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Lec:5

Cellular Elements In The CNS

1- Glial Cells

- ❖ The major distinction is that glia do not participate directly in synaptic interactions and electrical signaling. Neuroscience currently identifies four main functions of glial cells:
- ❖ To surround neurons and hold them in place
- ❖ To supply nutrients and oxygen to neurons
- ❖ To insulate one neuron from another
- ❖ To destroy pathogens and remove dead neurons.

There are two major types of glial cells:

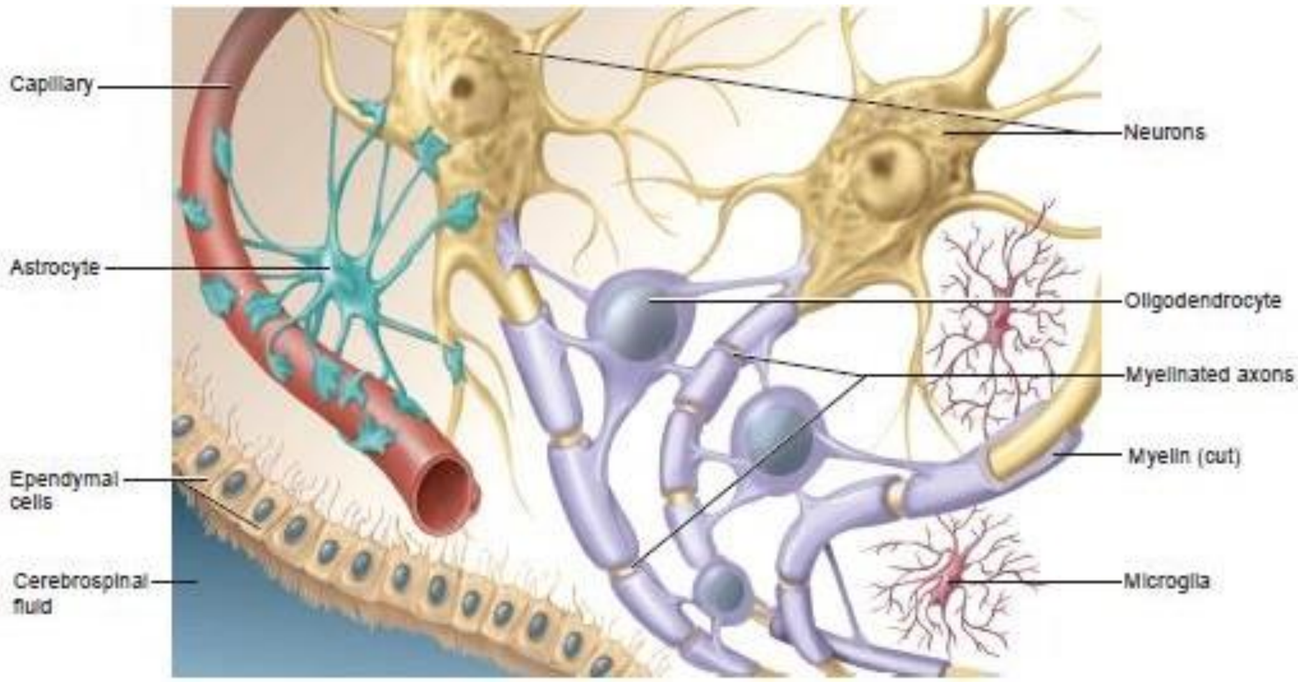
1-Microglia

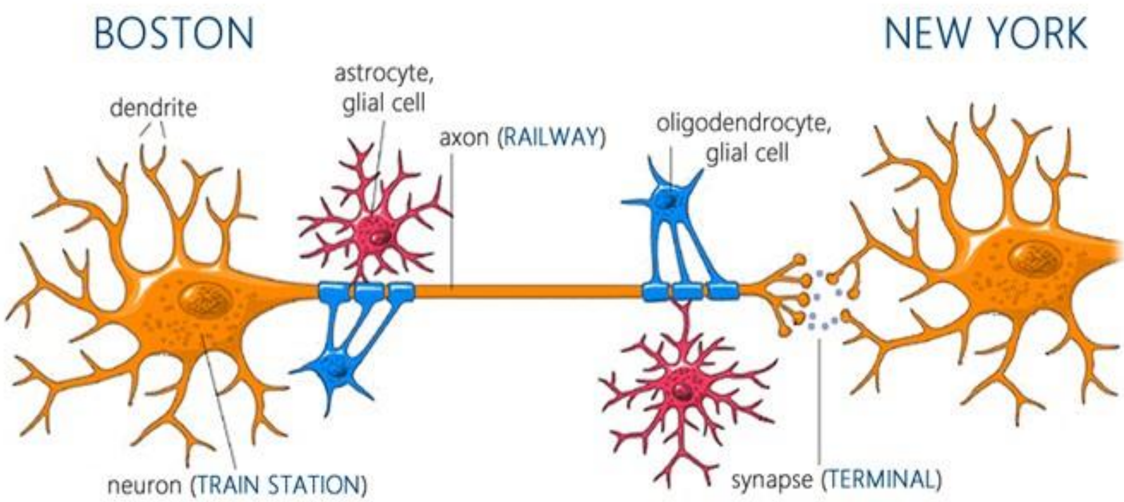
are scavenger cells that resemble tissue macrophages and remove debris resulting from injury, infection, and disease.

