

HISTOLOGY OF CEREBRAL CORTEX

PRESENTED BY- DR.A.RAMYA (First year pg)

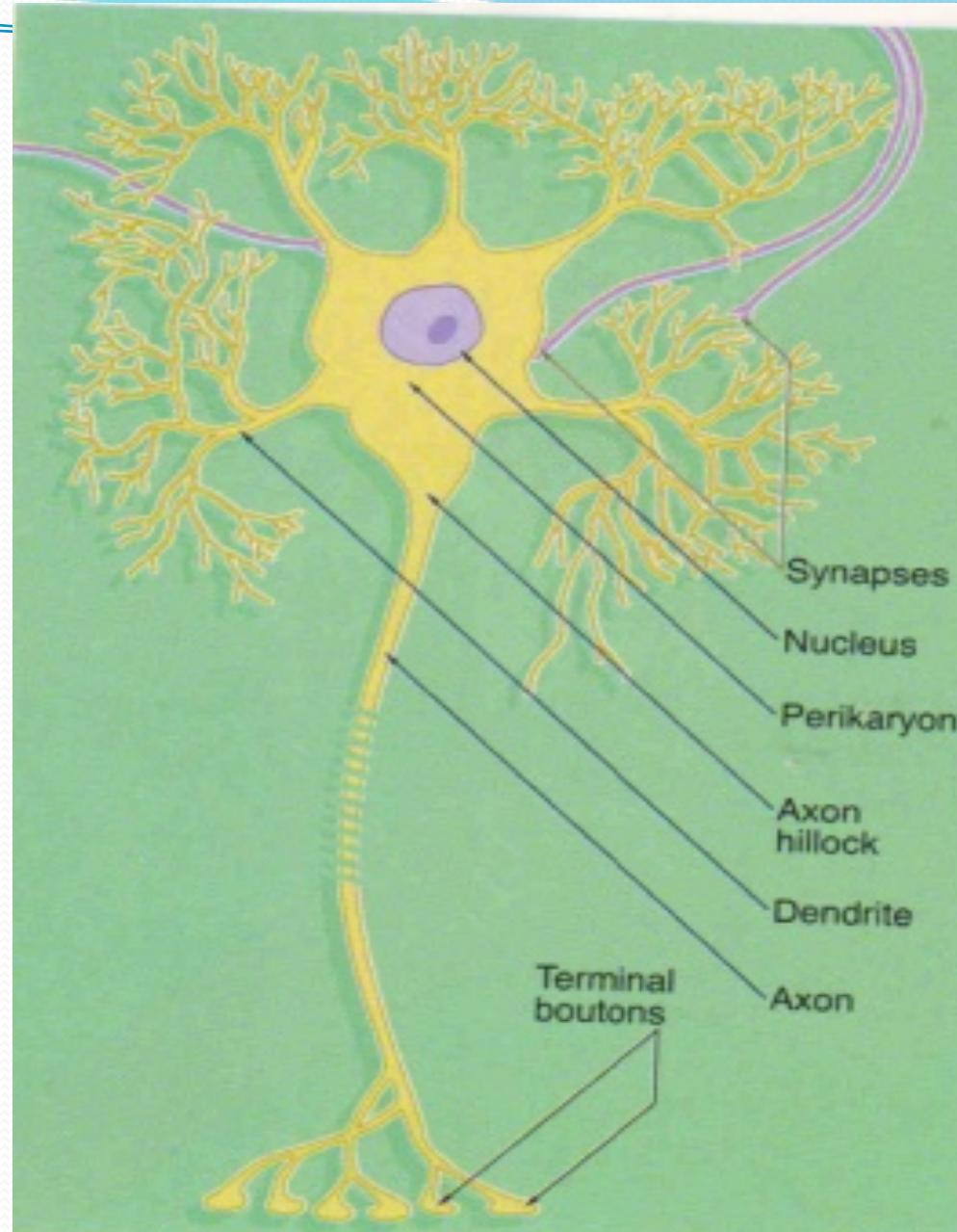
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DR.NEELIMA (Asst.Prof)**

INTRODUCTION

- The central nervous system consists of the brain and spinal cord, which are composed of neurons, the supporting glial cells and blood vessels.
- Basic structure of a neuron consists of
 - cell body
 - dendrites
 - axon

- Structure of Neuron

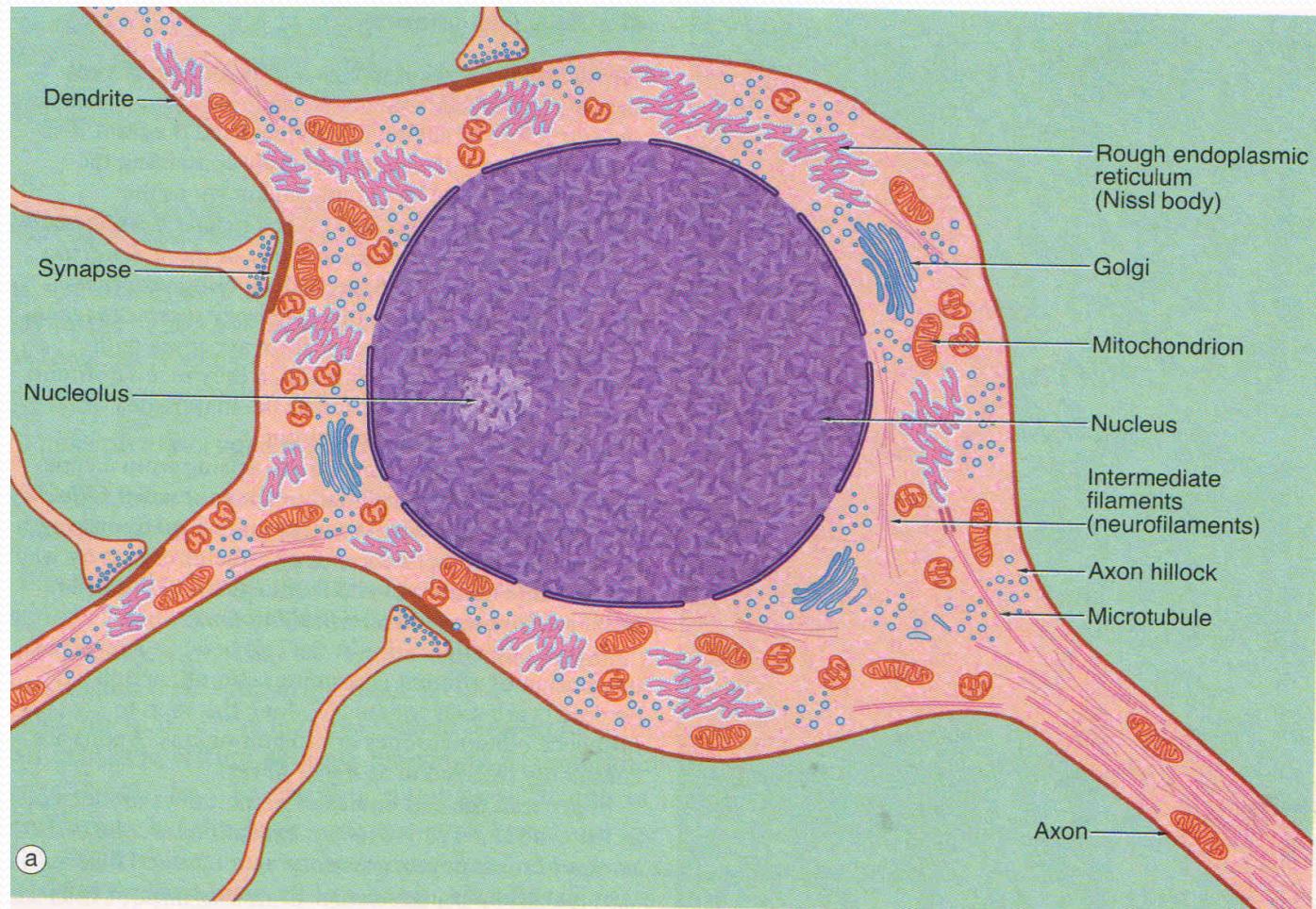


Basic neuron types

-Based on the arrangement of the axon and dendrites, with respect to cell body.



ULTRASTRUCTURE OF NEURON

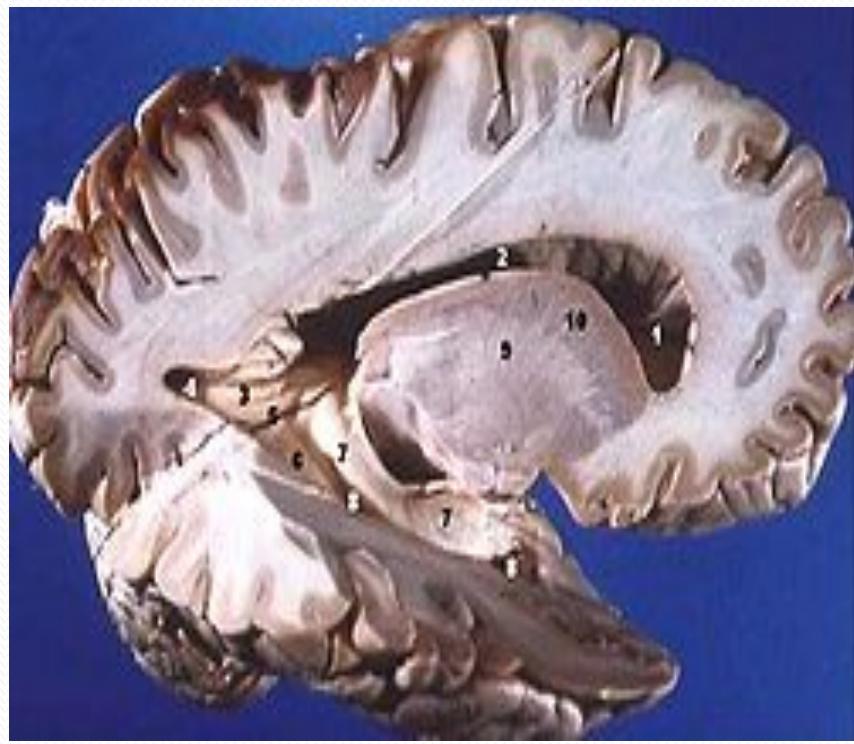


CEREBRAL CORTEX

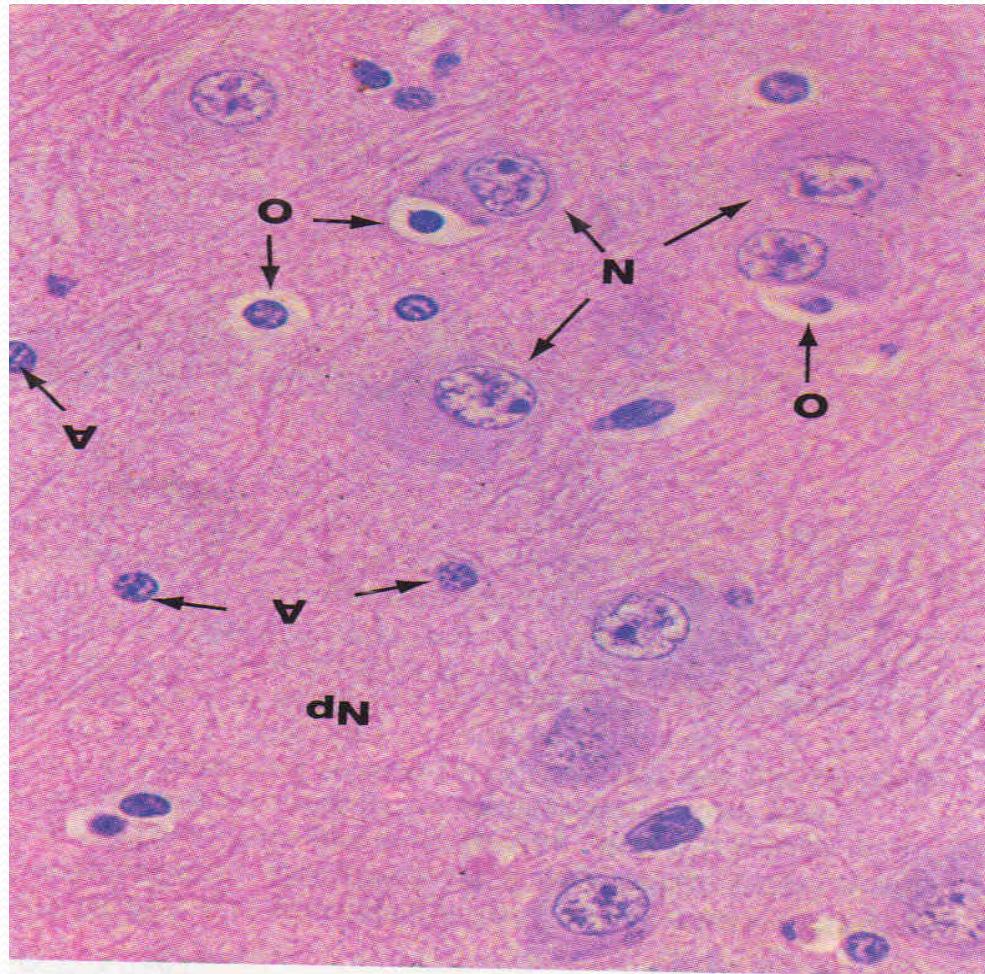
- The cerebral hemispheres consists of a convoluted cortex of grey matter overlying central medullary mass of white matter.
- The grey matter consists of neuron cell bodies and their dendritic interconnections & glial cells.
- The white matter conveys fibers between different parts of the cortex and from other parts of CNS.

