



# Medical physics module

## Semester 1

Session 4

Lec. 8

***Physics of the ear and  
hearing***

**By: Lect. Dr. Nadia Hussein Sahib**



# Objectives

- Mechanical principle of hearing process.
- Physical aspect of ear and hearing.
- Sensitivity of the ear.
- Hearing loss (Deafness) and hearing aids



## **Obj.1 The sense of hearing involves**

- 1. The mechanical system that stimulates hair cells in the cochlea.**
- 2. The sensors that produce the action potentials in the auditory nerves.**
- 3. The auditory cortex, the part of the brain that decodes and interprets the signals from the auditory nerves.**

**Deafness or hearing loss results if any of these parts malfunction. The ear is a cleverly designed converter of very weak mechanical waves in air into electrical pulses in the auditory nerve**





## The Ear: Hearing and Balance

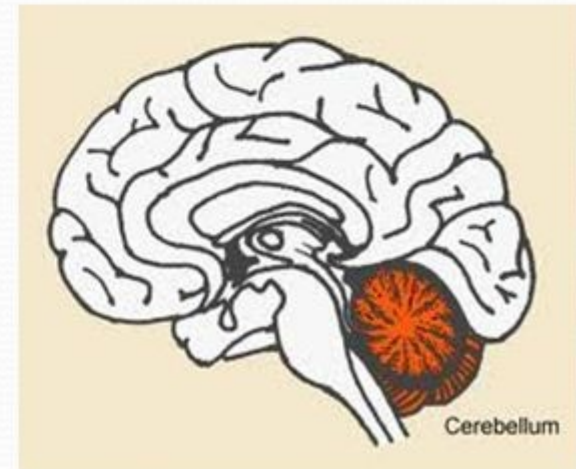
- The three parts of the ear are the inner, outer, and middle ear
- The outer and middle ear are involved with hearing
- The inner ear functions in both hearing and equilibrium
- Receptors for hearing and balance:
  - Respond to separate stimuli
  - Are activated independently

