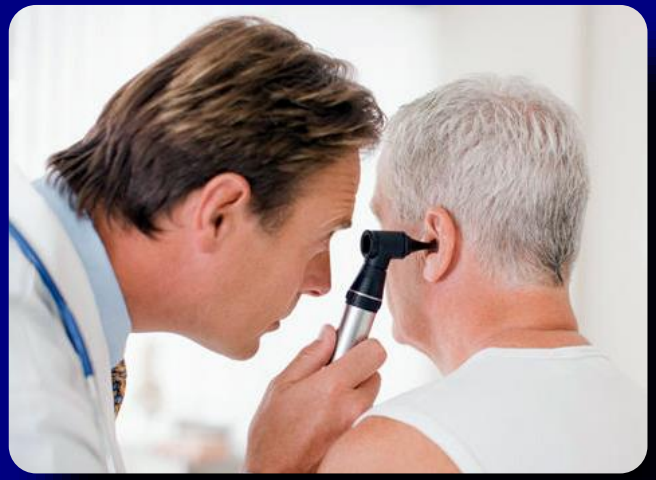
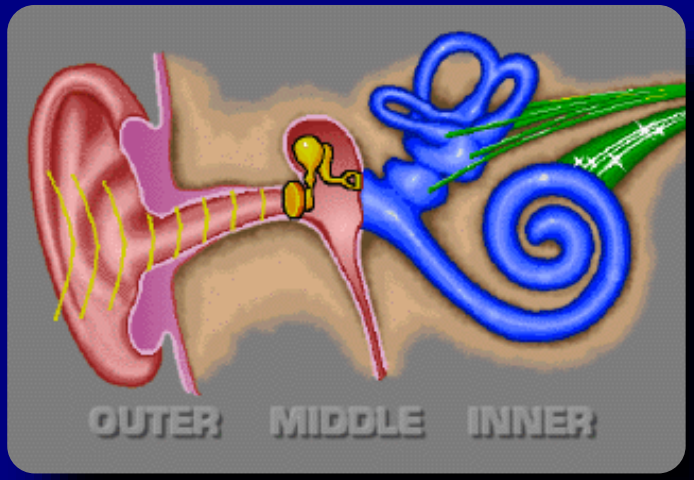
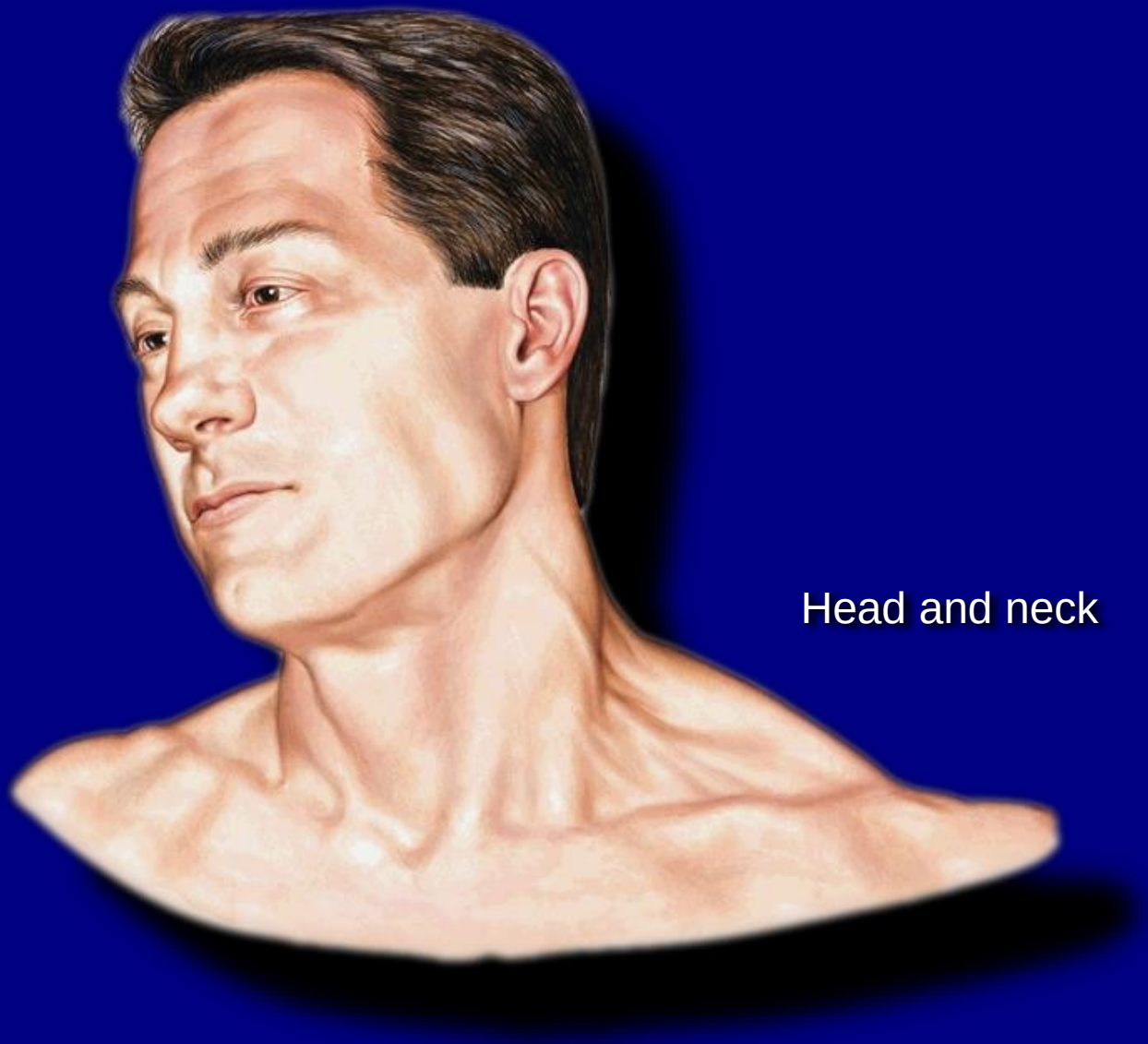
THE EAR – CLINICAL NOTES





Thieme F. Netter M.D. Sobotta GRAY'S Anatomy

THE BEAUTY OF VARIATION!

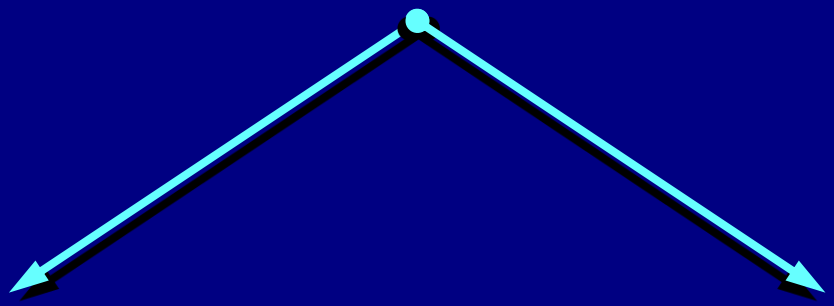


Head and neck

Human ear consists of:

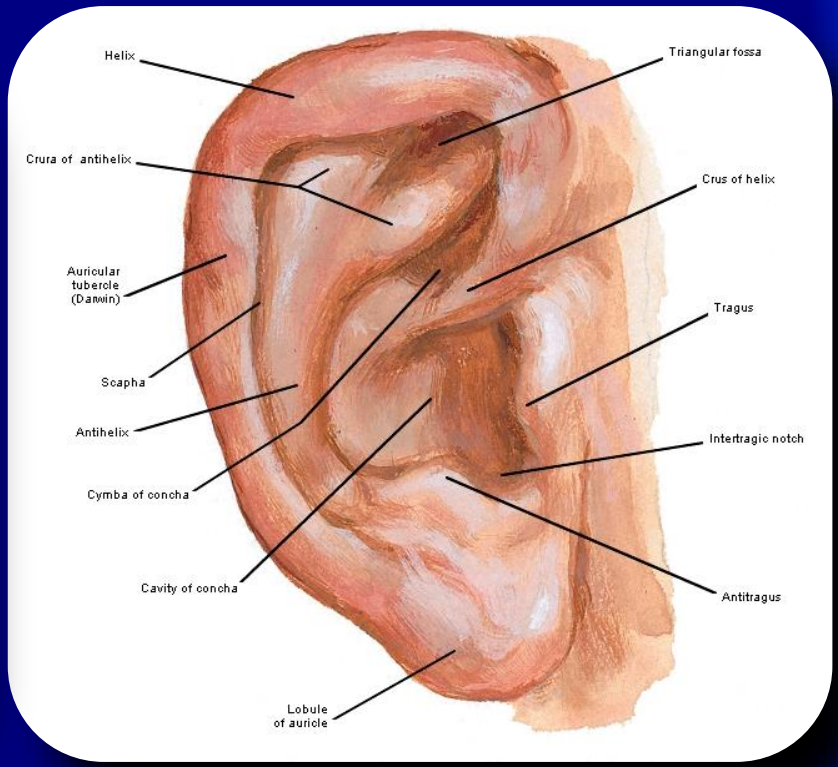
- external ear
- middle ear
- internal ear

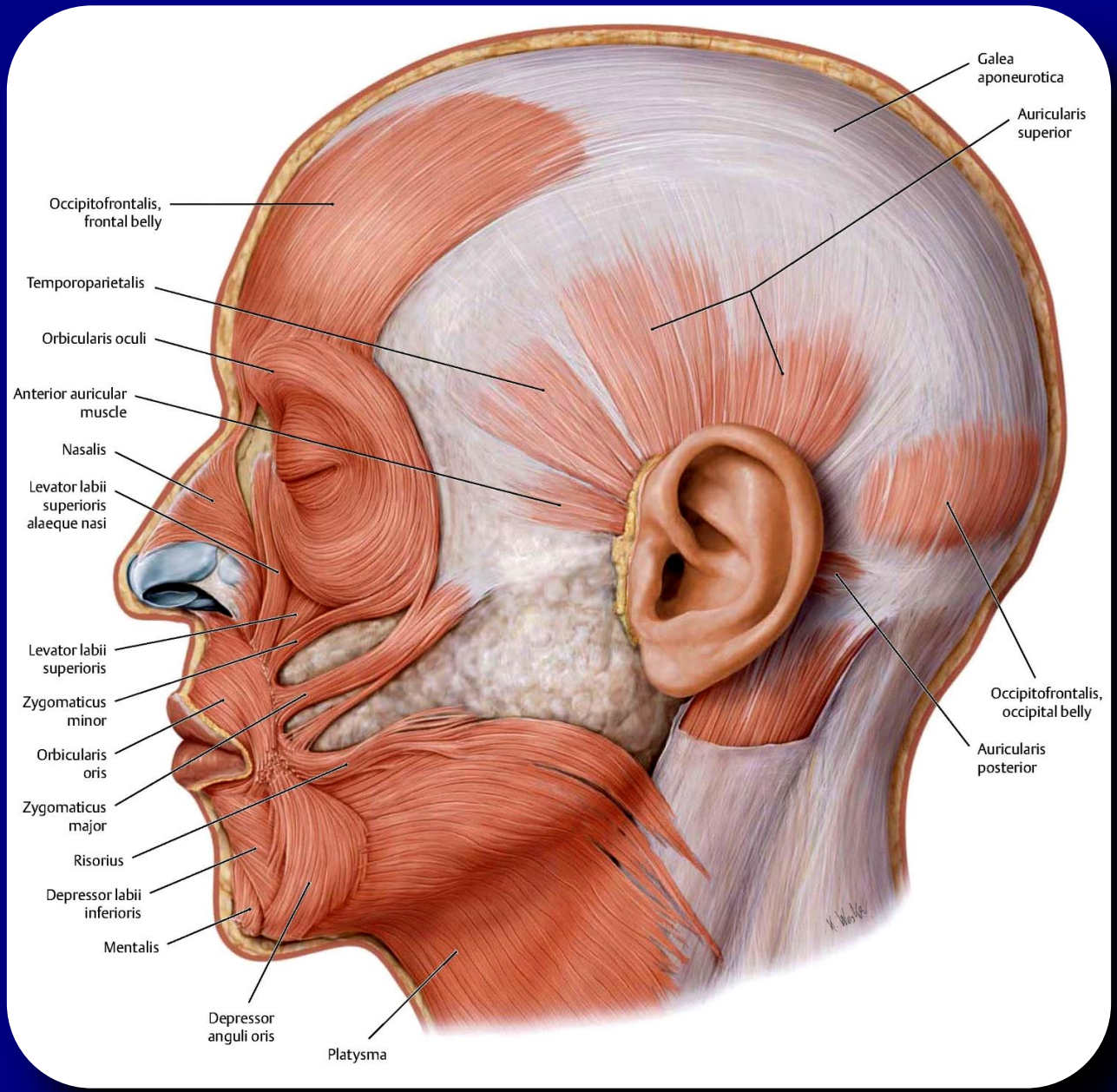
External ear

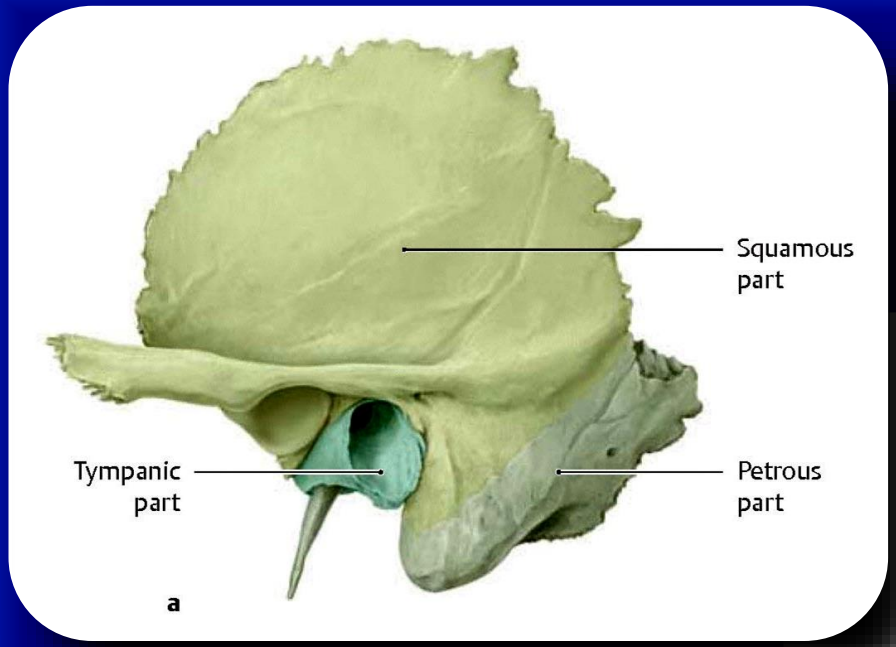


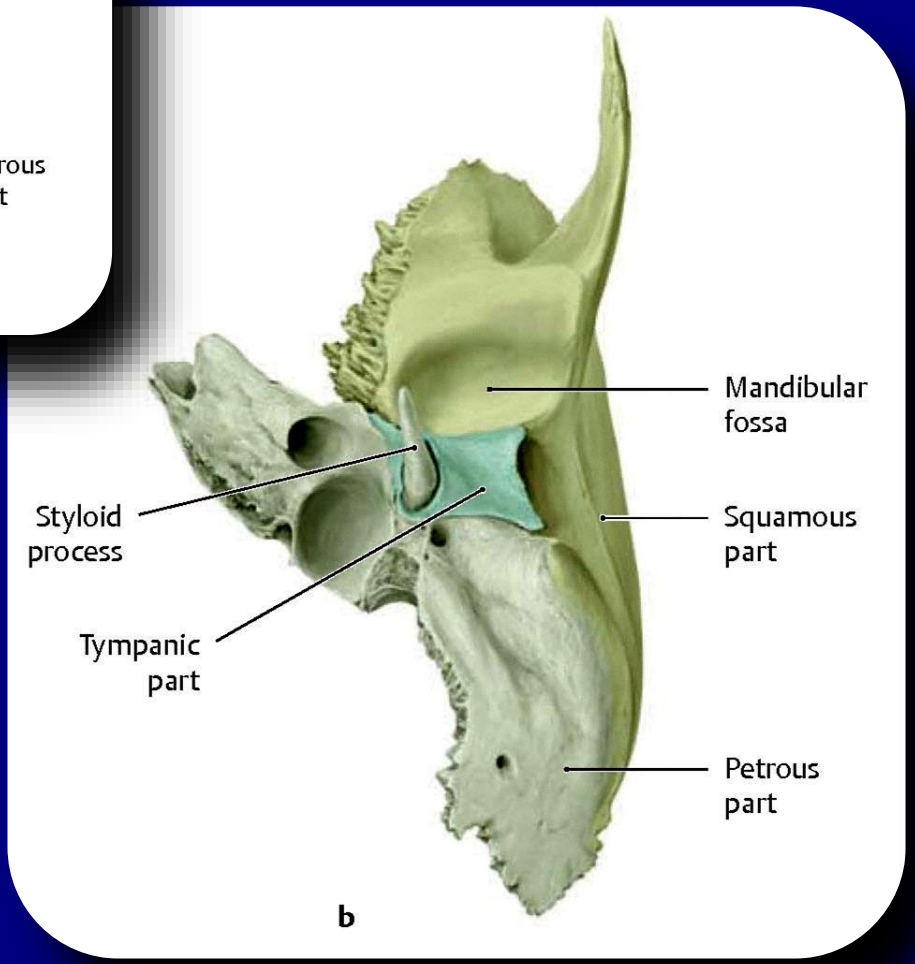
auricle

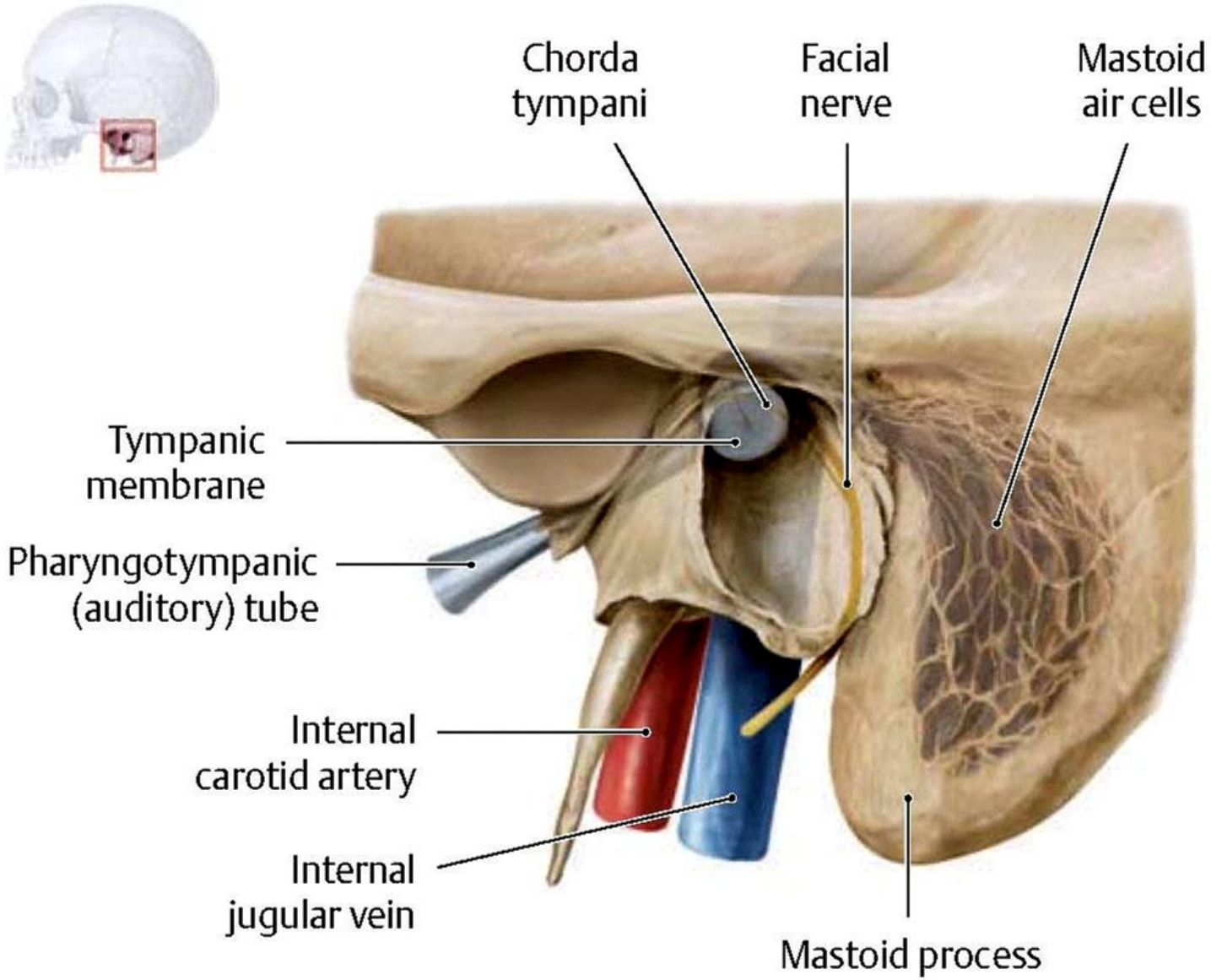
external auditory canal (meatus)

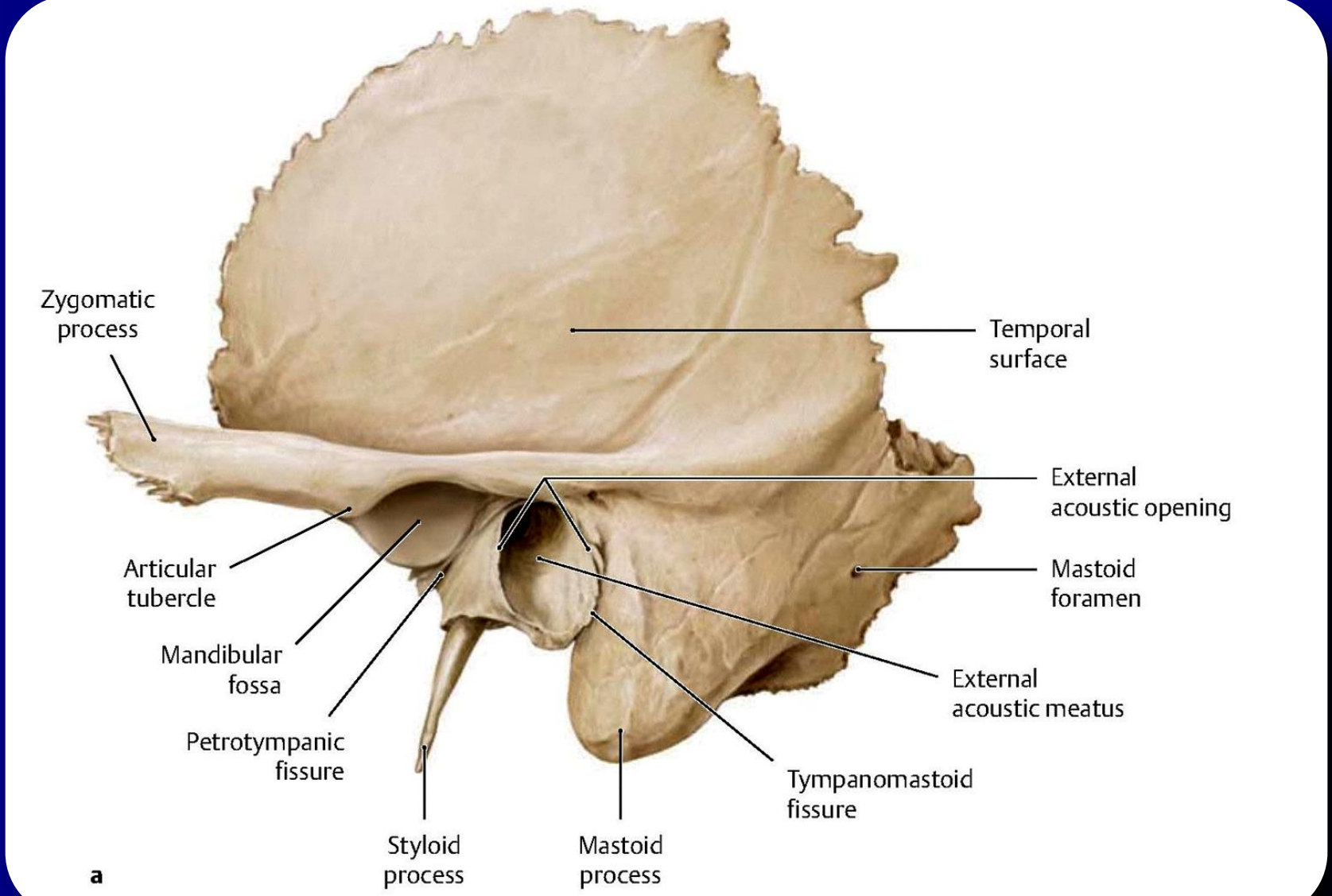

Helix
Triangular fossa
Crura of antihelix
Crus of helix
Auricular tubercle (Darwin)
Tragus
Scapha
Antihelix
Intertragic notch
Cymba of concha
Cavity of concha
Antitragus
Lobule of auricle

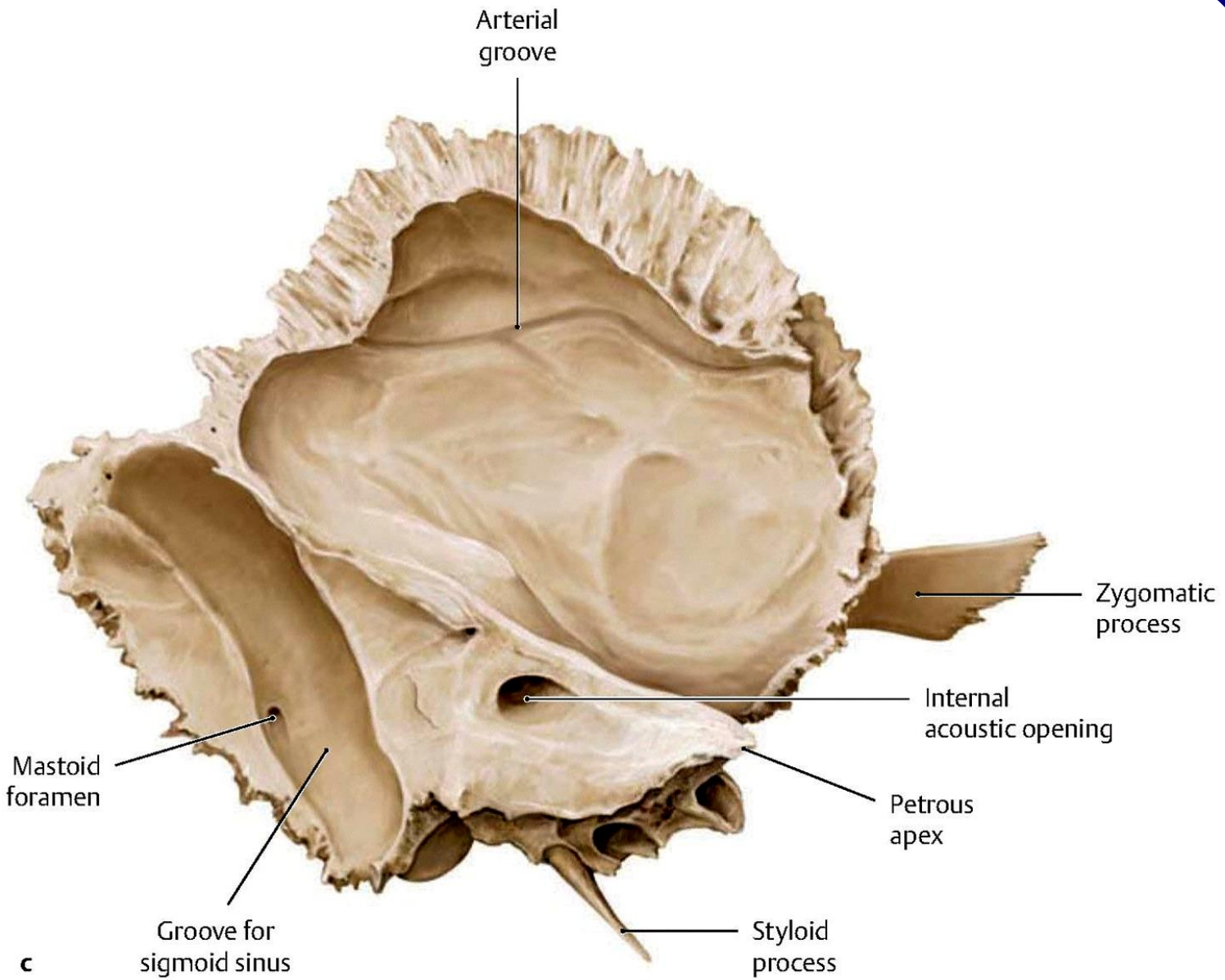

Galea aponeurotica
Auricularis superior
Occipitofrontalis, frontal belly
Temporoparietalis
Orbicularis oculi
Anterior auricular muscle
Nasalis
Levator labii superioris alaeque nasi
Levator labii superioris
Zygomaticus minor
Orbicularis oris
Zygomaticus major
Risorius
Depressor labii inferioris
Mentalis
Depressor anguli oris
Platysma
Occipitofrontalis, occipital belly
Auricularis posterior

