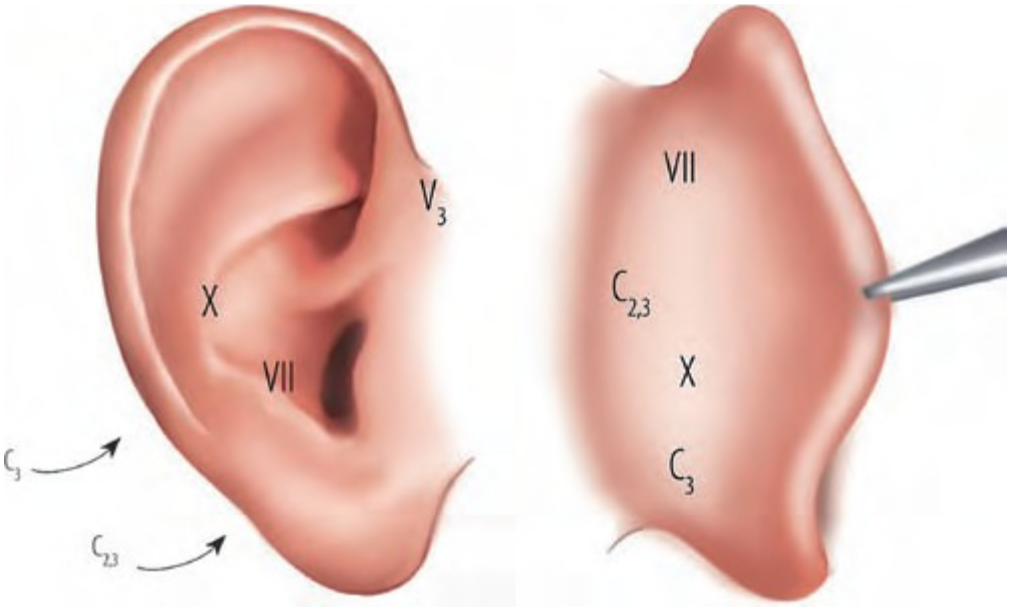
Anatomy & Physiology of the Ear

The external ear consists of the pinna and the external auditory canal.

- **Pinna**

Elastic cartilage surrounded on either side by a layer of ***skin***. There is minimal subcutaneous tissue between the skin and the perichondrium.

Function :::>>, the pinna acts to **funnel sound waves** from the outside environment into the ear canal. The shape of the external ear provides approximately 20 dB of gain to sounds in the middle frequency range (2–4 kHz).



- **External Auditory Canal** (EAC)

Approximately 2.5 cm in length.
Outer one third ::::;>cartilaginous[fibrocartilaginous]
Inner two-thirds :::::>bony..
The narrowest part of the external auditory canal (***isthmus***)is located between the fibrocartilaginous and the bony canal.
Anterior to the bony canal is the temporomandibular joint. The skin of the ear canal is **thicker in the cartilaginous** canal and contains glands that secrete cerumen (ear wax). The skin of the bony ear canal is **very thin and fixed to the periosteum**. No cerumen is secreted in the bony ear canal.

Nerves
The great auricular nerve (from nerve roots C2 and C3) provides sensory innervations to the skin overlying the mastoid process as well as the majority of the pinna. Cranial nerves V (the trigeminal nerve), VII (the facial nerve), and X (the vagus nerve) innervate the external auditory canal.

