ALLEN CAREER INSTITUTE KOTA (RAJASTHAN)

path to success

PRE-MEDICAL

ZOOLOGY

ENTHUSIAST | LEADER | ACHIEVER

STUDY MATERIAL

Sensory Organs

ENGLISH MEDIUM

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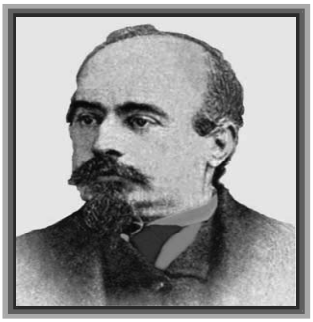
FRANS CORNELIS DONDERS

Frans Cornelis Donders, (born May 27, 1818,Tilburg, Neth.-died March 24, 1889, Utrecht), ophthalmologist, the most eminent of 19th-century Dutch physicians, whose investigations of the physiology and pathology of the eye made possible a scientific approach to the correction of refractive disabilities such as nearsightedness, farsightedness, and astigmatism. During his career, he was a professor of physiology in Utrecht, and was internationally regarded as an authority on eye diseases, directing the Netherlands Hospital for Eye Patients.

As professor of physiology at the University of Utrecht (1852-89), Donders did research that immediately improved diagnosis, operative treatment, and use of eyeglasses to correct impairments of vision. He found (1858) that hypermetropia (farsightedness) is caused by a shortening of the eyeball, so that light rays refracted by the lens of the eye converge behind the retina. He discovered (1862) that the blurred vision of astigmatism is caused by uneven and unusual surfaces of the cornea and lens, which diffuse light rays instead of focusing them. This last finding created the field of scientific clinical refraction.

ALFONSO GIACOMO GASPARE CORTI



Alfonso Giacomo Gaspare Corti (22 June 1822 - 2 October 1876) was born at Gambarana, near Pavia in 1822.

Corti was one of the biologists who in the middle of the nineteenth century sought to explain the fine structure of organs. Inspired by the colour effect of chromic acid solutions, which were used as fixing agents, he introduced carmine staining into microscopic technology.

He also described the most important components of the membranous cochlea, and in all his work he looked for the connection between structure and function.

Corti's observations are remarkable since he could use only freshly prepared pieces of the membranous cochlea and not fine sections of it. He described the ganglion spirale cochleae with its bipolar cells, the lamina spiralis membranacea, the uas spirale, the columns, the hair cells, and the membrana tectoria. He even saw the vascular epithelium of the stria vascularis ductus cochlearis and recognized it as the source of the endolymph. He was unsure only how and where the fibers of the nervus cochlearis end. Thus he was unable to clarify completely the function of the individual parts of the membranous cochlea. Nevertheless, he expressed the ideas upon which Helmhotz later based his "resonance" theory of hearing.

He is now generally known for the organ in the cochlea, described by him, which at Kölliker's suggestion was designated the "Organ of Corti", a name familiar to students of medicine and the natural sciences.

SENSORY ORGANS

01. INTRODUCTION

- **Introduction**
- **Eye (Photoreceptor)**
- **Internal Structure of Eye Ball**
- **Working of Eyes**
- **Ear (Stato-acoustic organ)**
- **Working of Ear**

Animals possess some specialised structures to perceive the different type of changes (stimuli) occurring in their external environment. These structures are known as **sense organs.**

After receiving these stimuli, sensory organs transmit these to the central nervous system through the sensory nerve fibres.

A sensory organ is only sensitive to a specific kind of stimulus to which it is specialized like temperature, chemicals, touch, light etc. Based on their location in the body, sensory organs are of three types :

(1) EXTEROCEPTORS

These sense organs receive stimuli from external environment because they remain in contact with the external environment.

Example- nose, eyes, tongue, ears and skin.

- Eye, ear and nose are also called **"teleoreceptors"**, because they receive impulse from far places.

(2) INTEROCEPTORS

These sensory organs are associated with internal environment of body and receive the changes taking place in the internal environment.

Examples- changes in the composition of blood, concentration of carbon-dioxide, hunger, thirst (osmoreceptor), asphyxia etc.

(3) PROPRIOCEPTORS

These sensory organs are present in joints, tendons, muscles and connective tissues which perceive the tension and pressure exerted during the activities of equilibrium maintenance and orientations of body.

In human body, five types of exteroceptors are found which are known as sense organs. The main sense organs include skin, eye, nose, ear and tongue.

- **Nose & Tongue**
- We smell things by our nose, taste by tongue, hear by ear and see objects by eyes.
- The nose contains mucus-coated receptors which are specialised for receiving the sense of smell and called olfactory receptors. These are made up of olfactory epithelium that consists of three kinds of cells. The neurons of the olfactory epithelium extend from the outside environment directly into a pair of broad bean-sized organs, called olfactory bulb, which are extensions of the brain's limbic system. Both nose and tongue detect dissolved chemicals.
- The chemical senses of gustation (taste) and olfactory (smell) are functionally similar and interrelated.
- The tongue detects tastes through taste buds, containing gustatory receptors. With each taste of food or sip of drink, the brain integrates the differential input from the taste buds and a complex flavour is perceived.
- In the following sections, you will be introduced to the structure and functioning of the eye (sensory organ for vision) and the ear (sensory organ for hearing).

02. EYE (PHOTORECEPTOR)

- These are **photosensitive organs**.
- Each eye is an hollow ball like round (Nearly spherical) structure called eye ball. Each eye - ball is situated in the notch of lacrimal bone in the skull. It is called "Eye - orbit". Human eyes are situated in eye orbit lateral to nose.
- Only $1/5^{th}$ part of whole eye is visible from out side in between the eye lashes.

  Remaining $4/5^{th}$ part is in the eye orbit.

(1) EYE LIDS OR PALPEBRAE

- There are two muscular eyelids for the protection of eye. These bear eye lashes at their free surface. Both the eyelids are named according to their situation i.e. upper & lower eyelids.
- There is present one more transparent membrane in the eye. It is called nictitating membrane or third eye lid. It is found constricted at one corner of eye ball, but at the time of need, it may be expanded over entire eye ball.
- Nictitating membrane is vestigeal in human. It is also called **"Plica semilunaris".**

(2) GLANDS

For the cleaning and for lubrication/moisturising the exposure part of eye.

03. INTERNAL STRUCTURE OF EYE BALL

The wall of remaining eye ball has three layers.

(1) FIBROUS TUNIC

It is the outermost covering of eye ball. It is made up of hard and thick connective tissue.

