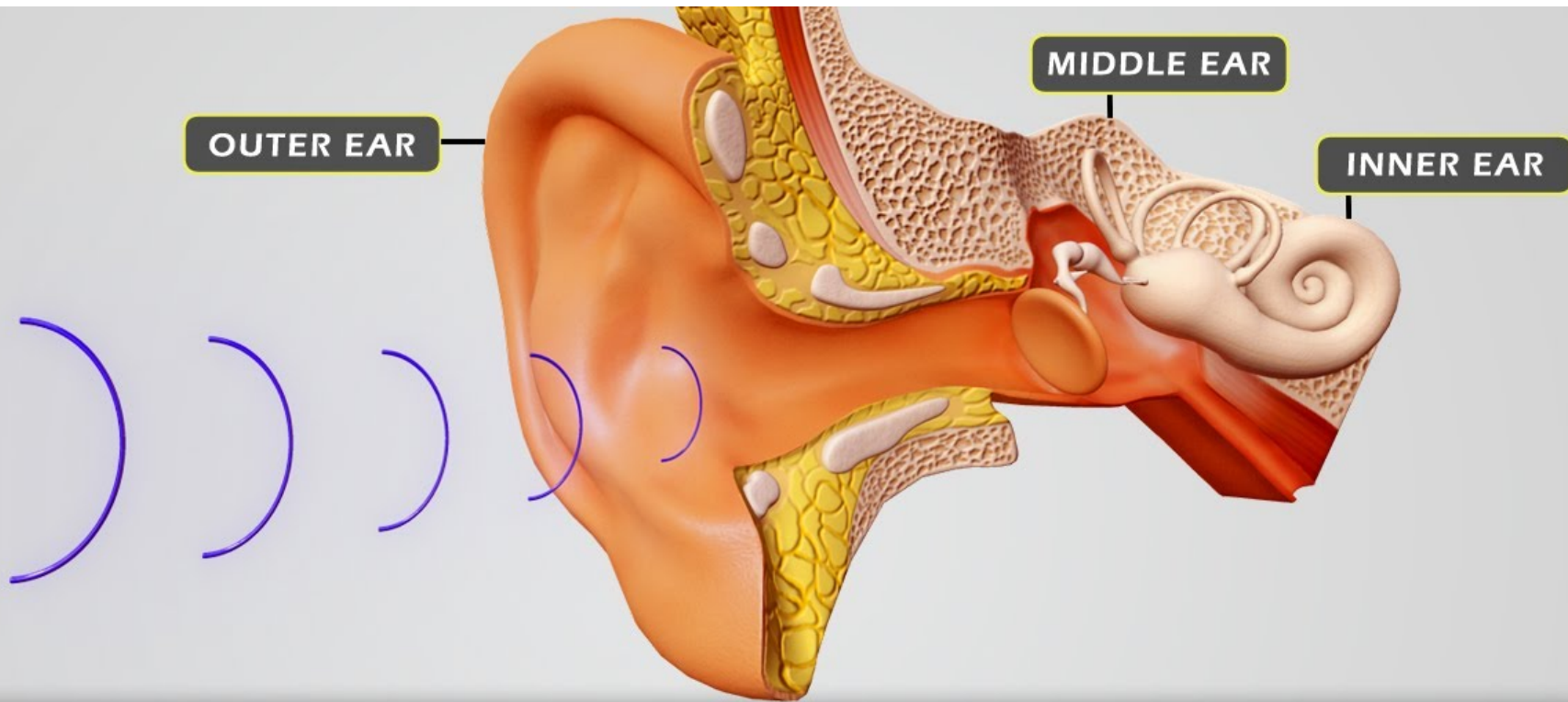


Special senses

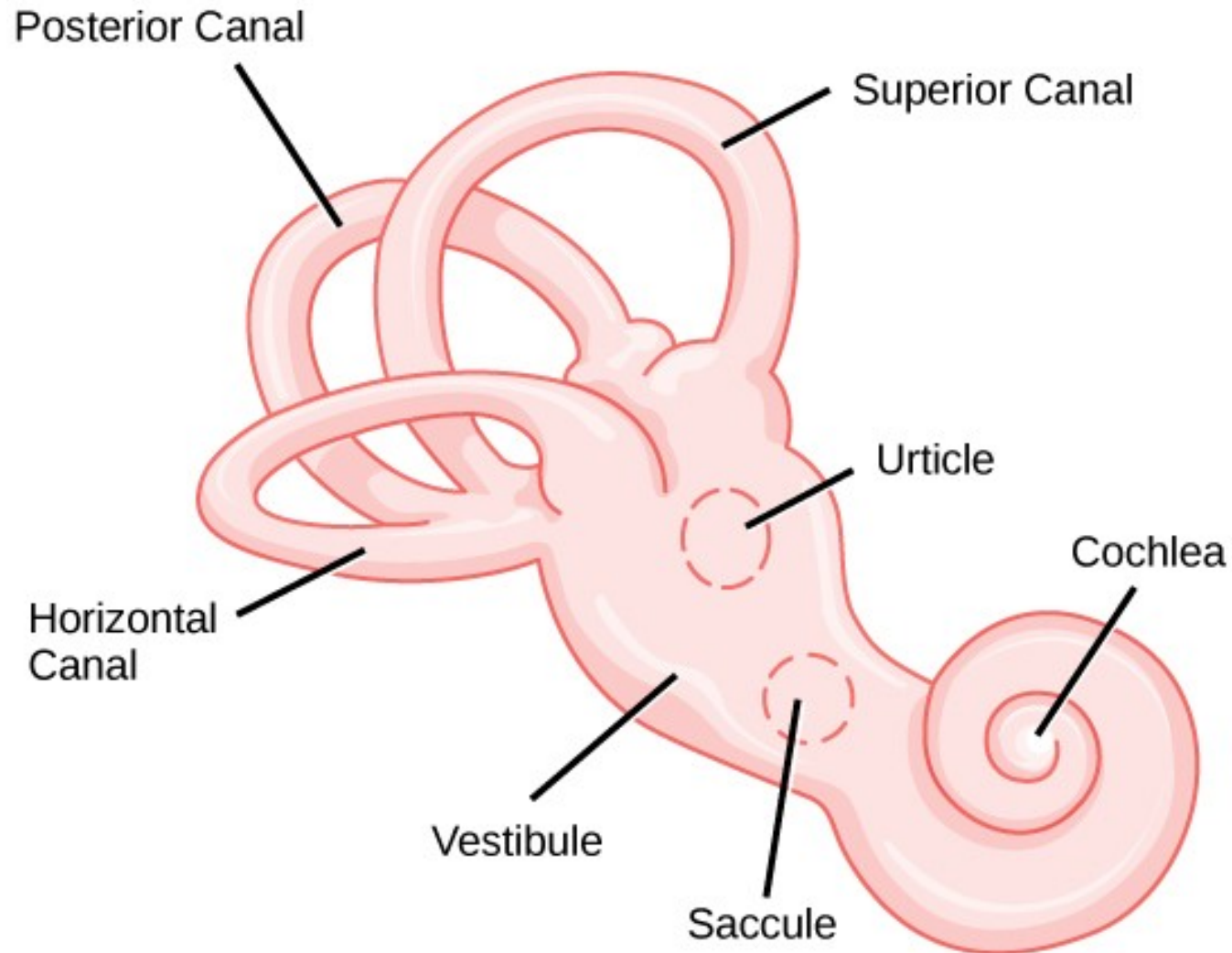
Hearing

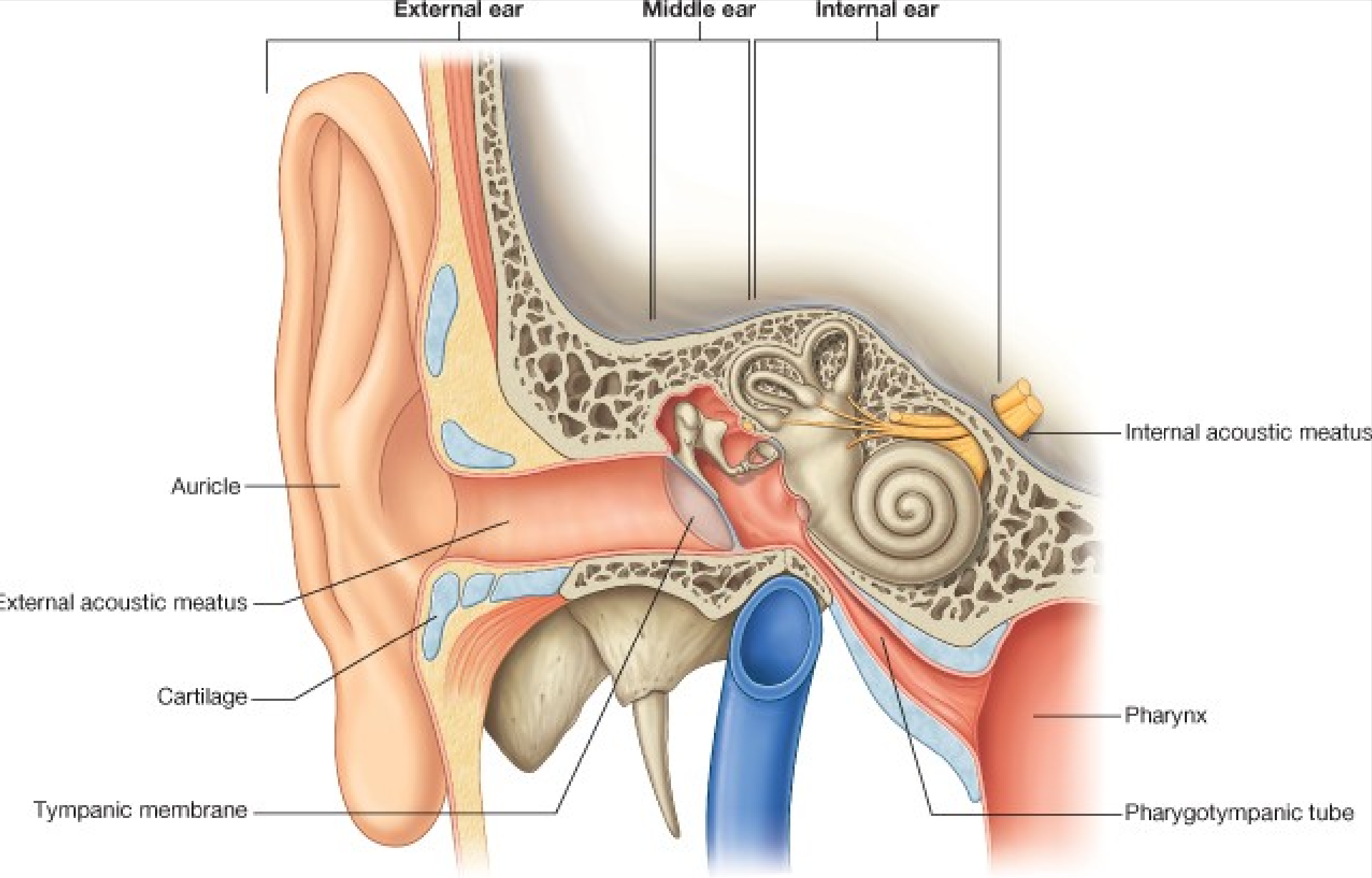
Figures in this ppt are from guyton, ganong, best & taylor, tortora, netters, gray's anatomy and google images



THE HUMAN EAR

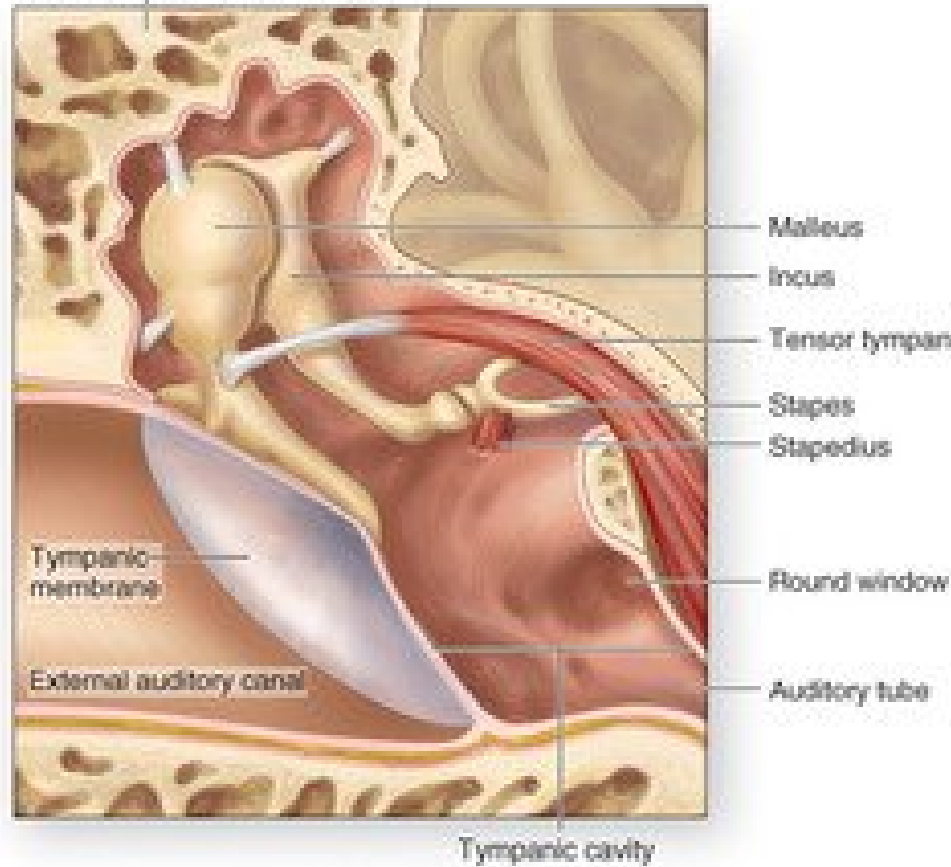
Vestibulo-cochlear apparatus





Middle ear

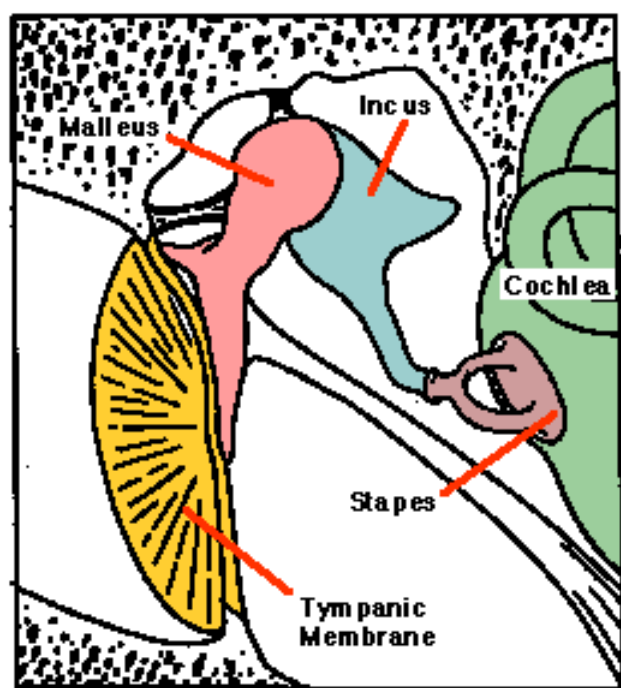
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Temporal bone (petrous portion)



