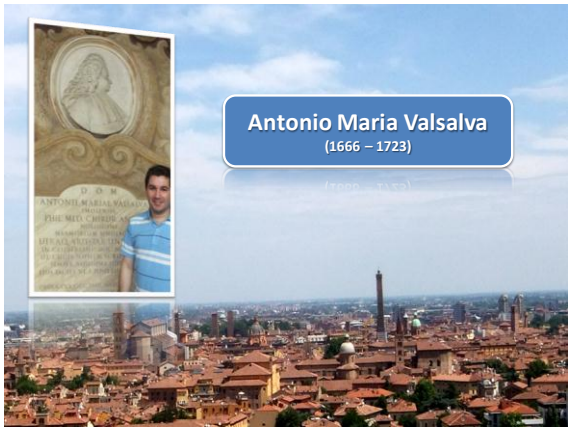
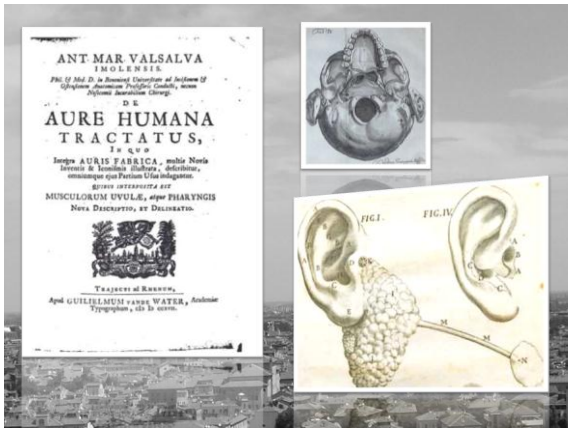
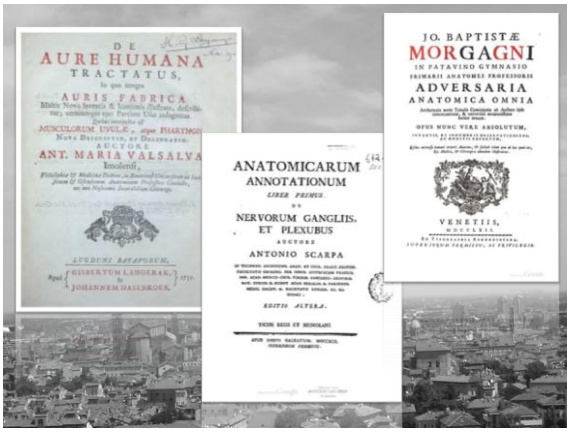
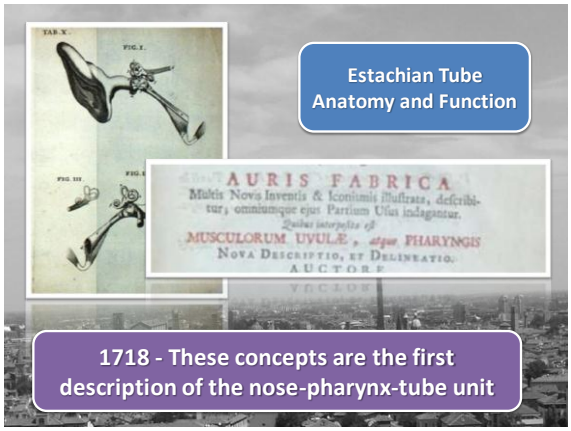

ANATOMIA E FISIOLOGIA
OTOLOGIA
sinus & oto
CENTRO
João Flávio Nogueira, MD
Sinus Centro
Fortaleza, Brazil

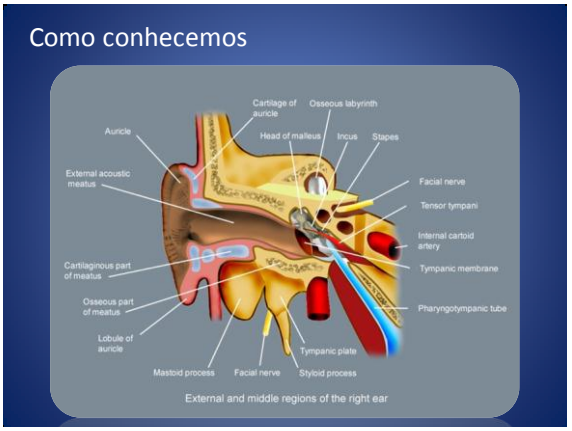

Bologna, Italy – 1700's


Antonio Maria Valsalva
(1666 – 1723)


ANT MAR VALSALVA
IMOLENSIS
DE
AURE HUMANA
TRACTATUS,
MUSCULORUM UVULÆ, atque PHARYNGIS
Nova Descriptio, et Delineatio.
FIG. I.
FIG. IV.


DE
AURE HUMANA
TRACTATUS,
AURIS FABRICA
ANATOMICARUM
ANNOTATIONUM
NERVORUM GANGLIIS,
ET PLEXUBUS
ANTONIO SCARPA
JO. BAPTISTÆ
MORGAGNI
ADVERSARIA
ANATOMICA OMNIA
VENETIIS,

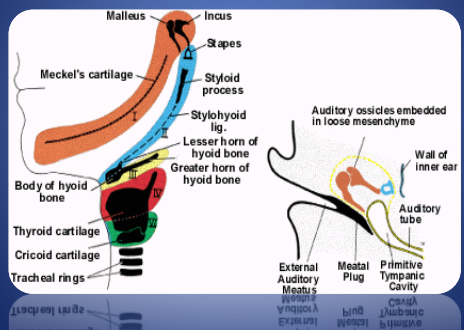

Estachian Tube
Anatomy and Function
AURIS FABRICA
Multis Novis Inventis & Iconismis illustrata, describitur, omniumque ejus Partium Usus indagantur.
MUSCULORUM UVULÆ, atque PHARYNGIS
Nova Descriptio, et Delineatio.
AUCTORE
1718 - These concepts are the first description of the nose-pharynx-tube unit


Como conhecemos
Cartilage of auricle
Osseous labyrinth
Auricle
Head of malleus
Incus
Stapes
External acoustic meatus
Facial nerve
Tensor tympani
Internal cartoid artery
Cartilaginous part of meatus
Tympanic membrane
Osseous part of meatus
Pharyngotympanic tube
Lobule of auricle
Tympanic plate
Mastoid process
Facial nerve
Styloid process
External and middle regions of the right ear

