

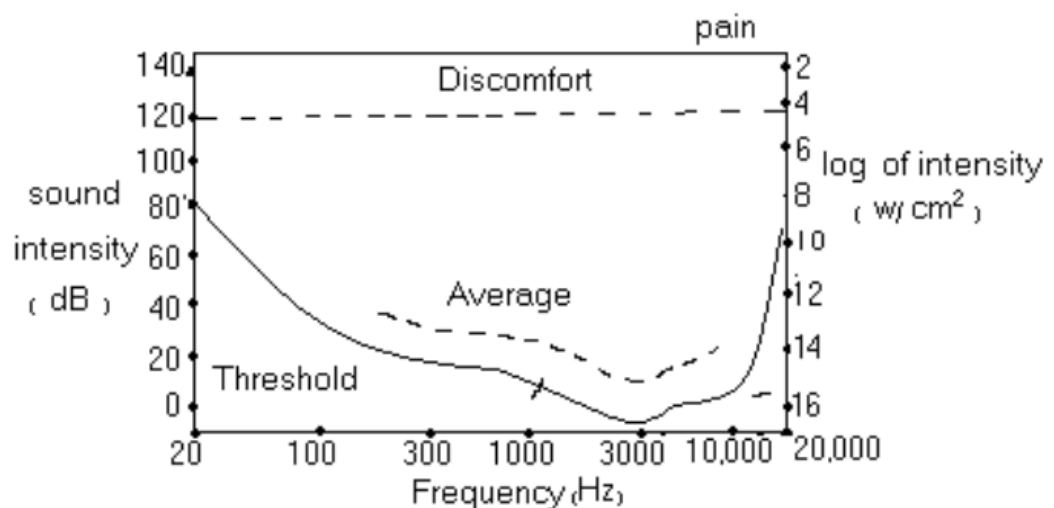
Physics of ear and hearing construction of the ear

1- The outer ear:

1. The auricle : It is the least important of the hearing system. It aids only slightly in funneling sound waves.
2. The external auditory canal :It is 2.5 cm long and 0.5 cm diameter :closed at the end by the eardrum ; for this (length = $\lambda/4$).It services to:
 - a. Increase the ear sensitivity in the region of 3 to 4kHz
 - b. Storage of ear wax.
3. The eardrum (tympanic membrane): It is 0.1mm thick and 6.5mm area.It couples the vibrations in the air to the ossicles .It does not vibrate symetrically like a drum head because of its off-center attachment to the hummer.

The pressure at the eardrum is 2 atmospheric .The motion of the eardrum is very small 10 cm at 3khz and 10 cm at 20hz.

The eardrum stiffened at high frequencies and reduces its movements for protection. A sound pressure of ≥ 160 dB can rupture the eardrum.



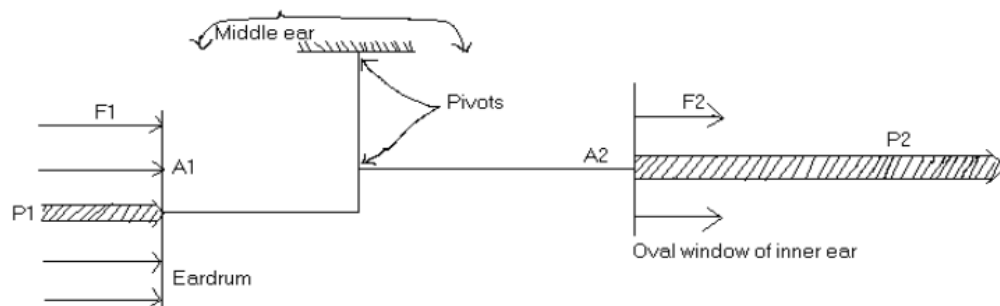
- 2- The middle ear: It is a small air-filled cavity separated from the outer ear by the eardrum and houses the ossicles ,which are full adult size bones before birth (the fetus can hear while it is still in the womb).

The ossicles:

a. The hammer (malleus).

b. The anvil (incus). c. The stirrup (stapes). They are connected to the walls of the inner ear by muscles that act as a kind of automatic volume control. They play important role in:

- Matching the impedance of the sound waves at the eardrum to the liquid-filled chambers of the inner ear.
- Protection the ear from possible damage by loud sound by rotating the stirrup and pulling it a way from the oval window by the muscles which stiffens the eardrum as well.
- Amplification of the pressure behind the oval window by 40 to 90 times and the intensity of sound to the square of this pressure because the oval window is 15 times smaller than the eardrum.
- Transmission poorly vibrations in the skull and even the large vibrations from the vocal cords.



3- The Eustachian canal

It leads to the mouth and maintains the pressure in the middle ear to the atmospheric pressure / chewing , yawning or swallowing cause a momentary opening of this canal.

4- The inner ear:

It is hidden deep within the temporal bone, the hardest in the body. It consists of a small spiral-shaped structure filled with fluid called the cochlea. It is 2.3/4 turns over a length of 5 mm. It is communicated with the middle ear via the oval window. It is divided into 3 chambers:

- a. Vestibular canal: Leading from the oval window, filled with perilymph liquid
- b. Tympanic canal: It ends in the round window, filled with perilymph liquid. It joins up with the vestibular canal at the apex of the cochlea through a small opening called helicotrema.
- c. Cochlear duct: It is separated from the vestibular canal by a thin membrane (Reissner's membrane) and from the tympanic canal by the basilar membrane.

It is filled with endolymph liquid which is separated from the perilymph. The basilar membrane supports the organ of Corti which contains the ends of 30,000 auditory nerves and occupies an area of 3 cm long by 0.3 mm wide.

Inside the cochlea the original pressure wave in air has become a pressure wave in liquid where viscosity plays the dominant role. This wave induces wave-like ripples in the basilar membrane that is stimulated depends on the frequency of the original sound wave.

The organ of Corti converts the mechanical energy into electrical energy and sends the information to the brain via the auditory nerves. The organ of Corti is a gelatinous structure of 7500 interrelated parts containing a mass of hairs fixed on both ends which stimulates the ends of the auditory nerves.

Hearing Test:

The test is normally done in a sound proof room for each ear separately through a comfortable headset through frequencies from 250 to 8000 Hz . The hearing thresholds are plotted on a chart and can be compared to normal hearing thresholds.

