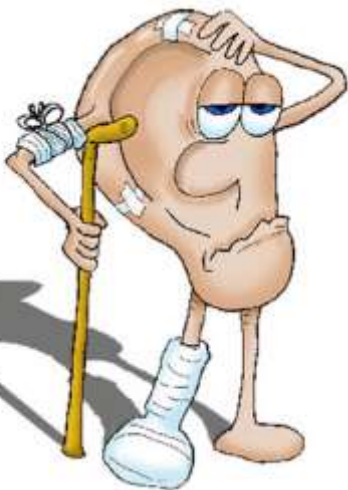


# Vestibulocochlear Apparatus

1. The ear – embryonic development
2. The external ear – auricle and ear canal
3. The middle ear – tympanic cavity
4. The internal ear:
  - ✓ the osseous labyrinth
  - ✓ the membranous labyrinth
5. Auditory and vestibular pathways





# Anatomy of the ear

- The peripheral auditory apparatus, **the ear**, *auris*, *Gr. us, wto = genitive for ear*:

- ✓ external (outer) ear, ***auris externa***

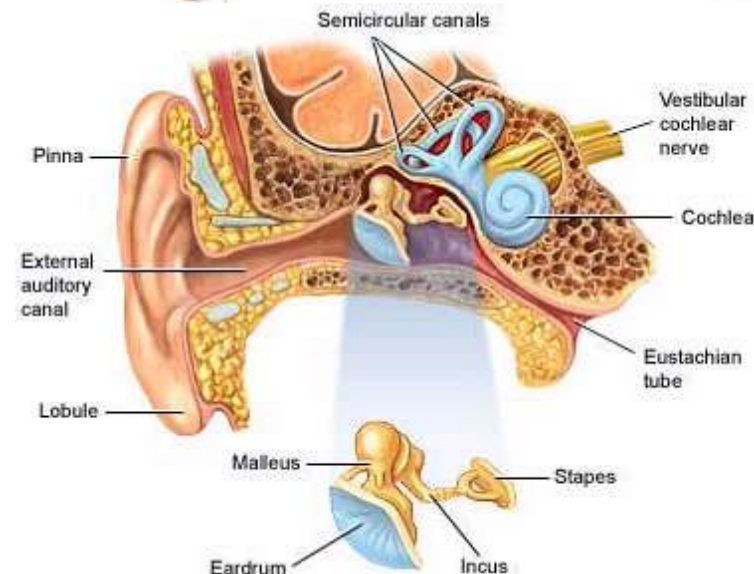
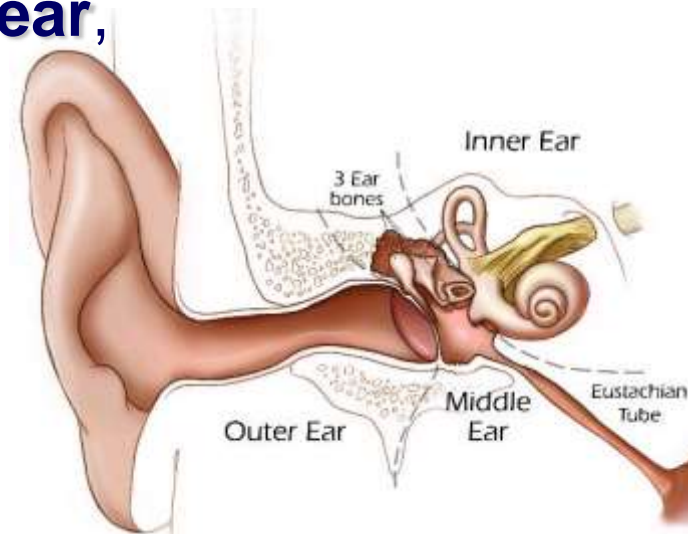
- auricle (pinna)
- external auditory meatus (ear canal)

- ✓ middle ear, ***auris media***

- tympanic membrane (ear drum)
- tympanic cavity
- auditory (Eustachian) tube
- auditory ossicles

- ✓ internal (inner) ear, ***auris interna***  
auditory and vestibular portions:

- osseous labyrinth
- membranous labyrinth





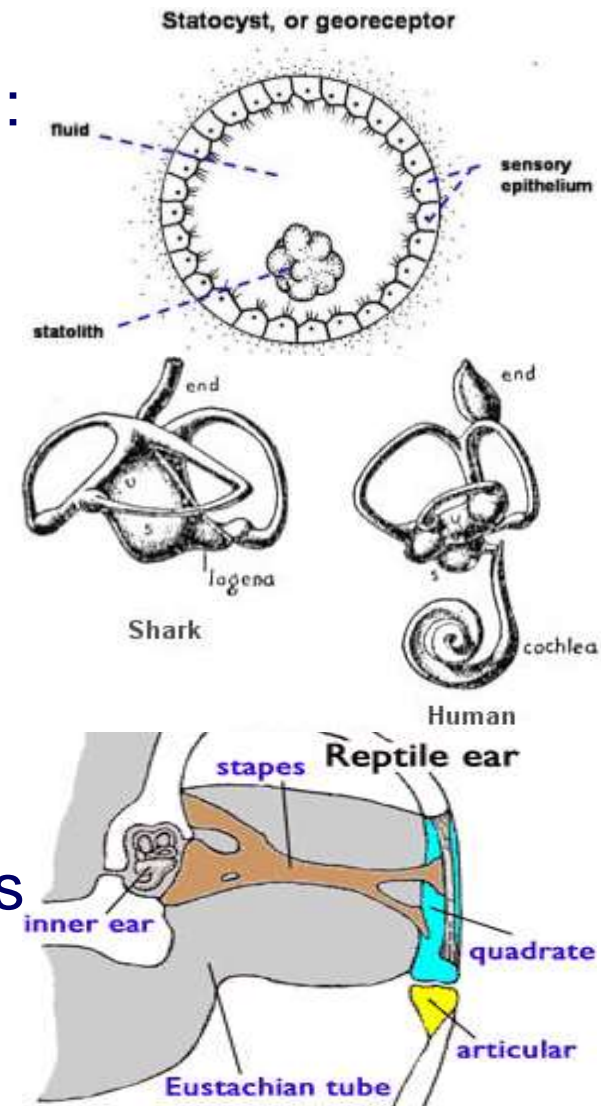
# Phylogenesis of the ear

- The vestibular system – antedates the cochlear system:

- ✓ invertebrates – statocyst
- ✓ vertebrates – appearance of semicircular ducts

- The cochlear system – begins with amphibians:

- ✓ fishes – internal ear, primitive cochlea (*lagena*)
- ✓ amphibians – middle ear, sound conduction apparatus
- ✓ mammals – external ear, auricle and ear canal



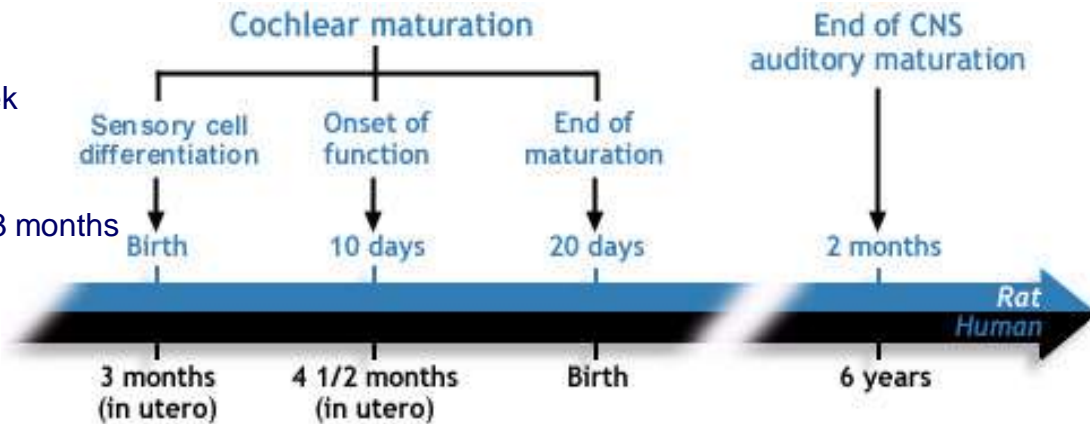


# Ontogenesis of the ear

- first appearing sensory structure in developing embryo
- 3<sup>rd</sup> week – **ectodermal thickenings** ⇒ otic placodes ⇒ otocyst:

## ✓ internal ear:

- endolymphatic duct – 4<sup>th</sup> week
- three semicircular ducts
- membranous labyrinth – 1-3 months
- cochlear rudiment – 5<sup>th</sup> week
- osseous labyrinth – 6<sup>th</sup> month



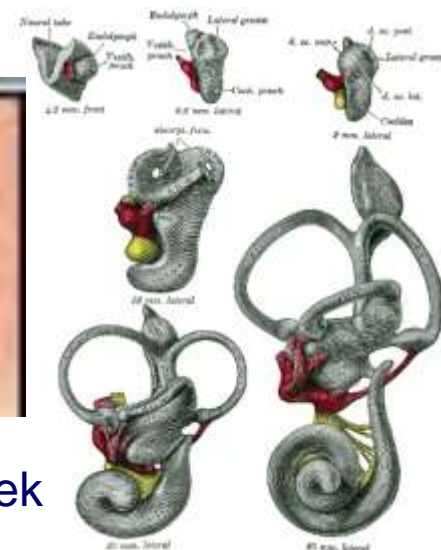
## ■ head mesenchyme:

### ✓ middle ear:

- tympanic cavity and auditory tube – derived from the first pouch in 1<sup>st</sup> month
- auditory ossicles – derived from first and second branchial arches

### ✓ external ear – first and second arches

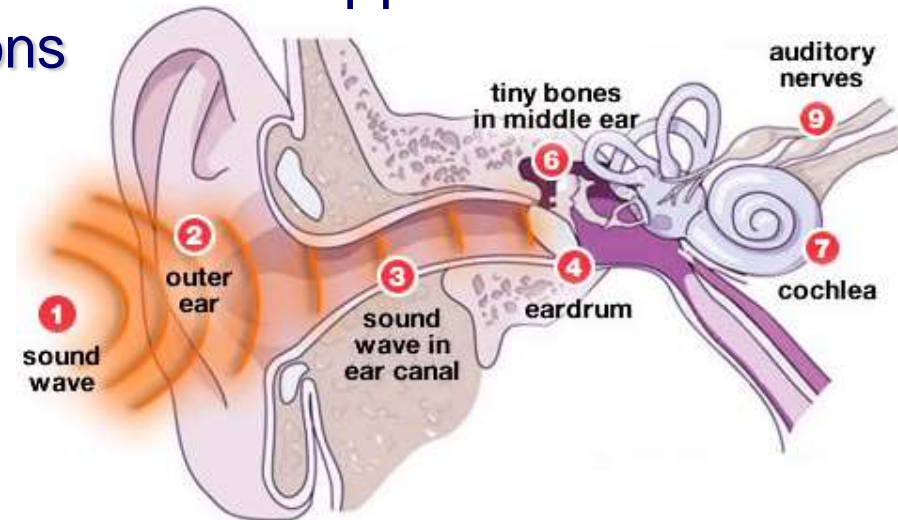
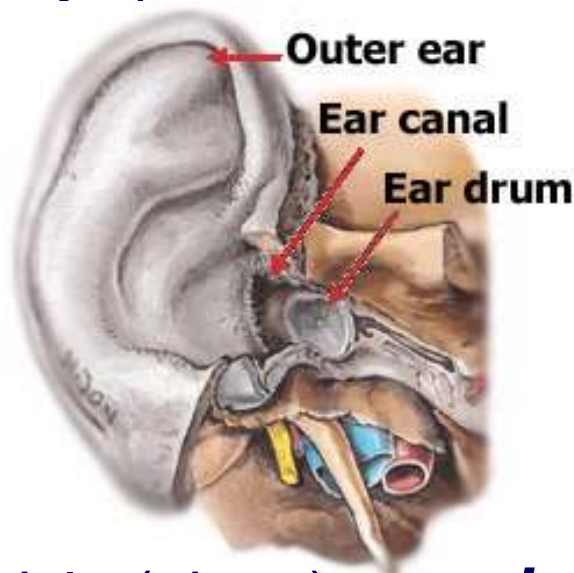
- auricle – six mesenchymal hillocks
- external acoustic meatus – begin of development: 8<sup>th</sup> week





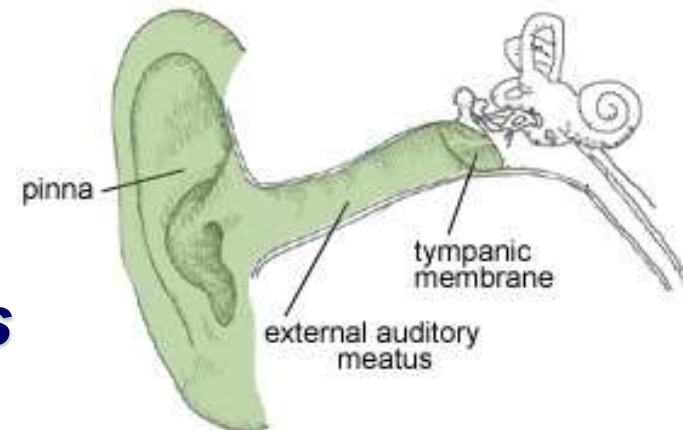
# External ear, *auris externa*

- the first structure of the sound conduction apparatus – serves to collect and conduct the air vibrations to the tympanic membrane



## Outer Ear

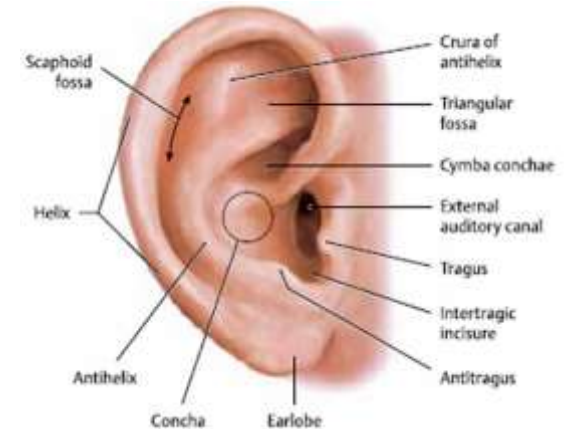
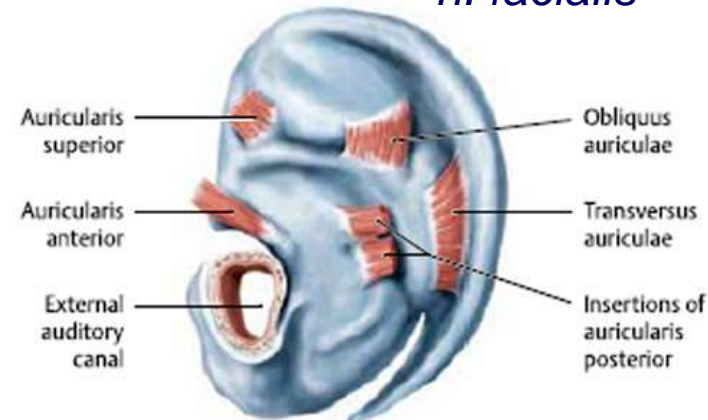
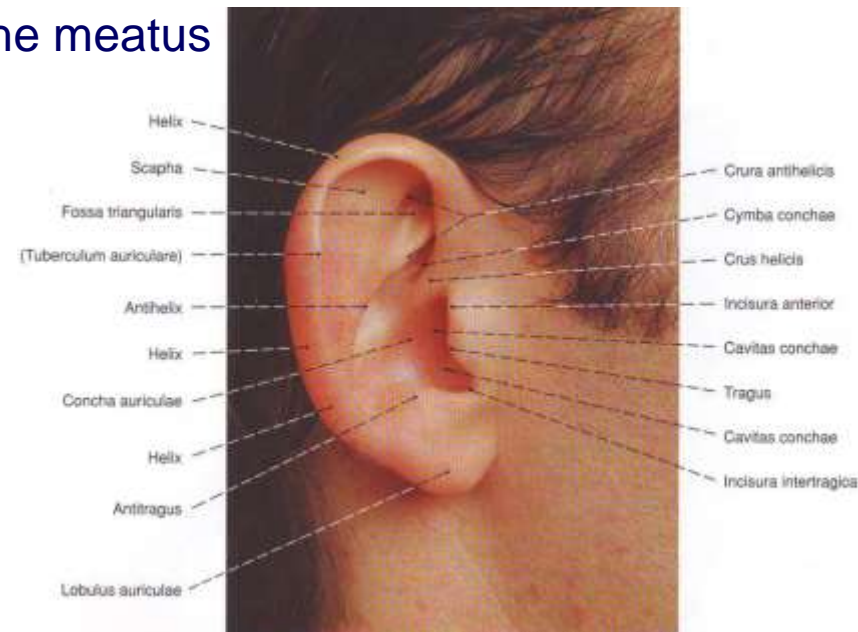
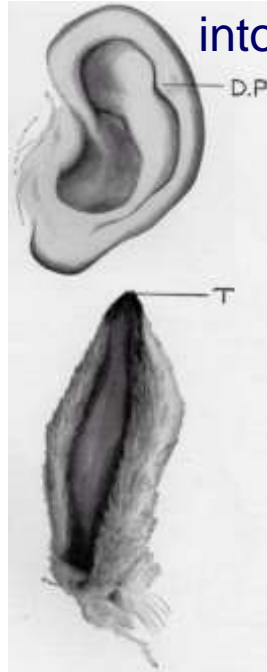
- ✓ auricle (pinna) – *auricula*
- ✓ external acoustic meatus (ear canal) – *meatus acusticus externus*





# Auricle, auricula

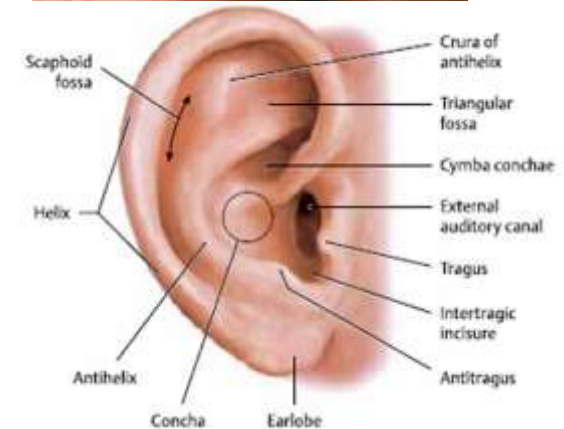
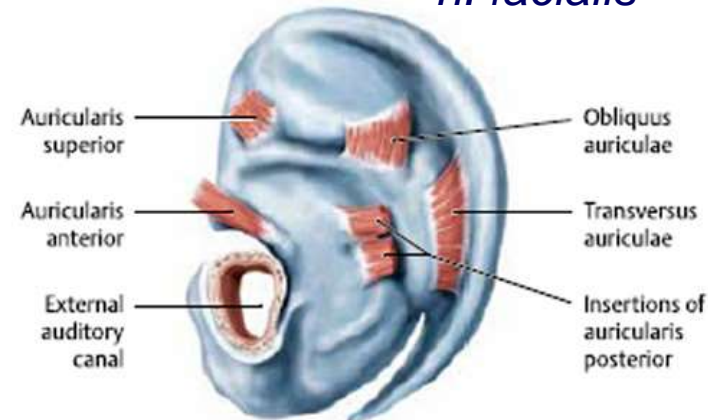
- pinna – Lat. *pinna*, a feather:
  - collects and funnels the sound waves into the meatus
- ✓ thin skin with fine hairs
- ✓ elastic fibrocartilage
- ✓ lobule of auricle
- ✓ auricular tubercle (of Darwin)
- ✓ ligaments of auricle, extrinsic and intrinsic,
- ✓ auricular muscles – extrinsic and intrinsic, *n. facialis*





# Auricle, auricula

- pinna – Lat. *pinna*, a feather:
  - ✓ thin skin with fine hairs
  - ✓ elastic fibrocartilage
  - ✓ lobule of auricle
  - ✓ auricular tubercle (of Darwin)
  - ✓ ligaments of auricle, extrinsic and intrinsic,
  - ✓ auricular muscles – extrinsic and intrinsic, *n. facialis*
- collects and funnels the sound waves into the meatus





# Why old men have big ears?

Dr **James Heathcote** a GP from Kent, who won the **IG Nobel** for his big-ear research

For his study, Dr Heathcote measured the ear length of more than 200 patients and discovered not only that old men have big ears but that ears grow about two millimeters (0.08 inches) per decade after age 30.

