Nerve tissue & the Nervous System

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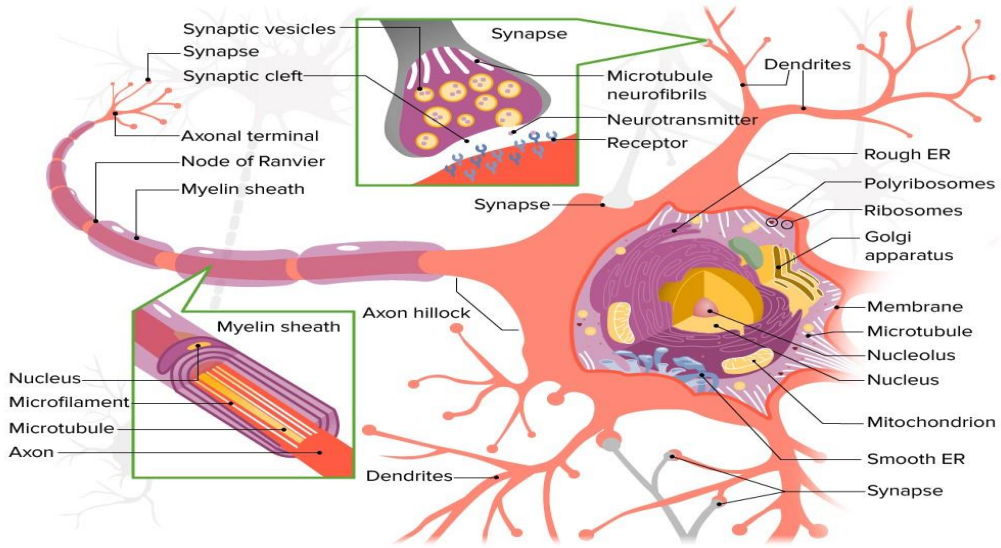
The human nervous system, by far the most complex system in the body, is formed by a network of many billion nerve cells (neurons), all assisted by many more supporting cells called glial cells.

Each neuron has hundreds of interconnections with other neurons, forming a very complex system for processing information and generating responses. 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 and spinal cord.
- **Peripheral nervous system (PNS),** composed of the cranial, spinal, and peripheral nerves conducting impulses to and from the CNS (sensory and motor nerves, respectively) and ganglia that are small groups of nerve cells outside the CNS.



Cells in both central and peripheral nerve tissue are of two kinds:

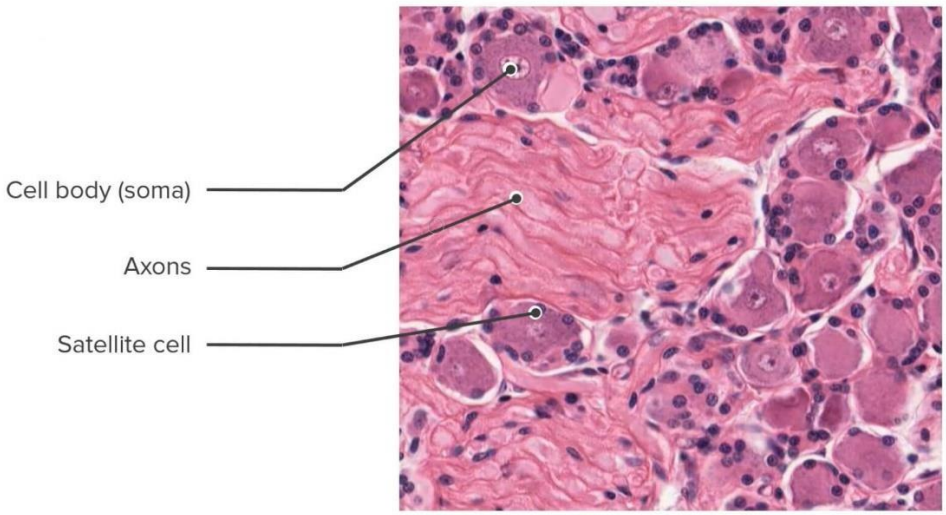
1. **Nerve cells or neurons,** responsible for conduction, propagation, and reception of nervous impulses. Processes called axons or dendrites extend

from these cells.

