



Batterjee Medical College
For Science and Technology

Human Nervous System



Objectives

- Identify the divisions of the nervous system.
- Identify the structure of a typical neuron and explain the function of each part.
- List the three types of neurons and provide a function for each.
- List the types of neuroglial cells in the CNS and PNS and explain their specific functions.
- Identify the major parts of the brain and their specific functions.
- Explain the structure and function of the spinal cord.
- Explain the effects of the autonomic nervous system on various organs.

Objectives

- Explain the pathway of a reflex arc.
- Define a synapse and describe its structure.
- Distinguish between electrical and chemical synapses.
- Explain the steps involved in the transmission of a nerve impulse across a chemical synapse.
- Describe the causes, symptoms, and effects of common nervous system disorders, including Alzheimer's disease and multiple sclerosis.

Nervous Tissue

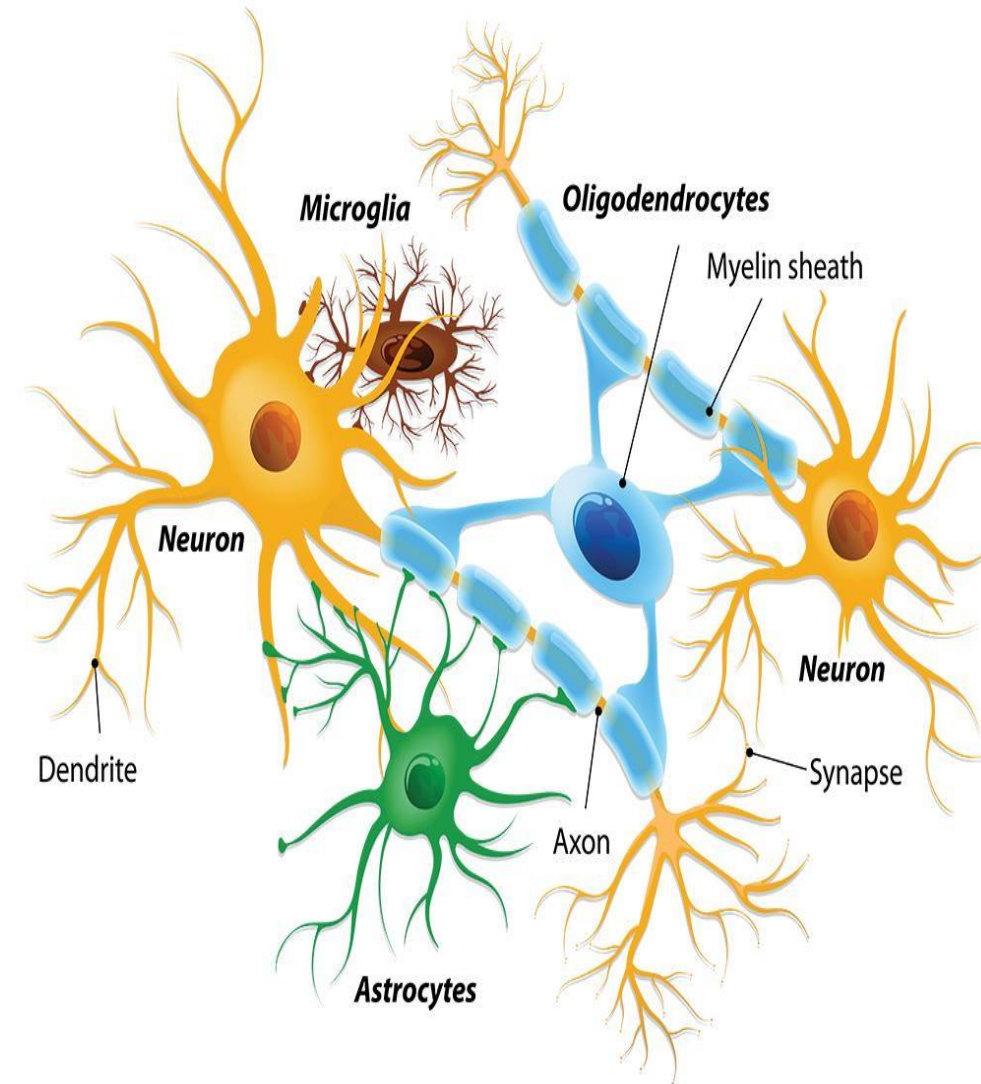
- Nervous tissue contains two types of cells:

Neurons and neuroglial cells.

1. Neurons :

- Are the **functional units** of the nervous system .
- Specialized cells for the **reception, conduction, and transmission** of electrochemical signals.
- It has many sizes and shapes .

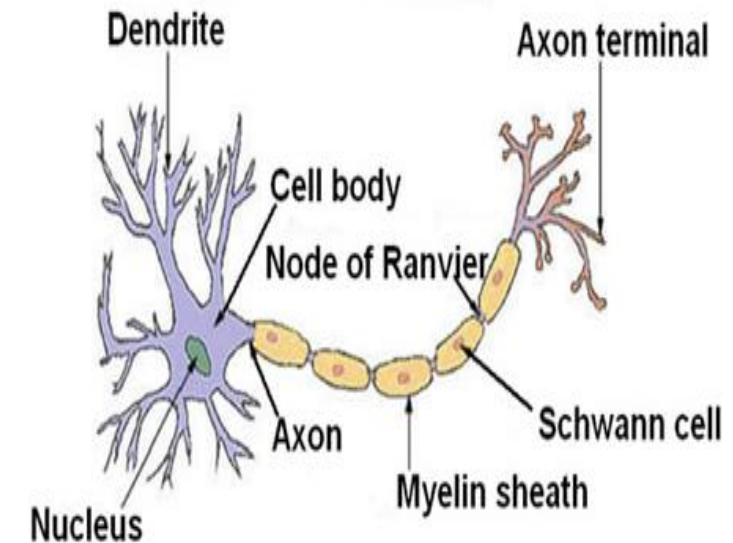
2. Neuroglial cells: Specialized connective tissue cells (Glia) which **support and nourish** neurons.



Neuron and neuroglial cells

Structure of neuron

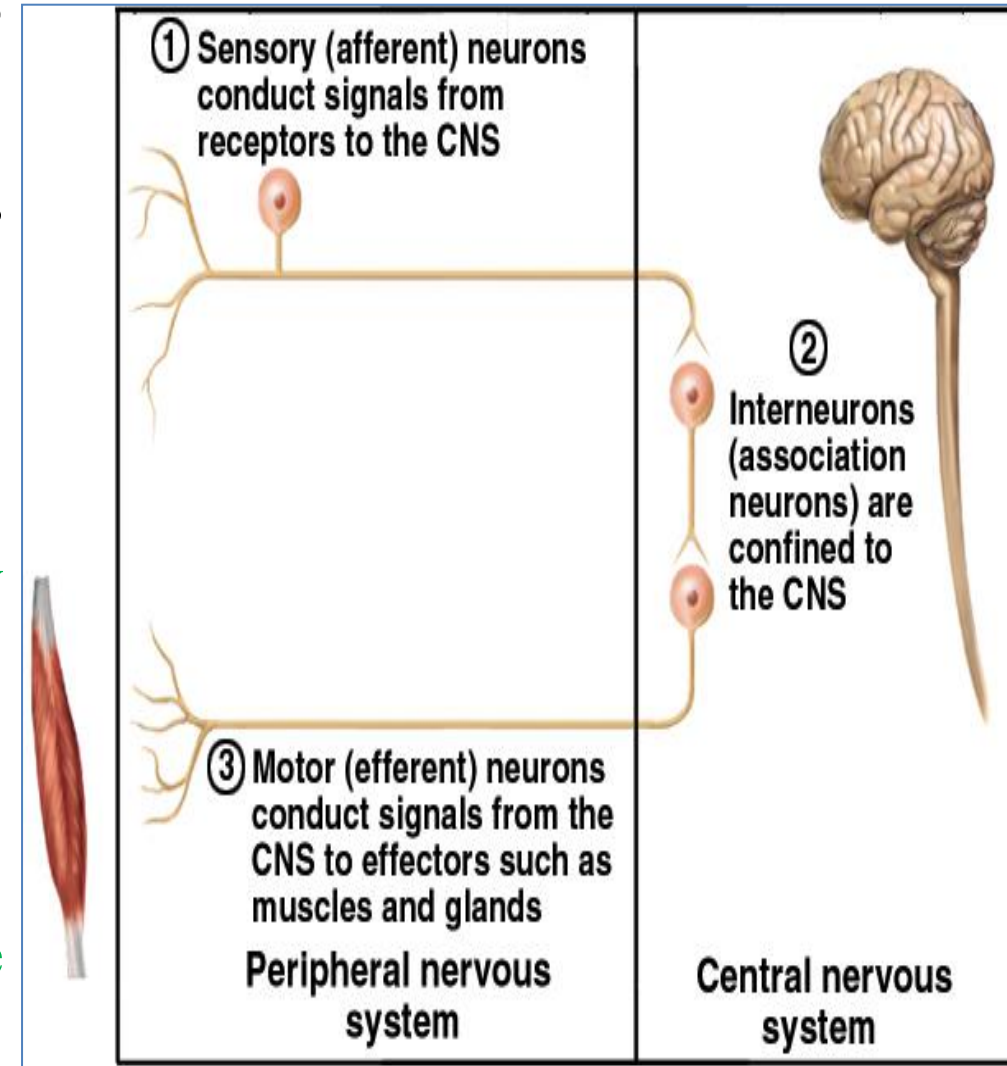
- Neurons vary in appearance, but all of them have three distinct structures: **a cell body, dendrites, and an axon.**
1. **Dendrites:** branch-like extensions that **receive impulses from sensory receptor or other neuron** and carry them toward cell body.
 2. **Cell body (soma):** contains nucleus and other organelles.
 3. **Axon:** single extension of the neuron that **carries impulses away from the cell body**. Many axons have a thick insulating lipid layer called **myelin sheath**. The axon branches out at ending to send impulses to many different neurons. Dendrites receive impulses from many other axons.