- **Middle Ear ::::consist of**
  1-Tympanic Membrane

2-tympanic cavity and its contents
3-eustachian tube
4-mastoid air cells

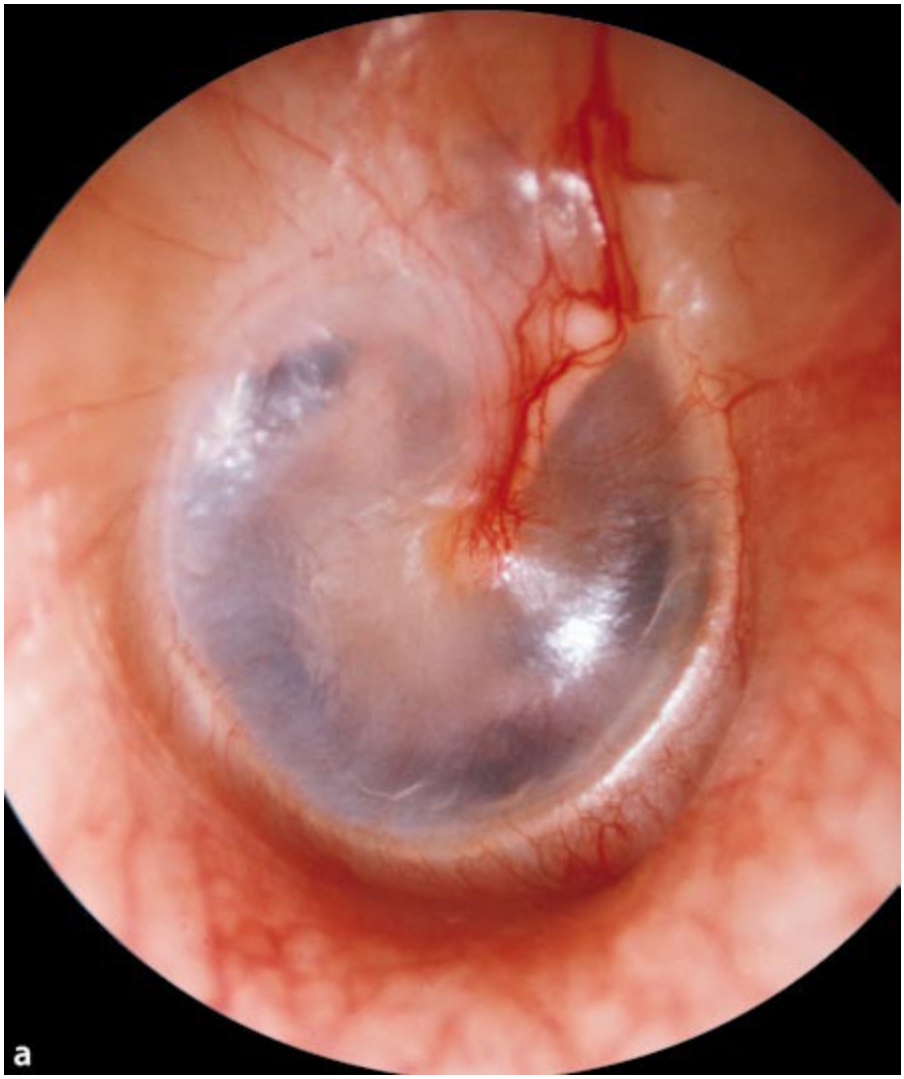
The tympanic membrane consists of **three layers**::::

- The outer layer, …… squamous epithelium.
- The middle layer …… fibrous of the tympanic membrane consists of both radial and circumferential fibers. Which maintain the strength of the tympanic membrane.
- The inner layer :::::::::::::: cuboidal mucosal epithelium.

The tympanic membrane has an **oval shape** and is approximately 8 mm wide by 10 mm high, **pale grey in colour**, surrounded by fibrous annulus, which is incomplete superior to the anterior and the posterior malleal folds.

This section of the tympanic membrane ***above*** the anterior and posterior malleal folds is the pars **flaccida**, while the section ***inferior*** to the folds is the pars **tensa**. Blood vessels enter the tympanic membrane through the **superior external auditory canal** skin (the vascular strip) as well as circumferentially from around the fibrous annulus.