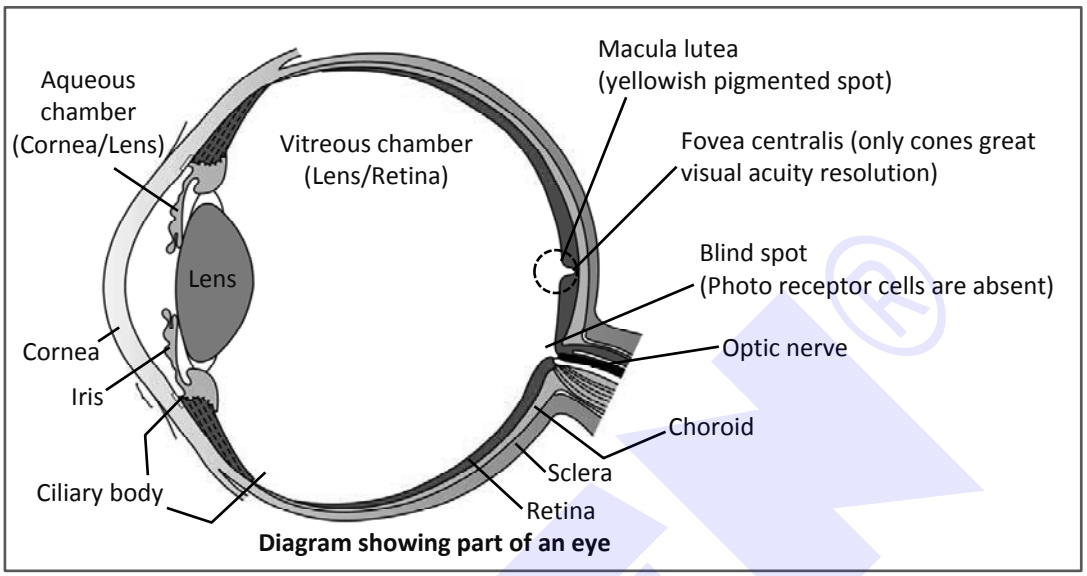


Diagram showing part of an eye

The layer is divided into 2 parts.

(A) Cornea :

It is the outer visible part of fibrous tunic, covered by *Non keratinized stratified squamous epithelium*.

- The joint between cornea and sclerotic layer is called "**Limbus**" or "Sclero - corneal junction".

Cornea transplantation is successful because it lacks blood vessels.

(B) Sclerotic Layer/Sclera :

It is made up of white, hard, opaque thick fibrous connective tissue in human. It is the inner portion of eye ball. It is non-vascularised. This layer is of white colour, so it is also called "**White of eye**".

- Inner layer of eyelids stretched over anterior part of sclera is called **conjunctiva**. Conjunctiva is the thinnest epidermis in animal body.

(2) VASCULAR TUNIC

It is the middle layer of eyeball. It is coloured part of eyeball. It is richly supplied with blood capillaries. Due to the presence of network of blood capillaries it is **highly vascularized**.

Melanin pigment is found in this layer. Due to the presence of melanin pigment in man eyes may be brown, black, blue, green according to the melanin present in it.

This layer has three parts :-

(A) Choroid Layer :

Choroid layer is the part of vascular tunic which lie below the sclerotic layer.

It contains abundant pigment cells, blood vessels and look bluish in colour.

It darkens the cavity of eyeball to prevent internal reflection of light.

It nourishes the retina.

(B) Ciliary Body :

It is the lower swollen portion below limbus.

It has ciliary processes which project into eyeball.

It has ciliary muscles (i) circular (ii) meridional.

(C) Iris :

Choroid layer or vascular tunic separates from sclerotic layer (Just after the cornea) inclines towards inner side and forms a coloured screen, it is called **iris.** Muscles of iris are **ectodermal** in origin whereas the muscles of body are **mesodermal** in origin. There is present an aperture in the Centre of iris, it is called **Pupil**. Light rays enter in the eyeball through pupil.

2 types of muscles are related with iris.

(i) Radial dilatory muscles :-

These are outer unstriated muscles, these are expanded in the iris breadth wise. Iris becomes constricted if these muscles contract and diameter of pupil is increased at that time. It happens in dim light, it is called **Mydriasis**.

(ii) Circular sphincter muscles :-

These are scattered in inner part of iris. Due to the contraction (In bright day light or high flashes of light) of these muscles in high light, Iris expands breadth wise and diameter of pupil is decreased. It is called **Miosis**.

Iris controls the intensity of light by increasing or decreasing the diameter of pupil i.e. Iris acts as diaphragm of a camera. *Except muscle of iris & ciliary body all vascular tunic of eye ball is* ***mesodermal*** *in origin. The parasympathetic fibres constrict & sympathetic fibres dilate the pupil.*

(3) NEUROSENSORY TUNIC

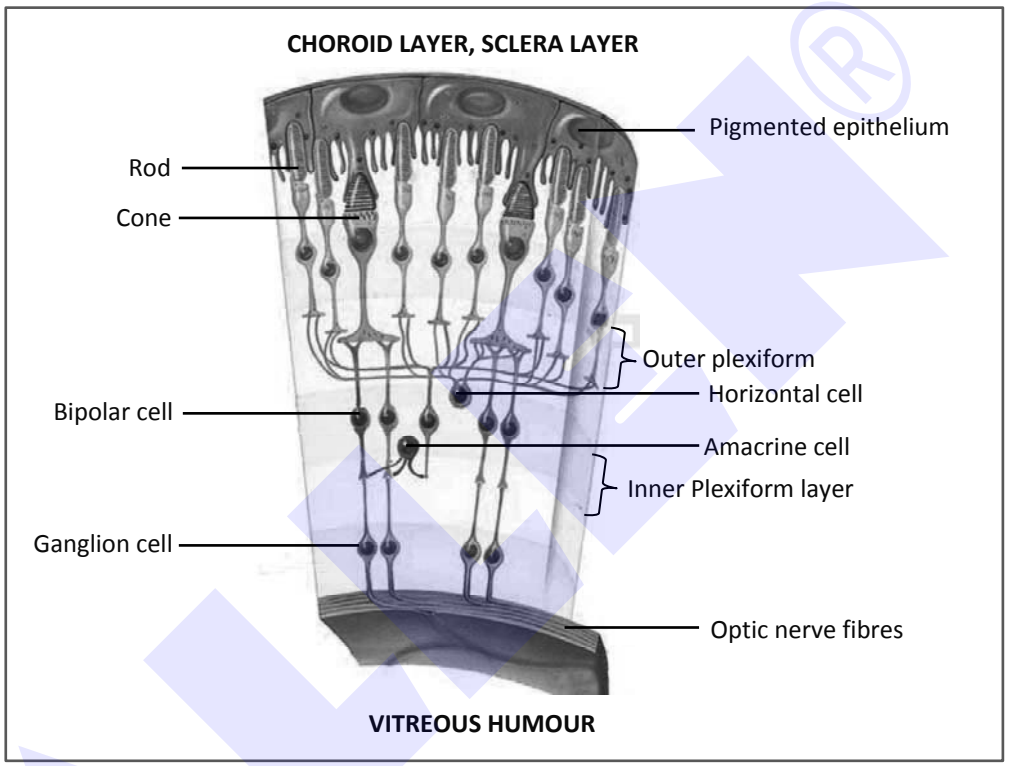
It is the inner most layer of eye ball :-

(A) Pigmented Layer :

It is the outer most layer. In the cells of this layer, pigment is found called melanin.

(B) Sensory Layer :

This layer is made up of specialized sensory cells. Rods and cones are found in this layer. Receptor cells are also known as photoreceptors/visual cells.



