Lectures of Histology

(1st Stage)

First Semester 2024-2025

Anatomy and Histology Department

By

Prof. Dr. Khulood Naji Rasheed

Nerve Tissue

It is a highly specialized tissue that receives stimuli from both internal and external environments, converts them into nervous impulses, analyses, and then transfers them to other parts of the body to cause a reaction or produce appropriate coordinated response to that stimulus. These functions are performed by specialized cells called **nerve cells** or **neurons** (Fig.1).

Nerve tissue is distributed throughout the body as an integrated communications network. Anatomically, the general organization of the nervous system has two major divisions:

- Central nervous system **(CNS)**, consisting of the brain (located in the cranial cavity) and spinal cord (located in the vertebral cavity).
- Peripheral nervous system **(PNS)**, composed of the cranial nerves (12 pairs), spinal nerves (31 pairs) conducting impulses to and from the CNS, and ganglia that are small aggregates of nerve cells outside the CNS. PNS can be subdivided into sensory (afferent) nerves and motor (efferent) nerves. Sensory nerves send nerve impulse from the body to CNS, while motor nerves send impulse from CNS to effector organs.

There is also **autonomic** nervous system **(ANS)**, which can be divided into two types: **sympathetic** and **parasympathetic**. In general, sympathetic nerves stimulate activities of the effector organs, while parasympathetic nerves inhibit activities of the effector organs.

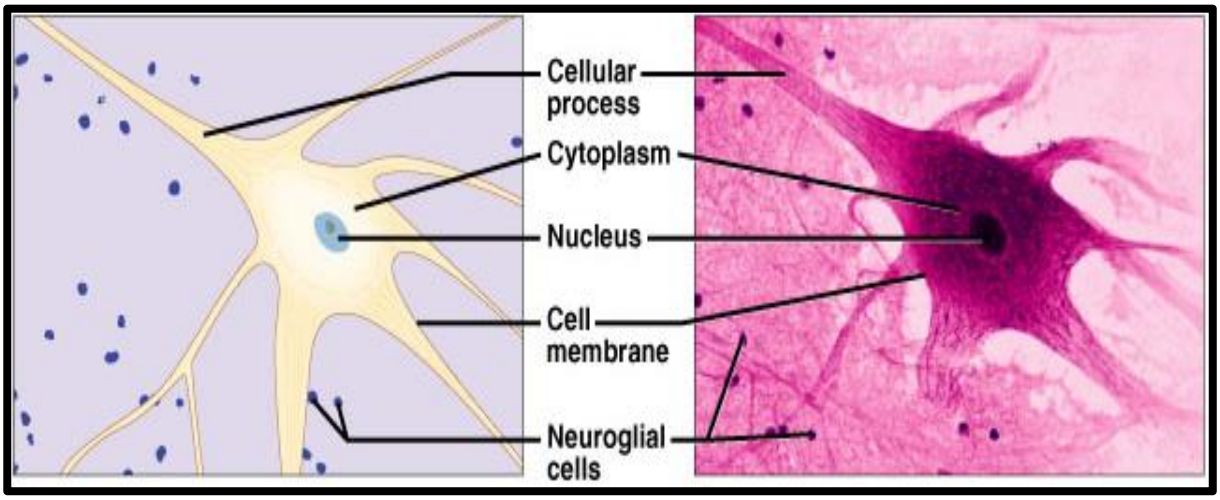


Fig. 1: Nerve cell (neuron).

* Types of cells in nerve tissue

1. Neurons (nerve cells)- functional units of the nervous system. They are specialized complex integrative circuits (receive, process, and transmit stimuli to and from other nerves, muscle cells, glands) they consist of cell body and protoplasmic projections (numerous long processes) (Fig.2).

2. Glial cells- accessory cells (which have short processes), outnumber neurons in a ratio of 1:10, support and protect neurons, participate in many neural activities, neural nutrition, and defense of cells.

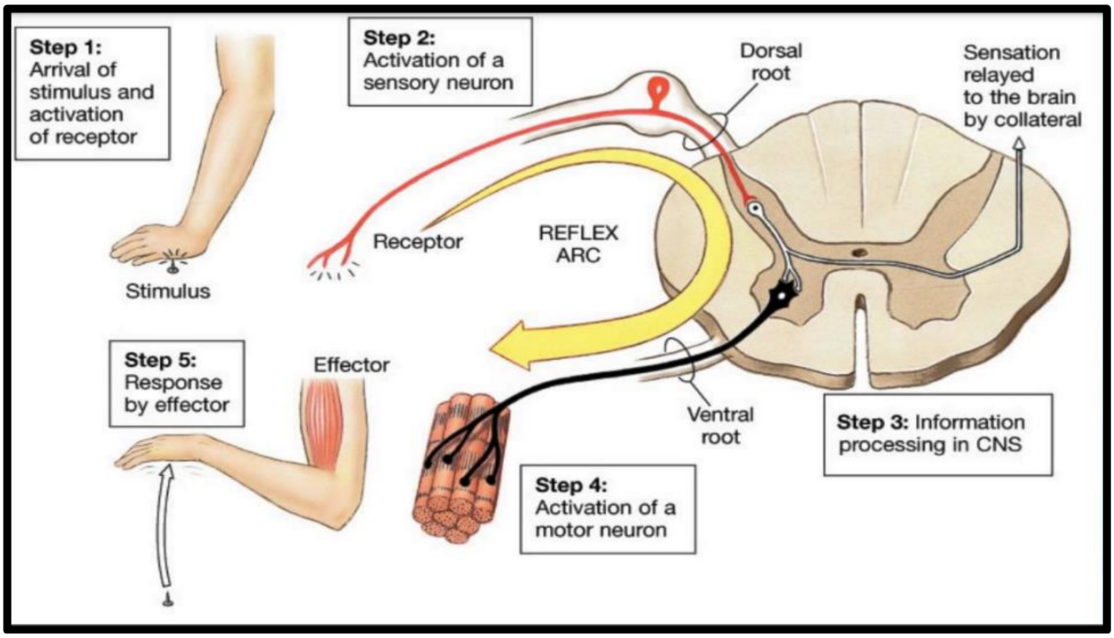


Fig. 2: **The reflex arc.**

* Most neurons have three main parts:

■ The cell body (also called perikaryon/soma) which contains the nucleus and most of the cell's organelles and serves as the synthetic or trophic center for the entire neuron.

■ The dendrites, are the numerous elongated processes extending from the perikaryon, have many branches (primary, secondary, tertiary, etc.), its specialized to receive stimuli from other neurons. They are thick at the area of their connection with cell body, then become finer and finer by increasing their branches. They may have spines on their surfaces to increase the surface area of connection or synapse (unique sites specialized to generate and conduct nerve impulses to other cells).

