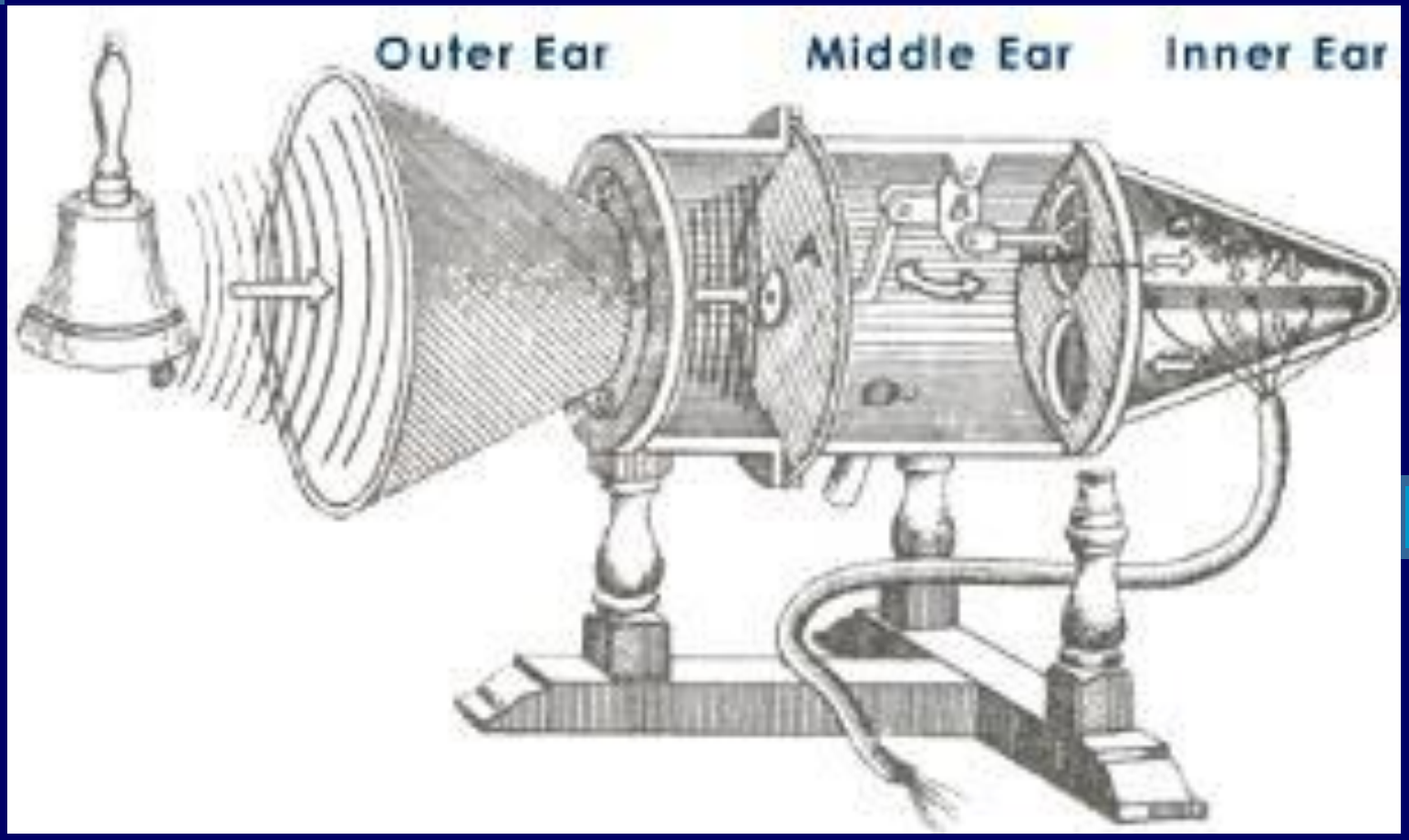
MECHANISM OF HEARING

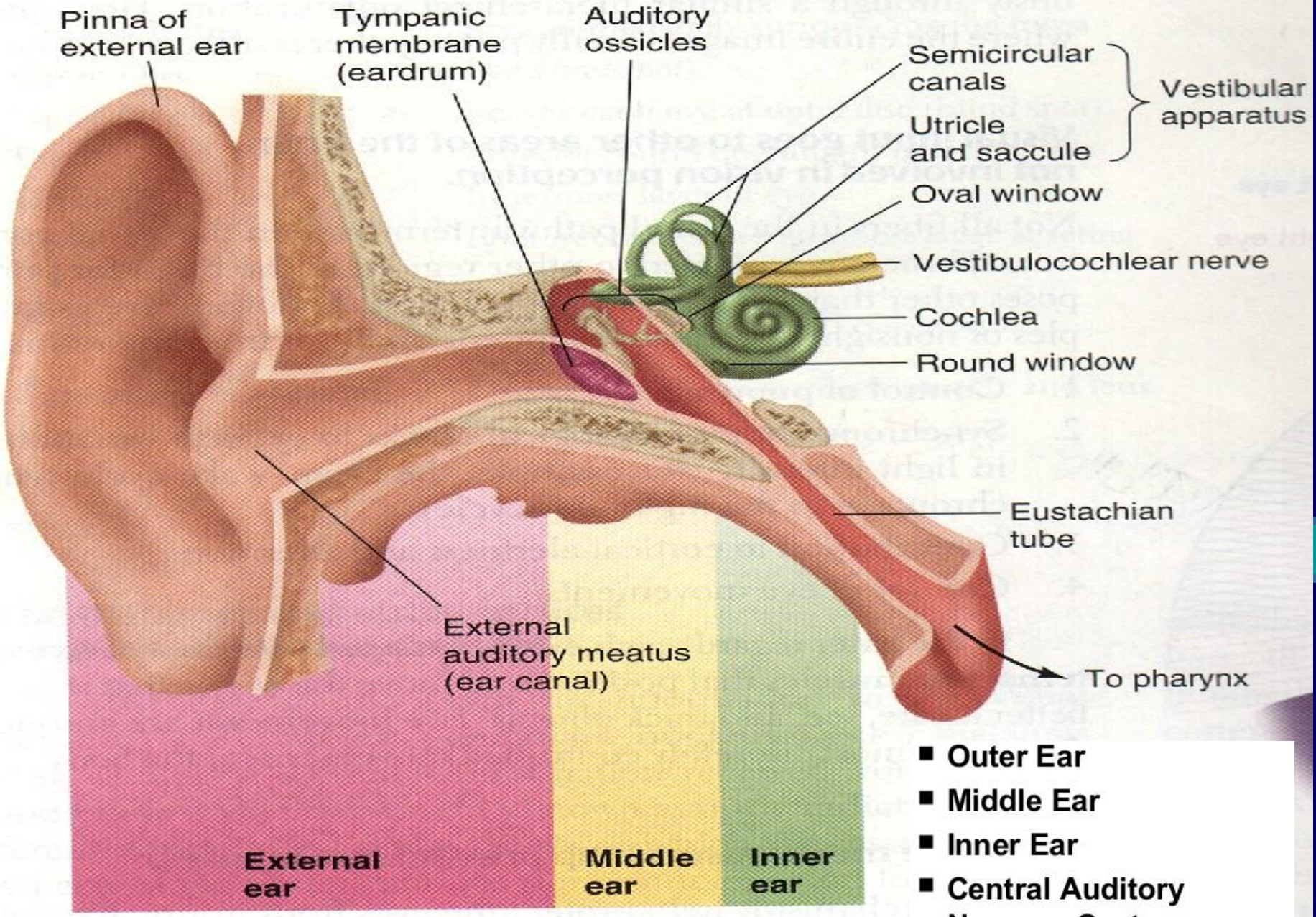
Sound: Sound is a vibration that propagates as an audible wave of pressure, through a transmission medium such as gas, liquid or solid.

