THE EAR

- Functions of the ear:

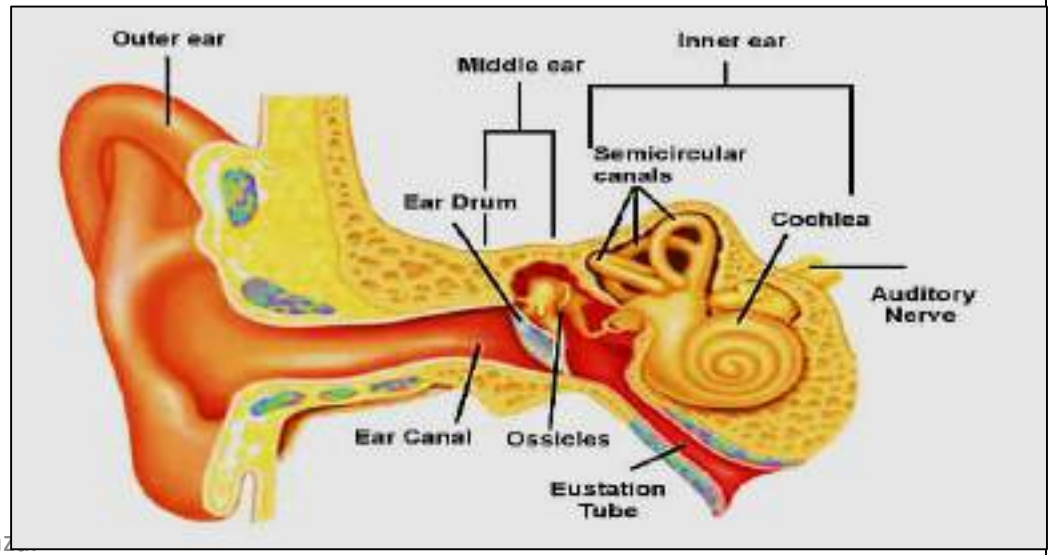
1- Hearing

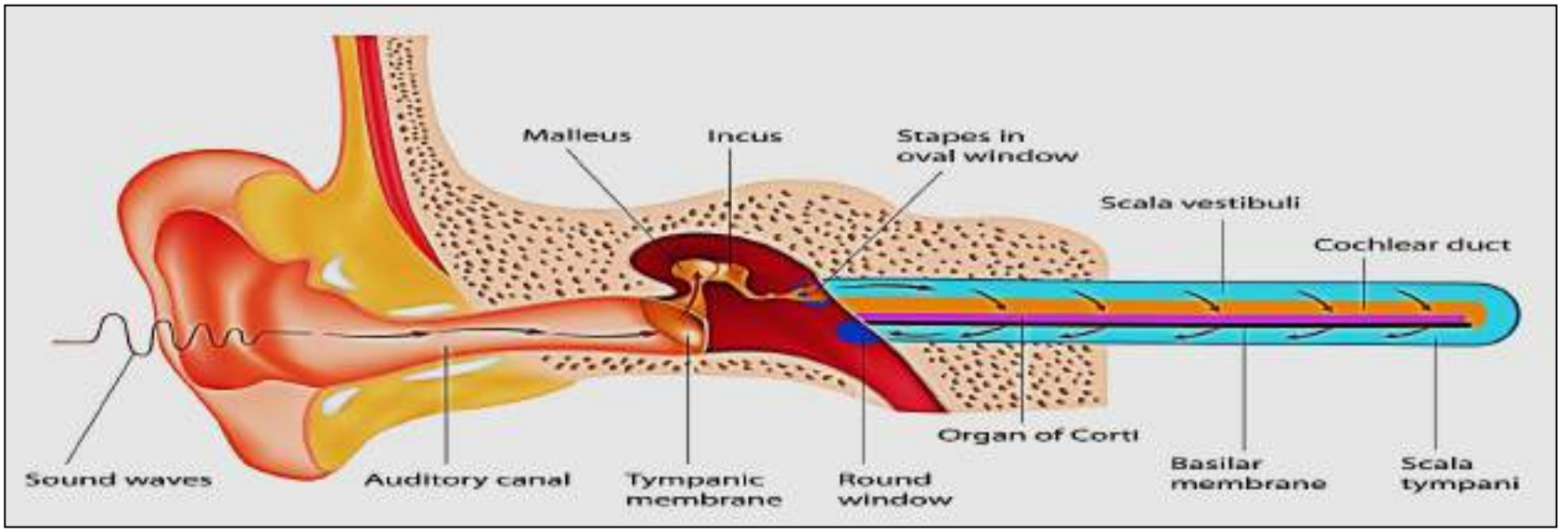
2- balance & equilibrium

- 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

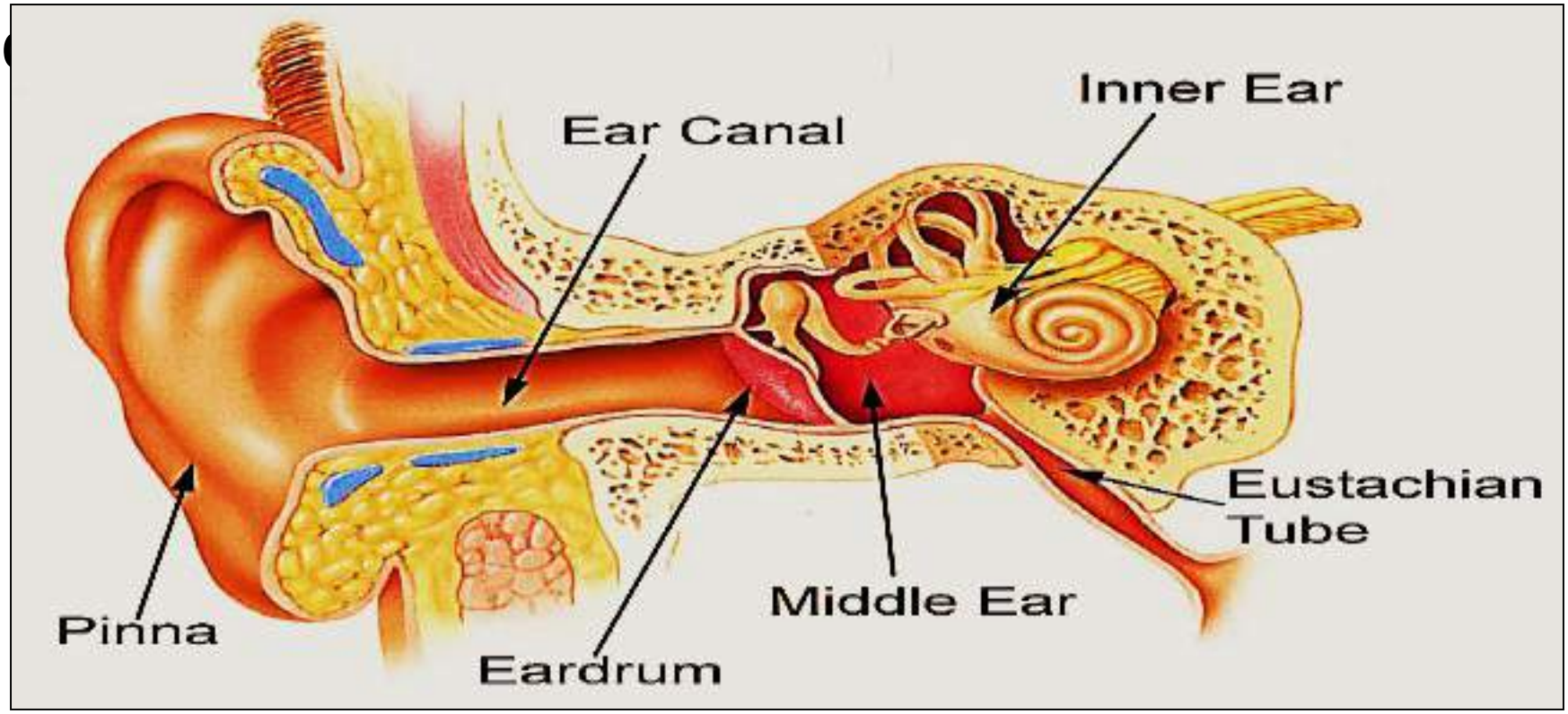
- **Inner ear**: contains fluid which movement stimulate **receptors** which then transduced to (signals) nerve impulses → CNS →
  (a) hear sounds
  (b) equilibrium (vestibular organs)

The External ear

Composed of: 1- Auricle (pinna)

2- External auditory canal(meatus)

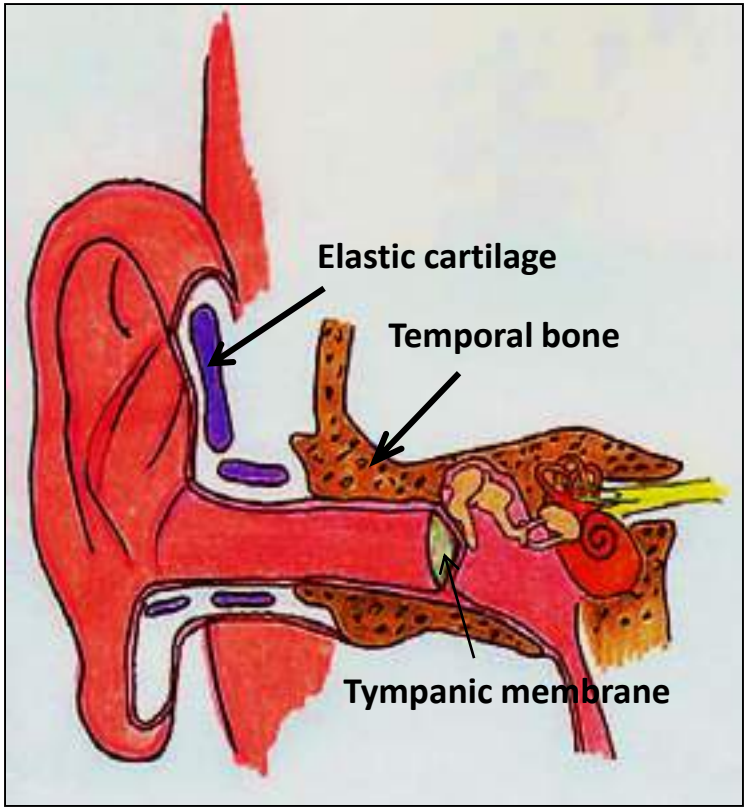
3- Tympanic membrane (Eardrum)



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 sweet glands)

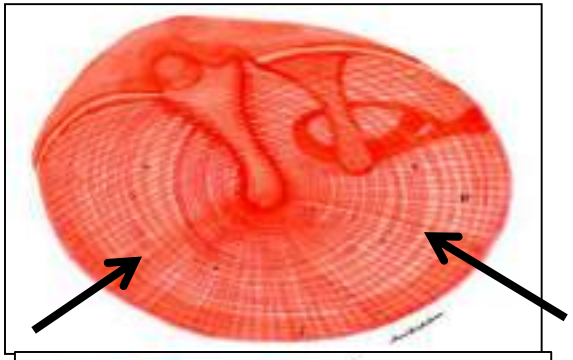


Cerumen: a waxy yellowish material, is mixture of secretions of both glands

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. Mitosis is present at marginal cells which responsible for regeneration of perforated drum

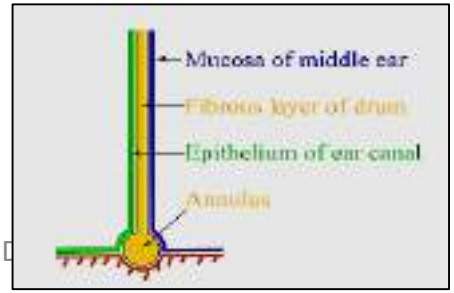


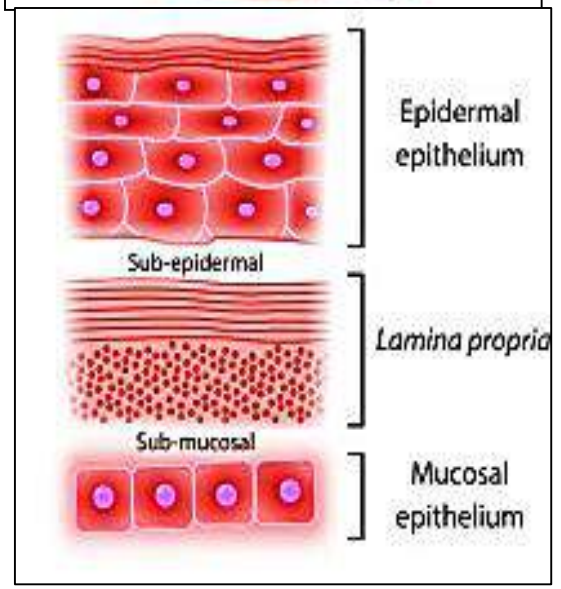
Intermediate layer: collagenous fibrous layer

made of outer radiating & inner Circular fibers

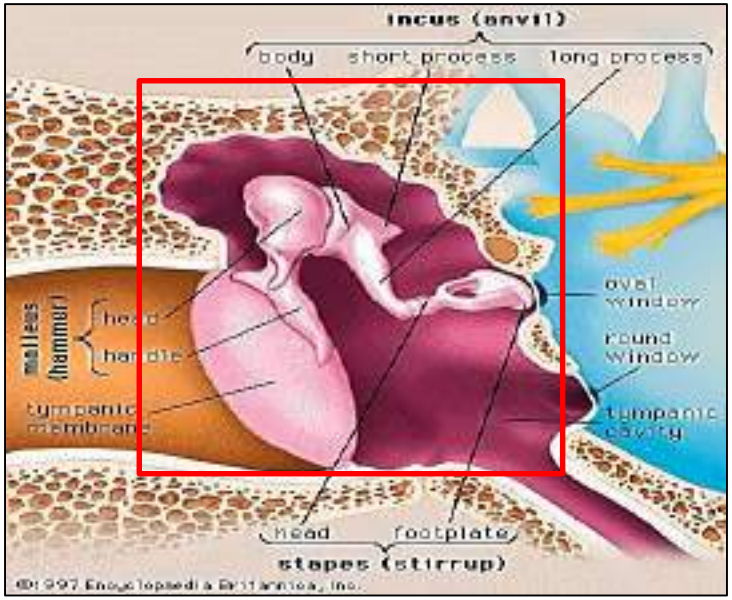
Inner mucousal layer: simple cuboidal epithelium

