VISWASS SCHOOL & COLLEGE OF NURSING

GNM 1ST YEAR
ANATOMY AND PHYSIOLOGY
UNIT-12
SENSE ORGANS
LONG QUESTIONS AND ANSWERS

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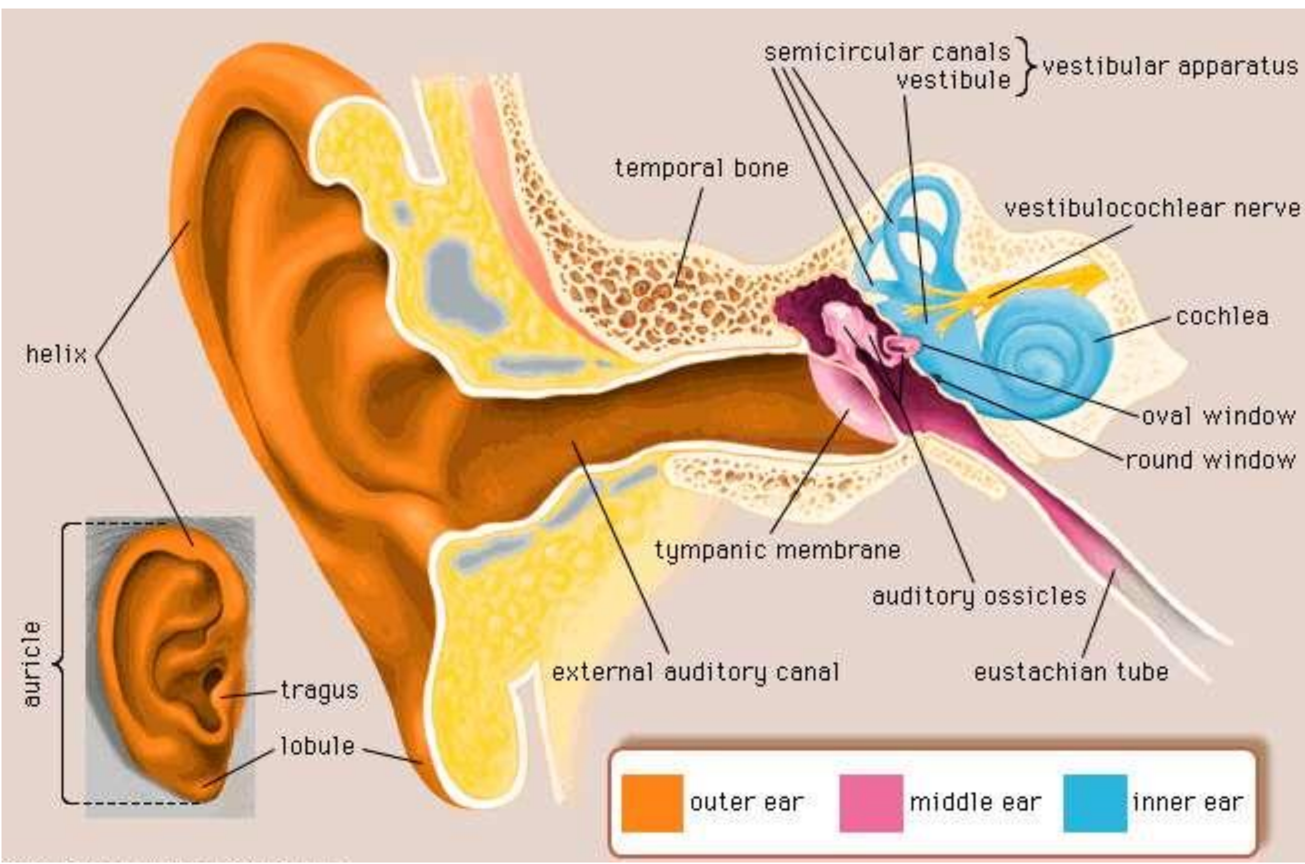
1)A)Explain about structure & functions of ear. (8+7)

B)Describe physiology of hearing.

A)<u>Ear:</u>

- **Human ear**, organ of hearing and <u>equilibrium</u> that detects and analyzes sound by transduction (or the conversion of sound waves into electrochemical impulses) and maintains the sense of balance (equilibrium).



- The human ear, contains sense organs that serve two quite different functions: that of hearing and that of postural equilibrium and coordination of head and eye movements.
- Anatomically, the ear has three distinguishable parts: the outer, middle, and inner ear.
- The outer ear consists of the visible portion called the auricle, or pinna, which projects from the side of the head, and the short external auditory canal, the inner end of which is closed by the tympanic membrane, commonly called the eardrum.
- The function of the outer ear is to collect sound waves and guide them to the tympanic membrane.
- The middle ear is a narrow air-filled cavity in the temporal bone.
- It is spanned by a chain of three tiny bones—the malleus (hammer), incus (anvil), and stapes (stirrup), collectively called the auditory ossicles.
- This ossicular chain conducts sound from the tympanic membrane to the inner ear.
- It is a complicated system of fluid-filled passages and cavities located deep within the rock-hard petrous portion of the temporal bone.
- The inner ear consists of two functional units: the vestibular apparatus, consisting of the vestibule and semicircular canals, which contains the sensory organs of postural equilibrium; and the snail-shell-like cochlea, which contains the sensory organ of hearing.
- These sensory organs are highly specialized endings of the eighth cranial nerve, also called the vestibulocochlear nerve.

