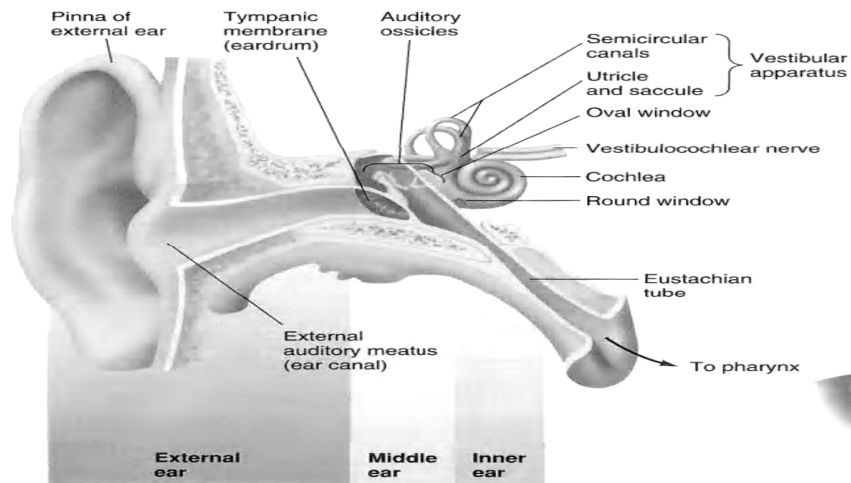


# HEARING



## Functions of the Ear:

- Hearing by: External ear.  
Middle ear.  
Internal ear.
- Equilibrium sense by: internal ear.

## Anatomical Consideration:

### - Outer ear:

- Pinna.
- External canal.
- Tympanic membrane ( funnel, pointing inward )

### - Middle ear: -MCQ-

- Air filled cavity.
- Three bones: malleus, incus, stapes ( stapes foot sitting on the oval window of inner ear).

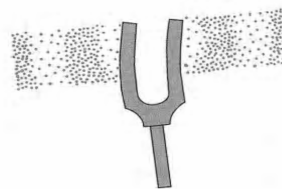
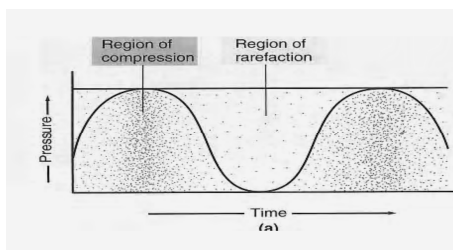
### - Inner ear:

- Bony and membranous labyrinth.
- Fluid filled cavity.

- Perilymph = fluid between the bony & membranous labyrinth.
- Endolymph = fluid inside the membranous labyrinth.

## Nature of Sound:

- Sound is produced from alternate compression and rarefaction of air molecule by vibrating body.



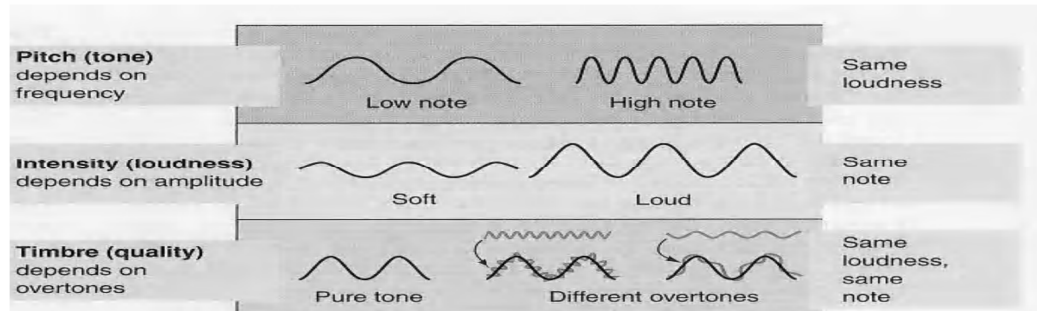
## **Characteristics of sound: -V.IMP MCQ-**

### **1- Pitch (tone):**

- depends on the number of cycles per second ( frequency).
- human ear can detect sound waves with frequency 20-20000 cycles/sec.

