



## EAR I-II

### Objectives:

- Anatomy of the ear .
- Physiology of the :
  - External ear.
  - Middle ear.
  - Inner ear.
- Otitis Externa.
- Malignant Otitis Externa.
- Otitis Media.

[ Color index : **Important** | **Notes** | Extra ]

**Resources:** Slides+433team+Notes.

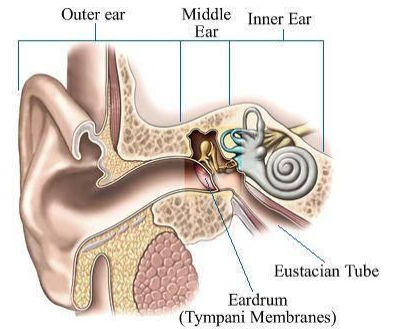
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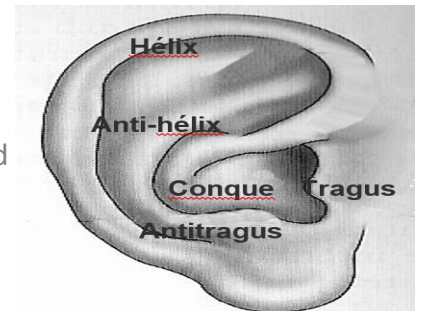
# Anatomy of the ear

- **External ear:** From the outer part till the eardrum (tympanic membrane).
- **Middle ear:** (tympanic cavity); From the eardrum till the stapes footplate.
- **Internal ear:** Cochlea and semicircular canals.



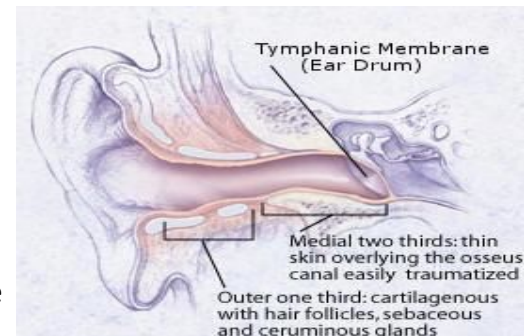
## External ear:

- Formed of Auricles and External auditory meatus (auditory canal).
- Both of them are lined by skin (Auricle and meatus).
- The external auditory meatus (2.5 cm) is an S shape canal (to protect the eardrum and middle ear. So, at examination you should pull the auricle posteriorly and superiorly to straighten the canal).



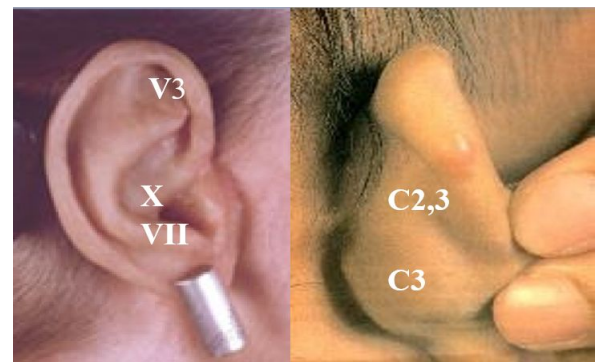
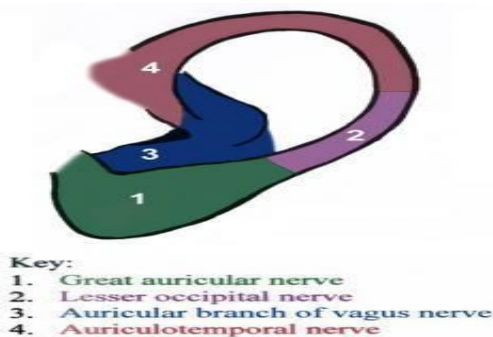
- **Auditory canal consists of:**

- **Cartilaginous part (outer 1/3):** formed by elastic cartilage and contains ceruminous glands (secrete wax). hair follicles, sebaceous and apocrine glands all together called (apopilosebaceous unit) .
- **Bony part (inner 2/3):** The narrowest portion is at the bony-cartilaginous junction. No subcutaneous tissue or appendages . The skin is thin and easy to be injured during examination.



