MODULE IV

BIOLOGICAL BASES OF BEHAVIOR

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Neurons: Basic structure – Organization of the Nervous System: The Central Nervous System (CNS) and the Peripheral Nervous System ((PNS). The brain: structure and functions – Hormonal bases of behavior: The endocrine system.

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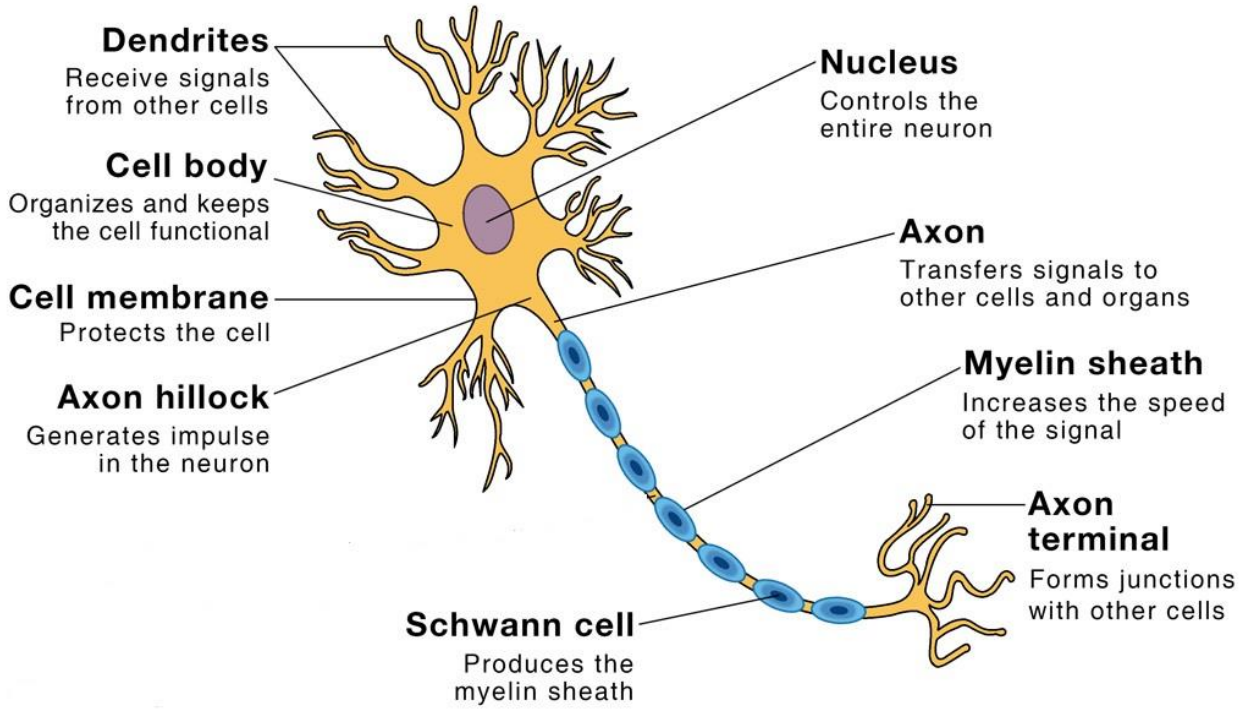
Nervous system is the system, which directs, controls, and co-ordinates all physiological activities within the body. It is a communication network system, which is fundamental to our behavior. It is mainly concerned with the perception of senses, transmission of impulses and response to stimuli. The structural and functional unit of the nervous system is the nerve cell or neuron.

NEURON: THE BASIC UNIT OF NERVOUS SYSTEM

The nerve cell or neuron is the structural and functional unit of a nervous system. There are nearly 12 billion neurons in the human brain. Neurons are specialized cells, which possess the unique property of converting various forms of stimuli into electrical impulse. Due to this property they are also called biological transducers.

Structure of Neuron

Each neuron consists of a) cell body, b) branched extension called dendrites and c) a long process called axon, which transmits electrical impulses. Dendrites receive stimuli or impulses and carry them towards their cell bodies and axons insulated with a fatty layer called myelin sheath. Such axons are called myelinated. Those axons, which do not have the myelin sheath, are called non-myelinated axons. The myelinated axons conduct the impulses faster and without leackage.