Structure:

- Outer ear
- the auricle is an almost rudimentary, usually immobile shell that lies close to the side of the head.
- It consists of a thin plate of yellow elastic cartilage covered by closely adherent skin.
- The cartilage is molded into clearly defined hollows, ridges, and furrows that form an irregular shallow funnel.
- The deepest depression, which leads directly to the external auditory canal, or acoustic meatus, is called the concha.
- It is partly covered by two small projections, the tonguelike tragus in front and the antitragus behind.
- Above the tragus a prominent ridge, the helix, arises from the floor of the concha and continues as the incurved rim of the upper portion of the auricle.

- An inner, concentric ridge, the antihelix, surrounds the concha and is separated from the helix by a furrow, the scapha, also called the fossa of the helix.
- In some ears a little prominence known as Darwin's tubercle is seen along the upper, posterior portion of the helix; it is the vestige of the folded-over point of the ear of a remote human ancestor.
- The lobule, the fleshy lower part of the auricle, is the only area of the outer ear that contains no cartilage.
- The auricle also has several small rudimentary muscles, which fasten it to the skull and scalp.
- In most individuals these muscles do not function, although some persons can voluntarily activate them to produce limited movements.
- The external auditory canal is a slightly curved tube that extends inward from the floor of the concha and ends blindly at the tympanic membrane.
- In its outer third, the wall of the canal consists of cartilage; in its inner two-thirds, of bone.
- The entire length of the passage (24 mm, or almost 1 inch) is lined with skin, which also covers the outer surface of the tympanic membrane.
- Fine hairs directed outward and modified sweat glands that produce earwax, or cerumen, line the canal and discourage insects from entering it

Tympanic membrane:

- The thin semitransparent tympanic membrane, or eardrum, which forms the boundary between the outer ear and the middle ear, is stretched obliquely across the end of the external canal.
- Its diameter is about 8–10 mm (about 0.3–0.4 inch), its shape that of a flattened cone with its apex directed inward.
- Thus, its outer surface is slightly concave. The edge of the membrane is thickened and attached to a groove in an incomplete ring of bone, the tympanic annulus, which almost encircles it and holds it in place.
- The entire tympanic membrane consists of three layers.
- The outer layer of skin is continuous with that of the external canal.

- The inner layer of mucous membrane is continuous with the lining of the tympanic cavity of the middle ear.
- Between these layers is a layer of fibrous tissue made up of circular and radial fibres that give the membrane its stiffness and tension.
- The membrane is well supplied with blood vessels and sensory nerve fibres that make it acutely sensitive to pain.

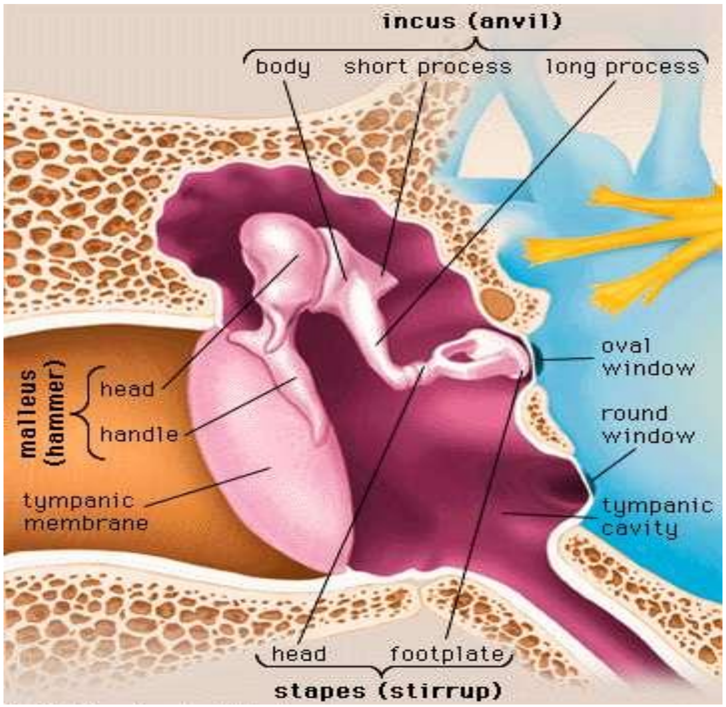
Middle-ear cavity

- The cavity of the middle ear is a narrow air-filled space.
- A slight constriction divides it into an upper and a lower chamber, the tympanum (tympanic cavity) proper below and the epitympanum above.
- These chambers are also referred to as the atrium and the attic, respectively. The middle-ear space roughly resembles a rectangular room with four walls, a floor, and a ceiling.
- The outer (lateral) wall of the middle-ear space is formed by the tympanic membrane.
- The ceiling (superior wall) is a thin plate of bone that separates the middle-ear cavity from the cranial cavity and brain above.
- The floor (inferior wall) is also a thin bony plate, in this case separating the middle-ear cavity from the jugular vein and the carotid artery below.
- The back (posterior) wall partly separates the middle-ear cavity from another cavity, the mastoid antrum, but an opening in this wall leads to the antrum and to the small air cells of the mastoid process, which is the roughened, slightly bulging portion of the temporal bone just behind the external auditory canal and the auricle.
- In the front (anterior) wall is the opening of the eustachian tube (or auditory tube), which connects the middle ear with the nasopharynx.
- The inner (medial) wall, which separates the middle ear from the inner ear, or labyrinth, is a part of the bony otic capsule of the inner ear.
- It has two small openings, or fenestrae, one above the other. The upper one is the oval window, which is closed by the footplate of the stapes.
- The lower one is the round window, which is covered by a thin membrane.