Contd..

- The cortex is a thin layer of neurons and their inter connections, measuring few mm and contains 30 billion neurons.
- The evolved cortex in mammals called neocortex consists of 6 layers of neurons.



HISTOLOGY OF GREY MATTER

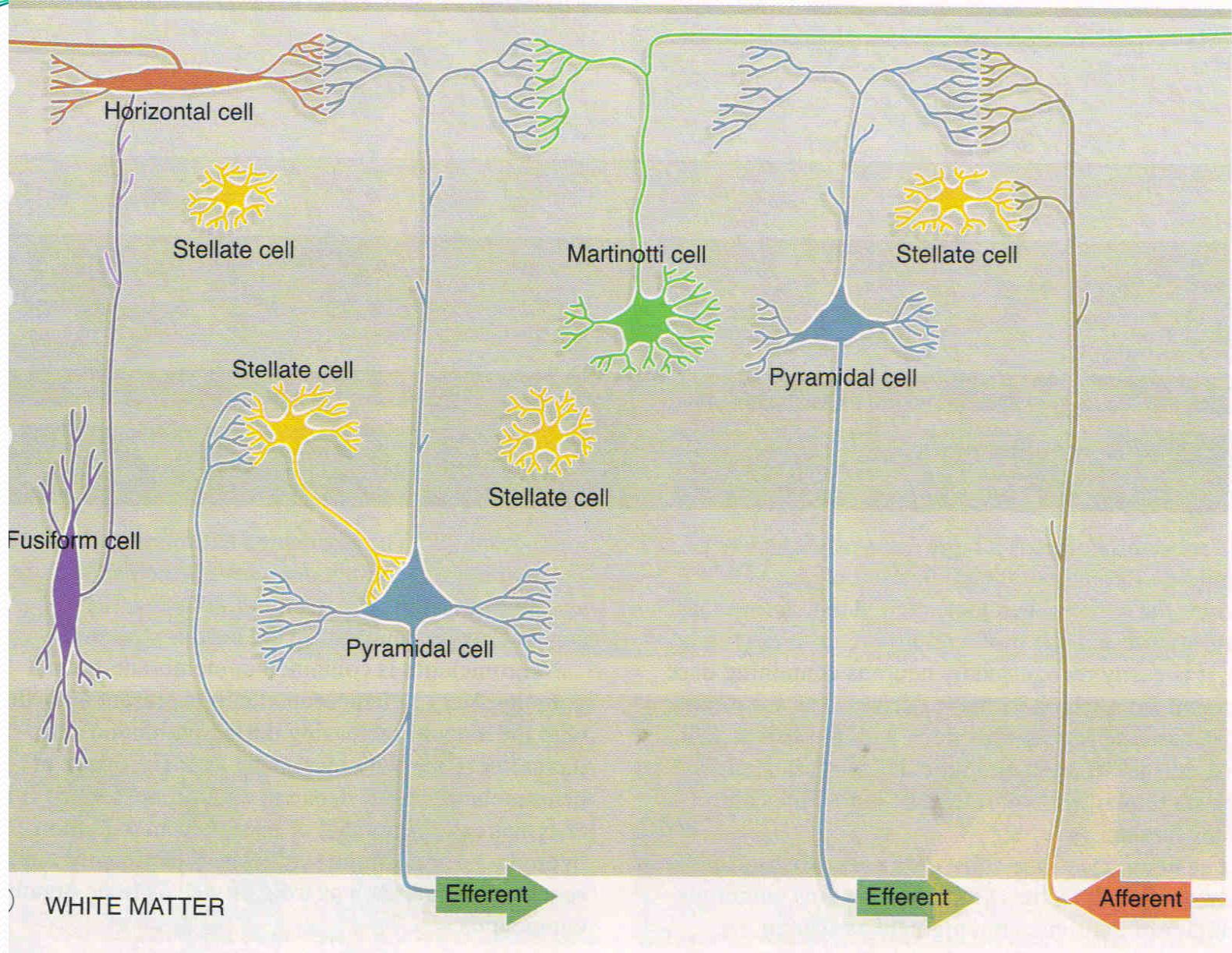


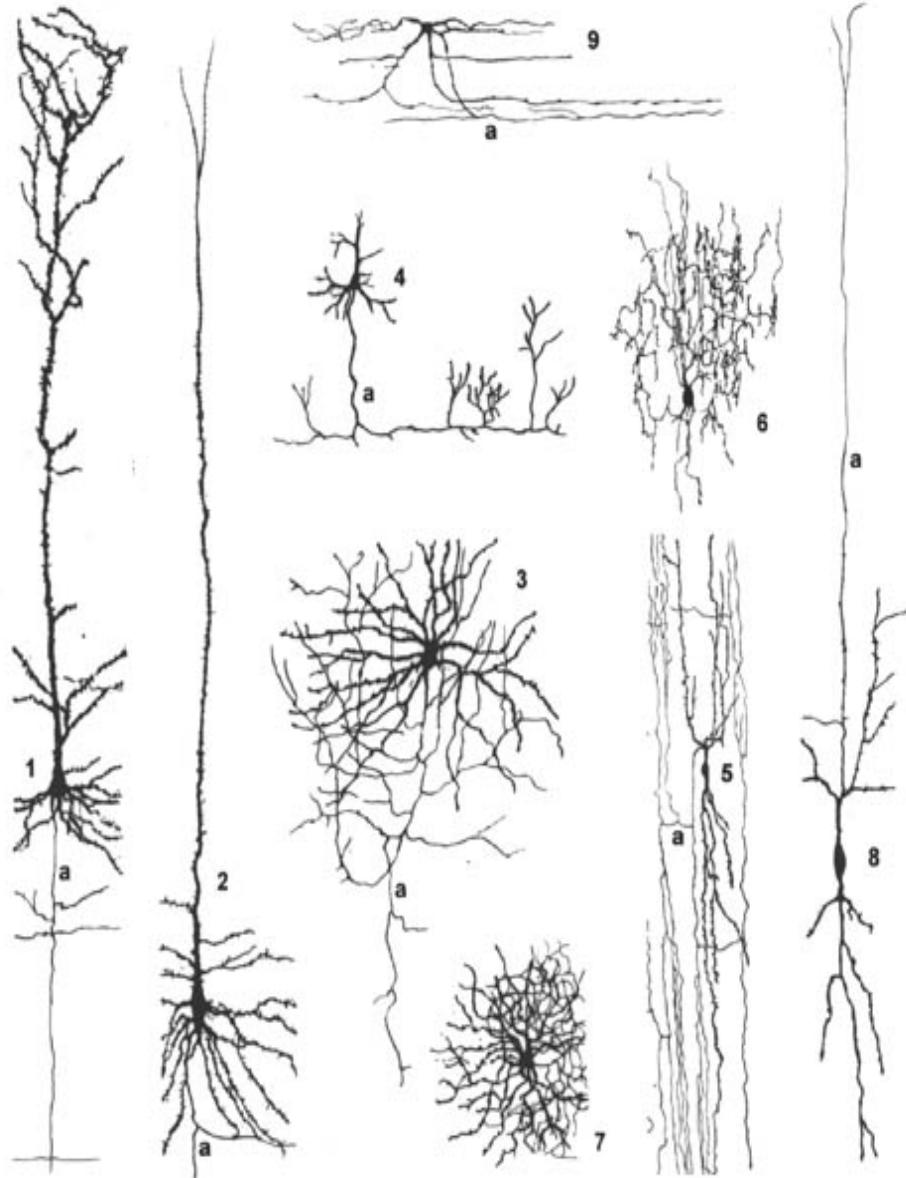
TYPES OF CORTEX

- Neocortex
 - >90 % of our total cortical area.
 - 6 layered structure.
 - Referred to as homogenous cortex.
- Paleocortex
 - Covers some parts of the base of the telencephalon.(olfactory area)
 - Forms heterogenous cortex.
- archicortex
 - The hippocampal formation.

Neuron Cell types

- Two principal cell types are present in neo cortex.
 - 1.The pyramidal cell
 - 2.The Stellate cell
- Other cells are
 - 3. The cells of Martinotti
 - 4.Fusiform cells
 - 5.Horizontal cells of cajal



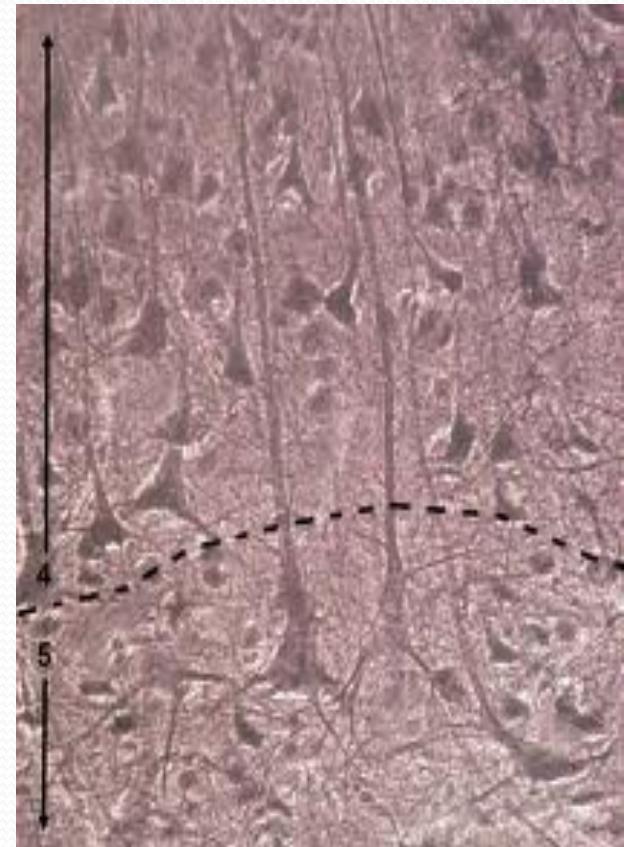


- 1. Pyramidal Cell**
- 2. Fusiform Cell**
- 3. Granular (Stellate) Cell**
- 4. Horizontal Cell of Cajal**
- 5. Cells of Martinotti**

a: axon

PYRAMIDAL CELLS

- Pyramid shaped cell bodies.
- About 10 microns to 70 microns in diameter.
- Axon arises from the base and the dendrite from the apex.
- The largest of the pyramidal cells are called the **BETZ cells**.

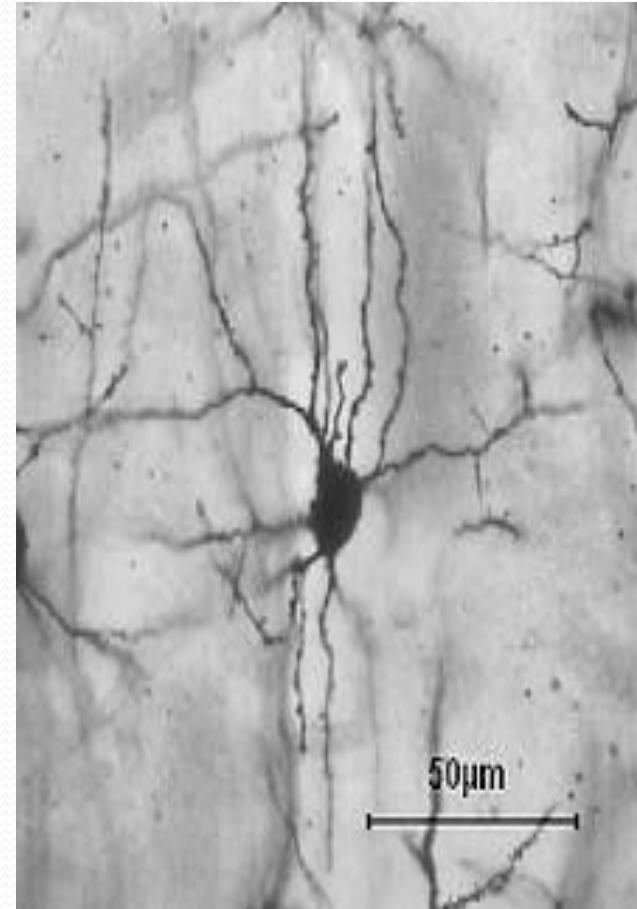


Functions of pyramidal cells

- The **apical dendrites** of pyramidal cells are studded with **dendritic spines**.
- These are **numerous small projections** that are the **preferential site of synaptic contact**.
- It has been suggested that dendritic spines may be the sites of synapses that are selectively modified as a result of learning.
- Most or all pyramidal cells have **long axons** that **leave the cortex** to reach either **other cortical areas** or to various **subcortical sites**.
- Therefore, pyramidal cells are the **principal output neurons**.