Structure of Neuron with Functions

Types of Neuron

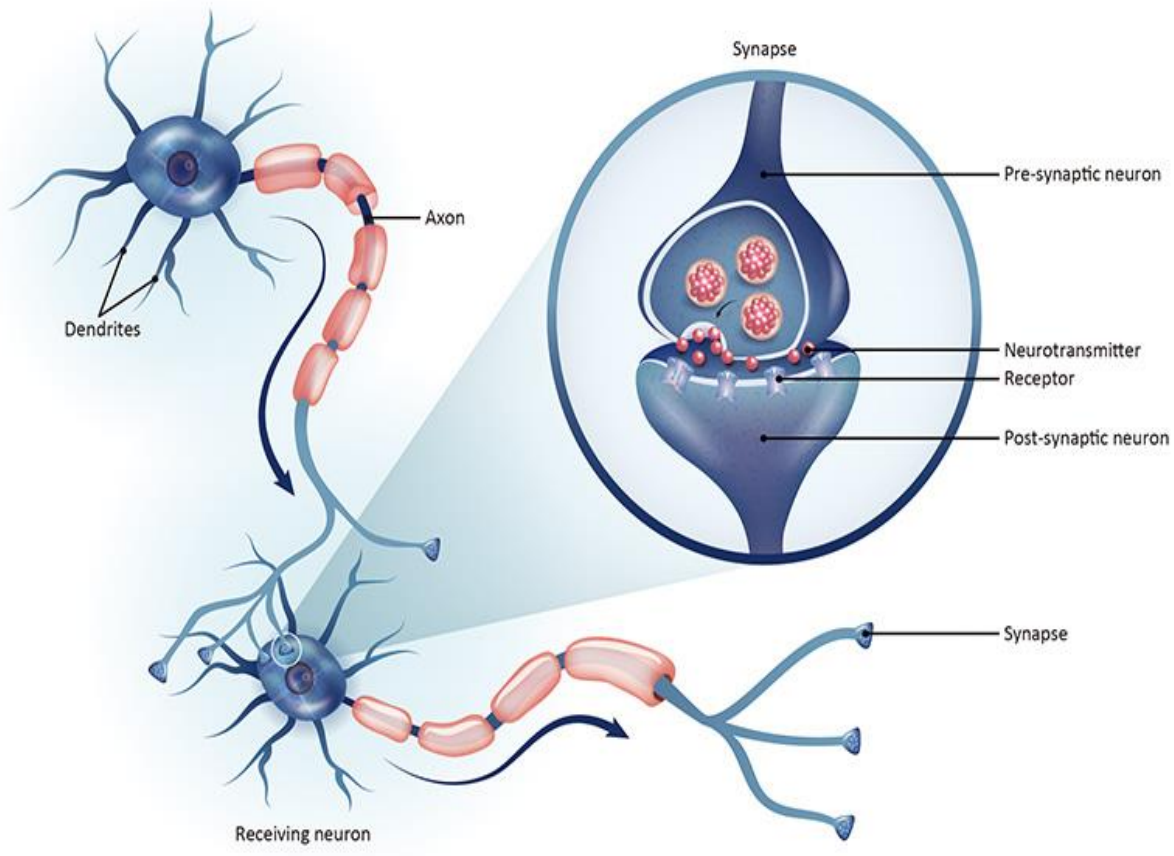
Neurons are classified into three on the basis of their functions.

1. **Sensory neurons or afferent neurons:** these neurons transmit impulses from sense organs to spinal cord or brain or any other nerve centre. When these impulses reach brain a person hears, smells, and so on.
2. **Motor neurons or efferent neurons:** these neurons send impulses to the effectors, such as muscles and as a result the person is able to move his legs, arms, neck, etc.
3. **Connecting neurons or connector neurons or association neurons:** these neurons connect the afferent and efferent fibres. In other words, they complete the circuit between incoming and outgoing messages. For instance, while when you see a red signal, you stop the cycle, which means that your sensory neuron

of the eye has carried the message from receptors to higher centers like brain. From there, motor neurons would have transmitted to effectors to exercise the necessary hand and leg movements to stop the cycle.

