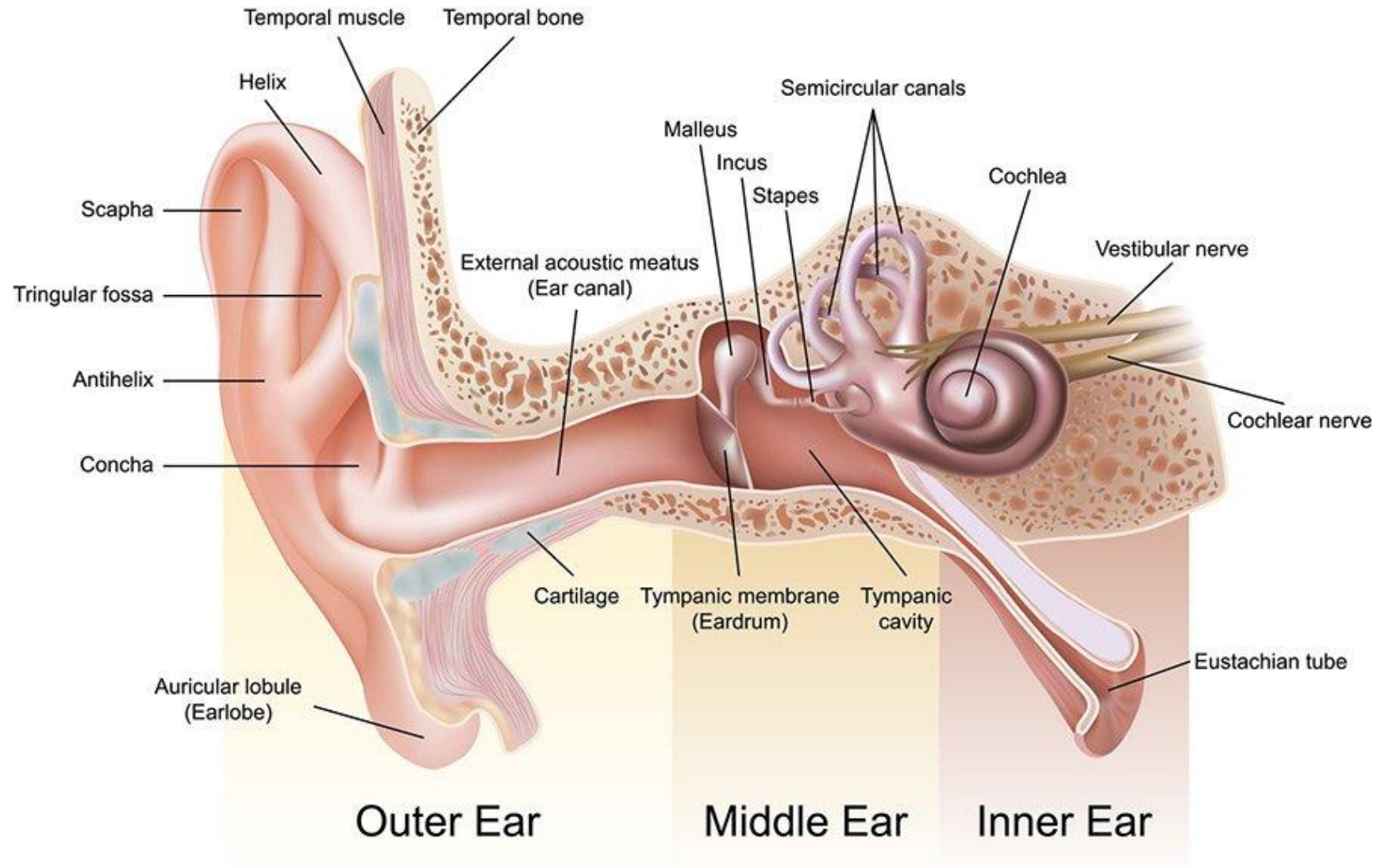


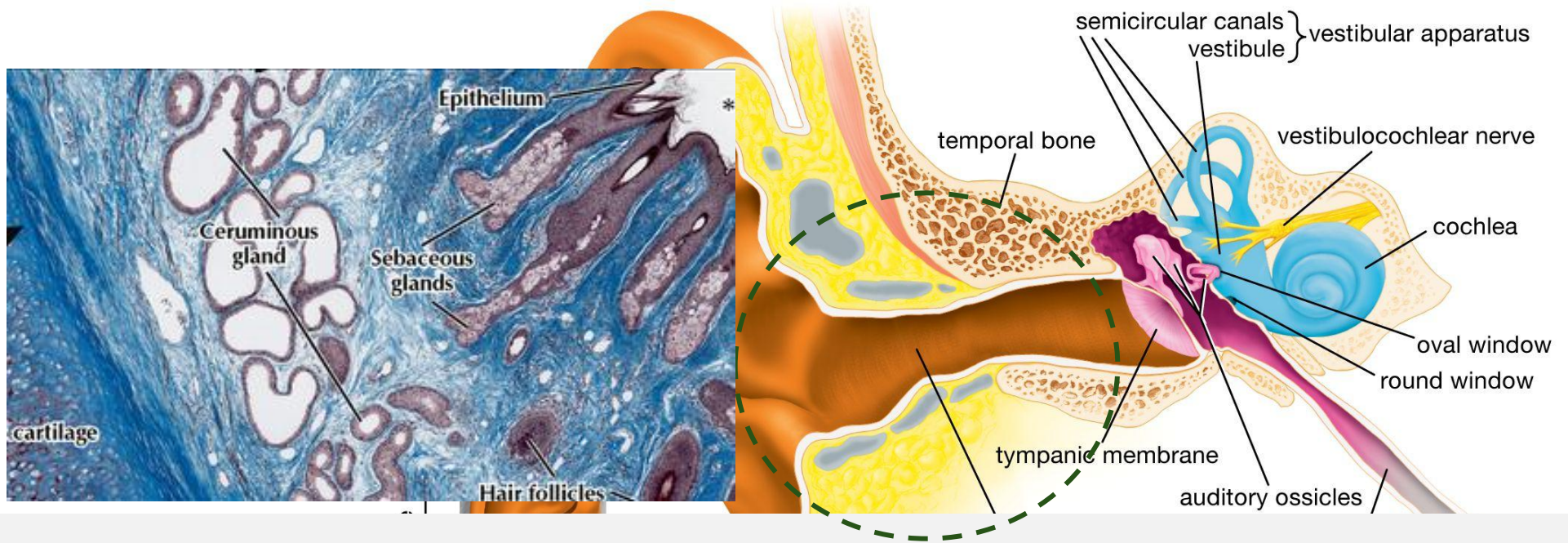


Hearing and balance

Ear structure

Anatomy of the Ear





Outer ear

Auricle - a skeleton made of elastic cartilage (except for the lobe), hairy skin with sebaceous glands (holocrine)

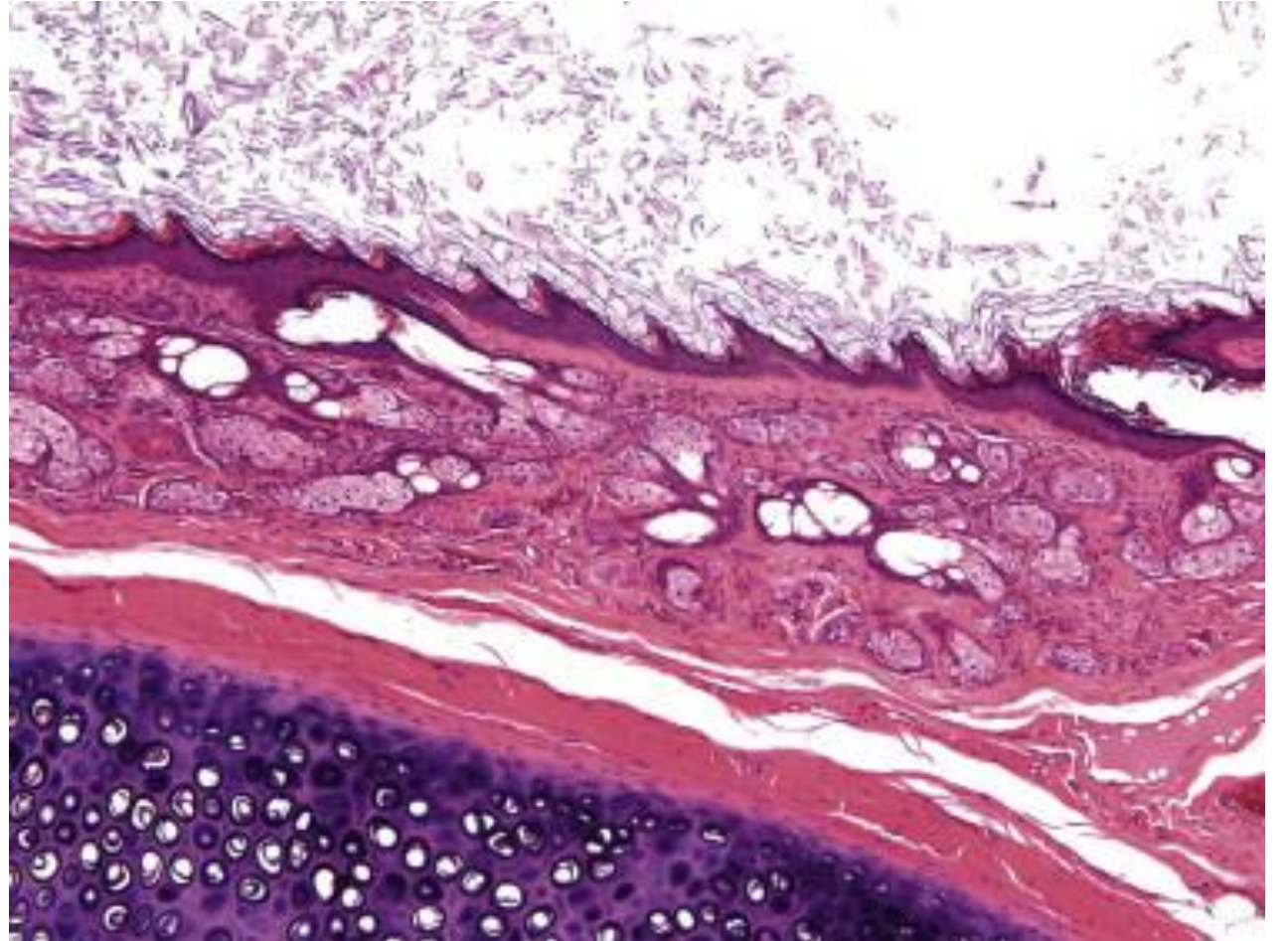
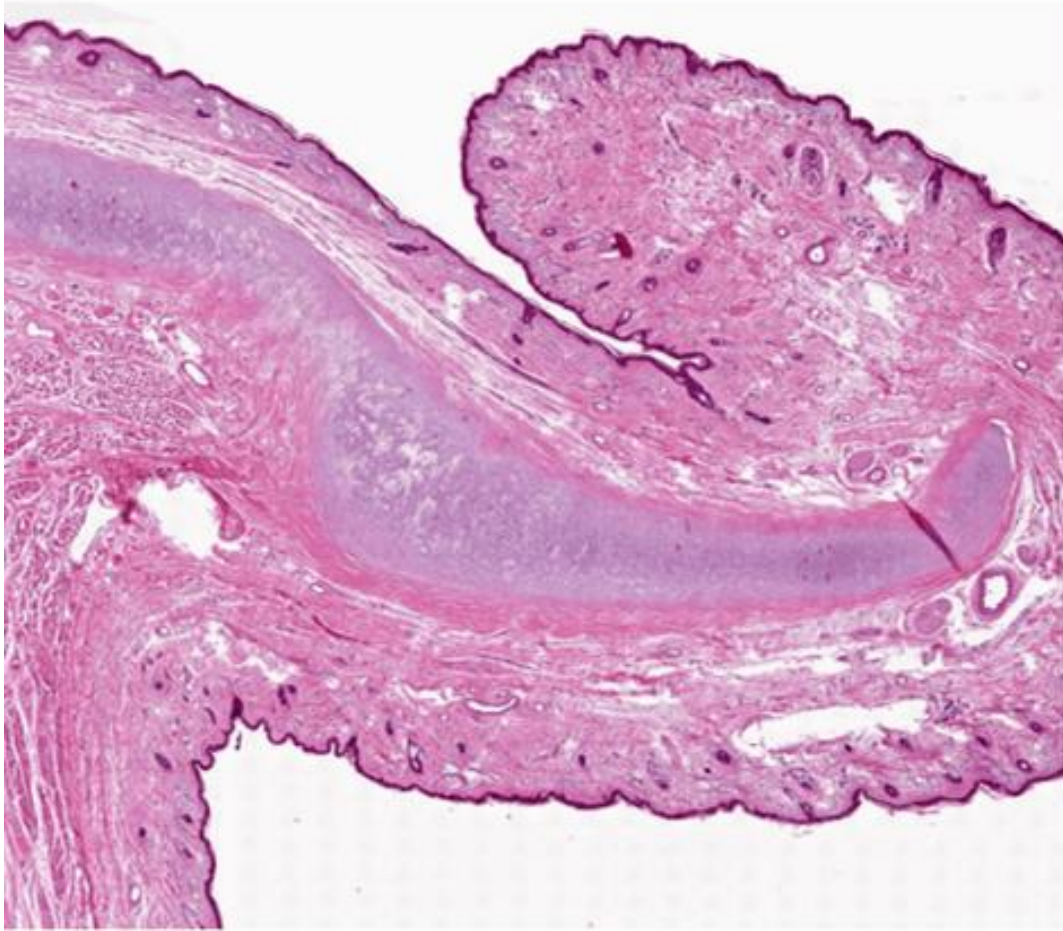
External ear canal :

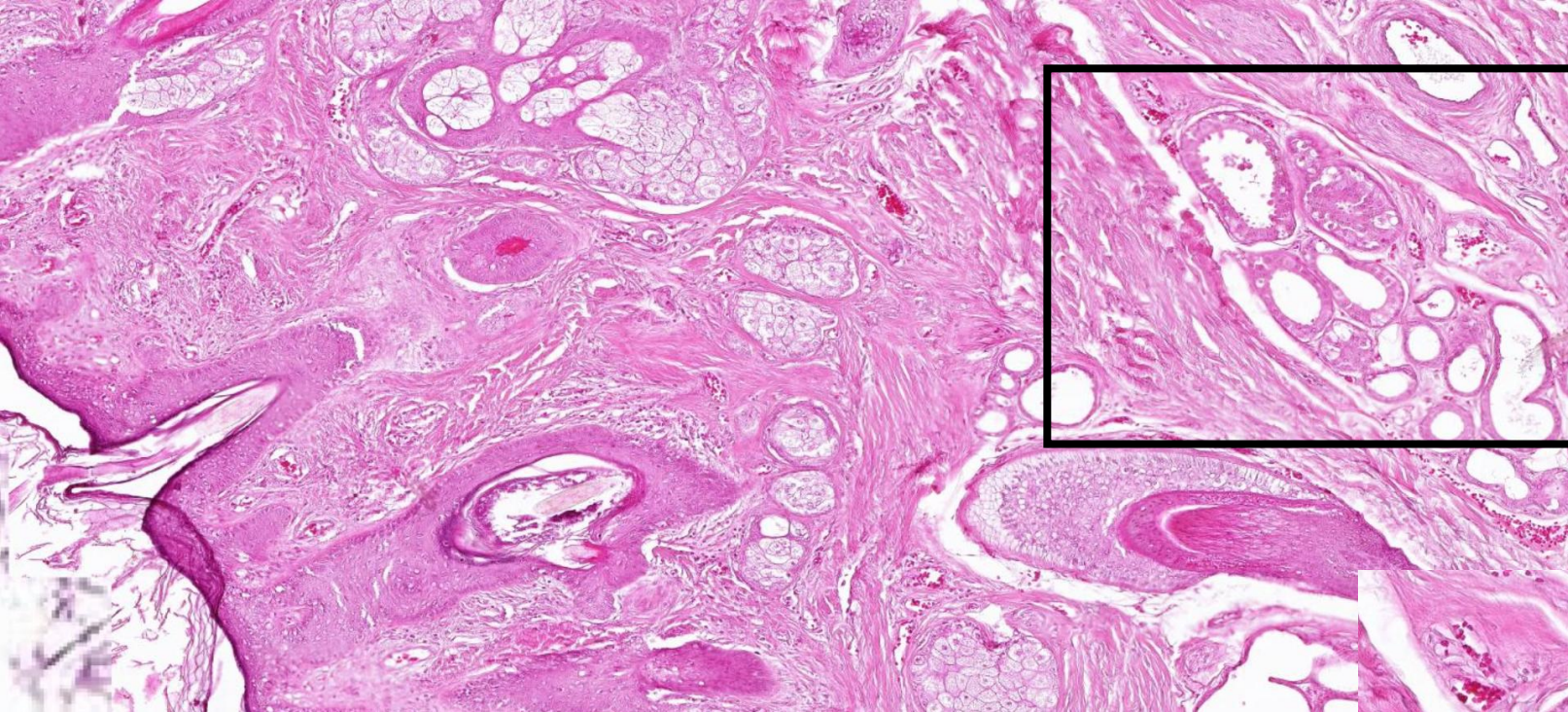
Outer part - skeleton made of elastic cartilage, cartilaginous

Inner part - skeleton made of temporal bone, periosteum

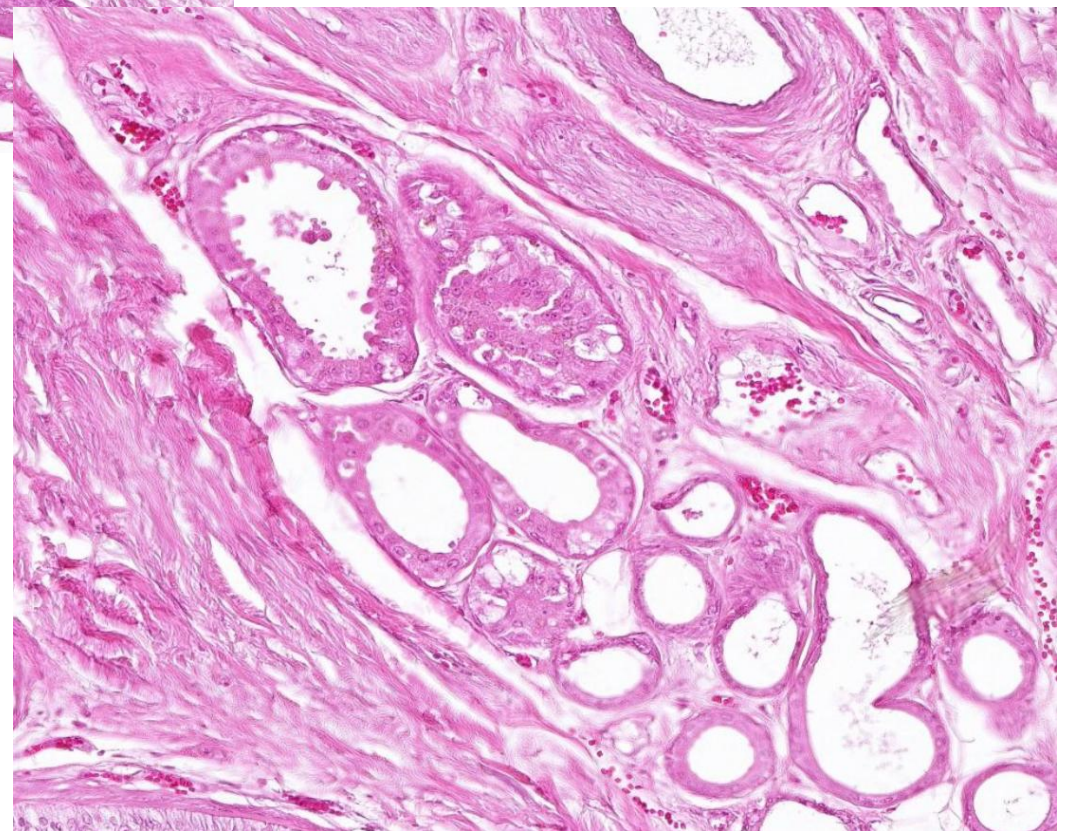
Covered with thin skin with sebaceous and earwax glands (apocrine)

