Revised By
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MED437

Hearing

Objectives:

- Appreciate the functions of outer, middle and inner ear.
- Describe nature of sound & its characteristics.
- Function of semicircular canals & utricle & saccule.
- To understand the role of middle ear in sound transmission, magnification and tympanic reflex effect.
- Recognize the function of hair cells of inner ear.
- Auditory pathway
- Differentiate between conductive and perceptive deafness.
- Hearing tests

Done by:

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Colour index:
- Important
- Numbers
- Extra

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Functions of The Ear

Hearing (Parts involved):

- External ear
- Middle ear
- Internal ear

Equilibrium sense (Parts involved):

- Internal ear

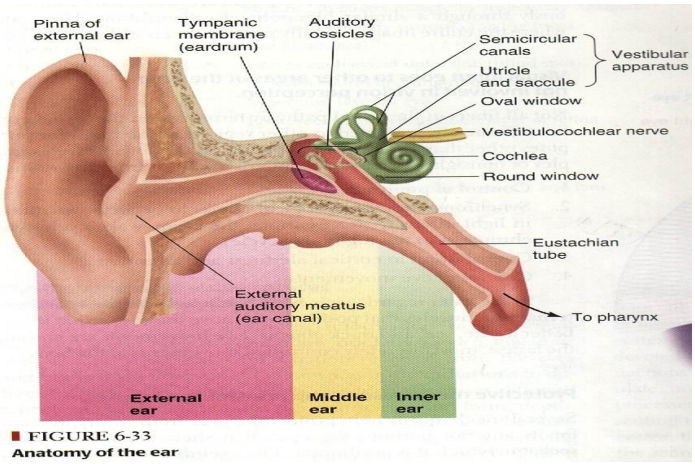


FIGURE 6-33
Anatomy of the ear

Anatomical Consideration

Outer ear:

- Pinna
- External canal
- Tympanic Membrane (funnel shaped, pointing inward)

Middle ear:

- Air filled cavity
- Three bones:

1) Malleus
2) Incus
3) Stapes (with its foot sitting on the oval window of the inner ear)

Inner ear:

- Bony and membranous labyrinth

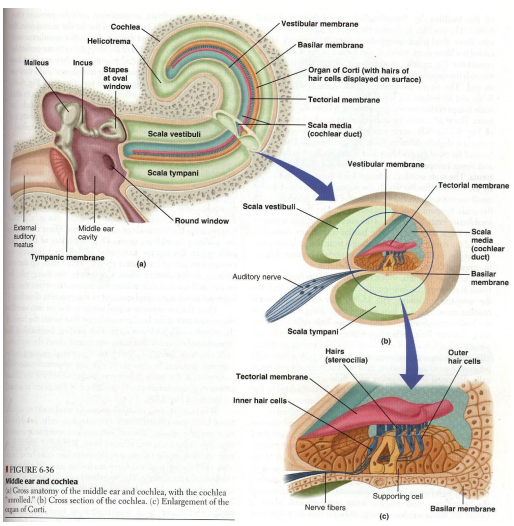
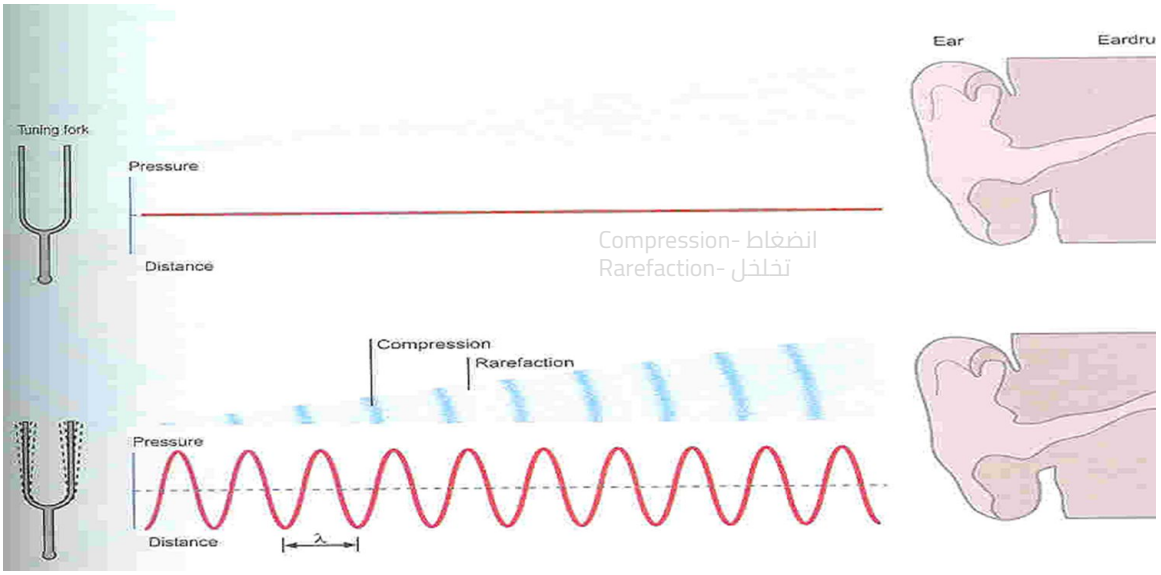