2-**Macroglia**

There are three types of macroglia: oligodendrocytes, Schwann cells, and astrocytes .

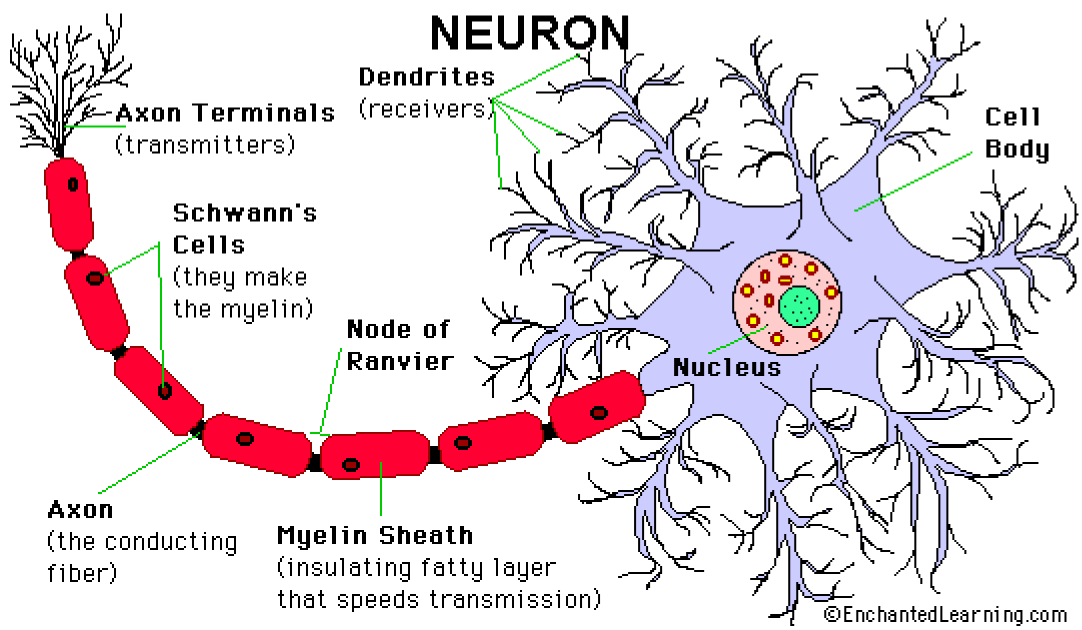
Oligodendrocytes and **Schwann** cells are involved in myelin formation around axons in the CNS and peripheral nervous system, respectively. **Astrocytes**, which are found throughout the brain, are of two subtypes. Fibrous astrocytes, which contain many intermediate filaments, are found primarily in white matter. Protoplasmic astrocytes are found in gray matter and have a granular cytoplasm. Both types send processes to blood vessels, where they induce capillaries to form the tight junctions making up the blood–brain barrier. They also send processes that envelop synapses and the surface of nerve cells.


Capillary
Astrocyte
Ependymal cells
Cerebrospinal fluid
Neurons
Oligodendrocyte
Myelinated axons
Myelin (cut)
Microglia


BOSTON
NEW YORK
dendrite
astrocyte, glial cell
axon (RAILWAY)
oligodendrocyte, glial cell
neuron (TRAIN STATION)
synapse (TERMINAL)

2-Neurons (nerve cells) :

Neurons in the mammalian central nervous system come in many different shapes and sizes. Most have the same parts as the typical spinal motor neuron .