- Malleus(Hammer)
- Incus(Anvil)
- Stapes (Stirrup)
- Tensor Tympani
- Stapedius
- Eustachian tube or pharyngotympanic tube or auditory tube

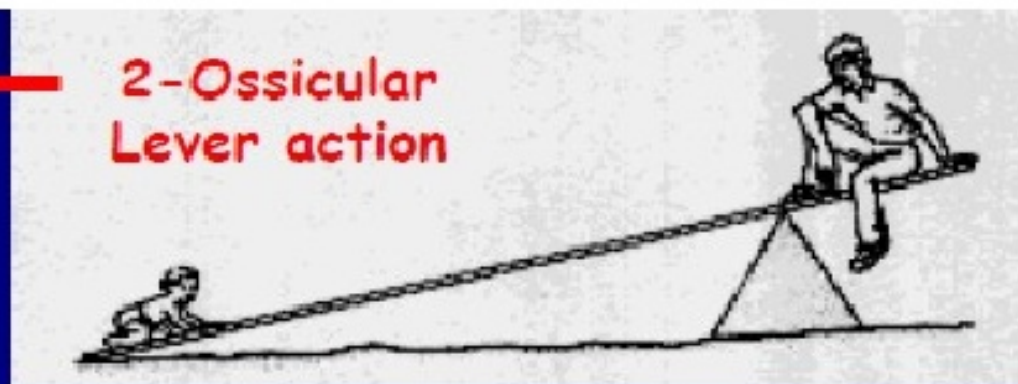
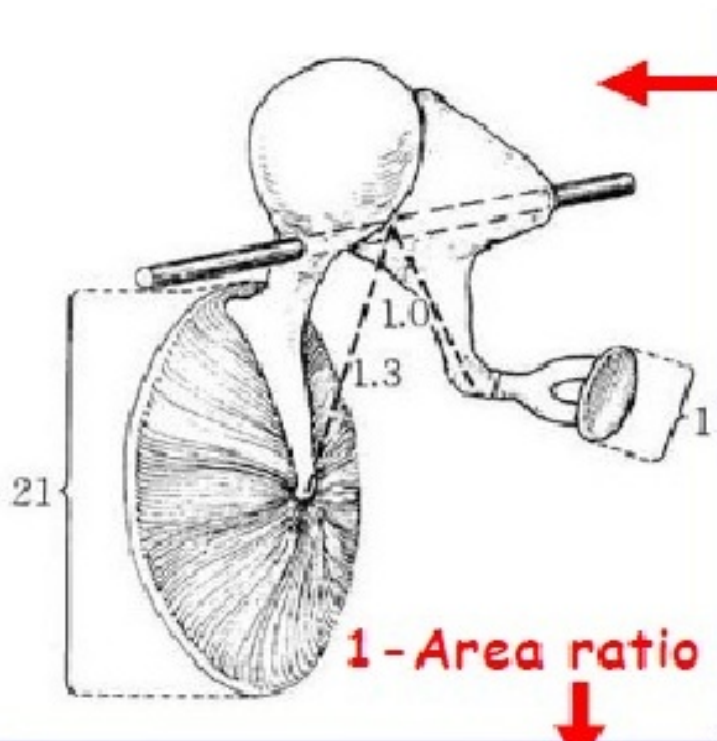
Bones of the Middle Ear (Malleus, Incus, Stapes) Amplify the Sound Waves

- The eardrum attaches to the malleus (hammer)
- The malleus attaches to the incus (anvil), which in turn attaches to the stapes (stirrup)
- The stapes is attached to the oval window of the cochlea
- Because of the way the bones are attached together the vibrations in the oval window are 20X larger than those in the eardrum (amplification)
- If the sound is too loud small muscles attached to the ear bones contract and dampen the vibrations



FUNCTIONS OF MIDDLE EAR:

1. IMPEDANCE MATCHING



Malleus and Incus
behave as
1st degree lever

Diameter of TM

Diameter of OW

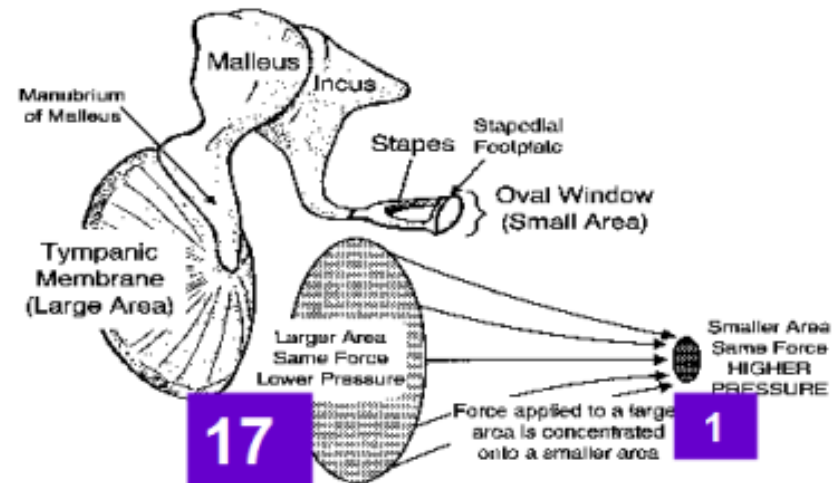
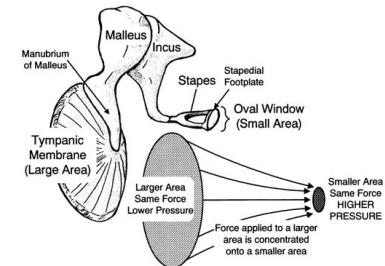
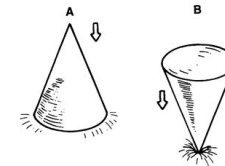
= Area ratio 21:1

Impedance matching

- Increases sound pressure so that fluid in internal ear is moved
- Lever action of ear ossicles 1.3 times
- Difference in size of tympanic membrane & footplate of stapes(oval window) 17 times
- $17 \times 1.3 = 22$ times

AREA ADVANTAGE

- The area of the tympanic membrane is 17x the oval window
- As the area decreases, the pressure increases

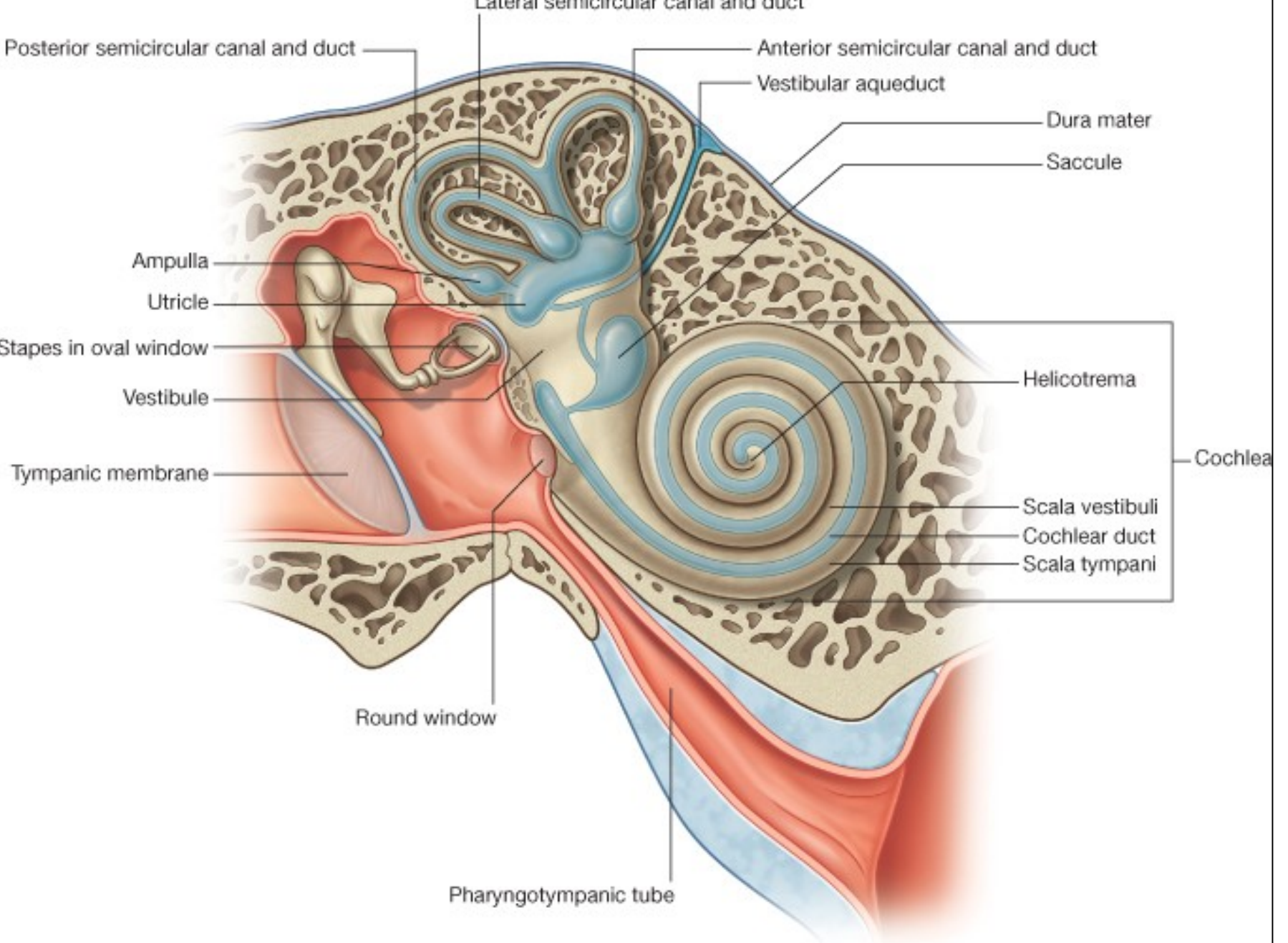


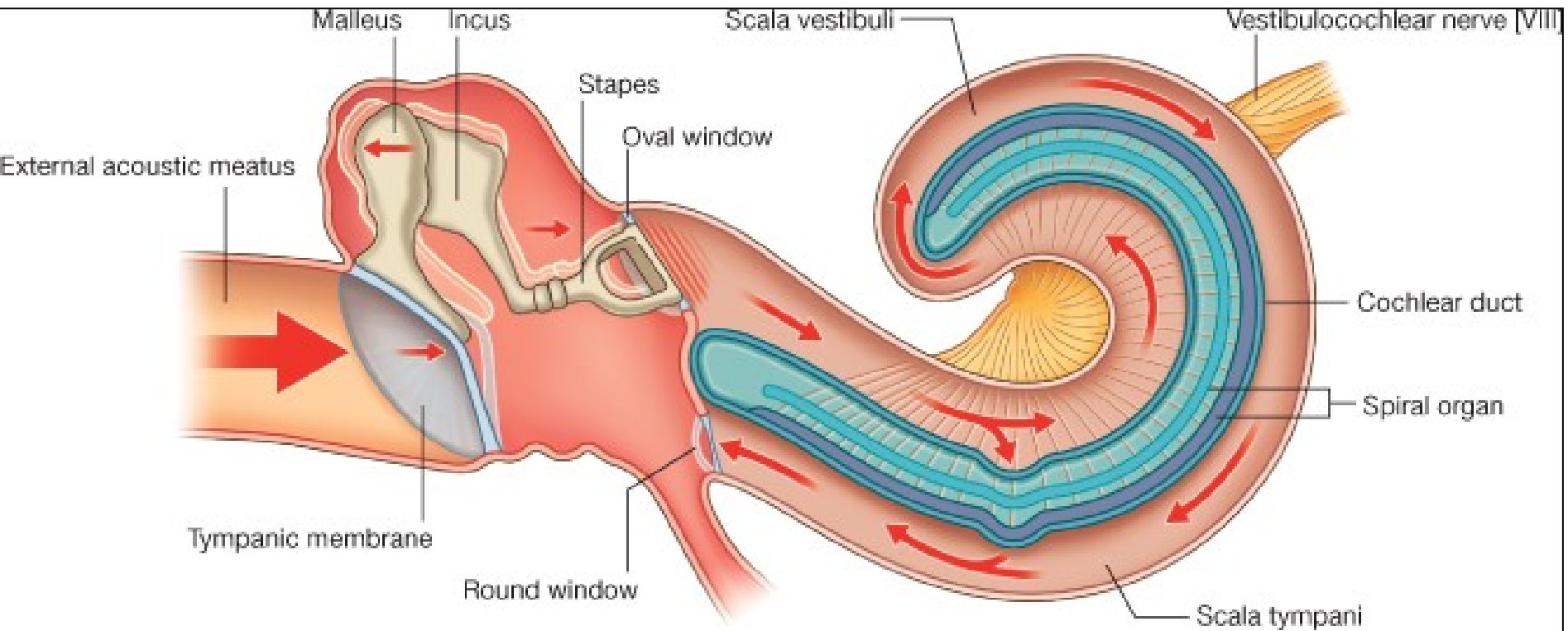
Tympanic reflex

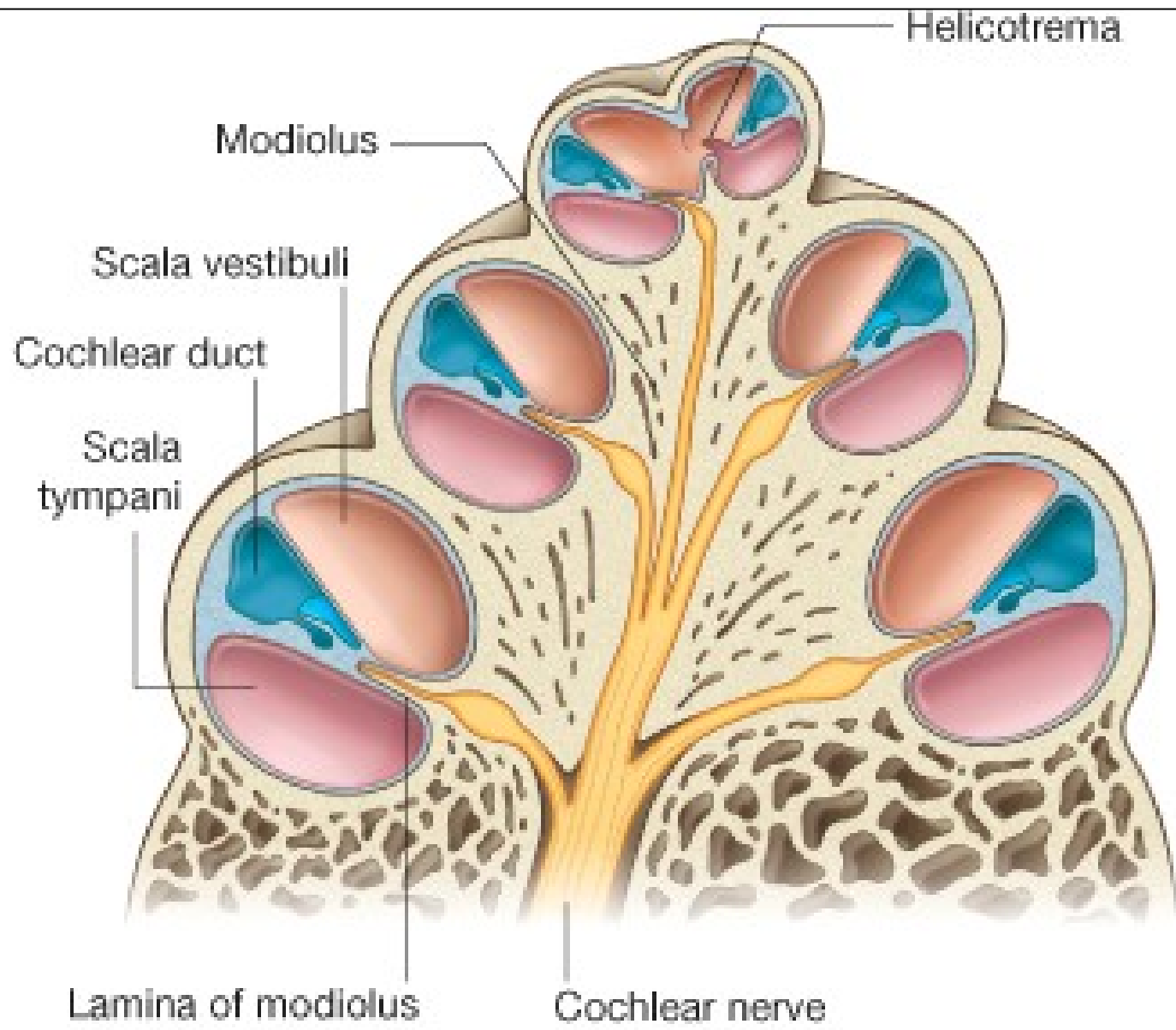
- Attenuation reflex or Acoustic reflex or Middle ear reflex or Stapedius reflex
- **Latent period 40-80 millisecond**(fails to protect from sudden loud noise)
- Involuntary muscle contraction in response to high intensity sound stimuli or when person starts to vocalize
- Protects inner ear from damage & reduces perception of our own voice