Sound is produced from alternate compression and rarefaction of air molecules by vibrating body

In human physiology and psychology, sound is the reception of such waves and their perception by the brain

Hearing: Hearing is the ability to perceive sound by detecting vibrations through the ear. Humans have a narrow range of hearing compared to other species. 20 Hz - 20,000 Hz.


Outer Ear
Middle Ear
Inner Ear



- Outer Ear
- Middle Ear
- Inner Ear
- Central Auditory Nervous System

FIGURE 6-33
Anatomy of the ear

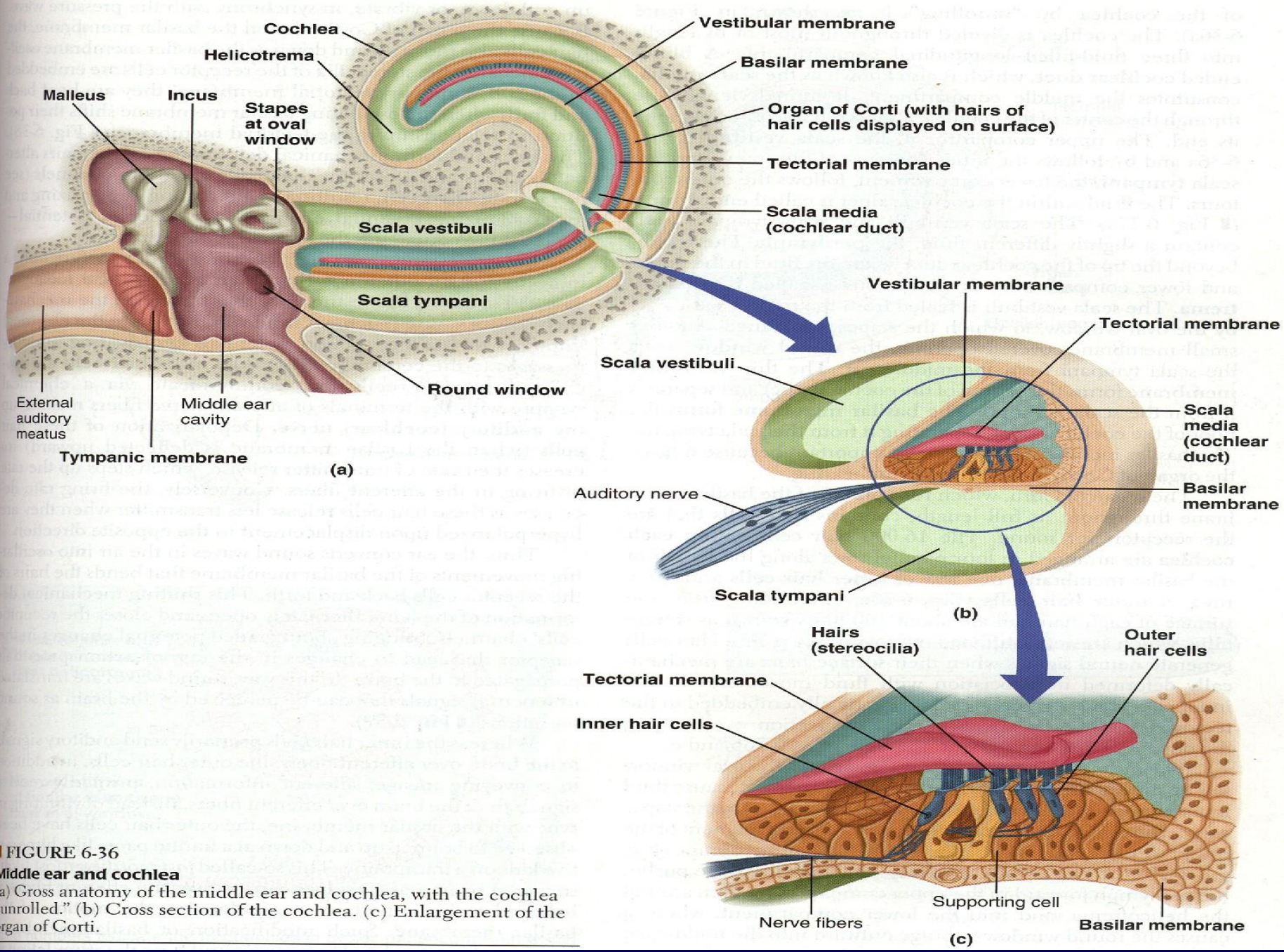


FIGURE 6-36

Middle ear and cochlea

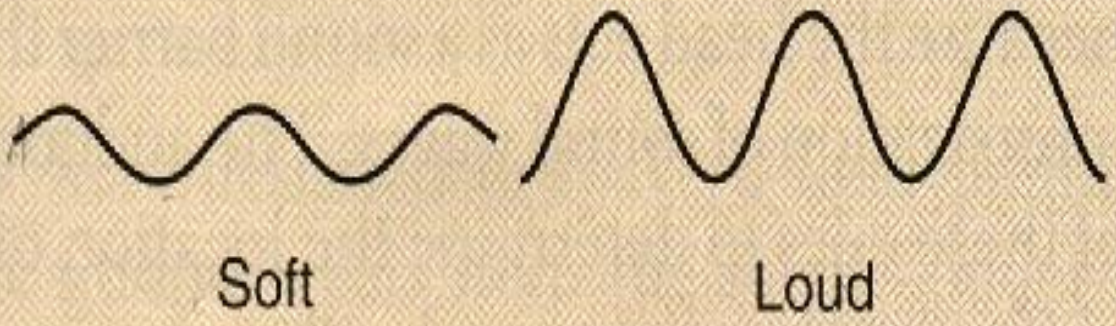
(a) Gross anatomy of the middle ear and cochlea, with the cochlea "unrolled." (b) Cross section of the cochlea. (c) Enlargement of the organ of Corti.

Characteristics of sound

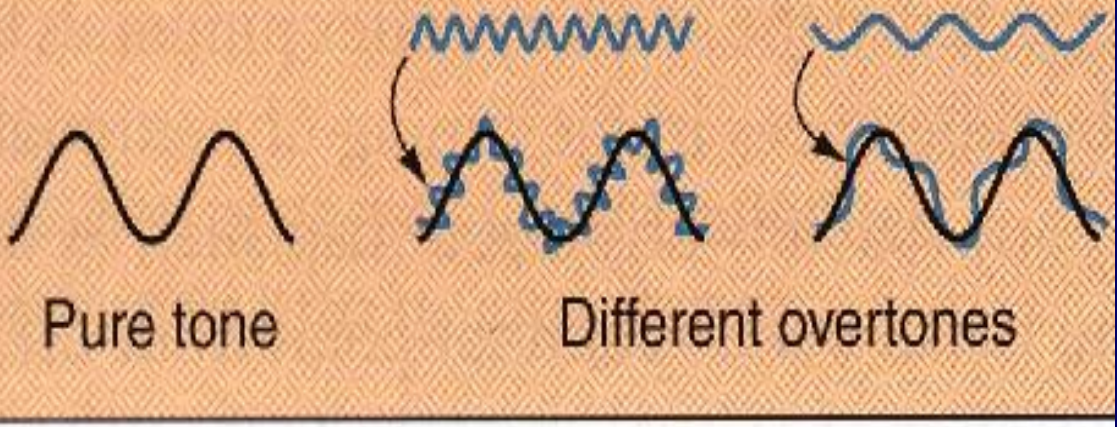
- **Pitch:** (Tone) depend on No. Of cycle / sec.
- Human ear can detect sound waves with freq 20-20000 cycle /sec
- **Intensity** (Loudness) depend on amplitude.
- **Quality** depend on the over tone or interference

Pitch (tone)
depends on
frequency

Intensity (loudness)
depends on amplitude



Timbre (quality)
depends on
overtones



Functions of the ear

- **External ear:**
  - Act as funnel to collect sound
  - Sound localisation (front, back, high, low)
  - Alter amplitude (Pinna)
  - Protection
  - Wax

Functions of the Ear

- **Middle ear:** it is a space between tympanic membrane and the inner ear (opens via Eustachian tube into nasopharynx)
- Content:
  - 1- Air
  - 2- Ossicles
    - Malleus
    - Incus
    - Stapes
  - 3- Muscles
    - 1- Tensor tympani
    - 2- Stepedius

Tensor tympani and stapedius muscles contract reflexly in response to constant loud sound

Functions of the Middle Ear

- 1- Ossicles:
  - Manbrium of the malleus attached to the back of the tympanic membrane and its short process attached to the incus.
  - The incus then articulates with the head of the stapes, and its foot plate attached to the oval window

Functions of the middle ear

- 2- Muscles:
  - Muscles contract reflexly in response to loud sound (over 70dB)
  - Contraction of the tensor tympani pulls the manubruim & makes the tympanic m. tens. Thus decreasing the vibration.
  - Contraction of the stapeduis pull the foot plate outward so that vibration reduced
  - (protection from constant loud noise, but not sudden noise, latency of 40-80 msec.

