NERVOUS SYSTEM

The **nervous system** enables the body to respond to continuous changes in its external and internal environment. It controls and integrates the functional activities of the organs and systems.

Anatomically, the nervous system is divided into the following:

• The **central nervous system (CNS)** consists of the brain and the spinal cord, which are located in the cranial cavity and spinal canal, respectively.

• The **peripheral nervous system (PNS)** consists of cranial, spinal, and peripheral nerves

Functionally, the nervous system is divided into the following:

• The **somatic nervous system (SNS)** consists of somatic *[Gr. soma, body]* parts of the CNS and PNS. It provides sensory and motor innervation to all parts of the body except viscera, smooth and cardiac muscle, and glands.

• The **autonomic nervous system (ANS)** consists of autonomic parts of the CNS and PNS. The ANS provides efferent involuntary motor innervation to smooth muscle, the conducting system of the heart, and glands. The ANS is further subdivided into a **sympathetic division** and a **parasympathetic division**.

COMPOSITION OF NERVE TISSUE

Nerve tissue consists of two principal types of cells: **neurons and supporting cells.**

The neuron (**nerve cell)**

is the functional unit of the nervous system. ***Parts of a Neuron***

***(1) Cell body* (*perikaryon* or *soma*)**

, contains a nucleus surrounded by cytoplasm that includes typical cellular organelles such as lysosomes, mitochondria, Golgi complex, free ribosomes and prominent clusters of rough endoplasmic reticulum, termed **Nissl bodies**. A **nerve fiber** is a general term for any neuronal process (extension) that emerges from the cell body of a neuron. Most neurons have two kinds of processes: multiple dendrites and a single axon.

(2) Dendrites : are the receiving or input portions of a neuron. The plasma membranes of dendrites (and cell bodies) contain numerous receptor sites for binding chemical messengers from other cells. they are short, tapering, a treeshaped. Their cytoplasm contains Nissl bodies, mitochondria, and other organelles.

(3) A**xon (axis)** :it is propagates nerve impulses toward another neuron, a muscle fiber, or a gland cell. An axon is a long, thin, cylindrical projection that often joins to

the cell body at a cone-shaped elevation called the **axon hillock**. The axon and its collaterals end by dividing into many fine processes called **axon terminals**.

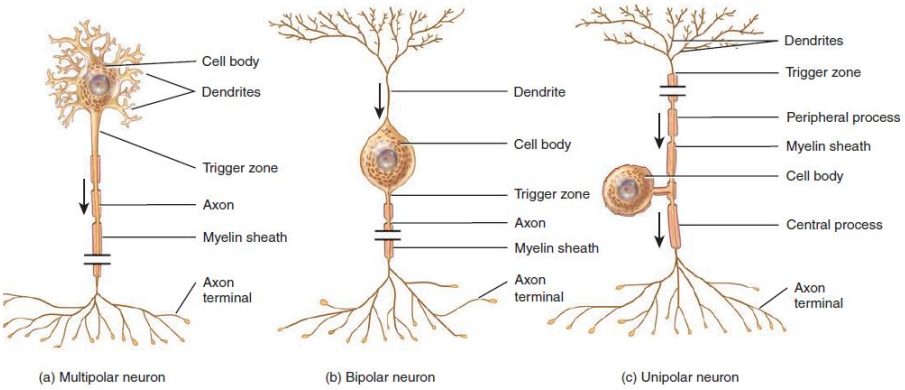
Classification of Neurons

1.Stractural classification, neurons are classified according to the number of processes extending from the cell body

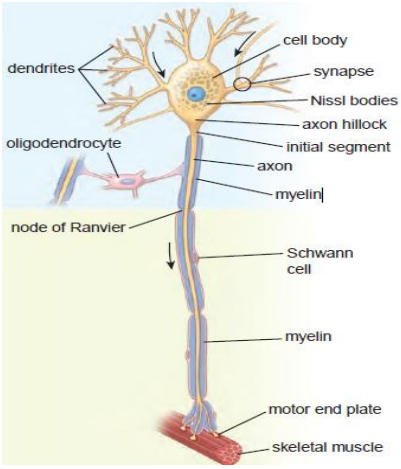
1. Multipolar neurons usually have several dendrites and one axon. (brain neurons)

