Essentials of Zoology
(Cytology and Histology)

Prof. Ahmed M. Ghoneim

1st year General Biology/Ecology students

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Lec. 9

Intended learning outcomes (ILO's):

By the end of this lecture, students should be able to:

1- List the basic functions of the nervous system.

2- Describe the basic structure of a neuron.

3- Identify the different types of neurons on the basis of polarity.

4- List the glial cells of the CNS and PNS, and describe their function

Nervous tissues

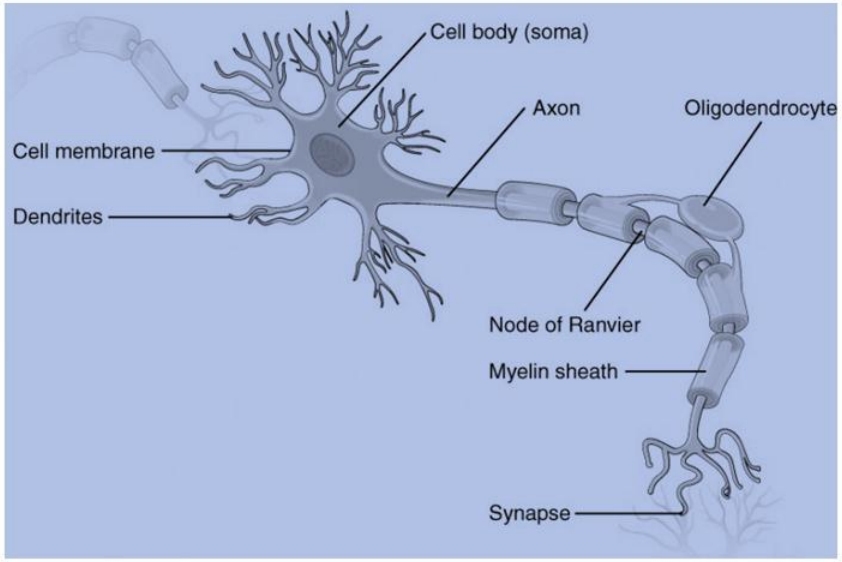
A nervous tissue is composed of 2 types of cells: Neurons and Glial cells

A- Neurons

- Neurons are the primary type of cells and they are responsible for the computation and communication that the NS provides.
- They are electrically active and release chemical signals to target cells.

Structure of a neuron

- The main part of a neuron is the cell body (The soma = the body), which contains the nucleus and most of the major organelles.