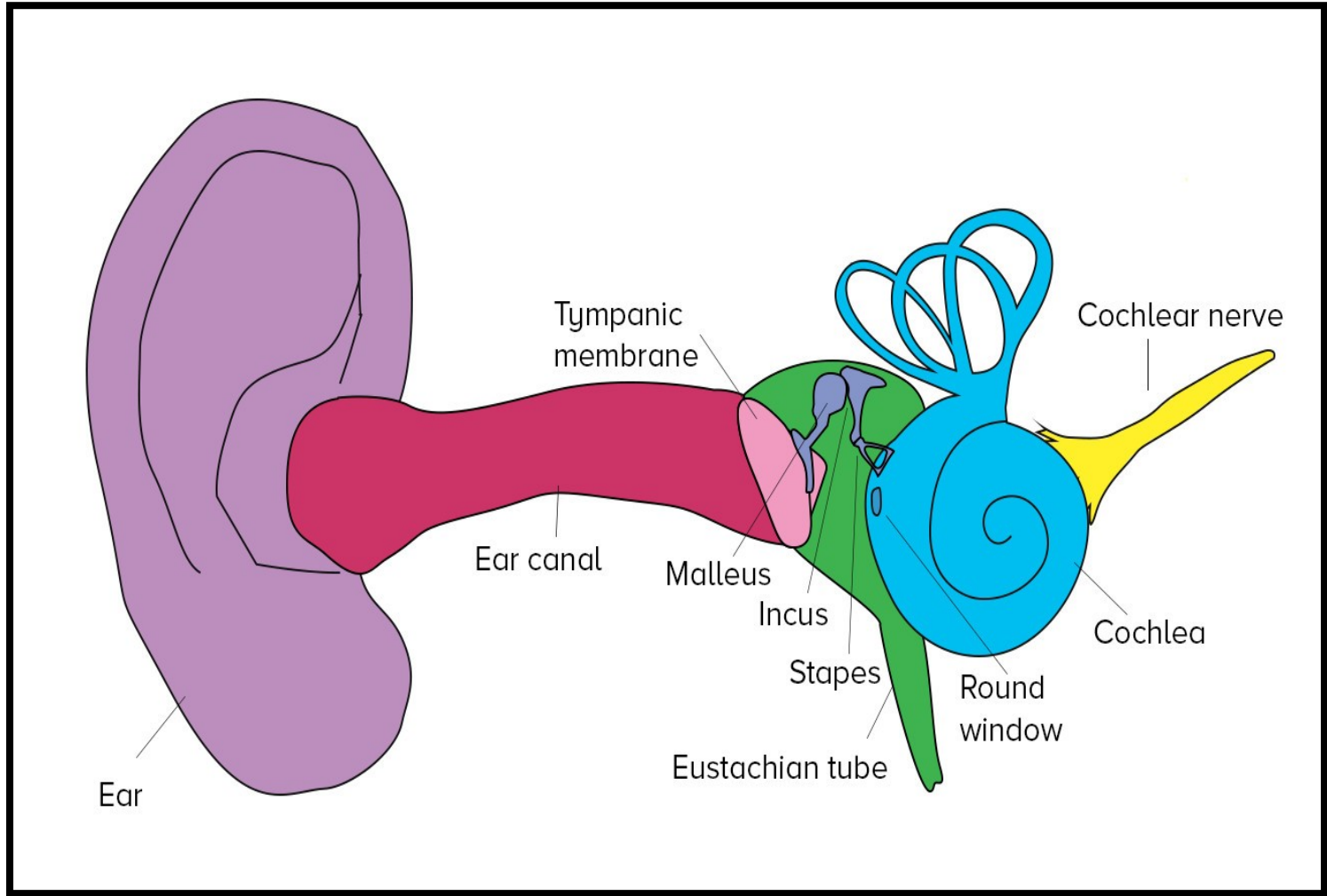
# How do we maintain balance?

Cerebellum monitors and controls balance.

It receives input from four main sources:

- **Maculae** (vestibule of inner ear)
- **Crista ampullaris** (semicircular canals of inner ear)
- **Photoreceptors** (eyes)
- **Proprioceptors** (receptors in muscles, tendons, and joints that detect tension)







