CHAPTER 1

Embryology and Anatomy of Ear

EMBRYOLOGY

The ear is comprised of three parts (as we go medially, *see* Fig. 1.1):

1. **External ear** (it has three parts, the pinna, the external auditory canal (EAC) and the lateral surface of the tympanic membrane (TM).
2. **Middle ear** (it is like a cuboid shaped box, extending medially from the TM and has bony ossicles and other structures). Through the Eustachian tube (pharyngo-tympanic tube) middle ear communicates with the nasopharynx.
3. **Inner ear** also called **Labyrinth** (it is comprised of a membranous labyrinth surrounded by a bony labyrinth).

The external ear and the middle ear are situated in petrous, tympanic and mastoid parts of temporal bone.

The whole of the inner ear is situated in the **petrous part** of the temporal bone (*see* Fig. 1.2). The petrous part of the temporal bone is pyramidal in shape with an anterior and a posterior slant. The anterior slant faces the middle cranial fossa and the posterior slant faces the posterior cranial fossa. On the posterior slant of the petrous part of temporal bone is an opening called the **Internal Acoustic Meatus (IAM)** which connects the inner ear to the posterior cranial fossa.

DEVELOPMENT OF PINNA

The **1st and 2nd branchial arch** mesoderm gives rise to 6 mesodermal thickenings (auricular tubercles) around the 1st pharyngeal cleft. These cartilaginous tubercles are known as "**HILLOCKS of HIS**" and they fuse to form the pinna.

The tragus (according to some books also some part of ascending crus of helix) develops from the first arch and the rest of the pinna is derived from the second arch (*see* Figs 1.3 and 1.11).

Developmental Anomalies of Pinna

- The incomplete fusion of the Hillocks of His leads to the formation of a sinus in front of the tragus. This is known as **"PRE-AURICULAR SINUS"** (Fig. 1.4). This is seen most commonly either above the tragus or at the root of helix. It can be inherited as autosomal dominant with incomplete penetrance.

  The preauricular sinus may get infected and discharge on and off. Management is surgical excision.
- Pinna can be malformed, it may be small known as "Microtia" or absent known as "Anotia" or there can also be accessory auricles. In this regard it is important to remember that the surgical **reconstruction of pinna is done at or after 6 years of age for the following two reasons:**

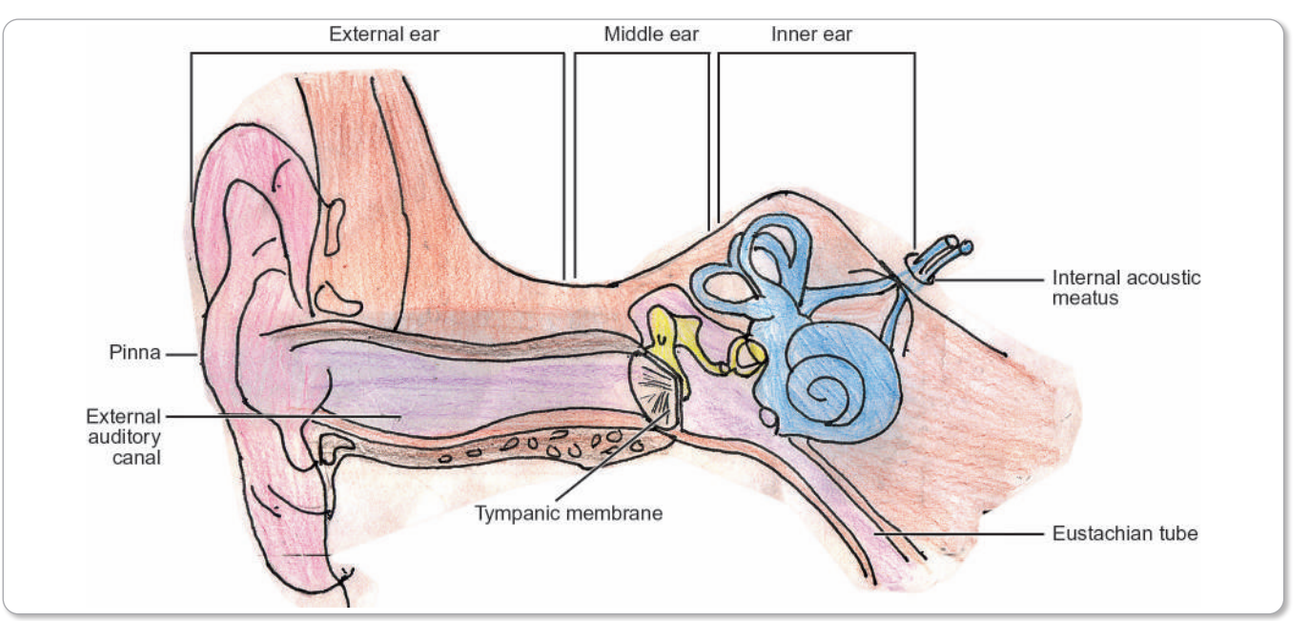


Fig. 1.1: Parts of ear

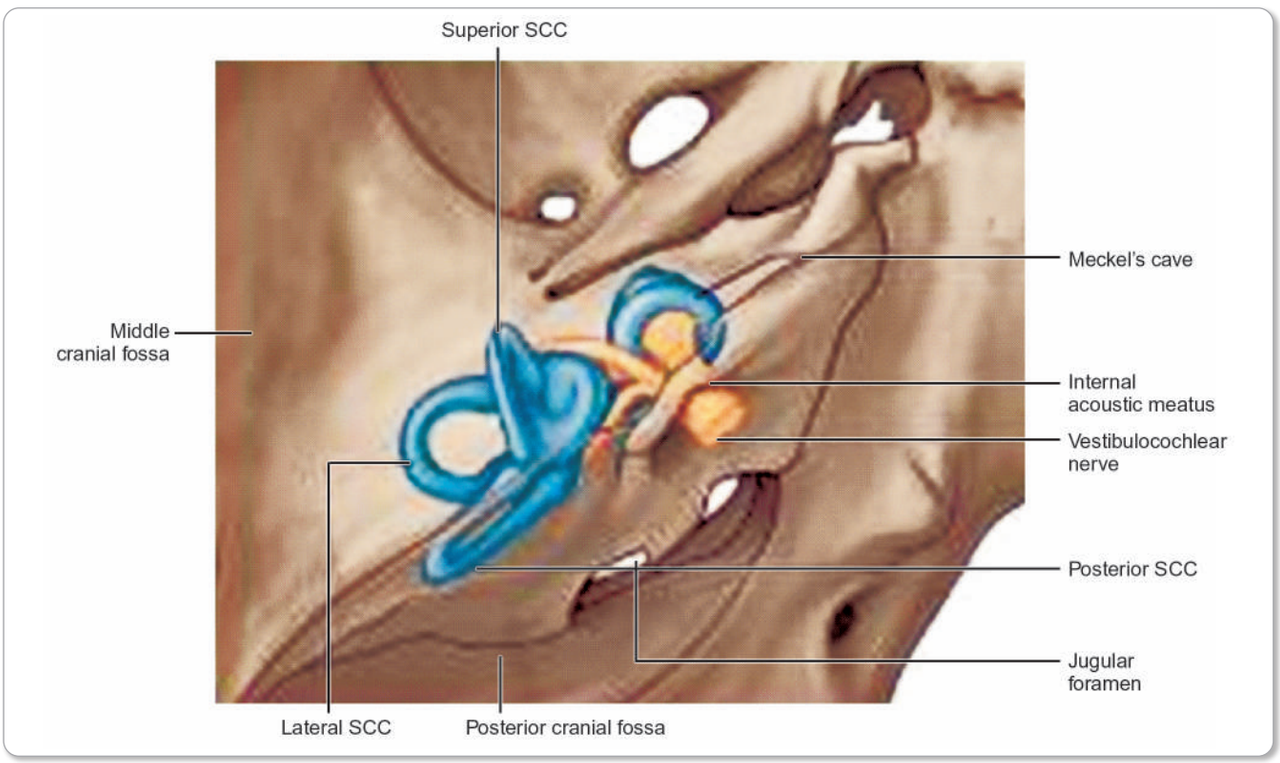


Fig. 1.2: Internal acoustic meatus in petrous part of temporal bone (left sided). The petrous part of temporal bone separates the middle cranial fossa from posterior cranial fossa and has anterior and posterior slants, the posterior slant having IAM.

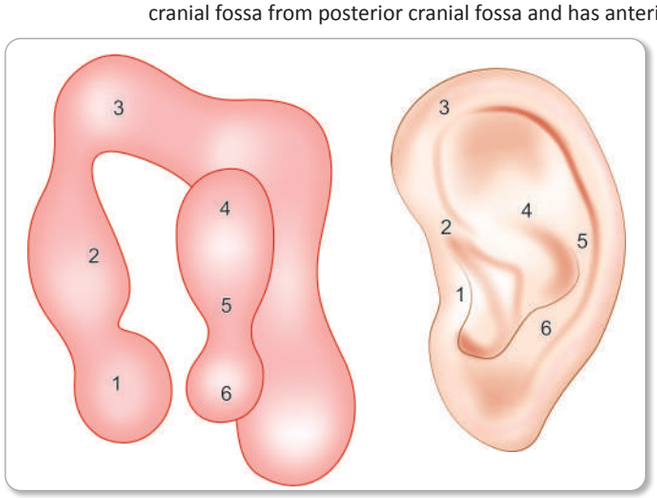


Fig. 1.3: Development of pinna from "Hillocks of His"

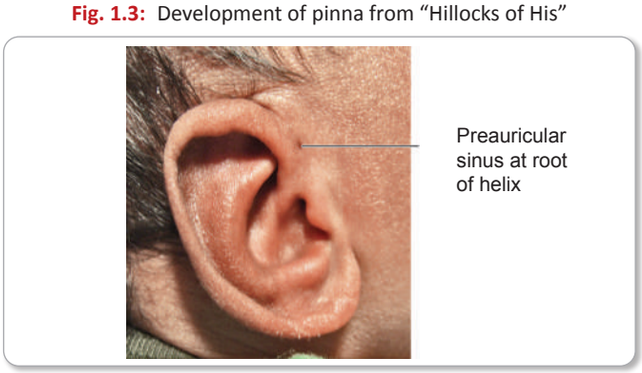


Fig. 1.4: Preauricular sinus

1. Autologous Costal (rib) cartilage is used as graft here. The costal cartilage gets developed enough for this purpose by 6 years of age.
2. Pinna attains almost the adult size by 6 years. So, the side which is to be reconstructed can be compared with the normal side pinna.

- Sometimes as a result of unequal turning in of the helix, in the fetus, develops a thickening on the postero-superior portion of the helix (usually at the junction of upper and middle third). This is known as Darwin's tubercle, shown in the picture below (Fig. 1.5). It can be U/L or B/L. Since some primates have pointed ear margin at the same site, it is considered as an atavistic feature linking humans and primates to a common ancestor. In people who have it, it can be used as a personal identification mark.

Fig. 1.5: Darwin's tubercle

1 CLINICAL CASE QS

A newborn presents with the following. Corrective surgery is usually performed at:

a. <1 year of age
b. 6–7 years of age
c. Puberty
d. Adulthood

DEVELOPMENT OF EXTERNAL AUDITORY CANAL (EAC)

The dorsal part of **1st ectodermal cleft** (or 1st branchial groove) grows medially and forms the external auditory canal (EAC), though the external auditory meatus develops as an invagination of the first arch. **At birth, only the cartilaginous part of EAC is completely developed; the bony part of EAC continues to grow after birth.** Due to this the tympanic membrane is nearly horizontally placed at birth. The completion of the bony part of EAC gives the tympanic membrane its adult angulation by 4–5 years.

Developmental Anomaly of EAC

Normally, the ventral or anterior part of this 1st cleft which connects the EAC to the neck disappears. But if it persists it leads to an abnormal connection between the EAC and the neck. This congenital anomaly is known as **"CALL-AURAL FISTULA"** (Fig. 1.6). The external opening of this Call-aural fistula is in between the angle of mandible and Sternocleidomastoid muscle and internal opening is in the floor of EAC.

The fistula may get infected and discharge on and off. Management is surgical excision.

2 CLINICAL CASE QS

Below is the picture of a patient with Call-Aural Fistula. This is:

a. 1st branchial cleft anomaly
b. 2nd branchial cleft anomaly
c. 1st branchial pouch anomaly
d. 2nd branchial pouch anomaly

DEVELOPMENT OF MIDDLE EAR AND TYPYANIC MEMBRANE

Middle Ear

The **1st endodermal pouch (or 1st visceral pouch) along with a small part of the 2nd pouch forms tubo-tympanic recess** which leads to the formation of Eustachian tube (tubo) and tympanic cavity (tympanic recess), i.e., middle ear cavity along with mastoid antrum (*see* below). Together the Eustachian tube, middle ear and mastoid antrum are called the **middle ear cleft (Figs 1.7A and B)**.

Of the 3 ossicles in the tympanic cavity, **Malleus and Incus develop from 1st arch**. The **supra-structure of stapes,** i.e., its head, neck and the two cruras develop from **2nd arch** (***mnemonic*: S** for suprastructure of stapes—**S**econd arch), whereas the **foot plate** of stapes overlying oval window develops from the inner ear bone which is called **"Otic capsule"** or bony labyrinth (*see* below). The **ossicles** attain **adult configuration by 20 weeks to 25 weeks** period of gestation (POG).

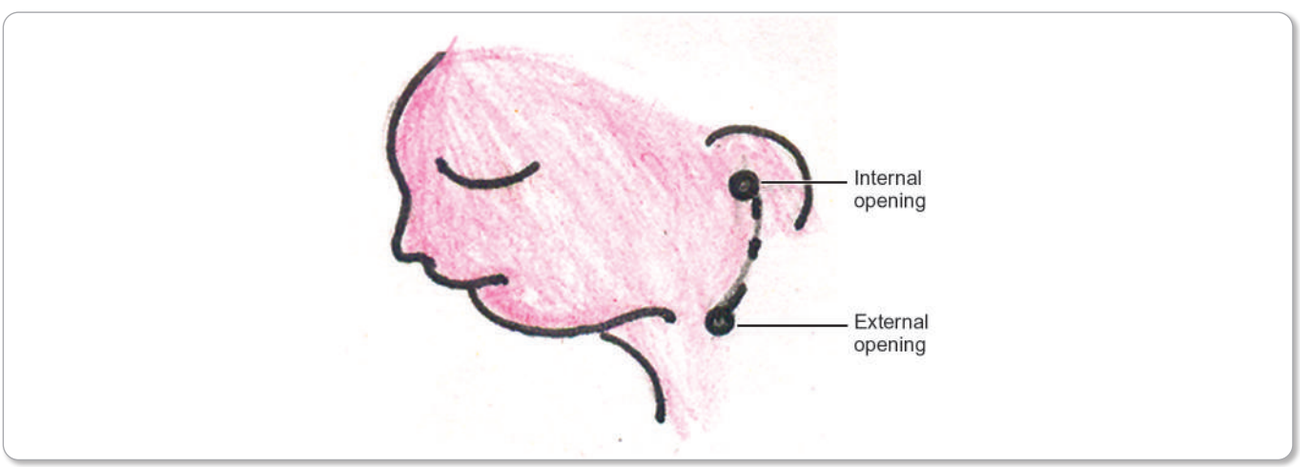
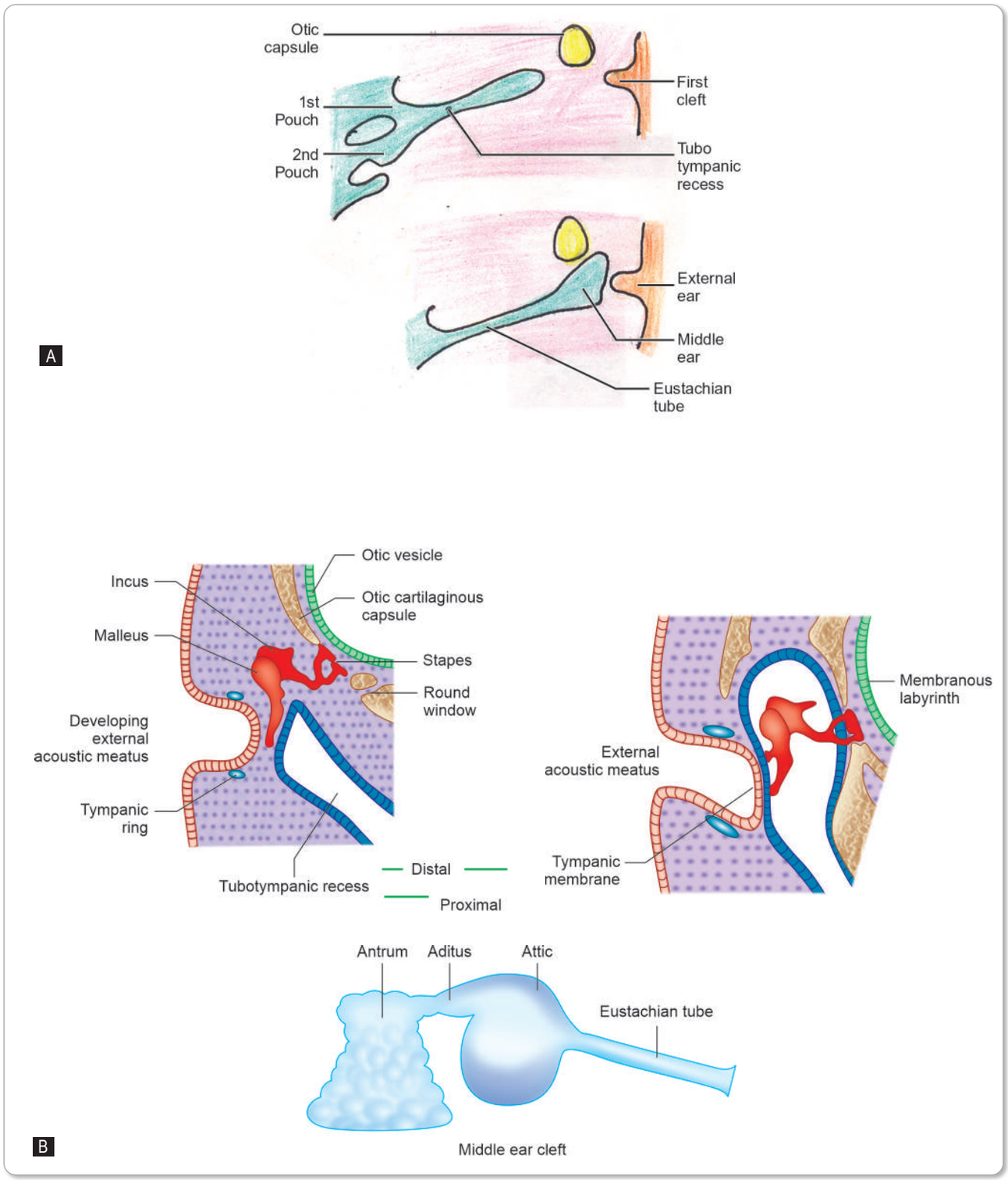


Fig. 1.6: Call-aural fistula



Figs 1.7A and B: Development of external auditory canal, middle ear and eustachian tube

Tympanic Membrane

The 1st cleft meets the 1st pouch with the mesoderm in between them to form the tympanic membrane (TM).

So, **the tympanic membrane develops from all the 3 layers**, of embryonic disc; outer epithelial layer from ectoderm, inner endothelial layer from endoderm and in between these two is the fibrous layer from mesoderm. Both the TM and middle ear cavity, like ossicles, are **completely developed at birth (Fig. 1.8)**.

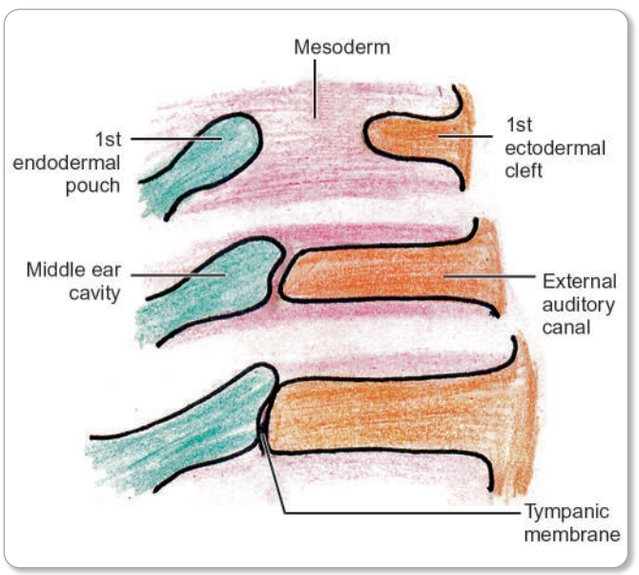


Fig. 1.8: Development of tympanic membrane

DEVELOPMENT OF MASTOID

Mastoid develops from the superficial squamous and the deep petrous parts of temporal bone. In between the 2 parts is the **petro-squamosal suture** which generally disappears. However, sometimes it persists and is called "**KORNER'S SEPTUM**" (Fig. 1.9).

Mastoid is a spongy bone and contains multiple air cells. The mastoid is incompletely developed at birth and continues to develop, till 18 years of age. The antrum is the largest and most prominent mastoid air cell which develops from 1st and 2nd pouch (tubo-tympanic recess, *see* above). The **antrum is present at birth and is almost of adult configuration.** The mastoid antrum lies in the petrous part deep to the Korner's septum. In diseases of mastoid, maximum disease lies in the mastoid antrum (Fig. 1.9).

