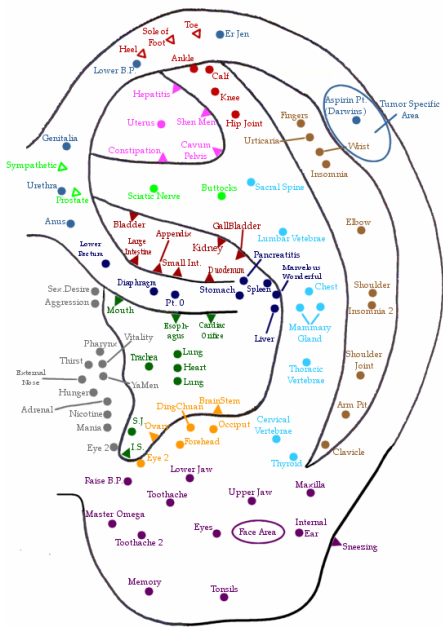
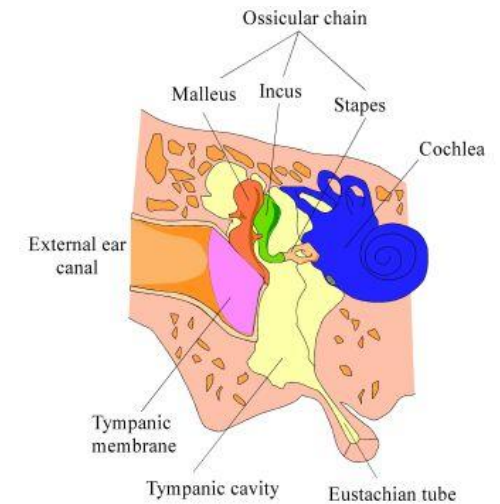


Auditory and vestibular system

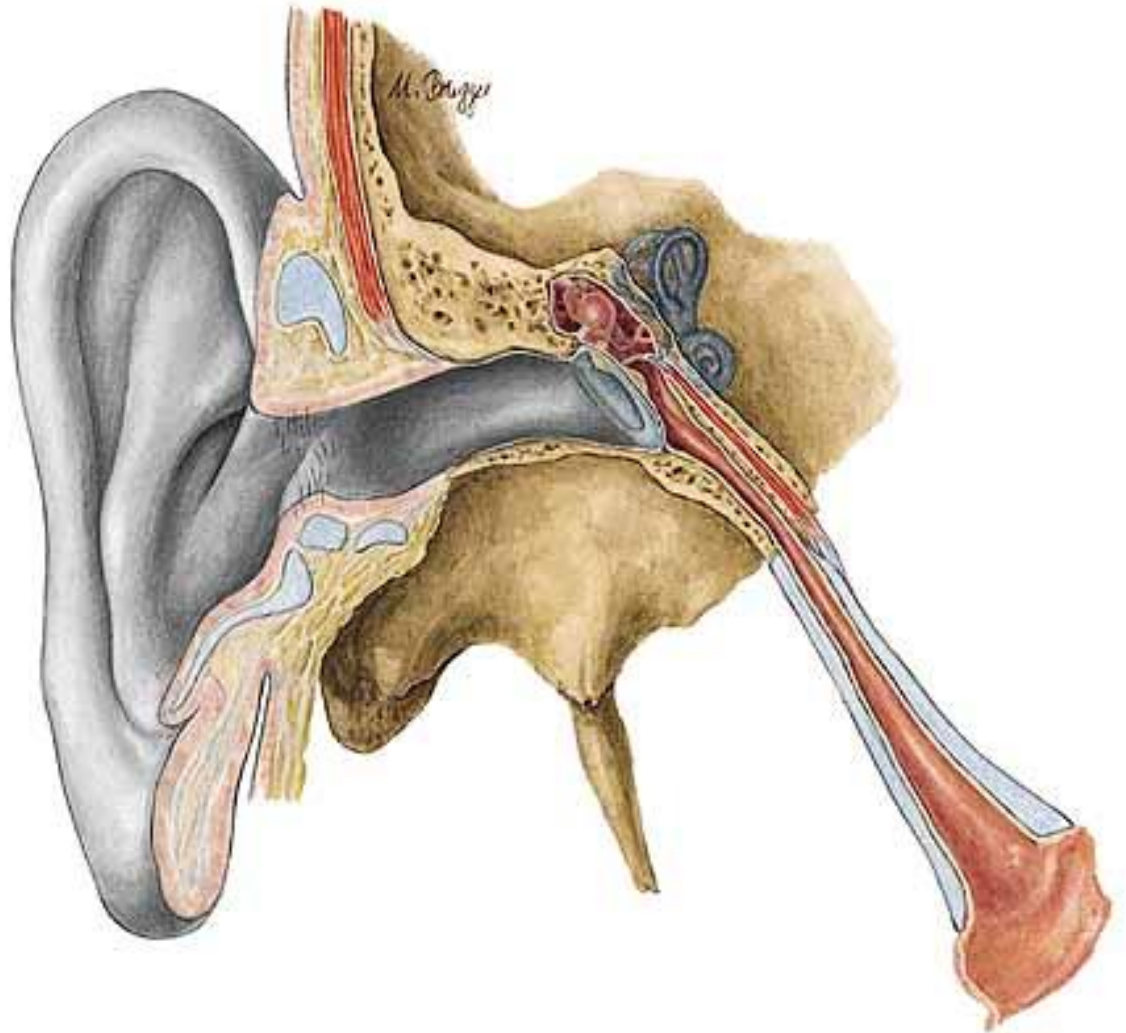


Auris, is = Us, oton



Auditory and vestibular system

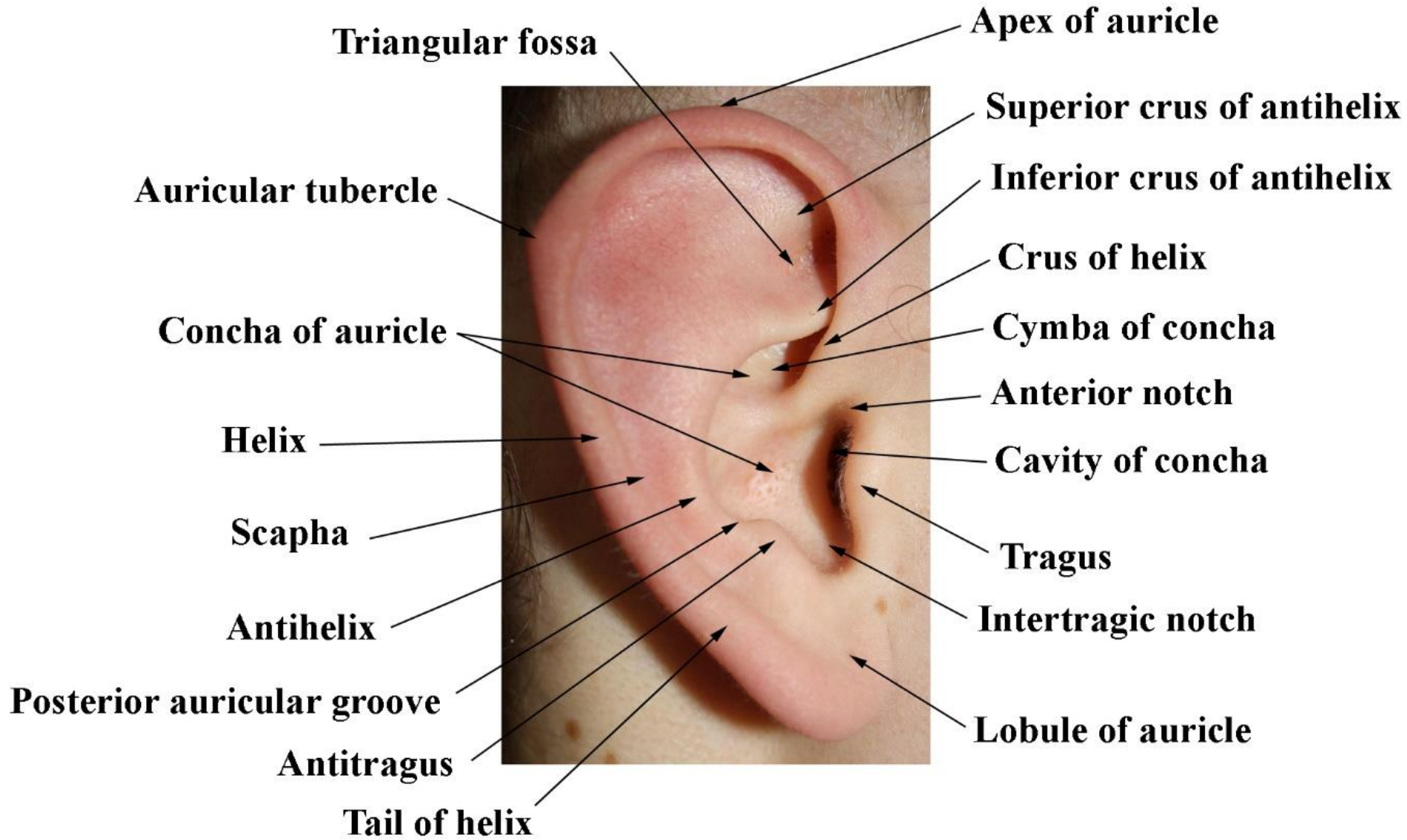
- external ear
(*auris externa*)
- middle ear
(*auris media*)
- internal ear
(*auris interna*)
= organum
vestibulo-
cochleare



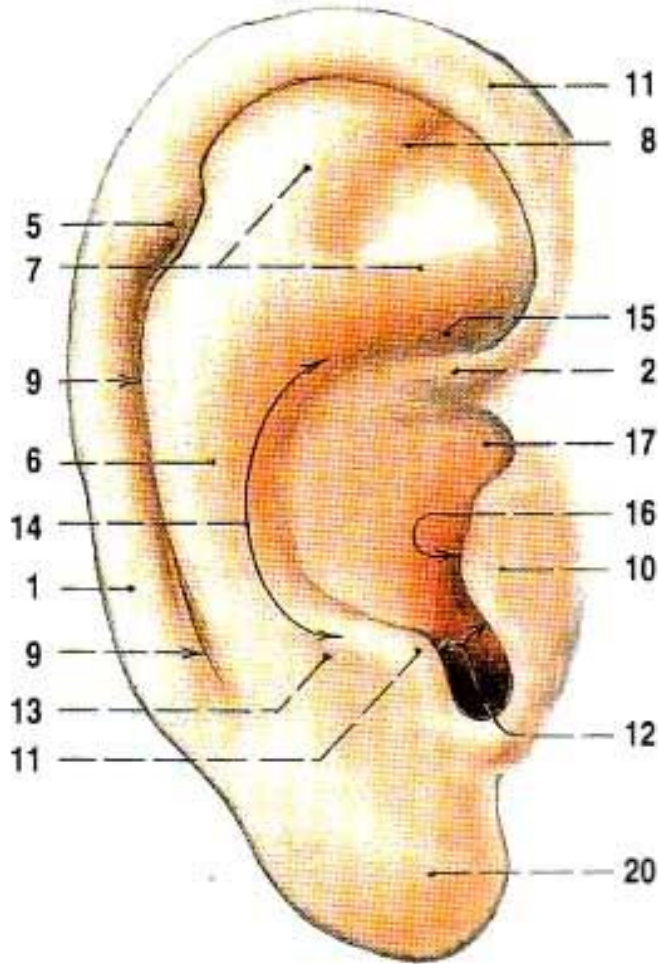
External ear (*Auris externa*)

- **auricle** (*auricula, pinna*)
 - elastic cartilage
- **external acoustic meatus**
(*meatus acusticus externus*)
- **tympanic membrane**
(*membrana tympanica, myrinx*)

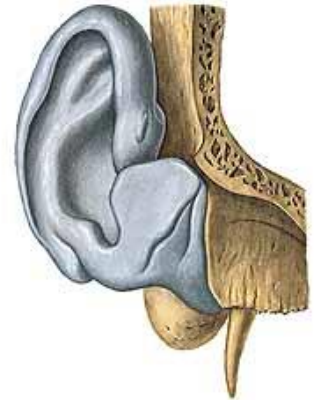




Auricle



- **helix**
 - crus, spina, cauda
 - (tuberculum auriculare *Darwini*, apex auriculae)
- **antihelix**
 - crura, fossa triangularis
- **scapha**
- **concha auriculae**
 - cymba, cavitas
- **tragus**
- **antitragus**
- **incisura intertragica**
- **lobulus auriculae**



posterior surface = negative image of the anterior one

ligaments: lig. auriculare ant., sup., post.

muscles – *innervation*: **n. facialis**

- extrinsic muscles = facial muscles
 - mm. auriculares (ant., sup., inf.)
 - m. temporoparietalis
- intrinsic muscles: *rudimentary*
 - m. tragicus + antitragicus
 - m. helicis major+minor
 - m. obliquus + transversus auriculae, m. pyramidalis auriculae

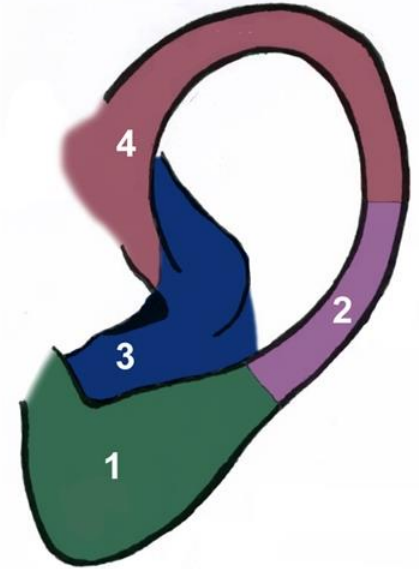
cartilage: cartilago auriculae - *elastic*

skin: dorsally more loosen, ventrally firmly
fixed to perichondrium - *othematoma*



Auricle – supply

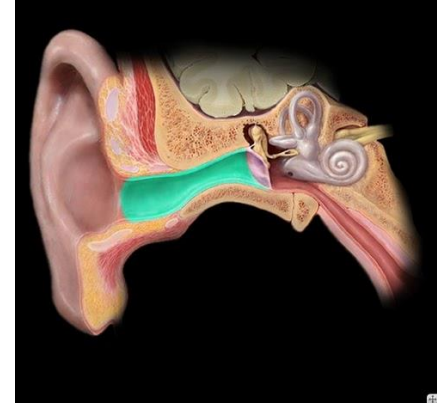
- arteries: a. temporalis superficialis → rr. auriculares ant.
 - a. carotis externa → a. auricularis post.
- veins: v. jugularis ext.
- lymph: nn. ll. parotidei, mastoidei
- nerves: sensory
 - nn. auriculares ant. from n. auriculotemporalis (*ventrocranial 2/3*)
 - r. auricularis n. X. (*concha*)
 - n. occipitalis minor (*dosrocranial*)
 - n. auricularis magnus (*oldal*)motor: n. VII.



Key:

1. Great auricular nerve
2. Lesser occipital nerve
3. Auricular branch of vagus nerve
4. Auriculotemporal nerve

External acoustic meatus (*meatus acusticus externus*)



- porus acusticus externus → oblique ventromedially → medially → again oblique ventromedially (totally converging ventrally 160° and convex descending, length about 22 mm)
- outer 2/3 – elastic cartilage opened ventrally and caudally (incisurae *Santorini*), lamina tragi (ventrally)
- transition – the narrowest point (isthmus) – *foreign bodies !!!*
- inner 1/3 – osseous – incisura tympanica *Rivini*
- glandulae ceruminosae + sebaceae → *cerumen – protection*
- tragi (*after age 30*)
- skin adheres firmly to perichondrium – *even little inflammation is painful !!!*
- anterior wall: relation to gl. parotidea and art. temporomandibularis

- Giovanni Domenico **Santorini**
 - 1681 – 1737
 - incisurae cartilagini meatus acustici



- Augustus Quirinus **Rivinus**
 - 1652 – 1723
 - botanist (*Viola riviniana*)
 - physician
 - incisura tympanica

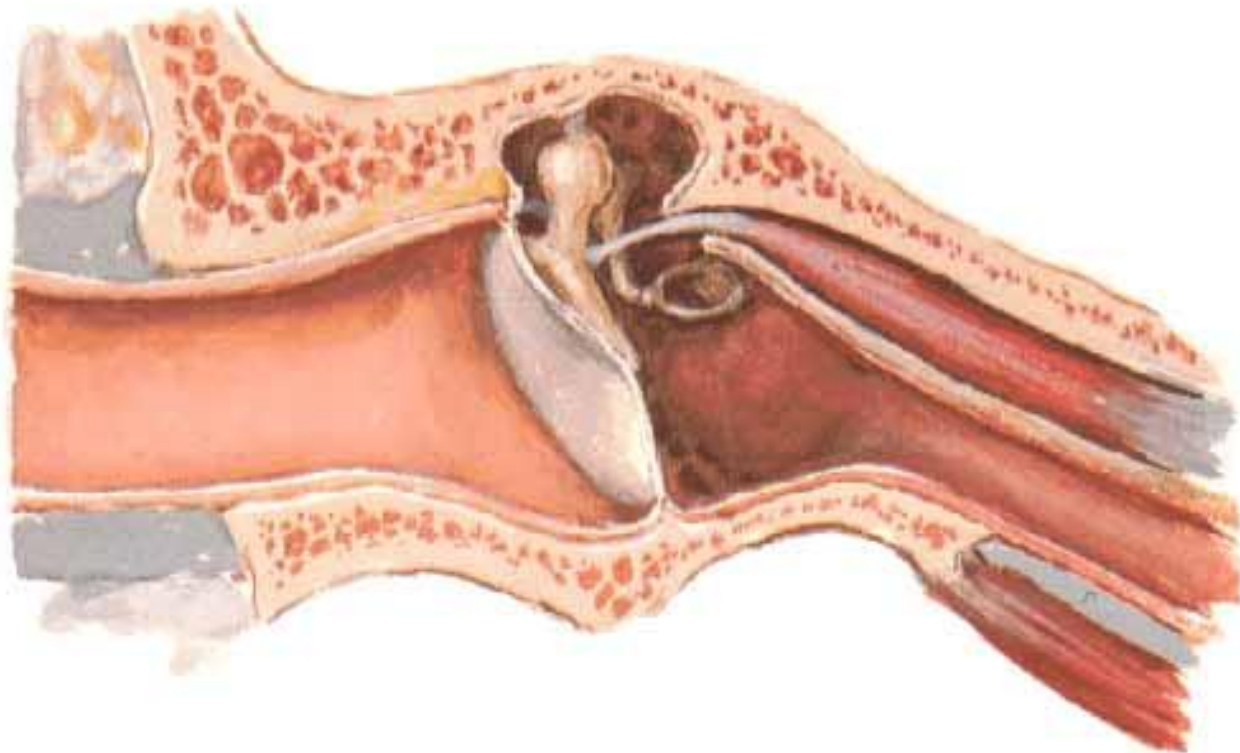


External acoustic meatus (*meatus acusticus externus*) *supply*

- arteries:
 - a. temporalis superficialis → rr. auriculares ant.
 - a. carotis externa → a. auricularis post.
 - a. maxillaris → a. auricularis prof.
- veins: v. temporalis superficialis, v. auricularis post.
- lymph: nn.ll. parotidei, mastoidei
- nerves: r. auricularis n.X. (dorsocaudal part), n. auriculotemporalis → r. meatus acustici externi

Tympanic membrane (*Membrana tympanica, Myrinx*)

External Ear and Tympanic Cavity
Coronal Oblique Section

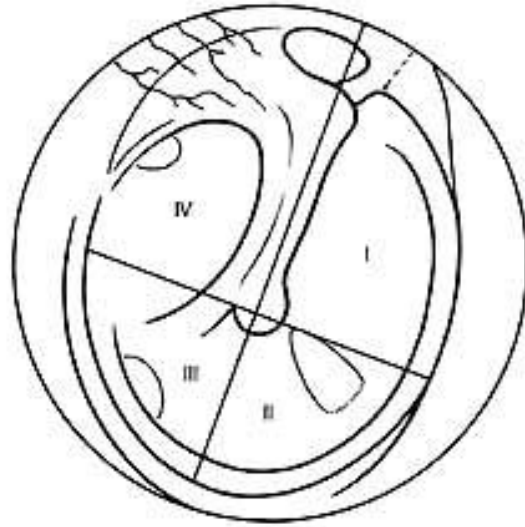


Tympanic membrane – *structure*

- sulcus tympanicus, incisura tympanica *Rivini*
- 9x10 mm, thickness 0,1 mm, surface 55 mm²
- anulus fibrocartilagineus

- outer surface – thinned epidermis (*ectoderm*)
- layer of dense connective tissue (*mesenchyme*)
- inner surface – simple cuboid epithelium (*endoderm*)

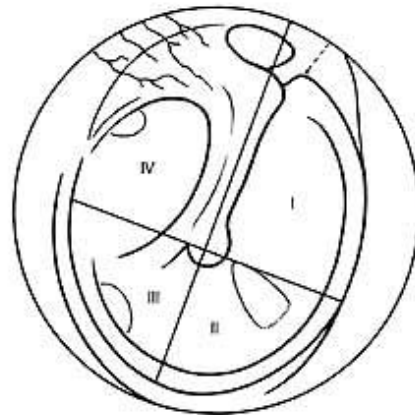
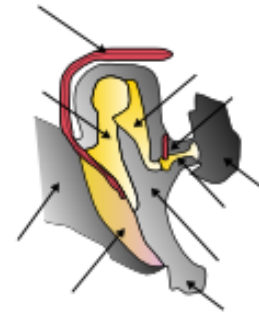
Tympanic membrane *Otoscopy*



- umbo m.t.
- stria mallearis
- promineta mallearis
- plica mallearis ant. + post.
- light reflex – trigonum of *Wilde*
(= cone of light, light reflex, Politzer's luminous cone)

Tympanic membrane – *Otoscopy*

- Bezold's trias: prominentia + stria + reflex
- pars flaccida *Shrapnelli* (5 mm²)
- pars tensa
- declination (50° sagittally)
- inclination (45° transversally)
- paracentesis: lower posterior quadrant



- Sir William Robert Wills **Wilde**
 - 1815 – 1876
 - son – Oscar Wilde
 - trigonum *Wildei* (cone of light)



- Friedrich **Bezold**
 - 1842 – 1908
 - examination of hearing by tuning fork
 - trias



External Ear

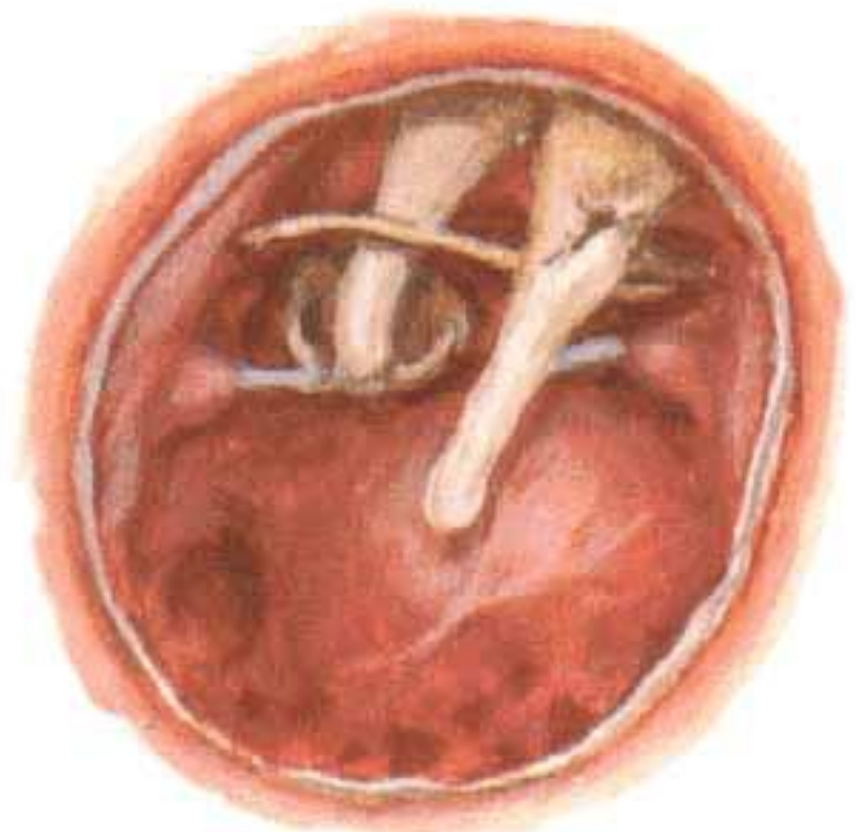
Right Tympanic Membrane



Viewed through speculum

Tympanic Cavity

Viewed from External Acoustic Meatus



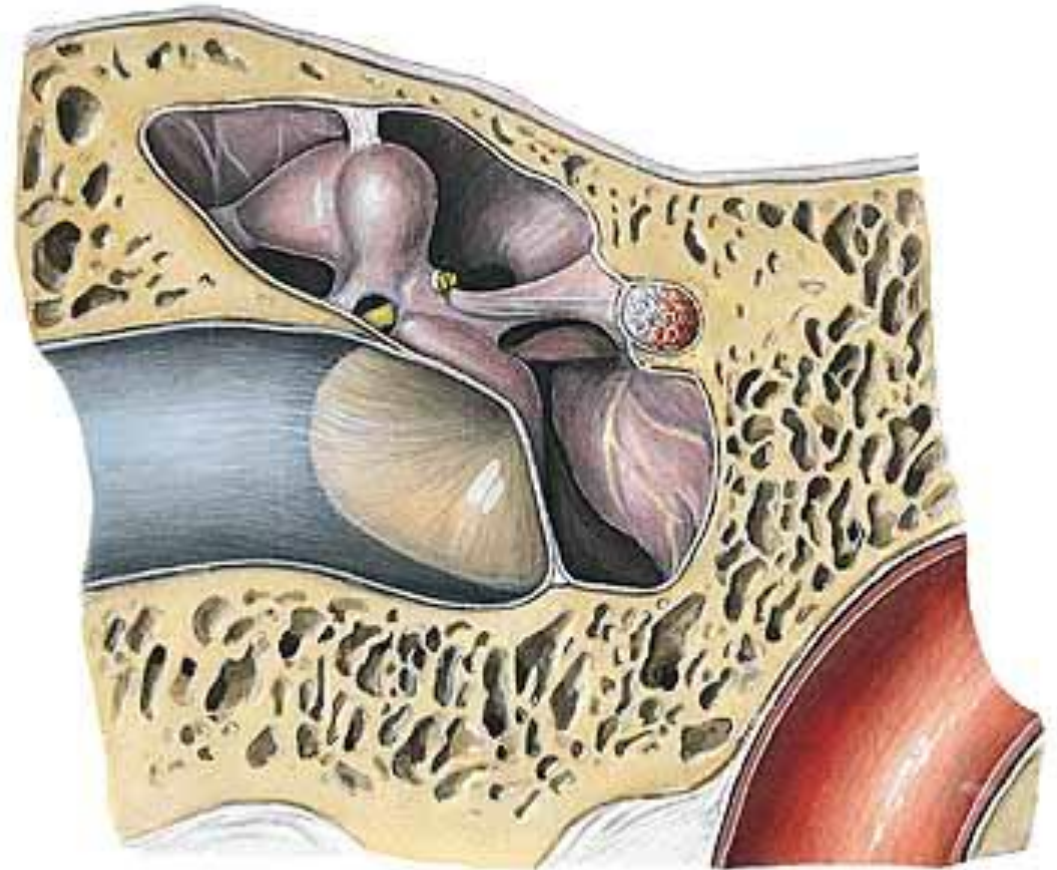
Tympanic Membrane Removed

Tympanic membrane – *supply*

- arteries:
 - a. maxillaris → a. auricularis prof. (*outer surface*)
 - aa. tympanicae (*inner surface*)
- lymph: nnl.l. mastoidei, parotidei
- nerves:
 - a. auricularis n.X.
 - n. auriculotemporalis → r. membranae tympani

Middle ear (*Auris media*)

- Tympanic cavity
(*Cavitas tympani*)
- Auditory ossicle
(*Ossicula auditus*)
- Articulations of auditory ossicles (*Articulationes ossiculorum auditus*)
- Muscles and ligaments auditory ossicles
(*Musculi et ligamenta ossiculorum auditus*)
- Auditory tube
(*Tuba auditiva Eustachii*,

