Chapter – 21

Neural Control & Coordination

NCERT Back Exercises:

Ques 1: Briefly describe the structure of the following:

(i) Brain

(ii) Eye

(iii) Ear

Ans 1:

(i) Structure of the brain

The brain acts as control and command system of the body. It is protected by skull and is covered by three meninges. It is divisible into three main regions: forebrain, midbrain and hindbrain.

(a) Forebrain – It consists of three regions:

- *Olfactory lobes:* These are a pair of very small, solid club-shaped bodies which are widely separated from each other. They are fully covered by cerebral hemispheres.

- *Cerebrum* – It is the largest and most complex of all the parts of human brain. A deep cleft divides the cerebrum into right and left cerebral hemispheres, connected by myelinated fibres, the corpus callosum.

- *Diencephalon* – It encloses a slit-like cavity, the third ventricle. The thin roof of this cavity is known as the epithalamus, the thick right and left sides as the thalami, and floor as the hypothalamus.

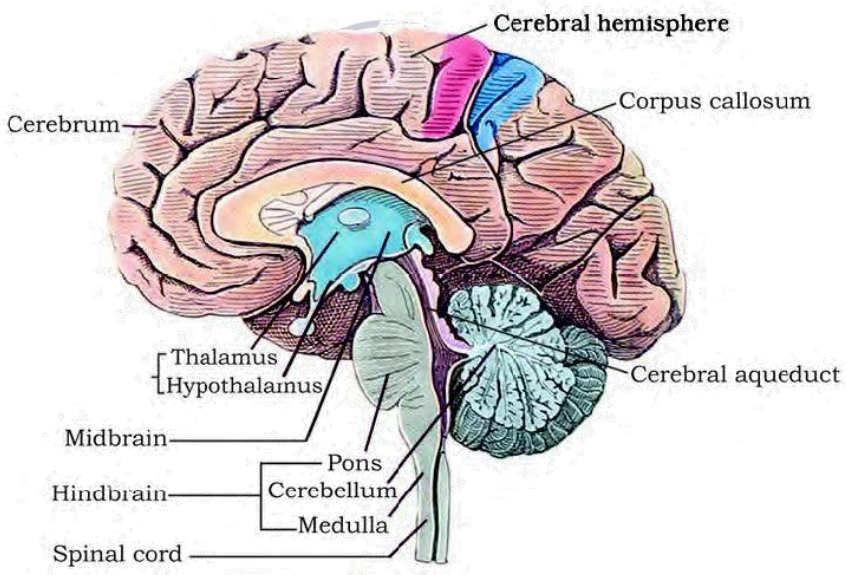
(b) Midbrain – It is located between thalamus/ hypothalamus of forebrain and pons of hindbrain. Its upper surface has two pairs of rounded protrusious called corpora quadrigemina and two bundles of fibres called crura cerebri.

(c) Hindbrain – It consists of:

- *Cerebellum* – The second largest part of the human brain is the cerebellum. It consists of two lateral cerebellar hemispheres and central worm-shaped part, the vermis. The cerebellum has its grey matter on the outside, comprising three layers of cells and fibres. It also has Golgi cells, basket cells and granule cells.

- *Pons varolii* – An oval mass, called the pons varolii, lies above the medulla oblongata. It consists mainly of nerve fibres which interconnect different regions of the brain.

- *Medulla oblongata* – It extends from the pons varolii above and is continuous with the spinal cord below. The mid brain, pons varolii and medulla oblongata are collectively called brain stem.



(ii) Structure of the Eye

Eye is a hollow spherical structure composed of three coats:
(i) Outer fibrous coat
(ii) Middle vascular coat
(iii) Inner nervous coat

(i) Fibrous coat: It is thick and protects the eyeball. It has two distinct regions – sclera and cornea. Sclera covers most of the eye ball. The sclera or white of the eye containsmany collagen fibres. Cornea is a transparent portion that forms the anterior one – sixth of the eyeball. The cornea is avascular (i.e., lacks blood supply).

(ii) Vascular coat: It comprises of 3 regions : choroid, iris, ciliary body.

(a) *Choroid:* It lies adjacent to sclera and contains numerous blood vessels and pigmented cells.

