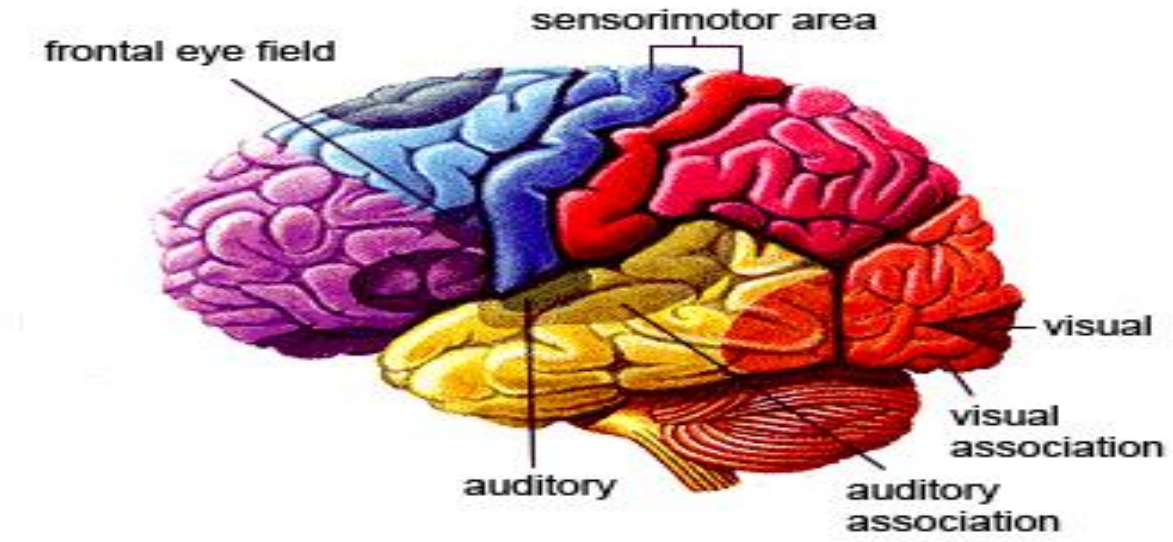
Physiology Team



Amna Baljoun

Ahlam Al Maawi
Areej Al Kahtani
Bodoor Al Tayeb
Asmaa` Bedawi

(these notes are combination of female and male slides + our notes)

The Inner Ear
(The Cochlea)

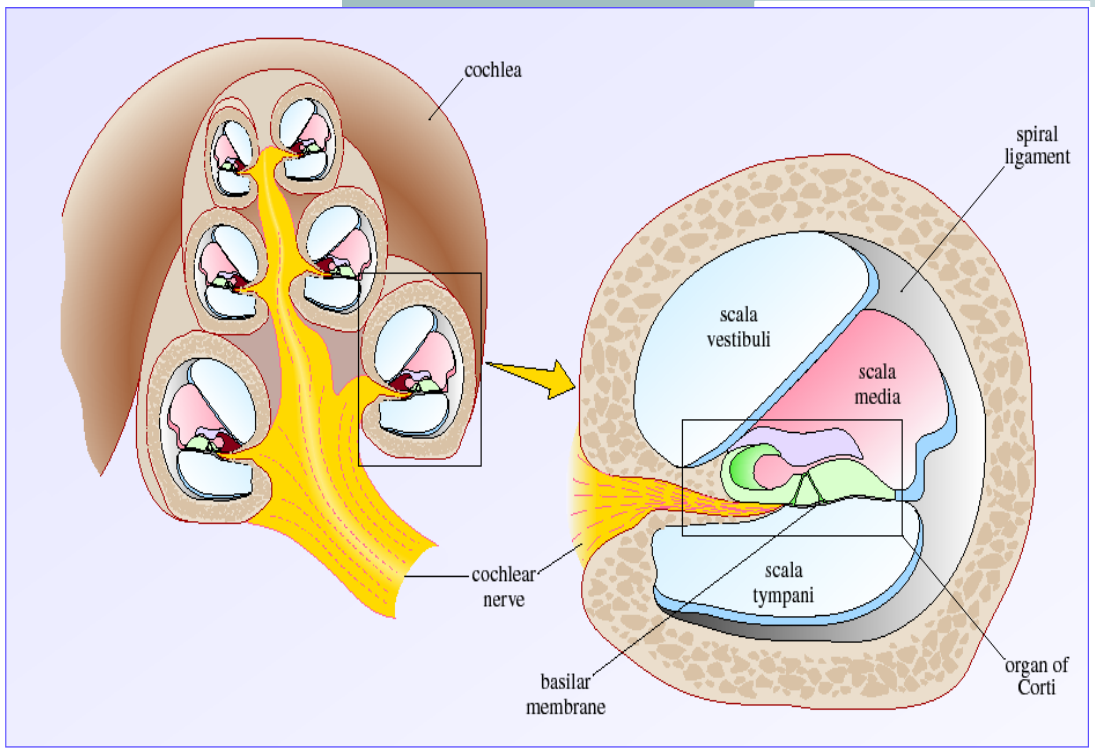
Cochlea

Bony structure lined by membrane (fluid filled cavity)

The tube is divided by the:
1- basilar membrane and
2- reissner's membrane
Into 3 chambers:

A- scala vistibuli
B- scala tympani
(which both filled with perilymph)

C- scala media
(which is filled with endolymph)

