EARS

Ear (External and Middle Ear)

We have recently explored the eye's structure and the vision mechanism. Similar to how light travels in the form of rays, sound travels as waves. Ears, being the sensory organs, detect and capture sound waves, transforming them into nerve impulses to facilitate hearing. However, hearing is not the only function performed by the ears. They also contribute to maintaining body balance and equilibrium.

Consequently, ears serve two sensory functions:

(i) Hearing, (ii) Maintenance of body balance

The human ear can be anatomically divided into three main sections:

(a) The outer ear, (b) The middle ear, (c) The inner ear

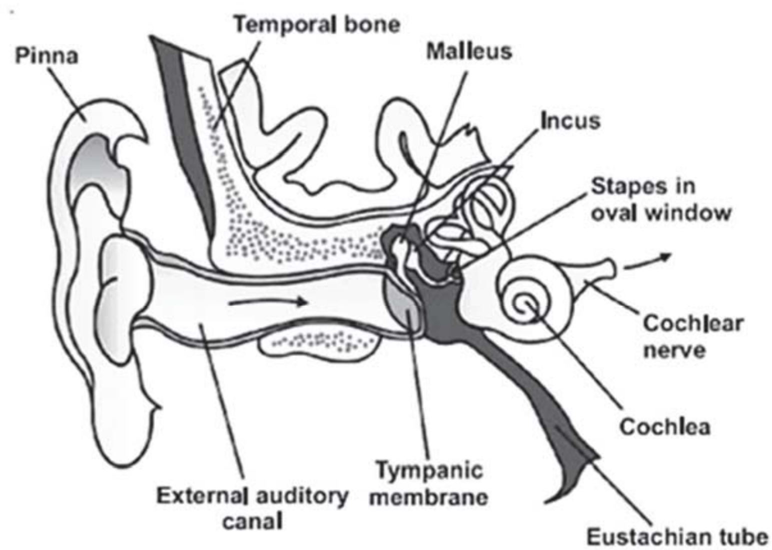

Fig. : Diagrammatic view of ear

The outer ear comprises the pinna and external auditory meatus, leading to a canal. The pinna, a flap of elastic cartilage visible externally, functions as a sound-gathering trumpet. It collects sound waves in the air, which require a medium to travel, provided by the air. The external auditory meatus and canal carry these sound waves inward, hence termed the external auditory canal.

The skin of the pinna and meatus contains small hairs and wax-secreting glands. Ceruminous glands, modified apocrine sweat glands, produce ear wax (cerumen). Both the fine hairs and ear wax serve the purpose of trapping dust particles, insects, and other irritants to prevent their entry into the delicate inner ear parts, averting potential damage.

The external auditory canal terminates at the tympanic membrane, also known as the ear drum or tympanum. This thin, semi-transparent, oval-shaped membrane marks the transition from the outer ear to the middle ear. Composed of connective tissues, the outer surface faces the outer ear and is covered with skin, while the inner surface facing the middle ear is covered with the mucous membrane.

Within the middle ear reside three delicate bones called ear ossicles: the malleus, incus, and stapes. The malleus is hammer-shaped, attaching to the inner side of the tympanic membrane. The incus, anvil-shaped, lies between the malleus and stapes, connecting them. The stapes, stirrup-shaped, is attached to the oval window (fenestra ovalis), resembling a 'door' to the inner ear.

Arranged in a chain-like fashion, these ear ossicles act as a lever system, amplifying the force of vibrations. When sound vibrations strike the eardrum, they set the malleus in motion. The malleus transmits vibrations to the incus, which further transfers them to the stapes. Finally, the stapes transmits vibrations to the inner ear, enhancing the intensity of the sound. This middle ear cavity, filled with air, is also known as the tympanic cavity, connecting to the pharynx and the inner ear, the labyrinth. The inner ear consists of the bony labyrinth, a series of channels made of bone, containing the membranous labyrinth. The inner ear is further divided into two types of fluid, perilymph and endolymph, housed within the labyrinth, maintaining compartmentalization within the inner ear.

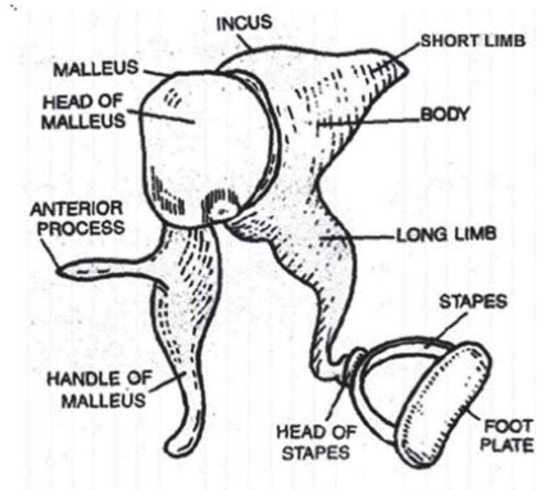

Fig. : Ear Ossicles

Following ones are the important structures present in the inner ear:

Cochlea

The spiral section of the labyrinth is referred to as the cochlea, serving as the primary auditory organ within the inner ear.

