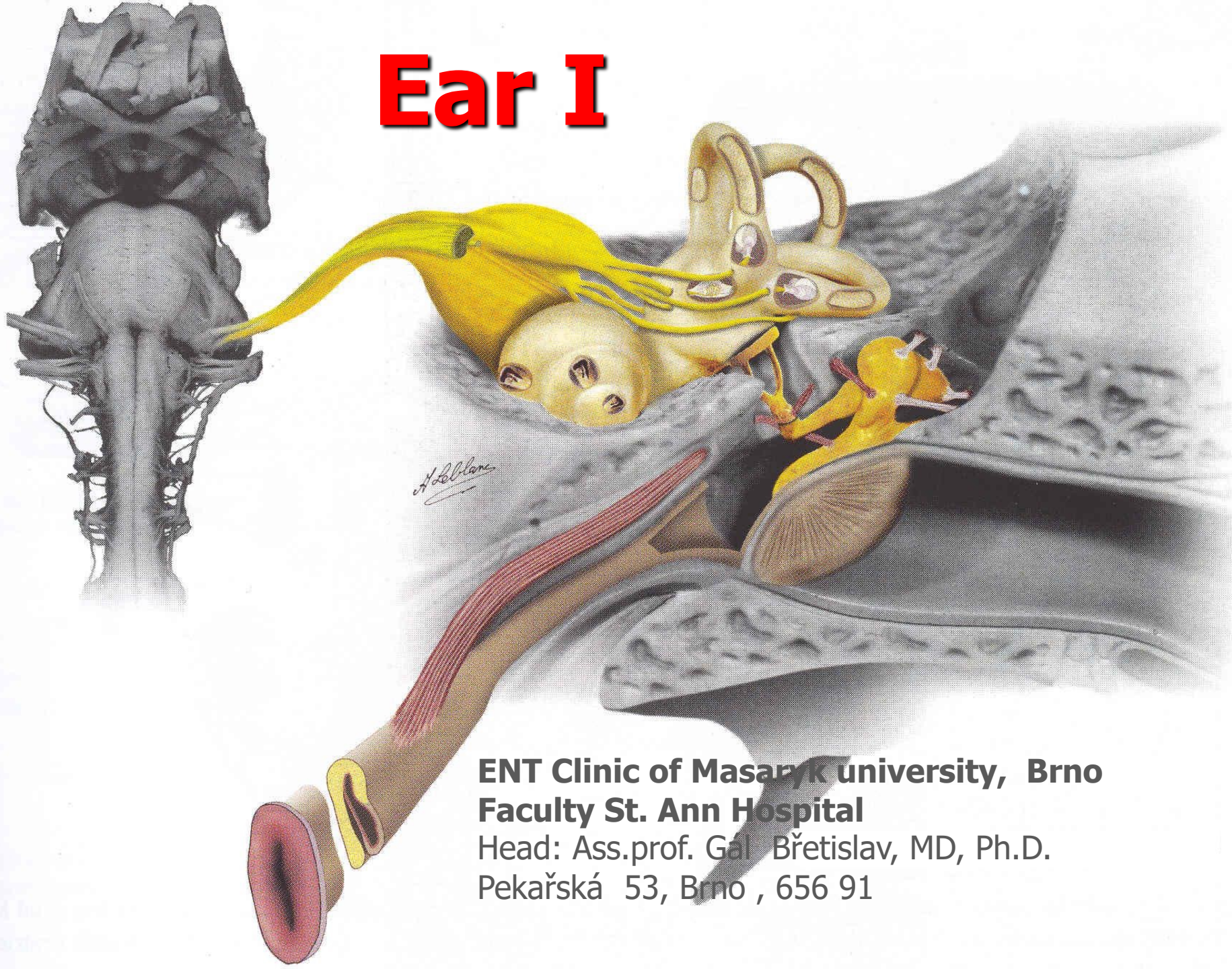


Literature:

Hans Behrbohm, Oliver Kaschke, Tadeus Nawka, Andrew Swift: **Ear, Nose, and Throat Diseases**: Founding Authors W. Becker, H.H. Naumann, C.R. Pfaltz (Paperback) Publisher: Thieme Publishing Group; 3rd Revised edition edition (12 Aug 2009). 471 pages , Language English. ISBN-10: 313671203X, ISBN-13: 978-3136712030.

Med Servis Mgr. Jaroslava Wilhelmová, Všetická 29,
602 00 Brno. Tel./fax. 05/43241146 .

Ear I

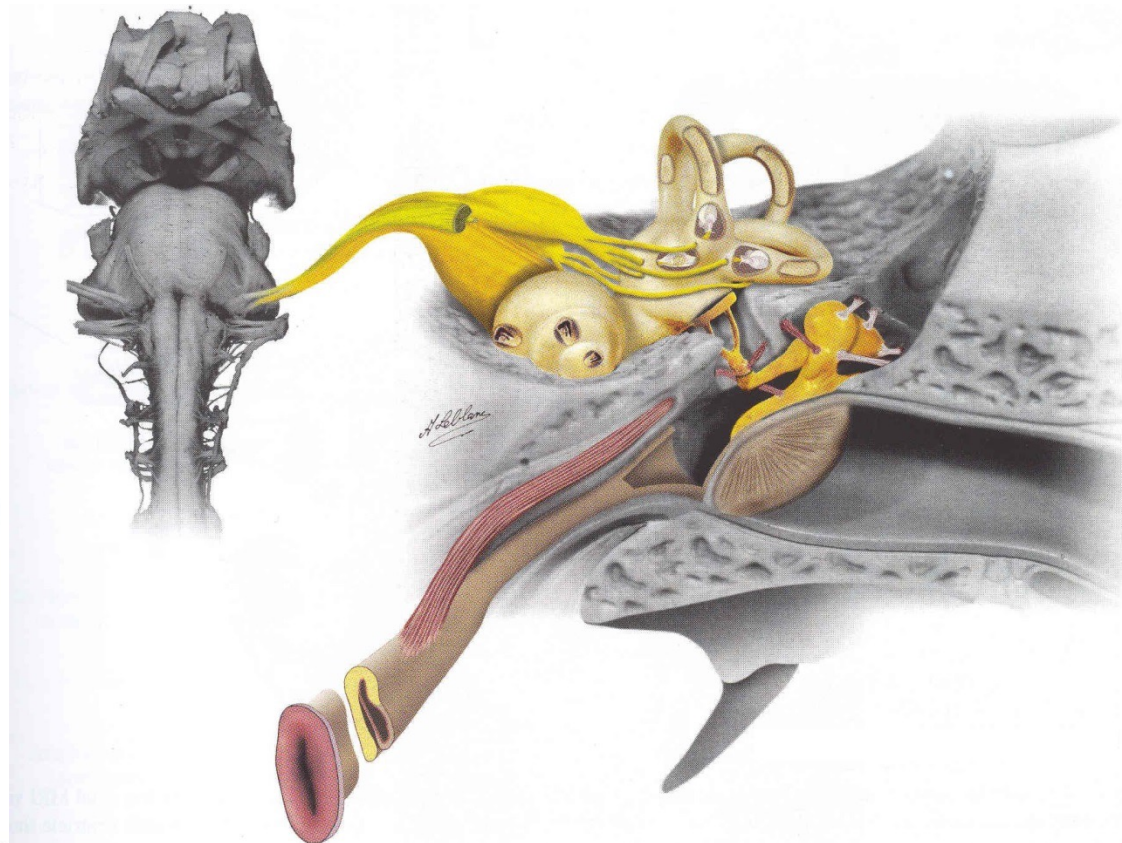
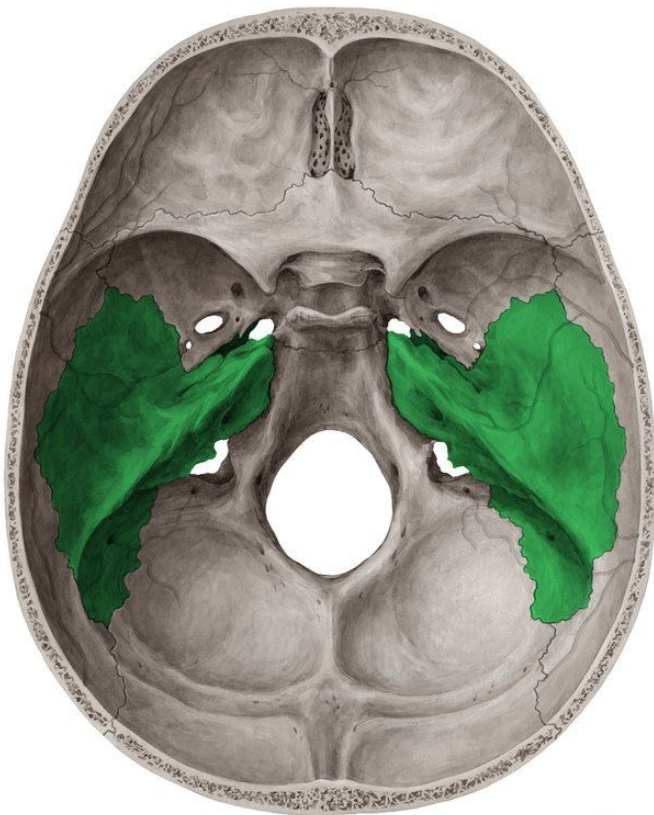


**ENT Clinic of Masaryk university, Brno
Faculty St. Ann Hospital**

Head: Ass.prof. Gál Břetislav, MD, Ph.D.
Pekařská 53, Brno , 656 91

The hearing and balance system

The hearing and balance system localized in temporal bone



The hearing and balance system

Two main subdivisions:

Peripheral Part

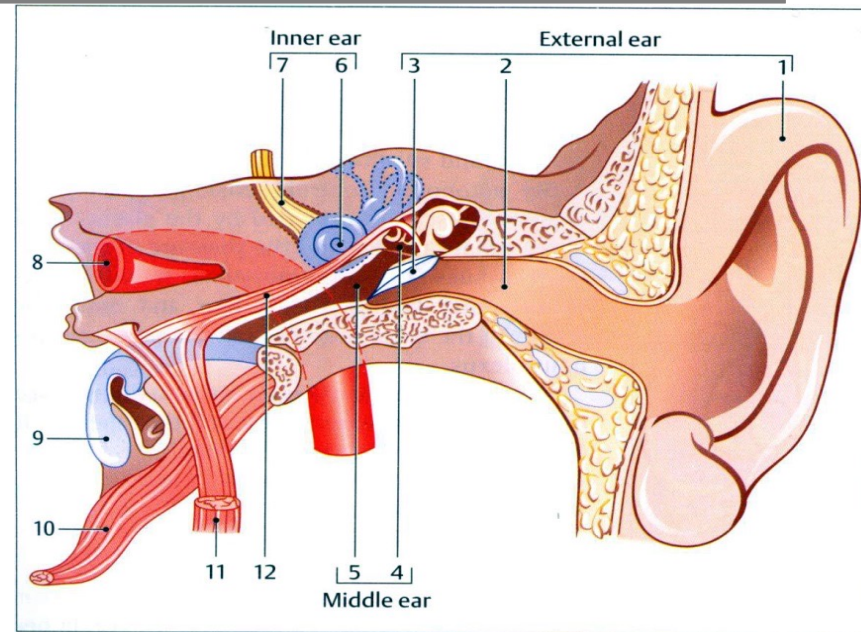
- external, middle and inner ear
- auditory nerve

Central Part

- central hearing pathways
- subcortical and cortical auditory centers
- central balance mechanism

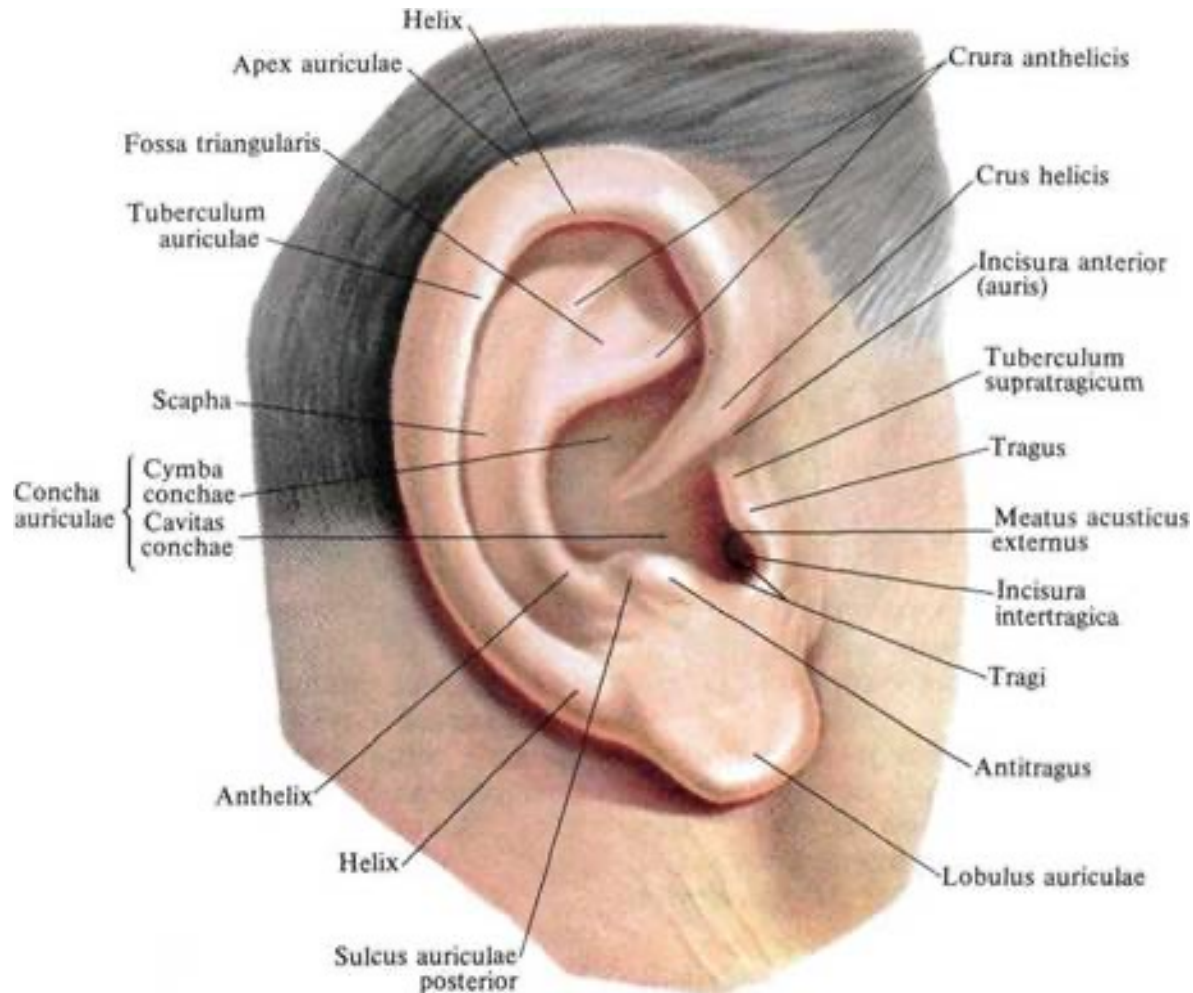
Anatomic boundary - entry the VIIth nerve into brainstem.

- The external and middle ear *transport* the stimulus
- cochlea *distributes* the stimulus
- the sensory cells *transform* the stimulus



External ear

Auricle – abundantly formatted cartilage



External meatus (meatus acusticus externus)

External part

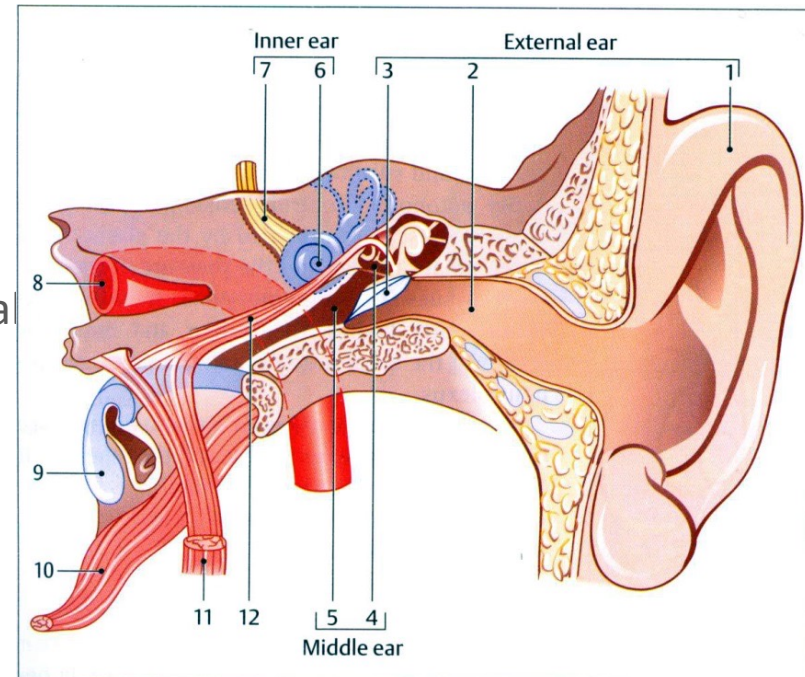
- cartilage
- Lined with skin and down (tragi) and sebaceous gland – cerumen

Internal part

- Temporal bone
- Lined with thinned epidermis

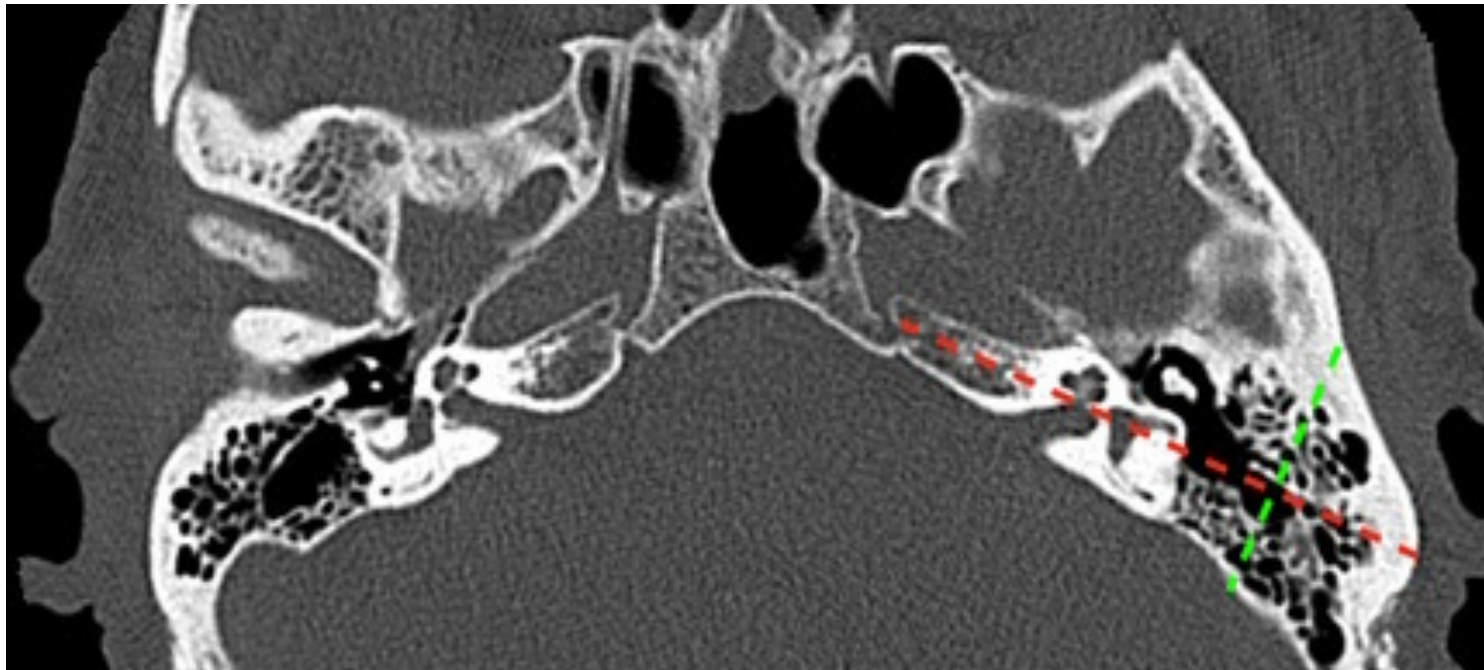
– curved cartilaginous mobile part –
must be drawn upward and posteriorly –
to bring the same axis