cover the inner surface of drum





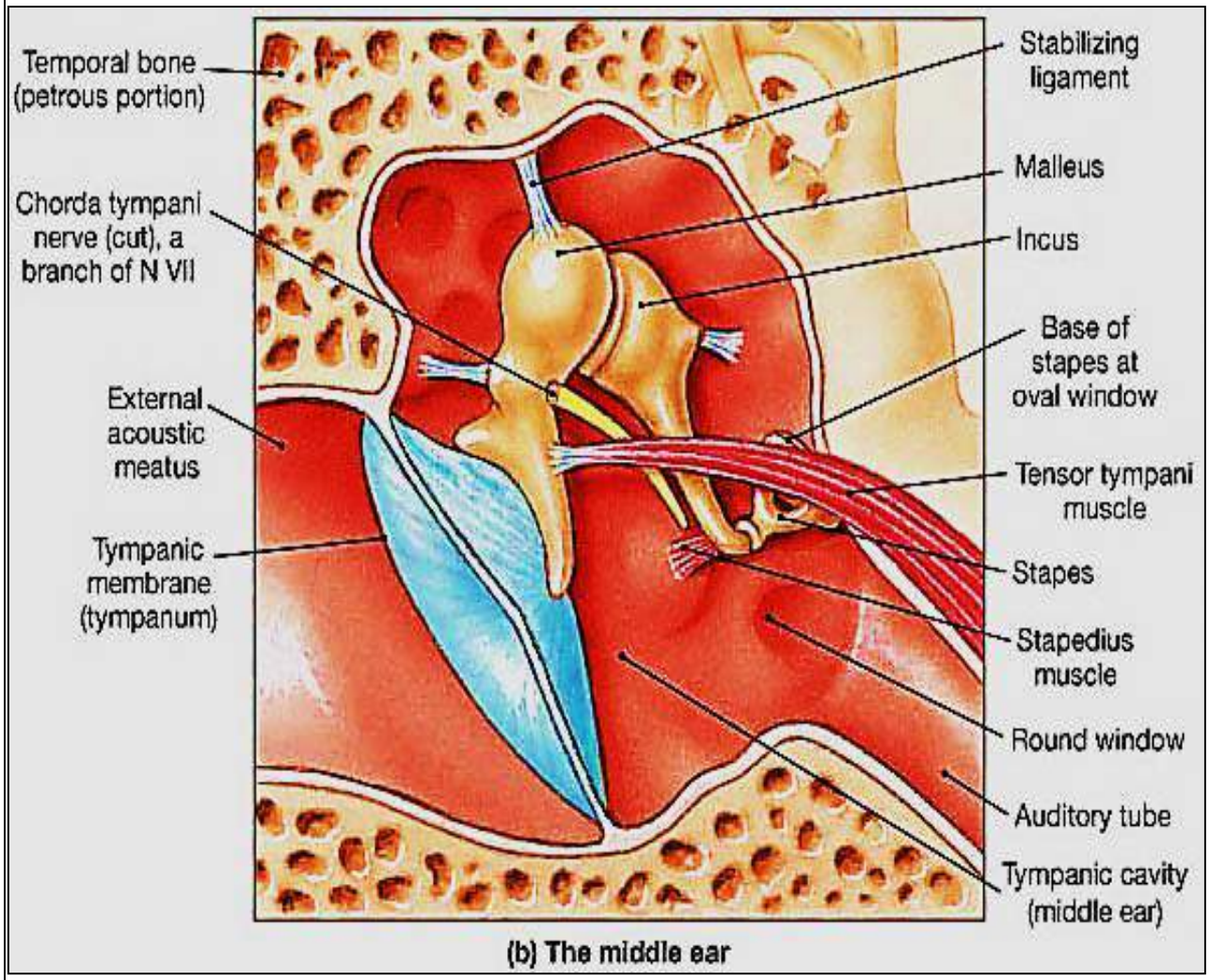
The Middle Ear (tympanic cavity)

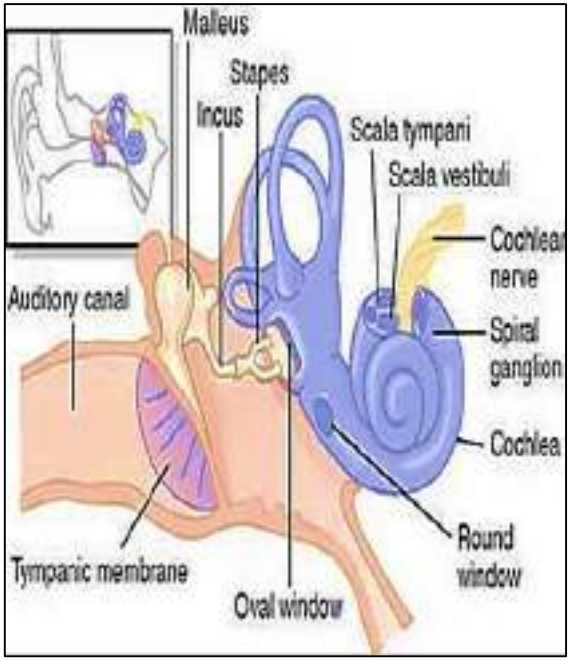


- Air filled cavity , within temporal bone. Lined with simple cuboidal epithelium
- Laterally: tympanic membrane,
- Medially : oval & round windows of inner ear
- Anteriorly: communicate with pharynx via Eustachian tube
  Posteriorly: temporal bone

Contents of Middle ear : (3221)

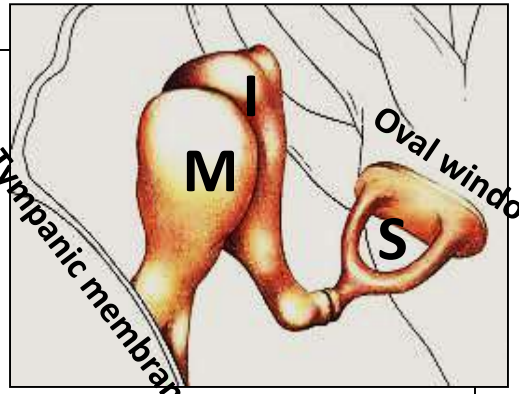
3 bony ossicles, 2 muscles, 2 windows, 1 chorda tympani n.



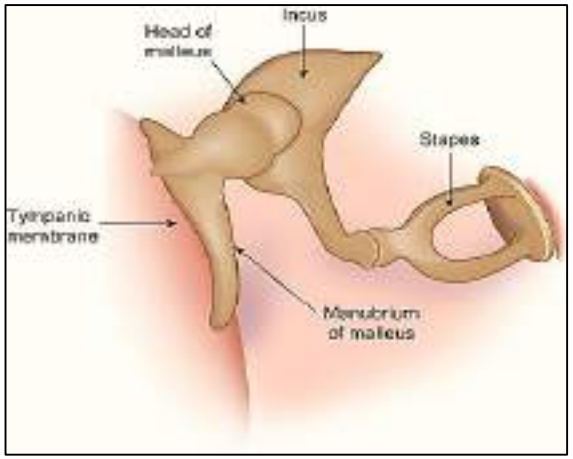


- **Auditory ossicles** : malleus, incus , stapes

(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):

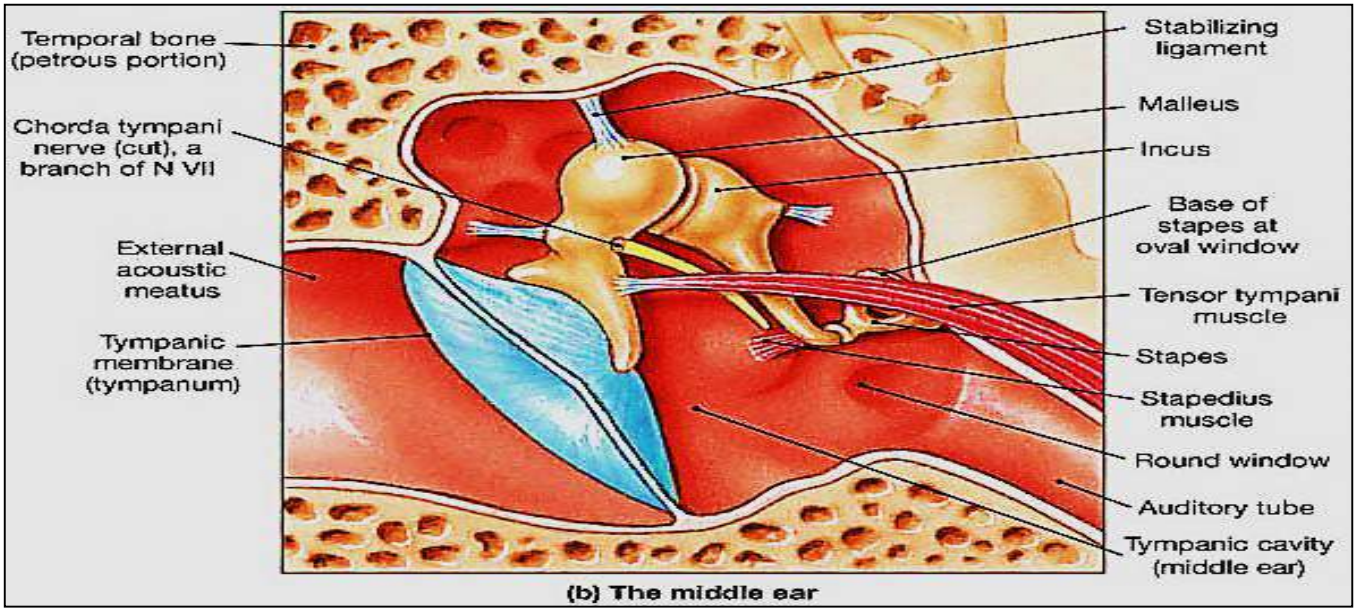
Tensor tympani & Stapedius

✓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

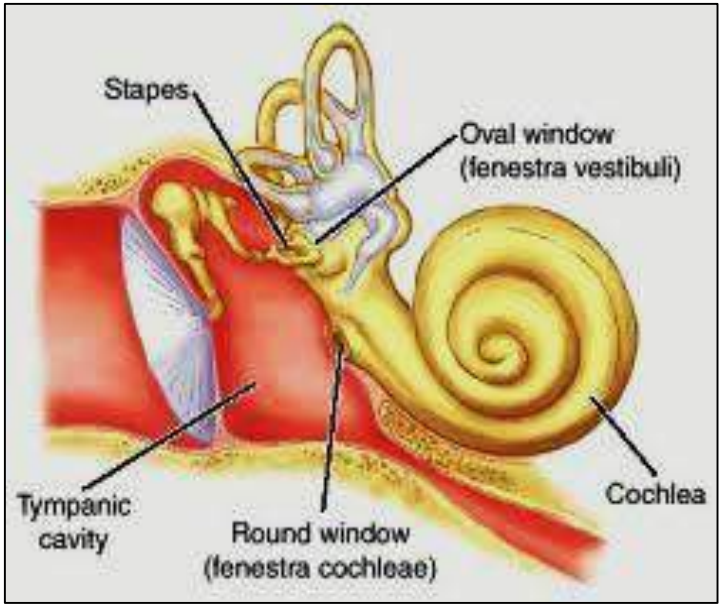


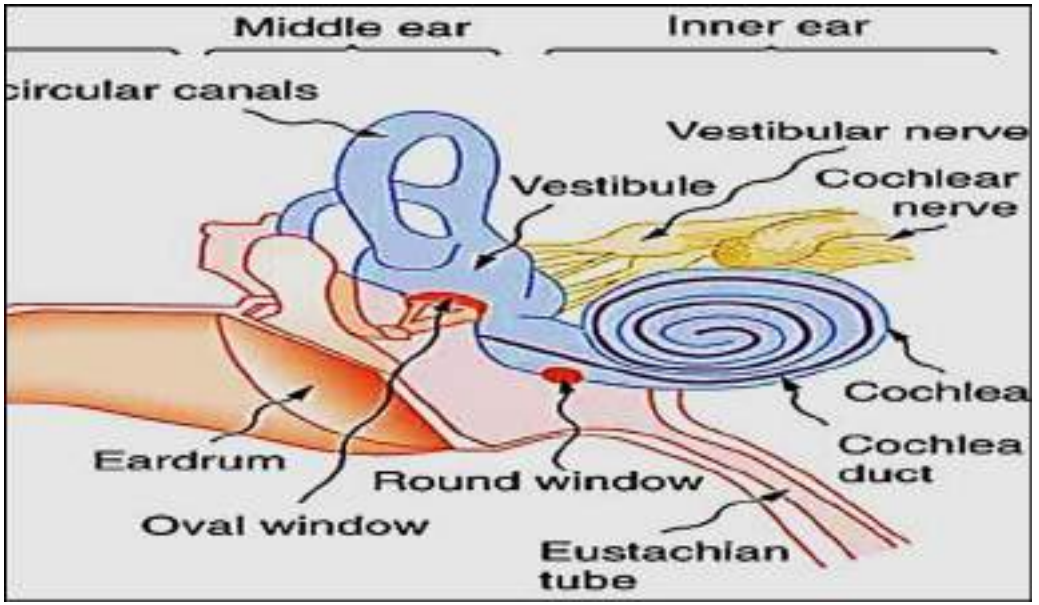
(b) The middle ear

- **<u>Windows</u>**: 2 openings covered by membranes, between middle and inner ear

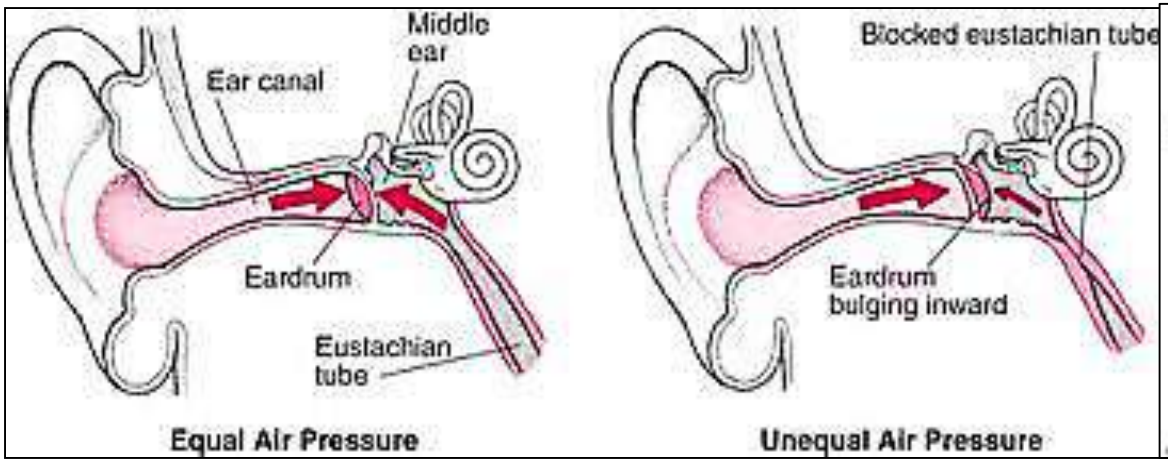
- Oval window(fenestra vestibule): closed by annular ligament which attached to foot plate of stapes. It transmits vibration to perilymph of vestibule of inner ear

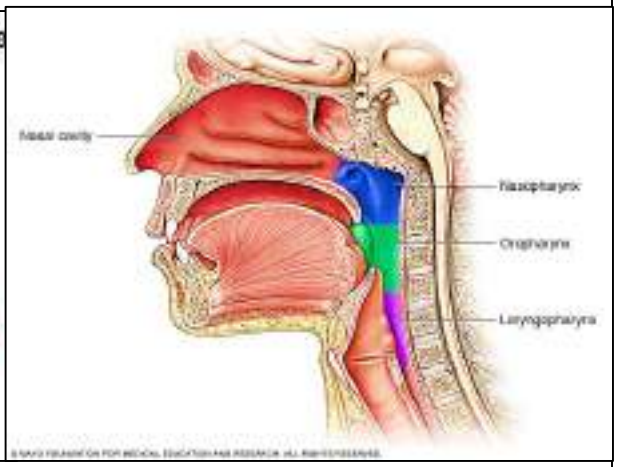
- Round window(fenestra cochlea):closed by elastic membrane called 2ry tympanic membrane