2. **Glial cells,** which have short processes, support and protect neurons, and participate in many neural activities, neural nutrition, and defense of cells in the CNS.

Neurons

The functional unit in both the CNS and PNS is the neuron or nerve cell. Some neuronal components have special names, such as “neurolemma” for the cell membrane.



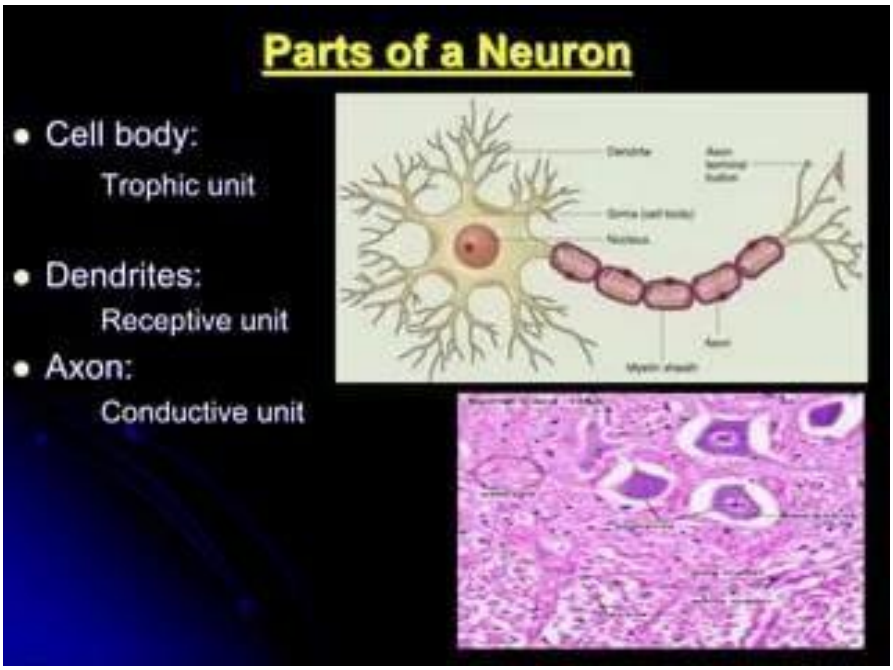
Most neurons consist of three main parts:

A) **Cell body or Perikaryon:** which contains the nucleus and most of the cell's organelles and serves as the synthetic or trophic center for the entire neuron:

(1) The nucleus is large, spherical, and pale staining and is centrally located in the soma of most neurons. It contains abundant euchromatin and a large nucleolus.

(2) Cytoplasmic organelles and inclusions:

- Nissl bodies are composed of polysomes and rough endoplasmic reticulum (RER). They appear as clumps under light microscopy and are most abundant in large motor neurons.



 The Golgi complex is near the nucleus, and mitochondria are scattered throughout the cytoplasm.

(3) Cytoskeletal components:

 Neurofilaments are abundant and run throughout the soma cytoplasm.