External meatus skin has 10x higher growth potential
than middle ear linen – theory of development of
acquired cholesteatoma



Middle Ear cavity

- summary name for the whole pneumatic system of temporal bone: tympanic cavity, cells of proc. mastoideus and Eustachian tube (tubotympanal and tympanomastoideal segment)



Tympanic membrane (membrana tympani)

- a sound pressure receptor and transformer

Inclination and declination angle to meatus axis
surface 55 mm²

- sulcus tympanicus
- annulus fibrocartilagineus

pars tensa

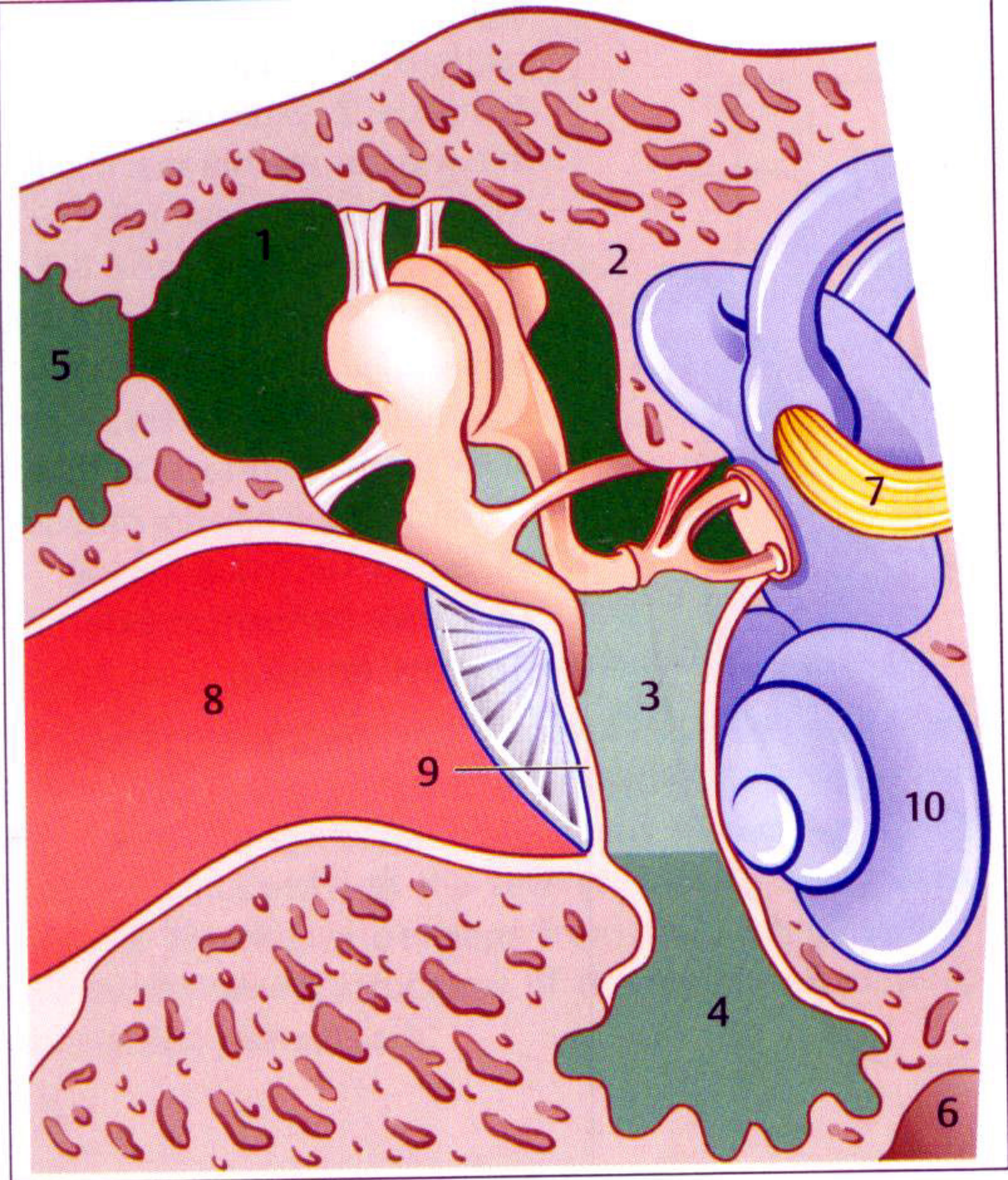
- *Three layers:*
 - external- epidermis (stratum cuneatum)
 - middle- fibrous layer ,str. fibrosum
 - internal- epitel, str. mucosum

pars flaccida (membrana Shrapnelli)

- Surface 5 mm² in superior part of ear drum
- Fibrous layer is missing



- 1,2 epitympanic recess
- 3 mesotympanum
- 4 hypotympanic recess





Cavum tympani - (shape of biconcave lens) 6 walls

Paries:

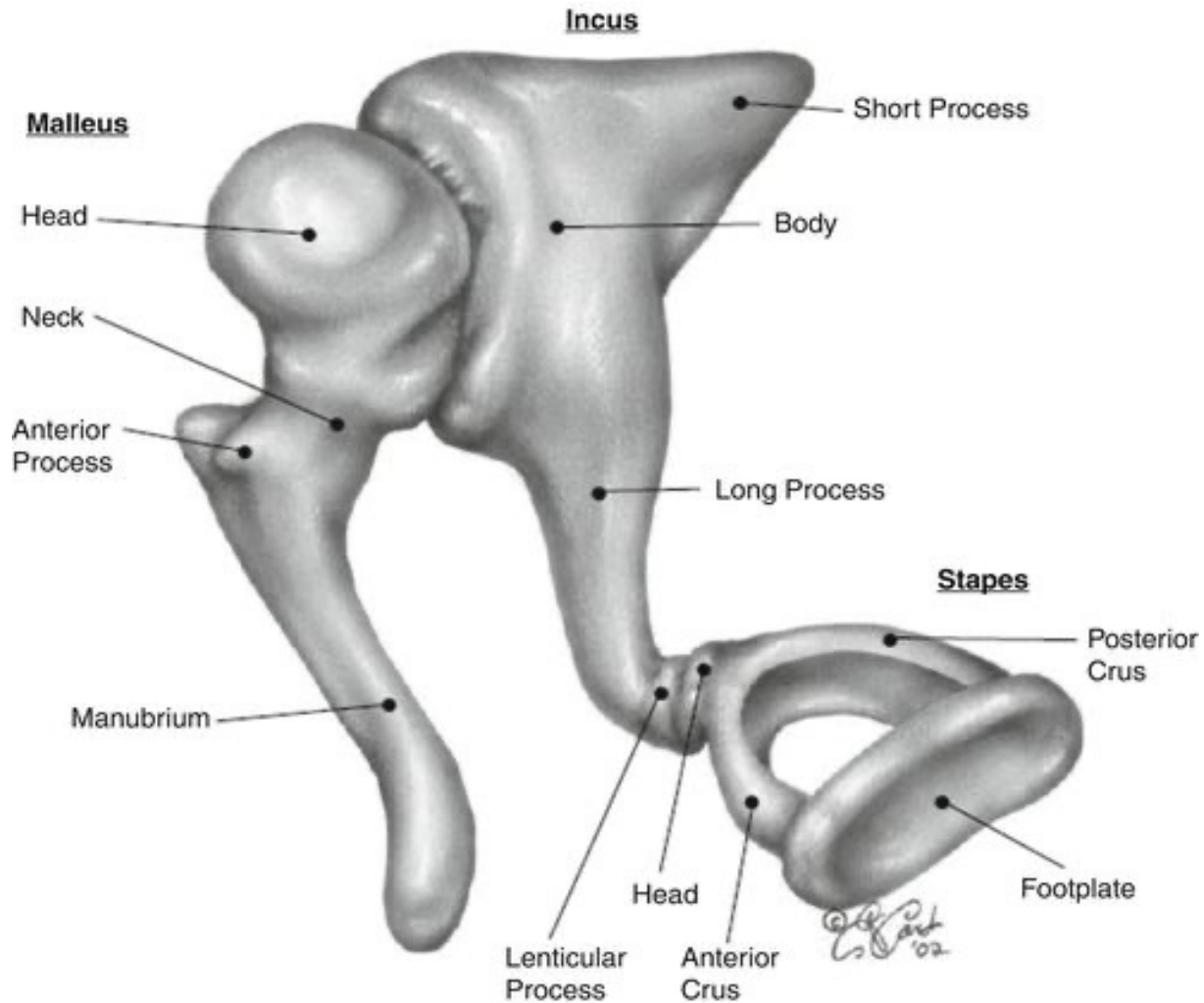
- membranaceus
- labyrinthicus
- tegmentalis
- jugularis
- mastoidea
- caroticus

Middle ear

Tympanic cavity (cavum tympani)

ossicular chain:

- *malleus*
- *incus*
- *stapes*)





HEARING FUNCTION (TRANSFER, SYSTEM)

1. Compensation of loss of acoustic energy (ear- liquid):

a/ tympanic membrane - oval window 14x

b/ lever-action system of ossicles 1,3x

c/ lever-action system due to uneven incurvation of ear drum,
all together 30-35dB

2. Mutual change of deviation and pressure acoustic vibration .

Gas = great deviation, low pressure.

Liquid = low deviation, great pressure .

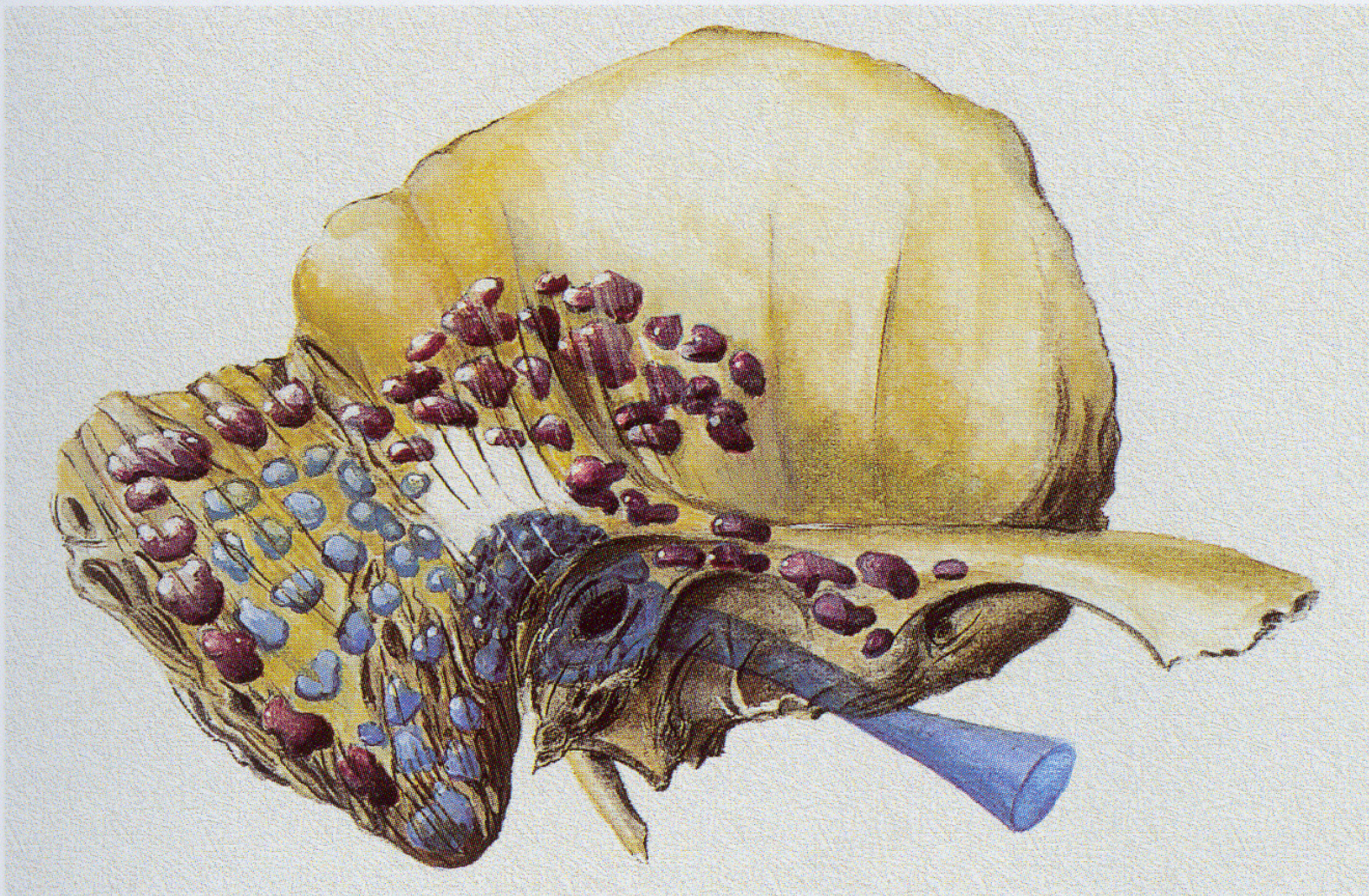


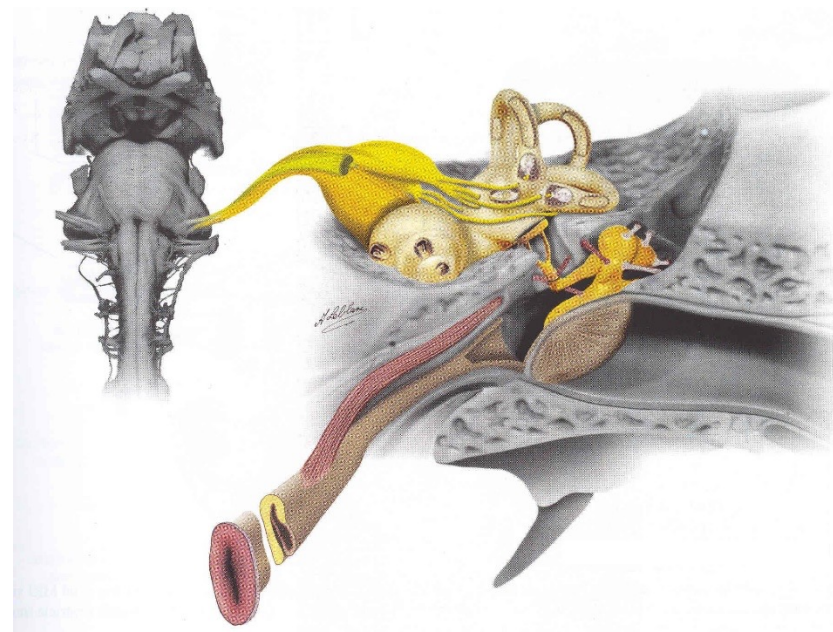
Fig. 26

Pneumatization types of the petrous bone

- compact mastoid process
- restrained pneumatization
- good pneumatization

Eustachian tube

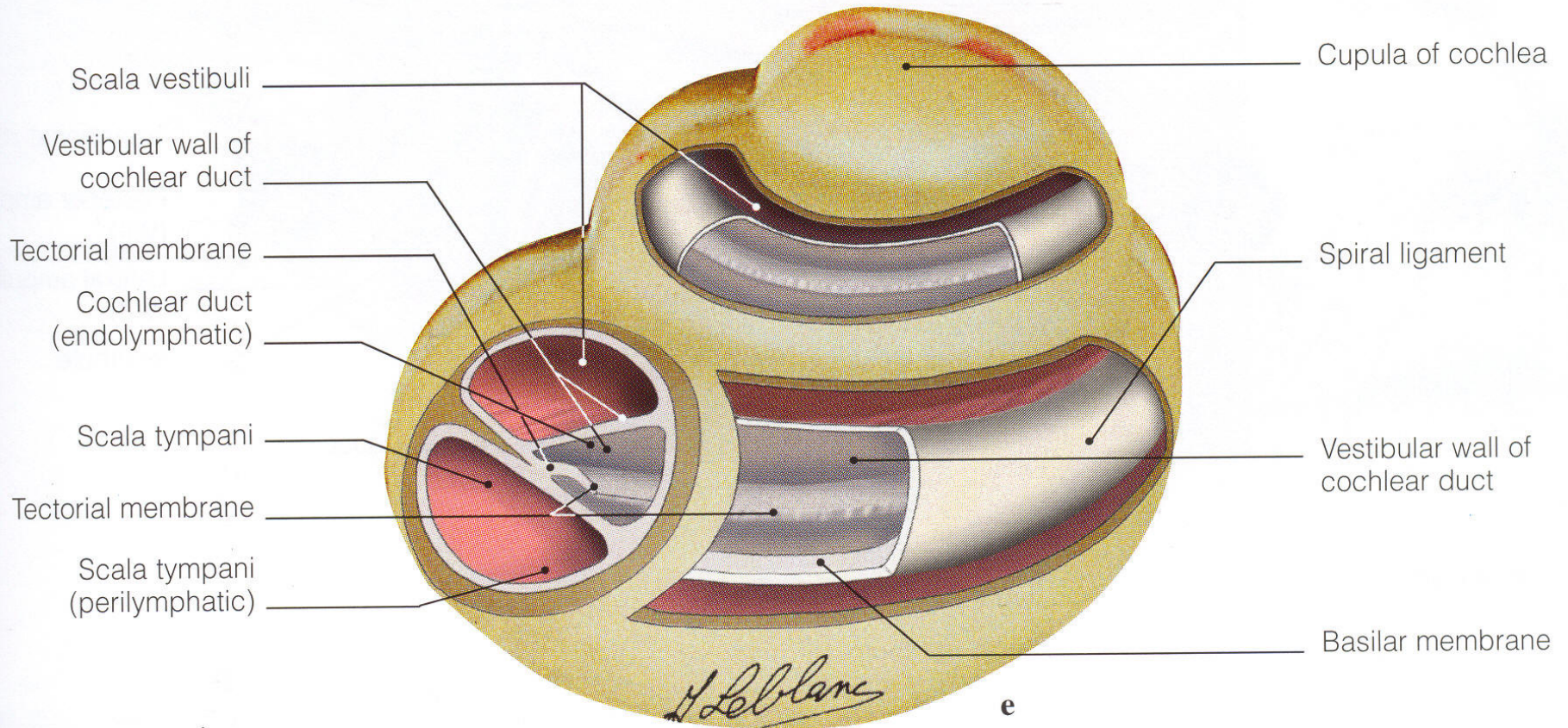
- **Ventilation function** - it serves to equalize the pressure between middle ear and the nasopharynx
- **Drainage function** – removal of secretion from middle ear cavity
- **Protective function** - before secretion penetration into middle ear cavity