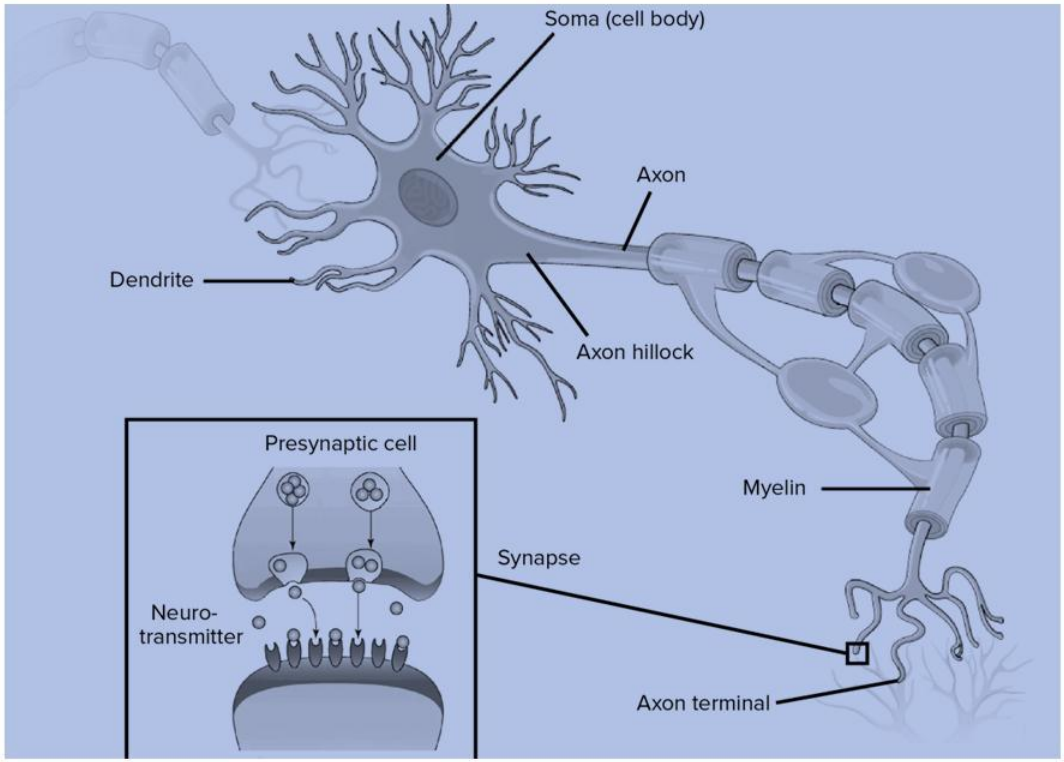


- Many extensions of cell membrane, referred to as processes.

- With only one axon; a fiber that emerges from the cell body and projects to target cells. Axon can branch repeatedly to communicate with many target cells. Axon propagates the nerve impulse, which is communicated to one or more cells.

- The other processes of the neuron are called dendrites, which receive information from other neurons at specialized areas of contact called synapses.

- Information flows through a neuron from the dendrites, across the cell body, and down the axon.



This gives the neuron a polarity—meaning that information flows in this one direction.

- The axon emerges from the cell body at a special region called the axon hillock (a tapering of the cell body toward the axon fiber). Within the axon hillock, the cytoplasm changes to a solution of limited components called axoplasm. The axon hillock represents the beginning of the axon and is referred to as the initial segment.

Axons may be wrapped by an insulating substance called myelin, which is actually made from glial cells.

Myelin acts as insulation much like the plastic or rubber that is used to insulate electrical wires.

There are gaps in the myelin; each gap is called a node of Ranvier and is important to the way that electrical signals travel down the axon.

The length of the axon between each gap is referred to as an axon segment.

At the end of the axon is the axon terminal, which usually include several branches extending toward the target cell; each branch ends in an enlargement called a synaptic end bulb. These bulbs make the connection with the target cell at the synapse.

Types of neurons

- NS contains trillions of neurons; many different types of neurons.

- Classified based on number of processes attached to cell body:

1- Unipolar

- With only one process emerging from the cell.

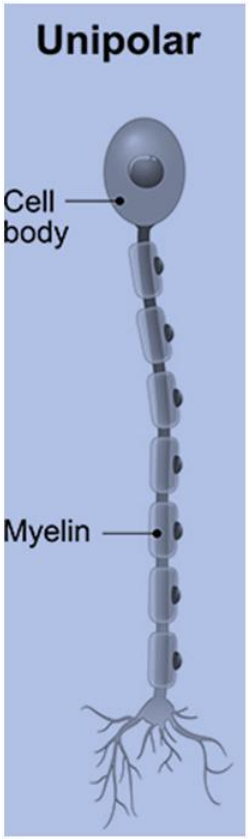
- Only found in invertebrate animals, do not have dendrites.

- In humans, the unipolar cells are more appropriately called "pseudo-unipolar" cells. With an axon that emerges from the cell body, but it splits to extend along a very long distance.

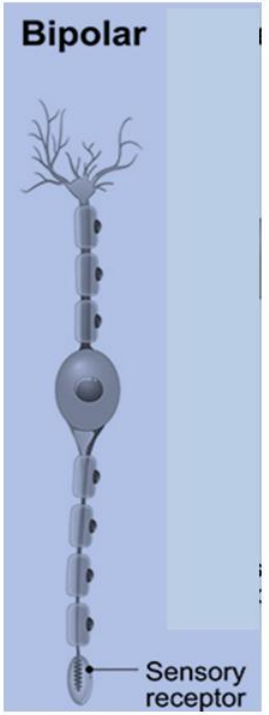
- Unipolar cells are exclusively sensory neurons and have 2 unique characteristics.

1- Termini receive sensory information, sometimes directly from the stimulus itself.

2- Cell bodies are always found in ganglia.



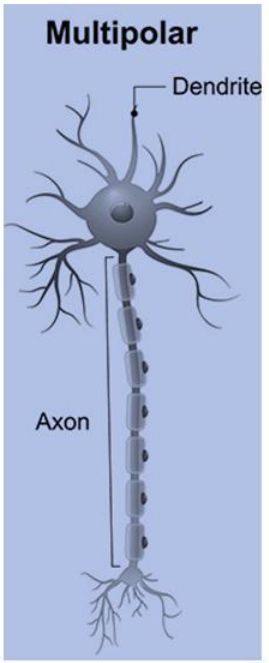
Note: Sensory reception is a peripheral function: Termini are in the periphery (e.g. skin) and the cell body is in the periphery, but closer to the CNS (in a ganglion).



