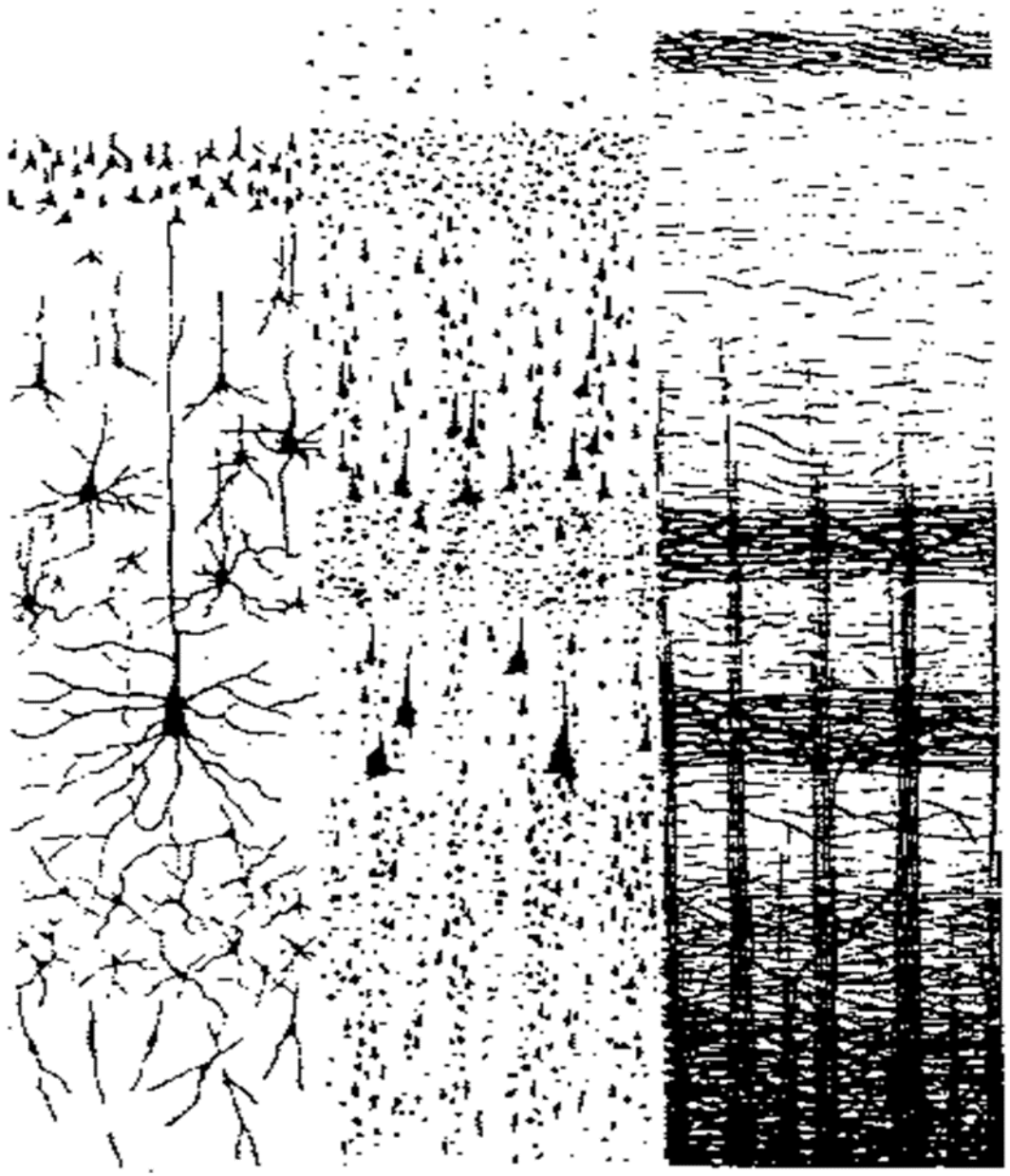

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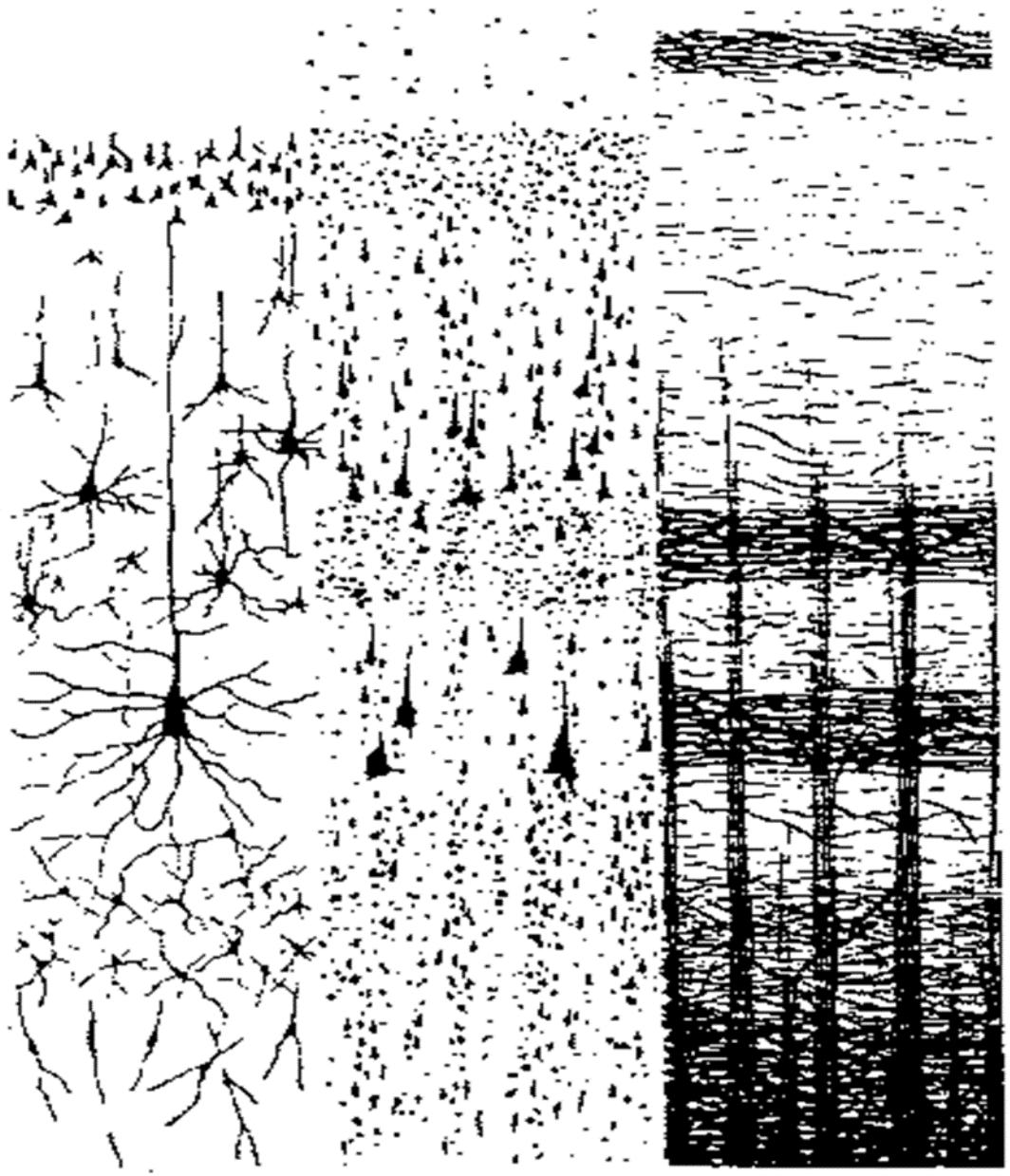