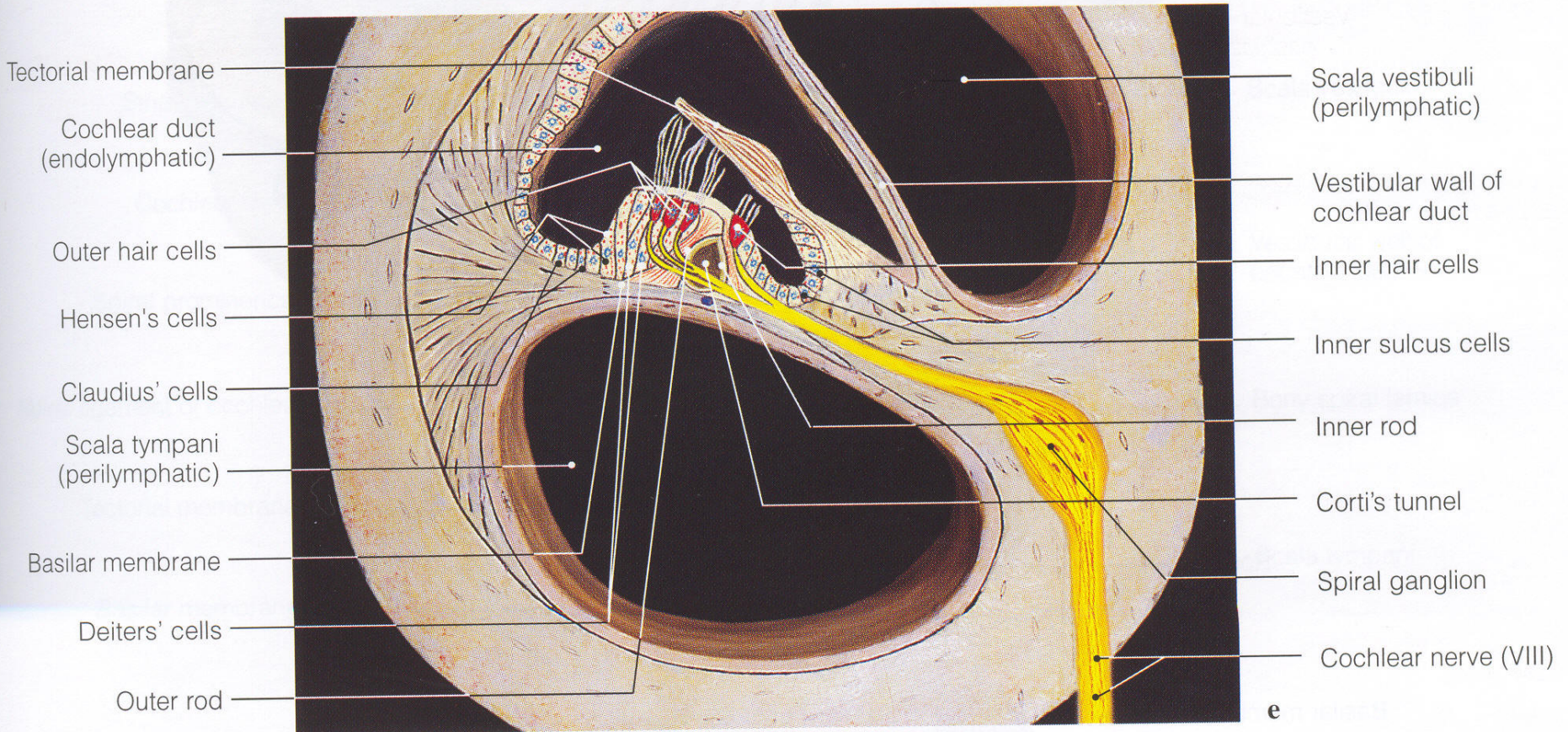
Cochlear function:

- Change of mechanic vibration on neural excitation
- Basic frequency analysis

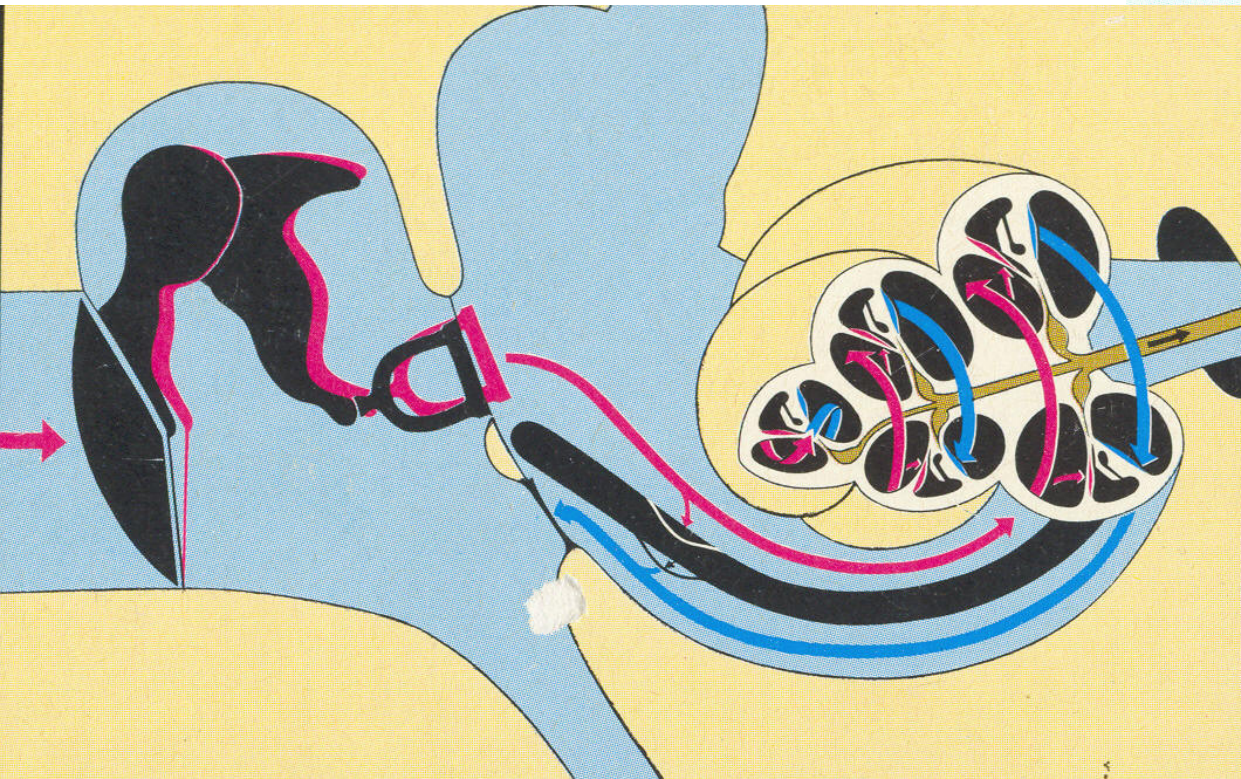
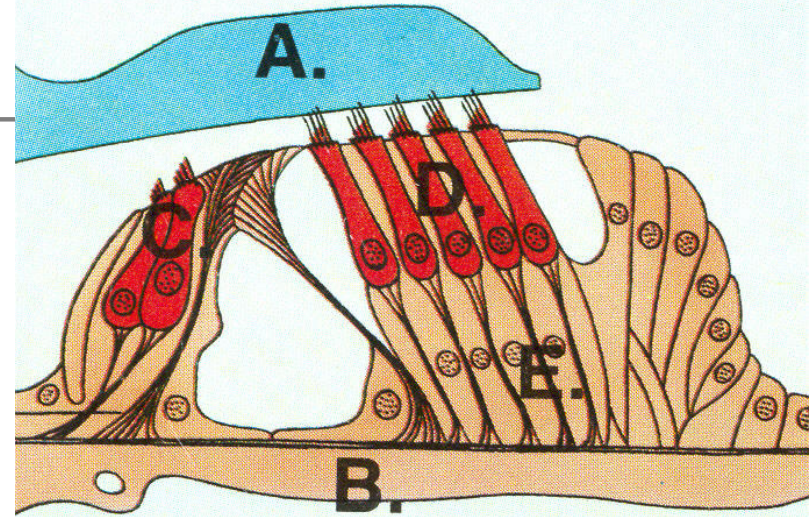
Cochlear cross-section



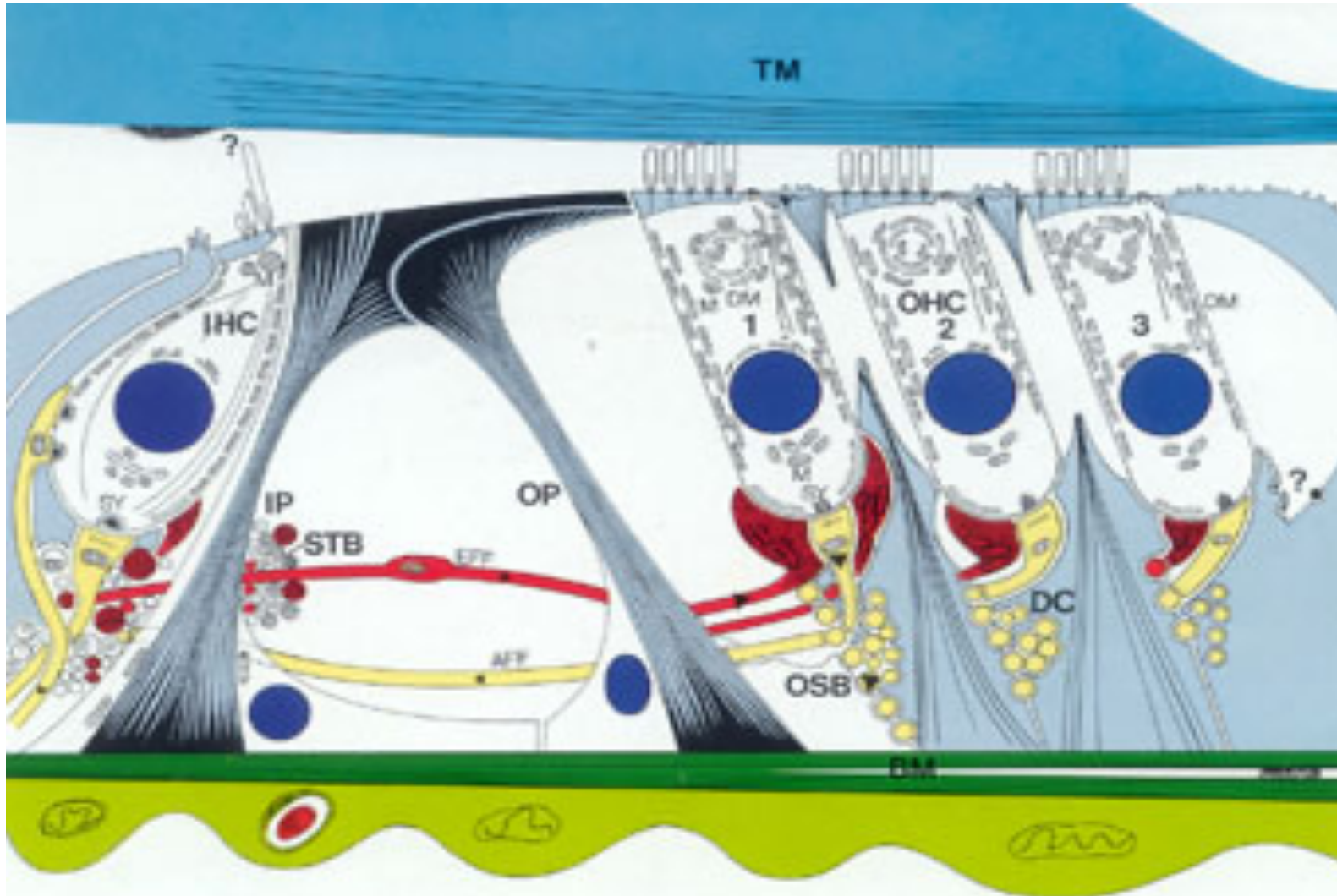
Cochlear duct cross-section



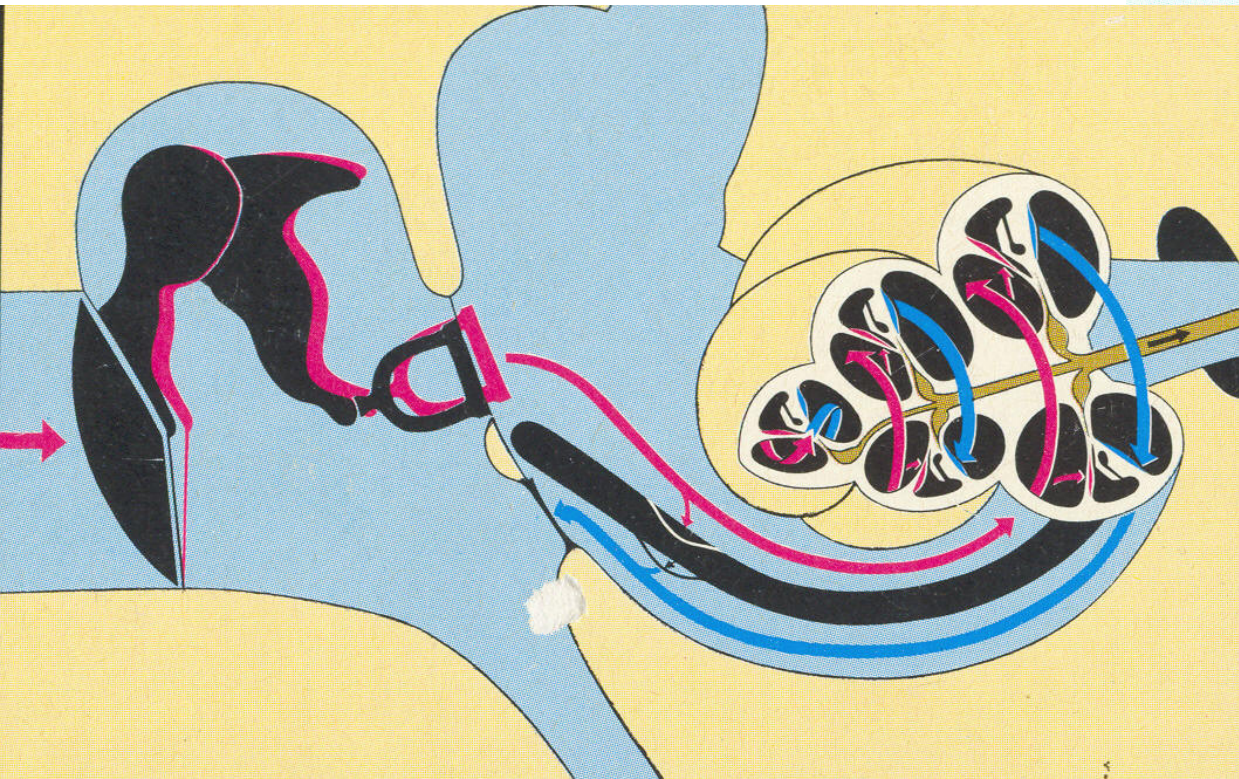
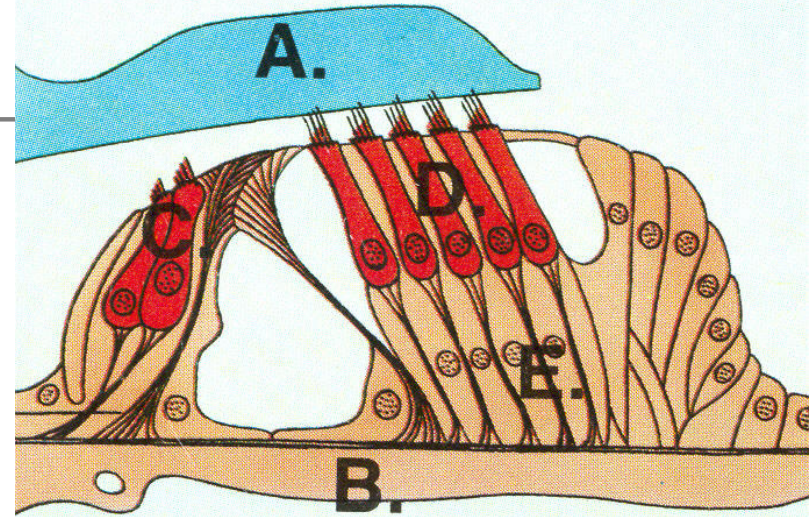
Conduction of vibration from tymp. membr. through cochlea, Organon Corti



Outer hair cells (OHC) = servomechanism for inner hair cells (IHC)



routing vibration from ear drum through cochlea, Organon Corti

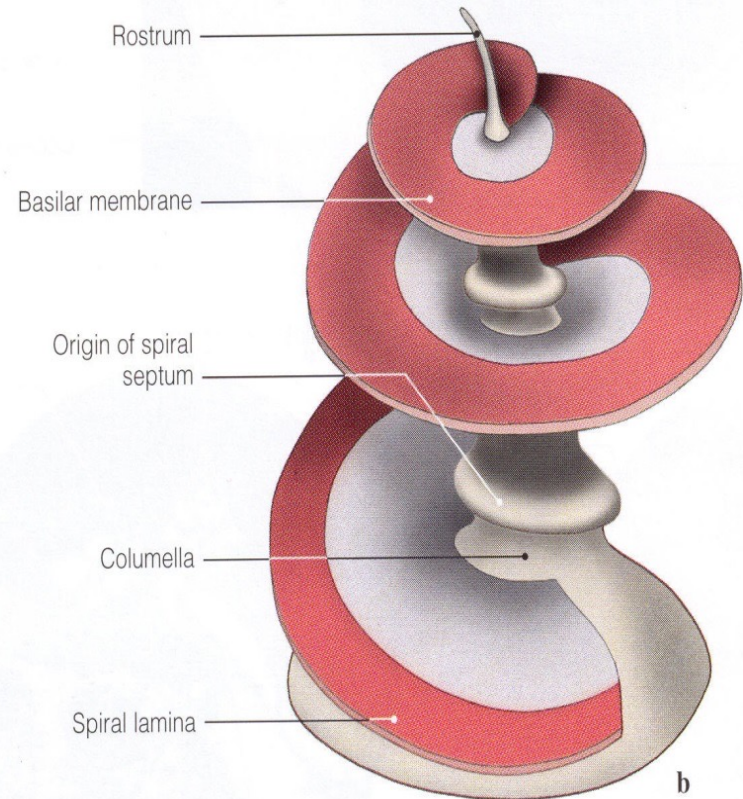


Cochlear septum

System of 3 membranes –
membrana basilaris, reticularis,
tectoria

Principle of tonotopy

– as higher frequency, the acoustic
pressure balanced near to stapes.
High frequency are perceived in
basal whorl, low frequencies in
apical whorl.





Wave hydrodynamic theory of hearing (von Bekesy theory of „traveling wave“)

- Acoustic tension is led from ear drum through ossicles into oval window.
- Liquid is not compressible, pressure changes are equalized on round window membrane, which vibrates in anti phase to stapes.
- Acoustic pressure is equalized on cochlear septum and it creates wave.
- a sound impulse sends a wave sweeping along the basilar membrane. ... And as Helmholtz had postulated, **Bekesy** found that the high-frequency tones were perceived near the base of the cochlea and the lower frequencies toward the apex." (**principle of tonotopy**).
- „traveling wave“ leads to shift of tectorial membrane of Organon Corti in relation to basilar membrane and deflection of hairs of sensory cells
- Thus the mechanical energy is changed into electric potential in VIII cranial nerve.