The cell body (***soma***) contains the nucleus and is the metabolic center of the neuron. Neurons have several processes called **Dendrites** that extend outward from the cell body and arborize extensively. Particularly in the cerebral and cerebellar cortex, the dendrites have small knobby projections called dendritic spines.

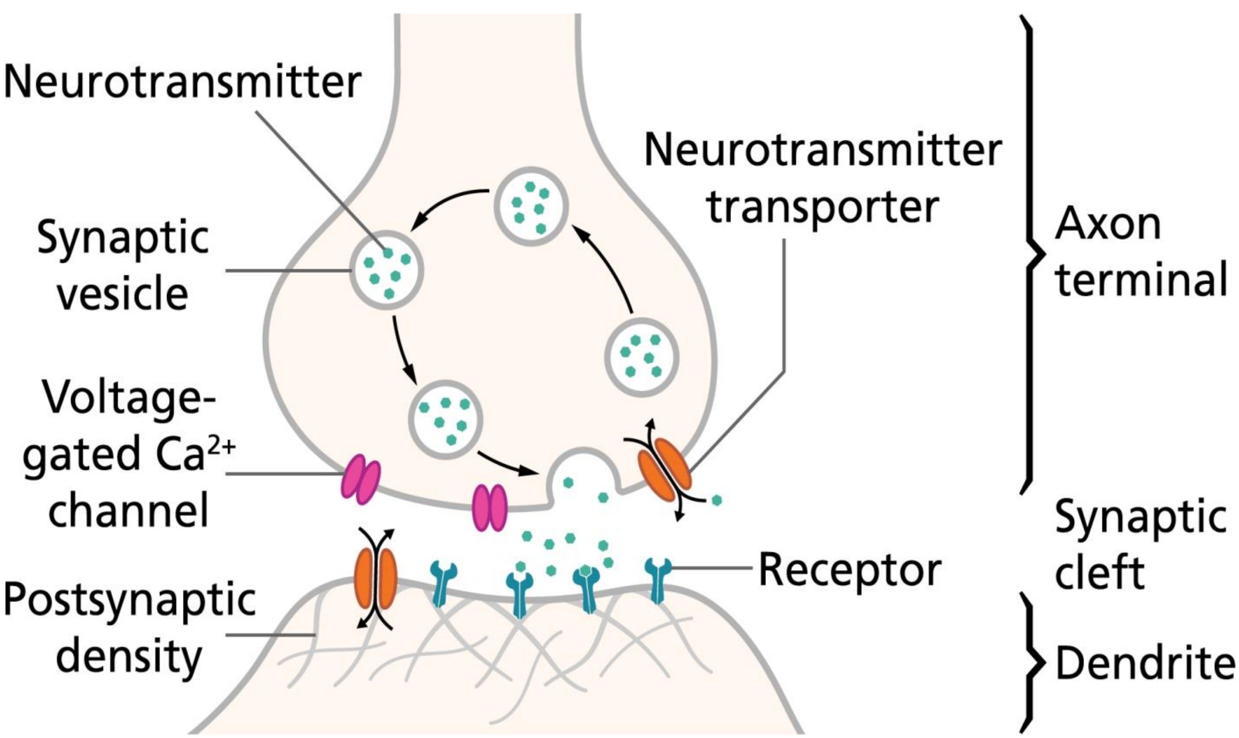
A typical neuron also has a long fibrous **axon** that originates from a somewhat thickened area of the cell body, the axon hillock. The first portion of the axon is called the initial segment. The axon branches into presynaptic terminals, each ending in a number of synaptic knobs which are also called terminal buttons or boutons.

The anatomically specialized junction between two neurons where one neuron alters the electrical and chemical activity of another is called a synapse. At most synapses, the signal is transmitted from one neuron to another by neurotransmitters, a term that also includes the chemicals efferent neurons use to communicate with effector cells (e.g., a muscle cell).