- **Sensibility:**

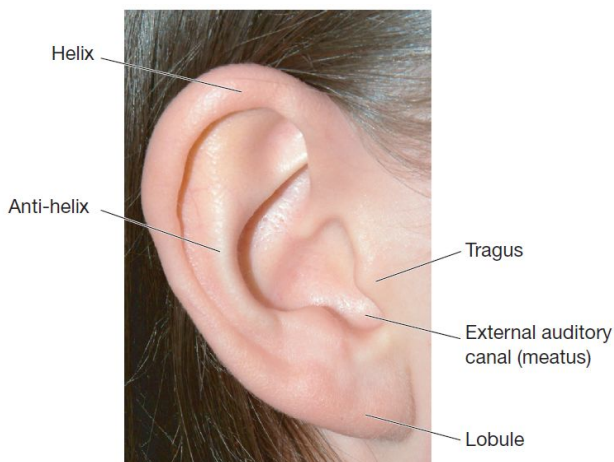
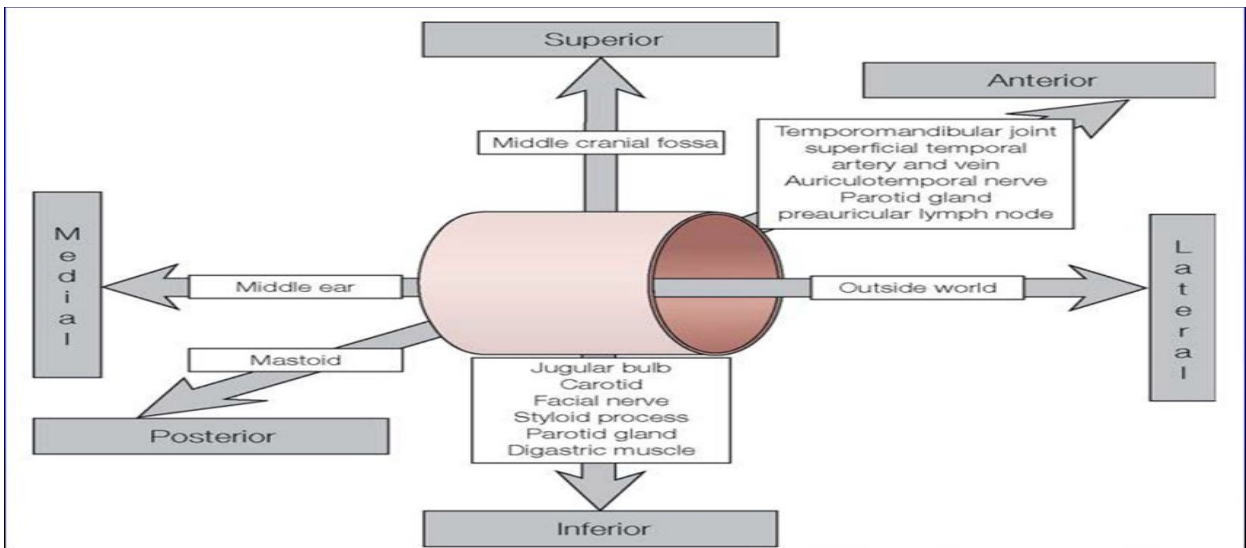
- **Great auricular nerve (C2,C3)** : lobule, lateral/inferior auricle
- **Lesser occipital (C2)**: medial surface of pinna
- **Auricular branch of vagus (Arnold's)** :concha, Post canal wall
- **Auriculotemporal nerve (V3)** : tragus. anterior helix, Ant canal wall
- **Facial nerve:** concha, Post canal wall



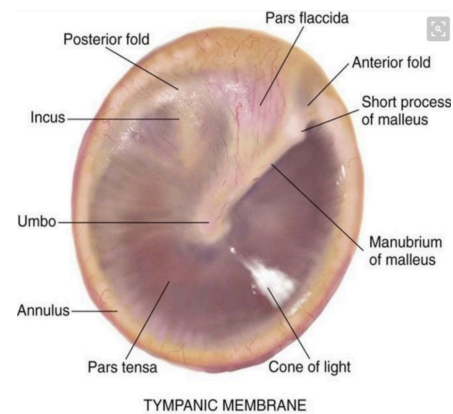
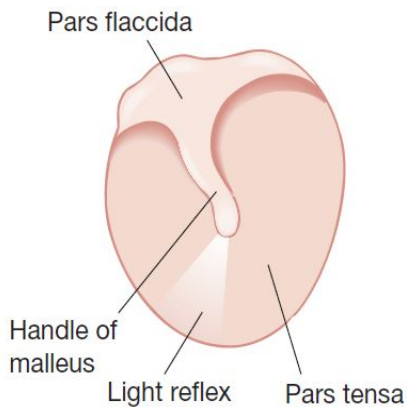
- **Referred Earache:**

- Pain in the ear due to a disease in an area supplied by a nerve that also supply the ear.
- **Cervical II & III:** Cervical spondylosis, neck injury etc.
- **V (Trigeminal) cranial nerve:** Dental infections, sinonasal diseases etc.
- **IX(Glossopharyngeal) cranial nerve:** Tonsillitis, post-tonsillectomy, carcinoma etc.
- **X (vagus) cranial nerve:** Tumors of hyopharynx, larynx & esophagus.

- **Anatomical relations of external auditory canal:**



- **Tympanic membrane<sup>1</sup>:** It forms the partition between the external auditory canal and the middle ear. Divided into **2 parts** :
  - **Pars Tensa.**
  - **Pars Flaccida.**
- *The Tympanic membrane consist of **three layers**:*
  - Outer layer **stratified squamous** epithelium (skin), **ectodermal origin.**
  - The middle layer or lamina propria fibrous layer, **mesodermal origin.**
  - The inner layer, of **endodermal origin**, comprising the middle ear mucosa.
- **TM supplied mainly** by **V3** (Mandibular) **anterior**, and **X** (Vagus) **posterior** on lateral (outer) aspect, **IX** (Glossopharyngeal) on **medial** (inner) aspect.



**Figure 1.2** The normal tympanic membrane (left). The shape of the incus is visible through the drum at 2 o'clock. The 'pars flaccida' is the part of the eardrum that covers the upper section of the middle ear. The drum is more 'tense' in the lower section – hence it is called the 'pars tensa'.

<sup>1</sup> The tympanic membrane is composed of three layers from out to in – skin, fibrous tissue and mucosa. The normal appearance of the membrane is pearly and opaque. When light reflects off the drum it forms a characteristic triangular 'light reflex' due to its concave shape. If you see this 'light reflex' that is good evidence that the drum is normal.

# Middle ear :

- Middle ear cleft formed of:
  - **Eustachian (Pharyngo-tympanic) Tube.**
  - **Tympanum (Middle Ear Cavity).**
  - **Mastoid Antrum and Air Cells.**
- Lining of the middle ear:
  - ciliated columnar anteriorly, and cuboidal or flat elsewhere.

Mucous membrane of the middle ear space consists of stratified cuboidal epithelium, which changes to pseudostratified ciliated epithelium around the mouth of the Eustachian tube. (433 team)

### ❖ Eustachian (Pharyngo-tympanic) Tube<sup>2</sup>:

- Connect the middle ear cavity with nasopharynx(upper aerodigestive tract).
- Lies adjacent to the ICA (internal carotid artery).
- open at torus tubarius.
- Parts of Eustachian Tube:
  - Lateral 1/3 is bone.
  - Medial 2/3 is fibro-cartilaginous.