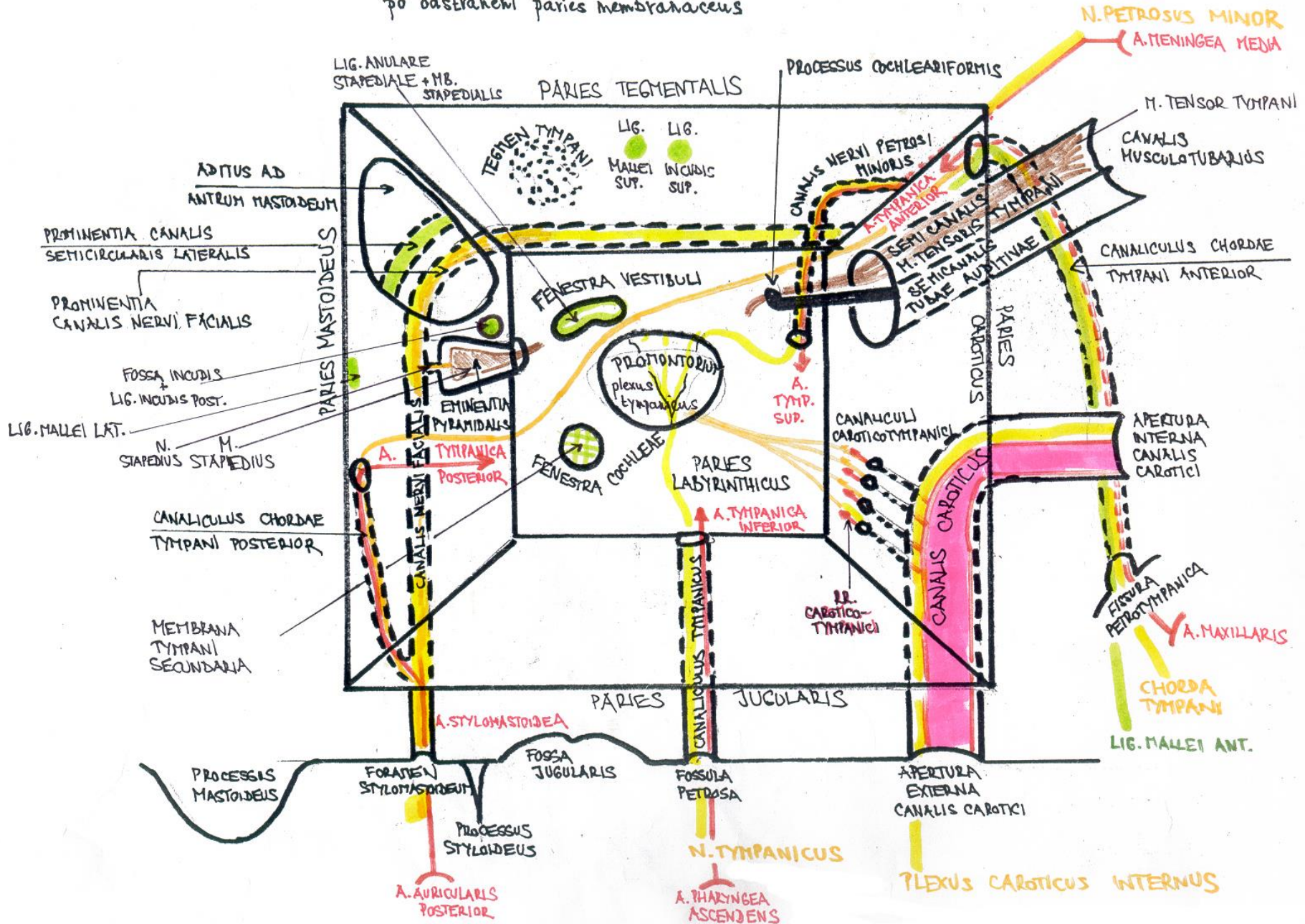


Tympanic cavity (*Cavitas tympani*) *walls*

- paries **tegmentalis**
- paries **jugularis**:
 - prominetia styloidea
 - apertura tympanica canaliculi tympanici
- paries **mastoideus**
- paries **caroticus**
- paries **membranaceus** = **membrana tympani**
- paries **labirinthicus**

CAVITAS TYMPANI

po odstranění l. dx.
paries membranaceus



Cavitas tympani paries labyrinthicus

- **promontorium**

= first turn of cochlea

- sulcus promontorii
(plexus tympanicus)

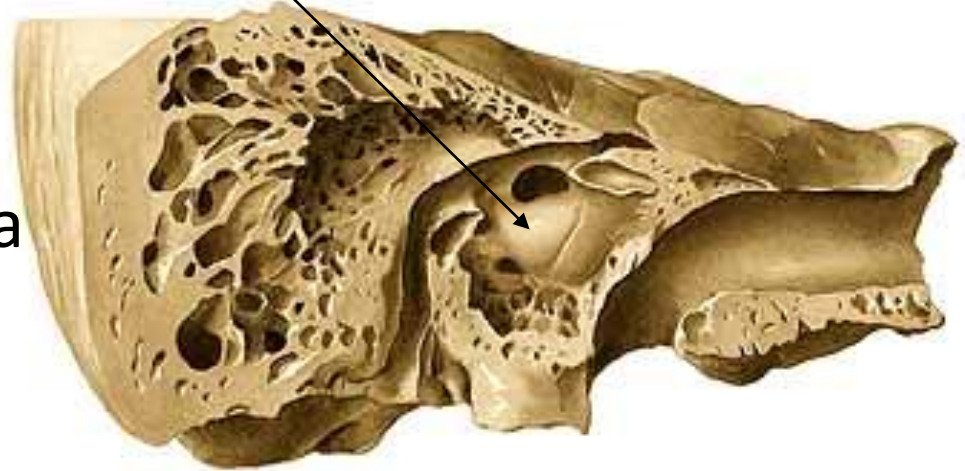
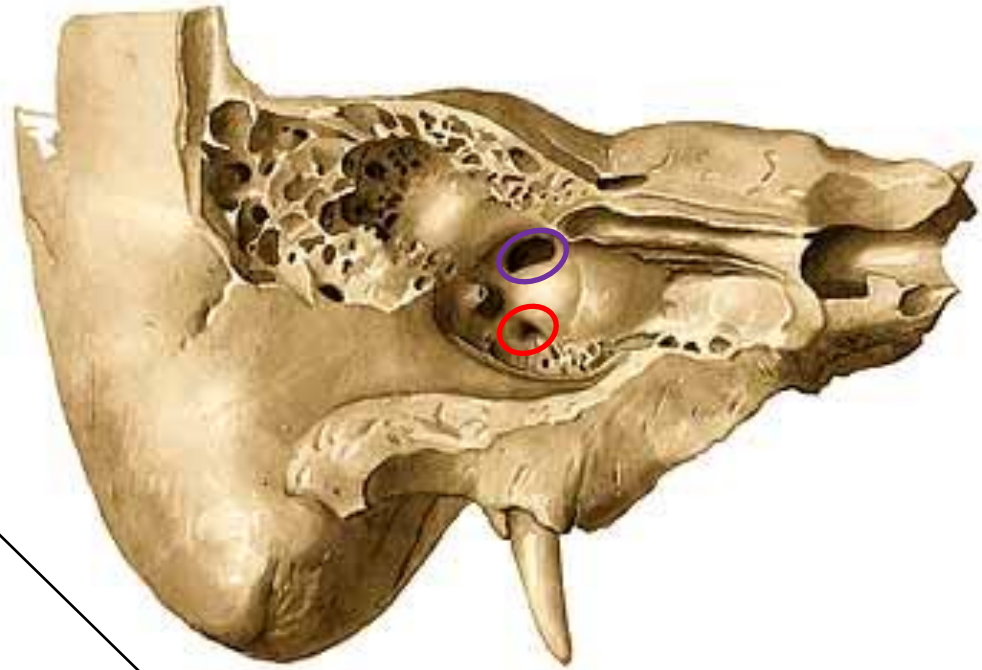
- **fenestra vestibuli**

(f. ovalis = oval window)

- basis stapedis +
membrana stapedia

- **fenestra cochlae** (f. rotunda
= round window)

- membrana tympani
secundaria

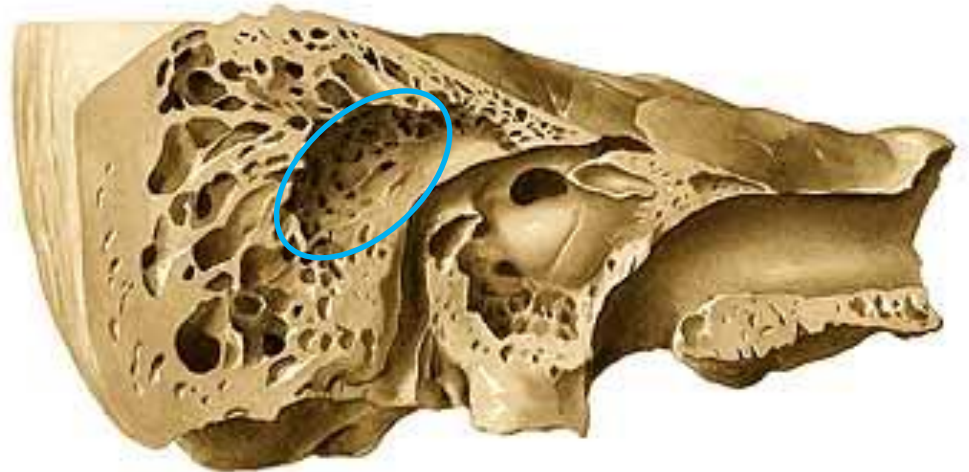
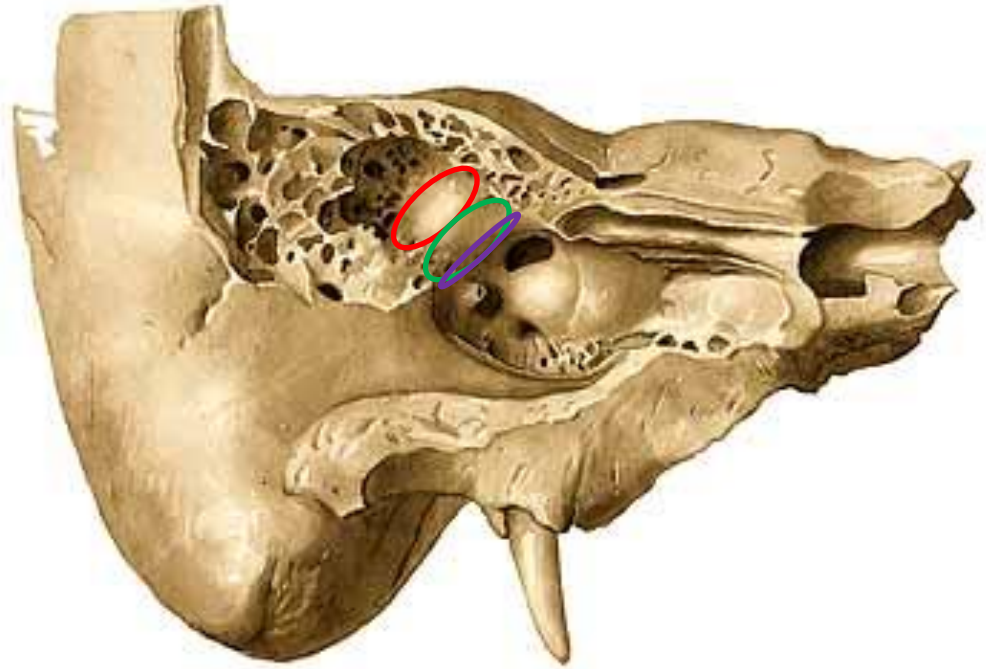


Cavitas tympani paries mastoideus

- **aditus antri
mastoidei**

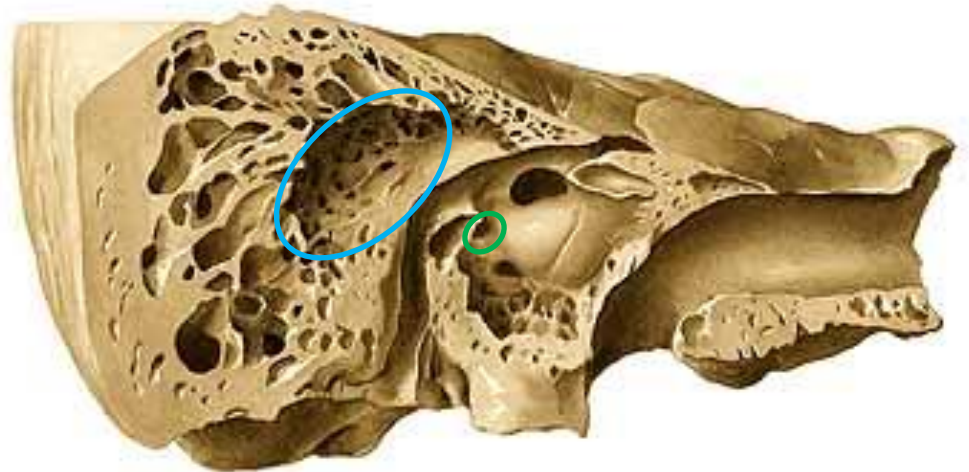
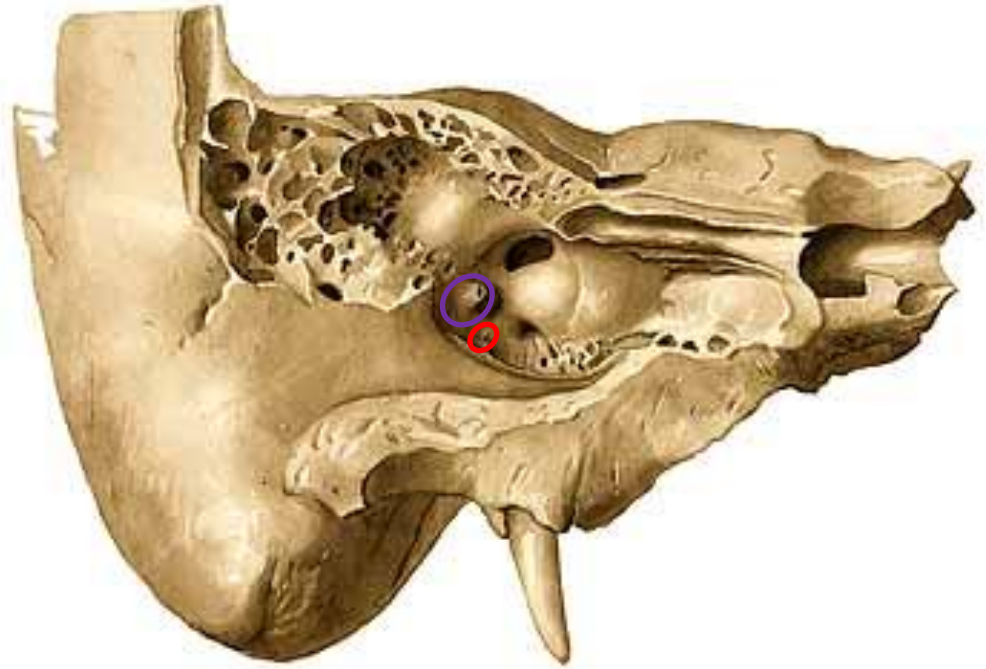
= entrance to **antrum
mastoideum** + cellulae
mastoideae

- **prominentia canalis
semicircularis
lateralis**
- **prominentia canalis
nervi facialis**



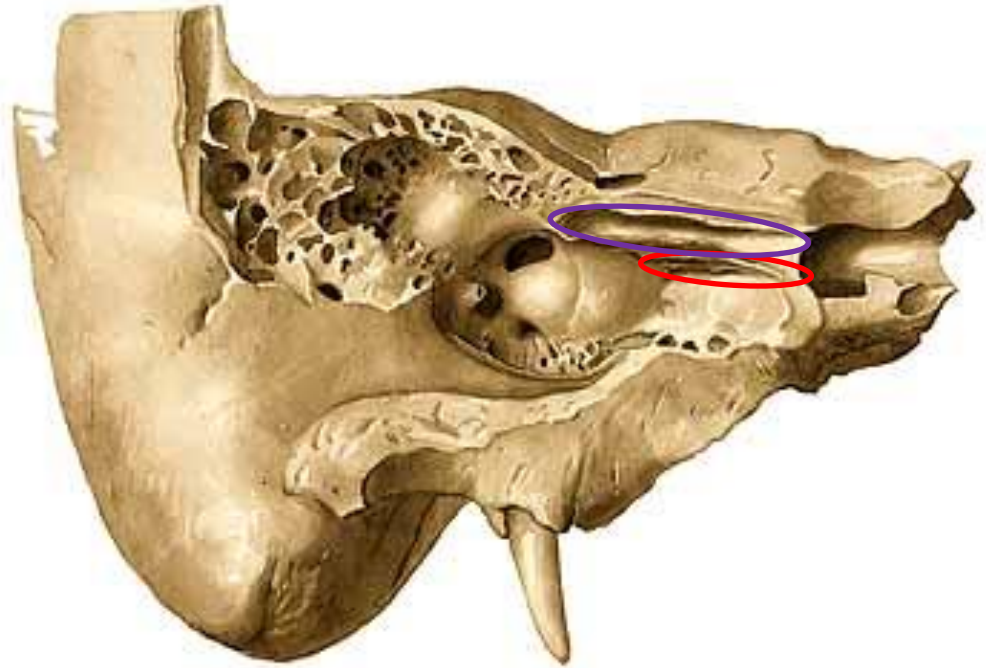
Cavitas tympani paries mastoideus

- eminentia pyramidalis
- eminentia chordae tympani
 - apertura tympanica canaliculi chordae tympani posterioris
- sinus tympani
- fossa incudis



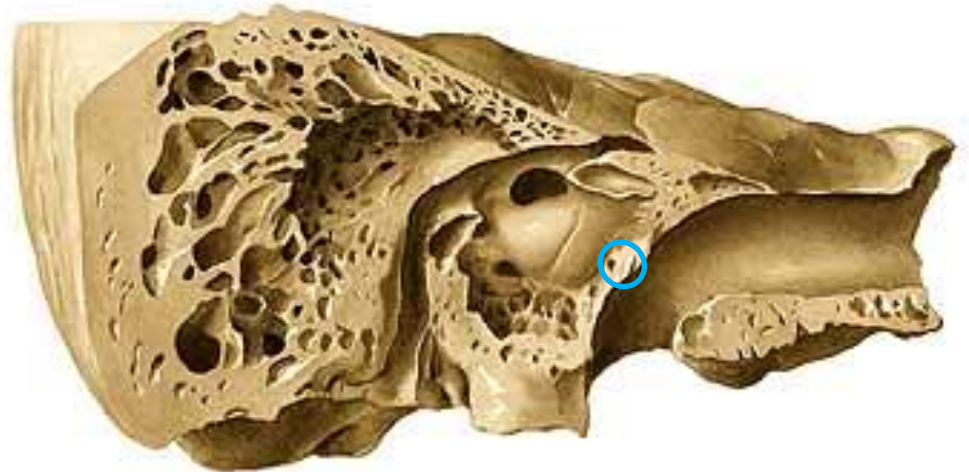
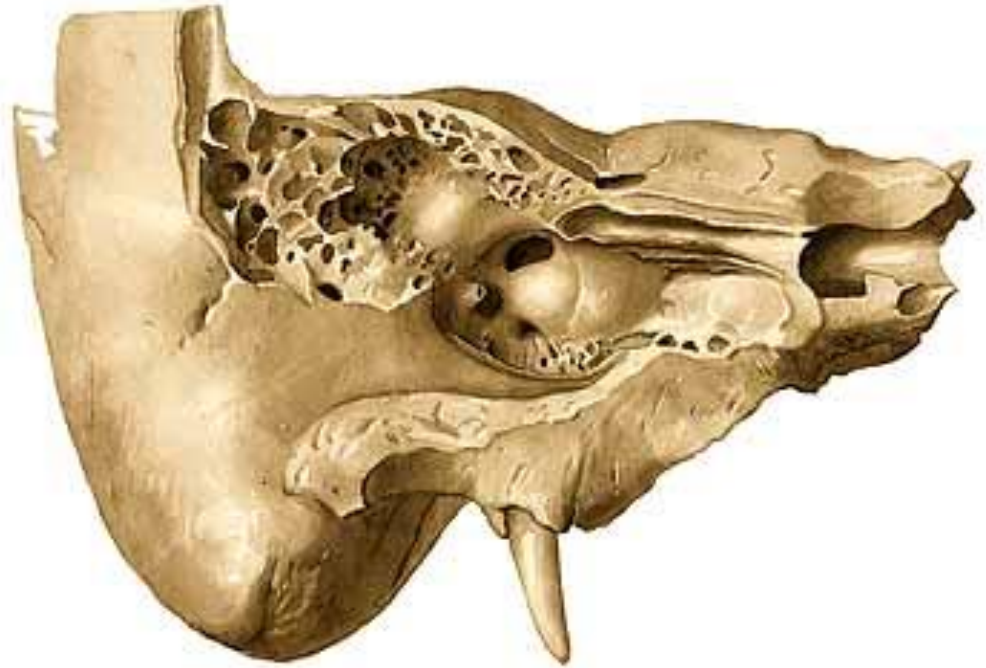
Cavitas tympani paries caroticus

- apertura tympanica
canalis nervi petrosi
minoris
- **canalis musculotubarius**
 - semicanalis m. tensoris
tympani
 - processus
cochleariformis
 - **semicanalis tubae
auditivae**

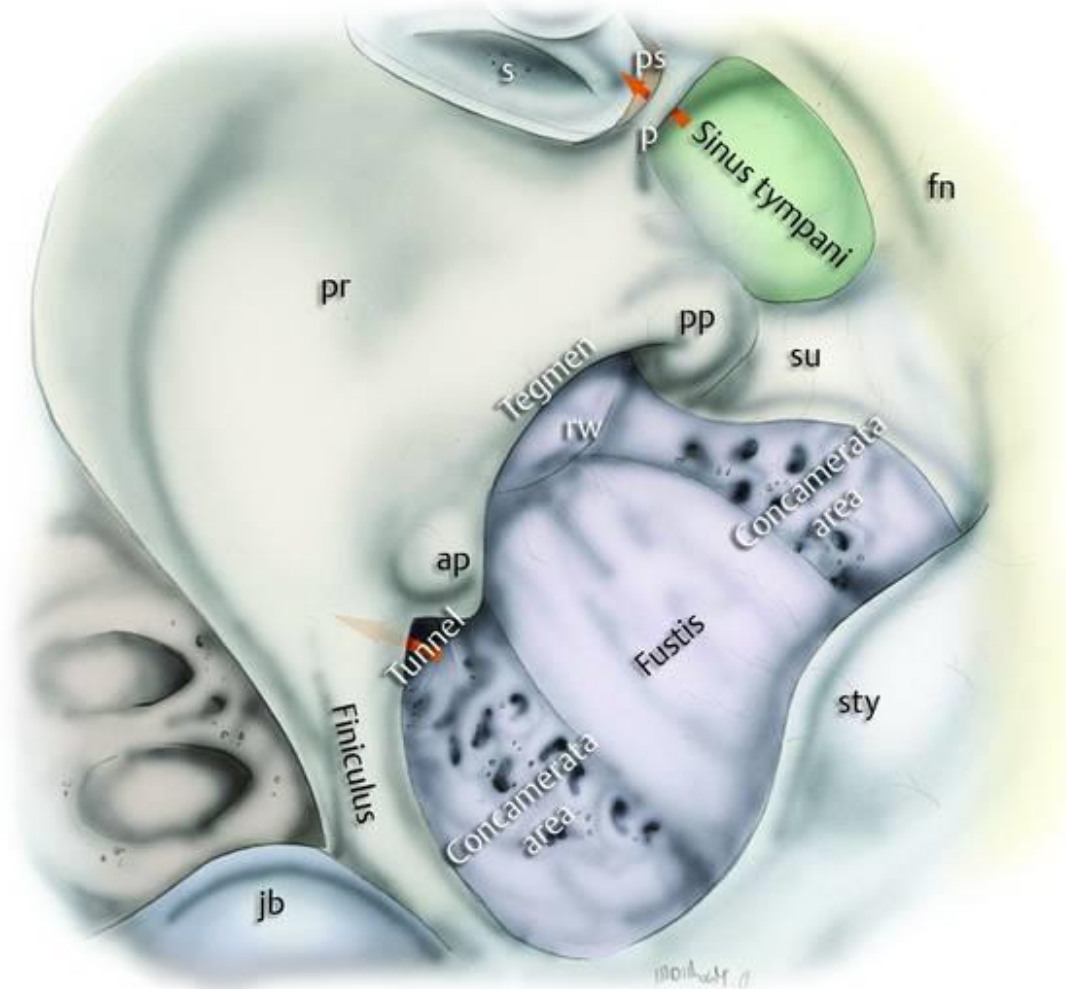


Cavitas tympani paries caroticus

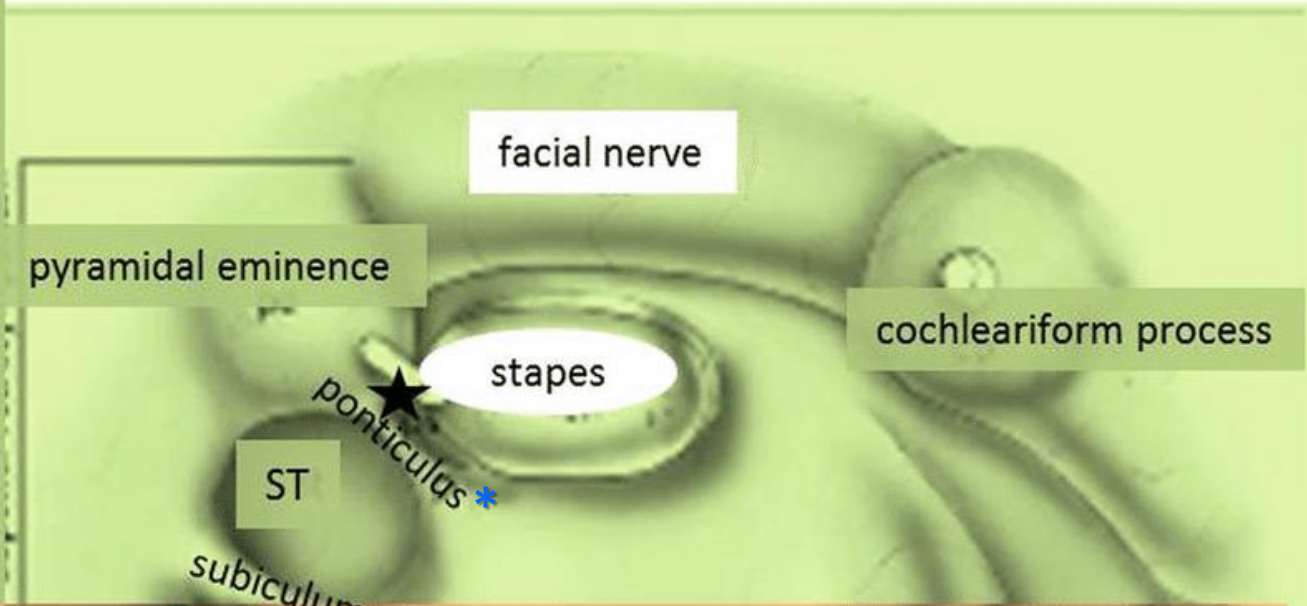
- apertura tympanica
canaliculi chordae
tympani anterioris
(*Huguieri*)
- fissura petrotympanica
(*Glaseri*)
- canaliculi
caroticotympanici



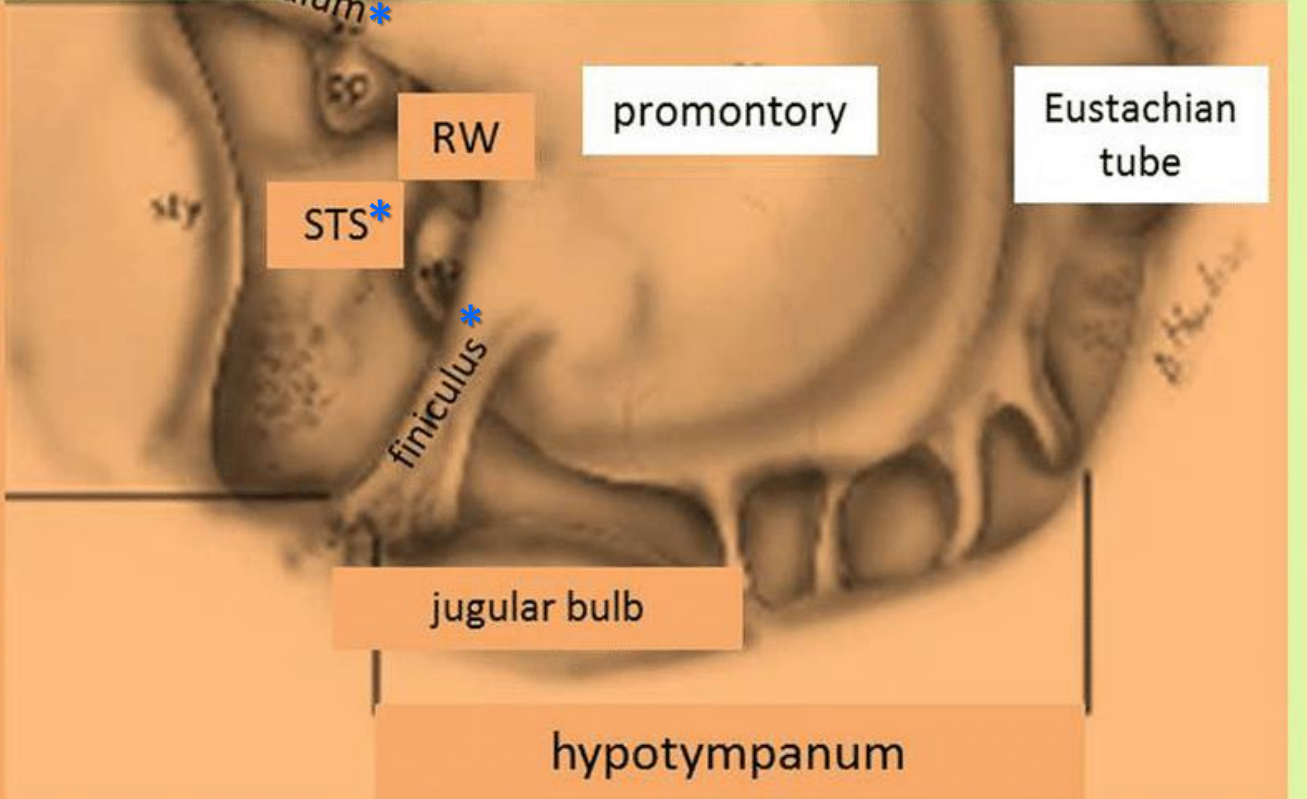
Cavitas tympani paries labyrinthicus – further details*



upper retrotymppanum



lower retrotymppanum



Tympanic cavity – *supply*

- arteries: **4 aa. tympanicae**, rr. caroticotympanici
- veins: vv. tympanicae to plexus pterygoideus + sinus petrosus sup.
- lymph: nn.ll. parotidei, mastoidei, cervicales profundi, retropharyngei
- nerves:
 - n. tympanicus (n.IX) – somatosensory + parasympathetic (ganglion tympanicum)
 - r. pharyngeus (n.V2) for cartilaginous part of auditory tube
 - nn. caroticotympanici (sympathetic)

Auditory ossicles (*Ossicula aditus*)

Malleus (*Hammer*)

- caput
- collum
- manubrium
 - processus spatuliformis
- processus lateralis
- processus anterior



Auditory ossicles (*Ossicula auditus*)

Incus (*Anvil*)

- corpus
- crus longum
 - processus lenticularis
- crus breve



Stapes (*Stirrup*)

- caput
- (collum)
- crus anterior + posterior
- basis



Joints of auditory ossicles (*Articulationes ossiculorum auditus*)

- syndesmosi tympanomallearis
- art. incudomallearis (saddle-shape)
- art. incudostapedialia (ball-and-socket)
- syndesmosis tympanostapedialis

