AUDITORY SYSTEM

Zoology 403 (B)

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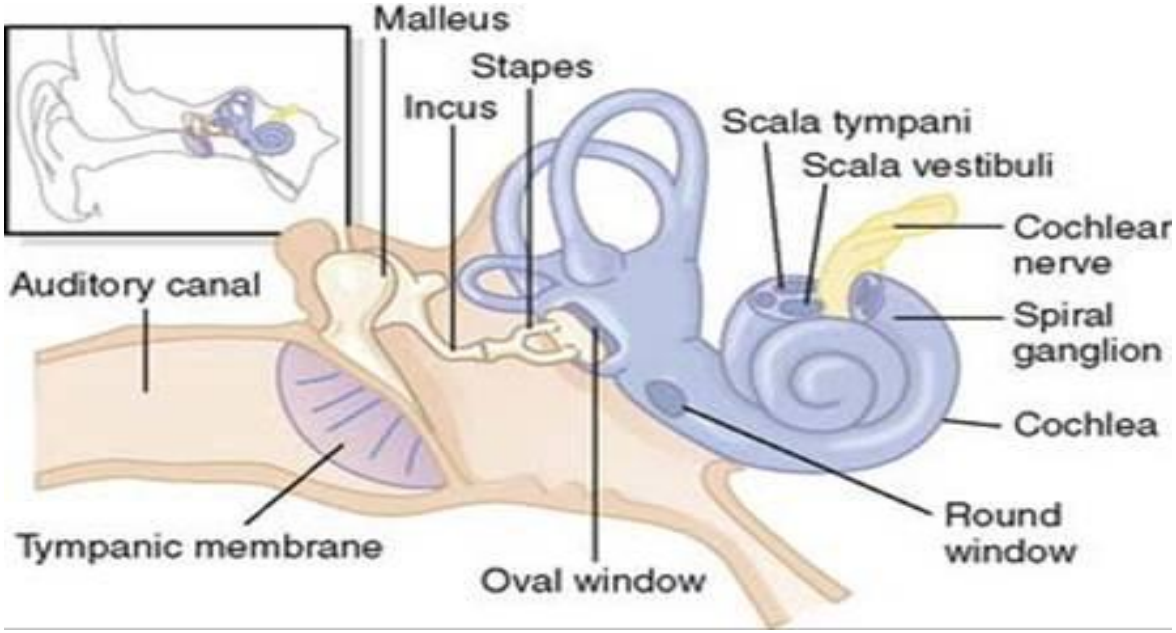
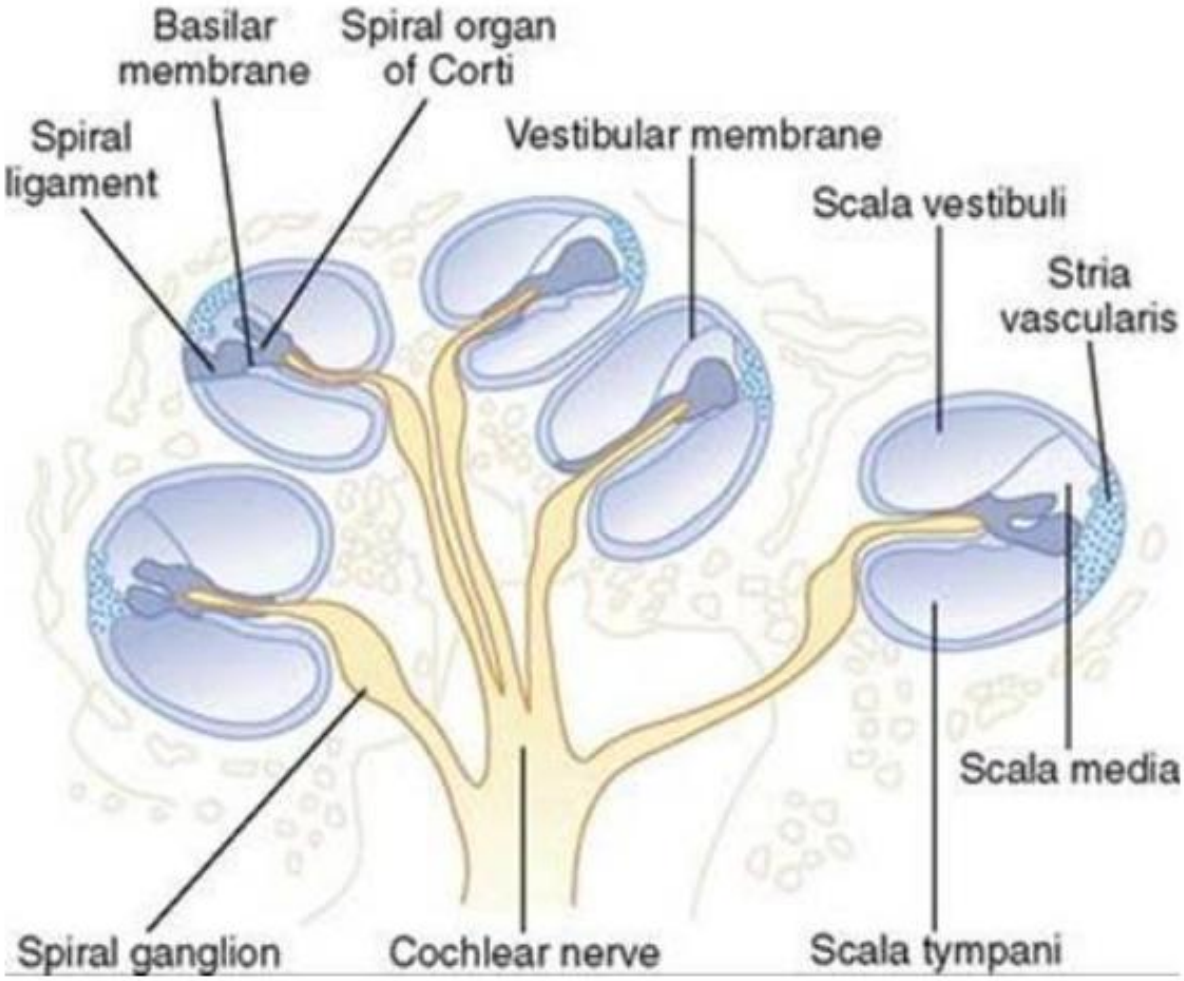
The structure of auditory System

