

THE EAR



- Functions of the ear:

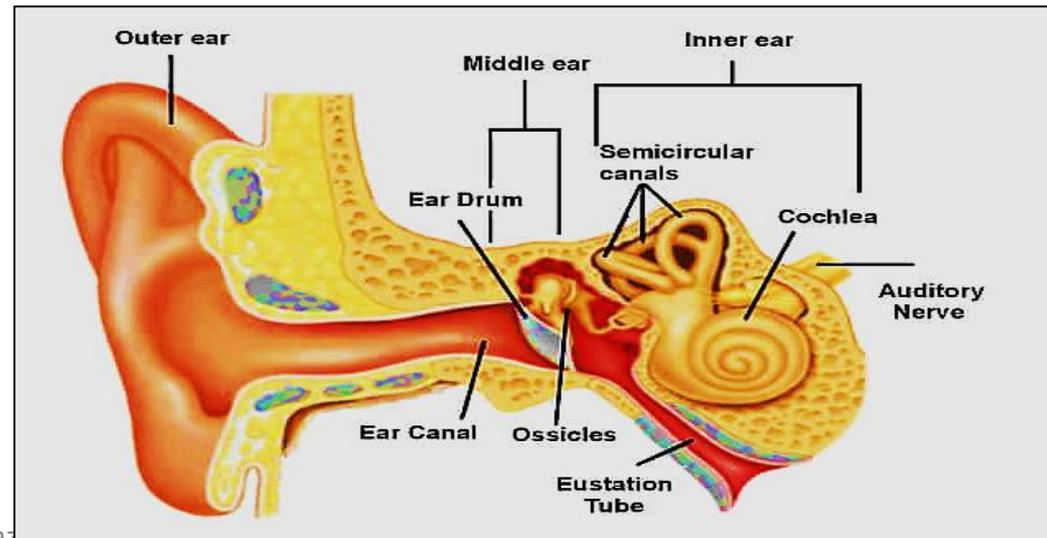
1- Hearing

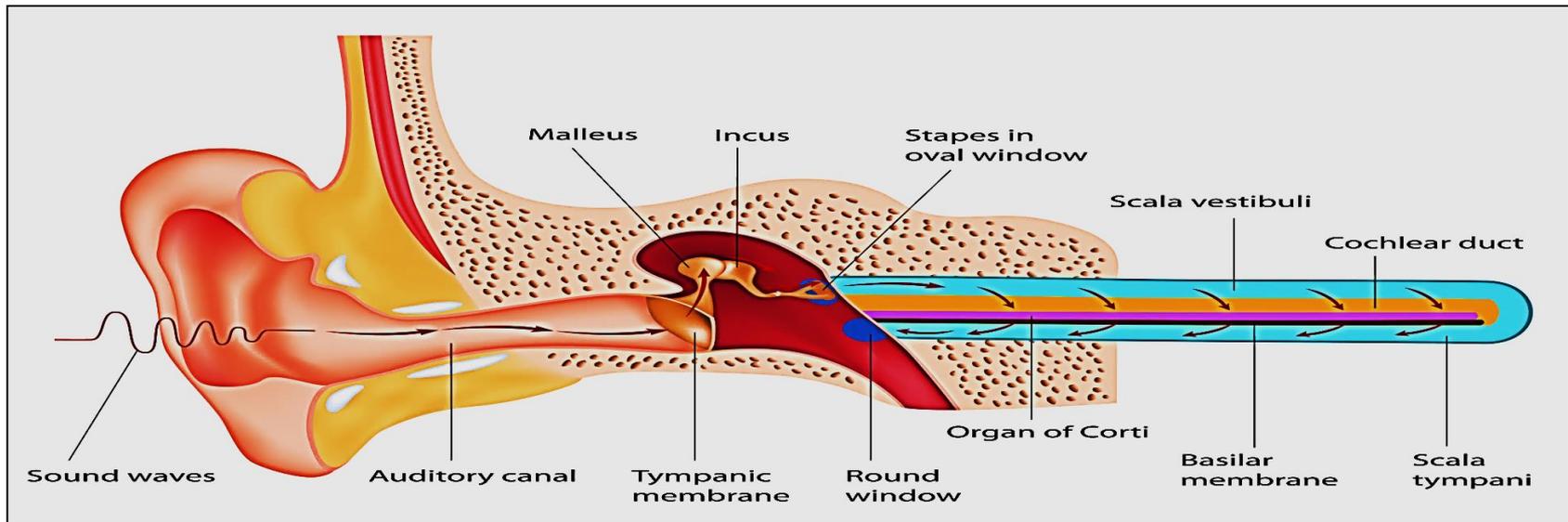
2- balance & equilibrium

- Parts of the ear:

composed of 3 parts:

- external ear
- middle ear
- inner ear





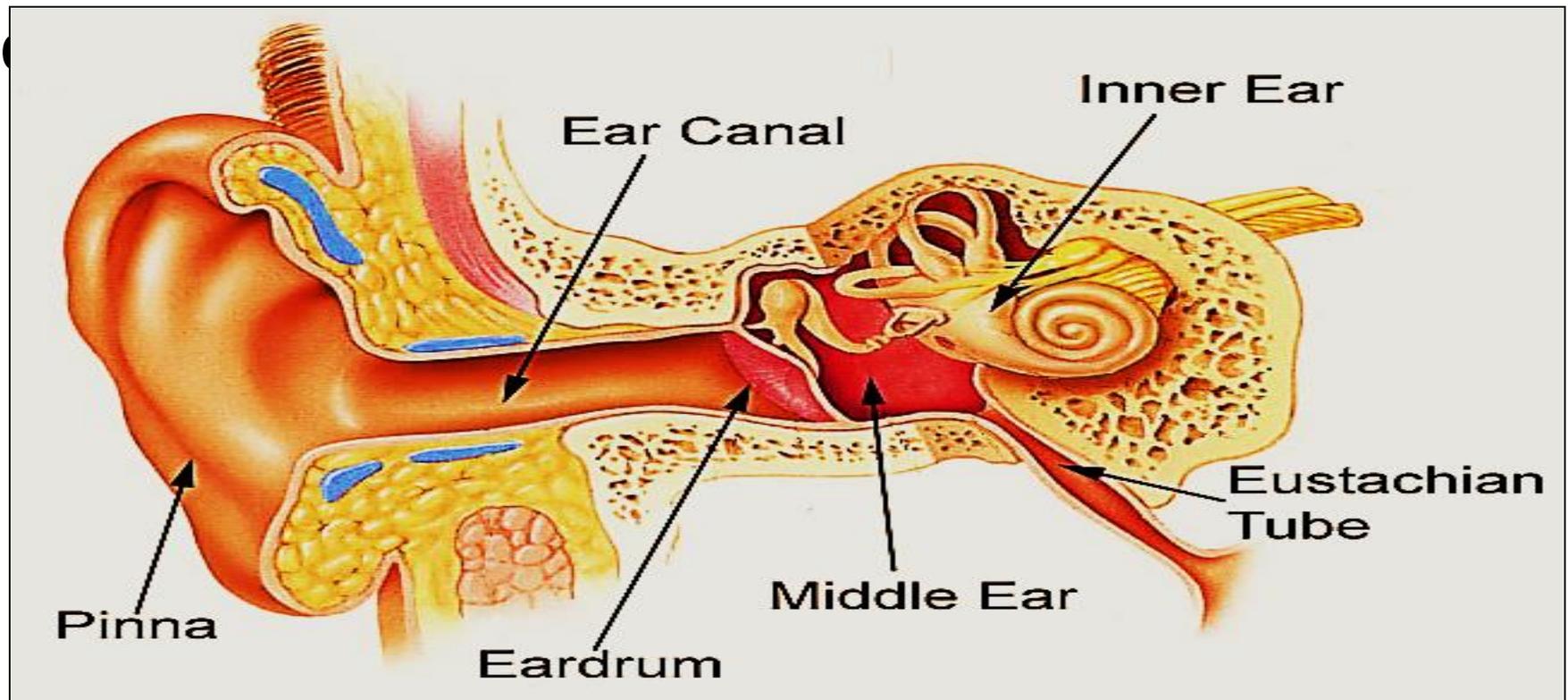
- **External ear:** receives sound waves
- **Middle ear:** cavity contains **3 small bones** which transmit sound waves (**mechanical vibration**) to inner ear
- **Inner ear:** contains fluid which movement are transduced to (signals) nerve impulses → CNS →
 - (a) **hear sounds**
 - (b) **equilibrium** (vestibular organs)

The External ear

Composed of: 1- Auricle (pinna)

2- External auditory canal(meatus)

3- Tympanic membrane (Eardrum)

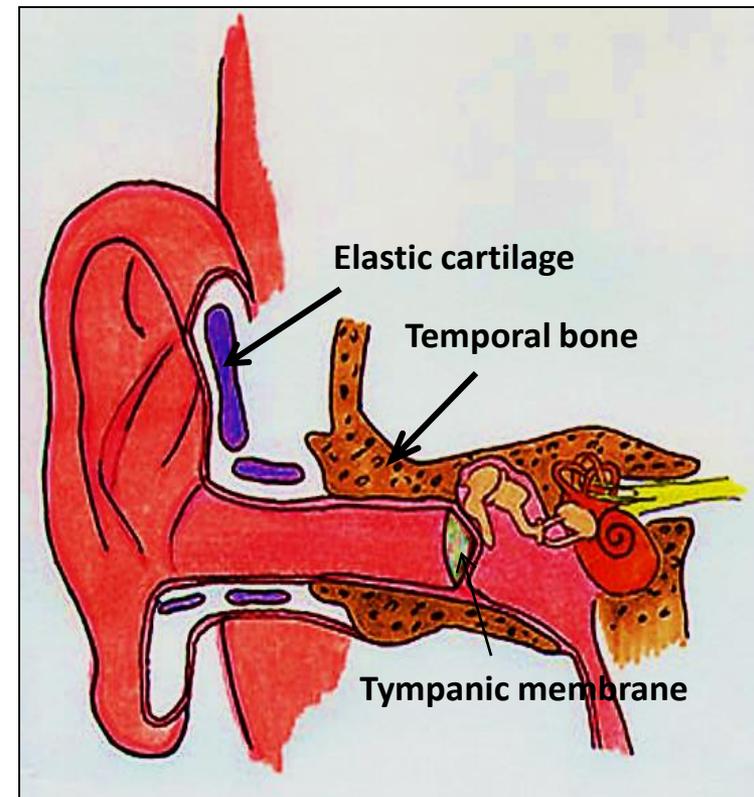


Auricle: funnel shaped, elastic cartilage, covered with skin, collect the sound waves toward the ear canal

External auditory canal:

- its **outer 1/3** is cartilage , inner **2/3 is bone** (temporal bone)
- lined with **keratinized stratified squamous epithelium**
- its lining has *hair follicles*,
sebaceous glands,
ceruminous glands
(modified apocrine sweat glands)

Cerumen: a waxy yellowish material, is mixture of secretions of both glands



Tympanic membrane (ear drum): thin connective tissue membrane covered by skin on outside & mucosa on internal surface, made of 3 layers

Outer layer : keratinized Stratified squamous epithelium devoid of hair

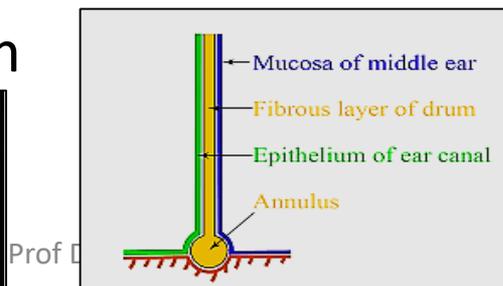
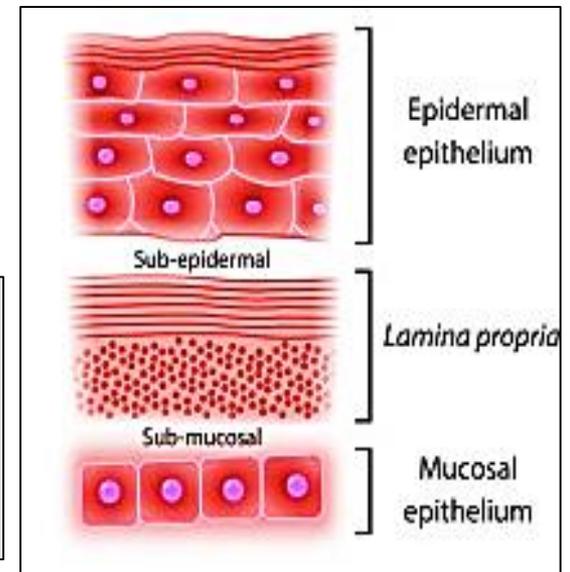
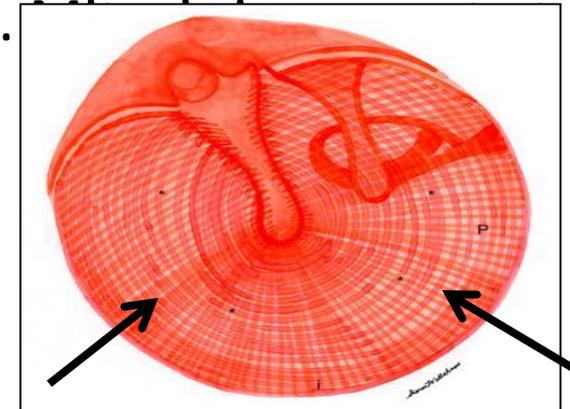
it is thin at the center & thick at periphery of drum.
marginal cells which responsible for regeneration of perforated drum