FIGURE 6-36
Middle ear and cochlea

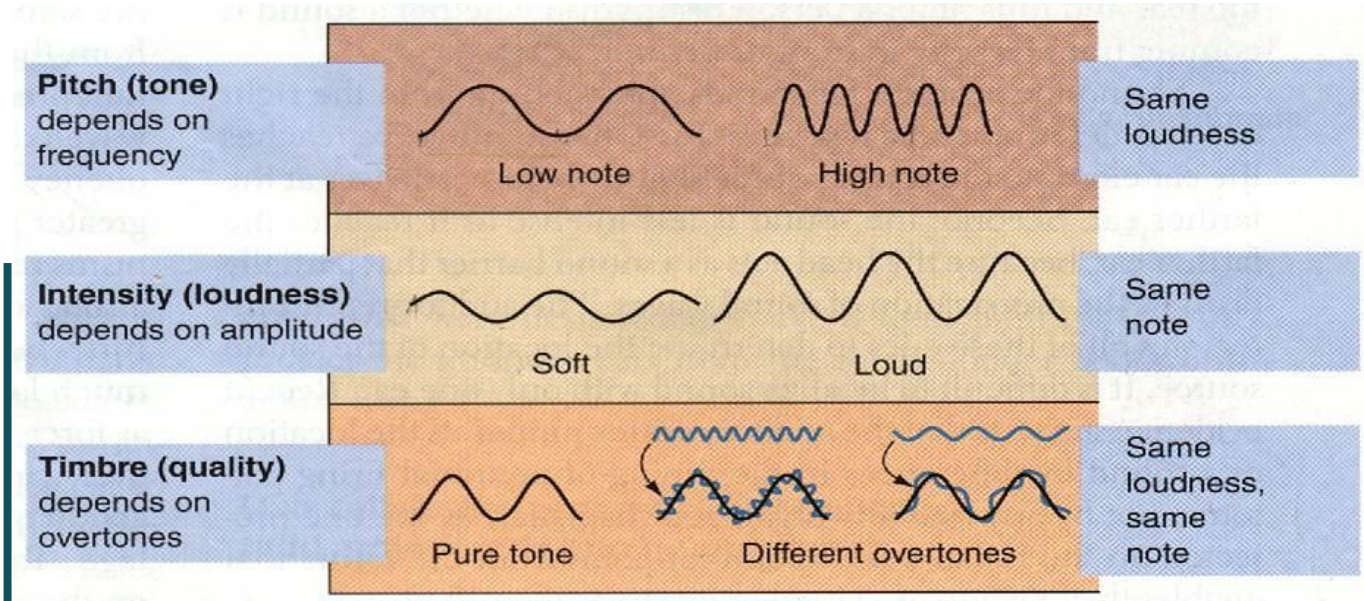
Nature of Sound

Sound is a vibration that propagates as an audible wave of the pressure, through a transmission medium such as gas, liquid or solid.
Sound is produced from alternate compression and rarefaction of air molecules by vibrating body.



Characteristics of Sound

1) **Pitch** (Tone) depend on No. of cycle/sec.
   (Human ear can detect sound waves with freq.. 20-20000 cycle /sec)
2) **Intensity** (Loudness) depend on amplitude.
3) **Quality** depend on the overtone or interference.