## Obj.2

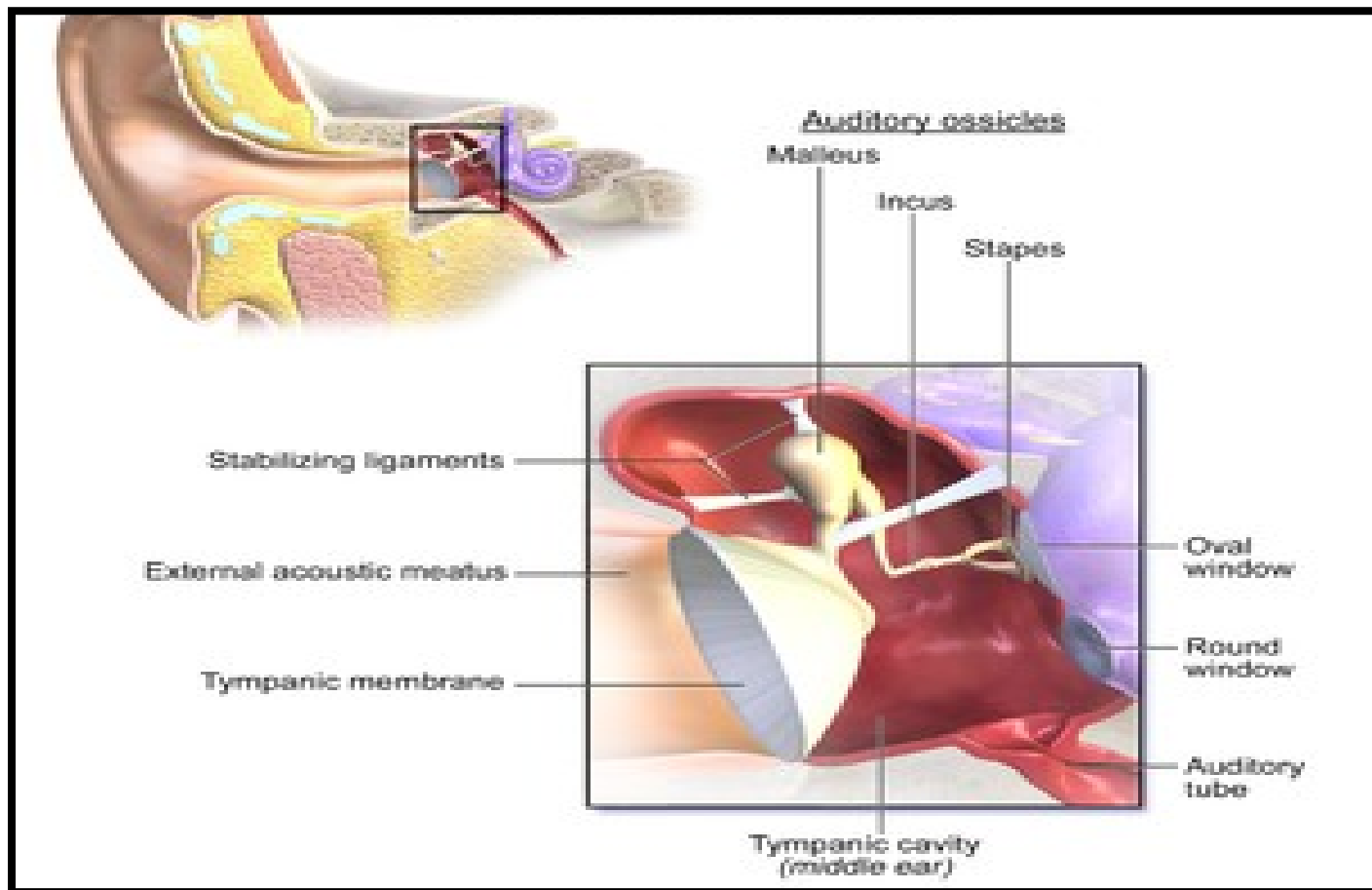
# The outer ear

It aids in funneling sound waves into the canal, the external auditory canal besides storage place for ear wax serves to increase the sensitivity in the region of **300 - 4000 Hz**, the canal is about **2.5 cm** length.