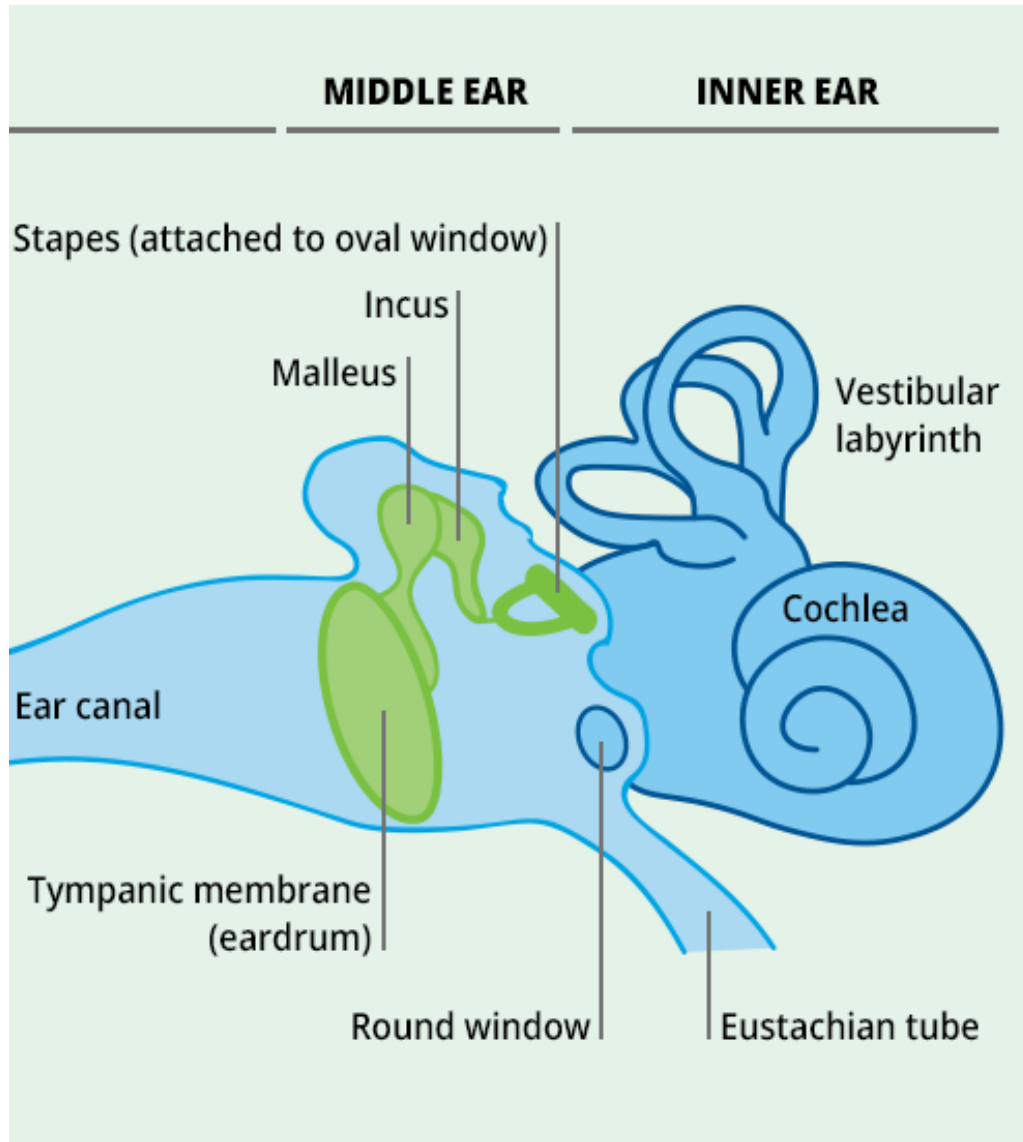
Outer ear – auricle and external auditory canal – cartilaginous part





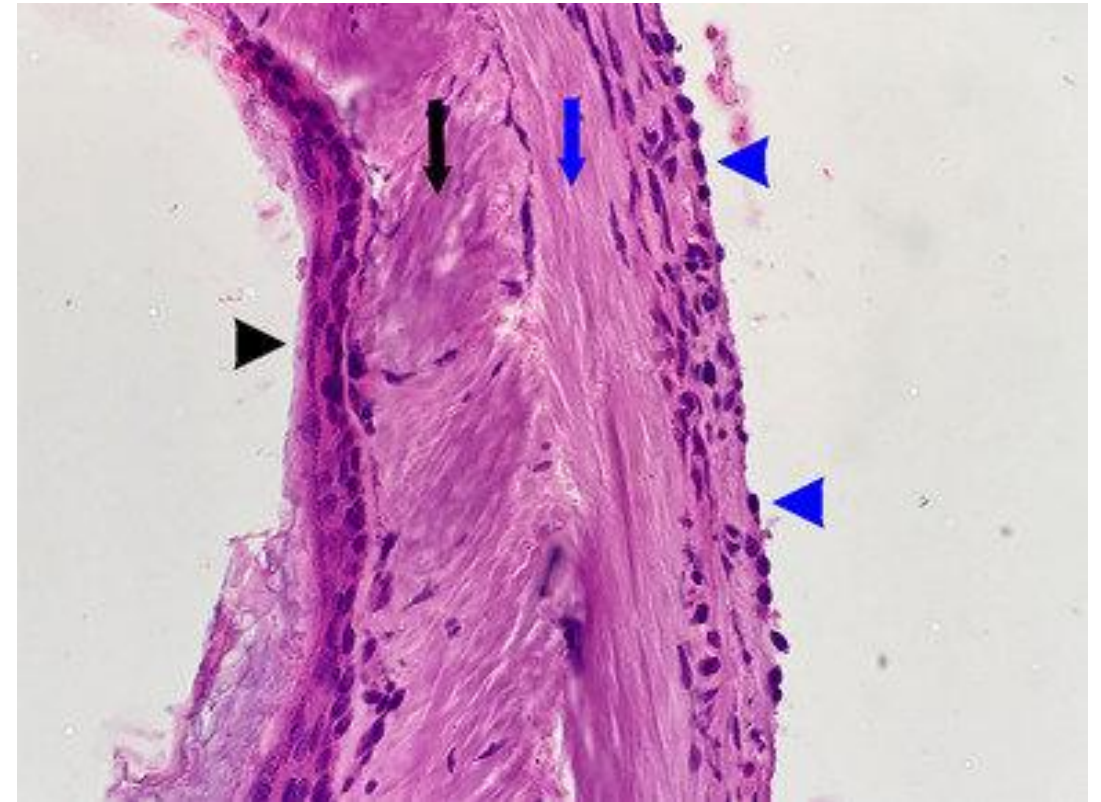
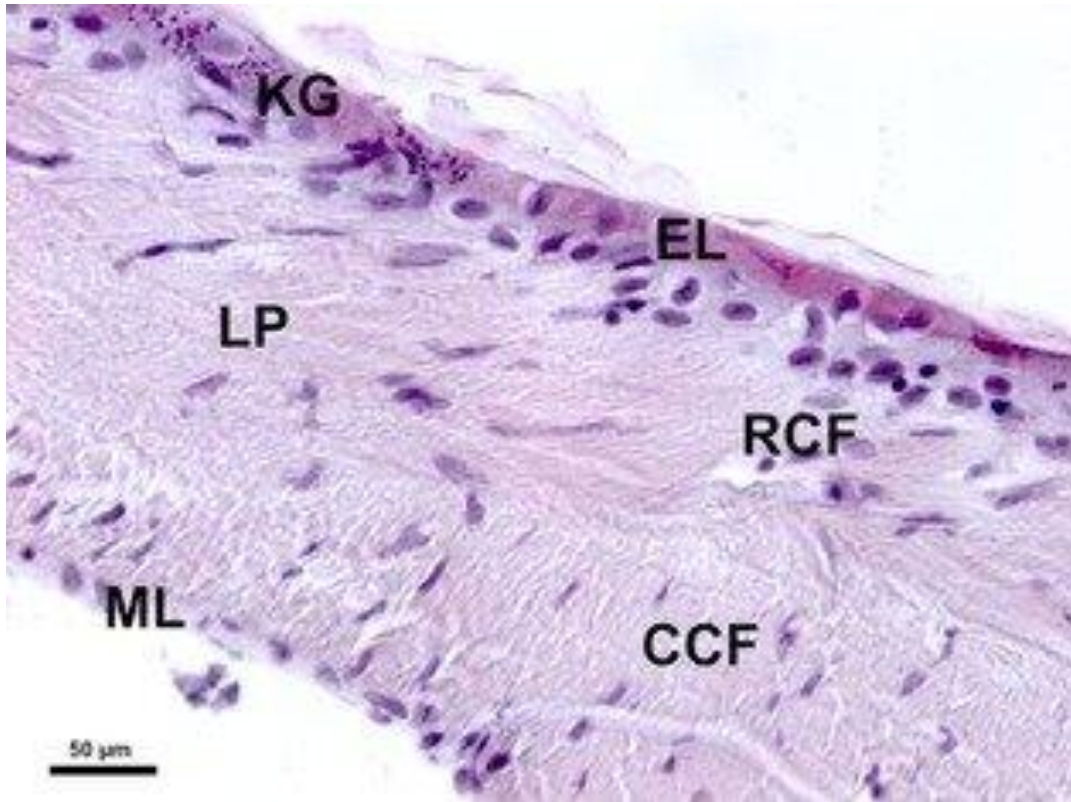
External auditory canal – sweat,
sebaceous and earwax glands
(apocrine)



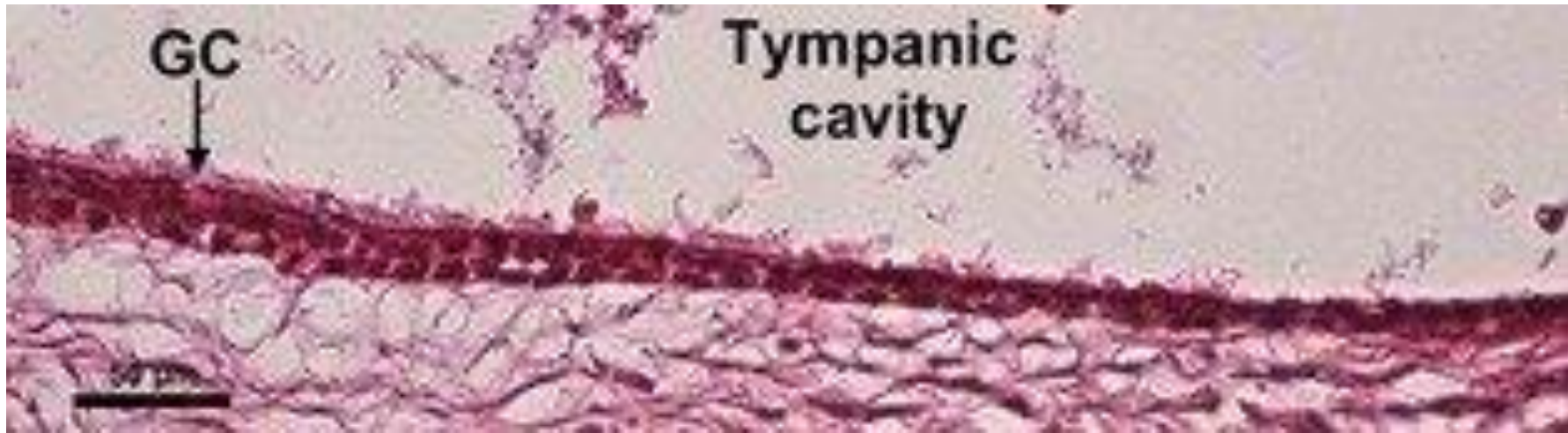


- **Middle ear (tympanic cavity located in the temporal bone)**
- **Eardrum (tympanic membrane)** – collagen fibers, elastin, fibroblasts; skin or mucous membrane of the tympanic cavity
- **Eustachian tube** - connection with the nasopharyngeal cavity; bone skeleton (from the tympanic side) or elastic cartilage; columnar respiratory epithelium with goblet cells; mucous glands and lymphatic nodules (**Eustachian tube tonsil**)
- **Auditory ossicles** (malleus, incus, stapes; covered with simple squamous epithelium)

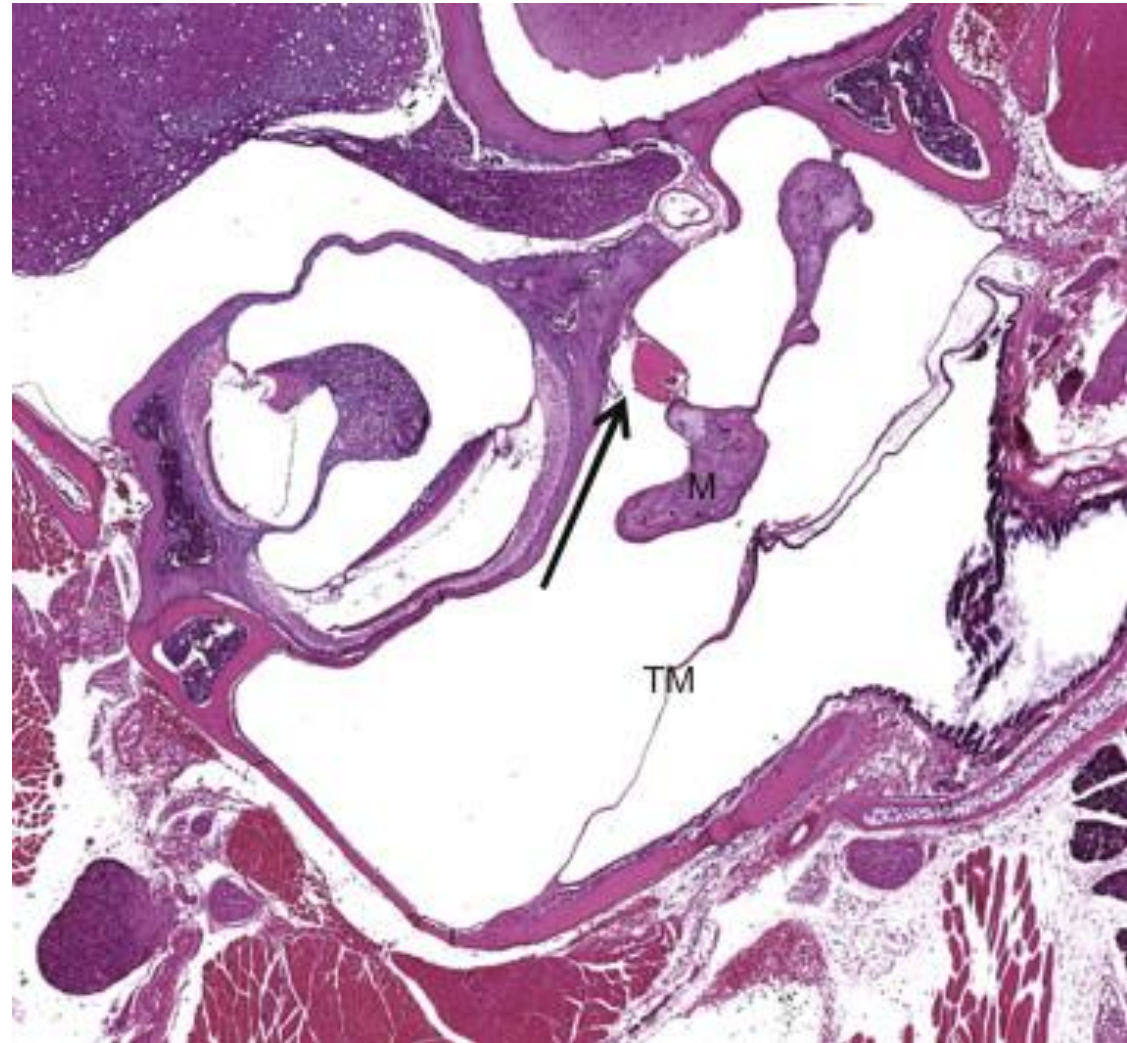
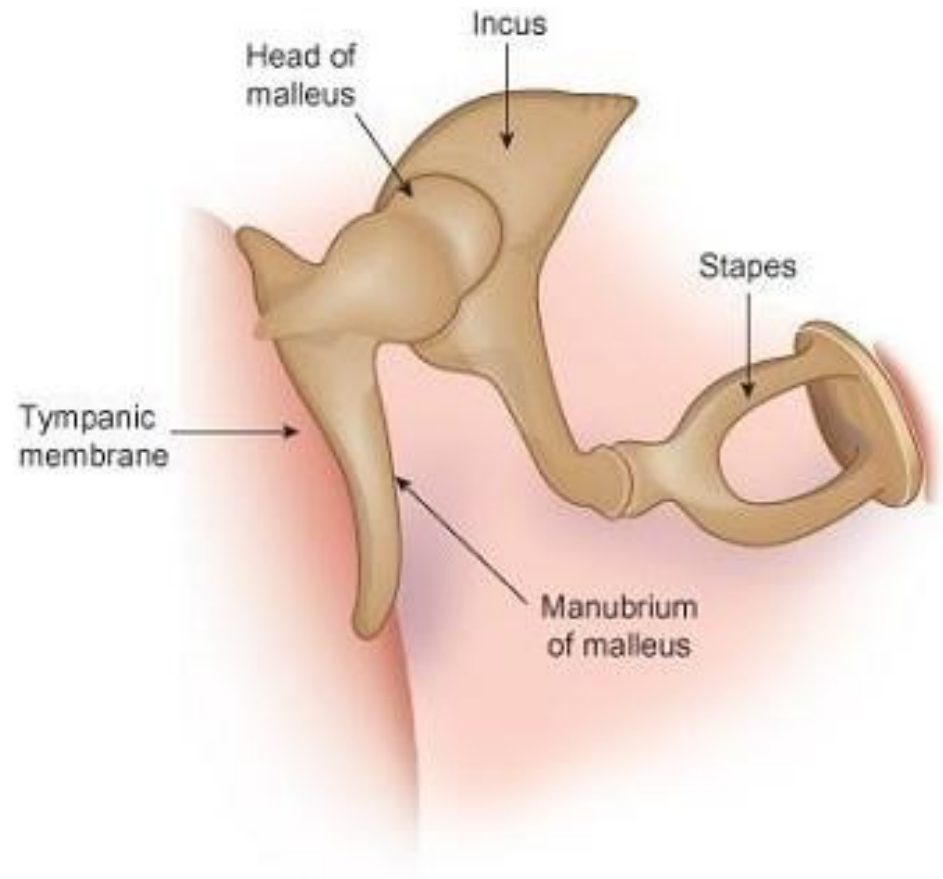
Middle ear – tympanic membrane



