

The Structure of the Human Ear

Three Main Parts



Outer Ear

Collects sound waves from the environment and funnels them towards the eardrum.



Middle Ear

Amplifies vibrations using three tiny bones and transmits them to the inner ear.



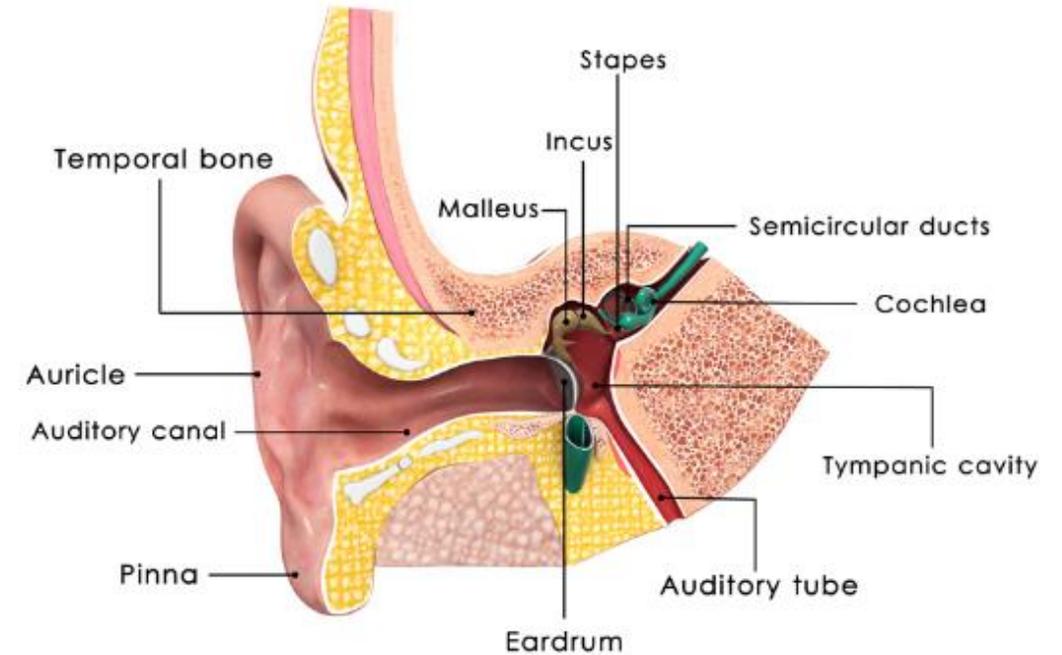
Inner Ear

Converts mechanical vibrations into electrical nerve signals and maintains balance.

1. The Pinna (Auricle)

The **Pinna** is the visible, flap-like cartilaginous structure on the side of the head.

- ✓ **Structure:** Made of elastic cartilage covered by skin. It has ridges and depressions (like the Helix and Lobule).
- ✓ **Function:** It acts like a funnel to collect sound waves from the air and direct them into the auditory canal.



2. External Auditory Meatus

The Ear Canal

A tubular passage extending from the pinna to the eardrum. It is about 2.5 cm long in adults.

Protection

The canal is lined with fine hairs and wax-secreting glands that prevent dust, insects, and microbes from entering deeper.

Ceruminous Glands (Ear Wax)



What are they?

Modified sweat glands located in the skin of the external auditory canal.



Secretion

They secrete a brownish, waxy substance called **Cerumen** (ear wax).



Role

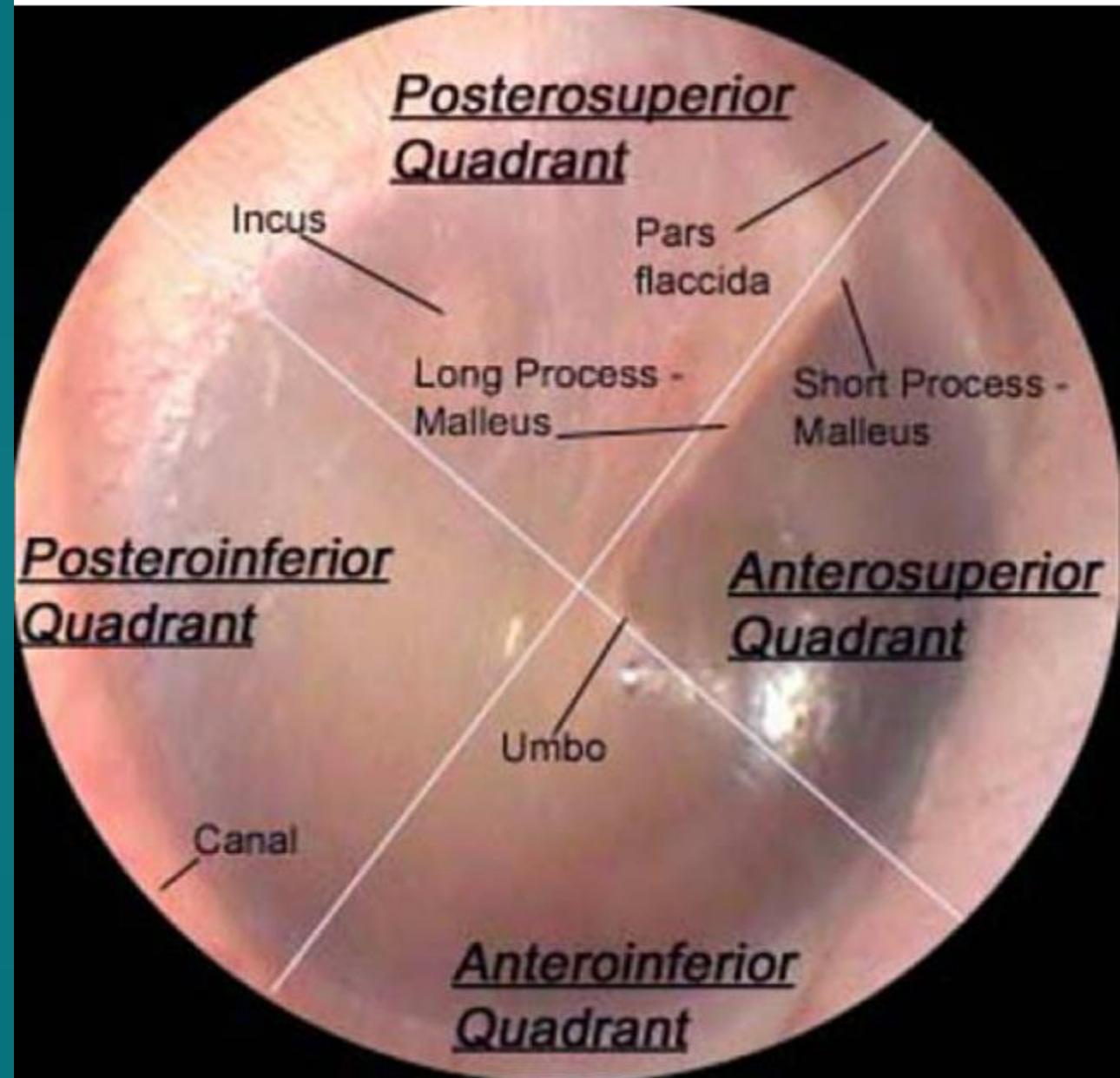
Cerumen traps dust and foreign particles, lubricates the canal, and has antimicrobial properties.