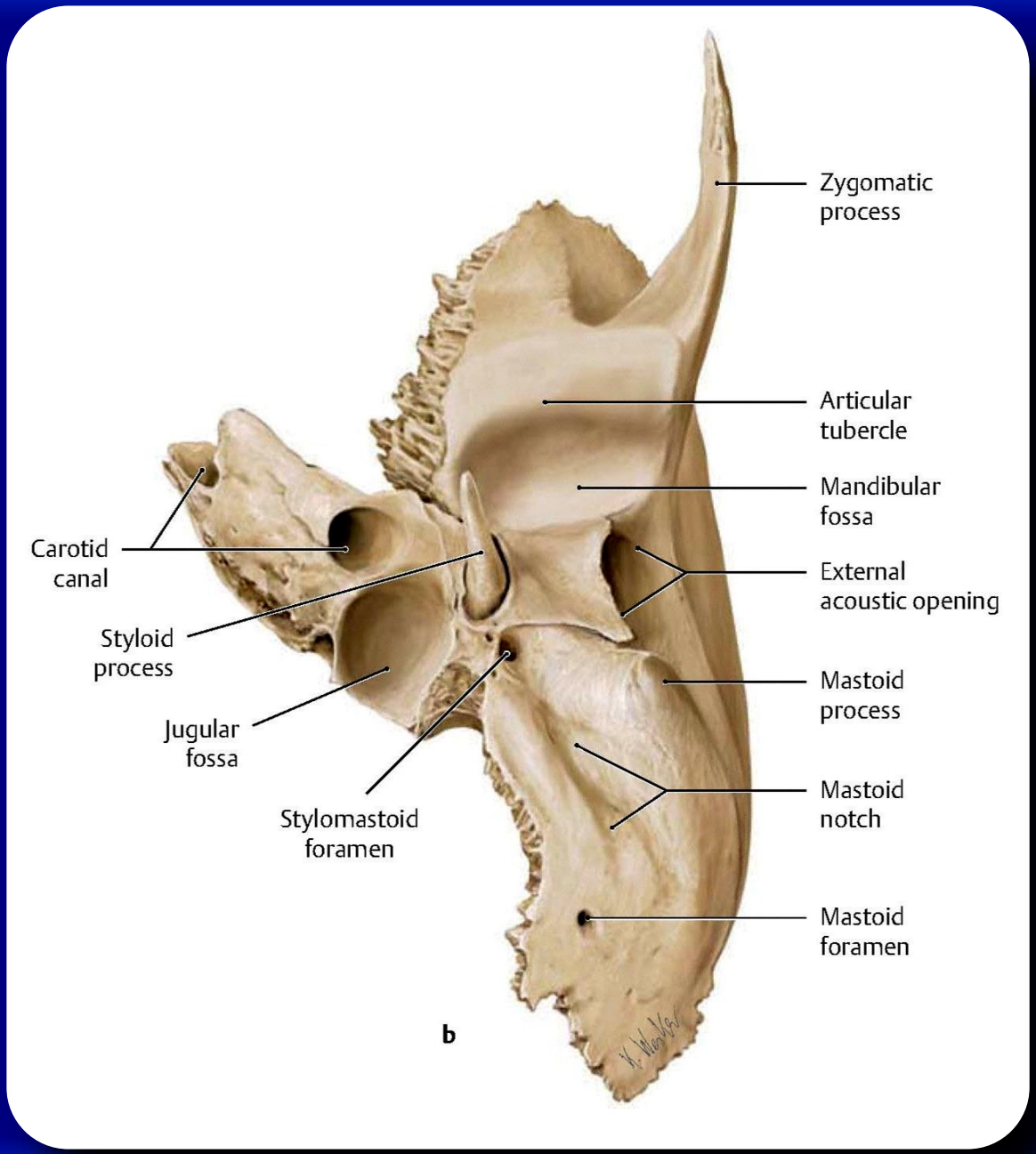

Squamous part
Tympanic part
Petrous part
a

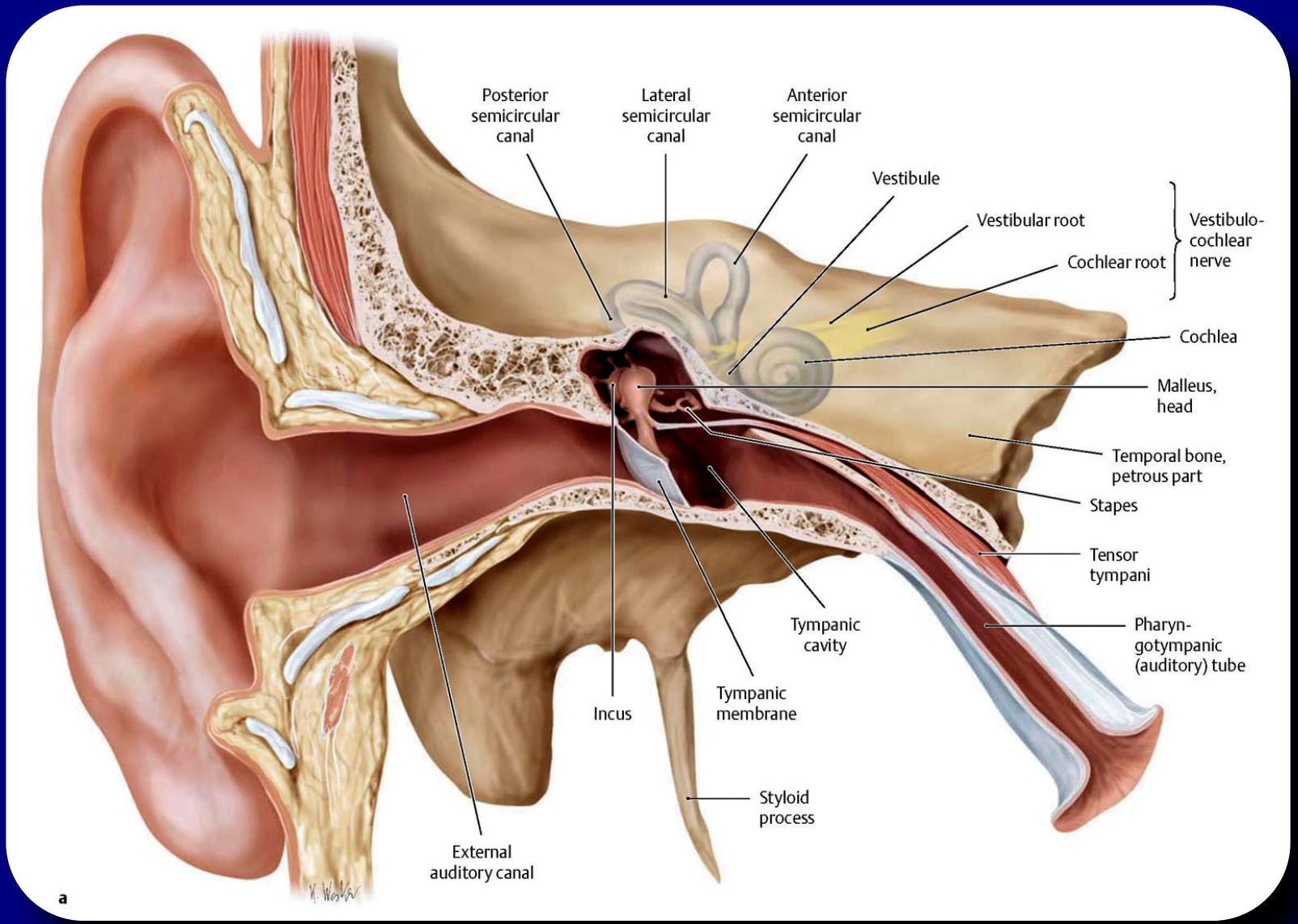

Mandibular fossa
Styloid process
Squamous part
Tympanic part
Petrous part
b


Chorda tympani
Facial nerve
Mastoid air cells
Tympanic membrane
Pharyngotympanic (auditory) tube
Internal carotid artery
Internal jugular vein
Mastoid process

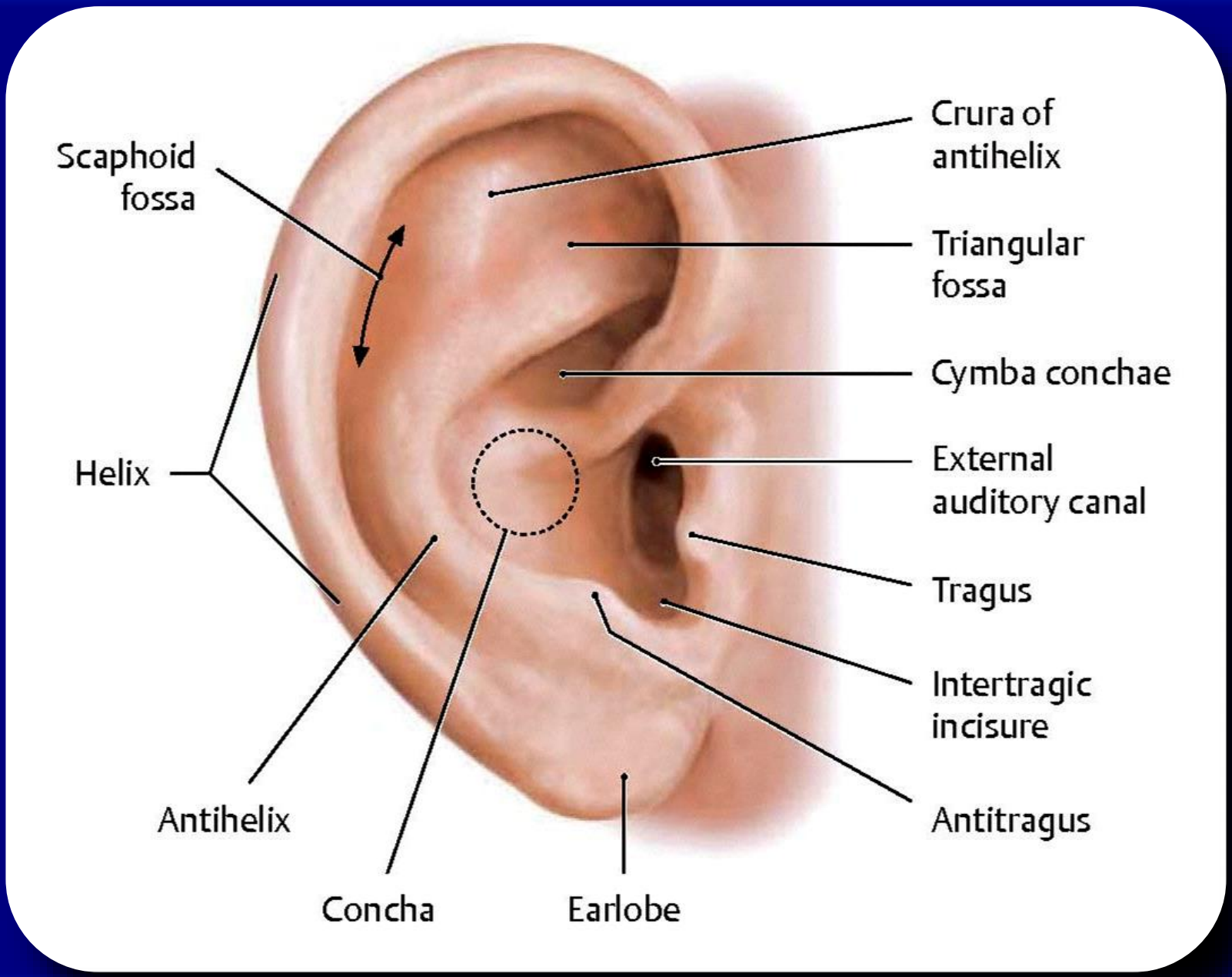

Zygomatic process
Temporal surface
External acoustic opening
Articular tubercle
Mastoid foramen
Mandibular fossa
External acoustic meatus
Petrotympanic fissure
Tympanomastoid fissure
Styloid process
Mastoid process
a

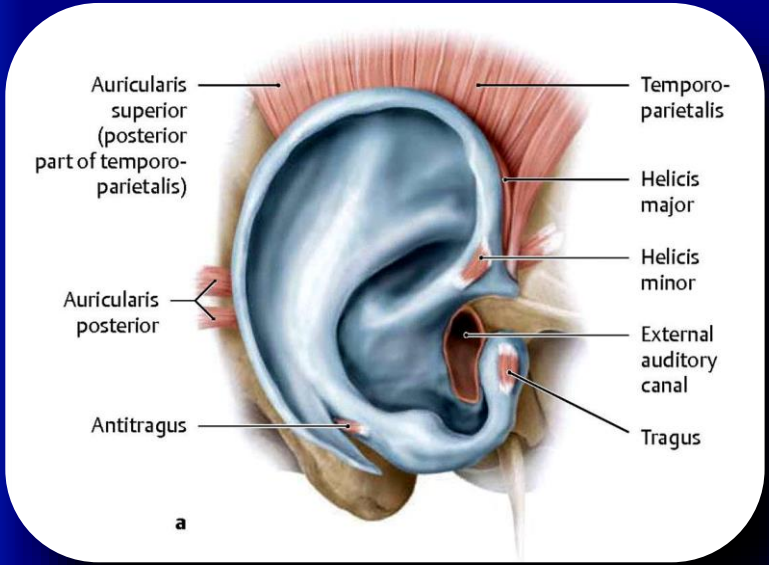

Arterial groove
Zygomatic process
Internal acoustic opening
Mastoid foramen
Petrous apex
Groove for sigmoid sinus
Styloid process
c

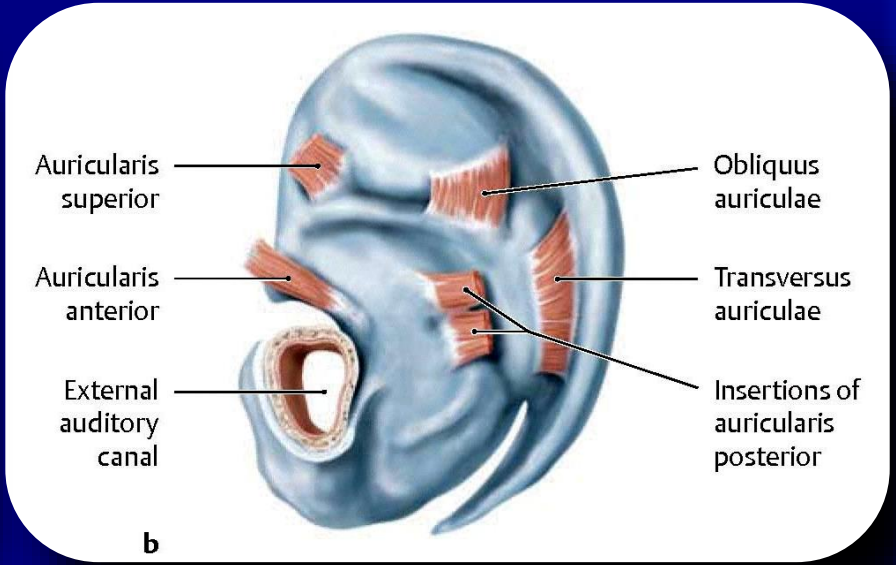

Zygomatic process
Articular tubercle
Mandibular fossa
External acoustic opening
Mastoid process
Mastoid notch
Mastoid foramen
Carotid canal
Styloid process
Jugular fossa
Stylomastoid foramen
b



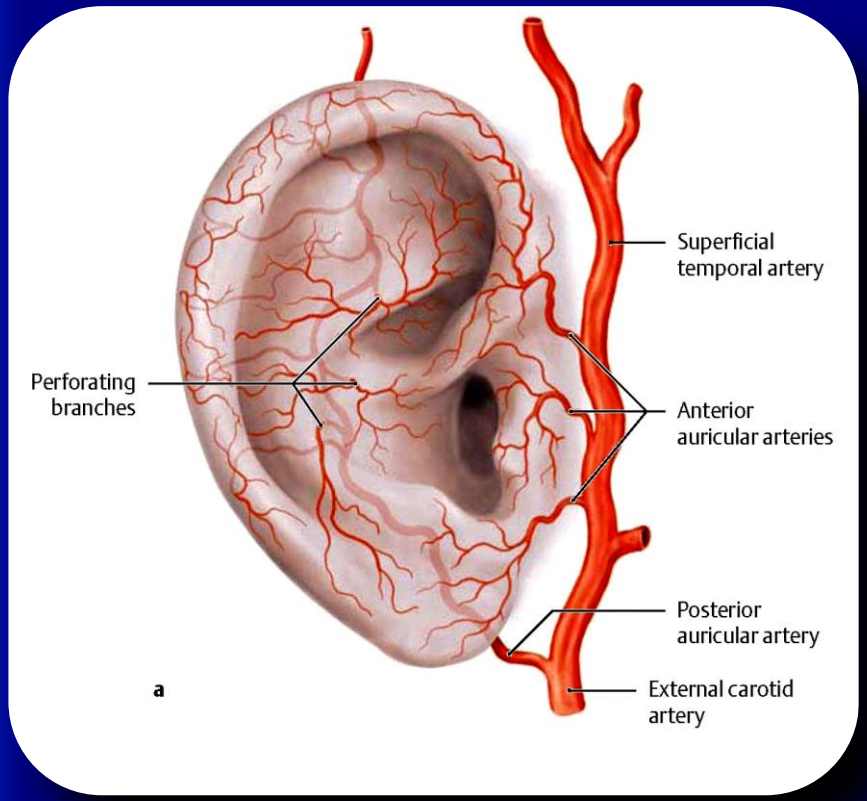
Auditory and vestibular apparatus in situ

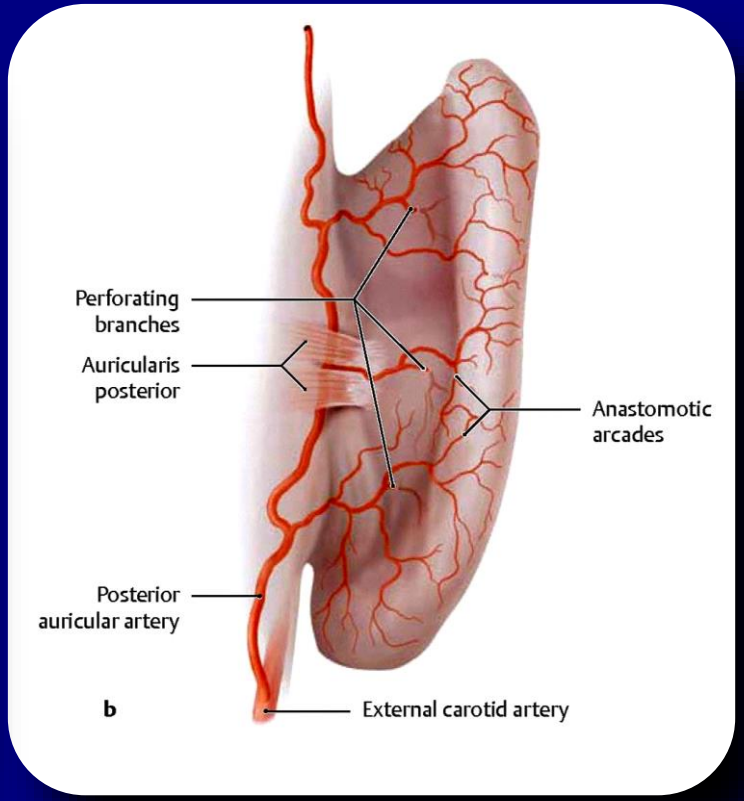

Scaphoid fossa
Crura of antihelix
Triangular fossa
Cymba conchae
Helix
External auditory canal
Tragus
Intertragic incisure
Antihelix
Antitragus
Concha
Earlobe



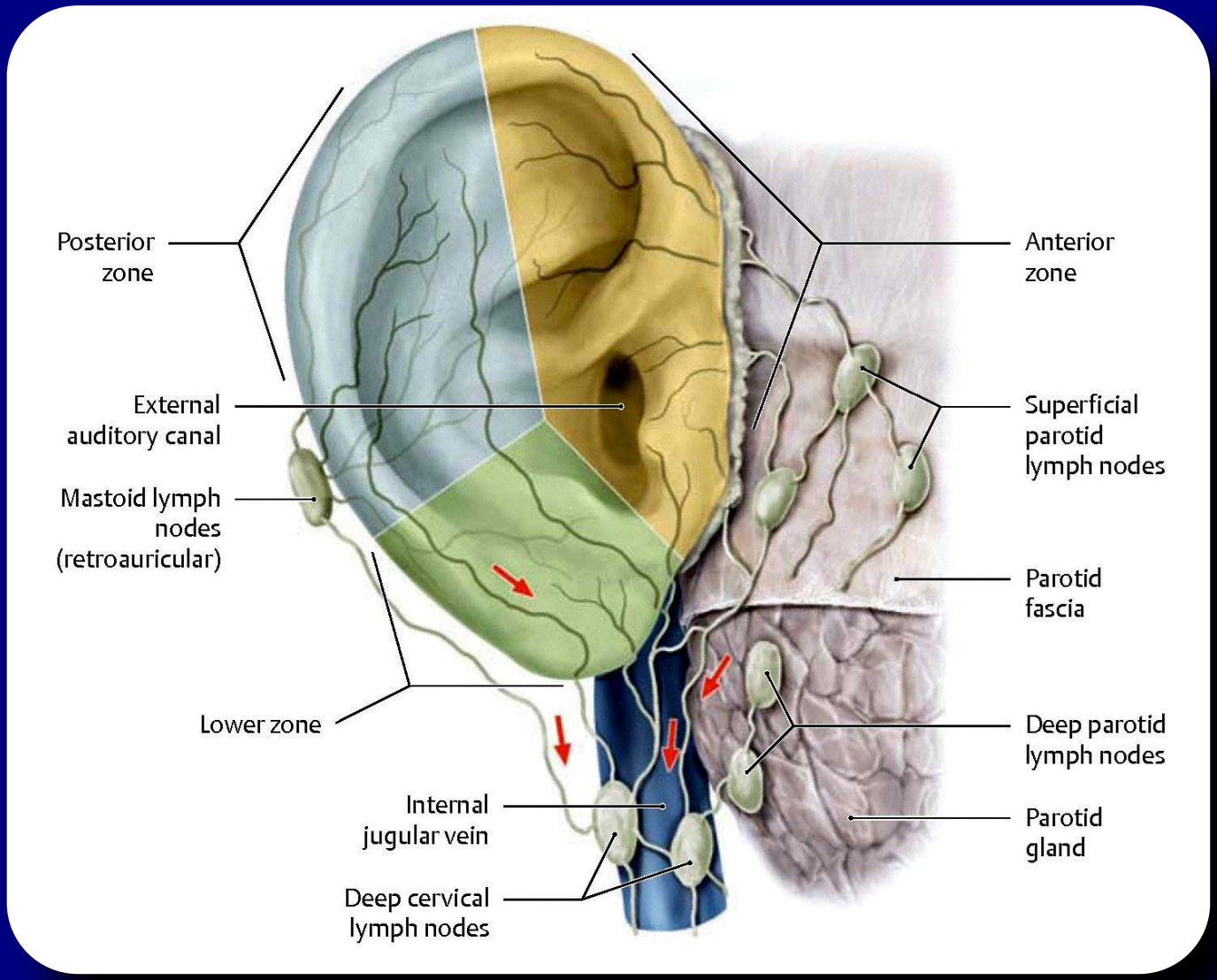


Cartilage and muscles of the auricle

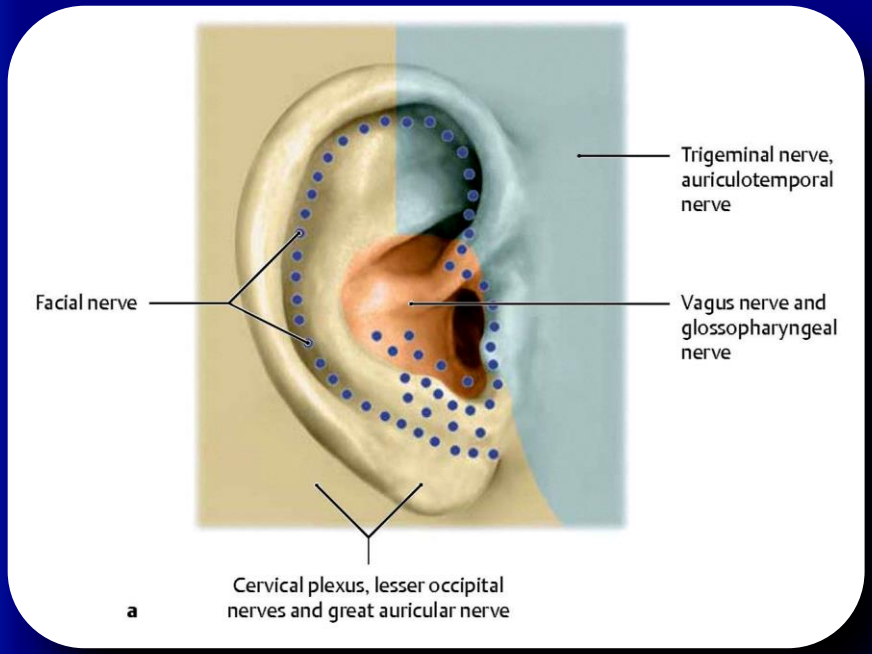


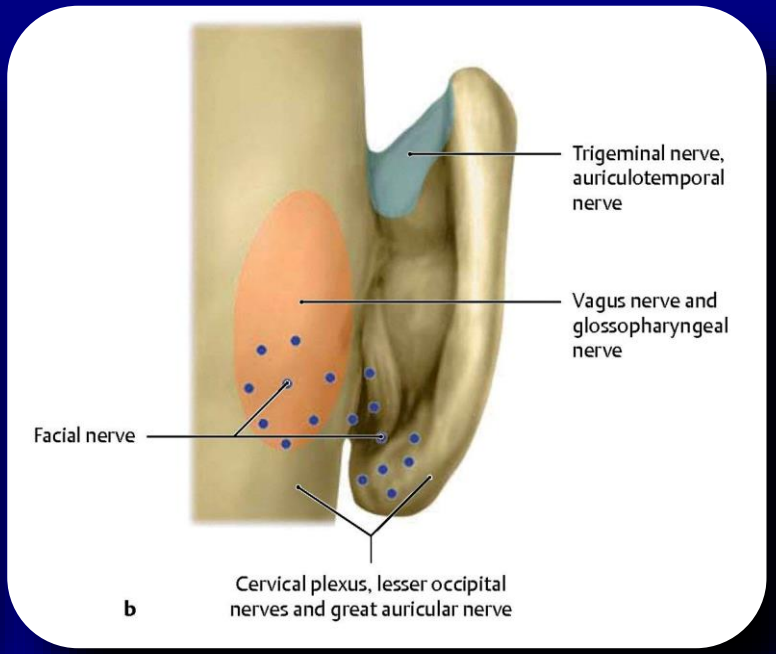


Arterial supply of the right auricle



Auricle and external auditory canal: lymphatic drainage and regional groups of lymph nodes





Sensory innervation of the auricle

Grade 1

Smaller than normal, but the ear has mostly normal anatomy

Grade 2

Part of the ear looks normal, usually the lower half

The canal may be normal, small or completely closed

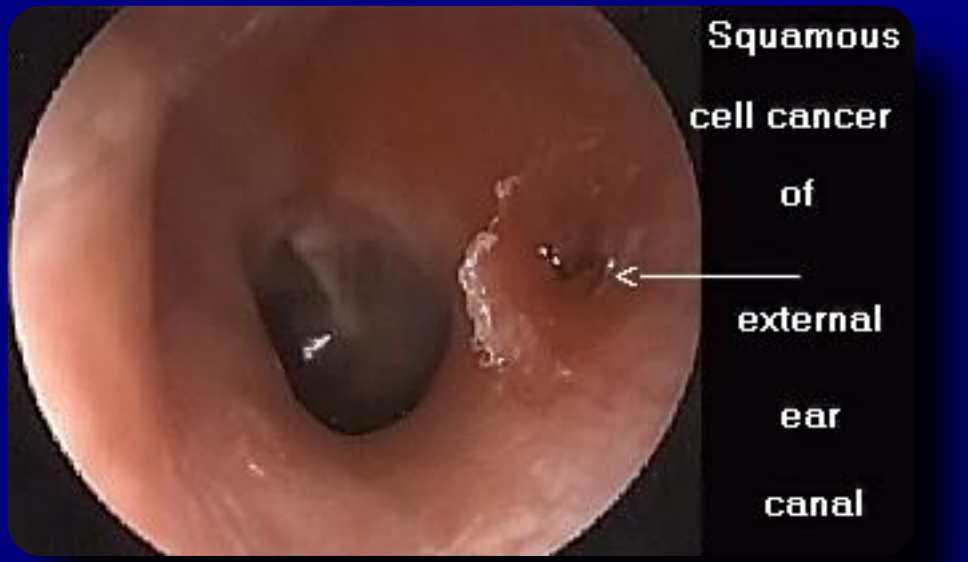
Grade 3

Just a small remnant of "peanut-shaped" skin and cartilage

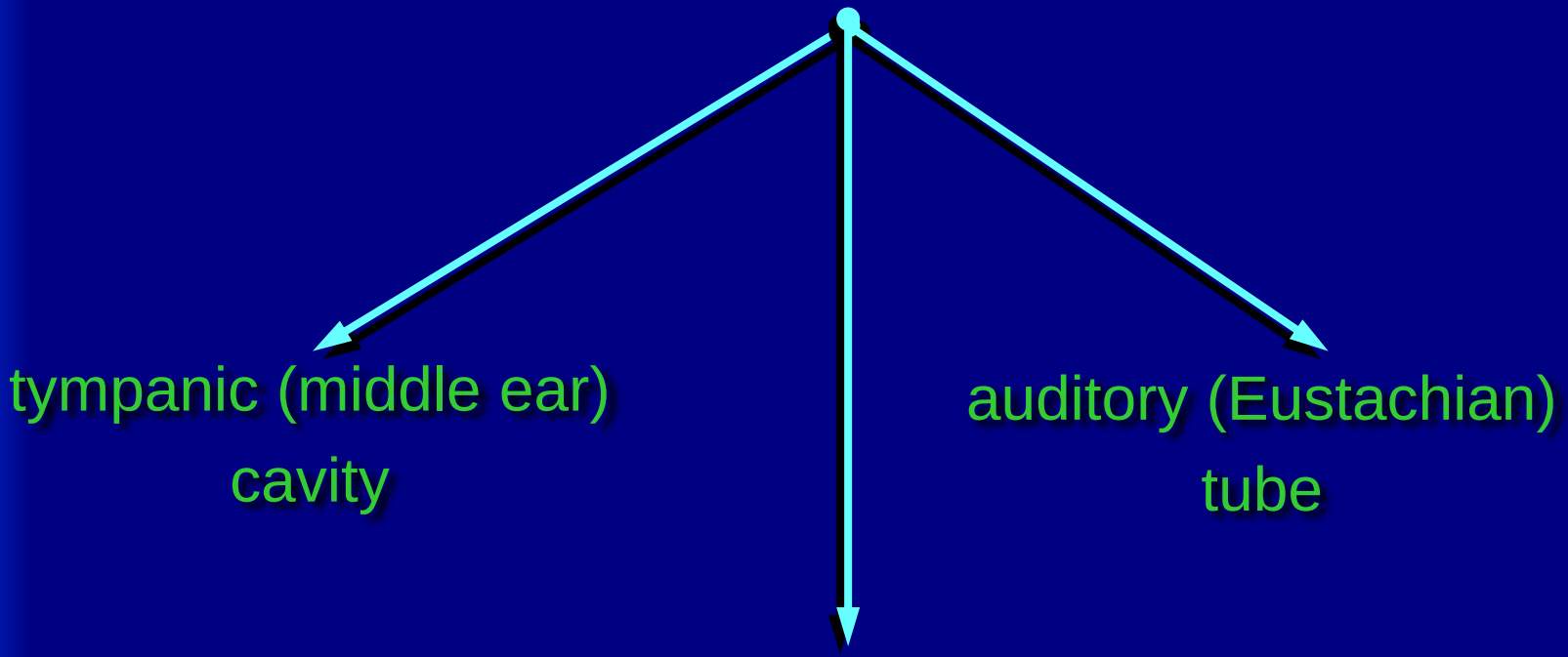
There is no canal, which is called aural atresia

