MECHANISM OF HEARING

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MECHANISM OF HEARING

Lecture Objectives

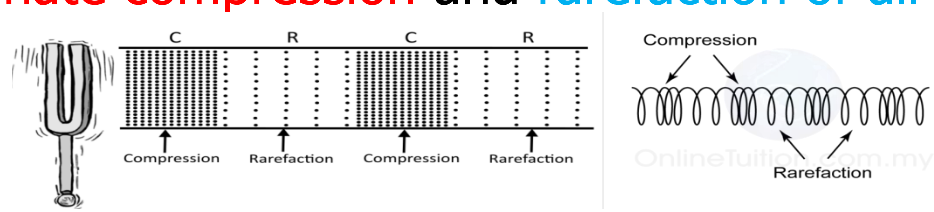
At the end of this lecture students should be able to:

- Appreciate the functions of outer, middle and inner ear
- Describe nature of sound & its characteristics
- Functions of semicircular canals& utricle & saccule.
- Understand the role of middle ear in sound transmission, Magnification and tympanic reflex effect
- Recognize the function of hair cells of inner ear
- Differentiate between conductive and perceptive deafness

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



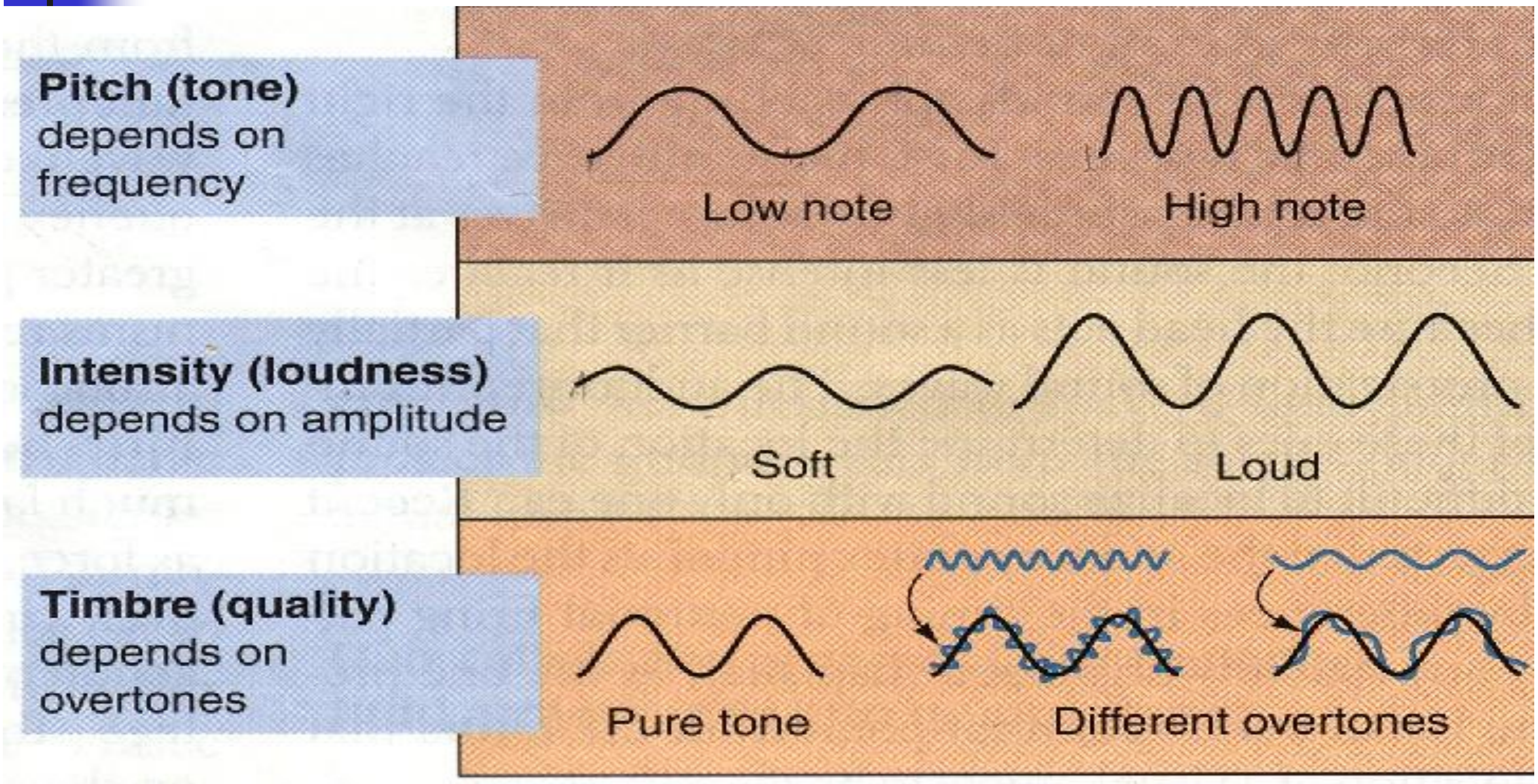
In human physiology and psychology, sound is the reception of waves and their perception by the brain

Hearing: Hearing is the ability to perceive sound by detecting vibrations through the ear. Human hearing range: 20 Hz-20,000 Hz.

Ear: Receives sound waves, discriminates frequencies, and transmits auditory information into the CNS, where meaning is deciphered.