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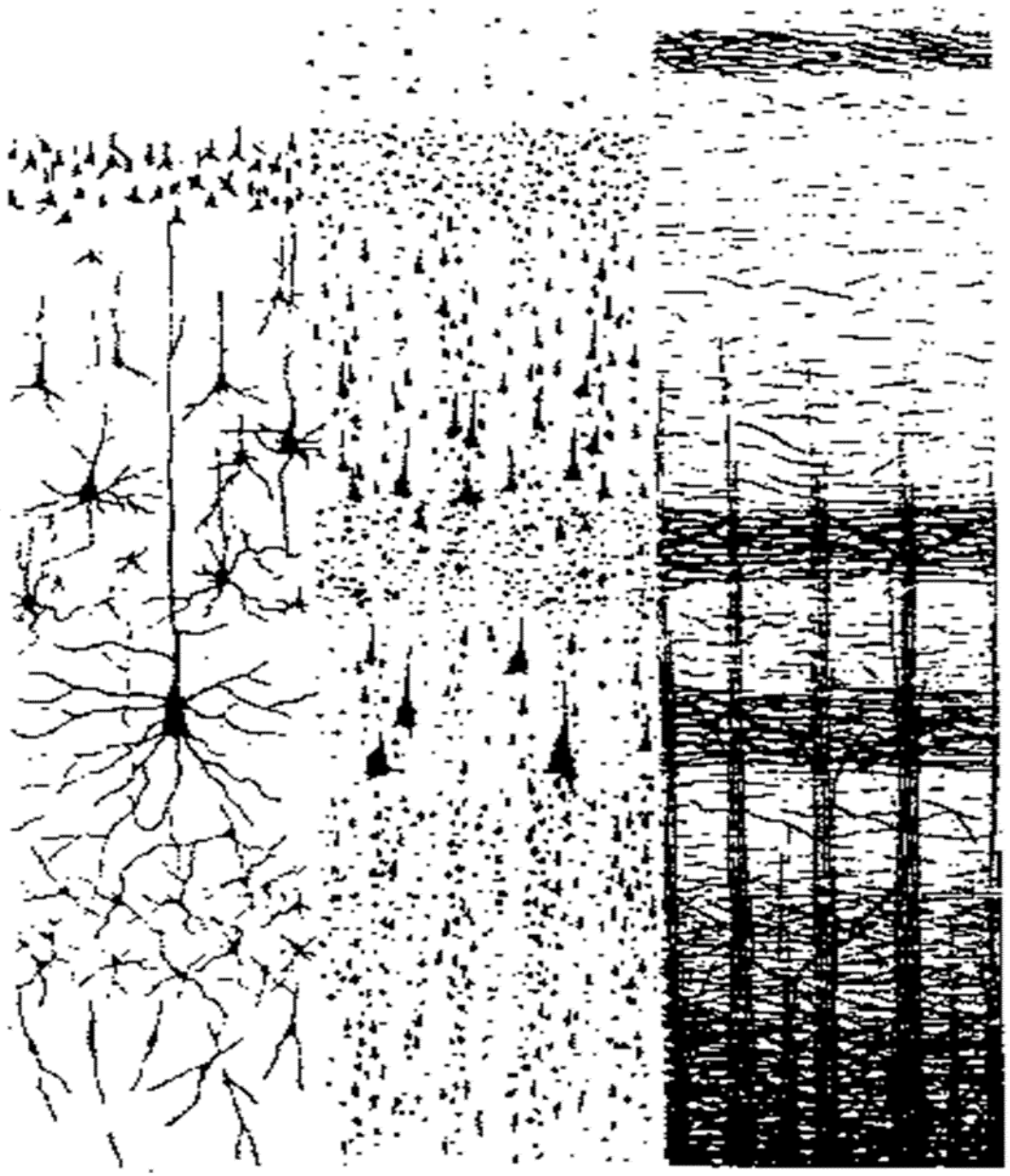


REGIONAL VARIATIONS OF THE NEOCORTEX

- Heterotypical variants – some lamina unidentifiable
- Homotypical Variants – all 6 laminae identifiable

HETEROTYPICAL VARIANTS

- ✓Agranular – Area 4, 6, 8 and 44
- ✓Granular - Lamina III and IV are poorly developed; associated with afferent projections

HOMOTYPICAL VARIANTS

- Intermediate forms
- ✓Frontal type
- ✓Parietal type
- ✓Polar type

CORTICAL COLUMN

- Group of cortical neurons which can be successively penetrated by a probe inserted perpendicular to the pial surface
- 2m functional columns in humans
- 50 to 100 cortical mini-columns in each column
- 80–120 neurons in each mini-column

PROPERTIES OF THE MODULE

- Have nearly identical receptive fields
- Respond to a single peripheral stimulus
- Vertical activation
- Lateral inhibition
- Based on thalamic projection to layer IV

CEREBELLUM

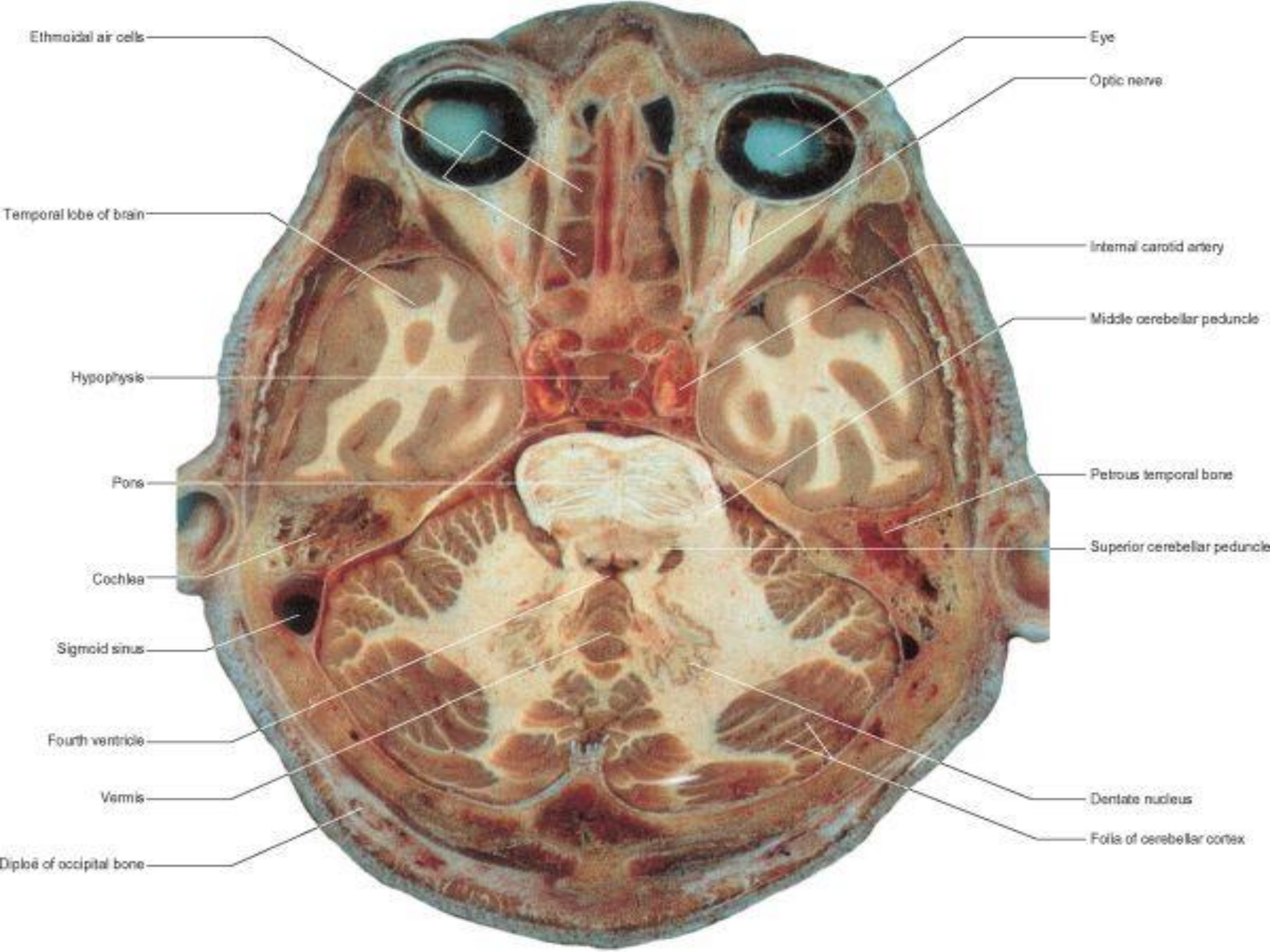
1. Name the parts of the cerebellum
2. State the functional lobes of the cerebellum
3. Name the cerebellar nuclei and state the connections of each
4. Layers of the cerebellar cortex
5. Cell types of the cerebellar cortex
6. Types of cerebellar inputs