### **2- Intensity (loudness): - depends on the amplitude.**

### **3- Quality: - depends on the over tone and interference**

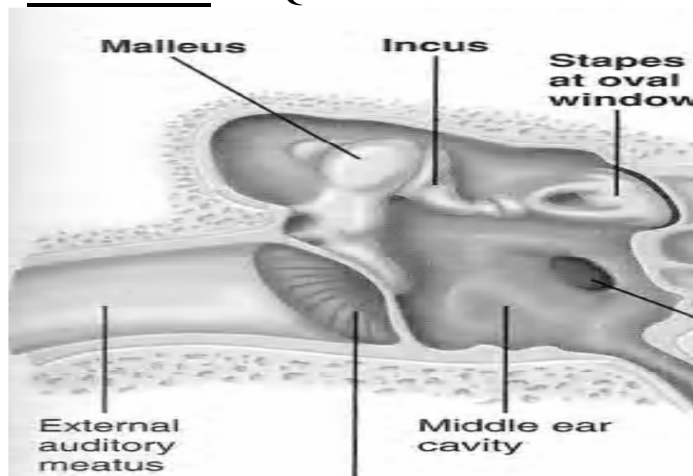


## **Functions of the ear:**

### **1- External ear:**

- Acts as funnel to collect sound.
- Sound localization ( front, back, high or low ).
- Protection ( due to wax and hair ).

### **2- Middle ear: -MCQ-**



- It is space between tympanic membrane and the inner ear (open via Eustachian tube into nasopharynx).
- **Contains**
  - 1- air.
  - 2- ossicles –bones- ( malleus, incus & stapes ) &
  - 3- muscles ( tensor tympani, stapedius).

➤ **Functions of middle ear:**

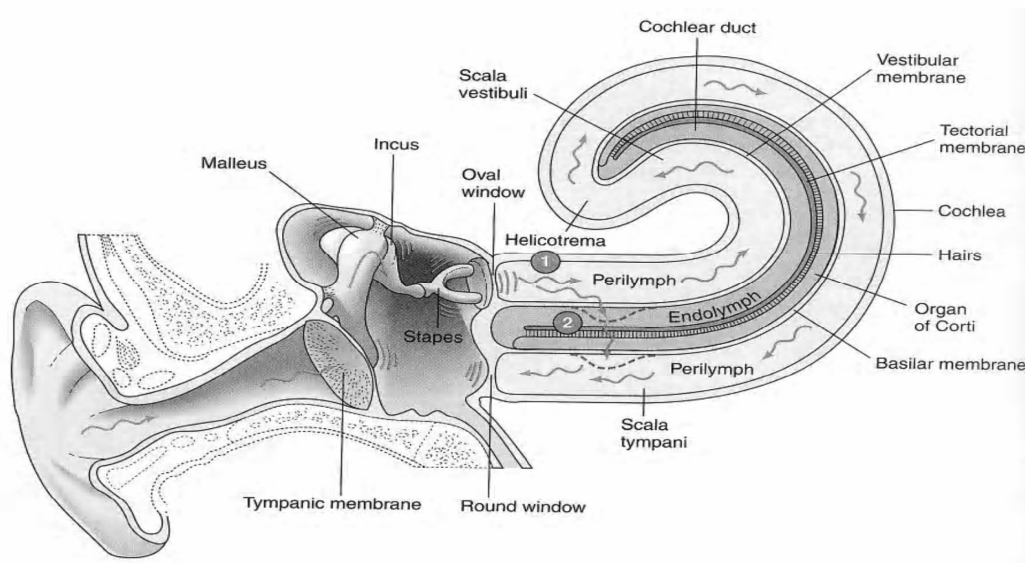
**\*Muscles:**

- Contract reflexly in response to loud sound ( over 70 dB ).
- Contraction of the tensor tympani pulls the manubrium- is the handle of malleus- and makes the tympanic membrane tense, thus it decreases the vibration.
- Contraction of stapedius pulls the foot plate outward so the vibrations are reduced.
- Protection of the inner ear from constant loud noise but not sudden noise-MCQ-, latency of 40-80 msec.
- The previous points constitute the **Tympanic Reflex** which is helpful to **decrease** the transmission of sound to the inner ear.-MCQ-

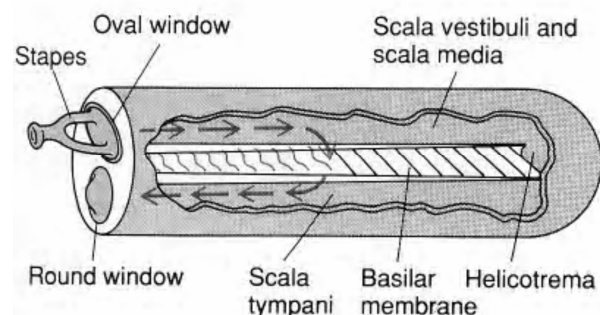
**\*Ossicles:**

- Manubrium of the malleus attached to the back of the tympanic membrane and its short process is attached to the incus.
- The incus then articulates with the head of stapes and its-stapes- foot plate is attached to the oval window.