3. Tympanic Membrane

Commonly known as the **Eardrum**, it separates the outer ear from the middle ear.

Structure: A thin, semi-transparent, oval-shaped connective tissue membrane.

Covering: Covered by skin on the outside and mucous membrane on the inside.



Function of the Eardrum

Vibration

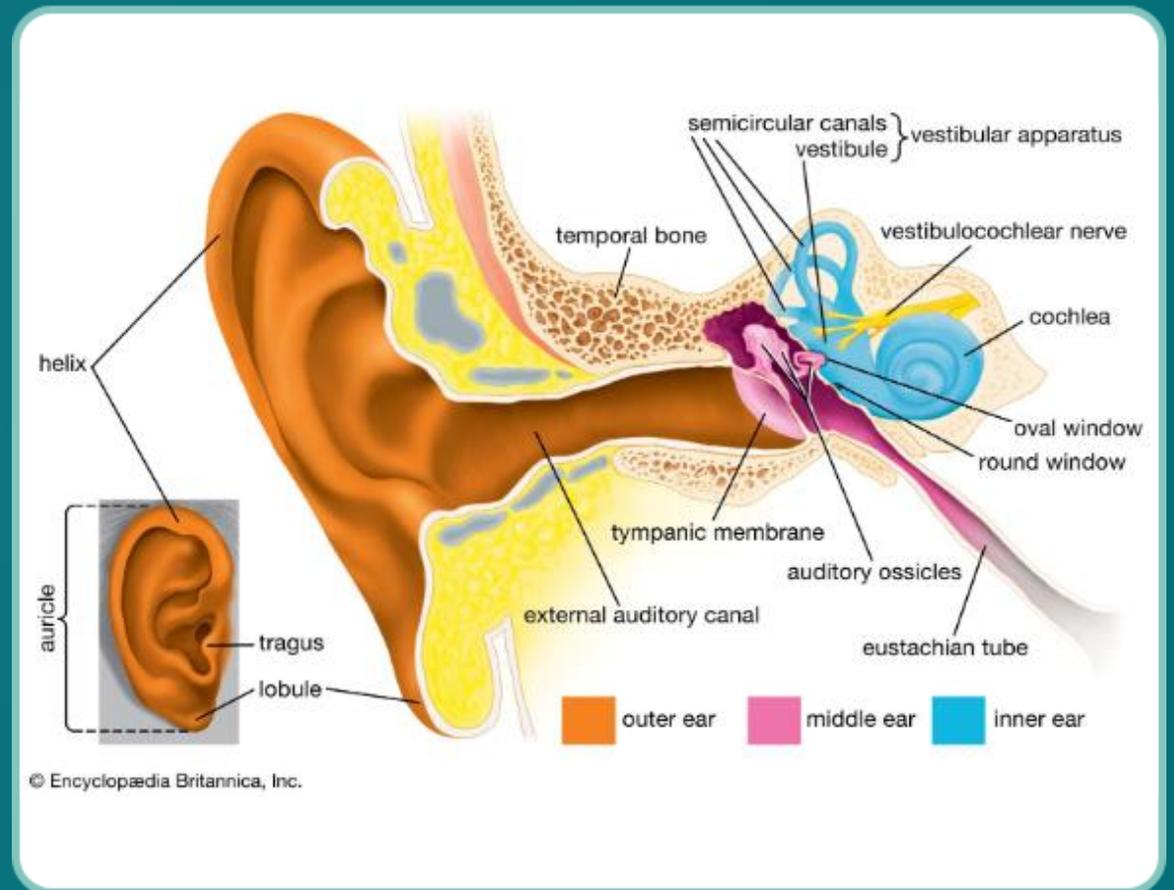
When sound waves traveling through the auditory canal strike the tympanic membrane, it sets into vibration.

Transmission

These vibrations are then passed on to the tiny bones (ossicles) of the middle ear. The eardrum is highly sensitive to even faint sounds.

The Middle Ear Cavity

- ✓ The middle ear is an air-filled space (tympanic cavity) located within the temporal bone of the skull.
- ✓ It acts as a bridge between the outer and inner ear.
- ✓ It contains three delicate bones called **Ear Ossicles** and opens into the throat via the Eustachian tube.