Structure of neuron

Types of Neurons

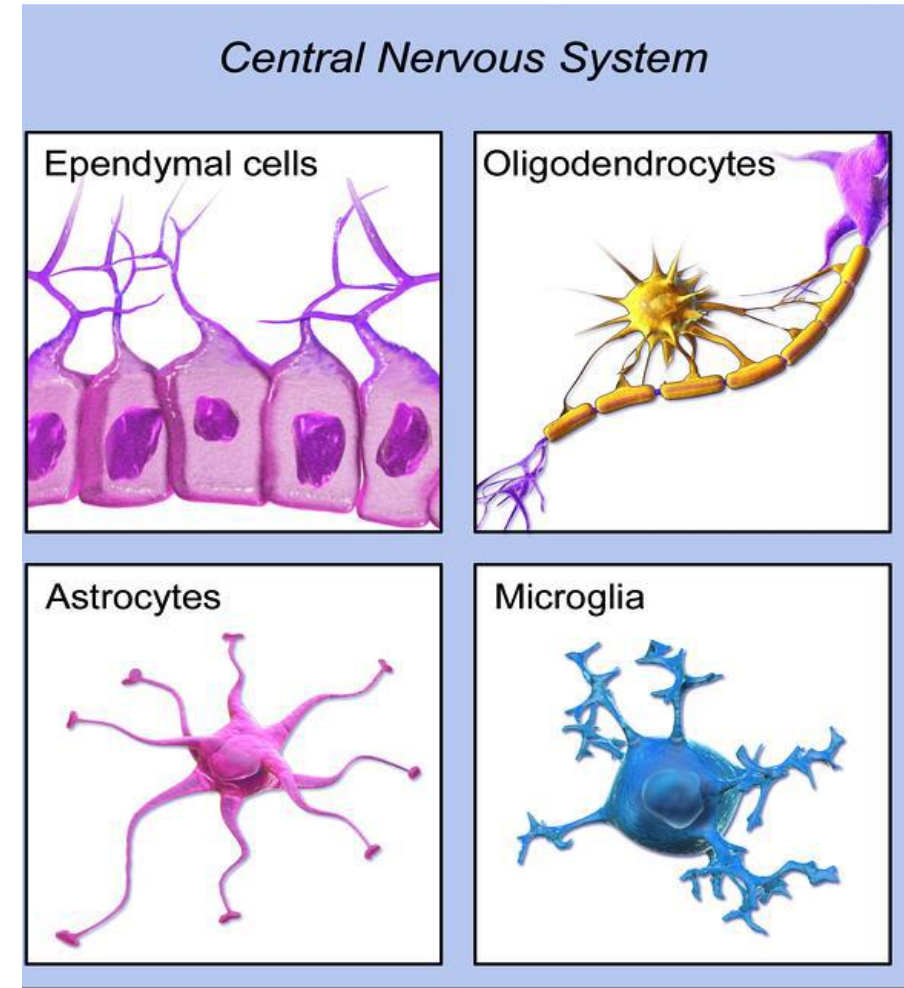
- The three types of neurons are classified according to function:
 1. **Sensory (afferent) neurons:** transport nerve signals from **sensory receptors to CNS**.
 2. **Interneuron:** located within the CNS, **integrate sensory input and motor output**.
 3. **Motor (efferent) neurons:** transport signals from **the CNS to effectors cells** (muscle fiber, organ, or gland).



Types of neurons

Types of Neuroglia in CNS

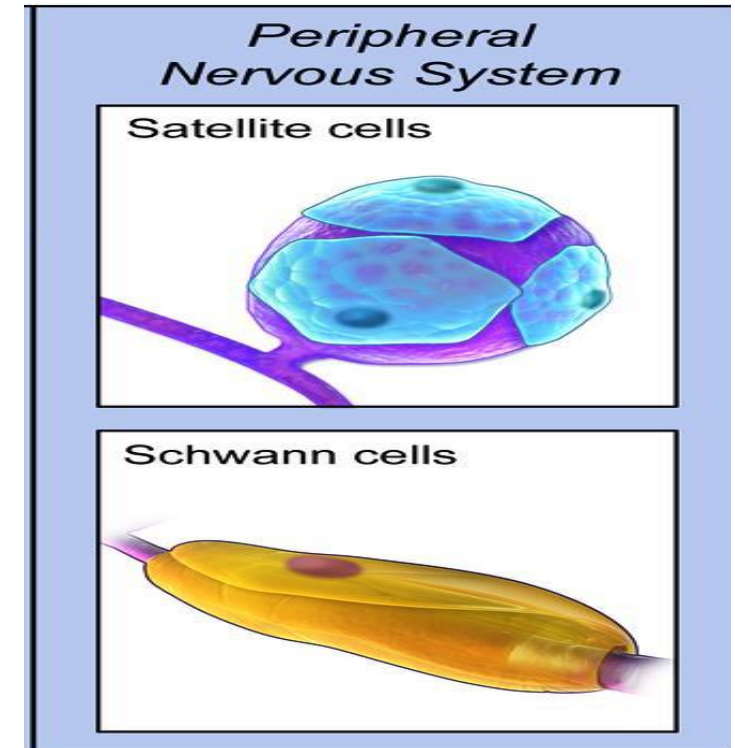
1. **Astrocytes** : star cells are found within the **CNS**. They provide **structural support** as their thread like branches hold blood vessels and neuron together .
2. **Ependymal cells** :line the spinal cord and the ventricular system of the brain. These cells are involved in the **creation and secretion of cerebrospinal fluid (CSF)** and beat their cilia to help circulate the CSF within **CNS**.
3. **Oligodendrocytes**: Form a **myelin sheath** within the **CNS**.
4. **Microglia**: They are like special types of macrophages located in the **CNS** that **phagocytose microbes and destroy them**.



Types of Neuroglia in CNS

Types of Neuroglia in PNS

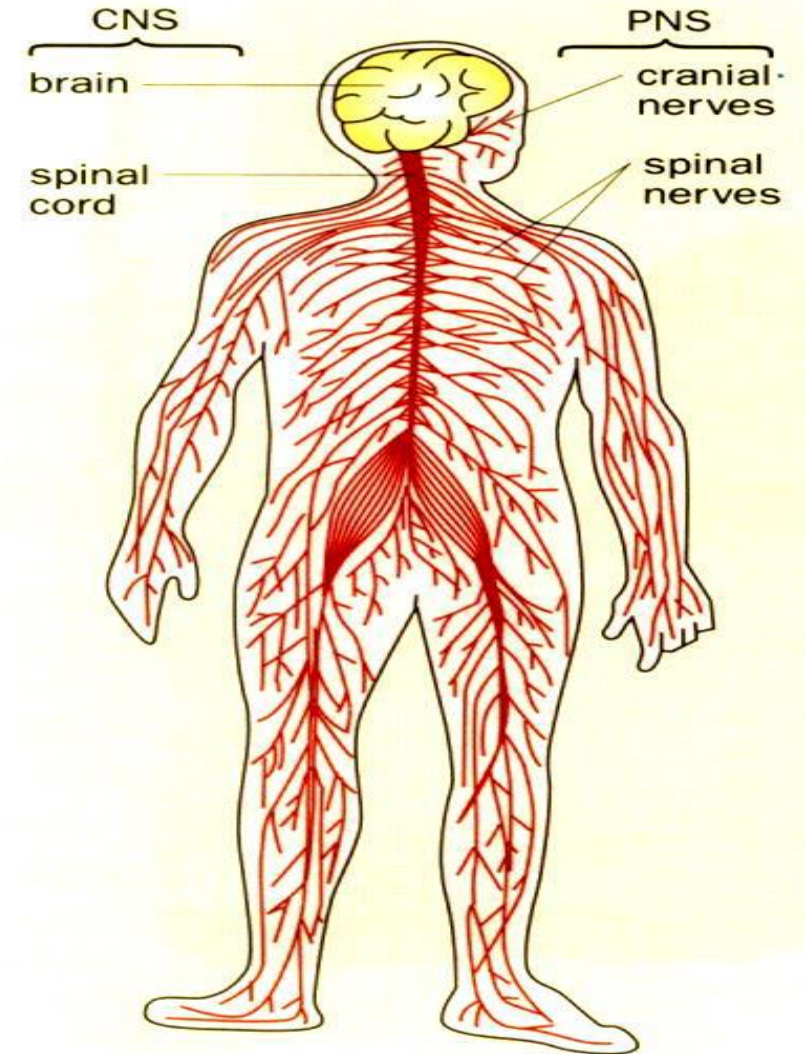
1. **Satellite cells:** These cells help regulate the external chemical environment in the *PNS*.
2. **Schwann cells:** Form a myelin sheath within the *PNS*.



Types of Neuroglia in PNS

Divisions of the Nervous System

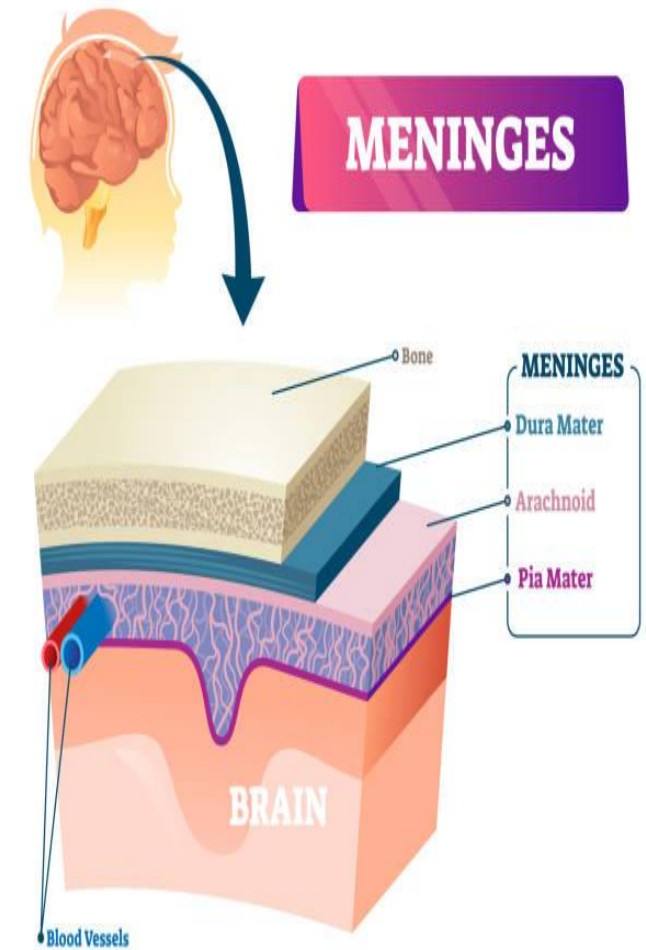
- The nervous system has two major divisions :
 - **Central nervous system (CNS):**
Consists of **Brain and Spinal cord**.
 - **Peripheral nervous system (PNS):**
Consists of **cranial nerves** from the brain and **spinal nerves** from spinal cord.



