Biology

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Nervous system

The nervous system is responsible for communication between different regions of the body, it is divided into:

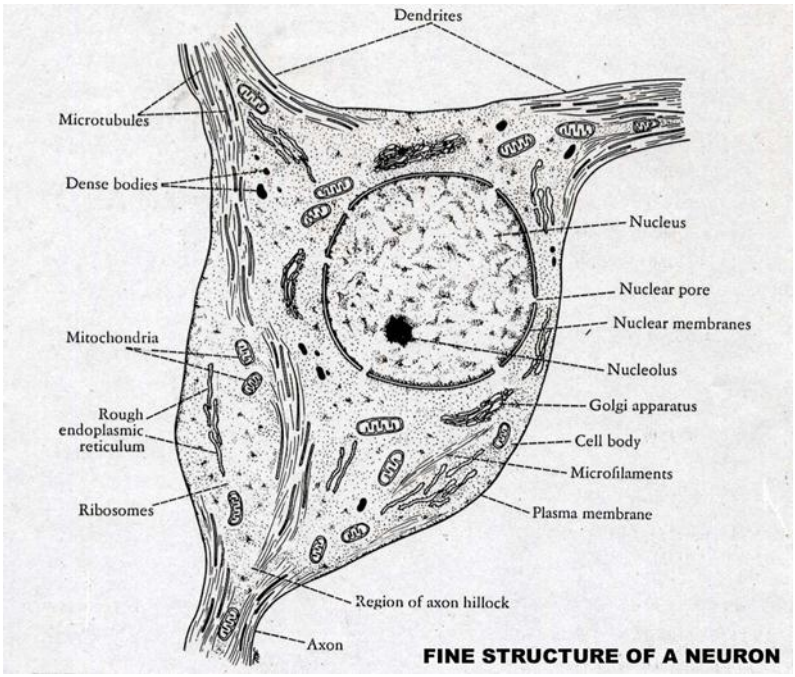
- **CNS (central nervous system) = brain + spinal cord**
- **PNS (peripheral nervous system) =nerves running between the CNS & other tissues.**

Nervous tissue consists of two major cell types:
neurons and neuroglia.

The Neuron:

Is the main functional unit of the nervous system , it consists of :

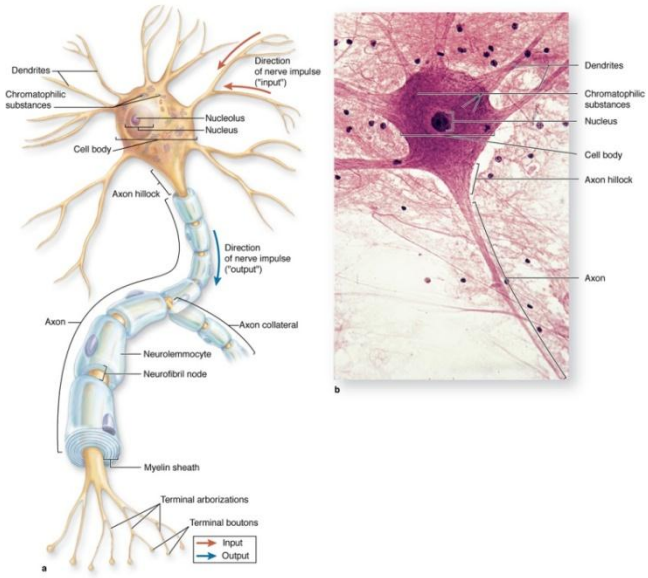
- **Cell body (perikaryon) :** containing large nucleus & central nucleolus. The cytoplasm contains abundant lysosomes & rough endoplasmic reticulum (RER), Nissl substances (RER and free ribosomes also called chromatophilic substances), well developed Golgi & large no. of mitochondria to provide energy, inclusions of pigmented material such as lipofuscin. The neurons are highly metabolically active cells.