- Rods are long, thin, cylindrical structures/cells. These are numerous in number. **(1200 Lacs)**
- Rods differentiate between light and dark. These are more sensitive than cones.
- A purple coloured pigment is found in rods called **Rhodopsin**/Visual purple.
- Cones are thick and small cells which differentiate among different colours in full light. **(65 Lacs)**

  Iodopsin/Visual violet is present in cones.
- A horizontal neurons layer is present just below the rods and cones, it is called **outer plexiform** layer. This layer connects rods and cones together.

- Then comes the layer of bipolar neurons. Each bipolar neuron has a dendron and one axon. Presence of bipolar neurons is a speciality of retina. Rest parts of body have multipolar neurons. Their dendrites form synapses between rods & cones.
- Axons are jointed together by specific nerve cells, called **Amacrine cells**. Such neurons do not have nerve fibres.
- The layer of amacrine cells is called "**Inner plexiform layer**".
- Between bipolar neurons, supporting cells are found and called **Muller's cells**.

(C) Ganglionic Layer :

This layer is made up of nerve ganglia. These nerve ganglia form synapses with axons of bipolar neurons.

Axons of all nerve cells combine to form optic nerve. This optic nerve penetrates the retina and goes to 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 eye ball. Photoreceptor cells are not present in that region and hence it is called the ***blind spot***. At the posterior pole of the eye lateral to the blind spot, there is a yellowish pigmented spot called *macula lutea* with a central pit called the ***fovea***. The fovea is a thinned-out portion of the retina where only the cones are densely packed. It is the point where the visual acuity (resolution) is the greatest.

- Neurosensory tunic or retina of eye ball is **ectodermal** in origin.
- **Lens :-** A *transparent, ectodermal, biconvex lens* is present just after iris. Lens is connected by ciliary body with the help of **"Suspensory ligaments"** called **zonula of zinn"** or **zonules.** These ligaments are flexible and this can slide the lens and can change it's focal length. Lens divides the cavity of eyeball into two chambers.

- **Aqueous chamber :-**

The part of eye ball which lies between cornea and lens is filled with an alkaline fluid, it is called *aqueous humor*. It is a type of transparent tissue fluid.

Iris divides this aqueous chamber into two parts :-

(i) Anterior chamber :

This chamber lies between cornea and iris, it is called Venous chamber. Veins carry CO_2, metabolic wastes outside from here.

(ii) Posterior Chamber :

This chamber lies between iris and lens, it is called arterial chamber. Arteries supply O_2 and nutrients here.

- **Vitreous chamber :**

  Cavity of eye ball which lies between lens and retina is called vitreous chamber. A jelly like fluid (transparent and thick like albumin) is filled in this chamber, This is called *vitreous humor*.

  - In this fluid 99% water, some salts, a mucoprotein called vitrin and a mucopolysaccharide-Hyaluronic acid are present. Gelatinous nature of vitreous humor depends upon fibrillar protein & hyaluronic acid. It is form during embryonic stage. In this chamber Hyalocytes cells are found.
  - Aqueous humor and vitreous humor both the fluids are secreted by the ciliary body. Aqueous humor leak out by **canal of Schlemm** into blood capillaries and again reach upto their veins.
  - Both these fluid maintain proper pressure inside the cavity of eye ball. These check the eye ball from collapsing.
  - If this canal of Schlemm is blocked by any reason and fluids do not return back to veins, the fluid is increased in the chambers of eye.
  - When amount of this humor is increased in the eye chambers then pressure is increased inside the eye ball. Thus retina pressure is increased. This is known as **glaucoma**.

04. WORKING OF EYES

- Light rays emitted by any object enter the eye. A *small, real* and *inverted* image of object is formed at retina. Sensory cells of retina are sensitized, and optic nerve carries this impulse to brain. At this time animal is able to see the object.
- Cornea, aqueous humor and biconvex lens completely refract the light rays coming from object. As a result of this an inverted image is formed at retina.

  Just like diaphragm of a camera, iris of eye decreases or increases the diameter of pupil according to light.

  Iris expands to decrease the pupil in high intensity of light so a small amount of light touches the retina.

  When light is dim, iris itself constricts to increase the diameter of pupil.

(1) ACCOMMODATION OR FOCUSSING

The ability to change the focal length of lens by changing the curvature of lens, is called **accommodation** power.

Only mammals and birds have this accommodation power in their eyes.

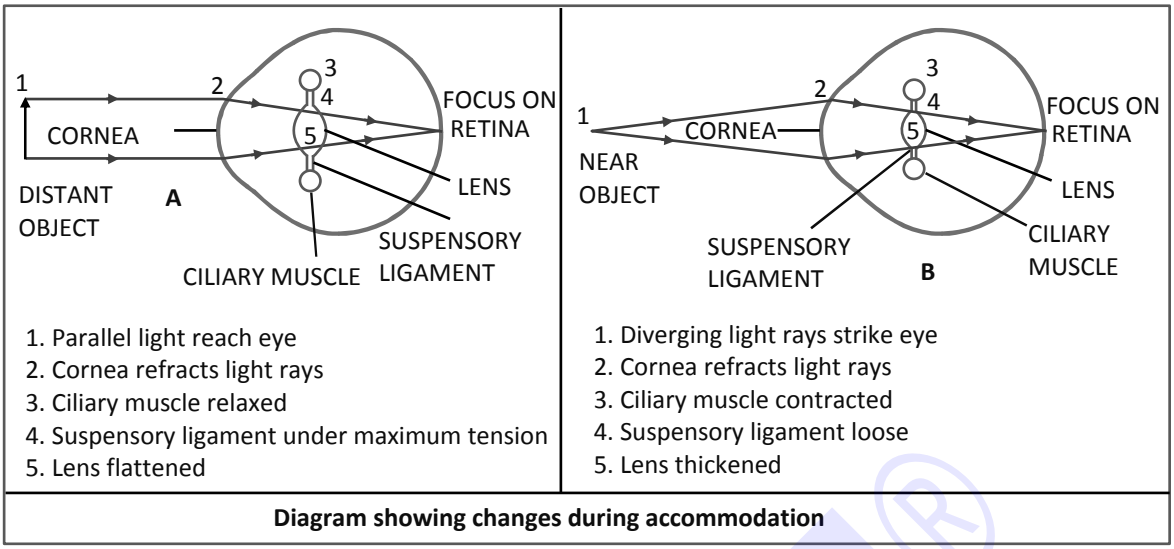


Diagram showing changes during accommodation

- In normal condition muscle fibres of ciliary body remain relaxed and lens is stretched by its suspensory ligaments, and due to this lens is flat. A flat lens has more focal length. As a result of this eye can see long distant objects easily.
- To see near by objects, sphincter muscles of ciliary body contract and ciliary body becomes broad, suspensory ligaments becomes loose and relaxed. As a result of this relaxation of ligament, lens becomes biconvex and now its focal length is reduced. Now animal is able to see near by object easily.