Middle ear – tympanic cavity



Middle ear – auditory ossicles

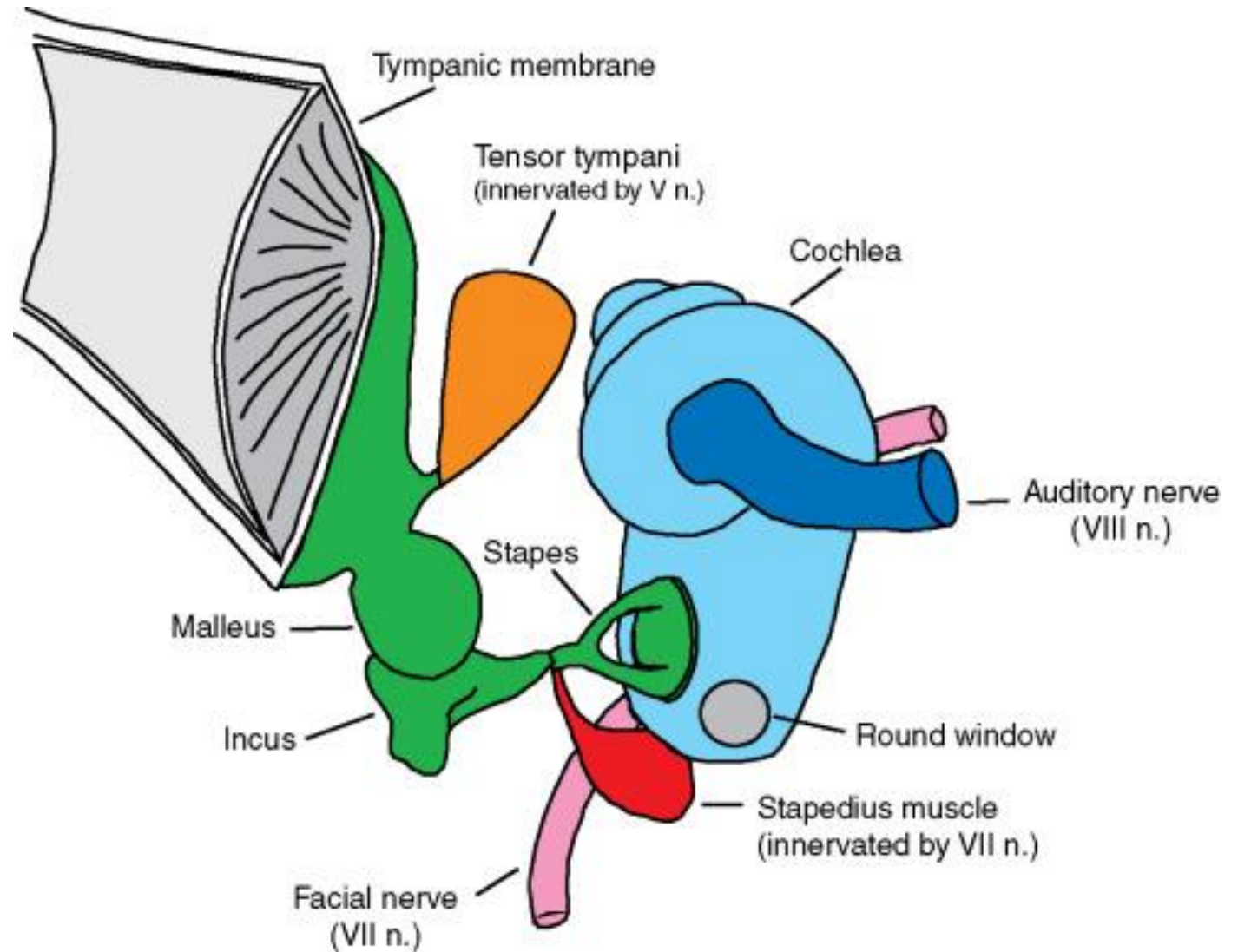


Middle ear – nerves and muscles

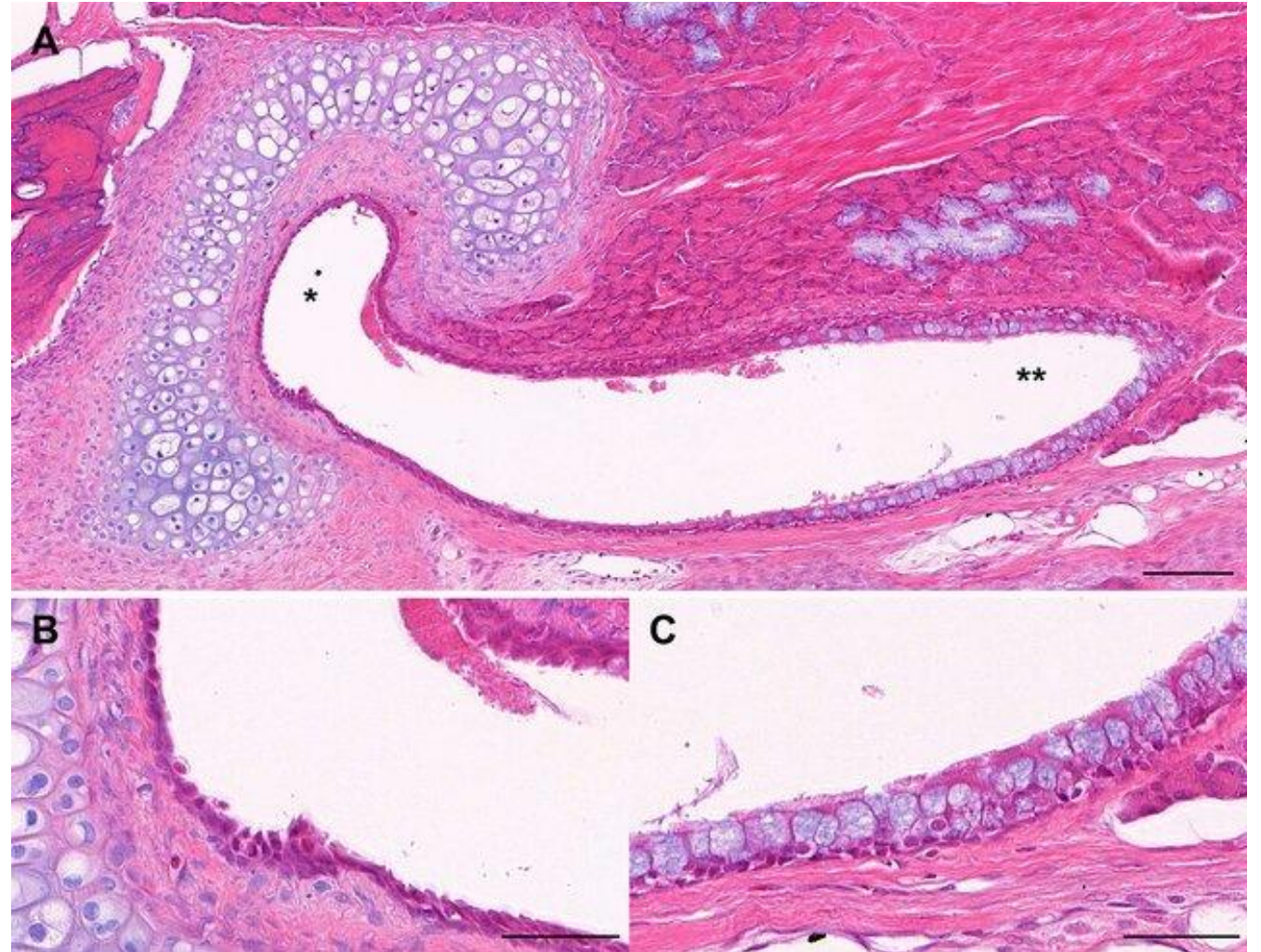
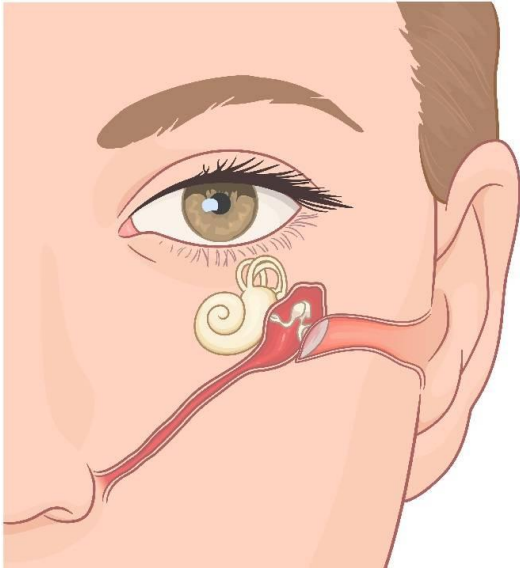
Tensor tympani muscle

Stapedius muscle

Chorda tympani

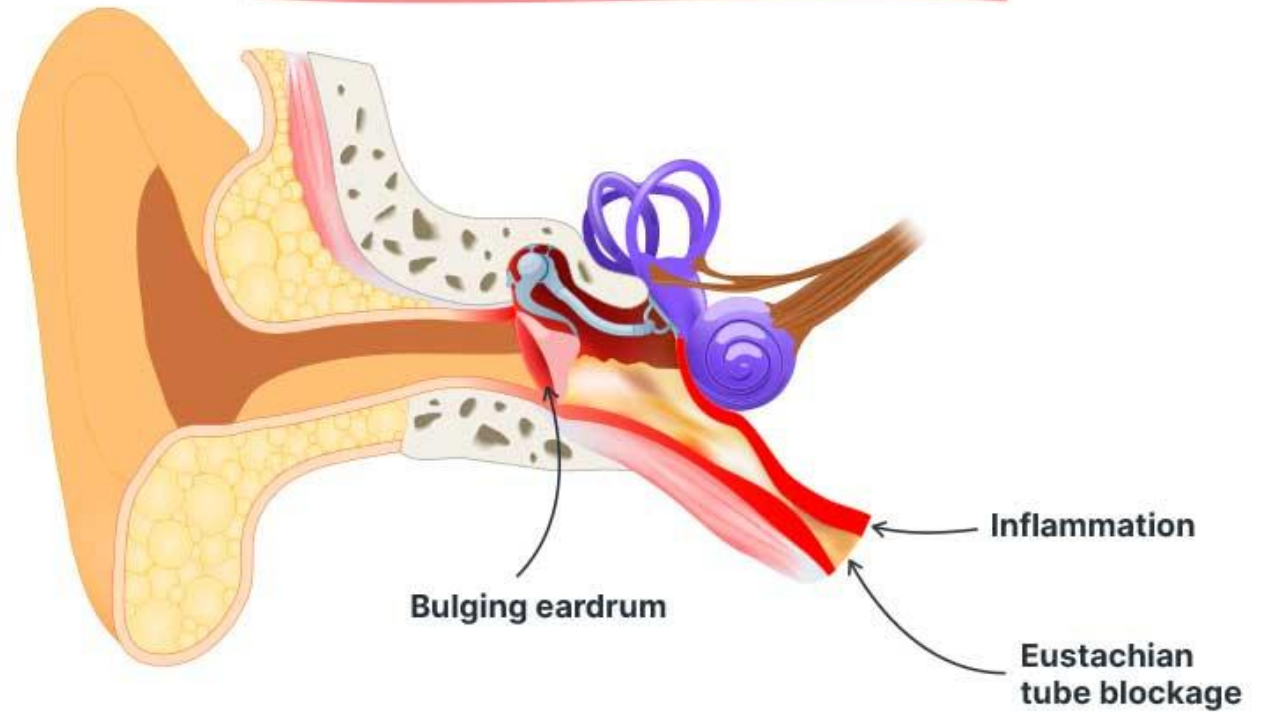


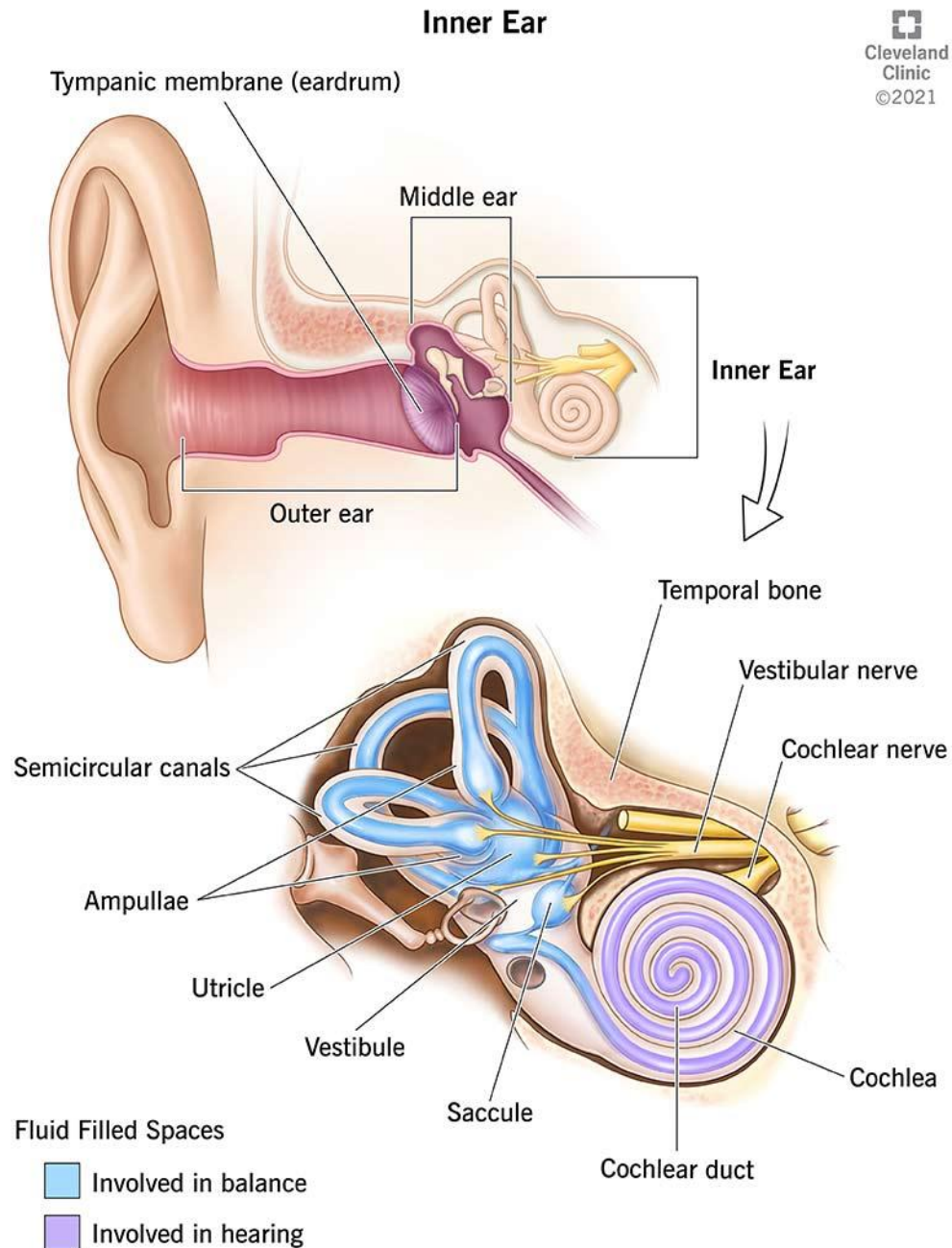
Eustachian tube





Otitis Media



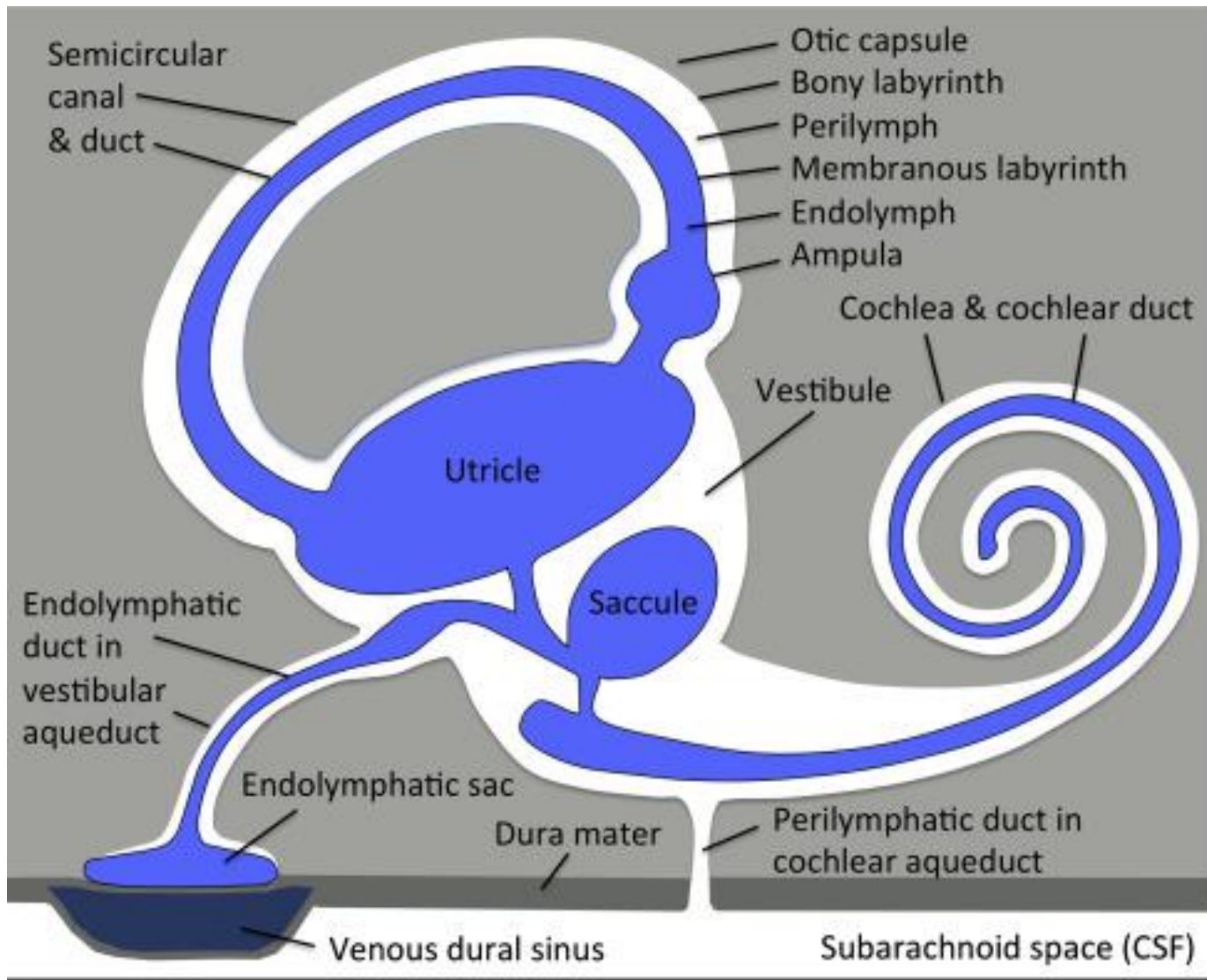


Inner ear

Bone labyrinth- Vestibule, semicircular canals, cochlea;