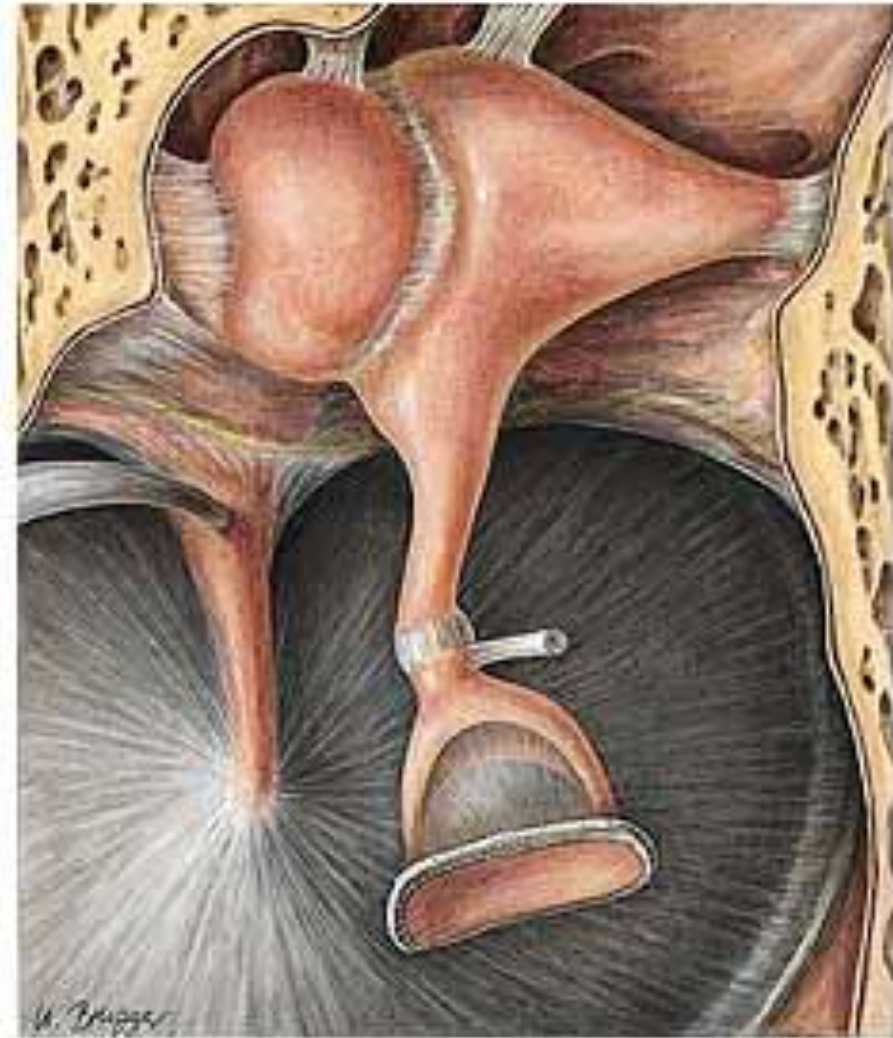
otosclerosis – *ossification*

*sometimes both articulations
are replaced with
syndesmosis*



Ligaments (*Ligg. ossiculorum auditus*)

- **lig. mallei ant.** (spina o.s.)+
sup.+ lat.
- **lig. incudis sup.** (fossa i.) +
post.
- **membrana stapedialis**
(between crura stapedis)
- **lig. anulare stapediale**
(fenestra vestibuli)
- **membrana tympani
secundaria**
(fenestra cochleae)



Muscles of auditory ossicles

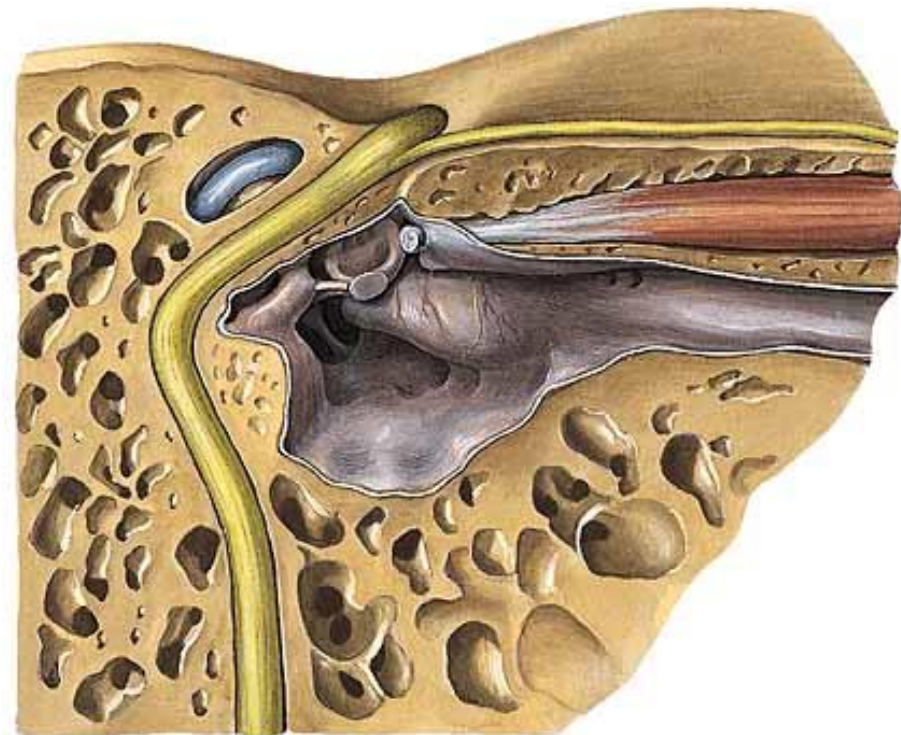
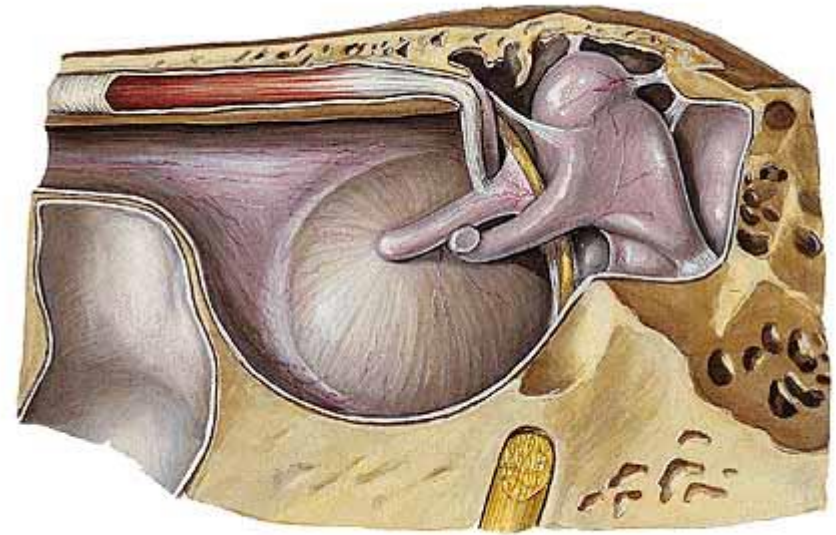
- **m. tensor tympani**
 - semicanalis m.t.t.
 - processus cochleariformis
 - manubrium mallei

innervation: n.V3

- **m. stapedius**
 - eminentia pyramidalis
 - collum stapedis

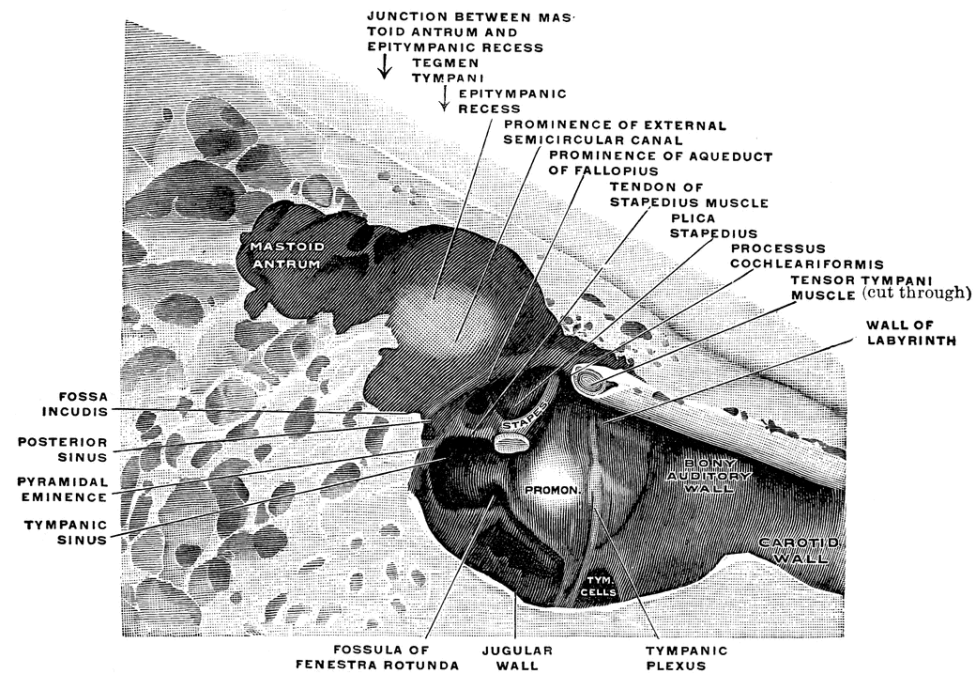
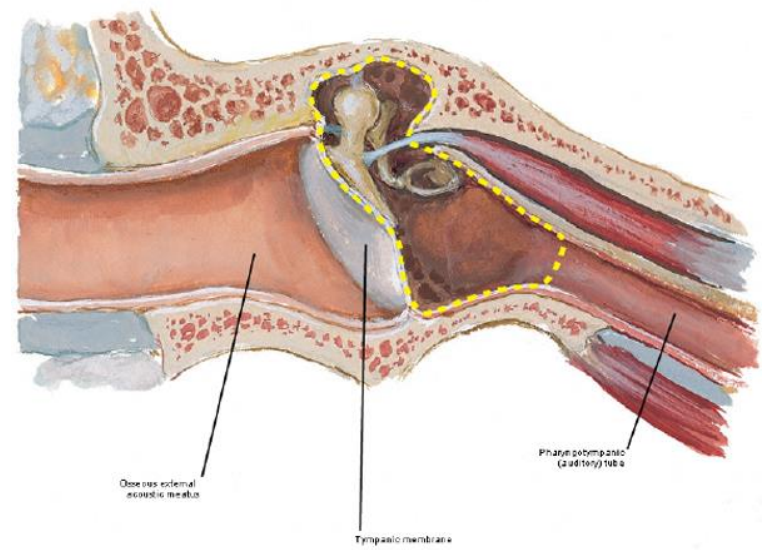
innervation: n.VII

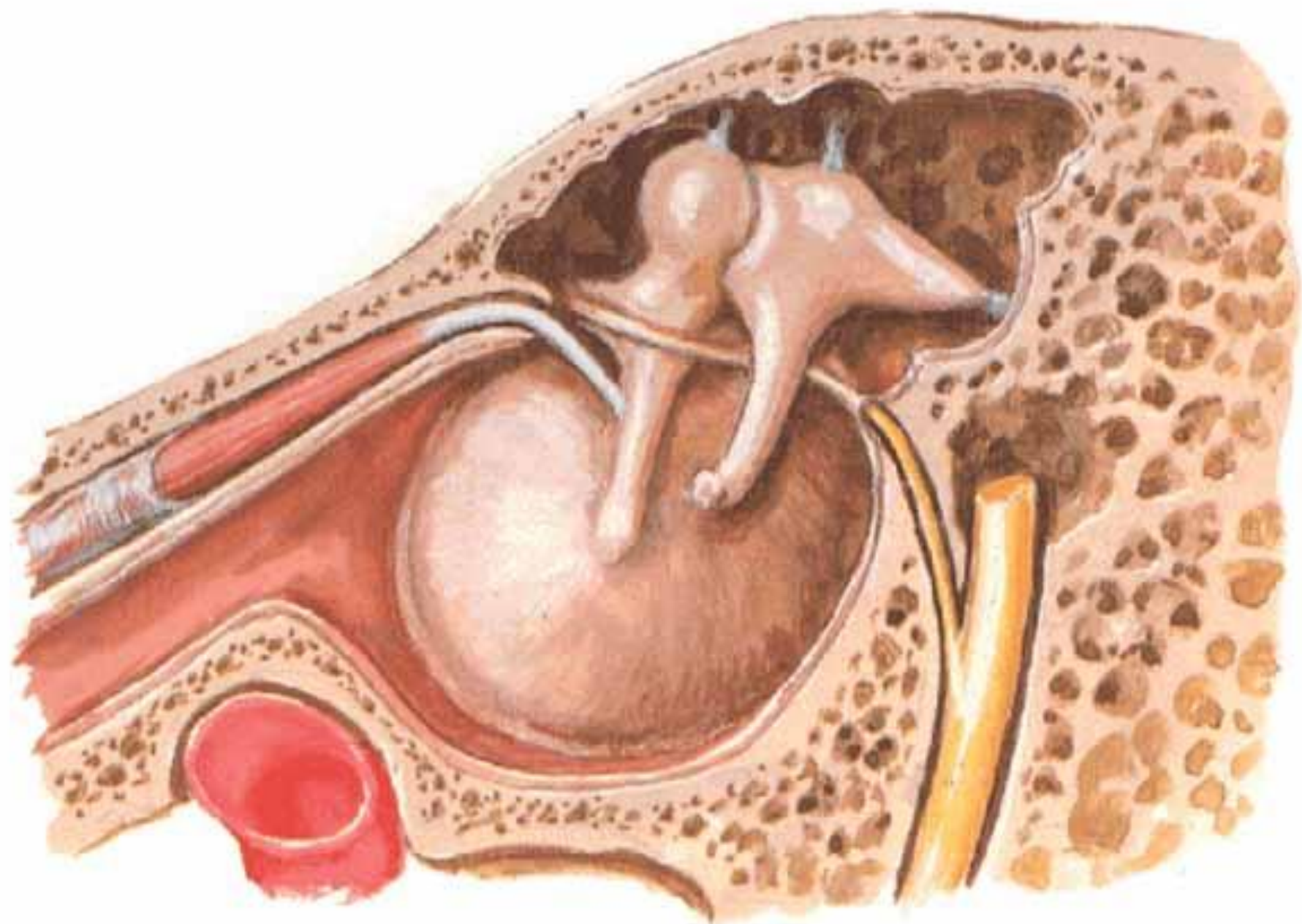
n. stapedius from pars
mastoidea canalis nervi
facialis



Middle ear cavity

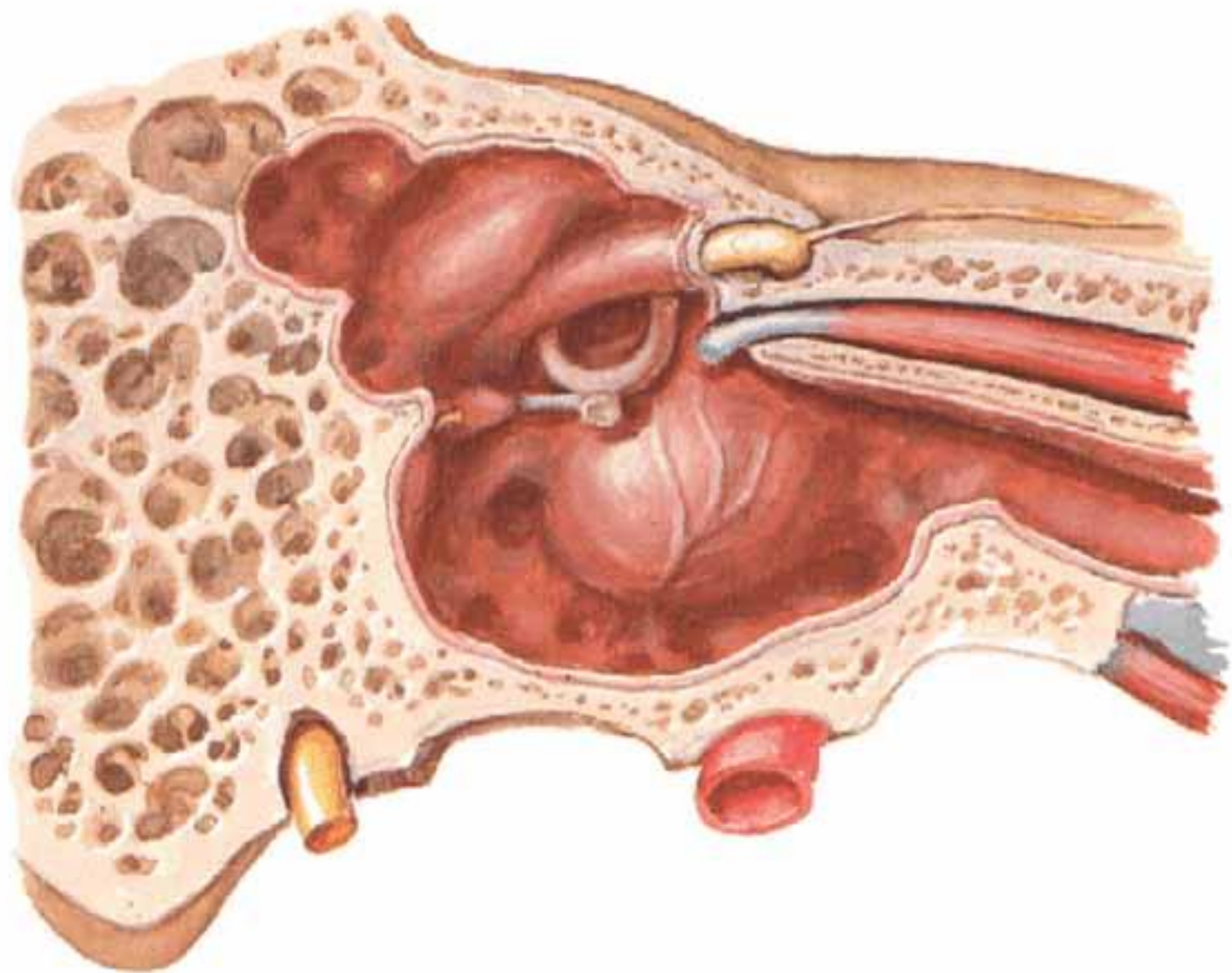
- cavitas tympani propria
 - recessus epitympanicus
 - recessus hypotympanicus
- extensions:
 - antrum mastoideum
 - cellulae mastoideae
 - celullae tympanicae
 - cellulae accessoriae
 - protypanum (*tuba auditiva Eustachii*)





Tympanic cavity

- shape of hourglass– 2 mm at level of tympanic membrane (= mesotympanon)
- recessus epitympanicus (= **atticus**, epitympanon, epitympanum) – 6 mm
- recessus hypotympanicus (hypotympanon) – 4 mm
- plicae malleares ant.+ post. → recessus ant.+ sup. (*Tröltsch's space*) + post. (*Prussak's space*)
- plica chordae tympani, incudialis, stapedialis
- mucosa – simple cuboid epithelium (various height)
- *neither goblet cells nor glands*
 - *only close to ostium pharyngeum tubae auditivae*



- aditus antri mastoideim

- **cellulae mastoideae**

*(developing postnatally –
6th year of age)*

- pneumatic type

- diploic type

- sclerotic type

- cellulae tympanicae

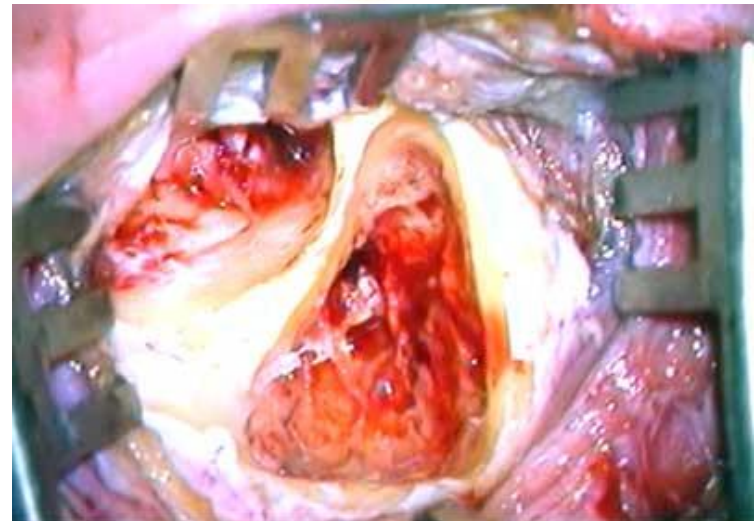
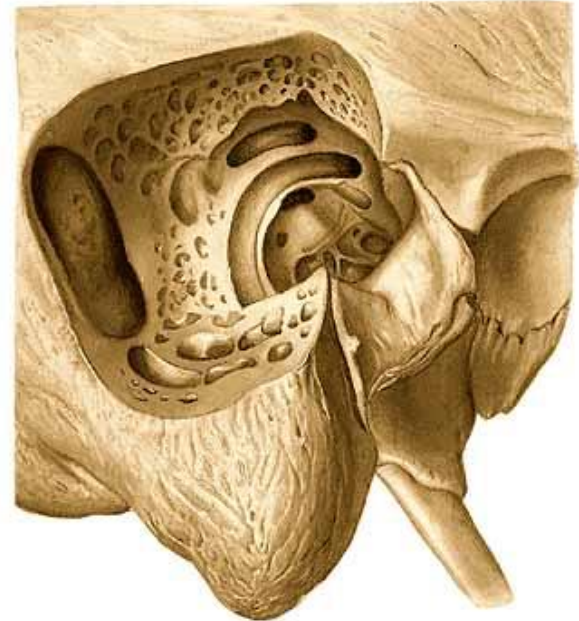
- simple flat epithelium

- **closely related to sinus
sigmoideus**

- *mastoidectomy*

Mastoid antrum

(Antrum mastoideum)

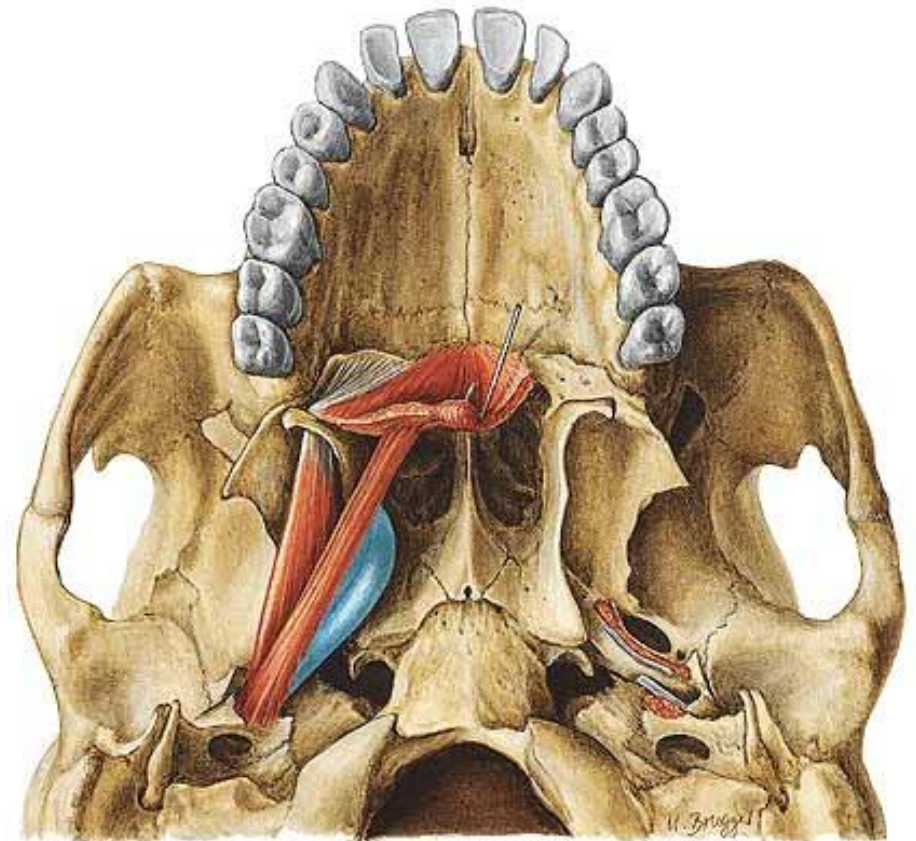


Auditory tube (*Tuba auditiva*)

Tuba auditoria, tuba pharyngotympanica
(pharyngotympanic tube), *salpinx, tuba Eustachii*

- ostium tympanicum
- pars ossea (= semicanalis t.a.) – cellulae pneumaticae
- pars cartilaginea – cartilago (lamina med.+ lat., lamina membranacea) – tonsilla tubaria
Gerlachi located under the mucosa
 - *in hypertrophy of tonsilla pharyngea* →
ventilation disturbance (mainly in children) →
mesotitis
- ostium pharyngeum (at level of meatus nasi inf.)

Auditory tube (*Tuba auditiva*)



Auditory tube (*Tuba auditiva*)

Tuba auditoria, tuba pharyngotympanica
(pharyngotympanic tube), *salpinx, tuba Eustachii*

- equalizes pressure in pharynx and in tympanic cavity
- width 2 mm, length 40 mm
- transition of pseudostratified columnar epithelium into simple columnar
- glandulae tubariae, goblet cells – *in cartilaginous part*
- **in children: more, horizontal, shorter and wider**
- *cathetrization via nasal cavity*

Auditory tube (*Tuba auditiva*)

Tuba auditoria, tuba pharyngotympanica
(pharyngotympanic tube), *salpinx, tuba Eustachii*

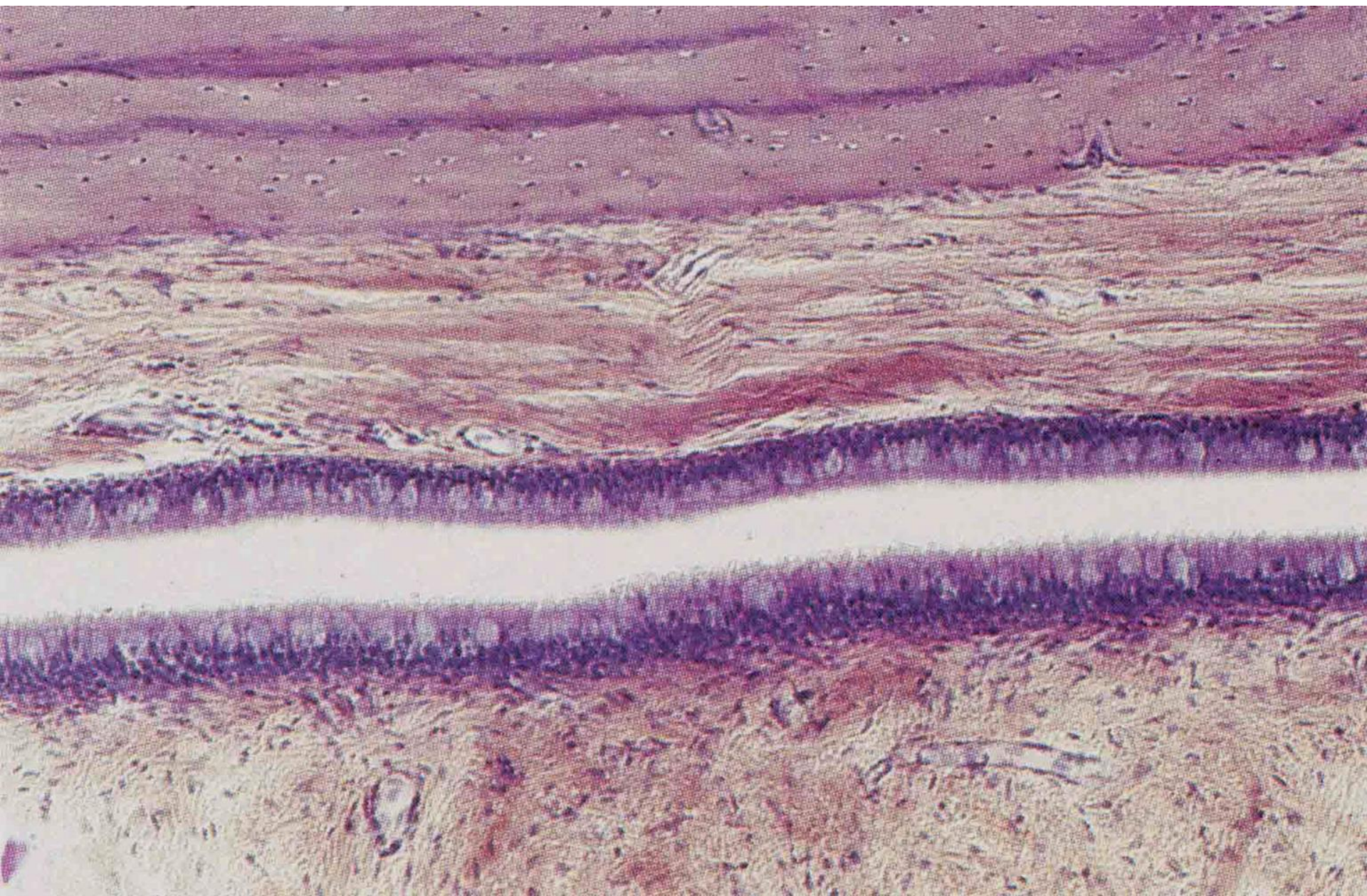
opened by:

- m. tensor tympani
- m. salpingopharyngeus

? role of m. levator veli
palatini unclear

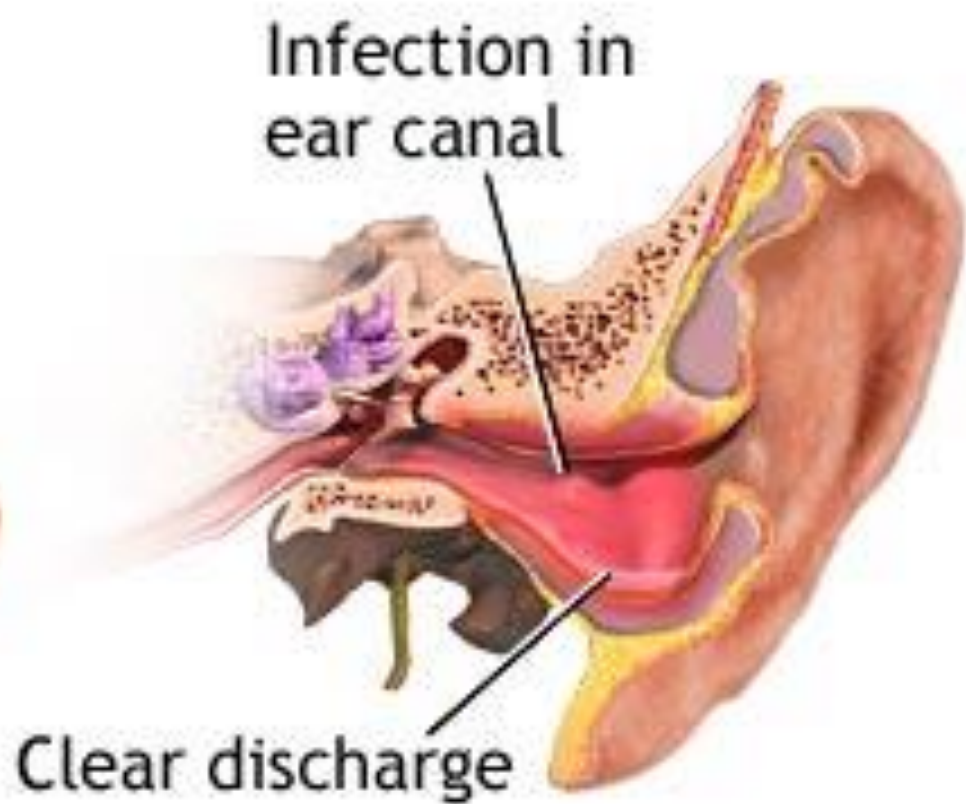
- corpus adiposum tubae
auditivae (Ostmann's fat pad)

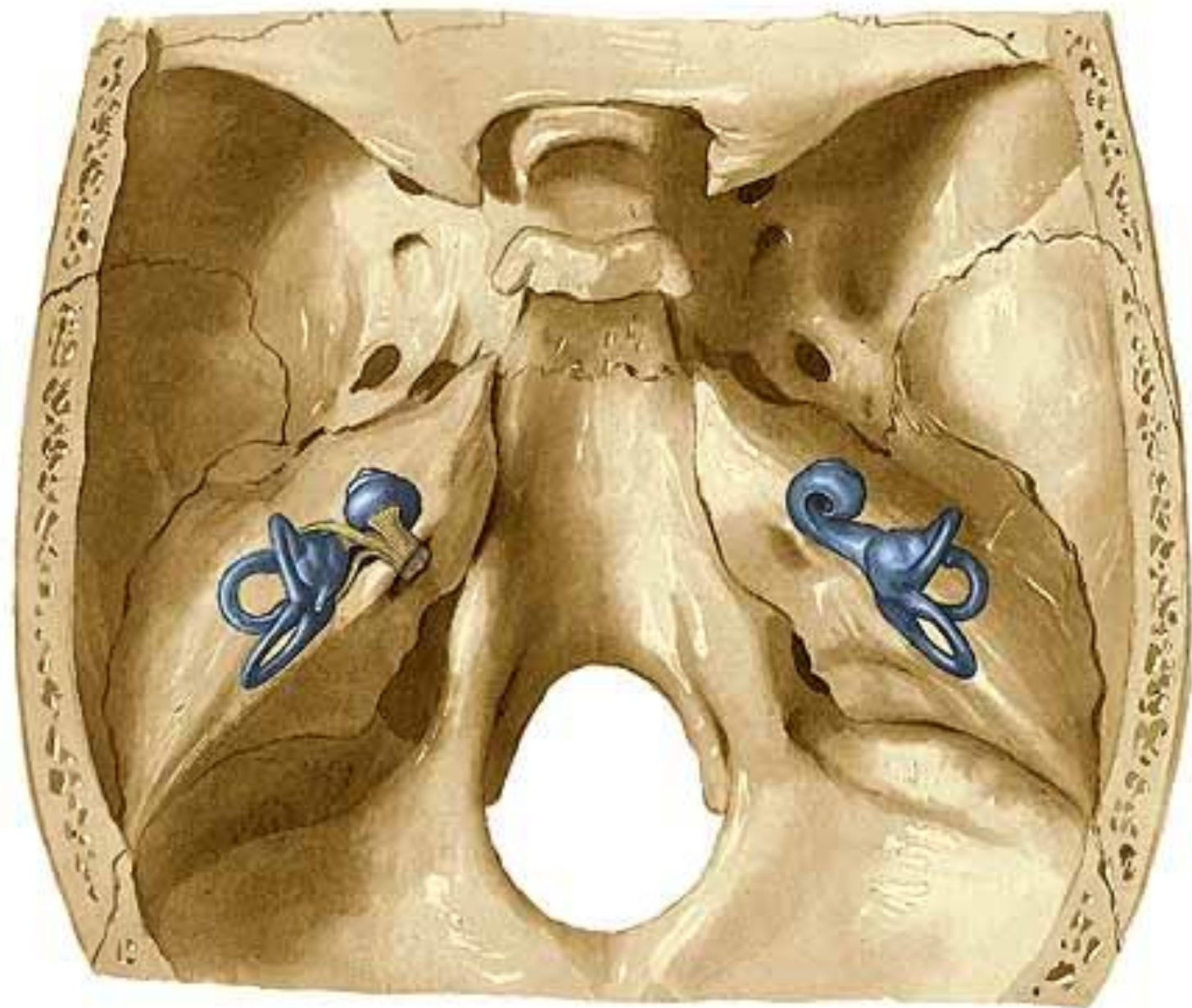




Internal ear (*Auris interna*)

- organum vestibulocochleare
- osseous labyrinth (*labyrinthus osseus*)
 - vestibule (*vestibulum*)
 - semicircular canals (*canales semicirculares*)
 - *cochlea*
 - internal acoustic meatus (*meatus acusticus internus*)
 - spatium perilymphaticum
- membranous labyrinth (*labyrinthus membranaceus*)
 - labyrinthus vestibularis
 - labyrinthus cochlearis
 - spatium endolymphaticum



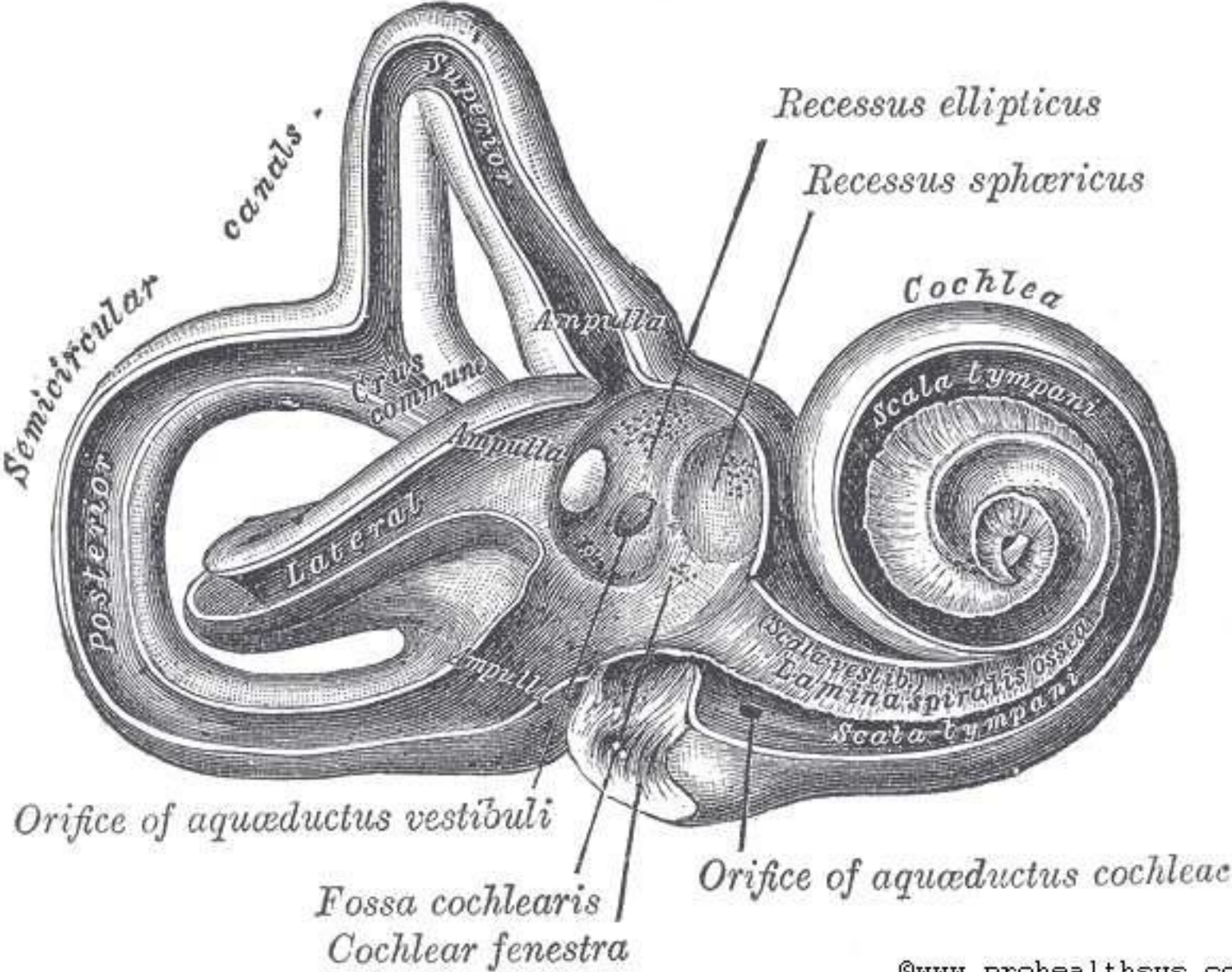


Osseous labyrinth (*labyrinthus osseus*) vestibule (*vestibulum*)

- **recessus ellipticus** (utricularis)
 - apertura interna canaliculi vestibuli
 - macula cribrosa superior
- crista vestibuli (pyramis vestibuli)
- **recessus sphericus** (saccularis)
- **recessus cochlearis**
 - macula cribrosa media
- macula cribrosa inferior (in ampulla canalis semicircularis posterioris)

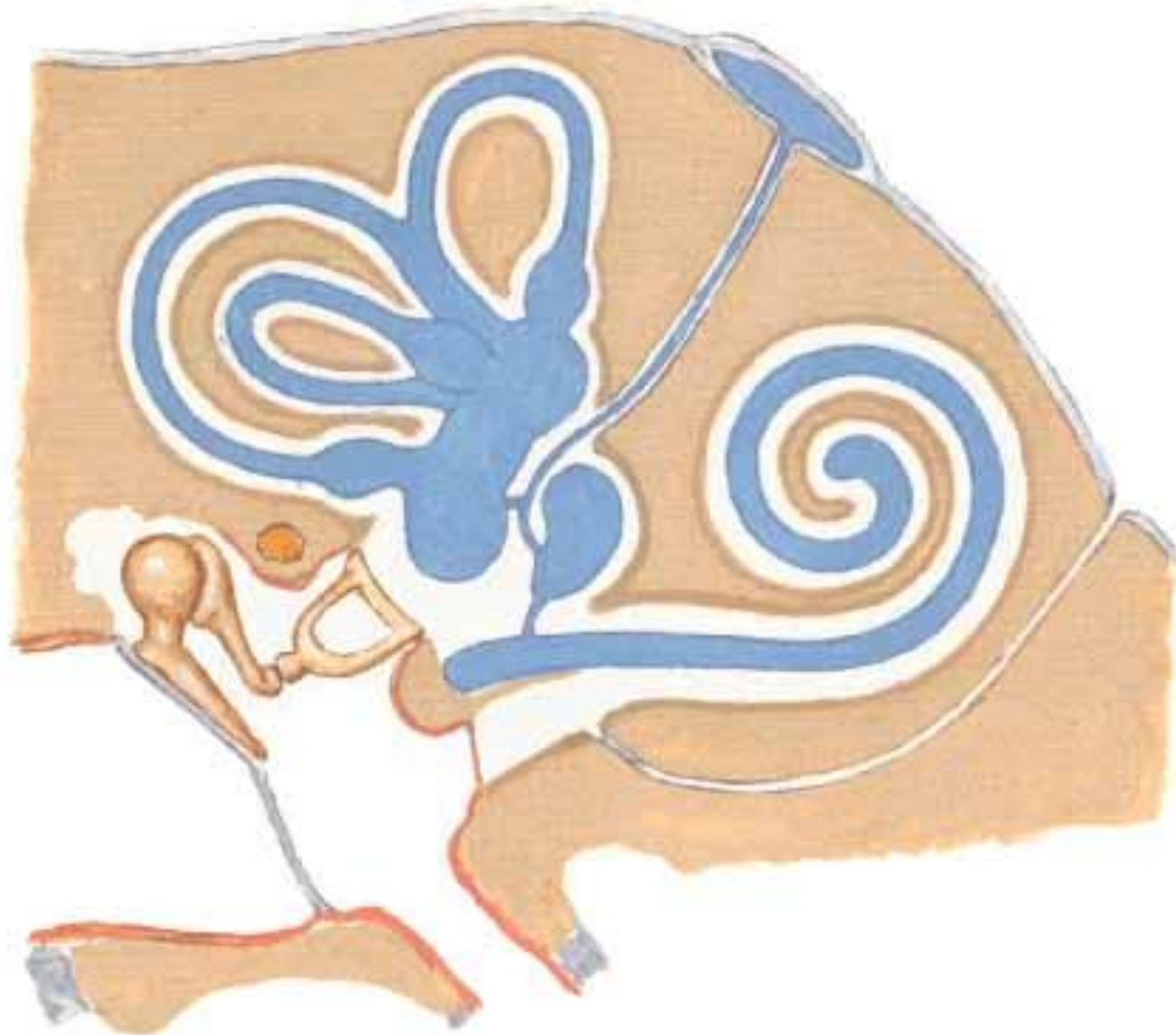


Osseous labyrinth (*labyrinthus osseus*)



Bony and Membranous Labyrinths

Schema

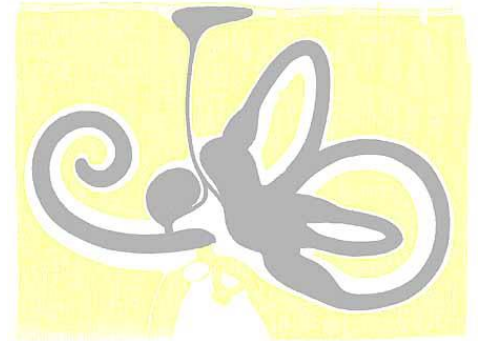


Membranous labyrinth

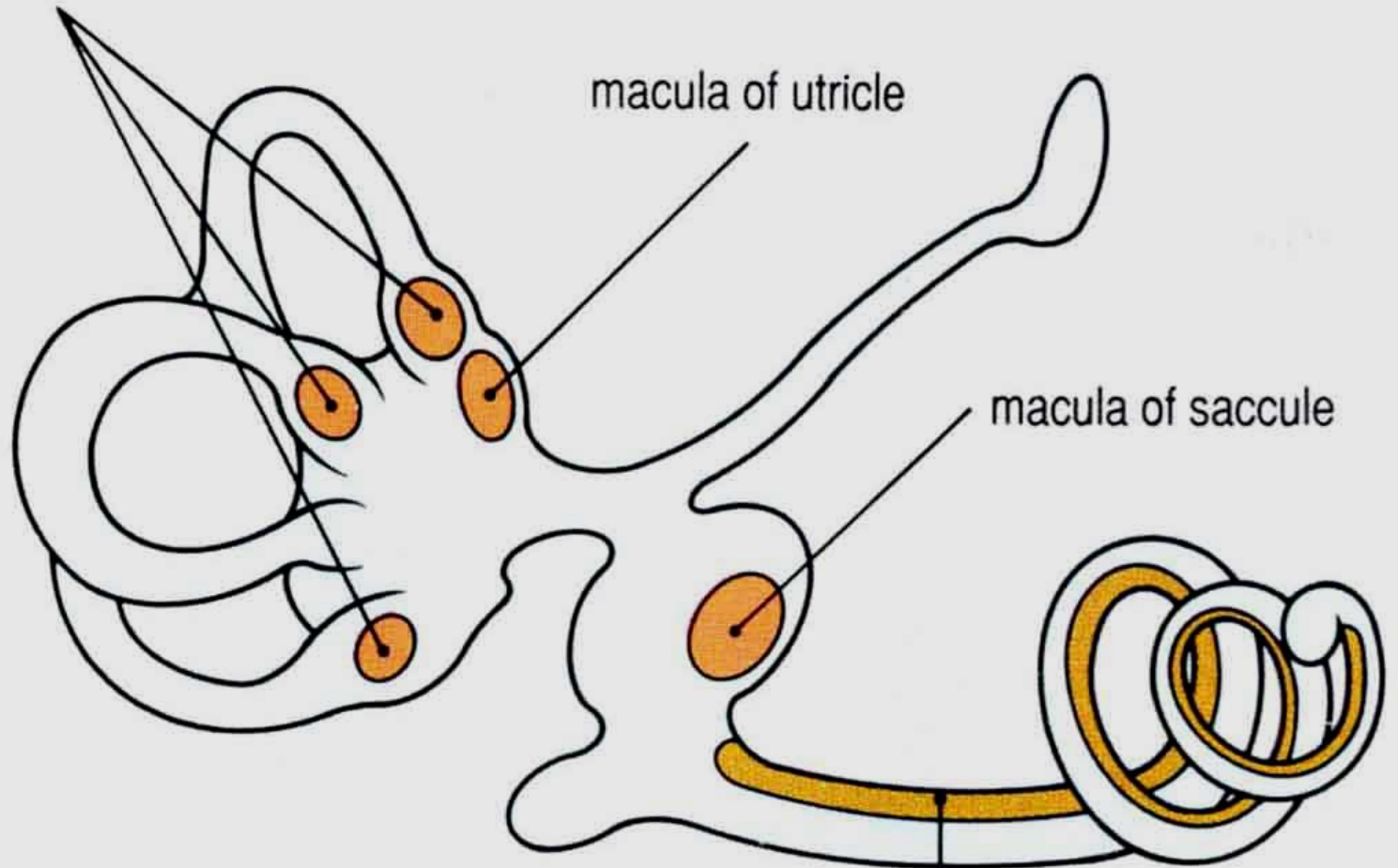
(Labyrinthus membranaceus)

Vestibular labyrinth (*Labyrinthus vestibularis*)

- utricle (*utricleus*)
- saccule (*sacculus*)
- semicircular ducts (*ductus semicirculares*)
 - ampullae, crura
- ductus utriculosaccularis, reuniens
- macula utriculi, sacculi
 - membrana statoconiorum (statoconium, striola)
- crista ampullaris (sulcus, cupula)



ampullae of semicircular
canals



macula of utricle

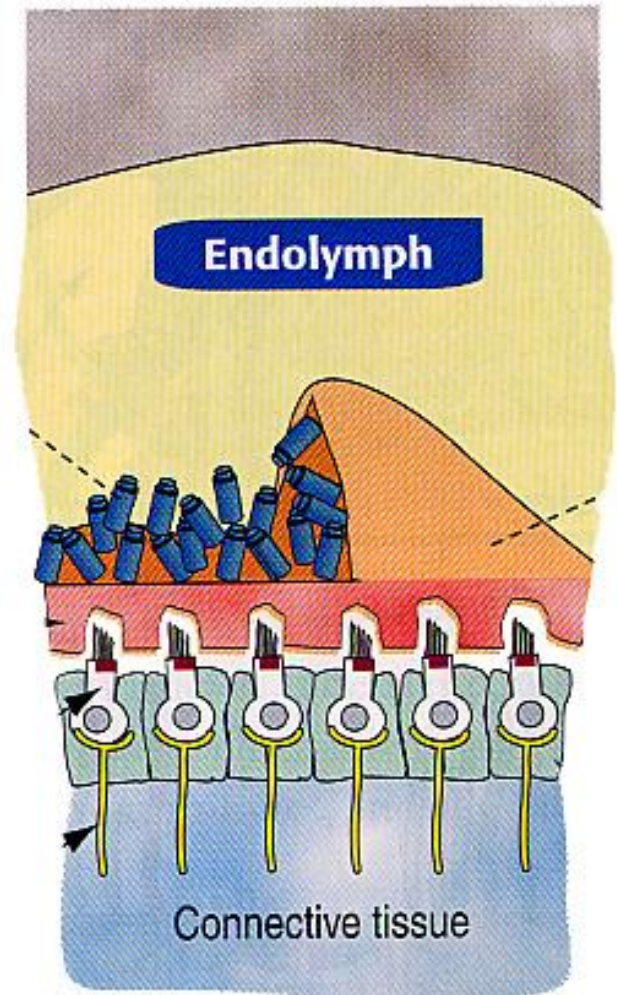
macula of saccule

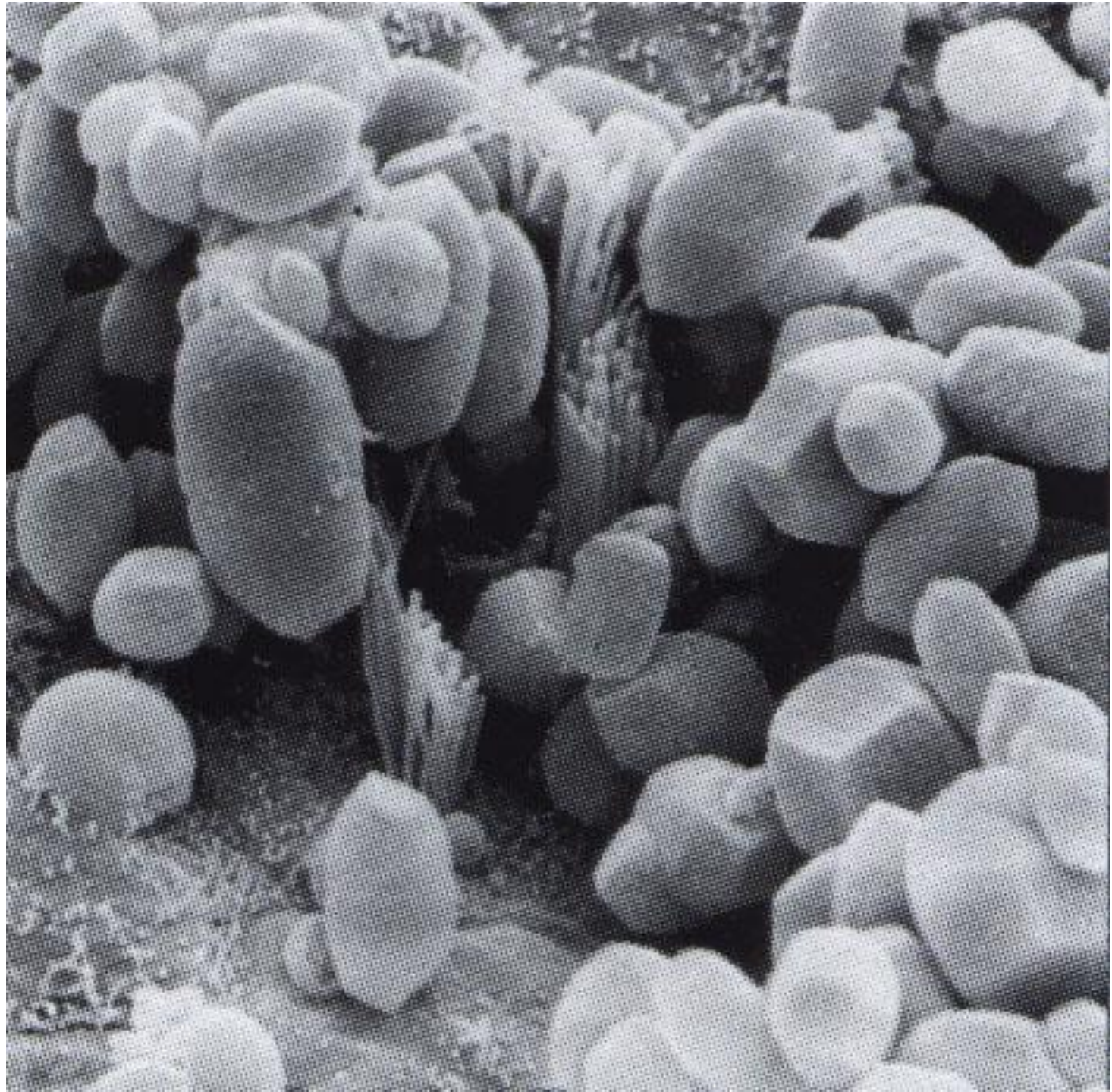
organ of Corti
of cochlea

Otolithic organs

sacculus et utriculus

- macula
- hair cells
- supporting cells
- gelatinous layer
- **otoconia** – crystals of CaCO_3
 - *otoliths* = term for crystal in reptiles



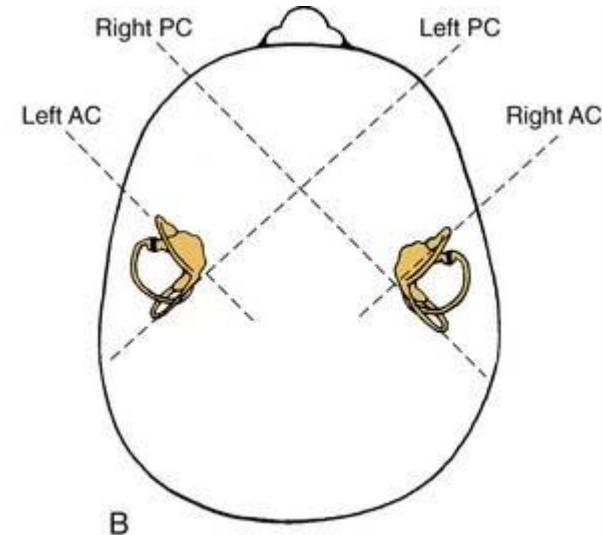
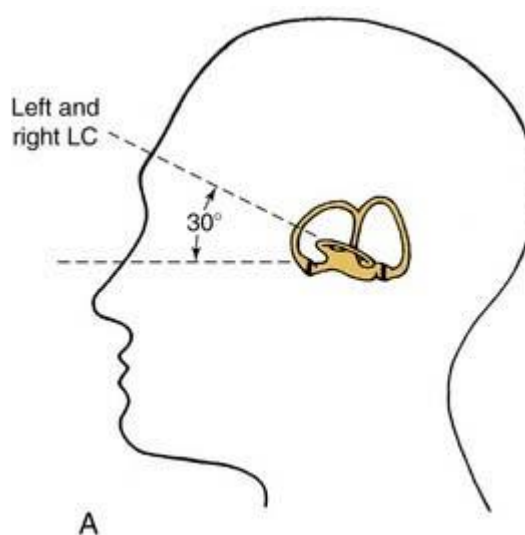


Osseous labyrinth (*Labyrinthus osseus*)

Semicircular canals (*Canales semicirculares*)

- Canalis semicircularis **anterior** (parallel with axis of petrosal bone) – eminentia arcuata
- Canalis semicircularis **posterior** (perpendicular)
- Canalis semicircularis **lateralis** (horizontal) – prominentia c.s.l.

ampulla ossea (3)
crus commune
(ant. + post.),
crus simplex (lat.)