(2) MECHANISM OF VISION

- *The light rays in visible wavelength focussed on the retina through the cornea and lens generate potentials (impulses) in rods and cones.*
  As mentioned earlier, the photosensitive compounds (photopigments) in the human eyes is composed of ***opsin*** *(a protein) and* ***retinal*** *(an aldehyde of vitamin A).*
  Light induces dissociation of the retinal from opsin resulting in changes in the structure of the opsin.
  This causes membrane permeability changes. As a result, potential differences are generated in the photoreceptor cells. This produces a signal that generates ***action potentials in the ganglion cells*** *through the bipolar cells.*
  These action potentials (impulses) are transmitted by the optic nerves to the visual cortex area of the brain, where the neural impulses are analysed and the image formed on the retina is recognised based on earlier memory and experience.
- Retinal is formed by **vitamin-A** so deficiency of vit. A causes **night blindness**.
- Rod helps in vision in dim light. Rod have photo pigment **rhodopsin** which dissociated into **scotopsin** and **retinal** in presence of light.
- Cones able us to differentiate among colours and bright light. Cones have a pigment called Iodopsin in place of rhodopsin of rods. In light it is decomposed into **photopsin** and **retinal.**

There are three types of cones in retina:-

(a) Erythrolab - Red cones
(b) Chlorolab - Green cones
(c) Cynolab - Blue cones.

} If they all are stimulated equally, then a sensation of white colour is produced

- We are able to acknowledge different colours due to these three types of cones and their combination.
- **Red, Green** and **Blue** are the primary colours.

Dimlight vision - Scotopic vision (Twilight vision) – By Rod

Bright light vision - Photopic vision (Daylight vision) – By Cone

(3) SOME IMPORTANT DEFECTS OF EYE

(A) Hypermeteropia (far sightedness):

- In this defect of eye, person is able to see objects placed at far distance but is unable to see objects close to him or her.
- This defect is due to small size of eyeball or flatness of lens. In this defect image is formed **behind the retina.** To cure this defect person should wear **convex** lenses in spectacles.
- Sometimes in old age this defect may occur due to reduction in the flexibility of lens or ciliary body, then it is known as **presbyopia**.

(B) Myopia or Nearsightedness or short sightedness:

- In this defect of eye, person is able to see objects near/close to him or her but is unable to see objects placed at far distance.
- This is due to enlargement of eyeball or increased convexity of lens.
- In this defect image is formed before the retina because light rays coming from distant objects converge before retina.
- To overcome this defect person should wear **concave** lenses in spectacles.

(C) Astigmatism:

In this defect curvature of cornea is changed as a result of that light rays do not focus on macula lutea but somewhere else, causing incomplete and blurred vision. This defect may be cured by **cylindrical** lenses.

(D) Night Blindness:

This is due to deficiency of vit A. In this disorder synthesis of Rhodopsin is reduced, as a result of this person is unable to see in dim light or night.

(E) Xerophthalmia:

It is due to keratinisation of conjunctiva and cornea, and conjuctiva becomes solid. It is also due to deficiency of vit A.

(F) Strabismus:

It is due to loosening or contraction of the any of 6 skeletal muscles which give the proper position to the eye ball in its orbit. Thus eye ball inclines towards one side of orbit. It is strabismus or squint eyes.

Particular muscle may be cured by operation and this defect is cured.

(G) Cataract:

In this defect, lens becomes more solid, brown or more flat. It occurs in old age mostly. The lens becomes opaque, and reduces its power of accommodation. At this stage person can not see. A new lens is administered in place of defective lens by operation.

(H) Glaucoma:

If the canal of Schlemm is blocked in eyeball, aqueous humour can not return to veins again as a result pressure is increased in eye chambers and retina is damaged, and person becomes totally blind.

Golden Key Points

- Conjuctiva is thin epidermis, vascular and absent at central part of cornea.
- Cornea is avascular part, it obtain oxygen from environment and aqueous humor.

BEGINNER'S BOX — EYE

1. The inner layer of eyeball retina and it contains three layers of cells from outside to inside.

(1) Sclera, Choroid, Retina
(2) Photoreceptor, Amacrine, Bipolar
(3) Photoreceptor, Bipolar, Ganglion
(4) Ganglion, Bipolar, Photoreceptor

2. Mark the vitamin present in Rhodopsin

(1) Vit A (2) Vit B (3) Vit C (4) Vit D

3. Human eyeball consists of three layers and it encloses

(1) Lens, iris, optic nerve
(2) Lens, aquous humor and vitreous humor
(3) Cornea, lens, iris
(4) Cornea, lens, optic nerve

4. Iris is a part of –

(1) Retina only
(2) Choroid only
(3) Sclera only
(4) Cornea only

5. Sensitive pigmented layer of eye is –
(1) Retina (2) Cornea (3) Sclera (4) None of these

6. Blind spot has –
(1) Cones but no rods (2) Rods but no cones
(3) No rods and cones (4) Cones and rods

7. Which of the following statement is correct ?
(1) Rods contain a purplish-red protein called rhodopsin/visual purple
(2) Rhodopsin is a derivative of vitamin-A
(3) The twilight (scotopic) vision is a function of the rods
(4) All the above

8. The path of light entering into the eye –
(1) Ganglion cell layer – Horizontal cell – Amacrine cell – Photoreceptor cell
(2) Ganglion cell layer – Bipolar cell layer – Photoreceptor cell
(3) Bipolar cell layer – Ganglion cell layer – Photoreceptor cell
(4) Photoreceptor cell – Bipolar cell layer – Ganglion cell layer

05. EAR (STATO-ACOUSTIC ORGAN)

These are also called **phonoreceptors**.

All the vertebrates have one pair of ears back to the eyes,

Functions of ears :-

- To receive sound waves (hearing)
- To maintain body balance. Main function of ear is to maintain the balance of body.

Structurally, ear may be divided into three parts :-
(1) External ear (2) Middle ear (3) Internal ear

(1) EXTERNAL EAR

It is the outer part of ear. It is well developed in mammals only. External ear may be divided again into 2 parts

(A) Ear Pinna, (B) Ear Canal

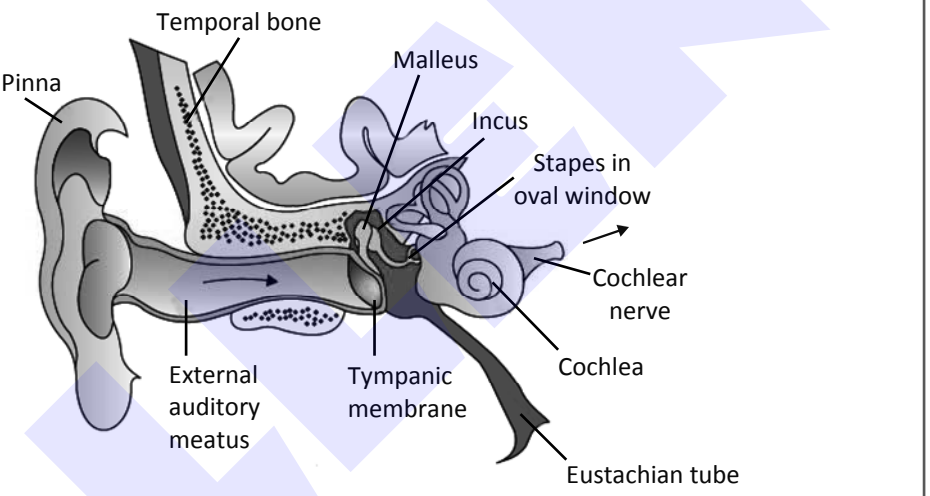
(A) Ear Pinna :

These may be small or large, **fan like** structure, important feature of mammals, but absent in **whale, seal, *Ornithorhynchus*** etc. The skin of ear pinna is hairy. These are having *yellow elastic cartilage*. A man can not move his pinna. Muscles of man's ear pinna are vestigeal. Pinna covers some of the ear canal, this part is called **choncha**.

