An important Chapter to fix your marks in NEET

The Sensory System

The sensory system is a part of the nervous system responsible for processing sensory information. A sensory system consists of sensory receptors that receive stimuli from external or internal environment, neural pathway that conducts information from the receptors to the brain (i.e., the ascending or sensory tracts in the spinal cord) and parts of the brain, that deal primarily with processing the information (i.e., somatosensory cortex) in the parietal lobe.

The commonly recognised sensory systems are those for vision, hearing, touch, taste and olfaction.

SENSORY RECEPTORS
All sensory receptors are similar in basic structure. The simplest and most primitive type of sensory receptor is a single afferent neuron with its receptor endings meant for detection of stimuli called primary sense cell or 1st order neuron, e.g., olfactory cells.

Secondary sense cells or 2nd order neurons are modified epithelial cells that form synaptic connections and transmit impulses to CNS, e.g., taste buds.

Sensory organs are the most complex sensory receptors, e.g., eye and ear.

Functioning of Sensory Receptors
The energy or chemical that impinges upon and activates a sensory receptor is known as a stimulus, e.g., light, sound, pressure, heat, osmotic potential, electric current, etc.

Each type of receptors is sensitive to a specific stimulus and almost non-responsive to other stimuli.

An animal responds to a stimulus in a four-step process:
(i) Sensory transduction: Sensory receptors transduce (transform) the energy of a stimulus into a localised nonpropagated electrical response which initiates nerve impulses in the neuron leaving the receptor.
(ii) Transmission: The sensory neuron relays the nerve impulse to the brain directly or through the spinal cord.
(iii) Integration: Nerve impulses (action potentials, often called receptor or generator potentials) that reach the brain via sensory neurons are termed as sensations. In the brain, the sensations are analysed and interpreted as perceptions. Thalamus is the main centre and cerebral cortex is the subsidiary centre of this analysis. The brain transmits motor impulses to appropriate effectors - muscles or glands.
(iv) Response: Effectors produce suitable responses. Muscles contract, or glands secrete chemicals, in response to the information sent to the brain by the receptors.

Classification of receptors according to the type of stimuli they receive
These receptors are of five main types: mechanoreceptors, photoreceptors, chemoreceptors, electroreceptors and thermoreceptors as shown in the table.
Table: Types of receptors

<table>
<thead>
<tr>
<th>Name of receptor</th>
<th>Types and Stimulated by</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Thermoreceptors respond to alteration in temperature</td>
<td>(a) For cold (low temperature)</td>
<td>End bulb of Krause in skin (frigidoreceptors)</td>
</tr>
<tr>
<td></td>
<td>(b) For heat (high temperature)</td>
<td>Ruffini's organs in skin (caloreceptor)</td>
</tr>
<tr>
<td>2. Mechanoreceptors stimulated by mechanical deformation like touch, pressure</td>
<td>(a) Tangoreceptors (located in the skin): touch and pressure</td>
<td>(i) Meissner's corpuscles (ii) Merkel's discs (iii) Basket nerve ending (iv) Pacinian corpuscles—for pressure</td>
</tr>
<tr>
<td></td>
<td>(b) Phonoreceptors: Air borne sound waves</td>
<td>Organ of Corti in internal ear</td>
</tr>
<tr>
<td></td>
<td>(c) Statoreceptors: Acceleration and gravity</td>
<td>Hair cells in cristae and maculae in internal ear</td>
</tr>
<tr>
<td></td>
<td>(d) Proprioreceptors: Position of parts of body</td>
<td>Free nerve endings, neuromuscular and neurotendinous spindles</td>
</tr>
<tr>
<td></td>
<td>(e) Rheoreceptors: Pressure waves and water currents</td>
<td>Lateral line sense organs in fish</td>
</tr>
<tr>
<td></td>
<td>(f) Baroreceptors: Blood pressure</td>
<td>Nerve endings in walls of atria, vena cava, carotid sinuses, aortic arch.</td>
</tr>
<tr>
<td>3. Photoreceptors stimulated by light</td>
<td>Light wavelengths (electromagnetic)</td>
<td>Retina in vertebrate eye, Ommatidia in compound eyes of arthropods</td>
</tr>
<tr>
<td>4. Chemoreceptors stimulated by chemicals</td>
<td>(a) Gustatoreceptors</td>
<td>Taste buds of tongue</td>
</tr>
<tr>
<td></td>
<td>(b) Olfactory receptors (Olfactoreceptors)</td>
<td>Olfactory epithelium, Ampulla of Lorenzini (Scoliodon)</td>
</tr>
<tr>
<td></td>
<td>(c) Humidoreceptors Humidity</td>
<td>Skin</td>
</tr>
<tr>
<td>5. Nociceptors</td>
<td>Pain, damage or injuries of the body tissue</td>
<td>Free nerve endings</td>
</tr>
<tr>
<td>6. Electroreceptors</td>
<td>Effective currents in surrounding water</td>
<td>Skin of some fishes</td>
</tr>
</tbody>
</table>