THE CEREBELLUM

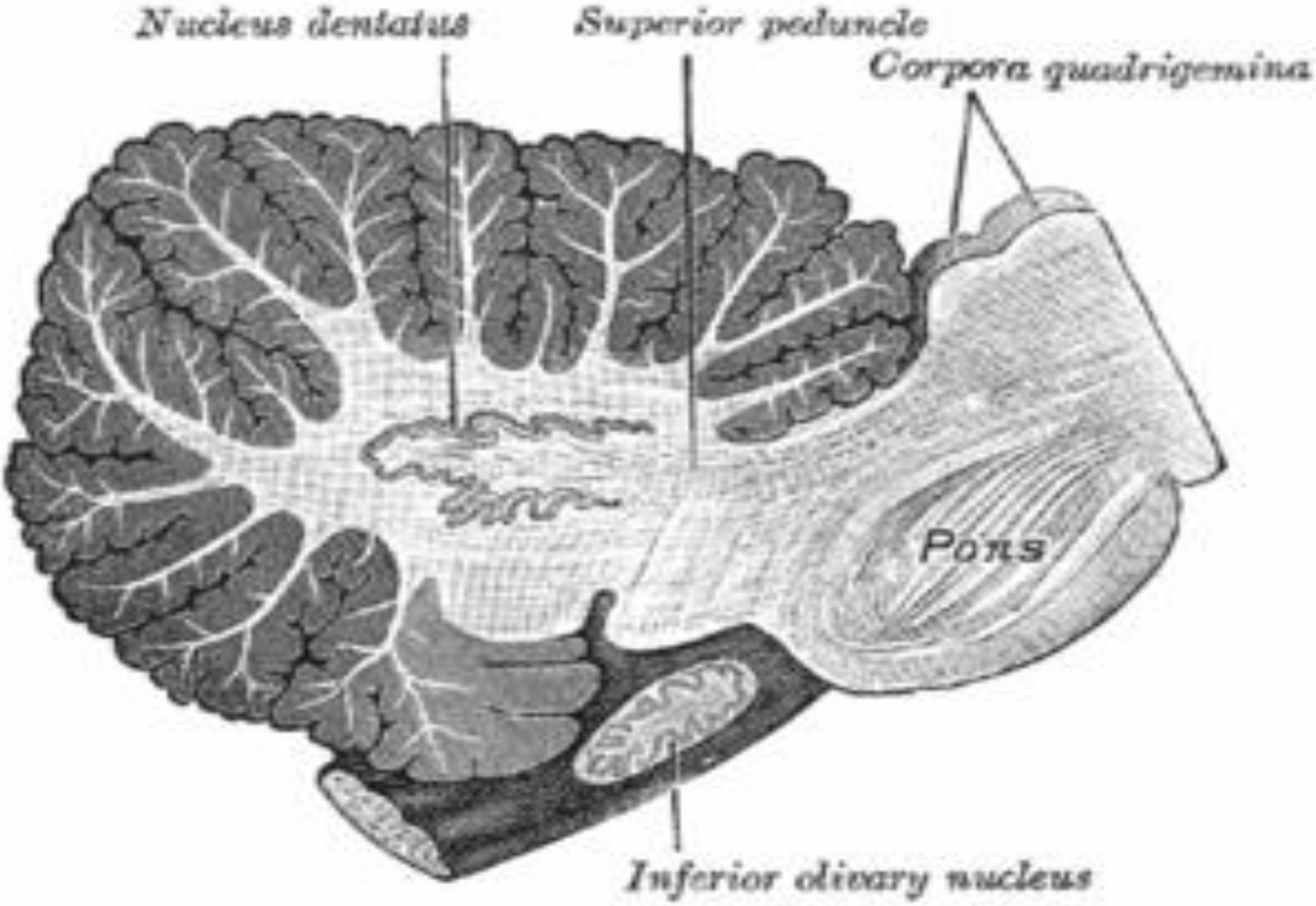
- Location – posterior cranial fossa
- Below tentorium cerebelli
- Dorsal to the pons, medulla and 4th ventricle
- 3 bilaterally paired cerebellar peduncles

INTERNAL ORGANIZATION

- Outer cortex overlying a dense core of white matter
- Cortex is highly convoluted (folia)
- White matter has characteristic branching - *arbor vitae*


Ethmoidal air cells
Eye
Optic nerve
Temporal lobe of brain
Internal carotid artery
Middle cerebellar peduncle
Hypophysis
Pons
Petrous temporal bone
Superior cerebellar peduncle
Cochlea
Sigmoid sinus
Fourth ventricle
Vermis
Dentate nucleus
Folia of cerebellar cortex
Diploë of occipital bone

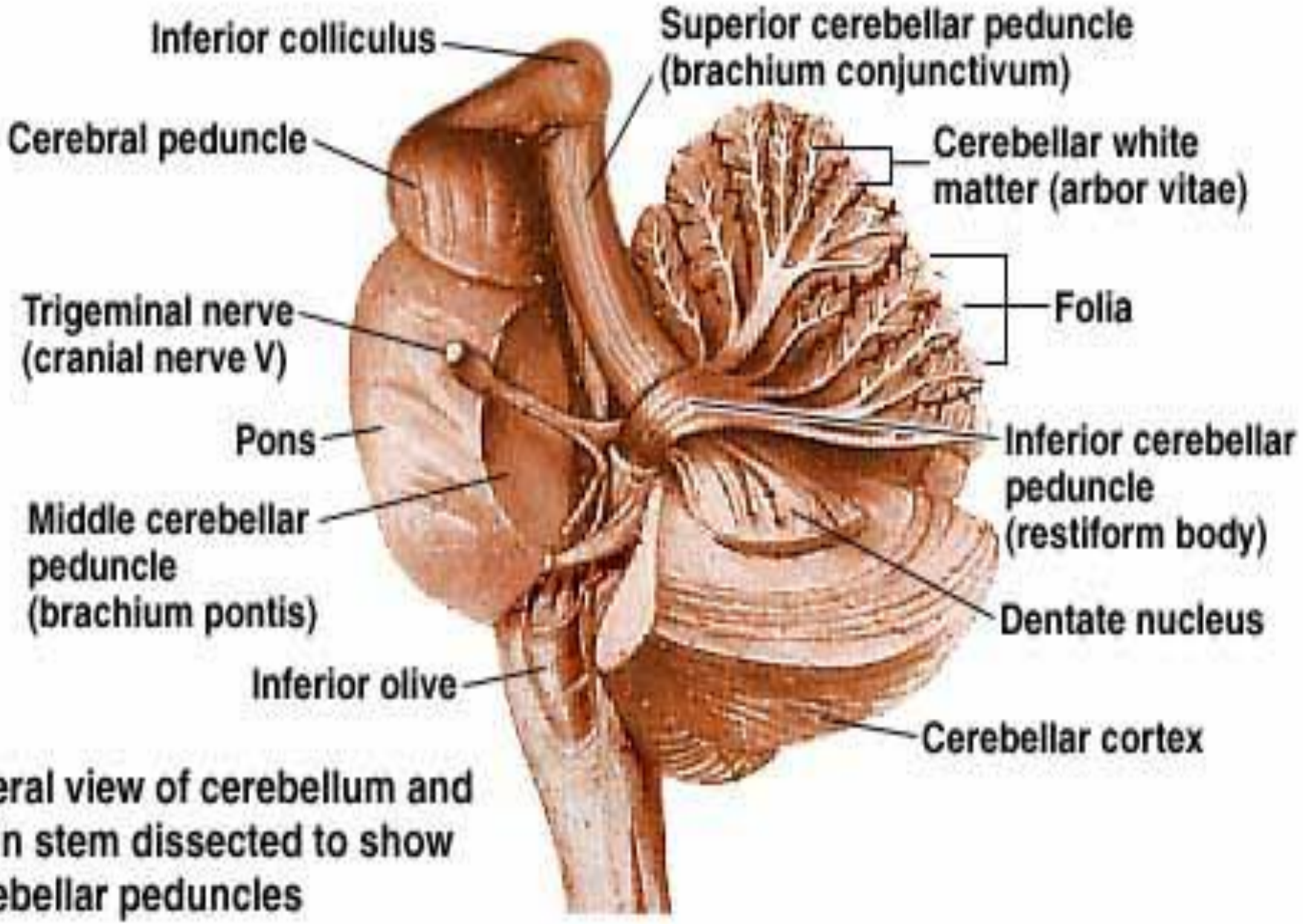
CEREBELLAR NUCLEI



CEREBELLAR CONNECTIONS

- Afferent input terminates in the cortex
- Cortical output by Purkinje neurons to the cerebellar nuclei
- Nuclei give the cerebellar efferent projections

CEREBELLAR PEDUNCLES



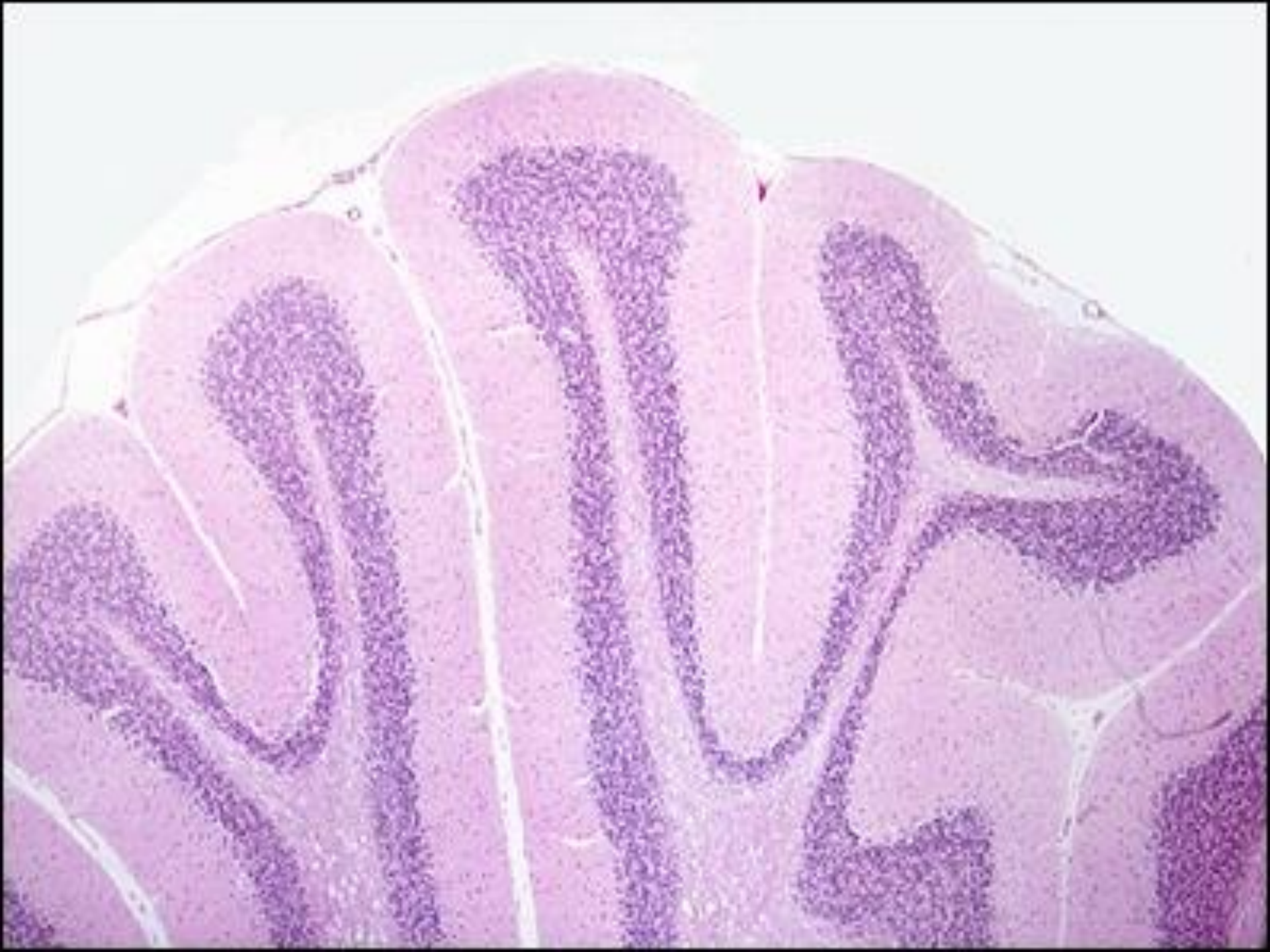
Lateral view of cerebellum and brain stem dissected to show cerebellar peduncles