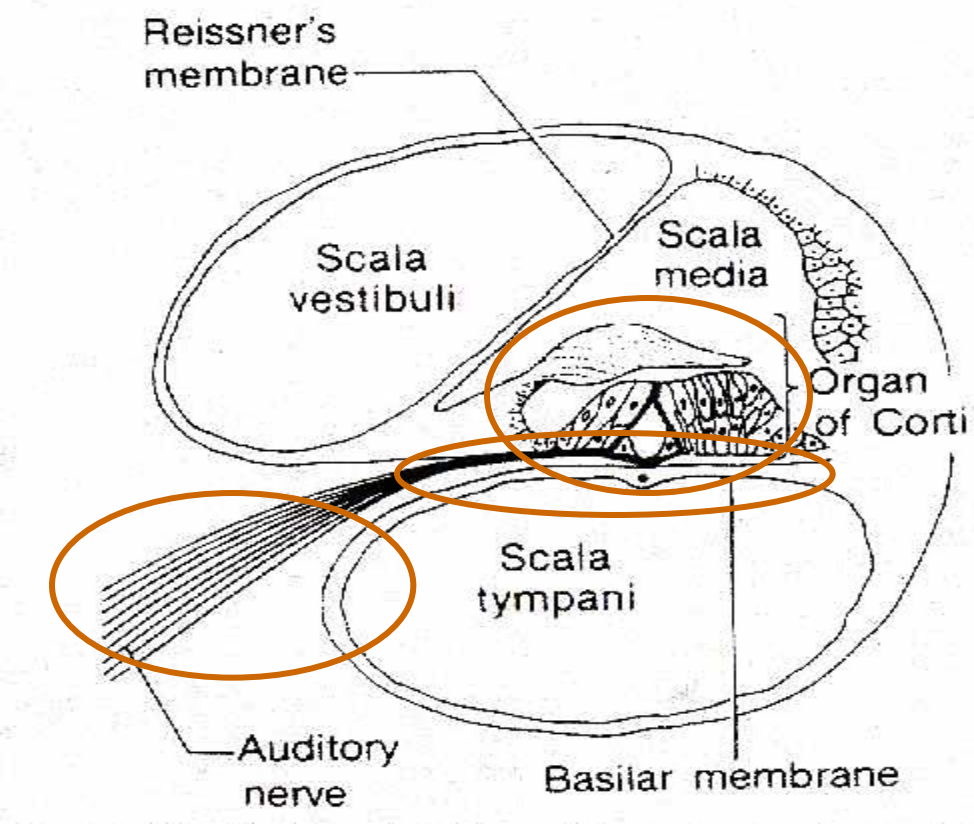


N.B:
Semi-circular canals>>> balance
Cochlea >>> hearing

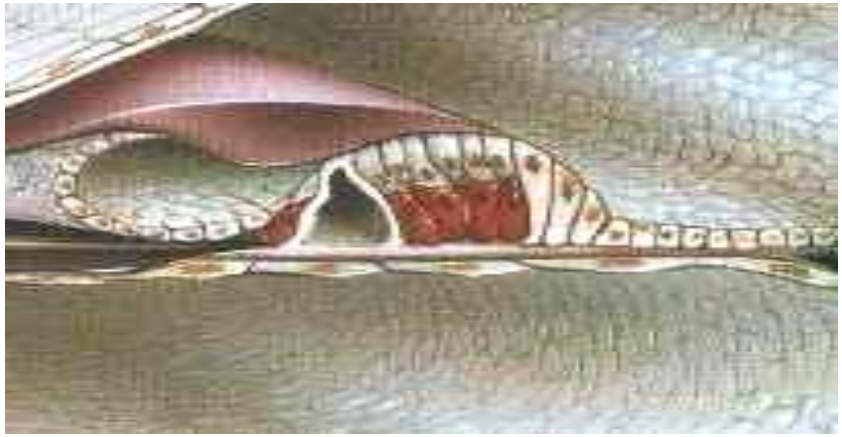
Cross section of the cochlea

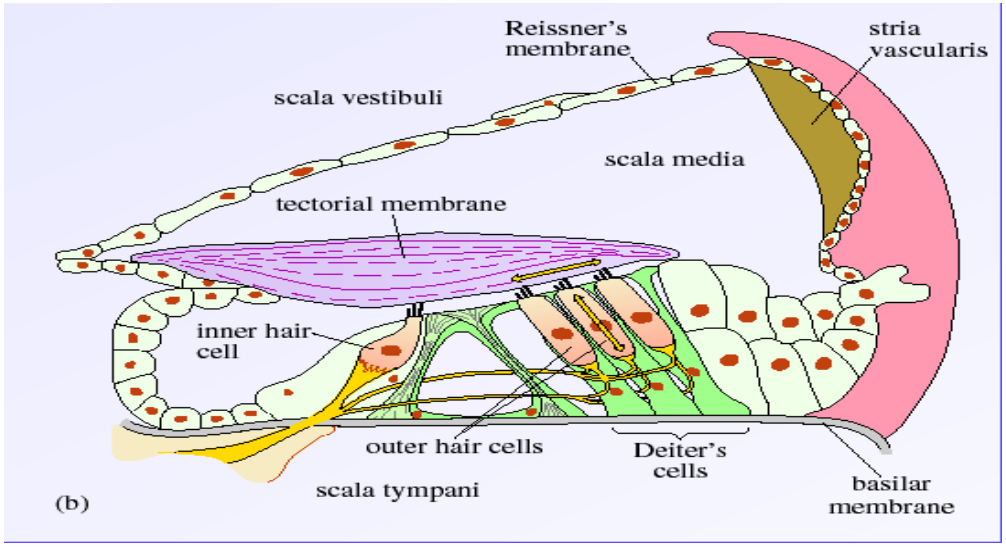
Main components are:

- the Organ of Corti
- auditory nerve
- and the basilar membrane



Organ of Corti

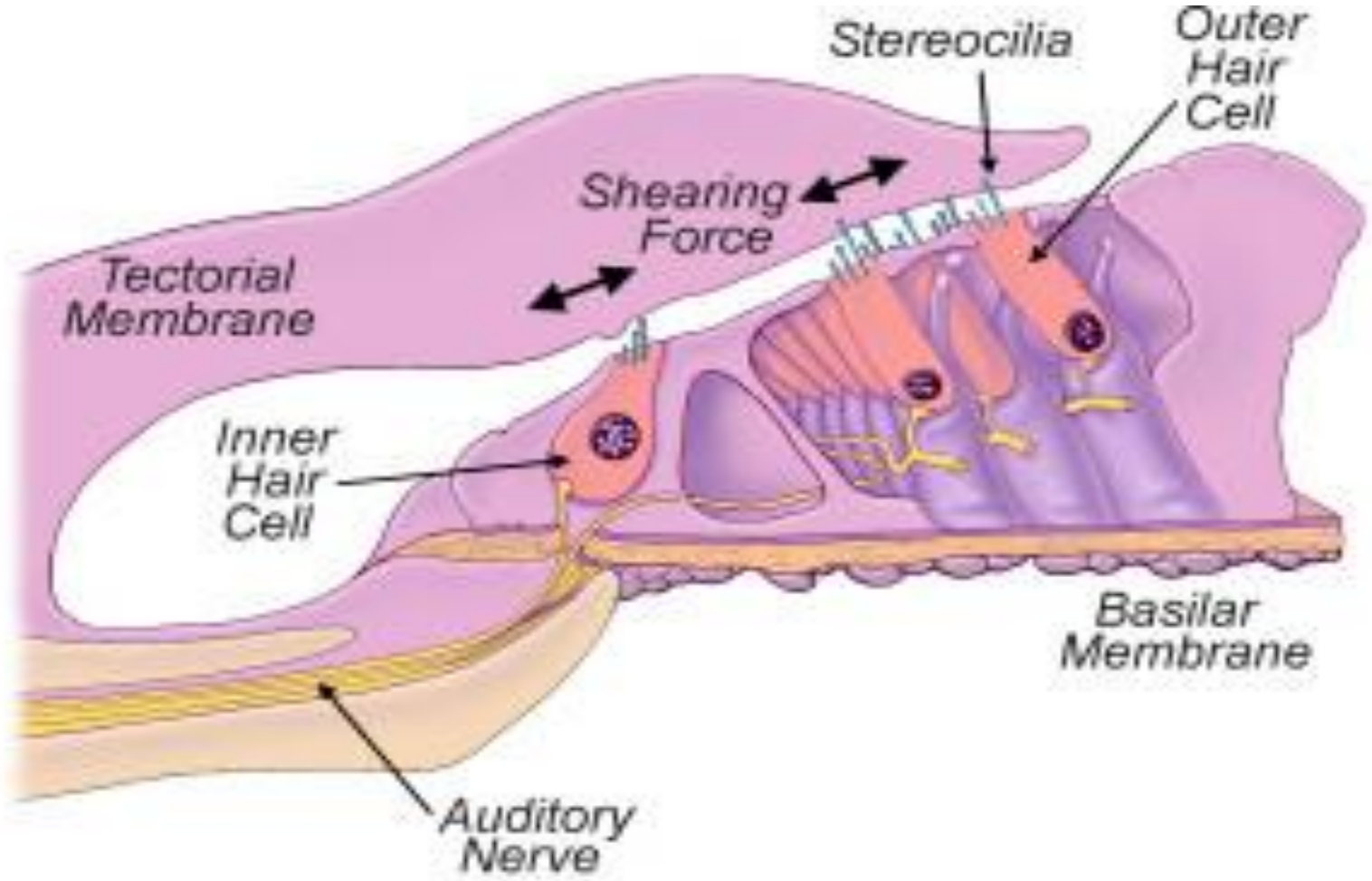




Organ of corti:
Collection of cells located in the basilar membrane in scala media

It contains:
1- one row of inner hair cells
2- three rows of outer hair cells
3- tectorial membrane :
one sided free moving membrane attached with the outer hair cells only.

