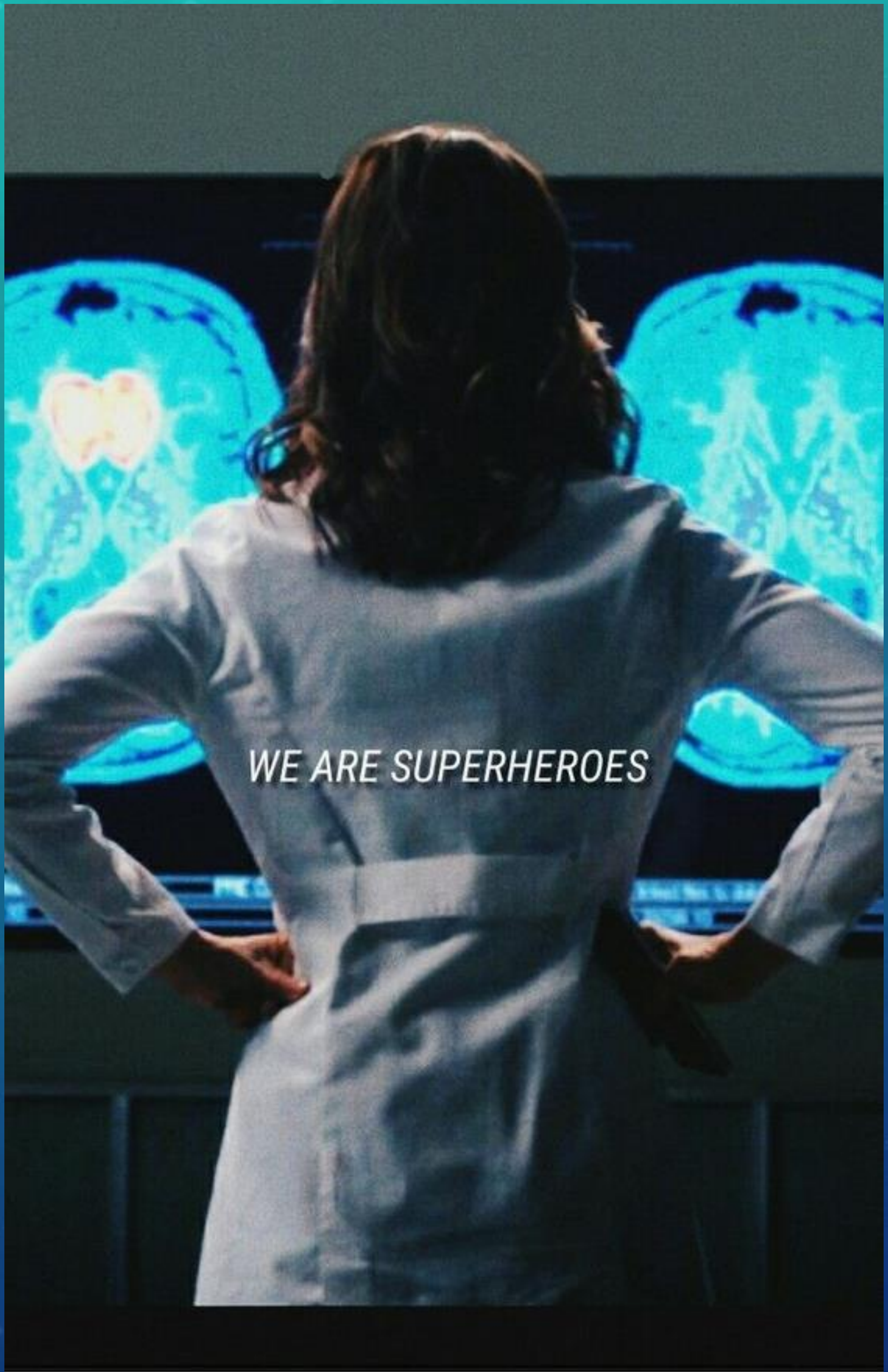
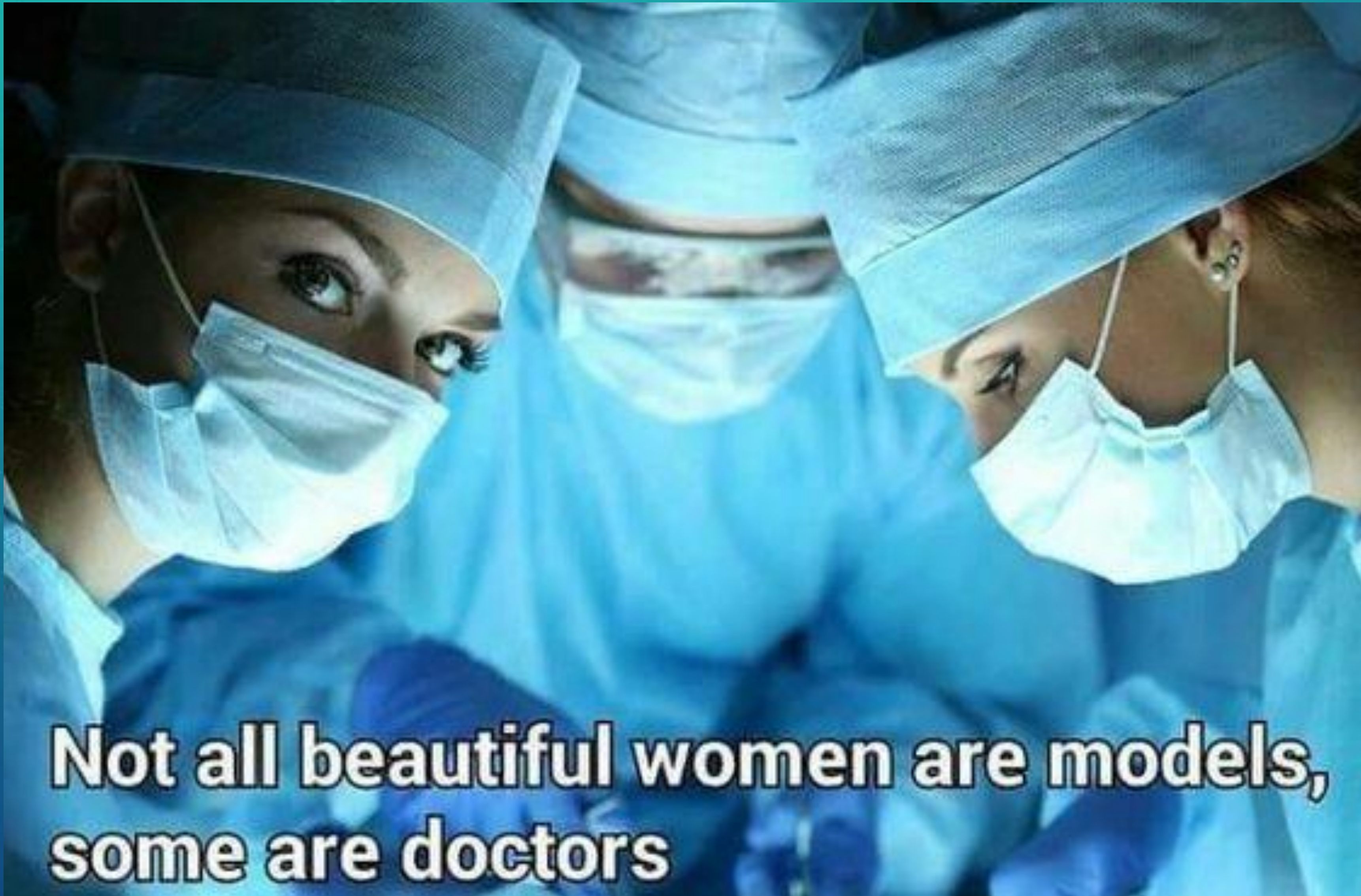
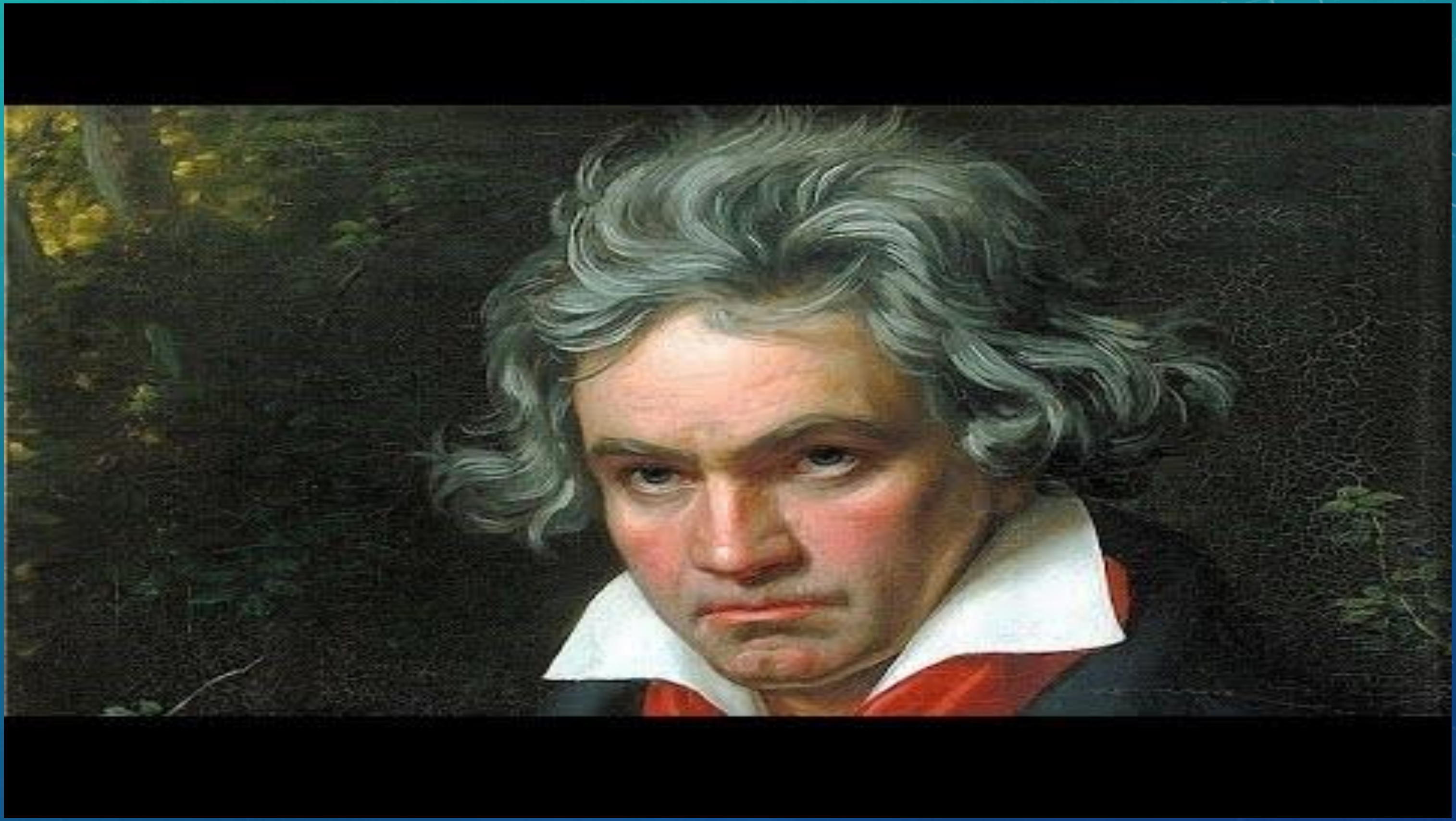

IF YOU CHANGE THE WAY YOU LOOK AT THINGS, THE THINGS YOU LOOK AT CHANGE.
G Q A N D W


WE ARE SUPERHEROES


Not all beautiful women are models,
some are doctors

# Best Teacher Ever! 😂

# DOES ANYONE KNOW WHO THIS IS????



https://www.youtube.com/watch?v=_mVW8tgGY_w

# BELIEVE IT OR NOT ….

History :

Ludwig van Beethoven, the famous 18th century composer who was almost completely deaf, discovered Bone Conduction.

Beethoven found a way to hear the sound of the piano and clenching it in his teeth.

He received perception of the sound when vibrations transfer from the piano to his jaw.

This has proven that sound could reach our auditory system throw another medium besides eardrums and the other medium is our bones.

# Physiology of Hearing

DR SARAH SHAHID
ASSISTANT PROFESSOR
PHYSIOLOGY

# TYMPANIC MEMBRANE & OSSICULAR SYSTEM

MIDDLE EAR

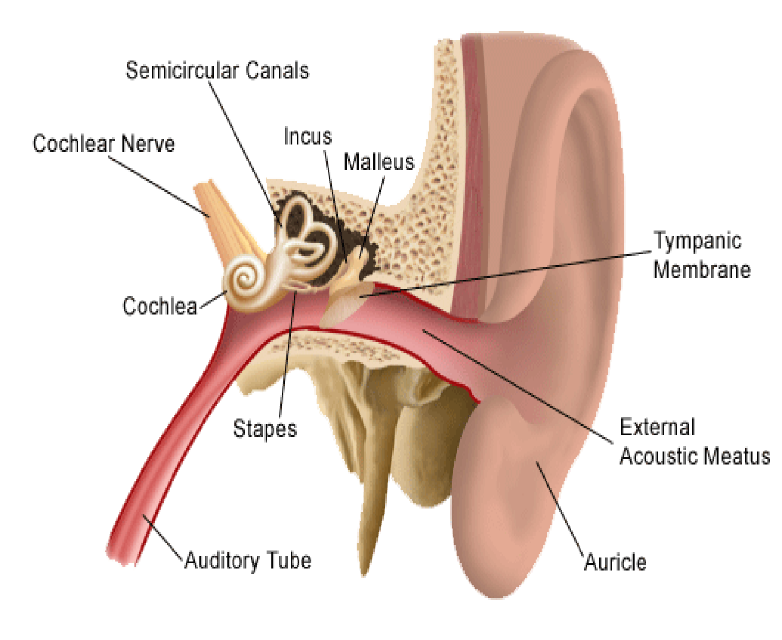
# LEARNING OBJECTIVES

- **Describe the conduction of sound from tympanic membrane to cochlea**
- **Describe the Impedance matching by the Ossicular system**
- **Describe the attenuation of sound by contraction of Tensor tympani and Stapedius muscle**
- **Describe the sound transduction** through bone

# RECALL OUR KNOWLEDGE… STRUCTURE OF HUMAN EAR

- 3 Parts

1. **External**
2. **Middle**
3. **Inner**



## External Ear

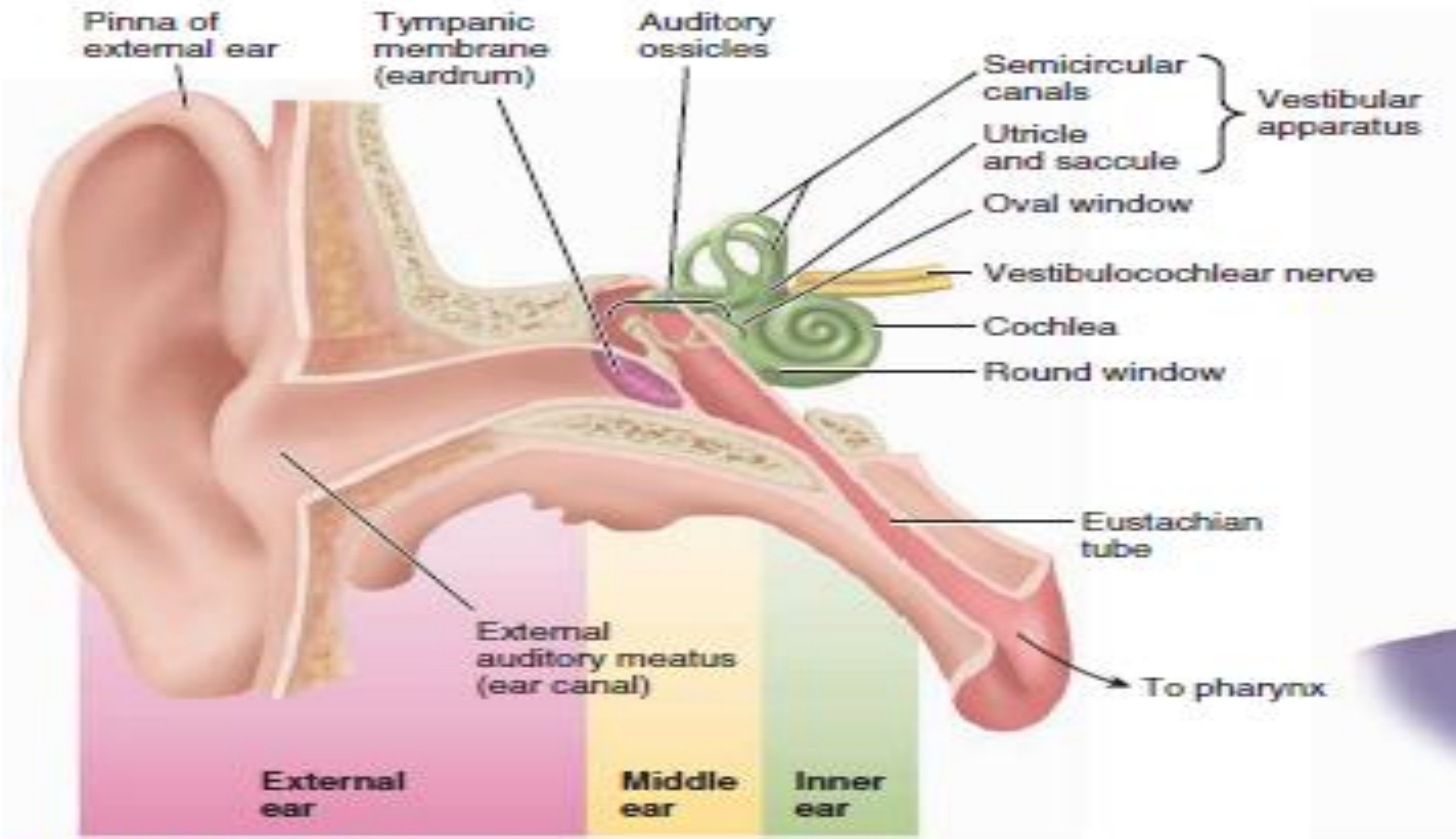
- has 2 parts:

- ➢ **Auricle**
- ➢ **External auditory meatus**

## Middle Ear

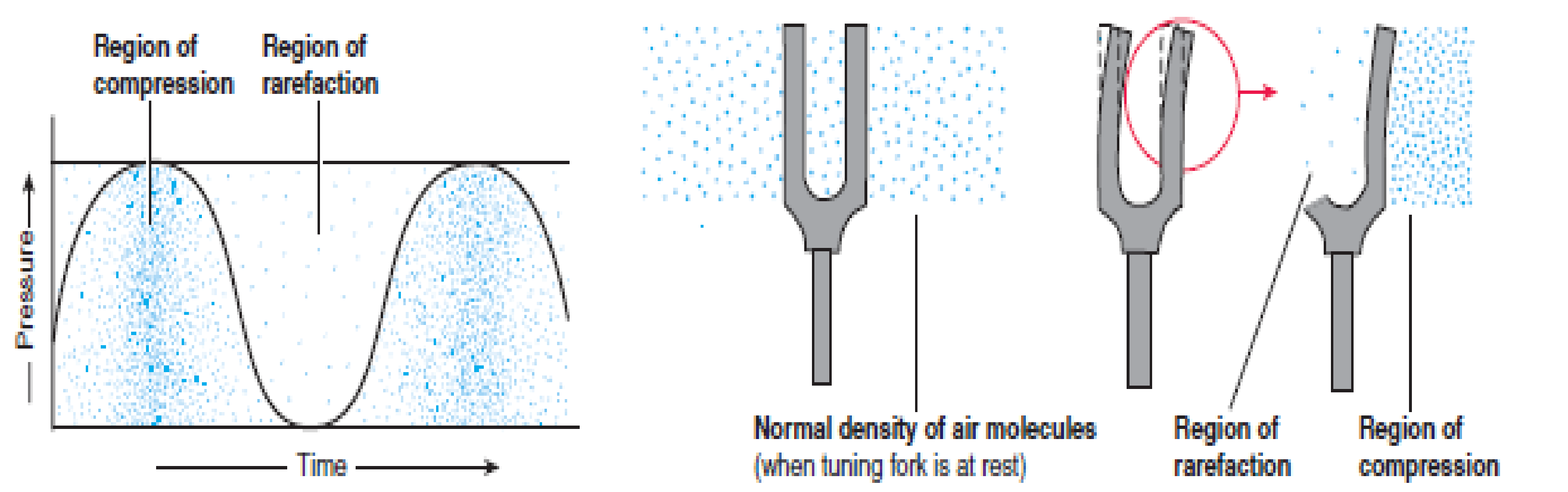
- ➢ **Tympanic cavity** with auditory ossicles
- ➢ **two small muscles**
- ➢ **Auditory tube**

# PARTS OF HUMAN EAR

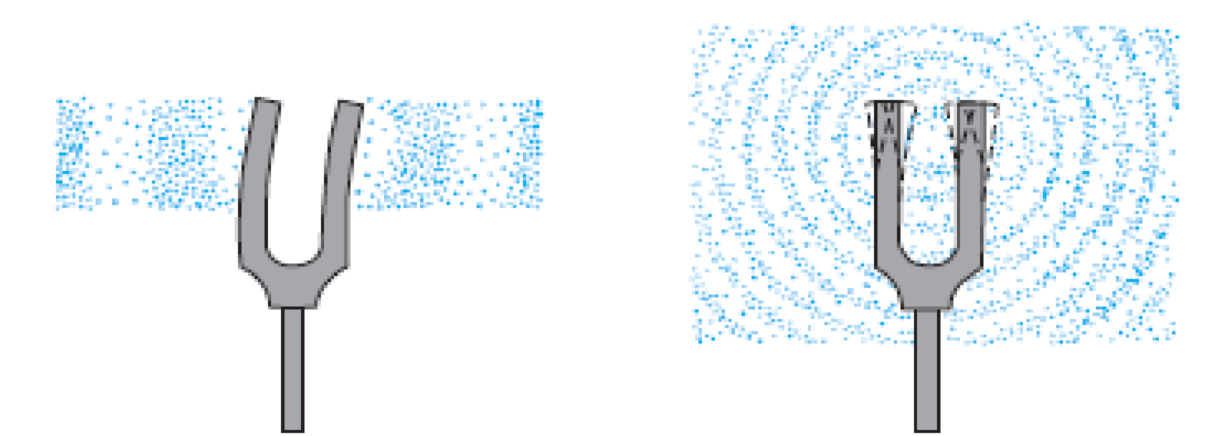



● FIGURE 6-32 Anatomy of the ear.

