BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024,
Tamil Nadu, India

Programme: M.Sc., Biomedical science

Course Title : Human Anatomy & Physiology

Course Code : BM12C2

Unit-II

TOPIC: Auditory System

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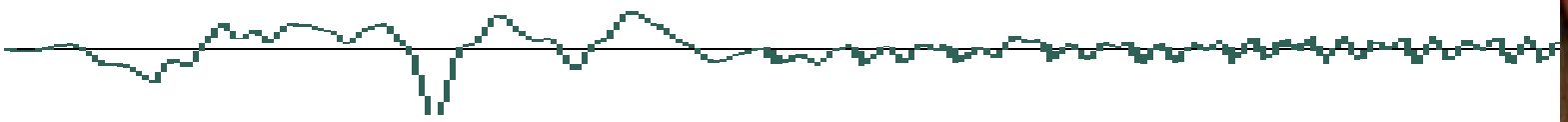
Major Divisions of the Ear



Peripheral Mechanism

Central Mechanism

Outer Ear

Middle Ear

Inner Ear

VIII Cranial Nerve

Brain

Outer Ear

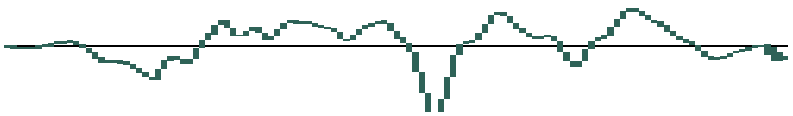
Function of Outer Ear

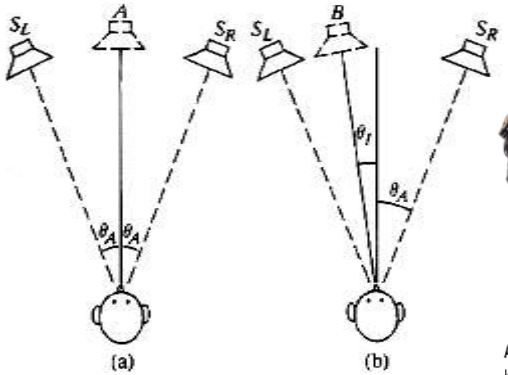
Pinna

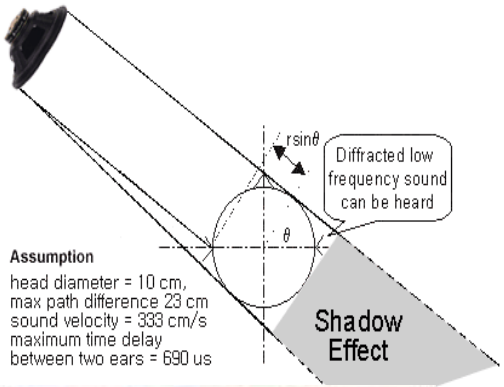
External Auditory Meatus

- Collect sound
- Localization
- Resonator
- Protection
- Sensitive (earlobe)

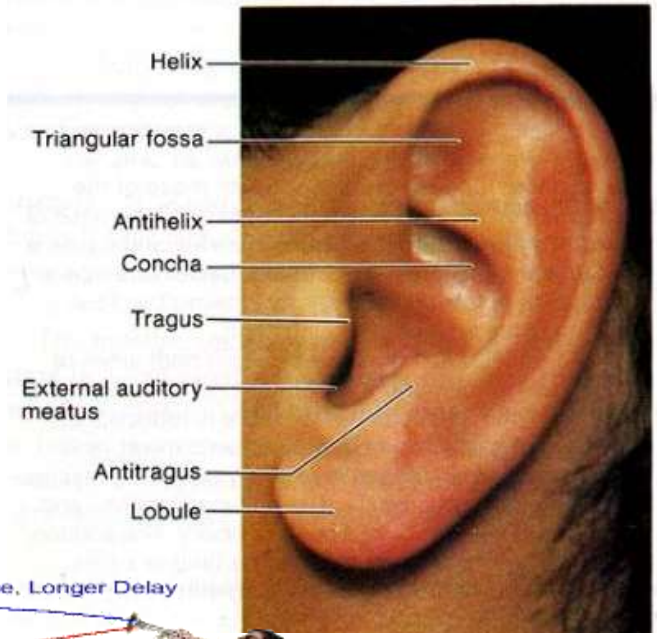
Pinna



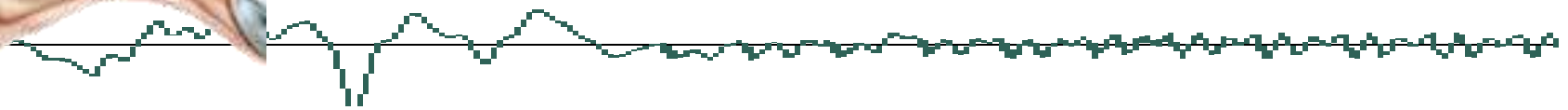




- The visible portion that is commonly referred to as "the ear"
- Helps localize sound sources
- Directs sound into the ear
- Each individual's pinna creates a distinctive imprint on the acoustic wave traveling into the auditory canal



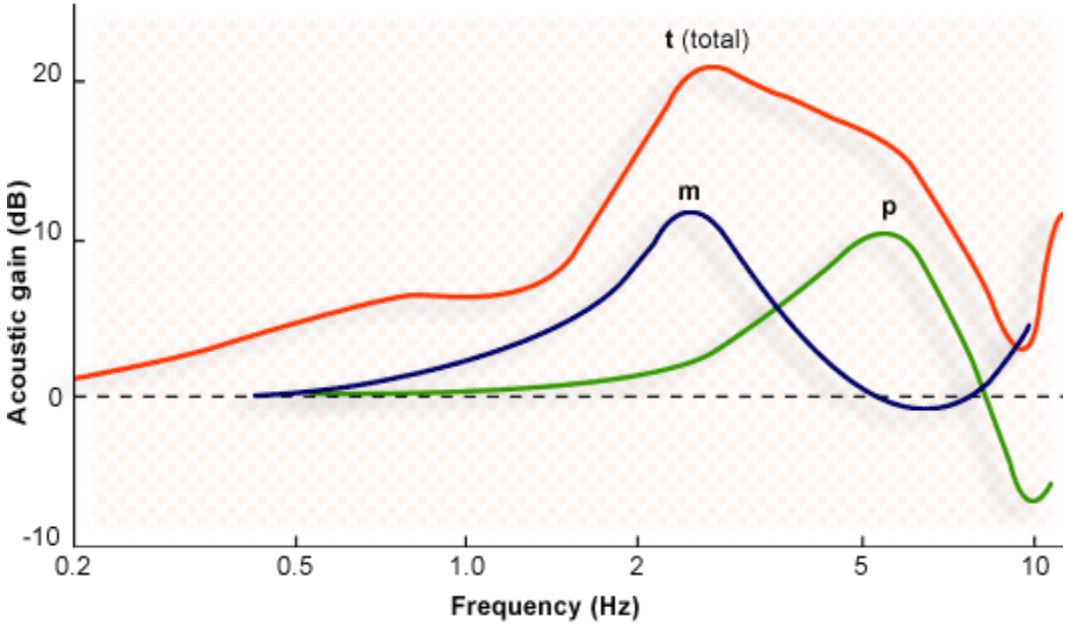
External Auditory Meatus



- Extends from the pinna to the tympanic membrane
  - About 26 millimeters (mm) in length and 7 mm in diameter in adult ear.
  - Size and shape vary among individuals.
- Protects the eardrum
- Resonator
  - Provides about 10 decibels (dB) of gain to the eardrum at around 3,300 Hertz (Hz).
- The net effect of the head, pinna, and ear canal is that sounds in the 2,000 to 4,000 Hz region are amplified by 10 to 15 dB.
  - Sensitivity to sounds greatest in this frequency region
  - Noises in this range are the most hazardous to hearing

Outer Ear Resonance

- Influence of pinna (p)
- Influence of ear canal (c)
- Combine influence (t)
- At 3000 Hz, the final amplification (t) is 20 dB

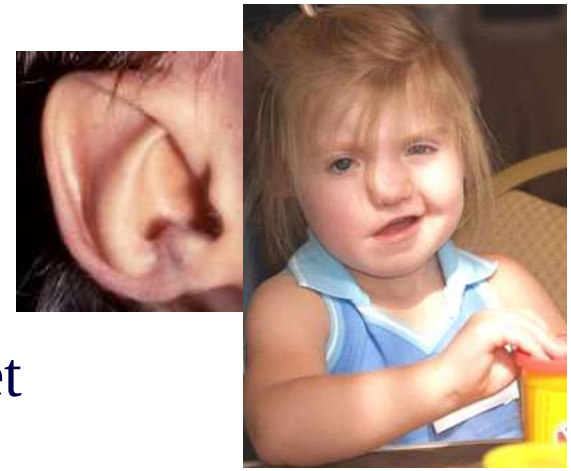


Cerumen

- The purpose of wax:
  - Repel water
  - Trap dust, sand particles, micro-organisms, and other debris
  - Moisturize epithelium in ear canal
  - Odor discourages insects
  - Antibiotic, antibacterial, antifungal properties
  - Cleanse ear canal

Outer Ear Hearing Disorders

- Outer ear
- CHARGE
- Down Syndrome
  - Ears small and low set
- Fetal Alcohol Syndrome
  - Deformed ears
- DiGeorge syndrome
  - Low set ears



External Ear Care

Hazardous to health:

- Ear candling
- Swabs
- Foreign objects

Middle Ear

Tympanic Cavity
Tympanic Membrane
Ossicles
Middle Ear Muscles
Eustachian Tube
Mastoid

Middle Ear Cavity

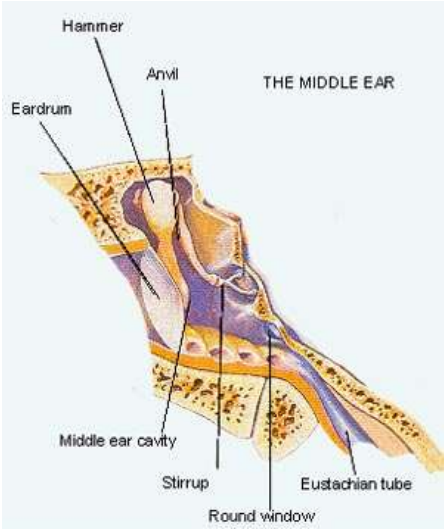
Ossicles

Middle Ear Muscles

Mastoid

Eustachian Tube

Function Amplifier



Cholesteatoma

Temporal bone fractures

Otitis Media

PE tubes Otosclerosis

Function of Middle Ear

- Conduction
  - Conduct sound from the outer ear to the inner ear
- Protection
  - Creates a barrier that protects the middle and inner areas from foreign objects
  - Middle ear muscles may provide protection from loud sounds
- Transducer
  - Converts acoustic energy to mechanical energy
  - Converts mechanical energy to hydraulic energy
- Amplifier
  - Transformer action of the middle ear
  - only about 1/1000 of the acoustic energy in air would be transmitted to the inner-ear fluids (about 30 dB hearing loss)

Middle Ear

Tympanum:

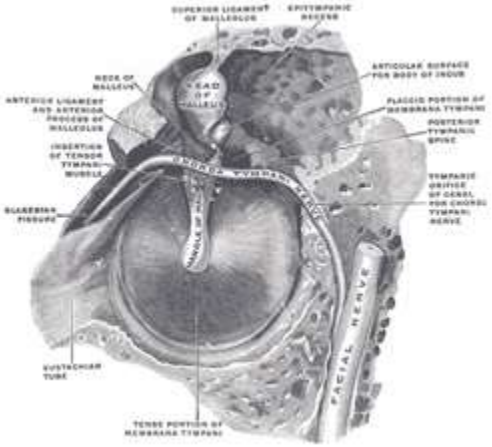
Timpani, or kettledrums, are musical instruments in the percussion family.