Transmission of sound through the middle ear

- sound waves vibrate the tympanic m.
- Tympanic m moves the handle of malleus
- Incus moves
- Stapes move in & out of the oval window. The pressure transmitted through cochlea cause stimulation of hair cells in the organ of corti, which will stimulate the auditory nerve

Inner ear

- **Cochlea** (snail like, coiled tubular system laying deep in the temporal bone)
  - Bony labyrinth
  - Membranous labyrinth

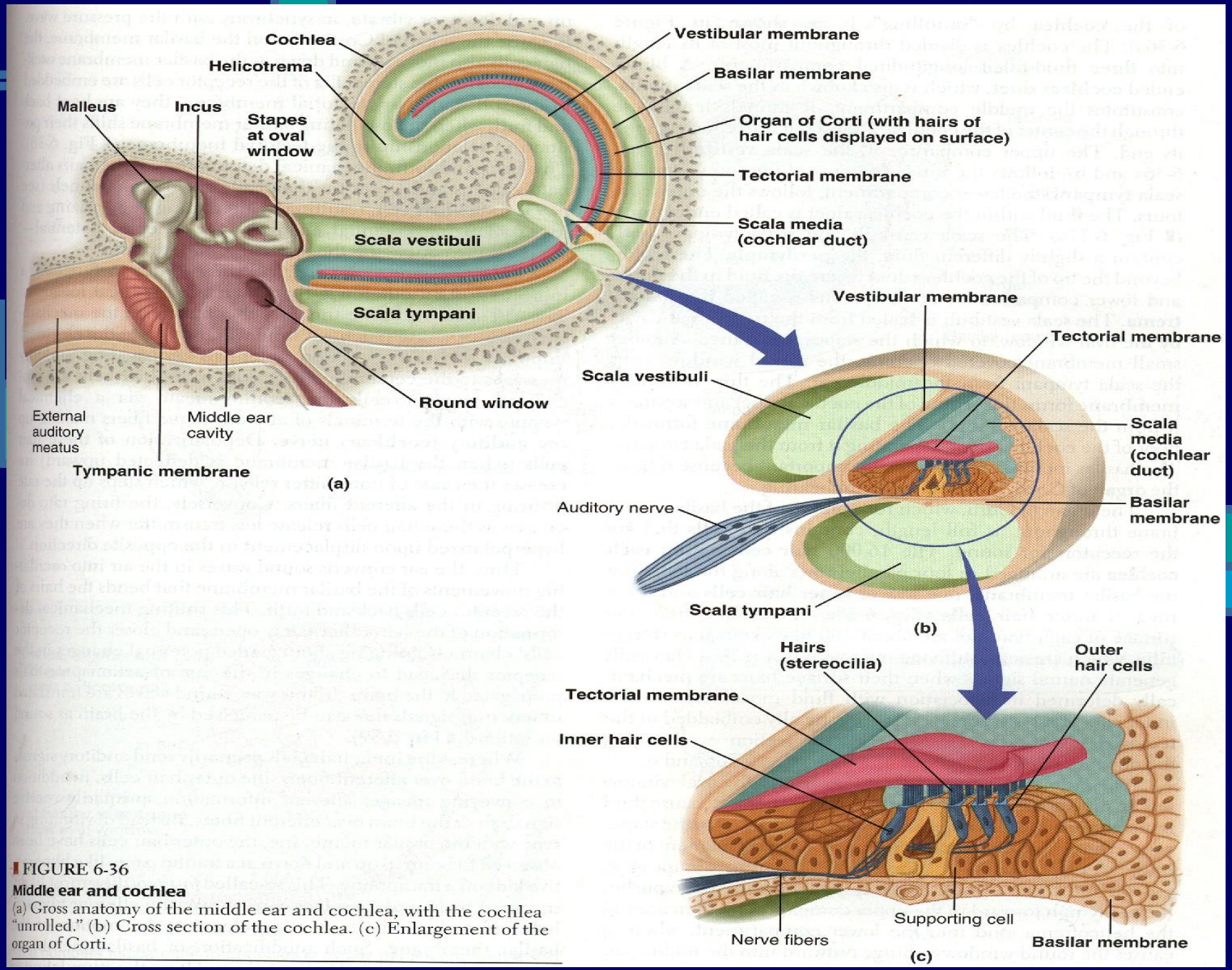
Cochlea

- It is a system of three coiled tubes through its length
- The basilar m. & the reissners m divide it into three canals:
  - Scala Vestibuli
  - Scala Media
  - Scala Tympani

- Scala Vestibuli: Na high K low
- Scala Tympani: Na high K low
- Scala Media : Na low K high

Organ of Corti

- Located (resting) on the basilar m.
- Contain inner & outer hair cells
- Extend from base to apex



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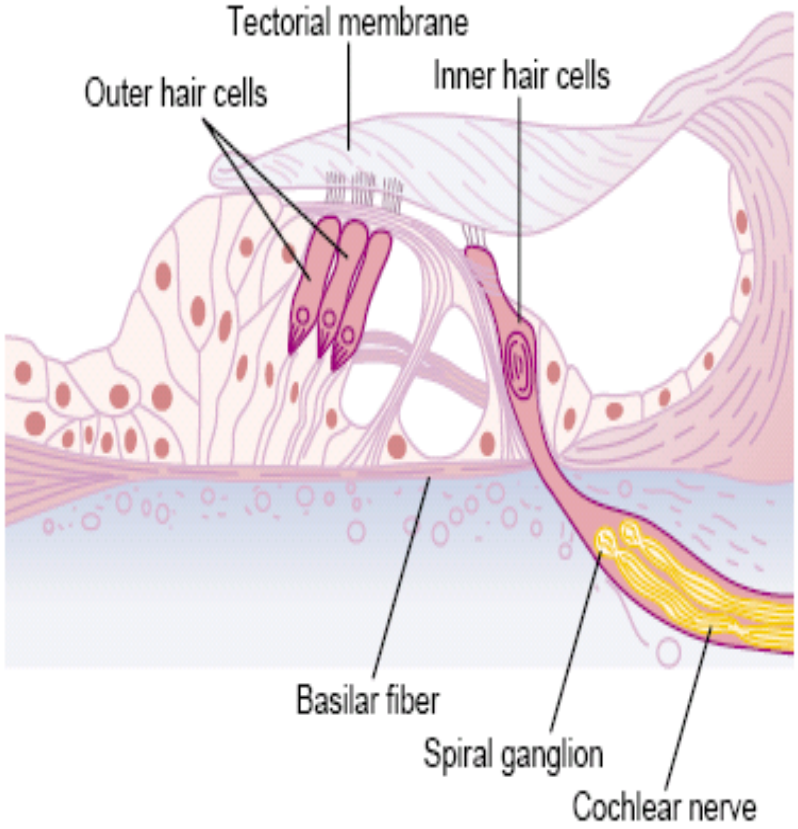