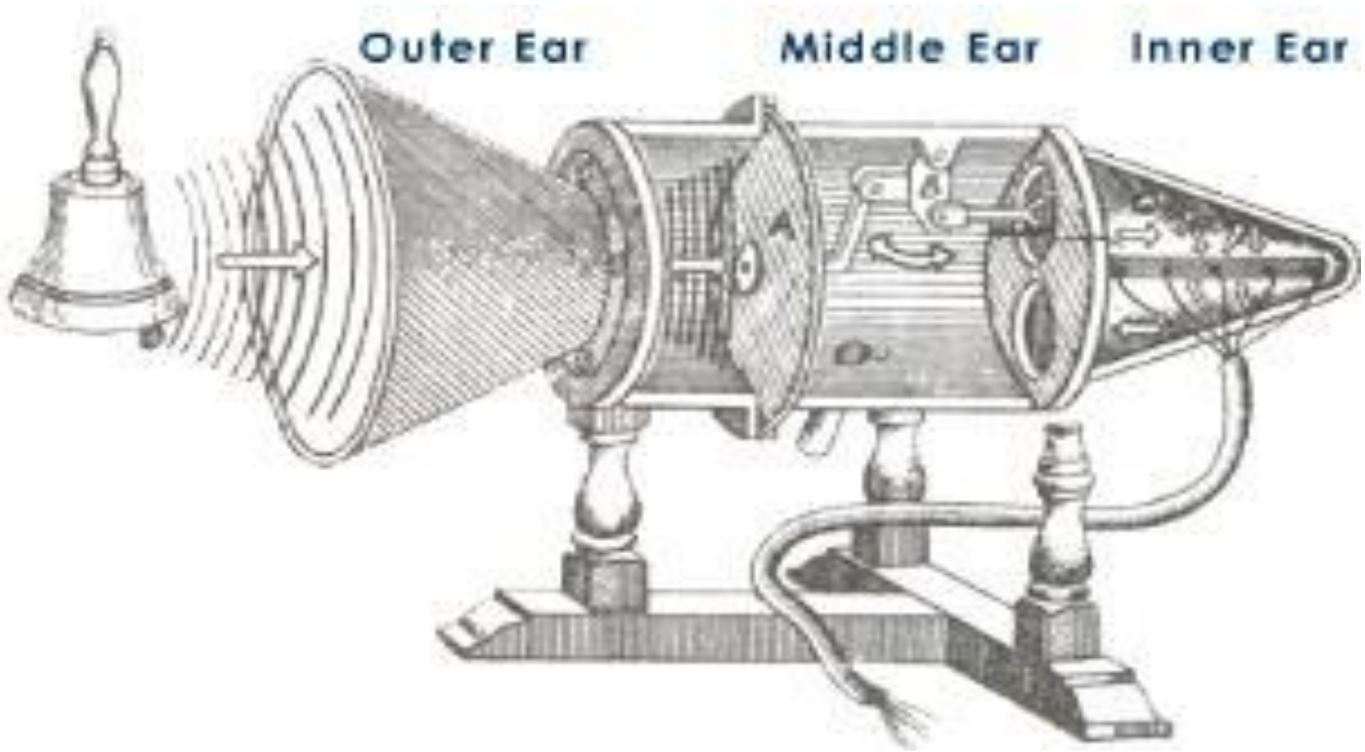
Guyton & Hall, 2016; Chapter 53; pp 673-682

CHARACTERISTICS OF SOUND



- **Pitch:** (Tone): depend on No. Of cycle / sec.
- **Intensity** (Loudness): depend on amplitude.
- **Quality:** depend on the over tone or interference

MECHANISM OF HEARING



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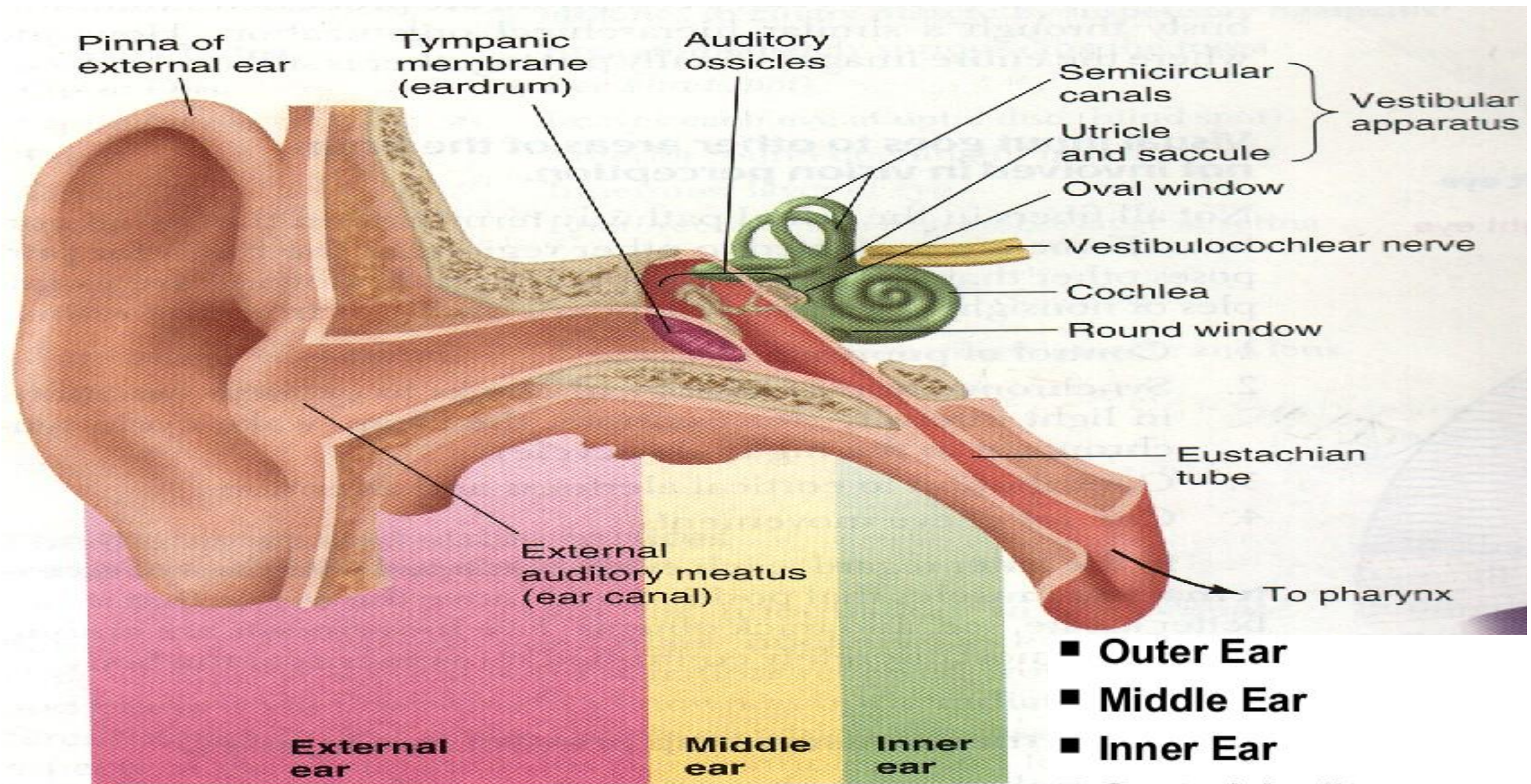
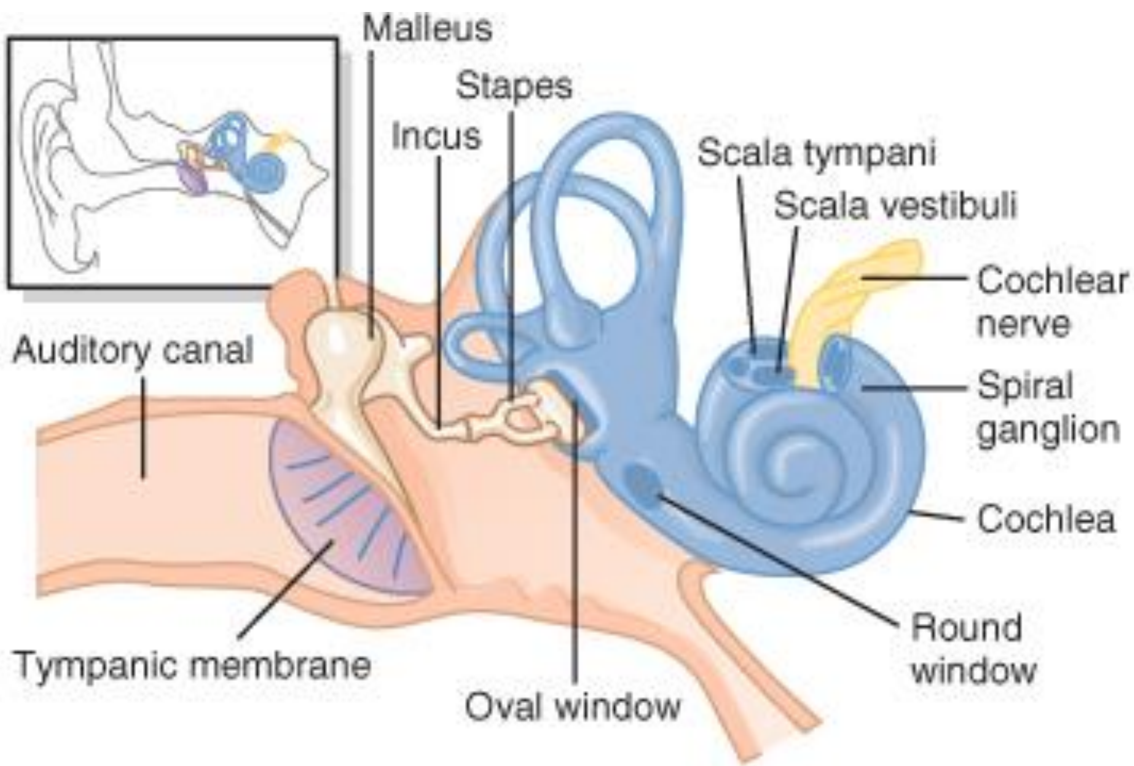


