

NERVE TISSUE & THE NERVOUS SYSTEM:

- 1-The human nervous system is by far the most complex system in the body histologically and physiologically and is formed by a network of many billion nerve cells (**neurons**), all assisted by many more supporting **glial cells**.
- 2-Each neuron has hundreds of interconnections with other neurons, forming a very complex system for processing information and generating responses.
- 3-Nerve tissue is distributed throughout the body as an integrated communications network. Anatomists divide the nervous system into the following:
 - A-Central nervous system (CNS), consisting of the brain and spinal cord.
 - B-Peripheral nervous system (PNS), composed of the cranial, spinal, and peripheral nerves conducting impulses to and from the CNS (motor and sensory nerves respectively) and **ganglia** which are small groups of nerve cells outside the CNS.

NEURONS:

The functional unit in both the CNS and PNS is the neuron or nerve cell. Most neurons consist of three parts :

- i) the **cell body**, or **perikaryon**, which is the synthetic or trophic center for the entire nerve cell and is receptive to stimuli.
- ii) the **dendrites**, many elongated processes specialized to receive stimuli from the environment, sensory epithelial cells, or other neurons.
- iii) the **axon** ,
 - A) which is a single process specialized in generating and conducting nerve impulses to other cells (nerve, muscle, and gland cells).
 - B) Axons may also receive information from other neurons, information that mainly modifies the transmission of action potentials to those neurons.
 - C) The distal portion of the axon is usually branched. Each branch terminates on the next cell in dilations called **end bulbs** , which interact with other neurons or non nerve cells at structures called **synapses**.
 - D) Synapses initiate impulses in the next cell of the circuit.

Synaptic Communication:

- 1-The synapse is responsible for the transmission of nerve impulses from neuron to another cell and insures that transmission is unidirectional.
- 2-Synapses are sites of functional contact between neurons or between neurons and other effector cells. The function of the synapse is to convert an electrical signal (impulse) from the **presynaptic** cell into a chemical signal that acts on the **postsynaptic** cell.

3-Most synapses transmit information by releasing **neurotransmitters** during this signaling process.

Neurotransmitters:

Neurotransmitters are chemicals that bind specific receptor proteins to either open or closed ion channels or initiate second-messenger cascades.

The first neurotransmitters to be described were acetylcholine and norepinephrine.

i) A norepinephrine-releasing axon terminal . Most neurotransmitters are amines, amino acids, or small peptides (neuropeptides).

ii) Inorganic substances such as nitric oxide can also act as neurotransmitters.

iii) Several peptides that can act as neurotransmitters are used as paracrine hormones elsewhere in the body eg, in the digestive tract.

iv) Neuropeptides are involved in regulating feelings and drives, such as pain, pleasure, hunger, thirst, and sex.

Types of synapses :

Morphologically, various types of synapses are seen between neurons.

i- If an axon forms a synapse with a cell body, it is called an **axosomatic synapse** . -

ii- If with a dendrite, it is called an **axodendritic**.

iii- If with an axon, it is called an **axoaxonic** . The axoaxonic synapse is less common and is used to modulate synaptic activity.

GLIAL CELLS :

There are six kinds of glial cells:

1-Oligodendrocytes:

i) Oligodendrocytes produce the myelin sheath that provides the electrical insulation for neurons in the CNS.

ii) Oligodendrocytes extend processes that wrap around parts of several axons, producing a myelin sheath . They are the predominant glial cell in CNS white matter.

2-Astrocytes:

i) Astrocytes have a large number of radiating processes and are unique to the CNS.

ii) Astrocytes with relatively few long processes are called **fibrous astrocytes** and are located in the white matter; **protoplasmic astrocytes**, with many short, branched processes, are found in the gray matter.

Function of astrocytes:

- i)* Astrocytes have supportive roles for neurons and are very important for proper formation of the CNS during embryonic and fetal development.
- ii)* Astrocytes have major roles in controlling the ionic environment of neurons.
- iii)* when the CNS is damaged, astrocytes proliferate to form cellular scar tissue .

3-Ependymal Cells:

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

4-Microglia:

- i)* It is less numerous than oligodendrocytes or astrocytes but more evenly distributed throughout gray and white matter, **microglia** are small cells with short irregular processes . Nuclei of microglial cells can be dense elongated structure.
- ii)* Microglia originate not from the embryonic neural tube but from circulating blood monocytes, belonging to the same family as macrophages and other antigen-presenting cells.