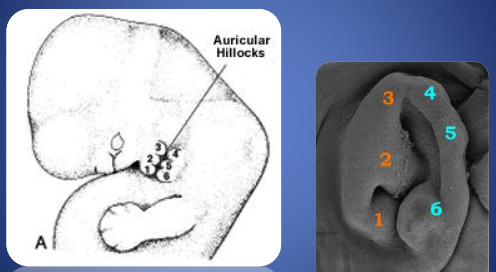
Subdivisões anatômicas

- **Ouvido externo**
  - Pavilhão auditivo e conduto auditivo externo
- **Ouvido médio**
  - Cavidade timpânica – MT, ossículos, músculos, ligamentos e tuba auditiva
- **Ouvido interno**
  - Labirinto membranoso – cóclea, sáculo, urtículo e canais semicirculares

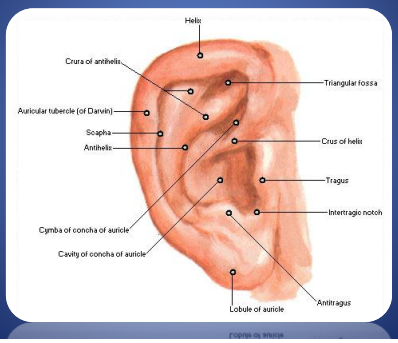
INTRODUÇÃO



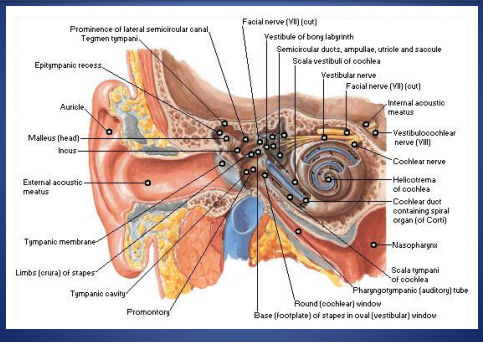
INTRODUÇÃO



ORELHA EXTERNA



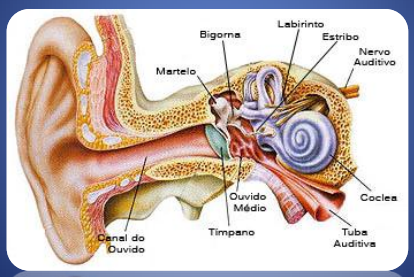
ORELHA MÉDIA



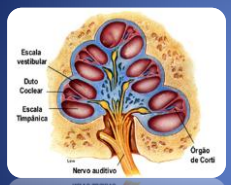
ORELHA MÉDIA

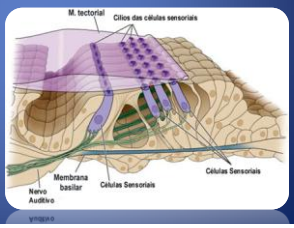
- Estribo é o MENOR osso do corpo humano
- Ao nascimento os ossículos já estão devidamente formados e não mais crescem...

ORELHA INTERNA



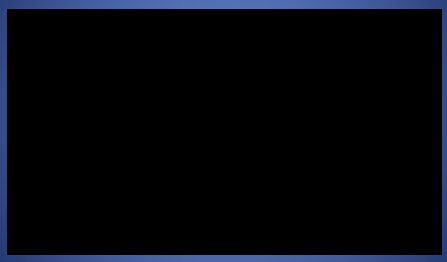
ORELHA INTERNA





COMO ESCUTAMOS ?

COMO ESCUTAMOS ?



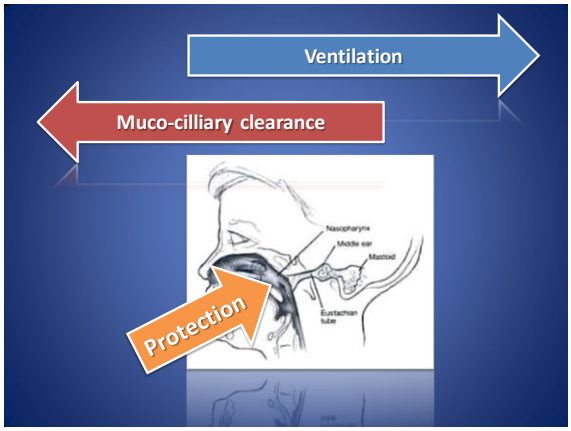
CURIOSIDADES

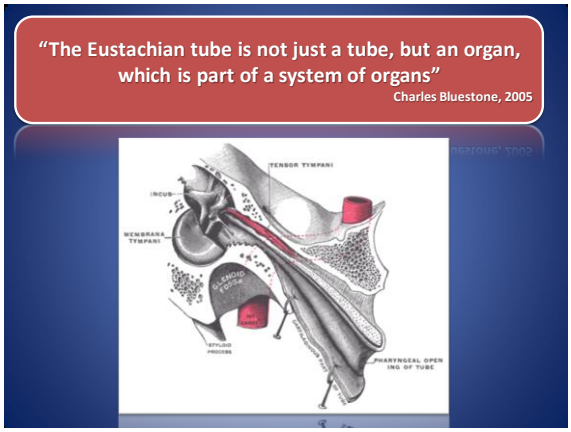
- Pavilhão auricular
  - 6a. Semana | 20a. Semana
- Meato acústico externo
  - 8a. Semana | 28a. Semana
- Orelha média
  - 3a. Semana | 30a. Semana
- Labirinto
  - 3a. Semana | 20a. Semana
- Cóclea
  - 3a. Semana | 20a. Semana