FIGURE 6-33
Anatomy of the ear

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

MECHANISM OF HEARING



The tympanic membrane, ossicular system of the middle and inner ear

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MECHANISM OF HEARING

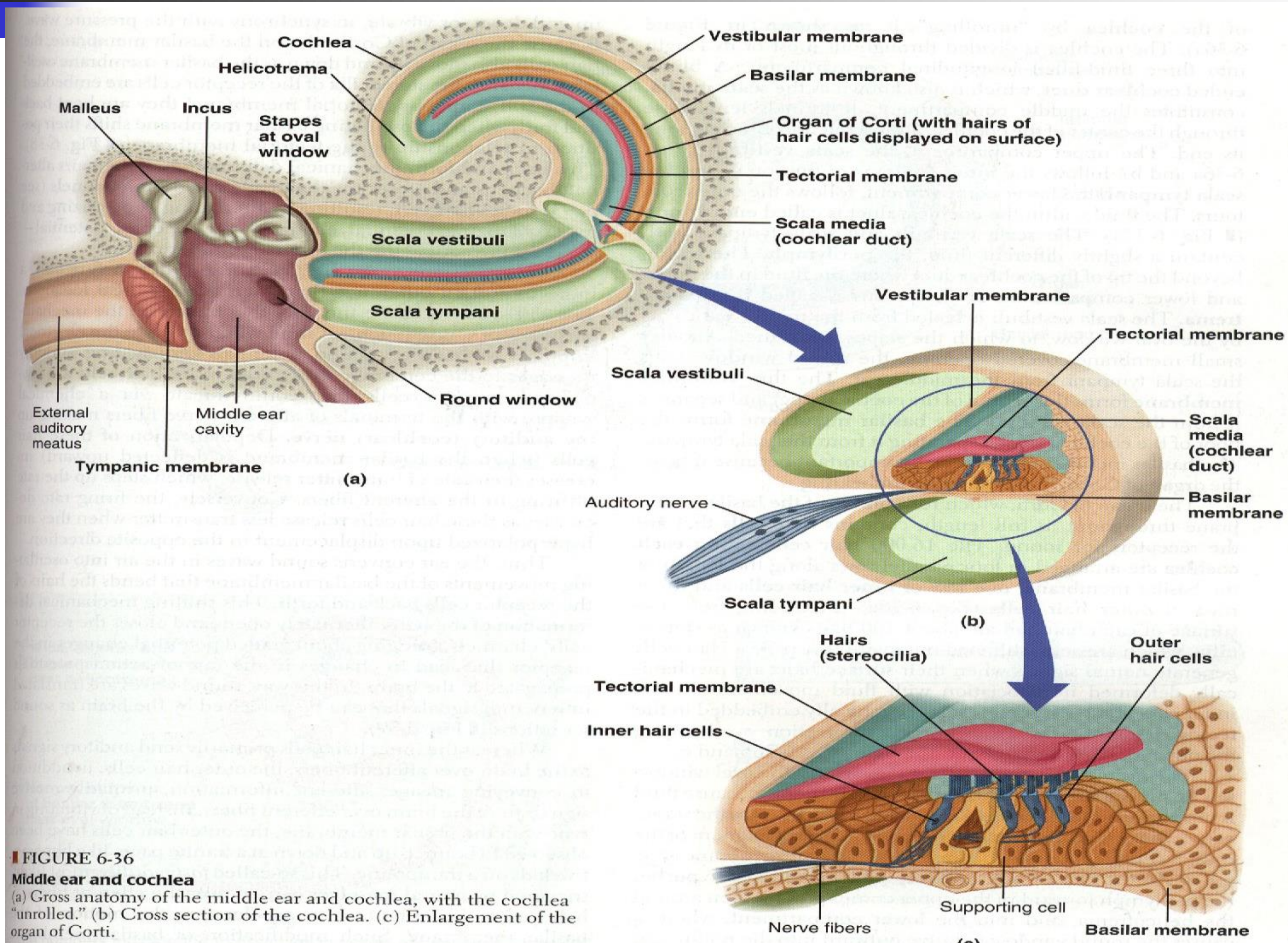

FIGURE 6-36
Middle ear and cochlea
(a) Gross anatomy of the middle ear and cochlea, with the cochlea "unrolled." (b) Cross section of the cochlea. (c) Enlargement of the organ of Corti.

FUNCTIONS OF THE EAR

External Ear:

- Act as funnel to collect sound
- Sound localization (front, back, high, low)
- Alter amplitude (Pinna)
- Protection
- Wax

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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 Stapedius

- Malleus and Incus act as a single lever
- Tympanic membrane (Eardrum) and ossicles, conduct sound from the tympanic membrane through the middle ear to cochlea (the inner ear).
- In the **absence** of the ossicular system and tympanic
- Membrane: Sound waves can still travel directly through the air of middle ear and enter the cochlea at the oval window. However, the sensitivity for hearing is 15 to 20 decibels less than for ossicular transmission

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

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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.

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TRANSMISSION OF SOUND THROUGH THE MIDDLE EAR

- Sound waves vibrate the tympanic m.
- Tympanic membrane 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 stimulate the auditory nerve.

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INNER EAR

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

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COCHLEA

- This is a system of three coiled tubes
- 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

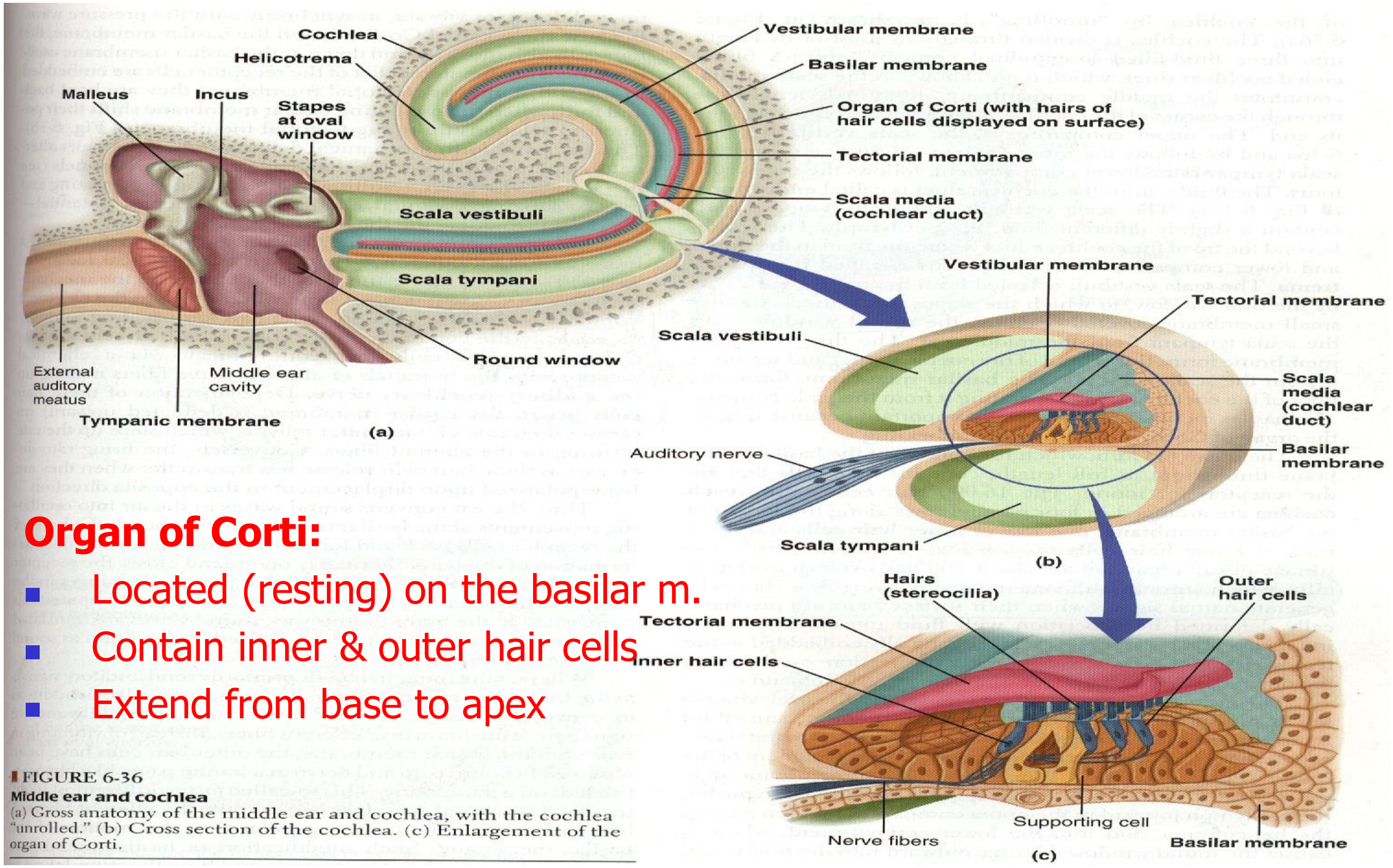

FIGURE 6-36
Middle ear and cochlea
(a) Gross anatomy of the middle ear and cochlea, with the cochlea "unrolled." (b) Cross section of the cochlea. (c) Enlargement of the organ of Corti.

