

NEUROGLIA & ITS APPLIED ASPECTS

An anatomical illustration showing various types of neuroglia. In the foreground, there are several large, star-shaped cells with multiple processes extending outwards, colored in shades of green and yellow. One prominent green cell is shown with its processes extending towards a red, cylindrical structure that resembles a blood vessel. Below these, there are blue, elongated structures that look like oligodendrocytes or astrocytes. In the background, there are more yellowish-green cells and a pinkish, layered structure on the right side, possibly representing the meninges or a layer of epithelial cells. The overall background is a light, textured beige.

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INTRODUCTION

Gift of the nature.....

- Mature neurons do not divide by mitosis after birth. This is a gift of nature, since DNA replication does not take place in non-dividing mature neurons.
- As such, nuclear DNA keeps itself engaged for transcription of RNA family & later for the translation into **proteins**, which is apart from the other metabolic functions, is stored as **memory molecules** in the cytoplasm of the neurons.

If these neurons undergo mitotic division then what happens to our memory ???

Fleeting memory.....

Mature neurons as a rule do not divide by the mitosis, then how the brain tumor occurs ????

- This is mainly due to supporting cells of the nervous system – **Neuroglial cells.**
- The neuroglia are the supporting cells of the CNS. The glial cells unlike the nerve cells, are non excitable & undergo mitotic division.
- Neuroglial cells are generally smaller than neurons & outnumber them 5 – 10 times. They comprise about half the total volume of the brain & spinal cord.



Glia were discovered in 1856 by the pathologist Rudolf Virchow in his search for a 'connective tissue' in the brain.

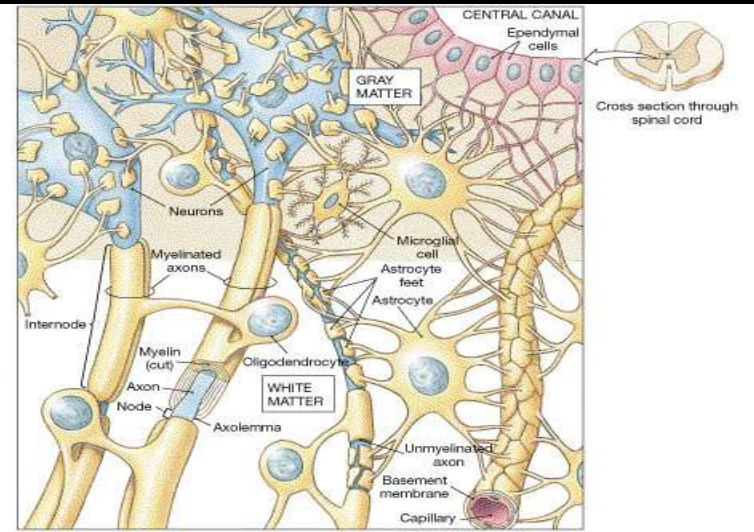
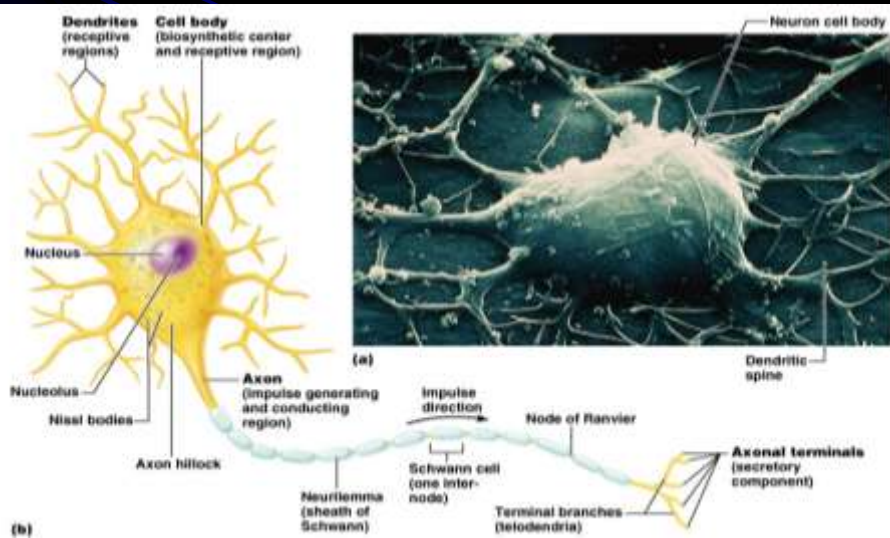
Nervous tissue