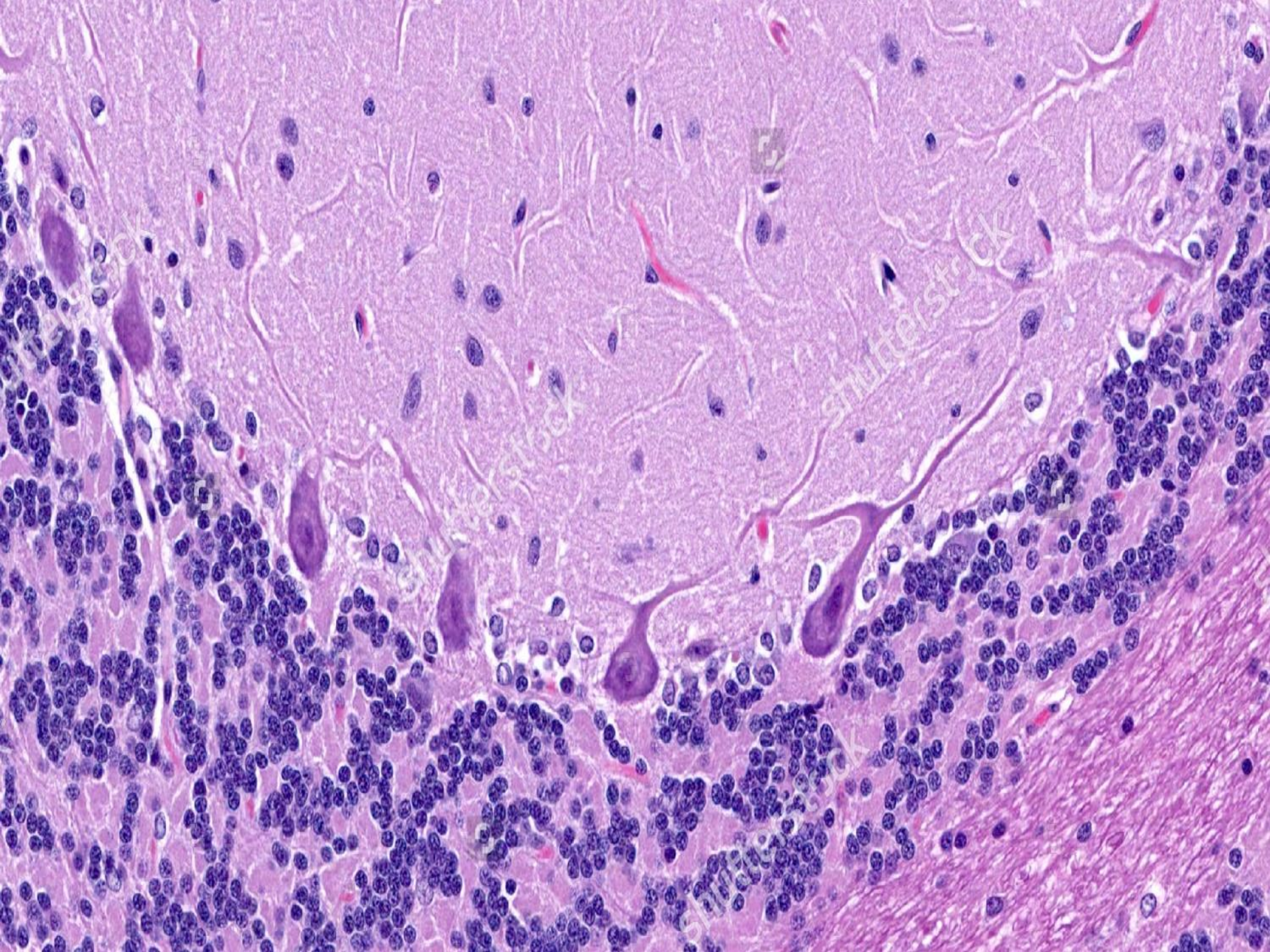
FUNCTIONAL DIVISIONS

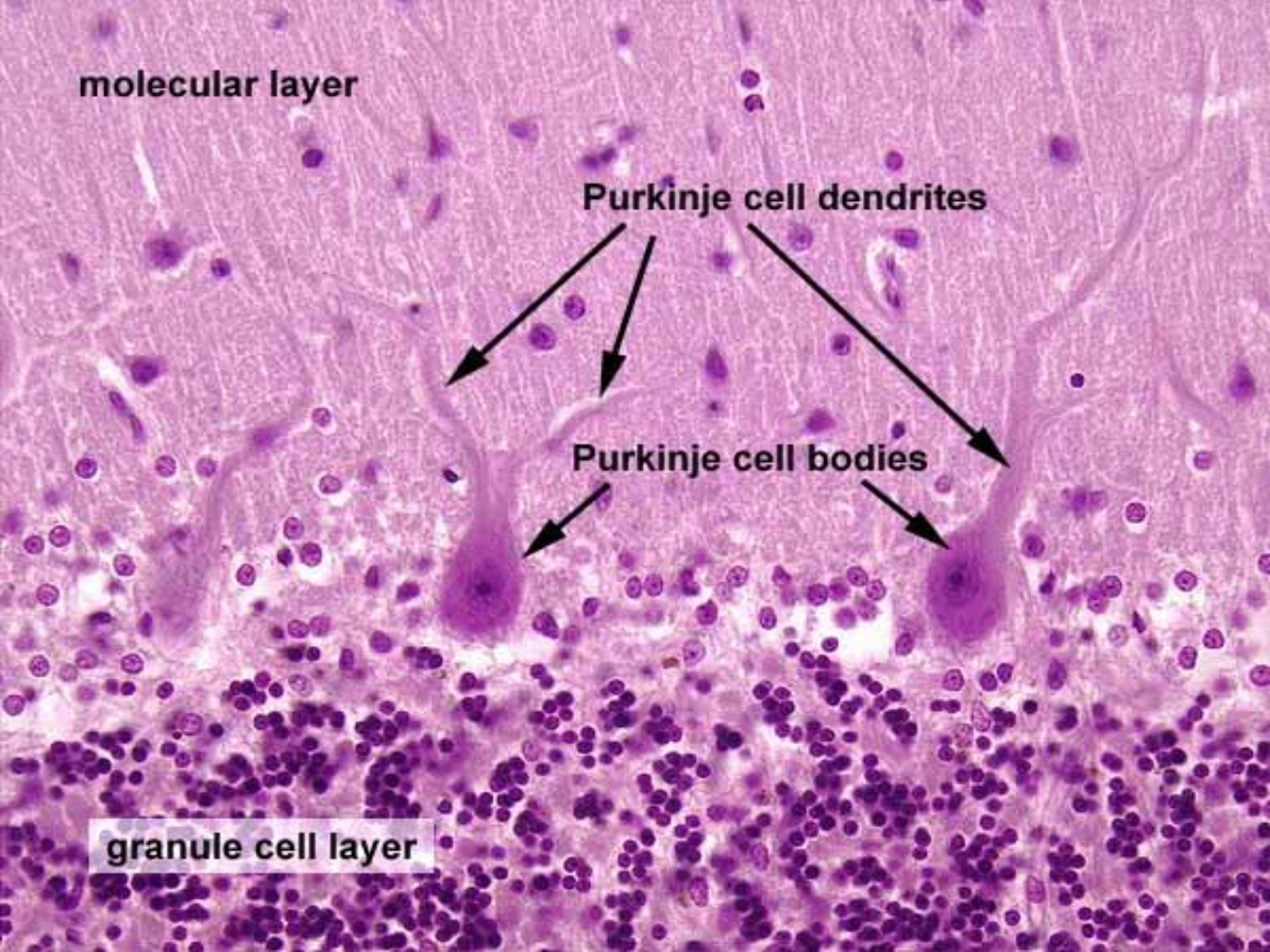
- Vestibulocerebellum
- Spinocerebellum
- Cerebrocerebellum

