CHAPTER

18 NEURAL CONTROL AND COORDINATION

CLASS 11TH

NCERT EXERCISE AND SOLUTIONS - BIOLOGY

Q. 1. Briefly describe the structure of the Brain

ANSWER:-

1. The brain is the central organ for processing information in the body, functioning as the 'command and control system.' It is protected within the skull.
2. The brain is covered by three membranes called cranial meninges: the outermost layer, the dura mater, is tough and fibrous; the middle layer, the arachnoid, is delicate and thin; and the innermost layer, the pia mater, is an extension of the brain tissue, rich in blood vessels.
3. The brain consists of three main regions:
   (i) Forebrain
   (ii) Hindbrain
   (iii) Midbrain

Forebrain – Comprising three key parts: the cerebrum, hypothalamus, and thalamus

→ **Cerebrum:** The largest and most important part of the brain, divided into two cerebral hemispheres by a deep cleft. These hemispheres are connected by the corpus callosum, a bundle of nerve fibers. The cerebrum has an inner medulla and an outer cortex. The cortex, made up of neuron cell bodies, appears grey and is called grey matter. It features grooves (sulci) and folds (gyri), with more convolutions indicating higher intelligence. The cortex includes sensory, motor, and association areas, which are responsible for functions like communication, memory, and sensory integration. The medulla, made of axons, appears white and is called white matter. Deep within the cerebrum are structures like the amygdala and hippocampus, forming the limbic system.

Role – The cerebrum controls memory, intelligence, consciousness, voluntary actions, and willpower.

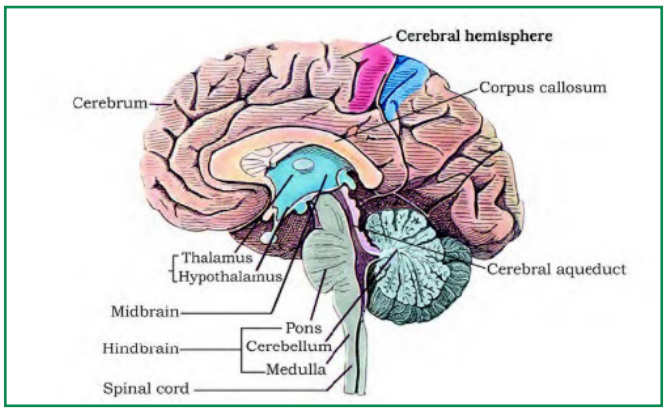
→ **Thalamus:** Made of grey matter and located above the midbrain.

Role – It relays motor and sensory impulses to the cerebrum and plays a role in emotional expression, as well as the perception of heat, pain, and cold.

→ **Hypothalamus:** Positioned below the thalamus, it contains the optic chiasma where the optic nerve fibers cross, and the infundibulum, a greyish projection containing the pituitary gland.

Role – The hypothalamus regulates body temperature, homeostasis, blood pressure, and appetite. It also governs sleep, fatigue, thirst, pleasure, anger, and remorse. Its neurosecretory

cells produce hormones that control the pituitary gland, influencing various body functions, including sexual behavior.



Midbrain: Composed of the cerebral peduncles and the corpora quadrigemina.

→ **Cerebral Peduncles:** Thick fibrous tracts connecting the cerebrum and cerebellum.

Role – They relay sensory and motor impulses between the hindbrain and forebrain.

→ **Corpora Quadrigemina:** Located in the dorsal part of the brain, consisting of two pairs of lobes: the superior colliculi (visual reflexes) and inferior colliculi (auditory reflexes).

Role – They control visual and auditory reflexes, as well as the movement of the eyes and head in response to stimuli.

Hindbrain: Includes the cerebellum, pons varolii, and medulla oblongata.

→ **Cerebellum:** Situated at the back of the brainstem, with grey matter on the outside and white matter on the inside. It is connected to the cerebrum and medulla oblongata through fiber tracts.

Role – It coordinates balance and muscular activity, controlling voluntary movements initiated by the cerebrum.

