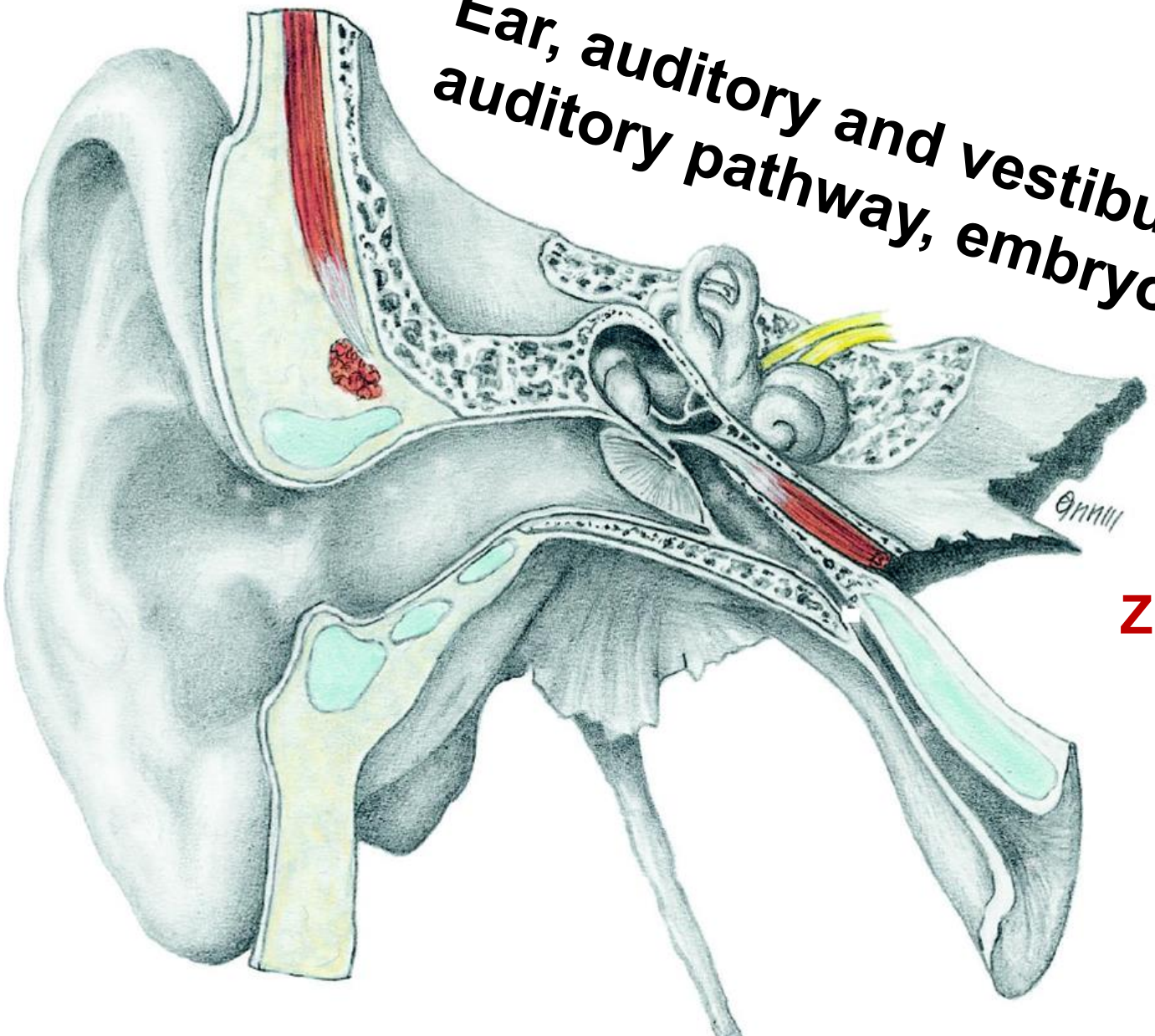
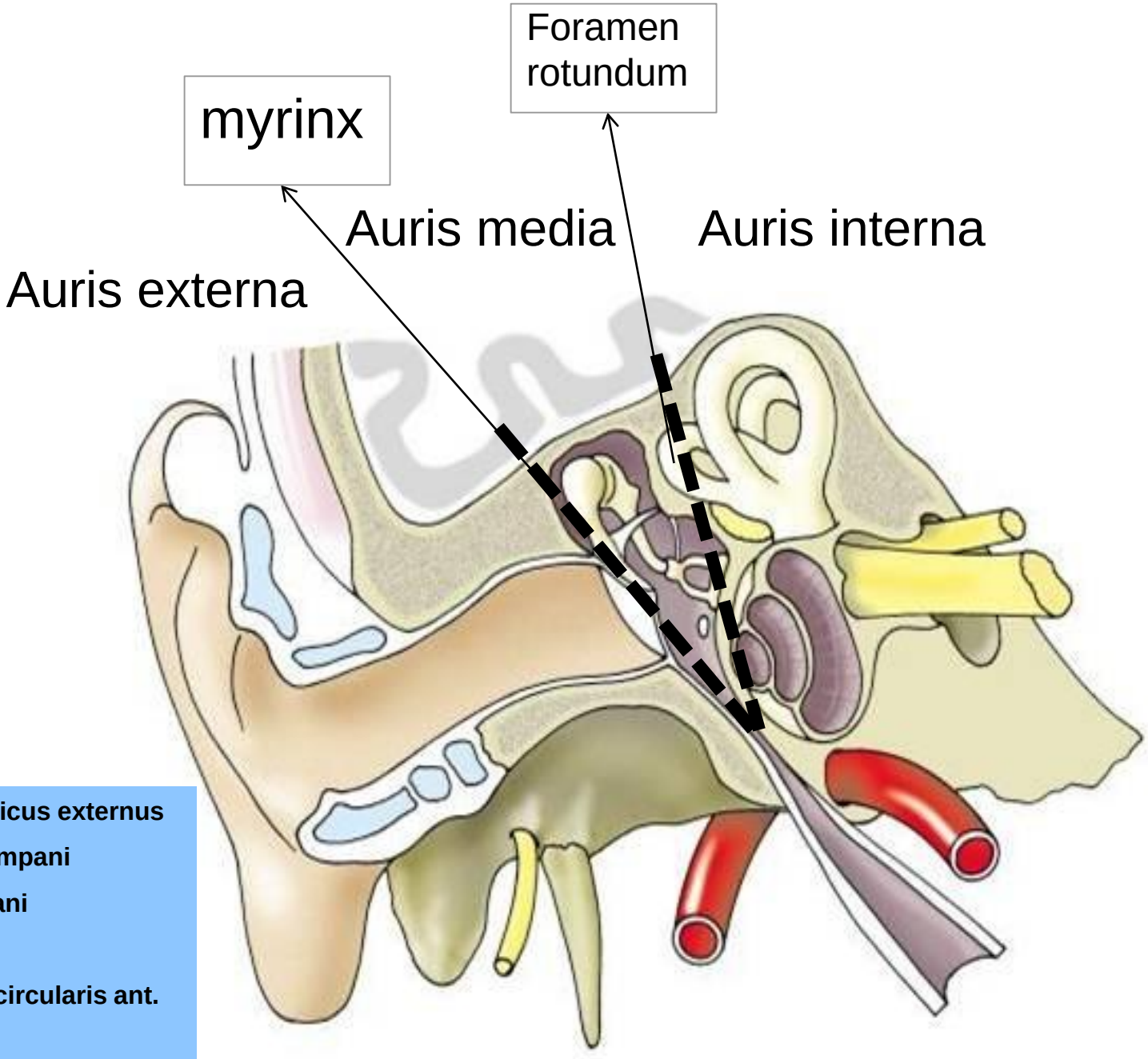
Ear, auditory and vestibular system, auditory pathway, embryology



Zdeněk Fík



A Meatus acusticus externus

B Membrana tympani

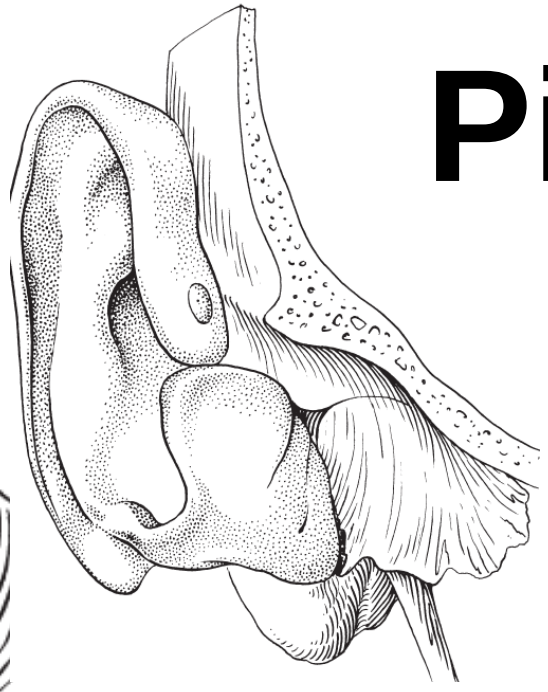
C Cavum tympani

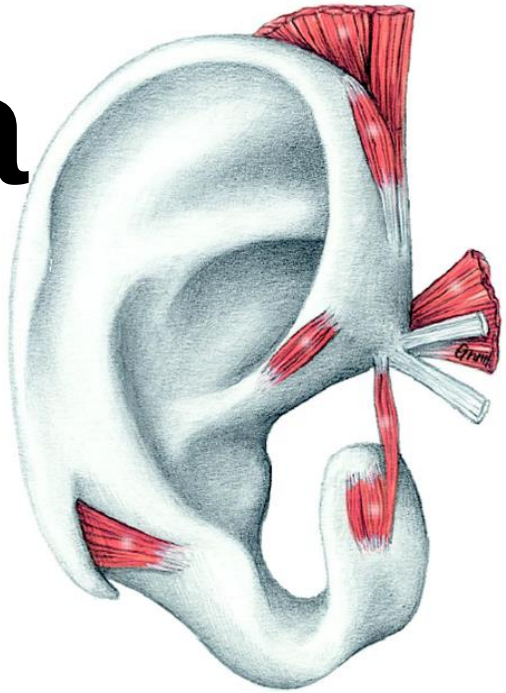
D Cochlea

E Canalis semicircularis ant.

F Tuba auditiva

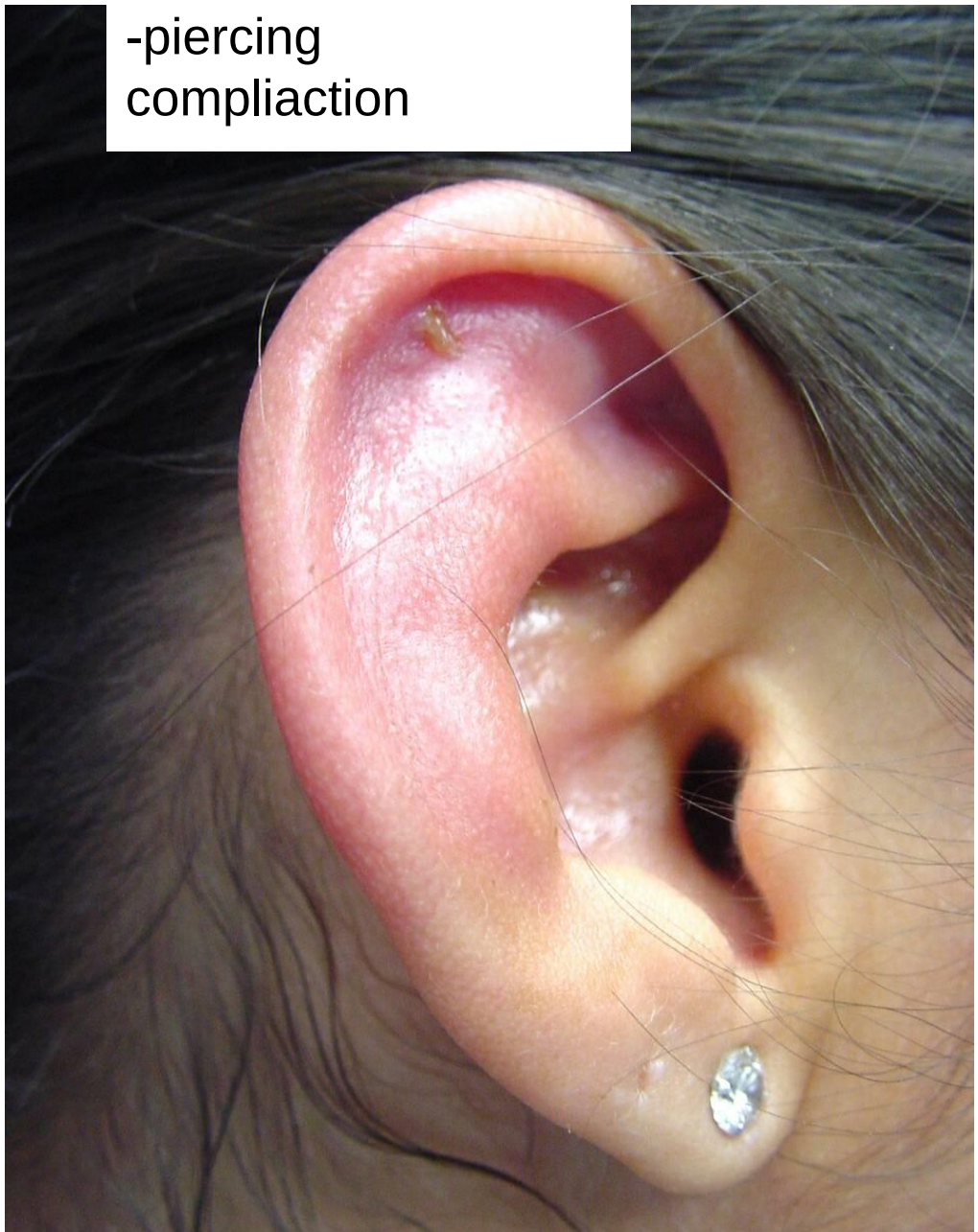
Pinna





Elastic cartilage – missing in lobulus

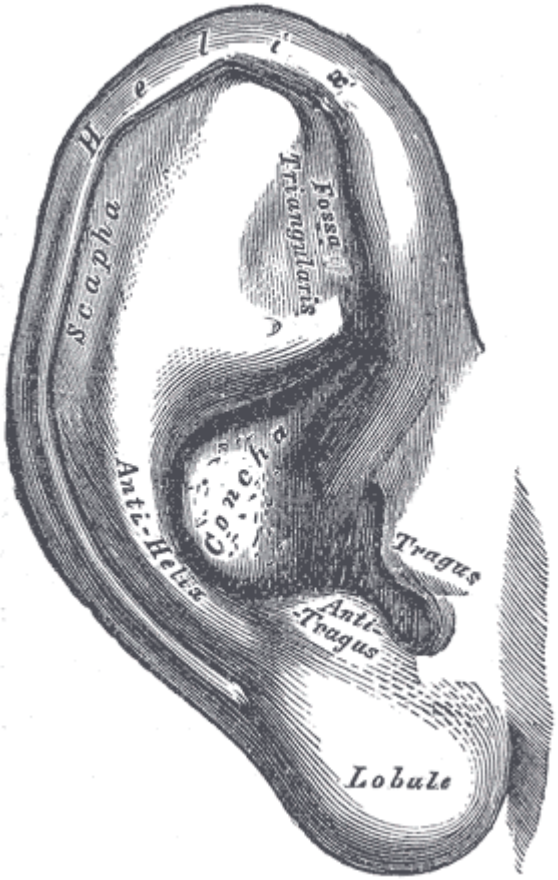
Perichondritis
-piercing
compliaction

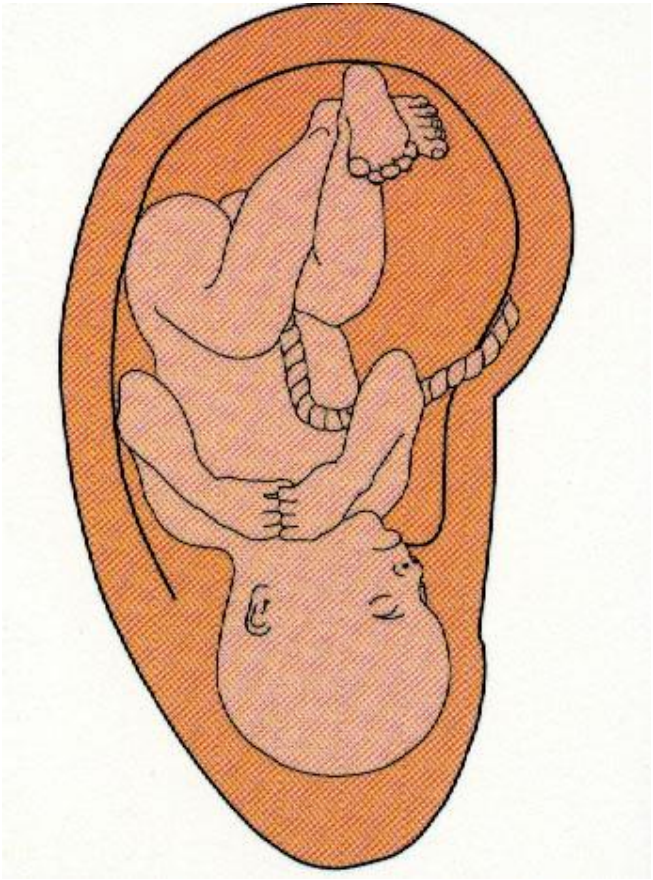


Cauliflower deformity
– wrestling fighter

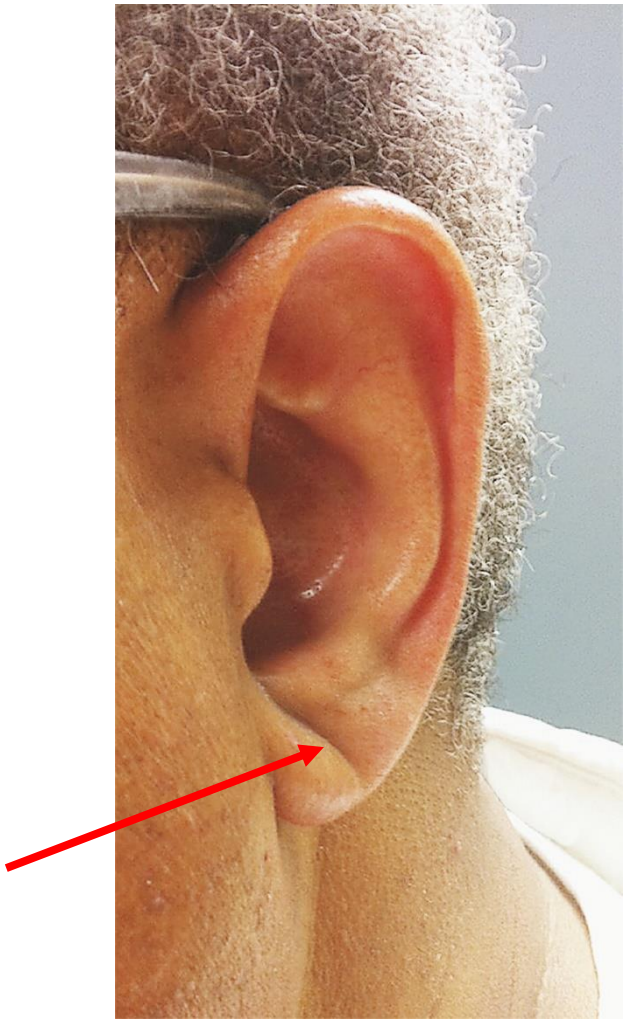
Otapostasis

Auricular acupuncture





Frank sign



Griffing G. N Engl J Med 2014;370:e15.

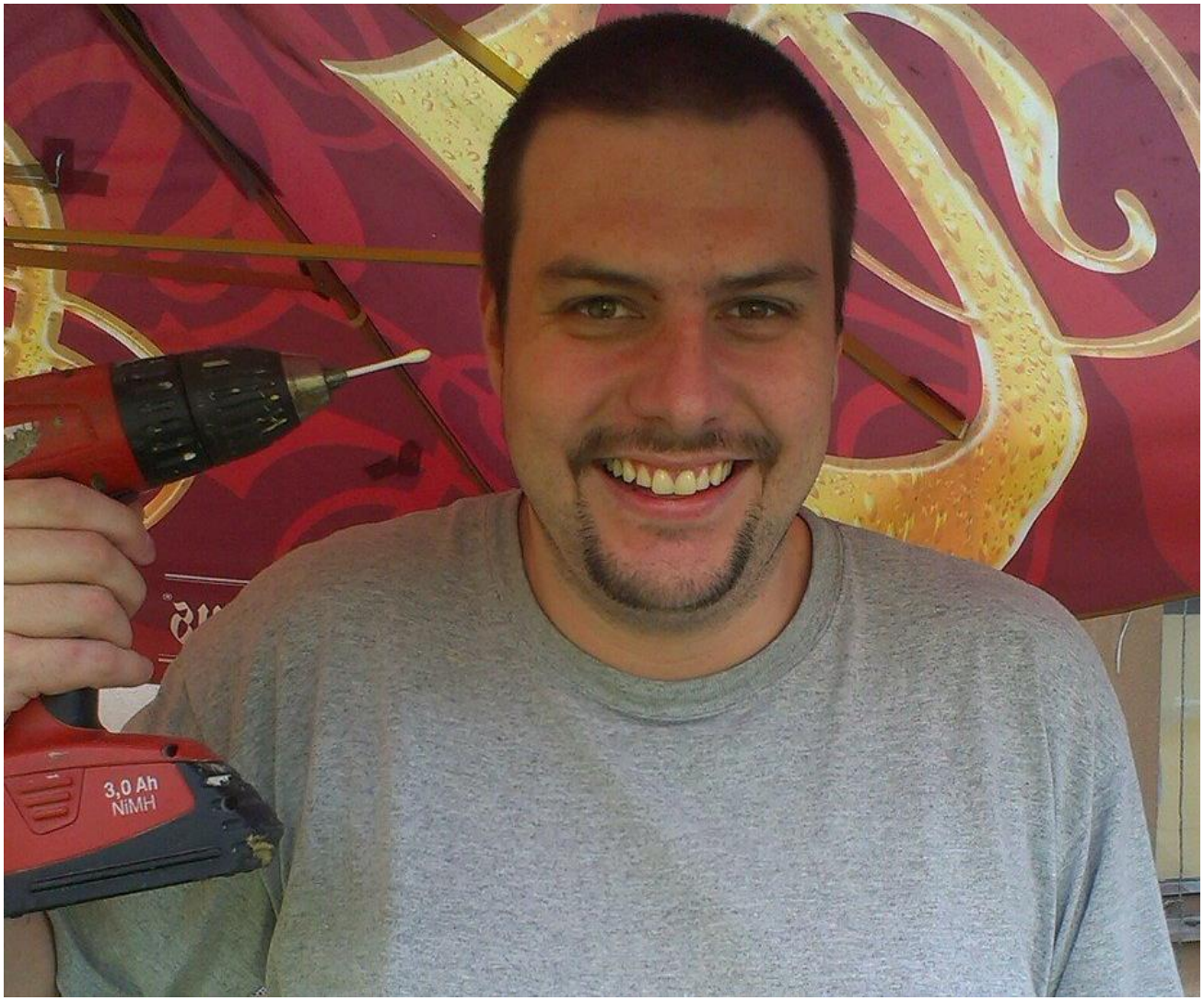
Sign of early degeneration of elastic fibres in the skin and vessels.

Indicates possible damage of coronary arteries.

The NEW ENGLAND JOURNAL of MEDICINE

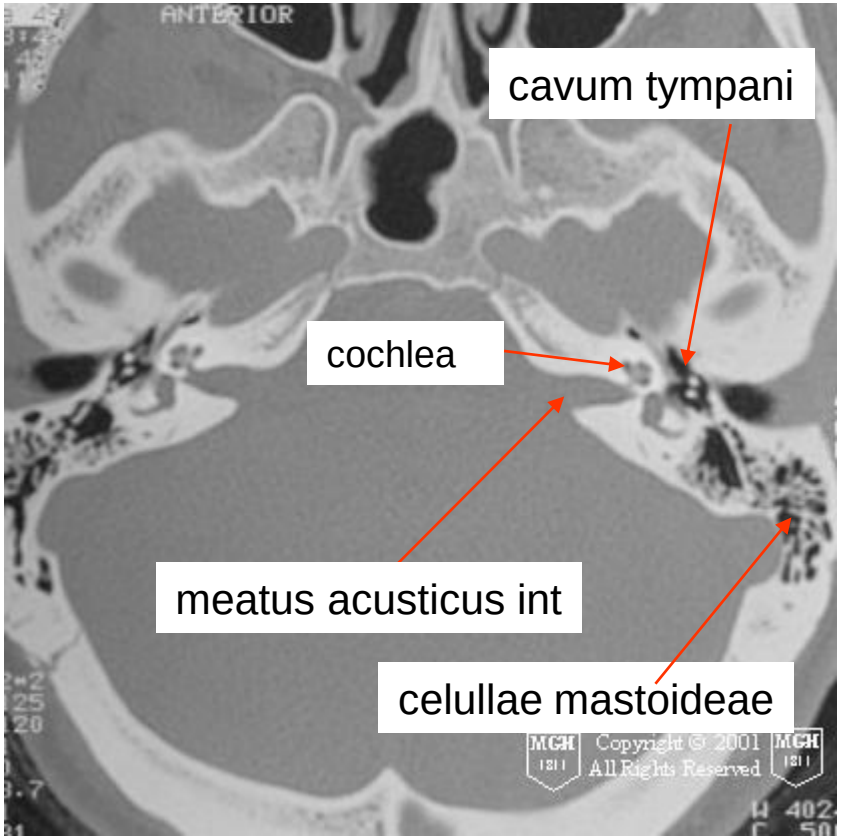
Nanda, A., et al. (2011). "Implant-supported auricular prosthesis." Indian J Dent Res **22**(1): 152-156.

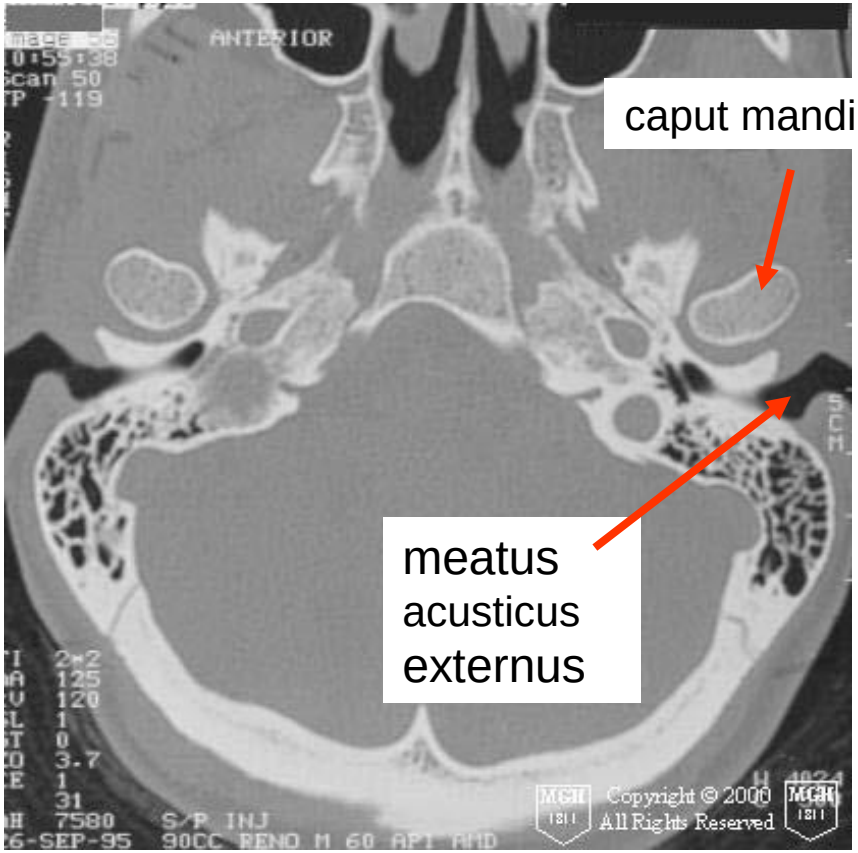
Ear canal

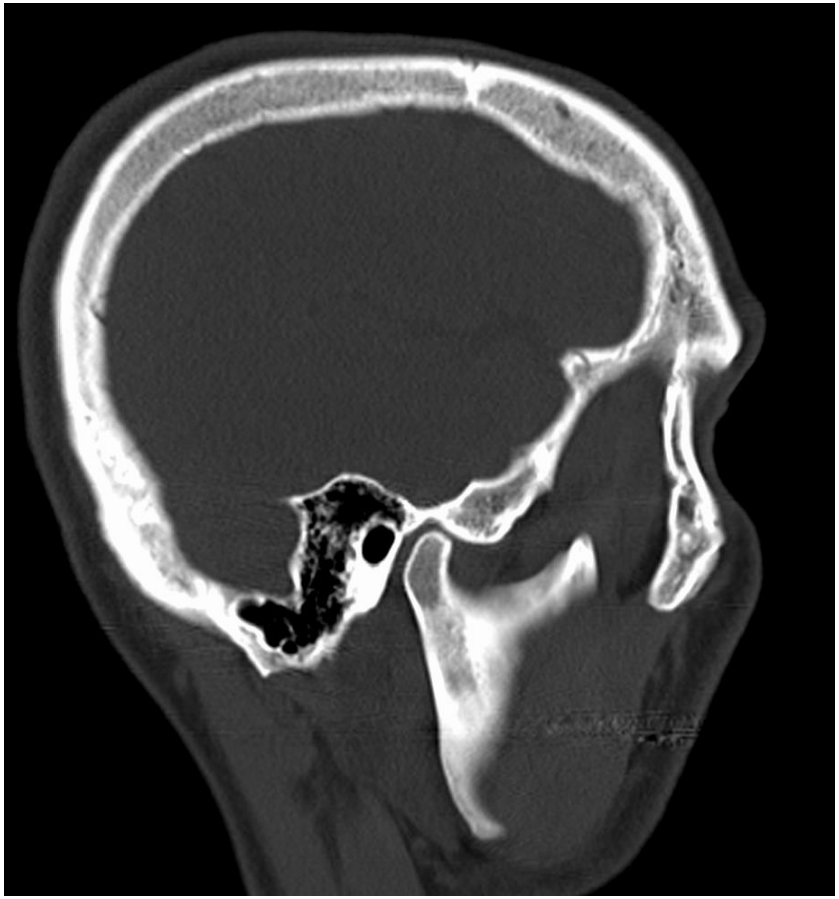


Meatus acusticus externus

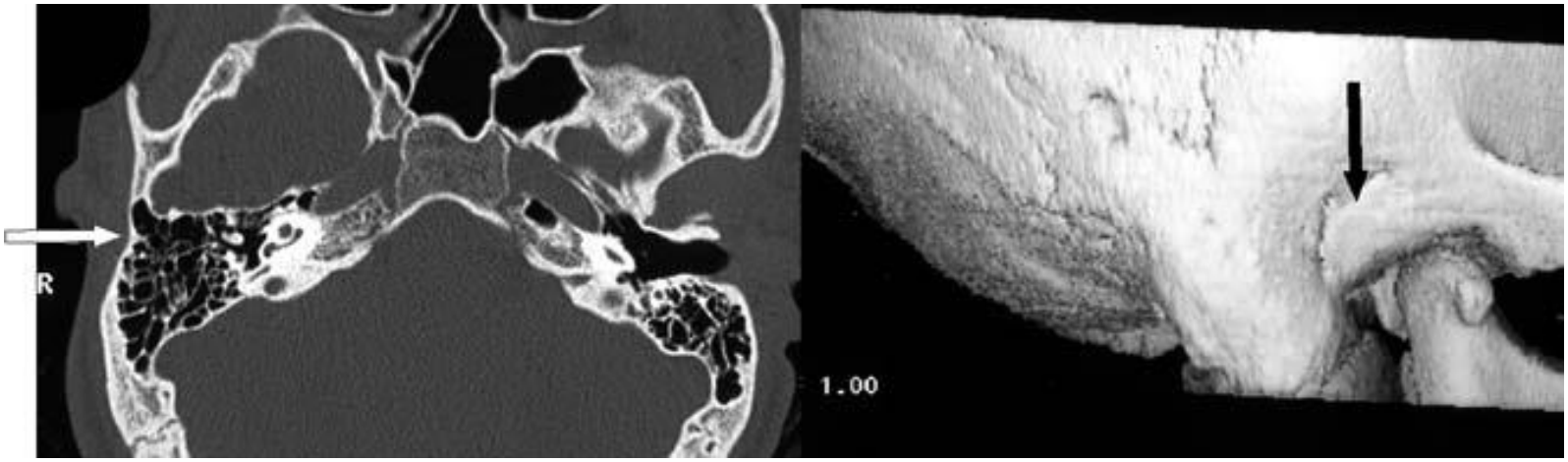
CT horizontal section

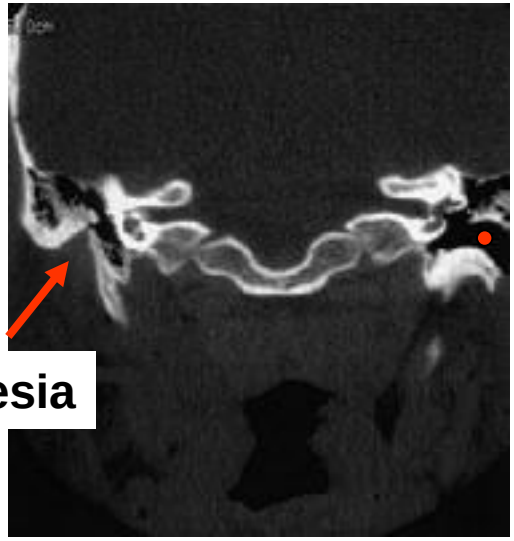






Ear canal atresia

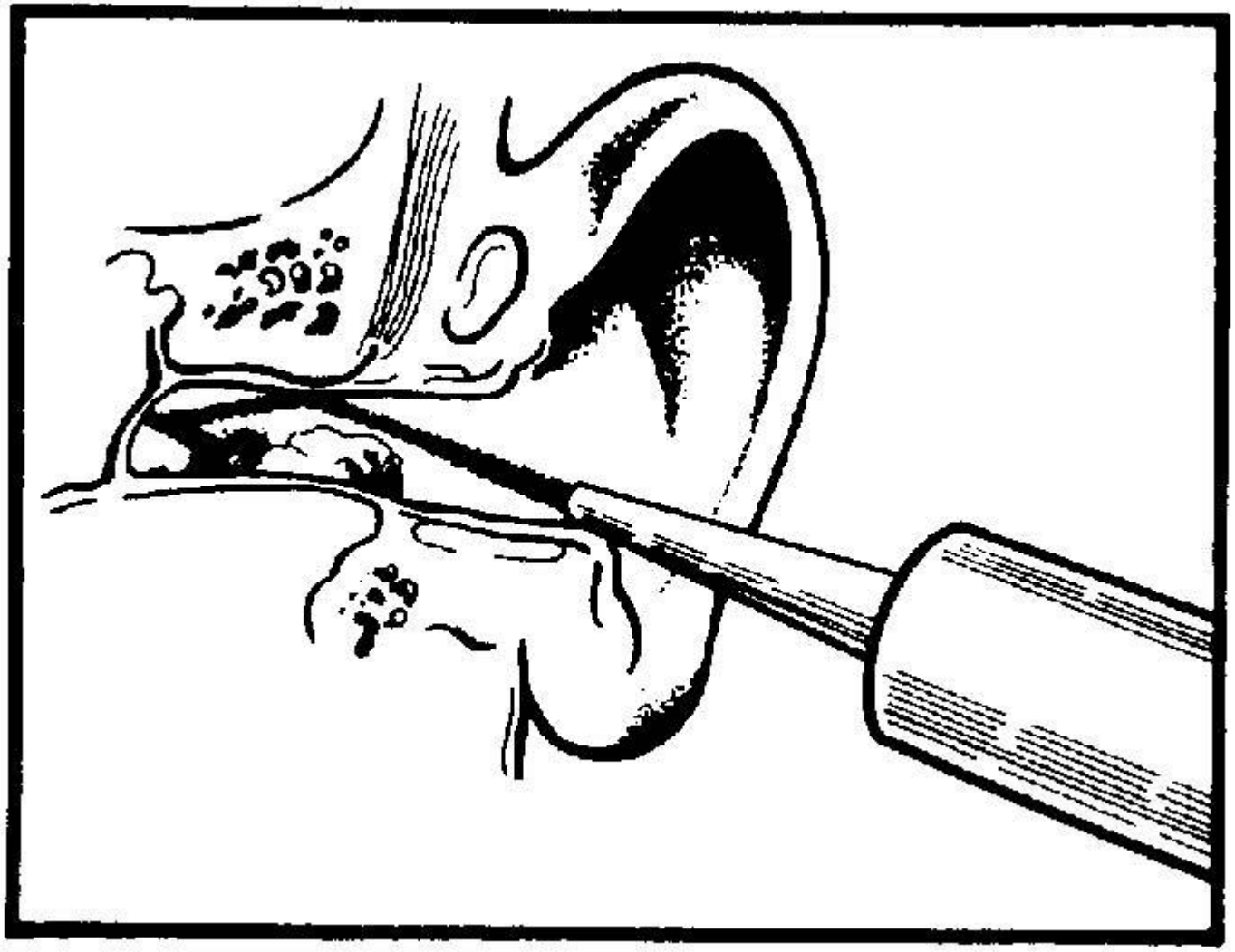




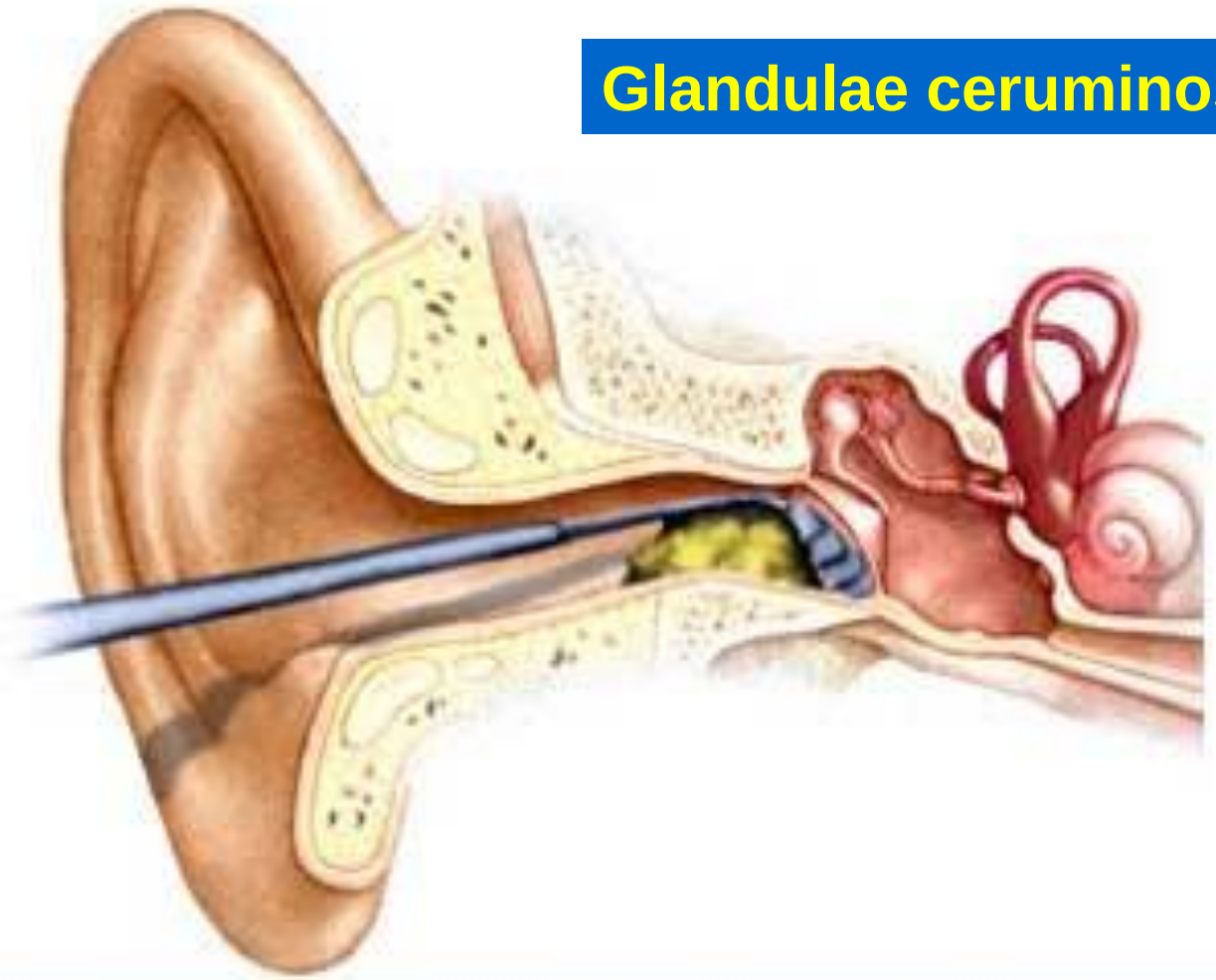
Tragi – hair in the ear canal (adults)