2. Bipolar neurons have one main dendrite and one axon. (retina)

3. Unipolar neurons have dendrites and one axon that are fused together to form a continuous process that emerges from the cell body. These neurons are more appropriately called **pseudounipolar neurons** because they begin in the embryo as bipolar neurons



Neuron types



neuron

2.Functional classification neurons are classified according to the direction in which the nerve impulse (action potential) is conveyed with respect to the CNS.

1. Sensory or **afferent neurons** contain sensory receptors at their distal ends (dendrites)

2. Motor or **efferent neurons** convey action potentials *away* from the CNS to **effectors** (muscles and glands)

3. Interneurons or **association neurons** are mainly located within the CNS between sensory and motor neurons.

Supporting cells (**neuroglial cells** or **glia**)

are non conducting cells that are located close to the neurons.

Functions of the various neuroglial cell types include:

• physical support (protection) for neurons,

• insulation for nerve cell bodies and processes that facilitates rapid transmission of nerve impulses,

• repair of neuronal injury,

• regulation of the internal fluid environment of the CNS,

• clearance of neurotransmitters from synaptic clefts, and

• metabolic exchange between vascular system and neurons of the nervous system

1.Central Neuroglia

There are four types of central neuroglia:

• **Astrocytes** are morphologically heterogeneous cells that provide physical and metabolic support for neurons of the CNS.

• **Oligodendrocytes** are small cells that are active in the formation and maintenance of myelin in the CNS.

• **Microglia** are inconspicuous cells with small, dark, elongated nuclei that possess phagocytotic properties.

• **Ependymal cells** are columnar cells that line the ventricles of the brain and the central canal of the spinal cord.

2.Peripheral Neuroglia

include **Schwann cells**, **satellite cells**, and a variety of other cells associated with specific organs or tissues. The main function of Schwann cells is to support myelinated and unmyelinated nerve cell fibers. **The node of Ranvier** represents the junction between two adjacent Schwann cells. **Satellite Cells** The neuronal cell bodies of ganglia are surrounded by a layer of small cuboidal cells called **satellite cells**. Although they form a complete layer around the cell body.

In addition to neurons and supporting cells, an extensive vasculature is present in both the CNS and the PNS. The blood vessels are separated from the nerve tissue by the basal laminae and variable amounts of connective tissue, depending on vessel size. This selective restriction of blood-borne substances in the CNS is called the blood–brain barrier.

Organization of the peripheral nervous system

The **peripheral nervous system (PNS)** consists of peripheral nerves with specialized nerve endings and ganglia containing nerve cell bodies that reside outside the central nervous system.

Peripheral Nerves

A peripheral nerve is a bundle of nerve fibers held together by connective tissue. The nerves of the PNS are made up of many nerve fibers that carry sensory and motor (effector) information between the organs and tissues of the body and the brain and spinal cord. The bulk of a peripheral nerve consists of nerve fibers and their supporting Schwann cells. The individual nerve fibers and their associated Schwann cells are held together by connective tissue organized into three distinctive components, each with specific morphologic and functional characteristics

• The **endoneurium** includes loose connective tissue surrounding each individual nerve fiber.

• The **perineurium** includes specialized connective tissue surrounding each nerve fascicle.

• The **epineurium** includes dense irregular connective tissue that surrounds a peripheral nerve and fills the spaces between nerve fascicles.

Afferent (Sensory) Receptors

Afferent receptors are specialized structures located at the distal tips of the peripheral processes of sensory neurons.

• **Exteroceptors** react to stimuli from the external environment for example, temperature, touch, smell, sound, and vision.