STELLATE CELLS

- Also known as granular cells.
- They are the principal interneurons of cortex .
- These come in a **wide assortment of shapes**.
- They are typically **small (< 10 micrometres) multipolar neurons**.



FUNCTIONS OF STELLATE CELLS

- The **short axons of stellate cells do not leave the cortex.**
- Stellate cells are the **principal interneurons** of the neocortex.

CELLS OF MARTINOTTI

- Small polygonal cells.
- Have very few short dendrites.
- The axon extends towards the surface and bifurcate to run horizontally in most superficial layers.
- Forms synapses with the pyramidal cells.

FUSIFORM CELLS

- Spindle shaped cells.
- They are oriented at right angles to the cortex.
- Axon arises from the side of the cell body and passes superficially.
- Dendrites extend from each end of the cell body branching into deeper and more superficial layers.
- Functions are similar to that of pyramidal cells.

HORIZONTAL CELLS OF CAJAL (OR) RETZIUS CAJAL CELLS

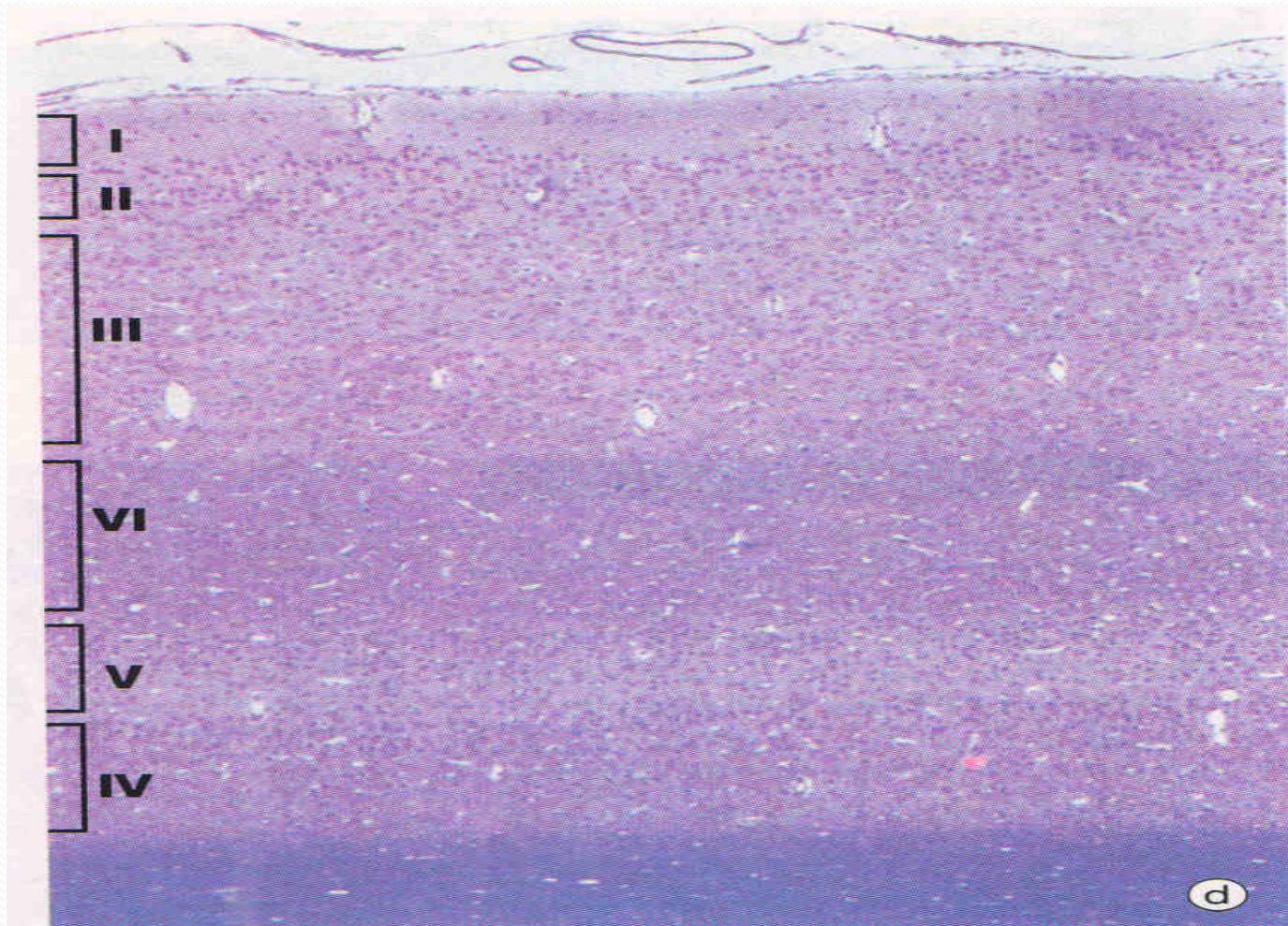
- Small ,spindle shaped.
- Oriented parallel to the surface.
- Least common cell type.
- Found only in most superficial layer.
- Axons pass laterally to synapse with dendrites of pyramidal cells.
- They are prominent during development, but disappear after birth.

LAYERS OF NEOCORTEX

Differing in neuron morphology, size and population density, there are 6 layers in the neocortex.

1. plexiform or molecular layer
2. outer granular layer
3. outer pyramidal cell layer
4. inner granular layer
5. inner pyramidal cell layer/ganglion cell layer
6. multiform cell layer

-The six neocortical layers are not equally prominent everywhere. They form granular & agranular layers.



1.PLEXIFORM LAYER

- Most superficial layer.
- Contains many dendritic and axonal synapses with one another.
- Sparse nuclei are seen that belongs to neuroglia.
- Occasional horizontal cells of cajal are seen.



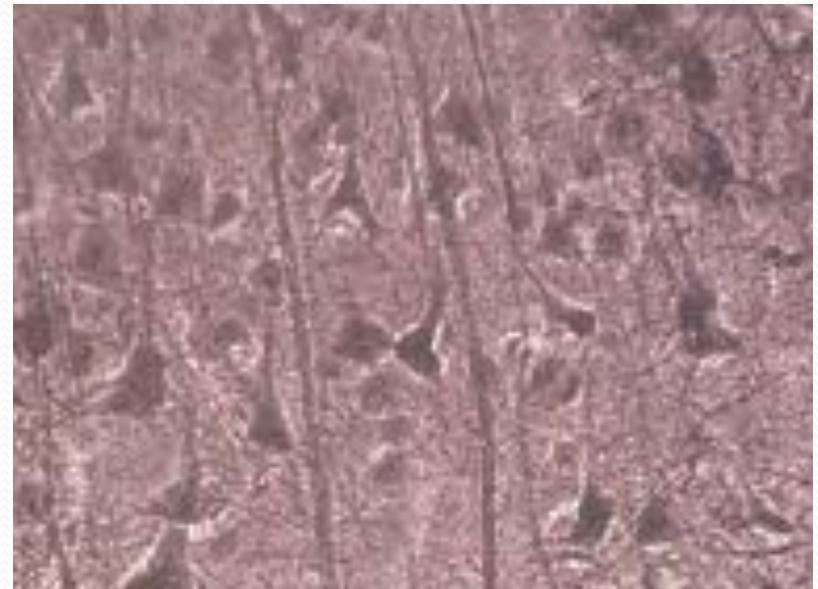
2. OUTER GRANULAR LAYER

- Dense population of small pyramidal cells and stellate cells.
- Also contains various axons and dendritic connections.



3.PYRAMIDAL CELL LAYER

- Moderate sized pyramidal cells predominate.
- Large pyramidal cells are present in further deeper layers.
- Martinotti cells are also present.



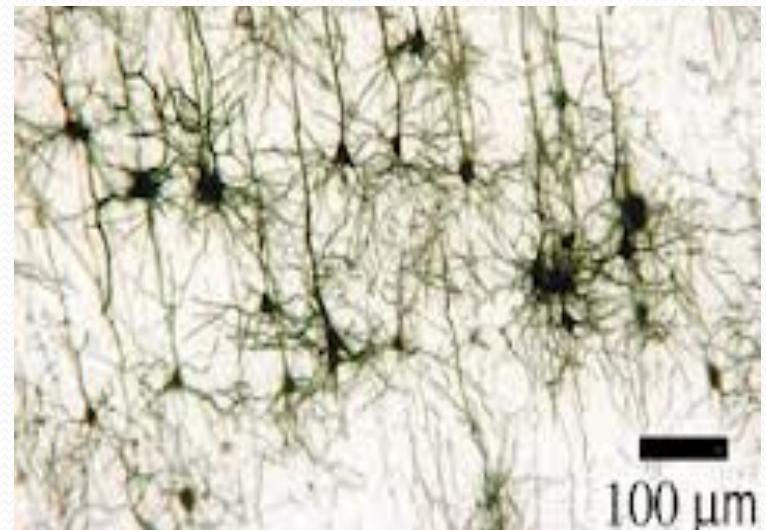
4. INNER GRANULAR LAYER

- Consists of densely packed stellate cells.



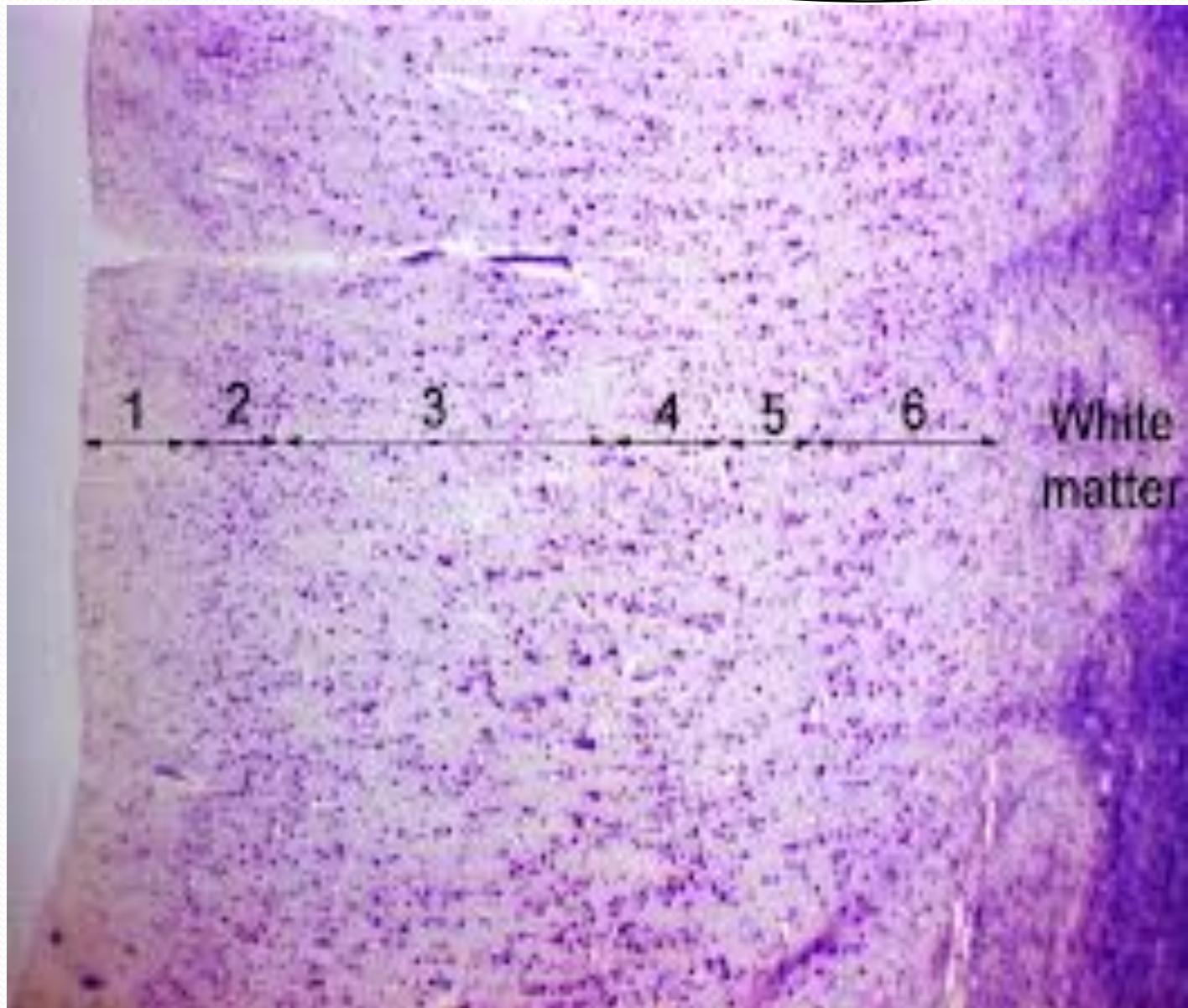
5. GANGLIONIC LAYER

- Large pyramidal cells
- Stellate cells (few)
- Cells of martinotti
- Huge pyramidal Betz cells of motor cortex are present. Hence the name ganglion cell layer.