Functions of The Ear

1- External ear:

- Act as funnel to collect sound
- Sound localisation (front, back, high, low)
- Alter amplitude (Pinna)
- Protection Filtration by hair
- Wax

Also, humidification and warming the air entering the ear

2- Middle ear:

It is a space between tympanic membrane and the inner ear (opens via Eustachian tube into nasopharynx)

Content:

- Air Connected to the atmospheric pressure
- Ossicles: Malleus, Incus, Stapes. (Magnify the sound waves)
  - Manubrium Of the malleus attached to the back of the tympanic membrane and its short process attached to the incus.
  - The incus then articulates with the head of the stapes, and its foot plate attached to the oval window
- Muscles: Tensor tympani, Stapedius.
  - Muscles contract reflexly in response to loud sound (over 70 dB)
  - Contraction of the tensor tympani pulls the manubrium & makes the tympanic m. tens. Thus decreasing the vibration.
  - Contraction of the stapeduispull the foot plate outward so that vibration are reduced
  - (protection from constant loud noise, but not sudden noise, latency of 40-80 msec.

Loud noise anything over 80 dB; feel pain 140dB
Normal conversation 40 dB
Whispering 20-15 dB

3- Inner ear:

Anatomy:

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

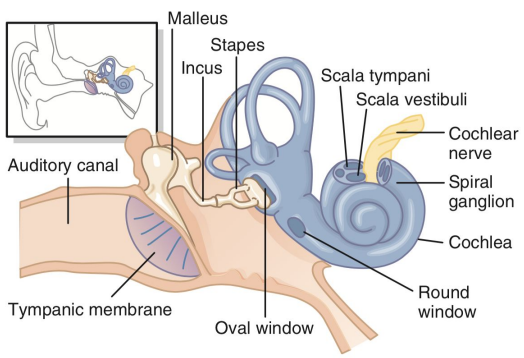


Figure 53-1. The tympanic membrane, ossicular system of the middle ear, and inner ear.

Transmission of Sound Through The Middle Ear

- Sound waves vibrate the tympanic m.
- Tympanic m. moves the handle of malleus
- Incus moves
- Stapes move in & 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

1. The force from a large surface area (Tympanic m.) are concentrated to a small (oval window) the ratio is 17=1
2. Lever action of ossicles= the lever action of ossicles increase the force of movement 1.3 times
3. ▲ the total increase 17 X 1.3 = 22 times

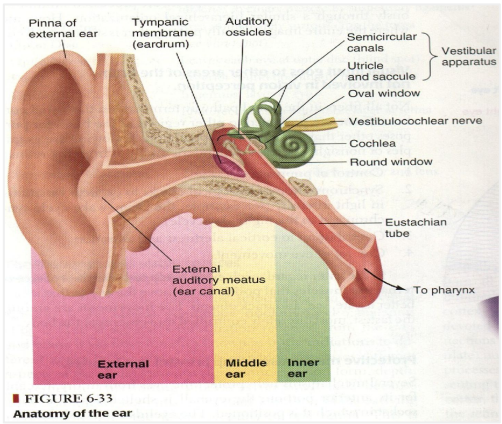


FIGURE 6-33
Anatomy of the ear

Inner ear

- ➢ It is a system of three coiled tubes through its length.
- ➢ The basilar m. & the reissner's m. divide it into three canals:
  1. Scala Vestibuli
  2. Scala Media
  3. Scala Tympani

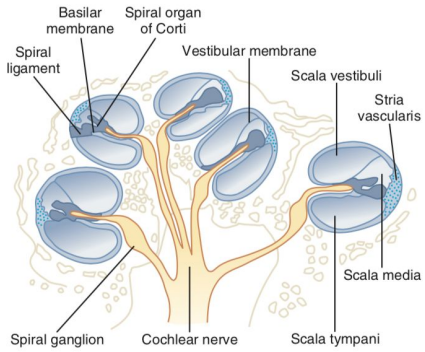


Figure 53-2. The cochlea. *(Modified from Drake RL, Vogl AW, Mitchell AWM: Gray's Anatomy for Students, ed 2, Philadelphia, 2010, Elsevier.)*

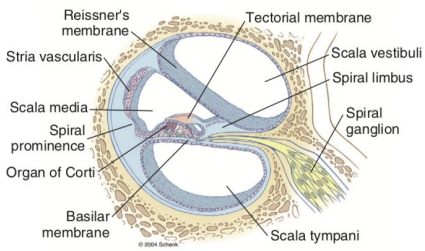


Figure 53-3. Section through one of the turns of the cochlea.