2- Bipolar

- With 2 processes, which extend from each end of the cell body, opposite to each other. One is the axon and one the dendrite.

- Not very common. Found mainly in the olfactory epithelium (to sense smell stimuli), and as part of the retina.



3- Multipolar

- With 1 axon and 2 or more dendrites (usually many more).

- Except for the unipolar sensory cells (in ganglia), and the 2 specific bipolar cells mentioned above, all other neurons are multipolar.

B- Glial cells

- Glial cells (=neuroglia=glia), are known to play a supporting role for nervous tissue.

- Neurons are the important and are the basis in signaling, but without glial support they would not be able to perform their function. They help neurons complete their function for communication.

- The name glia comes from the Greek word that means "glue," proposed by the German pathologist Rudolph Virchow, who wrote in 1856: "This connective substance, which is in the brain, the spinal cord, and the special sense nerves, is a kind of glue (neuroglia) in which the nervous elements are planted."

- Today, research has shown that there are many deeper roles that these cells play.…much more about them in the future!

- 6 types of glial cells, 4 of them are found in the CNS and 2 are found in the PNS.

- Classification of glial cell types by location and basic function:

CNS glia	PNS glia	Basic function
Astrocyte	Satellite cell	Support
Oligodendrocyte	Schwann cell	Insulation, myelination
Microglia	–	Immune surveillance and phagocytosis
Ependymal cell	–	Creating CSF

a- Glial cells of the CNS

1- Astrocyte

- Star-shaped under the microscope (astro- = star).

- With many processes extending from the cell body (not axons or dendrites like neurons, just cell extensions). Those processes extend to interact with neurons, blood vessels, or the connective tissue covering the CNS (Pia mater).

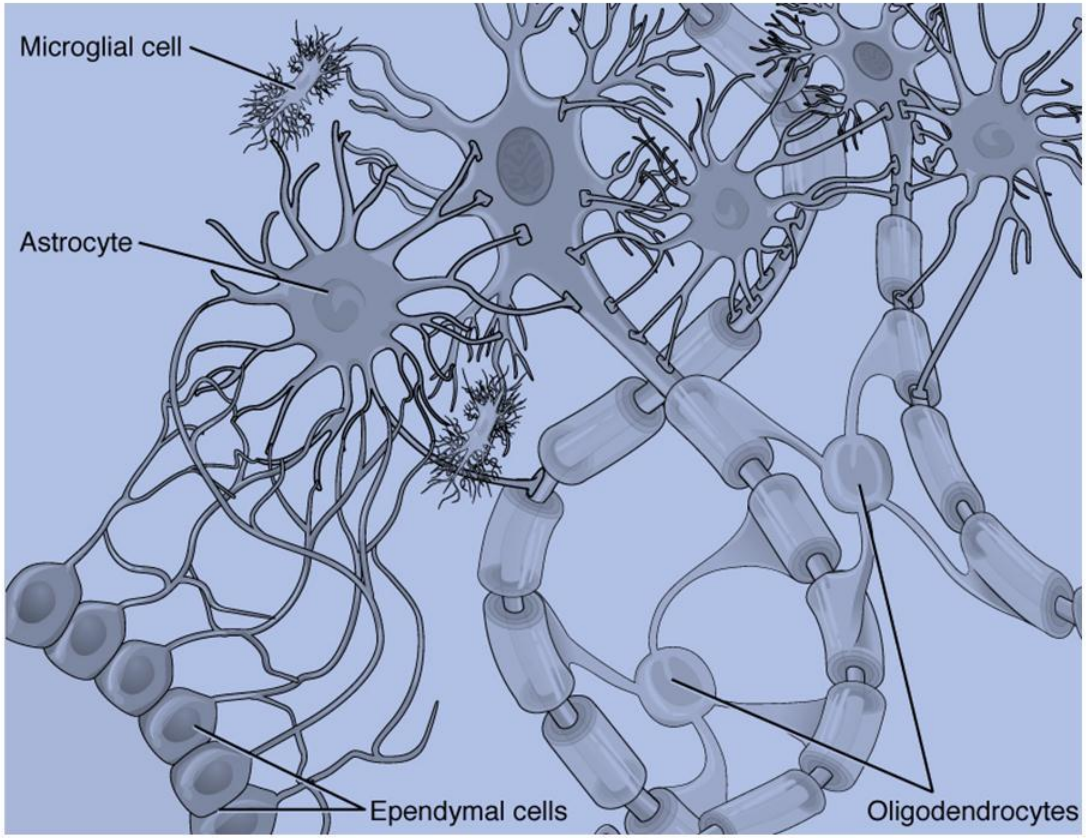
- Some ways of their role to support neurons in CNS are by maintaining the concentration of chemicals in the extracellular space, removing excess signaling molecules, reacting to tissue damage, and contributing to the blood-brain barrier (BBB).