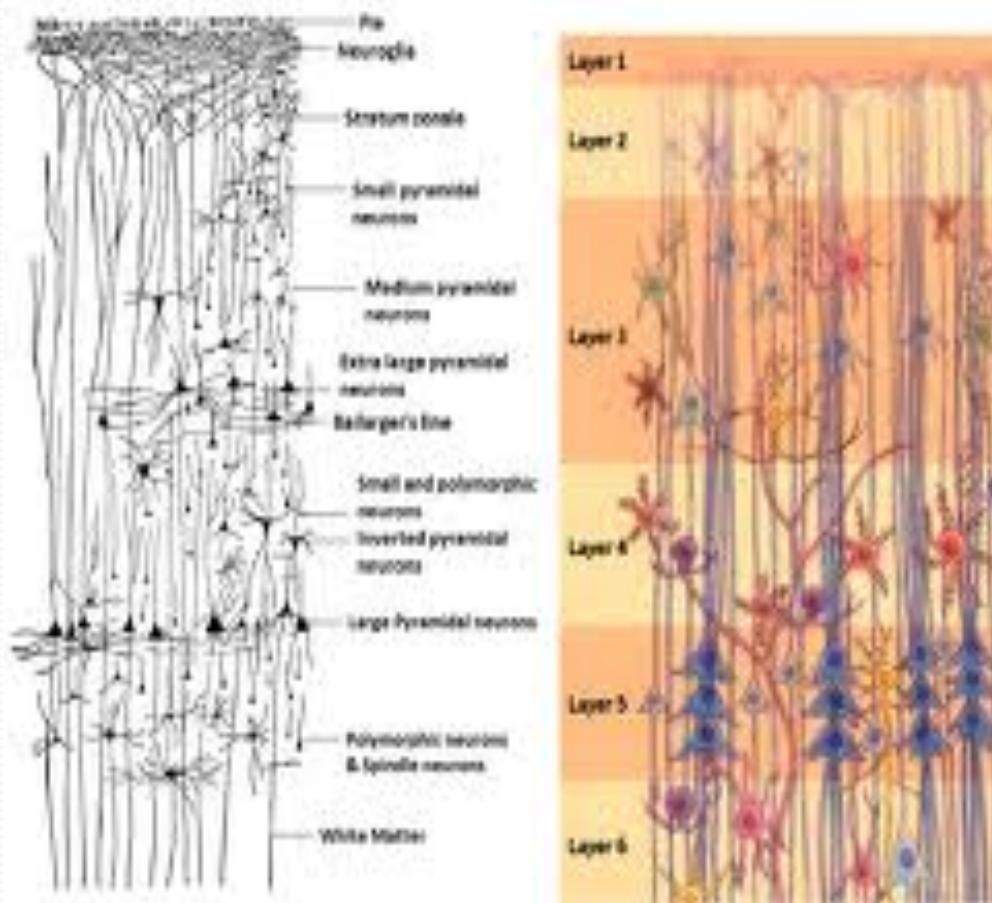


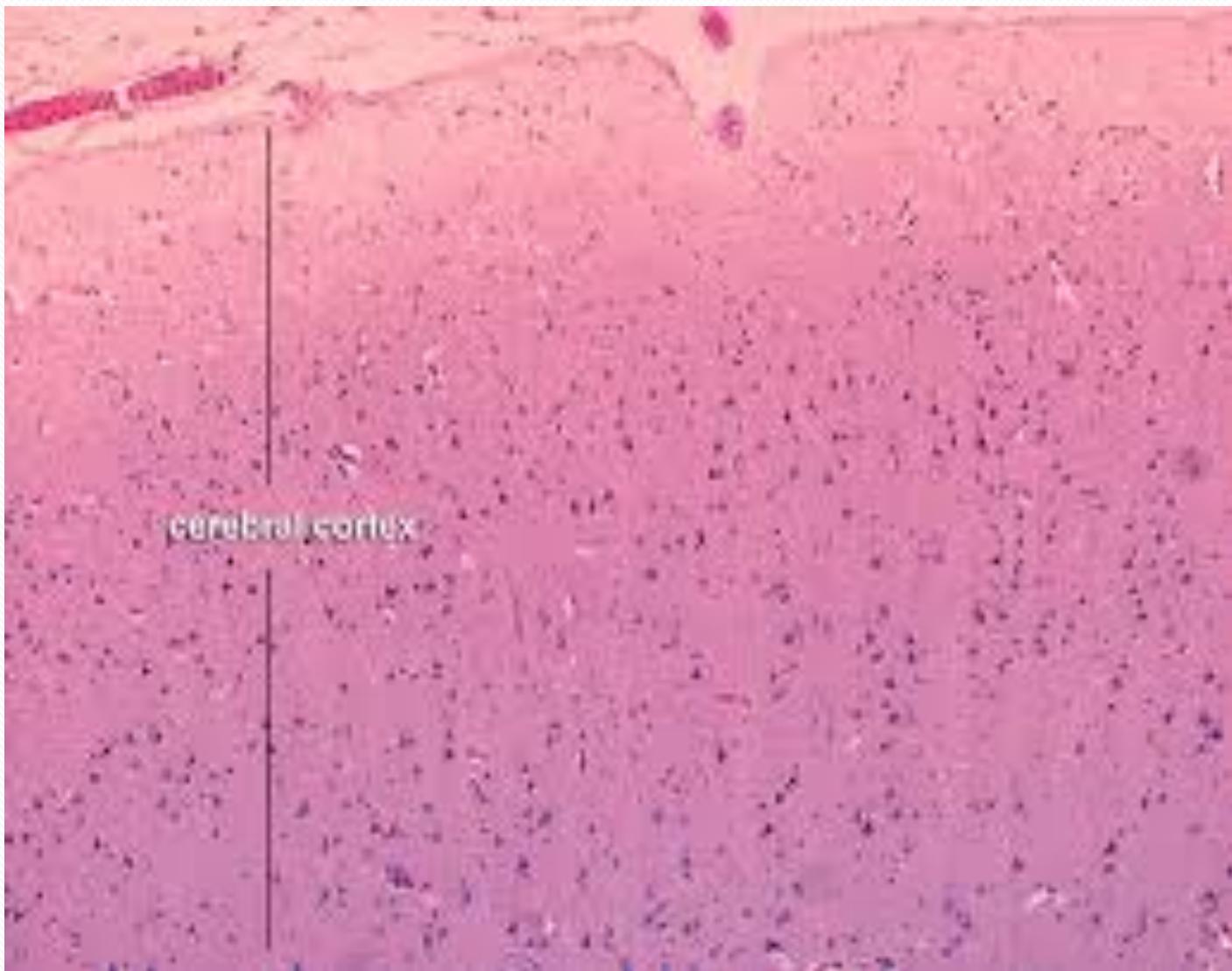
6. MULTIFORM CELL LAYER

- All morphological forms are found in this layer.
- Fusiform cells in deeper and other cells are present superficially in this layer.

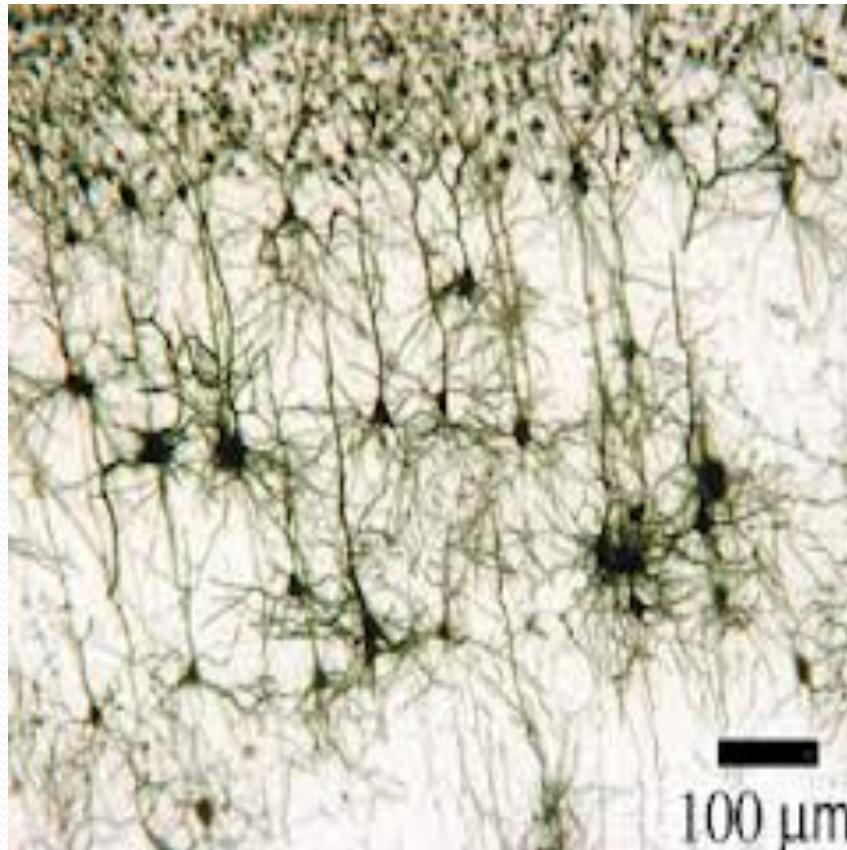


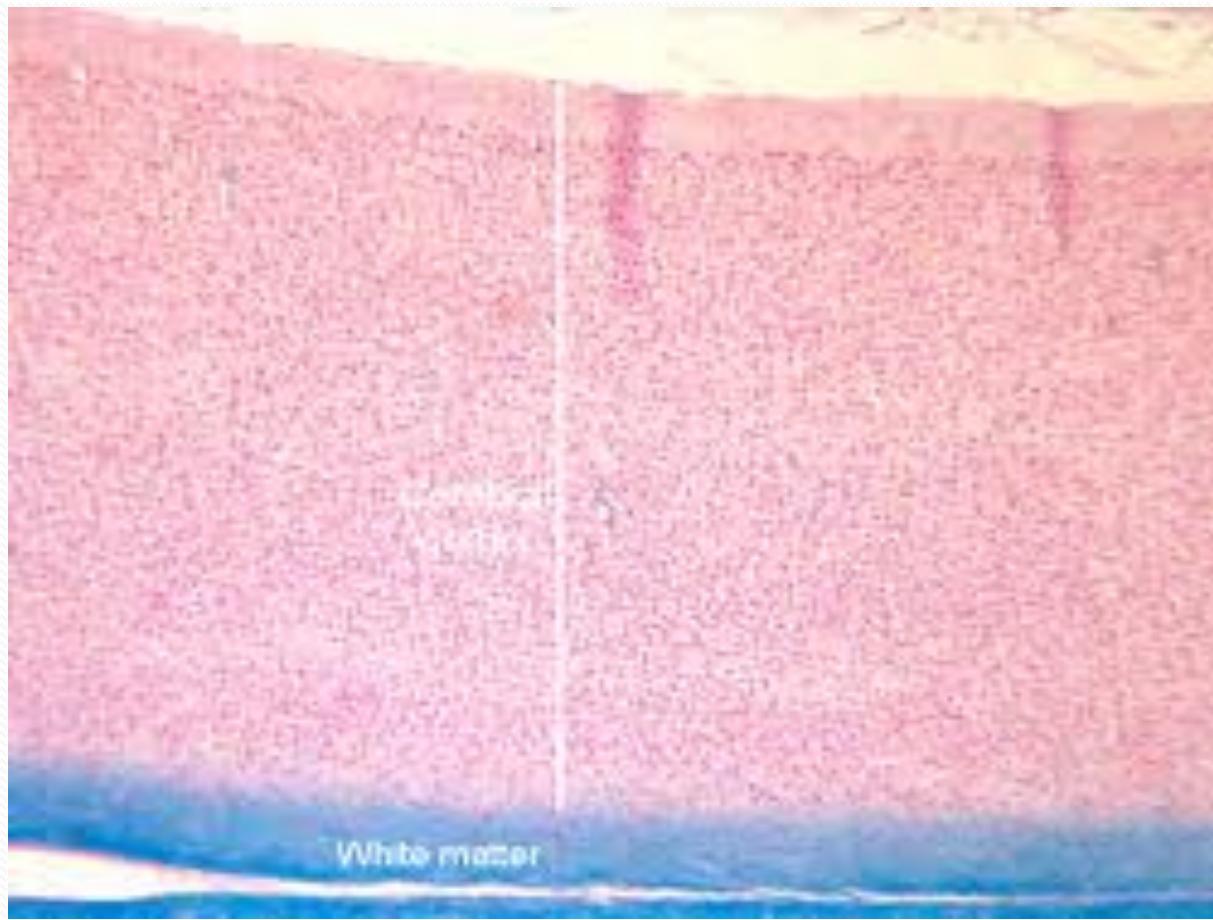
Histological Structure of the Cerebral Cortex





