The nervous system

(CNS & PNS)

BY

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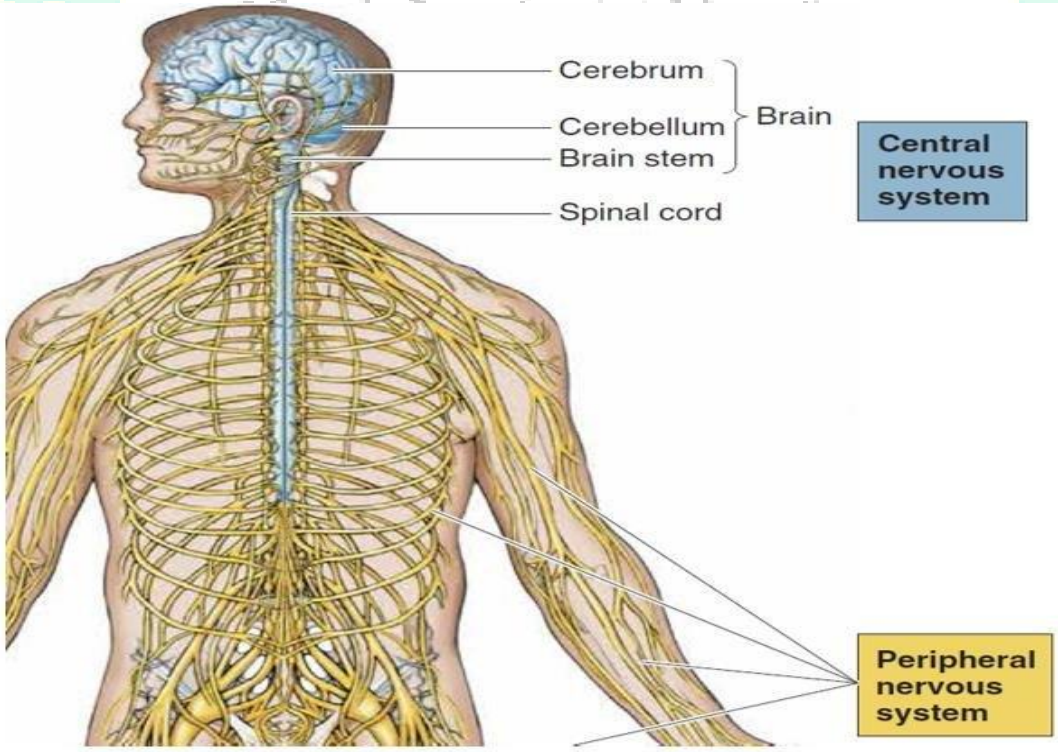
Introduction

The human nervous system, 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:

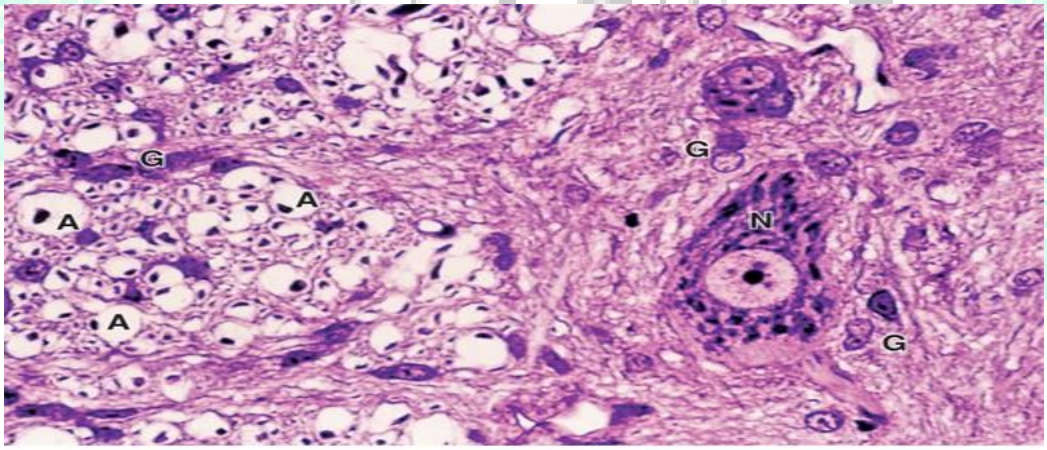
1. Central nervous system (CNS)
2. Peripheral nervous system (PNS)



Central nervous system

The major structures comprising the CNS are the **cerebrum**, **cerebellum**, and **spinal cord**. The CNS is completely covered by **connective tissue layers**, the **meninges**, but CNS tissue contains **very little collagen** or similar material, making it relatively soft and easily damaged by injuries affecting the protective skull or vertebral bones.

