1. **Describe the structure of the following:**

   (a) Brain (b) Eye (c) Ear

**Solution:**

(a) Brain

The brain is the main centre for coordinating the physiochemical processes of the body. It is a part of the central nervous system (CNS). The cranial meninges protect the brain. The **meninges** are made up of three layers: the outer layer dura mater, a thin middle layer arachnoid, and an inner layer pia mater.

The brain is divided into three main regions — **forebrain, midbrain, and hindbrain**.

i. **Forebrain:** It is the central thinking part of the brain. It comprises of the cerebrum, thalamus, and hypothalamus.

   - **Cerebrum:**
     
     The cerebrum or cortex is the most substantial part of the brain having four-fifths of the brain’s weight. The cerebrum is divided into **two hemispheres**, separated by a deep **longitudinal cerebral fissure**. These hemispheres are joined by a nerve fibre called the **corpus callosum**. The cerebral hemispheres are covered by cerebral cortex or **grey matter**. The innermost part of cerebrum gives an opaque white appearance to the layer and is known as the **white matter**. The cerebral cortex is divided into four lobes: frontal lobe, parietal lobe, occipital lobe, and temporal lobe.

     **Frontal Lobe** - is related to reasoning, planning, parts of speech, movement, emotions, and problem-solving.

     **Parietal Lobe** - is related to mobility, orientation, recognition, perception of stimuli.

     **Occipital Lobe** - is related to visual processing.

     **Temporal Lobe** - is associated with the identification of auditory stimuli, memory, and speech. The hippocampus, located in the temporal lobe, is involved in memory. The **amygdala** is an
almond-shaped nuclei found deep within the temporal lobe, which plays a key role in the processing of emotions.

- **Thalamus:**

Thalamus is the main centre of coordination for sensory and motor signalling. The cerebrum wraps around it. It’s part of a limbic system.

- **Hypothalamus:**

It is situated at the base of the thalamus and contains several centres that regulate body temperature and the urge for drinking and eating. It’s also involved in the regulation of sexual behaviour and expression of emotional reactions such as pleasure, fear, excitement, etc. It secretes hormones that act on the pituitary gland to regulate biological processes, including metabolism, growth, and the development of reproductive system organs. It’s part of a limbic system.

[Note: Pineal gland: It produces the hormone melatonin, which plays a role in the control of sleep and wake cycles.]

**ii. Midbrain:**

It is located between the thalamus region of the forebrain and pons region of hindbrain. The midbrain is concerned with the sense of sight, movements of the eye and hearing. Midbrain and hindbrain form the brain stem.

**iii. Hindbrain:**

The hindbrain consists of three regions – pons, cerebellum, and medulla oblongata.

- The **pons** is the most substantial part of the brainstem, located above the medulla and below the midbrain. It connects the forebrain with the hindbrain and the cerebrum to the cerebellum through the cerebral peduncle. Pons deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation, and posture.

- The **cerebellum** 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. It coordinates voluntary movements such as posture, balance, coordination, and speech, resulting in smooth muscular activity.

- The **medulla oblongata** is the posterior part of the brain, located beneath the cerebellum. Its lower end extends in the form of the spinal cord and leaves the skull through the foramen magnum. The medulla oblongata helps in regulating breathing, heart and blood vessel function, digestion, sneezing and swallowing. It is a centre for respiration and circulation.
Figure: Structure of the human brain
(b) Eye

Eyes are in a pair which are spherical structures located in the sockets of the skull called orbits. Eyes consist of three layers.

(i) The outer layer is made of dense connective tissue is called **sclera**, also known as white of the eye. The anterior portion of this layer is called the **cornea**, which is transparent and lacks blood vessels and is nourished by lymph from the nearby area.

(ii) The middle layer of the eye is **choroid**, which consists of a ciliary body and iris. Choroid lies next to the sclera and contains numerous blood vessels that provide nutrients and oxygen to the retina and other tissues.

- **Ciliary body**: It is a thick anterior portion that contains blood vessels, ciliary muscles, and ciliary processes.
- **Iris**: At the junction of sclera and cornea, the ciliary body continues forward to form a thin pigmented and opaque structure called iris. It is the visible coloured portion of the eye.
- The eye contains a transparent, elastic and biconvex structure behind the iris, which is known as a **lens**. The lens is held by suspensory ligaments attached to the ciliary body.
- The lens divides the eyeball into two chambers – an anterior aqueous and posterior vitreous chamber.
- The space between the cornea and the lens is called the **aqueous chamber** and contains a thin watery fluid called aqueous humor. The space between the lens and the retina is called the **vitreous chamber** and is filled with a transparent gel called vitreous humor.

(iii) The innermost layer of eye is **retina**, which is made up of three layers of neural cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells.