The inner and outer hair cells



The Organ of Corti

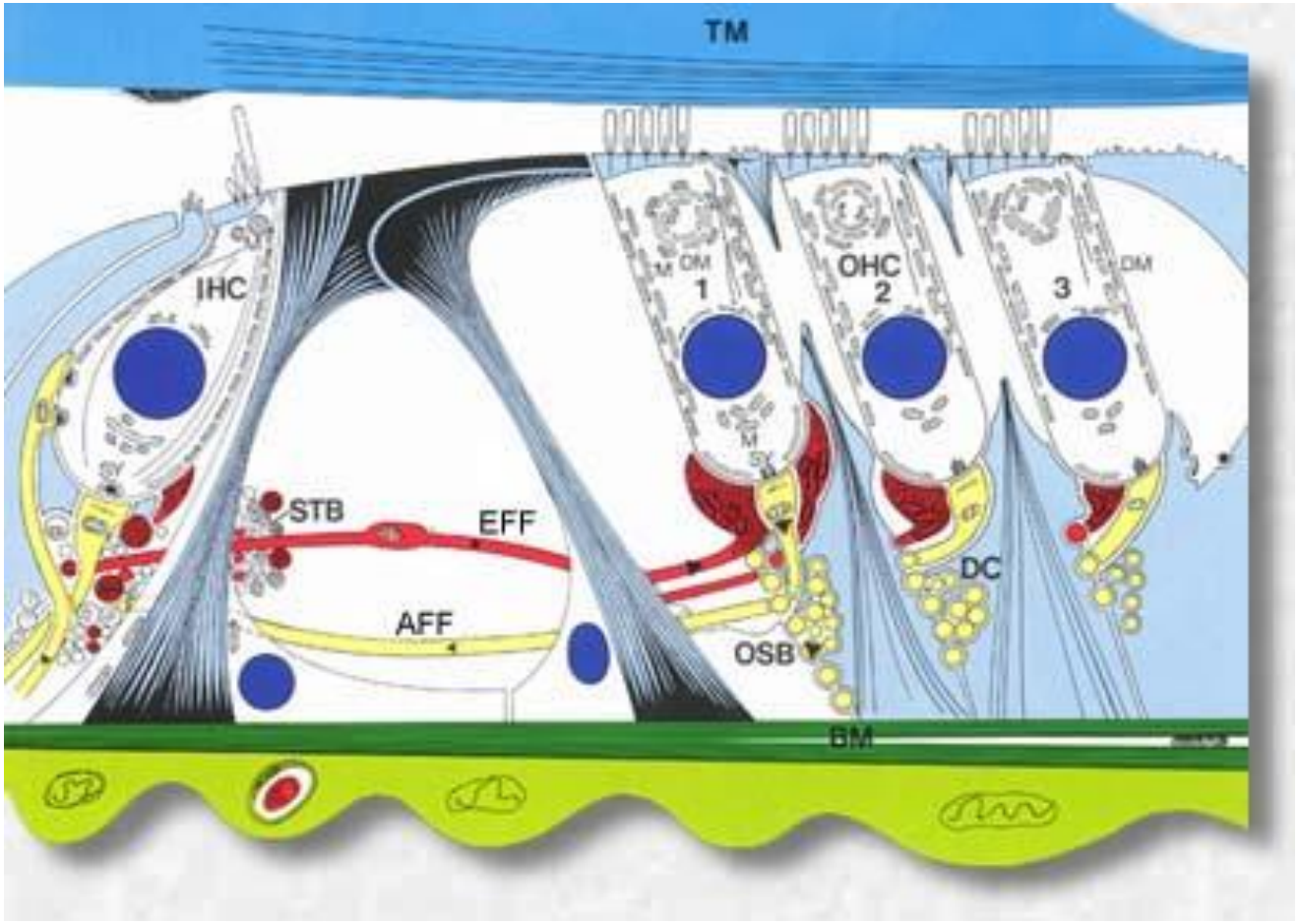
Composition of Endolymph & Perilymph

	Endolymph	Perilymph
K^+ (mmol/l)	144.8	4.8 (mmol/l)
Na^+ (mmol/l)	15.8	150.5 (mmol/l)
Cl^+ (mmol/l)	107.1	121.5 (mmol/l)
Protein (mg/dl)	15.0	50.0 (mg/dl)

The **endolymph** has the property of the **intracellular fluid** (depolarized)

While the **perilymph** has the property of the **extracellular fluid** (hyperpolarized)

Auditory Receptors



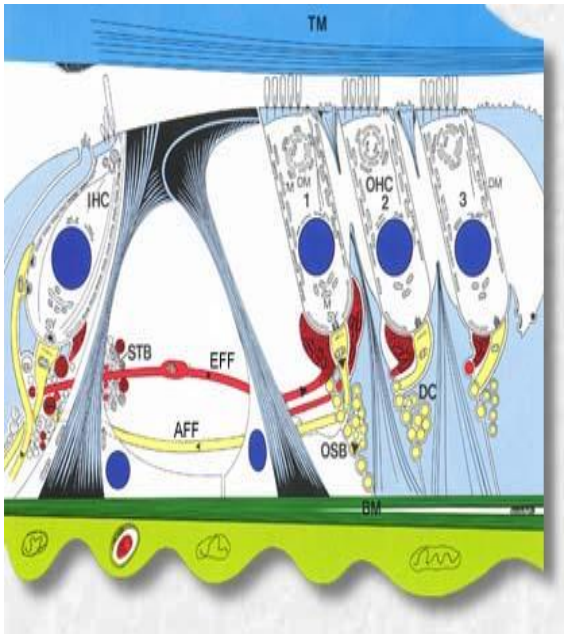
Auditory Receptors

- Receptors are hair cells (have stereocilia)
- Hair cells - two types:
  - Inner hair cells: single row (n=3500)
  - Outer hair cells: three row (n=20,000)

  - 90-95% of auditory nerve fibres innervate inner hair cells & 5-10 innervate the outer hair cells

Function of the hair cells

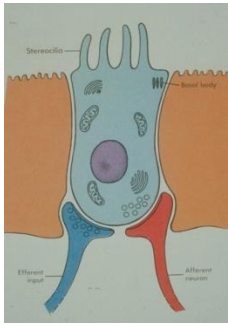
- Inner Hair cells:
  - Primary receptors for sound
  - Hairs are bent by fluid movement under the tectorial membrane
    - i.e. transducing fluid movement into action potentials in the auditory nerve
    - N.B: tectorial membrane attached to the tip of outer hair cells only



Function of the hair cells- cont.