\* Junction between 2 parts is isthmus, **narrowest part of the tube.**

### ➤ Physiology of Eustachian tube:

- Opens actively by contraction of tensor veli palatine and passively by contraction of levator veli palatine (it releases the tension in tubal cartilage).
- Closed by elastic recoil of elastin hinge + deforming force of Ostmann's fat pad.
- Protection, Drainage, Ventilation (most important function).

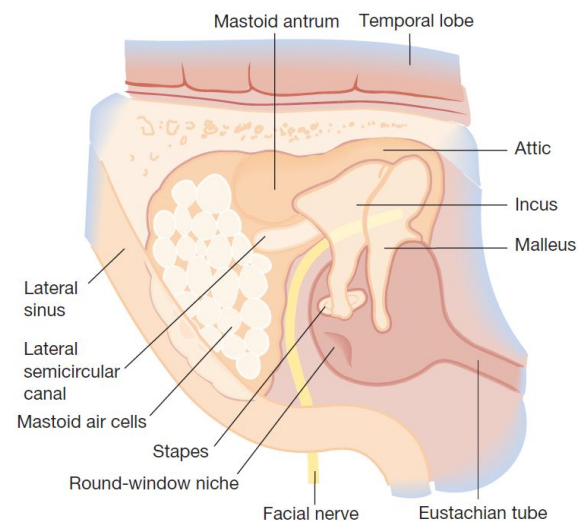
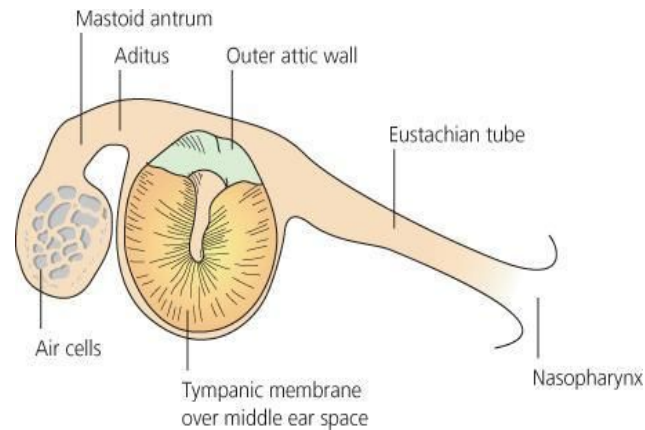


Figure 1.3 Diagram to show the anatomy of the middle ear and mastoid air cells.

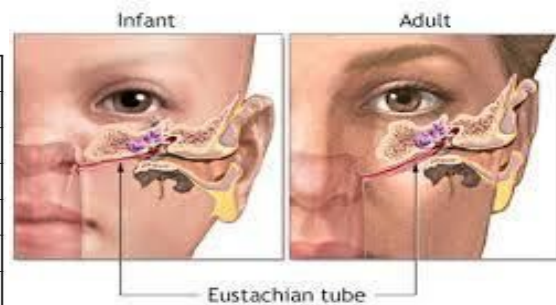
<sup>2</sup> The Eustachian tube connects the middle ear with the nasopharynx at the back of the nasal cavity.



The Eustachian tube connects the middle ear with the nasopharynx at the back of the nasal cavity. The tube permits aeration of the middle ear and if it is obstructed fluid may accumulate in the middle ear causing deafness. The tube is shorter, wider and more horizontal in the infant than in the adult. Secretions or food may enter the tympanic cavity more easily when the baby is supine particularly during feeding. The tube is normally closed and opens on swallowing because of movement of the muscles of the palate. This movement is impaired in cleft palate children who often develop accumulation of middle-ear fluid (otitis media with effusion).

Adult vs INFANT

	ADULT	INFANT
<b>Length</b>	<b>36 mm</b>	<b>18 mm</b>
<b>Angle with horizontal</b>	<b>45 °</b>	<b>10 °</b>
<b>Lumen</b>	<b>Narrower</b>	<b>Wider</b>
<b>Angulation at isthmus</b>	<b>Present</b>	<b>Absent</b>
<b>Cartilage</b>	<b>Rigid</b>	<b>Flaccid</b>
<b>Elastic recoil</b>	<b>Effective</b>	<b>Ineffective</b>
<b>Ostmann's fat</b>	<b>More</b>	<b>Less</b>



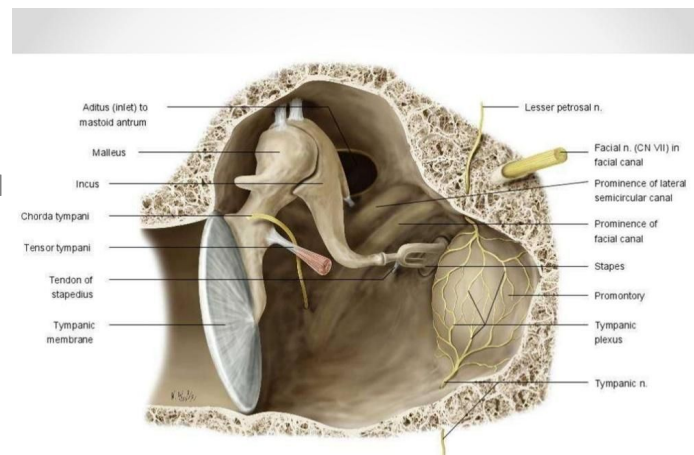
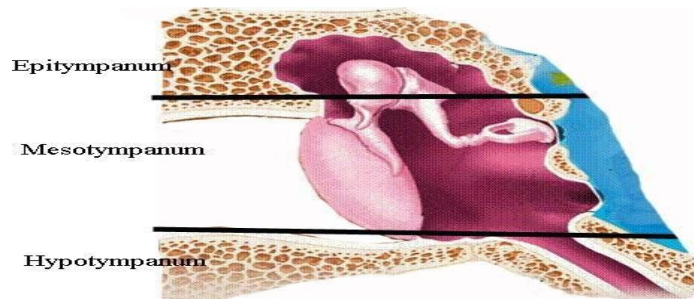
ADAM

### ◆ Tympanic cavity (Middle ear cavity):

#### ● Contents of tympanic cavity:

- Ossicles: the **malleus, incus** and **stapes**.
- Intratympanic muscles: **Tensor tympani, Stapedius**.
- Chorda tympanim.
- Tympanic plexus.

