THE NERVOUS SYSTEM

The nervous system is the part of an animal body that coordinates its voluntary and involuntary actions and transmits signals between different parts of the body. Together with endocrine system, nerve it controls the vital aspects of the body and functions and maintains homeostasis.
The nervous system consists of brain, spinal cord and peripheral nerves.
The nervous system is broadly classified into :-

1) Central nervous system, consisting of brain and spinal cord.
2) Peripheral nervous system consisting of all the nerves outside the brain and spinal cord

CELLS OF THE NERVOUS SYSTEM :-

There are two broad classes of cells in the N. System. — neurons and glial cells. The neurons form the basic structural and functional unit of the nervous system where as the glial cells acts as supporting system both mechanically and metabolically.

Neurons

Neurons are the fundamental cellular unit of the central nervous system and PNS.

Essential features of neurons are:-

1) To recieve, process and transfer information. This information is made up of chemical or electrical signals
2) They are considered as Proliferate
3) Mature neurons do not ~~regenerate~~ in the CNS after birth. i.e, only once formed they remain as such throughout the life at atrophy with advancing age.
4) Neurons do not regenerate if their cell body is damaged. However, the dendrites can regenerate and sometimes axons can regenerate, also
5) For their survival, they need a continuous supply of oxygen and glucose.

Structure of neurons:-

Neurons have three main parts in their structure:-

1) Cell body 2) Dendrites 3) Axon.

Nerve cell body:-

Nerve cell body is also known as Soma. It is irregular in shape. Like any other cell, it is constituted by a mass of cytoplasm called neuroplasm covered by a cell membrane. The cytoplasm contains a large nucleus, Nissl bodies (rough endoplasmic reticulum), mitochondria and Golgi apparatus.

Cell bodies form the grey matter of the nervous system and are found at the periphery of the brain and in the centre of the spinal cord. Groups of cell body are called nuclei in the CNS and ganglia in the PNS.

Axons-

It is the longer process of the nerve cell. Each neuron has only one axon. Axon arises from axon hillock of the nerve cell body. Axon has a long central core of cytoplasm called axoplasm and is covered by a membrane called the axolemma. Axoplasm along with axolemma is called the axis cylinder. Axis cylinder of the nerve fibre is covered by a membrane called neurilemma. At its end, the axon

breaks into minute branches that terminate in small swellings called Synaptic knobs containing neurotransmitters in small Synaptic vesicles.

Myelinated neurones: Large axons and axons of P.N.S are covered by a thick lipoprotein sheath called myelin sheath and those neurons are called myelinated neurons. Myelin sheath consists of Concentric layers of Schwann cells with a fatty substance in b/w the cells. myelin sheath is absent at regular intervals and at that place axolemma is exposed. These areas where myelin sheath is absent are called Nodes of Ranvier.

Non-myelinated neurones: In this type, a no. of axons are embedded in one Schwann cell. The adjacent Schwann cells are in close association and there is no node of Ranvier.

Axons form the white matter of the nervous system. Axons are found in groups in brain where they are called tracts. They are referred to as nerves or nerve fibres outside the brain and Spinal cord.

Dendrites:

These are branched processes of neurone and receive and carry incoming impulses towards the cell bodies. They have the same structure as axon but are shorter

Nerves and their coverings:-

A nerve consists of a no. of neurones collected into bundles. Each bundle has several coverings of protective connective tissue as:-

→ Endoneurium:→ Surrounds each individual nerve fibre

→ Perineurium:→ Surrounding each bundle of fibres.

→ Epineurium:→ Fibrous tissue which surrounds and encloses a no. of bundles of nerve fibres.

Classification of Nerve fibres/(TYPES)

1) Depending upon Structure:-

a) Myelinated N. fibres:- Those nerves covered by myelin sheath.

b) Non-myelinated N. fibres:- Those nerve

not covered by myelin sheath.

2) DEPENDING UPON DISTRIBUTION:-

a) Somatic Nerve fibres - Nerves supplying the skeletal muscles of the body.

b) Visceral or Autonomic N. fibres :- Nerves which supply various internal organs of the body..

3) DEPENDING UPON ORIGIN:-

a) Cranial N. Fibres:- Nerves arising from brain

b) Spinal Nerves:- Nerves arising from the spinal cord.