We have discussed ‘Eye’ in detail in our April ’18 issue.

**SKIN RECEPTORS**

The skin contains receptors called the cutaneous receptors that respond to touch, pressure, pain and temperature. Cutaneous receptors are mainly of three types—mechanoreceptors, thermoreceptors pain receptors. Most of the skin receptors possess connective tissue sheaths and mostly occur in the dermis. Some are with free nerve endings may penetrate the epidermis.

![Sensory receptors in skin](image-url)
Different skin receptors
Free nerve endings are distributed between cells of the epidermis. Most of these nerve endings are sensitive to pain.
Root hair plexus is associated with the skin hair and responds to touch.
Meissner’s corpuscles are located in the papillary layer of the dermis just below the epidermis which respond to touch and pressure.
Merkel’s discs occur in the epidermis respond to touch and pressure.
Pacinian corpuscles are located in the dermis respond to vibration and deep pressure.
Ruffini’s corpuscles are located in dermis and respond to heat and skin stretch.
Krause’s corpuscles are located in dermis and are excited by cold.

SMELL RECEPTORS
The sense of smell arises from stimulation of receptors in the olfactory mucous membrane.
Olfactory sensation is the most primitive of all special senses and is much more acute than taste, with smell receptor as much as 3,400 times more sensitive than taste receptors.
The receptors for smell occur in a small (about 5 cm²) patch of olfactory neuroepithelium (pseudostratified epithelium) located in the roof of the nasal cavity, with nearly 20 million olfactory receptors.

Structure of Olfactoreceptor
Olfactory epithelium (also called Schneiderian membrane) is a modified pseudostratified epithelium. It is yellowish in colour and has three types of cells: receptor cells, supporting cells and basal cells, resting on a thick lamina propria.
(i) Receptor cells – These are also called olfactory cells, or olfactoreceptors. They act as sensory receptors as well as conducting neurons. They are receptors for chemicals. They are spindle-shaped bipolar neurons with rounded nuclei in the middle region. Olfactory receptor cells are unique in that they are the only neurons that undergo turnover throughout adult life. The olfactory cells survive only for about 2 months.
(ii) Supporting cells – These are columnar cells with large oval nuclei. They lie between the olfactory cells to support them.
(iii) Basal cells – These are small cells that do not reach the surface. They give rise to new olfactory cells to replace the worn out ones.

Olfactory glands (Bowman’s glands) – Many olfactory glands occur below the olfactory epithelium, that secrete mucus to spread over the epithelium, to keep it moist. The mucus also protects the cells from dust and bacteria.

Function
The dissolved chemicals stimulate the olfactory receptors by binding to protein receptors in the olfactory hair (cilia), and opening specific Na⁺ and K⁺ channels. This leads ultimately to an action potential that is conducted to the first relay station in the olfactory bulb.
The fibres of the olfactory nerves synapse with mitral cells (second order neurons) in complex structures called glomeruli (balls of yarn). When the mitral cells are activated, impulses travel from the olfactory bulbs via olfactory tracts to main destinations (e.g., temporal lobe of the cerebrum).