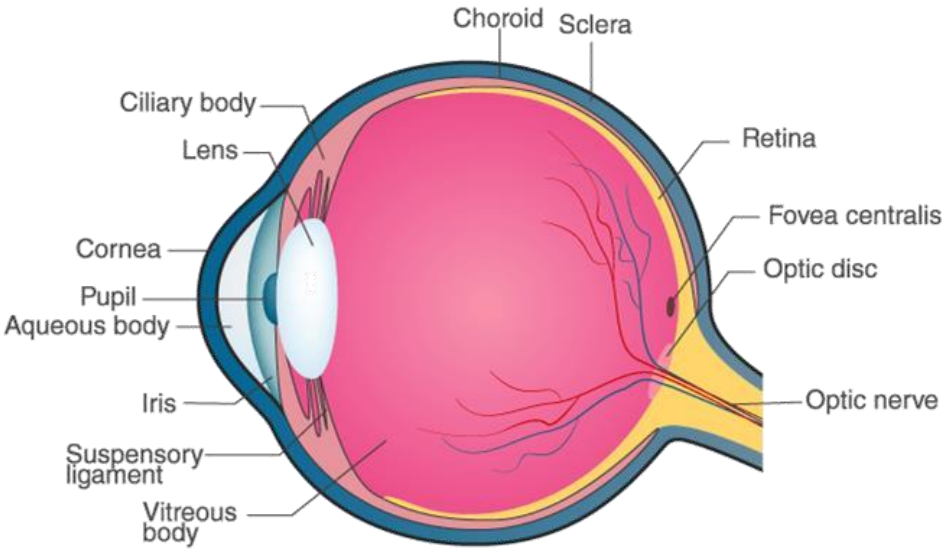
(b) *Iris:* The iris is a circular muscular diaphragm containing the pigment giving eye its colour. It extends from the ciliary body across the eyeball in front of the lens.It 2 has an opening in the centre called the pupil.

(c) Ciliary body: Behind the peripheral margin of the iris, the vascular coat is thickened to form the ciliary body. It is composed of the ciliary muscles and the ciliary processes.

(iii) Nervous coat: It consists of retina which is neural and sensory layer of an eye ball. It consists of three layers; ganglion cells, bipolar cells and photoreceptor cells (rods andcones).

(iv) Lens: It is a transparent, biconvex, elastic structure that bends light waves as they pass through its surface. It is composed of epithelial cells that have large amounts of clear cytoplasm in the form of fibres.

Chambers of eyeball: The lens, suspensory ligament and ciliary body divide the eye into an anterior aqueous chamber and a posterior vitreous chamber which are filled with aqueous humour and vitreous humour respectively.



(iii) Structure of the Ear

The human ear has two sensory functions – enables hearing and maintains the balance of the body. It can be divided into three main sections:

(i) Inner ear
(ii) Outer ear
(iii) Middle ear.

(i) Inner ear: It also known as the labyrinth, it is split into membranous labyrinth and the bony labyrinth. Membranous labyrinth is filled with endolymph while bony labyrinth is filled with perilymph.

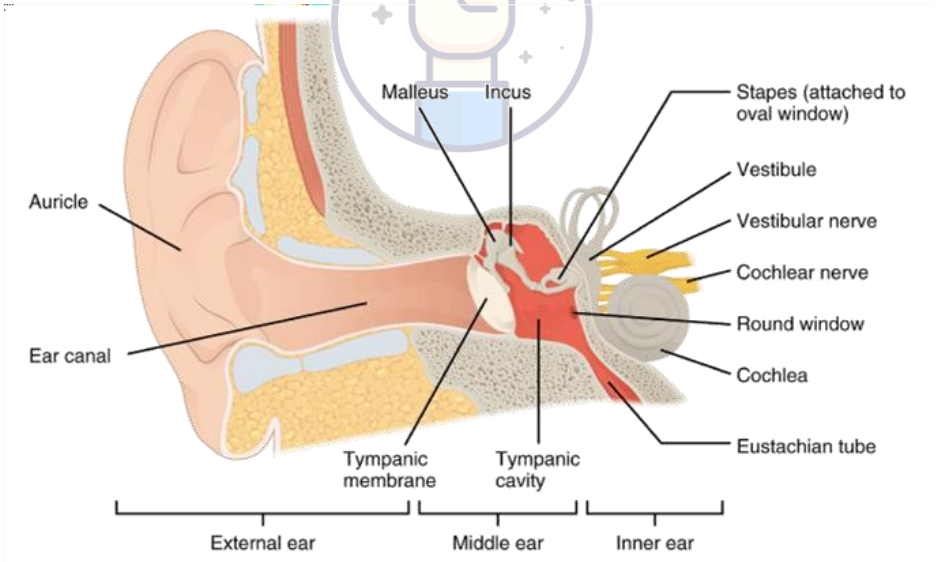
(a) The Membranous labyrinth is segregated into two portions – vestibular apparatus and the cochlea. The vestibular apparatus consists of three semi-circular canals and otolith. Each semi-circular canal lies is in a different plane at right angles to each other. The membranous canals are suspended in the bony canals (perilymph). The base of the canals is swollen and is known as ampulla containing crista ampullars – a projecting ridge which has hair cells.