Many structural features of CNS tissues can be seen in unstained, freshly dissected specimens. Many regions show organized areas of **white matter** and **gray matter**, differences caused by the differential distribution of lipid-rich myelin. The gray matter has many glial cells, neuronal cell bodies, and neuropil; white matter also contains glia but consists mainly of axons.



A cross section of H&E-stained spinal cord shows the transition between white matter (left region) and gray matter (right). The gray matter has many glial cells (G), neuronal cell bodies (N), and neuropil; white matter also contains glia (G) but consists mainly of axons (A) whose myelin sheaths were lost during preparation, leaving the round empty spaces shown. Each such space surrounds a dark-stained spot that is a small section of the axon. (X400)

Peripheral nervous system

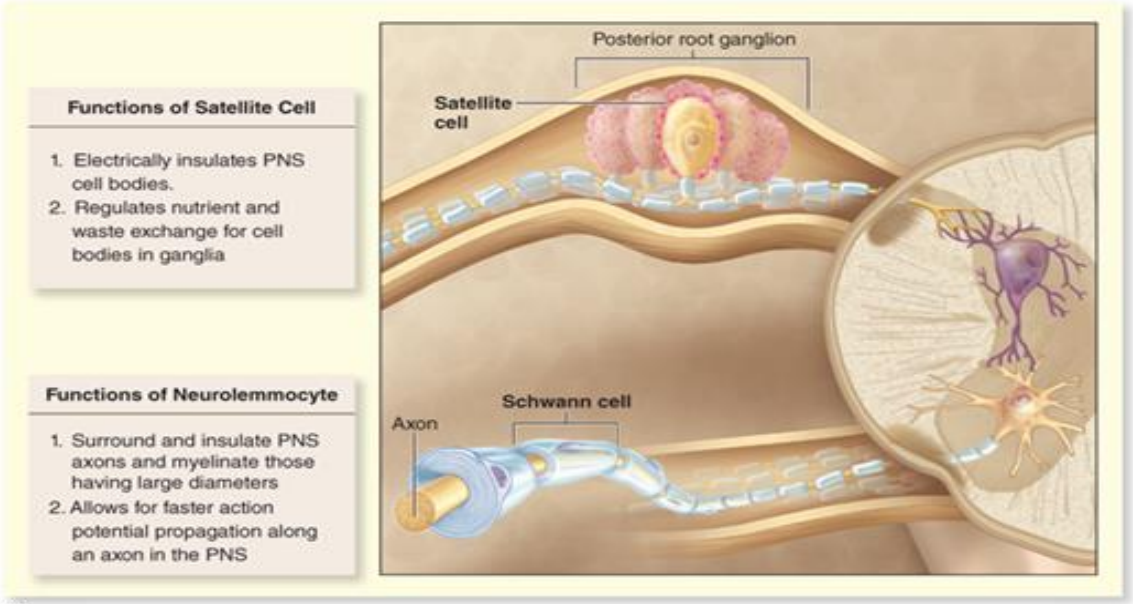
The main components of the peripheral nervous system (PNS) are the **nerves, ganglia**, and **nerve endings.**

Nerves are bundles of nerve fibers (axons) surrounded by Schwann cells and layers of connective tissue.

Nerve fibers are analogous to tracts in the CNS, containing axons enclosed within sheaths of glial cells specialized to facilitate axonal function. In peripheral nerve fibers, axons are sheathed by Schwann cells, or neurolemmocytes. The sheath may or may not form myelin around the axons, depending on their diameter

Ganglia

Ganglia are typically ovoid structures containing neuronal cell bodies and their surrounding glial satellite cells supported by delicate connective tissue and surrounded by a denser capsule. Because they serve as relay stations to transmit nerve impulses, at least one nerve enters and another exits from each ganglion. The direction of the nerve impulse determines whether the ganglion will be a sensory or an autonomic ganglion.