Auditory ossicles

- Crossing the middle-ear cavity is the short ossicular chain formed by three tiny bones that link the tympanic membrane with the oval window and inner ear.

- From the outside inward they are the malleus (hammer), the incus (anvil), and the stapes (stirrup).
- The malleus more closely resembles a club than a hammer, and the incus looks more like a premolar tooth with uneven roots than an anvil.
- These bones are suspended by ligaments, which leave the chain free to vibrate in transmitting sound from the tympanic membrane to the inner ear.



- The malleus consists of a handle and a head.
- The handle is firmly attached to the tympanic membrane from the centre to the upper margin.
- The head of the malleus and the body of the incus are joined tightly and are suspended in the epitympanum just above the upper rim of the tympanic annulus, where three small ligaments anchor the head of the malleus to the walls and roof of the epitympanum.

Muscles

- Two minuscule muscles are located in the middle ear. The longer muscle, called the tensor tympani, emerges from a bony canal just above the opening of the eustachian tube and runs backward and then outward as it changes direction in passing over a pulley like projection of bone.

- The tendon of this muscle is attached to the upper part of the handle of the malleus.
- When contracted, the tensor tympani tends to pull the malleus inward and thus maintains or increases the tension of the tympanic membrane.
- The shorter, stouter muscle, called the stapedius, arises from the back wall of the middle-ear cavity and extends forward and attaches to the neck of the head of the stapes.
- Its reflex contractions tend to tip the stapes backward, as if to pull it out of the oval window.
- Thus, it selectively reduces the intensity of sounds entering the inner ear, especially those of lower frequency.

Nerves

- The seventh cranial nerve, called the facial nerve, passes by a somewhat circuitous route through the facial canal in the petrous portion of the temporal bone on its way from the brainstem to the muscles of expression of the face.
- A small but important branch, the chorda tympani nerve, emerges from the canal into the middle-ear cavity and runs forward along the inner surface of the pars tensa of the membrane, passing between the handle of the malleus and the long process of the incus.
- Since at this point it is covered only by the tympanic mucous membrane, it appears to be quite bare.
- Then it resumes its course through the anterior bony wall, bringing sensory fibres for taste to the anterior two-thirds of the tongue and parasympathetic secretory fibres to salivary glands.

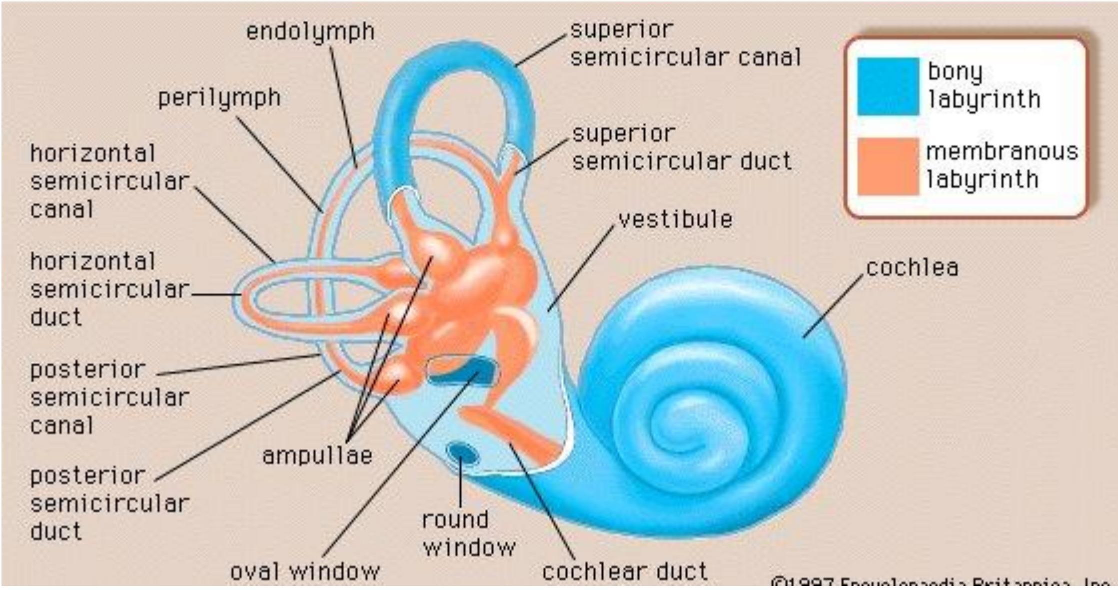
Eustachian tube

- The eustachian tube, about 31–38 mm (1.2–1.5 inches) long, leads downward and inward from the tympanum to the nasopharynx, the space that is behind and continuous with the nasal passages and is above the soft palate.
- At its upper end the tube is narrow and surrounded by bone. Nearer the pharynx it widens and becomes cartilaginous.

- Its mucous lining, which is continuous with that of the middle ear, is covered with cilia, small hairlike projections whose coordinated rhythmical sweeping motions speed the drainage of mucous secretions from the tympanum to the pharynx.
- The eustachian tube helps ventilate the middle ear and maintain equal air pressure on both sides of the tympanic membrane.
- The tube is closed at rest and opens during swallowing so that minor pressure differences are adjusted without conscious effort.