**TASTE RECEPTORS**

The receptors for taste are found in about 10,000 taste buds, mostly located on the tongue but also found on the palate, pharynx and epiglottis, and even in the proximal part of oesophagus. The number of taste buds declines after 45 years of age.

At least 13 possible chemical receptors are found in taste cells such as 2 sodium receptors, 2 potassium receptors, 1 chloride receptor, 1 adenosine receptor, 1 inosine receptor, 2 sweet receptors, 2 bitter receptor, 1 glutamate receptor and 1 hydrogen ion receptor.

Anterior surface of the tongue is covered with numerous small projections called papillae. Taste buds are located in the walls of papillae. There are 4 types of papillae - fungiform, filiform, vallate and foliate. Filiform papillae do not contain taste buds.

**Structure of taste bud**

Each taste bud is an oval body consisting of three kinds of cells:

(i) **Gustatory receptor cells**: They bear microvilli at the free end projecting into the taste pore. The microvilli have special protein receptor sites for taste-producing molecules when come in contact with the food being eaten. Nerve fibres of the cranial nerves VII (Facial), IX (Glossopharyngeal) or X (Vagus) end around the gustatory receptor cells, forming synapses with them. The gustatory receptor cells (taste cells) survive only about 10 days and are then replaced by new cells.

(ii) **Supporting cells**: These cells lie between the gustatory receptor cells in the taste bud. They bear microvilli but lack nerve endings.

(iii) **Basal cells**: These cells are found at the periphery of the taste bud. They produce supporting cells, which then develop into gustatory receptor cells.

**Disorders of Smell**

- **Anosmia**: Loss of the ability to smell, caused by head injury, infection or blockage of nose
- **Hyperosmia**: Increased sensitivity to odours
- **Dysosmia**: Disagreeable or distorted sense of smell
- **Hyposmia**: Reduction in olfactory sensation due to constant exposure to a particular odour
- **Rhinorrhea**: Nasal flow
- **Rhinitis**: Inflammation of the nasal mucous membrane
- **Sinusitis**: An infection of the sinus (cavities, or air filled pockets) near the nose. These infections usually occur after a cold or after an allergic inflammation.

![Fig.: Position of taste buds and section through a taste bud showing detailed structure.](image-url)
Function
Specific chemicals in solution, pass into the taste bud through the taste pore, to come in contact with the protein receptor sites on the microvilli of the gustatory receptor cells. The latter set up nerve impulses in the sensory nerve fibres.

The facial nerve (VII) serves the anterior two-thirds of the tongue, the glossopharyngeal nerve (IX) serves the posterior one-third of the tongue and the vagus nerve (X) serves the pharynx and epiglottis but not the tongue.

Disorder of Taste
Hypogeusia: It is the condition of diminished taste sensitivity. It is seen in aged people and tobacco addicts.
Dysgeusia or Parageusia: It causes unpleasant disturbed sense of taste.
Ageusia: It is the absence of the sense of taste. Some drugs like captopril and penicillamine can cause temporary loss of taste sensation. It can also be due to damage to the lingual or glossopharyngeal nerve.

EAR: THE ORGAN OF HEARING
The ear is the organ that detects sound. It not only acts as a receiver for sound, but plays a major role in the sense of balance and body position. It contains both receptors that respond to movements of the head and receptors that convert sound waves into nerve impulses.

Structure of Human Ear
The human ear consists of three parts: the external ear, the middle ear and the internal ear.

External ear
It comprises a pinna and external auditory meatus (canal).
(i) Pinna: It serves to direct sound waves to the auditory meatus. It is attached by ligaments and muscles to the skull. It consists of a cartilaginous framework of elastic connective tissue covered with skin. Its most prominent outer ridge is called the helix. The lobule is the soft pliable part at its lower end, composed of fibrous and adipose tissue, richly supplied with blood capillaries. It is sensitive as well as effective in collecting sound waves.
(ii) External auditory meatus: It is a tubular passage supported by cartilage in its external part and by bone in its inner part. The meatus (canal) is internally lined by hairy skin (stratified epithelium) and ceruminous glands (wax glands). The latter are modified sweat glands which secrete a waxy substance - the cerumen (ear wax) which prevents the foreign bodies entering the ear.