Organ of Corti:

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

ORGAN OF CORTI

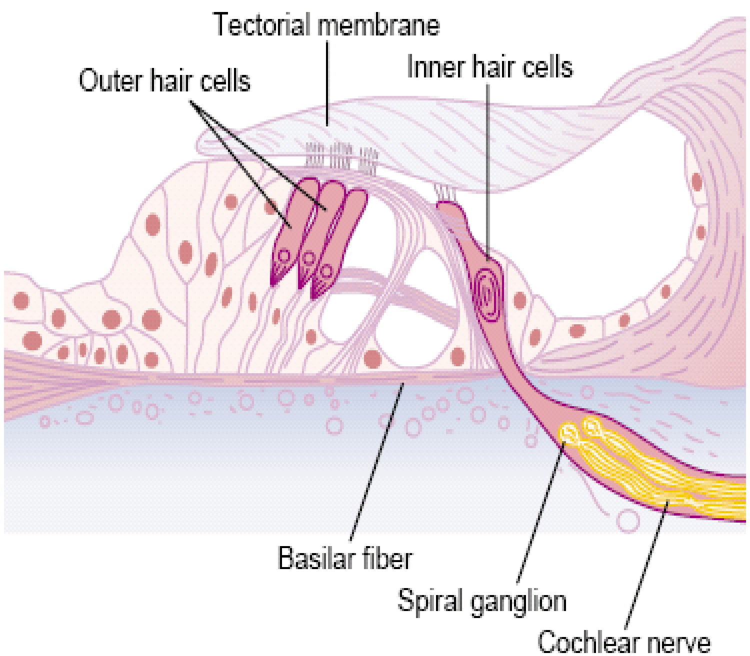

Figure 52–7

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

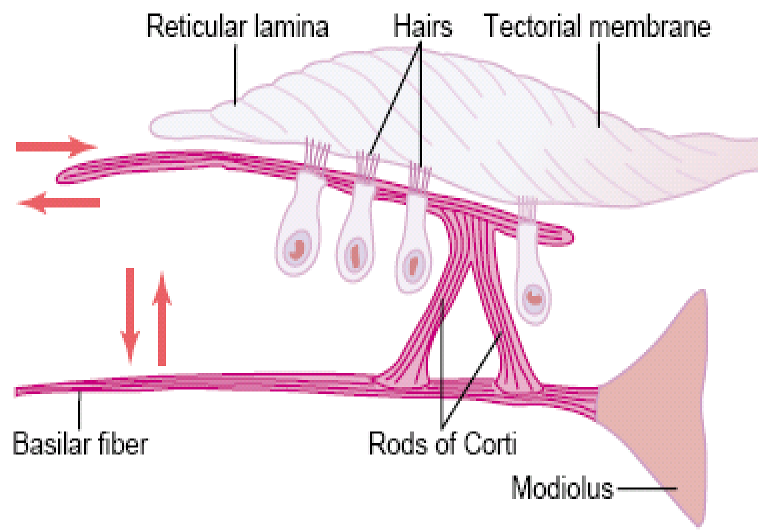

Figure 52–8

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

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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

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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

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RECEPTORS & ENDOCOCHLEAR POTENTIALS

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

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

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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

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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)

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THE CENTRAL AUDITORY PATHWAY

- There is a bilateral cortical connection of auditory area
- Damage to one side only slightly reduces hearing
- Destruction of both primary auditory cortices greatly reduces sensitivity for hearing.
- Destruction of one side slightly reduces hearing in the opposite ear;
- It does not cause deafness in the ear because of many crossover connections from side to side in the auditory neural pathway. However, it does affect ability to localize the source of a sound.

Normal Frequency Range of Hearing:
Young Person: Between 20 and 20,000 cycles/sec.
Sound range depends to a great extent on loudness.
Old age: Frequency range is shortened 50 to 8000 cycles/ sec or less