❖ Inner ear

- There are actually two labyrinths of the inner ear, one inside the other, the membranous labyrinth contained within the bony labyrinth.
- The bony labyrinth consists of a central chamber called the vestibule, the three semicircular canals, and the spirally coiled cochlea.
- Within each structure, and filling only a fraction of the available space, is a corresponding portion of the membranous labyrinth: the vestibule contains the utricle and saccule, each semicircular canal its semicircular duct, and the cochlea its cochlear duct.
- Surrounding the membranous labyrinth and filling the remaining space is the watery fluid called perilymph.
- It is derived from blood plasma and resembles but is not identical with the cerebrospinal fluid of the brain and the aqueous humour of the eye.
- Like most of the hollow organs, the membranous labyrinth is lined with epithelium (a sheet of specialized cells that covers internal and external body surfaces).
- It is filled with a fluid called endolymph, which has a markedly different ionic content from perilymph.
- Because the membranous labyrinth is a closed system, the endolymph and perilymph do not mix



Vestibular system

- The vestibular system is the apparatus of the inner ear involved in balance.
- It consists of two structures of the bony labyrinth, the vestibule and the semicircular canals, and the structures of the membranous labyrinth contained within them.

Cochlea

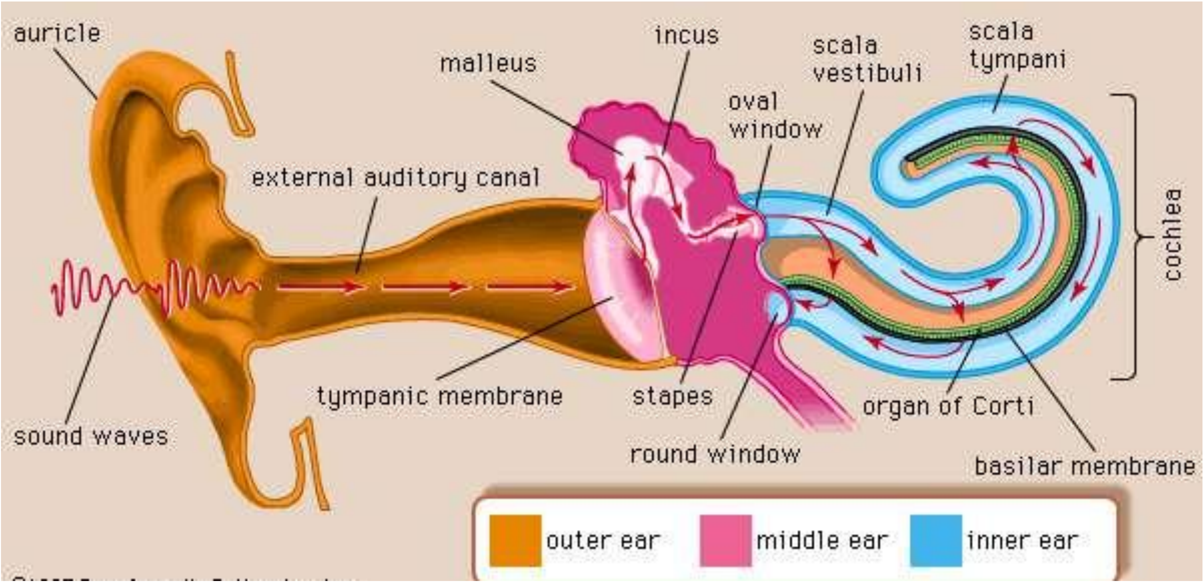
Structure of the cochlea

- The cochlea contains the sensory organ of hearing.
- The cochlea is a spiral tube that is coiled two and one-half turns around a hollow central pillar, the modiolus.
- It forms a cone approximately 9 mm (0.35 inch) in diameter at its base and 5 mm in height.
- When stretched out, the spiral tube is approximately 30 mm in length. It is widest—2 mm—at the point where the basal coil opens into the vestibule, and it tapers until it ends blindly at the apex.
- The otherwise hollow centre of the modiolus contains the cochlear artery and vein, as well as the twisted trunk of fibres of the cochlear nerve.
- This nerve, a division of the very short vestibulocochlear nerve, enters the base of the modiolus from the brainstem through an opening in the petrous portion of the temporal bone called the internal meatus.

- The spiral ganglion cells of the cochlear nerve are found in a bony spiral canal winding around the central core.

B)<u>**Physiology of ear:**</u>

- <u>Hearing</u> is the process by which the ear transforms sound vibrations in the external environment into nerve impulses that are conveyed to the brain, where they are interpreted as sounds.
- The ear can distinguish different subjective aspects of a sound, such as its loudness and pitch, by detecting and analyzing different physical characteristics of the waves.
- Pitch is the perception of the frequency of sound waves—i.e., the number of wavelengths that pass a fixed point in a unit of time.
- In order for a sound to be transmitted to the central nervous system, the energy of the sound undergoes three transformations.
- First, the air vibrations are converted to vibrations of the tympanic membrane and ossicles of the middle ear.
- These in turn become vibrations in the fluid within the cochlea.
- Finally, the fluid vibrations set up traveling waves along the basilar membrane that stimulate the hair cells of the organ of Corti.
- These cells convert the sound vibrations to nerve impulses in the fibres of the cochlear nerve, which transmits them to the brainstem, from which they are relayed, after extensive processing, to the primary auditory area of the <u>cerebral</u> cortex, the ultimate centre of the brain for hearing. Only when the nerve impulses reach this area does the listener become aware of the sound.