Intermediate layer: collagenous fibrous layer

made of outer radiating & inner Circular fibers

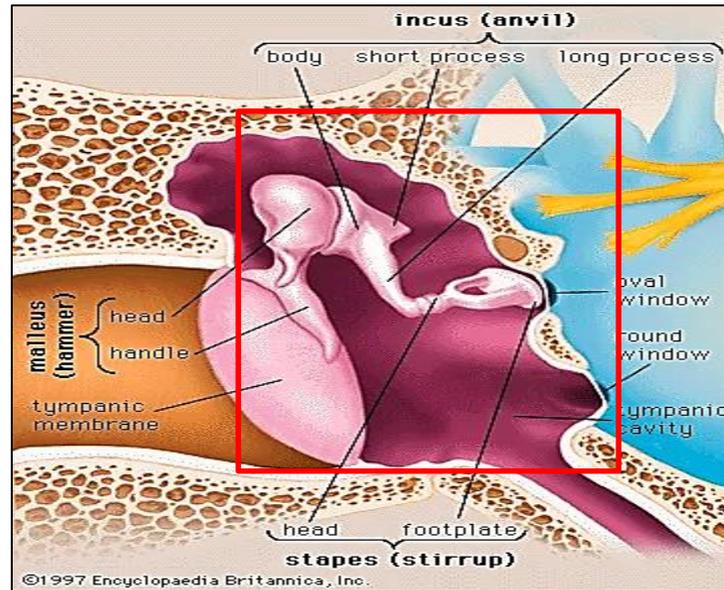
Inner mucous layer: simple cuboidal epithelium

cover the inner surface of drum



Prof D

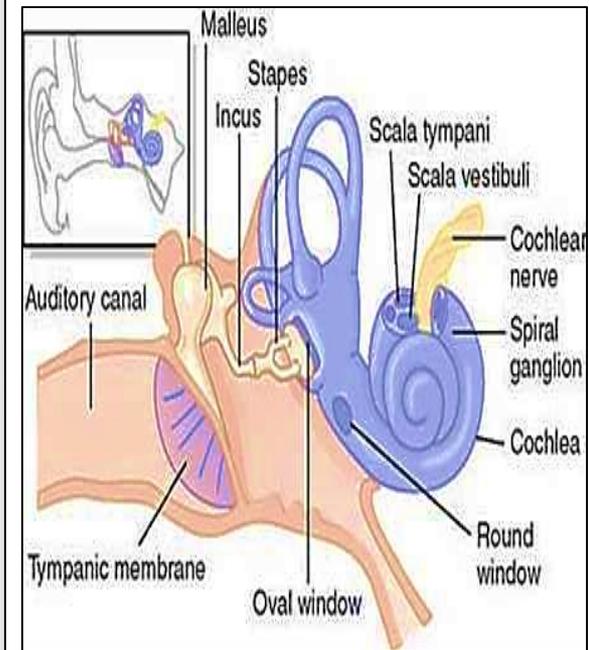
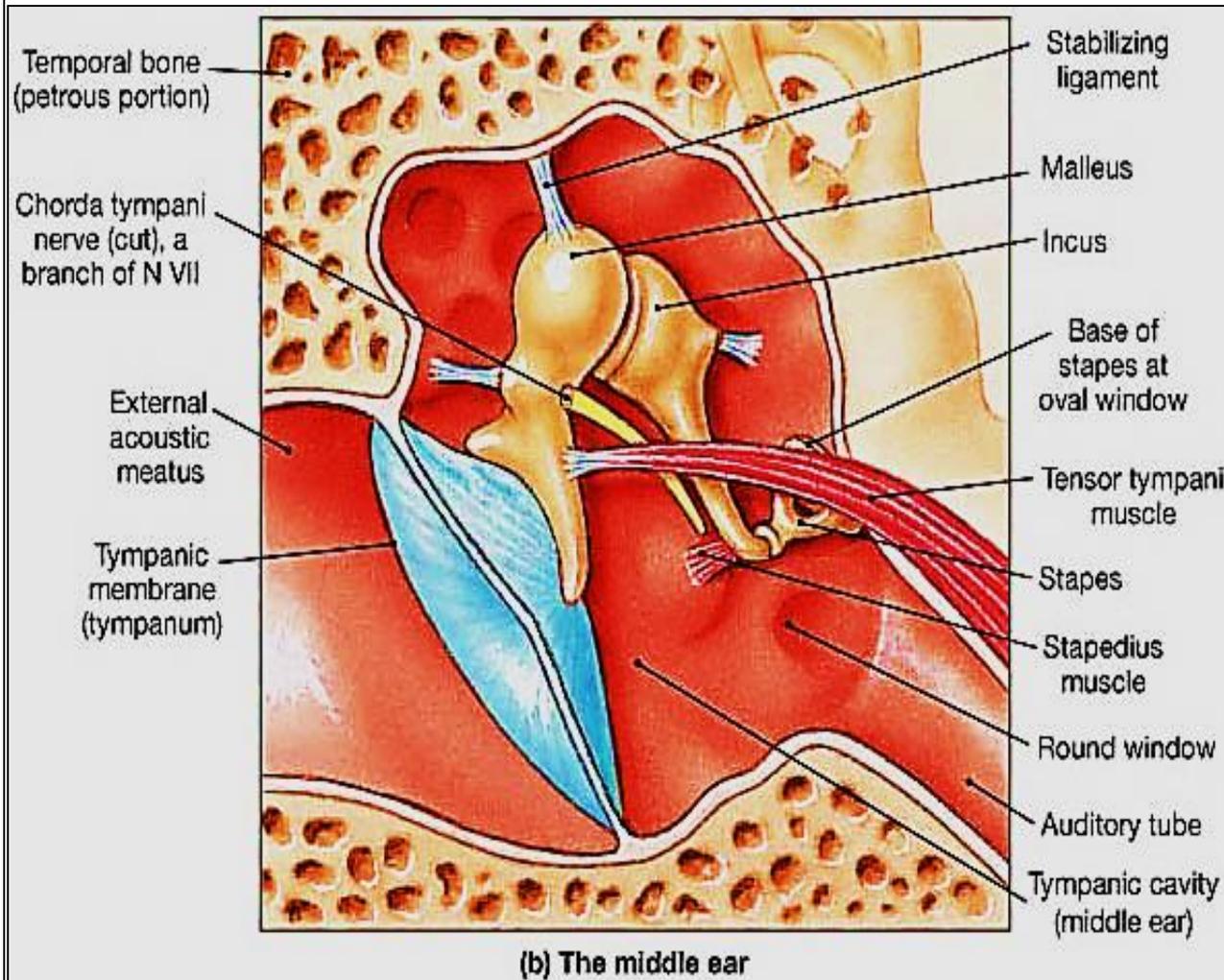
The Middle Ear (tympanic cavity)



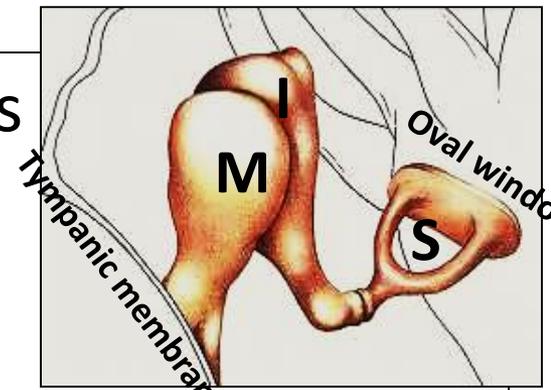
- **Air filled cavity , within temporal bone. Lined with **simple cuboidal epithelium****
- **Laterally:** tympanic membrane,
- **Medially :** oval & round windows of inner ear
- **Anteriorly:** communicate with pharynx via Eustachian tube
- **Posteriorly:** temporal bone

Contents of Middle ear : (3221)

3 bony ossicles, 2 muscles, 2 windows, 1 chorda tympani n.



- **Auditory ossicles** : malleus, incus , stapes
(hammer, anvil, stirrup)

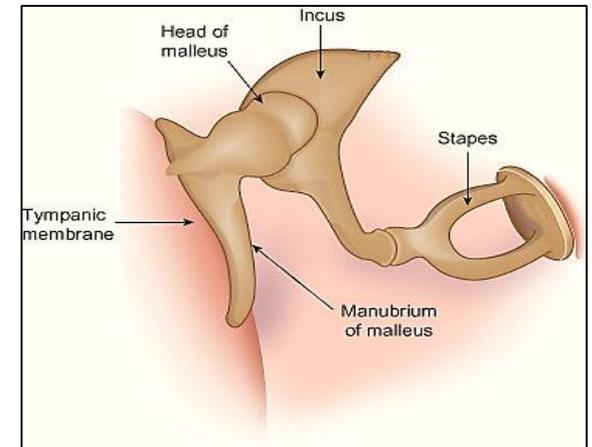


- Malleus attached to tympanic membrane, Stapes to membrane of oval window.
- The auditory ossicles transmit vibration of ear drum to **perilymph** of inner ear
- They are **compact bone** without epiphysis, they articulate with each other by **synovial joints** & held together by ligaments.

- **Muscles** (2 **striated involuntary ms**):

Tensor tympani & Stapedius

Prof Dr Hala Elmazar

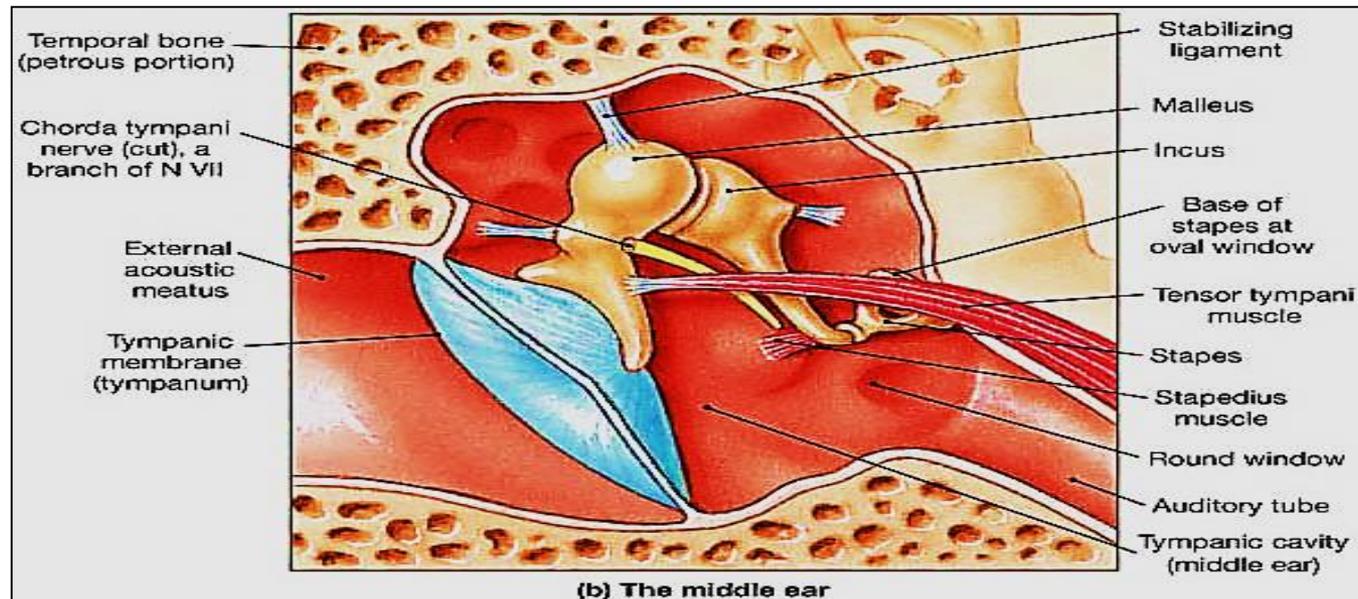


✓ Tensor tympani:

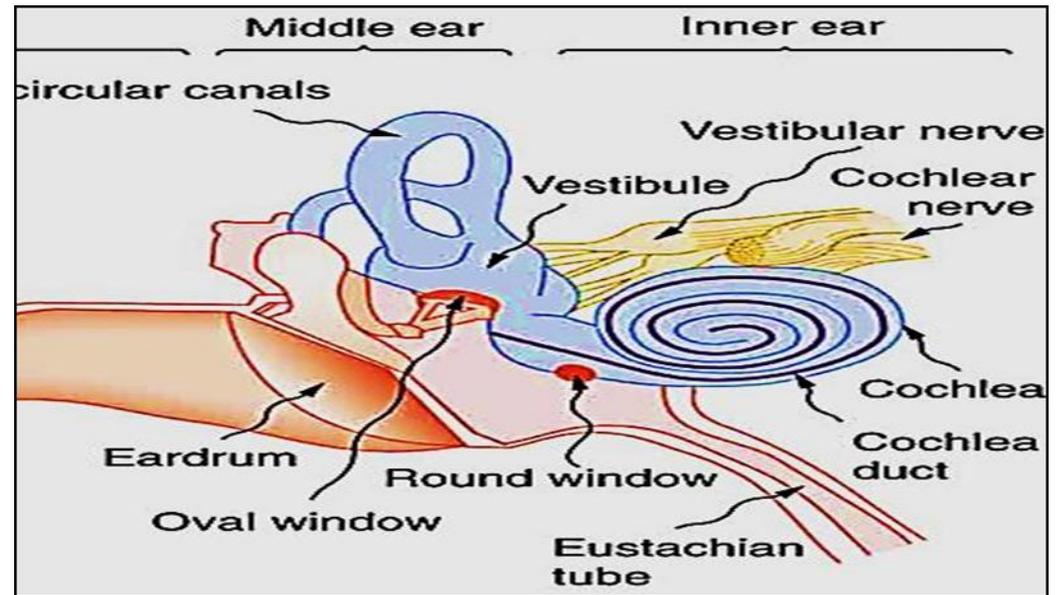
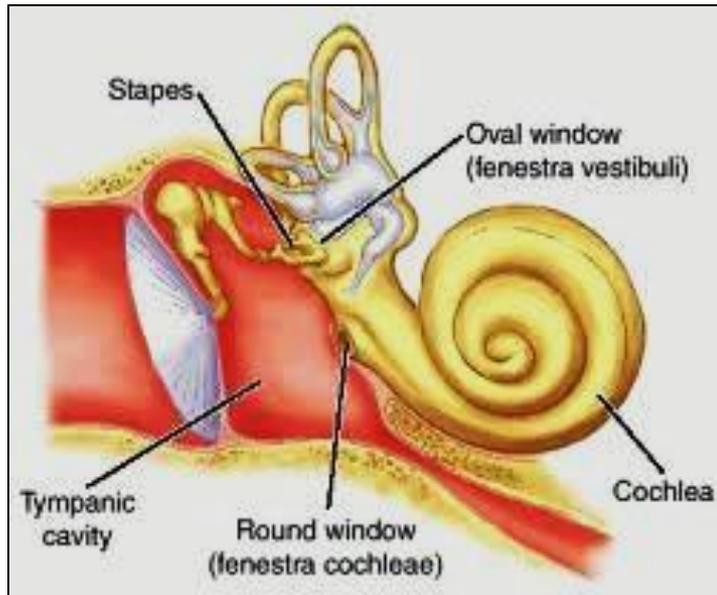
attach to handle of malleus. Its contraction → stretch ear drum → protect against loud sounds

✓ Stapedius :

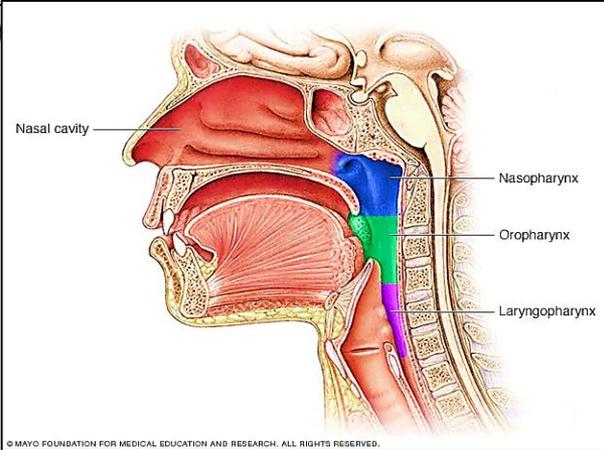
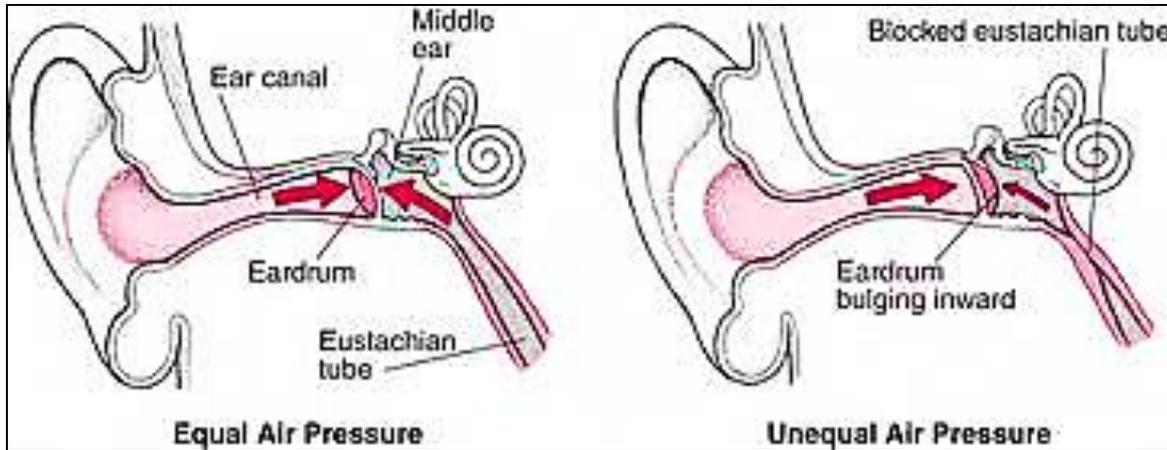
Attach to neck of stapes. Its contraction → pull stapes out → protect inner ear against loud noise