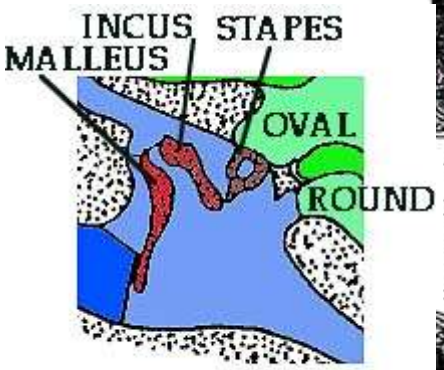
A type of drum, they consist of a skin called a head stretched over a large bowl commonly made of copper.

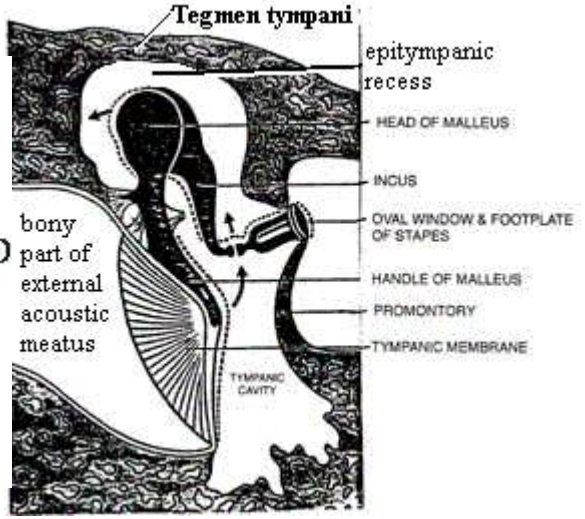
They are played by striking the head with a special drum stick called a timpani stick.

Timpani evolved from military drums to become a staple of the classical orchestra in the 17th century.

Today, they are used in many types of musical ensembles including classical orchestra

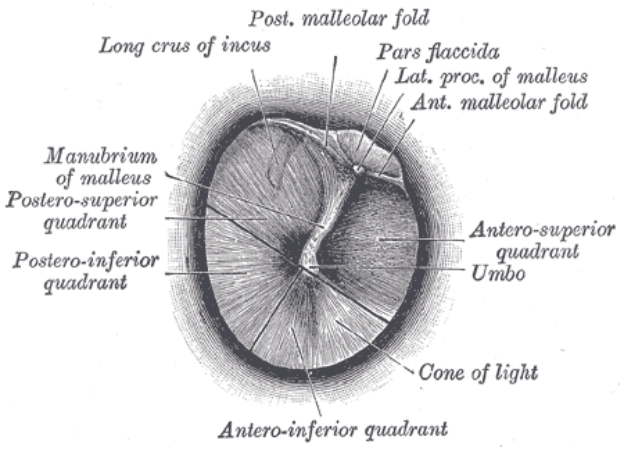




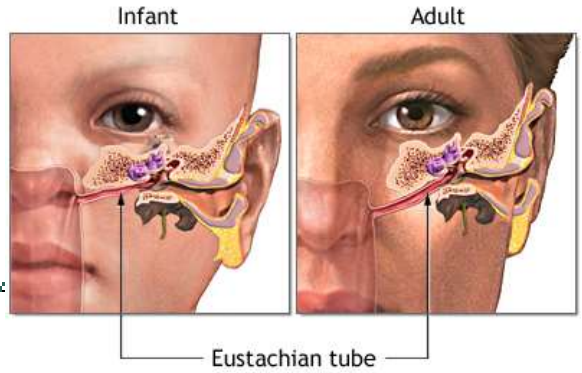


Tympanic Membrane

- The eardrum separates the outer ear from the middle ear
- Creates a barrier that protects the middle and inner areas from foreign objects
- Cone-shaped in appearance
  - about 17.5 mm in diameter
- The eardrum vibrates in response to sound pressure waves.
- The membrane movement is incredibly small
  - as little as one-billionth of a centimeter



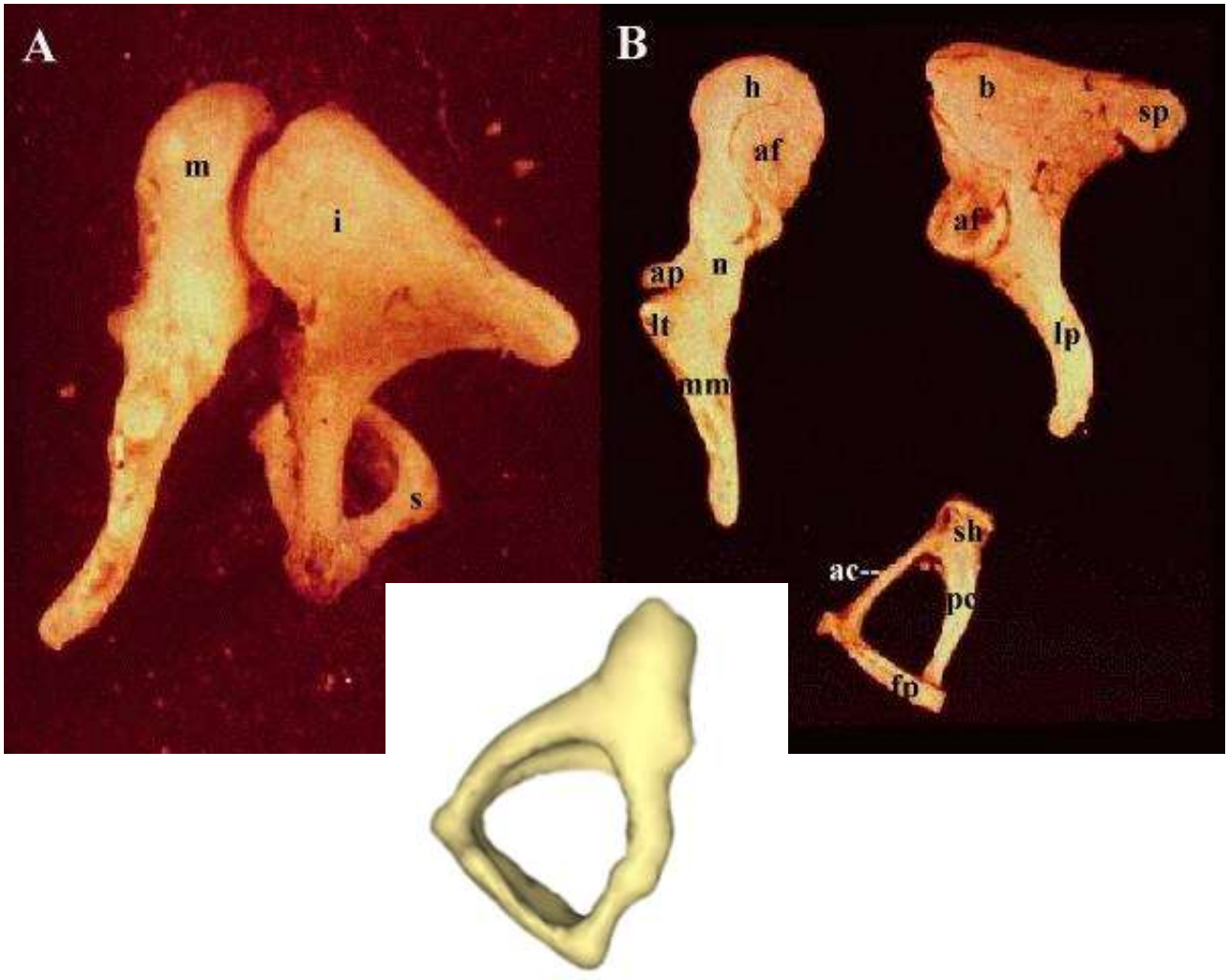
Eustachian Tube



- The eustachian tube connects the front wall of the middle ear with the nasopharynx
- The eustachian tube also operates like a valve, which opens during swallowing and yawning
  - This equalizes the pressure on either side of the eardrum, which is necessary for optimal hearing.
  - Without this function, a difference between the static pressure in the middle ear and the outside pressure may develop, causing the eardrum to displace inward or outward
    - This reduces the efficiency of the middle ear and less acoustic energy will be transmitted to the inner ear.

Ossicles

- Malleus (hammer)
- Incus (anvil)
- Stapes (stirrup) smallest bone of the body

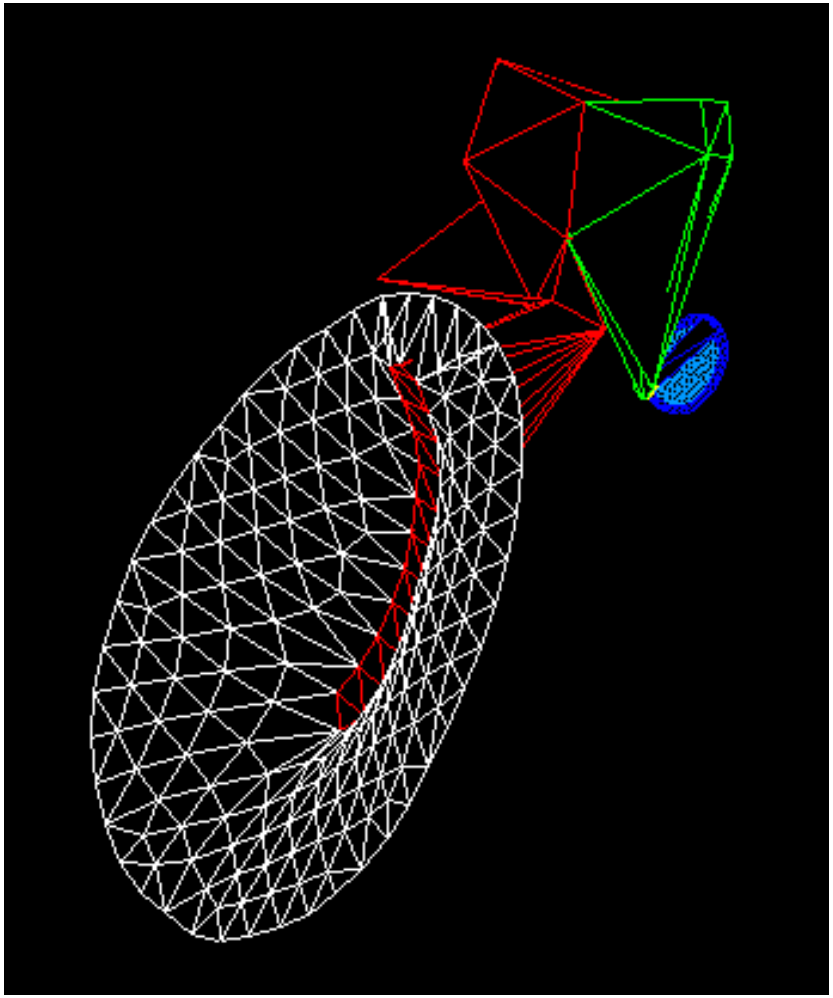


Transformer/Amplifier

- Transform the vibrating motion of the eardrum into motion of the stapes.
- The middle ear enhances the transfer of acoustical energy in two ways:
  - The area of the eardrum is about 17 times larger than the oval window
    - The effective pressure (force per unit area) is increased by this amount.
  - The ossicles produce a lever action that further amplifies the pressure
- Without the transformer action of middle ear, about 1/1000 of acoustic energy in air transmitted to inner-ear fluids (about 30 dB loss).
- Malleus and incus vibrate together, transmitting the sound waves from the eardrum to the footplate of the stapes (this pushes the oval window in and out)(mechanical energy)