Layer 4&5

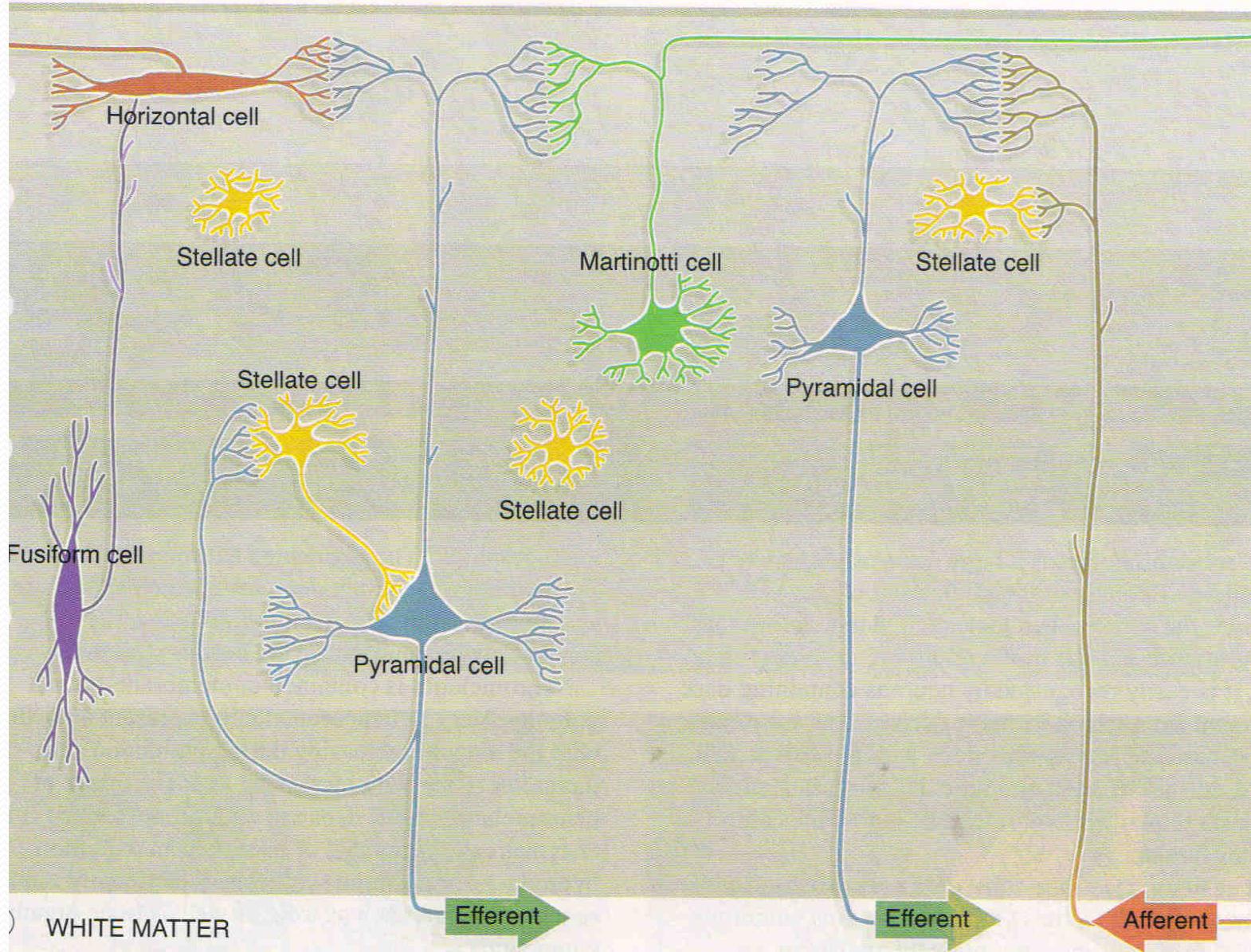




White matter

INTERCONNECTIONS OF CORTEX

- Afferent fibers synapse high (superficially) in the cortex with dendrites of efferent neuron.
- Efferent fibers, typically the axons of pyramidal cells tend to give off branches.
- These branches pass back into the superficial layers to communicate with their own dendrites.
- This can be via interneuronal connectins or involving other cortical cell types.



Contd...

- **Afferent Input**

Association nuclei(Thalamus)

Other cortical areas

Intralaminar nuclei(Thalamus)

- **Efferent Output**

- corticothalamic fibers

- corticocortical fibers

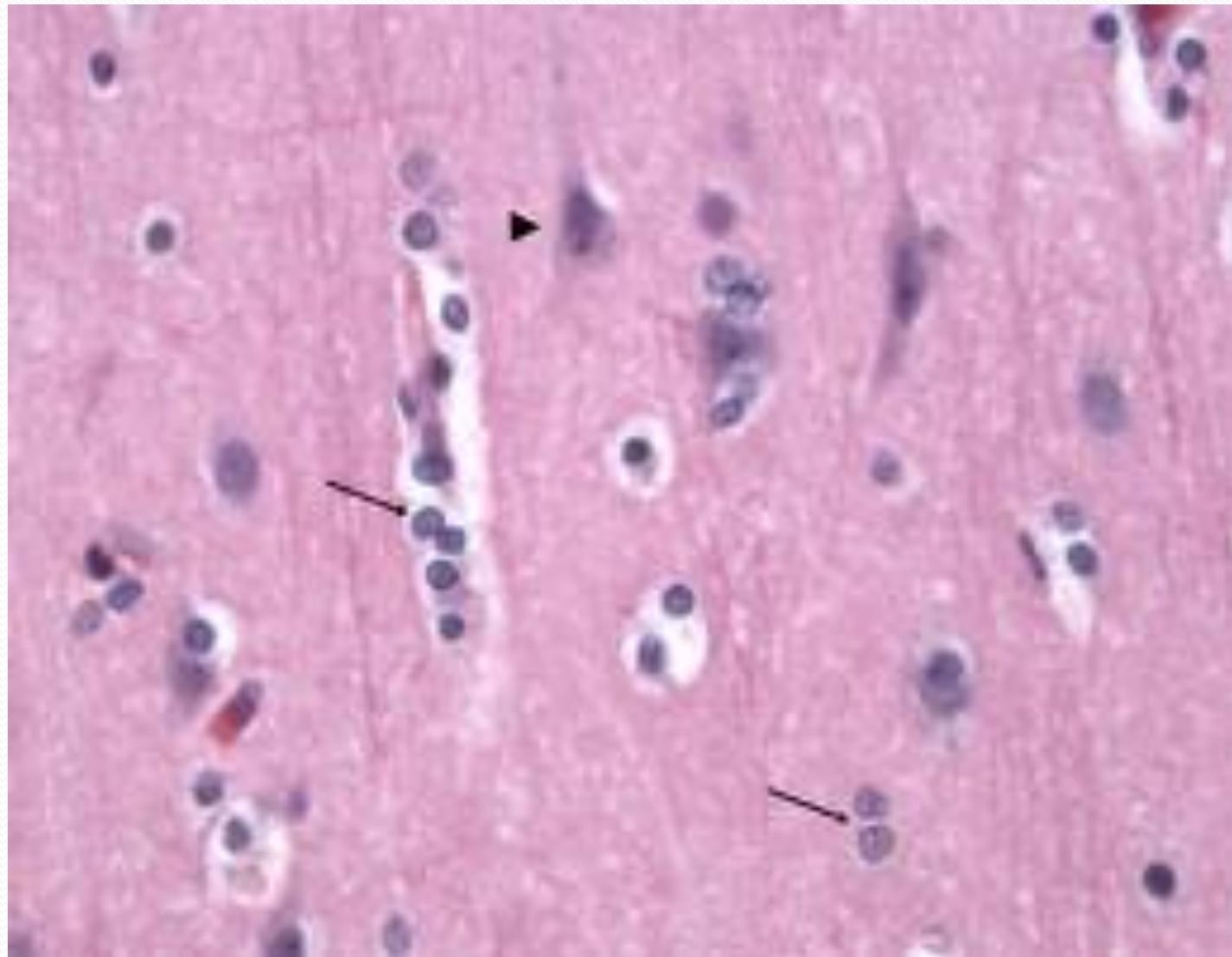
- corticostriate fibers to
brainstem & spinal cord

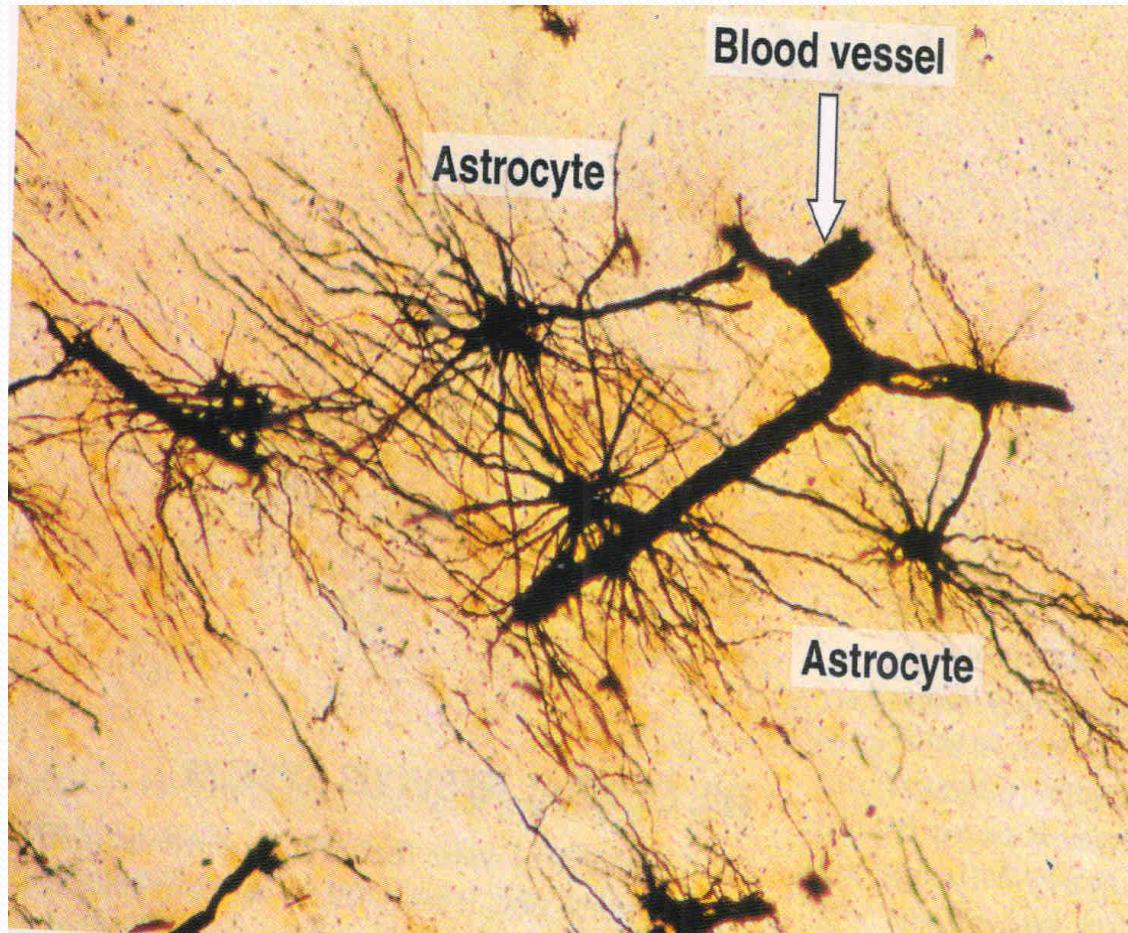
NEUROGLIAL CELLS

- In addition to neurons, the cortex contains supporting neuroglial cells.
- They are-
 - 1. Astrocytes
 - 2. Oligodendroglial cells
 - 3. Microglial cells
 - 4. Ependymal cells

ASTROCYTES

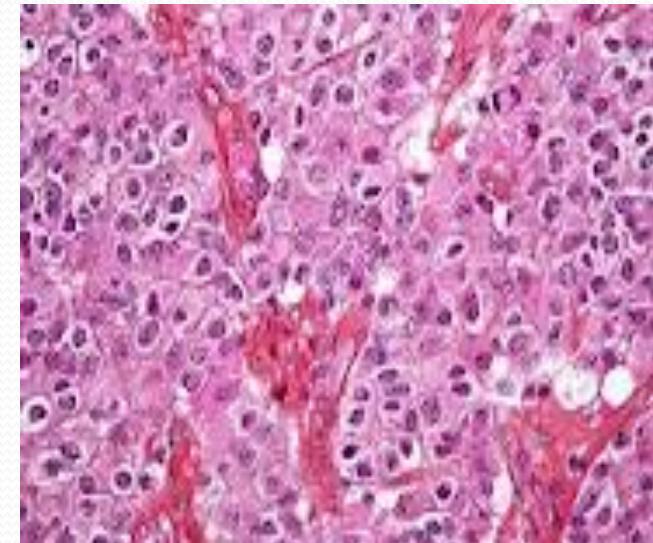
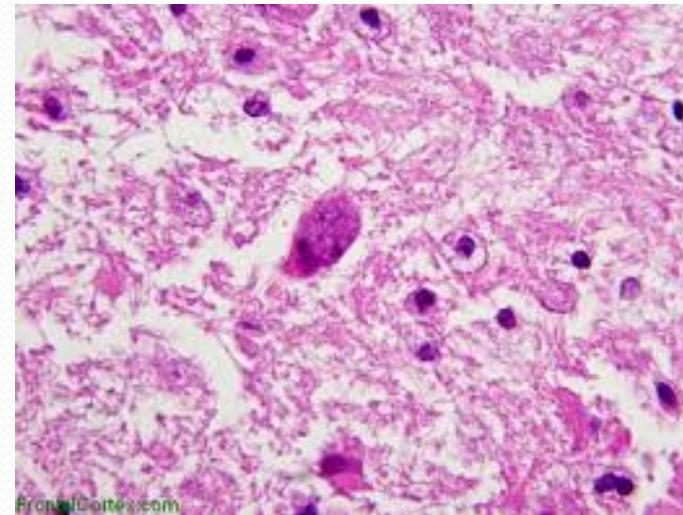
- Most numerous glial cells in the grey matter.
 - The nucleus is round to oval with open chromatin and peripheral nucleoli.
 - The cytoplasm is highly branched that occupy most of the neuropil - protoplasmic astrocytes
 - The foot process act as BBB called glia limitans.
- Function(s):
 - ..Supply of nutrients to neurons.
 - ..Removes excess neurotransmitters
 - ..Maintains appropriate balance of Ca^{2+} and K^+ ions (which are important in passing nerve impulses at synapses).
 - ..Helps migration of neurons during brain development.
 - ..Aids formation of the blood-brain barrier.