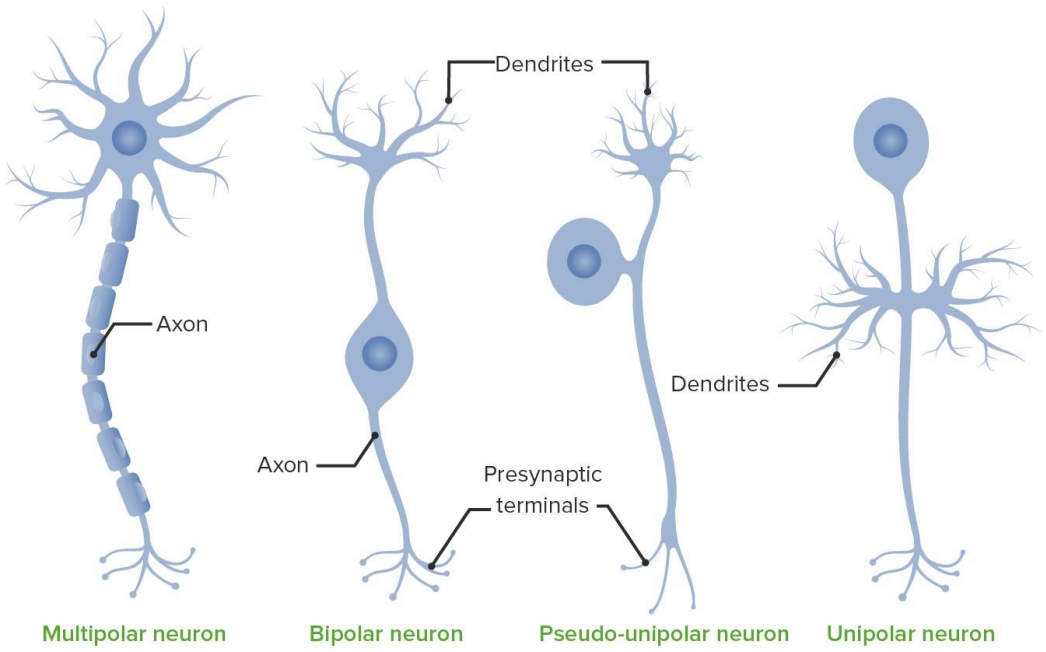
 Microtubules are also present in the soma cytoplasm.

 Microfilaments are associated with the plasma membrane.

B) **Dendrites:** which are the numerous elongated processes extending from the perikaryon and specialized to receive stimuli from other neurons at unique sites called synapses.

C) **Axon:** which is a single long process ending at synapses specialized to generate and conduct nerve impulses to other cells (nerve, muscle, and gland cells). Axons may also receive information from other neurons, information that mainly modifies the transmission of action potentials to those neurons.

Neurons can be classified according to the number of processes extending from the cell body:



- **Multipolar neurons**, which have one axon and two or more dendrites. Most neurons are multipolar.

- **Bipolar neurons,** with one dendrite and one axon. Bipolar neurons are found in the retina, olfactory mucosa, and the (inner ear) cochlear and vestibular ganglia, where they serve the senses of sight, smell, and balance, respectively.

Unipolar or pseudo unipolar neurons, which 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.

Pseudo unipolar neurons are found in the spinal ganglia (the sensory ganglia found with the spinal nerves) and in most cranial ganglia.

- **Anaxonic neurons,** with many dendrites but no true axon, do not produce action potentials, but regulate electrical changes of adjacent neurons.

Nervous components can also be subdivided functionally:

- **Sensory neurons** are afferent and receive stimuli from the receptors throughout the body.
- **Motor neurons** are efferent, sending impulses to effector organs such as muscle fibers and glands. Somatic motor nerves are under voluntary control and typically innervate most skeletal muscle; autonomic motor nerves control the "involuntary" activities of glands, cardiac muscle, and

most smooth muscle.

- **Interneurons** establish relationships among other neurons, forming complex functional networks or circuits (as in the CNS and retina).

Interneurons are generally multipolar or anaxonic and are estimated to include 99% of the neurons in the human CNS

Glial cells

Glial cells support neuronal survival and activities, and are ten times more abundant in the mammalian brain than the neurons. There are six types of glial cells.

Four of them are found in the CNS and two are found in the PNS. Glial Cells of the CNS

1) Astrocytes

Astrocytes are the largest of the neuroglial cells that reside in the CNS. They have many processes, some of which possess expanded pedicles (vascular feet) that surround blood vessels, whereas others exhibit processes that contact the pia mater.