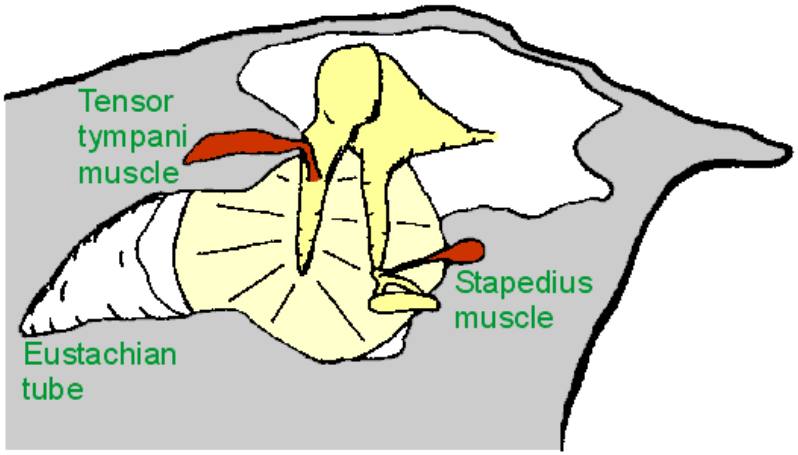
Transformer/Amplifier

- Area ratio
  - Thumbtack
- Lever
  - crowbar



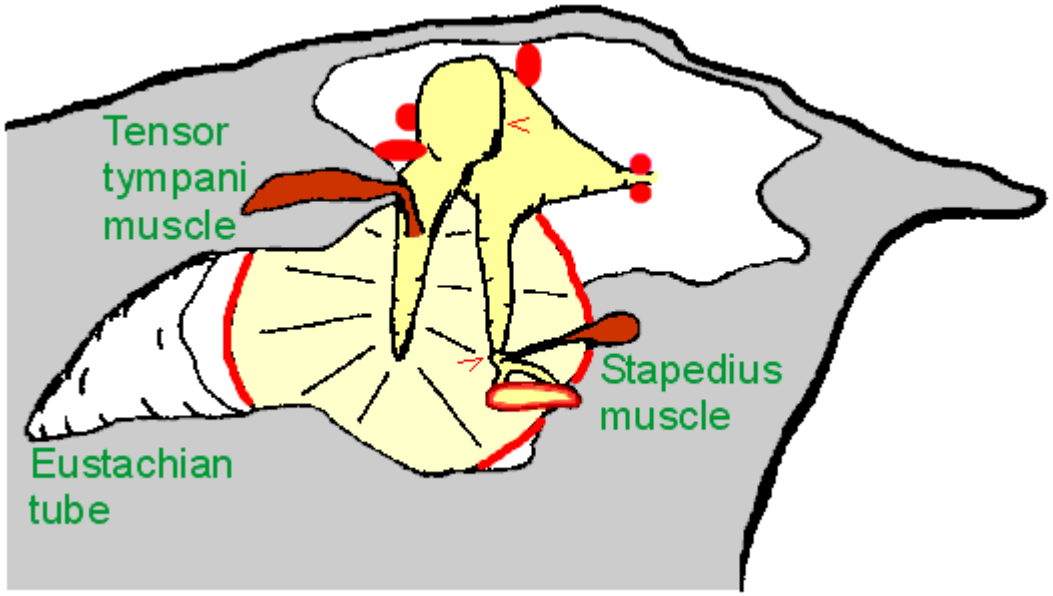
Middle Ear Muscles

- Tensor tympani
  - Attached to malleus
  - Innervated by V, trigeminal nerve
- Stapedius
  - Attached to stapes
  - Innervated by VII, facial nerve
- Middle Ear Muscle Function:
  - Help maintain ossicles in proper position
  - Protect inner ear from excessive sound levels
    - When ear exposed to sound levels above 70 dB, the muscles contract, decreasing amount of energy transferred to inner ear
  - This protective reflex termed "acoustic reflex"

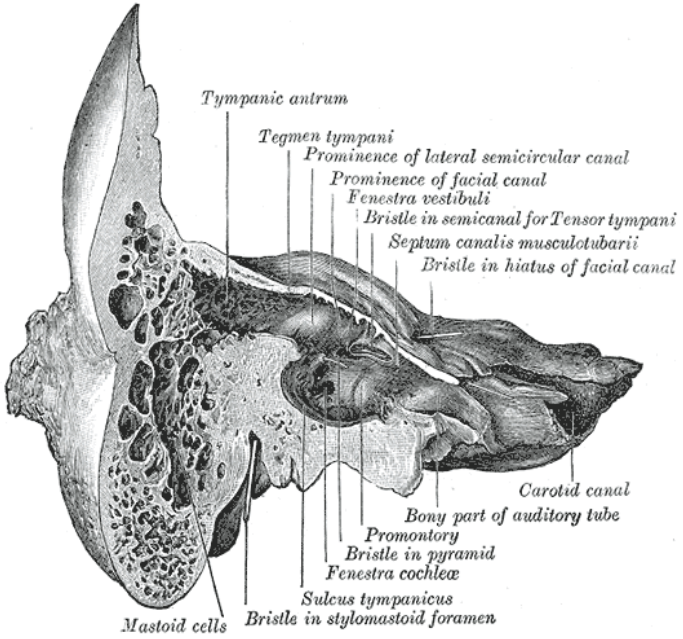


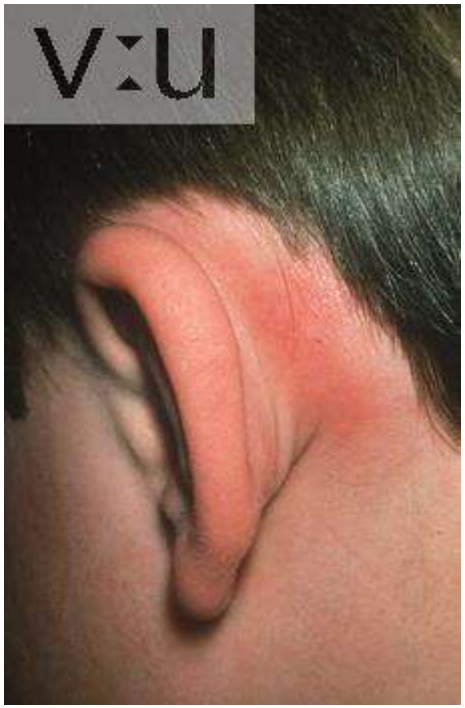
Ligaments of Middle Ear

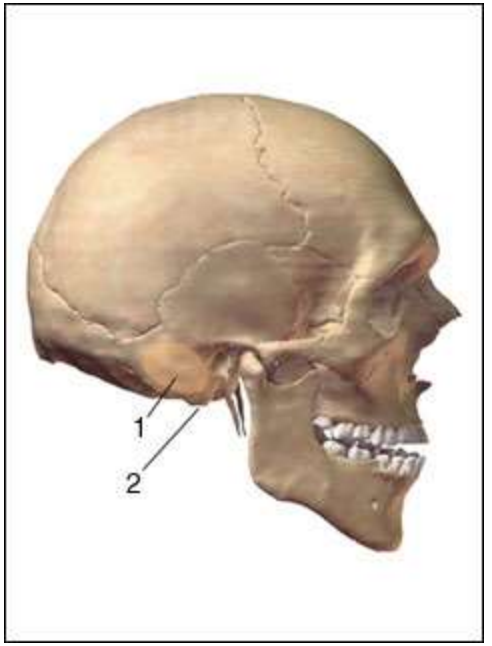
- Function
  - restrict and confine the effect of ossicles to act as a lever
  - restrict movements to reduce the chance of damage to the inner ear
  - prevents distortion to sound



Mastoid


Tympanic antrum
Tegmen tympani
Prominence of lateral semicircular canal
Prominence of facial canal
Fenestra vestibuli
Bristle in semicanal for Tensor tympani
Septum canalis musculotubarii
Bristle in hiatus of facial canal
Carotid canal
Bony part of auditory tube
Promontory
Bristle in pyramid
Fenestra cochleæ
Sulcus tympanicus
Mastoid cells
Bristle in stylomastoid foramen

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Middle Ear Disorders

- Middle Ear disorders
  - Acute otitis media
  - Otosclerosis
  - Disarticulation
  - Mastoiditis
  - Tympanosclerosis
  - OME
  - TM Perforation
  - TM Retraction
  - Cholesteatoma
- Down Syndrome
- Treacher Collins Syndrome
- BOR Syndrome

Inner Ear

Auditory

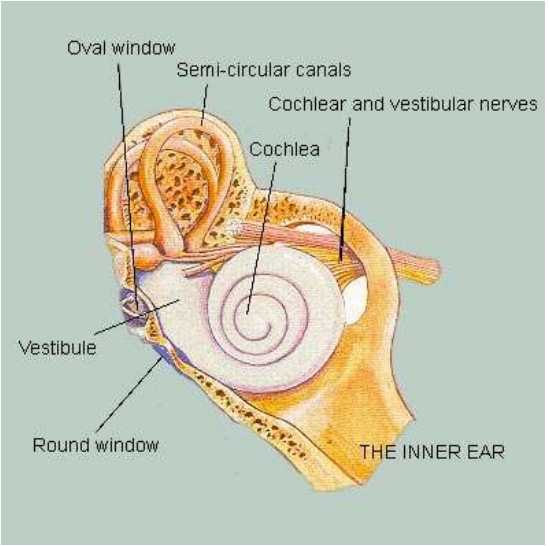
Vestibular

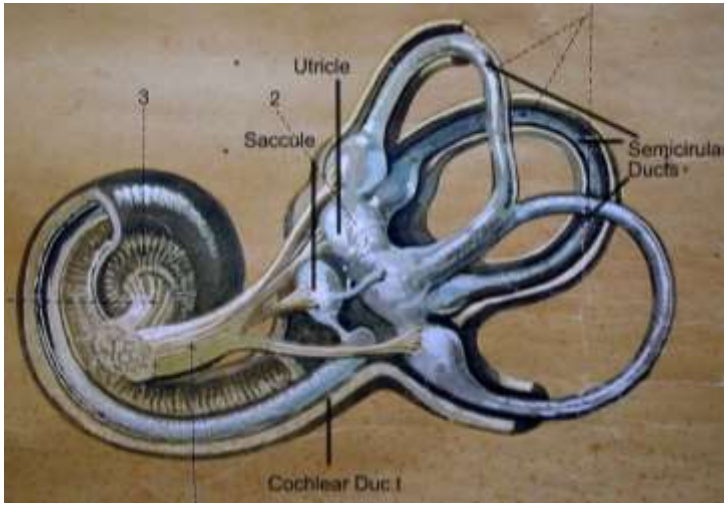
Vestibular

- semicircular canals
- utricle and saccule

Cochlear

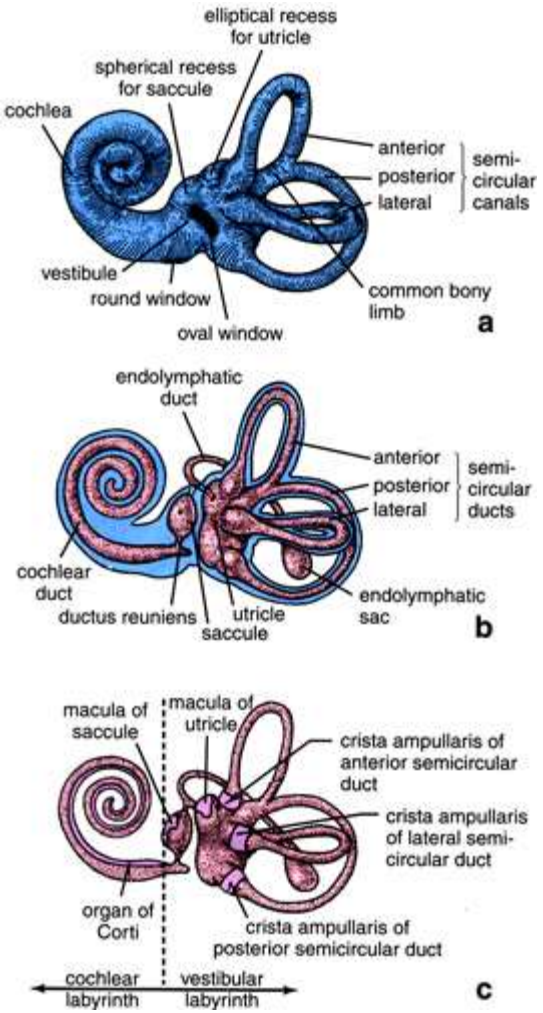
- traveling wave
- traveling wave
- traveling wave
- pathologies