- **Eustachian tube:**

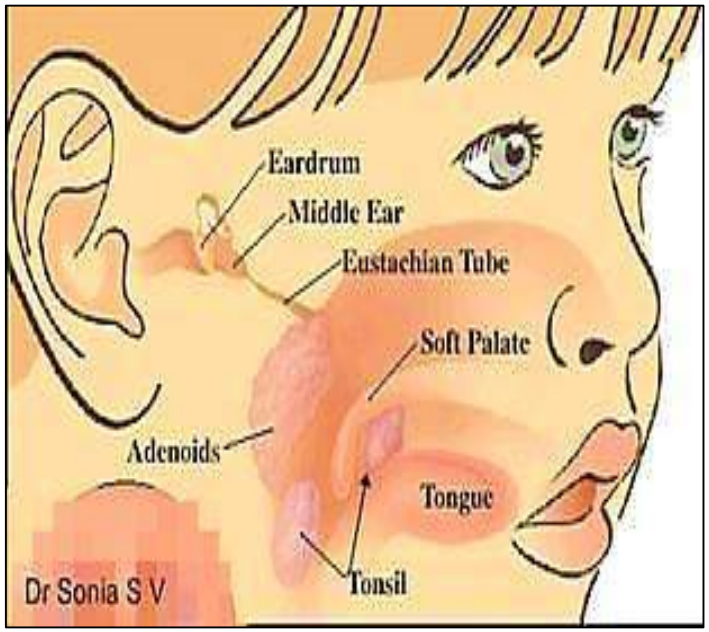


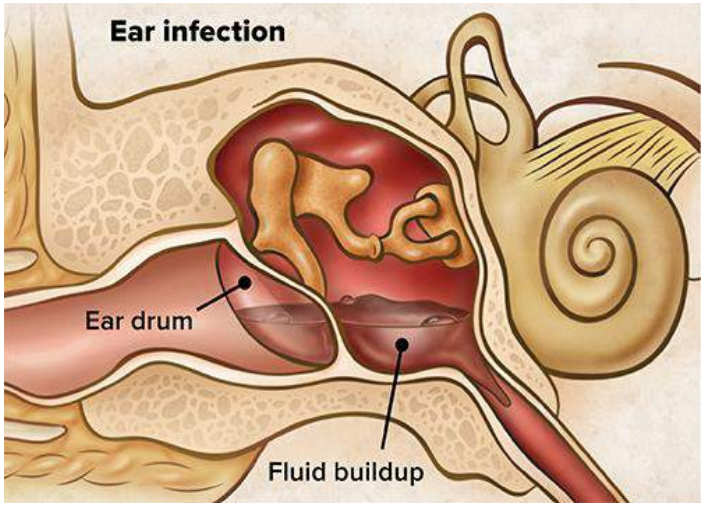


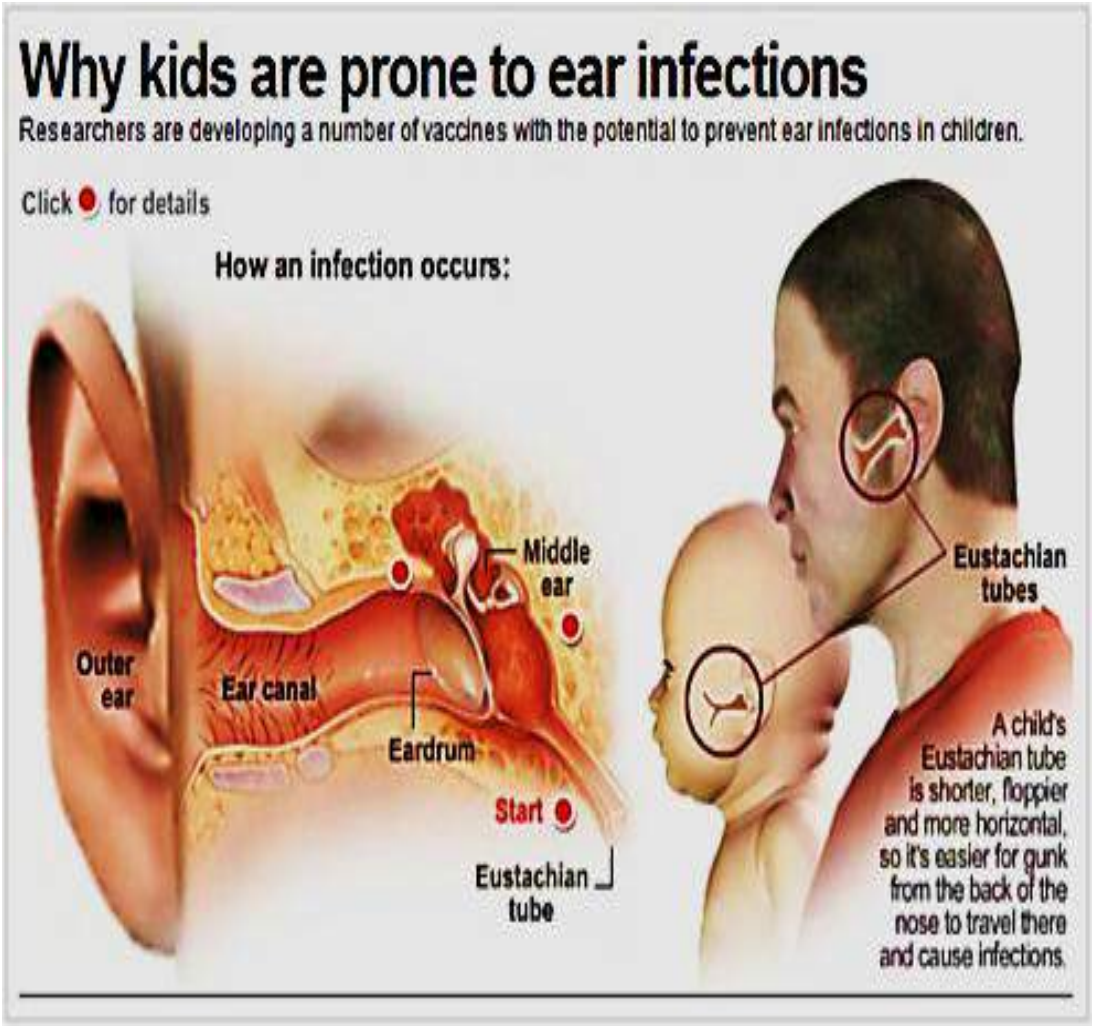
- It connects the middle ear e nasopharynx, open during swallowing
- serves to balance the air pressure in middle ear with atmospheric pressure.
- It has 2 parts:

→ **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**


Eardrum
Middle Ear
Eustachian Tube
Soft Palate
Adenoids
Tongue
Tonsil
Dr Sonia S V


Ear infection
Ear drum
Fluid buildup

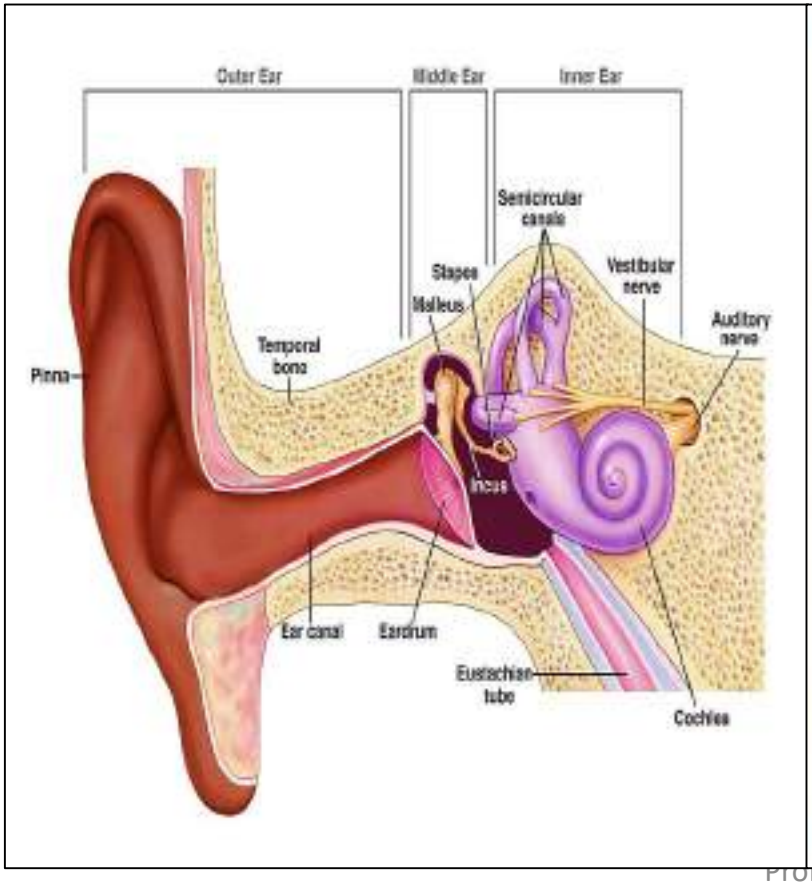

Why kids are prone to ear infections
Researchers are developing a number of vaccines with the potential to prevent ear infections in children.
Click for details
How an infection occurs:
Outer ear
Ear canal
Middle ear
Eardrum
Start
Eustachian tube
Eustachian tubes
A child's Eustachian tube is shorter, floppier and more horizontal, so it's easier for gunk from the back of the nose to travel there and cause infections.

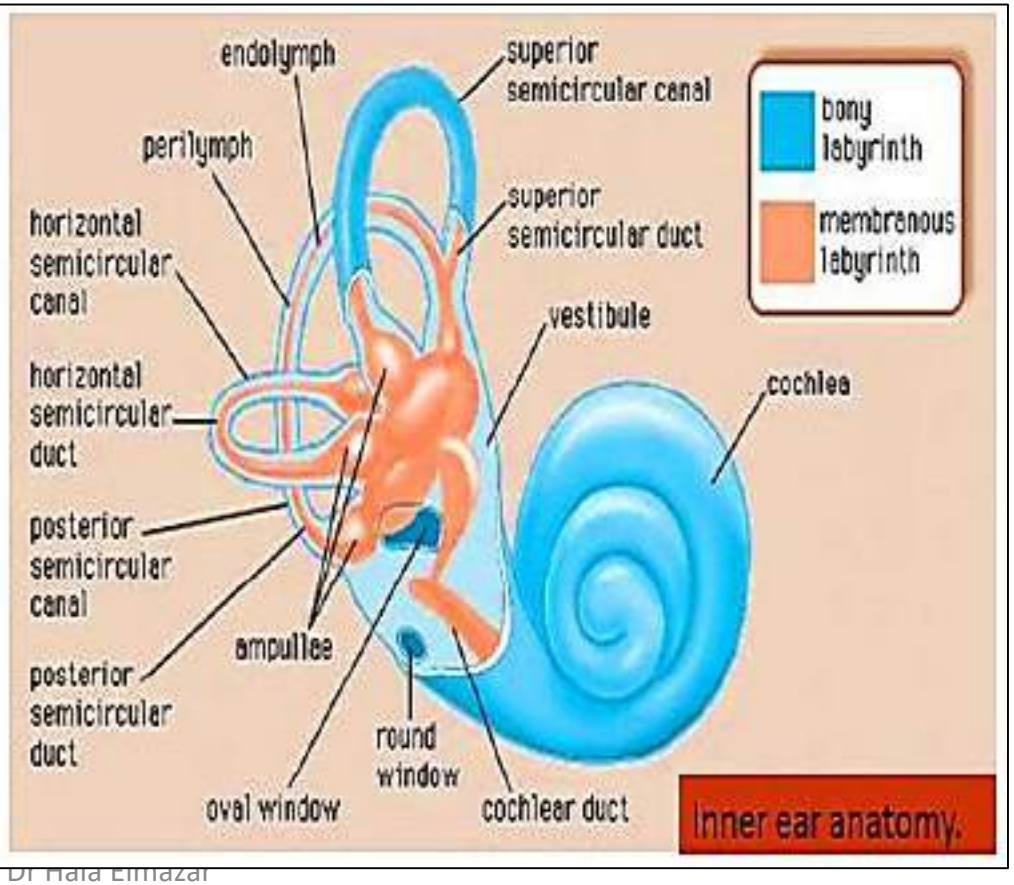
The Inner Ear (labyrinth)

Located completely within temporal bone

Consists of: **bony labyrinth**

membranous labyrinth

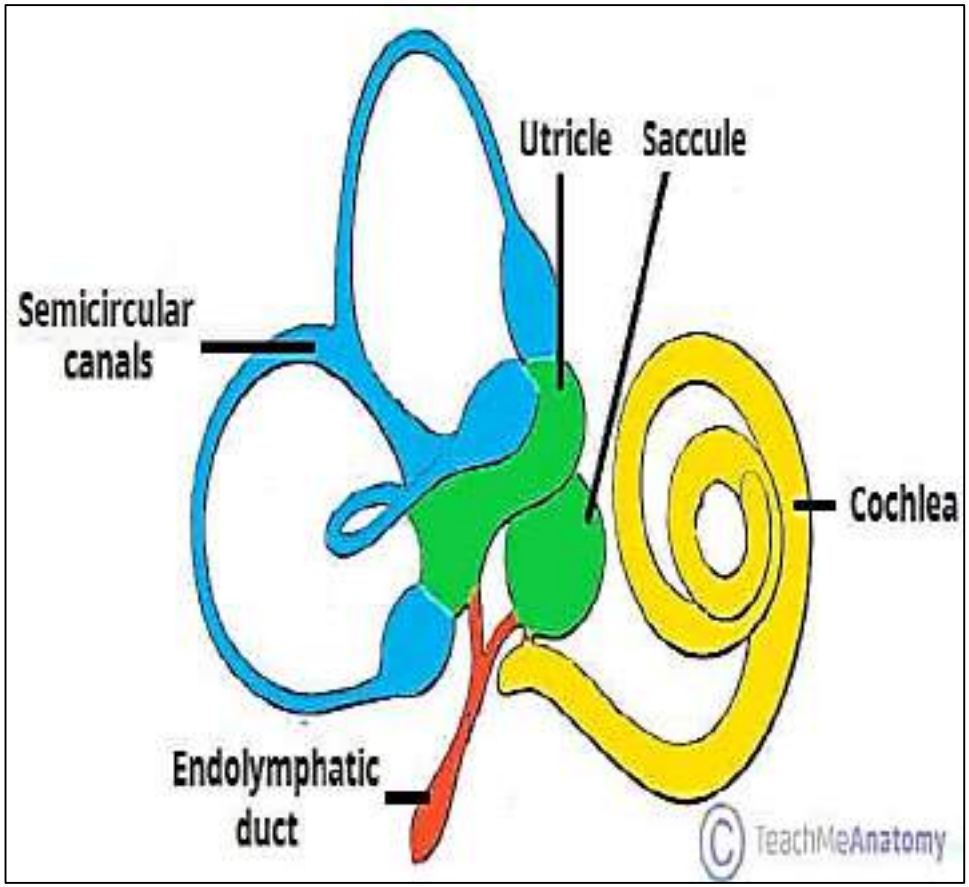




Bony labyrinth

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

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



- It Consists of 3 parts:

➢ Cochlea

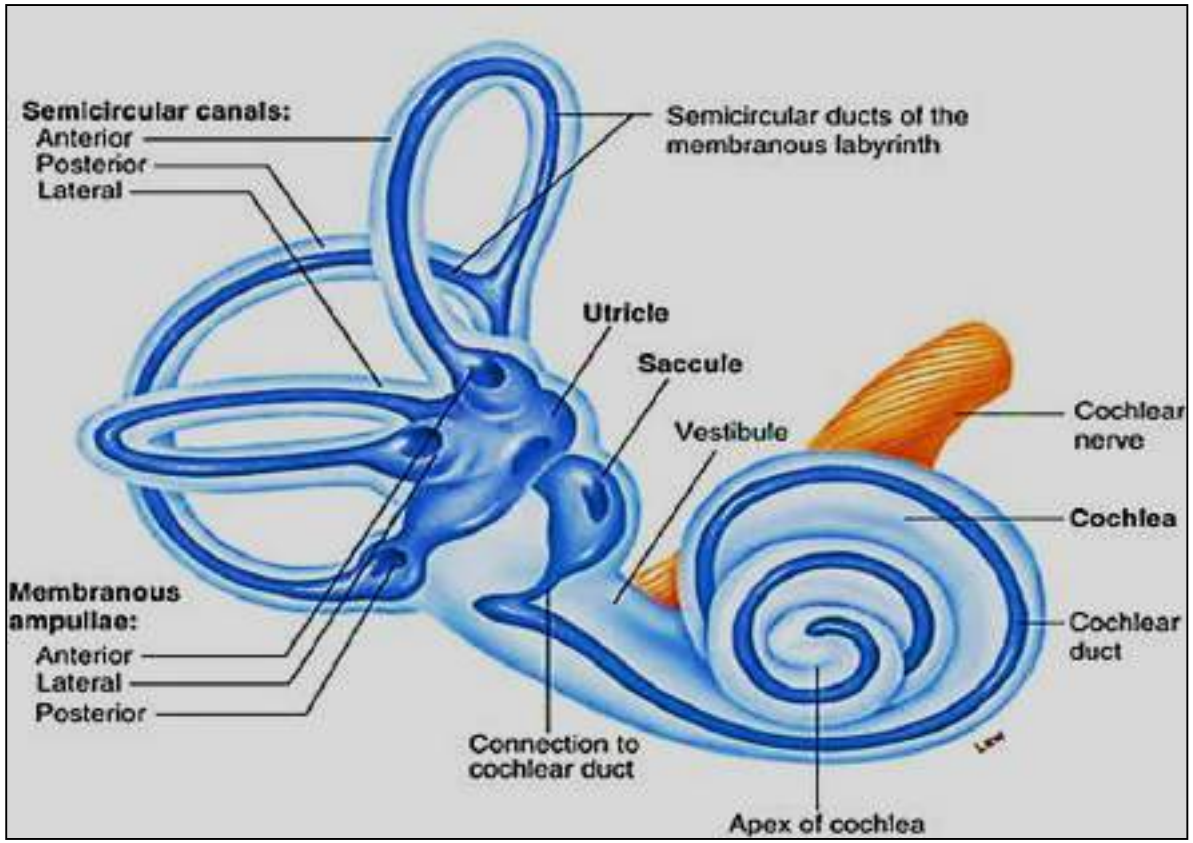
➢ 3 semicircular canals

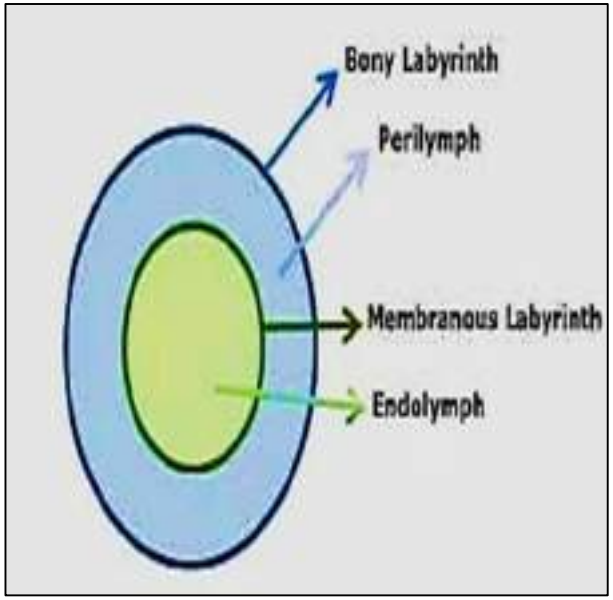
➢ Vestibule → utricle

→ saccule

Membranous labyrinth

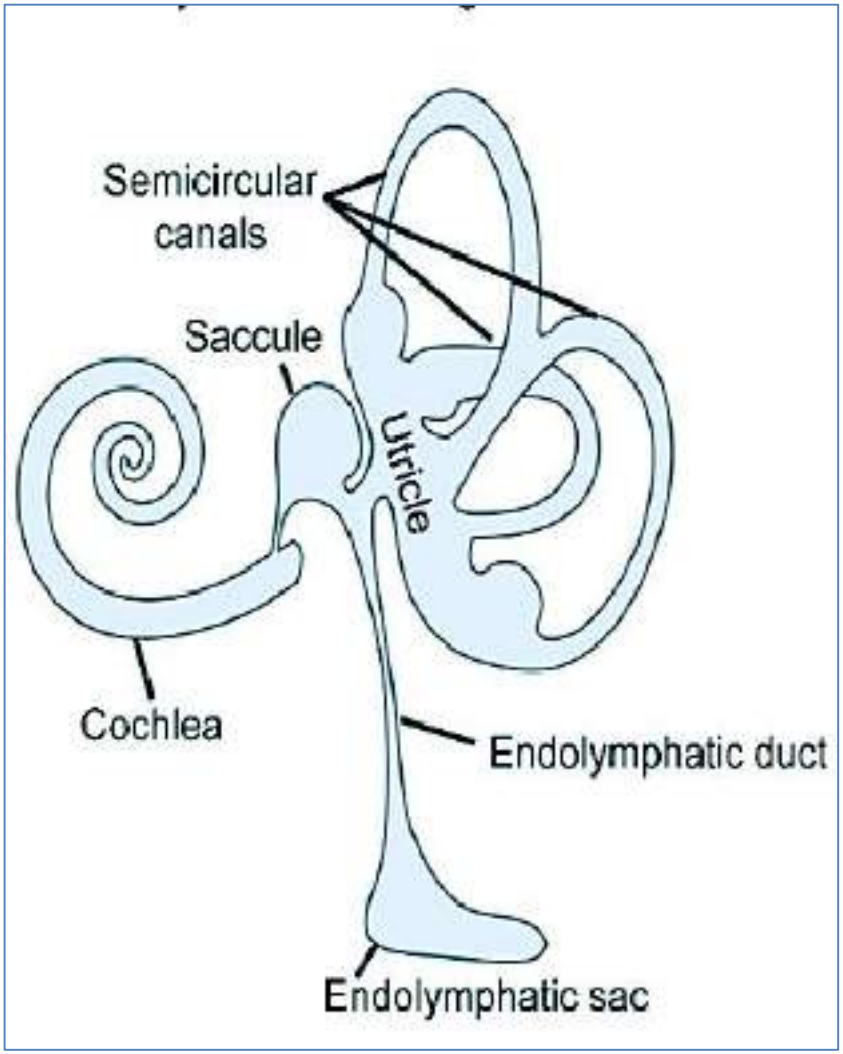
They are membranous tubules & sacs present within the bony labyrinth connected with each other & filled with fluid called endolymph (↓Na^+, ↑K^+)



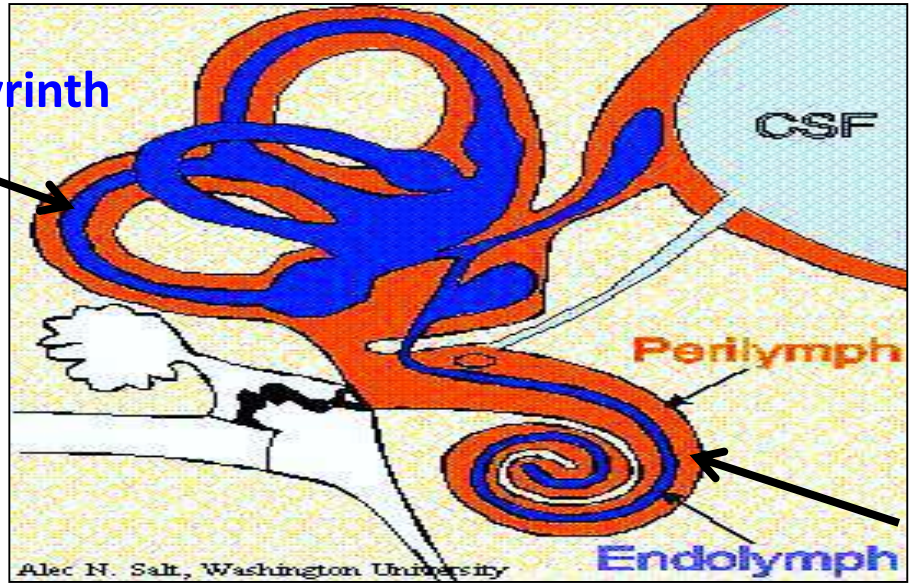


- The endolymph duct & sac drain / absorb the endolymph.

- Endolymph is produced continuously and is drained through the fenestrated blood vessels (venules) into the sigmoid sinus
- Meniere's disease : vertigo attacks due to obstruction in the drainage of endolymph



Membranous labyrinth

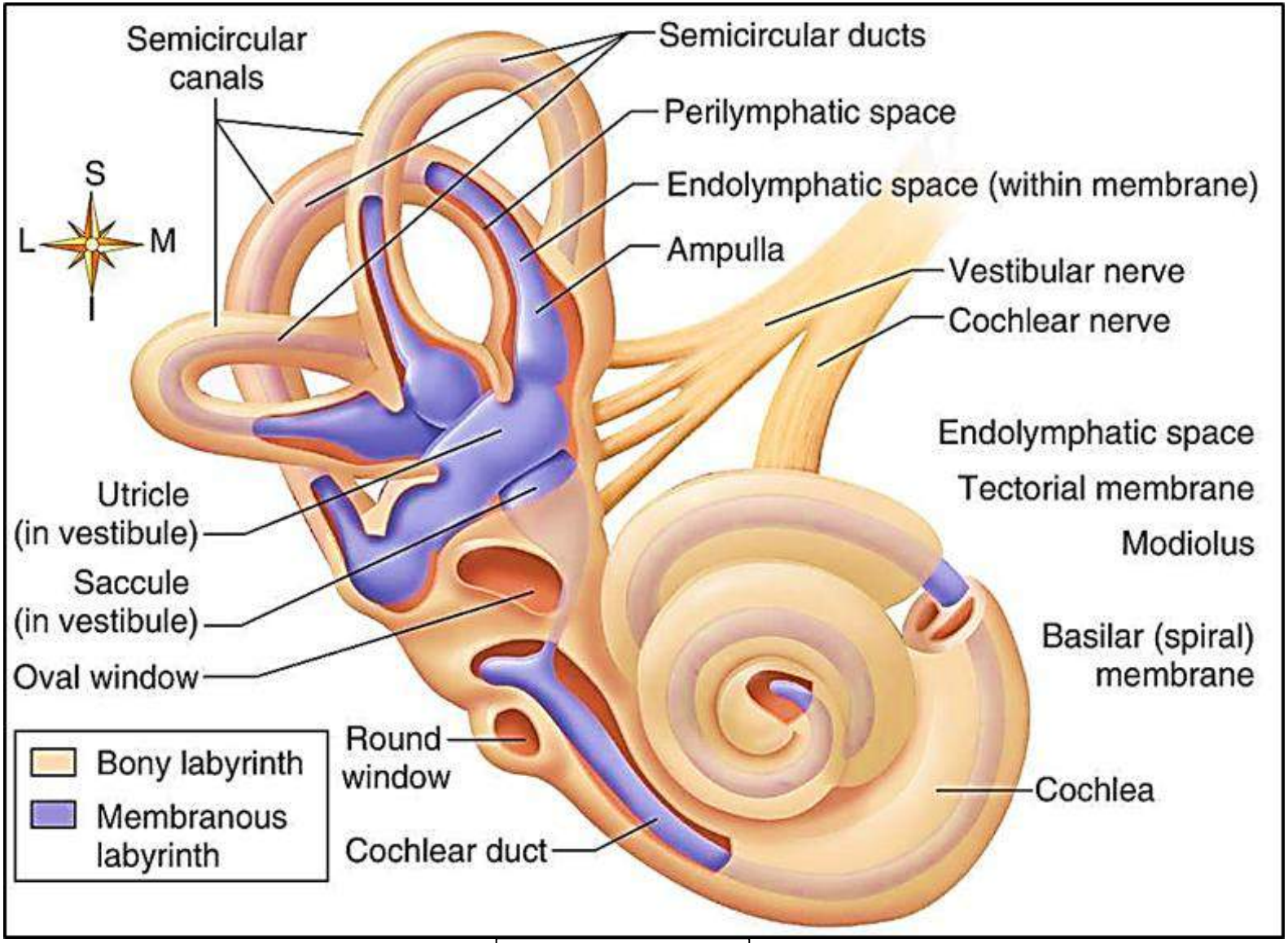


Bony labyrinth

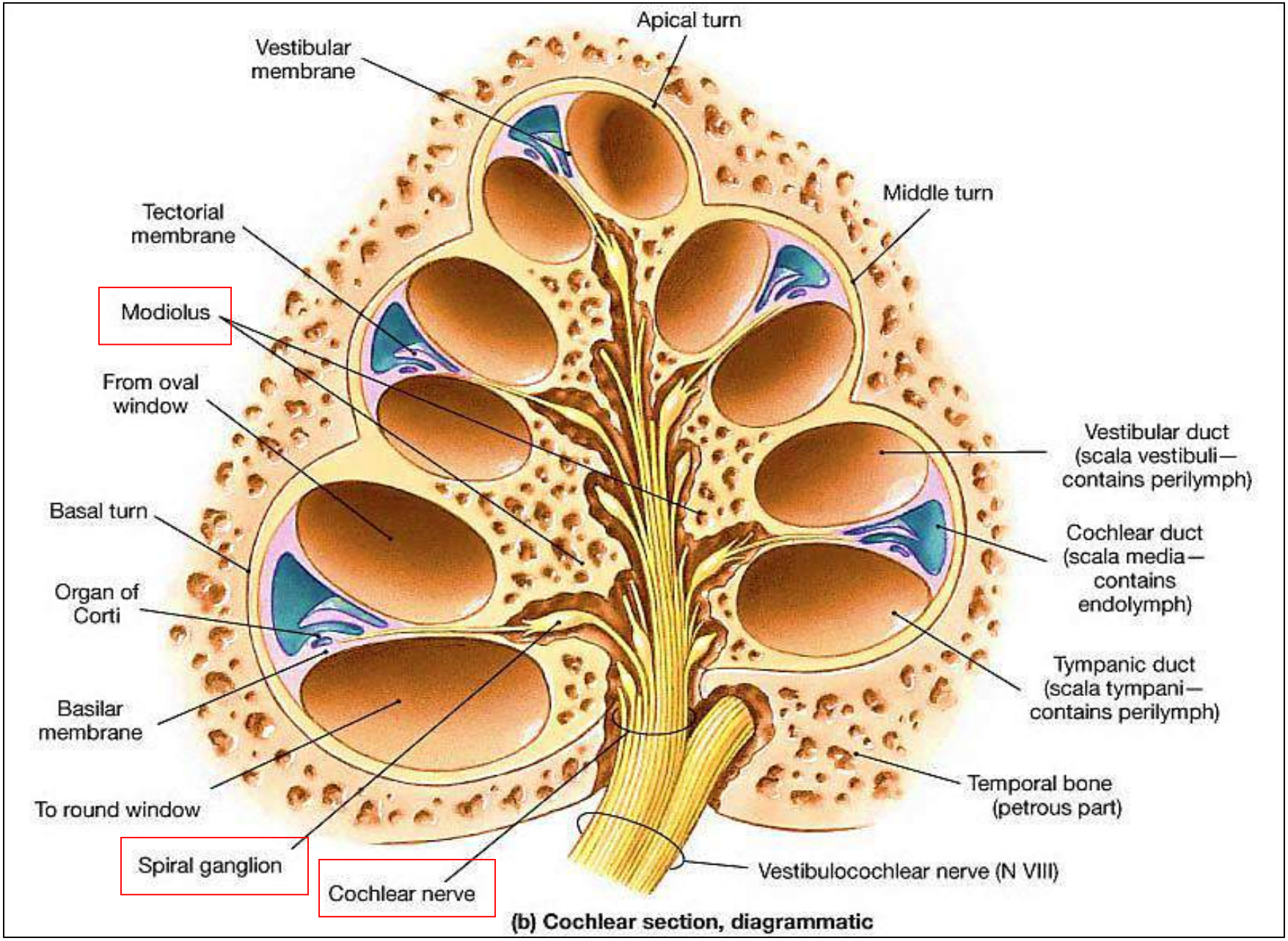
- The Cochlea is responsible for the sense of **hearing**
- The vestibular organs for the sense of **equilibrium & balance** :
  - saccule
  - utricle
  - semicircular canals