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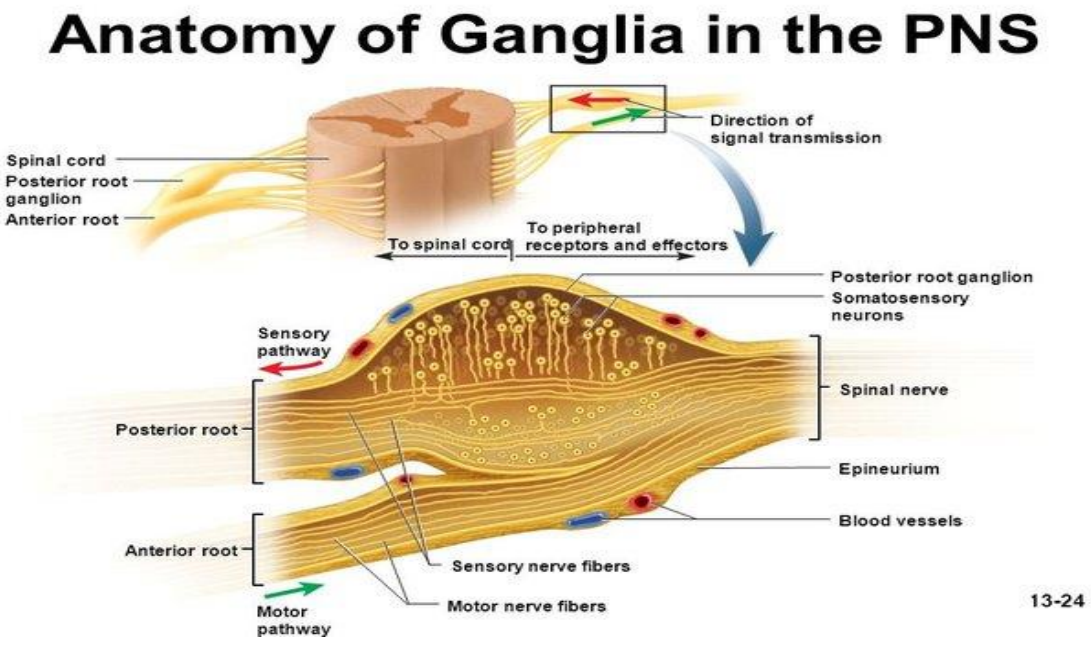
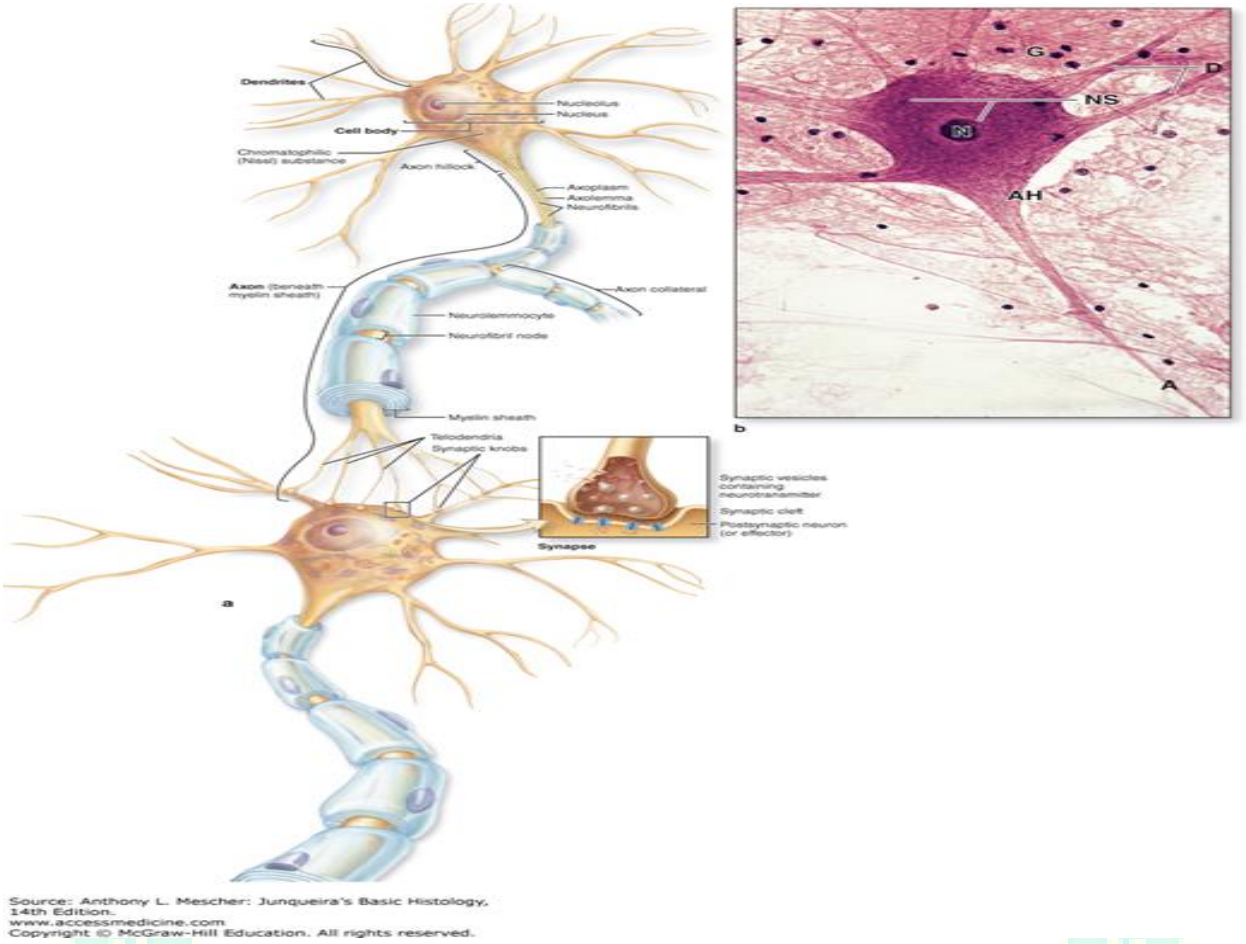