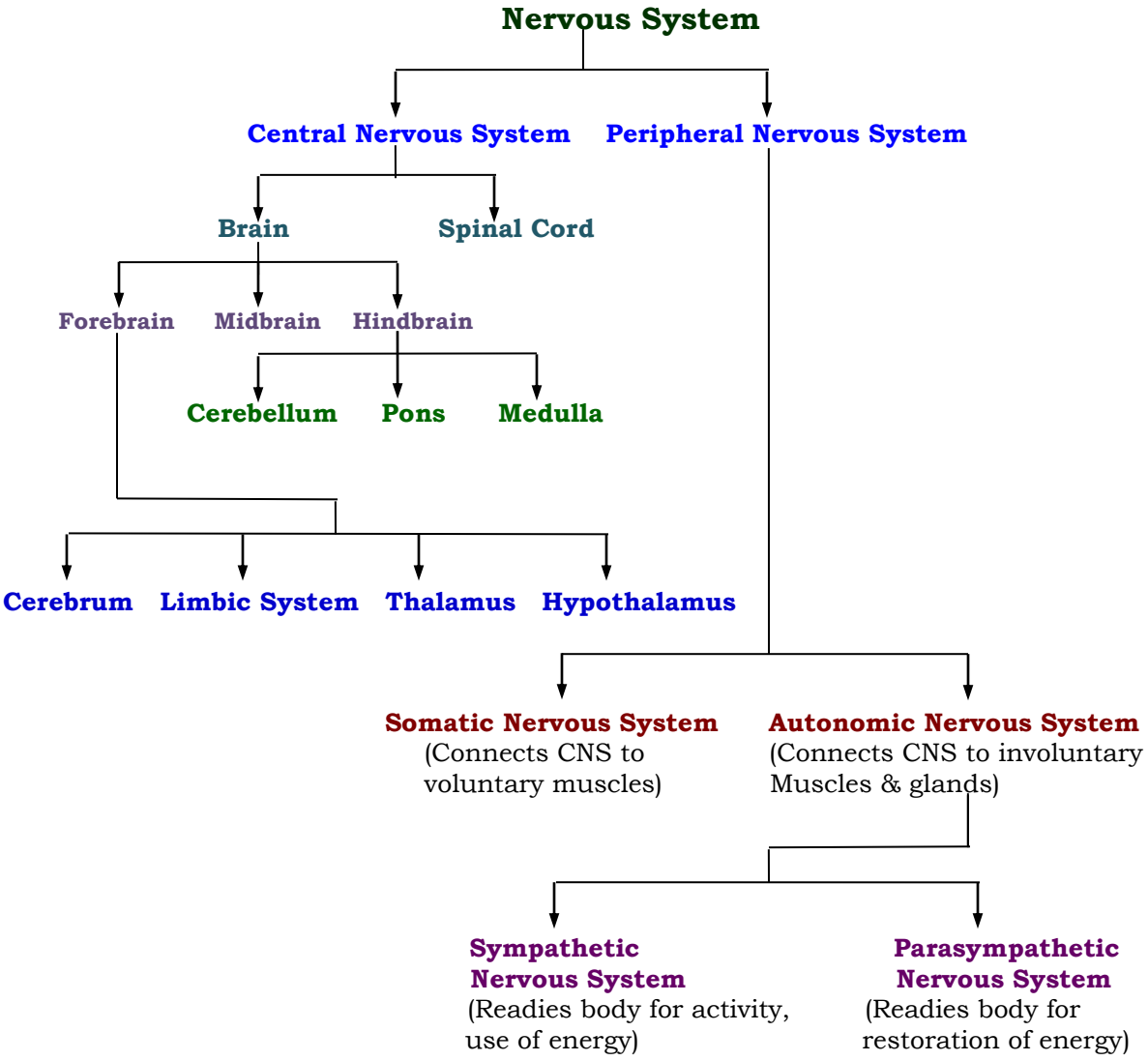
Synapse

When the nerve impulse arrives at the end of the axon or axon terminal it has to cross a gap to get to the next neuron. The gap is called the synapse – a minute fluid-filled junction through which neurons communicate chemically. The chemicals that do so are called neurotransmitters. These neurotransmitters play important role in communicating messages across the millions of neurons all over the body. Some of the important neurotransmitters are acetylcholine, noradrenaline, serotonin, dopamine, gamma-aminobutyric acid (GABA) and endorphin.



Organization of the Nervous System

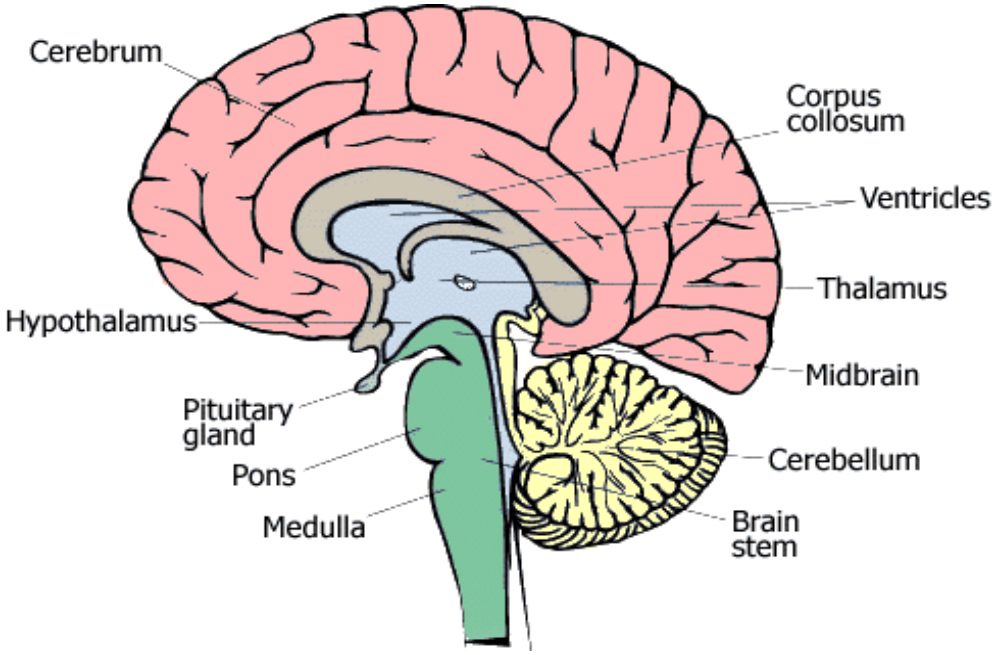
Human nervous system is divided into two divisions called Central Nervous System and Peripheral Nervous System. The following chart shows the organization of the nervous system as a whole.