- Outer ear: pinna, middle ear: tympanic membrane and auditory canal, inner ear: cochlea.
- Visible portion of ear is pinna, which collects the sound. It transfers the sound waves in auditory canal.
- Auditory canal ends at tympanic membrane. Tympanic membrane is connected with ear ossicles (malleus, incus, stapes). Ossicles transfer the sound waves to oval window.
- Oval window is connected with cochlea, which is a hollow tube and coiled upon a bony structure called modiolus.



Anatomy of cochlea



- At the base of Cochlea two membrane-covered holes are present
  - oval window
  - round window

- Cochlea contains three chambers
  - Scala vestibuli
  - Scala media
  - Scala tympani

- Reissner's membrane is present between S. Vestibuli and S. Media; Basilar membrane is present between S. Media and S. Tympani.

- Organ of Corti (contains auditory neurons) present on the basilar membrane and tectorial membrane which is hanging upon it.

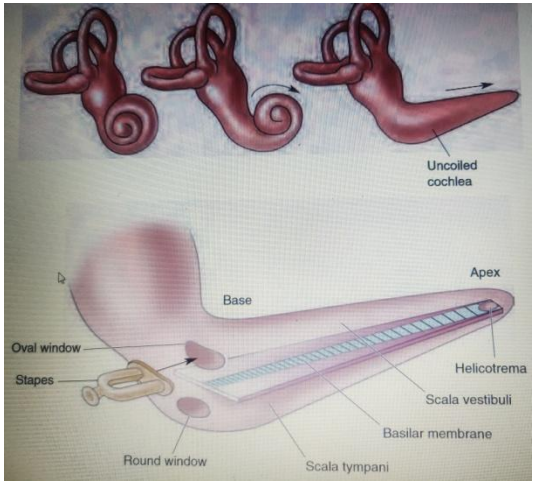
- S. Tympani connects with the S. Vestibuli via a hole- helicotrema.

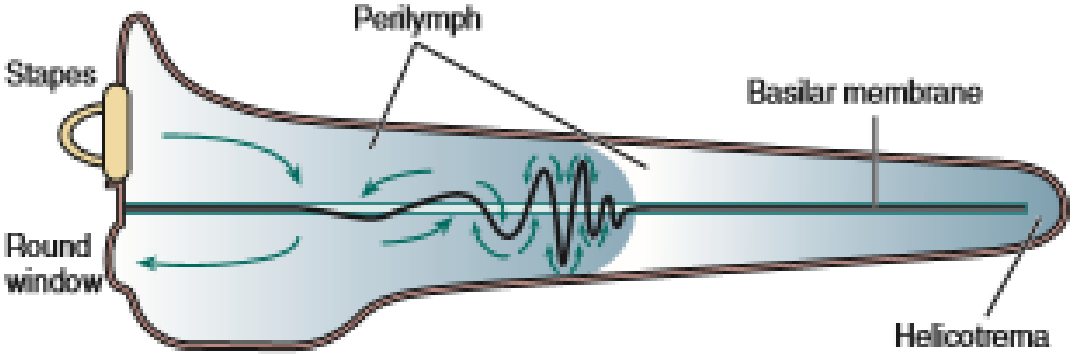
- S. Vestibuli and S. Tympani contains perilymph (low K^+ and high Na^+), while S. Media contains endolymph (high K^+ and low Na^+).

Physiology of cochlea

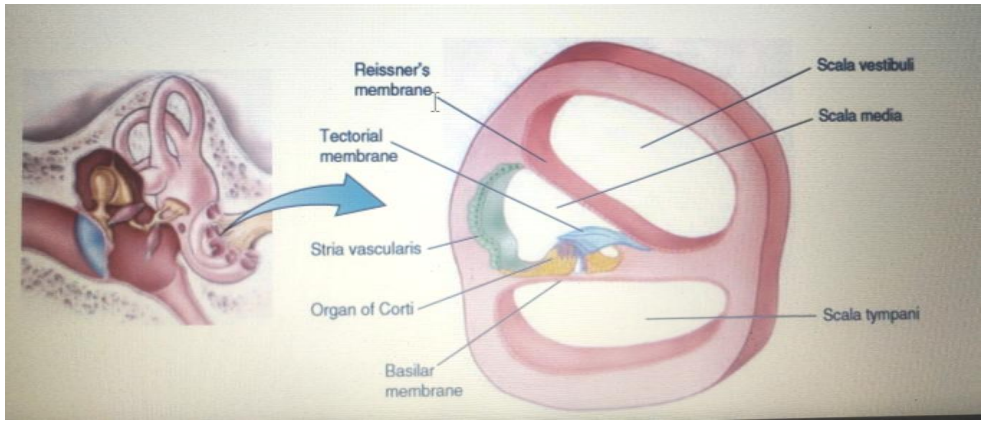
Sound wave → ossicles move → move the membrane of oval window →