- The axon, it is always single, and generally a constant diameter smaller than diameter of dendrites and longer than it, ends with many branches (but less than the dendrites) called telodendria, which are attached to the dendrites of another neuron or with its body (at synapse). Telodendria ends have small bulges called boutons terminaux.

*** Cell body (Perikaryon or Soma)**

A typical neuron (Fig.3) has an unusually large nucleus with a prominent nucleolus. Cytoplasm often contains numerous free polyribosomes and highly developed RER. Histologically these regions with concentrated RER and other polyribosomes are basophilic and are distinguished as chromatophilic substance (or Nissl substance, Nissl bodies). The amount of this material varies with the type and functional state of the neuron and is particularly abundant in large nerve cells such as motor neurons. The Golgi apparatus is located only in the cell body, but mitochondria can be found throughout the cell and are usually abundant in the axon terminals.

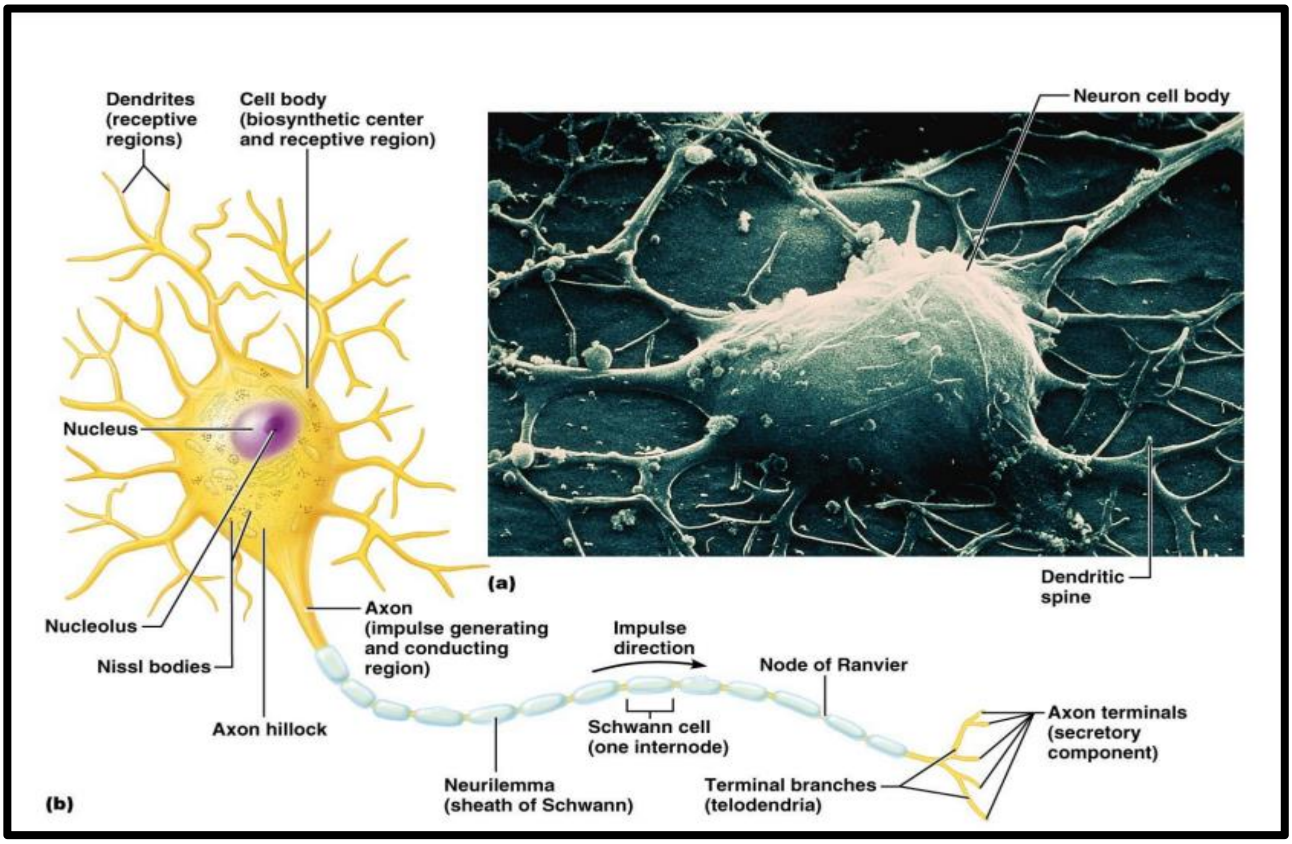


Fig. 3: **Cell body (Perikaryon or Soma).**

Neurons and their processes are extremely variable in size and shape. Cell bodies can be very large, measuring up to (150) µm in diameter. Other neurons, such as the cerebellar granule cells are among the body's smallest cells, measuring (4-5) µm. Neurons can be classified according to the number of processes extending from the cell body into (Fig.4):

- Multipolar neurons, each with one axon and two or more dendrites, are the most common.
- Bipolar neurons, with one dendrite and one axon, comprise the sensory neurons of the retina, the olfactory epithelium, and the inner ear.
- Unipolar or pseudounipolar neurons, which include all other sensory neurons, each have a single process that bifurcates close to the perikaryon, with the longer branch extending to a peripheral ending and the other toward the CNS.
- Anaxonic neurons, with many dendrites but no true axon, do not produce action potentials, but regulate electrical changes of adjacent CNS neurons.