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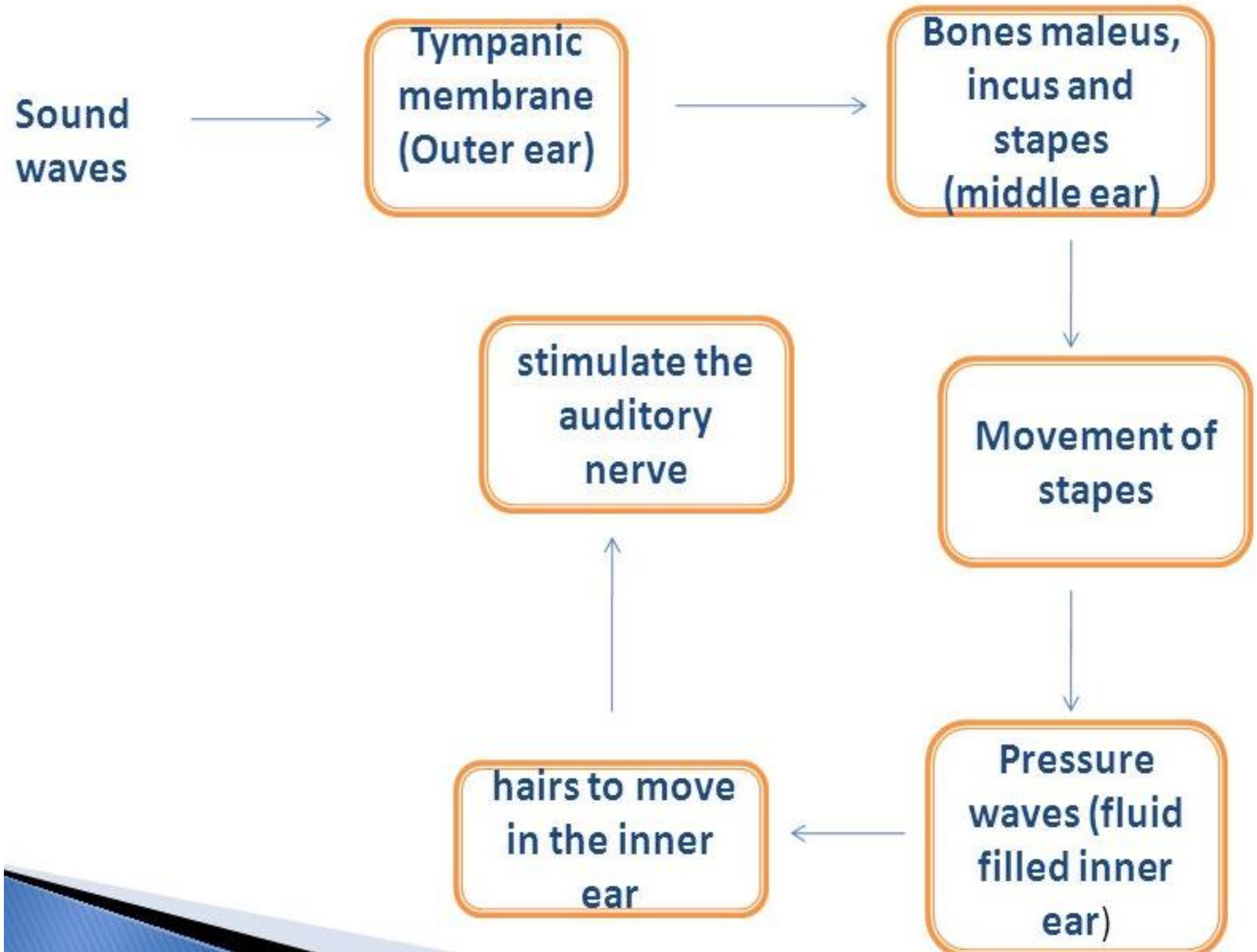
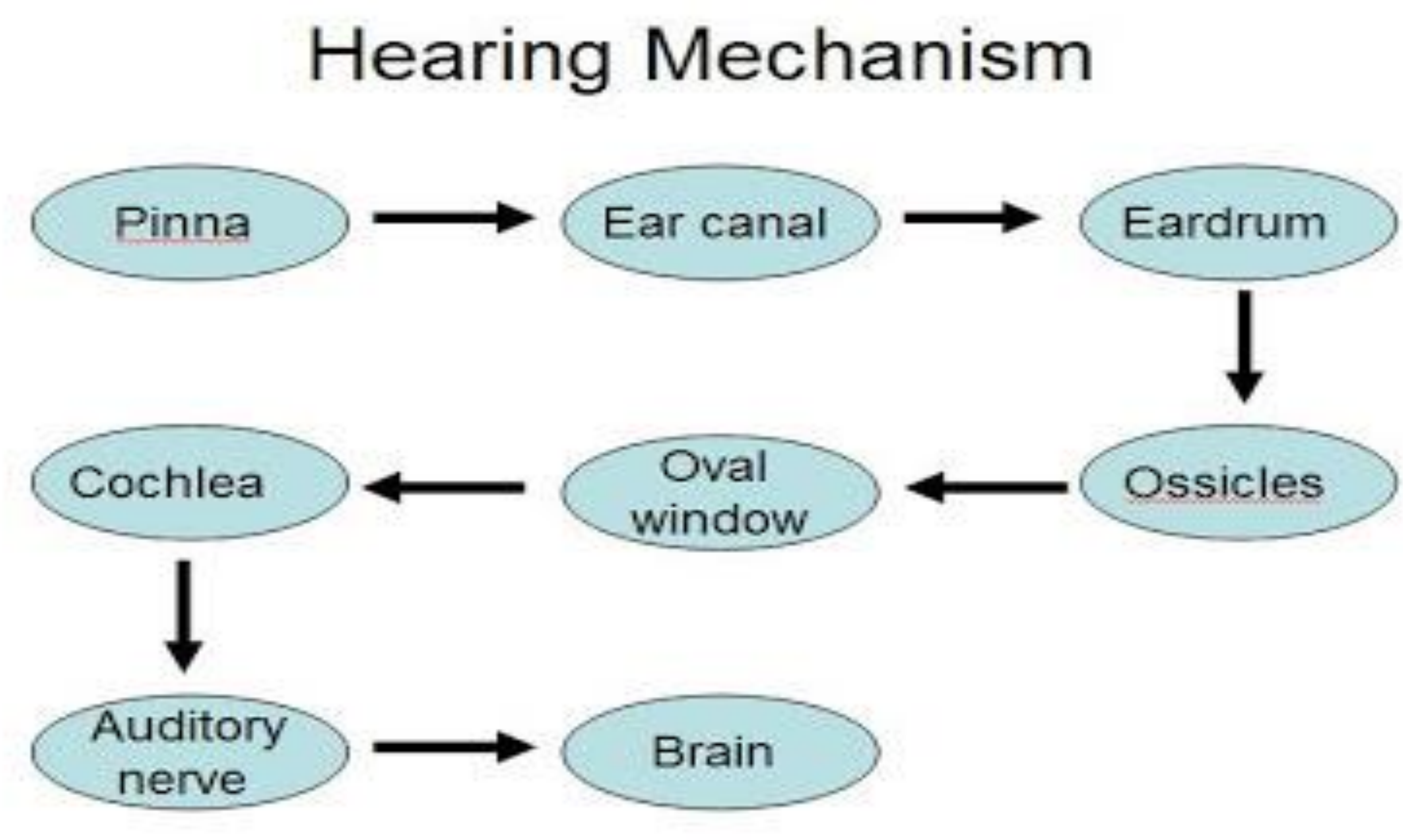
General mechanism of hearing