- Radchakanta Bažpaj and his 13 cm long tragi – Guinness world record

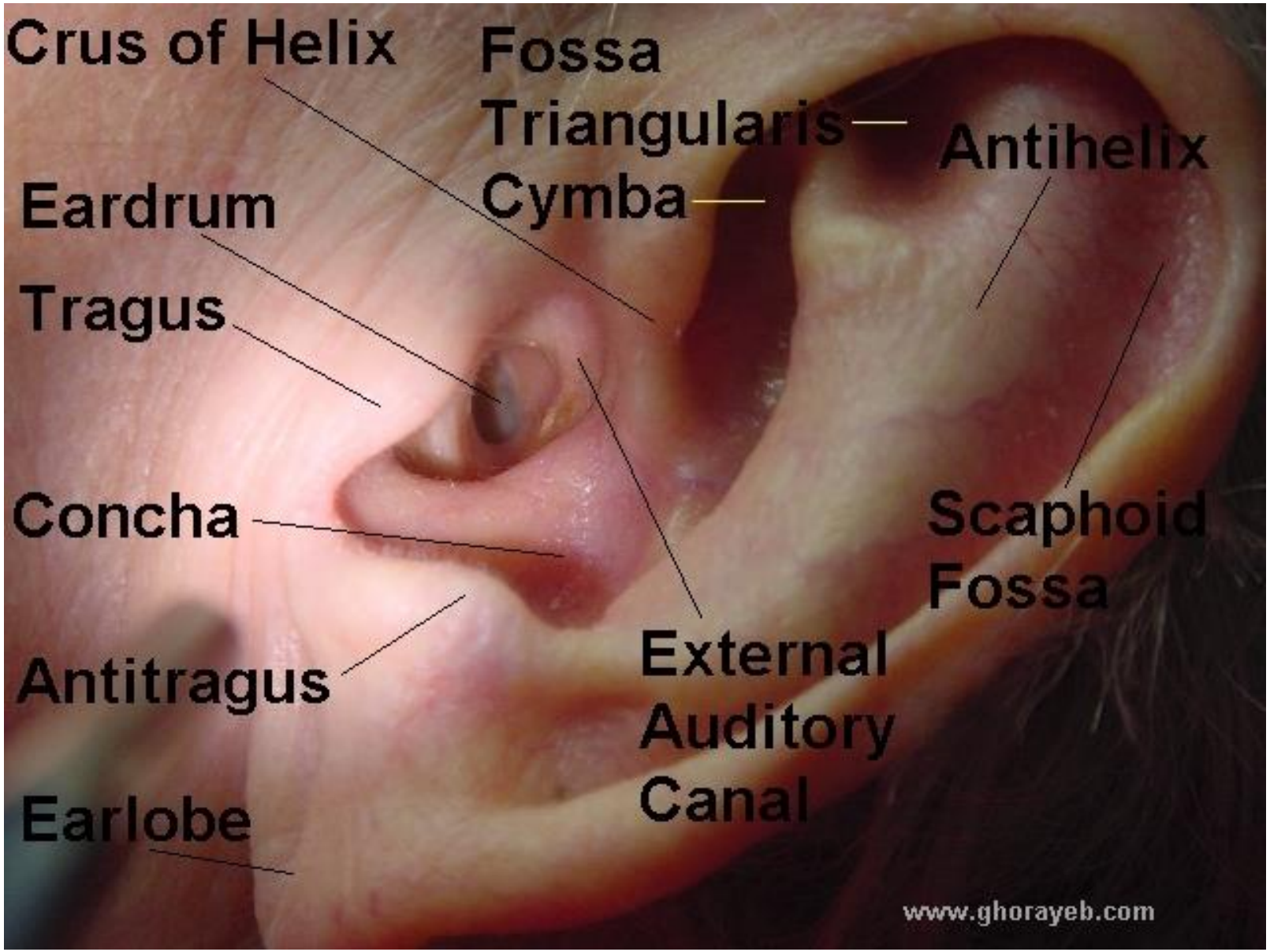
Ear canal irrigation



Earwax removal



Wide and straight ear canal



Eardrum

1 - stria mallearis

2 – plica mallearis ant

3 – plica mallearis post

4 – pars flaccida membranae tympani

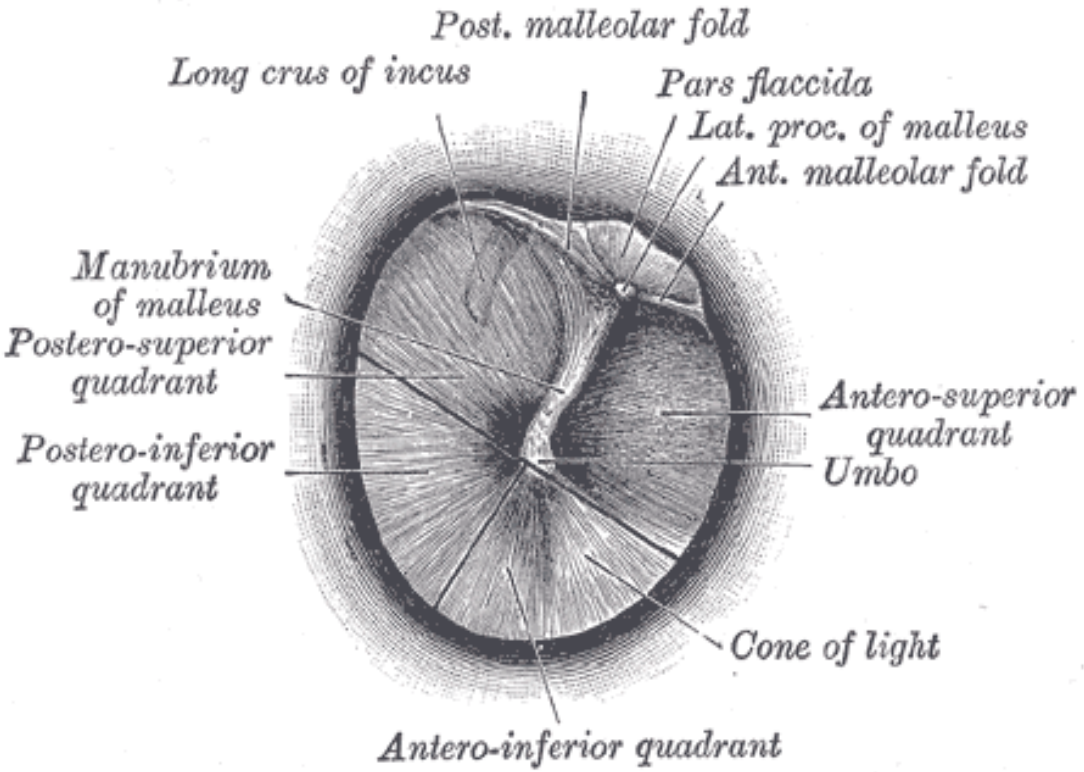
5 – umbo

6 - prominentia mallearis

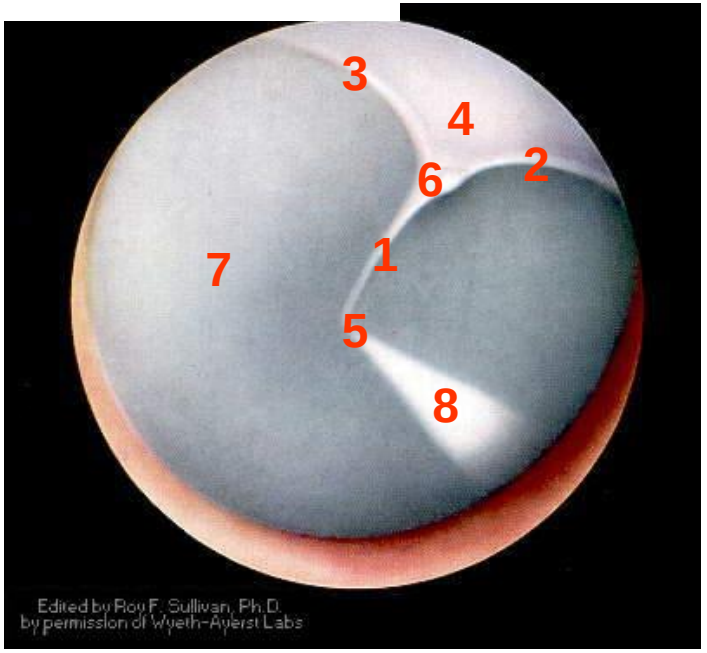
7 – pars tensa membranae tympani

8 - reflex

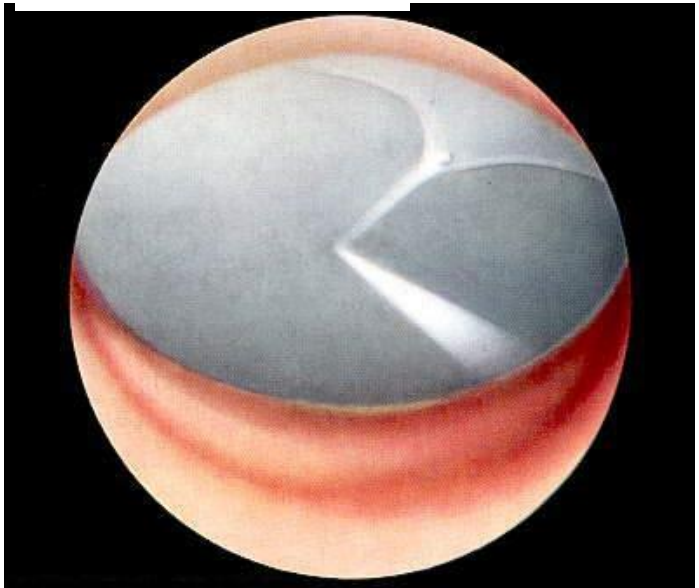
Otoscopic view

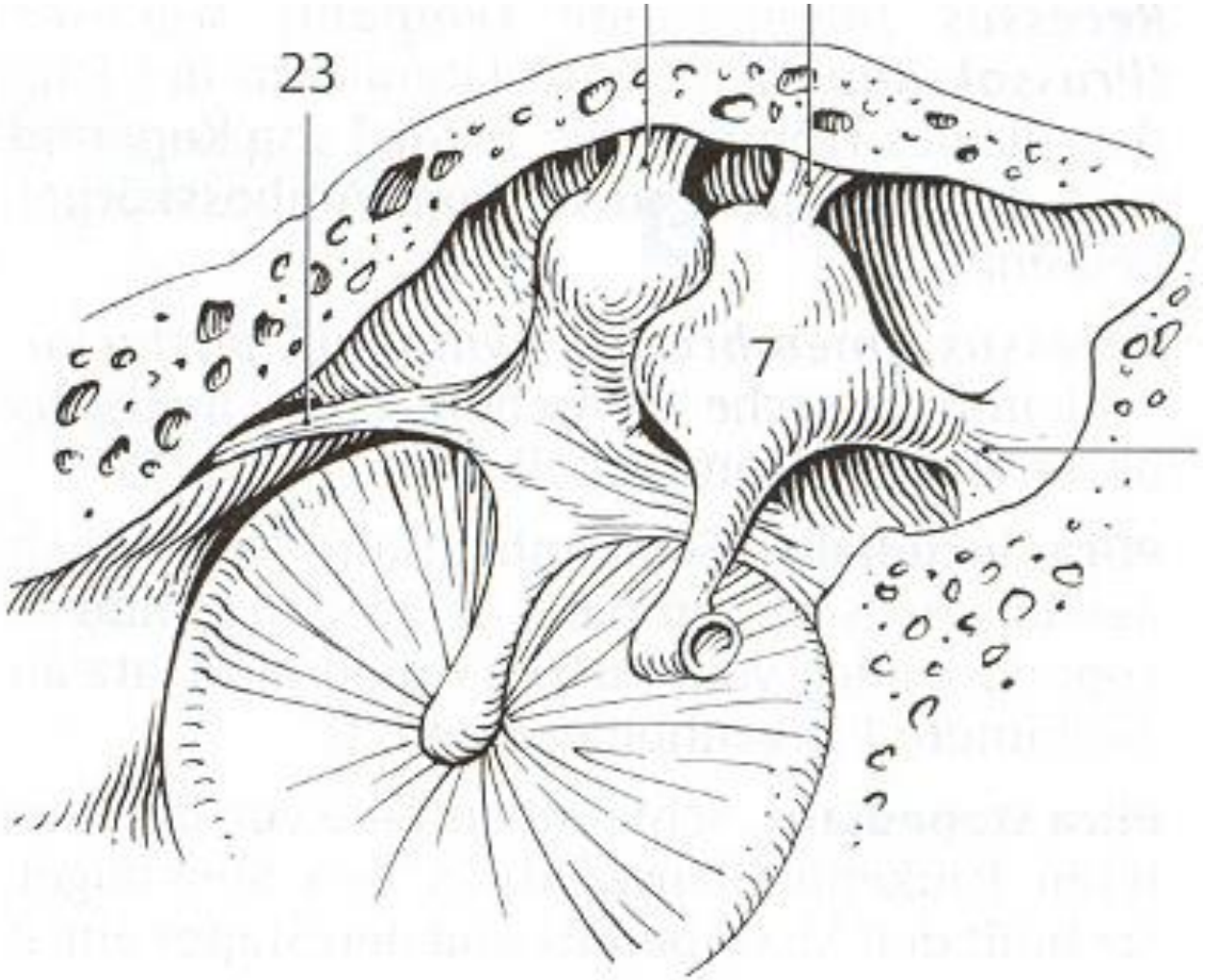


Eardrum - adult



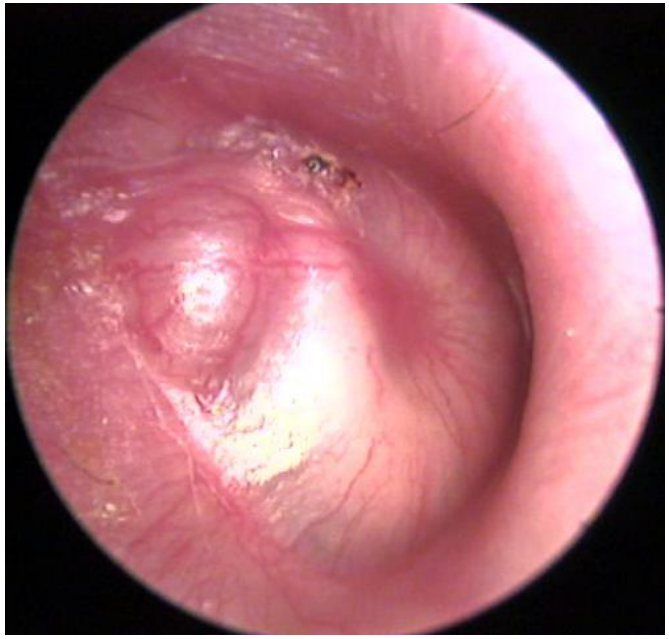
Eardrum - child



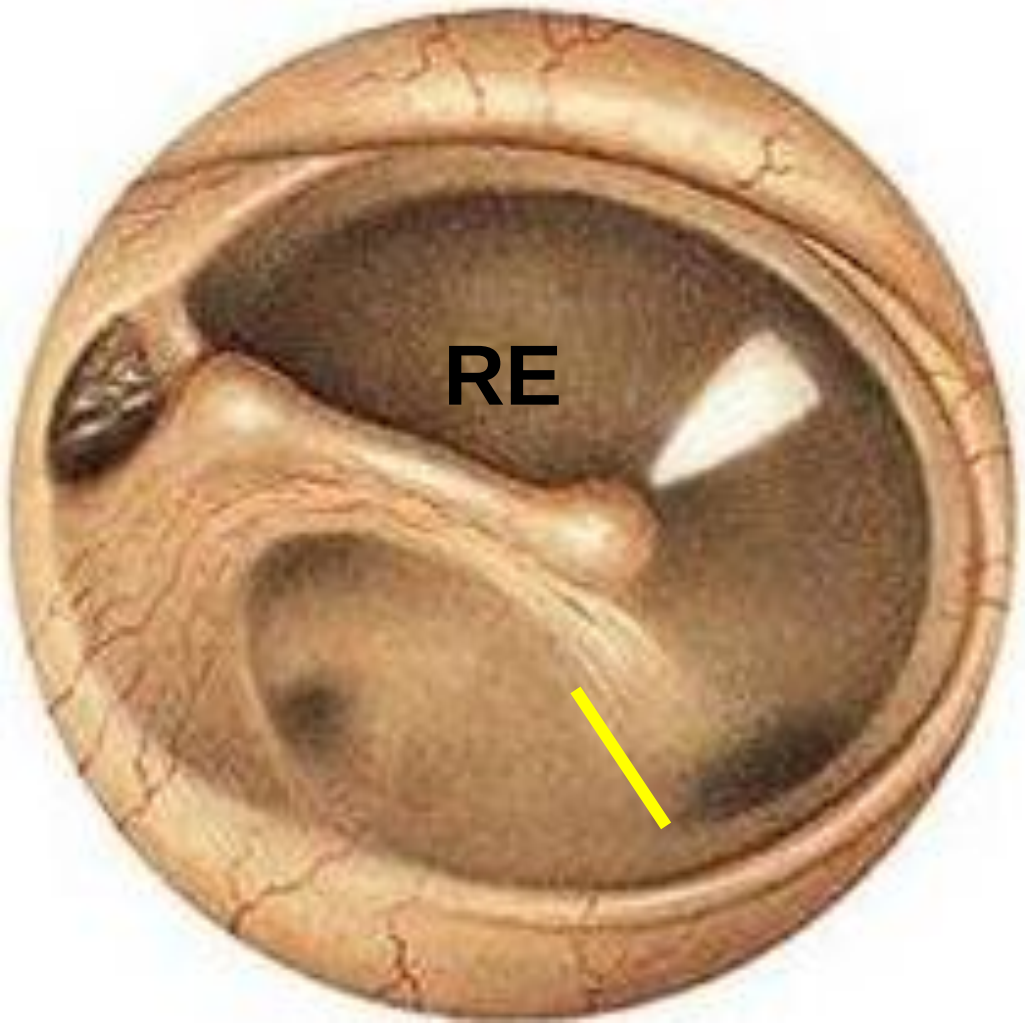

23
7

Normal otoscopic view

Pathologic otoscopy view



Paracentesis



Hair?

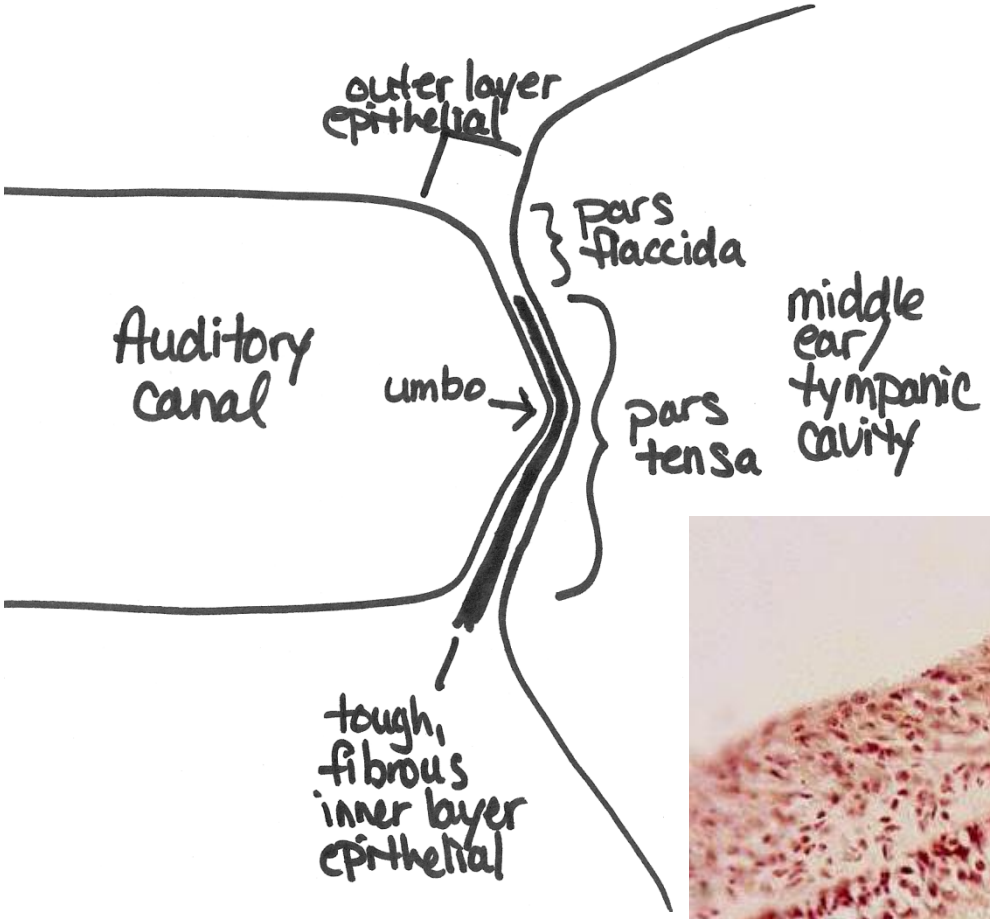
neck

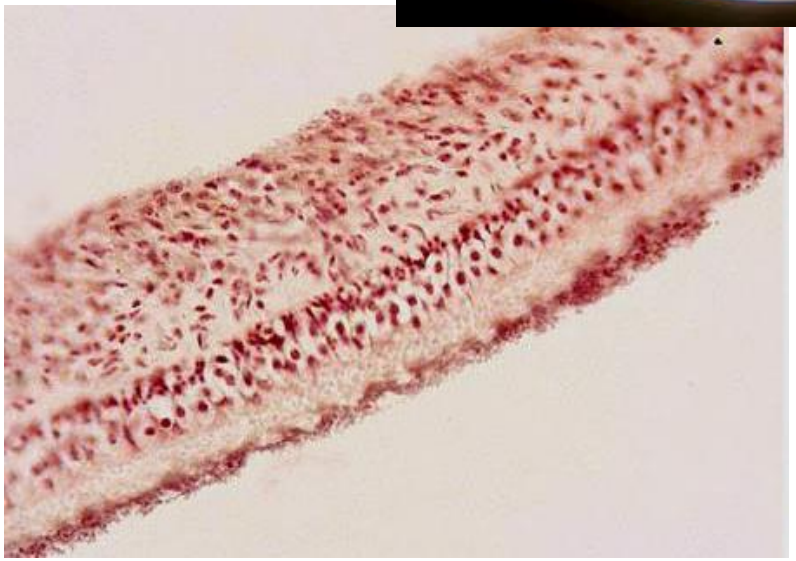
nape

Myringostomy – ventilation tube

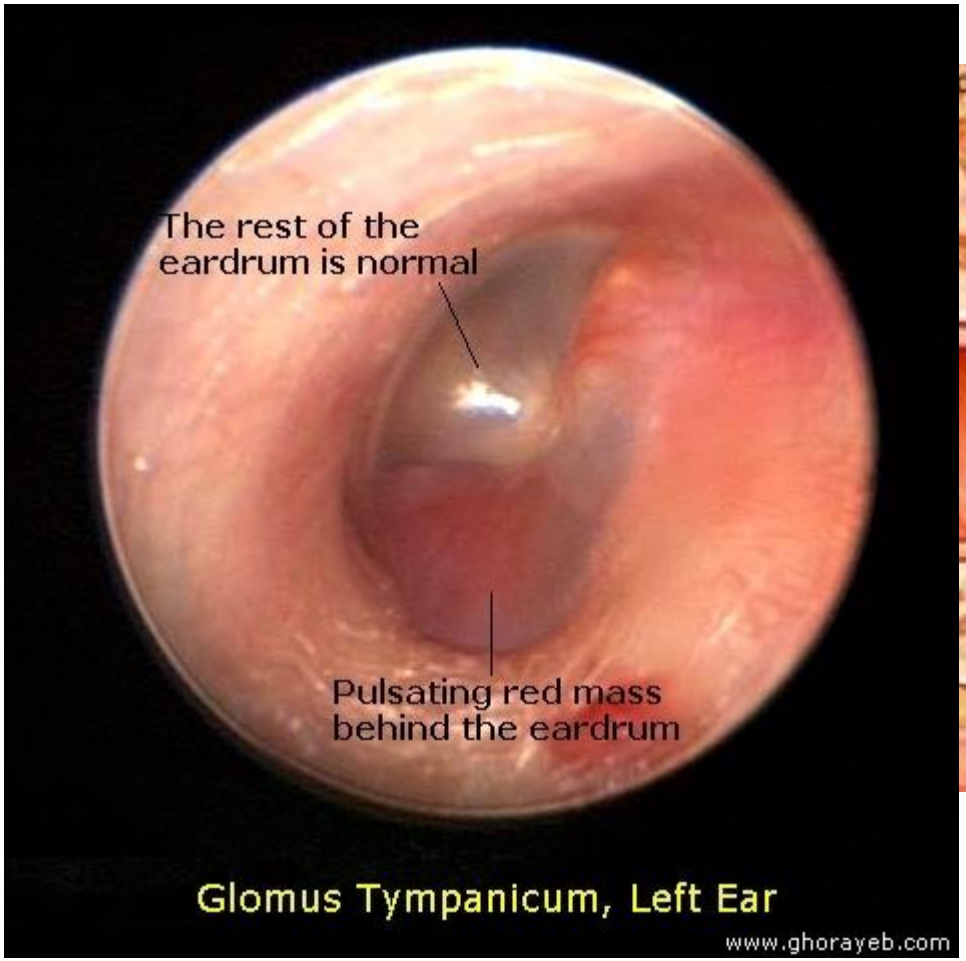
- **Secretory otitis media**

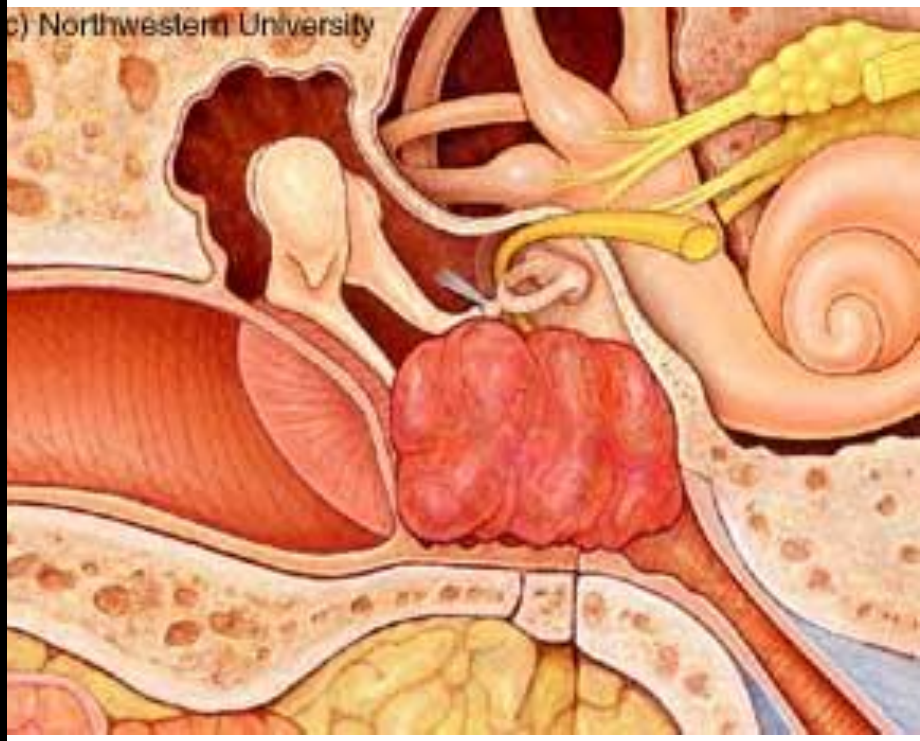
Pars flaccida
Pars tensa



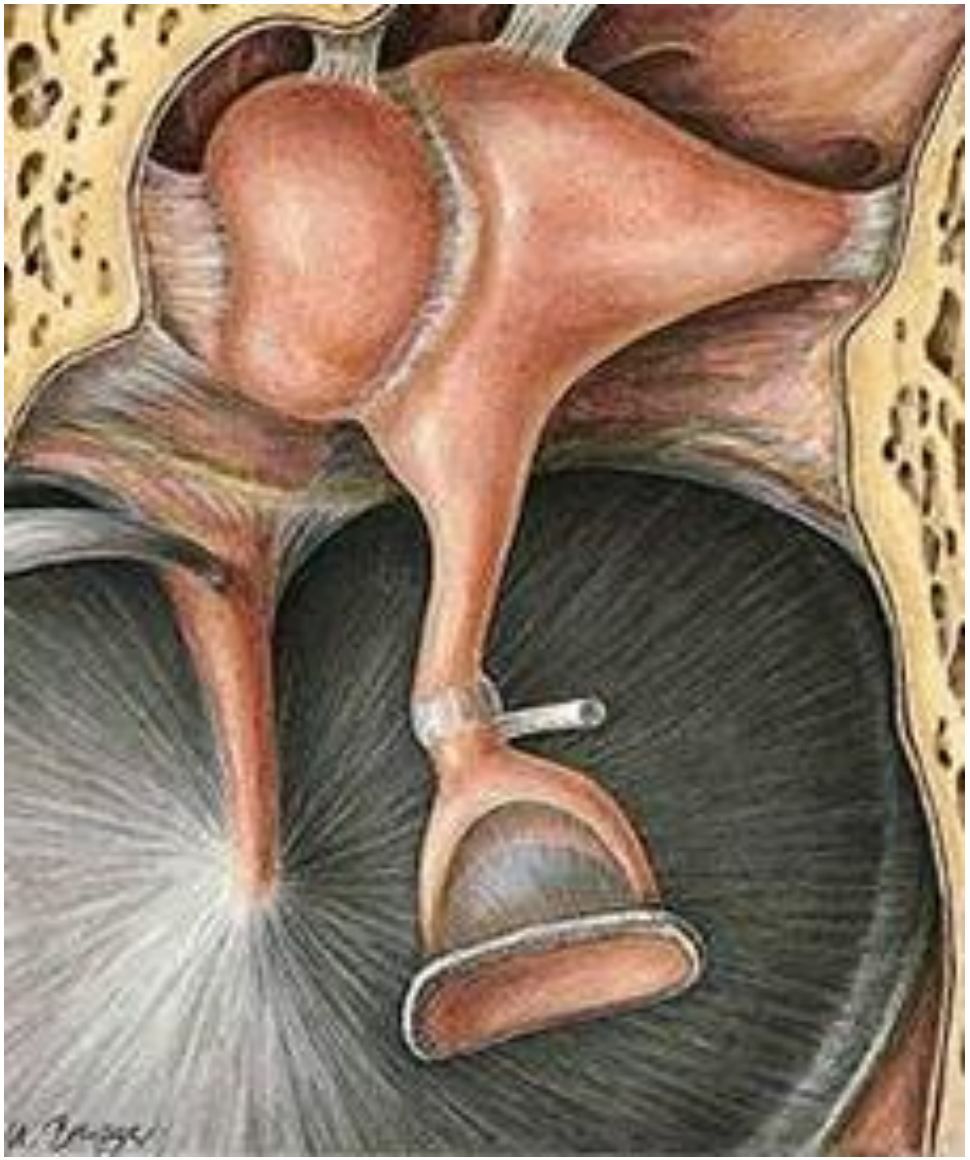


Tympanic paraganglioma

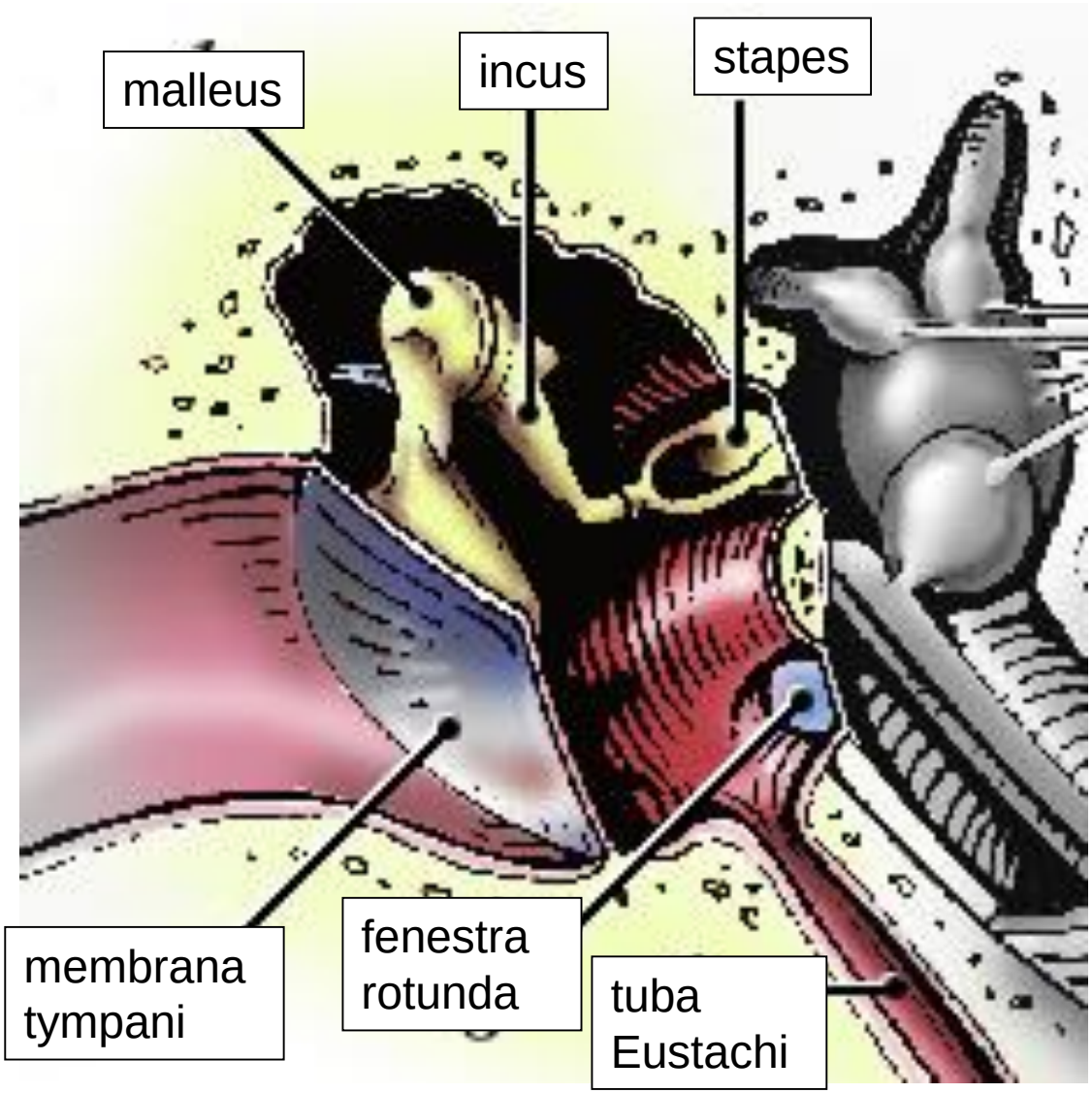


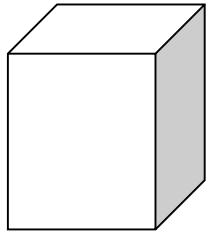


Middle ear



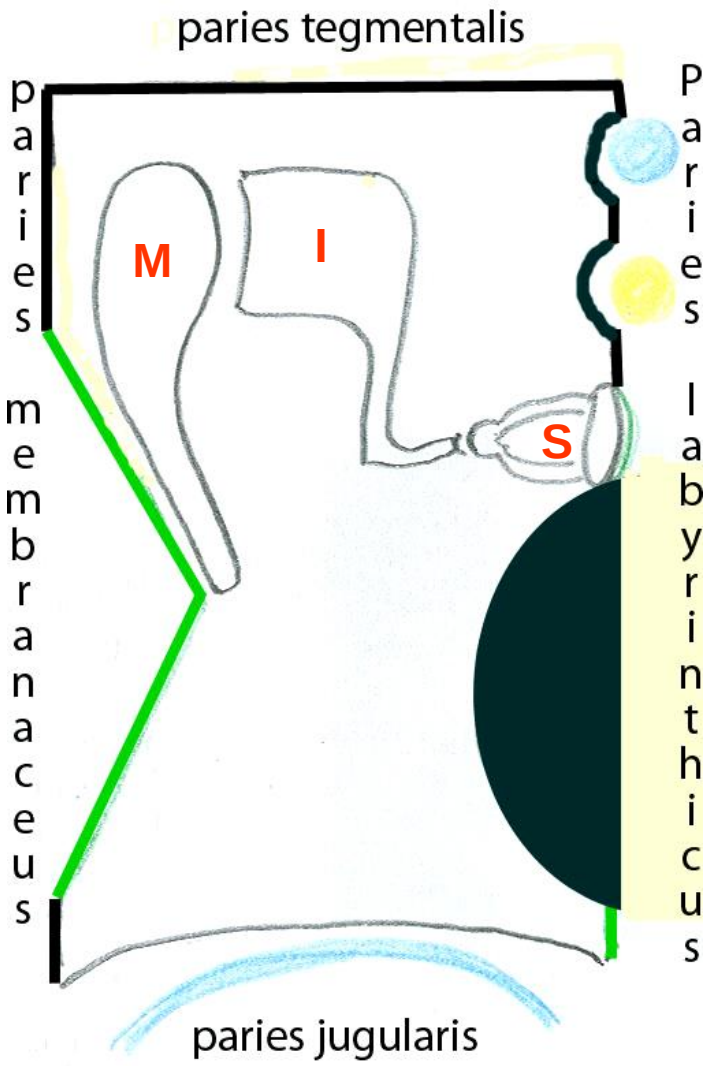
Tympanic cavity





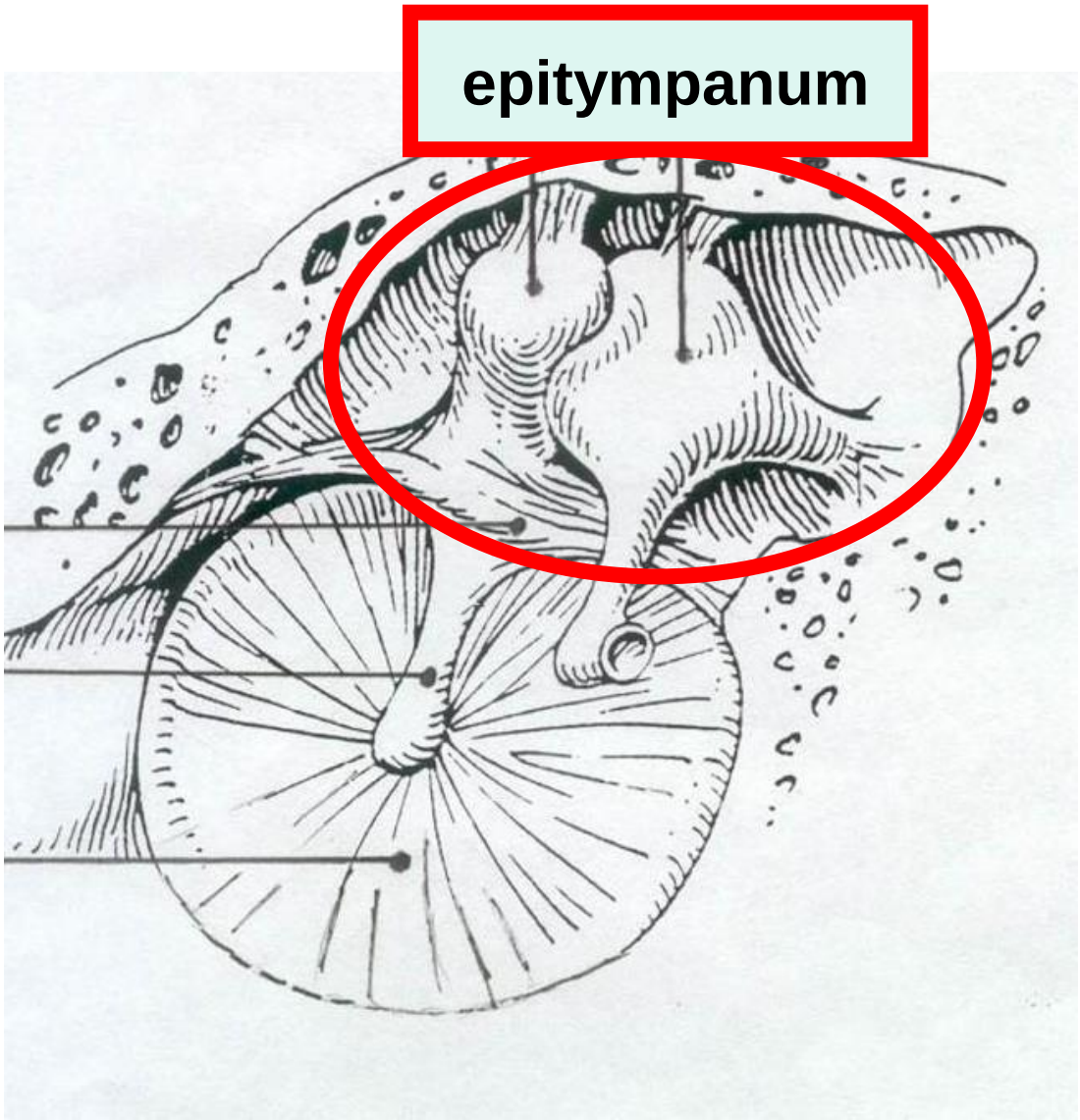
paries membranaceus
paries labyrinticus
paries tegmentalis
paries jugularis
paries caroticus
paries mastoideus

Tympanic cavity



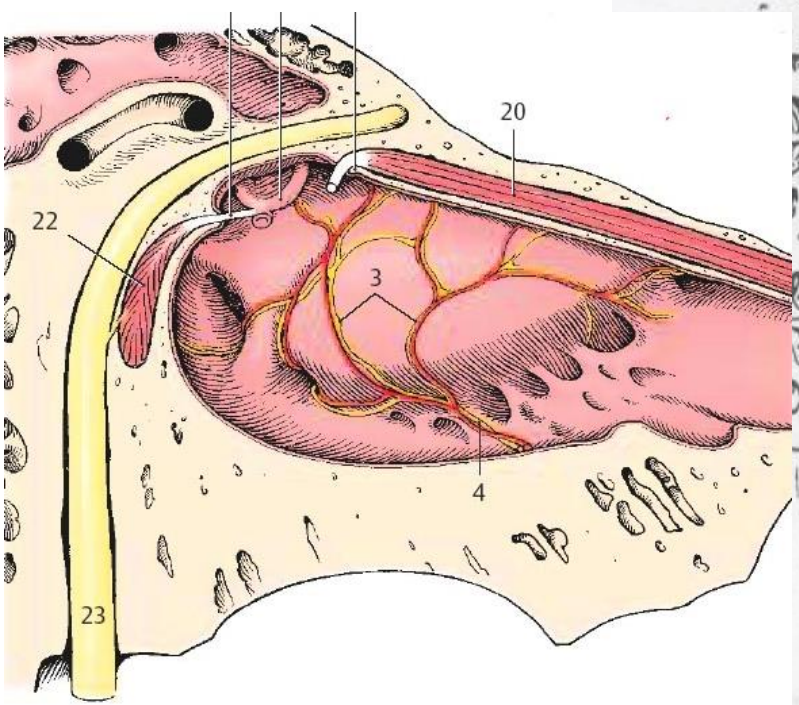
Paries membranaceus

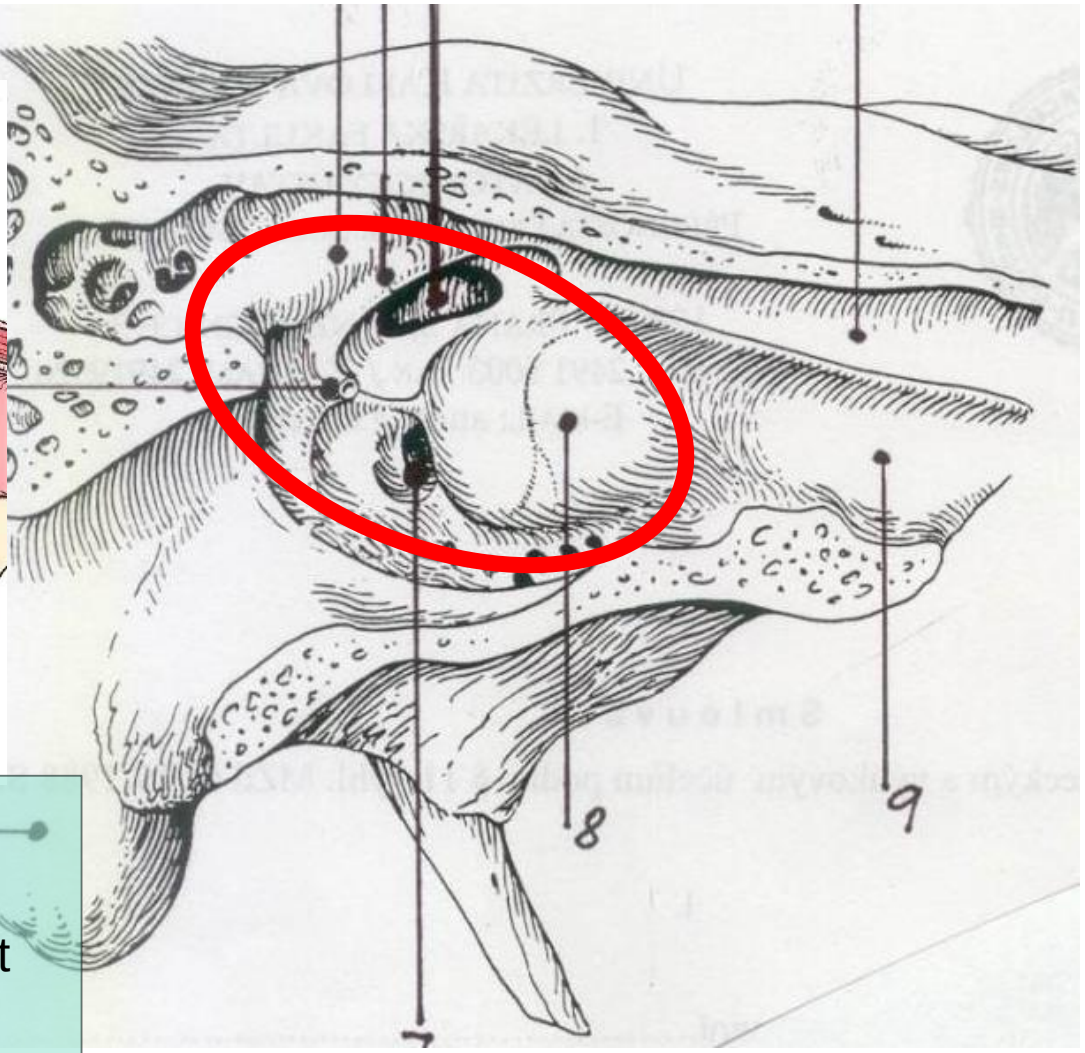
- Lateral wall



Paries labyrinthicus

- Medial wall

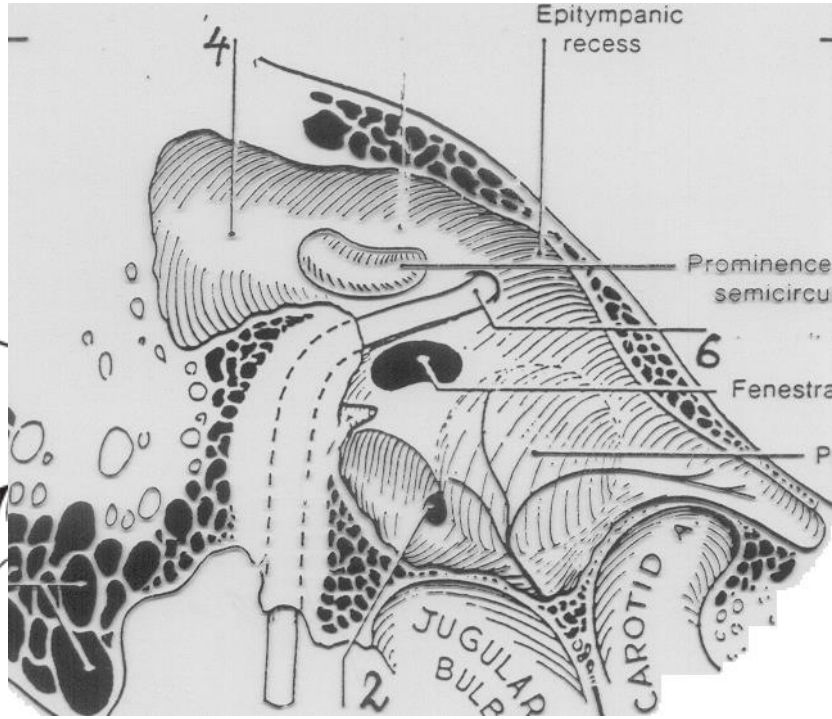




Fenestra vestibuli ovalis
Fenestra cochlae rotundum
Prominentia canalis semicircularis lat
Prominentia canalis n.facialis