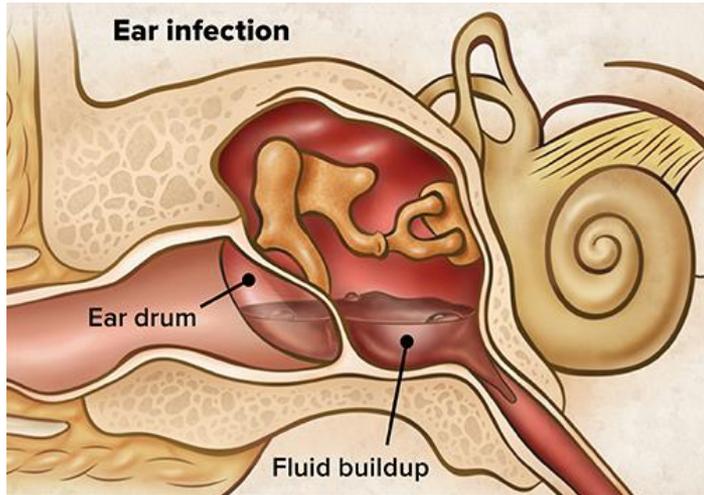
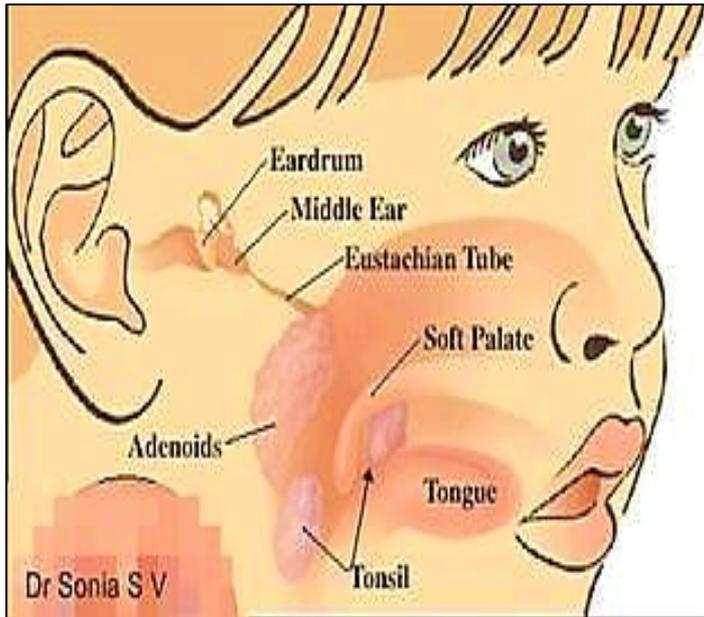
- **Windows**: 2 openings covered by membranes, between middle and inner ear
- **Oval window**(fenestra **vestibule**): closed by annular ligament which attached to foot plate of stapes. It transmits vibration to perilymph of **vestibule** of inner ear
- **Round window**(fenestra **cochlea**):closed by elastic membrane called 2ry tympanic membrane



■ Eustachian tube:



- It connects the middle ear e nasopharynx, open during swallowing
- serves to balance the air pressure in middle ear with atmospheric pressure.
- It has 2 parts:
 - **Bony part (tympanic):** posteriorly, formed of compact bone & lined with **simple columnar ciliated epithelium**
 - **Cartilaginous part (pharyngeal):** anteriorly, formed of elastic cartilage, **lined with respiratory epithelium**

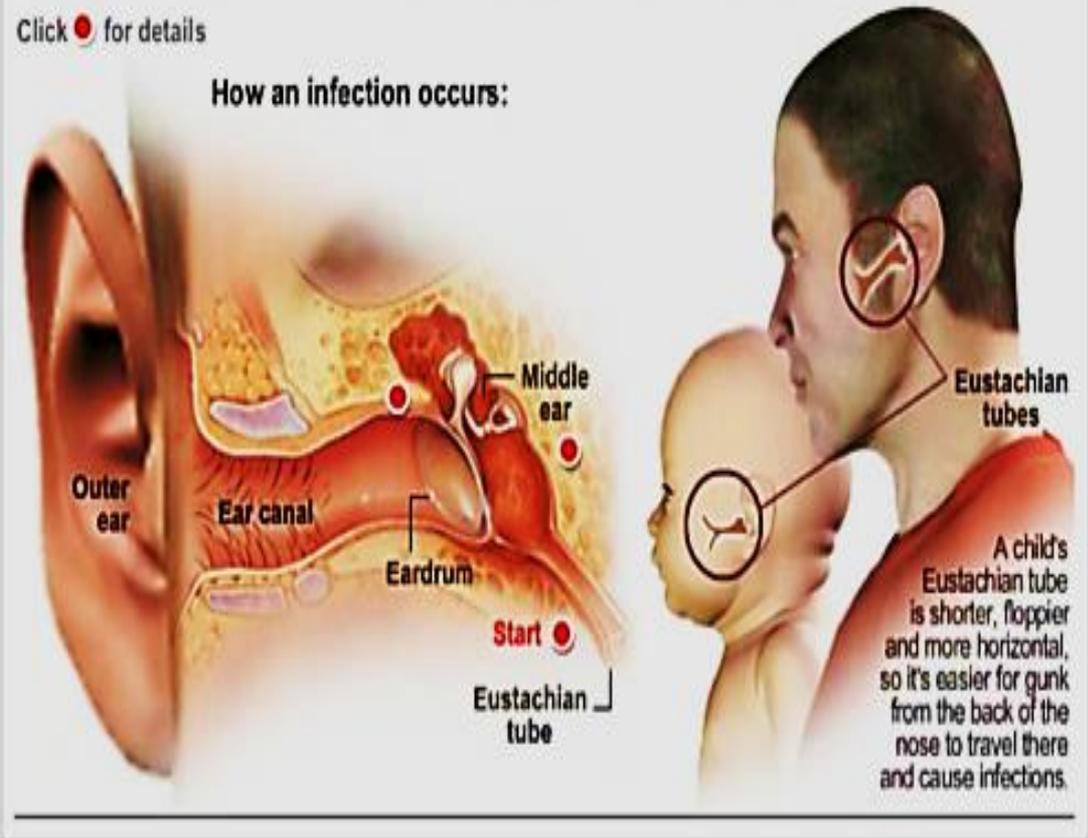


Why kids are prone to ear infections

Researchers are developing a number of vaccines with the potential to prevent ear infections in children.

Click  for details

How an infection occurs:

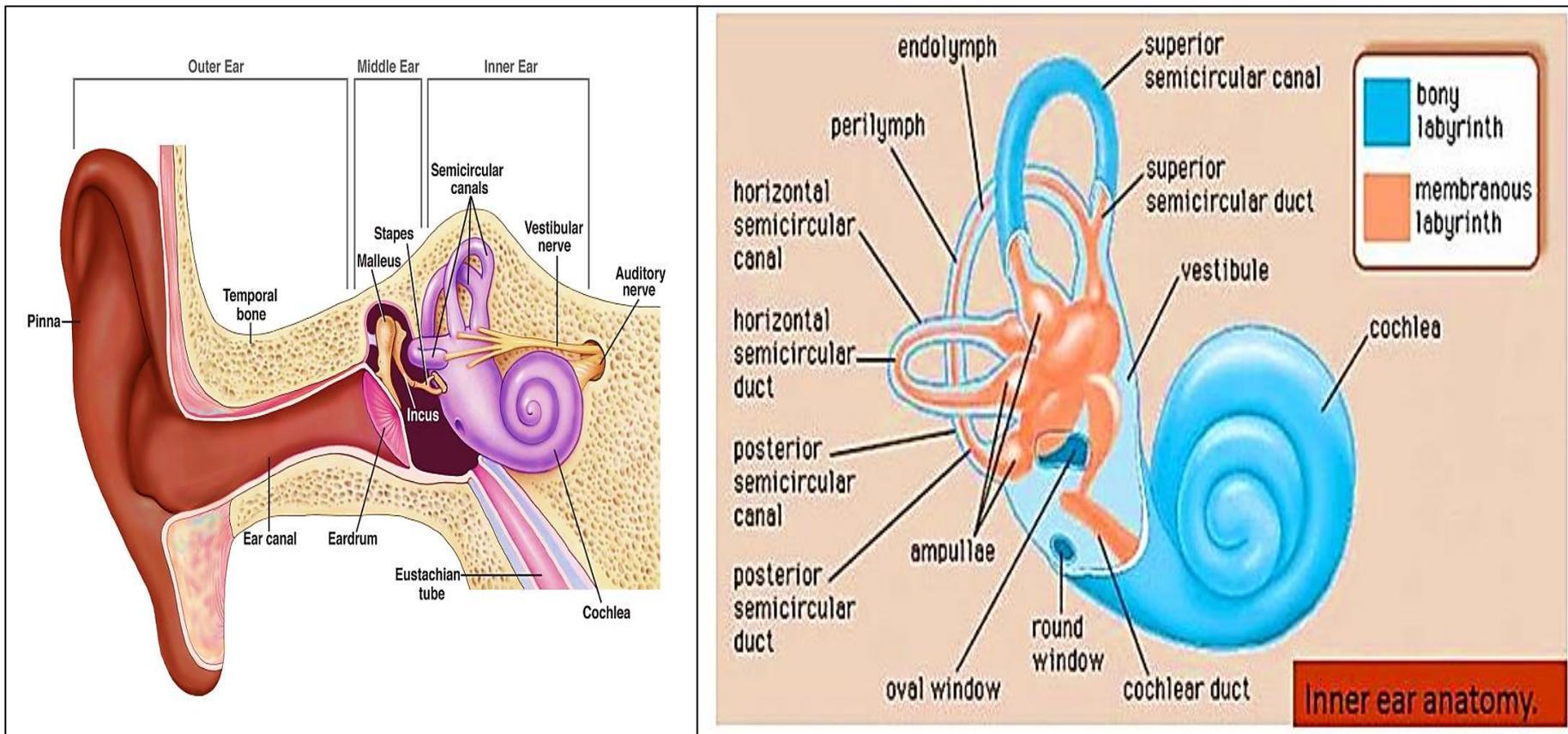


The Inner Ear (labyrinth)

Located completely within temporal bone

Consists of: **bony labyrinth**

membranous labyrinth



Bony labyrinth

- Formed of bony canals & cavities lined with endosteum, & is filled with fluid called

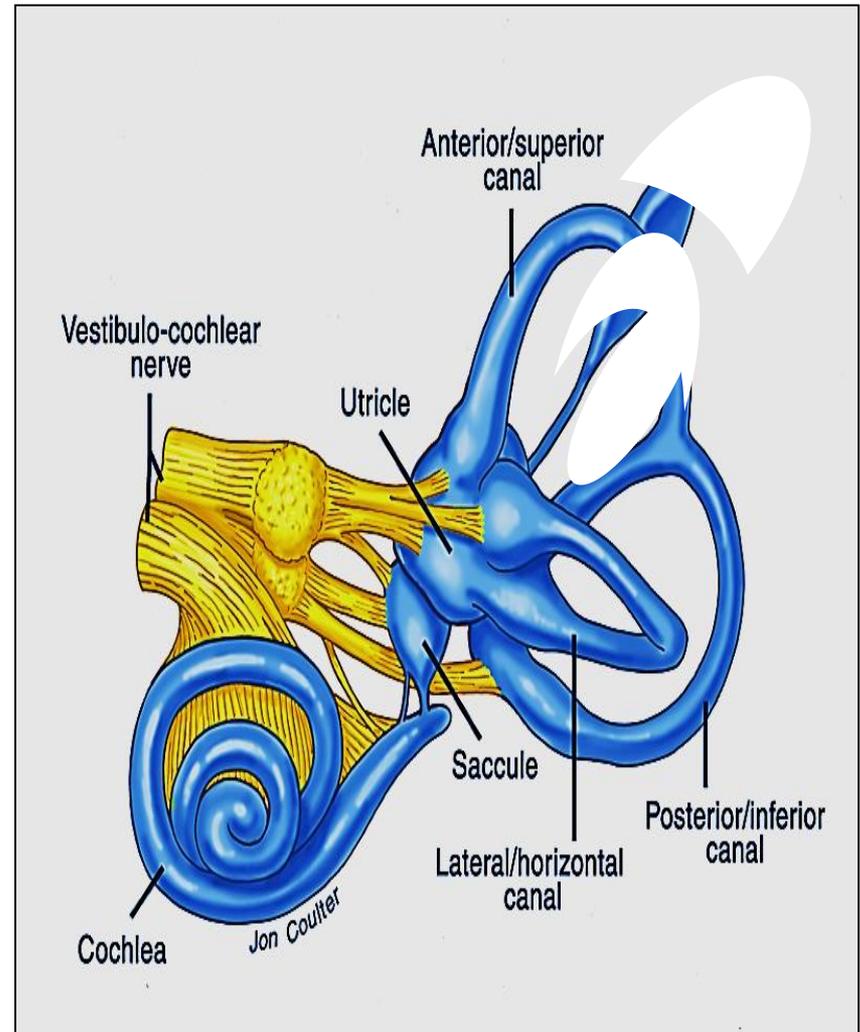
perilymph ($\uparrow \text{Na}^+$, $\downarrow \text{K}^+$)

- It Consists of 3 parts:

➤ Cochlea

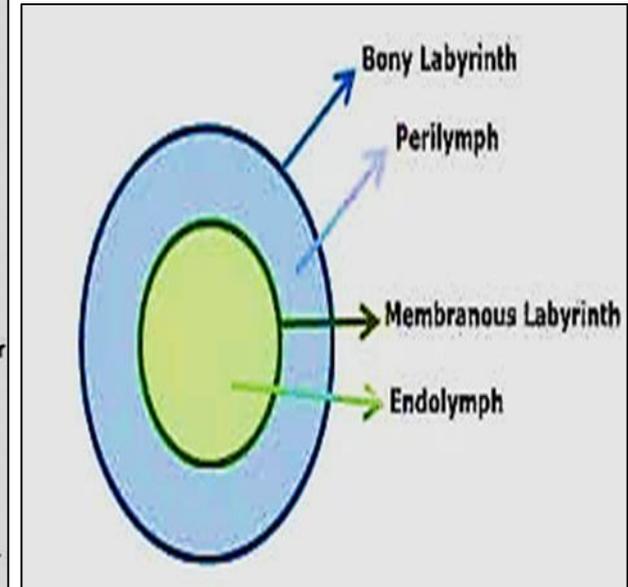
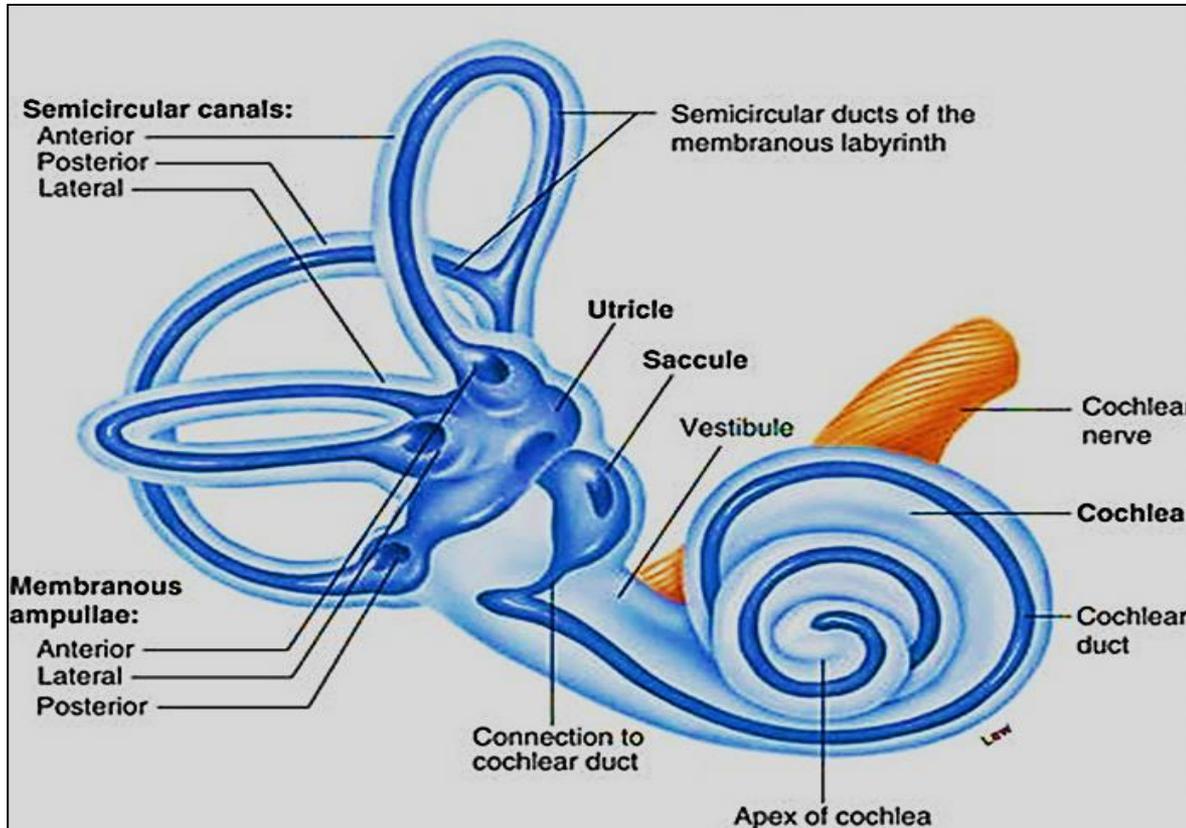
➤ 3 semicircular canals

➤ Vestibule → utricle
→ saccule

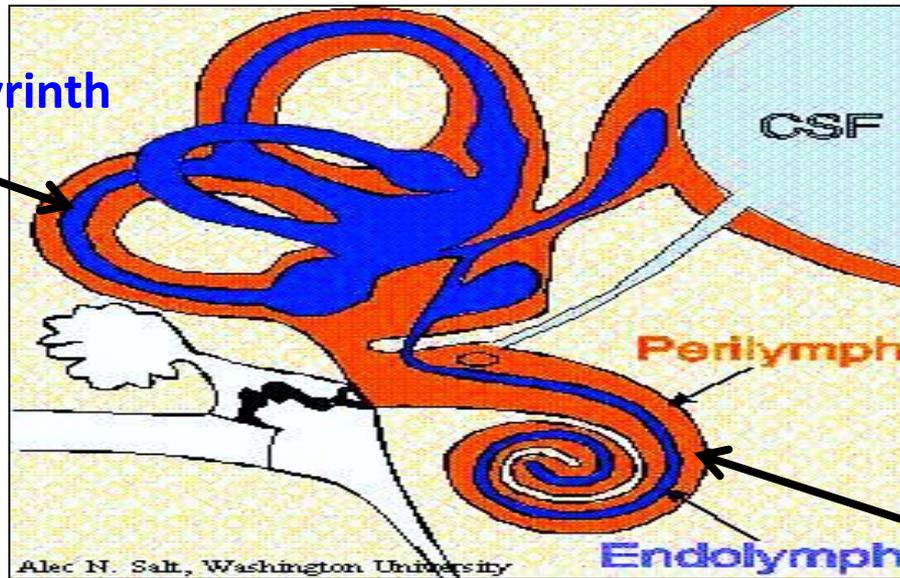


Membranous labyrinth

They are **membranous tubules & sacs** present within the bony labyrinth **connected with each other** & filled with fluid called **endolymph** ($\downarrow \text{Na}^+$, $\uparrow \text{K}^+$)



Membranous labyrinth



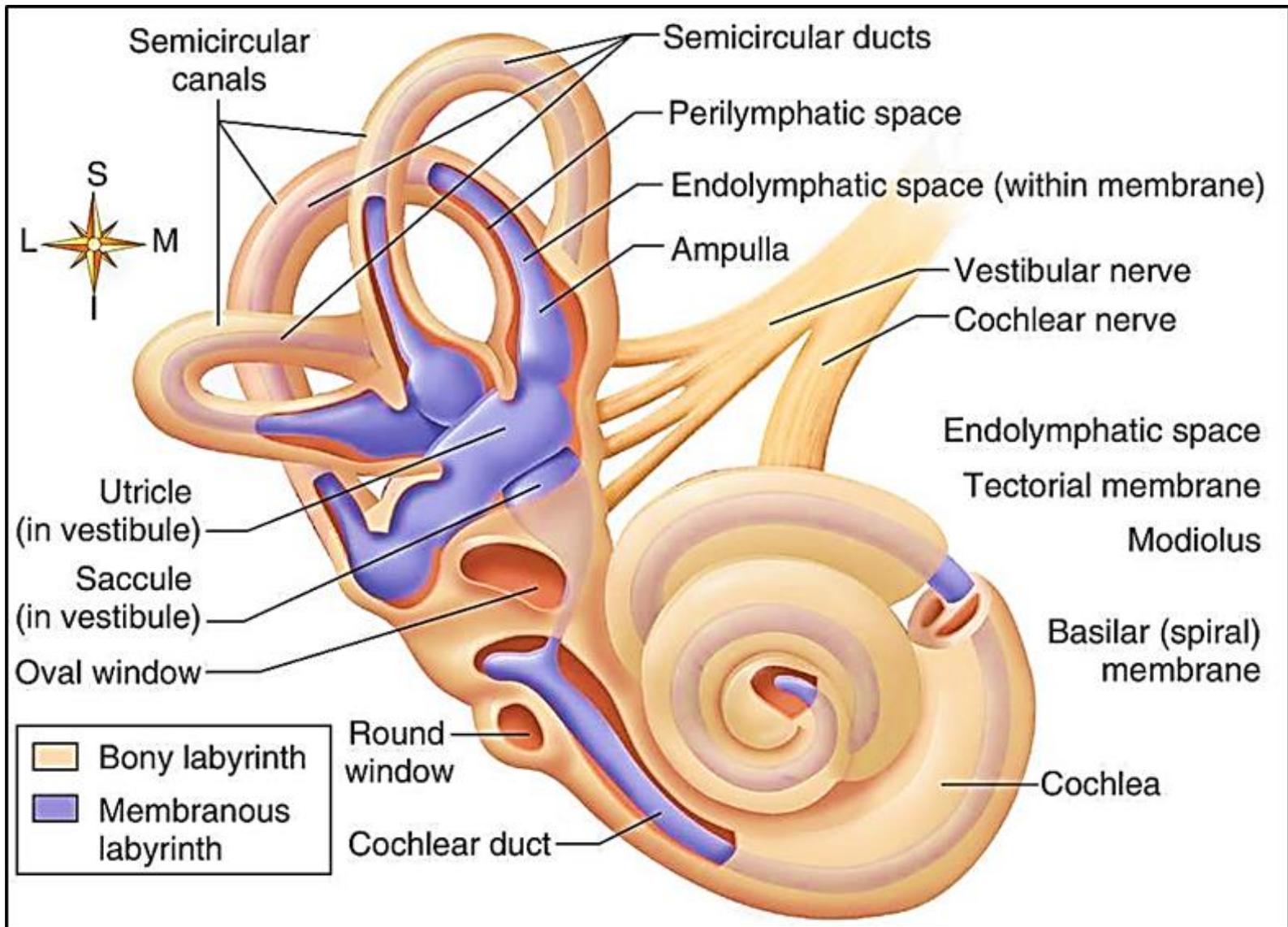
Bony labyrinth

- The Cochlea is responsible for the sense of **hearing**
- The vestibular organs for the sense of **equilibrium & balance** :
 - saccule
 - utricle
 - semicircular canals

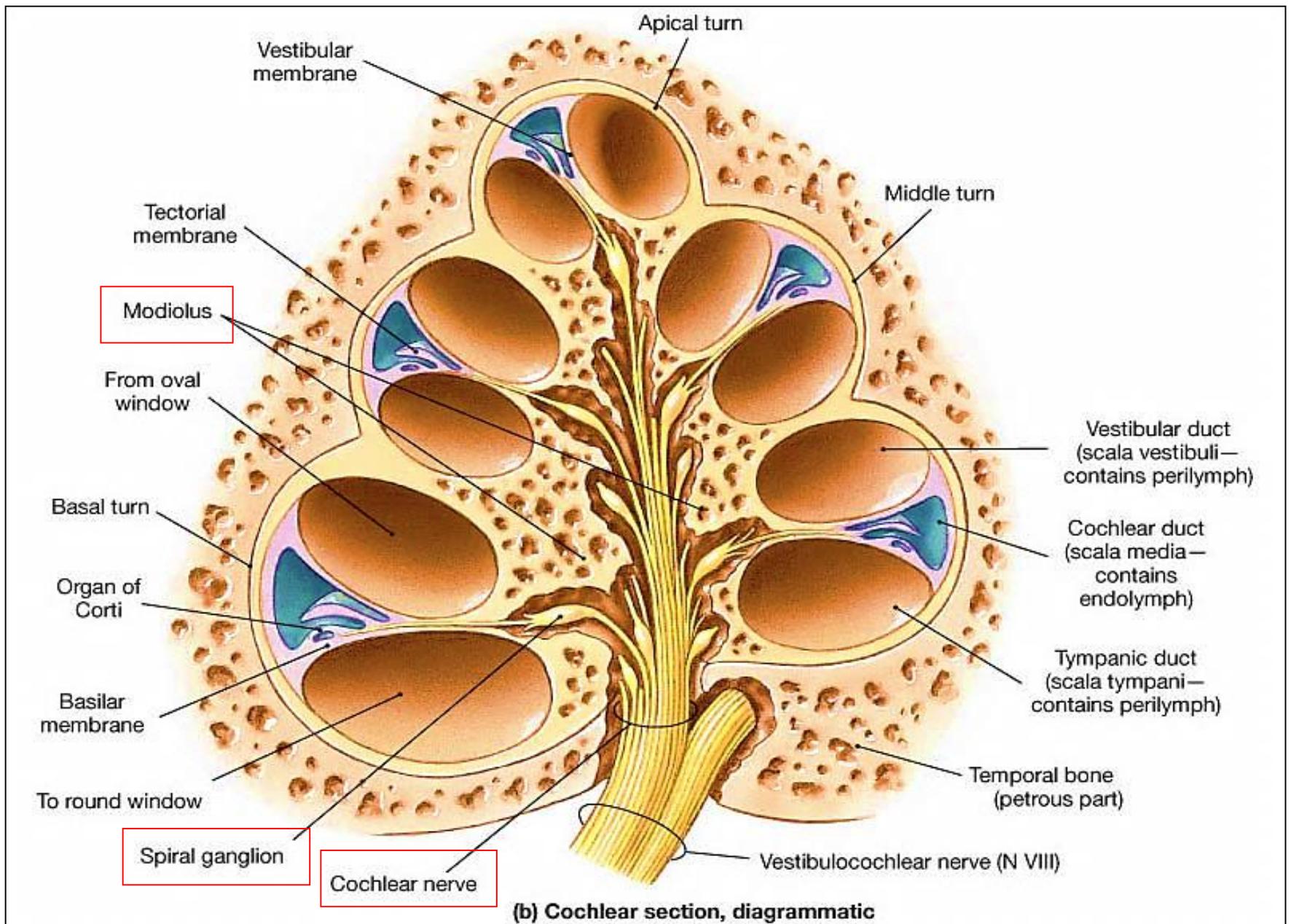
The Cochlea



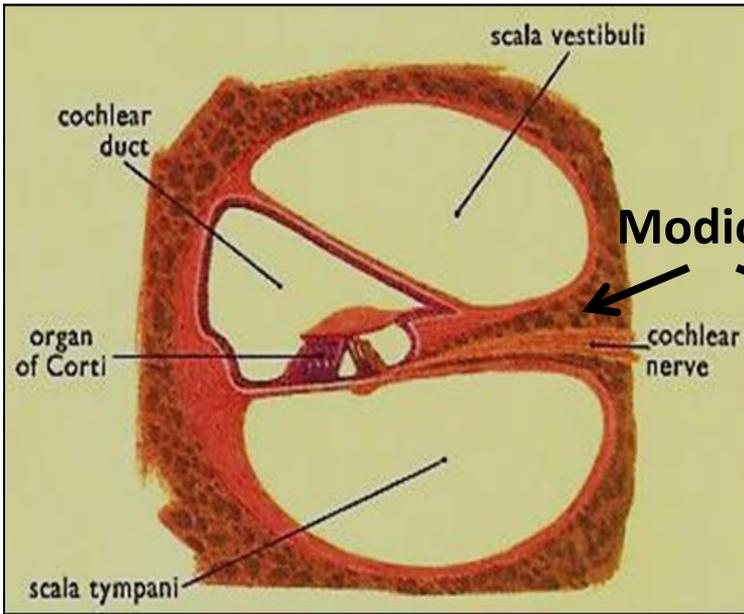
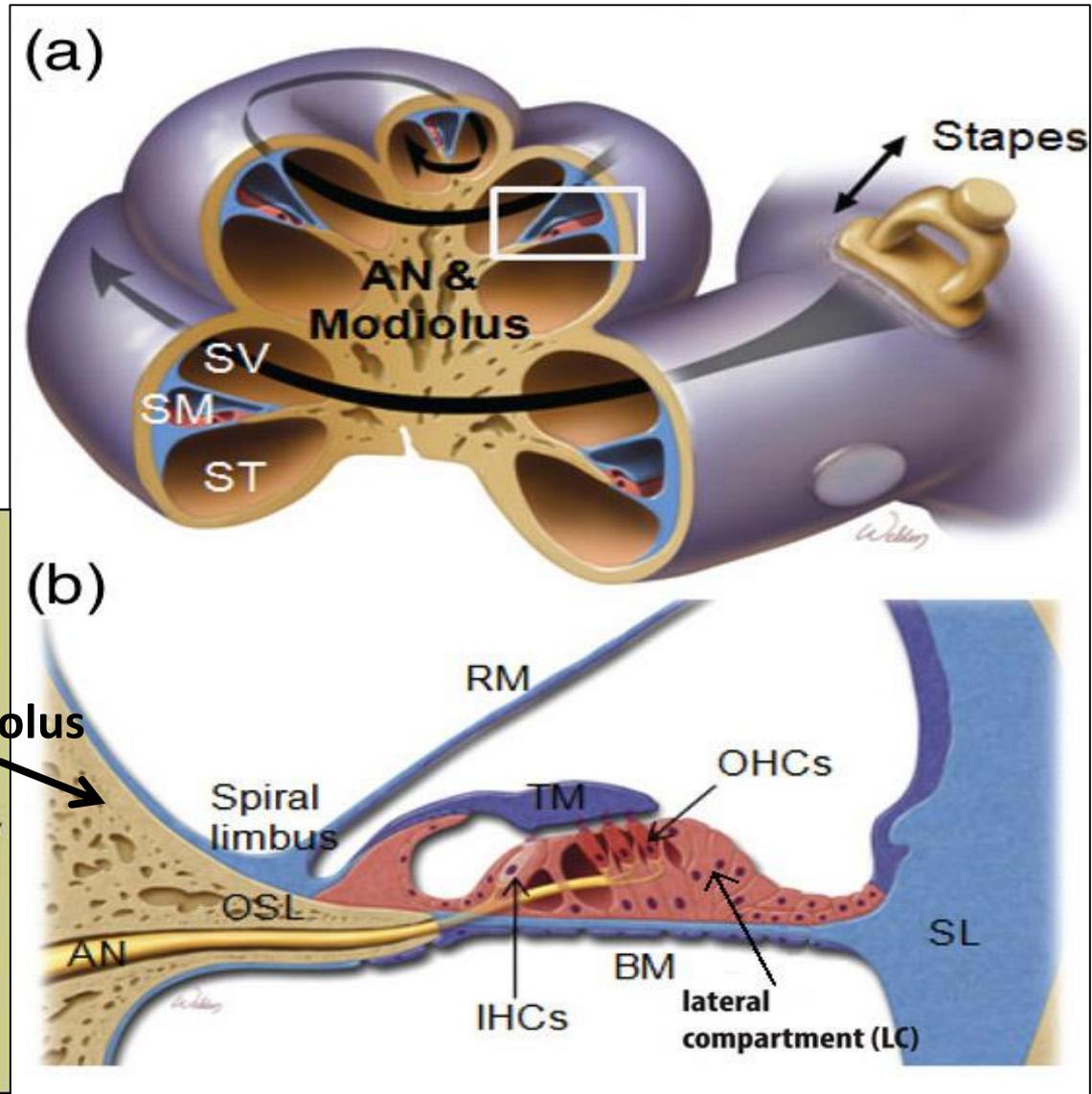
- The auditory organ of the inner ear
- Snail-like (spiral) shape
- Makes 2½ turns around a bony axis called **modiolus**.
- The modiolus is a **spongy bone** contains: blood vessels, spiral ganglia & cochlear nerve
- Cochlea has bony part & membranous part
- The membranous part of the cochlea called **cochlear duct**