Excitable cells

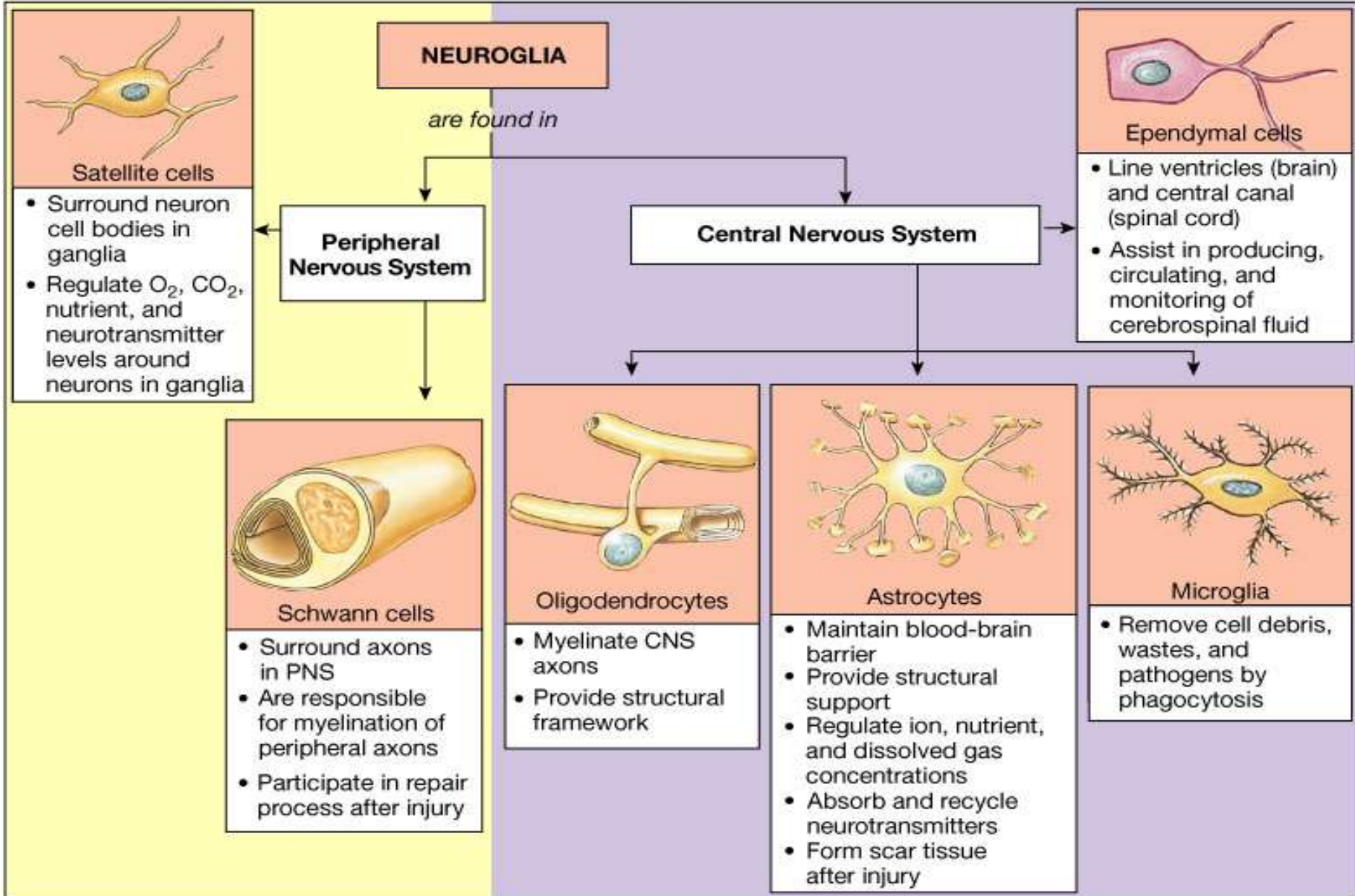
Neurons

Non excitable cells

Neuroglial cells



Classification of Neuroglial cells



Classification

The neuroglia of CNS are classified into

- **Macroglia**
- **Microglia**

The macroglia include – Astrocytes

Oligodendrocytes

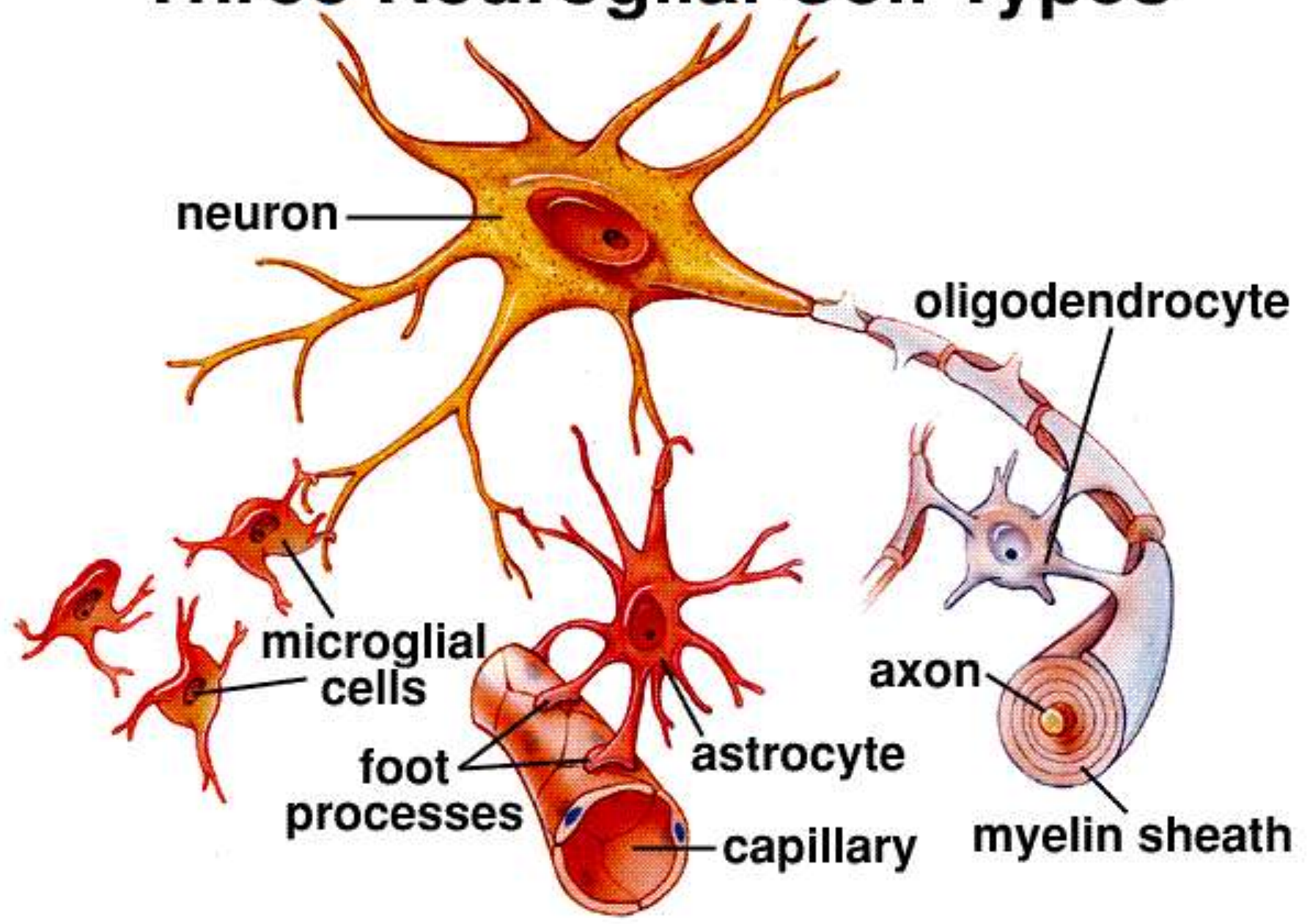
Ependymal cells

The macroglia are developed from the embryonic neuroectoderma.

The microglia are derived from the mesoderm & appear in the developing brain & spinal cord with the growth of blood vessels in the CNS.

Most neuroglia are visualized by metallic impregnation method of staining with silver or gold.

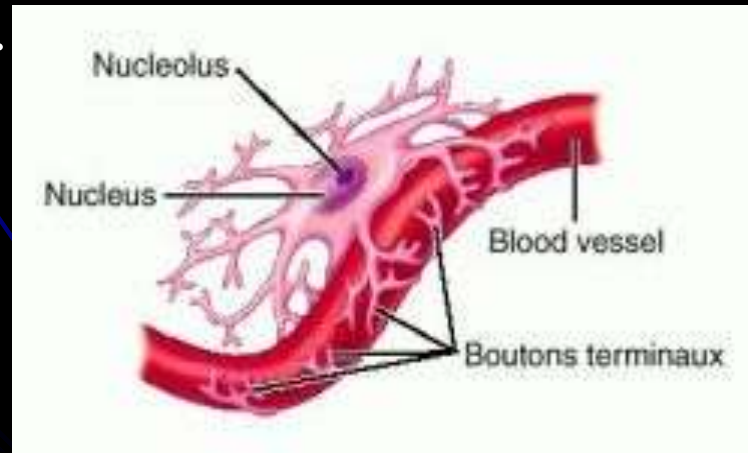
Three Neuroglial Cell Types



Macroglia

Astrocytes

- These are stellate in appearance
- Each cell presents oval nucleus & many radiating cytoplasmic processes.
- Some astrocytes present around the nucleus numerous microfilaments known as gliofibrils, which extend into processes.
- A number of small granular swellings known as gliosomes project out from the processes & contain clumps of lysosomes.
- The cytoplasm is rich in glycogen & contain organelles similar to normal animal cells.



There are 2 types of Astrocytes –

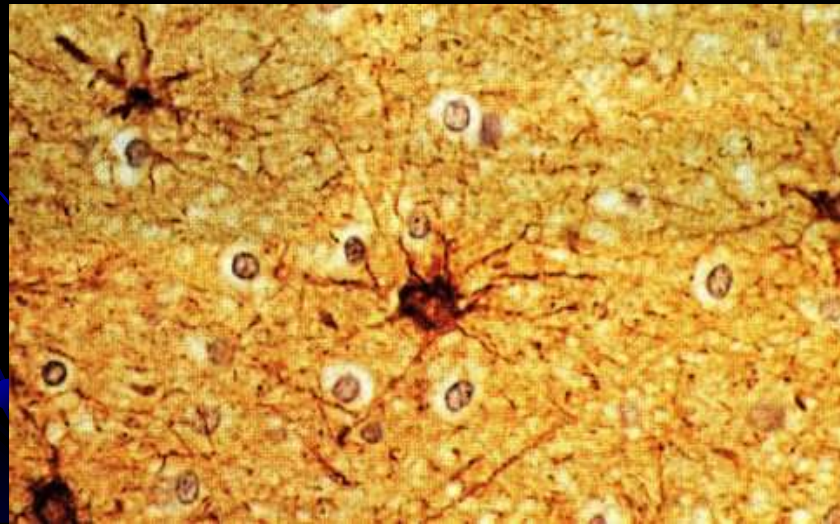
- Fibrous
- Protoplasmic

Fibrous – Are found in the white matter;

They present longer & thinner processes & contain gliofibrils.

Protoplasmic – Are devoid of gliofibrils, present numerous short & thick processes & are confined in the grey matter.

- At the outer & inner surfaces of the CNS, the processes of astrocytes are loosely interwoven to form outer & inner glial limiting membranes.
- On the outer surface of the brain, the pia matter together with astrocytes form the pia – glial membrane.
- Similarly, over the lining of the ventricles & central canal of the spinal cord they form the ependyma glial membrane.



Functions

- They participate in the metabolism of neurotransmitters
- Maintain the proper balance of potassium ions for generation of nerve impulses
- Participate in brain development
- Help to form the blood brain barrier, which regulates entry of substances into the brain, & provide a link between neurons & blood vessels.

