431

CNS Central Nervous System

Block

Physiology Team

	Female Side	Male side
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Team notes:

Blue for additional information

Green for information from male slides

Red for important information

Hearing

Anatomy and functions of the Ear

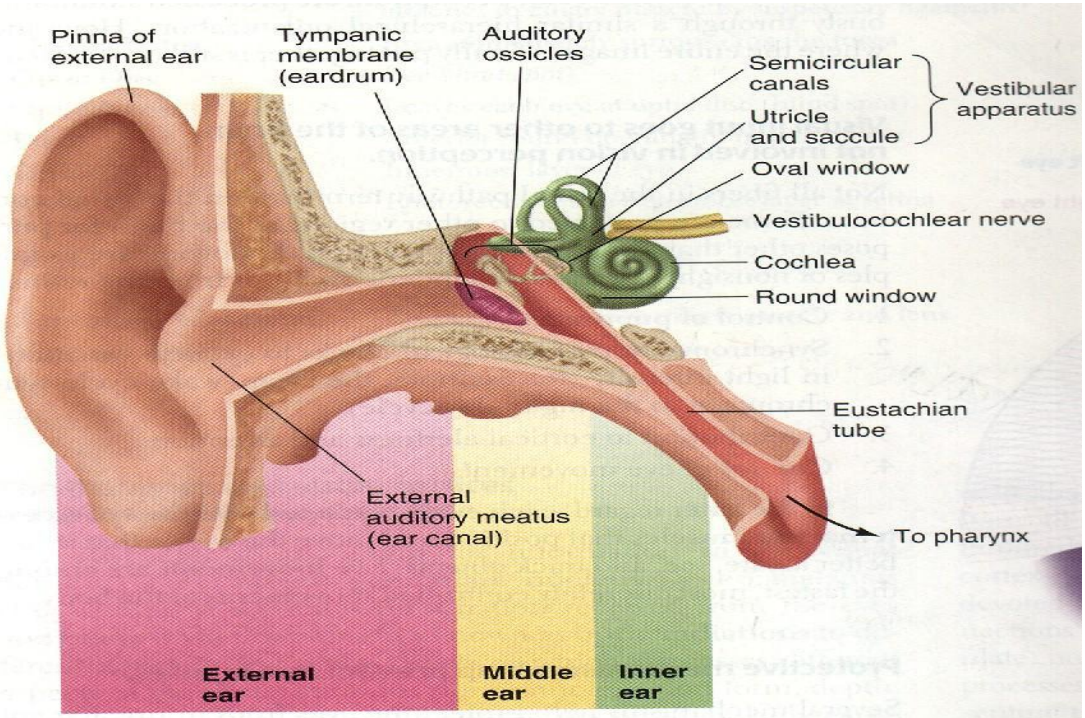
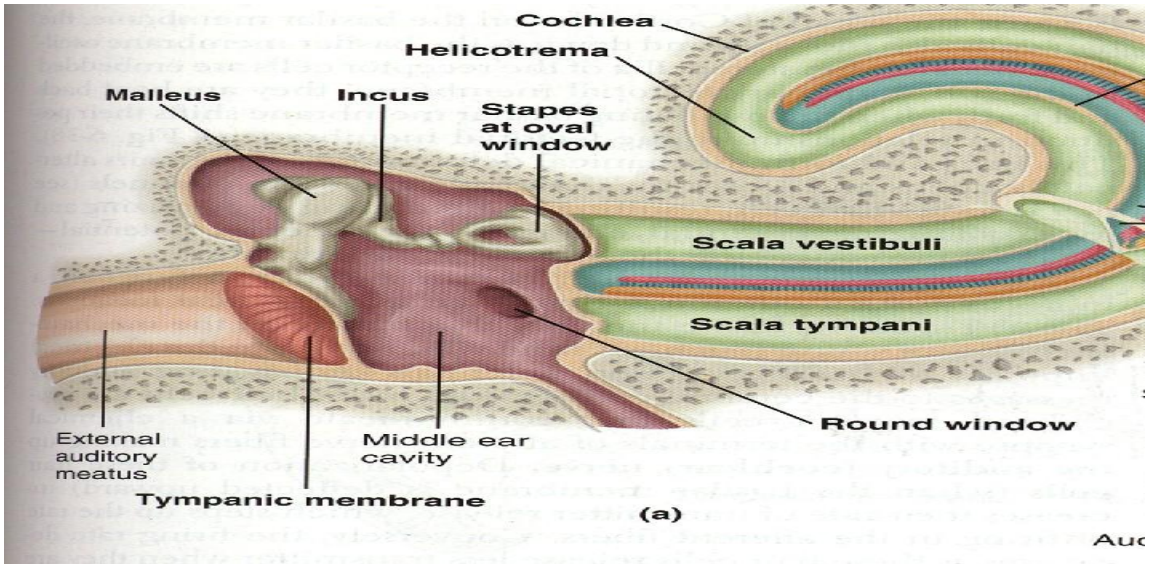


FIGURE 6-33
Anatomy of the ear

Parts of Ear	Anatomy	Function
External Ear (Hearing)	1. **Pinna (auricle).** 2. **External canal** 3. **Tympanic Membrane** (funnel shaped, pointing inward).	• Funnel shaped to collect sound • Sound localisation (front, back, high, low) • Protection (ear wax). • Transmission of sound waves from External ear to Middle Ear by tympanic membrane.