**Transmission of Sound Through the Middle Ear:**



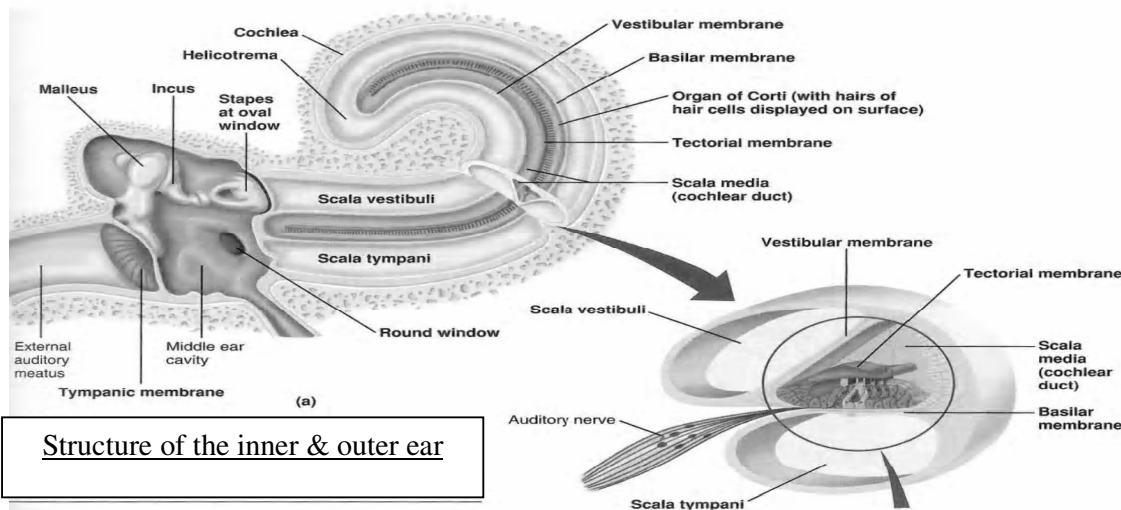
- Sound waves vibrate the tympanic membrane.
  - Tympanic membrane moves the handle of malleus.
  - Incus moves.
  - Stapes moves in and out of the oval window.
- The pressure transmitted through cochlea cause stimulation of hair cells in the organ of corti, which will stimulate the auditory nerve.



## Middle Ear Magnifying Effect: -V.IMP MCQ-

- 1- The force from a large surface area ( tympanic membrane ) are concentrated to a small (oval window) the ratio 17 to 1.
- 2- Lever action of ossicles: the lever action of ossicles increases the force of movement 1,3 times => the total increase  $17 \times 1,3 = 22$  times (the force of the sound vibration when it arrives at oval window).

## Inner Ear:



### Anatomy:

- Cochlea ( snail like, coiled tubular system lying deep in the temporal bone).
- Bony labyrinth.
- Membranous labyrinth.