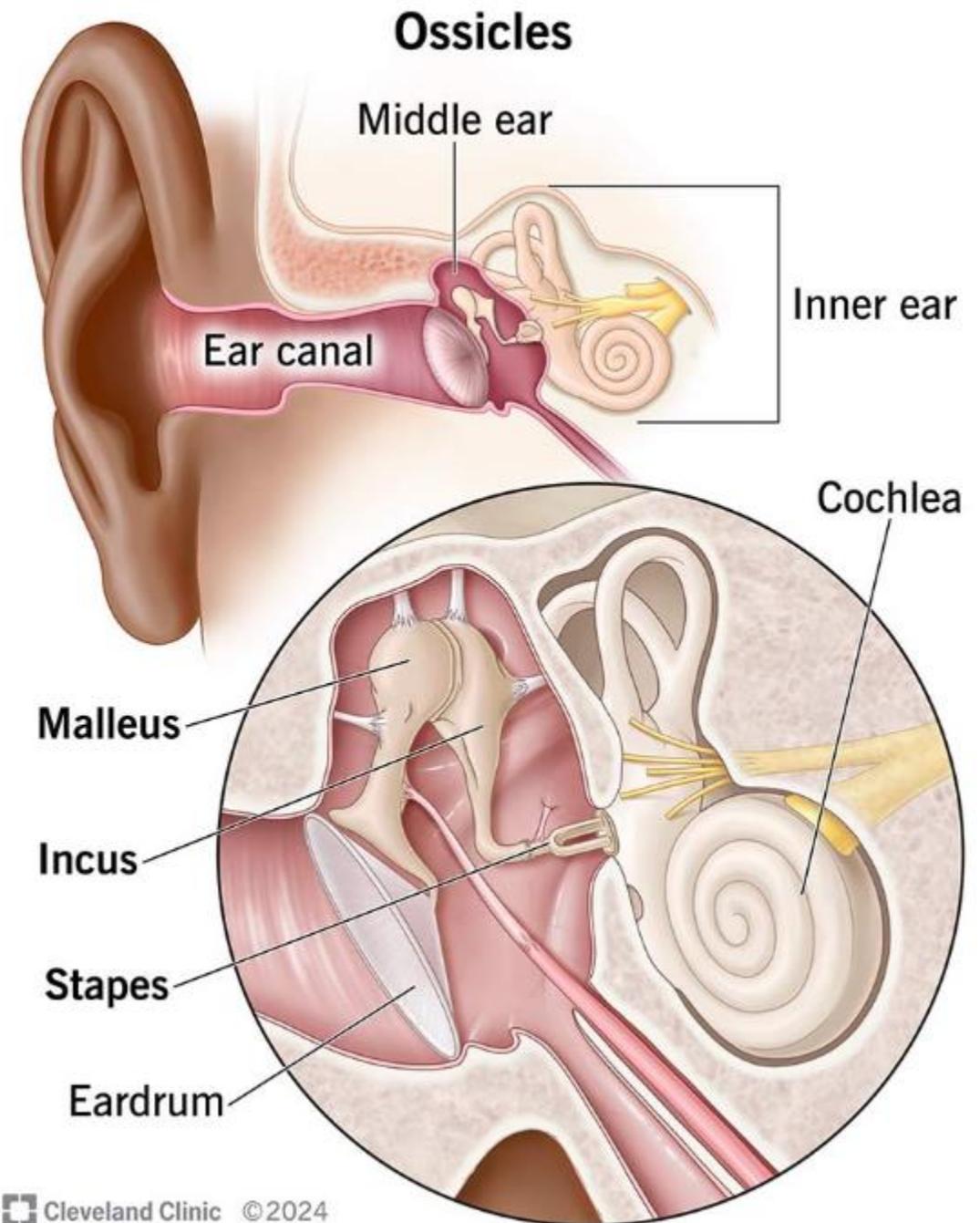


The Ear Ossicles

Three tiny bones linked together in a chain across the middle ear. They are named after their shapes:

- **Malleus** (Hammer)
- **Incus** (Anvil)
- **Stapes** (Stirrup)

These are the smallest bones in the human body.



Malleus

Shape & Attachment

The **Malleus** is shaped like a hammer. Its handle is attached to the inner surface of the tympanic membrane.

Function

It picks up the mechanical vibrations directly from the eardrum and passes them to the next bone, the Incus.

Incus

Position

The **Incus** is the middle bone, shaped like an anvil. It is connected to the Malleus on one side and the Stapes on the other.

Role

It acts as a lever, transmitting the vibratory motion from the Malleus to the Stapes.

Stapes

Smallest Bone

The **Stapes** is the smallest bone in the human body, shaped like a stirrup used in horse riding.

Connection

Its footplate is attached to the **Oval Window** (Fenestra Ovalis), a membrane-covered opening that leads to the inner ear.

Why do we need Ossicles?

The primary function is **Amplification**. Sound waves in air are weak compared to the fluid in the inner ear.

The lever action of the ossicles increases the force of vibration by about 20 times!

20x

Amplification Factor

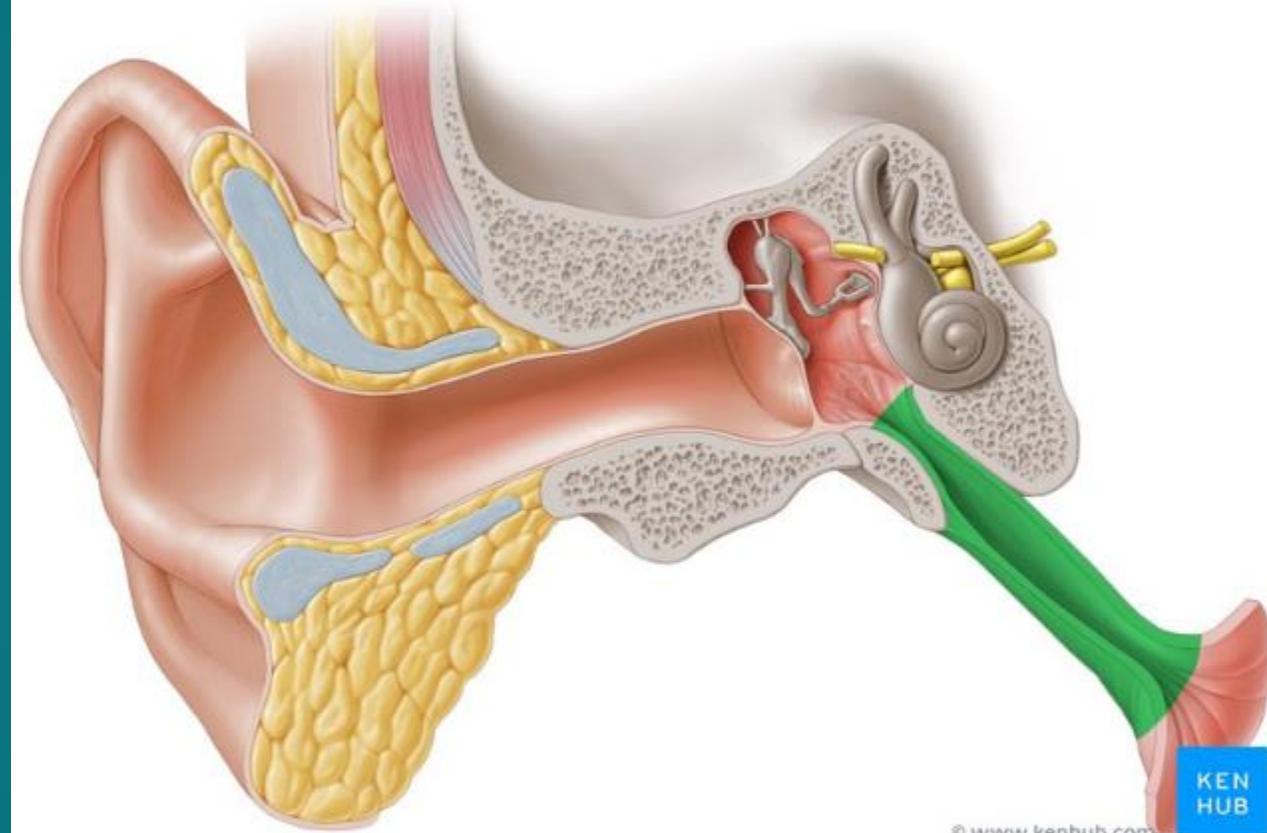
(Impedance Matching)

The Eustachian Tube

Also known as the auditory tube.

Connection: It connects the middle ear cavity with the nasopharynx (the back of the nose and throat).

State: It is normally collapsed (closed) but opens when we swallow or yawn.



Function of Eustachian Tube

Pressure Balance

It helps equalize air pressure on both sides of the eardrum. This prevents the eardrum from rupturing during pressure changes (like in an airplane).