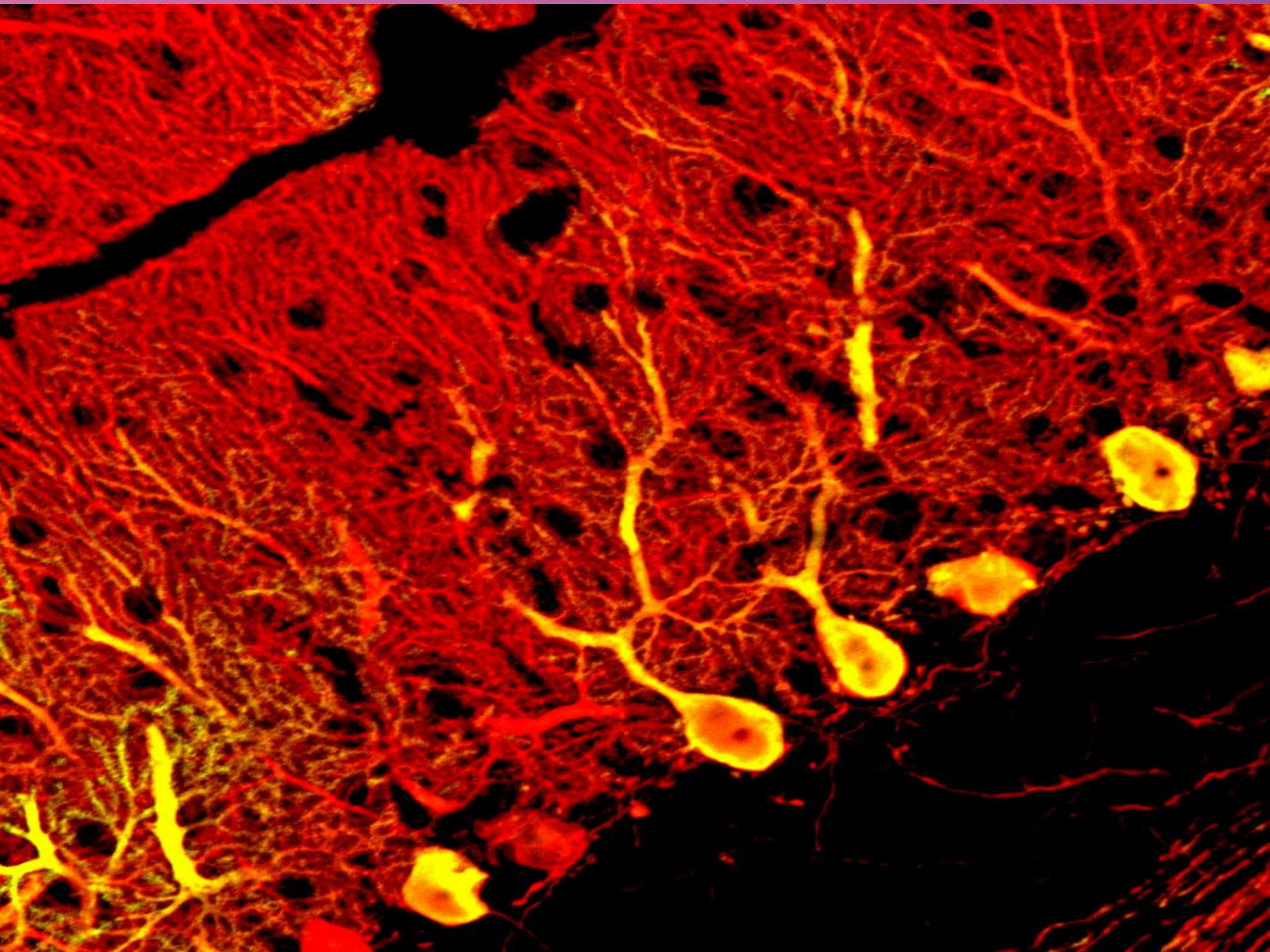
CEREBELLAR CORTEX

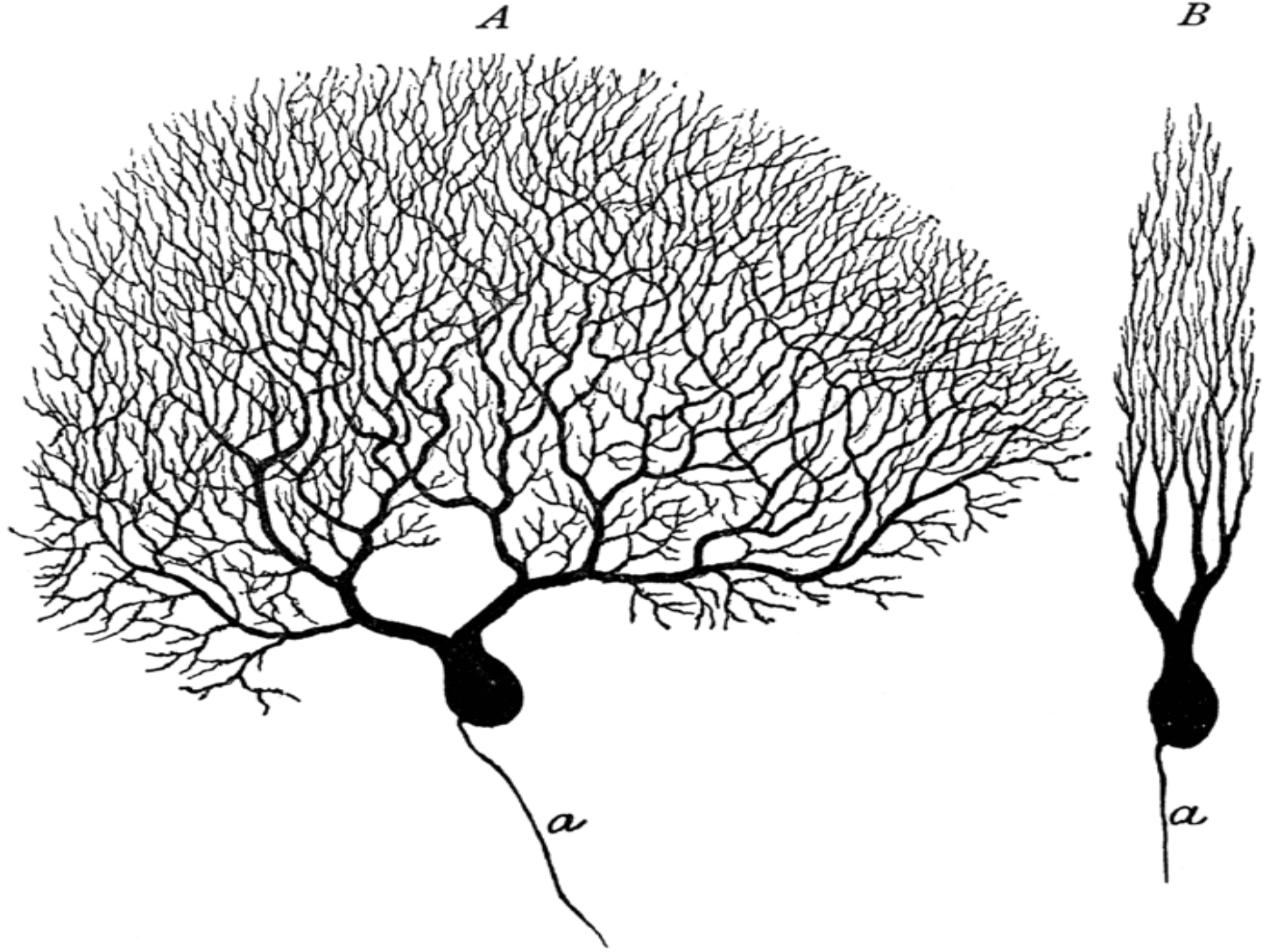
- Highly convoluted and densely packed grey matter
- Terminations of afferent fibers
- Neurons – granular, stellate, basket, Golgi and Purkinje
- Neuroglia
- Blood vessels