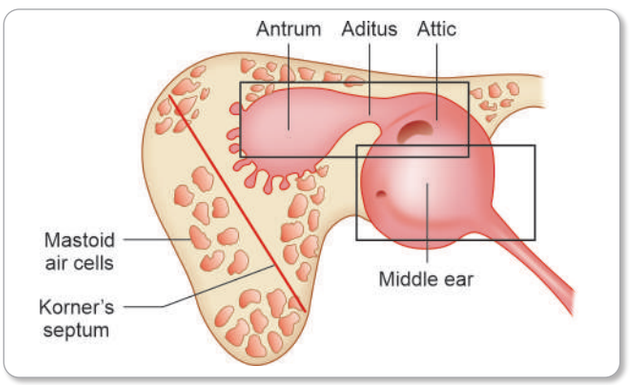


Fig. 1.9: Korner's septum

Surgical Importance of Korner's Septum

While removing disease from mastoid, if the Korner's septum is present, the surgeon might confuse the Korner's septum with medial most wall of antrum, i.e., the boundary which separates the antrum from the posterior cranial fossa. For the fear of entering posterior cranial fossa the surgeon stops the surgery at the Korner's septum, whereas he has not yet entered the mastoid antrum. This will lead to incomplete clearance of disease from the mastoid.

Surgical Importance of Mastoid Tip

The tip of mastoid develops by 2 years of age because of the constant pull by the sternocleidomastoid and the posterior belly of digastric muscle. The facial nerve exits from stylomastoid foramen just below the mastoid tip and turns horizontally toward the parotid gland, in which it gives off motor branches for the muscles of face.

The mastoid tip being absent below 2 years, the facial nerve lies very superficial just below the skin. So, in a child below 2 years with post auricular abscess, the incision should be superior and horizontal so as to avoid damage to facial nerve.

To summarise:

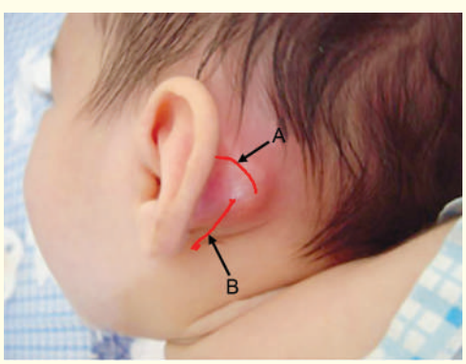
Ear part	Embryonic layer	Respective Ectodermal cleft/ Mesodermal arch Endodermal pouch or other area	Congenital anomaly/ developmental importance
Pinna (cartilage)	Mesoderm	1st and 2nd arch	Pre-auricular sinus, Microtia, Anotia
EAC (epithelium)	Ectoderm	1st cleft/groove (dorsal part)	Call-aural fistula
TM	All the three; Ectoderm, Endoderm and Mesoderm	1st cleft grows medially to join 1st pouch along with the mesodermal layer in between to form the TM	Small TM (congenital Rubella syndrome)
Middle ear cavity along with mastoid antrum and Eustachian tube	Endoderm	1st and 2nd pouch forms tubo-tympanic recess	Antrum lying deep to Korner's septum (see its importance in the text)
Malleus and incus	Mesoderm	1st arch	Rare congenital malformations
Supra structure of stapes	Mesoderm	2nd arch	Rare congenital malformations

Contd...

Ear part	Embryonic layer	Respective Ectodermal cleft/ Mesodermal arch Endodermal pouch or other area	Congenital anomaly/ developmental importance
Foot plate of stapes	Mesoderm	Enchondral bone formation from Otic capsule	Fixation of stapes is the most common congenital middle ear anomaly
Mastoid	Mesoderm	Squamous and petrous parts of temporal bone	Mastoid tip absent below 2 years leading to superficially lying facial nerve
Membranous labyrinth (see below)	Surface Neuro-ectoderm (Otic placode)	Neuro-ectoderm Overlying hind brain	Michel aplasia. Scheibe, Mondini and Alexander dysplasia (see below)
Bony labyrinth (see below)	Mesoderm	Mesenchymal tissue around the membranous labyrinth	Michel aplasia Scheibe, Mondini and Alexander dysplasia

3 CLINICAL CASE QS

Below is the picture of a one year child who presents with this abscess. A decision to drain the abscess was made. Two incisions were marked as shown. Which of the following statement is true?



a. The mastoid is completely developed in this child
b. Incision B can injure the facial nerve
c. In this child, the facial nerve is protected below the mastoid tip
d. Incision A can injure the jugular bulb

DEVELOPMENT OF INNER EAR

Development of Membranous Labyrinth

The inner ear consists of a membranous labyrinth surrounded by a bony labyrinth. The membranous part of inner ear also called membranous labyrinth develops from a specialised area of **surface ectoderm** overlying the developing hind brain. This area of surface ectoderm is called "Otic Placode". This becomes otic pit and then otic vesicle. This otic vesicle which is like a sac or balloon ultimately forms membranous labyrinth. So, the membranous labyrinth is like a designer balloon (designed by God!) and being a **closed sac does not communicate with any other structure.**

When fully developed, the membranous labyrinth has the following parts (*see* Figs 1.10 and 1.11):

1. **Three semicircular canals:** Lateral (horizontal), posterior and superior (anterior). The semicircular canals are at an angle of 90 degrees to each other. This angle formed among the three semicircular canals is known as **solid angle**.
2. **Utricle:** The three semicircular canals open into utricle by 5 openings (why 5? actually there have to be 6!). This is because one of the crus (crus means an elongated part of an anatomical structure, especially one which occurs in the body as a pair) of the posterior and superior semicircular canals fuse together to form a common crus called **"crus commune"**, which then opens into the utricle.
3. **Saccule:** The utricle is connected to the saccule through a utriculo-saccular duct. This utriculo-saccular duct forms the endolymphatic duct which ends blindly into **Endolymphatic sac**. This endolymphatic sac is situated in between the endosteal and meningeal layer of the dura mater, i.e., in between the dura of the posterior fossa and skull bone (Please note: This is not the subdural space which is in between dura and arachnoid).

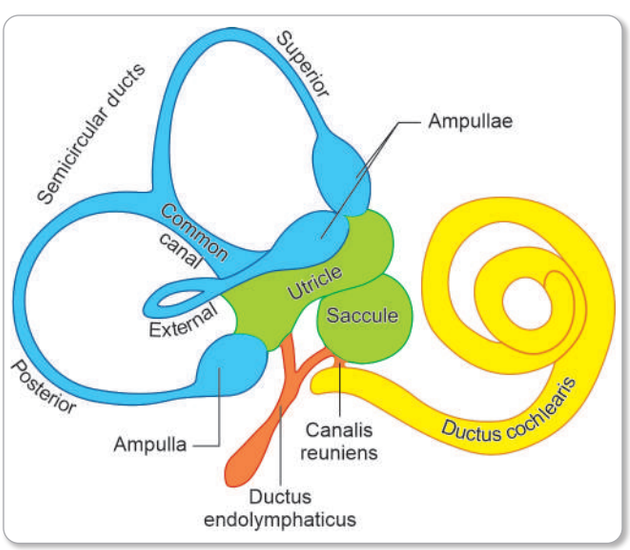


Fig. 1.10: Membranous labyrinth

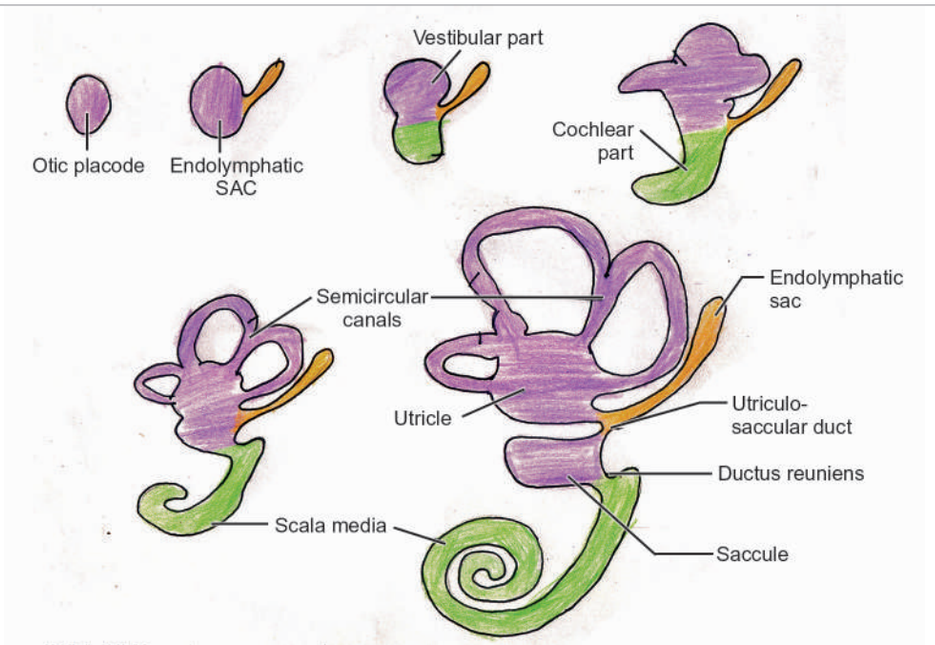


Fig. 1.11: Development of membranous labyrinth

The **Endolymphatic sac** is responsible for the absorption of endolymph. Endolymph is the fluid that fills the whole of the membranous labyrinth [i.e., the 3 semicircular canals, utricle, saccule and the scala media (*see* Fig. 1.11)].

4. **Membranous cochlea:** After the saccule is the membranous cochlea. Saccule is connected with the cochlea by ductus reunions. The membranous cochlea is also known as "Scala media" or cochlear duct. This membranous cochlea or scala media is a coiled tube which takes **2½ to 2¾ turns** around a bony axis which is known as "modiolus".

Certain areas of the membranous labyrinth ultimately differentiate into specialized areas of hearing and balance (*see* Fig. 1.12). Hence, diseases involving inner ear either present as hearing loss or as imbalance or both.

Sensory end Organ of Hearing

The sensory organ of hearing is known as "**Organ of Corti**". It is situated inside the scala media/membranous cochlea.

The organ of Corti situated in the **basal turn** of membranous cochlea is responsible for sensing **high frequency** sounds, whereas the organ of Corti situated in the **apical turns** is responsible for sensing **low frequency** sounds (easy to remember basal turn is wider so senses (larger) higher frequency, and apical turn is narrow with less space so senses (smaller) lower frequency sounds).

Therefore, diseases affecting the apical turn will lead to low frequency hearing loss, whereas those affecting basal turn will lead to high frequency hearing loss.

In Meniere's disease which is characterised by increase in endolymph, the narrow apical part of scala media experiences the dilatation first therefore, affecting low frequency sounds first.

Whereas ototoxic drugs, noise trauma, presbycusis, etc. which involve basal turns first, affect high frequency sounds early.

The organ of Corti is differentiated to such a degree by **20 weeks** POG that the fetus can hear and respond to fluid borne sounds. The organ of Corti approximates the adult structure by 25 weeks (in Mahabharata Abhimanyu heard about the technique of breaking the chakravheu while he was a 5 months fetus).

The whole of the bony and membranous labyrinth gets completely developed at birth.

Structures which are fully developed at birth are:

- TM
- Middle ear cavity with the ossicles
- Mastoid antrum
- Bony and membranous labyrinth

Sensory end Organs of Balance

The sensory end organs of balance are called Cristae and Maculae (*see* Fig. 1.12).

Cristae are present in semi-circular canals (easy to remember C for C). They are responsible for sensing **rotational and angular movements** (again to remember easily, semicircular canals being round (rotational) and are at an angle of 90 degrees to each other (senses angular movements).

Maculae are present in the utricle and saccule and sense **linear acceleration, gravitational** (movement either with or against gravity) and **head tilt movements** and it helps to maintain **static equilibrium** (by facilitating postural, tonic neck and righting reflexes).

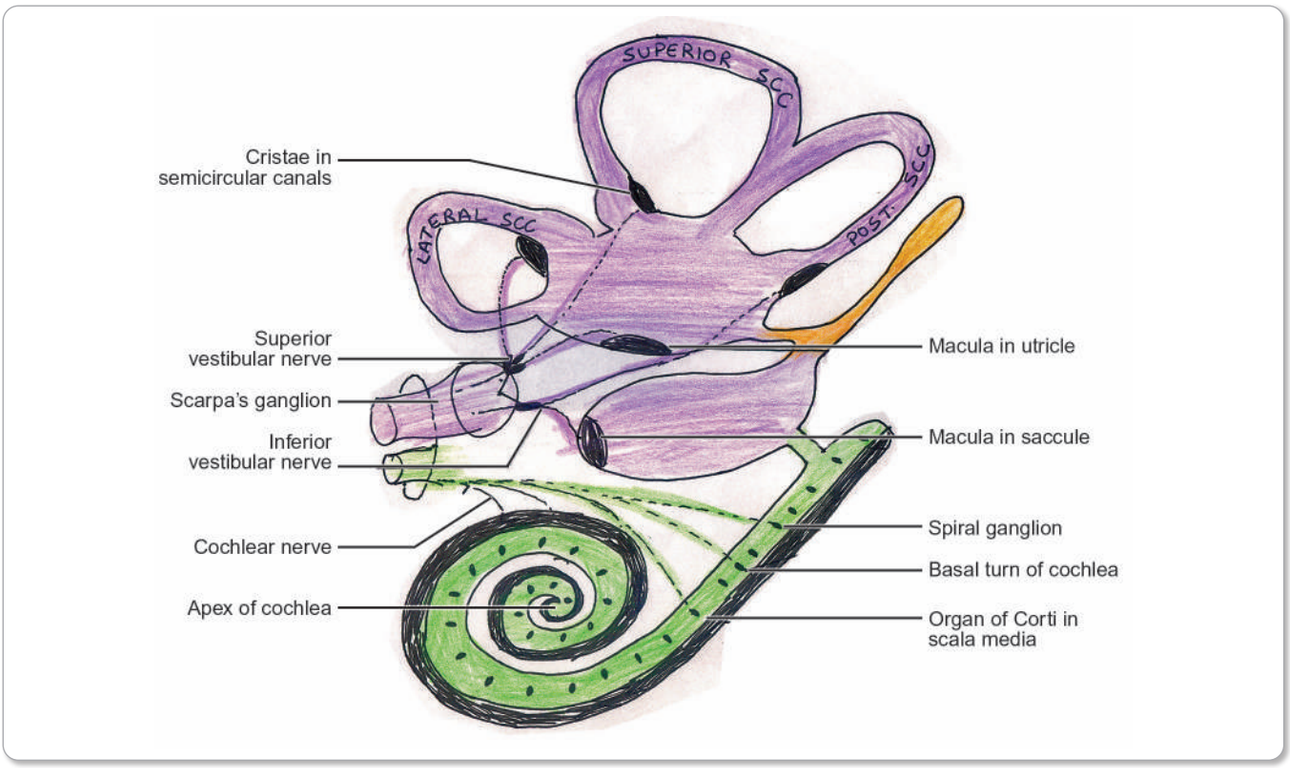


Fig. 1.12: Sensory end organs of hearing and balance

Development of Bony Labyrinth

Once the development of membranous labyrinth is complete, the mesenchymal tissue around the membranous labyrinth **condenses to form cartilage.** Later **endochondral bone formation** occurs in this cartilage to form the bony labyrinth (otic capsule).

However, some portions of the bony labyrinth remain cartilaginous, i.e., they retain their activity to divide. One such area is **"Fissula ante fenestrum"** (just anterior to fenestra of oval window). With certain stimuli, it may start dividing and subsequently undergoes endochondral bone formation. Since this area lies anterior to the oval window on which is present the footplate of stapes, this overgrowth extends till foot plate of stapes leading to its fixation. This condition is called otosclerosis.

To summarize **bony labyrinth is derived from mesoderm, whereas membranous labyrinth is formed from surface neuro-ectoderm.**

The following parts of bony labyrinth can be recognised:

1. **Three bony semi-circular canals:** This is the bony labyrinth around membranous semi-circular canals.
2. **Vestibule:** It is the bony labyrinth around utricle and saccule. The bony canal around the utriculo-saccular duct and endolymphatic duct is called **vestibular aqueduct**.
3. **Bony Cochlea, Scala vestibuli and Scala tympani** are the portions of bony labyrinth on the two sides of Scala media (that is why the term media).The Scala vestibuli lies above the Scala media, whereas the Scala tympani lies below it. As discussed above the Scala media is filled with endolymph, whereas the Scala vestibuli and Scala tympani, along with rest of the bony labyrinth, are filled with perilymph which is an extension of CSF (*see* below). The Scala vestibuli meets the Scala tympani at the apex of Scala media. The area where they meet is called **"Helicotrema"**.

The membranous labyrinth being a closed sac, does not communicate with any other structure, however the bony labyrinth is connected laterally to the middle ear and medially to the cranial fossa.

The **bony labyrinth communicates with middle ear via two openings** present on the common wall between inner ear and middle ear, i.e., the medial wall of middle ear. These are:

1. **Oval window:** This is situated on the bone separating the vestibule (mnemonic; **OV**al–**O**val **V**estibule) from the middle ear, hence it is also known as fenestra vestibuli (*see* Figs 1.13 and 1.14). The **foot process of stapes** overlies the oval window. Hence, the foot plate of stapes develops from the enchondral bone of the bony labyrinth, whereas the rest of stapes is formed from 2nd arch, as discussed above.

The importance of oval window:

- The **sound vibrations** are transmitted through the **footplate of stapes** to the oval window and then **through the vestibular perilymph to the Scala vestibuli** and then through helicotrema to the Scala tympani toward the round window. So, whenever the stapes foot plate causes the oval window to move in, the round window moves out. This opposite movement leads to deflection of the basilar membrane (which forms the lower boundary of scala media, *see* below) and stimulation of the organ of Corti situated upon it in the Scala media.

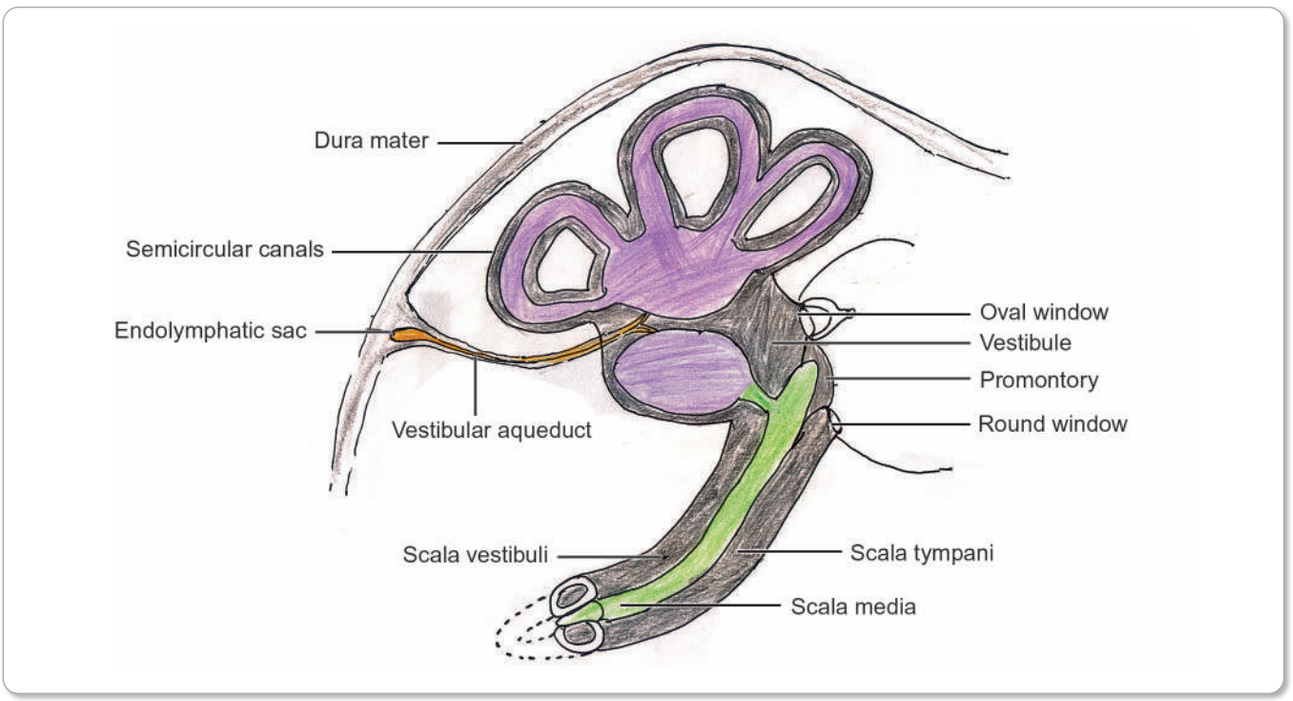


Fig. 1.13: Parts of bony labyrinth

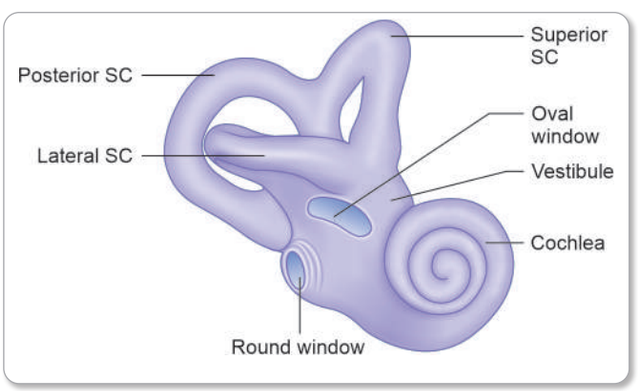


Fig. 1.14: Right bony labyrinth

- Normally during sound transmission foot plate does not stimulate the utricle and saccule. Therefore, a loud sound normally does not cause imbalance. In Meniere's disease which is characterised by the hydrops of utricle and saccule (due to increase in endolymph), the utricle and saccule bulge and come very close to the oval window. The excessive movement of stapes on loud sounds now causes stimulation of utricle and saccule leading to imbalance. Vertigo on loud sounds is known as **"TULLIO'S phenomenon"**. It is seen in Meniere's disease and superior semicircular canal dehiscence (*see* Chapter 12).
- In congenital syphilis where the foot plate of stapes is hyper mobile, external pressure changes in the EAC by tragal pressure or Siegel's speculum lead to excessive movement of the footplate, stimulating the utricle and saccule, causing imbalance. This vertigo, on external pressure changes, is known as **"HENNEBERT'S sign"**.
- The foot plate can become fixed (in otosclerosis) and not allow the sound to go from middle ear to inner ear leading to hearing loss.

