VISWASS SCHOOL & COLLEGE OF NURSING

GNM 1ST YEAR

ANATOMY AND PHYSIOLOGY

UNIT-11

THE NERVOUS SYSTEM

LONG QUESTIONS AND ANSWERS

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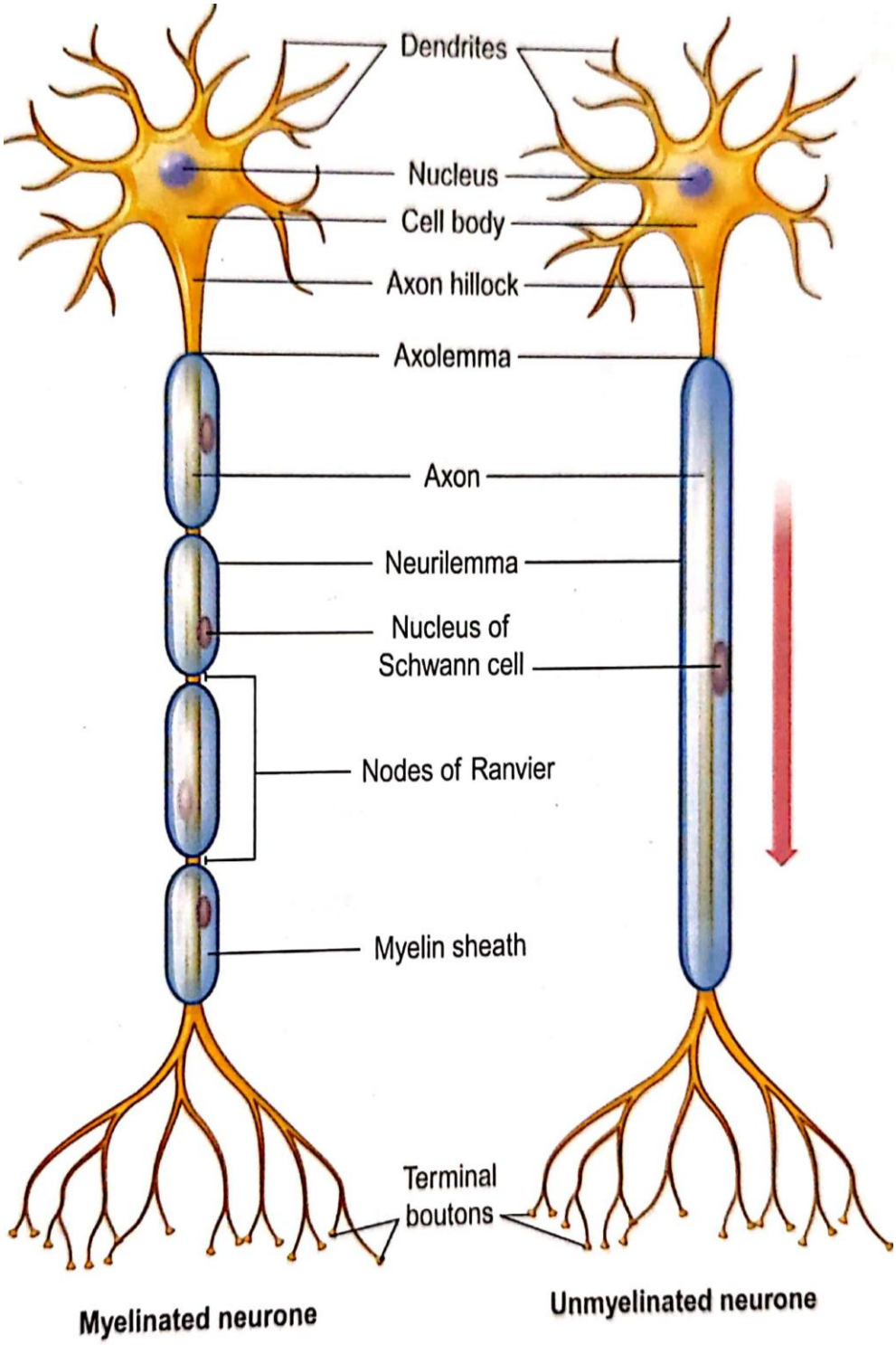
1)a)Explain about neurons.

b)Describe the detail about spinal cord. (8+7)

a)Neurones:

- Each neurone consists of a cell body and its processes:one axon and , usually, many dendrites.
- Neurones are commonly referred to as nerve cells.
- Neurons cannot divide, and for survival they need a continuous supply of oxygen and glucose.
- Unlikes many other cells, neurons can normally synthesis chemical energy. Only from glucose.
- Neurons generate and transmit electrical impulses called action potentials.
- The initial strength of the action potential is maintain through out the length of the neuron.
- Action potentials can be initiated in response to stimuli from:
    - Out side the body, e.g. touch, light waves
    - Inside the body, e.g. a change in the concentration of carbon dioxide in the blood alters respiration; a thought may result in voluntary movement.



Cell bodies:

- Nerve cells very considerably in size and shape but they are all too small to be seen by the naked eye.

- Cell bodies form the gray matter of the nervous system and are found at the periphery of the brain and in the central of the spinal cord.
- Groups of cell bodies are called nuclei in the CNS and ganglia in the PNS. An important exception is the basal ganglia situated within the cerebrum.

Axons & dendrites:

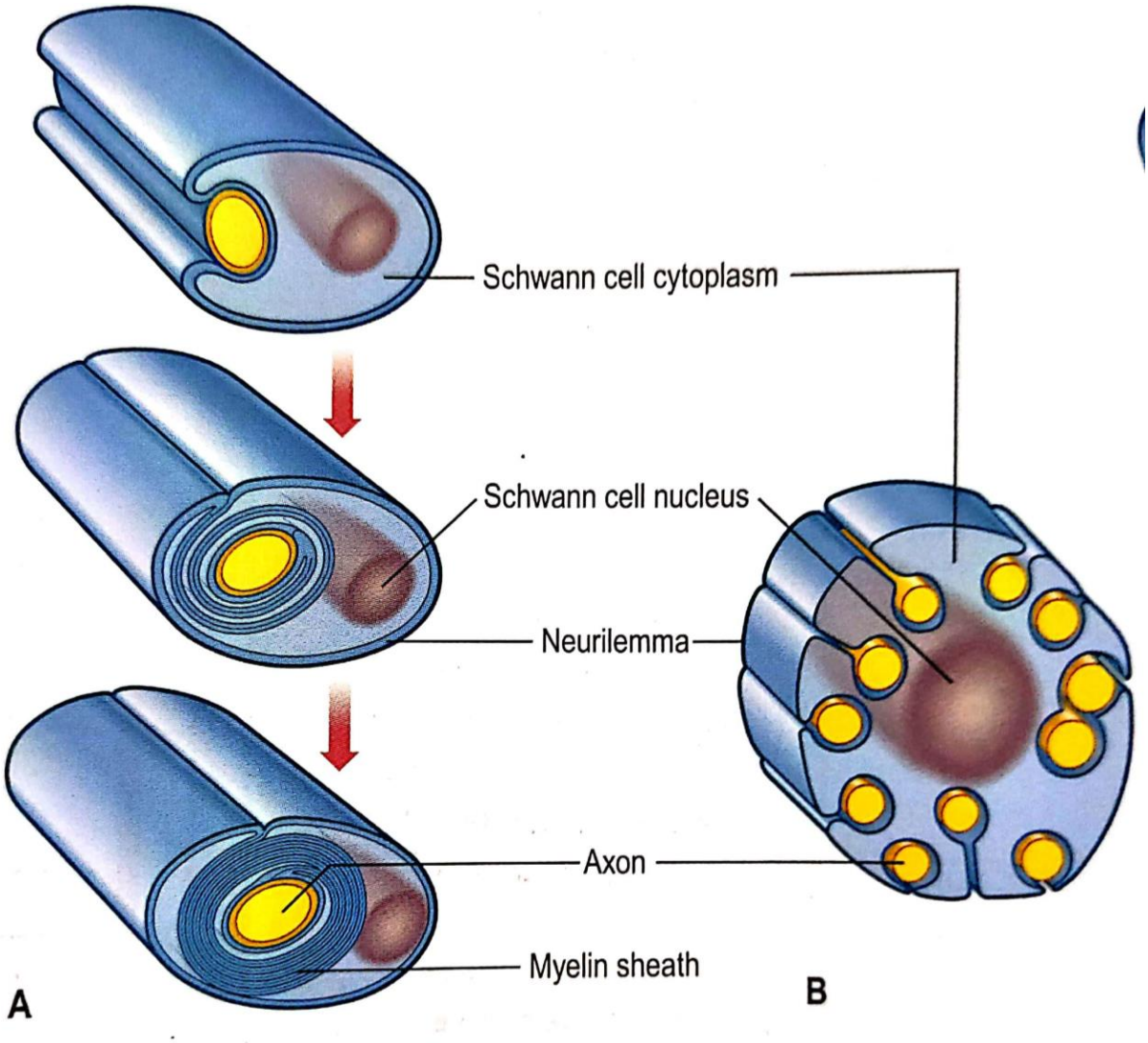
Axons and dendrites are extensions of cell bodies and form the white matter of the nervous system. Axons are found deep in the brain and in groups, called tracts, at the periphery of the spinal cord. They are referred to as nerves or nerve fibres outside the brain and spinal cord.

Axons:

- Each nerve cell has only one axon, which begins at a tapered area of the cell body, the axon hillock.
- Axons carry impulses away from the cell body and are usually much longer then the dendrites, some times as long as 100 cm.

Structure of axon:

- The membrane of the axon is called the axolemma and it encloses the cytoplasmic extension of the cell body.
- Myelinated neurons: large axons and those of peripheral nerves are surrounded by a myelin sheath.
  This consist of a series of Schwann cells arranged along the length of the axon.
  Each one is wrapped around the axon so that it is covered by a number of concentric layers of Schwann cell plasma membrane.
  Between the layers of plasma membrane is a small amount of fatty substance called myelin.
  The outermost layer of the Schwann cell plasma membrane is the neurilemma.
- Unmyelinated neurons: postganglionic fibres and some small fibres and some small fibres in the CNS are unmyelinated.
  In this type, several axons are embedded in one Schwann cell.
  The adjacent Schwann cells are in close association and there is no exposed axolemma.
  Conduction of action potentials is significantly slower in unmyelinated fibres.



Dendrites:

- These are the many short processes that receive and carry incoming action potentials towards cell bodies.
- They have the same structure as axons but are usually shorter and branching.
- In motor neurons dendrites form part of synapses and in sensory neurons they form the sensory receptors that respond to specific stimuli.

The action potential(nerve impulse)

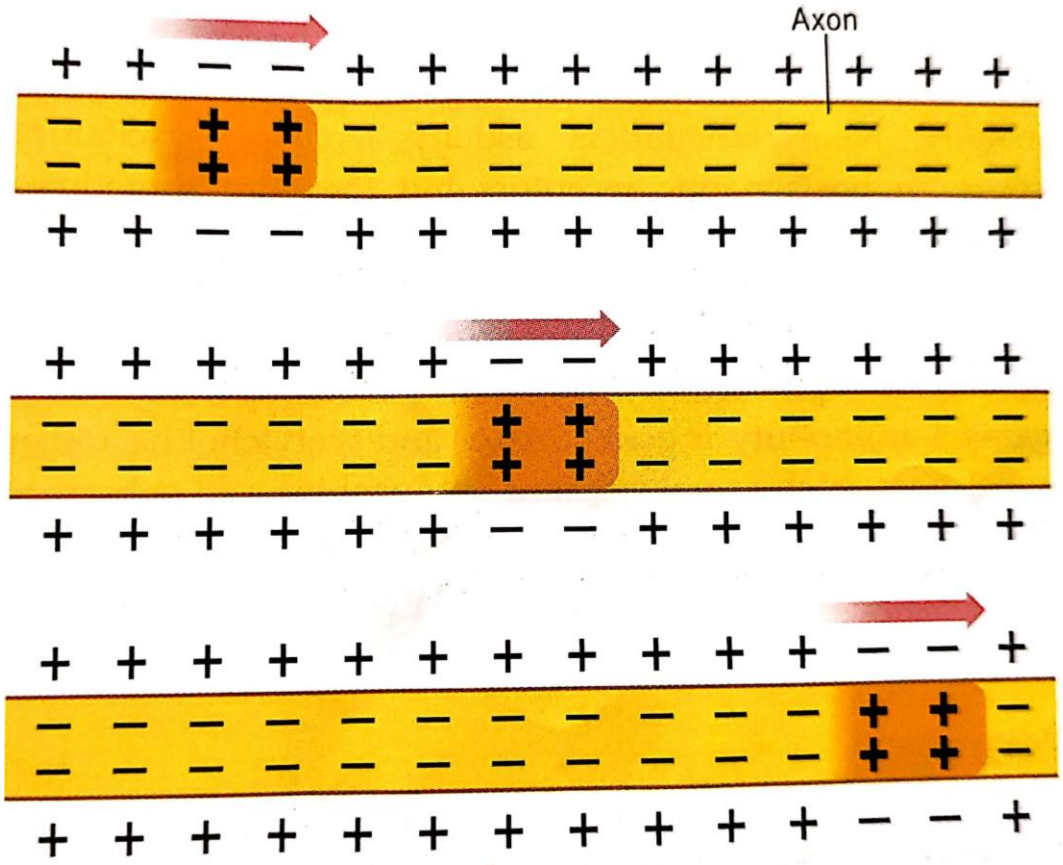
- An impulse is initiated by stimulation of sensory nerve endings or by the passage of an impulse from another nerve.