- **Axon :** a single long process which conducts the electrical signals from the cell body of the neuron to other cells. axons can range in length from 1 millimeter to as long as 1 meter. Sometimes axons branch into one or more collateral axons. Each axon may have several small branches at the end; these are called axon terminals. Axons are **output** channels. The conical region of an axon where it joins the cell body is called the axon hillock, this is the region where the signals that travel down the axon are generated. Near its end, an axon usually divides into several branches, each of which ends in a synaptic terminal. The site of communication between a synaptic terminal and another cell is called a synapse. At most synapses, information is passed from the transmitting neuron (the presynaptic cell) to the receiving cell (the postsynaptic cell) by means of chemical messengers called neurotransrnitters.

- **Dendrites:** Dendrites (from the Greek dendron, tree) are short processes which receive the signals from the axons of other neurons by making synapse which allows a direct communications between the cells. A single neuron can have anywhere from 1 to 20 dendrites, each of which can branch many times. Dendrites are **input** channels.

- **Terminal button:** is the branched terminal end of the axon. Many **neurotransmitters** are synthesized and stored in the axon terminals. Some are synthesized in the cell body and transported down the axon to the terminals. When released, neurotransmitters carry chemical messages between neurons and muscle fibers, which they cause to contract. They also carry messages to organs and glands that affect the function of all the body systems.



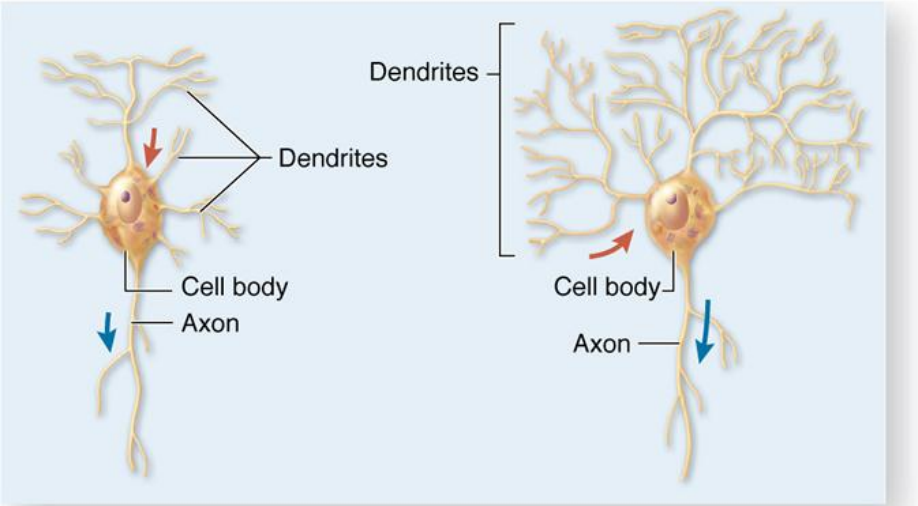
Unlike most other cells, neurons do not divide to reproduce themselves. Also unlike most other cells, neurons are able to transmit an electrochemical signal. Neurons, on the other hand, are irregular in shape and have a number of extensions (sometimes called "processes") coming off them. This makes them look something like a many-legged spider.

Types of the Neurons:

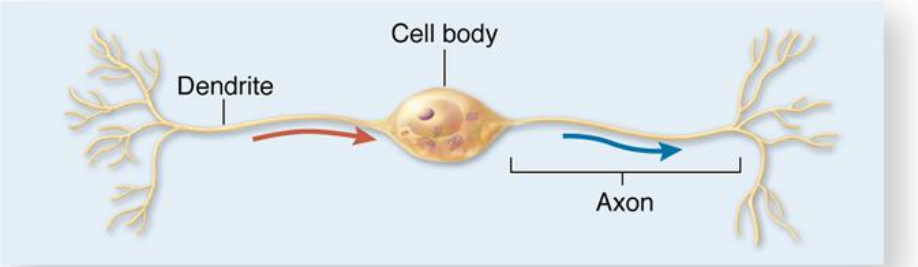
- **Multipolar (motor) neurons :** have large cell body + large axon + many dendritic processes.
- **Unipolar (pseudounipolar) (sensory) :** cell body + one large process divided into 2 branches, one is axon & other is dendrite.
- **Bipolar :** simple cells provide local communications within the CNS having 2 main processes of equal size one axon & other dendrite.