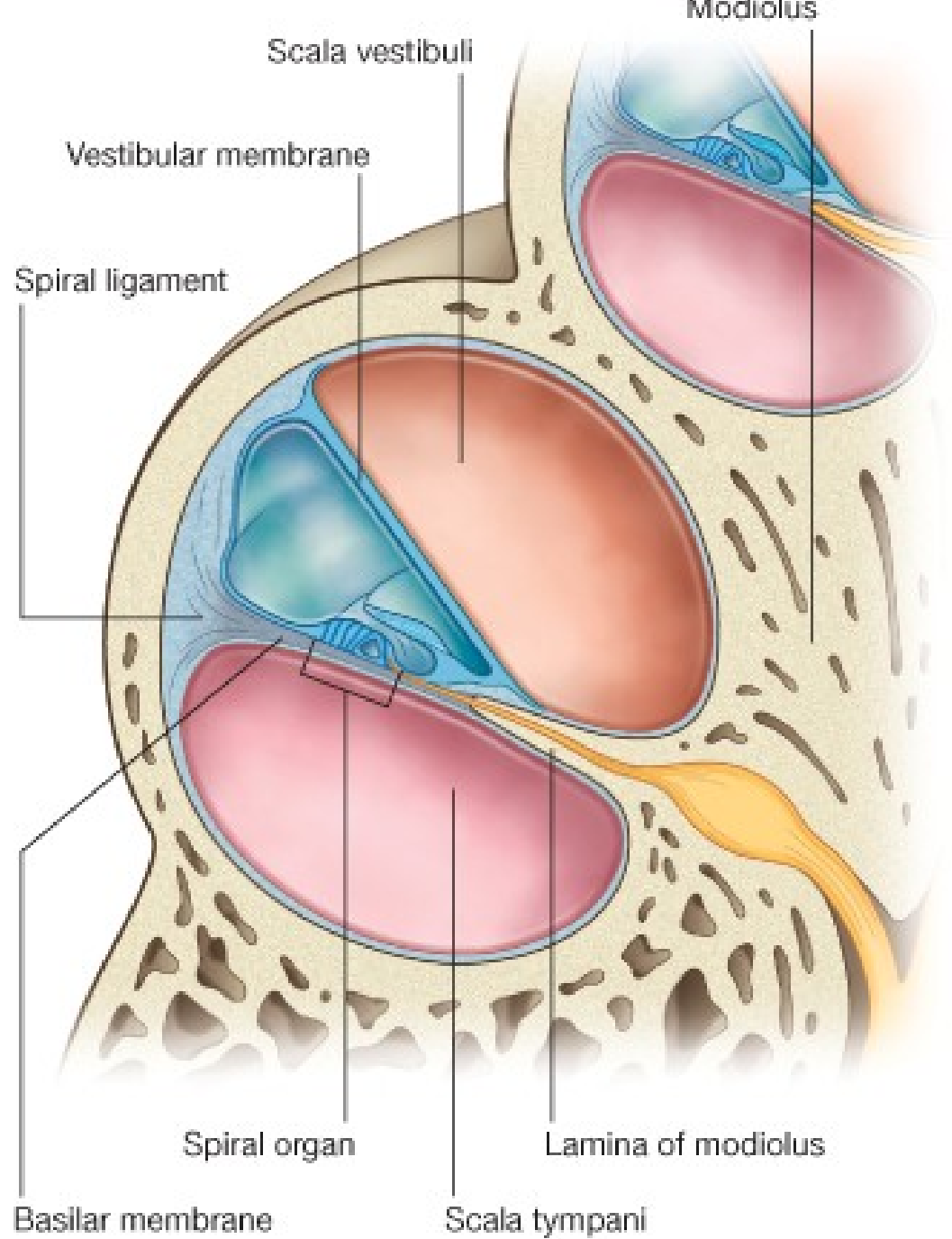
Internal ear- cochlea



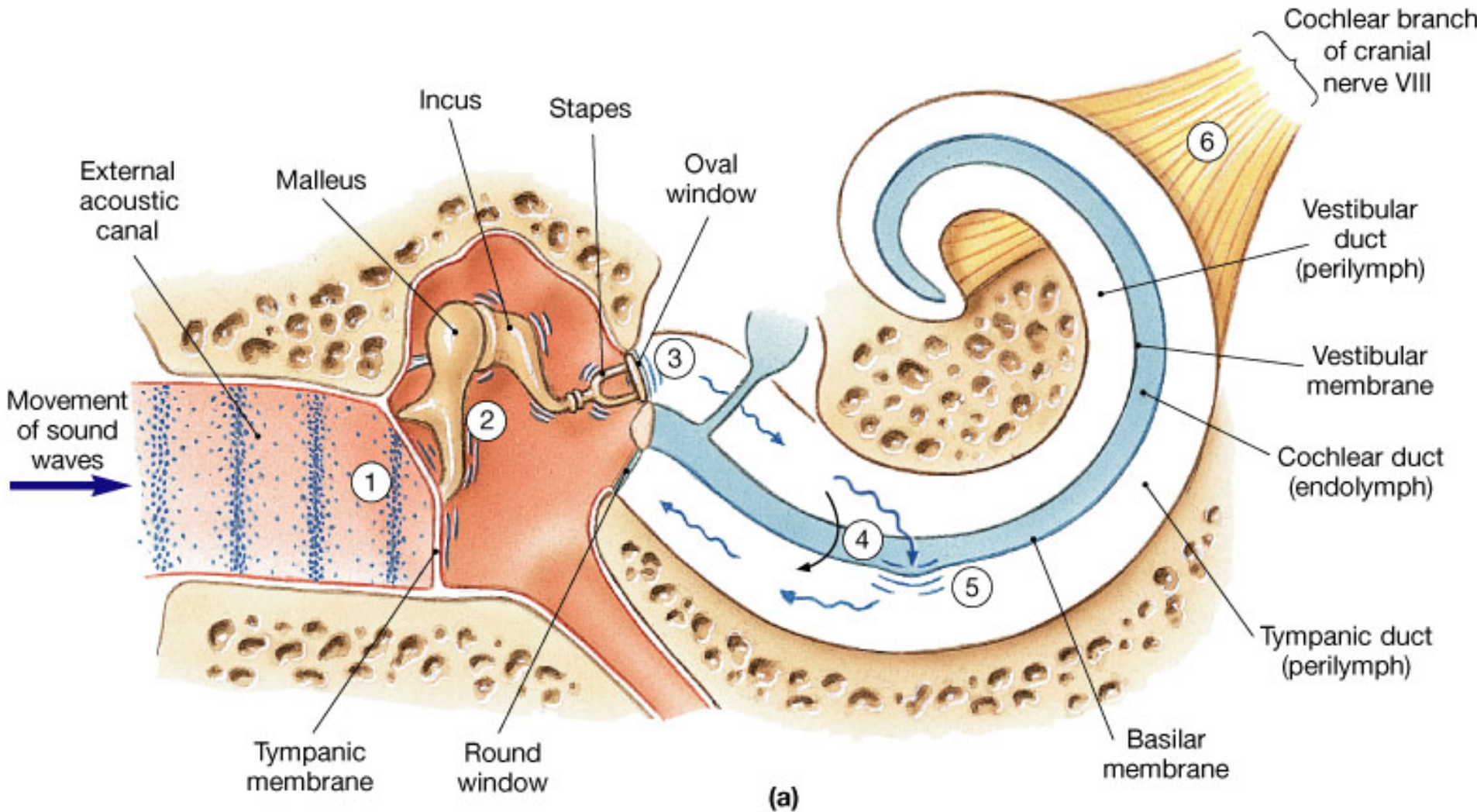




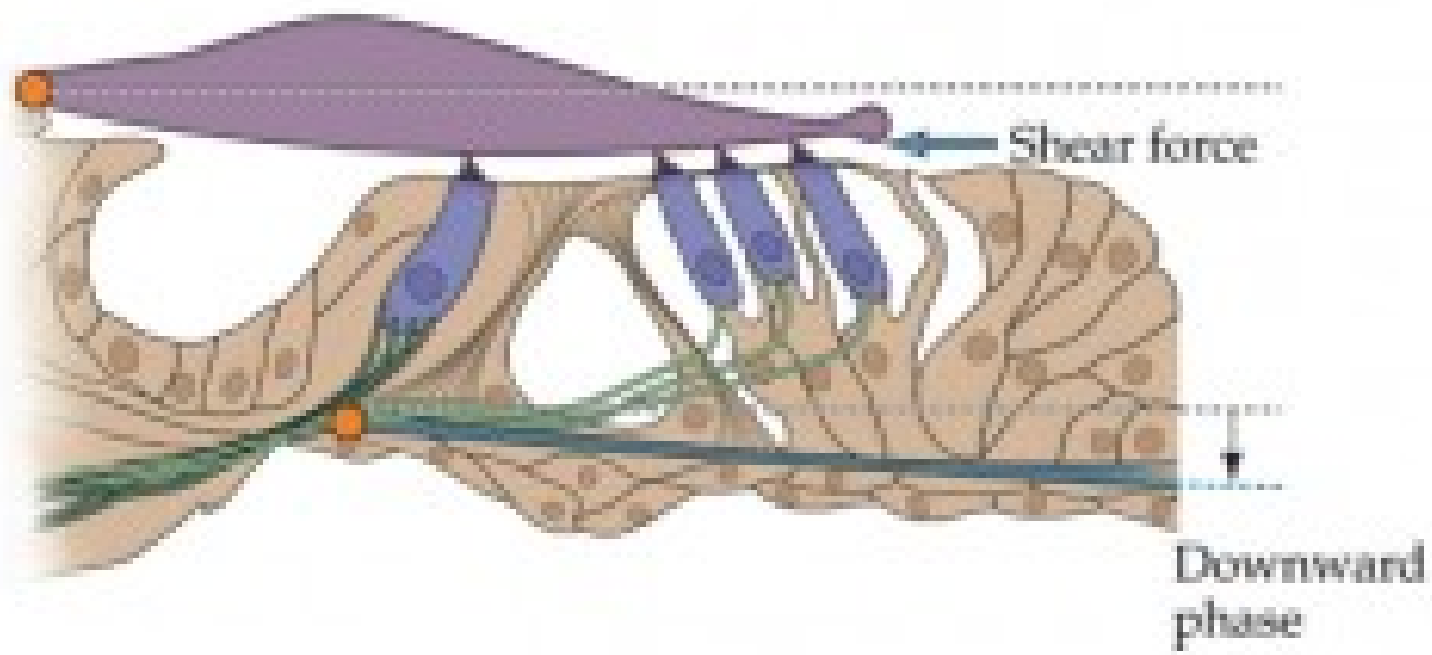
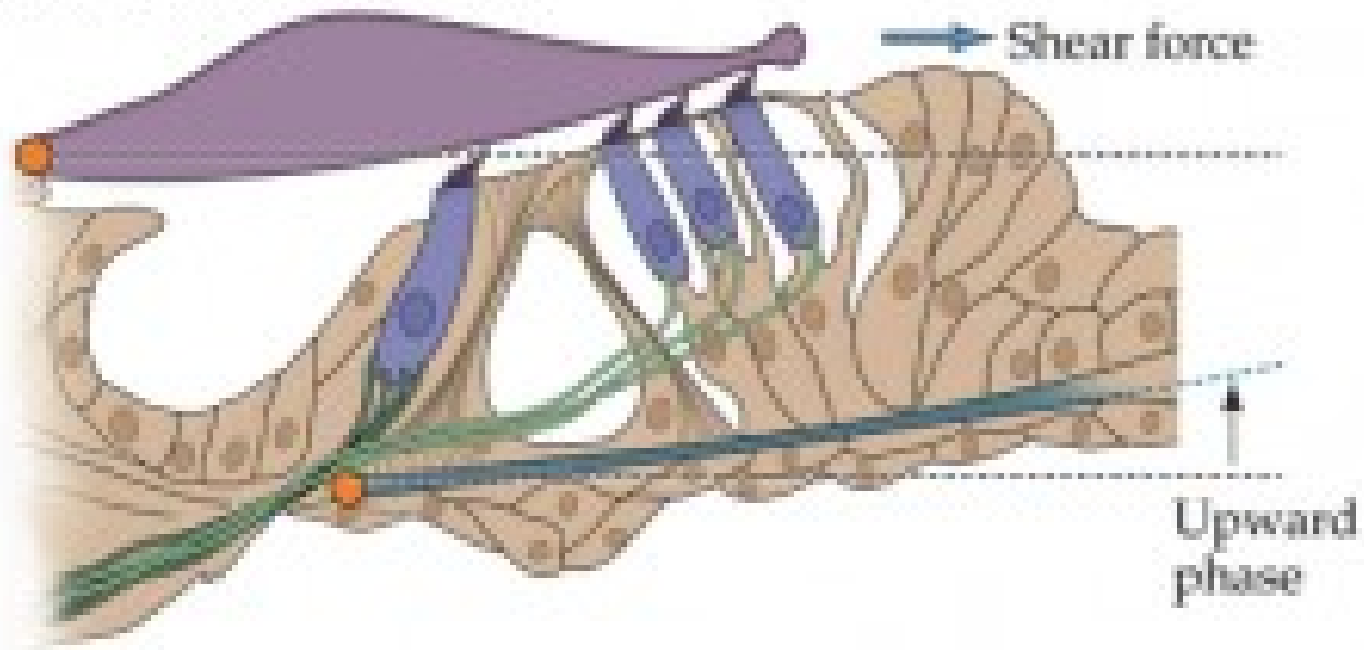