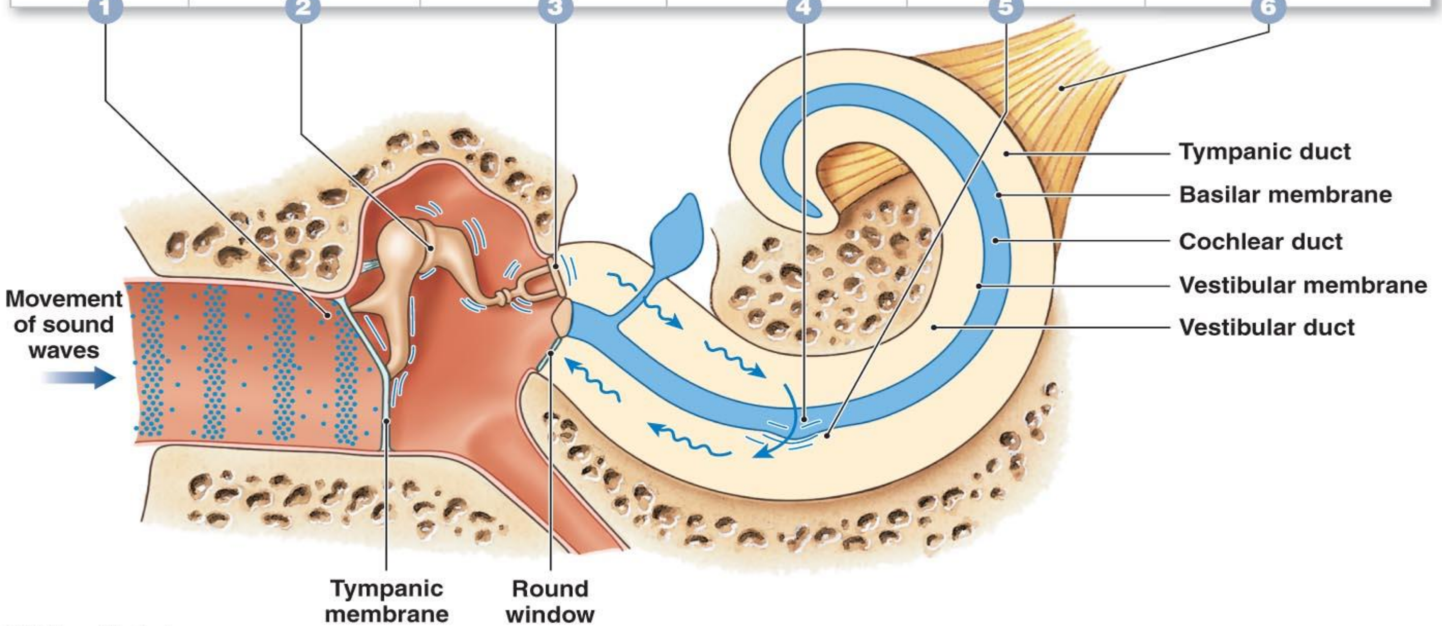
THE CENTRAL AUDITORY PATHWAY



THE CENTRAL AUDITORY PATHWAY

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.