Paries caroticus

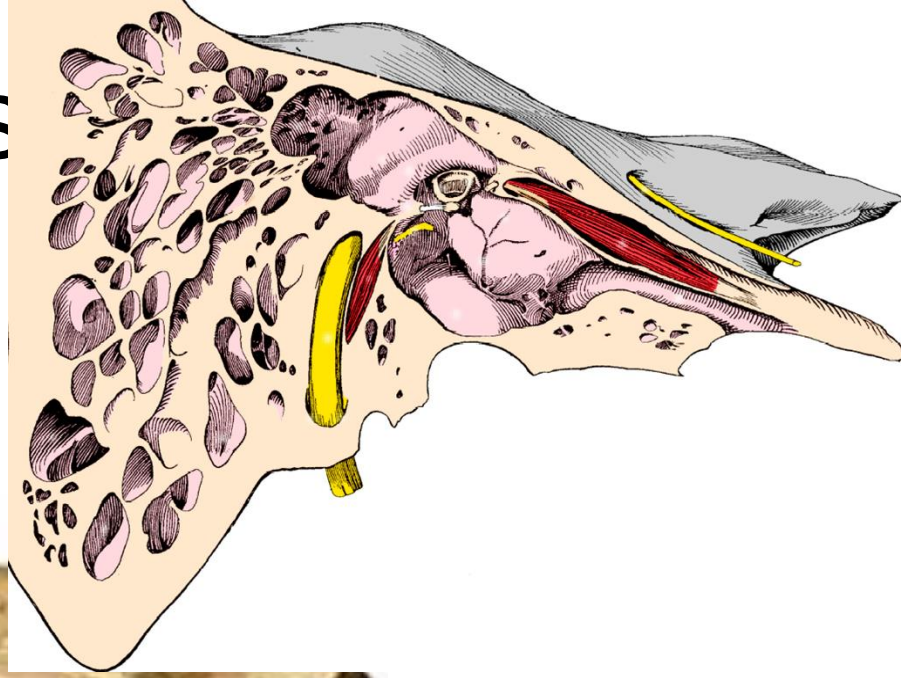
- Anterior wall



Tuba auditiva

Paries mastoideus

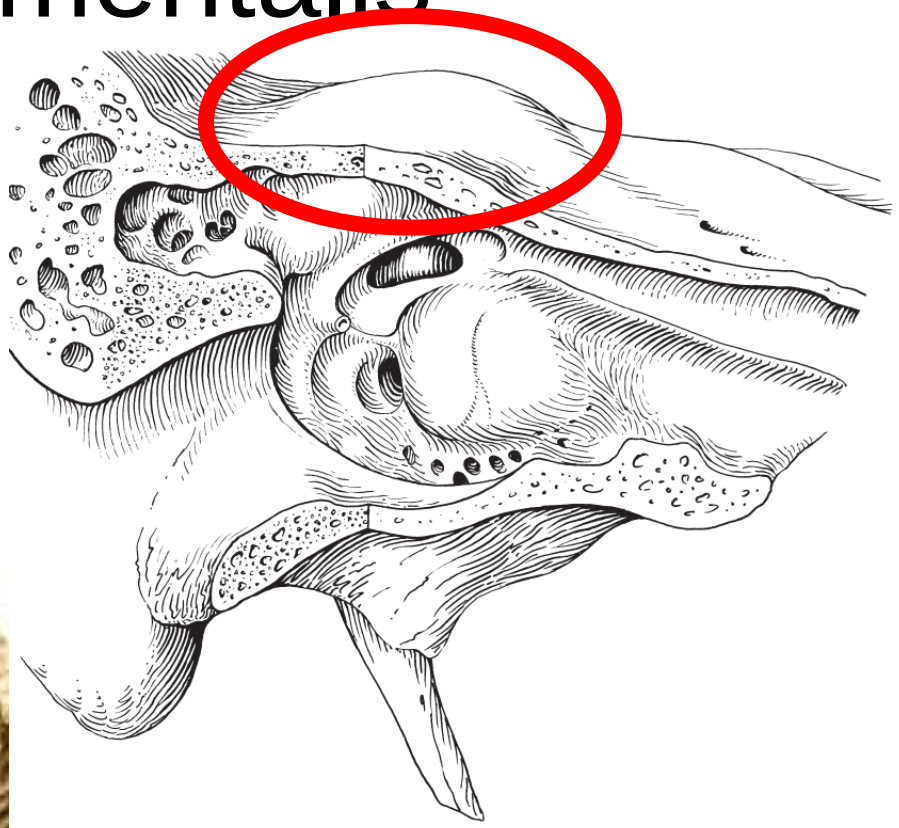
- Posterior wall

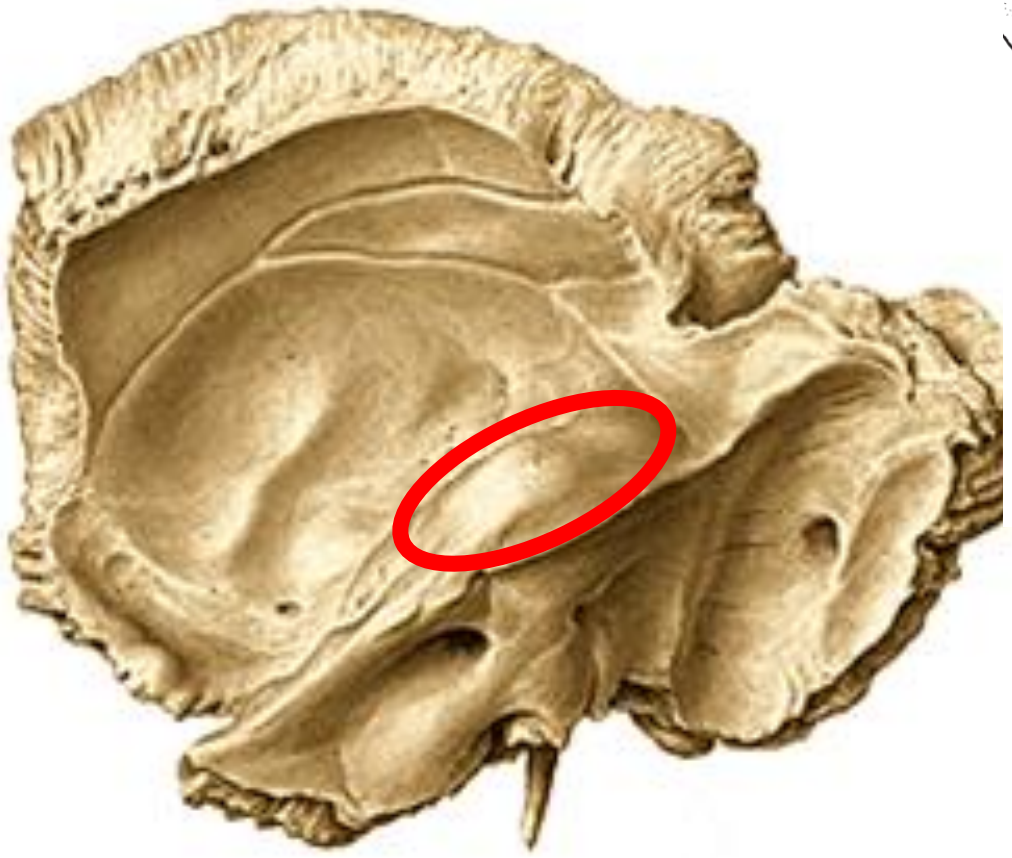


Antrum mastoideum
Eminentia pyramidalis
Chorda tympani

Paries tegmentalis

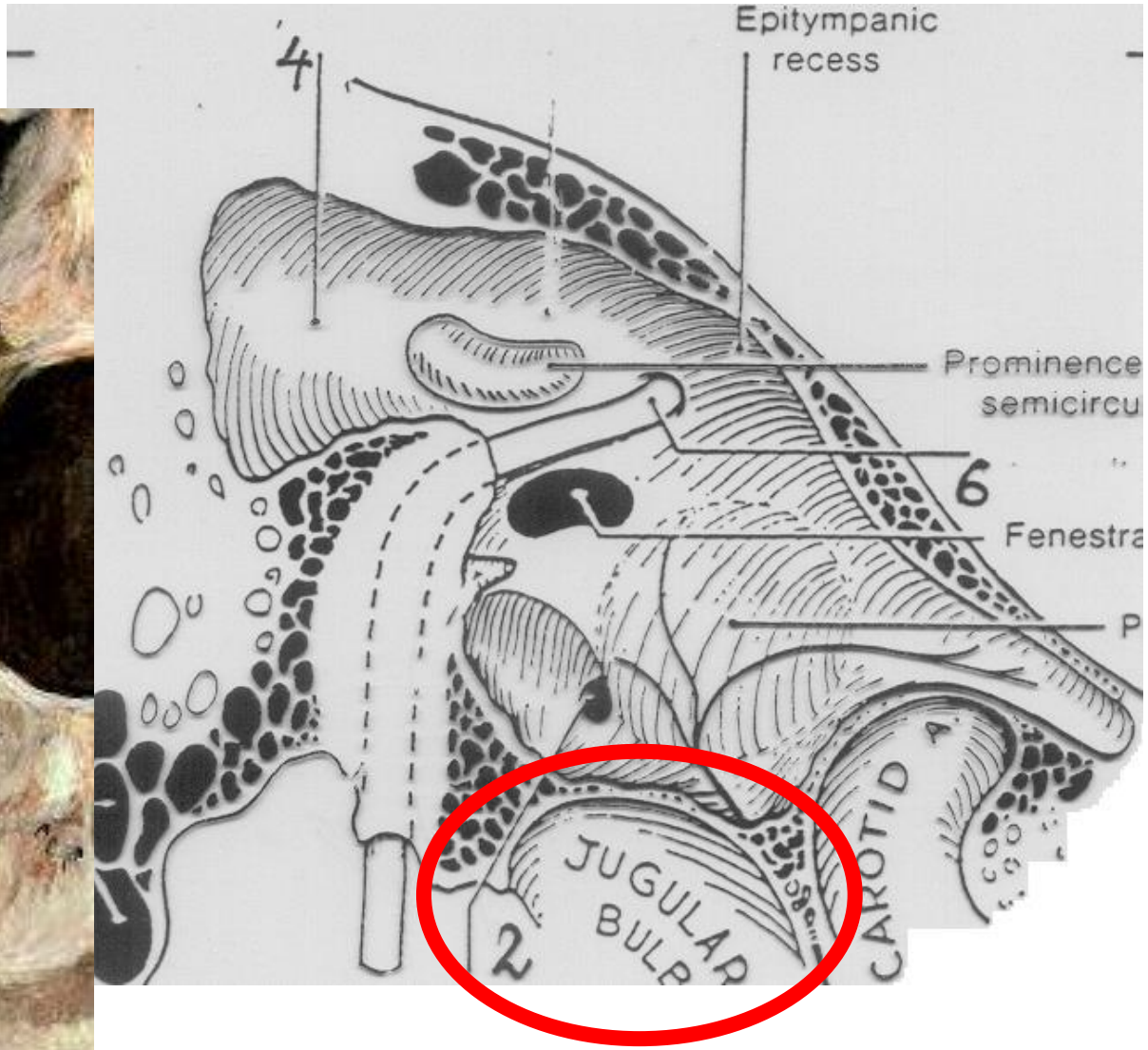
- Upper wall



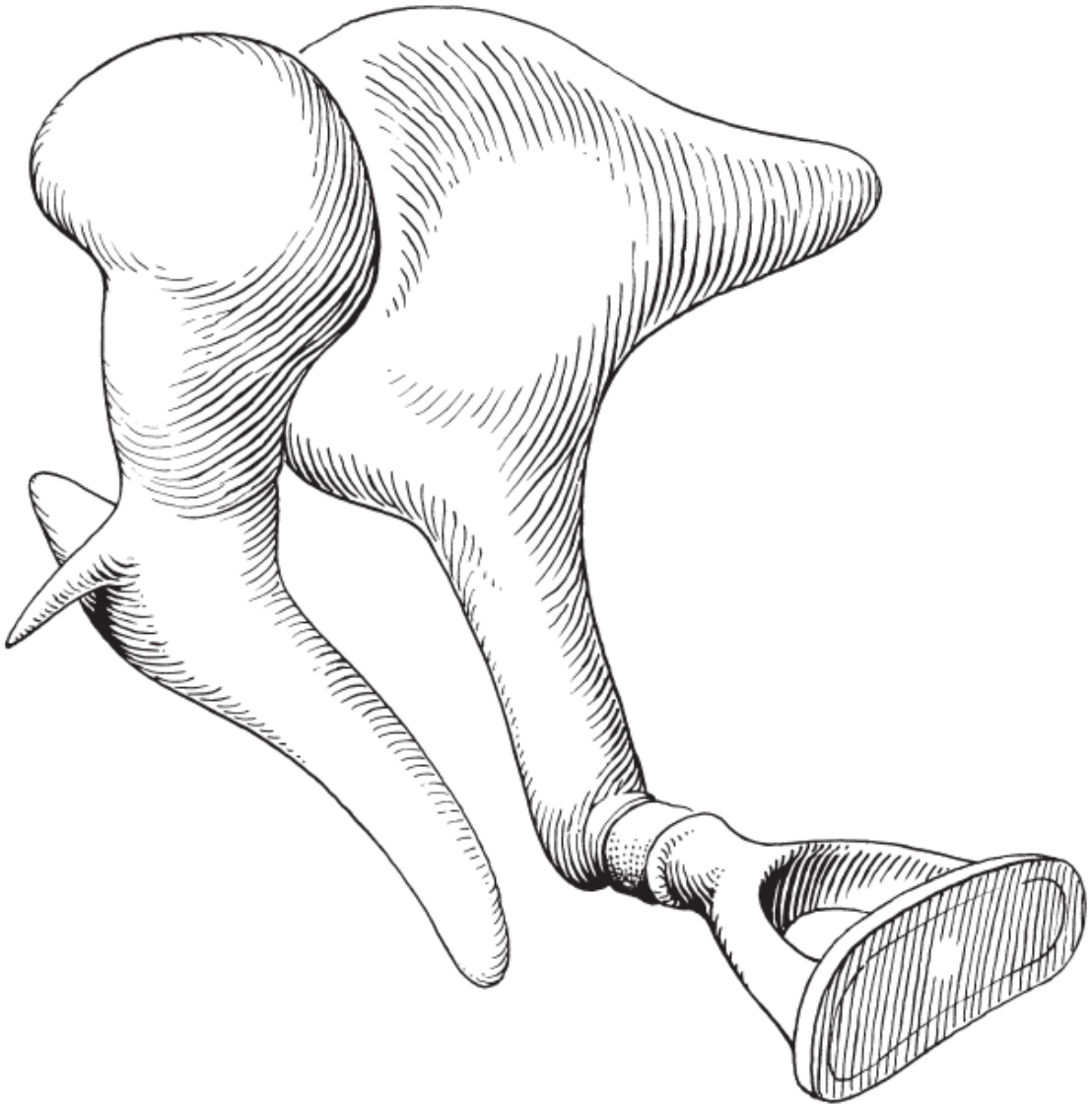


Paries jugularis

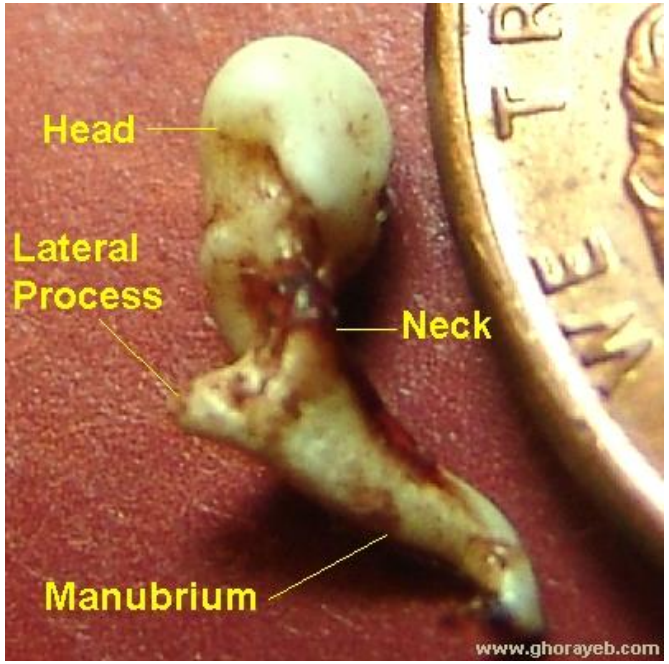
- Lower wall

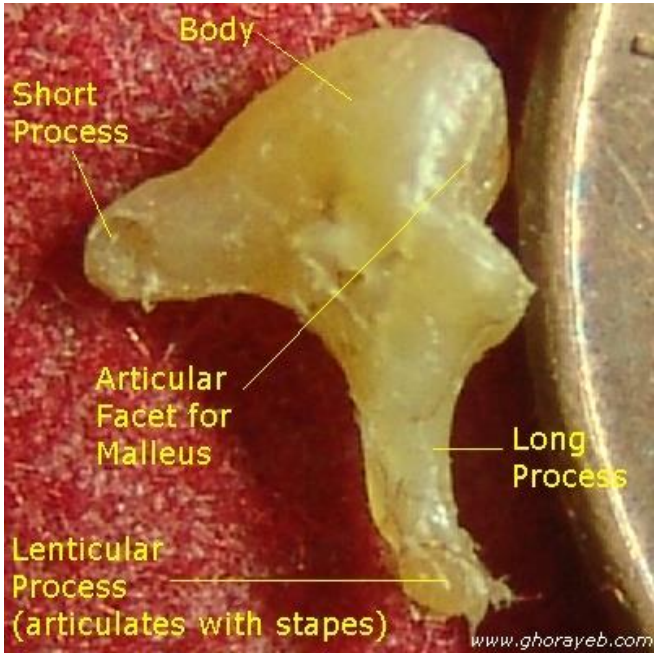


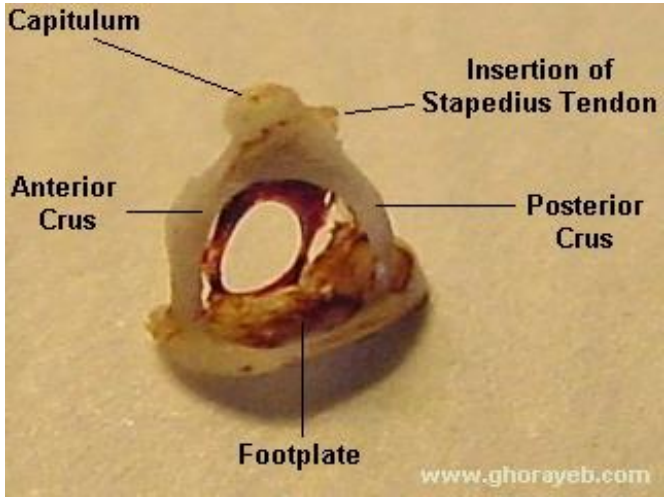
Ossicula auditus



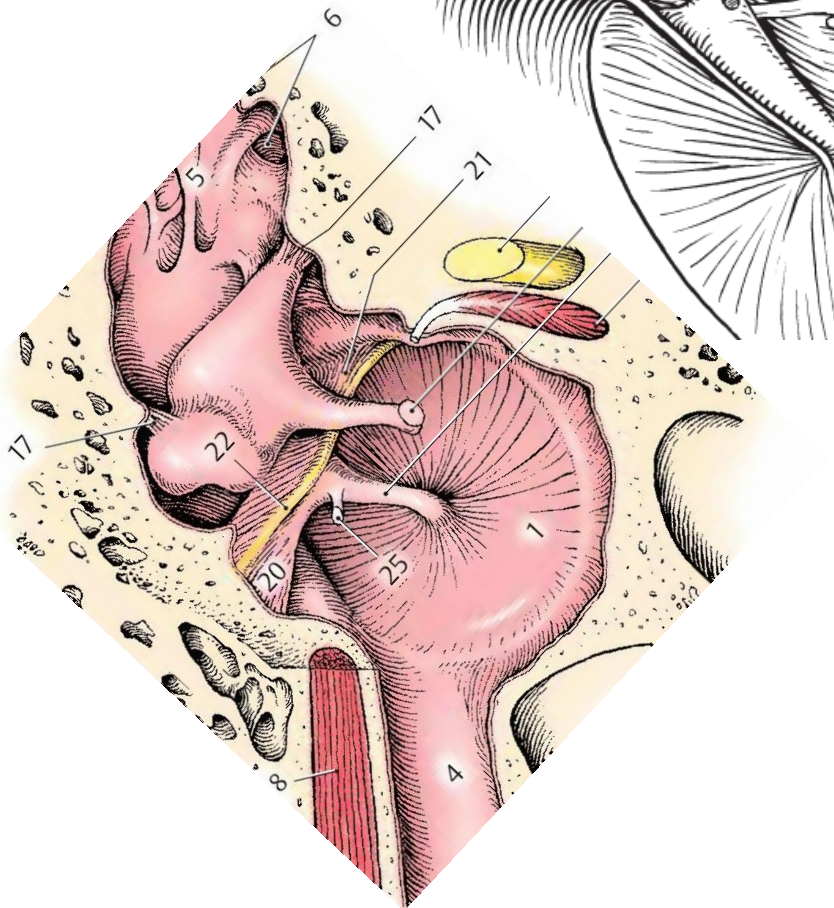
Malleus, incus, stapes

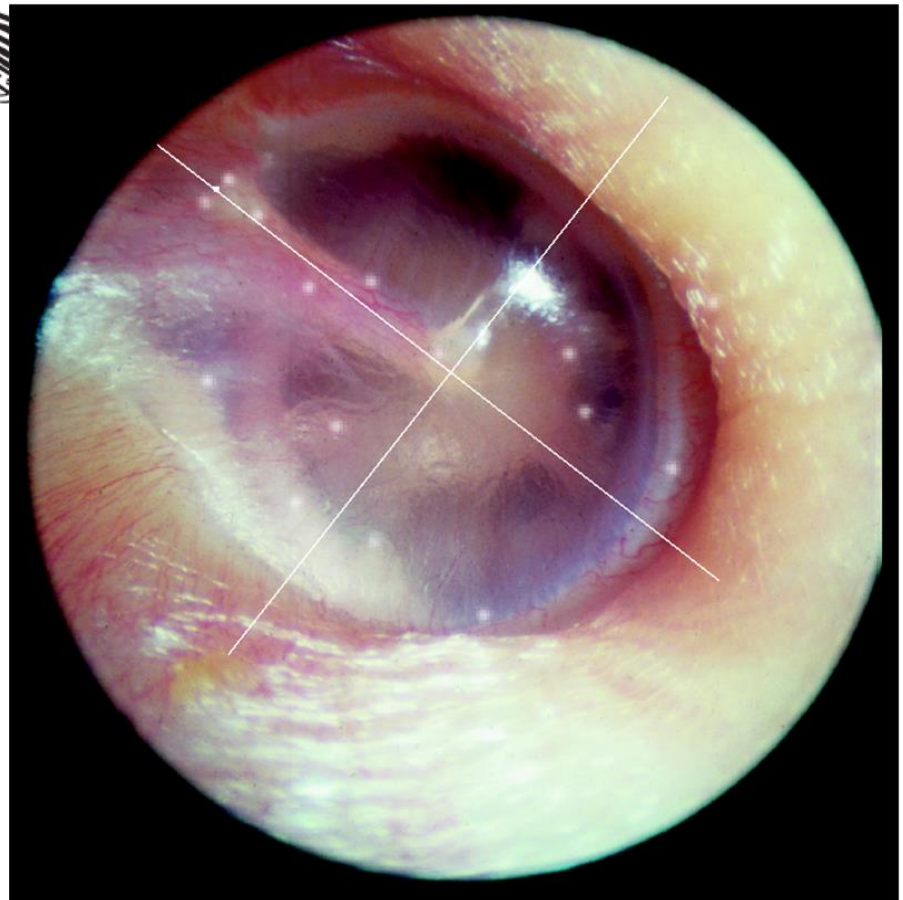


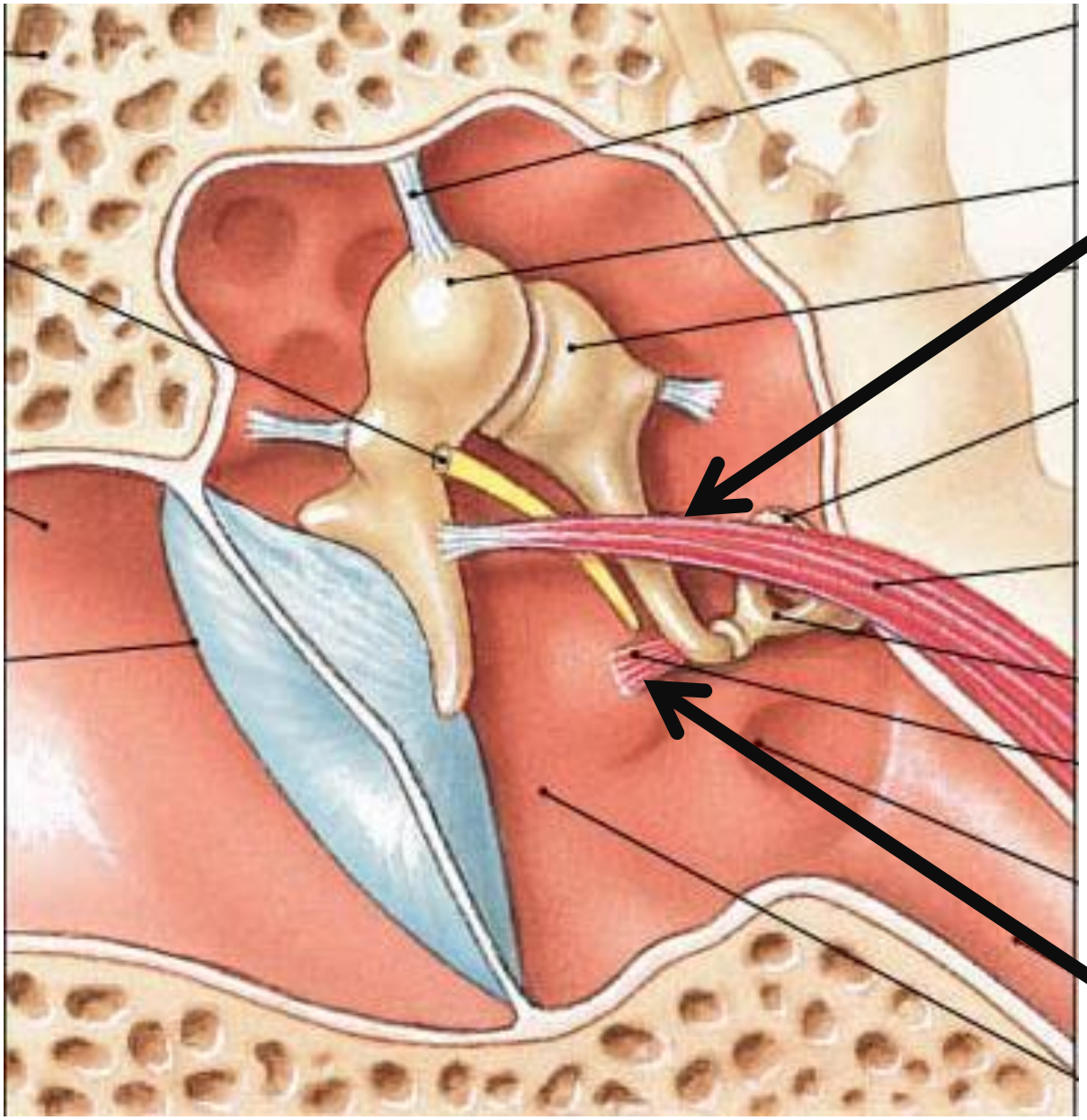




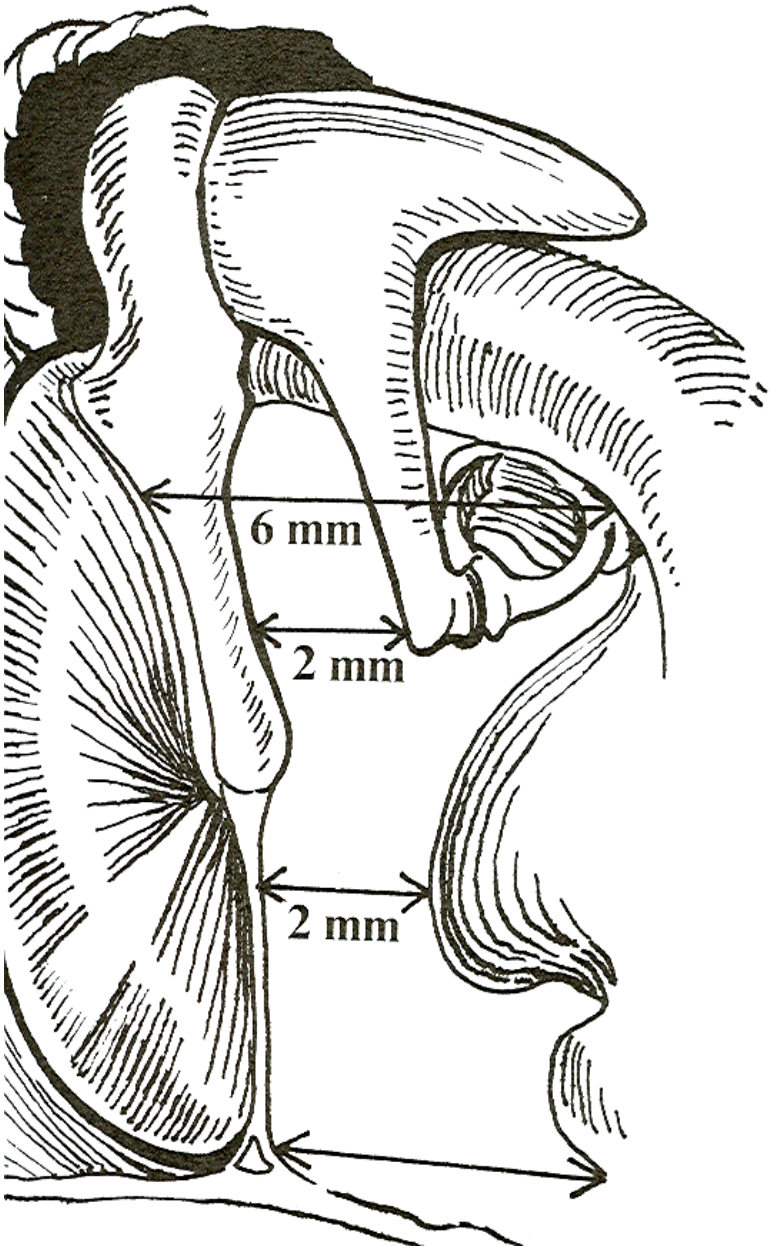
Ossicula auditus





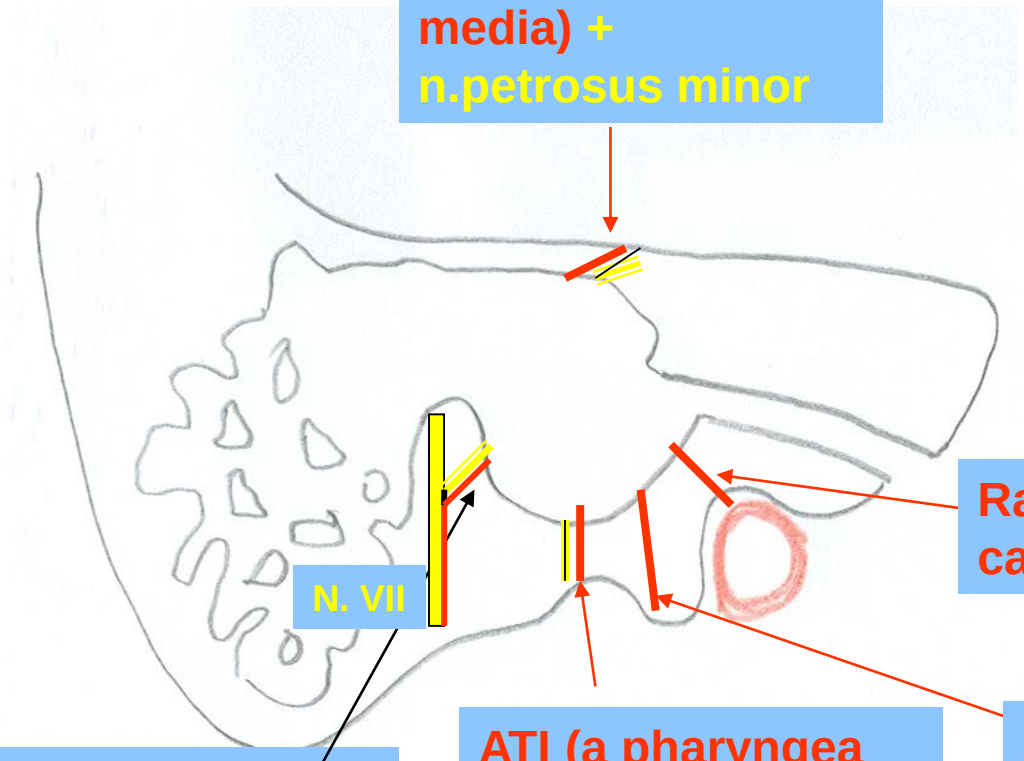

Tensor tympani muscle
(n.V)
Stapedial muscle
(n.VII)

Tympanic cavity – proportions

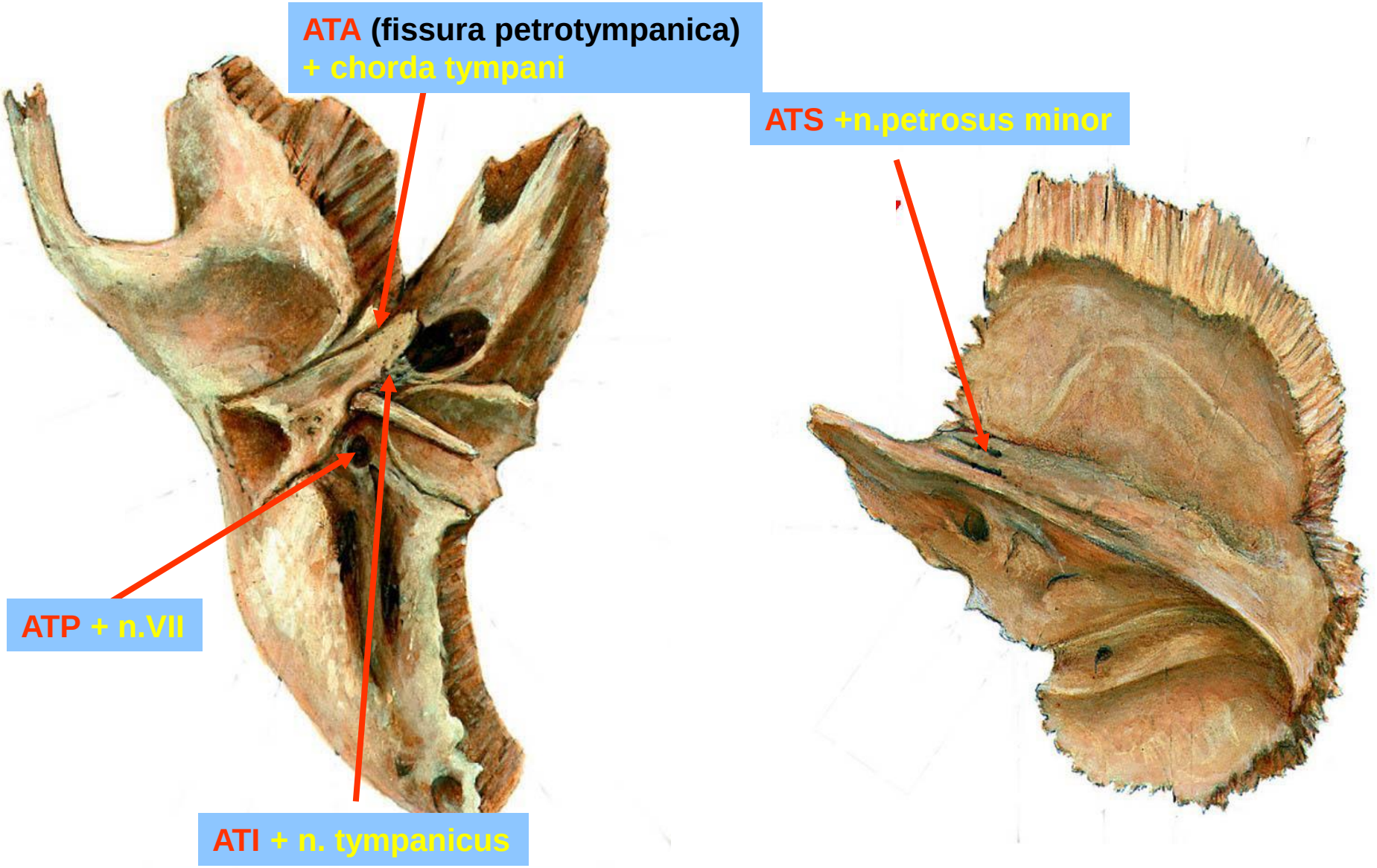


Cavum tympani – blood supply

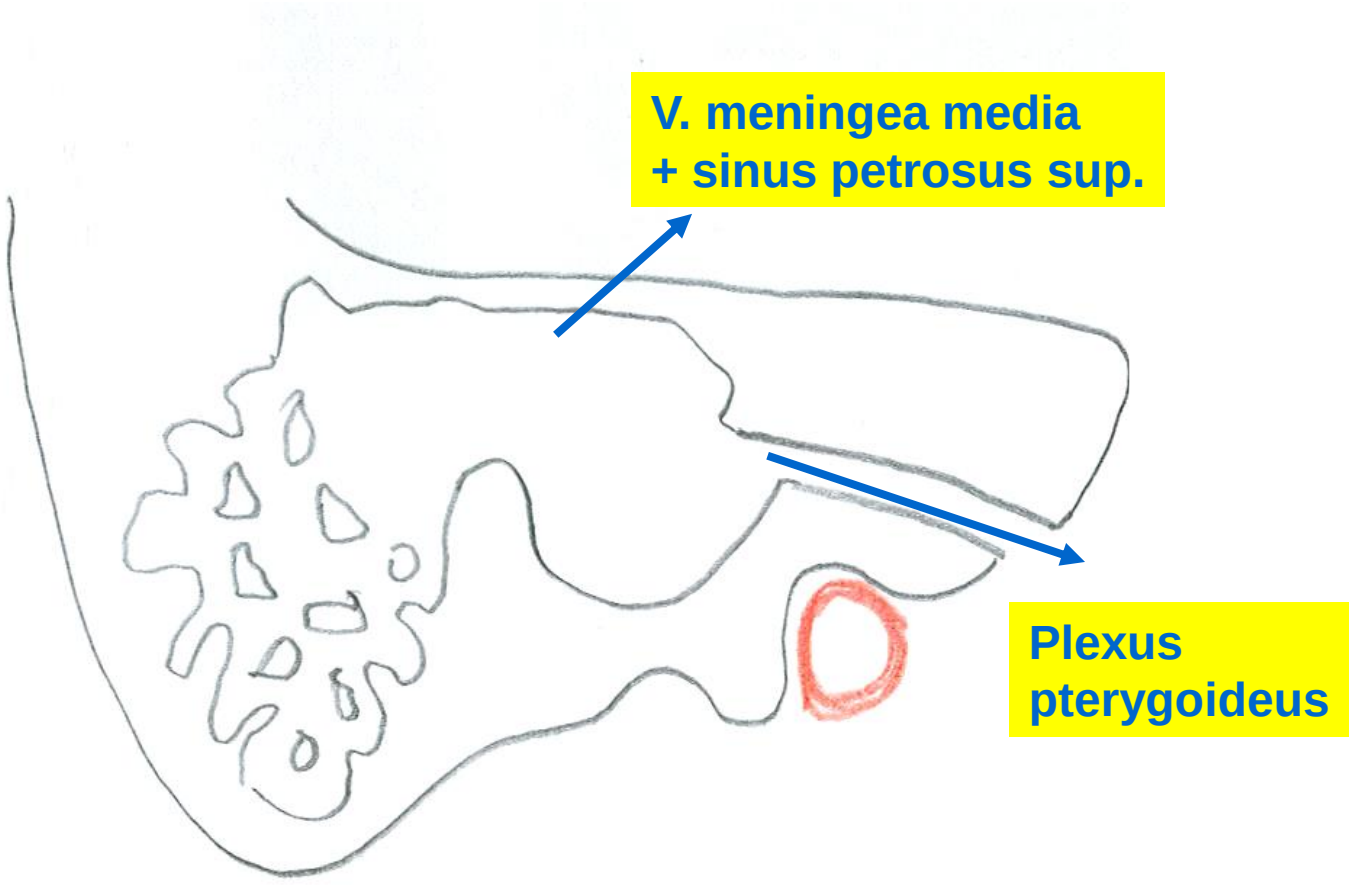
arterie tympanicae (superior, inferior, anterior, posterior) – AT (S,I,A,P)



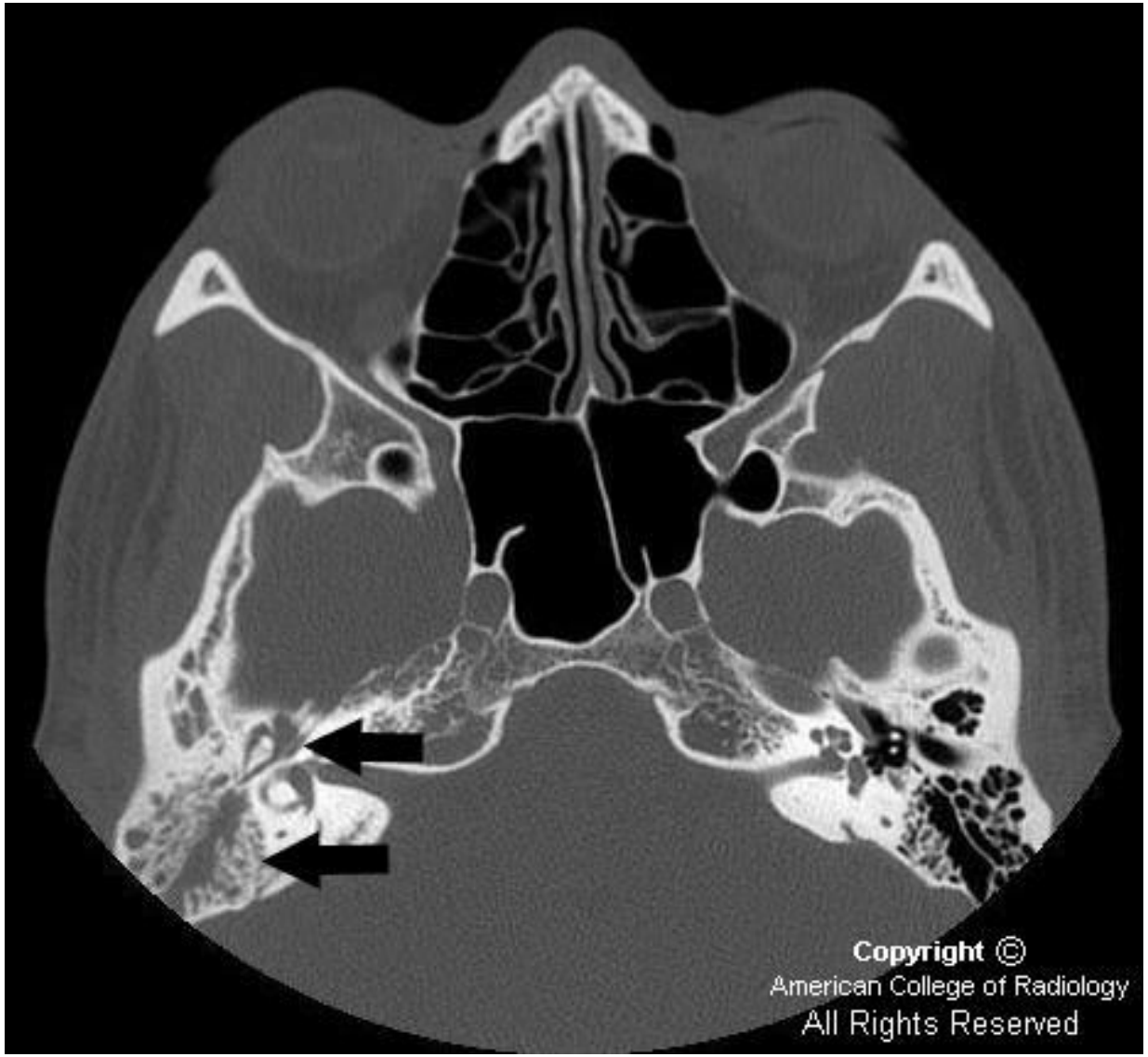
Blood and nervous supply



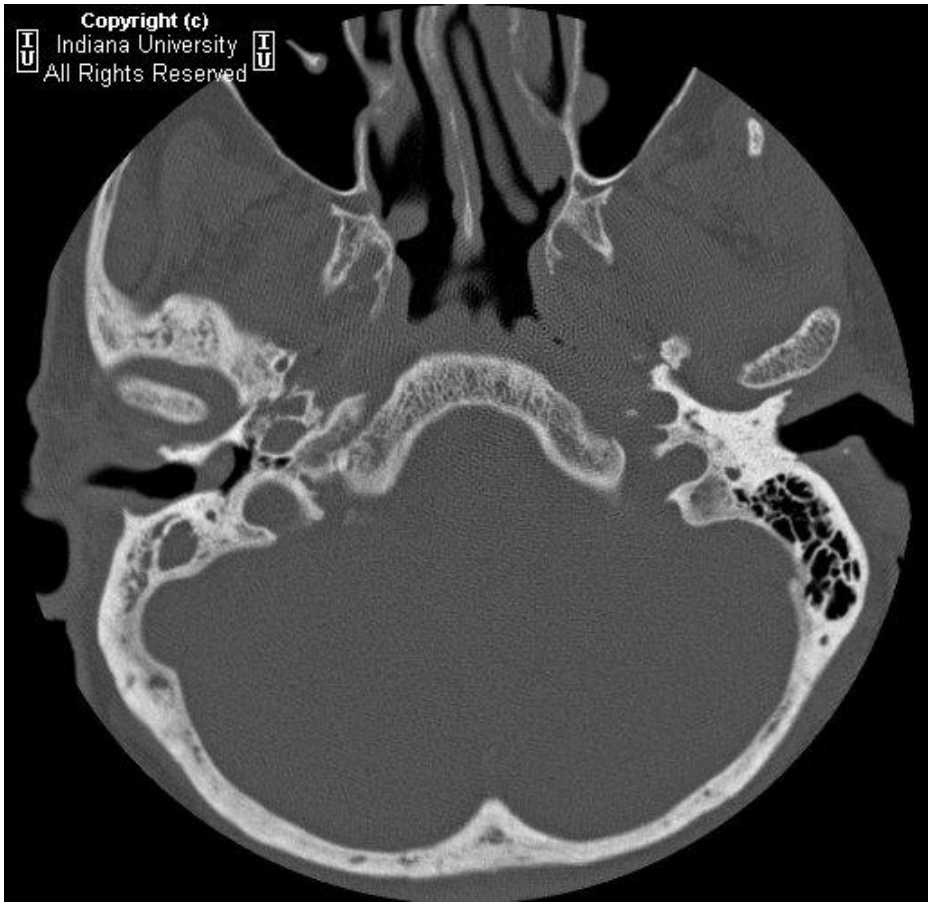
Venous drainage

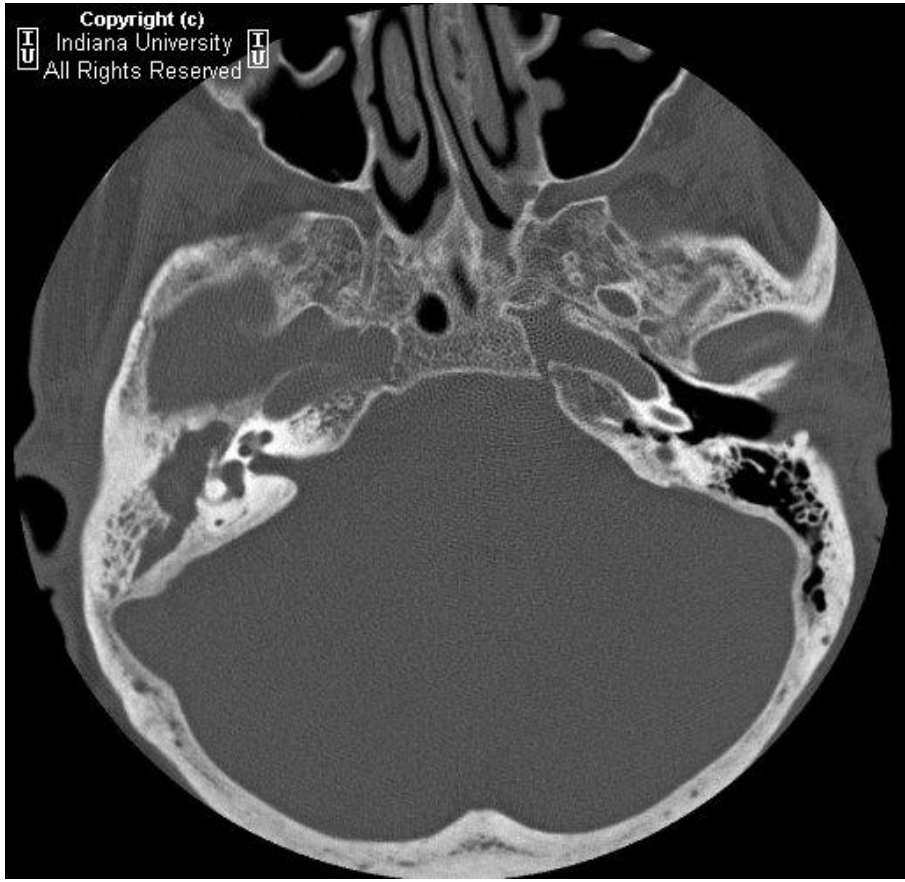


CT otitis and mastoiditis



Cholesteatoma – right side



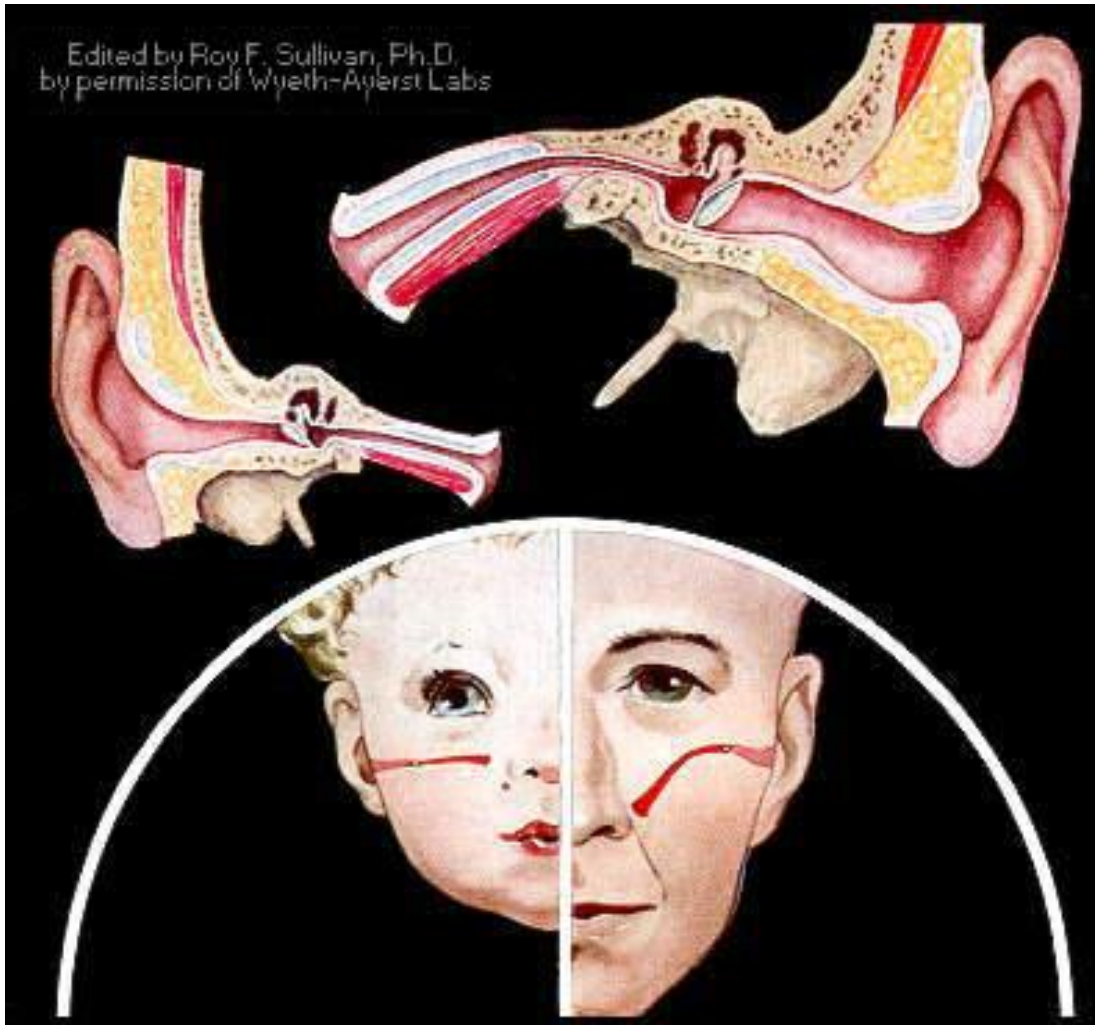


Eustachian tube

1/3 bone 2/3 cartilage

Children

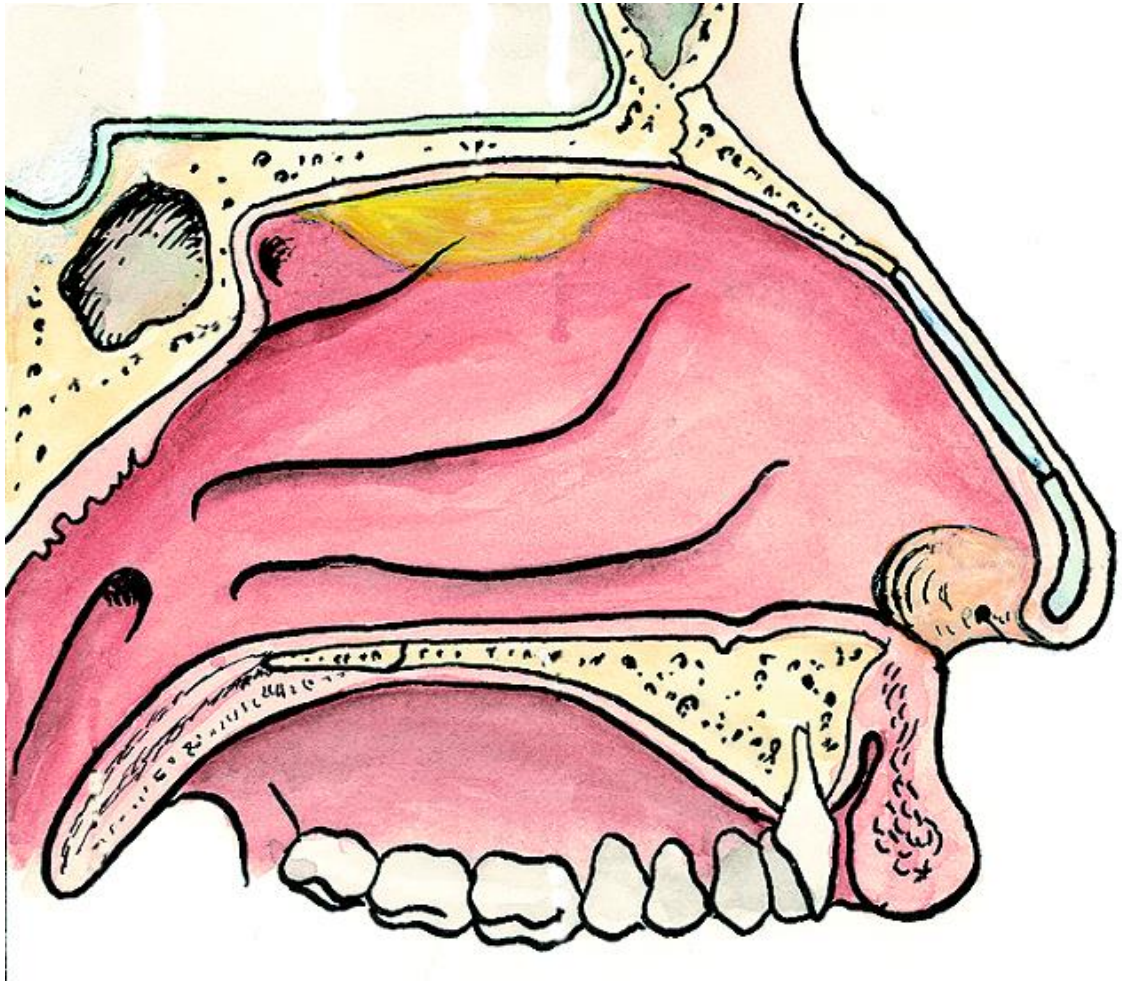
1. **3cm short**
2. **2,5mm wide**
3. **open**
4. **straight**



