

The Nervous System is the:

It is the Master controller and communicating system in the body. Every thought, action and emotion reflects its activity. It signals the body through electrical impulses that communicate with the body cells. Its signaling and responding abilities are highly specific and rapid.

Functions:

The Nervous System is capable of:

1. *Sensory input* – gathering information
 - To monitor changes occurring inside and outside the body
 - Changes = are called stimuli
2. *Integration*
 - N.S. is able to integrate the sensory information, process, interpret and decide if action is needed
3. *Motor output*
 - A response to the integrated stimuli
 - The response activates muscles or glands

The NS does not work alone in maintaining homeostasis. It enlists the Endocrine system for regulating and maintaining the body functions.

Structural Classification of the Nervous System:-

- Central nervous system (CNS)
 - Brain
 - Spinal cord
- Peripheral nervous system (PNS)
 - Nerve outside the brain and spinal cord

Nervous tissue:

It is comprised of 2 types of cells:

1-*Neurons* = nerve cells that transmit impulses

2- *Neuroglia* = supporting cells. They act as insulators, adhesive, protectors and nourishers.

1-Neurons:-

The Neurons are nervous cells that transmit messages.

The structure of the neuron has:

- A Cell body – with a nucleus, a large nucleolus
- The Dendrites – conduct impulses toward the cell body (afferent), away from the receptors
- The Axons – conduct impulses away from the cell body (efferent) toward the muscle or endocrine (effector).

Functions:

- The Neurons (nervous cells) must perform 4 specialized functions
 1. Receive information from the internal or external environment
 2. Integrate the information received and produce an appropriate output signal (or response)
 3. Conduct the signal to its terminal
 4. Transmit the signal to another cell (effector)

Anatomy:-

The Neurons cells have:

Cell body has :

-A nucleus, a large nucleolus

-Nissl substance - specialized rough endoplasmic reticulum.

-Neurofibrils – intermediate cytoskeleton that maintains cell shape.

- Extensions outside the cell body:

Dendrites – conduct impulses toward the cell body.

Axons – conduct impulses away from the cell body

Axons and Nerve Impulses:

Axons end in axonal terminals. Axonal terminals contain vesicles with neurotransmitters. Axonal terminals are separated from the next neuron by a gap called Synaptic cleft.

Synapse – junction between nerves.

Nerve Fiber Coverings:

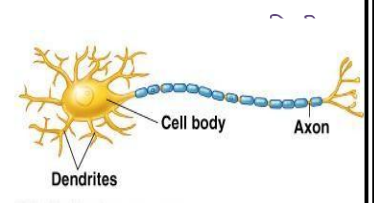
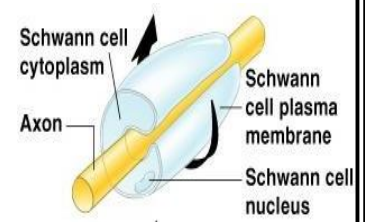
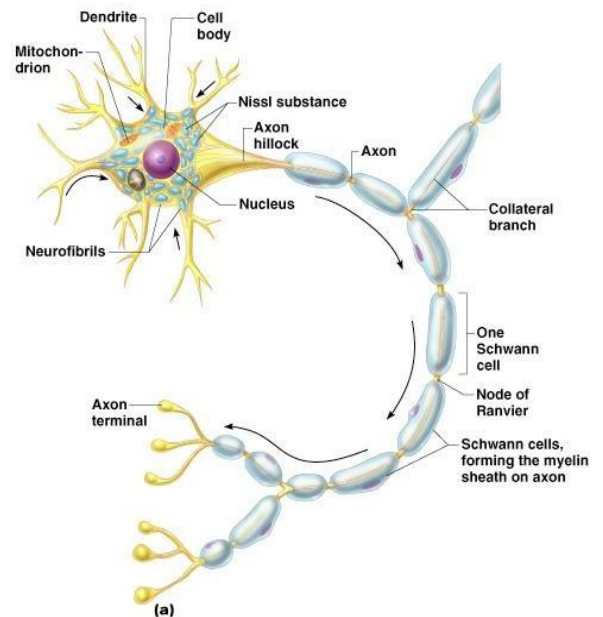
- Schwann cells – produce myelin sheaths in jelly-roll like fashion.
- Nodes of Ranvier – gaps in myelin sheath along the axon.

Location of Neuron:-

Most are found in the central nervous system

Gray matter – cell bodies and unmyelinated fibers

Nuclei – clusters of cell bodies within the white matter of the central nervous system.



Ganglia – collections of cell bodies outside the central nervous system.

Structural Classification of Neurons:-

- Multipolar neurons – many extensions from the cell body.(figure 1)
- Bipolar neurons – one axon and one dendrite.(Figure2)
- Unipolar neurons – have a short single process leaving the cell body.(figure 3)



(b) Bipolar neuron

Functional Classification of Neurons:-

1-Sensory (afferent) neurons

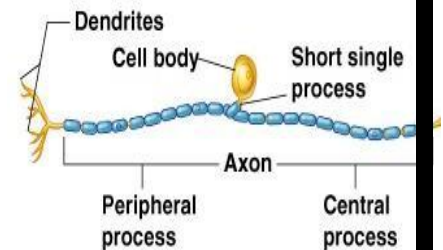
- Carry impulses from the sensory receptors
 - Cutaneous sense organs
 - Proprioceptors – detect stretch or tension

2- Motor (efferent) neurons

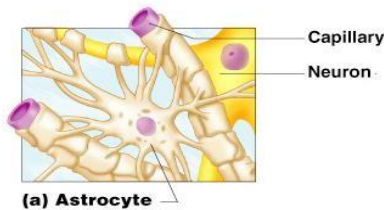
- Carry impulses from the central nervous system.