Landmarks visible at otoscopy:: the 1-lateral or short process of the malleus 2- the handle of the malleus, 3-the pars flaccida, and the pars tensa with 4- the umbo and the triangular cone of light (light reflex). (In the thin, transparent tympanic membrane: the chorda tympani, the long process of the incus and the head of the stapes)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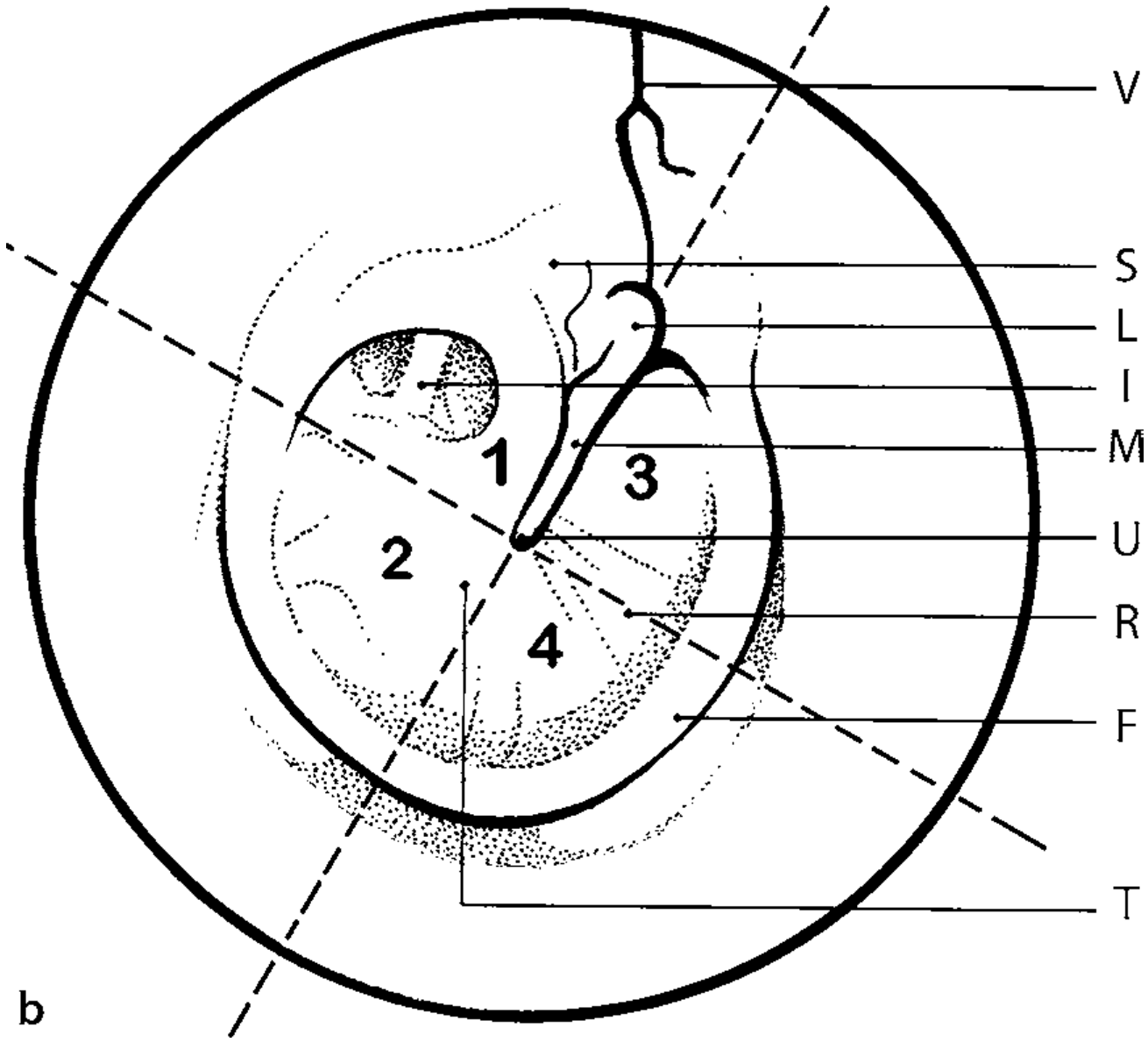


- **Middle Ear Cavity**

Boundaries

Laterally----------tympanic membrane

medial wall---------- promontory of inner ear

Posterior---------- mastoid air cells

Anterio-medially----------Eustachian tube opening

The mastoid air cells is connect with the attic portion of the middle ear cavity through the aditus and antrum. The middle ear cavity and mastoid air cells are lined with ***ciliated mucosal epithelium***. The blood supply of the middle ear and mastoid originate from the internal and external carotid arteries.