Membranous labyrinth- structures made of connective tissue and epithelium

Perilymph and endolymph



- **Perilymph** - cerebrospinal fluid, rich in **sodium ions**
- **Endolymph** - rich in **potassium ions**

- In the vestibule of **membranous labyrinth**:
 - **Utricle and saccule**– connective tissue, simple squamous epithelium (columnar epithelium in **maculae**)

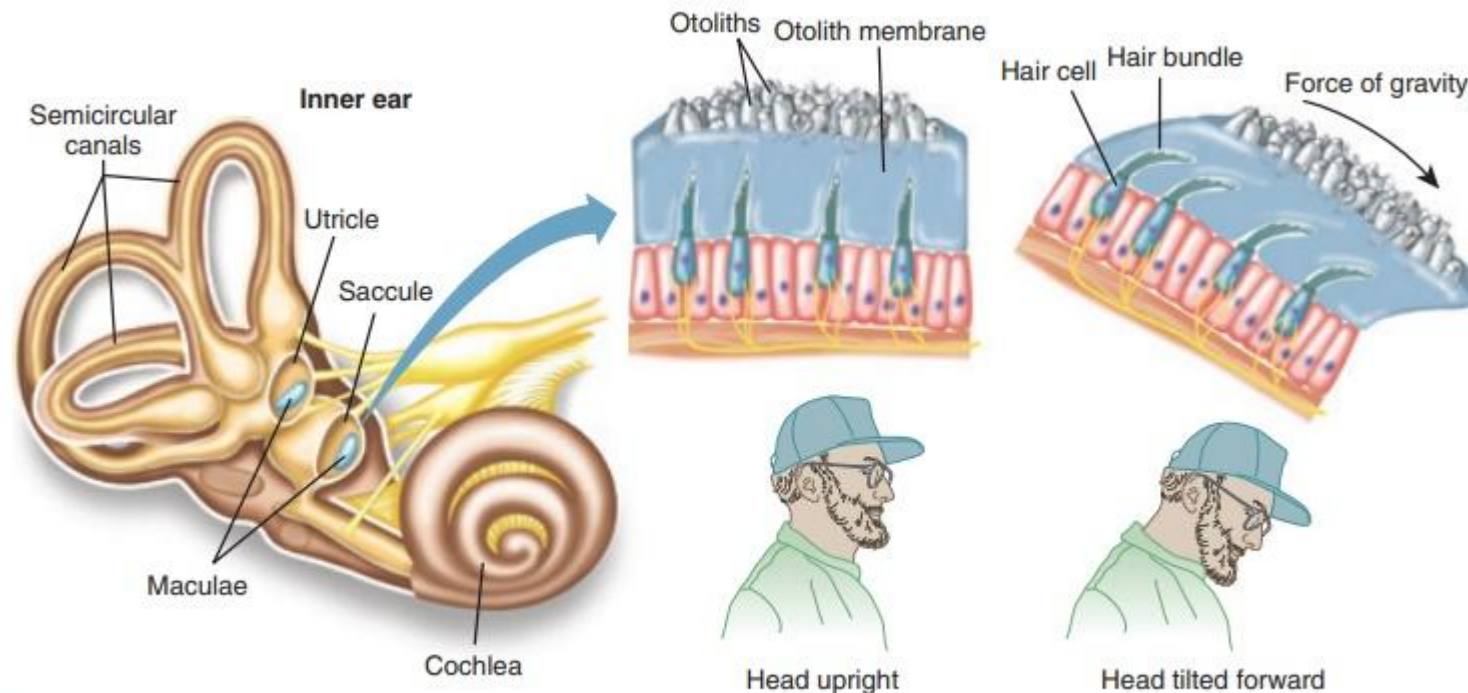
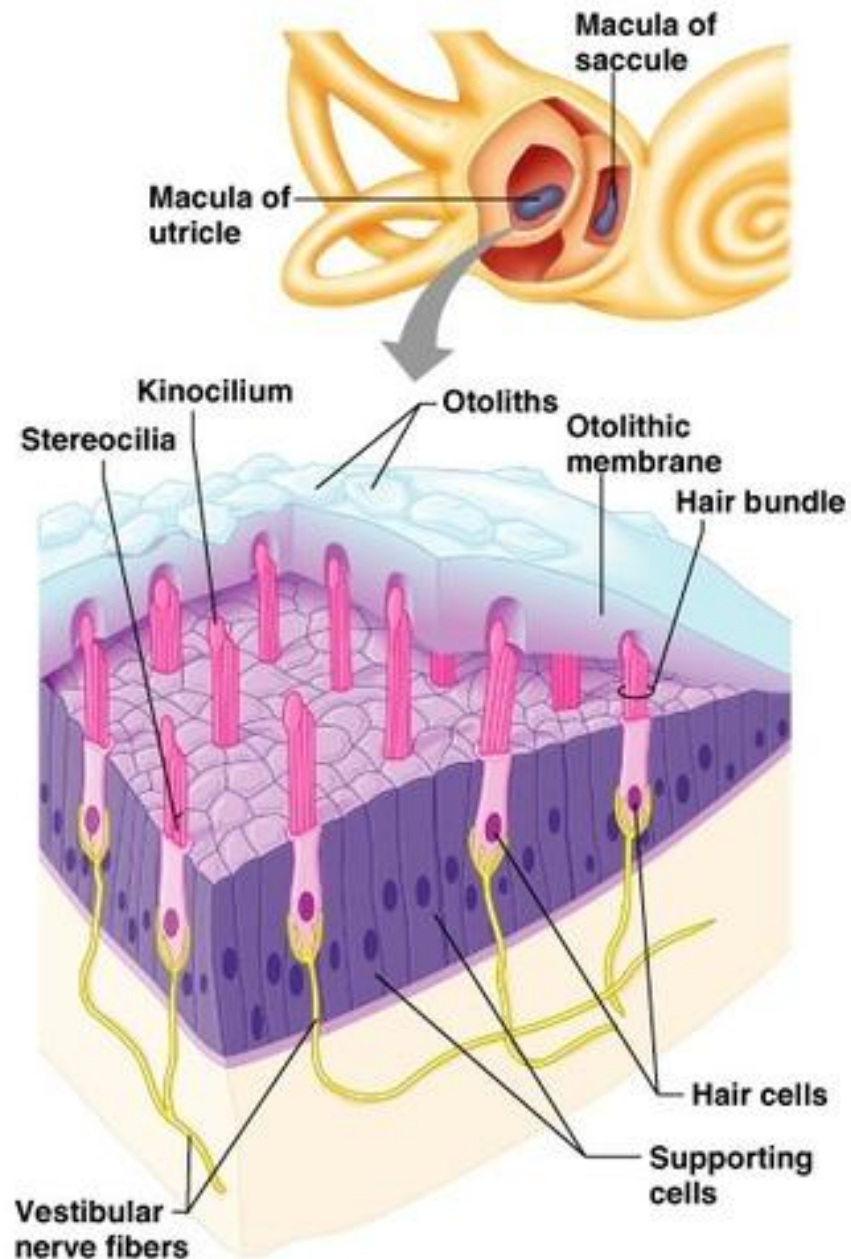


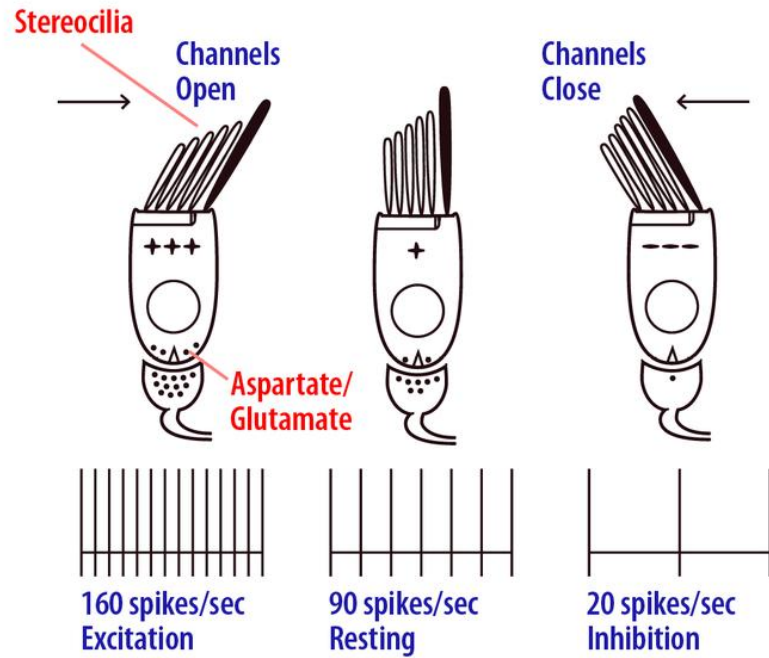
FIGURE 15-6 How the maculae respond to changes in the head position.



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Macula of saccule and utricle

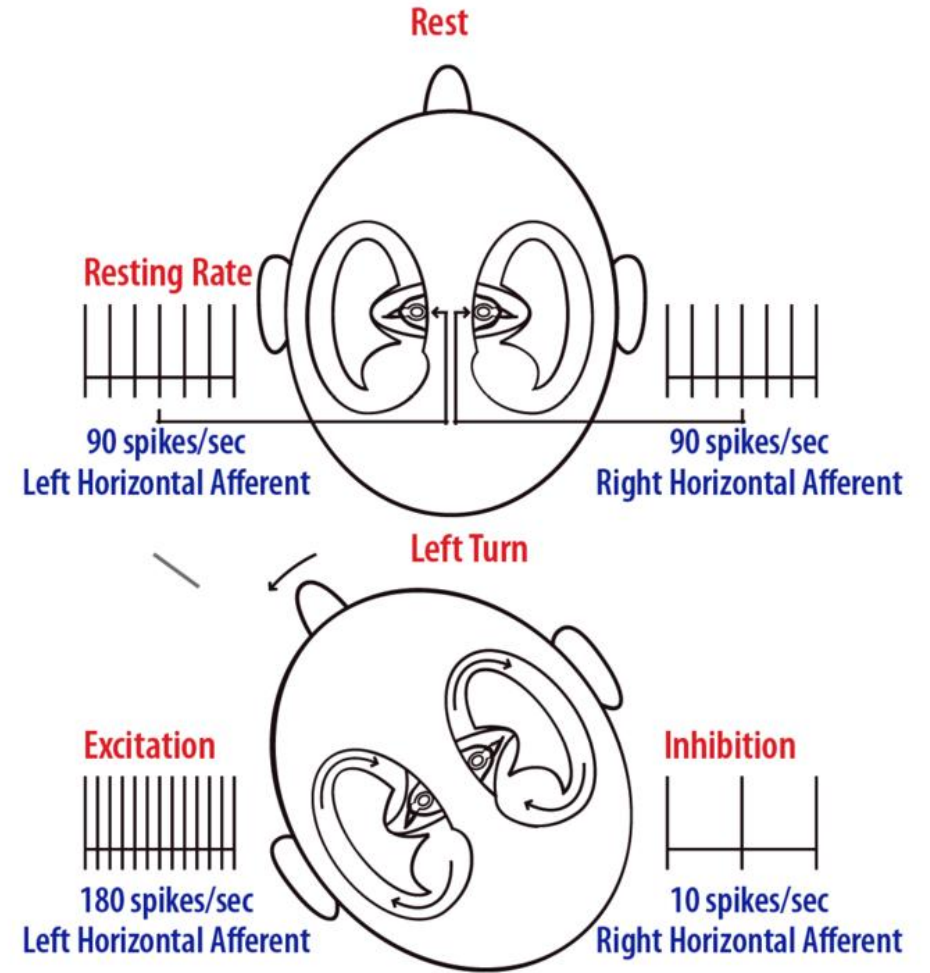
- Gelatinous otolithic membrane and calcium otoliths
- Columnar epithelium:
 - Supporting cells
 - Type I and II sensory cells with kinocylum (cilia) and stereocilia (microvilli)



At rest, hair cells release the neurotransmitter at intervals, which regularly triggers cell depolarized

When the **stereocilia bend towards the kinocilium**, the cell depolarizes more rapidly

When the **stereocilia bend from the kinocilium**, the cell becomes hyperpolarized

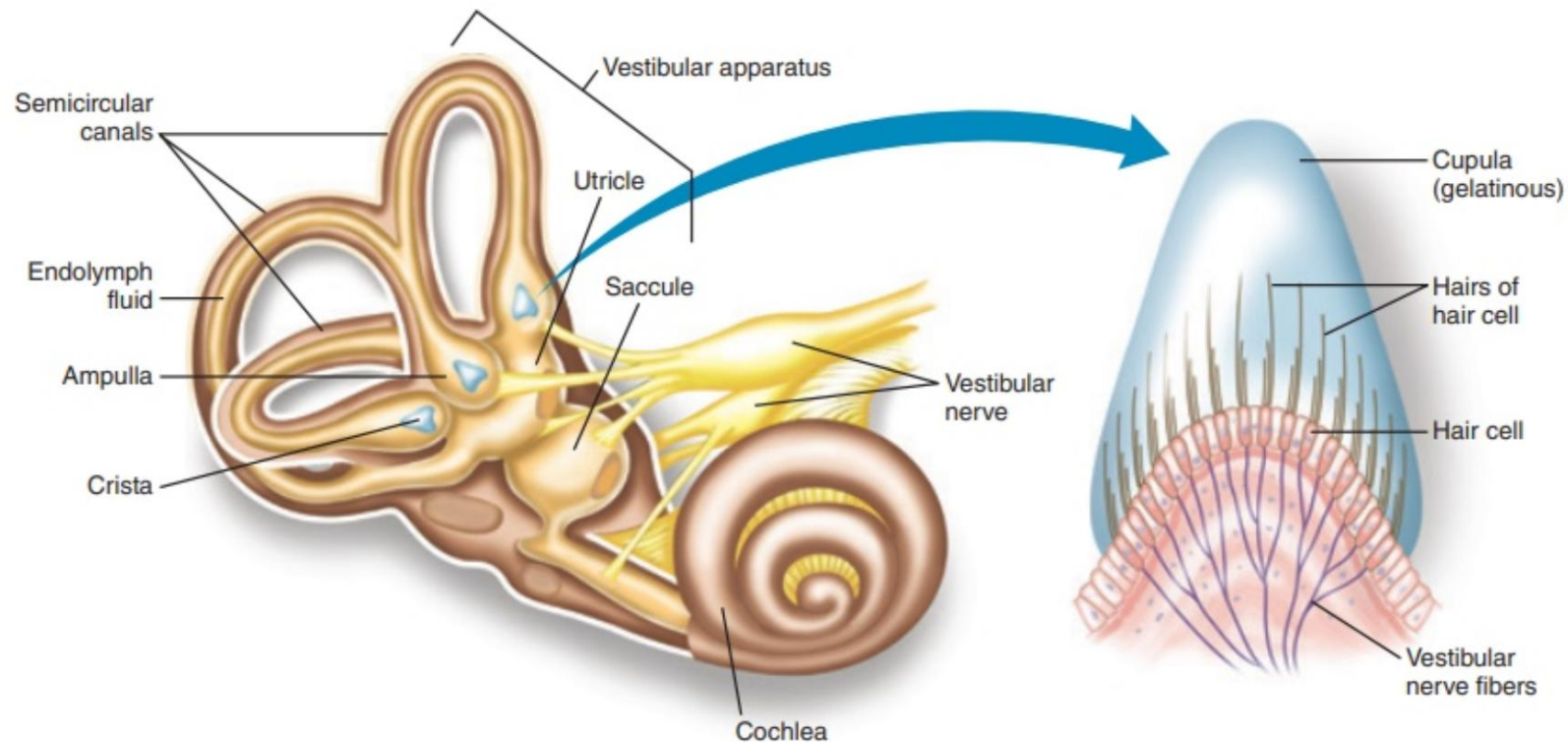


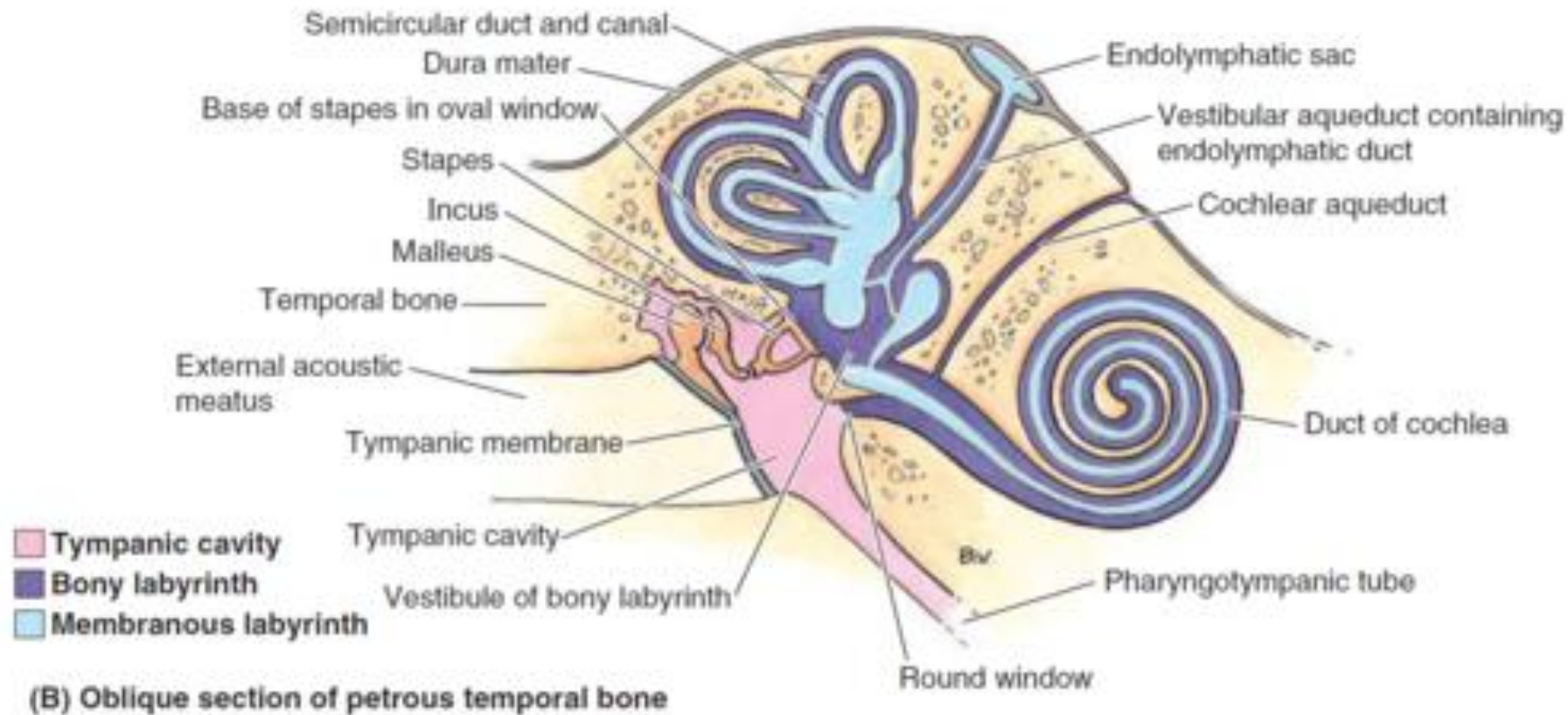
Semicircular canals – ending with the ampulla opening into vestibular apparatus