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

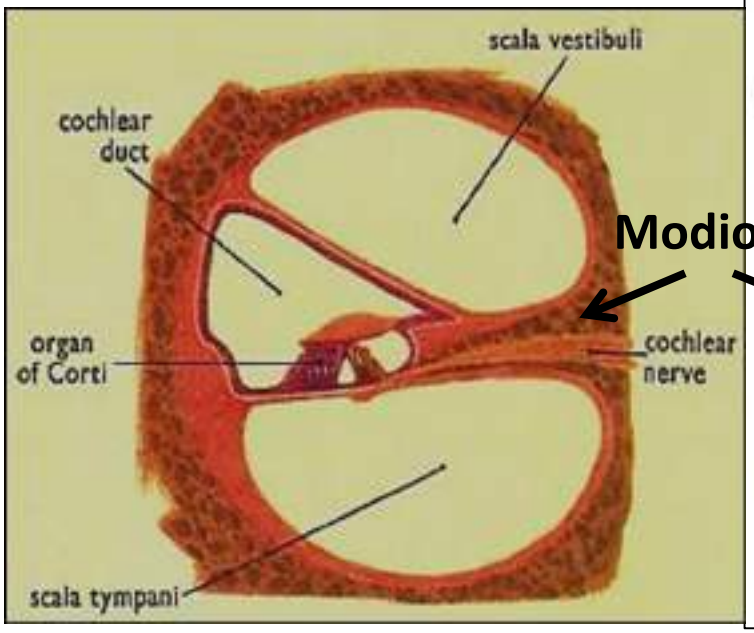


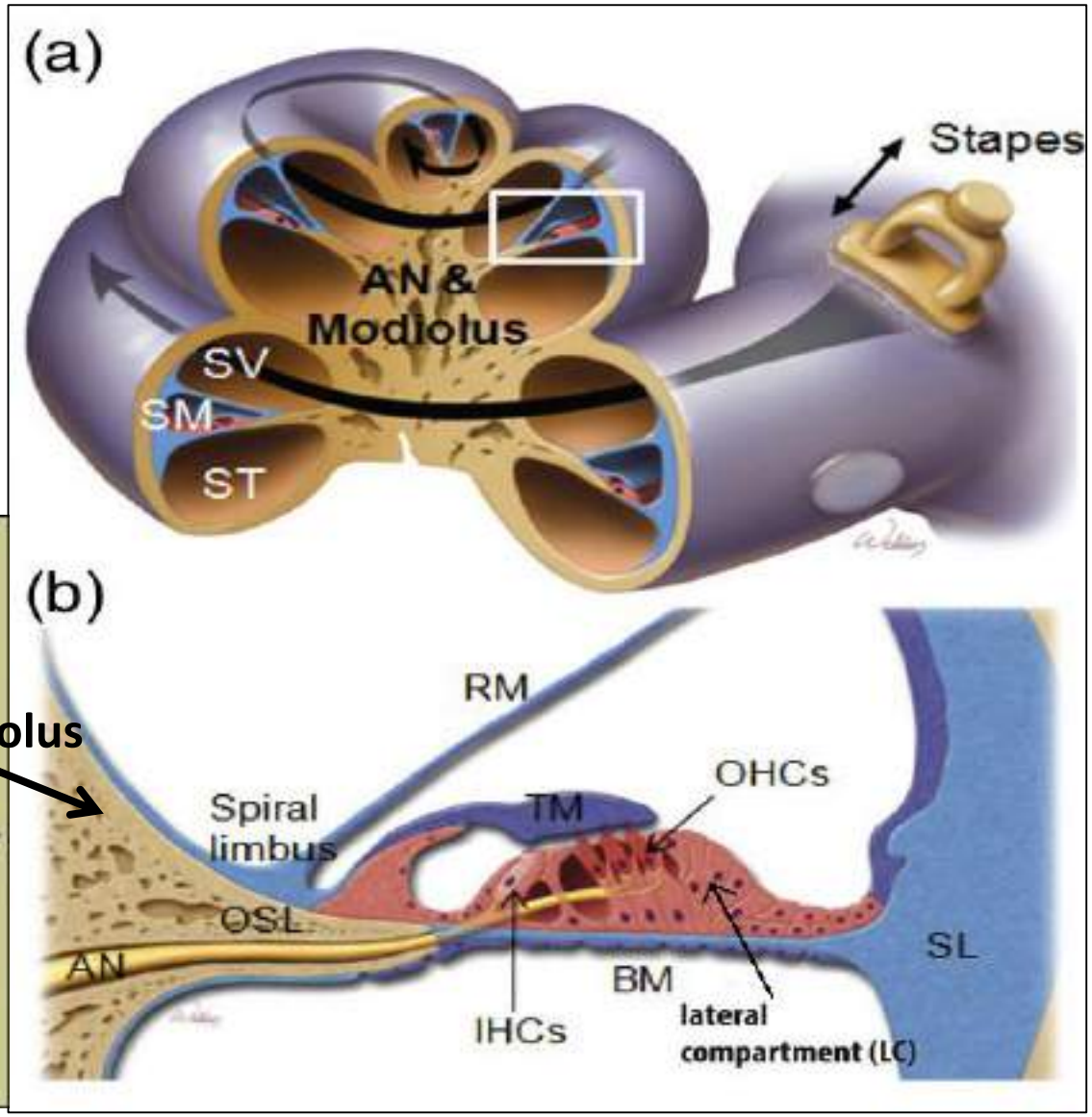
Cochlear duct



(b) Cochlear section, diagrammatic

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



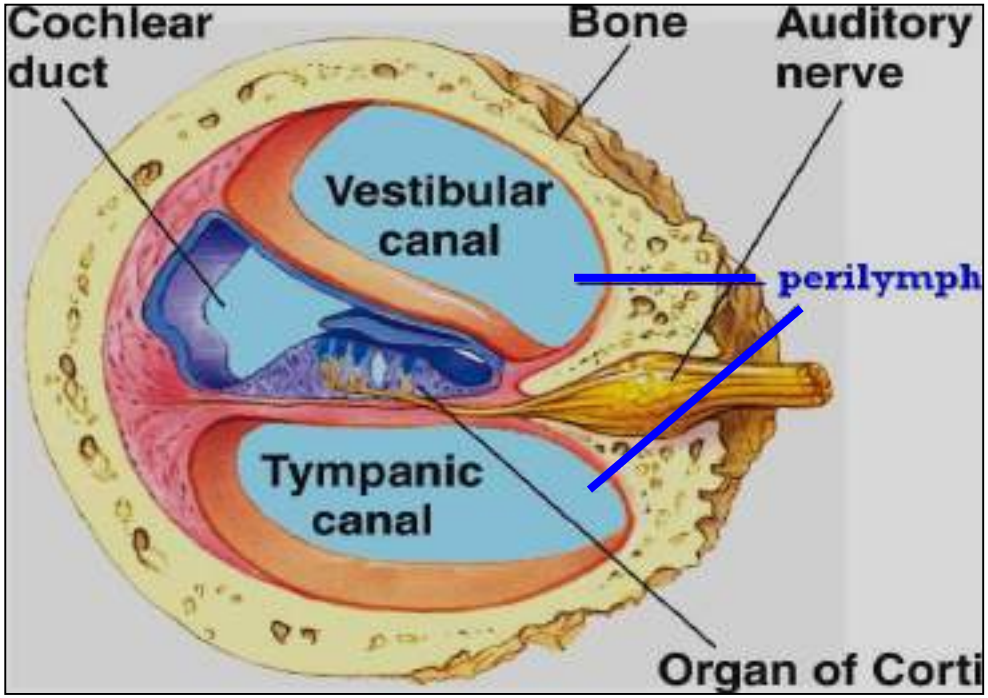


The cochlear duct divides the bony canal into **3 spaces** :

a. Scala vestibuli (above)

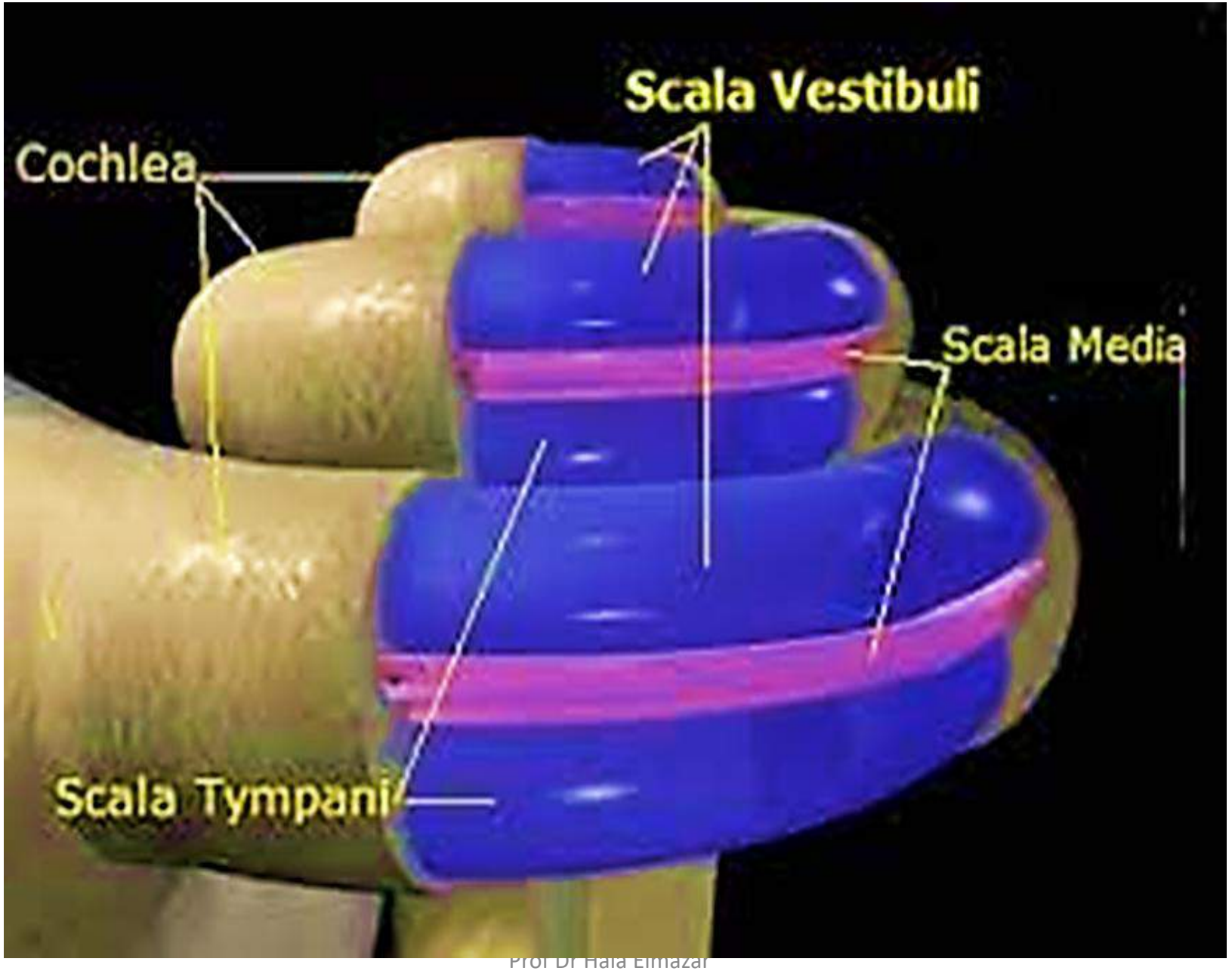
b. Scala media (middle)

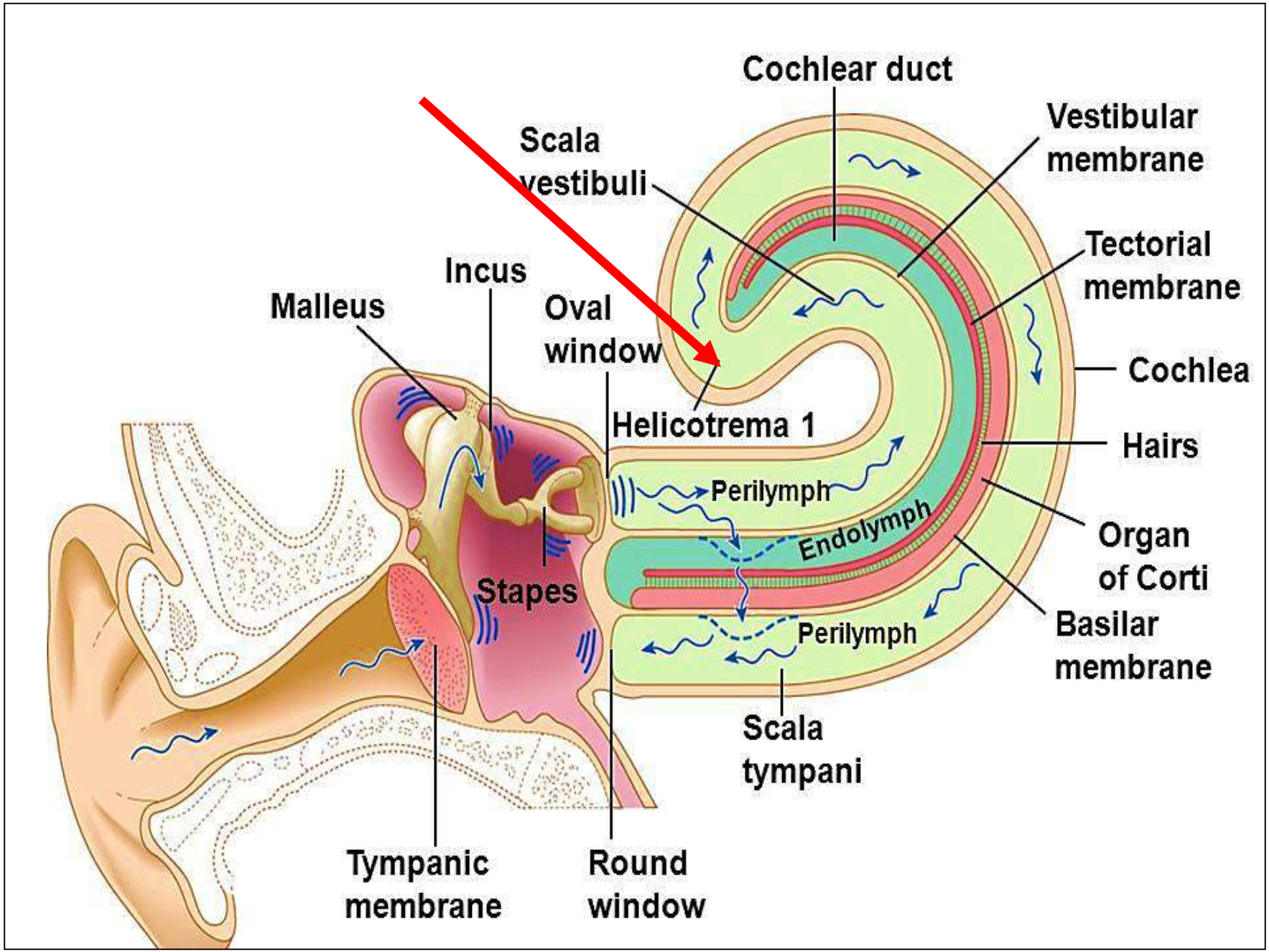
c. Scala tympani (below)