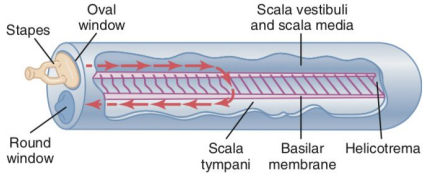
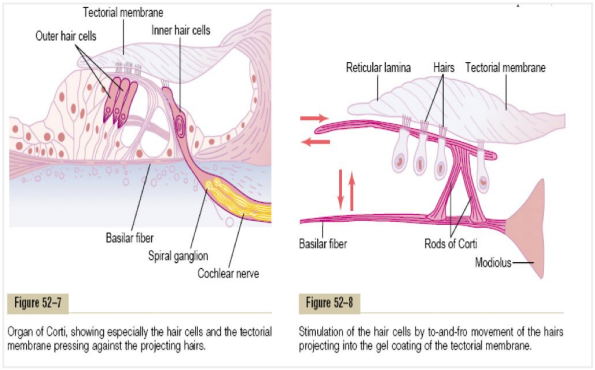


Figure 53-4. Movement of fluid in the cochlea after forward thrust of the stapes.

Composition		
Scala Vestibuli	Na high	K low
Scala Tympani	Na high	K low
Scala Media	Na **low**	K **high**

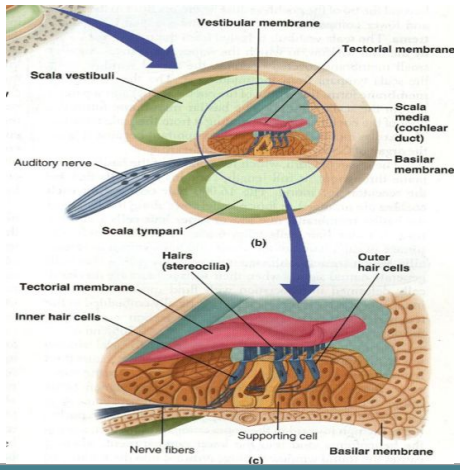
Organ of Corti

- Located (resting) on the basilar m.
- Contain inner & outer hair cells.
- Extend from base to apex



Hair Cells

- Stereocilia extend from the top
- Arrangement:
  - Three rows of outer hair cells (attached to the reticular lamina or tectorial m.)
  - One row of inner hair cells (not attached to tectorial m.)



Function of Inner Hair Cells	Function of Outer Hair Cells
• Striocellia not embedded in tectorial m. but bent by fluid movement under the tectorial m.	• Large number, but stimulate only small fraction of nerve fibres in the cochlear nerve.
• They are primary receptors for sound, transducing fluid movement in cochlea into action potential in the auditory nerve	• If damaged, significant loss of hearing (they control the sensitivity of inner hair cells to particular sound frequency)

by controlling the tension of the basilar membrane

Receptors & Endocochlear Potentials

- ➔ Sound transmission into the inner ear cause upper & lower movements of the reticular m. (tectorial m.)
- ➔ » produce bending of stereocilia of the hair cells alternatively open & close cation channels at the tip of the stereocilia
- ➔ » (inward current) depolarization
- ➔ » (outward current) hyperpolarization
- ➔ » the net results is depolarization
- ➔ Production of cells receptors potentials
- ➔ » release of neurotransmitter
- ➔ »production of action potentials

The Central Auditory Pathway

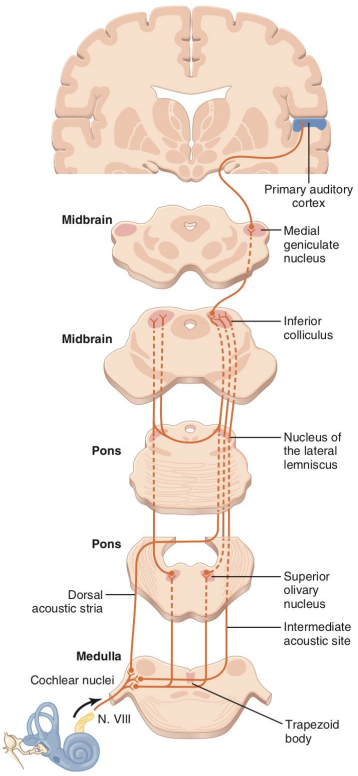
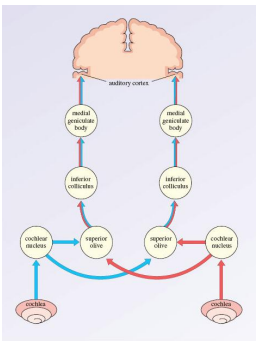
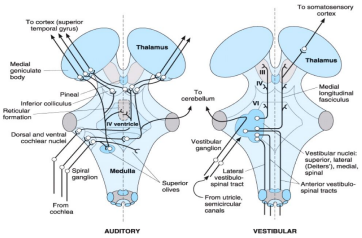