Canals – simple squamous epithelium

Cristae of ampulla – simple columnar epithelium

- Support and hair cells (sensory)
- Thick layer of gelatinous substance– cupula; no otoliths



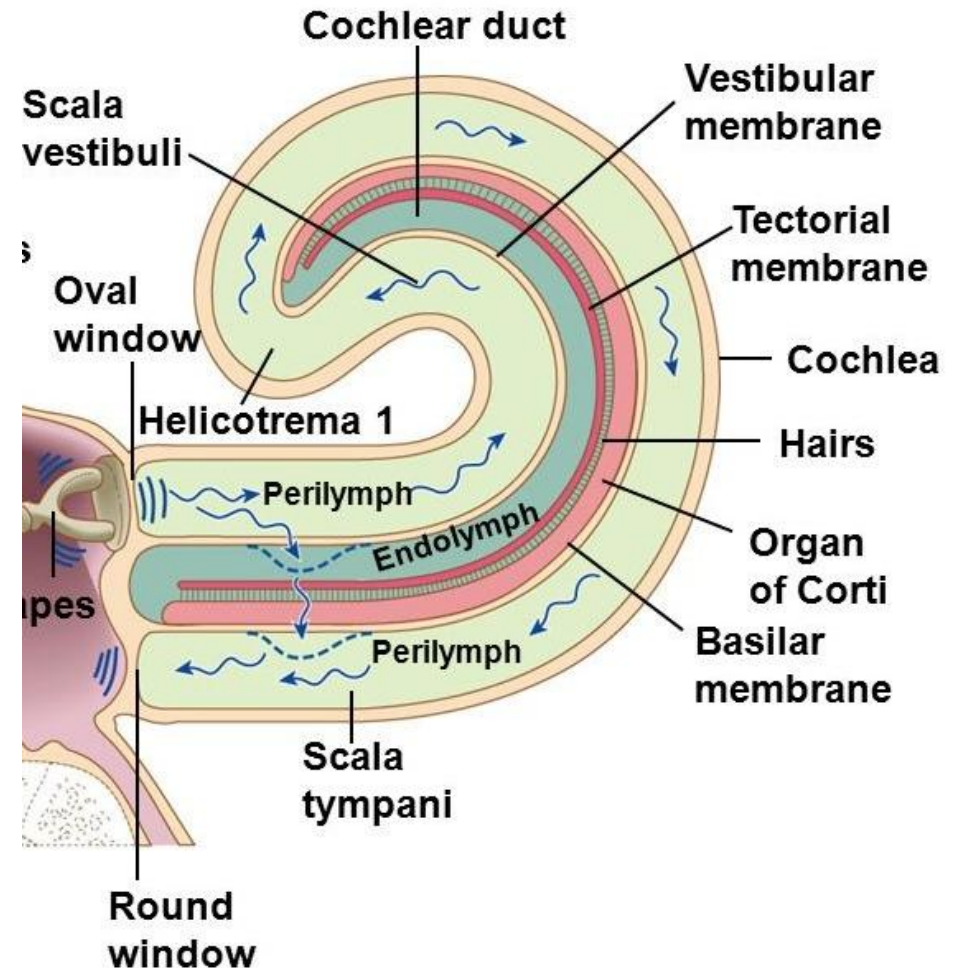


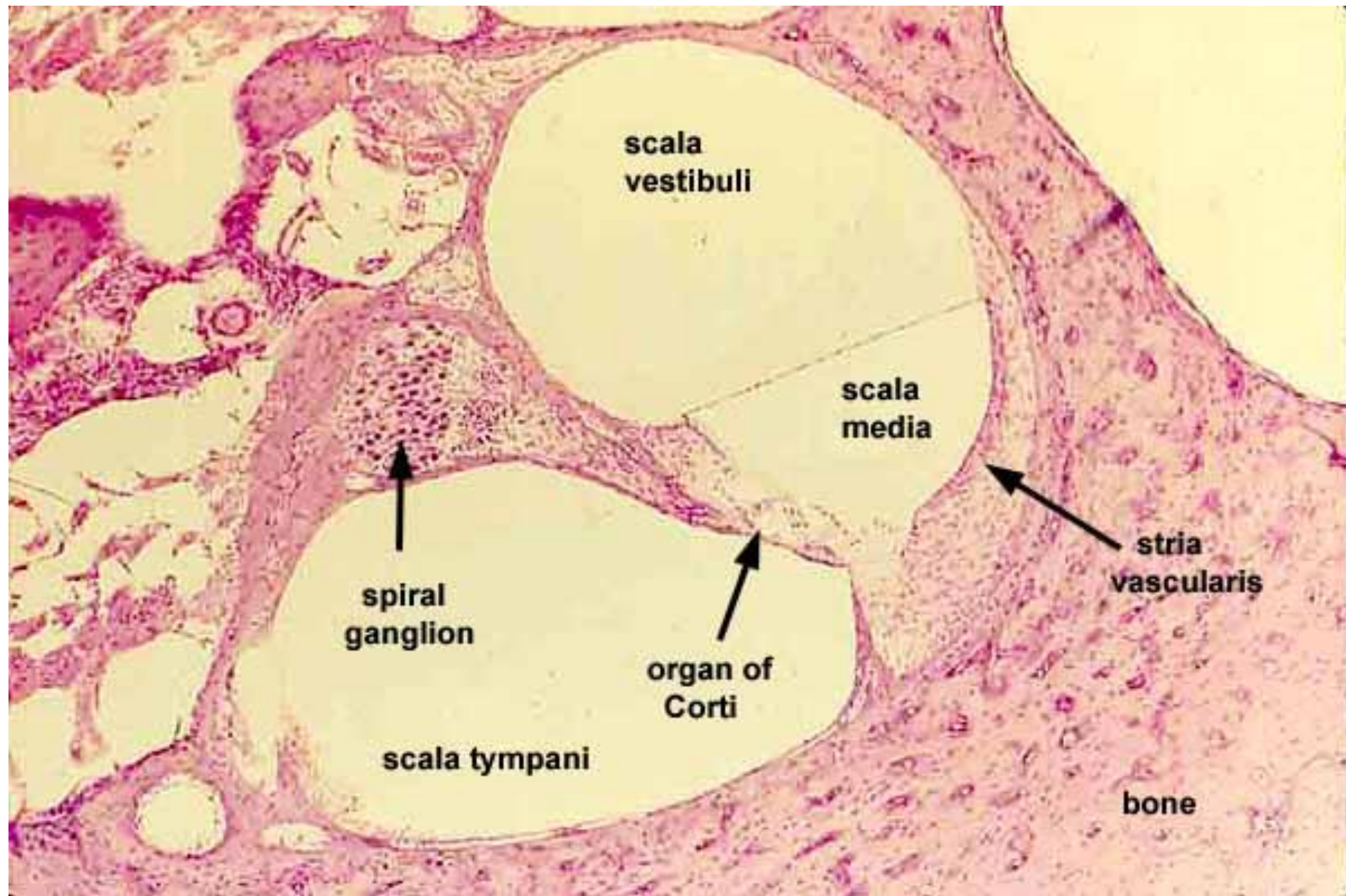
Endolymphatic duct and sac

- Wall – connective tissue proper
- Duct - simple squamous epithelium
- Sac – simple columnar epithelium – here endolymph is absorbed

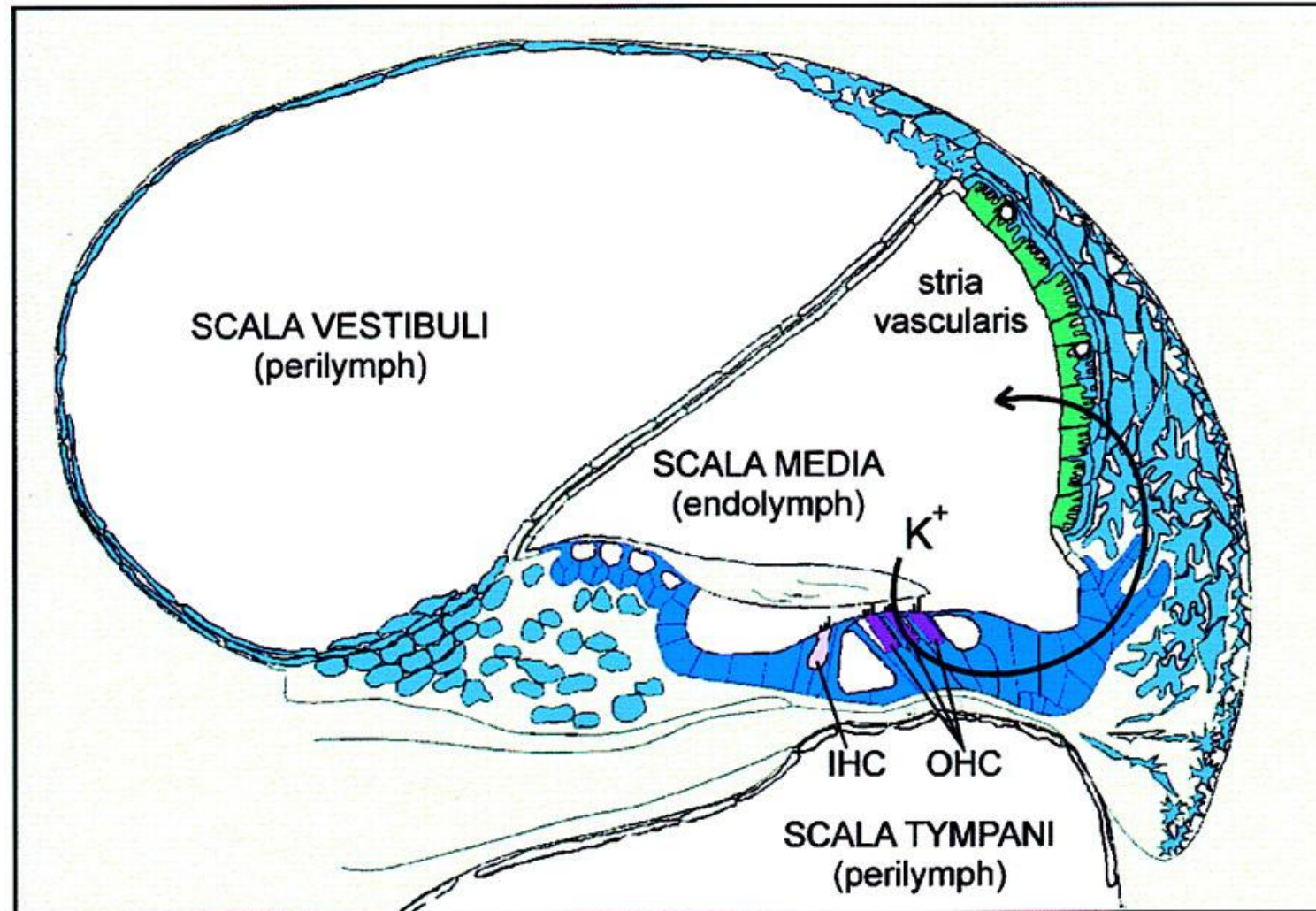
Cochlea

- **Scala vestibuli** and **scala tympani** - simple squamous epithelium on connective tissue fused with the periosteum
- **Scala media (cochlear duct)** separated from scala vestibule and scala tympani with vestibular membrane (Reissner membrane) – organ of Corti and stria vascularis

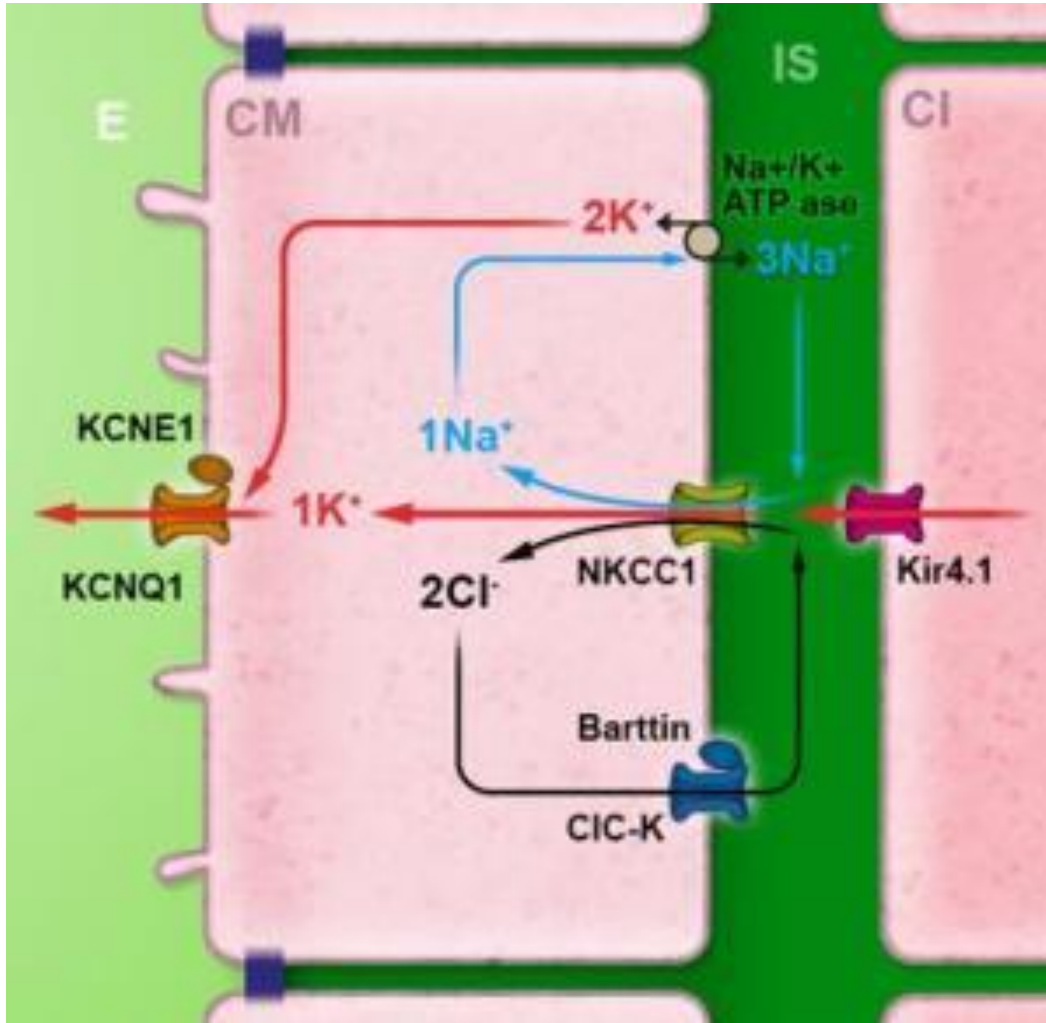




Stria vascularis



-  marginal cells of stria vascularis (KCNQ1 & KCNE1)
-  connective tissue system (GJB2)
-  epithelial cell system (GJB2)
-  outer hair cells (KCNQ4)



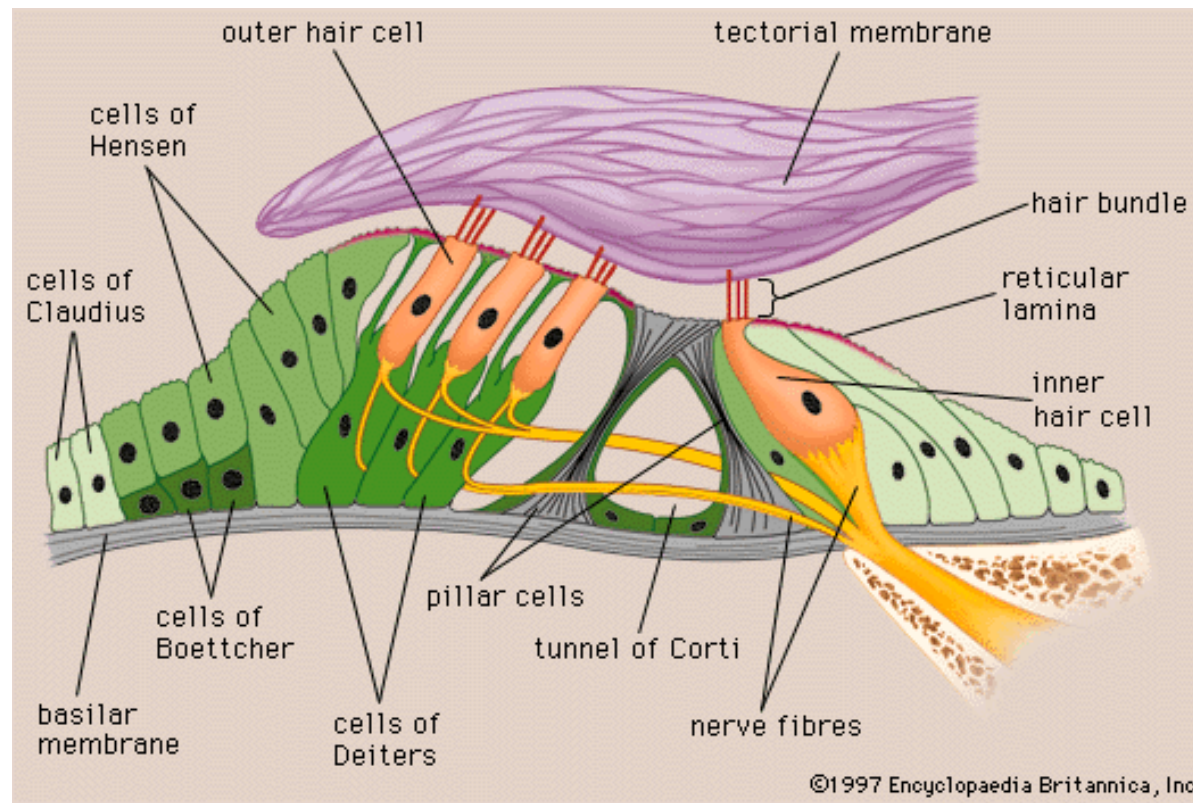
Potassium is transported from the basal cells to marginal cells through a series of channels – passive and active

Kir4.1 – the mutation causes **EAST syndrome** (Epilepsy, Ataxia, Sensorineural deafness and Tubulopathy)

Sodium-potassium pump– transports potassium to marginal cells

Symport **NKCC1** (sodium, chlorine, potassium) in the membrane of marginal cells – uses a gradient of sodium ions to transport potassium