The Stapes receives the insertion of stapedius muscle. Handle of Malleus receives the insertion of Tensor tympani muscle. Contraction of the stapedius muscle restrict the movement of the stapes (this is considered as a physiologic reflex that protects the inner ear from very loud sounds (Attenuation reflex). (Team 431)



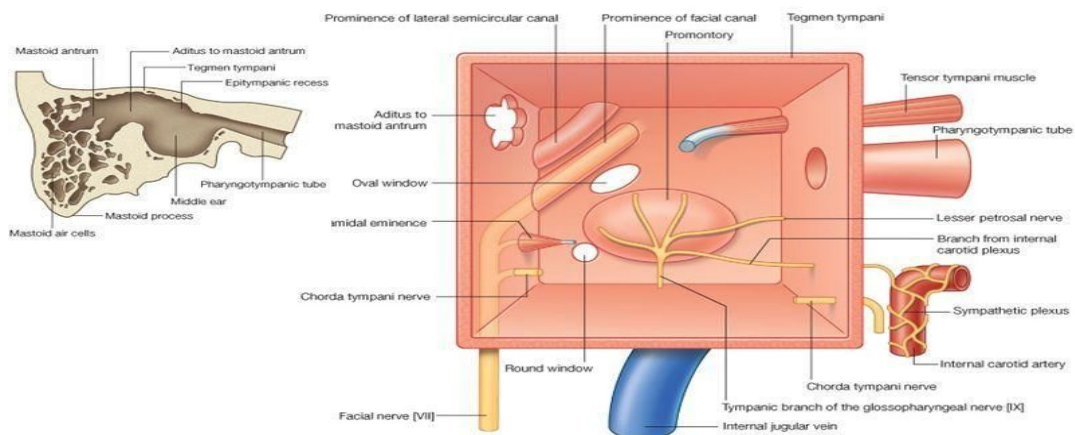
- **LINING OF THE MIDDLE EAR:**

- Mucous membrane of the middle ear space consists of **stratified cuboidal epithelium**, which changes to pseudostratified ciliated epithelium around the mouth of the Eustachian tube.

- **Nerve supply:**

- Sensory nerve supply of the middle ear mucosa:
  - Tympanic branch of the glossopharyngeal nerve.
  - Auriculotemporal branch of the trigeminal nerve.
- Motor nerve supply of the middle ear muscles :
  - Stapedius muscle supplied by the stapedial branch of the facial nerve.
  - Tensor tympani muscle supplied by the mandibular division of the trigeminal nerve.

## Boundaries of Middle Ear



**Roof:** tegmen tympani; separates tympanic cavity from MCF.

**Floor:** Thin bone separates tympanic cavity from superior bulb of IJV.

**Anterior wall:** Thin bone; separates tympanic cavity from ICA and at its upper part are openings into two canals (auditory tube & canal for tensor tympani).

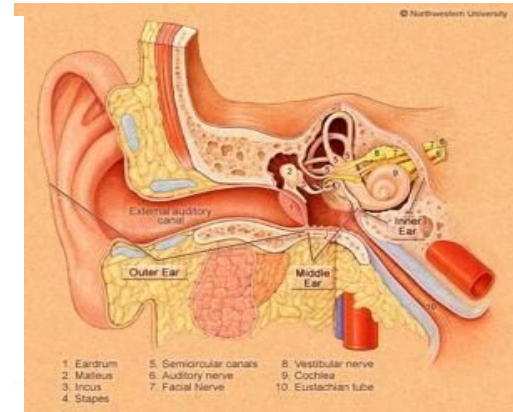
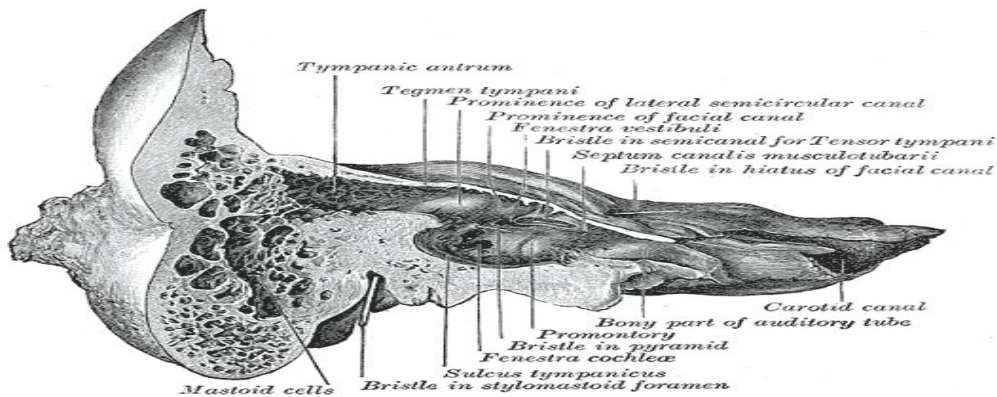
**Posterior wall:** Aditus to the mastoid antrum superiorly & Pyramid inferiorly ( for stapedius)

**Lateral wall:** tympanic membrane inferiorly & Lateral wall of attic superiorly.

**Medial wall:** Lateral wall of the inner ear.

## ❖ Mastoid antrum and air cells:

- Air-containing cells of the mastoid process are continuous with the air in the middle ear.
- Pneumatization is complete between the sixth and twelfth years of life.
- Normal tubal function is a prerequisite for biologically active, healthy middle ear mucosa, and thus for the normal process of pneumatization.