Cochlear duct



In axial section in the cochlea, the **bony canal** appear circular and the **membranous cochlear duct** appears triangular in shape

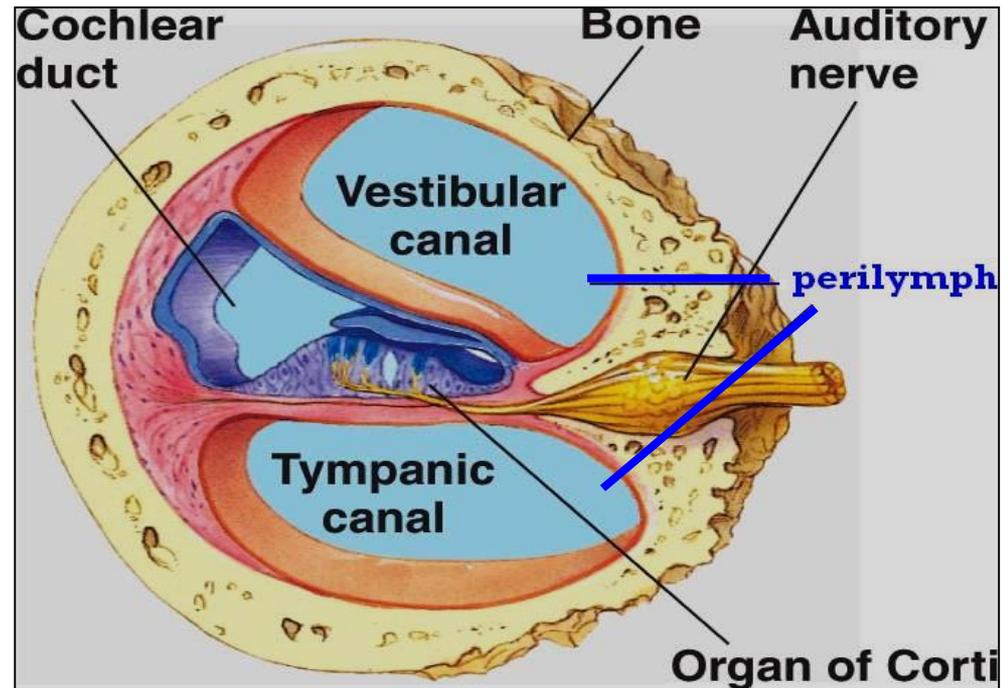


The cochlear duct divides the bony canal into 3 spaces :

a. Scala vestibuli (above)

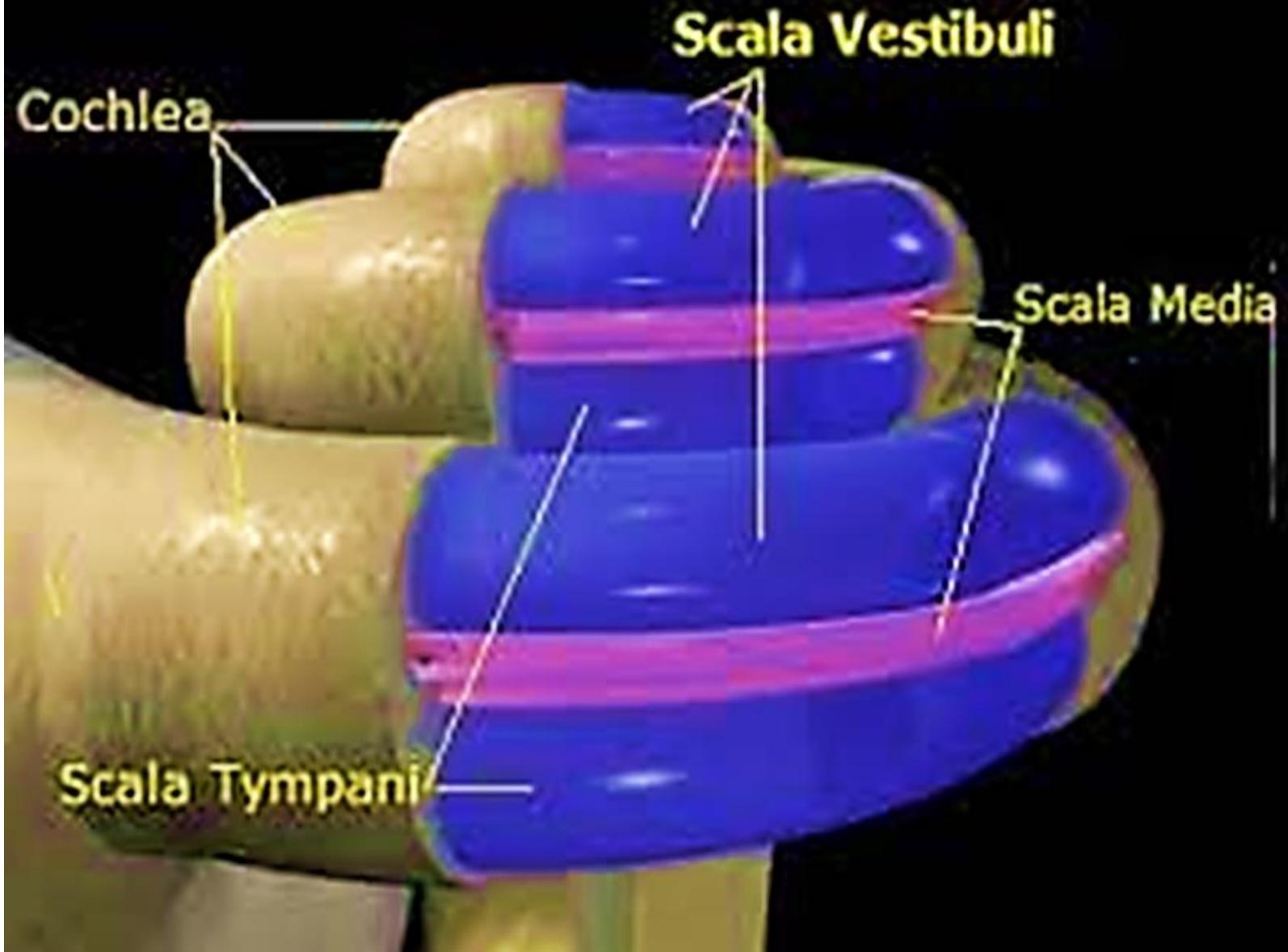
b. Scala media (middle)

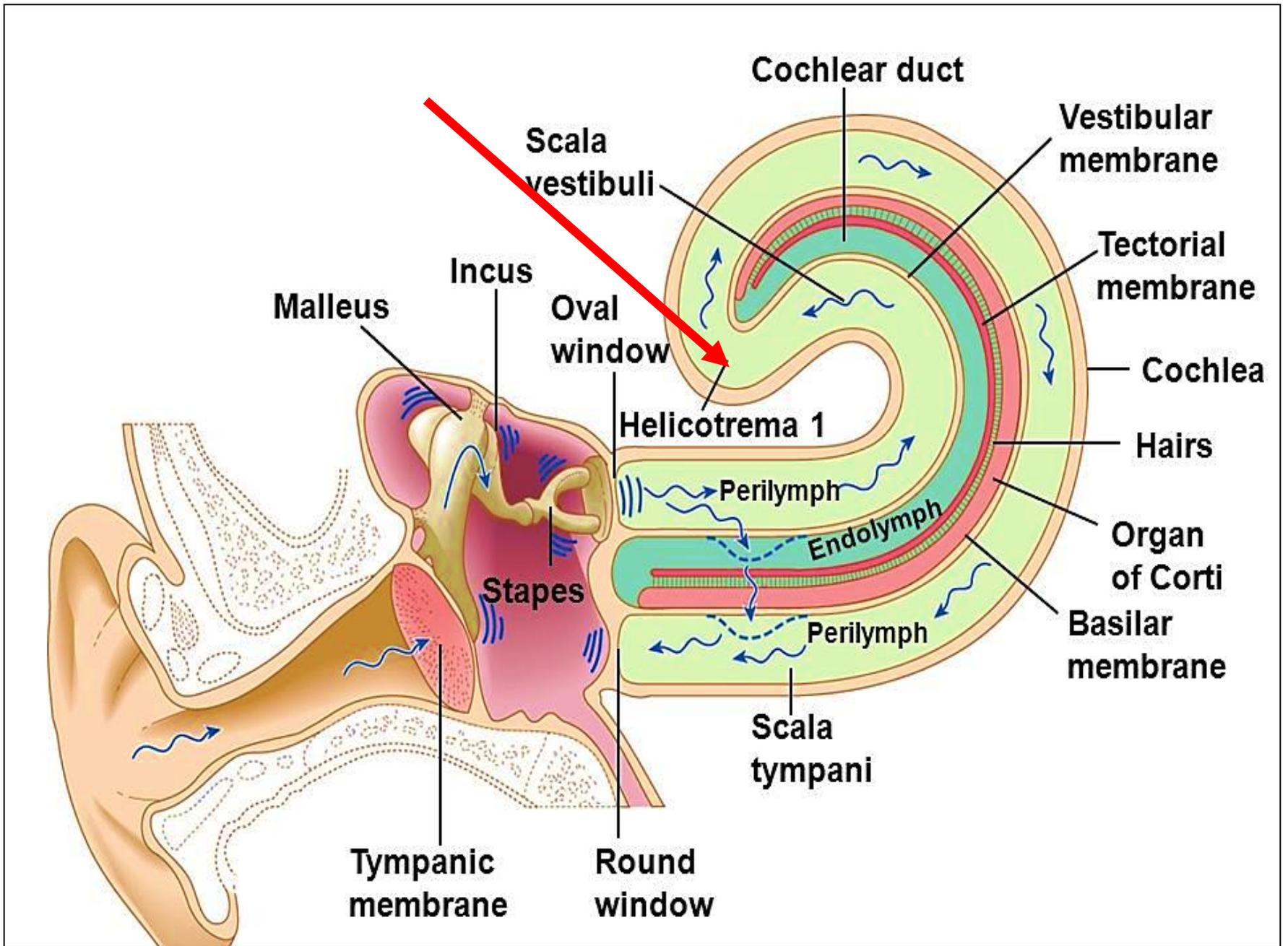
c. Scala tympani (below)



➤ **Scala vestibuli:** communicates with the vestibule, contains perilymph

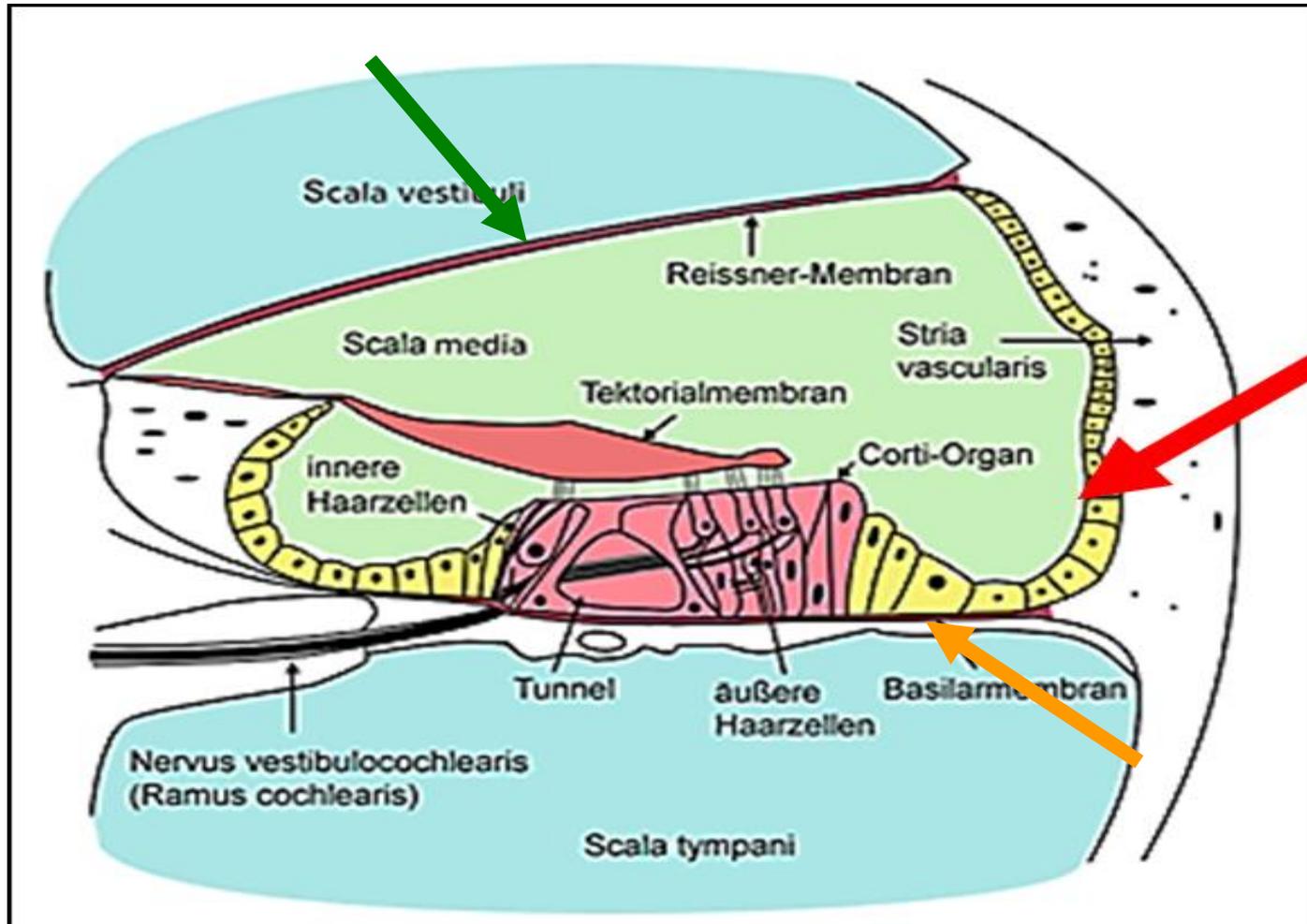
➤ **Scala tympani:** communicate e middle ear through the round window, contains perilymph