2. **Round window:** This connects the Scala tympani with the middle ear. It is also known as fenestra cochleae. The round window is covered by **secondary tympanic membrane** (easy to remember secondary tympanic membrane (STM) over scala tympani (ST)).

The importance of round window:

- The round window is also important in sound transmission: as mentioned in the Ist bullet above.
- The electrodes of cochlear implant are **introduced** through this window and **placed** in the scala tympani.
- Drugs are given via this window (by continuous infusion by Micro Wick and micro catheter sustained release devices) into the inner ear, e.g., Gentamicin in Meniere's disease and steroids in sudden sensorineural hearing loss of immune aetiology.

The Bony Labyrinth Communicates with the Cranium via 2 Openings

1. **Cochlear aqueduct:** This is the connection between the CSF and scala tympani. Via this connection the **CSF** in the subarachnoid space enters scala tympani and becomes **perilymph** which circulates in whole of the bony labyrinth. CSF being an

extracellular fluid therefore, perilymph is rich in Na^+. So, Scala Tympani communicates with middle ear, Scala Vestibuli and subarachnoid space via round window, helicotrema and cochlear aqueduct respectively.

2. **Internal acoustic meatus:** This is the opening connecting the inner ear to the posterior cranial fossa. The 7th and 8th cranial nerves respectively enter and leave the inner ear through the internal acoustic meatus. This is present in the petrous part of temporal bone on its posterior slant (*see* Fig. 1.2).

Any meningeal infection can lead to labyrinthitis or any labyrinthitis can lead to meningitis through these connections between inner ear and cranium.

APLASIA/DYSPLASIAS OF THE INNER EAR

The semicircular canals and utricle are known as **pars superior** and develop earlier than the saccule and cochlea known as **pars inferior**. Most of the developmental abnormalities involve the pars inferior which develop later. During development there can be certain anomalies of the inner ear, these are:

- **Scheibe's dysplasia:** This is the most common anomaly of the inner ear. It involves dysplasia of the saccule and cochlea, hence it is also known as cochleosaccular dysplasia. It can be managed with cochlear implantation.
- **Mondini's dysplasia:** Here the cochlea has only **1.5 turns**. Hearing rehabilitation with **cochlear implantation can** also **be done** here.
- **Alexander's dysplasia:** It involves deformity of the basal turn of cochlea. High frequency sound is therefore, affected here. Again, it can be managed with cochlear implantation.
- **Michel aplasia:** Here there is complete nondevelopment of both bony and membranous labyrinth and the vestibulocochlear nerve. Therefore, cochlear implantation cannot be done here. Michel aplasia is an **absolute contraindication** to do cochlear implantation.

Scheibe's and Alexander's dysplasia involve only the membranous labyrinth, whereas Mondini's and Michel aplasia involve both the membranous and bony labyrinth.

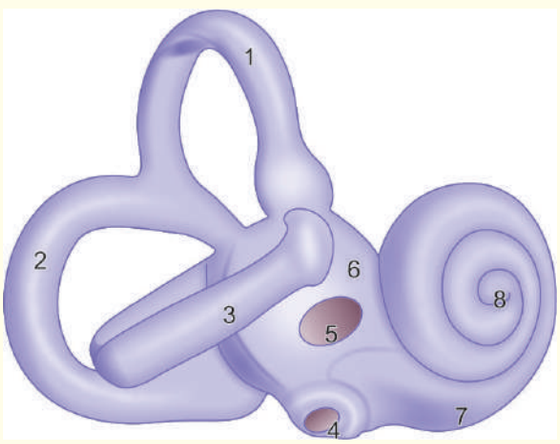
HIGH YIELD POINT

Superior Semicircular Canal Dehiscence (SSCD)

- A congenital anomaly involving the bony labyrinth is superior semicircular canal dehiscence.
- The bulge of superior semicircular canal is present on the anterior slant of petrous part of temporal bone in the base of skull and is known as **arcuate eminence**. Superior semicircular canal dehiscence is a rare condition where the bone between the Superior semicircular canal and brain area is missing or thin.
- This leads to the formation of a 3rd mobile window in the inner ear (the other two being the round and oval window). This SSCD faces the middle cranial fossa.
- This dehiscence leads to exposure of inner ear to changes in intracranial pressure as well as external pressure causing symptoms very similar to that of a round or oval window fistula.
- For further details *see* Chapter 12 on Meniere's disease and disorders of vestibular system.

4 CLINICAL CASE QS

Match the following parts of the inner ear along with the clinical significance.



a. Projects on the anterior slant of petrous temporal bone as arcuate eminence.
b. It is present between middle ear and vestibule.
c. Electrodes of cochlear implant are passed through it.
d. Senses low frequency sounds.

ANATOMY OF EAR

PINNA (AURICLE)

The pinna is made up of a **single** elastic fibrocartilage (formed by the fusion of the "HILLOCKS of HIS").

The Various Parts of Pinna or Auricle are shown in Figure 1.15

Tragus, helix, and lobule—these are the structures at the boundary. Anterior to the helix is the prominence of ante-helix. Just behind the tragus is the opening of external auditory canal (EAC), also called external acoustic meatus (EAM). Just behind the EAM, the part of pinna is called concha. The concha extends anteriorly and superiorly into an area which is called cymba conchae.

The **cymba conchae** is the cartilaginous landmark for mastoid antrum.

Medial to the cymba conchae (on the mastoid process), is a bony landmark for mastoid antrum called "**Macewen's" triangle** or suprameatal triangle.

- Between the tragus and the ascending crus of helix is an inter-cartilaginous area which is devoid of cartilage (see the development of Pinna, Tragus and adjacent part of helix develops from the 1st arch and rest of the Pinna by 2nd arch). This is called "**INCISURA TERMINALIS**". This is the site where incision is made in "ENDAURAL" approach (an approach to tympanic membrane and middle ear through the external acoustic meatus) for various ear surgeries.

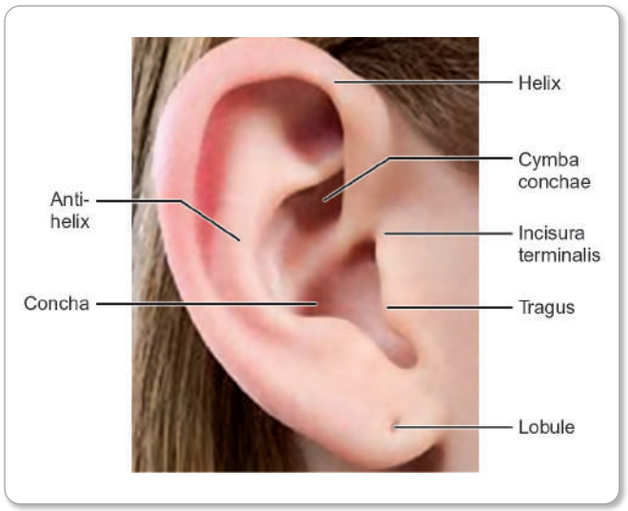


Fig. 1.15: Parts of pinna

- The skin on the lateral side of pinna is more tightly adherent to underlying perichondrium than on medial side, where it is loose. Therefore, any condition of the pinna (perichondritis, furuncle, etc.) on its lateral side is more painful than on the medial side.
- The tragal and conchal cartilage can be used for reconstructive surgeries of middle ear (tympanoplasty) and nose (augmentation rhinoplasty for depressed nasal bridge).

EXTERNAL AUDITORY CANAL (EAC)

The EAC in adults is S-shaped and is **24 mm** long. It has 2 parts (*see* Fig. 1.16):

1. **Cartilaginous part:** This is the **outer 1/3rd,** i.e., **8 mm** long (easy to remember the part of EAC adjoining the cartilaginous pinna is cartilaginous).

   At birth, only the cartilaginous part of EAC is completely developed; the bony part of EAC continues to grow after birth. So, in comparison to adults the EAC is straight and short in children. In adults, the cartilaginous part of EAC courses **upwards, backwards and medially**.

   - The skin in this cartilaginous EAC is thick and contains hair follicles, therefore a furuncle is localised only to the cartilaginous part of EAC.

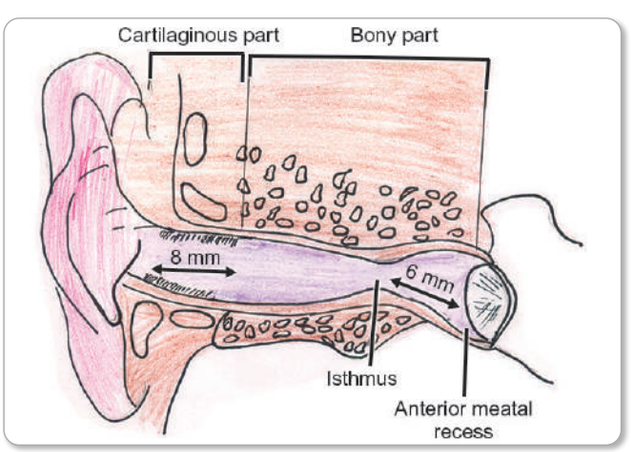


Fig. 1.16: External auditory canal anatomy

   - The skin in this cartilaginous EAC also contains ceruminous glands which are the modified sweat (apocrine) glands. So, wax is produced in this portion of EAC.
   - In the antero-inferior part of this cartilaginous portion are deficiencies known as **"fissures of SANTORINI"**.

   Through these fissures of Santorini, the EAC communicates with parotid. So, parotid infection can track through these fissures and can involve the EAC. Similarly infection in the canal may lead to involvement of parotid.

2. **Bony part:** This is the **inner 2/3rd** portion (i.e., **16 mm** long) of the EAC. This part is not completely developed at birth. This is lined by thin skin which is devoid of hair follicles and ceruminous glands. In adults, the bony part of EAC courses downwards, forwards (in contrast to the cartilaginous part which was upwards and backwards, *see* above) and medially. Therefore, to see the TM in adults, we have to pull the pinna upwards, backwards and laterally so that the cartilaginous and the bony parts of EAC come in straight line.

   - The narrowest part of EAC called **isthmus** is situated in this bony portion. The isthmus is situated 5 mm lateral to the tympanic membrane.
   - Foreign bodies lodged medial to the isthmus, get impacted and are therefore, difficult to remove.

   After the narrowing at isthmus, there is a dilatation.

   This dilatation in the floor of EAC is called **anterior meatal recess**. Any discharge through middle ear tends to collect in this anterior meatal recess. It is difficult to access area.

   - Like the cartilaginous portion, the bony part of EAC in the antero-inferior aspect also has a deficiency which is called "**foramen of HUSCHKE**". This foramen of Huschke also permits infections to and from the parotid.
   - The bony-cartilaginous junction, fissures of Santorini and foramen of HUSCHKE are the potential paths for the spread of infections and tumors from EAC to the base of skull and parotid.

TYMPANIC MEMBRANE

- The tympanic membrane is present at an angle of **55 degrees** with horizontal. The longest diameter of TM is 10 mm and its shortest diameter is 9 mm. The approximate **surface area of TM is 90 mm²**. **But the effective vibratory area** of TM is only approx. **55 mm²** (easy to remember same as the angle of TM).
- It is obliquely set; therefore its postero-superior part is more lateral than antero-inferior part which is medial. This orientation makes the posterior part of EAC shorter than its anterior part and also the posterior part of TM more accessible through the EAC.
- The tympanic membrane is **pearly grey** in color and is translucent.
- The tympanic membrane develops from all the **3 embryonic layers,** therefore, it has an outer epithelial layer in continuation with the epithelium of bony EAC, a middle fibrous layer and an inner mucosal layer in continuation with the lining of middle ear cavity.

The tympanic membrane (TM) is divided into two parts, a lower "pars tensa" and an upper "pars flaccida" (Fig. 1.17).

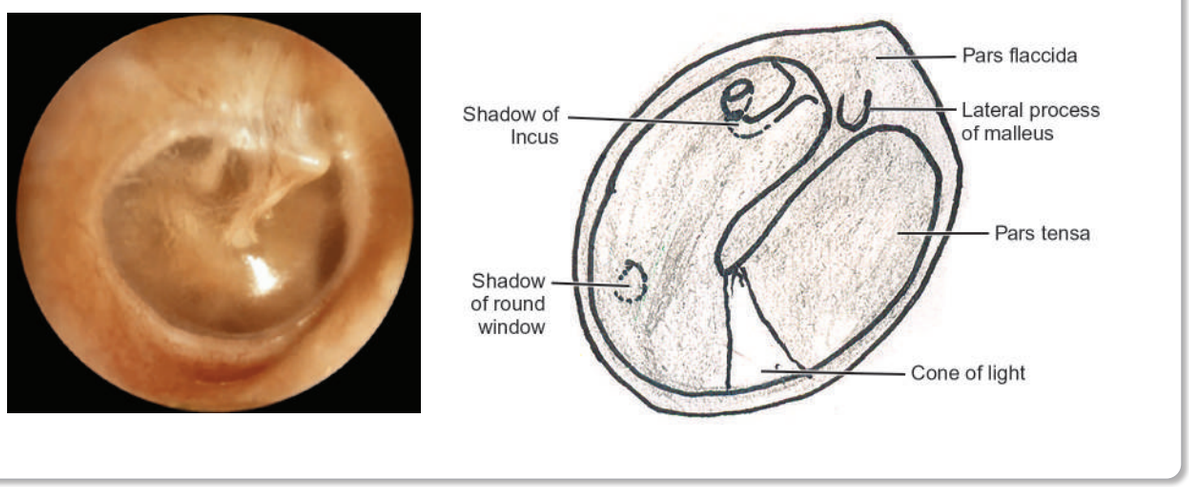


Fig. 1.17: Right tympanic membrane

Pars Tensa

This is so called because it is firm and tense. This is because in its periphery/rim the fibrous layer coalesces to form a fibrous annulus which fits tightly into the surrounding tympanic sulcus, thus tightly anchoring the pars tensa to the surrounding bone. It forms lower 2/3rd of the TM.

In the center of the TM is attached the tip of the handle of malleus leading to central tenting (the cone of this tent points toward the middle ear contributing to narrowing of the middle ear at mesotympanum (please read below the anatomy of middle ear). This central tented part of TM is called **"UMBO"**. Since, the TM is fixed at the center (where it attaches to the tip of handle of malleus) as well as the annulus, therefore, the **paramedian portion of the TM** (on either side of malleus) **is most mobile.**

A **cone of light** extends from the umbo to the periphery of pars tensa in the antero-inferior quadrant. This is the reflection of the handle of malleus due to the obliquity of the tympanic membrane. In right TM, the cone of light is on the right side and in left TM, it is on the left side (as shown in Fig. 1.18). This helps in the identification of the TM drawing.

Pars Flaccida

This is so called because it is loose or flaccid, as the middle fibrous layer here contains more loosely arranged collagen fibrils.

The fibro cartilaginous ring, i.e., the tympanic annulus is deficient superiorly. This deficient area is known as the notch of Rivinus**.** This notch of Rivinus is the upper attachment of pars flaccida.

Pars flaccida is also known as "**SHRAPNELL'S Membrane**".

The pars flaccida being flaccid therefore, it is more susceptible to retraction whenever pressure in the middle ear cavity becomes negative due to Eustachian tube blockade.

Hence, pars flaccida is the most common site of **retraction pocket formation** leading to **primary cholesteatoma** formation (*see* Chapter on unsafe CSOM).

NERVE SUPPLY OF THE EXTERNAL EAR

Pinna or Auricle

The pinna is supplied by the **G**reater auricular nerve, **lesser O**ccipital nerve, **A**uriculotemporal nerve and **A**uricular branch of vagus (this is also called **A**rnold's or Alderman's nerve). It also receives some fibers from the facial nerve. Mnemonic to remember the nerve supply of pinna-**G O A A** (*see* Fig. 1.18).

1. **G**reater auricular nerve (C2, 3) supplies most of the pinna. On the lateral side it supplies the lobule, posterior aspect of helix and ante-helix. It supplies most of the medial surface except the upper part and the post-auricular groove. This nerve crosses the sternocleidomastoid muscle while going toward the parotid gland and divides into anterior and posterior branches. Hypoesthesia in the distribution of the greater auricular nerve which is often sacrificed during parotidectomy is a frequent consequence of parotidectomy. Patients are informed preoperatively that they will feel numbness around the ear following surgery, especially at the lobule and the shaving area. Preservation of the posterior branches of the greater auricular nerve is recommended to achieve faster and more complete recovery in sensory function.
2. Lesser **O**ccipital (C2) supplies only the upper part of the medial surface.
3. **A**uriculotemporal, a sensory branch of the mandibular division of the trigeminal nerve (i.e., V3), supplies tragus and ascending crus of helix and some area of cymba conchae.
4. **A**uricular branch of vagus (X), also called Arnold's nerve supplies the concha on the lateral surface and the postauricular groove medially.
5. Facial nerve (VII) also supplies the concha and the post- auricular groove along with the auricular branch of Vagus.

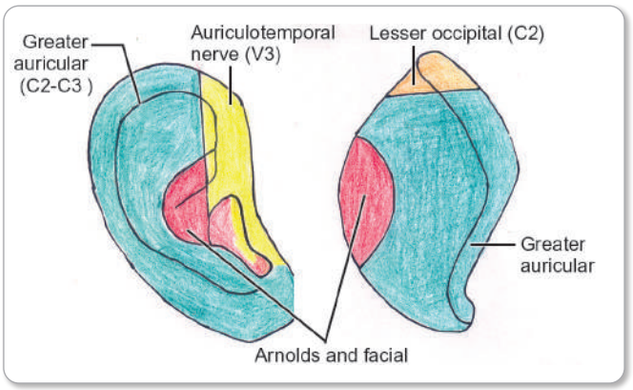


Fig. 1.18: Nerve supply of pinna (lateral and medial surface)

External Auditory Canal

As can be anticipated three nerves supplying the pinna, supply the EAC (the last two As of GO**AA** along with facial nerve).

1. **A**uriculotemporal (V3) supplying the tragus continues inwards to supply the anterior wall and roof of the external auditory canal (EAC).

2. and 3. **A**uricular branch of Vagus **(Arnold's nerve)** and Facial nerve supplying the concha continues inwards to supply the posterior wall and floor of the EAC. The cough response caused while cleaning the ear canal is mediated by the vagus which also supplies the larynx.

Tympanic Membrane

The nerves supplying the external auditory canal supply the lateral surface of tympanic membrane (TM) and the nerves supplying the middle ear supply the medial surface of tympanic membrane.

Hence, the **nerve supply of the tympanic membrane** is as follows:

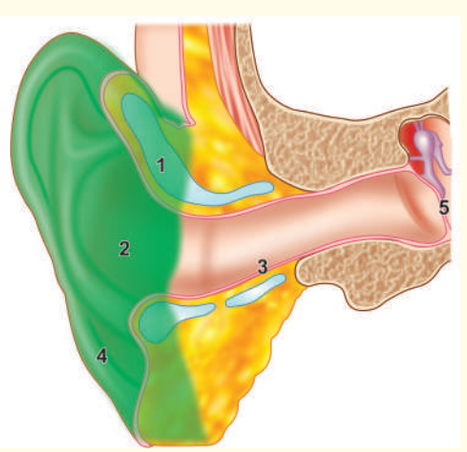
1. **Auriculotemporal (V3)** supplying the anterior wall of EAC supply the anterior half of the lateral surface of the TM.
2. **Auricular branch of Vagus (X)** supplying the posterior wall of EAC supplies the posterior half of the TM. **Please note:** On the TM, Facial nerve does not accompany the Vagus.
3. **Glossopharyngeal (IX):** Tympanic branch of Glossopharyngeal also called Jacobson's nerve, is the sensory nerve of whole of the middle ear (please read Middle ear). Therefore, it supplies the medial aspect of the TM.

Therefore, pain in the ear can be either because of direct involvement of external ear or middle ear known as primary otalgia or referred pain/referred otalgia from the other territories of supply of any of the above nerves.

Pain referred to the ear from:	The common nerve, responsible
TM joint and dental conditions and parotid infections/tumor	Auriculotemporal (V_3)
Acute tonsillitis, peritonsillar abscess and carcinoma base of tongue or tonsils	Glossopharyngeal (IX) (Jacobson's)
Carcinomas of the larynx and hypopharynx and thyroid	Vagus (X) (Arnolds/Alderman's)
Cervical spine degenerative conditions	Greater auricular, lesser occipital nerve
Hitselberger sign (Acoustic neuroma)	Facial (VII) (nervus intermedius/Wrisberg)

5 CLINICAL CASE QS

A patient comes to the ENT OPD with the complain of pain in the right ear. On examination, the ear looks absolutely normal. Which of the following marked in the given figure is the correct site for the referral of the pain through given nerves?



1. From TM joint through Auriculotemporal nerve.
2. From larynx through vagus.
3. From the tonsil through vagus.
4. From cervical spine through greater auricular.
5. From the anterior 2/3 of tongue through the glossopharyngeal nerve.