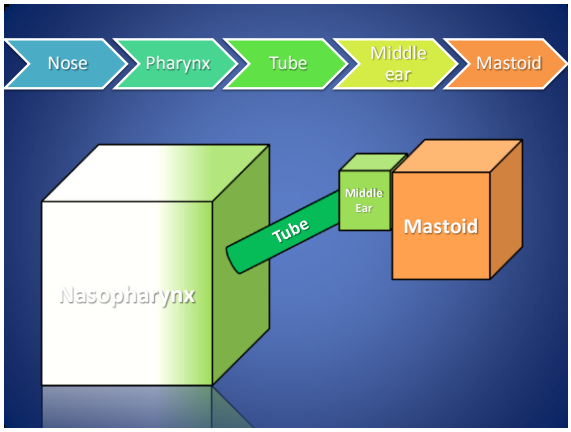
Ventilation

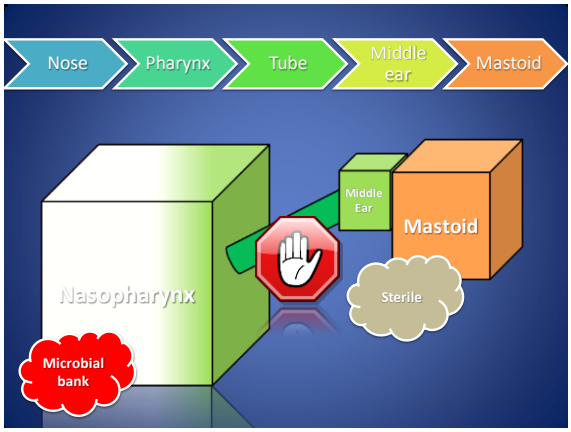
Muco-cilliary clearance

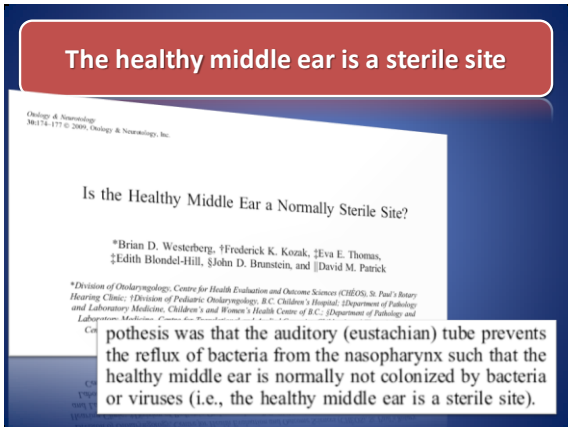
2 units


Ventilation
Muco-cilliary clearance
Protection
Nasopharynx
Middle ear
Mastoid
Eustachian tube

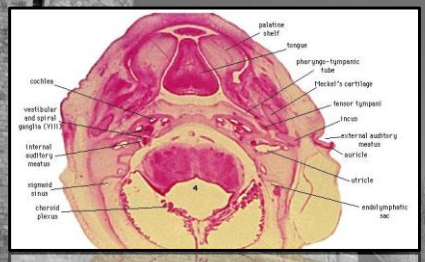

"The Eustachian tube is not just a tube, but an organ, which is part of a system of organs"
Charles Bluestone, 2005
TENSOR TYMPANI
INCUS
MEMBRANA TYMPANI
STYLOID PROCESS
PHARYNGEAL OPENING OF TUBE


Nose
Pharynx
Tube
Middle ear
Mastoid
Nasopharynx
Tube
Middle Ear
Mastoid


Nose
Pharynx
Tube
Middle ear
Mastoid
Nasopharynx
Middle Ear
Mastoid
Sterile
Microbial bank


The healthy middle ear is a sterile site
Is the Healthy Middle Ear a Normally Sterile Site?
*Brian D. Westerberg, †Frederick K. Kozak, ‡Eva E. Thomas, ‡Edith Blondel-Hill, §John D. Brunstein, and ‖David M. Patrick
pothesis was that the auditory (eustachian) tube prevents the reflux of bacteria from the nasopharynx such that the healthy middle ear is normally not colonized by bacteria or viruses (i.e., the healthy middle ear is a sterile site).

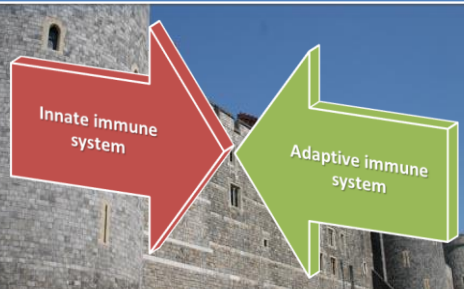
Eustachian tube embryology



54 – 56 days

Available at: http://embryology.med.unsw.edu.au/wwwhuman/lowpower/HumB/BS.htm

Eustachian tube immunity



Eustachian tube immunity

REVIEW

Normal and pathological mucosa of the middle ear and Eustachian tube*

DAVID J. LIM

Research report

Mucosa-associated lymphoid tissue in middle ear and Eustachian tube in children

Shoji Matsune, Haruo Takahashi and Isamu Sando*

Department of Otolaryngology, University of Pittsburgh School of Medicine, The Eye & Ear Institute, 203 Lothrop Street, Room 153, Pittsburgh, PA 15213, USA

Received 28 January 1995; Revised 3 July 1995; accepted 6 July 1995. Available online 26 February 1999.

Abstract

The presence of mucosal lymphoid follicles with germinal centers, so called mucosa-associated lymphoid tissue (MALT), in the Eustachian tube (ET) and middle ear (ME) was investigated in 23 human temporal bones containing the entire ET obtained from 23 children, 3 months to 10 years old at death. Greater numbers of MALTs were found in specimens from children with otitis media (OM) than from those without OM. MALT showed a wedge-shaped distribution through the ME and ET: in all 3 specimens that had MALTs in the ME, these tissues were seen throughout the ET; in all 4 specimens with MALTs in the bony portion of the ET, these tissues were present both in the tympanic and pharyngeal portions of the cartilaginea ET; all 7 specimens that had MALTs in the tympanic half of the cartilaginea ET had MALTs in the pharyngeal portion of the cartilaginea ET as well. Furthermore, MALTs were noted in the pharyngeal portion of the ET in more than half of the specimens without OM but in none of the MEs of specimens without OM. These results support the hypothesis that persistent and recurrent inflammation in the nasopharynx spreads through the ET to play a role in the pathogenesis of chronic OM in children.

Author Keywords: Mucosa-associated lymphoid tissue; Middle ear; Eustachian tube; Otitis media; Temporal bone histopathology

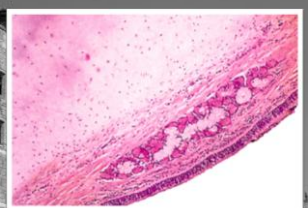
Eustachian tube immunity

M.A.L.T. → T.A.L.T.

Tube-Associated Lymphoid Tissue

Eustachian tube immunity

T.A.L.T.



Cartilaginous portion of auditory tube with seromucinous glands

Available at: http://flylib.com/books/en/2.953.1.20/1/

Eustachian organ immunity

- Immunity
  - Innate
    - Cartilagineous
  - Adaptative
    - Mucosal

Available at: http://flylib.com/books/en/2.953.1.20/1/

Tube-Tympanum-Mastoid immunity

T.T.M.
A.L.T.