### ❖ Cochlea:

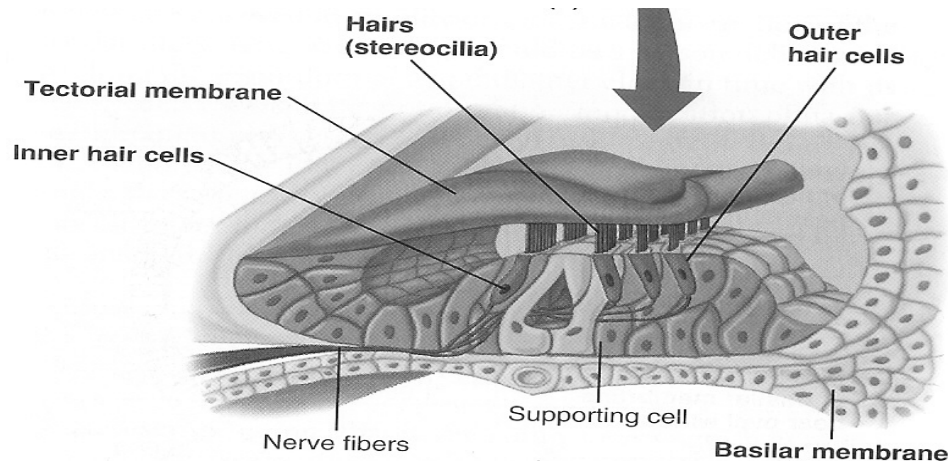
- It is a system of 3 coiled tubes its length.
- The basilar membrane ( which is flexible at the apex more than the base) –V.IMP MCQ- and the reissner's membrane divide it into 3 canals:
  - 1- Scala vestibuli ( upper chamber ) end laterally at oval window.
  - 2- Scala media ( =cochlear duct ), contain endolymph.
  - 3- Scala tympani ( lower chamber).

### \*\*Composition: -MCQ-

- Scala vestibuli: Na is high, K is low ( similar to ECF).
- Scala tympani: Na is high, K is low ( similar to ECF).
- Scala media: Na is low, k is high ( similar to ICF ).

### ❖ Organ of Corti:

- Located ( resting ) on the basilar membrane. -MCQ-
- Contains inner and outer hair cells.
- Extend from base to apex



### ❖ Hair Cells: ( receptor for hearing in the organ of corti ) -MCQ-

- Have stereocilia extend from the top.

#### - Arrangement:

- 1- Three rows of outer hair cells ( attached to the reticular lamina or tectorial membrane).
- 2- One row of inner hair cells ( not attached to tectorial membrane).

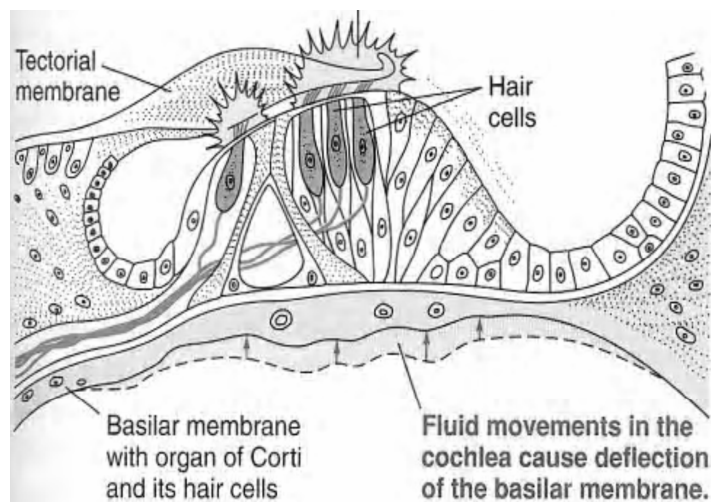
**Fluid in Scala Tympani & Vestibuli** is perilymph.

**Fluid in Scala Media** is endolymph. -MCQ-

### ❖ Functions of the Inner Hair Cells:

\*Stereocilia of the inner hair cells are not embedded in the tectorial membrane but bend by fluid movement under the tectorial membrane.

\*\* They-inner hair cell are primary receptors for sound –  
**MCQ-**, transducing fluid movement in cochlea into action potentials in the auditory nerve.



### ❖ Functions of the Outer Hair Cells:

( depolarization=>short, hyperpolarization=>long)

Large number, but stimulate only small fraction of nerve fibers in the cochlear nerve. **-MCQ-**

If damaged, significant loss of hearing ( they control the sensitivity of the inner hair cells to particular sound frequency).