Drainage

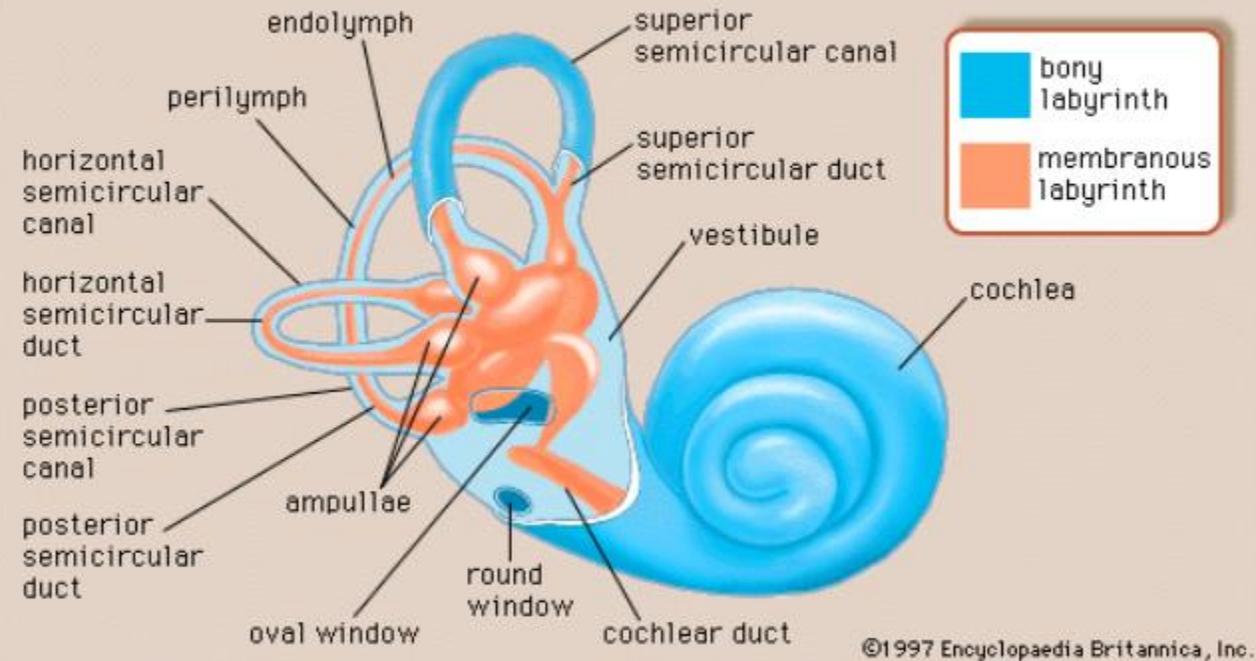
It also allows fluids produced in the middle ear to drain into the throat, preventing accumulation and infection.

The Inner Ear

Also called the **Labyrinth** because of its complex, maze-like structure.

It consists of two main parts:

- **Bony Labyrinth:** A series of cavities in the skull bone.
- **Membranous Labyrinth:** A series of fluid-filled sacs inside the bony labyrinth.



Membranous Labyrinth

Structure

The membranous labyrinth floats inside the bony labyrinth. It perfectly mirrors the shape of the bony shell but is smaller.

Components

It is divided into:

- ✓ **Cochlea:** For hearing.
- ✓ **Vestibular Apparatus:** For balance.

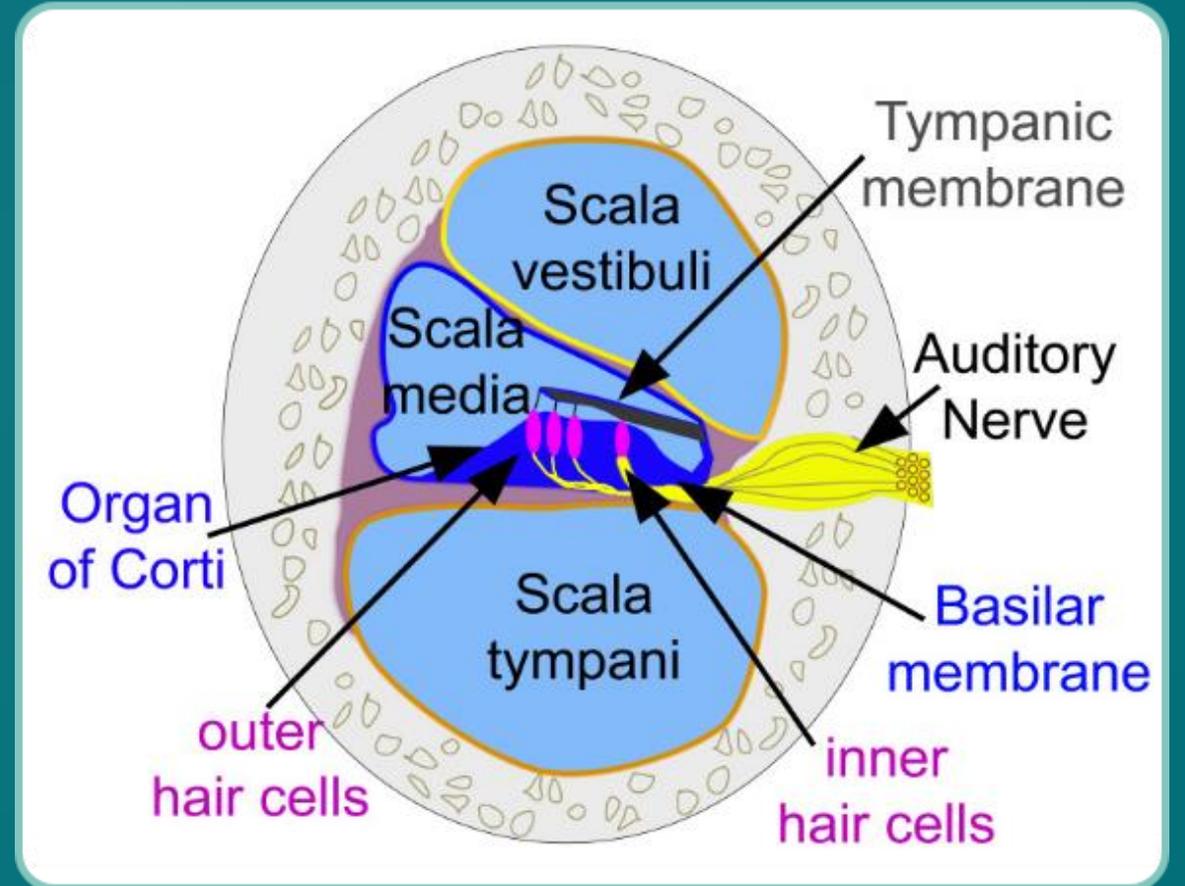
Inner Ear Fluids

Fluid	Location	Characteristics
Perilymph	Between Bony & Membranous Labyrinth	Similar to extracellular fluid (High Sodium).
Endolymph	Inside the Membranous Labyrinth	Similar to intracellular fluid (High Potassium).

The Cochlea

The **Cochlea** is the coiled, snail-shell-like portion of the inner ear.