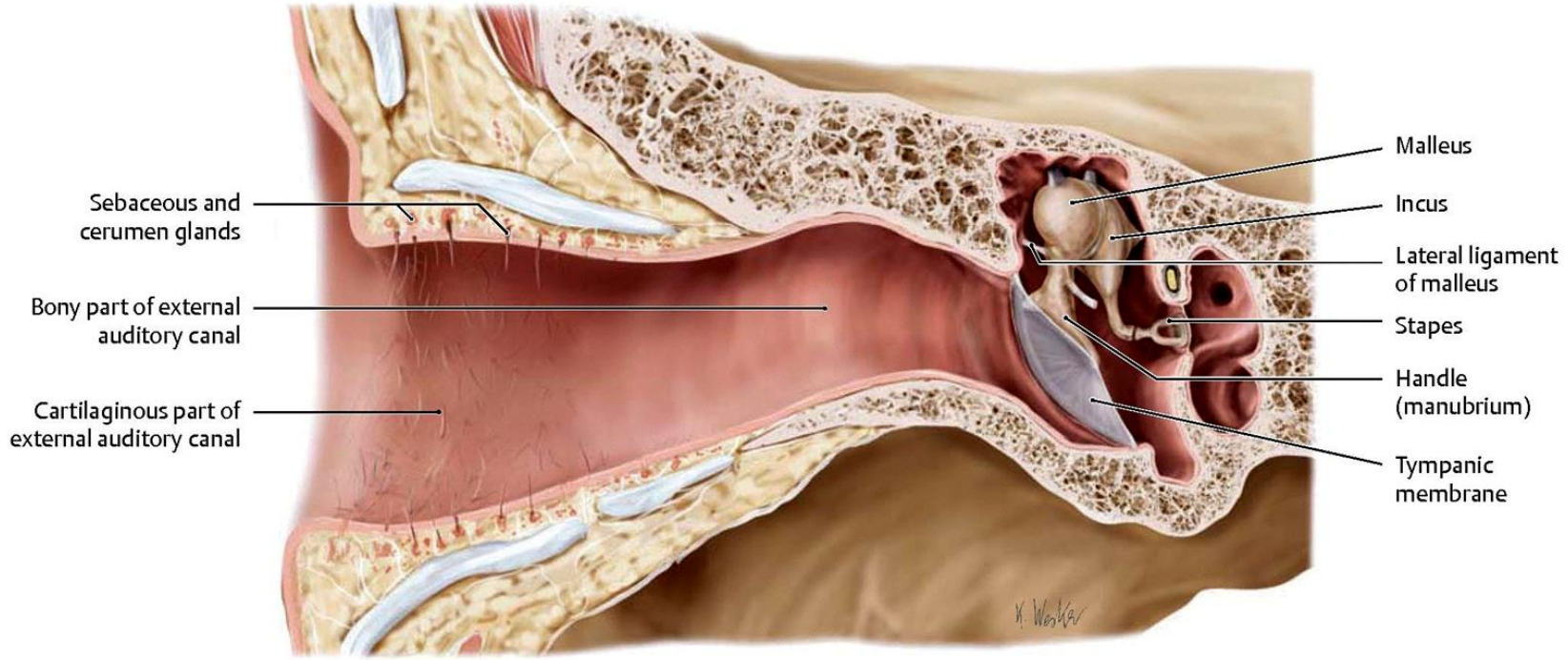
Grade 4

Complete absence of both the external ear and the ear canal, also called "anotia"

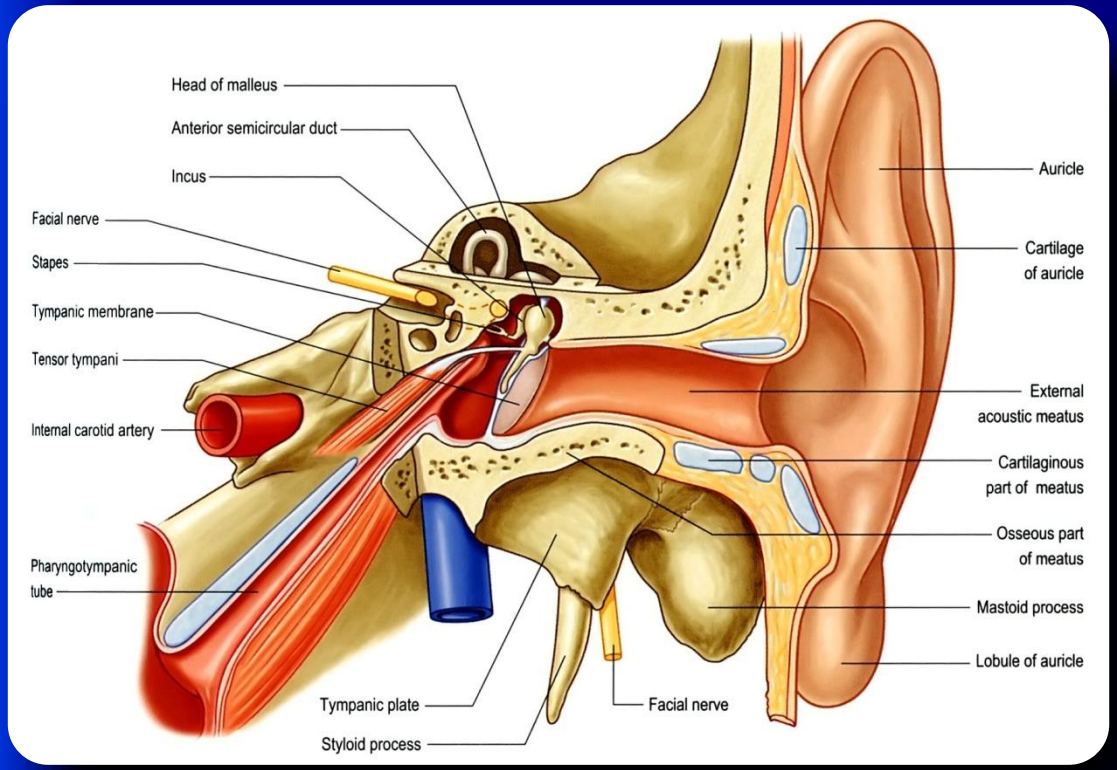

Squamous
cell cancer
of
external
ear
canal

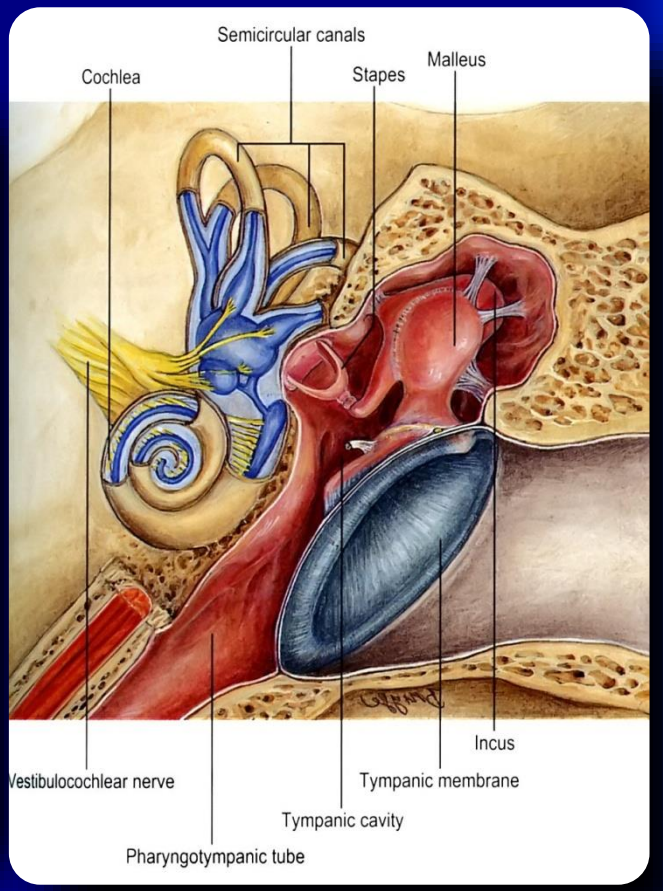
Middle ear consists of:

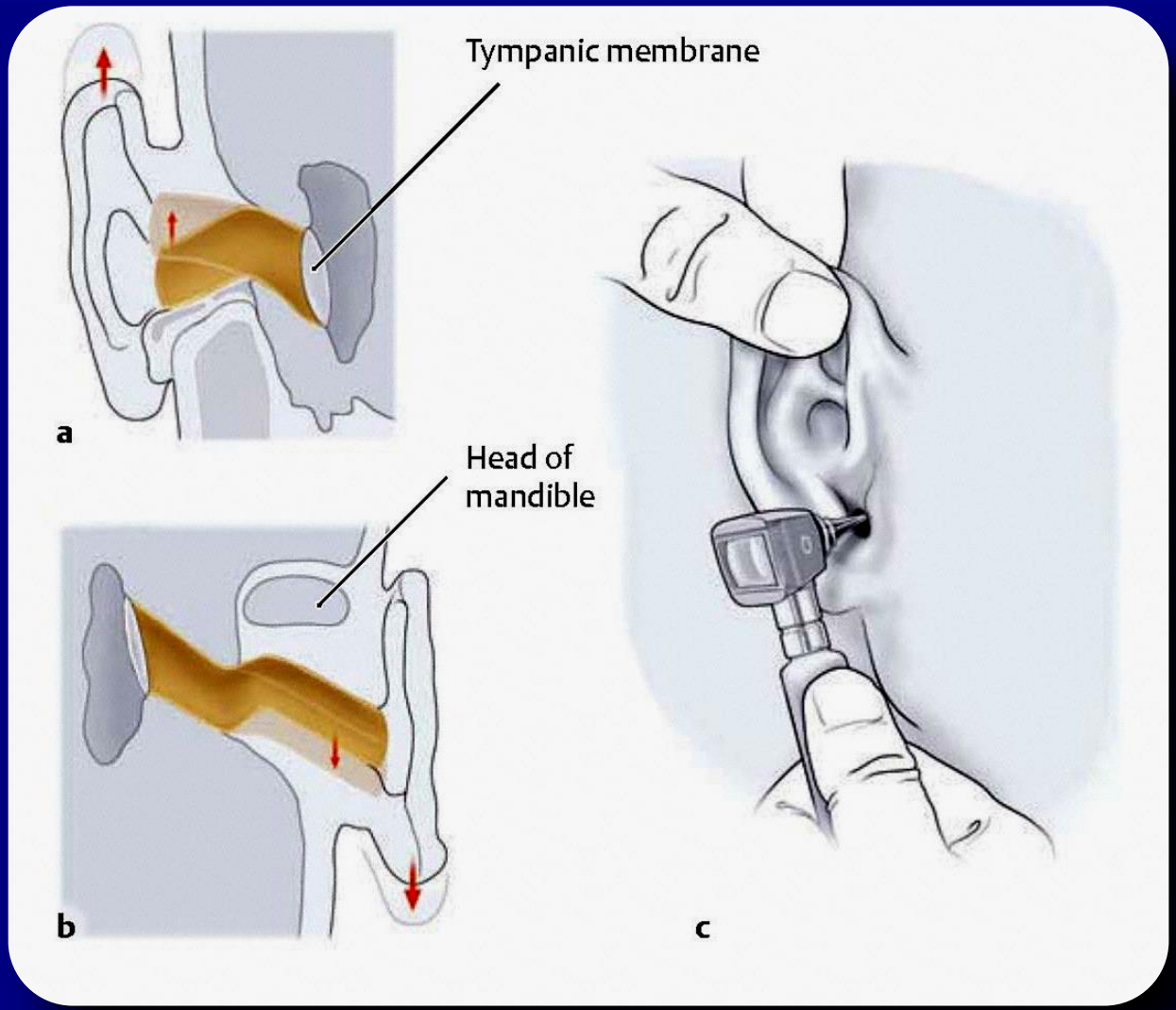




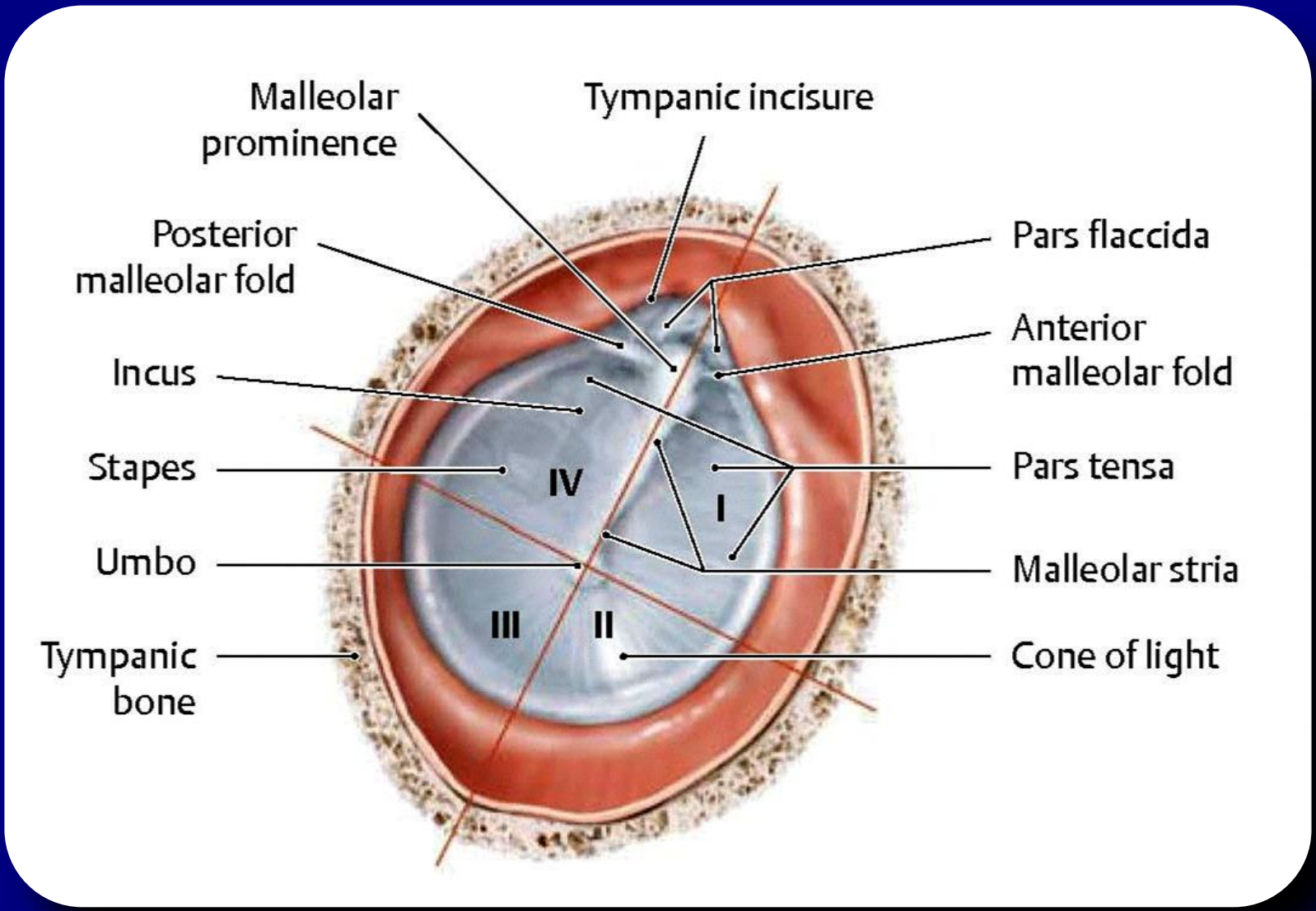
External auditory canal, tympanic membrane, and tympanic cavity


Head of malleus
Anterior semicircular duct
Incus
Facial nerve
Stapes
Tympanic membrane
Tensor tympani
Internal carotid artery
Pharyngotympanic tube
Tympanic plate
Styloid process
Facial nerve
Auricle
Cartilage of auricle
External acoustic meatus
Cartilaginous part of meatus
Osseous part of meatus
Mastoid process
Lobule of auricle

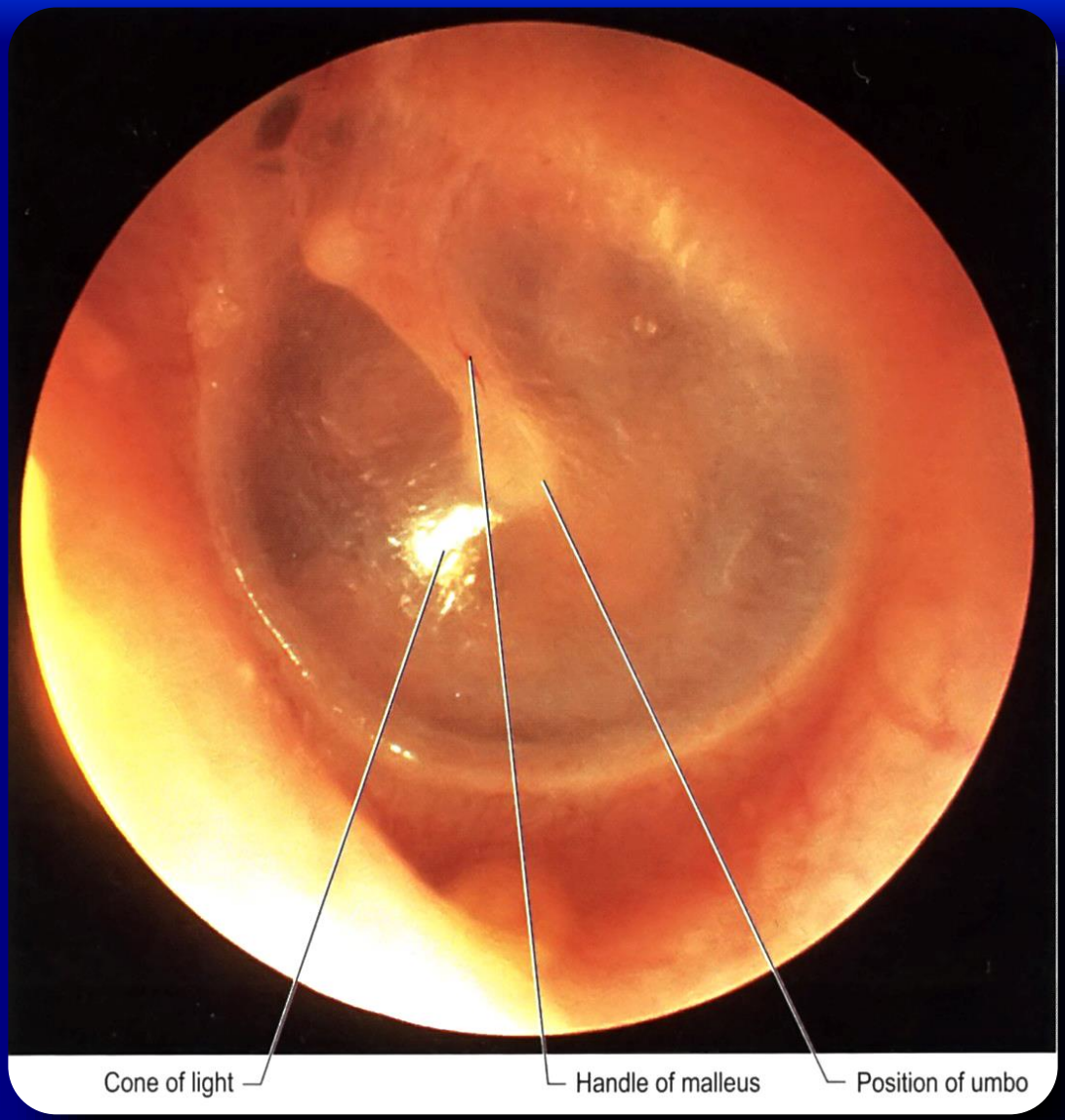

Semicircular canals
Cochlea
Stapes
Malleus
Incus
Vestibulocochlear nerve
Tympanic membrane
Tympanic cavity
Pharyngotympanic tube



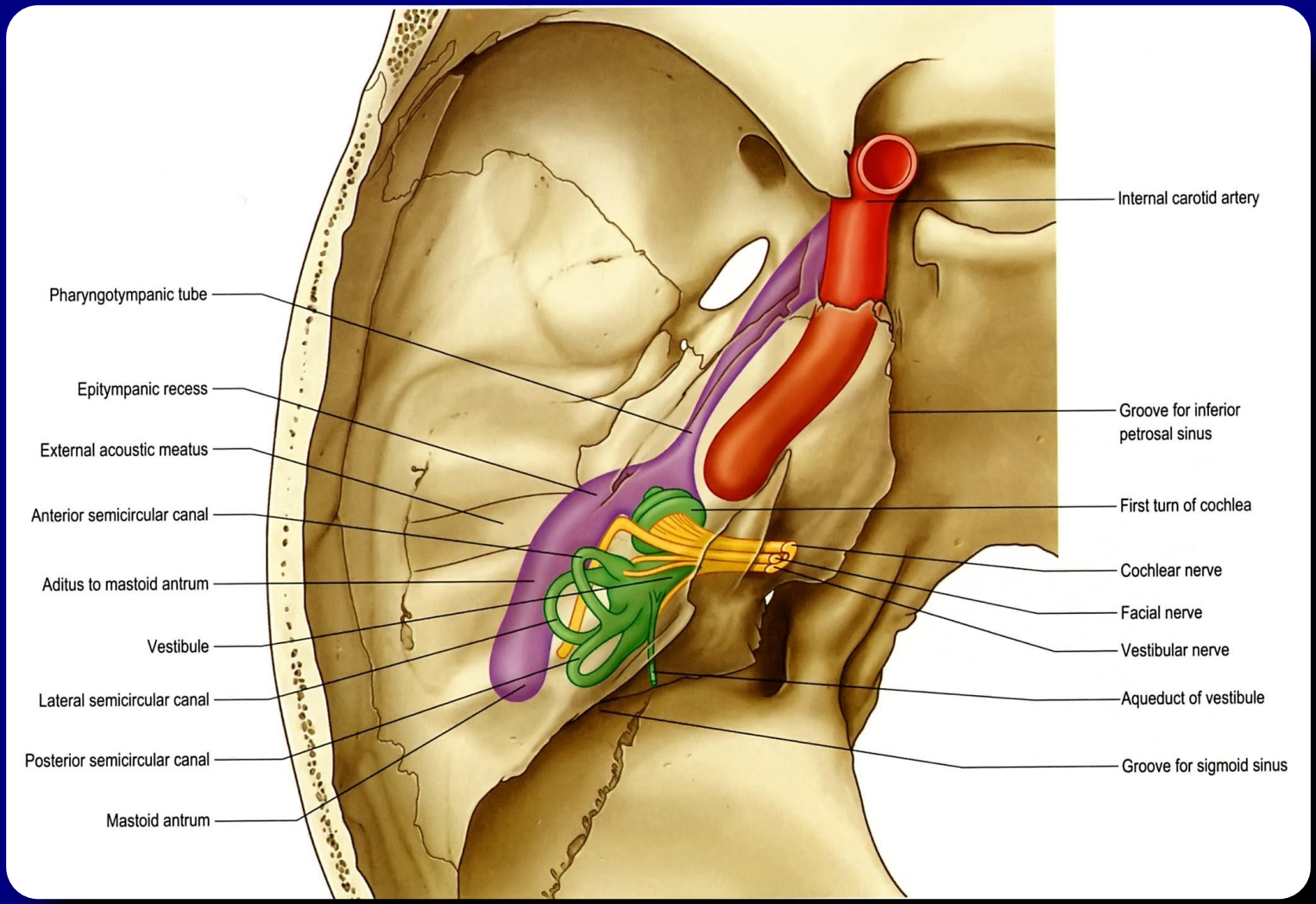
Curvature of the external auditory canal



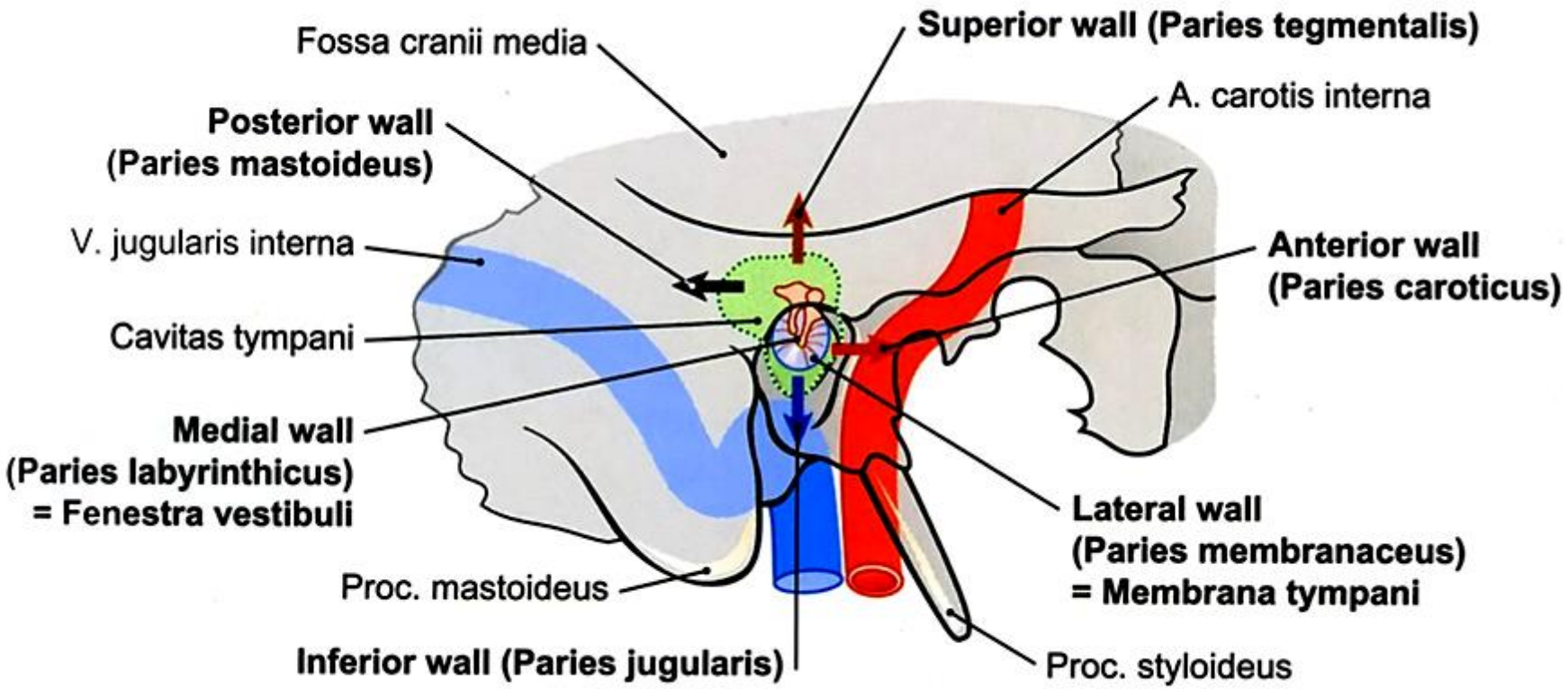
Tympanic membrane



Auroscopic view of left tympanic membrane. Note that a bright cone of light is seen in the anteroinferior quadrant of the membrane when it is illuminated.

