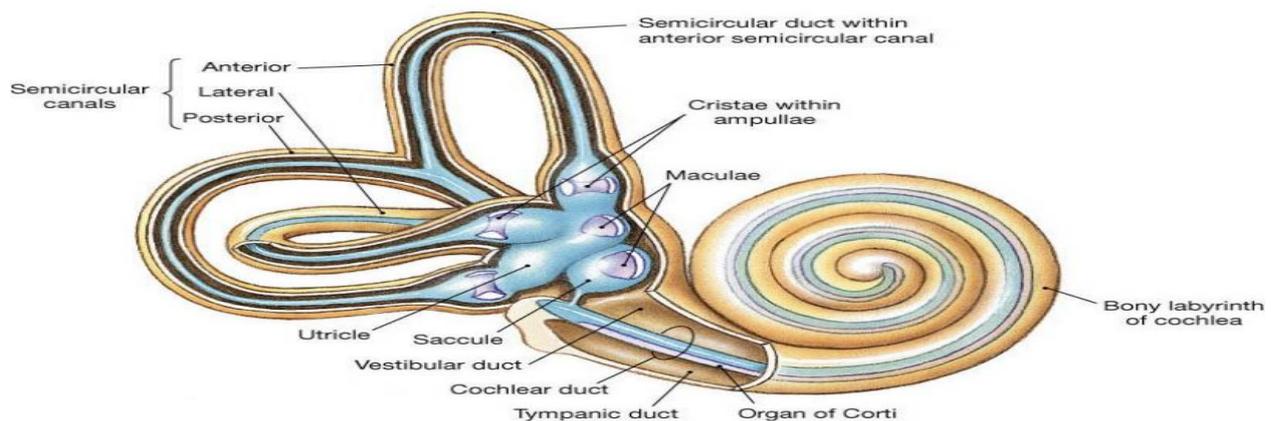


*noise* and allows a person to *concentrate on sounds above 1000 Hz*.

3. It **decreases the person's hearing sensitivity to his own speech**, (this effect is activated by collateral signals transmitted to these muscles during speech).

### **C) The Inner Ear**

- It is situated in the **petrous portion of the temporal bone**.
- It consists of **2 parts**:
  - a. **The cochlea**, which is the organ of hearing.
  - b. **The vestibular apparatus**, which is concerned with posture & equilibrium.



**Fig: inner ear**

### **The Cochlea**

- The cochlea is a **coiled bony tube about 3.5 cm long** that makes **2 and half turns** around bony axis called **modiolus**.
- It starts by a **broad base** to a **narrow apex**.
- **The cavity of the cochlea is divided by 2 membranes, vestibular and basilar into 3 compartments (or scalae):** scala vestibuli, scala media, and scala tympani.
- **The scala media or endocochlear duct** is filled with **endolymph** which is similar

to **intracellular fluid** and it *ends at the apex* of the cochlea as a blind sac.

- **Both scala vestibuli and scala tympani** contain perilymph which is similar to **extracellular fluid** and *communicate with each other at the apex* of the cochlea.
- **At the base of the cochlea**, the scala vestibuli ends at the **oval window** which is sealed by the **footplate of the stapes** while the scala tympani ends at the **round window** which is closed by a flexible membrane called "**2ry tympanic membrane**".
- **The vestibular membrane** is a thin membrane, moves easily and transmits the vibrations from scala vestibuli to scala media.
- **The basilar membrane** is a fibrous membrane and carries the "Organ of Corti".
- **It contains** about **25.000 basilar fibers** that project from the *modiolus* toward the *outer wall of the cochlea*.
- **The basilar membrane** fibers have special **gradual change in length, diameter and stiffness** as they go from base to apex. **At the base**, they are short, thick a stiff whereas **at the apex**, they are long, thin and lax with gradual change in between.

### **The Organ of Corti**

**\* Def:** It is the sense organ of hearing.

**\* Site:** It lies on the basilar membrane, extending in a spiral shape from the base to the apex of the cochlea.

**\* Structure:** It consists of:

**1) Receptor cells (hair cells):** are of 2 types

a. **Outer hair cells:**

- They are about **20000 cells** and form **3-4 rows**.