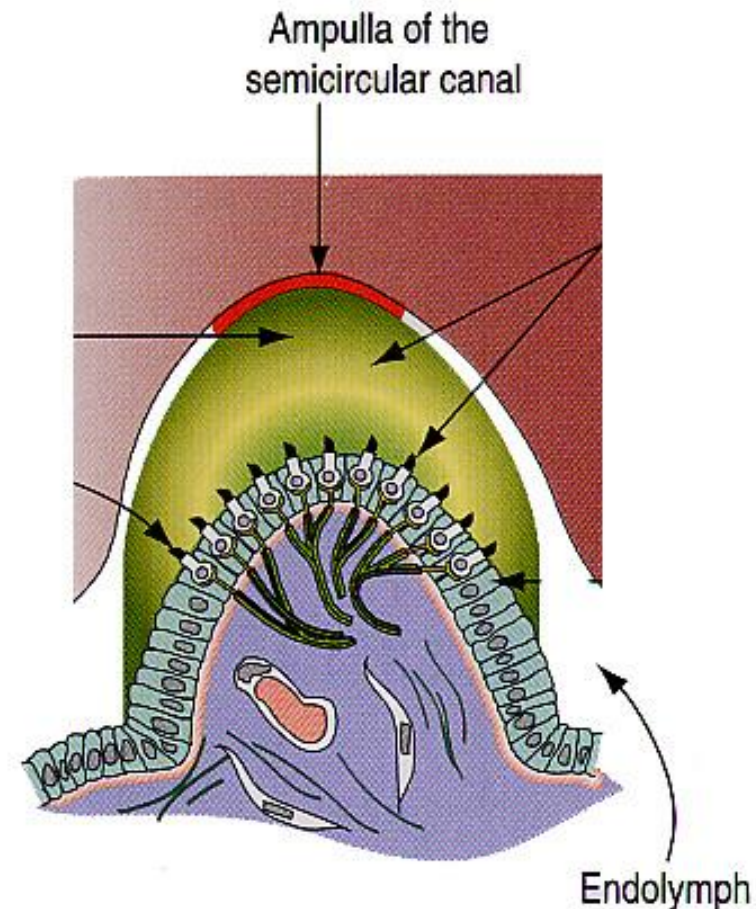
a



b

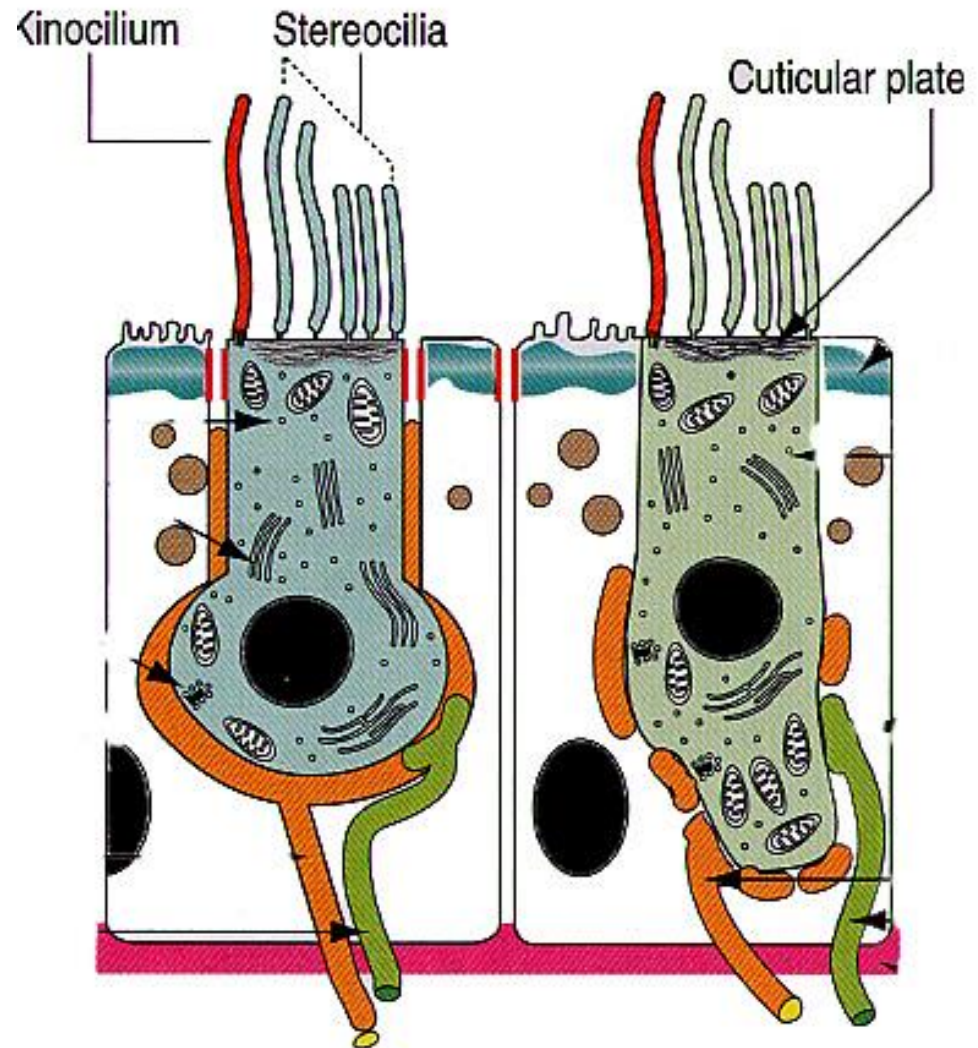
Semicircular canals and ducts

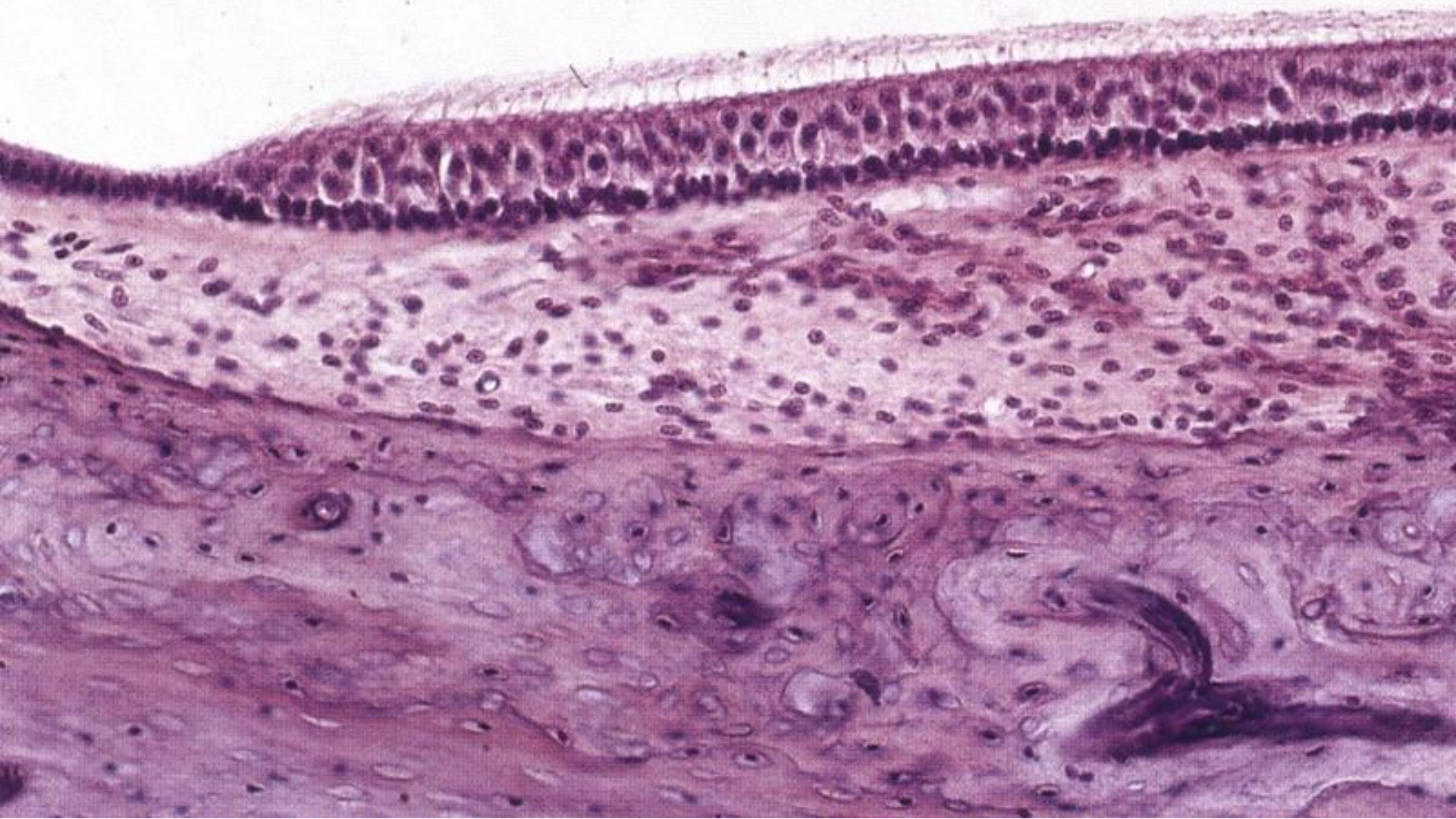
- membranous **ducts** inside bony **canals**
- receptors in ampullae
- cristae ampullares
 - perpendicular to axis of canal
 - gelatinous mass
 - hair cells
 - supporting cells



Hair cells

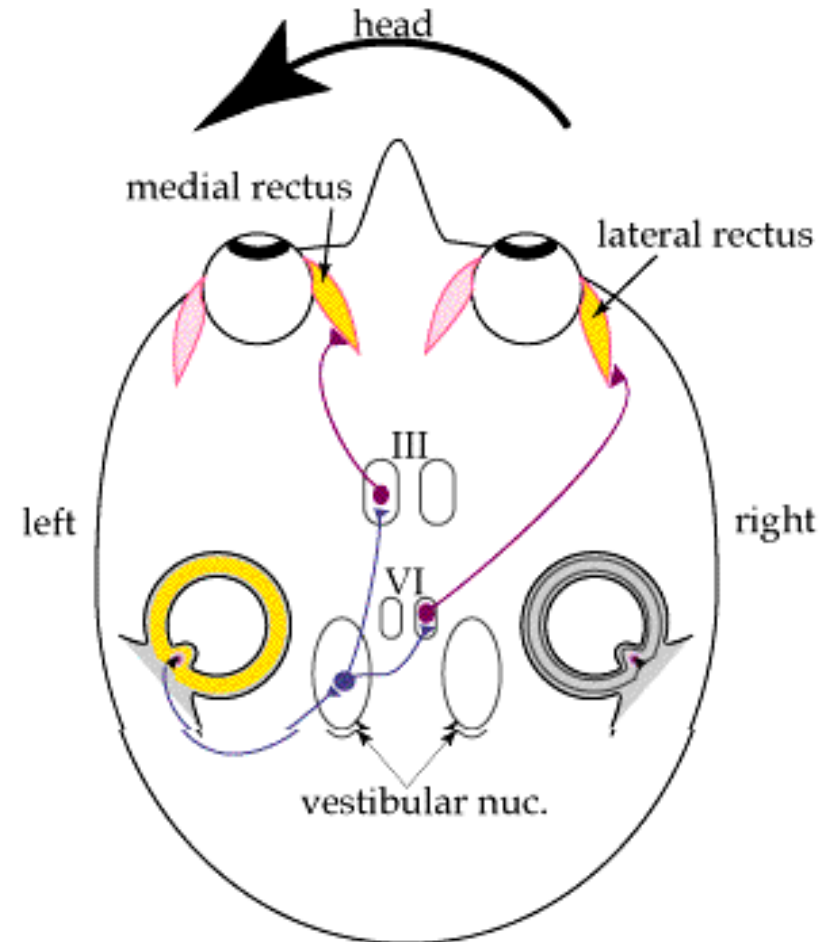
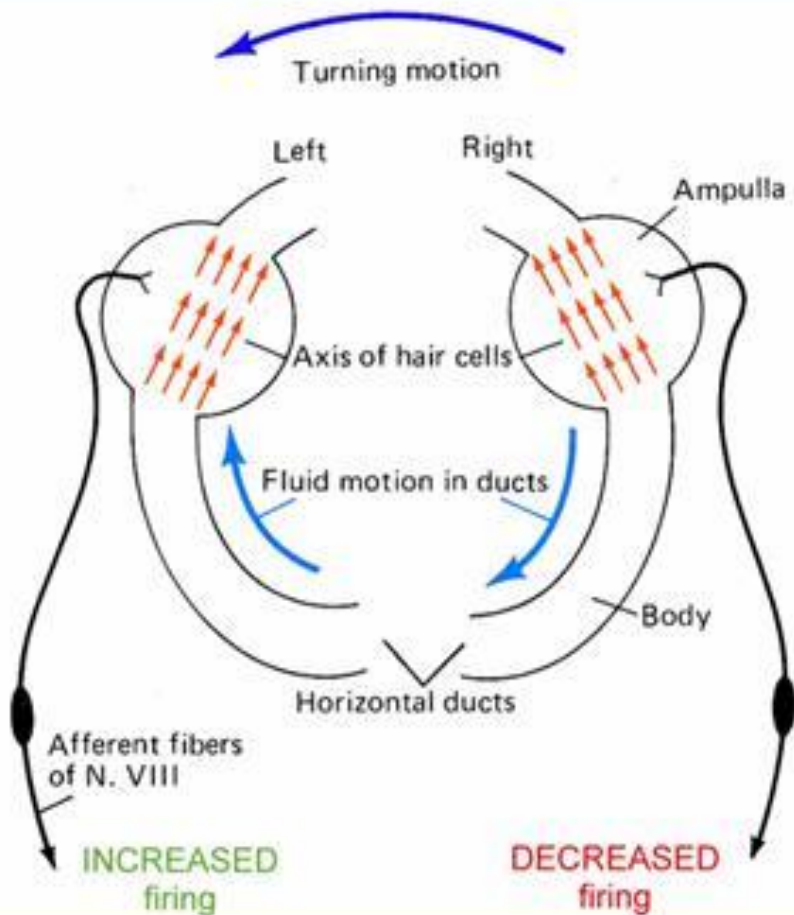
- two types
- apical surface:
 - 1 kinocilia
 - more stereocilia
- basally – synapsis with nerve fibers

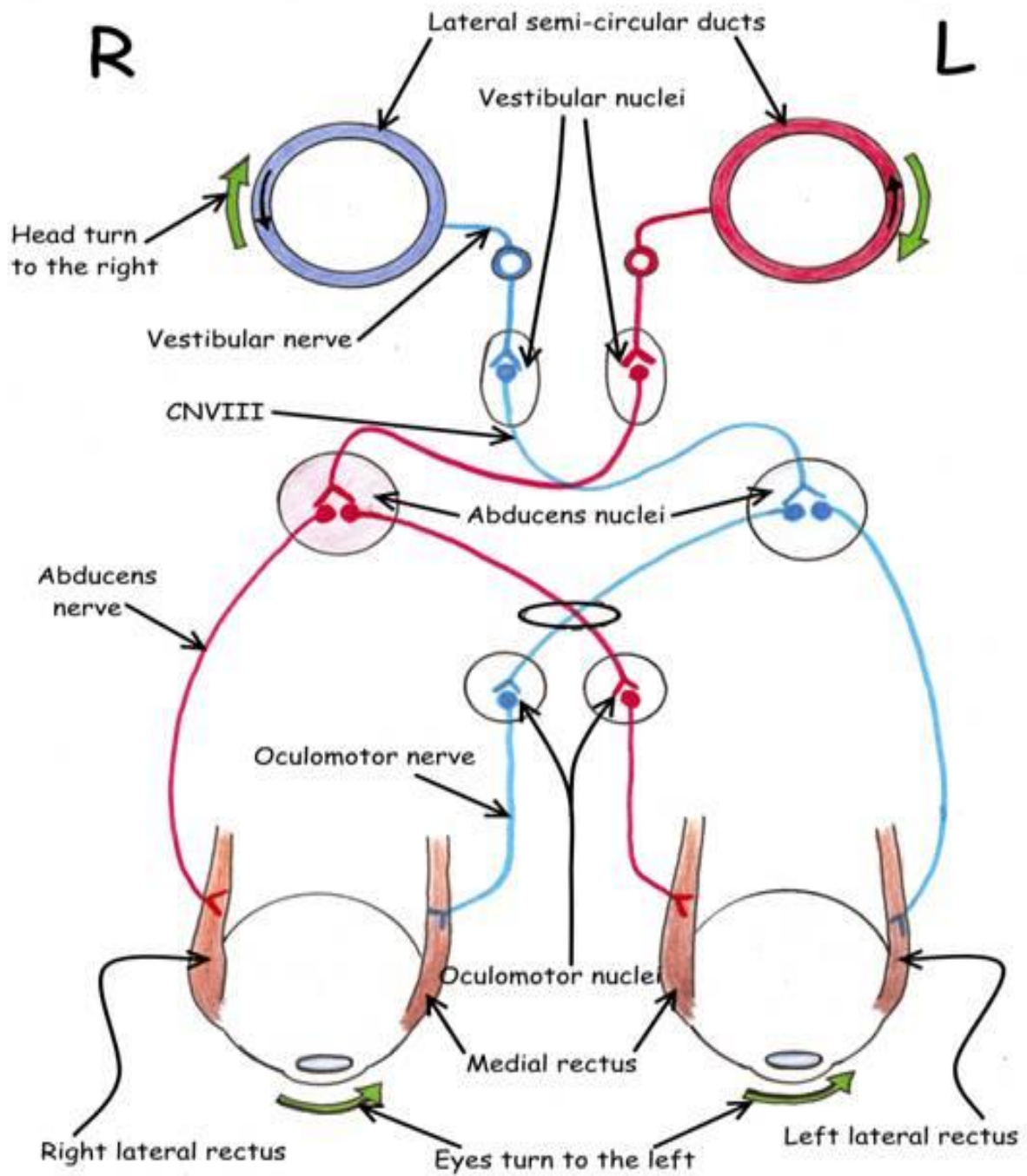




Movements of the head and eyes

Vestibulo-ocular reflex

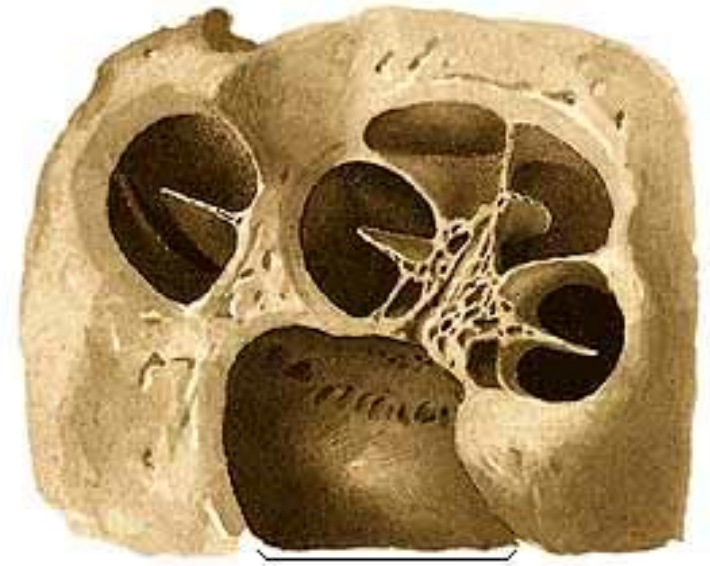




Osseous labyrinth (*Labyrinthus osseus*)

Cochlea

- cupula, basis (2 and $\frac{3}{4}$ turn)
- scala vestibuli → helicotrema → scala tympani
- canalis spiralis cochleae
- lamina spiralis ossea
 - lamella vestibularis + spiralis
 - hamulus l.s. (*ends in helicotrema*)
- lamina spiralis secundaria (*in first turn only*)
- apertura interna canaliculi cochleae



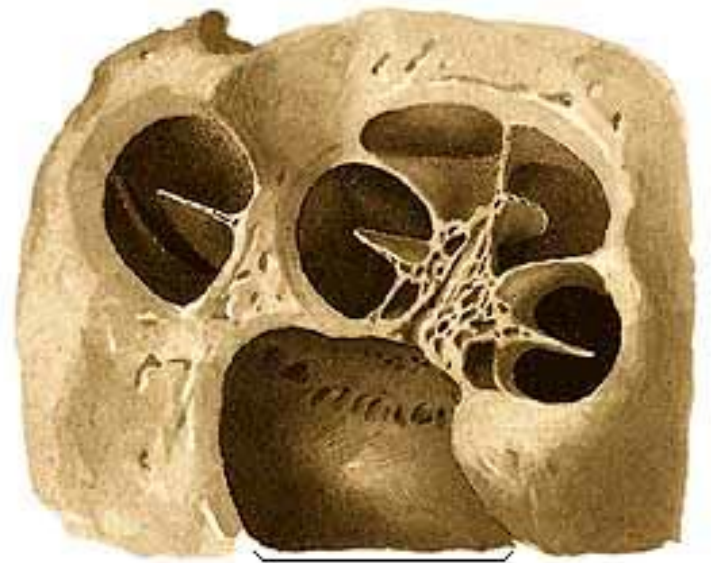
length 34 mm

Osseous labyrinth (*Labyrinthus osseus*)

Cochlea

Modiolus

- basis
- lamina
- canalis spiralis – *ganglion cochleare*
- canales longitudinales – *n. cochlearis*

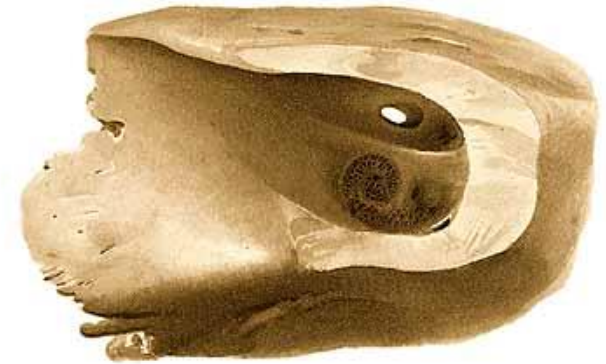




Osseous labyrinth (*Labyrinthus osseus*)

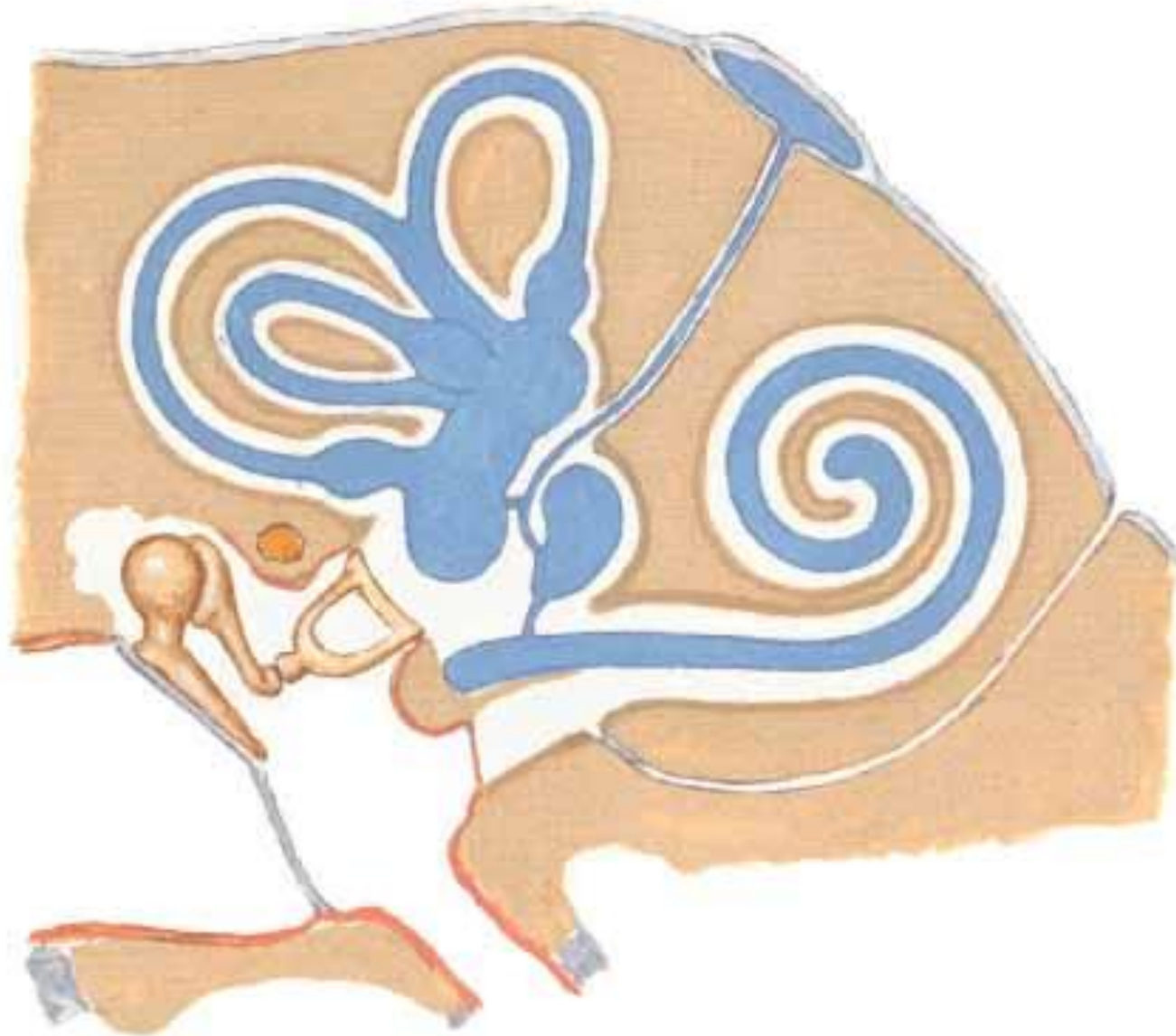
Internal acoustic meatus (*Meatus acusticus internus*)

- porus acusticus internus
- fundus m.a.i.
- crista transversa + verticalis
- area n. VII.
- area cochlearis – tractus spiralis foraminosus
- area vestibularis sup. + inf.
- foramen singulare



Bony and Membranous Labyrinths

Schema

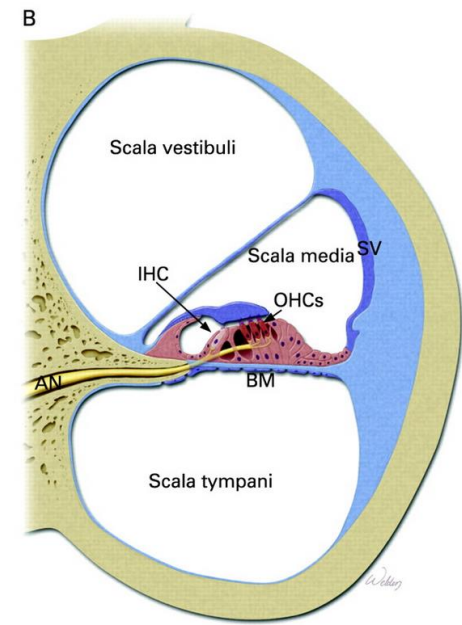


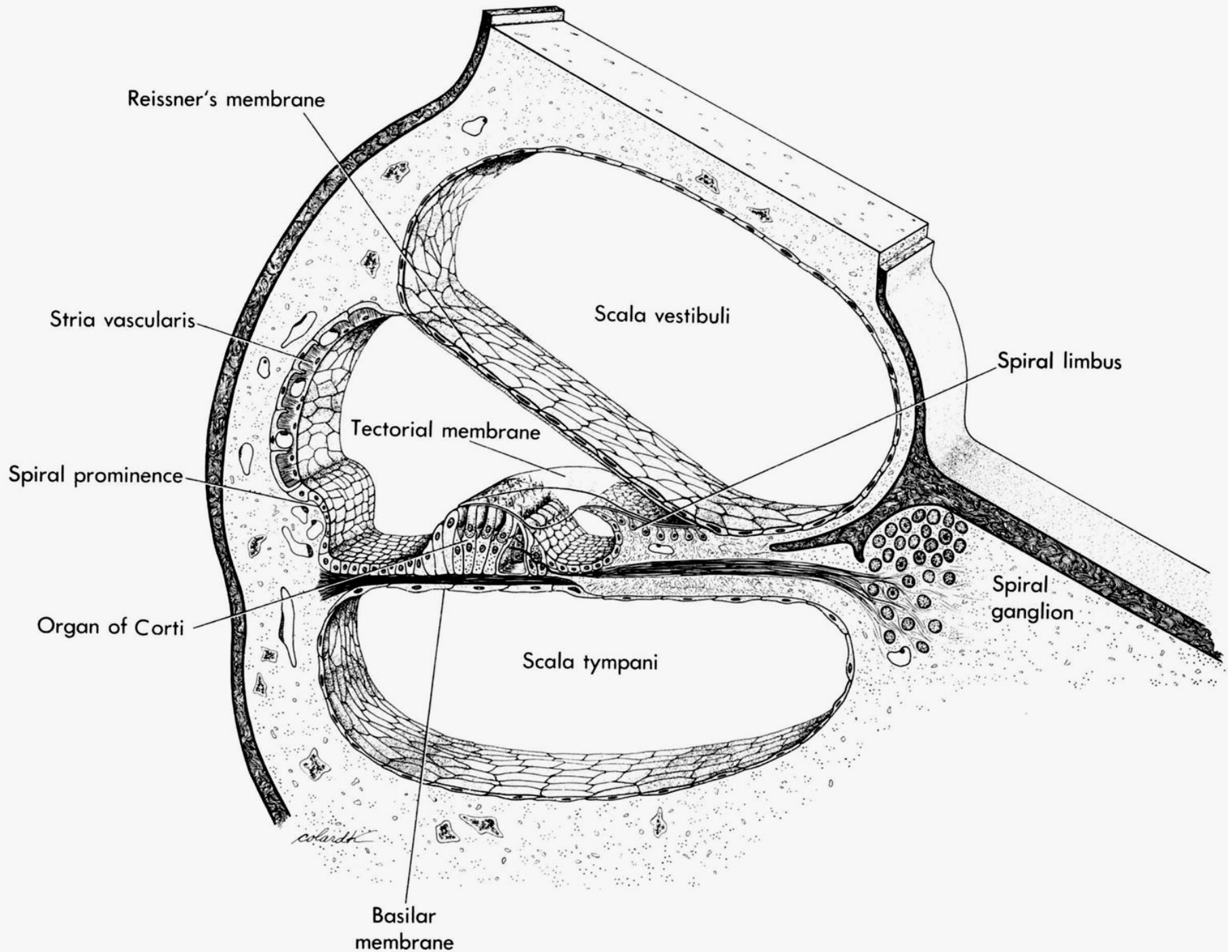
Membranous labyrinth (*labyrinthus membranaceus*)

Cochlear labyrinth (*Labyrinthus cochlearis*)

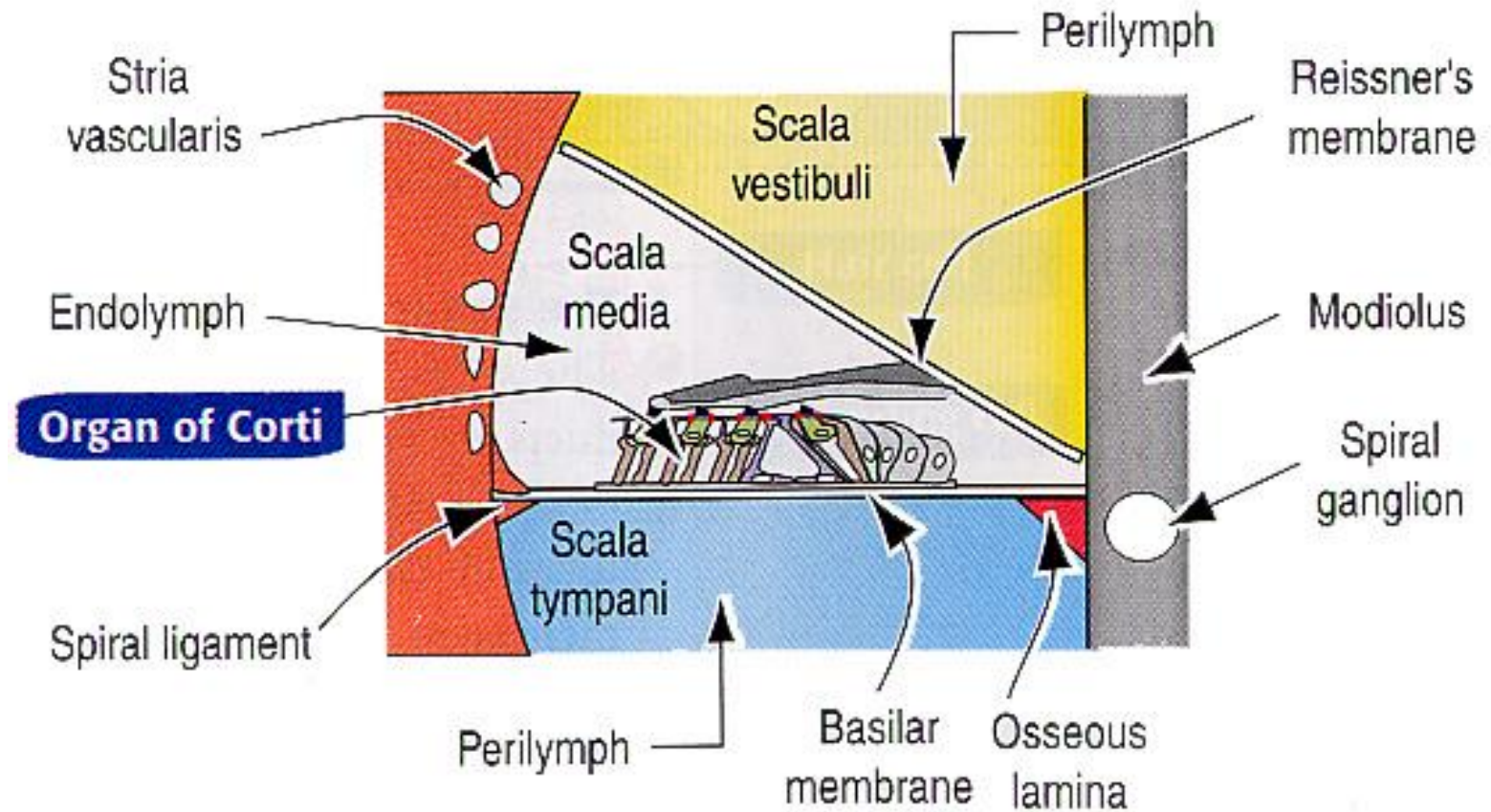
scala media = ductus cochlearis

- paries vestibularis: **membrana vestibularis Reissneri**
- paries externus: **stria vascularis**, prominentia spiralis, vas prominens, lig. spirale
- paries tympanicus (= membrana spiralis): crista basilaris, **lamina basilaris**, vas spirale
- limbus spiralis: labium limbi tympanici, labium limbi vestibularis, (dentes acustici)
- **membrana tectoria**
- **organum spirale Corti**
 - membrana reticularis, sulcus spiralis int.+ ext.