→ **Pons Varolii:** A thick bundle of white nerve fibers above the medulla oblongata.

Role – It synchronizes the activities of the cerebellum's lobes and houses the pneumotaxic center, which controls breathing.

→ **Medulla Oblongata:** Conical in shape and located at the base of the skull, it connects the brain to the spinal cord.

Role – It conducts nerve impulses between the spinal cord and brain and regulates vital functions such as breathing, heartbeat, and internal organ control. An injury here can be fatal.

Q. 2. Compare the following:

(a) Central neural system (CNS) and Peripheral neural system (PNS)

(b) Resting potential and action potential

ANSWER:-

(a) Central neural system (CNS) and Peripheral neural system (PNS)

Central Nervous System (CNS)	Peripheral Nervous System (PNS)
Comprises the brain and spinal cord	Comprises spinal nerves and cranial nerves
The spinal cord is encased in the vertebral column, and the brain is enclosed within the skull	Lacks protective coverings
No further subdivisions	Divided into the autonomic and somatic nervous systems

Processes and interprets information, controlling responses to impulses	Transmits impulses to the CNS and relays responses from the CNS to body structures
Neurons are grouped into nuclei	Neurons are grouped into ganglia

(b) Resting potential and action potential

Resting Potential	Action Potential
Refers to the potential difference across the membrane when the neuron is in a resting state	Refers to the potential difference across the membrane when the neuron is activated
The outside of the neuron is positively charged, while the inside is negatively charged	The outside of the neuron becomes negatively charged, while the inside becomes positively charged
The plasma membrane of the neuron is more permeable to K^+ ions	The plasma membrane of the neuron is more permeable to Na^+ ions
The sodium-potassium ATPase pump is active to maintain the resting potential, moving Na^+ ions outside the neuron	The pump operates in reverse, moving Na^+ ions into the neuron

Q. 3. Explain the following processes:

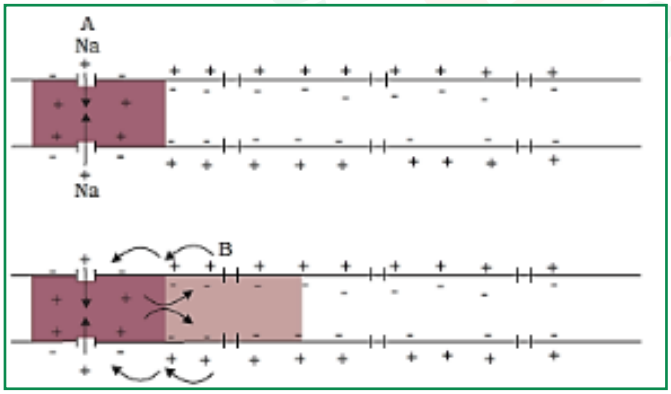
(a) Polarisation of the membrane of a nerve fibre

(b) Depolarisation of the membrane of a nerve fibre

(c) Transmission of a nerve impulse across a chemical synapse

ANSWER:-

(a) Polarisation of the membrane of a nerve fibre



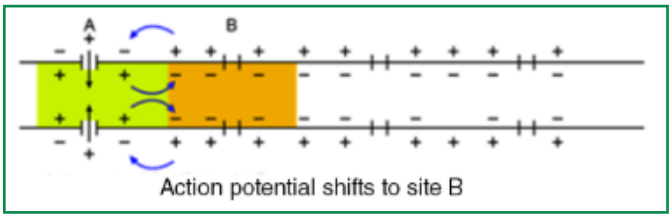
Impulse conduction through an axon

A nerve fibre is considered to be in a polarized state during its resting phase. In this state, the membrane of the nerve fibre exhibits a resting potential. Below are the steps involved in the polarization of a nerve fibre membrane:

1. Initially, when a previously depolarized region of the nerve fibre becomes polarized, there is a higher concentration of K+ ions outside the nerve fibres, while the axon membrane contains an excess of Na+ ions.
2. As the membrane starts to polarize, it becomes more permeable to K+ ions and impermeable to negatively charged proteins and Na+ ions.