THE CENTRAL AUDITORY PATHWAY

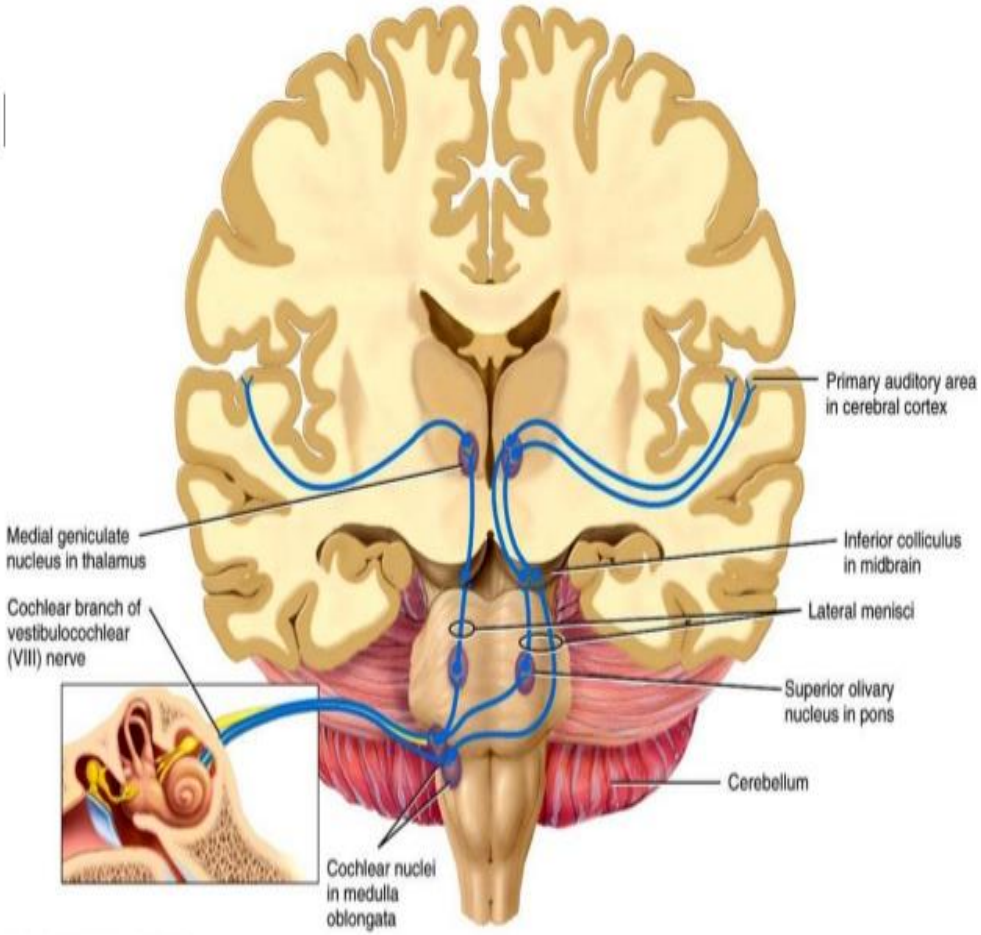
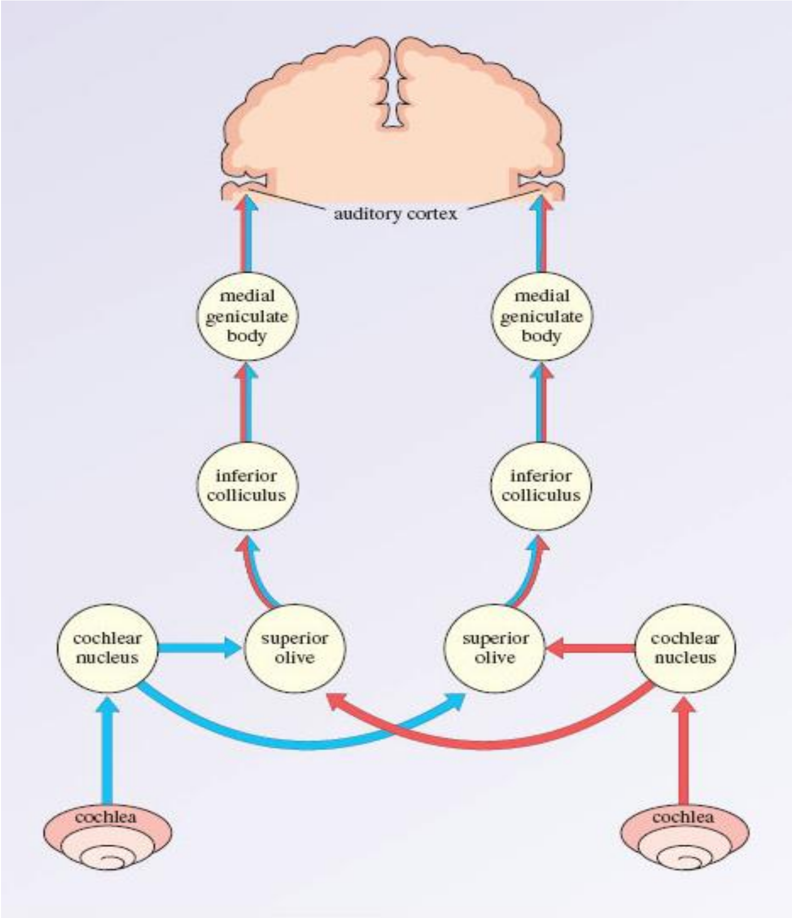
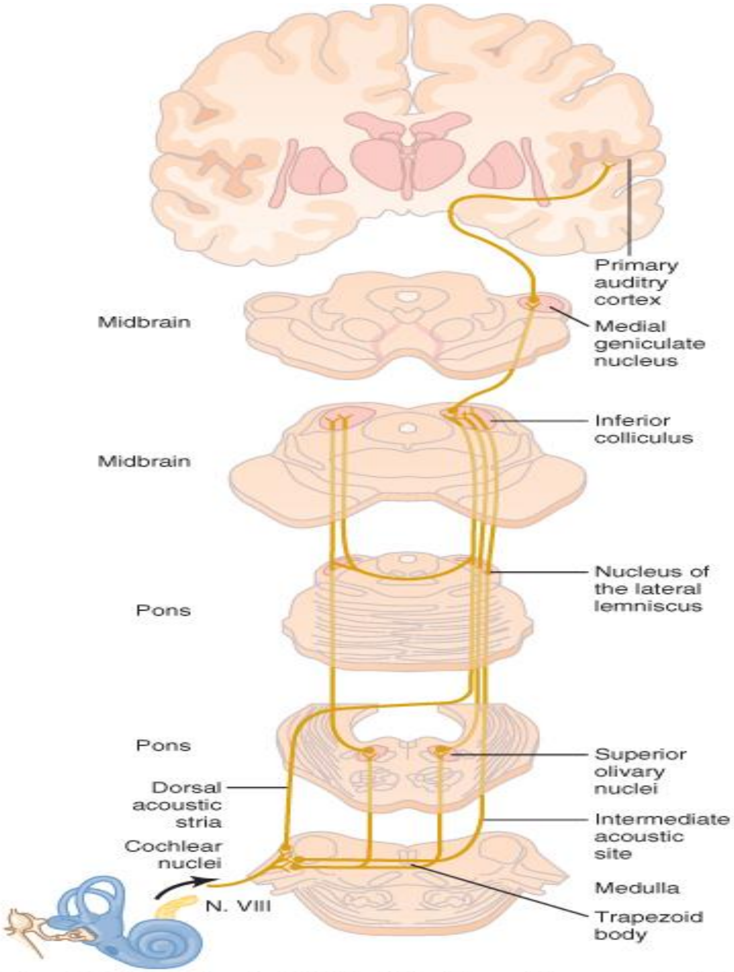