Women's ears grow with age, too, but their ears are smaller to start with, and men's big ears may be more noticeable because they tend to have less hair, he found.

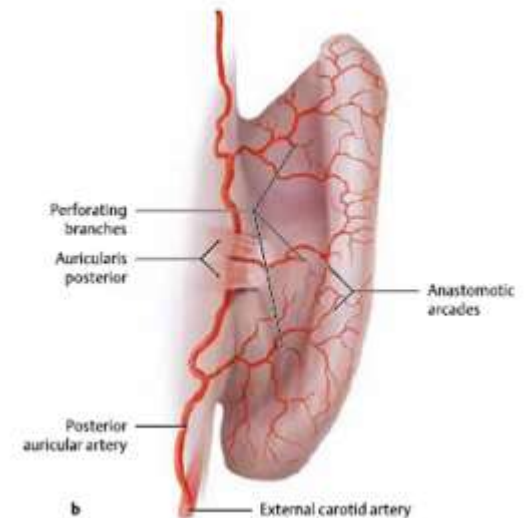
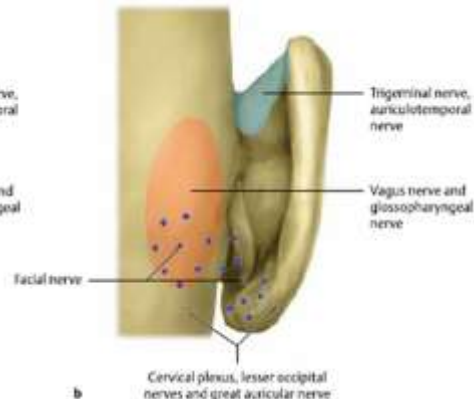
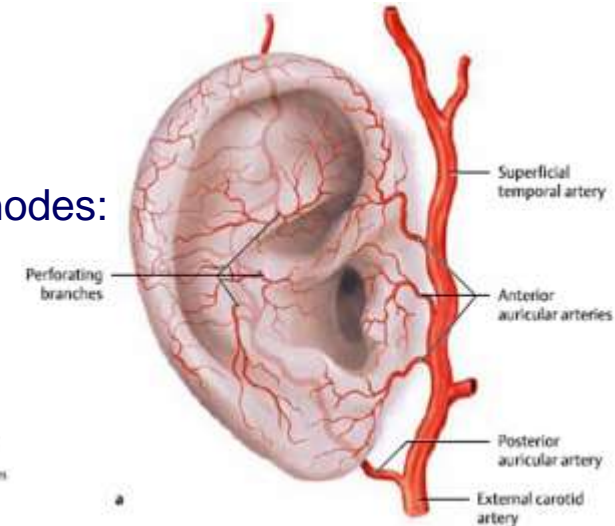
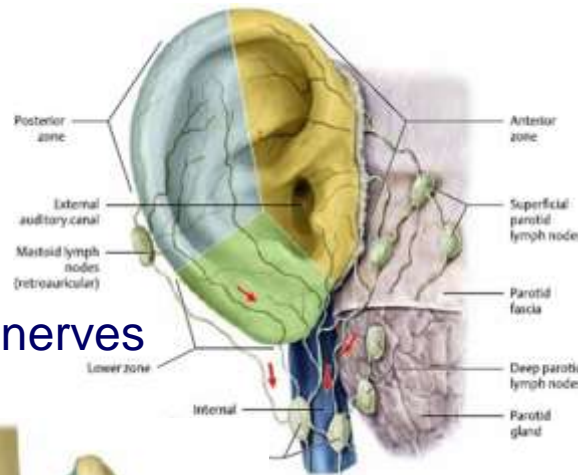






# Auricle, auricula

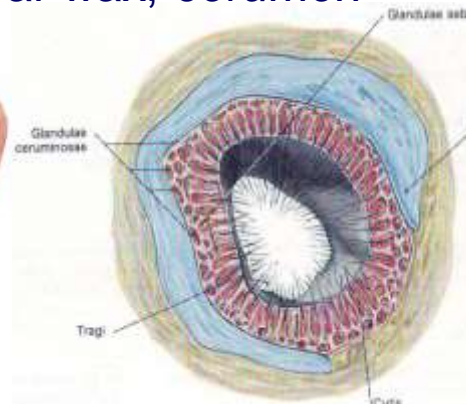
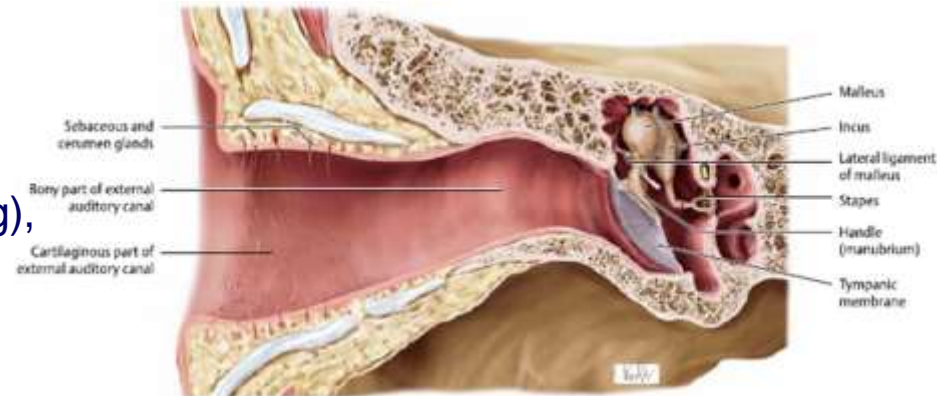
- Arterial supply of the auricle:
  - ✓ anterior auricular artery
  - ✓ posterior auricular artery
  - ✓ perforating branches
- Lymphatic drainage – three zones ⇒ deep cervical lymph nodes:
  - ✓ anterior zone
  - ✓ posterior zone
  - ✓ lower zone
- Sensory innervation:
  - ✓ trigeminal nerve
  - ✓ facial nerve
  - ✓ glossopharyngeal & vagus nerves
  - ✓ cervical plexus





# External acoustic meatus, *meatus acusticus externus*

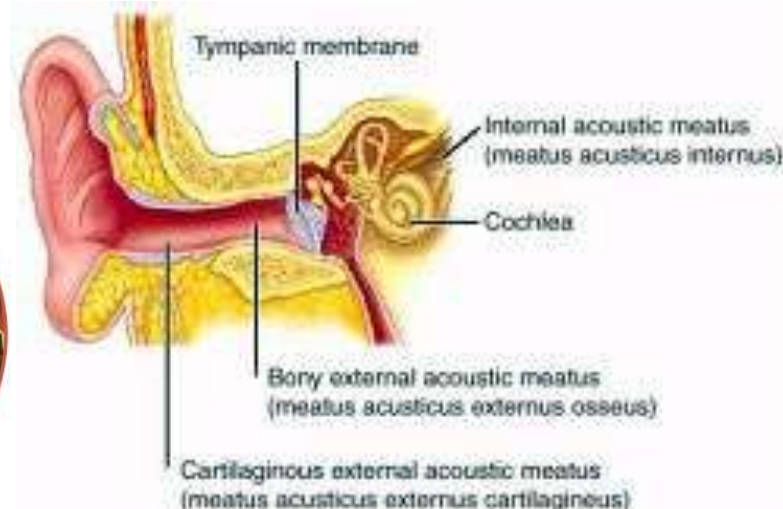
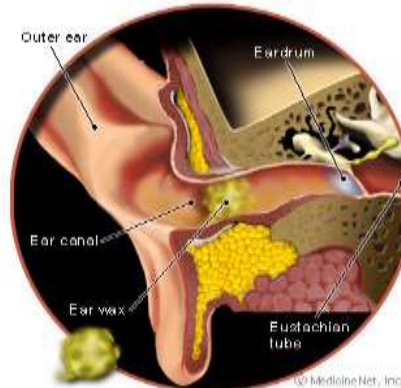
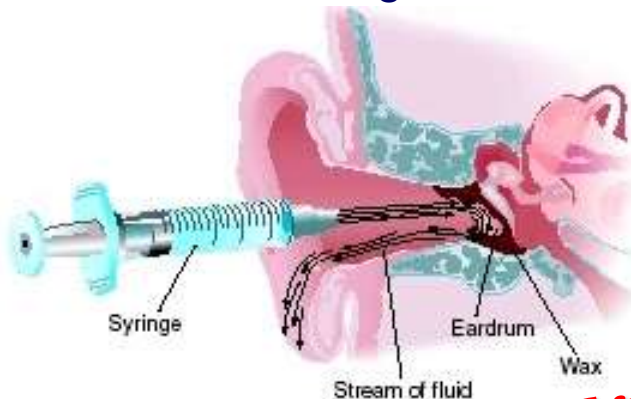
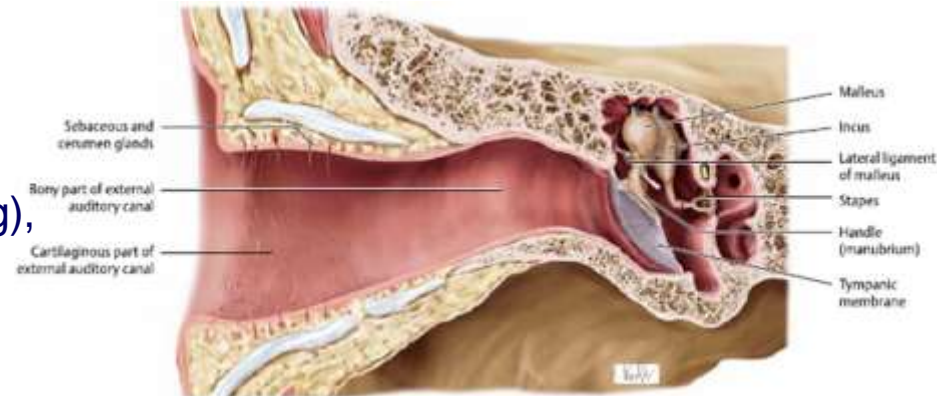
- external auditory meatus (ear canal), Lat. *meo*, a passage
  - ✓ length ~ 2.5 cm; 7 mm in diameter
  - ✓ S-shaped curve (140°)
- structure – two parts:
  - ✓ cartilaginous part – outer  $\frac{1}{3}$  (~8 mm long), *cartilago meatus acustici*
  - ✓ osseous part – inner  $\frac{2}{3}$  (~16 mm long), *meatus acusticus externus*
  - ✓ thin skin; the thicker cerumen-producing ear canal skin has fine hairs, *tragi*
  - ✓ sebaceous glands  $\Rightarrow$  in the hair follicles
  - ✓ ceruminous glands  $\Rightarrow$  ear wax, *cerumen*



**NB:** The ear wax assists in cleaning and lubrication, and also

# External acoustic meatus, *meatus acusticus externus*

- external auditory meatus (ear canal), Lat. *meo*, a passage
  - ✓ length ~ 2.5 cm; 7 mm in diameter
  - ✓ S-shaped curve (140°)
- structure – two parts:
  - ✓ cartilaginous part – outer  $\frac{1}{3}$  (~8 mm long), *cartilago meatus acustici*
  - ✓ osseous part – inner  $\frac{2}{3}$  (~16 mm long), *meatus acusticus externus*
  - ✓ thin skin; the thicker cerumen-producing ear canal skin has fine hairs, *tragi*
  - ✓ sebaceous glands  $\Rightarrow$  in the hair follicles
  - ✓ ceruminous glands  $\Rightarrow$  ear wax, *cerumen*

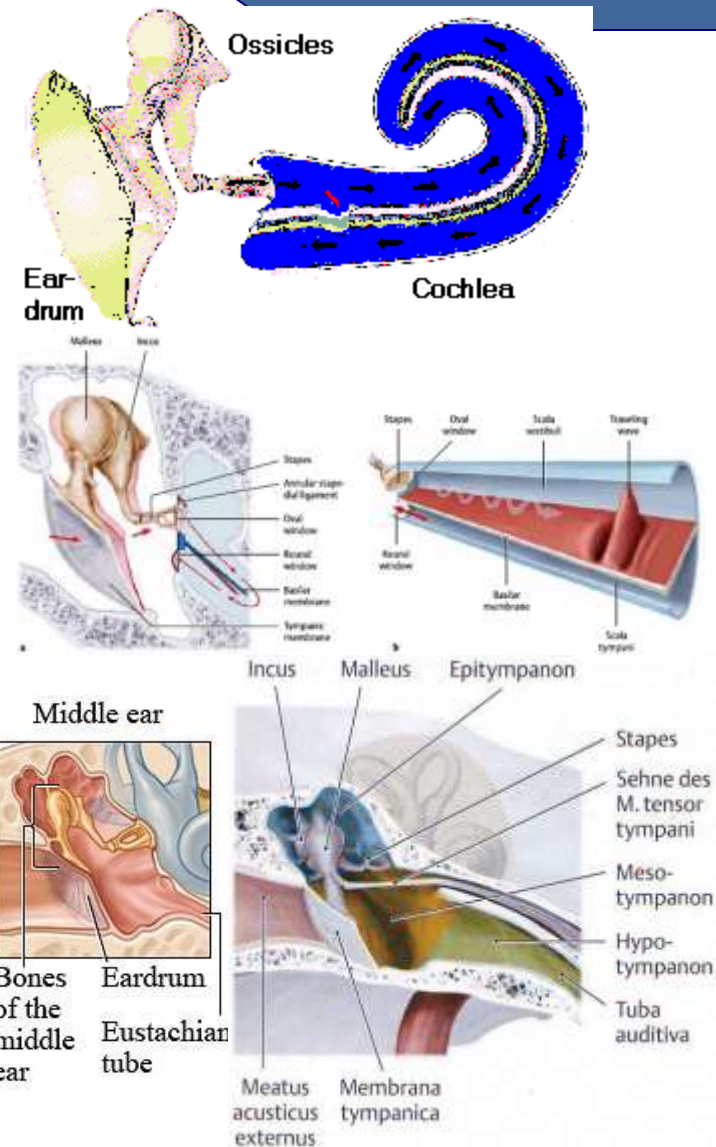
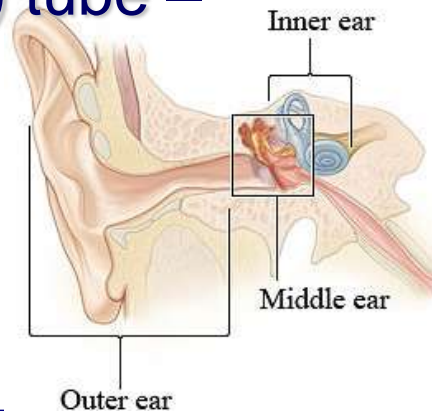


**NB:** The ear wax assists in cleaning and lubrication, and also



# Middle ear, *auris media*

- a structure of the sound conduction apparatus
- primary functions:
  - ✓ transmission of the vibrations of the tympanic membrane to the internal ear
  - ✓ efficient transfer of acoustic energy from compression waves in air to fluid – membrane waves within the cochlea
- ✓ tympanic membrane – ***membrana tympani (tympanica)***
- ✓ tympanic cavity – ***cavitas (cavum) tympani***
- ✓ auditory (eustachian) tube – ***tuba auditiva (auditoria)***
- ✓ auditory ossicles – ***ossicula auditus (auditoria)***





# Tympanic membrane, *membrana tympani*

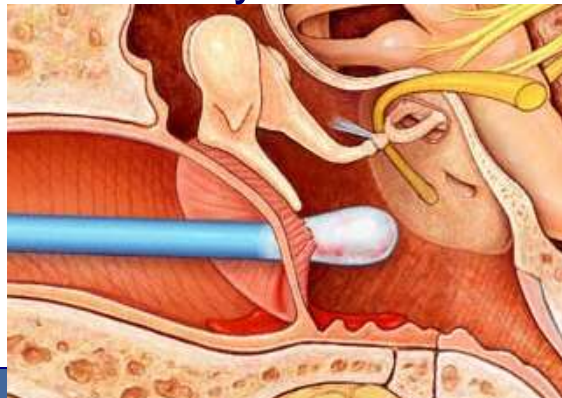
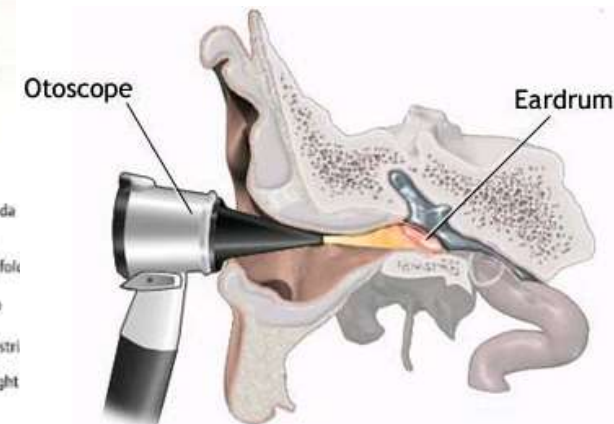
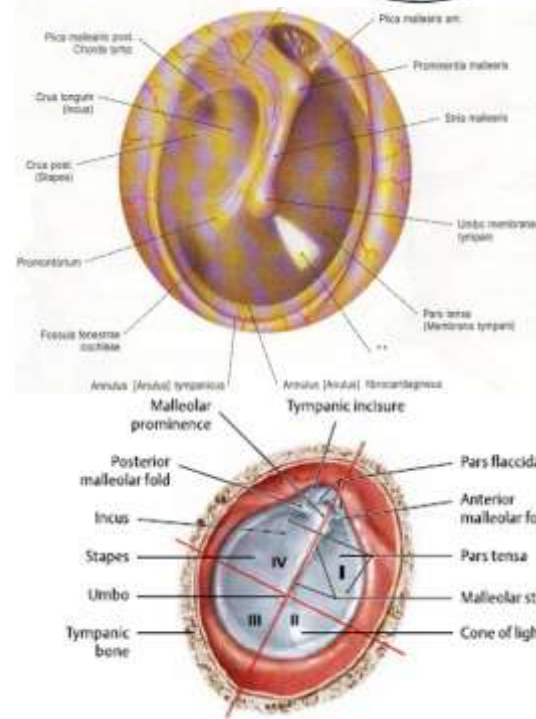
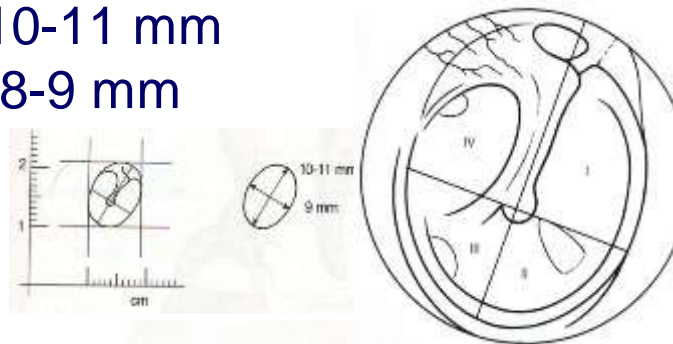
- **ear drum** – thin, semi-transparent, nearly oval in form:

- ✓ longest diameter  $d=10-11$  mm
- ✓ shortest diameter  $d=8-9$  mm

- *pars flaccida* – Schrapnell's membrane

- *pars tensa*  $\Rightarrow$  *umbo*

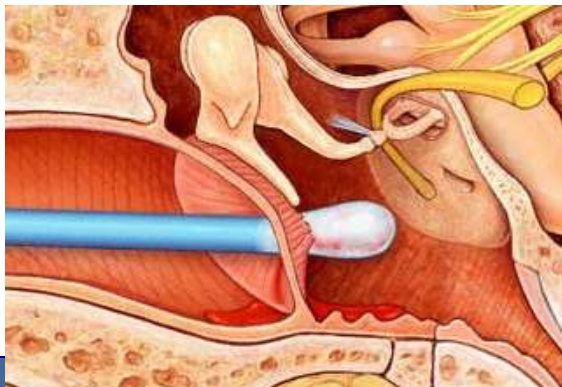
- ✓ cuticular layer
- ✓ fibrous layer – absent in *pars flaccida*:
  - radiate fibers
  - circular fibers
- ✓ mucous layer





# Tympanic membrane, *membrana tympani*

- **ear drum** – thin, semi-transparent, nearly oval in form:
  - ✓ longest diameter  $d=10-11$  mm
  - ✓ shortest diameter  $d=8-9$  mm
- *pars flaccida* – Schrapnell's membrane
- *pars tensa*  $\Rightarrow$  *umbo*
  - ✓ cuticular layer
  - ✓ fibrous layer – absent in *pars flaccida*:
    - radiate fibers
    - circular fibers
  - ✓ mucous layer

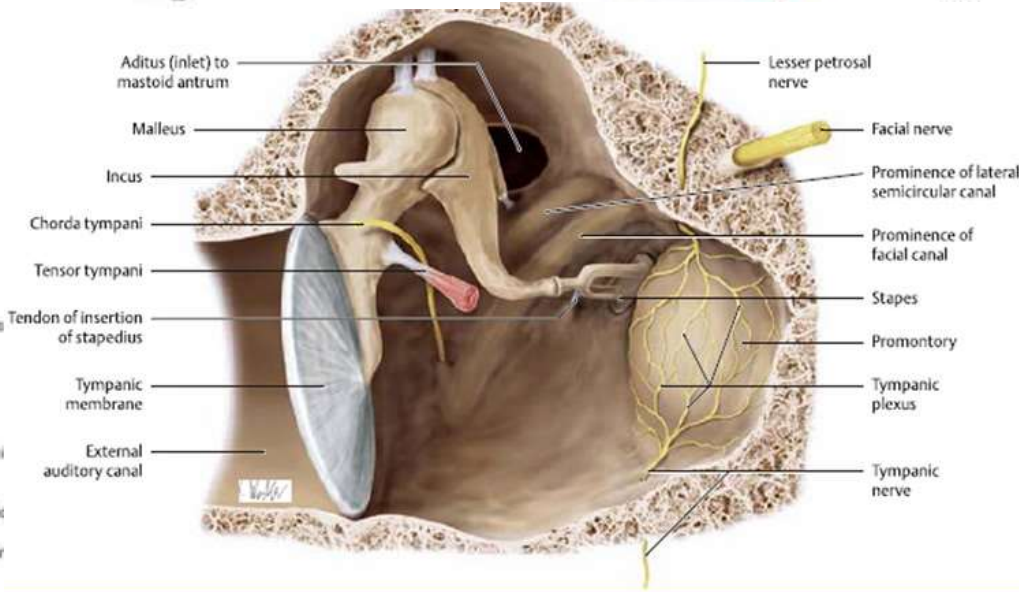
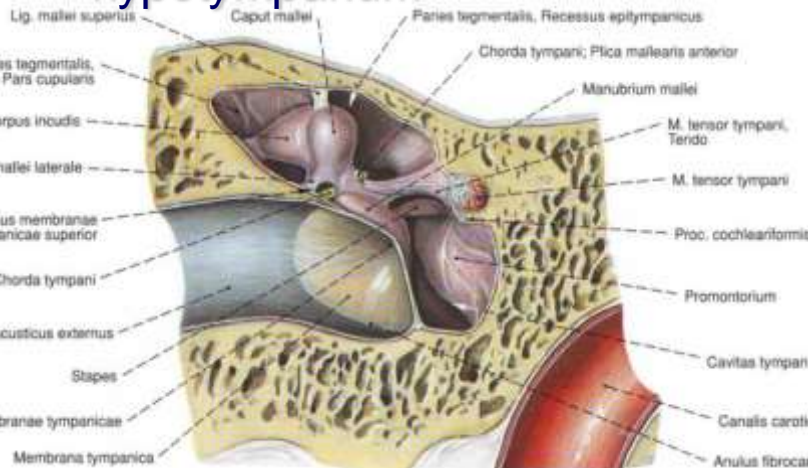
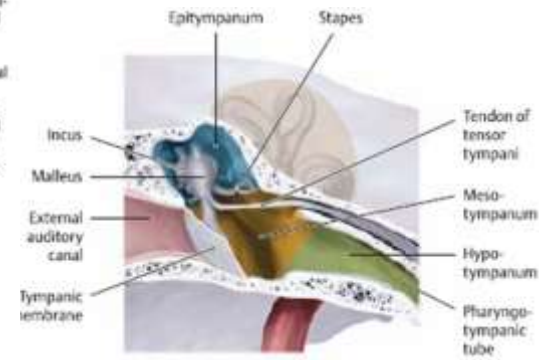
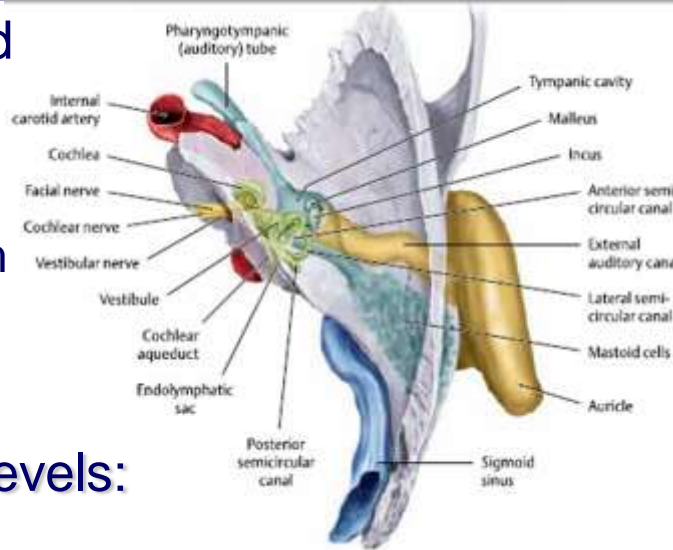


"I can see it! Boy, that is a small cellular phone!"



# Tympanic cavity, *cavum tympani*

- volume – 1.5 cm<sup>3</sup>, air-filled
- diameters:
  - ✓ vertical – 15 mm
  - ✓ transverse – 6-4-2 mm
  - ✓ antero-posterior – 15 mm
- two parts:
  - ✓ tympanic cavity proper
  - ✓ epitympanic recess
- three clinically important levels:
  - ✓ epitympanum
  - ✓ mesotympanum
  - ✓ hypotympanum





# Walls of the tympanic cavity

■ six walls, lined with mucoperiosteum:

✓ lateral wall – ***paries membranaceus***:

*membrana tympani et recessus epitympanicus*

✓ medial wall – ***paries labyrinthicus***

✓ superior wall, roof – ***paries tegmentalis***:

*tegmen tympani* ⇒ otogenic meningitis

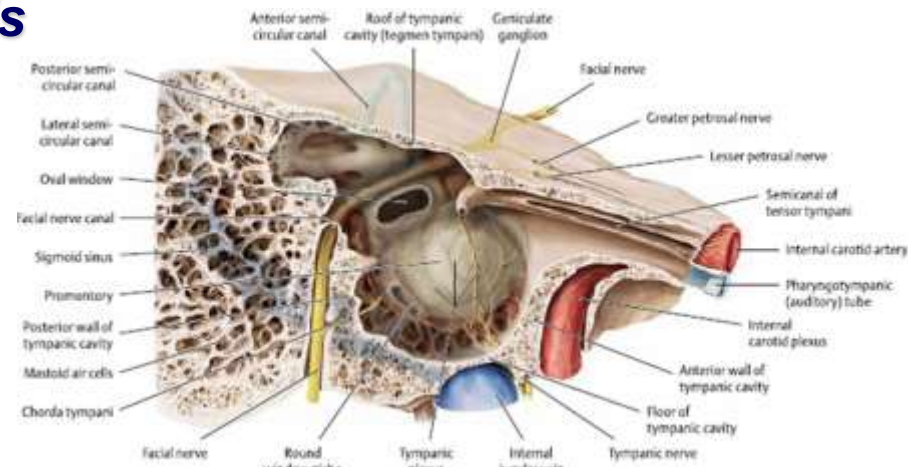
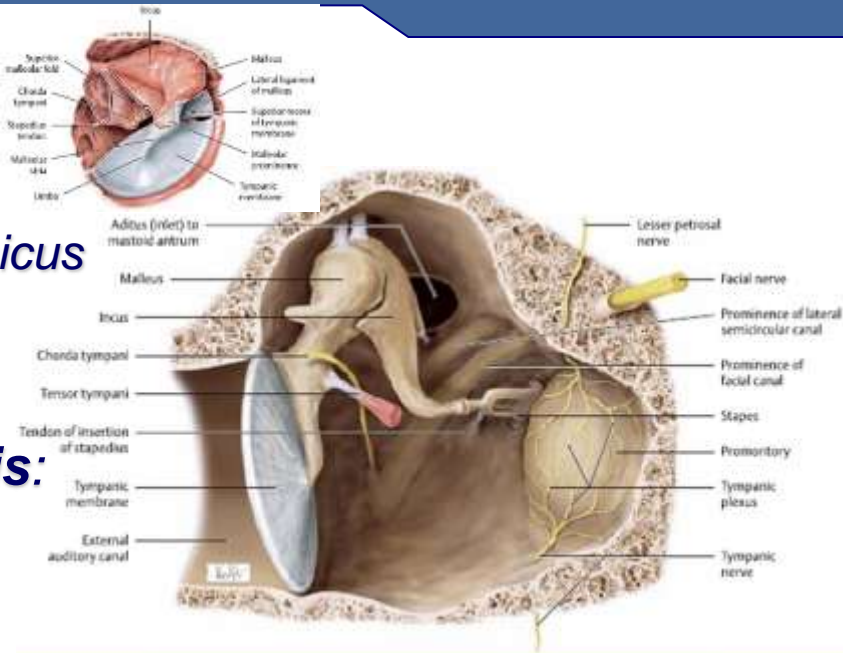
✓ inferior wall, floor – ***paries jugularis***

⇒ *canaliculus tympanicus*

✓ anterior wall – ***paries caroticus***

✓ posterior wall – ***paries mastoideus***

⇒ *antrum mastoideum*

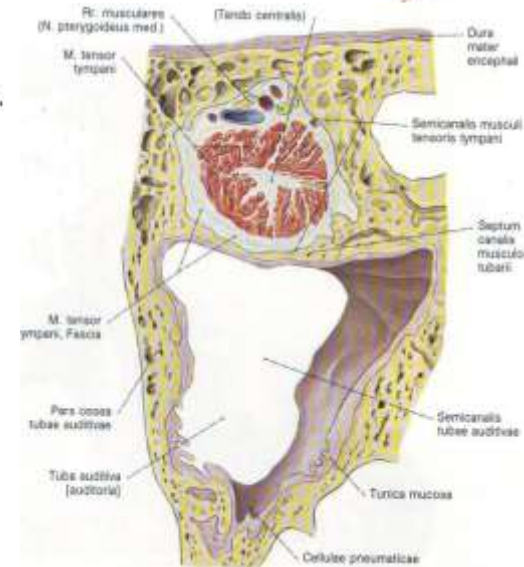
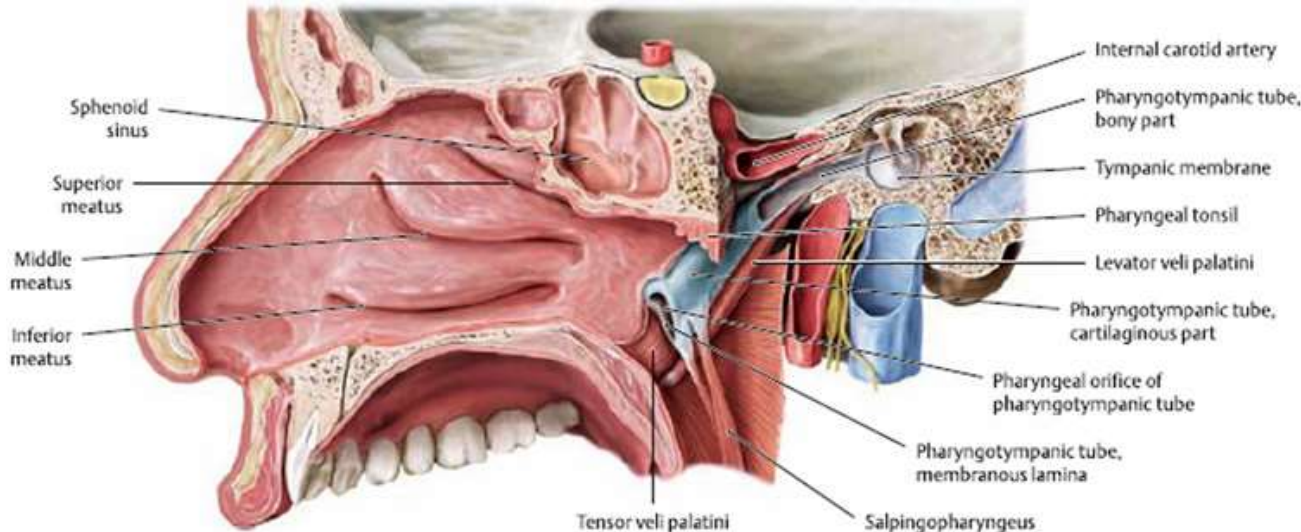
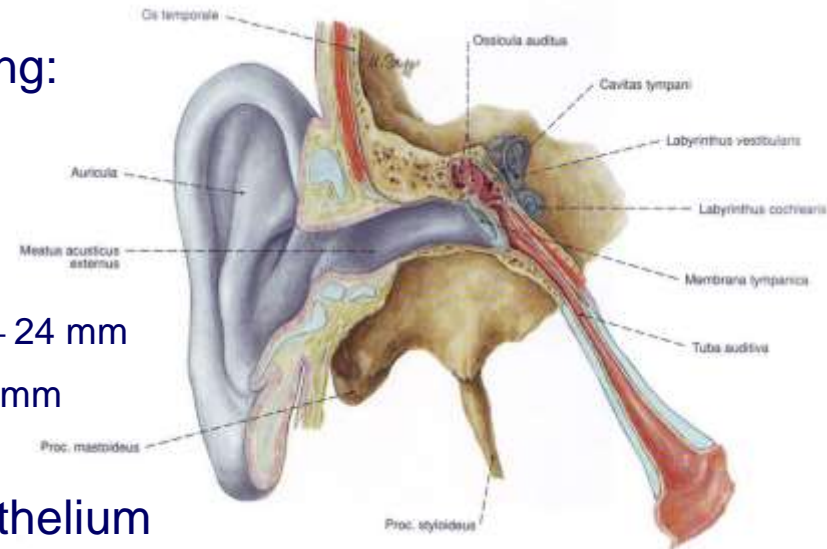






# Auditory tube, *tuba auditiva*

- **Eustachian (pharyngotympanic) tube,** links the pharynx to the middle ear, ~3.5 cm long:
  - ✓ *ostium tympanicum* } *tubae*
  - ✓ *ostium pharyngeum* } *auditivae*
- two parts:
  - ✓ cartilaginous part -  $\frac{2}{3}$  (*cartilago tubae auditivae*) – 24 mm
  - ✓ bony part -  $\frac{1}{3}$  (in *semicanalis tubae auditivae*) – 12 mm
  - ✓ *isthmus tubae auditivae*
  - ✓ mucous membrane – ciliated columnar epithelium

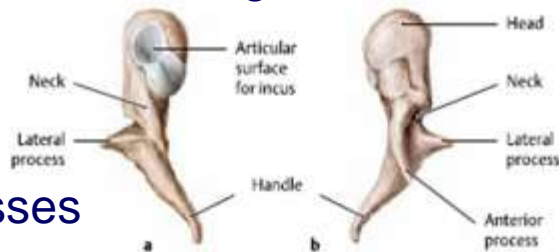




# Auditory ossicles, *ossicula auditus*

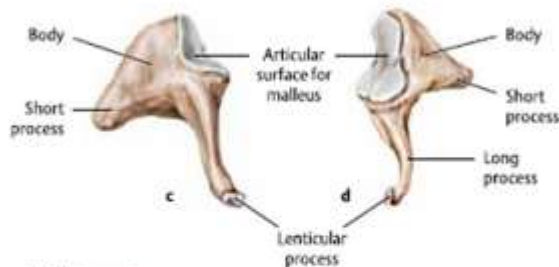
- **malleus** – Lat. = mallet, hammer; the largest, 8-9 mm long:

- ✓ head, *caput mallei*
- ✓ neck, *collum mallei*
- ✓ handle, *manubrium mallei*
- ✓ anterior and lateral processes



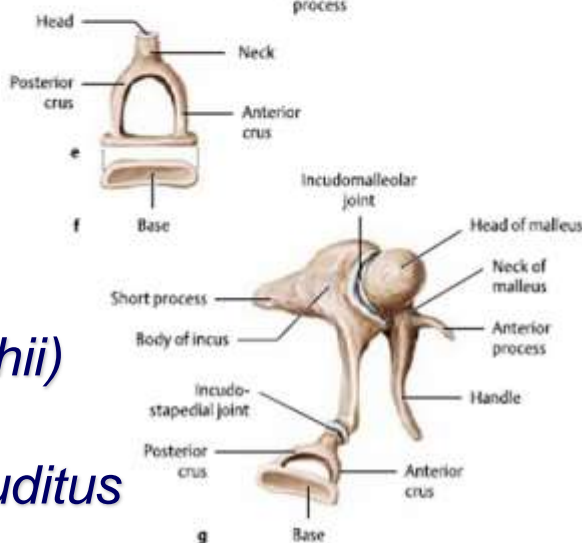
- **incus** – Lat. = anvil:

- ✓ body, *corpus incudis*
- ✓ long process, *crus longum*  
⇒ lenticular process
- ✓ short process, *crus breve*



- **stapes** – Lat. = stirrup:

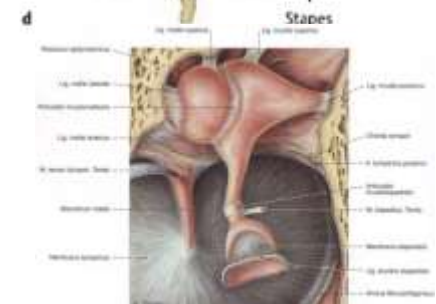
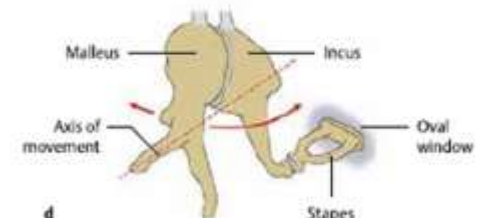
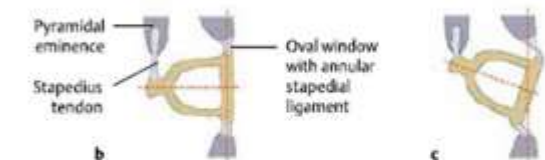
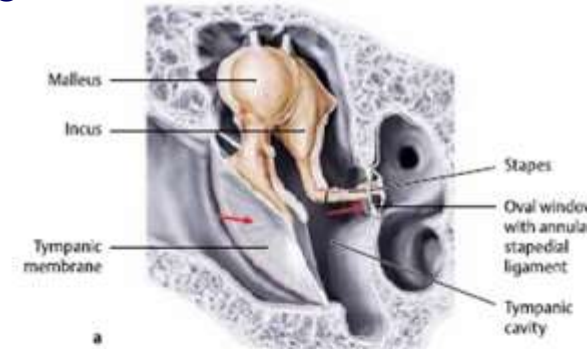
- ✓ head, *caput stapedis*
- ✓ limbs (*crura*)
  - *anterior*
  - *posterior*
- ✓ base, *basis stapedis*



- *m. tensor tympani (Eustachii)*

- *m. stapedius*

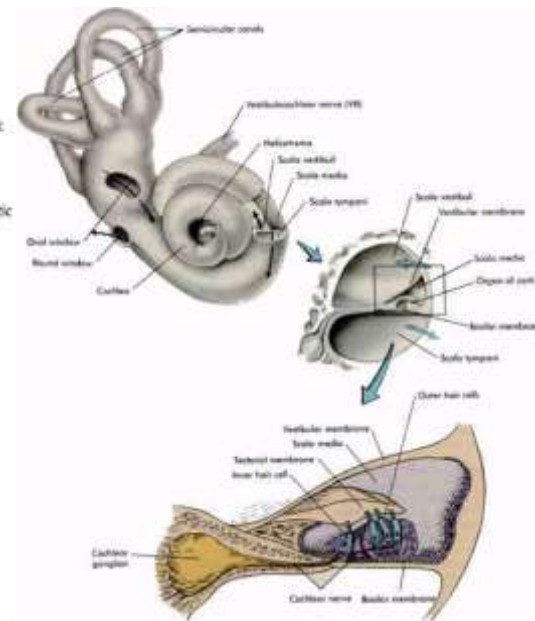
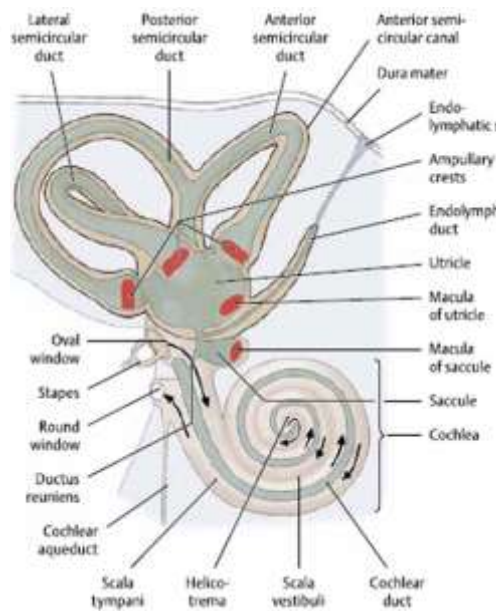
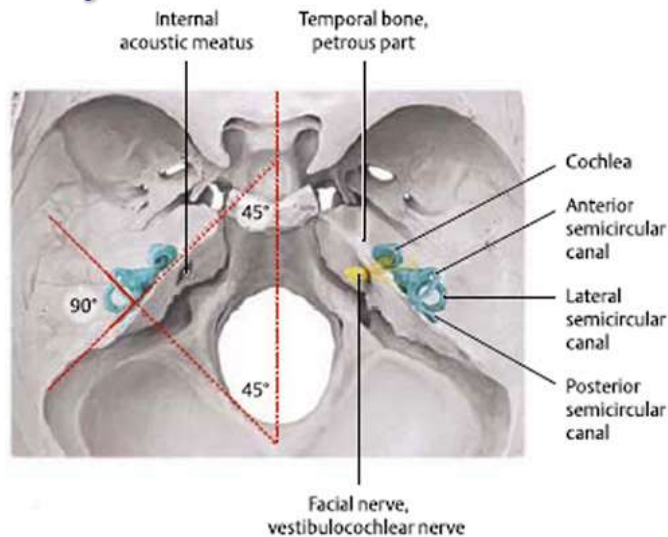
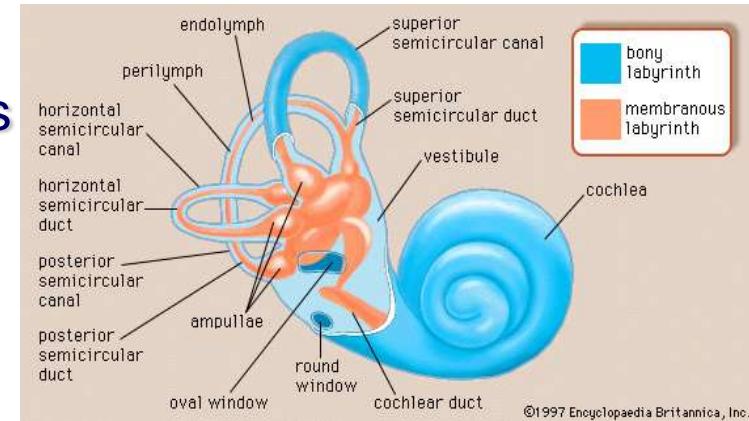
- *ligg. et artt. ossiculorum auditus*





# Internal ear, *auris interna*

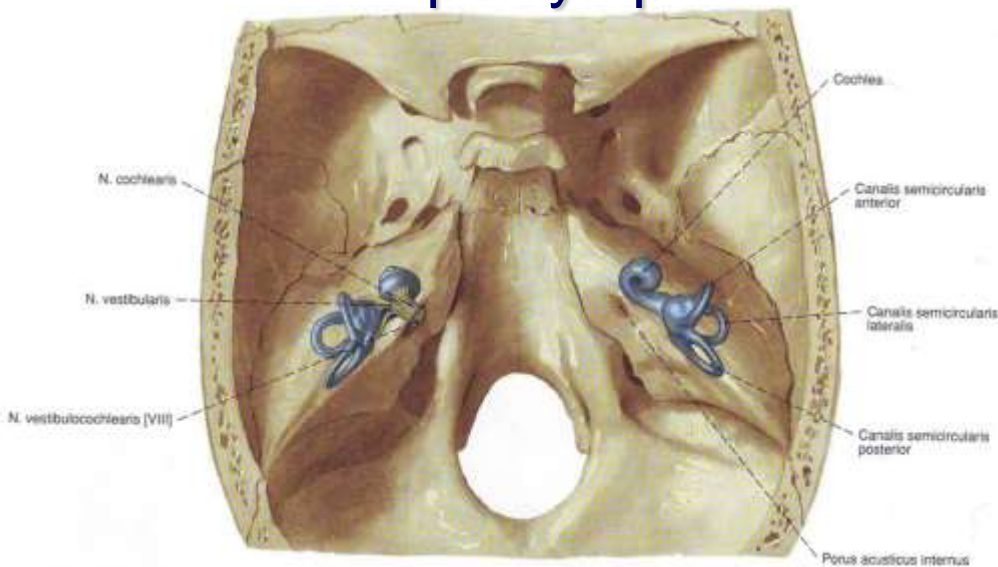
- location – in *pars petrosa ossis temporalis*
- main functions:
  - ✓ converts sound waves into nerve impulses
  - ✓ registers changes in equilibrium
- composition:
  - ✓ osseous labyrinth, ***labyrinthus osseus***
  - ✓ membranous labyrinth, ***labyrinthus membranaceus***



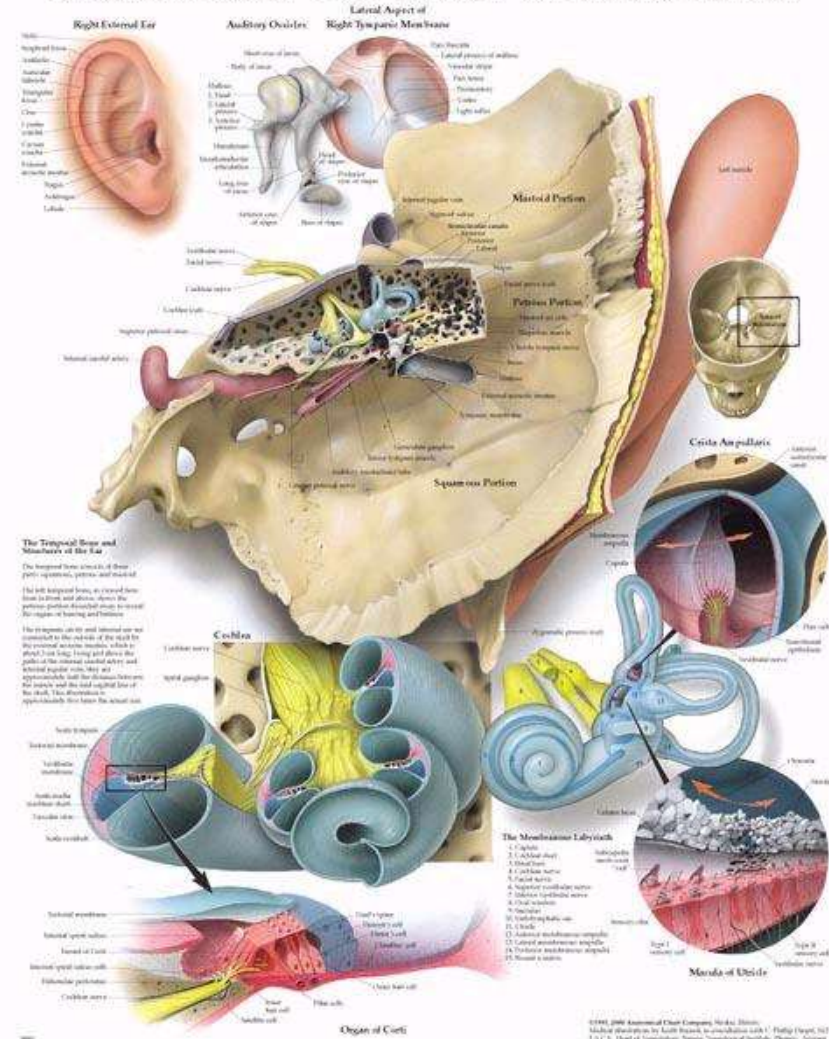


# Osseous labyrinth, *labyrinthus osseus*

- vestibule, *vestibulum*
- three semicircular canals, *canales semicirculares*:
  - ✓ *canalis semicircularis lateralis*
  - ✓ *canalis semicircularis anterior*
  - ✓ *canalis semicircularis posterior*
- *cochlea*
- filled with perilymph



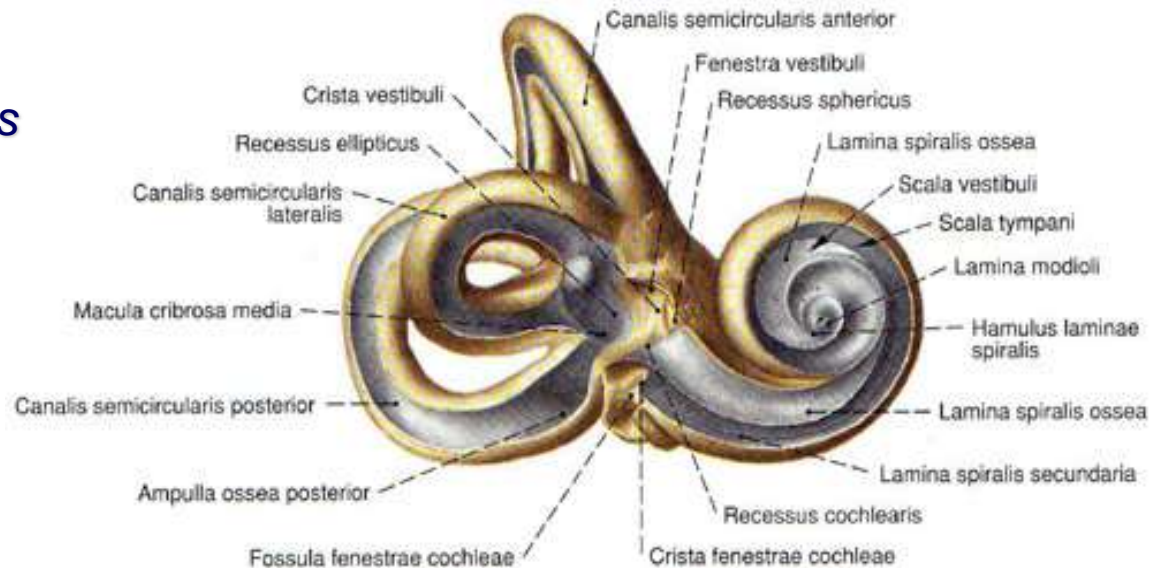
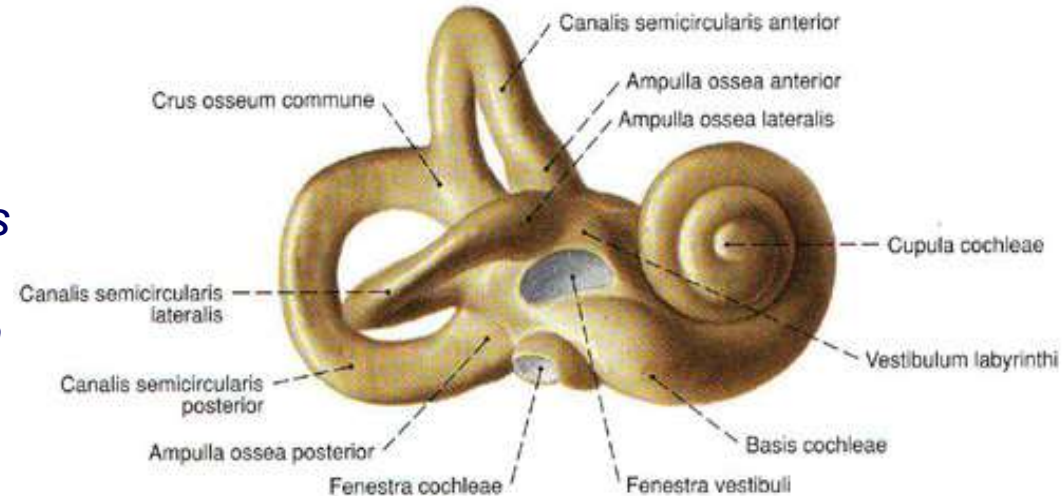
## ANATOMY OF THE INNER EAR





# Vestibule, vestibulum

- lateral wall – *paries labyrinthicus*:
  - ✓ *fenestra vestibuli* ⇒ closed by *basis stapedis*, fixed with *lig. annulare stapedis*
  - ✓ *fenestra cochleae* ⇒ *membrana tympani secundaria*
- medial wall:
  - ✓ elliptical recess ⇒ *utricleus*
  - ✓ vestibular crest ⇒ aqueduct of the vestibule
  - ✓ spheroid recess ⇒ *sacculus*
  - ✓ cochlear recess
  - ✓ *maculae cribrosae* ⇔ *pars vestibularis n. vestibulocochlearis*:
    - *macula cribrosa superior*
    - *macula cribrosa media*
    - *macula cribrosa inferior*