Organization of the Human Nervous System

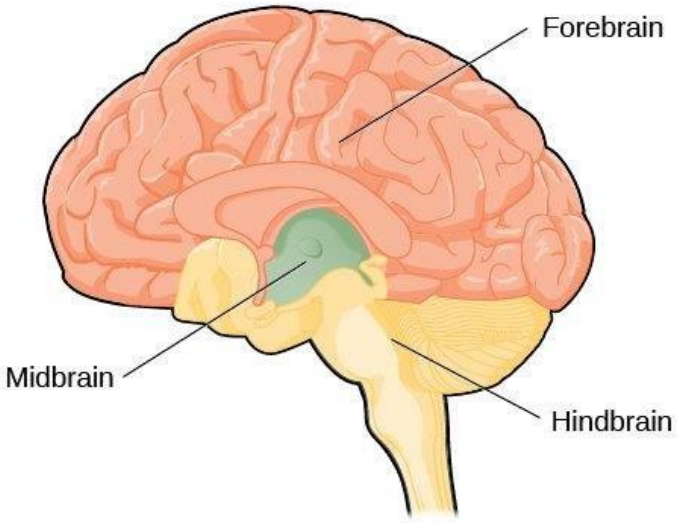
CENTRAL NERVOUS SYSTEM

The CNS is central to all your behaviors and mental processes. It is the central processing center – every action, thought, feeling and sensation you experience is processed through CNS. The CNS comprises brain and spinal cord.



STRUCTURE OF BRAIN

I. <u>BRAIN</u>: Brain has three divisions namely, forebrain, midbrain, and hindbrain.



1. Forebrain:

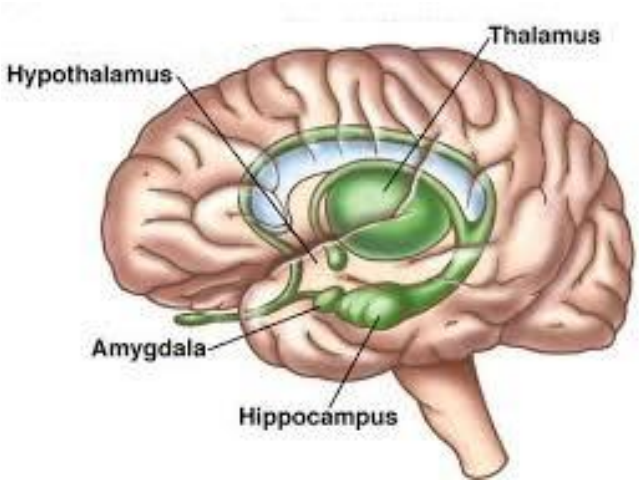
The important parts of the forebrain are: thalamus, hypothalamus, limbic system, and cerebrum (cortex).

a) Thalamus: It is located just above hypothalamus. The thalamus is a relay station transmitting almost all the sensory messages to other centers. Pathways from all sense organs except that of the sense of touch connect to thalamus.

b) Hypothalamus: It forms a junction between thalamus and midbrain. Hypothalamus regulates activities such as eating, drinking, sexual behavior and emotional reactions such as fear, anger, etc. Hypothalamus consists of several nerve cells which function as centers of excitation and inhibition. Feelings of hunger, satiation, thirst, and sexual drives can be evoked by stimulation of hypothalamic centers. In addition to these functions hypothalamus regulates and controls internal environment of the body. This is called homeostasis. This involves heart rate, blood pressure, temperature, etc. Hypothalamus also has intimate connection with pituitary, an endocrine gland. These connections are neural as well as vascular.

c) Limbic System:

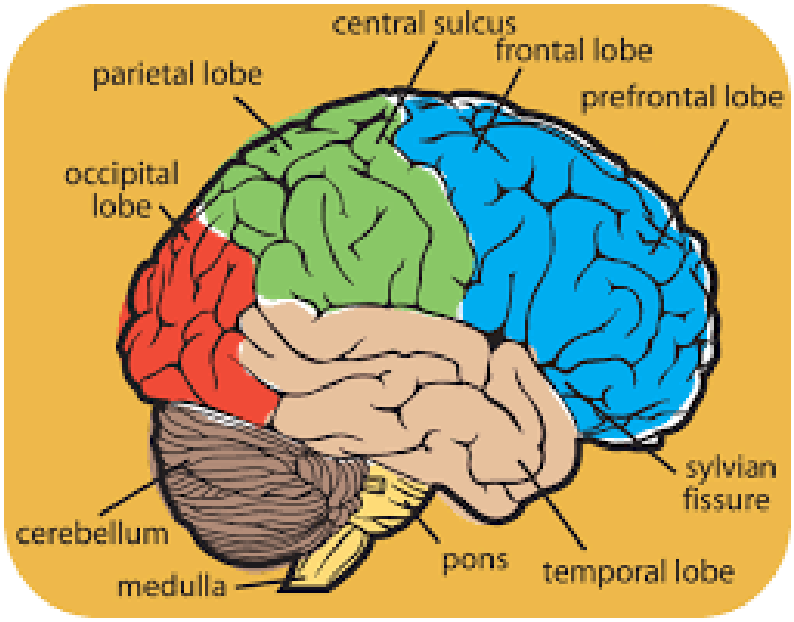
This system consists of a group of interconnected structures. These are concerned with various emotional states. Parts of frontal and temporal lobes are also included in the limbic system. The limbic system is concerned with visceral functions like eating, drinking, etc. and emotional states particularly related to sex. The entire system functions as a single unit. It also plays an important role in both normal and abnormal emotional behavior.