Divisions of the nervous system

Central Nervous System

- The Central Nervous System controls all the body's activities.
- Consists of brain and spinal cord.
- The brain and the spinal cord are wrapped in protective membranes known as meninges.
- The meninges are three layers, the outermost layer is the dura mater, the middle layer is the arachnoid mater, and the innermost layer is the pia mater.
- The spaces between the meninges are filled with cerebrospinal fluid, CSF, which protects the CNS.
- The meninges offer protection to the brain and the spinal cord by acting as a barrier against bacteria and other microorganisms.



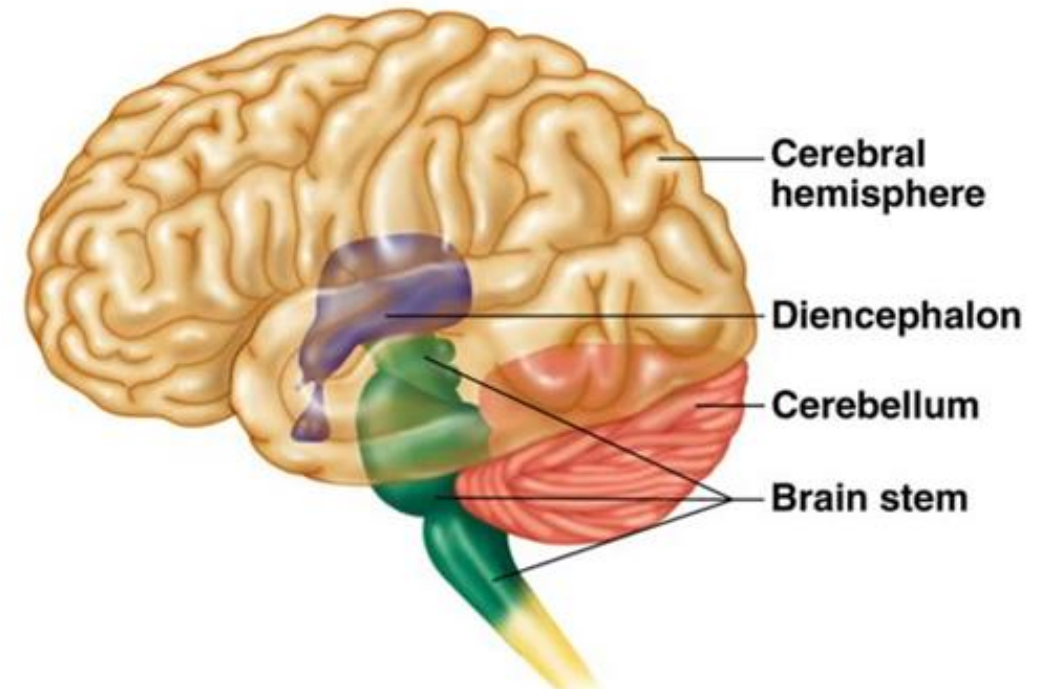
Layers of meninges

Brain

- The brain is a mass of soft nerve tissue, which is encapsulated within the skull.

- **The Brain has four main parts:**

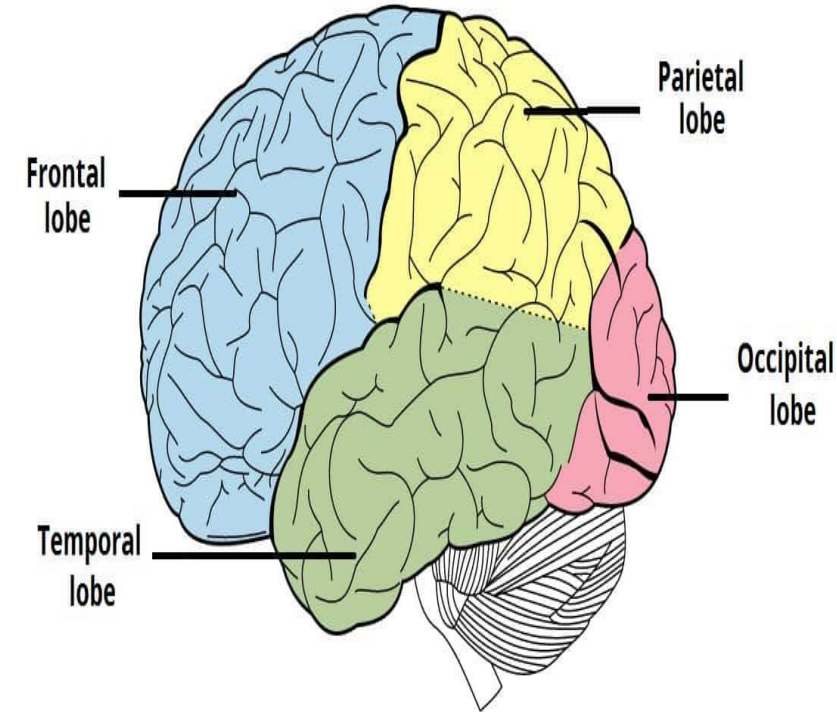
1. The cerebrum
2. The cerebellum
3. The brain Stem
4. The diencephalon



Parts of the brain

The Cerebrum

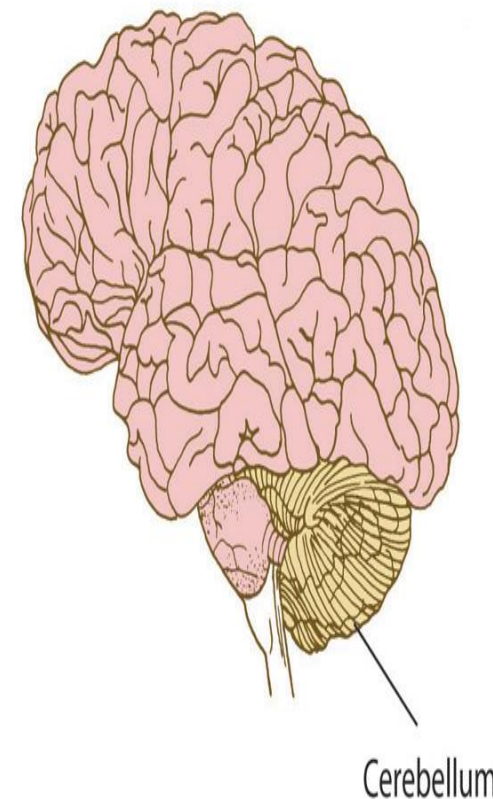
- The Cerebrum is the **largest part of the brain**.
- It is divided into two halves which are called left and right cerebral hemispheres.
- Each cerebral hemisphere is divided into four lobes: **frontal, parietal, temporal, and occipital**.
- The cerebrum has areas for **speech, hearing, smell, sight, memory, learning, motor and sensory areas**.



Parts of the cerebrum

The Cerebellum

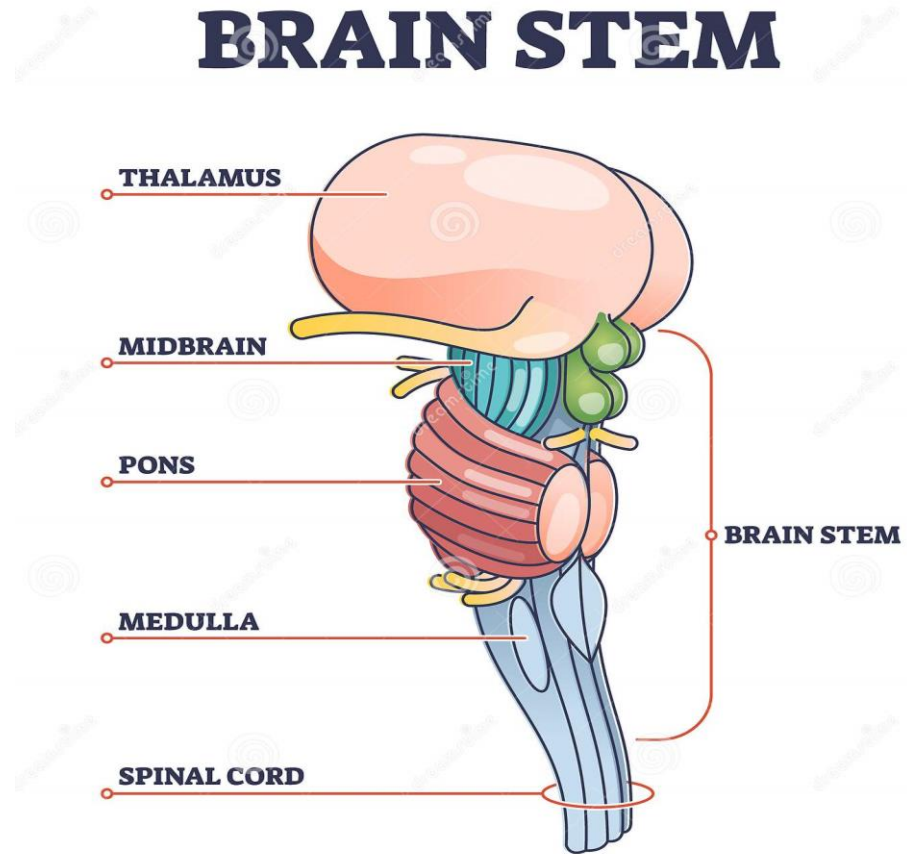
- The cerebellum is located at the back of the brain, underlying the occipital and temporal lobes of the cerebral cortex.
- The cerebellum is involved in the following functions:
 - Maintenance of balance and posture. The cerebellum is important for making postural adjustments to maintain balance.
 - It also ensures that all the muscles work together to produce smooth, coordinated, voluntary movements.
 - The cerebellum assists in the learning of new motor skills, such as playing the piano or hitting a baseball.