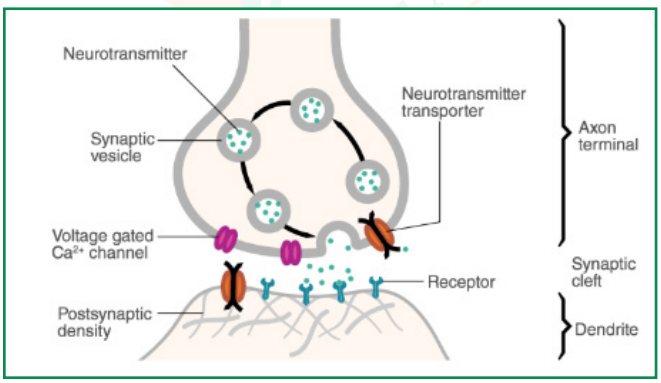
3. The sodium-potassium pump transports 2 K+ ions into the axon and 3 Na+ ions out of the axon via active transport.
4. Due to the movement of potassium and sodium ions, the outer side of the membrane becomes electropositive, while the inner side becomes electronegative, resulting in the polarization of the nerve fibre.

(b) Depolarisation of the membrane of a nerve fibre



1. A nerve fibre is considered to be in a depolarized state when it is stimulated.
2. In this state, the membrane of the nerve fibre undergoes an action potential.
3. During the depolarization of the nerve fibre membrane, the following steps occur:
   (i) In the polarized state, the axon has a higher concentration of K+ ions, while Na+ ions are more concentrated outside the axon.
   (ii) When the nerve fibre is stimulated, the permeability of the membrane to Na+ and K+ ions is reversed.
   (iii) The membrane's permeability to Na+ ions increases.
   (iv) There is a rapid influx of Na+ ions into the axon.
   (v) As a result, the inner side of the membrane becomes positively charged, while the outer side becomes negatively charged.
   (vi) This leads to the depolarization of the nerve fibre membrane, resulting in the generation of an action potential.

(c) Transmission of a nerve impulse across a chemical synapse



1. The synapse is formed by the membranes of the pre-synaptic and post-synaptic neurons.
2. A synaptic cleft refers to the gap present in some synapses, though it may not always be present.
3. At a chemical synapse, the pre-synaptic and post-synaptic neurons are separated by the synaptic cleft.
4. When an impulse reaches the axon terminal, calcium ions present in the synaptic cleft enter the synaptic knobs at the terminal of the pre-synaptic neuron.

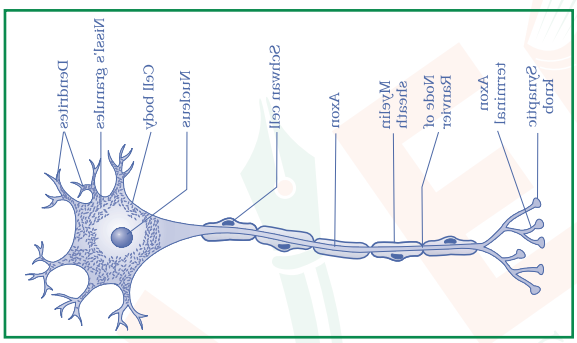
5. The synaptic knobs of the pre-synaptic neuron contain synaptic vesicles, which move towards and fuse with the plasma membrane.
6. The vesicles release the neurotransmitter acetylcholine into the synaptic cleft.
7. Acetylcholine molecules bind to protein receptors on the plasma membrane of the post-synaptic neuron.
8. This binding opens ion channels, allowing sodium ions to enter the post-synaptic neuron, while potassium ions exit the post-synaptic membrane.
9. As a result, an action potential is generated in the post-synaptic neuron membrane, transmitting the impulse to the post-synaptic neuron.