- Transmission of the action of the action potential is carried out by movement of ions across the nerve cell membrane is polarized due to differences in the concentrations of ions across the plasma membrane.
- This means that there is a different electrical charge on each side of the membrane, which is called the resting membrane potential.
- At rest the charge on the outside is positive and inside it is negative.
- The principal ions involved are:

  Sodium(Na^+), the main extracellular cation

  Potassium (K^+), the main intracellular cation
- In the resting state there is a continual tendency for these ions to diffuse down their concentration gradients, i.e. K^+ outwards and Na^+ into cells.
- When stimulated, the permeability of the nerve cell membranes to these ions changes.
- In response to the arrival of an action potential, sodium channels in the membrane open and Na^+ floods into the neuron from the extracellular fluid.
- This causes depolarization and triggers an action potential.
- Depolarization is very rapid, enabling the conduction of a nerve impulse along the entire length of a neuron in a few milliseconds.
- It passes from the point of stimulation in one direction only, i. e. away from the point of stimulation towards the area of resting potential.
- Action potential transmission along a nerve os one-way because the membrane behind the travelling action potential is temporarily unexcitable until repolarisation occurs.
- Almost immediately following the entry of Na^+, K^+ channels open and K^+ floods out of the neurons.
- The movement of these ions returns the membrane potential to its resting state.
- This is called the refractory period, during which restimulation is not possible.
- The action of the sodium-pottasium pump, which is in continual operation, expels Na^+ from the cell in exchange for K^+ , returning levels of Na^+ and K+ to the original resting state and repolarising the neurons.
- In myelinated neurons the insulating properties of the myelin sheath prevent the movement of ions.
- Therefore electrical changes across the membrane can occur only at the gaps in the myelin sheath, i.e. at the nodes of Ranvier.

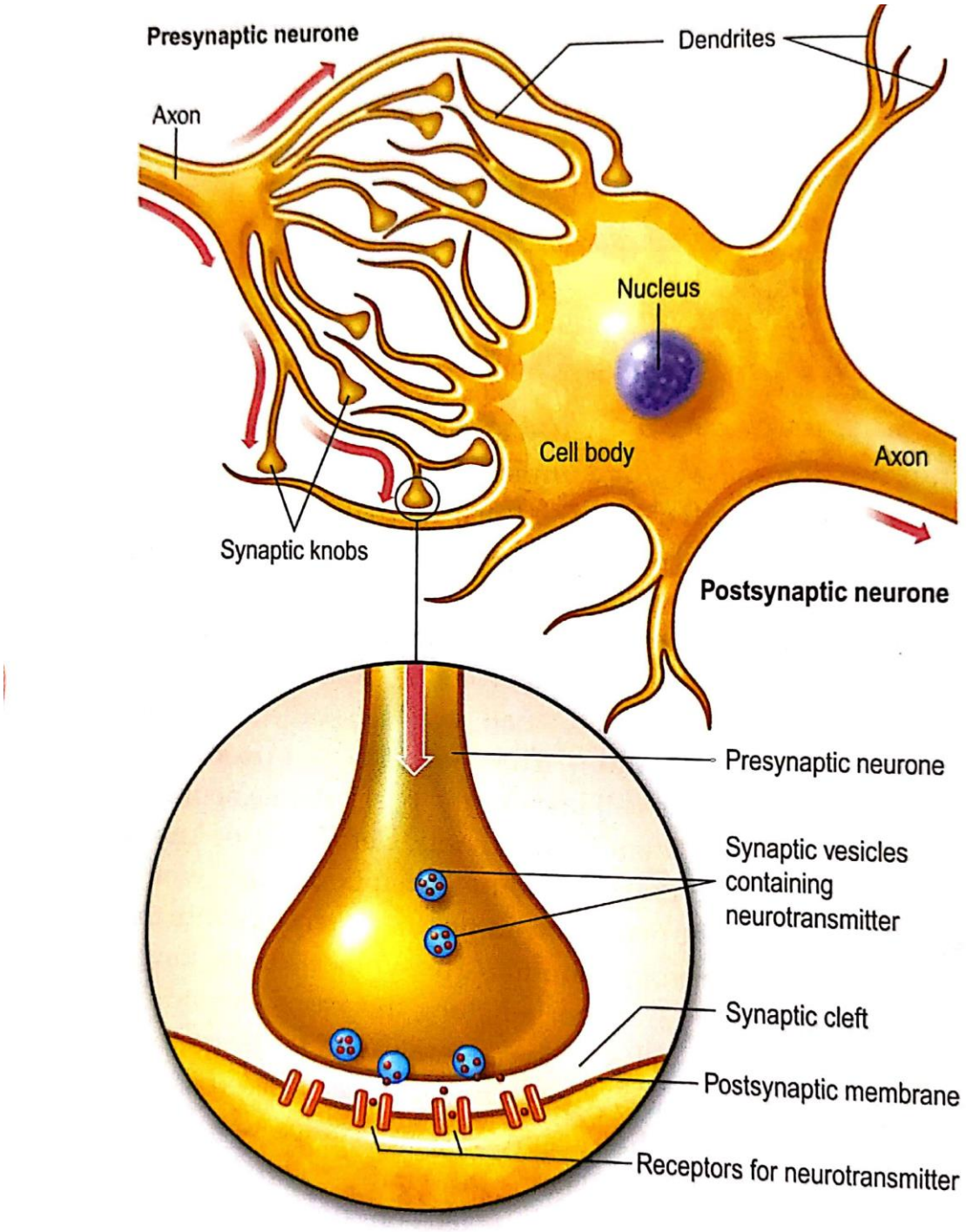
- When an impulse occurs at one node, depolarization passes along the myelin sheath to the next node, so that the flow of current appears to `leap` from one node to the next. This is called `saltatory conduction`.
- The speed of conduction depends on the diameter of the neuron: the larger the diameter, the faster the conduction.