Outer Hair cells:

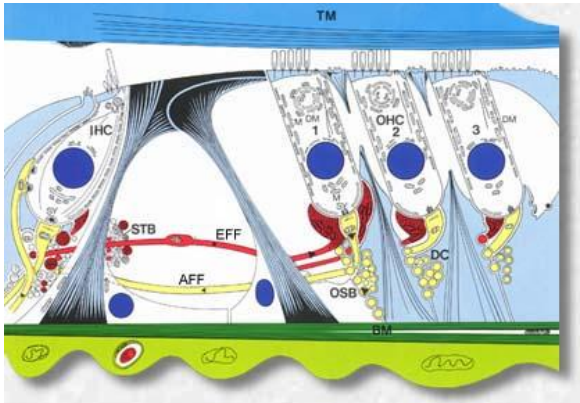
- Supplied by efferent cholinergic fibres from superior olivary complex



- Contractile

Tension in Basilar membrane

(least movement will be distinguished)

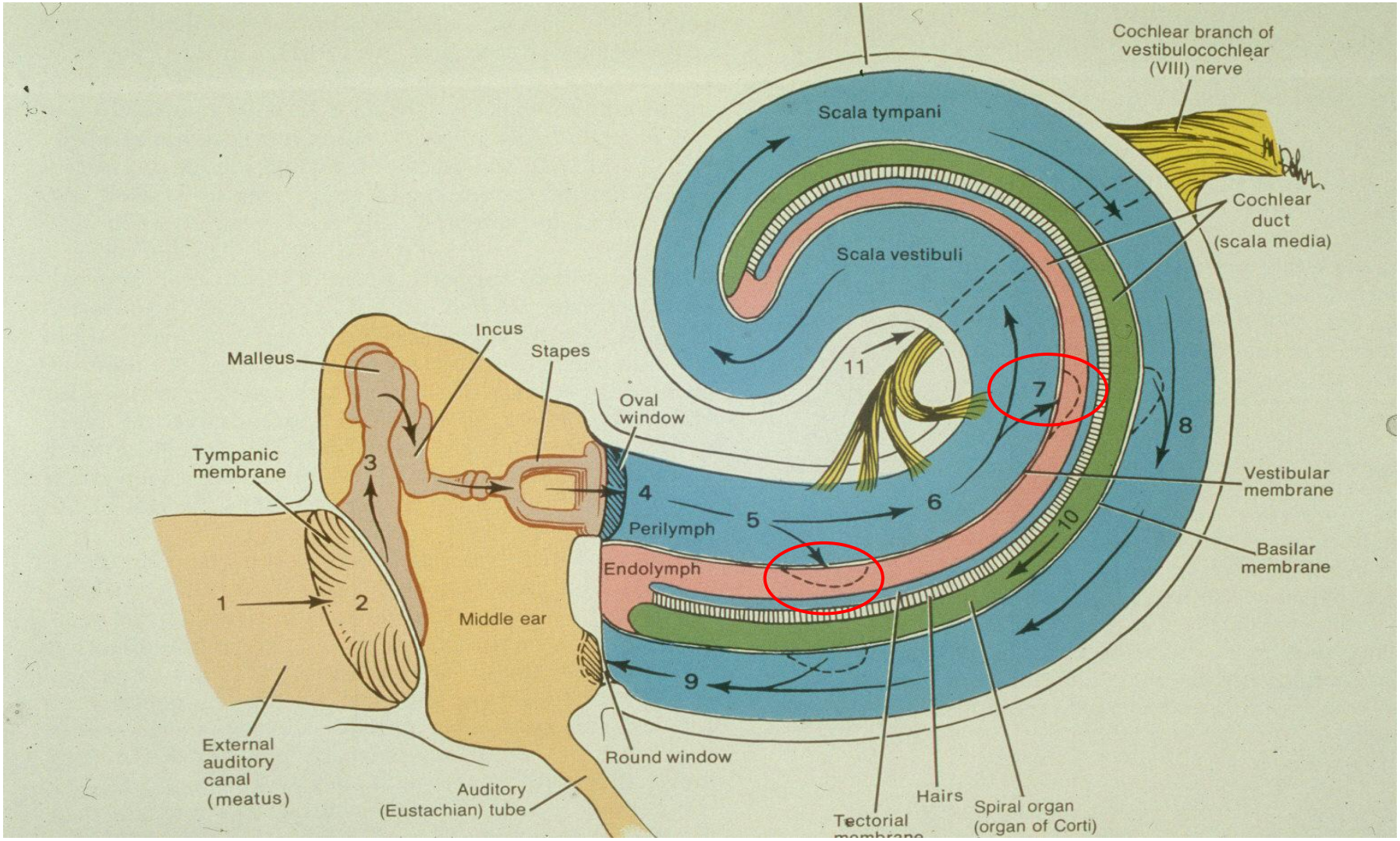


- The tectorial membrane hits the stereocilia of the hair cell >> produce an action potintial at aduitary nerve
- Inner hair cell: primary receptor of hearing
- Outer hair cell: control the sensitivity of the inner hair cell to particular sound frequency by change the tension of the basilar membrane.

Sound Transmission in the middle & Inner Ears

- Bony wall ….. is rigid
- Reissener's and Basilar Membranes are flexible
- Basilar membrane is depressed by peaks of waves in the scala vestibuli
- Bending of hair cells
- Generation of action potential
- The wave goes to the round window to terminate their

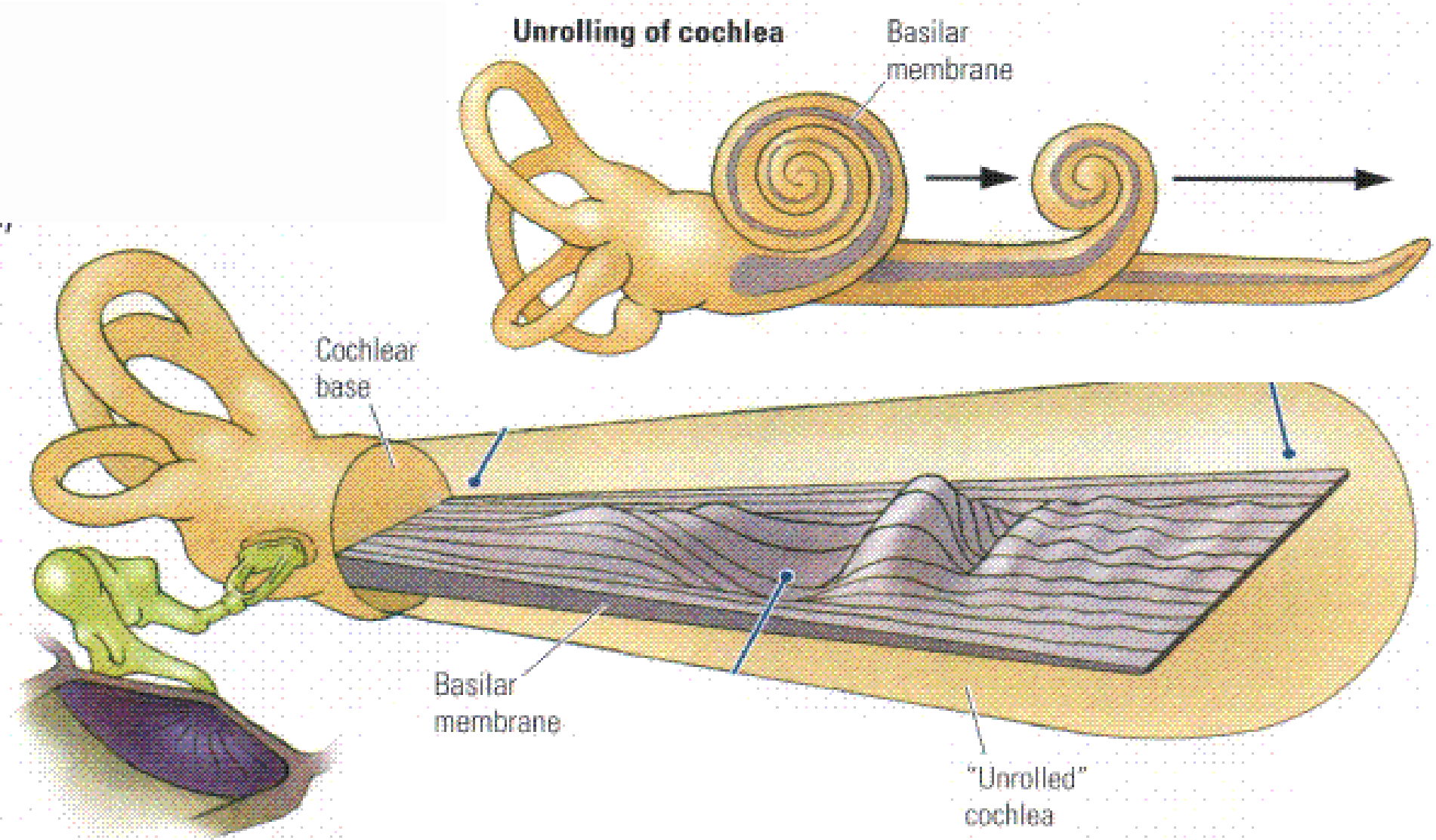
Sound Transmission in the middle & Inner Ears