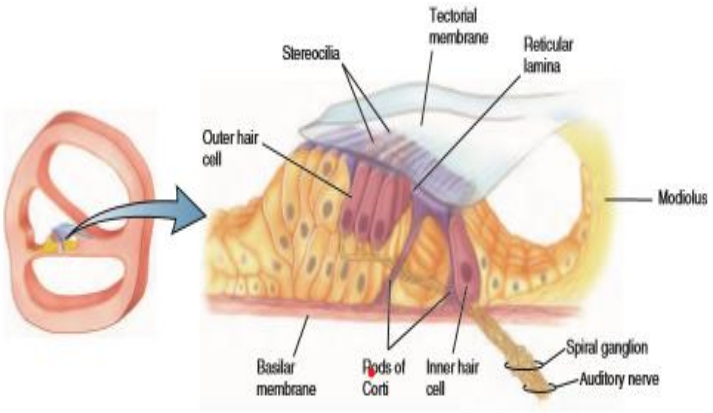
Pushes the perilymph into S. Vestibuli → increase fluid pressure in S. Vestibuli reach in S. Tympani up to membrane of round window → basilar membrane bends in response to sound waves





Transduction mechanism in organ of Corti





- Organ of Corti consists: auditory receptor cells (hair cells), rods of Corti, supporting cells.
- Hair cells are present between basilar membrane and reticular lamina. Hair cells between modiolus and rods of Corti are called inner hair cells (3500) and cells far away from rods of Corti are called outer hair cells (15000-20000;arranged in three raws)
- Rods of Corti provide structural support.
- Auditory receptor cells or hair cells convert mechanical energy (sound vibration) into a change in membrane potential.
- Each auditory receptor neuron contains about 100 hairy projections known as stereocilia, transduction of sound into neuronal signal generated by bending of these cilia.

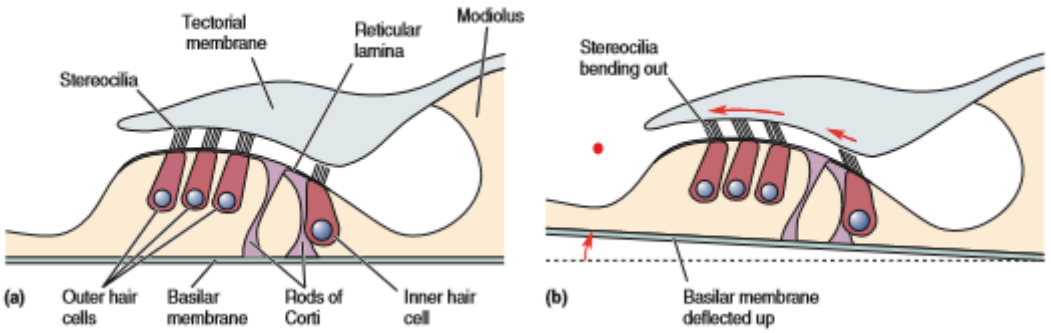
➢ The stereocilia at the top of the hair cells extend above the reticular membrane and ends in gelatinous substance of tectorial membrane.

➢ Hair cells synapse with neurons, neuronal cell bodies present in spiral ganglion, axons from spiral ganglion enter with the auditory nerve (part of cranial nerve VIII) and projects to cochlear nucleus of medulla.

➢ Basilar membrane, rods of Corti, hair cells and reticular membrane are connected and due to the movement of stapes all are moved like a unit ⟶ upward/away from tectorial membrane.

basilar membrane moves up ⟶ reticular lamina moves up and towards the modiolus

basilar membrane moves down ⟶ R. lamina moves down and away from modiolus



(a) at rest

(b) in the presence of sound wave

- Movement of R. Lamina also cause the movement in tectorial membrane in the same way.

- This bends the stereocilia on outer hair cell (bend in during downward motion and bend out in upward motion).

- Stereocilia contain actin filaments which provide stiffness so these bend like rigid rods.