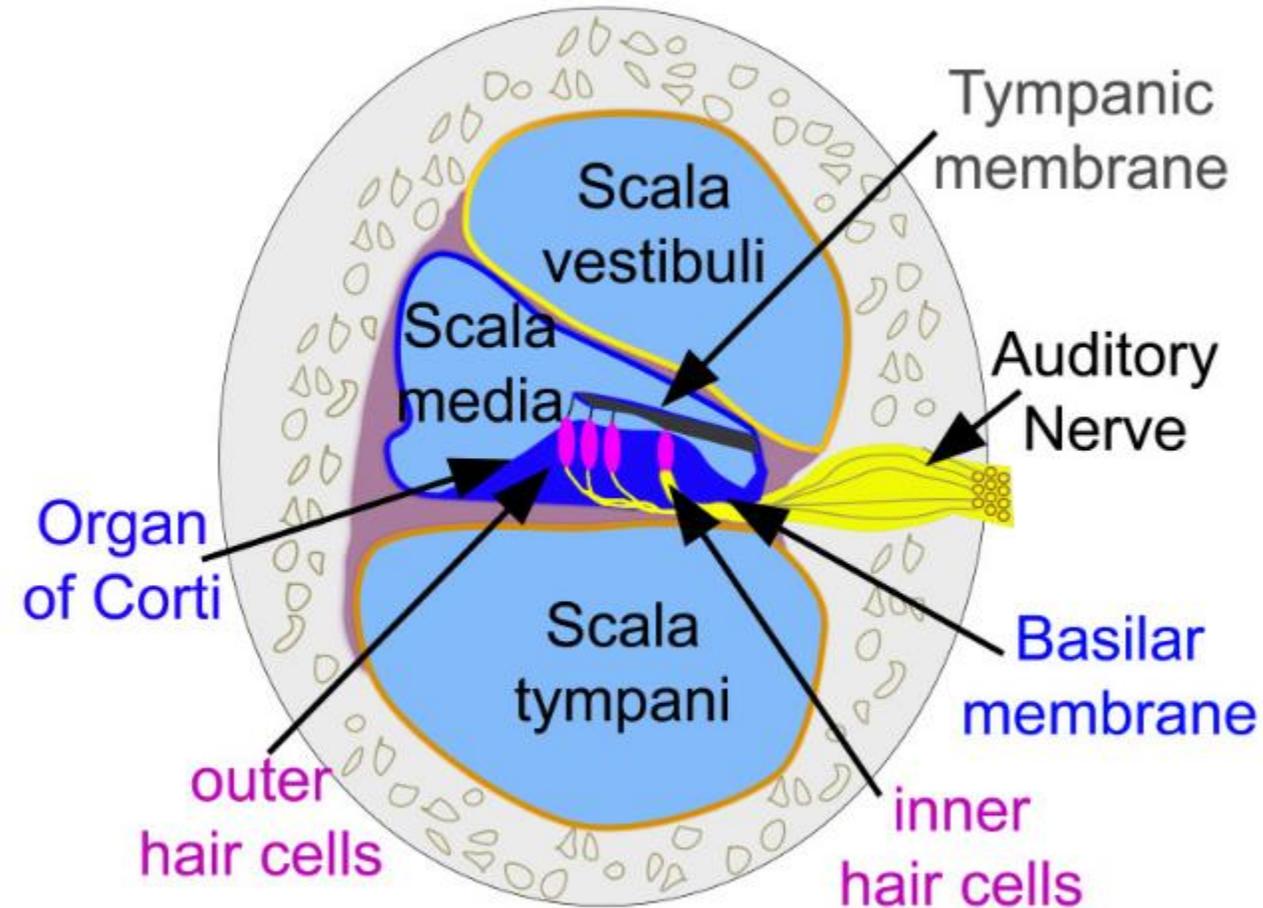
- ✓ It forms the organ of hearing.
- ✓ It makes about 2.5 to 2.75 turns around a central bony axis called the **Modiolus**.
- ✓ It contains the specialized sensory cells for sound.



Cochlear Chambers

Internally, the cochlea is divided into three parallel canals:

1. **Scala Vestibuli:** Upper chamber (Perilymph).
2. **Scala Media:** Middle chamber (Endolymph).
3. **Scala Tympani:** Lower chamber (Perilymph).



Basilar Membrane

Location

This membrane separates the Scala Media from the Scala Tympani.

Significance

It supports the Organ of Corti (the hearing organ).
Sound vibrations cause this membrane to ripple, which is the key to sound detection.

Reissner's Membrane

Location

Also known as the Vestibular Membrane. It separates the Scala Vestibuli from the Scala Media.

Function

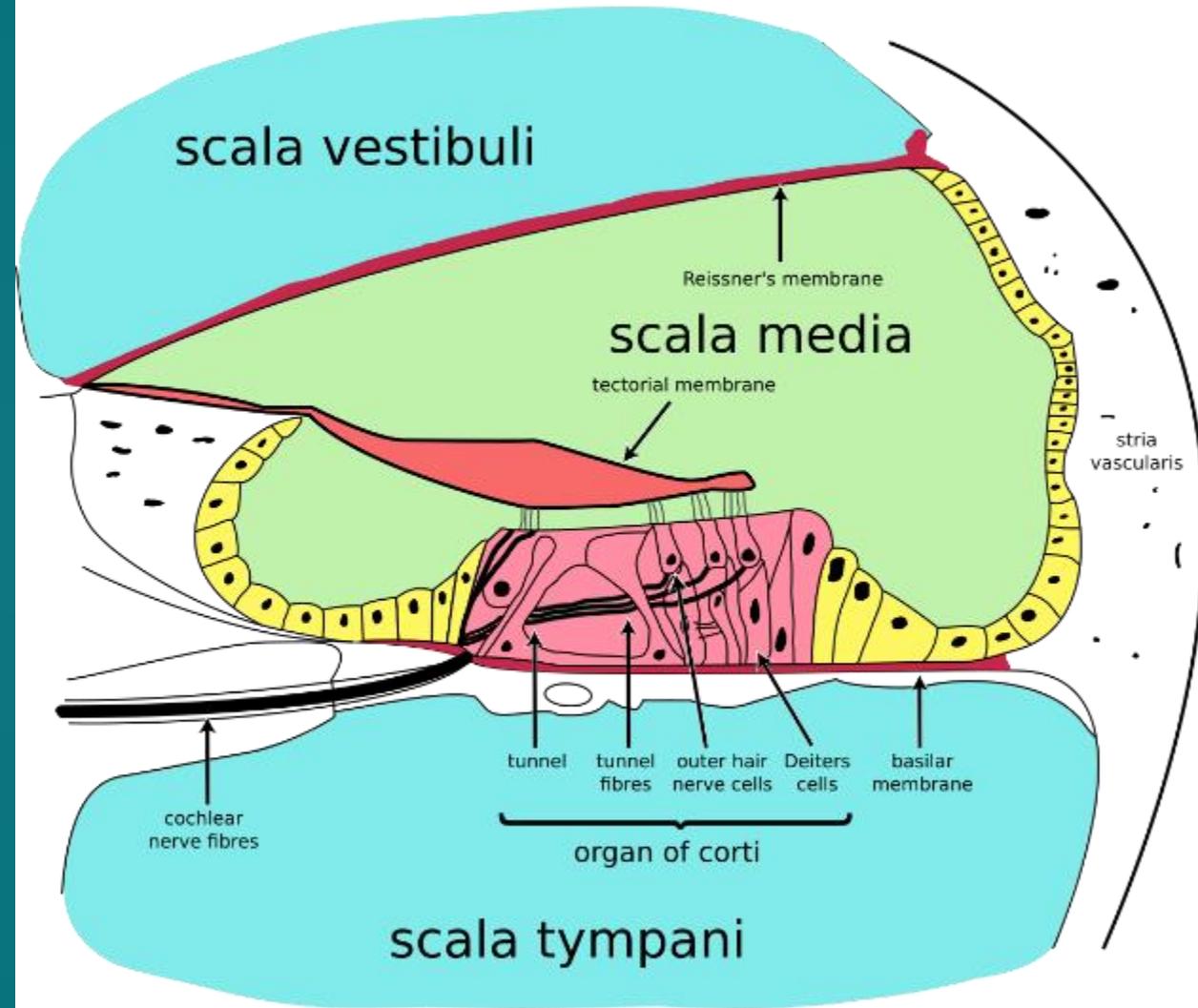
It is very thin and allows fluid pressure waves to easily pass from the upper chamber to the cochlear duct.