• **Enteroceptors** react to stimuli from within the body for example, the degree of filling or stretch of the alimentary canal, bladder, and blood vessels.

• **Proprioceptors,** which also react to stimuli from within the body, provide sensation of body position and muscle tone and movement.

The simplest receptor is a **bare axon** called a **non encapsulated (free) nerve ending**. This ending is found in epithelia, in connective tissue, and in close association with hair follicles. Most sensory nerve endings acquire connective tissue capsules or sheaths of varying complexity , are called encapsulated endings. Many encapsulated endings are mechanoreceptors located in the skin and joint capsules (Krause's end bulb, Ruffini's corpuscles, Meissner's corpuscles, and Pacinian corpuscles). **Muscle spindles** are encapsulated sensory endings located in skeletal muscle; Functionally related Golgi tendon organs are encapsulated tension receptors found at musculotendinous junctions.

Central nervous system CNS

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. Most CNS neurons and their functional organization are more appropriately covered in neuroscience rather than histology courses, but certain important cells and basic topics will be introduced here. 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 main components of white matter are myelinated axons , often grouped together as **tracts**, and the myelin-producing oligodendrocytes. Astrocytes and microglia are also present, but very few neuronal cell bodies. Gray matter contains abundant neuronal cell bodies, dendrites, astrocytes, and microglial cells, and is where most synapses occur. Gray matter makes up the thick cortex or surface layer of both the cerebrum and the cerebellum; most white matter is found in deeper regions. Deep within the brain are localized, variously shaped darker areas called the **cerebral nuclei**, each containing large numbers of aggregated neuronal cell bodies. In the folded **cerebral cortex** neuroscientists recognize six layers of neurons with different sizes and shapes. The most conspicuous of these cells are the efferent **pyramidal neurons** . Neurons of the cerebral cortex function in the integration of sensory information and the initiation of voluntary motor responses.

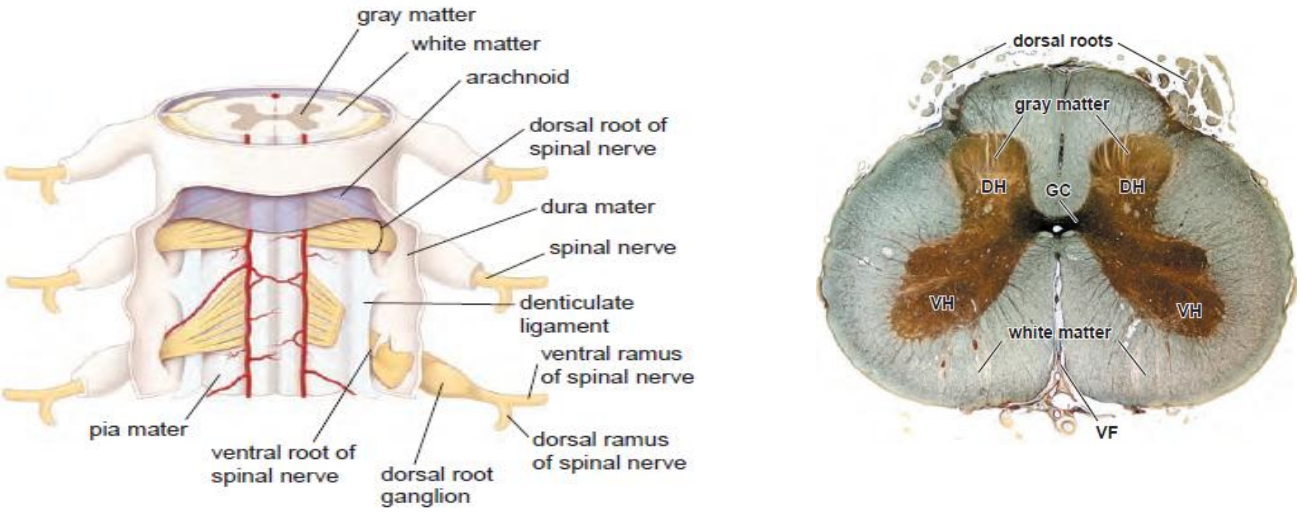
The sharply folded **cerebellar cortex** coordinates muscular activity throughout the body and is organized with three layers:

1. A thick outer **molecular layer** has much neuropil and scattered neuronal cell bodies.

2. A thin middle layer consists only of very large neurons called **Purkinje cells** . These are conspicuous even in H&E-stained sections, and their dendrites extend throughout the molecular layer as a branching basket of nerve fibers

3. A thick inner **granular layer** contains various very small, densely packed neurons (including granule cells, with diameters of only 4-5 μ m) and little neuropil.

In cross sections of the **spinal cord** the white matter is peripheral and the gray matter forms a deeper, H-shaped mass. The two anterior projections of this gray matter, the **anterior horns**, contain cell bodies of very large motor neurons whose axons make up the ventral roots of spinal nerves. The two **posterior horns** contain interneurons which receive sensory fibers from neurons in the spinal (dorsal root) ganglia. Near the middle of the cord the gray matter surrounds a small **central canal**, which develops from the lumen of the neural tube, is continuous with the ventricles of the brain, is lined by ependymal cells, and contains CSF.



Transvers section of the Spinal cord

CNS connective tissues

The CNS is completely enclosed by three connective tissue layers called meninges: (1) the tough external dura mater; (2) the middle arachnoid layer; and (3) the delicate pia mater that directly contacts neural tissue.

Meninges

The skull and the vertebral column protect the CNS, but between the bone and nervous tissue are membranes of connective tissue called the **meninges**. Three meningeal layers are distinguished: the dura, arachnoid, and pia maters

Dura Mater

The thick external **dura mater** (L. *dura mater*, tough mother) consists of dense irregular connective tissue organized as an outer periosteal layer continuous with the periosteum of the skull, and an inner meningeal layer. These two layers are usually fused, but along the superior sagittal surface and other specific areas around the brain they separate to form the blood-filled **dural venous sinuses**

Arachnoid

The **arachnoid** (Gr. *arachnoeides*, spider web-like) has two components: (1) a sheet of connective tissue in contact with the dura mater and (2) a system of loosely arranged trabeculae composed of collagen and fibroblasts, continuous with the underlying pia mater layer. Surrounding these trabeculae is a large, sponge-like cavity, the **subarachnoid space**, filled with CSF. This fluid-filled space helps cushion and protect the CNS from minor trauma. The subarachnoid space communicates with the ventricles of the brain where the CSF is produced. The connective tissue of the arachnoid is said to be avascular because it lacks nutritive capillaries, but larger blood vessels run through it

Pia Mater

The innermost **pia mater** (L. *pia mater*, tender mother) consists of flattened, mesenchymally derived cells closely applied to the entire surface of the CNS tissue.

Blood-Brain Barrier

The **blood-brain barrier** (BBB) is a functional barrier that allows much tighter control than that in most tissues over the passage of substances moving from blood into the CNS tissue. The main structural component of the BBB is the **capillary endothelium**, in which the cells are tightly sealed together with well-developed occluding junctions, with little or no transcytosis activity, and surrounded by the basement membrane. The BBB protects neurons and glia from bacterial toxins, infectious agents, and other exogenous substances, and helps maintain the stable composition and constant balance of ions in the interstitial fluid required for normal neuronal function. The BBB is not present in regions of the hypothalamus where plasma components are monitored, in the posterior pituitary which releases hormones, or in the choroid plexus where CSF is produced.

Choroid plexus

The choroid plexus consists of tufts of small vascular elements (derived from the pia-arachnoid) that are covered by modified ependymal cells (simple cuboidal in shape). These structures, located in the ventricles of the brain, are responsible for the formation of the cerebrospinal fluid.