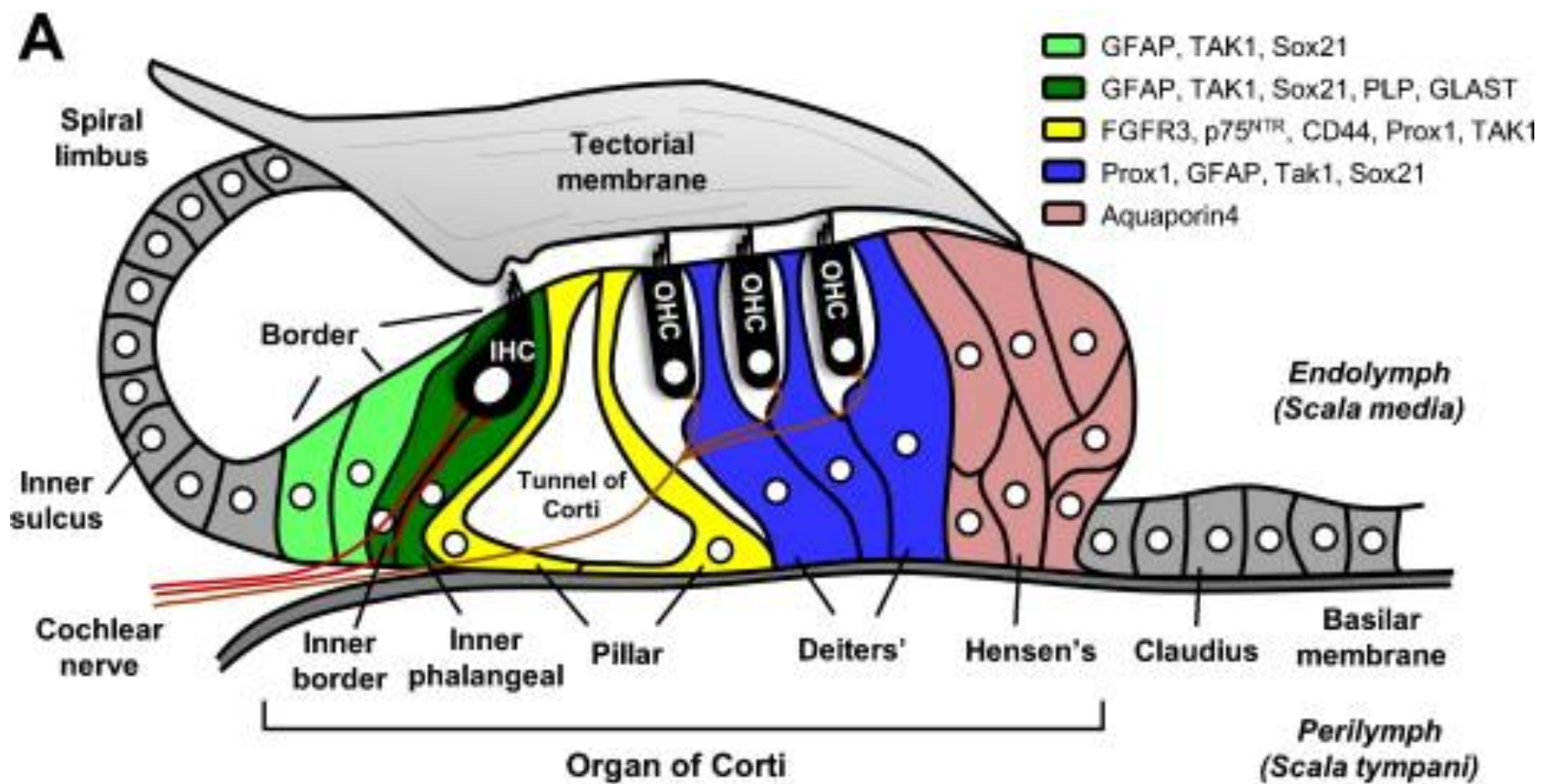
Channel **KCNQ1** for potassium - releases potassium into the endolymph – the mutation causes **Lange-Nielsen syndrome** (hearing loss, cardiac arrhythmias)



• Organ of Corti

- **Supporting cells** (external and internal pillar cells, internal phalangeal cells (cells of Dieter – house sensory cells, Hensen, Claudius, Boettcher cells)
- **Sensory cells – hair cells**
- **Tectorial membrane** - gel-like structure containing 97% water. Its dry weight is composed of collagen (50%), non-collagenous glycoproteins (25%) and proteoglycans (25%)

Support cells



Hensen cells – cubic

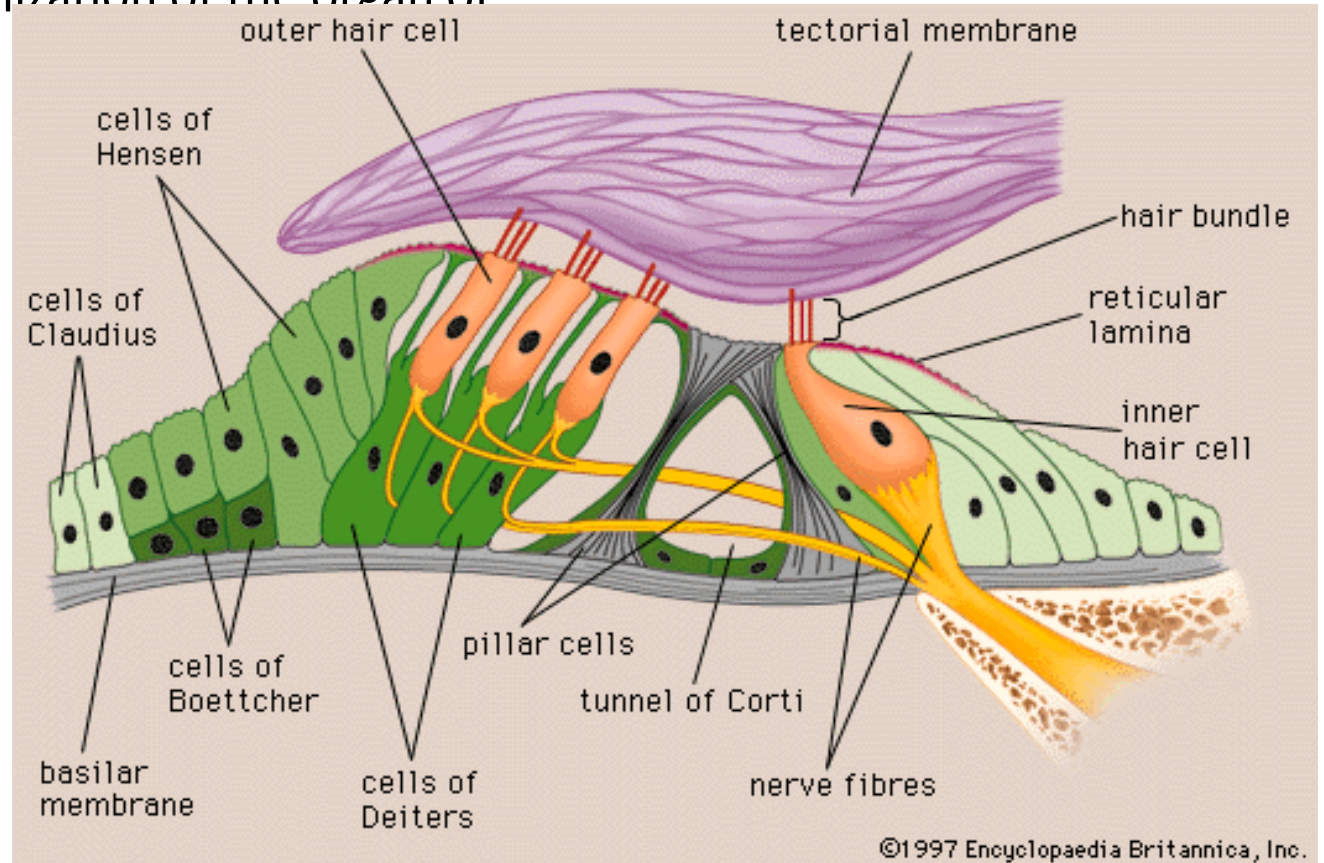
Cells of Dieter and **pillar cells** – well developed cytoskeleton, long processes – they maintain the structures of the tunnel of Corti

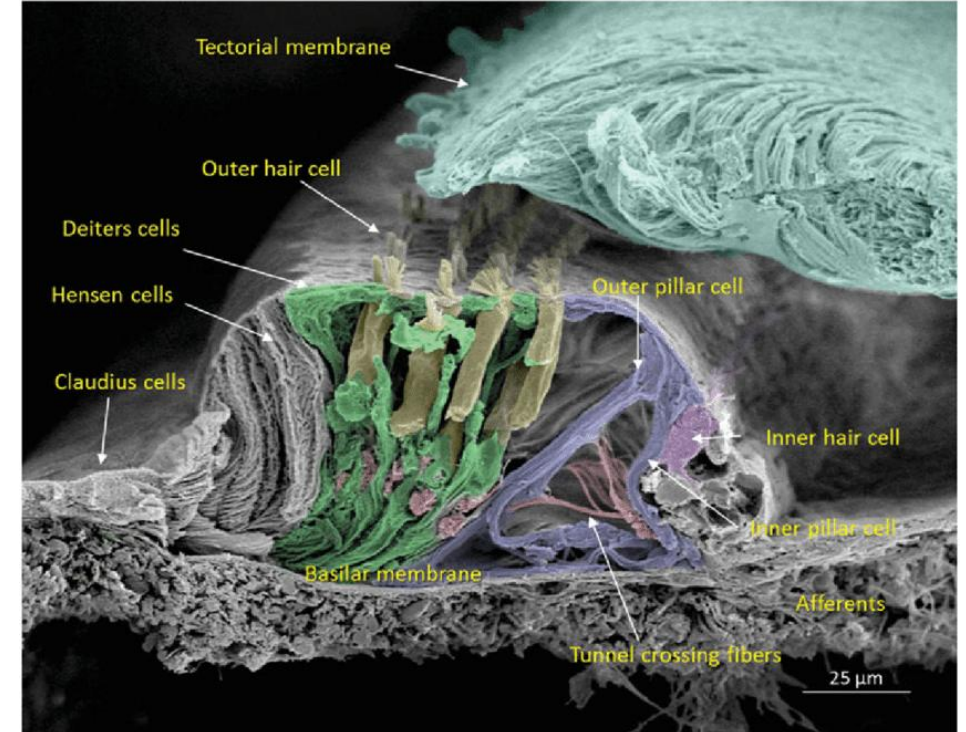
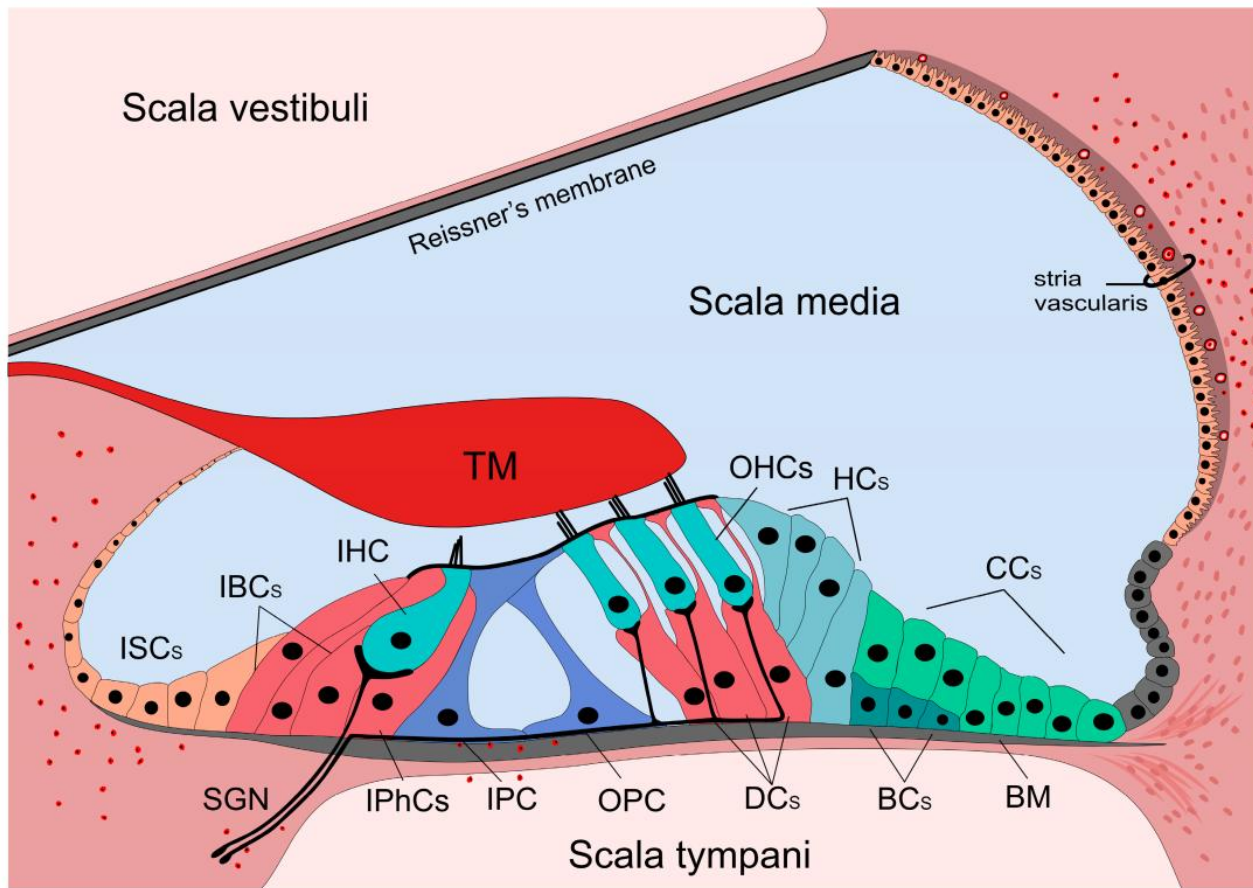
Functions of support cells:

During the development of the ear – the organization of the organ of Corti, the development of hair cells

In the mature ear:

- Maintaining hair cells
- Maintaining the integrity of the Corti organ
- Homeostasis of ions and neurotransmitters
- Participation in mechanotransduction
- Extracellular matrix production
- **reticular membrane**