MIDDLE EAR

The middle ear can be assumed to be like a cuboid and therefore, has six walls (*see* Fig. 1.19).

1. **Lateral wall:** This is the common wall between external auditory canal and middle ear. This is formed by **tympanic membrane (TM) below and scutum above**. The scutum is the bone above the pars flaccida forming the lateral wall of attic (the attic is the upper part of the middle ear cavity), *see* Fig. 1.20.
2. **Medial wall:** This is the common wall between middle ear and inner ear. The six important structures on this medial wall are:
   i. **Promontory:** This is a bulge in the center of the medial wall, produced by the basal turn of cochlea. On the promontory, tympanic plexus is present (please read below).
   ii. **Processus Cochleariformis:** This is a hook like structure present antero-superiorly on the medial wall. It has the following two significance:
   - The **tensor tympani** muscle originates from a canal in the anterior wall of middle ear. It then runs medially where its tendon winds around the processus cochleariformis and then turns laterally to get attached to the malleus (just below its neck).
   - It acts as a **landmark for the first genu** (or turn) of facial nerve. The first genu of facial nerve lies above the processus cochleariformis.

   The facial nerve enters the inner ear through the internal acoustic meatus. After running through the inner ear it enters the middle ear on its medial wall. Here it takes a turn called the 1st genu and continues horizontally backwards toward the posterior wall of middle ear as the horizontal or tympanic segment. The geniculate ganglion is situated at the first genu. Please also *see* the chapter on facial nerve.

   iii. **Bulge of lateral semicircular canal:** The bulge of lateral/horizontal canal is present on the most posterosuperior portion of the medial wall just above the horizontal or tympanic segment of facial nerve.
   iv. **Oval window:** This lies postero-superiorly on the medial wall, with foot process of stapes overlying it, separating the vestibule from the middle ear. The oval window lies inferior to the horizontal or tympanic segment of facial nerve.

   The bulge of lateral semicircular canal and oval window are important landmarks of the tympanic segment of facial nerve. The tympanic segment of facial nerve runs horizontally in the posterior direction on the medial wall between the bulge of lateral semicircular canal (lying above) and oval window (lying below it).
   v. **Round window:** This lies postero-inferiorly on the medial wall. This is covered by secondary tympanic membrane, separating the middle ear from the scala tympani. See the importance of round window above in the embryology section.
   vi. **Facial nerve:** The facial nerve coming from the inner ear enters the middle ear on its medial wall where it takes a turn called the 1st genu. It then continues horizontally backwards toward the posterior wall as the horizontal or tympanic segment. The processus cochleariformis, bulge of lateral semicircular canal and oval window are its important landmarks on the medial wall, as discussed above.

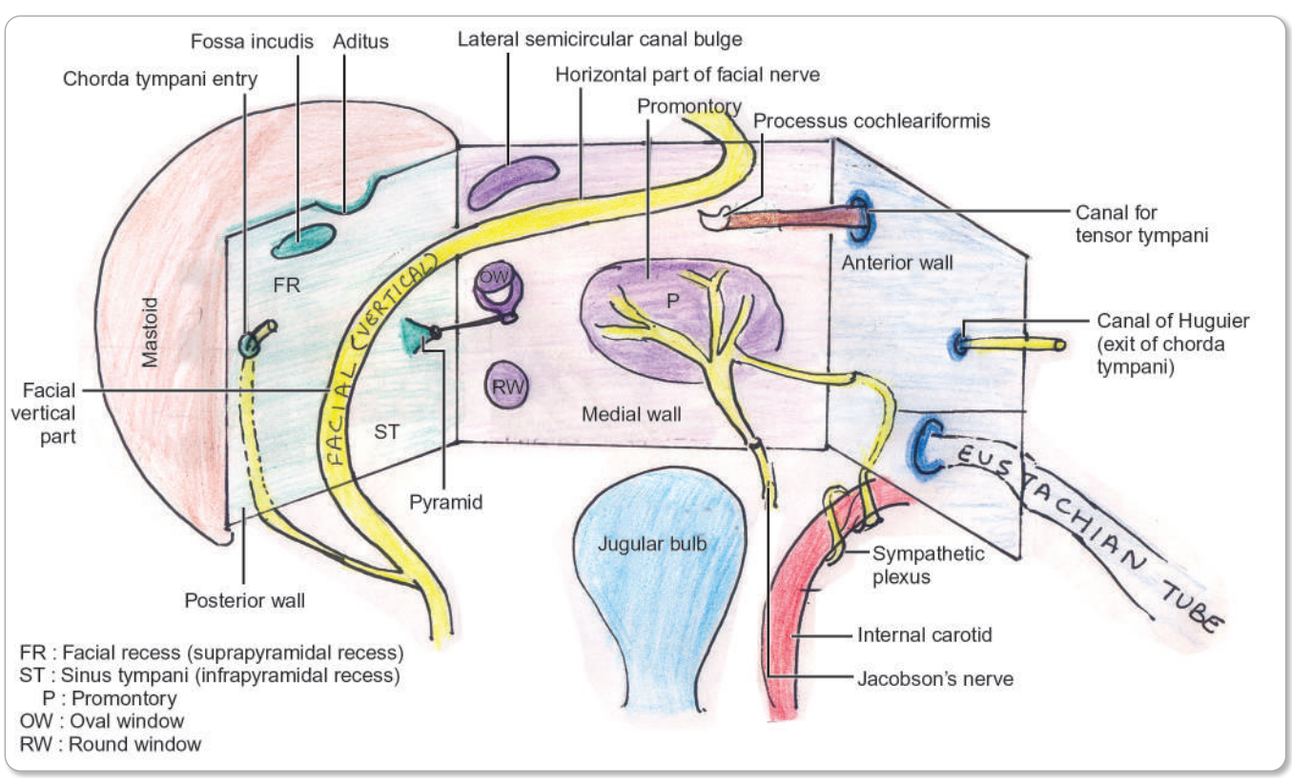


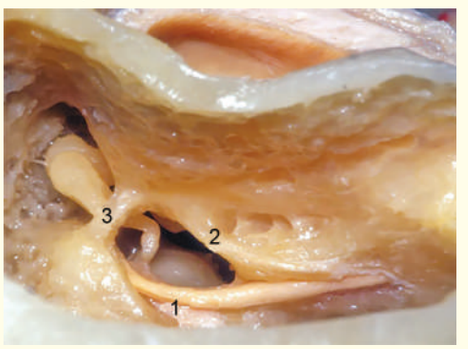
Fig. 1.19: Walls of middle ear

3. **Posterior wall:** This is the common wall between middle ear and mastoid. The seven important structures on this posterior wall are:
   i. **Aditus:** On the upper border of this wall there is an opening known as aditus which connects the attic (the attic is the upper part of the middle ear cavity) to the mastoid antrum.
   ii. **Pyramid:** It is a projection on the posterior wall from which originates the **stapedius muscle**. The stapedius attaches to the neck of stapes. The stapedius muscle, like the suprastructure of stapes, is a second arch derivative and therefore is supplied by the nerve of the 2nd arch, i.e., facial nerve. It mediates an important protecting reflex known as **stapedial reflex**. This reflex protects the inner ear from loud noise. Please refer to chapter on audiometry.
   iii. **Facial nerve:** At the junction of medial and posterior wall, the **tympanic or horizontal segment** of facial nerve takes a lateral turn onto the posterior wall known as the 2nd genu. It then descends vertically down behind the pyramid and here it is named as vertical or descending or mastoid segment of facial nerve.
   iv. **Sinus tympani/Infra pyramidal recess:** It is the area medial to the bulge of vertical/descending or mastoid part of facial nerve bounded above by ponticulus and below by subiculum. The ponticulus and subiculum are respectively the upper and lower bony ridges extending from the promontory to the posterior wall.
   Sinus tympani is considered as the **hidden area** of the middle ear. It is the most common site for residual cholesteatoma, *see* chapter on unsafe CSOM.
   v. **Chorda tympani nerve entry:** The vertical or descending part of facial nerve in the posterior wall of middle ear, i.e., in the mastoid portion of temporal bone ultimately exits the temporal bone through the stylomastoid foramen. Just 4–6 mm before its exit, it gives the chorda tympani nerve which then ascends up and enters the middle ear cavity through an opening on the posterior wall. Passing between the fibrous and mucosal layers of TM, the chorda tympani then runs in between the neck of malleus and the body of incus in the attic (or epitympanum, i.e., the upper part of middle ear cavity, *see* below). It then ultimately exits the middle ear cavity through the **canal of "HUGUIER"** present in the anterior wall of middle ear (***mnemonic***—since chorda is leaving the middle ear it's been given a HUG-here). The chorda tympani gives taste sensations to the anterior 2/3rd of the tongue.
   vi. **Fossa incudis:** It is a fossa on the posterior wall on which rests the short process of incus.
   vii. **Facial recess/Supra pyramidal recess:** This is an area on the lateral side of the vertical or descending segment of the facial nerve, i.e., on the other side of sinus tympani. The facial recess is limited **superiorly** by the fossa incudis, **laterally** by chorda tympani entry and **medially** by the descending facial nerve segment.

The surgical importance of facial recess is that, it is the site where opening is made on the posterior wall to access the middle ear cavity through the mastoid, e.g., in **"INTACT CANAL WALL"** surgeries of the ear. Also the **electrodes of cochlear implant** are introduced into the middle ear from the mastoid through the facial recess. This approach of the middle ear through its posterior wall is known as the **posterior tympanotomy approach**, see chapter on unsafe CSOM.

6 CLINICAL CASE QS

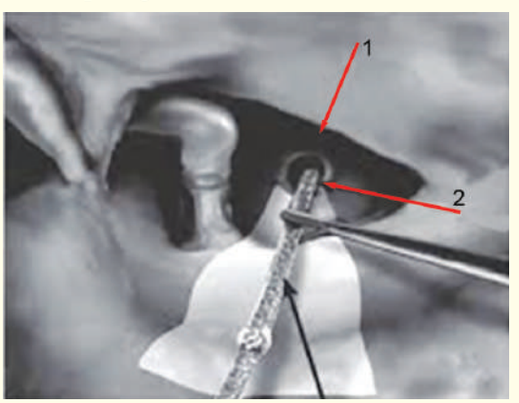
While doing intact canal wall surgery through the mastoid the surgeon has made an opening in the facial recess area. You are asked to identify the marked boundaries.



a. 1-tympanic segment of facial, 2- chorda tympani, 3- fossa incudis
b. 1- sinus tympani, 2 chorda tympani, 3- short process of incus
c. 1- mastoid segment of facial, 2- tympanic annulus, 3- aditus
d. 1- mastoid segment of facial, 2- chorda tympani, 3- fossa incudis

7 CLINICAL CASE QS

The given procedure was being done in a deaf child. Identify the marked openings.



a. 1- round window, 2- facial recess
b. 1- aditus, 2- round window
c. 1 - facial recess, 2- round window
d. 1 - facial recess, 2- oval window

4. **Anterior wall:** It is a thin plate of bone separating the middle ear from **internal carotid** artery. The four important structures on this wall are:
   i. **Opening of Eustachian or pharyngo-tympanic tube:** The Eustachian tube connects the middle ear cavity with the nasopharynx. From the anterior wall of the middle ear cavity starts its **bony part,** which forms the **lateral 1/3rd**, following which the **medial 2/3rd** is **fibro-cartilaginous** (easy to

remember the lateral part being in continuation with bony middle ear cavity, is bony). The fibro-cartilaginous portion of the ET is surrounded by a collection of adipose tissue known as ostmann fat pad (read Chapter 6 for the clinical importance of Ostmann pad of fat).

The fibro-cartilaginous nasopharyngeal opening is present 1–1.25 cm behind and a little below the posterior end of inferior turbinate.

The length of Eustachian tube is about 36 mm (32–38 mm) out of which the bony part is 12 mm and the cartilaginous part is 24 mm. The narrowest part of Eustachian tube is the junction of the bony and cartilaginous parts and is known as **isthmus**.

The Eustachian tube is at an angle of 45° with the horizontal.

The length of Eustachian tube at birth is approximately half the length of adults, i.e., around 13–18 mm. It reaches adult size by 7 years of age. The Eustachian tube in children is wider, shorter, more horizontal and flaccid (containing less of elastin) making children prone to retrograde reflux of nasopharyngeal secretions into the middle ear and thereby increased frequency of nasopharyngeal infections reaching the middle ear. Also the Eustachian tube ventilatory function is less efficient in children than in adults.

External auditory canal	Eustachian tube
2/3rd part is bony and	1/3rd part is bony and
1/3rd part is cartilaginous	2/3rd part is cartilaginous
Lateral 1/3rd is cartilaginous in continuation with the cartilaginous pinna	Lateral 1/3rd is bony in continuation with the bony middle ear cavity
Total length 24 mm (cartilaginous part 8 mm and bony part 16 mm)	Total length 36 mm (12 mm bony and 24 mm cartilaginous)
Narrowest part (isthmus) is situated in the bony part 6 mm lateral to the TM	Narrowest part (isthmus) is the junction of bony and cartilaginous parts

Eustachian tube normally remains closed and opens intermittently during swallowing, yawning and sneezing. **Tensor palati** plays the major role in opening the tube.

Normally the Eustachian tube opens frequently, stably maintaining the middle ear pressure between +50 mm and –50 mm H_2O.

ii. **Canal for origin of tensor tympani muscle:** Tensor tympani originates from a canal in the anterior wall of middle ear. As discussed above, it then runs medially where its tendon winds around the processus cochleariformis and then turns laterally to get attached on the upper part of the handle of malleus (i.e., just below its neck).

The tensor tympani muscle like malleus is a **derivative of 1st arch** and is **supplied by** the nerve of the 1st arch, i.e., **mandibular nerve** (through its **anterior or motor branch**).

In response to loud noises, usually those of chewing, the tensor tympani contracts pulling the neck of malleus medially, thereby decreasing the conduction of these sounds.

iii. **The canal of Huguier:** As stated previously this is the exit site for chorda tympani from middle ear.

iv. **Petro-tympanic fissure (Glaserian fissure):** This is the site of attachment of anterior ligament of malleus and the site for entry of anterior tympanic artery. Sometimes the canal of Huguier opens in the petro-tympanic fissure.

5. **Roof:** The roof of the middle ear is known as **"TEGMEN TYMPANI"**. It contributes to the anterior slant of the petrous part of the temporal bone and separates the middle ear from the middle cranial fossa (temporal lobe), *see* Fig. 1.20 below.
6. **Floor:** It is a thin plate of bone separating the middle ear from the **jugular bulb** along with the 9th and 10th cranial nerves.

The tympanic segment of glossopharyngeal nerve (also known as **"JACOBSON'S NERVE"** enters the middle ear through floor and along with sympathetic plexus (coming into the middle ear from around the internal carotid artery) forms tympanic plexus on the promontory (*see* Fig. 1.19).

This tympanic plexus gives sensory nerve supply to whole of the middle ear cavity, Eustachian tube and medial surface of the tympanic membrane.

MIDDLE EAR CAVITY

The middle ear cavity is lined by mucus secreting ciliated respiratory mucosa. It is divided into 3 parts (*see* Fig. 1.20) by lines drawn from the upper and lower borders of pars tensa.

These are:

- **Epitympanum or Attic:** As the name it is the uppermost part of the middle ear cavity. This is the **widest** part of the middle ear cavity. It lies medial to pars flaccida below and scutum above. It has a width of 6 mm. As can be seen in Fig. 1.20, the **epitympanum contains** the head, neck, anterior and lateral process of malleus and the body and short process of incus (the head of malleus articulates with the body of incus). The Chorda tympani nerve (branch of facial carrying taste sensations from anterior 2/3 of tongue) passing in between the neck of malleus and the body of incus also lies in the epitympanum. The space of the epitympanum, lying in between the Shrapnell's membrane or pars flaccida and the neck of malleus is known as "**PRUSSAK'S SPACE**". When a retraction pocket on Pars flaccida (leading to the formation of primary cholesteatoma, *see* chapter on unsafe CSOM) grows medially, it goes into this Prussak's space making this the most common site of primary cholesteatoma.
- **Mesotympanum:** As the name it is the middle part of the middle ear cavity. This is the **narrowest** part of middle ear due to the constrictions caused by umbo laterally and promontory medially. The distance between the TM (UMBO) and promontory is **2 mm**.

  Mesotympanum contains the handle of malleus, the long process of incus ending in lentiform nodule which articulates with the head of stapes and the whole of the stapes (the head, neck, anterior and posterior crura and footplate).
- **Hypotympanum:** This is the lower compartment of middle ear cavity.

It is the **smallest part** of middle ear cavity. It has a width of 4 mm.

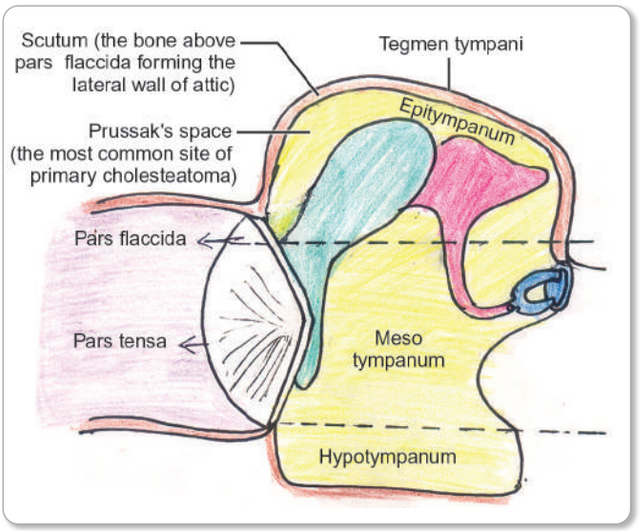
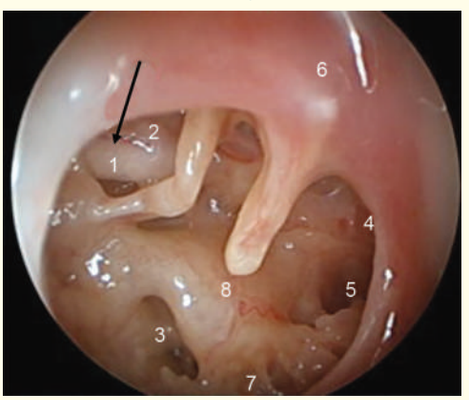


Fig. 1.20: Parts of middle ear cavity

8 CLINICAL CASE QS

A student has labeled the endoscopic picture of the middle ear. What has he not marked correctly?



1. This is the Tympanic segment of facial nerve.
2. This is the lateral semicircular canal.
3. Cochlear implant electrodes passed into scala tympani.
4. Chorda tympani nerve enters middle ear from here.
5. Infection from nasopharynx reaches middle ear.
6. Site for primary cholesteatoma.
7. Jugular bulb lies below this wall.
8. Is produced by the apical turn of cochlea.

OSSICLES AND THEIR PARTS

The middle ear contains 3 ossicles – the malleus, incus and stapes: (Fig. 1.21)

1. Malleus -the malleus has a head, neck, anterior and lateral process (bulging laterally as a projection on the tympanic membrane). The head and neck of malleus lie in the attic. The handle runs downwards, medially and backwards and lies between the mucosal and squamosal layers of the tympanic membrane. It is adherent to the tympanic membrane at the lower end (umbo) and at the lateral process. On the medial surface of the handle, near its upper end inserts the tensor tympani tendon. Just above this insertion, passes the chorda tympani from the posterior to the anterior wall.
2. The incus is the largest of the ossicles. It has a body, short, long and lenticular process. The body lies in the epitympanum and articulates with the malleus head. This **incudomalleolar joint** is a **saddle type** of **synovial joint. The short process projects backwards on the fossa incudis.**

   The long process of incus descends down in the mesotympanum and ends in a small medially directed process known as lentiform process, which articulates with the head of stapes. This **incudostapedial joint** is a **ball and socket** type of **synovial joint**.
3. The stapes is the smallest ossicle. It is shaped like a stirrup and has a head, neck, anterior and posterior crura and footplate. The stapedius tendon inserts on the posterior part of neck and upper portion of posterior crus. The footplate lies on the oval window and attaches to the bony margins by the annular ligament. It transmits sound to the inner ear.

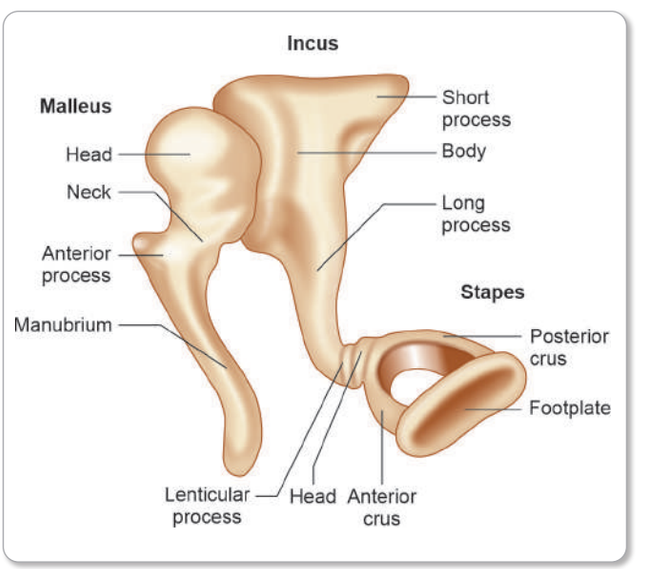


Fig. 1.21: Ossicles and their parts

MASTOID

Posterior to the middle ear cavity is the mastoid. The mastoid is a **pneumatic** bone which encloses numerous air cell spaces giving it a honeycomb appearance.