The Organ of Corti

This is the actual "Microphone" of the ear.

Location: It sits on the Basilar Membrane within the Scala Media.

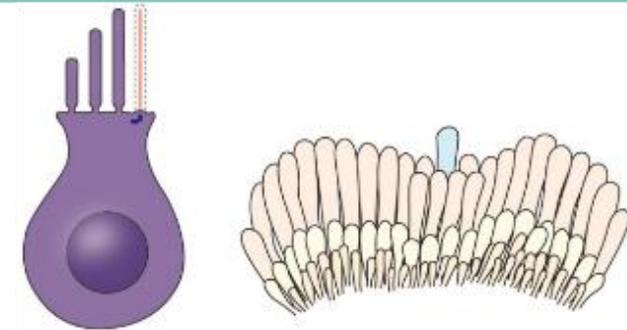
Composition: It consists of thousands of specialized receptor cells called **Hair Cells**.



Hair Cells

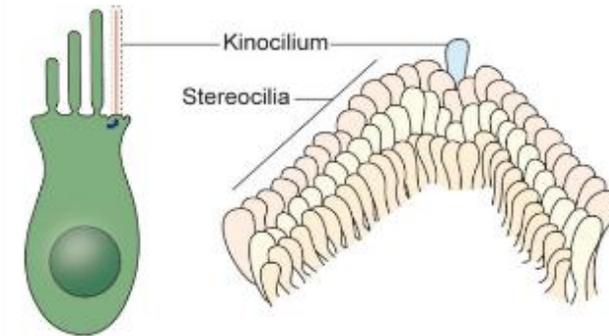
Hair cells are the auditory receptors.

- ✓ They are arranged in rows: inner hair cells (single row) and outer hair cells (three rows).
- ✓ **Stereocilia:** Tiny hair-like projections on the top of each cell.
- ✓ Movement of these stereocilia triggers nerve impulses.



Inner hair cell

Hair bundle of IHC



Outer hair cell

Hair bundle of OHC

Tectorial Membrane

The Roof

A thin, jelly-like flap that hangs over the Organ of Corti.

Contact

The tips of the hair cell stereocilia are embedded in or touch this membrane. When the basilar membrane moves up, the hairs are pushed against this roof.

Step 1: Sound Collection



Gathering

The Pinna collects sound waves from the air.



Traveling

Waves travel down the Auditory Canal.



Striking

Waves hit the Tympanic Membrane, causing it to vibrate.

Step 2: Amplification

Chain Reaction

Vibrations pass from Eardrum -> Malleus -> Incus -> Stapes.

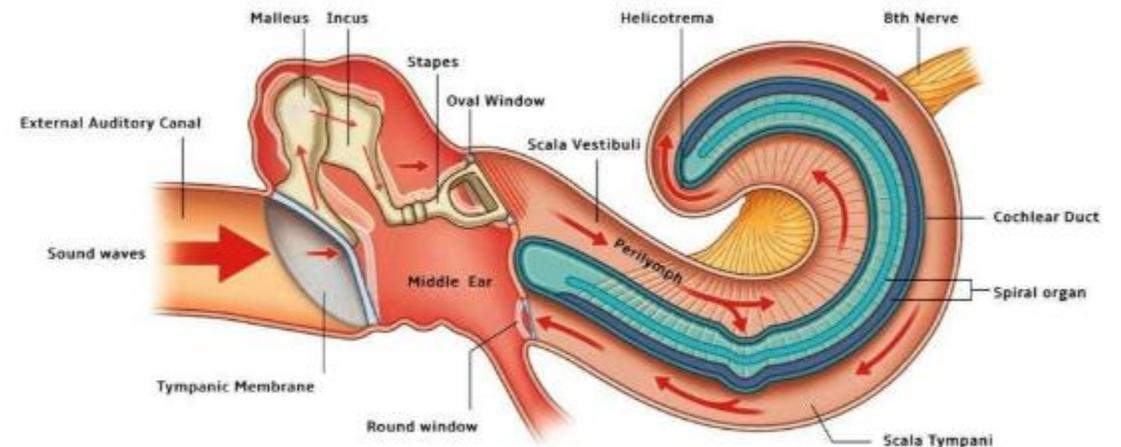
Force Increase

The ossicles amplify the pressure of the sound wave. The footplate of the Stapes pushes in and out of the Oval Window.

Step 3: Fluid Waves

The movement of the Stapes at the oval window creates pressure waves in the perilymph of the **Scala Vestibuli**.

These waves travel through the cochlea and push the membranes, causing ripples in the endolymph of the **Scala Media**.



Mechanism of Hearing

Step 4: Transduction

Bending Hairs

The ripples in the fluid cause the Basilar Membrane to move up and down. This pushes the hair cells against the Tectorial Membrane, bending their stereocilia.

Signal Generation

This bending opens ion channels, generating an electrical nerve impulse in the base of the hair cells.

The Auditory Nerve

Transmission

The electrical impulses generated by thousands of hair cells are picked up by the auditory nerve fibers.