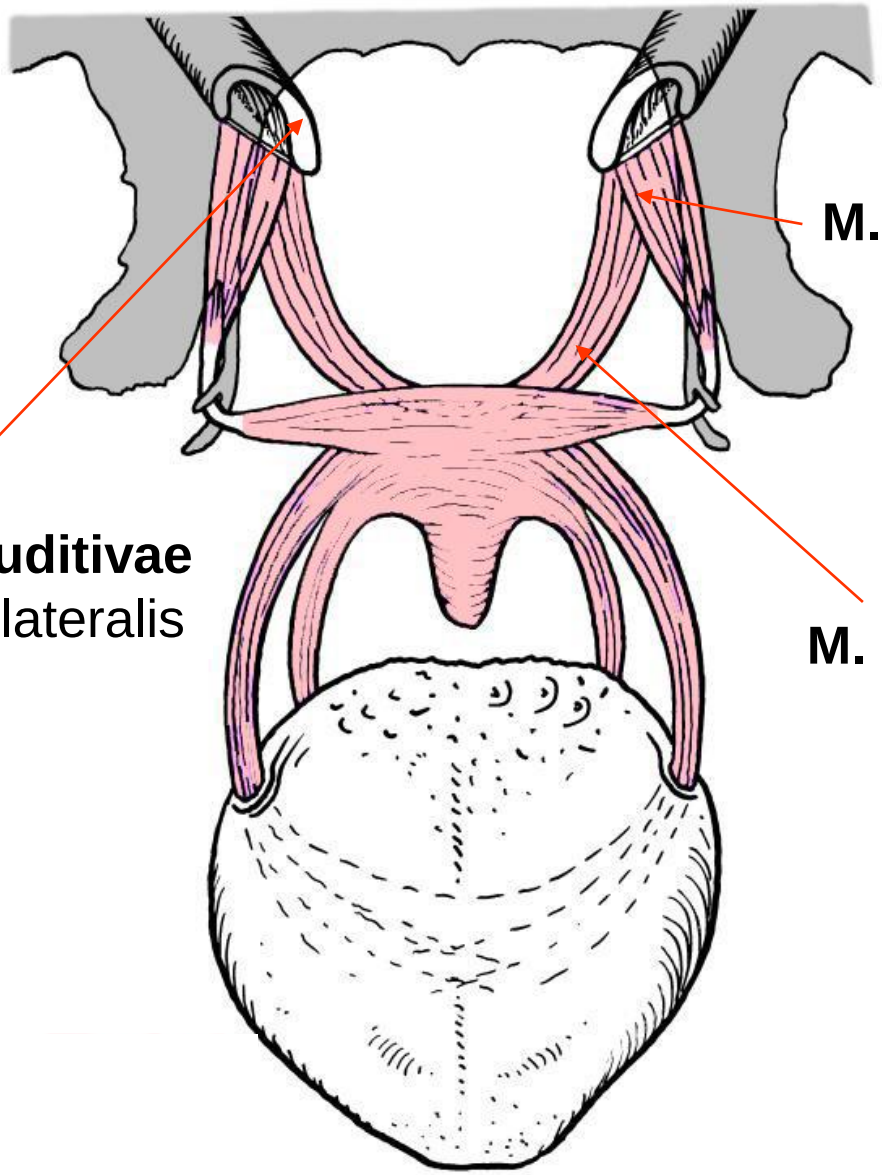
Adult

1. **3,8cm long**
2. **1 mm narrow**
3. **partly open**
4. **bent**

Tuba Eustachi



Middle ear ventilation during swallowing

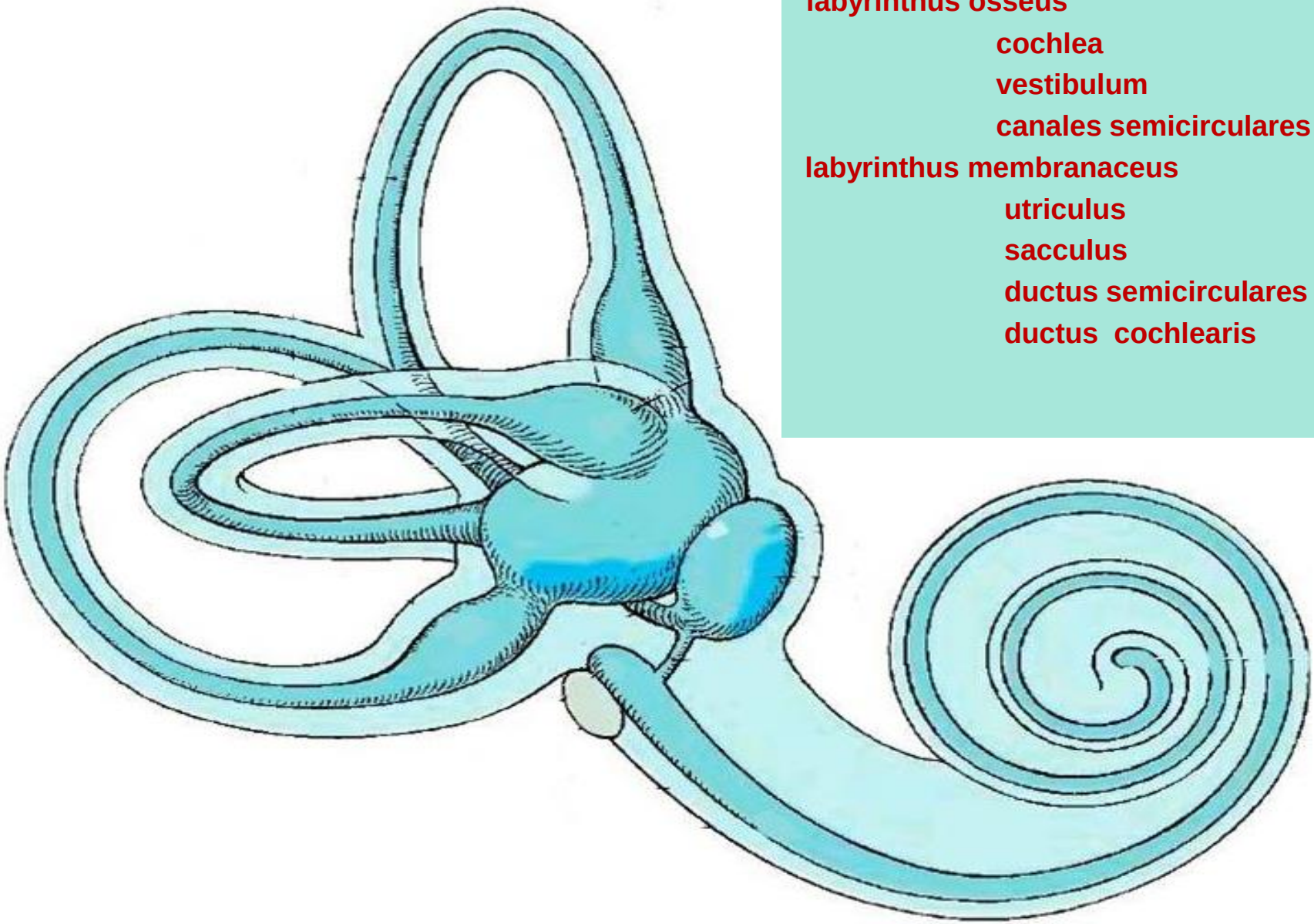


M. tensor veli palatini

Cartilago tubae auditivae
lamina medialis et lateralis

M. levator veli palatini

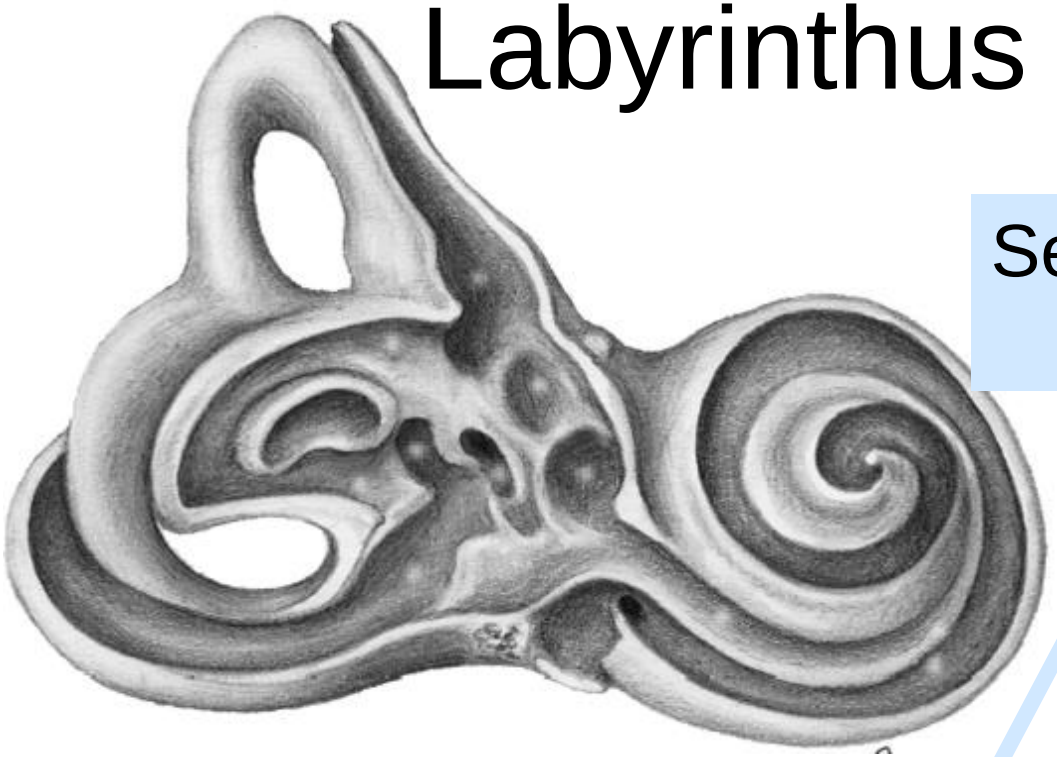
Auris interna



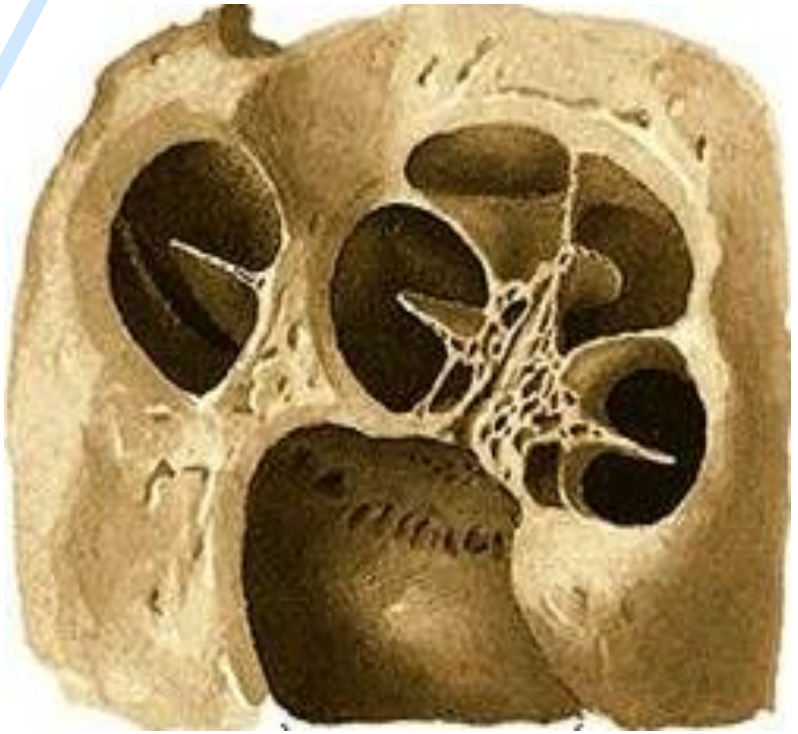
labyrinthus osseus
- cochlea
- vestibulum
- canales semicirculares

labyrinthus membranaceus
- utriculus
- sacculus
- ductus semicirculares
- ductus cochlearis

Labyrinthus osseus



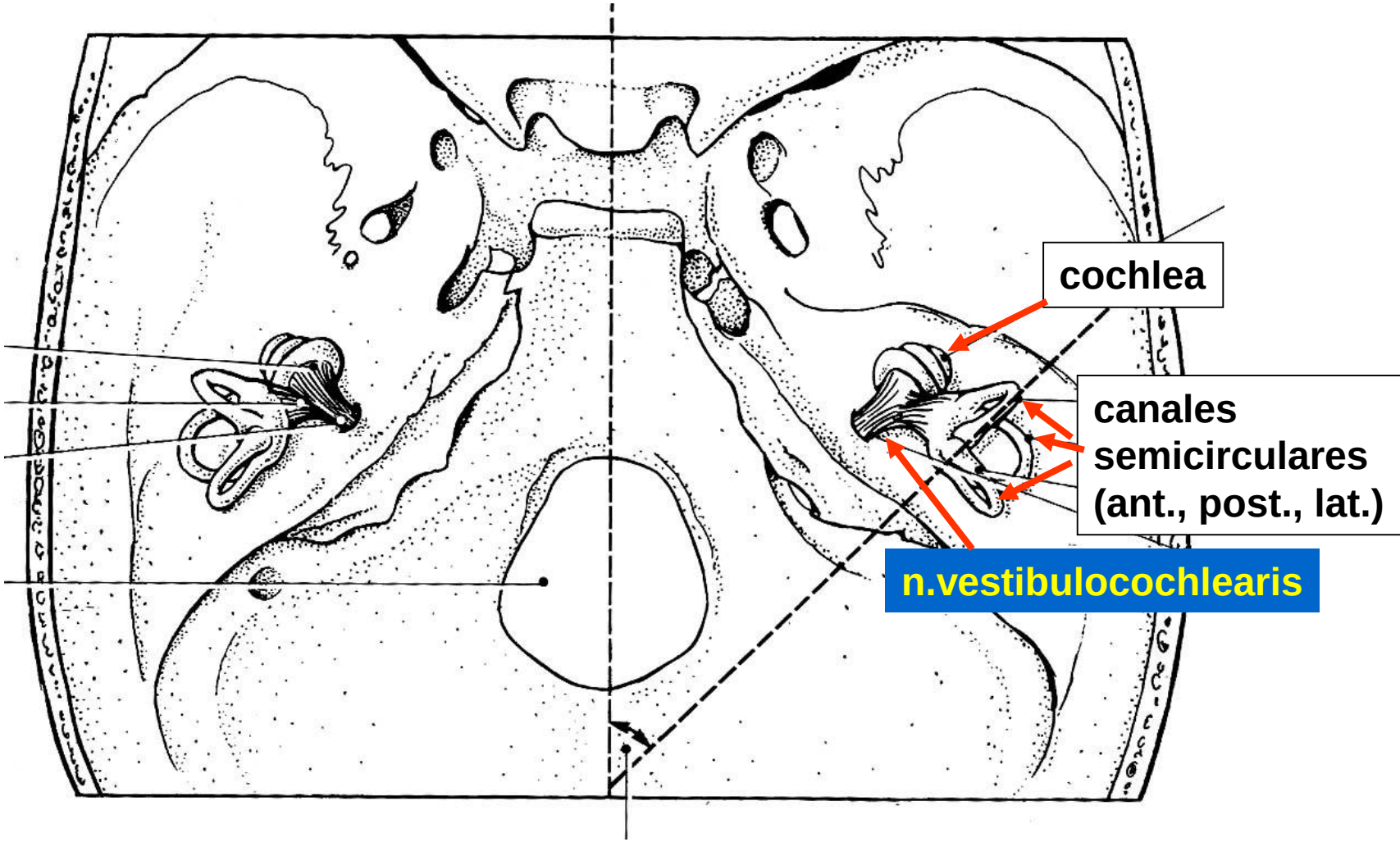
Separated with spongiosa from <u>os petrosum</u>



<u>Exceptions:</u>

- Fundus meatus acustici interni
- Facies ventrobasalis ossis petrosis

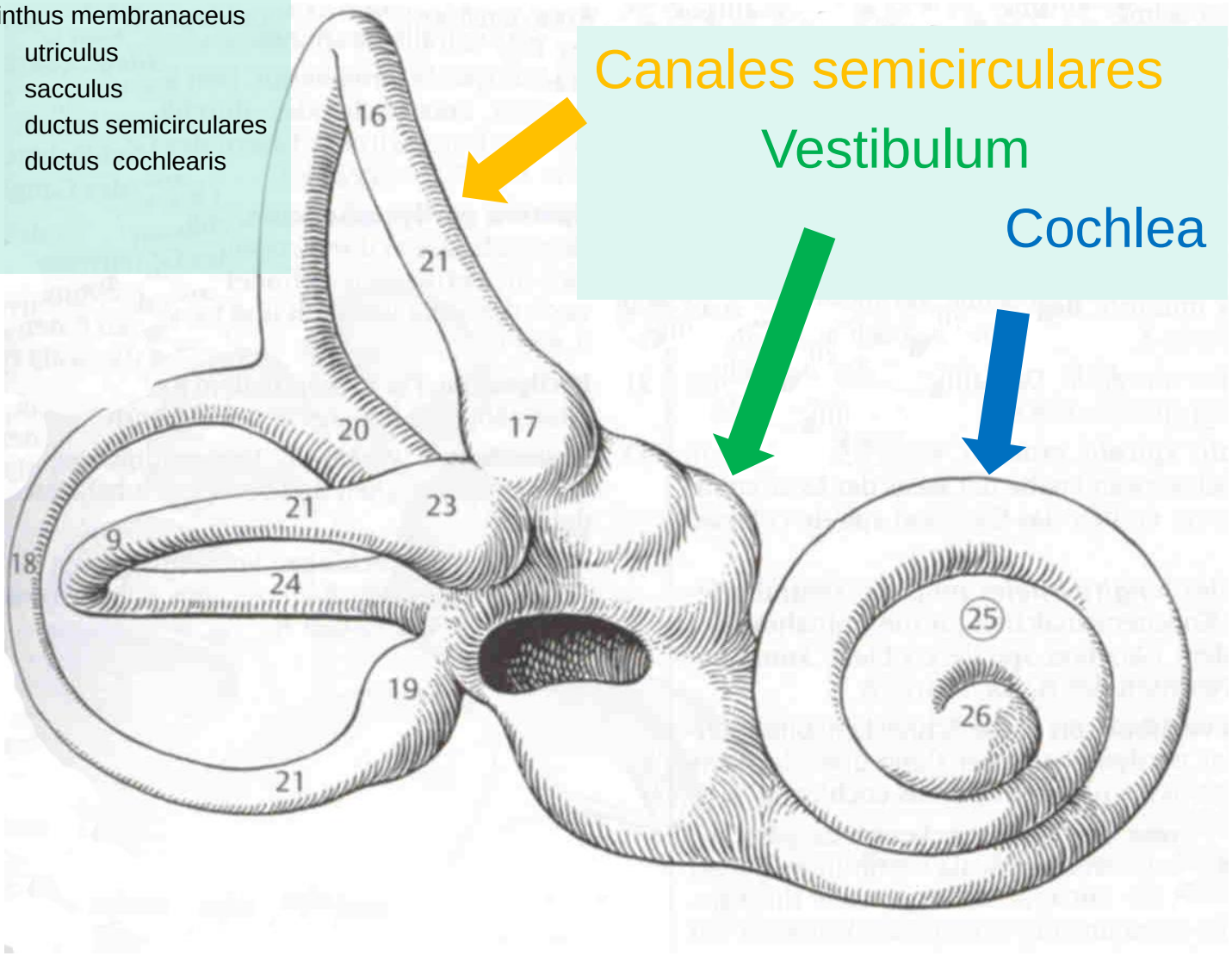
Position of the inner ear



Auris interna

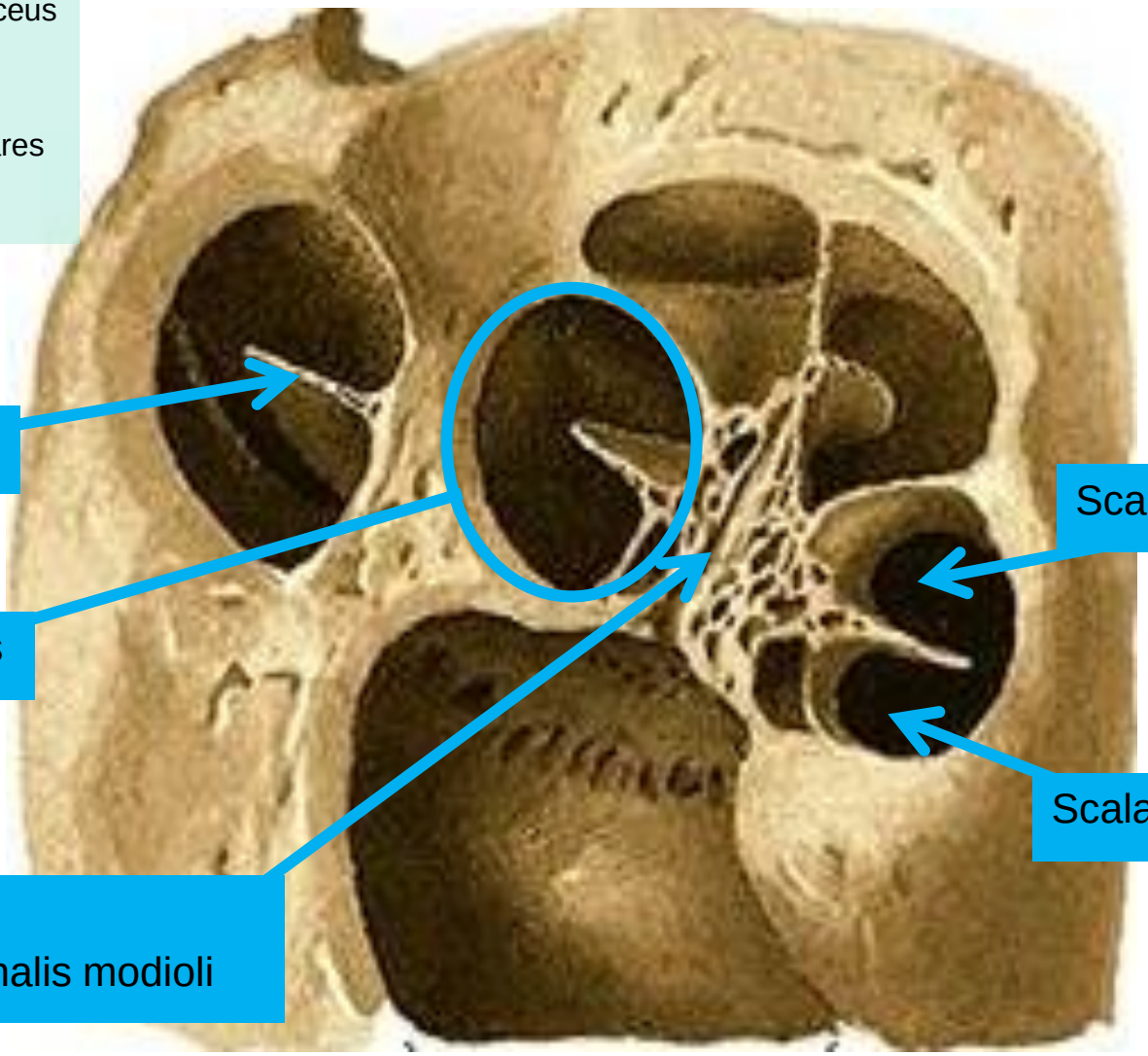
- **labyrinthus osseus**
  - cochlea
  - vestibulum
  - canales semicirculares
- labyrinthus membranaceus
  - utriculus
  - sacculus
  - ductus semicirculares
  - ductus cochlearis

Labyrinthus osseus



Auris interna
- labyrinthus osseus
  - **cochlea**
  - vestibulum
  - canales semicirculares
- labyrinthus membranaceus
  - utriculus
  - sacculus
  - ductus semicirculares
  - ductus cochlearis

Cochlea



Lamina spiralis ossea

canalis spiralis osseus

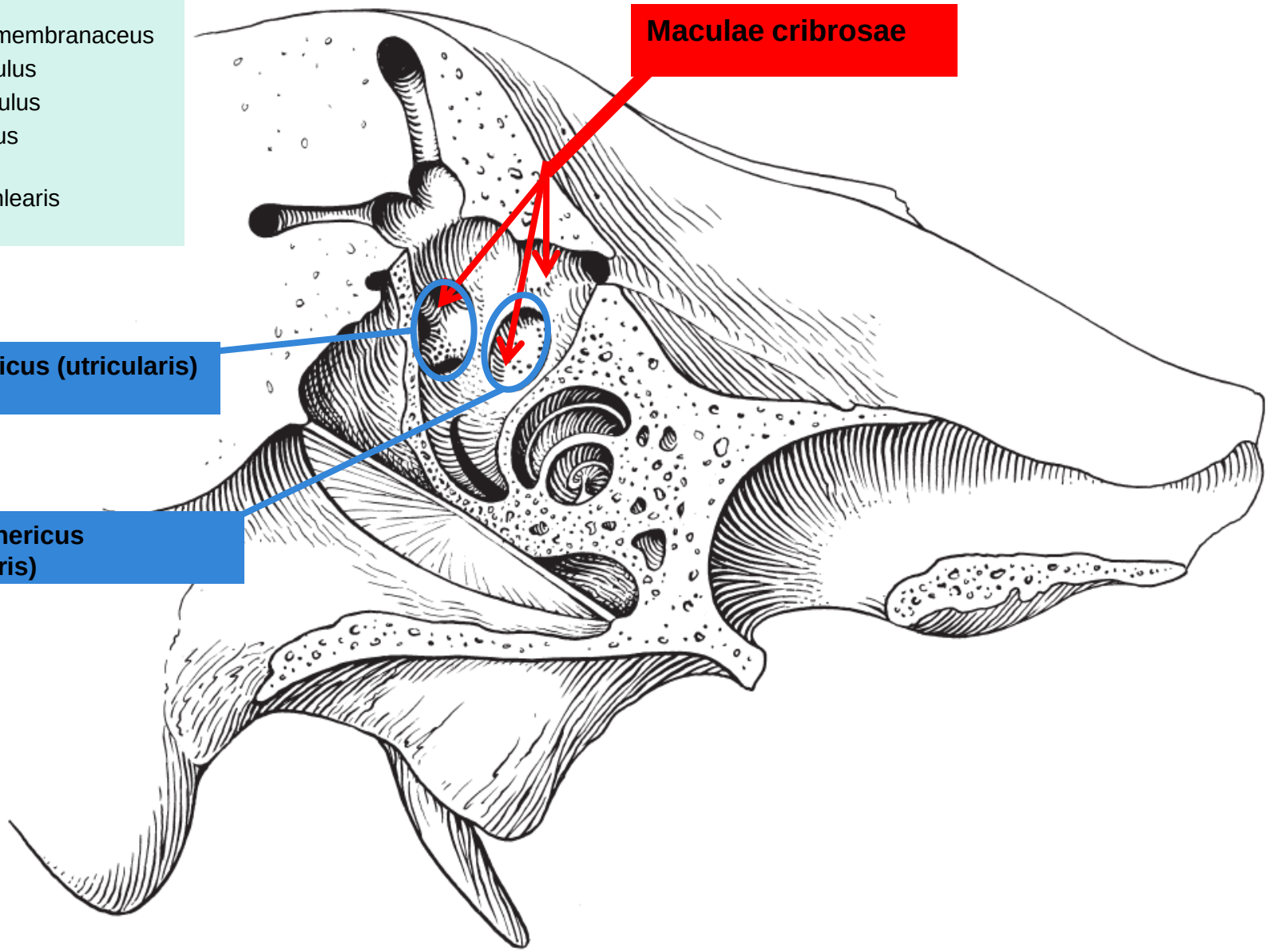
Scala vestibuli

Scala tympani

- Modiolus
- Canalis longitudinalis modioli

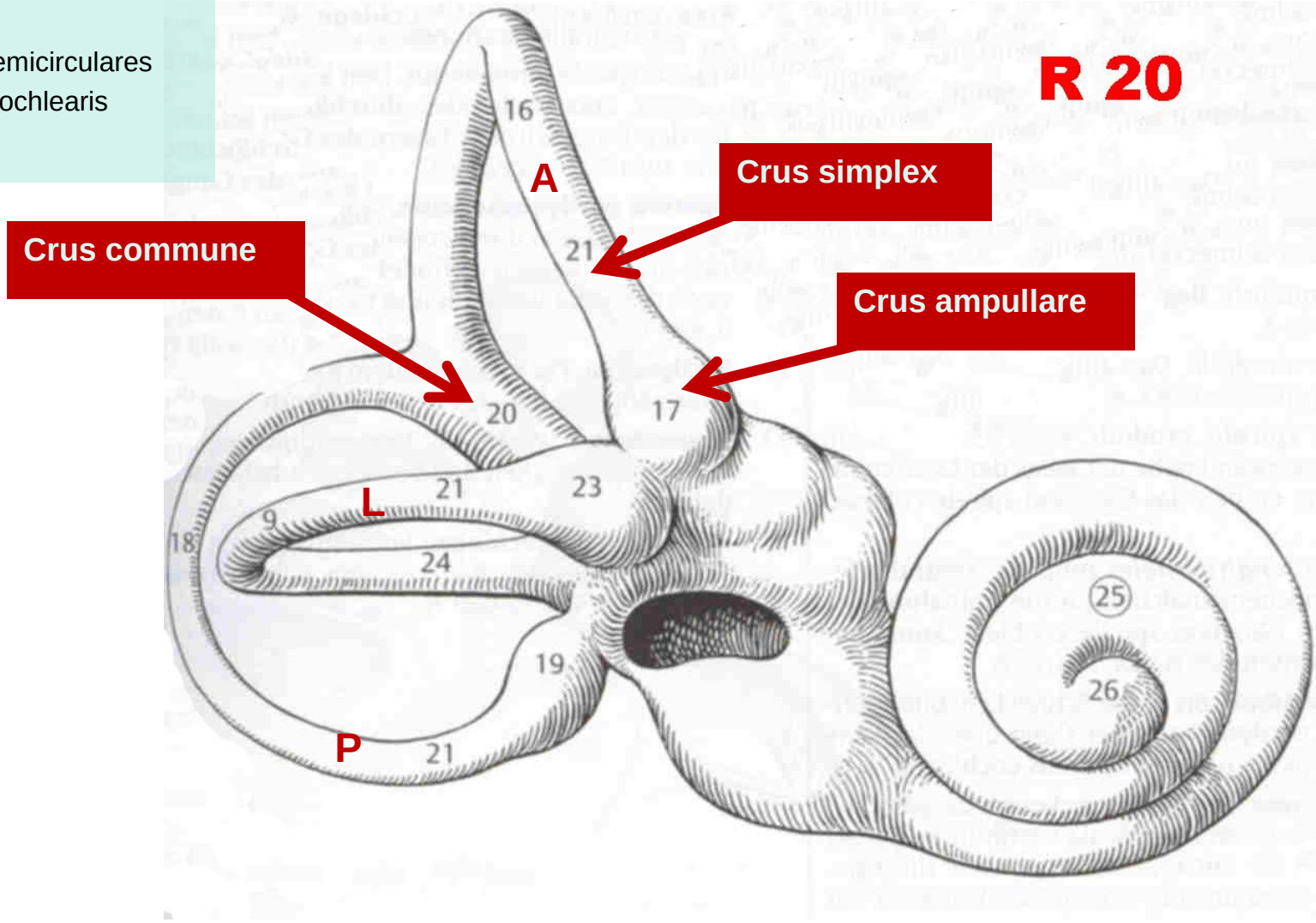
Auris interna
- labyrinthus osseus
  - cochlea
  - **vestibulum**
  - canales semicirculares
- labyrinthus membranaceus
  - utriculus
  - sacculus
  - ductus semicirculares
  - ductus cochlearis

Vestibulum



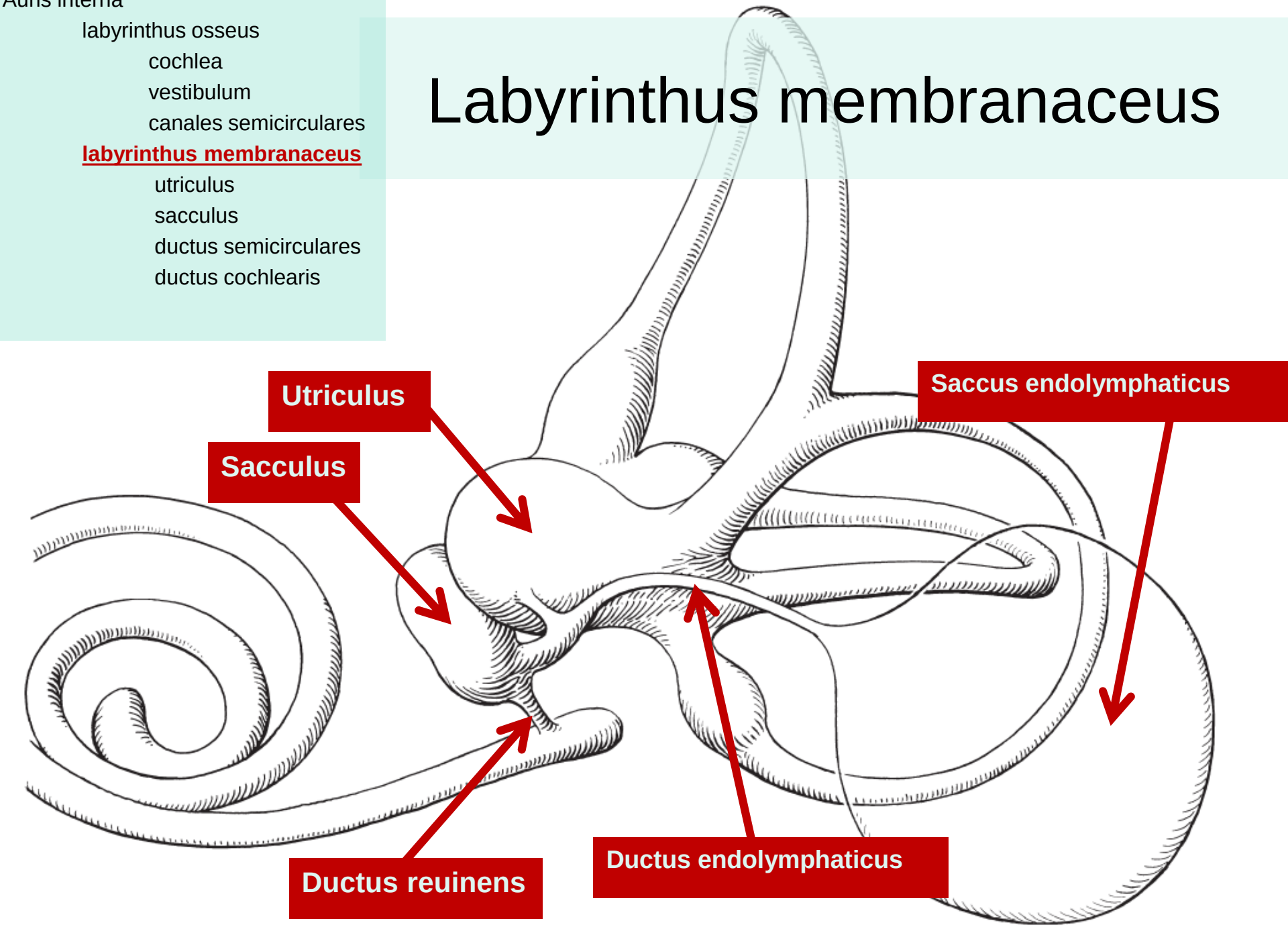
- Auris interna
  - labyrinthus osseus
    - cochlea
    - vestibulum
    - **canales semicirculares**
  - labyrinthus membranaceus
    - utriculus
    - sacculus
    - ductus semicirculares
    - ductus cochlearis

Canales cemicirculares



Auris interna
- labyrinthus osseus
  - cochlea
  - vestibulum
  - canales semicirculares
- **labyrinthus membranaceus**
  - utriculus
  - sacculus
  - ductus semicirculares
  - ductus cochlearis

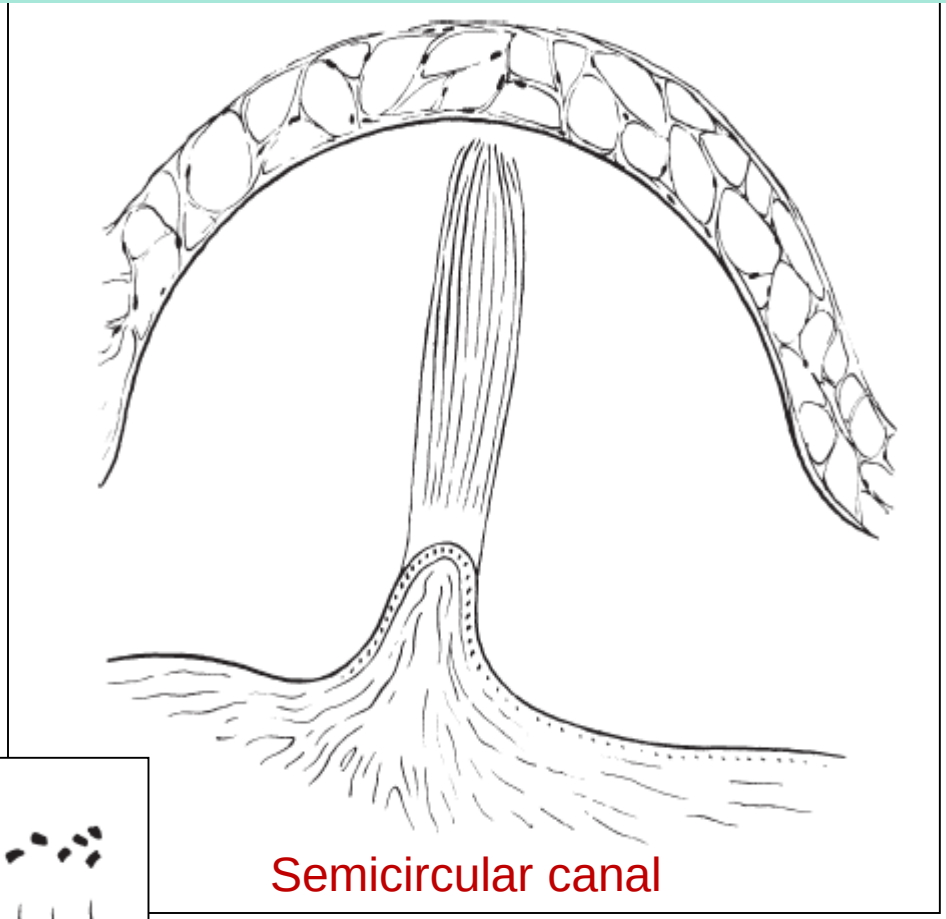
Labyrinthus membranaceus



Auris interna

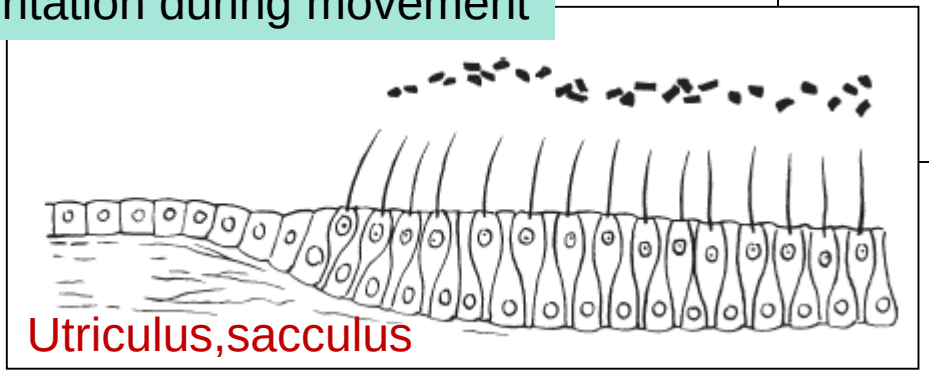
- labyrinthus osseus
  - cochlea
  - vestibulum
  - canales semicirculares
- **labyrinthus membranaceus**
  - utriculus
  - sacculus
  - ductus semicirculares
  - ductus cochlearis

Irritation at the beginning and the end of movement



Semicircular canal

Irritation during movement

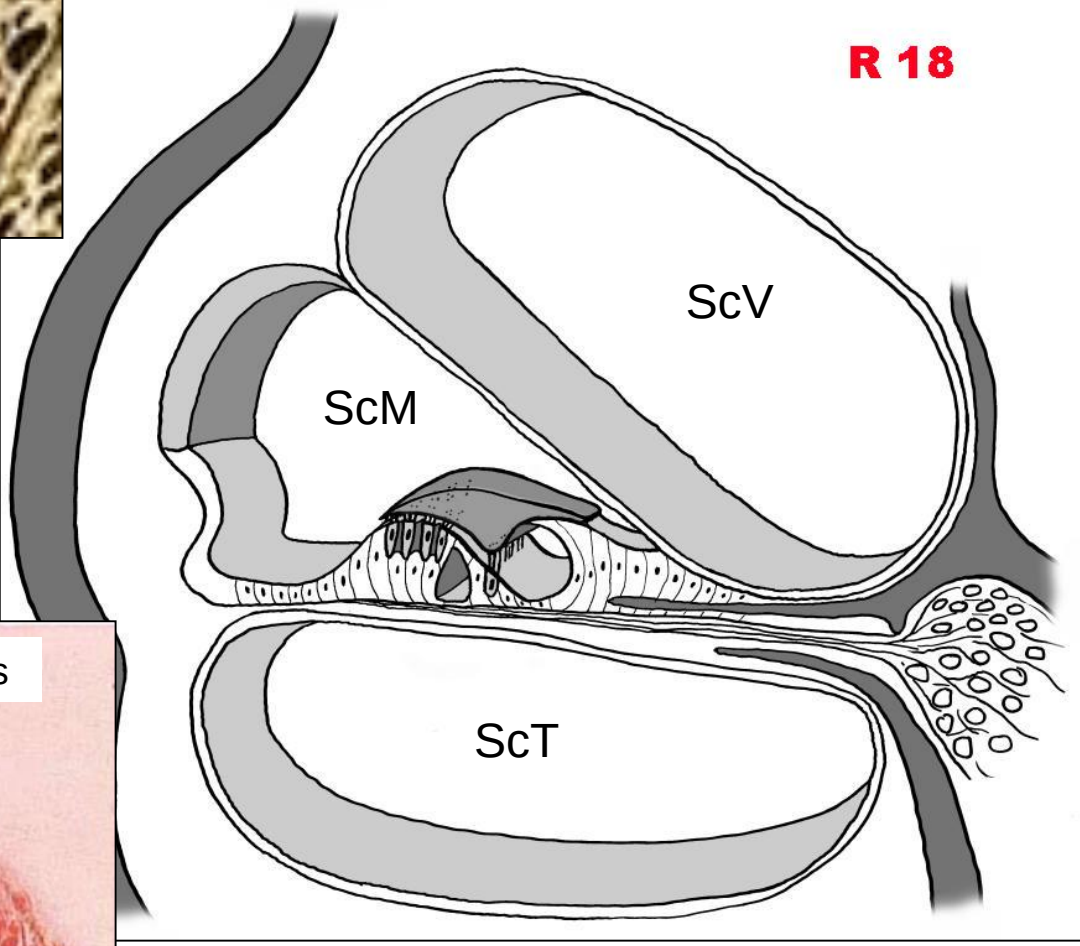


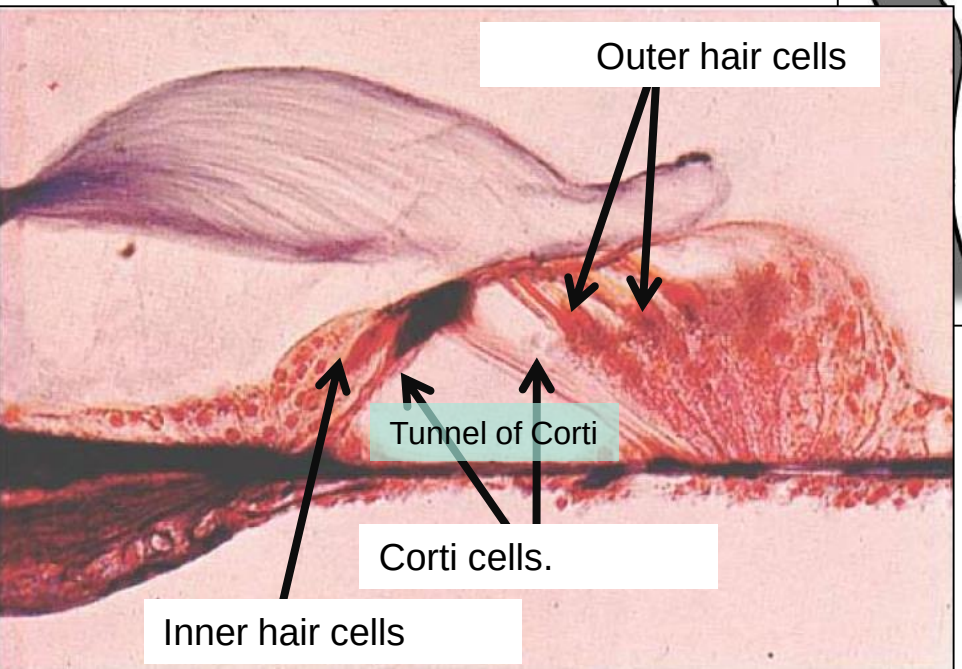
Utriculus,sacculus

Ductus cochlearis

Auris interna

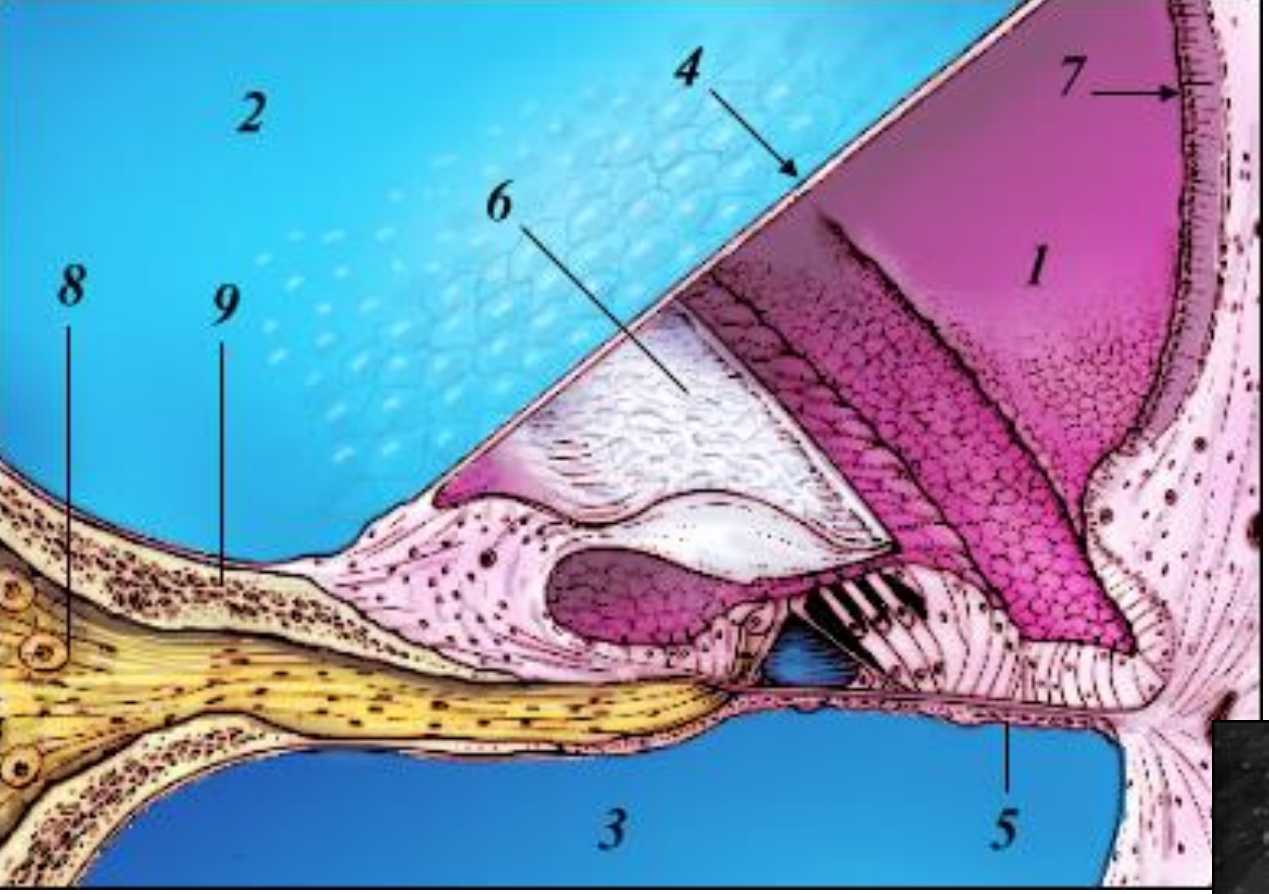
- labyrinthus osseus
  - cochlea
  - vestibulum
  - canales semicirculares
- labyrinthus membranaceus
  - utriculus
  - sacculus
  - ductus semicirculares
  - **ductus cochlearis**

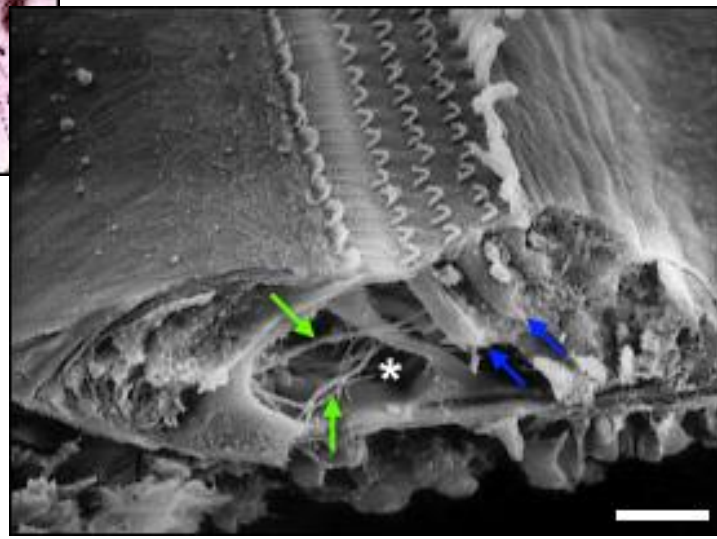




ScV, ScT – perilymph
ScM – endolymph

Cochlear section





1-ductus cochlearis

2- scala vestibuli

3 -scala tympani

4 –membrana vestibularis (Reissneri)