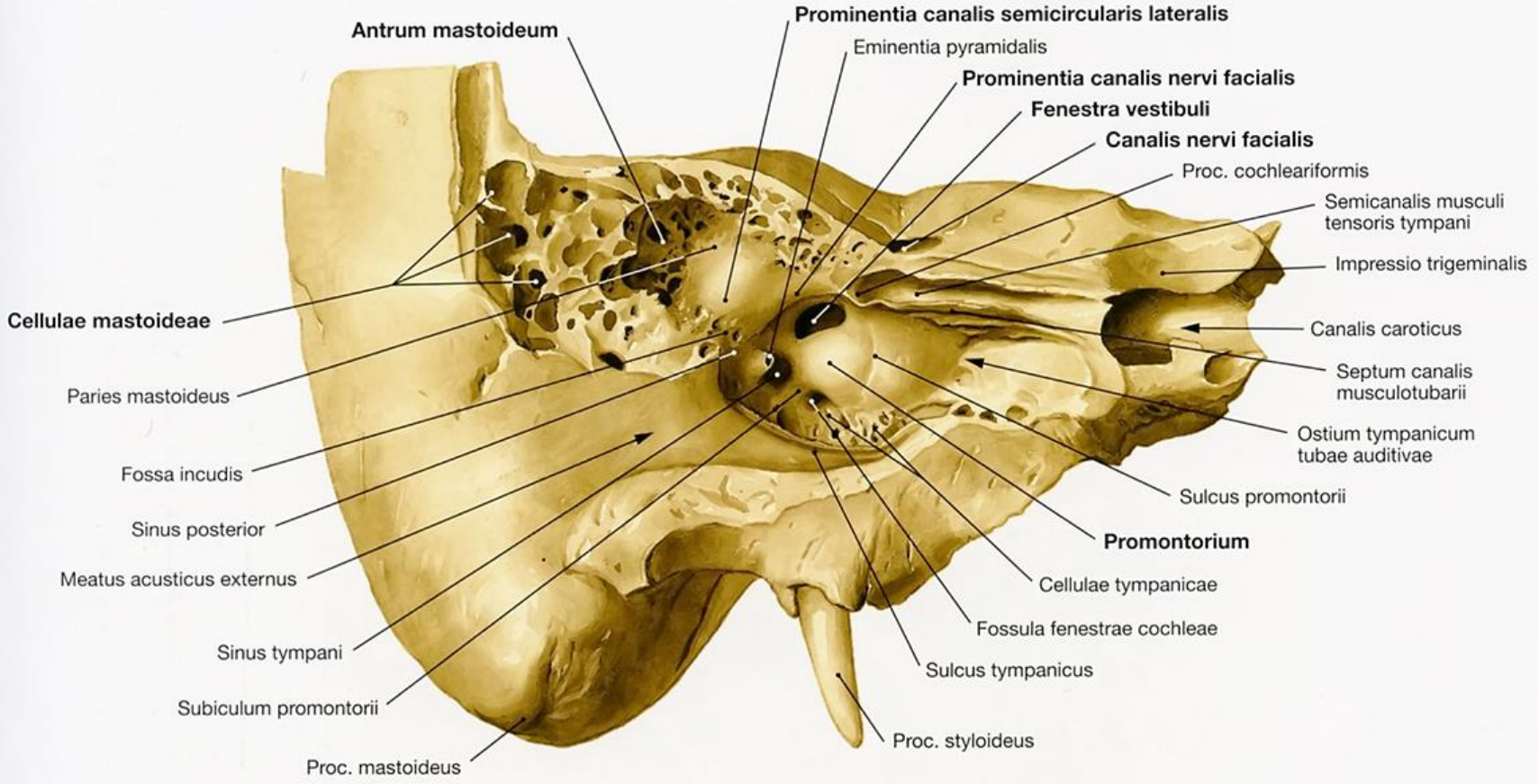


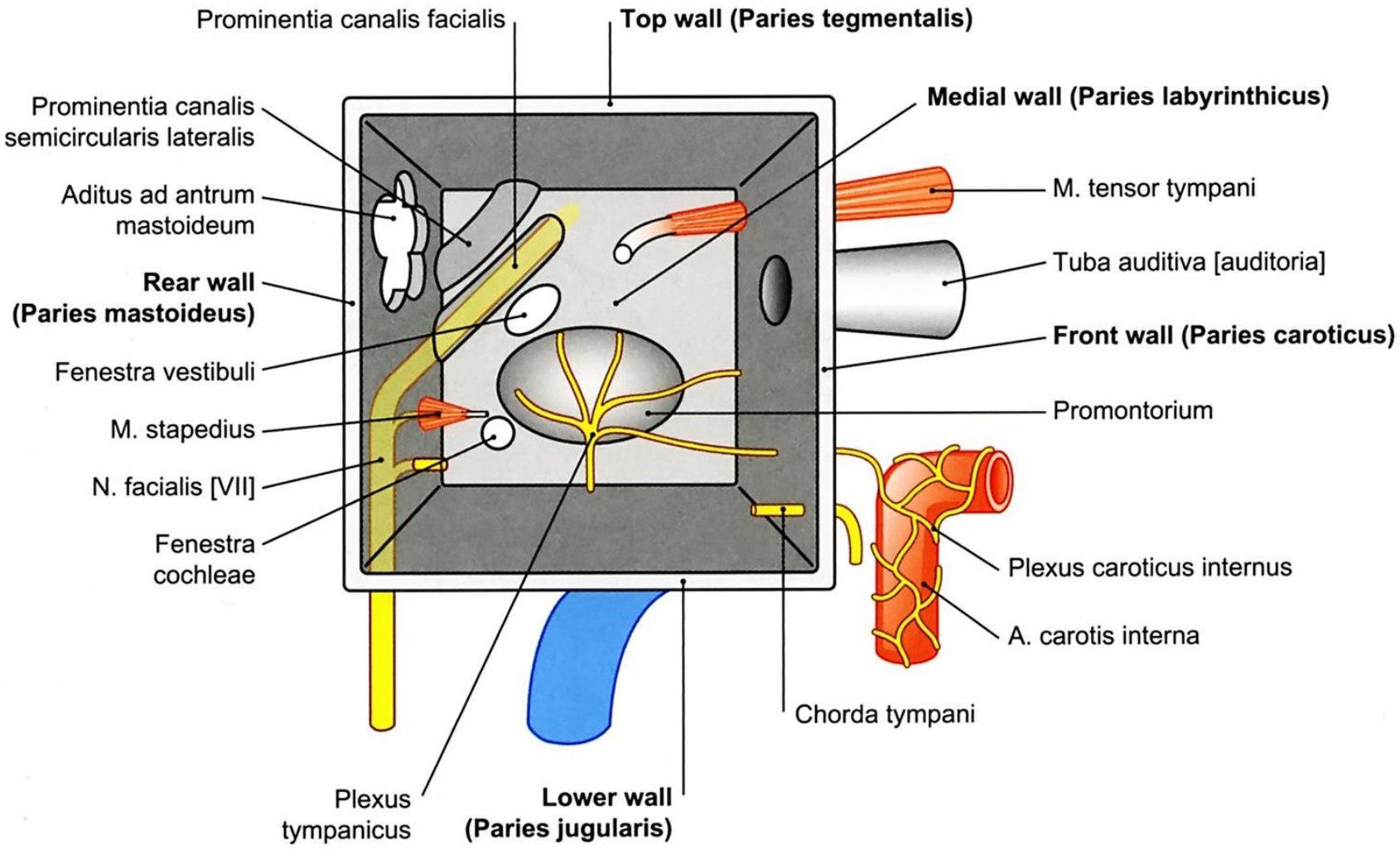
The left auditory apparatus as if viewed through a semi-transparent temporal bone. Note the genu in the facial nerve at the site of the geniculate ganglion.

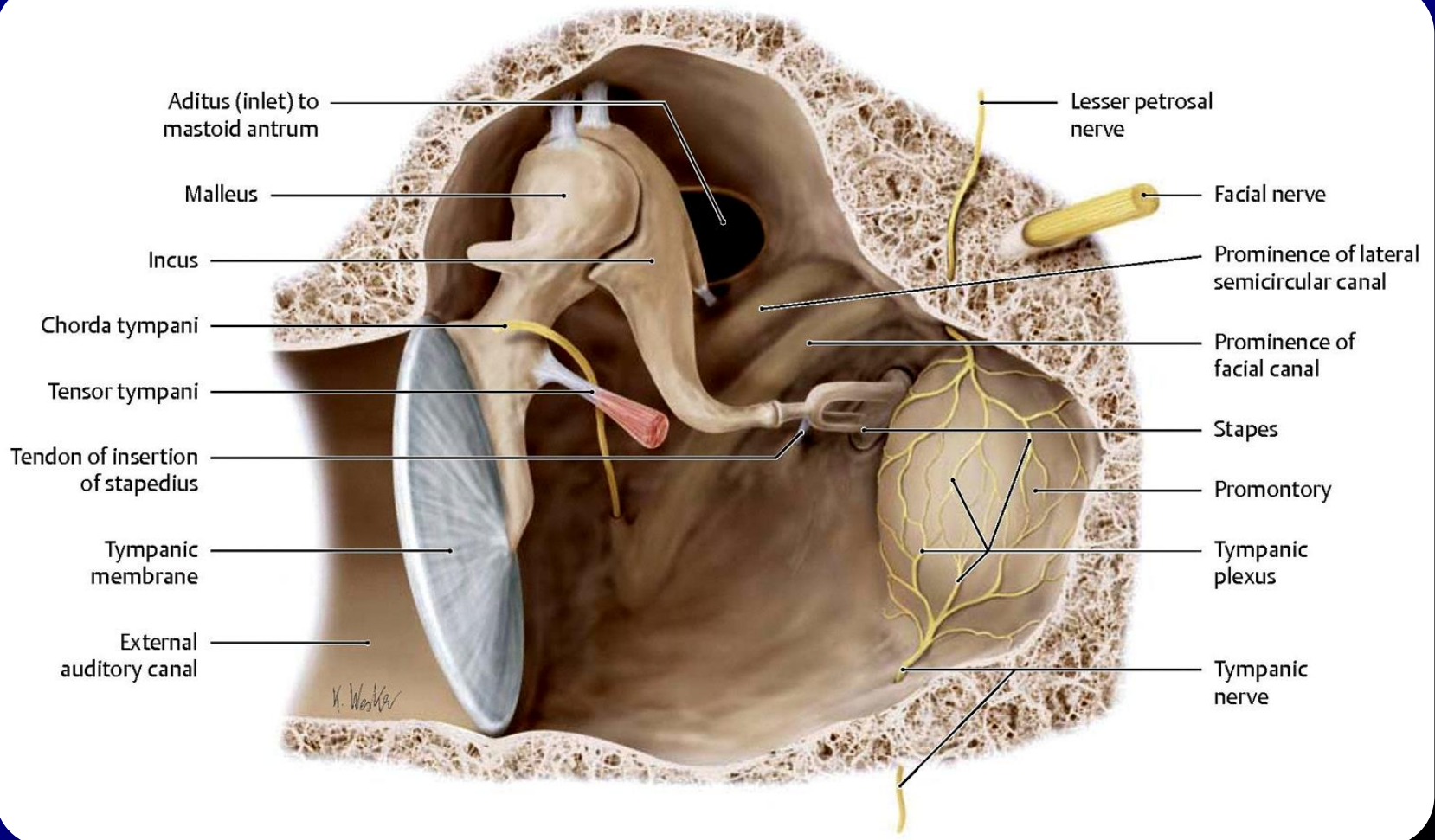

Fossa cranii media
Superior wall (Paries tegmentalis)
A. carotis interna
Posterior wall
(Paries mastoideus)
V. jugularis interna
Anterior wall
(Paries caroticus)
Cavitas tympani
Medial wall
(Paries labyrinthicus)
= Fenestra vestibuli
Lateral wall
(Paries membranaceus)
= Membrana tympani
Proc. mastoideus
Inferior wall (Paries jugularis)
Proc. styloideus

Tympanic Cavity (Cavitas tympani)

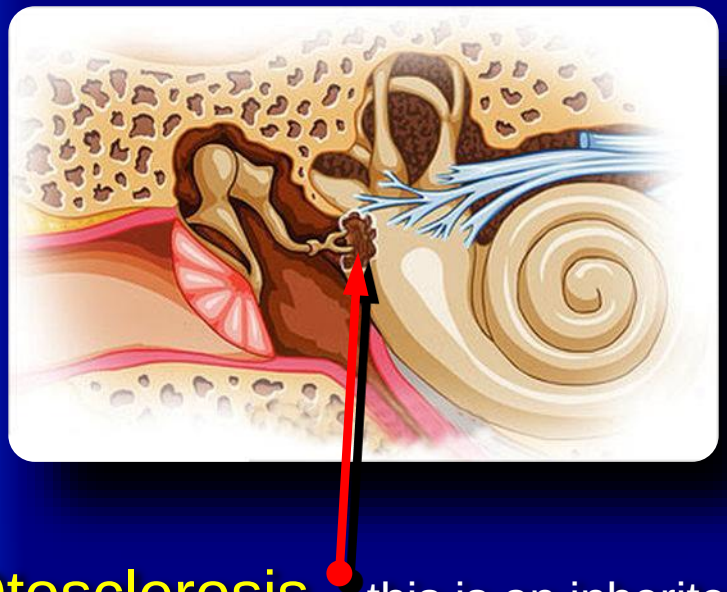
mastoid process (Paries mastoideus)	posterior wall (Proc. mastoideus)
V. jugularis (Paries jugularis)	inferior wall (Fossa jugularis)
A. carotis interna (Paries caroticus)	anterior wall (carotid canal)
middle cranial fossa (Paries tegmentalis)	superior wall (middle cranial fossa)
oval window (Paries labyrinthicus)	medial wall (labyrinth)
tympanic membrane (Paries membranaceus)	lateral wall (tympanic membrane)


Antrum mastoideum
Prominentia canalis semicircularis lateralis
Eminentia pyramidalis
Prominentia canalis nervi facialis
Fenestra vestibuli
Canalis nervi facialis
Proc. cochleariformis
Semicanalis musculi tensoris tympani
Impressio trigeminalis
Cellulae mastoideae
Canalis caroticus
Paries mastoideus
Septum canalis musculotubarii
Ostium tympanicum tubae auditivae
Fossa incudis
Sulcus promontorii
Sinus posterior
Promontorium
Meatus acusticus externus
Cellulae tympanicae
Fossula fenestrae cochleae
Sinus tympani
Sulcus tympanicus
Subiculum promontorii
Proc. styloideus
Proc. mastoideus


Prominentia canalis facialis
Top wall (Paries tegmentalis)
Prominentia canalis semicircularis lateralis
Medial wall (Paries labyrinthicus)
Aditus ad antrum mastoideum
M. tensor tympani
Rear wall (Paries mastoideus)
Tuba auditiva [auditoria]
Front wall (Paries caroticus)
Fenestra vestibuli
Promontorium
M. stapedius
N. facialis [VII]
Plexus caroticus internus
Fenestra cochleae
A. carotis interna
Chorda tympani
Plexus tympanicus
Lower wall (Paries jugularis)

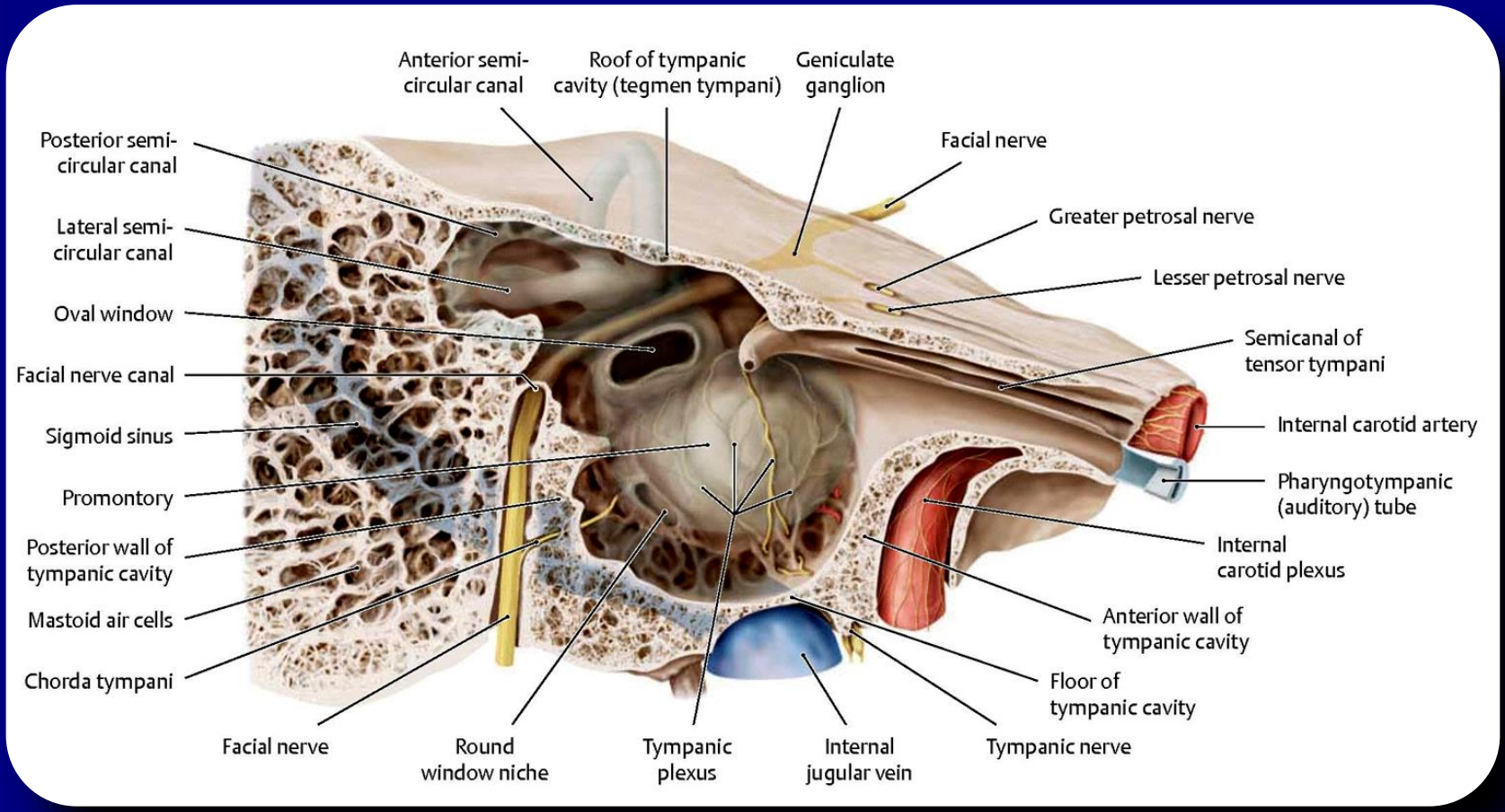


Walls of the tympanic cavity

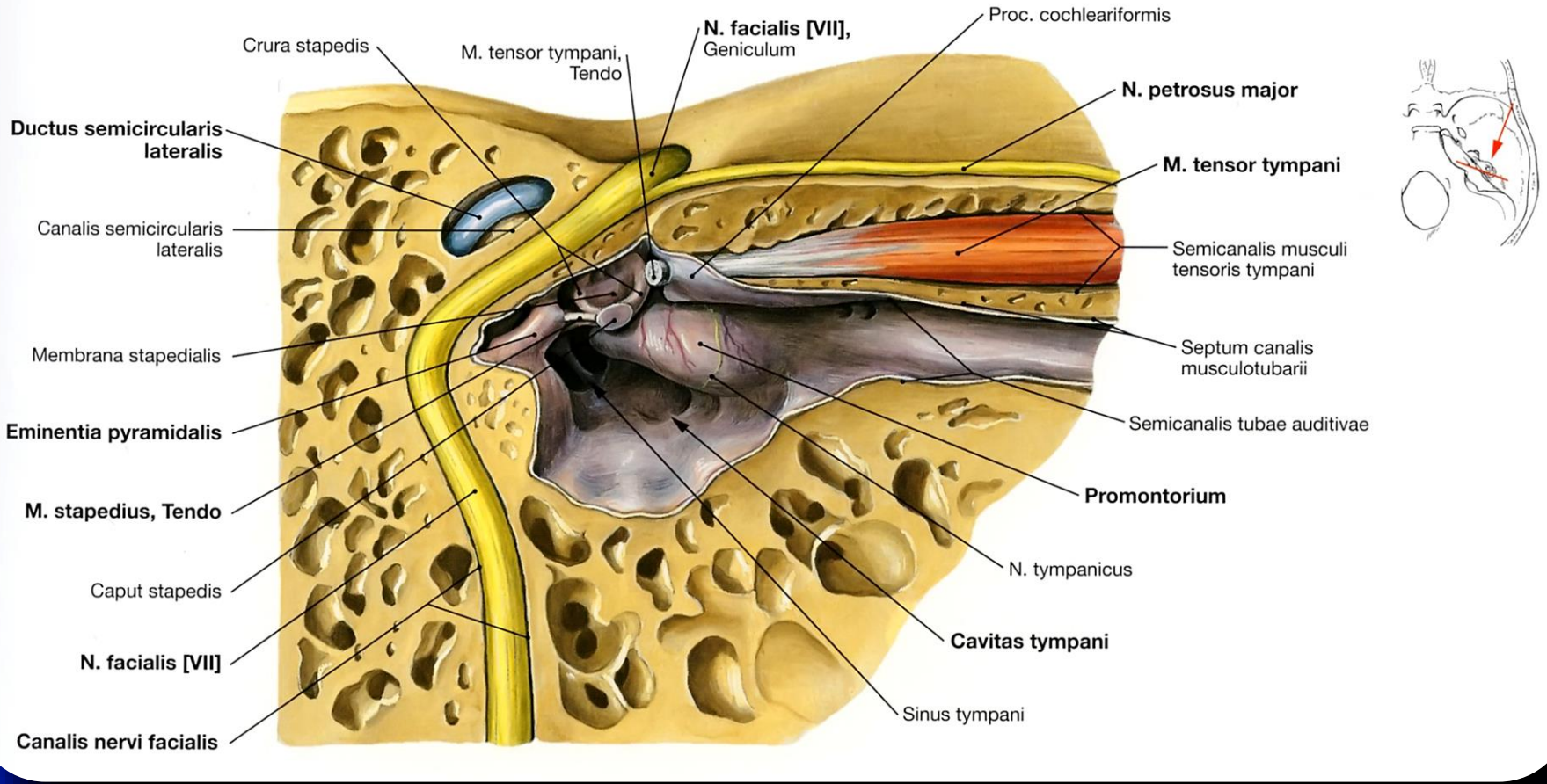


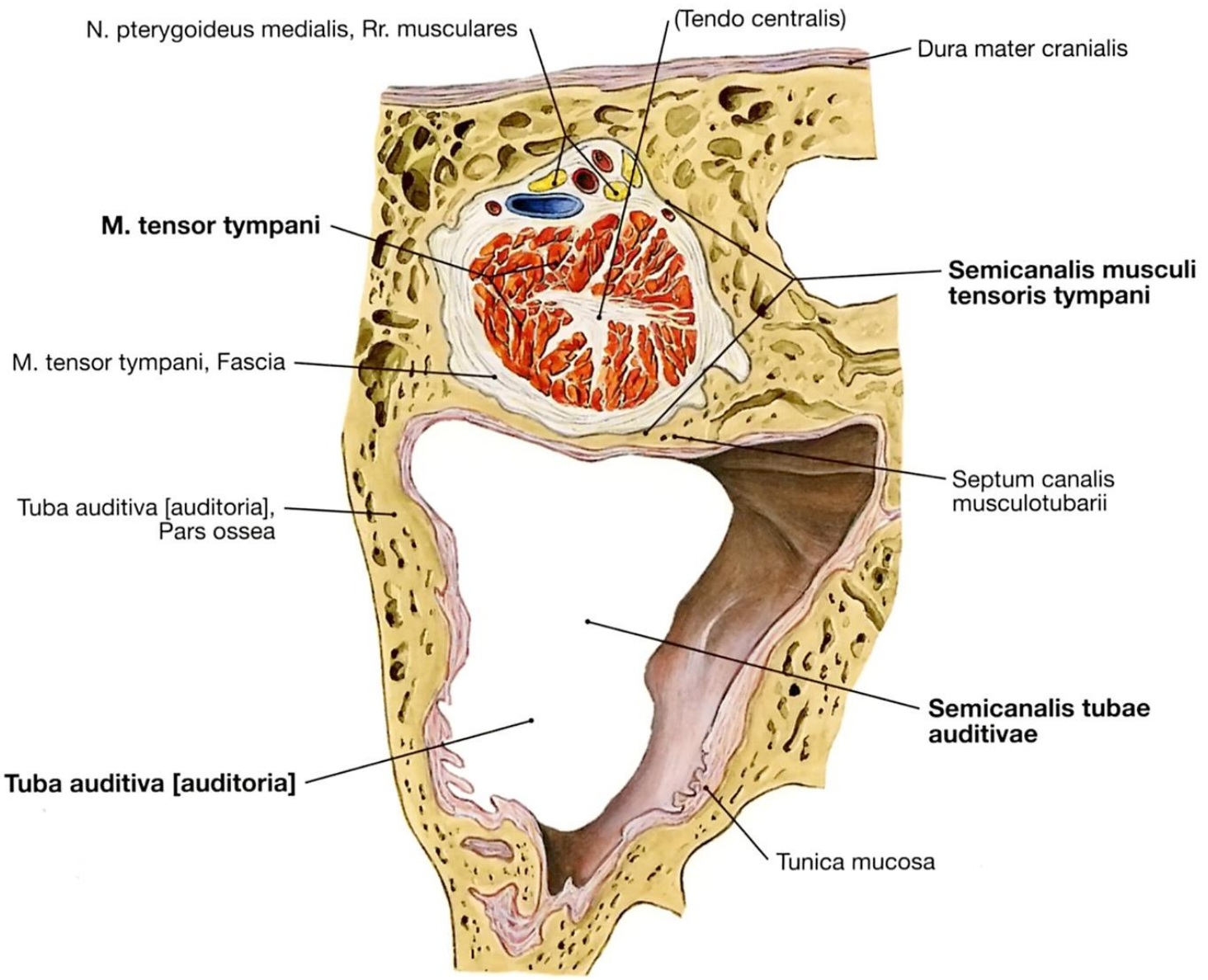
Otosclerosis – this is an inherited disease. The primary form of hearing loss in otosclerosis is conductive hearing loss (CHL) whereby sounds reach the ear drum but are incompletely transferred via the ossicular chain in the middle ear, and thus partly fail to reach the inner ear (cochlea). This usually will begin in one ear but will eventually affect both ears with a variable course. On audiometry, the hearing loss is characteristically low-frequency, with higher frequencies being affected later.

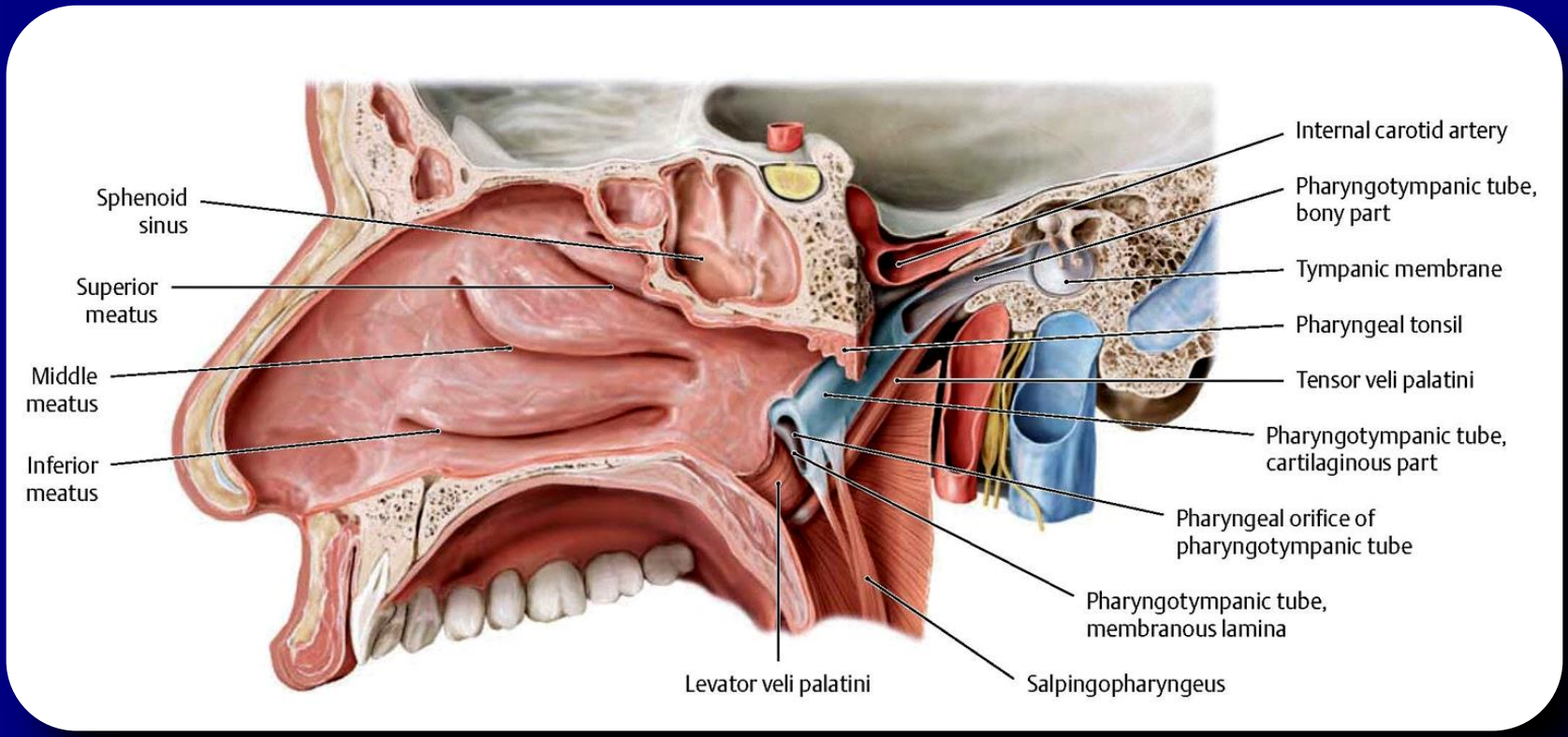
Conductive hearing loss occurs when there is a problem conducting sound waves anywhere along the route through the outer ear, tympanic membrane (eardrum), or middle ear (ossicles). This type of hearing loss may occur in conjunction with sensorineural hearing loss (mixed hearing loss) or alone.