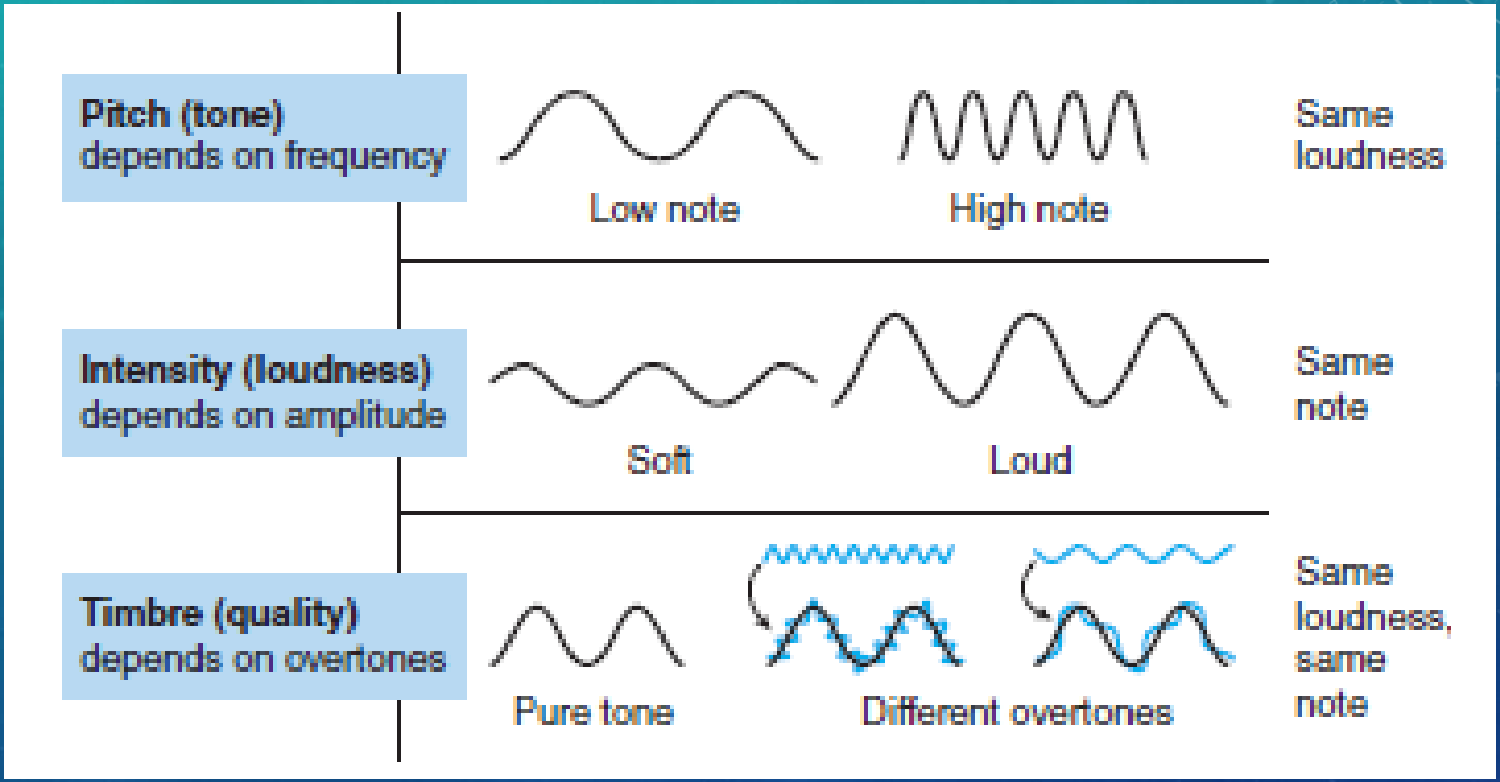
# FORMATION OF SOUND WAVES



(a) Sound waves (b) Tuning fork setting up sound waves


(c) Sound waves traveling from source

# PROPERTIES OF SOUND WAVES



# FREQUENCY RANGE OF HEARING

- A young person can hear between 20 and 20,000 cycles per second.
- In old age this range is shortened to 50 to 8000 cycles per second or less.

# MIDDLE EAR

**1/ TYMPANIC CAVITY**

small chamber within the temporal bone →

**AUDITORY OSSICLES**

a/ MALLEUS
b/ INCUS
c/ STAPES

Tympanic Membrane → separates the middle ear from external auditory meatus

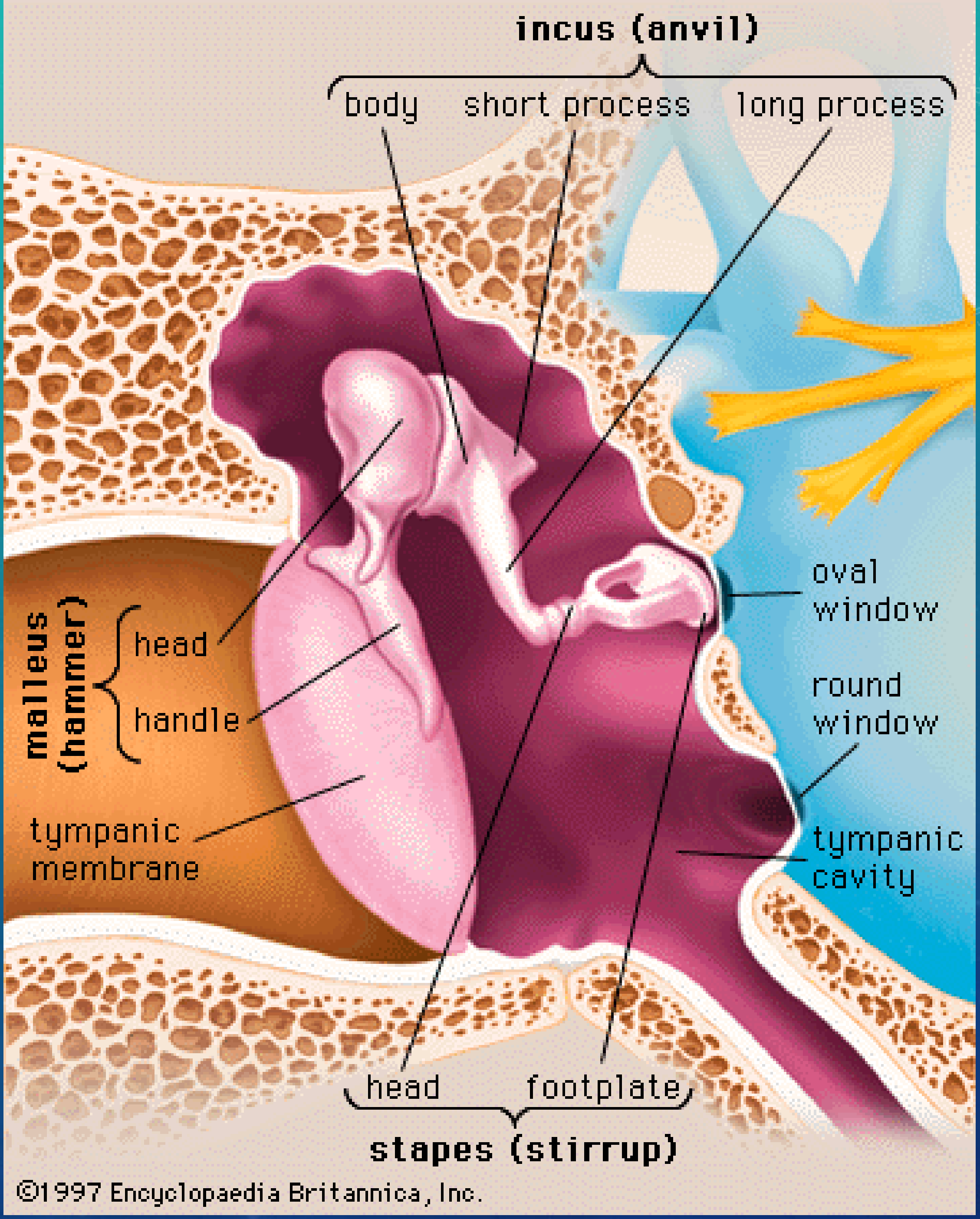
**2/ AUDITORY MUSCLES**

**a/ TENSOR TYMPANI** keeps tympanic membrane tense, attached to tympanic membrane through malleus

**b/ STAPEDIUS** lies on the posterior wall of tympanic cavity and is inserted into the neck of stapes

**3/ AUDITORY TUBE**

a narrow canal extending from anterior wall of middle ear to the nasopharynx and forms passage between middle ear and nose


incus (anvil)
body
short process
long process
malleus (hammer)
head
handle
tympanic membrane
oval window
round window
tympanic cavity
head
footplate
stapes (stirrup)
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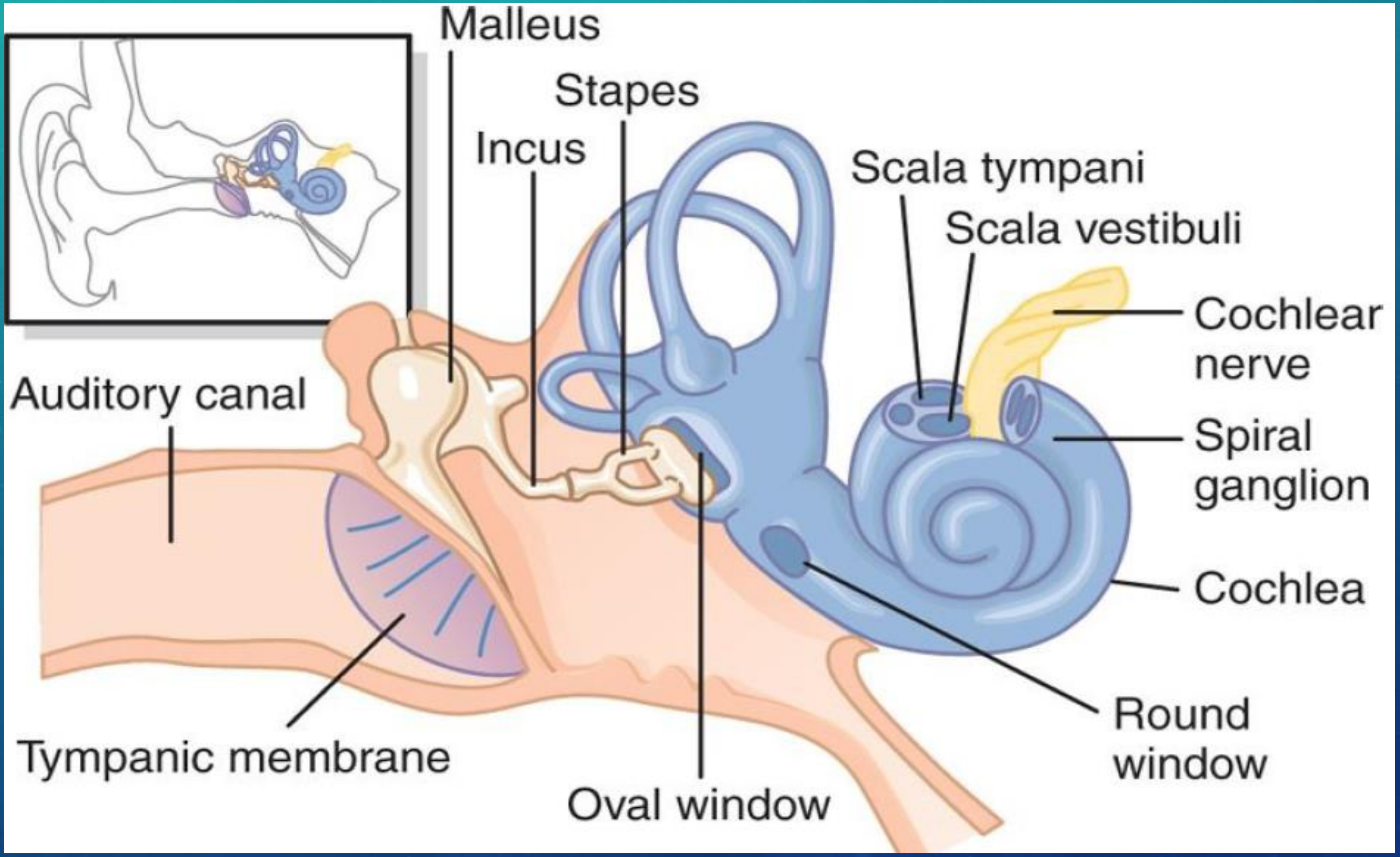
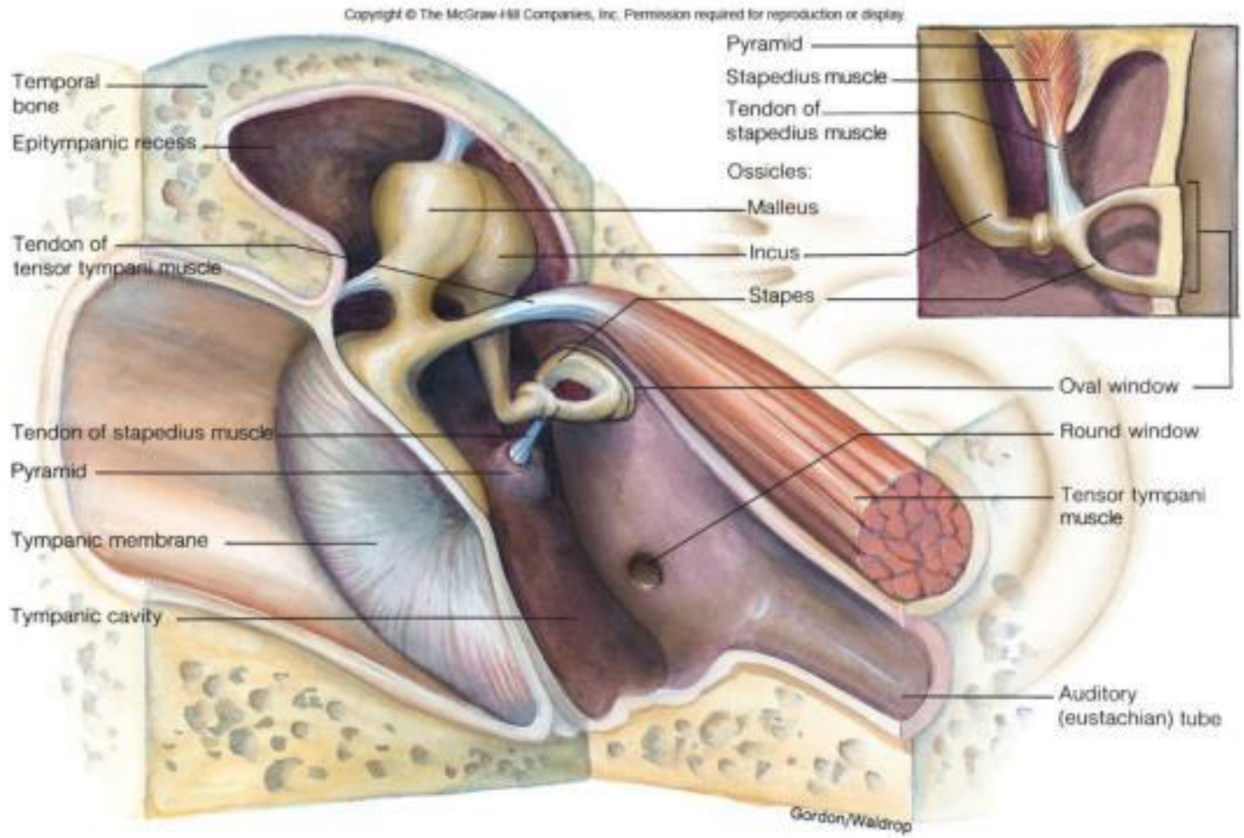
# TYMPANIC MEMBRANE, OSSICULAR SYSTEM OF MIDDLE AND INNER EAR



# The middle ear conducts sound- and the stapedius muscle protects it



FUNCTIONS OF MIDDLE EAR-

# CONDUCTION, PROTECTION, TRANSDUCER, AMPLIFIER

- **Conduction**

**-conducts sound** from the outer ear to the inner ear

- **Protection**

-Creates a barrier that protects the middle and inner areas from foreign objects

- -Middle ear muscles provide protection from loud sounds
- **Transducer**
- -Converts acoustic energy to mechanical energy
- **Amplifier**
- - Transformer action of the middle ear

# INTERNAL EAR

- Internal ear or labyrinth is a membranous structure enclosed in petrous part of temporal bone

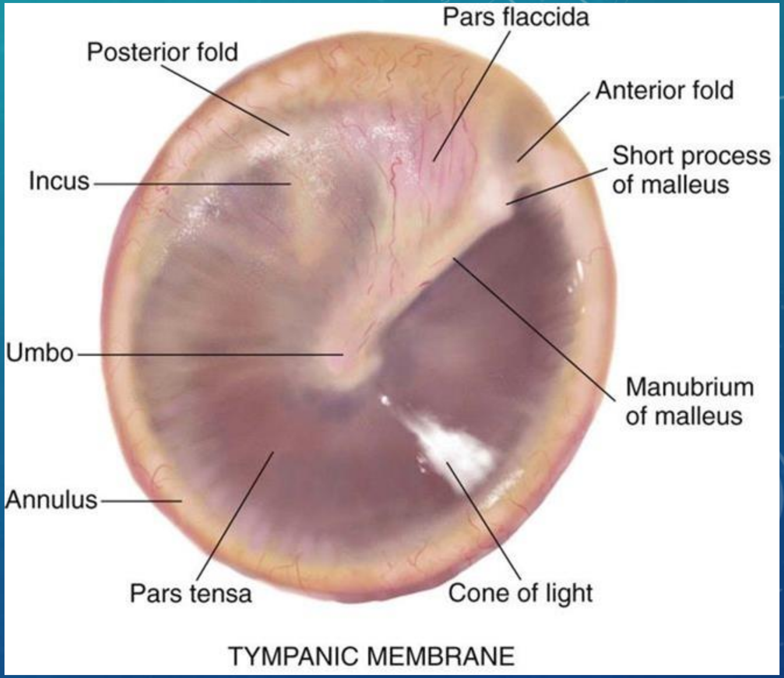
- It has 2 sense organs

1. HEARING
2. EQUILIBRIUM

- **Organ of hearing is cochlea**
- **Organ of equilibrium is vestibular apparatus**

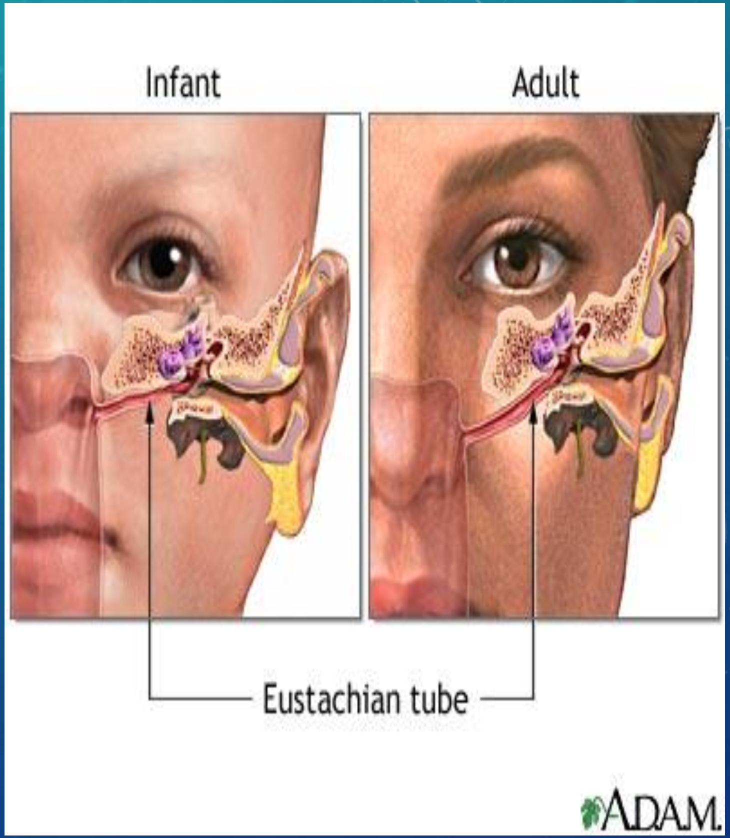
# TYMPANIC MEMBRANE

- The eardrum separates the outer ear from the middle ear
- Creates a barrier that protects the middle and inner areas from foreign objects
- Cone-shaped in appearance
- Surface area is 55 sq m
- The eardrum vibrates in response to sound pressure waves.