Transmission of sound waves through the outer and middle ear

Transmission of sound by air conduction

- The outer ear directs sound waves from the external environment to the tympanic membrane.
- The auricle, the visible portion of the outer ear, collects sound waves and, with the concha, the cavity at the entrance to the external auditory canal, helps to funnel sound into the canal.
- The canal helps to enhance the amount of sound that reaches the tympanic membrane.
- Sounds reaching the tympanic membrane are in part reflected and in part absorbed.
- Only absorbed sound sets the membrane in motion.
- The tendency of the ear to oppose the passage of sound is called acoustic impedance.
- The magnitude of the impedance depends on the mass and stiffness of the membrane and the ossicular chain and on the frictional resistance they offer.
- When the tympanic membrane absorbs sound waves, its central portion, vibrates as a stiff cone, bending inward and outward.
- The greater the force of the sound waves, the greater the deflection of the membrane and the louder the sound.
- The higher the frequency of a sound, the faster the membrane vibrates and the higher the pitch of the sound is.

- The motion of the membrane is transferred to the handle of the malleus, the tip of which is attached at the center.
- At higher frequencies the motion of the membrane is no longer simple, and transmission to the malleus may be somewhat less effective.
- The malleus and incus are suspended by small elastic ligaments and are finely balanced, with their masses evenly distributed above and below their common axis of rotation.
- The head of the malleus and the body of the incus are tightly bound together, with the result that they move as a unit in unison with the tympanic membrane.
- At moderate sound pressures, the vibrations are passed on to the stapes, and the whole ossicular chain moves as a single mass.
- However, there may be considerable freedom of motion and some loss of energy at the joint between the inc
- us and the stapes because of their relatively loose coupling.

Function of the ossicular chain

- In order for sound to be transmitted to the inner ear, the vibrations in the air must be changed to vibrations in the cochlear fluids.
- There is a challenge involved in this task that has to do with difference in impedance—the resistance to the passage of sound—between air and fluid.
- This difference, or mismatch, of impedances reduces the transmission of sound.
- The tympanic membrane and the ossicles function to overcome the mismatch of impedances between air and the cochlear fluids, and thus the middle ear serves as a transformer, or impedance matching device.
- in the perilymph of the scala vestibuli would be opposed by those in the perilymph of the scala tympani, and little effective movement of the basilar membrane would result.
- As it is, sound is delivered selectively to the oval window, and the round window moves in reciprocal fashion, bulging outward in response to an inward movement of the stapes footplate and inward when the stapes moves away from the oval window.
- The passage of vibrations through the air across the middle ear from the tympanic membrane to the round window is of negligible importance.
- have been perfected so that defects causing conductive impairment often can be corrected and a useful level of hearing restored.

Function of the muscles of the middle ear

- The muscles of the middle ear, the tensor tympani and the stapedius, can influence the transmission of sound by the ossicular chain.
- Contraction of the tensor tympani pulls the handle of the malleus inward and, as the tympanic membrane.
- Contraction of the stapedius pulls the stapes footplate outward from the oval window and thereby reduces the intensity of sound reaching the cochlea.
- The stapedius responds reflexly with quick contraction to sounds of high intensity applied either to the same ear or to the opposite ear.
- The reflex has been likened to the blink of the eye or the constriction of the pupil of the eye in response to light and is thought to have protective value.
- Unfortunately, the contractions of the middle-ear muscles are not instantaneous, so that they do not protect the cochlea against damage by sudden intense noise, such as that of an explosion or of gunfire.
- They also fatigue rather quickly and thus offer little protection against injury sustained from high-level noise, such as that experienced in rock concerts and many industrial workplaces.

Transmission of sound by bone conduction

- There is another route by which sound can reach the inner ear: by conduction through the bones of the skull.
- When the handle of a vibrating tuning fork is placed on a bony prominence such as the forehead or mastoid process behind the ear, its note is clearly audible.
- Similarly, the ticking of a watch held between the teeth can be distinctly heard. When the external canals are closed with the fingers, the sound becomes louder, indicating that it is not entering the ear by the usual channel.
- Instead, it is producing vibrations of the skull that are passed on to the inner ear, either directly or indirectly, through the bone.
- The higher audible frequencies cause the skull to vibrate in segments, and these vibrations are transmitted to the cochlear fluids by direct compression of the otic capsule, the bony case enclosing the inner ear.
- Because the round window membrane is more freely mobile than the stapes footplate, the vibrations set up in the perilymph of the scala vestibuli are not canceled out by those

in the scala tympani, and the resultant movements of the basilar membrane can stimulate the organ of Corti.

- This type of transmission is known as compression bone conduction.

2)A)Draw a labelled diagram of human eye. (4+5+6)

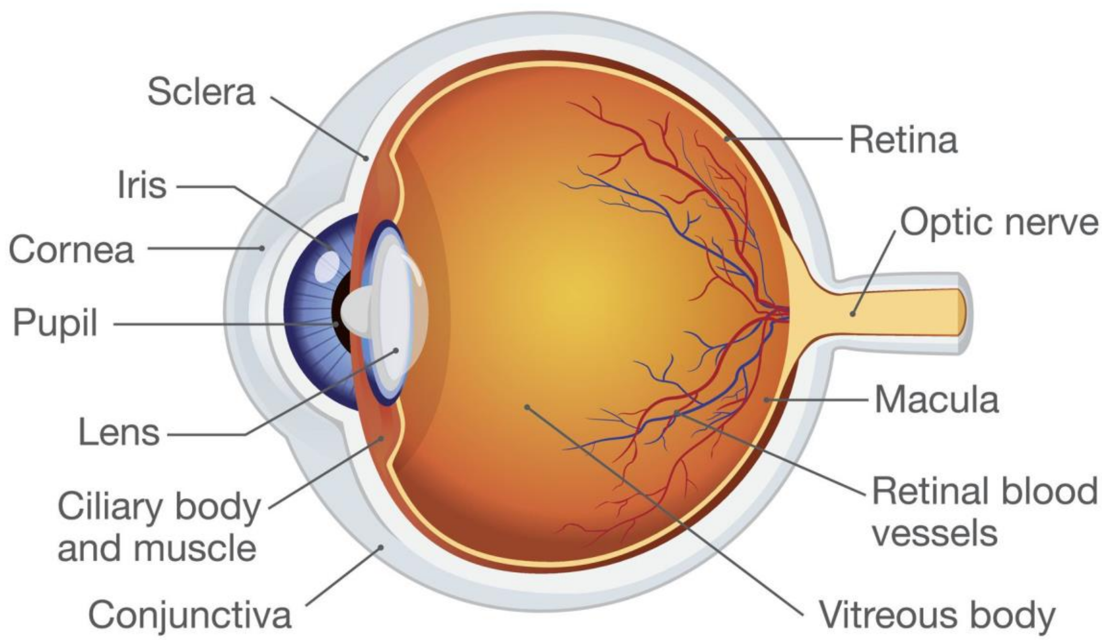
B)Describe the function of each structure.