Neurons can be grouped into three general types:

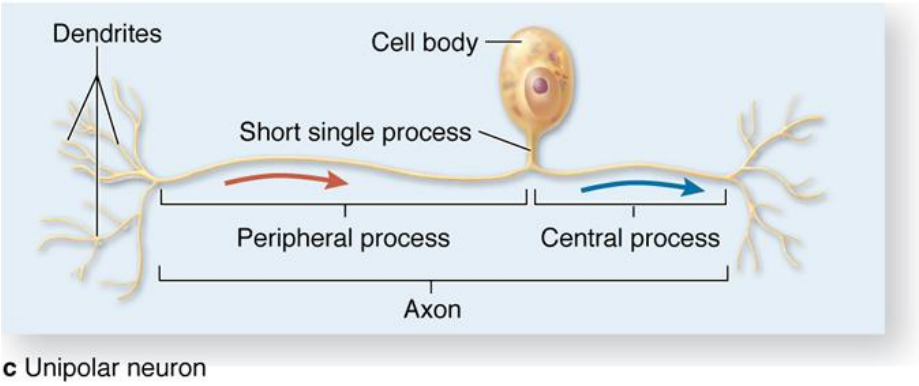
1. **Sensory** neurons (afferent): transmit impulses from receptors to the CNS (such as somatic afferent fibers that transmit sensations of pain, temperature, touch & pressure from body surface). While visceral afferent transmit pain impulses from internal organs, mucous membranes, glands & blood vessels.
2. **Motor** neurons (efferent): transmit impulses from the CNS or ganglia to effectors cells. Somatic efferent neurons send voluntary impulses to skeletal muscles, while visceral efferent neurons transmit involuntary impulses to smooth muscle, cardiac conducting cells & glands.
3. **Interneurons**: form communicating & integrating network between the sensory & motor neurons, it is estimated that 99.9% of all neurons belong to this integrating network.



a Multipolar neurons



b Bipolar neuron

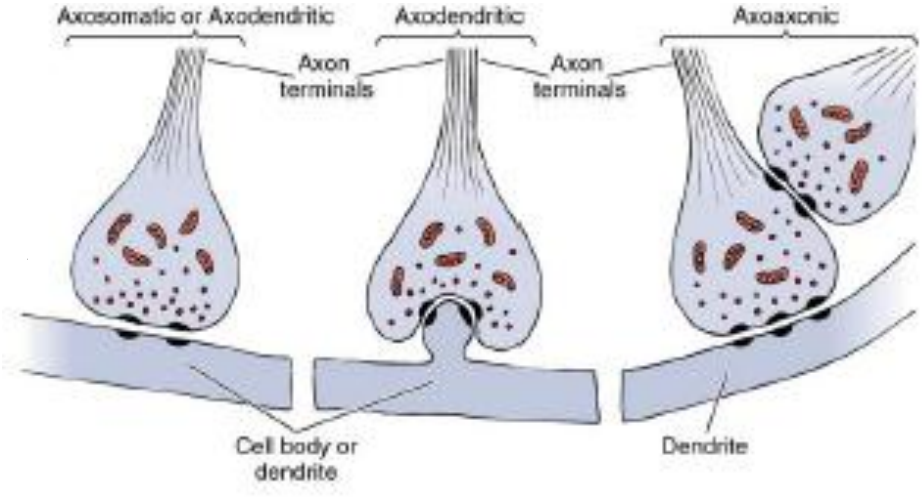


c Unipolar neuron

Synapses:

Synapses are the sites where 2 neurons contact each other. At synapses information are transmitted (in a unidirectional way) in the form of action potentials between two neurons (or between one neuron & other effector cell such as muscle or glandular cells). Synapse is formed by axonal terminal (presynaptic terminal) that delivers the signal, a region on the surface of another cell at which a new signal is generated (postsynaptic terminal) & a thin intercellular space between them (synaptic cleft). An axon terminal may synapse with a cell body (axosomatic synapse), a dendrite (axodendritic synapse), or another axon (axoaxonic synapse). In humans, synapses work by chemical molecules (neurotransmitters) released from presynaptic neuron terminal & affect the postsynaptic cell. This type is called chemical synapse. On the

other hand, action potentials may be transmitted directly from the presynaptic cell to postsynaptic cell through gap junctions (electrical synapse) which is extremely rare in human.