3- Interneurons (association neurons)

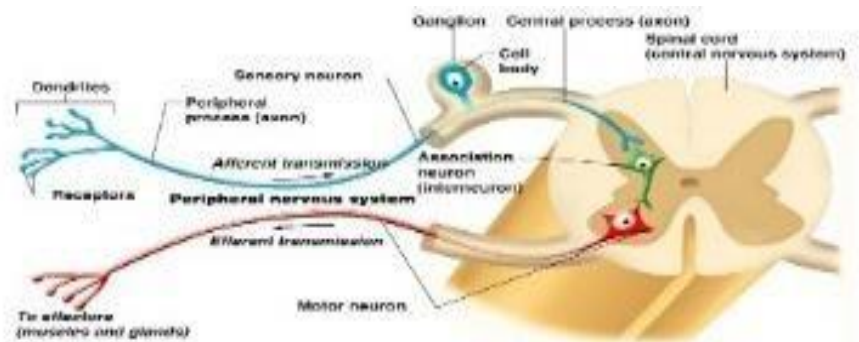
- Found in neural pathways in the central nervous system
- Connect sensory and motor neurons.



(c) Unipolar neuron



(a) Astrocyte



2-Neuroglia:-

Nervous Tissue Supporting Neuroglias include:

1. Astrocytes

- There are an abundant of these star-shaped cells
- They brace themselves onto neurons
- They control the chemical environment of the brain

2. Microglia

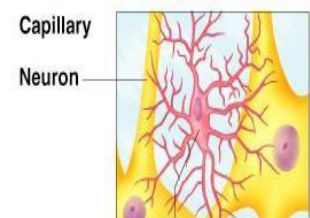
- These are Spider-like phagocytes that dispose of debris.

3. Oligodendrocytes

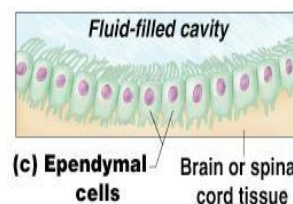
- Produce myelin sheath around nerve fibers in the central nervous system

4. Ependymal cell

- Epithelial-type cells that line the nervous system (brain and spinal cord). They form the Meninges – Dura Mater, Mater and Pia Mater.