**Length =  $(\lambda / 4)$  and resonance frequency about (3300 Hz),  $\lambda = 10$  cm**



# The Middle Ear

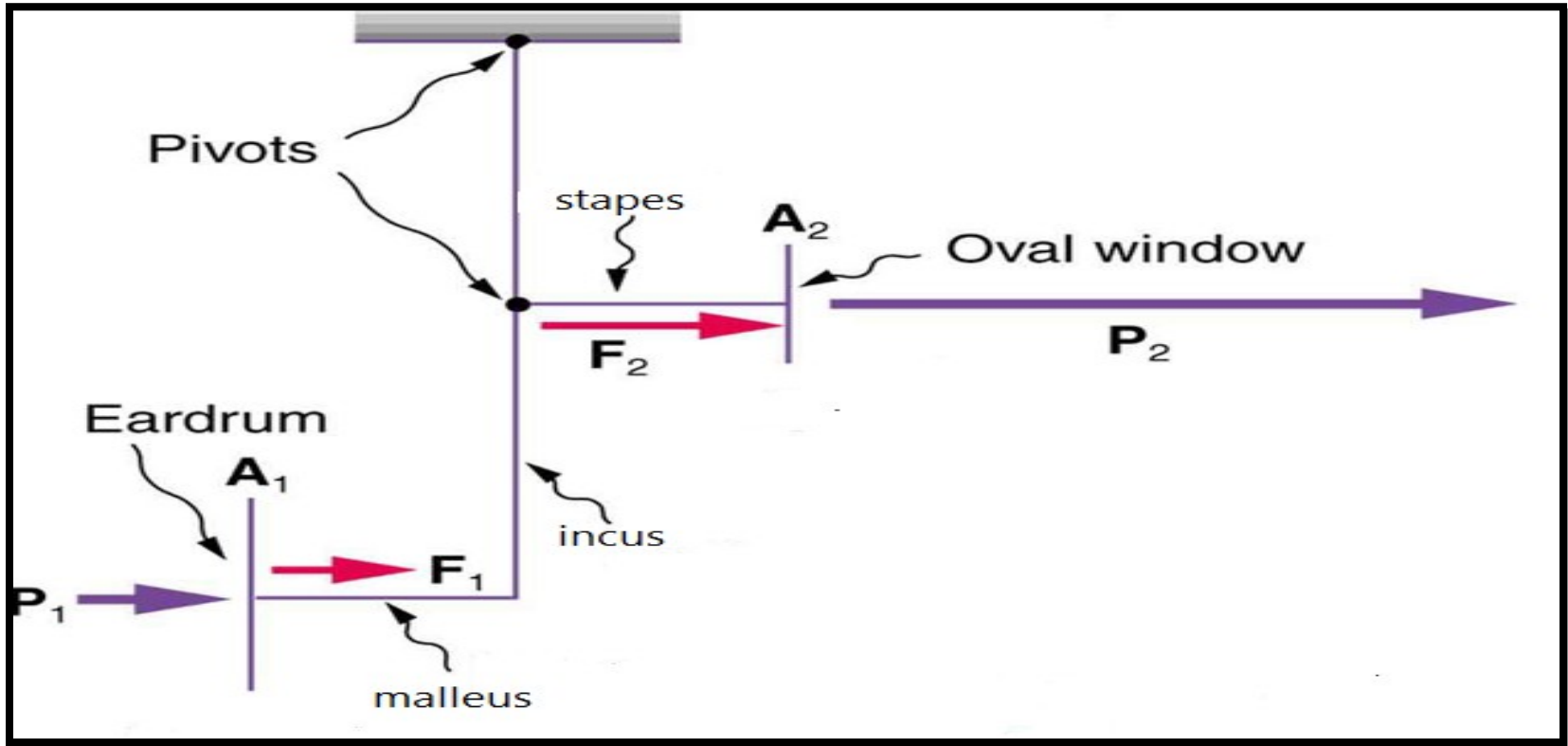




Consist of three bones called *ossicles* are full adult size. Before birth the fetus can hear while it is still in the womb.

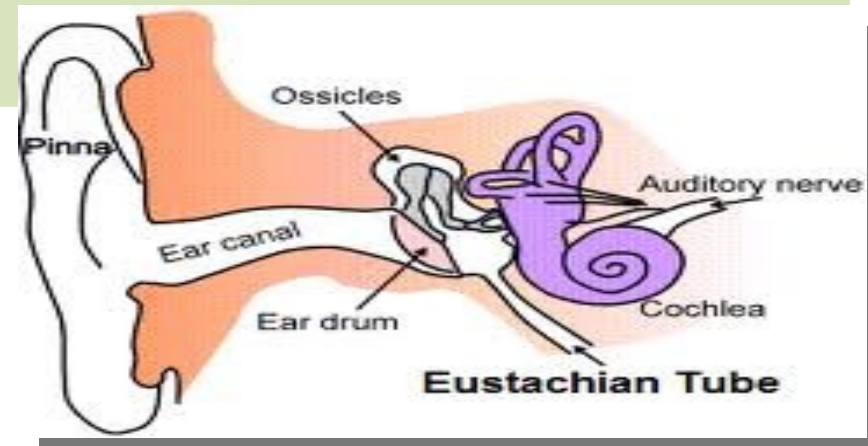
**They transmit vibrations from eardrum to inner ear, the ossicles amplify pressure of sound waves to inner ear.**

The lever action amplify the force by a factor about 1.3, a much larger gain in pressure obtained by piston Action.