Functionally the nervous system consists of:

1. **Sensory (afferent)**
    a. Somatic – sensory input perceived consciously (eg, from eyes ears, skin, musculoskeletal structures)
    b. Visceral – sensory input not perceived consciously (eg, from internal organs and cardiovascular structures)
2. **Motor (efferent)**
    a. Somatic – motor output controlled consciously or voluntarily (eg, by skeletal muscle effectors)
    b. Autonomic – motor output not controlled consciously (eg, by heart or gland effectors)

The functional unit in both the CNS and PNS is the **neuron**. Some neuronal components have special names, such as "**neurolemma**" for the cell membrane. Most neurons have three main parts:

1. **The cell body (also called the perikaryon or soma)** contains the nucleus and most of the cell's organelles and serves as the synthetic or trophic center for the entire neuron.
2. **The dendrites**, which are the numerous processes extending from the perikaryon and specialized to receive stimuli from other neurons at unique sites called synapses.
3. **The axon**, 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.



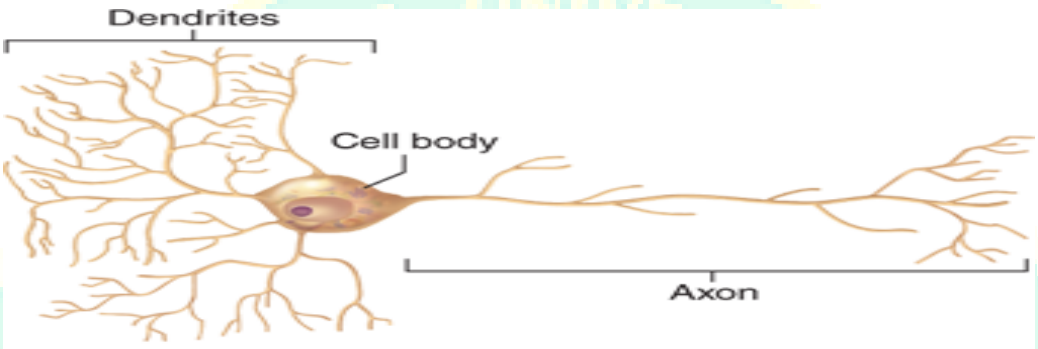
Source: Anthony L. Mescher: Junqueira's Basic Histology, 14th Edition.
www.accessmedicine.com

(a) A "typical" neuron has three major parts: (1) The cell body (also called the perikaryon or soma) is often large, with a large, euchromatic nucleus and well-developed nucleolus. The cytoplasmic contain basophilic Nissl substance or Nissl bodies, which are large masses of free polysomes and RER indicating the cell's high rate of protein synthesis. (2) Numerous short dendrites extend from the perikaryon, receiving input from other neurons. (3) A long axon carries impulses from the cell body and is covered by a myelin sheath composed of other cells. The ends of axons usually have many small branches (telodendria), each of which ends in a knob-like structure that forms part of a functional connection (synapse) with another neuron or other cell.