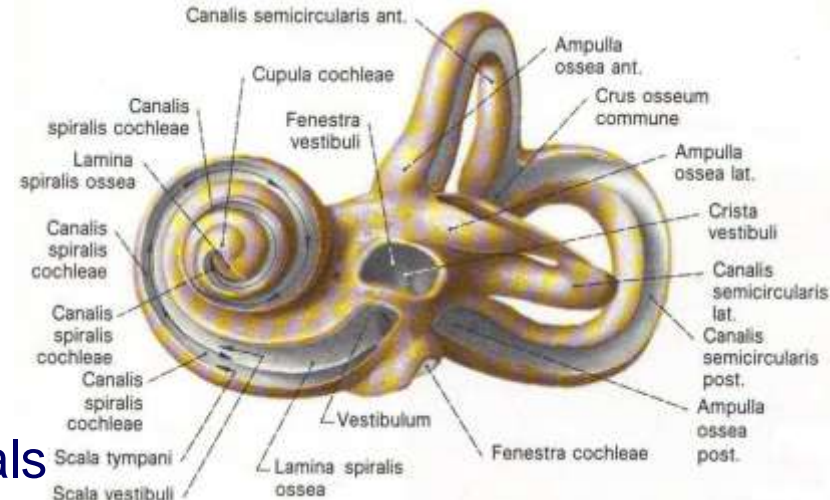
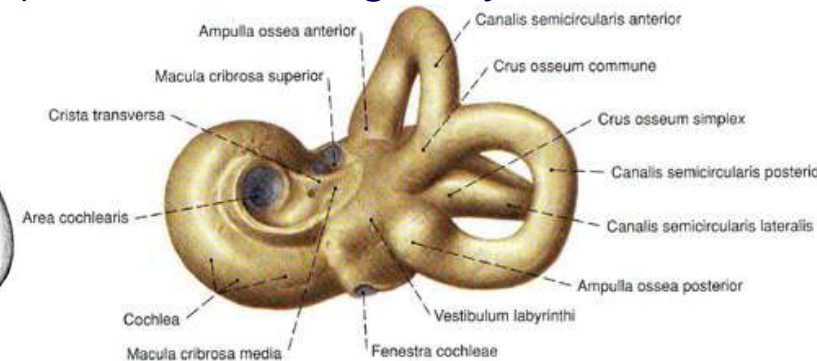
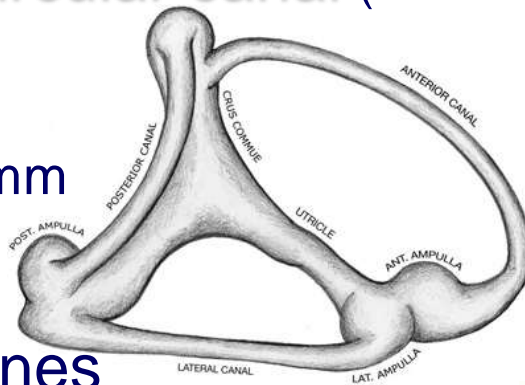




# Semicircular canals, *canales semicirculares*

- ✓ lateral semicircular canal (14 mm) – directed horizontally
- ✓ anterior (superior) semicircular canal (18 mm) – vertical in direction
- ✓ posterior semicircular canal (22 mm) – directed sagittally backwards

- $\frac{2}{3}$  of a circle
- diameter = all ~ 1 mm
- located in three perpendicular planes
- filled with semicircular ducts
- initial portion – *ampulla ossea*
- end part – *crus osseum*:
  - ✓ *simplex* – for lateral canal
  - ✓ *commune* – for anterior&posterior canals





# Osseous cochlea

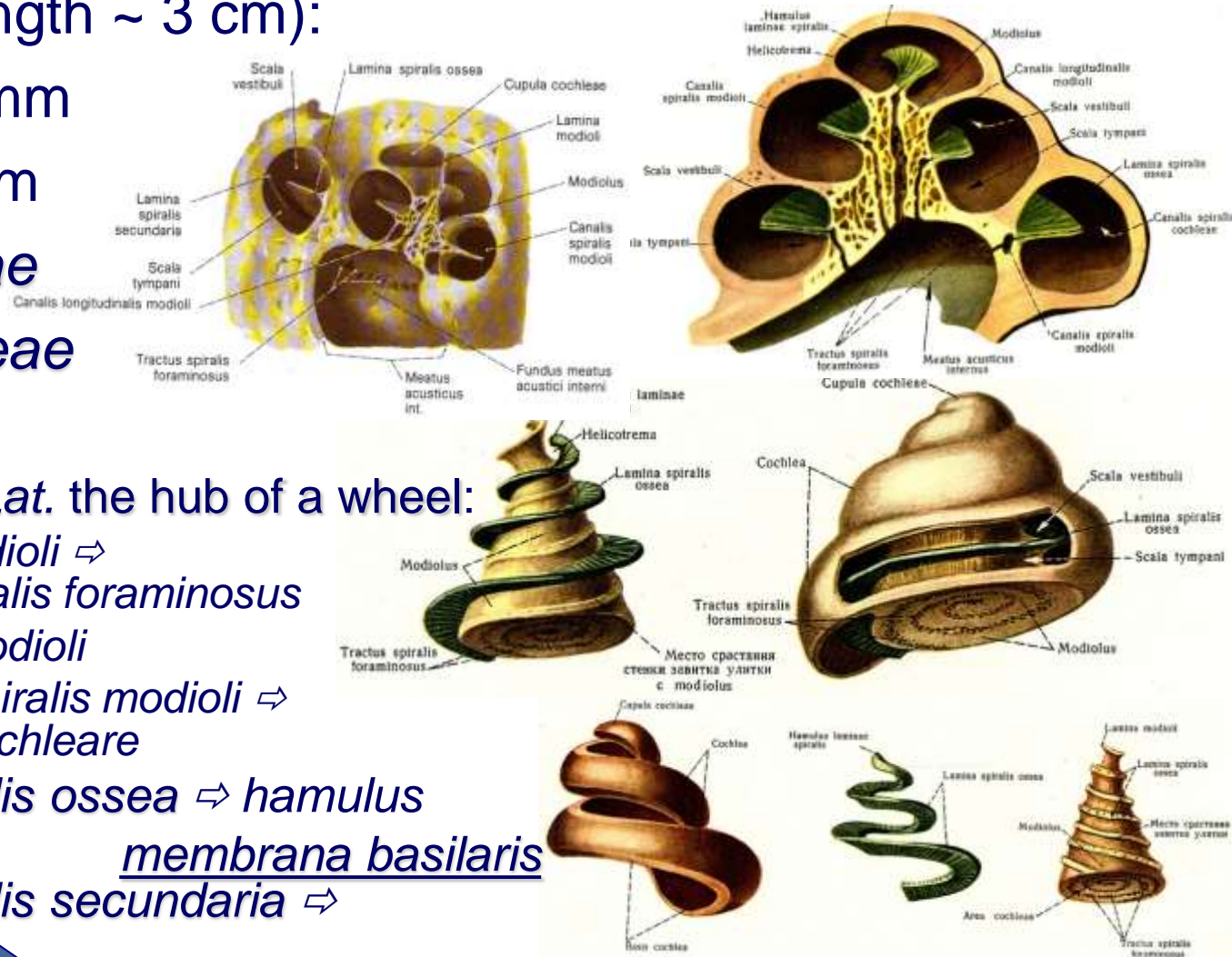
■ spiral canal, *canalis spiralis cochleae* –  
2½-2¾ turns (length ~ 3 cm):

- ✓ height – 4-5 mm
- ✓ base – 8-9 mm
- ✓ *basis cochleae*
- ✓ *cupula cochleae*
- ✓ structure:

➤ *modiolus* – Lat. the hub of a wheel:

- *basis modioli* ⇨ *tractus spiralis foraminosus*
- *lamina modioli*
- *canalis spiralis modioli* ⇨ *ganglion cochleare*
- *lamina spiralis ossea* ⇨ *hamulus helicotrema*
- *lamina spiralis secundaria* ⇨ *membrana basilaris*

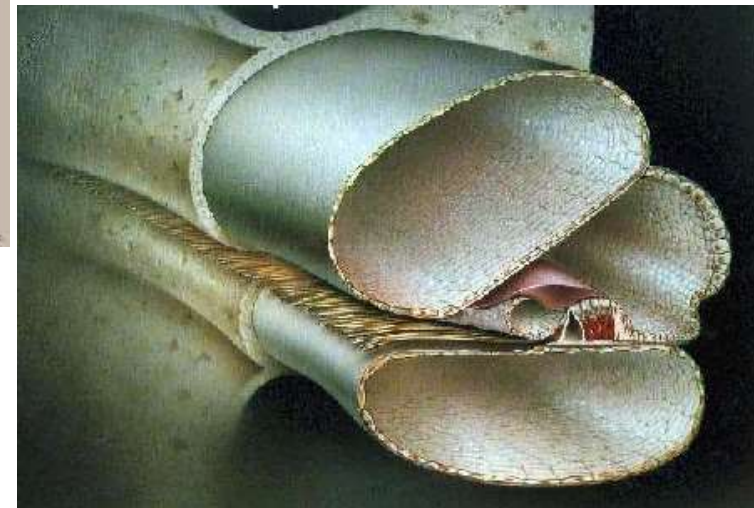
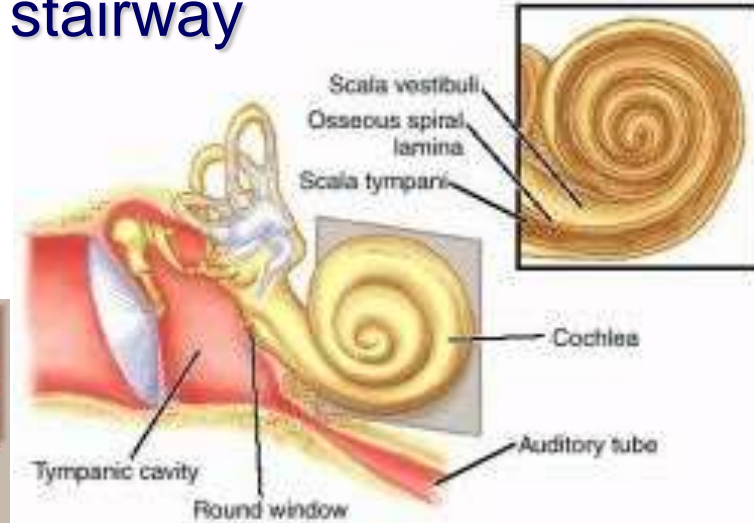
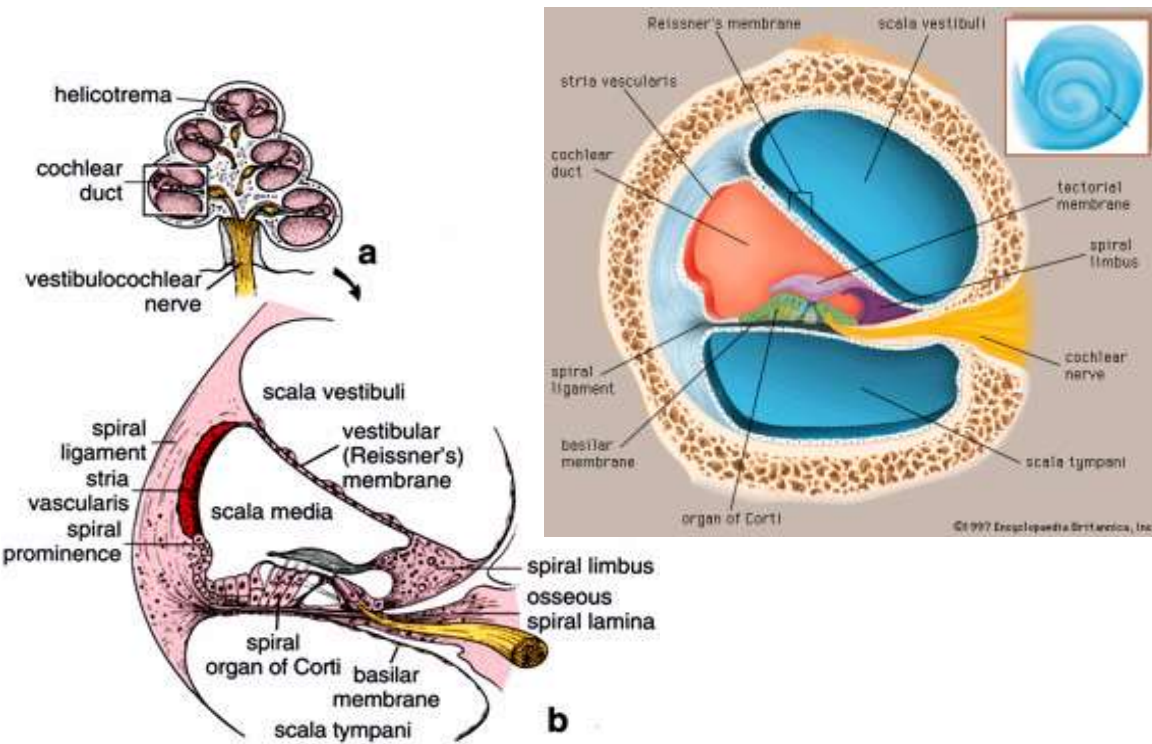
Lat. *cochlea*, snail shell





# Cochlear canal, *canalis cochlearis*

- ✓ ***scala vestibuli*** Lat. *scala*, stairway
- ✓ ***scala tympani***
- ✓ ***scala media*** (*ductus cochlearis*)  
⇒ *organum spirale Corti*





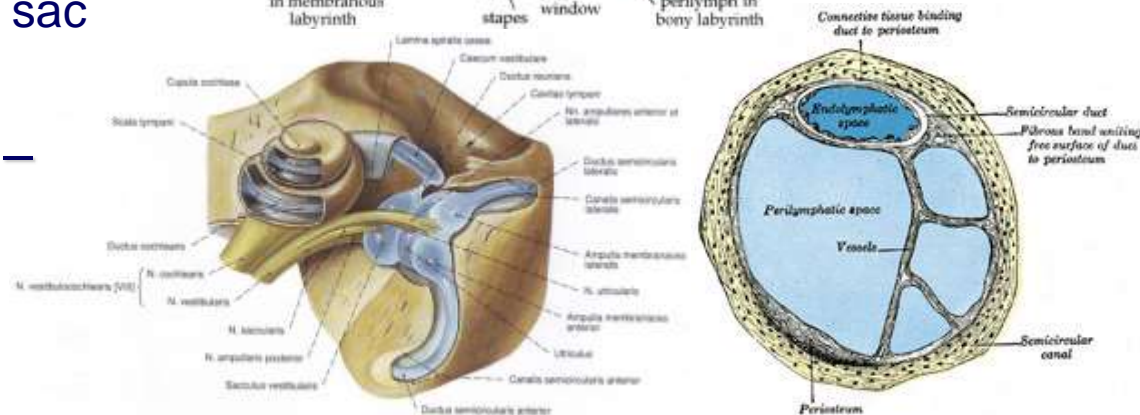
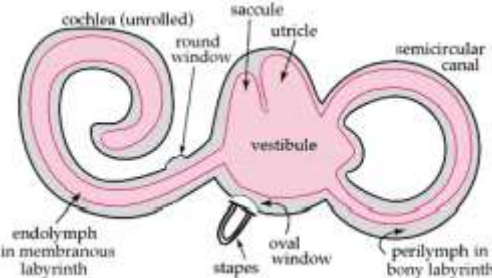
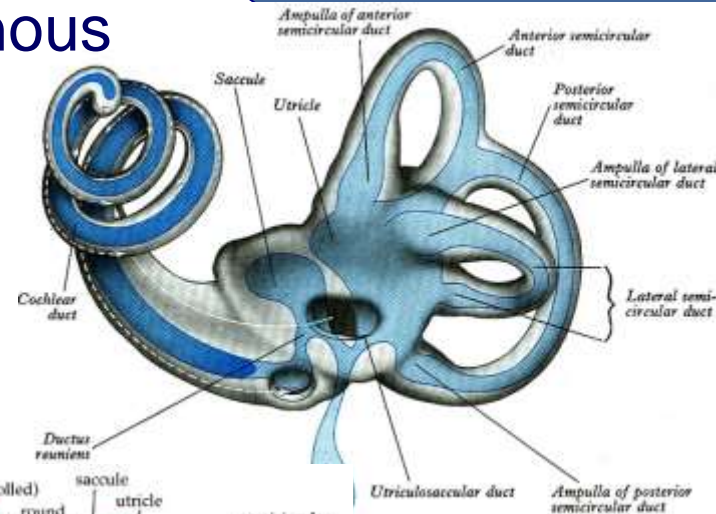


# Membranous labyrinth, *labyrinthus membranaceus*

- a closed system of fluid-filled membranous channels (sacs) of ectodermal origin
- location – within the bony labyrinth
- filled with endolymph
- surrounded by perilymph – perilymphatic space

- ✓ ***labyrinthus vestibularis*** –
  - within the osseous vestibule – *utricle and saccule*
  - endolymphatic duct and sac
  - three semicircular ducts

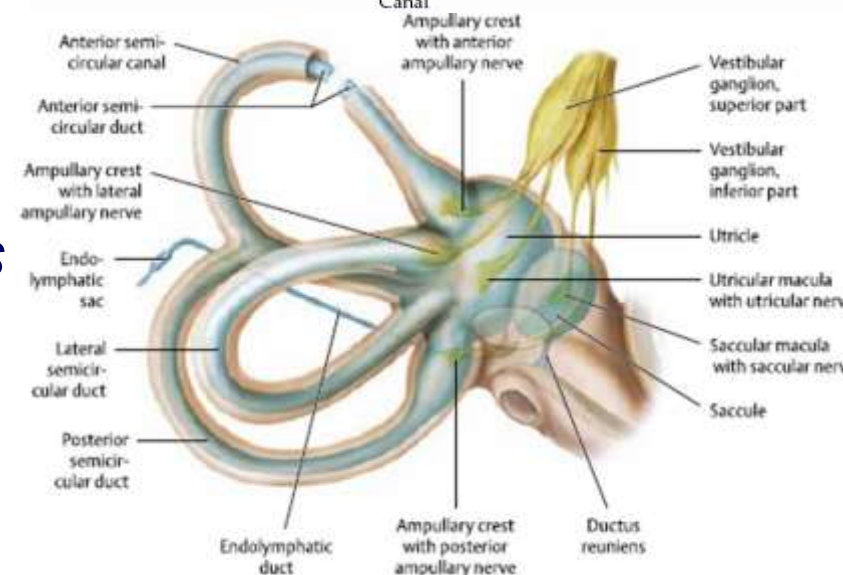
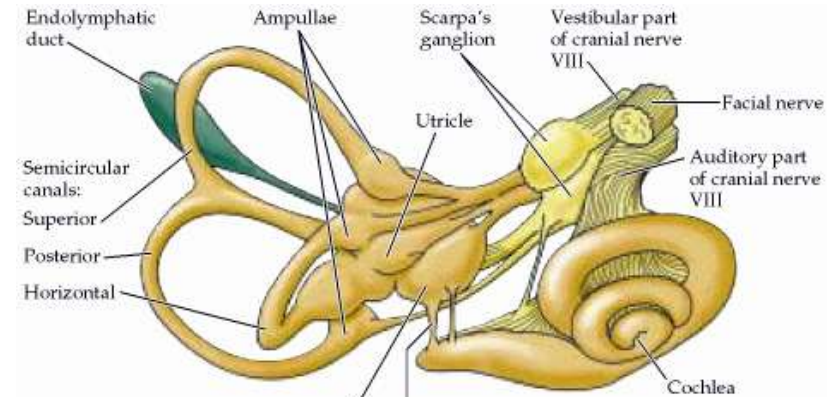
- ✓ ***labyrinthus cochlearis*** –
  - membranous cochlea (cochlear duct)
  - spiral organ of Corti