Q. 4. Draw labelled diagrams of the following:

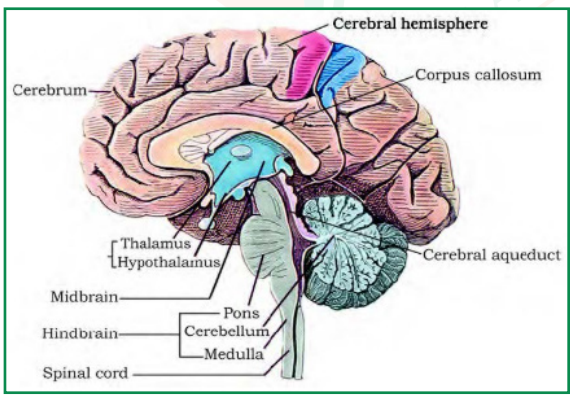
(a) Neuron
(b) Brain

ANSWER:-

(a) Neuron



(b) Brain



Q. 5. Write short notes on the following:

(a) Neural coordination
(b) Forebrain
(c) Midbrain

(d) Hindbrain

(e) Synapse

ANSWER:-

(a) **Neural coordination** – This refers to the process by which two or more organs interact and enhance each other's functions through the body's neural system. Various physiological processes in the body are interconnected, and the neural and endocrine systems work together to coordinate and integrate the actions of the organs, ensuring they operate in harmony. The neural system provides a structured and organized network for quick, point-to-point communication, while the endocrine system facilitates chemical integration through hormones.

(b) **Forebrain**

The forebrain consists of three main parts: the cerebrum, hypothalamus, and thalamus.

→ Cerebrum is the largest and most important part of the brain. It is divided into two hemispheres by a deep cleft, known as the cerebral hemispheres. These hemispheres are connected by the corpus callosum, a bundle of nerve fibers. The cerebrum's internal structure is hollow, with the walls consisting of an inner medulla and an outer cortex.

The cerebral cortex contains the cell bodies of neurons, which give it a grey appearance, earning it the name "grey matter." The grey matter features many grooves (sulci) and folds (gyri), with more convolutions generally correlating with higher intelligence.

The cortex includes sensory, motor, and association areas, responsible for functions such as communication, memory, and intersensory associations.

The cerebral medulla is composed of nerve fiber axons, giving it a white appearance, hence the term "white matter." Deep within the cerebral hemispheres, interconnected structures such as the amygdala and hippocampus form the limbic system, which is involved in emotions and memory.

Role – The cerebrum governs memory, intelligence, consciousness, voluntary actions, and willpower.

→ **Thalamus**

The thalamus, composed of grey matter, is situated above the midbrain.

Role – It relays motor and sensory impulses to the cerebrum and is involved in emotional responses and the perception of heat, pain, and cold.

→ **Hypothalamus**

Located at the base of the thalamus, the hypothalamus contains the optic chiasma, where optic nerve fibers cross. Behind it lies the infundibulum, which holds the pituitary gland.

Role – The hypothalamus regulates body temperature, homeostasis, blood pressure, and appetite. It controls hunger, sleep, fatigue, thirst, pleasure, anger, and penance. The hypothalamus's neurosecretory cells produce hormones that control pituitary gland activity. Along with the limbic system, it also plays a role in regulating sexual behavior.

(c) **Midbrain**

The midbrain includes the cerebral peduncles and the corpora quadrigemina.

→ **Cerebral Peduncles**

These are thick fibrous tracts that connect the cerebrum to the cerebellum.

Role – They relay sensory and motor impulses between the hindbrain and forebrain.

→ **Corpora Quadrigemina**

Located in the dorsal brain, the corpora quadrigemina consists of two pairs of solid lobes: the superior colliculi and the inferior colliculi.

Role – The corpora quadrigemina controls visual reflexes and eye and head movements, while also regulating auditory reflexes and head movements for locating sound sources.

(d) **Hindbrain**

he hindbrain includes the cerebellum, pons varolii, and medulla oblongata.