## Inner ear :

- Consists of:
  - Labyrinth
  - Internal auditory canal.

## ❖ Labyrinth consists of:

### ➤ Bony Labyrinth, its parts :

- Bony Cochlea 35 mm long, 2.5 turns.
- Vestibule
- Bony semicircular canals, Its contents:
  - Perilymph fluid: extracellular-like fluid; found in scala tympani and vestibuli  $K^+ = 4 \text{ mEq/L}$   $Na^+ = 139 \text{ mEq/L}$



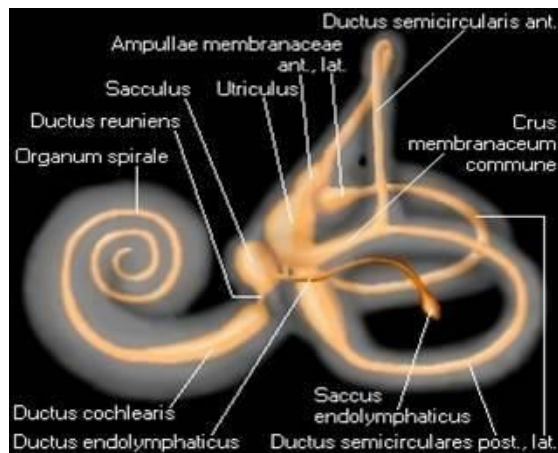
➤ **Membranous Labyrinth, its parts:**

- Cochlear duct
- Sacculle and utricle
- Membranous semicircular ducts, Its contents:

- **Endolymph:** intracellular-like fluid; found in scala media; contributes to positive DC resting potential of 80 mV in scala media; produced from perilymph by marginal cells of stria vascularis; absorbed within the endolymphatic sac.

✓  $K^+ = 144 \text{ mEq/L}$

✓  $Na^+ = 13 \text{ mEq/L}$



**Bony Labyrinth**

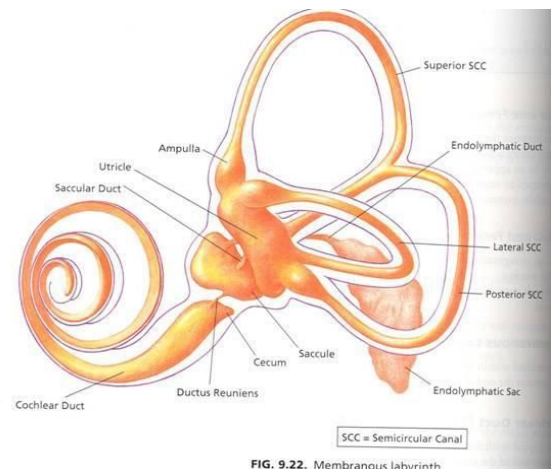


FIG. 9.22. Membranous labyrinth.

**Membranous Labyrinth**

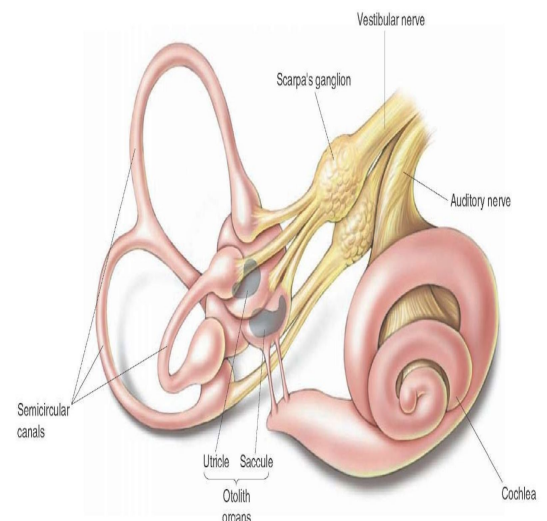
● **Sensory epithelium:**

➤ **Cochlea:**

- Organ of Corti : rests on basilar membrane and osseous spiral lamina; major components include:
  - Outer and inner hair cells.
  - Supporting cells: provide structural and metabolic support.
  - Tectorial membrane.
  - Reticular lamina.

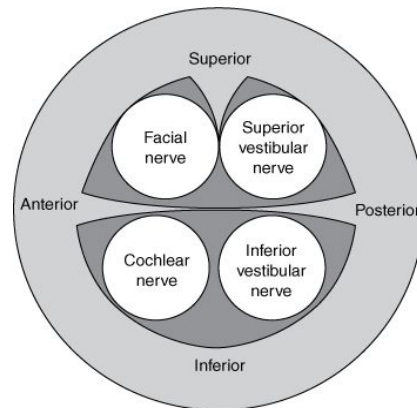
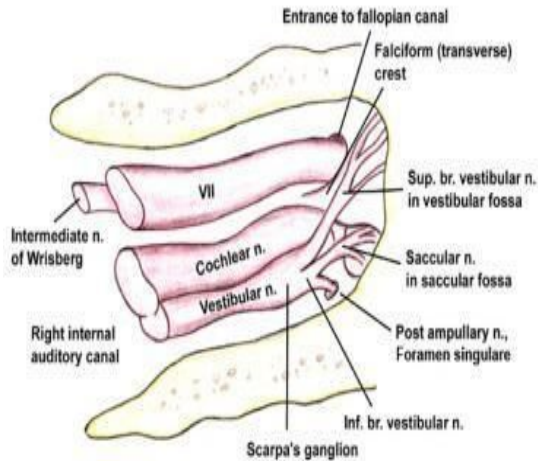
➤ **Utricle & saccule:** maculae.