4) DEPENDING UPON FUNCTION:-

a) Sensory or Afferent nerves:- Those nerves which carry sensory impulses from different parts of the body to the CNS.

b) Motor or Efferent Nerves:- Those nerves which carry motor impulses from CNS to the different body parts.

c) Mixed Nerves:- Outside the Spinal Cord, Sensory and motor N. are enclosed within the same sheath of connective tissue called mixed N.

THE NERVE IMPULSE

A nerve impulse is an electrical signal that travels along an axon. There is an electrical difference between the inside of the axon and its surroundings, when the nerve is activated by stimulation of the nerve or by the passage of an impulse from another nerve, There is a sudden change in the voltage across the wall of the axon, caused by the movement of ions in and out of the neuron. This triggers a wave of electrical activity that passes from the cell body along the length of the axon to the synapse.

The electrical difference across the membrane is called the resting membrane potential. At rest, the charge on the outside is positive and inside it is negative. The ions involved in this charge difference are :-

a) Sodium (Na^+), the main extracellular cation

b) Potassium (K^+) the main intracellular cation.

When a nerve cell is stimulated, the permeability of the nerve cell to these ions changes e.g. Na^+ moves into the neuron from the extracellular fluid causing depolarisation thus creating a

tiny diverticula of arachnoid matter called arachnoid villi into the venous sinuses.

Functions of the CSF:-

1) Protective function:-
CSF acts as fluid buffer and protects the brain and spinal cord from shock by maintaing a uniform pressure around these vital structures.

2) Regulation of Cranial Content volume:-
It is essential because brain may be affected if the volume of cranial content increases. Increase in cranial content volume is prevented by greater absorption of CSF to give space for the increasing cranial contents.

3) Medium of Exchange:-
CSF is the medium through which many substances, particularly nutritive substances and waste materials are exchanged b/w blood and brain tissues.

4) It keeps the brain and spinal cord moist.

PARTS OF BRAIN:-

The brain is a large organ weighing around 1.4kg that lies within the cranial cavity. Its parts are:-

1) Fore brain (Prosencephalon) → Including Cerebrum, Thalamus and hypothalamus. The thalamus and hypothalamus are together called diencephalon.
2) Mid brain: Also called as Mesencephalon
3) Hind brain:- Including Pons, medulla oblongata and Cerebellum: Hind brain is also called as Rhombencephalon.

The mid brain, Pons and medulla are together called the Brain Stem.

CEREBRUM:-

It is the largest part of the brain. It is divided by a vertical fissure the longitudinal cerebral fissure into right and left cerebral hemispheres, each containing one of the lateral ventricles. Internally the

Two cerebral hemispheres are connected by Corpus Callosum. Surface of the Cerebral Cortex is characterised by complicated pattern of sulci (depression) and gyri (raised ridge). Cerebrum is made up of outer gray matter (cell bodies) and inner white matter (axon fibres). Each Cerebral hemisphere is devided into different lobes by a no. of sulci. These are:-

1) Frontal lobe
2) Parietal lobes
3) Temporal lobes
4) Occipital lobes.

The sulci are:-

- Central sulcus b/w frontal and parietal lobes
- Parieto-occipital sulcus — b/w parietal and occipital lobe
- Lateral sulcus b/w Parietal and temporal lobes.

Functions of the cerebrum

1) Cerebrum controls and initiates the skeletal muscle contraction, so it is concerned with the voluntary movement of the body.

2) Frontal lobe helps in controlling emotions, planning, creativity, judgement, movement and problem solving. It also helps in learning and memorising things.
3) Parietal lobe's main function is to control the temperature, taste, pressure touch, pain. Some language functions may also be controlled by the parietal lobe.
4) Temporal lobe controlles the most hearing and language functions. Temporal lobe also helps in the perception of the smell.
5) The Occipital lobe controlls the vision and the ability to recognise objects.

THALAMUS :-

Thalamus is a small structure within the brain located just below the corpus Callosum. It consists of two masses of grey and white matter, one on each side of the 3rd ventricle.

Functions of thalamus:-

1) Relay centres:
Thalamus forms the relay centre for the sensations. Impulses of almost all the

sensations like touch, pain, temp and information from the special sense organs reach the nuclei. After being processed in the thalamus, the impulses are carried to the cerebral cortex.

2) Thalamus forms the major centre for processing the sensory information.
3) Controls sleep and awake state.

HYPOTHALAMUS:-

It is a small but important structure weighing around 7g and consists of a no. of nuclei. It is situated below and infront of the thalamus, above the pituitary gland. It is attached to the anterior pituitary by complex system of blood vessels and to the posterior pituitary by nerve fibres.