(b) The utricle and the saccule have a projecting ridge known as macula. The macula and the crista are the particular receptors of the vestibular apparatus that has a role to play in maintaining the posture and body balance.

(c) Sacculus has a coiled and long outgrowth – cochlea which is the chief hearing structure consisting of three membranes. A hearing organ, the organ of corti, is situated on the basilar membrane possessing hair cells.

(ii) Outer ear: It has the pinna and the external auditory canal (meatus). The pinna gathers the vibrations in the air that generate sound. The external auditory canal extends up to the ear drum (tympanic membrane). It has very fine hair, wax-secreting glands in the skin of the meatus and the pinna. The tympanic membrane consists of connective tissues covered with mucous membrane inside and with skin on the outside.

(iii) Middle ear: It consists of three ossicles known as the malleus, stapes and incus that are linked tone another in a chain pattern. The malleus is linked to the tympanic membrane and the stapes is linked to the oval window of the cochlea. The ear ossicles increases the efficiency of transmission of sound waves to the inner ear. The middle ear cavity is connected to the pharynx through the Eustachian tube which aids in equalizing the pressure on both sides of the ear drum.



Ques 2: Compare the following:

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

(ii) Resting potential and action potential

(iii) Choroid and retina

Ans 2:

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

	Central neural system (CNS)	Peripheral neural system (PNS)
1.	Consists of the spinal cord and the brain	It consists of the spinal nerves and the cranial nerves
2.	Spinal column is protected by the vertebral column whereas the brain is protected by the skull	No protective structures
3.	No subdivisions	It is divided into autonomic nervous system and the somatic nervous system
4.	Processes information and regulates the responses to impulses.	Nerves of PNS passes impulses to the CNS and responses from the CNS to various structures of the body
5.	Group of neurons is known as nuclei	Group of neurons is known as ganglia

(ii) Resting potential and action potential

Resting potential		Action potential
1.	When the neuron is at the resting phase, it is the potential difference across membrane	When the neuron is triggered it is the potential difference across the membrane
2.	The exterior side of the neuron is positively charged while the interior side is negatively charged	The exterior side of the neuron is negatively charged and the interior side of the neuron is positively charged
3.	Permeability of K^+ ions is observed to be more by the plasma membrane of neurons	Permeability of Na^+ ions is observed to be more by the plasma membrane of the neurons
4.	To maintain the resting potential, the sodium- potassium ATPase pump is activated, sending Na^+ ions outside the neuron	It functions in a reverse pattern wherein the sodium-potassium ATPase pump sends Na^+ ions to the neuron.

(iii) Choroid and retina

Choroid		Retina
1.	Forms the mid coat of the eyeball	Forms the inner coat of the eye ball
2.	Forms the vascular layer of the eyeball	Forms the neurosensory layer of the eyeball
3.	Has no photoreceptor cells	Has two kinds of photoreceptors – rods and cones
4.	Prevents reflection of light in the eye and nourishes the retina	Imparts vision

Ques 3: Explain the following processes:

(i) Polarisation of the membrane of a nerve fibre

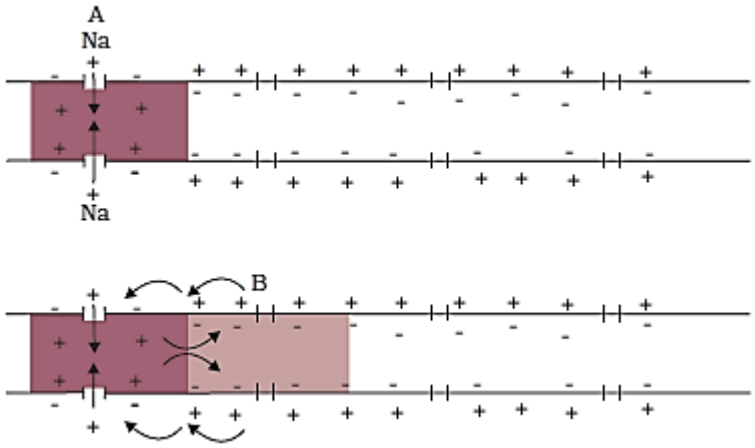
(ii) Depolarisation of the membrane of a nerve fibre