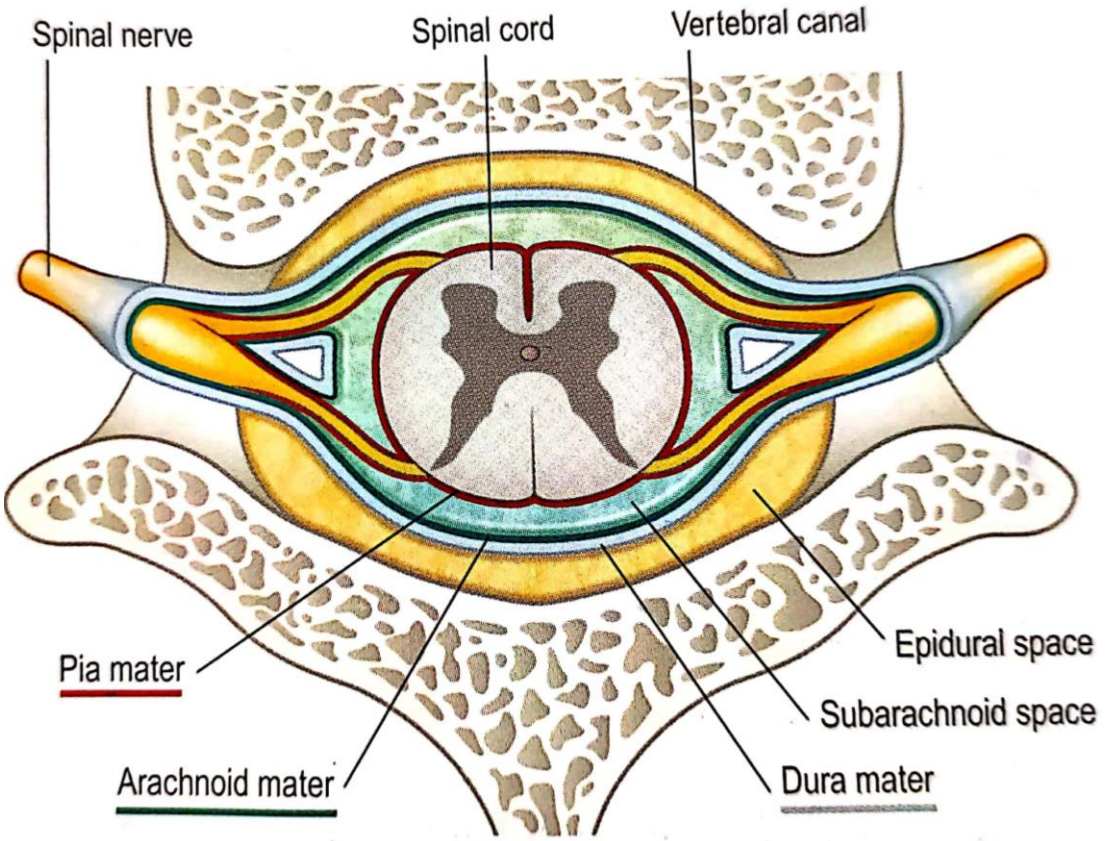
The synapse and neurotransmitters:

- There is always more than one neuron involved in the transmission of a nerve impulse from its origin to its destination, whether it is sensory or motor.
- There is no physical contact between two neurons. The point at which the action potential passes from the presynaptic neuron to the postsynaptic neuron is the synapse.
- At its free end, the axon of the presynaptic neuron break up into minute branches that terminate in small swellings called synaptic knobs, or terminal boutons.
- These are in close proximity to the dendrites and the cell body of the postsynaptic neuron.

- The space between them is the synaptic cleft. Synaptic knobs contain spherical membrane-bound synaptic vesicles, which store a chemical the neurotransmitter that is released into the synaptic cleft.
- Neurotransmitters are synthesized by nerve cell bodies, actively transported along the axons and stored in th synaptic vesicles.
- They are released by exocytosis in response to the action potential and diffuse across the synaptic cleft, where they act on specific receptor sites on the postsynaptic membrane.