Figure 52–7

Organ of Corti, showing especially the hair cells and the tectorial membrane pressing against the projecting hairs.

of the inner hair cells at different sound pitches, a

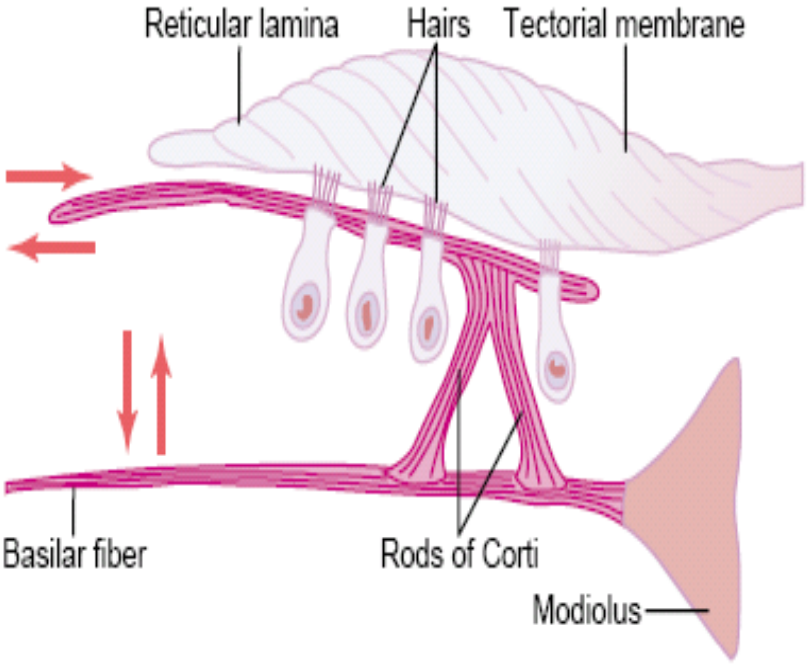


Figure 52–8

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

Hair cells

Arrangement:

- Three rows of outer hair cells (attached to the reticular lamina or tectorial m.)
- One row of inner hair cells (not attached to tectorial m.)

Functions:

- Inner hair cells are the primary receptors for sound, transducing fluid movement in cochlea into action potential in the auditory nerve

Receptors & Endocochlear potentials

- Sound transmission into the inner ear cause upper & lower movements of the reticular m. (tectorial m.)
- Produce bending of steriocillia of the hair cells alternatively open & close cation channels at the tip of the steriocillia

- Inward current: Depolarization
- Outward current: Hyperpolarisation
- The net results is depolarization

- Production of cells receptors potentials
- Release of neurotransmitter
- Production of action potentials

The Central Auditory pathway

- Organ of Corti
  - Located within the cochlea
  - Hearing receptors → hair cells on the basilar membrane
  - Gel-like tectorial membrane is capable of bending hair cells
  - Cochlear nerve attached to hair cells transmits nerve impulses to auditory cortex on temporal lobe

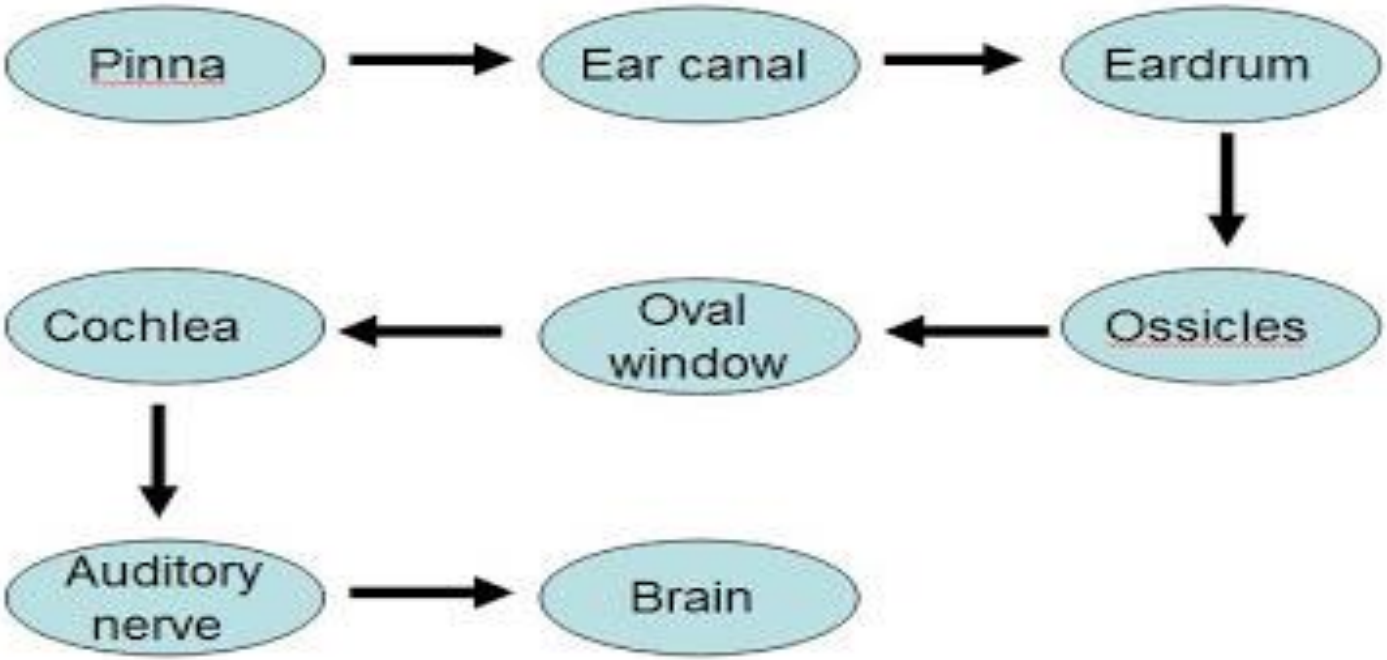
The Central Auditory pathway

- This pathway begins in the organ of corti
- End in the primary auditory cortex (are 41 & 42, superior temporal gyrus in the temporal lobe of the brain
- Fibres end in the auditory area, where it is heard, then interpretation occurs in the auditory association areas (wernikes area)