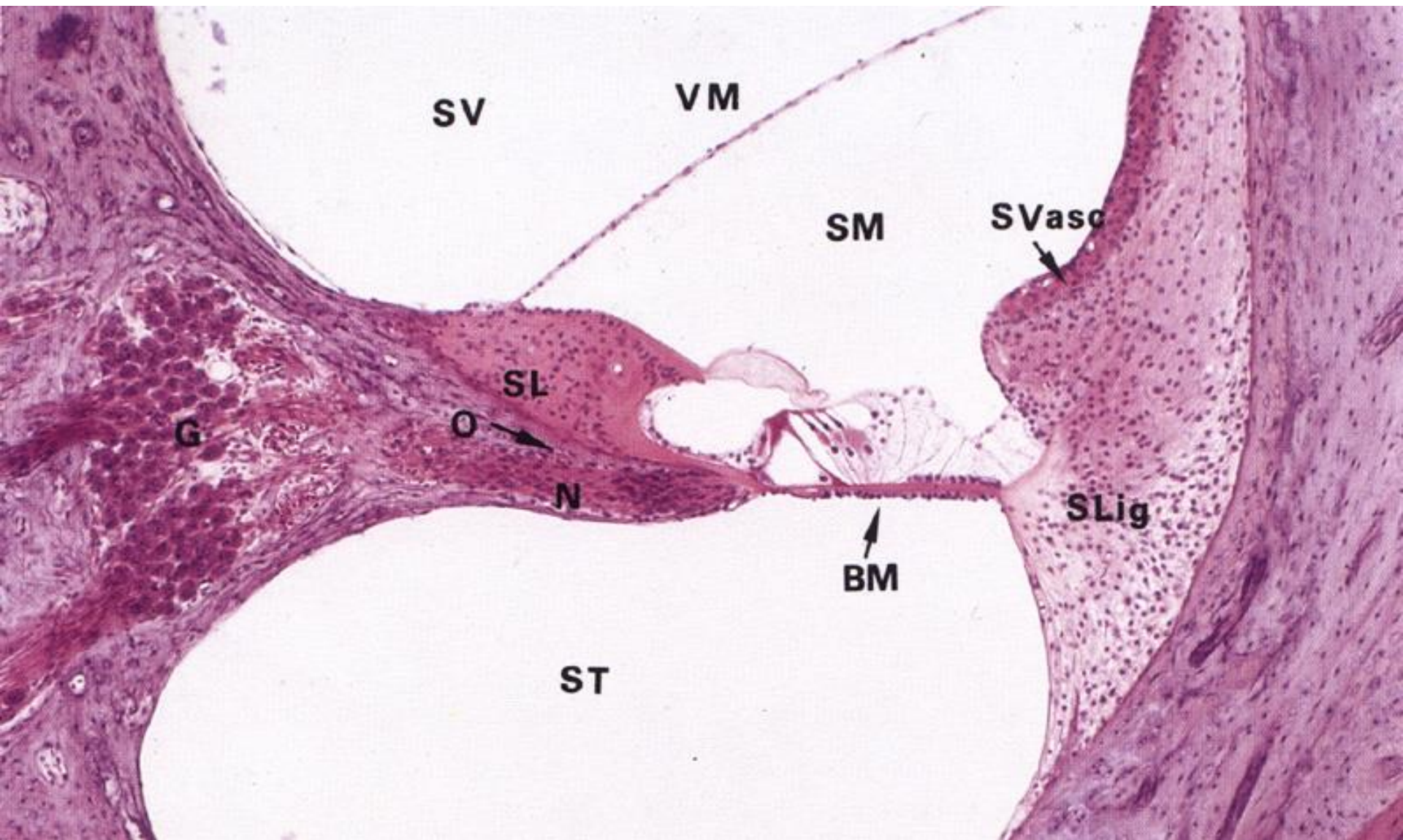


Cochlea



Scala media

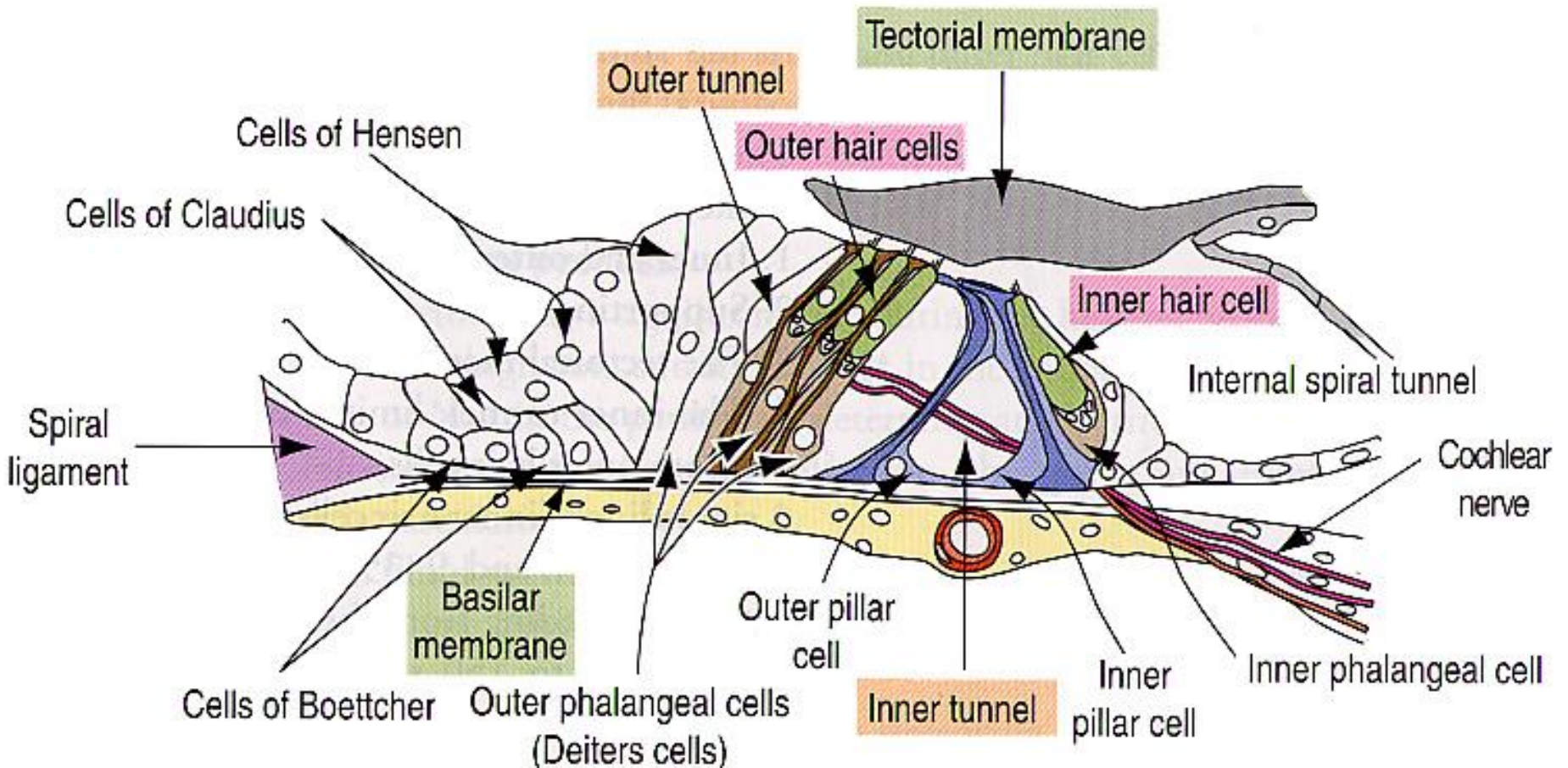
- contains endolymph
- lamina basilaris with Corti's organ
- membrana tectoria covers Corti's organ
- osseous lamina spiralis
- ligamentum spirale



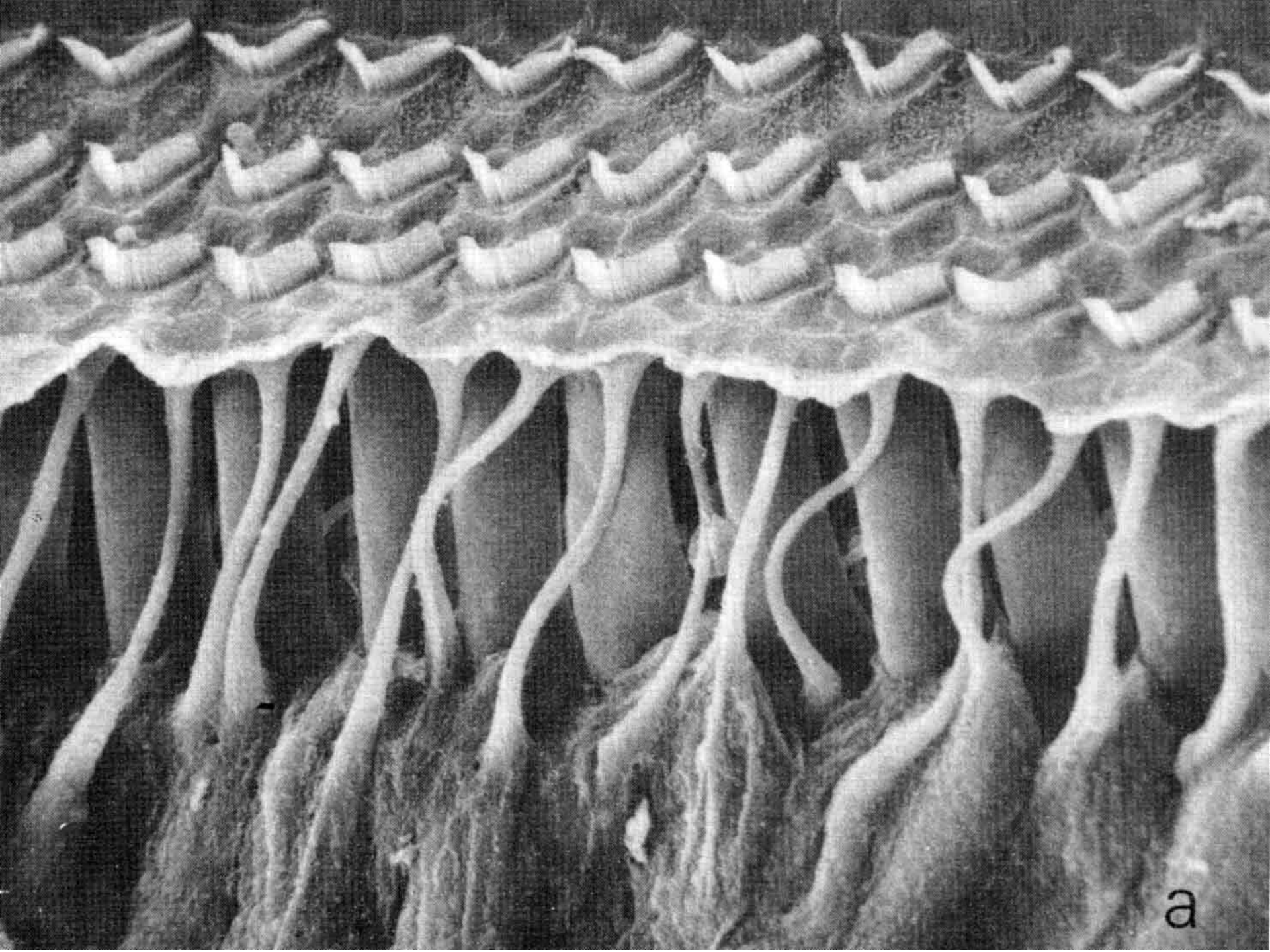
Corti's / spiral organ (*Organum spirale*)

- hair cells
 - external (3-4 rows) and internal (1 row)
 - stereocilia on surface
 - ends inserted in membrana tectoria
 - *Nuel's space* in between
- supporting cells
 - pillar cells (*Corti*) – lay the internal tunnel
 - phalangeal (*Deiters*) – cover hair cells
 - outer supporting – columnar (*Hensen*) and cuboid (*Claudius*)

Corti's / spiral organ (*Organum spirale*)



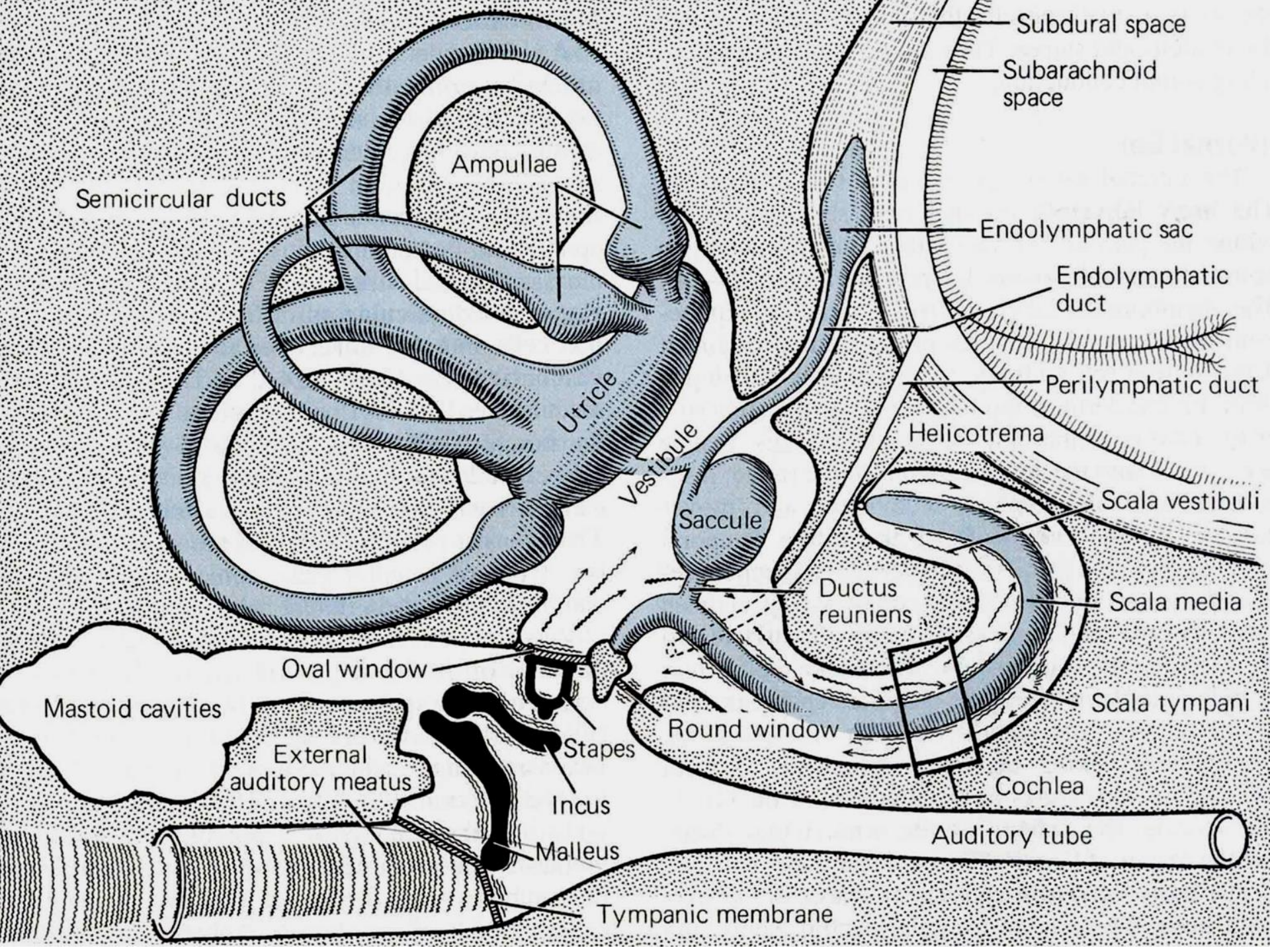




a

Endolymph and perilymph

- endolymph: similar to intracellular fluid
stria vascularis → scala media → ductus
endolymphaticus → saccus endolymphaticus
(blind) → veins
- perilymph: similar to CSF
canaliculus cochleae is connected with
subarachnoid space



Subdural space

Subarachnoid space

Endolymphatic sac

Endolymphatic duct

Perilymphatic duct

Helicotrema

Scala vestibuli

Scala media

Scala tympani

Cochlea

Auditory tube

Ampullae

Semicircular ducts

Utricule

Vestibule

Sacculle

Ductus reuniens

Round window

Oval window

Mastoid cavities

External auditory meatus

Stapes

Incus

Malleus

Tympanic membrane

Internal ear – *vascular supply*

arteries: a. basilaris → a. inf. ant. cerebelli → a. labyrinthi

veins:

- vv. labyrinthi → sinus petrosus inf.
- v. aqueductus vestibuli, v. aqueductus cochleae

lymph: replaced with endolymph and perilymph

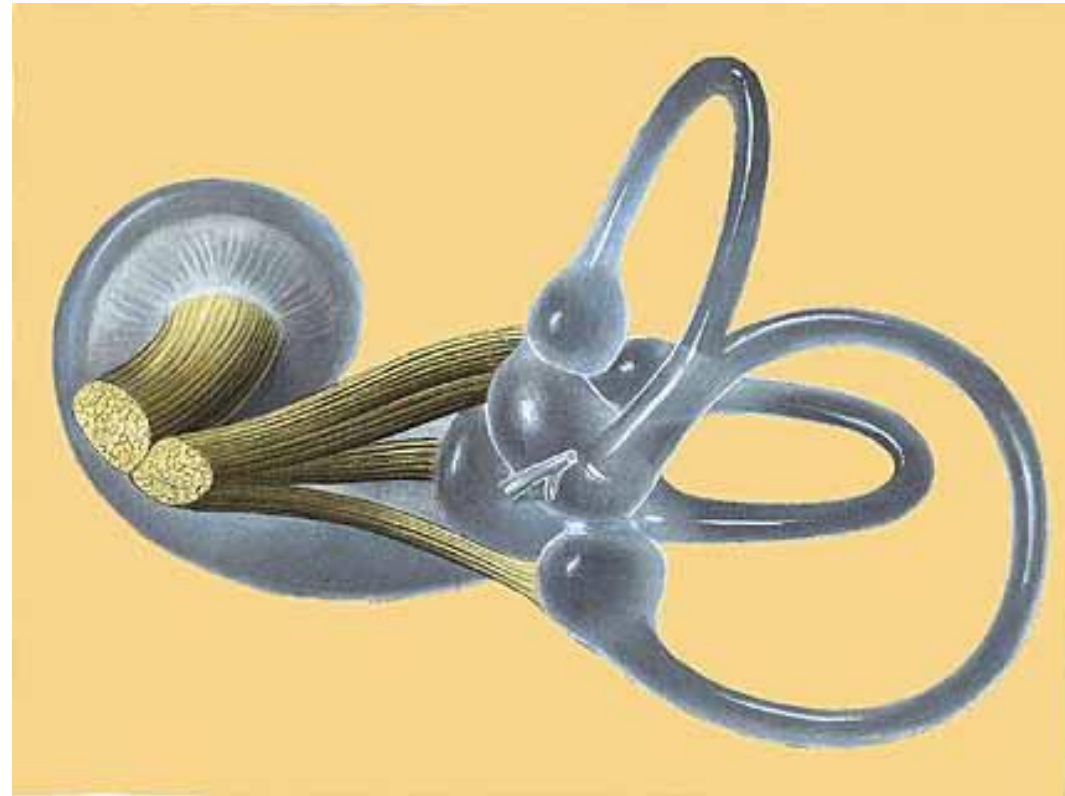
Internal ear - *nerves*

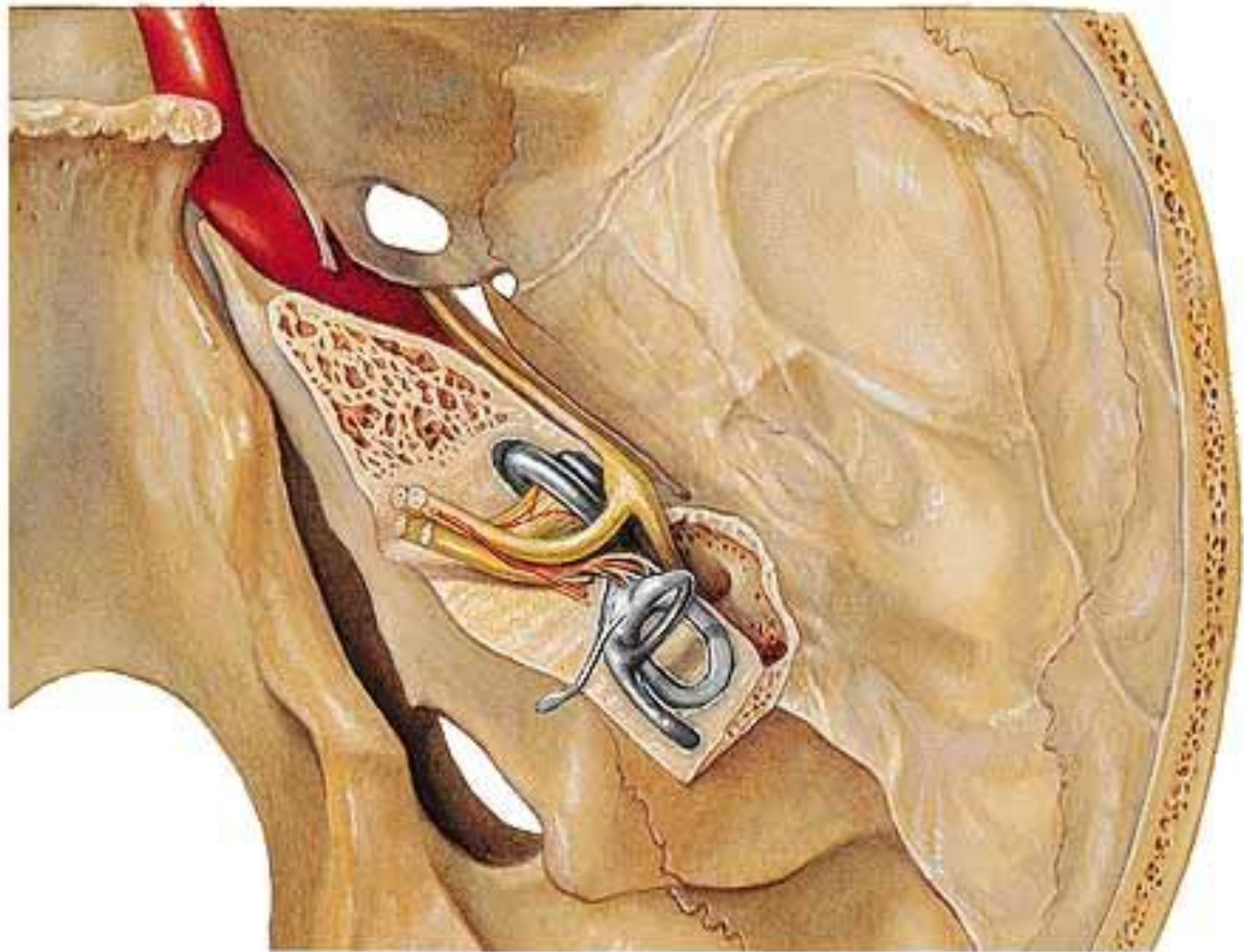
nervus vestibularis – ggl.
vestibulare *Scarpae*

- pars superior
 - n. utriculoampullaris
- pars inferior
 - n. saccularis
 - n. ampullaris posterior

nervus cochlearis – ggl.
cochleare *Corti*

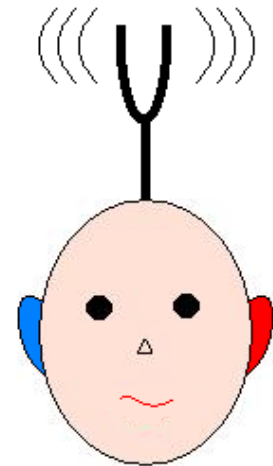
!!! *bipolar neurons* !!!







VIII. - Nervus vestibulocochlearis examination

- tuning-fork examination (Rinné, Weber, Schwabach)
- examination of nystagmus (9 direction – Hering classification)
- Romberg – stand with closed eyes
- Hautant – sit, stretch arms forwards and close eyes
- Unterberger – close eyes and march on site for 30 s



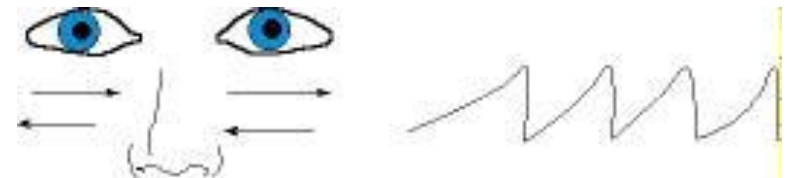
 Orella dolenta
 Orella sana



VIII. - Nervus vestibulocochlearis

irritation / palsy

- affection of hearing (= hypacusis → anacusis)
 - deafness (= surditas)
 - tinnitus – humming, screeching ,ringing...
 - dizziness (= vertigo)
 - involuntary eye movement (= nystagmus)
- = alternating smooth pursuit in one direction and saccadic movements in the other direction.
- slow-phase – stronger side suppresses the weaker one
 - fast-phase – compensatory movements back – serve for description of nystagmus



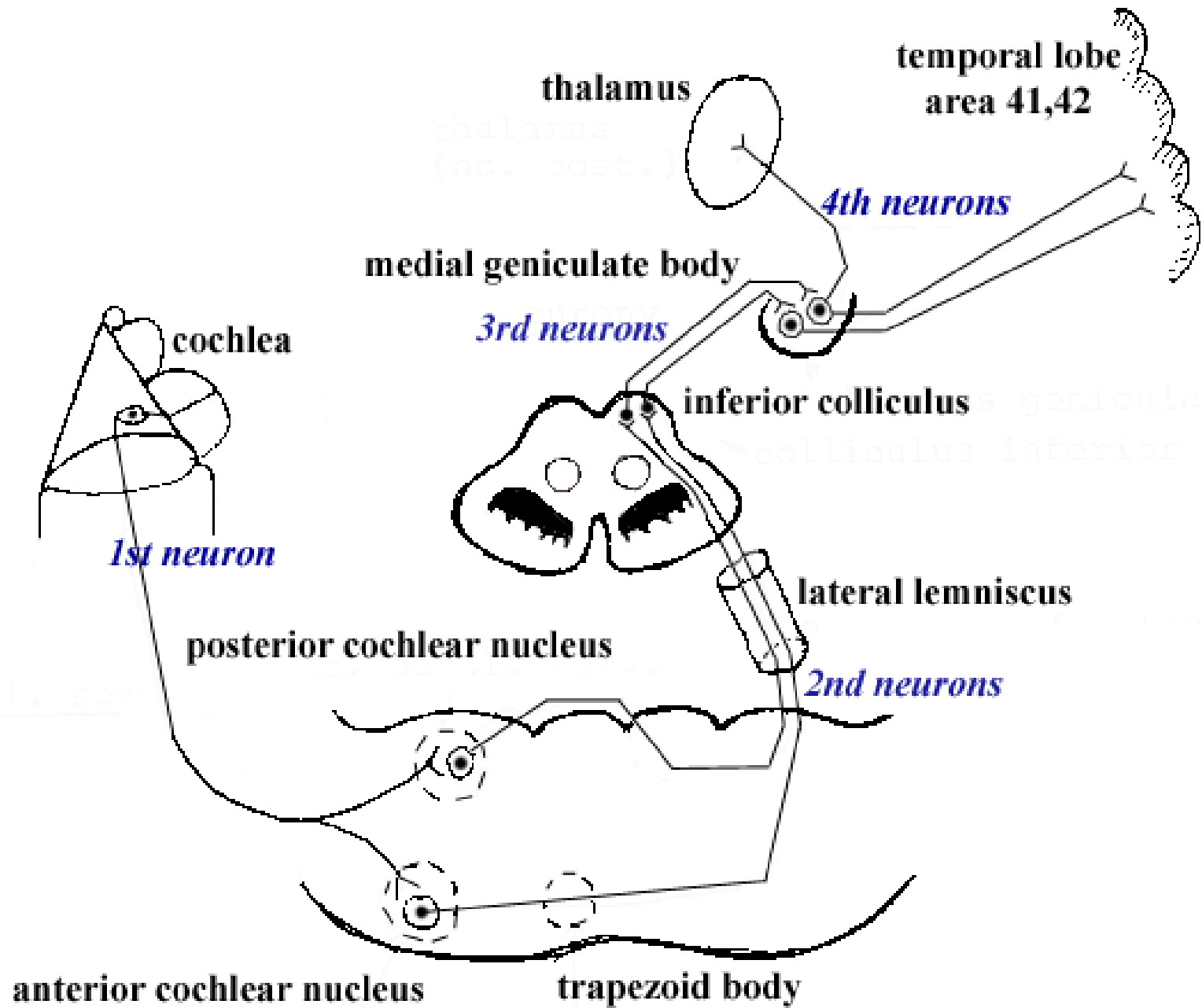
- disorders of stand and gait (= ataxia)

Auditory pathway I.