Available at: http://flylib.com/books/en/2.953.1.20/1/

Nose-Pharynx-Tube-Tympanum-Mastoid Unit

Nose-Pharynx-Tube-Tympanum-Mastoid Unit

3 units

- Ventilation
- Muco-cilliary
- Immunological

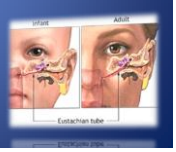
Nose-Pharynx-Tube-Tympanum-Mastoid Unit

- Innate immunity
- Muco-cilliary clearance
  - Mucins
  - Surfactant
  - Acquaporins
- Peptides and Antimicrobial Proteins
  - Lysozime (Lz)
  - Lactoferrin (Lf)
  - Defensins
  - Collectins and surfactant (SP-A, SP-D)

Differences of the Nose-Pharynx-Tube-Tympanum-Mastoid Unit

Differences of the Nose-Pharynx-Tube-Tympanum-Mastoid Unit

- Under 4 years, the closing mechanism is little effective
- 1:8 – Bone:Cartilage in children
- 1:4 – Bone:Cartilage in adults
- Pediatric tube is less permeable



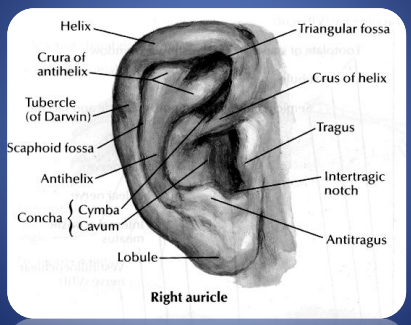
PRINCIPAIS SINTOMAS

- Otalgia
  - OE
  - OM
  - Cerumen
  - Sd. Ramsay-Hunt
  - Miringite bolhosa
  - Alt. dentárias / ATM
  - Ca base da língua
  - Neuralgias (Trigêmio / Glossofaríngeo)
  - Mastoidites
  - Alterações cervicais

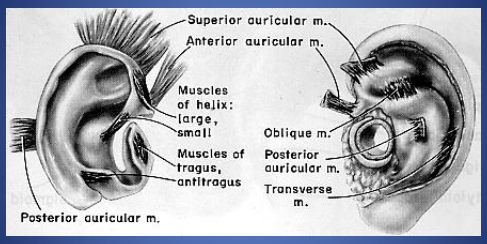
PRINCIPAIS SINTOMAS

- Surdez
- Autofonia
- Otorréia
- Prurido
- Zumbido
- Vertigem
- Fonofobia
- Diplacusia

Anatomia

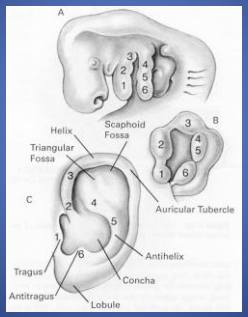


Anatomia

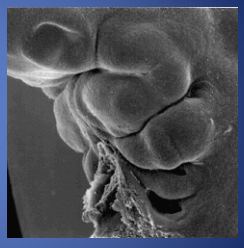


Motor: ramos pós-auriculares do n. facial - músculos anterior, superior, posterior e aricular

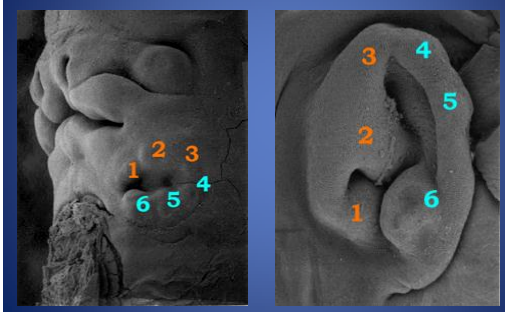
Embiologia



1o e 2o Arcos Faríngeos



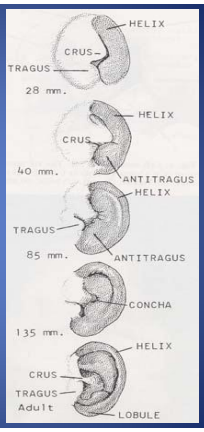
Vilosidades auriculares (lóbulo não deriva destas estruturas)



Embriologia

6 Vilosidads

2 Dobras



Embriologia Ouvido Externo

- Formação de cartilagem se inicia após 7a semana
- Tubérculo pode se desenvolver na margem posterior da hélix (tubérculo de Darwin), ficando evidente com 6 meses
- Orelha adulta – 20 semanas
- Tamanho adulto – 9 anos de idade

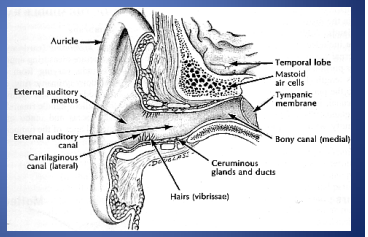
Correlatos clínicos

- Embriológico
  - Sem orelha
  - Desenvolvimento impróprio (fendas, nódulos acessórios)
- Adquirida
  - Orelha em couve-flor

Conduto auditivo externo

- 2,5 cm comprimento
- 1/3 lateral – cartilaginoso (células pilosas e glândulas ceruminosas)
- 2/3 medial – ósseo
- Fissuras de Santorini – deiscências do canal que podem levar à infecções na parótida

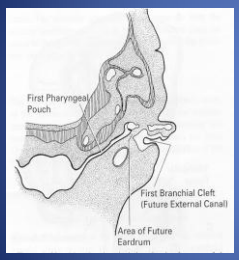
Conduto auditivo externo

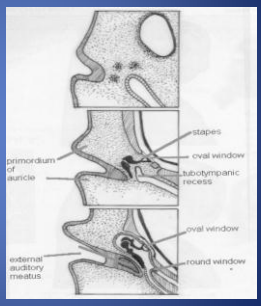


Embriologia do CAE

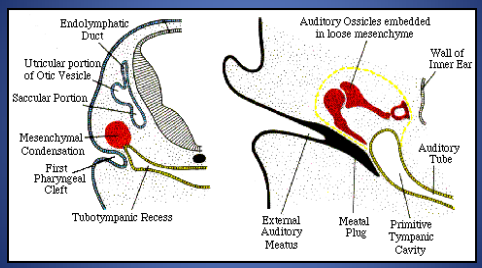
- 4a semana – 1a fenda branquial ectodérmica tem forma (canal cartilaginoso)
- 6a semana – desenvolvimento mesenquimal
- 9a semana – corda epitelial até a placa timpânica (canal ósseo)
- 20-28 semanas – canalização do canal de medial para lateral