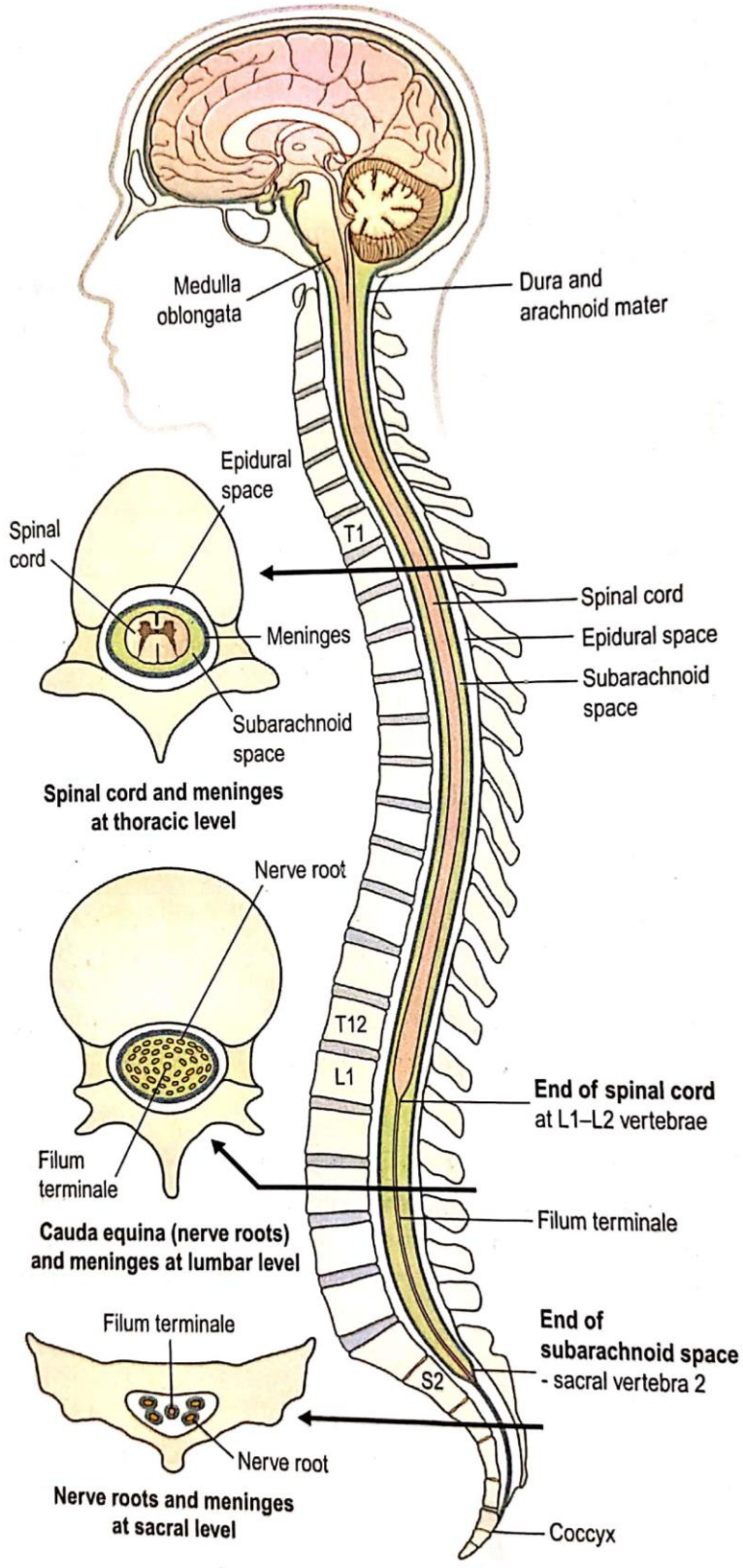


b)Spinal cord:



- The spinal cord is an elongated, almost cylindrical part of the CNS, which is suspended in the vertebral canal surrounded by the meninges and CSF.
- The spinal cord is continuous above with the medulla oblongata and extends from the upper border of the atlas to the lower border of the 1st lumber vertebra.
- It is approximately 45cm long in adult males and is about the thickness of the little finger.
- Except for the cranial nerves, the spinal cord is the nervous tissue link between the brain and the rest of the body.
- Nerves conveying impulses from the brain to the various organs and tissues descend through the spinal cord.
- At the appropriate level they leave the cord between adjacent vertebrae and pass to the structure they supply.
- Similarly, sensory nerves from organs and tissues enter and pass upwards in the spinal cord to the brain.
- Some activities of the spinal cord are independent of the brain and are controlled at the level of the spinal cordby spinal reflexes.

- To facilitate these, there are extensive neuron connections between sensory and motor neurons at the same or different levels in the cord.
- A cross section of the spinal cord shows that it is almost completely divided into two equal part:anteriorly by a short, shallow median fissure and posteriorly by a deep narrow septum, the posterior median septum.
- It is composed of grey matter in the centre surrounded by white matter supported by neuroglia.
- Two bundles of nerve fibres merge into each side of the spinal cord. Known as nerve roots, those of the dorsal nerve roots carry sensory nerve impulses into the spinal cord while the fibres of the ventral nerve root carry motor impulses away from the spinal cord.


Medulla oblongata
Dura and arachnoid mater
Epidural space
Spinal cord
Meninges
Subarachnoid space
Spinal cord and meninges at thoracic level
T1
Spinal cord
Epidural space
Subarachnoid space
Nerve root
Filum terminale
Cauda equina (nerve roots) and meninges at lumbar level
T12
L1
End of spinal cord at L1–L2 vertebrae
Filum terminale
Filum terminale
Nerve root
Nerve roots and meninges at sacral level
End of subarachnoid space - sacral vertebra 2
S2
Coccyx

Gray matter:

- The arrangement of gray matter in the spinal cord resembles the shape of the letter H, having two posterior, two anterior and two lateral column.
- The gray column extend the length of the spinal cord, containing the cell bodies of the neurons that run up and down the cord.
- The area of gray matter lying transversely is the transverse commissure and it is pierced by the central canal, an extension from the fourth ventricle containing CSF.
- The nerve cell bodies may belong to:
    - Sensory neurons, which receive impulses from the periphery of the body
    - Lower motor neurons, which transmit impulses to the skeletal muscles
    - Interneurons, which directly link a sensory and a motor neuron to form a reflex arc.
- The sensory and motor nerves may enter and leave the spinal cord at the same or at different levels.

  Posterior column of gray matter:
    - There are composed of the cell bodies of sensory nerves, which carry information from the body up to the brain.
    - The nerve fibre of these cells of contribute to the white matter of the cord and transmit the sensory impulses upwards to the brain.

  Anterior column of gray matter:

    - These are composed of the cell bodies of the lower motor neurons or the inter neurons linking the anterior or posterior columns to form reflex arcs.

<u>White matter:</u>

- The white matter of the spinal cord is arranged in 3 columns or tracts anterior, posterior or lateral.
- These tracts are formed by sensory nerve fibres ascending to the brain, motor nerve fibres descending from the brain and fibres of interneurons.
- Tracts are often named according to their points of origin and destination, e.g. spinothalamic, corticospinal.

Sensory nerve tracts in the spinal cord:

Neurons that transmit impulses toward the brain called sensory. These are two main sources of sensation transmitted to the brain via the spinal cord.

The skin:

The sensory receptors in the skin are stimulated by pain, heat, cold and touch, including pressure.

The tendons, muscles and joints:

Sensory receptors are specialized nerve endings in these structures, called proprioceptors, and they are stimulated by stretch.

