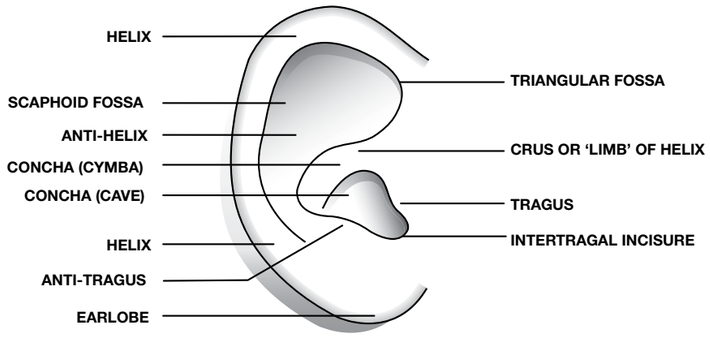
Anatomy and physiology – Advanced



Auricle or pinna

The auricle helps with spatial hearing/ awareness. It also functions mainly as a sound collector whilst making hearing slightly more efficient. People with very large auricles do not seem to be any more sensitive to sounds than people with small auricles. If people do not have auricles however they can experience some hearing loss.

Concha bowl

The concha bowl is shaped so that it can direct sounds into the ear canal.

Ear canal

The ear canal is also called the external auditory meatus (EAM) or the external auditory canal (EAC). The shape and diameter of the ear canal have an effect on its resonance characteristics. In a normal adult, the ear canal is s-shaped, approximately 25mm in length and 8mm in diameter. The first portion of the ear canal, which is cartilaginous, is between a third and a half of the full length and has a variable diameter. The rest of the ear canal is made of bone and has a fixed diameter. Wax (cerumen) is produced in the ear canal. Hairs inside the ear canal and shedding of skin inside the ear canal helps to move wax and foreign debris.

Related information

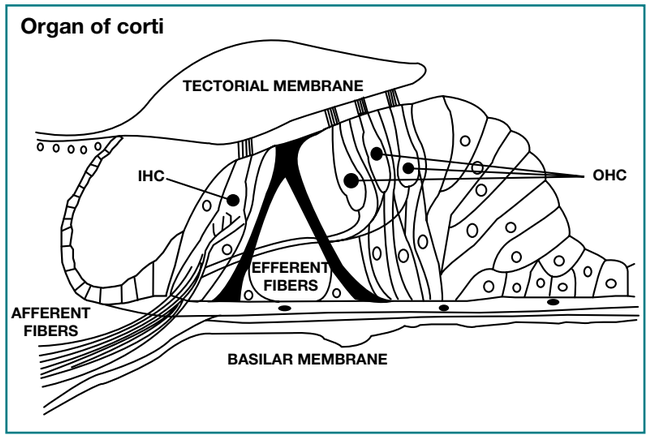
Also refer to the section in this manual on **Otoscopy** and **Acoustics.**

Outer hair cells and inner hair cells

Outer hair cells (OHCs) and inner hair cells (IHCs) are located in the organ of corti, within the scala media. OHCs help to sense soft sounds and help us to recognise frequencies that are close together. They receive information from the brain and chemical messages from within the cochlea. IHCs are essential to hearing. They send information to the brain and without them we would not have the ability to hear.

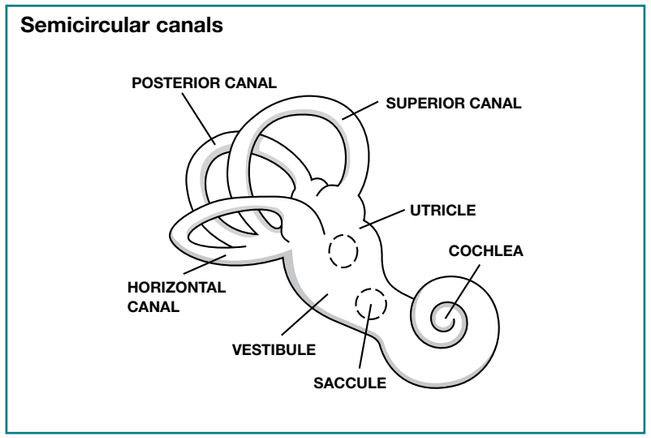
The stereocilia of the OHCs are squeezed into the tectorial membrane. When soft sounds are received, the OHCs pull down the tectorial membrane so that it touches the stereocilia of the IHCs. This movement temporarily affects the basilar membrane so that it sharpens the peak of the travelling wave along the basilar membrane.