Embriologia do CAE





Embriologia do CAE



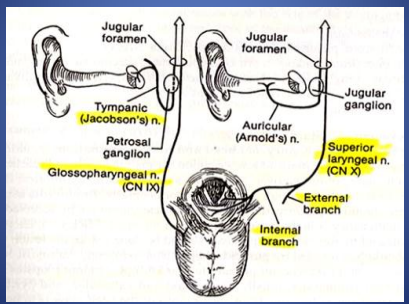
Correlatos clínicos

- Embriológicos
  - Atresia – falha da formação do plug, falha na canalização
  - Infecção – primeiro trimestre (Rubéola, 1:20.000 nascimentos)
  - Forame de Huschke – falha na obliteração da abertura inferior do meato auditivo externo
- Adquirido
  - Perda auditiva condutiva (cerumen)

Inervação Ouvido Externo

- Orelha
  - Pinna anterior – Ramo auriculotemporal (V_3)
  - Pinna posterior – N Grande auricular (C-2), n occipital menor, n facial
- CAE
  - Canal anterior e MT – Auriculotemporal (V_3)
  - Meato posterior, meato próximo à MT
    - Ramo auricular do vago (X) – n de Arnold - (único ramo cutâneo do X) – estimulação pode resultar em vômitos ou tosse
    - Ramo do VII

Correlato clínico - Otalgia



Vascularização da Orelha Externa

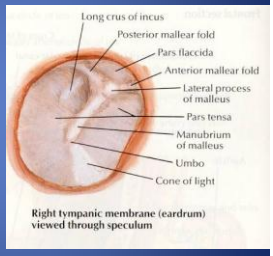
- Vascularizaçãoa – Orelha externa e CAE
  - Auricular posterior, Occipital, Temporal Superficial, Maxilar Interna (CAE) – Carótida Externa

Orelha Média

- MT
- Paredes
- Ossículos
- Músculos
- Nervos
- Tuba auditiva
- Mastóide
- Mucosa
  - Epitélio ciliado respiratório
  - Epitélio cubóide na mastóide

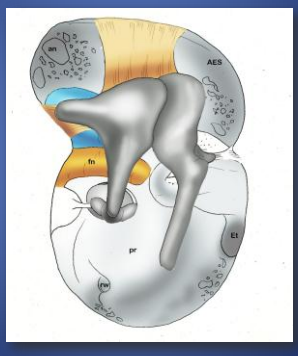
Membrana Timpânica

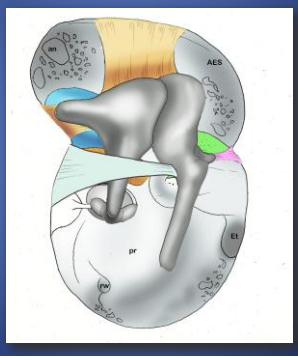
- MT se adere
  - Martelo no umbo e processo lateral
  - Anel timpânico no ânulo fibroso
- Pars Tensa – camada mesenquimal = fibras radiais/circulares. Condução sonora
- Pars Flaccida – camada mesenquimal = fibras elásticas. Cobrem espaço de Prussak's, entrada ao epitímpano
- Área fisiológica é 17 vezes menor que a janela oval (pressão sonora amplificada por fator de 17)

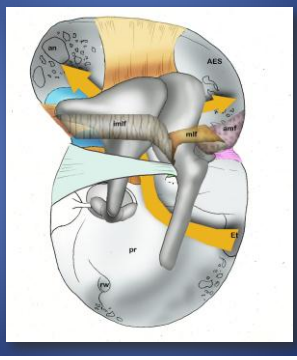


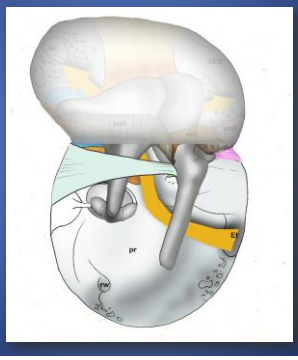
Membrana Timpânica

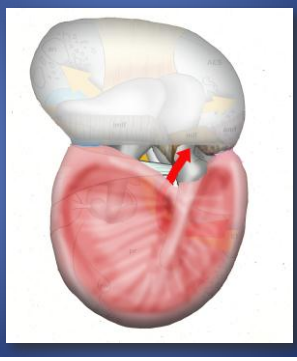
- Três camadas:
  - Epitélio escamoso lateralmente (remanescente do primeiro arco ectodermico – CAE)
  - Camada média – fibrosa
  - Epitélio colunar medialmente (contínuo com mucosa respiratória da orelha média do primeiro arco branquial).











EXAME - OMA

Correlação Clínica - Perfuração

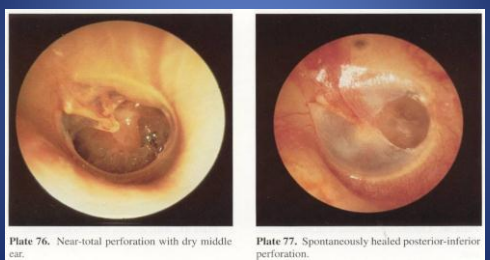
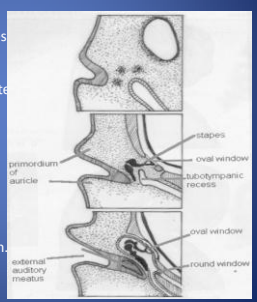


Plate 76. Near-total perforation with dry middle ear.

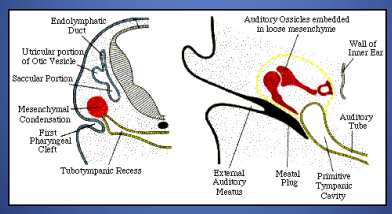
Plate 77. Spontaneously healed posterior-inferior perforation.

Middle Ear Embryology – Tympanomastoid Compartment

- 3rd wk – tubotympanic recess (1st branchial pouch endoderm) approaches 1st cleft ectoderm.
- 6th wk – Ossicular mesenchyme separate cleft and pouch.
- 20th wk – tympanic cavity grows to enclose ossicles.
- 22nd wk – extension to form mastoid antrum.
- 33rd wk – early mastoid pneumatization.