# THE EUSTACHIAN TUBE

- Eustachian connects the front wall of the middle ear with the nasopharynx
- operates like a valve, which opens during swallowing and yawning
- equalizes the pressure on either side of the eardrum, which is necessary for optimal hearing.
- Not directly involved in hearing

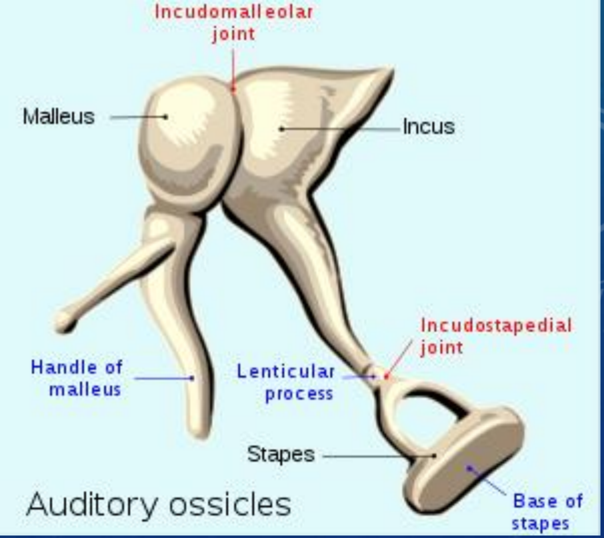


# AUDITORY OSSICLES

These are the smallest three bones of the body, connected by synovial joints

## Malleus

- Word malleus is Latin for hammer
- It is the first bone of the middle ear
- The handle of malleus is attached with internal surface of eardrum
- Head of malleus is attached with body of incus.
- The primary function of the malleus is the transmission of sound waves or vibrations from the eardrum to the incus

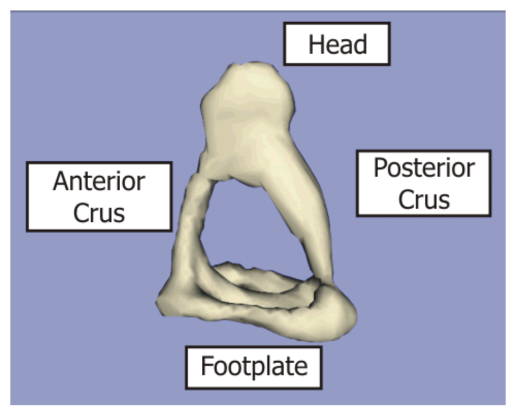


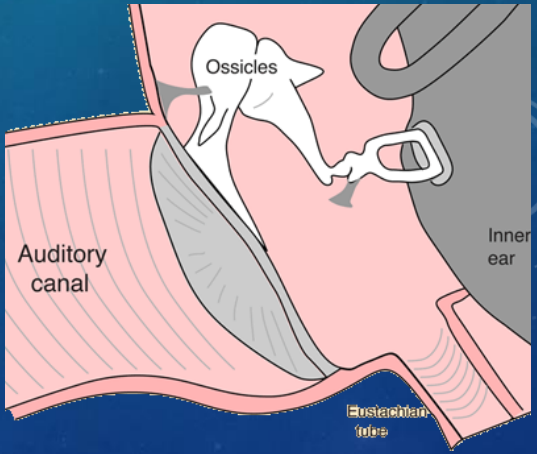
# INCUS (ANVIL)

- Articulates with head of stapes
- located in between the malleus and the stapes
- The incus transmits vibrations from the malleus to the stapes

# STAPES

- It is the smallest and lightest bone of the human body
- The stapes connects to the incus on the outward side and to the oval window on the inward side.
- The primary function of the stapes is transmitting sound waves from the incus to the membrane of the inner ear.
- The base or footplate of stapes fits into oval window



# IMPEDANCE MATCHING

- *the force delivered through the mechanical advantages of the lever action of the tympanic ossicles and the areal ratio of the tympanic membrane to the oval window to overcome the acoustic **impedance** between the ambient air and the fluid in the inner **ear**.*

**Middle ear is an efficient impedance transformer**

# TWO PROCESSES ARE INVOLVED IN THE IMPEDANCE MATCHING MECHANISM OF MIDDLE EAR

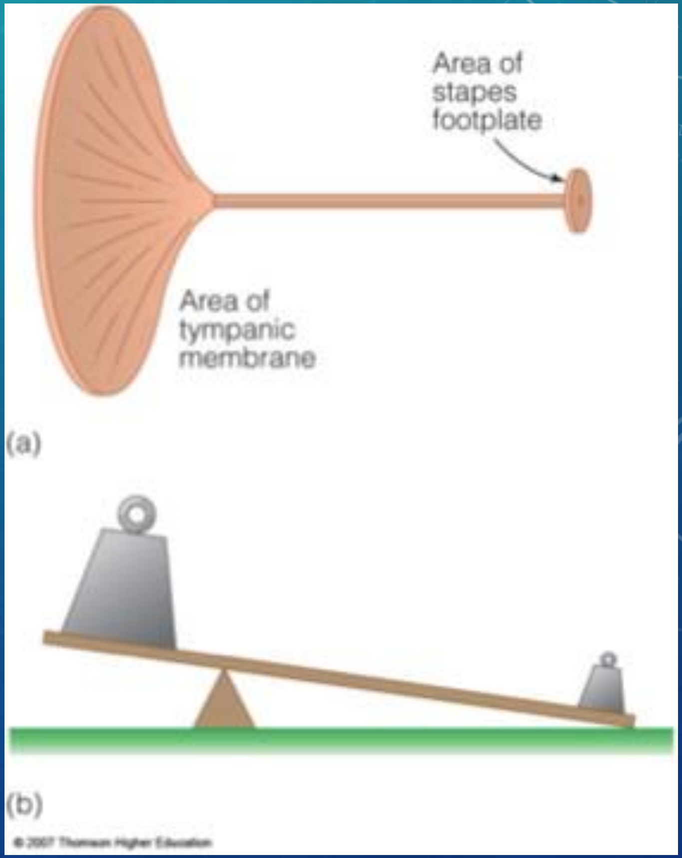
- **The area of the tympanic membrane is larger than that of the stapes foot plate in the cochlea. The forces collected over the ear drum are concentrated over a smaller area, thus increasing the pressure over oval window. The pressure is increased by the ratio of these two areas i.e. 17 times.**
-

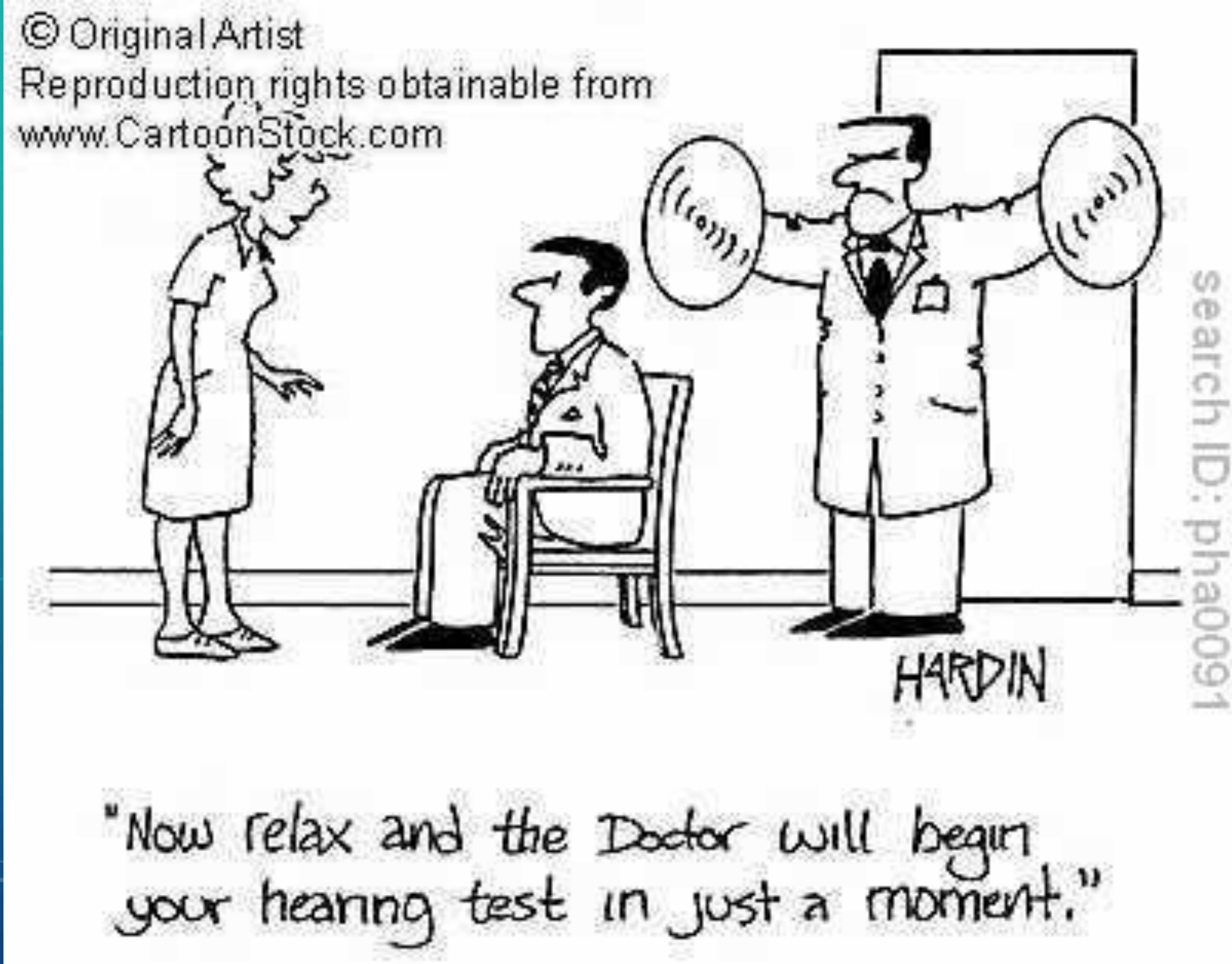
# TWO PROCESSES ARE INVOLVED IN THE IMPEDANCE MATCHING MECHANISM OF MIDDLE EAR

- **The second process is the lever action of the middle ear bones. The arm of the incus is shorter than that of the malleus, and this produces a lever action that increases the force at the stapes. Since the malleus is 1.3 times longer than the incus, the lever action multiplies the force by 1.3 times.**

# MIDDLE EAR IS AN EFFICIENT IMPEDANCE TRANSFORMER

- *The primary function of the middle ear is that of an impedance* transformer.
- ➢ Diameter of TM is 17 times the diameter of oval window
- ➢ Ossicular lever action increases pressure 1.3 times
- ➢ Total increase will be 22 times




© Original Artist
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www.CartoonStock.com
search ID: pha0091
HARDIN
"Now relax and the Doctor will begin your hearing test in just a moment."

# ATTENUATION REFLEX

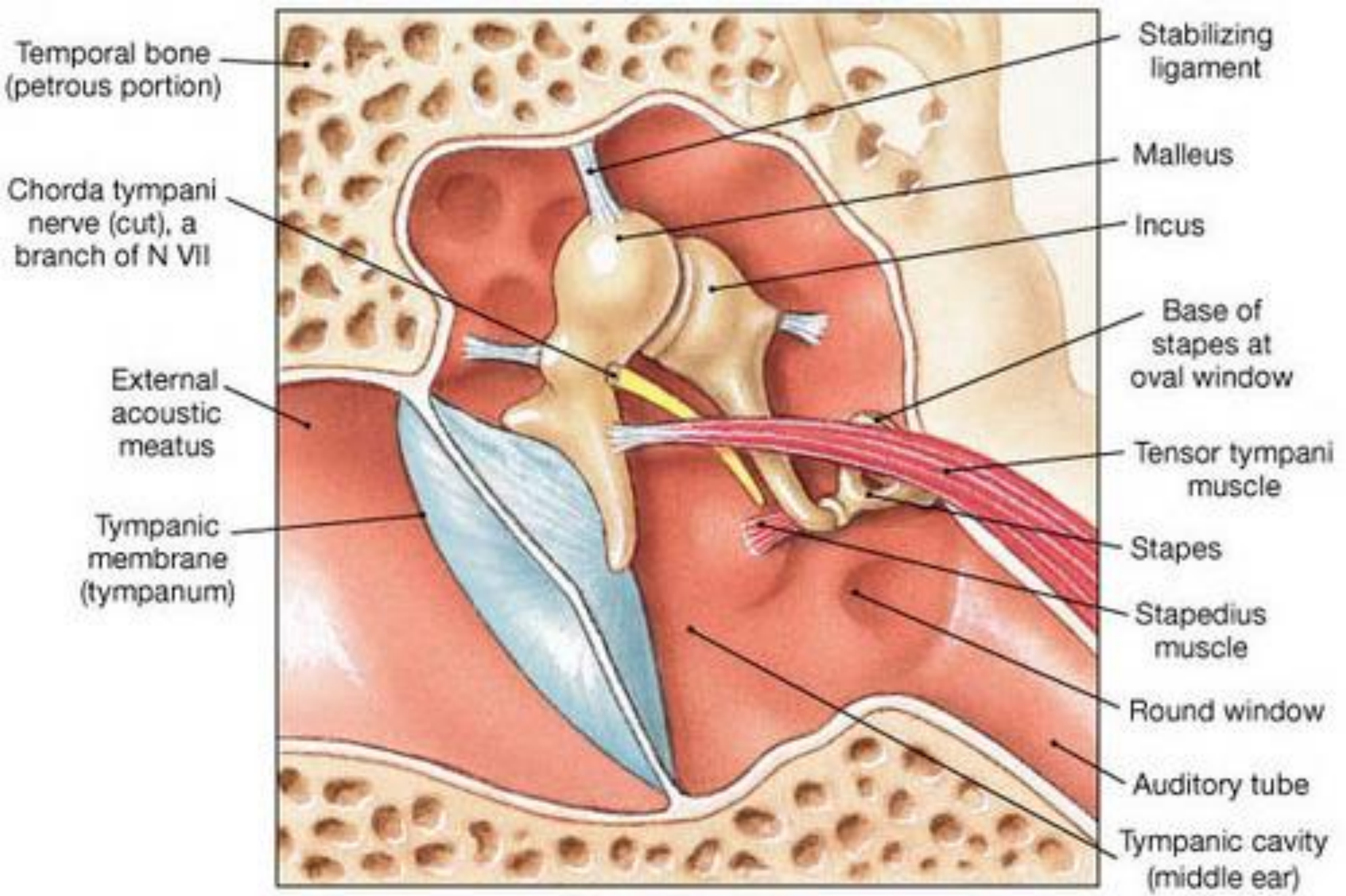
- also known as acoustic reflex
- an involuntary muscle contraction that occurs in the middle ear in response to loud sound stimuli or when the person starts to vocalize.

# ATTENUATION REFLEX

- When loud sounds are transmitted through the ossicular system and from there into the central nervous system, a reflex occurs after a latent period of only 40 to 80 milliseconds to cause contraction of the *stapedius muscle* and, to a lesser extent, the *tensor tympani muscle*.
- The tensor tympani muscle pulls the handle of the malleus inward while the stapedius muscle pulls the stapes outward.

- These two forces oppose each other and thereby cause the entire ossicular system to develop increased rigidity, thus greatly reducing the ossicular conduction of low-frequency sound, mainly frequencies below 1000 cycles per second.

- This *attenuation reflex* can reduce the intensity of lower-frequency sound transmission by 30 to 40 decibels, which is about the same difference as that between a loud voice and a whisper.




(b) The middle ear

# THE FUNCTION OF THIS MECHANISM IS BELIEVED TO BE TWOFOLD:

- 1. To *protect* the cochlea from damaging vibrations caused by excessively loud sound.
- 2. To *mask* low-frequency sounds in loud environments. This usually removes a major share of the background noise and allows a person to concentrate on sounds above 1000 cycles per second, where most of the pertinent information in voice communication is transmitted

- Another function of the tensor tympani and stapedius muscles is to decrease a person’s hearing sensitivity to his or her own speech. This effect is activated by collateral nerve signals transmitted to these muscles at the same time that the brain activates the voice mechanism

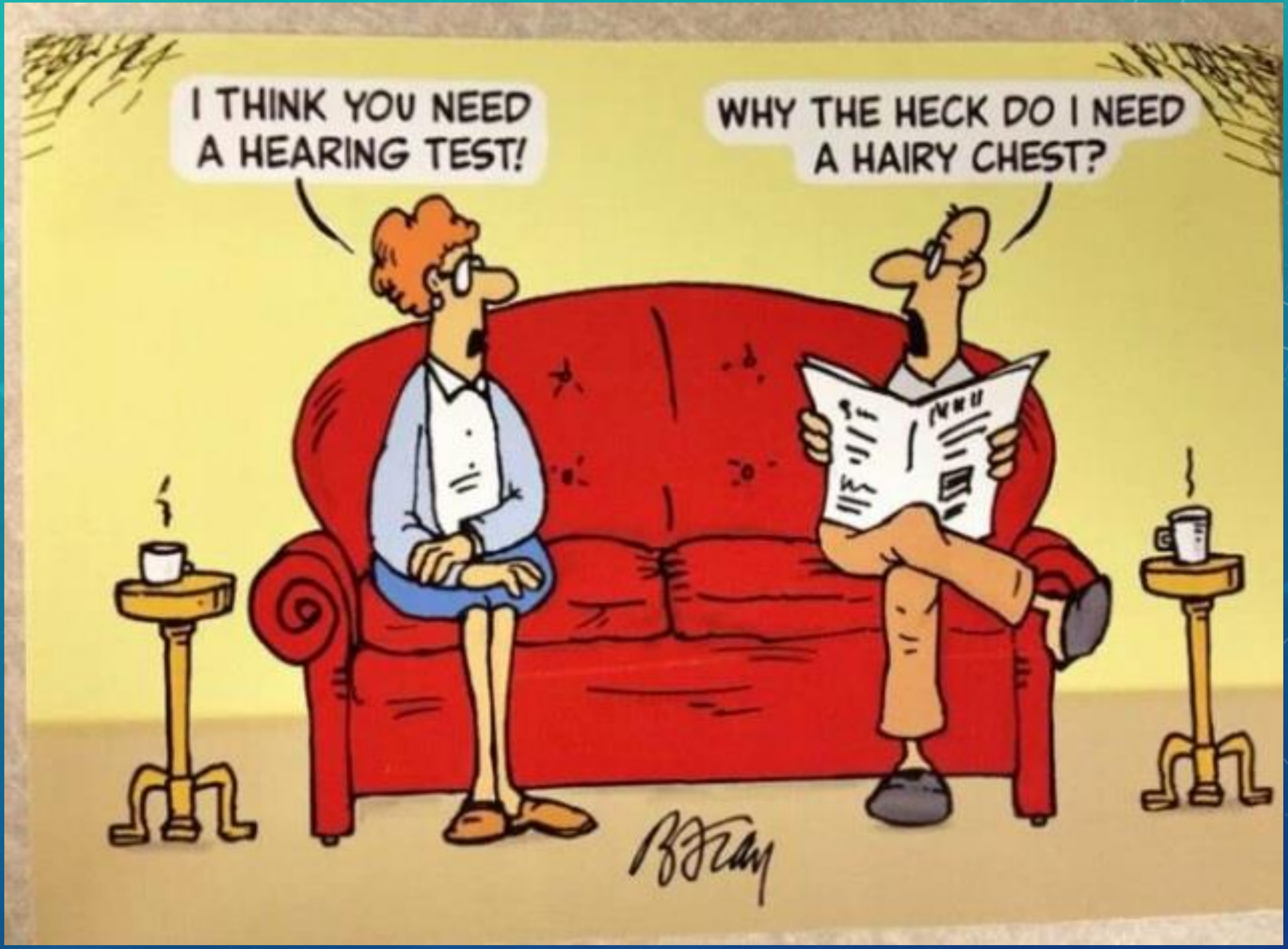
# TRANSMISSION OF SOUND THROUGH BONE

- Because the inner ear, the *cochlea*, is embedded in a bony cavity in the temporal bone, called the *bony labyrinth*, vibrations of the entire skull can cause fluid vibrations in the cochlea itself.
- Therefore, a tuning fork or an electronic vibrator placed on any bony protuberance of the skull, but especially on the mastoid process near the ear, causes the person to hear the sound.
- However, the energy available even in loud sound in the air is not sufficient to cause hearing via bone conduction unless a special electromechanical sound-amplifying device is applied to the bone.