molecular layer
Purkinje cell dendrites
Purkinje cell bodies
granule cell layer




A
B
a
a

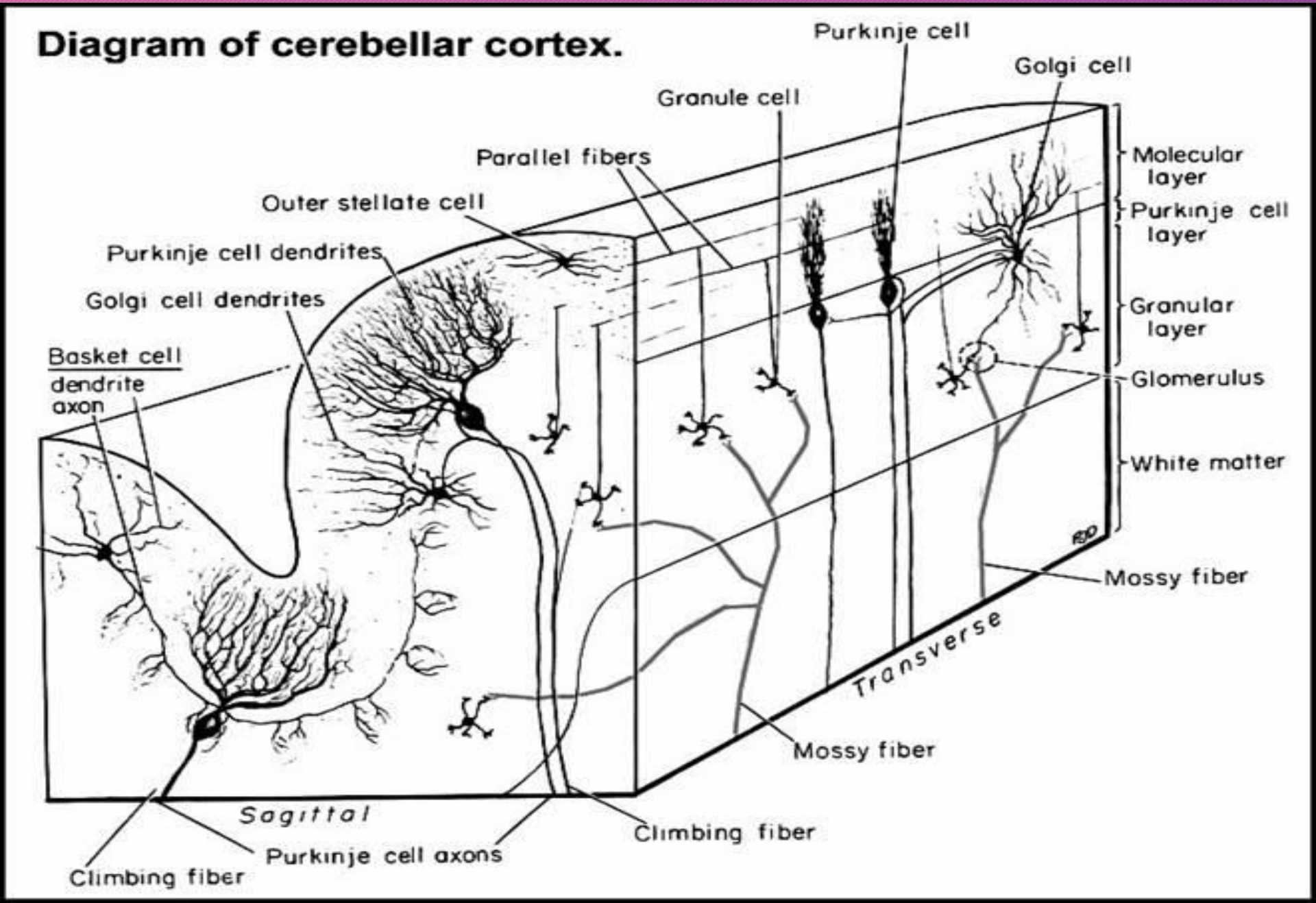
BASKET AND STELLATE CELLS

- Neurons within molecular layer
- Dendrites parallel to the Purkinje cell dendritic tree
- Are inhibitory

GOLGI NEURONS

- Occupy the superficial zone of the granular layer
- Dendrites radiate into the molecular layer
- Inhibitory neurons

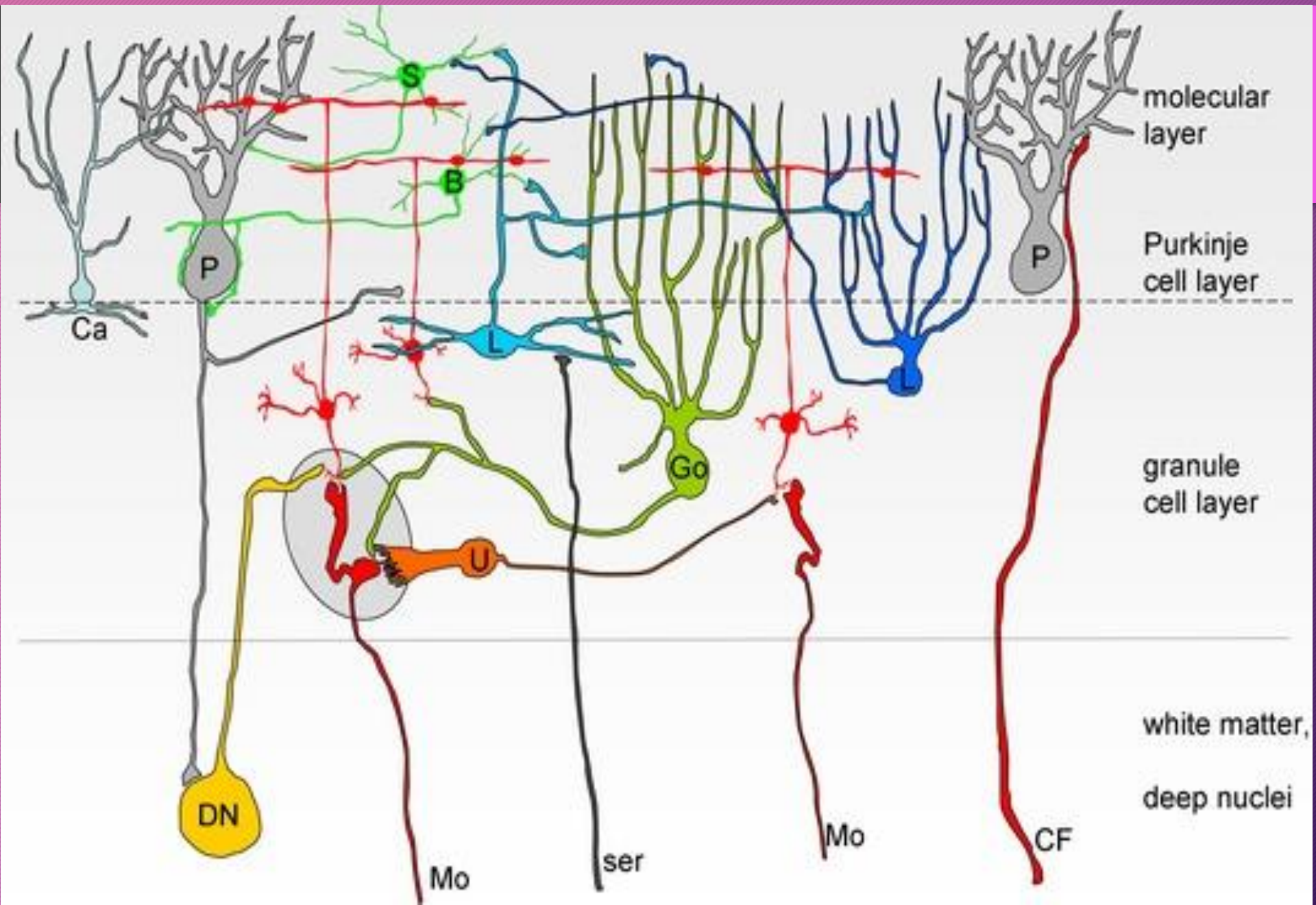
GOLGI NEURONS



GRANULE CELLS

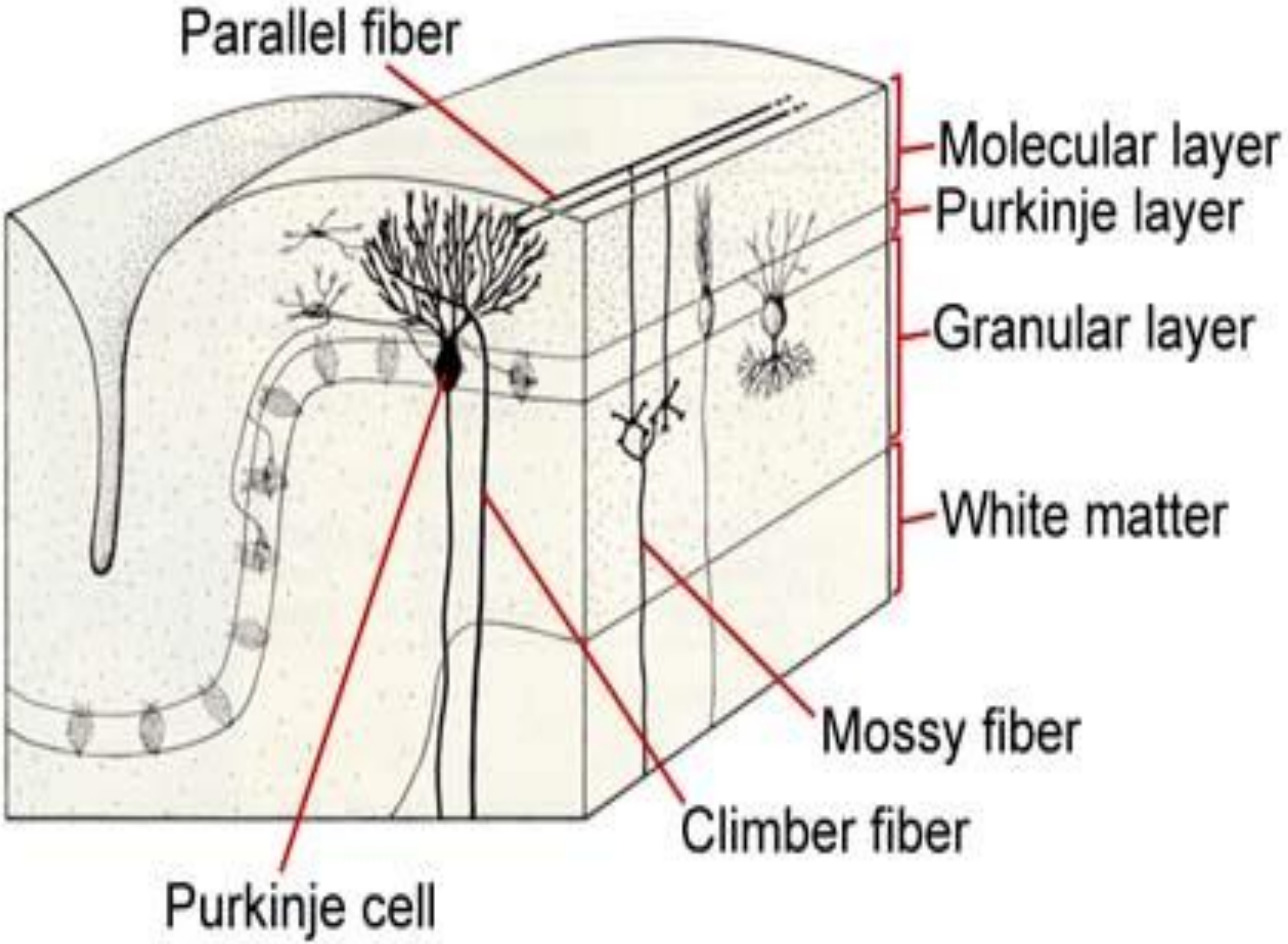
- In the granular layer
- Give rise to 3 to 5 short dendrites, which end in claw-like terminals within the synaptic glomeruli
- Axons enter the molecular layer and branch at a T-junction to form parallel fibers