Functions of hypothalamus:-

1) It is the site of secretion of the posterior pituitary hormones — ADH and Oxytocin. These are secreted by hypothalamus, and transported by means hypothalamo-hypophyseal tracts to the posterior pituitary where they are stored and released thereafter.

2) It also controls the secretion of anterior pituitary gland by secreting releasing hormone and inhibiting hormones.
3) Hypothalamus controls autonomic nervous system.
4) Regulation of body temperature is the imp. function of hypothalamus.
5) It regulates the hunger hunger and food intake.
6) It also regulates the sleep and wakefulness
7) Regulation of sexual function especially in females.
8) It has role in controlling over behaviour and emotional changes.

Midbrain:-
The midbrain is also called the mesencephalon. It connects the hindbrain with the fore-brain. Its cavity is known as the Cerebral aqueduct which connects the 3rd ventricle c̄ the 4th ventricle. It consists of nuclei and nerve fibres which connect the ~~cerebrum~~ cerebrum c̄ lower parts of the brain and c̄ the spinal cord. The nuclei act as relay centres for the ascending and descending nerve fibres and have important roles in auditory and visual reflexes.

Pons:- It is a rounded eminence on the ventral surface of the brainstem. It lies between the medulla and midbrain infront of cerebellum. It contains ~~the~~ fibre tracts connecting the medulla and cerebellum c̄ the upper portions of the brain. There are nuclei within the ~~brain~~ ~~the~~ pons which act as relay centres and also contains two respiratory centres (pneumotaxic and apneustic centres) that work with

the respiratory centres of the medulla oblongata. Anatomically the pons has grey matter internally and white matter externally.

Medulla Oblongata:-
It is the lower-most part of the brain. It is situated below pons and is continued downwards as spinal cord. It is about 2.5 cm long and lies just within the cranium above the foramen magnum. Its anterior and posterior surface is marked by longitudinal fissures. It has white matter externally and grey matter internally. Medulla has a ~~to~~ no. of vital centres which are groups of cell bodies which control the vital functions. There are

1) Cardiovascular Centre which controls the rate and force of cardiac contraction. It also controls the Blood pressure.
2) Respiratory centre which controls the rate and depth of respiration. It works in close association c̄ pneumotaxic and apneustic centres of the pons.

3) Reflex centres of vomiting, coughing, sneezing and swallowing which are protective reflexes that attempt to expel irritants.

One of the special feature of the medulla is that the a no. of motor and sensory nerves descends descending or ascending to and from the brain cairs-cross or decussate decussate which means that the left hemisphere of the cerebrum controls the right half of the body and vice-versa.

Cerebellum.

This portion of the brain forms the largest segment of the hind brain. It lies behind the Pons and medulla occupying the posterior cranial fossa. It consists of two cerebellar hemispheres connected by a central worm like body called vermis. It is formed by grey matter over the surface and white matter internally.

Functions:

It is responsible for coordination of voluntary movements, the speed, stopping

of movements and for maintaining posture and balance.

SPINAL CORD:-

Spinal cord lies loosely in the vertebral canal. It extends from foramen magnum where it is continuous with medulla oblongata upto the lower border of the first lumbar vertebra below. Spinal cord is cylindrical in shape and is about 45 cm long in males and abt 43 cm in females. The spinal cord is covered by sheaths called meninges which are duramater, pia mater and arachnoid mater. These coverings continue as coverings of brain. The spinal cord is made up of 31 segments, which are 8 cervical segments, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal segments. These segments give rise to the spinal nerves. On the anterior surface of the spinal cord, there is a deep furrow known as anterior median fissure and on the posterior aspect, there is a depression called posterior median sulcus.

This fissure and sulcus divides the spinal cord into two equal halves. Internally, spinal cord is divided into grey matter and white matter.

Grey matter:-

It is placed centrally in the form of wings of the butterfly and it resembles the letter 'H'. Exactly in the centre of the grey matter there is a canal called the spinal canal filled c CSF. Grey matter is the collection of nerve cell bodies and dendrites. The area of grey matter lying transversally is called transverse commissure. Each lateral half of the grey matter is composed of ventral (anterior) and dorsal (posterior) horns. In addition, the grey matter forms a small projection in between the anterior and posterior horns in all the thoracic and first two lumbar segments. called the lateral grey horn.