(B) Ear Canal or External Auditory Meatus :

It is a **2.5 cm** long canal which is expanded from base of pinna to inner side.

- Apart from *mammals, birds* and *reptiles* also have ill or less developed ear canal.
- At the end of ear canal a stretched, thin, obliquely placed membrane is present, it is called **ear drum** or **tympanic membrane** or **tympanum**. It separates the ear canal to middle ear.
- Tympanum is composed of connective tissue covered with skin outside and with mucus membrane inside.
- In the wall of external auditory meatus or ear canal, there are found sebaceous glands and modified sweat glands also called **ceruminous** glands/sudoriferous glands. These secrete **cerumen** or ear wax, which moisten the ear drum and protects it.
- Ear drum remains always in stretched position because malleus ear ossicle/bone pulls it towards tympanic cavity by ***tensor tympani muscle***.
- **Ear drum is a part of External ear. It is composed by connective tissue covered with skin outside and with mucous membrane inside.**



Diagrammatic view of ear

(2) MIDDLE EAR

Middle ear consists of tympanic cavity, which is filled with air. This cavity is covered by a flask like bone called *tympanic bulla*. This bone is a part of temporal bone of skull.

- Middle ear cavity is connected by pharyngeal cavity through a canal. It is called **eustachian duct**.

  Due to this tube, pressure at both the side of tympanic membrane remains always equal. This duct maintain sound equilibrium. It expels high volume sounds through mouth, to avoid the damage of ear drum.
- Tympanic cavity is connected by internal ear cavity by two apertures :-
  - Oval aperture ***fenestra ovalis*** *(oval window)* and
  - Spherical aperture ***fenestra rotundus*** *(round window)*.
  - A thin and firm membrane covers each aperture.

- Three ear ossicles (small bones) are present and arranged in a chain with movable joints connected together in tympanic cavity. These ear ossicles are :-

(A) Malleus :

- It is situated towards outer ear.
- It is the largest of three bones and of ***hammer*** shaped.
- Malleus and incus are Joint together by **synovial hinge joint**.

(B) Incus :

- The incus is ***anvil*** shaped.
- Its outer broad part is connected by malleus and inner thin part is connected by **stapes.**
- Incus is joined by stapes by **ball and socket joint**.

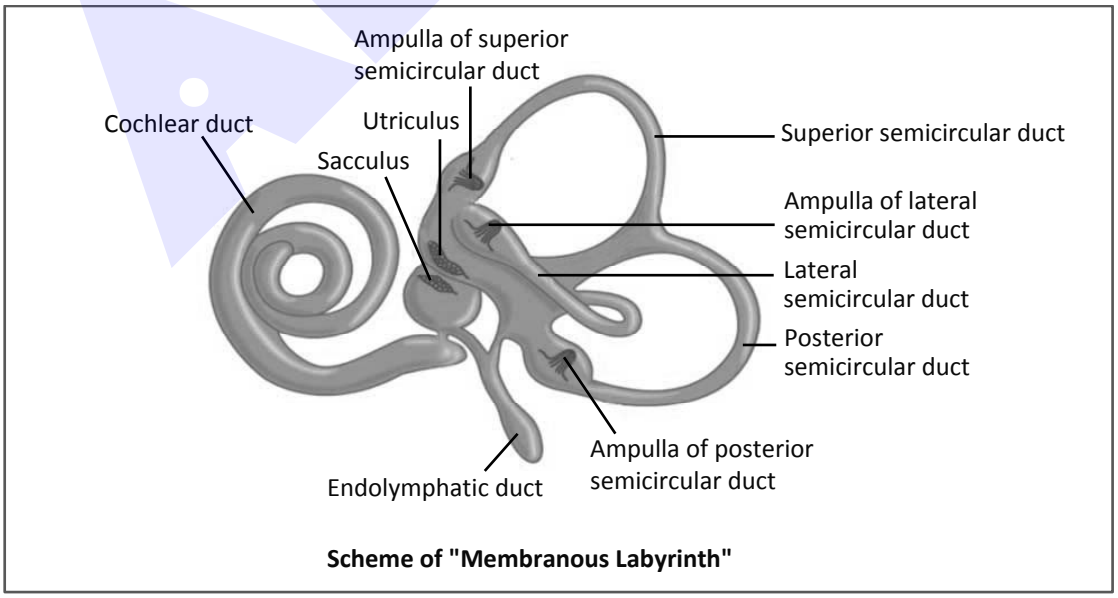
(C) Stapes :

- It looks like ***stirrup*** of horse.
- *It is the smallest bone of body.*
- Stapes is connected to incus at one side and on the other side it is connected to membrane stretched over fenestra ovalis.

- All the three ear ossicles are arranged in ear cavity by ligaments. These carry sound wave from ear drum to internal ear through fenestra ovalis.

(3) INTERNAL EAR

The fluid-filled inner ear called **labyrinth** consists of two parts, the bony and the membranous labyrinths. The **bony labyrinth** is a series of channels. Inside these channels lies the **membranous labyrinth**, which is surrounded by a fluid called **perilymph**. The membranous labyrinth is filled with a fluid called **endolymph**.



Scheme of "Membranous Labyrinth"

(A) Internal Structure of Vestibular and Cochlear Apparatus :

(i) Vestibular apparatus :

- It is sensory part for balancing, located above the cochlea.
- It is consist of

  (a) three semi-circular canal (scc)

  (b) one utriculus

  (c) one sacculus
- Each semi-circular canal lies in different plane at right angle to each other.
- The base of canal is swollen structure called ***Ampulla*** which contain projecting ridge called **crista Ampullaris (Crista)** which has hair cells.