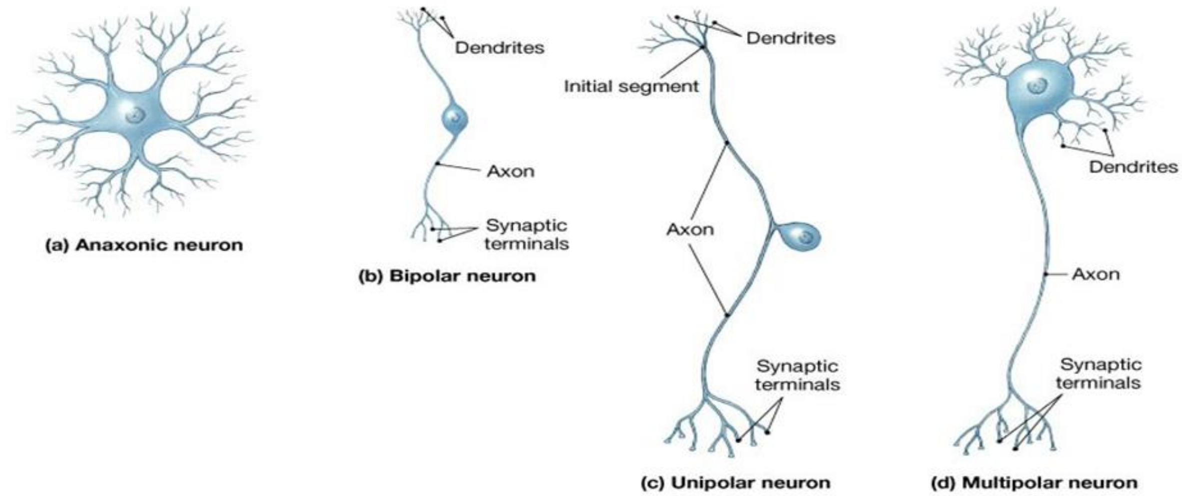
The neurotransmitters released from one neuron alter the receiving neuron by binding with specific protein receptors on the membrane of the receiving neuron.

Most synapses occur between an axon terminal of one neuron and a dendrite or the cell body of a second neuron. Sometimes, however, synapses occur between two dendrites or between a dendrite and a cell body or between an axon terminal and a second axon terminal. A neuron that conducts a signal toward a synapse is called a presynaptic neuron, whereas a neuron conducting signals away from a synapse is a postsynaptic neuron.

A postsynaptic neuron may have thousands of synaptic junctions on the surface of its dendrites and cell body, so that signals from many presynaptic neurons can affect it.



Presynaptic terminals contain granules or vesicles in which the synaptic transmitters secreted by the nerves are stored. Based on the number of processes that emanate from the cell body, neurons can be classified as unipolar, bipolar, and multipolar.



Neurons generally have four important zones:

(1) A receptor, or dendritic zone, where multiple local potential changes generated by synaptic connections are integrated.

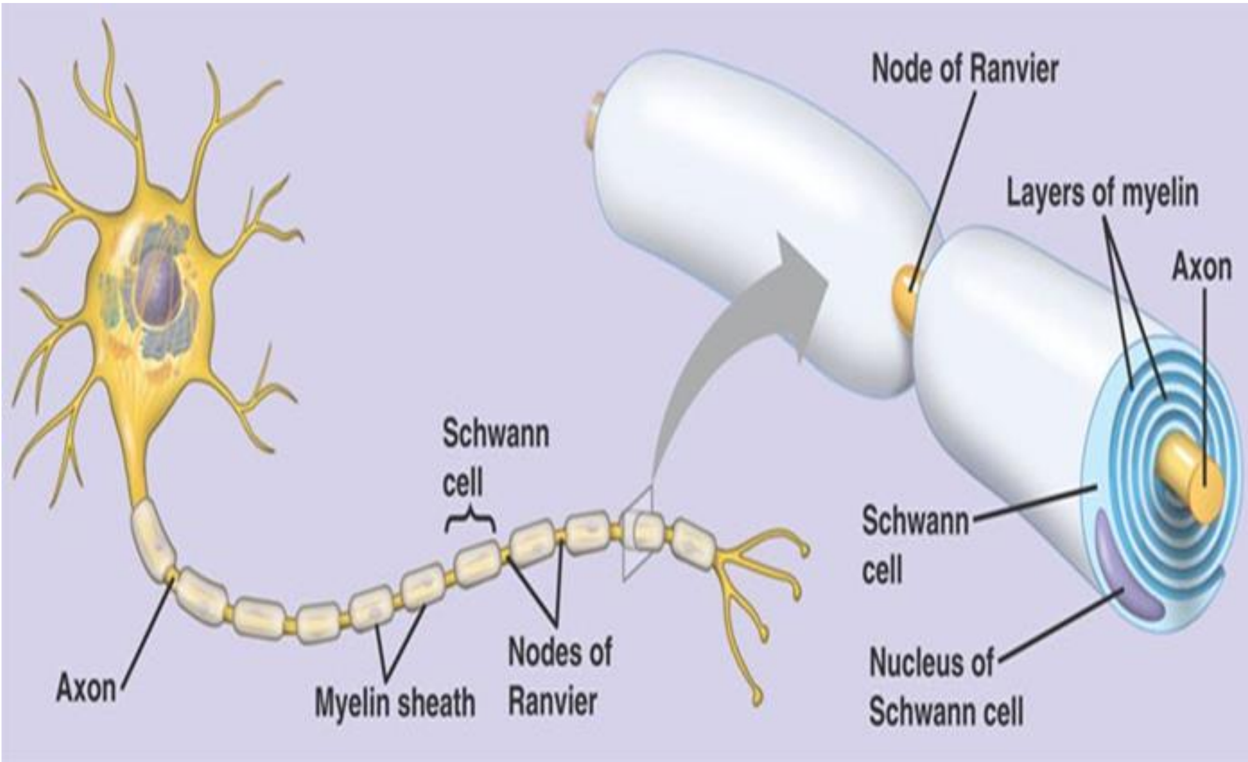
(2) A site where propagated action potentials are generated (the initial segment and the initial node of Ranvier.