White matter:-

It surrounds the grey matter. It is formed by the bundles of the both myelinated and non-myelinated fibers. It is

arranged in three columns or tracts (i.e, anterior, posterior and lateral. These tracts are either ascending sensory tracts or descending motor fibres.

PERIPHERAL NERVOUS SYSTEM:-

The portion of the nervous system outside the central nervous system. It consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves. PNS is divided into two subdivisions:-

1) Somatic N. System:- which is concerned i the somatic function. It includes nerves supplying the skeletal muscles. which is responsible for muscular activities and movements of body.

2) Autonomic N. System:- Concerned with regulation of visceral functions so it is also called involuntary nervous system. It is further divided into two division ie, Sympathetic and Parasympathetic division.

SPINAL NERVES:

There are 31 Pairs of spinal nerves leaving the vertebral canal by passing through the intervertebral foramina on both sides. They are named and grouped according to the vertebrae with which they are associated. These are:-

1) 8 cervical
2) 12 Thoracic
3) 5 lumbar
4) 5 Sacral
5) 1 Coccygeal.

The lumbar, sacral and coccygeal nerves leave the spinal cord near its termination at the level of the 1st lumbar vertebra, and extend downwards inside the vertebral canal as the subarachnoid space forming Cauda equina.

Nerve roots: Each spinal nerve is formed by an anterior (ventral) root and posterior (dorsal) root, hence a mixed nerve. The anterior root arises from the anterior horn of the grey matter in the spinal cord and the

posterior nerve root arises from the posterior horn of the spinal cord. Also the anterior roots are made consist of motor nerve fibres while as posterior roots consist of sensory nerve fibres.

PLEXUSES:

Plexus is defined as a network of nerves. In the cervical, lumbar and sacral regions, the anterior rami unite near their origin to form large masses of nerves called plexuses where nerve fibres are regrouped and rearranged before proceeding to supply the concerned organ. This means that the concerned area has a nerve supply from more than one spinal nerve. There are five large plexuses of mixed nerves formed on each side of the vertebral column. They are:-

1) Cervical P.
2) Brachial P.
3) Lumbar P.
4) Sacral P.
5) Coccygeal P.

Cervical Plexus:-

It is formed by anterior rami of the first 4 cervical nerves. It lies deep within the neck opp. 1st, 2nd, 3rd, 4th cer. vertebra under the sternocleidomastoid muscle. One of the imp. nerve arcane of this Plexus is Phrenic nerve which help in initiating respiration; other nerves supply the muscles of neck.

Brachial Plexus:-

Formed by ant. rami of lower four cervical nerves and larger part of 1st thoracic nerve. This plexus is situated within the neck and shoulder and in the axilla.

The imp. nerves of this plexus are:-

1) Axillary N.
2) Radial N.
3) Musculocutaneous N.
4) Median N.
5) Ulnar N.
6) Medial cutaneous N.

Lumbar Plexus:-

It is formed by the anterior rami of the first three and part of the 4th lumbar nerves. It is situated in front of the transverse processes of the lumbar

vertebrae and is behind the Psoas muscle. The main nerves of this plexus are:-

- Ilio hypogastric N.
- Ilioinguinal N.
- Genitofemoral N.
- Femoral N
- Obturator N.

Sacral Plexus:-

It is formed by the anterior rami of the L4, 5 and 1st, 2nd and 3rd sacral nerves. It lies in the posterior wall of the Pelvic cavity. The imp. nerves of this plexus are:-

- Sciatic N.
- Tibial N.
- The Common peroneal N.
- The pudendal N.

Coccygeal Plexus:-

Very small plexus formed by part of the 4th and 5th sacral and the coccygeal nerves. The nerves from this plexus supply the skin around the coccyx and anal

Thoracic Nerves:

These nerves do not form the plexuses. They form the intercostal nerves and pass b/w the ribs and supply intercostal muscles and overlying skin. The 12th pair of thoracic N. is the subcostal N.

Cranial Nerves:

These are the nerves that emerge directly from the brain and the brainstem. They directly exchange information between the brain and various regions. Each cranial nerve is paired and is present on both sides. Depending on source there are 12 pairs of cranial nerves in humans. The 12 pairs of cranial nerves are:-

I) Olfactory (Sensory N).
II. Optic (Sensory)
III Oculomotor (motor)
IV Trochlear (motor)
V Trigeminal (Mixed)
VI Abducens (motor)
VII Facial (Mixed)
VIII vestibulocochlear (Sensory)

IX Glossopharyngeal (Mixed)
X Vagus (Mixed)
XI Accessory (Motor)
XII Hypoglossal (Motor).

