BIOLOGY

NEURAL CONTROL AND COORDINATION

Human Nervous System

- Central Nervous System
- Peripheral Nervous System

Coordination: Coordination is the process through which two or more organs interact and complement the function of each other.

The endocrine system: Neural system provides an organized network of point-to-point connection for quick coordination. The endocrine system provides chemical integration through hormones.

Neural system: Neural system of animals is composed of specialized cells called neuron, which can detect, receive, and transmit different kinds of stimuli. In hydra neural system is composed of network of neuron. In insects it consists of brain and a number of ganglia. Vertebrates have highly developed neural system.

Central nervous system (CNS): Central nervous system (CNS) includes brain and spinal cord. It is the site for information processing and control.

Peripheral nervous system: Peripheral nervous system includes all nerves associated with CNS.

There are two types of nerve fibers:

Afferent fibers: Afferent fibers transmit impulses from tissue/ organ to CNS.

Efferent fibers: Efferent fibers transmit regulatory impulses from CNS to concerned peripheral organs.

Peripheral nervous system are divided in two parts:

- Somatic neural system
- Autonomic neural system

Somatic neural system and Autonomic neural system: Somatic neural systems relay impulses from CNS to skeletal muscles. Autonomic neural system transmits impulses from CNS to involuntary system and smooth muscles.

Autonomic neural system:

- Sympathetic
- Parasympathetic

Neuron as Structural and Functional Unit of Neural System

Neuron is made up of three major parts- cell body, dendrite and axon.

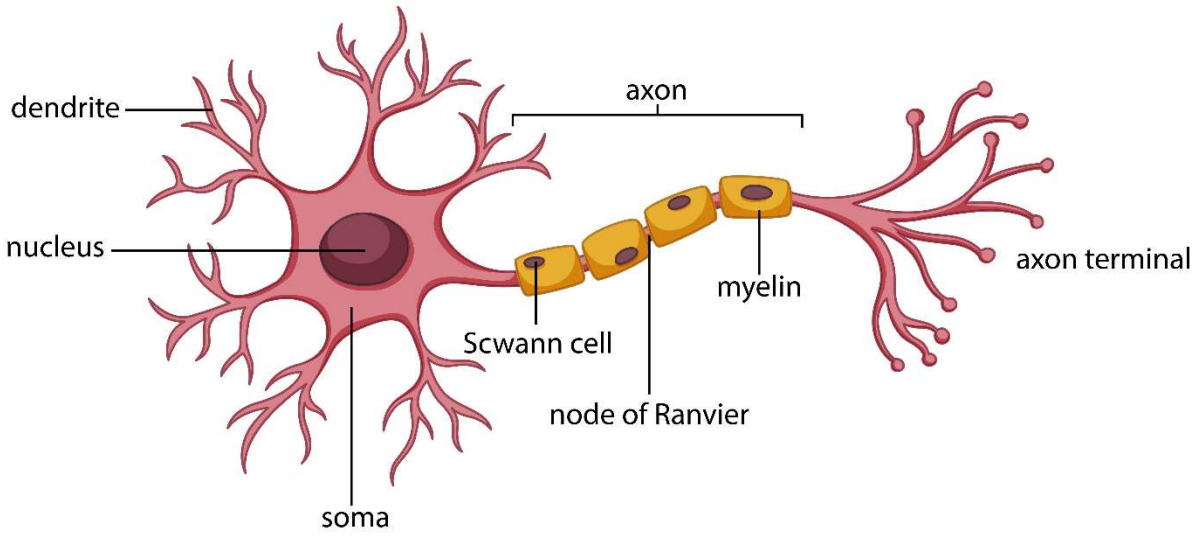
Cell body contains cytoplasm, cell organelles and Nissl's granules. Short fibers projecting out from cell body is called dendrites. The axon is long fiber having branched structure at the end that terminates into knob like structure called synaptic knob.

Based on number of axon and dendrites neuron are of three types:

- **Multipolar:** One axon and two or more dendrite found in cerebral cortex.
- **Bipolar:** One axon and one dendrite found in retina of eyes.
- **Unipolar:** Cell body with only one axon found in embryonic stage.

There are two types of axon:

- **Myelinated:** Fibers are enveloped with Schwann cells to form myelin sheath around the axon. The gap between two myelin sheaths is called nodes of Ranvier. Found in spinal and cranial nerves.
- **Unmyelinated:** Fiber is enclosed by Schwann cells that do not form myelin sheath around the axon. Found in autonomous and somatic neural system.



Generation and Conduction of Nerve Impulse

- Ion channels are present in neural membrane which is selectively permeable to different ions. When neuron is not conducting impulse (resting), axonal membrane is more permeable to K+ ions and impermeable to Na^+ ions.
- Ionic gradient across the resting membrane is maintained by active transport of ions by sodium-potassium pump. This will develop positive charge outside the axonal

membrane and negative charge on inner side.

- The electrical potential difference across the resting membrane is called resting potential.
- When stimulus is applied at site A, the membrane becomes permeable to Na^+ ions to make rapid influx of Na^+ ions to create outer surface negatively charged and inner membrane positively charged that create Action Potential or nerve impulse.
- The nerve impulse from A moves to B in inner surface and B to A on outer surface. This process is repeated several times to transmit the impulse.
- Nerve impulse is transmitted from one neuron to another neuron through synapse.