The Central Auditory pathway

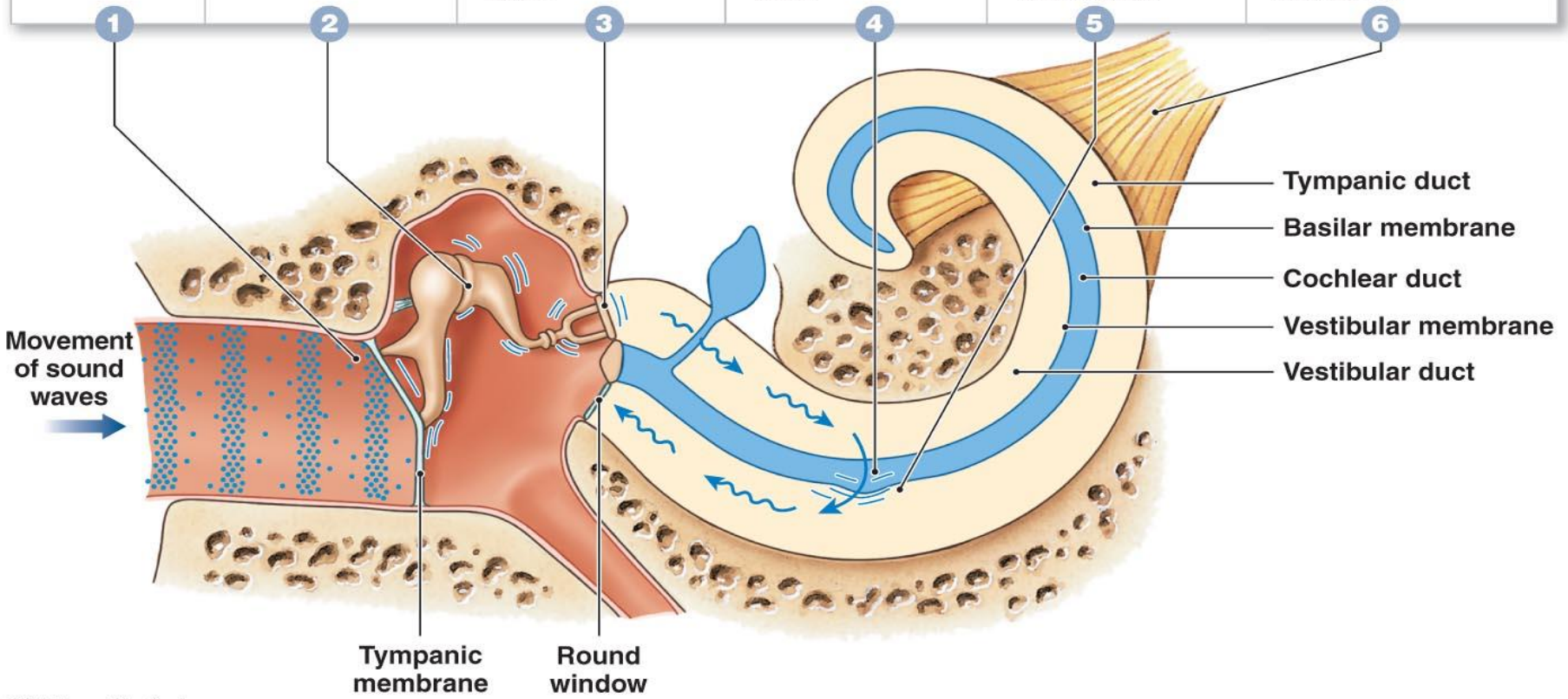
- There is a bilateral cortical connection of auditory area
- Thus damage to one side only slightly reduces hearing