→ **Cerebellum**

Situated behind the brainstem, the cerebellum has an outer cortex made of grey matter and an inner medulla of white matter. It is connected to the cerebrum and medulla oblongata by white matter tracts.

Role – The cerebellum coordinates balance and muscular activity, controlling voluntary movements initiated in the cerebrum.

→ **Pons Varolii**

This structure is a thick bundle of white nerve fibers located above the medulla oblongata.

Role – The pons coordinates the two cerebellar lobes and houses the pneumotaxic center, which regulates breathing.

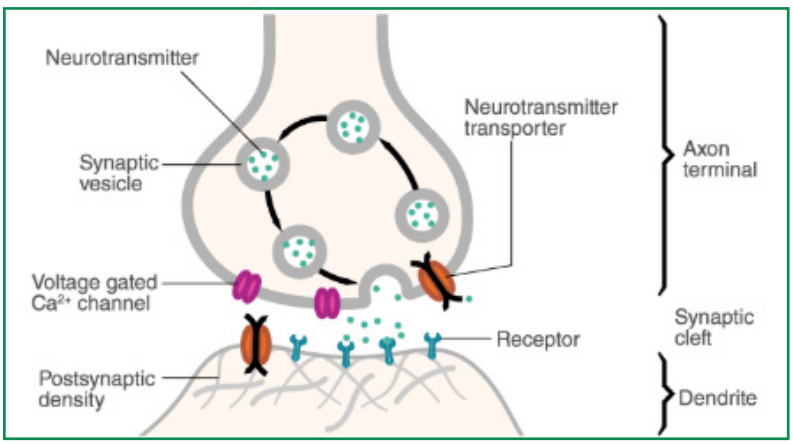
→ **Medulla Oblongata**

The medulla oblongata is conical and located at the base of the skull, continuing into the spinal cord. Damage to this area can be fatal.

Role – It serves as a passage for nerve impulses between the spinal cord and brain and controls internal organ **functions, including breathing and heartbeat.**

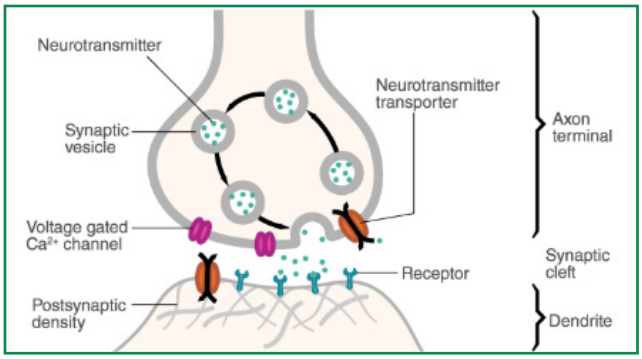
(e) **Synapse**

A synapse is formed by the membranes of a pre-synaptic and a post-synaptic neuron, which may or may not be separated by a gap called the synaptic cleft. Synapses are of two types: chemical synapses and electrical synapses.



Q. 6. **Give a brief account of Mechanism of synaptic transmission.**

ANSWER:-



Synapses are junctions where nerve impulses are transmitted from one neuron to another. They are formed by the membranes of a pre-synaptic and a post-synaptic neuron, which may or may not be separated by a gap called the synaptic cleft. There are two types of synapses: chemical synapses and electrical synapses.

In electrical synapses, the membranes of the pre-synaptic and post-synaptic neurons are closely aligned, allowing electrical currents to flow directly from one neuron to another. The transmission of impulses across electrical synapses is faster than that across chemical synapses, as it is similar to the conduction of an impulse along a single axon. Electrical synapses are less common in the human body.

In chemical synapses, the membranes of the pre-synaptic and post-synaptic neurons are separated by a synaptic cleft, which is a fluid-filled space. Neurotransmitters, chemical substances, are involved in the transmission of impulses at these synapses.