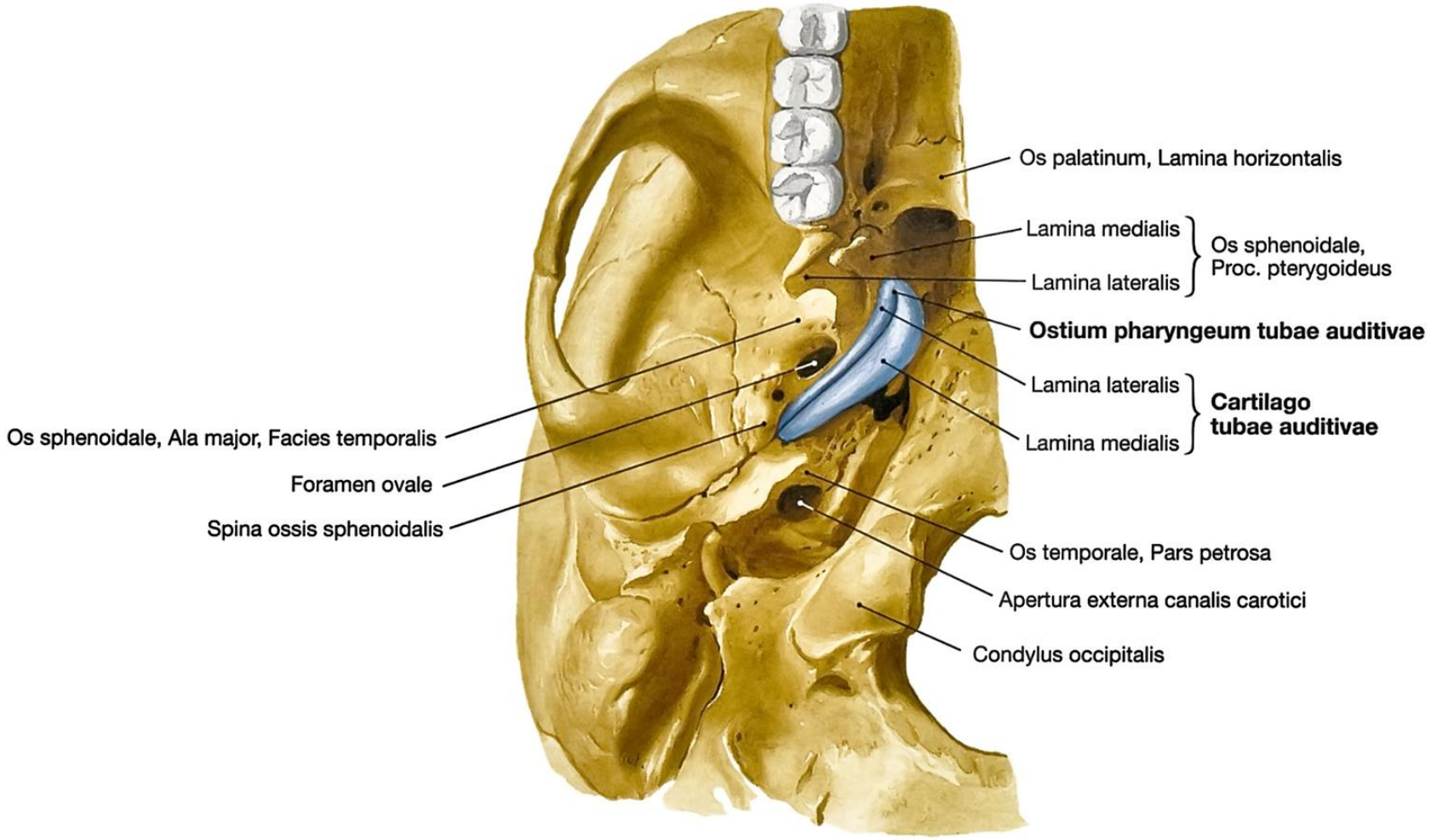
Tympanic cavity: clinically important anatomical relationships

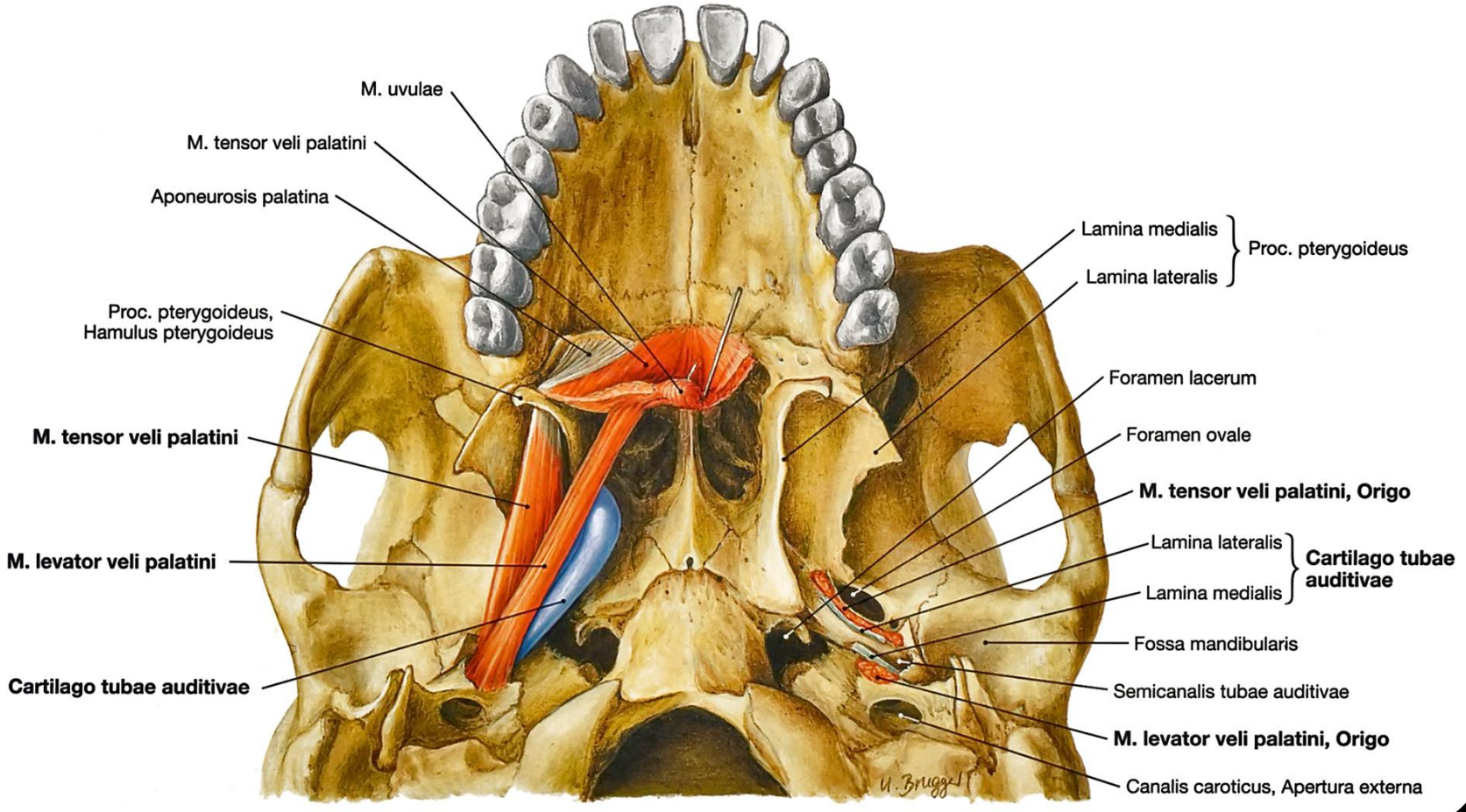

Crura stapedis
M. tensor tympani, Tendo
N. facialis [VII], Geniculum
Proc. cochleariformis
N. petrosus major
M. tensor tympani
Ductus semicircularis lateralis
Canalis semicircularis lateralis
Semicanalis musculi tensoris tympani
Membrana stapedialis
Septum canalis musculotubarii
Eminentia pyramidalis
Semicanalis tubae auditivae
Promontorium
M. stapedius, Tendo
N. tympanicus
Caput stapedis
Cavitas tympani
N. facialis [VII]
Sinus tympani
Canalis nervi facialis

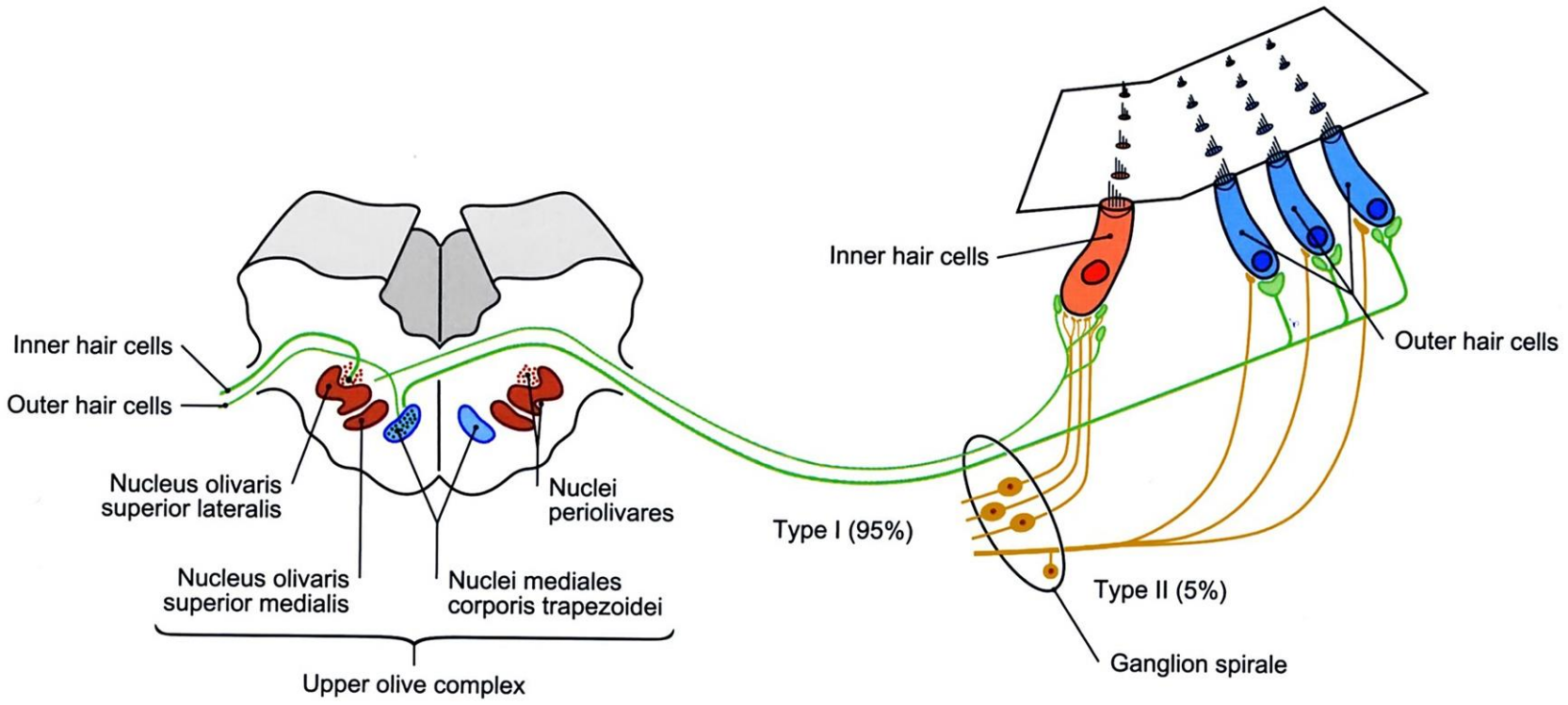

N. pterygoideus medialis, Rr. musculares
(Tendo centralis)
Dura mater cranialis
M. tensor tympani
Semicanalis musculi tensoris tympani
M. tensor tympani, Fascia
Septum canalis musculotubarii
Tuba auditiva [auditoria], Pars ossea
Semicanalis tubae auditivae
Tuba auditiva [auditoria]
Tunica mucosa

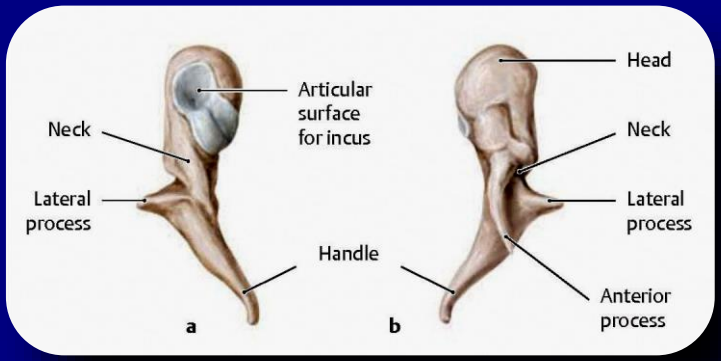


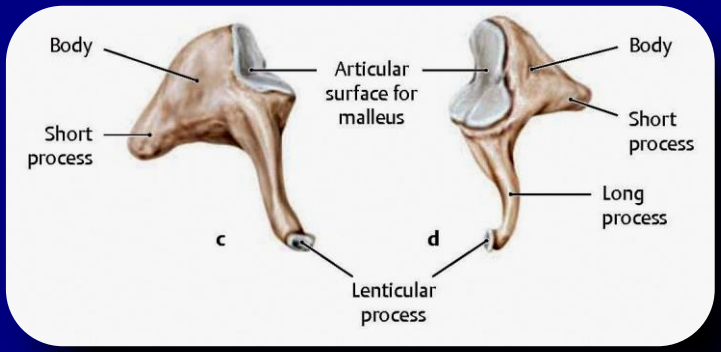
Pharyngotympanic (auditory) tube

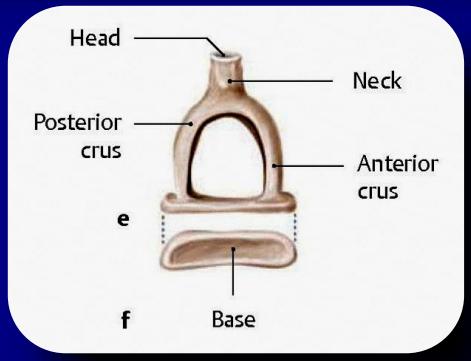

Os palatinum, Lamina horizontalis
Lamina medialis
Lamina lateralis
Os sphenoidale, Proc. pterygoideus
Ostium pharyngeum tubae auditivae
Lamina lateralis
Lamina medialis
Cartilago tubae auditivae
Os sphenoidale, Ala major, Facies temporalis
Foramen ovale
Spina ossis sphenoidalis
Os temporale, Pars petrosa
Apertura externa canalis carotici
Condylus occipitalis

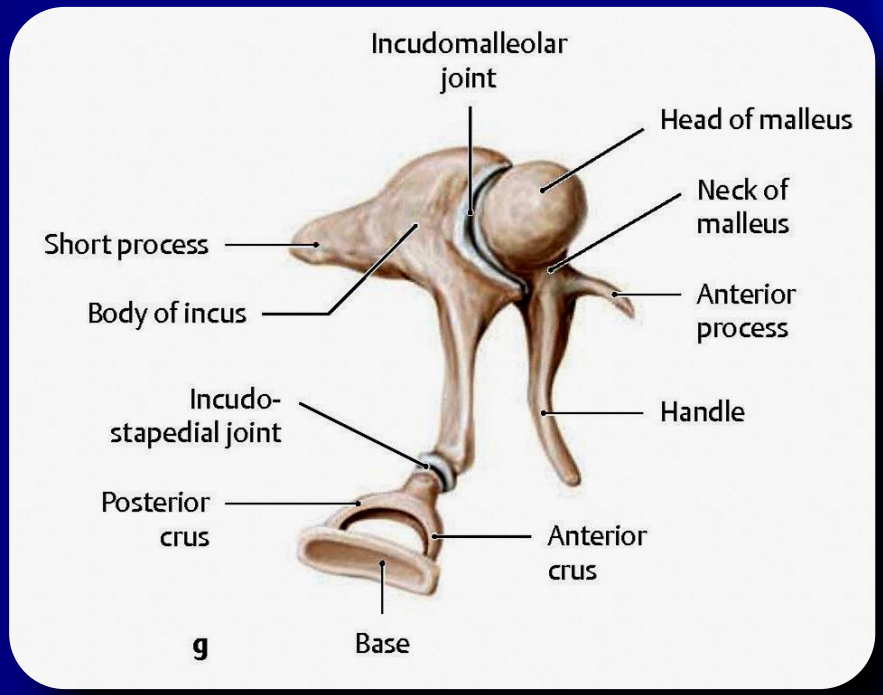

M. uvulae
M. tensor veli palatini
Aponeurosis palatina
Proc. pterygoideus,
Hamulus pterygoideus
M. tensor veli palatini
M. levator veli palatini
Cartilago tubae auditivae
Lamina medialis
Lamina lateralis
Proc. pterygoideus
Foramen lacerum
Foramen ovale
M. tensor veli palatini, Origo
Lamina lateralis
Lamina medialis
Cartilago tubae auditivae
Fossa mandibularis
Semicanalis tubae auditivae
M. levator veli palatini, Origo
Canalis caroticus, Apertura externa


Inner hair cells
Outer hair cells
Nucleus olivaris superior lateralis
Nucleus olivaris superior medialis
Nuclei periolivares
Nuclei mediales corporis trapezoidei
Upper olive complex
Inner hair cells
Outer hair cells
Type I (95%)
Type II (5%)
Ganglion spirale