Oligodendrocytes

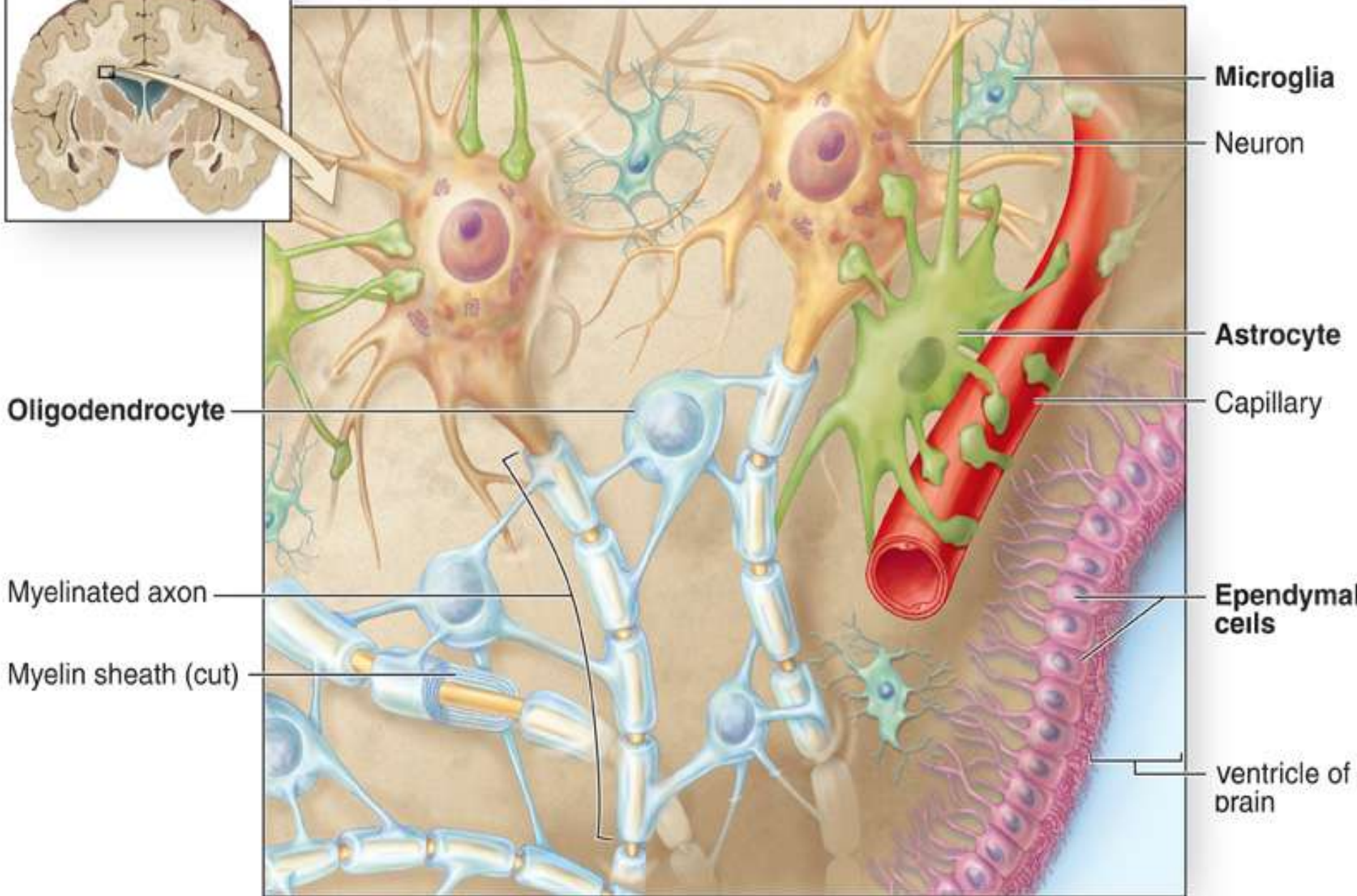
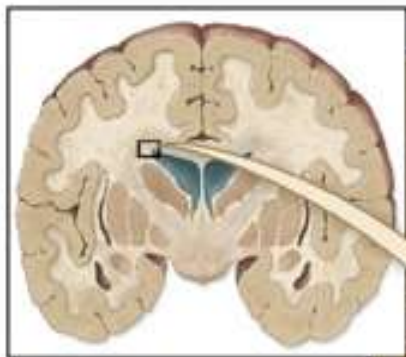
They are smaller than astrocytes, possess less branching processes & are found in both grey & white matters.

They are distributed as –

- Peri neural satellite cells in the grey matter around the cell bodies & dendrites of neurons.
- Peri fascicular cells in the white matter & are arranged in rows along the myelinated nerve fibres.
- Juxtra-vascular cells , where the processes of some oligodendrocytes terminates as foot plates upon the wall of blood vessels; they help in the intrinsic control of blood flow.

Functions

- They help in the formation & maintenance of myelin sheath around the nerves of CNS. A single oligodendrocyte confers myelin to a number of axons. A flange passes along each axon & spirals around it depositing myelin sheath. The interval between 2 successive glial wrapping is a node.
- In tissue culture both oligodendrocytes & schwann cells are found to contract rhythmically. Probably the contractile cells help maintaining the axoplasmic flow.



Microglia

Neuron

Astrocyte

Capillary

Ependymal cells

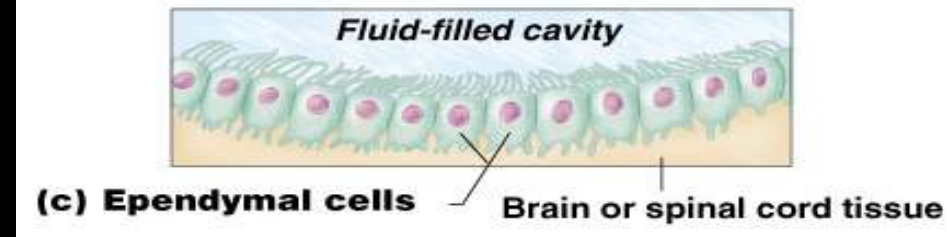
ventricle of brain

Oligodendrocyte

Myelinated axon

Myelin sheath (cut)

Ependymal cells

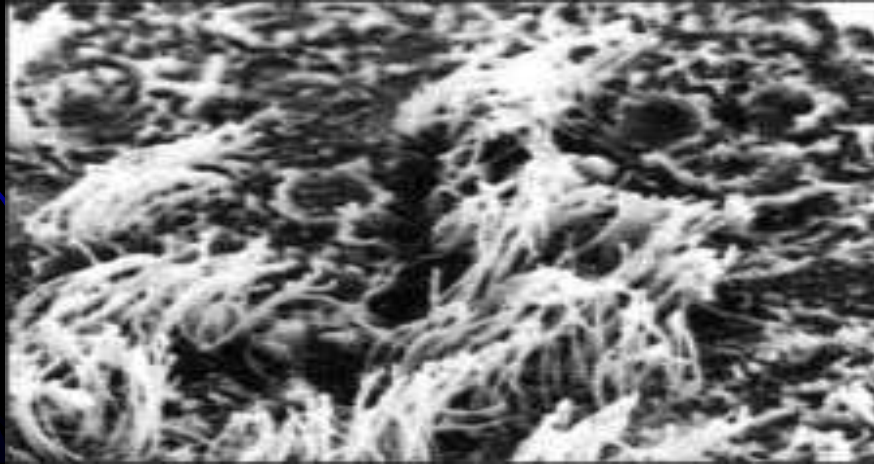


- These are simple ciliated columnar cells lining the ventricles of the brain and central canal of spinal cord.
- Most of the cilia are non motile and resemble the microvilli which help exchange of substances between the brain and cerebrospinal fluid.
- Bases of some ependymal cells lining the floor of third ventricle give rise to long cytoplasmic processes which extend deeply towards the neurons and other neuroglia cells; these cells are called the tanycytes which are capable of selecting molecules from the CSF.
- The ependyma lining the choroid plexus of the ventricles helps actively in the formation of CSF by presenting Blood-CSF barrier.

The barrier consists of

- Fenestrated endothelium of choroid capillaries
- Basement membrane,
- A tissue space intervening between the vascular endothelium and the pial membrane
- A continuous layer of ependymal cells connected by tight junctions.

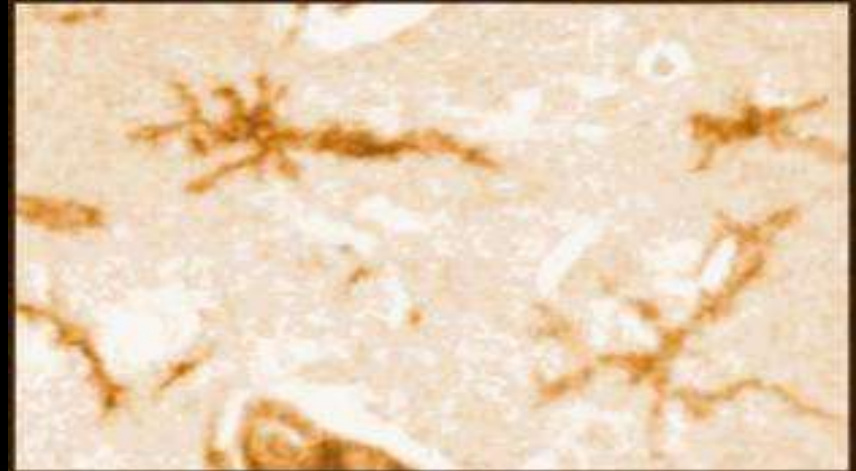
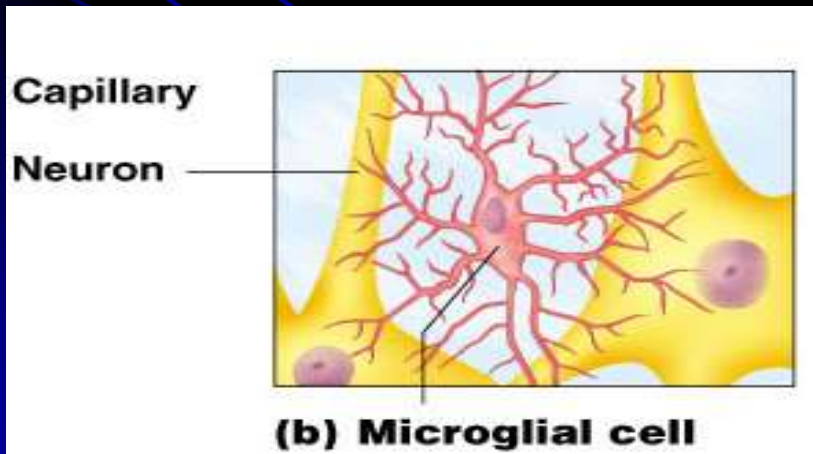
The ependyma cells form the germinal layer of the primitive neural tube and give rise to the development of neuroblasts and spongioblasts; the latter differentiate into astrocyte and oligodendrocytes.