Functions of external ear
It directs sound waves towards the tympanic membrane. The sound waves produce pressure changes over the surface of the tympanic membrane. The cerumen (ear wax) prevents the entry of the foreign bodies into the ear.

Middle ear
The middle ear is an air-filled cavity called tympanic cavity, located in the temporal bone of skull, behind the ear drum (tympanic membrane). It includes the three ear bones or ossicles. The opening of the Eustachian tube is also within the middle ear.
(i) Tympanic membrane: The tympanum (tympanic membrane) or ear drum is a thin, double-layered, epithelial partition between the external auditory meatus and the middle ear.
The handle of the malleus (manubrium) is firmly attached to the membrane’s inner surface.
The tympanic membrane is innervated by the auriculotemporal nerve, a branch of the mandibular portion of the Trigeminal (V) cranial nerve and the auricular nerve, i.e., a branch of the Vagus (X) cranial nerve.
(ii) Eustachian tube: The tympanic cavity, filled with air is connected with the nasopharynx through the Eustachian tube (auditory tube), which serves to equalise the air pressure in the tympanic cavity with that on the outside.
Ear ossicles: A chain of three small, movable, articulated bones, the ear or auditory ossicles are located in the middle ear. The outer ossicle is hammer-shaped. It is called the malleus. It is attached to the inner surface of the tympanic membrane. The inner ossicle is stirrup-shaped. It is known as the stapes. Its foot plate is attached by an angular ligament to the walls of oval window or fenestra ovalis. Stapes is the smallest bone in the body. The middle ossicle is anvil-shaped. It is called the incus. It is joined to the malleus, at the outer end and stapes, at the inner end. The three ossicles articulate by synovial joints.

Two small skeletal muscles, tensor tympani and stapedius, are joined to the malleus and stapes respectively. Contraction of former pulls the manubrium of the malleus medially and decreases the vibrations of the tympanic membrane and contraction of latter pulls the foot plate of the stapes out of the oval window. Hence, they prevent damage to the delicate internal ear when the ear is exposed to loud sounds. They dampen sound by controlling amplitude, e.g., while chewing and talking.

Stapedius is the smallest muscle in the body.

The middle ear is connected with the inner ear through two small openings closed by the membranes. These openings are (i) fenestra ovalis (oval window) and (ii) fenestra rotunda (round window).

The fenestra ovalis is covered by foot plate of the stapes. The fenestra rotunda is closed by a flexible secondary tympanic membrane. The latter is responsible for equalising the pressure on either side of the tympanic membrane.

Functions of middle ear

The ossicles transmit and amplify sound waves across the tympanic cavity from the tympanic membrane to the oval window. The ossicles are connected in such a way as to act as a lever system, to increase the force of the vibration from the ear drum. In addition, the force of vibration is intensified, as it is transmitted from the relatively large surface of the eardrum, to the smaller surface area of the oval window. The combined effect increases the force of vibrations roughly twenty times. It may be noted that the frequency of sound does not change.

From the tympanic cavity, extra sound is carried to the pharynx through Eustachian tube.

Internal ear

The inner ear includes both the organ of hearing (cochlea) and a sense organ that is attuned to the effects of both gravity and motion (vestibular apparatus).

The internal ear (labyrinth) is made up of two parts: bony labyrinth and membranous labyrinth, one within the other. The bony labyrinth is a series of channels in the petrous portion of temporal bone.
Inside these channels, surrounded by a fluid called perilymph (similar in composition to cerebrospinal fluid) is the membranous labyrinth. This membranous structure more or less duplicates the shape of the bony channels. It is filled with a fluid called endolymph (similar in electrolyte composition to intracellular fluid) and there is no communication between the spaces filled with endolymph and those filled with perilymph. These fluids provide the media for vibrations involved in hearing and maintenance of equilibrium.

The membranous labyrinth consists of three semicircular ducts, utricle, saccule, endolymphaticus and cochlea.