OHCs and IHCs play an important role in both diagnostic testing and hearing instrument fittings. For example, otoacoustic emissions (OAEs) test the function of OHCs and some forms of compression in hearing instruments copy the function of OHCs.



Semicircular canals

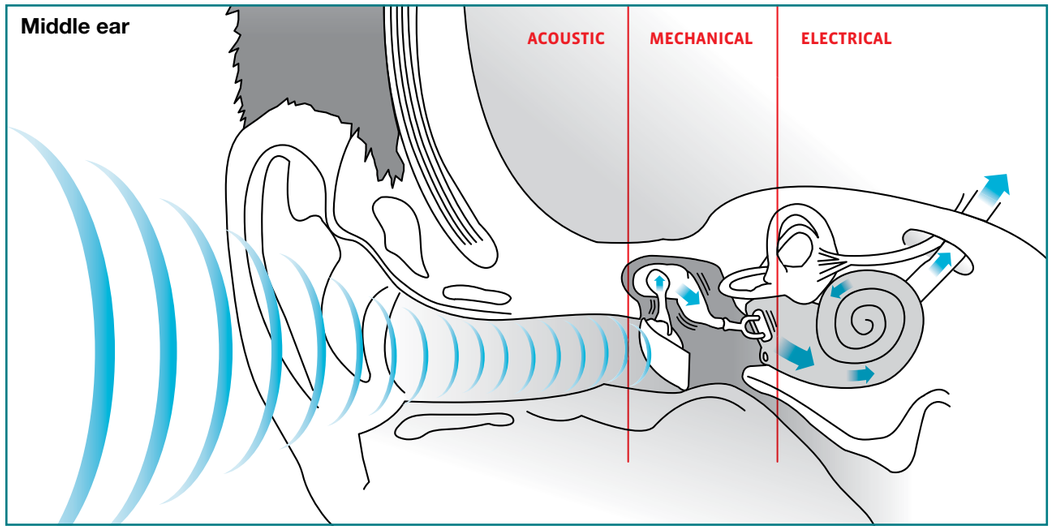
The semicircular canals are attached to the cochlea. They are filled with fluid and control our balance. They have no influence over our ability to hear.



Related information

Also refer to the sections in this manual on **Electronystagmography (ENG)**, **Hearing instruments and hearing loss (Types of hearing loss)**, **Pure tone audiometry**, **Auditory brainstem response (ABR)**, **Otoacoustic emissions (OAE)**, **Evoked potentials.**

Transfer of energy from acoustic to mechanical



The auricle collects sound and directs it down the ear canal towards the tympanic membrane. This acoustic energy hits the tympanic membrane and is transferred as mechanical energy along the ossicular chain to the oval window. As the tympanic membrane has a comparatively large surface area and all the energy is transferred to the comparatively small surface area of the stapes footplate, the result is an amplification of sound by approximately 25dB. This amplification is required to enable sound to get through the fluid-filled inner ear.

Tensor tympani

The tensor tympani muscle opens the Eustachian tube (also called the auditory tube) in order to equalise pressure between the atmosphere and the middle ear. The Eustachian tube does not affect how we hear so even when blocked, it is still possible to have normal hearing.

Stapedius muscle

The stapedius muscle is the smallest in the body and it connects to the top of the stapes. Sufficiently loud sounds cause the stapedius muscle to contract and swing outward and backward from the oval window. This action is called the acoustic reflex. It limits the motion of the ossicles, reduces the vibration of the bottom of the stapes, the stapes footplate, and reduces the fluid motion in the inner ear. This helps protect the inner ear from damage caused by loud sounds, particularly at low frequency.

Ossicles

The names of the ossicles are:

- Malleus (also called the Hammer)
- Incus (also called the Anvil)
- Stapes (also called the Stirrup)

Oval window

The oval window is the area where the stapes presses on the cochlea.