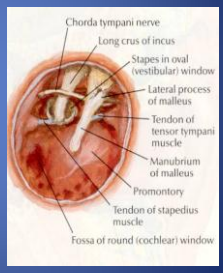


Middle ear forms as inner ear differentiates



Middle Ear Anatomy - Muscles

- Smallest striated muscles/ highest fiber to nerve ratio.
- Tensor Tympani
  - Arises from Sphenoid and Eustachian tube
  - Inserts at neck of Malleus
  - Action – Tense TM to protect cochlea from noise greater than 80 dB SPL.
- Stapedius
  - Arises from Pyramidal Eminence
  - Inserts at head/posterior crus of stapes.
  - Action – Tilt stapes footplate and tenses annular ligament.



Ligaments

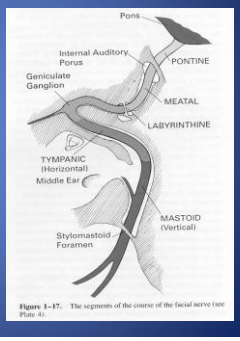
- Anterior ligament of malleus
  - angular spine of sphenoid bone to neck of malleus
- Superior mallear ligament
  - upper tegmen tympani to head of malleus
- Lateral mallear ligament
  - notch of Rivinus to neck of malleus
- Superior incudal ligament
  - tegmen to body of incus (joins with superior mallear)
- Ligament of short process (posterior incudal)
  - incudal fossa to floor of antrum
- Annular ligament of stapes
  - footplate to margins of vestibular window

Middle Ear Anatomy - Nerves

- Somatic sensation –
  - Jacobson's nerve (IX)
  - Arnold's nerve (X)
- Motor –
  - Tensor tympani (V)
  - Stapedial nerve (VII)
- Chorda Tympani (VII) –
  - Passes through middle ear cavity between malleus and incus on way to tongue/ salivary glands.

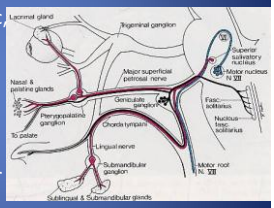
Middle Ear Anatomy - Nerves

- Facial Nerve (VII)
  - After 1st genu, passes between utricle and cochlea on way to geniculate ganglion.
  - Tympanic segment protrudes from medial/posterior wall of middle ear.
  - Chorda tympani splits off within middle ear and passes through cavity to Gaussian fissure.
  - Mastoid/Tympanic segments at risk during otologic surgery.



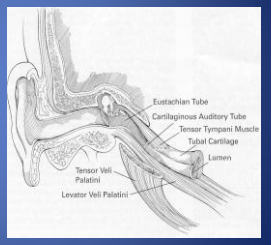
Facial Nerve:
In brief

- Muscles: facial expression, stylohyoid, posterior digastric, stapedius
- Parasympathetic: lacrimal, seromucous, submandibular and subligual glands
- Sensory: taste from anterior 2/3 of tongue



Middle Ear Anatomy – Eustachian Tube

- 35mm tube – distal 2/3 fibrocartilage/ other 1/3 osseous.
- Actively opened during swallowing by contraction of Tensor Veli Palatini muscle (V). Acts to aerate middle ear space and prevent nasopharyngeal reflux.
- Attachment for Tensor Tympani and Levator Veli Palatini – elevates palate with swallow.

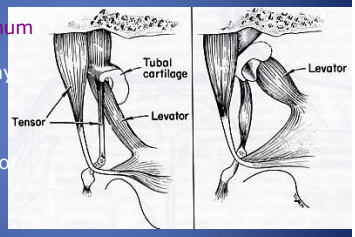


Middle Ear Anatomy – Eustachian Tube

•Opens in protympanum (anteromedial ME)
•This segment is bony

•Becomes cartilagenous
•Ends in lateral wall of pharynx

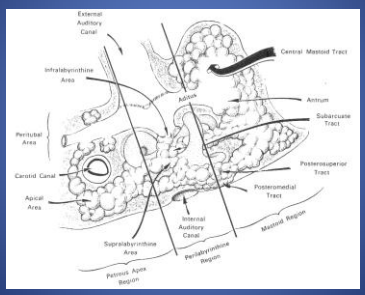
•Levator is mainly responsible for distortion of tubal cartilage when "popping ears."



Middle Ear Anatomy - Mastoid

- Antrum and aditus ad antrum located in posterior/superior aspect of epitympanum.
- Epitympanum beyond Prussak's space is difficult to visualize.
- Cholesteatoma involving ossicles, epitympanum (attic) and mastoid antrum can be hidden until significantly progressed.

Antrum/Mastoid Air Cells

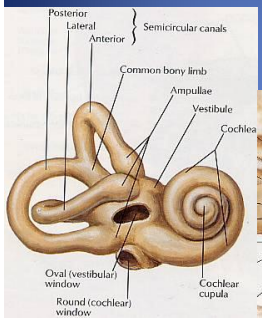


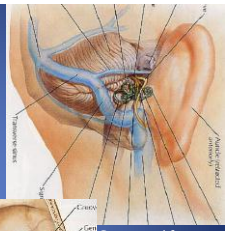
Embryology

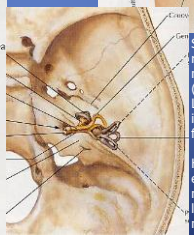
Weeks	3	4	5	6	7	8	9	10	11	12 - - - - - 30+
TM		Pouch/ groove join		Mesoderm forms fibrous layer			Fits into tympanic ring (by 16th week)			
Cavity	Formation & expansion Constriction by 2nd arch (7th wk)					Expansion				Mucoid resorption Pneumatization (30+ wk)
Ossicles		Development begins			Cartilaginous modeling			Growth to adult size		Ossifi-cation
Mastoid/ Antrum										Antrum (21wk) Pyramid (28wk) Mastoid (33wk)

Clinical Correlations - Cholesteatoma and Otosclerosis

Inner Ear Anatomy
Position and overview

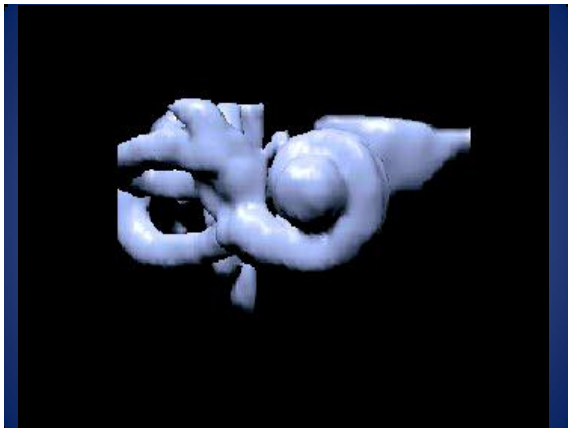






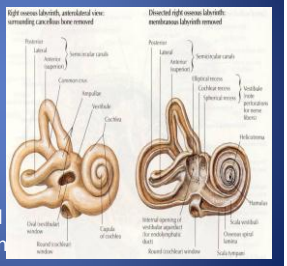
Sup. canal forms ridge in floor of middle cranial fossa (arcuate eminence)
Landmark for IAC in middle cranial fossa approach