- They control the **sensitivity of inner ear for different sound pitches.**

**b. Inner hair cells:**

- They are about 3500 cells and form single row.
- They are important for the detection of sound.

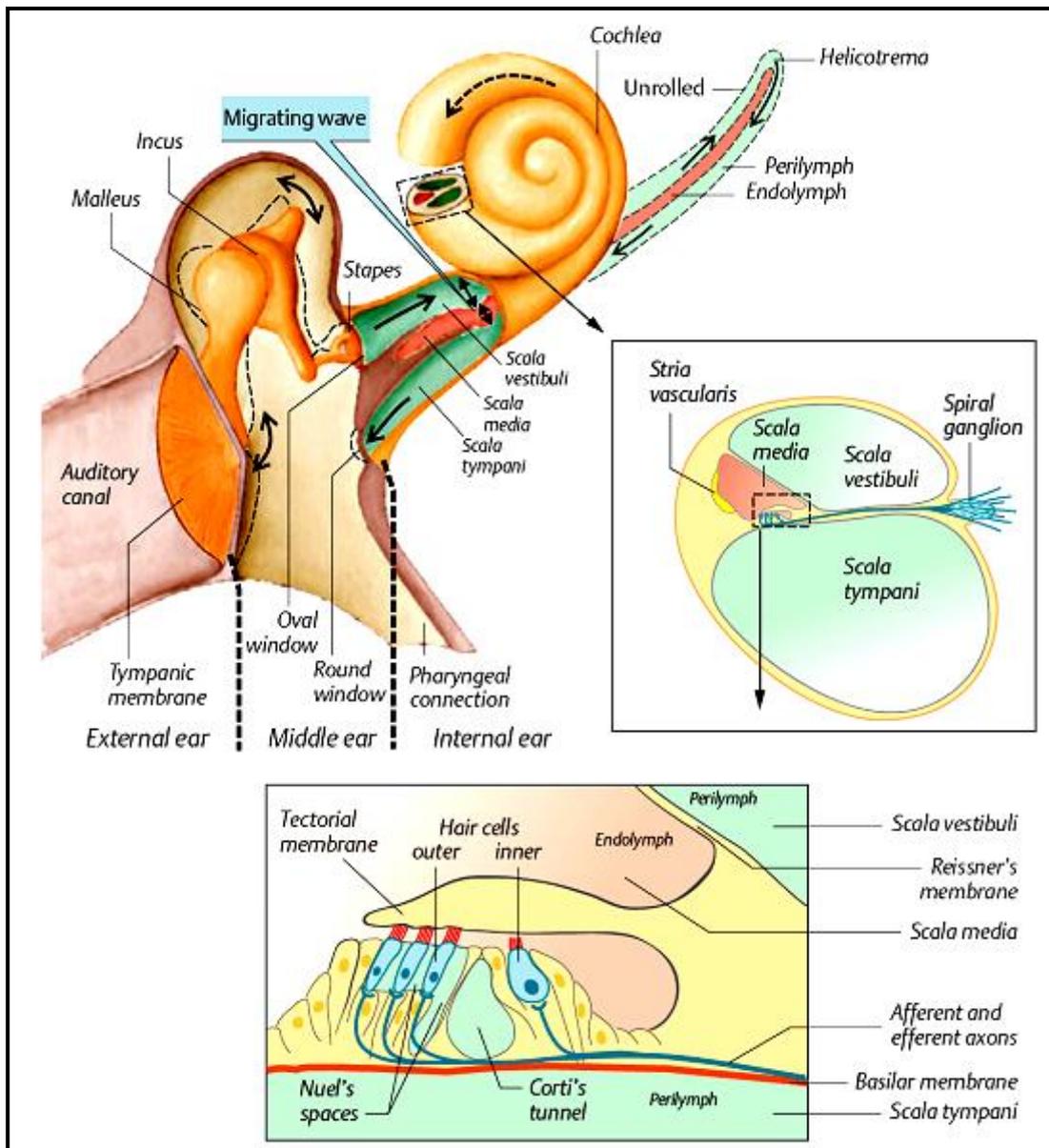
- ✓ Both types are separated by the arches of the tunnel of Corti (rods of Corti).
- ✓ The hair-bearing end of the hair cells are held firmly together by a rigid membrane called the reticular lamina which by its turn is supported on the rods of Corti.
- ✓ The bases and sides of the hair cells are surrounded by a network of cochlear nerve endings.