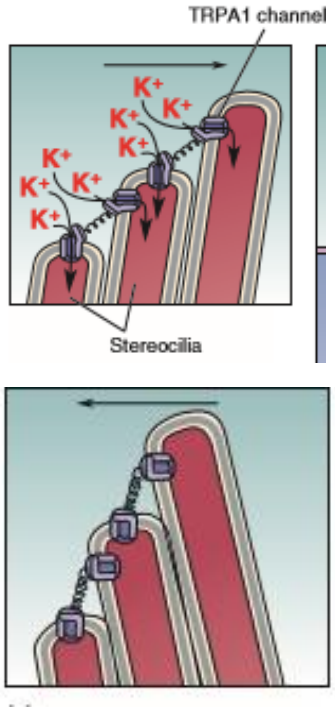
- In addition, cross link filaments connect the stereocilia of each hair cell so all cillia of a hair cell move together as a unit.

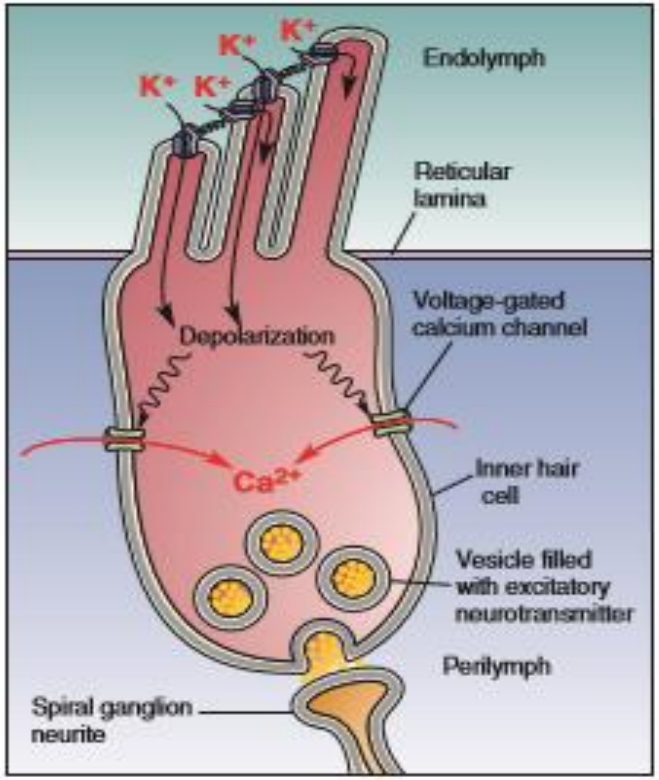
- TRPA1 cation channels are present on the tips of stereocilia.

- Bending of stereocilia generate the changes in the receptor potential in hair cells.

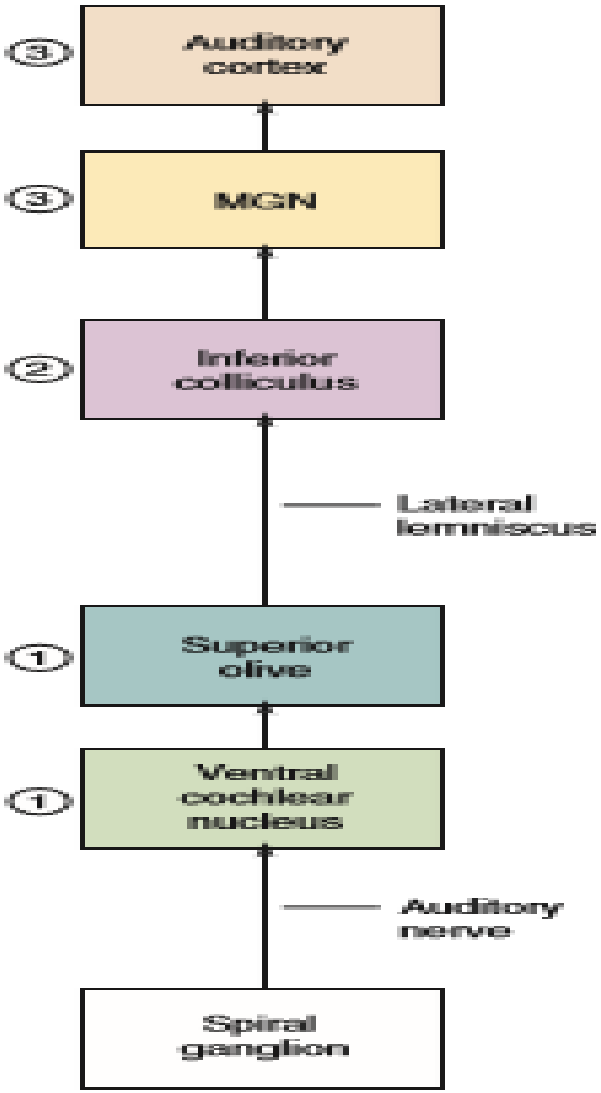
➢ Displacement of cilia in one direction increase the inward movement of K^+, which causes depolarization and activates voltage gated channels Ca^+ and this triggers the neurotransmitter release.