Cerebellum

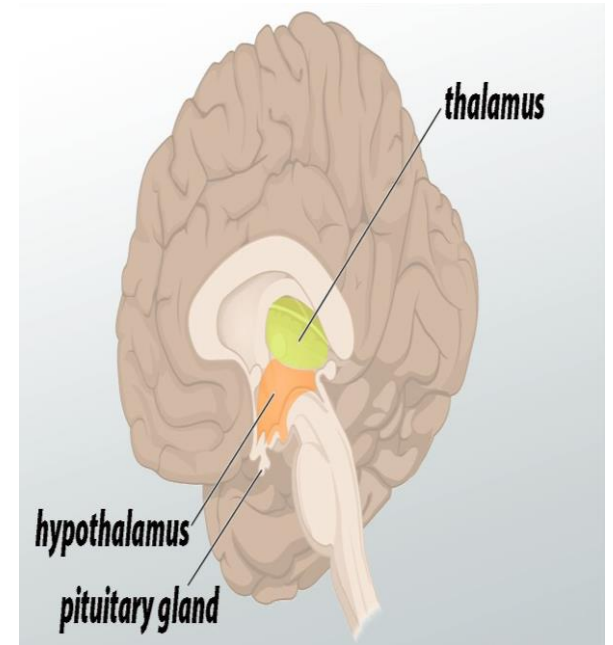
The brain stem

- The Brain Stem connects the brain to the spinal cord.
- Made up of midbrain, pons, and medulla oblongata.
- The nerves in the brain stem control heart rate, breathing, and blood pressure.



The Diencephalon

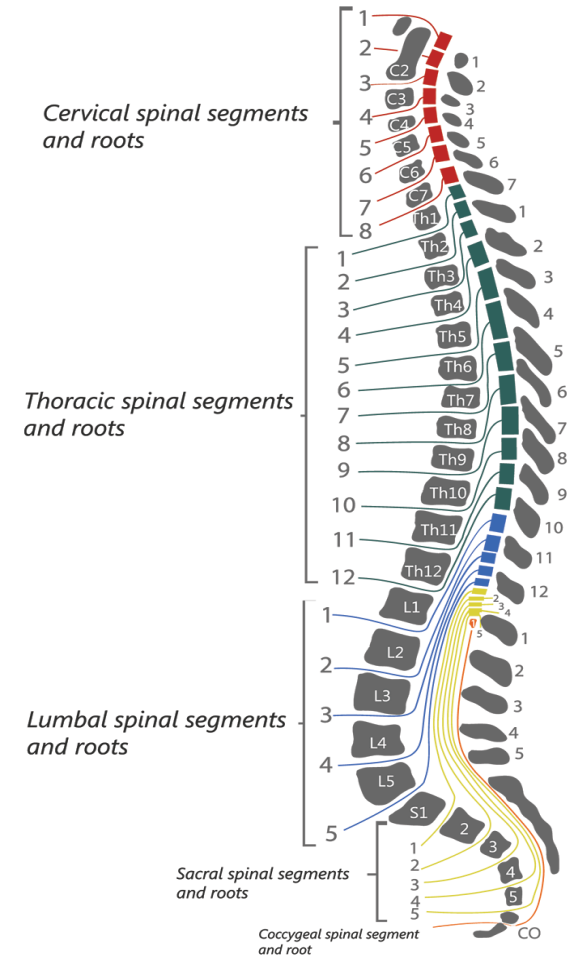
- A relay center for sensory information and motor responses
- The **thalamus** and **hypothalamus** are also located here.
- The hypothalamus:
 - Secretes hormones that control the pituitary gland.
 - Also regulates circadian rhythm, body temperature, heart rate, blood pressure and controls smooth muscle contraction.



Diencephalon

Spinal Cord

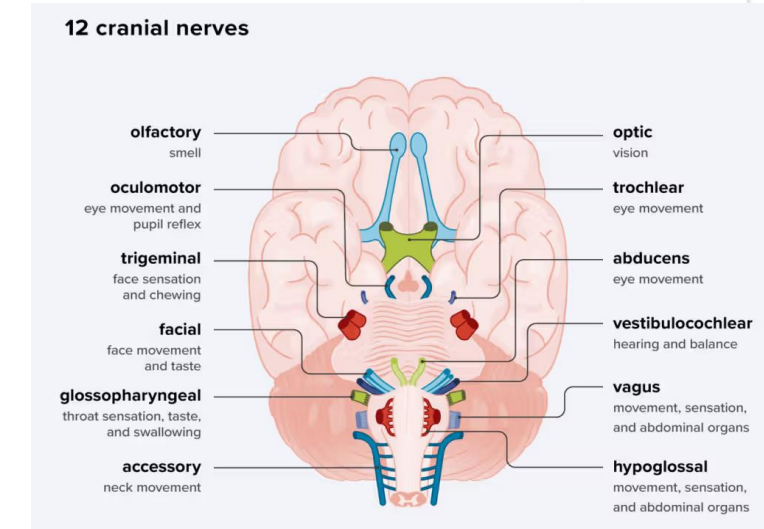
- The spinal cord is a mass of nervous tissue that extends inferiorly from the brain stem through the vertebral canal of the cervical and thoracic regions, ending around the T12 to L1 vertebra.
- The spinal cord is composed of a series of **31 segments**. A pair of spinal nerves comes out of each segment.
- Functions primarily in the **transmission of neural signals between the brain and the rest of the body**.



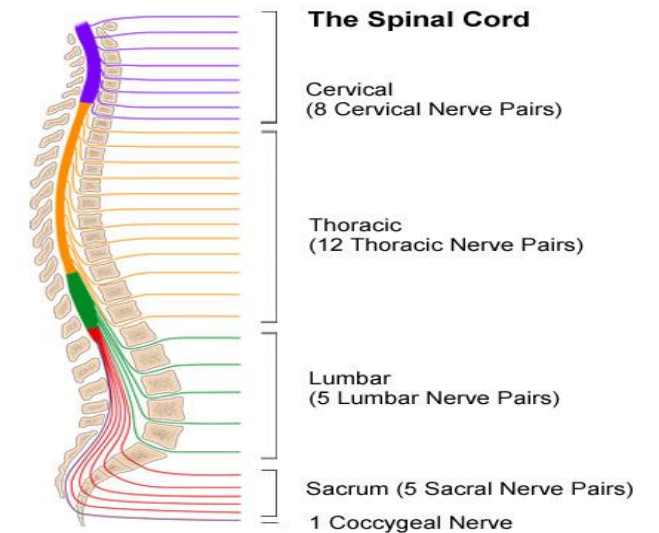
Spinal Cord

The Peripheral Nervous System

- Made up of all the nerves that carry messages to and from the central nervous system.
- Has two types of nerves: **sensory (in)** and **motor (out)** nerves.
- The peripheral nervous system consists of:
 - **Cranial nerves:** These are 12 pairs originating from the brain. Each pair has a name and a roman number (I-XII). They may contain only sensory, only motor or mixed sensory and motor fibers.
 - **Spinal nerves:** There are 31 pairs, eight pairs of cervical nerves, twelve pairs of thoracic nerves, five pairs of lumbar nerves, five pairs of sacral nerves, and one pair of coccygeal nerves.