Microglia

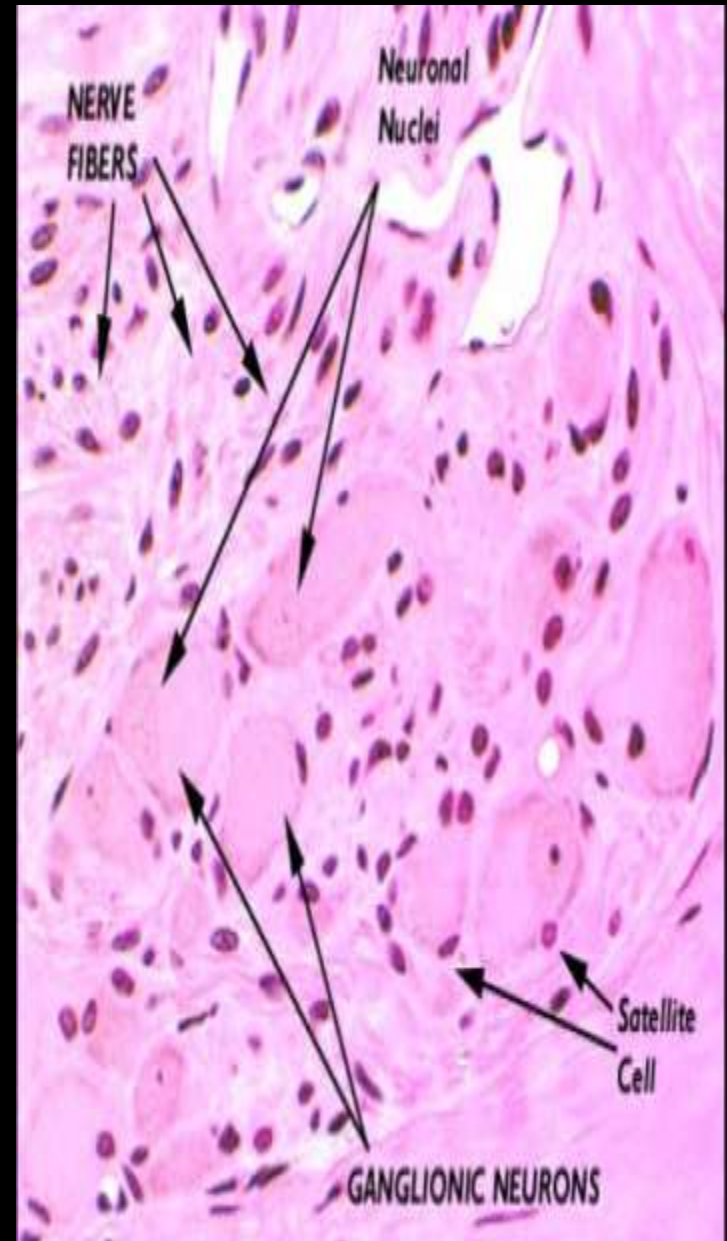
These are small cells bearing tiny & tortuous spinous processes. The microglia appear in the CNS along the perivascular coat of the blood vessels.

They possess amoeboid movement & are phagocytic in function. The microglia act as macrophage cells of the CNS.



Satellite cells

- Also called **amphicytes**
- Surround the neuron cell bodies in ganglia
- Regulate environment around neurons in PNS just like astrocytes do in CNS



Schwann cells

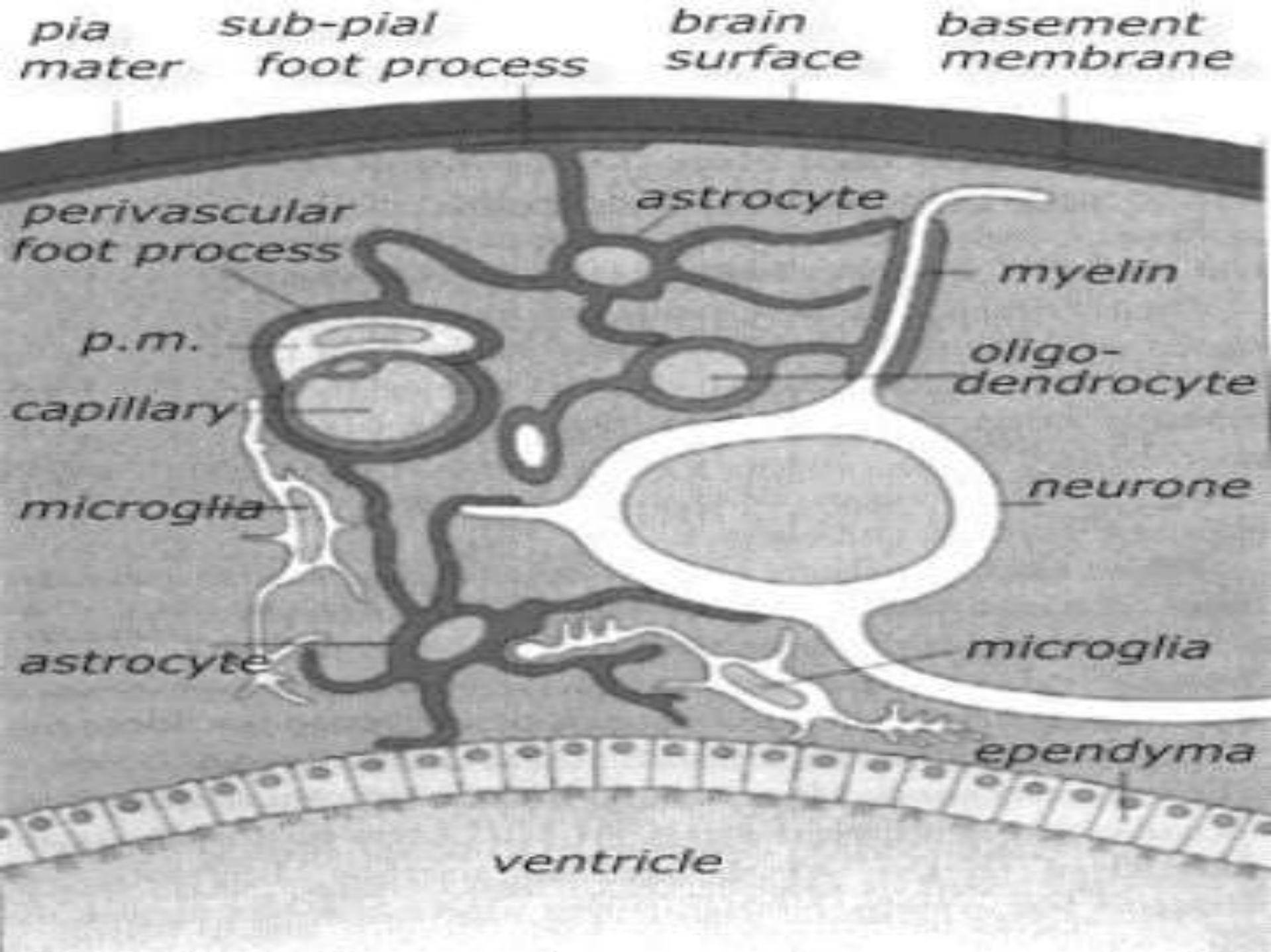
- Also called **neurilemma cells**
- Form a sheath around peripheral axons
- Wherever a Schwann cell covers an axon, the outer surface of the Schwann cell is called the neurilemma
- Most axons in the PNS, myelinated or unmyelinated, are separated from interstitial fluid by Schwann cells
- A series of Schwann cells is required to enclose an axon along its entire length



Blood brain barrier

Some of the processes of astrocytes are attached to the outer surface of the capillaries of the brain & acts as blood brain barrier, the most important constituent being the tight junctions of the capillary endothelium.

The barrier conveys nutrition to the neurons, permits entry of water, oxygen, co₂ readily, but restricts the passage of macromolecules of proteins, bile salts & catecholamines to the brain cells.