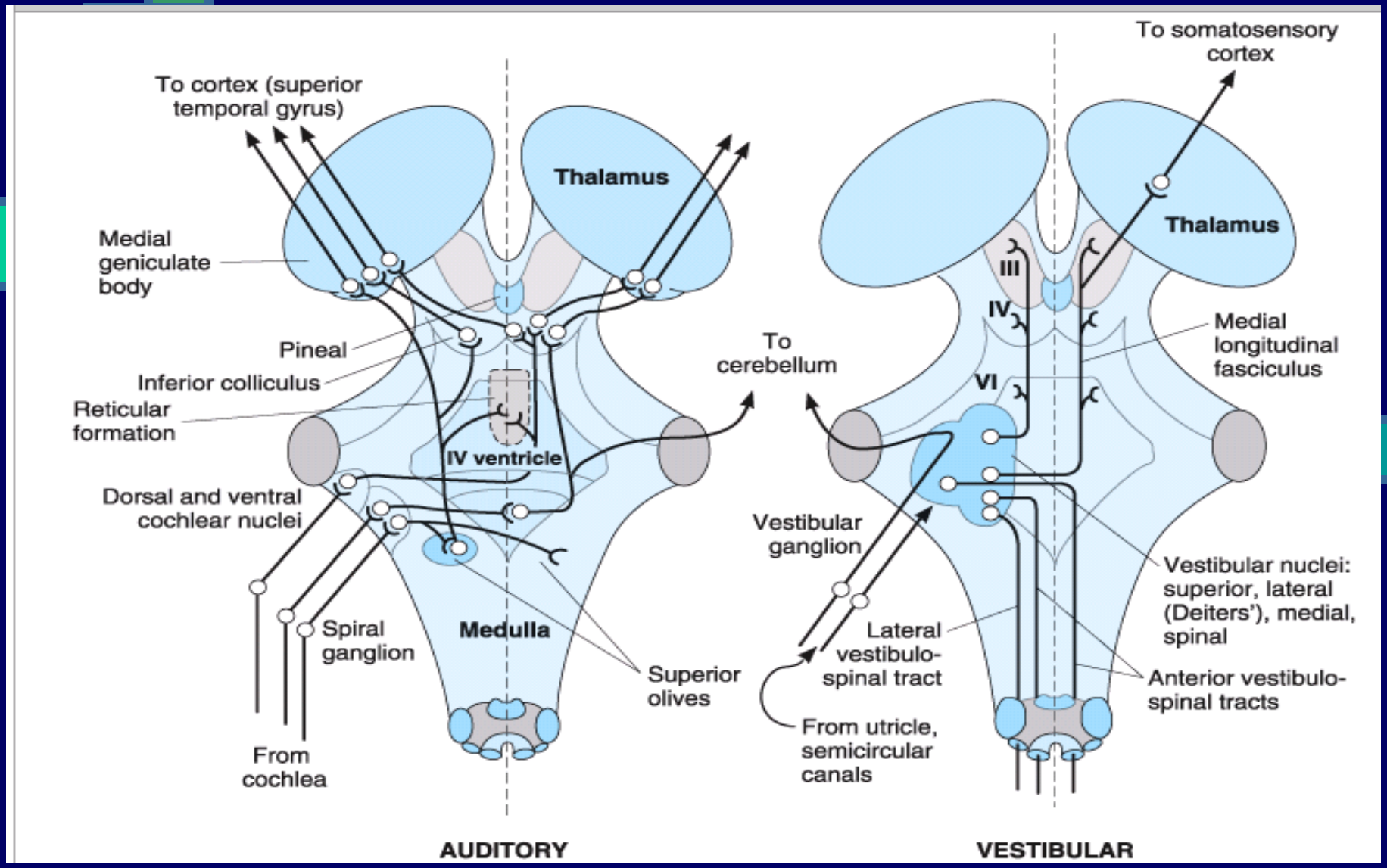
Hearing Mechanism

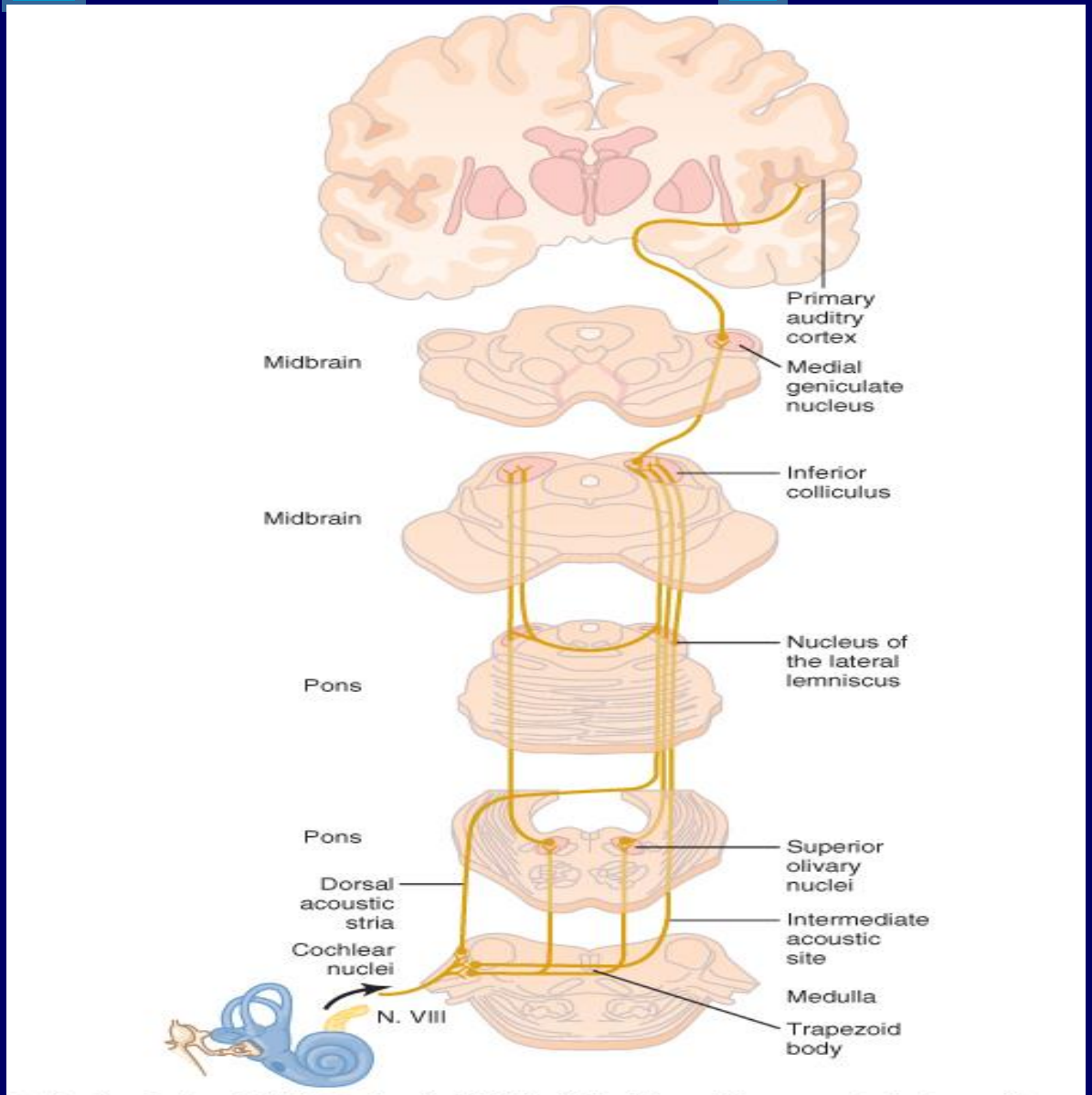


Events Involved in Hearing

1	2	3	4	5	6
Sound waves arrive at the tympanic membrane.	Movement of the tympanic membrane causes displacement of the auditory ossicles.	Movement of the stapes at the oval window establishes pressure waves in the perilymph of the vestibular duct.	The pressure waves distort the basilar membrane on their way to the round window of the tympanic duct.	Vibration of the basilar membrane causes vibration of hair cells against the tectorial membrane.	Information about the region and the intensity of stimulation is relayed to the CNS over the cochlear branch of cranial nerve VIII.