Function:

- Astrocytes scavenge ions and debris from neuron metabolism and supply energy for metabolism.

• Along with other components of the neuroglia, astroglia form a protective sea led barrier between the pia mater and the nervous tissue of the brain and the spinal cord.

• They provide structural support for nervous tissue.

• They proliferate to form scar tissue (glial scar) after injury to the CNS.

2) **Oligodendrocytes**

• Oligodendrocytes are neuroglial cells that live symbiotically with neurons (i.e., each cell type is affected by the metabolic activities of the other). These cells are necessary for the survival of neurons in the CNS.

• They are located in both gray matter and white matter.

• They possess a small, round, condensed nucleus and only a few short processes.

• Their electron- dense cytoplasm contains ribosomes, numerous microtubules, many mitochondria, RER, and a large Golgi complex.

• Oligodendrocytes produce myelin, a lipoprotein material organized into a sheath that insulates and protects axons in the CNS.

Each oligodendrocyte forms several processes, and each process produces myelin for a single internode for a single axon.

In this fashion, an oligodendroglion can myelinate an internode for several axons.

3) Microglia

Microglia are small, phagocytic neuroglial cells that are derived from the mononuclear phagocytic cell population in the bone marrow.

They have a condensed, elongated nucleus and many short, branching processes.

Normally they are inactive but during injury or pathogen invasion they release interferon-y which activates neighboring microglia.

Activated microglial cells remove residues of cellular injury and secrete cytokines that attract T cells to the site of injury.

Microglia also possess the ability to become antigen presenting cells and present the antigens to the newly arrived T cells.

4) Ependymal Cells

Ependymal cells are columnar or cuboidal cells that line the ventricles of the brain and central canal of the spinal cord. In some CNS locations, the apical ends of ependymal cells have cilia, which facilitate the movement of cerebrospinal fluid (CSF), and long microvilli, which are likely involved in absorption.

1) Schwann Cells

Schwann cells, sometimes called neurolemmocytes, are found only in the PNS and differentiate from precursors in the neural crest. Schwann cells have trophic interactions with axons and importantly allow for their myelination, like the oligodendrocytes of the CNS.

As discussed with peripheral nerves, one Schwann cell forms myelin around a segment of one axon, in contrast to the ability of oligodendrocytes to branch and unsheathe parts of more than one axon.

2) Satellite Cells

Also derived from the embryonic neural crest, small satellite cells form an intimate covering layer over the large neuronal cell bodies in the

ganglia of the PNS. Satellite cells exert a trophic or supportive effect on these neurons, insulating, nourish in g, and regulating their microenvironments

Central nervous system

The major regions of the central nervous system (CNS) are the cerebrum, cerebellum, and spinal cord. The CNS is covered by three connective tissue layers, the meninges, but contains very little collagen or fibrous tissue throughout its substance, making it relatively soft and easily damaged by injuries affecting its protective cranium or vertebral bones. Most neurons of the CNS and their functional organization are more appropriately covered in neuroscience rather than histology courses, but certain important cells and basic topics are described here.

Many structural features of CNS tissues can be seen in unstained, freshly dissected specimens. The entire CNS displays organized areas of white matter and gray matter, differences caused by the differential distribution of myelin.

The main components of white matter are myelinated axons, often grouped together as tracts, and the myelin-producing oligodendrocytes. White matter contains very few neuronal cell bodies, but astrocytes and microglia are present.

Gray matter contains abundant neuronal cell bodies, dendrites, the initial unmyelinated portions of axons, astrocytes, and microglial cells. Gray matter is where most synapses occur, and it occupies the thick surface or cortex of both the cerebrum and the cerebellum; most white matter is found in deeper regions.

Deep regions of the CNS also have darker aggregates called nuclei consisting of large numbers of neuronal cell bodies and surrounded by white matter.