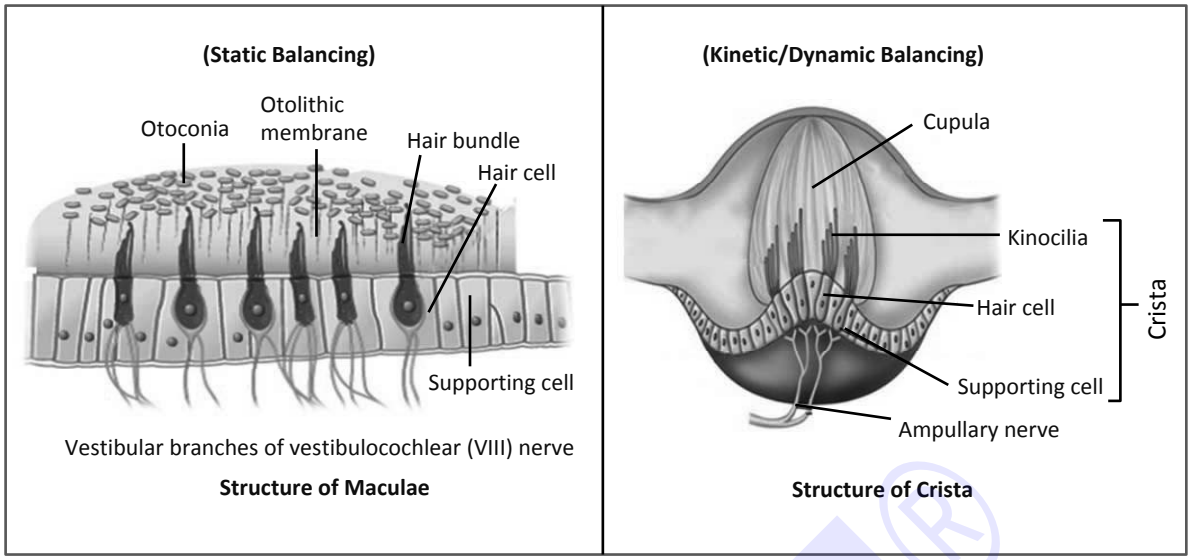
(B) Internal Structure of Ampulla :

- In this ampulla, internal cuboidal epithelium forms a ridge like projection called **acoustic ridge.** It is formed of small immovable microvilli found at the free edges of sensory cells of acoustic ridge. These are called **stereocilia**. Along with these, there are found single movable cilium called **kinocillium**.
- Otoconia are absent in crista of ampulla. All the microvilli of ridge are bind together like a bag and form **cupula**.

(C) Internal Structure of Macula :

- The utricules and sacculus contain a projecting ridge called ***Macula***.
- One structure each is present in utriculus and one in sacculus, these are called **Maculae**. Numerous $CaCO_3$ particles are found in endolymph these are called **Otoconia.**
- These sensory cells situated in internal ear are in contact with small nerves. All these nerve combine to form **vestibular nerve (branch of auditory nerve)**.
- The **crista** and **macula** are the specific receptors of the vestibular apparatus responsible for maintenance of balance of the body and posture.

- **Cristae** control and maintain body equilibrium at the time of movement and **maculae** regulate this at static position.

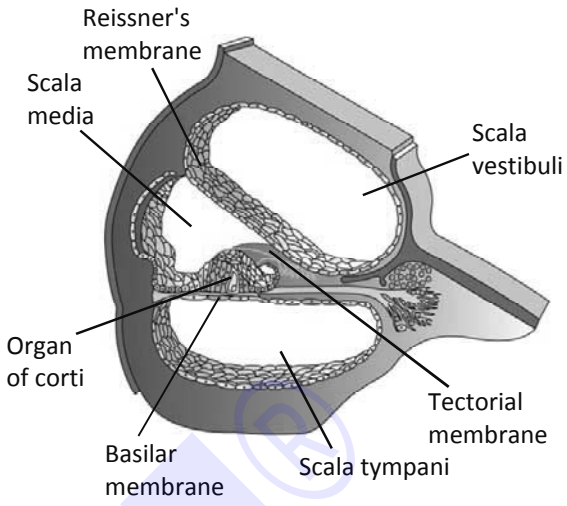


(D) Cochlea :

- It is sensory structure for hearing.
- It is coiled structure present below vestibular apparatus.
- The cochlea in cross section show 3-canals :
  - **(i) Scala vestibuli** - It is situated at dorsal side and filled with ***Perilymph***.
  - **(ii) Scala media** - It is situated between the scala vestibuli and scala tympani. It is filled with ***Endolymph***.
  - **(iii) Scala tympani** - It is situated at the ventral side below the scala media. It is filled with ***Perilymph***.
- The membrane of the roof of scala media which separates scala vestibuli from scala media is call ***Reissner's membrane***. The membrane at the floor of scala media, which separates scala media from scala tympani is called ***basilar membrane*** of the base.
- At the base of the cochlea, the scala vestibuli ends at the oval window, while the scala tympani terminates at the round window which opens to the middle ear.

(E) Internal Structure of Cochlea & Cochlear Canal

- 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 internal side of the organ of Corti.
- The basal end of the hair cell is in close contact with the afferent nerve fibres that forms cochlear nerve branch.
- A large number of processes called stereo cilia are projected from the apical part of each hair cell.
- Above the rows of the hair cells (organ of Corti) is a thin elastic membrane called **tectorial membrane**.
- Main credit of hearing goes to "Organ of Corti".



Diagrammatic representation of the sectional view of "Cochlea"

NCERT XI Page No. 326, Figure No. 21.8

06. WORKING OF EAR

- Ears are stato- acoustic organs of body. Thus these help the body to balancing and hear the body.
- **Primary function → Balancing**
- **Secondary function → Hearing**

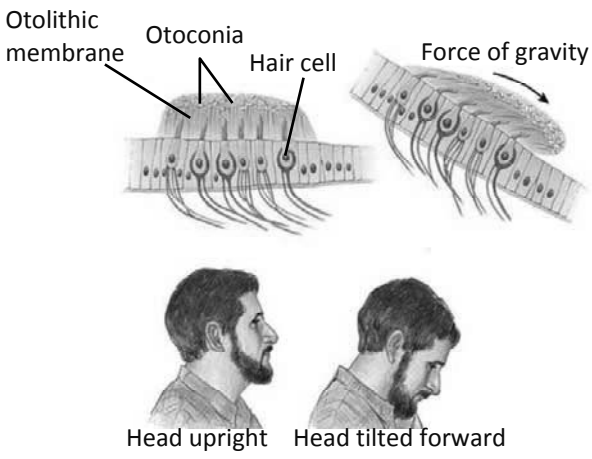
(1) EQUILIBRIUM

The first and basic function of ears is to maintain balance of body.