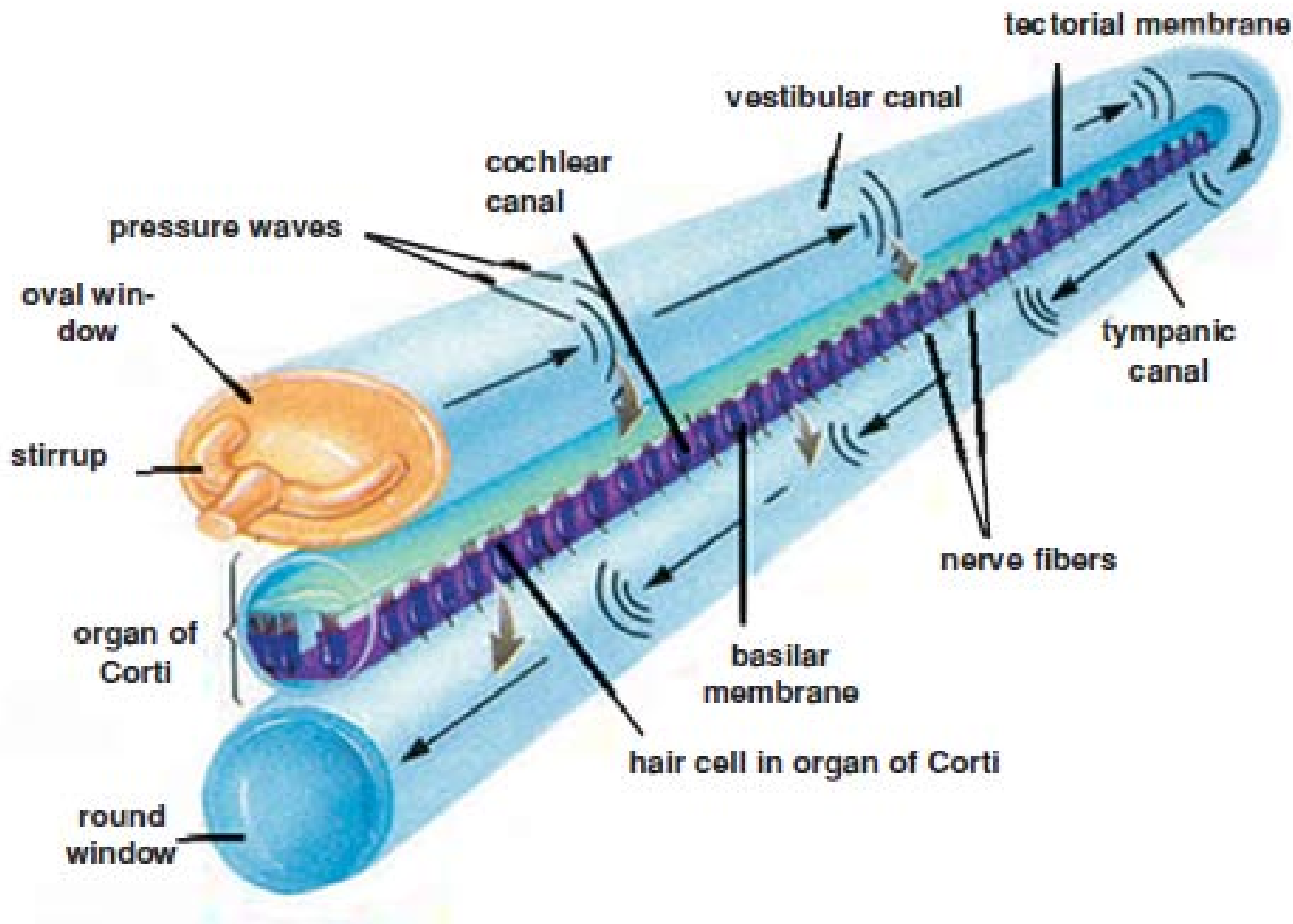


Hearing cont...

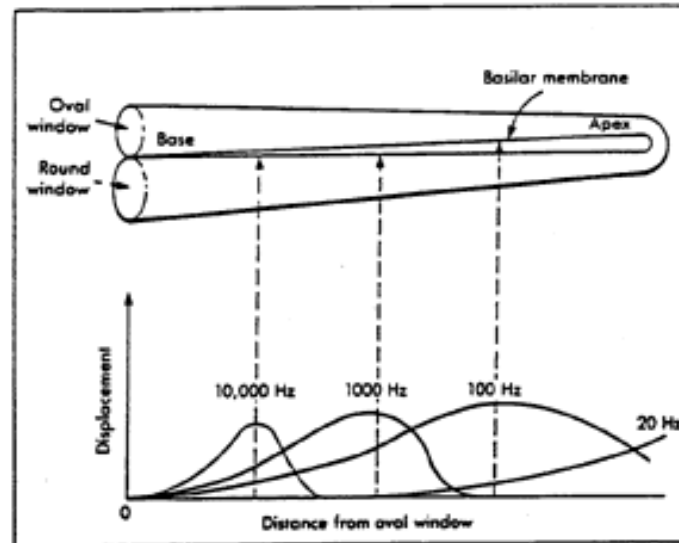
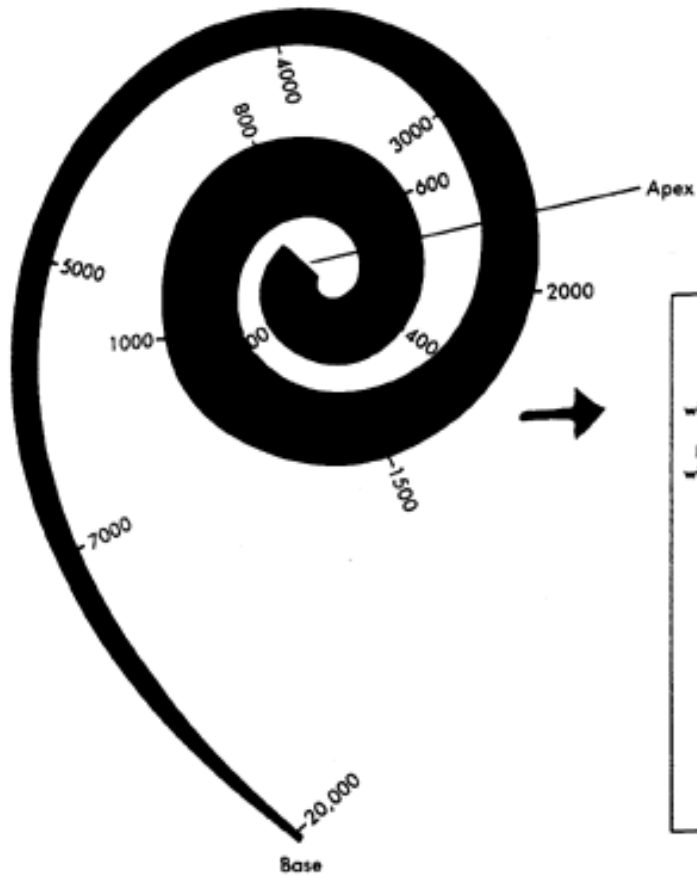