Figure 53-10. Auditory nervous pathways.

- This pathway begins in the organ of corti.
- End in the primary auditory cortex (are 41 & 42, superior temporal gyrus in the temporal lobe of the brain)
- Fibres end in the auditory area, where it is heard, then interpretation occurs in the auditory association areas (wernicke area)
- There is a bilateral cortical connection of auditory area
- Thus damage to one side only slightly reduces hearing

Complete hearing loss is inherited & unlikely





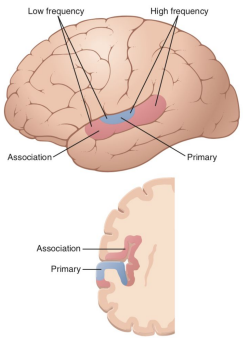


Figure 53-11. Auditory cortex.

Sound Localization

- Differences in the time arrival of the sound wave at the ears (time-lag)
- Differences in the loudness

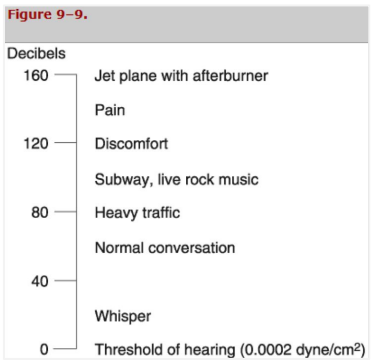
Masking Effect

- Presence of one sound decreases an individual's ability to hear other sounds. This phenomenon is known as **Masking**.
- Presence of background noise affect the ability to hear another sound, due to some receptors are in refractory period
- Masking is more clear if two sound are having the same frequencies.

Note: In children, their cochlea for a particular sound waves frequency is producing AP, therefore any sound waves will come in the same freq. will not be perceived by this organ of corti because the nerve here is in refractory period, it will not be able to receive any impulses (they will not hear if you call them until you change your tone of voice).

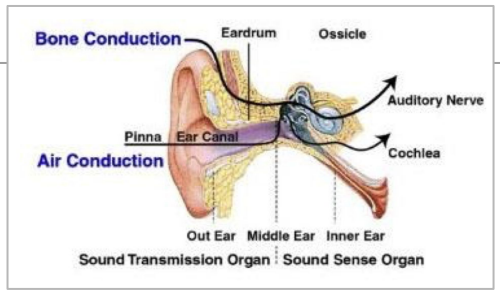
Noise pollution

- Noise pollution is an environmental hazard.
- Exposure to sound intensity above 80 db. may damage outer hair cells.



Conduction of Sound Wave

Air conduction	Bone conduction
Normal situation of hearing, sound travel in air causes vibration of Tympanic m., transmitted by ossicles to the oval window	Sound cause vibration of skull bones directly transmitting the sound vibration to the cochlea (eg when placing tuning fork on the head or mastoid process)



Deafness

Conductive Deafness

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

- Wax
- Repeated infection
- Perforated drum
- Destruction of ossicles
- Osteosclerosis (pathological fixation of stapes on the oval window)

- All sound frequencies are equally affected
- Bone conduction is better than air conduction

Perceptive Deafness

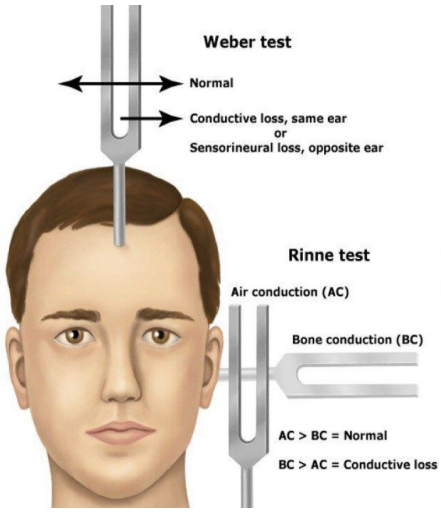
Due to congenital or damage to cochlea or auditory nerve pathway due to:

- Toxins (antibiotics, gentamicin)
- Inflammation
- Vascular
- Tumour

- Both air and bone conduction are affected

Hearing tests

- Audiometer
- Weber test
- Rinnes test



Weber Test

★ Tuning fork is placed on the patient's forehead (or in the middle line)

Rinnes Test

- The base of the tuning fork placed on mastoid process until the sound is not heard
- Then the prongs of the fork held in air near the ear
- Normal subject continue to hear near ear (positive test)
- If not reveres the test (if heard near the mastoid process, negative test)

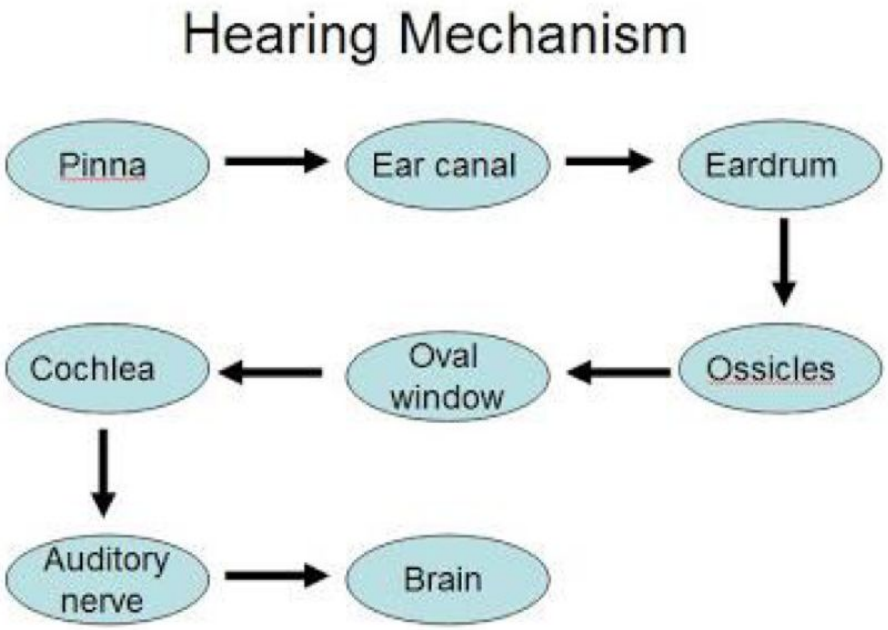
Common tests with a tuning fork to distinguish between nerve and conduction deafness.