Horizontal canal extends into mastoid
landmark in mastoidectomy



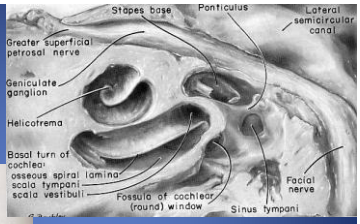
Inner Ear Anatomy – Osseous Labyrinth

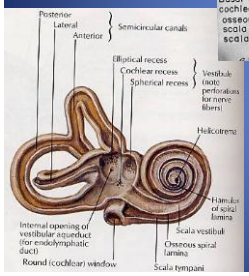
- Hardest bone in body – endosteal/endochondrial bone within cancellous bone of mastoid.
- Vestibule, 3 semicircular canals, cochlea.
- Completely enclosed except: oval and round windows and cribrose areas for innervation



Inner Ear Anatomy

Saccule in spherical recess
Utricle in elliptical recess





- Developed and contained in otic capsule
- Filled with perilymph and endolymph
- Canals are posterior
- Superior canal on one side in same plane as posterior on other side
- Is this the right or left ear?

Inner Ear Anatomy – Membranous - Vestibular

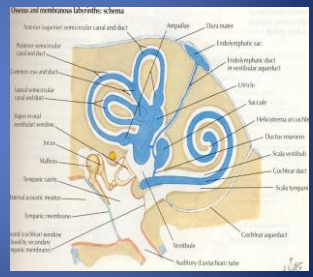
Blue=endolymph
White=perilymph

- In canals are ducts
- In vestibule is utricle, saccule filled with endolymph
- Common crus for sup and lat
- 5 openings in utricle for ducts

- Plane of horizontal canals is angled, with the anterior portion elevated from true horizontal by 30°

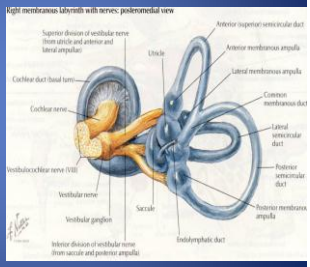
Inner Ear Anatomy – Membranous - Vestibular

- Utricle – horizontally oriented macula
- Saccule – vertically oriented macula.
- Endolymphatic duct and sac – immune monitoring and endolymph resorption.
- Ductus reuniens – connects saccule to scala media of cochlea.



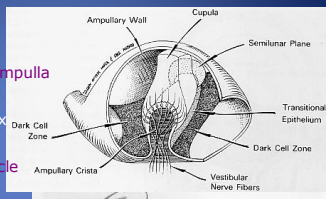
Inner Ear Anatomy – Membranous - Vestibular

- Three semicircular canals:
  - Superior (Anterior) and Posterior oriented in the vertical plane.
  - Lateral oriented in the horizontal plane.
  - Each ampullae contains cristae ampullares with overlying cupula.



Inner Ear Anatomy

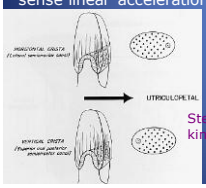
Balance



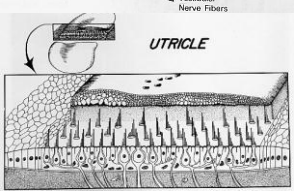
•Crista and cupula in each ampulla sense angular acceleration

•Otoliths in gelatinous matrix of these organs

•Maculae in saccule and utricle sense linear acceleration

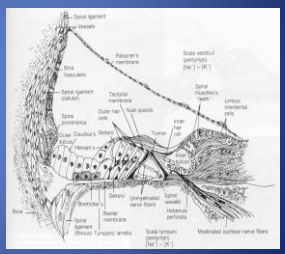


Stereocilia, kinocilium

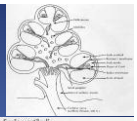


Inner Ear Anatomy – Membranous - Cochlea

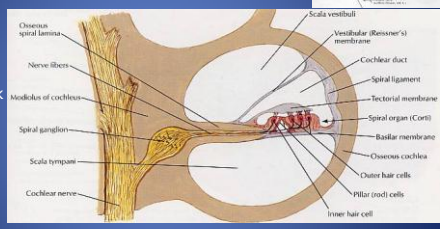
- 2 and ¾ turn osseous spiral.
- Perilymph spaces:
  - Scala vestibuli, continuous with vestibule
  - Scala tympani, end at round window
- Endolymph space: Scala media, houses Organ of Corti.



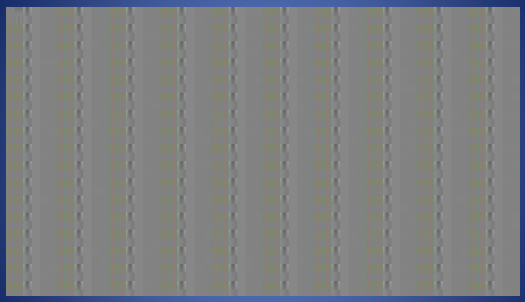
Inner Ear Anatomy – Membranous - Cochlea

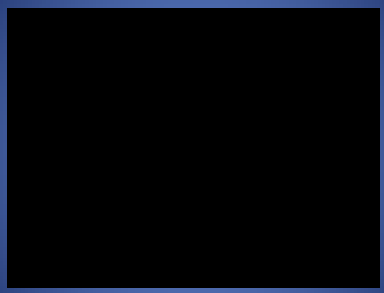


Sound waves travel in oval window, up scala vestibuli, back down scala tympani and "out" round window



High frequency pressure waves (sound) stimulate hair cells at the basal turn, and low frequency waves at the apex

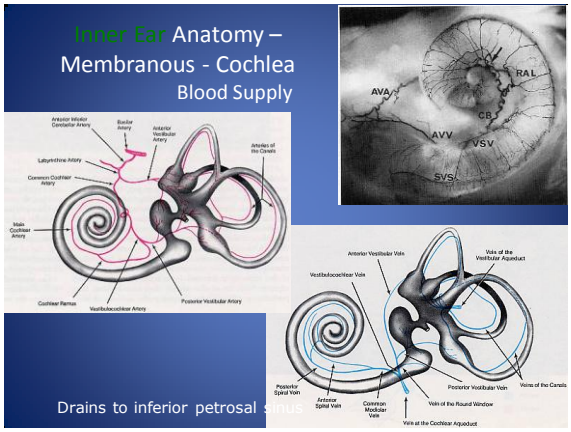




Inner Ear Anatomy - Other

- Innervation – Cranial Nerve VIII:
  - Cochlear branch synapses at spiral ganglion within modiolus of cochlea.
  - Vestibular synapse at vestibular ganglion, medial to otic capsule.
- Vascular – Blood supply via Labyrinthine artery a branch of AICA off the Basilar artery.