(b) Microglial cell



(c) Ependymal cells

Arachnoid

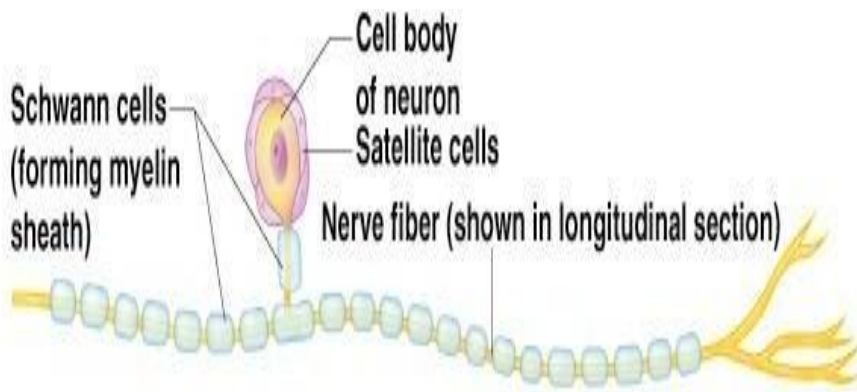
5. Satellite cells

- Protect neuron cell bodies

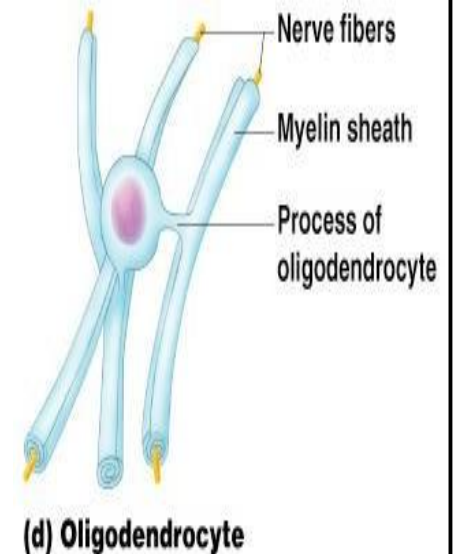
6. Schwann cells

- Form myelin sheath in the peripheral nervous system

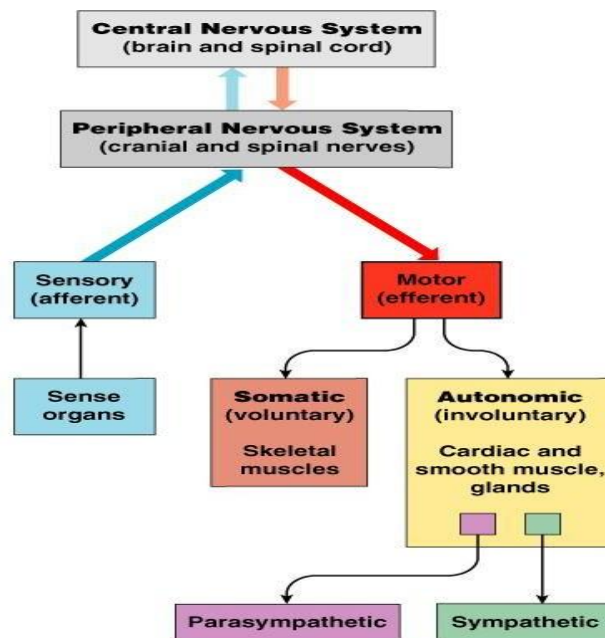
- Nodes of Ranvier – gaps in myelin sheath along the axon



(e) Sensory neuron with Schwann cells and satellite cells



Organization of the Nervous System



Starting a Nerve Impulse:-

- Depolarization – a stimulus depolarizes the neuron's membrane
- A depolarized membrane allows sodium (Na^+) to flow inside the membrane
- The exchange of ions initiates an action potential in the neuron (figure 2)

The Action Potential:-

- If the action potential (nerve impulse) starts, it is propagated over the entire axon
- Potassium ions rush out of the neuron after sodium ions rush in, which repolarizes the membrane
- The sodium-potassium pump restores the original configuration
 - This action requires ATP

Nerve Impulse Propagation:-

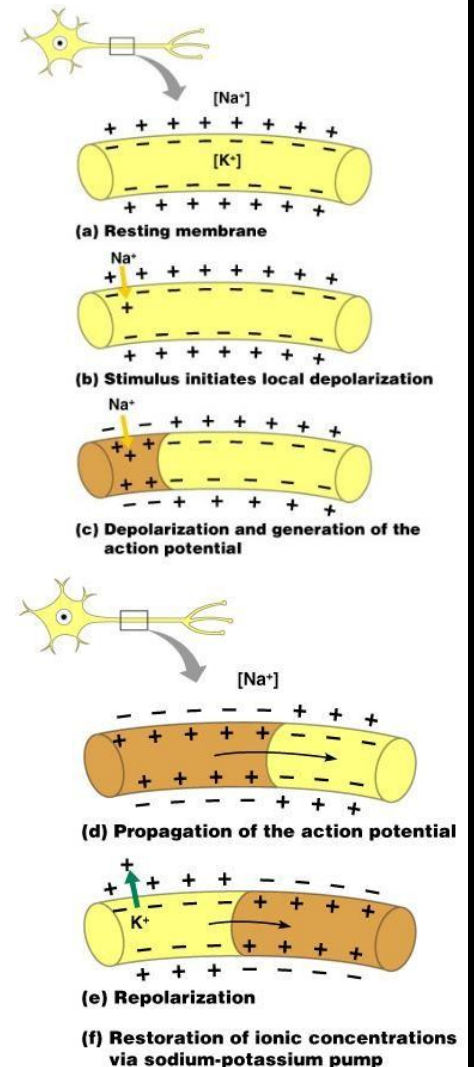
- The impulse continues to move toward the cell body
- Impulses travel faster when fibers have a myelin sheath.