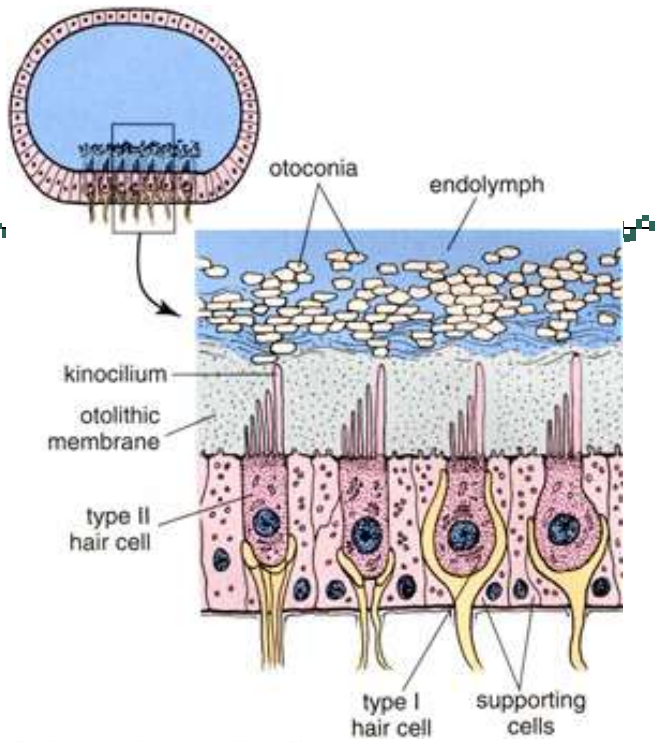
Function of Inner Ear

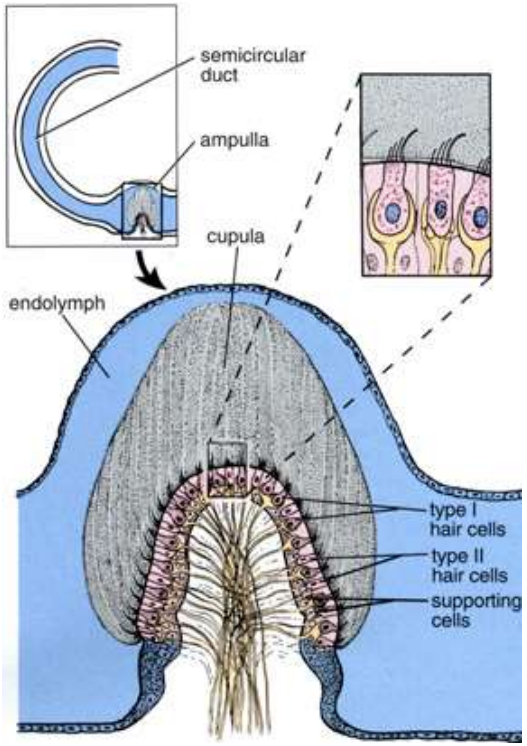
- Convert mechanical sound waves to neural impulses that can be recognized by the brain for:
  - Hearing
  - Balance