Stimulation of the Organ of Corti (The Duplex Theory)

1. Traveling waves (Place Theory)
2. Volley Effect

Place Theory (Coding)
(von Bekesy's travelling wave theory)

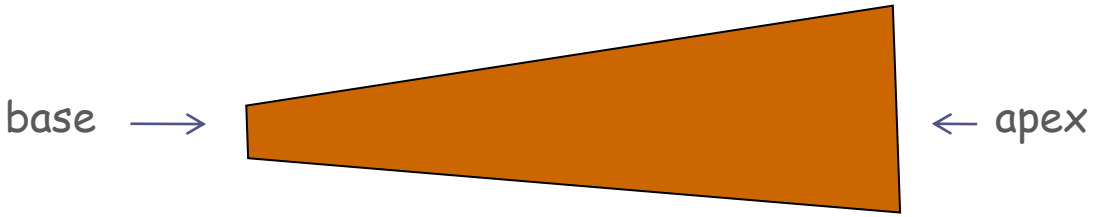


Place Coding - von Bekesy's travelling wave theory

von Bekesy observed the Basilar Membrane in action

Two important findings:

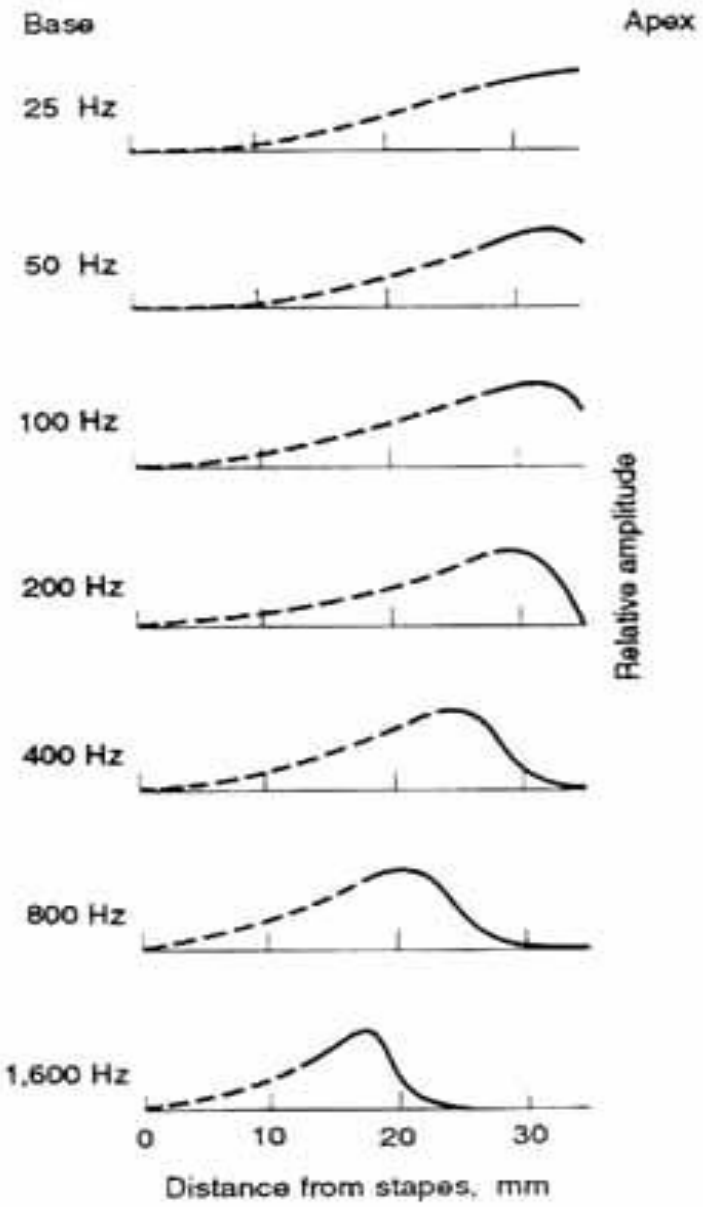
1. The base is 3-4 time narrower than apex



2. The base is also much stiffer than the apex

Stimulation of the Organ of Corti (The Duplex Theory)

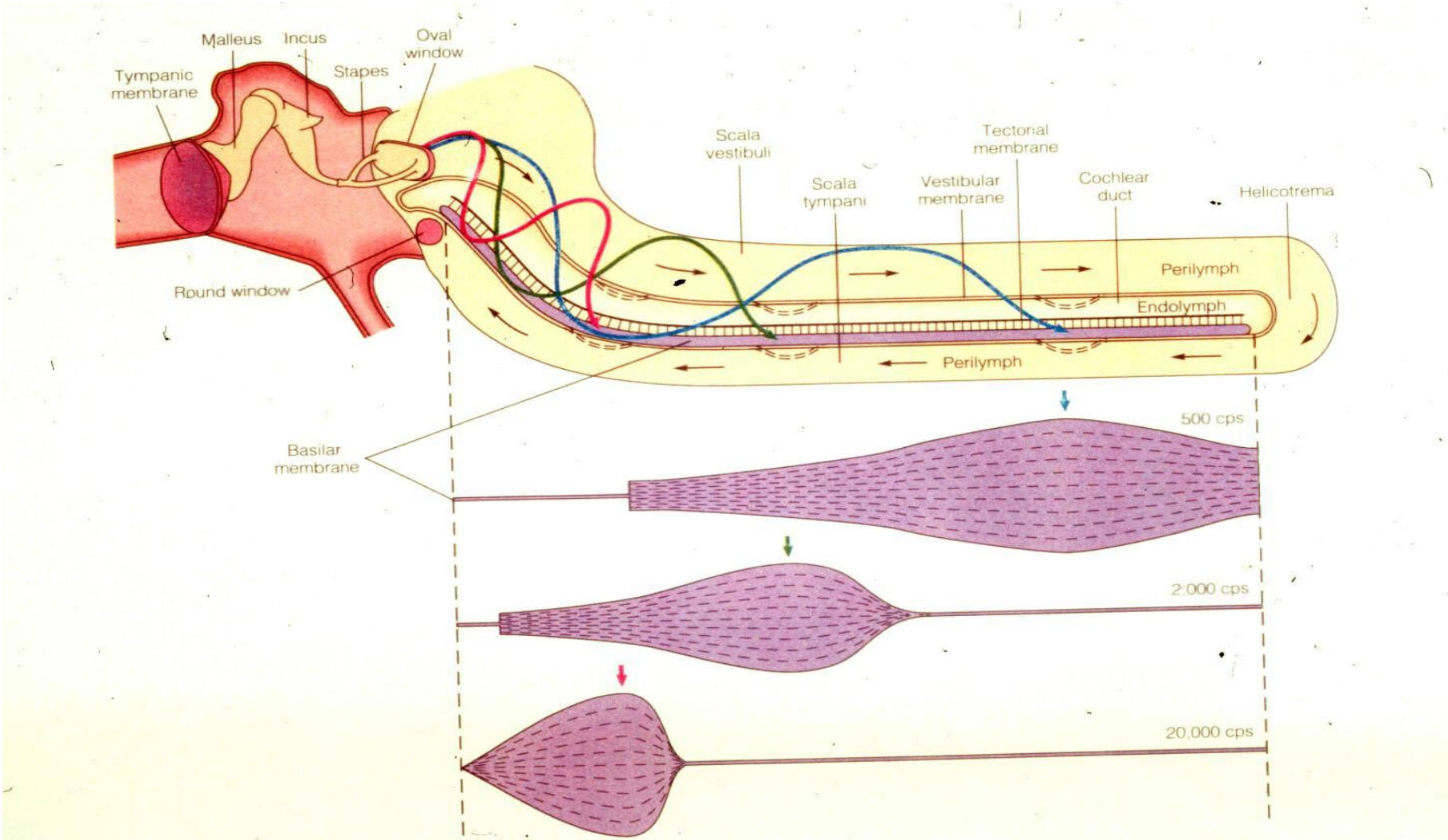
1. Traveling waves (Place Theory)
   - Pressure waves travel to a peak and decline
   - High Frequency Waves peak near the BASE of the cochlea
   - Low Frequency Waves peak at the APEX of the cochlea