C)Explain the mechanism of vision.

A)Human Eye:

- The human eyes are the most complicated sense organs in the human body.
- From the muscles and tissues to nerves and blood vessels, every part of the human eye is responsible for a certain action.
- Furthermore, contrary to popular belief, the eye is not perfectly spherical; instead, it is two separate segments fused together.
- It is made up of several muscles and tissues that come together to form a roughly spherical structure.
- From an anatomical perspective, the human eye can be broadly classified into the external structure and internal structure.

Human Eye Anatomy



B)**Structure and functions:**

- ❖ Conjunctiva

  - ➢ The conjunctiva is a thin, transparent layer of tissues covering the front of the eye, including the sclera and the inside of the eyelids.
  - ➢ The conjunctiva keeps bacteria and foreign material from getting behind the eye.
  - ➢ The conjunctiva contains visible blood vessels that are visible against the white background of the sclera.

- ❖ Sclera

- ➢ The white part of the eye that one sees when looking at oneself in the mirror is the front part of the sclera.
- ➢ However, the sclera, a tough, leather-like tissue, also extends around the eye.
- ➢ Just like an eggshell surrounds an egg and gives an egg its shape, the sclera surrounds the eye and gives the eye its shape.

- ➢ The extraocular muscles attach to the sclera. These muscles pull on the sclera causing the eye to look left or right, up or down, and diagonally.

❖ Anterior Chambers:

- ➢ Anterior Chamber

- The anterior chamber is the fluid-filled space immediately behind the cornea and in front of the iris.
- The fluid that fills this chamber is called the aqueous humor. The aqueous humor helps to nourish the cornea and the lens.
- Anterior Chamber Angle and the Trabecular Meshwork
- The anterior chamber angle and the trabecular meshwork are located where the cornea meets the iris.
- The trabecular meshwork is important because it is the area where the aqueous humor drains out of the eye.
- If the aqueous humor cannot properly drain out of the eye, the pressure can build up inside the eye, causing optic nerve damage and eventually vision loss, a condition known as glaucoma.

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❖ Cornea

- ➢ The cornea is the transparent, clear layer at the front and center of the eye.
- ➢ In fact, the cornea is so clear that one may not even realize it is there.
- ➢ The cornea is located just in front of the iris, which is the colored part of the eye.

- The main purpose of the cornea is to help focus light as it enters the eye. If one wears contact lenses, the contact lens rests on the cornea.

- Iris and Pupil

- The iris, which is the colored part of the eye, controls the amount of light that enters the eye.
- The iris is a ring shaped tissue with a central opening, which is called the pupil.
- The iris has a ring of muscle fibers around the pupil, which, when they contract, causes the pupil to constrict (become smaller).
- This occurs in bright light. A second set of muscle fibers radiate outward from the pupil.
- When these muscles contract, the pupil dilates (becomes larger). This occurs under reduced illumination or in darkness.

- Posterior Chamber

- The posterior chamber is the fluid-filled space immediately behind the iris but in front of the lens.
- The fluid that fills this chamber is the aqueous humor. The aqueous humor helps to nourish the cornea and the lens.

- Lens

- The lens is a clear, flexible structure that is located just behind the iris and the pupil.
- A ring of muscular tissue, called the ciliary body, surrounds the lens and is connected to the lens by fine fibers, called zonules.
- Together, the lens and the ciliary body help control fine focusing of light as it passes through the eye.
- The lens, together with the cornea, functions to focus light onto the retina.

- Vitreous Cavity

- The vitreous cavity is located behind the lens and in front of the retina.
- It is filled with a gel-like fluid, called the vitreous humor.
- The vitreous humor helps maintain the shape of the eye.

- ❖ Retina/Macula/Choroid

- ➢ The retina acts like the film in a camera to create an image.
- ➢ When focused light strikes the retina, chemical reactions occur within specialized layers of cells.
- ➢ These chemical reactions cause electrical signals, which are transmitted through nerve cells into the optic nerve, which carries these signals to the brain, where the electrical signals are converted into recognizable images.
- ➢ Visual association areas of the brain further process the signals to make them understandable within the correct context.
- ➢ The retina has two types of cells that initiate these chemical reactions.
- ➢ These cells are termed photoreceptors and the two distinct types of cells are the rods and cones.
- ➢ Rods are more sensitive to light; therefore, they allow one to see in low light situations but do not allow one to see color.
- ➢ Cones, on the other hand, allow people to see color, but require more light.
- ➢ The macula is located in the central part of the retina and has the highest concentration of cones.
- ➢ It is the area of the retina that is responsible for providing sharp central vision.
- ➢ The choroid is a layer of tissue that lies between the retina and the sclera. It is mostly made up of blood vessels.
- ➢ The choroid helps to nourish the retina.