There are two types of synapses:

- **Electrical synapse:** The membrane of pre and post synaptic neuron is very close to each other and current flow directly from one neuron to another.
- **Chemical synapse:** Pre and post synaptic neuron is separated by fluid filled space called synaptic cleft. Neurotransmitters are involved in transmission of impulses.

Central Neural System:

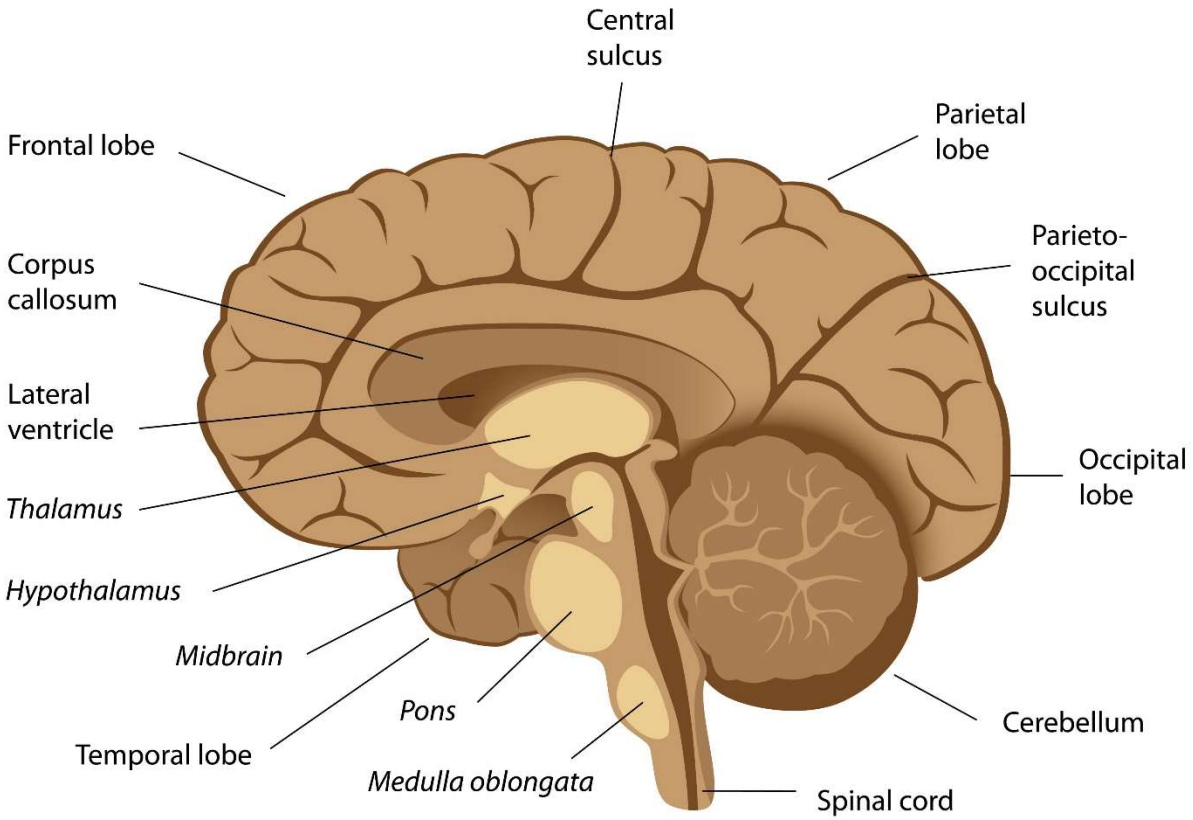
Brain is the central information processing organ of our body and act as command-and-control center. Human brain is protected by skull (cranium) and three layers of cranial meninges- outer dura mater, middle arachnoid, and inner pia mater.

Brain can be divided 3 parts- forebrain, midbrain, and hindbrain. Forebrain consists of cerebrum, thalamus, and hypothalamus. Cerebrum is divided into left and right cerebral hemispheres which are covered by cerebral cortex (grey matter). Cerebral cortex contains sensory neuron, motor neuron and association area. Association area controls complex functions like intersensory associations, memory, and communication.

Thalamus- cerebrum wraps around a structure called thalamus. It is a major coordinating center for sensory and motor signaling. Hypothalamus controls the urge for eating, drinking and body temperature. They also release hypothalamic hormones. Limbic system is involved in controlling sexual behavior and expression of emotional reactions. Midbrain is located between hypothalamus and pons of hindbrain. Dorsal portion consists of four round lobes called corpora quadrigemina. They are involved in relay of impulses back and forth between cerebrum, cerebellum, pons, and medulla. Hind brain consists of pons, medulla oblongata and cerebellum.

The medulla contains centers which control respiration, cardiovascular reflexes, and gastric secretions. Cerebellum controls balance and posture. Reflex action is a spontaneous autonomic mechanical response to a stimulus without the will of the organism. It is controlled by spinal cord. The afferent neuron receives the signal from sensory organs and transmits the

impulse to CNS. The efferent neuron carries the impulse from CNS to effector. Ex- knee-jerk reflex. The path followed by reflex action is called reflex arc.