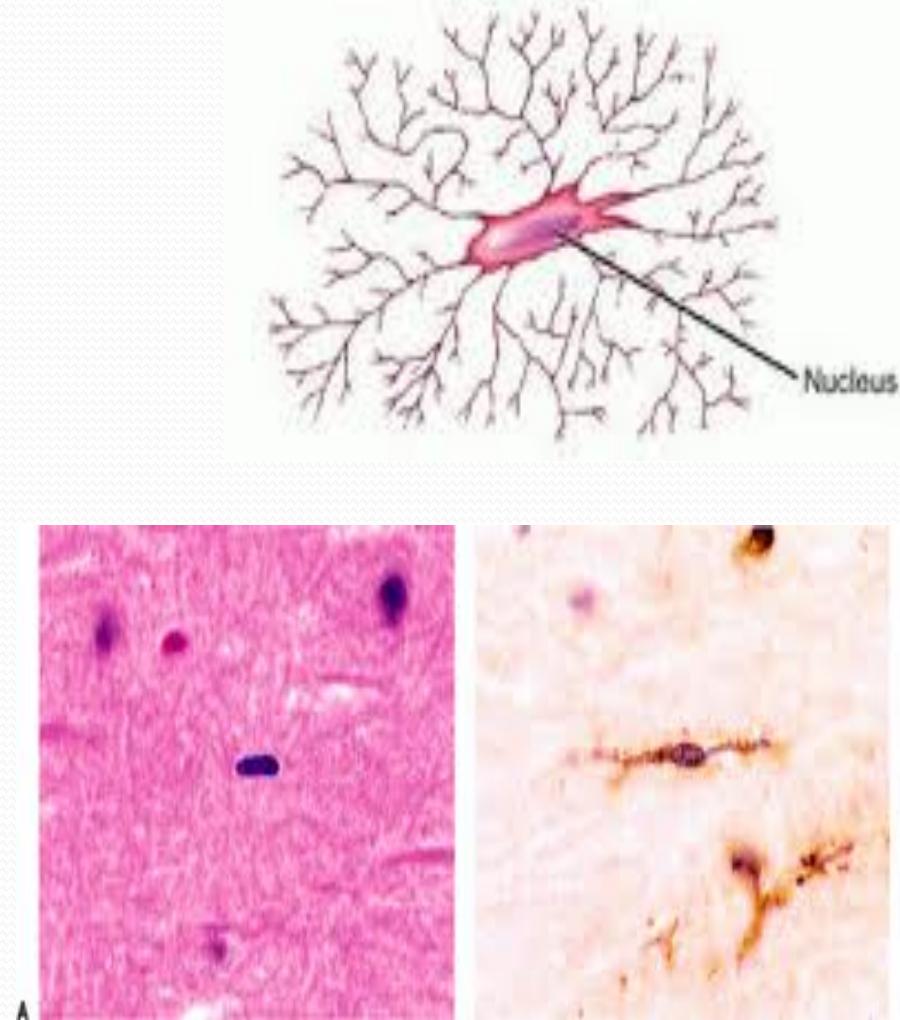
OLIGODENDROCYTES

- Found mainly adjacent to neurons/axon.
- FUNCTION-** myelination of neurons.
- They develop an artifactual vacuolisation around nuclei thus a halo appears around the nucleus.
- They are relatively large cells with dispersed nuclear chromatin and perinuclear halo.
- They also aggregate around nerve cell bodies in grey matter and function as supporting cells.



MICROGLIAL CELLS

- Small cells of mesenchymal origin.
- Have elongated nuclei and relatively little cytoplasm.
- The cytoplasm forms fine, highly branched processes.
- In response to tissue damage, they transform into large amoeboid phagocytic cells. Protects neurons from disease process.
- They function as scavengers of nervous system.
- CNS representatives of macrophage monocyte defence system.

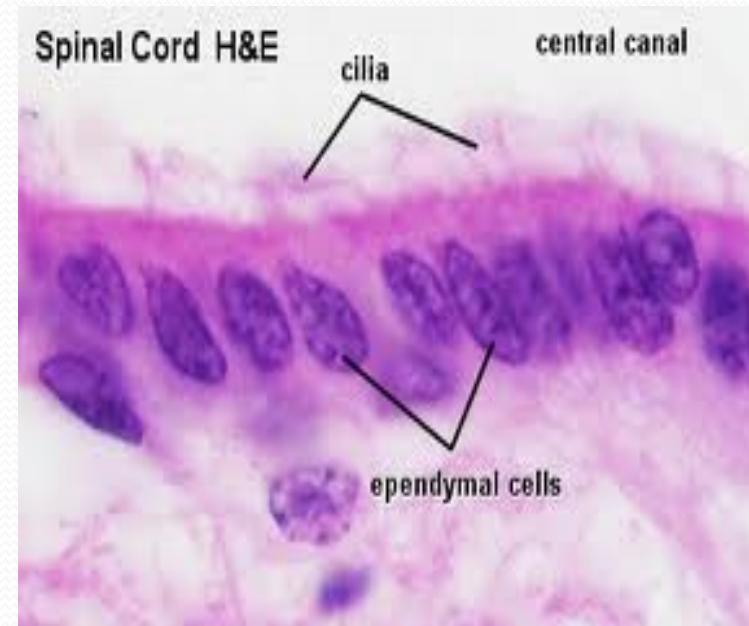


EPENDYMAL CELLS

- Forms the epithelial lining of ventricles and spinal cord.
- Cuboidal or low columnar in shape.
- Cells are bound at the luminal surface by epithelial junctional complexes.
- The bases of cells taper and break into fine branches which ramify into underlying layer of astrocytic processes.

FUNCTIONS

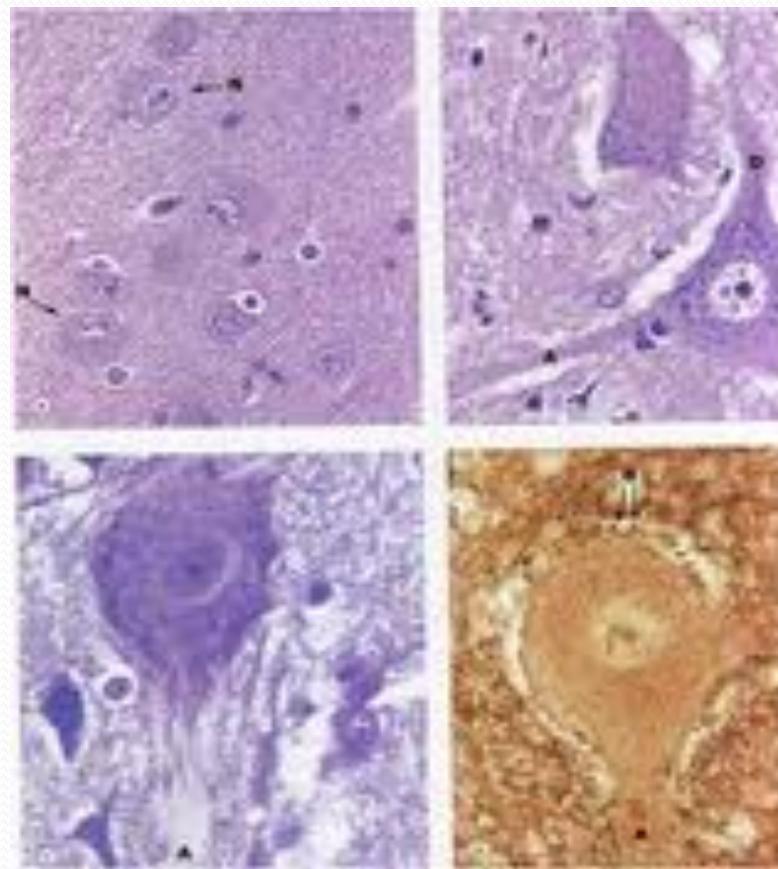
- Protection: Forms lining of the ventricles of the brain and central canal of the spinal cord. Forms cerebrospinal fluid (CSF).
- Aids circulation of cerebrospinal fluid (CSF).



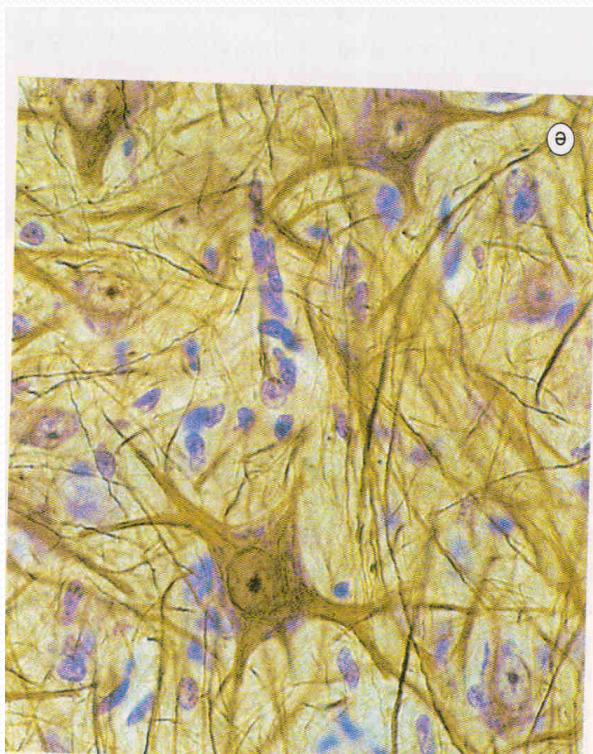
Staining of components of nervous system

- NEURON:
- General architecture -routine H&E stain.
- Hematoxylin & von Giesan stain
 - highlights vascular changes.
 - emphasises myelin staining.
 - provides cellular cytology.
- Nissl's substance-basic dyes-methylene blue,
toluedene blue,
neurtal red,
cresyl violet

CRESYL VIOLET, TOLUEDENE BLUE AND HEAVY METAL IMPREGNATION METHOD



HEAVY METAL IMPREGNATION TECHNIQUE WITH GOLD



- HMI techniques with gold and silver are valuable in the study of neuronal morphology.
- Cajal and Golgi are the pioneers of neuroanatomy who employed these techniques.