**2) Supporting cells** (phalangeal cells).

**3) Tectorial membrane:** a flap of gelatinous elastic tissue which rests on the top of the cilia of the hair cells.

**4) Nerve fibers:** the peripheral branches of cochlear nerve synapse with the hair cells.

The nerve fibers cross the tunnel of Corti to reach the spiral ganglion which lies in the modiolus of the cochlea.



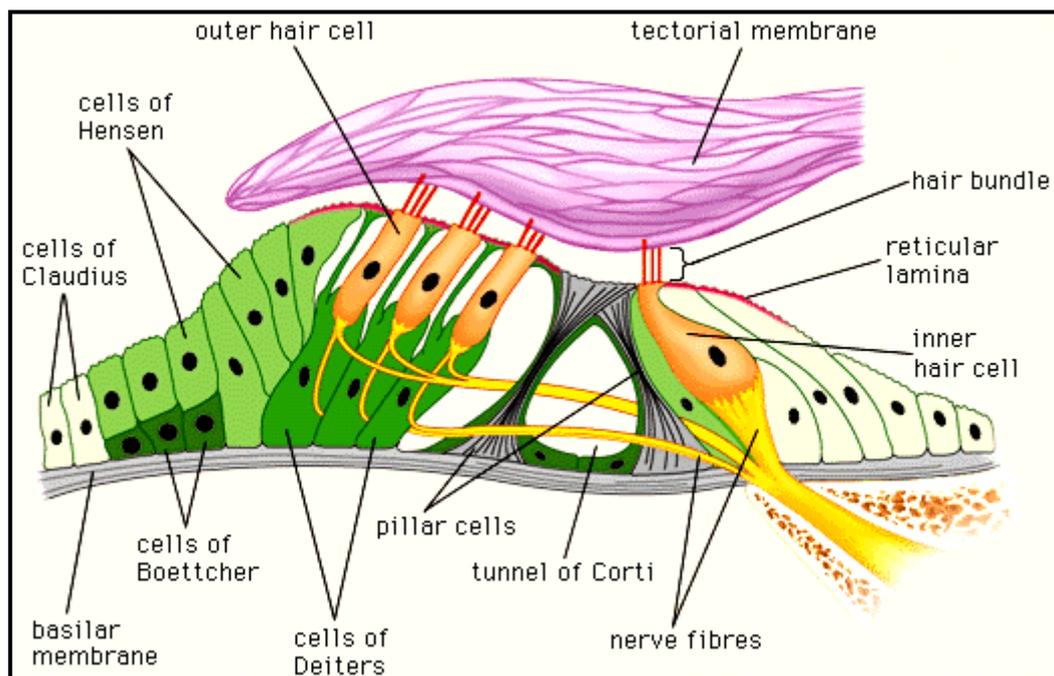
**Fig: Structure of Cochlea and organ of Corti**

## Auditory Hair Cells

\* They are **mechanoreceptors** that are specialized to **detect movement**.

### \* Structure:

- The cells have a **hair bundle** projecting from the apical end and **synaptic contacts** with cochlear nerve fibers at their basal ends.
- The **hair bundle** consists of a **large one** on one side of the bundle (**kinocilium**) while the **others** are falling away in height to the opposite side (called **stereocilia**).
- Within the bundle, **stereocilia are connected** one to the next with very fine elastic **protein filaments** called "**tip links**", but they can slide with respect to each other as the bundle is deflected side to side.