➤ **Semicircular canals:** cristae (angular acceleration).



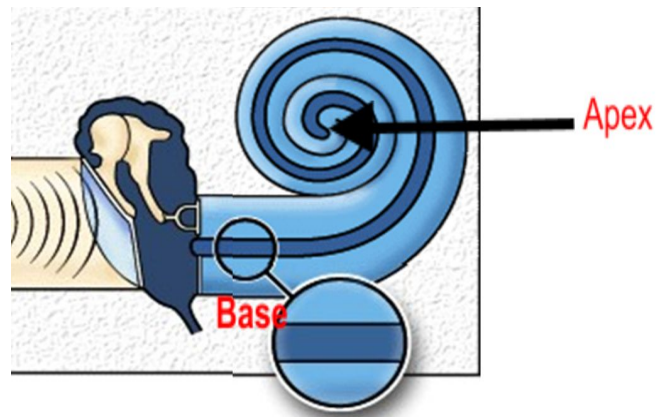
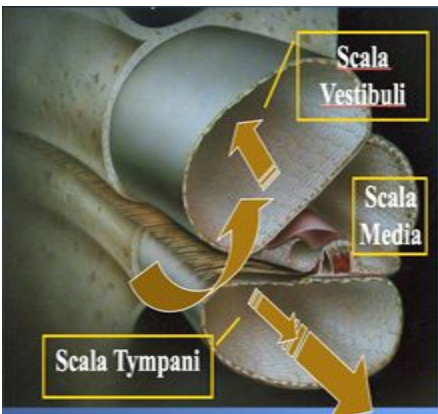
❖ **Internal Auditory Canal, Contains:**

- Cochleovestibular nerve
- Facial nerve



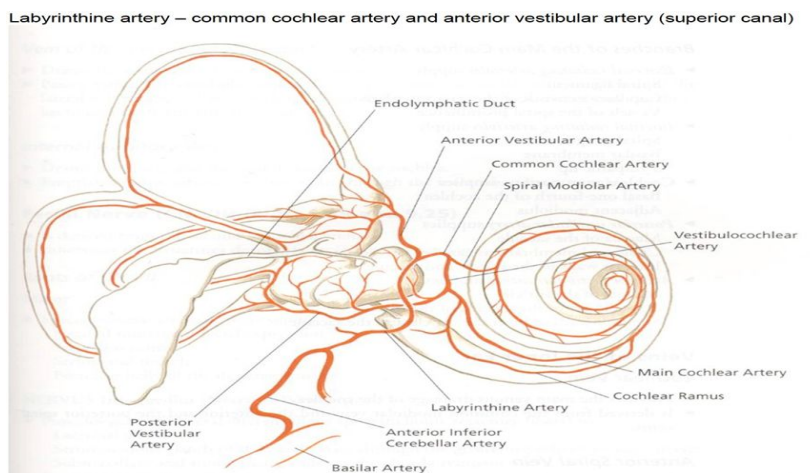
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**Internal Auditory Canal**



Sound of High frequency affects the basal portion of Cochlea  
Sounds of Low frequency affect the apical portion of Cochlea

- **Blood supply of inner ear:**
- Anterior inferior cerebellar artery  
→ Labyrinthine artery → common cochlear and anterior vestibular



# Physiology of the ear

	Function
<b>External Ear</b>	<ul style="list-style-type: none"> <li>● Protection of the middle ear:               <ul style="list-style-type: none"> <li>○ Cerumen.</li> <li>○ Curvature.</li> </ul> </li> <li>● Auditory functions:               <ul style="list-style-type: none"> <li>○ Sound Conduction.</li> <li>○ Increase sound pressure by the resonance function.</li> </ul> </li> </ul>
<b>Eustachian Tube</b>	<ul style="list-style-type: none"> <li>● <b>Protection.</b></li> <li>● <b>Ventilation.</b></li> <li>● <b>Drainage.</b></li> </ul>
<b>Middle Ear</b>	<ul style="list-style-type: none"> <li>● <b>Conduction of sound</b> <ul style="list-style-type: none"> <li>○ middle ear plays an important role in the process of impedance matching between the air-filled middle ear and the fluid-filled inner ear to allow for efficient sound transmission(Impedance matching):                   <ul style="list-style-type: none"> <li>■ Area ratio between the TM and the stapes footplate(20:1)</li> <li>■ Ossicular Coupling : lever ratio</li> </ul> </li> </ul> </li> <li>● <b>Protection to the inner ear.</b></li> <li>● <b>Stapedial reflex.</b> If the sound very loud it contract to reduce the sound energy.</li> </ul>
<b>Inner Ear</b>	<ul style="list-style-type: none"> <li>● <b>Hearing Function:</b> <ul style="list-style-type: none"> <li>○ Transduction of sound to action potentials</li> </ul> </li> <li>● <b>Vestibular Function:</b> <ul style="list-style-type: none"> <li>○ Participate in maintaining body balance, the mechanisms of maintaining body balance:</li> <li>○ Brain stem: is the center of balance. It's connected to:                   <ul style="list-style-type: none"> <li>■ Cerebellum to coordinate muscle tone and Cerebral cortex for the feeling of space.</li> <li>■ Input: Proprioceptive (sensation) Visual Vestibular</li> <li>■ Output: gives information to: Postural muscles Ocular muscle. (Team 431)</li> </ul> </li> </ul> </li> </ul>

## Diseases of External Ear:

### ◆ congenital diseases

#### Anotia (Atresia)

- It's the total absence of the auricle most often with narrowing or absence of the external auditory meatus.
- CT; to check if there is other malformations (internally).