To cortex (superior temporal gyrus)
Thalamus
Medial geniculate body
Pineal
Inferior colliculus
Reticular formation
IV ventricle
Dorsal and ventral cochlear nuclei
Spiral ganglion
Medulla
Superior olives
From cochlea
AUDITORY
To somatosensory cortex
Thalamus
III
IV
VI
Medial longitudinal fasciculus
To cerebellum
Vestibular ganglion
Vestibular nuclei: superior, lateral (Deiters'), medial, spinal
Lateral vestibulo-spinal tract
Anterior vestibulo-spinal tracts
From utricle, semicircular canals
VESTIBULAR


Primary auditry cortex
Midbrain
Medial geniculate nucleus
Inferior colliculus
Midbrain
Nucleus of the lateral lemniscus
Pons
Pons
Superior olivary nuclei
Dorsal acoustic stria
Intermediate acoustic site
Cochlear nuclei
Medulla
N. VIII
Trapezoid body
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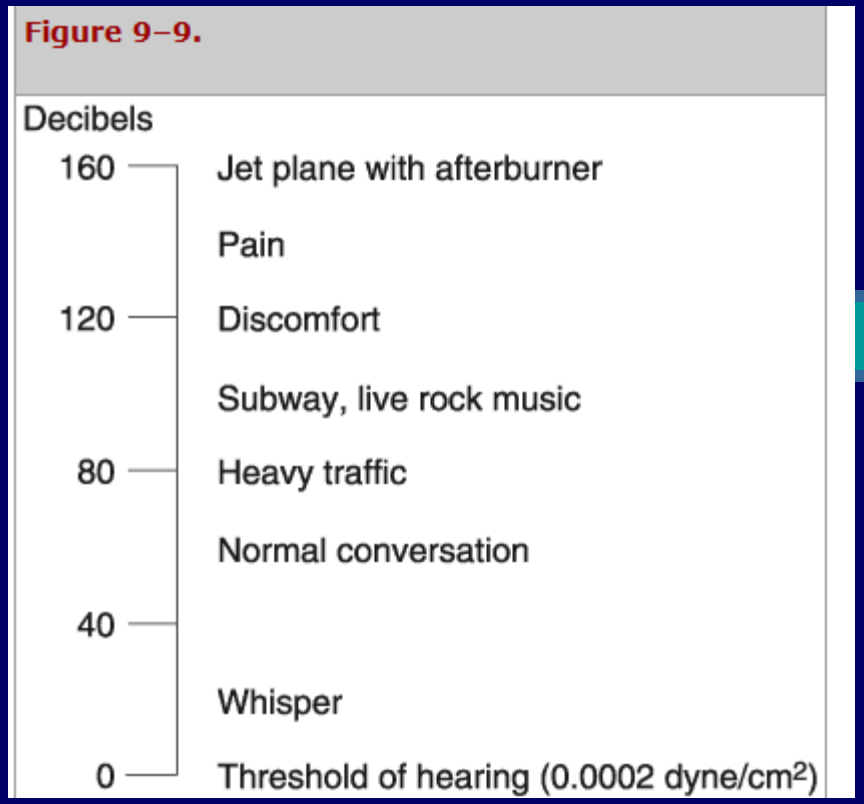
Masking effect

- Presence of one sound decreases an individual's ability to hear other sounds. This phenomenon is known as **masking**

- Presence of background noise affect the ability to hear another sound, **due to some receptors are in refractory period**
- Masking is more clear if two sound are having the same frequencies

NOISE POLLUTION

- Noise pollution is an environmental hazard
- Exposure to sound intensity above 80dB may damage outer hair cells



Conduction of sound wave

- Air conduction:
  - Normal situation of hearing, sound travel in air causes vibration of Tympanic m., transmitted by ossicles to the oval window

Conduction of sound wave

- Bone conduction:
  - Sound cause vibration of skull bones directly transmitting the sound vibration to the cochlea (eg when placing tuning fork on the head or mastoid process)

Deafness

- Conductive deafness
- Perceptive deafness

Conductive deafness

- Impairment of sound transmission through external or middle ear due to:
  - Wax
  - Repeated infection
  - Perforated drum
  - Destruction of ossicles
  - Osteosclerosis (pathological fixation of stapes on the oval window)
- All sound frequencies are equally affected
- Bone conduction is better than air conduction

Perceptive deafness

- Due to congenital or damage to cochlea or auditory nerve pathway due to:
  - Toxins (antibiotics, gentamycine)
  - Inflammation
  - Vascular
  - Tumour

  Both air and bone conduction are affected

Test of hearing

- Audiometery
- Rinnes test
- Weber test

Table 9–1. Common Tests with a Tuning Fork to Distinguish between Nerve and Conduction Deafness.

	Weber	Rinne	Schwabach
Method	Base of vibrating tuning fork placed on vertex of skull.	Base of vibrating tuning fork placed on mastoid process until subject no longer hears it, then held in air next to ear.	Bone conduction of patient compared with that of normal subject.
Normal	Hears equally on both sides.	Hears vibration in air after bone conduction is over.	
Conduction deafness (one ear)	Sound louder in diseased ear because masking effect of environmental noise is absent on diseased side.	Vibrations in air not heard after bone conduction is over.	Bone conduction better than normal (conduction defect excludes masking noise).
Nerve deafness (one ear)	Sound louder in normal ear.	Vibration heard in air after bone conduction is over, as long as nerve deafness is partial.	Bone conduction worse than normal.

THANK YOU