Middle Ear (Hearing)	**1- Air filled cavity:**
	It is a space between tympanic membrane and the inner ear (opens via Eustachian tube into nasopharynx)
	
	2- Three bones (Ossicles) :
	• Mallaus
	• Incus
	• Stapes
	  • Manbrium 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.
	
	3- Muscles :
	• Tensor tympani
	• Stepedius
	
	Ex: Eustachian tube connects the cavity of the middle ear to the nasopharynx. Up in the air the pressure outside is low however pressure in the middle ear is high (that explains why some children suffer from pain caused by middle ear infection) so when swallowing the Eustachian tube opens to maintain pressure.
		• Transmission of sound waves from middle ear to inner ear by the oval window.
		• Filtration of air particles(cleaning)
		• Modification
		• Warming of air.
		
		• Magnifying affect: (Ossicles)
		Caused by 2 factors:
		1- The force from a large surface area (Tympanic m.) are concentrated to a small (oval window) the ratio is 17=1. (size difference)
		2- Lever action of ossicles = (the lever action of ossicles increase the force of movement 1.3 times)
		▲ the total increase 17 X 1.3 = 22 times
		
		• Muscles: (Protection Effect)
		a. Muscles contract reflex in response to loud sound (over 70dB)
		b. Contraction of the tensor tympani pulls the manubrium of Malleus & makes the tympanic m. tens. (decreasing the vibration)
		c. Contraction of the stapeduis pulls the foot plate outward so that vibration is reduced.
		d. protection from constant loud noise, but not sudden noise, latency of 40-80 msec

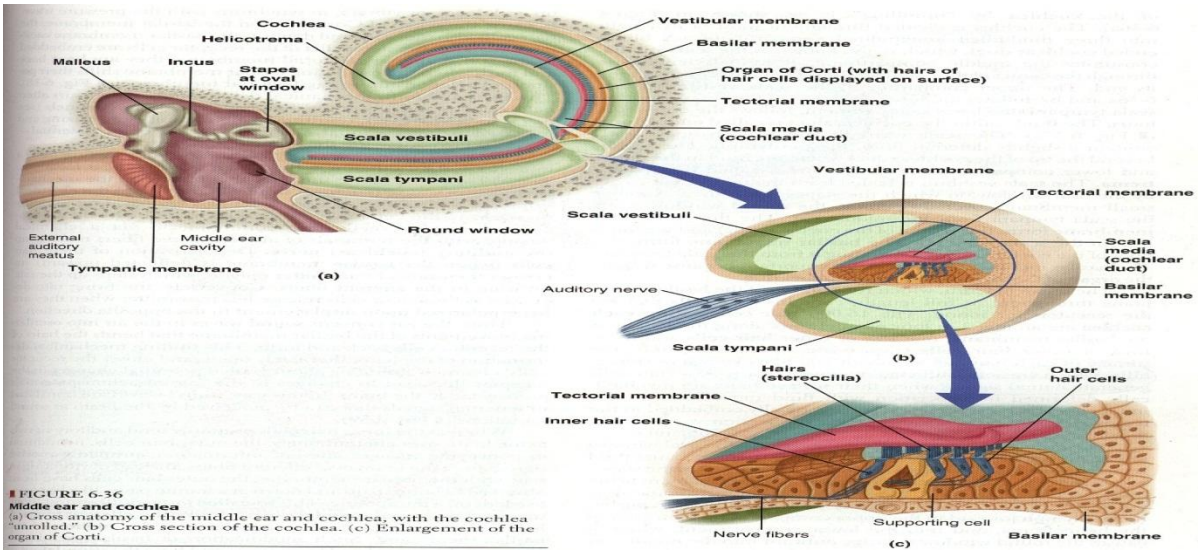


FIGURE 6-36
Middle ear and cochlea
(a) Gross anatomy of the middle ear and cochlea, with the cochlea "unrolled." (b) Cross section of the cochlea. (c) Enlargement of the organ of Corti.