- ❖ Optic Nerve

- ➢ The optic nerve, a bundle of over 1 million nerve fibers, is responsible for transmitting nerve signals from the eye to the brain.
- ➢ These nerve signals contain information for processing by the brain.
- ➢ The front surface of the optic nerve, which is visible on the retina, is called the optic disk or optic nerve head.

- ❖ Extraocular Muscles

- Six extraocular muscles are attached to each eye to move the eye left and right, up and down, and diagonally, or even around in circles when one wishes.

C)<u>**Mechanism of Vision:**</u>

Physiological events of vision consists of following;

1. Refraction of light entering the eye
2. Focusing of image on the retina by accommodation of lens
3. Convergence of image
4. Photo-chemical activity in retina and conversion into neural impulse
5. Processing in brain and perception

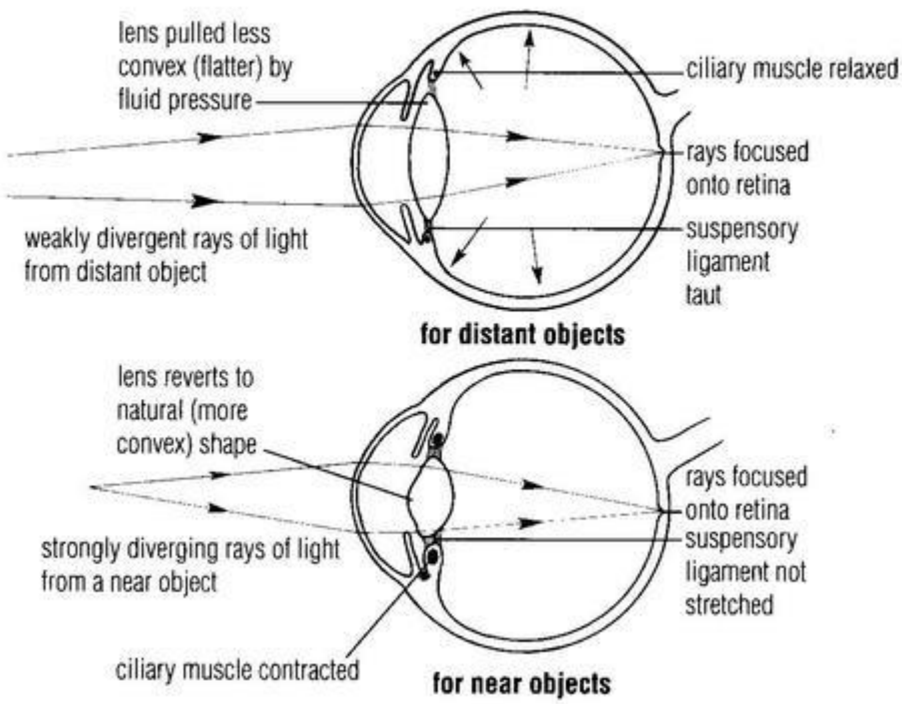
Refraction of light entering the eye:

- Light wave travels parallel to each other but they bend when passes from one medium to another. This phenomenon is called refraction.
- Before light reach retina it passes through cornea, aqueous humor, lens vitrous humor, so refraction takes place in every medium before it falls on retina.
- In normal eye, light wave focused on retina.
- However in myopic eye (short sightedness) light focused in front of retina. So this defect can be treated by using cancave lens.
- In case of far sightedness light focused behind retina, so no image is formed. This defect can be treated by using convex lens.

Accommodation of lens to focus image:

- Accommodation is a reflex process to bring light rays from object into perfect focus on retina by adjusting the lens.
- When an object lying less than 6 meter away is viewed, image formed behind retina. But due to accommodation of lens image formed in retina and we can see the object.

- For accommodation to view closer object, ciliary muscle contract and lens become thick which causes focus on closer object.
- Similarly, when distant object is viewed, ciliary muscles relaxes, so the tension of ligament become greater which pull lens and lens become thinner, due to which image forms on retina.
- The normal eye is able to accommodate light from object about 25 cm to infinity.



Focus on nearer object:

Ciliary muscle contract——-ciliary body pull forward and inward ———tension on suspensory ligament of lens reduced ——lens become thicker and round due to its elasticity ——possible to focus near object

Focus on distant object:

Ciliary muscles relaxes——ciliary body return to its normal resting state—–tension on suspensory ligament of lens increases——-lens become thinner and flat———possible to focus distant object