Sound-induced vibration



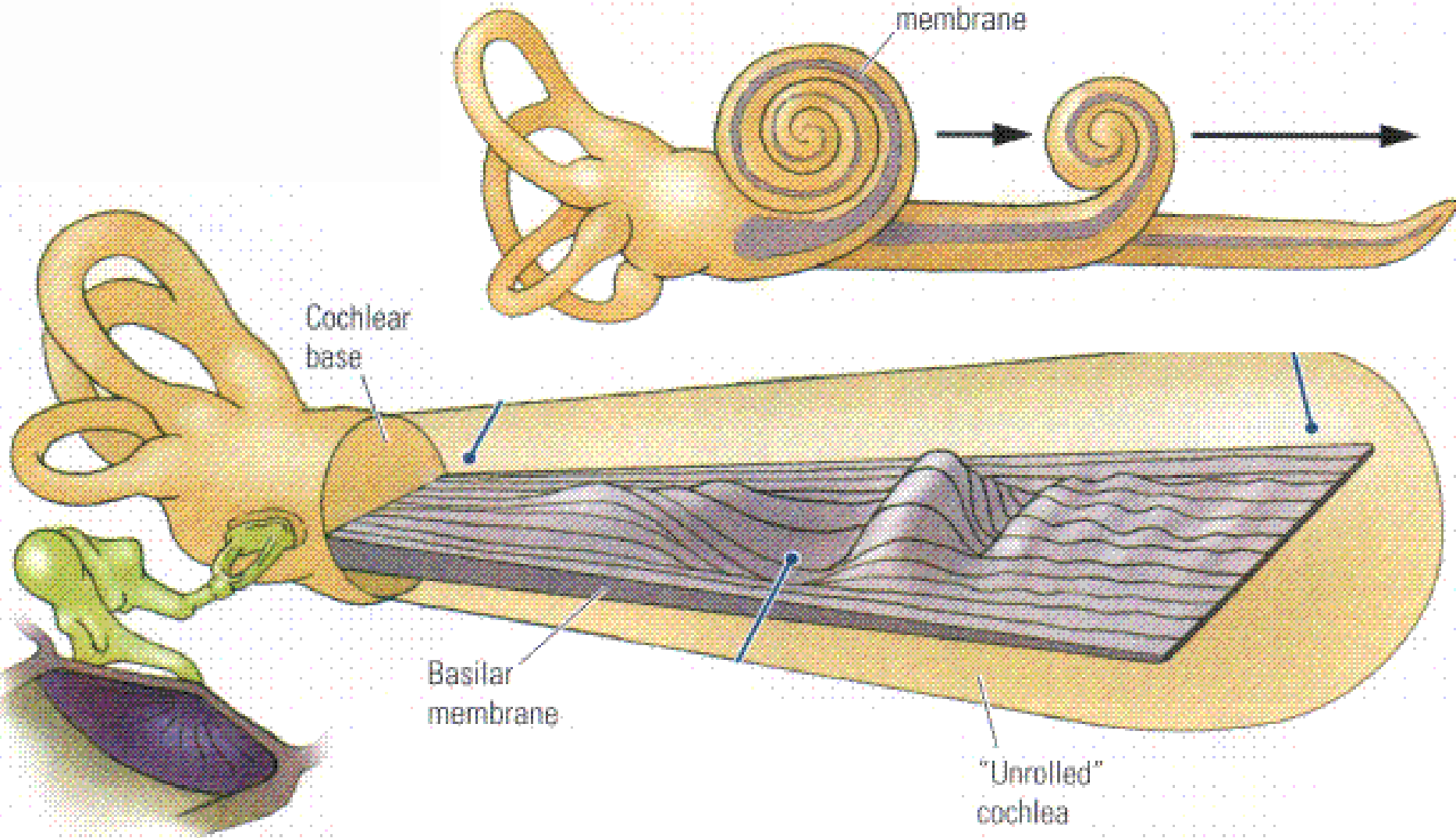


Basilar Membrane



Unrolling of cochlea

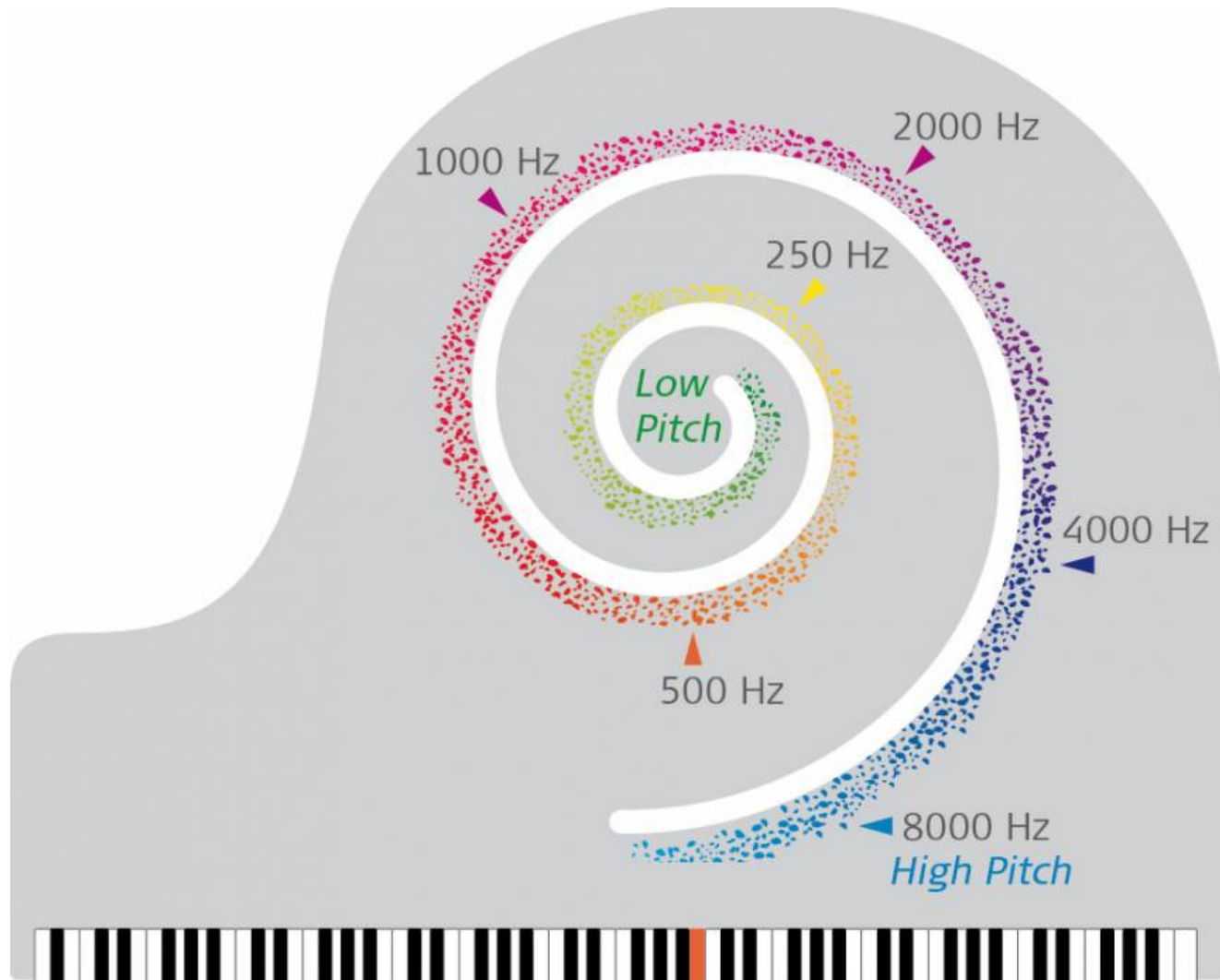
Basilar membrane



Cochlear base

Basilar membrane

"Unrolled" cochlea



Low Pitch

500 Hz

High Pitch



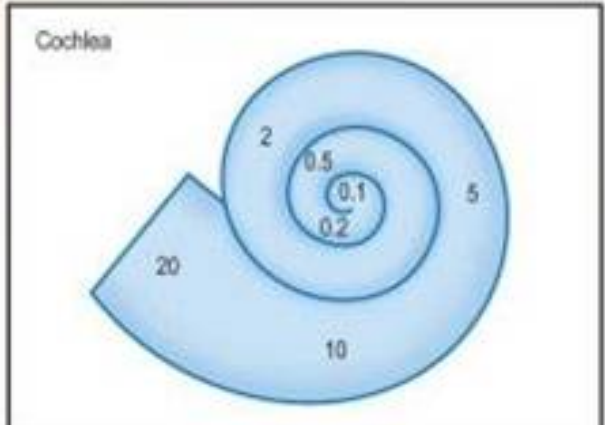
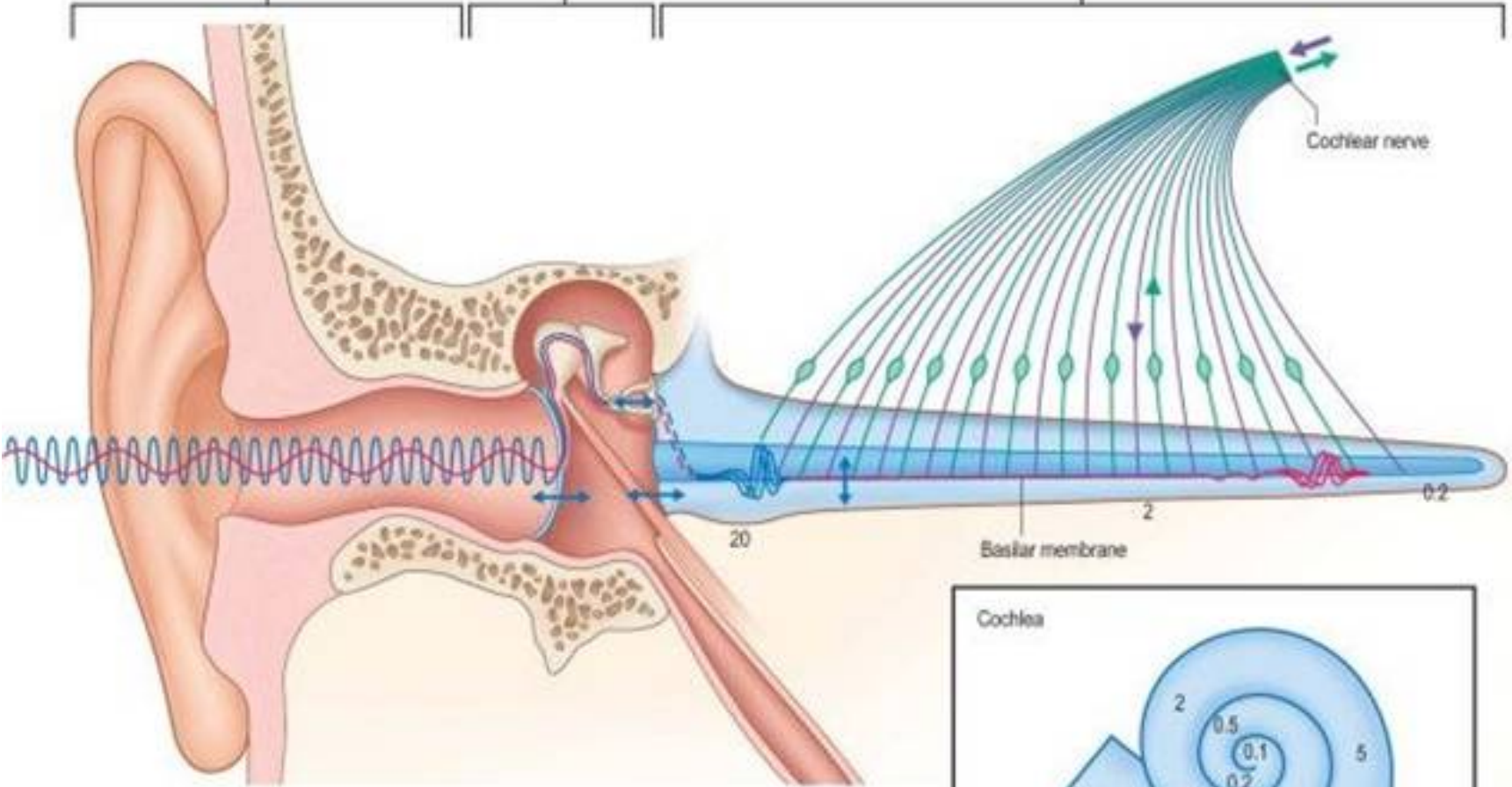
Apical Region

Basal Region

EXTERNAL EAR
Sound collection and amplification;
source location.

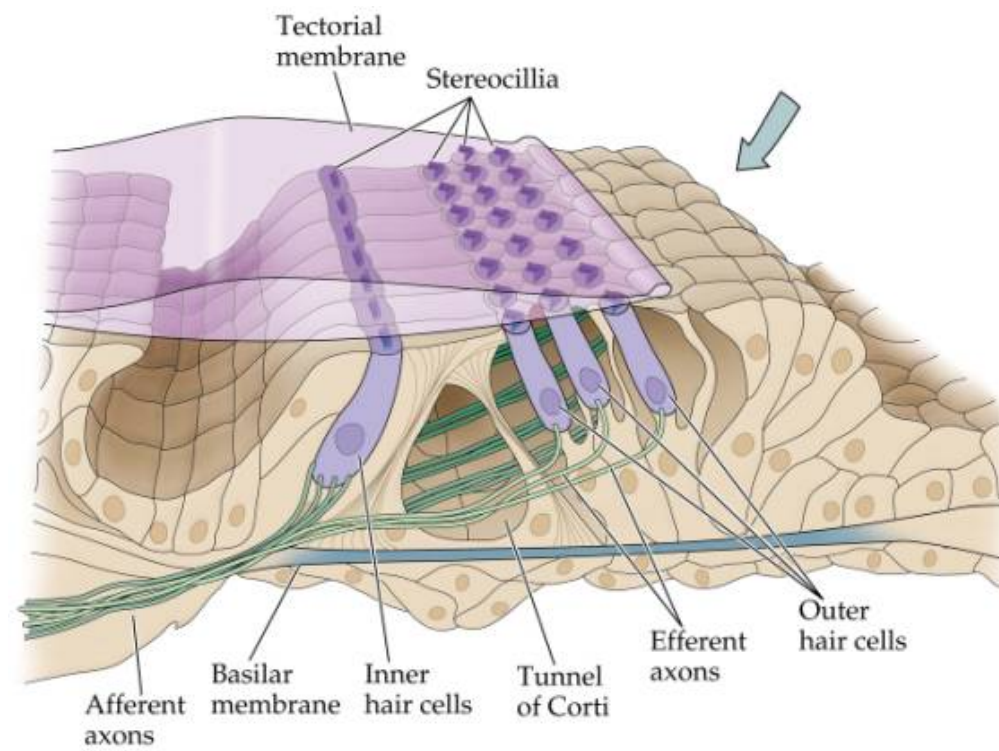
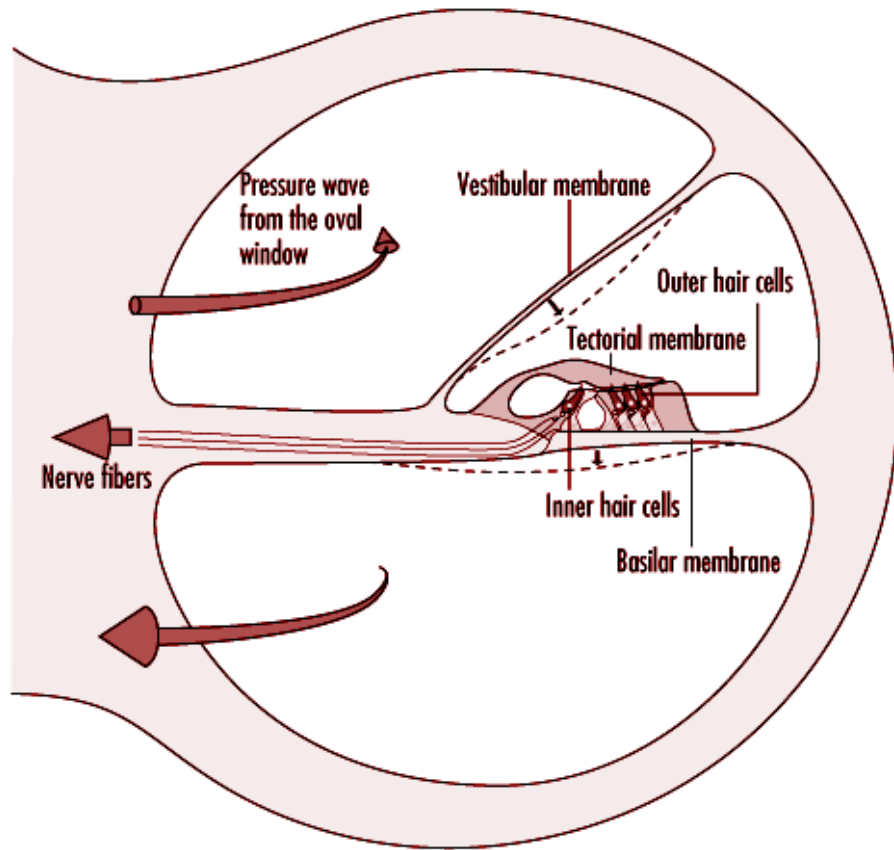
MIDDLE EAR
Amplification of signal (force
per unit area); impedance
matching between air and
water vibrations; neural
reflex and mechanical damping
of excessive vibration; pressure
equalizing through
pharyngotympanic tube.

INNER EAR
Mechanical and neural filtering and
analysis of signals by organ of Corti;
stimulus transduction by sensory
cells; action potential initiation
at synapses between cochlear
fibres and sensory cells; central
control by centrifugal fibres.

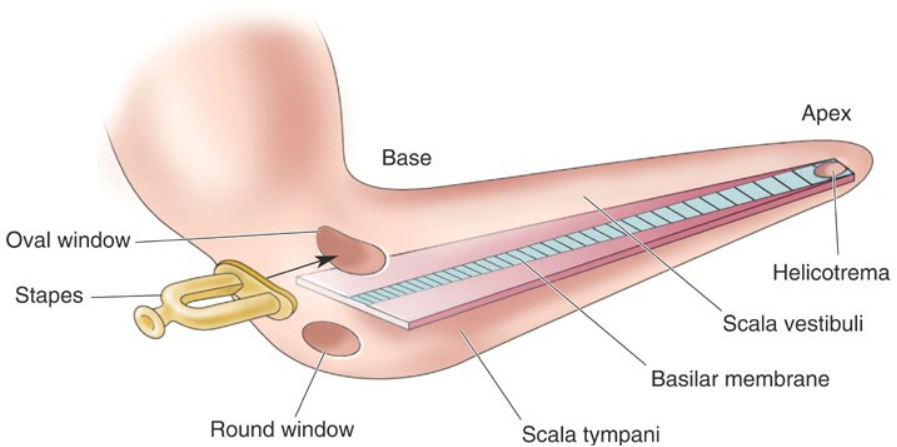
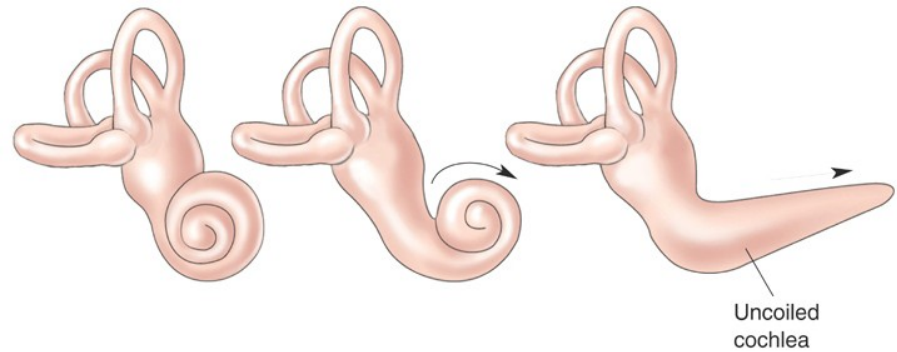


 High frequency vibrations

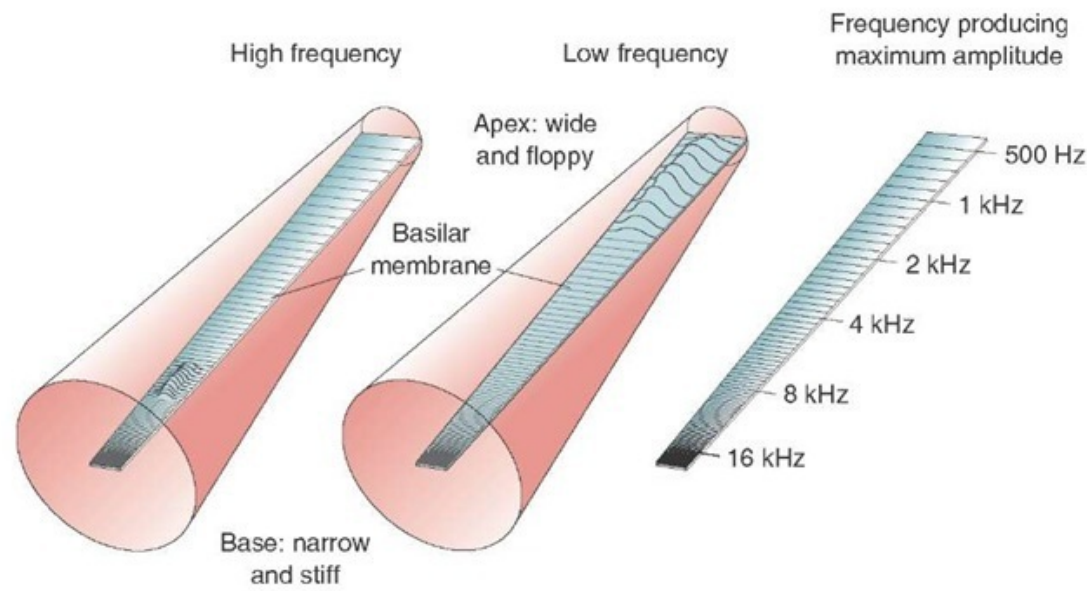
 Low frequency vibrations

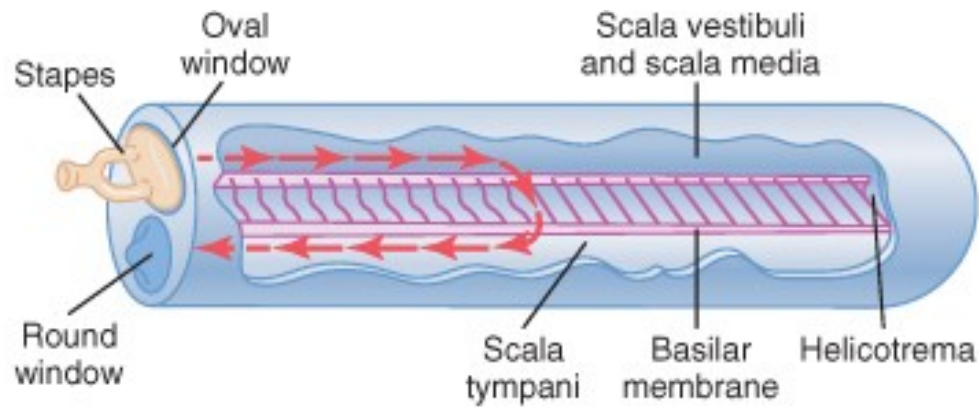


Source: Hohmann and Schmuckli 1989.