- These **photoreceptor cells** are of two types – rod cells and cone cells.
  - **Rod cells** – The rods contain the rhodopsin pigment (visual purple) that is highly sensitive to dim light. It is responsible for **night vision**.
  - **Cone cells** – The cones contain the iodopsin pigment (visual violet) and are highly sensitive to high-intensity light. They are responsible for **daylight and colour visions**. The three types of cones are sensitive to red, green and blue colours.

- The innermost **ganglionic cells** give rise to optic nerve fibre that forms optic nerve in each eye and is connected with the brain.
- The optic nerves leave the eye, and the retinal blood vessels enter it at a point medial to and slightly above the posterior pole of the eyeball. Photoreceptor cells are not present in that region, and hence, it is called the **blind spot**.
- Adjacent to the blind spot, there is a yellowish pigmented spot called **macula lutea** with a central pit called the **fovea**. At the fovea, there is a thinned-out portion of the retina where only the cones are densely packed. It is the point where the visual resolution is the greatest.
Figure: Anatomy of the human eye
(c) Ear
The ear is a sense organ for hearing and equilibrium/balance. It has three portions – external ear, middle ear, and internal ear.

i. External ear:
It contains pinna, external auditory meatus (canal), and a tympanic membrane (eardrum).
- Pinna collects the vibrations from the air into the ear to produce sound.
- External auditory meatus is a cartilaginous tubular passage towards the internal ear.
- The tympanic membrane is a thin membrane near the auditory canal. It separates the middle ear from the external ear.

ii. Middle ear:
It is an air-filled tympanic cavity that is connected with pharynx through the eustachian tube. The eustachian tube helps to equalize the air pressure on both sides of the tympanic membrane. The middle ear contains a flexible chain of three middle bones called ear ossicles. The three ear ossicles are malleus, incus, and stapes attached to each other.

iii. Internal ear:
It is also known as the labyrinth. The labyrinth is divided into the bony labyrinth and a membranous labyrinth. The bony labyrinth is filled with perilymph while a membranous labyrinth is filled with endolymph. The membranous labyrinth is divided into two parts.
- Cochlea:

The cochlea is the main hearing organ present in the inner ear, which is a long and coiled extension of the sacculus. The coiled portion of the labyrinth is called cochlea.

Cochlea consists of three membranes:
(i) Upper − scala vestibuli
(ii) Middle − scala media
(iii) Lower − scala tympani

The space within the cochlea (scala media) is filled with endolymph. At the base of the cochlea, the scala vestibuli ends at the oval window, while the scala tympani terminates at the round window that opens to the middle ear.

The organ of corti is a structure located on the basilar membrane which contains hair cells that act as auditory receptors.

- Vestibular labyrinth:
Vestibular apparatus is a central sac-like part which is divided into utriculus and saccus. A special group of sensory cells called macula are present in sacculus and utriculus. Vestibular apparatus also contains three semi-circular canals. The lower end of each semi-circular canal contains a projecting ridge called crista ampularis. Each ampulla has a group of sensory cells called crista. Crista and macula are responsible for the maintenance of the balance of body and posture.
Figure: Anatomy of the human ear
2. Compare the following:
   (a) Central neural system (CNS) and Peripheral neural system (PNS)
   (b) Resting potential and action potential
   (c) Choroid and retina

Solution:

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

<table>
<thead>
<tr>
<th>Central neural system</th>
<th>Peripheral neural system</th>
</tr>
</thead>
<tbody>
<tr>
<td>It consists of the brain and spinal cord.</td>
<td>It consists of sensory receptors, sensory neurons and motor neurons.</td>
</tr>
<tr>
<td>The damage to their nerves can cause an effect on the overall body.</td>
<td>The damage to their nerves is local.</td>
</tr>
<tr>
<td>Their neurons can not be regenerated.</td>
<td>Most of their nerves can be regenerated.</td>
</tr>
<tr>
<td>Their main function is to analyse the information received from the sensory organs.</td>
<td>Their main function is to transmit the impulse to CNS and pass motor impulse to effector organs.</td>
</tr>
</tbody>
</table>

(b) Resting potential and action potential

<table>
<thead>
<tr>
<th>Action potential</th>
<th>Resting potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the potential difference across nerve fibre when there is conduction of nerve impulse.</td>
<td>It is the potential difference across the nerve fibre when there is no conduction of nerve impulse.</td>
</tr>
<tr>
<td>The membrane is more permeable to Na$^+$ ions than to K$^+$ ions.</td>
<td>The membrane is more permeable to K$^+$ ions than to Na$^+$ ions.</td>
</tr>
<tr>
<td>The membrane becomes permeable to negatively charged proteins present in the axoplasm.</td>
<td>The membrane is impermeable to negatively charged proteins present in the axoplasm.</td>
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<tr>
<td>+40 mv</td>
<td>-70 mv</td>
</tr>
</tbody>
</table>
### (c) Choroid and retina