In humans, the cochlea manifests as a spirally coiled structure (2%), bearing a resemblance to the shell of a snail. Its configuration exhibits a gradual tapering from a broad base to an almost pointed apex, with the oval window positioned at the broad base of the cochlea. This structure further divides the bony labyrinth into three chambers or channels. The upper membrane of the cochlea is identified as Reissner's membrane, while the lower membrane is known as the basilar membrane. These membranes, Reissner's and basilar, segment the surrounding perilymph-filled bony labyrinth into the following three chambers:

(a) An upper scala vestibuli (b) A middle scala media (c) A lower scala tympani

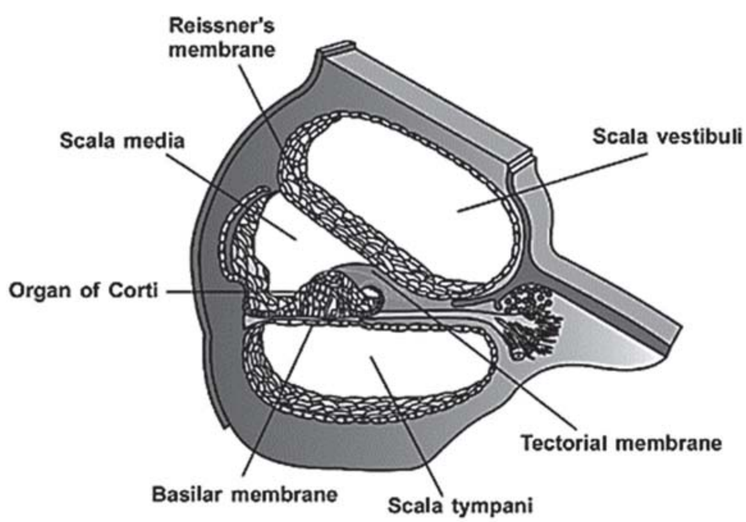

Fig.: Diagrammatic representation of the sectional view of cochlea

1. The interior of the cochlea is designated as the Scala media. In this context, the Reissner's and basilar membranes serve as the upper and lower boundaries of the scala media or the cochlea.
2. Positioned above the scala media is the scala vestibuli, while the scala tympani lies below it. The scala media is filled with endolymph, whereas both the scala vestibuli and scala tympani contain perilymph.
3. The connection between the middle ear and the inner ear is facilitated through two membranous-covered openings: the upper oval-shaped oval window and the lower round-shaped round window. At the cochlea's base, the scala vestibuli (upper chamber) terminates at the oval window, and the scala tympani concludes at the round window, which opens into the middle ear.
4. The apex of the cochlea features a small aperture, the helicotrema, connecting the scala vestibuli and scala tympani with each other.

Mechanism of Hearing

Once you've acquainted yourself with the ear's structure, the next phase involves delving into the process of hearing. How do ears transform sound waves into neural impulses, which the brain senses and processes to recognize a sound?

The external ear gathers and captures sound waves, directing them towards the eardrum or tympanic membrane. These sound waves travel through the external auditory canal. Upon reaching the eardrum, it responds by vibrating. The vibrations produced in the eardrum are then transmitted to the three ear ossicles (malleus, incus, and stapes) in the middle ear. The ear ossicles enhance the intensity of the sound vibrations and convey them to the oval window. As previously discussed, the membrane covering the oval window acts as the entrance to the inner ear, namely the labyrinth.

As sound vibrations pass through the oval window into the cochlea, they create waves in the lymph present in the cochlea. Initially, waves are generated in the perilymph of the scala vestibuli, as it is directly connected to the oval window through which the sound vibrations enter the inner ear. Subsequently, these waves are transmitted to the endolymph present in the scala media. The sound vibrations produced in the endolymph of the scala media create ripples in the basilar membrane of the scala media.

External ear receives sound waves

↓

Directed towards the ear drum

↓

When the waves strike the tympanic membrane the alternate compression and decompression of the air causes the membrane to vibrate

↓

Vibrations are transmitted through the ear ossicles (M→I→S) to oval window

↓

The movement of the oval window set up wave in the perilymph of scala vestibuli

↓

Vibration of endolymph of scala media

↓

The waves in the endolymph induced a ripple in the basilar membrane

↓

Basilar movements bend the hair cells pressing them against the tectorial membrane

↓

Nerve impulse generated in the associated afferent neurons

↓

Impulse transmitted to auditory region of brain via auditory nerve

↓

Impulse gets analysed and sound is recognised

Fig.: Mechanism of Hearing

The organ of Corti is situated on the basilar membrane, and the movements of this membrane cause the hair cells within the organ of Corti to bend. This bending action of the hair cells in the organ of Corti brings them into contact with the flexible tectorial membrane covering them. Consequently, nerve impulses are generated in the afferent neurons linked with the hair cells of the organ of Corti. These impulses are then conveyed by afferent nerve fibers through the auditory nerves to the auditory cortex of the brain. The cochlear branch of the auditory nerve transmits neural impulses related to hearing, while the vestibular branch conveys neural impulses associated with balance. The cortex analyzes these nerve impulses, leading to the recognition of sound. In summary, the mechanism of hearing can be outlined as follows.