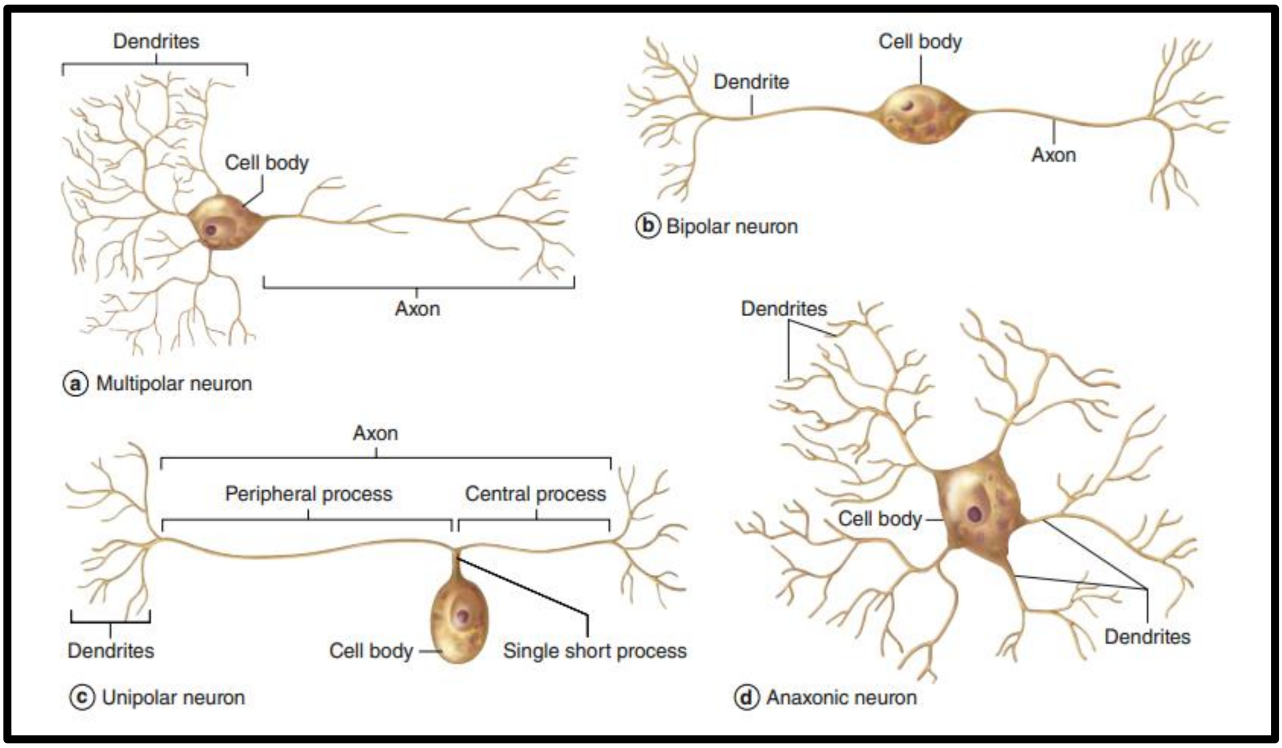


Fig. 4: **Structural classification of neurons.**

* Myelinated fibers

- Myelinated axons (Fig.5) are enclosed by a lipoprotein substance called myelin sheath produced by type of neuralgia cell celled (Schwann cells in PNS and Oligodendrocytes in CNS) while axons that have no myelin sheath are called unmyelinated axons.

- Myelin sheath insulates the axon leaving only narrow gaps called nodes of Ranvier to allow action potential to occur. This type of nerve impulse propagation where action potential jumps from one gap to the next is referred to as "saltatory conduction" (which increases the rate of impulse transmission by 240 folds).

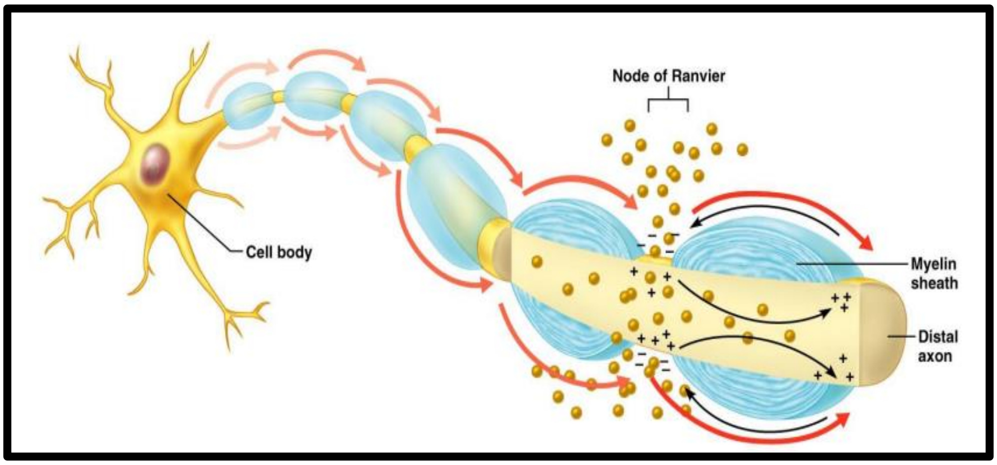


Fig. 5: **Myelinated fibers.**

* Glial cells and neuronal activity

- Types of neuroglia in CNS:

1. Astrocytes: star-shaped cells have processes that attach to the walls of blood capillaries (Fig.6). They are the most abundant glial cells (found in two types: protoplasmic in gray matter, and fibrous in white matter). They control the chemical environment of the brain, as well as, forming blood-brain barrier.

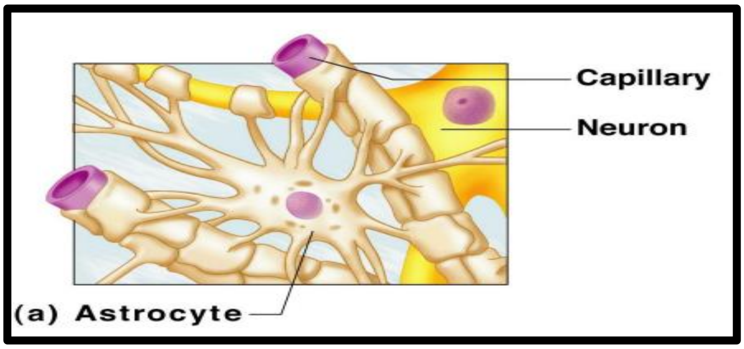


Fig. 6: **Astrocyte.**

2. **Microglial cells:** small cells, spider-like phagocytes, evenly distributed throughout gray and white matter. Microglia do not originate from neural progenitor cells like other glia, but from circulating blood monocytes, belonging to the same family as macrophages and other antigen-presenting cells (Fig.7). They constitute the major mechanism of immune defense, removing any microbial invaders and dispose of debris like dead cells.

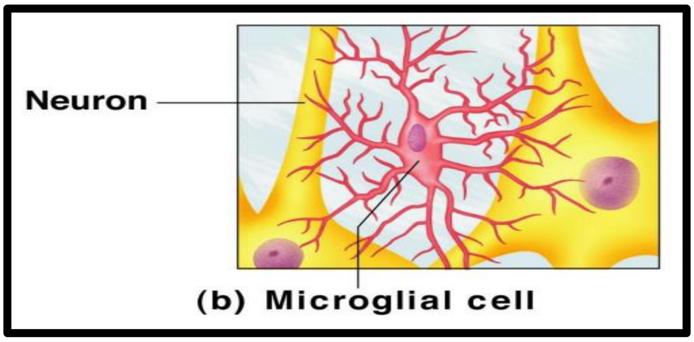


Fig. 7: Microglial cell.

3. **Ependymal cells:** columnar or cuboidal cells that line the fluid-filled ventricles of the brain and central canal of spinal cord (Fig.8). They facilitate the movement of cerebrospinal fluid by beating their cilia, and long microvilli which are likely involved in absorption.