Limbic System

d) Cerebrum: It is the largest part of the brain. It is divided into two hemispheres known as the right and left hemispheres. These two hemispheres are connected by a fibrous tract called corpus callosum. The outer region of the cerebrum made up of grey matter is called the cerebral cortex. Cerebral cortex is the area of higher sensory activities and the center of intelligence, thought, learning, memory, etc. it also controls speech, muscular movements, and perceives smell, taste, light and sound. Lying below the cortex is the white matter called cerebral medulla consists of bundles of nerve fibres.

The two cerebral hemispheres are separated by a large crevice (passage), which runs from front to rear called longitudinal fissure. In addition, each hemisphere is further divided into four lobes: frontal; parietal, temporal, and occipital. The functions of these four lobes are described below.



i) **<u>Frontal lobe:</u>** It is situated to the front of the central fissure. The principal function of this lobe are:

   a. It initiates, sustains and controls voluntary movements and numerous activities such as eating, speaking, walking, etc.

   b. The left frontal lobe is concerned with the functioning of the right side of the body and the right frontal lobe is concerned with the left side.

   c. It regulates mental activities such as thinking, attention, memory, learning, reasoning, etc.

   d. It facilitates proper coordination of psychomotor activities like driving a car, painting, etc.

   e. It inhibits and controls autonomic and emotional response. People with frontal lobe injury display subtle personality changes. They are described as people who are unable to plan ahead, unreliable, rude, and impulsive. It can also lead to impairment of speech and intellectual functioning.

ii) **<u>Parietal lobe</u>:** Parietal lobe is located behind the central fissure on left and right sides of the brain. Its main functions are:

a. Coordination of the sensory input and motor output
b. Speech.
c. Integration of visual and auditory stimuli with body stimuli and its orientation.
d. To understand stimuli in the three-dimensional level.

Damage to this lobe leads to weakening of sensations, spatial disorientations, right and left disorientations visual field defects.

iii) <u>Temporal lobe</u>: Temporal lobes are located above the ears. Some of their functions are:

a. Auditory reception.
b. Memory for symbolic sounds or words.
c. Storage of visual and verbal memory.

Damage to the temporal lobe has been found to result in loss of memory, speech, and even psychological blindness. Surgical removal of an affected part of the temporal lobe reduces the frequency of seizures in epileptic patients.

iv) <u>Occipital Lobe</u>: the main functions of this lobe are

a. Receiving impulses from the eye.
b. Interpretation of visual impulses.
c. Memory for visual stimuli.

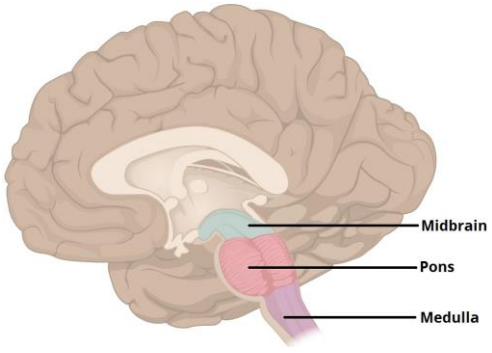
Damage to the occipital lobe leads to impairment of visual discrimination, loss of ability to recognize colors, form sizes, etc. Damage to these areas in human beings can lead to total or partial blindness even though the eyes may be perfect anatomically.

Human behavior thus involves integrated and coordinated functioning of all the lobes.

2. Mid Brain

The mid brain lies between the hindbrain and forebrain. The roof of the midbrain has a special role to play in visual and auditory activity. The portion of a midbrain, which has a dense network of neurons, is called the reticular activating system (RAS). These neurons originate in hindbrain and extend to hypothalamus and thalamus. They appear as a criss-crossed or reticulated set of fibres running up and down through a large portion of brain. The ascending fibres of RAS regulate the state of alertness in the organism by activating higher centers of the brain.

There are various auditory signals reaching our ears and various visual stimuli fall on our retina, but we are not aware of all these stimuli. Only one or two at a given moment are noticed and responded to. Here the filtering process takes place, which is known as sensory gating. Sensory gating means a less stronger or important sensation from one set of sense organs, which is temporarily held back. The descending fibres of the RAS are part of a large system that mediates movement. Mid brain also plays a role in governing movements of the head and neck.



3. Hind Brain:

Hindbrain consists of cerebellum, pons, and medulla oblongata.