- projection → ascending → sensory
- 4-neuronal pathway
- decussated and partially non-decussated

1st-order neuron:

bipolar cell in ganglion cochleare *Corti* in
shape of a spiral → n. cochlearis → n. VIII
→ splits into two fasciculi → nucleus
cochlearis ant. + post.



1. 2011 2. 2011 3. 2011 4. 2011 5. 2011 6. 2011 7. 2011 8. 2011 9. 2011 10. 2011 11. 2011 12. 2011

Auditory tract II.

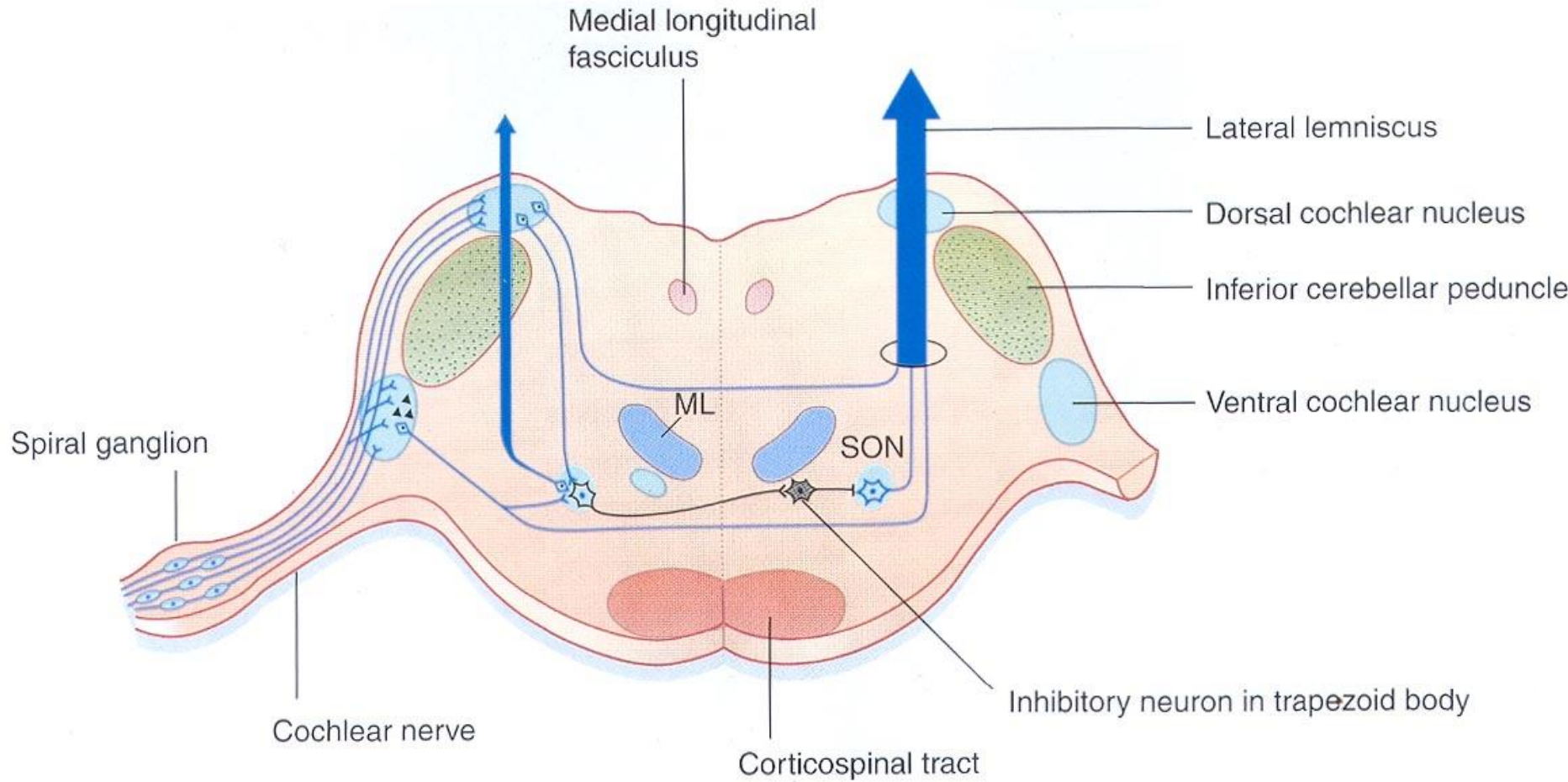
2nd neuron: *pons*

cells in nucleus cochlearis posterior (depth of tones) et anterior (intensity of tones) – separated with pedunculus cerebellaris inferior → decussatio → lemniscus lateralis → colliculus inferior

collateral to:

nucleus olivaris superior (← inhibited collaterally from ncl. corporis trapezoidei) → learning of auditory space orientation

Auditory tract



Auditory tract III.

3rd neuron: *mesencephalon*

cells in colliculus inferior → brachium
colliculi inferioris

tonotopic arrangement

commissura colliculi inferioris

4. neuron: *diencephalon - metathalamus*

cells in corpus geniculatum mediale → lobus
temporalis - gyrus temporalis transversus
Heschli, area 41

Frontal horn of lateral ventricle

Third ventricle

Cerebral aqueduct

Primary auditory cortex in transverse temporal gyrus

Acoustic radiation

Medial geniculate body

Inferior brachium

Superior colliculus

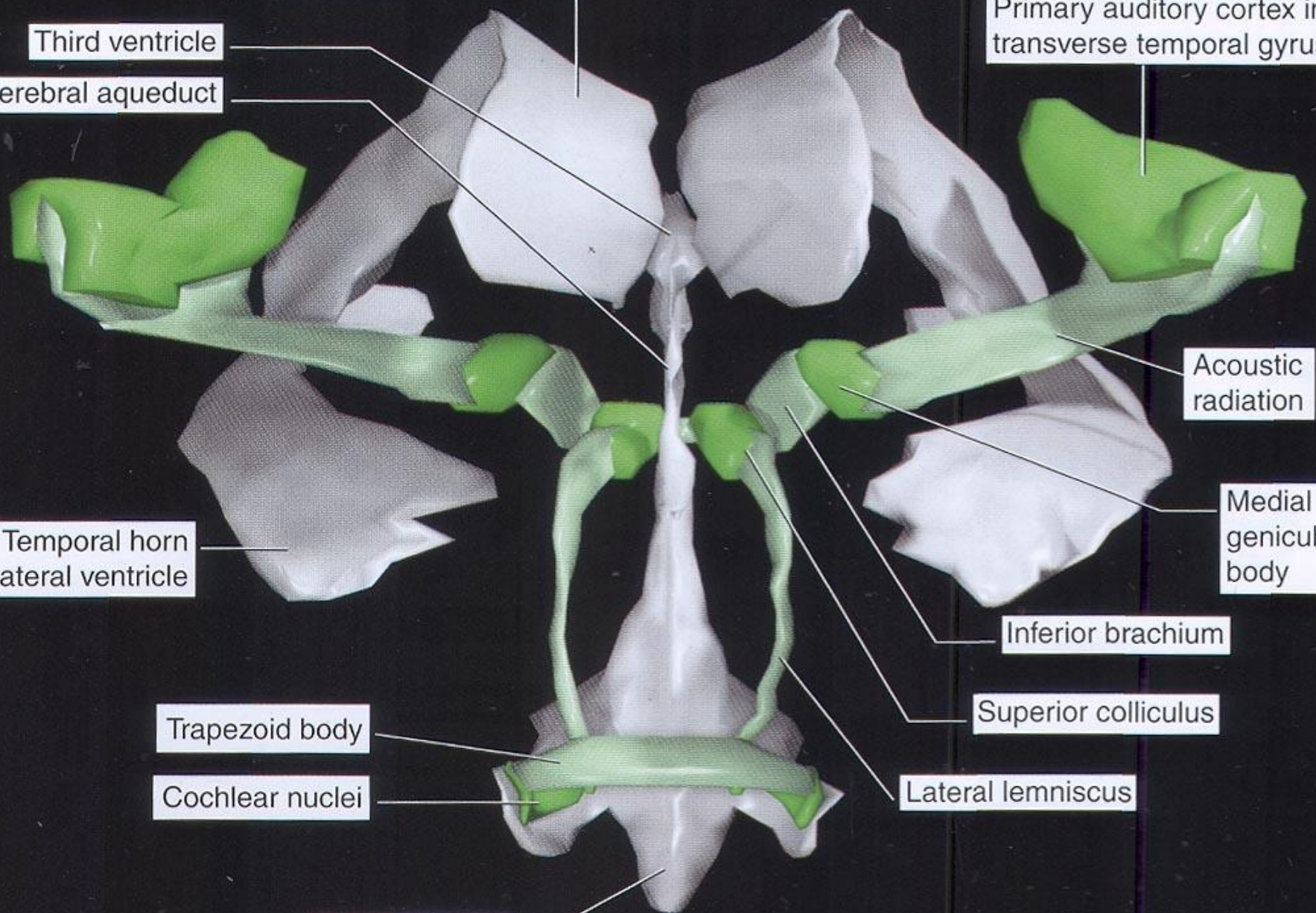
Lateral lemniscus

Temporal horn of lateral ventricle

Trapezoid body

Cochlear nuclei

Fourth ventricle



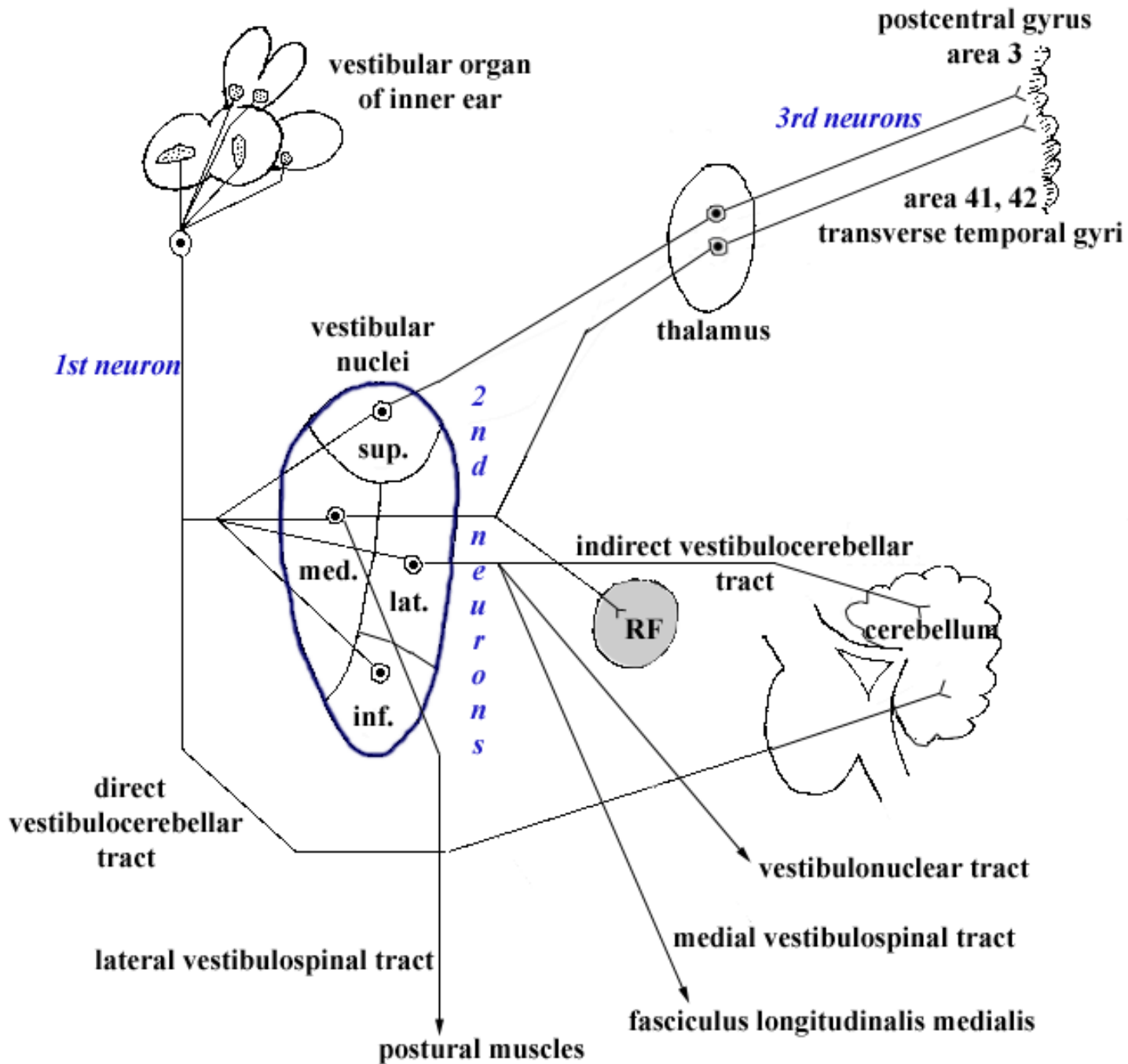
Vestibular tract I.

- projection → ascending → sensory
- 3-neuron-tract, decussated

1st neuron: bipolar cell in ganglion vestibulare
Scarpa → n. vestibularis → n. VIII

- some fibers run as tractus vestibulocerebellaris directus to cerebellum without interpolation

2nd neuron: cells in nuclei vestibulares pontis →
axons into various structures of CNS



Vestibular tract II. – *where?*

- cerebral cortex
- cerebellum
- RF → facilitating descending system
- spinal cord
- nuclei of oculomotor nerves
 - via paramedian pontine RF
 - *reflex head-eye*

Vestibular tract III. – *to cortex*

3rd neuron: cells in nuclei ventrales thalami → cerebral cortex

- lobus parietalis - gyrus postcentralis (area 2) – *primary cortex*
- parieto-insular cortex (gyrus insularis longus) + lobus temporalis - gyrus temporalis transversus *Heschli* (area 41,42)

Vestibular tract III. – *to cerebellum*

- tractus vestibulocerebellaris **directus**

vestibulum → corpus juxtarestiforme (via PCI) →
nodulus + uvula (*ipsilat.*)

- tractus vestibulocerebellaris **indirectus**

vestibulum → ncl. vestibulares → corpus
juxtarestiforme (via PCI) → lobulus
flocclulonodularis + vermis (*bilat.*)

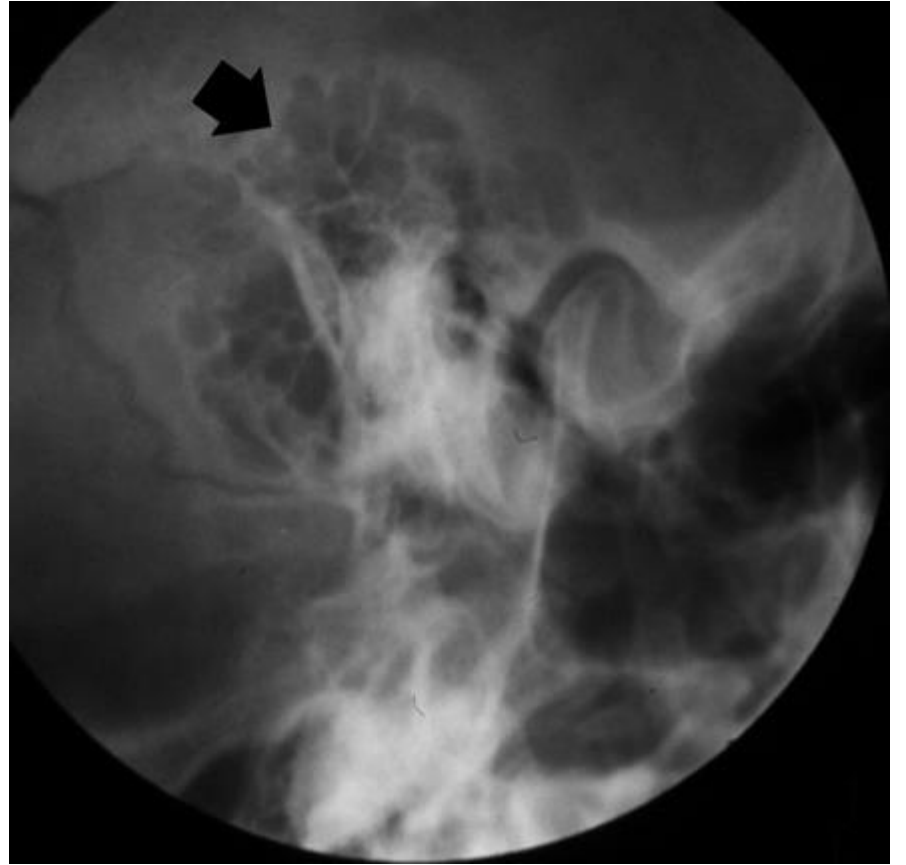
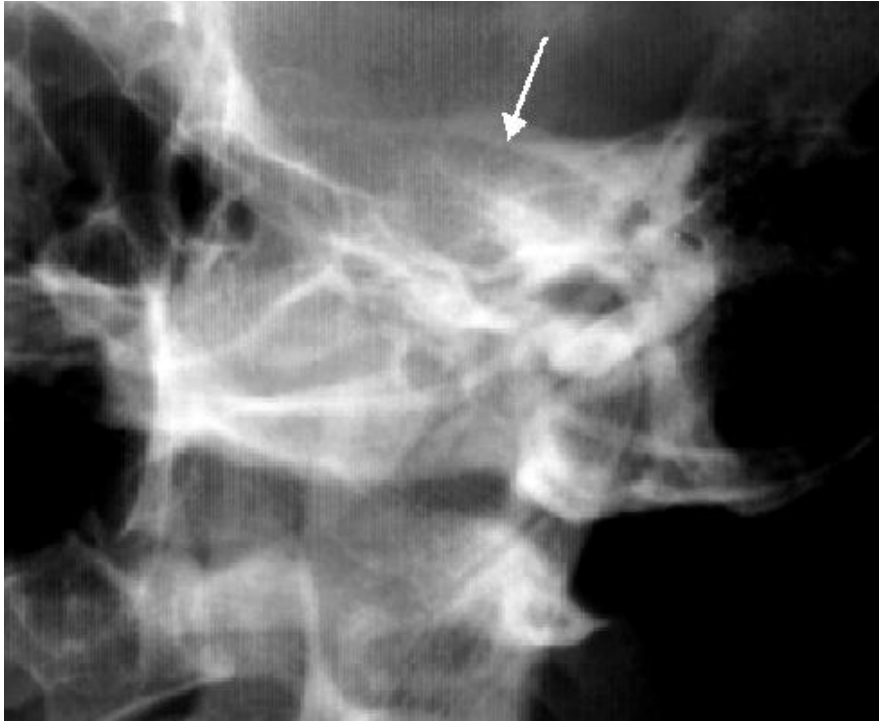
Vestibular tract III. – *to spinal cord*

- ncl. fastigii cerebelli → ncl. vestibularis lat.
Deitersi (bilat.) → **tr. vestibulospinalis lateralis**
→ alfa + gama-motoneurons for extensors
- ncl. vestibularis medialis + inferior →
fasciculus longitudinalis medialis →
interneurons (+ a -) in cervical spinal cord

reflex head-eye

Examination

- otoscopy, otomicroscopy – tympanic membrane
 - paracentesis, grometes
- tuning fork examinations
- vestibuloocular reflex – nystagmus
- vestibulospinal reflexes (*Romberg's, Unterberger's test*)
- X-ray (*Stenvers' projection – meatus acusticus internus, Schüller's – proc. mastoideus*), CT, angiography
- audiometry
- BER/BERA (ERA, AEP, ABR)
- otoacoustic emission (*from outer hair cells*)
- nystagmus – ENG (PENG), caloric test



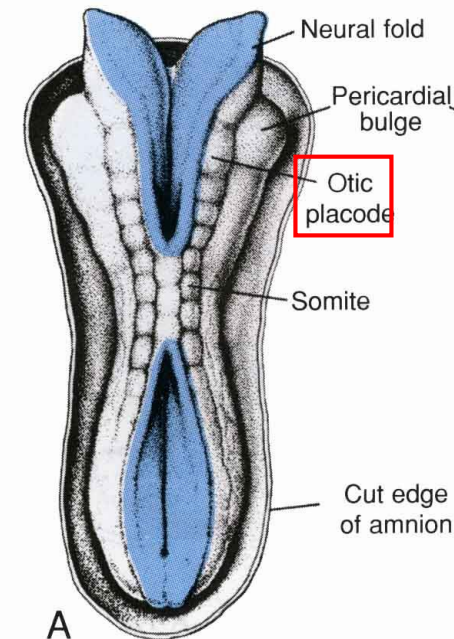
Symptoms and diseases

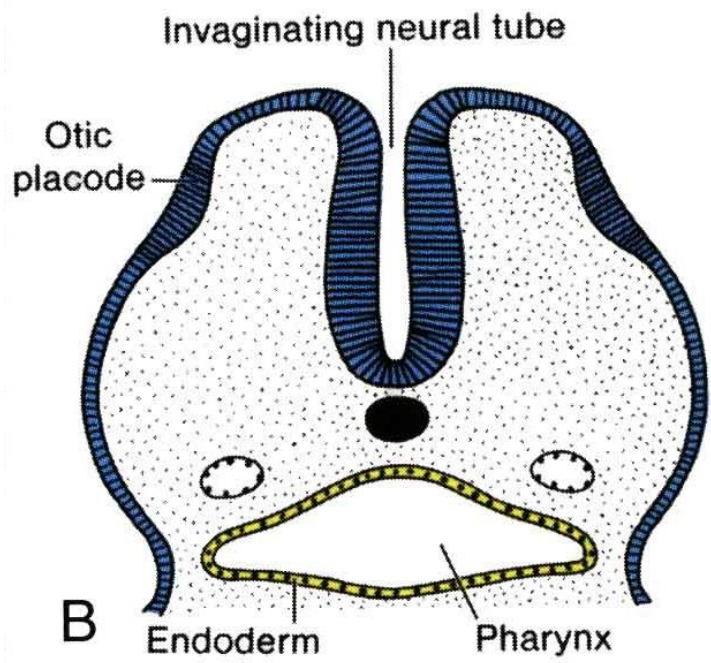
- ear pain = otalgia
- dizziness = vertigo
- spontaneous ringing and buzzing in ears = tinnitus
- nystagmus = rhythmic, oscillating motions of eyes
- hypacusis
- deafness = surditas
- morbus Menière – ions dysbalance
- atherosclerosis of a. lybyrinthi
- meningitis – *most frequent cause of acquired deafness*

Development of vestibulo-cochlear system

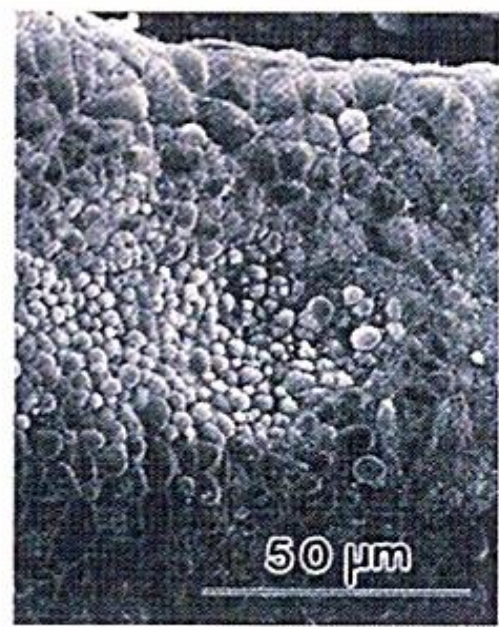
3 sources+ nerve fibers

- 1st pharyngeal pouch, cleft and membrane
- ectomesenchyme of 1st and 2nd pharyngeal arch
- surface ectoderm of head
- fibers from mesencephalon

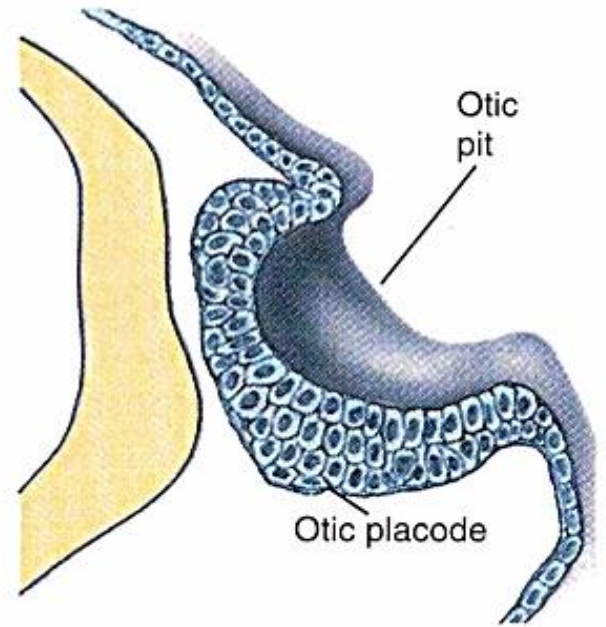




A 25 days



B 25 days

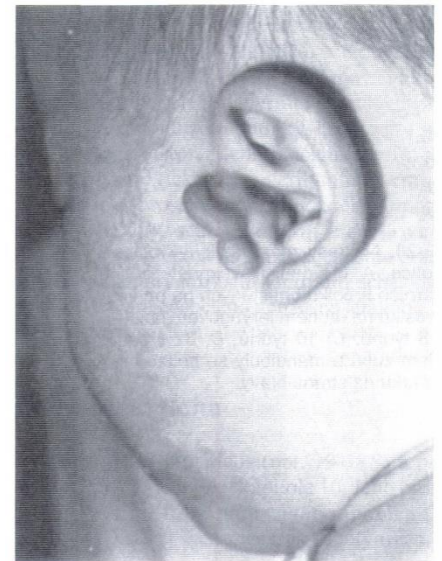


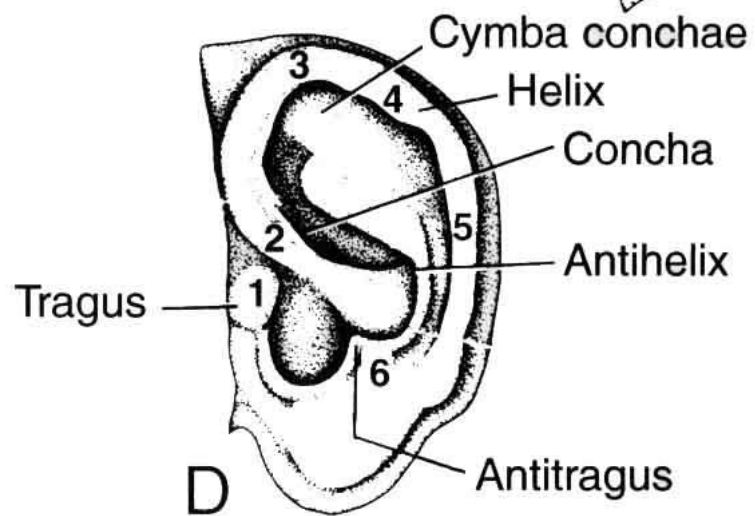
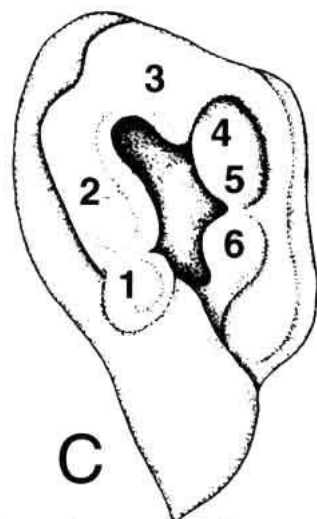
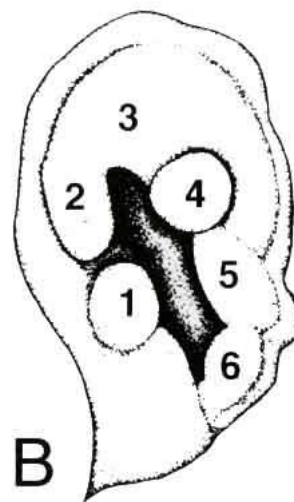
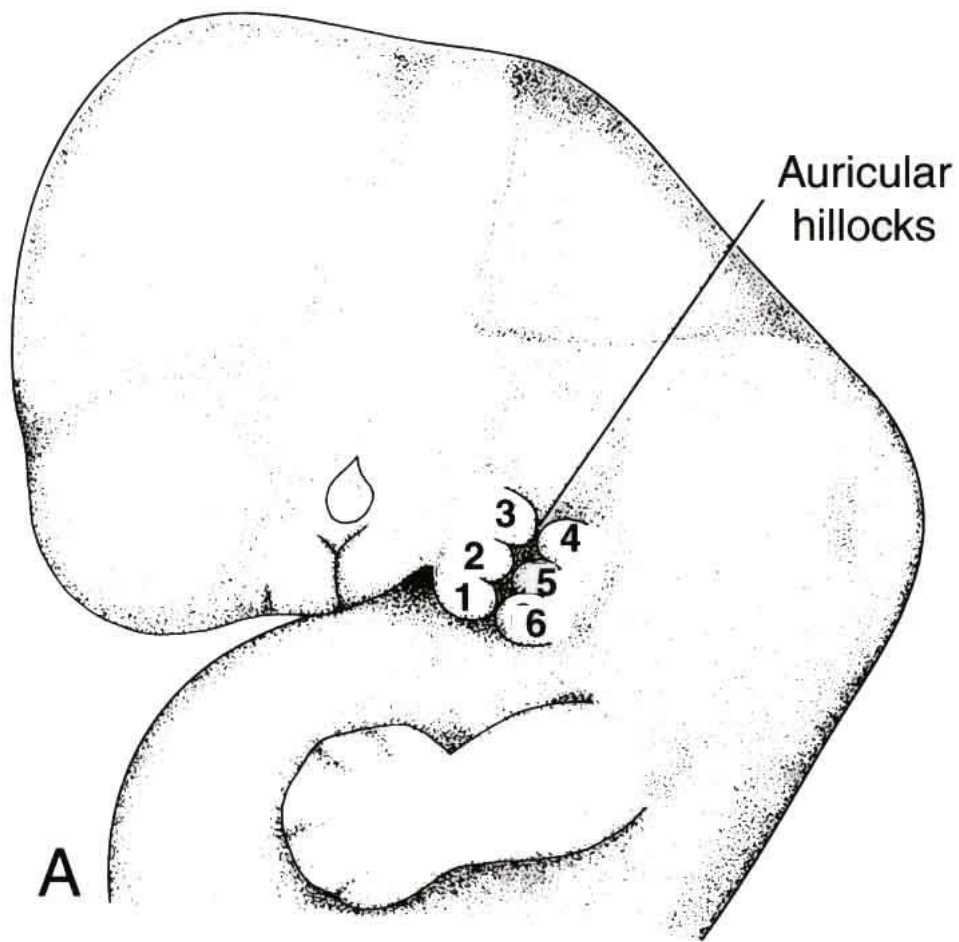
3:10