cranial nerves

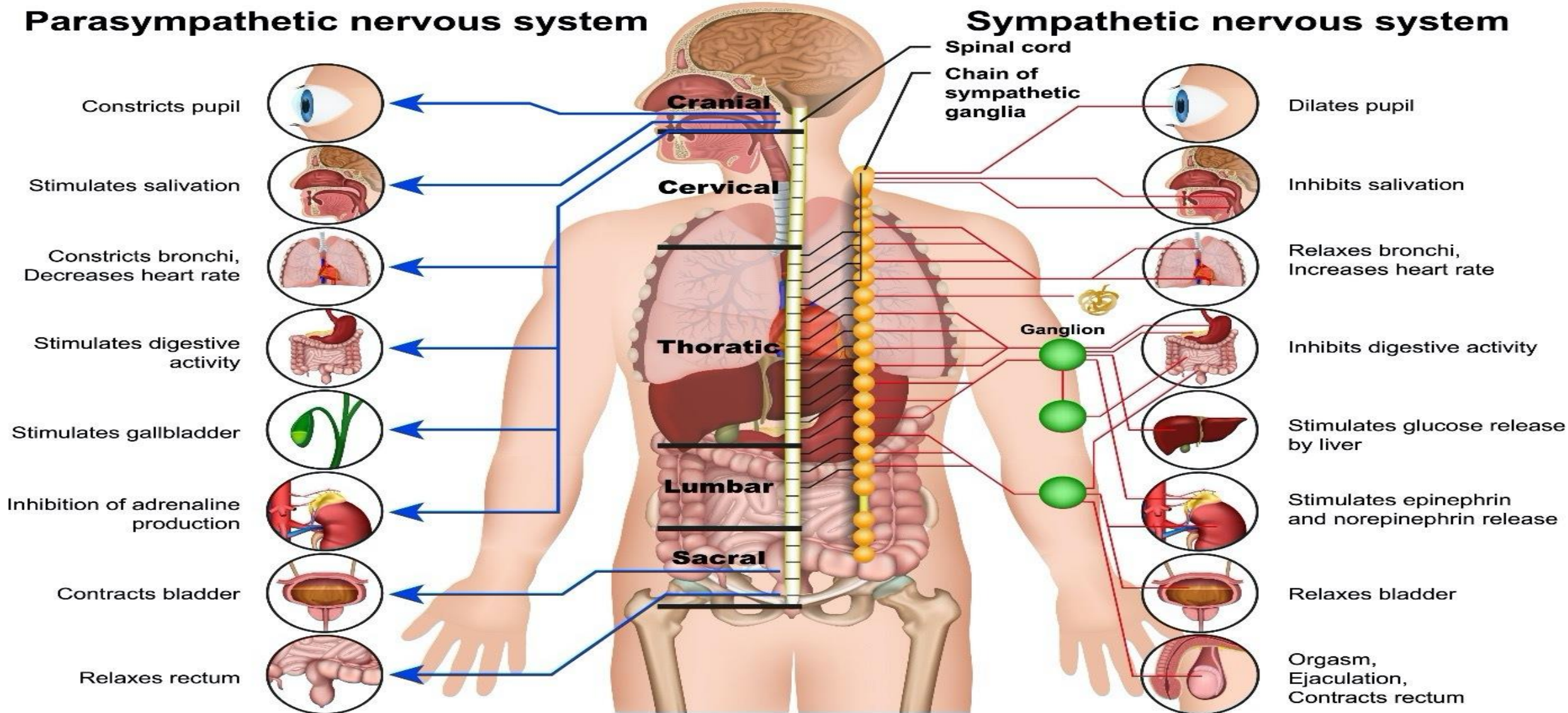


Spinal nerves

Peripheral Nervous System

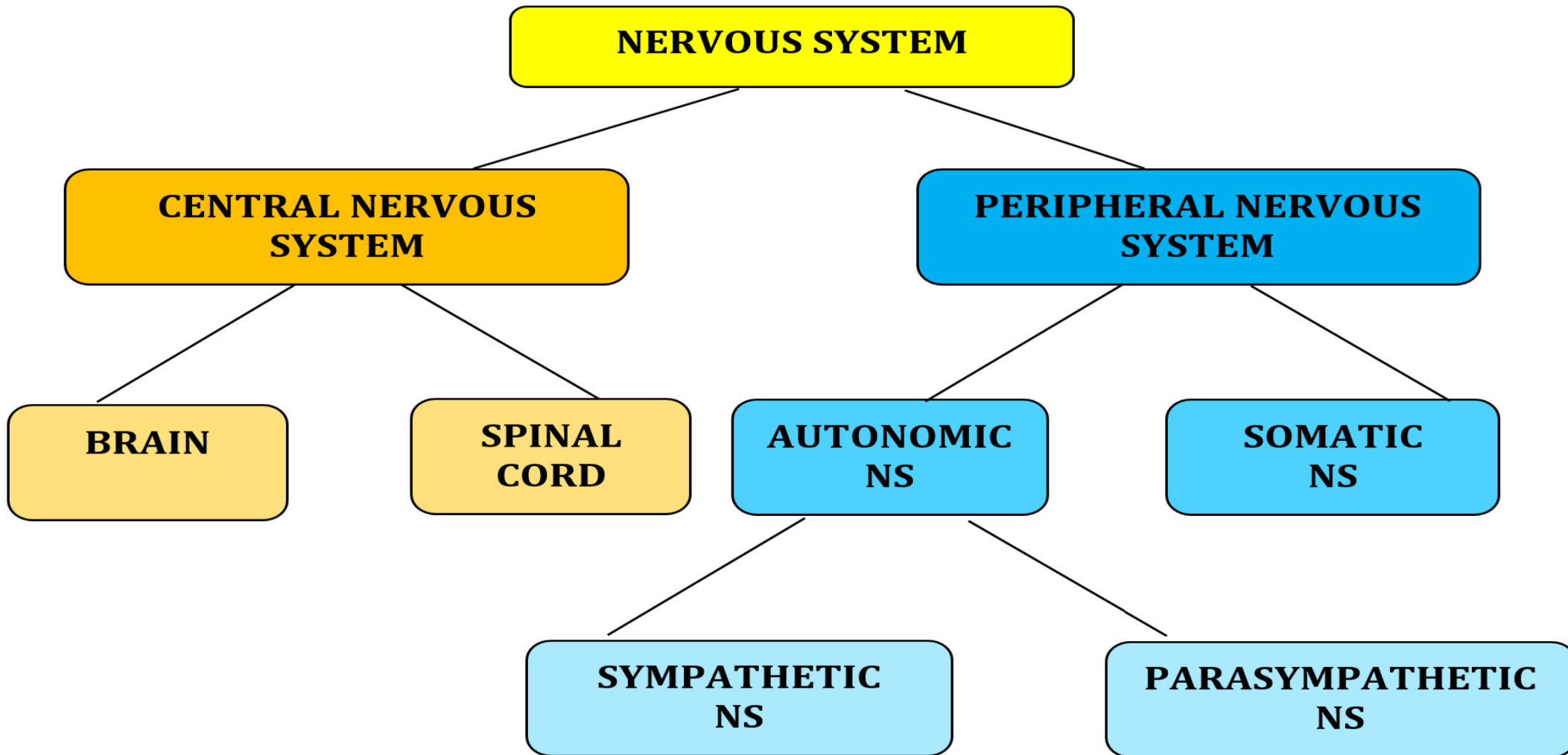
- PNS is further subdivided into:
 - Somatic Nervous System(Voluntary)
 - Autonomic Nervous System(Involuntary)
- The somatic division is involved in conscious movement.
 - It regulates voluntary movement of skeletal muscles.
- The autonomic division is involved in involuntary and unconscious reactions.
 - It regulates the activity of cardiac and smooth muscles, organs, and glands.
- The Autonomic Nervous System has two divisions :
 - Sympathetic Nervous System: operates under conditions of stress or emergency (Fight or flight responses).
 - Parasympathetic Nervous System: operates under normal conditions (Rest and digest responses).

Autonomic Nervous System



The action of parasympathetic nervous system and sympathetic nervous system

Illustration represent the divisions of the nervous system



Reflex Arc

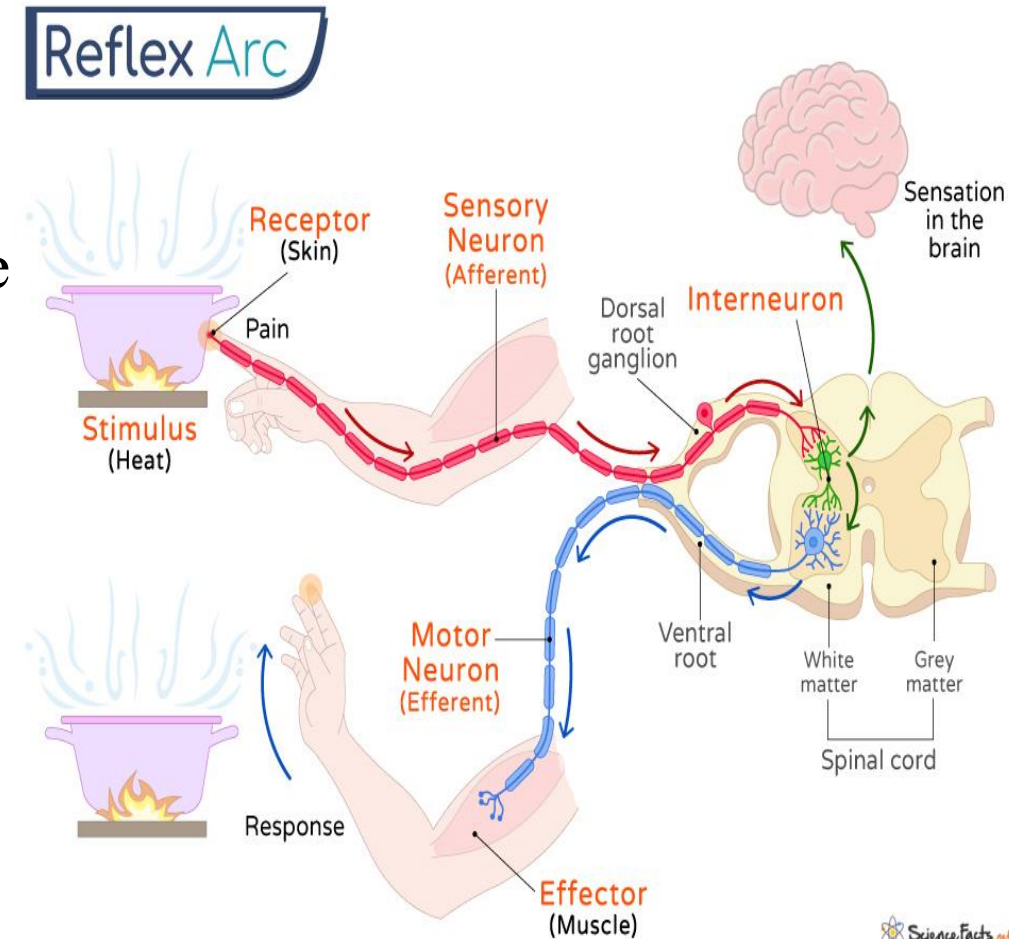
■ Reflex :

Rapid, involuntary reaction to a stimulus.

■ **Reflex arc:** is a specialized pathway by which impulse can travel from receptors to effector.

■ Reflex arc consists of:

1. Sensory receptor detects stimulus.
2. Sensory neuron conducts impulse to CNS.
3. Integration center (Brain & spinal cord).
4. Motor neuron conducts message to effector.
5. Effector(muscle or gland): respond to motor nerve impulse.