(iii) Conduction of a nerve impulse along a nerve fibre

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

Ans 3:

(i) Polarisation of the membrane of a nerve fiber: Polarisation of the membrane of a nerve fibre : In the resting (not conducting impulse) nerve fibre the plasma membrane separates two solution of different chemical composition but having approximatelythe same total number of ions. In the external medium (tissue fluid), sodium ions (Na^+) and Cl^- ions predominate, whereas within the fibre (intracellular fluid) potassium ions (K^+) predominate. The differential flow of the positively charged ions and the inability of the negatively charged organic (protein) ions within the nerve fibre to pass out cause an increasing positive charge on the outside of the membrane and negative charge on the inside of the membrane. This makes the membrane of the resting nerve fibre polarized, extracellular fluid outside being electropositive (positively charged) with respect to the cell contents inside it.



(ii) Depolarisation of the membrane of a nerve fibre: Depolarisation of the membrane of a nerve fibre: During depolarisation, the activation gates of Na channels open, and the K channels remain closed. Na^+ rush into the axon. Entry of sodium ions leads to depolarisation (reversal of polarity) of the nerve membrane, so that the nerve fibre contents become electropositive with respect to the extracellular fluid.

(iii) Conduction of a nerve impulse along a nerve fibre: Conduction of a nerve impulse along a nerve fibre: Nervous system transmits information as a series of nerve impulses. A nerve impulse is the movement of an action potential as a wave through a nerve fibre. Action potentials are propagated, that is, self-generated along the axon. The events that set up an action potential at one spot on the nerve fibre also transmit it along the entire length of the nerve fibre. The action potential then moves to the neighbouring region of the nerve fibre till it covers the whole length of the fibre.

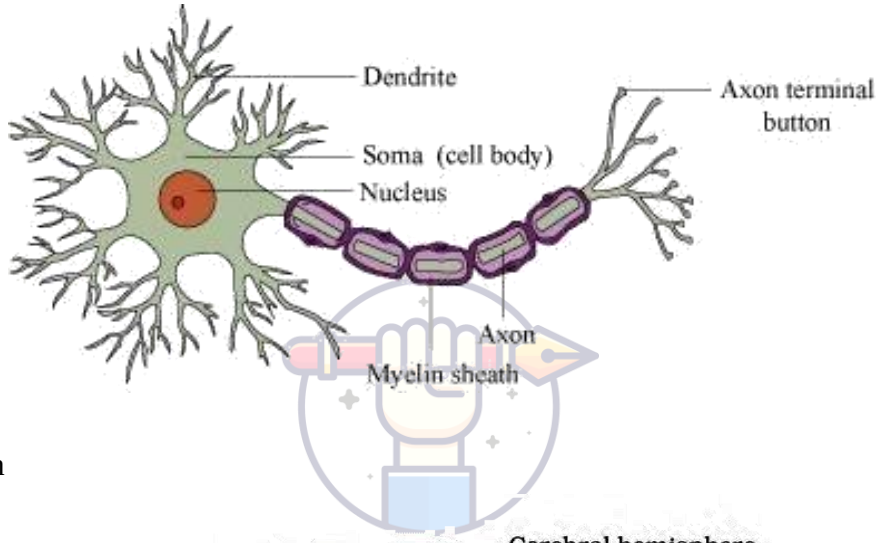
(iv) Transmission of a nerve impulse across a chemical synapse: At a chemical synapse, the membranes of the pre- and post- synaptic neurons are separated by a fluid- filled space called synaptic cleft. Chemicals called neurotransmitters are involved in the transmission of impulses at these synapses. The axon terminals contain vesicles filled with these neurotransmitters. When an impulse (action potential) arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with the plasma membrane and burst to release their neurotransmitters in the synaptic cleft. The released neurotransmitters bind to their specific receptors, present on the post- synaptic membrane. This binding opens ion channels allowing the entry of ions which can generate a new potential in the post- synaptic neuron. The new potential developed may be either excitatory or inhibitory.