Internal Ear (Hearing & Balance)	❖ Bony labyrinth and a Membranous labyrinth (filled with fluid). **1- Semicircular canals** **2- Cochlea** (Hearing): Snail like, laying deep in the temporal bone (fluid filled cavity). There are two membranes(Basilar membrane & vestibular "reisseners" membrane) there main function is to divide the cochlea into three chambers: • Scala Vestibuli Na High-K Low • Scala Media Na Low-K High • Scala Tympani Na High-K Low Scala tympani and vestibule are both filled with the perilymph while the scala media is filled with the endolymph. Endolymph the only extracellular fluid with high K like intracellular. **Main component of cochlea is the organ of corti:** • Located in scala media (resting) on the basilar membrane. • Extend from base to apex of cochlea. • Contain inner, outer hair cells & tectorial membrane(covering hair cells) • Steroclia (Hairs) extend from the top.	Related to balance. Organ of corti transform sound waves to action potential. a- One row of inner hair cells (not attached to tectorial m.) • They are primary receptors for sound (auditory receptors), transducing fluid movement in cochlea into action potential in the auditory nerve b- Three rows of outer hair cells (attached to the tectorial membrane): • Large number, but stimulate only small fraction of nerve fibres in the cochlear nerve. • Steroclia of the outer hair cells embedded in tectorial membrane) • If damaged, significant loss of hearing • They control the sensitivity of inner hair cells to particular sound frequency by mechanism that controls the tension of basilar membrane.

***Hair cells (base of cochlea) in organ of corti: sensitive to high frequency.**

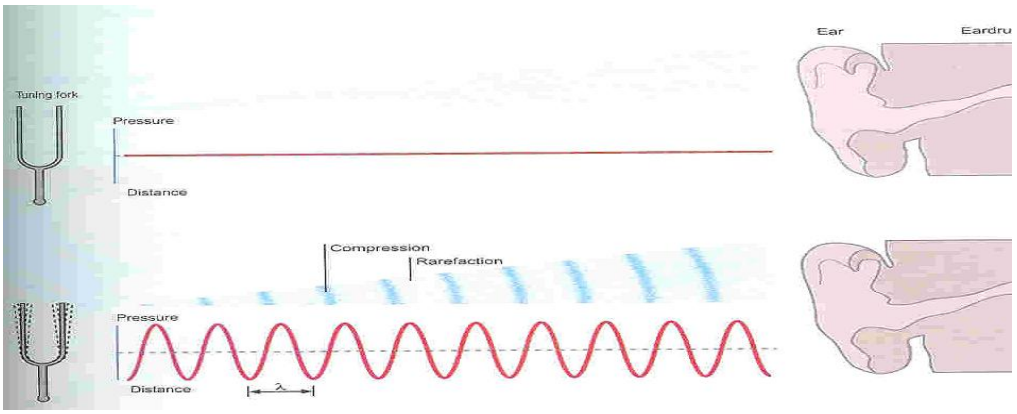
***Hair cells (apex of cochlea) in organ of corti: sensitive to low frequency.**

The endolymph has the property of the intracellular fluid, while the perilymph has the property of the extracellular fluid.

- Volley effect Sound frequency > 2000Hz >>>> produce impulses in the auditory nerve as the same frequency as the Sound waves

Nature Of Sound : Sound is produced from alternate compression and rarefaction of air molecules by vibrating body.

Alternate pressure of air particles around the vibrating body will give us sound wave (same as our vocal cords when they vibrate they cause the air molecules to compress and refracts).

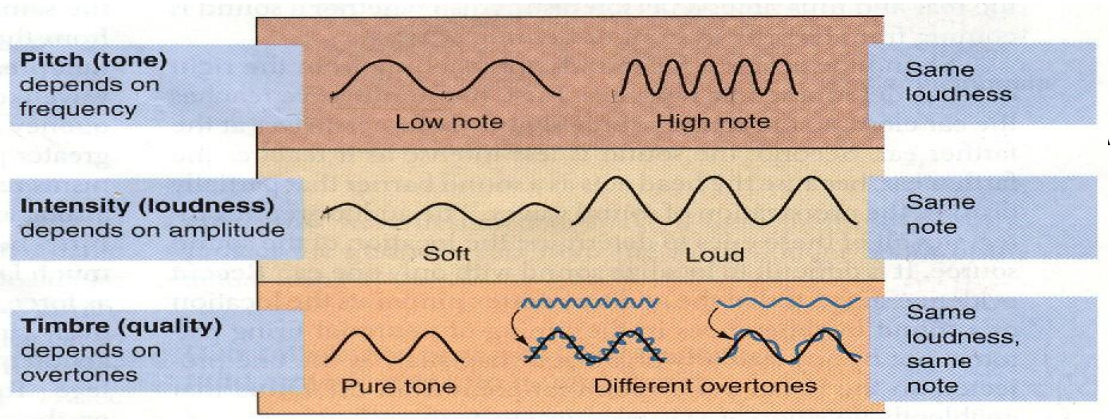


Characteristics of Sounds :

- 1- Pitch (Tone) (Frequency) depend on No. of cycle/sec. Human ear can detect sound waves with freq. 20-20000 cycle /sec.