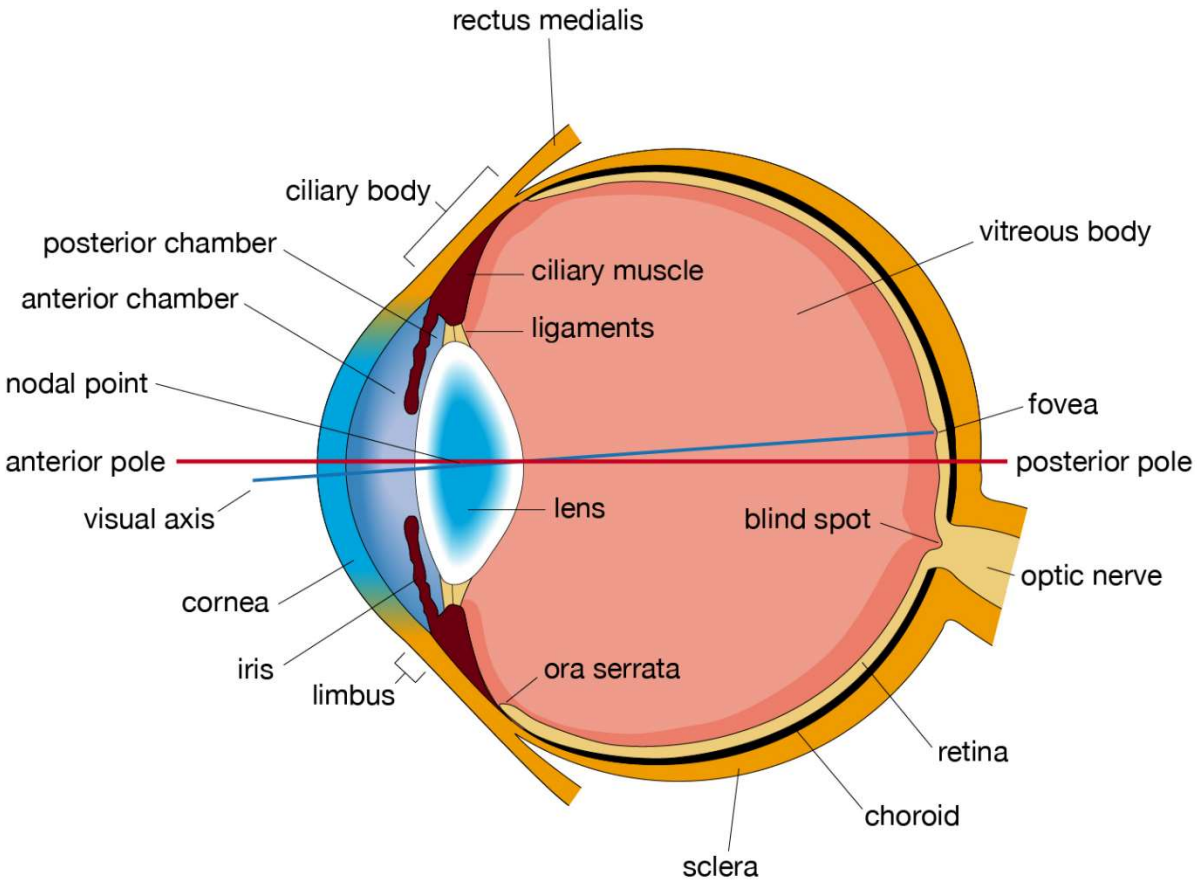


Human Eye

Spherical structure consists of three layers, external layer is sclera whose anterior part is called cornea, middle layer choroid and innermost layer is called retina. Retina contains three layers of cells: inner ganglion cells, middle bipolar cells, and outer photoreceptor cells. There are two types of photoreceptor cells called rods and cones. The daylight (photopic) vision and color vision are functions of cones. The twilight (scotopic) vision is the function of the rods.

Mechanism of Vision:

The light rays of visible wavelength fall on retina through cornea and lens to generate impulses in rods and cones. Photosensitive pigments opsin and retinal get dissociated due to light to change its shape. Change in shape of opsin cause change of permeability to generate action potential that is transmitted to brain via optic nerve.