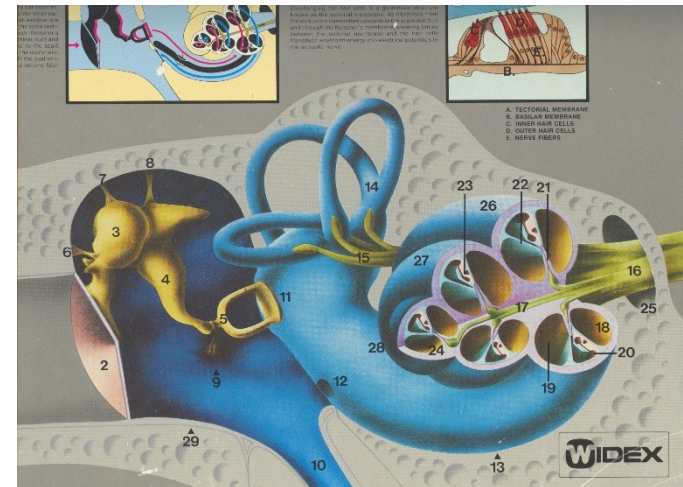
Vestibular system

Basic function

- Equilibrium of human body in stand and in walking
- Stabilization of retinal picture and keeping visual sharpness in movement

Basic reflex circles

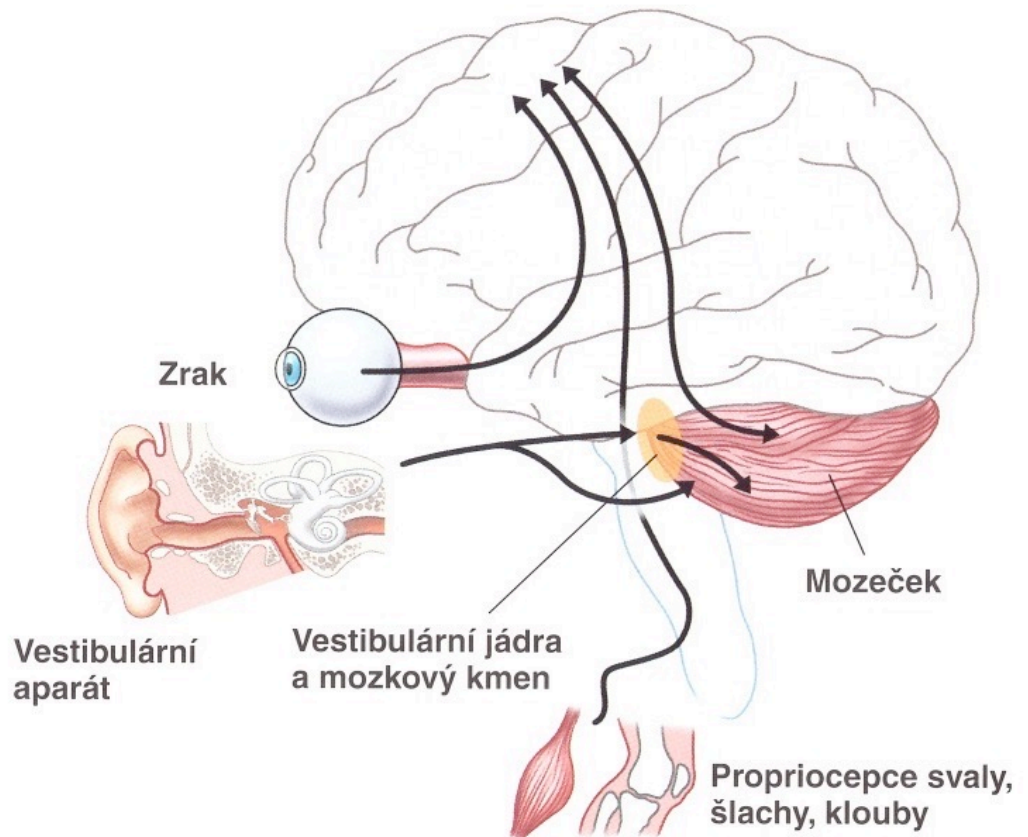
- vestibulo-ocular reflex (VOR)
- Vestibulo-spinal reflex (VSR) - help keep head and body in upright position due to vestibulospinal system.



Equilibrium

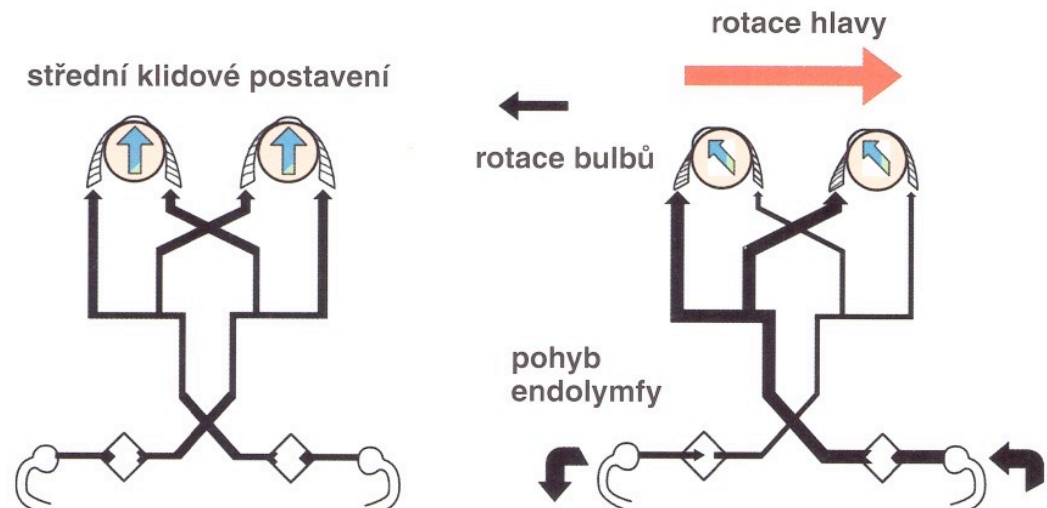
Interaction of eye, vestibular-semicircular system, proprioception and cerebellum on keeping balance

Three afferent sources of equilibrium: eye, proprioception and vestibular system.



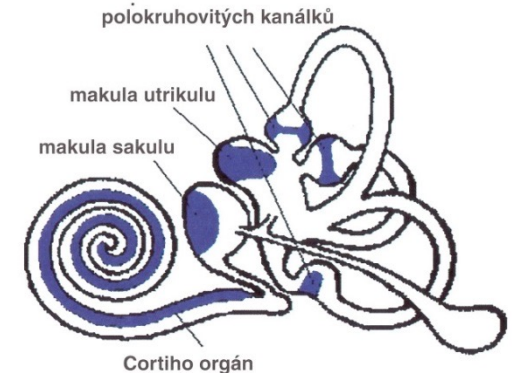
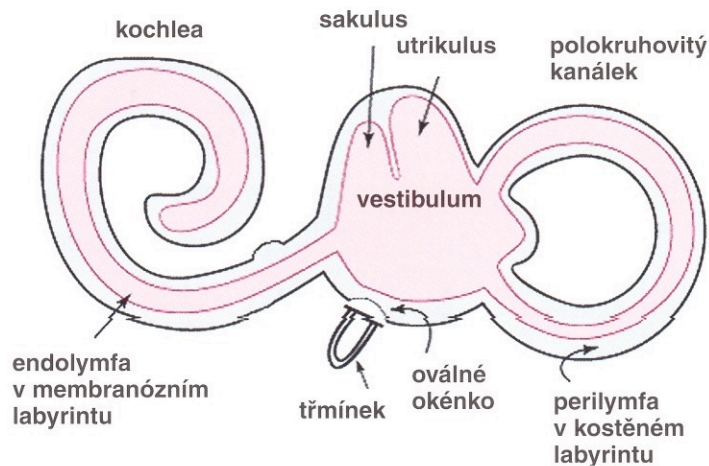
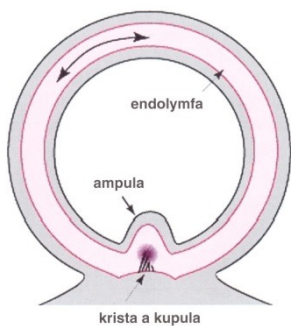
Vestibulo-ocular reflex

Create movement of eye, which are opposite to movement of head in some plains. Nystagmus – conjugated, coordinated eye movement around a specific axis. **The movement consists of rhythmically alternating slow – and fast beating phases.** The direction of the fast components determines the laterality of the nystagmus.



Membranous labyrinth

- Vestibular apparatus localized in pyramis ossis temporalis; membranous labyrinth: saccule, utricle and three semicircular canal; filled with endolymph.
- Every semicircular canal begins with pars **ampullaris with ampullary crest**, sense organ is **static macula**.

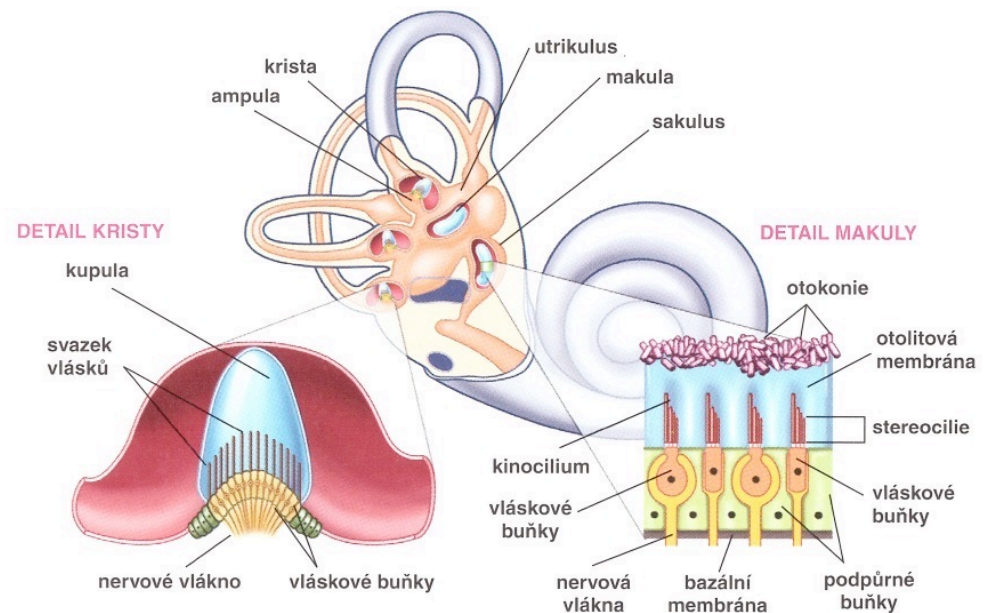


Section of semicircular canal, schema of membranous labyrinth (with one canal), sensory organs.

Genesis of receptor potential

Ampullary crests and **maculae utricule and saccule** are created **supporting cells and hair cells**. On their surface lie the **otoliths** (statoconia) – calcium carbonate crystal.

Linear acceleration changes the otolith pressure, **deflecting the sensory hairs**. this stimulates the sensory cell by altering the resting **potential**.





Vestibular function Tests

- History – subjective feeling of dizziness
- Nystagmus
- Vestibule-spinal and cerebellar reflexes:
 - Hautant test (spontaneous deviation test),
 - Romberg test,
 - Barany test (finger-nose pointing test) ; posturography
- Head impulse test: from mild eccentric head position we provide passive quick rotation movement from side to side.



Vestibular function Tests

- Head shaking nystagmus – spontaneous Ny can be provoked by gentle, passive, horizontal shaking of the patients head
- Detail evaluation of eye movement -
electronystagmography, video oculography
- Unterberger test, walk „on the rope“
- Stabilometric plain - static and dynamic



Vertigo (dizziness)

- ***Periferal type*** – feeling of rotation of itself body or surroundings, direction of rotation is usually into healthy part, loss of stability or feeling of swimming
- ***Central type*** – ineptitude by walk, inability of walk, vertigines with aura (EPI), disorder of vision "*black outs*" – diplopia is seen by disorder of oculomotory.



Symptom	Peripheral (harmonic) VS	Central VS
Nystagmus	Horizontal rotatory on side of most reactive labyrinth	Other than Horizontal rotatoric (only horizontal, vertical, „gaze“ nystagmus, rebound nystagmus etc)
Tonic deviation	On side of weak labyrinth (to affected ear) in relation to position of head	Without to relation to head position
Eye fixation	In absence of eye fixation nystagmus is growing	In absence of eye fixation nystagmus not changejd
Cranial nerves	Without laesion (excl.: n. VII)	Laesion of cranial nerves present
Cerebellar symptoms	Not present	Could be present
Disturbance of oculomotoric function	Not present	Could be present
Hearing disorder	Usually Could be present	Usually Not present
Central compensation	Gradually compensation, harmonic symptoms: intensity of vertigo correlates with nystagmus intensity and tonic deviations	Not present, disharmonic symptoms

History of ear disease

Physician itself is a „remedy“. (Michael Balint)

Hearing
disorder

Otorrhoea
Ear discharge

Tinnitus

Pain

Dizziness

Ear evaluation, oto(mikro)scopy

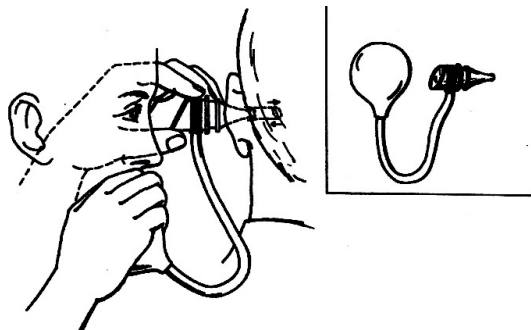
■ Aspection and palpation

- Auricle shape, deformities
- Skin lesions, scars (also retroauriculars)
- Discharge from external meatus
- Pain in pressure on tragus (by otitis externa)
- Pain in pressure on processus mastoideus (by mastoiditis acuta)



■ Otoscopy and oto(mikro)scopy evaluation

- Ear speculum
- Illuminated otoscope, pneumo-otoscopy
- otomicroscope

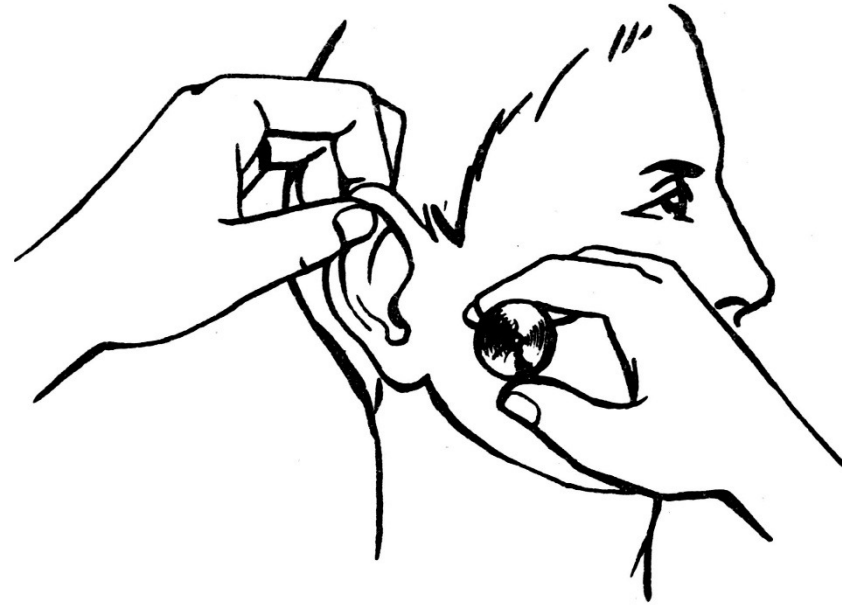


Vyšetřování Sieglovým zrcátkem



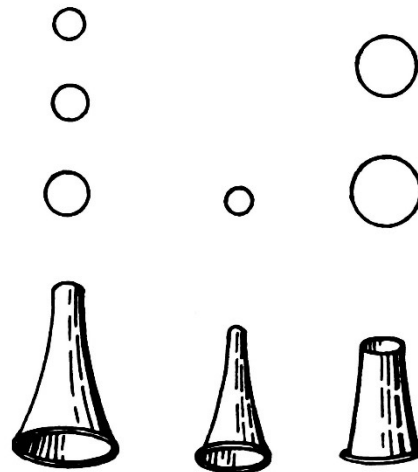


Obr. 13: Zavádění ušního zrcátka u dítěte



Obr. 12: Zavádění ušního zrcátka u dospělého

Otoscopy
 eye evaluation of
 deeper parts of
 external meatus
 and ear drum



Obr. 11: Ušní zrcátka

The cartilaginous part of
 ext. meatus is stretched
 by pulling the auricle
 upward and backward

Bezold's trias

- Prominentia mallearis
- Stria mallearis
- Light reflex





Otoscopy – tympanic membrane quadrants and zones



p - prominenciz malleolární

z - stria malleolární

u - umbo

r - světlý reflex

Kvadranty:

pl - přední dolní

ph - " horní

zl - zadní dolní

zh - " horní

zóny: c - centrální, i - intermediární, p - periferní

Rozdělení bubínku na kvadranty a zóny

Normal ear drum

(Někdy může
prosvítat)

třmínek

kovadlinka

plica malleol. post.

proc. later. mallei

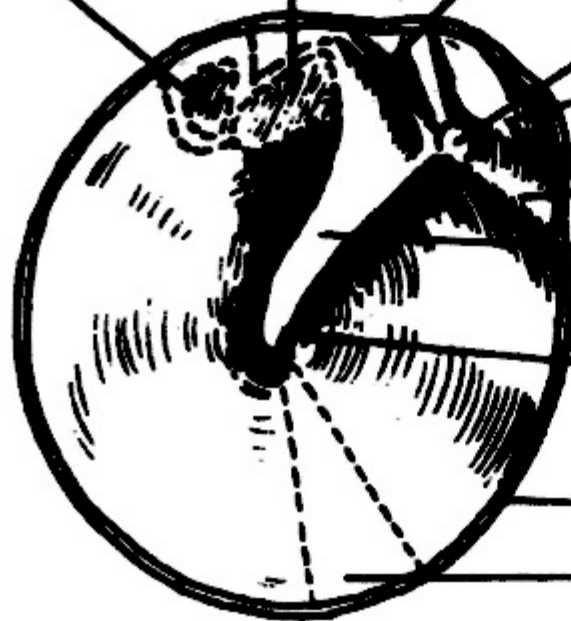
pars flaccida membr.
tympani

plica malleol. ant.

manubrium mallei
(stria malleolaris)

umbo membr. tympani

anulus tympanicus
reflex





Basic pathologic finding on tympanic membrane

- Injection of the vessels of the tympanic membrane
- (**position**) **bulging due to exudate** - hyperemia, moist infiltration and opacity of the surface, the contours of the handle of malleus and short process disappear
- **retraction** - injection of blood vessels
- (**integrity**) perforations –
 - after injury
 - inflammatory - **acute**
 - **chronic** - central (mesotympanic)
 - **chronic** - marginal (peripheral)
- (**changes after inflamm.**) thickening of the tympanic membrane, scars
- changes **behind** the ear-drum: middle ear effusion, fluid level, air bubbles