The largest and most prominent air cell is called the mastoid antrum. The mastoid antrum is well developed at birth and attains a volume of about 2 mL by adult life.

On the mastoid process, is a bony landmark for mastoid antrum called "**Macewen's" triangle** or suprameatal triangle The boundaries of MacEwen's triangle are (*see* Fig. 1.22) superiorly temporal line/ supra mastoid crest, anteriorly posterosuperior segment of bony external auditory canal or post-auricular groove and postero-inferiorly by a tangent drawn to meet the above two lines.

- Just anterior to the MacEwen's triangle on the mastoid bone is a projection known as **spine of Henle**, which is seen during surgery. It acts as another important bony landmark of mastoid antrum.

These landmarks are important while doing mastoid surgeries in approaching the mastoid antrum.

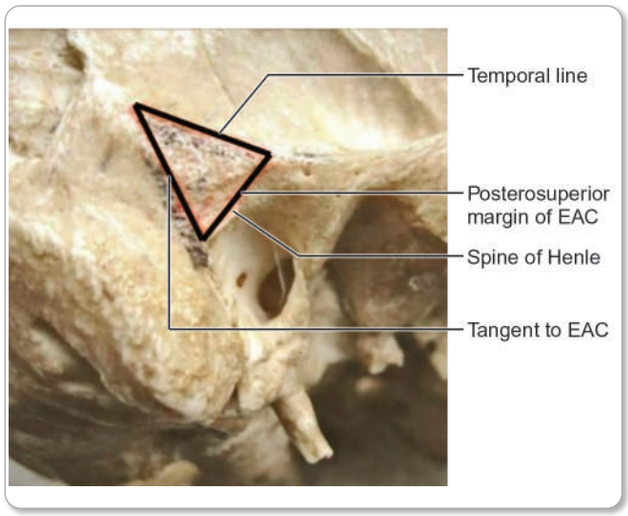


Fig. 1.22: Boundaries of MacEwen's triangle

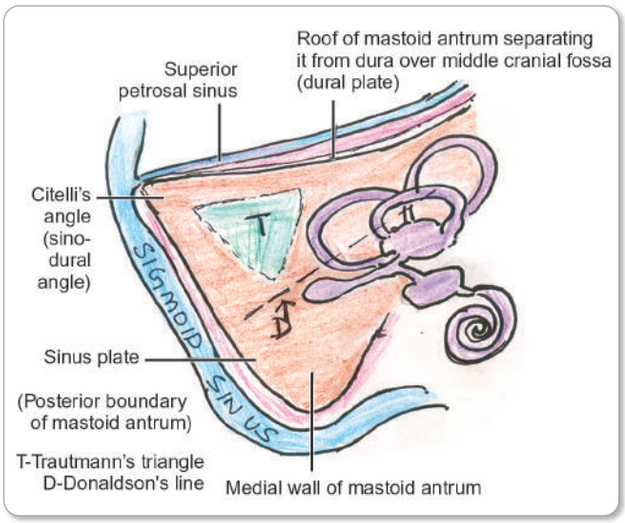


Fig. 1.23: Medial wall of mastoid antrum

This is because any other approach to mastoid antrum can be dangerous because mastoid is surrounded all around by important structures (mentioned below) which can be damaged during mastoid surgeries.

Superiorly is the bone separating mastoid from middle cranial fossa; posteriorly is the bone separating mastoid from sigmoid sinus. Inferiorly lies the facial nerve just below the mastoid tip.

Boundaries of Mastoid Antrum (see Figs 1.23 and 1.24)

- **Superiorly** is the base of skull, also known as tegmen antri, which separates it from the dura overlying, the temporal lobe in the middle cranial fossa. Hence, tegmen antri is also called **dural plate**.
- Posteriorly **is the base of skull which separates it from the sigmoid** sinus (**sinus plate**).

  The sinodural angle formed in between the dural plate superiorly and the sinus plate posteriorly is known as **Citelli's angle**. It is the position where superior petrosal sinus enters the sigmoid sinus (superior petrosal sinus joins the sigmoid sinus with cavernous sinus).
- **Medially:** The medial wall of mastoid antrum is related superiorly to the posterior semicircular canal and inferiorly to the base of skull separating it from the endolymphatic sac and posterior cranial fossa.

  The surgical landmark of endolymphatic sac on this wall is an imaginary line, drawn from the lateral semicircular canal bisecting the posterior semicircular canal, known as **"Donaldson's line".**

  The endolymphatic sac lies inferior to this Donaldson's line, *see* Figure 1.23.

  A triangular area on the medial wall of mastoid antrum, bounded superiorly by the superior petrosal sinus, posteriorly by the sigmoid sinus and anteriorly by the bony labyrinth is used as a landmark to approach the posterior cranial fossa. This triangular area is known as **Trautmann's triangle**. Since the bone in this area is relatively thin, it is also a potential site for spread of infections from the mastoid to the cerebellum.
- **Laterally** the antrum is anatomically marked by the **MacEwen's triangle** or suprameatal triangle on the outer surface of the skull. The antrum lies approximately 1.5 cm deep to MacEwen's triangle (please refer to the development of mastoid and the anatomy of pinna for these landmarks).
- **Anteriorly** the antrum is bounded by the posterior wall of middle ear. The antrum is connected to the attic (epitympanum) through the aditus on the posterior wall of middle ear (please refer to the middle ear anatomy).

Besides antrum, the various other mastoid air cells are also named. These are named according to their anatomical site in the temporal bone. These are:

a. Zygomatic cells (in the zygomatic root)
b. Tegmen cells (in the roof)
c. Perisinus cells (on the sinus plate)
d. Marginal cells (behind the sinus plate)
e. Tip cells (in the mastoid tip)
f. Retrofacial cells (around the facial nerve)
g. Peri-labyrinthine cells (around the labyrinth)
h. Squamosal cells (in the squamous part of temporal bone)

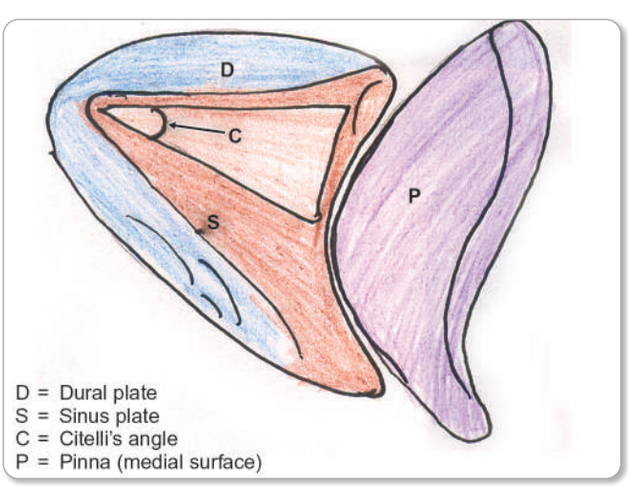


Fig. 1.24: Showing Citelli's angle

9 CLINICAL CASE QS

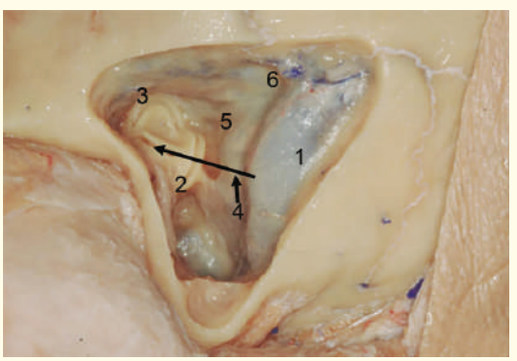
An ENT surgeon was doing a mastoid exploration for chronic squamosal otitis media. During this surgery, what is the sequence of encountering the following structures from lateral to medial:

1. MacEwen's triangle
2. Korners' septum
3. Mastoid antrum
4. Trautmann's triangle
5. Posterior cranial fossa

a. 1, 4, 2, 5, 3
b. 1, 2, 4, 5, 3
c. 1, 2, 3, 4, 5
d. 3, 5, 2, 4, 1

10 CLINICAL CASE QS

Below is a surgical specimen after mastoidectomy of the left ear marked by a student. Which of the following has not been correctly marked?



1. Jugular vein.
2. Superior SCC.
3. Posterior SCC.
4. Donaldson's line.
5. Trautmann's triangle.
6. Citelli's angle.

INNER EAR ANATOMY

Most of the anatomy of the inner ear has already been discussed in the section of the embryology of inner ear (*see* Figs 1.25 and 1.26).

Structure of Scala Media

Membranous cochlea or Scala media or cochlear duct is a coiled tube, coiling over a bony axis which is known as "**modiolus**". It takes **2 and 1/2 to 2 and 3/4 turns** around the modiolus.

Osseous spiral lamina or ligament is a bony canal running spirally around the modiolus, within the lumen of the membranous cochlea. Inside this bony spiral lamina is the "**Rosenthal canal**" which contains the 8th nerve ganglion known as the **spiral ganglion**.

The Scala media or cochlear duct is triangular in cross section (*see* Fig. 1.25) and is bounded by:

- *Basilar membrane:* It separates Scala media or cochlear duct from Scala tympani. The organ of Corti rests on the basilar membrane. The thickeness of the basilar membrane and the mass and height of the organ of Corti increase from the base to the apex of the cochlea. The changes in the mechanical properties of the basilar membrane along with the changes in the mass on the membrane, results in different frequencies producing maximum vibration and stimulation of different parts of the organ of Corti. High frequencies are detected at the basal end and low frequencies at the apical end.
- *Reissner's membrane:* It separates Scala media from Scala vestibuli.
- *Stria vascularis:* It is the site for the **production of endolymph**. It plays an important role in cochlear homeostasis by generating the endocochlear potential and maintaining the ionic composition of endolymph.

It contains Na^+ K^+ ATPase and Na^+ K^+ 2 Cl^- channel (the same channel is present in the loop of Henle in the nephronic tubule on which act the loop diuretics) which is responsible for making the endolymph rich in K^+ leading to the development of an **endolymphatic potential** of **+ 80 to + 85 mV**. As discussed above, in comparison to endolymph, the perilymph is rich in Na^+. The Bartter's syndrome (an inherited tubulointerstitial disease of the kidney) is characterised by mutation of the Na^+ K^+ 2 Cl^- channel and as a result one of the manifestations in Bartter's is sensorineural deafness.

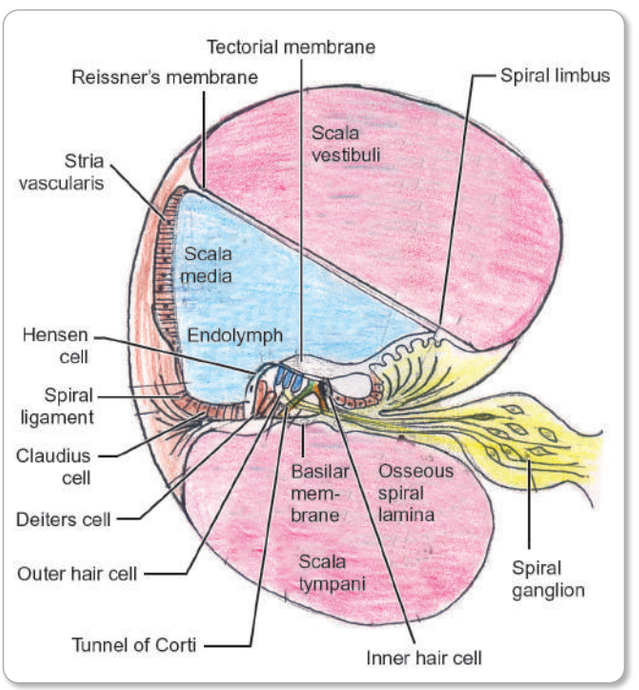


Fig. 1.25:

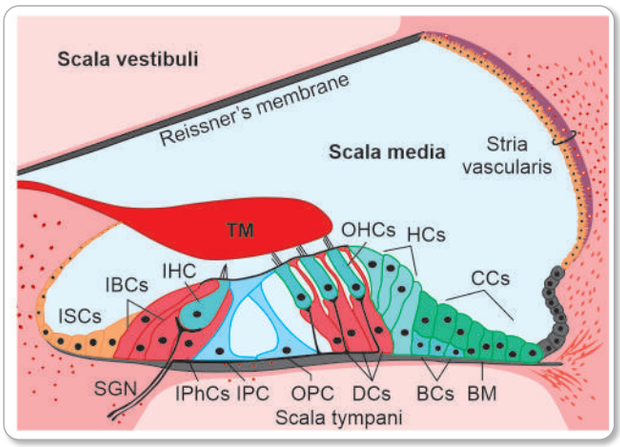


Fig. 1.26

Structure of Organ of Corti (see Fig. 1.25)

- **Hair cells:** There are two types of hair cells in the organ of Corti, the inner (IHC) and the outer hair cells (OHC). The OHC are present on the most flexible part of the basilar membrane. The longest stereocilia of the outer hair cells project into a membrane which is known as **Tectorial membrane**. The movement of the basilar membrane induces movement of the OHC and movement of the stereocilia leading to opening up of the mechnoelectrtical transduction channels. The OHC amplify the signal before transmitting to the IHC. The activity of the OHC produces sound waves which are emitted from the ear as Otoacoustic emissions (OAE). These can be recorded from microphones fitted in the external ear and can be used as an objective method for testing the functioning of the OHC and indirectly functioning of the organ of Corti, in cases of hearing loss.
- **Supporting cells:** These support the outer hair cells. They are named as cells of Dieters, Claudius and Hensen (***mnemonic***—DCH). They provide mechanical support to the organ of Corti and also plays an important role in maintaining cochlear haemostasis.
- **Tunnel of Corti:** It is formed by the inner and outer rods and contains a fluid called cortilymph.

Difference between inner and outer hair cells of organ of Corti

Inner hair cell	Outer hair cell
These are arranged in a single row, therefore these are less in number	These are arranged in 3–4 rows, therefore, these are much more in number
These are more resistant to noise trauma and ototoxic drugs (easy to remember, body's defence strategy-inner cells being less in number so more resistant)	These are less resistant to noise trauma and ototoxic drugs
Nerve supply–mainly afferent	Nerve supply–mainly efferent
Therefore, their function is to transmit auditory stimuli	They modulate the function of inner hair cells and generate oto-acoustic emissions (easy to remember outer-oto)

Auditory Pathway

Inner hair cells → afferent nerves which fuse to form the Cochlear nerve → spiral ganglion (this is the cochlear nerve ganglion present in Rosenthal canal inside spiral lamina) → Cochlear nerve exits through the internal acoustic meatus (here it is inferior to the facial nerve–please see below) → dorsal and ventral cochlear nuclei (in the pons).

The mnemonic of further auditory tract is **S L I M.**

From the cochlear nuclei, the fibers go to both ipsilateral and contralateral Superior Olivary complex **(S)** (the crossing to the contralateral superior olivary complex occurs through "**TRAPEZOID Body**" → **L**ateral lemniscus (L) → **I**nferior Colliculus (I) → **M**edial geniculate body (**M**)).

From medial geniculate body, the auditory fibers pass through the **posterior limb of internal capsule to transverse temporal gyrus** (Auditory cortex- Broadmann area no 41). **Appreciation of sound occurs in the transverse temporal gyrus which is a part of superior temporal gyrus.**

The auditory pathway of both the sides have multiple interconnections because of which sound, even if heard from one ear, is perceived by both the cerebral hemispheres.

There are also interconnections at **superior olivary complex with facial nerve mediating stapedial reflex** (please refer to the audiology section).

The auditory pathways (mainly the superior olivary complex and inferior colliculus) and the **higher auditory center is responsible mainly for sound localisation and selective listening,** i.e., allowing an individual to listen to one channel of information while blocking out sounds in other competing channels (as hearing in noisy environment) (Fig. 1.27).

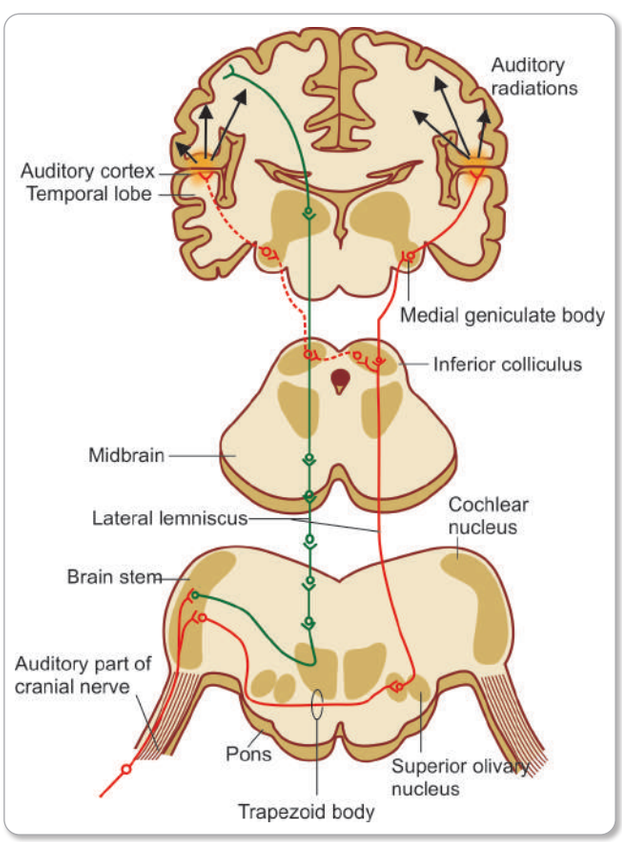


Fig. 1.27: Auditory pathways

11 CLINICAL CASE QS

Arrange the structures of the auditory pathway in the sequential order of sound transmission:

1. Cochlear nerve
2. Superior olivary complex
3. Inferior colliculus
4. Cochlear nuclei
5. Lateral lemniscus
6. Medial geniculate body

a. 1, 4, 2, 5, 3, 6
b. 1, 2, 3, 4, 5, 6
c. 6, 3, 2, 5, 4, 1
d. 1, 2, 5, 4, 6, 3

Structure of Cristae

These are the rotational or angular acceleration sensing structures inside the semi-circular canals.

The cristae contain type 1 and type 2 hair cells which project into a gelatinous matrix known as "**CUPULA**". *See* Fig. 1.28.

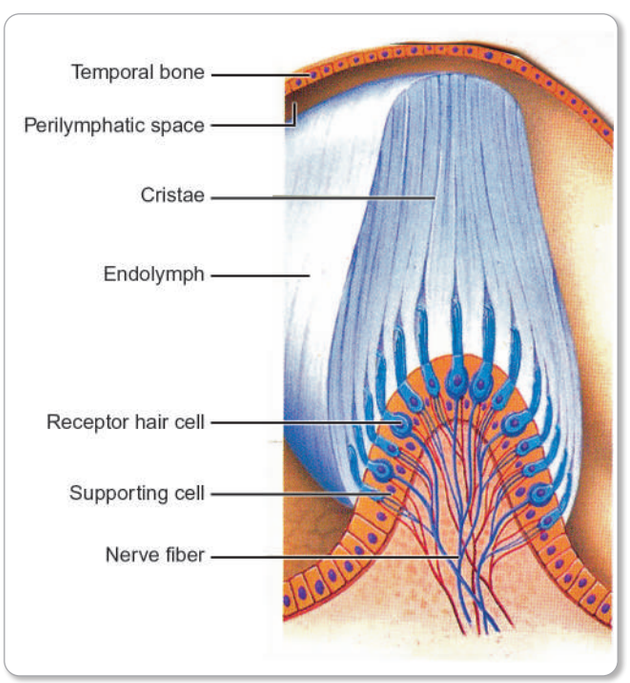


Fig. 1.28: Cristae

Structure of Maculae

These are the linear acceleration sensing structures (*see* above in the embryology section) present in the utricle and saccule. Here again there are two types of hair cells, **type 1 and type 2**. The cilia of these hair cells project into a gelatinous matrix which is covered by calcium carbonate crystals on its top. *See* Fig. 1.29.

These **calcium carbonate crystals are known as "Otolith or Otoconia"** and together with the gelatinous mass is known as "Otolithic membrane".

The ionic concentration of the endolymph in the vestibular system is maintained by Dark cells. These are ion transporting epithelium in the area around the cristae of semicircular canals and maculae of the utricle. They stain darker than the rest of the cells in the histological sections and hence, are known as dark cells.

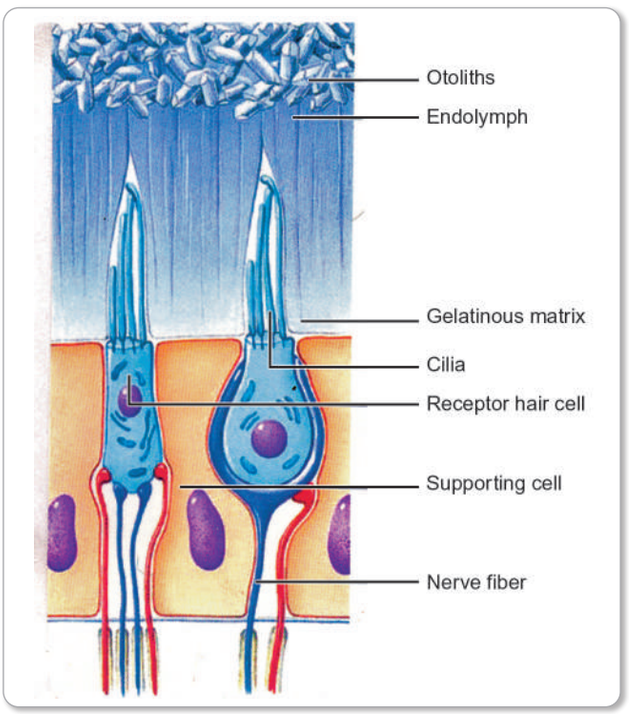


Fig. 1.29: Maculae

Note

Hair cells in the Organ of Corti, in the Cristae and in the Maculae have cilia emerging from their apical surfaces. There are tiny thread-like connections from the tip of each cilium to non-specific cation channels on the side of the neighboring cilium. These connections called **"The tip links"** open these channels mechanically due to the **distortion effect** caused by cilliary movement. This then leads to an influx of potassium.