- https://www.youtube.com/watch?v=qgdqp-oPb1Q

- https://www.youtube.com/watch?v=m_9SqIQ0BQQ

- https://www.youtube.com/watch?v=flIAxGsV1q0


I THINK YOU NEED A HEARING TEST!
WHY THE HECK DO I NEED A HAIRY CHEST?


# QUESTIONS, COMMENTS, FEEDBACK…

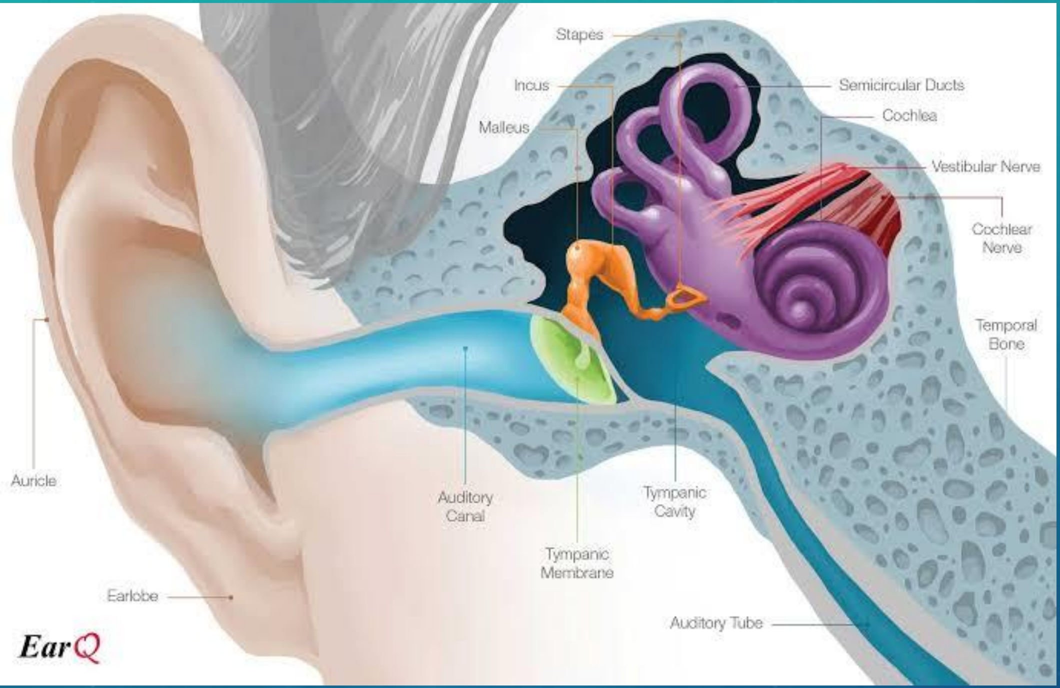
# PART 2


بسم الله
الذي لا يضر مع اسمه شيء
في الأرض ولا في السماء
وهو السميع العليم
@PEARLA0203


Asma ul Husna
اَلسَّمِيعُ
As-Sami'
The All-Hearer
26
#BlessedRamadhan

# Can you hear me calling?

*When darkness falls in the forests of the Upper Amazon Basin, the males of this species of spiny devil katydid (Panacanthus cuspidatus) begin to sing. Their loud, high-pitched, whistle-like songs travel high into the air to reach the ears of listening females.*
*(The left ear with its two eardrums is visible just below the creature's left "knee." )*




# PHYSIOLOGY OF THE INNER EAR

## BY DR SARAH SHAHID

# INNER EAR - the cochlea

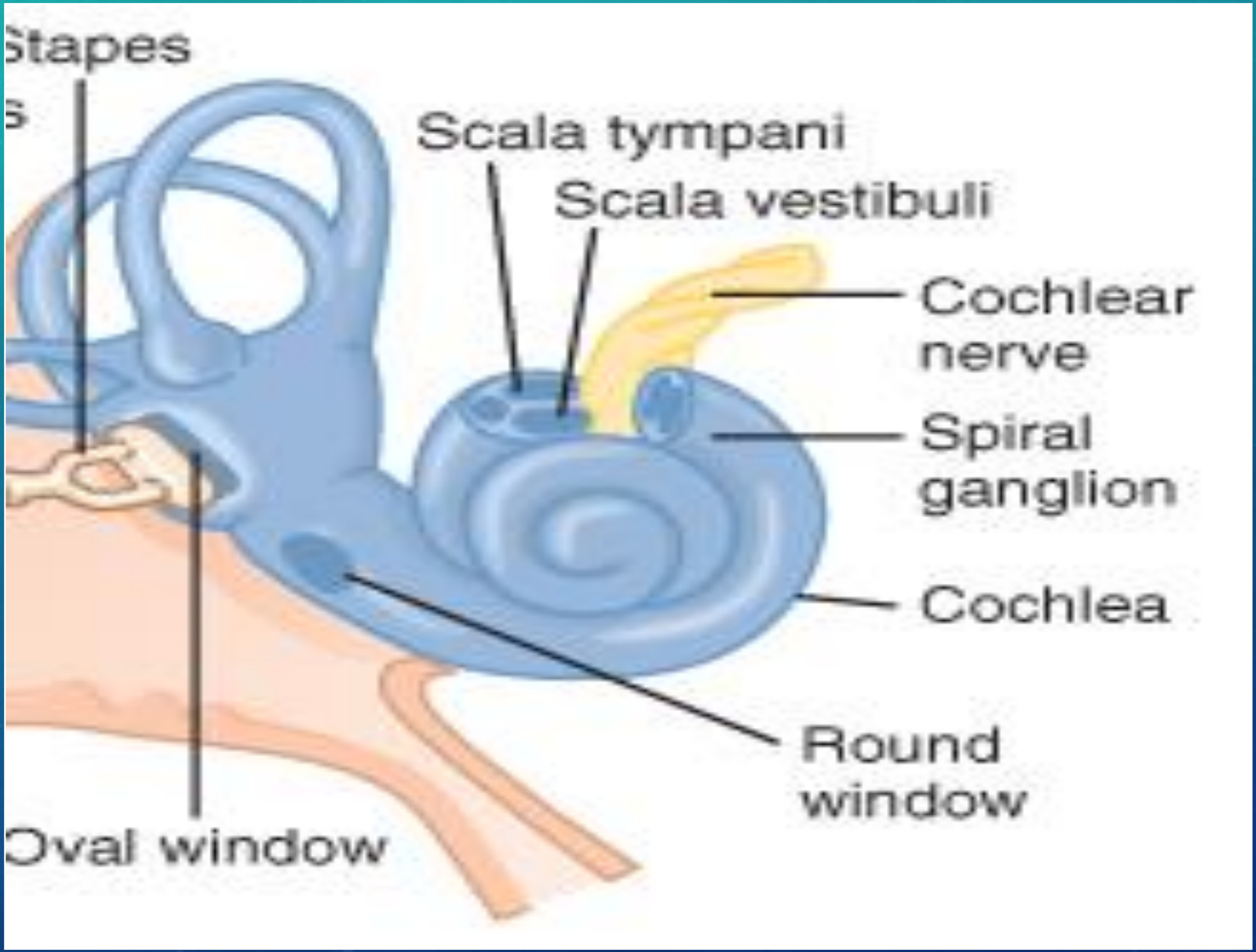
It's a coiled structure like a snails shell, consists of 2 structures:

- **Modiolus** which is a central conical axis made up of spongy bone
- **Bony canal or tube** which winds round modiolus

2 membranes Basilar and Reissner's divide the spiral canal of cochlea into 3 compartments called

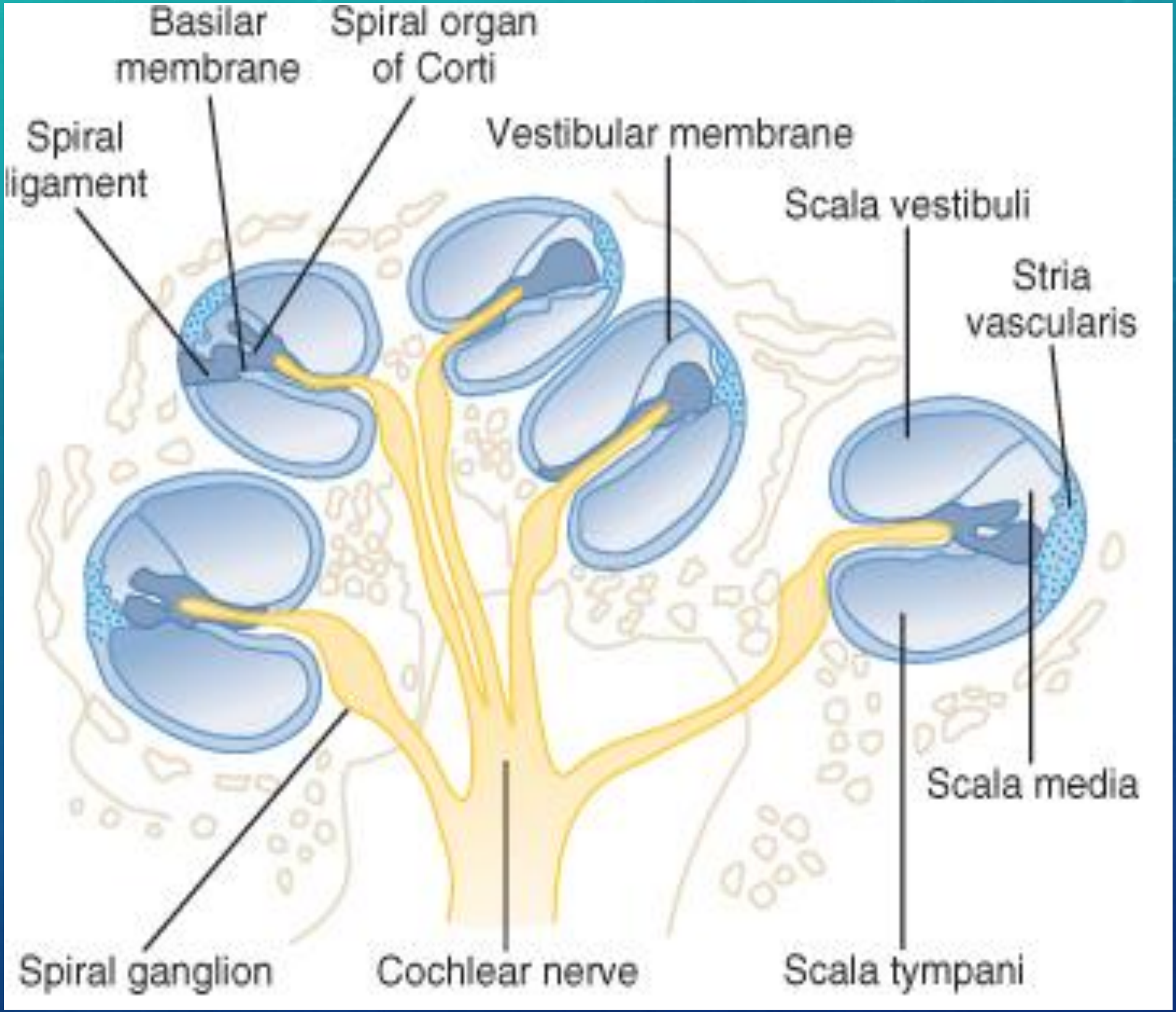
- **scala vestibuli**
- **scala tympani**
- **scala media** called cochlear duct or membranous cochlea

# COCHLEA

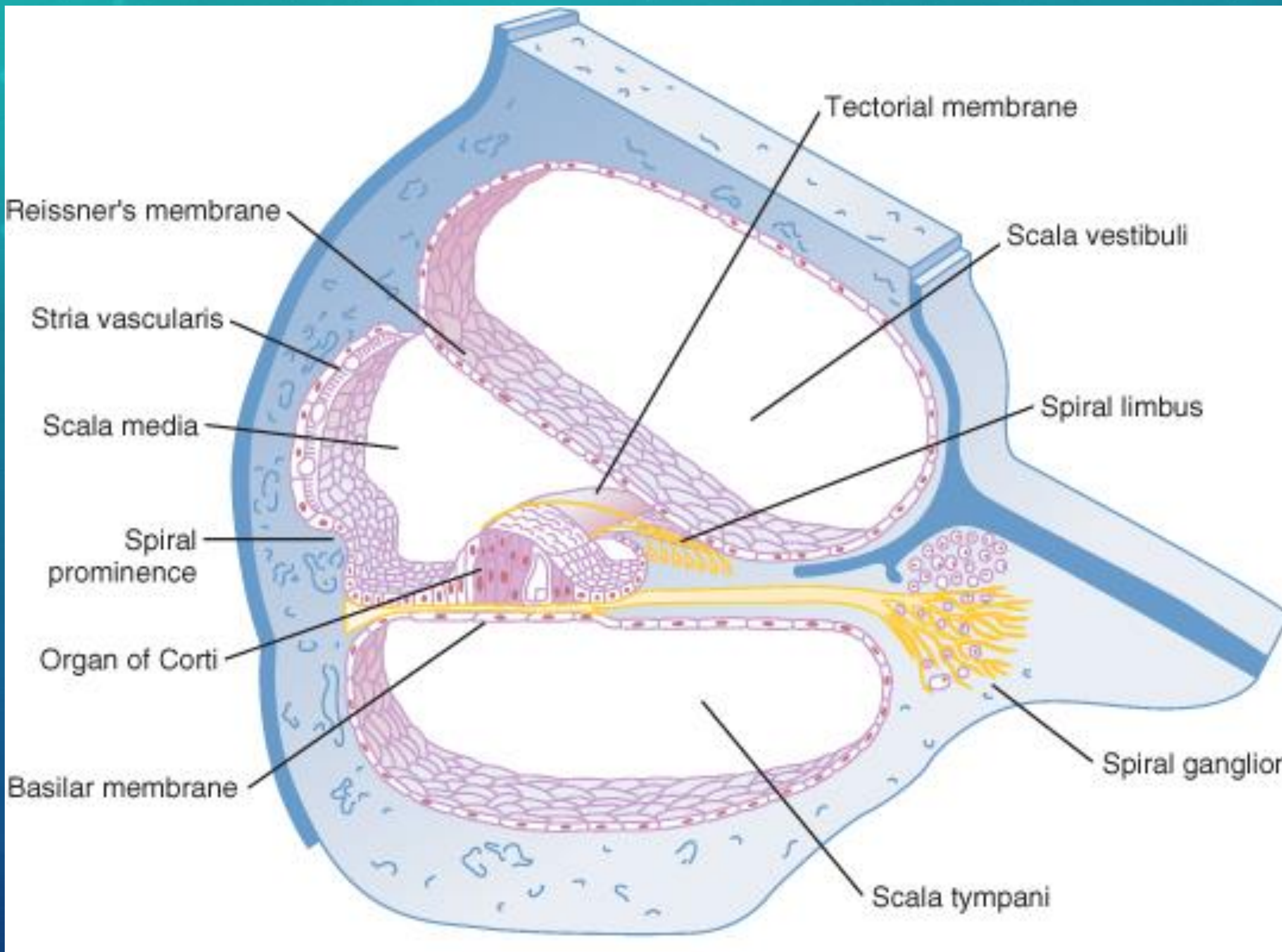


Stapes
Scala tympani
Scala vestibuli
Cochlear nerve
Spiral ganglion
Cochlea
Round window
Oval window

# COCHLEA


Basilar membrane
Spiral organ of Corti
Spiral ligament
Vestibular membrane
Scala vestibuli
Stria vascularis
Scala media
Spiral ganglion
Cochlear nerve
Scala tympani

# COCHLEA



Tectorial membrane
Reissner's membrane
Scala vestibuli
Stria vascularis
Scala media
Spiral limbus
Spiral
prominence
Organ of Corti
Basilar membrane
Spiral ganglion
Scala tympani

# *COCHLEA*

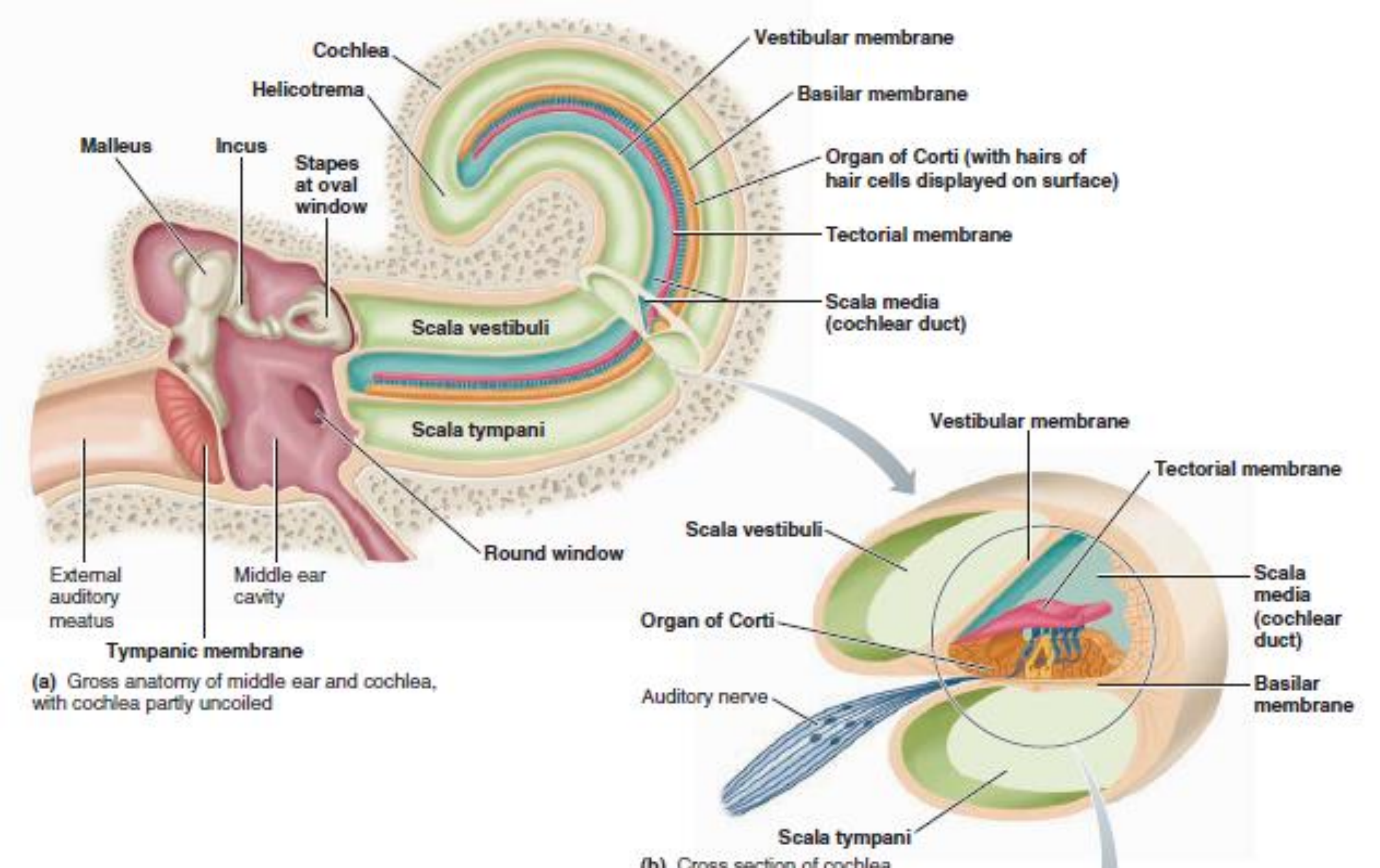
- Scala media and Scala Tympani are separated by **Basilar membrane**
- Basilar membrane deficient near the tip
- Helicotrema - S. Vestibuli and S Tympani continue with each other
- Hearing receptors “Organ of Corti” are present on Basilar membrane