Various types of ear drum perforations



Centrální perforace



ruptura bubínku

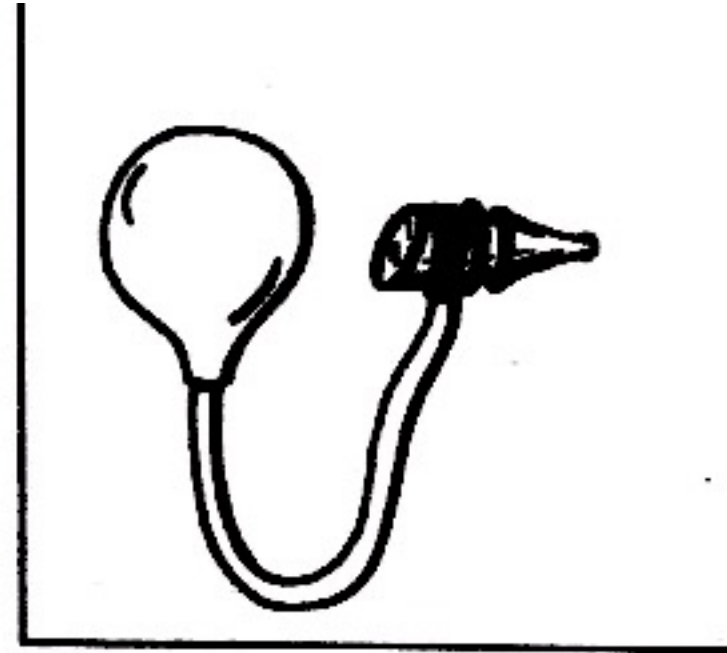
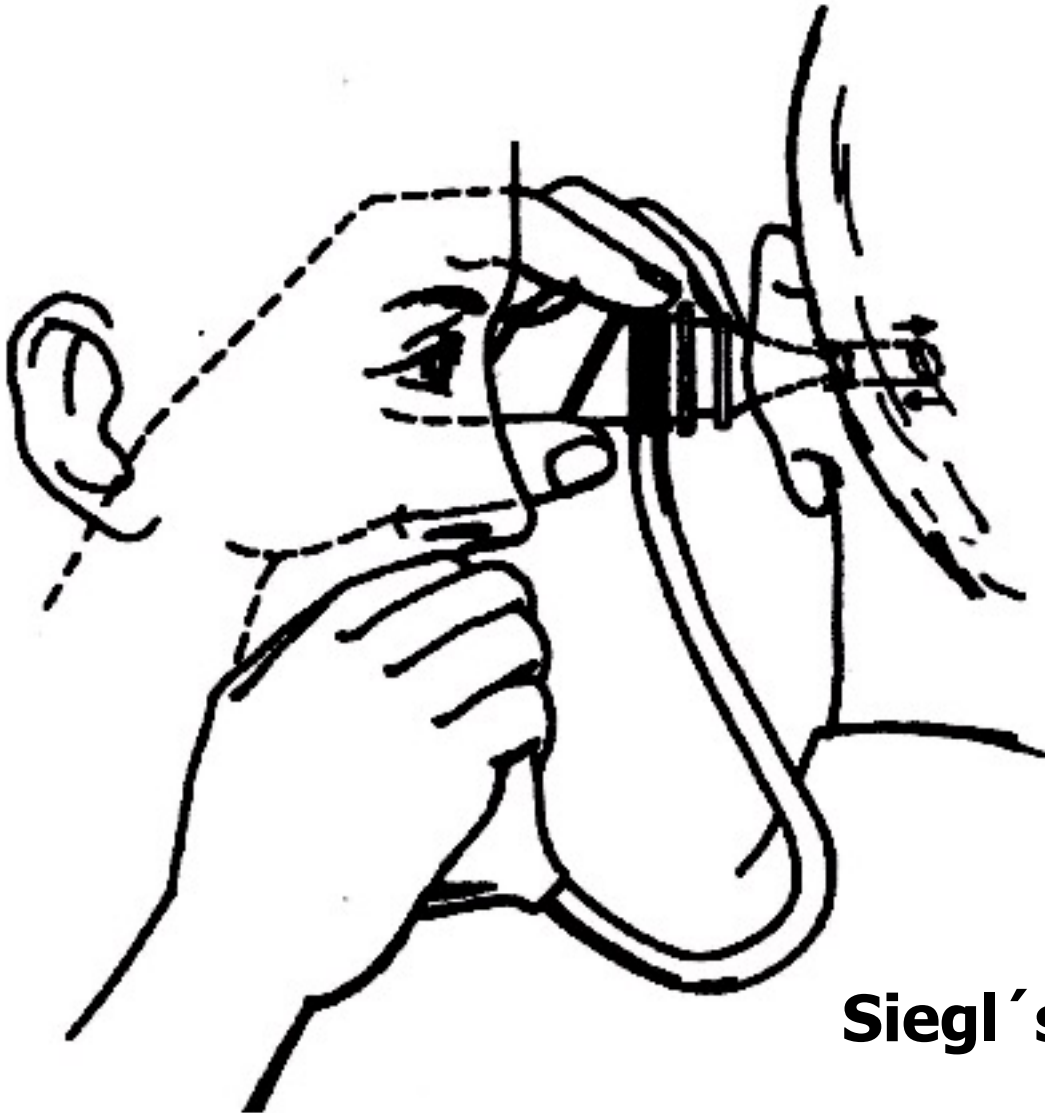


okrajově perforace

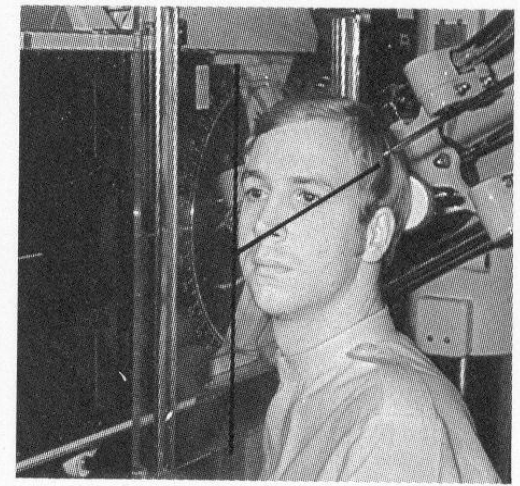
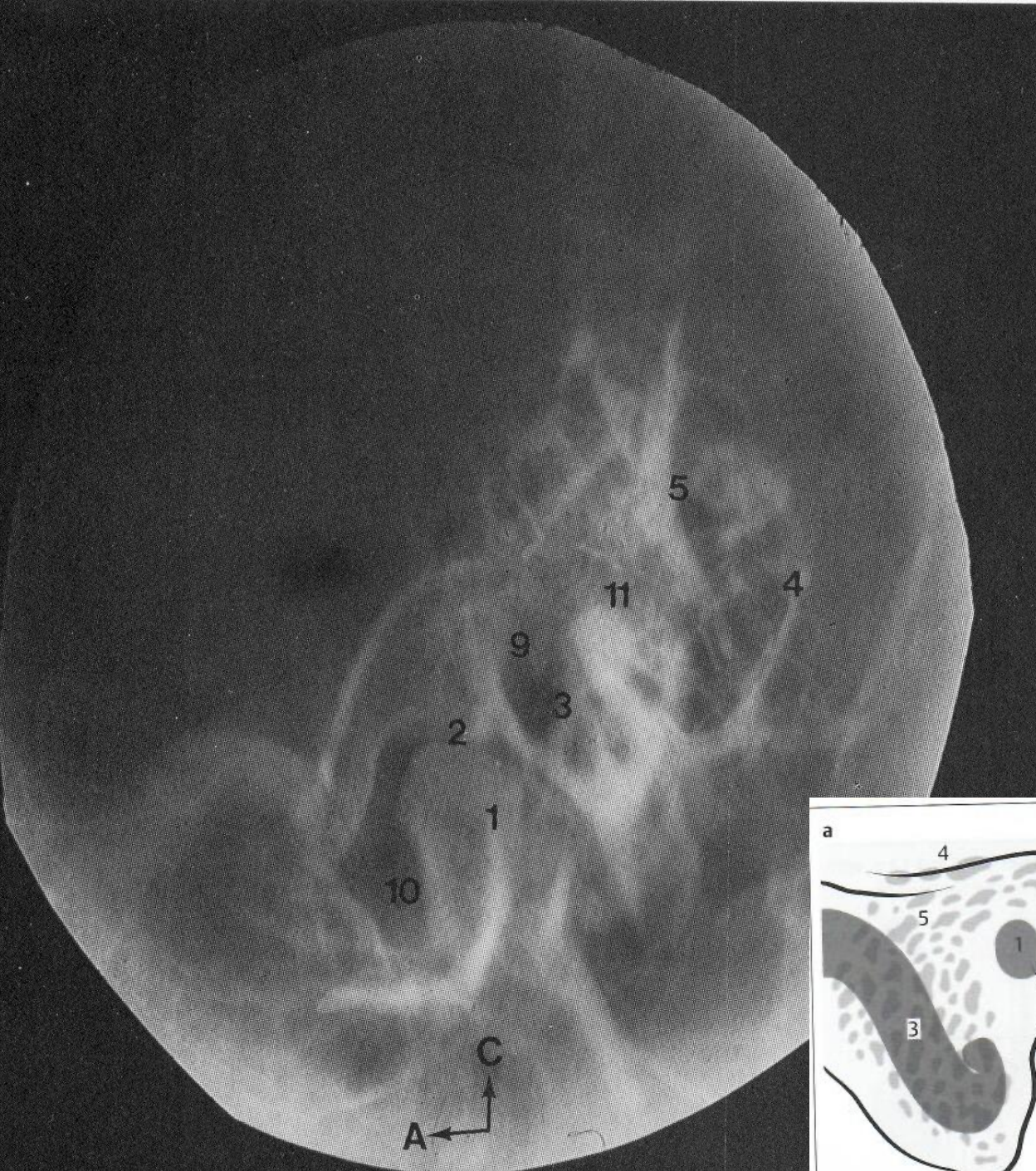


okrajově a centrální perforace

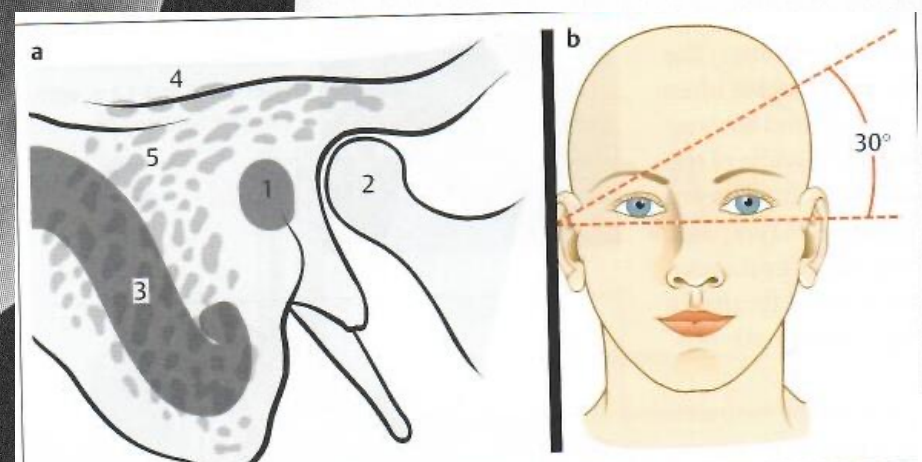
Siegl's ear speculum



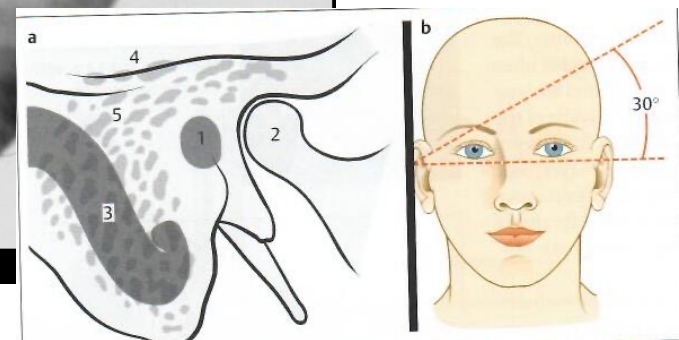
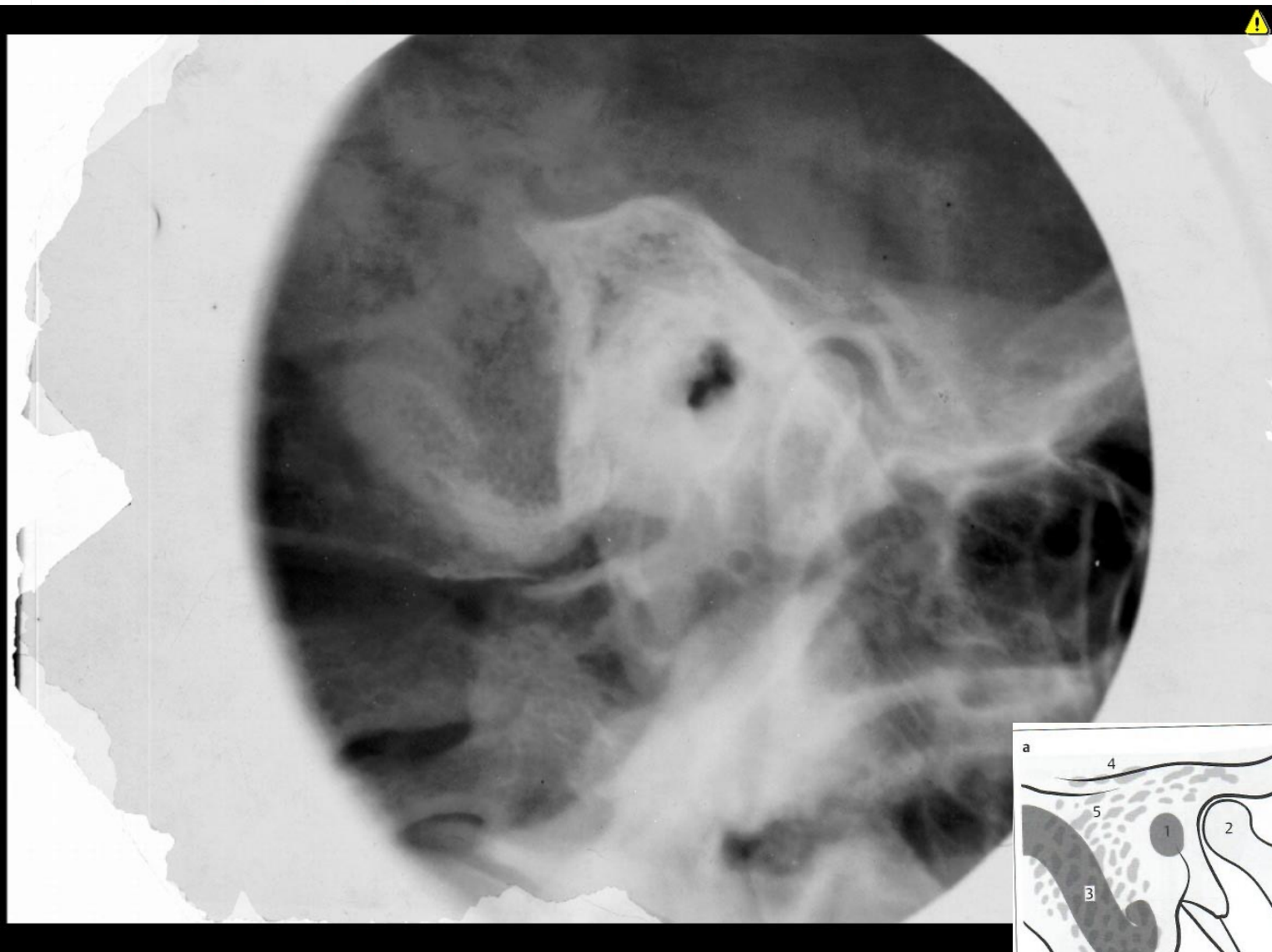
Siegl's ear speculum



**Radiographs in
Schüller wiew**



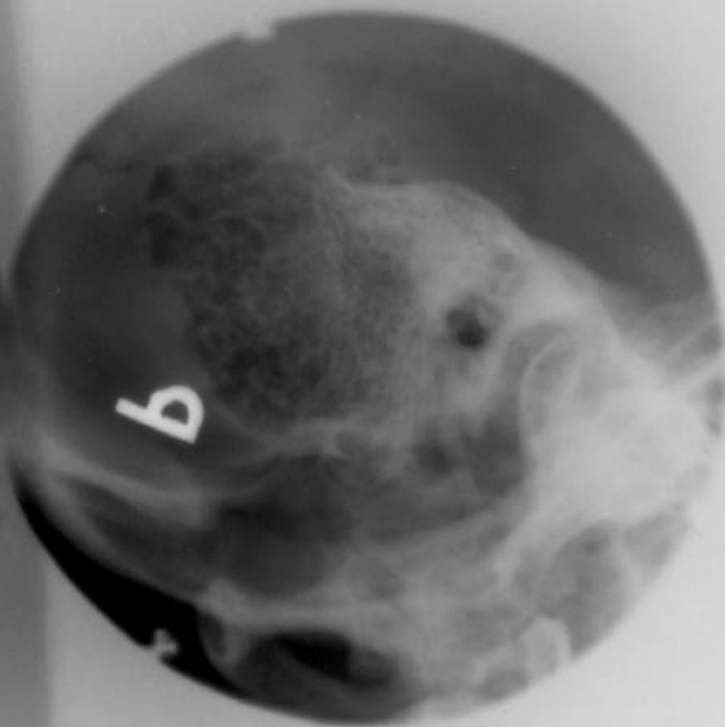
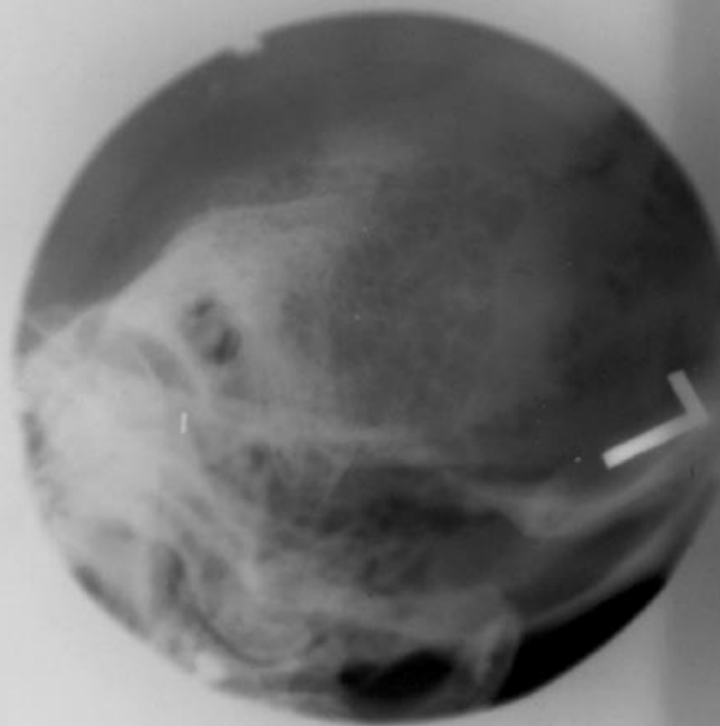
Radiographs in Schüller wiew



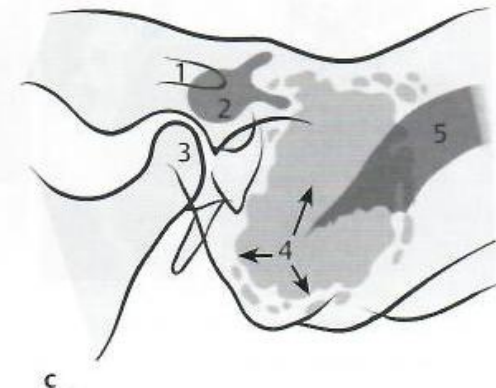
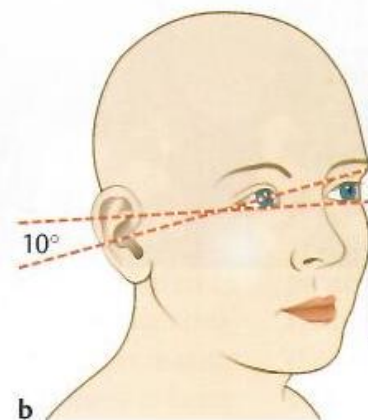
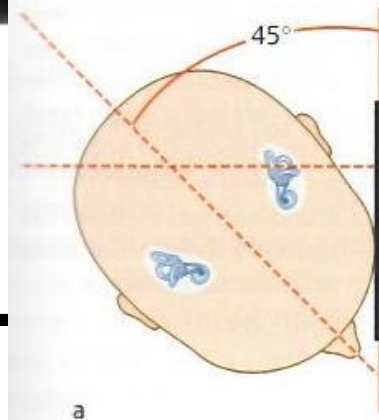
Mladrova

Ohňo med sup. ae. c. mastoiditide
(křídlo zadrženo pneumotické systémem)

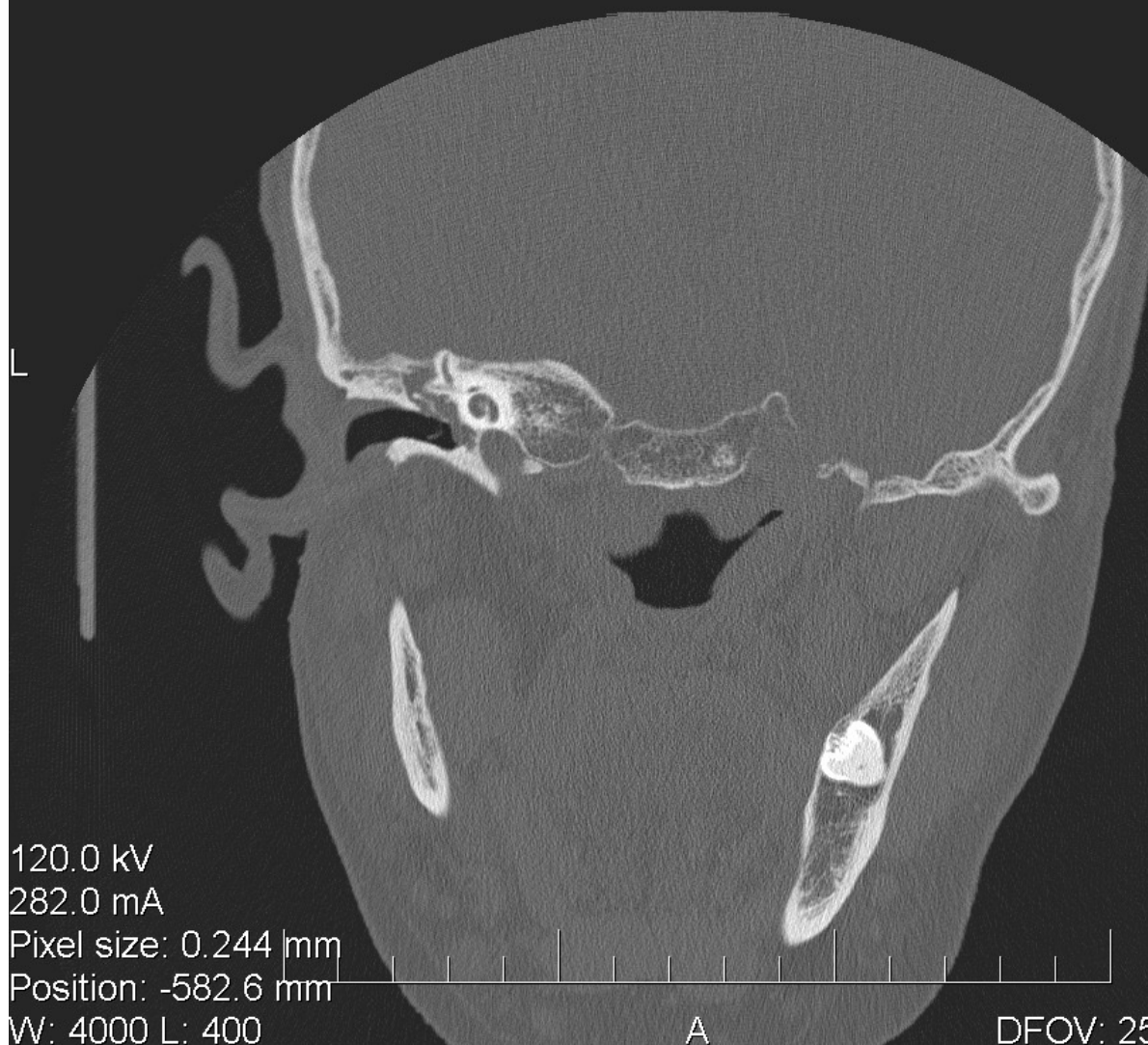
Normální vnitřek.