(Depends on the movement velocity of the vibrating body per second) (Each alphabet has a frequency. Ex: G has more frequency than the C.

- 2- Intensity (Loudness) depends on amplitude. (Low sound means low amplitude and vise versa).
- 3- Quality (timbre) depend on the over tone or interference.
  Over tone (radio): receptor receives more than one tone.
  Pure tone: receptor receives one tone only.



High Frequency Waves peak near the BASE of the cochlea

Low Frequency Waves peak at the APEX of the cochlea

The Organ of Corti Discrimination of loudness of sound waves

The more the displacement of the tympanic membrane (louder sound) the more the frequency of action potentials along the auditory nerve fibers.

The more the displacement of the tympanic membrane the more the number of stimulated (nerve fibers (i.e. more action potential generated.

Decibel ratings of common sounds (decibel scale):

Measuring scale:

1 decibel (dB) = 0.1 Bel

It's the unit to measure the sound as a whole wave

Sound rating (dB) less than (bel)

Absolute silence	0
Automobile- 30 ft.	60
Conversation- 3ft	70
Loud radio	80 Jet
aircraft at takeoff	150+

Mechanisms of hearing:

1- External Ear:

- Collection And Localization of sound waves (Explains the funnel shape which collects the sounds to one point).

2- Middle Ear:

- Sound waves vibrate the tympanic membrane.
- Tympanic membrane 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.

3- Inner Ear: (Receptors & Endocochlear potentials)

- Sound transmission into the inner ear cause upper & lower movements of the reticular membrane. (Tectorial membrane.)
- Produce bending of steriocillia of the hair cells alternatively open & close cation channels at the tip of the steriocillia.
- (Inward current) depolarization, (outward current) hyperpolarization.
- The net result is depolarization.
- Production of cells receptors potentials.
- Release of neurotransmitter.
- Production of action potentials in the auditory nerve.

The Central Auditory pathway

- Begins in the organ of corti.
- End in the primary auditory cortex (are 41& 42,at the anterior part of superior temporal gyrus in the temporal lobe of the brain).
- Fibres end in the auditory area, where it is heard, and then interpretation (Understanding) occurs in the auditory association areas (wernikes area) at the posterior end of superior temporal gyrus.
- There is a bilateral cortical connection of auditory area.
- Damage to one side only slightly reduces hearing.

Electrical activity of the auditory receptors

1. **Cochlear Microphonic (CM):**

Movement of BM → bending of hairs → Cochlear Microphonic

- **directly proportional to movement of BM (Represents Generator potential)**

cochlear microphonic the electrical potential generated in the hair cells of the organ of Corti in response to acoustic stimulation.

2. Endocochlear Potentials:

- **Endolymph in scala media +80mv Vs**
- **Hair cells -70mV versus endolymph**

Sound localization:

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

Masking effect:

- Presence of background noise affect the ability to hear another sound, due to some receptors is in refractory period (they are occupied by other sound).
- Masking is clearer if two sounds are having the same frequencies.
- Noise pollution is an environmental hazard.
- Exposure to sound intensity above 80dB may damage outer hair cells.

Conduction of sound wave

- **Air conduction:**

Normal situation of hearing, sound travel in air causes vibration of Tympanic membrane transmitted by ossicles to the oval window

- **Bone conduction:**

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

Questions:

1- Middle ear opens to the nasopharynx through:

a) Eustachian tube.
b) External canal.
c) Semicircular canals.

2-Transmitting of sound waves from middle ear to internal ear by:

a) Oval window.
b) Round window.
c) Fenestra cochlea.

3-Organ of corti lies on:

a) Tectorial membrane.
b) Basilar membrane.
c) Membranous membrane.

4-Central auditory pathway begins at:

a) Primary auditory cortex
b) Middle ear
c) Organ of corti

5-Action potential is produced by:

a) The vibration of tympanic membrane.
b) Movement of ossicles.
c) Movement of tectorial membrane and hair cells.

6-Heir cells of organ of corti located in the apex of cochlea are stimulated by:

a) Low frequency.
b) High frequency
c) Medium frequency.

7-Which of the following is the primary receptor:

a) Inner hair cell.
b) Outer hair cell.
c) Both inner and outer hair cell.

8-function of the middle ear:

a) Tensor tympani cause tension in tympanic membrane.
b) It reduces sound in case of low sound

9-Endolymph in scala media is similar to:

a) ICF
b) ECF

10-High frequency waves go to:

a) Base of cochlea
b) Apex of cochlea