Ques 4: Draw labelled diagrams of the following:

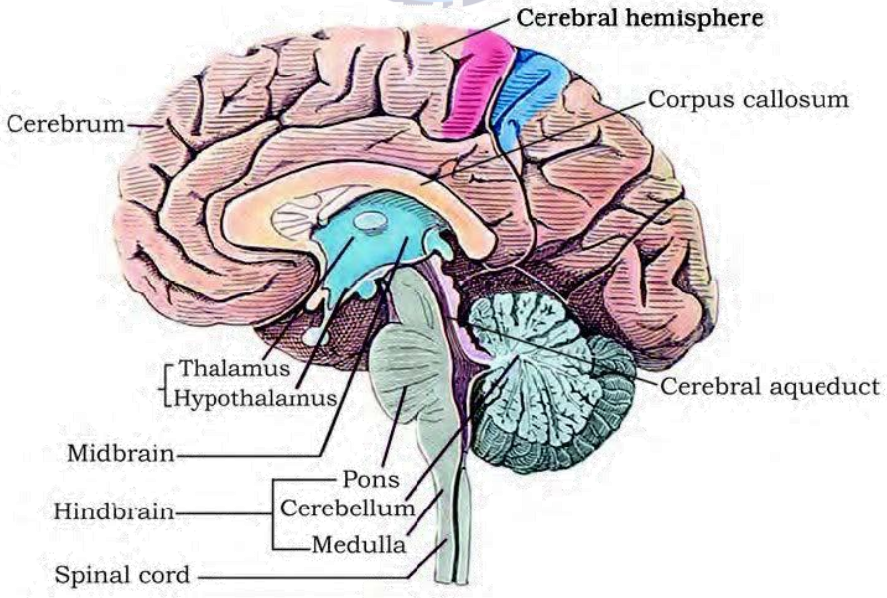
(i) Neuron
(ii) Brain
(iii) Eye
(iv) Ear

Ans 4:

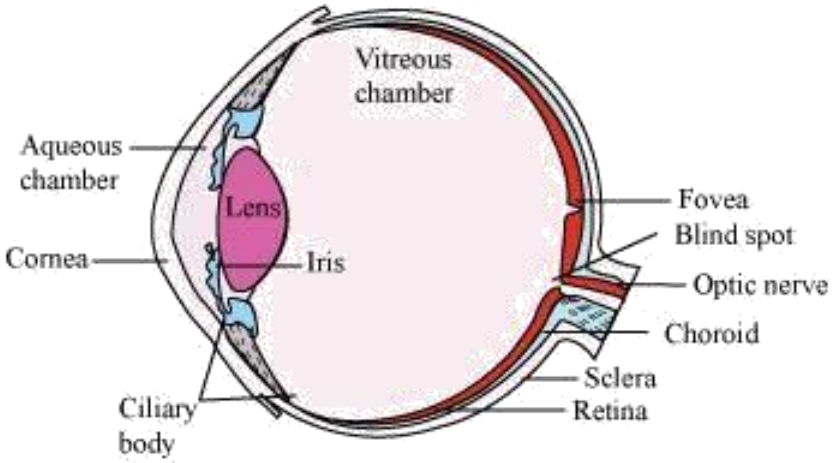
(i) Neuron



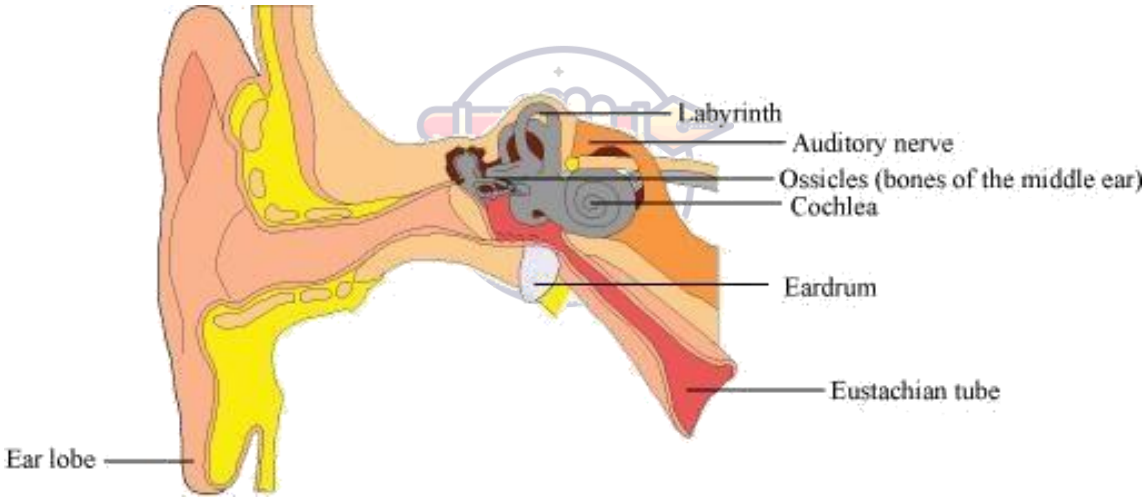
(ii) Brain



(iii) Eye



(iv) Ear



Ques 5: Write short notes on the following:

(i) Neural coordination
(ii) Forebrain(iii)Midbrain
(iv) Hindbrain
(v) Retina
(vi) Ear ossicles
(vii) Cochlea
(viii) Organ of Corti
(ix) Synapse

Ans 5:

(i) Neural coordination: When higher animals respond to various stimuli, each response to a specific stimulus generally involves many organs (parts) of their bodies. Therefore, it is necessary that all the concerned organs (parts) of the body should work in a systematic manner to produce the response. The working together of various organs (parts) of the body of multicelullar organism in a proper manner to complement the functions of each other is called coordination. This is achieved by three overlapping processes of nervous system-sensory input, integration and motor output.

(ii) Forebrain: It consists of Olfactory lobes, the paired structures concerned with the sense of smell. Cerebrum which is the largest and most complex of all the parts of thehuman brain. It is divided by a cleft into left and right cerebral hemispheres which are connected by a large bundle of myelinated fibres the. corpus callosum. The outer cover of cerebral hemisphere is called cerebral cortex. It consists of sensory and motor areas. Hypothalamus region of forebrain contains centres which control body temperature, hunger and also contains group of neurosecretory cells.

(iii) Midbrain: The midbrain is located between the thalamus/hypothalamus of the forebrain and pons of the hindbrain. A canal called the cerebral aqueduct passess through the midbrain. The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called corpora quadrigemina. Midbrain and hindbrain form the brain stem.

(iv) Hindbrain: It consists of three regions – pons, cerebellum, and medulla oblongata.

(a) *Pons* is a band of nerve fibres that lies between medulla oblongata and midbrain. It connects the lateral parts of cerebellar hemisphere together.

(b) *Cerebellum* is a large and well developed part of hindbrain. It is located below the posterior sides of cerebral hemispheres and above the medulla oblongata. It is responsible for maintaining posture and equilibrium of the body.

(c) *Medulla oblongata* is the posterior and simplest part of the brain. It is located beneath the cerebellum. Its lower end extends in the form of spinal cord and leaves the skull through foramen magnum.

(v) Retina: Retina is the innermost layer. It contains three layers of cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells. The receptor cellspresent in the retina are of two types – rod cells and cone cells.

(a) *Rod cells*: The rods contain rhodopsin pigment (visual purple), which is highly sensitive to dim light. It is responsible for twilight vision.

(b) *Cone cells:* The cones contain iodopsin pigment (visual violet) and are highly sensitive to high intensity light. They are responsible for daylight and colour visions.

The innermost ganglionic cells give rise to optic nerve fibre that forms optic nerve in each eye and is connected with the brain. In this region, the photoreceptor cells are absent. Hence, it is known as the blind spot. At the posterior part, lateral to blind spot, there is a pigmented spot called macula lutea. This spot has a shallow depression at itsmiddle known as fovea. Fovea has only cone cells. They are devoid of rod cells. Hence, it is the place of most distinct vision.

(vi) Ear ossicles: The middle ear possesses three ear ossicles known as malleus, incus and stapes that are interlinked to one another in a chain-like pattern. The malleus is in contact with the tympanic membrane, the incus with stapes and stapes inturn with the oval window of the cochlea. The ear ossicles promote and cause an increase in the efficiency of sound wave transmission to the inner ear.

(vii) Cochlea: It is the coiled portion of the labyrinth. The membranes that constitute it, the basilar and reissner's segregate the enveloping perilymph that is filled with the bony labyrinth into an upper scala vestibule and a lower scala tympani. The scala media(space within cochlea) is filled with endolymph and at the base of the cochlea, the scala vestibule terminates at the oval window whereas the scala tympani ends at the round window that opens to the middle ear.

(viii) Organ of Corti: Organ of corti is the hearing organ. It is located on the basilar membrane that contains hair cells. Hair cells act as auditory receptors. They are present on the internal side of organ of corti.

(ix) Synapse: It is formed by the membranes of a pre-synaptic and a post-synaptic neuron, that may or may not be segregated by a gap known as the synaptic cleft. These are thetwo types of chemical synapses and electrical synapses.

Ques 6: Give a brief account of:

(i) Mechanism of synaptic transmission

(ii) Mechanism of vision

(iii) Mechanism of hearing

Ans 6:

(i) Mechanism of synaptic transmission: Synapses are the junctions where the nerve impulses are transmitted from one neuron to another. These are formed by the membranes of a pre- synaptic and a post-synaptic neuron, that may or may not be segregated by a gap known asthe synaptic cleft. These are the two types of chemical synapses and electrical synapses.