Radiographs in the Stenver view







120.0 kV
282.0 mA
Pixel size: 0.244 mm
Position: -582.6 mm
W: 4000 L: 400

A

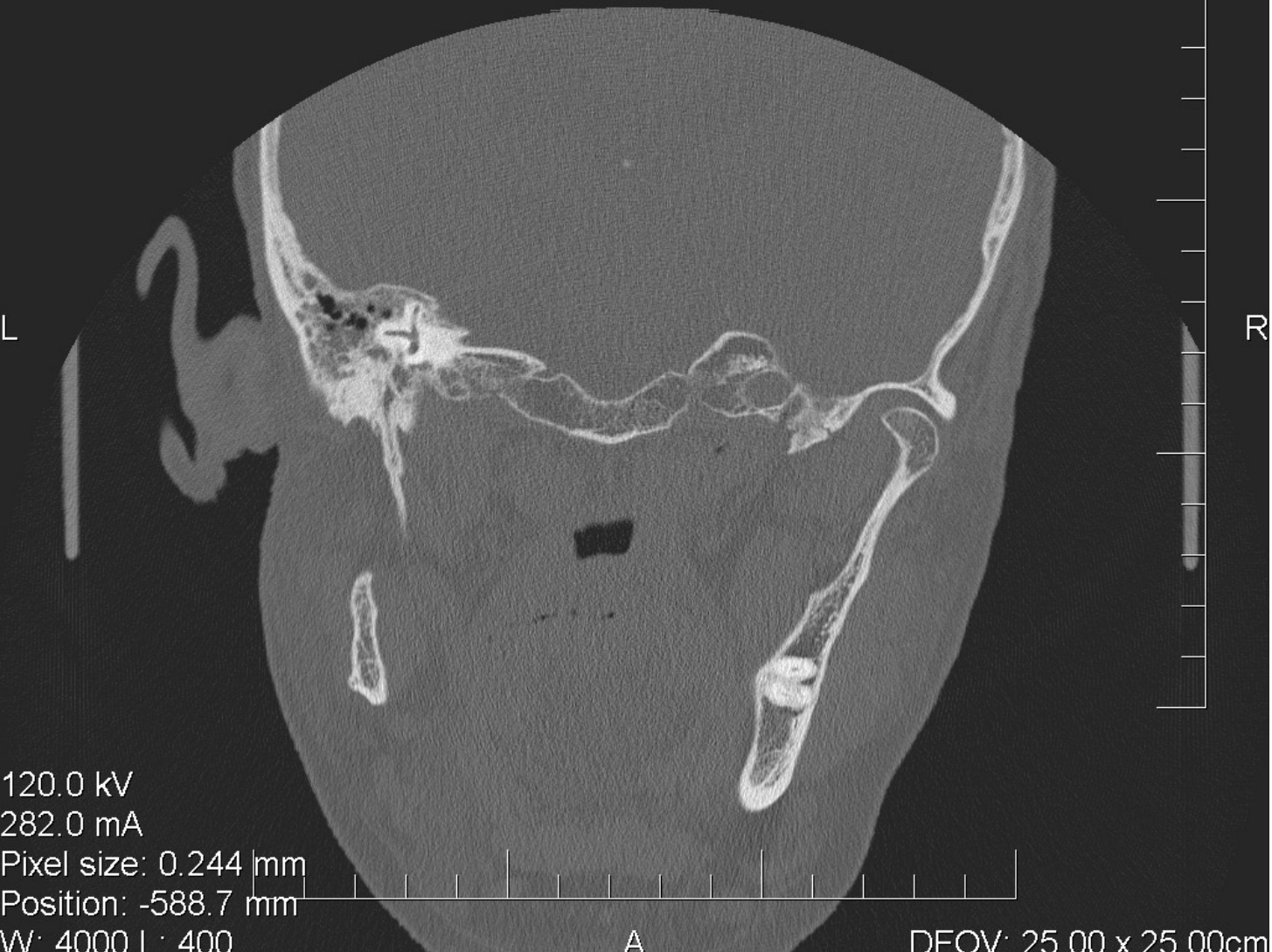
DFOV: 25.00 x 25.00cm

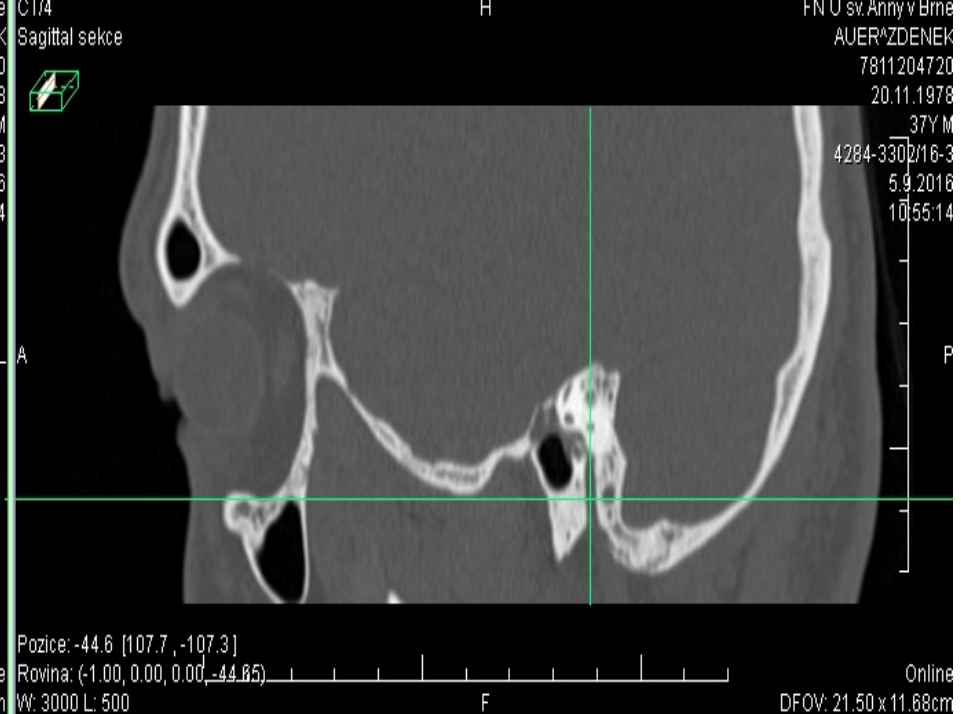
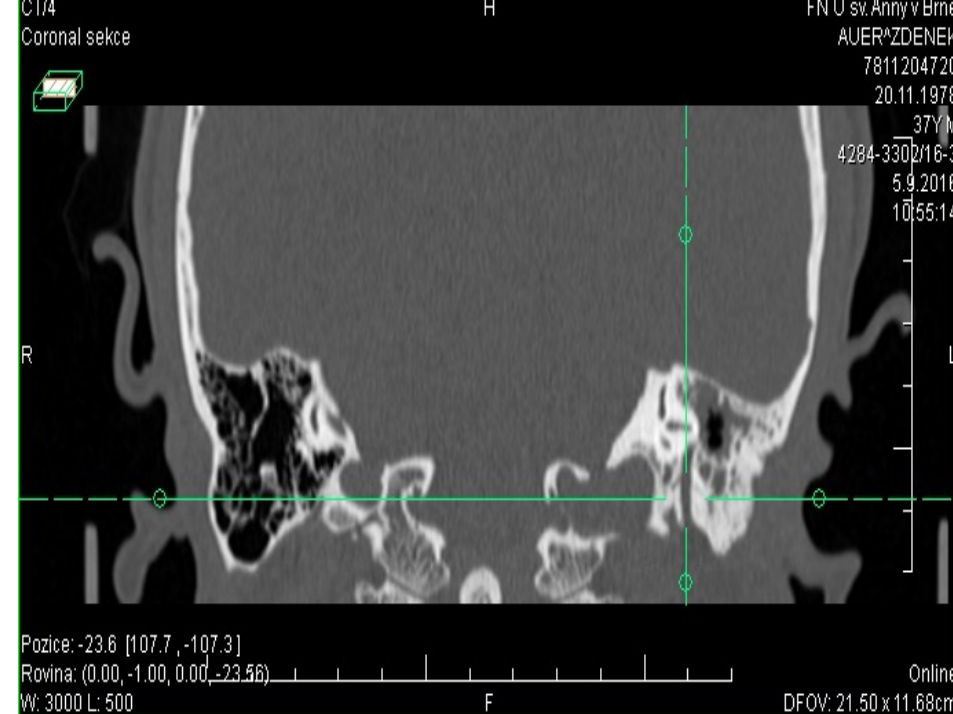
CT/835/19
Axial F->H

P

FN U sv.Anny v Brne
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2006/3/13
10:23:21

Canalis
Fallopi

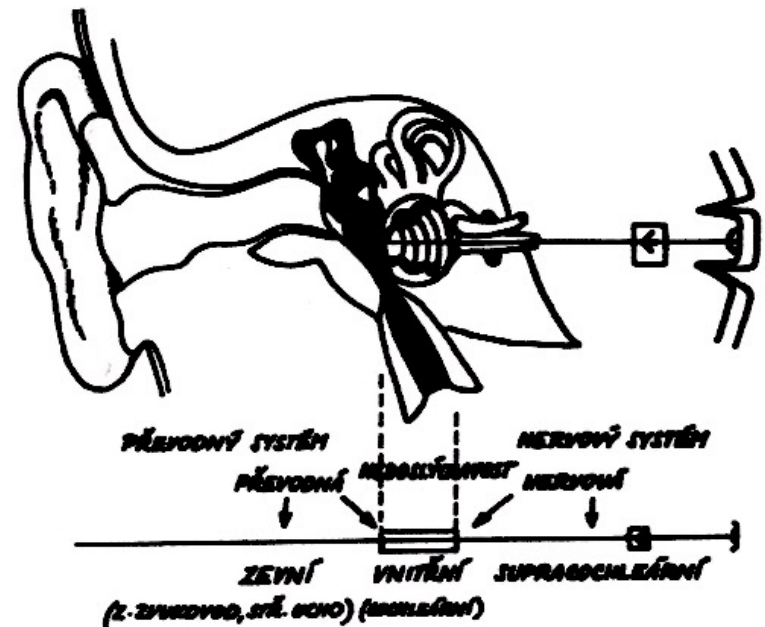


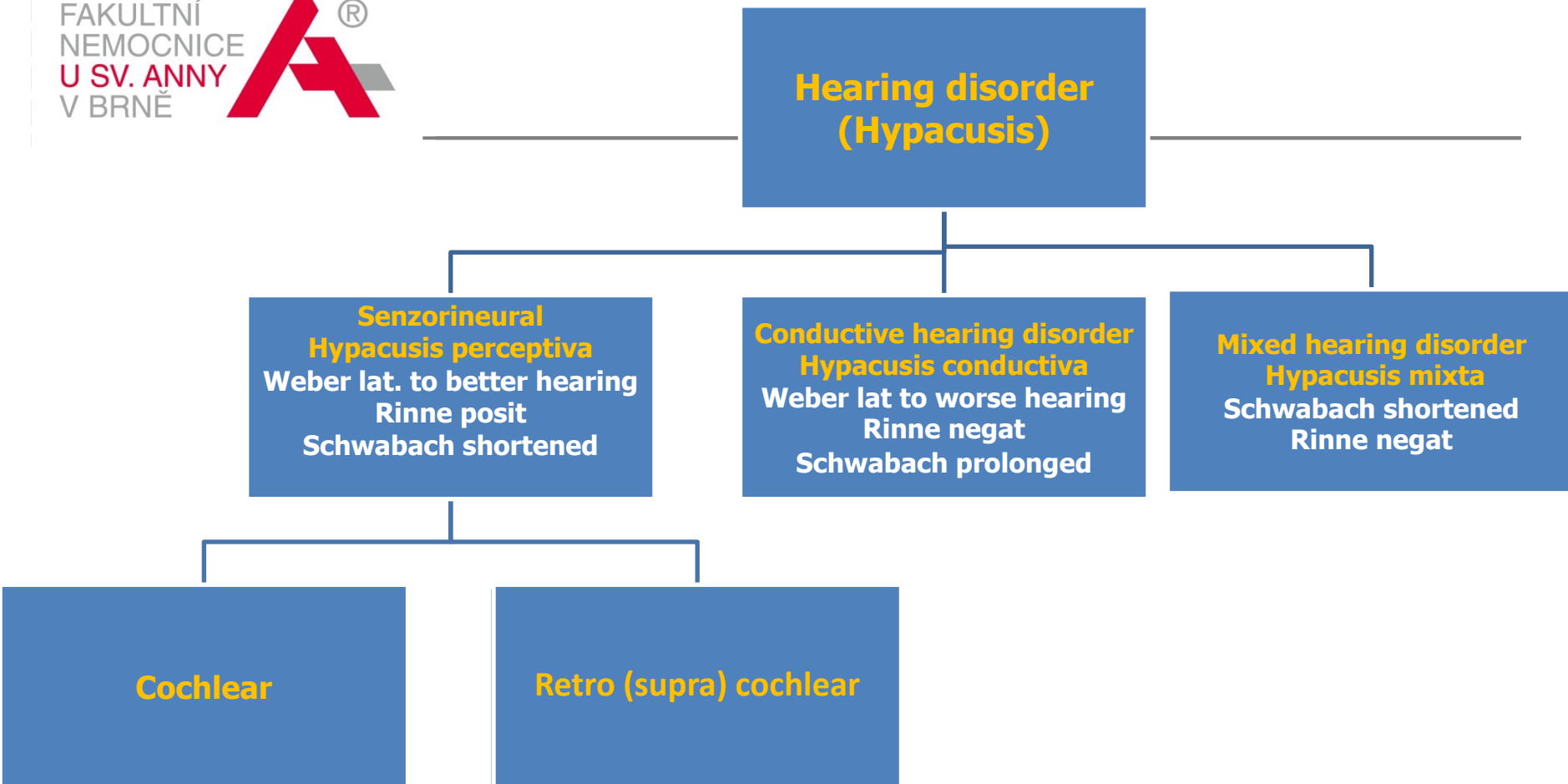


Hearing disorder according to place of lesion

Schema of hearing organ:

- External ear – conductive hearing loss
- Inner ear sensorineural intracochlear hearing disorder
- Central pathways – retro cochlear hearing disorder





Classification of basic type of hearing dysfunction according to place of lesion



Evaluation of hearing function

We evaluate on growing level of objectivity:

- „Classical“ hearing test
- Audiometry
- Objective evaluating methods
 - tympanometry
 - evoked potentials
 - otoacoustic emissions

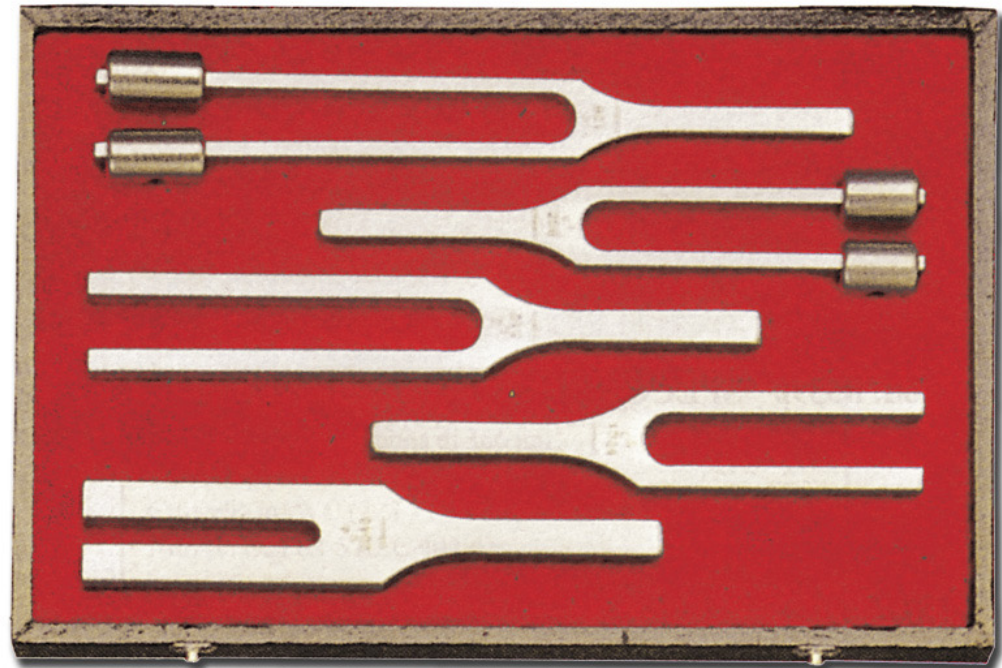
Classical hearing test

Important part of hearing tests:

- + quick, easy, cheap, information about understanding speech
- only for orientation

Tuning fork tests:

- Rinne
- Weber
- Schwabach,
Gellé, ...





Basic types of hearing disorder

P		L
4	V	10
0,5	Vs	10
← W →		
+ R +		
zkr.	Sch	norm

Hypacusis perceptiva (Sensorineural deafness)

Weber unto better hearing ear

Rinne posit

Schwabach shorter

Retrocochlear

P		L
4	V	10
3	Vs	10
← W →		
— R +		
prod.	Sch	norm.