### ❖ Receptors and Endocochlear Potential:

Sound transmission into the inner ear cause upper and lower movement of the reticular membrane ( tectorial membrane ) => produce bending of stereocilia of the hair cells alternatively open and close cation channels at the tip of the stereocilia =>

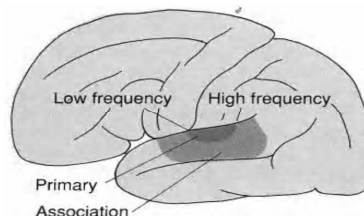
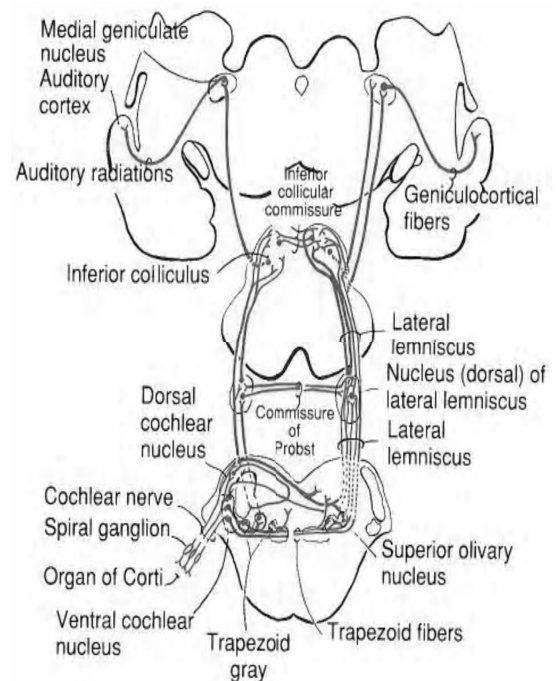
- ( inward current ) depolarization = short

- ( outward current) hyperpolarization = long

=>production of cells receptor potentials => release of neurotransmitter => production of action potential.

### ❖ The Central Auditory Pathway:

- This pathway begins in the organ of corti.
- End in the primary auditory cortex ( area 41 & 42, superior temporal gyrus in temporal lobe).
- Organ of corti => spiral ganglion of the organ of corti => the axons from spiral ganglion project into medulla oblongata ( synapse in the dorsal and ventral cochlear nucleus) => most of fibers cross to the opposite side at this level => fibers transmitted upward through successive neuron in the superior olivary nucleus, inferior colliculus and medial geniculate nucleus fibers.
- Part of the signals travel on the same side of the brain stem.
- From medial geniculate body (nucleus) fibers finally terminate in the primary auditory center located the superior temporal gyrus.
- Fibers end in the auditory area, where it is heard, then interpretation occurs in the auditory association area ( Wernikes area ) .



\*\*There is a bilateral cortical connection of the auditory area, thus damage to one side only slightly reduces hearing.

### ❖ Sound Localization:

- Differences in the time arrival of the sound wave of the ear ( time-lag).
- Differences in the loudness.

\*\*lesion of auditory cortex => disrupt localization.

### ❖ Masking Effect:

Presence of background noise affect the ability to hear another sound, due to some receptors are in refractory period.

Masking is more clear if 2 sounds are having the same frequencies.

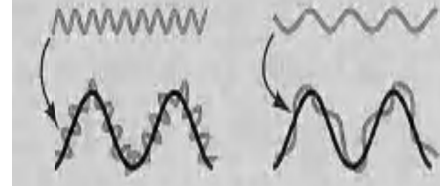
\*\*Noise pollution is an environmental hazard.

Exposure to sound intensity above 80 dB may damage outer hair cells.

60 dB => normal conversation.

80 dB => heavy traffic.

100dB => rock music.



### Conduction of Sound Waves:

- Air conduction:

( more efficient )

Normal stimulation of hearing, sound travel in air causes vibration of tympanic membrane, transmitted by ossicles to the oval window.

- Bone conduction:

Sound causes vibration of skull bones directly transmitting the sound vibration to the cochlea ( e.g. when placing tuning fork on the head or mastoid process).

### DEAFNESS

Conductive & Perception deafness .

#### 1- Conductive Deafness:

impairment of sound transmission through external or middle ear due to:

- wax.
- Repeated infection.
- Perforated drum.
- Destruction of the ossicles.
- Osteoporosis ( pathological fixation of stapes on the oval window ) .
- All sound frequencies are equally affected.
- Bone conduction is better than air conduction.

#### 2- Perceptive Deafness:

Is also called sensory neural or neural deafness.

Due to congenital or aquired damage to cochlea or auditory nerve pathway due to:

- toxins. ( antibiotics, gentamycin)
- inflammation.
- Vascular.
- Tumor.
- Both air and bone conductions are affected.

**Test of hearing:**

- **Audiometer:**  
measure auditory acuity.
- **Weber test:**  
( fork => vertex of skull ).
- **Rinnes test:**  
( fork => mastoid process ).