# Vestibular labyrinth, *labyrinthus vestibularis*

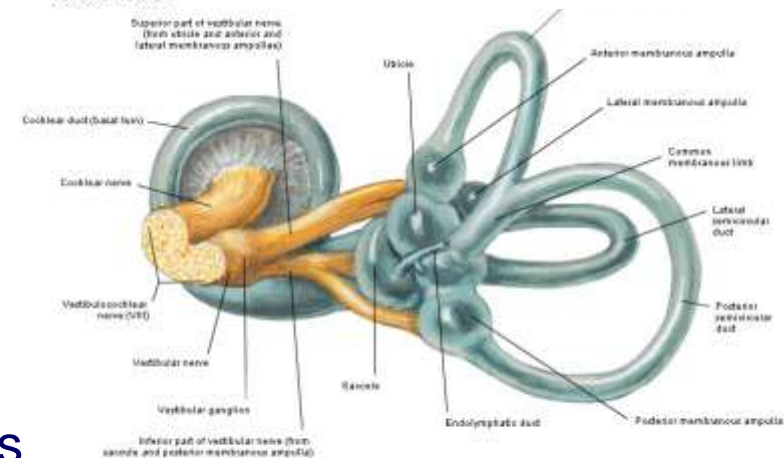
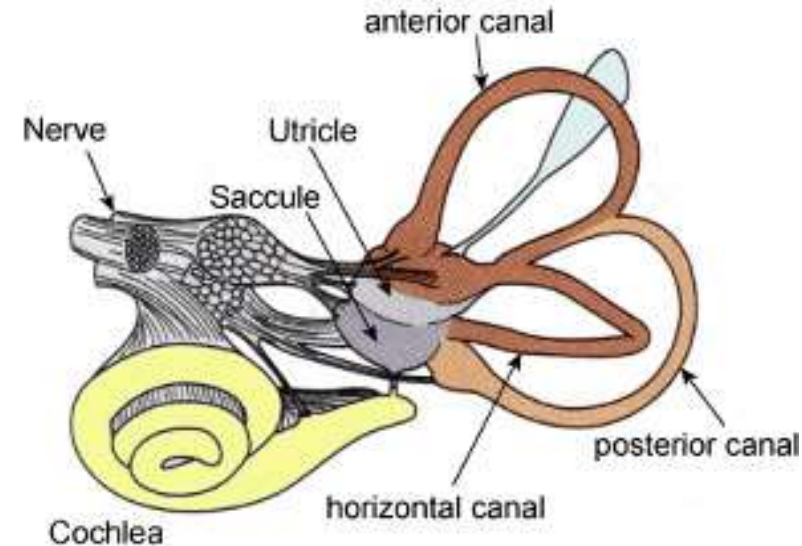
- *utricle* – in *recessus ellipticus*:
  - ✓ *ductus utriculosaccularis*
  - ✓ *macula utriculi* –  $\frac{2}{3}$  mm: *pars utricularis n. vestibulocochlearis*
- *sacculus* – in *recessus sphericus*:
  - ✓ *ductus reuniens*  $\Rightarrow$  *ductus cochlearis*
  - ✓ *macula sacculi* – *pars saccularis n. vestibulocochlearis*
- *ductus endolymphaticus*  
 $\Rightarrow$  *saccus endolymphaticus*



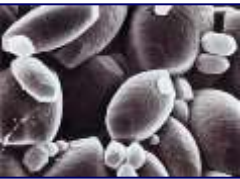


# Vestibular labyrinth, *labyrinthus vestibularis*

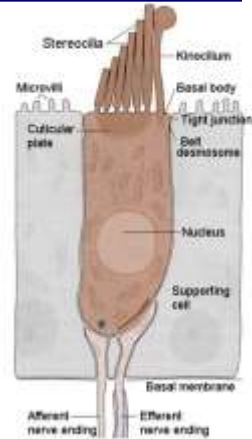
- semicircular ducts:
  - ✓ *ductus semicircularis lateralis*
  - ✓ *ductus semicircularis anterior*
  - ✓ *ductus semicircularis posterior*
- ¼ of the semicircular canals
- *ampulla membranacea*
- *crus membranaceus*:
  - ✓ *simplex* – for lateral duct
  - ✓ *commune* – anterior&posterior ducts
- wall – thickened, three layers:
  - ✓ inner – simple squamous epithelium
  - ✓ middle – vascular connective tissue
  - ✓ outer – fibrous tissue with blood vessels clothed by flattened perilymphatic cells



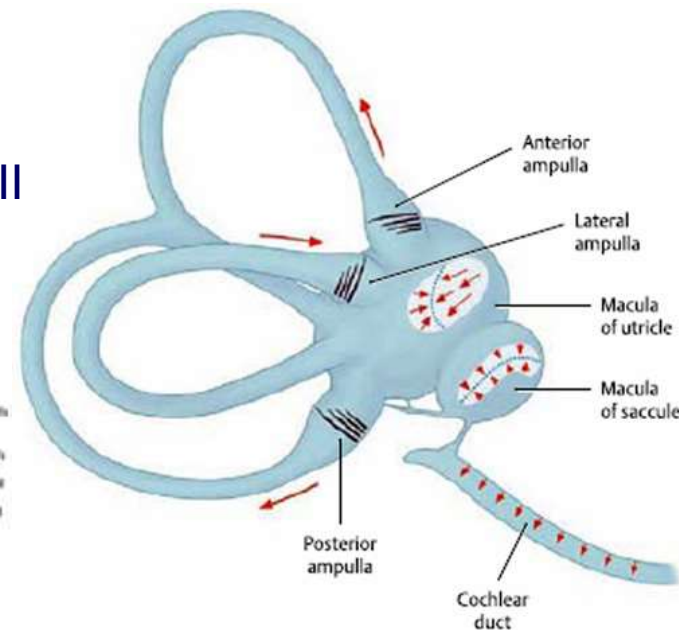
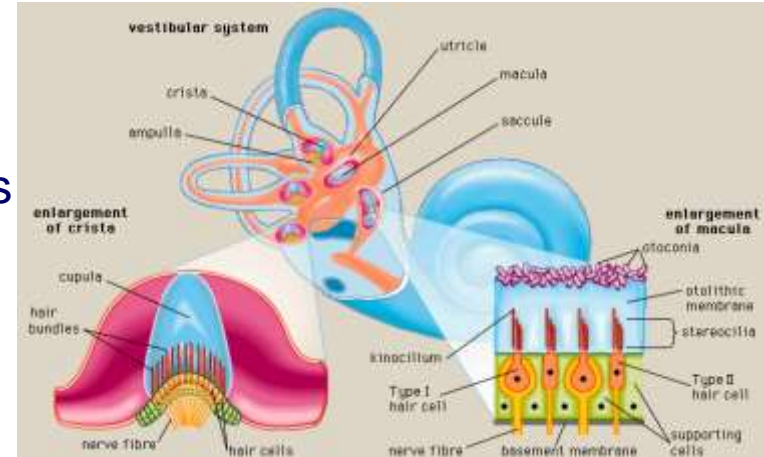
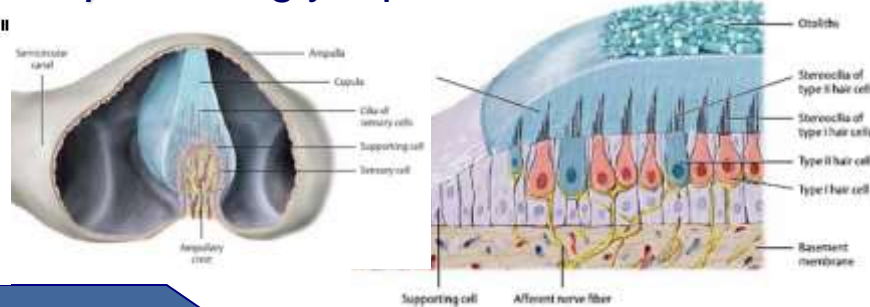
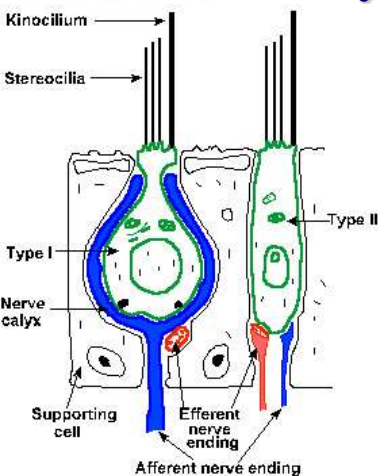
# Vestibular system



- Statoreceptor spots:
  - ✓ *macula utriculi* and *macula sacculi*:
    - neuroepithelium:
      - *epitheliocyti sensorii pilosi* – 2 types
        - ⇒ 40-80 stereocilia; 1 kinocilium
      - *epitheliocyti sustentantes*
    - *membrana statoconiorum* – otoliths, *statoconia* (Gr. *oto-*, ear + *λιθος, lithos*, a stone)



- ✓ *cristae ampullares*:
  - neuroepithelium:
    - *epitheliocyti sensorii pilosi* – type I and II
    - *epitheliocyti sustentantes*
  - cupula* – a glycoprotein substance

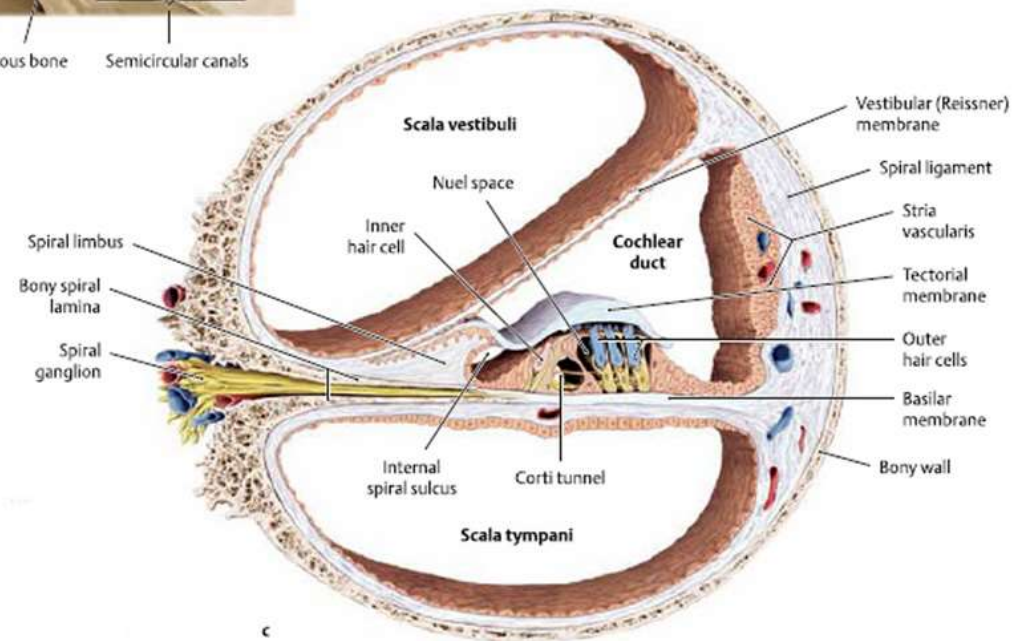
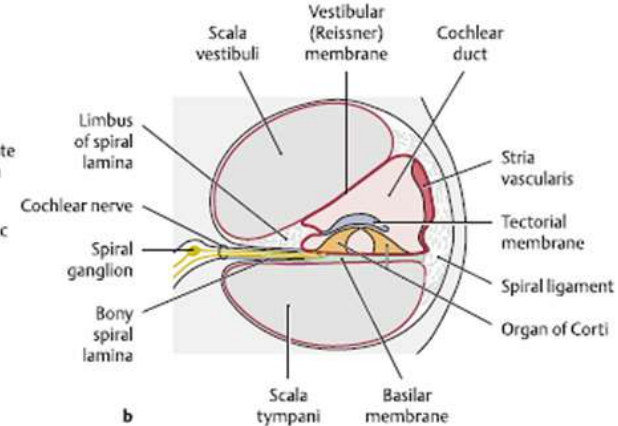
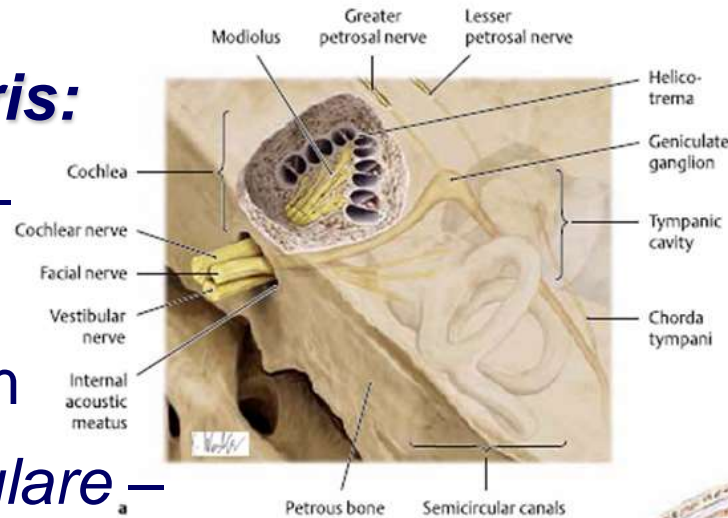




# Cochlear labyrinth, *labyrinthus cochlearis*

## cochlear duct, *ductus cochlearis*:

- ✓ *scala media* – endolymph
- ✓ length ~35 mm
- ✓ *cecum vestibulare* – in *recessus cochlearis*
- ✓ *cecum cupulae* – in *cupula cochleae*





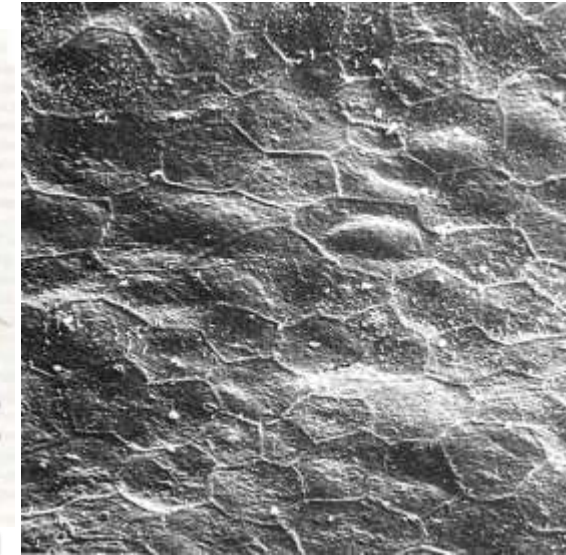
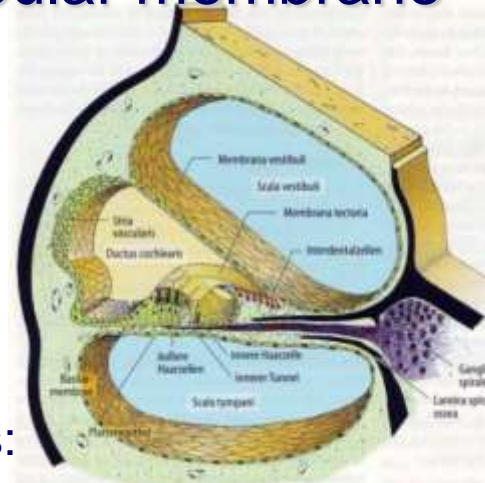
# Cochlear duct, *ductus cochlearis*

- *paries vestibularis* – vestibular membrane (of *Reissner*) – two layers:

- ✓ basal lamina
- ✓ simple squamous epithelium

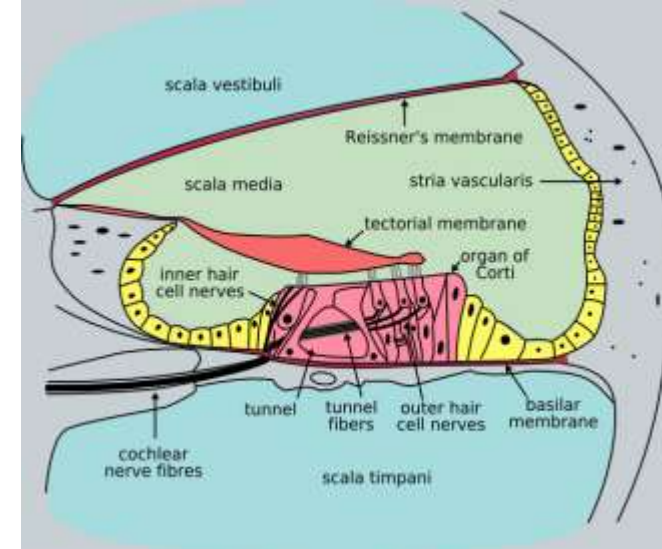
- *paries externus*:

- ✓ *lig. spirale cochleae*
- ✓ *stria vascularis*: three cell types: marginal, intermediate and basal – secrete endolymph



- *paries tympanicus* – basilar membrane (*membrana spiralis*):

- ✓ internal zone – *sulcus spiralis internus*, *limbus spiralis* (tympanic and vestibular lips ⇒ *membrana tectoria*),
- ✓ middle zone – spiral organ of *Corti*
- ✓ external zone – *sulcus spiralis externus*



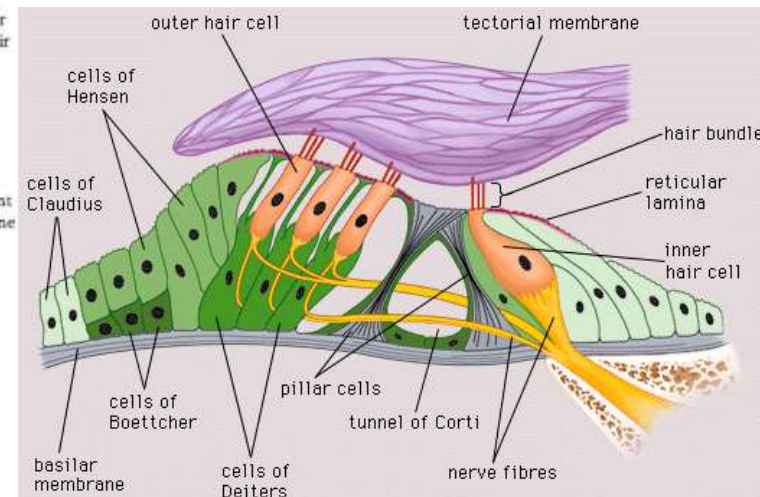
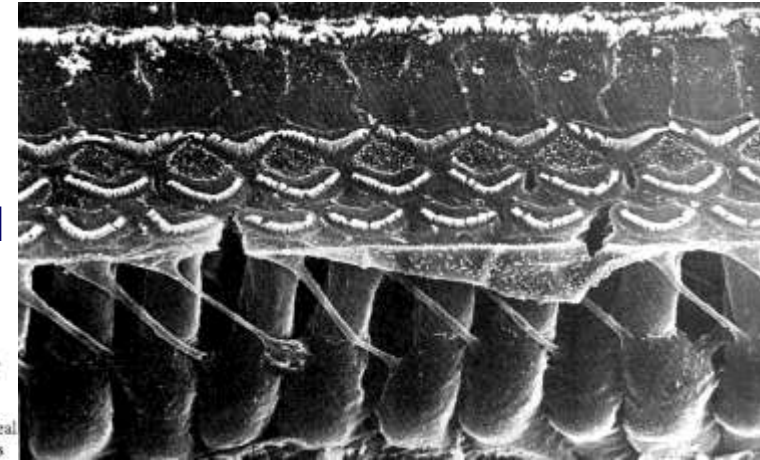
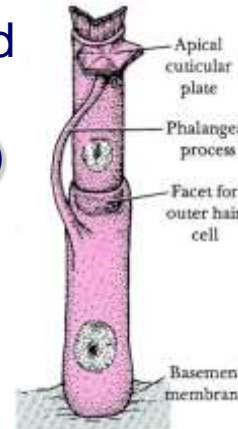
# Spiral organ of Corti, *organum spirale*