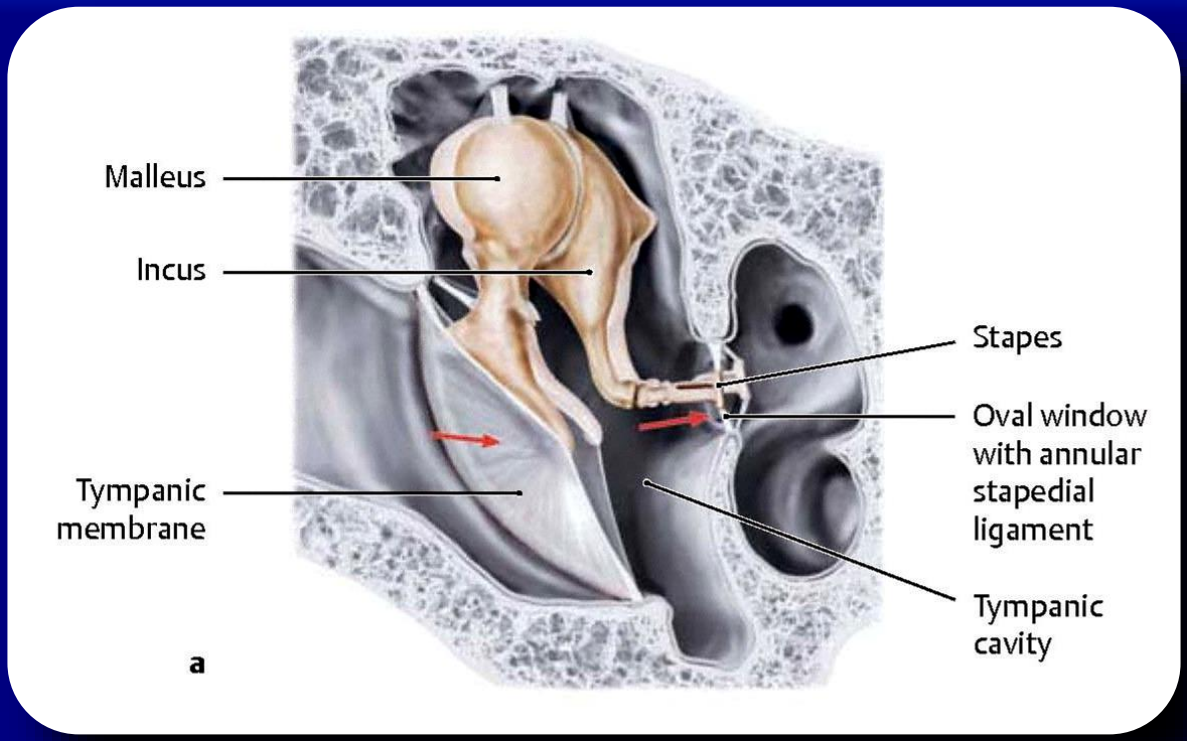


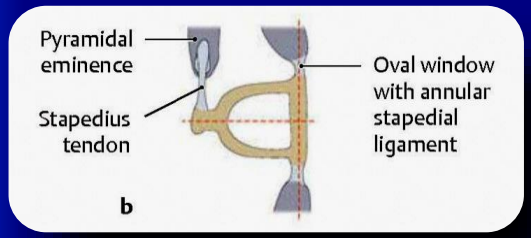


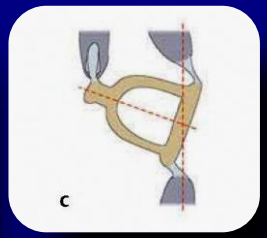


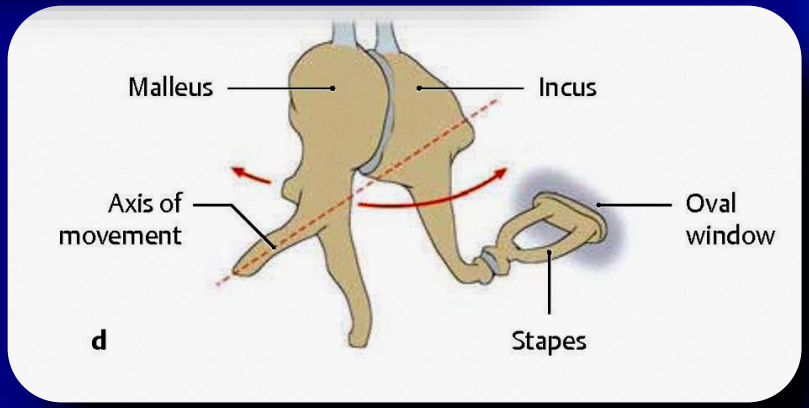


Auditory ossicles

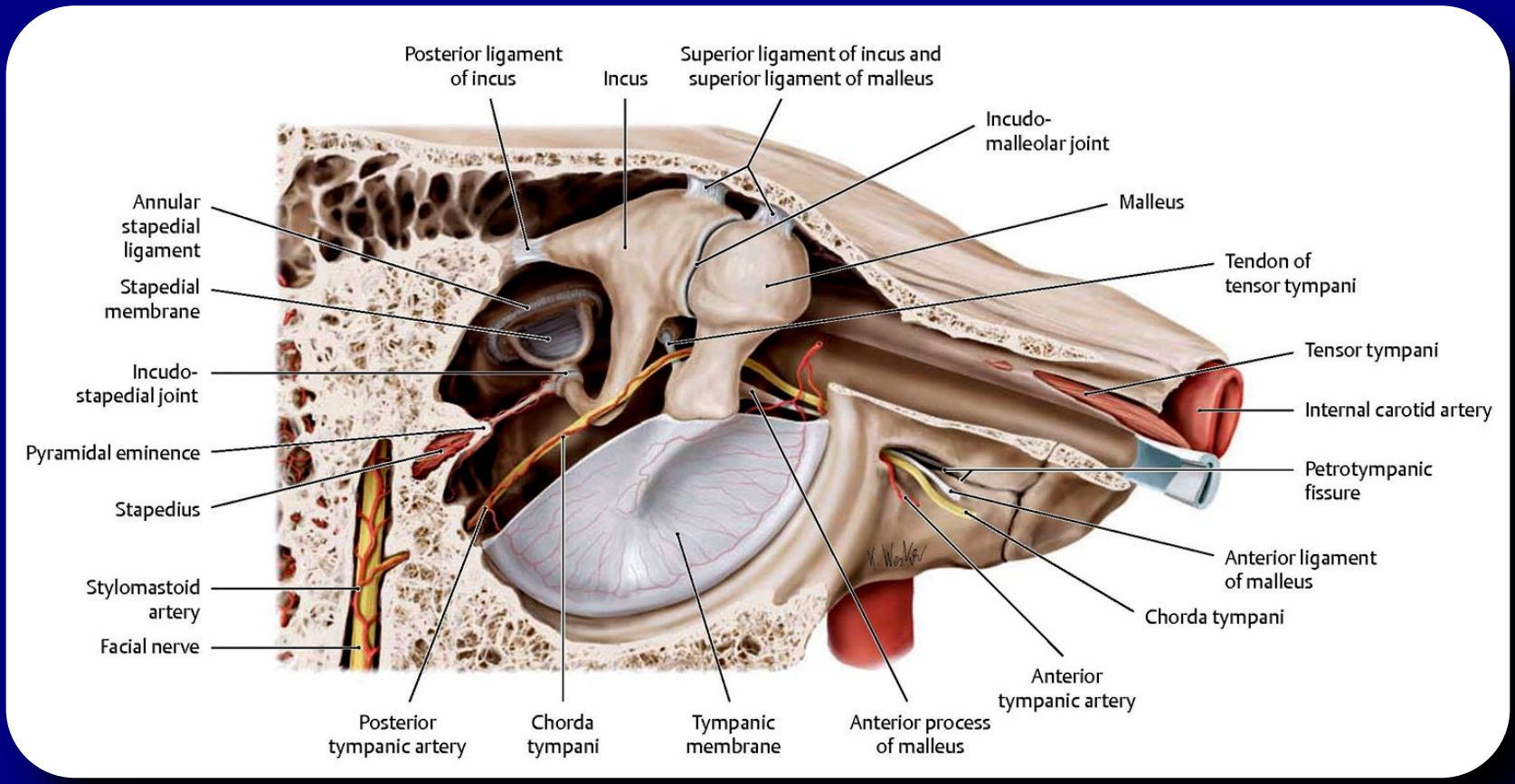




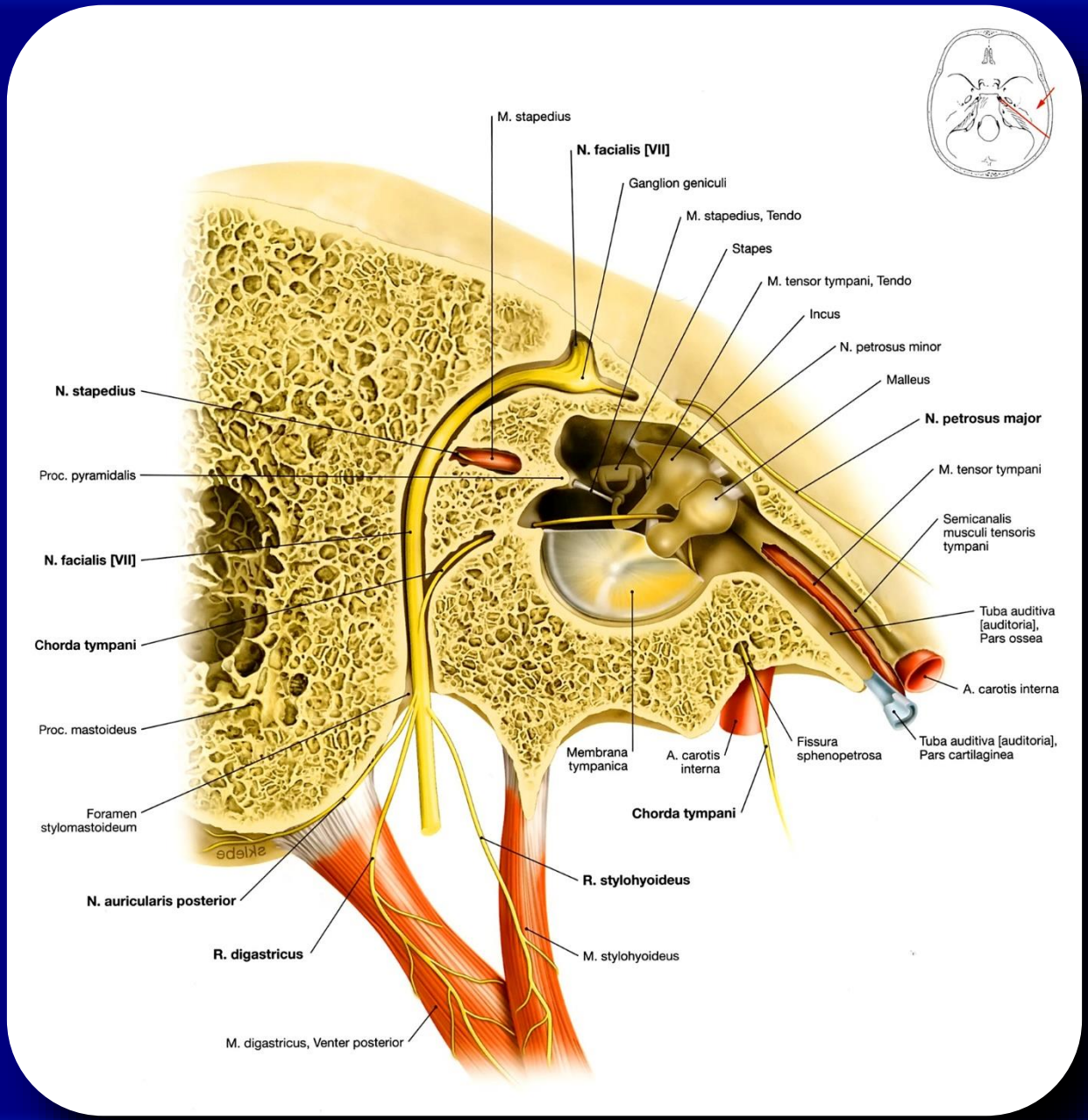


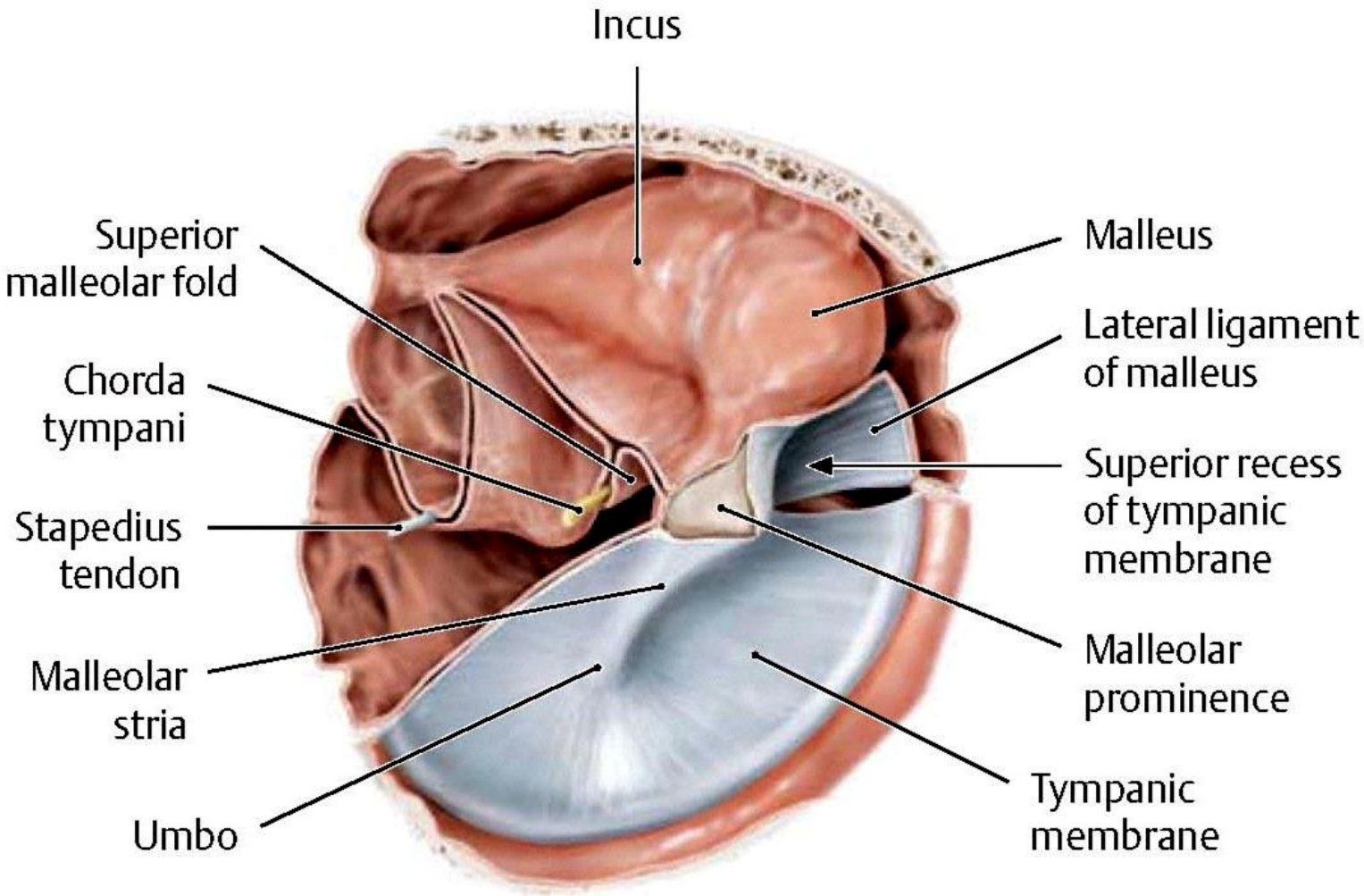


Function of the ossicular chain

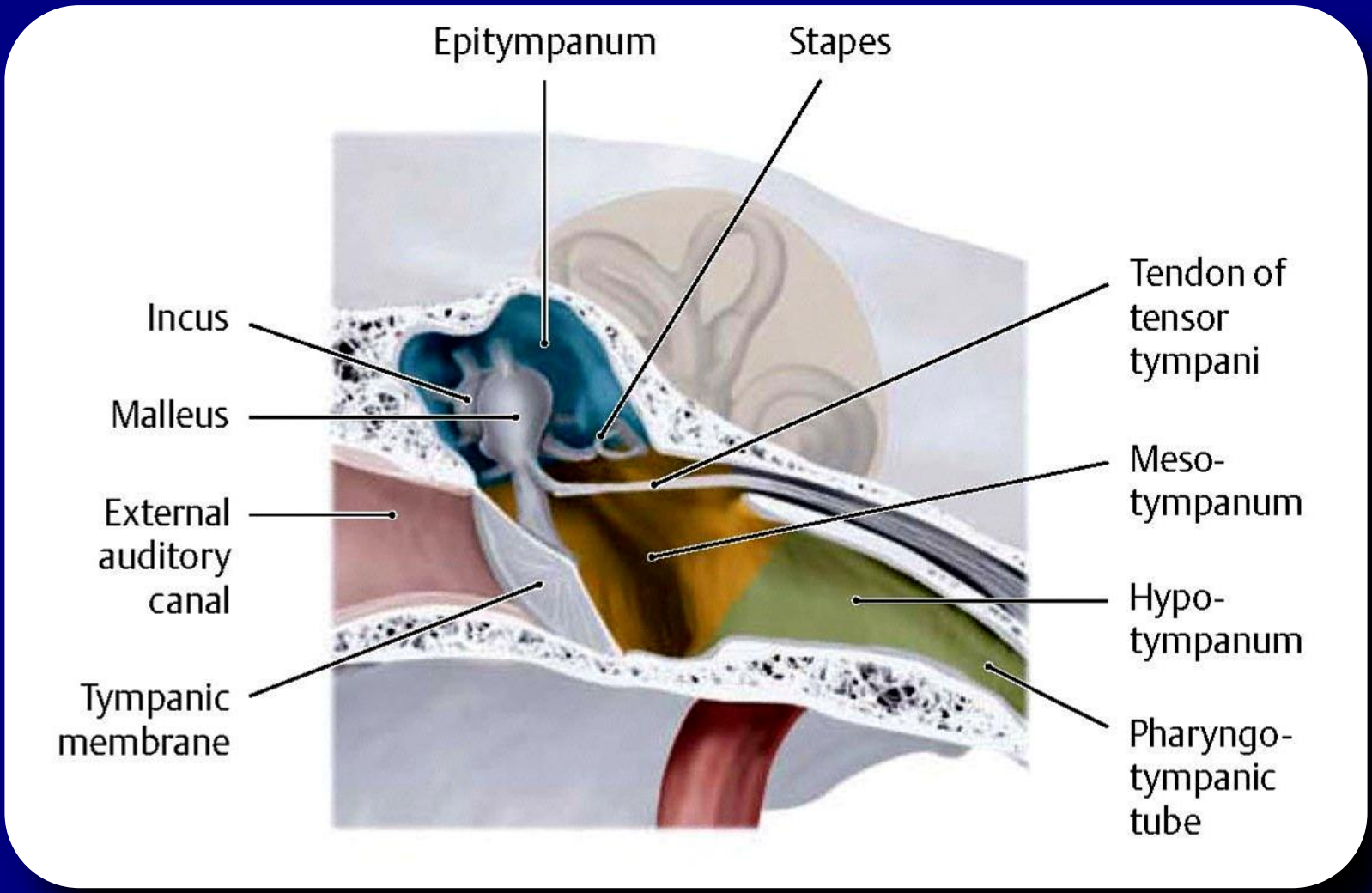


Ossicular chain in the tympanic cavity


M. stapedius
N. facialis [VII]
Ganglion geniculi
M. stapedius, Tendo
Stapes
M. tensor tympani, Tendo
Incus
N. petrosus minor
Malleus
N. petrosus major
M. tensor tympani
Semicanalis musculi tensoris tympani
Tuba auditiva [auditoria], Pars ossea
A. carotis interna
Tuba auditiva [auditoria], Pars cartilaginea
Fissura sphenopetrosa
A. carotis interna
Membrana tympanica
Chorda tympani
N. stapedius
Proc. pyramidalis
N. facialis [VII]
Chorda tympani
Proc. mastoideus
Foramen stylomastoideum
N. auricularis posterior
R. digastricus
M. digastricus, Venter posterior
R. stylohyoideus
M. stylohyoideus

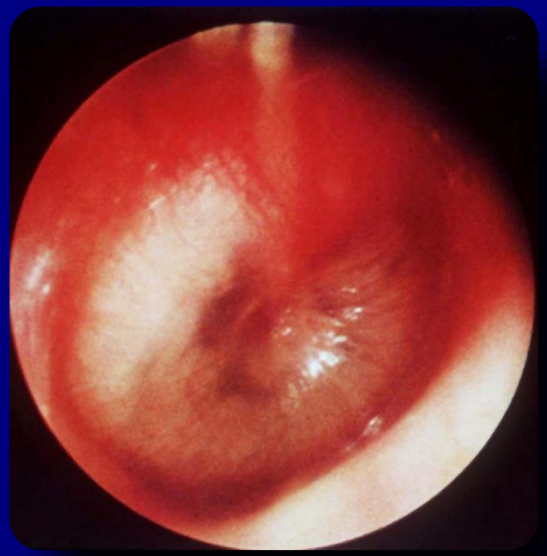


Mucosal lining of the tympanic cavity



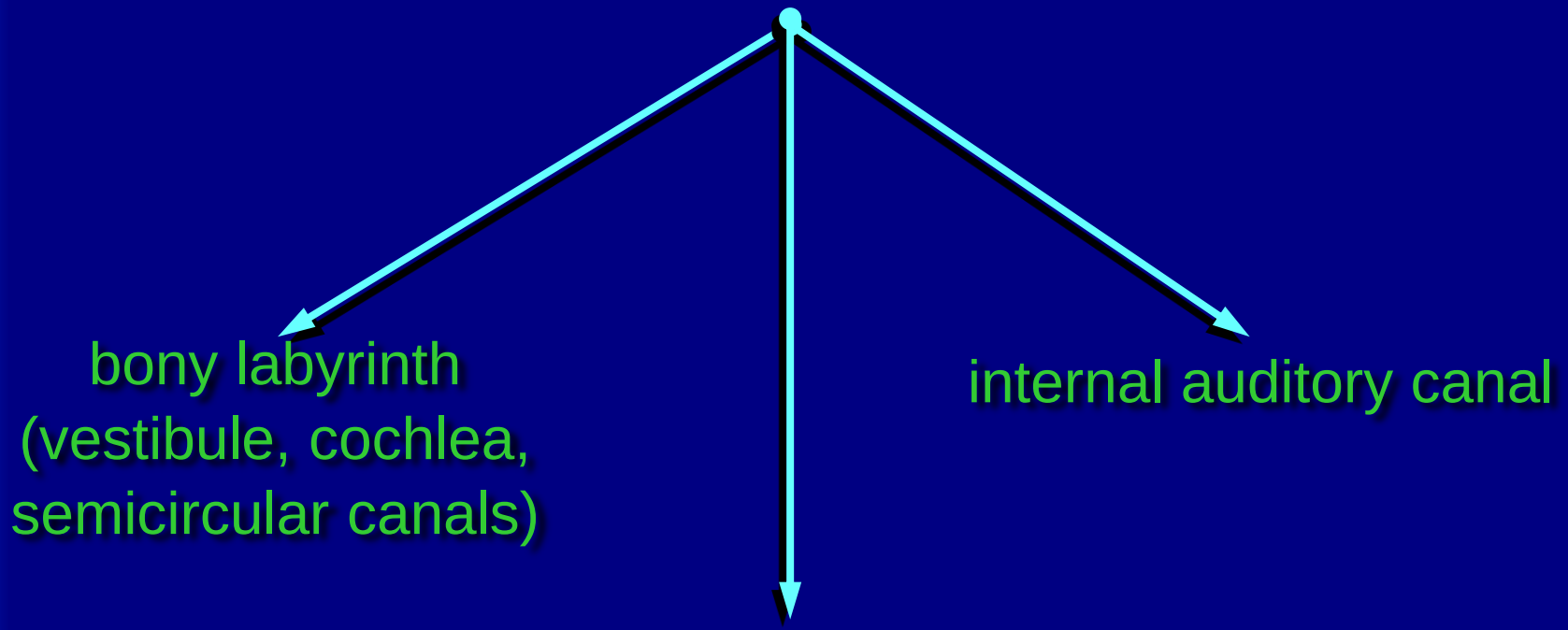
Clinically important levels of the tympanic cavity

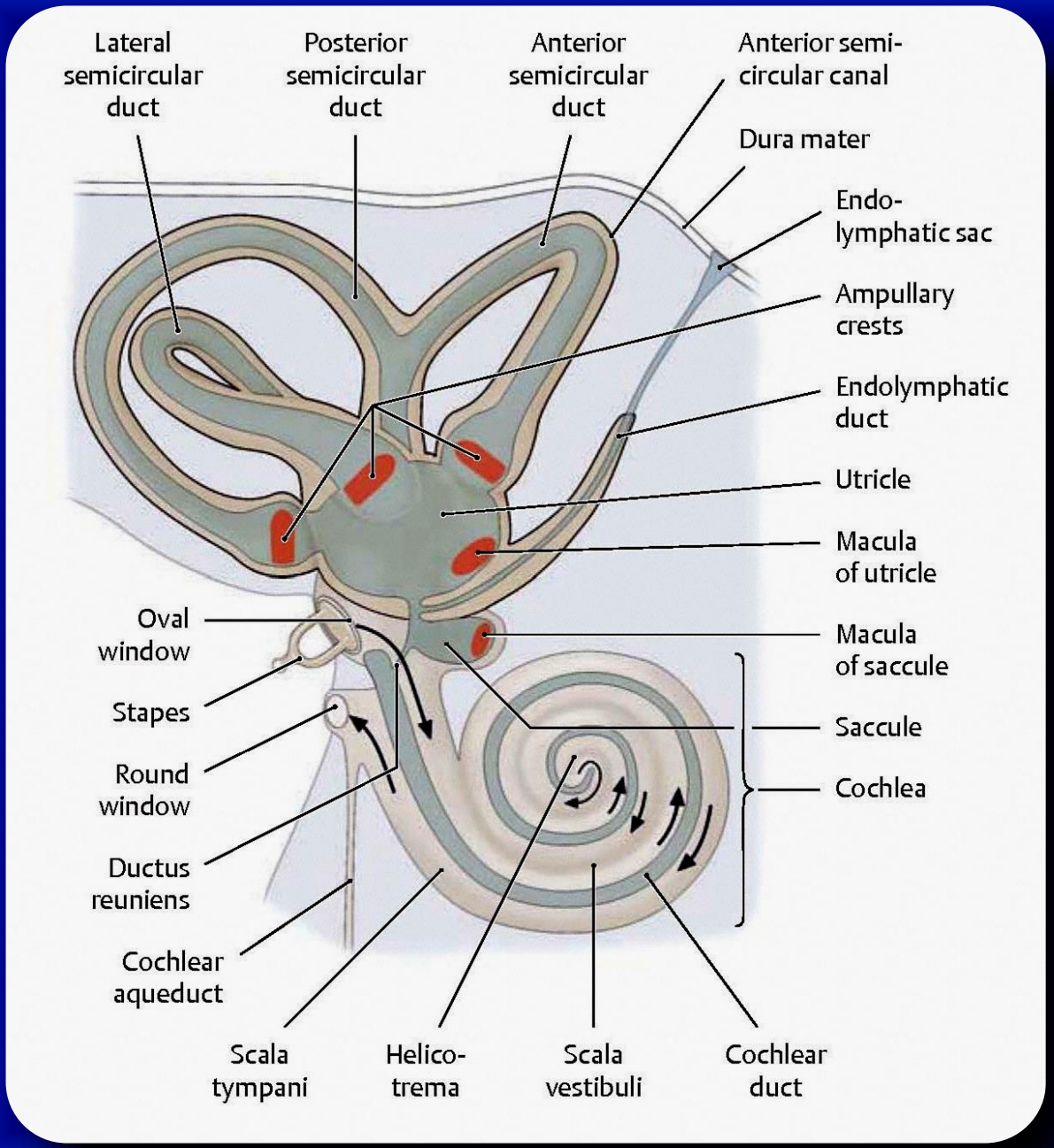
Otitis media – is a group of inflammatory diseases of the middle ear – *Streptococcus pneumoniae, Haemophilus influenzae*, *Moraxella catarrhalis,* and *Staphylococcus aureus*.



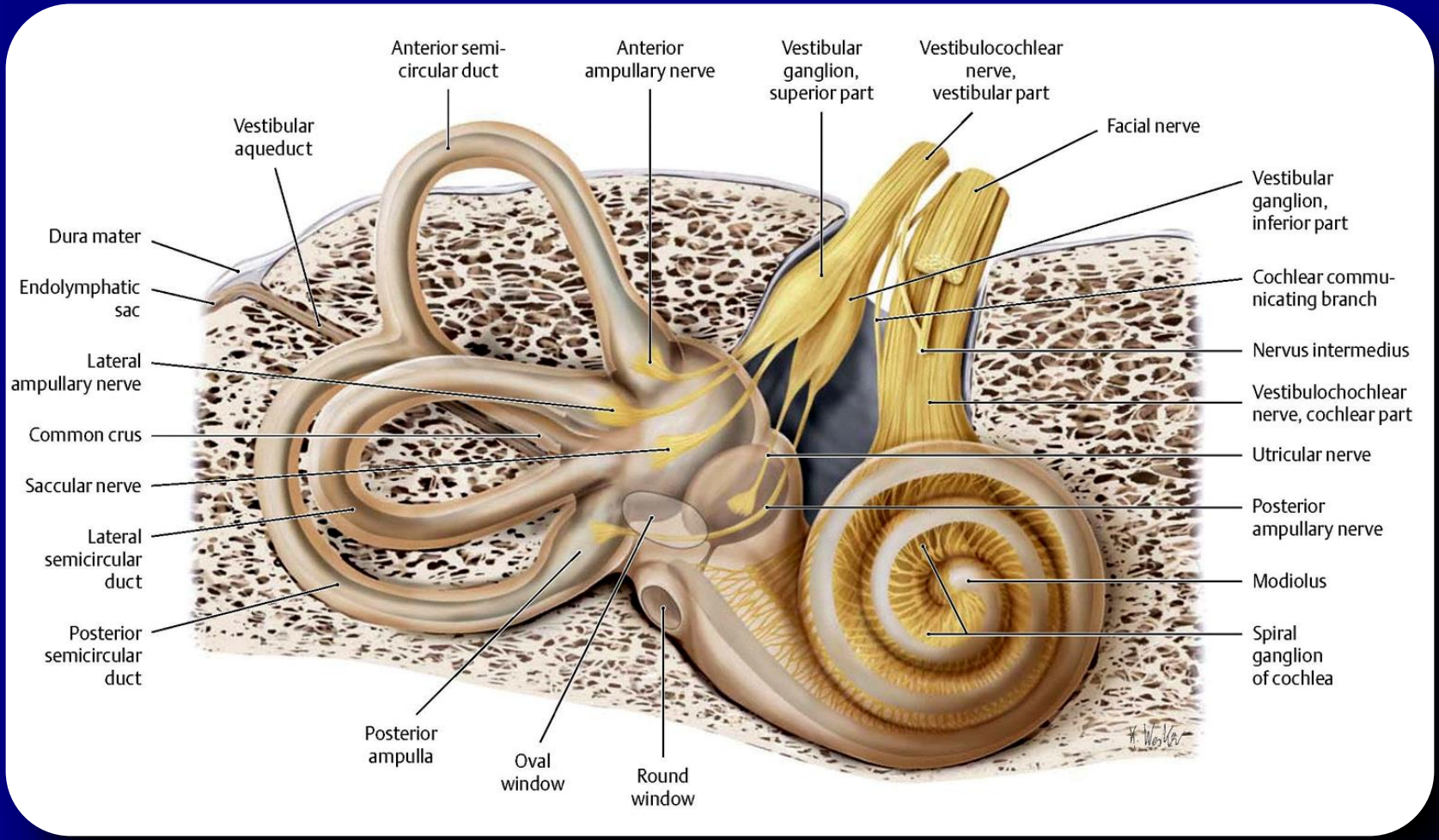
Acute otitis media is very common in childhood. It is the most common condition for which medical care is provided in children under five years of age in the US.

Internal (inner) ear consists of:





Schematic diagram of the inner ear



Clinically important levels of the tympanic cavity

Hyperacusis – is a debilitating hearing disorder characterized by an increased sensitivity to certain frequency and volume ranges of sound (a collapsed tolerance to usual environmental sound). A person with severe hyperacusis has difficulty tolerating everyday sounds, some of which may seem unpleasantly or painfully loud to that person but not to others.

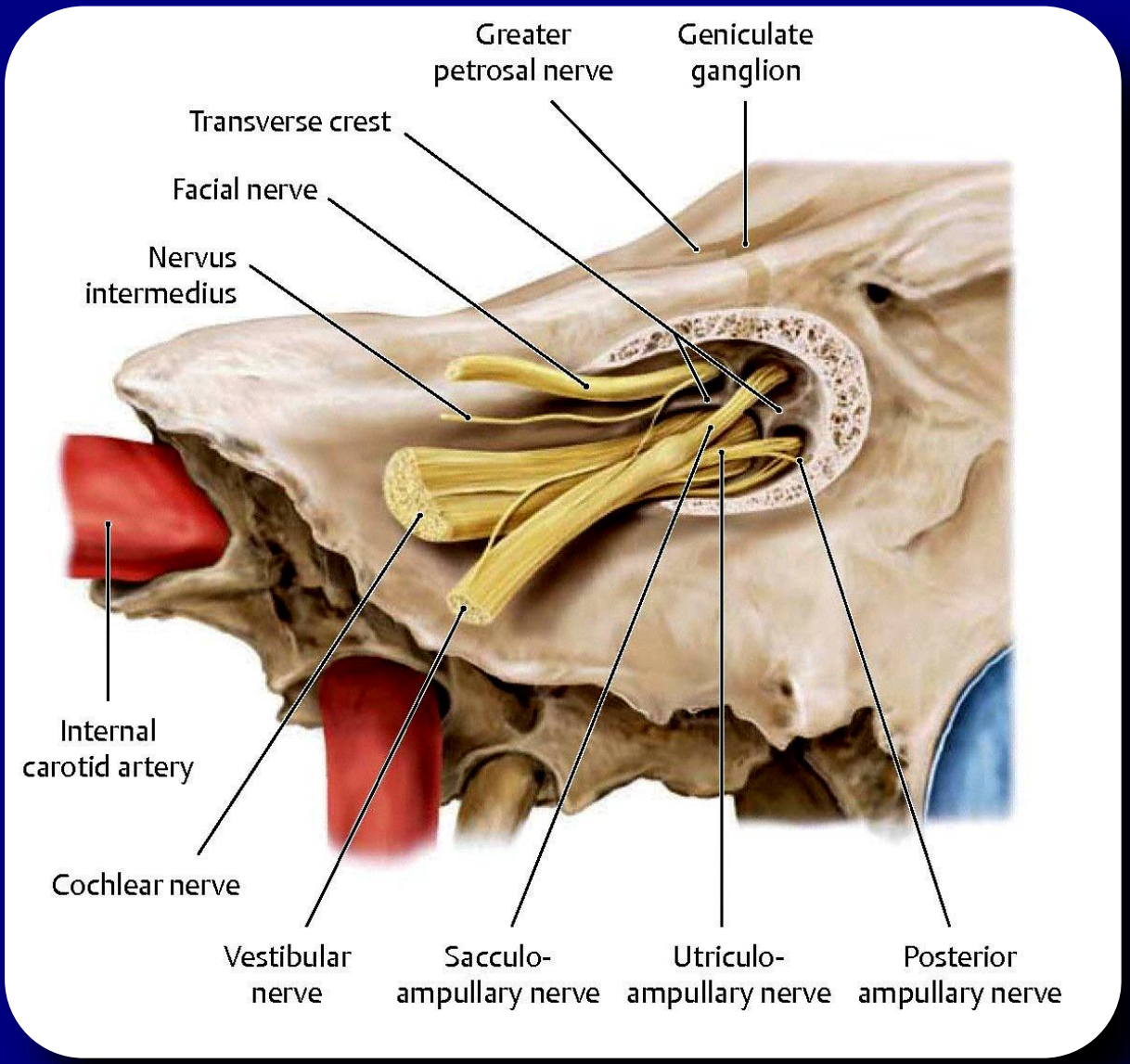
- Cochlear Hyperacusis – damage to the sound sensing organ (cochlea) that results in the brain having sound sensitivities around certain pitches;
- Vestibular Hyperacusis – a form of Hyperacusis that also affects a person's Vestibular (balance) system resulting in nausea, dizziness and the sensation of falling, in addition to sound hypersensitivity and/or Tinnitus and hearing loss.

Causes include, but are not limited to:

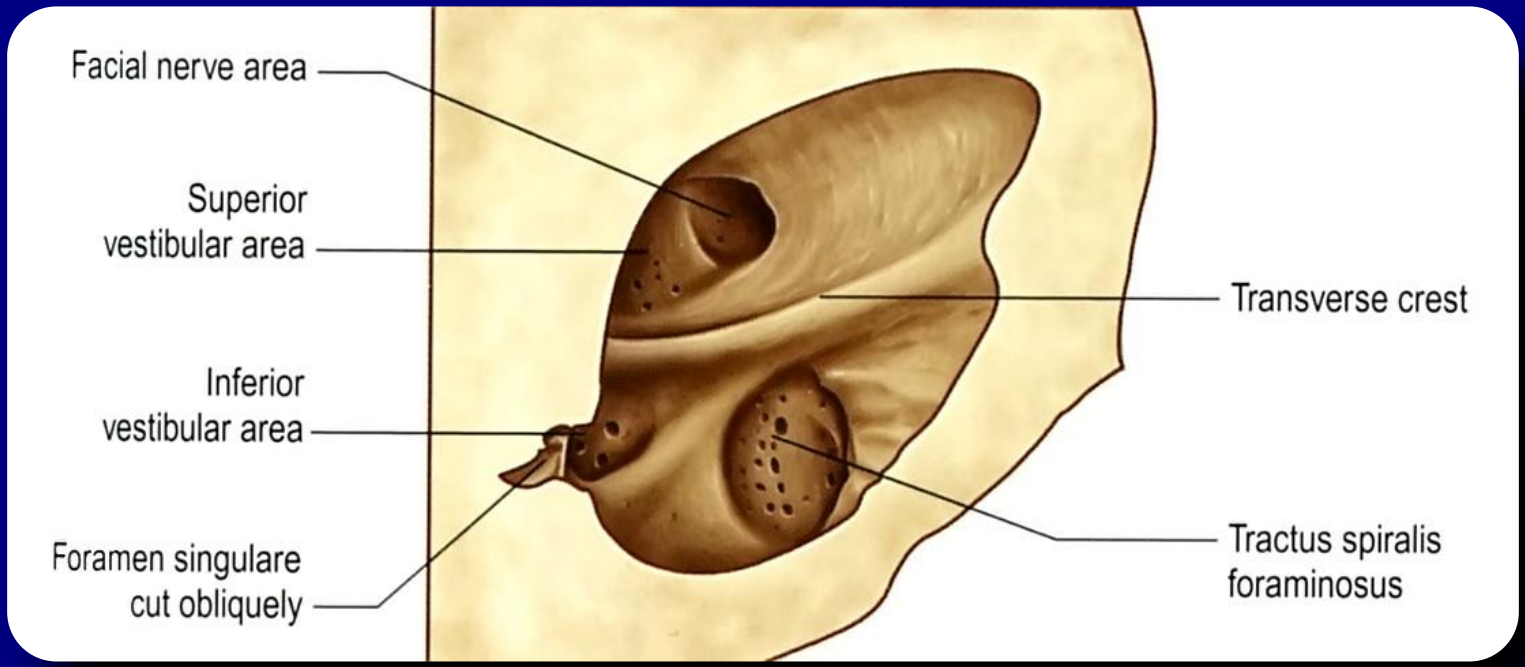
- Adverse drug reaction
- Ankiety
- Autism spectrum
- Bell’s palsy
- Chronic ear infections
- Chronic fatigue syndrome
- Ciprofloxacin antibiotic (quinolone family)
- Depression
- Developmental coordination disorder
- Ear irrigation
- Electroconvulsive Therapy
- Facial nerve dysfunction (to stapedius)
- Fibromyalgia
- Head injury
- Lyme disease
- MAO inhibitor discontinuation syndrome
- Migraine
- Ménière's disease
- Multiple Sclerosis
- Noise-induced hearing loss
- Posttraumatic stress disorder
- Sensory Processing Disorder
- Severe head trauma
- Superior canal dehiscence syndrome (SCDS)
- Surgery
- Systemic lupus erythematosus (SLE)
- Tay–Sachs disease
- Temporomandibular joint disorder
- Tension myositis syndrome
- Tinnitus
- Williams syndrome

Symptoms are ear pain, annoyance, and general intolerance to many sounds that most people are unaffected by.