- This act is done by utriculus, sacculus and three semicircular canals. Equilibrium impulse/sensation is of two types:-

(A) Static balancing:

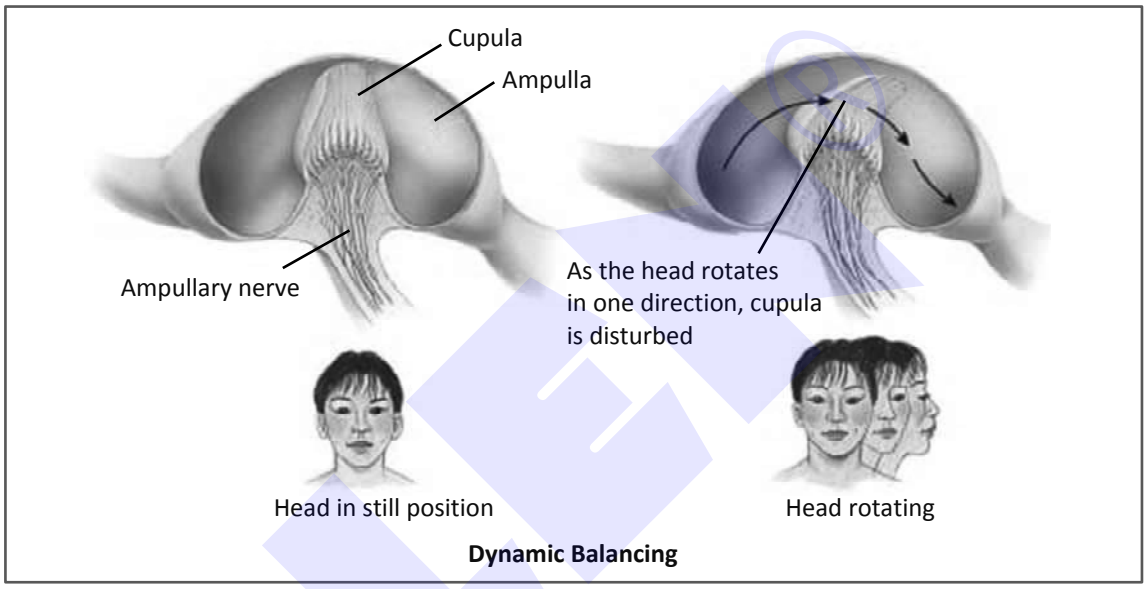
- The senses of changes of head are produced and carried mainly by utriculus, sacculus and their sensory receptors (macula).
- Sensory hair cells of these receptors are sensitized by **otoconia or otolith or ear dust**. These sensations or impulses are carried to brain by auditory nerve. After this, messages of appropriate reactions are sent through motor fibres to the skeletal muscles of the body.



Static Balancing

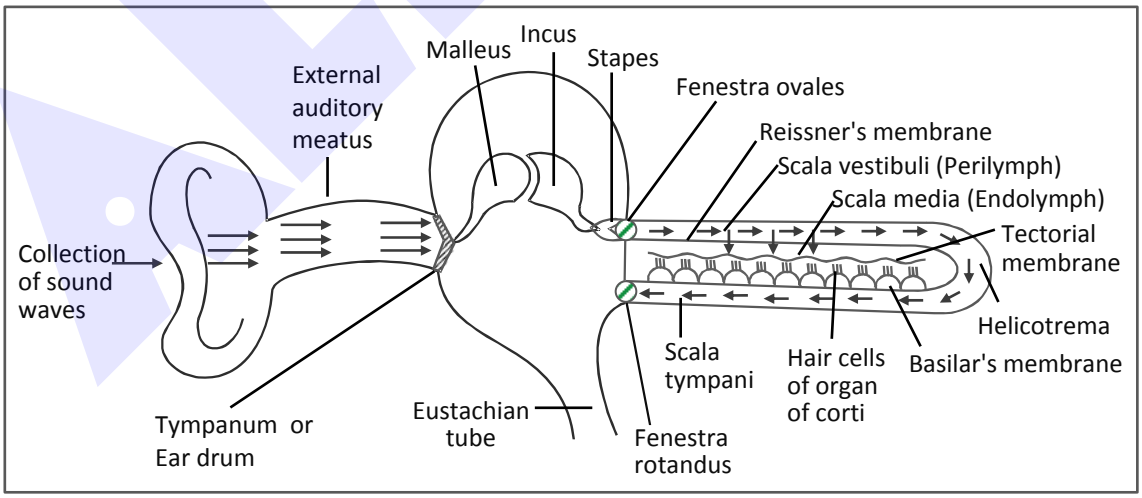
(B) Dynamic balancing:

- It is the action to maintain balance of body during movement.
- This act is done by sensory ridges of ampula of semicircular canals.
- At the time of movement the endolymph of ampulla produces waves in it. Cupula of ampula are effected by these waves and sensory cells are irritated. This sensation or stimulation is carried to brain by auditory nerve and proper messages are sent to limb muscles. This is how the body is balanced at the time of walking.



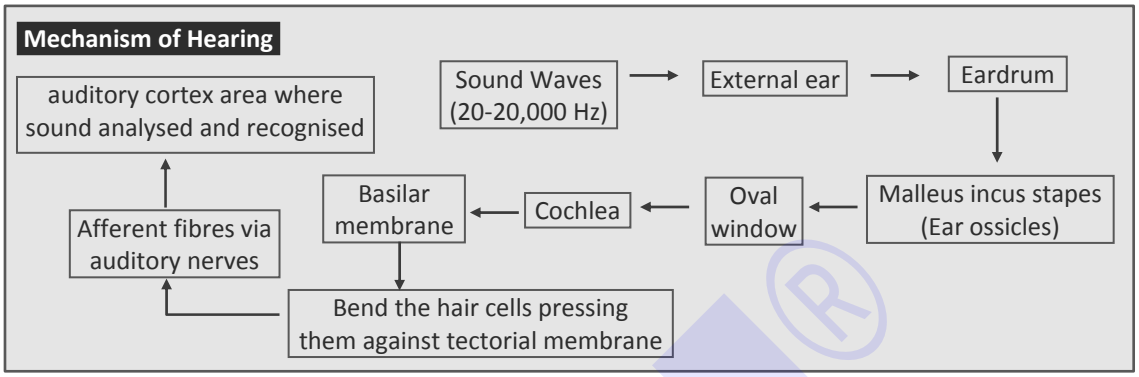
Dynamic Balancing

(2) HEARING



- This act is done by "**Organ of Corti**".
- Sound waves are collected by ear pinnae. These sound waves travel through ear canal and hit the ear drum. As a result of it ear drum get vibrated.

- These vibrations reach up to stretched membrane of fenestra ovalis through ear ossicles. **These ossicles increase the efficiency of transmission of sound waves to the inner ear.**
- As a result of this travelling (from ear drum to fenestra ovalis) sound waves become more strong.



- When the membrane of fenestra ovalis starts vibrating, perilymph of scala vestibuli also starts vibrating, some vibrations reach up to scala tympani (fenestra rotundus) and its perilymph.
- Due to these vibrating waves, reissner membrane and basilar membrane of the walls of scala media also start vibrating. These vibrations travel through endolymph reach upto organ of corti. The organ of corti also starts vibrating.
- At this place, sensory hair of sensory cells (cells of organ of corti) hit by the tectorial membrane. Now stimulation of hearing takes place.
- Cochlear nerve carries this impulse to brain through auditory nerve. Appropriate massages are send to receptor organs by brain accordingly.
- Vibrations / waves produced by cochlea travel through perilymph, reach up to membrane stretched at fenestra Rotandus and are destroyed.
- Some sound waves are also destroyed, when coming from helicotrema.