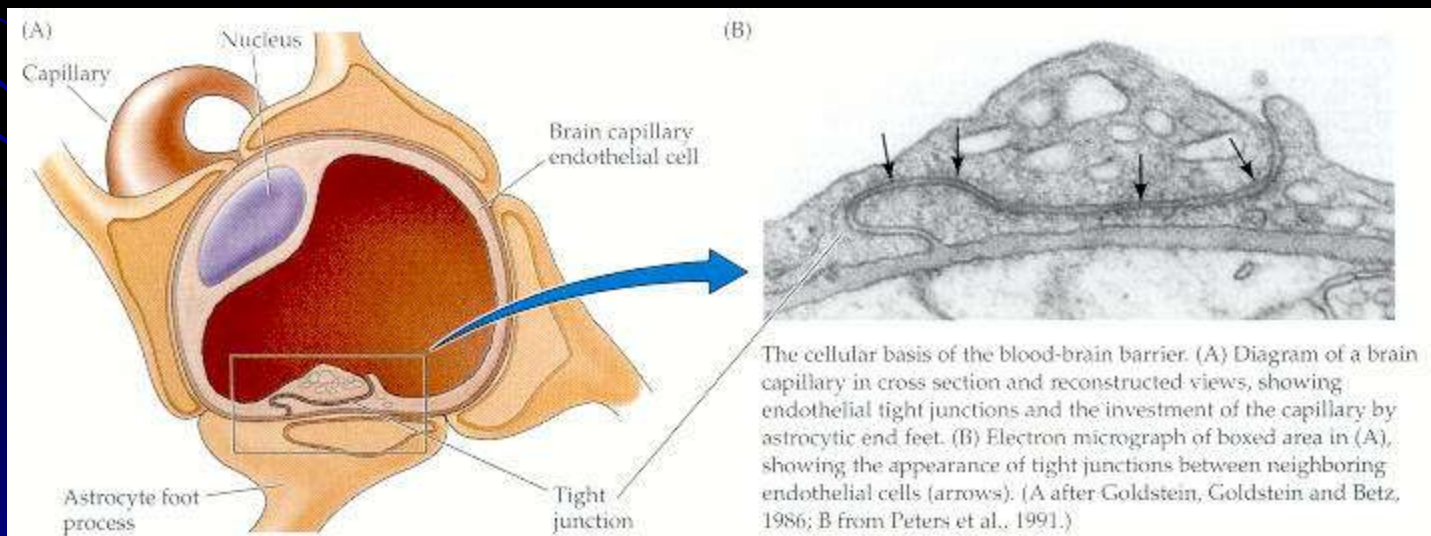
Such a barrier however absent in the following areas of brain –

- Pineal body
- Posterior lobe of pituitary gland
- Area postrema
- Organum vasculosum lamina terminalis
- Intercolumnar tubercle

• The BBB is poorly develop in children. In severe jaundice affecting infants, the bile may damage the basal ganglia producing Kernicterus.

The BBB is consists of the following from blood to the brain.

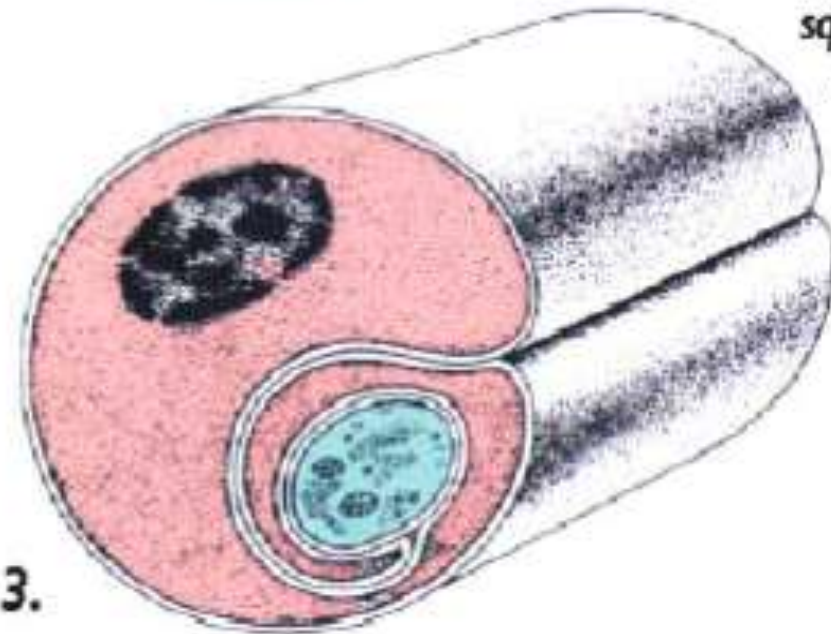
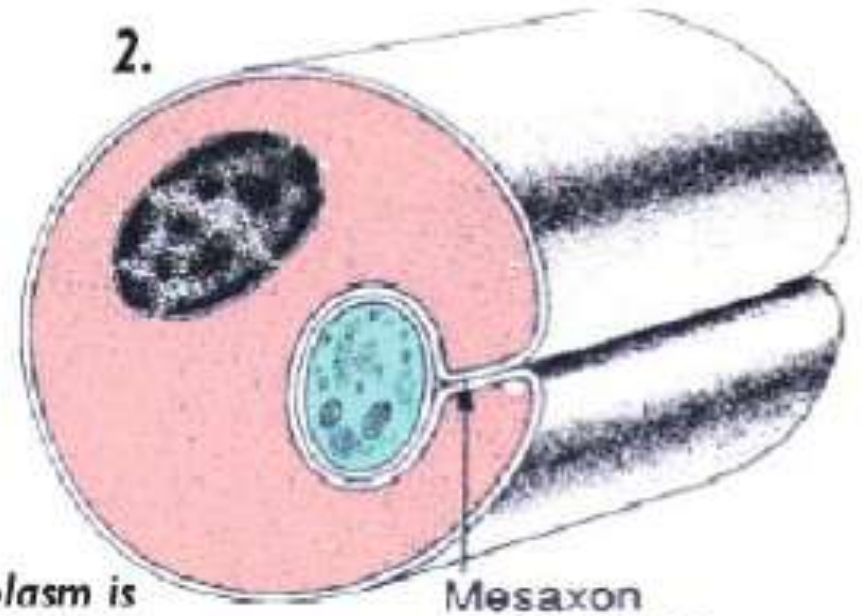
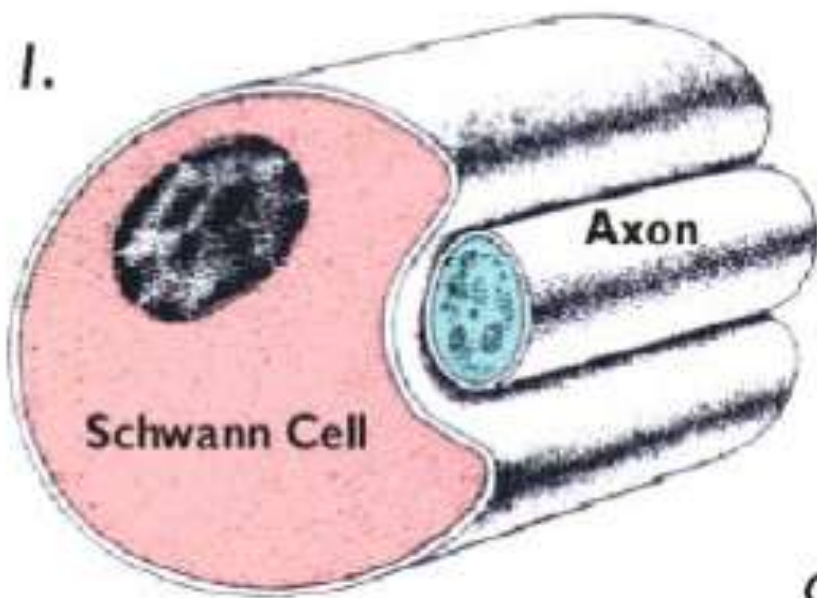
- Non fenestrated endothelium of the capillaries.
- A substantial basement membrane.
- Perivascular foot & the cell body of astrocytes.
- A network of intercellular spaces intervening between the astrocytes & neurons.
- Processes & cell bodies of neurons.



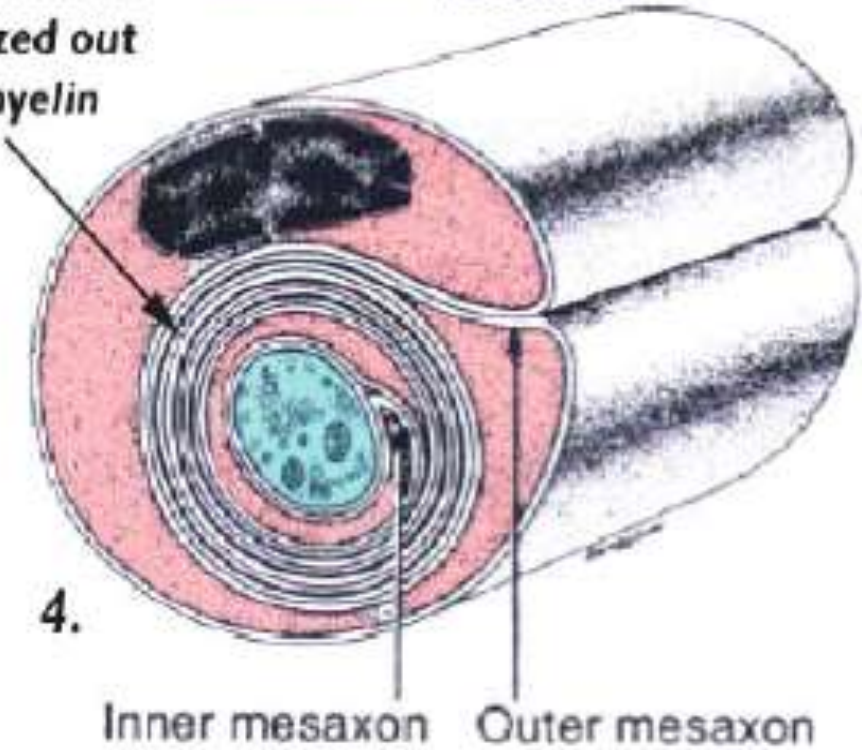
Myelination

- The axons of most mammalian neurons are surrounded by a multilayered lipid & protein covering produced by neuroglia that is called the myelin sheath.
- The sheath electrically insulates the axon of a neuron & increases the speed of nerve impulse conduction.
- Axons with such a covering are said to be myelinated, where as those without it are unmyelinated.
- Electron micrographs reveal that even unmyelinated axons are surrounded by a thin coat of neuroglial plasma membrane.