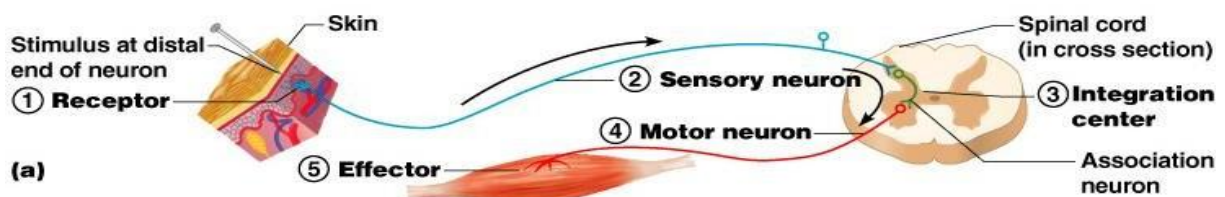
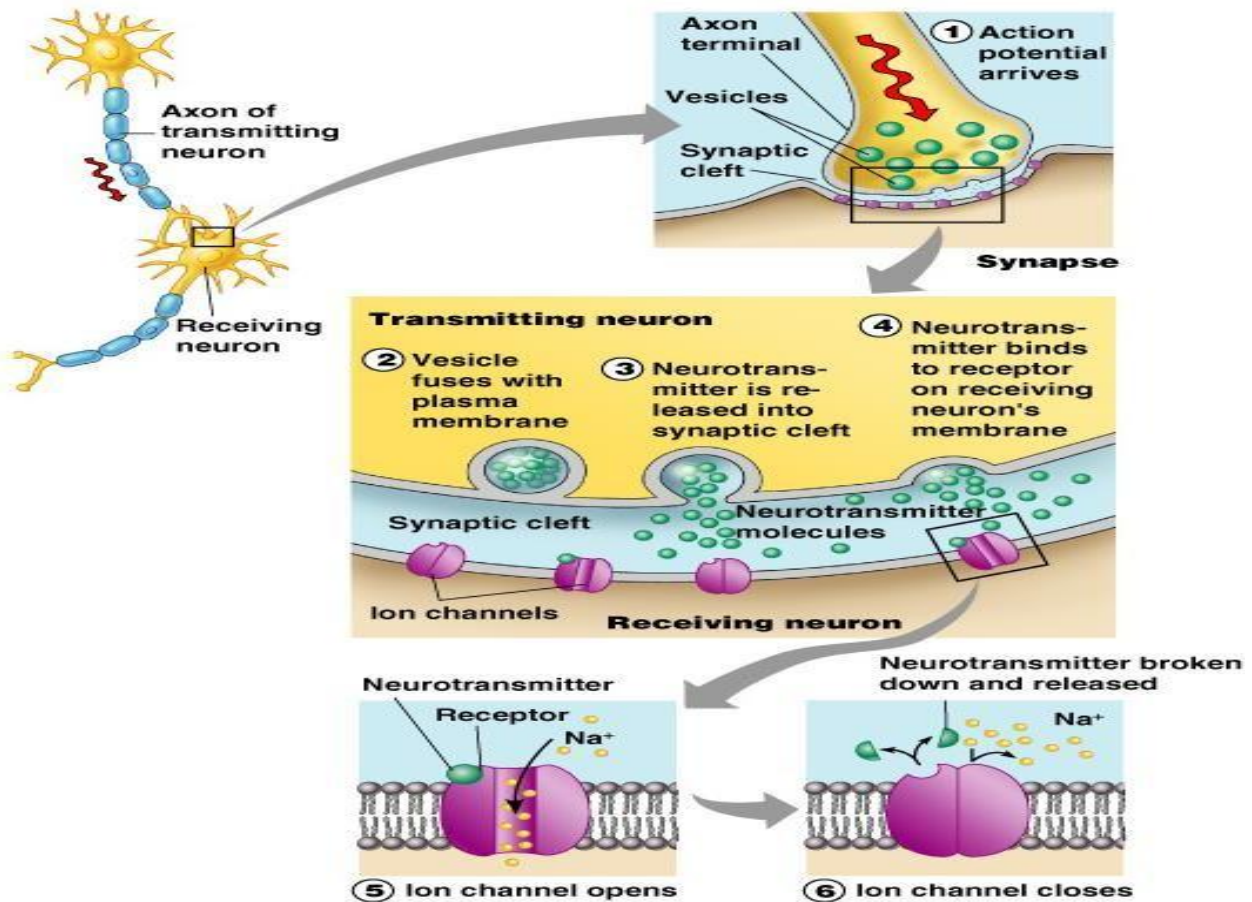
Continuation of the Nerve Impulse between Neurons:-

- Impulses are able to cross the synapse to another nerve
 - Neurotransmitter is released from a nerve's axon terminal
 - The dendrite of the next neuron has receptors that are stimulated by the neurotransmitter
 - An action potential is started in the dendrite

How Neurons Communicate at Synapses:-

-**Synapsis** (synaptic terminals) – the site that receives signals and communicates with other cells, tissues or organs. (figure 3).





The Reflex Arc

- Reflex – is rapid, predictable, and involuntary responses to stimuli
- Reflex arc – directs the route from a sensory neuron, to an interneuron, to an effector

Types of Reflexes and Regulation

- Autonomic reflexes – involves Smooth muscle regulation of the Heart and blood pressure, vessels, Regulation of endocrine glands and the Digestive system regulation. It also involves Somatic reflexes which Activates the skeletal muscles and Voluntary motions.

How do Sensory Receptors Work?

- Receptors are cells or clusters of cells that transduce the energy of a specific signal into an electrical signal
- Receptor potential

EXAMPLE: the ear captures, transmits and converts sound into electrical signals

- a. The Outer ear captures sound waves
- b. Middle ear converts vibrations from sound waves into electrical signals (cochlea)
- c. Cochlea is a fluid-filled chamber with 2 membranes (basilar & tectorial) and sensory receptors called hair cells
- d. The basilar membrane vibrates in response to sound waves
- e. The vibrations causes the hair cells to bend, which generates receptor potentials
- f. Larger vibrations bend the hair cells even more, which is perceived as louder sound.
 - *Loud, prolonged sounds damage hair cells*
- g. Different parts of the basilar membrane vibrate at different frequencies of sound waves
- h. This allows for perception of different pitches

Visual Sensory

- The eye collects, focuses and transduces light waves
- Adjustable lenses allows for distant and nearby focusing.
 - Eyeball long – near sightedness
 - Eyeball short – farsightedness
- Light strikes the retina's photoreceptors
- Rods & cones transduce light signals
- Electrical signals are transmitted and processed
- Axons of ganglion cells carry signals to the brain

Rods & Cones

- Rods – dim vision (periphery)
- Cones – color vision (fovea)

Taste that Smell – the Olfactory receptors

- Responsible for sense of smell
 - Located at the roof nasal cavity
- Olfaction contributes to taste perception. Taste receptors are located in clusters on the tongue

Other Special Senses

- **Pain receptors** – with Specialized chemical sense
- **Echolocation** - a type of sonar receptor. Some animals have specialized receptors for navigating and detecting prey. Some birds and fishes use the earth's magnetic field to navigate long-distance migration
- **Electolocation** - Some fish use electrolocation for hunting and communicating

Central Nervous System (CNS):-

CNS develops from the embryonic neural tube

- The neural tube becomes the brain and spinal cord
- The opening of the neural tube becomes the ventricles
- Four chambers within the brain
- Filled with cerebrospinal fluid.