# REISSNER'S MEMBRANE

- is so thin and easily moved that it does not obstruct the passage of sound vibrations from the scala vestibuli into scala media

- as far as fluid conduction of sound is concerned, scala vestibuli and scala media are considered to be a single chamber

# Middle ear and cochlea




(a) Gross anatomy of middle ear and cochlea, with cochlea partly uncoiled

(b) Cross section of cochlea

# Basilar membrane and cochlea

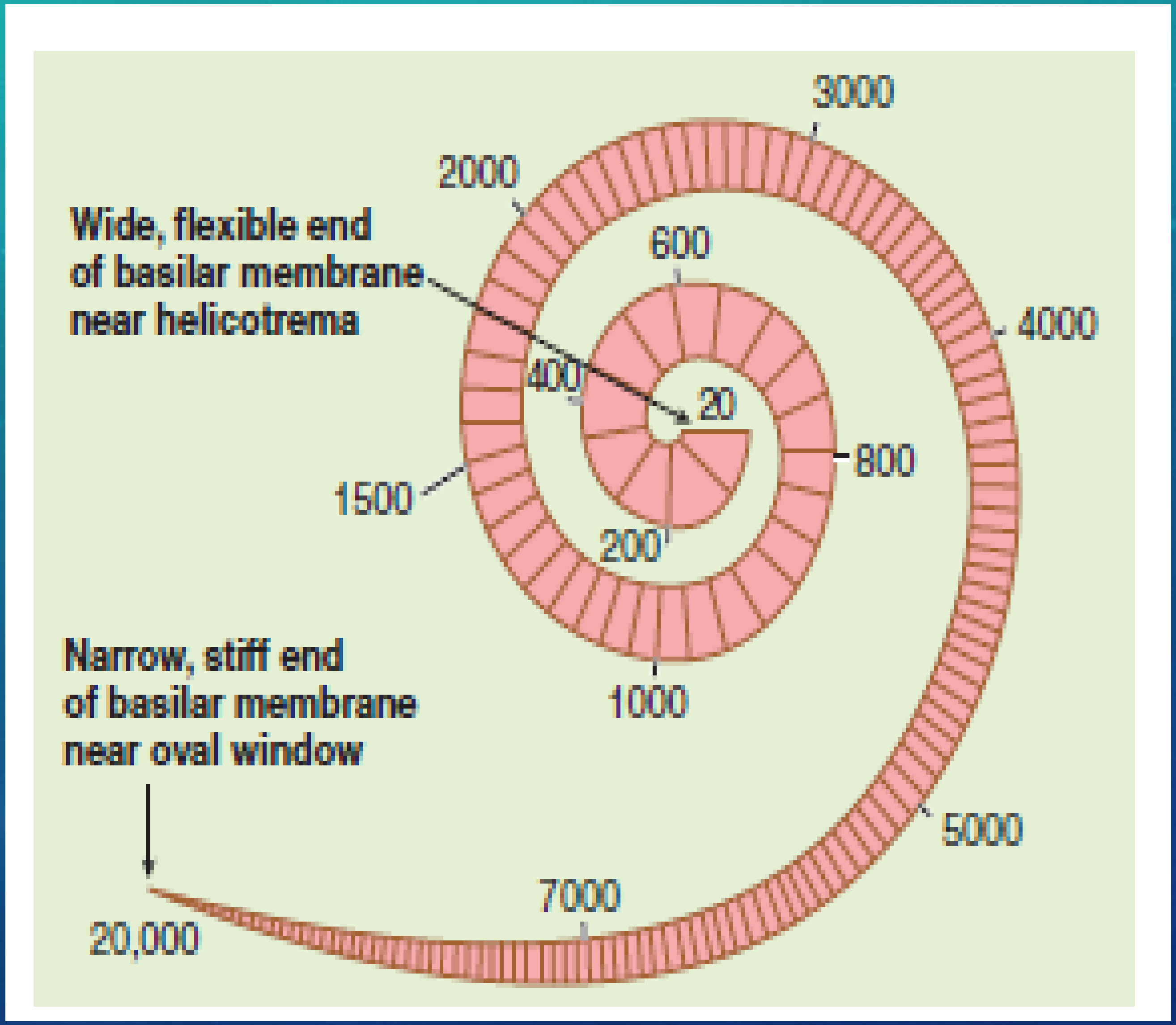
- Basilar membrane contains **20,000 to 30,000** stiff and elastic basilar fiber
- fibers are fixed at one end
- **Distal ends are free** in basilar membrane

- **Length of fibers increases** from proximal end of cochlea to distal end (0.04 mm to 0.5 mm)

- Overall **stiffness decreases 100 times**

- *Proximal fibers can vibrate at high frequencies*
- *Distal fibers can vibrate at lower frequencies*

# BASILAR MEMBRANE PARTIALLY UNCOILED



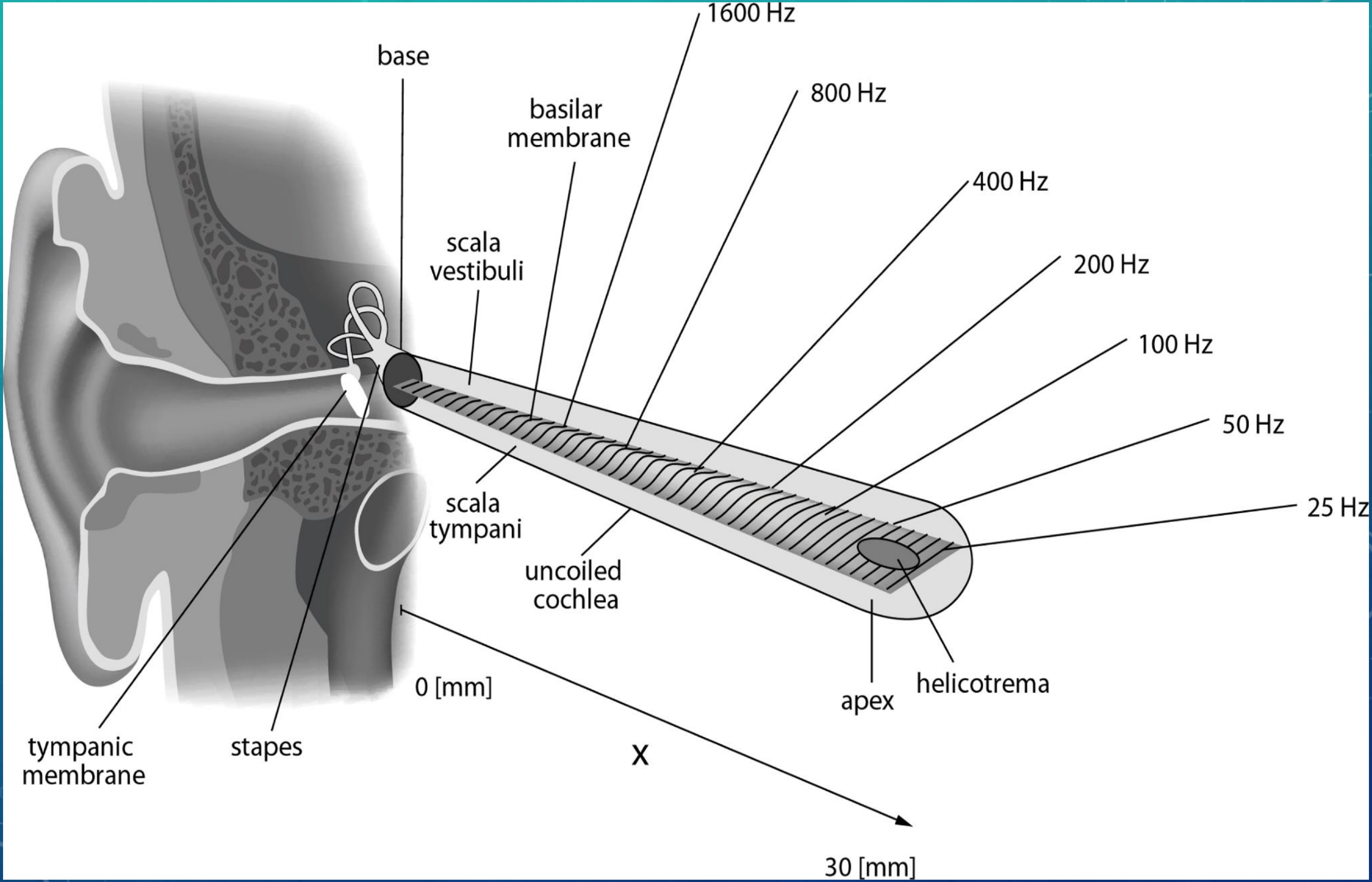
# Place principle

- **High** frequencies vibrate **proximal** portion of basilar membrane to maximum extent

- **Medium** frequencies vibrate **middle** portions

- **Low** frequencies vibrate **distal** portions

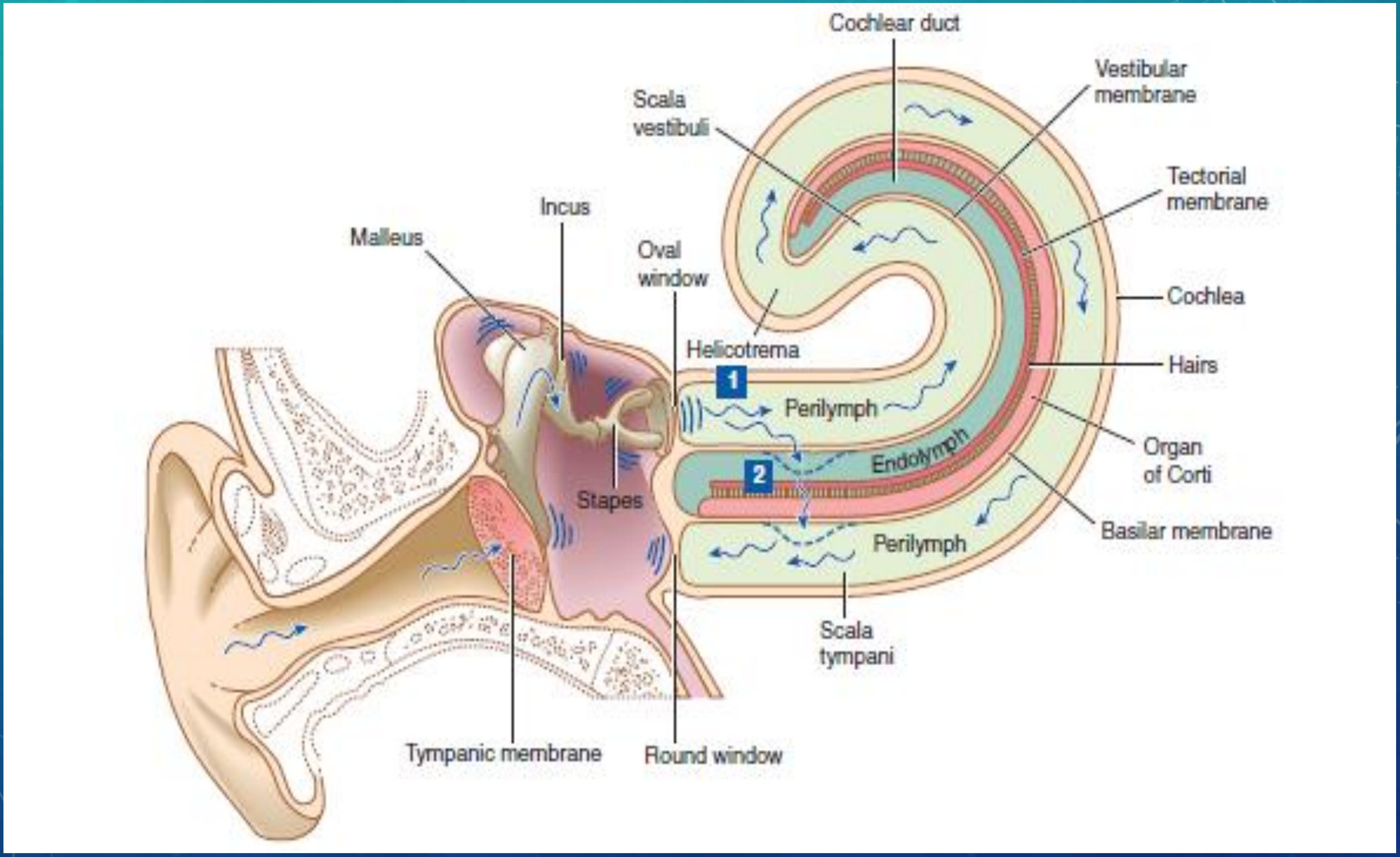
- Specific areas are connected to specific neurons
- Specific neurons are stimulated by specific frequencies


1600 Hz
base
800 Hz
basilar membrane
400 Hz
scala vestibuli
200 Hz
100 Hz
50 Hz
25 Hz
scala tympani
uncoiled cochlea
0 [mm]
apex
helicotrema
tympanic membrane
stapes
x
30 [mm]

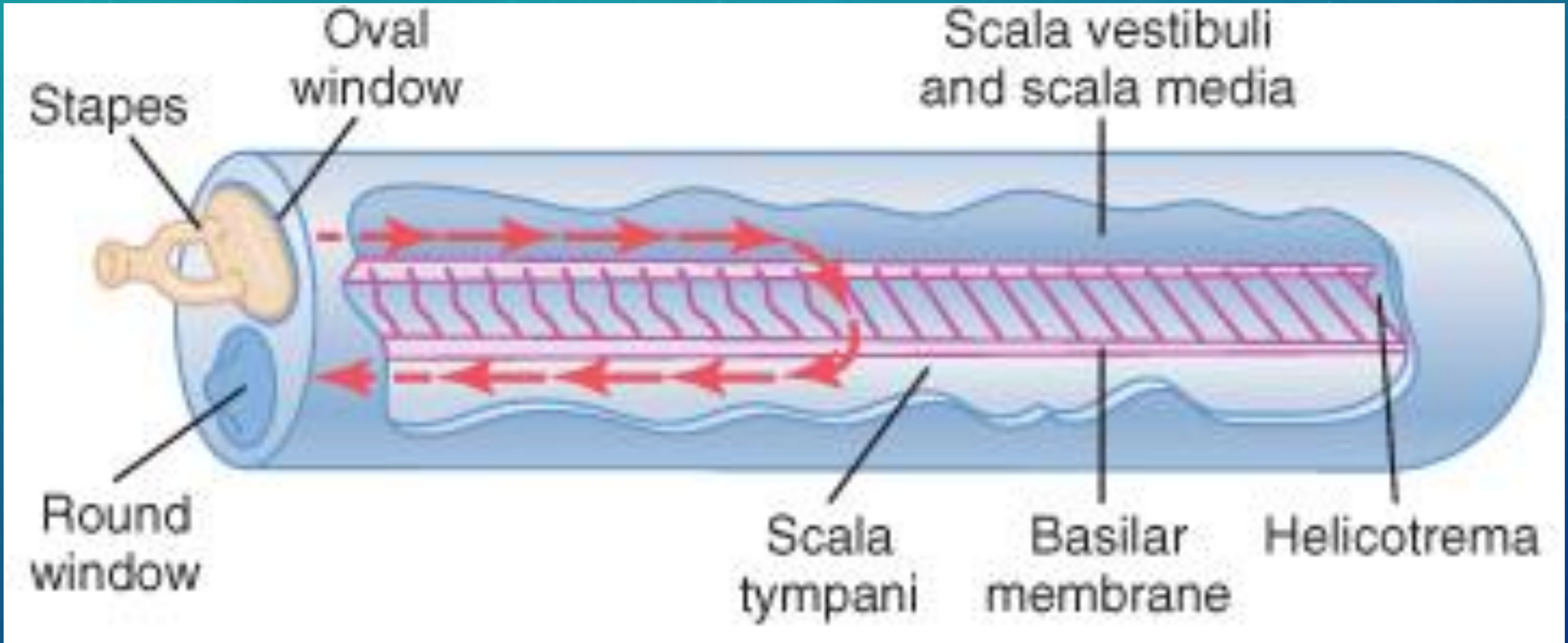
# FLUID MOVEMENT IN COCHLEA

- Sound vibrations → scala vestibuli from faceplate of stapes at oval window
- The faceplate covers this window and is connected with window's edges by a loose annular ligament so that it can move inward and outward with the sound vibrations
- **Inward movement** → fluid to move forward in scala vestibuli and scala media, and **outward movement** → fluid to move backward