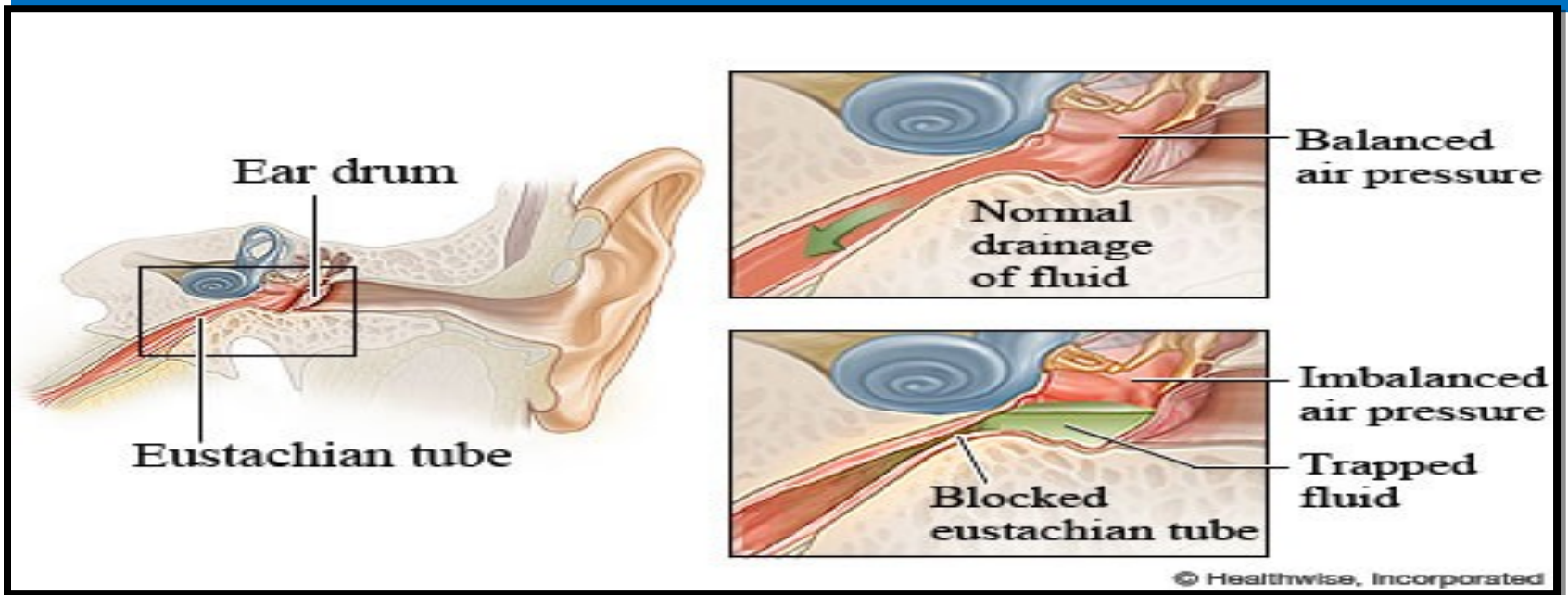


**The piston action of middle ear ossicles**

**Eustachian tube is a canal that connects the middle ear to the nasopharynx, which consists of the upper throat and the back of the nasal cavity. It controls the pressure within the middle ear, making it equal with the air pressure outside the body. It is normally closed rather than open, serves to equalize pressure.**