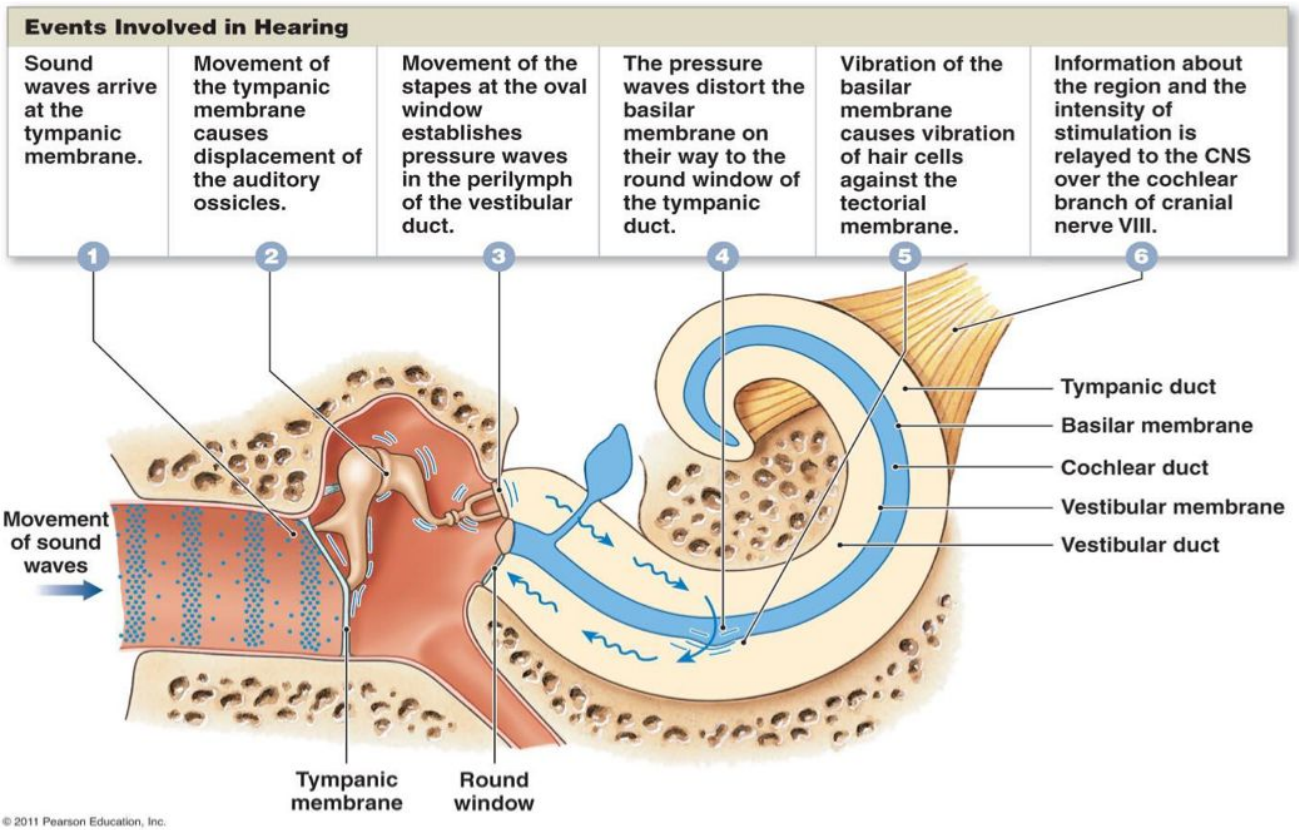
	Weber	Rinne	Schwabach
Method	Base of vibrating tuning fork placed on the vertex of skull	Base of vibrating tuning fork placed on mastoid process until subject no longer hears it, then held in air next to ear	Bone conduction of patient compared with that of normal subject
Normal	Hears equally on both sides	Hears vibration in air after bone conduction is over	
Conduction deafness (one ear)	Sound louder in diseased ear because masking effect of environment noise is absent on diseased side	Vibrations in air not heard after bone conduction is over	Bone conduction better than normal (conduction defect excludes masking noise)
Nerve deafness (one ear)	Sound louder in normal ear.	Vibration heard in air after bone conduction is over, as long as nerve deafness is partial	Bone conduction worse than normal

Summary

Very important info. (Will asked about)

- Each frequency will be received by special area in the cochlea.
- High frequency is likely to stimulate the organ of corti in the base of cochlea.
- Lower frequency sound waves stimulates the area on the apex.





1.Which part of Ear maintain the equilibrium?
A)External Ear
B)Middle Ear
C)Inner Ear

2.The quality of sound depends on:
A)No. of cycle/sec
B)Overtone
C)Amplitude

3.Sound is produced from alternate compression and rarefaction by vibrating body.
A)True
B)False

4.Which one of the following isn't a cause of perceptive deafness?
A)Wax
B)Toxin
C)Inflammation

5.All sound frequencies are equally affected in:
A)Perceptive deafness
B)Conductive deafness

6.Arrangement of hair cells:
A)5 rows of outer hair cells, 2 rows inner
B)3 rows of inner hair cells, 1 row outer
C)3 rows of outer hair cells, 1 row inner

7.How many type of conductive pathways?
A)2 types
B)3 types
C)4 types

8.If the patient has damage in his outer hair cells, that means he exposed to sound intensity :
A)above 80 dB
B)above 50 dB
C)above 35 dB

9.A man comes to hospital complains of pain in his ear.
A)Mention the parts of ear:
External (outer) ear , Middle ear , Inner ear.
B)Which tests can we do to him?
Audiometer , Weber test , Rinnes test
C)What are the conductive pathway of sound waves?
Air and Bone

Answers
1.C
2.B
3.A
4.A
5.B
6.C
7.A
8.A