Semicircular ducts

Three semicircular ducts are present: the anterior, the posterior and the lateral semicircular ducts. Each semicircular duct is enlarged at one end to give rise to a small rounded ampulla. The anterior and lateral semicircular ducts bear ampullae at their anterior ends, while the posterior duct contains an ampulla at its posterior end. Each ampulla contains a sensory patch of cells, the crista. Each crista consists of two kinds of cells, the sensory and supporting cells. The sensory cells bear long sensory hair at their free ends and nerve fibres at the other end. The sensory hair are partly embedded in a dome shaped gelatinous mass, the cupula. The cristae are concerned with balance of the body.

Utricle, endolymphaticus and saccule

The utricle is a dorsally placed structure to which all the three semicircular ducts are connected. The saccule is a ventrally situated structure which is joined with the utricle by a narrow utriculosaccular duct. From this duct a long tube, the ductus endolymphaticus arises which ends blindly as the saccus endolymphaticus. Both utricle and saccule contain sensory patches, the maculae. A macula comprises sensory and supporting cells similar to those of the crista. The hair are not actually motile and are embedded in a gelatinous membrane, the otolith membrane in which small crystals of calcium carbonate are also found, called otolith. The cristae and maculae are the receptors of balance therefore, they are concerned with equilibrium.

Cochlea

It is the main hearing organ which is connected with saccule. It is a spirally coiled tube that resembles a snail shell in appearance. It tapers from a broad base to an almost pointed apex. Internally, it consists of three fluid filled chambers or canals, the upper scala vestibuli, lower scala tympani, and the middle scala media (cochlear duct). Both scala vestibuli and scala tympani are filled with perilymph. However, scala media is filled with endolymph. Both the scala vestibuli and scala tympani are connected with each other at the apex of the cochlea by a small canal, the helicotrema. It is important to mention that near the base of the scala vestibuli the wall of the membranous labyrinth comes in contact with the fenestra ovalis, while at the lower end of the scala tympani lies the fenestra rotunda. The scala media is the most important canal or channel of the cochlea. It bears an upper membrane, the Reissner’s membrane, and lower membrane, basilar membrane. On the basilar membrane a sensory ridge, the Organ of Corti is present.

Organ of Corti

It is located on the basilar membrane and contains the hair cells which are the auditory receptors. This organ extends from the apex to the base of the cochlea and consequently has a spiral shape. The processes of the hair cells pierce the tough, membrane-like reticular lamina that is supported by the rods of Corti. The cochlea contains 16,000 to 24,000 hair cells arranged in four rows. In three of the rows, the hair form V-shaped patterns called outer hair cells. In, the fourth row, the hair cells form a straight line called inner hair cells. The inner hair cells are supported by inner phalangeal cells, while the outer hair cells are supported by Deiter’s cells (outer phalangeal cells). From the upper surface of the hair cell project tiny ‘cilia’, also called stereocilia. Covering the rows of hair cells is a thin, viscous, but elastic tectorial membrane in which the tips of the hairs of the outer, not the inner hair cells, are embedded.
The cell bodies of the afferent neurons that arborise around the bases of the hair cells are located in the **spiral ganglion** within the **modiolus**, the bony core around which the cochlea is wound.

90 to 95% of these afferent neurons innervate the inner hair cells; only 5 – 10% innervate the more numerous outer hair cells, and each neuron innervates several of these outer cells.

By contrast, most of the efferent fibres in the auditory nerve terminate on the outer hair cells rather than on the inner hair cells. More than 30,000 neurons and nerve fibres emerging from chain cells, convey the electrical signals to the brain, just 2 cm away via auditory (vestibulo-cochlear) nerve.

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**Snap Shots**

- The stereocilia, which pass through reticular lamina are bathed in endolymph whereas the bases of the hair cells are bathed in perilymph.
- Tectorial membrane is an elastic structure attached at one end to the limbus and its outer edge is attached to the Hensen’s cells (supporting cells of organ of Corti which lie outside the outer hair cells).