<table>
<thead>
<tr>
<th><strong>Choroid</strong></th>
<th><strong>Retina</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The choroid is the central vascular layer of the eye lying between the retina and sclera. Its <strong>function</strong> is to provide <strong>nourishment</strong> to the outer layers of the retina through blood vessels. The choroid layer is thin at the posterior two-thirds of the eyeball, but it becomes thick at the anterior part to form the <strong>ciliary body</strong>. The ciliary body continues to form a pigmented and opaque structure called the <strong>iris</strong>.</td>
<td>The retina is the innermost neural layer of the eye, followed by choroid and sclera. The retina is responsible for <strong>day</strong> vision and <strong>colour</strong> vision due to cones cells and <strong>night</strong> vision due to rods. The retina contains three layers of cells from inside to outside, i.e., <strong>ganglion</strong> cells, <strong>bipolar</strong> cells and <strong>photoreceptor</strong> cells.</td>
</tr>
</tbody>
</table>
3. Explain the following processes:

(a) Polarisation of the membrane of a nerve fibre
(b) Depolarisation of the membrane of a nerve fibre
(c) Conduction of a nerve impulse along a nerve fibre
(d) Transmission of a nerve impulse across a chemical synapse

Solution:

(a)
- The sodium ions play an important role in the determination of the action potential.
- In the resting state, the sodium channels are more permeable to $K^+$ and almost impermeable to $Na^+$ ions.
- Also, the membrane is impermeable to the negatively charged proteins, and ions present inside the axon.
- Hence, axoplasm inside the axon has more negative ions, $K^+$ ions and less $Na^+$ ions.
- But, the fluid outside the axon contains less negative proteins, $K^+$ ions and more $Na^+$ ions.
- Such a gradient is maintained by transporting $3Na^+$ outside and $2K^+$ into the cell.
- So, the outer surface becomes more positive, and the inner surface becomes more negative and hence, is polarised.

Figure: Polarisation of the membrane of a nerve fibre
(b)
- In the **resting state**, the sodium channels are more permeable to $K^+$ and almost impermeable to $Na^+$ ions.
- So, the outer surface becomes more positive, and the inner surface becomes more negative.
- When a **stimulus** is applied, the receptors of the channel change their shape and become more permeable to $Na^+$, followed by a reversal of the polarity.
- So, the outer surface becomes more negative, and the inner surface becomes more positive.
- This reversal of polarity across the membrane is known as **depolarisation**.
- The rapid inflow of $Na^+$ ions causes the membrane potential to increase, thereby generating an **action potential**.

![Figure: Depolarisation of the membrane of a nerve fibre](image)

(c)
- The nerve fibre (axon) is cylinder-shaped, which is filled with axoplasm (i.e., cytoplasm of nerve cell) and the exterior of which is covered with a thin membrane called axon membrane (axolemma).
- The axon is in the extracellular fluid (ECF). The movement of solute takes place between the axoplasm and ECF through axolemma.
- During resting phase, the Na-K pump located on the axon membrane pumps $Na^+$ ($3Na^+$) from axoplasm to ECF and $K^+$ ($2K^+$) from ECF to axoplasm.
- The concentration of sodium ions will be about 14 times more in ECF (outside), and concentration of potassium ions will be about 28-30 times more in axoplasm (inside).
- So, the outer surface becomes more positive, and the inner surface becomes more negative and hence, is **polarised**.
- When a **stimulus** is applied, the receptors of the channel change their shape and become more permeable to Na\(^+\), followed by a reversal of the polarity.
- So, the outer surface becomes more negative, and the inner surface becomes more positive.
- This reversal of polarity across the membrane is known as **depolarisation**.
- The rapid inflow of Na\(^+\) ions causes the membrane potential to increase, thereby generating an **action potential**, which is termed as a nerve impulse.
- The sequence is repeated along the length of the axon and so the impulse is conducted.
- The rise in the stimulus-induced permeability to Na\(^+\) is extremely short-lived.
- It is rapidly followed by a rise in permeability to K\(^+\) and restores the resting potential to become once more responsive to further stimulation.

**Figure: Conduction of a nerve impulse along a nerve fibre (axon)**
(d) 

- There are two types of synapses: electrical synapses and chemical synapses.
- In a chemical synapse, the pre-synaptic neuron transmits an impulse (action potential) to the postsynaptic neuron. Here, the membranes of the pre- and post-synaptic neurons are separated by a fluid-filled space called synaptic cleft.
- The axon terminals contain vesicles filled with the chemicals called neurotransmitters (acetylcholine), which are involved in the transmission of impulses at these synapses.
- 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 release their neurotransmitters in the synaptic cleft.
- The released neurotransmitters bind to their specific receptors, present on the postsynaptic membrane.
- This binding opens ion channels allowing the entry of ions which can generate a new potential in the post-synaptic neuron.
- The enzyme acetylcholinesterase inactivates the acetylcholine. The enzyme is present in the postsynaptic membrane of the dendrite, which hydrolyses acetylcholine, and this allows the membrane to repolarise.
Figure: Axon terminal and synapse
4. Draw labelled diagrams of the following:
   (a) Neuron (b) Brain (c) Eye (d) Ear