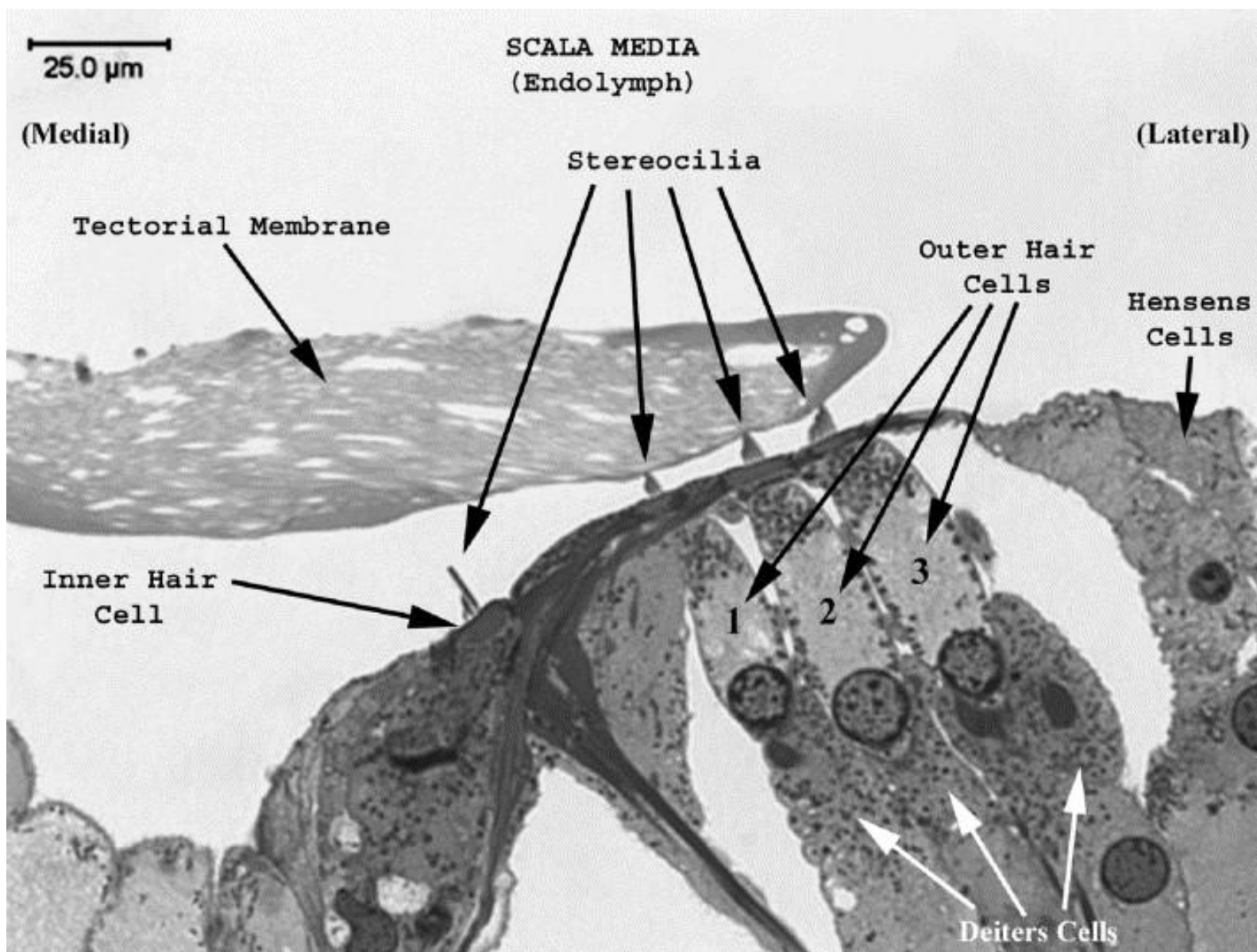




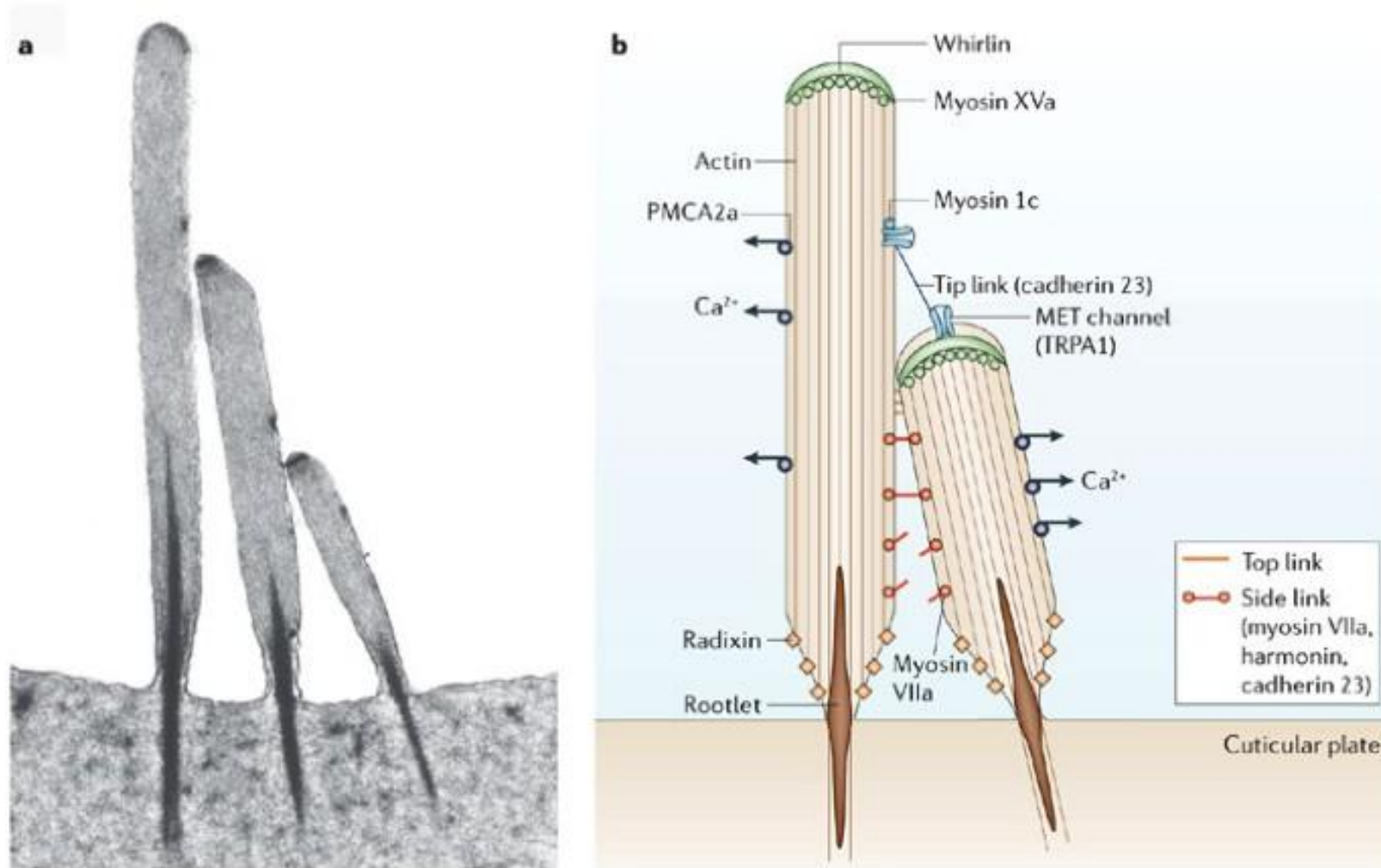
Sensory cells

inner hair cells (type I) with stereocilia

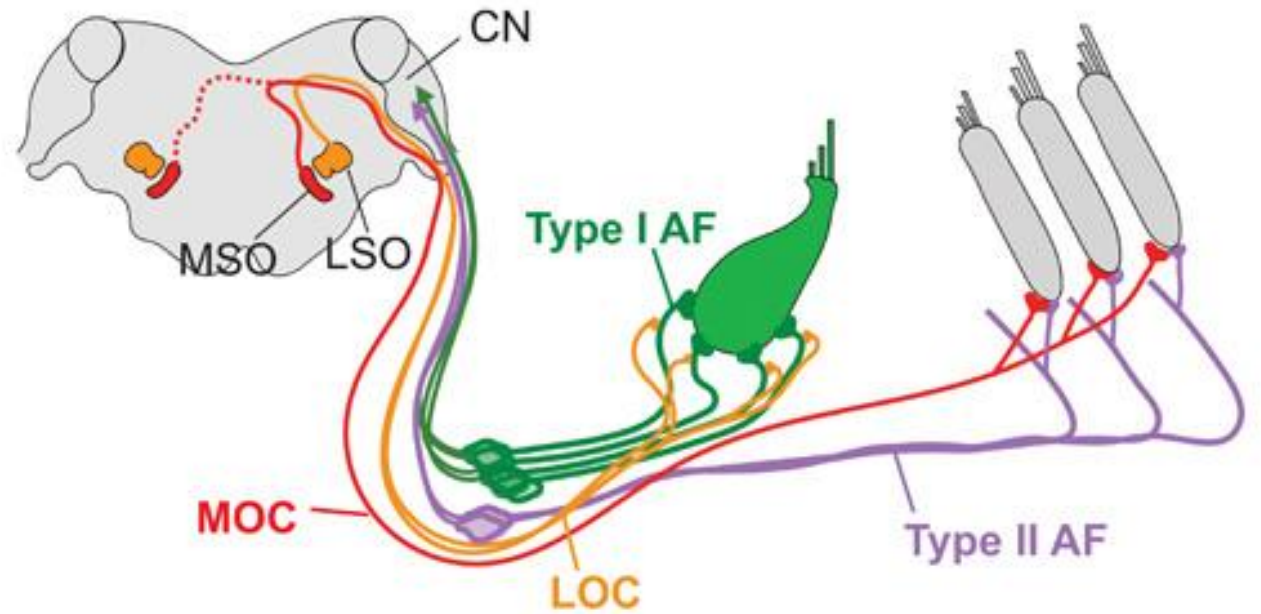
outer hair cells (type II) with stereocilia

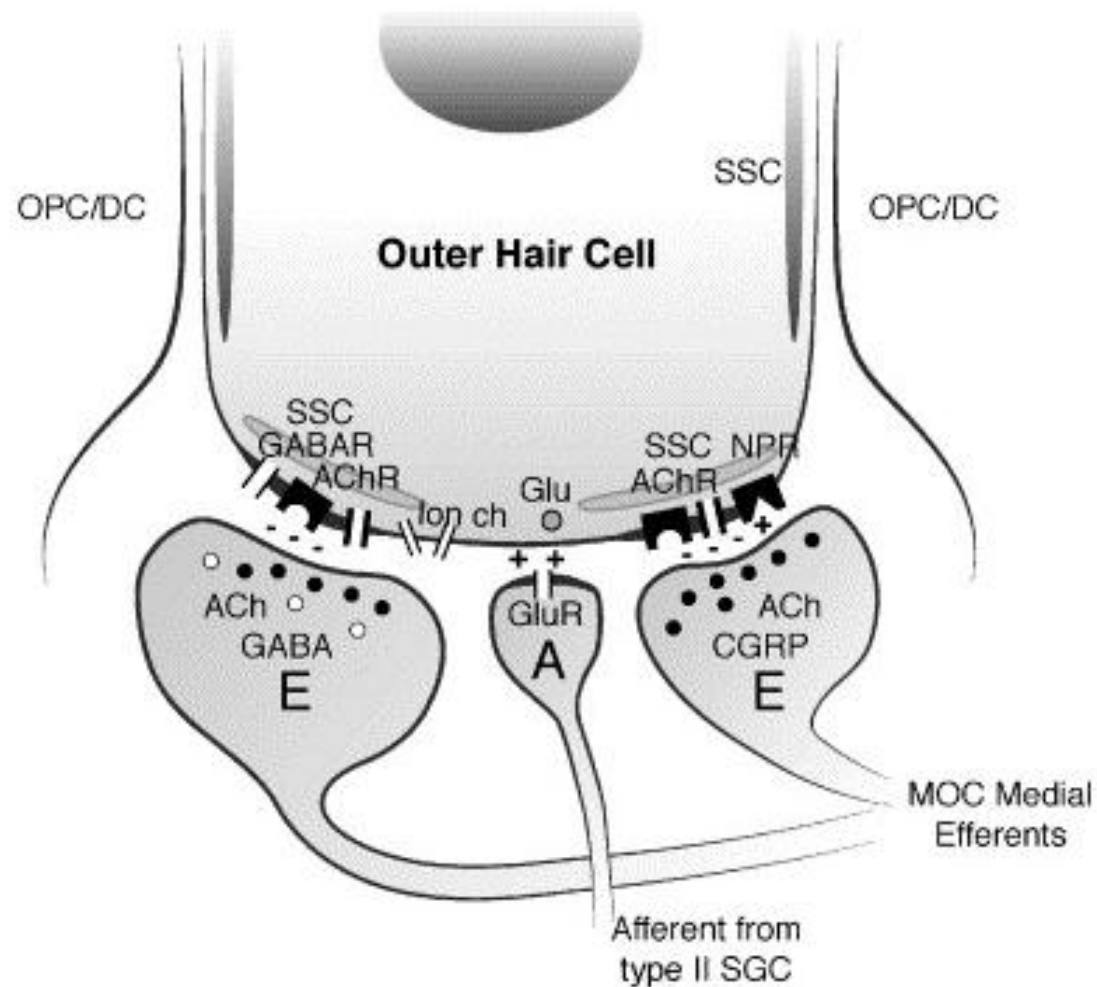
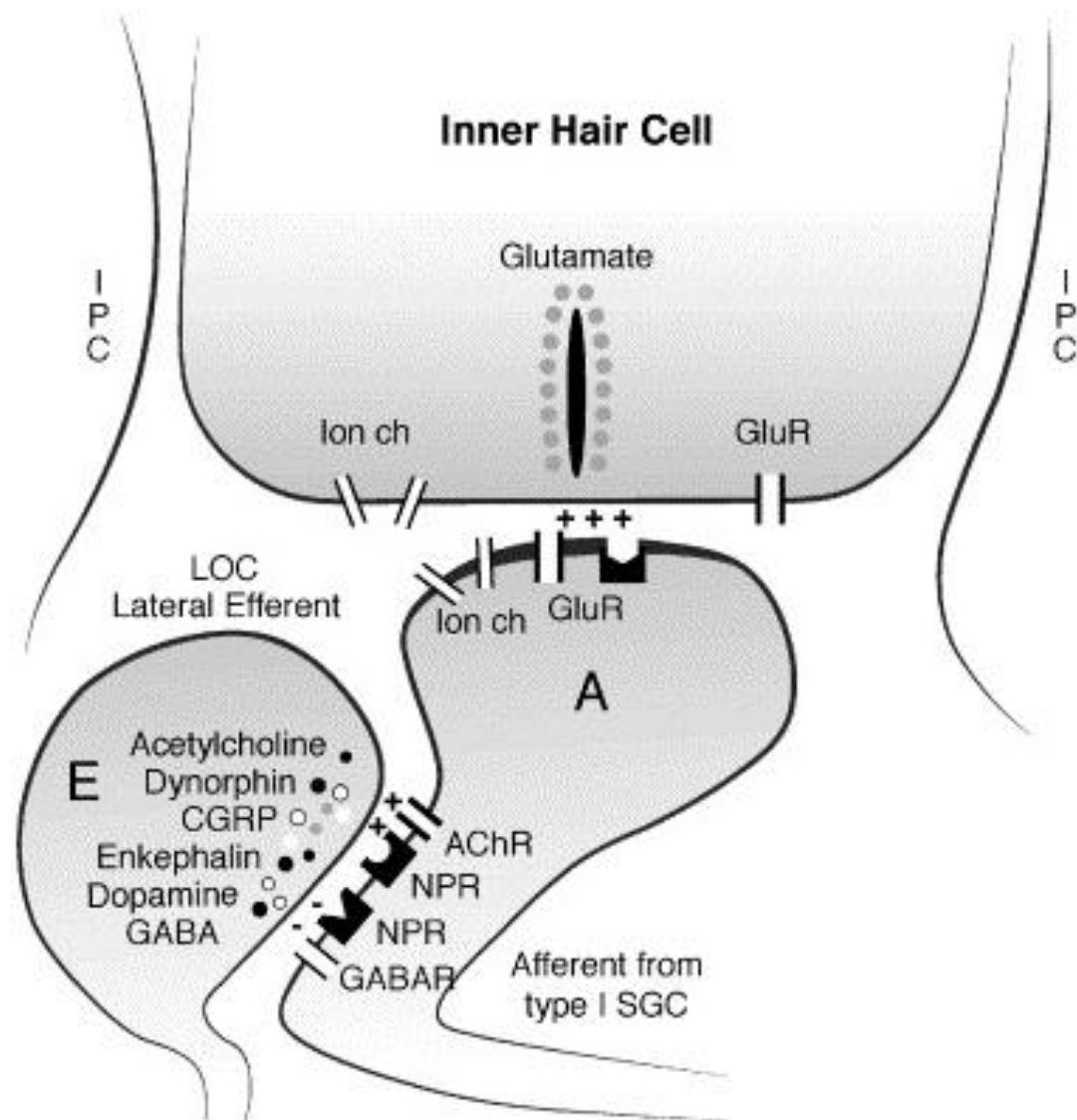


Hair cells

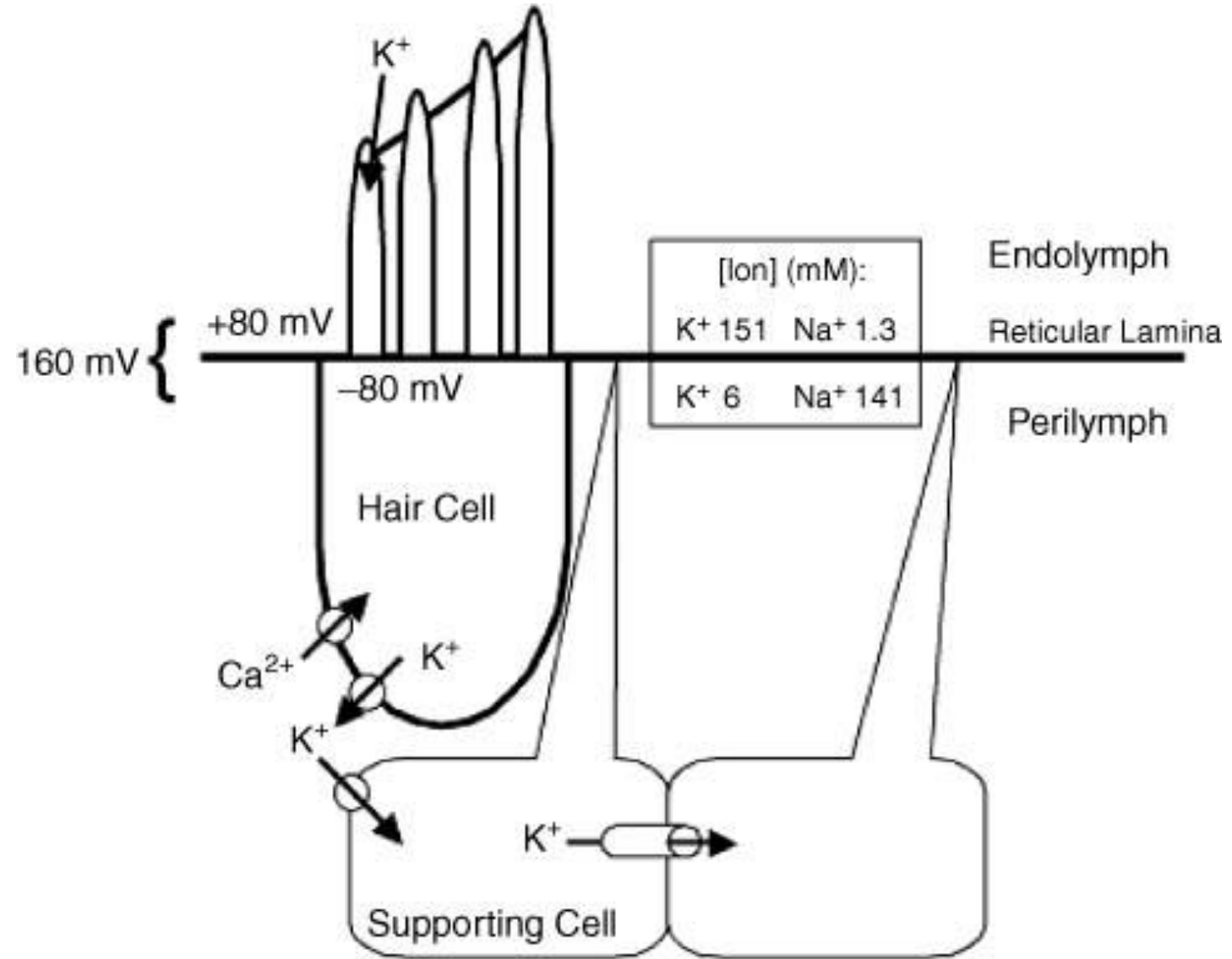


- **Afferent acoustic fibers** (AF type I and II) - dendrites of bipolar spiral ganglion cells—reach the hair cells
- **Efferent acoustic fibers** (LOC, MOC) – upper ganglion of the olivary nucleus – Innervates support and hair cells