Glia:

They outnumber neurons by about 10 to 1 in the brain , Like neurons, glia have many extensions coming off their cell bodies. Unlike neurons, however, glia probably do not send out electrochemical signals. Also unlike neurons, glia are replaced constantly throughout a person's life. Most neurons are unable to survive alone for long; they require the nutritional support provided by the **neuroglial cells.** More than half the volume of the human nervous system is composed of supporting neuroglial cells.

In the brain & the spinal cord there are 4 types of supporting cells:

1. Astrocytes: stellate-shaped cells with fine processes radiating in all directions.

a. Astrocytes provide nutritional support to neurons and help keep most substances other than oxygen, carbon dioxide, glucose, and essential amino acids from entering the brain from the bloodstream.

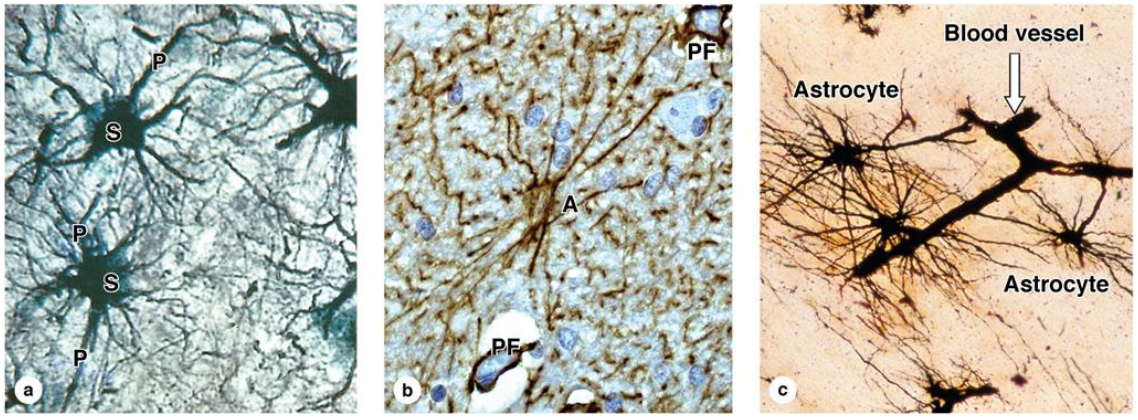
b. Astrocytes give structural support to hold neurons in place and also scavenge dead cells after an injury to the brain.

c. Processes from astrocytes called "end feet" adhere to the blood vessels of the brain and secrete chemical signals that induce the formation of tight junctions between the endothelial cells which line the blood vessels. As a result, substances from the extracellular fluid cannot move easily into these cells. Most large molecules cannot cross this blood-brain barrier. Small fat-soluble molecules and uncharged particles such as carbon dioxide and oxygen, however, diffuse easily across this barrier. So astrocytes play a role in the formation of blood-brain barrier which prevent diffusion of substances between the blood & the brain.

Astrocytes are of 2 types:

a. fibrous astrocytes found in the white matter of brain.

b. protoplasmic astrocyte found in the gray matter of brain.



2. Oligodendrocytes: round cells with few processes, these cell are located in both gray and white matter of CNS. They produce myelin within the CNS. In producing myelin, oligodendrocytes function similarly to the Schwann cells of the PNS, except that a single oligodendrocyte may wrap several axons with segments of myelin, whereas a single Schwann cell wrap only one axon with myelin.