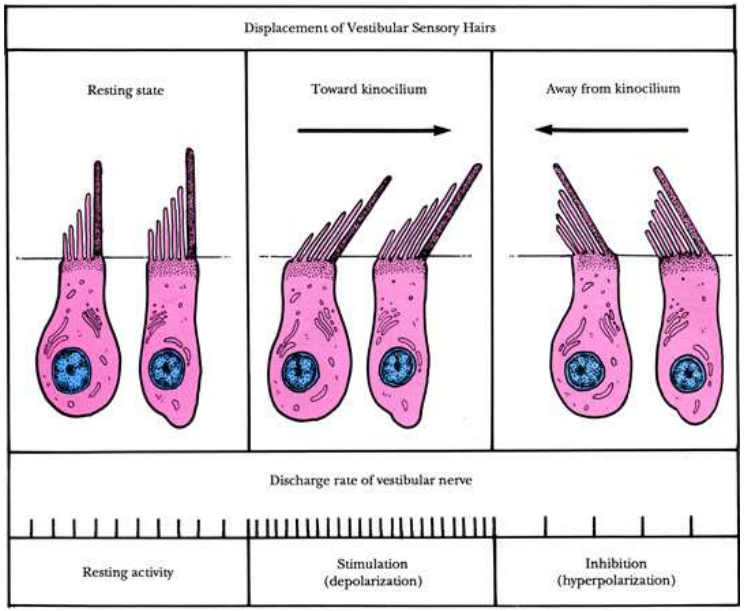


Balance

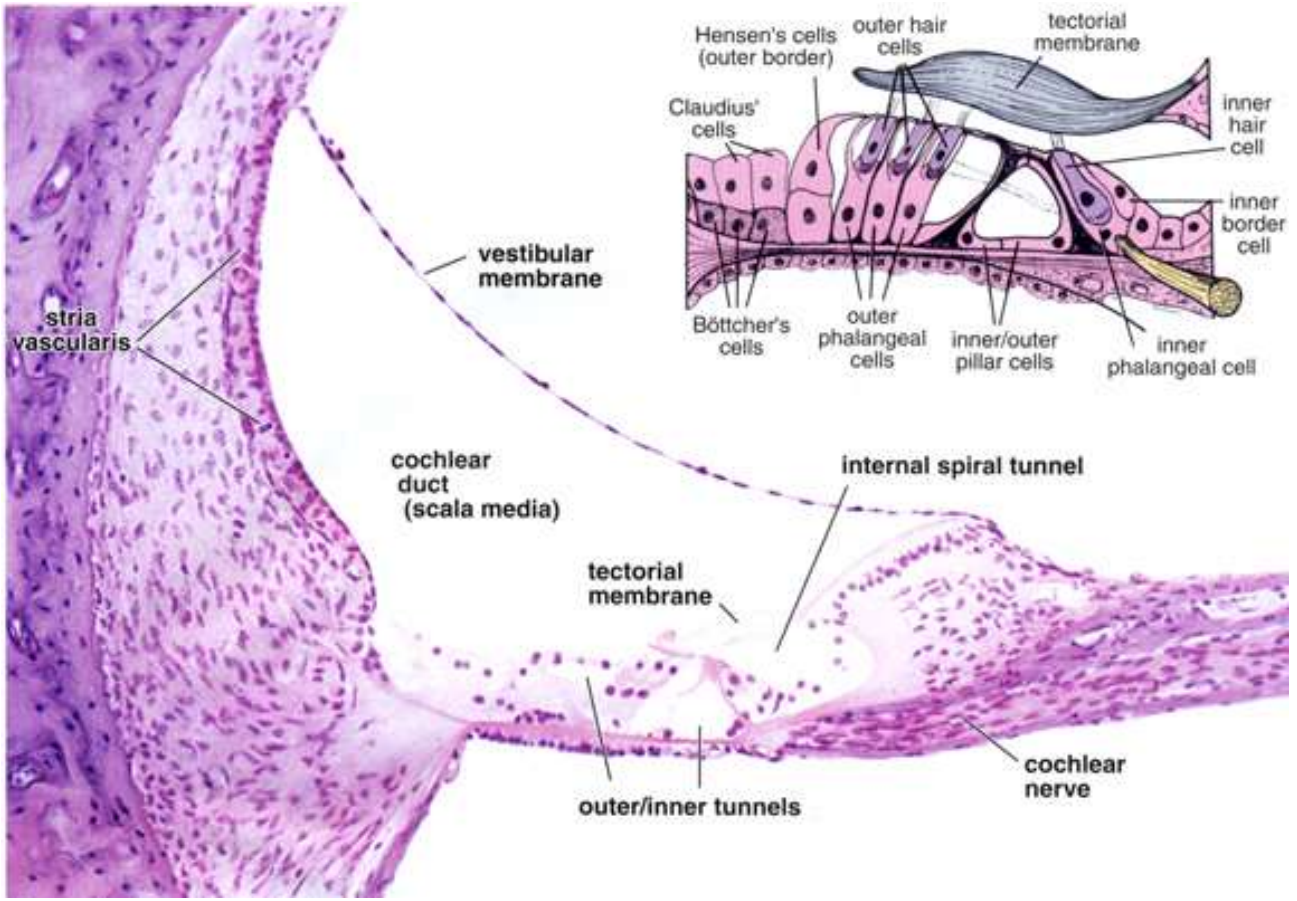
- Linear motion
- Rotary motion



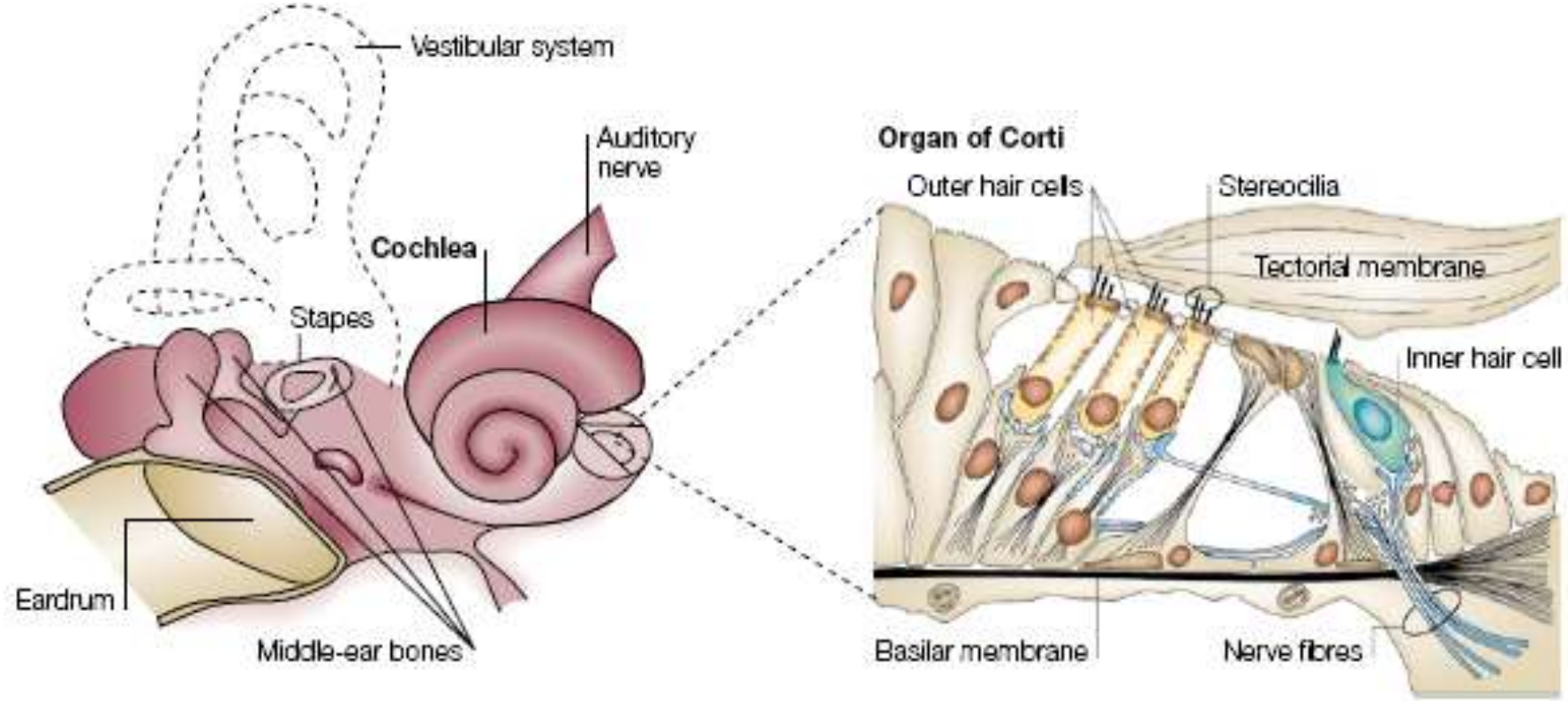




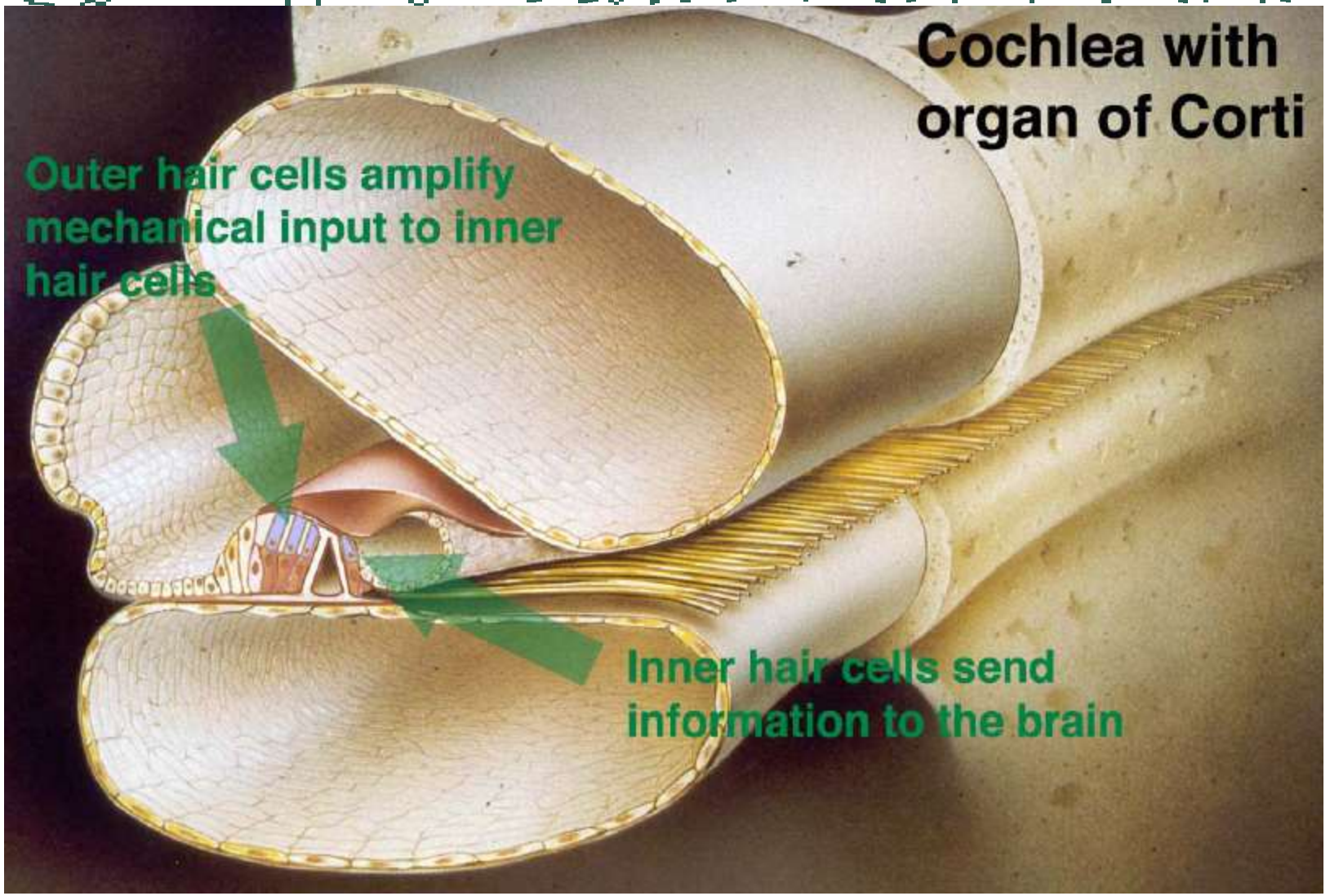
Organ of Corti



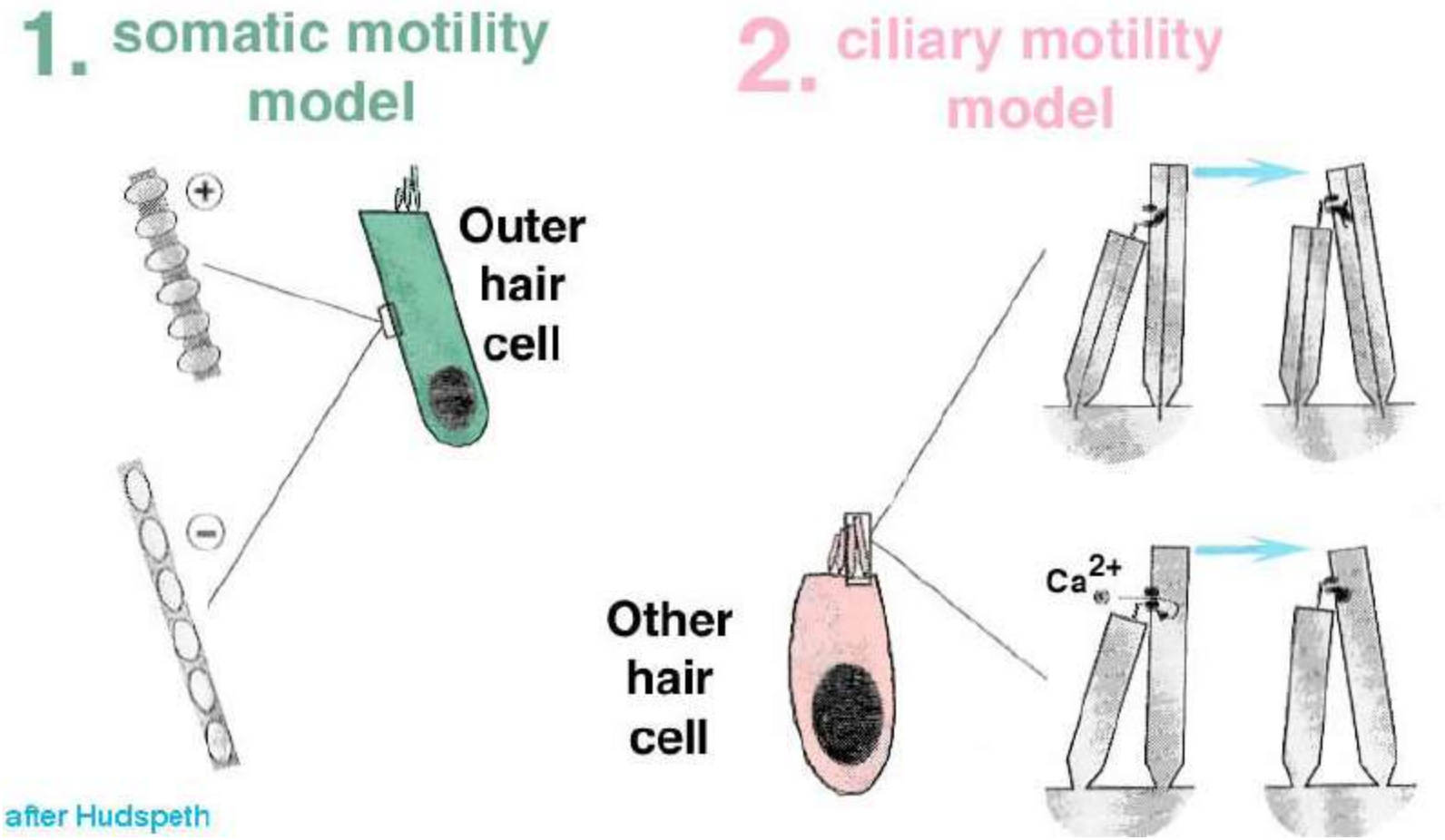
Organ of Corti



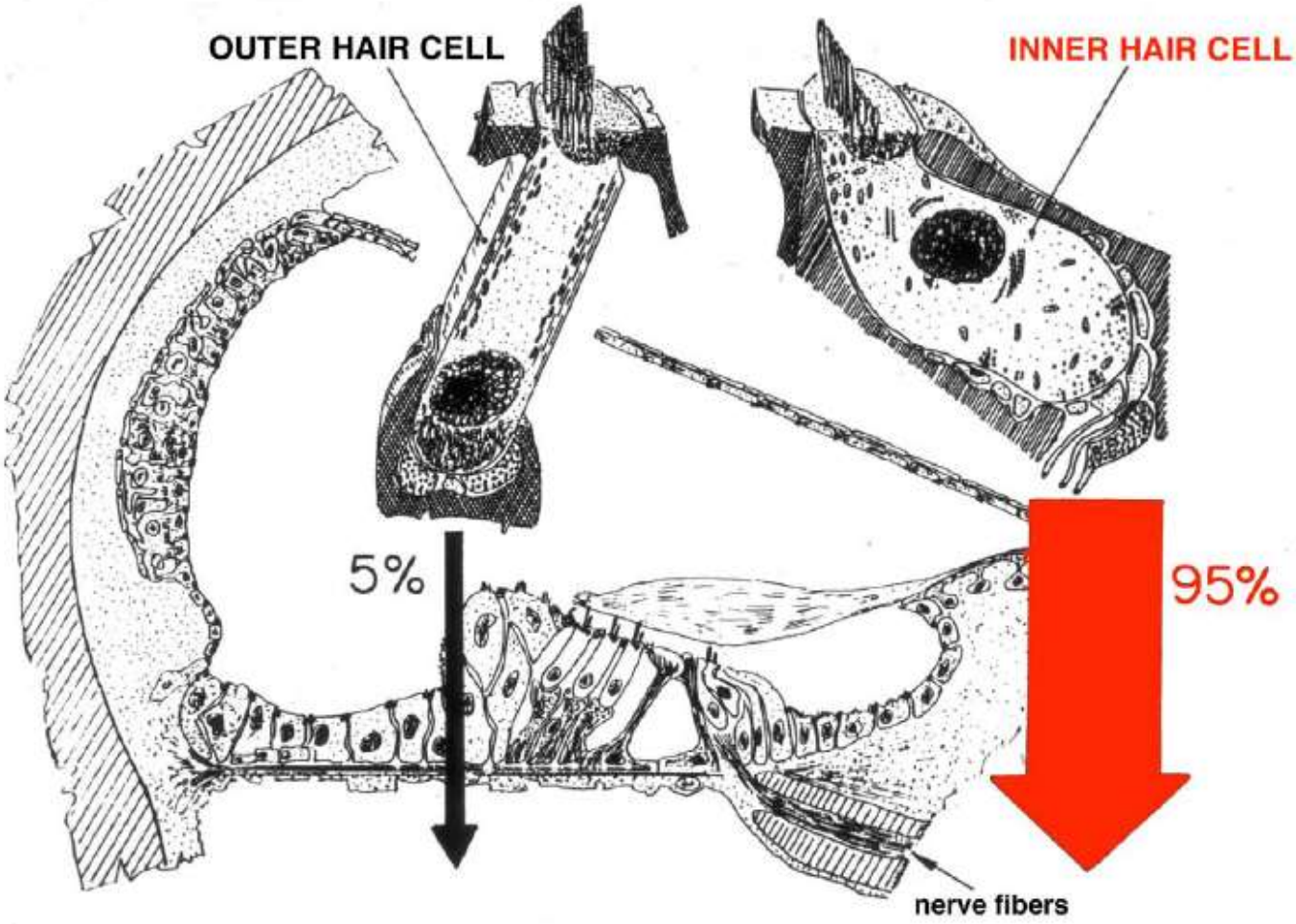