Round window

The round window equalises pressure between the scala vestibuli and the scala tympani.

Jargon Buster

Endolymph is the fluid in the scala media. It is similar to perilymph but has a different ionic composition.

Perilymph is the fluid in the scala vestibuli and the scala tympani. It is similar to the cerebrospinal fluid that surrounds the brain.

The **organ of corti**, within the cochlea of the inner ear, contains the hair cells that are auditory sensory cells.

Stereocilia are organelles that sit on top of the hair cells. They transform the mechanical energy of sound from the stapes into electrical energy for the hair cells.

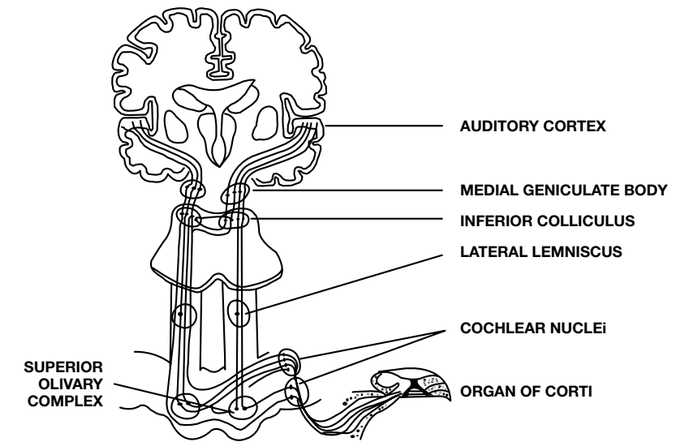
Related information

Also refer to the section in this manual on **Impedance** and **Hearing instruments and hearing loss (types of hearing loss).**

Transfer of energy from mechanical to electrical

The cochlea is located in the inner ear. The role of the cochlea is to transform mechanical energy to electrical energy, which is the language that the brain understands. This electrical energy is carried from the inner ear via the nerve pathway up through the brainstem to the auditory cortex in the brain.

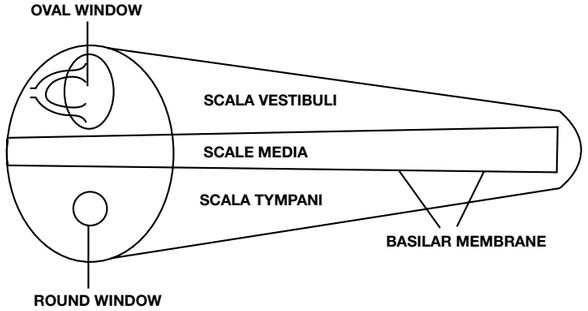
Auditory cortex



Membranous labyrinth and the basilar membrane

The membranous labyrinth is a soft-walled tube situated inside the bony labyrinth (bony cavity). The membranous labyrinth almost completely divides the bony labyrinth into the upper chamber (also called the scala vestibuli) and the lower chamber (also called the scala tympani). The middle, soft-walled chamber is called the scala media. In coming energy transmitted by the ossicular chain moves the fluid in the scala vestibuli and scala tympani.

The layout of the cochlea



The scala vestibuli and the scala tympani are filled with perilymph. The scala media is filled with endolymph. When the oval window is pushed inwards, the round window bulges outwards resulting in the perilymph moving back and forth. The horizontal back and forth motion occurs at the frequency of the sounds that created it. For example, a 1000Hz tone causes the stapes footplate to move 1,000 times per second.

Basilar membrane

When the basilar membrane moves vertically up and down, the scala media bends which stimulates the hair cells inside it. The vertical motion occurs due to energy fluctuation along the cochlea.

The basilar membrane resonates best at different points depending on the different frequencies it receives. It has different mass and stiffness properties at the base compared to the apex of the cochlea. There is more mass (it is wider) at the narrow apex of the bony labyrinth and less mass (it is narrower) at the wide base of bony labyrinth. The membrane is soft at the wide end and stiff at the narrow end. Low frequencies resonate with mass and less stiffness. High frequencies resonate with less mass and more stiffness. This means that low frequencies resonate best at the apex and high frequencies resonate best at the base.

Continued on the back...