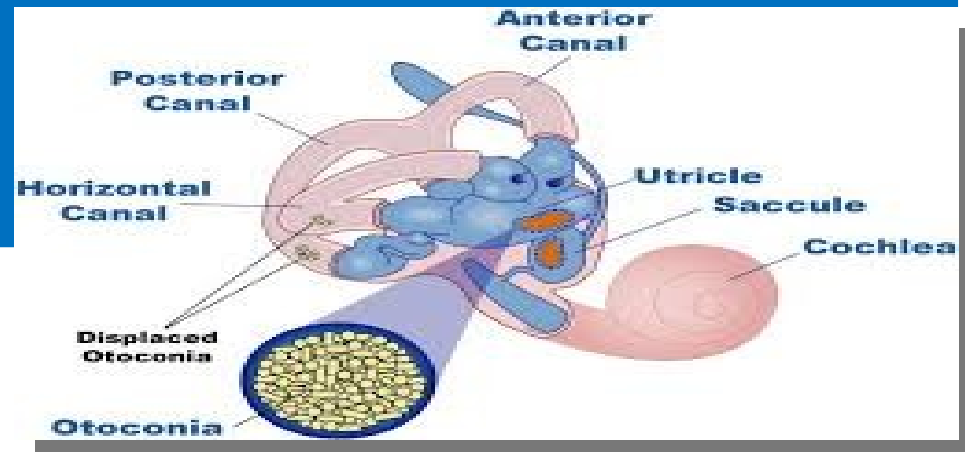


It common reasons for the failure of this equalizing system are the blockage of Eustachian tube by the viscose fluids from head cold and the swelling of tissues around the entrance of tube.



# The inner ear

The inner ear consist of small spiral shaped, fluid filled structure called cochlea, the ossicles of the middle ear communicate with cochlea via flexible membrane (the oval window) the stapes transmit its pressure variation of incoming sound to





## Obj.3

# Sensitivity of the ear.

Sensitivity changes with frequency and can be described in terms of the loudness.

The unit for the loudness is the phone which is normalized to the intensity at the fixed frequency of  $f = 1000 \text{ Hz}$ .

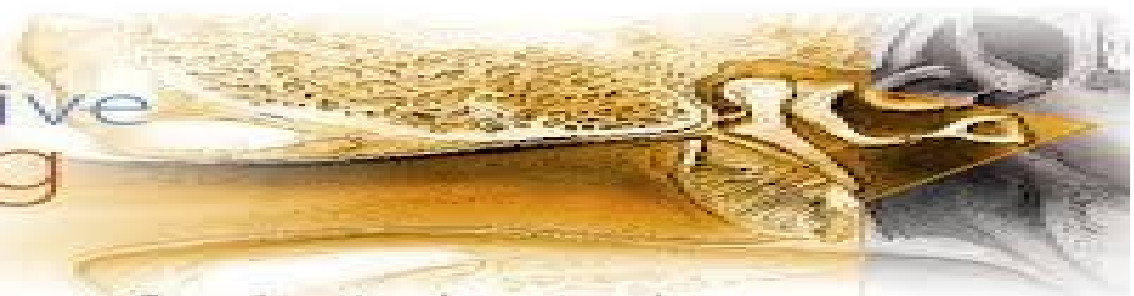
$$1 \text{ (phone)} = 1 \text{ (db)} = 1000 \text{ (Hz)}$$