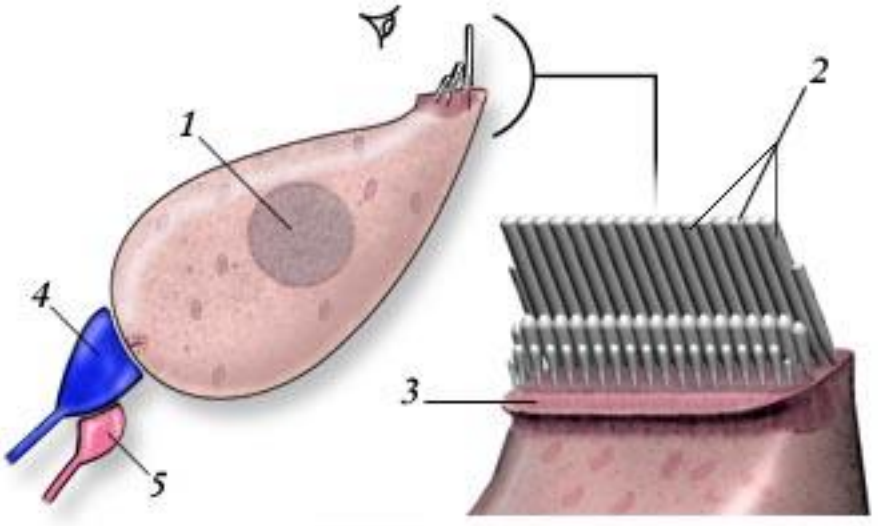
5- membrana basilaris

6- membrana tectoria

7 – stria vascularis

8- ganglion spirale cochleae

9 – lamina spiralis ossea

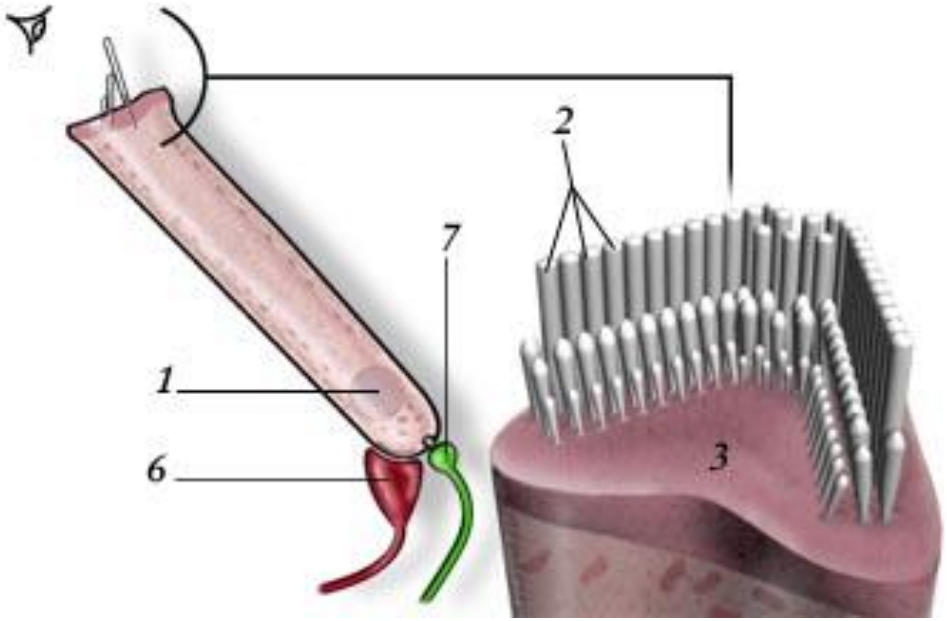


Inner hair cell 3 500

Afferent axon

Efferent axon 1 row

Contact with bipolar cells



Outer hair cell 15 000

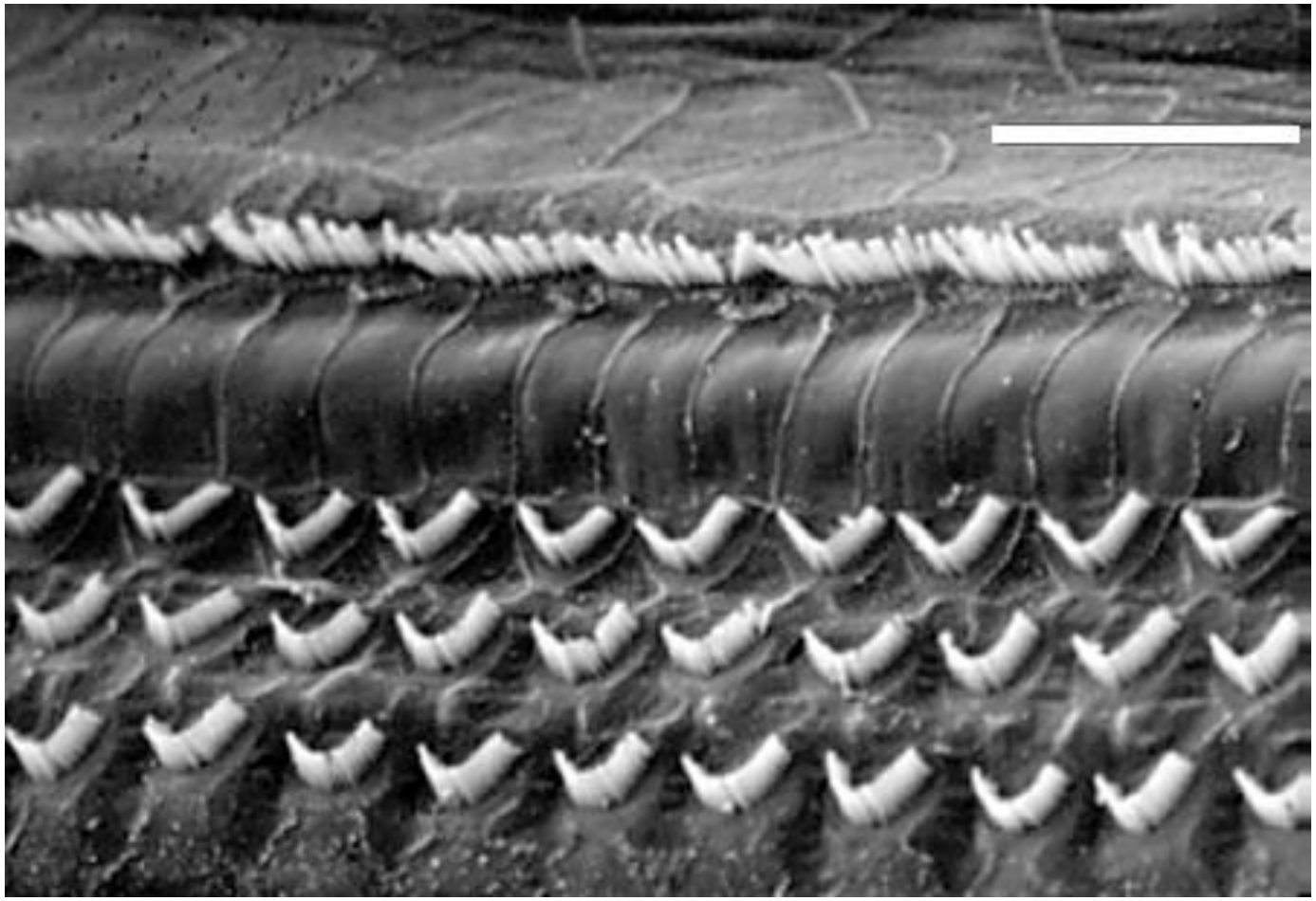
Efferent axon 3-4 rows

Afferent axon

Contact with unipolar cells

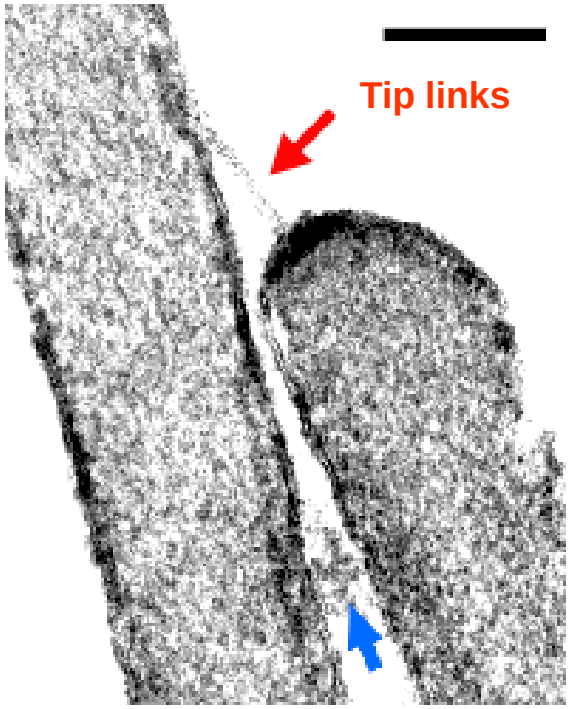
Electron microscopy

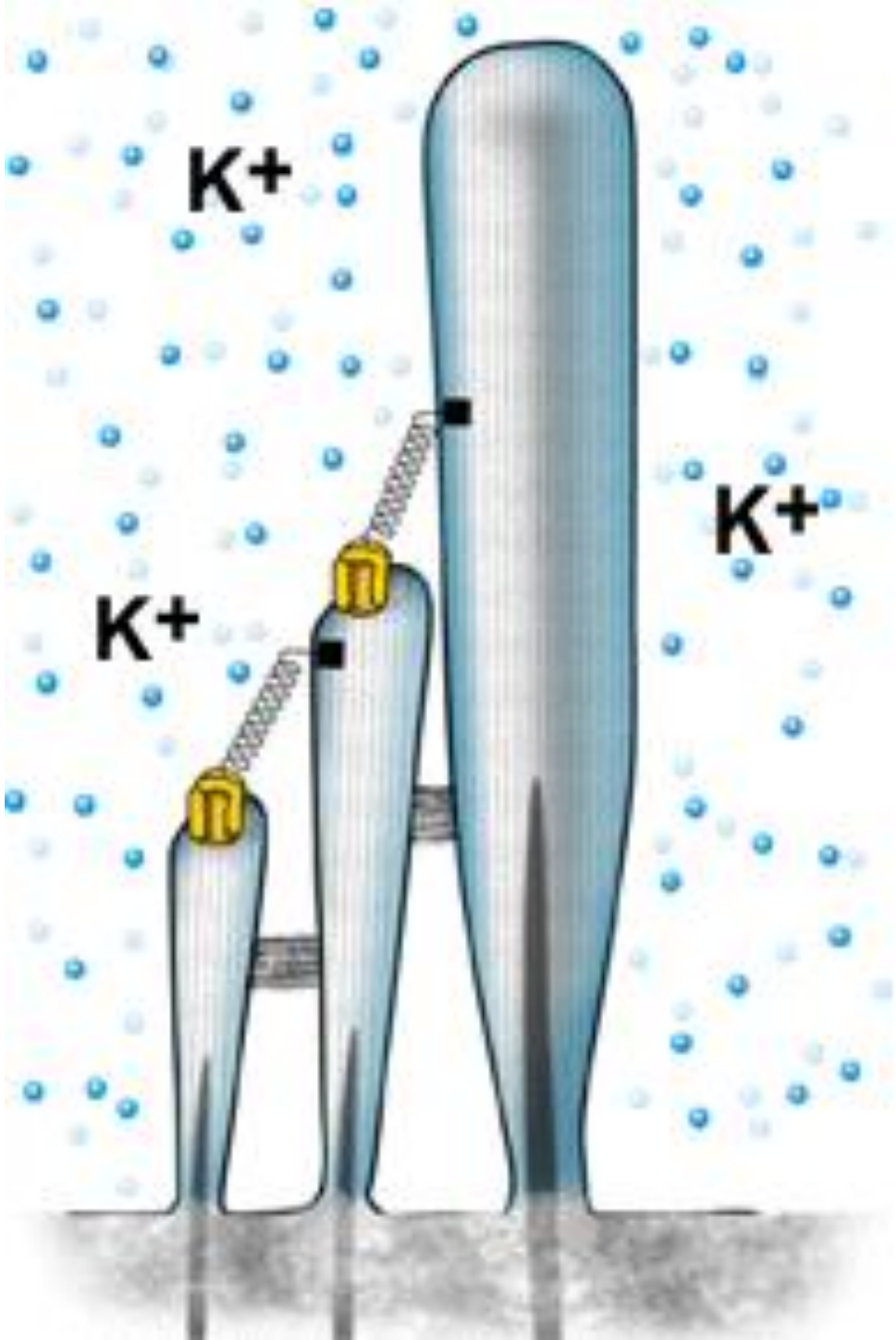
Inner



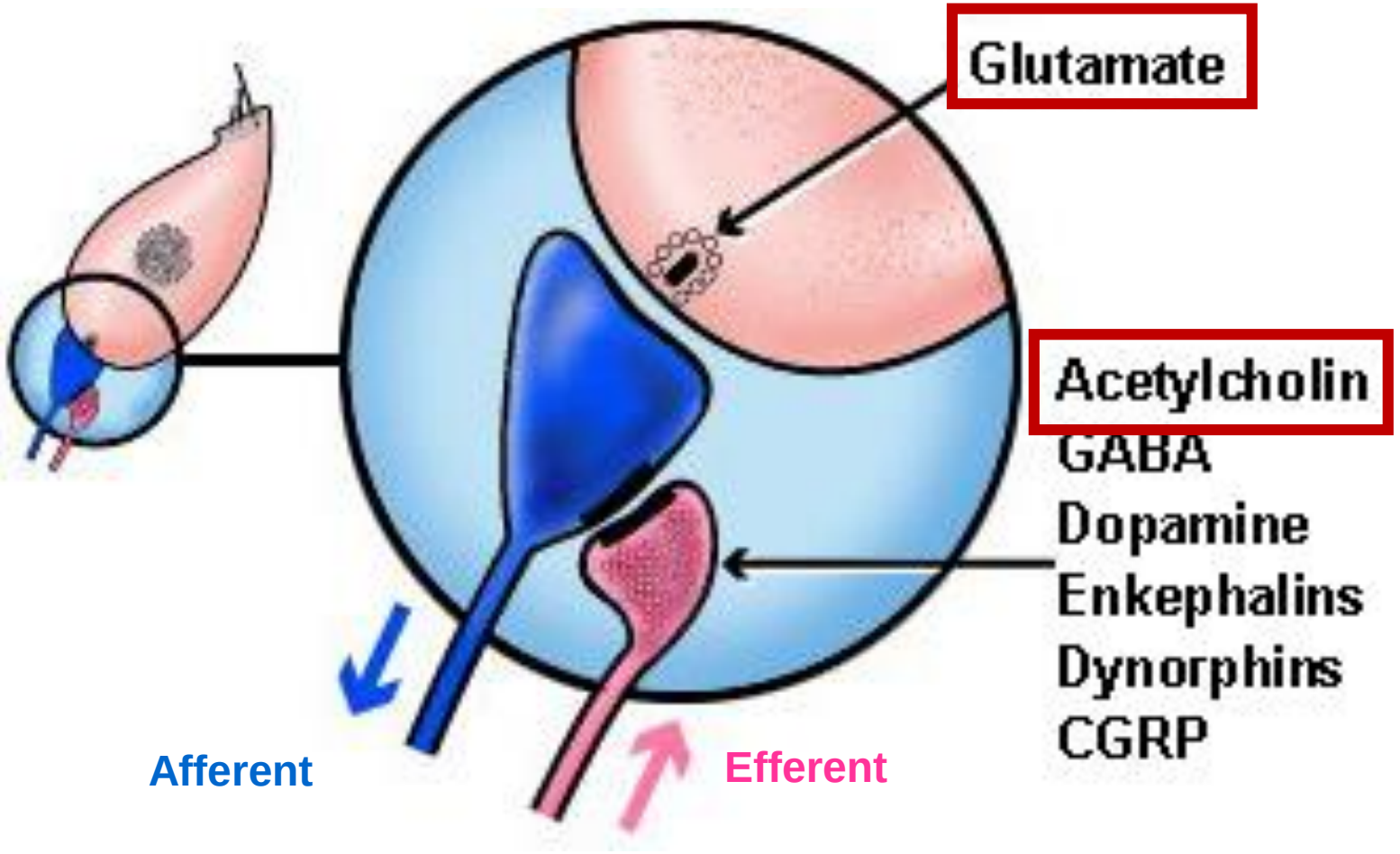
Outer

Mechanoelectric transduction

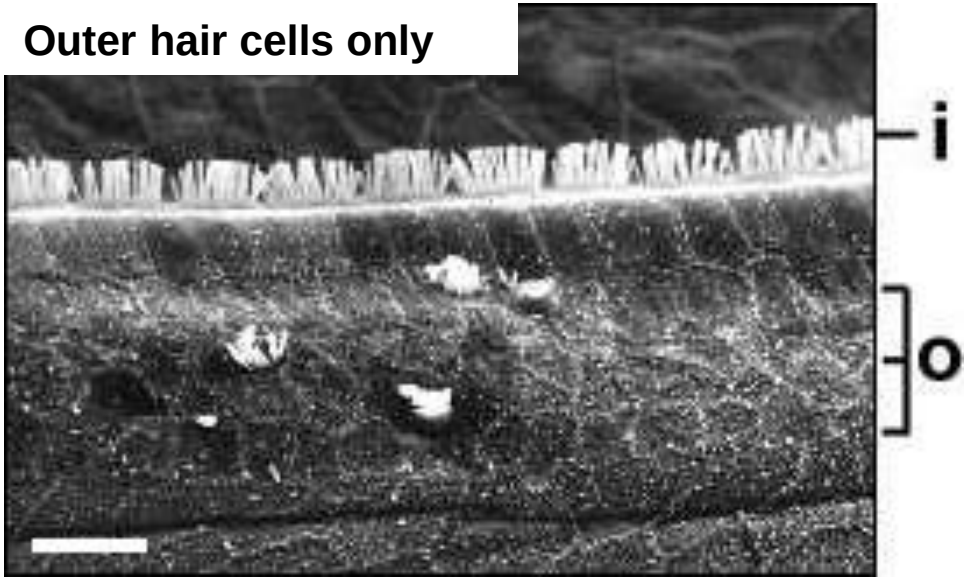


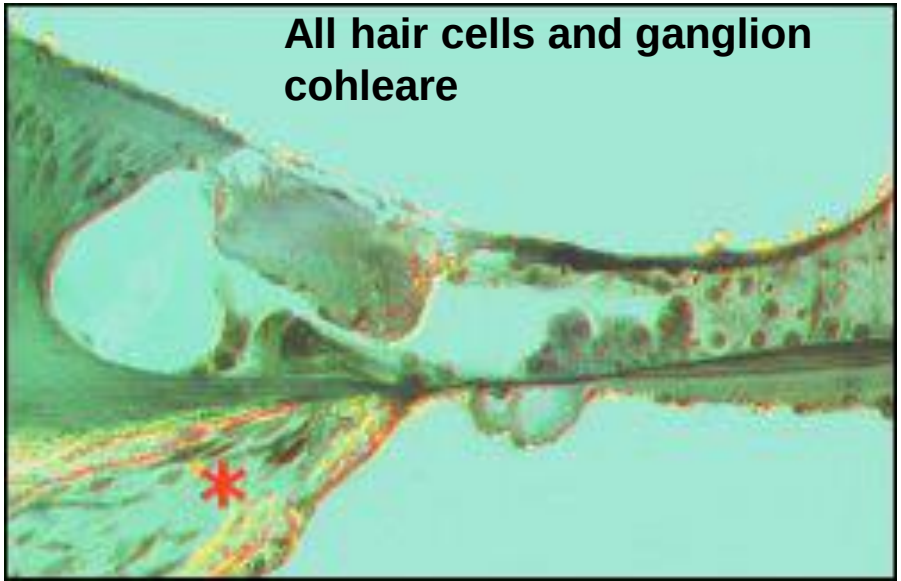


Hair cells mediators



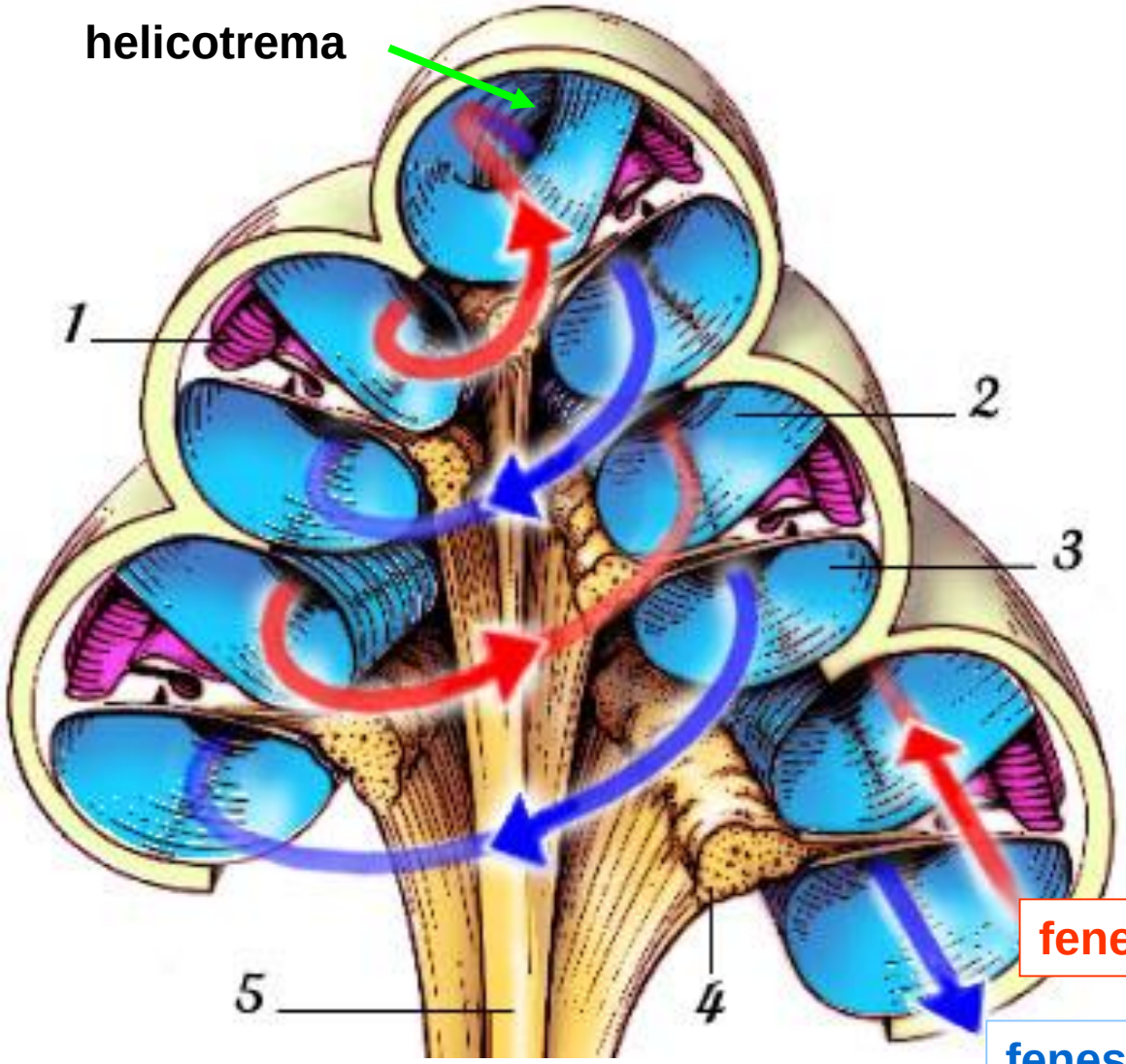
Organ of Corti damage





Cochlea

perilmyph movement



1-ductus cochlearis

2 – scala vestibuli

3 – scala tympani

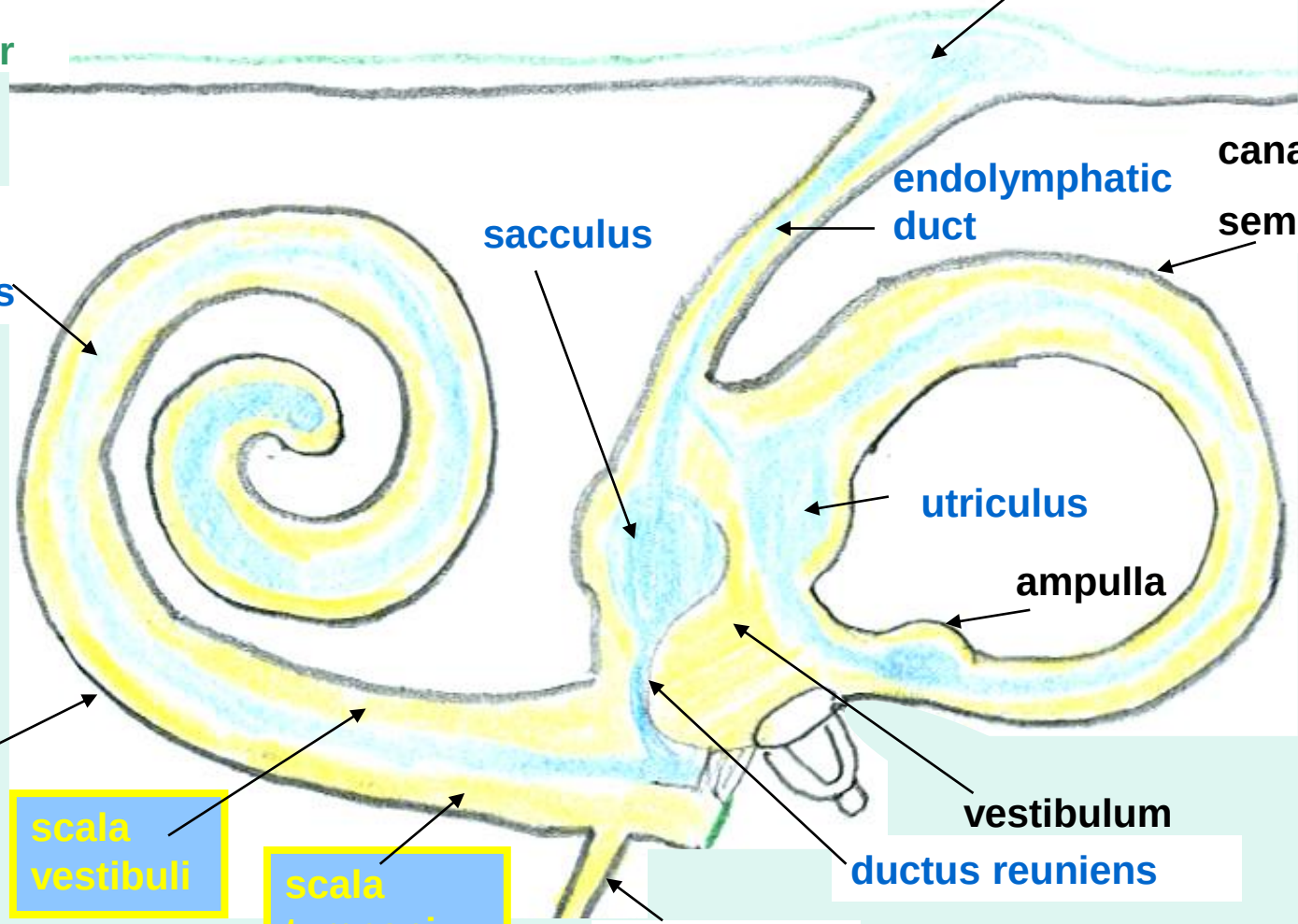
4 – ganglion spirale cochleae

5 – nervus cochlearis

fenestra vestibuli

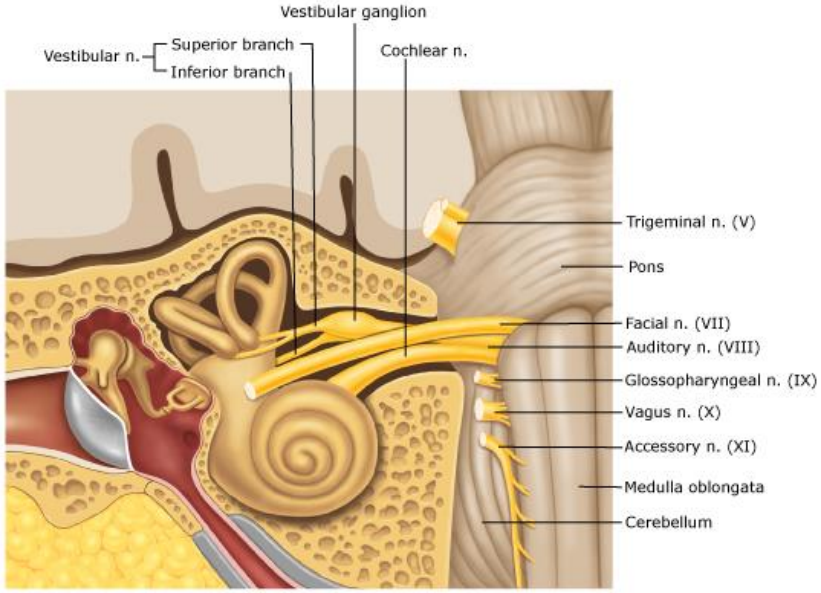
fenestra cochleae

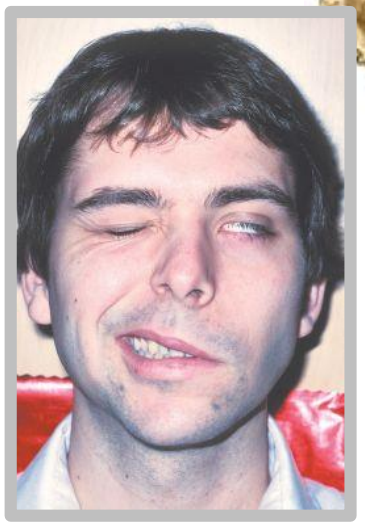
Inner ear

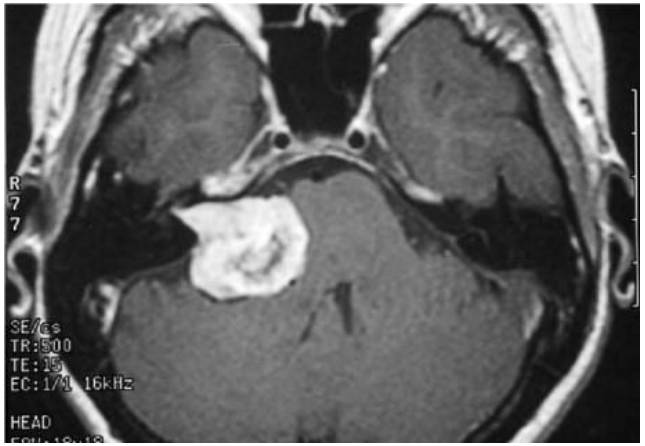


perilymph
endolymph

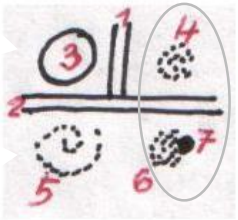
Meatus acusticus internus





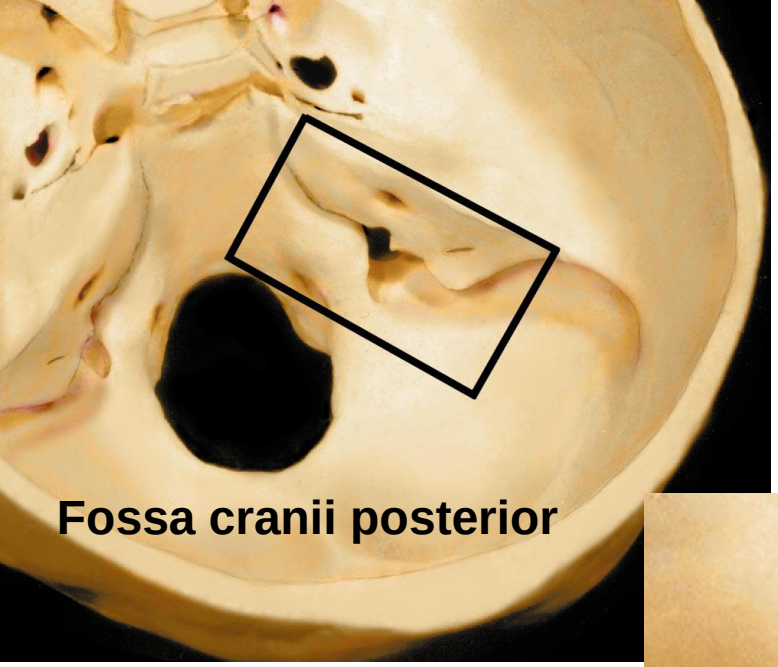


FUNDUS MEATUS ACUSTICI INTERNI (dx.)



1- crista verticalis
2 - crista transversa
3 - area n. facialis
4 - area vestibularis sup.: n. utriculoampullaris (n. vestibularis sup.)
5 - area cochleae: n. cochlearis (tractus spiralis foraminosus)
6 - area vestibularis inf.: n. saccularis (n. vestibularis inf.)
7 - foramen singulare: n. ampullaris post.

Posterior surface of the pyramid



Fossa cranii posterior

apertura externa aquaeductus vestibuli

fossa subarcuata

meatus acusticus internus (n.VII. a n.VIII.)

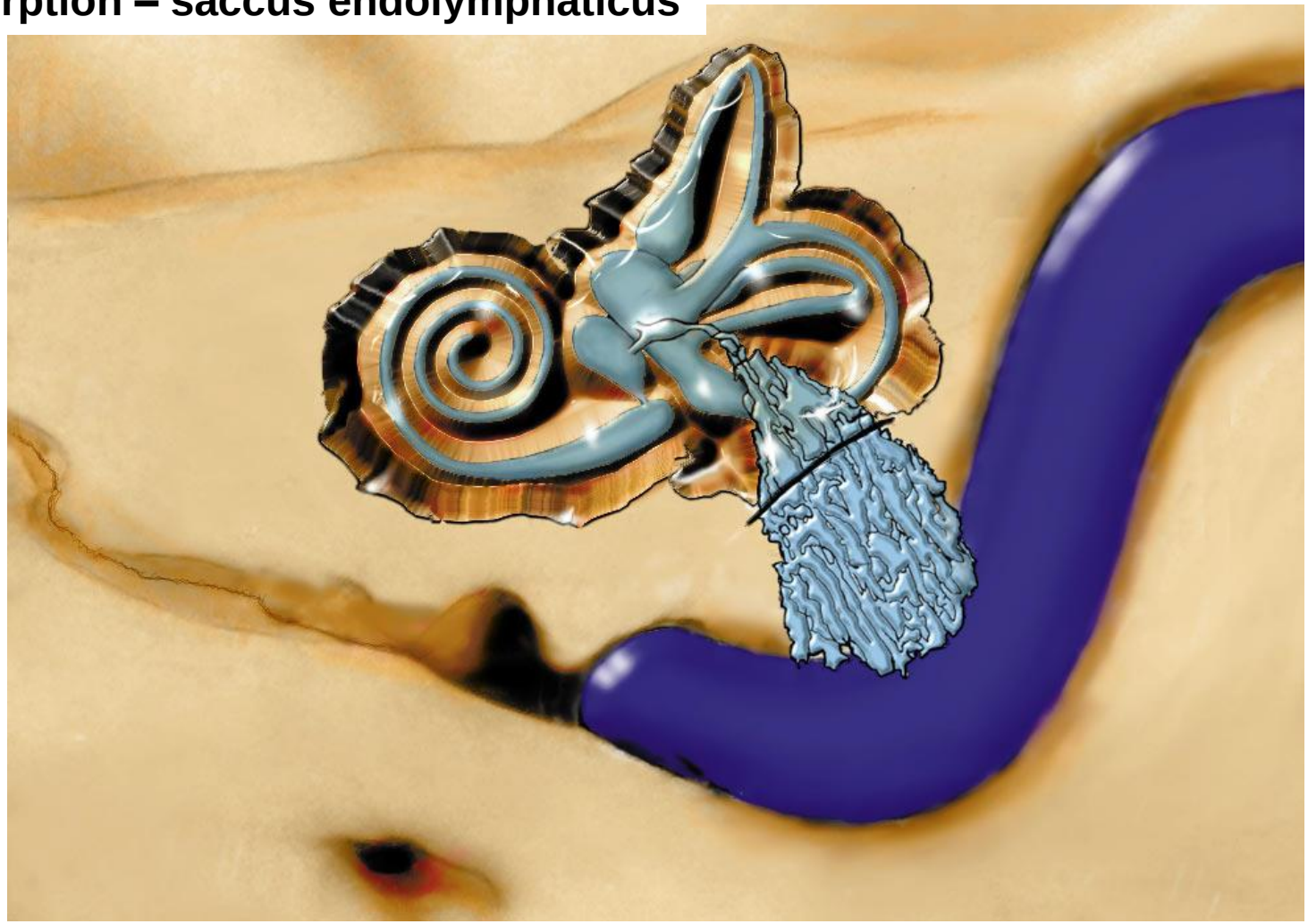
sulcus sinus petrosi inferioris

foramen jugulare (n.IX., X., a XI.)

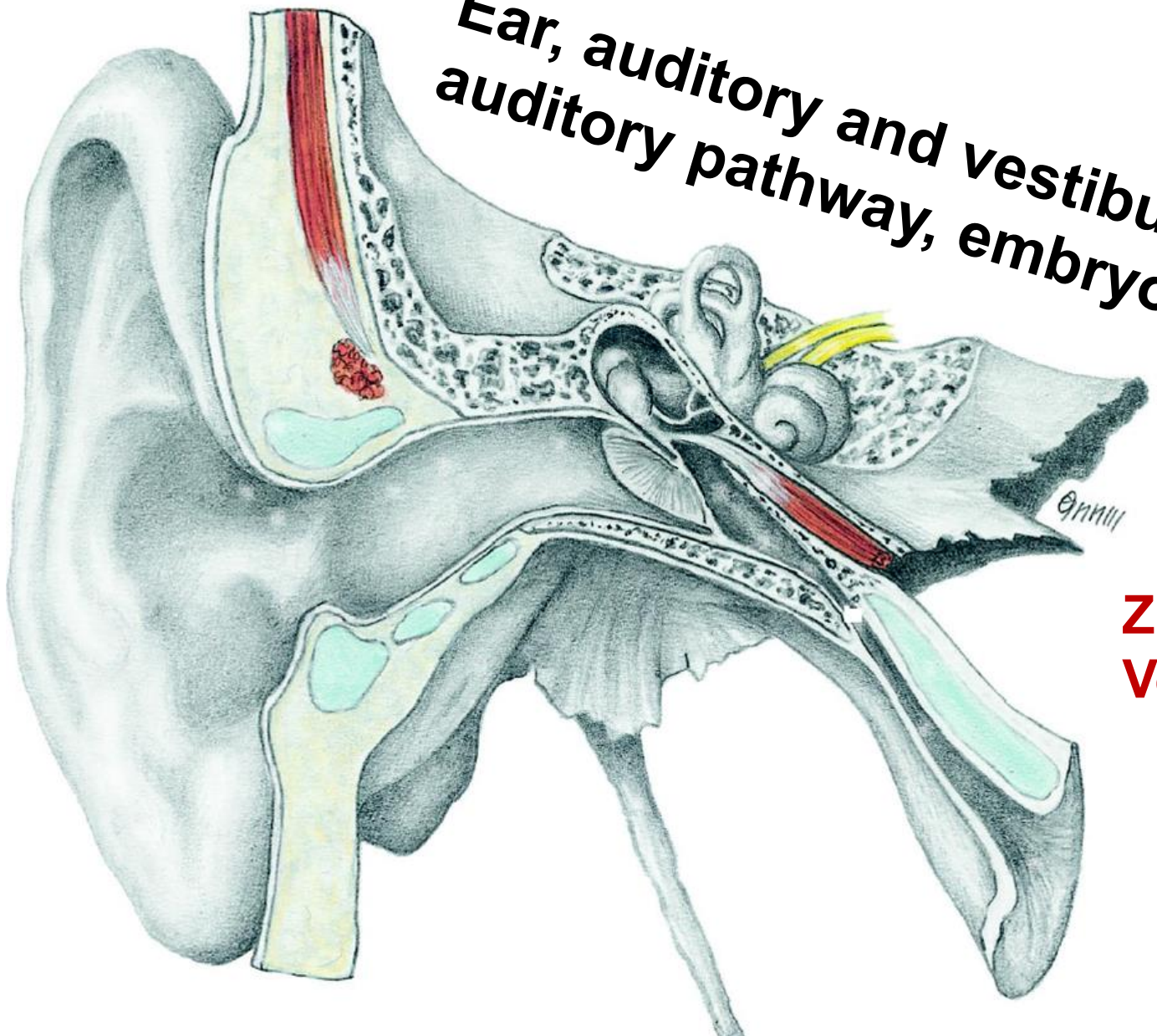
canalis nervi hypoglossi

sulcus sinus sigmoidei

Endolymph:
production - stria vascularis
Resorption – saccus endolymphaticus



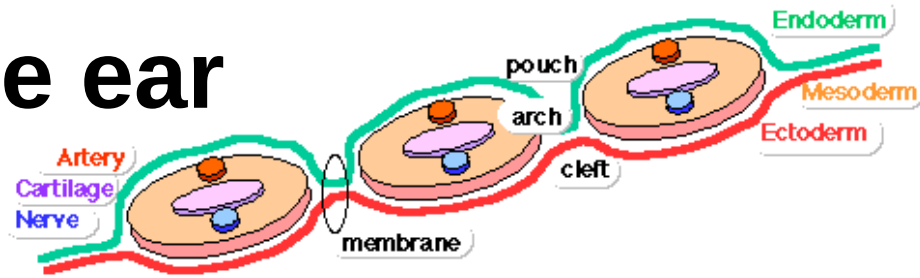
Ear, auditory and vestibular system, auditory pathway, embryology



Zdeněk Fík
Veronika Němcová

Embryology

External + middle ear



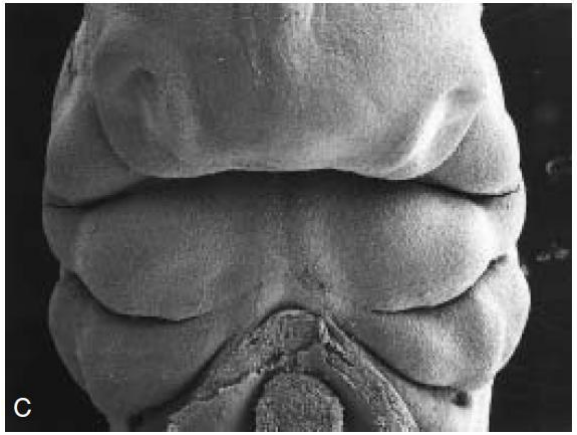
Pharyngeal arch

Pharyngeal cleft

Pharyngeal pouch

1. + 2.

Otic placode

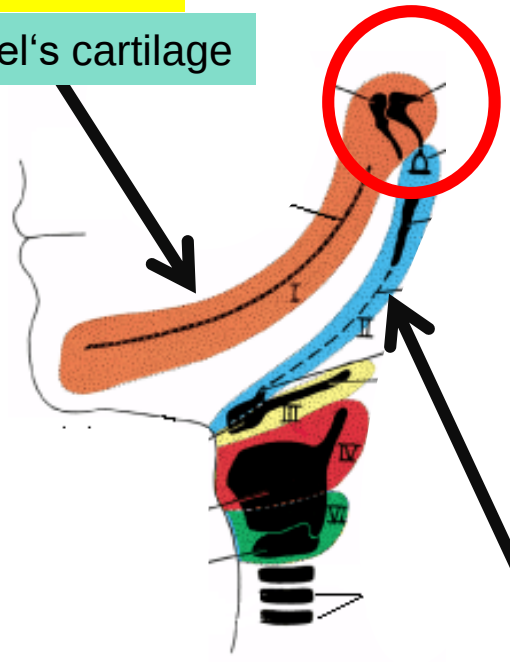


Sadler TW, Langman's Medical Embryology 10th Edition, Lippincott Williams and Wilkins, Baltimore MD, 2006

External + middle ear

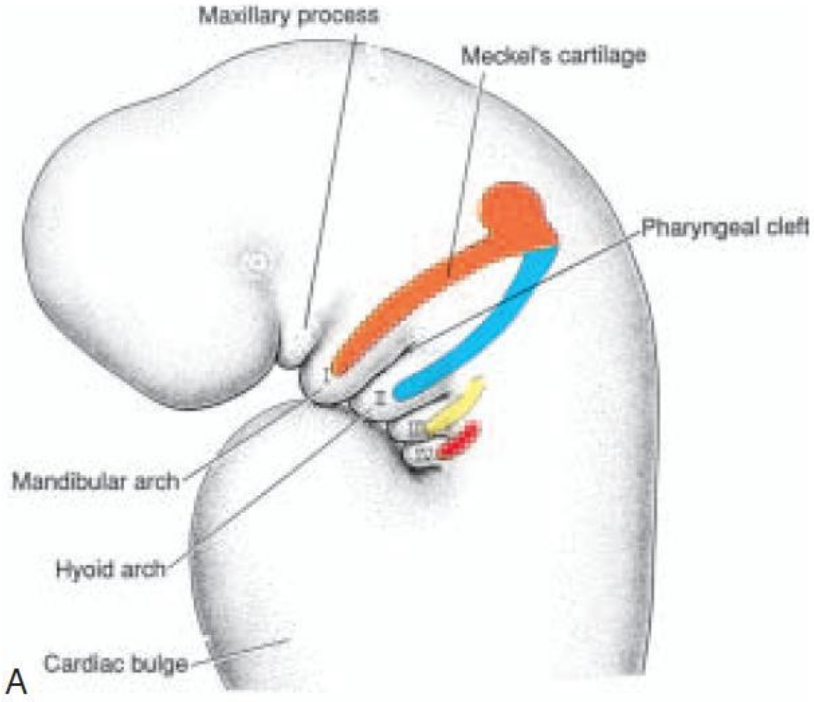
malleus
incus
Maxilla
Mandibula
Temporal b.

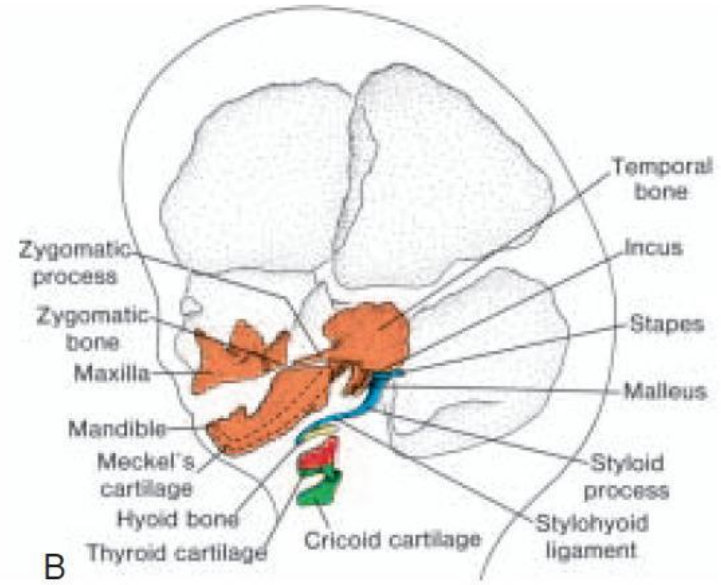
Meckel‘s cartilage



Reichert‘s cartilage

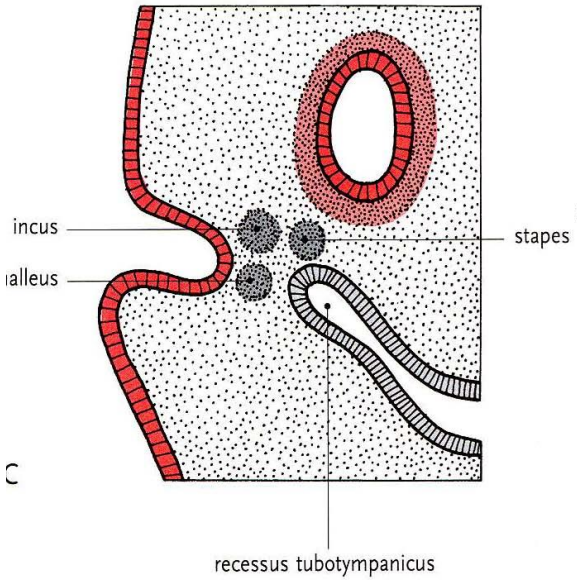
Stapes
Processus styloideus

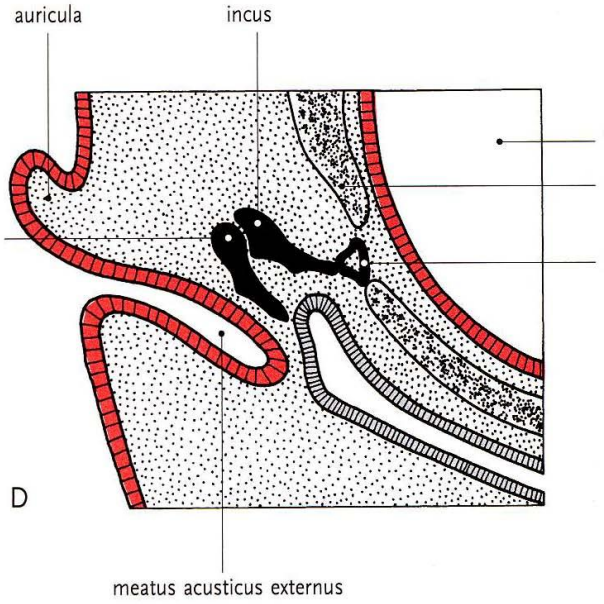




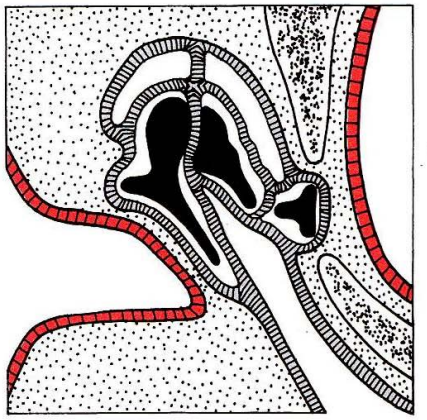
Sadler TW, Langman’s Medical Embryology 10th Edition, Lippincott Williams and Wilkins, Baltimore MD, 2006

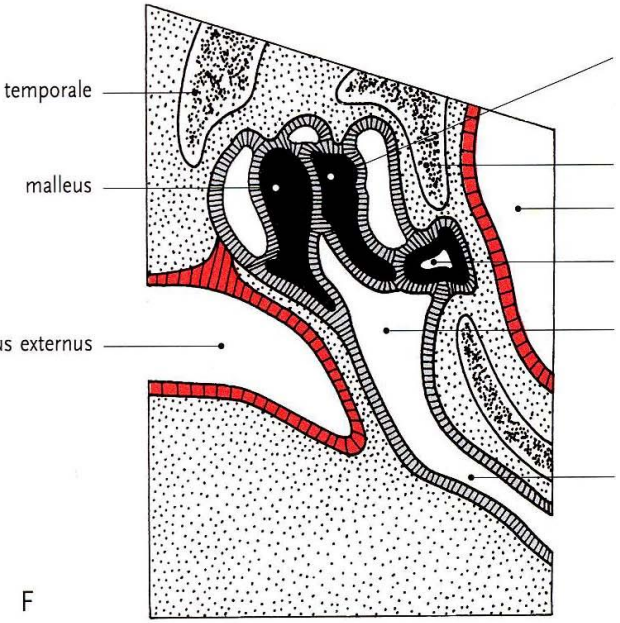
- **Pinna–**hillocks **of** 1. and 2. branchial arch
- **External ear canal** ectoderm of the 1. branchial pit
- **Drum–** 3 layers ectoderm, mesenchym, entoderm
- **Cavum tympani, and tuba Eustachi** – from the 1. pharyngeal pouch - recessus tubotympanicus, entodermal epithelium
- **Ossicles**– from the mesenchym of the 1. (malleus, incus) a 2. (stapes) branchial arch (cartilago Meckeli et Reicherti)
- **Inner ear –**from the otic placode (ektodermal plate), which deepens and pinches off from the surface and forms the otic vesicle (**otocyst**). The membranous labyrinth is developed from the otocyst with ectodermal epithelium inside