Hypacusis conductiva (Conductive hearing loss)

Weber unto worse hearing ear

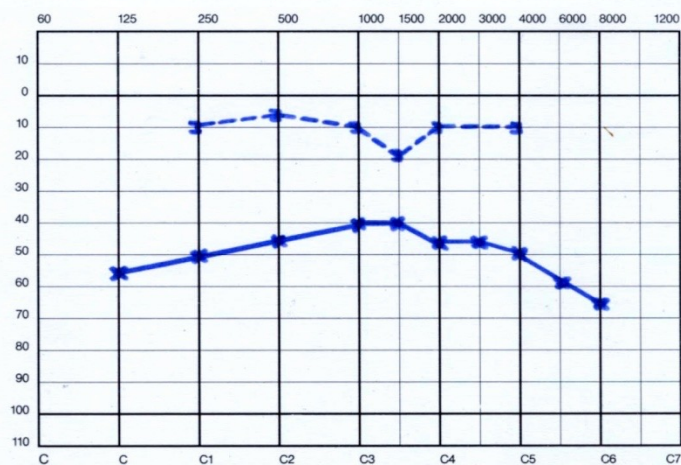
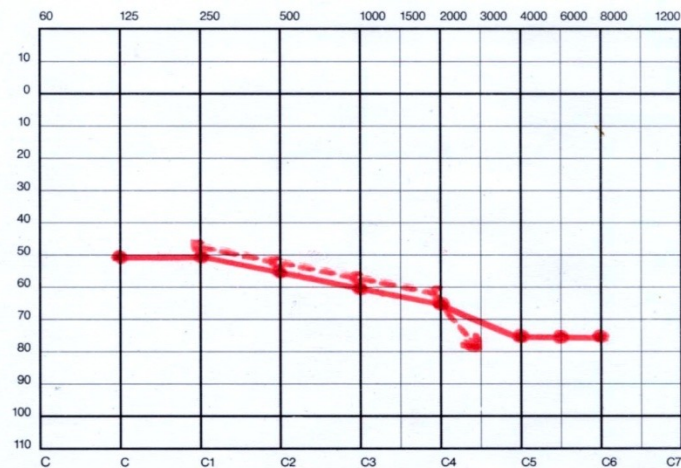
Rinne negat

Schwabach longer

Hypacusis mixta (Mixed hearing loss)

Schwabach shorter

Rinne negat.



Pure-tone audiometry

An Audiometer is an electric tone generator used to determine the **hearing threshold** for pure tones; generates tones of specific frequency (Hz) and intensity (dB).

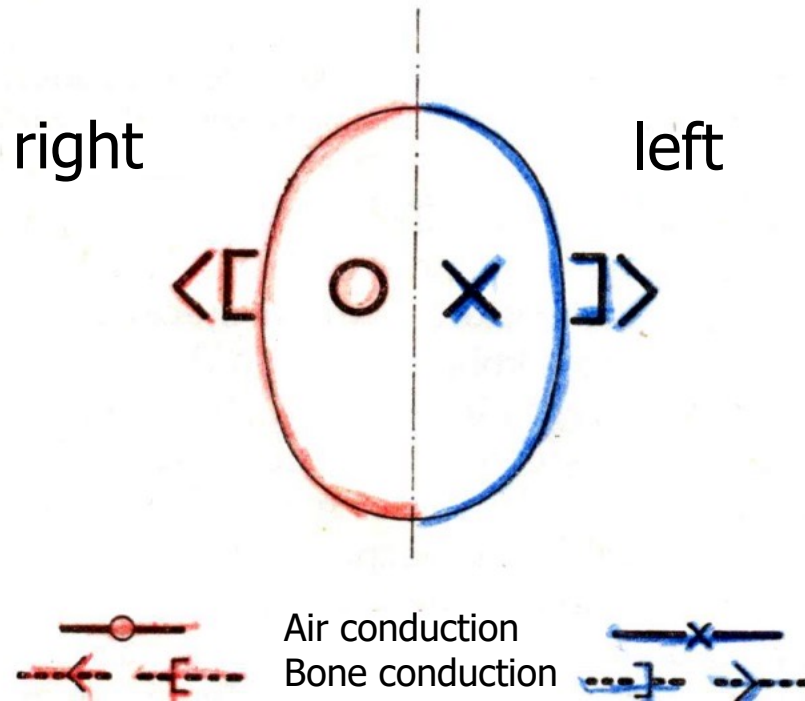
- audiometric room
- Air conduction:
 - headphones
- Bone conduction:
 - bone vibrator

Normal range – until 20 dB loss



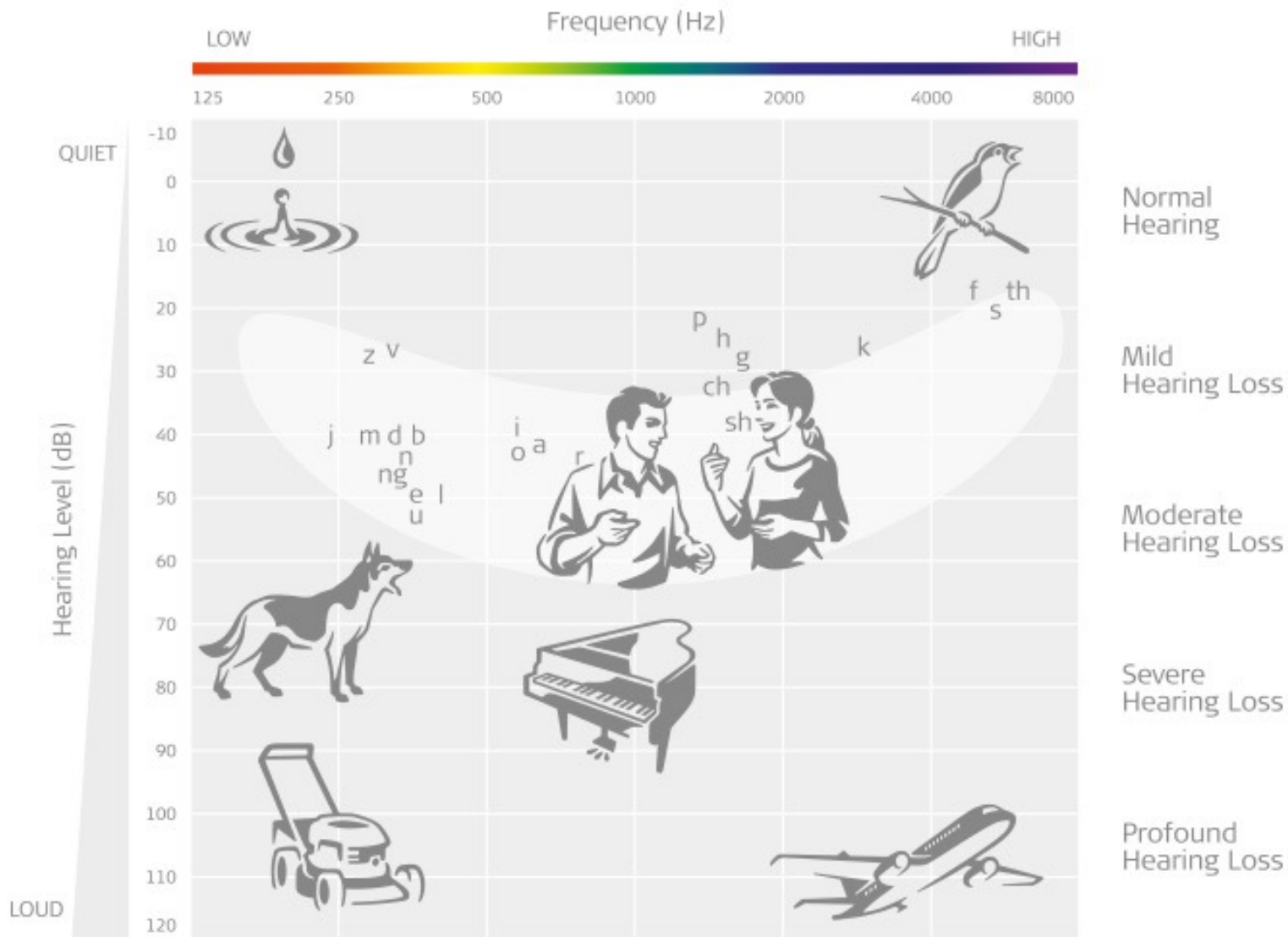


Symbols for record of audiometric evaluation



The speech field

Region of the best sensitivity for hearing

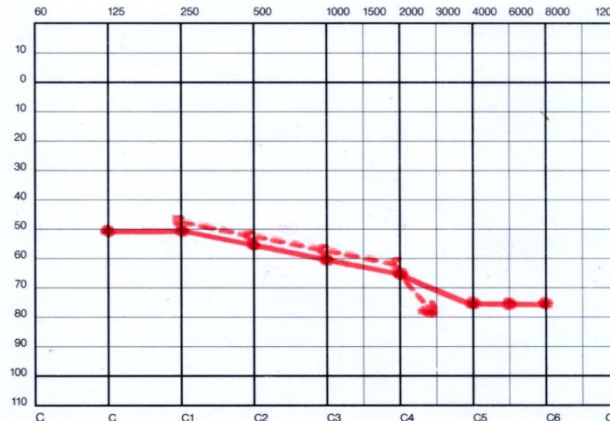
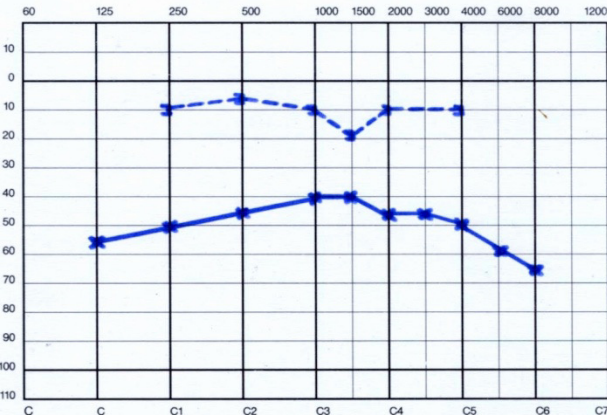


Hearing loss (Hypacusis)

Conductive

Sensorineural

Mixed

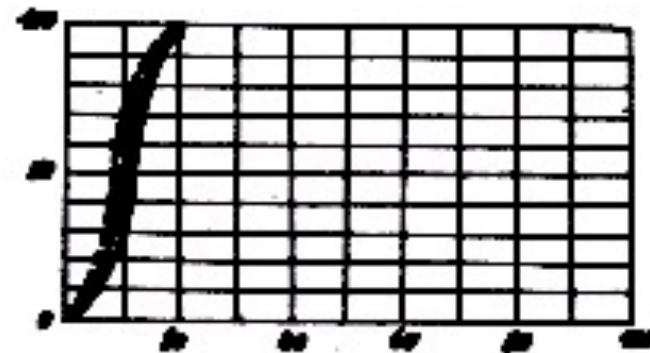


Speech audiometry

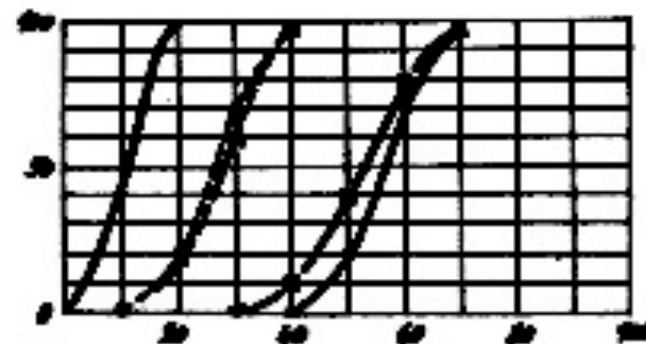
Patient repeats words which are reproduced. One correctly

repeated word means 10% of comprehension from one set. It is evaluated on increasing levels of intensity till 100% of comprehension or maximally possible per cent of comprehension .

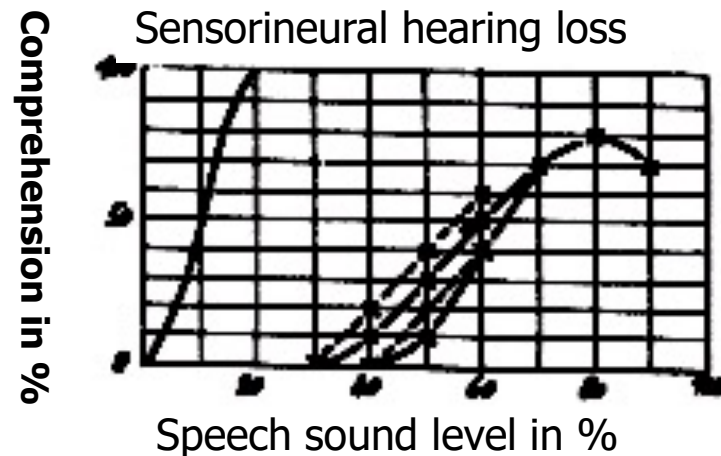
Normal hearing



Conductive hearing loss



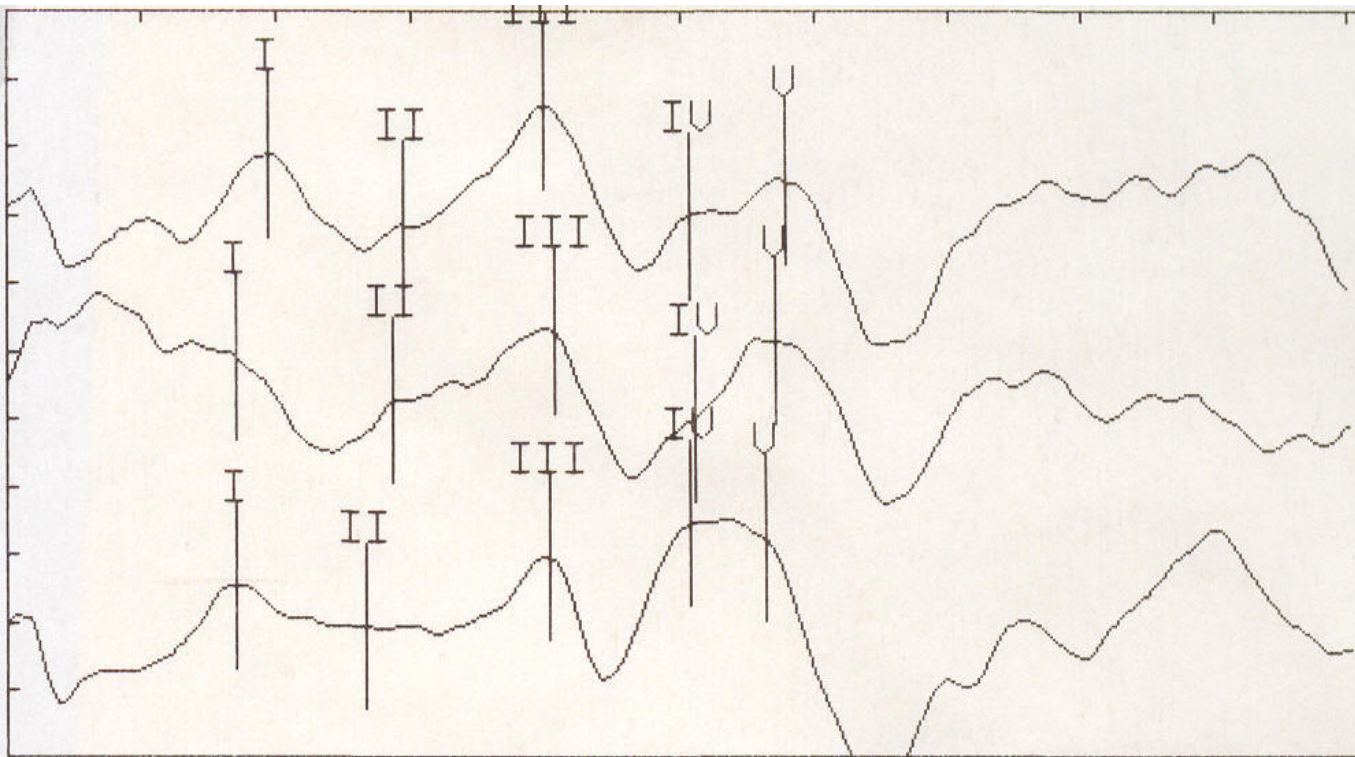
Sensorineural hearing loss



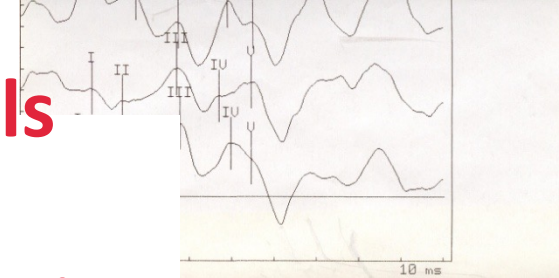


Auditory evoked potentials (BERA, CERA...)

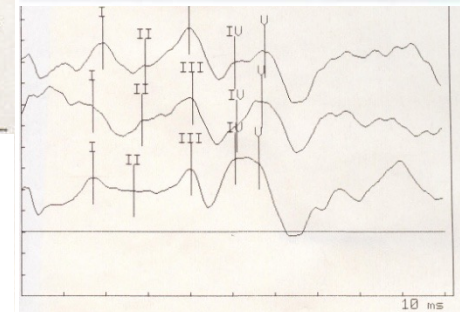
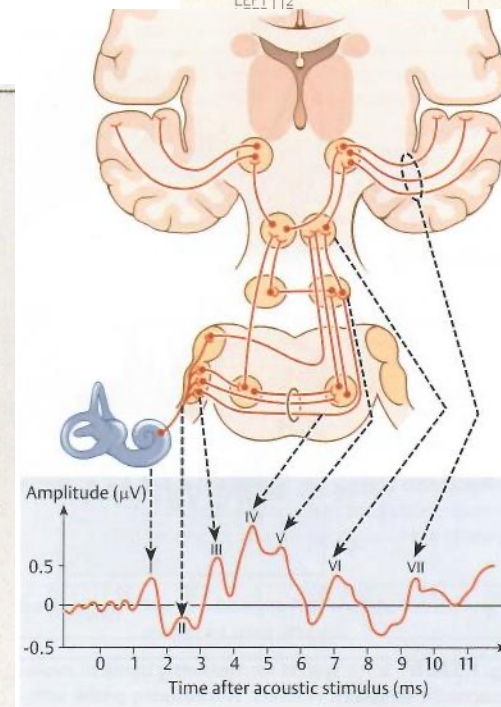
– prolonged latency of 0,2 ms – suspicion
on small schwannoma n. VIII



Patient repeatedly exposed to an acoustic stimulus, an EEG is recorded. **Averaging** – the individual response can be distinguished by mathematical analysis of numerous individual evoked potentials



SIDE	LABEL
LEFT	1/2
LEFT	



SENSITIVITY	SIDE	LABEL
100 $\mu\text{V}/\text{div}$	RIGHT	
100 $\mu\text{V}/\text{div}$	RIGHT	
100 $\mu\text{V}/\text{div}$	RIGHT	

Sensorineural hearing loss

According to type of audiometry curve:

- Basocochlear
- Pankochlear
- Apicocochlear
- Mediocochlear

**According to
lesion localisation:**

- Cochlear
- Retrocochlear





Cochlear lesion

- bothering, but not life threatening

Retrocochlear lesion

- bothering, but also they could life threaten



Sensorineural hearing loss (intra) cochlear

= damage of cochlear structures

Etiology:

- Presbycusis
- Heredo-degenerative
- Nois damage
- Toxic damage
- Menier´s disease
- Acute sensorineural hearing loss
- ... etc.