Solution:

(a) Neuron

![Figure: Schematic representation of a neuron]
(b) Brain

Figure: Schematic representation of a human brain
Figure: Schematic representation of anatomy of the human eye
(d) Ear

Figure: Schematic representation of the anatomy of the human ear
5. Write short notes on the following:

(a) Neural coordination

(b) Forebrain

(c) Midbrain

(d) Hindbrain

(e) Retina

(f) Ear ossicles

(g) Cochlea

(h) Organ of Corti

(i) Synapse

Solution:

(a) Neural coordination:

- “The process of two or more organs interacting and complementing the functions of each other through the neural system is called neural coordination.” Neural coordination is vital for any movement occurring in a human body. The neural system provides an organised network of point-to-point connections for quick coordination.

- The neural system of all animals is composed of highly specialised cells called **neurons** which can detect, receive and transmit different kinds of stimuli. The endocrine system provides chemical integration through hormones.

- In our body, the neural system and the endocrine system jointly coordinate and integrate all the activities of the organs so that they function in a synchronised fashion.

- All the physiological processes in the body are closely linked and dependent upon each other. For example, during exercise, our body requires more oxygen and food. Hence, the breathing rate increases automatically, and the heart beats faster. This leads to a faster supply of oxygenated blood to the muscles. Moreover, cellular functions require regulation continuously. These functions are carried out by the hormones. Hence, the neural system along with the endocrine system control and coordinate the physiological processes.
(b) Forebrain:

It is the central thinking part of the brain. It comprises of the cerebrum, thalamus, and hypothalamus.

- **Cerebrum:**

The cerebrum or cortex is the most substantial part of the brain having four-fifths of the brain’s weight. The cerebrum is divided into **two hemispheres**, separated by a deep **longitudinal cerebral fissure**. These hemispheres are joined by a nerve fibre called the **corpus callosum**. The cerebral hemispheres are covered by cerebral cortex or **grey matter**. The innermost part of cerebrum gives an opaque white appearance to the layer and is known as the **white matter**. The cerebral cortex is divided into four lobes: frontal lobe, parietal lobe, occipital lobe, and temporal lobe.

**Frontal Lobe**- is related to reasoning, planning, parts of speech, movement, emotions, and problem-solving.

**Parietal Lobe**- is related to mobility, orientation, recognition, perception of stimuli.

**Occipital Lobe**- is related to visual processing.

**Temporal Lobe**- is associated with the identification of auditory stimuli, memory, and speech. The hippocampus, located in the temporal lobe, is involved in memory. The **amygdala** is an almond-shaped nuclei found deep within the temporal lobe, which plays a key role in the processing of emotions.

- **Thalamus:**

Thalamus is the main centre of coordination for sensory and motor signalling. The cerebrum wraps around it. It’s part of a limbic system.

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It is situated at the base of the thalamus and contains several centres that regulate body temperature and the urge for drinking and eating. It’s also involved in the regulation of sexual behaviour and expression of emotional reactions such as pleasure, fear, excitement, etc. It secretes hormones that act on the pituitary gland to regulate biological processes, including metabolism, growth, and the development of reproductive system organs. It’s part of a limbic system.

[Note: Pineal gland: It produces the hormone melatonin, which plays a role in the control of sleep and wake cycles.]
(c) Midbrain:
- It is located between the thalamus region of the forebrain and pons region of hindbrain. Compared with forebrain and the hindbrain, the midbrain is relatively small.
- The midbrain serves essential functions in motor movement, particularly movements of the eye, and in auditory and visual processing.
- A canal called the cerebral aqueduct passes 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.

(d) Hindbrain:

The hindbrain consists of three regions – pons, cerebellum, and medulla oblongata.

- The pons is the most substantial part of the brainstem, located above the medulla and below the midbrain. It connects the forebrain with the hindbrain and the cerebrum to the cerebellum through the cerebral peduncle. Pons deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation, and posture.

- The cerebellum 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. It coordinates voluntary movements such as posture, balance, coordination, and speech, resulting in smooth muscular activity.

- The medulla oblongata is the posterior part of the brain, located beneath the cerebellum. Its lower end extends in the form of the spinal cord and leaves the skull through the foramen magnum. The medulla oblongata helps in regulating breathing, heart and blood vessel function, digestion, sneezing and swallowing. It is a centre for respiration and circulation.

(e) Retina:

The innermost layer of eye is retina, which is made up of three layers of neural cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells.
- These photoreceptor cells are of two types – rod cells and cone cells.
  Rod cells – The rods contain the rhodopsin pigment (visual purple) that is highly sensitive to dim light. It is responsible for night vision.
Cone cells – The cones contain the iodopsin pigment (visual violet) and are highly sensitive to high-intensity light. They are responsible for daylight and colour visions. The three types of cones are sensitive to red, green and blue colours.
- The innermost ganglionic cells give rise to optic nerve fibre that forms optic nerve in each eye and is connected with the brain.
- The optic nerves leave the eye, and the retinal blood vessels enter it at a point medial to and slightly above the posterior pole of the eyeball. Photoreceptor cells are not present in that region, and hence, it is called the blind spot.
- Adjacent to the blind spot, there is a yellowish pigmented spot called macula lutea with a central pit called the fovea. At the fovea, there is a thinned-out portion of the retina where only the cones are densely packed. It is the point where the visual resolution is the greatest.