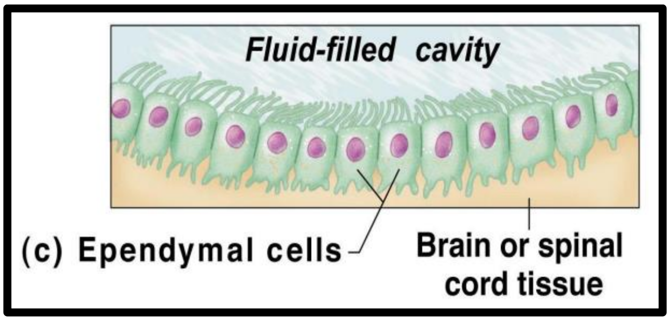


Fig. 8: Ependymal cell.

4. **Oligodendrocytes:** small round cells with few cytoplasmic processes. They are the predominant glial cells in white matter (Fig.9). They produce myelin sheaths.

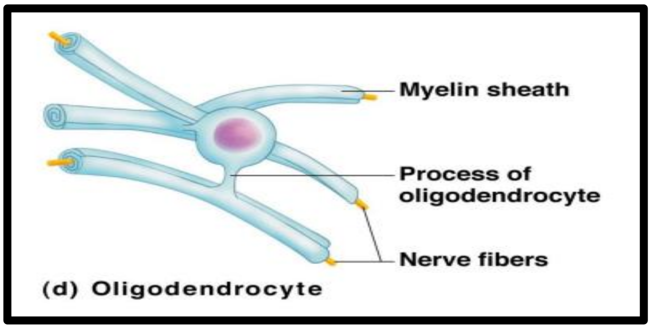


Fig. 9: Oligodendrocyte.

- Types of neuroglia in PNS:

1. Schwan cells: flattened cells with flattened nucleus. They are counterparts to oligodendrocytes of the CNS, however unlike an oligodendrocyte, a Schwann cell forms myelin sheath around a portion of only one axon (series of Schwann cells sheathing the full length of an axon) (Fig.10).

2. Satellite cells: small, flattened cells with prominent nuclei, form a thin, intimate glial layer around each large neuronal cell body in the ganglia of the PNS. Satellite cells exert a trophic or supportive effect on these neurons, insulating, nourishing, and regulating their microenvironments (Fig.10).