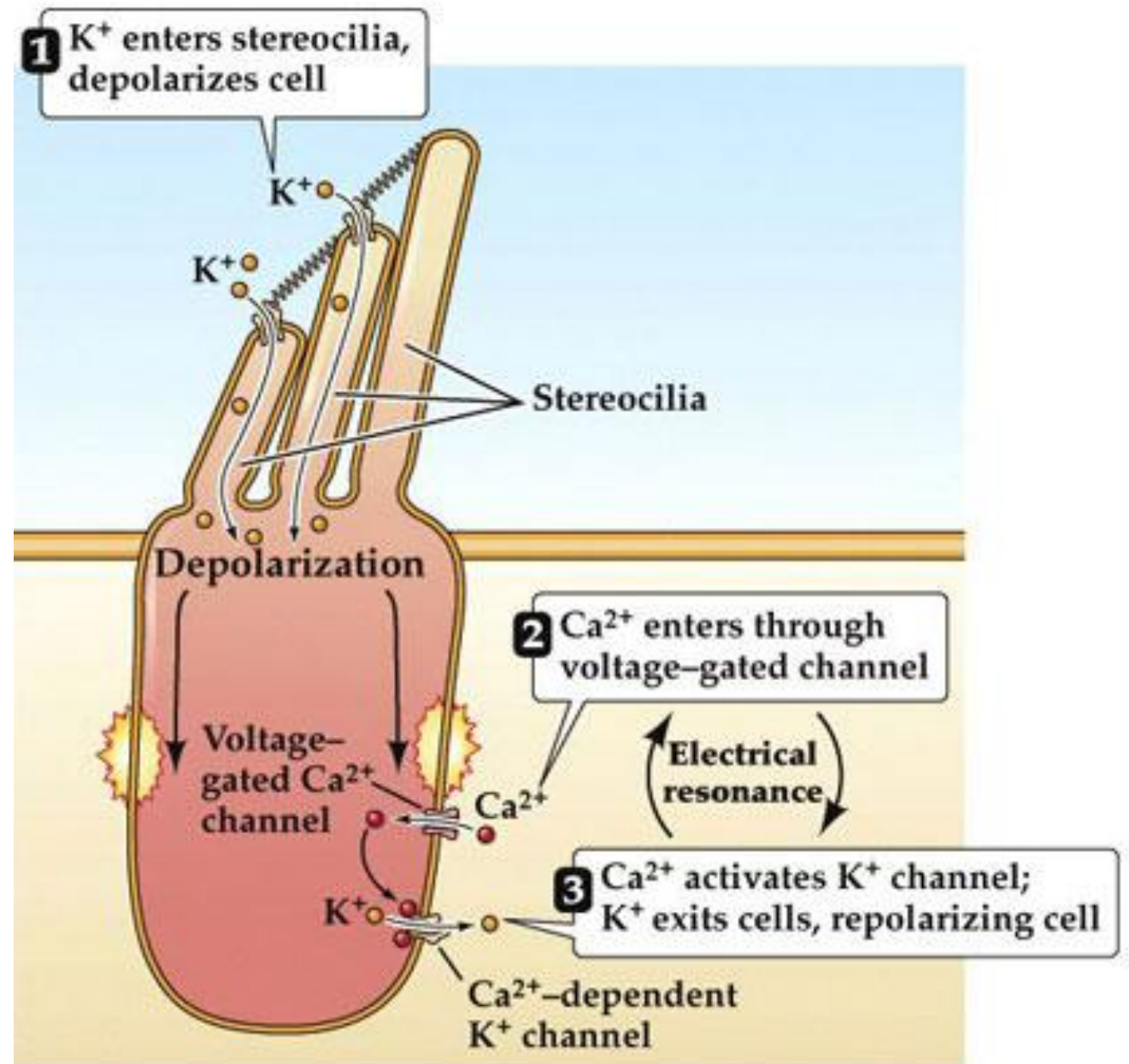


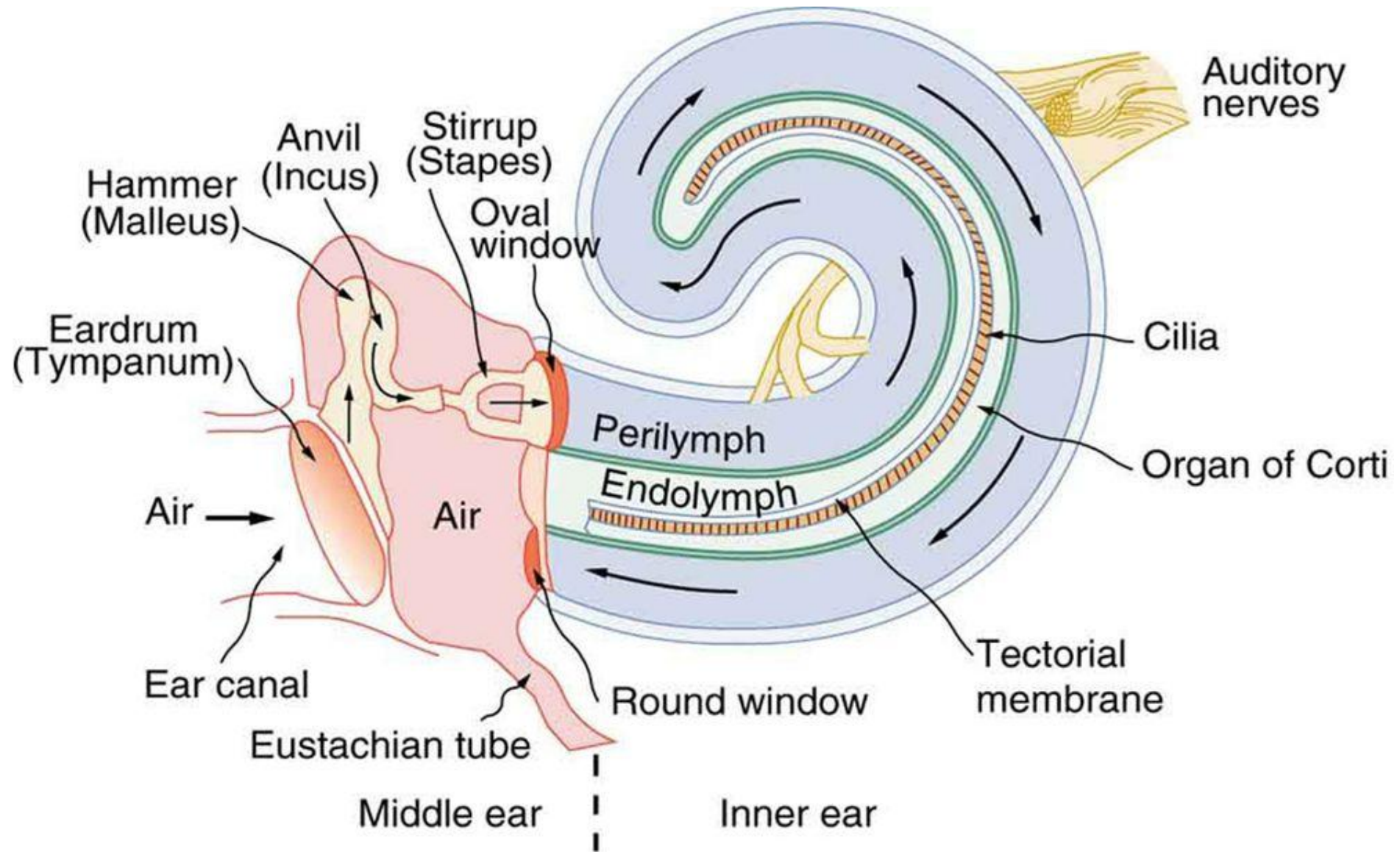
Cochlear potential

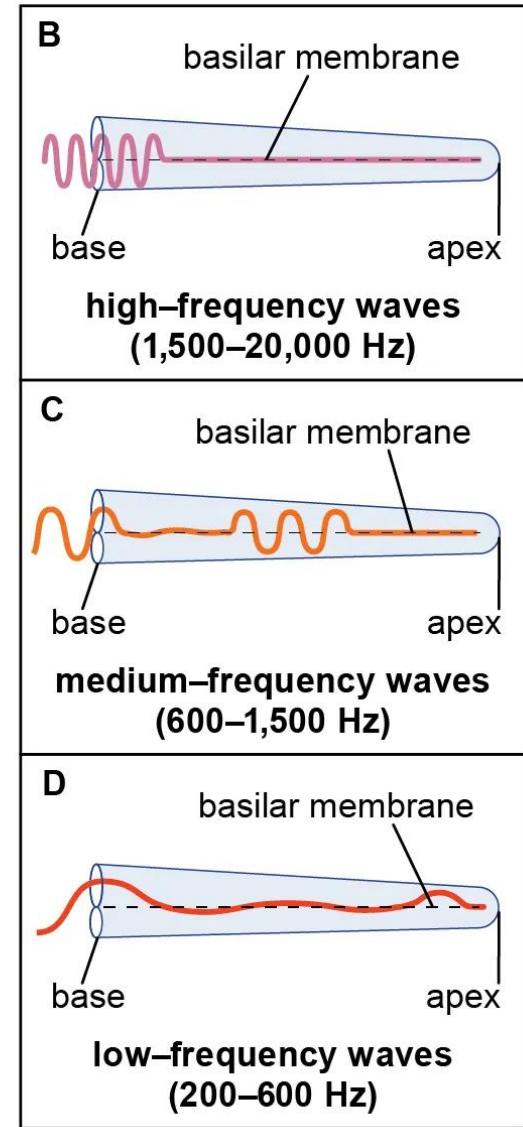
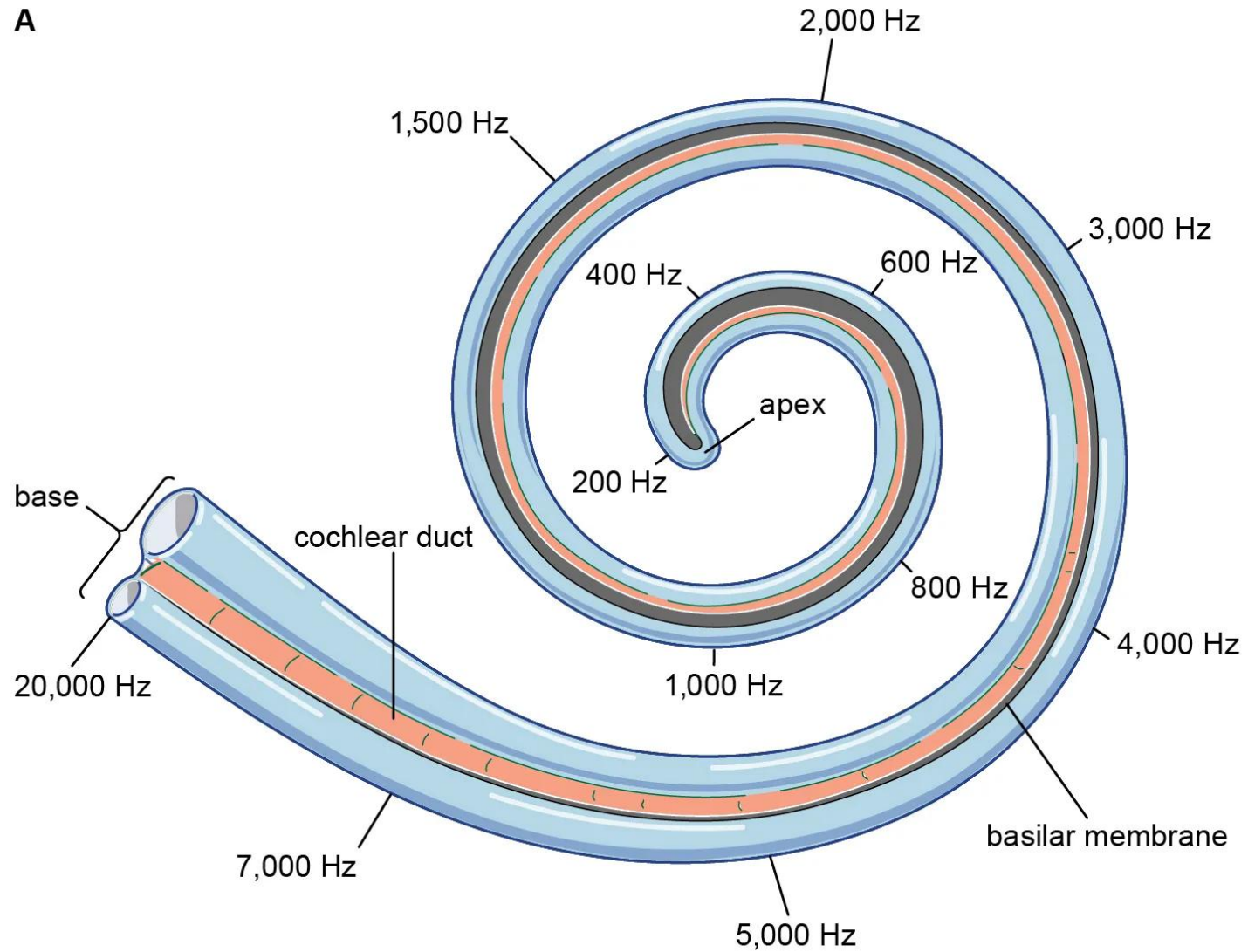


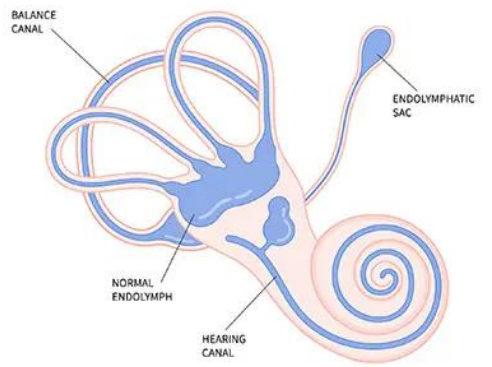
Potassium flow– a way to depolarize and repolarize without ATP expenditure

Potassium flows into the cell passively (**ENDOLYMPH** – high concentration of K^+), causing depolarization and then exits the cell according to a gradient in the basal portion that is immersed in the **PERILYMPH** (low concentration of K^+)









HEALTHY INNER EAR

MENIERE'S DISEASE

VERTIGO



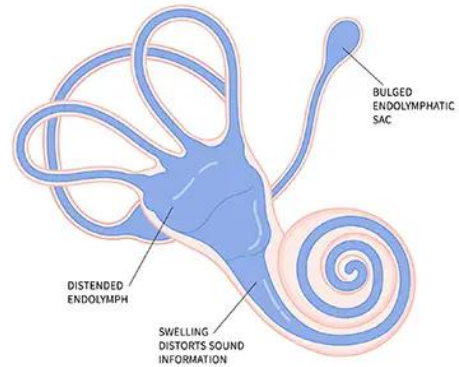
HEARING LOSS



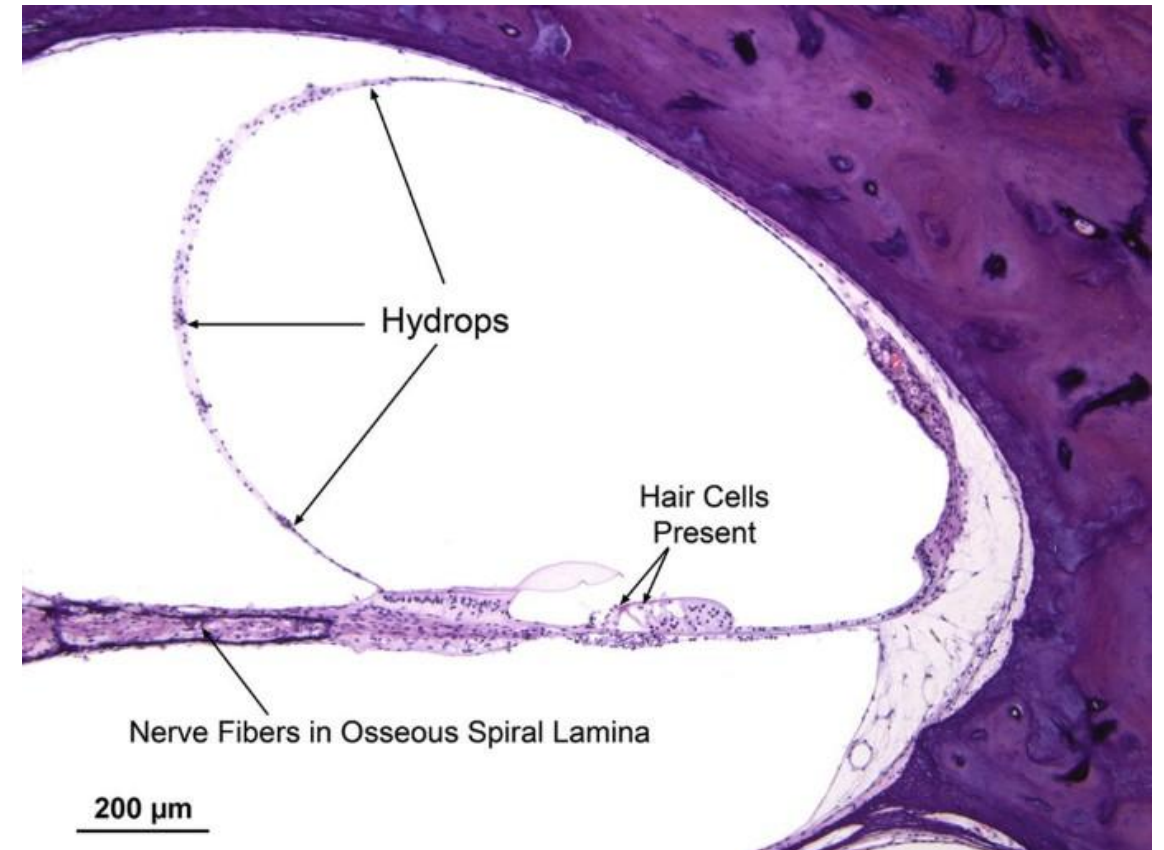
TINNITUS



AURAL FULLNESS



MENIERE'S DISEASE

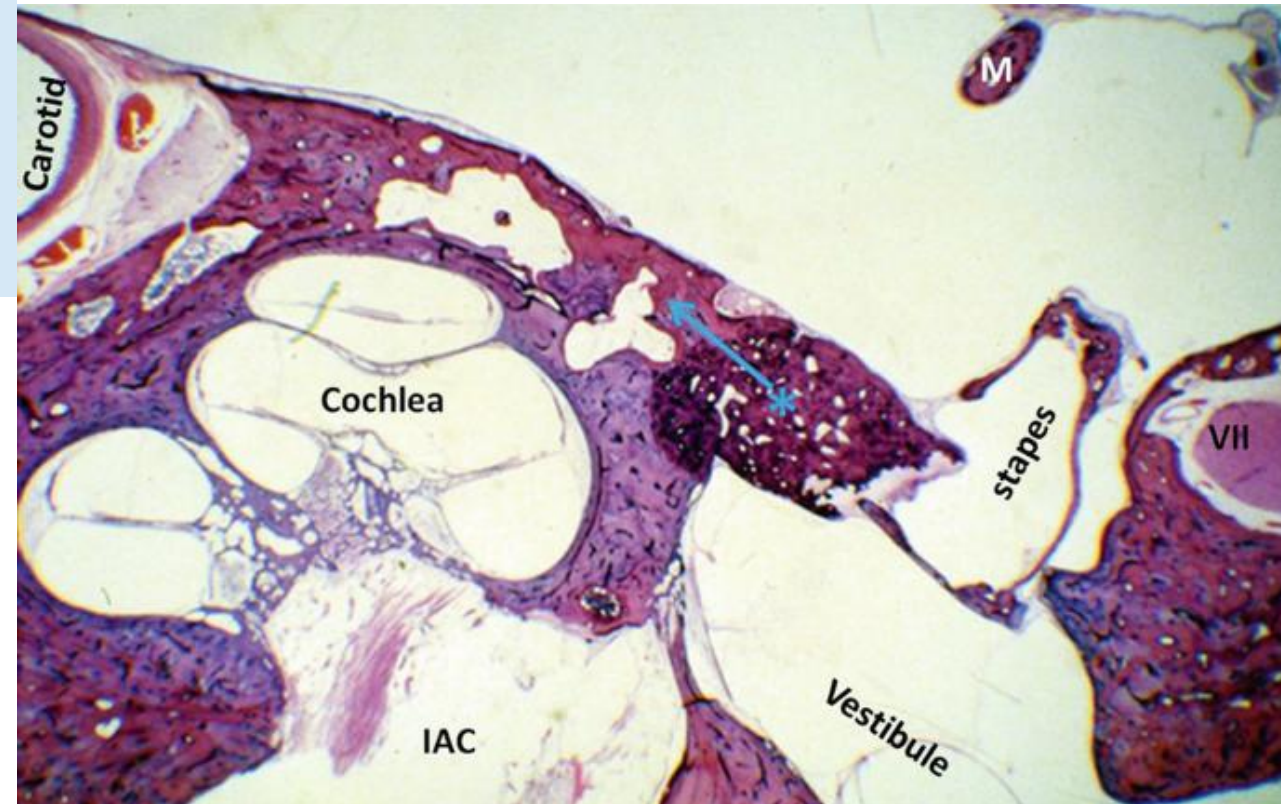
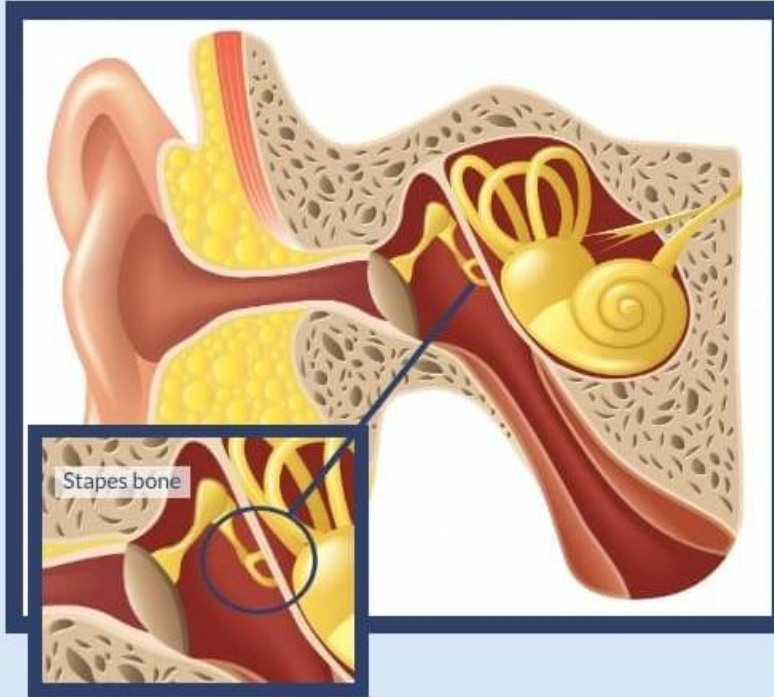


What is otosclerosis?

Otosclerosis is a condition that affects the tiny middle ear bone known as the stapes.

The stapes can become stuck, limiting its ability to vibrate.

These vibrations are crucial for hearing.



Cochlear implant