2- Oligodendrocyte (oligo)

- Insulates axons in the CNS.

- With a few processes that extend from the cell body. Each process reaches out and surrounds an axon to insulate it in myelin.

- One oligodendrocyte provides the myelin for multiple axon segments, either for the same axon or for separate axons.



3- Microglia

- It is suggested (not confirmed) that they may originate as macrophages that become part of CNS during early development.
- Function is similar to what macrophages do in the rest of the body (ingest and digest diseased or damaged cells or the pathogens that cause disease) (i.e. CNS-resident macrophages).

4- Ependymal cell

- Filters blood to make cerebrospinal fluid (CSF); fluid that circulates through the CNS)……How?

- The extracellular space in nervous tissue does not easily exchange components with the blood.

- Ependymal cells line each of the brain ventricles.

- The choroid plexus consists of a layer of epithelial cells surrounding a core of capillaries and loose connective tissue.

- The epithelium of the choroid plexus is continuous with the ependymal cell layer that lines the ventricles.

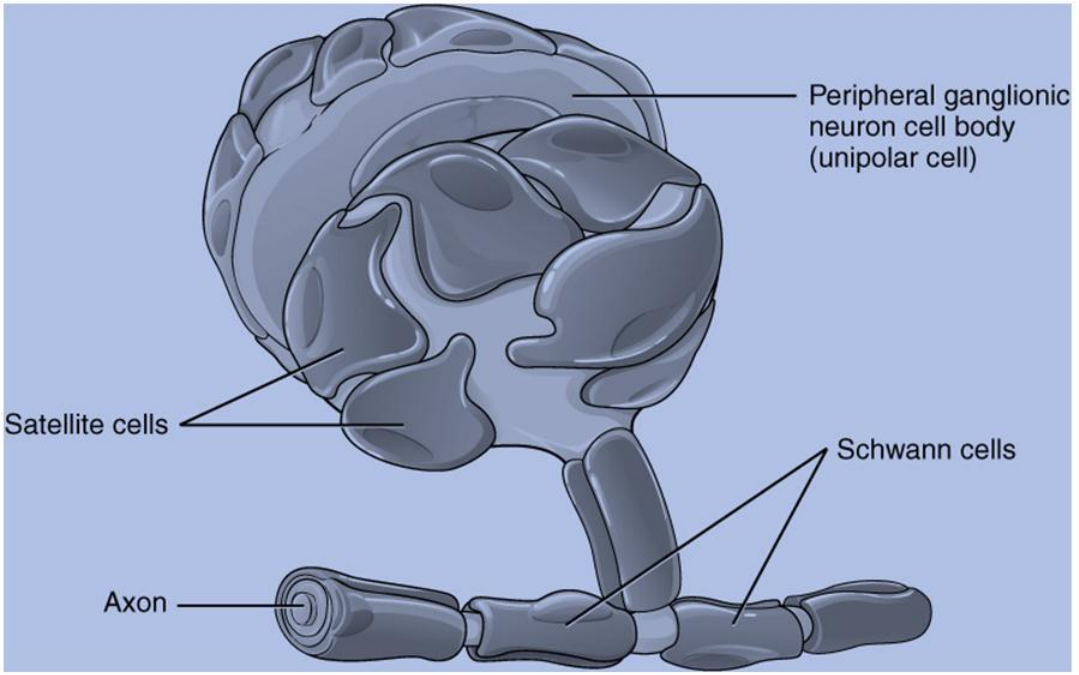
- The ependymal cells are in contact with blood vessels and filter and absorb components of the blood to produce CSF. Because of this, ependymal cells can be considered a component of the BBB, or a place where the BBB breaks down.

- The ependymal cells appear similar to epithelial cells, making a single layer of cells with little intracellular space and tight connections between adjacent cells. They also have cilia on their apical surface to help move the CSF through the ventricular space.

b- Glial cells of the PNS

1- Satellite cell

- Found in sensory and autonomic ganglia, where they surround the cell bodies of neurons. The name is based on their appearance under the microscope.