Function of Microglia:

- i)* Microglia migrate through the neuropil, analyzing the tissue for damaged cells and invading microorganisms.
- ii)* They secrete a number of immunoregulatory cytokines and constitute the major mechanism of immune defense in CNS tissues.

5-Schwann Cells (Neurolemmocytes):

- i)* **Schwann cells**, also called **neurolemmocytes**, are found only in the PNS and have trophic interactions with axons and allow for their myelination like the oligodendrocytes of the CNS.
- ii)* One neurolemmocyte forms myelin around a segment of one axon, in contrast to the ability of oligodendrocytes to branch and sheath parts of more than one axon.

6-Satellite Cells of Ganglia:

- i)* Derived from the embryonic neural crest like neurolemmocytes, small **satellite cells** form a covering layer over the large neuronal cell bodies in PNS ganglia .
- ii)* Closely associated with the neurons, the satellite cells exert a trophic or supportive role, but the molecular basis of their support is poorly understood.

CENTRAL NERVOUS SYSTEM:

1-The principal structures of the CNS are the **cerebrum**, **cerebellum**, and **spinal cord**. It has virtually no connective tissue and is therefore a relatively soft, gel-like organ.

2-When sectioned, the cerebrum, cerebellum, and spinal cord show regions of white (**white matter**) and gray (**gray matter**), differences caused by the differential distribution of myelin.

White matter:

*i)*The main components of white matter are myelinated axons and the myelin-producing oligodendrocytes.

*ii)*White matter does not contain neuronal cell bodies, but microglia are present.

Gray matter:

*i)*Gray matter contains abundant neuronal cell bodies, dendrites, the initial unmyelinated portions of axons, astrocytes, and microglial cells. This is the region where synapses occur.

*ii)*Gray matter is prevalent at the surface or cortex of the cerebrum and cerebellum, whereas white matter is present in more central regions.

*iii)*Aggregates of neuronal cell bodies forming islands of gray matter embedded in the white matter are called **nuclei**.

Cerebral cortex:

*i)*Cells of the cerebral cortex function in the integration of sensory information and the initiation of voluntary motor responses.

*ii)*The **cerebellar cortex**, which coordinates muscular activity throughout the body, has three layers :

a) an outer **molecular layer**:

*b)*a central layer of very large neurons called **Purkinje cells**: The Purkinje cell bodies are conspicuous even in H&E stained material and their dendrites extend throughout the molecular layer as a branching basket of nerve fibers .

*c)*an inner **granule layer**:The granule layer is formed by very small neurons (the smallest in the body),which are packed together densely, in contrast to the neuronal cell bodies in the molecular layer which are sparse .

Spinal cord:

1-In cross sections of the **spinal cord**, white matter is peripheral and gray matter is internal and has the general shape of an H.

2-In the center is an opening, the **central canal**, which develops from the lumen of the embryonic neural tube and is lined by ependymal cells.

3-The gray matter forms the **anterior** horns, which contain motor neurons whose axons make up the ventral roots of spinal nerves, and the posterior horns, which receive sensory fibers from neurons in the spinal ganglia (dorsal roots).

4- Spinal cord neurons are large and multipolar, especially the motor neurons in the anterior horns.

Meninges:

The skull and the vertebral column protect the CNS. Between the bone and nervous tissue are membranes of connective tissue called the **meninges**. Three meningeal layers are distinguished:

I-DURA MATER.

*i)*The dura mater is the thick external layer consisting of dense, fibroelastic connective tissue continuous with the periosteum of the skull.

*ii)*Around the spinal cord the dura mater is separated from the periosteum of the vertebrae by the **epidural space**, which contains a plexus of thin-walled veins and areolar connective tissue.

*iii)*The internal surface of all dura mater, as well as its external surface in the spinal cord, is covered by simple squamous epithelium of mesenchymal origin .

II-ARACHNOID.

A-The arachnoid has two components: (1) a sheet of connective tissue in contact with the dura mater and (2) a system of loosely arranged trabeculae containing fibroblasts and collagen. This trabecular system is continuous with the deeper pia mater.

B- Surrounding the trabeculae is a large, sponge-like cavity, the **subarachnoid space**, filled with CSF. This space protects the CNS from trauma.