An inward K^+ current then opens voltage-dependent calcium channels. This in turn causes neurotransmitter **(glutamate)** release at the basal end of the hair cell, eliciting an action potential in the dendrites of the VIIIth cranial nerve.

Vestibular Pathway

The hair cells of cristae in the **posterior semicircular canal** are **supplied by** the **singular nerve** which is a branch of inferior vestibular nerve (easy to remember s**in**gular-**in**ferior vestibular nerve). ***Mnemonic***—this important fact can be remembered in this fashion; posterior SCC is involved in BPPV (P for P here). BPPV is the single (singular nerve) most common cause of vertigo in clinics, see chapter on Meniere's.

The **inferior vestibular nerve** also **supplies** the hair cells of the **maculae in the Saccule**.

The hair cells of **cristae** in the **superior and lateral semicircular canals** and **maculae in the Utricle** are supplied by the **superior vestibular nerve**.

The ganglion of vestibular nerves is situated in the lateral part of internal acoustic meatus and is called the "**SCARPA'S GANGLION**". Finally the inferior and superior vestibular nerves exit the internal acoustic meatus to go to vestibular nuclei in the pons.

The vestibular nuclei of the two sides have inter-connections with each other as well as with Cerebellum, Spinal cord, Medial longitudinal bundle (and through this with 3rd, 4th and 6th ocular nerves), Autonomic nervous system and cerebral cortex.

The above together maintain the body's balance.

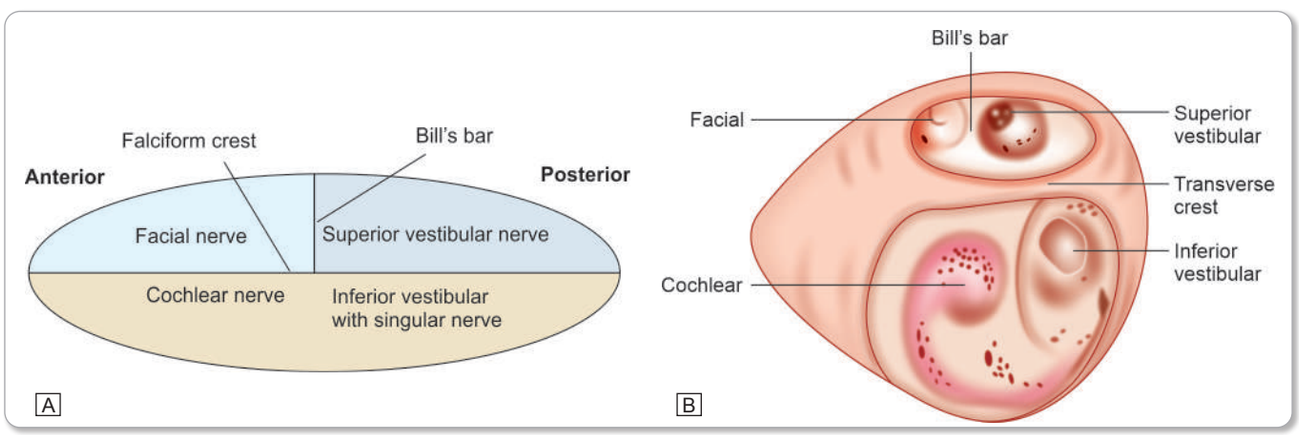
These inter-connections also explain the occurrence of several other clinical manifestations along with imbalance (e.g., nystagmus, vomiting, sweating, palpitations, etc.).

Internal Acoustic Meatus

The internal acoustic meatus (IAM) is a short canal around 1 cm in length situated in the petrous part of temporal bone on its posterior slant, facing the posterior cranial fossa.

The facial, cochlear and the vestibular nerves along with the internal auditory artery and vein pass from the cranial fossa to the inner ear through the IAM.

The lateral end of the IAM (toward the inner ear) is known as fundus and is closed by a plate of bone which is perforated for the passage of nerve and vessels. The IAM is divided into a superior and inferior part by a transverse crest known as falciform crest. The superior part is further divided into anterior and posterior parts by a vertical crest of bone known as "**BILL'S BAR**" *see* Figs 1.30A and B.



Figs 1.30A and B: Schematic diagram of internal acoustic meatus (right sided)

Note

The most common site of origin of acoustic neuroma is the inferior vestibular nerve in the IAM.

Through the antero-superior part of IAM passes the facial nerve. Bill's bar separates the facial nerve from the superior vestibular nerve which passes through the posterosuperior area of the IAM.

In the inferior part of IAM, Cochlear nerve lies anteriorly and the inferior vestibular along with singular nerve lies posteriorly.

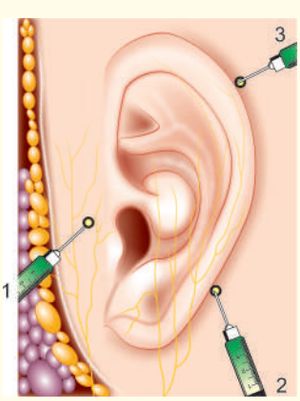
12 CLINICAL CASE QS

While operating on the internal acoustic meatus area for acoustic neuroma, the surgeon can see four nerves. He wants to identify the nerve of origin of the tumor and also monitor the facial nerve while removing the tumor. The intern assisting him has identified the nerves as follows. Pick the incorrect statement:

a. The facial nerve lies anterior to the bills bar.
b. The Superior vestibular lies anterior to the bills bar.
c. The Inferior vestibular nerve lies in the inferior compartment posteriorly and below superior vestibular.
d. The cochlear nerve occupies the inferior and anterior location, inferior to the facial nerve.

13 CLINICAL CASE QS

Before doing a myringoplasty in a patient of chronic otitis media the surgeon injects the anesthetic agent as shown in the figure below. Which nerves is he anesthetizing?



a. 1- Auriculotemporal, 2- Arnolds, 3- Greater auricular
b. 1- Auriculotemporal, 2- Greater auricular, 3- Jacobson's
c. 1- Auriculotemporal, 2- Greater auricular, 3- Lesser occipital
d. 1-Facial, 2- Greater auricular, 3- Lesser occipital.

BLOOD SUPPLY OF EAR

External Ear

The external ear is supplied by the two branches of the external carotid artery:

- Posterior auricular artery
- Superficial temporal artery.

Middle Ear

The middle ear is supplied by both the internal and external carotid arteries.

From the external carotid:

- Anterior tympanic artery and middle meningeal artery (middle meningeal artery gives superior tympanic and petrosal branches). Both anterior tympanic and middle meningeal arteries are branches of maxillary artery.
- Inferior tympanic artery, a branch of ascending pharyngeal artery.
- Stylomastoid artery, a branch of posterior auricular artery.

From the internal carotid:
Caroticotympanic

Inner Ear

The inner ear is supplied by labyrinthine artery which is a branch of Anterior Inferior Cerebellar Artery (AICA) or sometimes basilar artery.

Lymphatic Drainage of Ear

Part of the ear	Draining lymph nodes
Auricle and EAC	Parotid, preauricular, postauricular and upper deep cervical
Middle ear, mastoid and ET tube	Deep jugular and retropharyngeal
Inner ear	No lymphatics

Multiple Choice Questions

1. Arrange the structures of the auditory pathway in the sequential order of sound transmission: ***(INI- CET 2020)***

1. Cochlear nerve
2. Superior olivary complex
3. Inferior colliculus
4. Cochlear nuclei
5. Lateral lemniscus
6. Medial geniculate body

a. 1, 4, 2, 5, 3, 6 b. 1, 2, 3, 4, 5, 6
c. 6, 3, 2, 5, 4, 1 d. 1, 2, 5, 4, 6, 3

2. On stimulating the outer part of EAC, a person gets cough. This is because of stimulation of: ***(Recent Exam 2020)***

a. Auricular branch of vagus
b. Auriculotemporal
c. Greater auricular
d. Facial

3. Saccule develops from: ***(Recent Exam 2020)***

a. Sacculus medius b. Sacculus posticus
c. Pars superior d. Pars inferior

4. Following parotidectomy patient had numbness while shaving. The nerve to be involved is: ***(Recent Exam 2020)***

a. Facial b. Auriculotemporal
c. Greater auricular d. Maxillary

5. Pinna develops from:

a. 1st pharyngeal arch
b. 1st and 3rd pharyngeal arch
c. 1st and 2nd pharyngeal arch
d. 2nd pharyngeal arch

6. True regarding, the marked below is:

a. Improper fusion of auricular tubercles
b. Persistent opening of first branchial arch
c. Autosomal recessive pattern
d. First cleft anomaly

7. External auditory canal is formed by:

a. 1st branchial groove b. 1st visceral pouch
c. 2nd branchial groove d. 2nd visceral pouch

8. Eustachian tube develops from:

a. 2nd and 3rd pharyngeal pouch
b. 1st pharyngeal pouch
c. 2nd pharyngeal pouch
d. 3rd pharyngeal pouch

9. The proximal part of Tubotympanic recess leads to the formation of:

a. External Ear b. Pharyngotympanic tube
c. Middle ear cavity d. Antrum

10. The following structure represents all the three components of the embryonic disc:

a. Tympanic membrane b. Retina
c. Meninges d. None of these

11. Stapes develop from:

a. 1st arch b. 2nd arch
c. 3rd arch d. 4th arch

12. Koerner's septum is seen in:

a. Petrosquamous suture b. Temporosquamous suture
c. Petromastoid suture d. Frontozygomatic suture

13. All of the following are of the size of adult at birth except:

a. Tympanic membrane b. Ossicles
c. Tympanic cavity d. Mastoid

14. Inner ear is present in which bone:

a. Parietal bone
b. Petrous part of temporal bone
c. Occipital bone
d. Petrous part of squamous bone

15. Crus commune is a part of:

a. Cochlea b. Middle ear
c. Semicircular canal d. Vestibule

16. Endolymphatic duct connects which structure:

a. Scala media to subdural space ***(Recent Exam 2017)***
b. Scala vestibule to aqueduct of cochlea
c. Scala tympani to subdural space
d. Utriculo-saccular duct to endolymphatic sac

17. Not included in bony labyrinth: ***(Recent Exam 2017)***

a. Cochlea b. Semicircular canal
c. Organ of Corti d. Vestibule

18. The bony cochlea is a coiled tube making__ turns around a bony pyramid called ____: ***(Recent Exam 2017)***

a. 2 ¼, modiolus b. 2 ½, helicotrema
c. 2 ¾, modiolus d. 2 ¾, helicotrema

19. Organ of Corti is situated in: ***(Recent Exam 2017)***

a. Scala media b. S. tympani
c. S. vestibuli d. Saccule

20. Fetus starts hearing by what time in intrauterine life: ***(Recent Exam 2011)***

a. 14 weeks b. 20 weeks
c. 32 weeks d. 38 weeks

21. Semicircular canals are stimulated by: ***(Recent Exam 2013)***

a. Gravity b. Linear acceleration
c. Rotation d. Sound

22. Horizontal semicircular canal responds to:

a. Horizontal acceleration ***(Recent Exam 2017)***
b. Rotational acceleration
c. Gravity
d. Head tilt

23. Angular movements are sensed by: ***(Recent Exam 2013)***

a. Cochlea b. Saccule
c. Utricle d. Semicircular canals

24. Stapes foot plate covers: ***(AIIMS May 2003, Recent Exam 2017)***

a. Round window b. Oval window
c. Sinus tympani d. Pyramid

25. Movement of stapes causes vibration in: ***(Recent Exam 2002, 2017)***

a. Scala media b. Scala tympani
c. Scala vestibuli d. Semicircular canal

26. Where is electrode kept in cochlear implant? ***(AIIMS 2008, (Recent Exam 2008)***

a. Round window b. Oval window
c. Scala vestibuli d. Scala tympani

27. Micro wick and micro catheter sustained release device are used in: ***(AIIMS 2011)***
a. Drooling of saliva
b. Frey's syndrome
c. Control of epistaxis
d. Delivering drug to round window membrane

28. Perilymph contains: ***(Recent Exam 2013)***
a. Na^+ b. K^+
c. Mg^{++} d. Cl^-

29. Site where endolymph is seen: ***(Recent Exam 2013)***
a. Scala vestibuli b. Scala media
c. Helicotrema d. Scala tympani

30. Fluid, which has high potassium and low sodium content, is: ***(Recent Exam 2017)***
a. CSF b. Perilymph
c. Endolymph d. Pleural fluid

31. Cochlear aqueduct:
a. Connects internal ear with subarachnoid space
b. Connects membranous cochlea with vestibule
c. Contains endolymph
d. Connects endolymphatic sac to subarachnoid space

32. Most potential route for transmission of inner ear infection leading to meningitis is: ***(AIIMS 2011)***
a. Cochlear Aqueduct
b. Endolymphatic sac
c. Vestibular Aqueduct
d. Hyrtl's fissure

33. Infection of CNS spreads in inner ear through: ***(AIIMS 2010)***
a. Cochlear Aqueduct b. Endolymphatic sac
c. Scala media d. Vestibular aqueduct

34. The most common genetic defect of inner ear causing deafness is: ***(AIIMS 2010)***
a. Michel aplasia b. Mondini dysplasia
c. Scheibe dysplasia d. Alexander dysplasia

35. Skin over pinna is:
a. Firm on both sides b. Loose on medial side
c. Loose on lateral side d. Loose on both sides

36. Length of external auditory canal is: ***(Recent Exam 2016)***
a. 12 mm b. 24 mm
c. 36 mm d. 48 mm

37. Cartilaginous part of external auditory canal is: ***(Recent Exam 2017)***
a. Medial 1/3 b. Lateral 1/3
c. Medial 2/3 d. Lateral 2/3

38. Ceruminous glands present in the ear are: ***(AIIMS May 2005, Recent Exam 2017)***
a. Modified eccrine glands
b. Modified apocrine glands
c. Modified endocrine glands
d. Modified holocrine glands

39. Dehiscence in the external auditory canal cause infection in the parotid gland via: ***(AIIMS 2004, (Recent Exam 2017)***
a. Fissure of Santorini b. Notch of Rivinus
c. Petro-tympanic fissure d. Retro pharyngeal fissure

40. What is the color of the normal tympanic membrane? ***(Recent Exam 2017)***
a. Pearly grey b. Pink
c. Blue d. Red

41. Pars Flaccida of the tympanic membrane is also called:
a. Reissner's membrane ***(Recent Exam 2013)***
b. Shrapnell's membrane
c. Basilar membrane
d. Secondary tympanic membrane

42. Surface area of tympanic membrane: ***(Recent Exam 2013)***
a. 55 mm^2 b. 70 mm^2
c. 80 mm^2 d. 90 mm^2

43. The effective vibratory area of the tympanic membrane: ***(Recent Exam 2017)***
a. 25 mm^2 b. 30 mm^2
c. 40 mm^2 d. 55 mm^2

44. Which nerve supplies the tragus? ***(AIIMS 96, Recent Exam 2017)***
a. Greater auricular b. Auriculotemporal
c. Vagus d. Glossopharyngeal

45. Nerve supply for external ear are all, except:
a. Greater occipital nerve ***(Recent Exam 2016)***
b. Greater auricular nerve
c. Auriculotemporal nerve
d. Lesser occipital nerve

46. Arnolds nerve is a branch of: ***(AIIMS 99, Recent Exam 2017)***
a. Vagus b. Glossopharyngeal
c. Auditory d. Facial

47. Major part of the skin of pinna is supplied by:
a. Auriculotemporal nerve ***(Recent Exam 2017)***
b. Auricular branch of vagus
c. Lesser occipital nerve
d. Greater auricular nerve

48. All of the following nerves, supply auricle and external auditory canal except: ***(Recent Exam 2017)***
a. Trigeminal nerve b. Glossopharyngeal nerve
c. Facial nerve d. Vagus nerve

49. The cough response caused while cleaning the ear canal is mediated by stimulation of: ***(AIIMS Nov 2002, Recent Exam 2013)***
a. The Vth cranial nerve
b. Innervation of external ear canal by C1 and C2
c. The Xth cranial nerve
d. Branches of the VIIth cranial nerve

50. Nerve supply of the tympanic membrane is by:
a. Auriculotemporal ***(Recent Exam 2013)***
b. Auricular branch of vagus
c. Occipital nerve
d. Great auricular nerve
e. Glossopharyngeal nerve

51. Sensory nerve supply of middle ear cavity is provided by: ***(Recent Exam 2013)***
a. Facial b. Glossopharyngeal
c. Vagus d. Trigeminal

52. Which nerve is responsible for referred pain to the ear? ***(Recent Exam 2013)***
a. IX b. III
c. XI d. XII

53. Which of the following pain is not referred to ear? ***(Recent Exam 2017)***
a. Pharynx b. Tongue
c. TM joint d. Vestibule of nose

54. Referred otalgia can be due to: ***(AIIMS 2009)***
a. Carcinoma larynx b. Carcinoma oral cavity
c. Carcinoma tongue d. All of these

55. In carcinoma, base of tongue pain is referred to the ear through: ***(Recent Exam 2017)***
a. Hypoglossal nerve b. Vagus nerve
c. Glossopharyngeal nerve d. Lingual nerve

56. Stapedius is supplied by: ***(Recent Exam 2017)***
a. Maxillary nerve b. Facial nerve
c. Auditory nerve d. Mandibular nerve

57. Tensor tympani is supplied by: ***(Recent Exam 2017)***
a. Anterior part of V nerve b. Posterior part of V nerve
c. IX nerve d. VII nerve

58. Promontory seen in the middle ear is related to: ***(Recent Exam 2017)***
a. Jugular bulb b. Basal turn of cochlea
c. Semicircular canal d. Body of incus

59. Processus cochleariformis is related to:
a. Tendon of tensor tympani ***(Recent Exam 2016)***
b. Basal turns of cochlea
c. Handle of malleus
d. Incus

60. Secondary tympanic membrane is present over:
a. Round window ***(Recent Exam 2017)***
b. Oval window
c. Lateral wall of middle ear
d. Scala media

61. Facial recess is bounded by: ***(Recent Exam 2016)***
a. Medially by the vertical part of VII nerve
b. Laterally by the chorda tympani
c. Above by fossa incudis
d. All of the above

62. While doing posterior tympanotomy through the facial recess there are chances of injury to the following except: ***(AIIMS 2013)***
a. Facial nerve horizontal part
b. Chorda tympani
c. Dislodgement of short process of incus from fossa incudis
d. Vertical descending part of facial nerve

63. All are true about facial recess except: ***(Recent Exam 2017)***
a. Supra pyramidal recess
b. Medially it is bounded by chorda tympani and laterally by facial nerve
c. Important in cochlear implant
d. Middle ear can be approached through it

64. Eustachian tube opens into middle ear cavity at: ***(Recent Exam 2017)***
a. Anterior wall b. Medial wall
c. Lateral wall d. Posterior wall

65. The length of Eustachian tube is: ***(Recent Exam 2017)***
a. 16 mm b. 24 mm
c. 36 mm d. 40 mm

66. True about Eustachian tube is/are:
a. Size is 3.75 cm
b. 1/3rd cartilaginous and 2/3rd bony
c. Opens during swallowing
d. Nasopharyngeal opening is narrowest
e. Tensor palati helps to open it

67. True about Eustachian tube:
a. Length is 36 mm in children
b. Higher elastin content in adults
c. Ventilator function of ear better developed in infants
d. More horizontal in adults
e. Angulated in infants

68. Which of the following causes opening of Eustachian tube?
a. Salpingopharyngeus
b. Levator veli palatini
c. Tensor veli palatini
d. None of the above

69. Floor of middle ear cavity is in relation with:
a. Internal carotid artery ***(Recent Exam 2016)***
b. Bulb of the internal jugular vein
c. Sigmoid sinus
d. Round window

70. Tegmen tympani separates middle ear from the middle cranial fossa containing temporal lobe of brain by:
a. Medial wall of middle ear ***(Recent Exam 2016)***
b. Lateral wall of middle ear
c. Roof of middle ear
d. Anterior wall of middle ear

71. The distance between tympanic membrane and medial wall of middle ear at the level of center is: ***(Recent Exam 2017)***
a. 3 mm b. 4 mm
c. 6 mm d. 2 mm

72. Narrowest part of middle ear is: ***(Recent Exam 2017)***
a. Hypotympanum b. Epitympanum
c. Attic d. Mesotympanum

73. Prussak's space is situated in: ***(Recent Exam 2017)***
a. Epitympanum b. Mesotympanum
c. Hypotympanum d. Ear canal

74. All the following are components of epitympanum except: ***(Recent Exam 2017)***
a. Body of incus b. Head of malleus
c. Chorda tympani d. Foot plate of stapes

75. What is the type of joint between the ossicles of ear?
a. Fibrous joint
b. Primary cartilaginous
c. Secondary cartilaginous
d. Synovial joint

76. MacEwen's triangle is the landmark for: ***(Recent Exam 2017)***
a. Maxillary sinus b. Mastoid antrum
c. Frontal sinus d. None of these

77. The suprameatal triangle overlies the: ***(Recent Exam 2017)***
a. Mastoid antrum b. Mastoid air cells
c. Antrum d. Facial nerve

78. What forms lateral wall of mastoid antrum?
a. Squamous temporal ***(Recent Exam 2013)***
b. Tegmen antri
c. Posterior semicircular canal
d. None of these