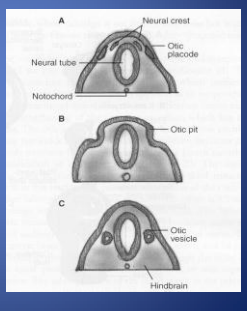
Inner Ear Anatomy – Membranous - Cochlea Blood Supply



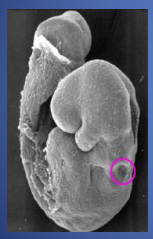
Drains to inferior petrosal sinus

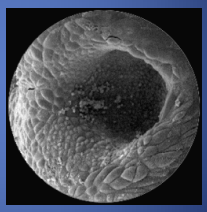
Inner Ear Embryology - Otocyst

- Inner ear phylogenetically oldest part of ear – vestibular older than cochlear
- 3rd wk – Otic placode of ectoderm forms next to neural tube (area of hindbrain of primordial CNS).
- 4th wk – Otic placode separates from neural tube and invaginates - forming Otocyst, precursor of membranous labyrinth.

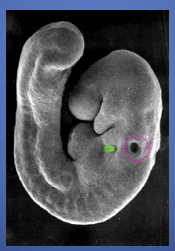


Otic pit forms as thickened placodal/ectoderm invaginates

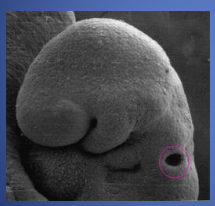


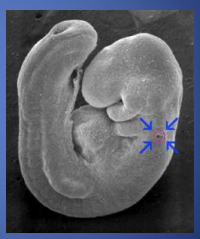


Otic pit is dorsal to 2nd pharyngeal cleft

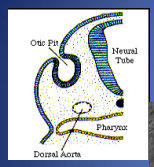


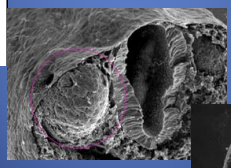
Otic pit deepens, pinches off…

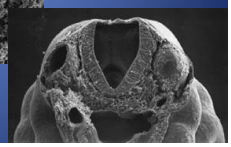




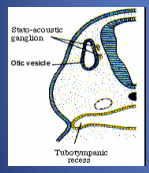
…and becomes otic vesicle

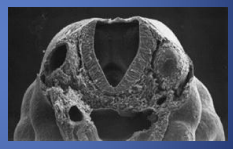




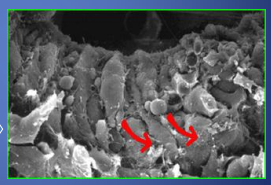


Vesicle near neural crest

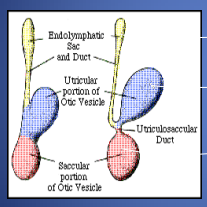


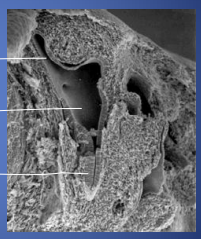


Stato (vestibulo) acoustic ganglion begins to form between vesicle and neural tube



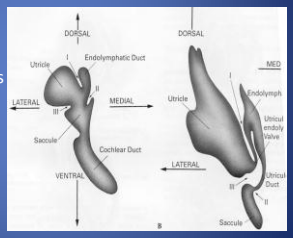
Otic vesicle differentiates





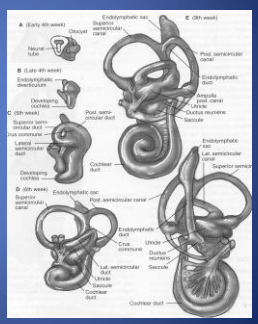
Inner Ear Embryology - Vestibular

- 5th wk: Otocyst separates into endolymphatic sac, utriculosaccular area, cochlear duct.
- 6th wk: Semicircular canals bud off utricle.
- 7th wk: Maculae develop and differentiate.
- 8th wk: Cristae appear.
- 12th wk: Otolithic membrane evident.



Inner Ear Embryology - Cochlea

- 6th wk – cochlear duct grows from saccule
- 7th wk – sensory epithelium develops with inner/outer ridges
- 8th wk – 1 ½ turns
- 10th wk – 2 ½ turns
- 11th wk – hair cells differentiate
- 20th wk – 2 ¾ turns
- 21st wk – Cochlea active



Clinical Correlate – Cochlear Malformation

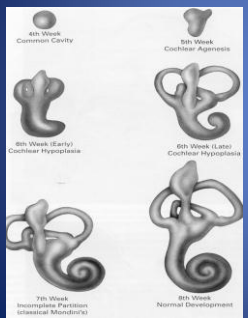


TABLE 128.2. CLASSIFICATION OF CONGENITAL INNER EAR MALFORMATIONS

- Malformations limited to the membranous labyrinth
  - Complete membranous labyrinthine dysplasia (Bing-Siebenmann)
  - Limited membranous labyrinthine dysplasia
    - Cochleosacular dysplasia (Scheibe)
    - Cochlear basal turn dysplasia
- Malformations of the osseous and membranous labyrinth
  - Complete labyrinthine aplasia (Michel)
  - Cochlear anomalies
    - Cochlear aplasia
    - Cochlear hypoplasia
    - Common cavity
    - Incomplete partition (Mondini)
  - Labyrinthine anomalies
    - Semicircular canal dysplasia
    - Semicircular canal aplasia
  - Aqueductal anomalies
    - Enlargement of the vestibular aqueduct
    - Enlargement of the cochlear aqueduct
  - Internal auditory canal abnormalities
    - Narrow internal auditory canal
    - Wide internal auditory canal

From Jackler RK. Congenital malformations of the inner ear. In: Cummings CW, Fredrickson JM, Harker LA, et al. Otolaryngology: head and neck surgery. St. Louis: Mosby–Year Book, 1993:2576–2771; with permission.