- They provide support (similar functions in the periphery as astrocytes do in the CNS except for establishing the BBB).

2- Schwann cell

- Insulates axons with myelin in the PNS.
- Differ from oligodendrocytes in:

1-Wrapping around a portion of only one axon segment and no others. Oligodendrocytes have processes that reach out to multiple axon segments, whereas the entire Schwann cell surrounds just one axon segment.

2- The nucleus and cytoplasm of the Schwann cell are on the edge of the myelin sheath.

Myelin

- The insulation for axons in the nervous system is provided by oligodendrocytes (in the CNS) and Schwann cells (in the PNS).

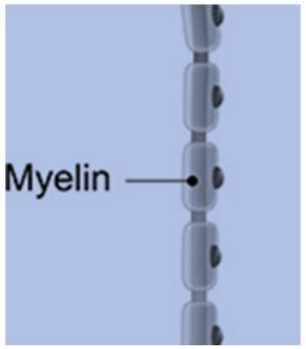
- The manner in which either cell associates with the axon segment (or segments) is different.

- Myelin is a lipid-rich sheath, which surrounds the axon to creates a myelin sheath that facilitates the transmission of electrical signals along the axon. The lipids are essentially the phospholipids of the glial cell membrane. The integral proteins of glial cell membrane hold the layers of the glial cells closely together.

- The glial cell is wrapped around the axon several times with little to no cytoplasm between the glial cell layers.

1- For oligodendrocytes, the rest of the cell is separate from the myelin sheath. A few other processes provide the same insulation for other axon segments in the area.

2- For Schwann cells, the whole cell is wrapped around the axon. The outermost layer of the myelin sheath contains the cytoplasm and the nucleus of the cell as a bulge on one side of the sheath.

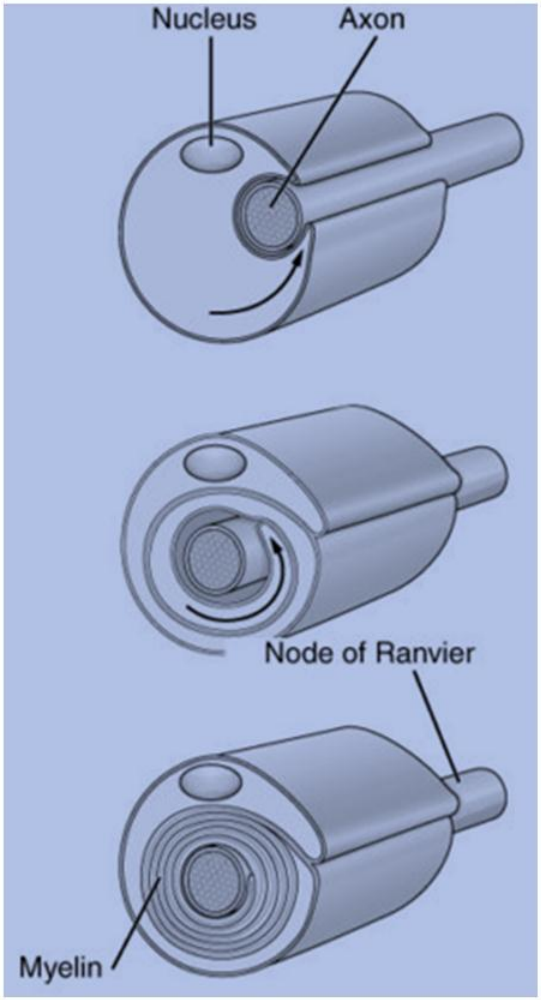


- Sheath development:

At early development, the glial cell is incompletely wrapped around the axon.

Then, the edges of this incomplete enclosure extend toward each other, and one end extends under the other.

The inner edge wraps around the axon, creating several layers, and the other edge closes around the outside so that the axon is completely enclosed.



الشعب التالية لم ترسل البيانات المطلوبة في المحاضرة السابقة حتي الأن:

1- شعبة الكيمياء الحيوية و الكيمياء

2- شعبة علوم البيئة

3- شعبة علوم البيئة و الكيمياء

سوف يتم القاء هذه المحاضرة لجميع الشعب عبر منصة ويبيكس Webex و سوف يتم ارسال المعلومات اللازمة عن طرق البريد الإلكتروني.

Thank you