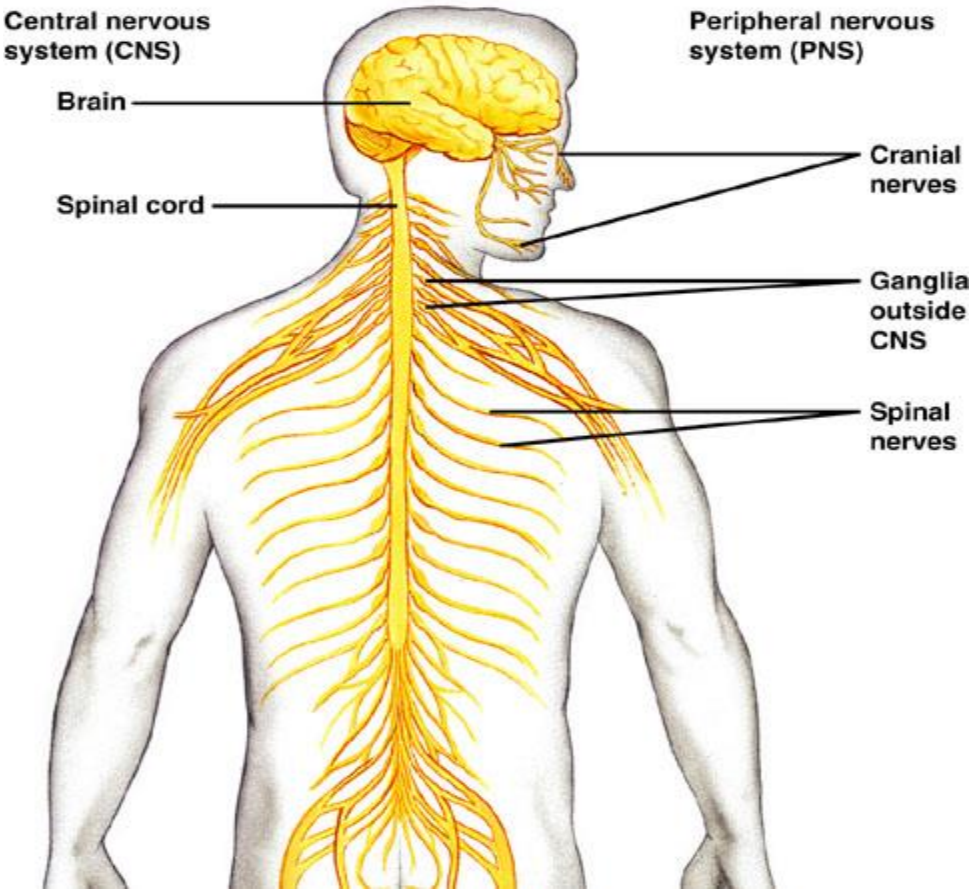
1. **Cerebellum:** It is a highly convoluted structure. Cerebellum regulates all fine muscular movement from playing to tying a shoelace. In addition, cerebellum is directly concerned with sense of balance, posture, muscle tones, etc. all motor coordinates are under its control. If cerebellum is removed or injured or the nervous pathways are damaged, animals and humans are said to become clumsy and uncoordinated after the removal of cerebellum. Shaking neck and hand tremor in older people are the result of the impairment of cerebellum.

2. **Pons:** It serves as a relay station for the auditory system. It contains 'nuclei' influencing respiratory movement and facial expressions.

3. **Medulla Oblongata:** It is the lowest part of the brain stem. Its primary function is to coordinate vital process of body like breathing, rate of heartbeat, and gastro-intestinal functions. In addition, it also controls activities of the autonomic nervous system, which is concerned with vegetative and emergency functions.

II. SPINAL CORD

A spinal cord leads down from the medulla. It is a long rope-like collection of nerve fibres, which runs along the full length of the body.



Two main functions of spinal cord are:

1. It provides connector mechanism for reflexes or aids the first level of integration.
2. It conveys messages to and from the higher centers of the brain through the ascending and descending tracks of nerve fibre.

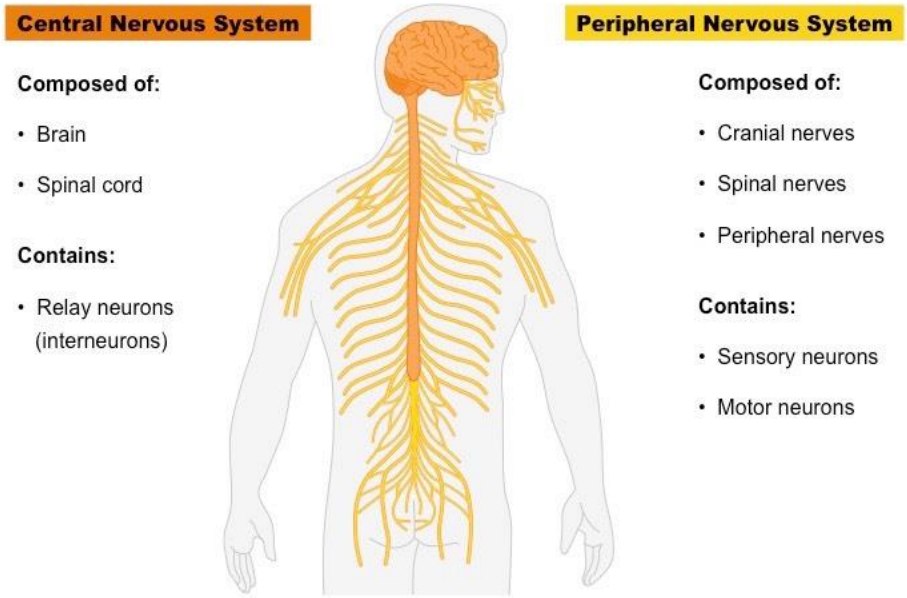
The butterfly-shaped mass of grey matter present in the centre of the spinal cord contrains association neurons and other cells. Surrounding the grey matter is the white matter of the spinal cord, which is composed of the ascending and descending neural tracts. These tracts appear whitish in color because fibres within them are covered with myelin sheath. Since the grey matter contains association neurons necessary for reflexes, it is concerned with the first level of integration. The white matter containing ascending and descending fibres which transmit

impulses from the higher centers of integration, i.e., brain thus serving the second purpose of the spinal cord.