THE BRAIN

Regions of the Brain:-

- Cerebral hemispheres
- Diencephalon
- Brain stem
- Cerebellum

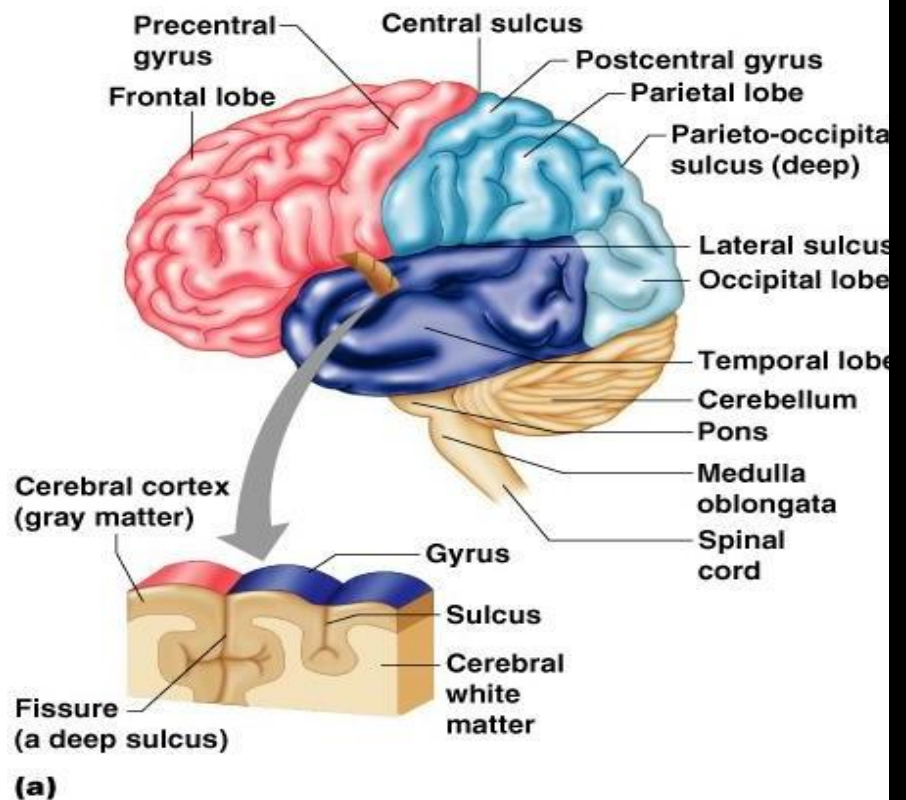
Cerebral Hemispheres (Cerebrum):-

The surface is made of ridges (gyri) and grooves (sulci)

Lobes of the Cerebrum

- Fissures (deep grooves) divide the cerebrum into lobes
- Surface lobes of the cerebrum

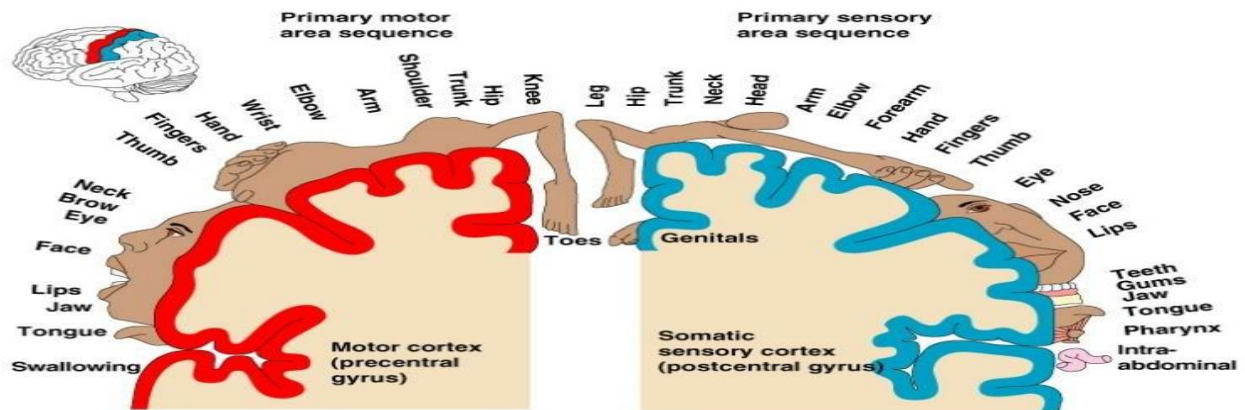
- Frontal lobe



- Parietal lobe
- Occipital lobe
- Temporal lobe

Lobes of the Cerebrum have Specialized Areas of the Cerebrum

- Somatic sensory area – receives impulses from the body's sensory receptors
- Primary motor area – sends impulses to skeletal muscles
- Broca's area – involved in our ability to speak