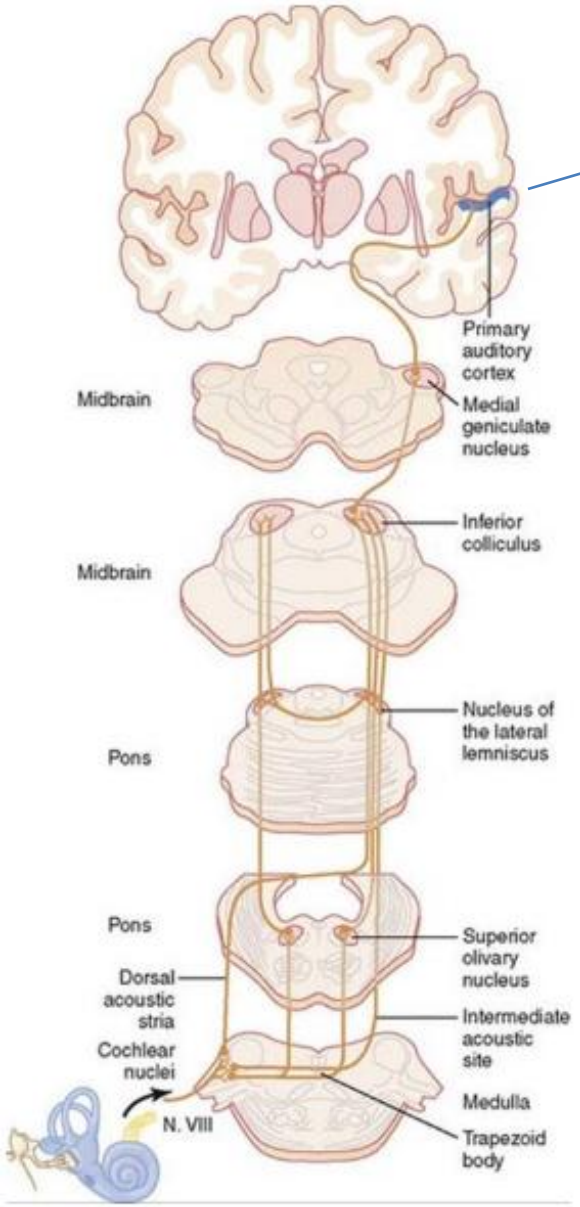
➢ Displacement of cilia in opposite direction close the TRPA1 channels and cause hyperpolarization.





Central auditory pathway





Auditory cortex: Located on temporal lobe and represents Broadmann's area 41.

Layer I contains few cell bodies

Layers II and III have small pyramidal cells

Layer IV contains granule cells

Layers V and VI contain large pyramidal cells

References

Bear, M.F., Connors B.W., Paradiso, M.A. *Neuroscience exploring the brain* (Third edition).

Hall, J.E. And Guyton, A.C. *Guyton and Hall Textbook of Medical Physiology* (twelfth Ed)