



# Central Nervous System

Sheet #

Subject | Anatomy

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- **Nervous system:** is a network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body.

- **The basic functions of the Nervous system:**

## 1- Sensation:

**The Nervous system** monitors the environment changes/events occurring in and outside the body.

External environment events like light, touch and temperature.

Internal environment events like gases concentrations in the blood as well as blood pressure which can be detected by chemoreceptors & baroreceptors respectively.

Such changes are known as **stimuli** and the cells that monitor them are called **receptors**, these receptors transform certain types of energy into action potentials. For example, electromagnetic waves are recognized by photoreceptors which transforms electromagnetic energy into an action potential.

The point behind all of these sensations whether external or internal is to inform the CNS about what is going on inside and outside the body.

## 2-Integration:

It means making a proper response upon receiving the signals.

It is the parallel processing and interpretation of sensory information to determine the appropriate response.

### 3-Motor output (reaction):

It can be somatic for the stimulation of skeletal muscles (**voluntary**) or autonomic for smooth muscles and gland secretion (**involuntary**).

*(NOTE: the word motor in CNS is applied for both muscle contraction as well as gland secretion).*

- Nervous tissue is **highly cellular** and has two cell types:

Neurons	Neuroglia
Functional highly specialized signal conducting cells.	Support, nourish, and protect the neurons.
They do not divide.	They can divide.
They are long lived cells.	Smaller cells, however they greatly outnumber neurons by about 5 to 50.
They have high metabolic activity.	They are divided further into 6 types ( 4 types in CNS and 2 types in PNS ).
Electrically excitable.	Have no role in nerve impulses transmission

As we mentioned above there are 6 types of neuroglia, 4 types in CNS and 2 types in PNS:

Central nervous system	Peripheral nervous system
<b>1- Astrocytes:</b> - star-shaped glial cells in the central nervous system. - Functions: <ul style="list-style-type: none"><li>- Form new synapses.</li><li>- Form blood brain barrier.</li></ul>	<b>1- Schwann cells:</b> secrete myelin sheath that wraps around axons in <b>PNS</b> .

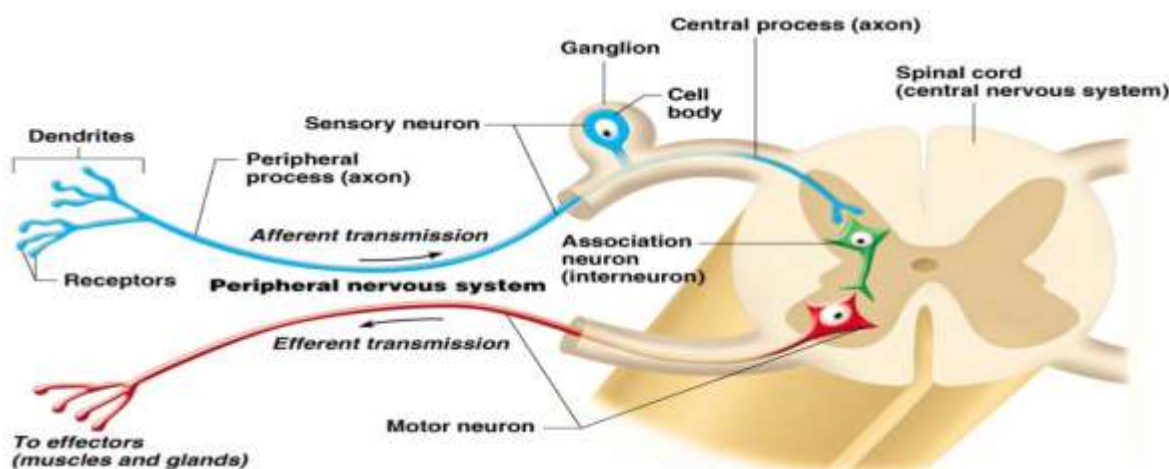
<ul style="list-style-type: none"> <li>- Buffering function, to get rid of excess neurotransmitters.</li> <li>- Involved in learning and memory.</li> </ul>	
<b>2- Microglia:</b> Fixed macrophages (monocyte origin), their function resembles that of kupffer cells in the liver and osteoclasts in the bones.	<b>2-Stellate cells:</b> Support the ganglia.
<b>3- Ependymal cells:</b> These cells line the CSF-filled ventricles in the brain and the central canal of the spinal cord	
<b>4- Oligodendrocytes:</b> Secrete myelin sheath that wraps around axons in CNS.	