III-PIA MATER.

A-The innermost pia mater is lined internally by flattened, mesenchymally derived cells closely applied to the entire surface of the CNS tissue, but this layer does not directly contact nerve cells or fibers.

B-Between the pia mater and the neural elements is a thin limiting layer of astrocytic processes, which adheres firmly to the pia mater.

PERIPHERAL NERVOUS SYSTEM:

The main components of the peripheral nervous system are the **nerves, ganglia,** and **nerve endings**. Nerves are bundles of nerve fibers (axons) surrounded by glial cells and connective tissue.

MYELINATED NERVE FIBERS.

1-As axons of large diameter grow in the PNS, they are engulfed along their length by many undifferentiated neurolemmocytes and become **myelinated nerve fibers**.

2-The plasma membrane of the covering neurolemmocyte (Schwann cell) fuses around the axon and becomes wrapped around the nerve fiber as the glial cell body moves around and around the axon many times .

3-The multiple layers of Schwann cell membrane unite as a layer **myelin**, a whitish lipoprotein complex whose abundant lipid component in all cell membranes .

4-Unlike oligodendrocytes of the CNS, Schwann cells only form myelin around a portion of one axon.

Nodes of Ranvier:

Between adjacent Schwann cells the myelin sheath shows small **nodal gaps** along the axon, also called **nodes of Ranvier** . Interdigitating processes of Schwann cells partially cover each node .

UNMYELINATED NERVE FIBERS.

1-The CNS is rich in unmyelinated axons which are not sheathed at all but run free among the other neuronal and glial processes.

2- In the PNS, even all unmyelinated axons are enveloped within simple folds of Schwann cells .

3-Each Schwann cell can enclose portions of many unmyelinated axons with small diameters. Adjacent Schwann cells along unmyelinated nerve fibers do not form nodes of Ranvier.

Function of nerves:

The nerves establish communication between centers in the brain and spinal cord and the sense organs and effectors (muscles, glands,). They generally contain both afferent and efferent fibers.

i- Afferent fibers carry information from the interior of the body and the environment to the CNS.

ii-Efferent fibers carry impulses from the CNS to effector organs commanded by these centers.

Sensory nerves :

Nerves possessing only sensory fibers are called **sensory nerves**; those composed only of fibers carrying impulses to the effectors are called **motor nerves**. Most nerves have both sensory and motor fibers and are called **mixed nerves** which usually have both myelinated and unmyelinated axons.

Autonomic nerves:

A)Autonomic nerves effect the activity of smooth muscle, the secretion of some glands, modulate cardiac rhythm and other involuntary activities by which the body maintains a constant internal environment (**homeostasis**).

B)Autonomic nerves use two-neuron circuits. The first neuron of the chain, with the **preganglionic fiber**, is located in the CNS. Its axon forms a synapse with postganglionic fibers of the second multipolar neuron in the chain located in a peripheral ganglion system.

C)The chemical mediator present in the synaptic vesicles of all preganglionic axons is **acetylcholine**.

Types of autonomic nervous:

Autonomic nerves comprise an autonomic nervous system with two parts, called the **sympathetic** and the **parasympathetic divisions**.

i)Neuronal cell bodies of preganglionic sympathetic nerves are located in the thoracic and lumbar segments of the spinal cord and those of the parasympathetic division are in the medulla and midbrain and in the sacral portion of the spinal cord.

ii)Sympathetic second neurons are located in small ganglia along the vertebral column, while second neurons of the parasympathetic series are found in very small ganglia always located near or within the effector organs, for example in the walls of the stomach and intestines.

Ganglia:

Ganglia are typically ovoid structures containing neuronal cell bodies and glial cells supported by connective tissue. Because they serve as relay stations to transmit nerve impulses, 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.

Types of ganglia:

I-SENSORY GANGLIA:

A) Sensory ganglia receive afferent impulses that go to the CNS. Sensory ganglia are associated with both cranial nerves (cranial ganglia) and the dorsal root of the spinal nerves (spinal ganglia).

B) These ganglia relay information from the ganglion's nerve endings to the gray matter of the spinal cord via synapses with local neurons.

II-AUTONOMIC GANGLIA:

Autonomic ganglia are small bulbous dilatations in autonomic nerves. Some are located within certain organs, especially in the walls of the digestive tract.