I Olfactory N:-

It is the first pair of cranial nerves which is the nerve for sence of smell. The nerve fibres originate from the olfactory epithelium of the nasal cavity and pass upwards through the cribriform plate of the ethmoid bone and then pass to the olfactory bulb. The nerve then proceed backwards to the area of smell in the temporal bone of the cerebrum.

II Optic N:-

It is second pair of cranial Nerves and is the nerve for vision. Each Nerve is formed by the axons of the Neurons which arise from retina and pass posteriorly through the optic foramina of the Sphenoid bone into the cranial cavity and join at the optic chasima, where the medial fibres of this nerve

Cross to the opposite side. The nerves procede backwards as the optic tracts to the lateral geniculate bodies of the thalamus. Impulses pass from here to the visual areas in the occ occipital lobes of the Cerebrum and to the Cerebellum. Occipital lobes preceives sight and the Cerebellum contributes to the mentenence of balance, posture, orientation of the head in space.

III Occulomotor :⇒

It is the third cranial nerve and originates in the mid-brain near the Cerebral aquiduct. It innervates the :-

1) Sperior, inferior and medial rectus muscle and the inferior ~~Obliquer~~ Oblique muscle of the eye (for movement of the eye ball)
2) The levator palpebrae superiores of the eyelids (for raising upper eyelid).
3) Ciliary muscle (for contraction for near vision)
4) Sphincter muscle fibres of iris (for pupil's ~~clary~~ Constriction).

IV Trochlear nerves:-

These nerves arise from the mid brain near the cerebral aqueduct. It is the 4th cranial nerve and supplies the superior oblique muscle of the eyes.

V Trigeminal nerve

The fifth cranial N., mixed in nature and is the largest of the cranial N. It arises from the pons. As the name suggests, there are three main branches of the ~~the~~ trigeminal N. —

a) The opthalmic N - which are sensory and supply the lacrimal glands, conjuctae of the eyes, forehead, eyelids, anterior aspect of the scalp and mucous membrane of the nose.
b) The Maxillary nerves — are sensory and supply the cheeks, upper gums, upper teeth and lower eyelids.
c) The mandibular nerves — contain both sensory and motor fibres and supply the teeth, gums of the lower jaw, pinnae of the ears, lower lip and tongue and chewing muscles.

VI Abducens nerves:-

It is the 6th cranial nerve arises from the nuclei lying on the floor of the 4th ventricle. They supply the lateral rectus of the muscle of the eyeballs causing abduction.

VII Facial nerve:-

The Seventh cranial nerve, which is mixed nerve. It arises from the nuclei in the pons. The motor (efferent) fibres supply the facial muscles and control the facial expressions. The sensory (affent) fibres supply the taste buds in the anterior 2/3 of the tongue and help in the perception of the taste.

VIII. Vestibulocochlear nerve (auditory).

It is the 8th nerve and is sensory in nature. It has two divisions - the vestibular and cochlear nerve. The vestibular nerve is concerned with balance and equilibrium. It arises from semicircular canals of the inner ear and conveys impulses to the cerebellum.

The cochlear nerve originates in the spiral organ of Corti in the inner ear and conveys impulse to the hearing area of the cerebral cortex where we perceive sounds.

IX Glossopharyngeal nerve:-

The 9th cranial nerve is mixed in nature the motor fibres arise from nuclei in the medulla and stimulate the muscles of the tongue and pharynx and the secretory cells of the parotid glands.

The sensory fibres convey impulses to the cerebral cortex from the posterior 3rd of the tongue, the tonsils and pharynx and form taste buds in the tongue and pharynx. These nerves are essential for the swallowing and gag reflexes.

X Vagus nerves

It is the 10th cranial nerve and is also mixed. These nerves have the most extensive distribution of the cranial nerves. So, also by why it is called vagus meaning wander

nerve impulse or action potential. This depolarisation is very rapid ie, the nerve impulse is conducted along the whole length of the neurone in few milliseconds and this impulse is also unidirectional. Almost immediately following the entry of Na^+, K^+ ion leaves out of the neurone into the extracellular fluid thus returning the membrane potential to its resting state. This process is called repolarisation. Na^+ and K^+ are brought to the original resting state by the $Na^+ - K^+$ pump which expells Na^+ out of the cell and in exchange of the K^+.