A Neuron is composed of Cell body & Processes (**Dendrites & axons**).

The figure below shows a cross section of spinal cord that emerges from it spinal nerves.

Each spinal nerve is a mixed nerve, formed from the combination of nerve fibers from its dorsal and ventral roots.

**The dorsal root is always sensory and the ventral root is always motor.**



### Functional Classification of Neurons:

1. Sensory (afferent) neurons carry impulses from the sensory receptor (in the periphery) to the brain. Their cell bodies are located in the **dorsal root ganglia**.
2. Interneurons (association neurons), found in neural pathways in the CNS which connect sensory and motor neurons.

(Most of the neurons in the CNS are interneurons)

3. Motor neurons: transfers the signals from the CNS to the periphery (effectors, muscles and glands). Their cell bodies are located in the **ventral root ganglia**.

Important terminology:

**Neuron:** is a single nerve cell.

**White matter:** aggregations of myelinated and unmyelinated axons of many neurons. It's divided into columns in the spinal cord.

**Grey matter:** aggregations of neuronal cell bodies, dendrites, unmyelinated axons, axon terminals, and neuroglia. It's divided into horns in the spinal cord.

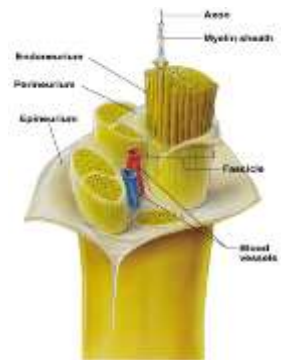
(Note: In the **brain** the **grey matter** is found outside and within the white matter while the **white matter** inside, the opposite in the **spinal cord** in which the **white matter** is found outside and the **gray matter** inside.)

**Nerve:** bundle of processes or axons in the PNS and it is **surrounded by connective tissue**.

**Tract:** bundle of processes or axons in the CNS and it is not surrounded by connective tissue. For example, ascending and descending tracts.

**Ganglion:** cluster of nerve cell bodies in PNS

**Nucleus:** cluster of nerve cell bodies in CNS surrounded by white matter, if not surrounded by white matter it's called **cortex**.



### Organization of the nervous system:

-Divided anatomically to central nervous system (CNS) and peripheral nervous system (PNS) –

The CNS consists of the brain (in the cranial cavity and protected by the skull) and the spinal cord (in the vertebral canal: vertebral foramina above each other), it is the center of integration and control.

-PNS is the nervous system outside of the brain and spinal cord, it consists of:

#### 1) 31 pairs of spinal nerves:

-Every spinal nerve is a mixed nerve after the ventral root (motor) of the corresponding segment joins the dorsal root (sensory) of the same segment

-They carry information to and from the spinal cord.

**2) 12 pairs of cranial nerves:** They carry information to and from the brain.

- 10 out of 12 cranial nerves emerge from the brain stem.

### **Brain:**

The anatomical and embryological division on the brain is:

**1-Hindbrain (Rhombencephalon):** It includes Pons, medulla oblongata, and cerebellum.

It is responsible for vital centers for example cardiovascular and respiratory centers.

**2-Midbrain (mesencephalon).**

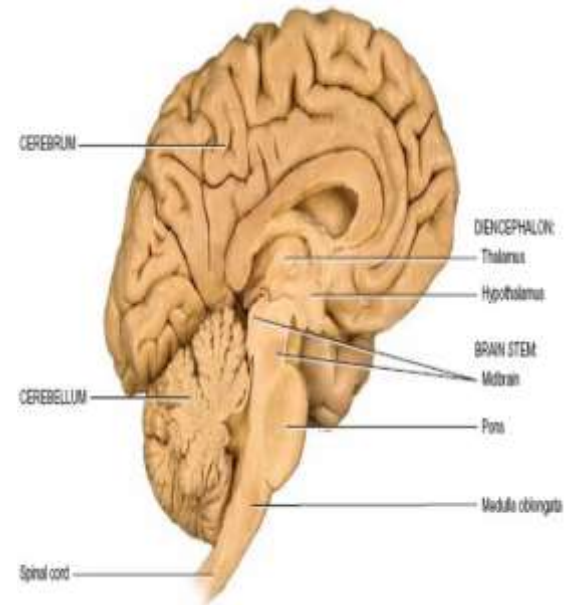
**3-Forebrain (Prosencephalon):** has 2 parts