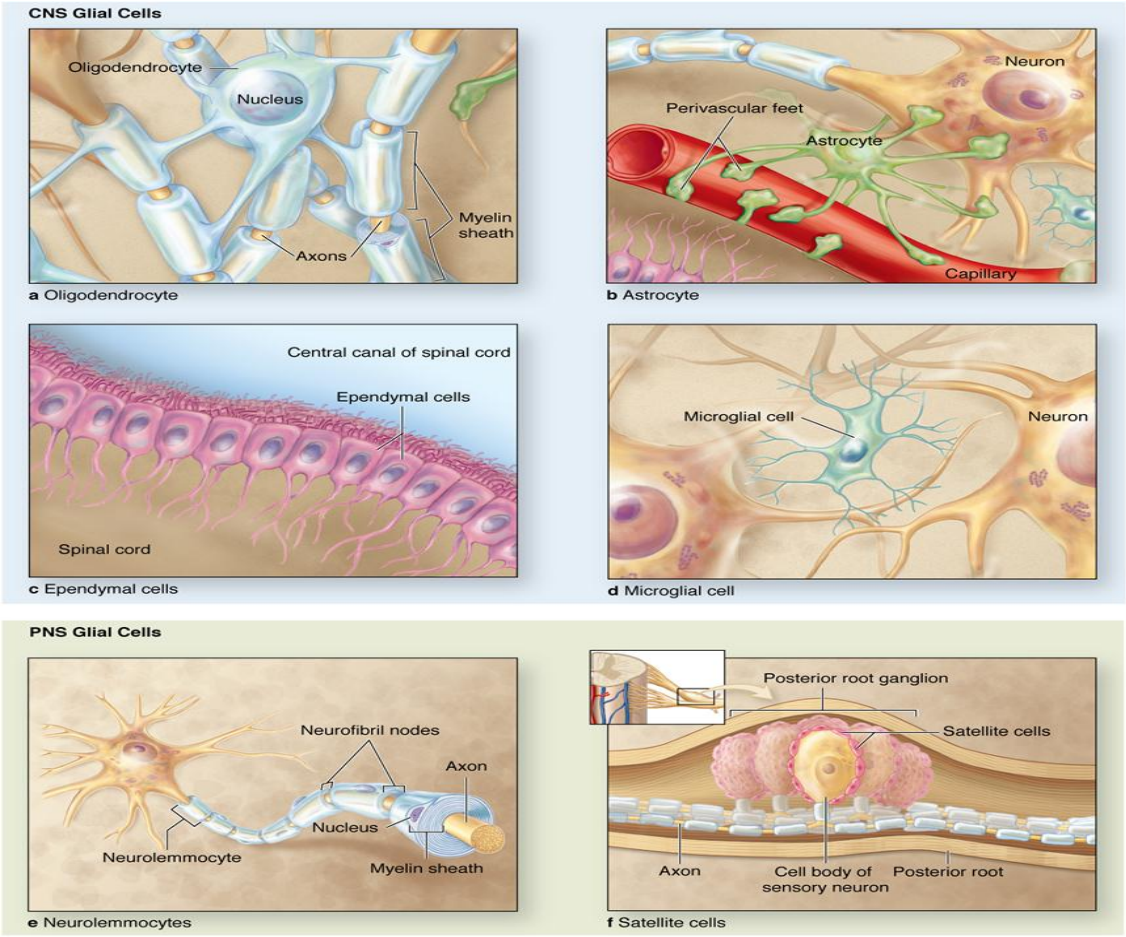
3. Ependymal cells: are epithelial cells lining the cavities (ventricles) of the brain as a sheet of cuboidal cells many of which are ciliated & they are in contact with the CSF. Cerebrospinal fluid acts as a shock-absorbing cushion to protect the brain from blows to the head. In effect, this fluid makes the brain float inside the skull. The cerebrospinal fluid also removes waste products from the brain.

4. Microglia cells: are specialized macrophages forming the immune cells in the CNS.

In PNS:

5. Schwann cell (neurolemmocytes): are found only in PNS, they function to envelop the axon of many neurons with a sheath of fatty material called myelin, which acts as an electrical insulator. Schwann cells produce myelin in the PNS, while oligodendrocytes produce myelin in the CNS. During development, these cells wrap themselves around each axon several times to form a **myelin sheath,** an insulating covering consisting of multiple layers of membrane. Schwann cells also help repair damaged nerves outside the brain and spinal cord.

6. Stellite cells of ganglia: form a covering layer over the large neuronal cell bodies in PNS ganglia and exert trophic or supportive role.



The peripheral nervous system

The main components of the peripheral nervous system are the nerves, ganglia and nerve endings.