(f) Ear ossicles:
- The middle ear contains a flexible chain of three middle bones called ear ossicles:
  (i) Malleus
  (ii) Incus
  (iii) Stapes
- The malleus is attached to the incus on one side and to the tympanic membrane on the other side.
- The incus is connected with stapes and stapes are attached with an oval membrane fenestra ovalis of the internal ear.
- The ear ossicles act as a lever that transmits sound waves from the external ear to the internal ear.

(g) Cochlea:

The cochlea is the main hearing organ present in the inner ear, which is a long and coiled extension of the sacculus. The coiled portion of the labyrinth is called cochlea.

Cochlea consists of three membranes:
  (i) Upper – scala vestibuli
  (ii) Middle – scala media
  (iii) Lower – scala tympani

The space within the cochlea (scala media) is filled with endolymph.

At the base of the cochlea, the scala vestibuli ends at the oval window, while the scala tympani terminates at the round window that opens to the middle ear.

(h) Organ of Corti:
- The organ of corti is a structure located on the basilar membrane which contains hair cells that act as auditory receptors.
- The hair cells are present in rows on the inner side of the organ of corti. Above the rows of the hair cells is a thin elastic membrane called the tectorial membrane.
- The basal end of the hair cell is in close contact with the afferent nerve fibres.
- A large number of stereocilia are projected from the apical part of each hair cell.

(i) Synapse:
- A nerve impulse is transmitted from one neuron to another through junctions called synapses. Synapse is a junction between the axon terminal of one neuron and the dendrite of next neuron. It may or may not be separated by a small gap known as the synaptic cleft.
- There are two types of synapses: (a) Electrical synapse, (b) Chemical synapse.
- In electrical synapses, the pre and postsynaptic neurons lie near each other. Hence, the impulse can move directly from one neuron to another across the synapse. This represents a faster method of impulse transmission. Electrical synapses are rare in our system.
- In chemical synapses, the pre and postsynaptic neurons are not nearby. A synaptic cleft separates them. The transmission of nerve impulses is carried out by chemicals such as neurotransmitters like acetylcholine. The axon terminals contain vesicles filled with these neurotransmitters.
6. Give a brief account of:
   (a) Mechanism of synaptic transmission
   (b) Mechanism of vision
   (c) Mechanism of hearing

Solution:

(a) A nerve impulse is transmitted from one neuron to another through junctions called synapses. Synapse is a junction between the axon terminal of one neuron and the dendrite of next neuron. It may or may not be separated by a small gap known as the synaptic cleft.
   - There are two types of synapses: (a) Electrical synapse, (b) Chemical synapse.
   - In electrical synapses, the pre and postsynaptic neurons lie near each other. Hence, the impulse can move directly from one neuron to another across the synapse.
   - This represents a faster method of impulse transmission. Electrical synapses are rare in our system.
   - In chemical synapses, the pre and postsynaptic neurons are not nearby. A synaptic cleft separates them. The transmission of nerve impulses is carried out by chemicals such as neurotransmitters like acetylcholine. The axon terminals contain vesicles filled with these neurotransmitters.
   - This is slower compared to the electrical synapse, and generally, the transmission of nerve impulse occurs through a chemical synapse.

(b) The retina is the innermost layer of the eye. It comprises three layers of cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells.
   - Photoreceptor cells are composed of proteins called opsins, and an aldehyde of vitamin A called retinal.
   - The retinal gets dissociated from opsin when light rays focus on the retina through the cornea.
   - This causes structural changes in opsin, which alters the permeability of the membrane, generating a potential difference in the cells.
- This generates an action potential in the ganglion cells and is transmitted to the visual cortex of the brain (occipital lobe) via the optic nerves.
- Here (in the cortex region of the brain), the impulses are analysed, and the image is formed on the retina.

(c)
- The pinna of the external ear receives the sound waves and leads them to the tympanic membrane (eardrum) via the external auditory canal.
- The eardrum then vibrates in response to the sound waves and directs these vibrations to the oval window through the ear ossicles (Malleus, Incus and Stapes). The ear ossicles increase the intensity of the sound waves.
- These vibrations are further passed on to the fluid of the cochlea, where they generate waves in the lymph.
- The waves in this lymph generate ripples in the basilar membrane, which stimulates the “sensory hair”.
- As a result of this stimulation, nerve impulses are generated in the connected afferent neurons.
- These impulses are transmitted to the auditory cortex of the cerebrum, via — auditory nerves. The auditory cerebral cortex (temporal lobe) analyses these impulses and interprets them as sound.
7. Answer briefly:
   (a) How do you perceive the colour of an object?
   (b) Which part of our body helps us in maintaining the body balance?
   (c) How does the eye regulate the amount of light that falls on the retina?