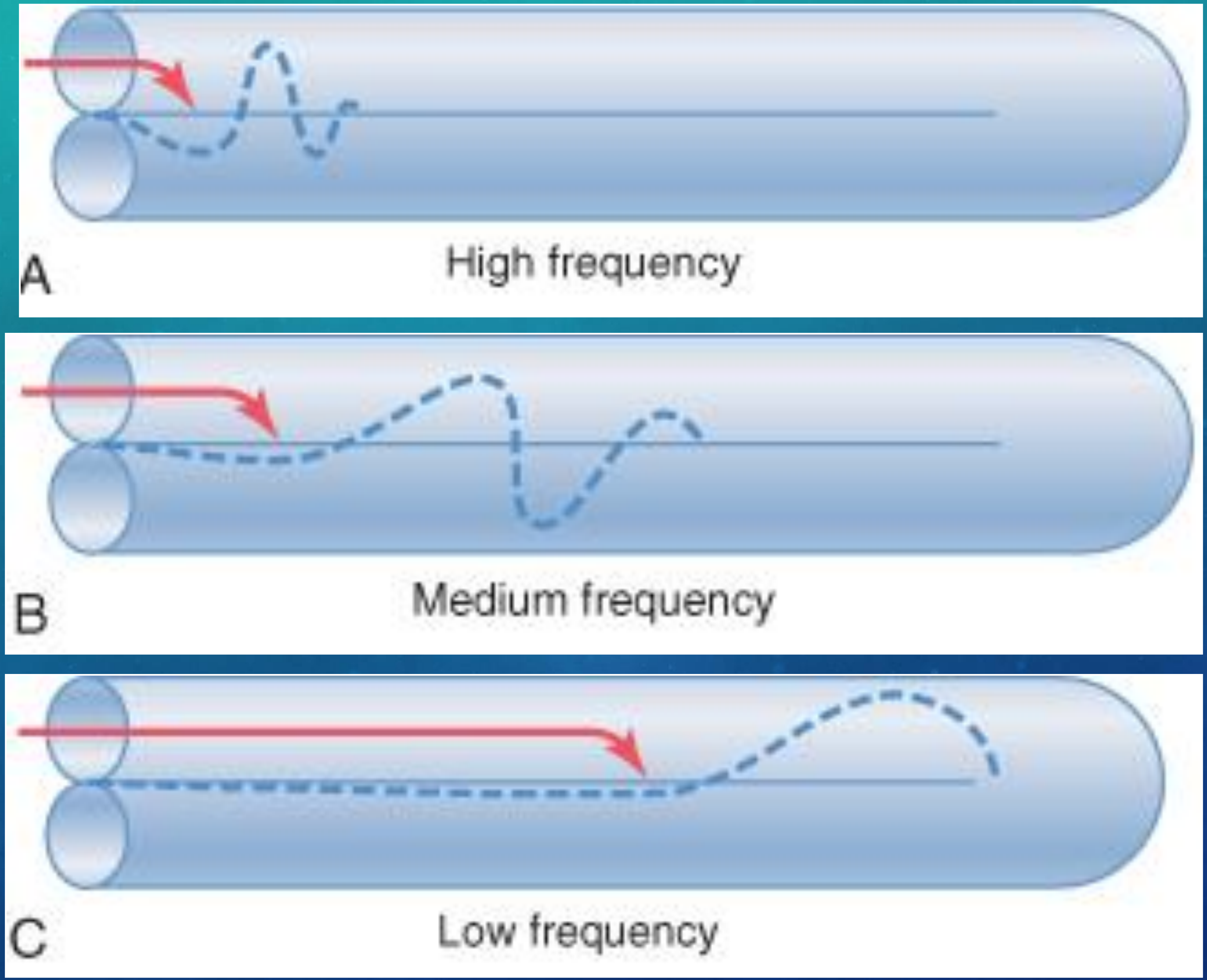
# FLUID MOVEMENT IN COCHLEA



# MOVEMENT OF FLUID IN COCHLEA



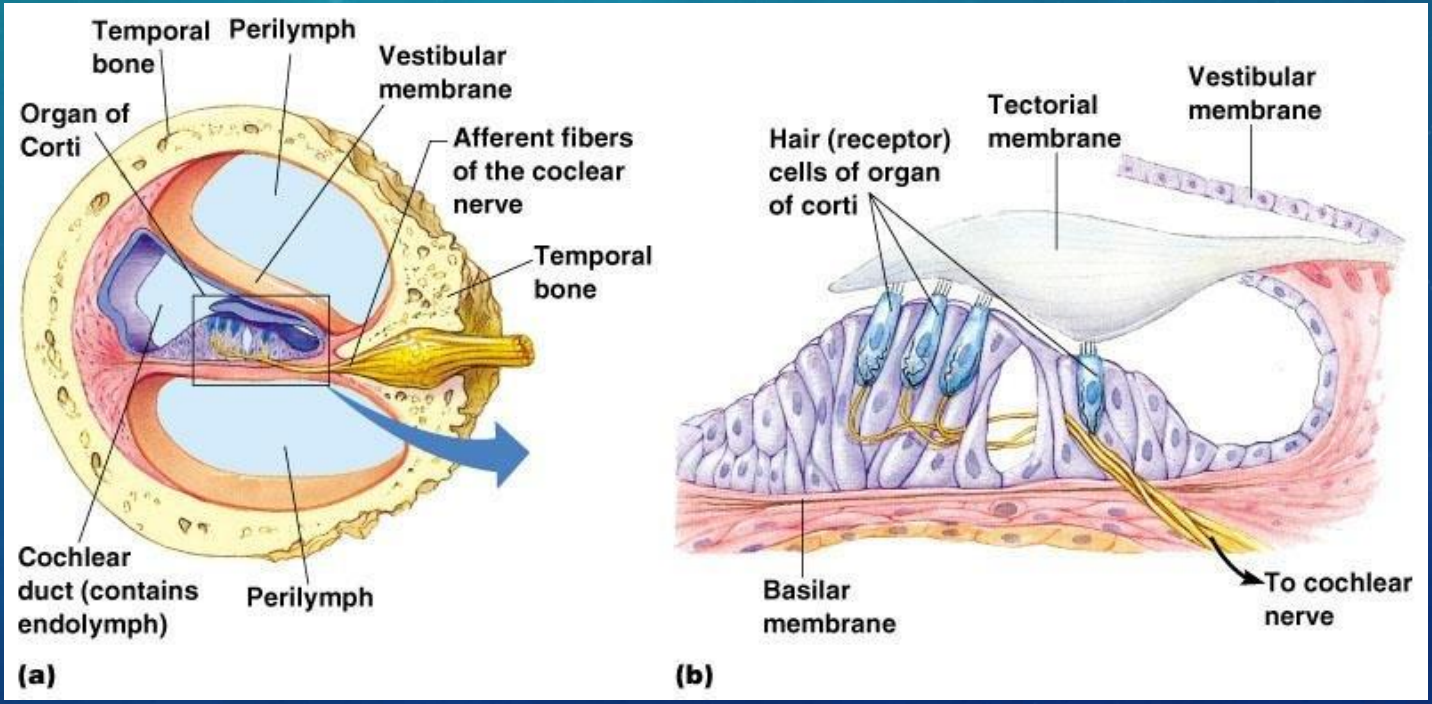
# TRAVELLING WAVE ALONG BASILAR MEMBRANE



# ORGAN OF CORTI

# ORGAN OF CORTI

- A special structure formed by epithelial cells on upper surface of basilar membrane → sensory part of organ of hearing
- made up of sensory elements called **hair cells** and **supporting cells**

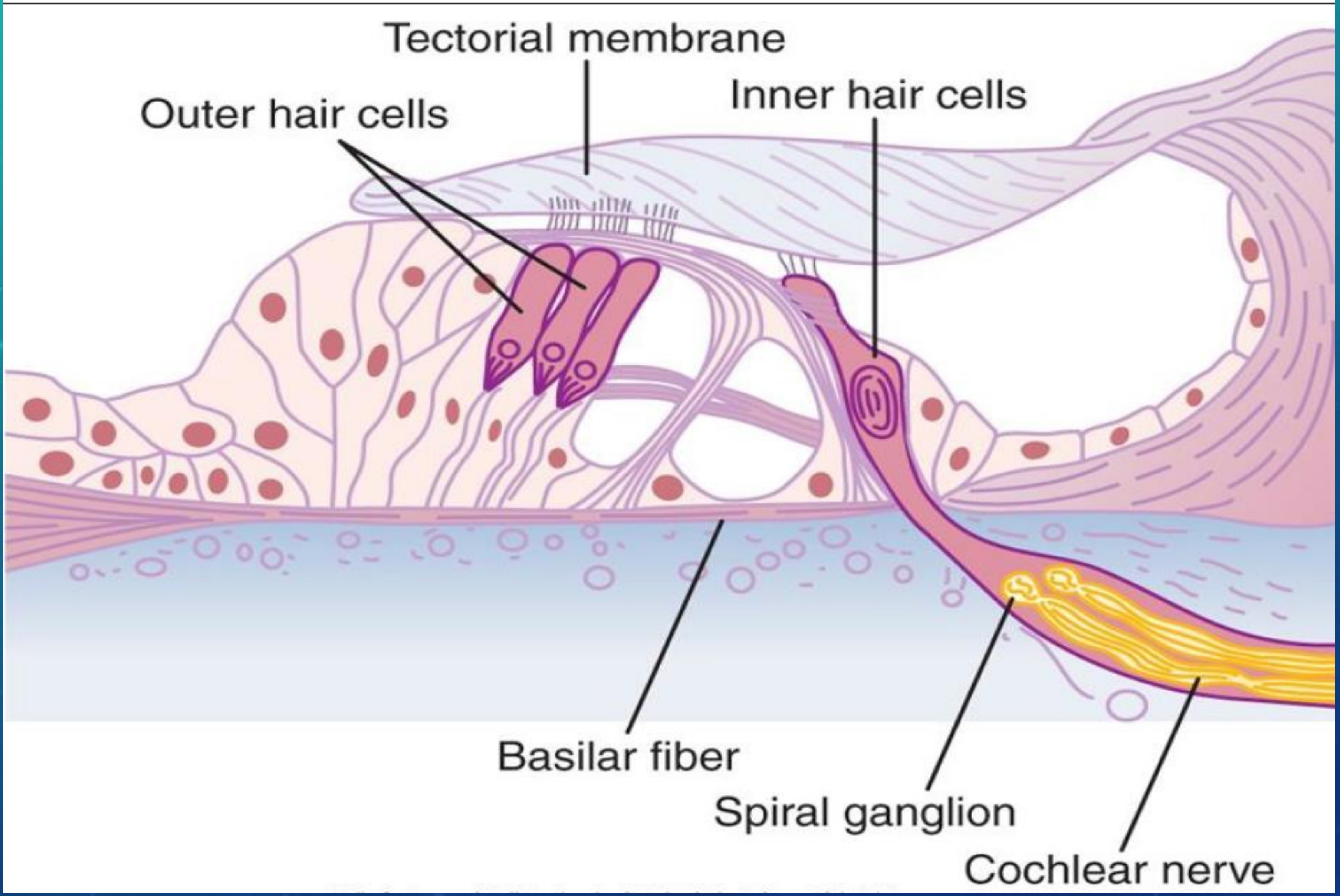


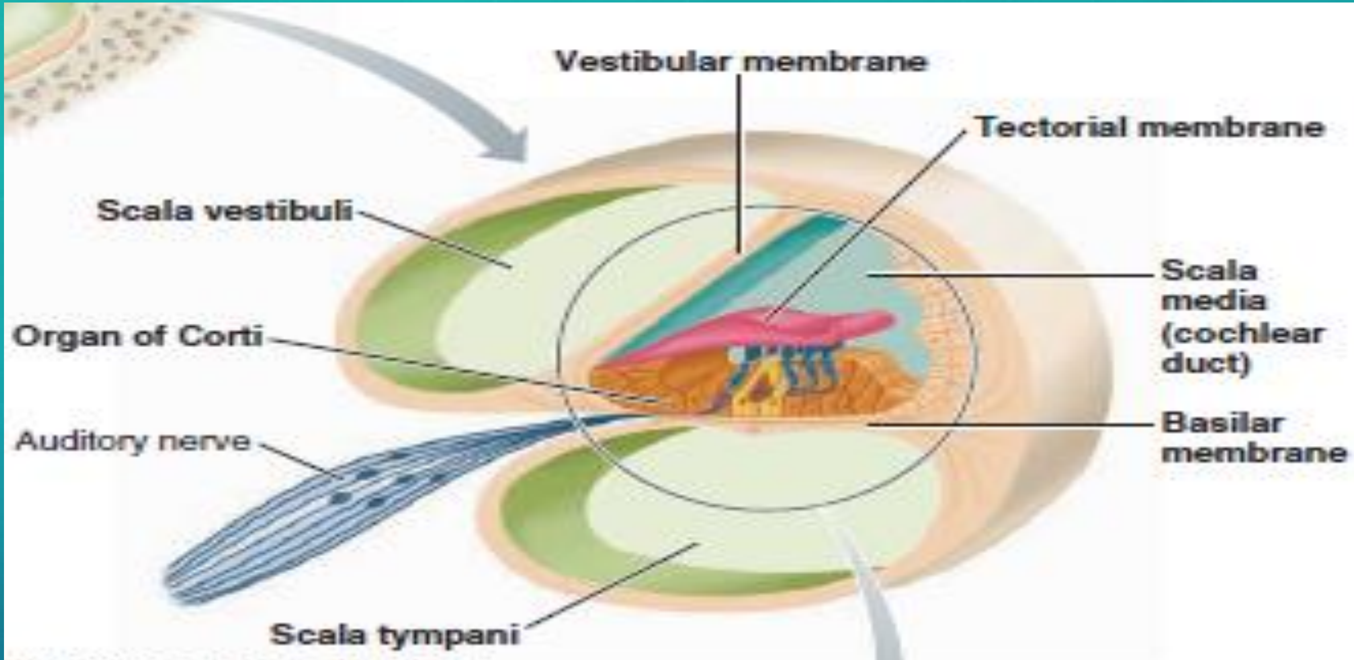
# FUNCTION OF ORGAN OF CORTI

- **Sensitive to vibration**
- Lies on basilar membrane
- **Hair cells**
  - Internal hair cells – 3500 – 12 µm - single row
  - External hair cells- 15000 – 8 µm - 3-4 rows

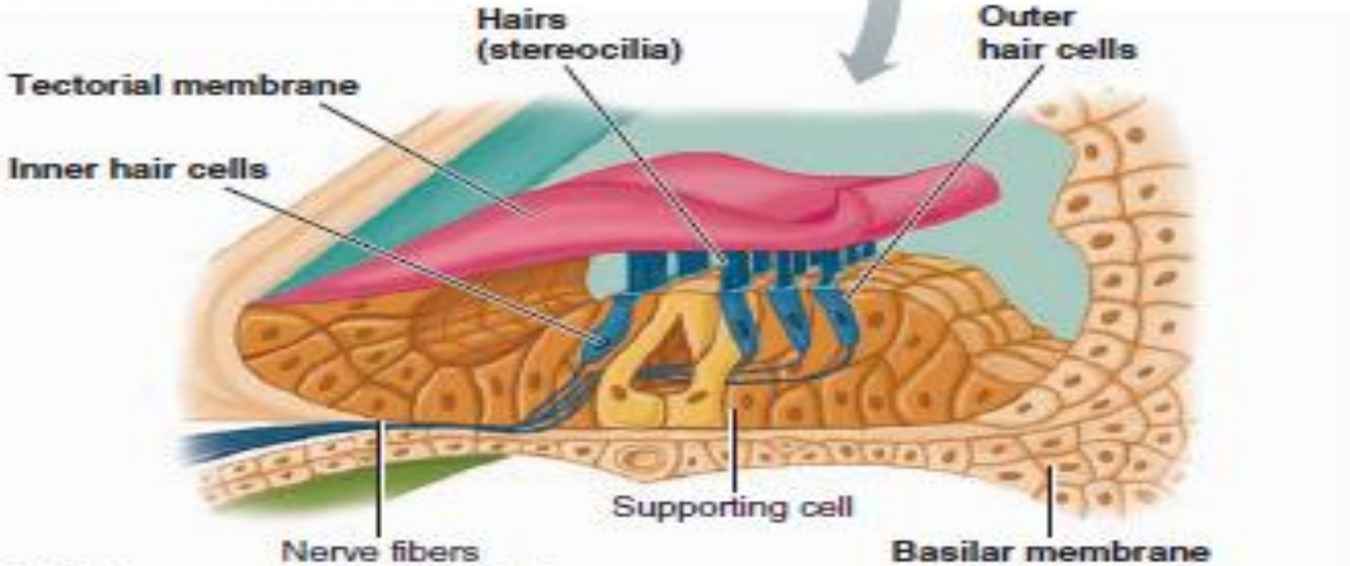
- Bases of hair cells synapse with cochlear nerve endings → 90-95% on inner hair cells
- Nerve fibers go to Spiral ganglion of Corti in the modiolus From spiral ganglion neuronal cells send approx 30000 axons into cochlear nerve

# ORGAN OF CORTI





(b) Cross section of cochlea



(c) Enlargement of organ of Corti

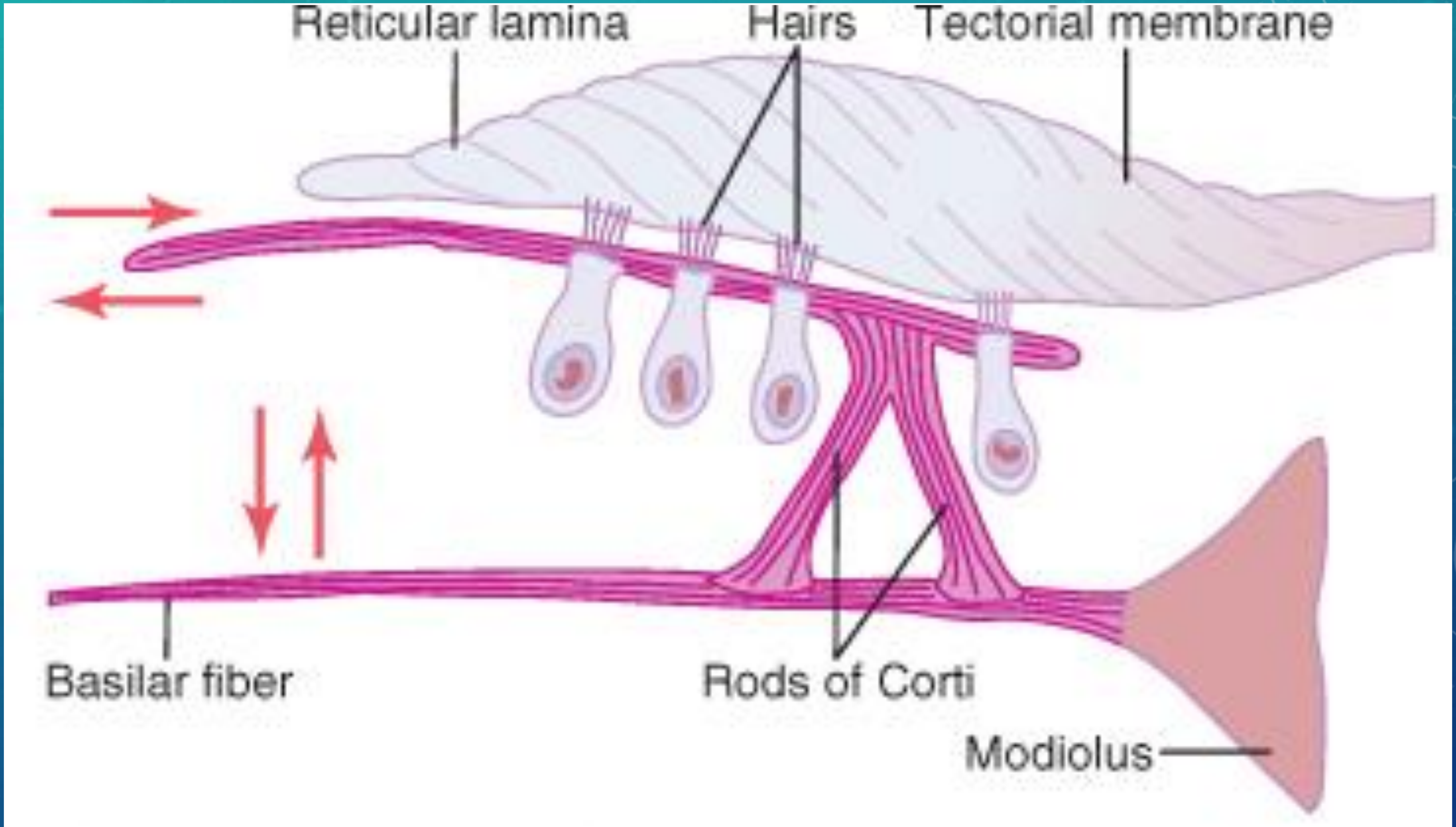
# ORGAN OF CORTI

- Stereocilia are stiff with rigid protein framework , project from top of hair cells and are embedded in a gel like Tectorial membrane
- Upper end of cilia bound together by thin filaments
- Tectorial membrane is in Scala media
- Bending of hair cells against tectorial membrane
  - Towards kinocilium – **depolarization**
  - In opposite direction– **hyperpolarization**

# ROLE OF HAIR CELLS

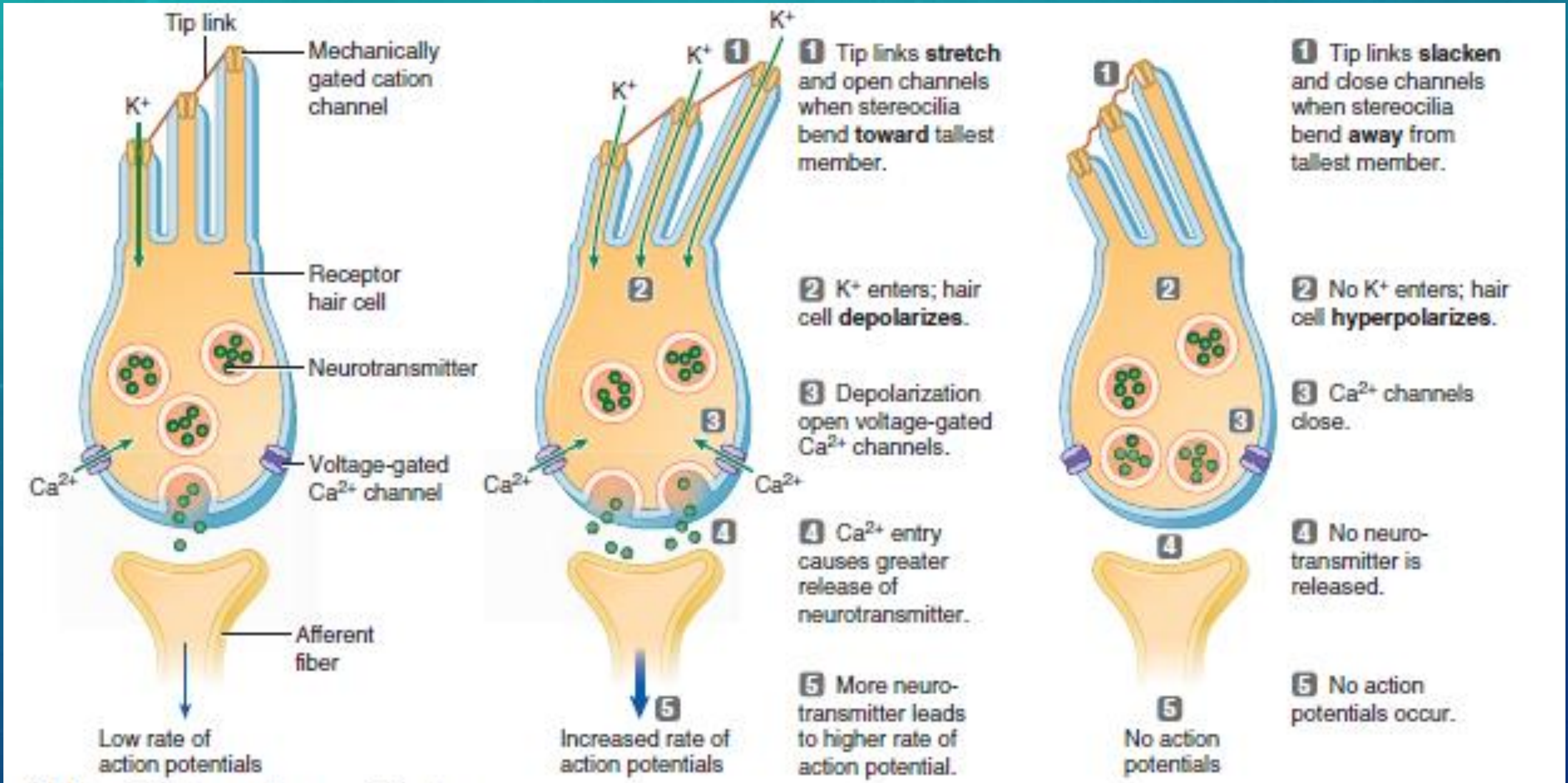
- About **90%** of auditory nerve fibers are stimulated by **inner cells** rather than by the outer cells
- **Outer hair cells** control the sensitivity of inner hair cells at different sound pitches, a phenomenon called **"tuning"** of receptor system