The Specialized Areas of the Cerebrum have cerebral areas that are involved in special senses

- Gustatory area (taste)
- Visual area
- Auditory area
- Olfactory area

Layers of the Cerebrum:-

- Gray matter
 - Outer layer
 - Composed mostly of neuron cell bodies
- White matter
 - Fiber tracts inside the gray matter
 - Example: corpus callosum connects hemispheres
- Basal nuclei
 - internal islands of gray matter

The brain has Interpretation areas of the cerebrum for

- Speech/language region
- Language comprehension region
- General interpretation area

The DIENCEPHALON:-

The **Diencephalon** Sits on top of the brain stem; it is enclosed by the cerebral heispheres and made of three parts:

- Thalamus
- Hypothalamus
- Epithalamus

Thalamus

- Is the relay station for sensory impulses
- Transfers impulses to the correct part of the cortex for localization and interpretation

Hypothalamus

- Under the thalamus
- Helps regulate body temperature
- Controls water balance
- Regulates metabolism
- An important part of the limbic system (emotions)
- The pituitary gland is attached to the hypothalamus

Epithalamus

- Houses the pineal body (an endocrine gland)
- Includes the choroid plexus – which forms cerebrospinal fluid

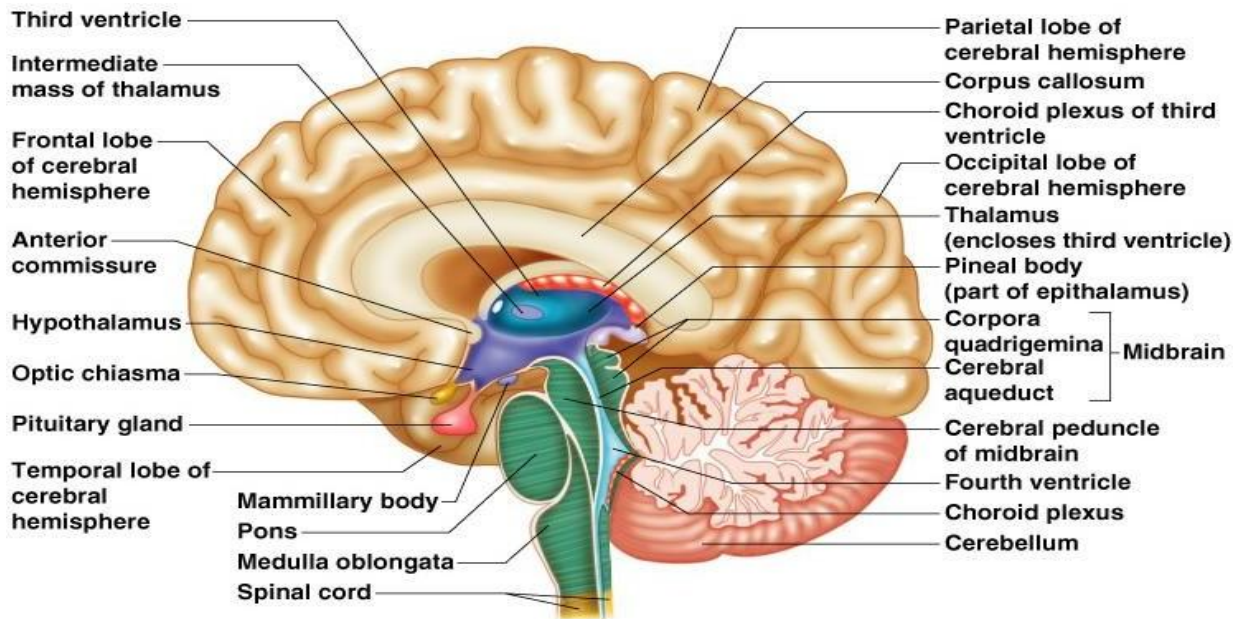
The BRAIN STEM:-

Brain Stem

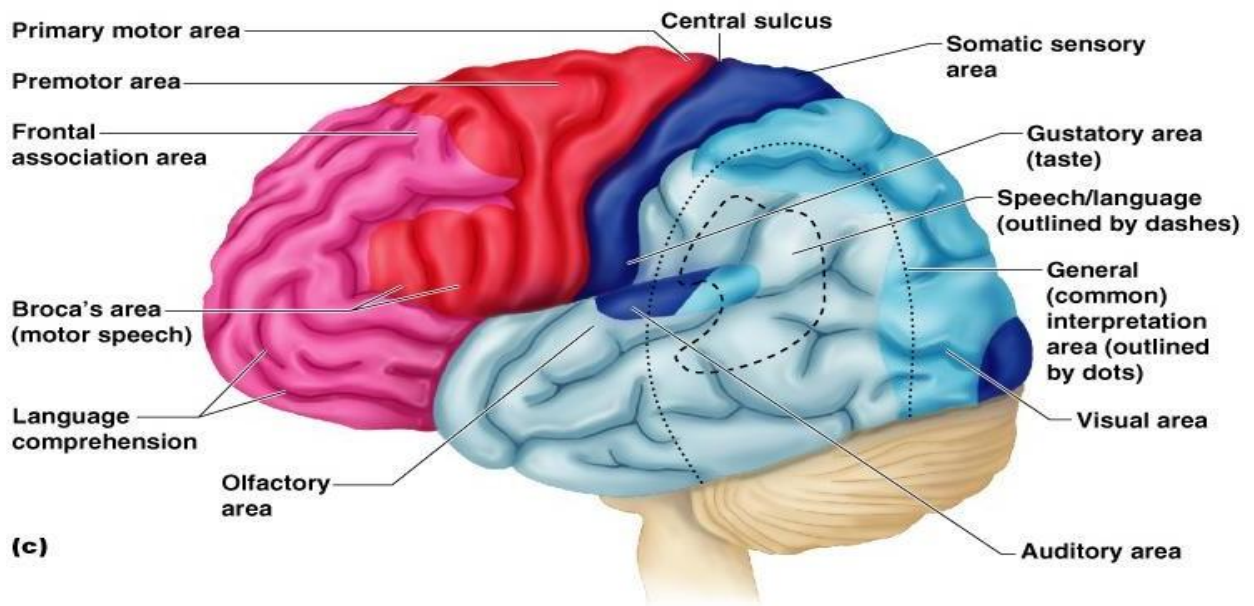
- Attaches to the spinal cord. Parts of the brain stem include:
 - The Midbrain, Pons and Medulla oblongata
- The Midbrain – is the Reflex centers for vision and hearing
 - The Pons – is the center part of the brain stem which is mostly composed of fiber tracts
 - Includes nuclei involved in the control of breathing
 - Medulla oblongata - lowest part of the brain stem
 - Merges into the spinal cord
 - Control center for: Respirations, H.R., B/P swallowing and vomiting

Reticular Formation:-

- Diffuse mass of gray matter along the brain stem
- Involved in motor control of visceral organs
- Reticular activating system plays a role in awake/sleep cycles and consciousness



(a)



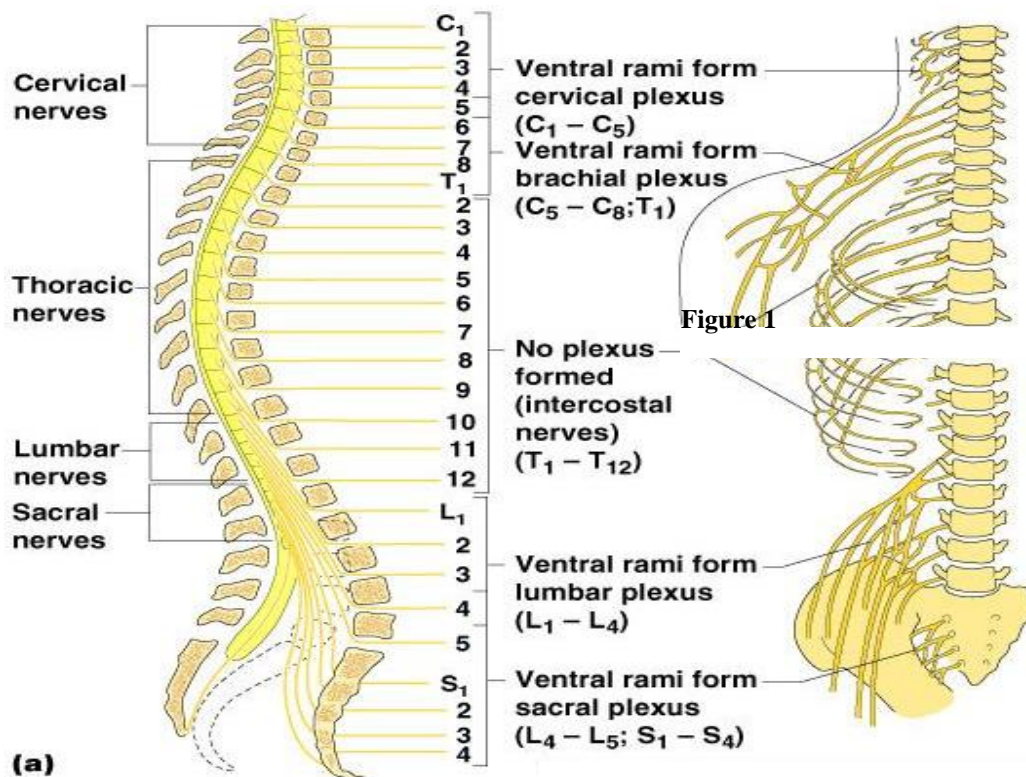
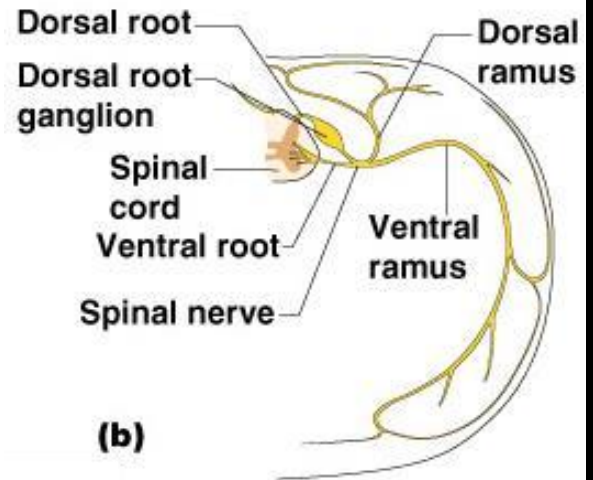
(c)