Motor nerve tracts in the spinal cord:

Neurons that transmit nerve impulses away from the brain are motor neurons. Stimulation of motor neurons result in :

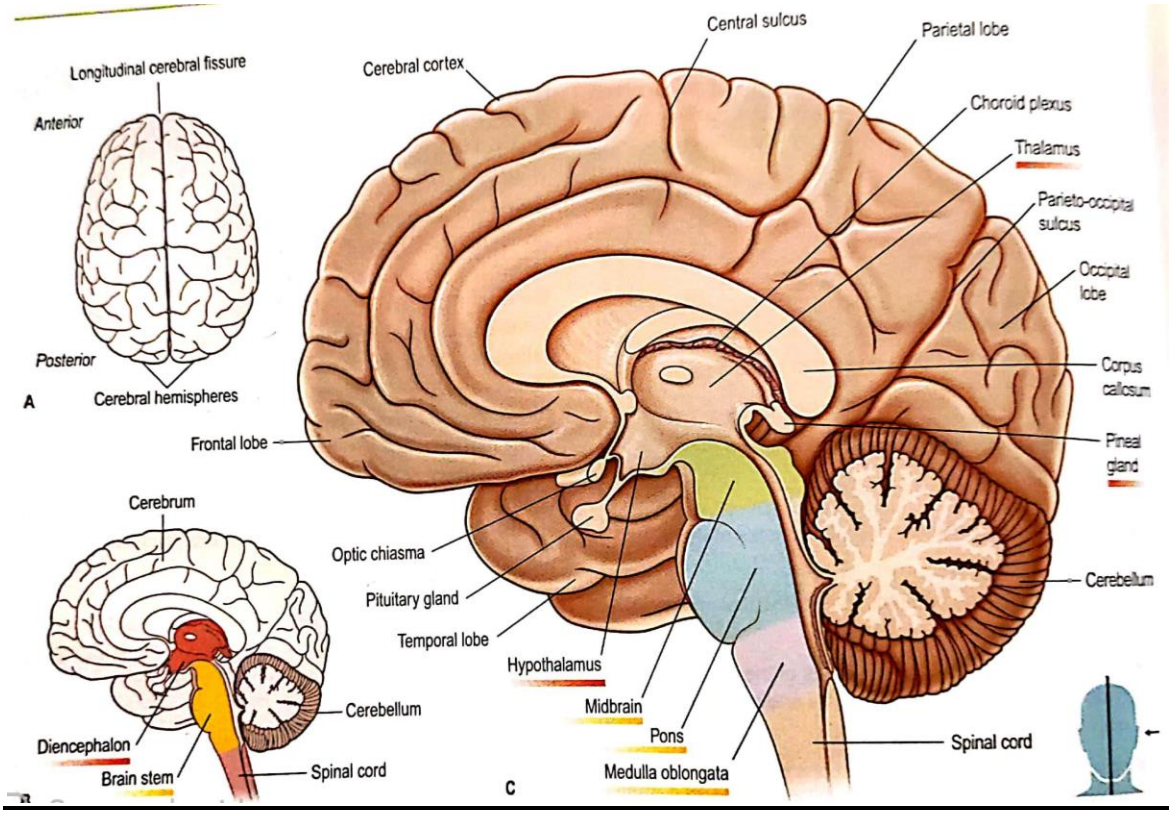
- Contraction of muscle
- Glandular secretion

2)a)Draw the diagram of the Human brain.

b)Explain the details about brain.

c)write down the functions of cerebrospinal fluid. (5+7+3)

a)<u>Diagram of the human brain</u>



b)<u>Brain:</u>

The brain is a large organ weighing around 1.4 kg, which lies with in the cranial cavity. Its parts are:

- Cerebrum
- Thalamus
- Hypothalamus
- Mid brain
- Pons
- Medulla oblongata
- Cerebellum

Blood supply and venous drainage:

- The circular arteriosus and its contributing arteries play a vital role in maintaining a constant supply of oxygen and glucose to the brain when the head is moved and also when a contributing artery is narrowed.
- The brain receives about 15% of the cardiac output, approximately 750 mL of blood per minute.
- Auto regulation f cerebral arteriolar diameter maintains a constant blood flow to the brain, compensating for fluctuations in systemic blood pressure.
- This mechanism protects the brain, provided that systemic blood pressure remains within the 65-140 mmHg range.
- Venous blood from the brain drains into the dural venous sinuses and then downwards into the internal jugular veins.