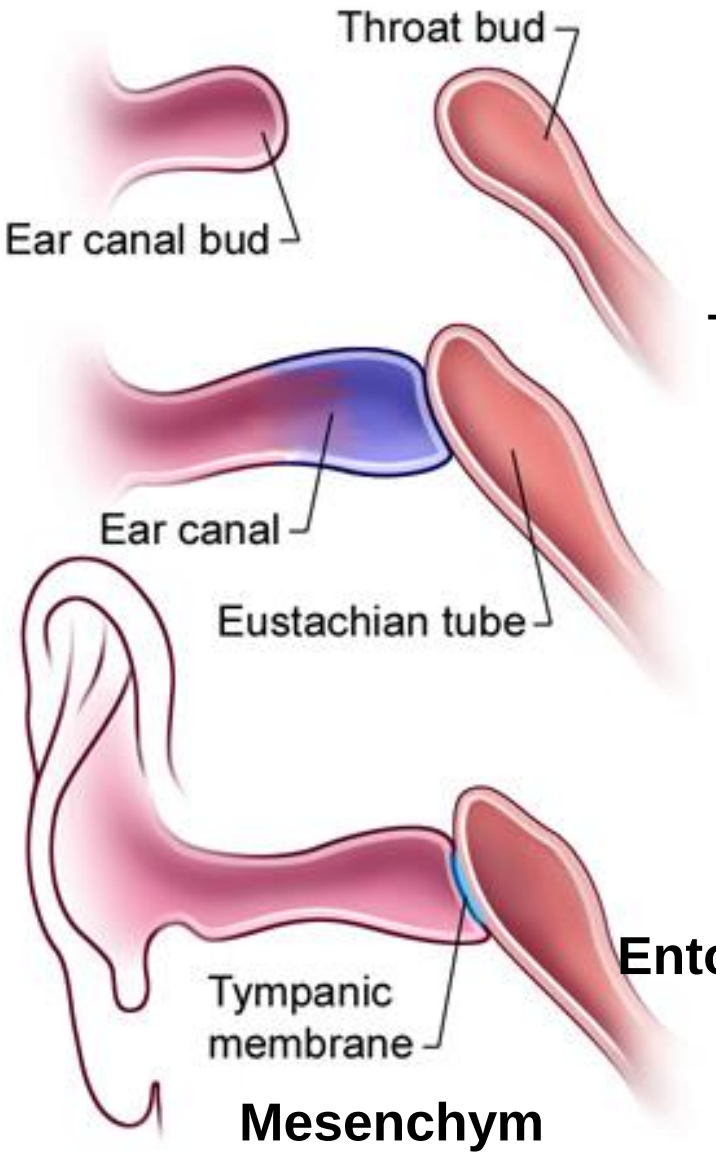


Ear development frontal sections

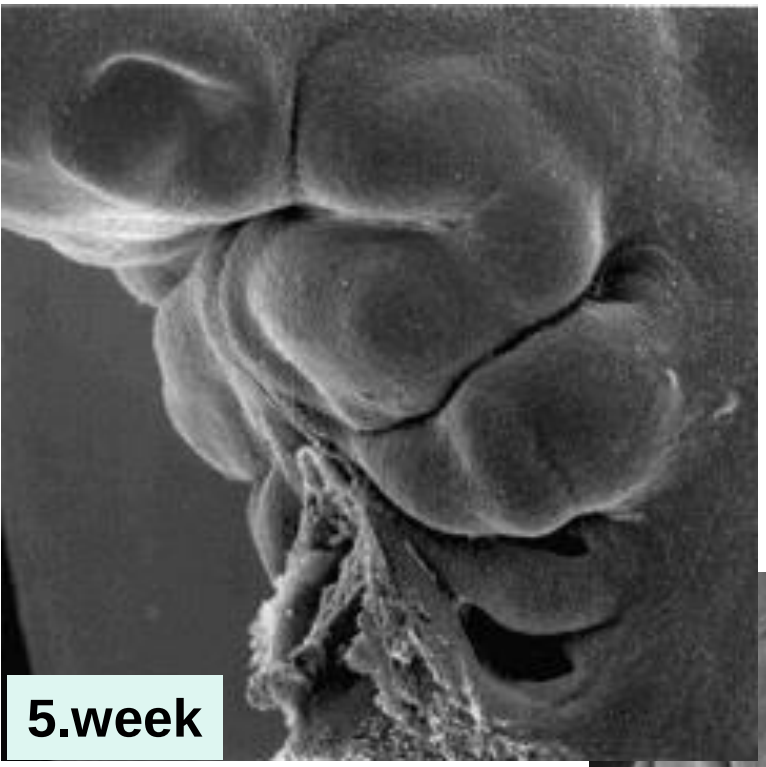


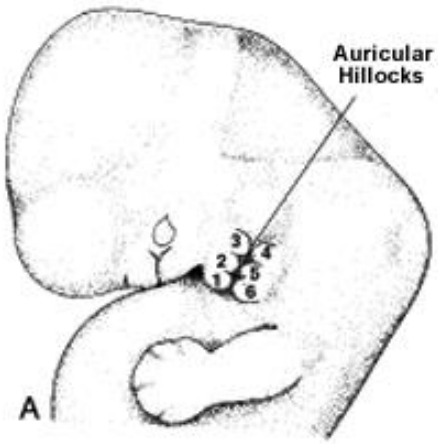


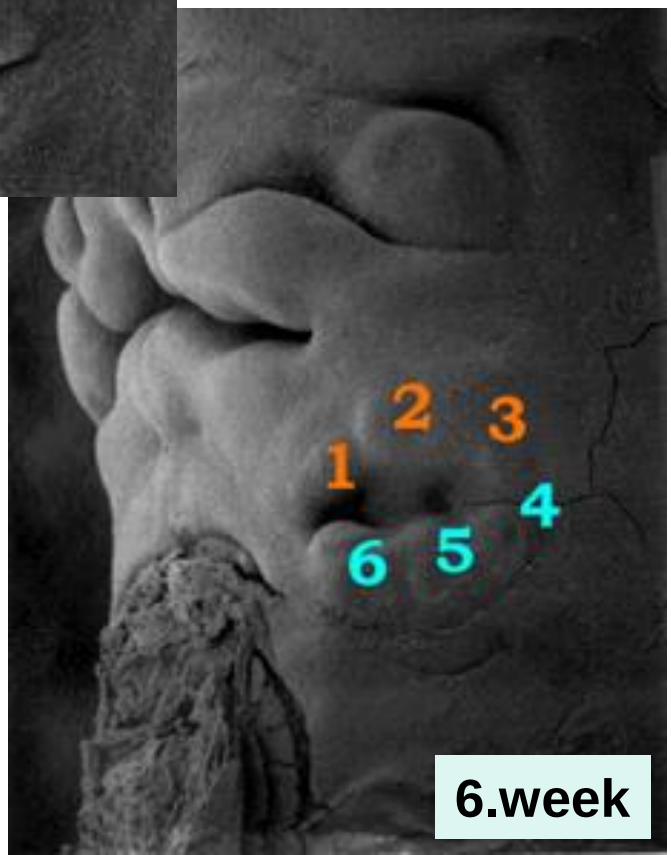
Outer and middle ear

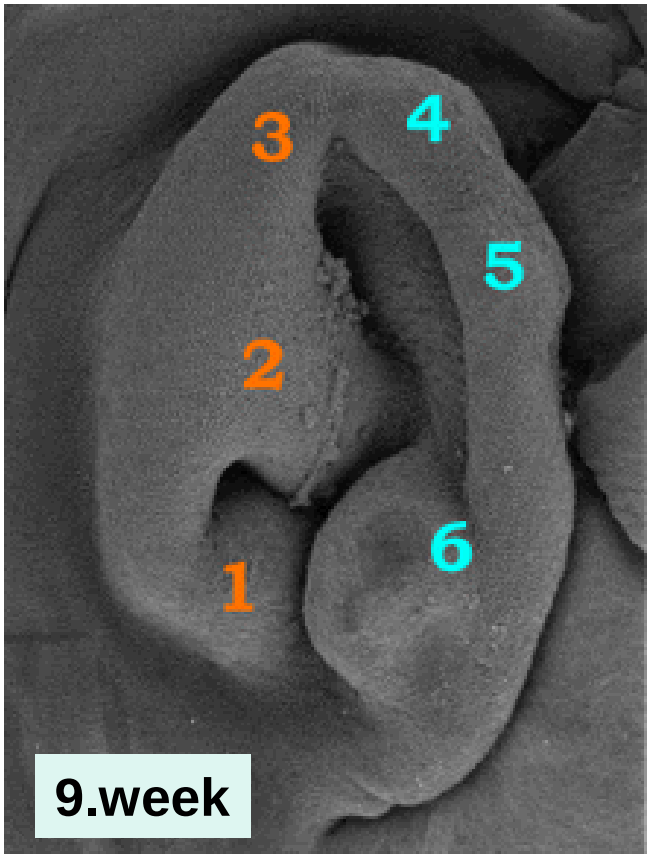


Pinna development

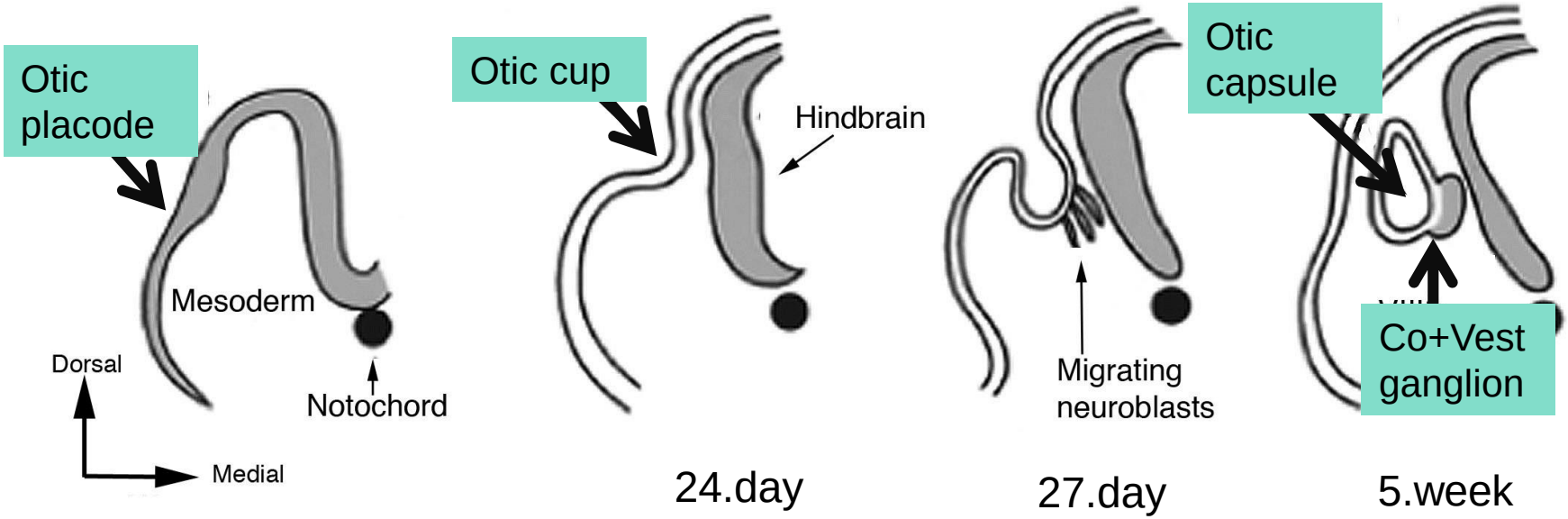


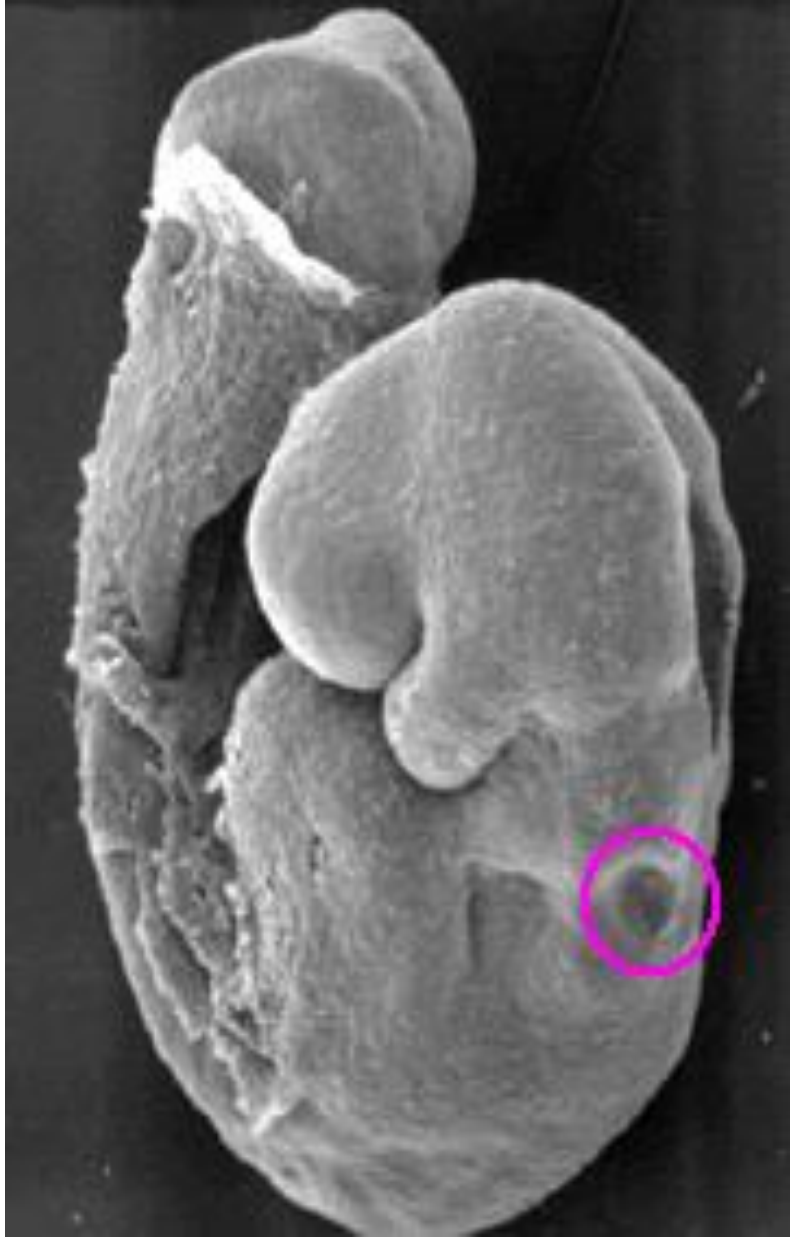


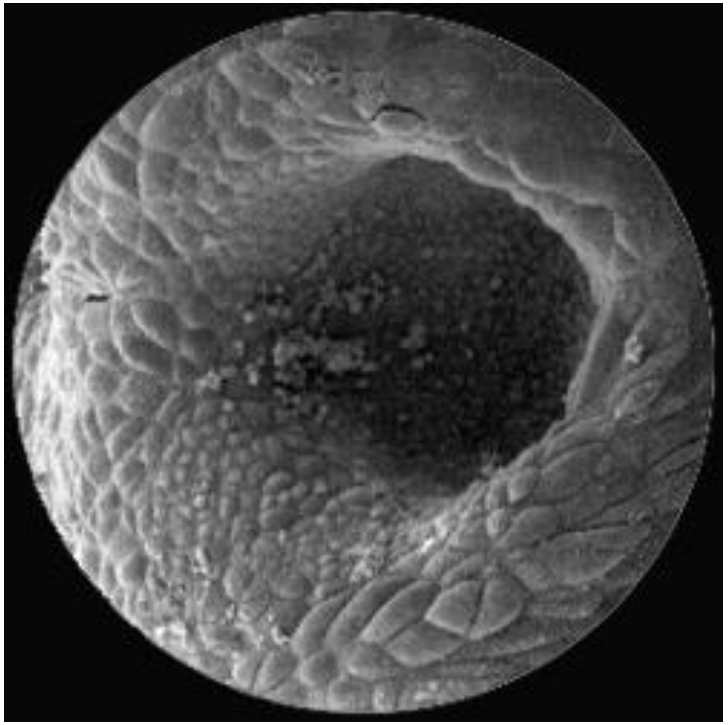




Inner ear

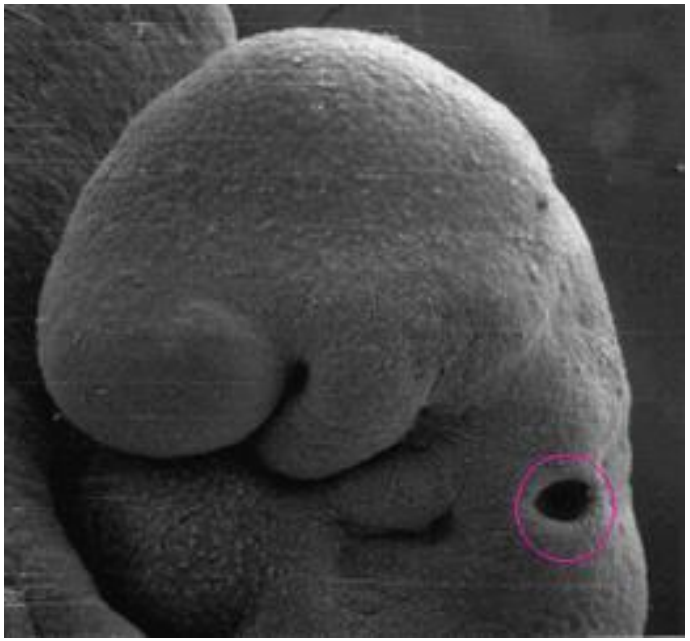

Otic placode
Mesoderm
Dorsal
Notochord
Medial
Otic cup
Hindbrain
24.day
Migrating neuroblasts
27.day
Otic capsule
Co+Vest ganglion
5.week

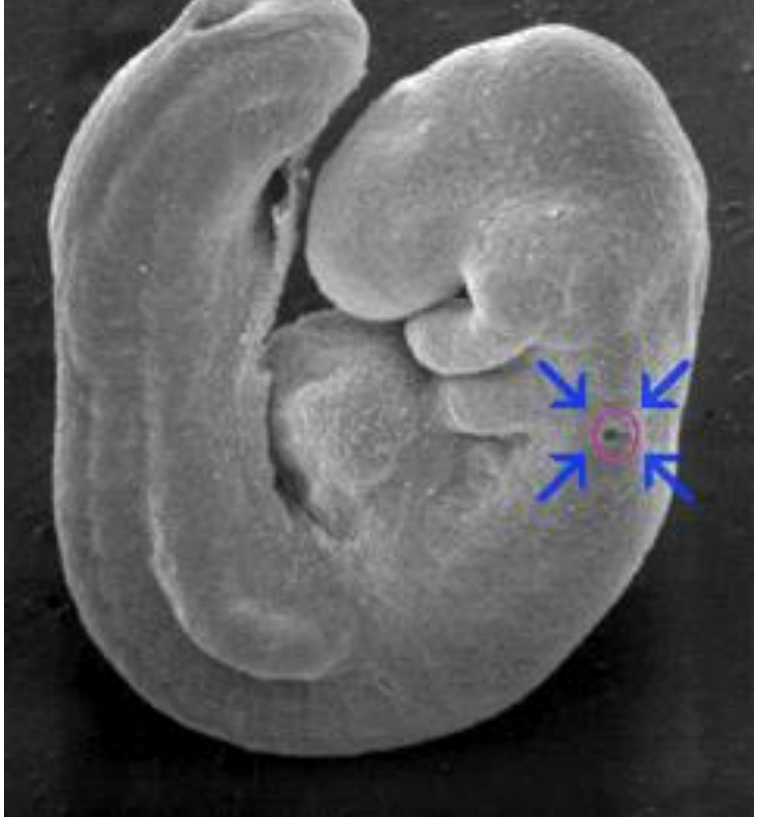


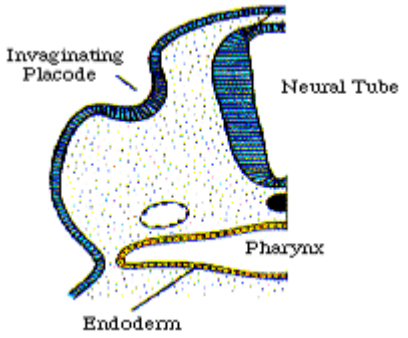


Day 26

- The otic pit forms as this thickened (placodal) ectoderm invaginates

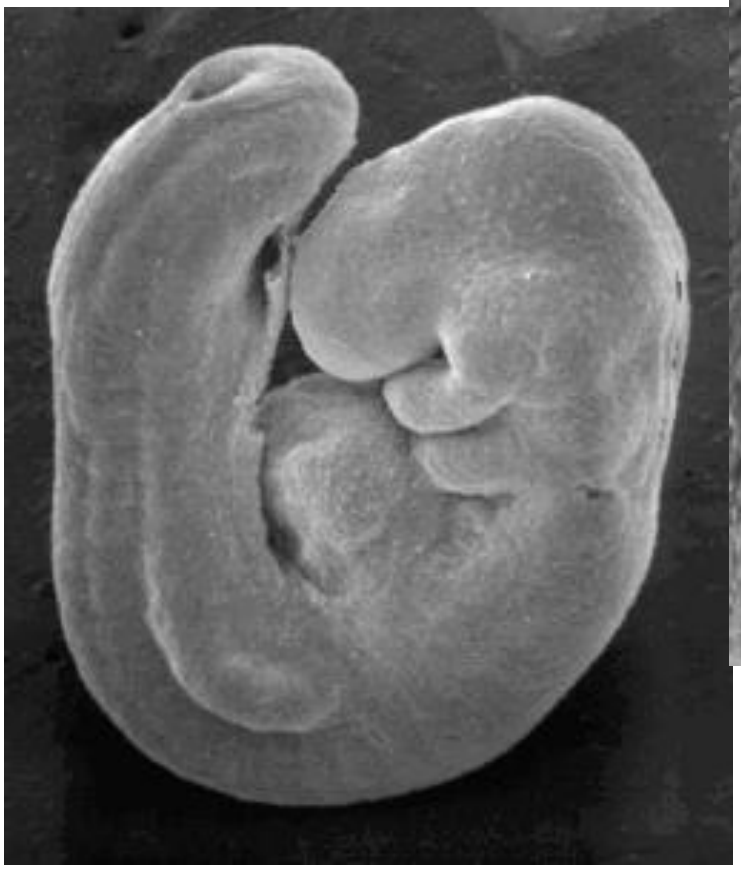


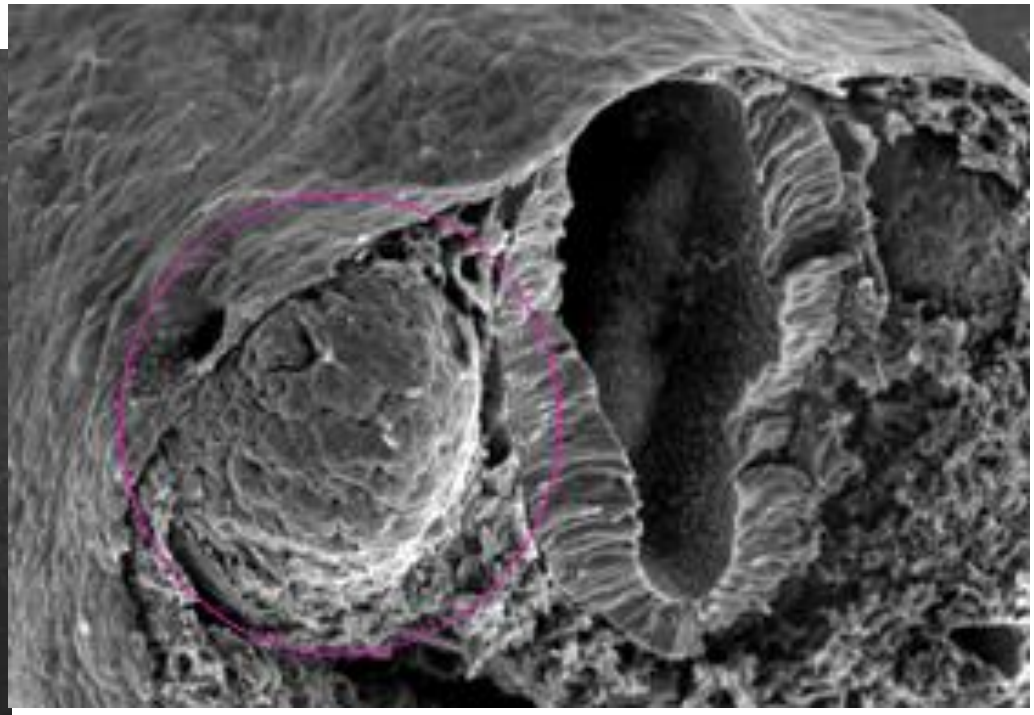




Day 28

- **The otic pit deepens and pinches off from the surface.**

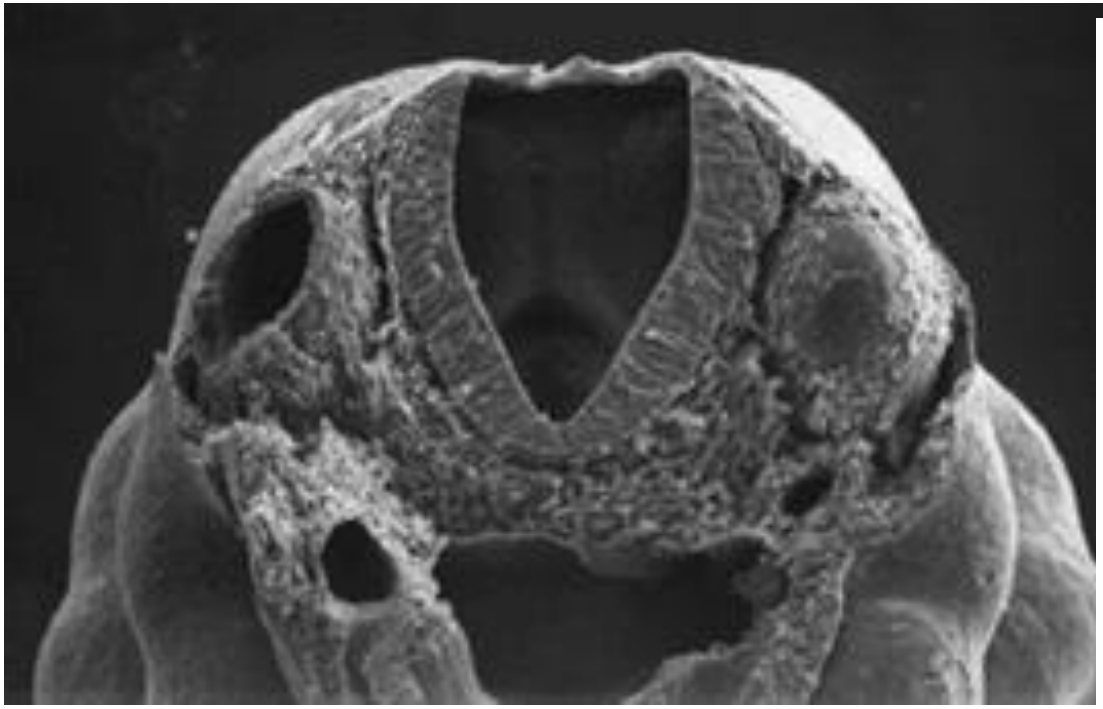




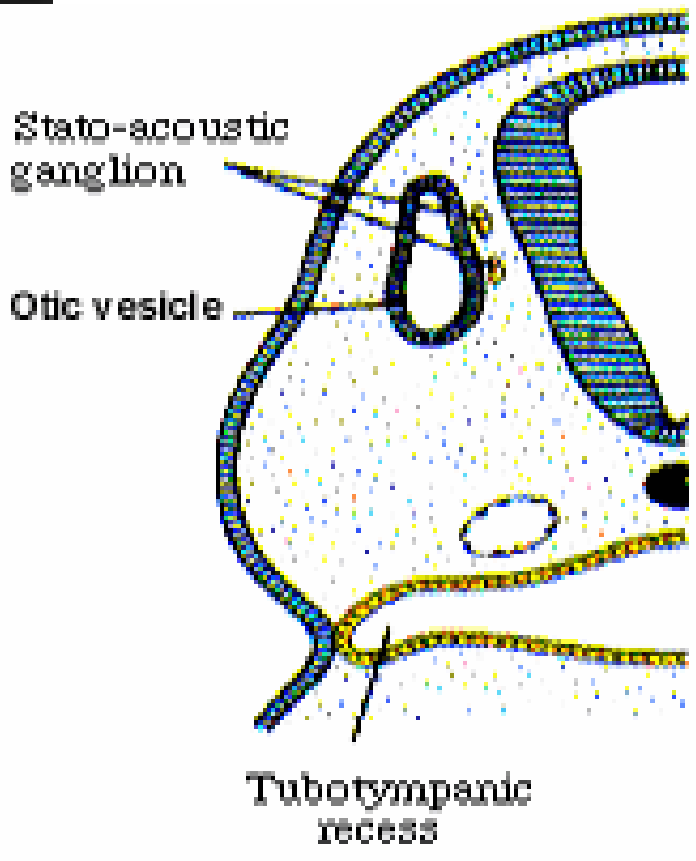
Day 29

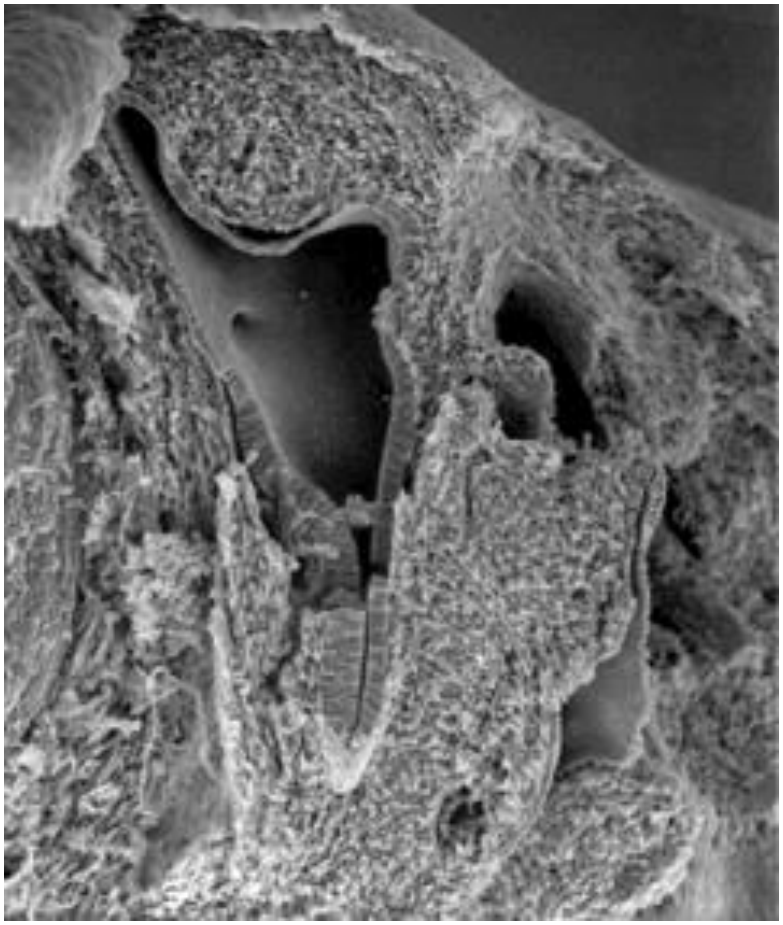
- **A cut through the otic pit at the time it is completing its separation from the surface ectoderm illustrates**

The stato (vestibulo)-acoustic ganglion begins to form between the otic vesicle (otocyst) and the neural tube.

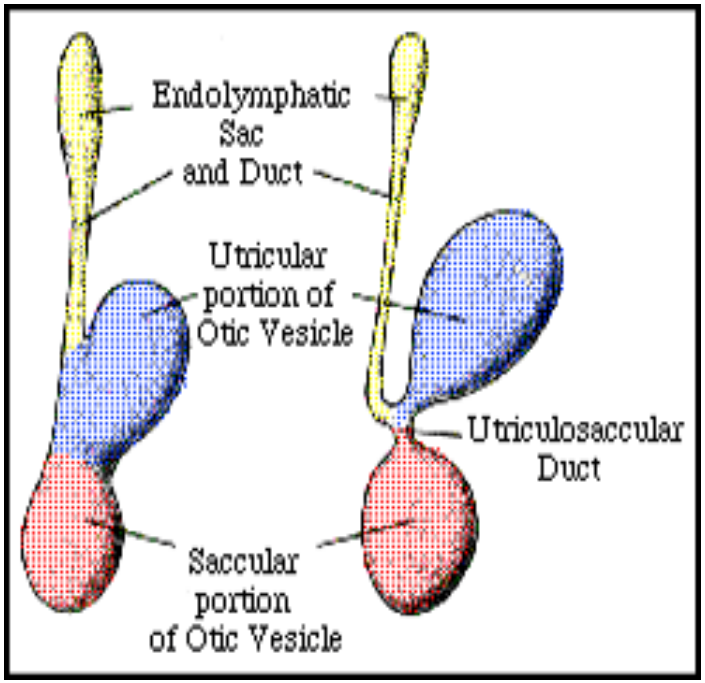


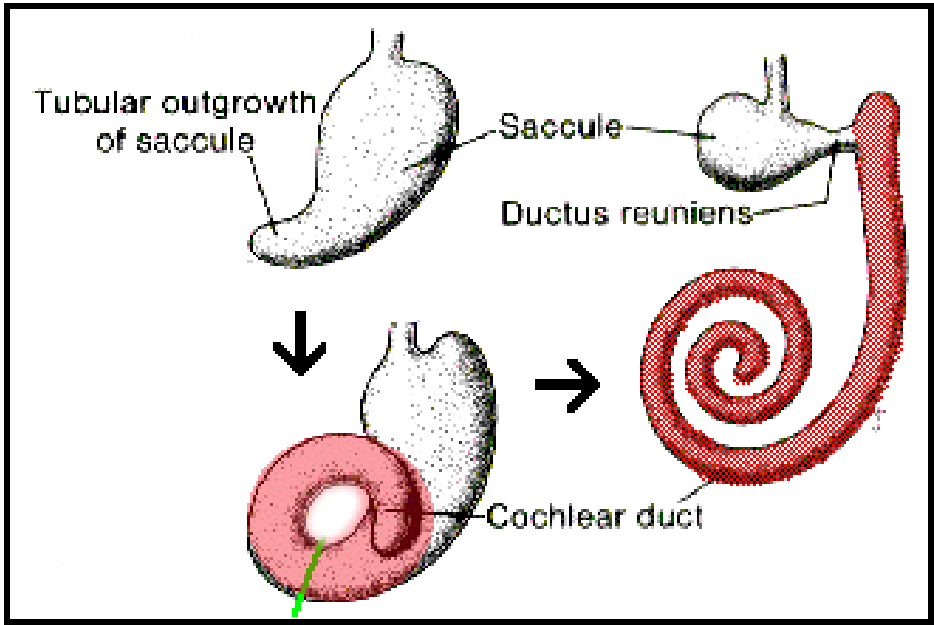
Day 30





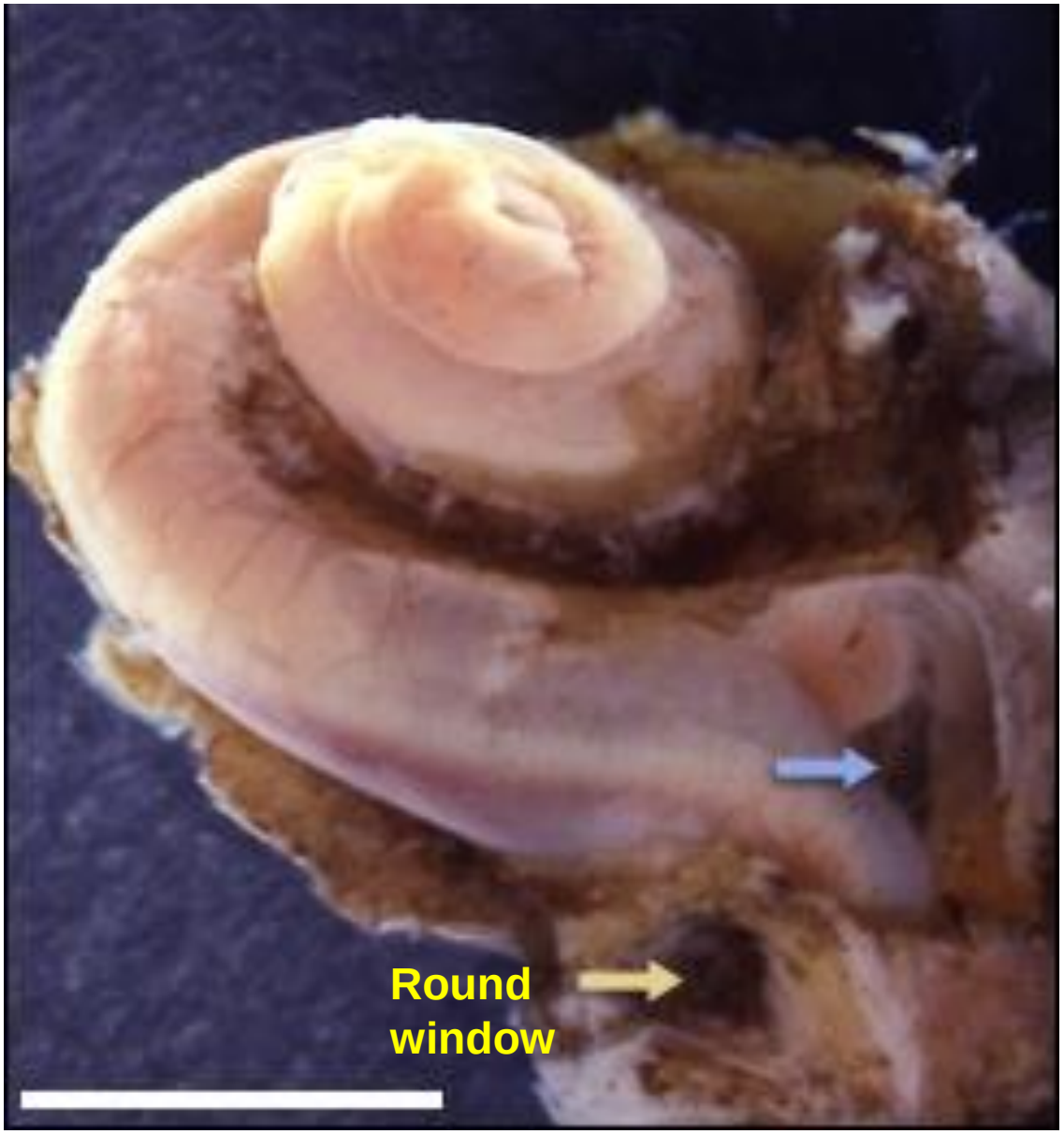
Day 36



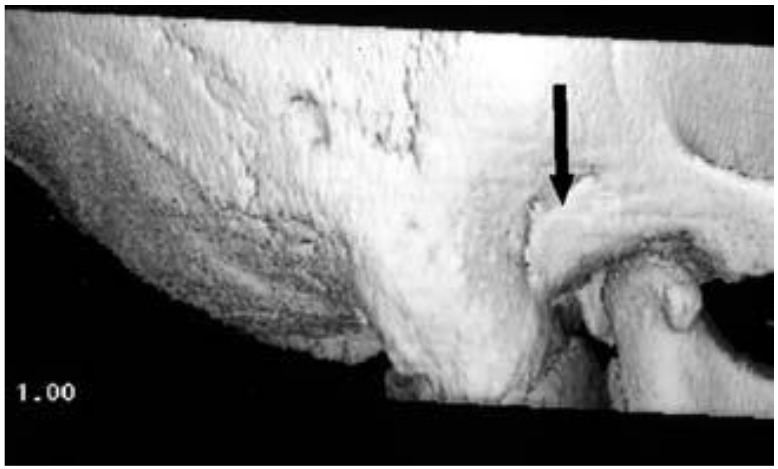


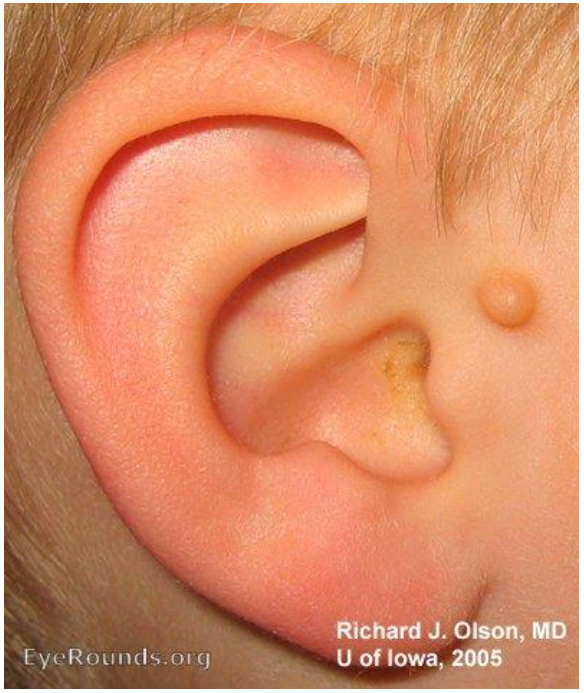
Development of the membranous labyrinth

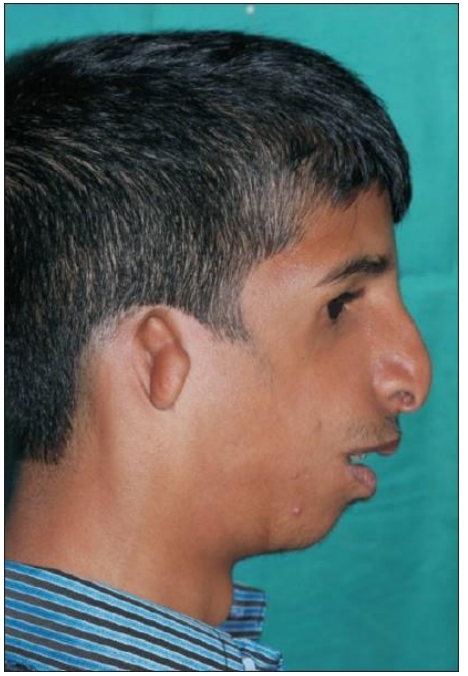
Cochlear duct of human fetus - 5 month of gestation



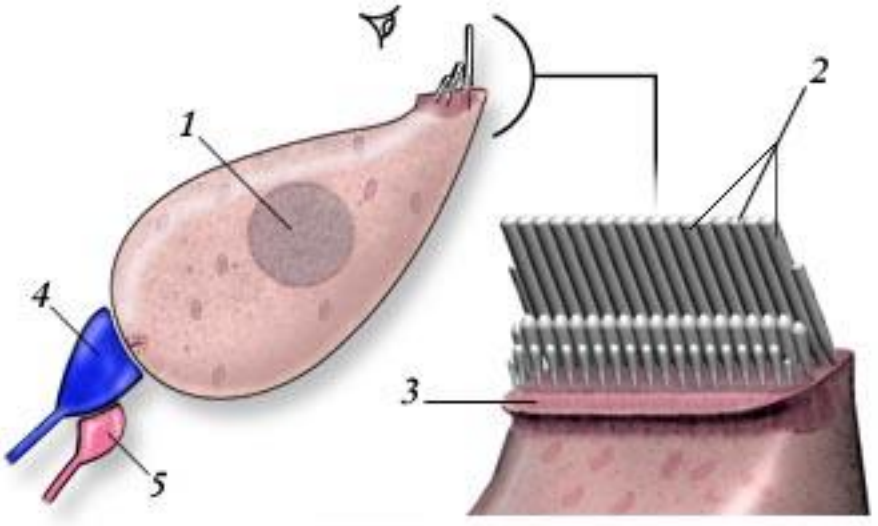
Developmental defects







Auditory pathway

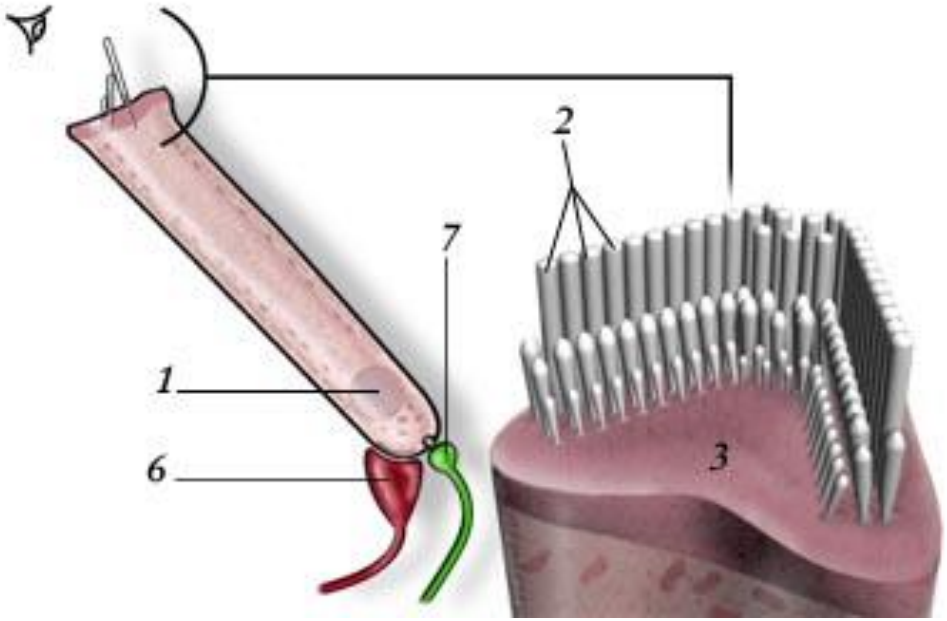


Inner hair cell 3 500

Afferent axon

Efferent axon 1 row

Contact with bipolar cells



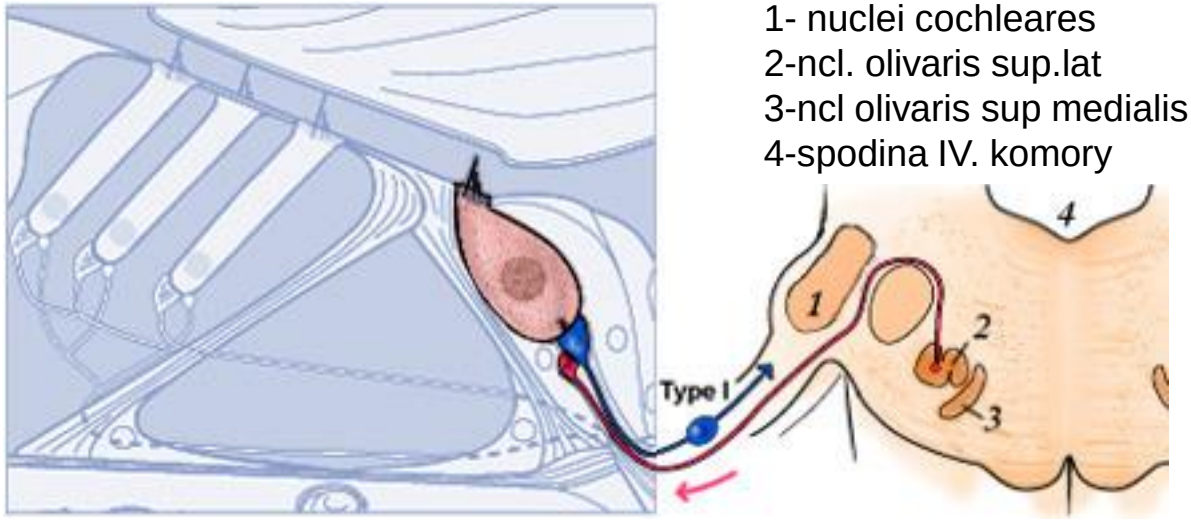
Outer hair cell 15 000

Efferent axon 3-4 rows

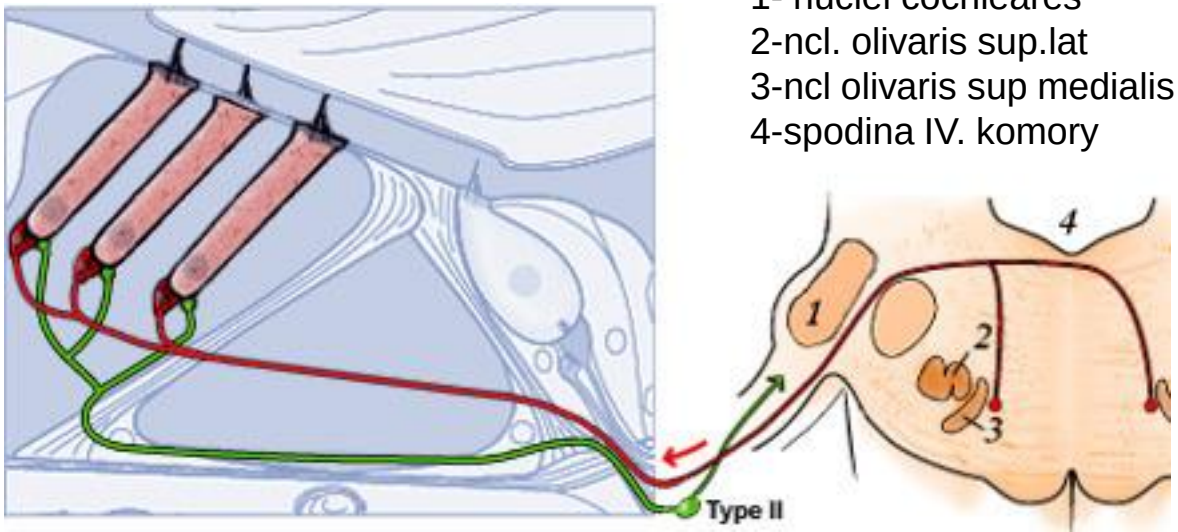
Afferent axon

Contact with unipolar cells

Afferents and efferents of the hair cells



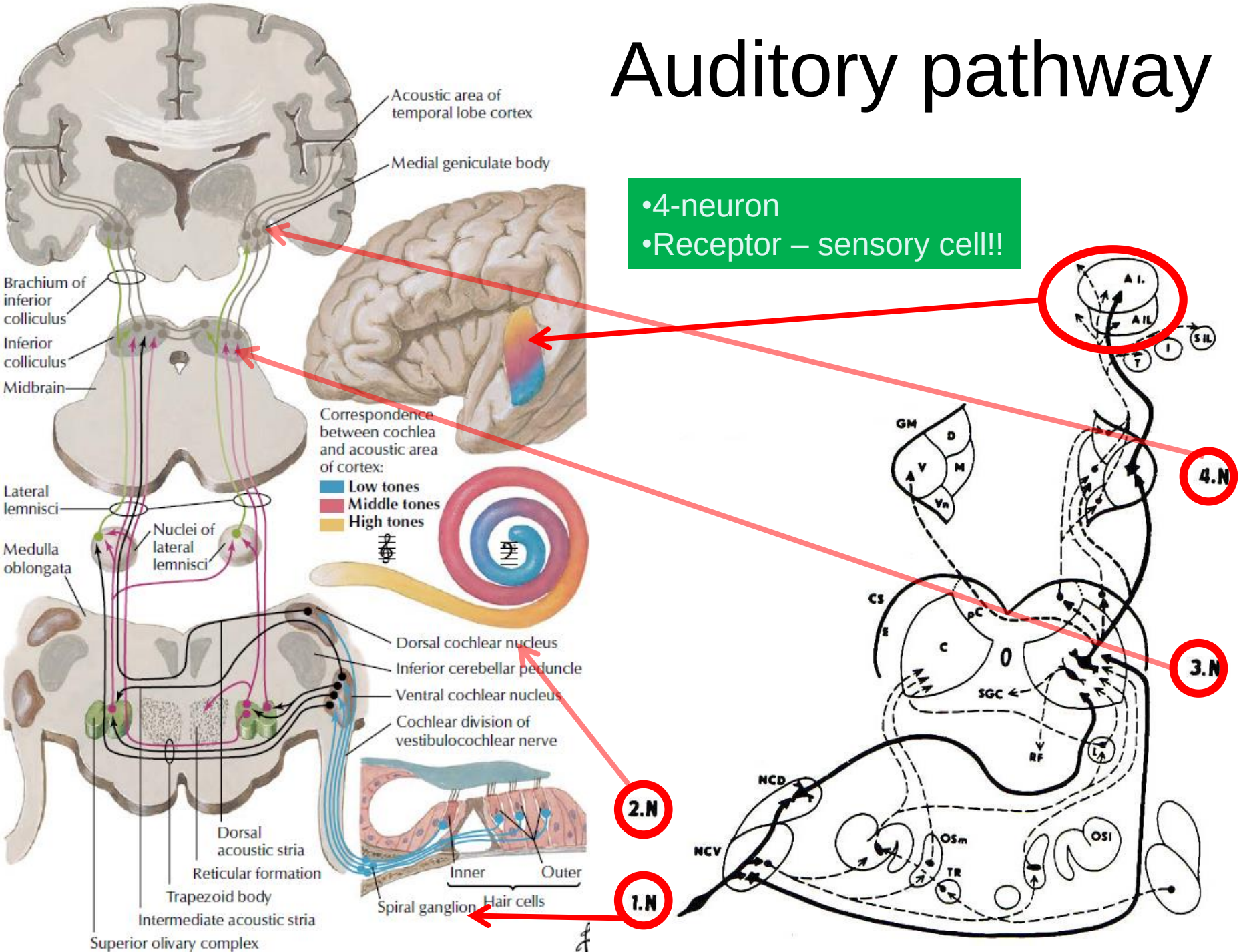
1- nuclei cochleares
2-ncl. olivaris sup.lat
3-ncl olivaris sup medialis
4-spodina IV. komory



1- nuclei cochleares
2-ncl. olivaris sup.lat
3-ncl olivaris sup medialis
4-spodina IV. komory

Auditory pathway

- 4-neuron
- Receptor – sensory cell!!