Solution:

(a)
- There are two types of photoreceptors in the human retina, rods and cones.
- The cones contain the iodopsin pigment (visual violet) and are highly sensitive to high-intensity light. They are responsible for daylight vision and colour vision.
- The three types of cones are sensitive to red (long wavelength), green (long wavelength) and blue (long wavelength) colours.
- These cells are stimulated by different lights, from various sources. The combinations of the signals generated help us see different colours. They communicate to the brain cells about the colours of the image formed on the retina.

(b)
- The inner ear (labyrinth) has two main structures — the cochlea: for hearing, and the vestibular system (consisting of the saccule, utricle and three semicircular canals): for maintaining balance.
- The semicircular canals contain fluid and hair cells, which are responsible for detecting movement rather than sound. When we move our head, the fluid within the semicircular canals also moves.
- This fluid motion is detected by the hair cells, which then send nerve impulses about the position of your head and body to the brain to allow you to maintain your balance.
- Similar to the semicircular canals, the saccule and utricle sense the body’s position relative to gravity and accordingly make postural adjustments.
- Crista and macula are the sensory spots of the vestibular apparatus controlling dynamic equilibrium.
(c)
- **Pupil** in the eyes functions as small apertures that regulate the amount of light entering the eye through iris.
- The **iris** has two sets of **smooth muscles**: dilators and sphincters, which regulate the amount of light entering the eyeball by altering the size of the pupil. The **autonomic nervous system** controls the muscles of the iris.
- In **bright light**, the **sphincter muscles contract**, making the pupil smaller so less light can enter the eye.
- In **the dim light**, the **dilator muscles contract** and widen the pupil because of which more light enters the eye.
8. Explain the following:
   (a) Role of Na\(^+\) in the generation of action potential.
   (b) Mechanism of generation of light-induced impulse in the retina.
   (c) Mechanism through which a sound produces a nerve impulse in the inner ear.

Solution:

(a) Role of Na\(^+\) in the generation of action potential:
- The sodium ions play an important role in the determination of the action potential. In the resting state, the sodium channels are more permeable to K\(^+\) and almost impermeable to Na\(^+\) ions. Also, the membrane is impermeable to the negatively charged proteins, and ions present inside the axon. Hence, axoplasm inside the axon has more negative ions, K\(^+\) ions and less Na\(^+\) ions. But, the fluid outside the axon contains less negative proteins, K\(^+\) ions and more Na\(^+\) ions. Such a gradient is maintained by transporting 3Na\(^+\) outside and 2K\(^+\) into the cell. So, the outer surface becomes more positive, and the inner surface becomes more negative and hence, is polarised.
- When a stimulus is applied, the receptors of the channel change their shape and become more permeable to Na\(^+\), followed by a reversal of the polarity. So, the outer surface becomes more negative, and the inner surface becomes more positive. This reversal of polarity across the membrane is known as depolarisation. The rapid inflow of Na\(^+\) ions causes the membrane potential to increase, thereby generating an action potential.
Figure: Role of Na⁺ in the generation of action potential

(b) Mechanism of generation of light-induced impulse in the retina.
- The retina is the innermost layer of the eye. It comprises three layers of cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells.
- Photoreceptor cells are composed of proteins called opsins, and an aldehyde of vitamin A called retinal.
- The retinal gets dissociated from opsin when light rays focus on the retina through the cornea.
- This causes structural changes in opsin, which alters the permeability of the membrane, generating a potential difference in the cells.
- This generates an action potential in the ganglion cells and is transmitted to the visual cortex of the brain (occipital lobe) via the optic nerves.
- Here (in the cortex region of the brain), the impulses are analysed, and the image is formed on the retina.

(c) Mechanism through which a sound produces a nerve impulse in the inner ear.
- The pinna of the external ear receives the sound waves and leads them to the tympanic membrane (eardrum) via the external auditory canal.
- The eardrum then vibrates in response to the sound waves and directs these vibrations to the oval window through the ear ossicles (Malleus, Incus and Stapes). The ear ossicles increase the intensity of the sound waves.
- These vibrations are further passed on to the fluid of the **cochlea**, where they generate waves in the lymph.
- The waves in this lymph generate ripples in the basilar membrane, which stimulates the “**sensory hair**”.
- As a result of this stimulation, **nerve impulses** are generated in the connected afferent neurons.
- These impulses are transmitted to the auditory cortex of the cerebrum, via — auditory nerves. The **auditory cerebral cortex** (temporal lobe) analyses these impulses and interprets them as sound.
9. Differentiate between:
   (a) Myelinated and non-myelinated axons
   (b) Dendrites and axons
   (c) Rods and cones
   (d) Thalamus and Hypothalamus
   (e) Cerebrum and Cerebellum