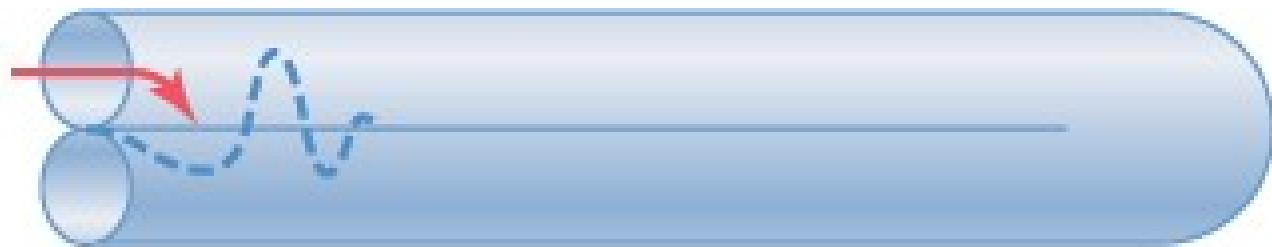


Neuroscience: Exploring the Brain, 3rd Ed, Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins





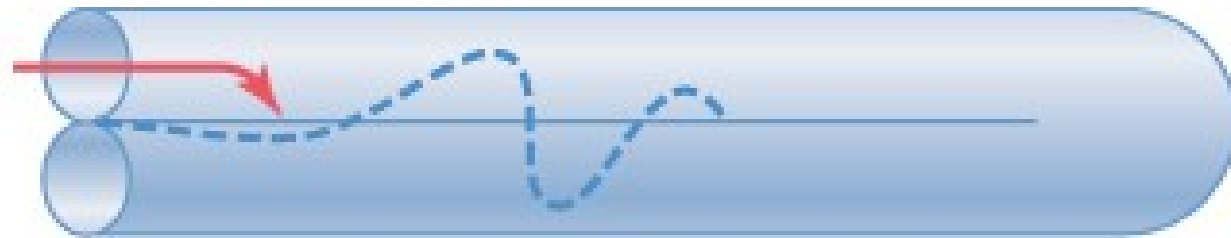
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A

High frequency

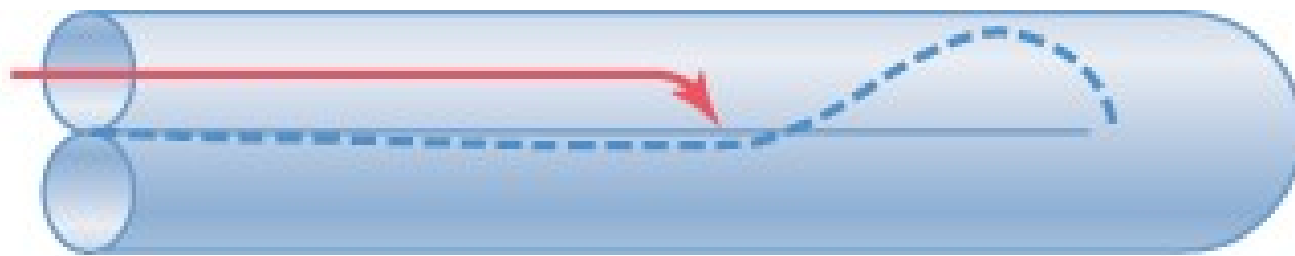
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B

Medium frequency

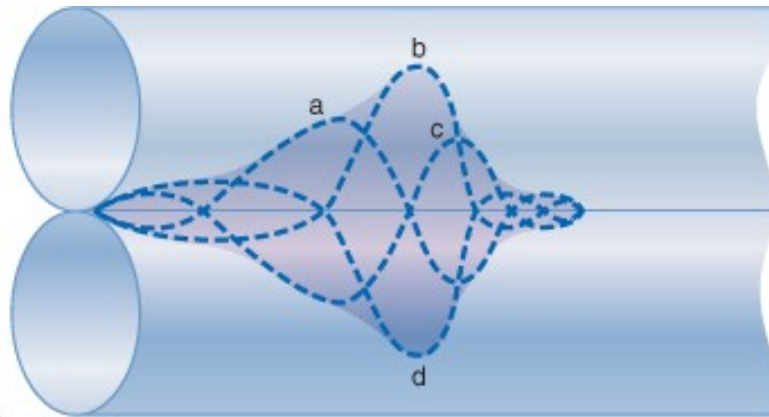
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C

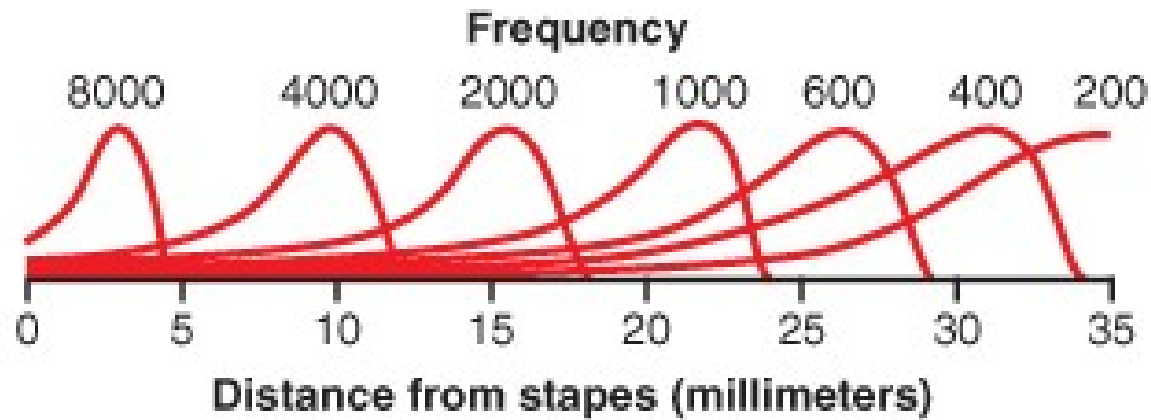
Low frequency

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A

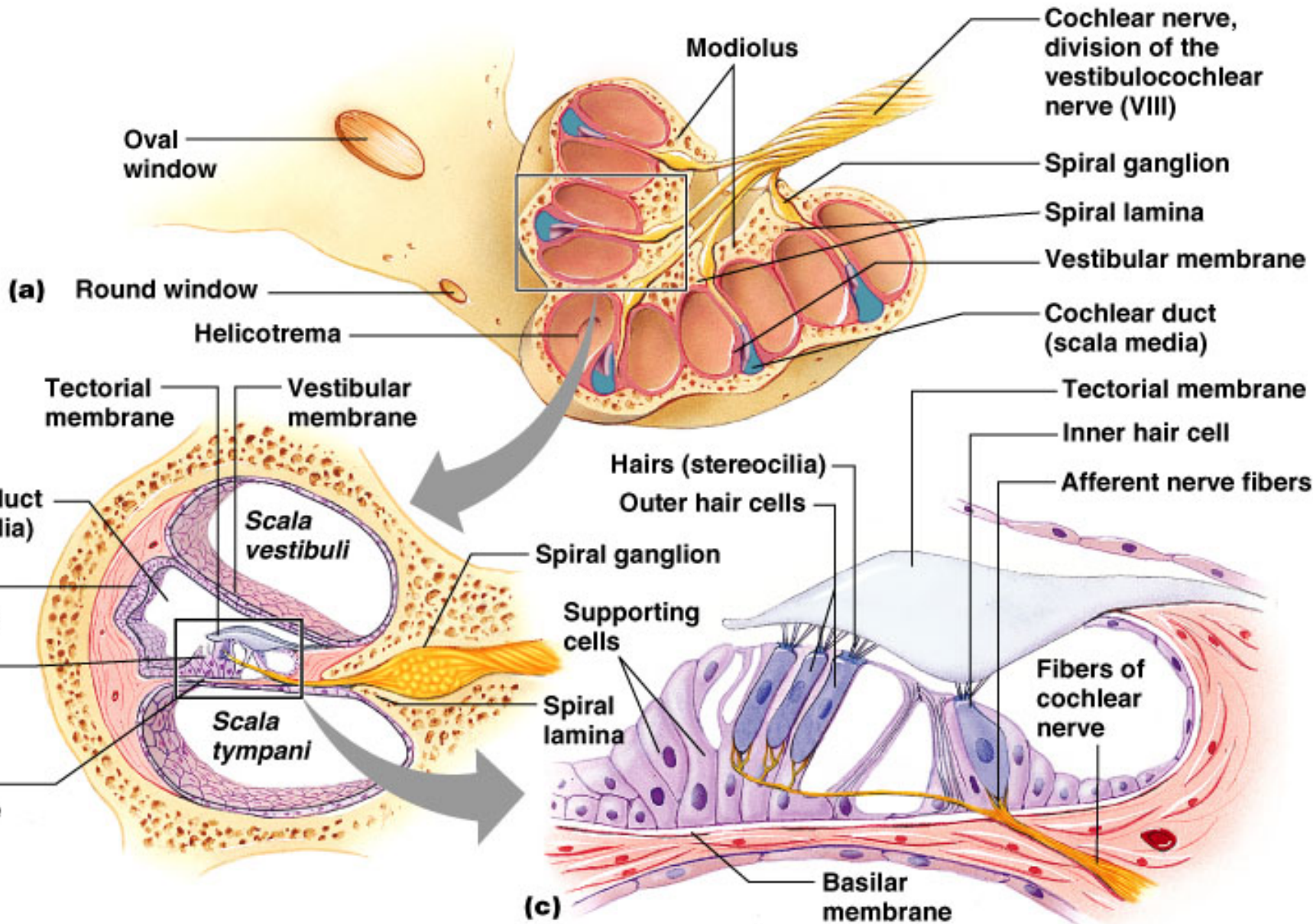
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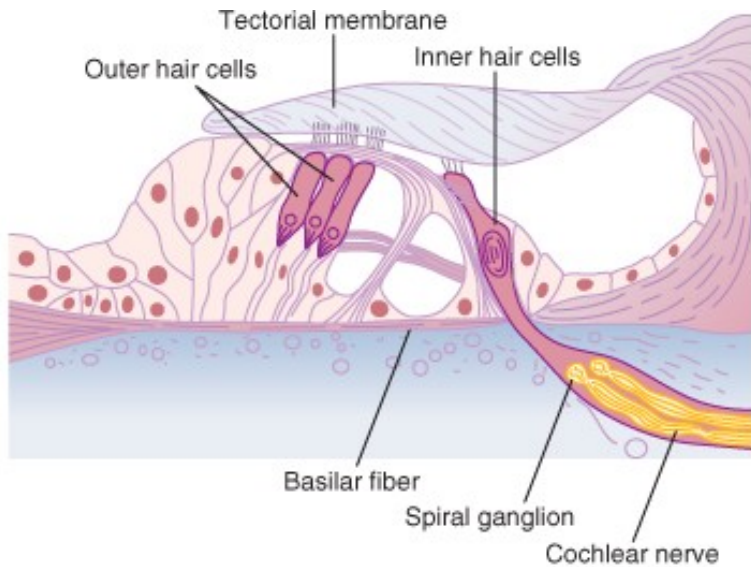


B

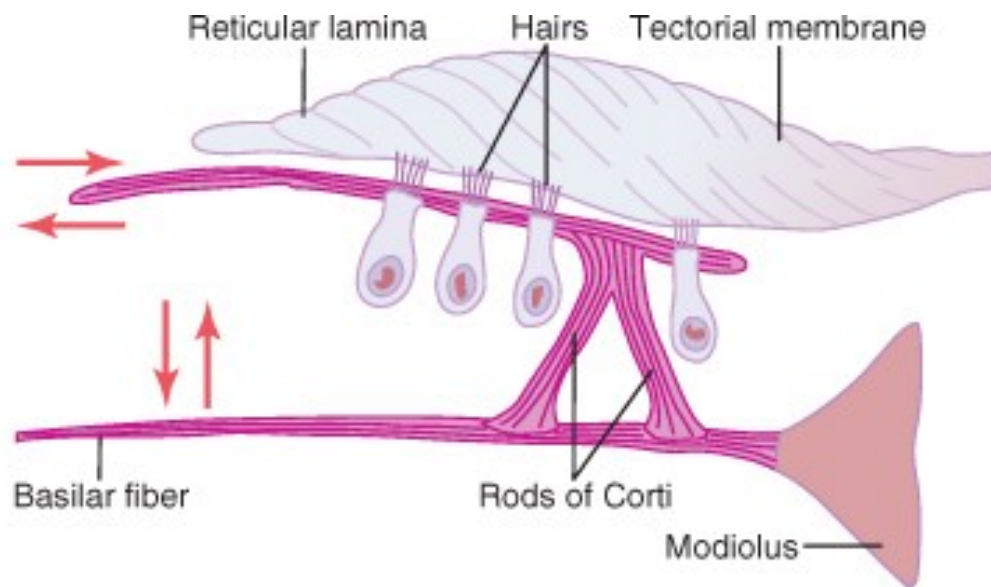
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Hearing cont...