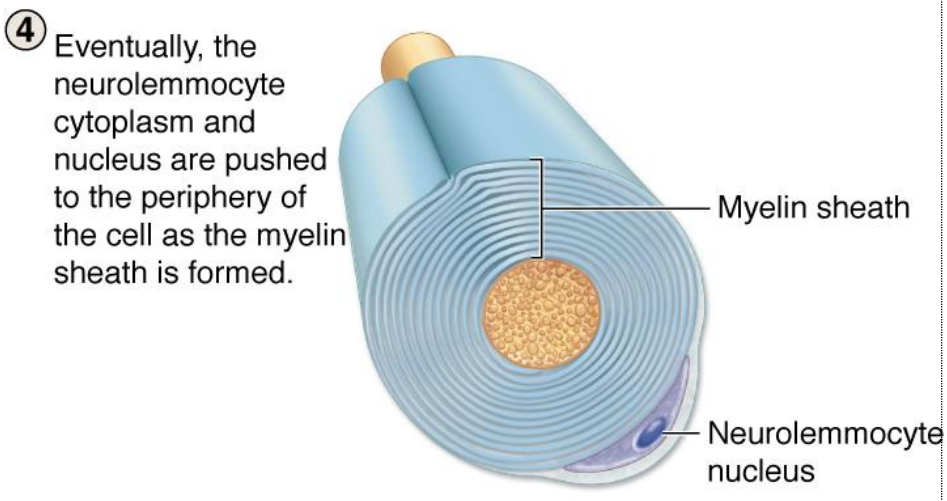
Nerves:- are bundles of nerve fibers surrounded by a series of connective tissue sheaths.

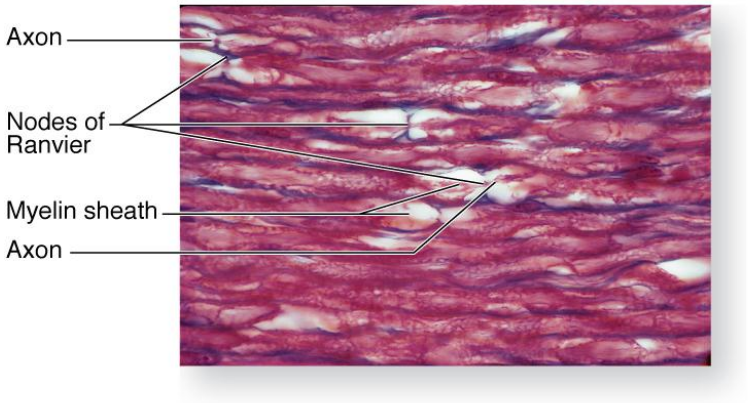
Nerve fibers:- consist of axons enveloped by a special sheath derived from cells of ectodermal origin. Nerve fibers exhibit differences in their enveloping sheaths, related to whether the fibers are part of the central or the peripheral nervous system. In peripheral nerve fibers, the sheath cell is the schwann cell, and in central nerve fibers it is the oligodendrocyte.

There are 2 types of nerve fibers:

1. **Myelinated nerve fibers:**

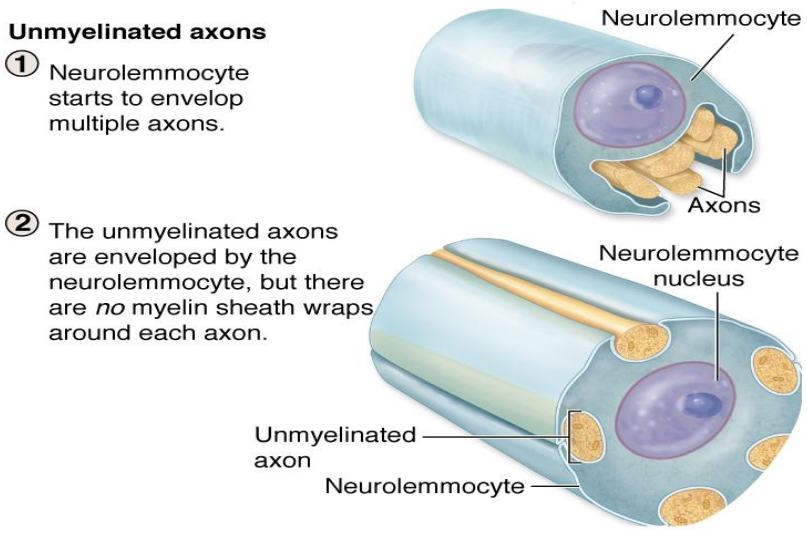
In myelinated nerve fibers of the PNS, the plasmalemma of the covering Schwann cell winds and wraps around the axon. The layers of membranes of the sheath cell unite and form myelin. In PNS, each axon is surrounded by myelin formed by a series of Schwann cells. The myelin sheath shows gaps along its path called the Nodes of Ranvier represent the spaces between adjacent Schwann cells along the length of the axon. The distance between 2 nodes is called an internode and consists of one Schwann cell. There are no Schwann cells in the CNS, there the myelin sheath is formed by the processes of the oligodendrocytes, which differ from Schwann cells in that different branches of one cell can envelope segments of several axons.