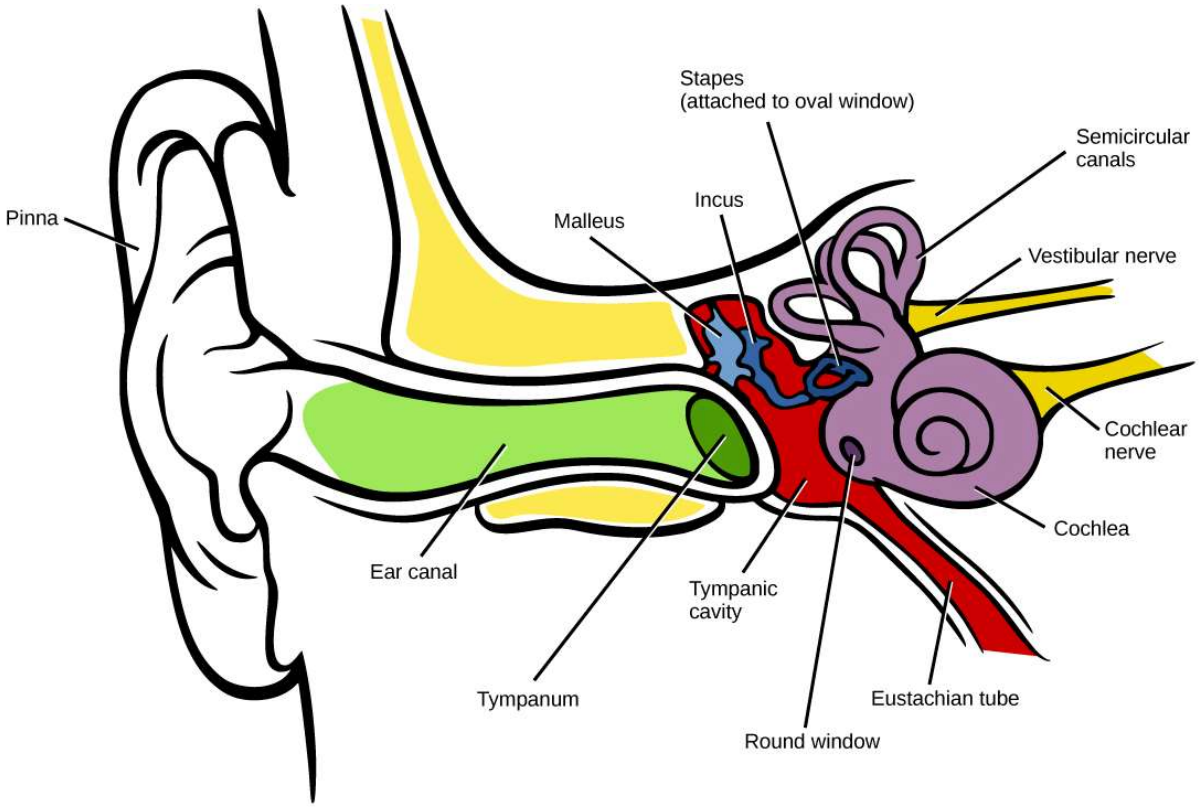


Human Ear

Divided into three regions: outer ear, middle ear and inner ear. The middle ear contains three ossicles called malleus, incus and stapes. The fluid filled inner ear is called the labyrinth, and the coiled portion of the labyrinth is called cochlea. The organ of corti contains hair cells that act as auditory receptors and is located on the basilar membrane.

Mechanism of Hearing:

External ear receives the sound wave and directs them to ear drum. Vibration of ear drum leads to vibration of ear ossicles. The vibration reaches cochlea that generate wave in lymph. The waves generate ripples in basilar membrane and hair cells in them. As a result, nerve impulses are generated in afferent neuron that passes to brain via auditory nerves.


Stapes
(attached to oval window)
Semicircular
canals
Incus
Malleus
Vestibular nerve
Pinna
Cochlear
nerve
Cochlea
Ear canal
Tympanic
cavity
Tympanum
Eustachian tube
Round window

CHAPTER : 21 NEURAL CONTROL AND COORDINATION

Neural Control and Coordination

Neural System

- Neural organization is very simple — Lower invertebrates
- Brain is present along with number of ganglia and neural tissues — Insects
- More developed neural system — Vertebrates

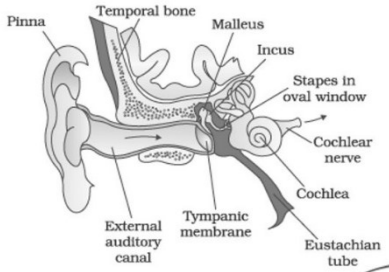
Human Neural System

- CNS
  - Brain
  - Spinal cord
- PNS
  - Somatic
  - Autonomic
    - Parasympathetic
    - Sympathetic
  - Cranial nerves (12 pairs)
  - Spinal nerves (31 pairs
- Nerve Fibres
  - Afferent Fibres
  - Efferent Fibres

Sense organs

Human Ear

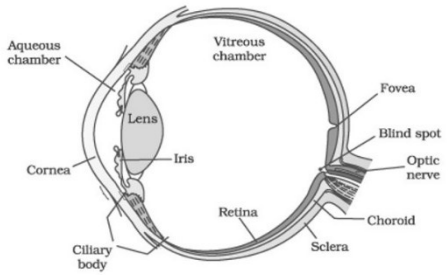
- Outer Ear : Pinna, Ear canal, Tympanic membrane
- Middle Ear - Three ear ossicles
- Inner Ear - Utriculus, Sacculus and Cochlea



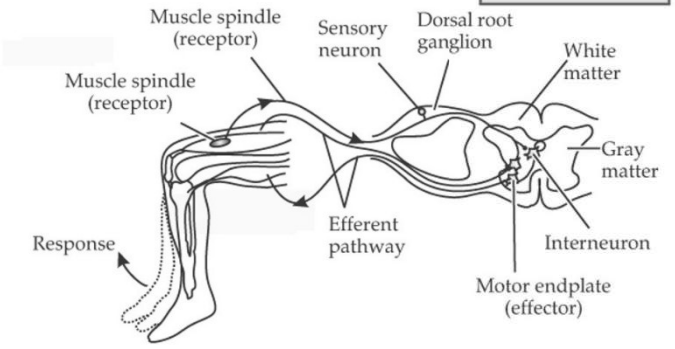
Human Eye

Layersof eye -

- Outer layer - Sclera and Cornea
- Middle layer- Choroid, Ciliary body, Iris, Pupil, lens
- Innermost layer- Retina



Reflex action and Reflex arc



Generation and conduction of nerve impulse

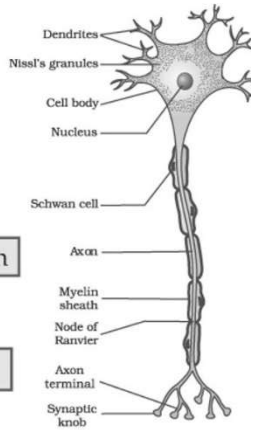
- Maintenance of resting potential
- Action potential
- Propagation of action potential

Brain

- Fore brain
  - Cerebrum
  - Thalamus
  - Hypothalamus
- Mid brain
- Hind brain
  - Pons
  - Cerebellum
  - Medulla