Hyperacusis can result in anxiety, stress and phonophobia.

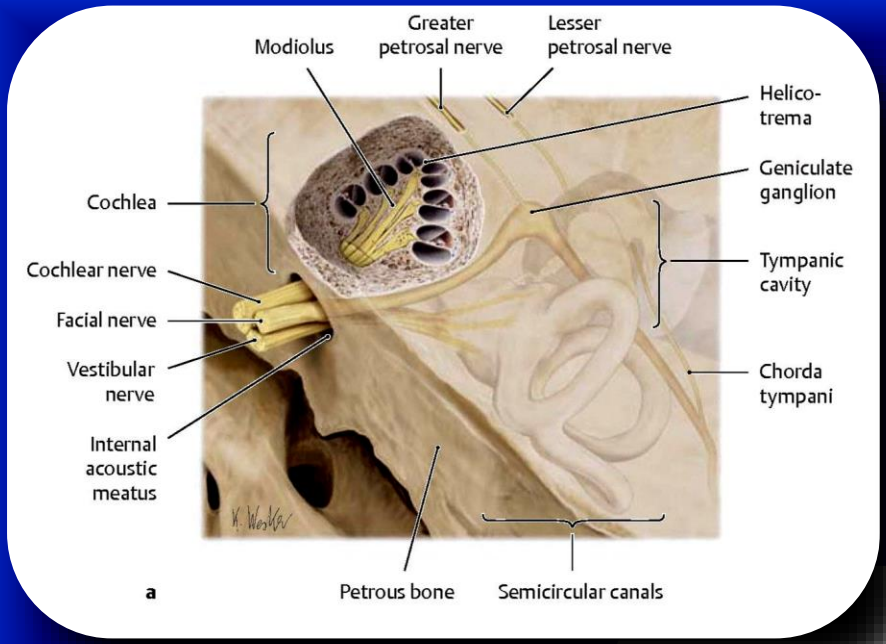


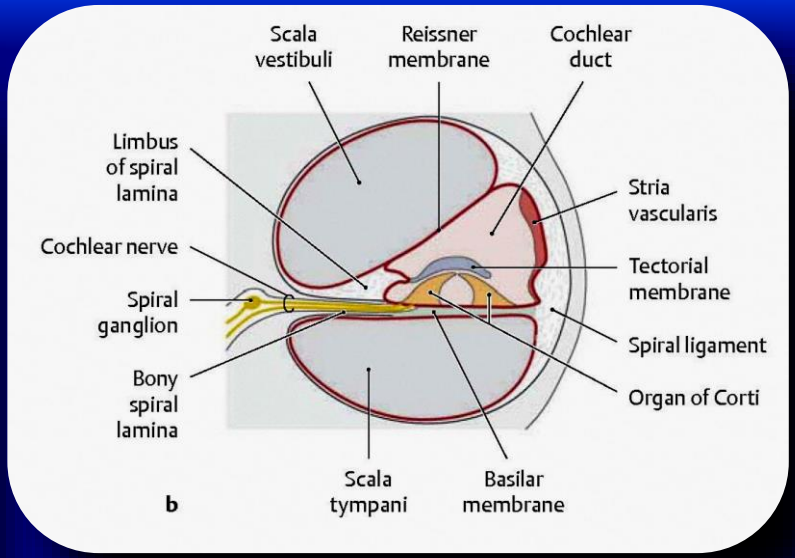
Passage of cranial nerves through the right internal acoustic meatus

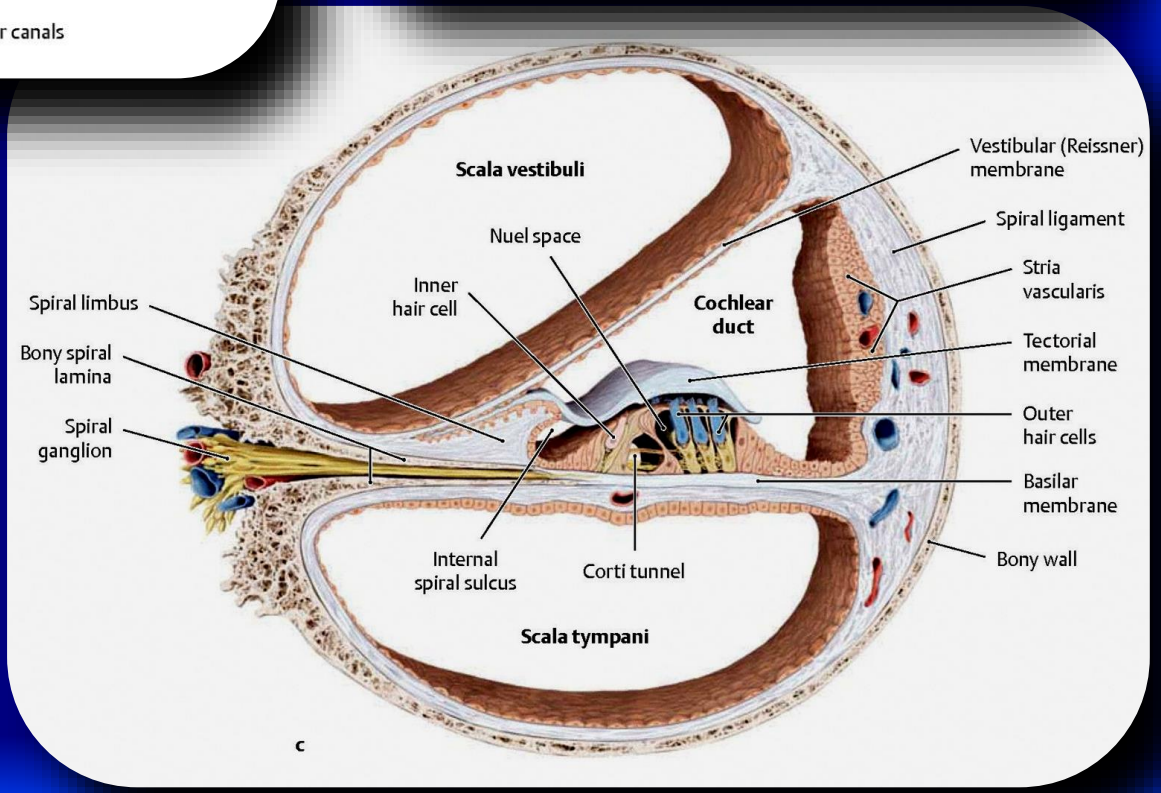


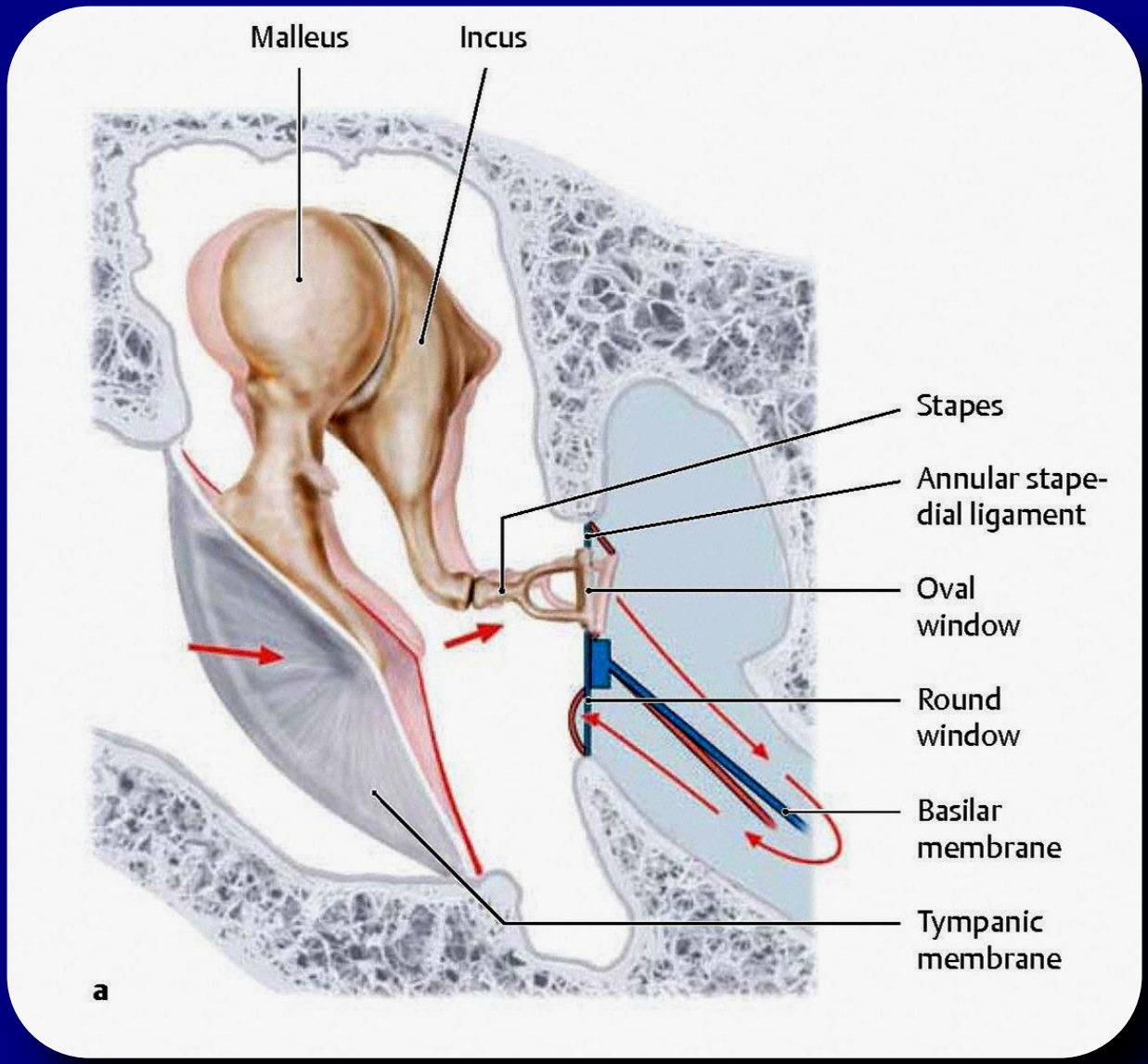
The fundus of the left internal acoustic meatus, exposed by a section through the petrous part of the left temporal bone nearly parallel to the line of its superior border.

Location and structure of the cochlea

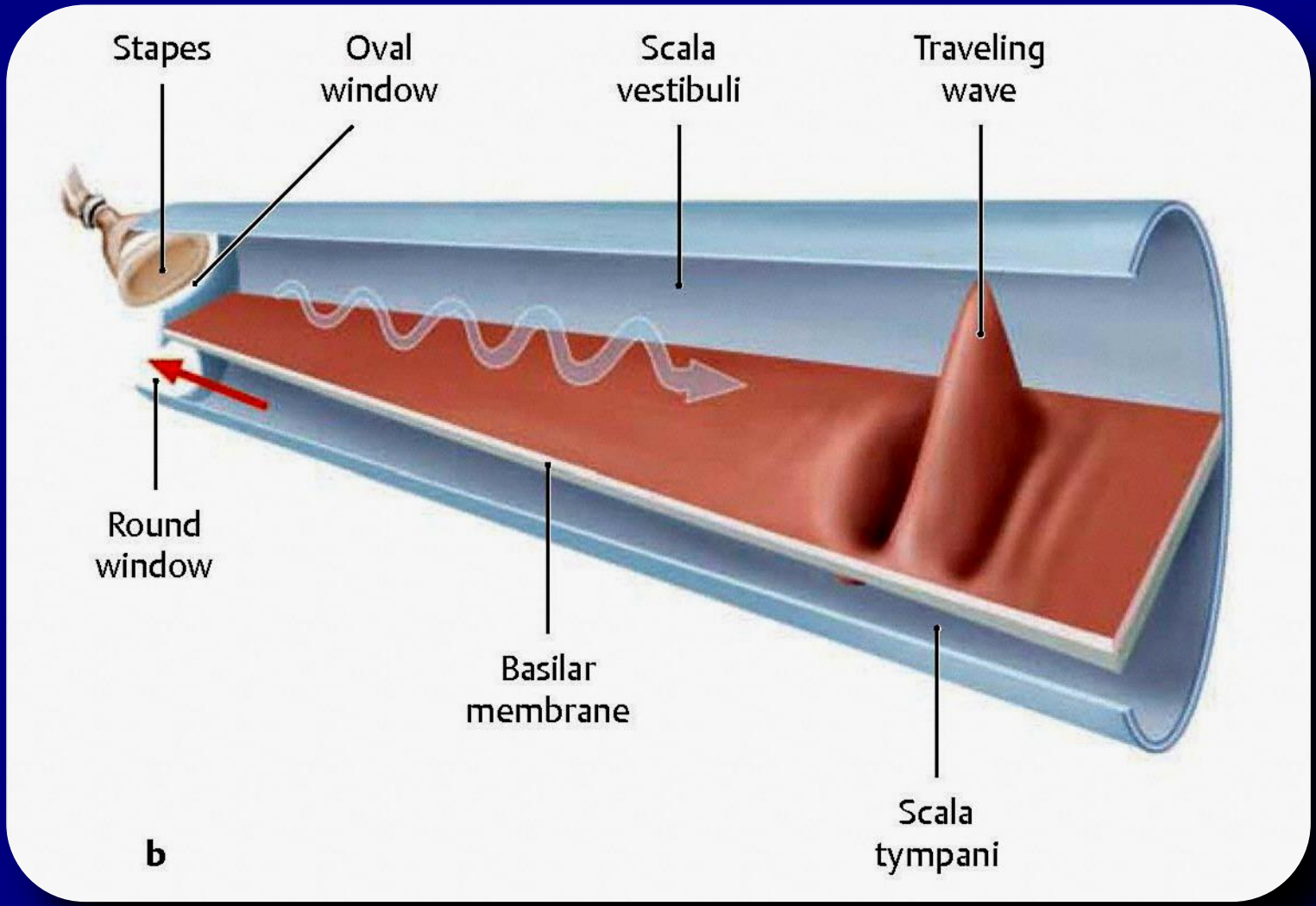








Sound conduction during hearing



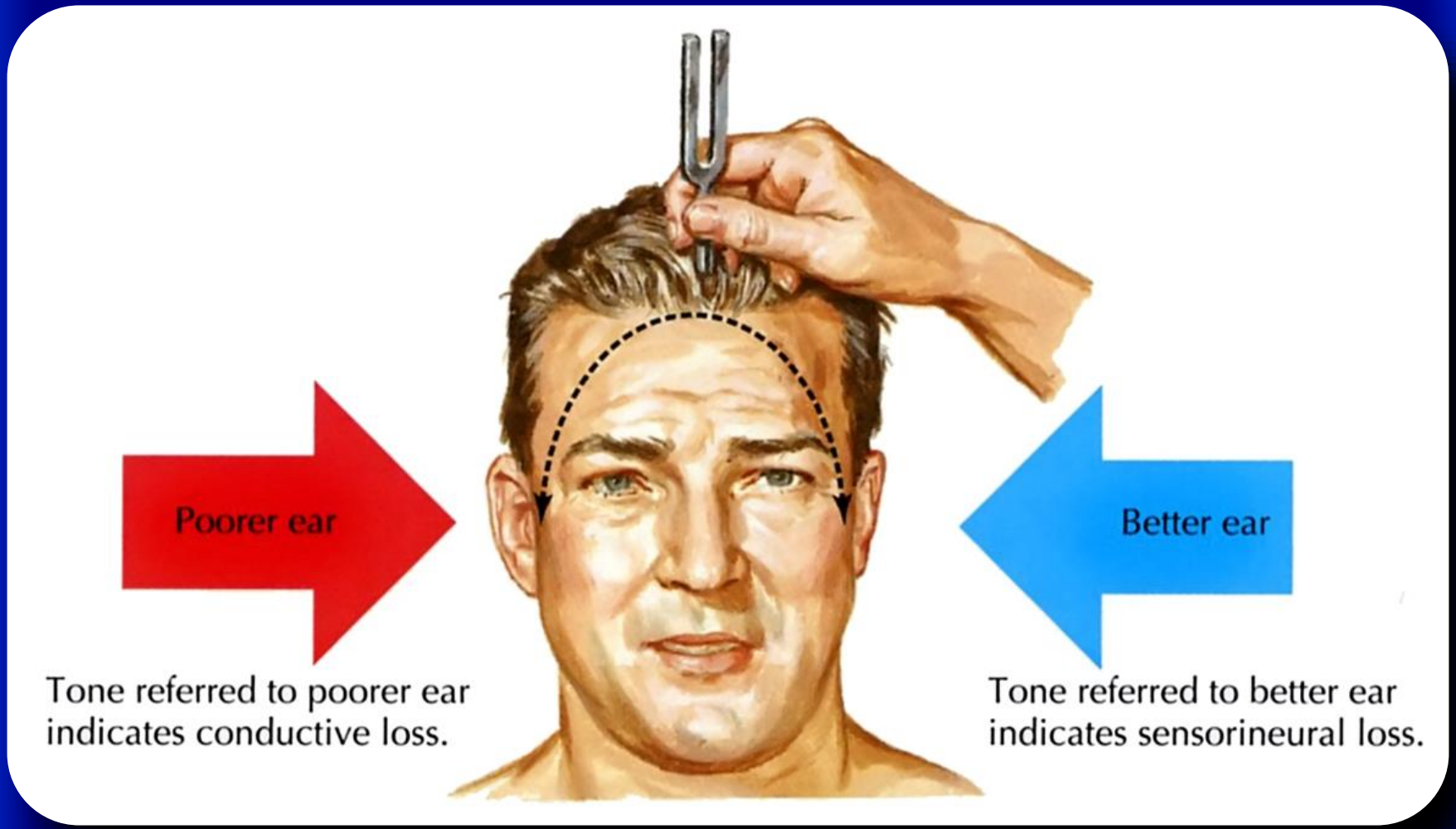
Sound conduction during hearing

Weber and Rinne Tests

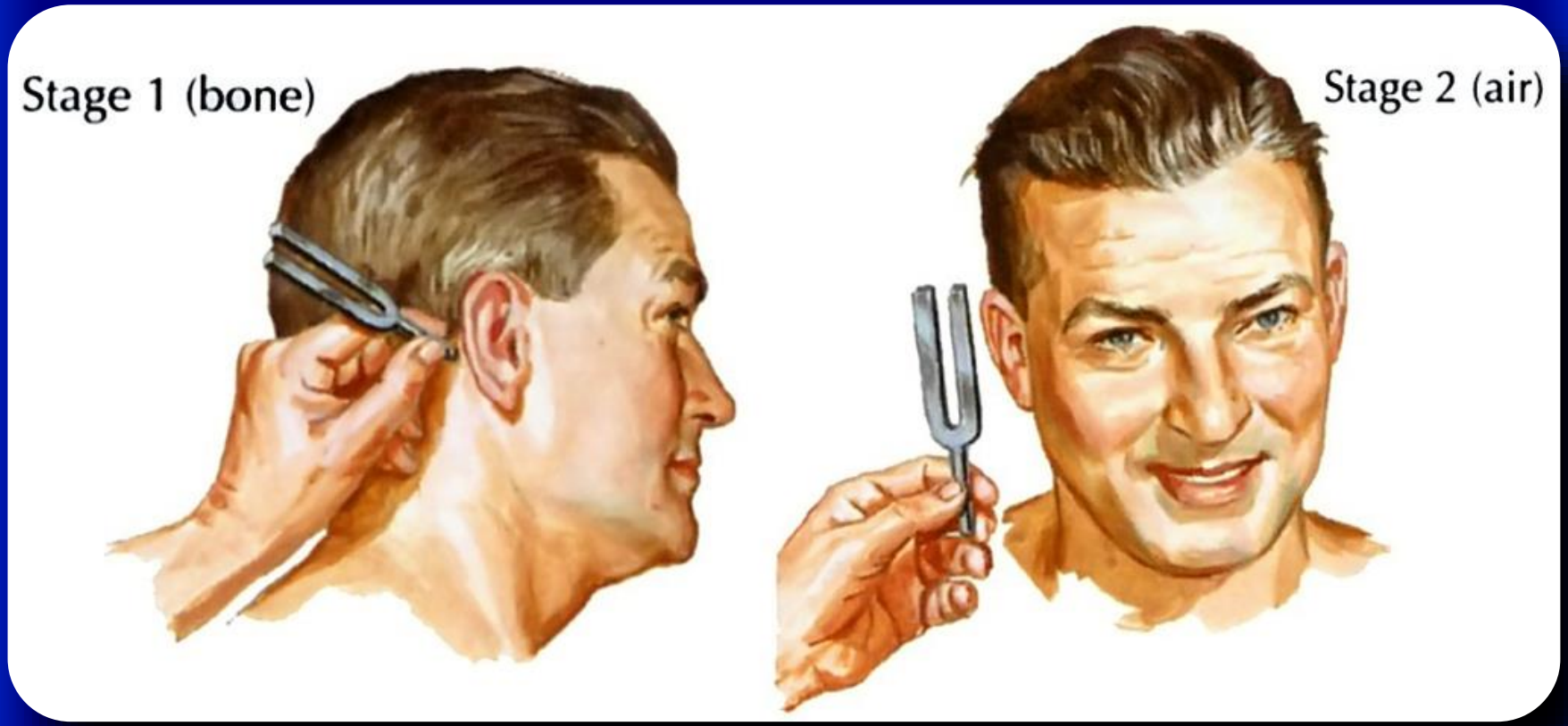
Sensorineural hearing loss suggests a disorder of the internal ear or the cochlear division of CN VIII.

Conductive hearing loss suggests a disorder of the external or middle ear (eardrum, ear ossicles, or both).

The Weber and Rinne tests offer an easy way to differentiate between sensorineural and conductive hearing loss.


Poorer ear
Better ear
Tone referred to poorer ear indicates conductive loss.
Tone referred to better ear indicates sensorineural loss.

Weber test



Normal: air conduction > bone

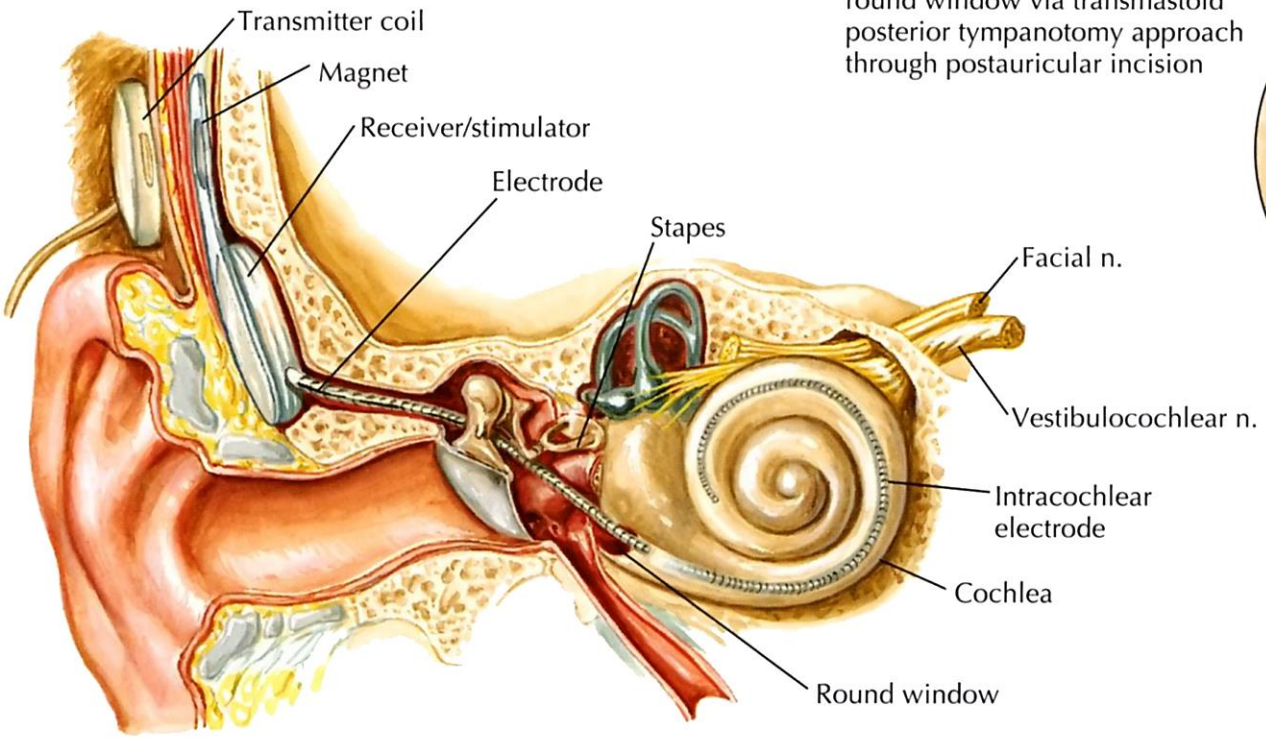
In ear with decreased hearing, if bone > air, evidence of conduction loss

In ear with decreased hearing, if air > bone, evidence of sensorineural loss

Test	Site	Findings
Weber	Fork placed on forehead	Sound heard in middle if normal hearing or equal deafness exists; lateralization to one side indicates a conductive loss on that side or a sensorineural loss on the opposite side
Rinne	Tines of fork held beside ear	Reveals air conduction hearing loss
	Handle placed on mastoid process	Reveals bone conduction hearing loss

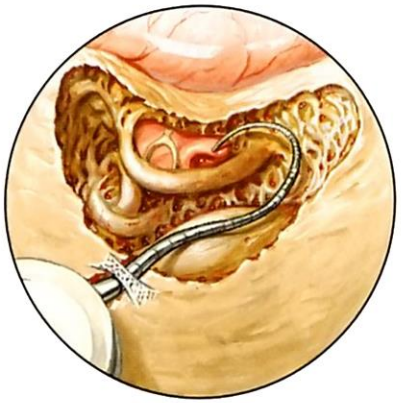
Cochlear Implant

Two million Americans have profound bilateral deafness. A cochlear implant consists of a speech processor and implanted electrodes. An external microphone detects sound, which is converted by the processor into electrical signals transmitted to the cochlear implant and vestibulocochlear nerve.