**Solution:**

(a) Myelinated and non-myelinated axons

<table>
<thead>
<tr>
<th>Myelinated axons</th>
<th>Unmyelinated axons</th>
</tr>
</thead>
<tbody>
<tr>
<td>They contain myelin sheath around the nerve fibre.</td>
<td>They do not contain myelin sheath around the nerve fibre.</td>
</tr>
<tr>
<td>Nodes of Ranvier are present.</td>
<td>Nodes of Ranvier are absent.</td>
</tr>
<tr>
<td>The depolarisation happens in the nodes of Ranvier only, and hence, it is faster.</td>
<td>The depolarization happens across the length of the nerve fibre is slower as a myelin sheath is absent.</td>
</tr>
<tr>
<td>Long axon nerve fibres are myelinated.</td>
<td>Short axon nerve fibres are unmyelinated.</td>
</tr>
<tr>
<td>They don’t lose the impulse during conduction due to the presence of myelin sheath.</td>
<td>They can lose the nerve conduction due to the absence of myelin sheath.</td>
</tr>
<tr>
<td>They are white.</td>
<td>They are grey.</td>
</tr>
</tbody>
</table>

(b) Dendrites and axons

<table>
<thead>
<tr>
<th>Dendrites</th>
<th>Axons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short fibres which branch repeatedly and project out of the cell body are called dendrites.</td>
<td>The axon is a long fibre, the distal end of which is branched.</td>
</tr>
<tr>
<td>These fibres transmit impulses towards the cell body.</td>
<td>These fibres transmit impulses away from the cell body.</td>
</tr>
</tbody>
</table>
They contain Nissl’s granules. | Nissl’s granules are absent.
---|---
Dendrites don’t contain myelin sheath. | Axons may or may not contain myelin sheath.

(c) **Rods and cones**

<table>
<thead>
<tr>
<th>Rods</th>
<th>Cones</th>
</tr>
</thead>
<tbody>
<tr>
<td>They are responsible for night vision.</td>
<td>They are responsible for day and colour vision.</td>
</tr>
<tr>
<td>They have a purple coloured pigment named rhodopsin.</td>
<td>They have a violet coloured pigment named iodopsin.</td>
</tr>
<tr>
<td>They are sensitive to dim light.</td>
<td>They are sensitive to bright light.</td>
</tr>
</tbody>
</table>

(d) **Thalamus and Hypothalamus**

<table>
<thead>
<tr>
<th>Thalamus</th>
<th>Hypothalamus</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the side part of the diencephalon.</td>
<td>It is the lower part of the diencephalon.</td>
</tr>
<tr>
<td>It does not secrete any hormone.</td>
<td>It secretes several hormones.</td>
</tr>
<tr>
<td>It is the part of the forebrain that receives nerve impulses of pain, temperature, touch, etc., and conducts them to the cerebral hemisphere.</td>
<td>It is the part of the forebrain that controls involuntary functions such as thirst, hunger, sweating, sleep, fatigue, sexual desire, temperature regulation, etc.</td>
</tr>
</tbody>
</table>

(e) **Cerebrum and Cerebellum**

<table>
<thead>
<tr>
<th>Cerebrum</th>
<th>Cerebellum</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the largest part of the brain.</td>
<td>It is a smaller part of the brain.</td>
</tr>
<tr>
<td>It is the largest part of the forebrain.</td>
<td>It is the largest part of the hindbrain.</td>
</tr>
<tr>
<td>It occupies two-thirds of the total space of the brain.</td>
<td>It is situated below the cerebrum.</td>
</tr>
</tbody>
</table>
### Neutral Control and Coordination

| It controls voluntary functions like intelligence, will power, memory, etc. | It controls voluntary functions and regulates the equilibrium. |

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Practice more on Neutral Control and Coordination  
www.embibe.com
10. Answer the following:
   (a) Which part of the ear determines the pitch of a sound?
   (b) Which part of the human brain is the most developed?
   (c) Which part of our central neural system acts as a master clock?

Solution:

(a) **Cochlea** determines the pitch of a sound.
- The **cochlea** (inner auditory ear) transforms the vibrations of the **cochlear** liquids and associated structures into a neural signal.

(b) The **forebrain** is the largest and most developed part of the human brain.
- The forebrain consists of the **cerebrum** (parietal lobe, frontal lobe, occipital lobe, temporal lobe), **thalamus**, **hypothalamus** and a pineal gland.