Neuron (Structural and functional unit of neural system)]

- Cytoplasm + typical cell organelles + Nissl's granules
- Structure
  - Cell body chain
  - Dendrite chain
- Types of Neuron
  - Multipolar
  - Bipolar
  - Unipolar
- Axon chain
  - Myelinated axon
  - Non-myelinated axon



Important Questions

➢ Multiple Choice Questions:

Question 1. Humain brain has greater development of

(a) Optic lobes

(b) Medullu oblongata

(c) Cerebrum

(d) Cerebellum

Question 2. Outer most covering of brain is

(a) Pia mater

(b) White matter

(c) Arachnoid

(d) Dura mater

Question 3. Third ventricle occurs in

(a) Brain

(b) Skull

(c) Bones

(d) Heart

Question 4. Tree like branched structure found in cerebellum is

(a) Areole

(b) Arachnoid

(c) Arboreal

(d) Arbor

Question 5. Number of spinal nerves in human being is

(a) 31

(b) 37

(c) 14

(d) 20

Question 6. Fourth cranial nerve is

(a) Trochlear (Pathetic)

(b) Optic

(c) Oculomotor

(d) Trigeminal

Question 7. Auditory nerve is responsible for

(a) Sight

(b) Hearing

(c) Smell

(d) None of these

Question 8. Synapse is a dose proximity of

(a) Two veins

(b) Two lymphatics

(c) Two neurons

(d) Two arteries

Question 9. Outer region of spinal cord is

(a) White matter

(b) Grey matter

(c) Pia mater

(d) Dura matere

Question 10. A nerve impulse leaves a neuron via the

(a) Dendrites

(b) Axon

(c) Cyton

(d) Nucleus

Question 11. Regulatory control of temperature

(a) Hypothalamus

(b) Cerebellum

(c) Superior

(d) Inferior colliculi

Question 12. Endolymph is found in

(a) Internal ear

(b) Cnidoblast

(c) Synovial cavity

(d) Posterior chamber of eye

Question 13. Sequence of ear ossicles is

(a) Stapes, malleus, incus

(b) Malleus, stapes, incus

(c) malleus, incus, stapes

(d) Incus, stapes, malleus

Question 14. Pupil is regulated by

(a) Radial and circular muscles

(b) Meridional muscles

(c) Radial muscles

(d) Circular muscles

Question 15. The hair cells in the ear are stimulated by movements of

(a) Lymph

(b) Endolymph

(c) Perilymph

(d) Haemolymph

➢ Fill In the Blanks:

1. …….. is the process through which two or more organs interact and complement the functions of one another.
2. The neural system of all animals is composed of highly specialised cells called '……..' which can detect, receive and transmit different kinds of stimuli.
3. The human neural system is divided into two parts, namely, (i) ……. and (ii) …….
4. The nerve fibres of the PNS are of two types, namely, (a) …….. and (b) ……..
5. The PNS is divided into two divisions called …….. and ……..
6. A neuron is a microscopic structure composed of three major parts, namely, ……., ……. and ……

➢ True or False:

1. The waves in the lymphs induce a ripple in the basilar membrane.
2. The saccula and utricle contain a projecting ridge called macula.
3. The inner ear also contains a complex system called hair cells.

4. The hair cells are present in rows on the internal side of the organ of corti.
5. At the base of the cochlea, the scala vestibuli ends at the otolith organ.
6. The fluid filled inner ear called labyrinth consists of two parts, the bony and the membranous labyrinths.

➢ Very Short Question:

1. What are the major divisions of the forebrain?
2. Which parts of the central nervous system constitute the grey matter?
3. Name the major lobes of the cerebral hemisphere?
4. What is the function of cerebral spinal fluid?
5. What is the junction between two neurons known as?
6. What is the polarized state of the nerve membrane?
7. Give two examples of unconditioned reflexes.
8. Name the types of cells present in the retina.
9. Where is iodopsin present in the eye?
10. Where are taste buds located?

➢ Short Questions:

1. What are receptors?
2. Why does vitamin A deficiency produce night blindness?
3. Why does the nerve impulse flow more rapidly in myelinated nerve fibers than in the non-myelinated fibers?
4. What is a synapse?
5. Draw a labeled diagram of a section of the retina to illustrate its structure.
6. What functions does the hypothalamus serve in coordinating the various activities of the body?
7. What is a nerve fiber? How is it classified according to myelin sheath?
8. Explain Motor-end plate.

1. Long Questions:

1. (a) Describe the reflex arc with a diagram.

   (b) Distinguish between conditioned reflex and unconditioned reflex.
2. (a) Give an account of spinal nerves in man.

   (b) What biological functions are served by the skeletal system?

3. Distinguish between:

   (a) Afferent neurons and efferent neurons.

   (b) Rods and cones

   (c) Resting membrane potential and action potential.

   (d) Impulse conduction in myelinated nerve fiber and unmyelinated nerve fiber.

   (e) Aqueous humor and vitreous humor.

   (f) Blindspot and yellow spot.

   (g) Cranial nerve and spinal nerves.

Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: Nerve conduction is the one way conduction.

   Reason: Nerve impulse is transmitted from dendrite terminals to axon terminals.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: The chemical stored in the synaptic vesicles are termed as neurotransmitters.