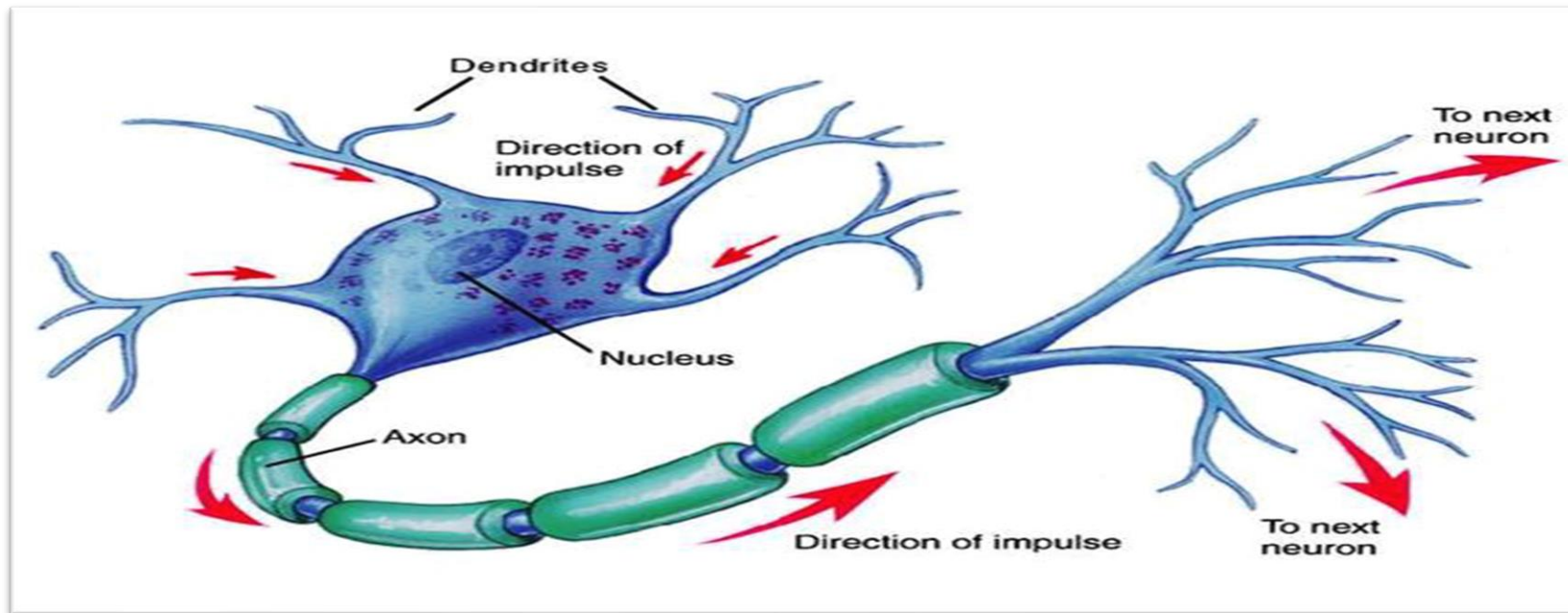
Reflex Arc

Nerve impulses

- Is an electrical signal transmitted by a neuron.
- Nerve impulses are conducted along a neuron in one direction:

Dendrite → cell body → axon

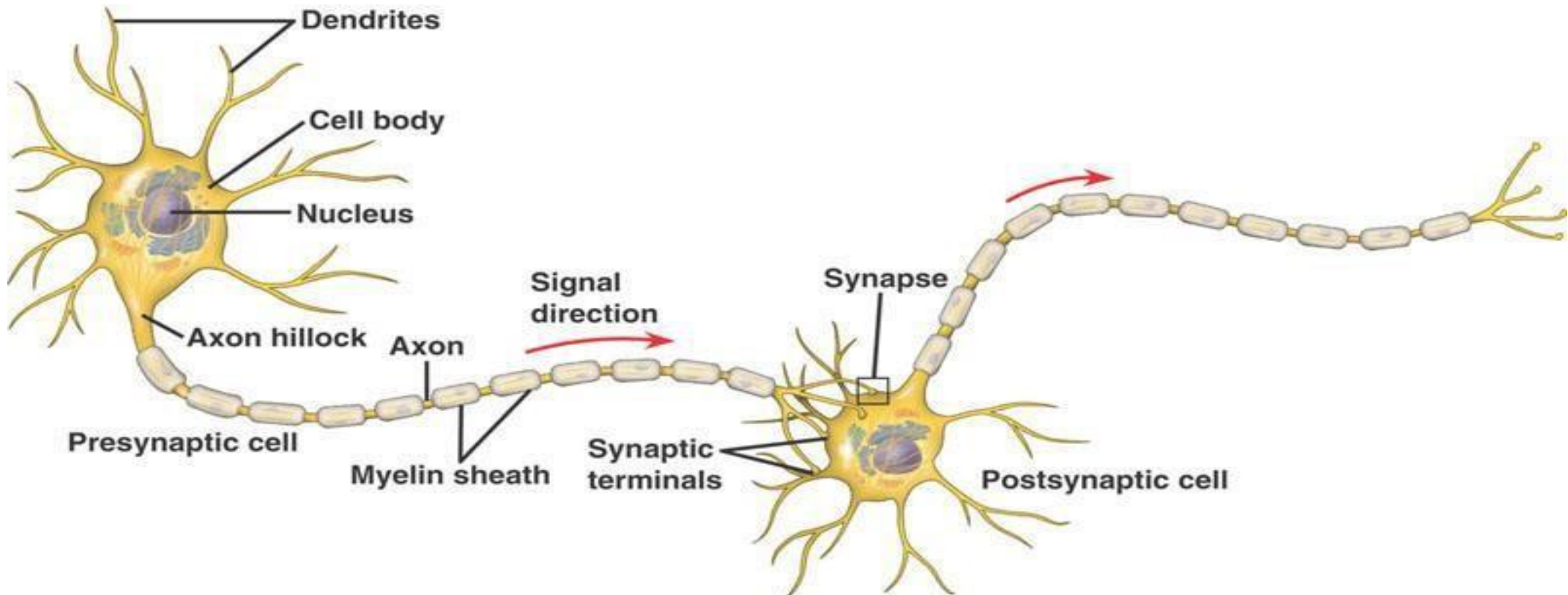
- It can be carried out to another neuron by the mean of **synapse**.



Direction of nerve impulse

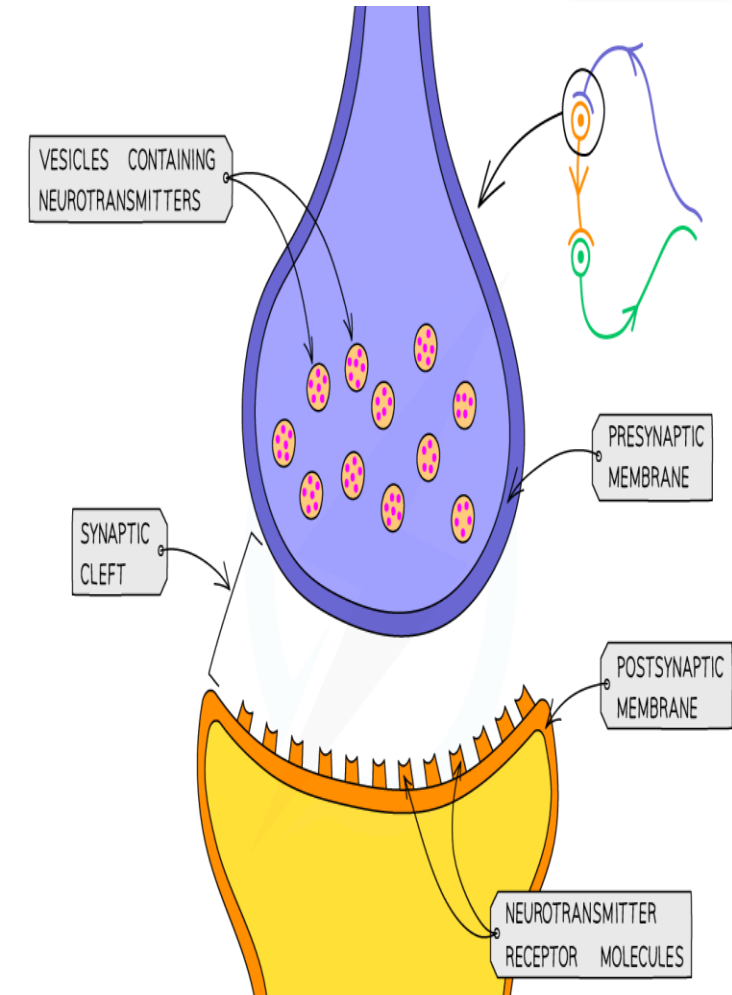
Synapse

- **Synapse** is a junction between 2 neurons where the axon of one neuron communicate with dendrites of another neuron in a neural pathway **or** where a neuron communicates with a muscle or gland cell.



Structures Making Up a Synapse

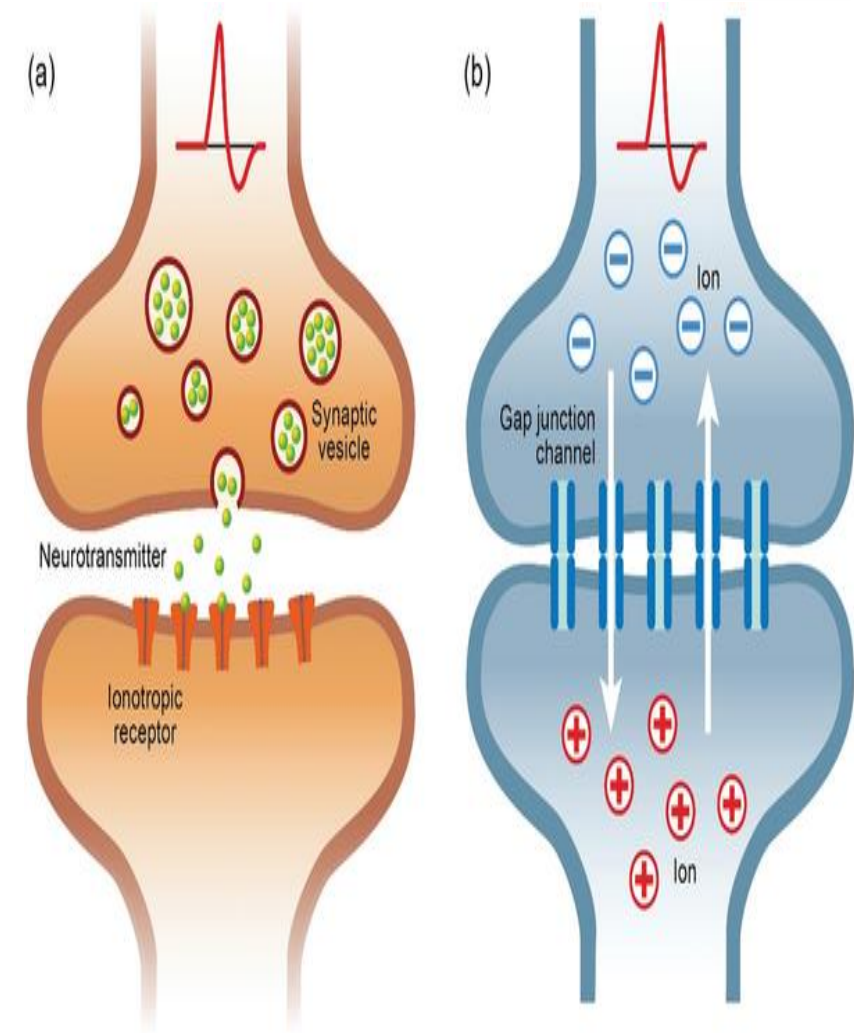
1. **Plasma membrane of presynaptic neuron:** The end-bulb of the presynaptic axon containing neurotransmitter (the chemicals through which neurons communicate).
2. **Synaptic cleft:** The narrow space between presynaptic membrane and post synaptic plasma membrane.
3. **Plasma membrane of postsynaptic neuron:** Membrane of the receiving neuron which has receptors.