1) Cerebrum (Telencephalon); located in the periphery (cortex).

It is the seat of higher-level thought like emotions and decision making.

2) Diencephalon; found in the middle and includes; Thalamus, Hypothalamus, Epithalamus, and Subthalamus.

**\*Brain stem:** consists of midbrain, pons, and medulla oblongata.



### **Peripheral Nervous system:**

Responsible for communication between the CNS and the rest of the body.

Can be divided into:

**\*Sensory Division (afferent division):**

-Conducts impulses from receptors to the CNS

-Informs the CNS of the state of the body interior and exterior

-Sensory nerve fibers can be somatic (from skin, skeletal muscles or joints) or visceral (from organs within the body cavity)

**\*Motor Division (efferent division):**

-Conducts impulses from CNS to effectors (muscles/glands)

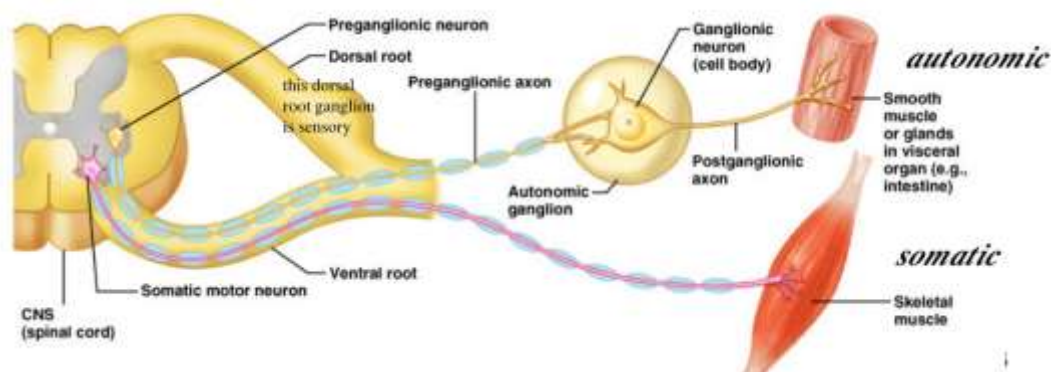
-Motor nerves can be **somatic** (goes to skeletal muscles that is responsible for voluntary movement), or **Autonomic** (goes to smooth muscles, cardiac muscles, and glands that is responsible for involuntary movement).

*\*The autonomic is subdivided into sympathetic (fight or flight) and parasympathetic (rest & digest)*

### ***Sensory system:***

Let's imagine that you touched a very hot cup, what will happen?

- 1- Your skin has receptors that transfer hot energy to chemical energy that travels through afferent nerves that enter the dorsal root ganglia in the spinal cord where cell body of the neuron is reside.
- 2- So the neuron synapses inside the spinal cord, the whole neuron that comes from the skin to the spinal cord is called primary afferent neuron or 1<sup>st</sup> order neuron.
- 3- The synapse will be between the 1<sup>st</sup> order neuron with cell body of the 2<sup>nd</sup> order neuron in the grey matter (dorsal horn) of the spinal cord.  
((The white matter is divided into columns (dorsal, anterior, lateral), and the grey matter is divided into horns (ventral, dorsal and some segments have lateral horn))).
- 4- The 2<sup>nd</sup> order neuron will travel up through spinal cord within the white matter (ascending tract).
- 5- Then it synapses in the thalamus (considered as a grey matter that has collection of cell bodies called nucleus) with cell bodies of 3<sup>rd</sup> order neuron which will project to the cortex.



***Best of luck***