(c) **Hypothalamus** acts as a master clock in the human body.
- The hypothalamus is part of a CNS, and it controls our biological clocks and controls our daily (circadian) rhythms of the body.
11. The region of the vertebrate eye, where the optic nerve passes out of the retina, is called the
(a) fovea
(b) iris
(c) blind spot
(d) optic chiasma

Solution:
(c) blind spot
- The innermost layer of eye retina, which is made up of three layers of neural cells – inner ganglion cells, middle bipolar cells, and outermost photoreceptor cells. The innermost ganglionic cells give rise to optic nerve fibre that forms optic nerve in each eye and is connected with the brain.
- The optic nerves leave the eye, and the retinal blood vessels enter it at a point medial to and slightly above the posterior pole of the eyeball. Photoreceptor cells are not present in that region, and hence, it is called the blind spot.
12. Distinguish between:
   (a) afferent neurons and efferent neurons
   (b) impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre
   (c) aqueous humor and vitreous humor
   (d) blind spot and yellow spot
   (f) cranial and spinal nerves

Solution:

(a) afferent neurons and efferent neurons

<table>
<thead>
<tr>
<th>Afferent neurons</th>
<th>Efferent neurons</th>
</tr>
</thead>
<tbody>
<tr>
<td>They carry the sensory impulse from</td>
<td>They take the motor impulse away from</td>
</tr>
<tr>
<td>effector/sensory organs towards CNS</td>
<td>CNS towards effector/sensory organs.</td>
</tr>
<tr>
<td>They are known as sensory neurons.</td>
<td>They are known as motor neurons.</td>
</tr>
<tr>
<td>They have short axons.</td>
<td>They have long axons.</td>
</tr>
<tr>
<td>They consist of one long dendron.</td>
<td>They include many short dendrons.</td>
</tr>
<tr>
<td>They are unipolar.</td>
<td>They are multipolar.</td>
</tr>
<tr>
<td>They consist of receptors.</td>
<td>They lack receptors.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Myelinated nerve fibre</th>
<th>Unmyelinated nerve fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td>They contain myelin sheath around the nerve</td>
<td>They do not contain myelin sheath around</td>
</tr>
<tr>
<td>fibre.</td>
<td>the nerve fibre.</td>
</tr>
<tr>
<td>Nodes of Ranvier are present.</td>
<td>Nodes of Ranvier are absent.</td>
</tr>
<tr>
<td>The transmission happens through nodes of</td>
<td>The transmission is slower as a myelin</td>
</tr>
<tr>
<td>Ranvier only, and hence, it is faster.</td>
<td>sheath is absent.</td>
</tr>
<tr>
<td>Long axon nerve fibres are myelinated.</td>
<td>Short axon nerve fibres are unmyelinated.</td>
</tr>
<tr>
<td>They don’t lose the impulse during conduction due to the presence of myelin sheath.</td>
<td>They can lose the nerve conduction due to the absence of myelin sheath.</td>
</tr>
</tbody>
</table>
They are white.  |  They are grey.
---|---
Action potential jumps from one node of Ranvier to another.  |  The action potential travels along the length of the nerve fibre.
Less amount of energy is required.  |  More amount of energy is required.

(c) **aqueous humor and vitreous humor**

<table>
<thead>
<tr>
<th>Aqueous humor</th>
<th>Vitreous humor</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the space between the cornea and the lens.</td>
<td>The space between the lens and the retina is called the vitreous chamber.</td>
</tr>
<tr>
<td>It contains a thin watery fluid.</td>
<td>It is filled with a transparent gel.</td>
</tr>
<tr>
<td>Ciliary processes continuously secrete it, and it is drained out of the eyes.</td>
<td>This fluid is irreplaceable.</td>
</tr>
<tr>
<td>It provides nourishment to cornea, lens and other parts of the interior of the eye.</td>
<td>It does not have nutritive values.</td>
</tr>
</tbody>
</table>

(d) **blind spot and yellow spot**

<table>
<thead>
<tr>
<th>Blind spot</th>
<th>Yellow spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photoreceptor cells are not present in the particular region of the optic nerve, and hence, it is called the <strong>blind spot</strong>.</td>
<td>Adjacent to the blind spot, there is a yellowish pigmented spot called <strong>macula lutea</strong> with a central pit called the <strong>fovea</strong>. At the fovea, there is a thinned-out portion of the retina where only the cones are densely packed.</td>
</tr>
<tr>
<td>There is no image detection in this area.</td>
<td>It is the point where the visual resolution is the greatest.</td>
</tr>
</tbody>
</table>
(f) cranial and spinal nerves

<table>
<thead>
<tr>
<th>Cranial nerves</th>
<th>Spinal nerves</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cranial nerves originate in the brain and pass in different regions of the head and upper body.</td>
<td>The spinal nerves originate from nerve roots of both the sides of a spinal cord.</td>
</tr>
<tr>
<td>There are 12 cranial nerve pairs.</td>
<td>It comprises 31 spinal nerve pairs.</td>
</tr>
<tr>
<td>They are numbered I to XII.</td>
<td>They are classified into 5 groups: 8 cranial nerve pairs, 12 thoracic nerve pairs, 5 lumbar nerve pairs, 5 sacral nerve pairs, and 1 coccygeal nerve pair.</td>
</tr>
<tr>
<td>Most of the cranial nerves contain axon and both sensory and motor neurons.</td>
<td>All of the spinal nerves contain axons of both sensory and motor neurons.</td>
</tr>
</tbody>
</table>