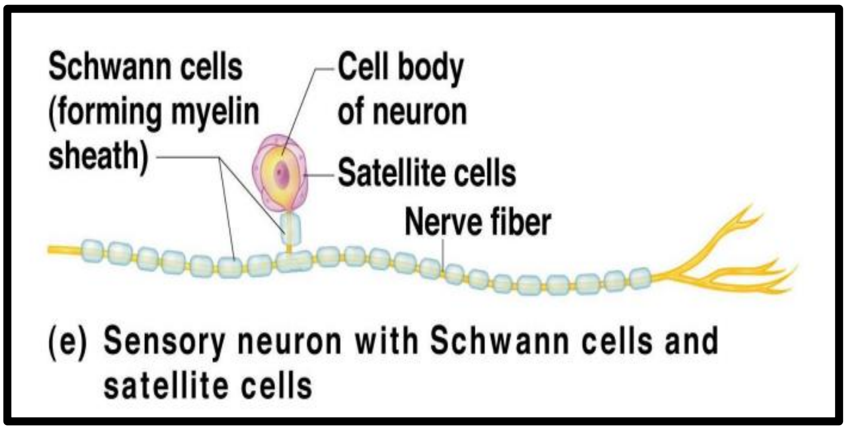
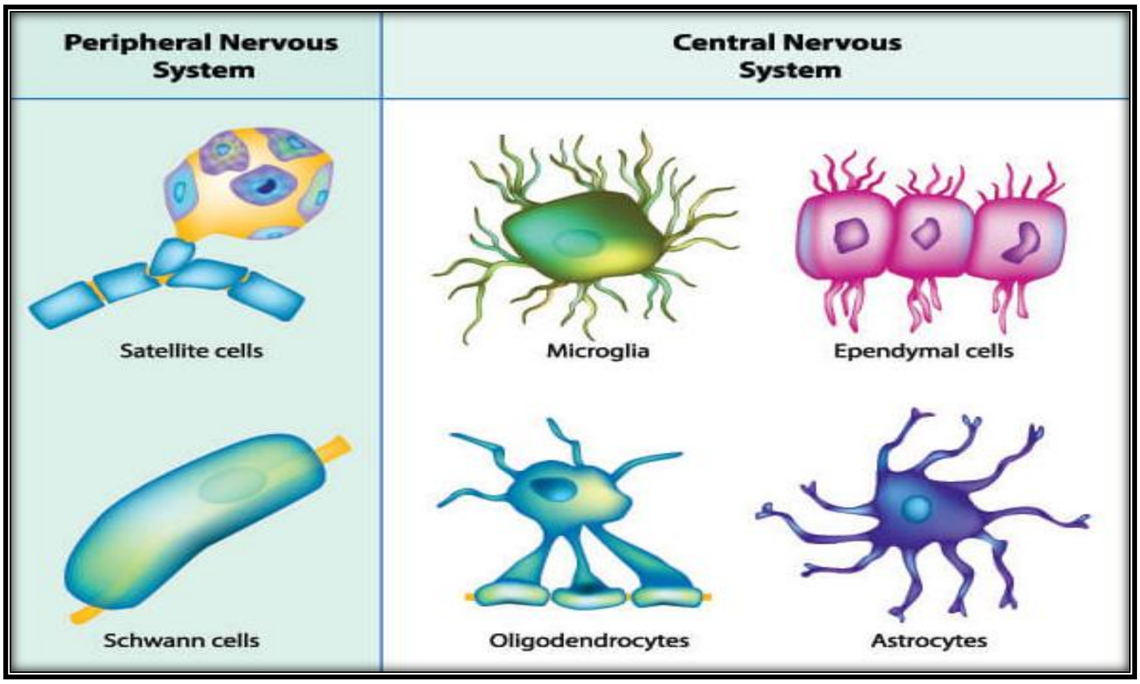
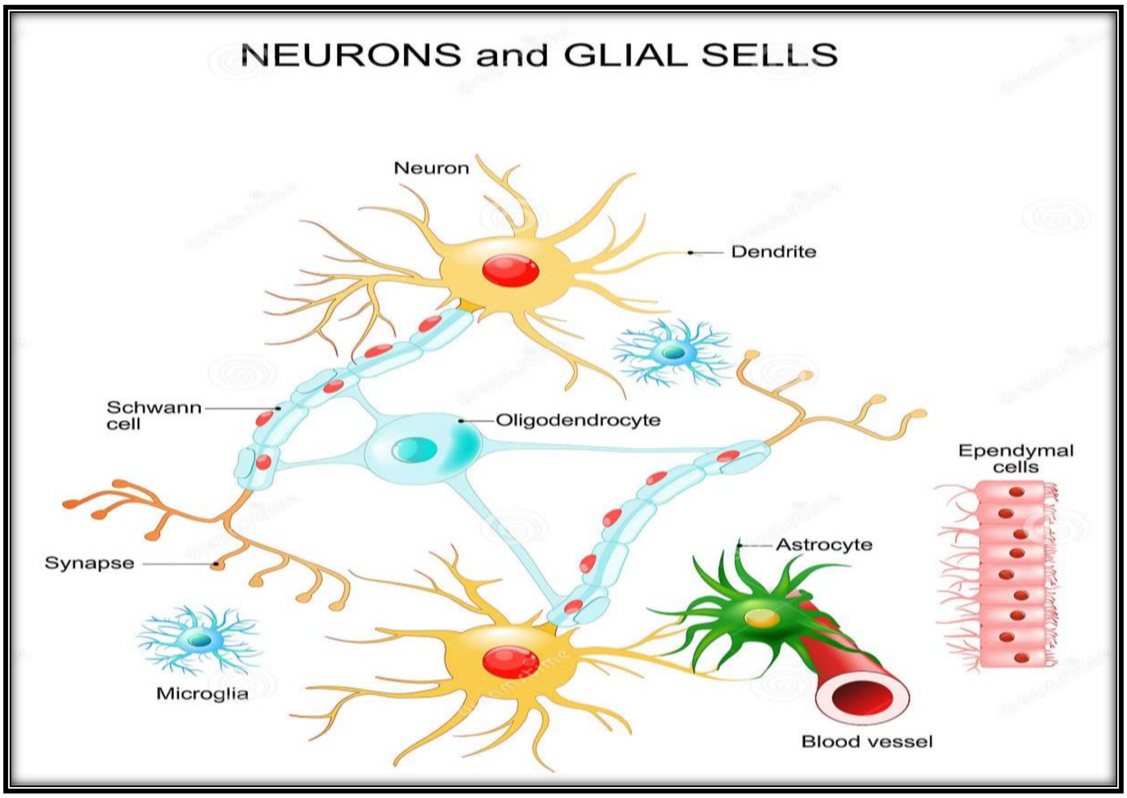
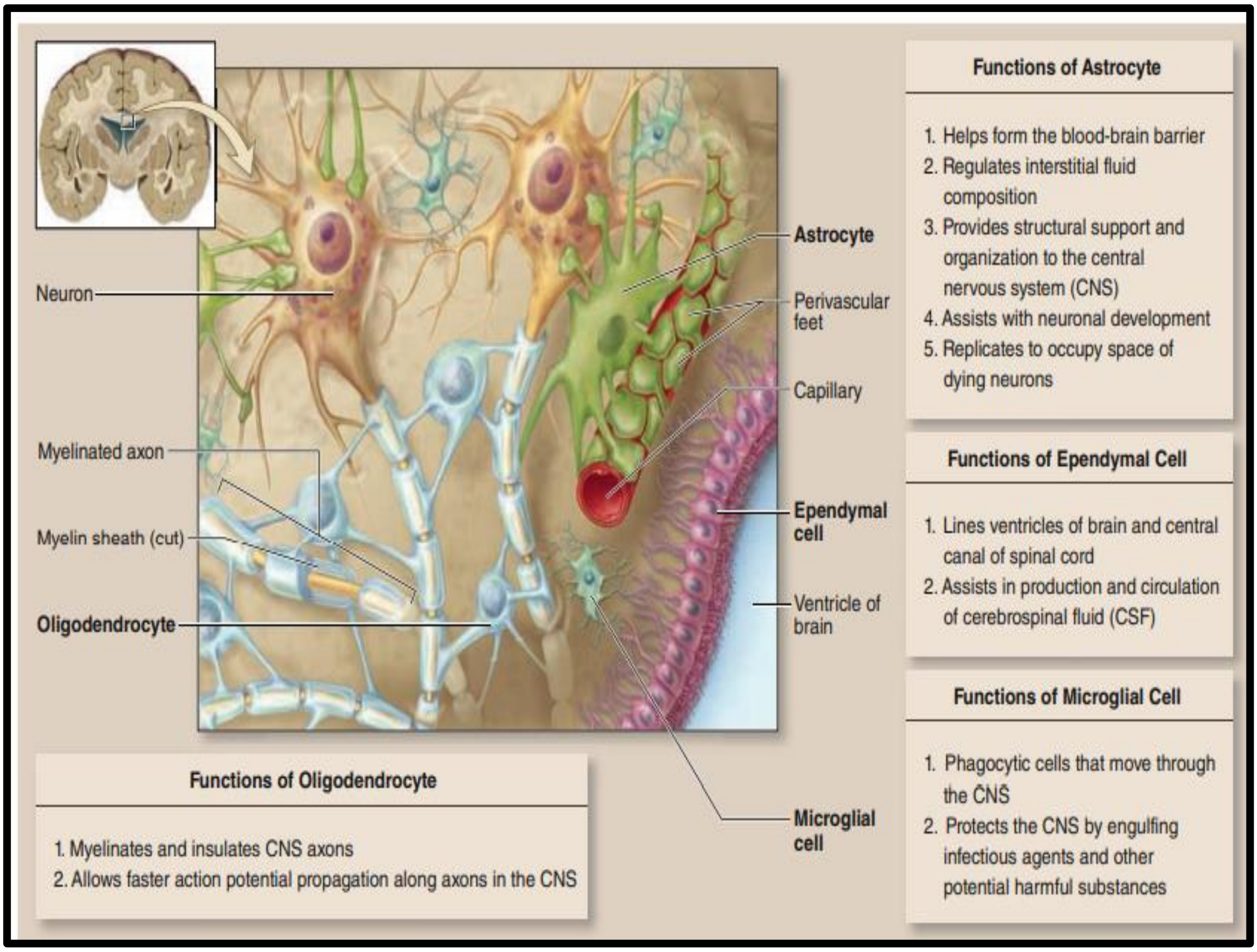
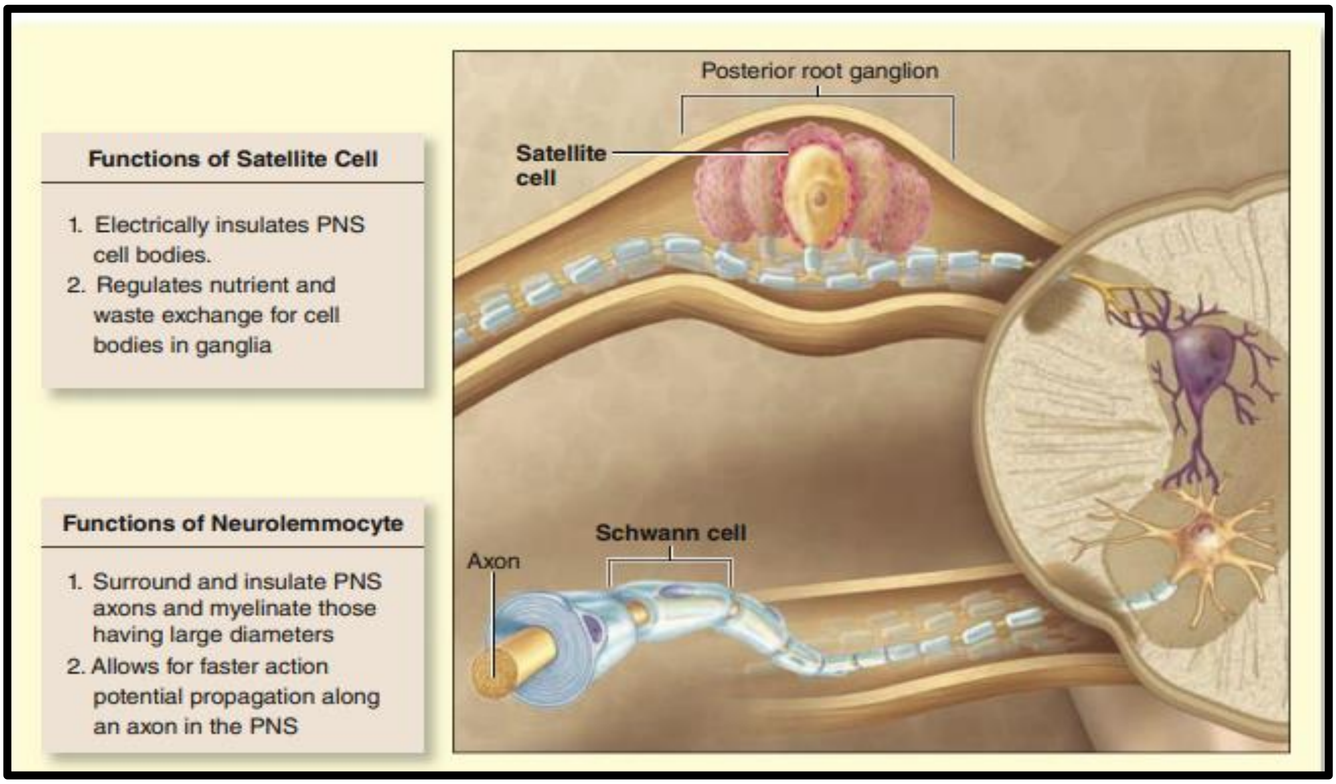