#### Microtia:

- It's a condition in which the external portion of the ear (the auricle) is malformed. There is also narrowing or absence of the external auditory canal



#### Accessory auricle

- It's a type of ear anomaly in the tragus area.  
Treatment: Plastic reconstruction, B.A.H.A (bone anchored hearing aid).



#### Pre auricular sinus

- It's a common congenital malformation characterized by a nodule, dent or dimple located anywhere adjacent to the external ear.
- Susceptible to infection
- Management: systemic antibiotics. If an abscess is present, it must be incised and drained



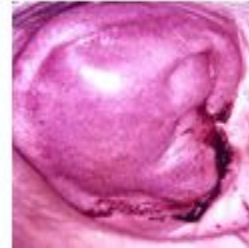
## Protruding Ear:

- Management: Pinnaplasty or otoplasty. Note: There is no direct blood supply to the cartilage!
- Antihelix pulls ear back while helix pushes it forward; Antihelix is absent.



## ❖ Trauma to The Auricle:

- Lacerations - Hematoma auris
- Treatment: Excise fibrous tissue - Apply pressure dressing - drain.



## ❖ PERICHONDRIITIS OF THE PENNA:

- Perichondritis is **inflammation** of the perichondrium, a layer of connective tissue, which surrounds cartilage.
- Usually follow **trauma** (hematoma auris, surgical, frostbite, burn) or otitis externa & piercing.
- Commonly caused by **Pseudomonas**.
- **Fever, pain, redness and swelling** (causes narrowing and further low hearing level).
- Treatment **immediately** by **antibiotics & Evacuation** (Any cartilaginous organ that forms a hematoma must be drained as early as possible)



**Tx:** Abx, incision & drainage, removal of necrotic tissue.

- Complications of Perichondritis or Trauma:
  - Cauliflower ear (End stage of untreated haematoma).  
The ear can be exposed to trauma and lacerations leading to the formation of Hematoma, so if anything happens between the skin and cartilage → Hematoma  
(Number 1 killer of the cartilage, why? Because the blood will not be able to reach the cartilage) → Ischemia → Necrosis → Ear deformity

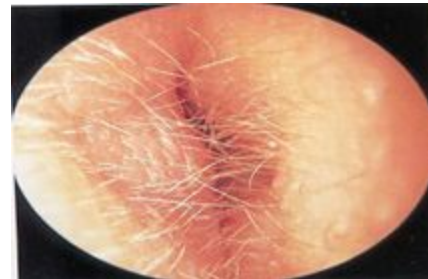


- Perichondritis may follow injury to the cartilage, mastoid surgery or ear piercing, particularly with the modern trend for multiple perforations that go through the cartilage.
- Treatment must be vigorous, with parenteral antibiotics and incision if necessary. If it is due to piercing the stud should be removed.
- Pic: Severe otitis externa and perichondritis of the pinna.



### ❖ Otitis Externa:

- An acute (Less than 3 months) or chronic (more than 3 months) **infection** of the whole or a part of the skin of the external ear canal. **Any pathology affecting skin can also affect external ear.**



- **Pathophysiology:**

- Aggressive washing of wax or retention water ,Microtrauma (cotton swabs, fingernails).

- **Infective:**

- **Bacterial:** **Pseudomonas (Most common)**, Staphylococcus aureus (furuncle)
- **Fungal:** Aspergillus Niger, Candida albicans
- **Viral:** **Herpes Zoster**... Others

- **Reactive:**

- **Seborrhea:** A disease of the sebaceous glands characterized by **excessive secretion of sebum** or an alteration in its quality, resulting in an oily coating, crusts, or scales on the skin. It's usually painless
- **Eczema/Dermatitis:** A noncontagious **inflammation** of the skin, characterized chiefly by redness, itching.

➤ **Clinical features of Otitis Externa:**

- **Itching**
- **Pain:** could be very severe because of underlying cartilage, evoked by movement of the jaw, because the ear auricle and external canal is attached to the TMJ (temporomandibular joint) pain can radiate to the throat!
- Tenderness and swelling, absent in otitis media.
- Otorrhea: No discharge or very little and scanty, not muciod. Large discharge in otitis media. (Not mucus discharge because the skin does not contain mucus-secreting cells. If the discharge doesn't contain mucus, then it is from the External ear however if it contains mucus it is originating from the middle ear)
- Deafness: deafness caused by external ear needs to be completely obstructed, which is rare in otitis externa.
- Changes in the lumen and skin of EAM(external auditory meatus)

➤ **Management (to all clinical types):**

- History and Physical examination.
- **Swab for culture and sensitivity for ABx.**
- Ear toilet: cleaning the ear.
- Keep the ear dry. Suction cleaning.
- Local Medication and analgesia. **Ear wick (best tx).**
- Systemic medications: as in diabetics.
- Surgery **may be required in chronic cases and failure of treatment because there is usually thickening in of the skin and closure of the canal.**
- IN CASE OF:
  - Aspergillus niger → Give antifungal drops.
  - Herpetic O.E Tx: → Acyclovir if < 3 days , Steroids to reduce inflammation.

**Clinical Types of Otitis Externa:**

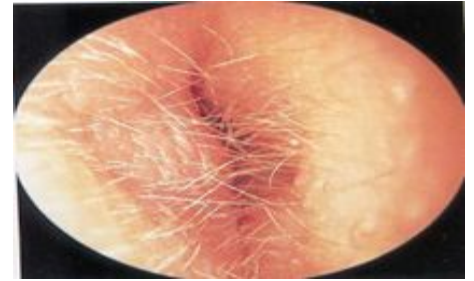
❖ **Localize O.E (furuncle):**

- small rounded swelling in the external canal.



❖ **Diffuse infective O.E. :**

- General narrowing of the canal. The canal will close and you will not be able to pass anything through it.



❖ **Otomycosis: fungal infection**

- Fungal vs. Bacterial
- Fungal: Less pain , more itching & NO fever.