Ossicular Chain

There are three ossicles the malleus, the incus, and the stapes.

The malleus has a long process, a short process, and a head. The malleus is bonded to the tympanic membrane from the tip of the long process (the umbo) to the short process. The head of the malleus articulates with the body of the incus in the attic.

The incus has a long process and a short process. The short process is tethered to the posterior wall of the middle ear cavity for structural support and the **long process** is connected to the stapes head.

The stapes consists of a footplate and a superstructure. The superstructure includes the anterior and posterior crus, which are attached at the head. The footplate is the bony covering that sits within the oval window.

Muscle :::: The stapedius muscle. The tensor tympani muscle is anchored to the malleus.

Eustachian Tube

- About 35 mm in adult life
- The bony part (11–14 mm) opens into the protympanum (tympanic ostium), and the fibrocartilaginous part (20–25 mm) opens into the lateral wall of the nasopharynx.
- Lined with respiratory ciliated mucosa, the tube connects the nasopharynx with the middle ear and permits ventilation of the pneumatized temporal bone spaces. It opens on swallowing.

Physiology of the Middle Ear

The middle ear amplifies the airborne sound vibration in two ways. **First**, the large surface area of the tympanic membrane, compared to the small surface area of the stapes (14:1), **Second**, the lever arm effect of the malleus and incus increase in vibrational amplitude (1.3:1.0). The total middle ear gain is 18.3:1.0 or 20–35 dB. This gain counteracts the loss that would result from the impedance mismatch between airborne sound and the fluid vibrations in the cochlea.

Changing the mass and stiffness of the middle ear modulates its frequency response, which can be observed clinically. For example, the stapedius and tensor tympani muscles contract through a neural reflex arc mediated by loud sounds (>80 dB). They act to stiffen the ossicular chain and protect the inner ear from noise damage, particularly at low frequencies.

- ## Inner Ear

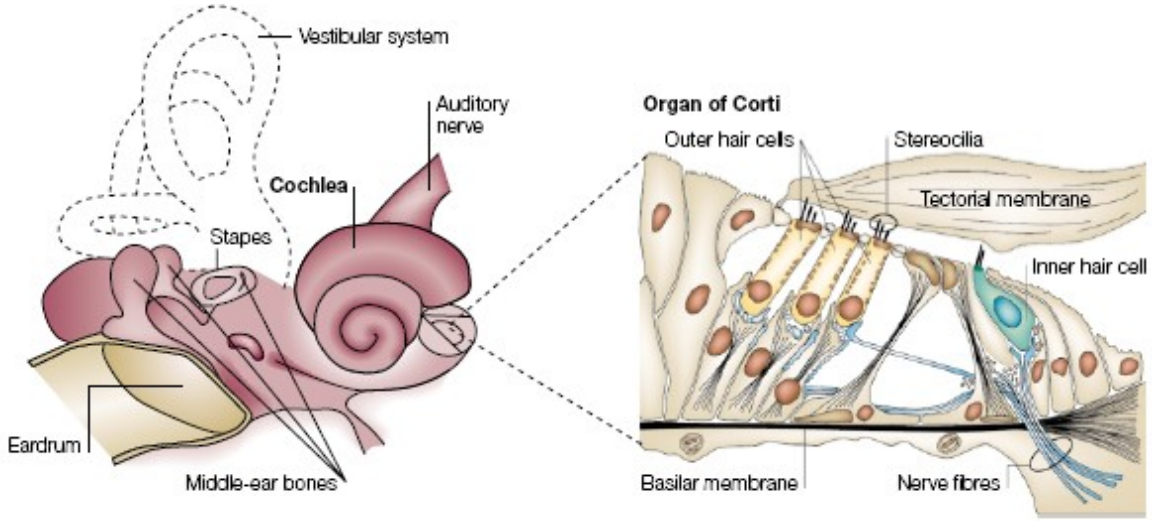
  The cochlea (the auditory apparatus)