Q. 7. **Explain the role of Na+ in the generation of action potential.**

ANSWER:-

When a nerve fibre is stimulated, the sodium channels in the neurilemma open and become activated. Sodium ions from the outside diffuse into the intracellular fluid due to the electrochemical gradient. As potassium ions move out of the cell, the membrane becomes negatively charged on the outside and positively charged on the inside. This rapid change in membrane potential is called the action potential, which leads to the depolarization of the membrane.

Q. 8. **Differentiate between:**

(a) Myelinated and non-myelinated axons

(b) Dendrites and axons

(c) Thalamus and Hypothalamus

(d) Cerebrum and Cerebellum

ANSWER:-

(a) Myelinated and non-myelinated axons

Characteristics/Features	Myelinated Axons	Non-myelinated Axons
Myelin Sheath		
Nodes of Ranvier	Present	Absent
Location	Autonomic nervous system, spinal cord	Spinal cord, white matter of the brain, autonomic nervous system
Nerve Impulse Conduction	Node to node	Continuous
Impulse Conduction Speed	Faster compared to non-myelinated axons	Slower in comparison

(b) Dendrites and axons

Dendrites	Axons
Dendrites are short extensions	Axons are long extensions
They transmit impulses toward the cell body of the neuron	They transmit impulses away from the cell body to other neurons
They are always branched	Axons may or may not have branches
Nissl's granules are present in the neuroplasm	Nissl's granules are not present in the neuroplasm

(c) Thalamus and Hypothalamus

Thalamus	Hypothalamus
Composed solely of grey matter	Composed of both white and grey matter
Does not produce hormones	Secretes hormones that regulate the pituitary gland's activity
Positioned above the midbrain	Located at the base of the thalamus
Contains centers for sensations such as cold, pain, and heat	Contains centers for regulating body temperature, homeostasis, and blood pressure

(d) Cerebrum and Cerebellum

Cerebrum	Cerebellum
The cerebrum covers the majority of the brain	The second largest part of the brain after the cerebrum
It is a part of the forebrain	It is a part of the hindbrain
It is divided into two cerebral hemispheres	It is divided into three lobes: central vermis and two lateral cerebral hemispheres
It is responsible for intelligence and memory	It is responsible for posture and body equilibrium

Q. 9. Answer the following:

(a) Which part of the human brain is the most developed?

(b) Which part of our central neural system acts as a master clock?

ANSWER:-

(a) The part of the human brain that is the most developed is the cerebrum

(b) The part of the central neural system that acts as a master clock is the hypothalamus

Q. 10. Distinguish between:

(a) afferent neurons and efferent neurons

(b) impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

(c) cranial nerves and spinal nerves.

ANSWER:-

(a) afferent neurons and efferent neurons

Property	Afferent Neurons (Sensory)	Efferent Neurons (Motor)
Function	Carry sensory information to the CNS	Carry motor information away from the CNS
Direction of Signal	Toward the CNS (brain or spinal cord)	Away from the CNS (to muscles or glands)
Type of Information	Sensory (e.g., touch, pain, temperature)	Motor (e.g., muscle movement, gland secretion)
Example	Transmitting pain signals to the brain	Triggering muscle contraction for movement
Location	Found in sensory organs and tissues	Found in the spinal cord and peripheral nerves

(b) impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

Myelinated Nerve Fiber Impulse Conduction	Unmyelinated Nerve Fiber Impulse Conduction
Impulse is transmitted between nodes	Impulse travels along the entire length of the nerve fiber
Conduction speed is 50 times faster than in unmyelinated fibers	Conduction speed is relatively slower
Requires less energy for impulse transmission	Requires more energy for impulse transmission

(c) cranial nerves and spinal nerves.

Cranial Nerves	Spinal Nerves
The human body contains 12 pairs of cranial nerves	The body has 31 pairs of spinal nerves
Cranial nerves arise from the brain and extend to various body parts	Spinal nerves originate from the spinal cord and extend to different body parts
Cranial nerves can be sensory, motor, or mixed	Spinal nerves are always mixed nerves