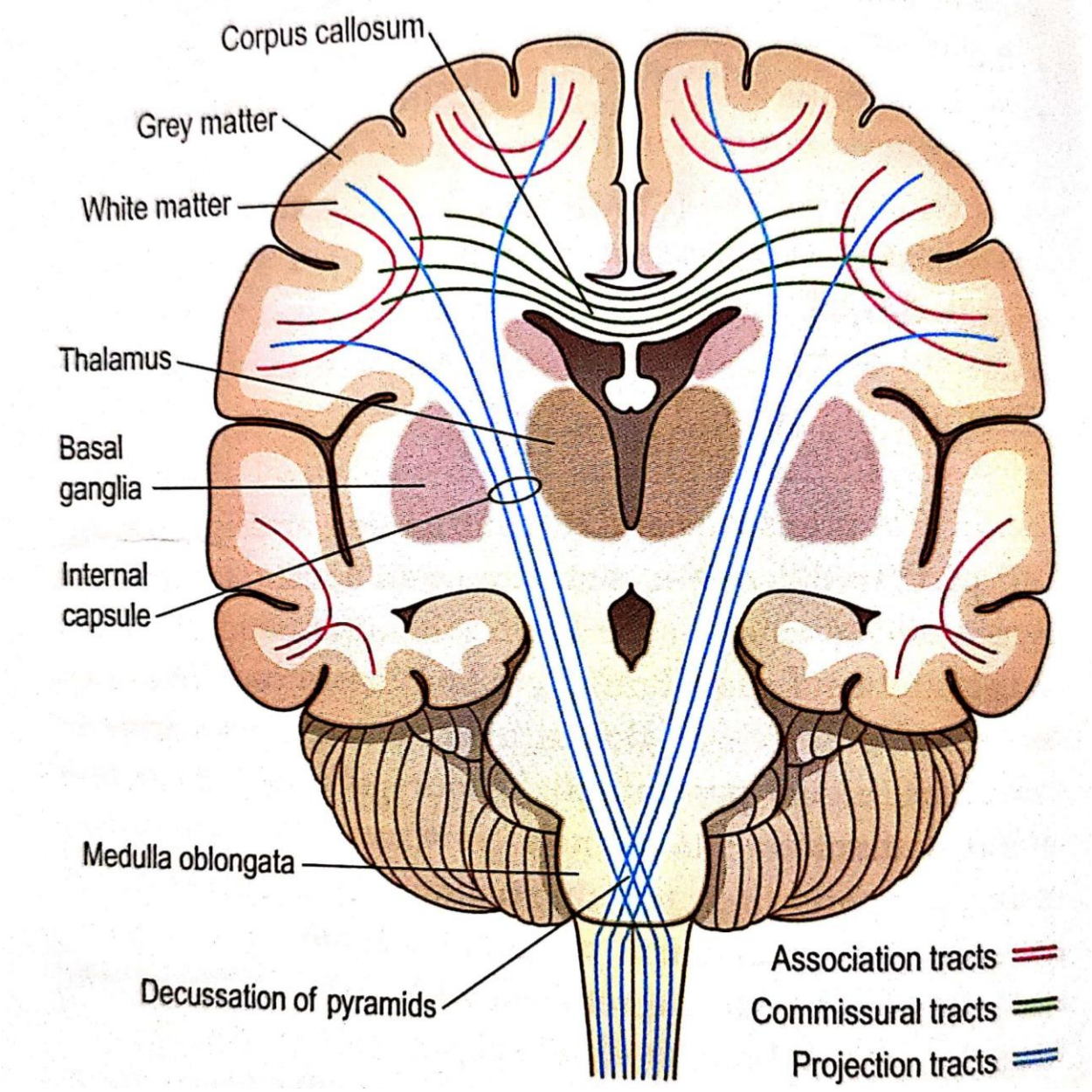
❖ <u>CEREBRUM</u>

- This is the largest part of the brain and it occupies the anterior and middle cranial fossae.
- It is divided by a deep cleft, the longitudinal cerebral fissure, into right and left cerebral hemispheres, each containing one of the lateral ventricles.
- Deep within the brain, the hemispheres are connected by a mass of white matter (nerve fibres) called the corpus callosum.
- The falx cerebri is formed by the dura mater.
- It separates the two cerebral hemispheres and penetrates to the depth of the corpus callosum.

- The superficial part of the cerebrum is composed of nerve cell bodies (grey matter), forming the cerebral cortex, and the deeper layers consist of nerve fibres (axons,white matter).
- The surface of the cerebral cortex shows many infoldings or furrows of varying depth.
- The exposed areas of the folds are the gyri(convolutions) and these are separated by sulci(fissures).
- These convolutions greatly increase the surface area of the cerebrum.
- For descriptive purposes, each hemisphere of the cerebrum is divided into lobes, which take the names of the bones of the cranium above them:
    - Frontal
    - Parietal
    - Temporal
    - Occipital
- The boundaries of the lobes are marked by deep sulci.
- These are the central, lateral and parieto-ocipital sulci.

<u>Cerebral tracts and basal ganglia:</u>

- The surface of the cerebral cortes is composed of grey matter (nerve cel bodies).
- Within the cerebrum the lobes are connected by mases of nerve fibres, or tacts, which make up the white matter of the brain.
- The afferent and efferent fibres linking the different parts of the brain and spinal cord are:
    - Association (arcuate) tracts, which are most numerous and connect different parts of a cerebral hemisphere by extending from one gyrus to another, some of which are adjacent and some distant.
    - Commissural tracts, hich connect corresponding areas of the two cerebral hemispheres; the largest and most important commissure is the corpus callosum.
    - Projection tracts, which connect the cerebral cortex with gyey matter of lower parts of the brain and with the spinal cord, e.g. the internal capsule.
- The internal capsule is an important projection tract that lies deep within the brain between the basal ganglia and the thalamus.



Basal ganglia:

- The basal ganglia are groups of cell bodies that lie deep within the brain and form part of the extrapyramidal tracts.
- They act as relay stations with connections to many parts of the brain, including motor areas of the cerebral cortex and thalamus.
- Their functions include initiation and fine control of complex movement and learned coordinated activities, such as posture and walking.
- If control is inadequate or absent, movements are jerky, clumsy and uncoordinated.

Functions of the cerebral cortex:

- There are many types of activity associated with the cerebral cortex:
    - Higher-order functions, e.g. language, memory, sense of responsibility, thinking, reasoning, moral decision making and learning
    - Sensory perception, including the perception of pain, temperature, touch, sight, hearing, taste and smell
    - Initiation and control of skeletal muscle contraction and therefore voluntary movement.

Functional areas of the cerebral cortex

- The main functional areas of the cerebral cortex have been identified but it is unlikely that any area is associated exclusively with one function.
- Except where specially mentioned, the different areas are active in both hemispheres; however, there is some variation between individuals.
- There are different types of functional area:
    - Motor, which direct skeletal (voluntary) muscle movement
    - Sensory, which receive and decode sensory impulses, enabling sensory perception
    - Association, which are concerned with integration and processing of complex mental functions such as intelligence, memory, reasoning, judgement and emotions.
- In general, areas of the cortex anterior to the central sulcus are associated with motor functions, and those lying posterior to it are associated with sensory functions.

Motor areas of the cerebral cortex:

- Primary motor area

- This lies in the frontal lobe, immediately anterior to the central sulcus.
- The cell bodies are pyramid-shaped and they control skeletal muscle activity.
- Two neurones are involved in the pathway to skeletal muscle.

- The first, the upper motor neurone, descends from the motor cortex through the internal capsule to the medulla oblongata.
- Here it crosses to the opposite side and descends in the spinal cord.
- At the appropriate level in the spinal cord it synapses with a second neurone (the lower motor neurone), which leaves the spinal cord and travels to the target muscle.
    - Motor speech (Broca's) area
- This is situated in the frontal lobe just above the lateral sulcus and controls the muscle movements needed for speech.
- It is dominant in the left hemisphere in right-handed people and vice versa.

DIENCEPHALON:

- The diencephalon connects the cerebrum and the midbrain.
- It consists of several structures situated around the third ventricles, the main ones being the thalamus and hypothalamus, which are considered here.
- The pineal gland and the optic chiasma are also situated there.

❖ Thalamus

- This consists of two masses of grey and white matter situated within the cerebral hemispheres just below the corpus callosum, one on each side of the third ventricle.
- Sensory receptors in the skin and viscera send information about touch, pain and temperature, and input from the special sense organs travels to the thalamus, where there is recognition, although only in a basic form, as refined perception also involves other parts of the brain.
- The thalamus is thought to be involved in arousal, and the processing of some emotions and complex reflexes,
- It relays and redistributes impulses from most parts of the brain to the cerebral cortex.