- In the PNS, neurolemmocytes begin to form myelin sheaths around axons during fetal development.
- Each neurolemmocytes wraps about 1mm of a single axon's length by spiraling many times around the axon.
- Eventually multiple layers of glial plasma membrane surround the axon, with the neurolemmocyte cytoplasm & nucleus forming the outermost layer. The inner portion, consisting of up to 100 layers of neurolemmocyte membrane, is the myelin sheath.
- The outer nucleated cytoplasmic layer of the neurolemmocyte, which encloses the myelin sheath is called the neurolemma. A neurolemma is found only around axons in the PNS.

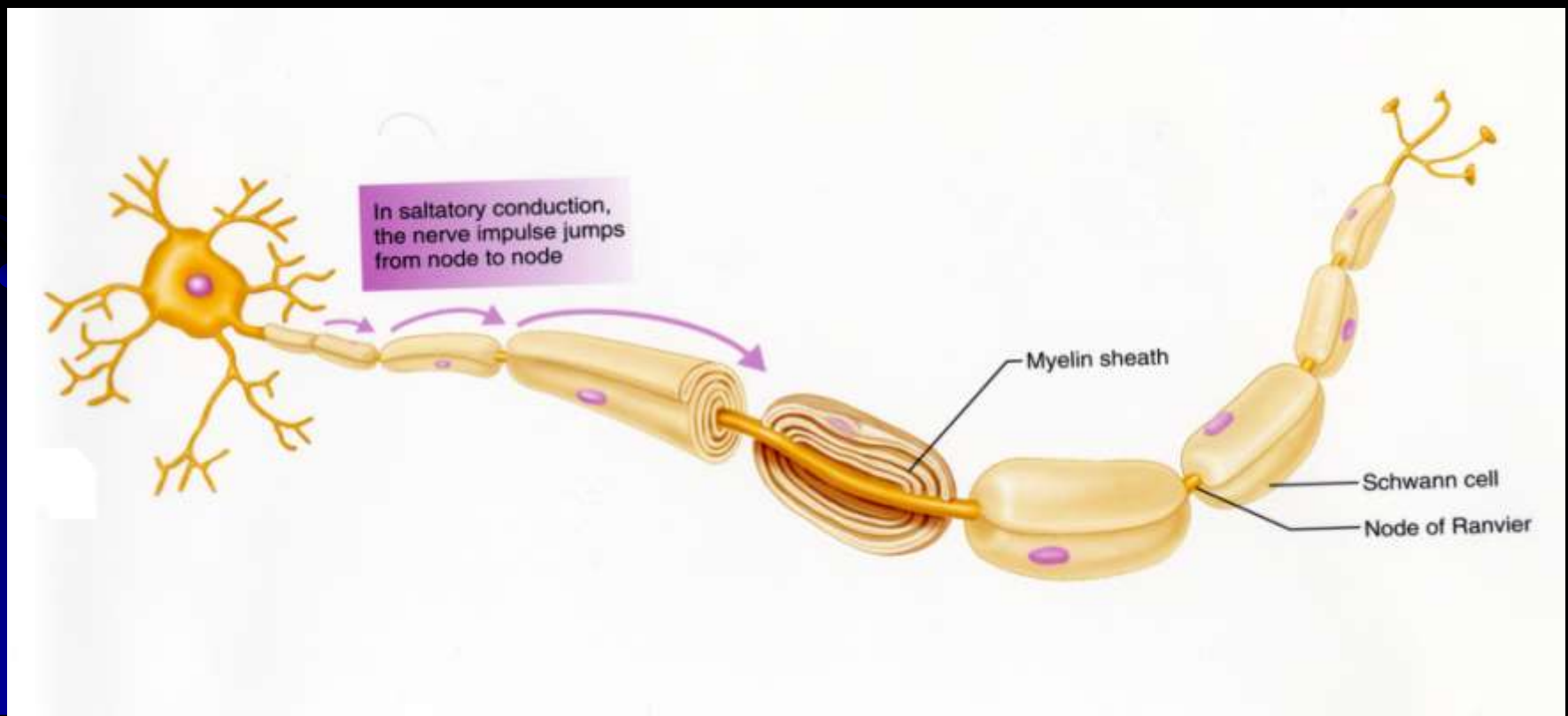


Cytoplasm is squeezed out of myelin



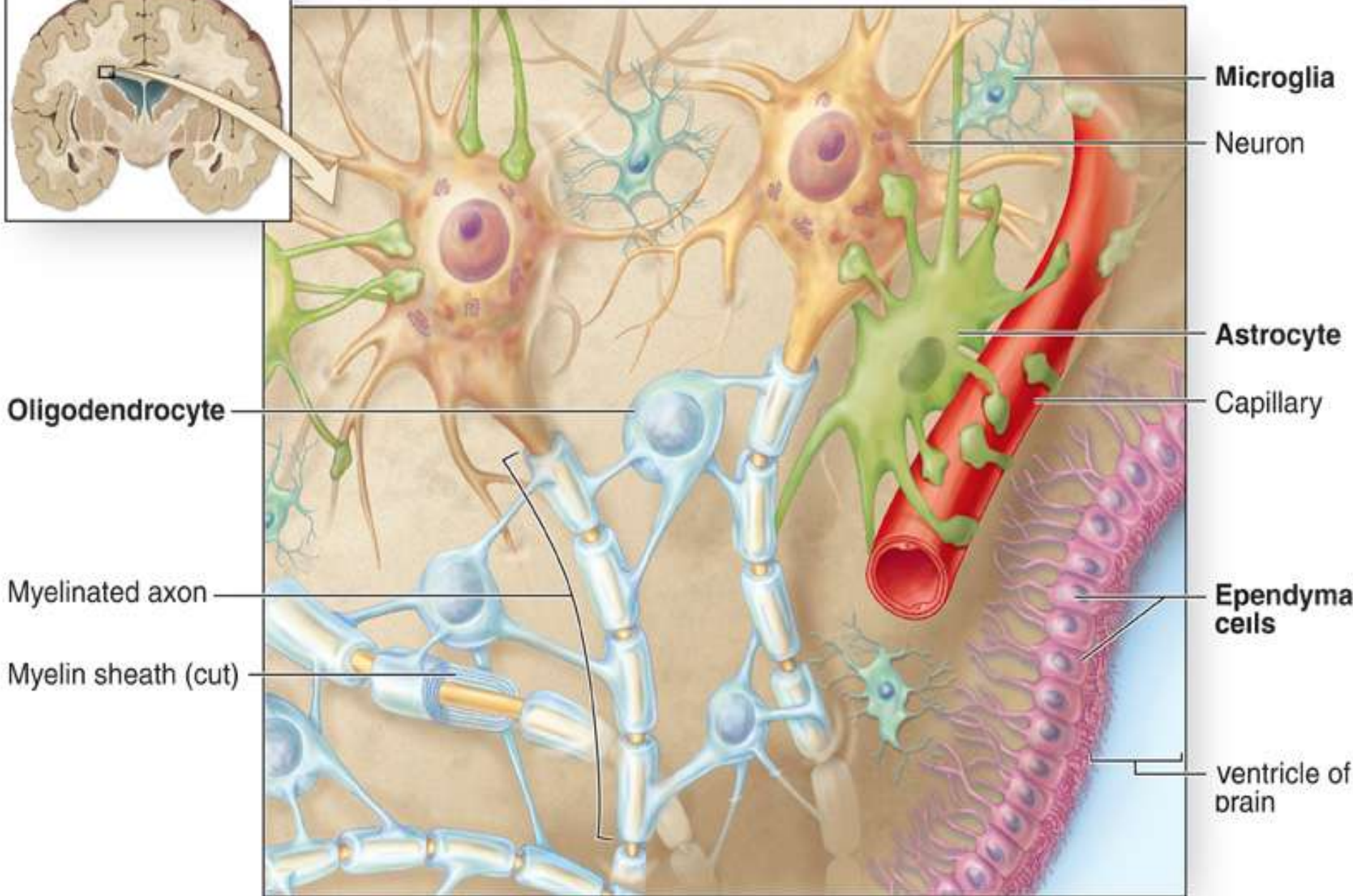
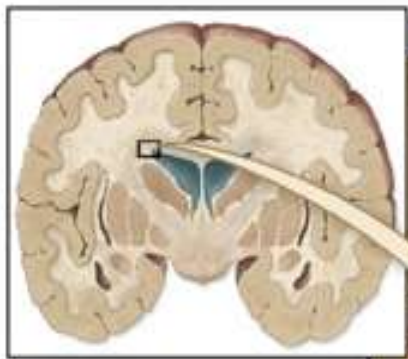
FORMATION OF MYELIN SHEATH

- At intervals along the axon, the myelin sheath has gaps called nodes of Ranvier. Each neurolemmocyte wraps the axon segment between 2 nodes.
- When an axon is injured, the neurolemma aids regeneration by forming a regeneration tube that guides & stimulates regrowth of the axon.