(3) An axonal process that transmits propagated impulses to the nerve endings; and

(4) The nerve endings, where action potentials cause the release of synaptic transmitters.

The axons of many neurons are myelinated, that is, they acquire a sheath of myelin, a protein–lipid complex that is wrapped around the axon . In the peripheral nervous system, myelin forms when a Schwann cell wraps its membrane around an axon up to 100 times.

- The myelin sheath envelops the axon except at its ending and at the nodes of Ranvier.



AXONAL TRANSPORT

Neurons are secretory cells, but they differ from other secretory cells in that the secretory zone is generally at the end of the axon, far removed from the cell body. The apparatus for protein synthesis is located for the most part in the cell body (due to the presence of the nucleus and ribosomes and thus has the genetic information and machinery necessary for protein synthesis), with transport of proteins and polypeptides to the axonal ending by axoplasmic flow and axonal transport .

Axoplasmic flow :transport rate comparatively slow (1–2 mm/day), molecules transported only from cell body, bulk movement of proteins in axoplasm, including microfilaments and tubules, transport accompanied by peristaltic waves of axon membrane.

Axonal transport : depends on a scaffolding of microtubule running the length of the axon and specialized types of motor proteins known as **kinesins** and **dyneins**.

At one end, these double-headed motor proteins bind to their cellular cargo, and the other end uses energy derived from the hydrolysis of ATP to "walk" along the microtubules. Kinesin transport mainly occurs from the cell body toward the axon terminals (anterograde) and is important in moving nutrient molecules, enzymes, mitochondria, neurotransmitter-filled vesicles, and other organelles. Dynein movement is in the other direction (retrograde), carrying recycled membrane vesicles, growth factors, and other chemical signals that can affect the neuron's morphology, biochemistry, and connectivity. Retrograde transport is also the route by which some harmful agents invade the CNS, including tetanus toxin and the herpes simplex, rabies, and polio viruses.

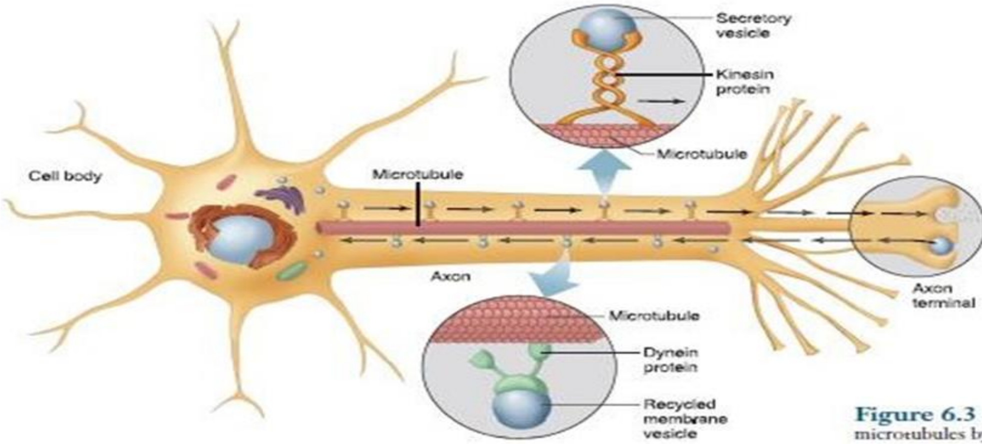


Figure 6.3 Axonal transport along microtubules by dynein and kinesin.