Fig. 10: Schwann cell and Satellite cell.




NEURONS and GLIAL SELLS
Neuron
Dendrite
Schwann cell
Oligodendrocyte
Ependymal cells
Synapse
Astrocyte
Microglia
Blood vessel

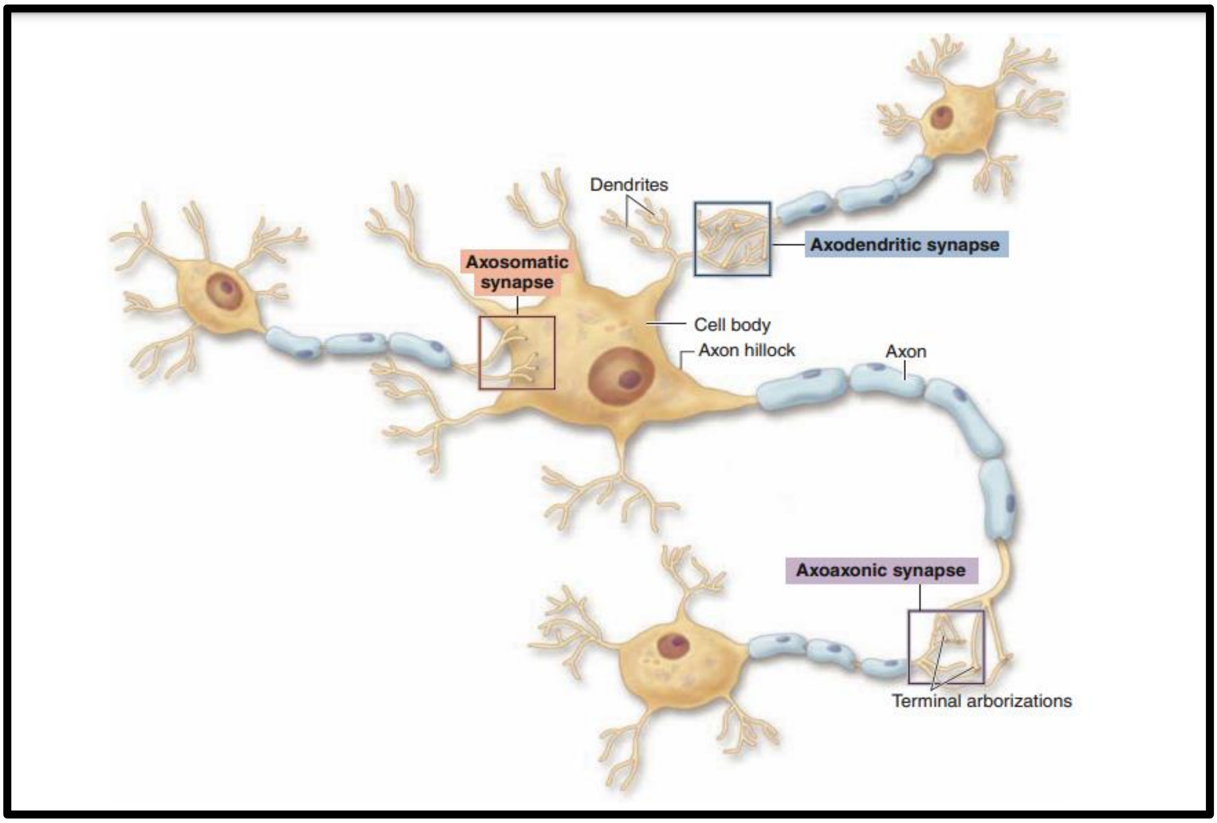

Neuron
Myelinated axon
Myelin sheath (cut)
Oligodendrocyte
Astrocyte
Perivascular feet
Capillary
Ependymal cell
Ventricle of brain
Microglial cell
Functions of Astrocyte
1. Helps form the blood-brain barrier
2. Regulates interstitial fluid composition
3. Provides structural support and organization to the central nervous system (CNS)
4. Assists with neuronal development
5. Replicates to occupy space of dying neurons
Functions of Ependymal Cell
1. Lines ventricles of brain and central canal of spinal cord
2. Assists in production and circulation of cerebrospinal fluid (CSF)
Functions of Microglial Cell
1. Phagocytic cells that move through the CNS
2. Protects the CNS by engulfing infectious agents and other potential harmful substances
Functions of Oligodendrocyte
1. Myelinates and insulates CNS axons
2. Allows faster action potential propagation along axons in the CNS