Low frequencies peak closer to the apex of the basilar membrane

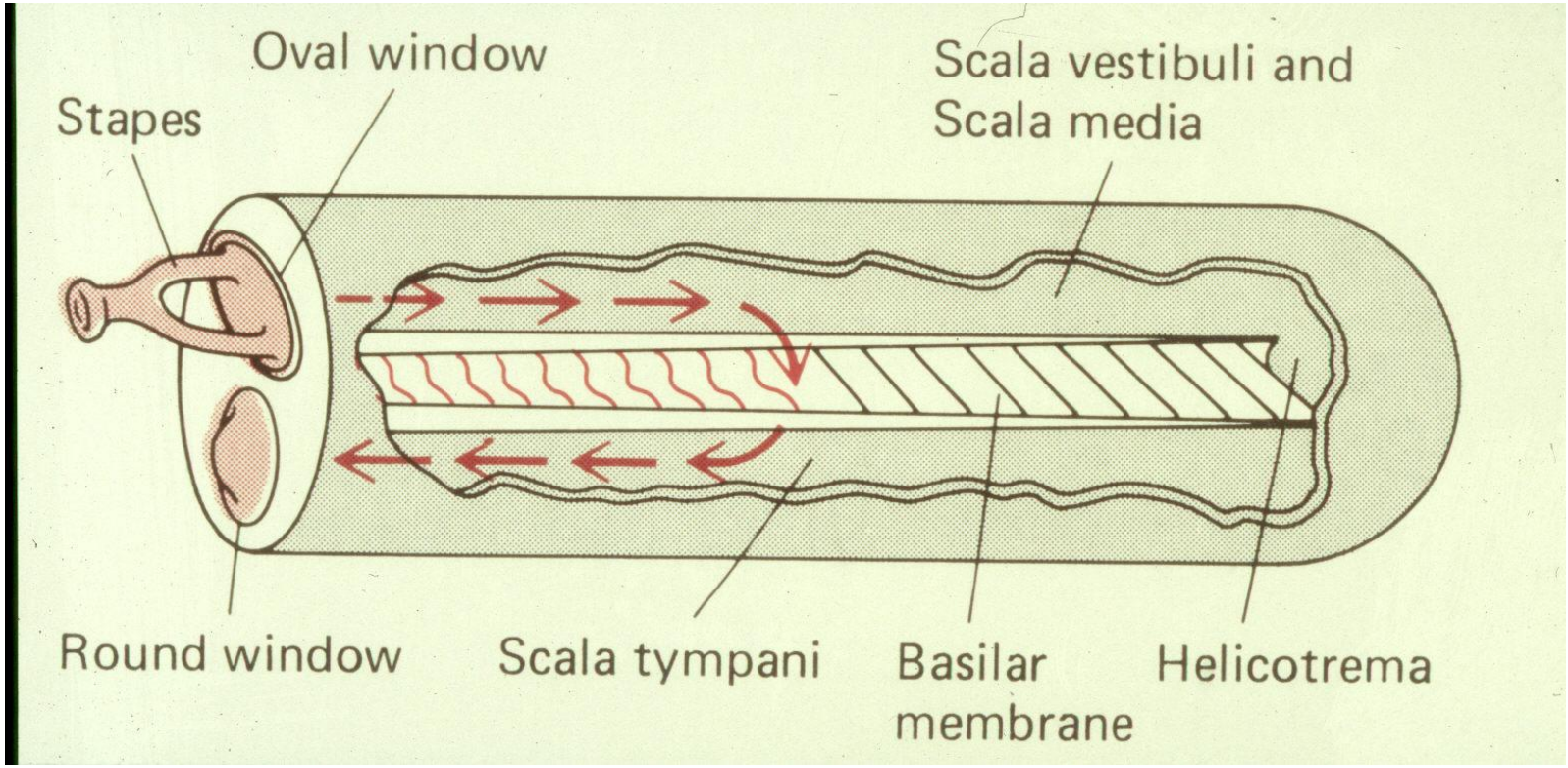
High frequencies closer to the base of the basilar membrane.