Structure of synapse

Types of Synapse

- There are two types of synapse:
 - Chemical synapse:** where the presynaptic neuron releases a chemical called neurotransmitter that binds to receptors in the postsynaptic cell.
 - Electrical synapse:** electrical current passes directly between the presynaptic and postsynaptic neuron through certain channels .



Chemical synapse

Electrical synapse

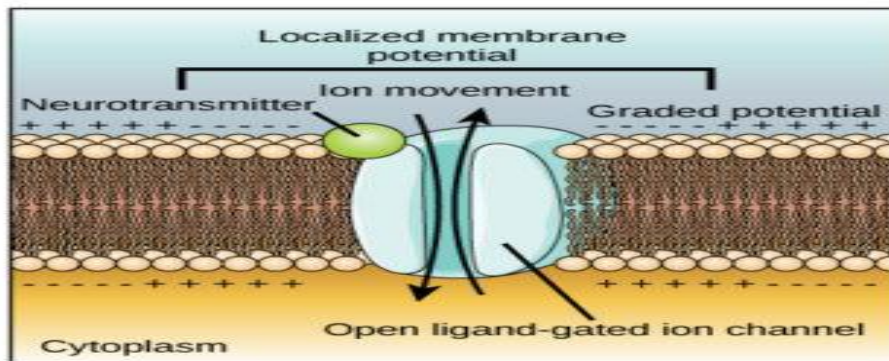
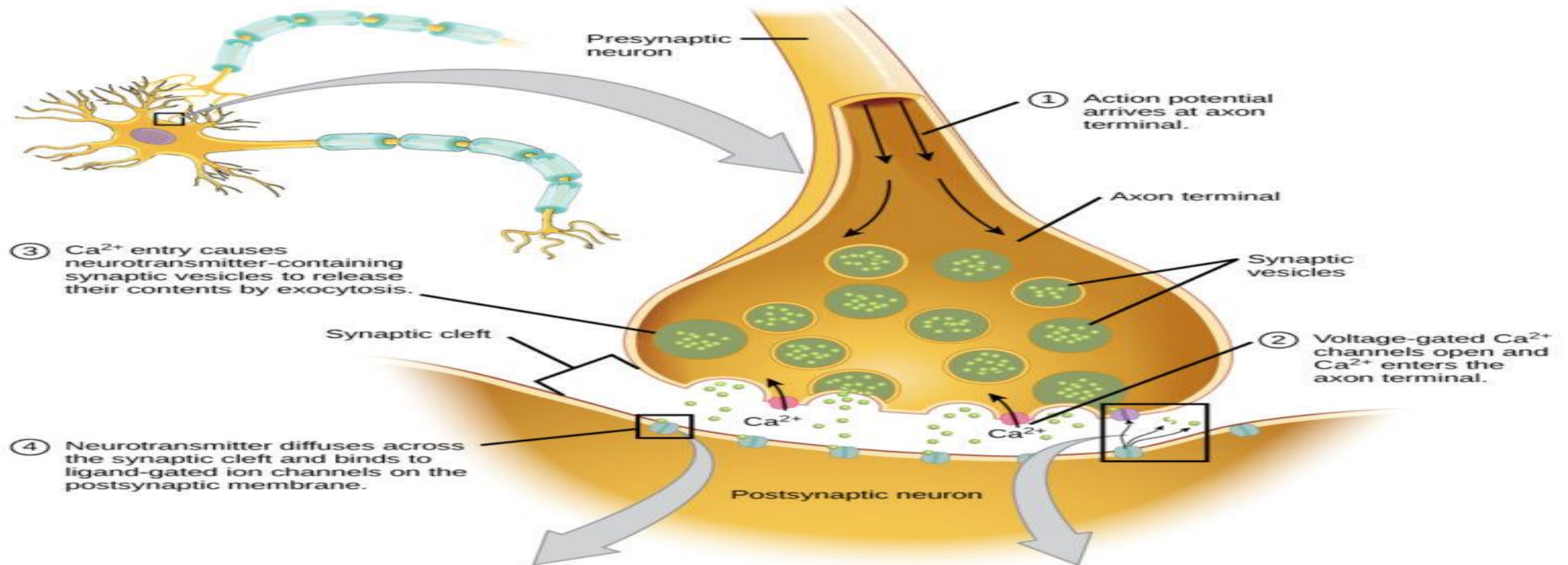
The Transmission of Impulse Through Chemical Synapses

- Neurotransmission is the process by which signaling molecules called neurotransmitters are released by a neuron (the presynaptic neuron) and bind to and activate the receptors of another neuron (the postsynaptic neuron).
- The events at a synapse are:
 1. Nerve signals traveling along an axon to reach an axon terminal.
 2. Calcium ions entering the terminal and stimulating synaptic vesicles to merge with the sending membrane.
 3. Neurotransmitter molecules releasing into the synaptic cleft and diffusing across the cleft to the receiving membrane.
 4. Neurotransmitter molecules bind with specific receptor proteins.

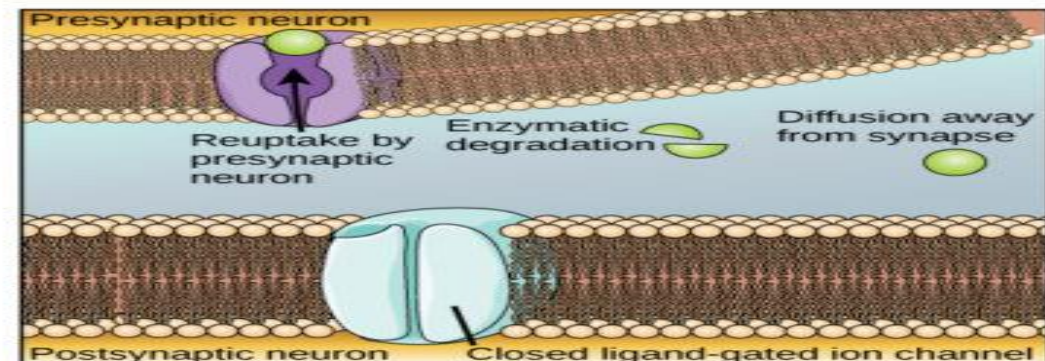
The Transmission of Impulse Through Chemical Synapses

5. Once a neurotransmitter has been released into a synaptic cleft and has initiated a response, it is removed from the cleft.
6. In some synapses, the receiving membrane contains enzymes that rapidly inactivate the neurotransmitter. For example, the enzyme **acetylcholinesterase (AChE)** breaks down the neurotransmitter **acetylcholine**.
5. In other synapses, the sending membrane (presynaptic membrane) rapidly reabsorbs the neurotransmitter, possibly for repackaging in synaptic vesicles or for molecular breakdown.
- Neurotransmitters molecules are chemical substances by which neurons communicate through synapse (**acetyl-choline & adrenaline**) .

The signal transmission through chemical synapses



- ⑤ Binding of neurotransmitter opens ligand-gated ion channels, resulting in graded potentials.

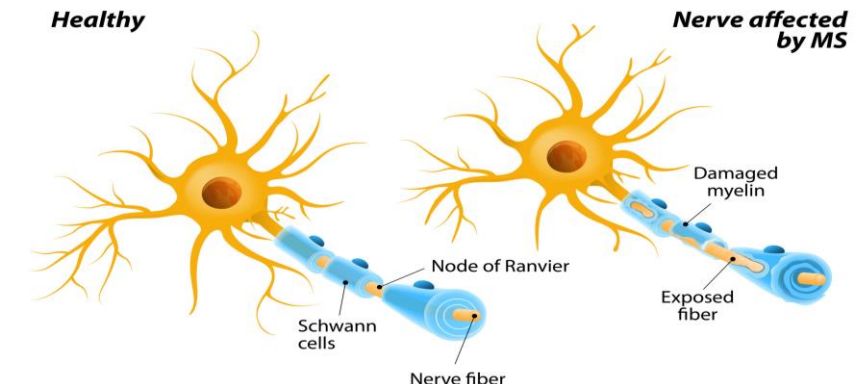
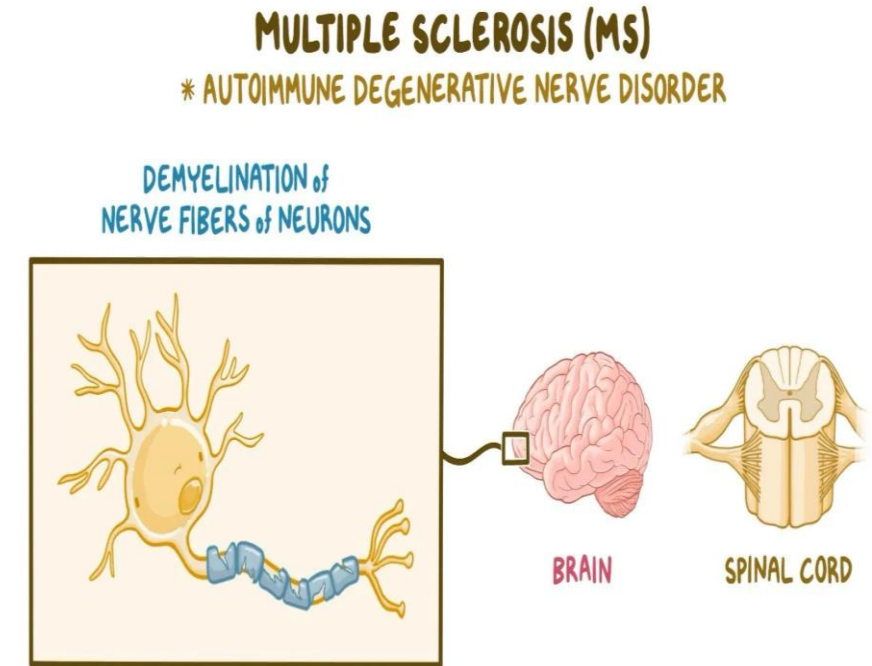


- ⑥ Reuptake by the presynaptic neuron, enzymatic degradation, and diffusion reduce neurotransmitter levels, terminating the signal.