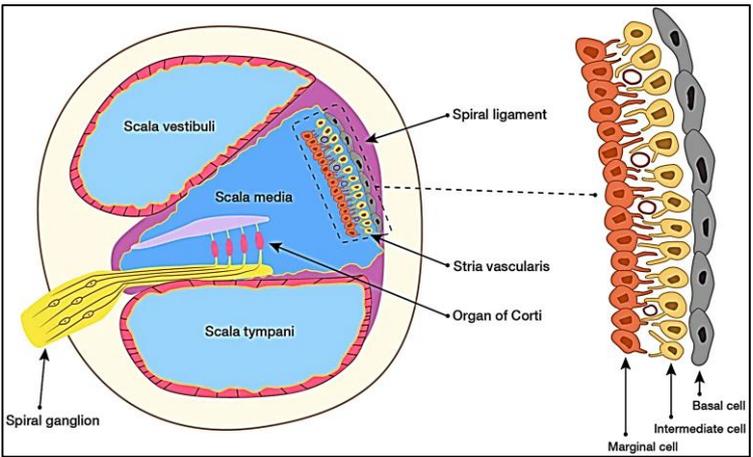
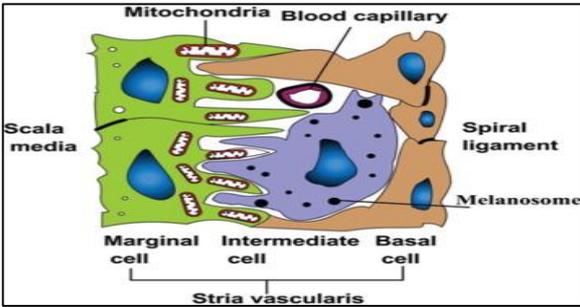
Scala media (Cochlear duct):

- is the membranous part of the cochlea
- contains **endolymph, & organ of Corti**



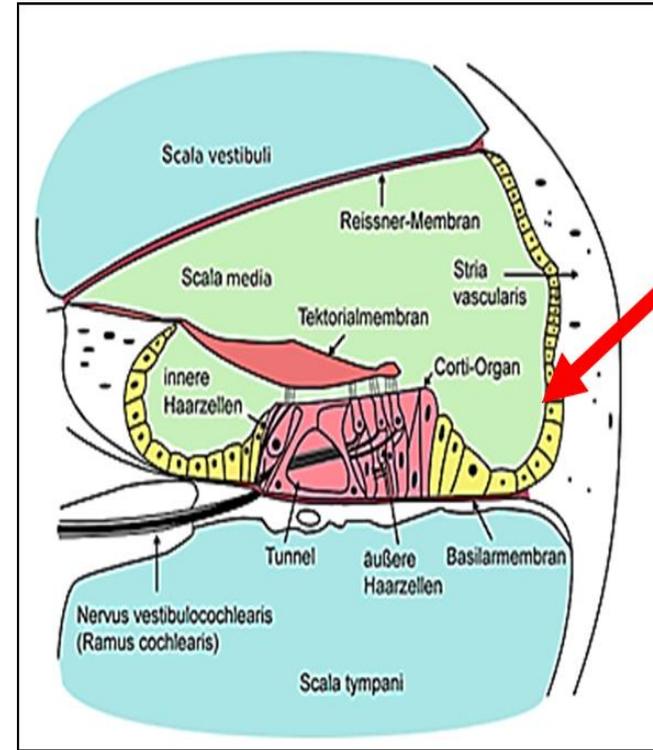
- The cochlear duct is triangular in shape
 - a. The lateral wall is formed by **stria vascularis**, which is **highly vascular** C.T., covered e stratified columnar cells, its cells secrete **endolymph**

The stria vascularis, composed of marginal, intermediate, and basal cells



it is responsible for maintaining the ion composition of the endolymph and producing an endocochlear potential (EP) in the scala media which is important for the function of the sensory cells in the ear

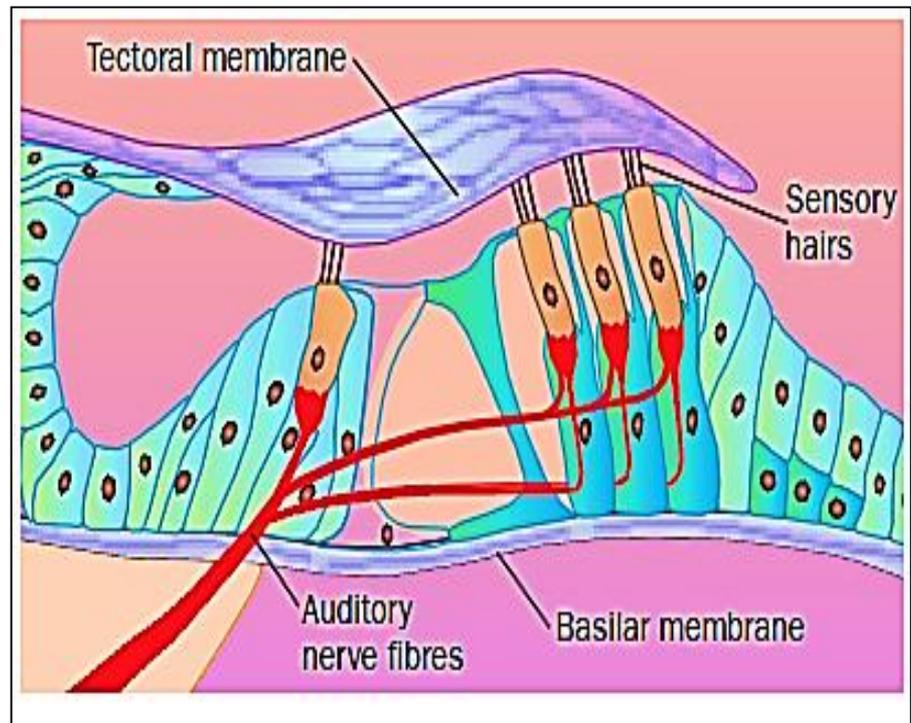
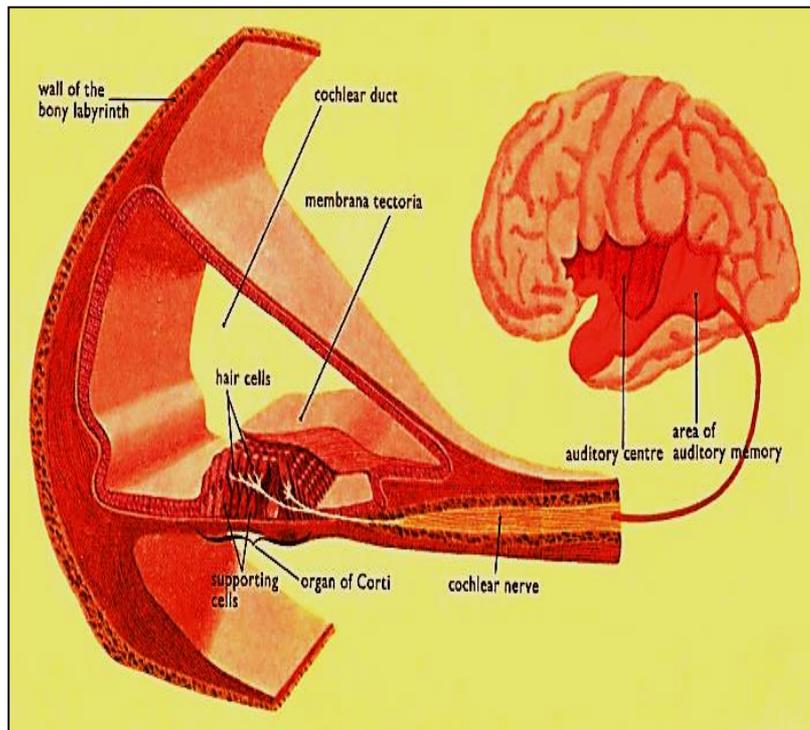
The **roof** is formed by **vestibular membrane,** **thick membrane** covered on both sides e **simple squamous epi**



The **floor** is formed by **basilar membrane** its upper surface support **organ of Corti,** its under surface covered e **simple squamous epithelium**

Organ of Corti

- **Neuroepithelium** , found in the **cochlear duct** on the **basilar membrane** responsible for hearing
- The organ of Corti is covered e **Tectorial membrane**



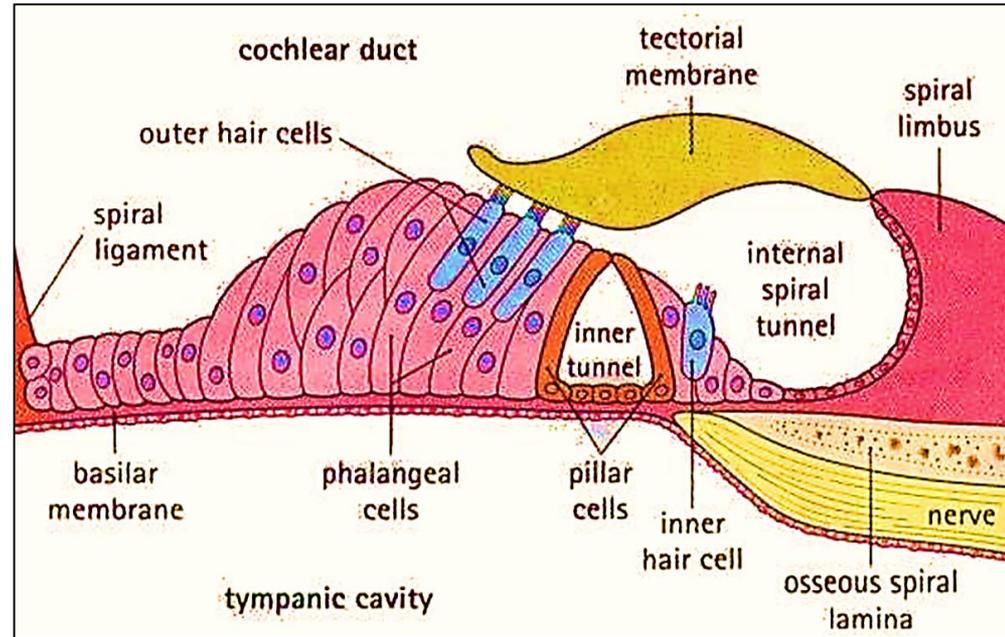
Structure of organ of Corti:

- I. Hair cells (receptors)
- II. supporting cells (pillar, phalangeal, Hensen & claudius)

The supporting cells (4):

1- pillar cells: 2 types
inner & outer

Tall cells their upper ends
attach by junctional complexes, together e basilar m. form
triangular space called **tunnel of Corti**



2- Phalangeal cells: 2 types

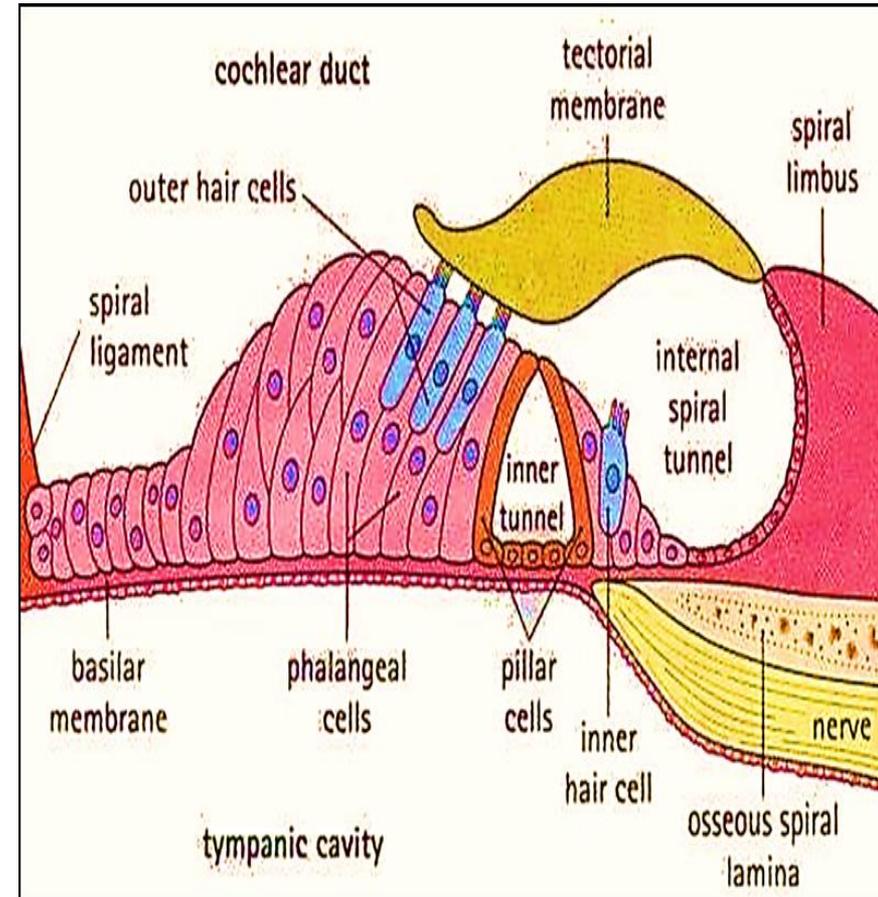
Inner ph. cells are 1 row

Outer ph. Cells are 3 rows

Columnar cells support the inner and outer hair cells & their nerve fibers

3- Hensen cells: tall cells, lateral to the outer phalangeal cells

4- Cells of Claudius: form the outermost border

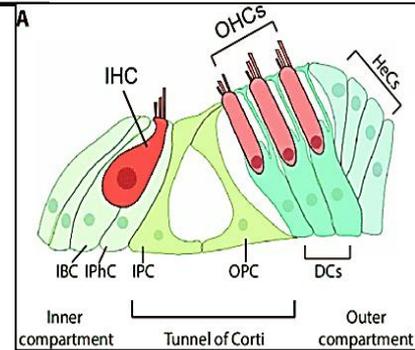


Hair cells (sensory, neuroepithelial) cells

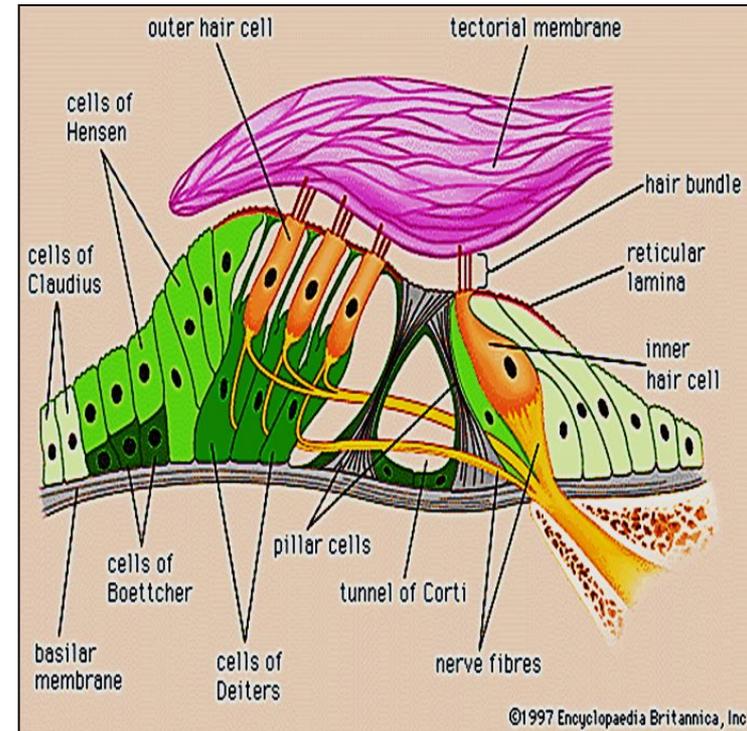
Hair cells 2 types :