Sound Transmission in the Inner Ears– Traveling Waves



29 The Effect of Sound Frequency on the Basilar Membrane
Figure 9.21

Sound transmission (pressure wave) in the inner ear

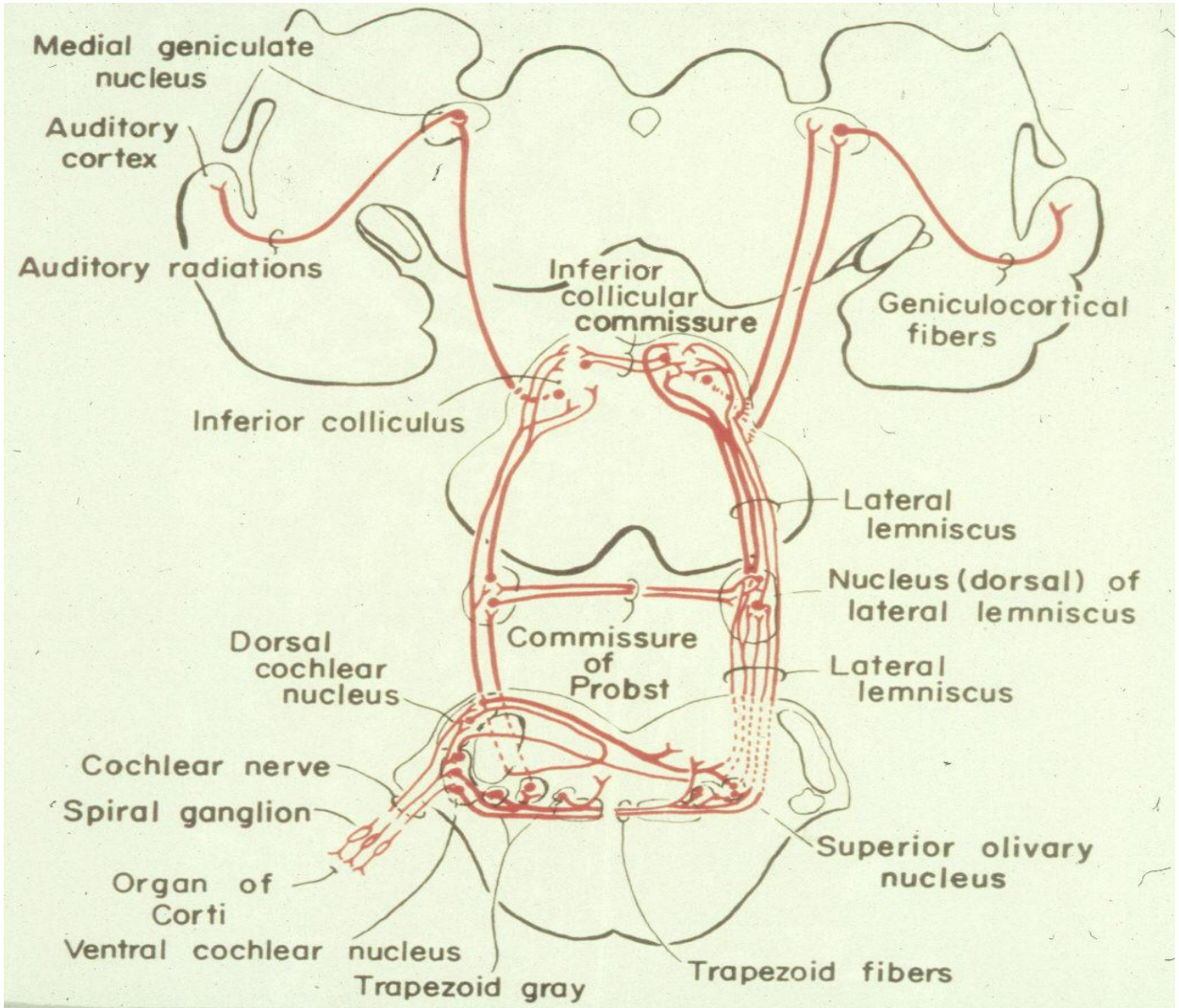


Stimulation of the Organ of Corti (The Duplex Theory) –cont.

2. Volley Effect:

- Sound frequency > 2000Hz >>>> produce impulses in the auditory nerve as the SAME frequency as the Sound waves

The Auditory Pathway



Electrical activity of the auditory receptors

1-Cochlear Microphonic (CM)
2-Endochlear potential

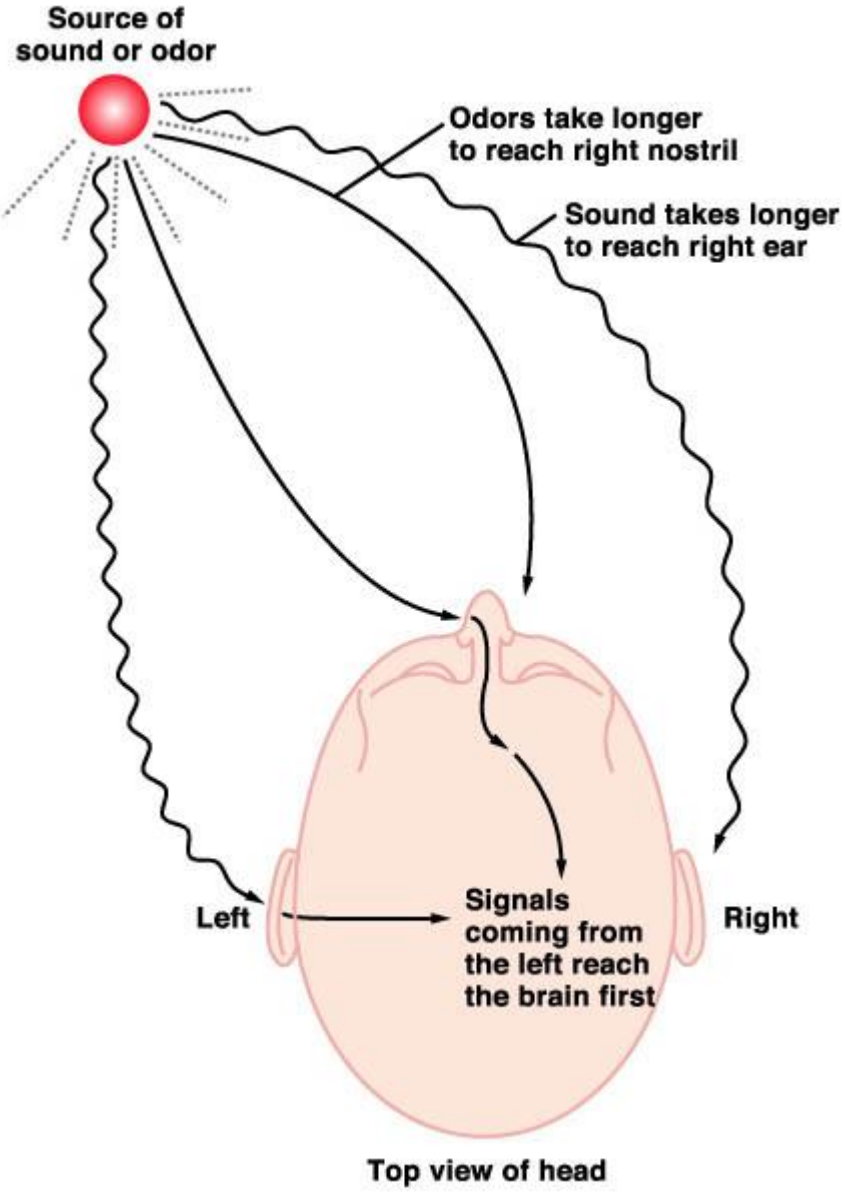
1-Cochlear Microphonic (CM):

Movement of BM

bending of hairs

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

Localisation of Sound



The localisation of a sound source is an integrative task that requires simultaneous input from both ears.

Since the output from the cochlear nuclei cross over from each side, the cortex receives auditory input from both ears.

Unless sound is coming directly from the front (or following an equal path) the sound will not reach both ears simultaneously nor at the same amplitude.

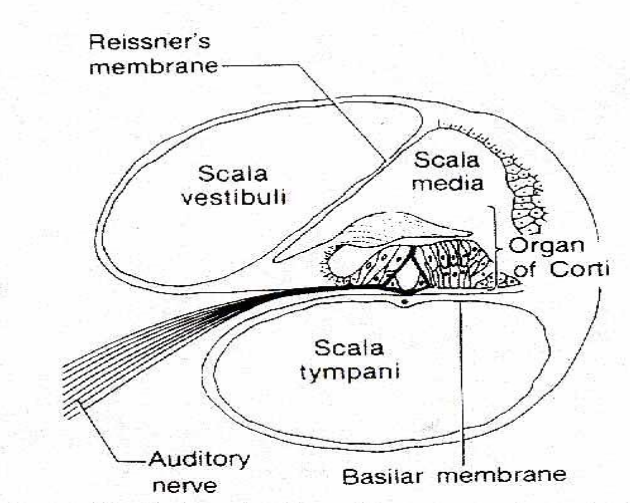
The brain uses time, phase and **amplitude differences between the input from each ear to compute the sound source.**

Head or ear movement can refine the location and hence the cortex can derive a 3D representation of the sound source.