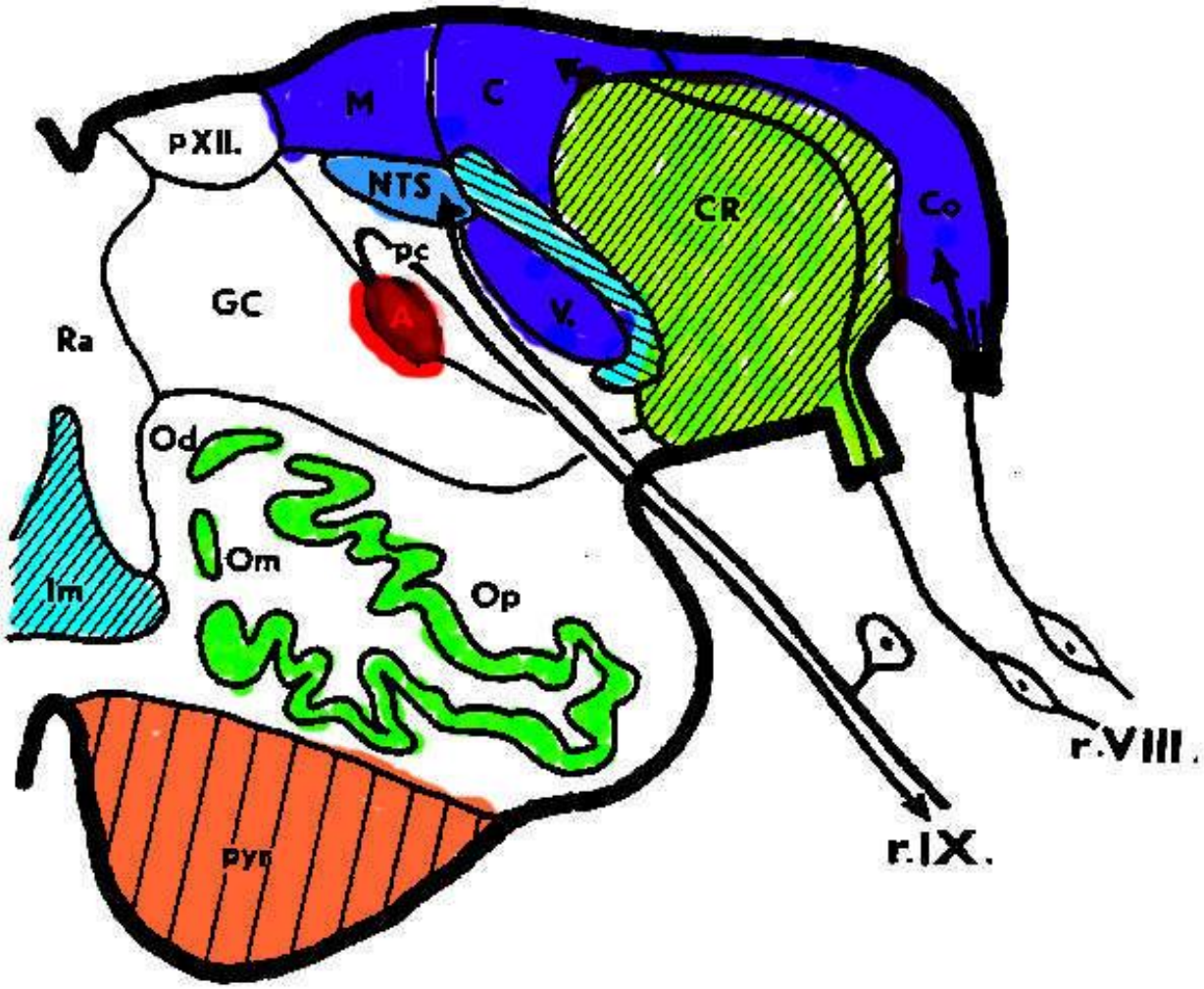
Tonotopic organisation

Membrana basilaris – apex – deep tones, basis high
Nuclei cochleares – deep tones ventrally

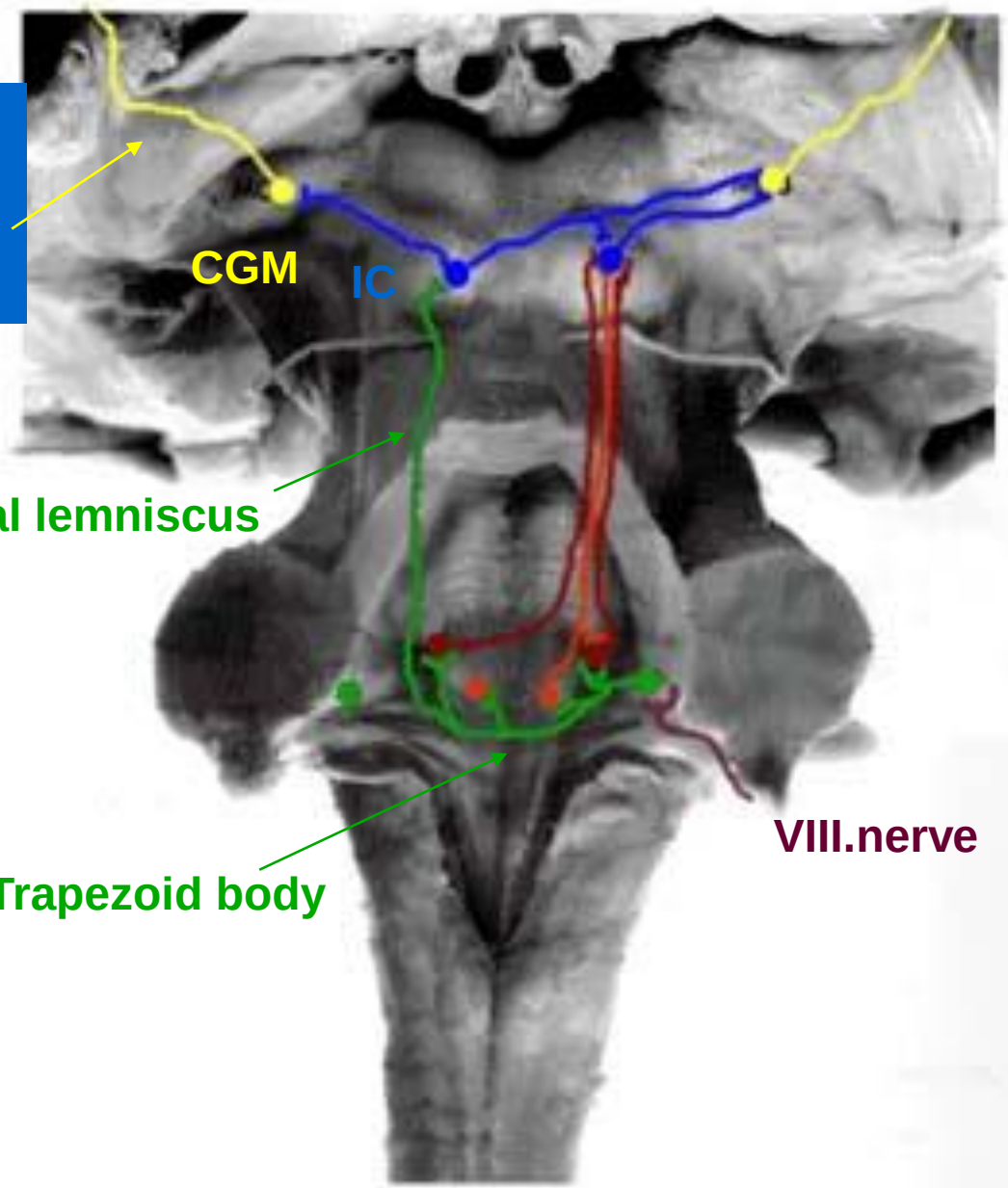
Colliculus inferior – deep tones dorsally

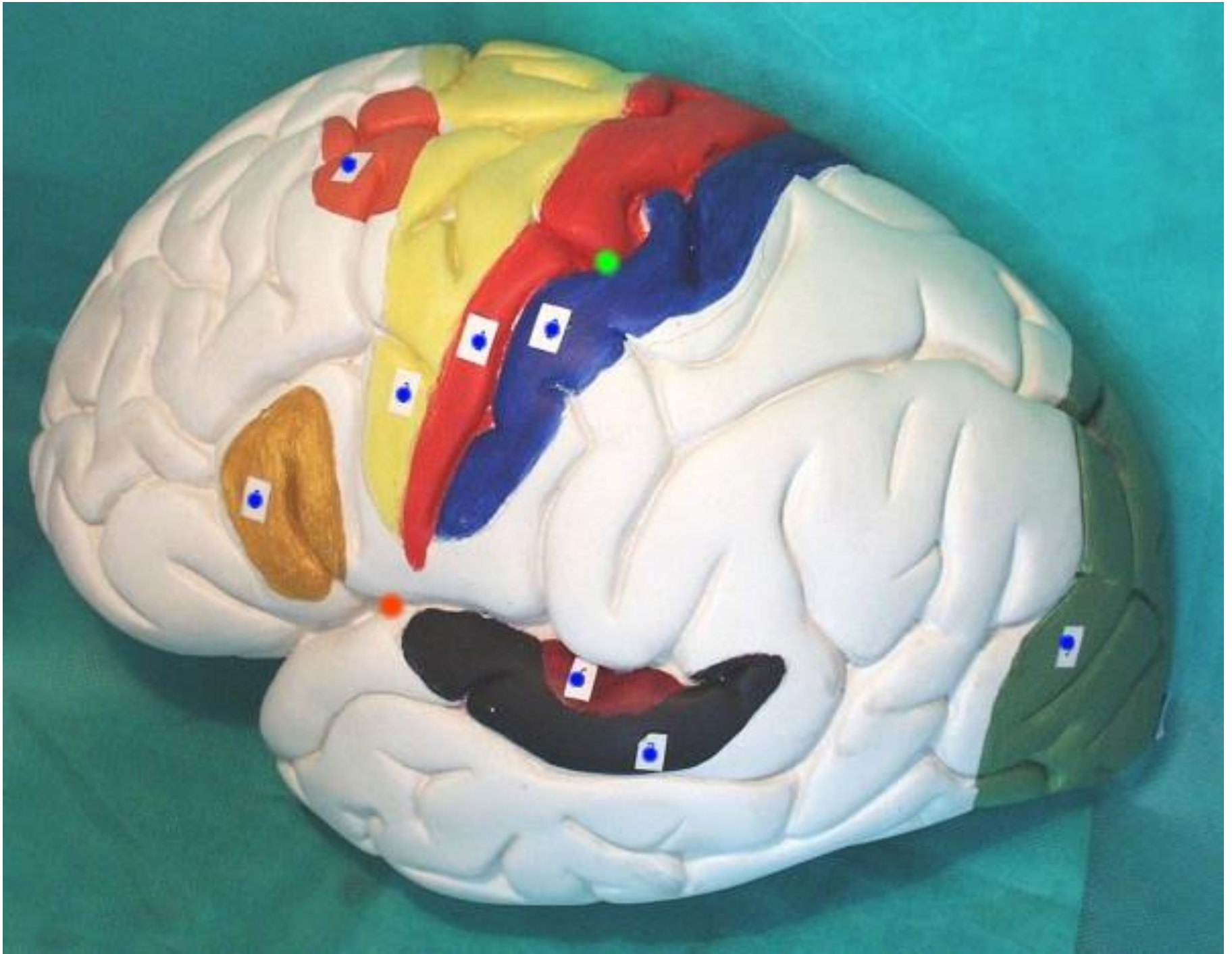
Corpus geniculatum mediale – deep tones laterally

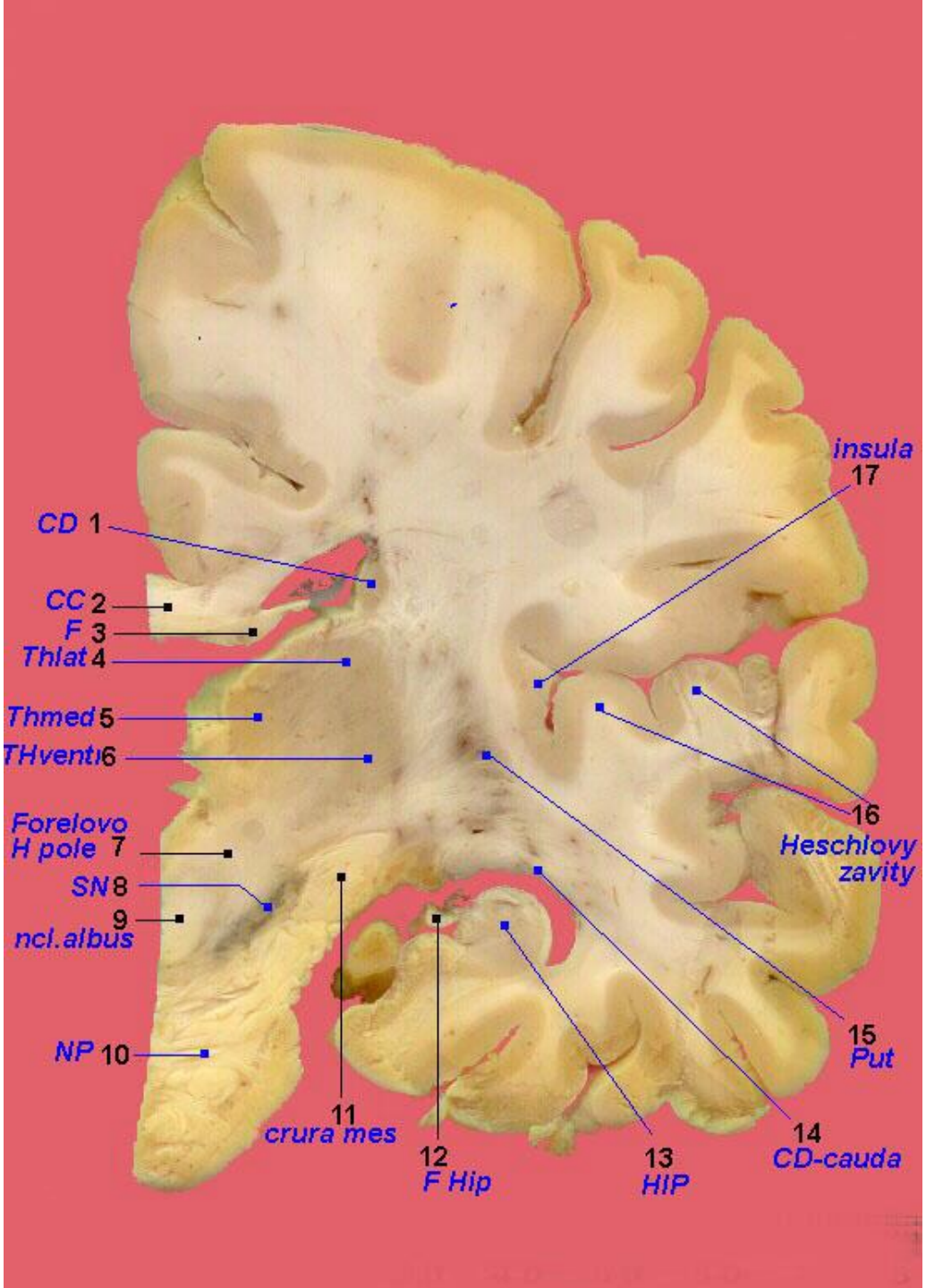
Sluchová kůra – deep tones anteriorly


M
C
pXII.
NTS
CR
Co
pc
GC
A
V.
Ra
Od
Om
Op
Im
Pyr
r.VIII.
r.IX.

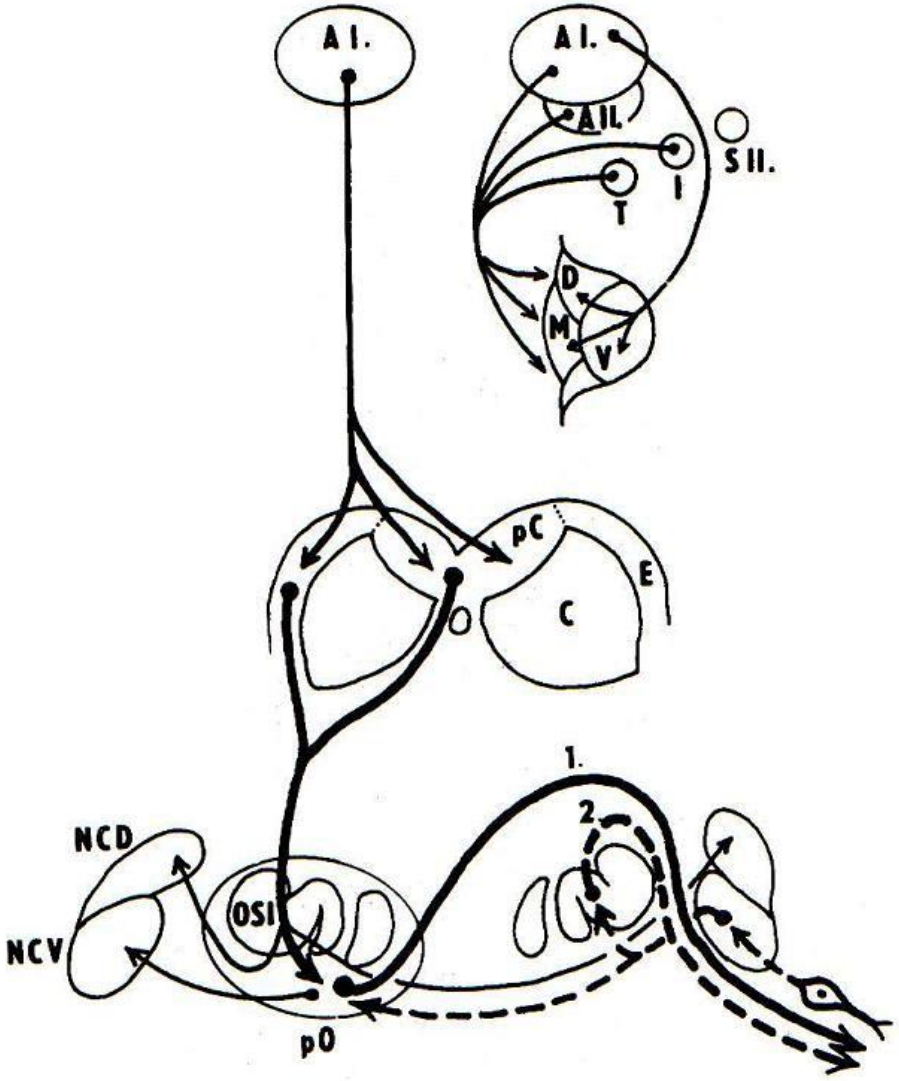
BA 41,42


Radiatio acustica (auditory radiations)
CGM
IC
Lateral lemniscus
Trapezoid body
VIII.nerve




CD 1
CC 2
F 3
Thlat 4
Thmed 5
THventl 6
Forelovo
H pole 7
SN 8
9
ncl.albus
NP 10
11
crura mes
12
F Hip
13
HIP
14
CD-cauda
15
Put
16
Heschlovy
zavity
insula
17

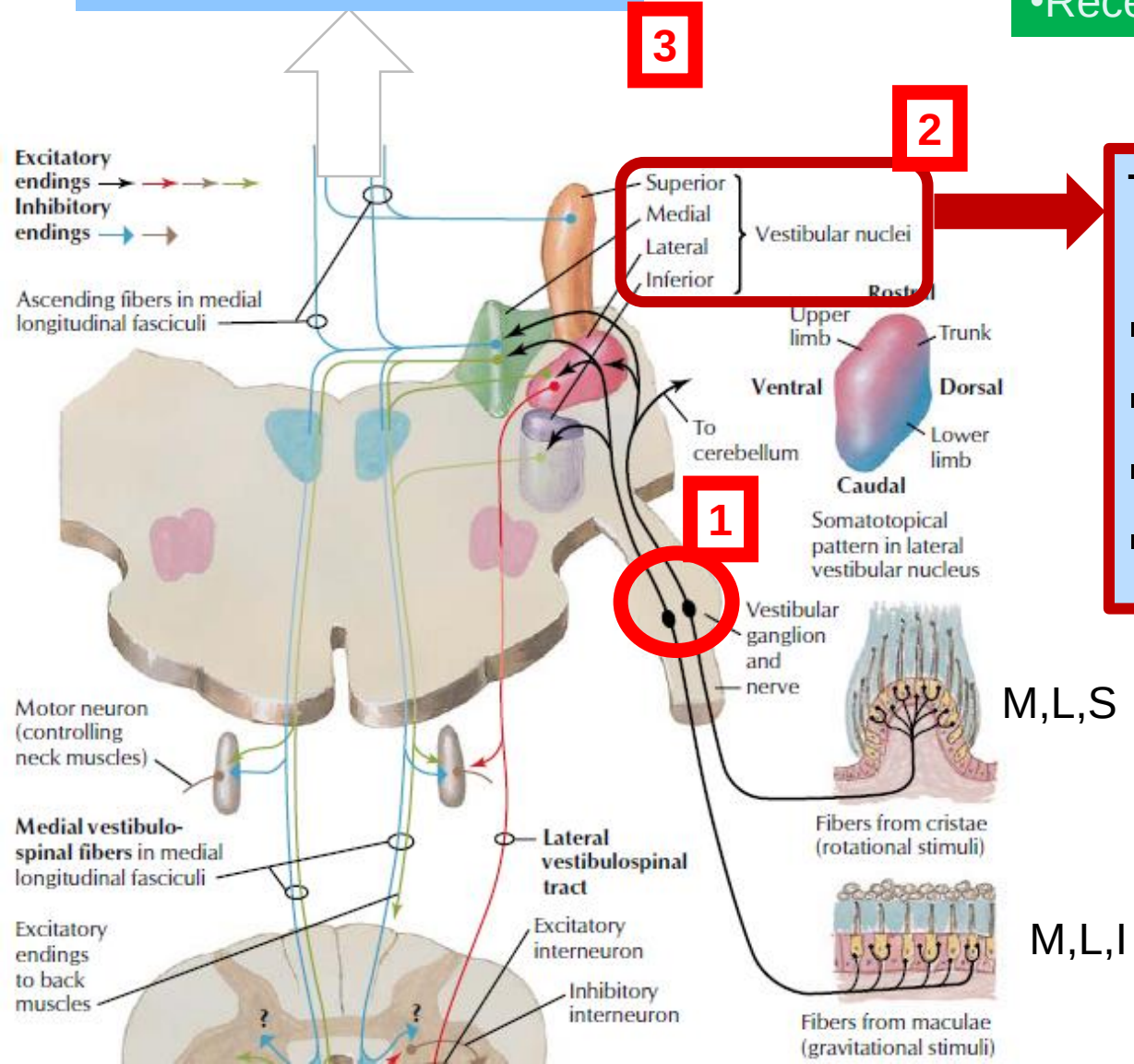
Descendent tracts in the auditory pathway



Vestibular pathway

Thalamus – VPL, VPM, VL

- 3-neuron
- Receptor – sensory cell!!



Tractus vestibulo –

- spinalis
- cerebellaris
- nuclearis
- reticularis

M,L,S

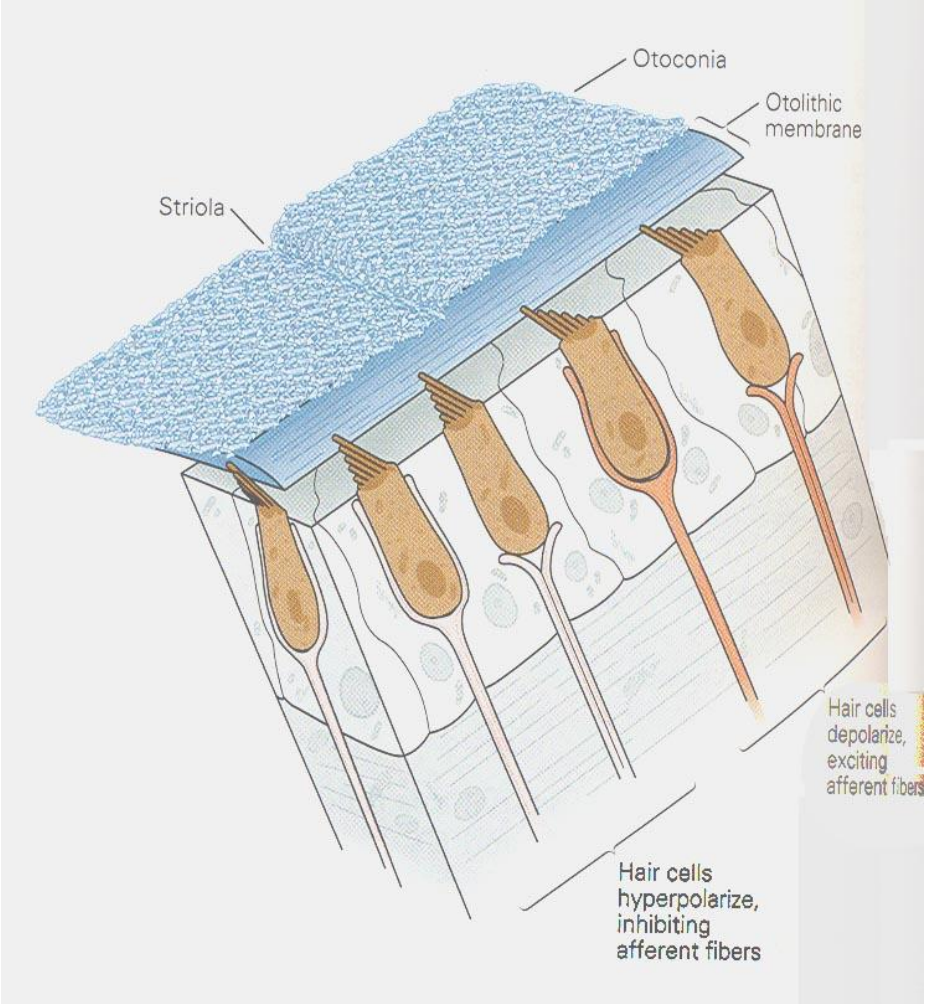
M,L,I

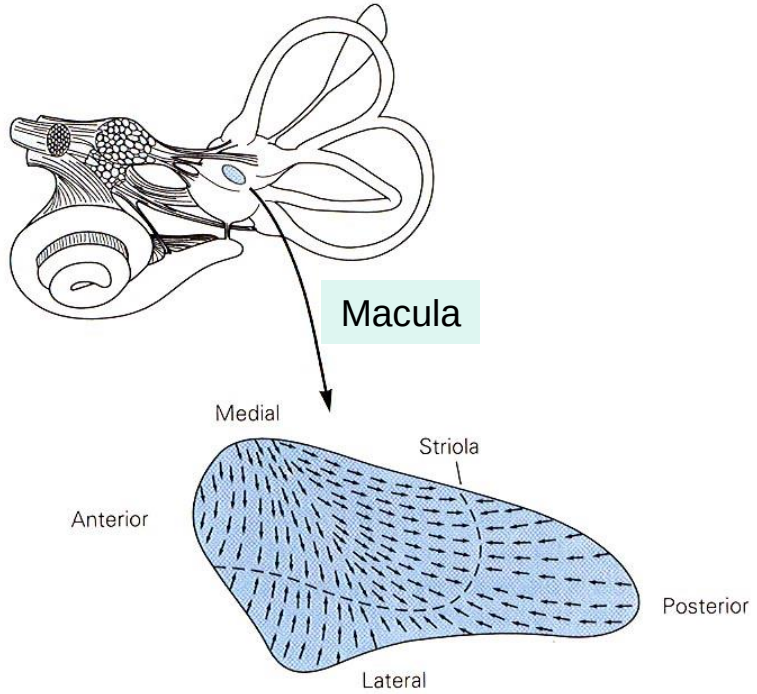
Vestibular pathway

- Receptor – hair cell in the macula sacculi et utriculi, cristae ampullares
- 1.N – bipolar cell in the ggl. vestibuli
- 2.N – vestibular nucleus
- 3.N – ventral nuclei of the thalamus

Cortex: temp. and pariet. lobe

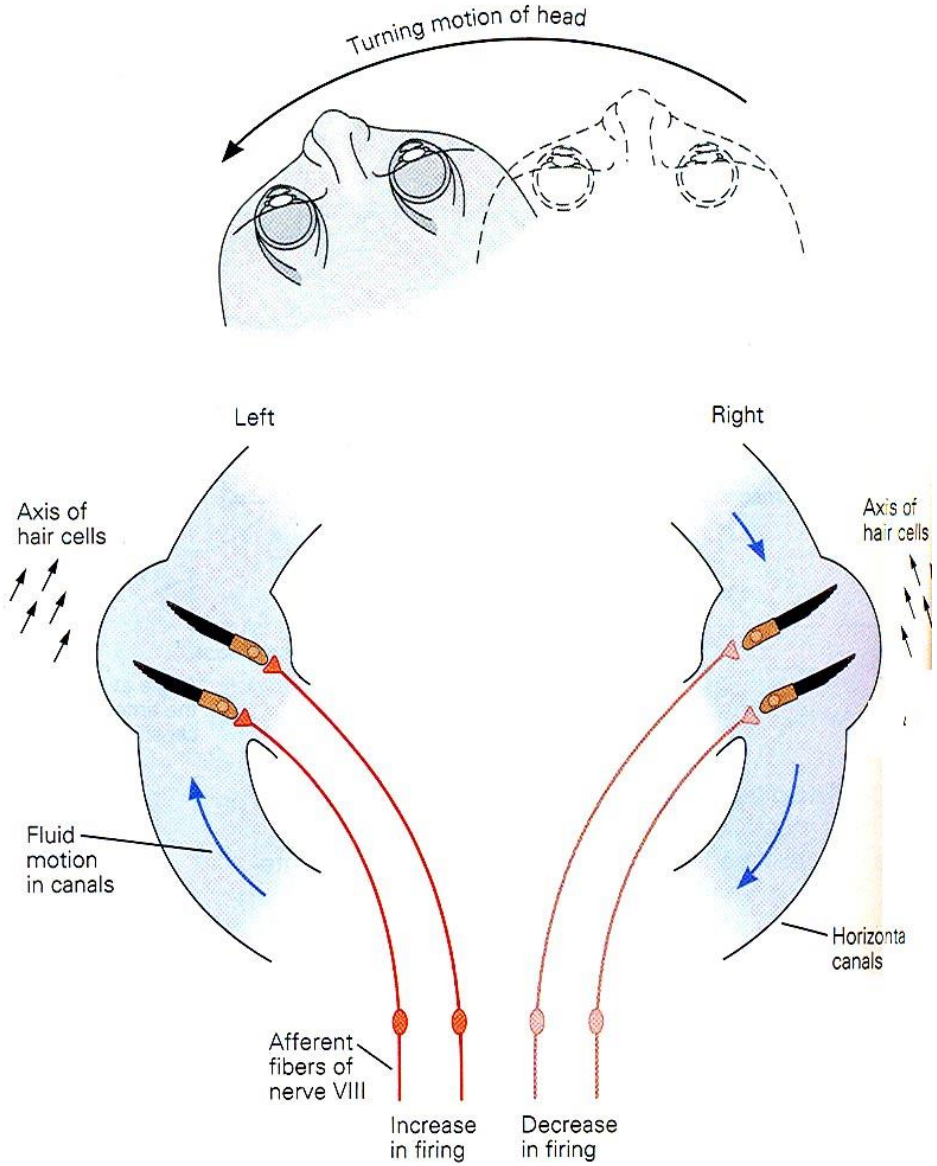
The utricle and the saccule detect linear accelaration



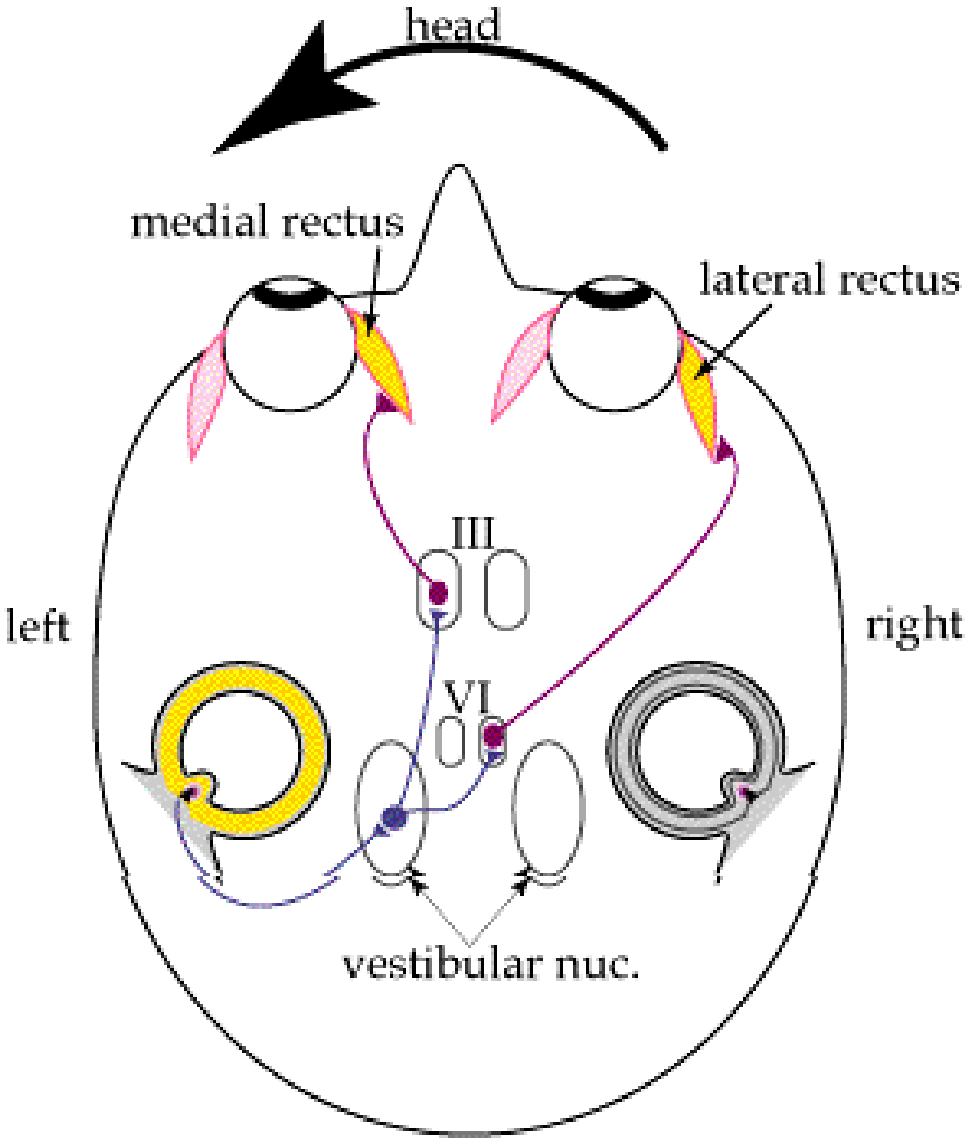


The axis of mechanical sensivity of each hair cell in the utricle is orientated toward the striola

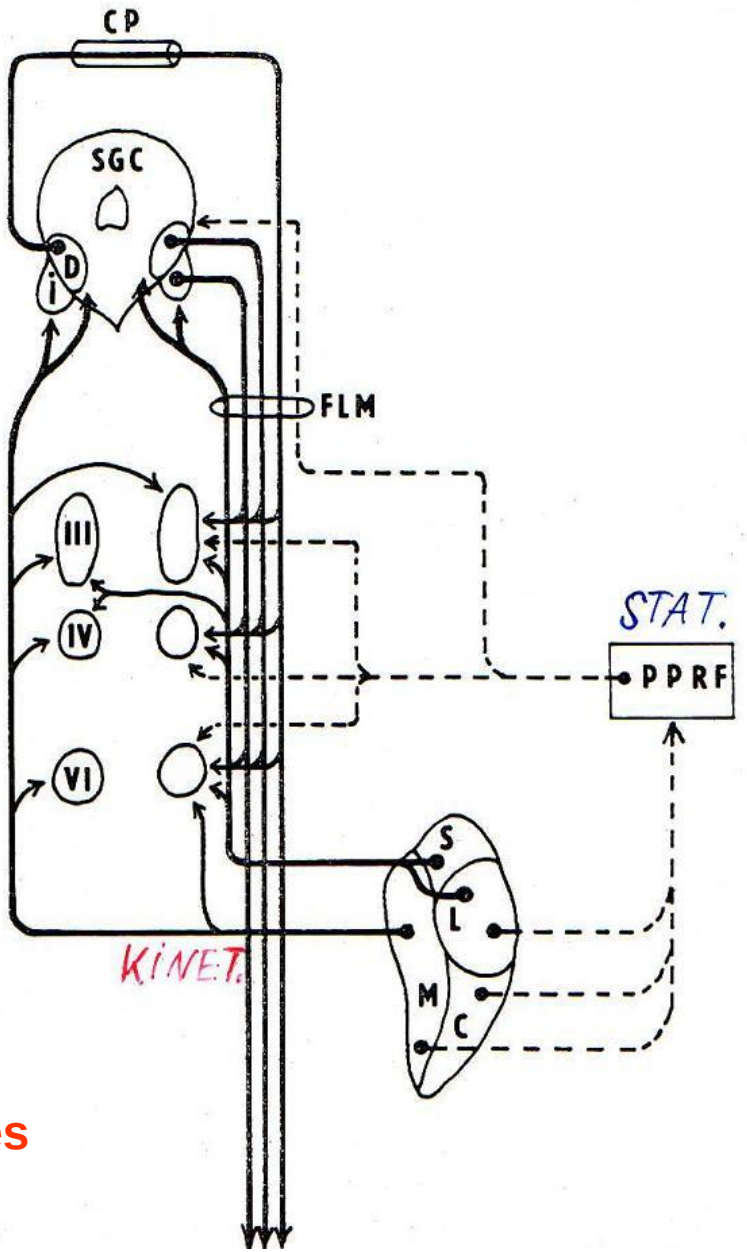
Function of the horizontal semicircular canals



Vestibulo-ocular reflex



Vestibulo-nuclear connections



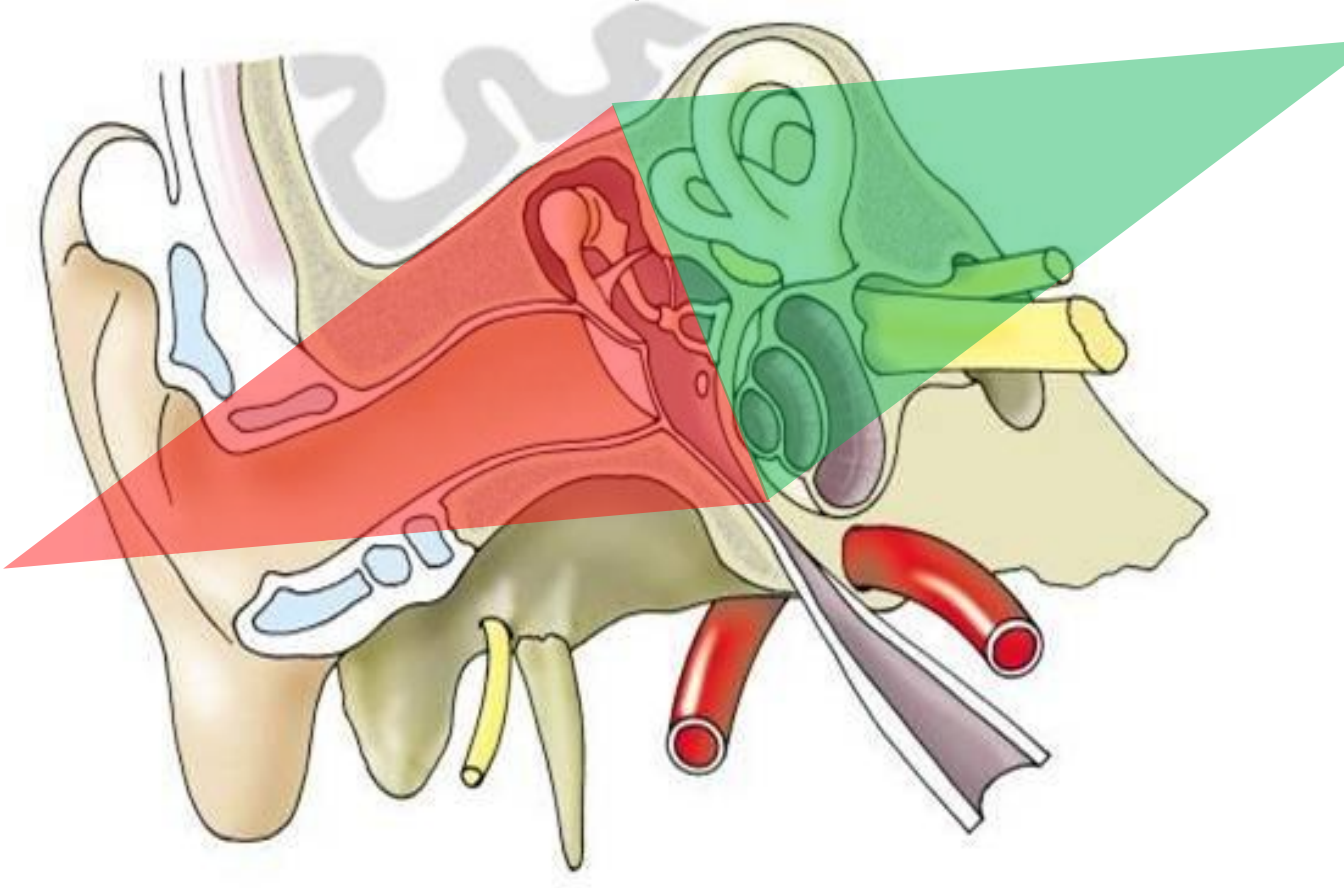
macula sacculi et utriculi

cristae ampullares

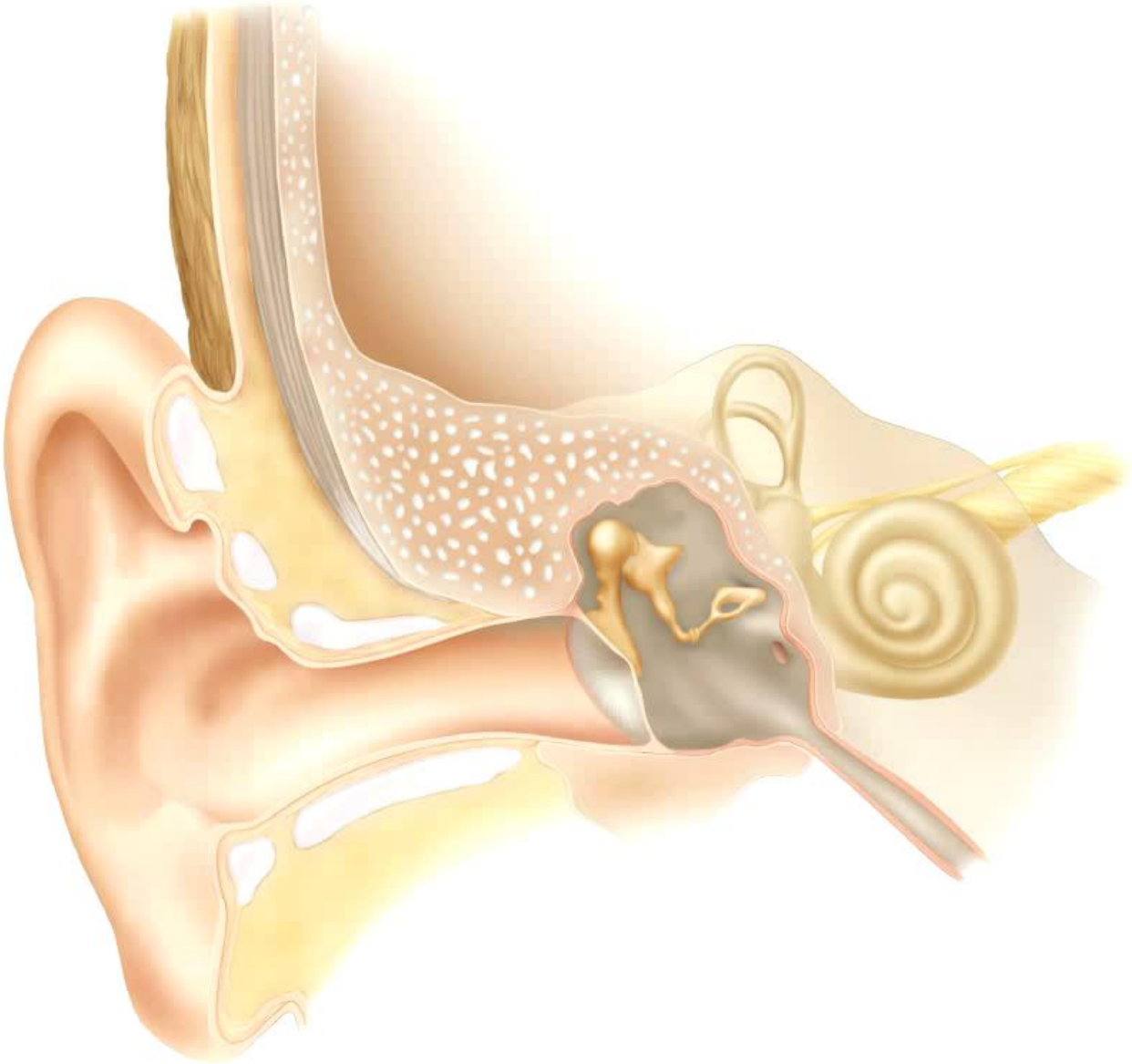
What with the imparied hearing??

Types of hearing loss

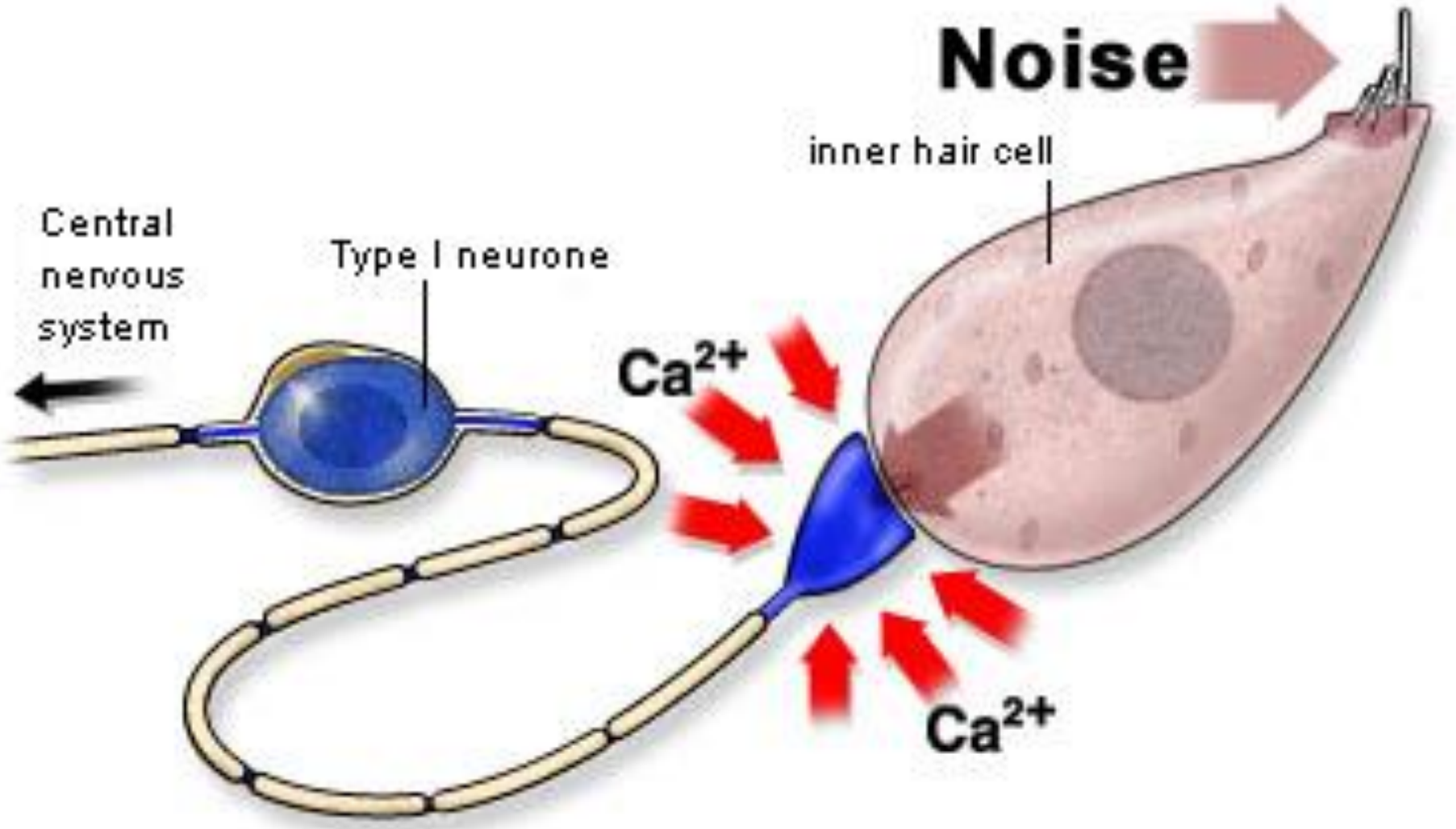
- Conductive – affected external or middle ear
- Sensorineural – affected inner ear, cochlear nerve or auditory tract
- Mixed



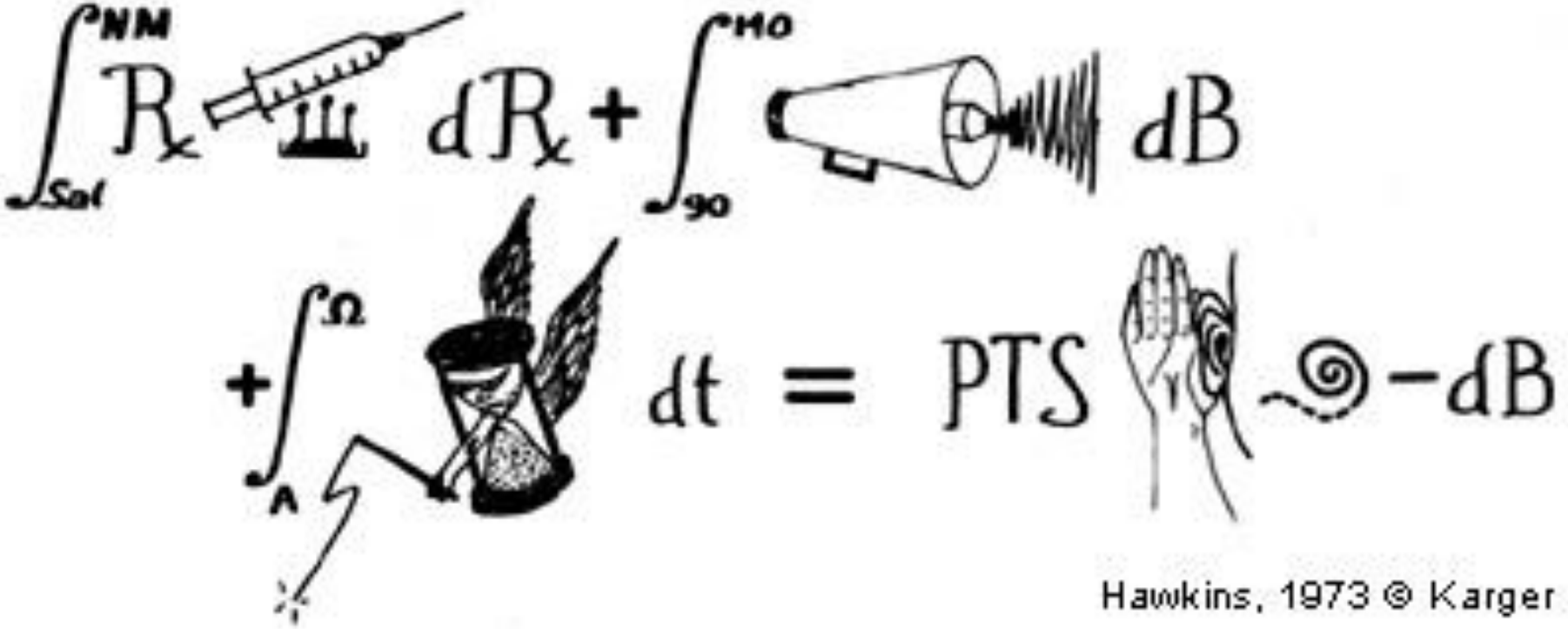
How we hear?