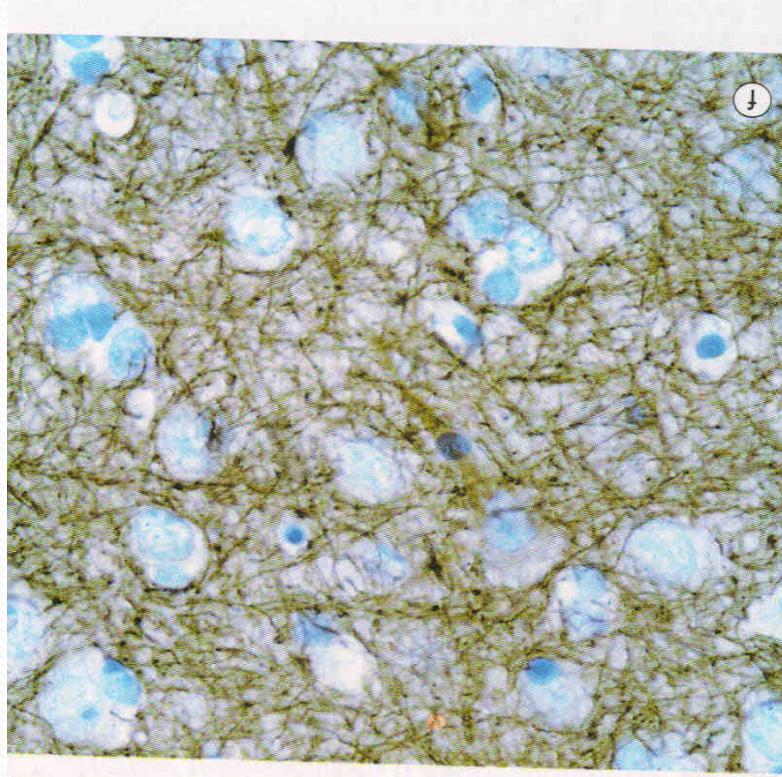
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- IHC OF NEURONS
- Anti-neurofilament antibody staining- Nf 70, Nf 150, Nf 200(cytoskeletal proteins)
- Ab to neuron specific enolase(cytoplasmic proteins)
- Proteins associated with neurosecretory granules

Chromogranin A

Synaptophysin

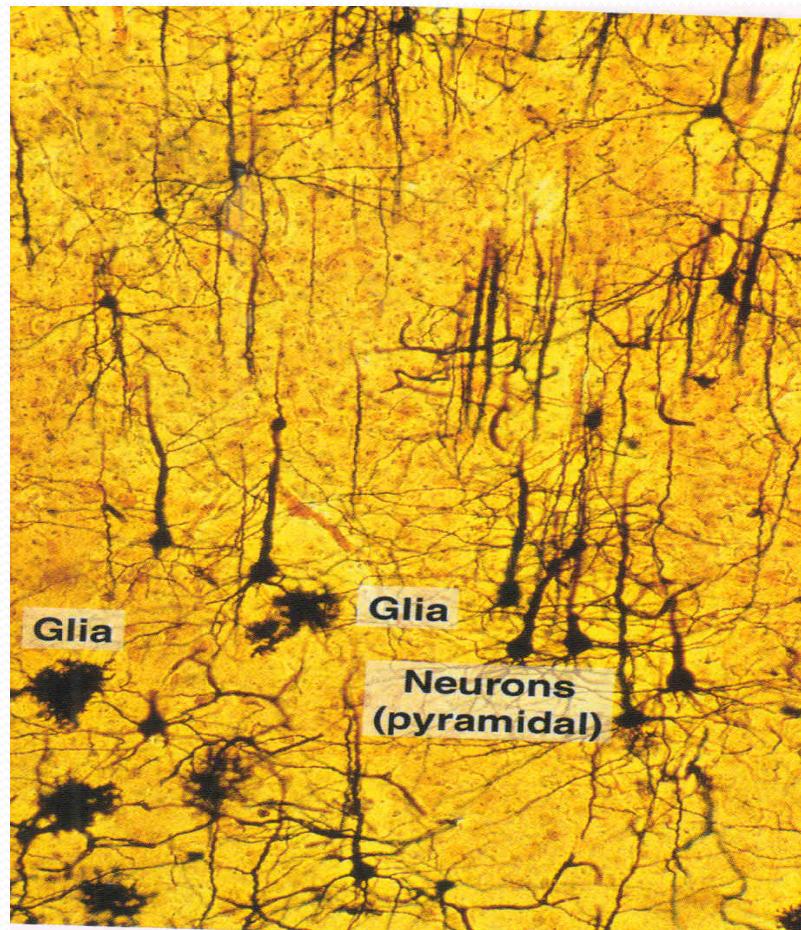
IHC- ANTIBODY TO NEUROFILAMENT PROTEIN Nf-70



Contd..

- For staining axons and neuronal processes – block impregnation method—ammonical silver soln.
- Bielschowsky's silver stain(silver nitrate soln)— neuro fibrils, dendrites & axons in parrafin & frozen sections. (Stains black)
- Erikson's staining for axons(ammonical silver soln)
- Earer's method for staining degenerated nerve fibers- stains brown to black(N-pale yellow)
- Myelin-solochrome cyanin+ aq. Iron alum—stains myelin sheaths blue.

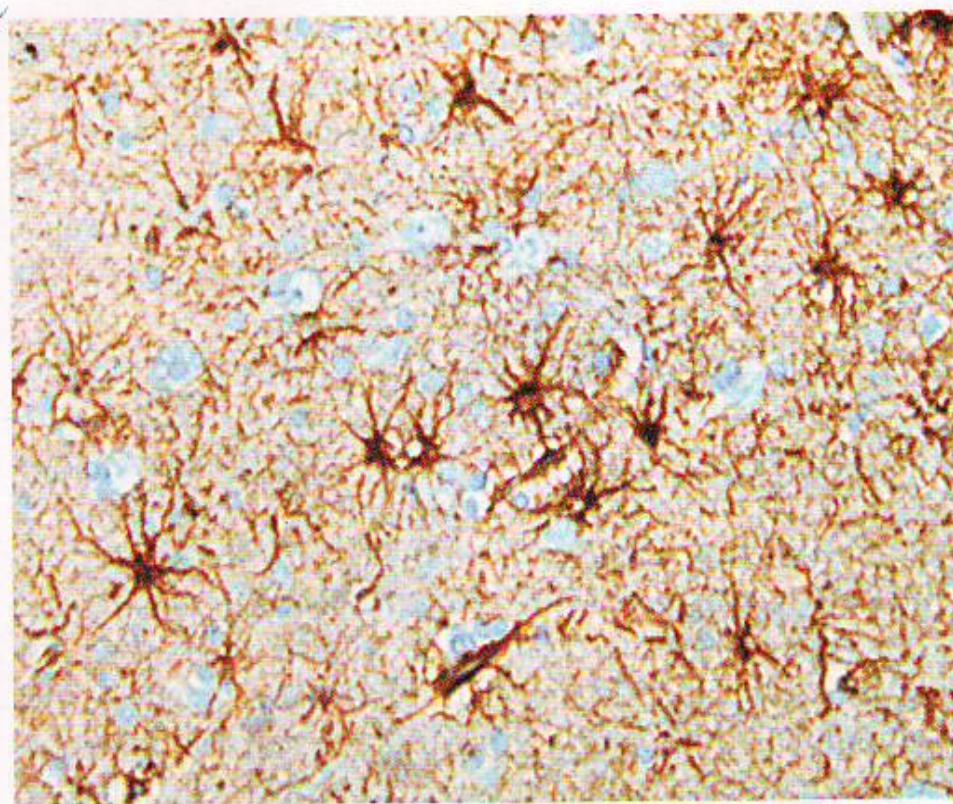
SILVER STAINED SECTION OF CEREBRAL CORTEX



SPECIAL STAINS FOR NEUROGLIAL TISSUE

- ASTROCYTES- Normal- Cajals gold sublimate.
reactive/gliosis- lithium carbonate technique, silver staining, PTAH(phosphotungstic acid hematoxylin)
- Astroglial neoplasms-GFAP immunoperoxidase.
- PTAH-stains astrocyte fibrils, nuclei,myelin- blue & neurons- pink
- Cajal's stain fibrous & protoplasmic astrocytes dark purple to black(background- light purple)

ASTROCYTES-IHC Staining for GFAP



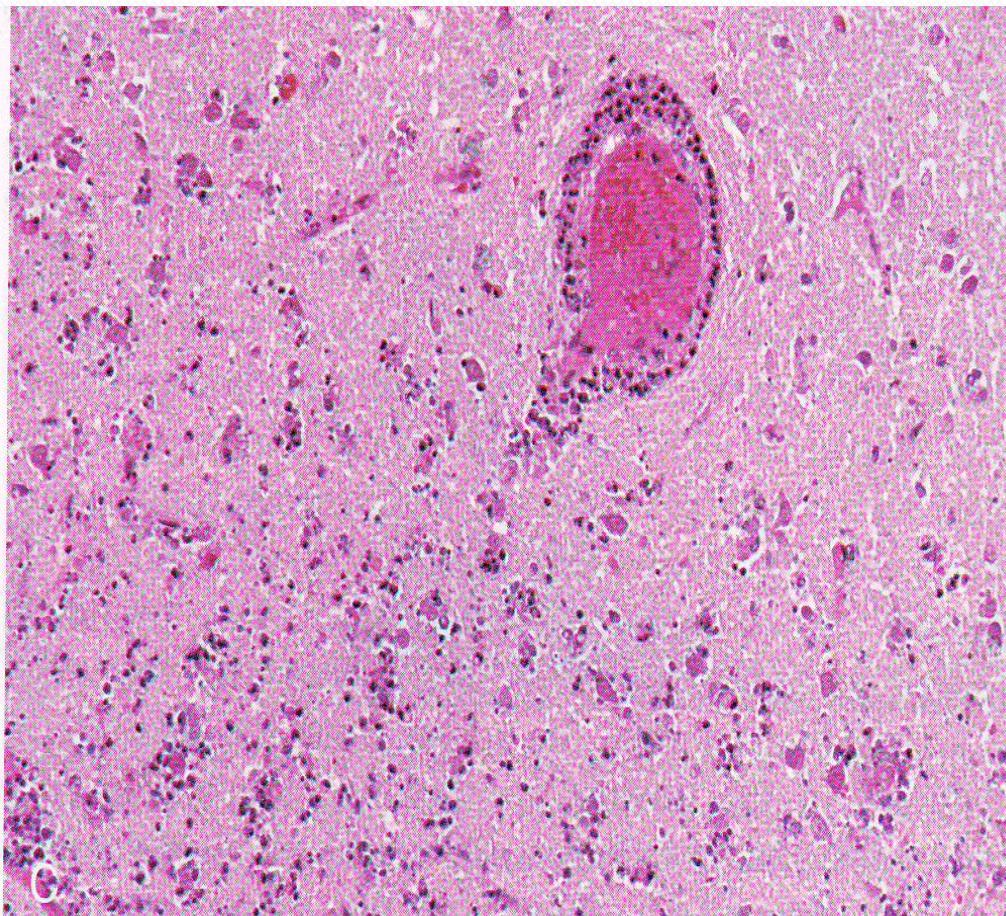
Contd..

- EPENDYMAL CELLS-iron hematoxylin/PTAH/GFAP immunoperoxidase.
- OLIGODENDROCYTES- H&E, toluedene blue.
- MICROGLIA-silver techniques, macrophage marker CD68.

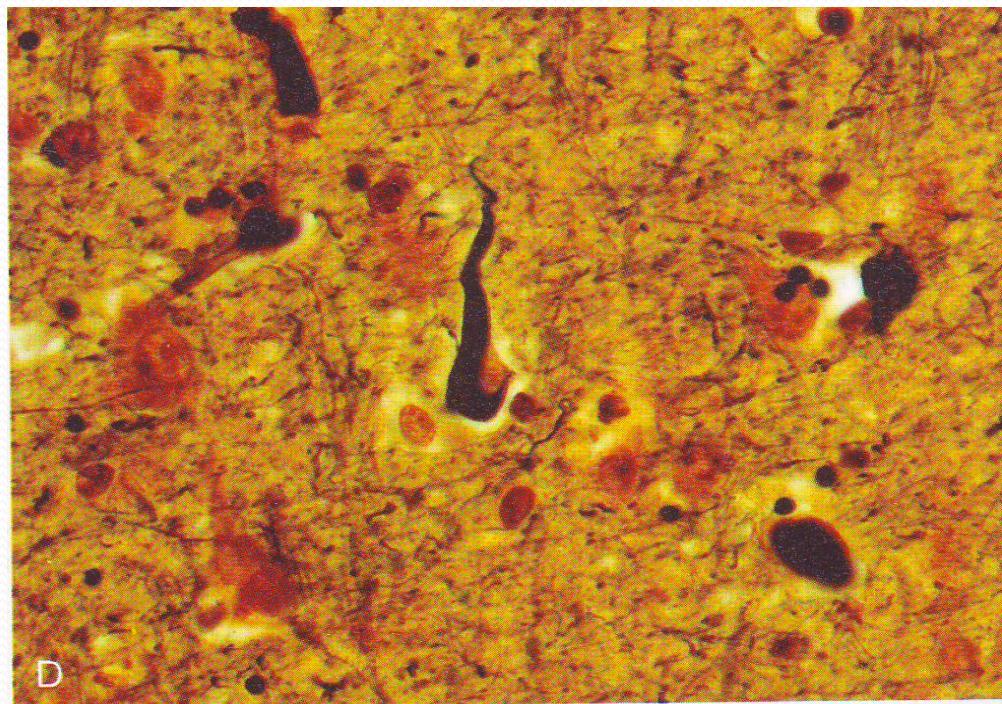
DISEASES OF CEREBRAL CORTEX

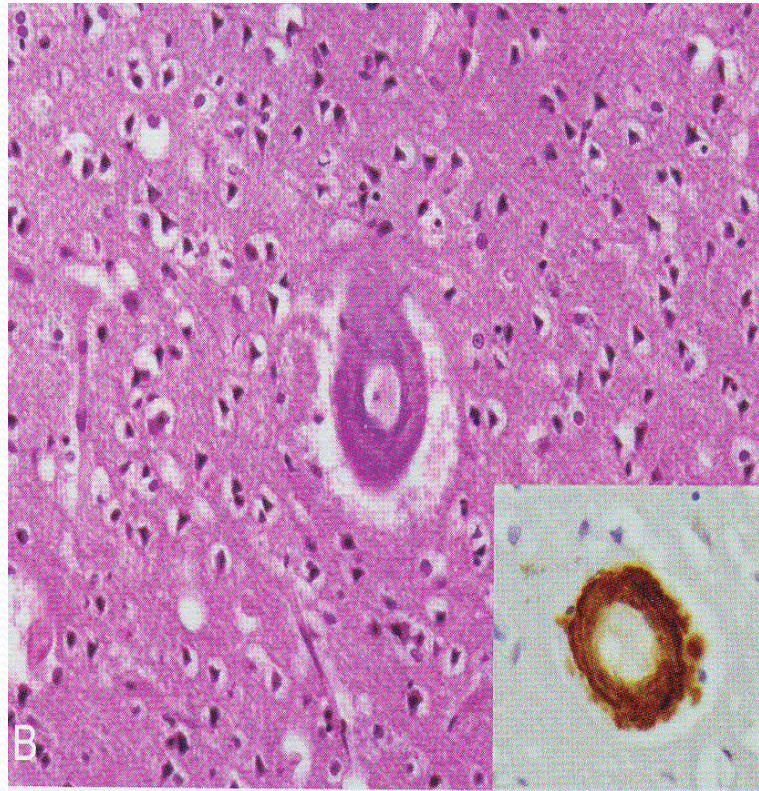
- Alzheimers's disease- senile plaques,neurofibrillary tangles.
- Lewy body dementia-Neuronal inclusions in cerebral cortex.
- Huntingtons disease- polyglutamin containing inclusions.
- Vascular dementia- multiple cerebral infarcts.
- NEOPLASMS- astrocytoma, oligodendrocytoma.
- Picks disease, tau-pathies, prion disease.