Figure 17.23 Tortora - PAP 12/e

THE CENTRAL AUDITORY PATHWAY





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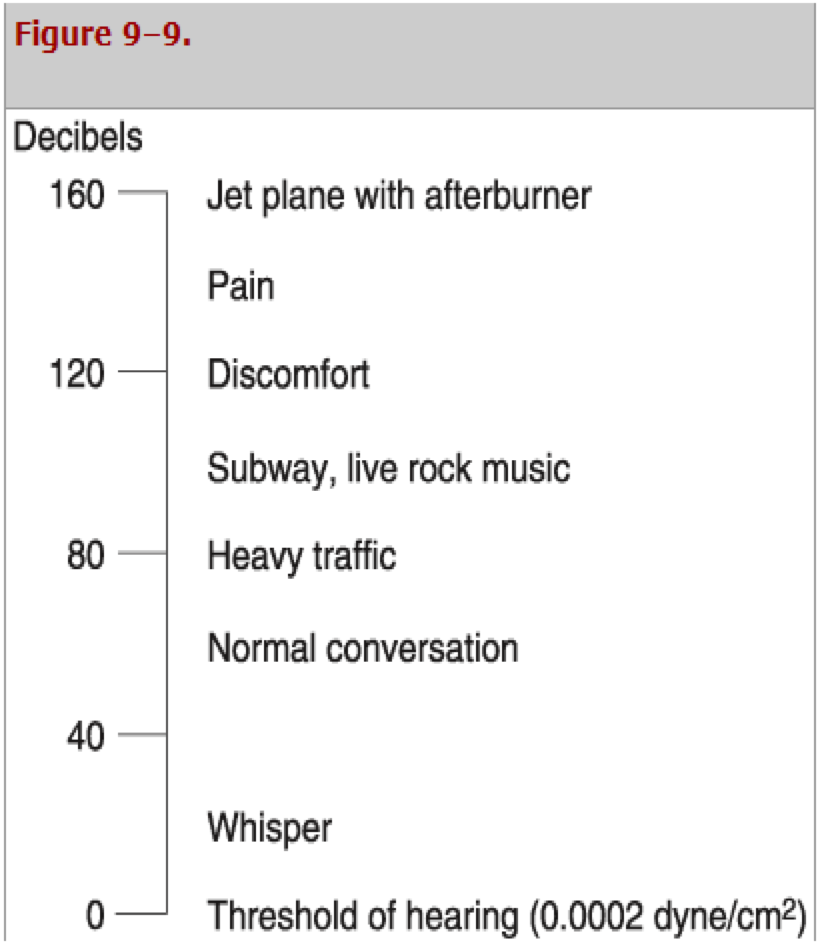
MASKING EFFECT

- 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

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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

TEST OF HEARING

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