White = Candida Albican Black= aspergillus niger

❖ **Herpetic O.E. :**

- herpes zoster oticus is a specific form of herpes zoster that presents with pre-eruptive (“pre-herpetic”) lesion reactivated from either the trigeminal or cervical ganglions
- characterized by: PAINFUL vesicles



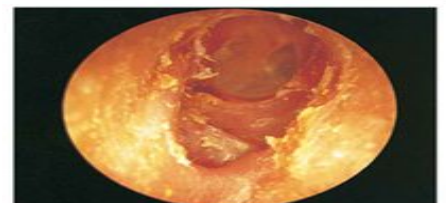
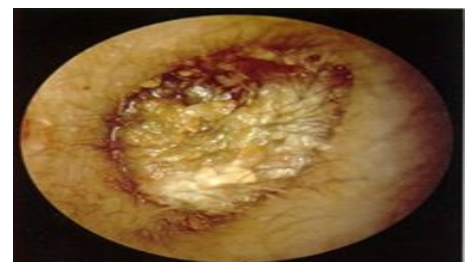
❖ **Ecematous and seborrheic :**

- O.E. painless



❖ **KERATOSIS OBTURANS :**

- Accumulation of desquamated epithelium in the bony canal.
- It may be associated with Sinusitis, Bronchiectasis, Primary ciliary dyskinesia.
- Usually cause deafness and pain.
- Treatment : periodic removal.



## ❖ BULLOUS MYRINGITIS :

- Inflammatory condition involves the lateral surface of the TM and the medial portion of the canal wall.
- It typically occurs in association with upper respiratory infections and is more common in winter.
- Clinical manifestations:
  - Severe otalgia;
  - Serosanguinous otorrhea;
  - Hearing loss.
- Treatment includes **analgesics, topical antibiotic/steroid drops** to prevent bacterial superinfection.
- The hallmark clinical finding is :
  - **bullae** over the TM and medial canal with serous or serosanguinous **fluid**.



## ❖ Acute necrotizing (malignant) otitis externa / Skull base Osteomyelitis: **Important**

- An acute Pseudomonas infection of the skin of the external ear canal, which spread to the adjacent bone. (Deep seated pain for more than a month).
- It occurs mostly in **elderly diabetic patients. (Immunocompromised) Important!**
- Severe otalgia. **Earache in early stage.**
- Lower Cranial nerve palsies (VIII, IX, X, XI, XII) and sometimes VII.
- No signs of acute inflammation & No swelling.
- Foul smelling **discharge from the floor of the external Auditory canal.**
- Granulation tissue & sequestra.
- It can infect the base of the skull, the cranium Causing meningitis, brain abscess.
- Radiology. **Bone (Petrous) scan to rule out osteomyelitis.**
- Granulation tissue at the junction of the bony and cartilaginous portions of the canal + -immunocompromised pt → Dx as Malignant Otitis Externa!
- Treatment:
  - **Control of diabetes (most important part of treatment)**
  - Anti-Pseudomonas antibiotics.
  - Local treatment and debridement. The role of surgery remains controversial.

## Acute Otitis Media:

- Acute infection of the mucous membrane lining of the middle ear cleft.
- The definition is specific to infection because in chronic Otitis media it can be due to infection of normal inflammation.

- **Predisposing factors:**

- Age: common in children as the Eustachian tube is more horizontal, wider and shorter.
- Males
- Bottle feeding: more likely to have milk regurgitation (because children tend to drink while lying) in middle ear
- Climate
- Crowded living conditions
- Heredity
- Associated conditions: cleft palate, immunodeficiency, ciliary dyskinesia, Down syndrome, and cystic fibrosis.

- **Route of infection:**

- Eustachian tube.
- External auditory canal (rupture): rare.
- Blood borne.

- **Bacteriology:**

- Streptococcus pneumonia (Most common)
- Haemophilus influenzae
- Moraxella catarrhalis
- Streptococcus pyogenes, Staphylococcus aureus.

- **Pathophysiology:**

- The patient has an antecedent event (viral URI or allergy) → the event results in Congestion of the respiratory mucosa of the nose, nasopharynx, and Eustachian tube → Congestion of the mucosa in the Eustachian tube obstructs the narrowest portion of the Tube, the isthmus → obstruction of the isthmus causes negative pressure followed by Accumulation of secretions produced by the mucosa of the middle ear → these secretions Have no egress and accumulate in the middle ear space → viruses and bacteria that Colonize the upper respiratory tract can reach the middle ear via aspiration, reflux, or Insufflation → microbial growth in the middle ear secretions may result in suppuration.



- **Clinical picture:**

- Discomfort, Autophony, **Fever**, Sever earache, **Deafness**, Bulging drum.
- Tympanic membrane rupture: Otorrhea, temp. & earache subside.



- **Treatment:**

- Symptomatic
  - Antimicrobials.
    - Amoxycillin ( 1st line)
    - Amoxycillin/clavulanic acid (B-lactamase bacteria) 2nd line.
    - Tri-methoprim.
    - Sulphamethoxazole.
    - Cefaclor, cefixime.
  - Decongestant.
  - Myringotomy +/- tube.
  - Ear toilet and local antibiotics.



- **Recurrent Acute Otitis Media:**

- **Three or more attacks** over a 6-months period or **(six attacks in a year)**.

- **Treatment:**

- Long-term low dose antimicrobials
- Ventilation tube insertion (Myringotomy with pressure equalization tube)



Note: In Recurrent otitis media, requirement for intervention with increase in frequency to avoid Intra temporal Complications: mastoiditis & facial nerve palsy. Extra temporal Complications: Meningitis  
Complications of Ventilation tube:

- Irritation
- Otorrhea
- Inserting in the middle ear
- Blockage – losing its function
- Expulsion