Destination

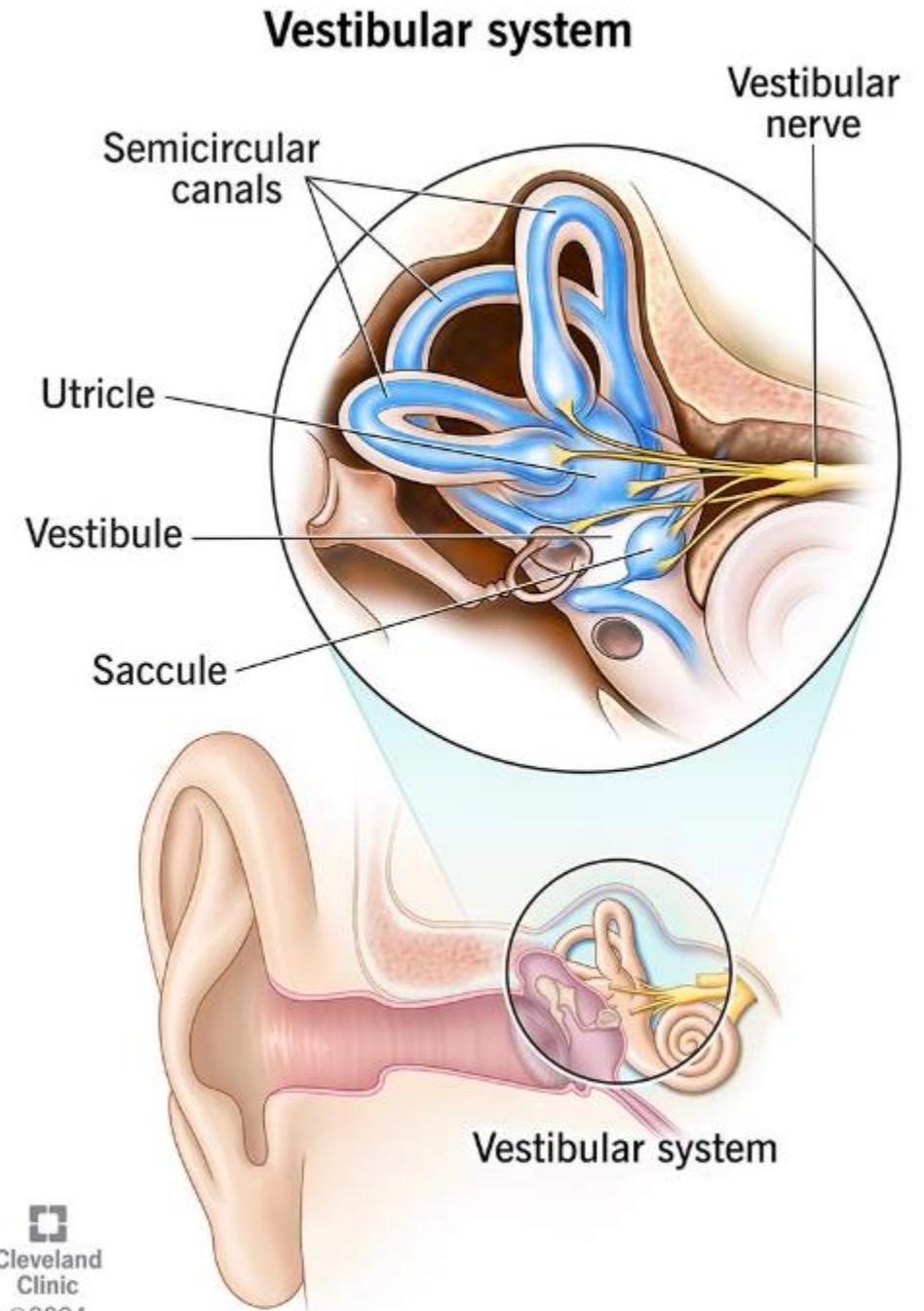
These fibers combine to form the **Cochlear Nerve** (part of the 8th Cranial Nerve), which carries signals to the brain.

Vestibular Apparatus

Located above the cochlea, this organ is responsible for maintaining body balance and posture.

It consists of:

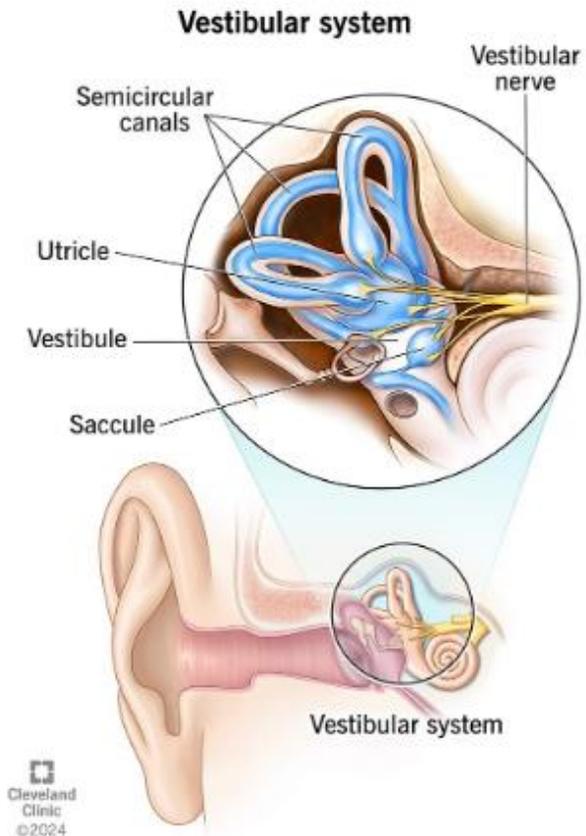
- **3 Semicircular Canals** (for rotational balance).
- **Otolith Organs** (Saccule & Utricle for linear balance).



Semicircular Canals

Three fluid-filled loops oriented at right angles to each other (X, Y, Z axes).

- ✓ They detect **Dynamic Equilibrium** (rotational movement of the head).
- ✓ Examples: Spinning, nodding, shaking head 'no'.



Crista Ampullaris

The Sensor

The base of each canal is swollen (called Ampulla).
Inside is a sensory ridge called **Crista Ampullaris**.

Mechanism

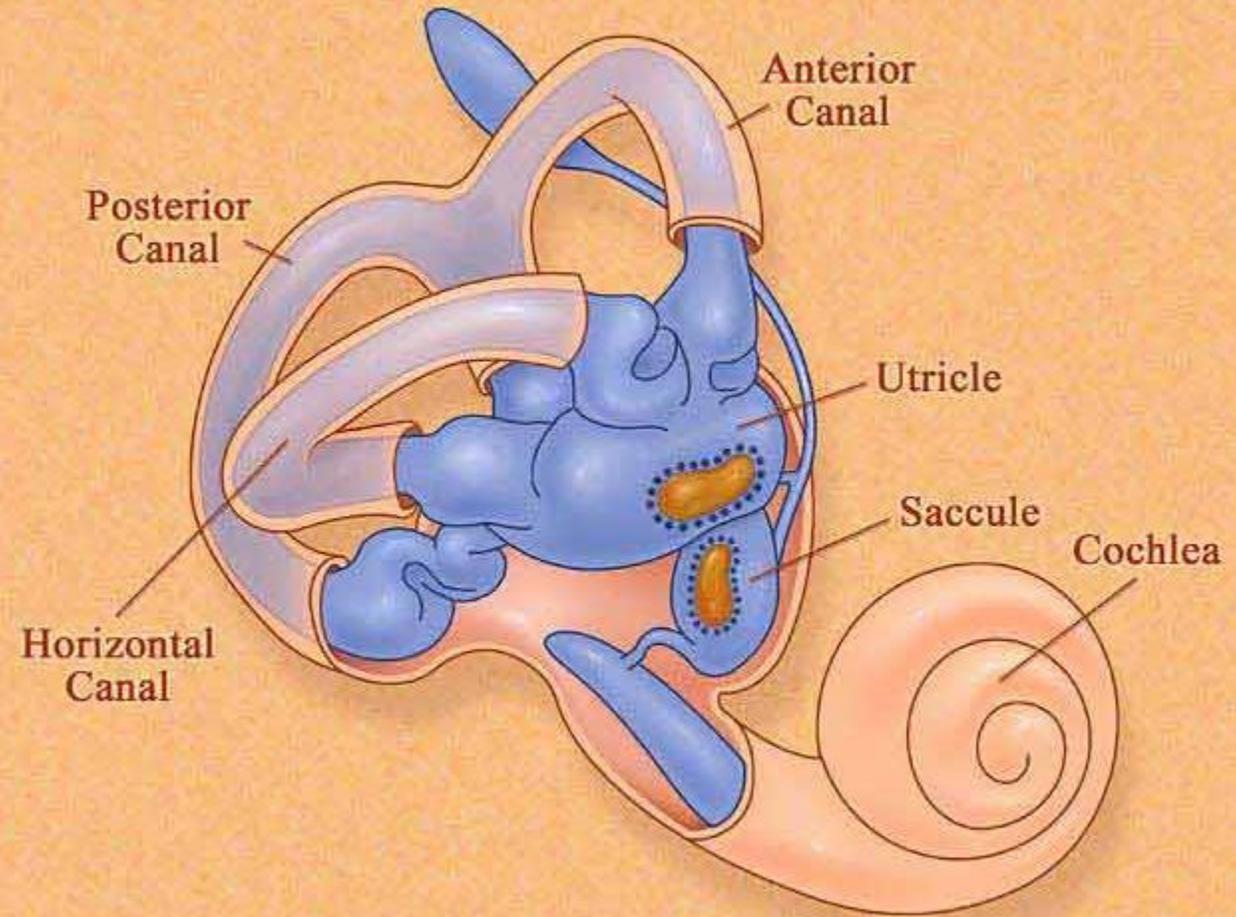
It has hair cells embedded in a gelatinous cap (Cupula). When the head rotates, fluid lags behind, pushing the Cupula and bending hair cells.