2- Endocochlear Potentials:

- Endolymph in scala media +80mv Vs perilymph in either scalae vestibuli & tympani

- Hair cells -70mV versus endolymph



Sound localization

Two mechanisms (two ears):

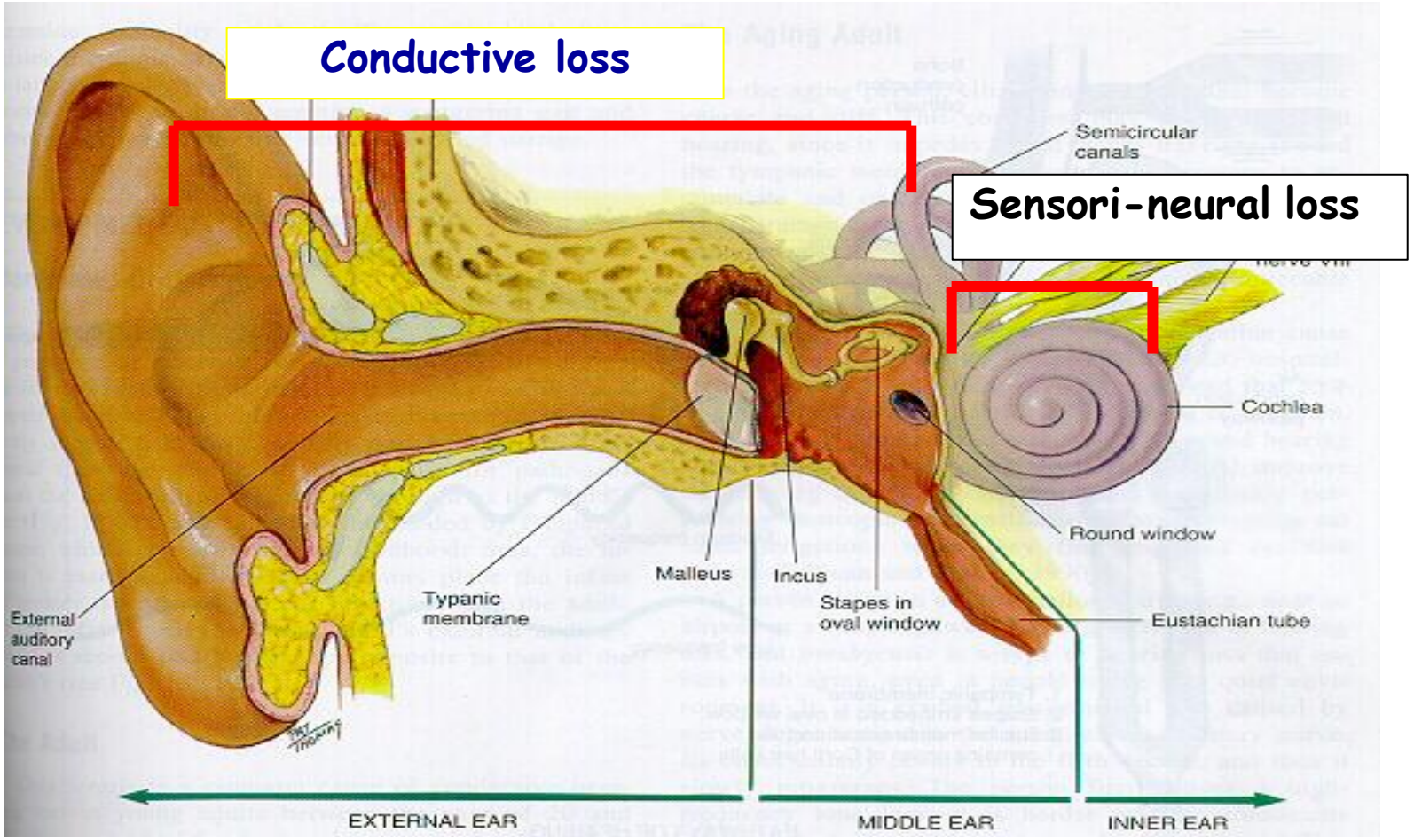
1-Difference in time of arrival of the sound waves at the two ears

2-Difference in the intensity (loudness): ear nearer to source of sound hears louder

"Noise" pollution

- Sound intensities above 80dB may damage the outer hair cells
- Damage is gradual and subject unaware of it

Hearing Loss (Deafness) 2 types



- **Sensori neural hearing loss:**
  - accounts for over 90% of hearing loss in adults
  - result of damage to the inner ear
  - Caused by
    - loud, sudden noises
    - Aging
    - Deterioration of nerves pathways most commonly caused by a tumor pinching the nerves (acostic neuroma)
    - Trauma to the head
    - Infection that reaches the inner ear (**Mumps, Measles, Meningitis, CMV**)
    - **Ototoxic drugs**
    - Heredity

Loss is generally irreversible (permanent).

Conductive hearing loss:

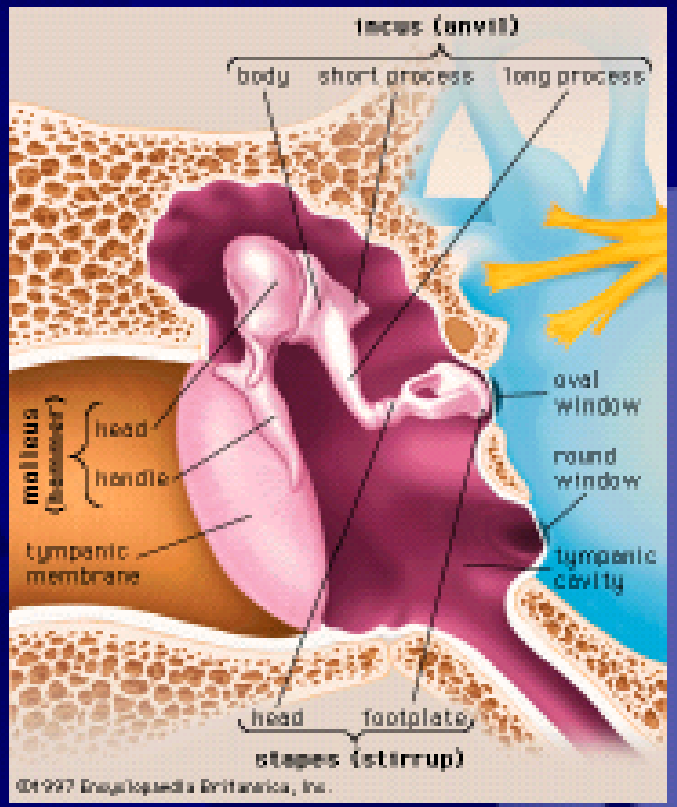
Causes:

- Blockage or damage in the external or middle ear → sound does not reach inner ear
- Ear wax in ext auditory meatus
- Fluid build up in middle ear, often due to ear infection
- Perforated ear drum

Hearing Loss can be corrected.

Middle Ear Disorders

- Prevent sound from being conducted into the inner ear
- Otosclerosis
  - stiffening of bones in middle ear
- Otitis Media
  - Middle ear infection



Middle ear infection often leads to conductive hearing loss (CHL)