OHC vs. IHC Function



OHC Motility Models



Afferent Neural Innervations



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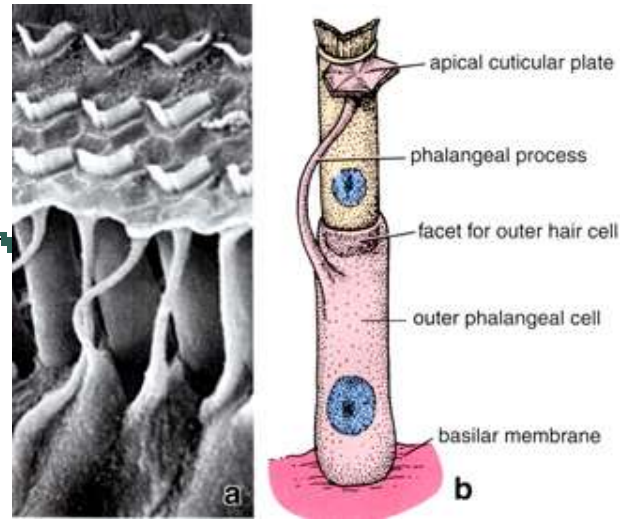
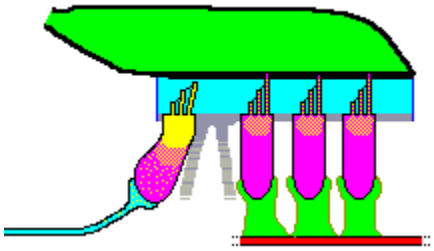
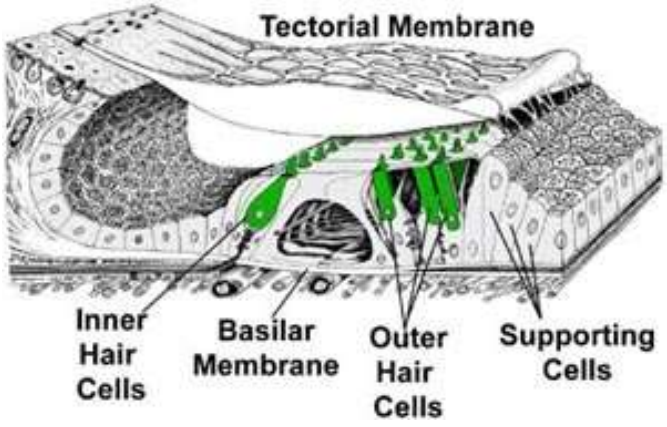
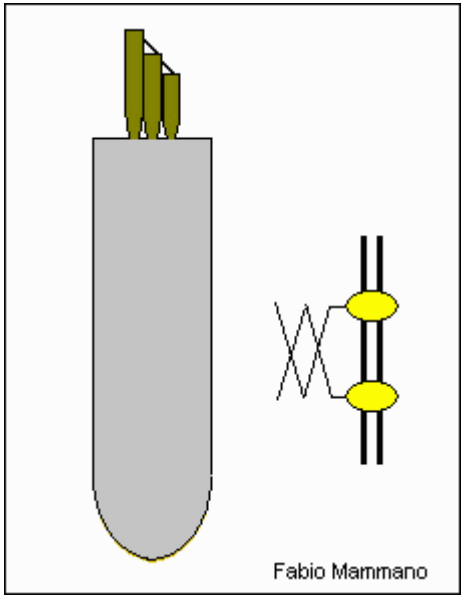
Hair Cells