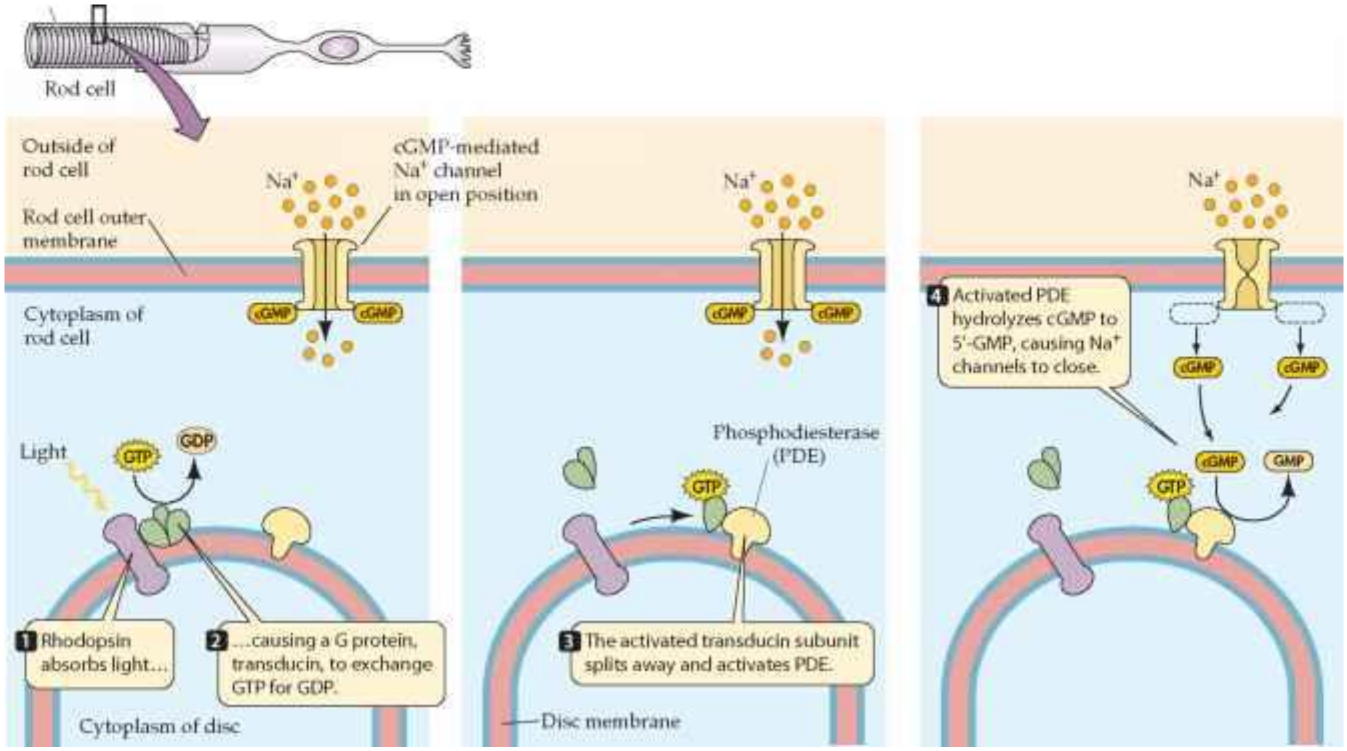
Convergence of image:

- Human eye have binocular vision, it means although we have two eye, we perceive single image
- In binocular vision, two eye ball turns slightly inward to focus a close object so that both image falls on corresponding points on retina at same time. This phenomenon is called convergence.

Photo-chemical activity in retina and conversion into neural impulse

1. Photochemical activity in rods:

- Each eye contains 125 million rods which are located in neuro-retina.
- Rods contains light sensitive pigment-rhodopsin.
- Rhodopsin is a molecule formed by combination of a protein scotopsin and a light sensitive small molecule retinal (retinene).
- Retinene (retinal) is a carotenoid molecule and is derivative of vitamin A (retinol).
- Retinal exists in two isomeric form- *cis* and *trans* according to light condition.
- The extra cellular fluids surrounding rod cells contains high concentration of Na^+ ion and low concentration of K^+ ions while concentration of Na^+ is low and K^+ is high inside rod cells. The concentration is maintained by Na-K pump.
- In resting phase, K^+ tends to move outside the rod cells creating slightly –ve charge inside.
- When light is falls on rod cell, it is absorbed by rhodopsin and it breaks into scotopsin and 11 cis- retinal. The process is known as bleaching.
- 11 cis-retinal absorb photon of light and change into all trans-retinal which inturn activates scotopsin into enzyme.
- This reaction produces large amount of transducin which activates another enzyme phosphodiesterase.
- Phosphodiesterase hydrolyses cGMP which causes to cease the flow of Na^+ ion inside rod cell. This causes increased negative charge inside cell creating hyperpolarized state.
- Hyperpolarized rod cells transmit the neural signal to bipolar cell.
- Bipolar cell, amacrine cell and ganglion cell process the neural signal and generate action potential to transmit to brain via optic nerve.



2. Photochemical activity in cones:

- Each eye contains 7 million cone cells.
- The neural activity in cone cell is similar to that of rod cell but there are three different types of cone cells and each cone cell contains different photo-pigment and are sensitive to red, green and blue.
- Like rod, cone cell contains iodopsin as photo-pigment which is composed of 11 cis-retinal and photopsin.
- The perception of color depends upon which cone are stimulated.
- The final perceived color is combination of all three types of cone cell stimulated depending upon the level of stimulation.
- The proper mix of all three color produce the perception of white and absence of all color produce perception of black.

Processing of image in brain and perception:

- All visual information originates in retina due to stimulation of rods and cones are conveyed to brain.

- Retina contains 5 types of cells and they are interconnected by synapse. These cells are photoreceptor cells (rod and cone), bipolar cell, ganglion cell, horizontal cell and amacrine cell.
- Photoreceptor cells, bipolar cells and ganglion cells transmit impulse directly from retina to brain.
- The nerve fiber of ganglion cells from both eyes carries impulse along two optic nerve.
- The optic nerves meets at optic chiasma where fibers from nasal half of each retina cross-over but fibers from temporal half of each retina do not cross-over.
- The optic nerve after crossing the chiasma is called as optic tract.
- Each optic tract continues posteriorly until it synapse with neuron in thalamus called lateral geniculate body which project to primary visual cortex in occipital lobe of cerebrum and image is perceived.