(b) Micrograph of a large motor neuron showing the large cell body and nucleus (N), along axon (A) emerging from an axon hillock (AH), and several dendrites (D). Nissl substance (NS) can be seen throughout the cell body and cytoskeletal elements can be detected in the processes. Nuclei of scattered glial cells (G) are seen among the surrounding tissue. (X100; H&E).

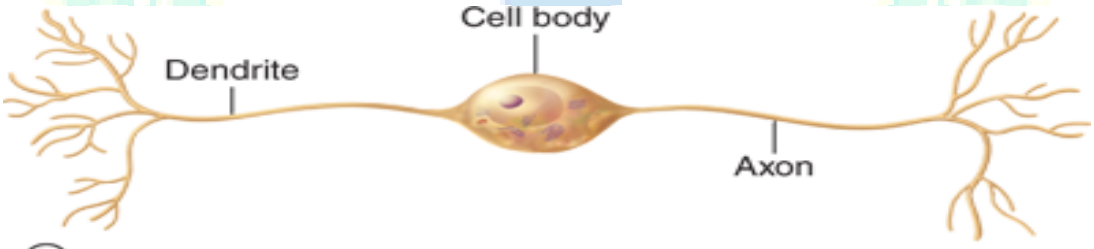
Neurons can be classified according to the **number of processes extending from the cell body**:

1. **Multipolar neurons**, each with **one axon** and **two or more dendrites** are the most common.



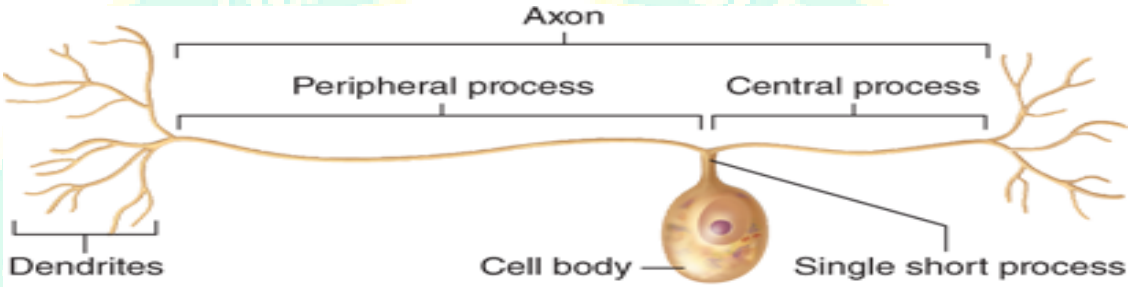
(a) Multipolar neuron

2. **Bipolar neurons**, with **one dendrite** and **one axon**, comprise the sensory neurons of the retina and the inner ear.



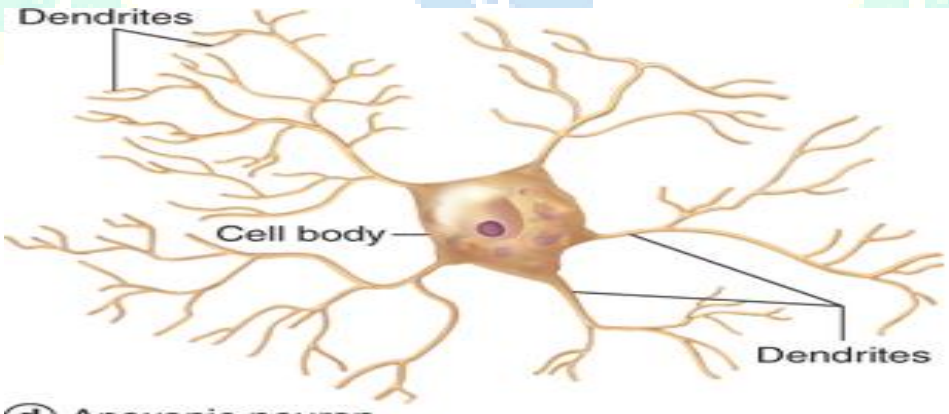
(b) Bipolar neuron

3. **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.



ⓒ Unipolar neuron

4. **Anaxonic neurons**, with **many dendrites** but no **true axon**, do not produce action potentials, but <u>regulate electrical changes of adjacent CNS neurons</u>.



ⓓ Anaxonic neuron