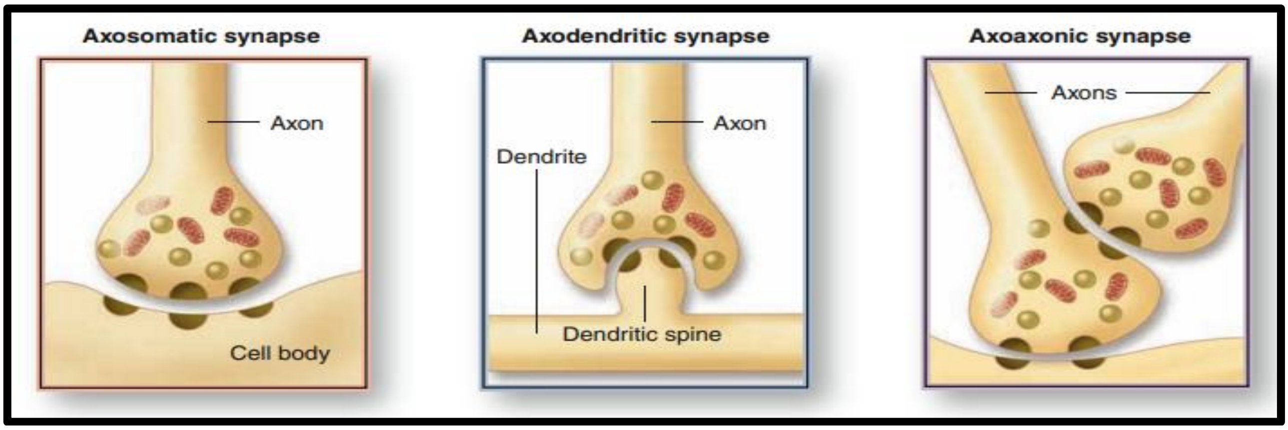


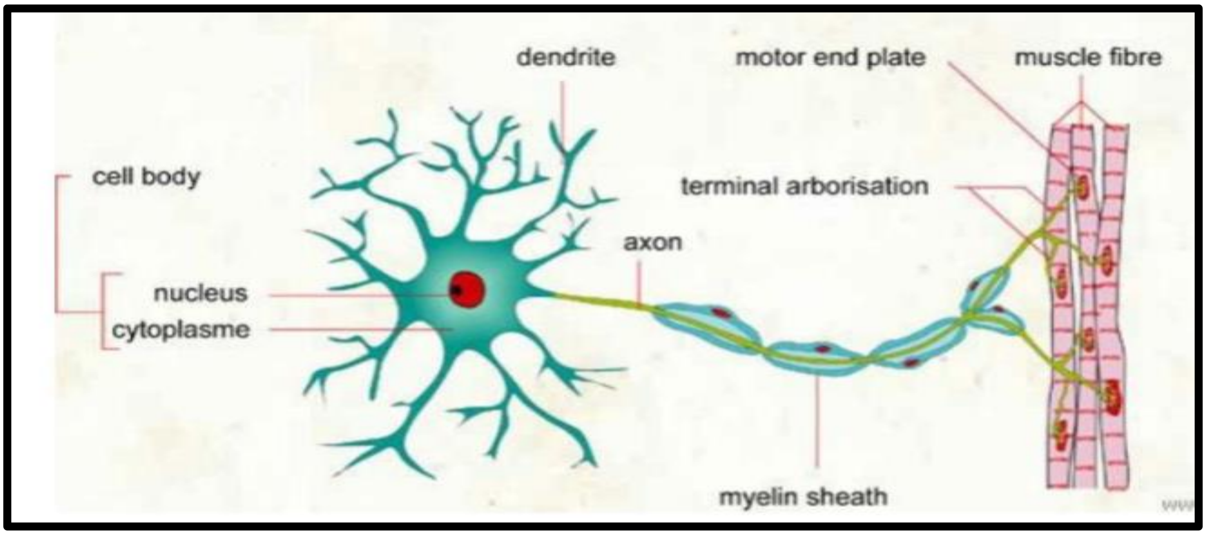
* Synaptic communication

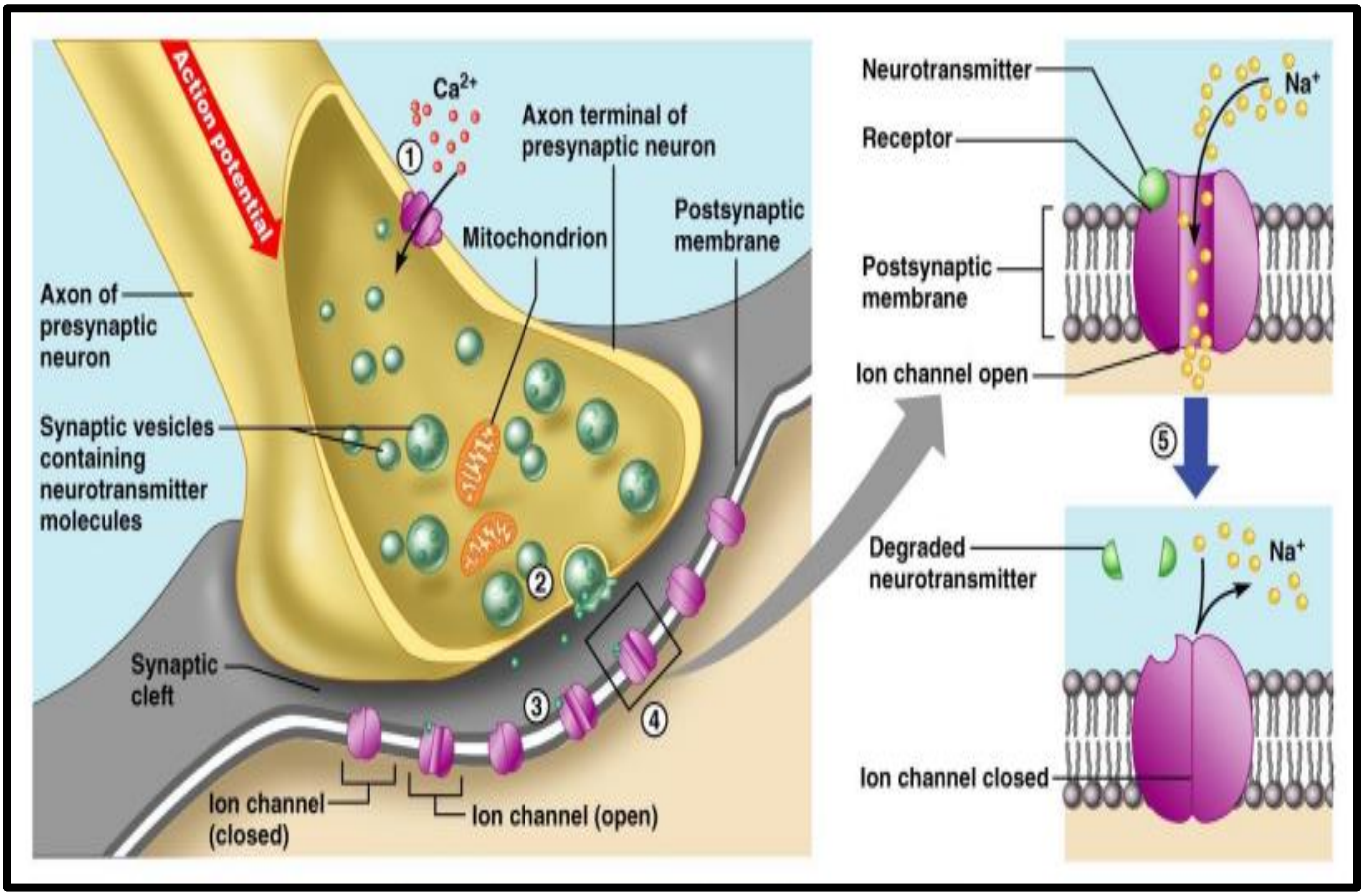
Synapses are sites where nerve impulses are transmitted from one neuron to another, or from neurons and other effector cells (muscle or gland), the structure of a synapse ensures that transmission is unidirectional (Fig.11). Synapses convert an electrical signal (nerve impulse) from the presynaptic cell into a chemical signal that affects the postsynaptic cell. Most synapses act by releasing neurotransmitters (e.g., acetylcholine, norepinephrine, dopamine, serotonin), which are usually small molecules that bind specific receptor proteins to either open or close ion channels. A synapse has the following components:

- The presynaptic axon terminal (terminal bouton): contains mitochondria, and numerous synaptic vesicles from which neurotransmitter is released by exocytosis.
- The postsynaptic cell membrane: contains receptors for the neurotransmitter, and ion channels or other mechanisms to initiate a new impulse.
- A 20- to 30-nm-wide intercellular space called the synaptic cleft: separates these presynaptic and postsynaptic membranes.


Dendrites
Axosomatic synapse
Axodendritic synapse
Cell body
Axon hillock
Axon
Axoaxonic synapse
Terminal arborizations


Axosomatic synapse
Axon
Cell body
Axodendritic synapse
Axon
Dendrite
Dendritic spine
Axoaxonic synapse
Axons


dendrite
motor end plate
muscle fibre
cell body
terminal arborisation
axon
nucleus
cytoplasme
myelin sheath



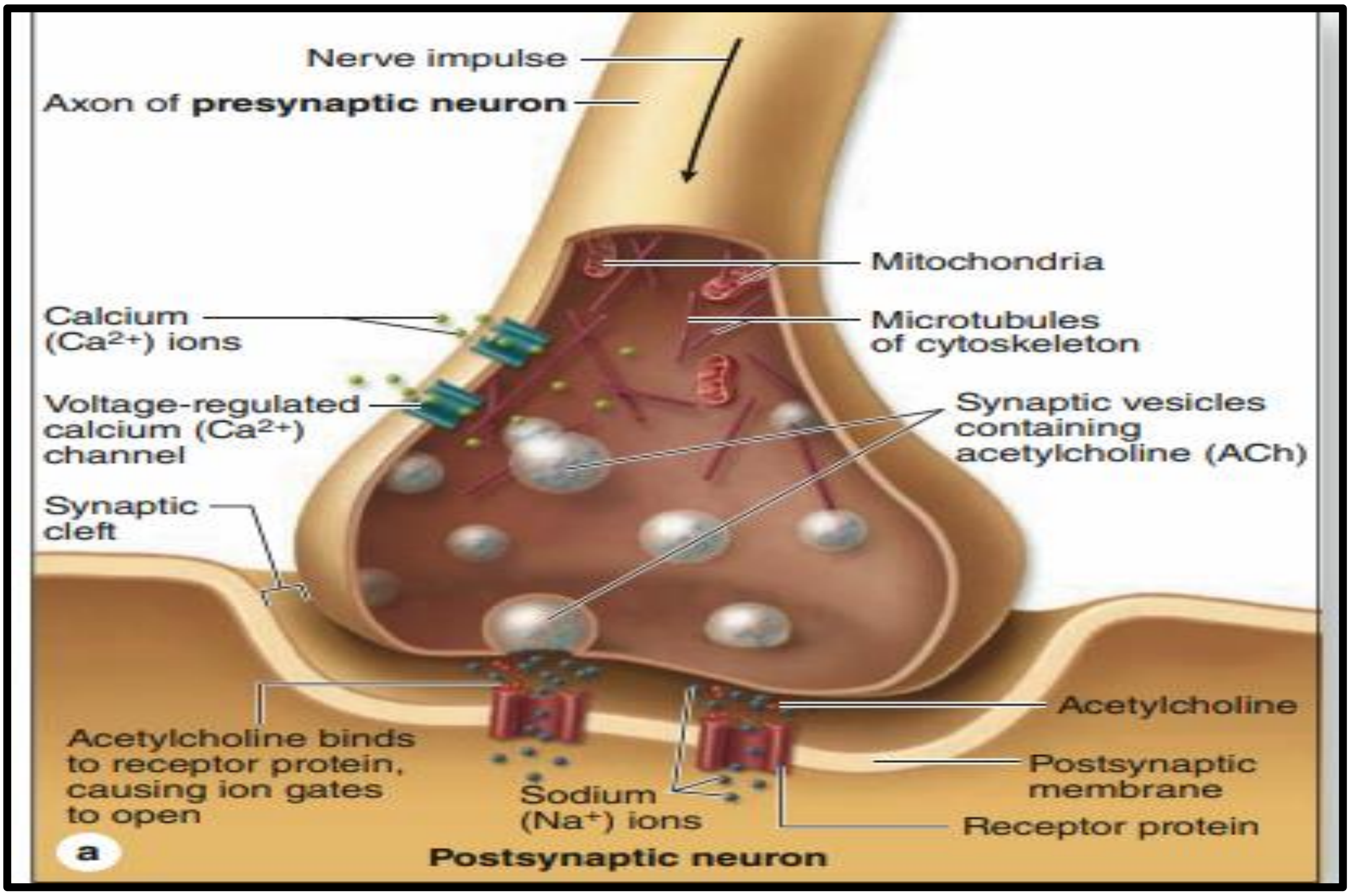


Fig. 11: Synapses.