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

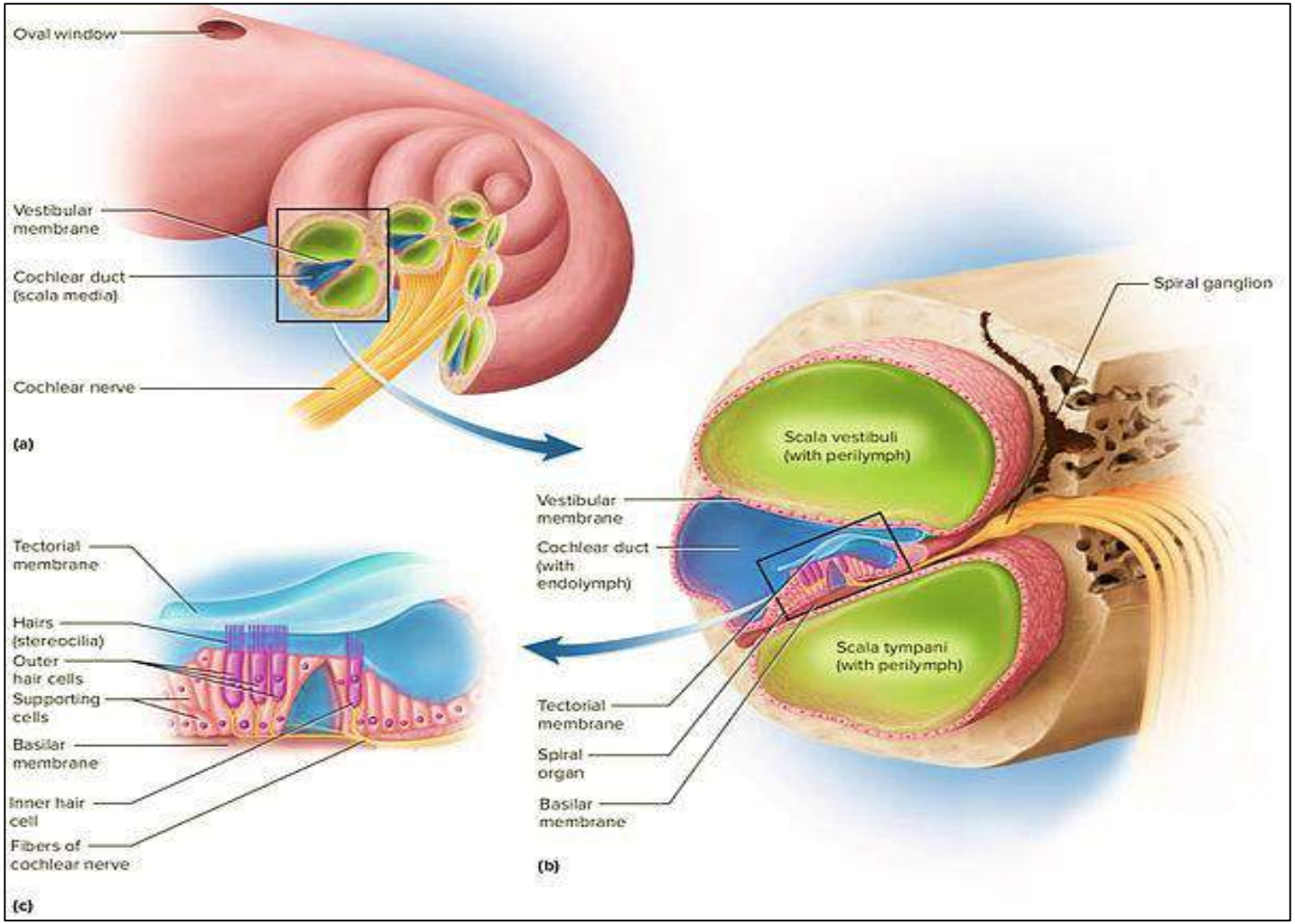
- **Scala tympani**: communicate e middle ear through the round window, contains perilymph


Scala Vestibuli
Cochlea
Scala Media
Scala Tympani


Cochlear duct
Vestibular membrane
Scala vestibuli
Tectorial membrane
Incus
Malleus
Oval window
Cochlea
Helicotrema 1
Hairs
Perilymph
Endolymph
Organ of Corti
Stapes
Perilymph
Basilar membrane
Scala tympani
Tympanic membrane
Round window

Scala media (Cochlear duct):

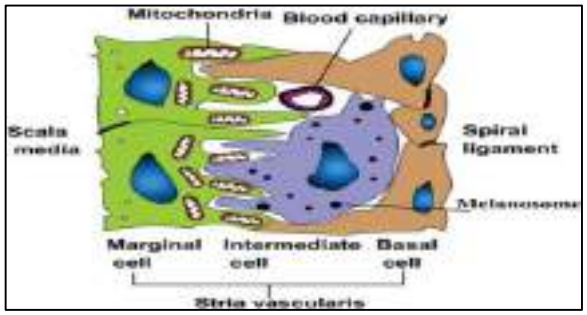
- is the membranous part of the cochlea
- contains **endolymph, & organ of Corti**

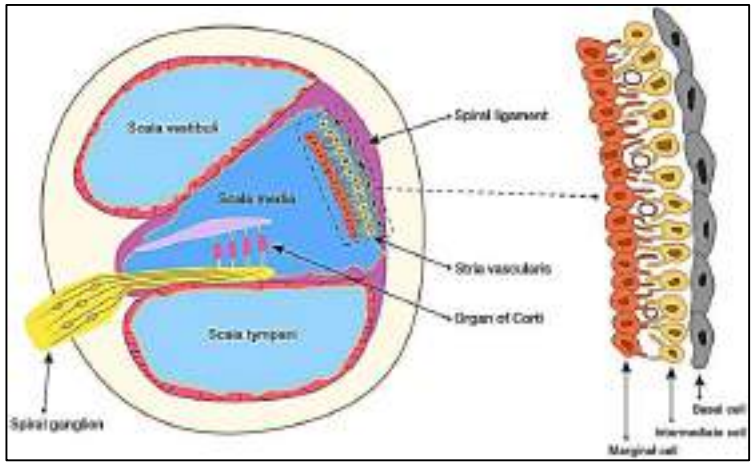


- The cochlear duct is triangular in shape

a. <u>The lateral wall</u> is formed by **stria vascularis,** which has highly vascular C.T., covered e **<u>stratified columnar cells</u>**, 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 for the function of the sensory cells in the ear

The **roof** is formed by

vestibular membrane,

thick membrane covered on

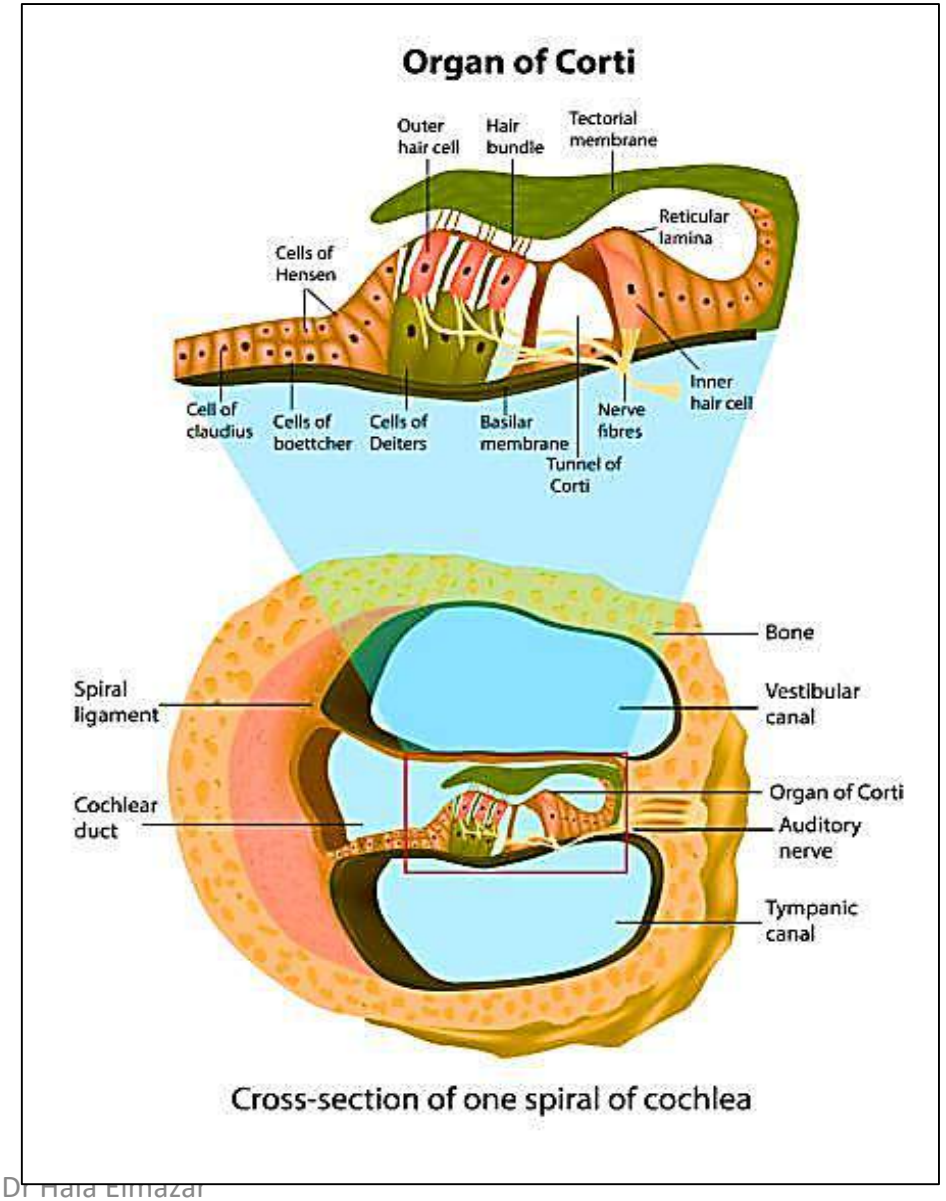
both sides e **simple squamous epi**

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

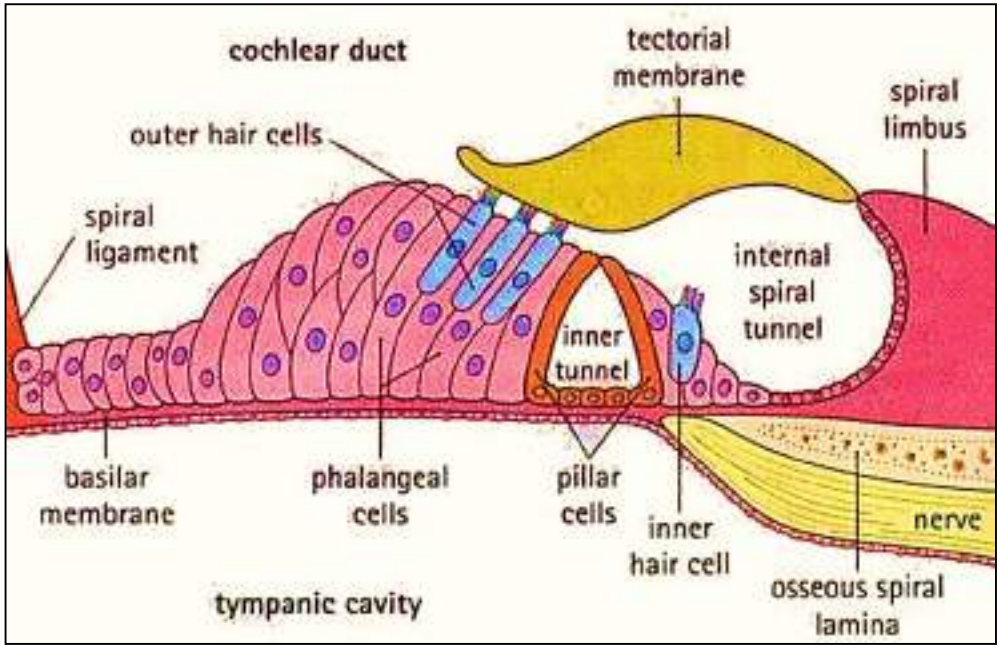
- The organ of Corti is covered e Tectorial membrane



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

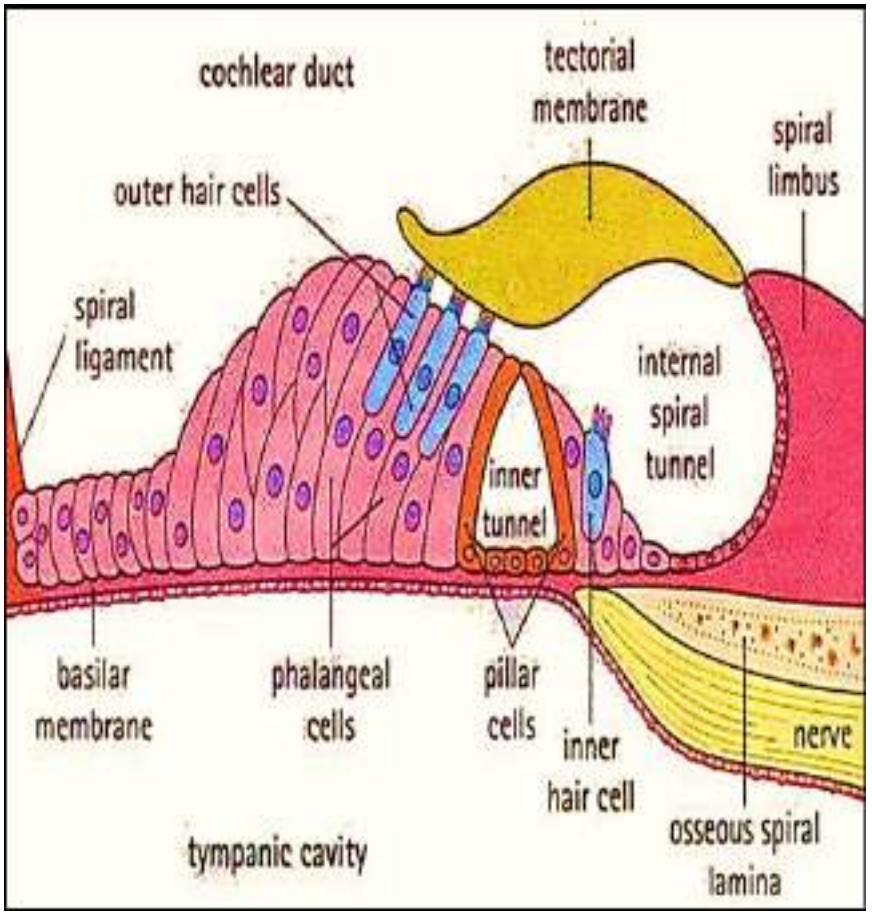
Inner ph. **cells are 1 row**

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

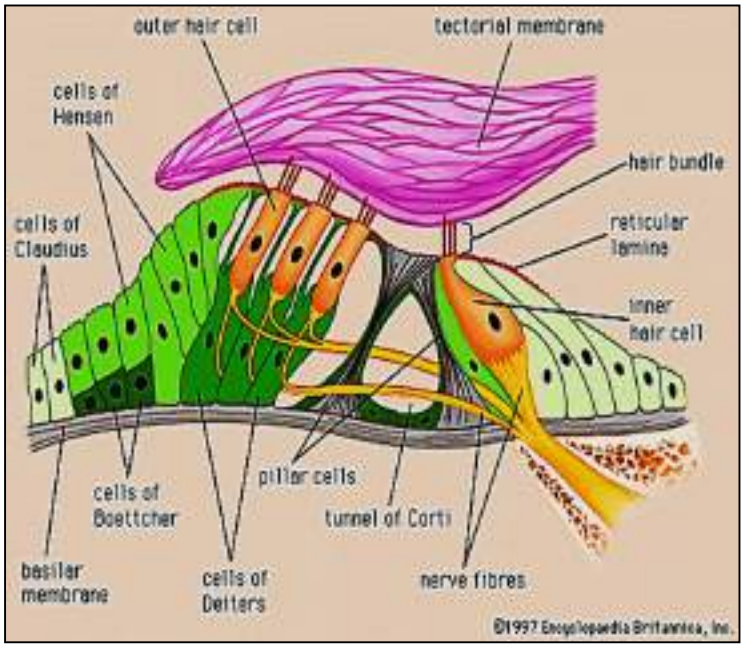
Hair cells 2 types :