CEREBRAL INFARCT



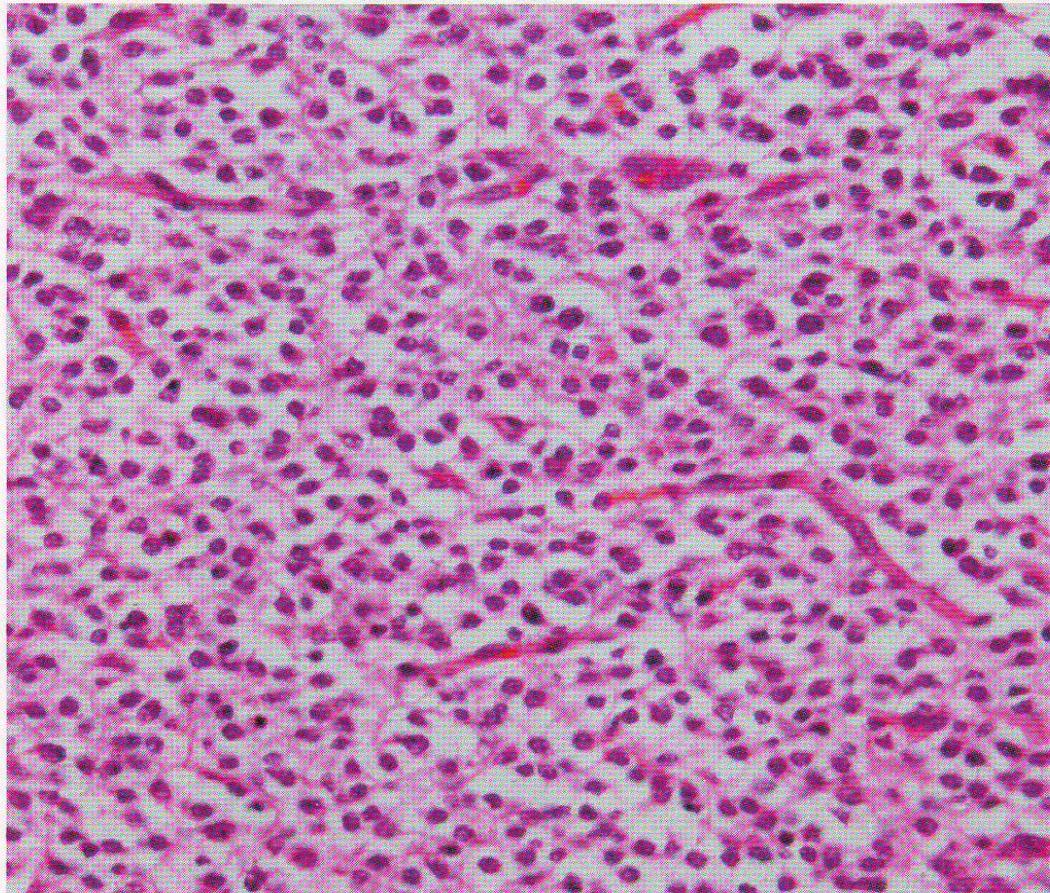
Silver stain – Alzheimers disease



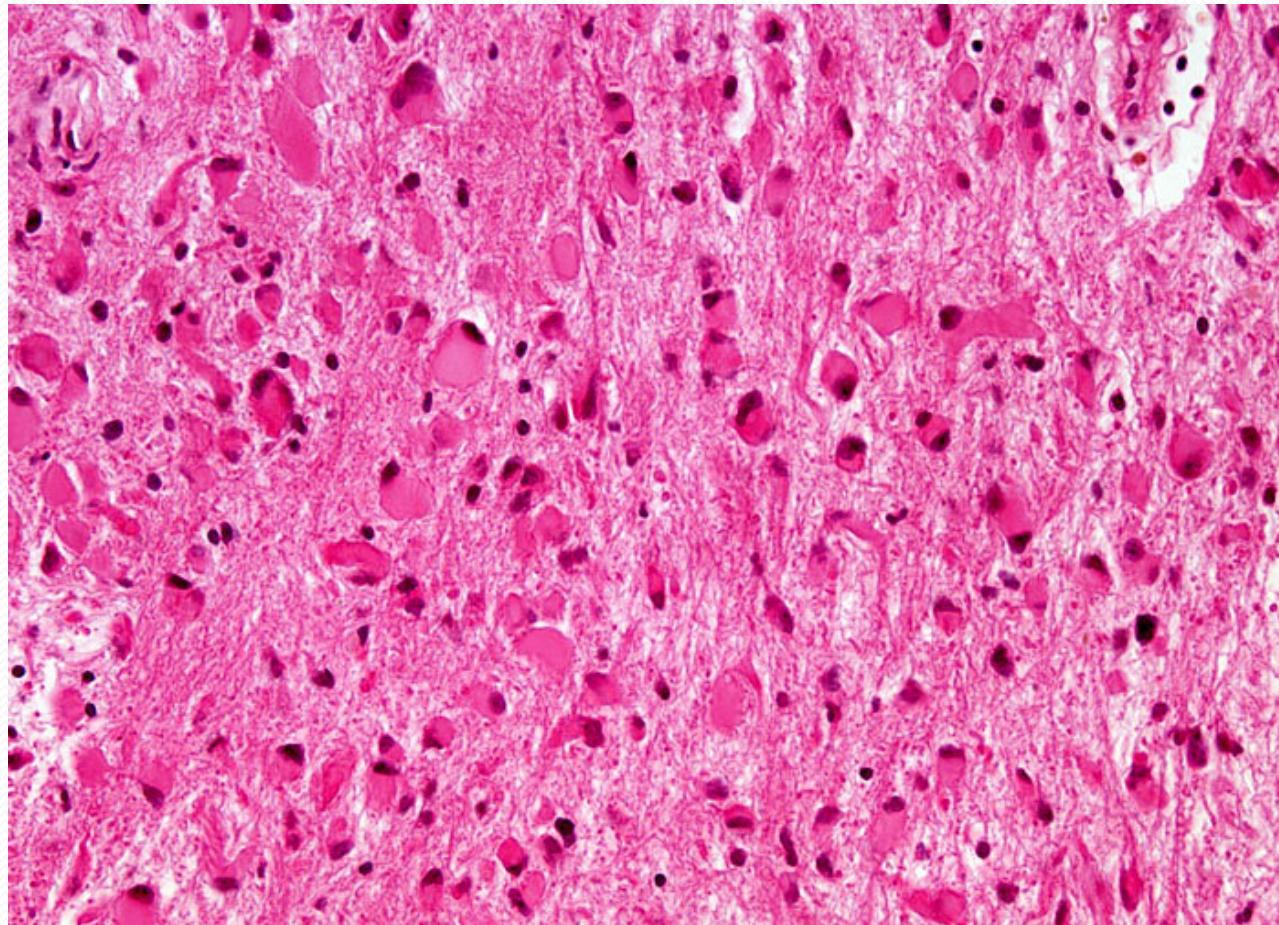


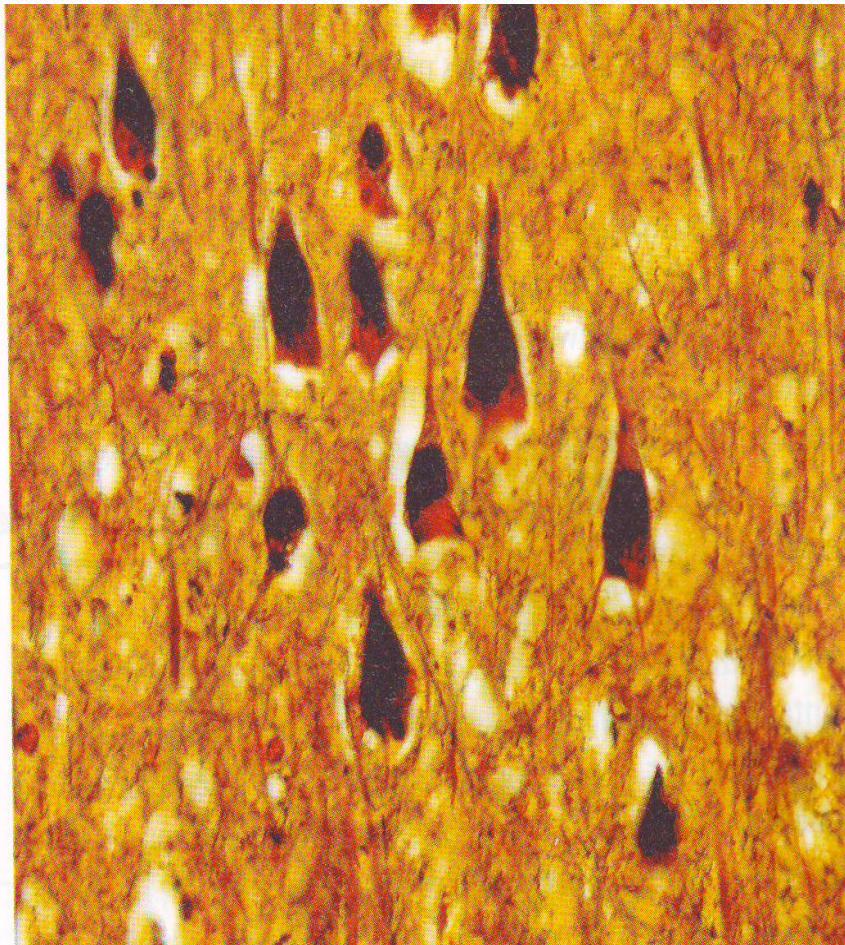
- Amyloid deposition in cortical arteriole in **CEREBRAL AMYLOID ANGIOPATHY**
- IHC Stain for A-beta deposits

OLIGODENRROGLIOMA

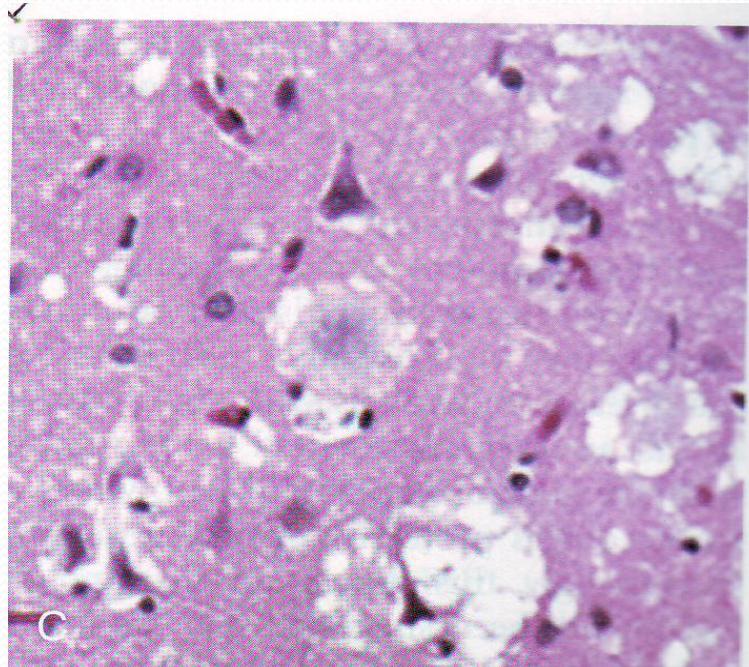


Astrocytoma





Silver stain-PICK
DISEASE showing Pick
bodies(inclusions)



PRION DISEASE- Cortical
plaques surrounded by
spongiform change in vCJD.

REFERENCE

- WHEATERS functional histology – Page399,123-127 5th edition.
- Text book of histology- I.B.SINGH
- JOHN D.BANCROFT- theory and practice of histological techniques-5th edition.
- ROBBINS & COTRAN-8th edition
- INTERNET



- ***THANK YOU***