- <https://www.youtube.com/watch?v=WiE7LJu3AL4>

Development of external ear

- meatus acusticus externus
 - 1st pharyngeal cleft
 - short in birth (beware of injury!)
- pinna
 - 6 auricular tubercles (mesenchyme)
 - mainly from 2nd pharyngeal arch
 - with contribution of 1st one as well
 - *appendices preauriculares*

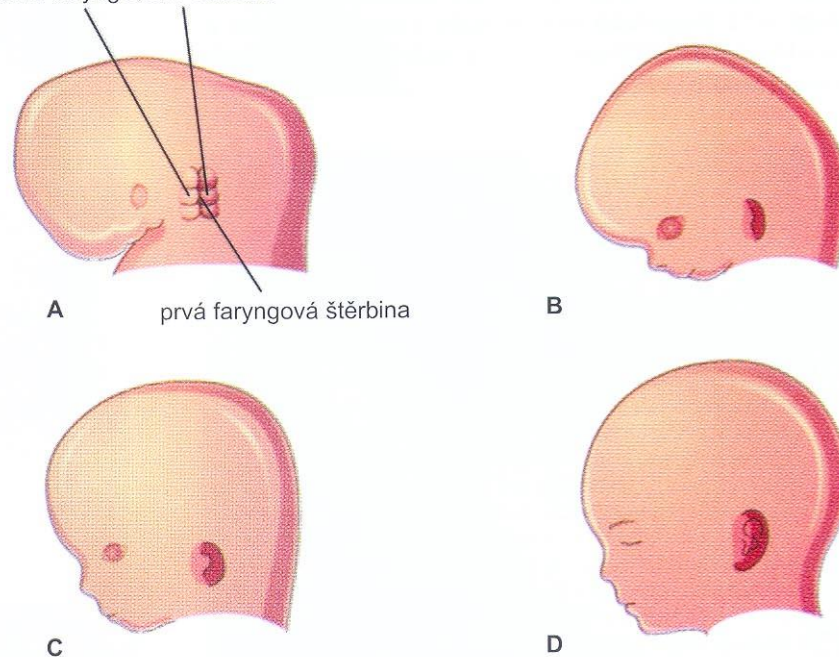




Development of external ear

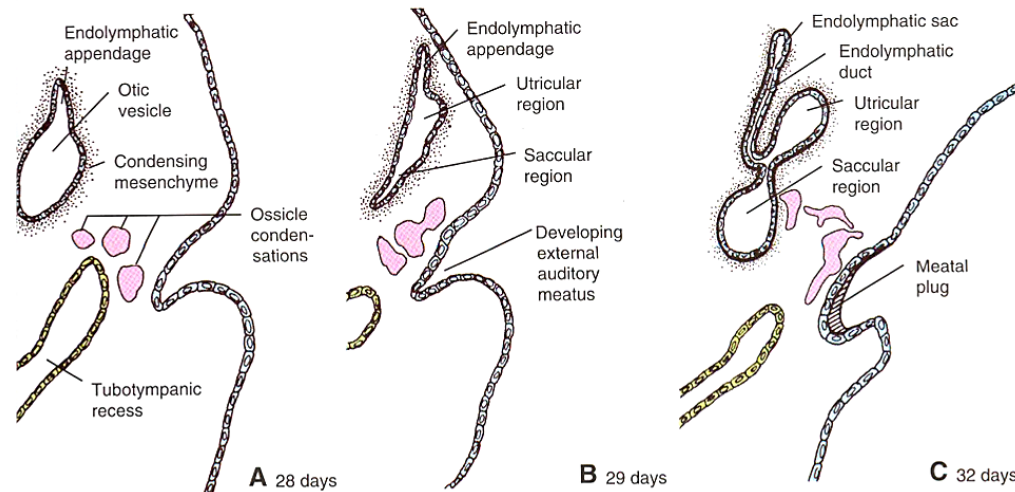
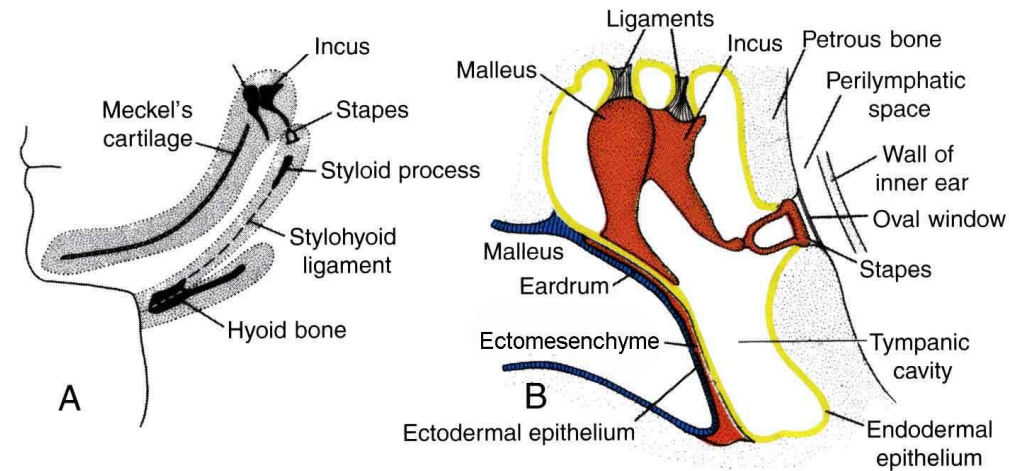
Obr. 19-20. Nákresy znázorňující vývoj ušního boltce. *A*, 6 týdnů. Povšimněte si tří aurikulárních hrbolků umístěných na prvním a třetí výrůstku na druhém faryngovém oblouku. *B*, 8 týdnů. *C*, 10 týdnů. *D*, 32 týdnů. S vývojem zubů a mandibuly se boltce posouvá z krku na stranu hlavy.

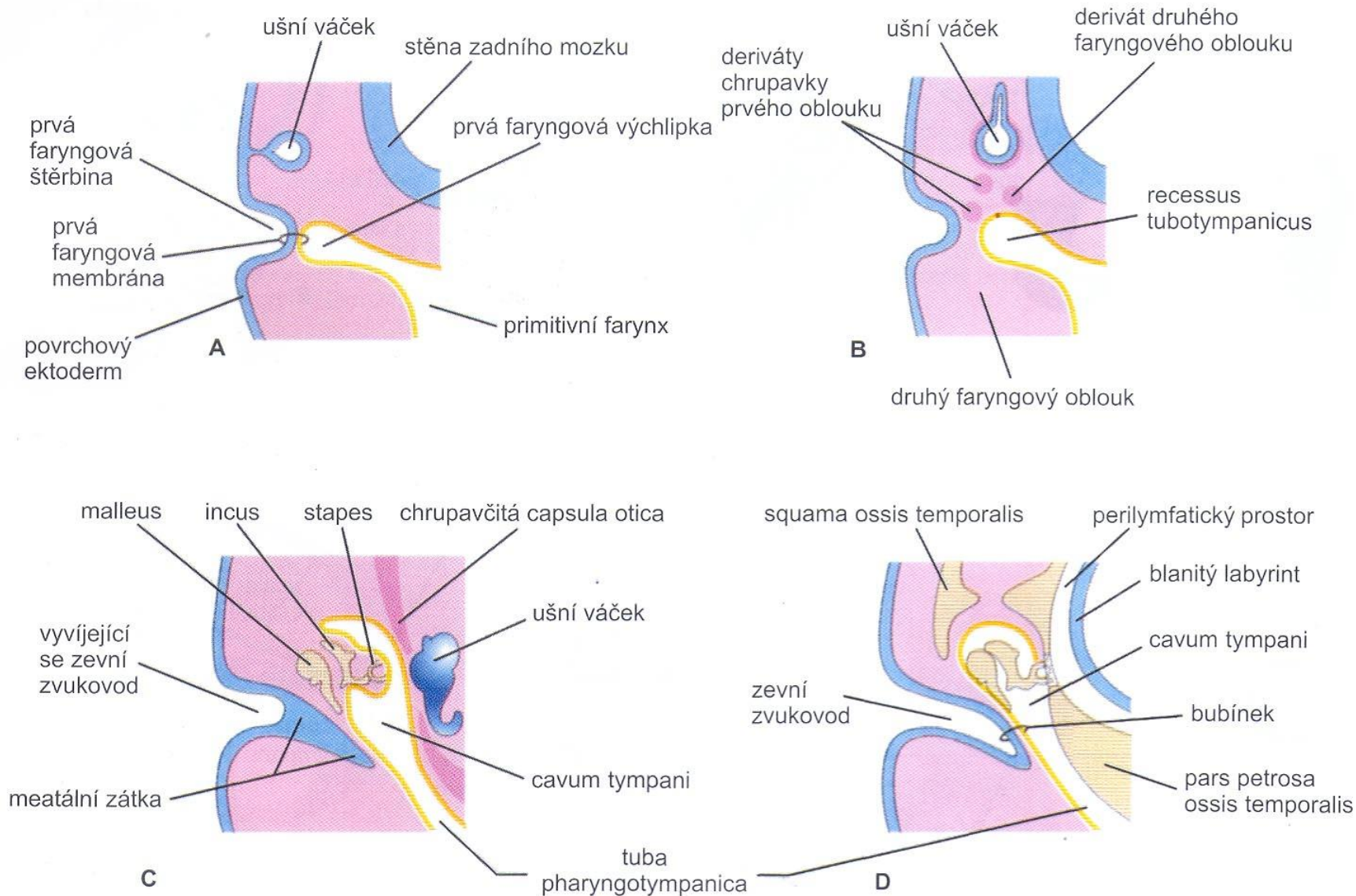
aurikulární hrbolky odvozené z prvního a druhého faryngového oblouku



Development of middle ear

- 1st pharyngeal pouch
 - tuba auditiva et cavum tympani
- 1st pharyngeal arch
 - malleus, incus
 - lig. mallei anterioris
 - m. tensor tympani
- 2nd pharyngeal arch
 - stapes
 - m. stapedius





Obr. 19-19. Schematické nákresy znázorňující vývoj zevního a středního ucha. Povšimněte si vztahů těchto částí sluchového ústrojí k ušnímu váčku, základu vnitřního ucha. *A*, 4 týdny, vztah ušního váčku k faryngovému aparátu. *B*, 5 týdnů, recessus tubotympanicus a chrupavky faryngových oblouků. *C*, Pozdější stadium, recessus tubotympanicus (pozdější cavum tympani a antrum mastoideum) počíná obalovat ušní kůstky. *D*, Nákres konečného stadia vývoje ucha znázorňující vztahy středního ucha k perilymfatickému prostoru a zevnímu zvukovodu. Povšimněte si, že bubínek vzniká ze tří zárodečných listů: povrchového ektodermu, mezodermu a endodermu tubotympanické výchlípky.

Development of middle ear

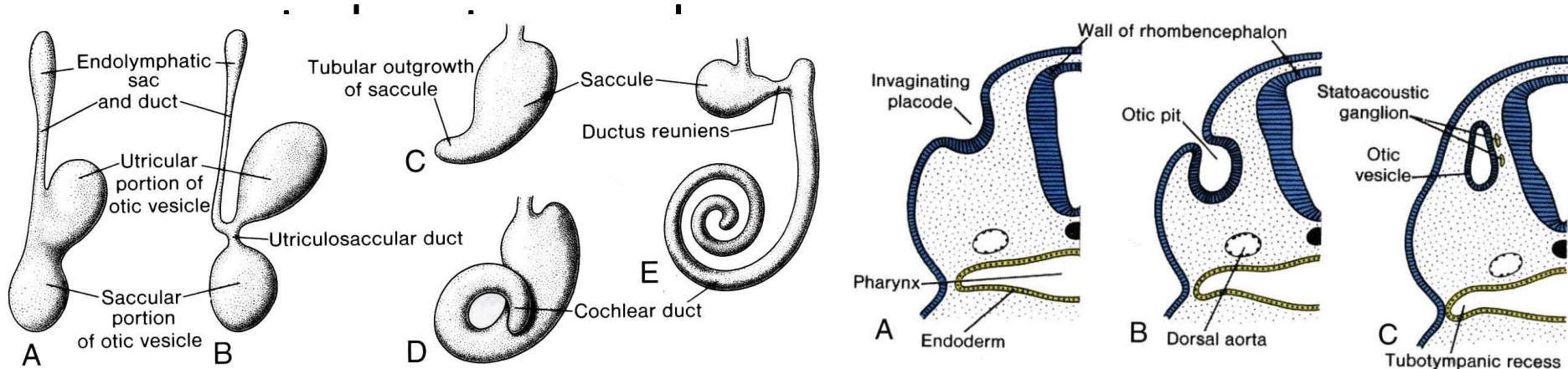
- antrum mastoideum
 - cellulae mastoideae are not developed at birth
 - appear in 2nd year of age
 - pneumatization finished in 6th year of age

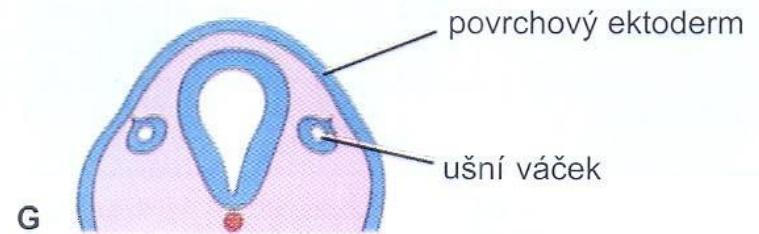
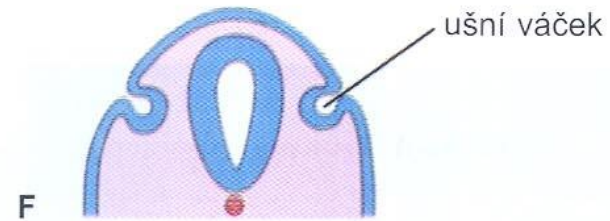
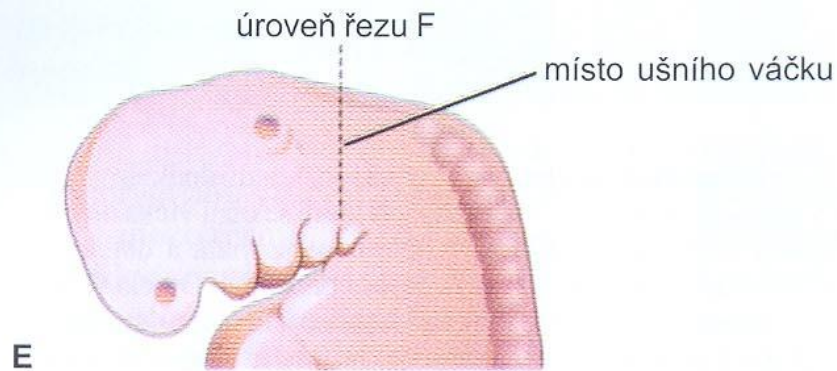
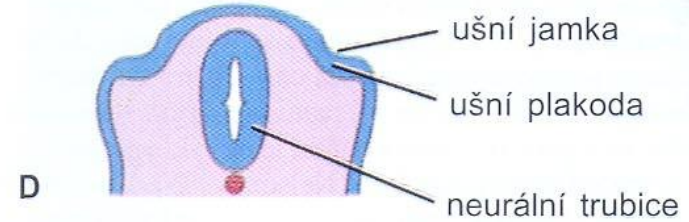
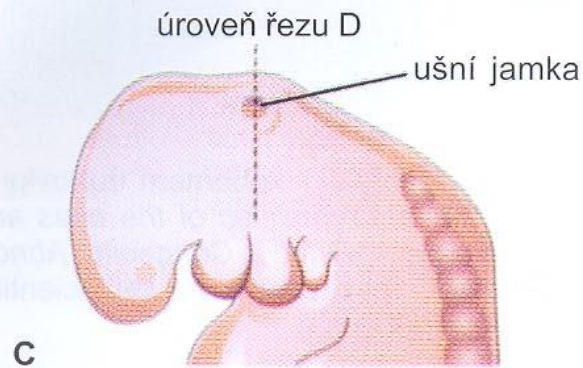
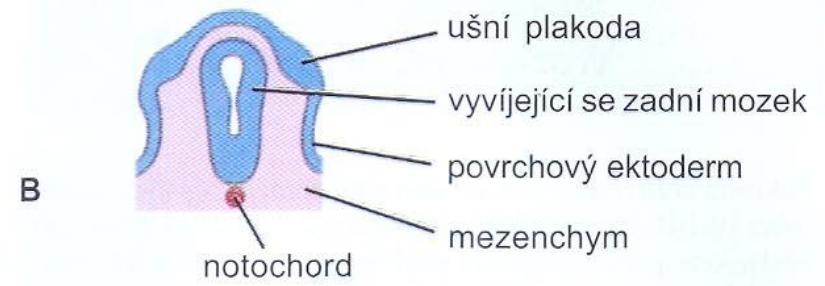
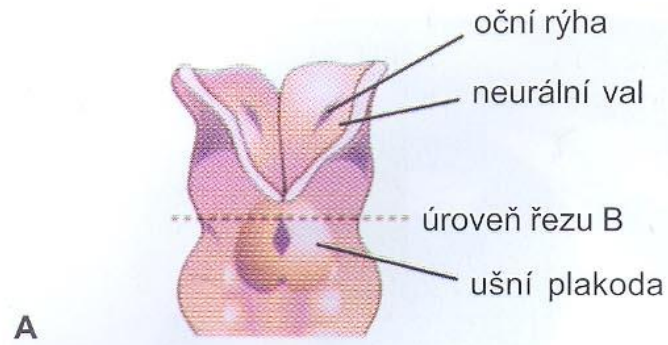
Development of membrana tympani

- outer epithelium from 1st pharyngeal cleft
- inner epithelium from 1st pharyngeal pouch
- ectomesenchyme from 1st and 2nd pharyngeal arch

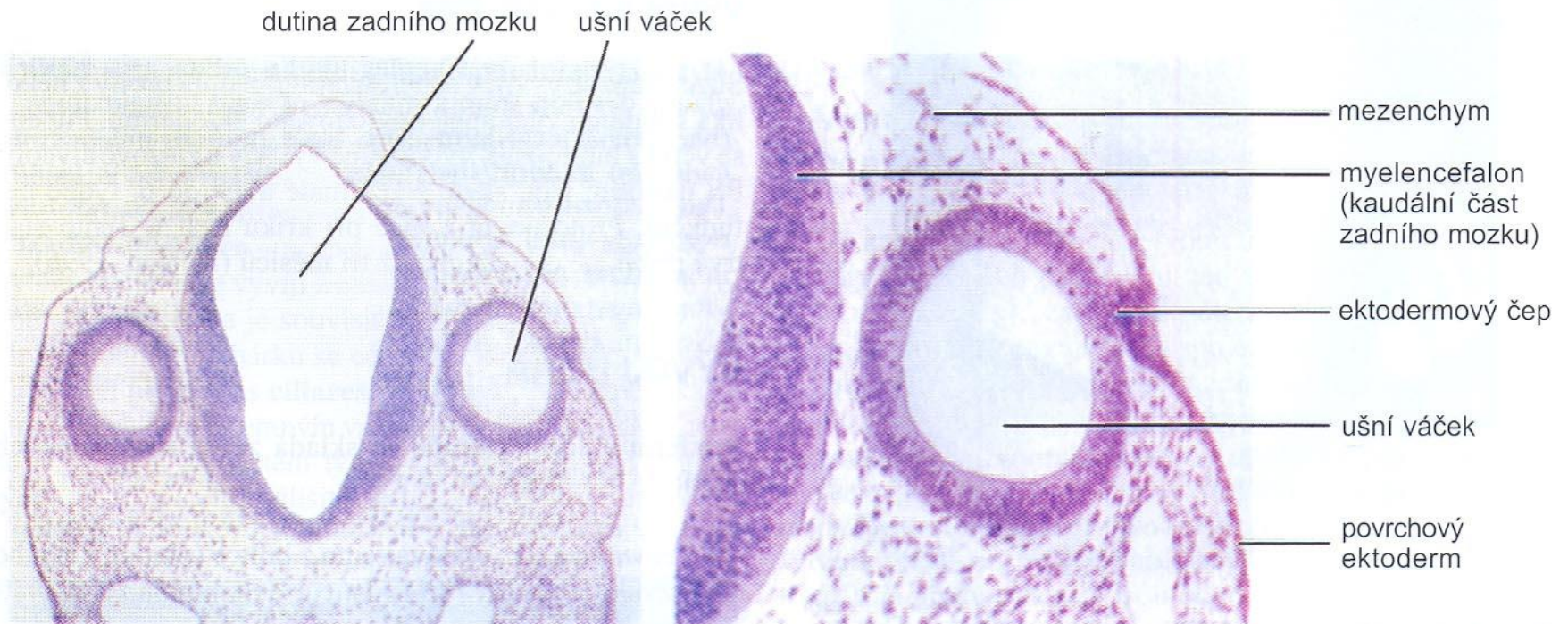
Development of internal ear

- beginning of 4th week – **otic placod** (*ectoderm*)
- auditory pit
- auditory vesicle (otocyst)
 - process for ductus + saccus endolymphaticus
 - dorsal part - utricular





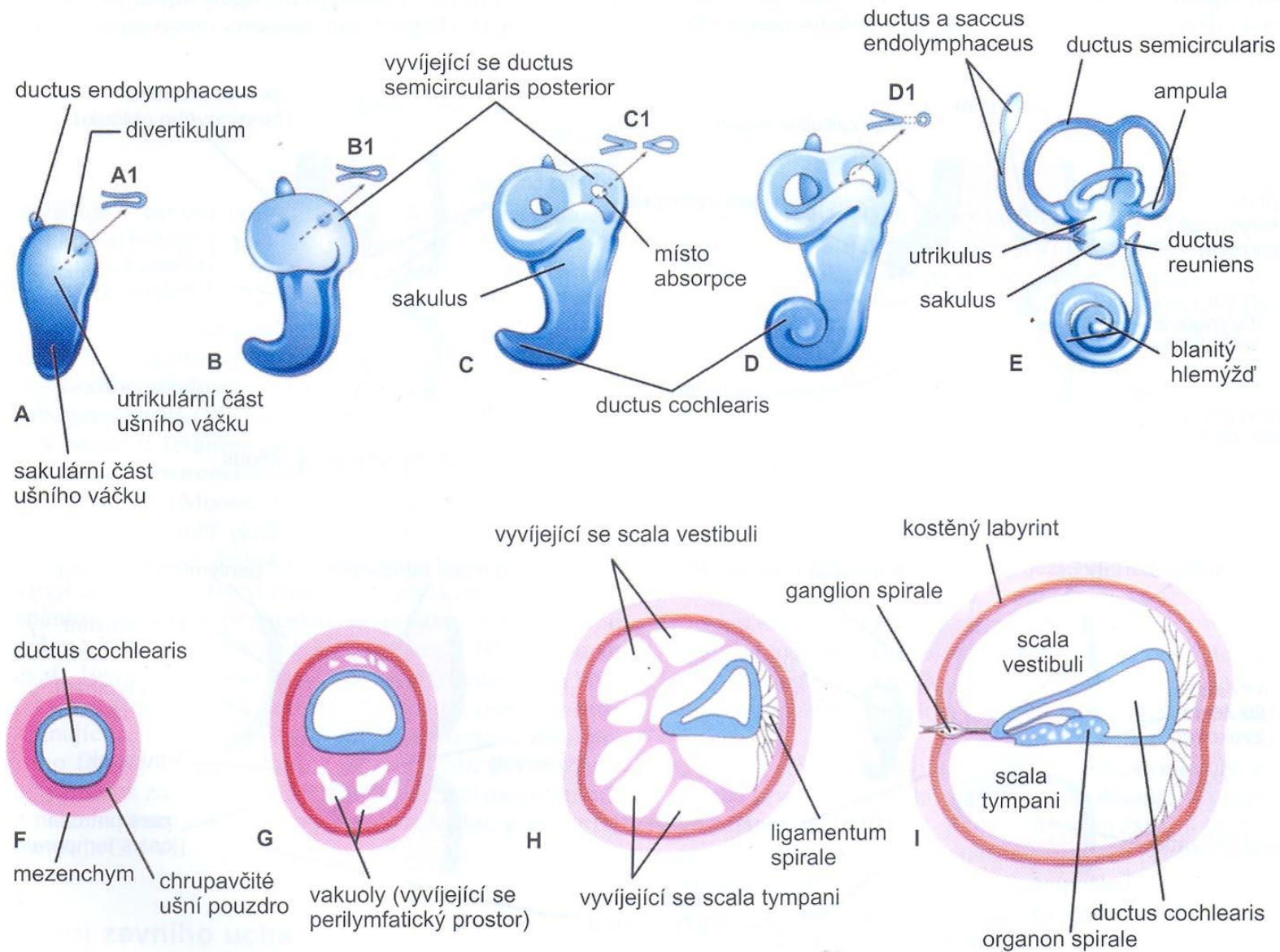
Obr. 19-16. Nákrisy zobrazující časný vývoj vnitřního ucha. *A*, Pohled na dorzální stranu čtyřtýdenního zárodka (kolem 22. dne), znázorňující ušní plakody. *B*, *D*, *F* a *G*, Schémata koronálních řezů ilustrující vývojová stadia ušních váčků. *C* a *E*, Boční pohledy na hlavovou krajinu embryí kolem 24. a 28. dne.



Obr. 19-17. Vlevo, Mikrofotografie příčného řezu zárodkem ($\times 55$) v Carnegie stadiu 12, kolem 26 dnů. Věnujte pozornost ušním (otickým) váčkům, základům blanitého labyrintu, jež dávají vznik vnitřnímu uchu. Vpravo, Pravý otický váček ve vyšším zvětšení ($\times 120$). Povšimněte si ektodermového čepu, který je dosud spojen se zbytkem ušní plakody. Otický váček brzy ztratí spojení s povrchovým ektodermem (základem epidermis). (Z Nishimura H [ed.]: *Atlas of Human Prenatal Histology*. Tokyo, Igaku-Shoin, 1983.)

Development of internal ear

- utricular part → :
 - discoid processes → ductus semicirculares
 - widening into the ampulla, formation of cristae ampullares
- saccular part → :
 - diverticulum ductus cochlearis (getting spiral)
 - ductus reuniens appears
 - Corti's organ (from wall of ductus cochlearis)
 - ganglion cochleare appears



Obr. 19-18. Nákrisy ušního váčku zobrazující vývoj blanitého a kostěného labyrintu vnitřního ucha. A až E, Boční pohledy znázorňující přeměnu ušního váčku v blanitý labyrint mezi pátým a osmým týdnem. A₁ až D₁, Schematické náčrtky vystihující vývoj polokruhovitých duktů. F až I, Řezy kochleárním duktem znázorňující postupný vývoj organon spirale (Corti) a perilymfatických prostorů mezi osmým a dvacátým týdnem.

Development of internal ear

- surrounding mesenchyme changes into cartilaginous capsula otica
- cavities appears inside the capsula → perilymphatic spaces
- Week 20-22: ossification of cartilaginous walls



Case-report 1

- male, 28 let
- returned back from holiday in Egypt
- otalgia for 3 days
- palpation painful

- objective examination: tragus sensitive in palpation
- otoscopic examination: swollen reddish external acoustic meatus with white matter of dead cells

Case report 1 - diagnosis

- otitis externa
- disease of summer months and bathing
- *complications*: mainly in diabetes mellitus
→ perichondritis or even destruction of temporal bones

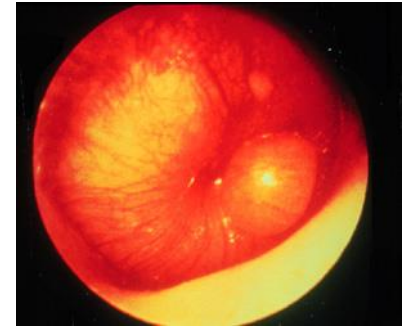


Case report 2

- female, 3 years
- during night sleep severe pain of right ear, weeping, cannot be calmed, blowing her nose for 2 days
- vomitting during examination
- temperature 38,3°C
- otoscopic examinatio: tympanic membrane dark red, without contours, convex

Case report 2 - diagnosis

- mesotitis (otitis media) acuta l. dx.



treatment: paracentesis

complications:

- perforation of tympanic membrane
- mastoiditis → thrombosis of sinus sigmoideus
- labyrinthitis
- (chronic mesotitis)



grometa



Case report 3

- female, 34 years
- feeling of pressure in left ear, sudden hypoacusis, buzzing tinnitus, rotation vertigo, vomitus
- vertigo disappeared, other symptoms persist
- objective examination: harmonic vestibular phenomens (signaling prevailing one labyrinth)
- audiometry: perceptive hypacusis with apicocochlear predominance

Case report 3 - diagnosis

- Menièr's disease
 - hydrops of labyrinth
- patient will return in one month with same symptoms
- dif.dg.: circulation disorders, atherosclerosis, sclerosis multiplex, acoustic neurinoma

Further study

- [https://www.youtube.com/watch?v=PeTriGTE
Noc](https://www.youtube.com/watch?v=PeTriGTE<u>Noc</u>)
- [https://www.youtube.com/watch?v=1JE8Wdu
JKV4](https://www.youtube.com/watch?v=1JE8Wdu<u>JKV4</u>)
- [https://www.youtube.com/watch?v=K13lOqc
b5ng](https://www.youtube.com/watch?v=K13lOqc<u>b5ng</u>)