   Reason: Synaptic vesicles release these chemicals in the synaptic cleft.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (c) Cerebrum
2. (d) Dura mater
3. (a) Brain
4. (a) Areole

5. (a) 31
6. (a) Trochlear (Pathetic)
7. (b) Hearing
8. (c) Two neurons
9. (a) White matter
10. (b) Axon
11. (a) Hypothalamus
12. (a) Internal Ear
13. (c) malleus, incus, stapes
14. (d) Circular muscles
15. (b) Endolymph

➢ Fill In the Blanks:

1. Coordination
2. neurons
3. the central neural system (CNS), the peripheral neural system.
4. afferent fibres, efferent fibres.
5. somatic neural system, autonomic neural system
6. cell body, dendrites, axon.

➢ True or False:

1. True
2. True
3. False
4. True
5. False
6. True

➢ Very Short Answers:

1. Answer: Cerebrum, Thalamus, Hypothalamus.
2. Answer: Areas that contain cell bodies of the neurons.
3. Answer: Frontal, parietal, temporal and occipital.
4. Answer: It maintains a constant pressure inside the cranium.

5. Answer: Synapse.
6. Answer: It is the state of the nerve membrane when its inner side is electronegative to its outer side.
7. Answer:

   (i) Salivation on tasting food.

   (ii) Constriction of the pupil on the illumination of the eye.
8. Answer: Rods, cones, bipolar neurons, ganglion cells, supporting cells.
9. Answer: In the cone cells of the retina
10. Answer: In the mucous membrane over the papillae on the tongue.

➢ Short Answer:

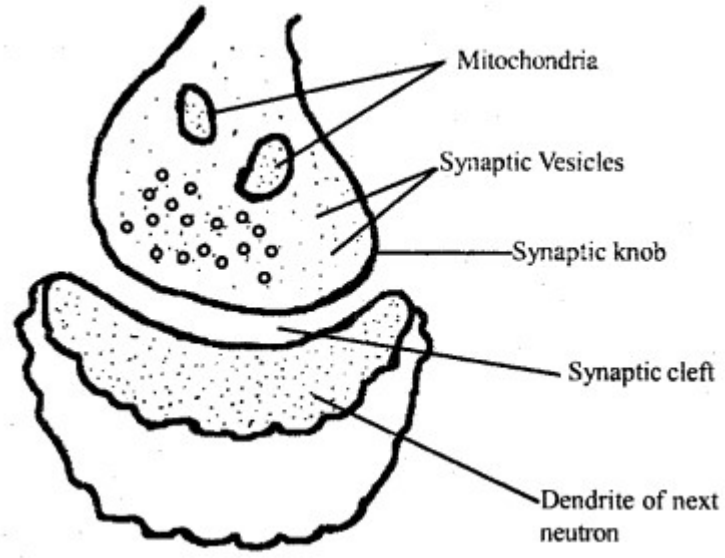
1. Answer: Receptors are peripheral nerve endings in the skin or special sense organs. They collect information from the external or internal environment of the body; transform them into electrical potential changes, which then pass along the afferent neurons to CNS.
2. Answer: Vitamin 'A' is the constituent of rhodopsin, a pigment present in the photoreceptor cells of the eye. Rhodopsin breaks up into opsin and rode to visualize things in bright and dim light. There is constant consumption of vitamin A in rod cells. Deficiency of vitamin A causes impairment of synthesis of rhodopsin leading to night blindness, i.e., inability to see in the dark.
3. Answer: Due to the following reasons nerve impulse flows more rapidly in myelinated nerve fibers:

   i. Myelin sheath provides insulation to the nerve fibers from electrical disturbances between the neighboring fibers.

   ii. Myelin sheath is impermeable to free ions present in the extracellular fluid. So, it prevents the exchange of ions between the extracellular fluid and the interior of the myelinated axon.

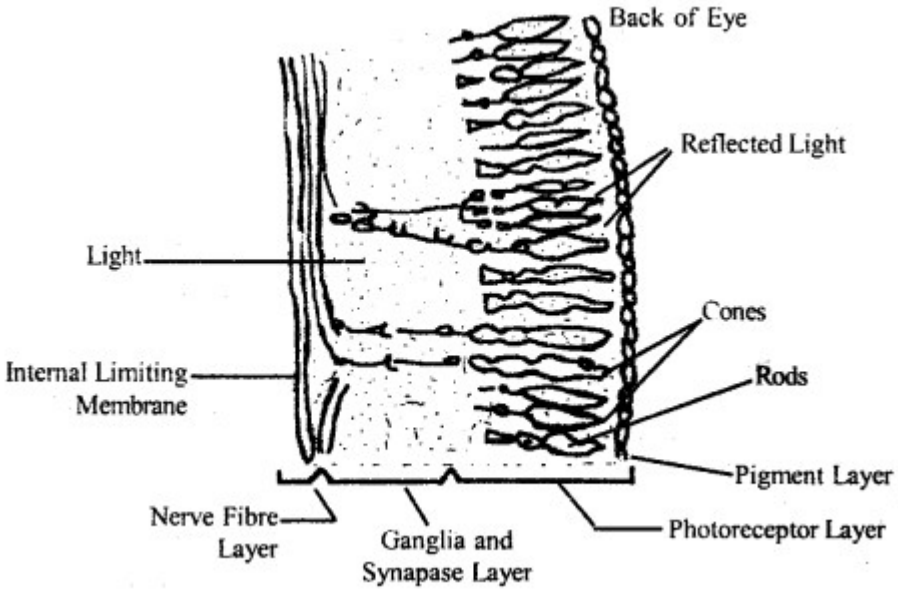
   iii. The myelin sheath is absent at the Nodes of Ranvier, so, action potential jumps from one Node of Ranvier to the next. Thus, the nerve impulse flows in the form of leaps or jumps. This is known as the saltatory conduction of impulse.

   iv. It is more rapid than the smooth flow of impulse.
4. Answer: It is the junction between axon terminals of a neuron and dendrites or the cell body of another neuron. There is a narrow fluid-filled space, called Synaptic Cleft separating axon terminals and dendrites at the synaptic junction. So, the two-neurons forming synapse does not form actual continuity between the neurons.