Outer hair cells: columnar cells arranged in 3 rows

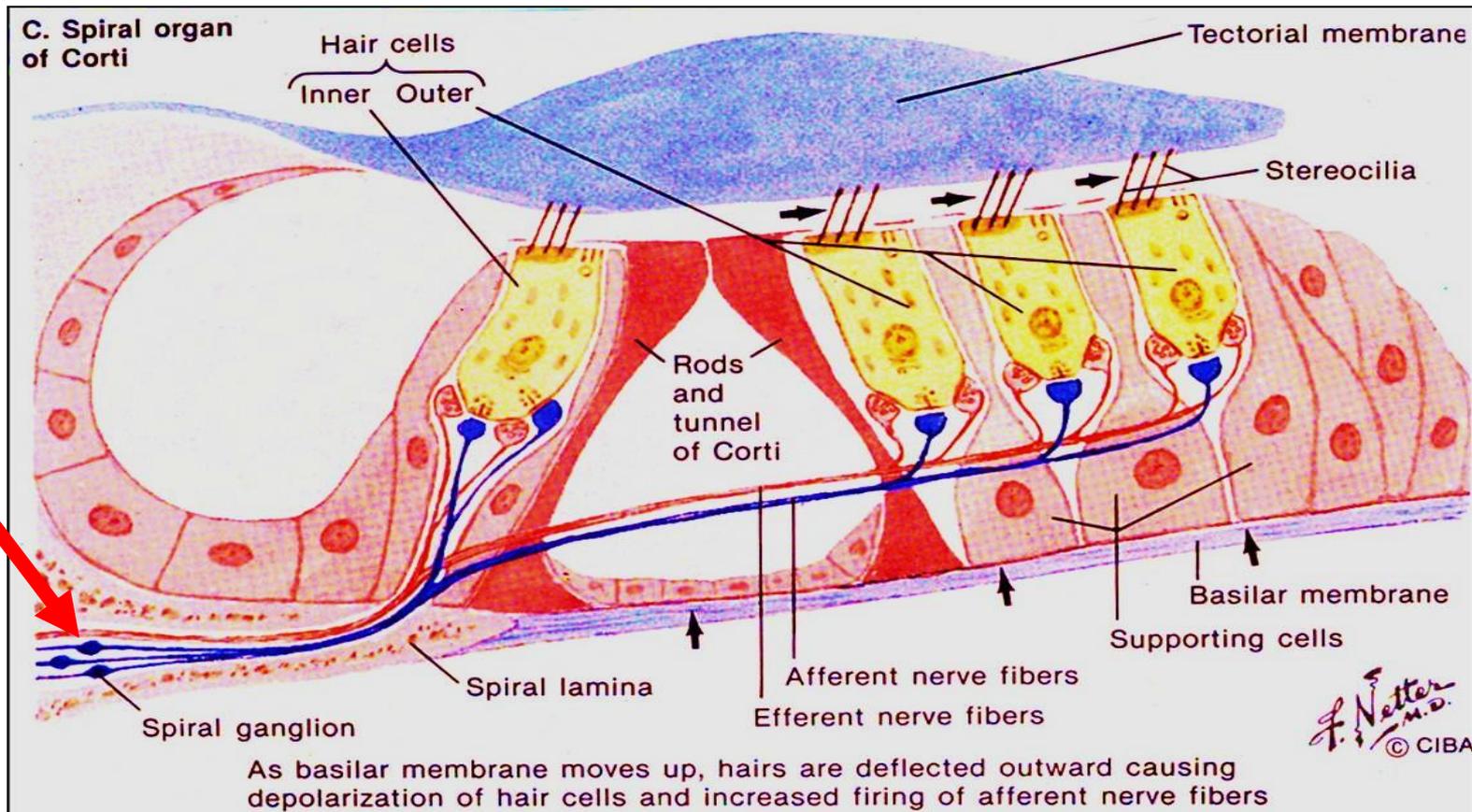
Inner hair cells: flask-shaped cells, arranged in 1 row



- Supported by inner & outer phalangeal cells respectively
- Their apical ends have **stereocilia**. Their bases have afferent nerves that synapse e bipolar nerve cells of spiral ganglion
- The tips of the stereocilia are in contact with the tectorial membrane

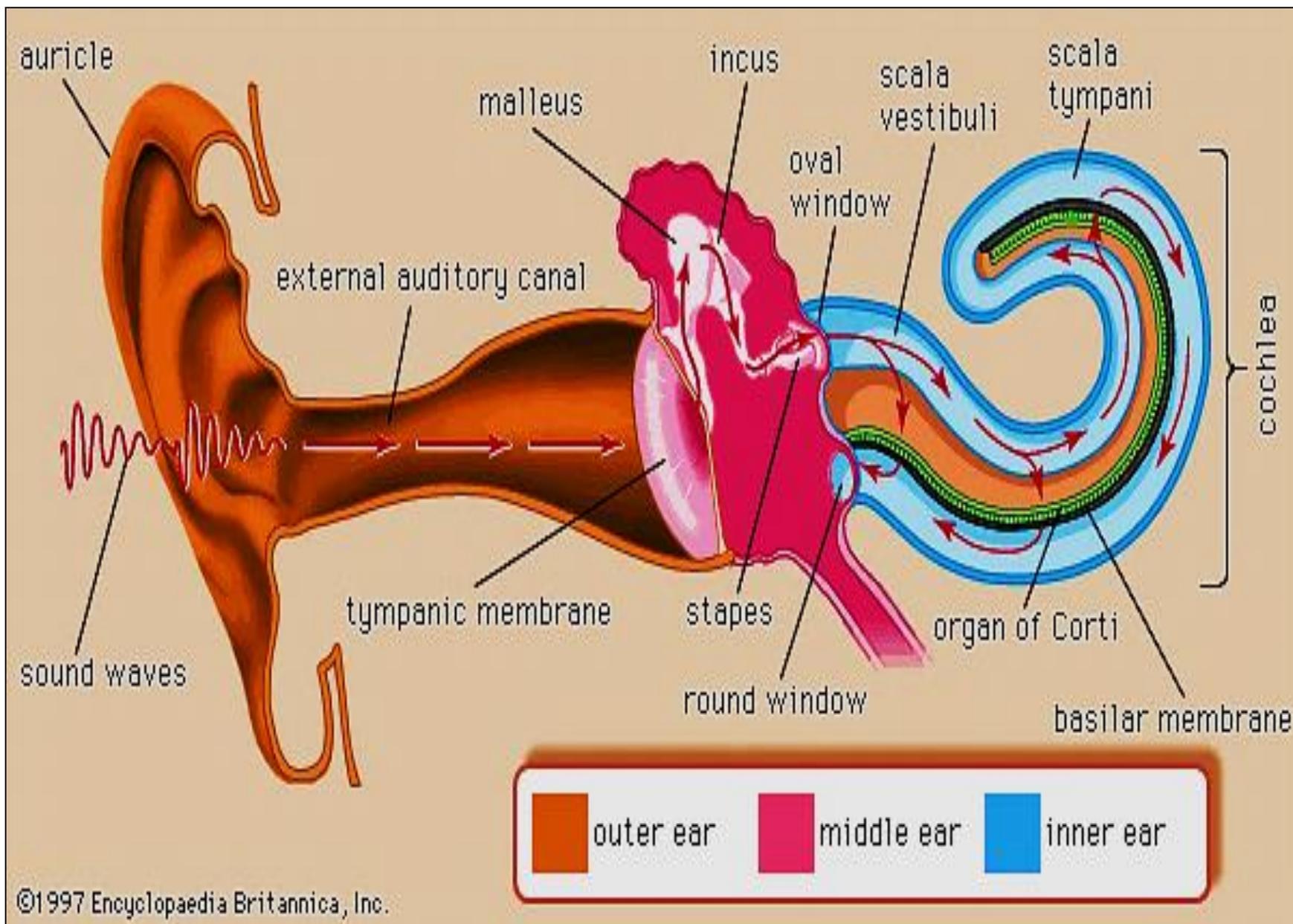


Axons of bipolar nerve cells form cochlear nerve



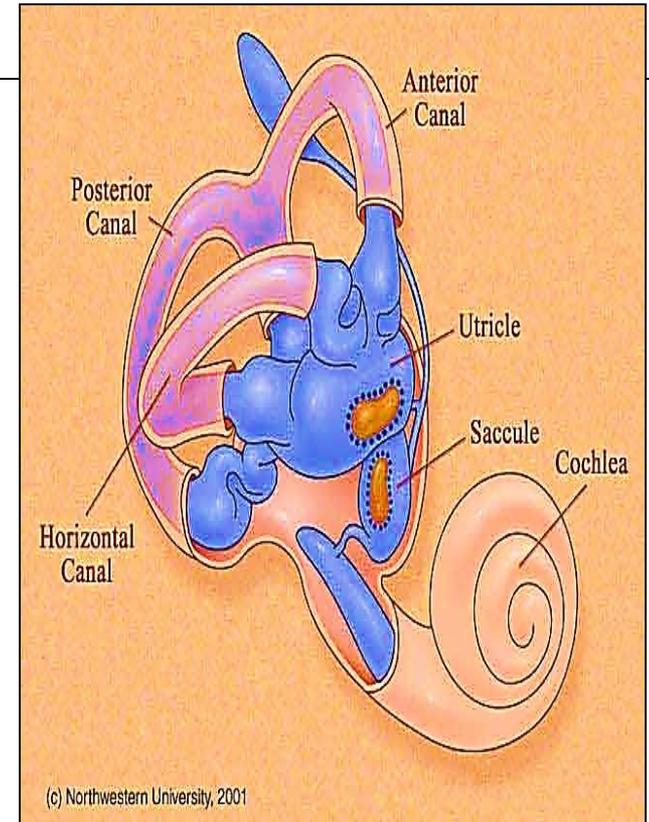
Mechanism of Hearing

External ear collect sound waves → tympanic membrane → The vibration of tympanic membrane will be **conducted & magnified** along the 3 bony ossicles → movement of stapes → vibration of perilymph in scala vestibule → vibrations of vestibular membrane → endolymph in cochlear duct (as pressure waves) → vibrate basilar membrane → movement of hair cells of organ of corti → initiate n.impluses → cochlear n. → brain



The vestibule

- Contains 2 structures :Utricle
Saccule
- Maintain the **equilibrium** of the body
- The utricle & saccule are membranous sacs lined with simple squamous epith. Filled with endolymph
- They contain **2 neuroepithelial structures, similar histologically: macula utriculi, macula sacculi**



Structure of maculae of utricle & saccule:

- Formed of: I- Hair cells II- supporting cells

The hair cells: 2 types

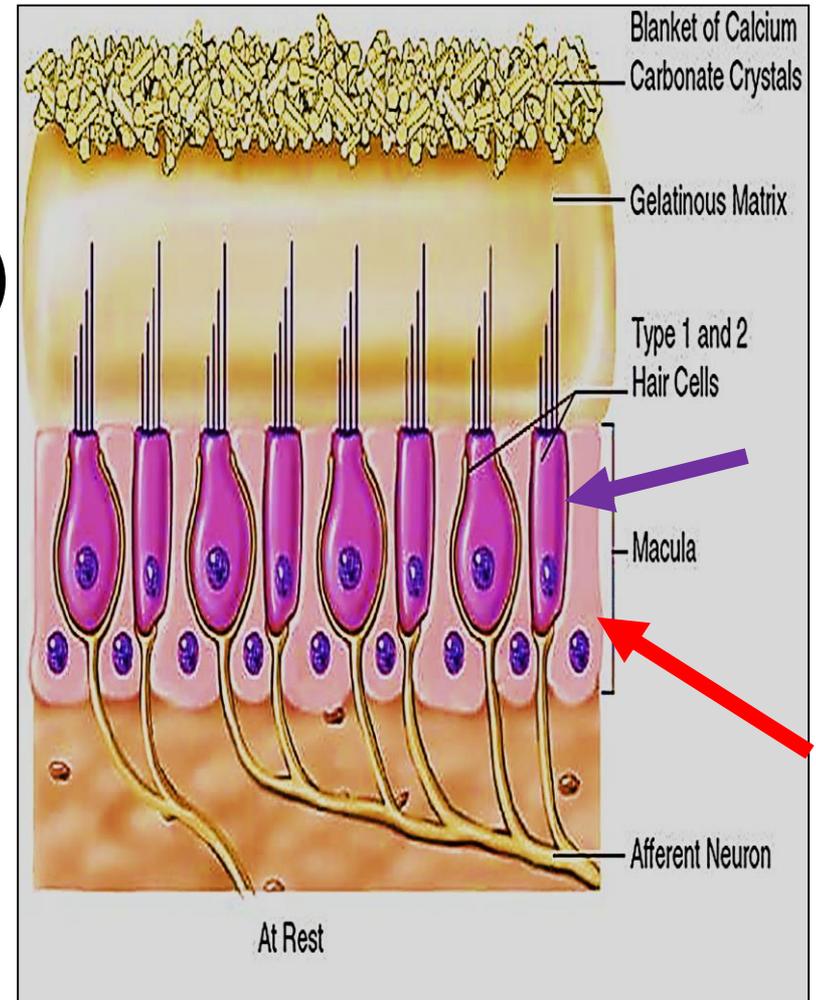
Type I (Flask- shaped)

Type II (cylindrical- shaped)