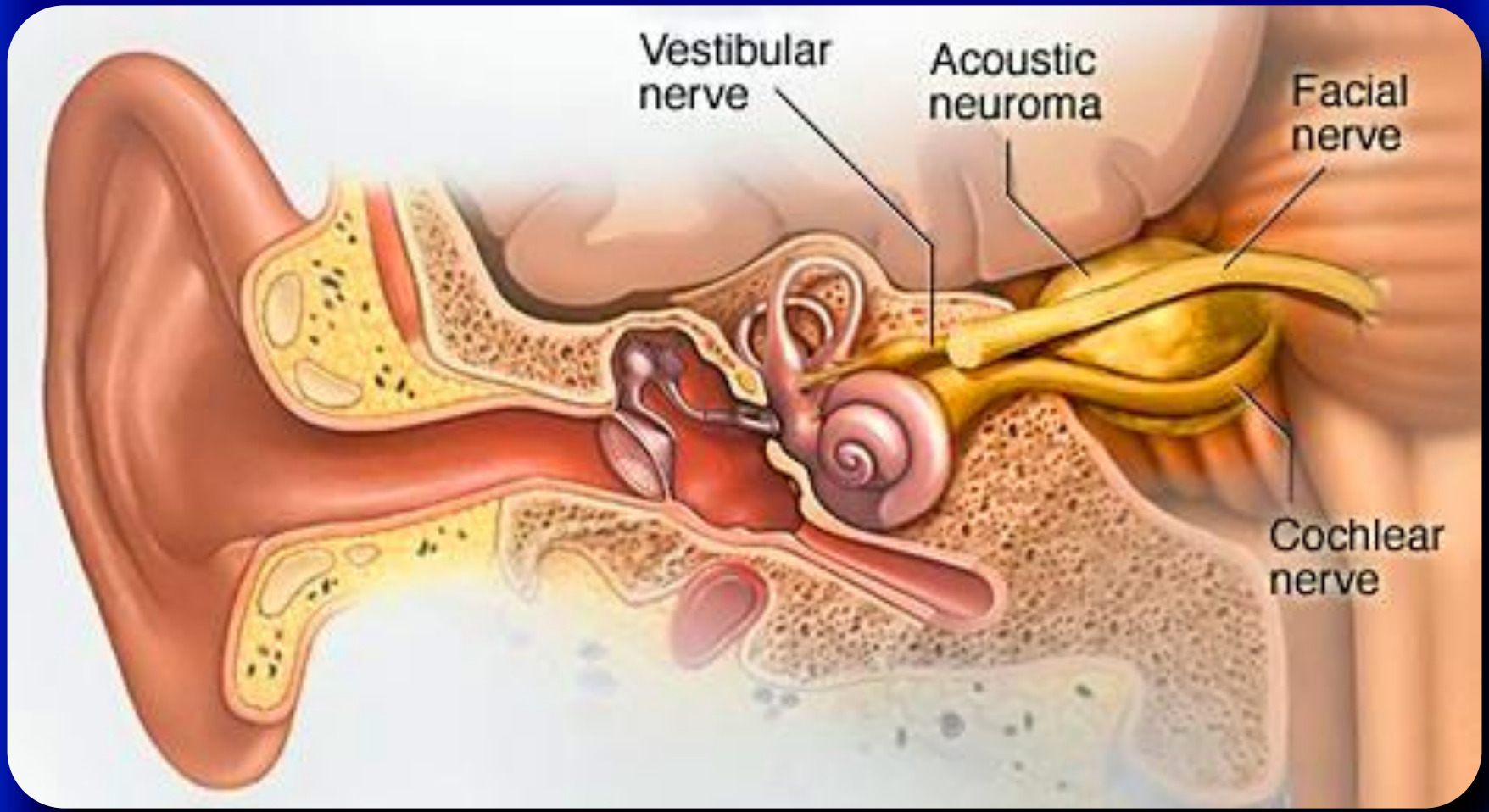


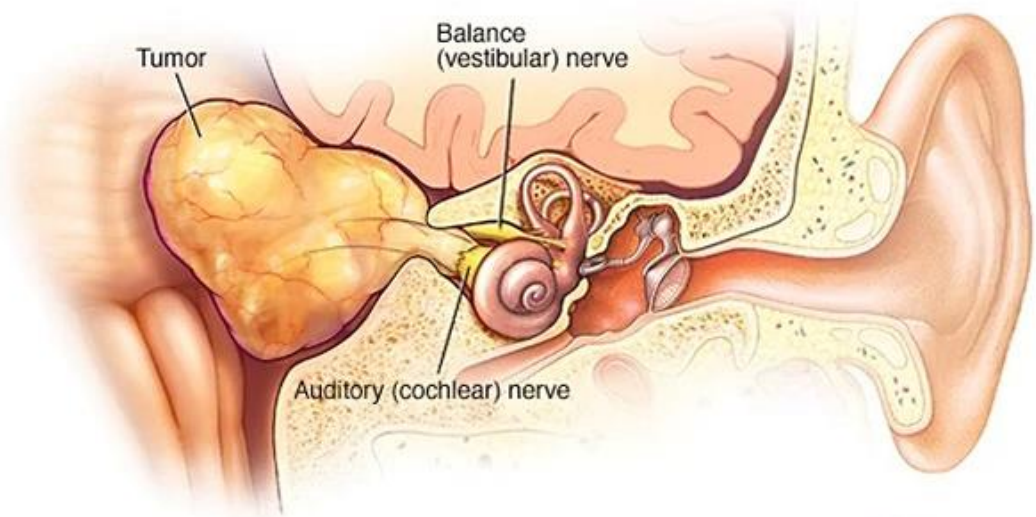
Placement of prosthesis

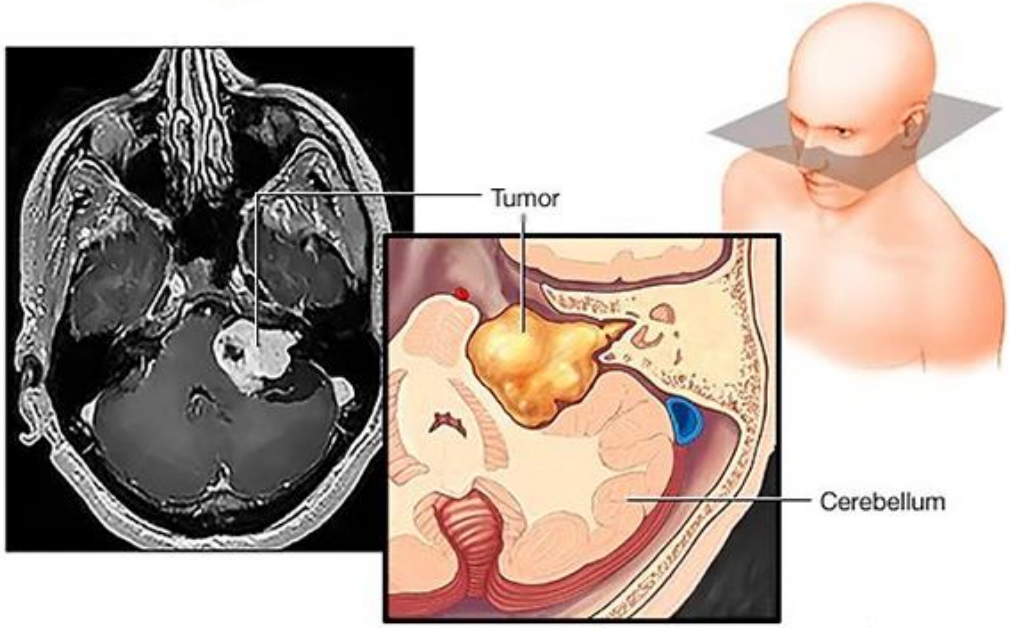
Electrode placed in cochlea near round window via transmastoid posterior tympanotomy approach through postauricular incision

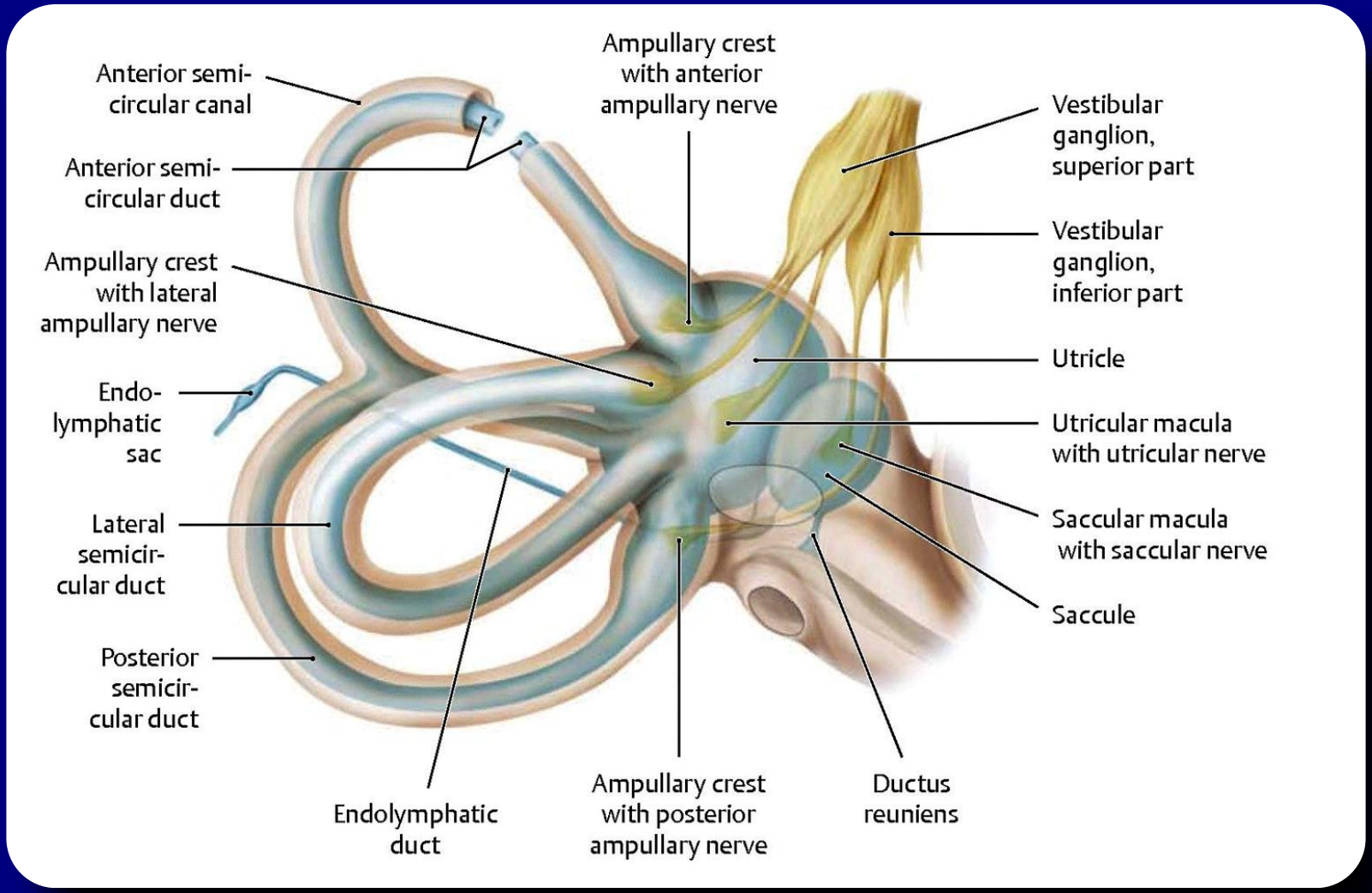


External device in position

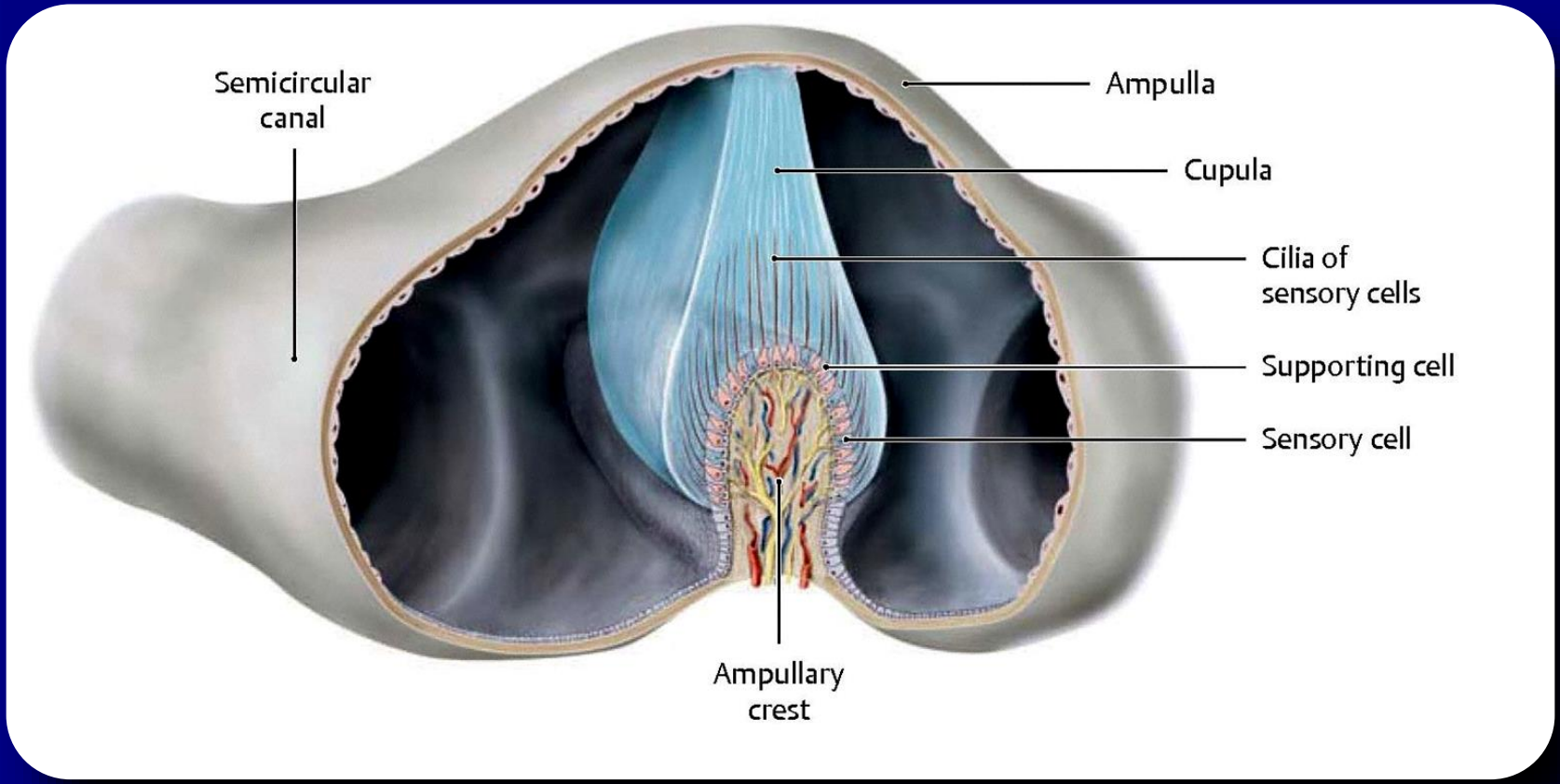

Vestibular nerve
Acoustic neuroma
Facial nerve
Cochlear nerve


Tumor
Balance
(vestibular) nerve
Auditory (cochlear) nerve

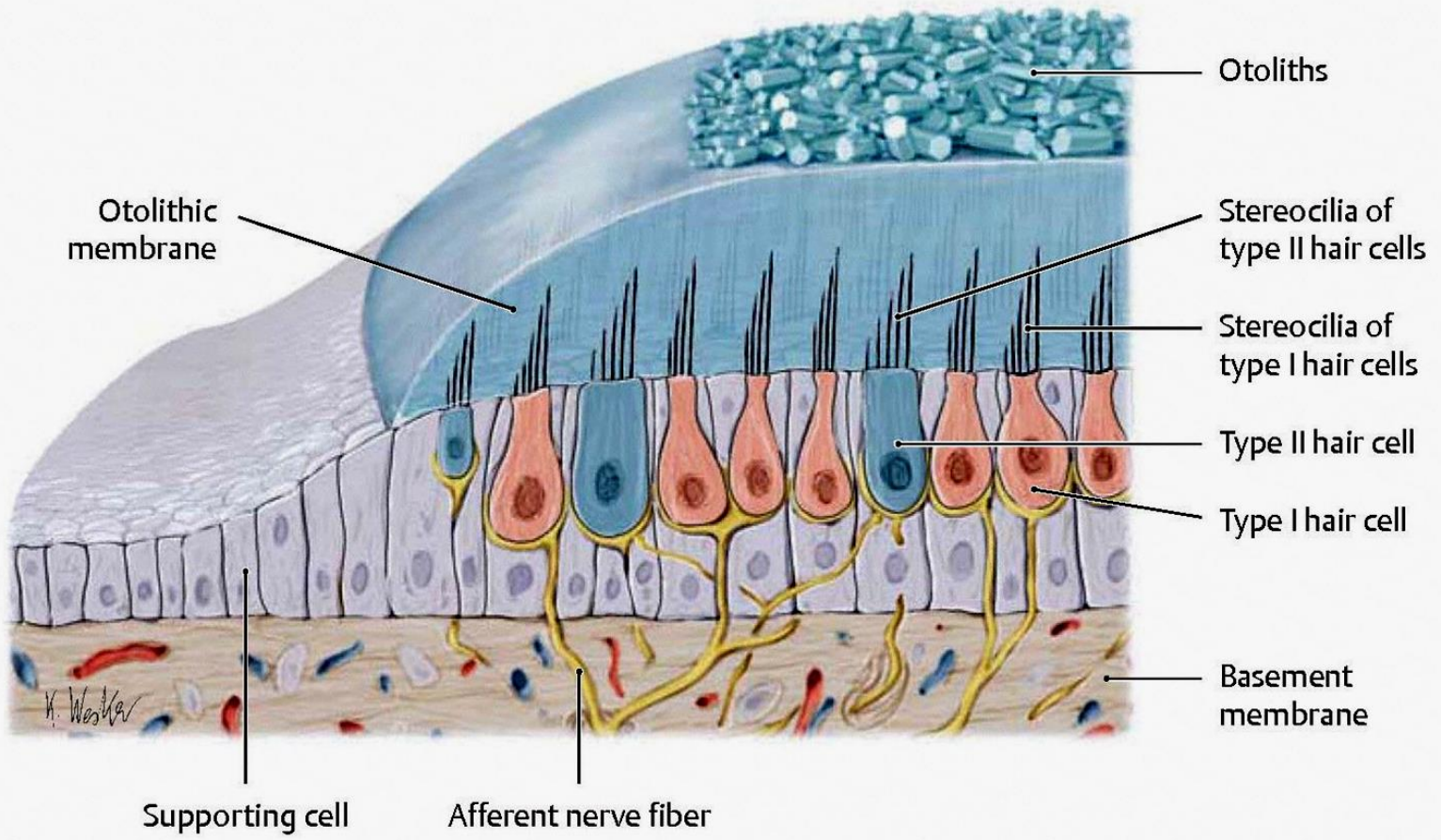

Tumor
Cerebellum



Structure of the vestibular apparatus



Structure of the ampulla and ampullary crest



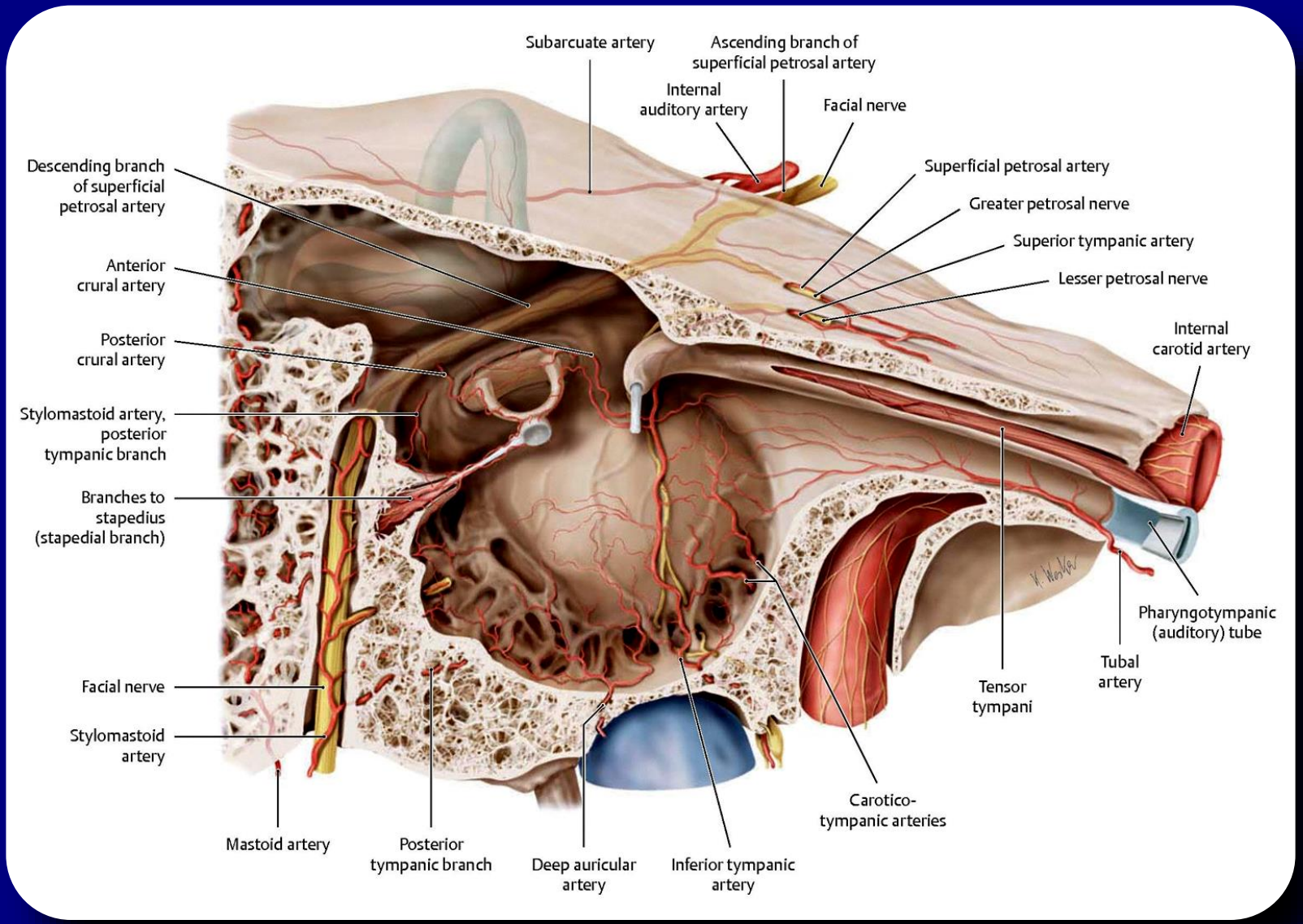
Structure of the utricular and saccular maculae

Meniere's disease – is a disorder of the inner ear that is characterized by episodes of feeling like the world is spinning (vertigo), ringing in the ears (tinnitus), hearing loss, and a fullness in the ear. Typically only one ear is affected, at least initially; however, over time both ears may become involved. Episodes generally last from 20 minutes to a few hours. The time between episodes varies. The hearing loss and ringing in the ears may become constant over time.

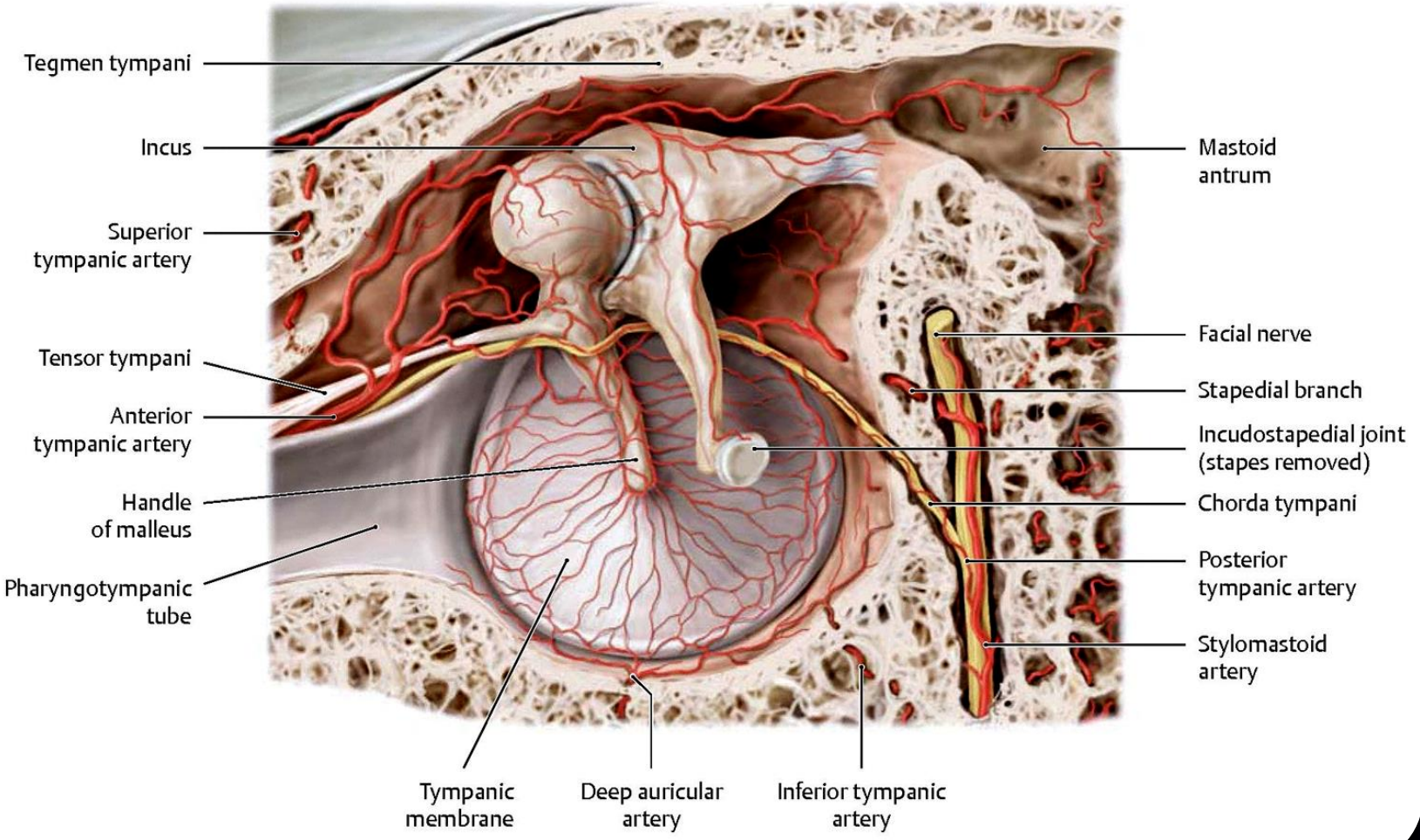
The cause of Ménière's disease is unclear but likely involves both genetic and environmental factors.

In 1972, the academy defined criteria for diagnosing Ménière's disease as:

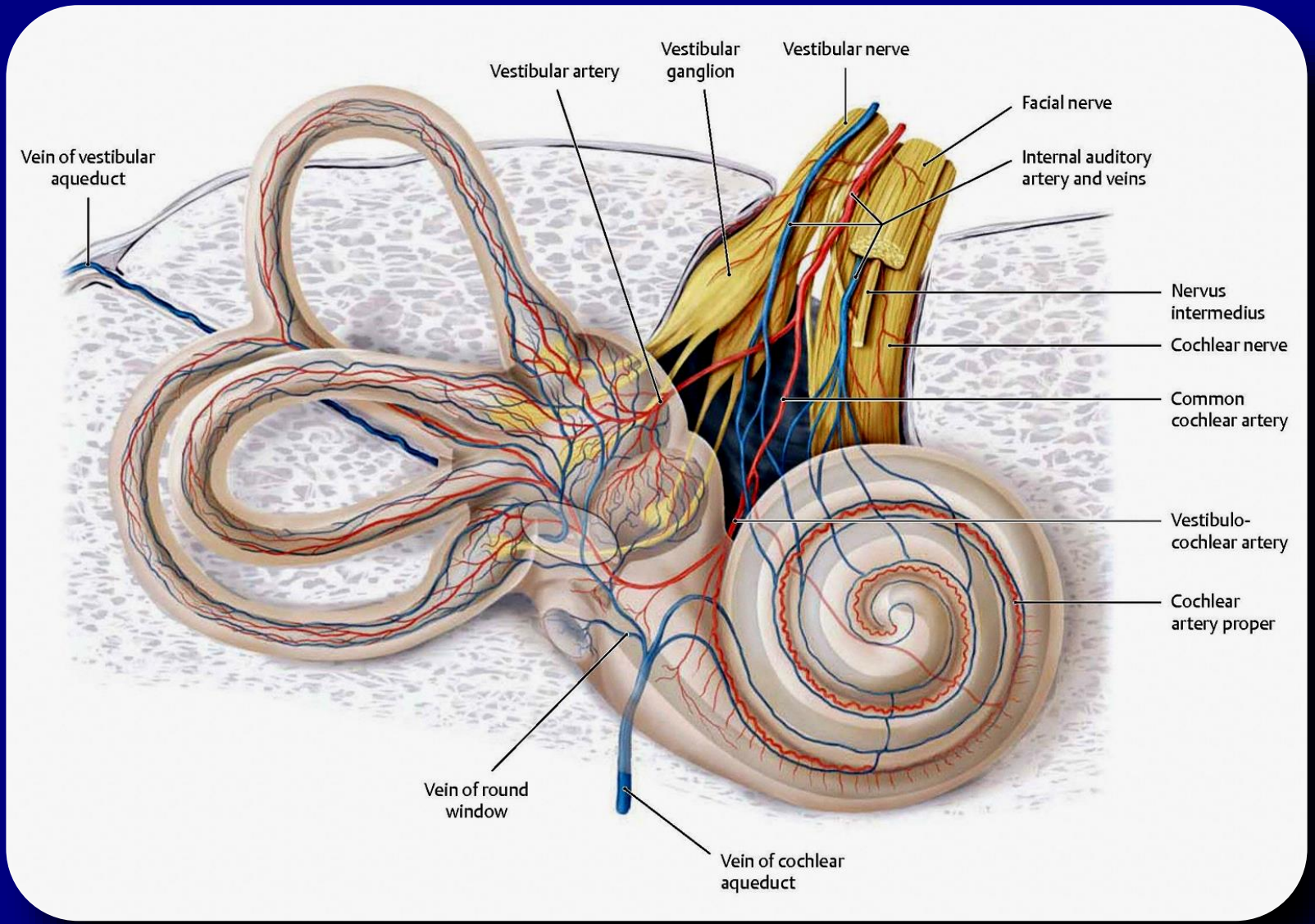
- Fluctuating, progressive, sensorineural deafness.
- Episodic, characteristic definitive spells of vertigo lasting 20 minutes to 24 hours with no unconsciousness, vestibular nystagmus always present.
- Tinnitus (ringing in the ears, from mild to severe) Often the tinnitus is accompanied by ear pain and a feeling of fullness in the affected ear. Usually the tinnitus is more severe before a spell of vertigo and lessens after the vertigo attack.
- Attacks are characterized by periods of remission and exacerbation.



Arteries of the tympanic cavity and mastoid air cells



Vascular supply of the ossicular chain and tympanic membrane



Blood supply of the labyrinth

Thank you very much