# EXCITATION OF HAIR CELLS

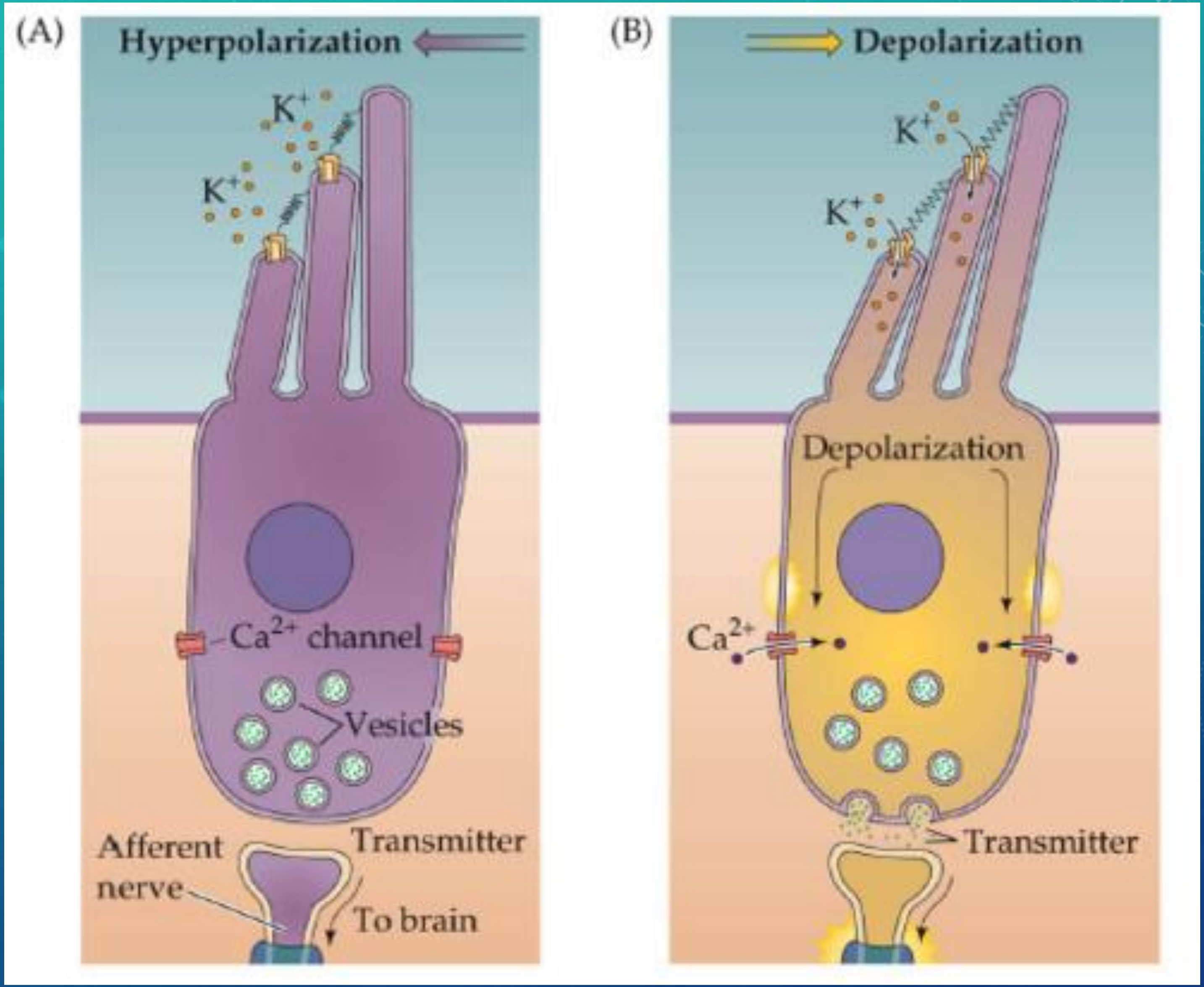


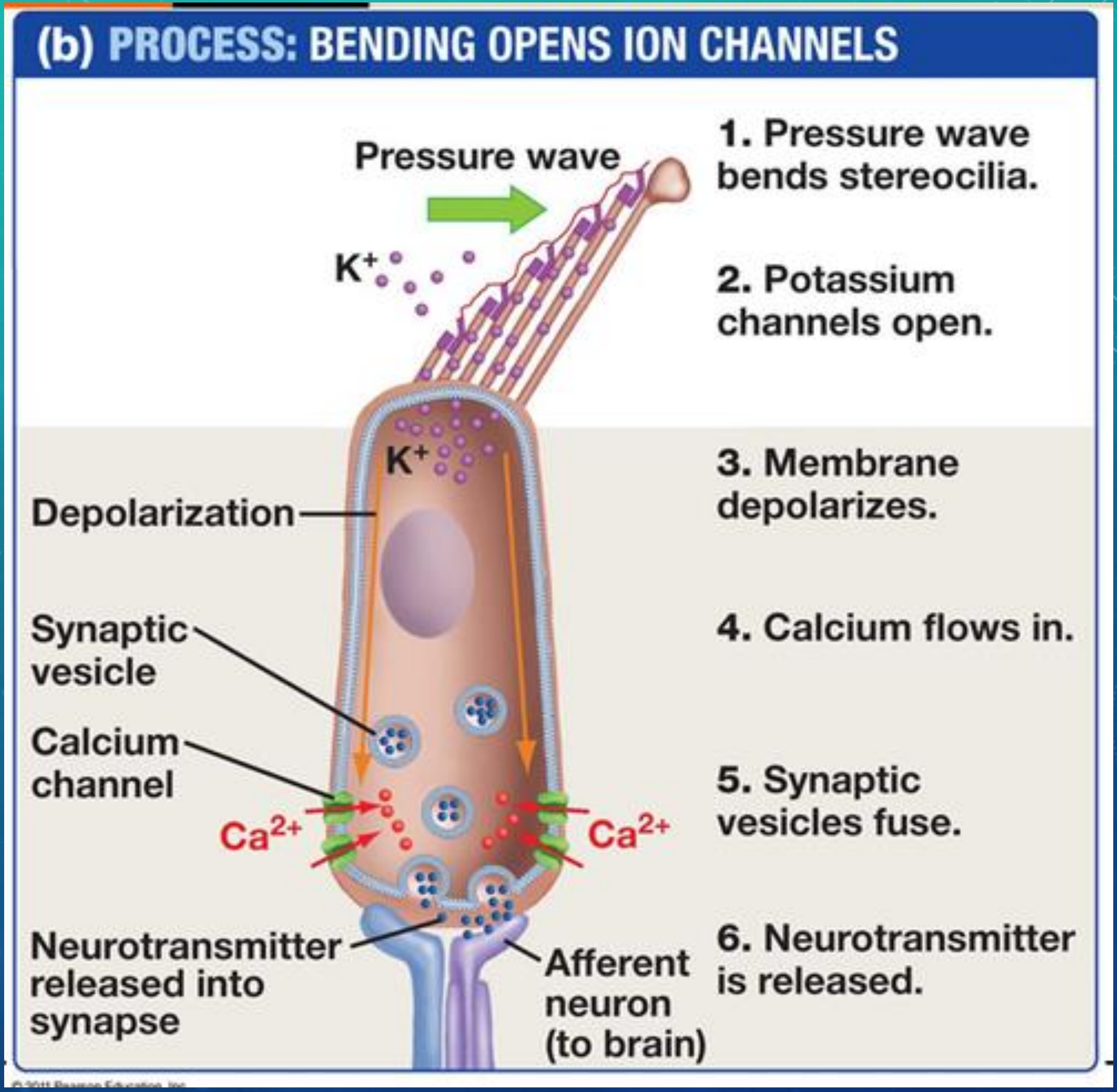

Stimulation of the hair cells by to-and-fro movement of the hairs projecting into the gel coating of the tectorial membrane.

# Role of stereocilia in sound transduction

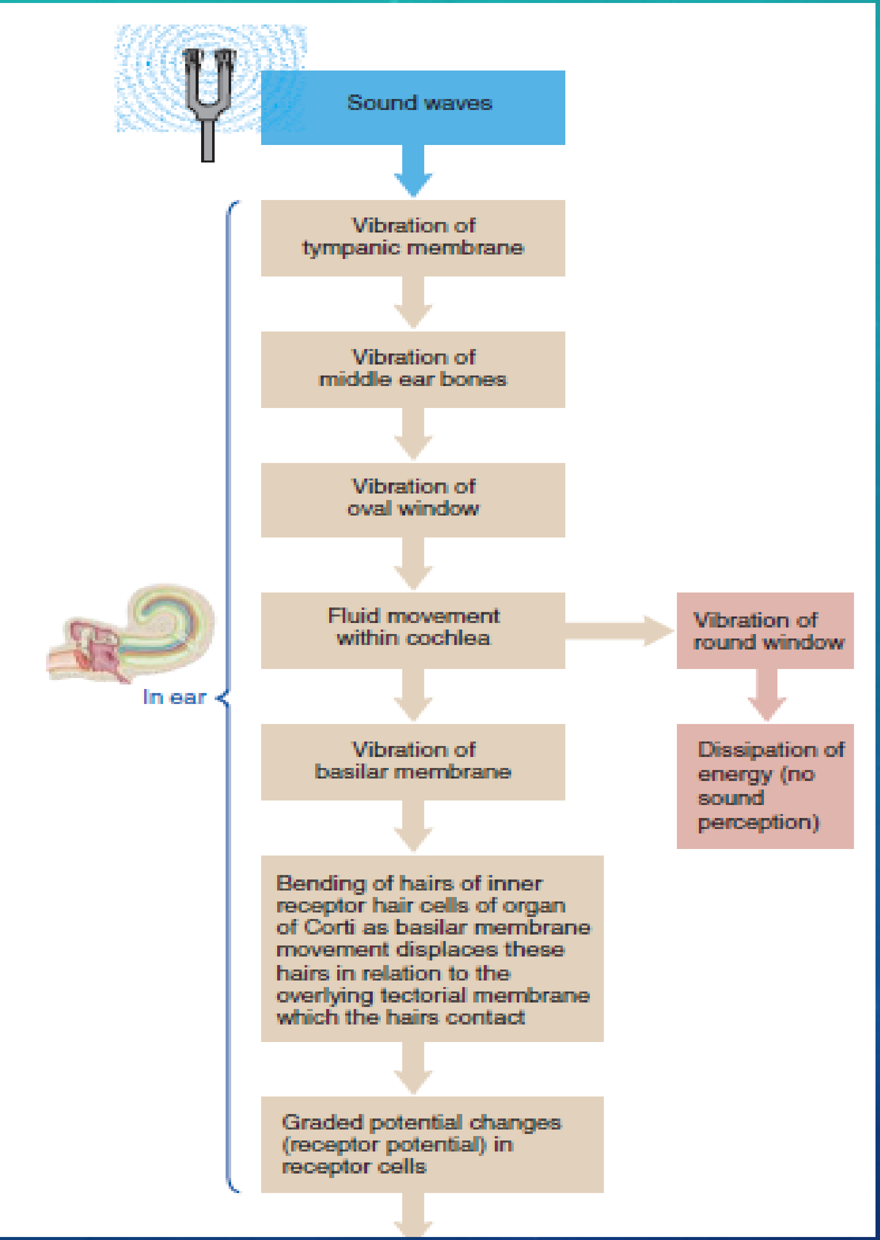


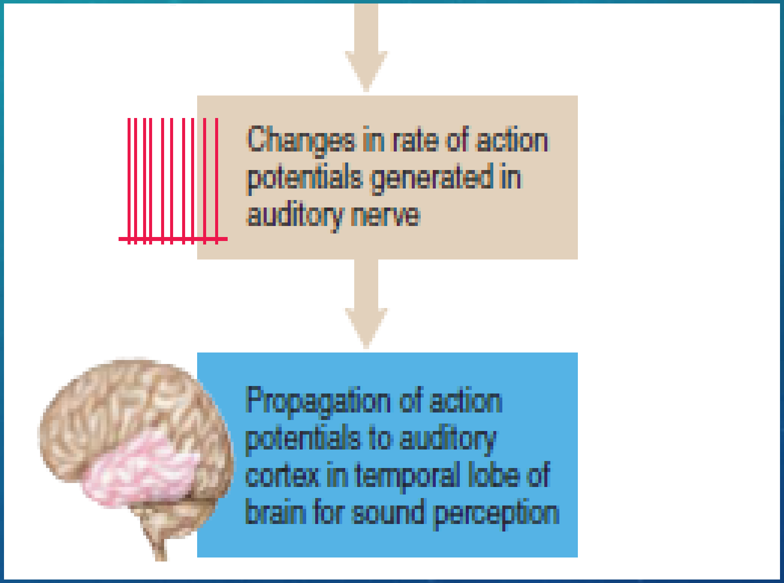
(c) Depolarization and hyperpolarization of receptor hair cell


(A)
Hyperpolarization
K+
K+
Ca2+ channel
Vesicles
Afferent
nerve
Transmitter
To brain
(B)
Depolarization
K+
K+
Depolarization
Ca2+
Transmitter

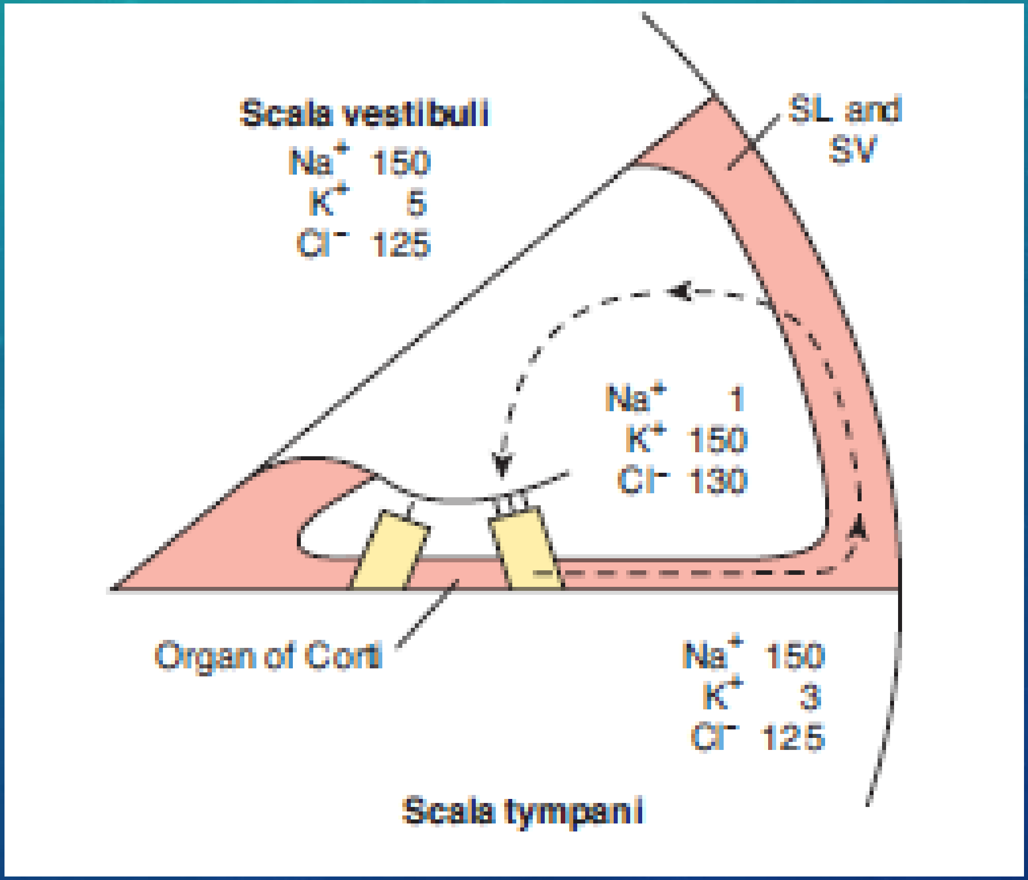

(b) PROCESS: BENDING OPENS ION CHANNELS
Pressure wave
$K^+$
1. Pressure wave bends stereocilia.
2. Potassium channels open.
$K^+$
Depolarization
3. Membrane depolarizes.
Synaptic vesicle
4. Calcium flows in.
Calcium channel
$Ca^{2+}$
$Ca^{2+}$
5. Synaptic vesicles fuse.
Neurotransmitter released into synapse
Afferent neuron (to brain)
6. Neurotransmitter is released.

# PATHWAY FOR SOUND TRANSDUCTION



# IONIC COMPOSITION IN DIFFERENT COMPARTMENTS OF COCHLEA



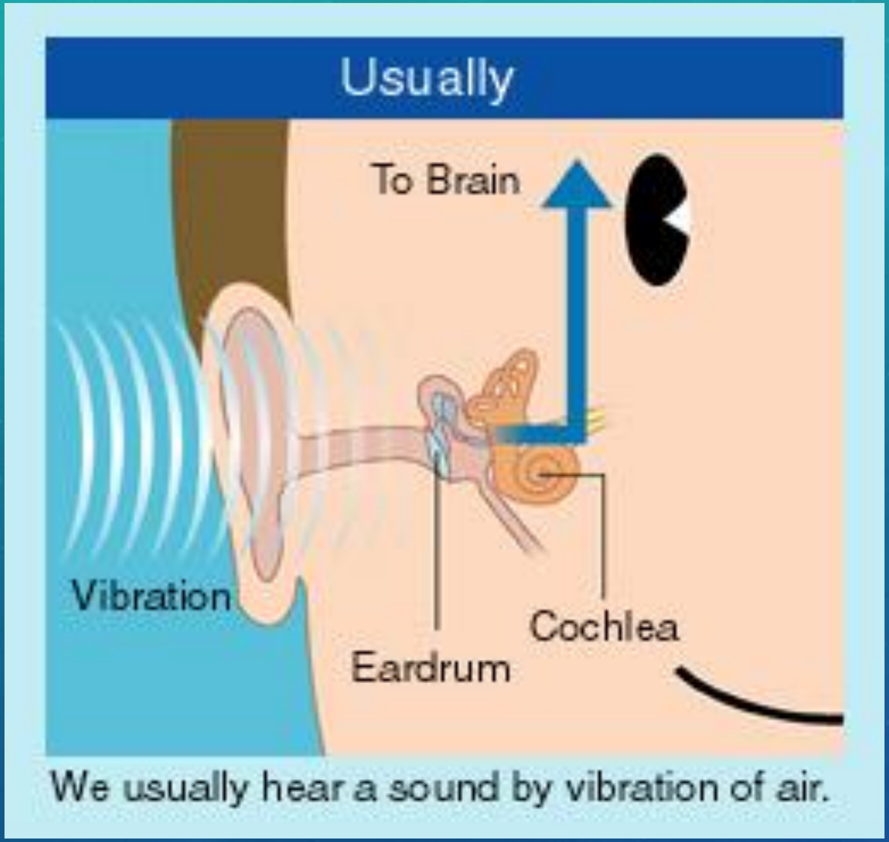
# ENDOCOCHLEAR POTENTIAL

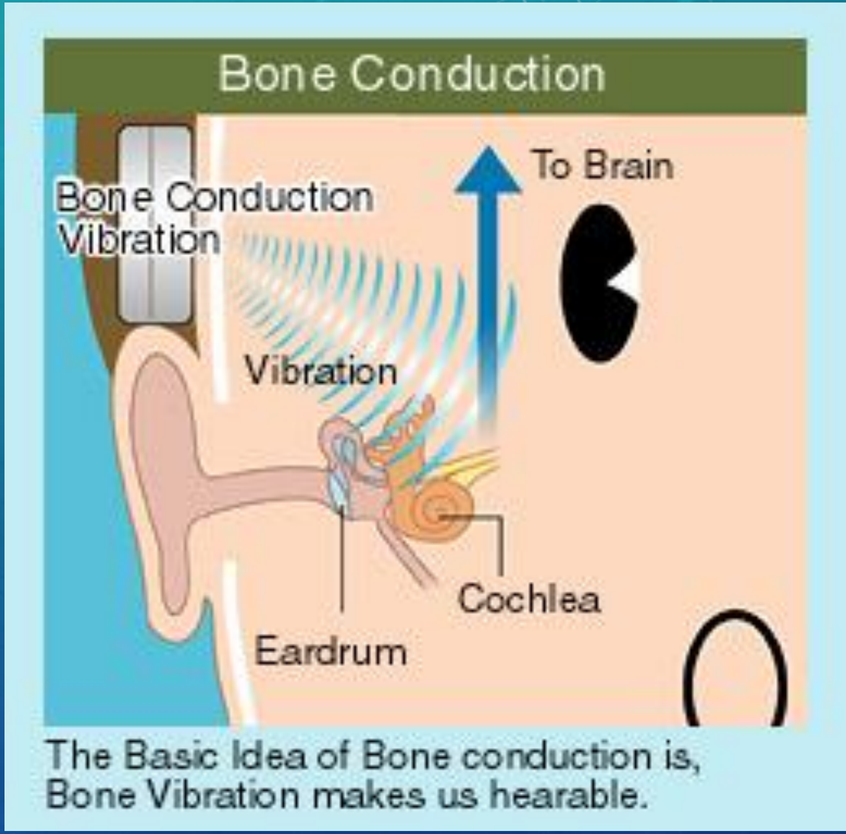
- Perilymph in Scala Vestibuli and Tympani
- Endolymph in Scala Media
  - **Secreted by Stria Vascularis**
  - **Contains ↑ $K^+$ and ↓$Na^+$**
  - Potential difference **+80 mV** as compared to perilymph