The apical surfaces of both types
Show single central **kinocilium**
surrounded e several **stereocilia**
(40 -70)

both cell types are surrounded

at their base with afferent fibers of vestibular nerve

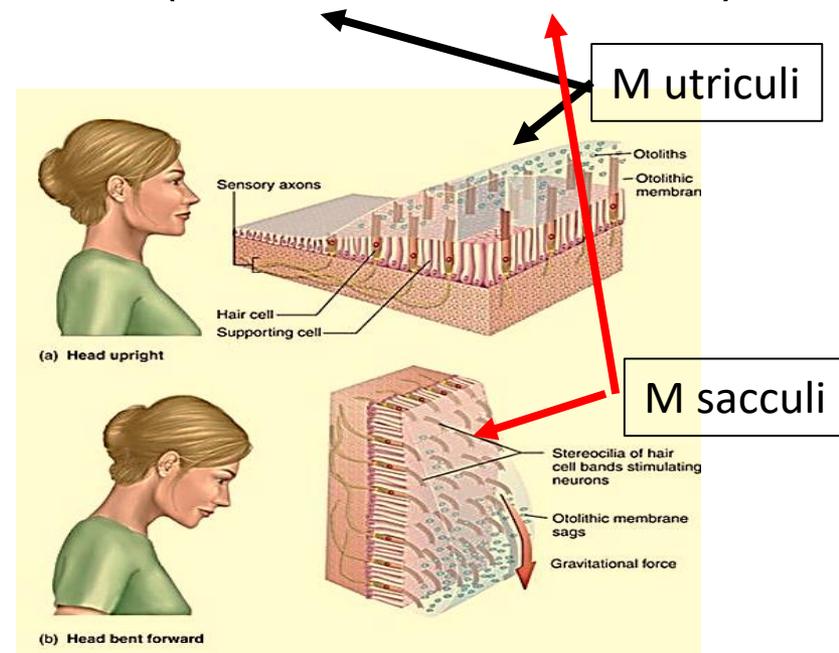
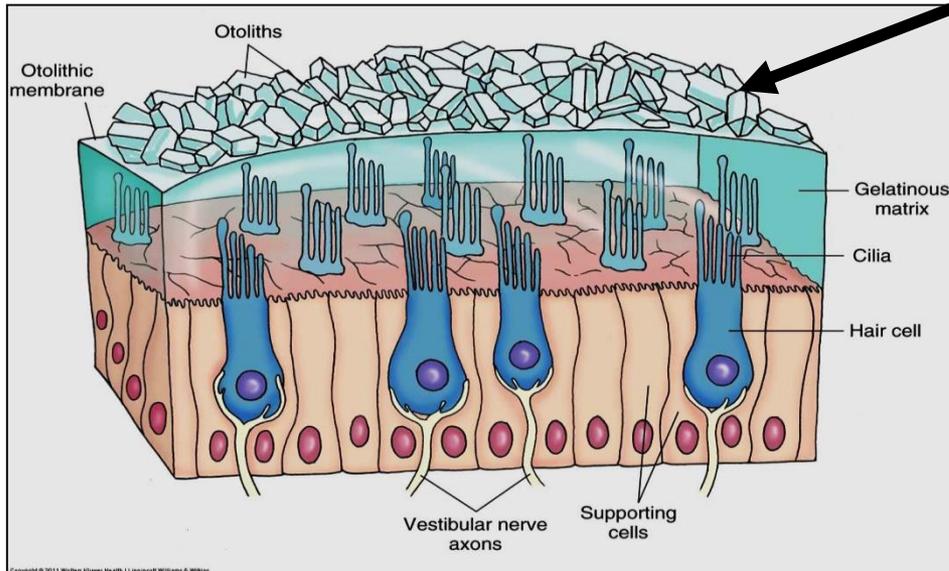


Otolithic membrane

The hair cells of both maculae are covered with gelatinous membrane made of protein & crystals of Ca^+ carbonate (Otoconia)

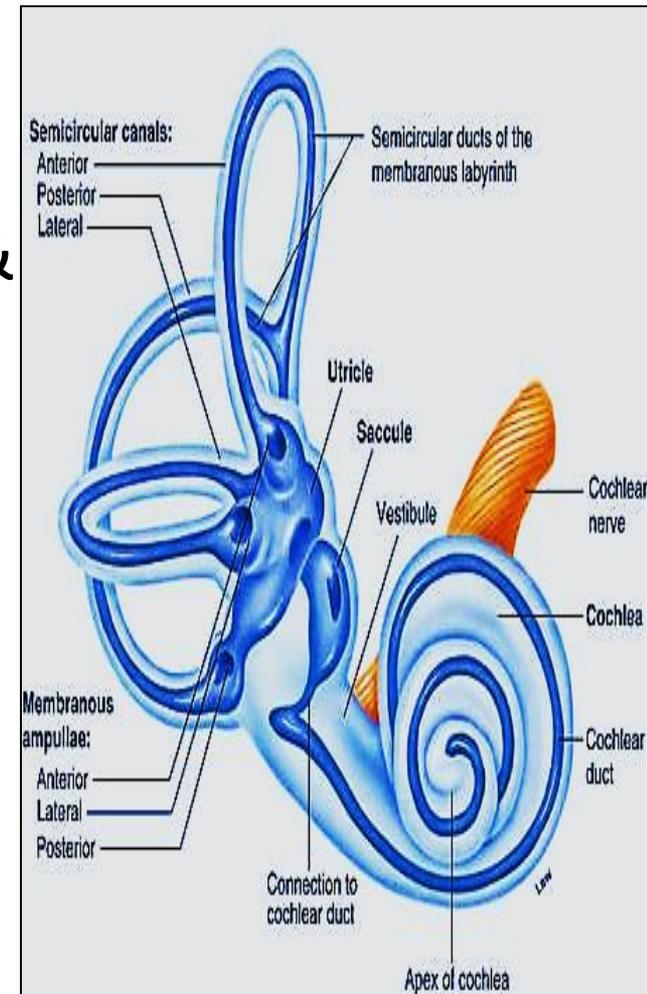
The membrane has Critical role in the brain's interpretation of equilibrium

Movement of head & Linear acceleration (horizontal & vertical)



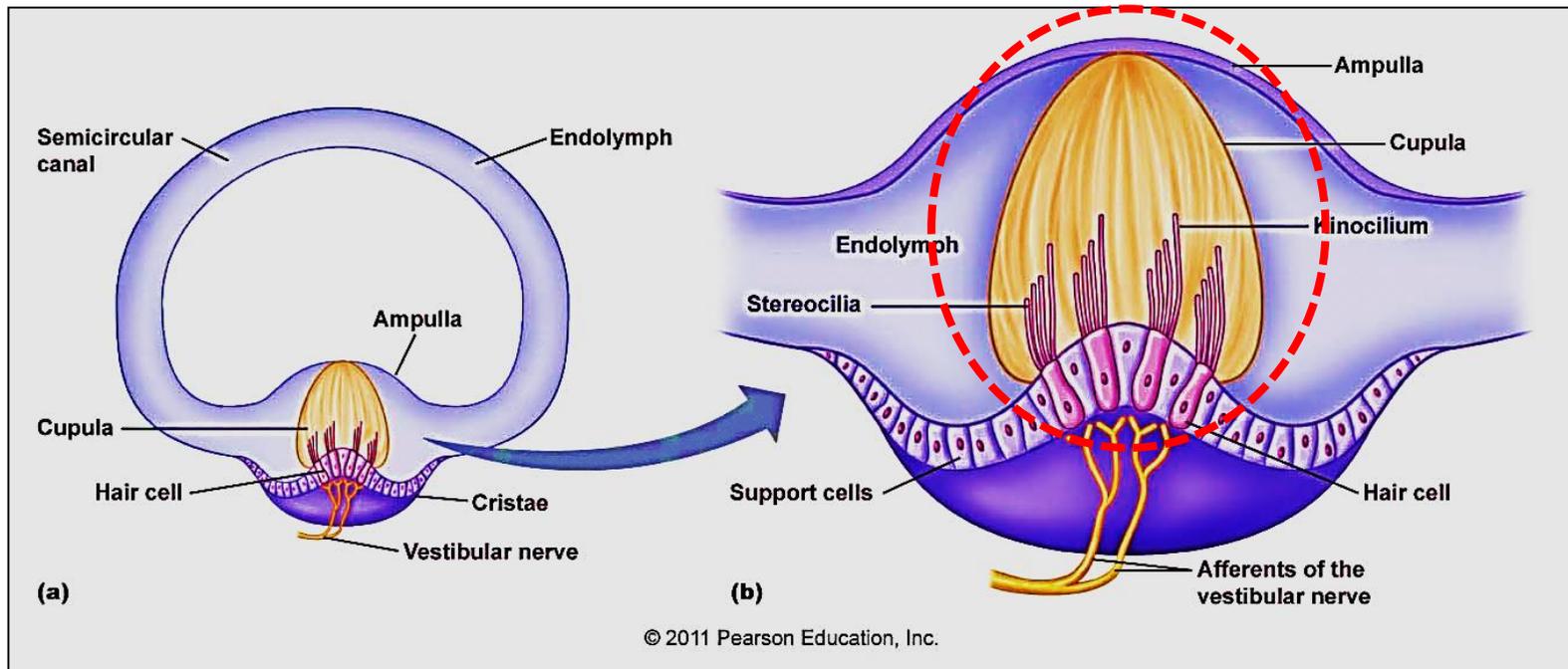
The Semicircular canals

- **3** canals, open into the **utricle** of the vestibule by **5** openings as 2 of them share one open.
- The membranous labyrinth inside the canals take the same shape, & is called the **semicircular ducts**
- Each duct has one expanded end called **ampulla** which contains the neuroepithelial structure called **Crista ampullaris (3/ ear)**



Structure of Crista ampullaris

- Each crista projects from the inner wall of each ampulla
- Each crista has 2 types of cells: hair cells & supporting cells



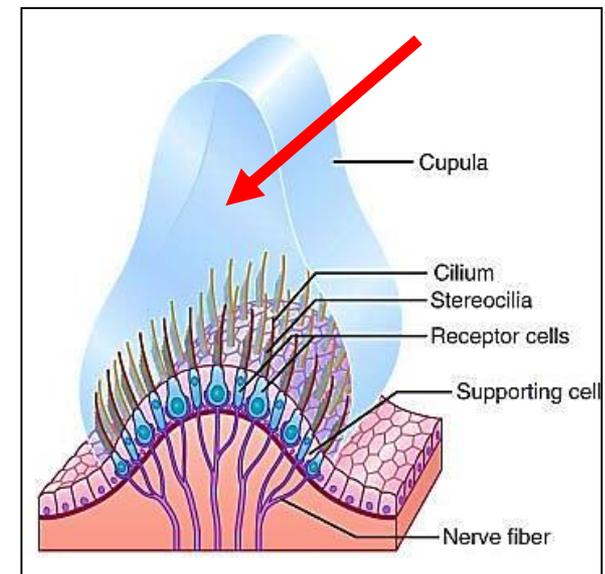
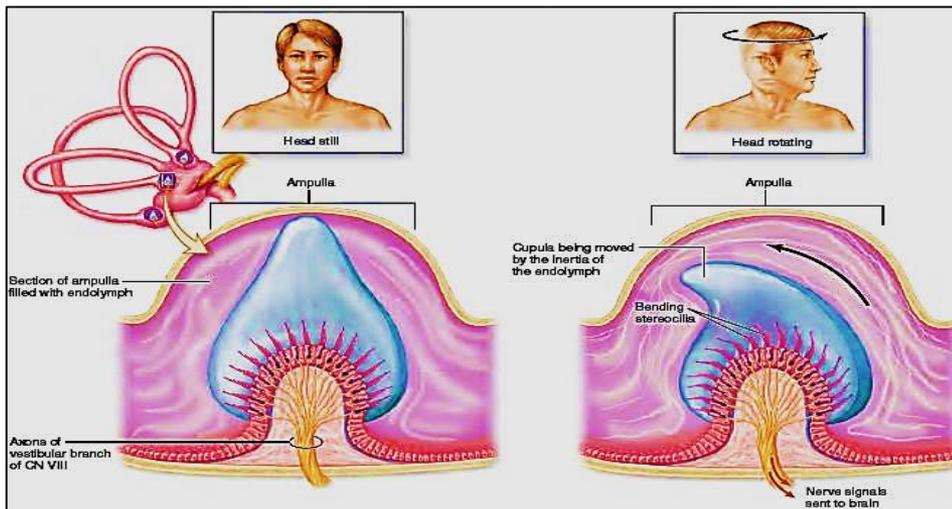
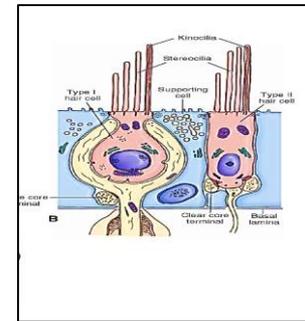
The hair cells of crista ampullaris: 2 types

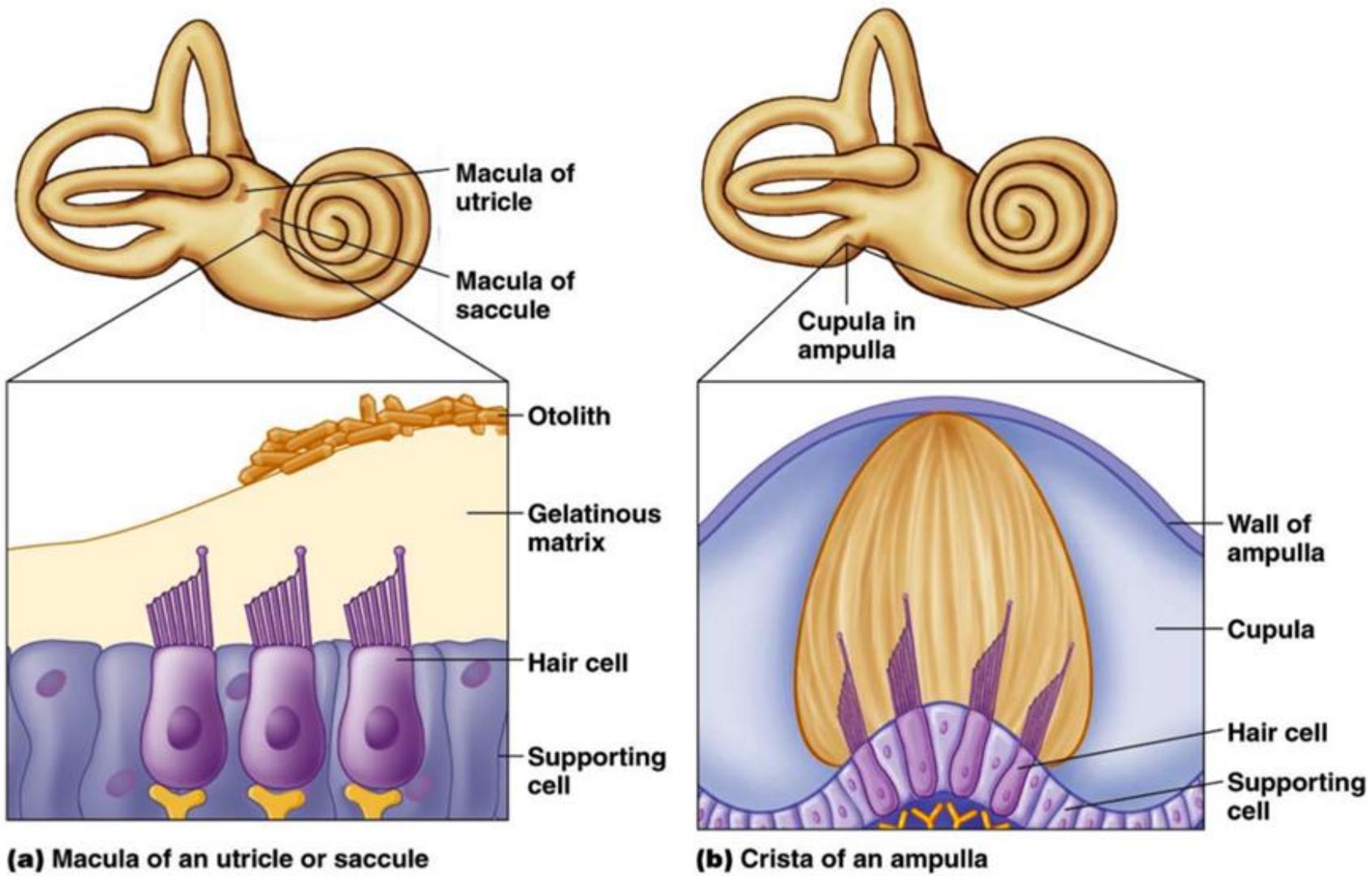
- Type I (**flask-shaped**) & Type II (**columnar**) cells
- Their bases surrounded with afferent fibers of vestibular n

Both types have stereocilia and kinocilium embedded in gelatinous membrane called **Cupula**

Cupula : glycoprotein Cap without

Ca⁺ carbonate crystals. Detect angular acceleration (rotation) of head





(a) Macula of an utricle or saccule

(b) Crista of an ampulla

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Difference between macula of vestibule & crista ampullaris of semicircular canals

Thank you