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Fig.: Cross section of the membrane and compartment of the inner ear with detailed view of the hair cells and other structures on the basilar membrane
**Functions of ear**
The ear performs two important functions: hearing and balancing (equilibrium).

1. **Mechanism of hearing**
The given flowchart describes the working of ear:
External ear receives sound waves → Directs it towards the eardrum → When waves strike the tympanic membrane, it vibrates → Vibrations are transmitted through ear ossicles to oval window → Movement of oval window sets up wave in the prilymph of scala vestibuli → Vibrations of endolymph of scala media → Waves in endolymph induces a ripple in basilar membrane → Basilar movements bends the hair cells pressing them against tectorial membrane → Nerve impulse generated in the associated afferent neurons → Impulse transmitted to auditory region via auditory nerve → Impulse gets analysed and sound is recognised.

2. **Equilibrium**
Two types of equilibrium are discussed here in the given table.

<table>
<thead>
<tr>
<th>Dynamic equilibrium</th>
<th>Static equilibrium and linear acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cristae in the ampullae, at the end of semicircular canals detect turning or rotational movements of the head (angular acceleration). Movements in any direction will stimulate the sensory cells of at least one crista, since the three semicircular ducts are arranged in three different planes. This causes bending of cupula, as well as hair cells in a particular crista. This disturbance stimulates the sensory cells and sets up action potential in the vestibular branch of the auditory nerve, which transmits it to the brain, for interpretation. Dizziness after spinning or travel is due to disturbance in endolymph or excessive sensitisation.</td>
<td>Maculae detect changes in the head (or body) with respect to gravity (static equilibrium) and in the movement in one direction (linear acceleration). With a change in the position of the body, the otoliths, being heavier than the endolymph, press upon the sensory hair of the maculae. This stimulates the sensory cells which initiates nerve impulse in the fibres of the vestibular branch of auditory nerve to the cerebellum for interpretation. Cerebellum then sends reflex signals for restoring static balance. The macula of utricle responds to vertical movements of the head, and the macula of saccule responds to lateral (sideways) movements of the head.</td>
</tr>
</tbody>
</table>

**Fig.:** Structure of crista ampullaris involved in equilibrium.

**(a) Head in still position (static equilibrium)**

**(b) Head rotating (dynamic equilibrium)**

**Ear Defects**

<table>
<thead>
<tr>
<th>Otitis externa: Inflammation of the canal between the ear drum and the external auditory meatus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otitis media: This is an acute infection of the middle ear caused mainly by bacteria and associated with infection of the nose and throat. The symptoms of otitis media are severe pain, fever and irritability.</td>
</tr>
<tr>
<td>Meniere's disease: It is due to an increased amount of endolymph that enlarges the membranous labyrinth. Its symptoms are spontaneous episodes of deafness, roaring tinnitus (ringing), spinning or whirling vertigo (dizziness).</td>
</tr>
<tr>
<td>Otalgia (Ear pain): It can originate within the ear i.e., ear canal or the external ear.</td>
</tr>
<tr>
<td>Deafness: Deafness may be partial or complete and may be caused by damage to the conduction system or to the nerve fibres or receptor cells.</td>
</tr>
<tr>
<td>Vertigo: It is most often a spinning sensation and loss of balance, associated particularly with looking down from a height. It is a symptom of disease either in the labyrinth of the inner ear or in the vestibular nerve or its nuclei in the brainstem which are involved in the sense of balance.</td>
</tr>
<tr>
<td>Tinnitus: A ringing sensation in the ear caused by irritative stimulation of either the inner ear or the vestibulo-cochlear nerve. In this, the person hears when there is no real sound. It is usually accompanied by hearing loss.</td>
</tr>
</tbody>
</table>
1. The upper membrane of the scala media is known as
   (a) Reissner’s membrane (b) tectorial membrane
   (c) basilar membrane (d) neurosensory membrane.

2. _______ of the human ear plays no role in hearing as such but is very much required otherwise.
   (a) Organ of Corti (b) Ear ossicles
   (c) Vestibular apparatus (d) Basilar membrane

3. Receptors in skin which can penetrate the epidermis is/are
   (a) end bulbs of Krause (b) free nerve endings
   (c) Merkel’s discs (d) both (b) and (c).