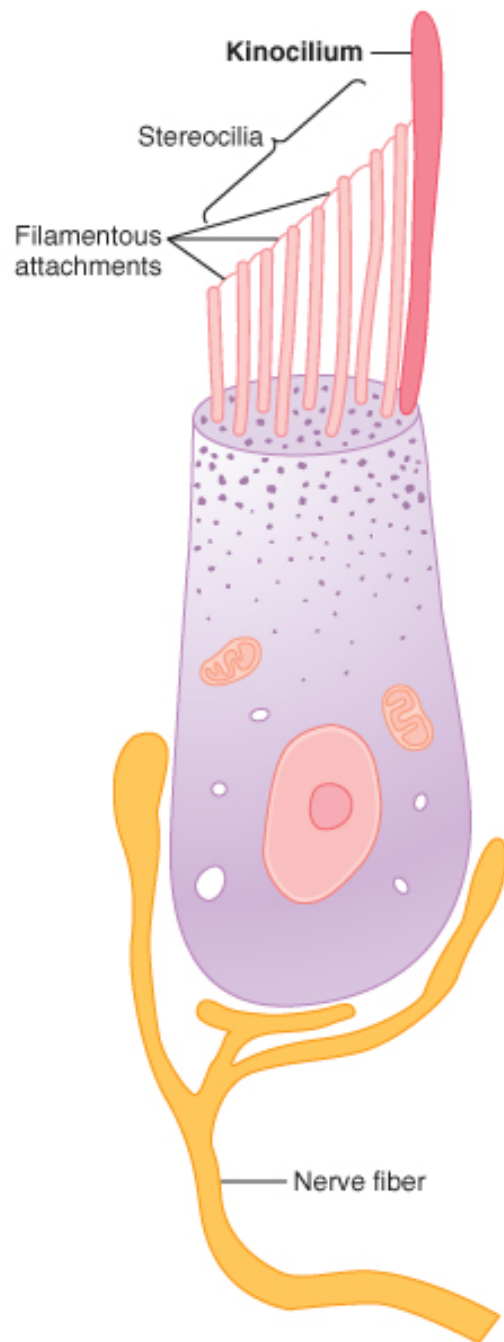


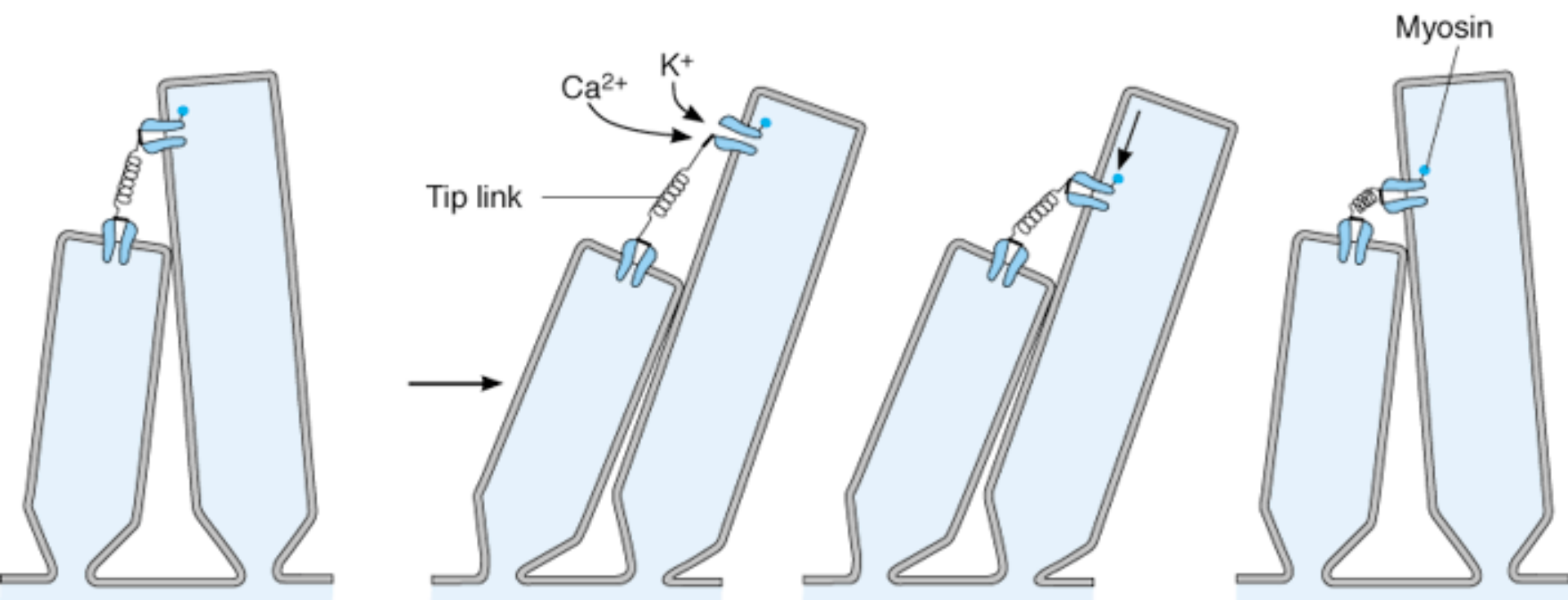


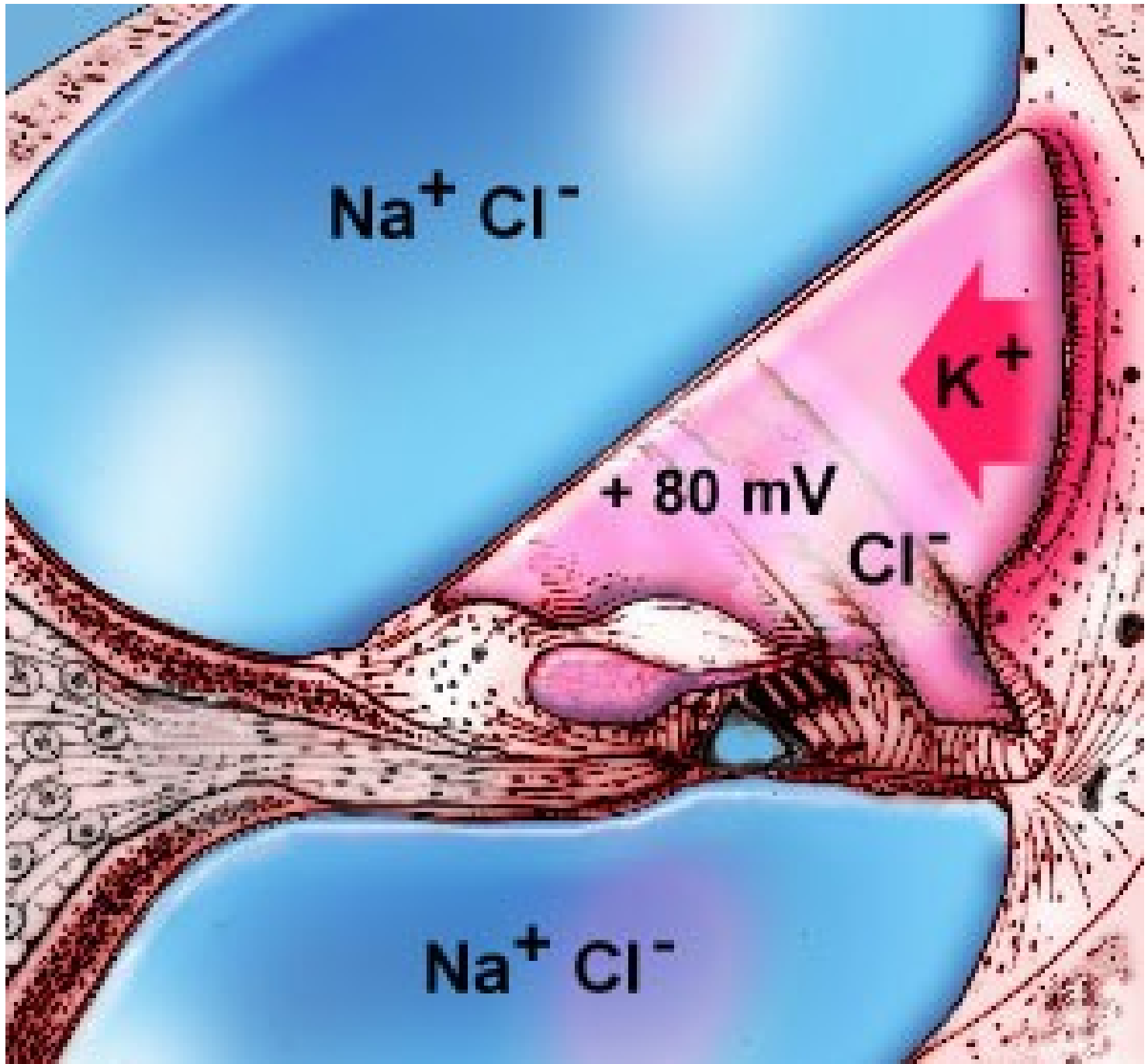
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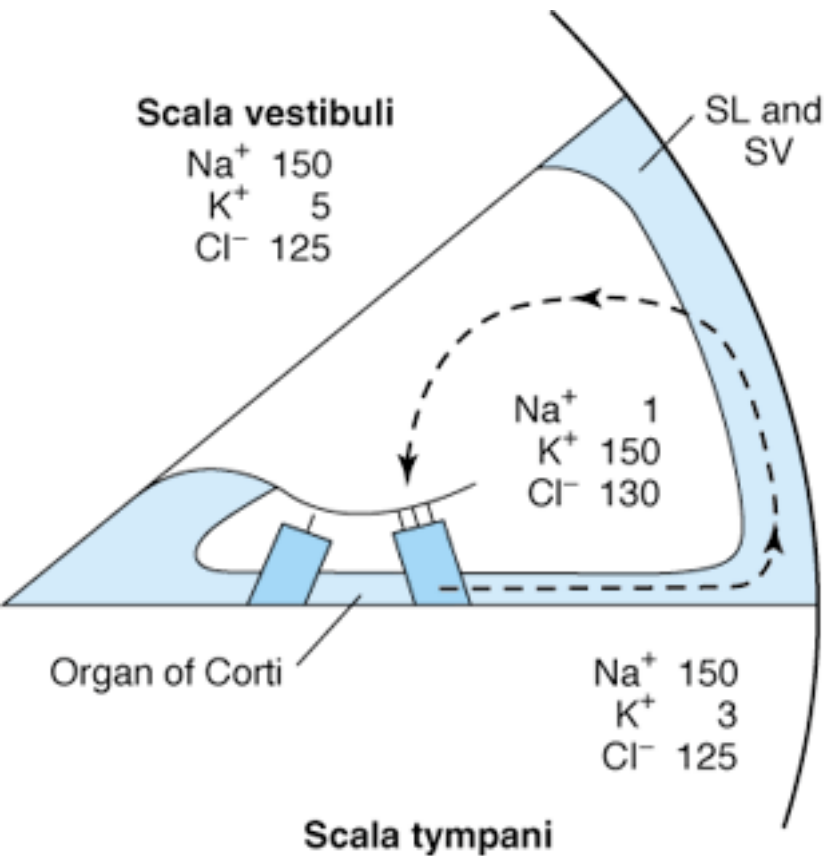
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Electrophysiology of hearing

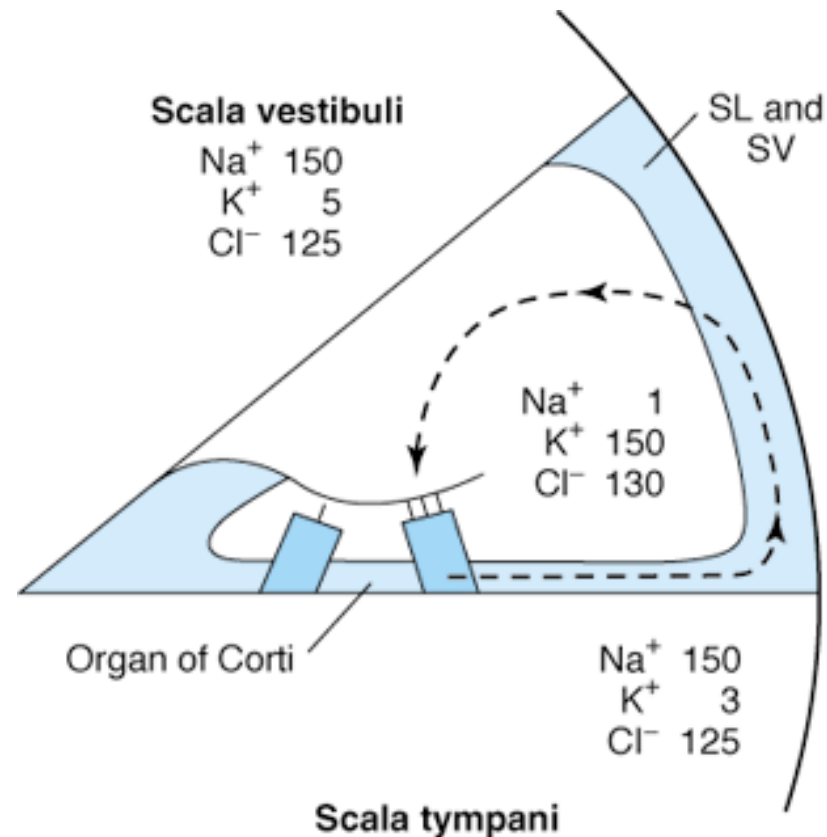


- Endolymphatic potential or endocochlear potential
- Resting membrane potential of inner hair cell
- Cochlear microphonics
- Action potential in 8th nerve fibers

Endolymphatic or Endocochlear Potential

- Endolymph is +80 mV positive compared to perilymph due to more concentration of K^+ ions secreted by stria vascularis.

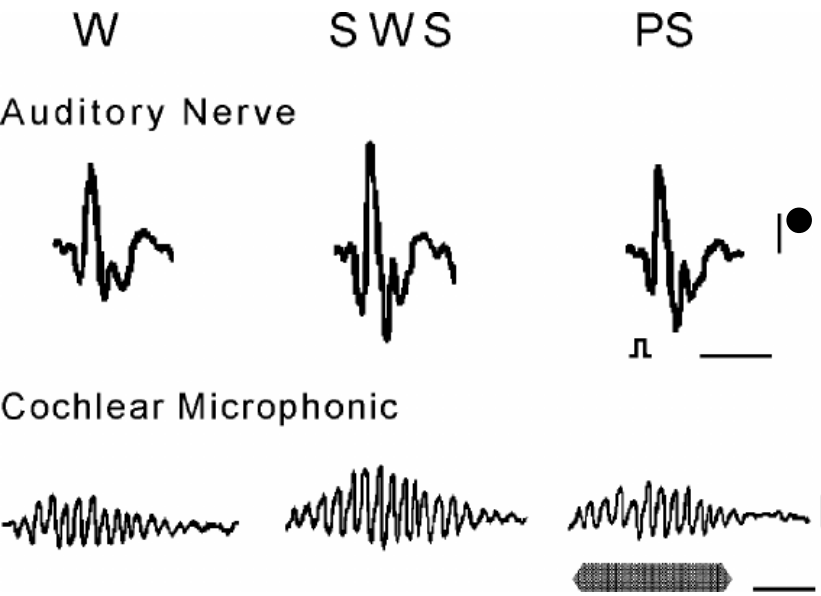
Inner hair cell resting membrane potential:-
It is -70 mV at base (bathed in perilymph) & -150 mV at apex (in relation to endolymph)



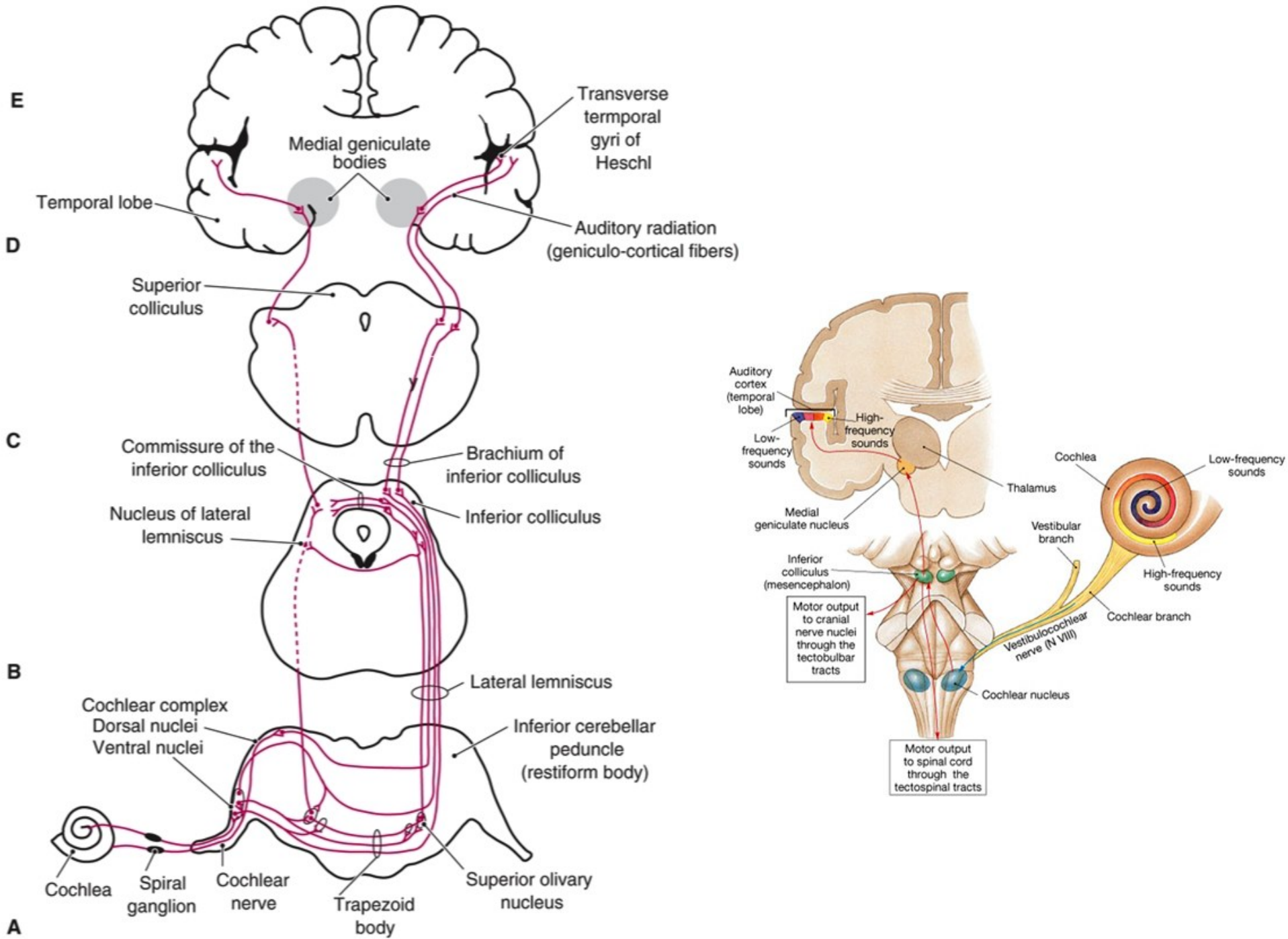
Cochlear microphonics(CMP)