79. All of the following form the boundary of MacEwen's triangle except:
a. Temporal line
b. Posterosuperior segment of bony external auditory canal
c. Promontory
d. Tangent drawn to the external auditory meatus

80. All are false about McEwen's triangle except: ***(Recent Exam 2017)***
a. Mastoid antrum lies 1.5 cm deep to it
b. Surgical landmark for facial nerve
c. Present in preauricular region
d. It is bounded by suprameatal crest anteriorly

81. Citelli's angle is: ***(Recent Exam 2013)***
a. Solid angle b. CP angle
c. Sinodural angle d. Part of MacEwen's triangle

82. Spine of Henle is a land mark for: *(Recent Exam 2017)*
a. Eustachian tube
b. Mastoid
c. Tympanic membrane
d. Facial nerve

83. Organ of Corti is situated on: *(Recent Exam 2017)*
a. Basilar membrane b. Utricle
c. Saccule d. None of these

84. In cochlea, endolymph has potential of: *(Recent Exam 2012)*
a. +80 mV b. –80 mV
c. +20 mV d. –20 mV

85. The function of stria vascularis is: *(Recent Exam 2017)*
a. To produce perilymph
b. To absorb perilymph
c. To maintain electric milieu of endolymph
d. To maintain electric milieu of perilymph

86. Primary receptor cells of hearing: *(Recent Exam 2013)*
a. Supporting cell
b. Tectorial membrane
c. Tunnel of Corti
d. Hair cell

87. All of the following are concerned with auditory pathway except: *(Recent Exam 2017)*
a. Trapezoid body b. Medial geniculate body
c. Genu of internal capsule d. Lateral lemniscus

88. Trapezoid body is associated with:
a. Auditory pathway b. Visual pathway
c. Pyramidal pathway d. Gustatory pathway
e. Extra pyramidal system

89. Higher auditory center determine: *(AIIMS 2009)*
a. Sound frequency
b. Loudness
c. Speech discrimination
d. Sound localization

90. Appreciation of sound occurs in: *(Recent Exam 2017)*
a. Organ of Corti b. Basilar membrane
c. Cochlear nuclei d. Transverse temporal gyrus

91. Otolith organs are concerned with function of: *(Recent Exam 2013)*
a. Hearing b. Rotatory nystagmus
c. Linear acceleration d. Angular acceleration

92. Static equilibrium is due to: *(Recent Exam 2013)*
a. Macula b. Cupula
c. End organ of Corti d. Cristae ampulla

93. All are correctly matched except: *(Recent Exam 2014)*
a. Otolith–made up of uric acid crystals
b. Position of otolith-changes with head position
c. Otolith–component of maculae
d. Otolith organs–stimulated by gravity and linear acceleration

94. Not correctly matched pair is: *(Recent Exam 2017)*
a. Utricle and saccule–cristae
b. Oval window–foot plate of stapes
c. Antrum–MacEwen's triangle
d. Scala vestibuli–Reissner's membrane

95. Vertical crest of bone in the internal acoustic meatus is: *(AIIMS 2011)*
a. Bill's bar b. Ponticulus
c. Cog d. Falciform crest

96. Singular nerve is a: *(Recent Exam 2017)*
a. Superior vestibular nerve supplying posterior semicircular canal
b. Inferior vestibular nerve supplying posterior semicircular canal
c. Superior vestibular nerve supplying anterior semicircular canal
d. Interior vestibular nerve supplying anterior semicircular canal

97. Labyrinthine artery is a branch of: *(AIIMS 91, Recent Exam 2013)*
a. Internal carotid artery
b. External carotid artery
c. Posterior inferior cerebellar artery
d. Anterior inferior cerebellar artery

98. What is scutum? *(Recent Exam 2014)*
a. Lateral wall of attic
b. Posterior wall of attic
c. Superior wall of attic
d. Inferior wall of attic

99. In the utricle, tip links in the hair cells are involved in:
a. Formation of perilymph
b. Regulation of distortion activated ion channels
c. Depolarization of stria vascularis
d. Movements of the basement membrane

100. Type of joint between malleus and incus is: *(Recent Exam 2014)*
a. Saddle b. Ball and socket
c. Hinge d. Pivot

101. Site of Darwin's tubercle is: *(Recent Exam 2016)*
a. Posterolateral part of helix
b. Tragus
c. Incisura terminalis
d. Lobule

102. Common nerve supplying pinna, TM and EAC:
a. Glossopharyngeal *(Recent Exam 2016)*
b. Arnolds
c. Greater Auricular
d. Occipital

103. The direction of bony EAC is: *(Recent Exam 2016)*
a. Upwards, backwards, medially
b. Upwards, backwards, laterally
c. Downwards, forwards, medially
d. Downwards, forwards, laterally

104. Oval window opens into: *(Recent Exam 2016)*
a. Utricle
b. Saccule
c. Scala tympani
d. Vestibule

105. Membranous labyrinth develops from: *(Recent Exam 2016)*
a. Surface ectoderm
b. First cleft
c. Tubotympanic recess
d. Mandibular arch

106. Complete absence of bony and membranous labyrinth:
a. Mondini aplasia *(Recent Exam 2016)*
b. Michel aplasia
c. Cochleo-saccular aplasia
d. Alexander aplasia

107. Pinna is made up of how many cartilage/s: ***(Recent Exam 2015)***

a. One
b. Six
c. Five
d. Two

108. Pain in tonsillitis is referred to the ear through: ***(Recent Exam 2016)***

a. IX
b. X
c. XI
d. VII

109. Location of preauricular sinus is: ***(Recent Exam 2016)***

a. Tragus
b. Anti-tragus
c. Root of helix
d. Anti-helix

110. Not seen on the medial wall of the middle ear: ***(Recent Exam 2016)***

a. Promontory
b. Oval window
c. Facial recess
d. Lateral semicircular canal bulge

111. Skin of the lower one-third of the auricle is supplied by the nerve:

a. Lesser occipital
b. Greater occipital
c. Greater auricular
d. Auriculotemporal

112. Sensory supply of the marked area is:

a. Auriculotemporal nerve
b. Lesser occipital nerve
c. Greater auricular nerve
d. Facial nerve

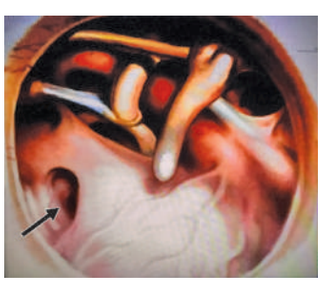
113. Chorda tympani passes between which layers of tympani membrane: ***(Recent Exam 2014)***

a. Outer and middle
b. Middle and inner
c. Epithelial layer
d. None of these

114. The angle of TM with the horizontal is: ***(Recent Exam 2016)***

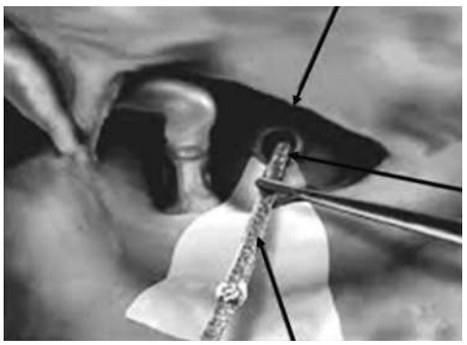
a. 35 degrees
b. 55 degrees
c. 75 degrees
d. 90 degrees

115. The significance of the marked structure is in the given picture:



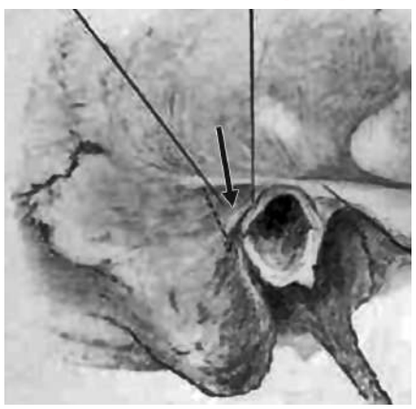
a. Stapes foot plate is present on it
b. Intact canal wall surgery is done through it
c. It ventilates the middle ear
d. Cochlear implant electrodes are introduced through it

116. Encircled area is: ***(AIIMS May 2016)***



a. Facial recess
b. Fossa incudis
c. Sinus tympani
d. Pyriform fossa

117. True about the marked area in the given picture:



a. It is the landmark for antrum
b. It is known as Trautmann's triangle
c. The Prussak's space is being depicted
d. It is the site for approach while doing myringotomy

118. Find the incorrect pair.

a. Tympanic membrane: malleus
b. Helicotrema: apex of cochlea
c. Basilar membrane: cochlea
d. Otoliths: semicircular canals

119. A 5-year-old child develops parotitis following otitis externa. This could have happened through

a. Cochlear aqueduct
b. Fissures of Santorini
c. Isthmus
d. Foramen of Morgagni

120. Cranial nerve passing through internal auditory meatus:

a. 7th cranial nerve
b. 9th cranial nerve
c. 10th cranial nerve
d. 11th cranial nerve
e. 12th cranial nerve

121. Otoconia is seen in: ***(Recent Exam 2016)***

a. Utricle
b. Superior semicircular canal
c. Lateral semicircular canal
d. Cochlea

122. Feature of Scheibe's dysplasia is: ***(Recent Exam 2016)***

a. Semicircular canal fistula
b. Abnormality in bony labyrinth
c. Dysplasia of cochlea and saccule
d. Middle ear anomaly

123. Facial nerve exits the skull through: ***(Recent Exam 2016)***

a. Stylomastoid foramen
b. Jugular foramen
c. Foramen Lacerum
d. Foramen Rotundum

124. Where is the auditory cortex located inside the brain? ***(Recent Exam 2016)***

a. Superior temporal gyrus
b. Inferior temporal gyrus
c. Area 31
d. Cingulate gyrus

125. Inferior and vertical postauricular incision in children less than 2 years old may cause damage to which cranial nerve? ***(Recent Exam 2016)***

a. VIII
b. VII
c. VI
d. V

126. Which of the following helps in detection of horizontal movement of head and body? ***(Recent Exam 2016)***

a. Cristae
b. Organ of Corti
c. Utricle
d. Endolymphatic sac

127. Facial nerve lies with which nerve in internal auditory meatus? ***(Recent Exam 2016)***

a. Trigeminal nerve
b. Abducens nerve
c. Vestibulocochlear nerve
d. Hypoglossal nerve

128. Korner's septum arises from: ***(Recent Exam 2016)***

a. Petrosquamous suture
b. Petrotympanic suture
c. Tympanomastoid suture
d. Tympanosquamous suture

129. Endolymph resembles: ***(Recent Exam 2016)***

a. CSF
b. ICF
c. ECF
d. Plasma

130. Most common congenital middle ear abnormality:

a. Absent footplate of stapes ***(AIIMS Nov 2015)***
b. Fixation of footplate of stapes
c. Oval window abnormality
d. Absent long process of incus

131. Volume of middle ear and mastoid antrum: ***(Recent Exam 2011)***

a. 2 mL
b. 6 mL
c. 12 mL
d. 15 mL

132. Ostmann pad of fat is related to: ***(Recent Exam 2018)***

a. Ear lobule
b. Buccal mucosa
c. Eustachian tube
d. Tip of nose

133. Not a part of middle ear cleft: ***(Recent Exam 2018)***

a. Semicircular canal
b. Mastoid antrum
c. Eustachian tube
d. Tympanic cavity

134. The structures marked in the given picture: ***(Recent Exam 2017, 2018)***

a. Malleus and round window
b. Incus and round window
c. Stapes and oval window
d. Promontory and aditus

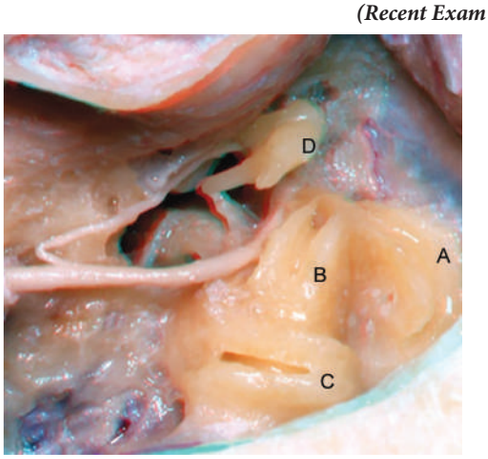
135. Following is true about the given picture: ***(Recent Exam 2017)***

a. It is the left TM
b. Posterior part is more easily assessible
c. Develops entirely from 1st arch
d. Shrapnell's membrane more tense

136. Inner hair cells of organ of Corti releases which excitatory neurotransmitter:

a. Glycine
b. Glutamate
c. GABA
d. Acetylcholine

137. The given image is of a patient in whom mastoidectomy is done. Identify the lateral semi-circular canal. ***(Recent Exam 2018)***



a. A
b. B
c. C
d. D

ANSWERS WITH EXPLANATIONS

1. Ans. (a) 1, 4, 2, 5, 3, 6

2. Ans. (a) Auricular branch of vagus.

3. Ans. (d) Pars inferior

4. Ans. (c) Greater auricular

5. Ans. (c) 1st and 2nd pharyngeal arch

(Ref: Scott Brown, 8th ed., Vol 2, page 541)

6. Ans. (a) Improper fusion of auricular tubercles

(Ref: Cummings, 6th ed., 2827)

- The failure of fusion of 1st and 2nd arch leads to the formation of the "PRE-AURICULAR SINUS". This is seen in between the tragus (from 1st arch) and the ascending limb of helix (from 2nd arch) most commonly either above the tragus or at the root of helix
  (*see* the clinical photo in the question).

7. Ans. (a) 1st branchial groove

(Ref: Scott Brown, 8th ed., Vol 2, page 541)

8. Ans. (b) and (c) 1st pharyngeal pouch, 2nd pharyngeal pouch

(Ref: Scott Brown, 8th ed., Vol 2, page 540)

Pharyngeal pouch	Structure develops
1st and a small part of 2nd (also called as tubo-tympanic recess)	Middle ear cleft, i.e., Eustachian tube, tympanic cavity and mastoid antrum.
2nd	Tonsil
3rd	Inferior parathyroids and the thymus
4th	Superior parathyroids and some part of the thyroid

9. Ans. (b) Pharyngotympanic tube

(Ref: Shambaugh, 6th ed., page 7)

10. Ans. (a) Tympanic membrane

(Ref: Scott Brown, 8th ed., Vol 2, page 540)

- The 1st cleft grows and meet 1st pouch medially to form the tympanic membrane.
- So, the tympanic membrane is made from all the 3 layers, outer epithelial layer from ectoderm and inner endothelial layer from endoderm and in between these is the fibrous layer from mesoderm.
- Retina develops from neuroectoderm.
- Dura mater is derived from mesoderm. Pia and arachnoid are derived from neural crest.

11. Ans. (b) 2nd arch

(Ref: Scott Brown, 8th ed., Vol 2, page 540)

12. Ans. (a) Petrosquamous suture

(Ref: Shambaugh, 6th ed., page 32)

13. Ans. (d) Mastoid

(Ref: Shambaugh, 6th ed., page 5)

- The mastoid is incompletely developed at birth and continues to develop till 18 years of age.
- The largest air cell of mastoid called mastoid antrum is present at birth and is of adult configuration.

Note

The bony part of EAC and the mastoid tip are not present at birth.

- The middle and inner ear structures attain adult size well before birth.
- TM is also of adult size but, in the absence of bony part of EAC, is horizontally placed.

14. Ans. (b) Petrous part of temporal bone

(Ref: Shambaugh, 6th ed., page 32)

15. Ans. (c) Semicircular canal

(Ref: Shambaugh, 6th ed., page 42)

- The posterior and superior semicircular canals fuse together to form a common crus called "crus commune" which opens into the utricle. Because of this the three semicircular canals open into utricle by five openings instead of six.

16. Ans. (d) Utriculo saccular duct to endolymphatic sac, please see the text.

(Ref: Shambaugh, 6th ed., page 42)

17. Ans. (c) Organ of Corti (it is a part of membranous labyrinth)

(Ref: Shambaugh, 6th ed., page 42)

18. Ans. (c) 2 ¾, modiolus

(Ref: Shambaugh, 6th ed., page 42)

19. Ans. (a) Scala media

(Ref: Shambaugh, 6th ed., page 73)

20. Ans. (b) 20 weeks

(Ref: Shambaugh, 6th ed., page 11)

21. Ans. (c) Rotation

(Ref: Shambaugh, 6th ed., page 113)

- Semicircular canals contain cristae which sense angular or rotational acceleration.
- Gravitational movements, head tilt and linear acceleration are sensed by maculae in the utricle and saccule.
- Sound is sensed by organ of Corti present in the scala media, situated on the basilar membrane.

22. Ans. (b) Rotational acceleration

(Ref: Shambaugh, 6th ed., page 113)

- The horizontal/lateral semicircular canal along with posterior and superior semicircular canal contains cristae which sense angular or rotational acceleration.
- Horizontal acceleration, i.e., linear acceleration, gravitational movements and head tilt movements are sensed by maculae in the utricle and saccule.

23. Ans. (d) Semicircular canals

(Ref: Shambaugh, 6th ed., page 113)

24. Ans. (b) Oval window

(Ref: Shambaugh, 6th ed., page 38)

- The Oval window is covered by the footplate of stapes.
- The Round window is covered by secondary tympanic membrane.
- The part of middle ear medial to the descending part of facial nerve is called sinus tympani.
- Pyramid is the projection on posterior wall from which originates the stapedius muscle.

25. Ans. (c) Scala vestibuli, please refer the text

(Ref: Cummings, 6th ed., 1997)

26. Ans. (d) Scala tympani

(Ref: Shambaugh, 6th ed., page 599)

- The electrodes of cochlear implant are placed into the Scala tympani by passing through the round window.

27. Ans. (d) Delivering drug to round window membrane

(Ref: Scott Brown, 8th ed., Vol 2, page 580)

28. Ans. (a) Na^+

(Ref: Shambaugh, 6th ed., page 79)

- Perilymph is the fluid which fills the bony labyrinth.
- Perilymph is actually an extension of CSF which enters from the subarachnoid space into the scala tympani through Cochlear aqueduct.
- CSF being an extracellular fluid therefore, perilymph is rich in Na^+.
- Endolymph filling the membranous labyrinth and secreted from stria vascularis is rich in K^+.

29. Ans. (b) Scala media

(Ref: Scott Brown, 8th ed., Vol 2, page 545)

- Endolymph is present in the membranous labyrinth, whereas perilymph is present in the bony labyrinth.
- Hence, scala vestibuli, scala tympani and their interconnection helicotrema, which are parts of bony labyrinth, are filled with perilymph.
- Scala media, utricle, saccule and semicircular canals, which are parts of membranous labyrinth, are filled with endolymph.

30. Ans. (c) Endolymph

(Ref: Scott Brown, 8th ed., Vol 2, page 545)

- Rest are extracellular hence, have more of sodium.

31. Ans. (a) Connects internal ear with subarachnoid space

(Ref: Scott Brown, 8th ed., Vol 2, page 545)

- The internal ear communicates with the cranium via two openings:
  1. **Cochlear aqueduct:** Via this CSF in the subarachnoid space enters scala tympani and becomes perilymph which circulates in the bony labyrinth.
  2. Internal acoustic meatus.
- Membranous cochlea is a part of membranous labyrinth which is a closed sac and is not connected to vestibule which is a part of the bony labyrinth.
- Endolymphatic sac is a blind pouch responsible for absorption of endolymph and is situated in between the endosteal and meningeal layer of the dura mater.

32. Ans. (a) Cochlear Aqueduct

(Ref: Cummings, 6th ed., 2992)

- Endolymphatic sac is a closed sac. It does not communicate with CSF.
- The bony canal around the utriculo-saccular duct and endolymphatic duct is called vestibular aqueduct.
- Hyrtle fissure is a tympanomeningeal fissure which obliterates by 26 weeks period of gestation. If persistent it can lead to a connection between CSF and middle ear.

33. Ans. (a) Cochlear Aqueduct

(Ref: Cummings, 6th ed., 2992; 2169)

34. Ans. (c) Scheibe dysplasia

(Ref: Cummings, 6th ed., 2982)

35. Ans. (b) Loose on medial side

(Ref: Scott Brown, 8th ed., Vol 2, page 526)

- The skin on the lateral side of pinna is firmly attached because of which any inflammatory condition on the lateral side is more painful.

36. Ans. (b) 24 mm

(Ref: Scott Brown, 8th ed., Vol 2, page 527)

37. Ans. (b) Lateral 1/3

(Ref: Scott Brown, 8th ed., Vol 2, page 527)

38. Ans. (b) Modified apocrine glands

(Ref: Shambaugh, 6th ed., page 30)

- Ceruminous glands are modified sudoriferous glands (sweat glands) located subcutaneously in the external auditory canal. They are apocrine glands, i.e., while discharging the secretions their cell's apical parts are shed off.
- Eccrine or merocrine glands secretions are thrown out of the cells by a process of exocytosis, the cell remaining intact, e.g., sweat glands.
- In some glands, the entire cell disintegrates while discharging its secretion. These are said to be holocrine glands, e.g., sebaceous glands.
- Apocrine, merocrine and holocrine are the descriptions of exocrine glands, i.e., the glands which pour their secretions on to an epithelial surface directly or through ducts.
- Endocrine glands pour their secretions into blood.

39. Ans. (a) Fissure of Santorini (please **see** the text)

(Ref: Cummings, 6th ed., 1981)

- The notch of Rivinus is the upper attachment of pars flaccida.
- Petro-tympanic fissure is present on the anterior wall of middle ear, on which attaches the anterior malleolar ligament.