*Fig: Structure of the organ of Corti, (in the basal turn of the cochlea).*

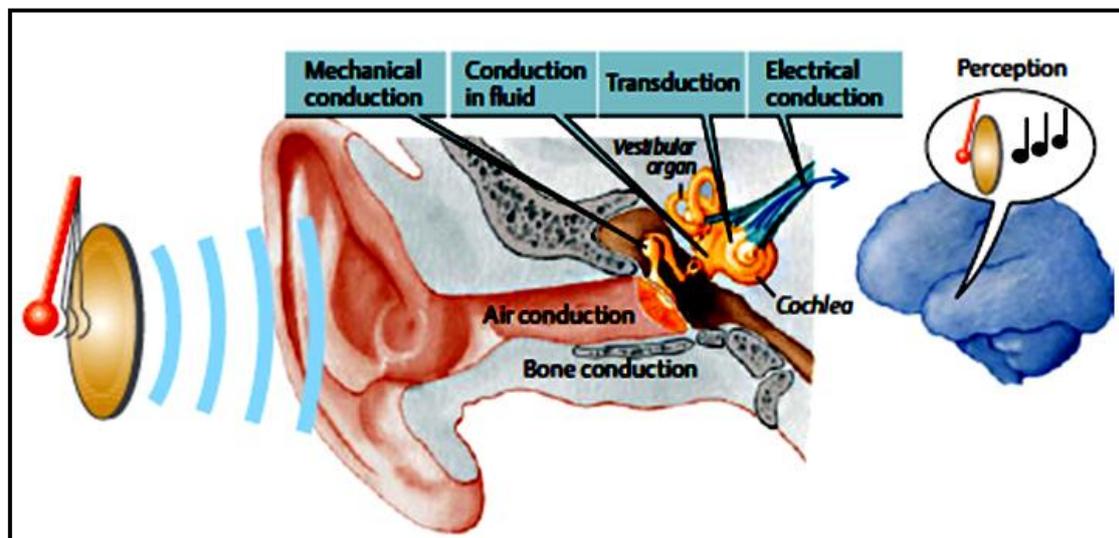
\* **Mechanism of stimulation of hair cells:** (See later; generation of receptor potential in hair cells).

## Mechanism of Hearing

Hearing occurs in the following steps:

### 1) Transmission of sound waves in the outer and middle ear:

- The ear pinna **collects and directs** the sound waves toward the external auditory canal.
- Sound waves cause **vibrations of the tympanic membrane** at the same frequency.
- Movements of the **tympanic membrane** are transmitted and amplified by the **bony ossicles** of the middle ear to the **oval window** via the footplate of the stapes.



*Fig: Conduction of sound waves in the ear.*

### 2) Transmission of sound waves in the cochlea (the traveling wave):

- This occurs in the form of **traveling wave** in the basilar membrane.
- **Inward movement of the footplate** of stapes increases the pressure in the scala vestibuli.
- This results in **displacement of the cochlear membranes** (vestibular and basilar) towards the scala tympani increasing its pressure and causing the round window to bulge in the middle ear.
- Rapid movements of the tympanic membrane in response to sound waves → **traveling waves** that move in the basilar membrane from base to apex.

### 3) Receptor potential and generation of cochlear nerve impulse:

- Up and down movements of the basilar membrane create a shearing force in the tectorial membrane → depolarization or hyperpolarization of the receptor cells.
- Because endolymph which surrounds the apex of the hair cells has a higher concentration of  $K^+$  than that inside the hair cells, the opening of  $K^+$  channels at the apex of the hair cells causes depolarization whereas its closure causes hyperpolarization.
- Bending of the stereocilia toward the kinocilium opens the apical channels →  $K^+$  influx → cellular depolarization → activation of  $Ca^{2+}$  channels, opening them →  $Ca^{2+}$  influx → release of an excitatory transmitter, probably glutamate → stimulation of the postsynaptic terminals of the sensory neurons.
- Bending of the stereocilia away from the kinocilium closes the apical channels → cellular hyperpolarization → inhibition of  $Ca^{2+}$  channels and release of chemical transmitter.
- Thus, hyperpolarization and depolarization of hair cells alter the rate of impulse discharge along the cochlear nerve.