GRANULE CELLS

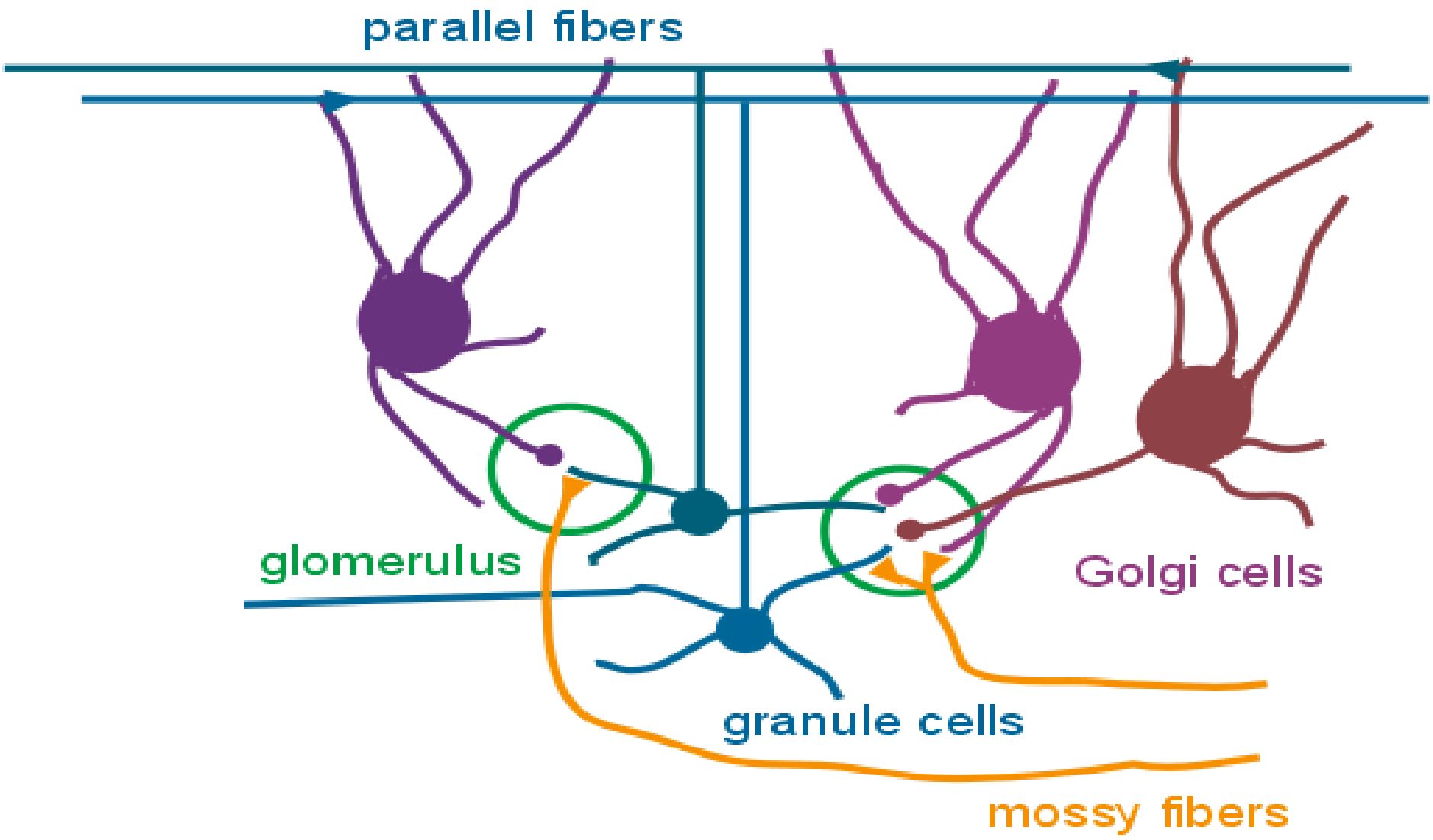


CEREBELLAR INPUTS

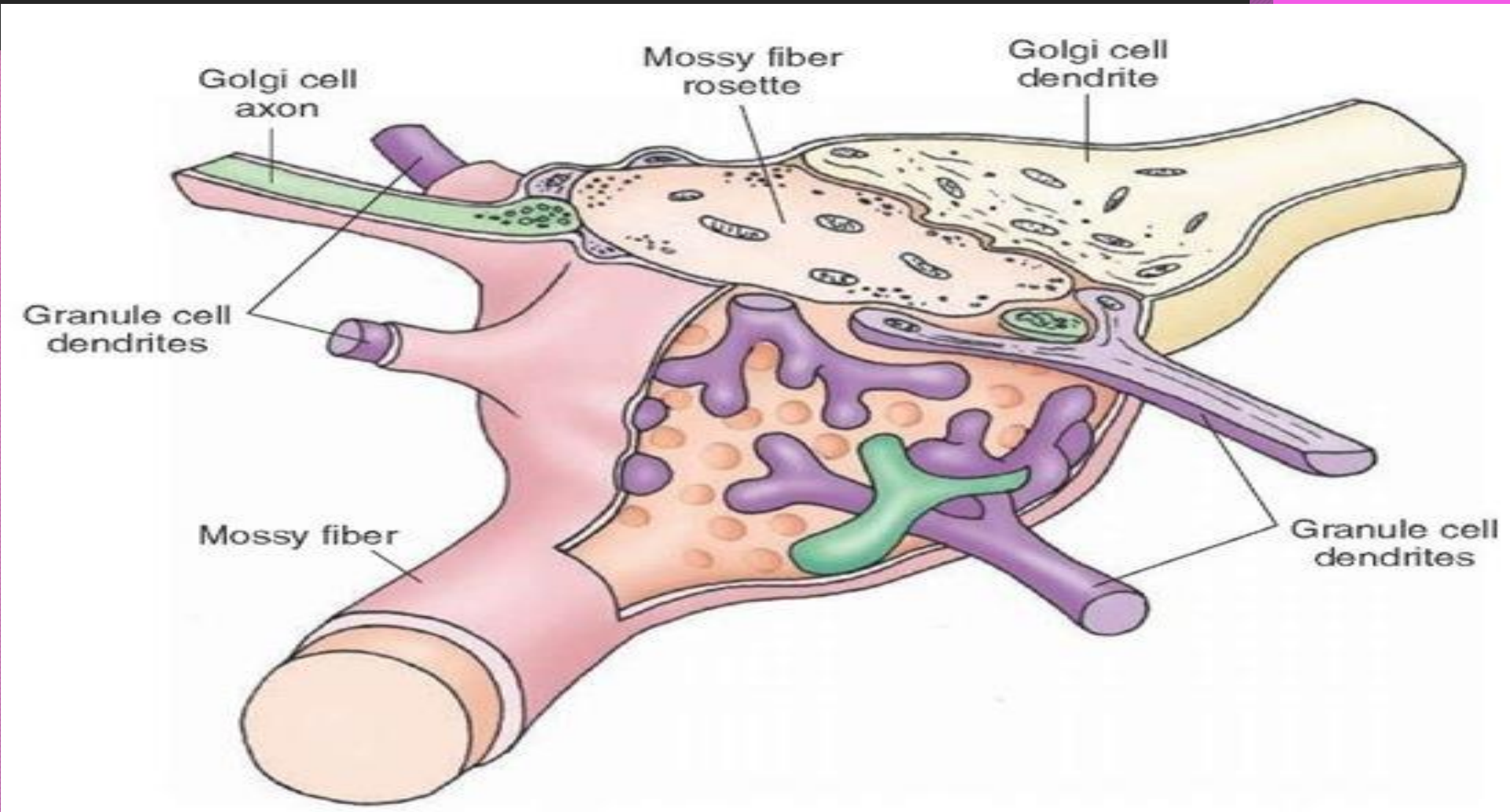
- Climbing fibers – *olivocerebellar*; synapse directly on Purkinje neurons
- Mossy fibers – other afferents to the Purkinje cells via *granular* neurons
- Monoaminergic from brainstem reticular formation