Disorders of Nervous system

Multiple sclerosis:

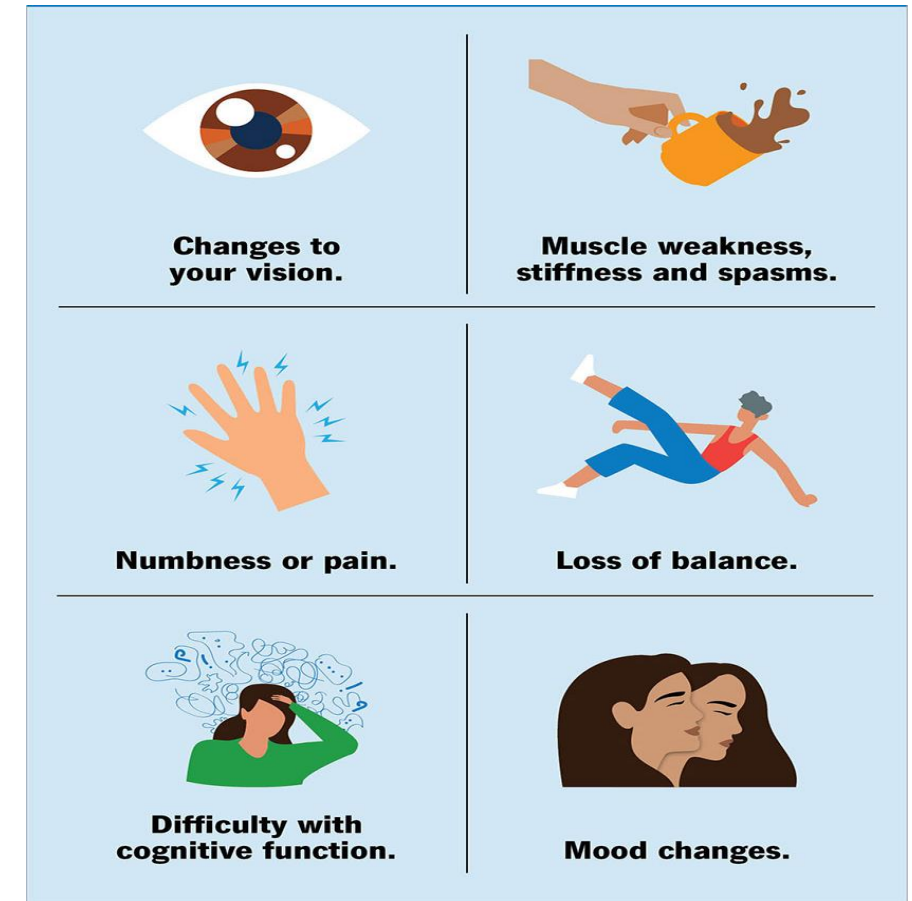
- Multiple sclerosis (MS) is a chronic neurological disease of the central nervous system that affects the **brain and spinal cord**, causing damage to the membrane surrounding neurons called **myelin sheath** converted to hardened sheaths called sclerosis. As a demyelinating disease, MS disrupts the nervous system's ability to transmit signals.
- It is an **autoimmune disorder** in which a protein component of the sheath is attacked.



Multiple sclerosis

■ Symptoms of MS :

- It appears suddenly to the patient, and they vary in severity depending on the degree and location of the disease.
- It includes:
 1. Double vision.
 2. Vision loss.
 3. Muscle weakness.
 4. Loss of balance.

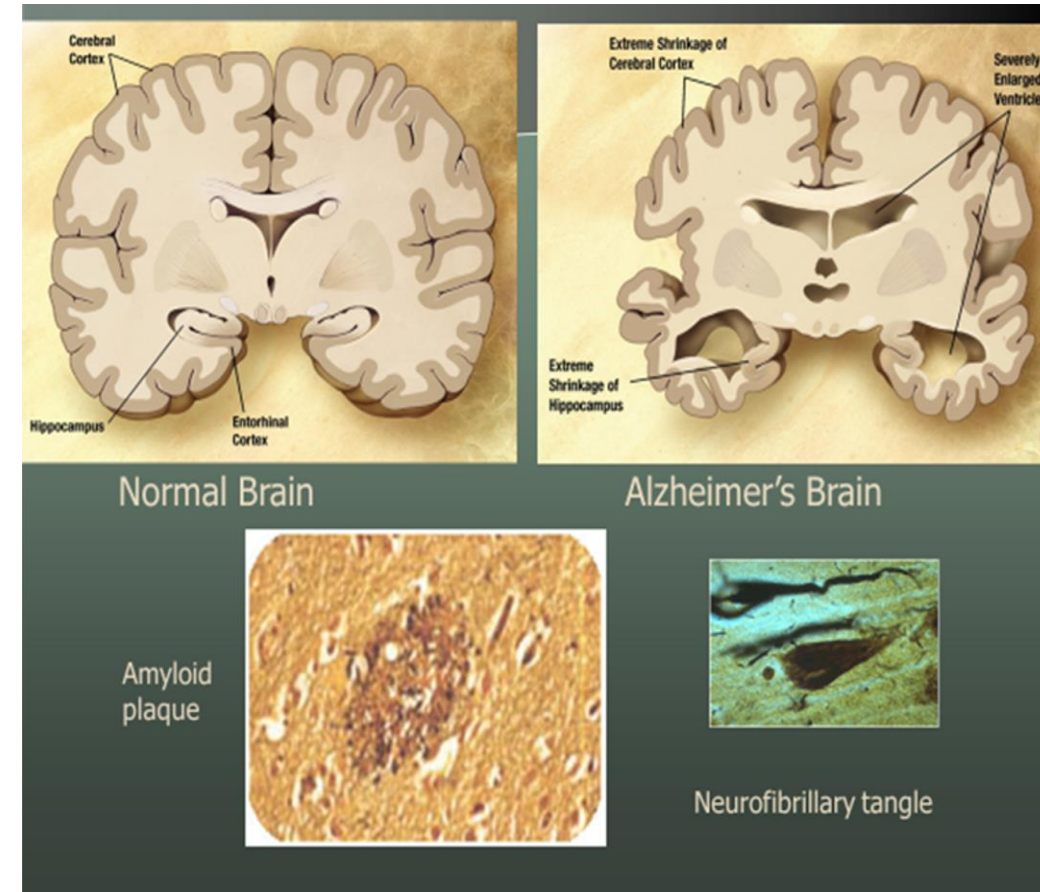


Symptoms of multiple sclerosis

Disorders of Nervous system

Alzheimer's disease

- It is a neurodegenerative disease that usually starts slowly and progressively worsens. It is the cause of 60–70% of cases of dementia.
- The study of the affected brain reveals structural changes in the brain including tangles of abnormal neurons and the development of large deposits of an abnormal protein called beta amyloid around neurons.



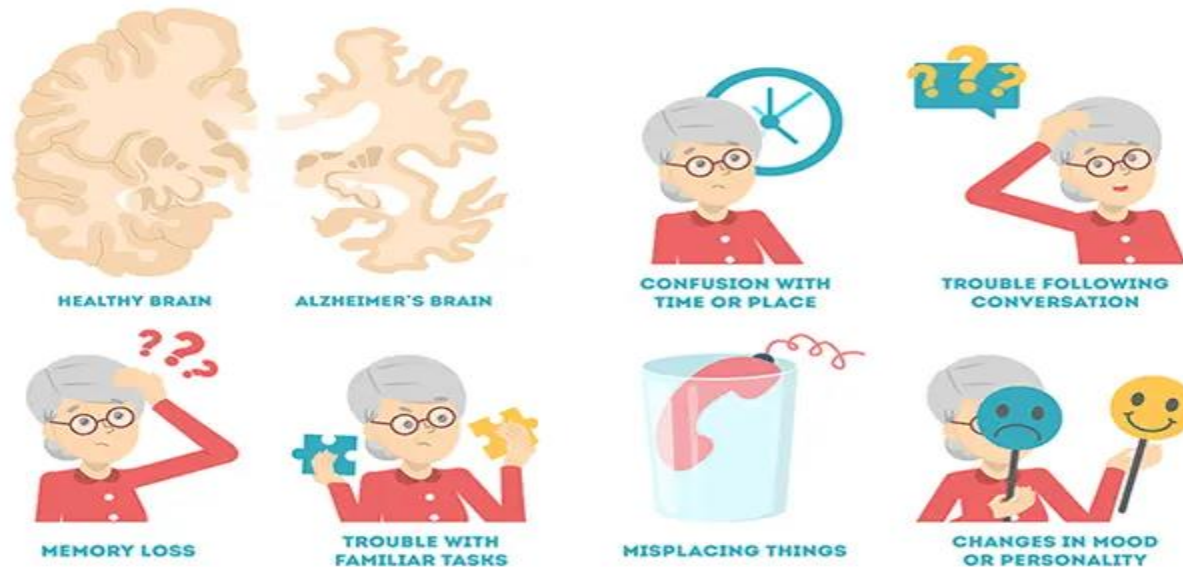
Difference between normal brain and Alzheimer's brain

Alzheimer's disease

■ Symptoms:

- The most common early symptom is difficulty in remembering recent events.
- As the disease advances, symptoms can include problems with language, disorientation (including easily getting lost), mood swings, loss of motivation, self-neglect, and behavioral issues to such an extent that it interferes with a person's daily life and activities.

SYMPTOMS OF ALZHEIMER'S



Questions

■ Choose the correct answer:

1. Which type of neuron carries impulses from receptors to the CNS?

- a) Motor neuron
- b) Interneuron
- c) Sensory neuron
- d) Relay neuron

2. What is the basic unit of the nervous system?

- a) Glial cell
- b) Neuron
- c) Dendrite
- d) Synapse

3. Which of the following choices is the outermost layer of the meninges ?

- a) Arachnoid mater
- b) Pia mater
- c) Dura mater
- d) Grey mater

Thank You