The membranes of a pre-synaptic and a post-synaptic neuron at the electrical synapses are in close proximity so that electrical current can directly flow from one neuron to the other acrossthese particular synapses. The transmission of an impulse across an electrical synapses is similar to conduction of an impulse along a single axon where the transmission is always quicker than that across a chemical synapse which is not commonly observed in the human body.

(ii) Mechanism of vision: The passage of light rays is as follows – pupil, lens, aqueous humour, vitreous humour and finally retina. This light causes the dissociation of the photo-pigment rhodopsin to retinal and opsin. The structure of opsin is subjected to changes due to the dissociation of opsin from the retinal which generates an action potential in the cones and rods of the retina. Furthermore, the action potential is transmitted to the ganglion cells via the bipolar neurons and ultimately transmitted to the visual cortex of the brain through the optic nerve. Analysis of impulses take place at the visual cortex, responses are sent back in order to form images on the retina.

(iii) Mechanism of hearing: The external ear receives sound waves and directs them to the ear drum. The ear drum vibrates in response to the sound waves and these vibrations are transmitted through the ear ossicles (malleus, incus and stapes) to the oval window. The vibrations are passed through the oval window on to the fluid of the cochlea, where they generate waves in the lymphs. The waves in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells, pressing them against the tectorial membrane. As a result, nerve impulses are generated in the associated afferent neurons.

Ques 7: Answer briefly:

(i) How do you perceive the colour of an object?

(ii) Which part of our body helps us in maintaining the body balance?

(iii) How does the eye regulate the amount of light that falls on the retina.

Ans 7:

(i) In humans, colour vision results from the activity of cone cells, a type of photoreceptor cells. In the human eye, there are three types of cones which possess their own characteristic photo pigments that respond to red, green and blue lights. Thesensations of different colours are produced by various combinations of these cones and their photo pigments. When these cones are stimulated equally, sensation of white light is produced. Yellow light, for instance, stimulates green and red cones approximately to equal extent, and this is interpreted by the brain as yellow colour.

(ii) Ears (cristae and maculae present in internal ears).

(iii) The iris contains two sets of smooth muscles – sphincters and dilators. These muscles regulate the amount of light entering the eyeball by varying the size of pupil. Contraction of sphincter muscles makes the pupil smaller in bright light so that less light enters the eye. Contraction of dilator muscles widens the pupil in dim light so that more light goes in eye to fall on retina.

Ques 8: Explain the following:

(i) Role of Na+ in the generation of action potential.

(ii) Mechanism of generation of light-induced impulse in the retina.

(iii) Mechanism through which a sound produces a nerve impulse in the inner ear.

Ans 8:

(i) Role of Na+ in the generation of action potential: When a nerve fiber is triggered, the sodium channels of the neurilemma are open and activated. From the outside, the sodium ions diffuse to the intracellular fluid due to the electrochemical gradient that is established. The membrane gets charged negatively from outside as the potassium ions move out and positively charged from inside. The immediate change that occurs in the membrane is known as action potential causing the membrane to get depolarized.

(ii) Mechanism of generation of light-induced impulse in the retina: Human eye consists of photo pigments known as retinal and opsin. These are dissociated when light induces bringing about a change in the structure of opsin, causing an action potential to generate inthe bipolar neurons. These action potential or impulses are conveyed to the visual cortex of the brain by the optic nerves where these impulses are read to analyze, recognizing an erect image.

(iii) Mechanism through which a sound produces a nerve impulse in the inner ear: Vibrations are received through the membrane layering the fenestra ovalis by the perilymph of the internal ear. From here (the perilymph), vibrations are conveyed to the scala vestibule of the cochlea and furthermore to the scala media via the Reissner's membrane, triggering the sensory hair of the organ of corti, which is the organ of hearing. These hair cells receive impulse to carry it to the brain through the auditory nerve, where the sense of hearing is felt.