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



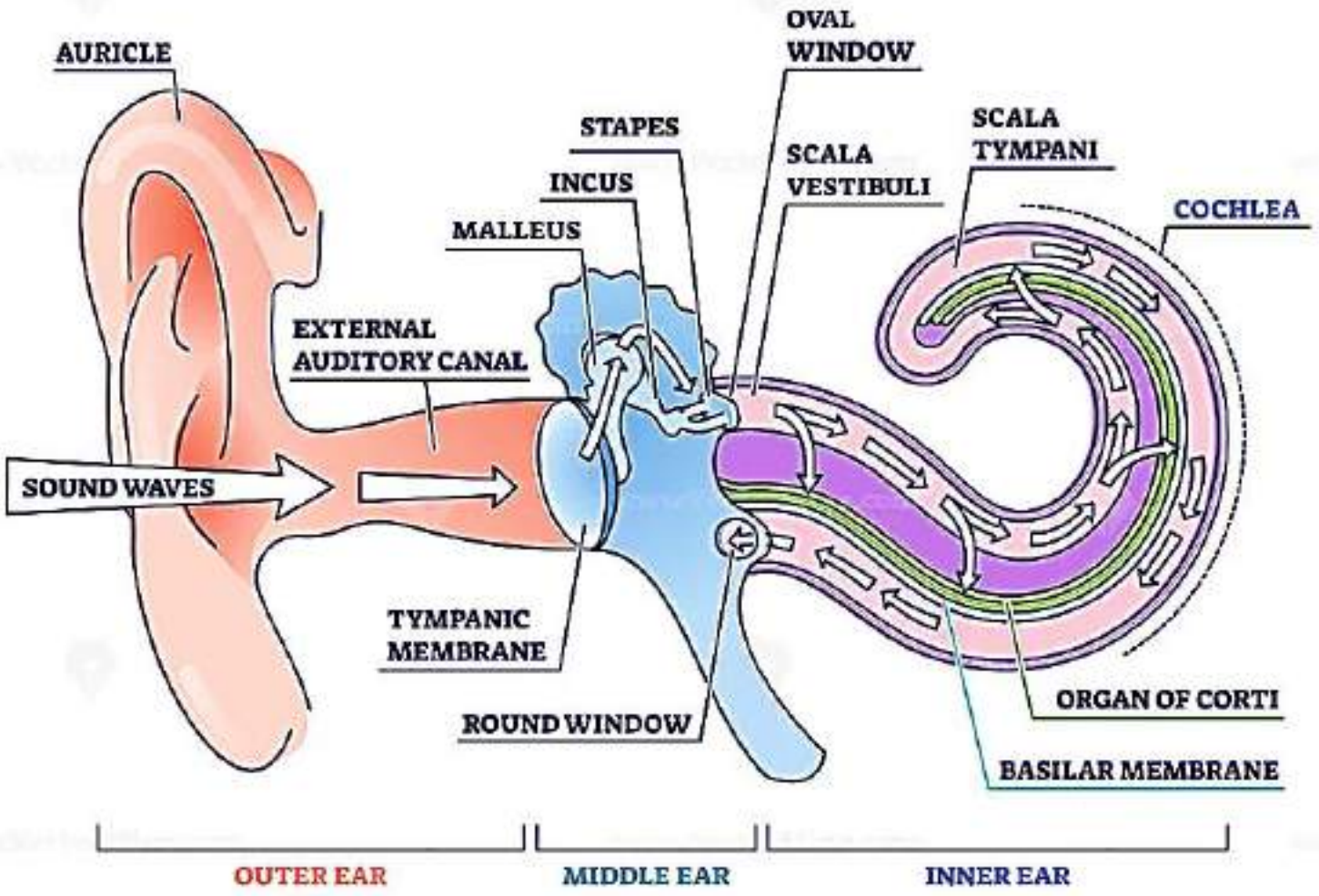
- The tips of the stereocilia
  are in contact with the tectorial
  membrane

- Axons of bipolar nerve cells form cochlear nerve

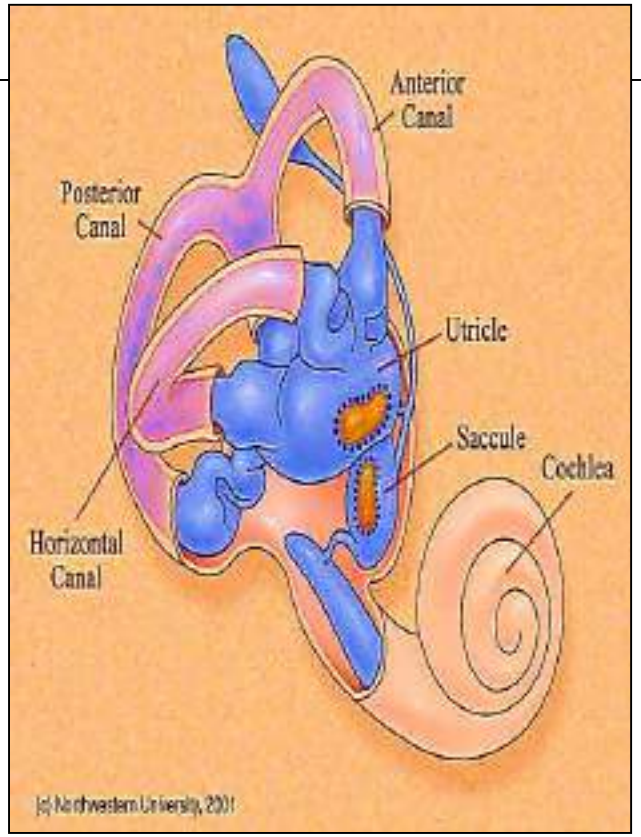
Mechanism of Hearing

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

COCHLEA


AURICLE
OVAL WINDOW
STAPES
SCALA TYMPANI
SCALA VESTIBULI
INCUS
COCHLEA
MALLEUS
EXTERNAL AUDITORY CANAL
SOUND WAVES
TYMPANIC MEMBRANE
ROUND WINDOW
ORGAN OF CORTI
BASILAR MEMBRANE
OUTER EAR
MIDDLE EAR
INNER EAR

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**

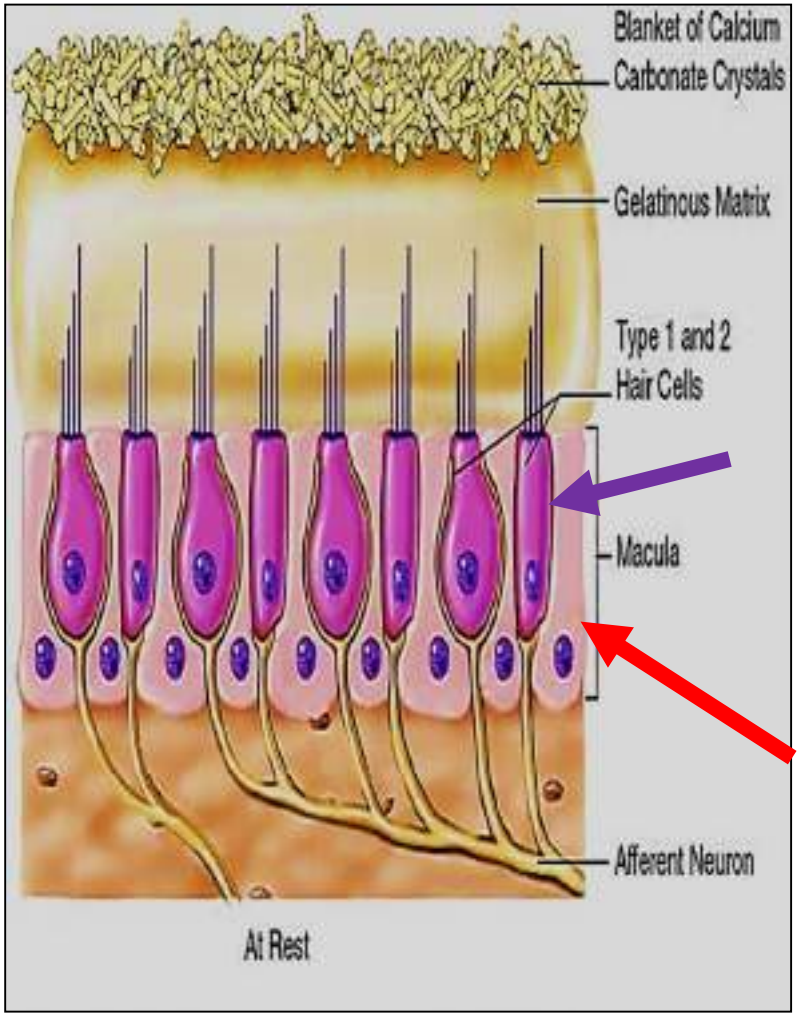
Structure of maculae of utricle & saccule:

- 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)

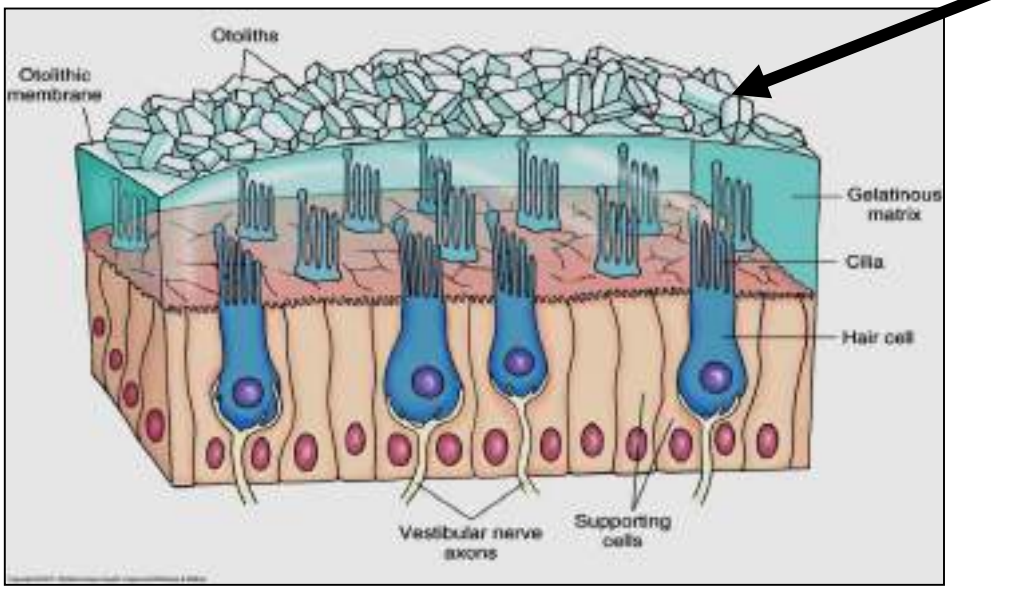
both cell types are surrounded at their base with afferent fibers of vestibular nerve

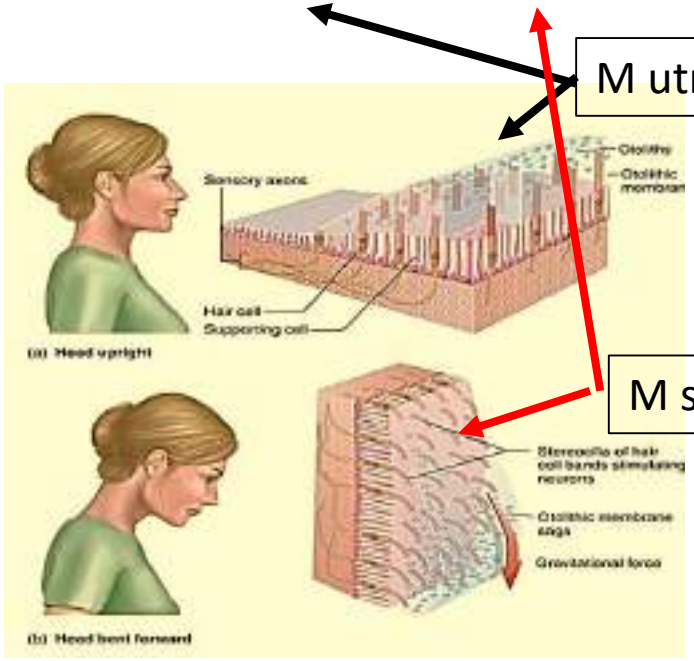
Otolithic membrane

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)