4. Olfactory cells are
   (a) complex sensory receptors (b) 1st order neurons
   (c) secondary sense cells (d) 2nd order neurons.

5. The structures in a human body that assist in body balance are located in
   (a) middle ear (b) inner ear
   (c) Eustachian tubes (d) external auditory meatus.

6. Read the following statements and select the incorrect one.
   (a) Tangoreceptors respond to mechanical stimuli.
   (b) Hair cells in cristae and maculae are photoreceptors.
   (c) Thermoreceptors respond to alteration in temperature.
   (d) Skin of some fishes have electromotors.

7. Nerve endings in walls of atria are
   (a) baroreceptors (b) proprioceptors
   (c) statorceptors (d) tangroceptors.

8. Membranous labyrinth of inner ear is filled with a fluid called
   (a) hololymph (b) endolymph
   (c) perilymph (d) juxtalymph.

9. The receptor potentials in response to sound develops in ear when
   (a) pigments absorb pressure
   (b) hairs are bent
   (c) surface proteins are altered by a change in pH
   (d) sodium - potassium pumps become deactivated.

10. Match the column I with column II and select the correct option given below.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ear canal</td>
<td>(i) Determines patterns of vibration of sound waves</td>
</tr>
<tr>
<td>B. Ear ossicle</td>
<td>(ii) Passage for sound waves from pinna to eardrum</td>
</tr>
<tr>
<td>C. Tympanic membrane</td>
<td>(iii) Has hearing receptors</td>
</tr>
<tr>
<td>D. Tectorial membrane</td>
<td>(iv) Transfers sound waves to ear ossicle</td>
</tr>
<tr>
<td>E. Cochlea</td>
<td>(v) Increases the efficiency of transmission of sound waves to the inner ear</td>
</tr>
</tbody>
</table>

11. The receptors absent in tongue are
   (a) thermoreceptors (b) gustatoreceptors
   (c) photoreceptors (d) none of these.

12. Select the correct sequence of ear ossicles.
   (a) Stapes, malleus and incus
   (b) Incus, malleus and stapes
   (c) Malleus, stapes and incus
   (d) Malleus, incus and stapes

13. In taste bud, the cells which bear microvilli but lack nerve endings, are known as
   (a) gustatory receptor cells (b) supporting cells
   (c) basal cells (d) gustatory hair.

14. Hyperosmia is the
   (a) loss of the ability to smell
   (b) increased sensitivity to odours
   (c) distorted sense of smell
   (d) diminished sense of smell.

15. The part of ear where sound is transduced is
   (a) tympanic membrane (b) malleus, incus and stapes
   (c) semicircular canals (d) cochlea.

16. Otitis media is the acute infection of the
   (a) Eustachian tube (b) middle ear
   (c) inner ear (d) ear canal.

17. The continuity between scala vestibuli and scala tympani is made by
   (a) cochlea (b) vestibule
   (c) helicotrema (d) lamina spiralis.

18. Given below is a diagrammatic cross section of a single loop of human cochlea.
Which one of the following options correctly represents the names of three different parts?
(a) D : sensory hair cells, A : endolymph, B : tectorial membrane
(b) A : perilymph, B : tectorial membrane, C : endolymph
(c) B : tectorial membrane, C : perilymph, D : secretory cells
(d) C : endolymph, D : sensory hair cells, A : serum

19. The organ of Corti is present on the
(a) basilar membrane (b) scala media
(c) scala vestibule (d) semicircular canal.

20. The balancing organ of ear consists of
(a) semicircular canal and utricle
(b) lagena and saccule
(c) semicircular canal and saccule
(d) otolith and lagena.

21. Static equilibrium is maintained by
(a) maculae (b) cristae
(c) cupula (d) reticular lamina.

22. The tubes which connect the buccopharyngeal cavity with the auditory capsule, are
(a) ampullae (b) Eustachian tubes
(c) inguinal canals (d) external auditory meatus.