Otolith Organs

Composed of the **Utricle** and **Saccule**.

They detect **Static Equilibrium** (position of head with respect to gravity) and linear acceleration.

Example: Tilting head sideways, going up in an elevator.



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Macula

Sensory Patch

The sensory part of the Utricle and Saccule is called the **Macula**.

Otoliths

Hair cells here are covered by a jelly layer containing calcium carbonate crystals called **Otoliths** (Ear Stones).

How Ear Stones Work

When you tilt your head, gravity pulls the heavy Otolith crystals. They slide over the jelly layer.

This sliding pulls on the hair cells beneath them, sending signals to the brain about head position.

Gravity

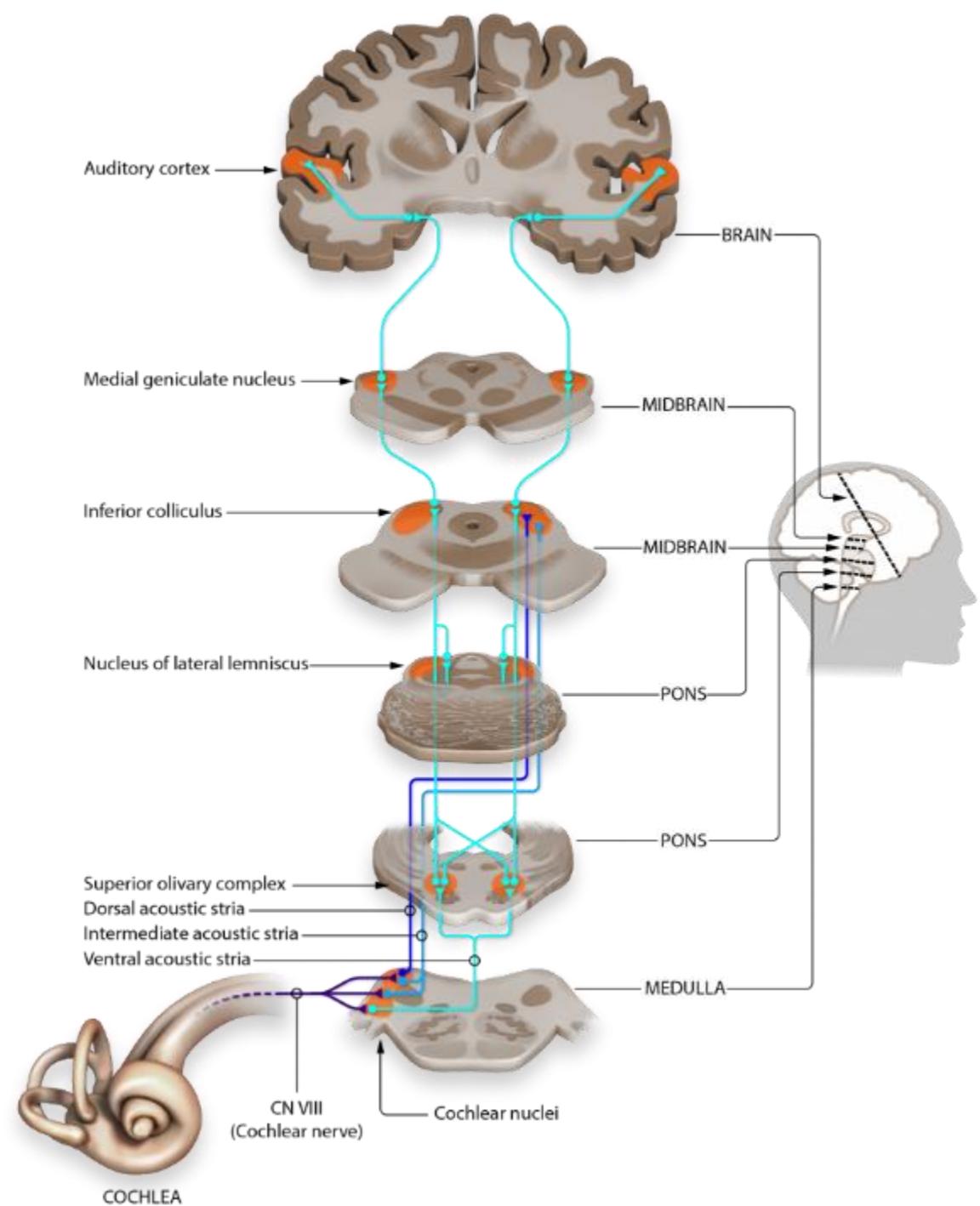
Detectors

To the Brain

The Vestibulocochlear Nerve (8th Nerve) carries both hearing and balance signals.

Path: Nerve -> Brainstem -> Thalamus -> **Auditory Cortex**
(Temporal Lobe).

Here, the brain interprets signals as recognizable sounds.



Common Ear Disorders



Otitis Media

Infection of the middle ear, common in children. Causes fluid buildup and pain.



Tinnitus

A ringing or buzzing noise in the ears, often caused by exposure to loud noise or aging.



Deafness

Can be Conductive (ossicle/eardrum problem) or Sensorineural (nerve/cochlea damage).

Caring for Your Ears

Avoid Noise

Prolonged exposure to loud music (earphones) can permanently damage hair cells.

Hygiene

Avoid inserting sharp objects (pins, buds) into the ear canal as they can rupture the eardrum.

Thank You!

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