## Obj.4 Hearing loss (Deafness) and hearing aids

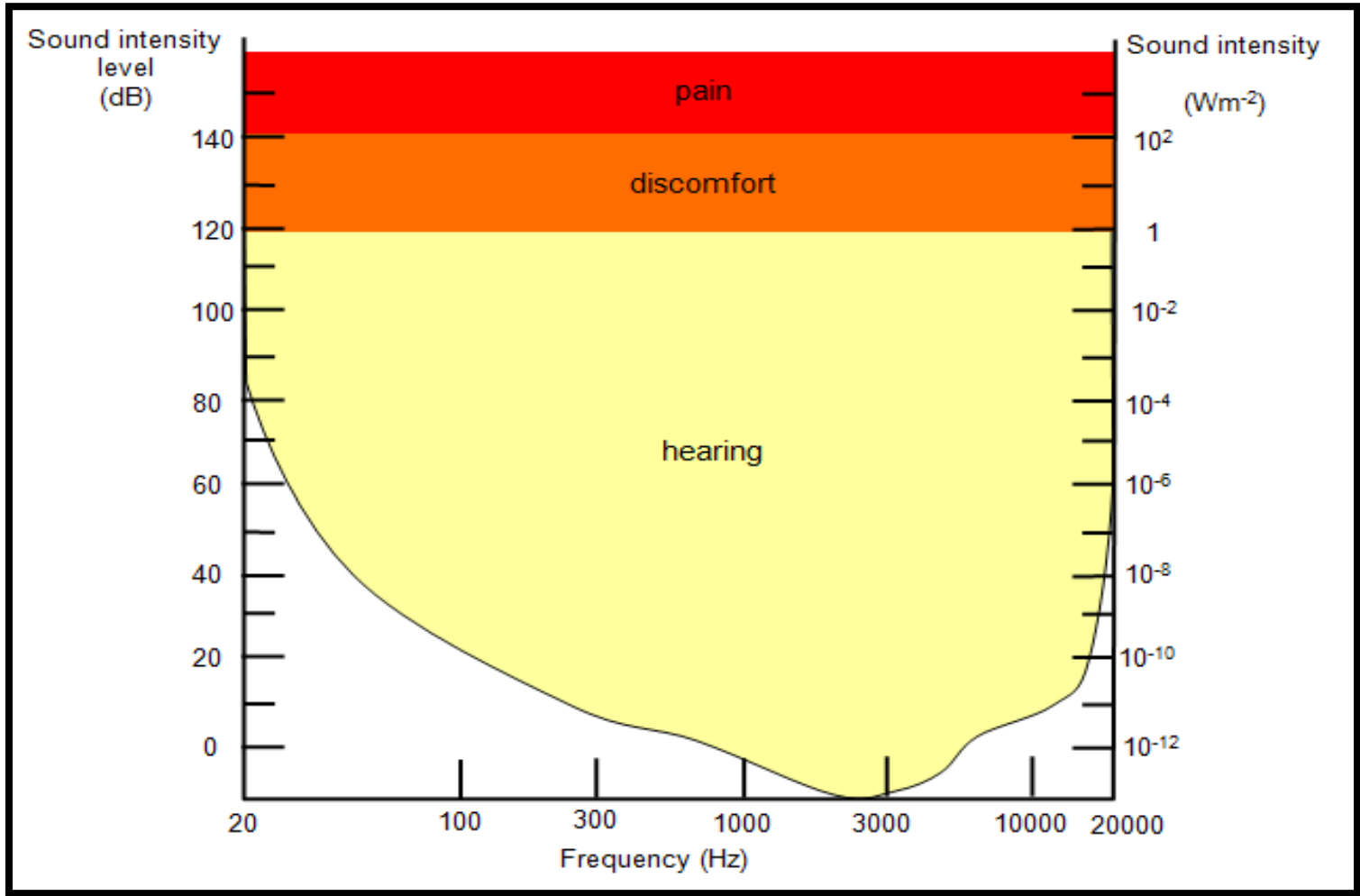
- Conduction hearing loss, in which the sound vibrations do not reach the inner ear.
- Nerve hearing loss, in which the sound vibrations reach the inner ear but no nerve signals are sent to brain

Conductive  
Hearing  
Loss



Conductive hearing loss occurs here in the outer ear.





# What is hearing loss?

The ear is  
Made up of 3 parts

- A. The outer ear  
(ear canal and pinna)
- B. The middle ear  
(eardrum and ossicles)
- C. The inner ear  
(Cochlea or hearing nerve)



Hearing loss is the result of damage  
to any of these ear parts



Decibel Ranges of Hearing Loss