Sensorineural hearing loss retro- (supra-) cochlear

= damage of structures proximal from cochlea

Etiology:

Demyelization

- atherosclerosis
- sclerosis multiplex

Inflammation

- borreliosis
- neuro-viruses
- meningitis
- meningoencephalitis

Tumors

- vestibular schwannoma
- meningioma
- other tumors of cerebellar angle

Trauma

- commotion, contusion
- skull base fractures



Differential diagnosis cochlear/retrocochlear

1. Subjective tests:

- time demanding
- active cooperation of pt
- complicated for understanding
- relatively low validity

2. Objective tests :

- time usually not so demanding
- demand only passive patient cooperation
- expansive technical equipment
- high validity



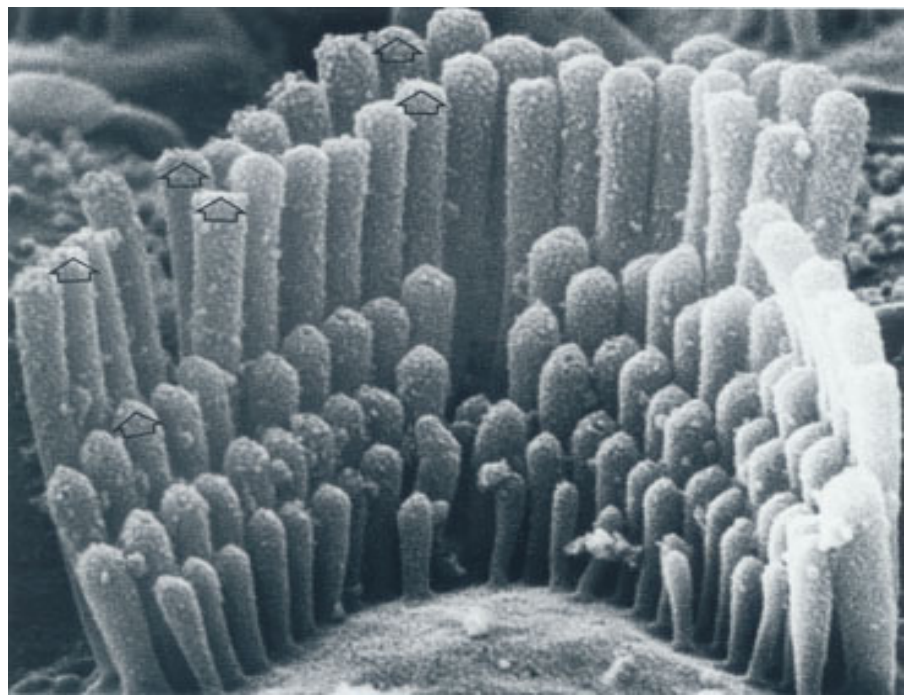
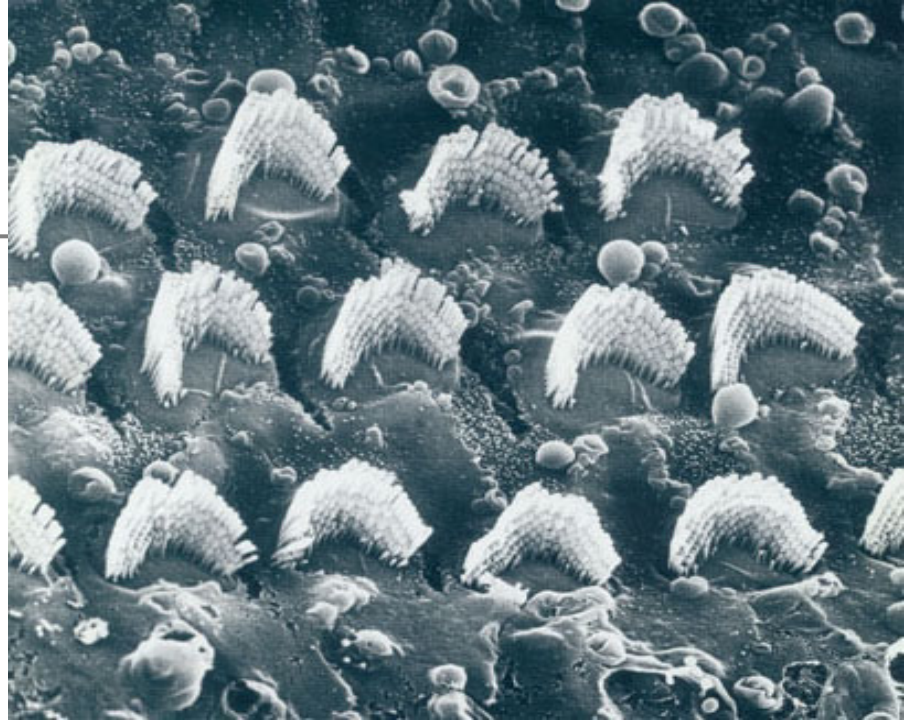
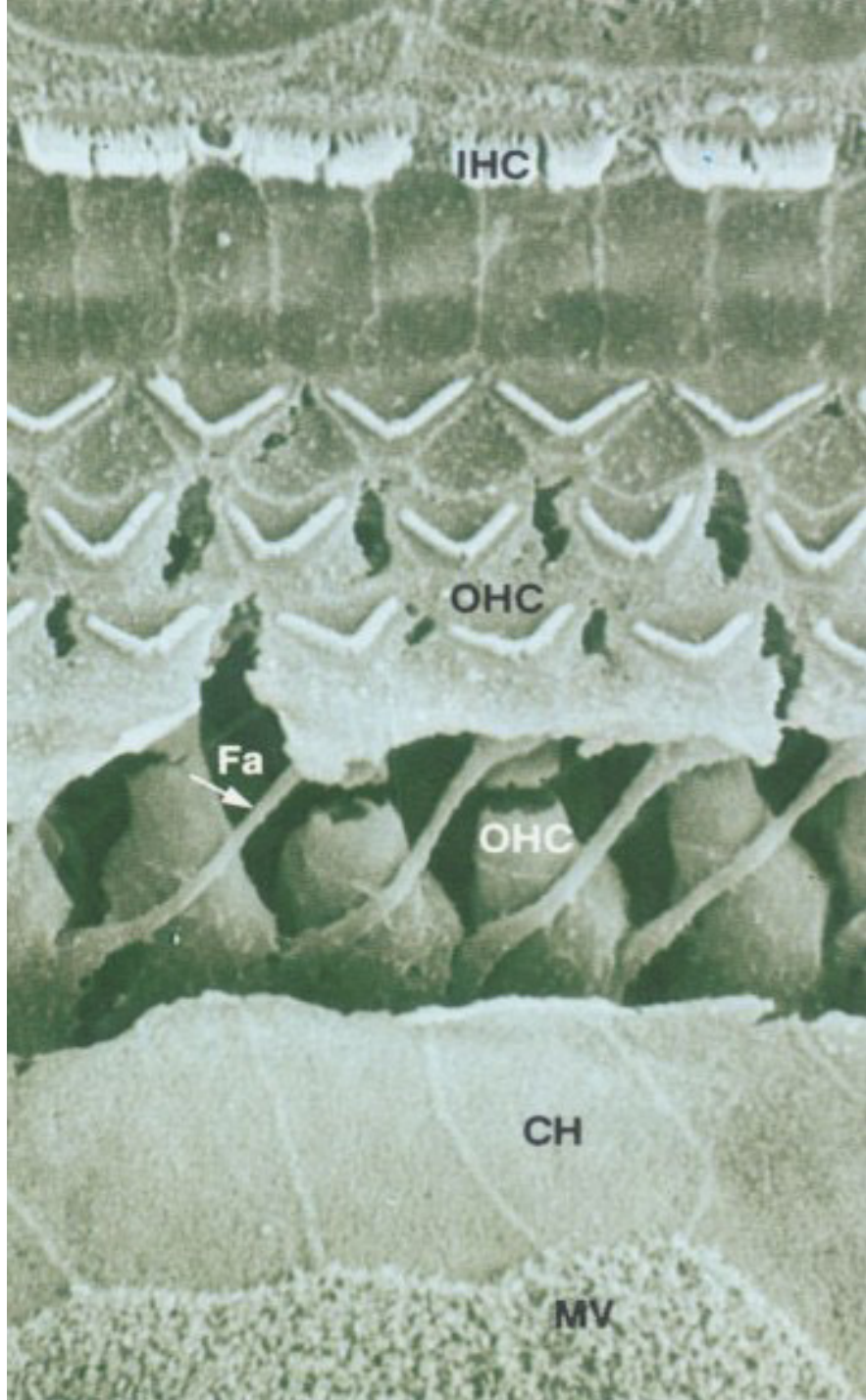
Subjective tests

Based on proof of:

mask effect of noise

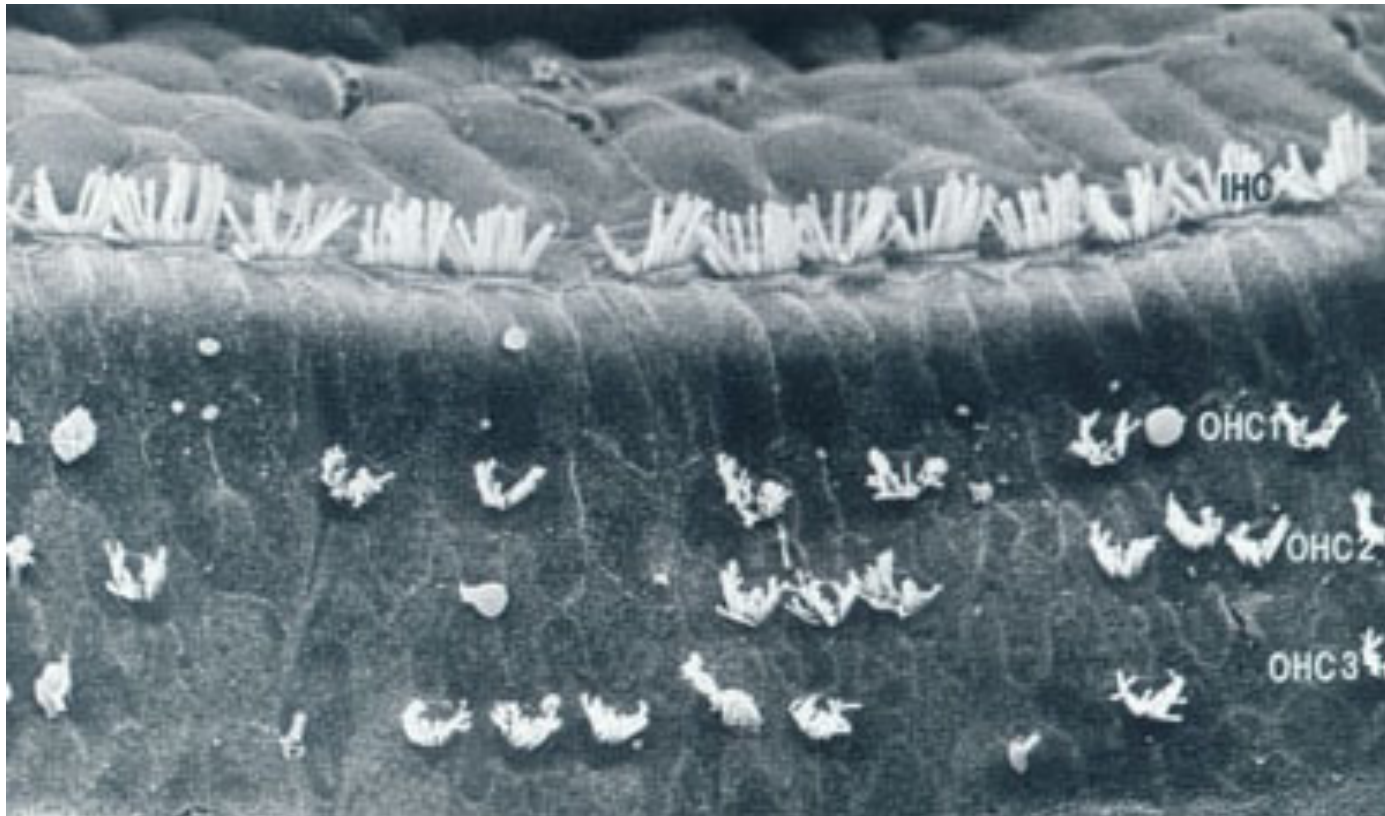
recruitment phenomena

wearisomeness of hearing organ



Recruitment phenomena

= abnormal increase of loudness in above-threshold in damage of OHC and normal function IHC

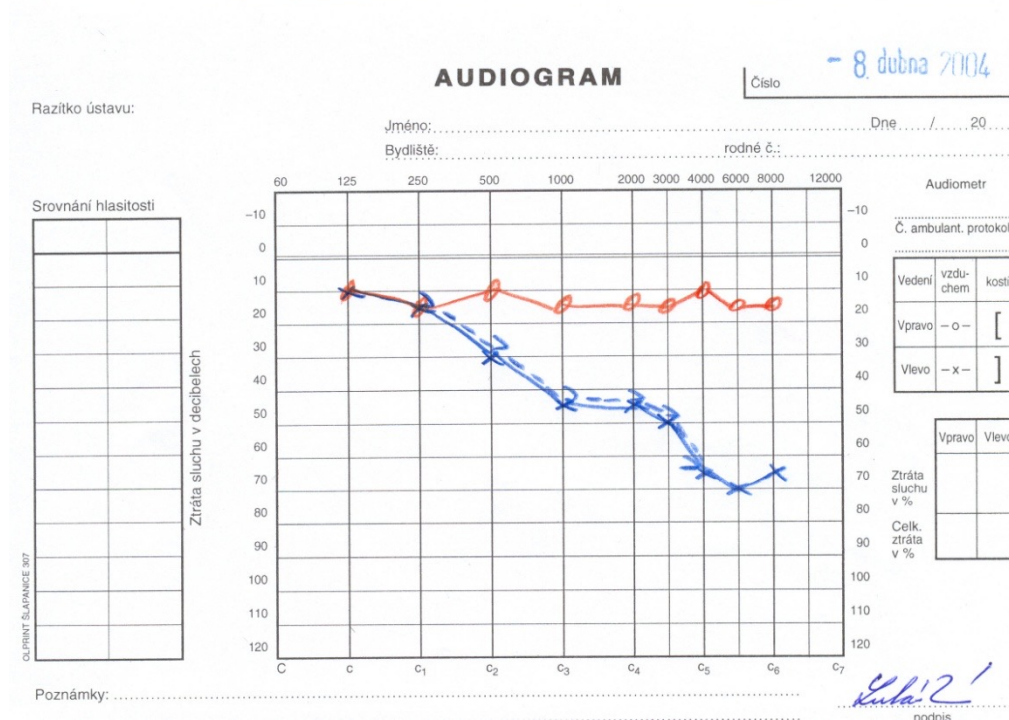
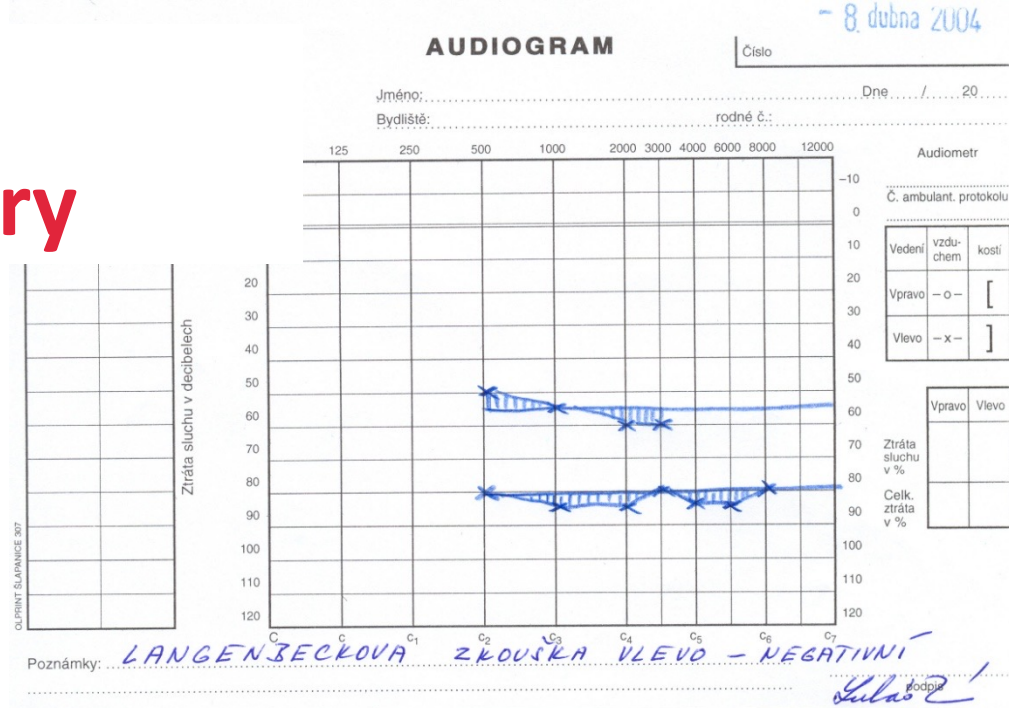




Noise audiometry

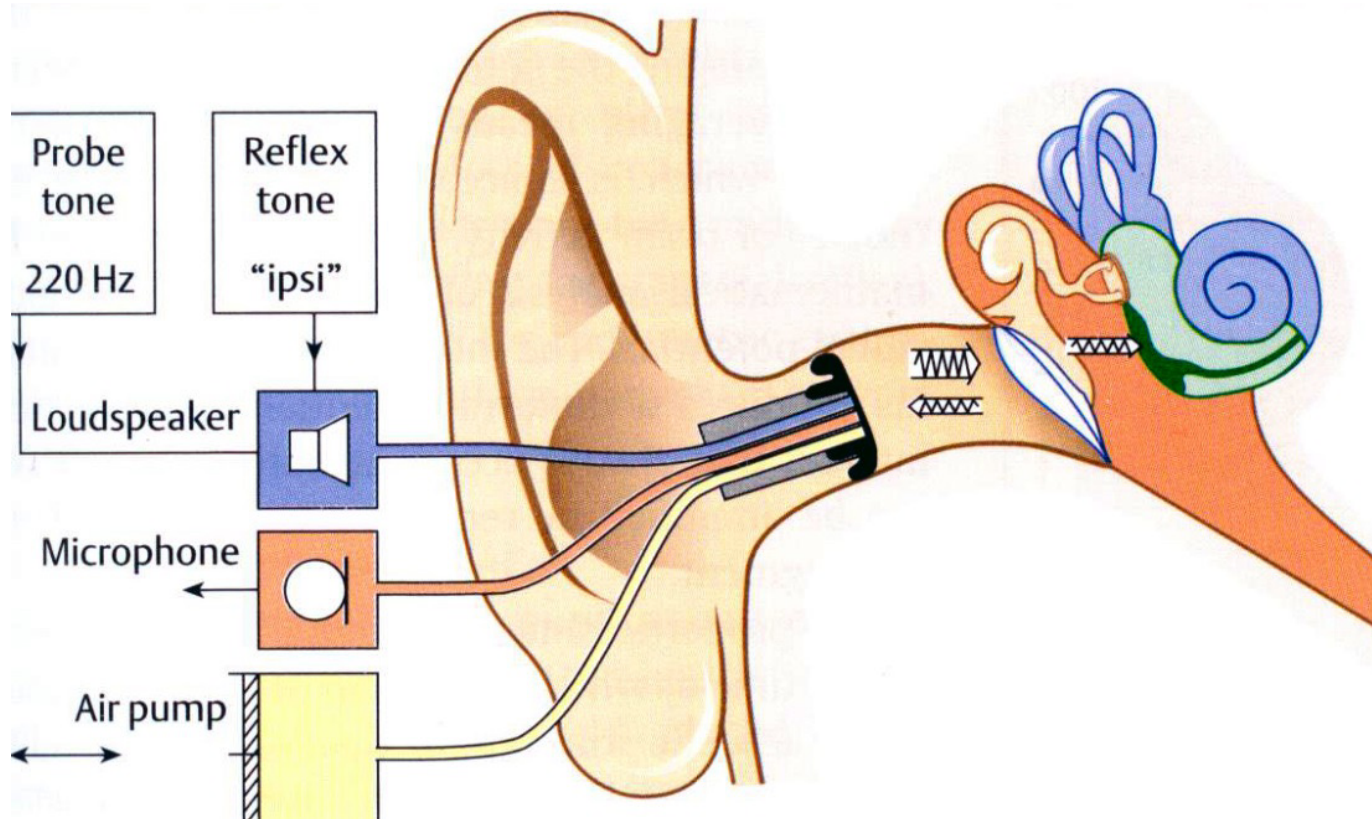
Langebeck test

= increase ability to mask tones by hum in supracochlear hearing loss. Thresholds are higher about more than 10 dB as level of ripple.



Tympanometry

The greater the pressure differential (before and behind ear drum), the greater is the impedance of tympanic membrane and **more acoustic energy is reflected back** into external meatus. The level of testing tone in meatus is measured by sensitive microphone .



Tympanometry