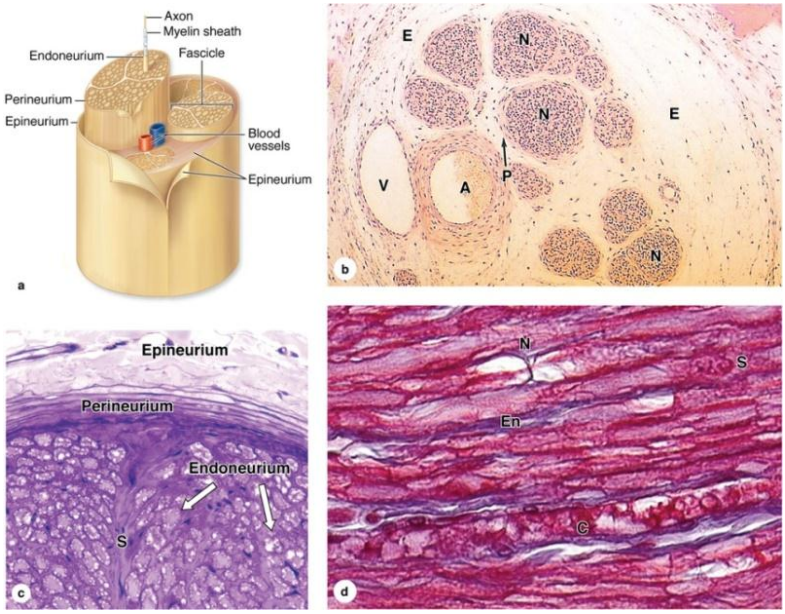
2. **unmyelinated nerve fibers:**

In both CNS, PNS, not all axons are sheathed in myelin. In the PNS, all unmyelinated axons are enveloped within simple clefts of the Schwann cells. Each Schwann cell can sheath many unmyelinated axons. Unmyelinated nerve fibers do not have nods of Ranvier, because abutting Schwann cells are united to form a continuous sheath.



Peripheral nerves:

Peripheral nerves are bundles of nerve fibers (axons) surrounded by several investments of connective tissue sheaths. Surrounding the whole nerve called epineurium, composed of collagen fibers, fibroblast, blood vessels, the bundles of nerve fibers each one surrounded by a sheath of C.T. called perineurium, within this perineurium are strands of fine C.T. extending between individual nerve fibers. These strands compose the endoneurium. These myelinated bundles (fascicles) appear white because of the presence of myelin. Each bundle of nerve fibers has both sensory and motor components.



Clinical notes:

1. Demyelinating Diseases can affect either PNS or CNS, which are characterized by damage to myelin sheath, resulting in decreased or lost ability to transmit impulses along nerve fibers.
2. Guillian-Barre syndrome (GBS) is a PNS demyelinating disease, affected patient suffers from ascending muscle paralysis & loss of cutaneous sensation
3. Multiple sclerosis (MS) is a disease that attacks myelin in the CNS, in which oligodendrocytes are targeted by immune response. It is characterized by neurological deficits such as vision loss, lack of muscle coordination.
4. Injured fibers in peripheral nerves have a good capacity for regeneration and return to function depending on the type of the nerve injury.