BEGINNER'S BOX — EAR

1. Wax gland present in the ear canal is called

(1) Sweat gland (2) Prostate gland

(3) Cowper's gland (4) Sebaceous gland/ceruminous gland

2. The part of internal ear responsible for hearing is

(1) Cochlea (2) Semicircular canal

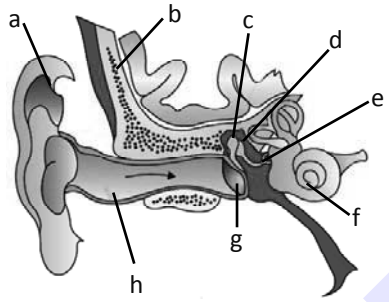
(3) Utriculus (4) Sacculus

3. The organ of corti is a structure present in

(1) External ear (2) Middle ear

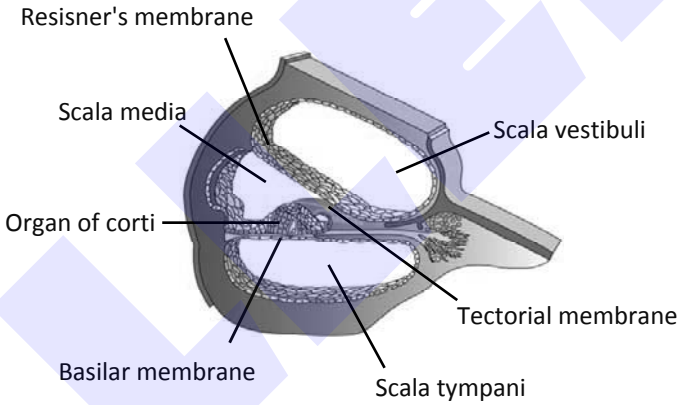
(3) Semi circular canal (4) Cochlea

4. In the given figure identify the part of ear which is responsible for hearing and contains organ of corti



(1) c, d, and e (2) Only g (3) Only f (4) All of these

5. The given figure describes the sectional view of cochlea. In the given figure identify the parts which are filled with perilymph



(1) Scala media (2) Scala vestibuli (3) Scala tympani (4) Both (2) and (3)

6. Dancers and sports person are able to maintain their proper body position by using their internal sense of balance. Sensing of this sort of body's internal condition and position is performed by :-

(1) Organ of corti (2) Crista (3) Macula (4) Otolithic organ

7. The base of membranous canals is swollen and is called ampulla which contains a projecting ridge called:-

(1) Otilith (2) Otoconia (3) Macula (4) Crista ampullaris

8. "Organ of Corti" is found in –

(1) Scala rotundus (2) Scala media (3) Scala vestibule (4) Scala tympani

EXTRA POINTS

1. The best colour differentiation is found in **primates** (Advanced mammals).
2. In the retina of man's eyes there are found **1200 lacs rods** and **65 lacs cones.**
3. Image of object is formed on retina and it is always **inverted & real.**
4. Ciliary body secretes aqueous humor and vitreous humor.
5. Atropine, Belladona and Cocaine medicines are used to **dilate** the **pupil.**
6. Cornea and lens of eye lack blood supply.
7. Eyes are most sensitive to the light having approximately 5000 A^0 **wavelength.**
8. From the fovea to the periphery, cones diminish and rods increase in number.
9. **TYPES OF VISION :**
   - **(a) Monocular vision or panoramic vision:-** Most of the vertebrates have their eyes situated on the lateral sides of head and due to this animal is capable to see large area of both the sides. It is called monocular vision. e.g. rabbit, frog, horse (Most of the herbivorous animals have this type of vision)
   - **(b) Binocular vision:-** Most of the carnivorous mammals have eyes in front of their heads and side by side, so as to focus on one object by both the eyes. It is called binocular vision. e.g. Man, monkeys and apes.
   - **(c) Stereoscopic vision:-** It is three dimensional vision found in human.
   - **(d) Telescopic vision:-** This is found in birds due to presence of **pecten**.

BEGINNER'S BOX — ANSWERS KEY

EYE

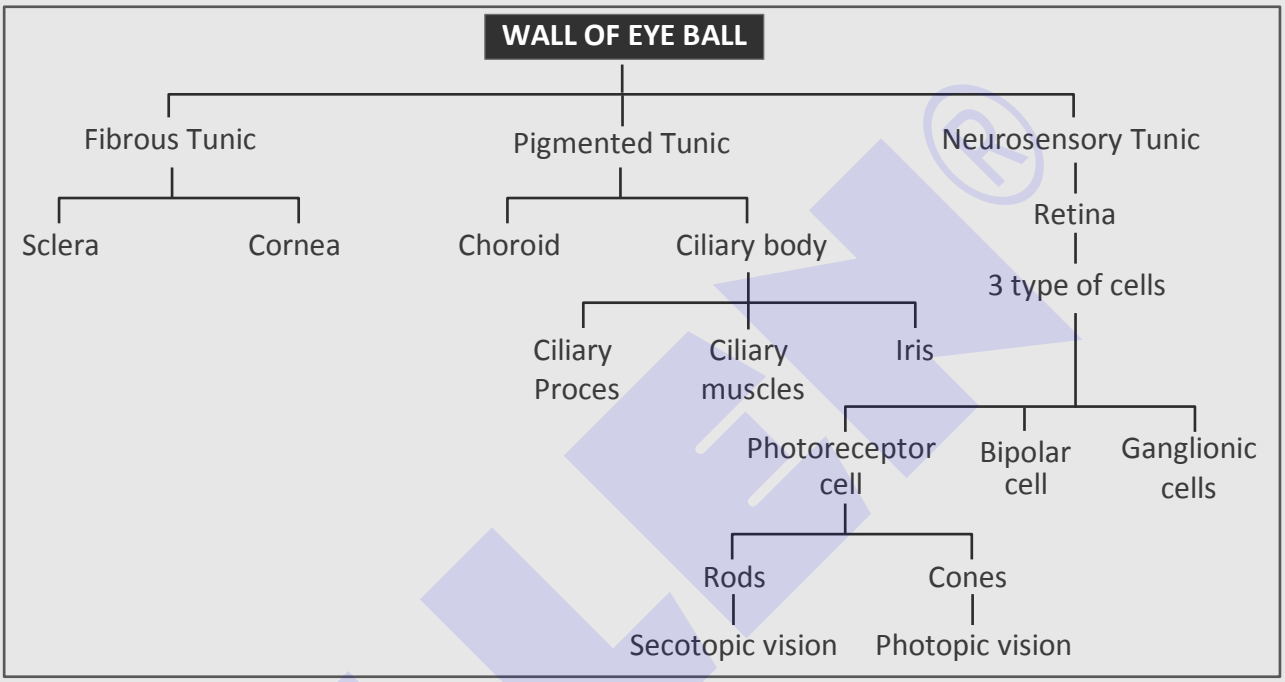
Que.	1	2	3	4	5	6	7	8
Ans.	**3**	**1**	**2**	**2**	**1**	**3**	**4**	**2**

EAR

Que.	1	2	3	4	5	6	7	8
Ans.	**4**	**1**	**4**	**3**	**4**	**2**	**4**	**2**

ESSENCE

- Nose has mucus coated olfactory receptors.
- Olfactory epithelium has three kinds of cells.
- Taste buds contain gustatory receptors.



- Path of light –
  Light → cornea → pupil → lens → ganglionic cell → bipolar cell → photoreceptor cell.
- Chamber ahead lens is aqueous chamber & behind lens is vitreous chamber.