Structure of Synapse

5. Answer:



Diagrammatic representation of the sectional view of the retina.

6. Answer:

   i. It contains nerve centers for temperature regulation, hunger, thirst, and emotional reactions.

   ii. It secretes neurohormones, which control the secretion of anterior pituitary hormones.

   iii. It synthesizes the posterior pituitary hormones and controls their release into the blood.

7. Answer: A nerve fiber is a long axon or dendrite of a neuron. According to the presence and absence of myelin sheath around the fibers.

   These are classified as:

   - Myelinated nerve fiber (i.e., presence of myelin sheath) and

- Non-myelinated nerve fiber (i.e., absence of myelin sheath).

8. Answer: A Motor-end plate is a specialized structure formed by the muscle fiber at the point where the axon terminal is applied to it. The axon of the motor neuron is divided into branches near the muscle fibers. Each branch loses its myelin sheath near its termination and ends in an expanded foot-like form which is supplied closely to a muscle fiber.

   There is no actual continuity between the neuron and muscle fiber. The membranes of the two are separated from each other by a narrow cleft-like fluid-filled space.

➢ Long Answer:

1. (a) Answer: The neurons forming the pathway taken by the nerve impulses in the reflex action form the Reflex Arc.

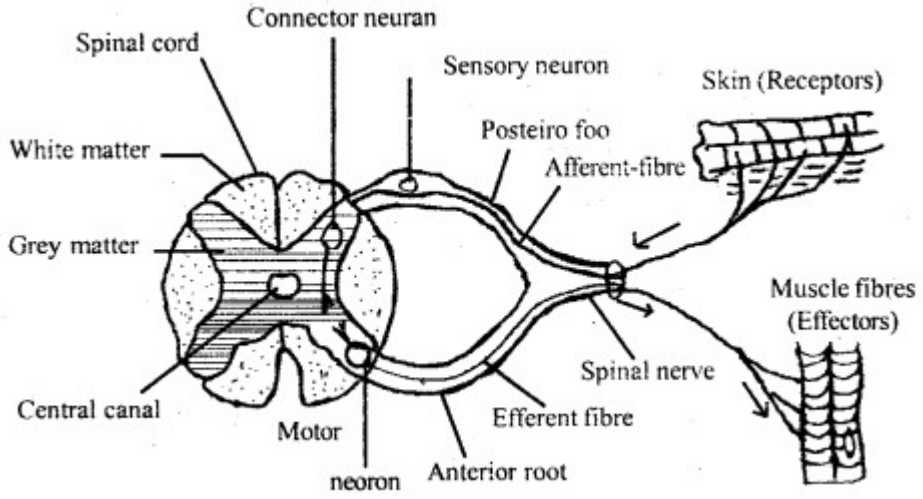
   The reflex arc consists of

   i. Receptor,

   ii. An afferent neuron or sensory neurons from receptor to CN system,

   iii. The efferent neuron of motor neurons from CN system to specific muscle fibers or gland cells,

   iv. a number of connectors or intermediate neurons conducting impulses form the afferent to the efferent neurons.



   Reflex Arc

   When a specific stimulus is applied to a specific group of receptors, it stimulates the receptor to initiate a nerve impulse along the afferent neurons. This impulse travels along with the afferent connector and efferent neurons to reach an effector-muscle or gland for that reflex. Thus the flow of impulse can only be in a single direction in a reflex arc, i.e.,

   Stimulus → receptor → afferent neuron → CN system efferent neuron ← (connector neuron)

   (b) Answer: Differences between conditioned reflex and unconditioned reflex:

Conditioned Reflex	Unconditioned Reflex
It is a reflex, acquired after birth by applying an indifferent stimulus before or along with the stimulus for an inborn reflex.	It is a reflex, which can be evoked even immediately after birth and needs no previous encounter with the stimulus exciting it.

1. (a) Answer: There are 31 pairs of a spinal nerve in man. From each segment of the spinal cord, there are two spinal nerves. Each spinal nerve is a mixed nerve, containing both sensory and motor nerve fibers. It runs between the spinal cord and peripheral tissue. The two roots, i.e., motor or ventral and sensory or dorsal connect the spinal nerve to the spinal cord.

   The DORSAL ROOT carries sensory or afferent fiber and has a dorsal root ganglion at its middle. The VENTRAL ROOT contains a motor or efferent nerve fibers. The dorsal root fibers bring impulses from the peripheral tissue and give rise to sensations like touch, temperature, and pain.

   The ventral nerve root fibers pass impulses to muscles and glands in the peripheral tissues. The spinal nerve has been named according to its relation with the vertebral column.

   These are

   - Eight pairs of cervical
   - 12 pairs of thoracic
   - 5 pairs of lumber,
   - 5 pairs of sacral and
   - a pair of coccygeal or caudal.