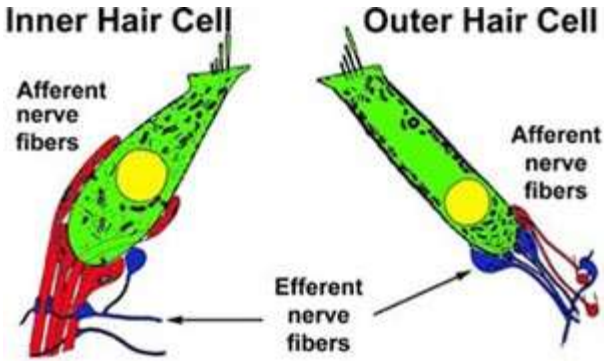
- Outer Hair Cells
- Inner Hair Cells



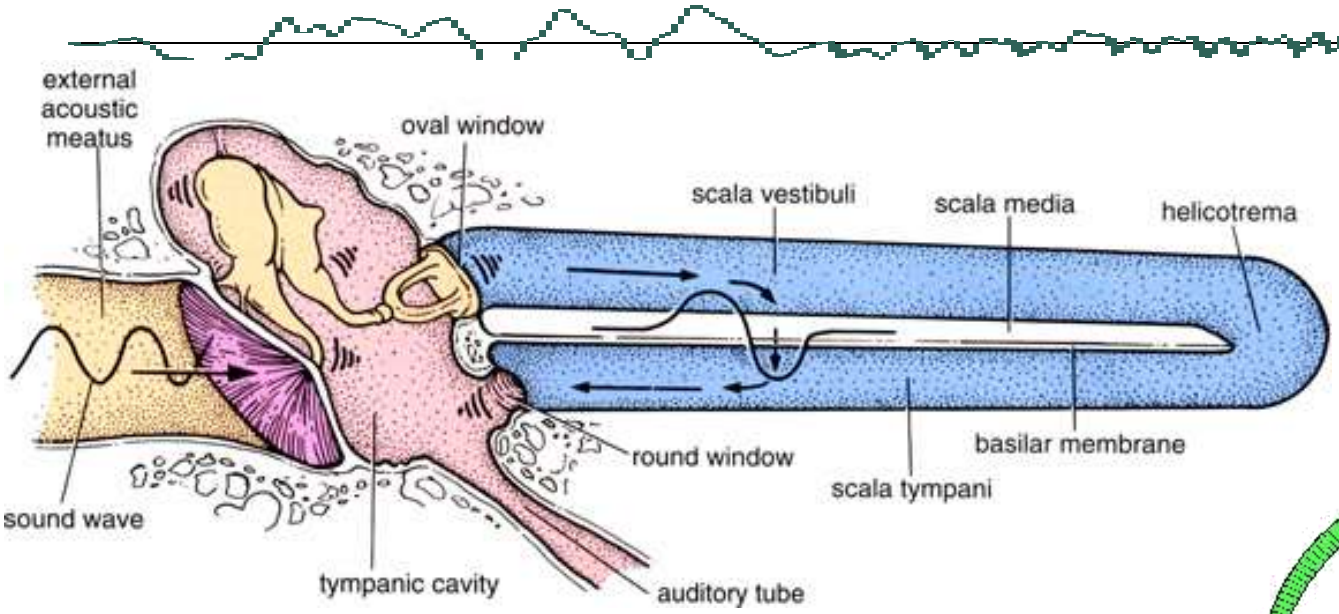


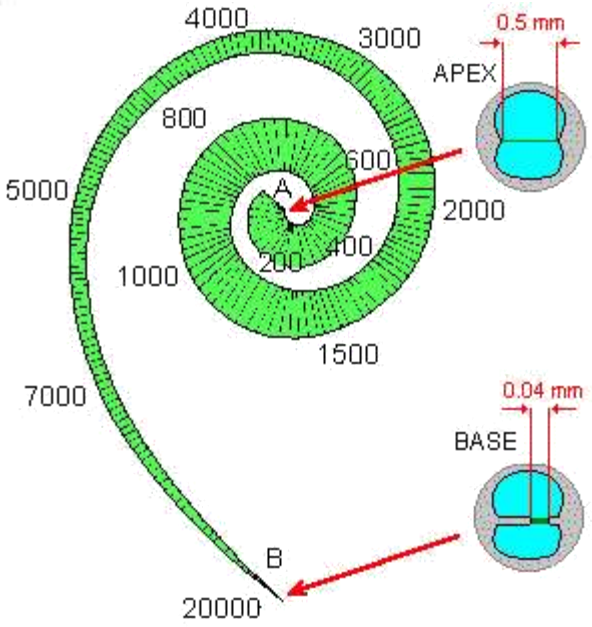






Traveling Waves



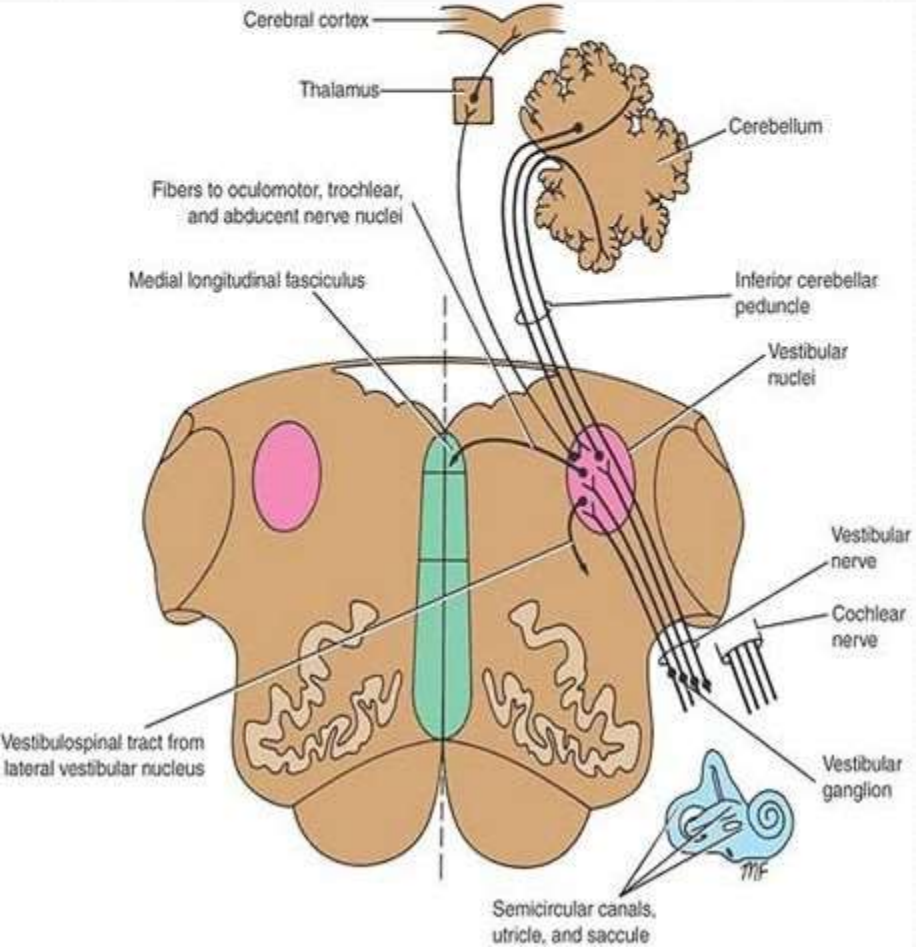


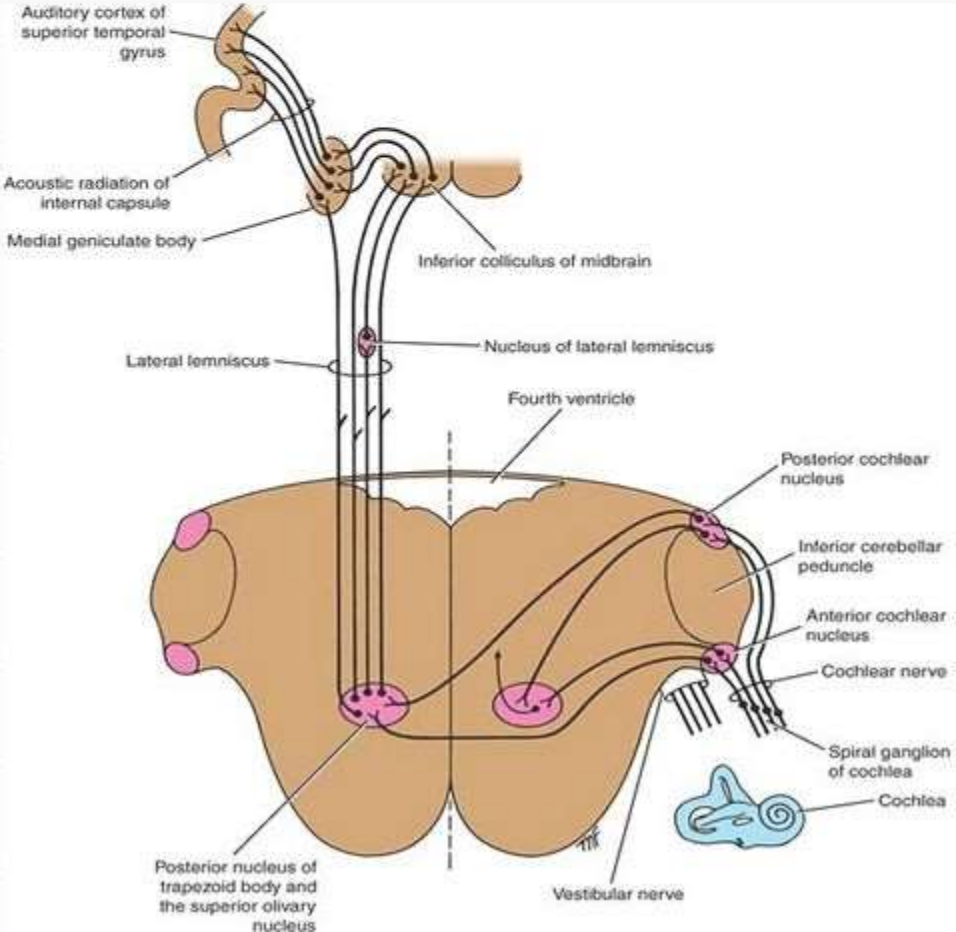
- Traveling wave
- Basilar membrane
- Traveling Wave info
- Cochlear Traveling Wave

Inner Ear Etiologies

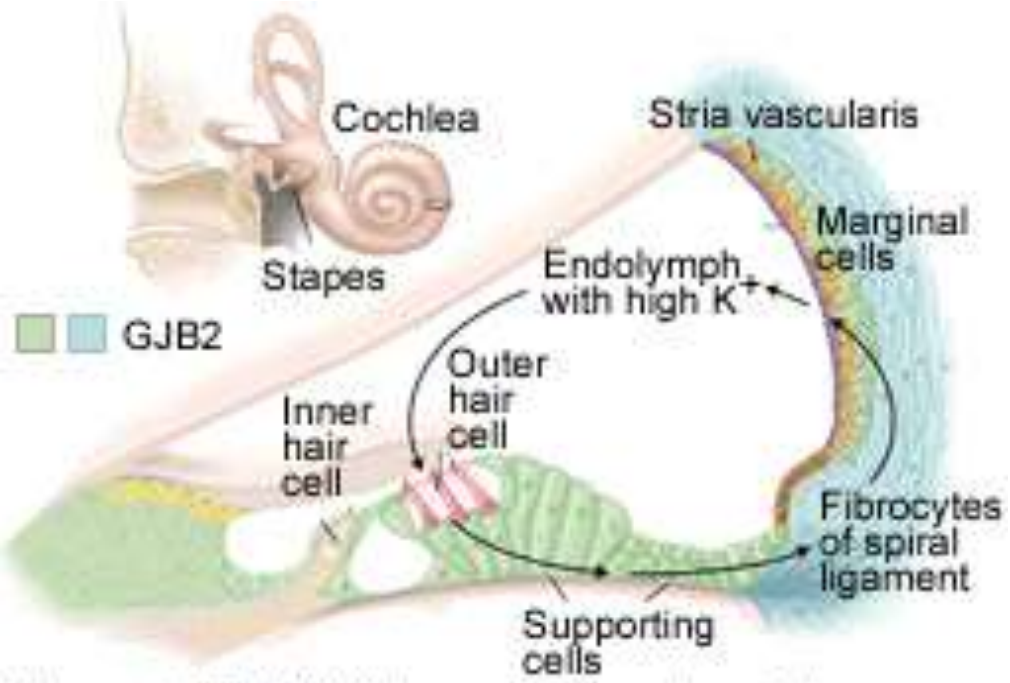
- Genetic
  - Connexin 26
- Excessive Noise
- Head Trauma
- Metabolic
  - Diabetes, thyroid dysfunction
- Ototoxic
  - Gentamiacin, cisplatin, etc.
- Disease

- **Vestibulocochlear Nerve (Cranial Nerve VIII)**
- **This nerve consists of two distinct parts:**
- **Vestibular nerve.** Nerve of equilibrium
- **Cochlear nerve.** Nerve of hearing
- **They are concerned with transmission of afferent information from internal ear to central nervous system.**





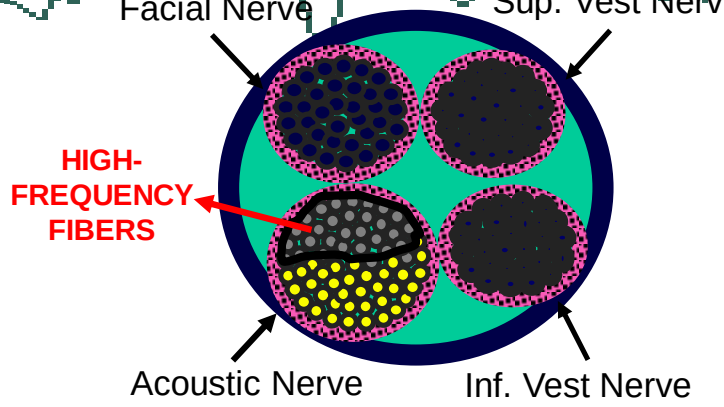
Connexin 26



Connexin 26 (GJB2) is one of the main proteins involved in potassium (K+) homeostasis in the cochlea of the inner ear. It is found in the supporting cells, fibrocytes of the spiral ligament and in cells of the spiral limbus.[Adapted from Steel, K.P. (1999) *Science* 285, 1363-1364, with permission.]

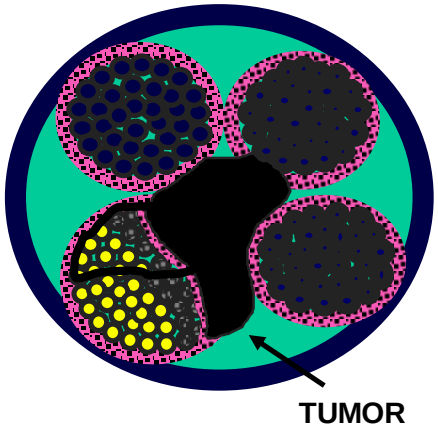
Standard ABR

Cross-section of Internal Auditory Canal

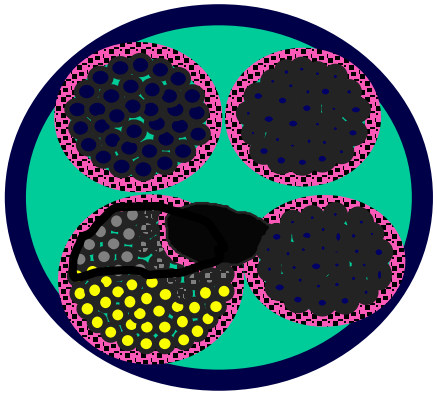


The wave V latency used in the standard ABR IT5 and I-V delay measures is dominated by neural activity from the high-frequency regions of the cochlea. Thus, unless the tumor affects these high-frequency fibers sufficiently, standard ABR latencies will be normal.