SYNAPSE:-

Synapse is a junction between two neurones. There is no anatomical continuation but only a physiological continuity between the two nerve cells. Neurone from which the axon arises is called the presynaptic neurone and the neurone on which the axon ends is called the postsynaptic neurone. Between the

pre and post synaptic neurone there is a space called the synaptic cleft. Axon of the presynaptic neurone divides into many small branches before forming the synapse called by axon terminals. Some of the axon terminals are swollen called terminal knobs. These knobs contain the neurotransmitters filled in the synaptic vesicles. When the action potential or nerve impulse reach terminal knobs, the neurotransmitters are released by the process of exocytosis into the synaptic cleft, which then act on the specific receptor sites of post synaptic membrane, thus the nerve impulse is carried further to the post synaptic neurone through the neurotransmitters.

Neurotransmitters: It is a chemical substance that acts as a mediator for the transmiss of nerve impulse from one neurone another neurone through a synapse. Neurotransmitters are of two types:-

1) Excitatory N.T:- Those chemical substance

which are responsible for the conduction of impulse from presynaptic neurone to postsynaptic neurone. eg; Adrenaline, Noradrenaline; Acetylcholine; Histamine, nitric oxide.

2) Inhibitory neurotransmitters:-
These chemical substances which inhibit the conduction of impulse from the presynaptic neurone to the post-synaptic neurone. eg; Gamma amino-butyric acid (GABA), Dopamine etc

NEUROGLIAL

Neuroglia or glia is the supporting cell of the nervous system. These cells are non-excitable and do not transmit nerve-impulse. Neuroglia continue to replicate throughout the life. There are four types of neuroglia in the nervous system which are as:-

1) Astrocytes:-
Astrocytes are star shaped neuroglial cells present in all the parts of the brain. Astrocytes twist around the nerve cells

and form the supporting network in brain and spinal cord. They form the blood-brain barrier and they thereby regulate the entry of substances from blood into the brain tissue.

2) Oligodendrocytes:- Also called oligodendroglia are a type of neuroglia. They are smaller than astrocytes. Their main function is to provide support and insulation to the axons in CNS by producing the myelin sheath

3) Ependymal cells:- These cells form the epithelial ~~list~~ lining of the ventricles in the brain and central canal of spinal cord. They also form epithelial layer surrounding the choroid plexus which is a network of ~~blood~~ blood vessels located in the wall of the 4 ventricles which secrete CSF.

4) Microglia:- They are the smallest neuroglial cells. These cells are derived from monocytes and enter the tissues of the nervous system from blood. They phagocytes

cells migrate to the site of infection or injury and are often called the macrophages of CNS.

CENTRAL NERVOUS SYSTEM:-

The central nervous system consists of the brain and the spinal cord. The brain is enclosed within the skull and spinal cord by the vertebrae that form the spinal column. Inside the bony skull, the brain is covered by coverings called the meninges which extend down to enclose the spinal cord as well.

The Meninges:-
These are connective tissue layers collectively called meninges which cover the brain and spinal cord. They are:-
1) Duramater 2) Arachnoid mater 3. Piamater

Duramater:- It is the thick, durable, double membrane. The outer layer is attached to the inner surface of the skull bone and

inner layer which is closer to the brain. The inner layer of the duramater sweeps inwards ~~between to~~ form the following structures:-
1) falx cerebri – which separates two cerebral hemispheres,
2) Falx cerebelli – which separates the lobes of the cerebellum
3) The tentorium cerebelli:- which separates the cerebrum from cerebellum.
The duramater also forms some venous sinuses between the two layers of the duramater which carry blood. These are:-
1) Superior - Sagittal sinus formed by falx cerebri
2) straight, inferior and transverse sinus are formed by tentorium cerebelli
The subdural space is a potential space between the duramater and the arachnoid mater.
The spinal duramater extends from the foramen magnum to the 2nd sacral vertebra as the extension of the cerebral duramater and is separated from the periosteum of the vertebrae by the epidural

space. Nerves entering and leaving the spinal cord pass through the epidural space.

Arachnoid mater :-

It is the middle layer of the meninges. It is so named because of its spider-web like appearance. It is separated from the duramater by the subdural space. In some areas, it projects into the sinuses formed by the duramater. These projections are called the arachnoid villi. They transfer CSF from ventricles back into the bloodstream. The arachnoid mater along with the inner layer of duramater forms the falx cerebri, tentorium cerebelli and falx cerebelli. Cerebral arachnoid layer continues downwards as spinal arachnoid layer and ends by merging with the duramater at the level of 2nd sacral vertebra.