Spinal Nerves:-

- There is a pair of spinal nerves at the level of each vertebrae for a total of 31 pairs
- Spinal nerves are formed by the combination of the ventral and dorsal roots of the spinal cord
- Spinal nerves are named for the region from which they arise

Anatomy of Spinal Nerves:-

- Spinal nerves divide soon after leaving the spinal cord.
- Dorsal rami – serve the skin and muscles of the posterior trunk
- Ventral rami – forms a complex of networks on anterior



Peripheral Nervous System:-

The **peripheral nervous system (PNS)** is one of the two components of the nervous system, the other part is the central nervous system (CNS). The PNS consists of the nerves and ganglia outside the brain and spinal cord. The main function of the PNS is to connect the CNS to the limbs and organs,

essentially serving as a relay between the brain and spinal cord and the rest of the body. Unlike the CNS, the PNS is not protected by the vertebral column and skull, or by the blood–brain barrier, which leaves it exposed to toxins and mechanical injuries.

The Peripheral nervous system is divided into:

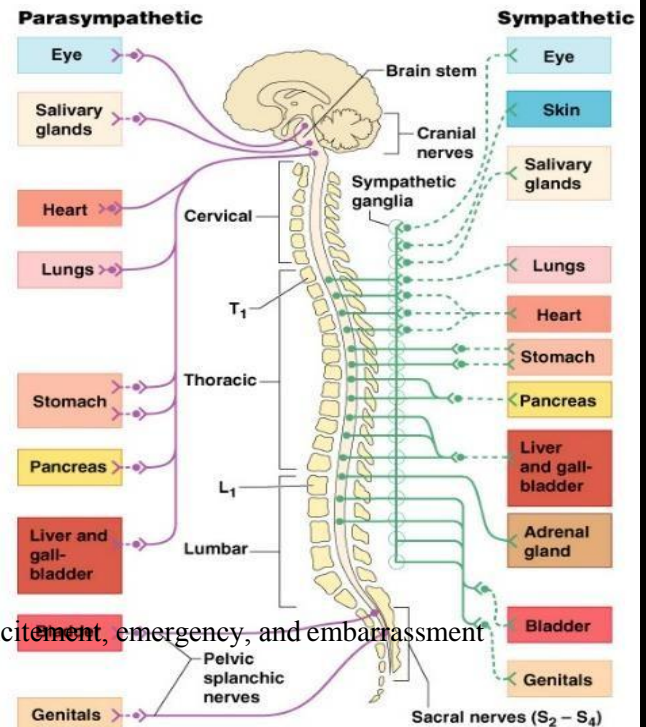
- 1- Autonomic Nervous system.
- 2- Somatic Nervous system.

1- Autonomic Nervous system:-

- The involuntary branch of the nervous system
- Consists of only motor nerves
- Divided into two divisions
 - Sympathetic division
 - Parasympathetic division

Autonomic Functioning:-

- Sympathetic – “fight-or-flight”
 - Response to unusual stimulus
 - Takes over to increase activities
 - Remember as the “E” division = exercise, excitement, emergency, and embarrassment
- Parasympathetic – housekeeping activities
 - Conserves energy
 - Maintains daily necessary body functions
 - Remember as the “D” division - digestion, defecation, and diuresis



Anatomy of the Sympathetic Division:-

- Originates from T₁ through L₂
- Ganglia are at the sympathetic trunk (near the spinal cord)
- Short pre-ganglionic neuron and long postganglionic neuron transmit impulse from CNS to the effector
- Norepinephrine and epinephrine are neurotransmitters to the effector organs

Anatomy of the Parasympathetic Division:-

- Originates from the brain stem and S₁ through S₄
- Terminal ganglia are at the effector organs
- Always uses acetylcholine as a neurotransmitter
-

DIFFERENCES BETWEEN SOMATIC AND AUTONOMIC NERVOUS SYSTEMS:-

- 1- Nerves

- Somatic – one motor neuron
- Autonomic – preganglionic and postganglionic nerves

2-Effector organs

- Somatic – skeletal muscle
- Autonomic – smooth muscle, cardiac muscle, and glands

3-Neurotransmitters

- Somatic – always use acetylcholine
- Autonomic – use acetylcholine, epinephrine, or norepinephrine
-

Development Aspects of the Nervous System:-

- The nervous system is formed during the first month of embryonic development
- Any maternal infection can have extremely harmful effects
- The hypothalamus is one of the last areas of the brain to develop
- No more neurons are formed after birth, but growth and maturation continues for several years
- The brain reaches maximum weight as a young adult