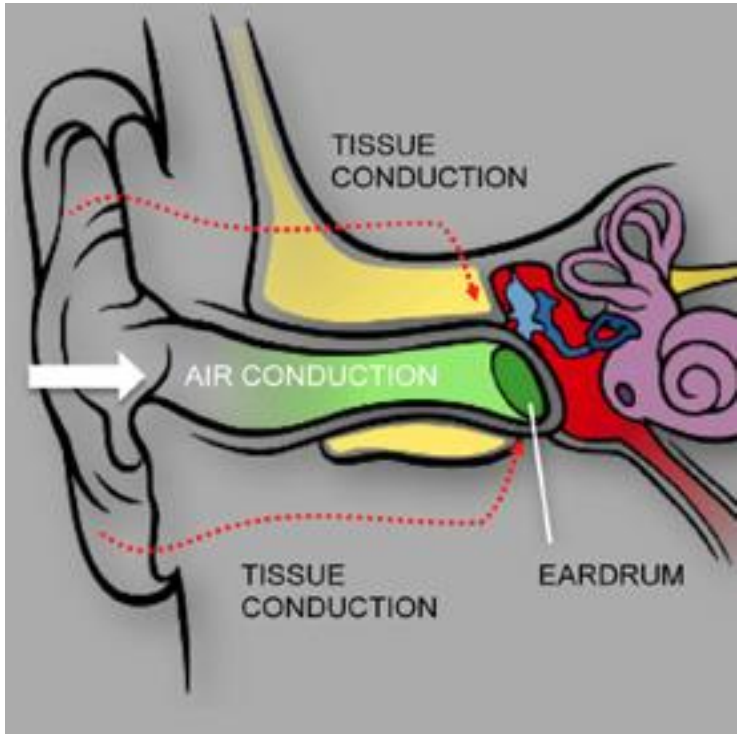
Noise


Noise
inner hair cell
Central nervous system
Type I neurone
Ca2+
Ca2+

Presbyacusis

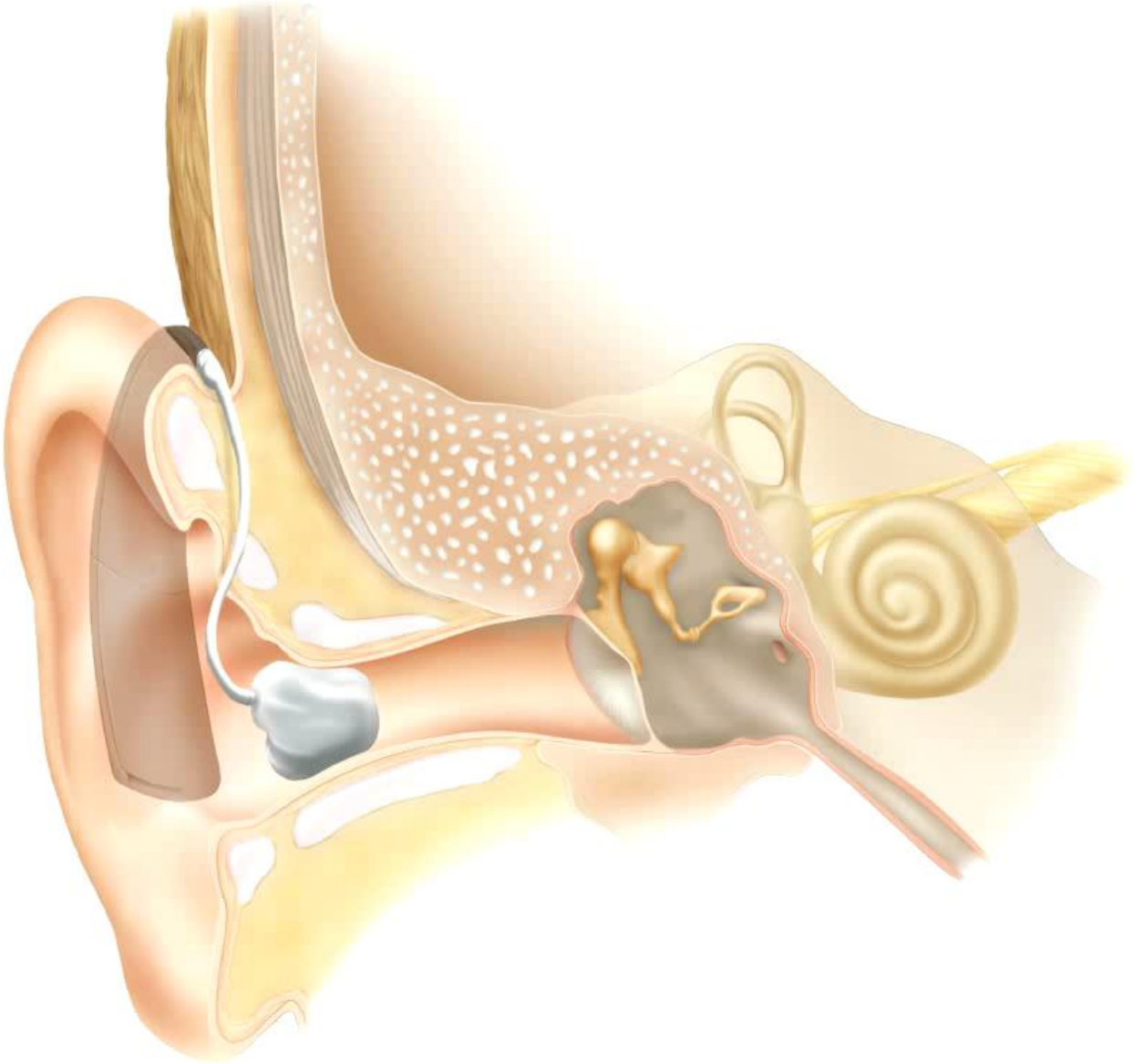


Bone conduction



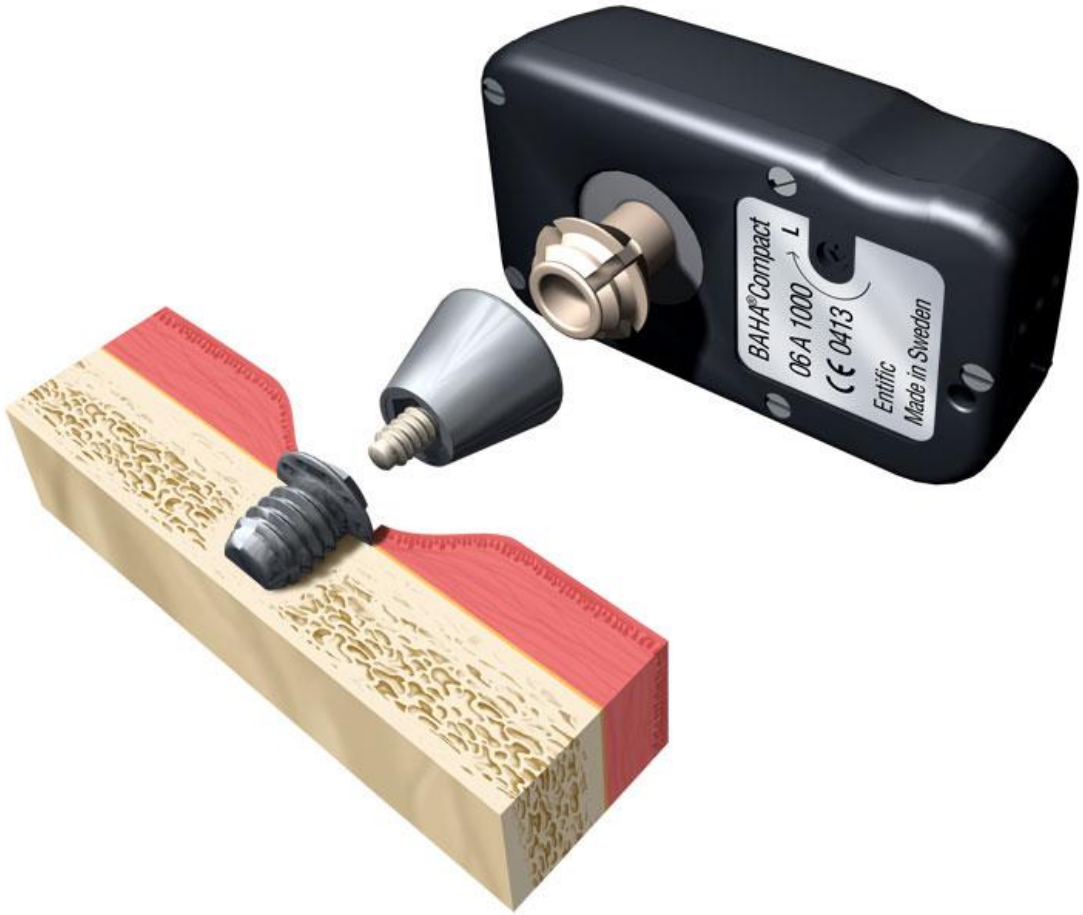
Hearing aids

Hearing aid

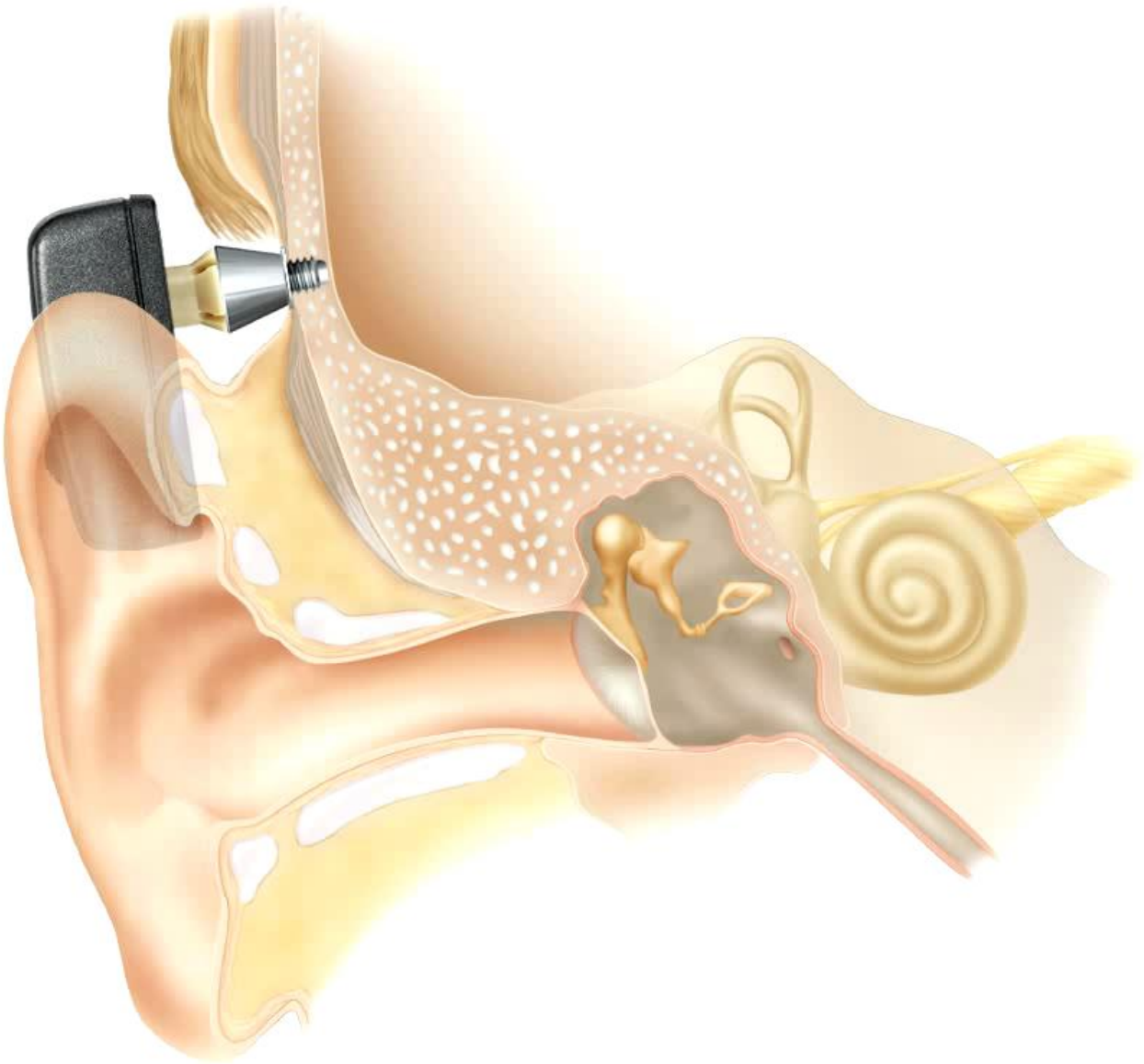


TORP/PORP

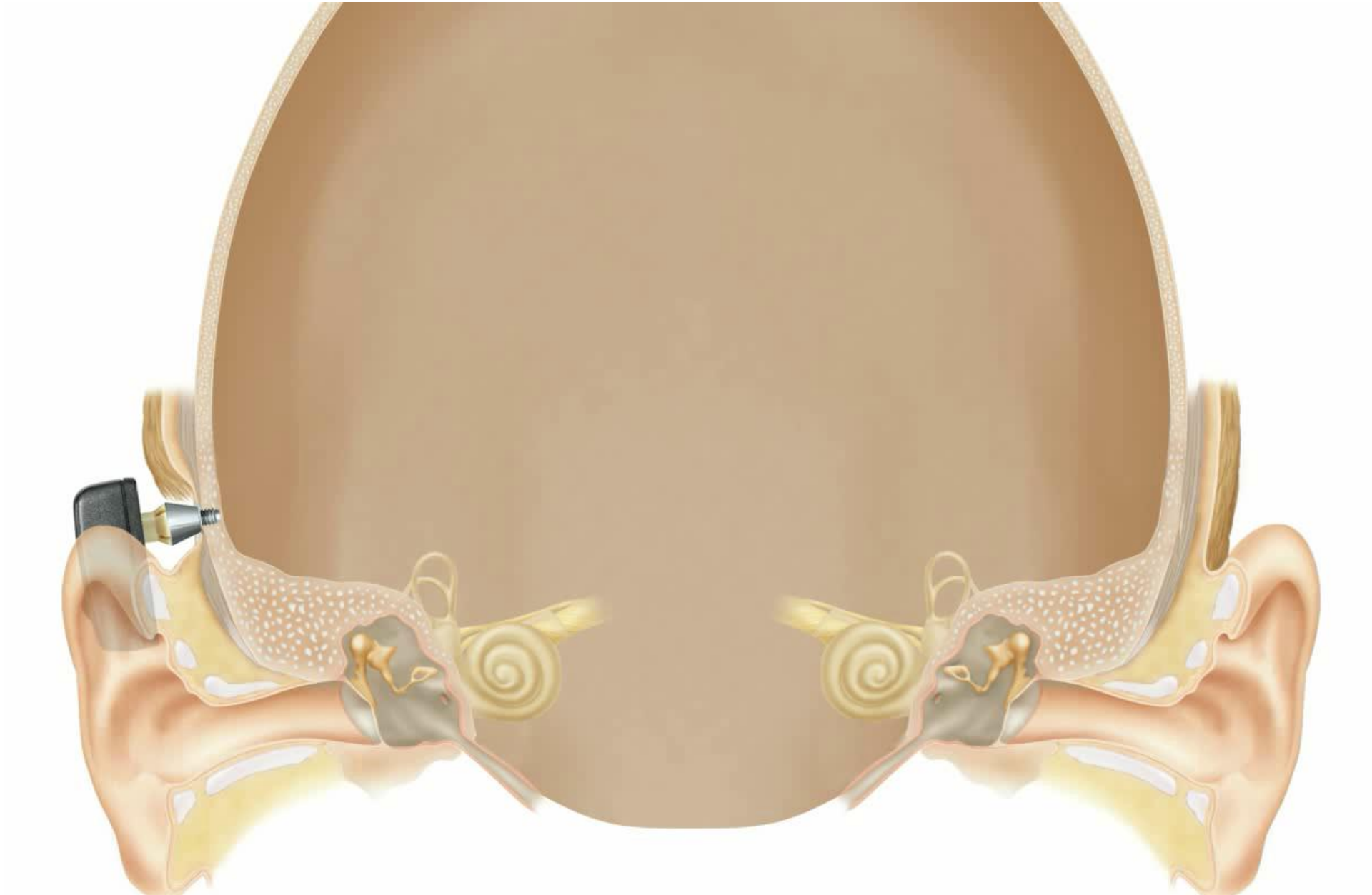
BAHA
(Bone anchored hearing device)



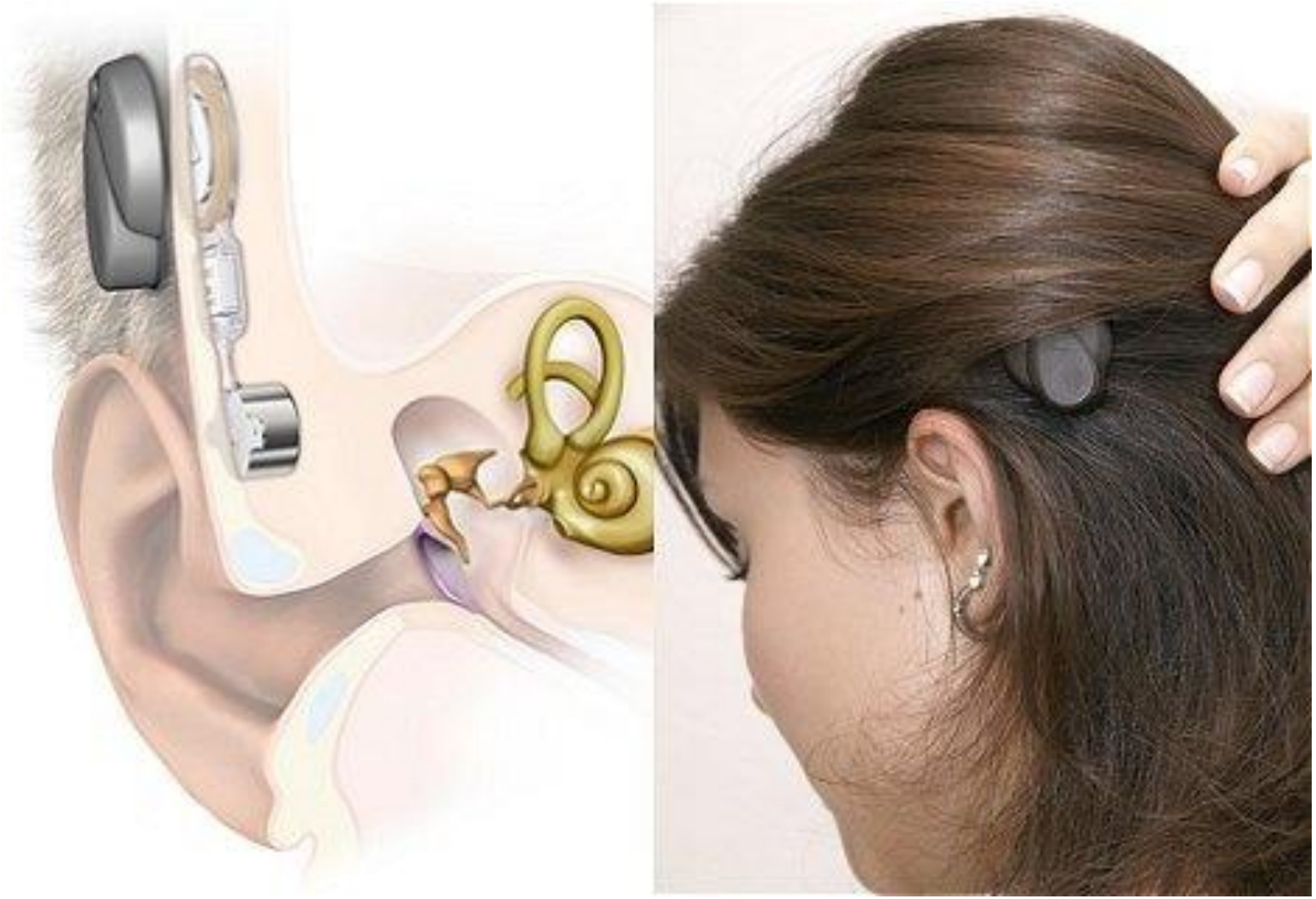
BAHA



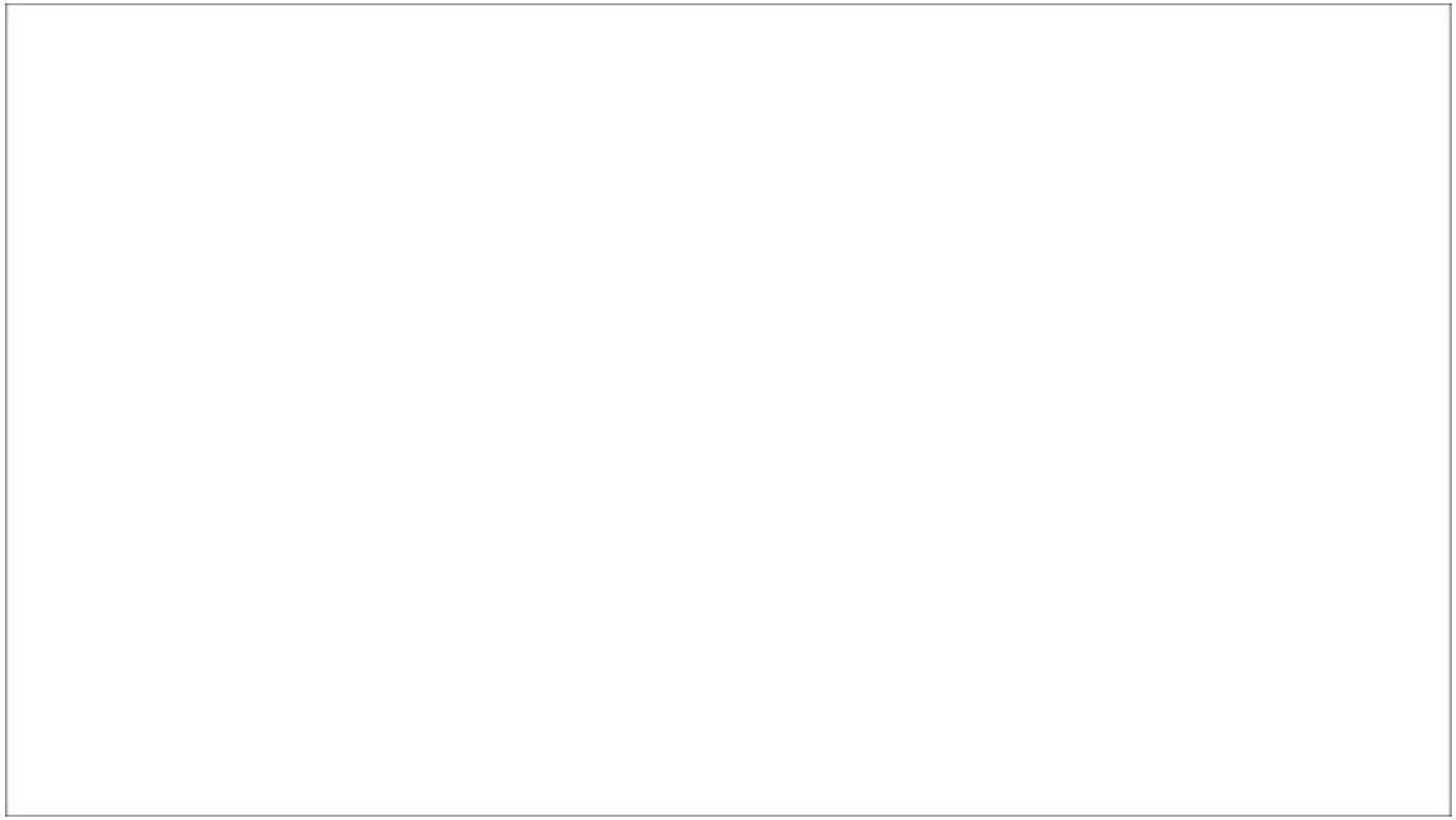
BAHA



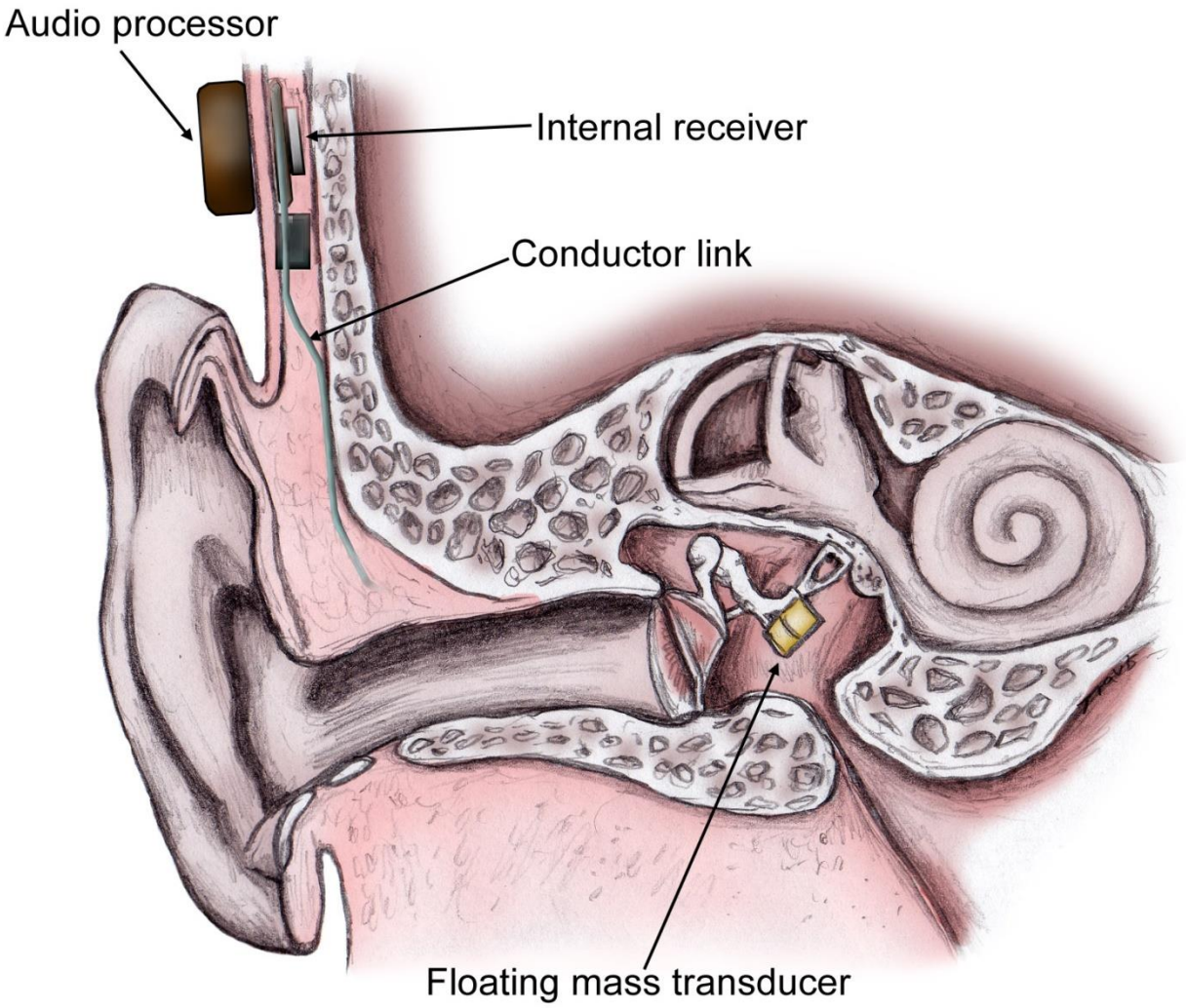
Bonebridge



Bonebridge

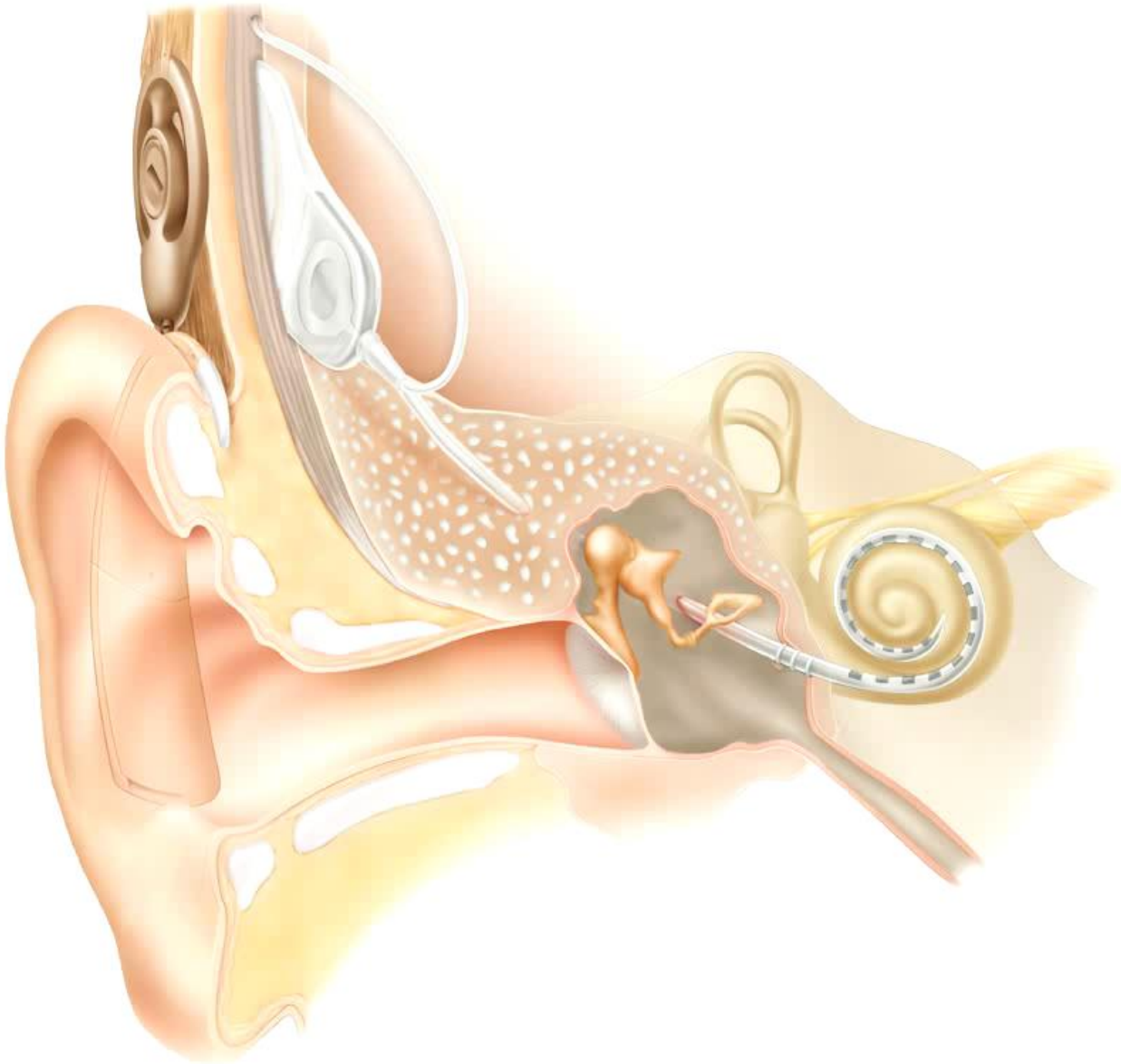


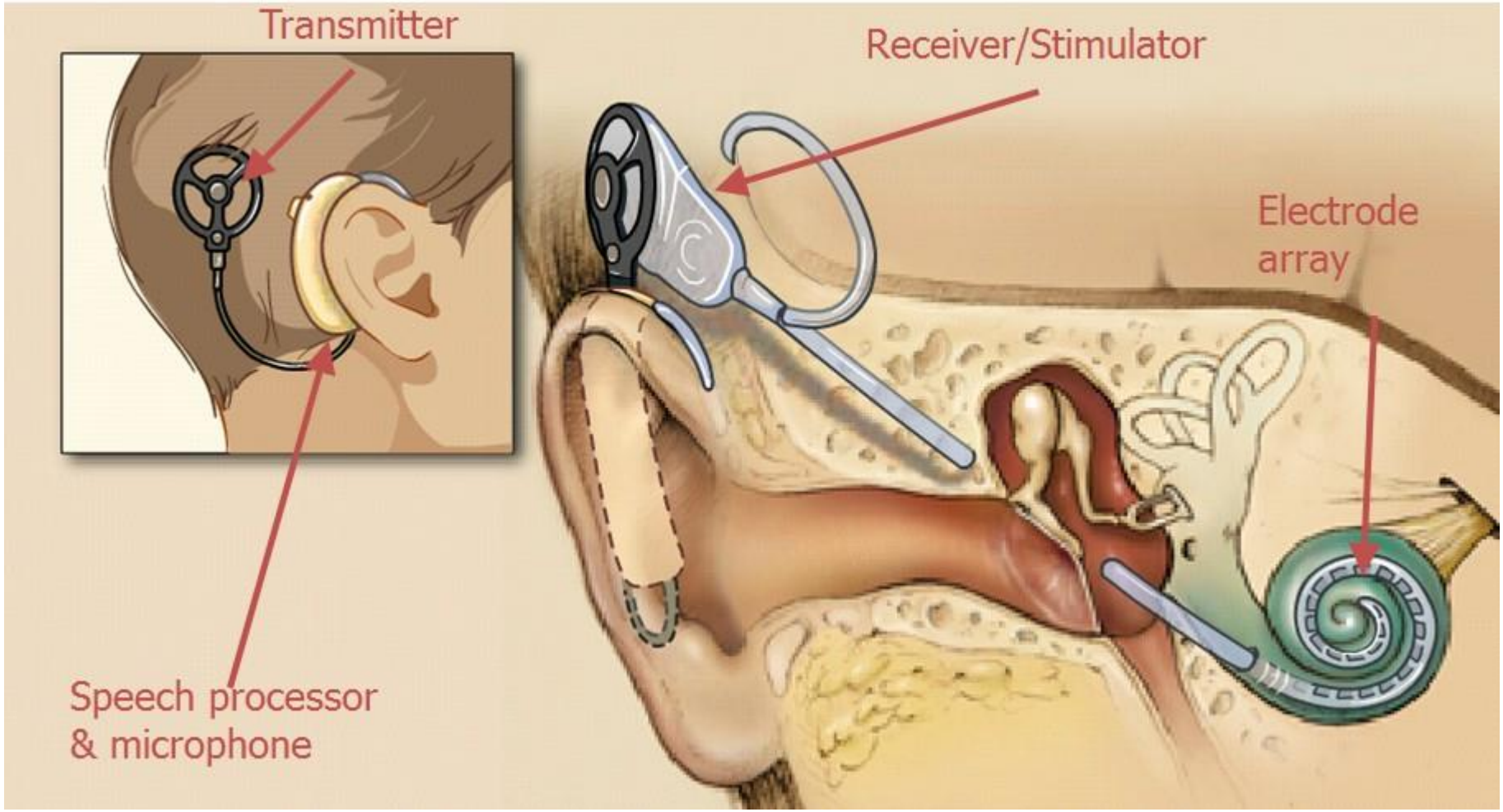
Active middle ear implant



Vibrant soundbidge

Cochlear implant

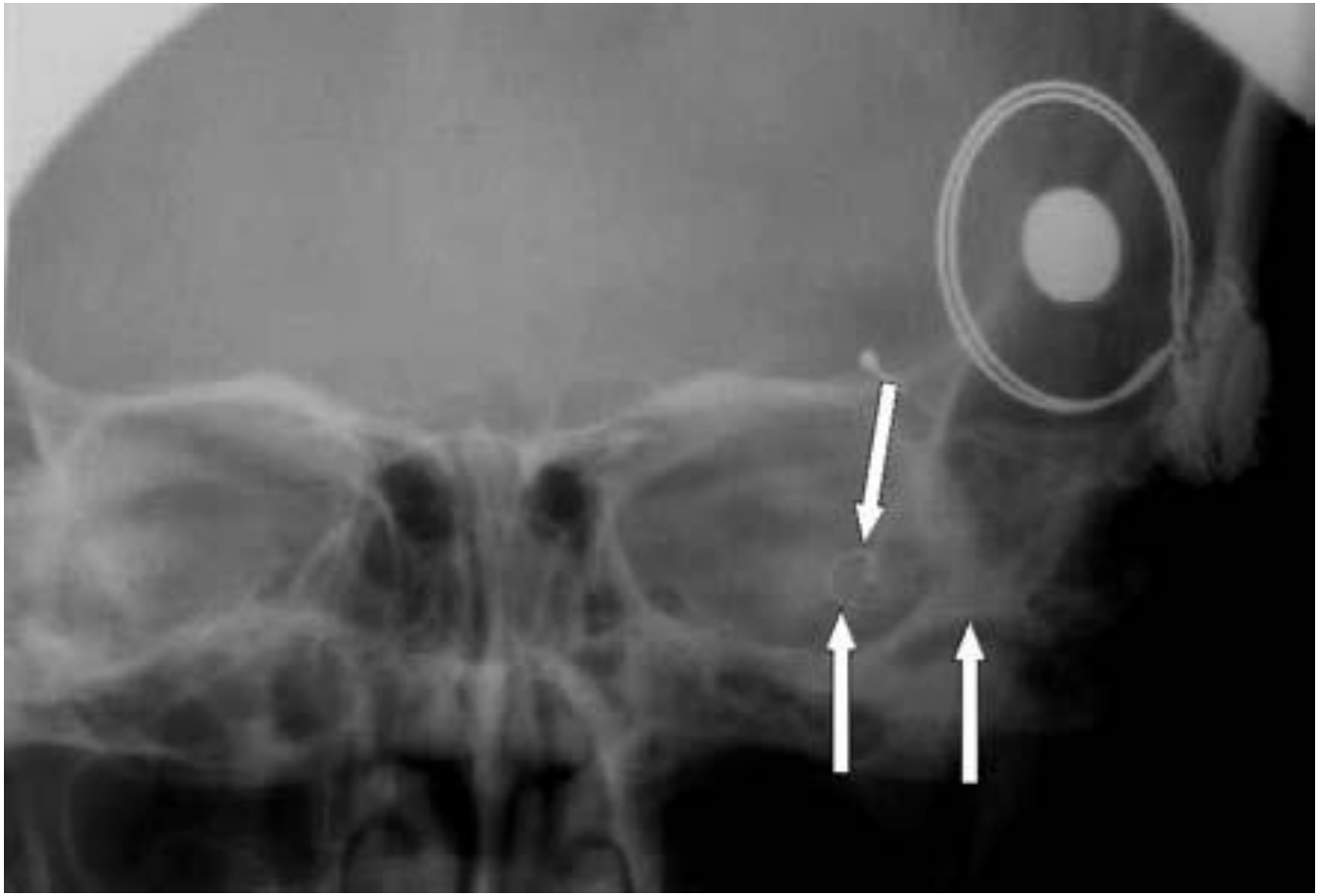




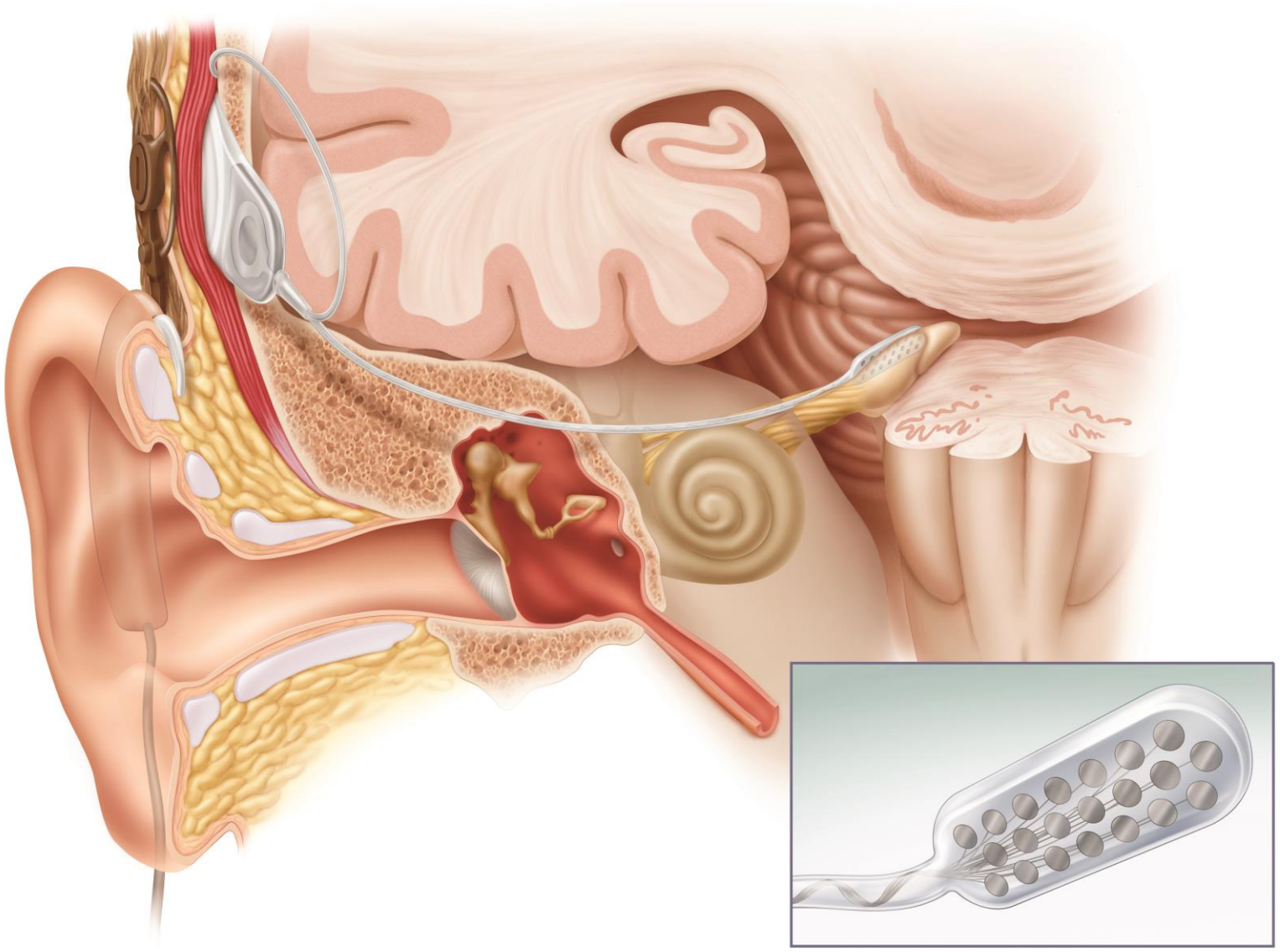
Cochlear implant

Elektroacustic stimulation

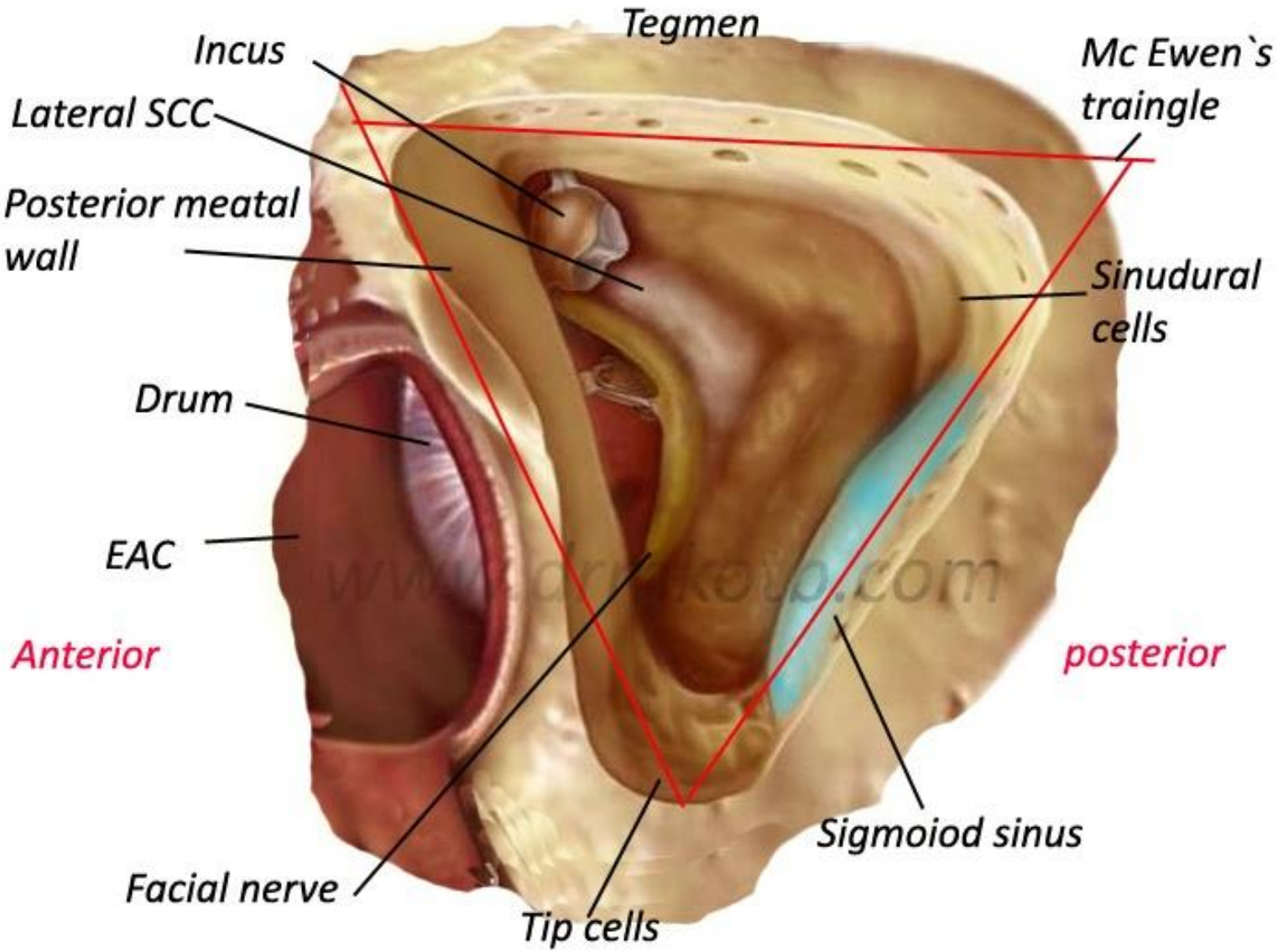
X-rays control



Brainstem implant



Surgical approaches



Suggested literature

- Petrovický, Anatomie III
- Černý, Betka, Atlas anatomie ucha
- Kahle, Frotscher, Color Atlas of Human Anatomy
- Gray, Anatomy
- tenDonkelaar et al., Klinische anatomie en embryologie
- http://www.iurc.montp.inserm.fr/cric/audition/english/corti/fcorti.htm
- http://www.rcsullivan.com/www/ears.htm
- http://anatomy.uams.edu/anatomyhtml/neuro_atlas.html
- http://anatomy.uams.edu/anatomyhtml/gross.html
- http://www.ghorayeb.com/Pictures.html
- http://www.med.unc.edu/embryo_images/unit-welcome/welcome_htms/contents.htm
- **H. Greess1 · U.Baum1 · W.Römer1 · B.Tomandl2 · W. Bautz1**

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  2Abteilung für Neuroradiologie der Neurochirurgischen Klinik,
  Friedrich-Alexander-Universität Erlangen-Nürnberg

  CT und MRT des Felsenbeins

http://www.radiologyassistant.nl/en/43facba0911f5

http://www.radiologen.nl/ostemporale/pagina's/Coronaal/index.html

- Černý, Betka, Atlas anatomie ucha
- http://www.iurc.montp.inserm.fr/cric/audition/english/corti/fcorti.htm
- http://www.rcsullivan.com/www/ears.htm
- http://anatomy.uams.edu/anatomyhtml/neuro_atlas.html
- http://anatomy.uams.edu/anatomyhtml/gross.html

Thank you for attention