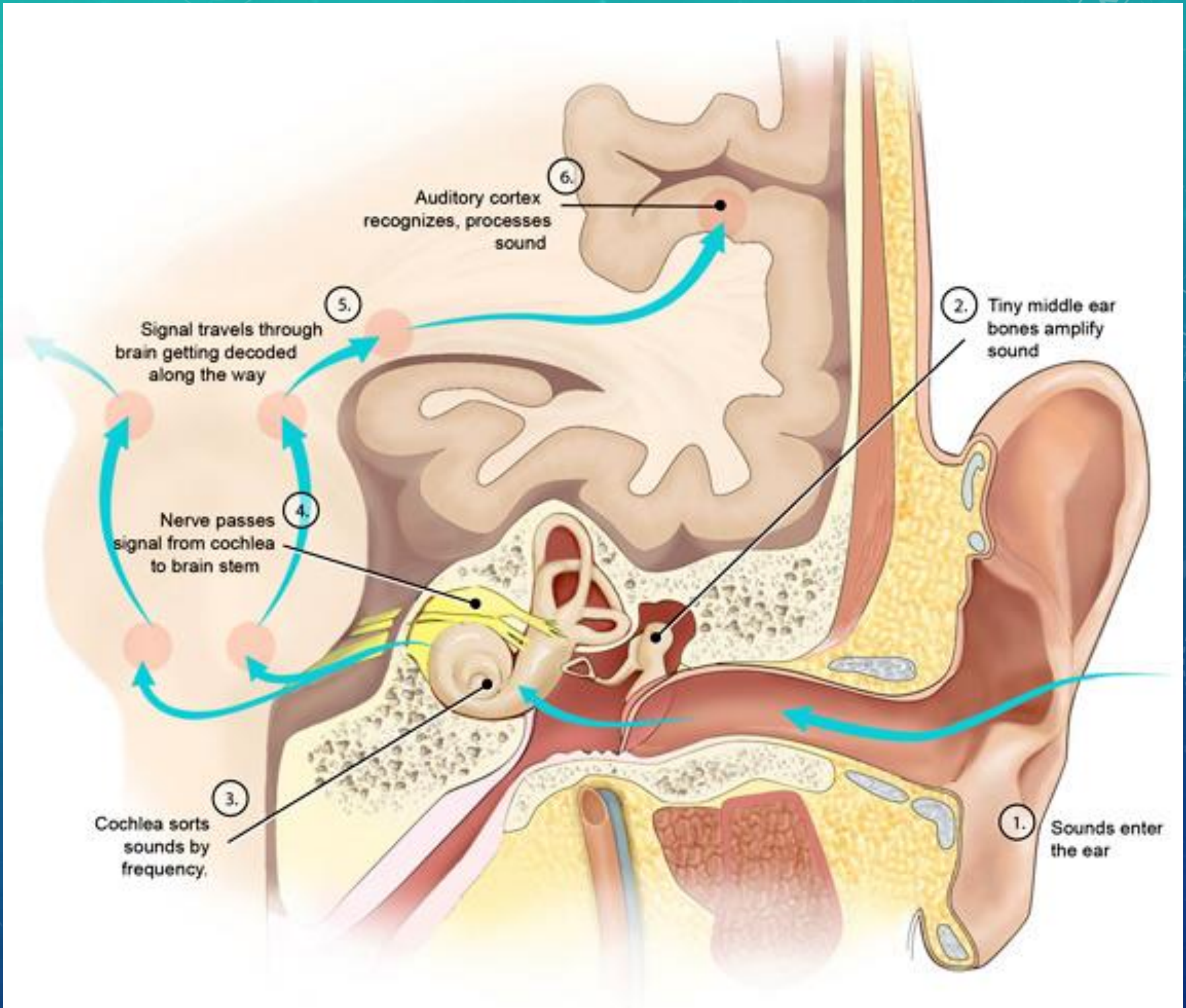
- RMP in the hair cells
  - Bases of the cells -70 mV with respect to perilymph
  - Upper parts -150 mV with respect to Endolymph

- Movement into endolymph causes depolarization

# Bone conduction

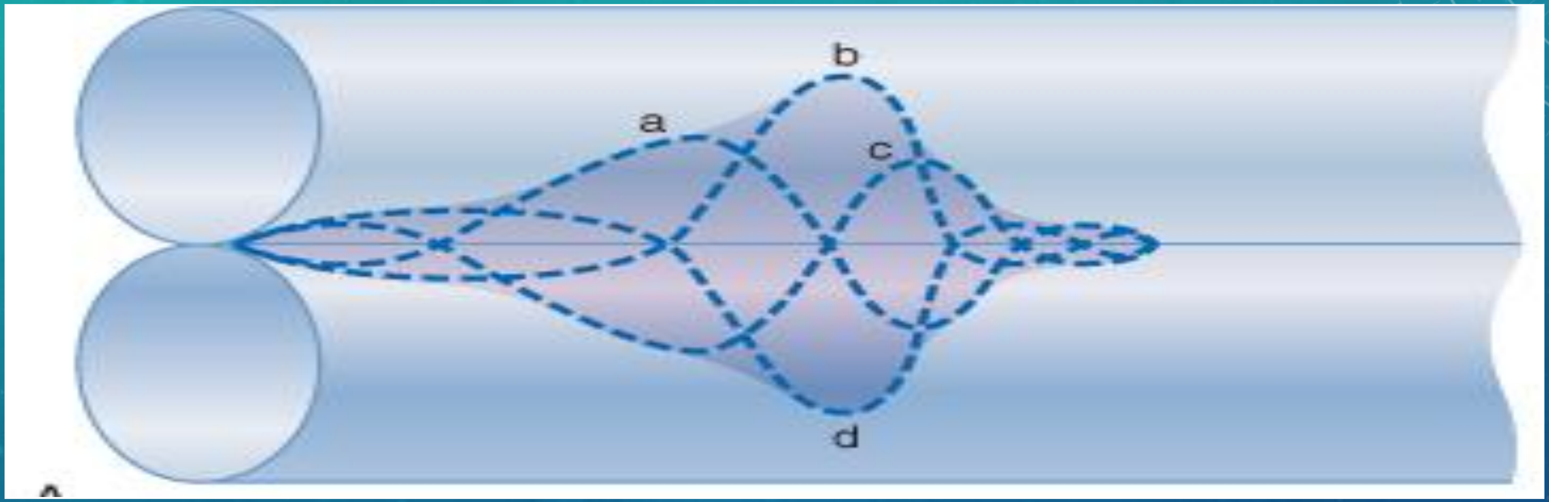


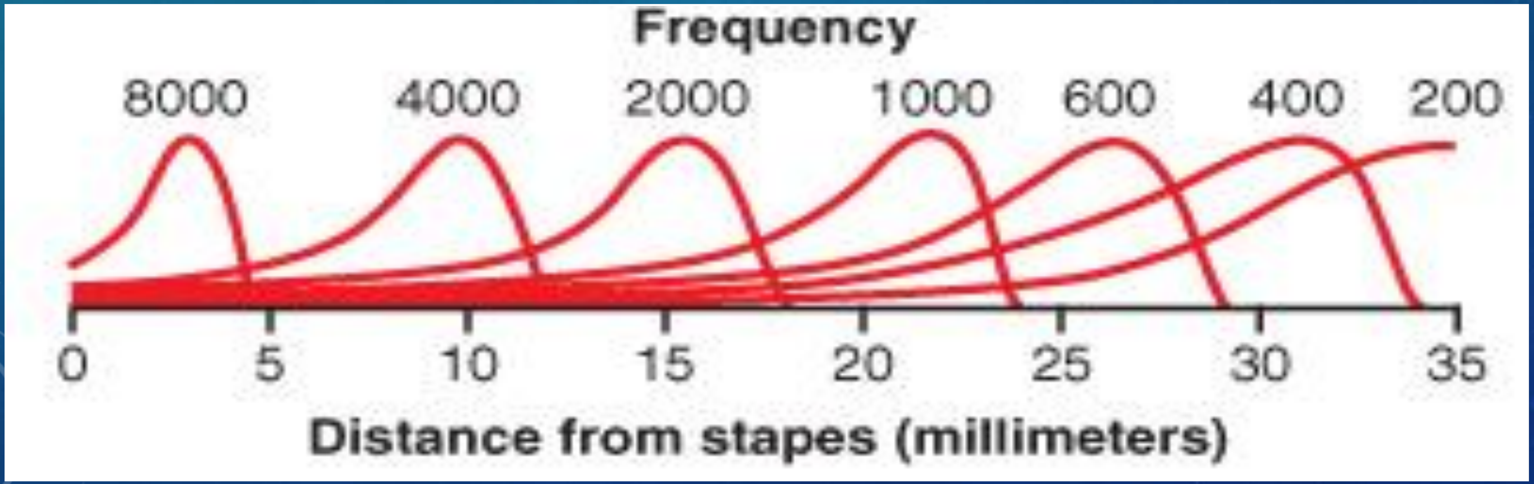





6.
Auditory cortex recognizes, processes sound
5.
Signal travels through brain getting decoded along the way
2.
Tiny middle ear bones amplify sound
4.
Nerve passes signal from cochlea to brain stem
3.
Cochlea sorts sounds by frequency.
1.
Sounds enter the ear

# Amplitude pattern of vibration

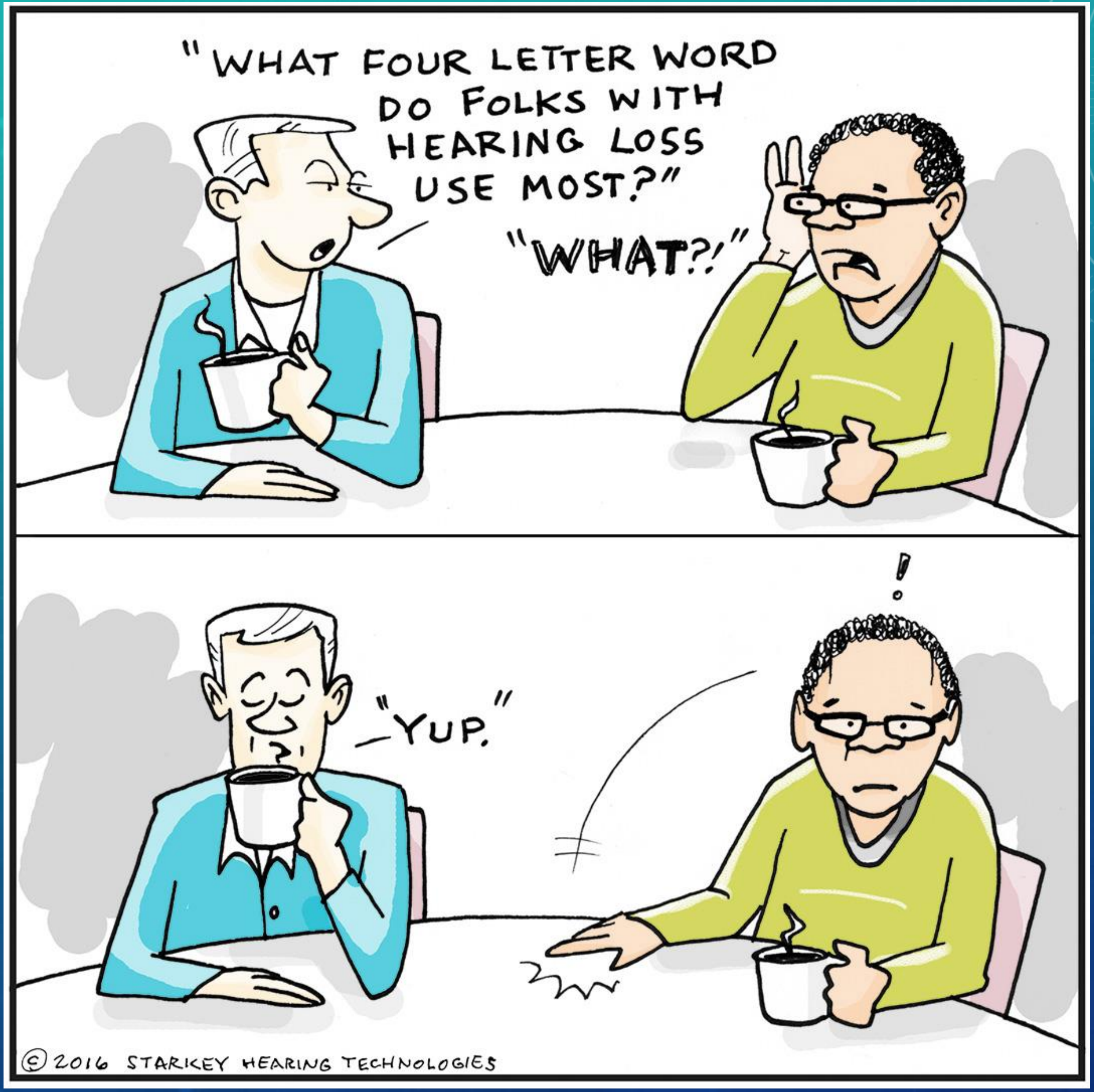


# Loudness of sound- intensity

- Loudness is determined by amplitude of the vibration
- Louder sound move TM more vigourously, grater movement of basilar membrane, greater bending of stercocilia in the reigon, more signal to the brain.
- Extermely loud noise causes violent vibrations of basilar membrane and damages hair cells leading to partial hearing loss.

- *Pitch discrimination depends on where the basilar membrane maximally vibrates And loudness depends upon how much this place vibrates*

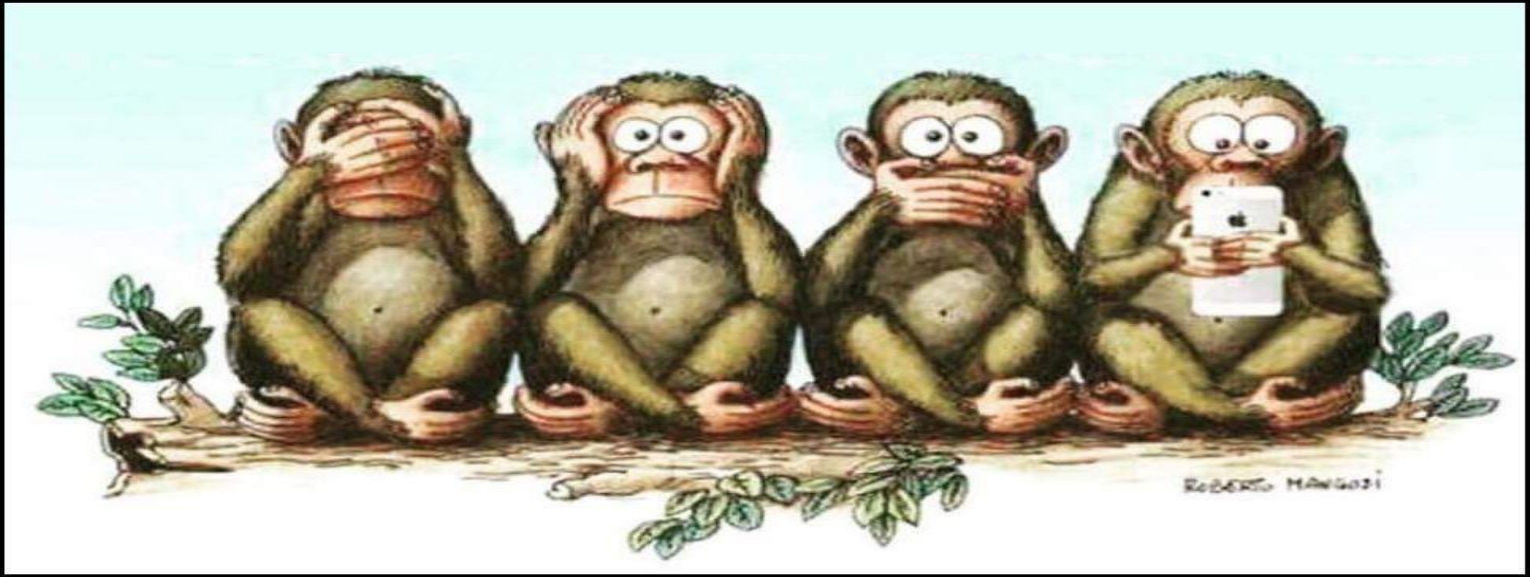

"WHAT FOUR LETTER WORD DO FOLKS WITH HEARING LOSS USE MOST?"
"WHAT?!"
"YUP."
!
© 2016 STARKEY HEARING TECHNOLOGIES

# Difference between hearing & listening???


SEE
NO EVIL
HEAR
NO EVIL
SPEAK
NO EVIL

# Finally The Fourth Ape!

Truth Inside Of You



He is the sum of the first three:

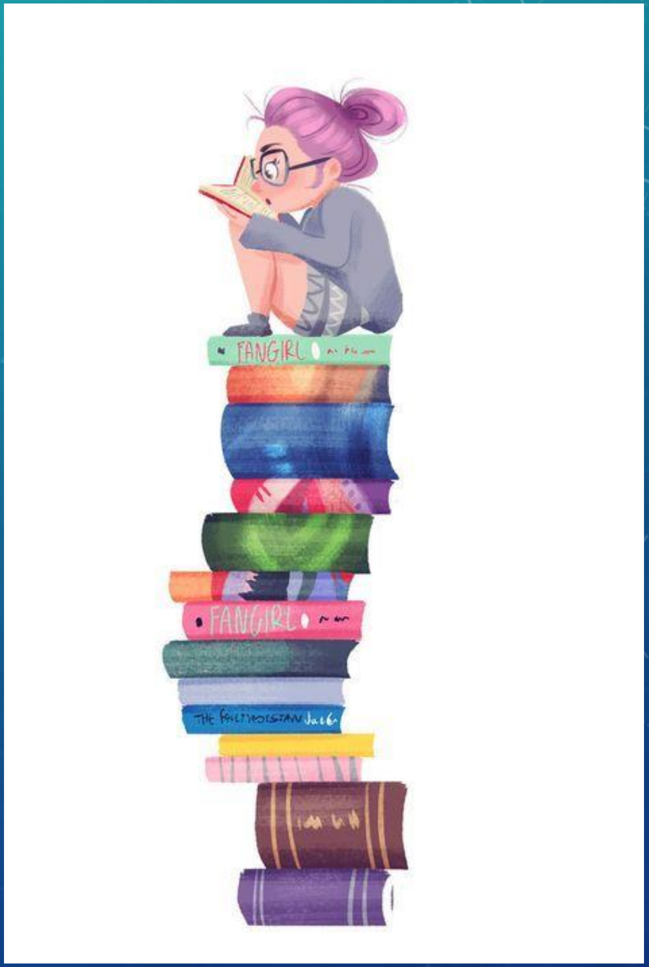
**He sees nobody, hears nobody and speaks to nobody!**

# RECOMMENDED BOOKS

- 1. Principles of Human Physiology

  -Lauralee Sherwood

- 2. Guyton & Hall Physiology
- 3. Ganong’s review of Medical Physiology




# Questions?
# Comments?
# Feedback?

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That's all Folks!