Pia mater :-

It is the innermost and delicate layer of the meninges. This layer closely adheres to the brain, dipping down into the sulci

covering the gyri. It is separated from the arachnoid mater by the subarachnoid space which contains the CSF. It is continued downwards surrounding the spinal cord. Beyond the cord it continues as the filum terminale finally terminating to fuse with the periosteum of the coccyx.

Cerebrospinal fluid – Formation and Circulation

Cerebrospinal fluid is a clear, colourless and transparent fluid that circulates through the ventricles of brain, subarachnoid space and central canal of spinal cord. It is a part of body's extracellular fluid.

CSF is secreted continuously at a rate of about 0.5 ml/min i.e. 720 ml per day. But the volume remains constant at about 150 ml.

Composition of CSF :-

- Water
- Proteins (albumin and globulin)
- Mineral salts
- Glucose
- Urea and creatinine
- Leucocytes

Formation of CSF :-

CSF is formed by choroid plexuses, situated within the ventricles of the brain. Choroid plexuses are a tuft of capillary projections present inside the ventricles and are covered by pia mater and ependymal coverings. A large amount of CSF is formed in the lateral ventricles.

Circulation of CSF :-

CSF circulates through following structures
- Ventricles of the brain
- Subarachnoid space
- Central canal of spinal cord.

Ventricles of brain :- The brain contains four irregular-shaped cavities or ventricles containing / secreting and circulating CSF. They are :-

1) Lateral ventricles (Right and Left) :- These are two cavities present of each hemisphere on either side of the median plane above the Corpus Callosum. They are separated from each other by septum

lucidum. They communicate with the 3rd ventricle by interventricular foramen through which the CSF enters the 3rd ventricle.

Third ventricle :- It is situated below the lateral ventricles between two parts of the thalamus. The CSF enters the 4th ventricle through the cerebral aqueduct.

Fourth ventricle :- It is situated between the cerebellum and pons behind the 3rd ventricle. It is continuous downwards as central canal of spinal cord and to the subarachnoid space by foramen in its roof. CSF enters the arachnoid space through these foramina and through the open distal end of the central canal of the spinal cord.

Major quantity of CSF is formed in lateral ventricles and enters 3rd ventricle by passing through the interventricular foramina. From here, it passes to 4th ventricle through cerebral aqueduct. CSF flows from 4th ventricle into the subarachnoid space to foramen and also into the central canal of spinal cord. CSF passes back into the blood through

These nerves form an important part of the parasympathetic nervous system. The motor fibres arise from nuclei in the medulla and supply c smooth muscle and secretory glands of the pharynx, larynx, trachea, bronchi, heart, carotid body, oesophagus, stomach, intestines, exocrine pancreas, gall bladder, bile ducts, spleen kidneys, ureters and blood vessels in the thoracic and abdominal cavities.

XI. Accessory nerves:
This is the 11th cranial nerve and is mixed in nature. These nerves arise from nuclei in the medulla oblongata and in the spinal cord. The fibres supply the sternocleidomastoid and trapezius muscle.

XII. Hypoglossal nerves:-
This the 12th cranial nerve & is a motor N. These nerves also arise from nuclei in the medulla oblongata. They supply the muscles of the tongue and muscles surrounding the hyoid bone and contribute in swallowing and speech.

AUTONOMIC NERVOUS SYSTEM:-
The autonomic nervous system also called involuntary nervous system controlls the involuntary body functions. This system is divided into two divisions:-
- Sympathetic
- Parasympathetic

The two division work in an integrated and complementary manner to maintain involuntary functions and homeostasis. Such activities include coordination and control of breathing, blood pressure, water balance, digestion and metabolic rate.

Each division has two efferent neurons b/w the central nervous system and effector org These are:-
- Preganglionic neurone
- Postganglionic neurone.

Sympathetic nervous System:-
This division is called -thoracolumbar outflo because the preganglionic neurons are situated in lateral grey horns of 12 thora and first two lumbar segments of spin

Cord. Fibres arising from here are known as preganglionic fibres. These fibres leave the spinal cord through anterior root and white rami Communicantes and terminate in the postganglionic neurons which are situated in the Sympathetic ganglia. Sympathetic ganglia division supplies smooth muscle fibres of all the visceral organs such as blood vessels, heart, lungs, glands, gastrointestinal organs etc. Post ganglionic neurone has its cell body in a ganglion and terminate in the Organ of tissue supplied.