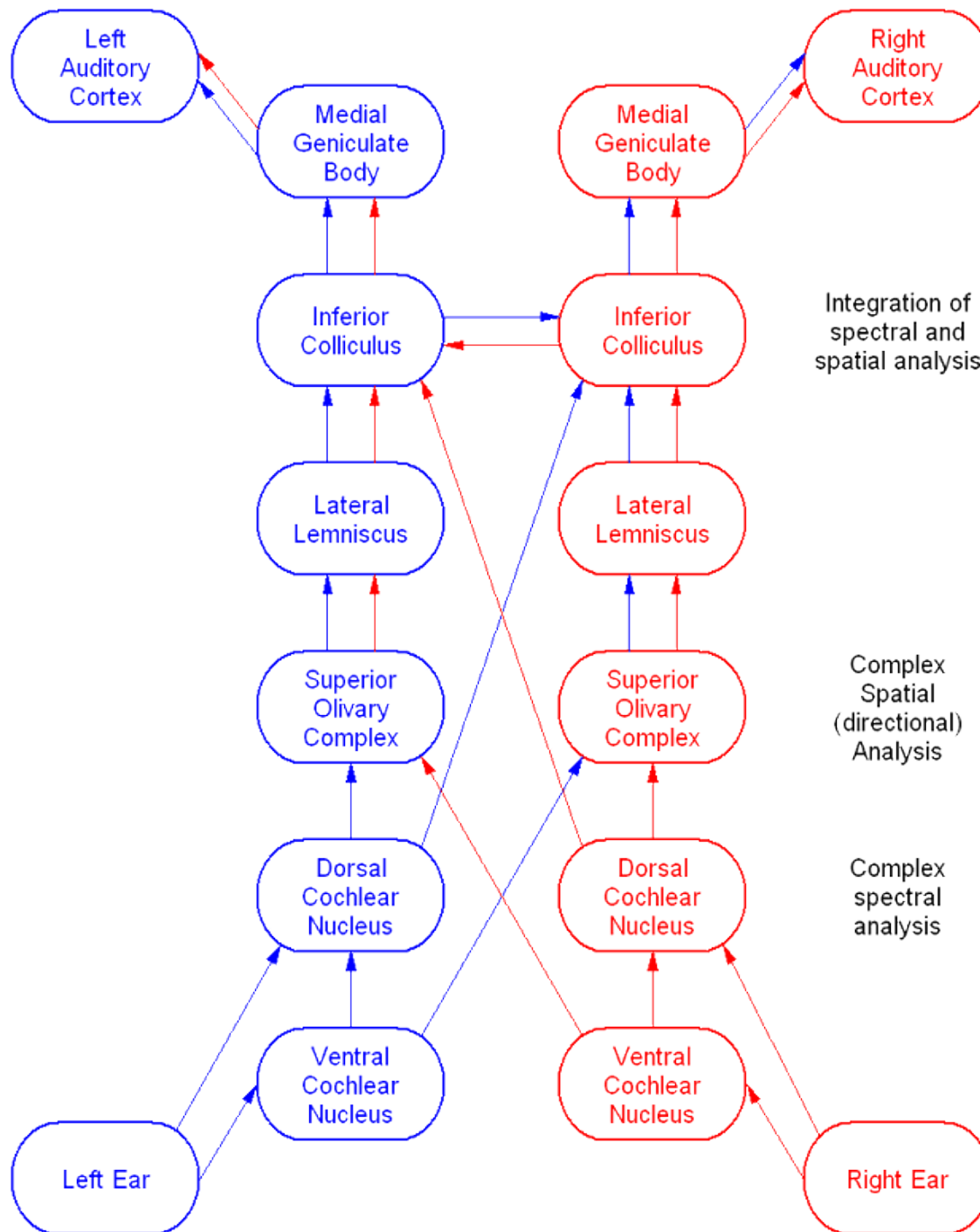
- **CMP** :-Sum of receptor potentials of a number of hair cells (outer hair cells)
- Do not have latent period or refractory period
- Do not follow all or none law.
- does not propagate
- Synchronise with frequency of acoustic stimulus
- Resistant to anaesthesia or ischaemia
- Kanamycin which selectively destroys outer hair cells ,decrease CMP

Action potential in 8th nerve fibers



- Compound action potential is recorded.
- Activity of large number of cochlear afferent fibers.
- Baseline impulses (8-10/sec) are continuously send to CNS
- When hair cells depolarise this impulses increase in number & when hyperpolarise then impulses decrease





Left Auditory Cortex

Right Auditory Cortex

Medial Geniculate Body

Medial Geniculate Body

Inferior Colliculus

Inferior Colliculus

Lateral Lemniscus

Lateral Lemniscus

Superior Olivary Complex

Superior Olivary Complex

Dorsal Cochlear Nucleus

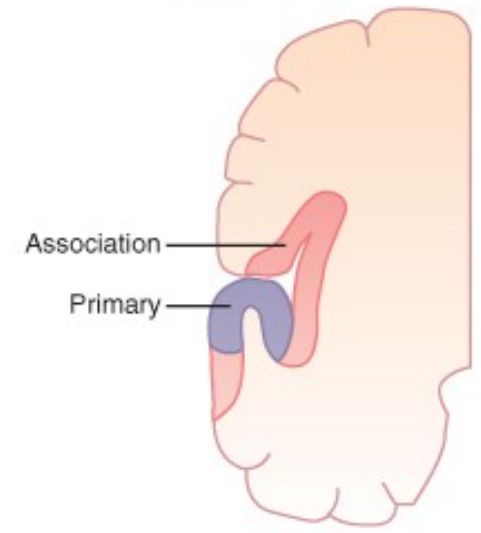
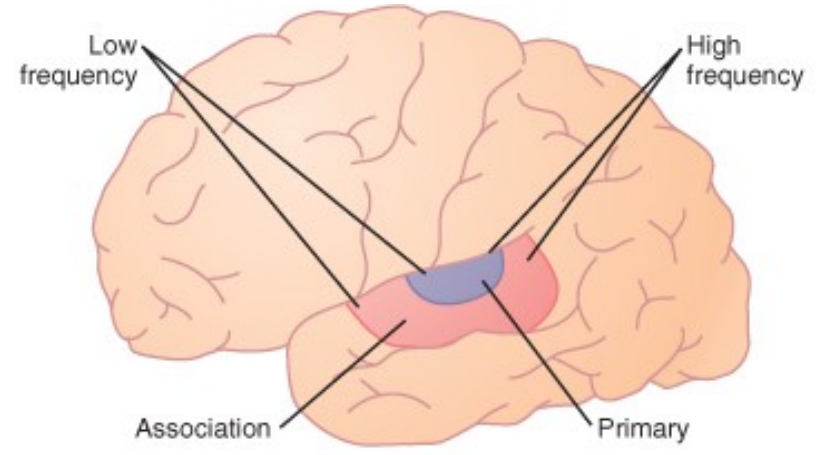
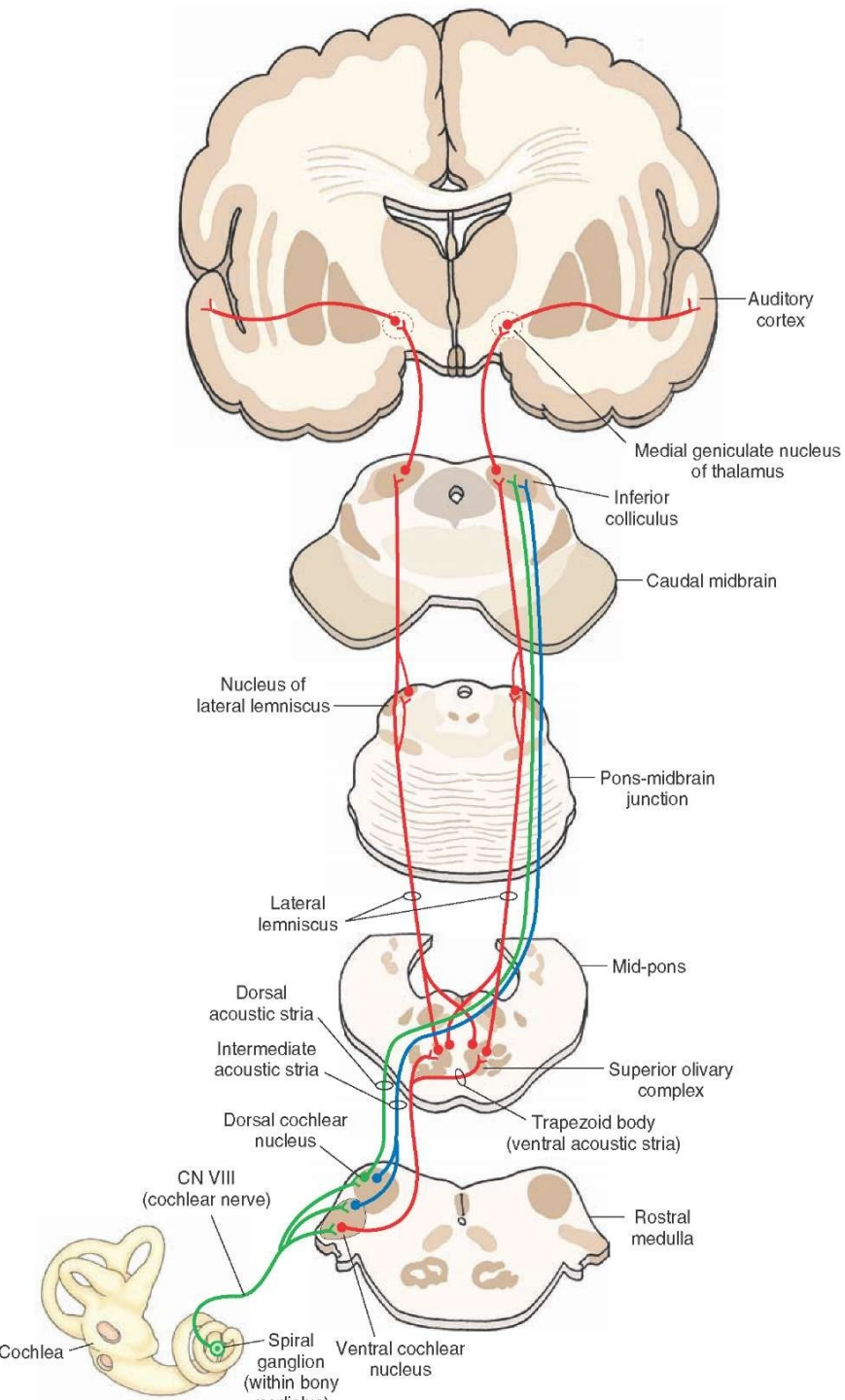
Dorsal Cochlear Nucleus

Ventral Cochlear Nucleus

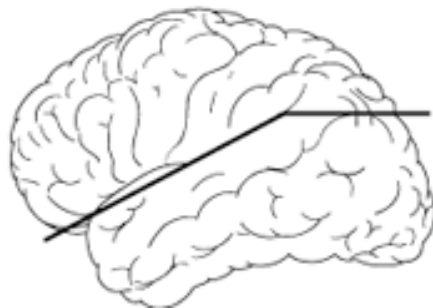
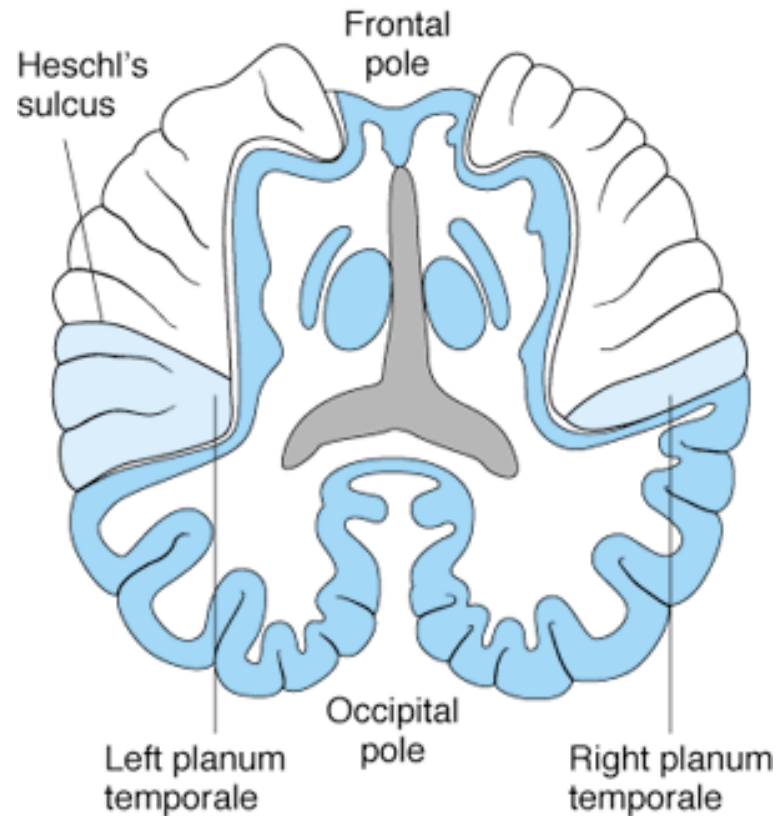
Ventral Cochlear Nucleus

Left Ear

Right Ear



6 tonotopic maps in auditory cortex



Applied

Deafness:-

- **Conductive**
- **Sensorineural**
- **Syndromic & non syndromic**
- **Pendred syndrome (bilateral neural deafness with decreased thyroid function due to mutant sulfate protein)**
- **Long QT syndrome:- mutation of one of K channel protein**

- **Presbycusis**
- **Tinnitus**:- ringing sensation of the ear. Irritative stimulation of either inner ear or 8th nerve. Acoustic neuroma (tumor of schwann cells of 8th nerve) irritates 8th nerve.

Thank you