- In the CNS, an oligodendrocyte myelinates parts of many axons in somewhat the same manner as a neurolemmocyte myelinates part of a single PNS axon.
- It puts forth an average of 15 broad, flat processes that spiral about CNS axons & deposit a myelin sheath.
- A neurolemma is not formed, however, because the oligodendrocyte cell body & nucleus do not envelop the axon.
- Neurofibril nodes are present, but they are fewer in number.

Axons in the CNS display little regrowth after injury. This is thought to be due, in part, to the absence of a neurolemma & in part to an inhibitory influence exerted by CNS neuroglia



Microglia

Neuron

Astrocyte

Capillary

Ependymal cells

ventricle of brain

Oligodendrocyte

Myelinated axon

Myelin sheath (cut)

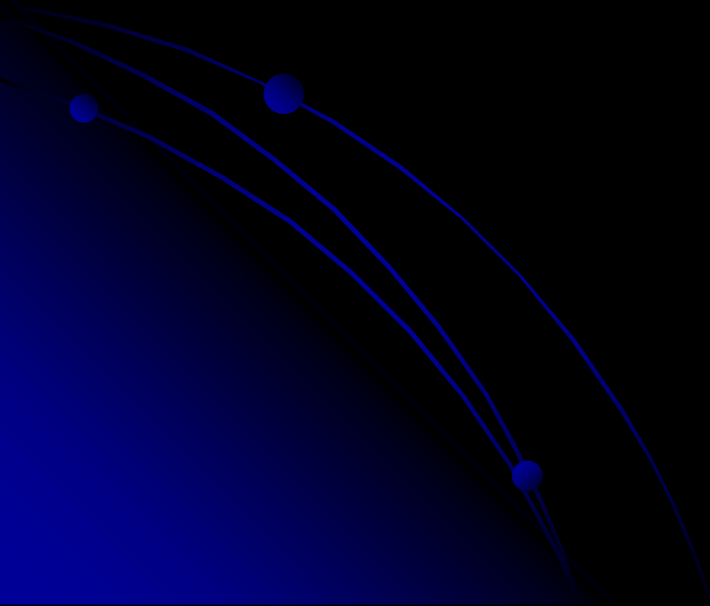
- The amount of myelin increases from birth to maturity, & its presence greatly increases the speed of nerve impulse conduction.

- Since myelination is still in progress during infancy, an infants response to stimuli are not as rapid or co-ordinated as those of an older child or an adult.

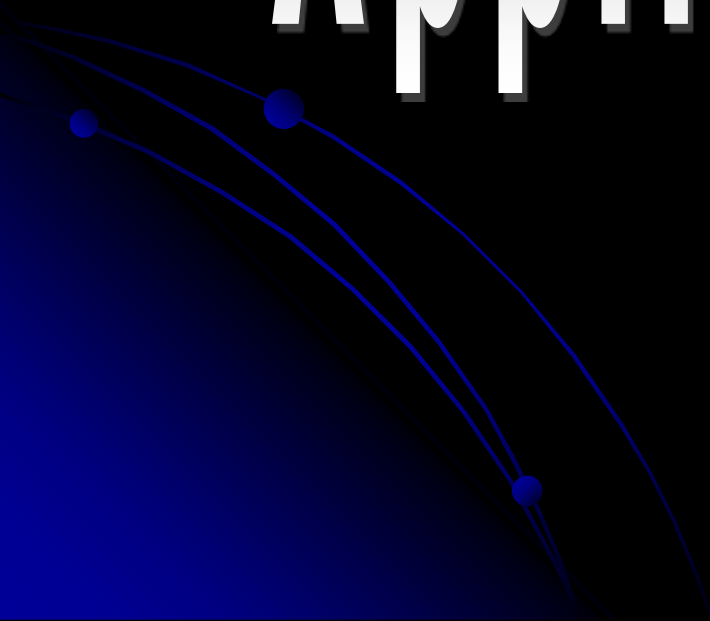
Neural conduction

Saltatory conduction - (saltus is latin for “to leap”) -
In myelinated neurons

Continuous conduction – In unmyelinated neurons

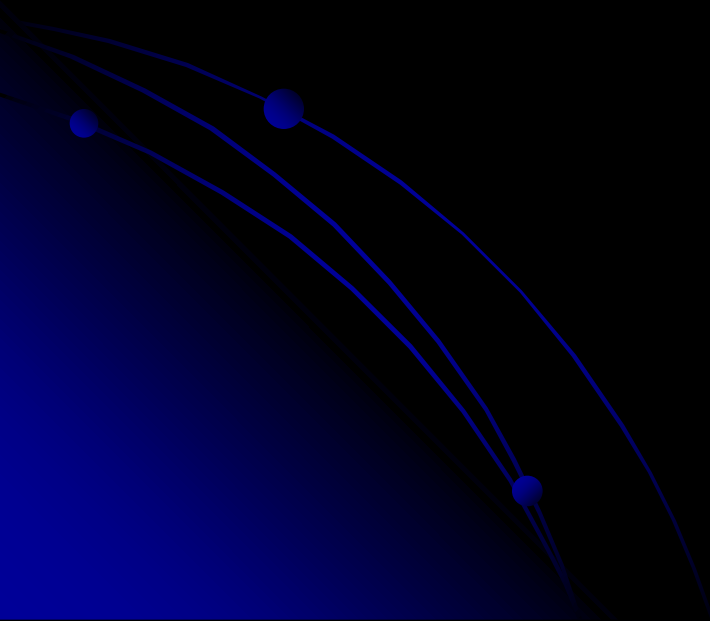


Applied Aspects



Brain tumors

Most of the brain tumors are neuroglial in origin & the majority are astrocytes. Such tumors are tend to be highly malignant & they grow rapidly.



Demyelination

- Progressive destruction of myelin sheaths
- Both in the CNS and PNS
- Results in loss of sensation and motor control that leaves affected regions numb and paralyzed
- Several unrelated conditions can cause demyelination including:
 - Heavy-metal poisoning
 - Diphtheria
 - Multiple sclerosis
 - Guillain-Barre syndrome
 - Pernicious anemia

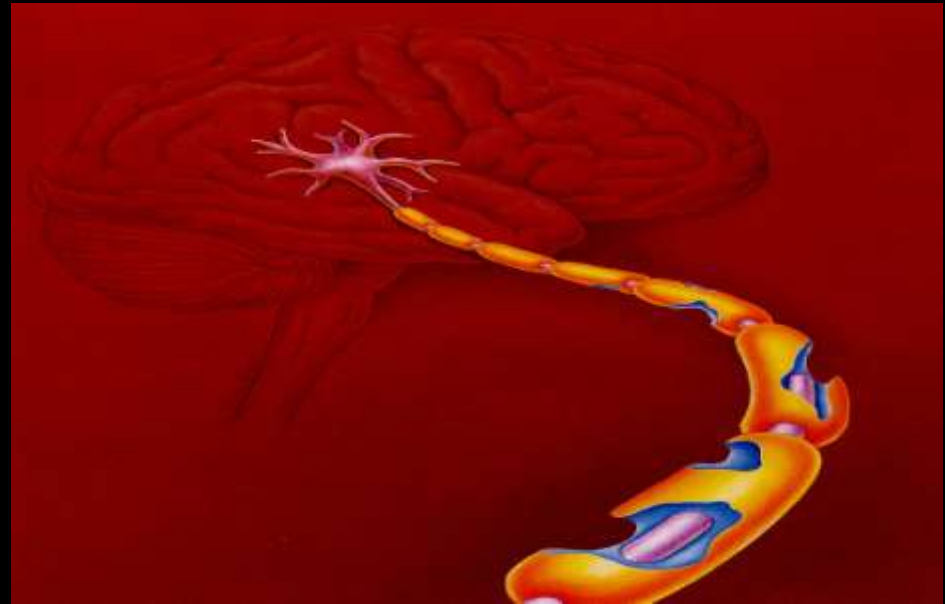
Diphtheria

- In the nervous system, the toxin produced by the bacteria damages Schwann cells
- Destroying the myelin sheath in the PNS
- This leads to sensory and motor problems;
- can eventually lead to paralysis