Alfonso Corti  
(1822–1876)

✓ located onto *basilar membrane*: 100  $\mu\text{m}$  basal, 500  $\mu\text{m}$  apical turns

receptor (sensory) and supporting cells:

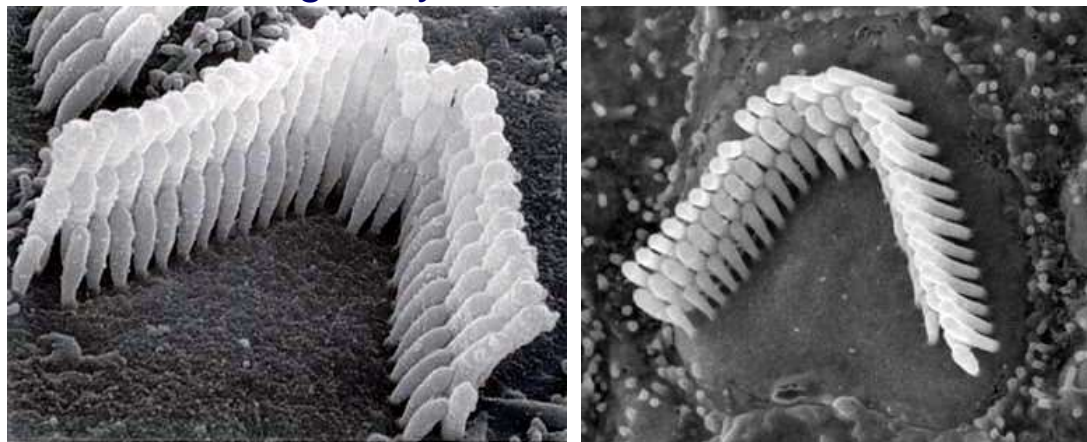
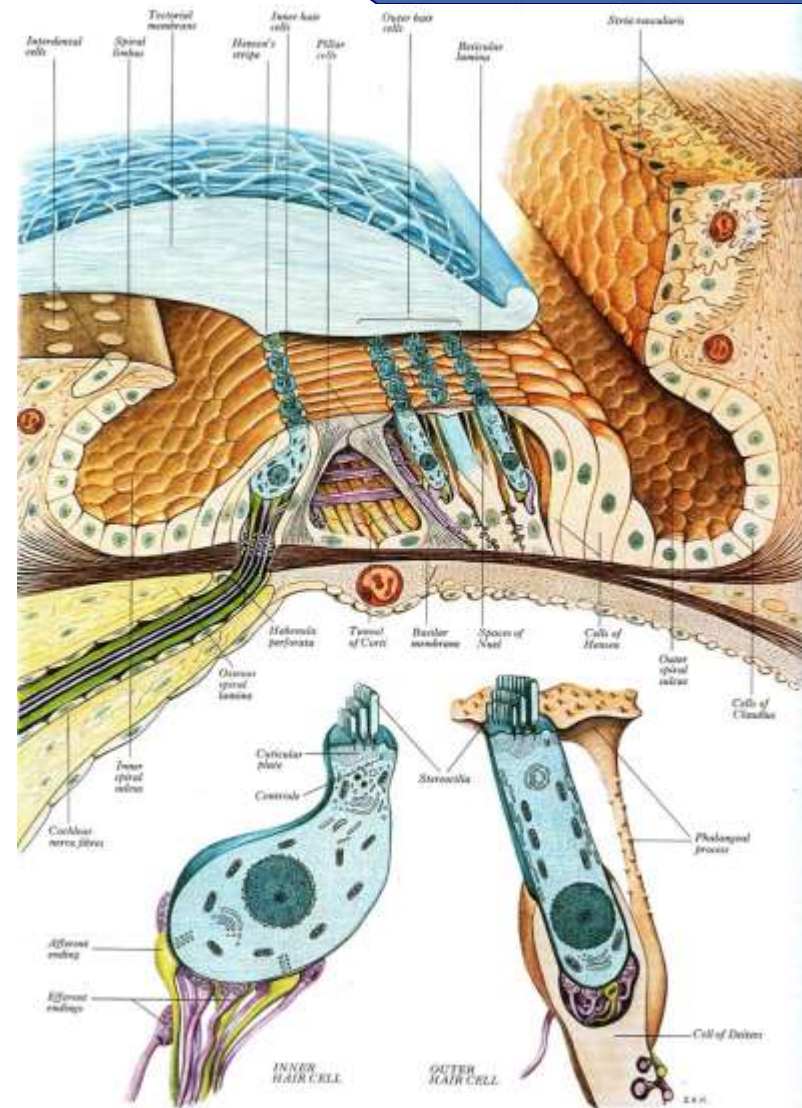
- ✓ internal and external rod (pillar) cells of Corti  
 ⇒ *cuniculus internus* (inner tunnel of Corti)  
 ⇒ *cuniculus medius* (space of Nuel)
- ✓ internal phalangeal cells of *Deiters* – 1 row and external phalangeal cells of *Deiters* – 3 rows
- ✓ internal (inner) hair cells – 1 row and external (outer) hair cells – 3 rows  
 ⇒ *cuniculus externus* (outer tunnel)
- ✓ *epitheliocytii limitantes externi* (cells of *Hensen*) – 3-4 rows
- ✓ *epitheliocytii sustentantes externi* (cells of *Claudius*)
- ✓ supporting cells of *Boettcher* – beneath *Claudius* cells in the lower turn of the cochlea
- ✓ *epitheliocytii limitantes interni* – 1-2 rows
- ✓ *epitheliocytii sustentantes interni* – 2-3 rows





# Hair cells, *epitheliocytii sensorii pilosi*

- inner (internal) hair cells:
  - ✓ ~ 3500 in number
  - ✓ arranged in a single row
  - ✓ carry 50-60 linear stereocilia
  - ✓ damaged by diuretics, ototoxic antibiotics (aminoglycosides)
- outer (external) hair cells:
  - ✓ longer cells, 12 000-20 000 in number
  - ✓ arranged in three rows (basally) and in 4-5 rows (apically)
  - ✓ carry stereocilia, arranged in V or W-forms
  - ✓ damaged by chinin derivatives

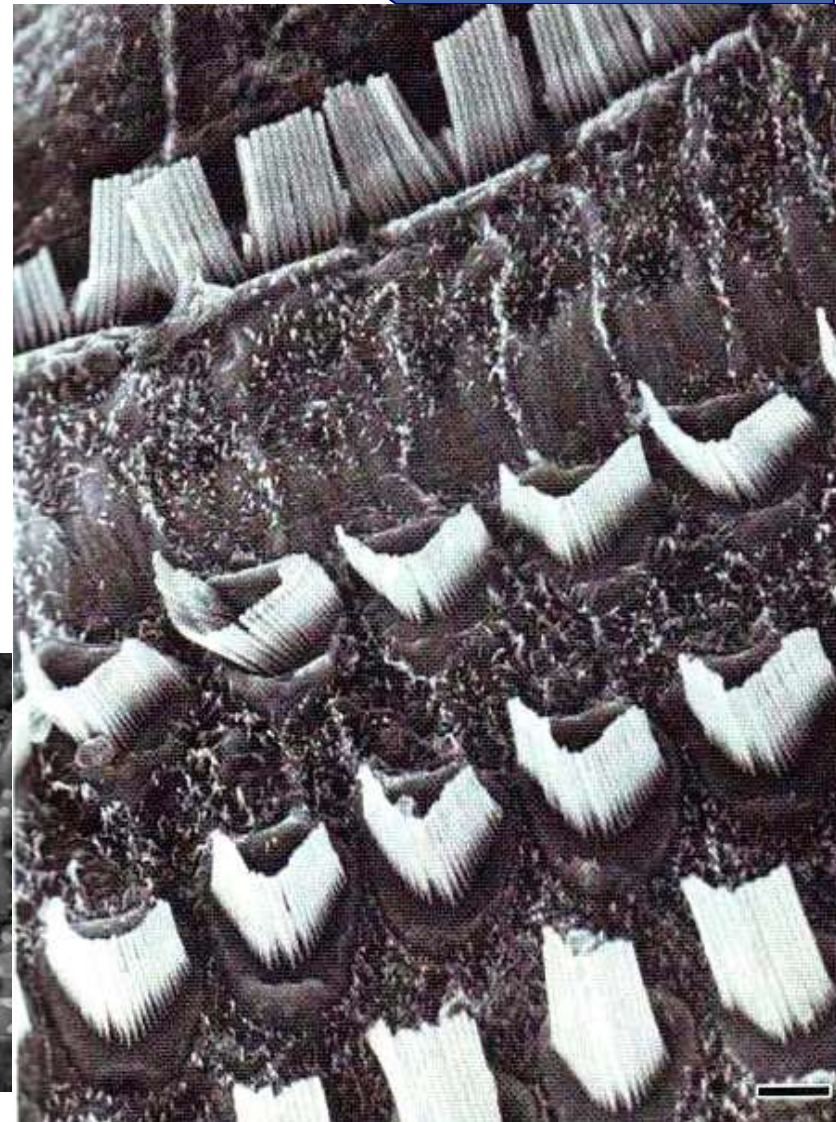
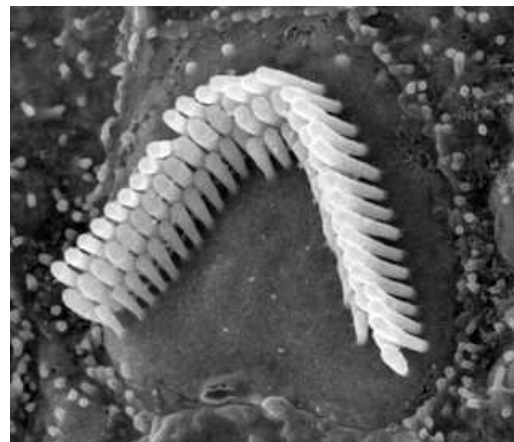
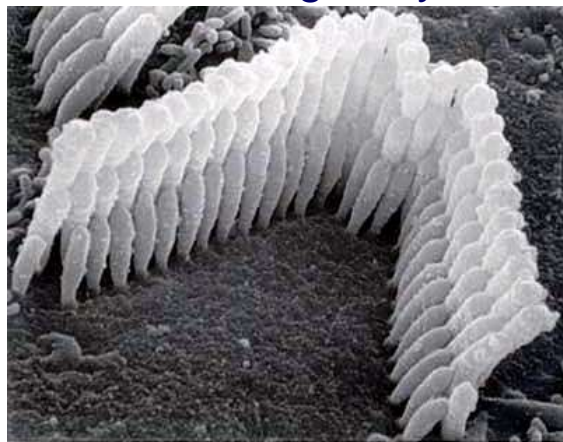






# Hair cells, *epitheliocytii sensorii pilosi*

- inner (internal) hair cells:
  - ✓ ~ 3500 in number
  - ✓ arranged in a single row
  - ✓ carry 50-60 linear stereocilia
  - ✓ damaged by diuretics, ototoxic antibiotics (aminoglycosides)
- outer (external) hair cells:
  - ✓ longer cells, 12 000-20 000 in number
  - ✓ arranged in three rows (basally) and in 4-5 rows (apically)
  - ✓ carry stereocilia, arranged in V or W-forms
  - ✓ damaged by chinin derivatives

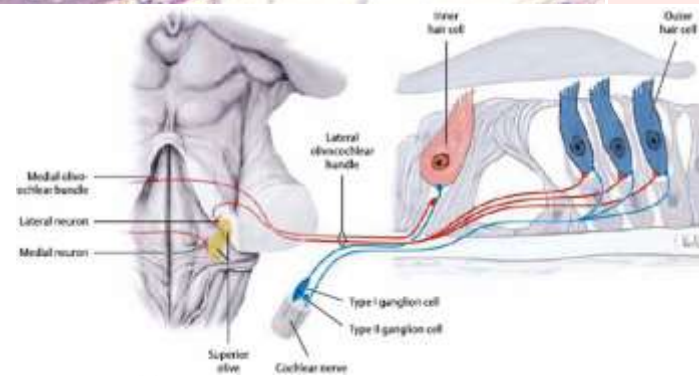
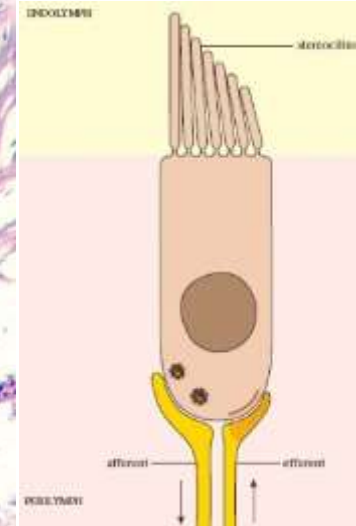
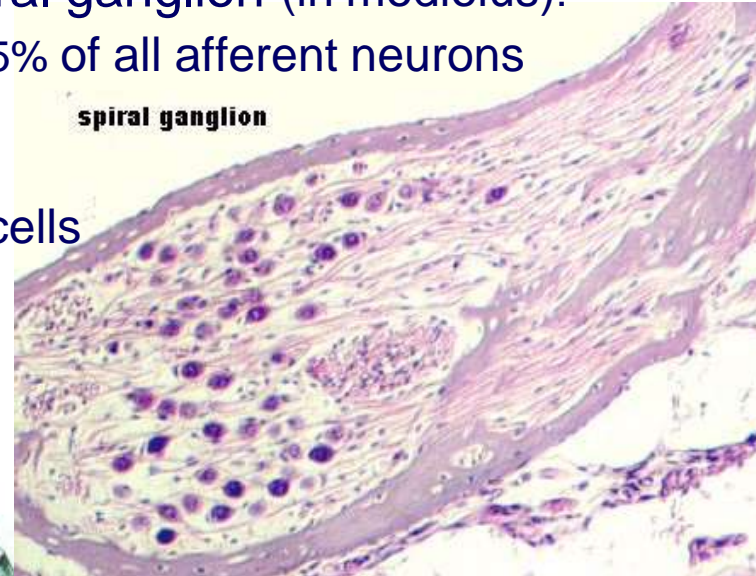
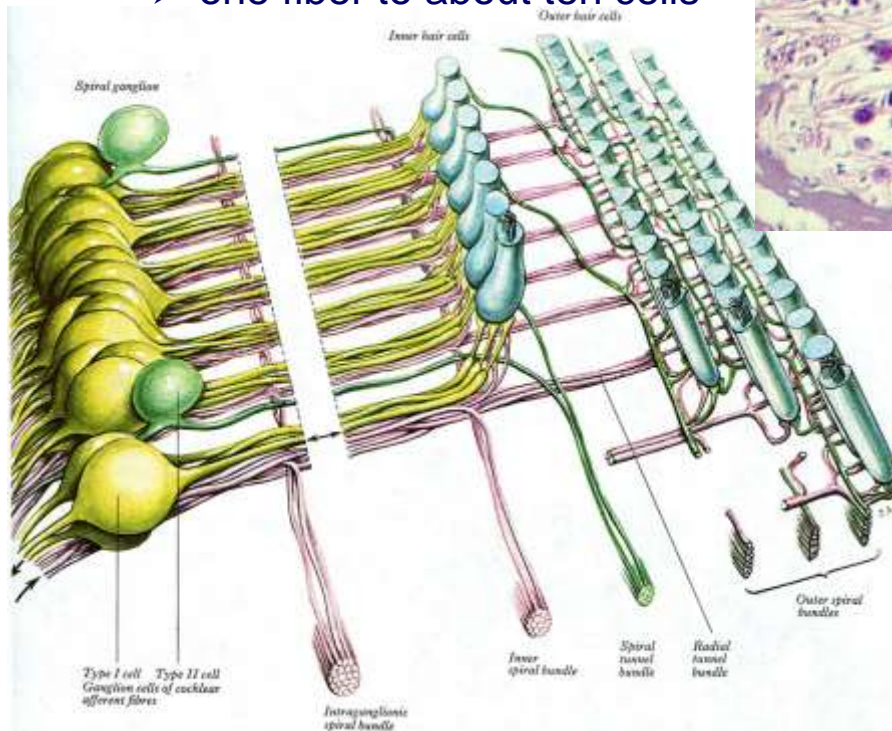




# Cochlear innervation

Afferent innervation – from spiral ganglion (in modiolus):

- ✓ large bipolar type I cells – ~ 95% of all afferent neurons
  - ⇒ inner hair cells
    - about ten fibers to each cell
- ✓ small pseudounipolar type II cells
  - ⇒ outer hair cells
    - one fiber to about ten cells