23. Which of the following statement is incorrect?
(a) Ageusia is the loss of taste sensation.
(b) Skeletal muscles, tensor tympani and stapedius are joined to the malleus and stapes respectively.
(c) Bony labyrinth consists of three semicircular ducts, utricle, saccule, endolympathicus and cochlea.
(d) Basal cells give rise to new olfactory cells to replace the worn out ones.

24. Tinnitus is
(a) partial deafness (b) complete deafness
(c) a ringing sensation (d) a spinning sensation.

25. Taste buds, on the tongue are found in
(a) 3 types of papillae (b) 4 types of papillae
(c) 2 types of papillae (d) 1 type of papillae.

26. Bowman’s glands occur
(a) below soft palate (b) below hard palate
(c) below olfactory epithelium (d) below uvula.

27. The gustatory receptor cells survive for (i) and the olfactory receptors cells survive for (ii).

(i) (ii)
(a) 10 days 2 days
(b) 2 months 10 days
(c) 10 months 2 months
(d) 10 days 2 months

28. A person is suffering from frequent episodes of nasal discharge, nasal congestion, red and watery eyes. These are the symptoms of
(a) rhinitis (b) bronchial carcinoma
(c) cyanosis (d) bronchitis.

29. High frequency sound waves vibrate the basilar membrane
(a) near the oval window (b) near the helicotrema
(c) in the middle of cochlea (d) from oval window to helicotrema.

30. Sensation of cold occurs due to
(a) caloreceptors (b) frigidoreceptors
(c) baroreceptors (d) humidoreceptors.

31. Which one is the correct pathway of sensory receptor functioning?
(a) Stimuli → Transmission → Transduction → Integration → Response
(b) Stimuli → Transduction → Transmission → Integration → Response
(c) Stimuli → Transmission → Integration → Transmission → Response
(d) Stimuli → Transduction → Integration → Transmission → Response

32. Select the mismatched pair.
(a) Mitral cells – Glomeruli
(b) Olfactory cells – Unipolar neuron
(c) Ageusia – Loss of sense of taste
(d) Dysgensa – Distorted sense of taste

33. The ear ossicles amplify intensity of tympanic membranes vibrations by _______ approximately.
(a) 5 times (b) 30 times
(c) 20 times (d) 65 times

34. External auditory meatus contains which of the following gland?
(a) Ceruminous gland (b) Lachrymal gland
(c) Harderian gland (d) Meibomian gland
35. Dieters’ cells are found in
(a) Reissner’s membrane
(b) malleus
(c) organ of Corti
(d) basilar membrane.

36. Malleus and incus are jointed by
(a) synovial joint
(b) ball and socket joint
(c) pivot joint
(d) gliding joint.

37. The internal ear is also known as
(a) utricle
(b) membranous labyrinth
(c) saccule
(d) ductus endolymphaticus.

38. Which is not correct about external ear?
(a) The most prominent outer ridge is called helix.
(b) Ceruminous glands are effective in collecting sound waves.
(c) Lobule is richly supplied by blood vessels.
(d) The external meatus is internally lined by stratified epithelium.

39. Otolith membrane is found in
(a) maculae   (b) cristae
(c) ampulla   (d) cupula.

40. A person is affected by Meniere’s disease. The symptoms he has are
(a) spinning, inflammation of ear, acute ear pain
(b) complete deafness
(c) ringing sensation, ear pain
(d) episodes of deafness, roaring tinnitus, spinning.

**ANSWER KEY**

1. (a)  2. (c)  3. (d)  4. (b)  5. (b)
6. (b)  7. (a)  8. (b)  9. (b)  10. (b)
11. (c)  12. (d)  13. (b)  14. (b)  15. (d)
16. (b)  17. (c)  18. (b)  19. (a)  20. (a)
21. (a)  22. (b)  23. (c)  24. (c)  25. (a)
26. (c)  27. (d)  28. (a)  29. (a)  30. (b)
31. (b)  32. (b)  33. (c)  34. (a)  35. (c)
36. (a)  37. (b)  38. (b)  39. (a)  40. (d)