❖ Hypothalamus

- The hypothalamus is a small but important structure, which weighs around 7g and consists of a number of nuclei.
- It is situated below and in front of the thalamus, immediately above the pituitary gland.
- The hypothalamus is linked to the posterior lobe of the pituitary gland by nerve fibres and to the anterior lobe by a complex system of blood vessels.
- Through these connections the hypothalamus controls the output of hormones from both anterior and posterior lobes of the pituitary gland.
- Other functions of the hypothalamus include control of:
    - Effectors of the autonomic nervous system
    - Appetite and satiety
    - Thrist and water balance
    - Body temperature
    - Emotional reactions, e.g. pleasure, fear, rage, sexual arousal
    - Circadian rhythms, including sleeping and waking cycles.

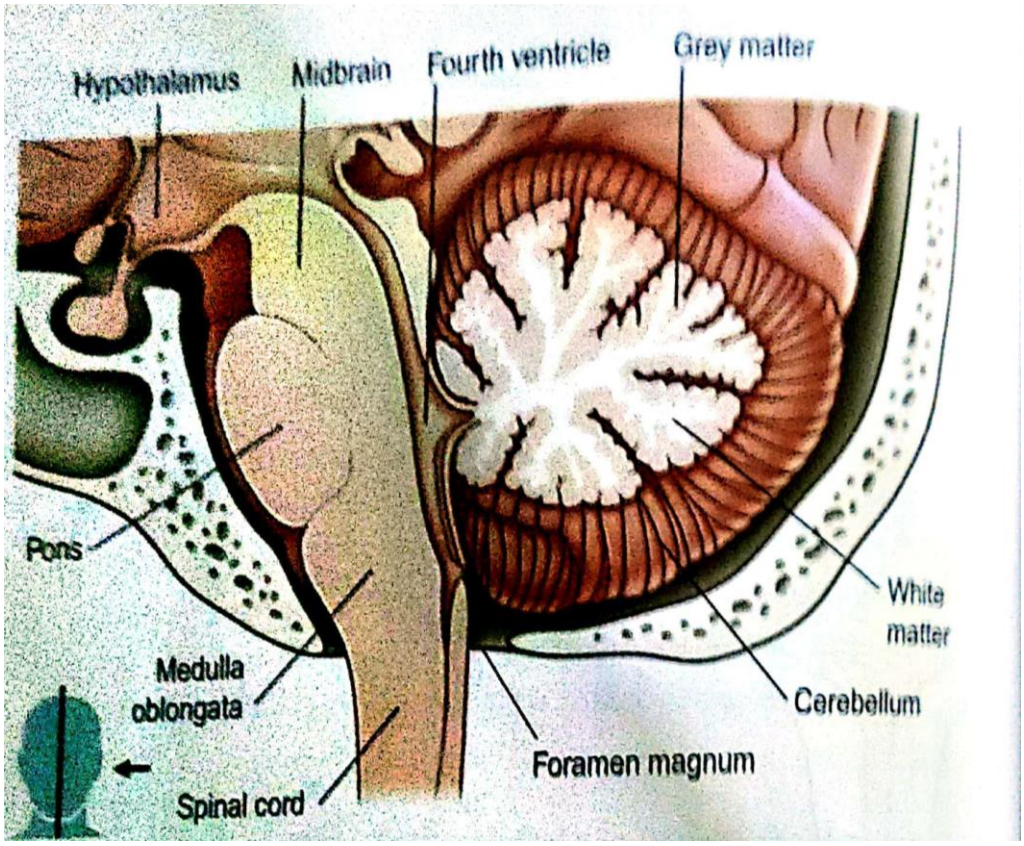
BRAIN STEM

- Midbrain
    - The midbrain is the area of the brain situated around the cerebral adequate between the cerebrum above and the pons below.
    - It consists of nuclei and nerve fibres (tract), which connect the cerebrum with lower parts of the brain and with the spinal cord.
    - The nuclei act as relay stations for the ascending and descending nerve fibres and have important roles in auditory and visual reflexes.
- Pons
    - The pons is situated in front of the cerebellum, below the midbrain and above the medulla oblongata,
    - It consists mainly of nerve fibres (white matter) that form a bridge between the two hemispheres of the cerebellum, and of fibres passing between the higher levels of the brain and the spinal cord.

- The pons also processes information from several of the cranial nerves, including the 5th cranial nerve (sensory information from the face, scalp, mouth and nose, and motor control of chewing) and 8th cranial nerve (hearing and balance).
- In addition, the pons contains the pneumotaxic area that operates in conjuction with the respiratory centre in the medulla oblongata to control respiration.
- The anatomical structure of the pons is opposite to that of the cerebrum, in that the cell bodies (grey matter) lie deeply and the nerve fibres are on the surface.

❖ <u>Medulla oblongata</u>

- The medulla oblongata, or simply the medulla, is the most inferior region of the brain stem.
- Extending from the pons above, it is continuous with the spinal cord below.
- It is about 2.5cm long and lies just within the cranium, above the foramen magnum.
- Its anterior and posterior surfaces are marked by central fissures.
- The outer aspect is composed of white matter, which passes between the brain and the spinal cord, and grey matter, which lies centrally.
- Some mendullary nerves relay information from the special senses of hearing and balance to higher centres in the brain.
- The vital centres, consisting of groupsof cell bodies (nuclei) associated with autonomic reflex activity, lie in its deeper structure.
- These are the:
    - Cardiovascular centre
    - Respiratory centre
    - Reflex centres of vomiting, coughing, sneezing and swallowing.



c)<u>Cerebrospinal fluid:</u>

- CSF circulates constantly from the ventricles through the subarachnoid space around the brain and spinal cord,
- CSF is a clear, slightly alkaline fluid with a specific gravity of 1.005, consisting of:
    - Water
    - Mineral salts
    - Glucose
    - Plasma proteins: small amounts of albumin and globulin
    - A few leukocytes
    - Small amount of creatinine
    - Small amounts of urea

<u>Functions of cerebrospinal fluid:</u>

- CSF supports and protects the brain and spinal cord by maintaining a uniform pressure around these vital structures and by acting as a cushion or shock absorber between the brain and the skull.
- CSF keeps the brain and spinal cord moist and there may be exchange of nutrients and waste products between CSF and the interstitial fluid of the brain.
- CSF is involved in regulation of breathing, as it bathes the surface of the medulla where the central respiratory chemoreceptors are located.