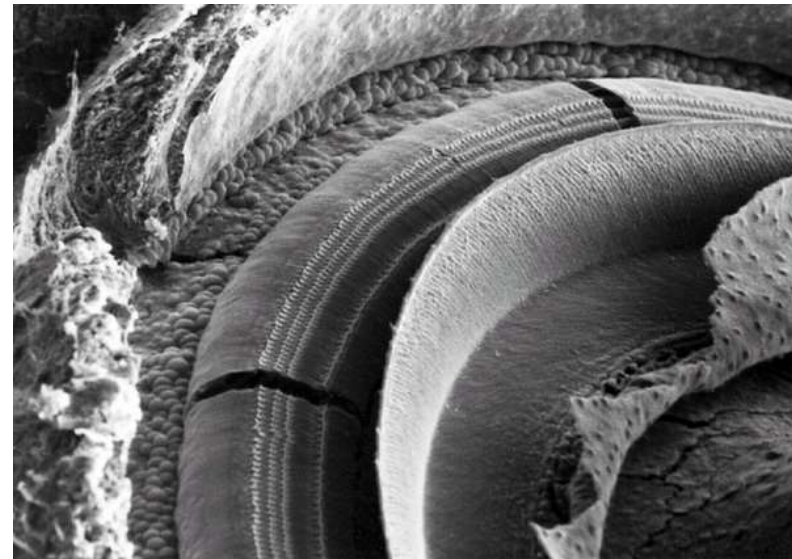
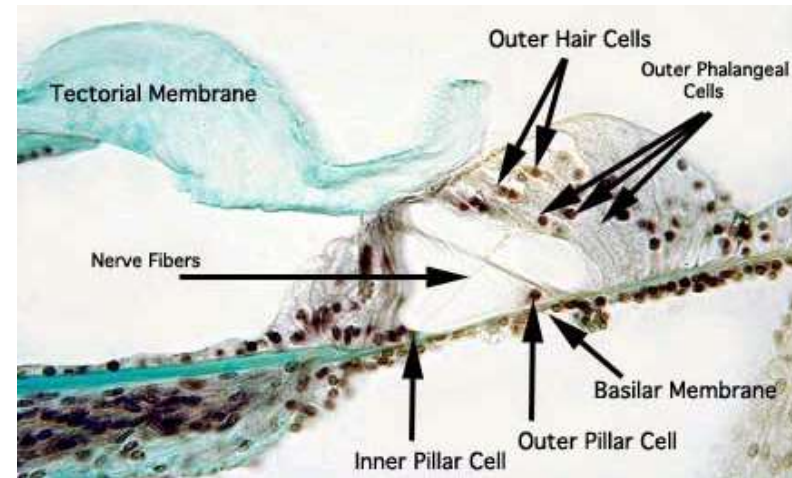
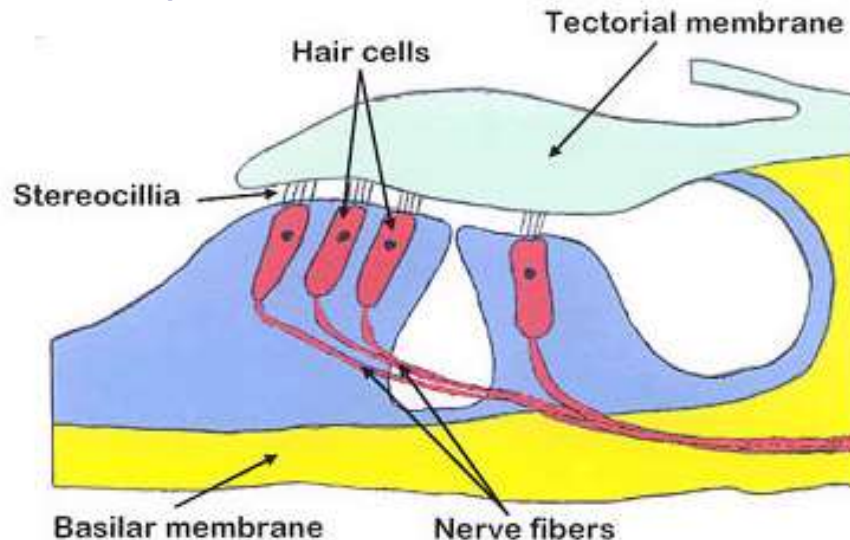


- Efferent innervation – *tractus olivocochlearis* (Rasmussen's tract)
  - ⇒ cholinergic inhibitory synapses



# Tectorial membrane, *membrana tectoria (Cortii)*

- overlies the sulcus spiralis internus and the spiral organ of *Corti*
- secreted by the epithelial cells of the vestibular lip of the *limbus laminae spiralis*
- colorless fibers embedded in a jelly-like matrix:
  - ✓ 4 μm filaments of soft keratin
  - ✓ glycosaminoglycans
- covers the hair cells in organ of *Corti*, making contacts with their stereocilia
- the vibrating mechanism in the cochlea



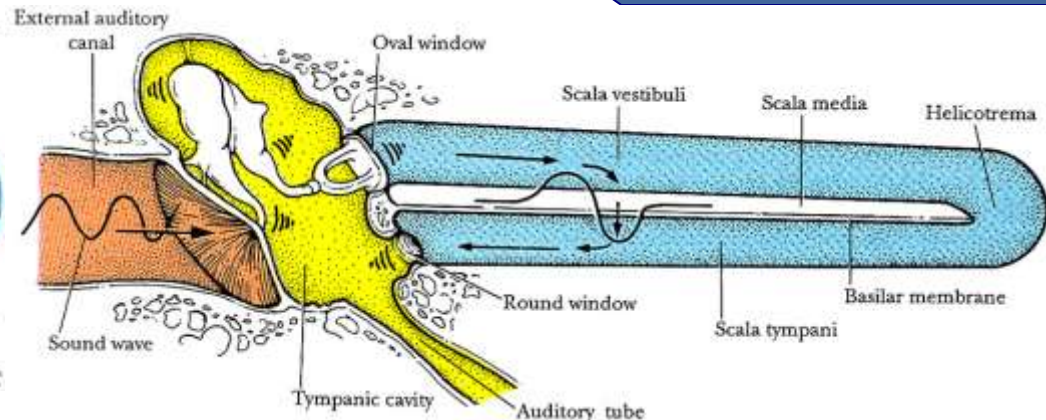
# Mechanism of the auditory reception



Georg von Békésy  
(1899-1972)



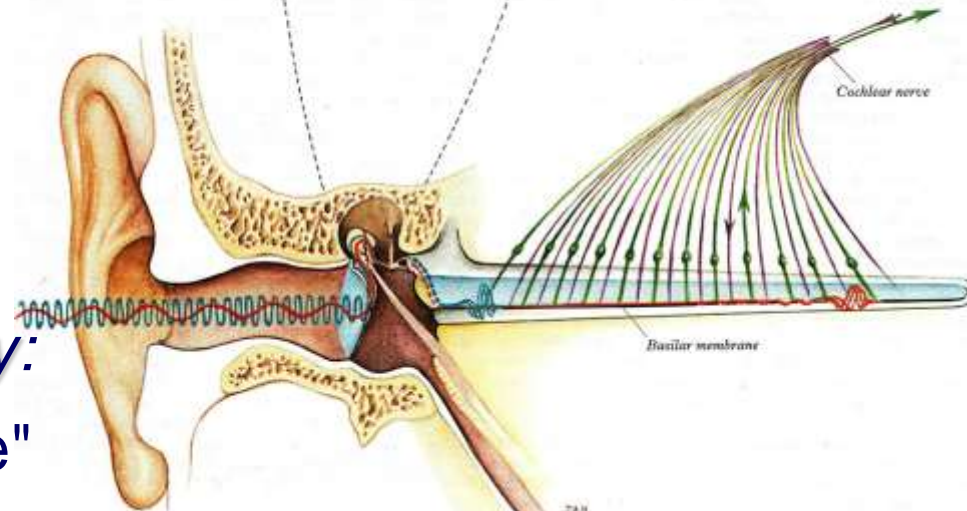
The Nobel Prize  
in Physiology or Medicine 1961  
"for his discoveries of the physical mechanism  
of stimulation within the cochlea"



**EXTERNAL EAR**  
Sound collection and amplification;  
source location.

**MIDDLE EAR**  
Amplification of signal (force  
per unit area); impedance  
matching between air and  
water vibrations; neural  
reflex and mechanical damping  
of excessive vibration; pressure  
equalizing through tympanic tube.

**INNER EAR**  
Mechanical and neural filtering and  
analysis of signals by spiral organ;  
stimulus transduction by sensory  
cells; action potential initiation  
at synapses between cochlear nerve  
fibers and sensory cells; central  
control by centrifugal fibres.



- Helmholtz resonance theory
- Rutherford telephone theory
- travelling wave theory of Békésy:
- ✓ basilar-membrane "resonance"

**NB:** The human ear can nominally hear sounds in the range 12 Hz

# Auditory pathways



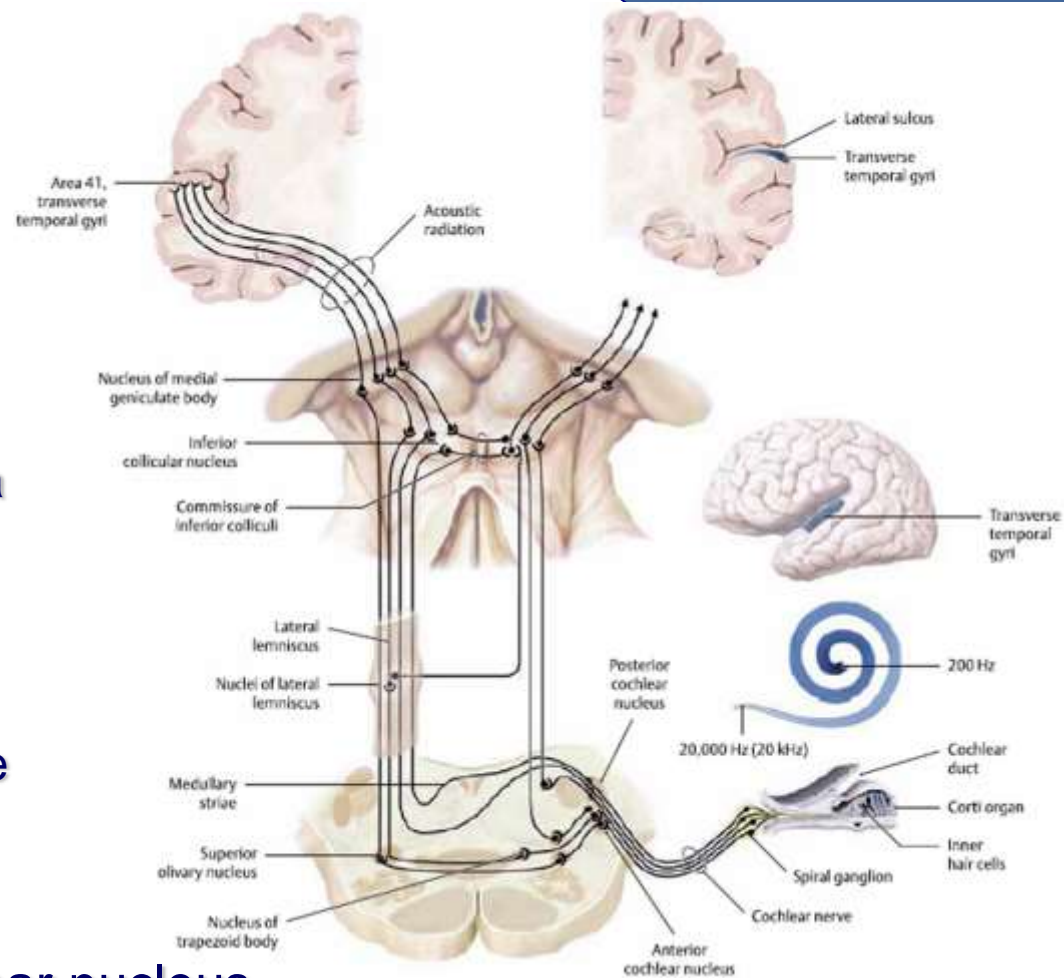
## I<sup>st</sup> neuron – spiral ganglion:

- ✓ true bipolar neurons – 30000-33000 cells
  - cell bodies in the spiral structure of the cochlea
  - peripheral processes ⇒ spiral organ of *Corti*
  - central processes ⇒ cochlear part of the vestibulocochlear nerve

## ■ II<sup>nd</sup> neuron – cochlear nuclei:

- ✓ dorsal (posterior) cochlear nucleus
- ✓ ventral (anterior) cochlear nucleus

} lateral lemniscus



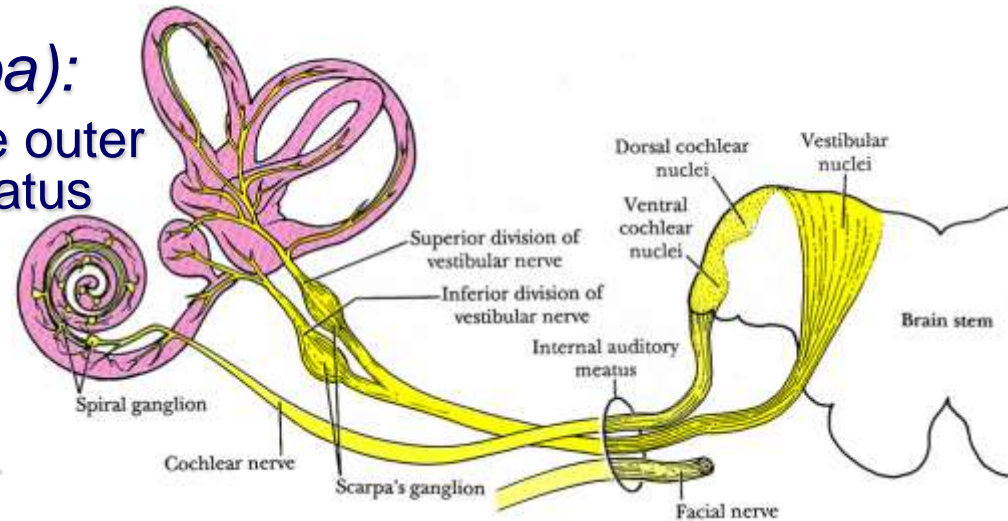




# Vestibular pathways

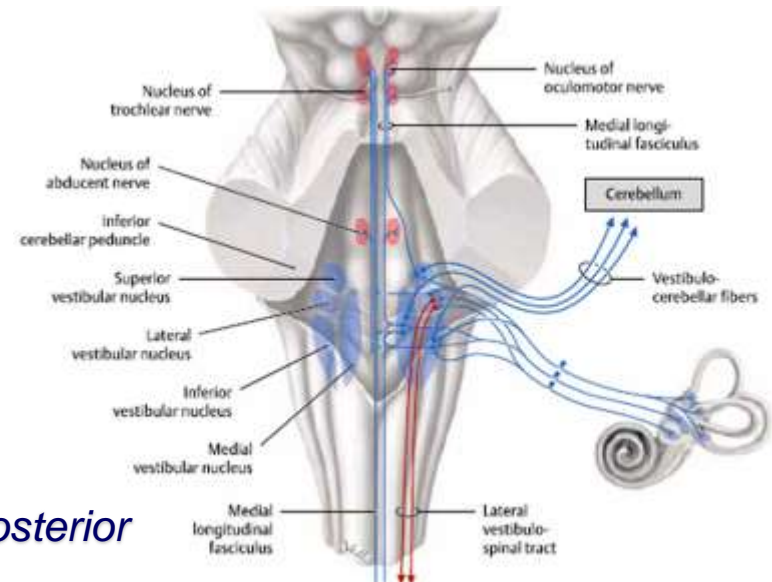
## I<sup>st</sup> neuron – vestibular ganglion (of Scarpa):

- ✓ situated in the upper part of the outer end of the internal auditory meatus
- ✓ true bipolar neurons – ~20000 cells
  - peripheral processes ⇒ statoreceptor spots in:
    - *maculae utriculi et sacculi* – linear acceleration
    - *semicircular ducts* – angular acceleration
  - central processes ⇒ vestibular part of the vestibulocochlear nerve



## II<sup>nd</sup> neuron – vestibular nuclei:

- ✓ superior (*Bechterew*)
- ✓ inferior (*Roller*) } lateral lemniscus
- ✓ medial (*Schwalbe*)
- ✓ lateral (*Deiters*) ⇐ *tractus spinocerebellaris posterior*





# Central vestibular pathways

- III<sup>rd</sup> neuron – medial geniculate nucleus
- IV<sup>th</sup> neuron – vestibular cortex

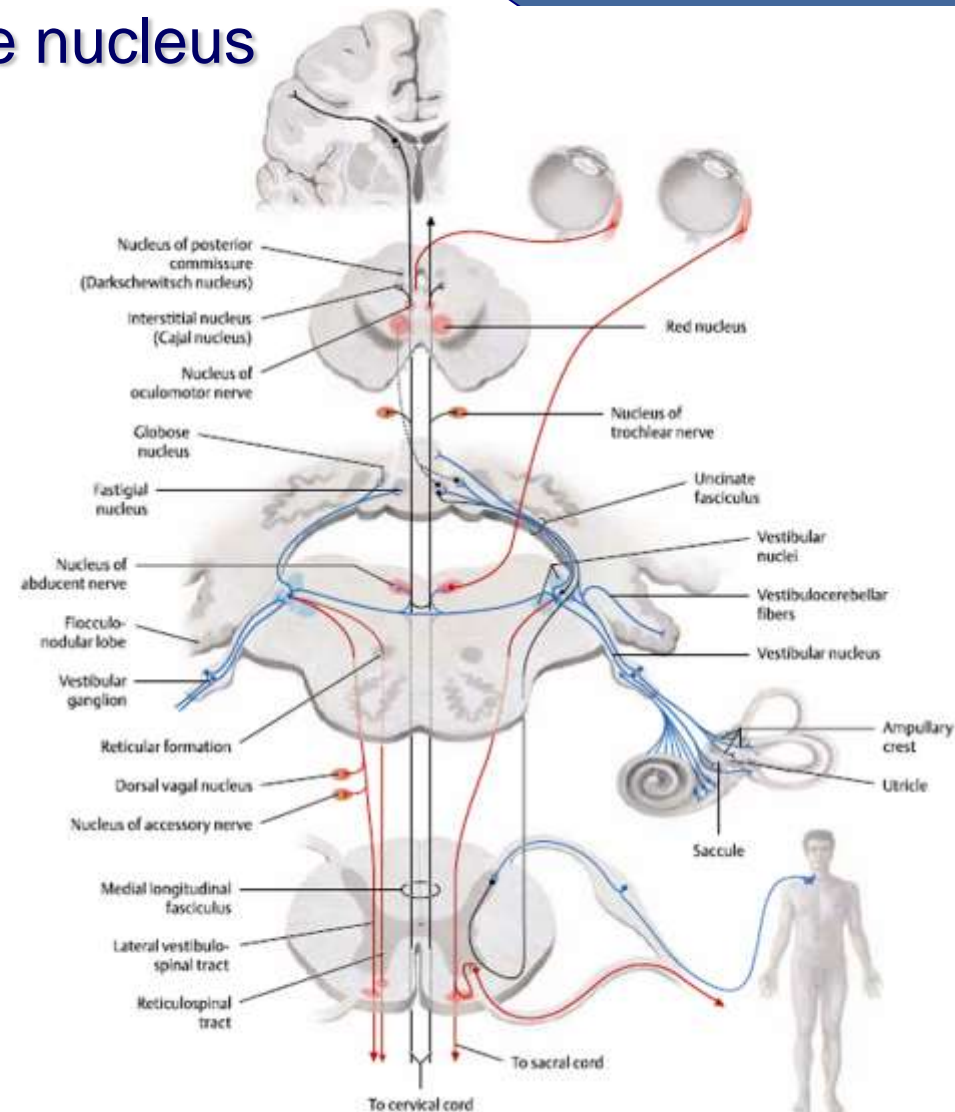
✓ rostral part of  
*gyrus temporalis superior*

✓ **tractus vestibulothalamicus** –

- *nucleus ventralis posterolateralis*
- *nucleus ventralis posterior inferior*

✓ **tractus thalamocorticalis** –

*internal capsule* ⇒ vestibular area in  
*gyrus postcentralis (area 3a)*  
and around *sulcus intraparietalis*







# Thank you...



**“Your chart showed a broken cochlea inside your ear, but we fixed it with Photoshop.”**