However, not all human activities are based on reflex actions. There are more complex actions, which take longer time to react and depend to a great extent on learning experiences. Some responses involve greater degree of coordination because these do not occur at the level of spinal cord but at the level of brain.

PERIHERAL NERVOUS SYSTEM (PNS)

The PNS consists of all neural material located outside the brain and spinal cord. PNS includes 12 pairs of cranial nerves and 31 pairs of spinal nerves. The cranial nerves are those that emerge from the brain and the spinal nerves are those that emerge from the spinal cord. PNS is divided into Somatic Nervous System and Autonomic Nervous System.



I. The Skeletal Nervous System (Somatic Nervous System)

It consists of motor neurons that control external behavior. This behavior is of two types. First, there is a voluntary behavior; lifting glass, combing your hair, and so

on. The other involuntary or reflex behavior; pulling your hand away from a hot stove, and so on.

II. The Autonomic Nervous System

The ANS controls various internal functions of the body, viz. breathing, blood circulation, salivation, stomach contractions, and many other emotional reactions. This system is also referred to as the involuntary nervous system because its primary function is to control internal reflexes. The ANS is further divided into two systems: Sympathetic Nervous System and Parasympathetic Nervous System.

a) **Sympathetic Nervous System:** SNS consists of a group of nerve centers located near the spinal cord. From these centers, fibres branch out to various organs of the body like heart, lungs, stomach, and liver. When this system is activated, the body is in a state of arousal or is said to be alert. This system releases energy during the state where action is needed and accomplished. When a person is in a state of emergency, his heart beats faster, he breathes rapidly, his liver secretes extra sugar into the blood for additional energy and so on.

b) **Parasympathetic Nervous System:** This system is mainly concerned with conservation of energy unlike the sympathetic system, which spends energy. This system conserves and replaces the energy lost during sympathetic activation. These two systems function in a complementary manner though they appear antagonistic. The parasympathetic nervous system slows the heartbeat, reduces rate of breathing, stops the flow of sugar into the blood and facilitates digestive activity. When the body quite down and the person feels calm and relaxed. It implies that the parasympathetic system is providing underlying basis for this.

	Parasympathetic *Body at rest*	Sympathetic *Emergency situations*
Eyes	**Constricts pupils**	**Dilates pupils**
Heart	**Beat more slowly**	**Beats faster and stronger**
Lungs	**Constricts airways**	**Relaxes airways, which lets you breathe more deeply**
Digestion	**Stimulates digestion**	**Inhibits digestion**
Muscles	**Reduces blood flow to skeletal muscles**	**Increases blood flow to skeletal muscles**

These two divisions of ANS function in co-ordination to achieve health and equilibrium of body in general. To summarize, the human nervous is a complex, finely communication system, the basic unit of which is the neuron.

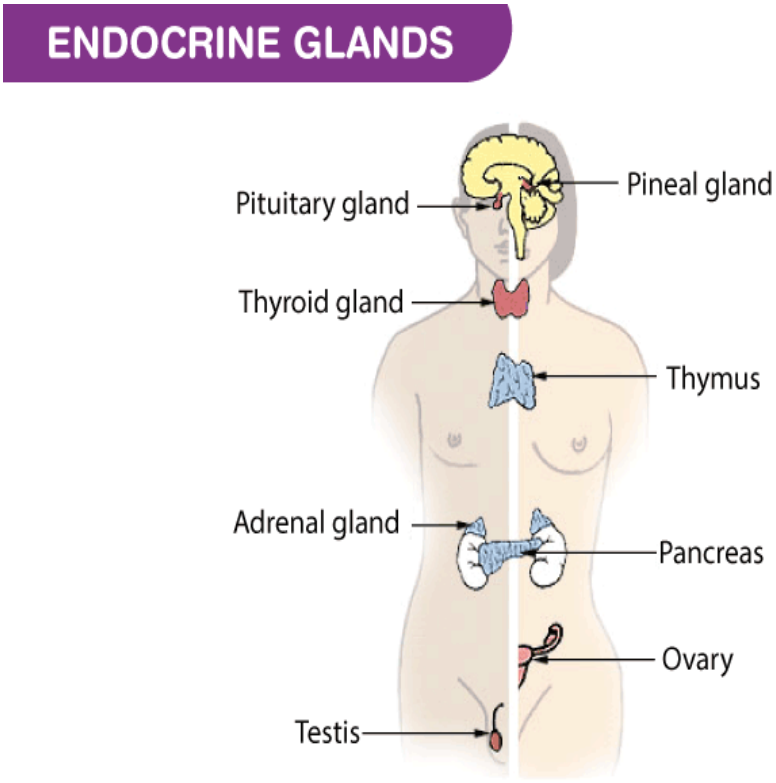
CRANIAL NERVES			
Sl.No.	**Name**	**Origin**	**Primary functions**
1	Olfactory	Olfactory bulb	Afferent for smell
2	Optic	Diencephalons	Afferent for vision
3	Oculomotor	Midbrain	Afferent and efferent to all eye muscles except two
4	Trochlear	Midbrain	A&E to one eye muscles
5	Trigeminal	Pons	A from skin and mucus membrane of head and from chewing muscles; E to chewing muscles
6	Abducent	Pons	A&E to one eye muscle
7	Facial	Medulla	A from taste buds of anterior two thirds of tongue.
8	Statoacoustic	Medulla	A from the inner ear (hearing and balance)
9	Glossopharyngeal	Medulla	A from throat, rear of tongue, and taste buds of posterior one third of tongue. E to throat and one salivary gland.
10	Vagus	Medulla	A from throat, viscera, and larynx; E to viscera
11	Spinal accessory	Medulla	E to viscera (via vagus), throat, larynx, neck, and shoulder muscles.
12	Hypoglosal	Medulla	A&E to tongue muscles