Sympathetic Ganglia :-

Ganglia of Sympathetic division are classified into three groups :-

A- Paravertebral or lateral chain of Sympathetic G.

These chains extend from the upper cervical level to the sacrum on both sides of the spinal cord. The ganglia are attached to eachother by longitudinal fibres to form the sympathetic chains.

B) Prevertebral Ganglia :-

There are three prevertebral ganglia which receive preganglionic fibres from $T_5 - L_2$ segments. Post ganglionic fibres from these ganglia supply the visceral organs of thorax, abdomen and pelvis. These ganglia are :-

- Coeliac G.
- Superior mesenteric G.
- Inferior mesenteric G.

C) Terminal or Peripheral Ganglia :-

These ganglia are situated within or close to structures innervated by them. Heart, bronchi, pancreas and urinary bladder are innervated by the terminal ganglia.

PARA SYMPATHETIC NERVOUS SYSTEM :-

This division is also called the craniosacral outflow because the fibres of this division arise from brain and sacral segments of the spinal cord. The cranial outflow includes the Oculomotor (III) N, Facial (VII) Glosso pharyngeal (IX) N, Vagus (X) N. and the sacral outflow includes the fibres from the sacral segments 2, 3, and 4.

The nerves arising at the cranial and sacral segments are called preganglionic fibres which are longer and reach the post ganglionic neuron. Preganglionic fibres are myelinated. The post ganglionic neurons are usually very short and has its cell body either in a ganglion or in the wall of the organ supplied.

Functions of the ANS:

⇒ Sympathetic division prepares the body to deal with exciting, emmergency and stressfull conditions also the emotional states like fear, anger etc. This causes the adrenal glands to secrete the hormones adrenaline and noradrenaline into the bloodstream. These hormones act as neurotransmitters when they reach target organs of the sympathetic nervous system.

⇒ Parasympathetic division has a tendency to slow down cardiac and respiratory activity but it stimulates digestion and absorption of food

and the functions of the genitourinary system. Its general effect is that of a peace maker.

Normally two system function together maintaining a regular heart beat, normal temperature and an internal environment compatible both with physiological needs and the immediate external surroundings

Effects of ANS on the body:-

Region	Sympathetic	Parasympathetic
Eye	dilates pupils	Constricts pupils
Lacrimal Glands	↓ secretion	↑ secretion
Salivary G.	↓ secretion	↑ secretion
Heart	- Uses strength and rate	- ↓ strength and heart rate
Lungs	- Dilates bronchioles and - Uses ventillation rate	- Constricts bronchioles and ↓ uses ventillation rate.
Gut	- Inhibits Peristalsis - Inhibits Secretion of alimentary juices - contracts and sphincter muscles.	- Stimulates presistalsis - stimulates secretion of digestive juices - Relaxes the anal Sphincter.

Blood	- Rises blood Pressure - Rises blood volume by contraction of spleen.	- ↓ blood Pressure
Skin	- Contracts hair erector pi muscles cause goose bumps - Constricts arterioles in the skin of limbs (skin whitens) - Rises the secretion of sweat.	- none - ⊗ - Dilates arterioles in the skin (skin reddens).
Kidney	Decreases Urine output.	none
Bladder	Contracts bladder sphincter muscle	Inhibits contraction of bladder sphincter muscles.
Urethral and Anal Sphincter	↑ tone thus inhibiting defecation and micturition	↓ tone and causes micturition and defecation.

Difference b/w Sympathetic & Parasympathetic Division

Feature	SYMPATHETIC	PARASYMPATHETIC
- Origion of neurones:-	Thoracic and lumbar regions (T_{1-12} and $L_{1,2}$)	Cranial & sacral regions (III, VII, IX, X C.N and $S_{2,3,4}$).
- Position of ganglion	Close to spinal cord	close to effector organ.
- Length of fibres	Short Preganglionic & long Post ganglionic F.	long Preganglionic & short Post ganglionic F.
- No. of fibres	Numerous postganglion fibres	few postganglionic f
- Neurotransmitter	Noradrenaline released at effector	Acetylcholine released at effector.
- overall effect	Excitatory homeostatic effect	Inhibitory homeostatic effect
- Conditions when active	Dominant during danger, stress & activity, Controls Reactions to stress	Dominant during Rest. Controls & conserve body activities.