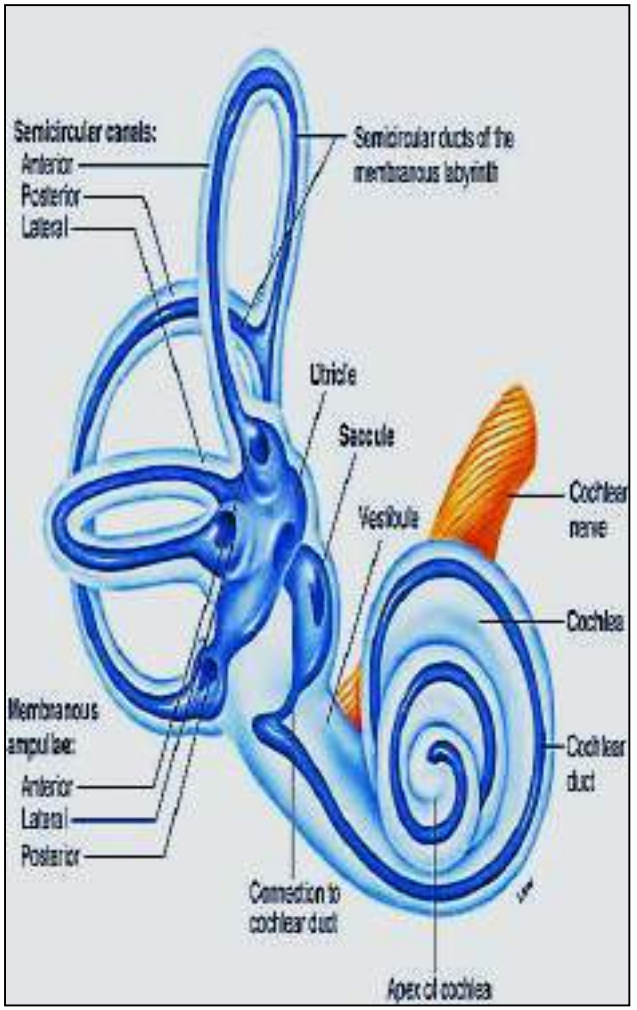


The Semicircular canals

- 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

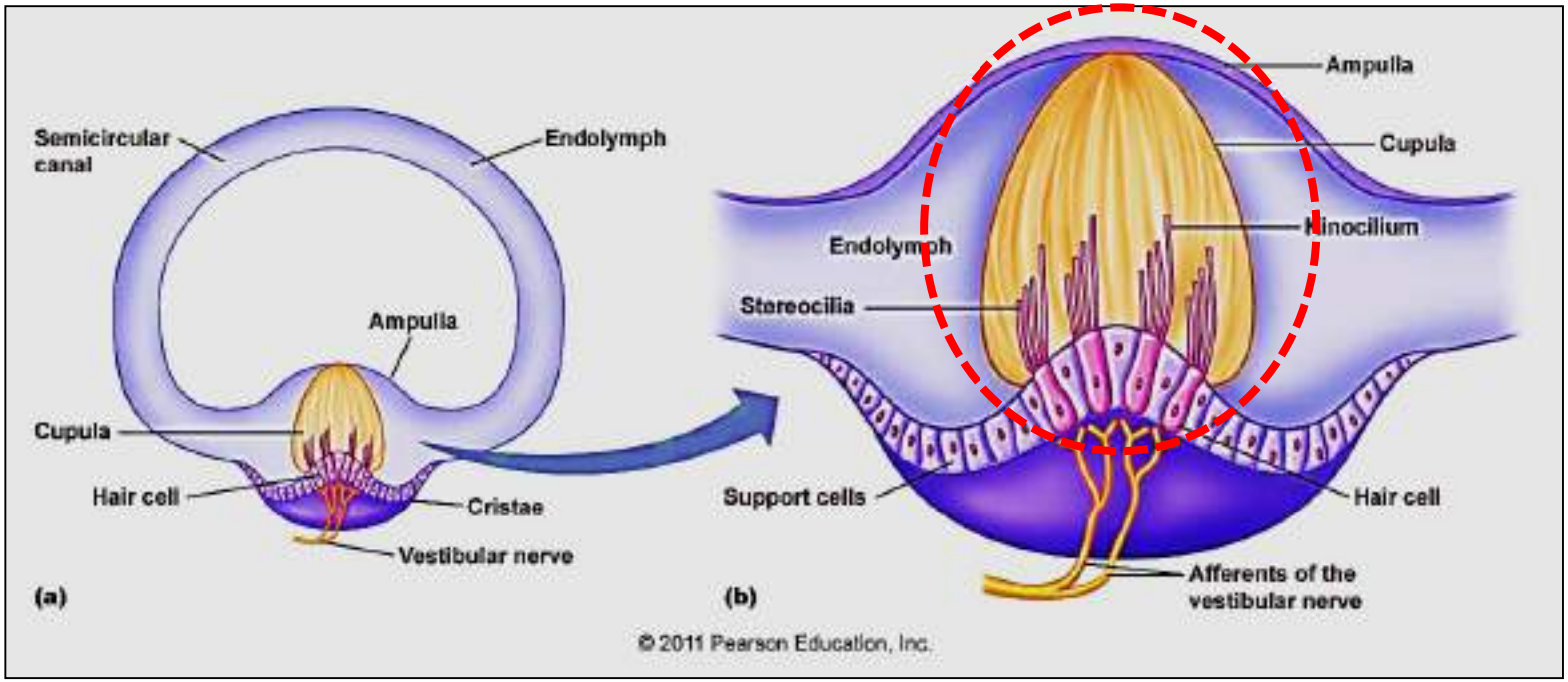
- Each duct has one expanded end called ampulla which contains the neuroepithelial structure Called **Crista ampullaris (3/ ear)**



Structure of Crista ampullaris

- Each crista is projects from the inner wall of each ampulla

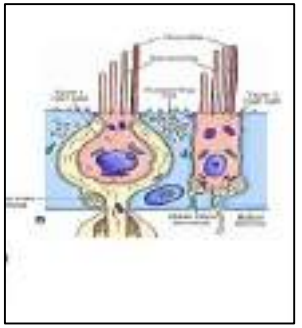
- Each crista has 2 types of cells: hair cells & supporting cells



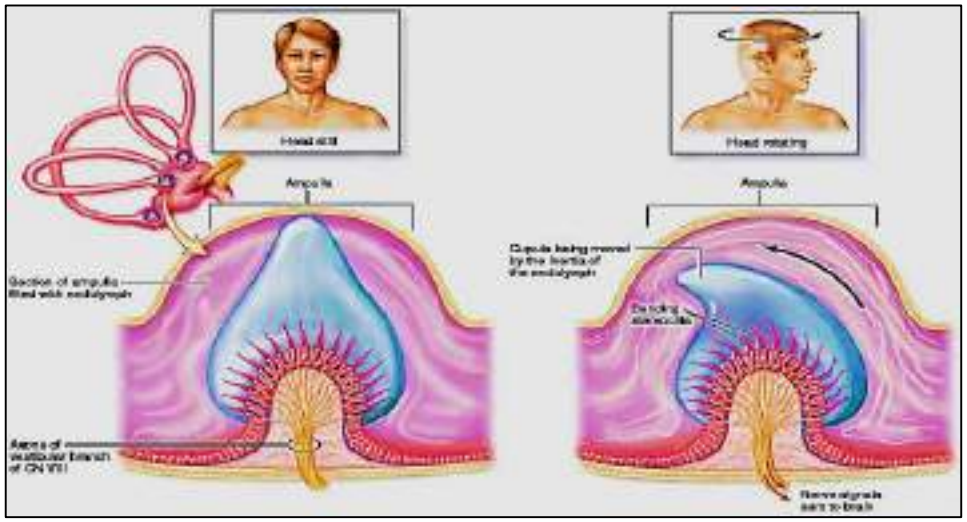
The hair cells of crista ampullaris: 2 types

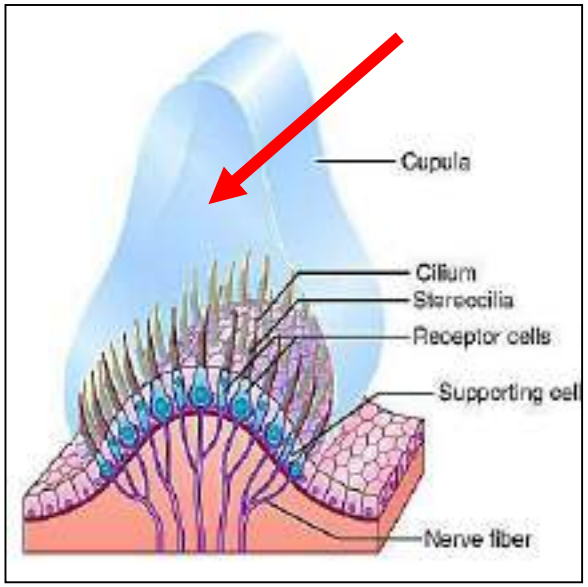
- Type I (flask- shaped) & Type II (columnar) cells
- Their bases surrounded with afferent fibers of vestibular n

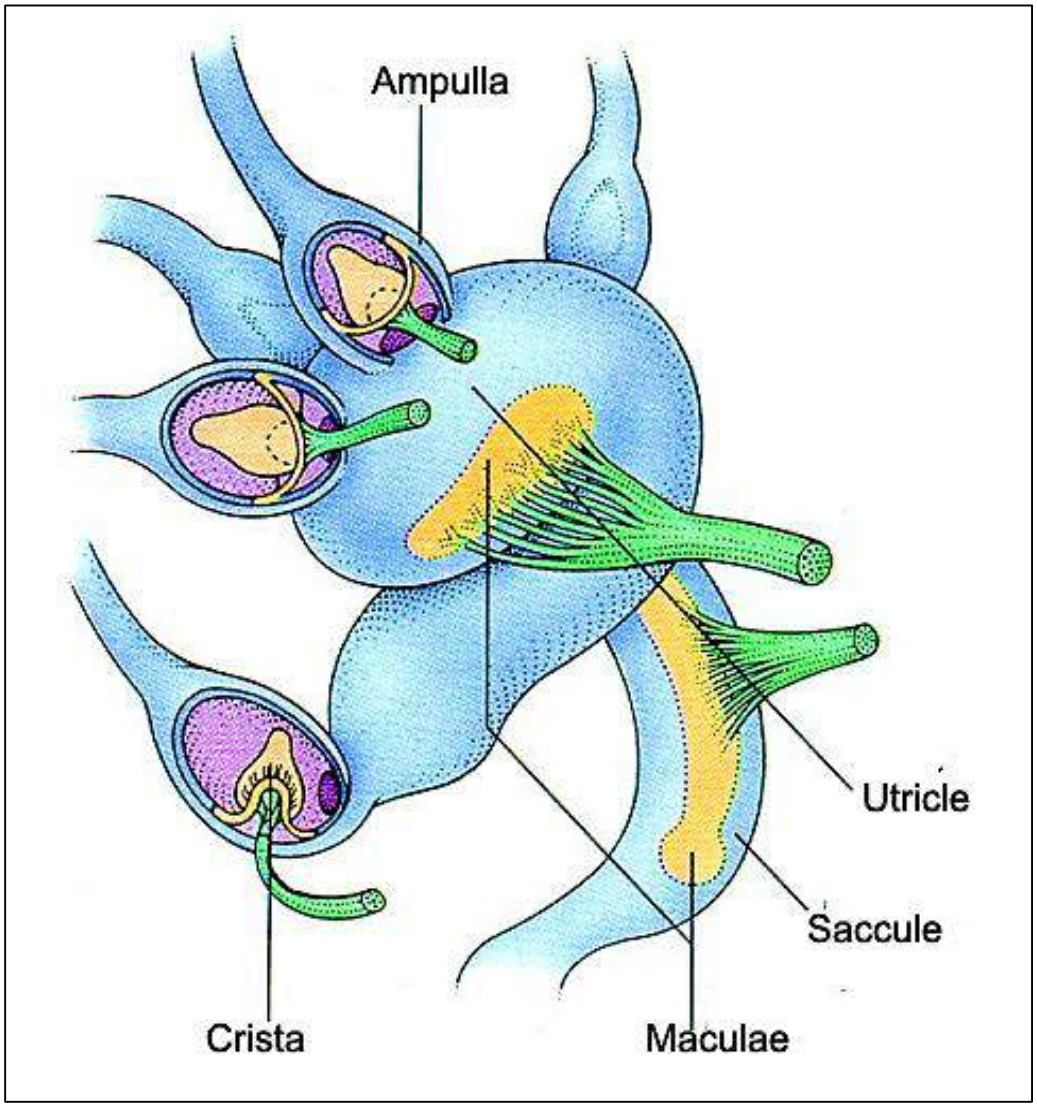
Both types have stereocilia and kioncilium embedded in gelatinous membrane called Cupula



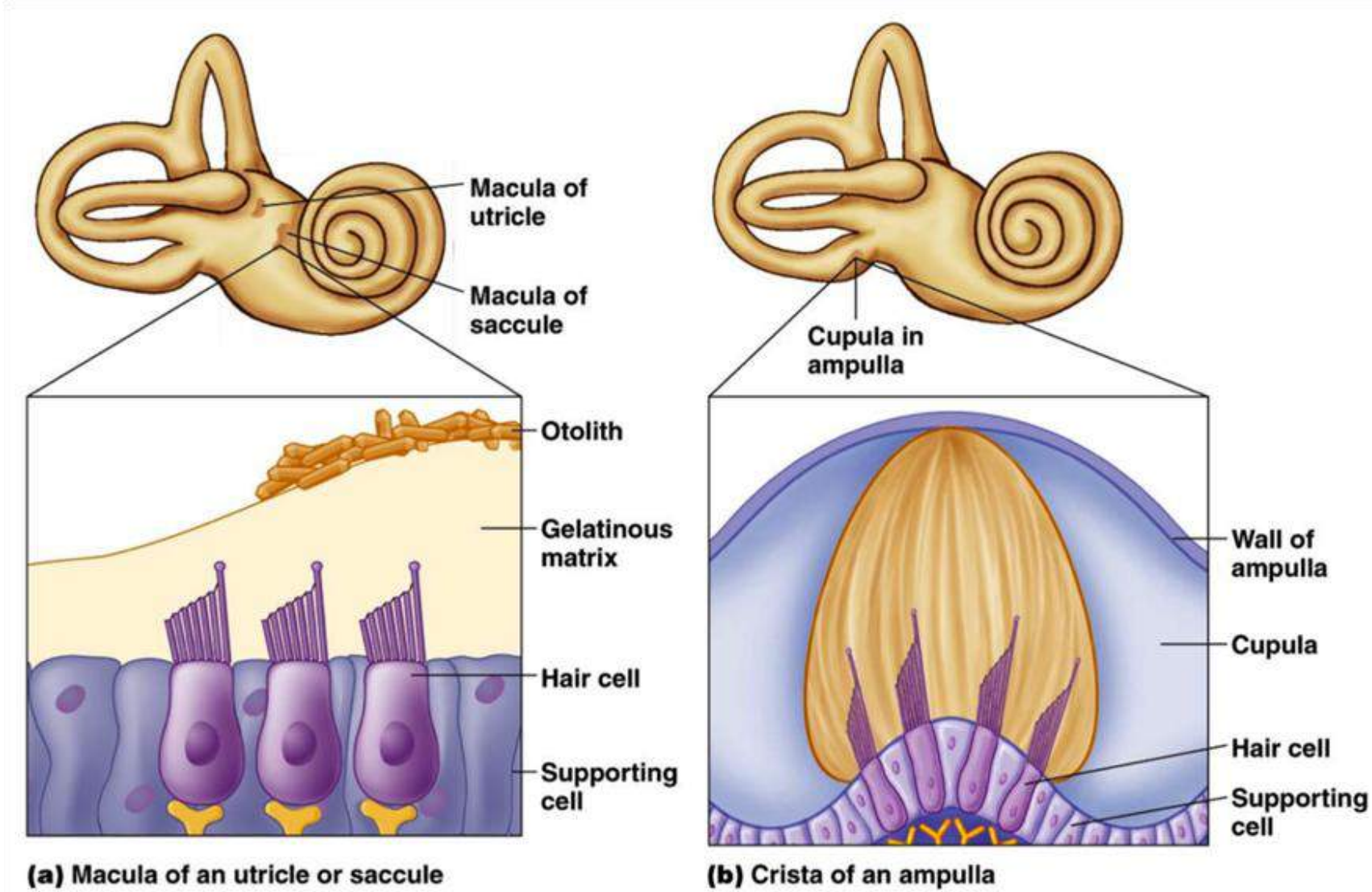
Cupula : glycoprotein Cap without Ca^+ carbonate crystals. Detect angular acceleration (rotation) of head







Neuroepithelium in utricle , saccule & semicircular canal



Difference between macula of vestibule & crista ampullaris of semicircular canals

Thank you