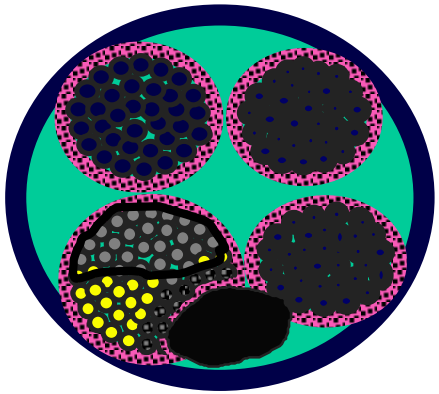
Large Tumor
Abnormal Standard ABR



Small Tumor
Abnormal Standard ABR

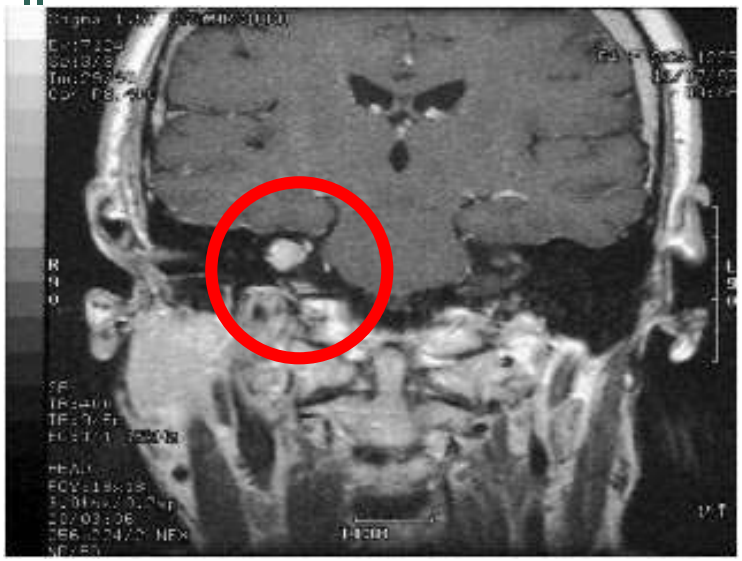


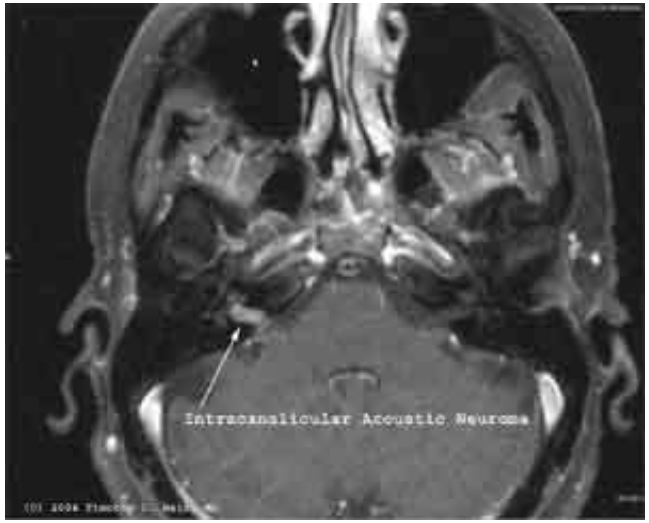
Small Tumor
Normal Standard ABR

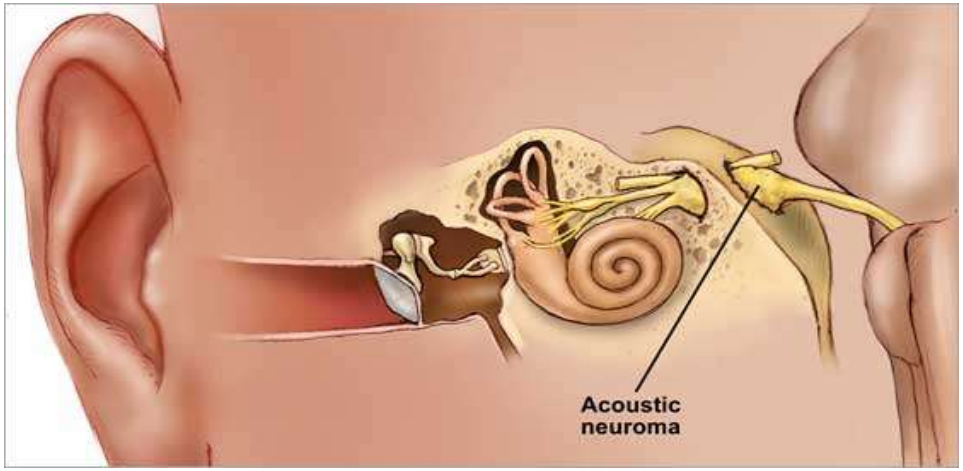


Acoustic Neuroma

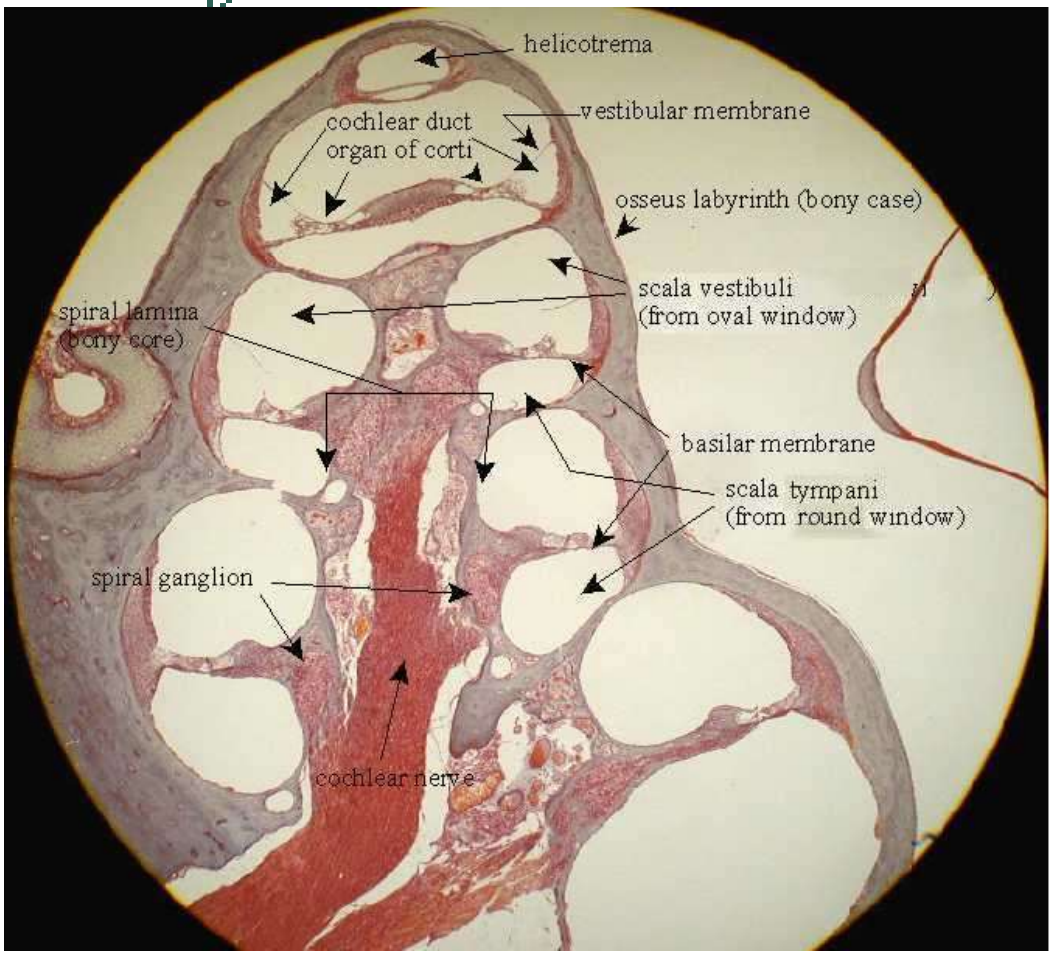
- Tumor







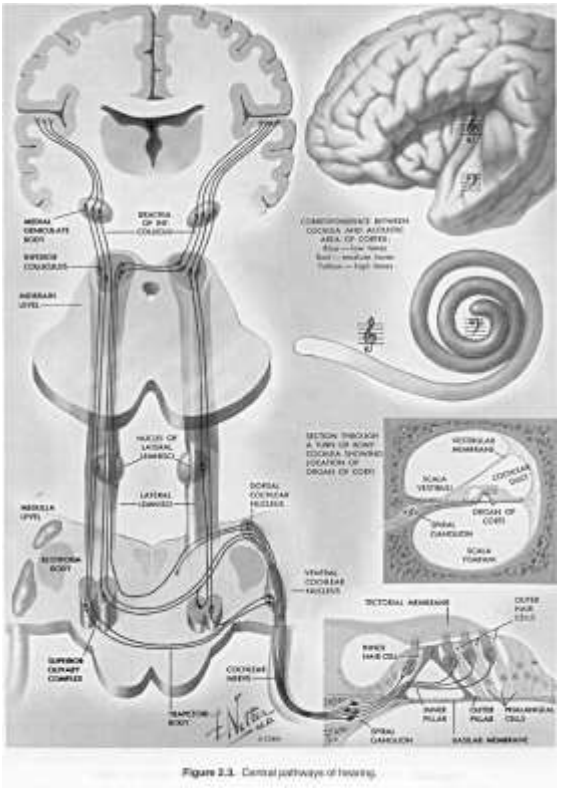
Spiral Ganglion



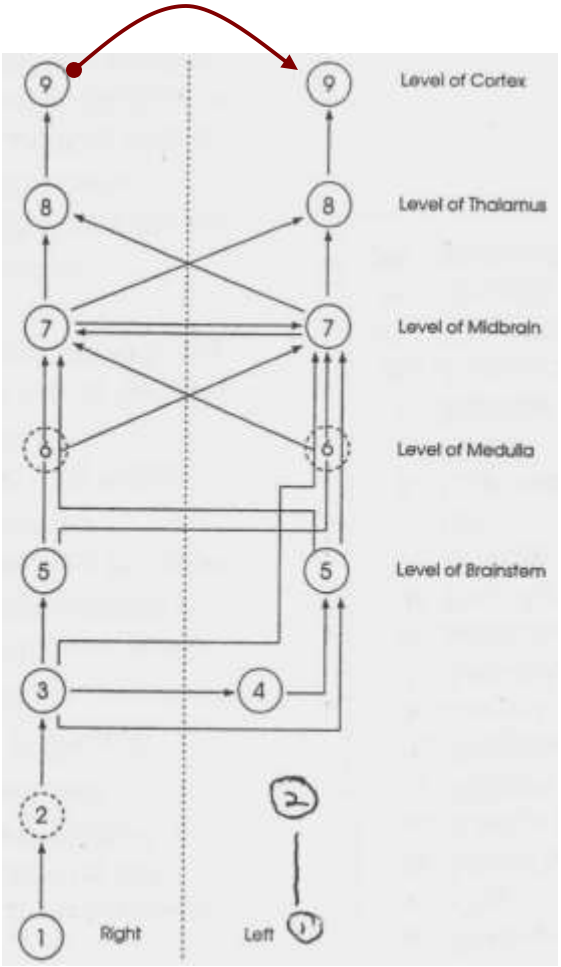
Central Auditory Mechanism

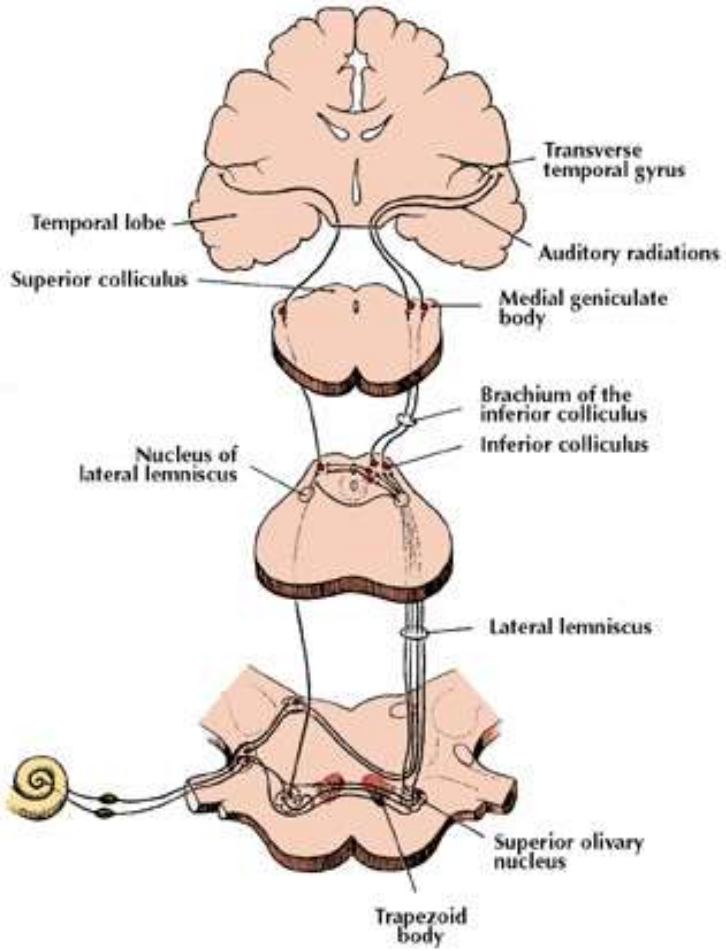
Auditory Path

Auditory Path



Central Auditory Path





Acknowledgement

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- Thanks are due to all the original contributors and entities whose pictures were used in the creation of this presentation.