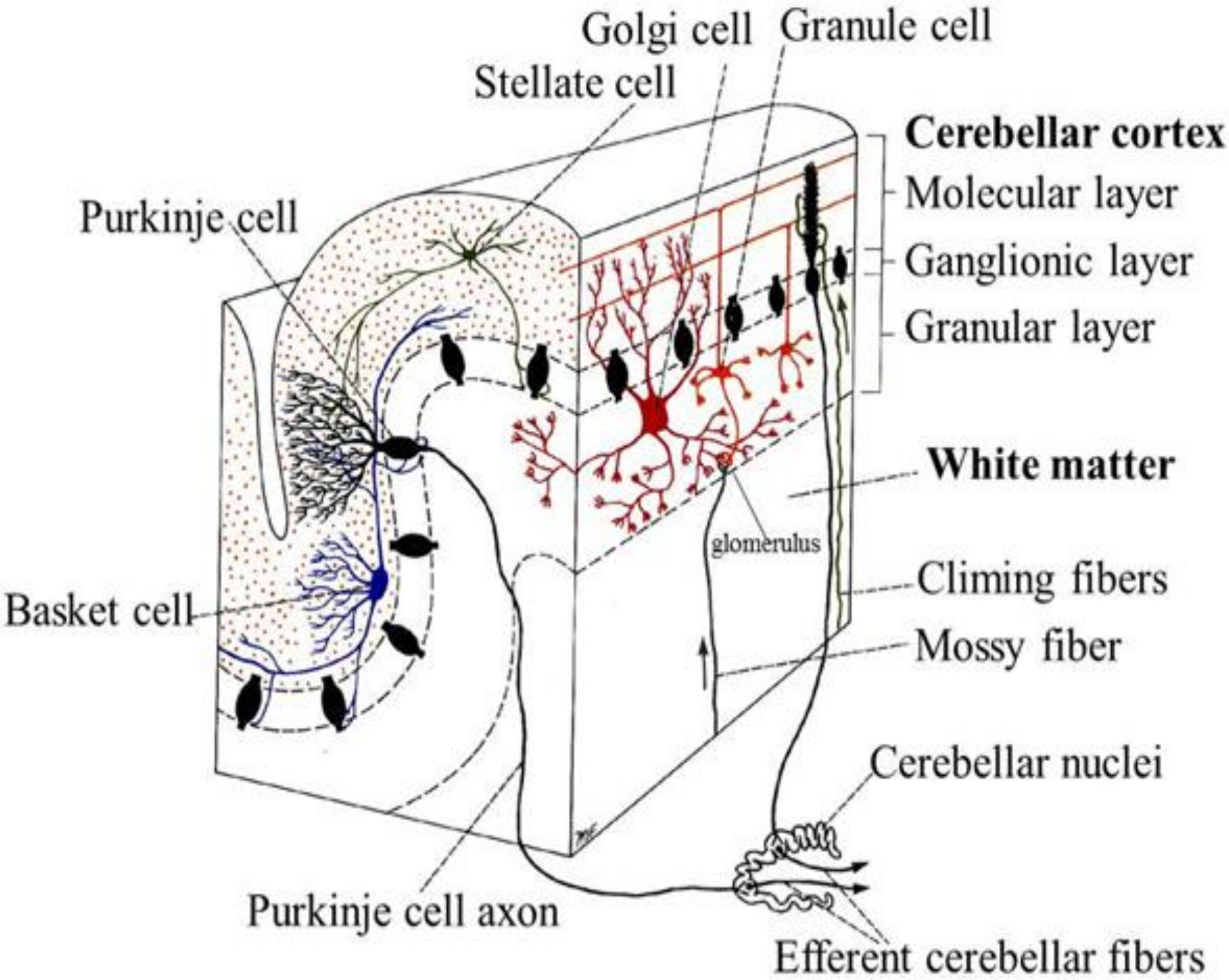

Parallel fiber
Molecular layer
Purkinje layer
Granular layer
White matter
Mossy fiber
Climber fiber
Purkinje cell

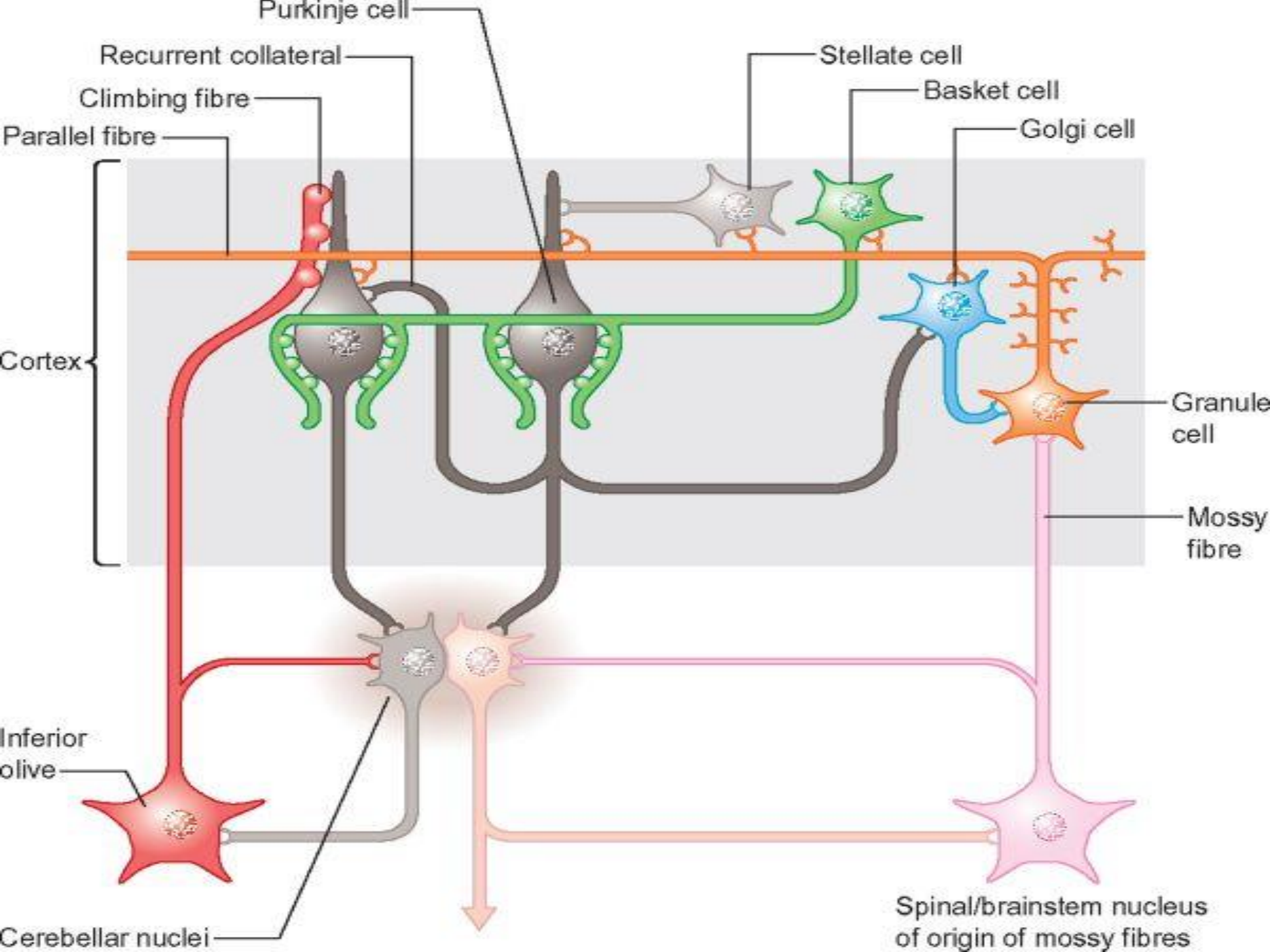
CEREBELLAR GLOMERULUS



MOSSY FIBRER ROSETTE




Golgi cell
Granule cell
Stellate cell
Cerebellar cortex
Molecular layer
Purkinje cell
Ganglionic layer
Granular layer
White matter
glomerulus
Climing fibers
Basket cell
Mossy fiber
Cerebellar nuclei
Purkinje cell axon
Efferent cerebellar fibers


Purkinje cell
Recurrent collateral
Climbing fibre
Parallel fibre
Stellate cell
Basket cell
Golgi cell
Cortex
Granule cell
Mossy fibre
Inferior olive
Cerebellar nuclei
Spinal/brainstem nucleus of origin of mossy fibres

FEATURES OF CEREBELLAR LESIONS

- Cerebellar ataxia
- Intention tremors
- Dysdiadochokinesia
- Dysmetria (past pointing)
- Dysarthria

THANK YOU