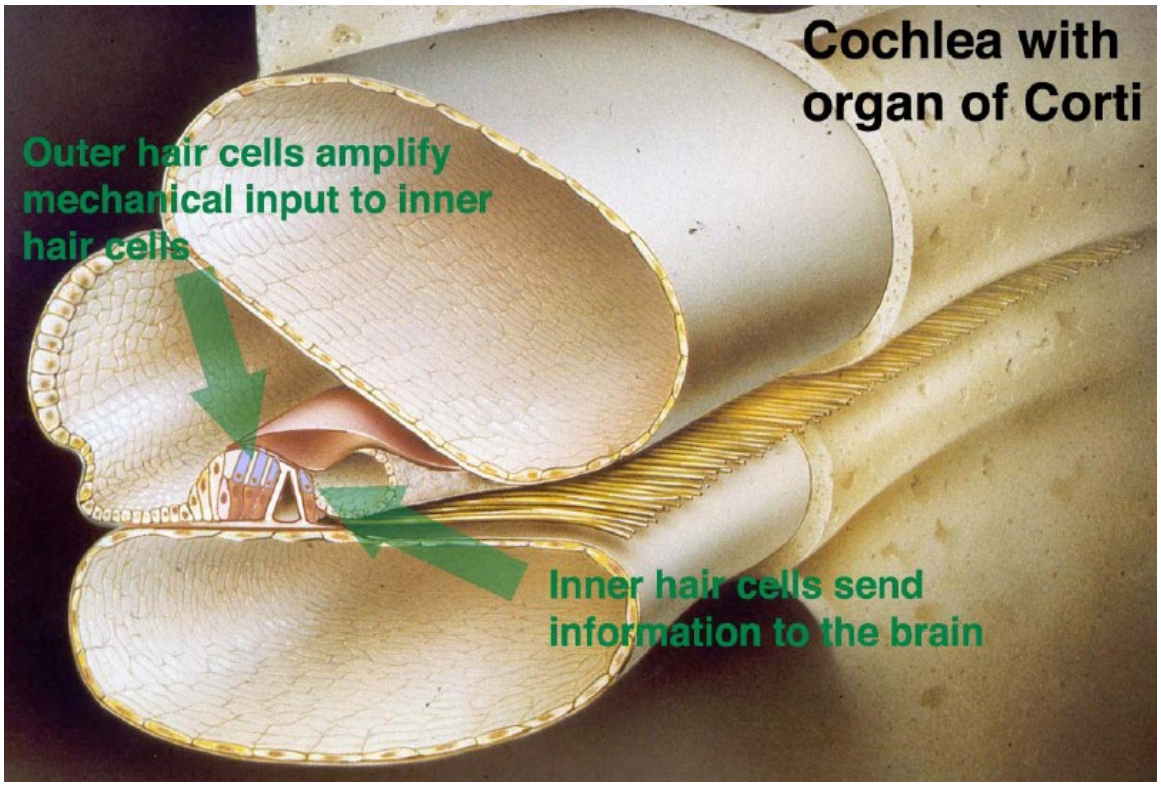
  The vestibular apparatus, composed of the utricle, saccule, and semicircular canals. These are surrounded by the petrous portion of the temporal bone known as the otic capsule.