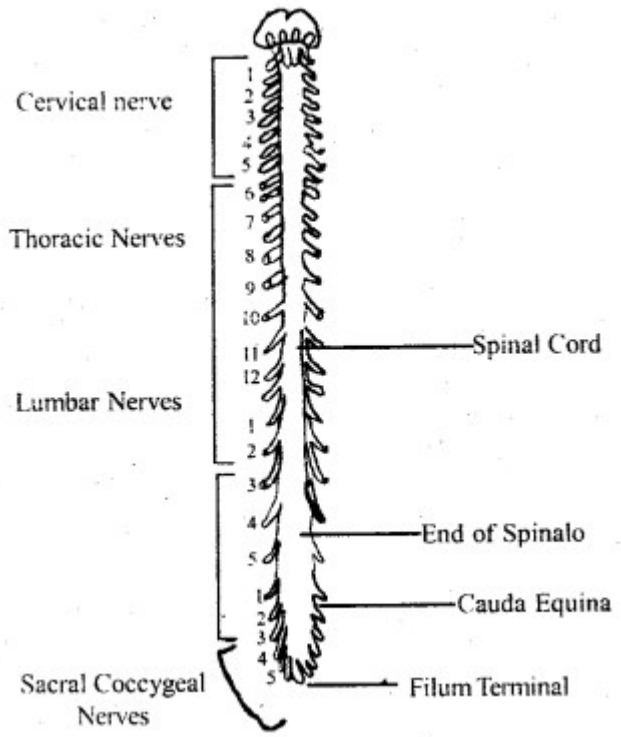
   (b) Answer:

   i. The skeletal system forms the rigid structural framework of the body and supports the weight of the body along with its limbs.

   ii. It affords protection to the internal organs against mechanical injury by forming cage-like compartments, e.g., skull.

   iii. It serves as a storage depot for calcium and phosphate, which are released for a number of functions of the body.

   iv. It participates in movement and locomotion.



The spinal nerve in man

3. (a) Answer: Afferent neurons and efferent neurons:

   Afferent neurons: These conduct sensory impulses from the receptors present in the peripheral organs and tissues towards the central nervous system. Their bodies are called afferent neurons.

   Efferent neurons: These conduct motor impulses from the central nervous system to the peripheral organs and tissues serving as effectors. Their cell bodies are called efferent neurons.

   (b) Answer: Rods: Rod cells are rod-like, elongated cells, bearing long, thin cylinders, containing a visual pigment called Rhodopsin. Rod cells are present on the periphery of the retina in the human eye. These cells do not form color vision.

   Cones: Cone cells are shorter, thicker, and conical in shape. These are highly sensitive to bright light and colors. They contain a violet color pigment called rhodopsin. Cone cells are responsible for the perception of different colors. Cones are abundant on the rear wall and fovea centralis of the retina.

   (c) Answer: Resting membrane potential: The surface of the axon carries a positive charge relative to its interior and this electrical potential difference across the plasma membrane is called resting membrane potential.

   Action potential: The shift of ions and consequents shift in electrical charges is sufficient enough; it will trigger a wave of transient membrane depolarization known as nerve impulse or Action potential.

   (d) Answer: Impulse conduction in myelinated nerve fiber: The myelinated fibers carry impulses nearly 20 times faster than the non-myelinated nerve fibers. These avoid dissipation of impulse into adjusting fibers. The myelin sheath serves as a highly insulating layer that prevents the flow

of ions. Impulses are rapid.

Non-myelinated nerve fiber: Ionic changes and depolarization are repeated over the membrane all along with the fiber. Impulse requires less energy and does not need to run all along with the fiber.

(e) Answer: Aqueous humor: The chamber between the cornea and lens is filled with a clear watery fluid, the aqueous humor.

Vitreous humor; The chamber behind the lens is filled with a semisolid gelatinous material the vitreous humor.

(f) Answer: Blindspot: It s a small insensitive light area of about 0.5 cm. in diameter. It is devoid of rod and cone cells. It is unable to receive light rays.

Yellow spot: A tiny circular area, about 6 mm in diameter in the retina is a yellow spot. Here the vision is sharpest. It has rod and cone cells.

(g) Answer: Cranial nerve: There are 12 pairs of cranial nerves, 10 originate from the brain stem, but all pass through the foramina of the skull. Cranial nerves contain only sensory fibers. The remainder contains both sensory and motor fibers.

Spinal Nerve: They arise from the cord. 31 pairs of segmental spinal nerves arise from the cord. They contain both receptor neurons and effectors neurons.

Assertion Reason Answer-

1. (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   Explanation: A Nerve electrical impulse only travels in one direction. In order for a "nerve impulse" to pass from cell to cell, it must cross synaptic junctions. The nerve cells are lined up head to tail all the way down a nerve track, and are not connected, but have tiny gaps between them and the next cell.

   Nerve impulses are mostly electrical signals along the dendrites to produce a nerve impulse or action potential. The action potential is the result of ions moving in and out of the cell. A nerve impulse travels from the dendritic end towards the axonal end.

2. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: The axon terminal of the neuron contains many membrane bound vesicles called synaptic vesicles, in its cytoplasm. Within these vesicles, chemical substances such as adrenaline and acetylcholine remain stored. These chemicals are called neurotransmitters, because they help to transmit nerve impulses across the synapses. When a nerve impulse passes the axon terminal, its synaptic vesicles release their stored chemicals to the synaptic cleft. These diffuse through the cleft to reach the membrane of the next neuron, stimulating the latter. This causes the nerve impulse to be transmitted along the next neuron.