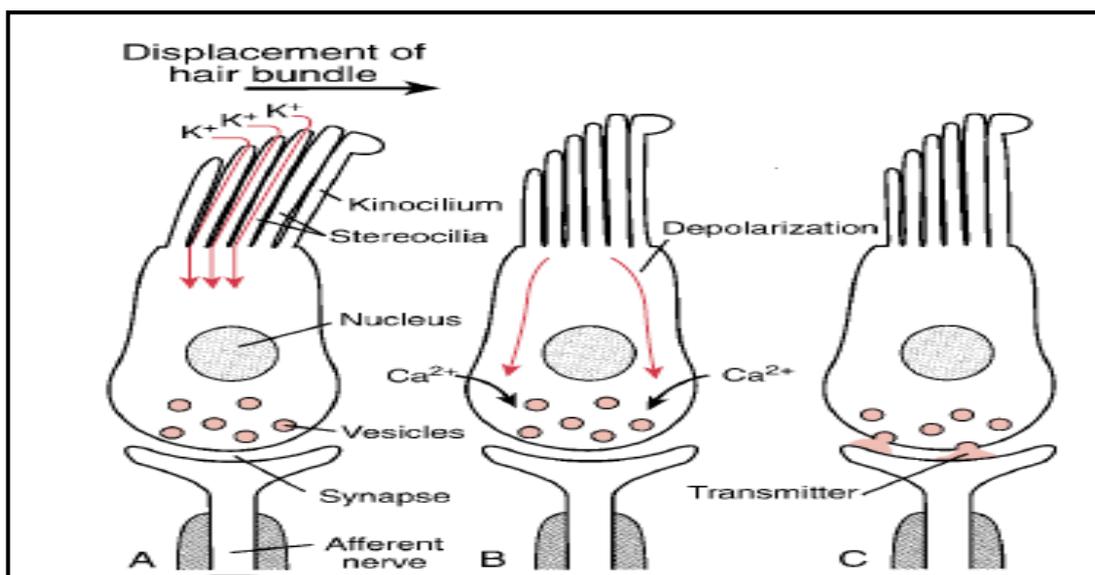
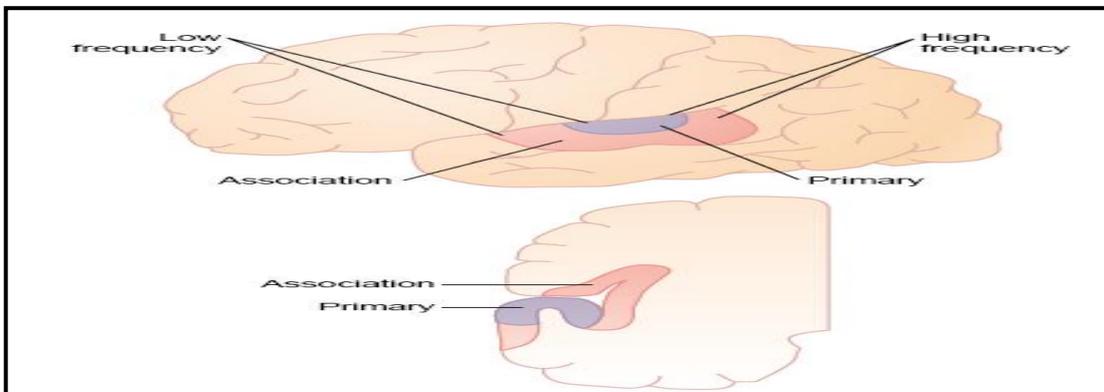


Fig: Mechanism of activation of cochlear hair cells.

## The Auditory Cortex

	<b>A) Primary auditory area (areas 41 &amp; 42):</b>	<b>B) Secondary (associated) auditory area (area 22):</b>
<b>Site:</b>	The upper part of temporal lobe.	Surrounds the primary area.
<b>Receive impulses from:</b>	-Both ears through fibers from the ipsilateral MGB. - <b>Anterolateral part</b> receives impulses from <b>apex</b> of cochlea ( <b>low pitched</b> sounds) and <b>posteromedial part</b> receives impulses from <b>base</b> of the cochlea ( <b>high pitched</b> sounds).	the primary auditory area
<b>Functions:</b>	-Perception of pitch, amplitude, and sound pattern without understanding its meaning. -Perception of the source of the sound.	-Interpreting & understanding the meaning of sounds.
<b>Lesion:</b>	- Bilateral damage → greatly reduces the capacity for hearing -Unilateral damage → slightly reduces hearing of the opposite ear	-The person will be unable to interpret the meaning of the heard sound ( <b>auditory aphasia or word deafness</b> ).



*Fig: Auditory cortex*