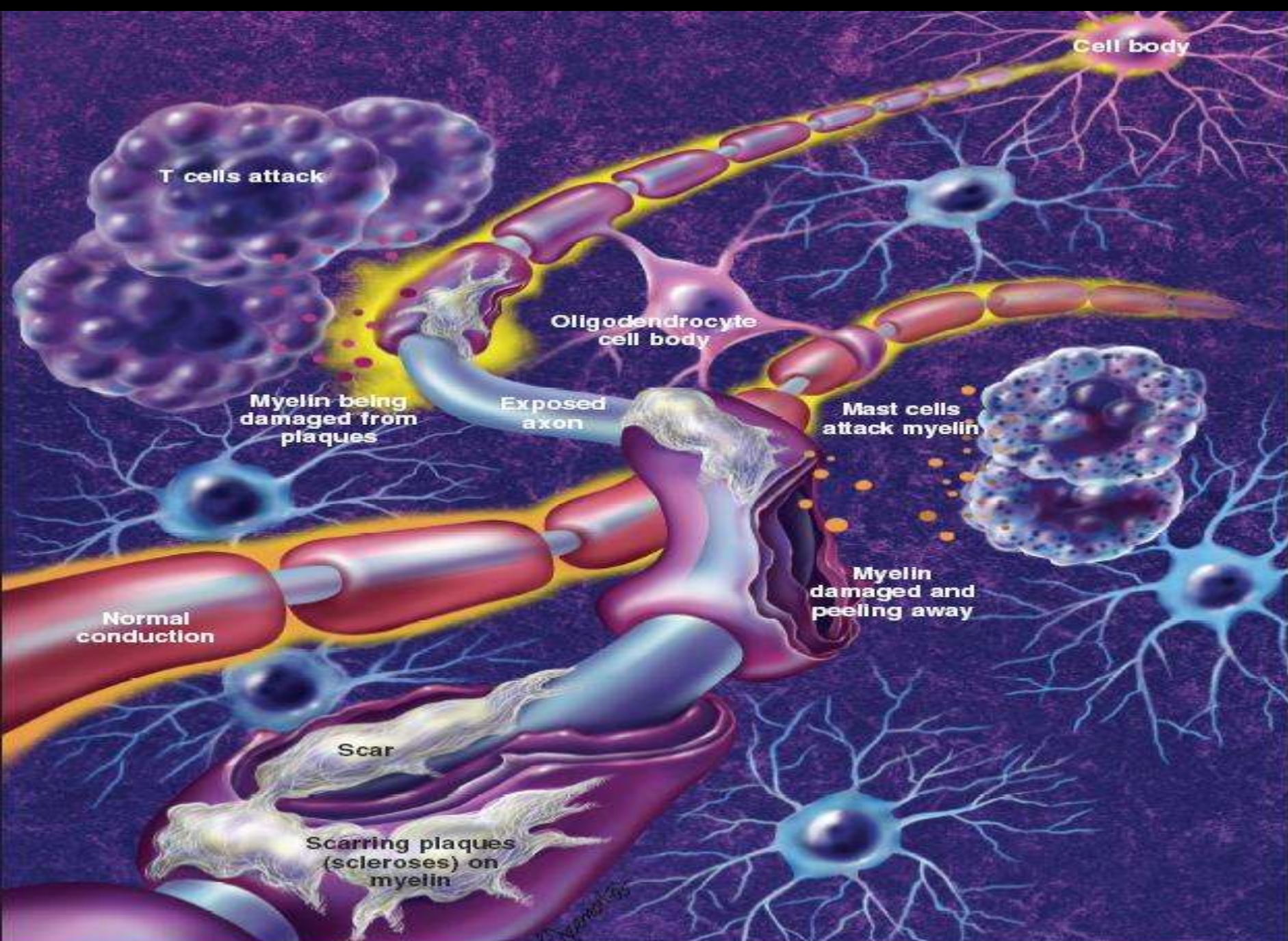


Multiple sclerosis

- Disease characterized by recurrent incidents of demyelination that affects axons in the:
 - Optic nerve
 - Brain
 - Spinal cord




- Women are more likely to have M.S. than men
- Average age at the first attack is 35



Inflammation, loss of myelin, scarring, and axonal damage represent the neurological insults that characterize MS.

Guillain-Barre syndrome

- Progressive but reversible demyelination of spinal roots or peripheral nerves
 - Initial symptoms include leg weakness
 - This spreads rapidly to the trunk
 - Some permanent loss of motor function can occur
- 

Pernicious anemia

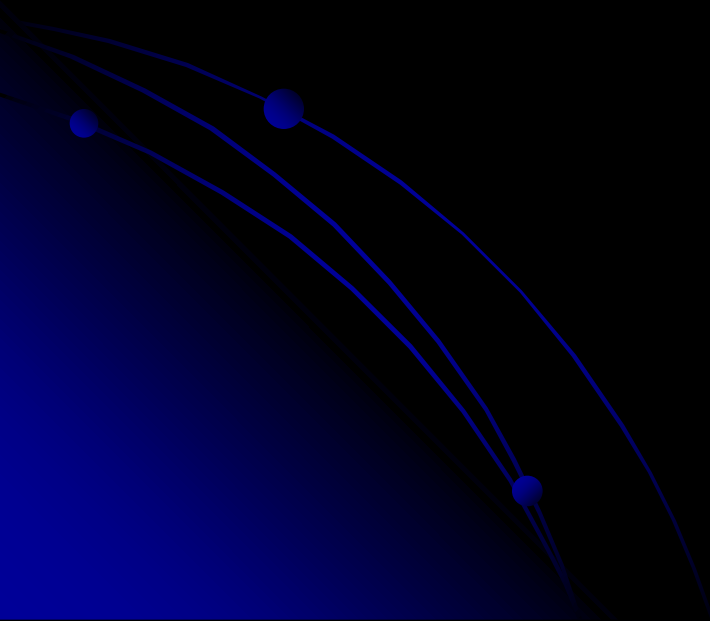
- Believed to be autoimmune disease
- Caused by anti-intrinsic factor antibodies
- These antibodies limit the production of intrinsic factor in the body
- A lack of intrinsic factor inhibits vitamin B12 absorption
- Vitamin B12 is a necessary component for manufacturing:
 - Red blood cells
 - Myelin

Tay-Sachs Disease

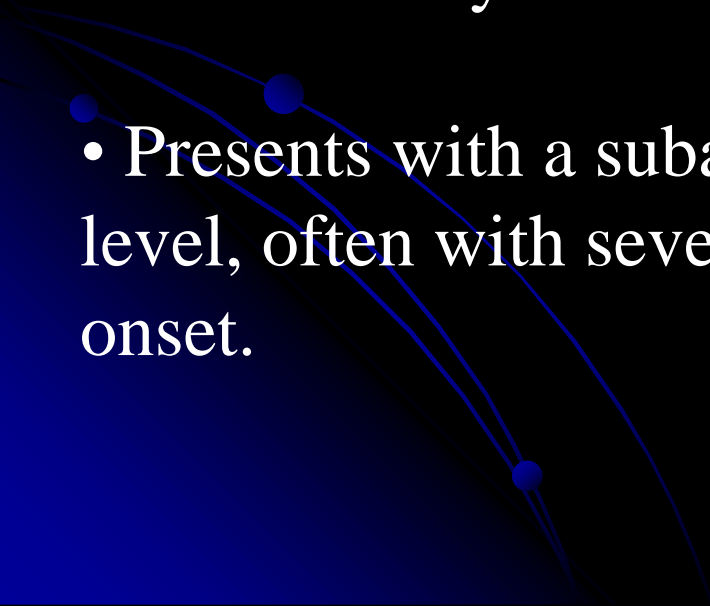
- A genetic abnormality transmitted as an autosomal – recessive trait
- Affected individuals lack the enzyme needed to break down a particular ganglioside, a component of neuron cell membranes
- Cause destruction of myelin sheath.
- Characterized by progressive mental and physical retardation and early death
- The disease is most prevalent in Jewish of Eastern European origin

Acute Disseminated Encephalomyelitis

- This is an acute monophasic demyelinating condition in which there are areas of perivenous demyelination widely disseminated throughout the brain & spinal cord.



Acute transeverse myelitis

- It is an acute monophasic inflammatory demyelinating disorder affecting the spinal cord over a variable number of segments.
 - Patients may be of any age.
 - Presents with a subacute paraparesis with a sensory level, often with severe pain in the neck or back at the onset.
- 

LEPROSY

Mycobacterium leprae - Infection of Schwann cell



IN SHORT.....

- The neuroglia are the supporting cells of the CNS. The glial cells unlike the nerve cells, are non excitable & undergo mitotic division.
- Neuroglia cells are fitted among the nerve cells & their fibres;
- The processes of some neuroglia form a continuous thin glial membrane between the blood vessels & the neurons.
- The main functions of glial cells are to surround neurons and hold them in place, to supply nutrients and oxygen to neurons, to insulate one neuron from another, and to destroy pathogens and remove dead neurons.
- The neuroglia are about 10 times more numerous than the neurons & form the major component of the total volume of human brain.



Thank You