Ques 9: Differentiate between:

(i) Myelinated and non-myelinated axons

(ii) Dendrites and axons

(iii) Rods and cones

(iv) Thalamus and Hypothalamus

(v) Cerebrum and Cerebellum

Ans 9:

(i) Myelinated and non-myelinatedaxons

Myelinated axons		Non-myelinated axons
1.	Transmission of nerve impulse is faster	Transmission of nerve impulse is slower
2.	Myelinated axon has a myelin sheath.	Myelin sheath is absent
3.	Node of Ranvier is present between adjacent myelin sheaths.	Node of Ranvier is absent
4.	Found in the brain, the spinal cord, thecranial and spinal nerves	Found in autonomous and somatic neural systems
5.	Schwann cells are observed inside the myelin sheath	Schwann cells are not observed inside the myelin sheath

(ii) Dendrites and axons

	Dendrites	Axons
1.	Dendrite is a small projection arising from the neuron. It conducts the nerve impulse toward the cell body.	Axon is a single, long projection that conducts the nerve impulse away from cell body to the next neuron.
2.	Nissl's granules are present indendrites.	Nissl's granules are absent from axons.
3.	They are branched, always	Axons may or may not be branched
4.	Nissl's granules are found in neuroplasm	Nissl's granules are absent in neuroplasm

(iii) Rod & Cones

	Rods	Cones
1.	Sensitive to dim light	Sensitive to bright light
2.	Contains rhodopsin pigment	Contains iodopsin pigment
3.	Not involved in colour vision	Crucial in imparting colour vision
4.	Rods are of one kind only	Three kinds of cones exist sensing – red, blue, green lights

(iv) Thalamus and Hypothalamus

	Thalamus	Hypothalamus
1.	Consists of grey matter only	Consists of white and grey matter
2.	Does not secrete hormones	Secretes several hormones that control the activity of pituitary gland
3.	Located above the midbrain	Located at the base of the thalamus
4.	Has the centre for sensationsnamely – cold, pain, heat	Has the centre for sensations namely – regulating body temperature, homeostasis, blood pressure

(v) Cerebrum and cerebellum

	Cerebrum	Cerebellum
1.	Brain is majorly covered by the cerebrum	Second largest part of the brain aftercerebrum
2.	It is portion of forebrain	It is part of hindbrain
3.	It is divided into two cerebral hemispheres	It is divided into three lobes namely – central vermis, two lateral cerebral hemispheres
4.	It is the centre for intelligence and memory	It is the centre for posture and body equilibrium

Ques 10: Answer the following:

(i) Which part of the ear determines the pitch of a sound?

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

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

Ans 10:

(i) The part of the ear that determines the pitch of a sound is **cochlea**

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

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

Ques 11: The region of the vertebrate eye, where the optic nerve passes outof the retina, is called the

(i) Fovea

(ii) Iris

(iii) Blind spot

(iv) Optic chaisma

Ans 11: The region of the vertebrate eye, where the optic nerve passes out of the retina, is called the **(iii) Blind spot**

Ques 12: Distinguish between:

(i) Afferent neurons and efferent neurons

(ii) Impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

(iii) Aqueous humor and vitreous humor

(iv) Blind spot and yellow spot

(v) Cranial nerves and spinal nerves.

Ans 12:

(i) Afferent neurons and efferent neurons

	Afferent neurons	**Efferent neurons**
1.	Afferent neuron conducts nerve impulses toward the brain or the spinal cord.	Efferent neuron conducts nerve impulses from the brain or spinal cord to the effector organs such as muscles or glands.

(ii) Impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

	Impulse conduction in a myelinated nerve fibre	**Unmyelinated nerve fibre**
1.	In a myelinated nerve fibre, the action potential is conducted from one node to another.	In an unmyelinated nerve fibre, the action potential is not conducted from node to node. It is carried along the whole length of the nerve fibre.
2.	The conduction of impulses is faster.	The conduction of impulses is slower.

(iii) Aqueous humor and vitreous humor

	Aqueous humor	**Vitreous humor**
1.	It is a thin, watery fluid present between the cornea and the lens.	It is a transparent gel present between the lens and the retina.

(iv) Blind spot and yellow spot

	Blind spot	Yellow spot
1.	Blind spot is a spot on the retina present at the point of origin of the optic nerve.	Yellow spot is a small area on the retina present at the posterior pole of the eye, lateral to the blind spot.
2.	Photoreceptor cells are absent from this region.	Only cones are present in this region.
3.	They are insensitive to light as both rods and cones are absent.	They are sensitive to bright light as cones are present.
4.	It is not functional in vision	The yellow spot is the region that has the most distinct vision

(v) Cranial nerves and spinal nerves

	Cranial nerves	Spinal nerves
1.	Human body has 12 pairs of cranial nerves	We have 31 pairs of spinal nerves
2.	Cranial nerves emerge from the brain and extend to other parts of the body	They originate from the spinal cord, extending to other parts of the body
3.	Cranial nerves can be mixed, motor or sensory	Spinal nerves are mixed nerves