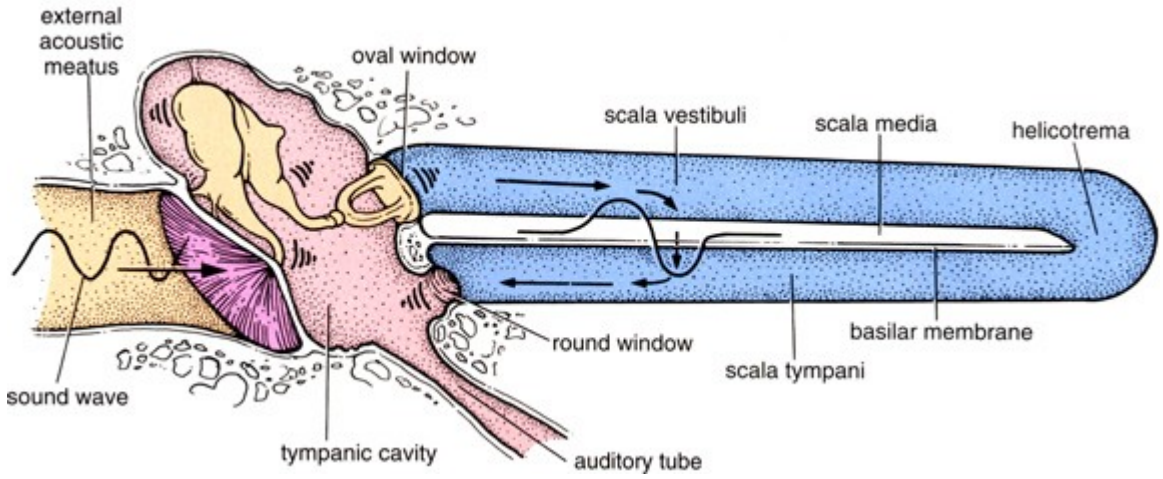
The Cochlea

The cochlea resembles a snail shell and spirals for about 2 3/4 turns around a bony column. Within the cochlea are three canals:

- Scala Vestibuli ------proximal end covered by oval window and stapes footplate.
- Scala Tympani------- proximal end covered by round window
- Scala Media







Fluid Compartments

The inner ear is divided into two fluid-filled chambers, one inside the other. The fluid in the outer or bony chamber is filled with a sodium salt solution called **perilymph** that resembles the salt composition in the blood or the fluids found in the brain. The inner or membranous chamber is filled with a potassium salt solution called **endolymph** that resembles the fluid that is normally found inside the cells of the body. The difference in the chemical composition between perilymph and endolymph provides the electrochemical energy that powers the activities of the sensory cells.

Organ of Corti

It is the key sensory area within the scala media. Here, inner and outer hair cells are rest on basilar membrane and can be stimulated, via bending of their stereocilia, by sound waves.

Hair cells are specialized mechanoreceptors that convert the mechanical stimuli associated with hearing and balance into neural information for transmission to the brain. Their name derives from the fact that they have about 100 stereocilia at their apical end.

Physiology of hearing

Sound waves from the vibrating stapes footplate in the oval window enter the scala vestibuli at the posterolateral end of the basal turn to circulate through the cochlear fluids. These waves are transmitted from the vibrating stapes footplate into perilymphatic fluid to displace the basilar membrane, on which the hair cells rest. The scalae vestibuli and tympani communicate at the cochlear apex.

Vestibular System

Anatomy & Physiology of the Vestibular Organs

The **utricle** and **saccule** make up the portion that perceives linear acceleration and position sense. They are located just deep and posterior to the end of the basal turn of the cochlea.

The semicircular canals—**lateral**, **superior**, and **posterior**—comprise the other portion of the vestibular system. They are oriented in three planes, each perpendicular to the other. These sense "rotational" head motion, or angular acceleration, interacting with the neck and eyes to maintain orientation during turning motions

The vestibular nerve, receiving information from the balance organs, has a superior and inferior division. These divisions converge with the auditory nerve from the cochlea to form cranial nerve VIII. Cranial nerve VIII is immediately adjacent to the facial nerve (cranial nerve VII) as the two enter the brainstem via the IAC and its internal auditory meatus.