THE ENDOCRINE SYSTEM

The endocrine system is the chemical communication network system that sends messages through out the nervous system through bloodstream. This system consists of various glands, which secretes chemical substances necessary for the growth and maintenance of the body.

Glands are of two types: exocrine or duct glands which secrete hormones through ducts of tubes (e.g., tear glands) and endocrine or ductless glands which secrete hormones through blood stream. The chemical substances secreted by these glands are called hormones.

The endocrine glands do not initiate any activity of the organs like heart, liver, etc. but it regulates the activities. Thus secretion of hormone is necessary to maintain the chemical equilibrium of the body. Under secretion (hypo) and over secretion (hyper) of hormones leads to physical and psychological changes.



1. **Pineal Gland:** this gland is located inside the brain. It lies on the upper surface of the thalamus between the two halves of the cerebrum. Its size is that of a pea. The hormone secreted by this gland is melatonin, which helps the growth of the body and reproductive functions.

2. **Pituitary Gland:** this gland is located beneath the brain. This gland secretes nine protein hormones: somatotropic hormone, thyroid stimulating hormone, adreno corticotropic hormone, melano stimulating hormone, etc. Since pituitary gland influences growth and controls all other glands, it is also called the *master gland.* Under activation of the pituitary gland results in dwarfism and over secretion leads to gigantism. It also influences testes and ovaries (Gonads). Insufficient or excess secretion of these hormones leads to under or over sexuality.

3. **Thyroid Gland:** thyroid gland is located in the lower portion of the neck region. The chief hormone secreted by this gland is thyroxin. It controls metabolic rate. Deprivation of thyroxin in children leads to cretinism, feeble mindedness and deprivation of thyroxin in adults leads to myxodema, characterized by overweight and general sluggishness. Deficiency of thyroxine also leads to mental retardation and other clinical disorders. Under secretion of this hormone results in neurological, cardiovascular, renal, and respiratory disorders. Over secretion results in restlessness, tension, etc.

4. **Parathyroid Gland:** this gland is located below the thyroid gland. The chief hormone produced by this gland is parathormone, which regulates calcium and phophyurus metabolism. The primary function of this hormone is to maintain the bony structure of the body. Damage or removal of this gland leads to a neurological disorder tetany. This state is related with muscular spasm particularly of hands, feet, and jawbones. Further, removal of this

gland also leads to weakening of bones due to loss of calcium, and often characterized by aches, pains, and groans.

5. **Thymus Gland:** this gland is located below the parathyroid gland. It is large and active during childhood. It becomes fully developed by about 7 years and degenerates and disappears after 14 years. Degeneration hastens sexual maturation.

6. **Adrenals:** adrenal gland is located in the mid region of the body above the kidneys. Each gland has two parts: an outer part called adrenal cortex and an inner part called adrenal medulla. Adrenal medulla secretes two stress hormones: epinephrine (adrenaline) and norepinephrine (nonadrenaline). These hormones are produced during the times of stress, resulting due to fear, anger, aggression, etc. Under secretion of these hormones results in fatigue, loss of appetite, anemia, weakness, sleepiness, and darkening of skin. This is popularly known as addison's disease.

   Adrenal cortex secretes aldosterone, cortisol, and sex hormones. It regulates carbohydrate and salt metabolism. Oversecretion of these hormones leads to cushing's sundrome, characterized by obesity and hirsutism (excessive hair), diabetes and hypogonadism. Excessive androgen in women causes virilism (musculinization). Excessive estrogen in men causes faminisation. In children, excessive sex hormone results in sexual maturity.

7. **Pancreas Gland:** Pancreas gland is located in the middle part of the body. It is characterized by both exocrine and endocrine in its secretary function. The endocrine part secretes insulin, which regulates the blood sugar by disposition of glucose as glycogen in liver and muscles.

8. **<u>Reproductive Glands (Gonads):</u>** Glands that produce sex hormones are called gonads. The glands in females are called ovaries and the glands in males are called testes.

Testes affect physical development, reproductive organs and sexual behavior in males. Male sex hormones are called androgens or testosterone. Androgen is responsible for maturation of male sex characteristics such as hair growth and voice change at puberty.

Ovaries affect physical development, reproductive organs and sexual behavior in females. Ovaries produce two hormones: estrogen and progesterone. Estrogen helps maturation of internal reproductive structure and the emergence of secondary sex characteristics like pubic hair, breast and menstruation. Progesterone prepares the uterus for implantation of the fertilized egg.

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