  Retropharyngeal fissure does not exist.

40. Ans. (a) Pearly grey

(Ref: Scott Brown, 8th ed., Vol 2, page 923)

Condition of the ear	Color of TM
Normal	Pearly grey
Glue ear or SOM	Blue
ASOM	Red (congested)
Active otosclerosis	Flamingo pink

41. Ans. (b) Shrapnell's membrane

(Ref: Shambaugh, 6th ed., page 380)

- Reissner's membrane separates Scala media from Scala vestibuli in the inner ear.
- Basilar membrane separates Scala media or cochlear duct from Scala tympani in the inner ear. The organ of Corti rests on the basilar membrane.
- Secondary TM overlies the round window in the middle ear.

42. Ans. (d) 90 mm²

(Ref: Dhingra, 6th ed., page 14)

43. Ans. (d) 55 mm²

(Ref: Dhingra, 6th ed., page 14)

44. Ans. (b) Auriculotemporal

(Ref: Scott Brown, 8th ed., Vol 2, page 526)

45. Ans. (a) Greater occipital nerve

(Ref: Shambaugh, 6th ed., page 30) (does not supply pinna, please see text for the nerve supply of external ear).

46. Ans. (a) Vagus

(Ref: Shambaugh, 6th ed., page 30)

47. Ans. (d) Greater auricular nerve

(Ref: Shambaugh, 6th ed., page 30)

48. Ans. (b) Glossopharyngeal nerve

(Ref: Shambaugh, 6th ed., page 30)

- Glossopharyngeal does not supply auricle and external auditory canal. It gives sensory supply to middle ear.

49. Ans. (c) The Xth cranial nerve

(Ref: Shambaugh, 6th ed., page 45)

- The Xth cranial nerve also supplying the larynx leads to cough on cleaning the ear canal.

50. Ans. (a) Auriculotemporal; (b) Auricular branch of vagus; (e) Glossopharyngeal nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 529)

51. Ans. (b) Glossopharyngeal

(Ref: Scott Brown, 8th ed., Vol 2 page 535)

- The sensory supply of the middle ear is by the tympanic plexus which is formed by the Jacobson's nerve which is the tympanic branch of Glossopharyngeal (IX) along with sympathetic plexus from around the internal carotid.

52. Ans. (a) IX nerve, i.e., the glossopharyngeal nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 535)

- The rest of the nerves do not supply the ear.

53. Ans. (d) Vestibule of nose

(Ref: Shambaugh, 6th ed., page 45)

- Vestibule of nose is supplied by the maxillary nerve which does not supply the ear.
- Pharynx is supplied by the pharyngeal plexus formed by the vagus and Glossopharyngeal, both of which also supply the ear.
- Tongue is supplied by the lingual branch of mandibular, Glossopharyngeal and vagus, all of which also supply the ear.
- TM joint is supplied by the Auriculotemporal nerve which also supplies the ear.

54. Ans. (d) All of these

(Ref: Shambaugh, 6th ed., page 45)

- Larynx is supplied by the vagus which also supplies the ear.

- Tongue and oral cavity is supplied by the lingual branch of mandibular, Glossopharyngeal and vagus, all of which also supply the ear.

55. Ans. (c) Glossopharyngeal nerve

(Ref: Shambaugh 6th ed., page 45)

- The base of tongue is mainly supplied by the glossopharyngeal nerve which also supplies the ear.

Note

- Anterior 2/3rd of the tongue is supplied by lingual nerve (a branch of mandibular). Auriculotemporal nerve also a branch of mandibular nerve supplies the ear so in carcinoma anterior 2/3rd of tongue pain is referred to ear through mandibular nerve.
- Posterior 1/3rd, i.e., the base of the tongue is mainly supplied by glossopharyngeal nerve and the posterior most part of this posterior 1/3rd tongue is supplied by vagus, both of which also supply the ear, so in carcinoma of this part of tongue, pain will be referred to ear through both glossopharyngeal and vagus.
- But since glossopharyngeal supplies most of the base of the tongue so in pathologies of base of tongue the pain is referred to the ear mainly through the glossopharyngeal nerve.

56. Ans. (b) Facial nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 580)

- The stapedius muscle is a second arch derivative and therefore, is supplied by the nerve of the 2nd arch, i.e., facial nerve.

57. Ans. (a) Anterior part of V nerve

(Ref: Shambaugh, 6th ed., page 38)

- The tensor tympani muscle is a derivative of 1st arch and is supplied by the nerve of the 1st arch, i.e., mandibular nerve (anterior or motor branch).

58. Ans. (b) Basal turn of cochlea

(Ref: Shambaugh, 6th ed., page 39)

- Promontory is a bulge in the center of the medial wall of middle ear, produced by the basal turn of cochlea. On the promontory, tympanic plexus is present.
- Lateral semicircular canal bulge is present on the most postero-superior portion of the medial wall of middle ear just above the horizontal or tympanic segment of facial nerve.
- Jugular bulb is below the floor of the middle ear.
- Body of incus is present in the epitympanum of middle ear cavity.

59. Ans. (a) Tendon of tensor tympani

(Ref: Shambaugh, 6th ed. page 38)

- Processus Cochleariformis is a hook like structure present antero-superiorly on the medial wall of middle ear.
- The tensor tympani muscle originating from a canal in the anterior wall of middle ear runs medially where its tendon winds around the processus cochleariformis and then turns laterally to get attached on the upper part of the handle of malleus (i.e., just below its neck).

60. Ans. (a) Round window

(Ref: Scott Brown, 8th ed., Vol 2, page 580)

61. Ans. (d) All of the above

(Ref: Cummings, 6th ed., 509; 2192)

- Facial recess is an area on the posterior wall of middle ear. The facial recess is limited superiorly by the fossa incudis, laterally by chorda tympani entry and medially by the descending/vertical facial nerve segment.
- The facial recess is the site where opening is made on the posterior wall to access the middle ear cavity through the mastoid in "INTACT CANAL WALL" ear surgeries. This is known as the posterior tympanotomy approach. See chapter on unsafe CSOM

62. Ans. (a) Facial nerve horizontal part

(Ref: Cummings, 6th ed., 509; 2192)

63. Ans. (b) Medially it is bounded by chorda tympani and laterally by facial nerve

(Ref: Cummings, 6th ed., 509)

- Medially the facial recess is bounded by facial nerve and laterally by chorda tympani

64. Ans. (a) Anterior wall

(Ref: Shambaugh, 6th ed., page 245)

65. Ans. (c) 36 mm

(Ref: Shambaugh, 6th ed., page 245)

66. Ans. (a) Size is 3.75 cm; (c) Opens during swallowing; (e) Tensor palati helps to open it

(Ref: Shambaugh, 6th ed., page 245)

- The length of Eustachian tube is 32–38 mm, i.e., 3.2–3.8 cm.
- Its 1/3rd part is bony and 2/3rd part is cartilaginous, just the opposite of EAC.
- Eustachian tube normally remains closed and opens intermittently during swallowing, yawning and sneezing.
- Tensor palatini plays the major role in opening the tube.
- The narrowest part of Eustachian tube is the junction of the bony and cartilaginous parts known as isthmus.

67. Ans. (b) Higher elastin content in adults, refer the text

(Ref: Cummings, 6th ed., 2028)

68. Ans. (c) Tensor veli palatini

(Ref: Shambaugh, 6th ed., page 245)

69. Ans. (b) Bulb of the internal jugular vein

(Ref: Cummings, 6th ed., 1983)

- The floor of middle ear cavity is a thin plate of bone separating the middle ear from jugular bulb below.
- Internal carotid artery is in relation to the anterior wall of middle ear.
- Sigmoid sinus is not related directly with middle ear cavity. It lies posterior to the mastoid antrum.
- Round window lies postero-inferiorly on the medial wall of middle ear.

70. Ans. (c) Roof of middle ear

(Ref: Cummings, 6th ed., 1983)

- The roof of the middle ear is known as "TEGMEN TYMPANI". It separates the middle ear from the middle cranial fossa.

71. Ans. (d) 2 mm

(Ref: BD Chaurasia, Human Anatomy 6th ed., Vol 3, page 277)

Part of the middle ear cavity	*Distance from lateral to medial wall*
Epitympanum	6 mm (widest)
Mesotympanum (center)	2 mm (narrowest)
Hypotympanum	4 mm

72. Ans. (d) Mesotympanum–2 mm

(Ref: BD Chaurasia, Human Anatomy 6th ed., Vol 3, page 277)

- Epitympanum or attic is widest–6 mm
- Hypotympanum–4 mm

73. Ans. (a) Epitympanum

(Ref: Cummings, 6th ed., 1983)

- The space of the epitympanum, lying in between the Shrapnell's membrane or pars flaccida and the neck of malleus is known as "PRUSSAK'S SPACE".
- When the retraction pocket on Pars flaccida grows medially, it goes into this Prussak's space making this the most common site of primary cholesteatoma.

74. Ans. (d) Foot plate of stapes (it is in mesotympanum)

(Ref: Cummings, 6th ed., 1983)

	Epitympanum contains	*Mesotympanum contains*
1.	Head, neck, anterior and lateral process of malleus	Handle of malleus
2.	Body and short process of incus	Long process of incus
3.	Incudomalleolar joint (the head of malleus articulates with the body of incus)	Incudostapedial joint and the whole of the stapes
4.	The Chorda tympani nerve	—
5.	Prussak's space	—

- The hypotympanum does not contain anything.

75. Ans. (d) Synovial joint

(Ref: Scott Brown, 8th ed., Vol 2 page 533)

- The head of malleus articulates with the body of incus. This incudomalleolar joint is a saddle type of synovial joint.
- The long process of incus ends in a lentiform nodule. This lentiform nodule of incus articulates with the head of stapes. This incudostapedial joint is a ball and socket type of synovial joint.

76. Ans. (b) Mastoid antrum

(Ref: Shambaugh, 6th ed., page 32)

- MacEwen's triangle or suprameatal triangle is a bony landmark for mastoid antrum. It is important while doing mastoid surgeries in approaching the mastoid antrum.

77. Ans. (a) Mastoid antrum

(Ref: Shambaugh, 6th ed., page 32)

78. Ans. (a) Squamous temporal

(Ref: Scott Brown, 8th ed., Vol 2, page 543)

- Tegmen antri forms the roof of antrum.
- The medial wall of mastoid antrum is related to the posterior semicircular canal, which lies in its superior aspect.

79. Ans. (c) Promontory (refer the text)

(Ref: Shambaugh, 6th ed., page 32)

80. Ans. (a) Mastoid antrum lies 1.5 cm deep to it

(Ref: Shambaugh, 6th ed., page 32)

- It is a surgical landmark for the mastoid antrum, lying in the postauricular area. It is bounded superiorly by temporal line/supra mastoid crest which is the posterior extension of suprameatal crest.
- The suprameatal crest is the superior root of the zygomatic process.

81. Ans. (c) Sinodural angle

(Ref: Shambaugh, 6th ed., page 775)

82. Ans. (b) Mastoid

(Ref: Shambaugh, 6th ed., page 773)

83. Ans. (a) Basilar membrane

(Ref: Shambaugh, 6th ed., page 73)

- Organ of Corti rests on the Basilar membrane which separates Scala media from Scala tympani.
- Utricle and Saccule contain the sensory end organ of balance for linear acceleration known as maculae.

84. Ans. (a) +80 mV

(Ref: Shambaugh, 6th ed., page 79)

- The endolymph is rich in K^+ which leads to the development of an endolymphatic potential of +80–85 mV.

85. Ans. (c) To maintain electric milieu of endolymph

(Ref: Scott Brown, 8th ed., Vol 2, page 561)

86. Ans. (d) Hair cell

(Ref: Scott Brown, 8th ed., Vol 2, page 558)

87. Ans. (c) Genu of internal capsule

(Ref: Cummings, 6th ed., 1991)

- Genu of internal capsule is not concerned with auditory pathway; it is the posterior limb of internal capsule through which ultimately the fibers pass through and reach the auditory cortex.

88. Ans. (a) Auditory pathway

(Ref: Cummings, 6th ed., 1991)

89. Ans. (d) Sound localization

(Ref: Cummings, 6th ed., 1991)

90. Ans. (d) Transverse temporal gyrus

(Ref: Cummings, 6th ed., 1991)

91. Ans. (c) Linear acceleration

(Ref: Shambaugh, 6th ed., page 113)

92. Ans. (a) Macula

(Ref: Shambaugh, 6th ed., page 113)

- Maculae sense linear acceleration, gravitational (movement either with or against gravity) and head tilt movements and they also help to maintain static equilibrium (by facilitating postural, tonic neck and righting reflexes).

93. Ans. (a) Otolith– made up of uric acid crystals

(Ref: Shambaugh, 6th ed., page 113)

- Otolith is made up of calcium carbonate.
- They are present in the maculae and stimulated by gravity, linear acceleration and head tilt movements.

94. Ans. (a) Utricle and saccule–cristae

(Ref: Shambaugh, 6th ed., page 113)

- Utricle and saccule contain maculae.
- Cristae are present in the semicircular canal.
- Foot plate of stapes overlies oval window.
- MacEwen's triangle or suprameatal triangle is the bony landmark of mastoid antrum.
- Scala vestibuli is separated from scala media by Reissner's membrane.

95. Ans. (a) Bill's bar

(Ref: Shambaugh, 6th ed., page 42)

- Ponticulus is a ridge which runs from the oval window to the sinus tympani forming its superior extent.
- Cog is a bony projection from the roof of middle ear, i.e., tegmen tympani to the processus cochleariformis, serving as an approximate landmark for the facial nerve.
- Falciform crest divides the internal acoustic meatus into a superior and inferior part.

96. Ans. (b) Inferior vestibular nerve supplying posterior semicircular canal (Please refer the text)

(Ref: Shambaugh, 6th ed., page 45)

97. Ans. (d) Anterior inferior cerebellar artery

(Ref: Shambaugh, 6th ed., page 47)

- The inner ear is supplied by Labyrinthine artery which is a branch of Anterior inferior cerebellar artery or sometimes the basilar artery.

98. Ans. (a) Lateral wall of attic

(Ref: Scott Brown, 8th ed., Vol 2, page 529)

99. Ans. (b) Regulation of distortion activated ion channels

(Ref: Scott Brown, 8th ed., Vol 2, page 554)

100. Ans. (a) Saddle

(Ref: BD Chaurasia, Human Anatomy, 6th ed., Vol 3, page 280)

101. Ans. (a) Posterolateral part of helix

(Ref: Scott Brown, 8th ed., Vol 2, page 525)

102. Ans. (b) Arnolds

(Ref: Shambaugh, 6th ed., page 30)

103. Ans. (c) Downwards, forwards, medially

(Ref: Scott Brown, 8th ed., Vol 2, page 527)

104. Ans. (d) Vestibule

(Ref: Scott Brown, 8th ed., Vol 2, page 531)

105. Ans. (a) Surface ectoderm

(Ref: Shambaugh, 6th ed., page 9)

106. Ans. (b) Michel aplasia

(Ref: Cummings, 6th ed., 2983)

107. Ans. (a) One

(Ref: Scott Brown, 8th ed., Vol 2, page 526)

108. Ans. (a) IX

(Ref: Shambaugh, 6th ed., page 45)

109. Ans. (c) Root of helix

(Ref: Scott Brown, 8th ed., Vol 2, page 541)

110. Ans. (c) Facial recess

(Ref: Scott Brown, 8th ed., Vol 2, page 531)

111. Ans. (c) Greater auricular

(Ref: Shambaugh, 6th ed., page 30)

112. Ans. (c) Greater auricular nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 526)

113. Ans. (b) Middle and inner

(Ref: Scott Brown, 8th ed., Vol 2 page 530)

114. Ans. (b) 55 degrees

(Ref: Scott Brown, 8th ed., Vol 2, page 529)

115. Ans. (d) Cochlear implant electrodes are introduced through it

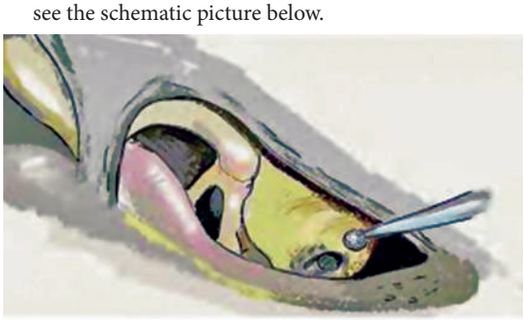
(Ref: Shambaugh, 6th ed., 599)

- The middle ear is seen here. The marked structure is the round window, through which the cochlear implant electrodes are introduced into the inner ear.
- Stapes foot plate is present on the oval window, which is seen in the picture above the round window opening
- Intact canal wall surgery is done through the facial recess present on the posterior wall of the middle ear, not visible in the picture
- ET tube ventilates the middle ear which is present on the anterior wall, not visible in the picture

116. Ans. (a) Facial recess

(Ref: Cummings, 6th ed., 2192)

- In the given picture, the encircled area is the facial recess through which the round window opening is visible, also see the schematic picture below.



- Facial recess is used to approach the middle ear through the mastoid, e.g., in cochlear implantation and in intact canal wall surgeries of the mastoid.
- Schematic picture of facial recess, through which a drill is pointing toward round window.

117. Ans. (a) It is the landmark for mastoid antrum

(Ref: Shambaugh, 6th ed., page 32)

- The marked area is the MacEwen's or suprameatal triangle. It is the landmark for mastoid antrum.
- Trautmann's triangle is present on the medial wall of mastoid antrum and is the landmark to approach posterior cranial fossa.
- Prussak's space is a space in the epitympanum lying medial to pars flaccida, please see the text.
- Myringotomy is making an opening on the TM to remove fluid or pus from the middle ear. Mastoid is not opened while doing myringotomy.

118. Ans. (d) Otoliths: Semicircular canals

(Ref: Cummings, 6th ed., 2014)

119. Ans. (b) Fissures of Santorini

(Ref: Cummings, 6th ed., 1981)

120. Ans. (a) 7th cranial nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 539)

121. Ans. (a) Utricle

(Ref: Cummings, 6th ed., 2014)

122. Ans. (c) Dysplasia of cochlea and saccule

(Ref: Cummings, 6th ed., 2982)

123. Ans. (a) Stylomastoid foramen

(Ref: Cummings, 6th ed., 1985)

124. Ans. (a) Superior temporal gyrus

(Ref: Cummings, 6th ed., 1991)

- The middle and inferior temporal gyrus are involved in cognitive processes, semantic memory, language process, visual perception and integrating information from different senses.

125. Ans. (b) VII

(Ref: Cummings, 6th ed., 1985)

126. Ans. (c) Utricle

(Ref: Cummings, 6th ed., 2014)

127. Ans. (c) Vestibulocochlear nerve

(Ref: Scott Brown, 8th ed., Vol 2, page 539)

128. Ans. (a) Petrosquamous suture

(Ref: Shambaugh, 6th ed., page 32)

129. Ans. (b) ICF

(Ref: Scott Brown, 8th ed., Vol 2, page 545)

- Endolymph resembles intracellular fluid as it has more of K^+.
- Perilymph resembles intracellular fluid as it has more of Na^+.

130. Ans. (b) Fixation of footplate of stapes

(Ref: Scott Brown, 8th ed., Vol 2, page 108)

- According to Teunissen and Cremers classification, the most common congenital anomaly of the middle ear is fixation of footplate of stapes.

131. Ans. (a) 2 mL

(Ref: Scott Brown, 8th ed., Vol 2, page 538)

132. Ans. (c) Eustachian tube

(Ref: Cummings 6th ed., 2031)

133. Ans. (a) Semicircular canal

(Ref: Scott Brown, 8th ed., Vol 2, page 529)

134. Ans. (a) Malleus and round window

(Ref: Scott Brown, 8th ed., Vol 2, page 531)

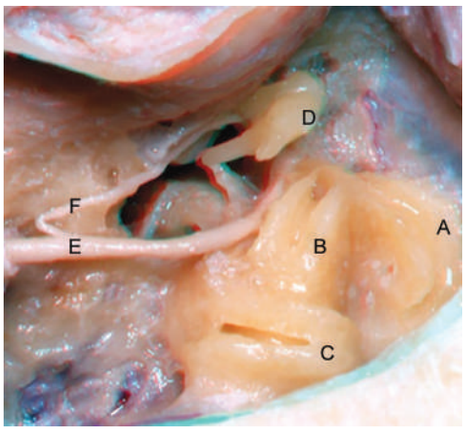
135. Ans. (b) Posterior part is more easily assessible

(Ref: Scott Brown, 8th ed., Vol 2 page 529)

136. Ans. (b) Glutamate

(Ref: Scott Brown, Vol 2, page 756)

137. Ans. (b) B



A- superior SCC
B- lateral SCC
C- posterior SCC
D- body and short process of incus
E- vertical segment of facial nerve
F- chorda tympani originating from vertical segment of facial nerve

ANSWERS OF CLINICAL CASE QUESTIONS

1. Ans. (b) 6–7 years of age

2. Ans. (a) 1st branchial cleft anomaly

3. Ans. (b) Incision B can injure the facial nerve

4. Ans. a-1, b-5, c-4, d-8

5. Ans. 1, 2, 4

6. Ans. (d) 1- mastoid segment of facial, 2- chorda tympani, 3- fossa incudis

7. Ans. (c) 1 - facial recess, 2- round window

8. Ans. 4, 8

9. Ans. (c) 1, 2, 3, 4, 5

10. Ans. 2, 3

11. Ans. (d) 1, 2, 5, 4, 6, 3

12. Ans. (b) The Superior vestibular lies anterior to the bills bar

13. Ans. (c) 1- Auriculotemporal, 2- Greater auricular, 3- Lesser occipital


Note