Hearing

Lecture Objectives:

- Structure and functions of the ear
- External Middle Internal ears
- Sound characters
- Auditory pathway
- Air conduction
- Bone conduction
- Conductive and perceptive deafness
- Hearing tests

Functions of the ear

- Hearing (Parts involved):
  - External ear
  - Middle ear
  - Internal ear
- Equilibrium sense (Parts involved):
  - Internal ear

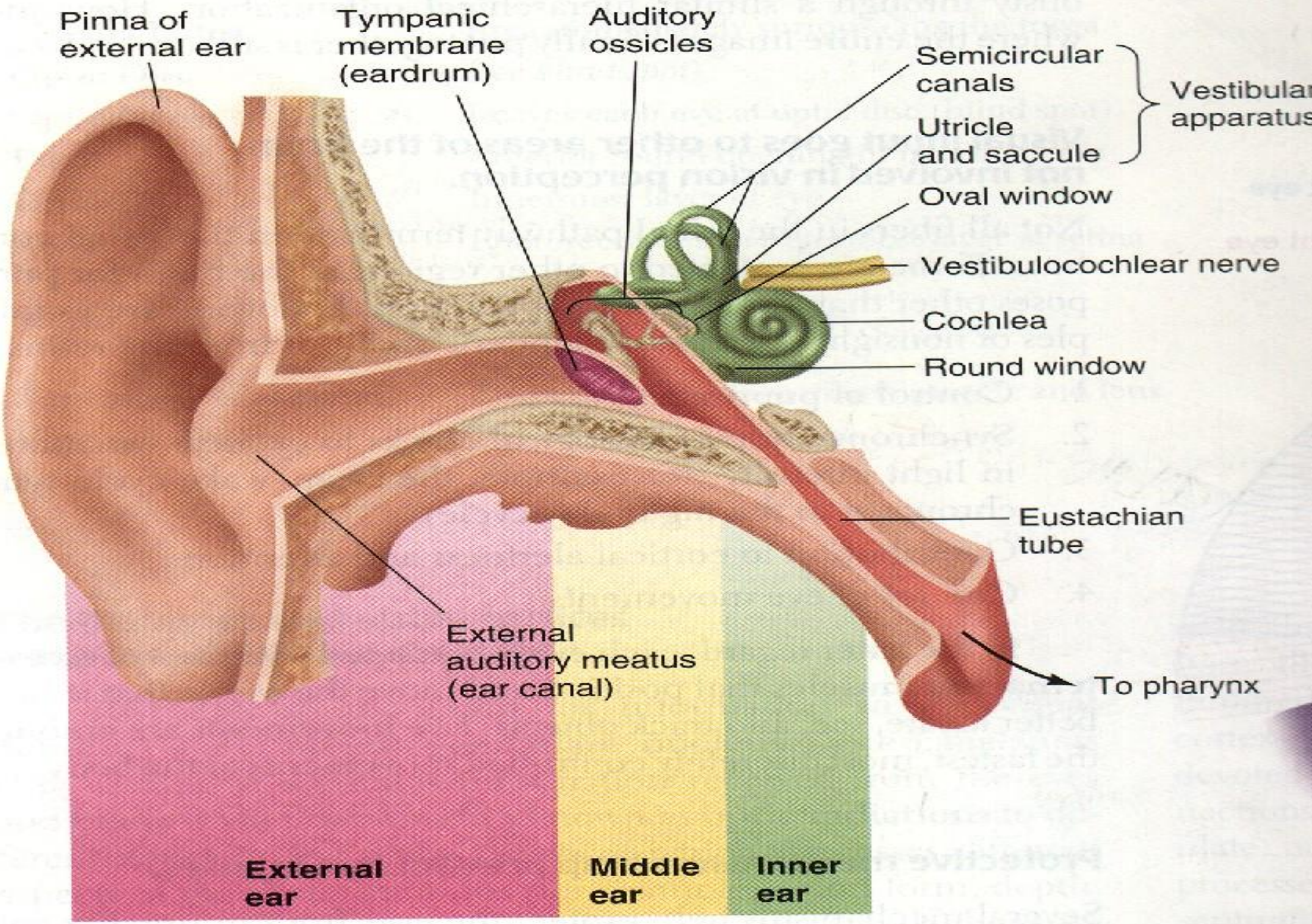


FIGURE 6-33

Anatomy of the ear

Anatomical consideration

- Outer ear:
  - Pinna
  - External canal
  - Tympanic Membrane (funnel shaped, pointing inward)

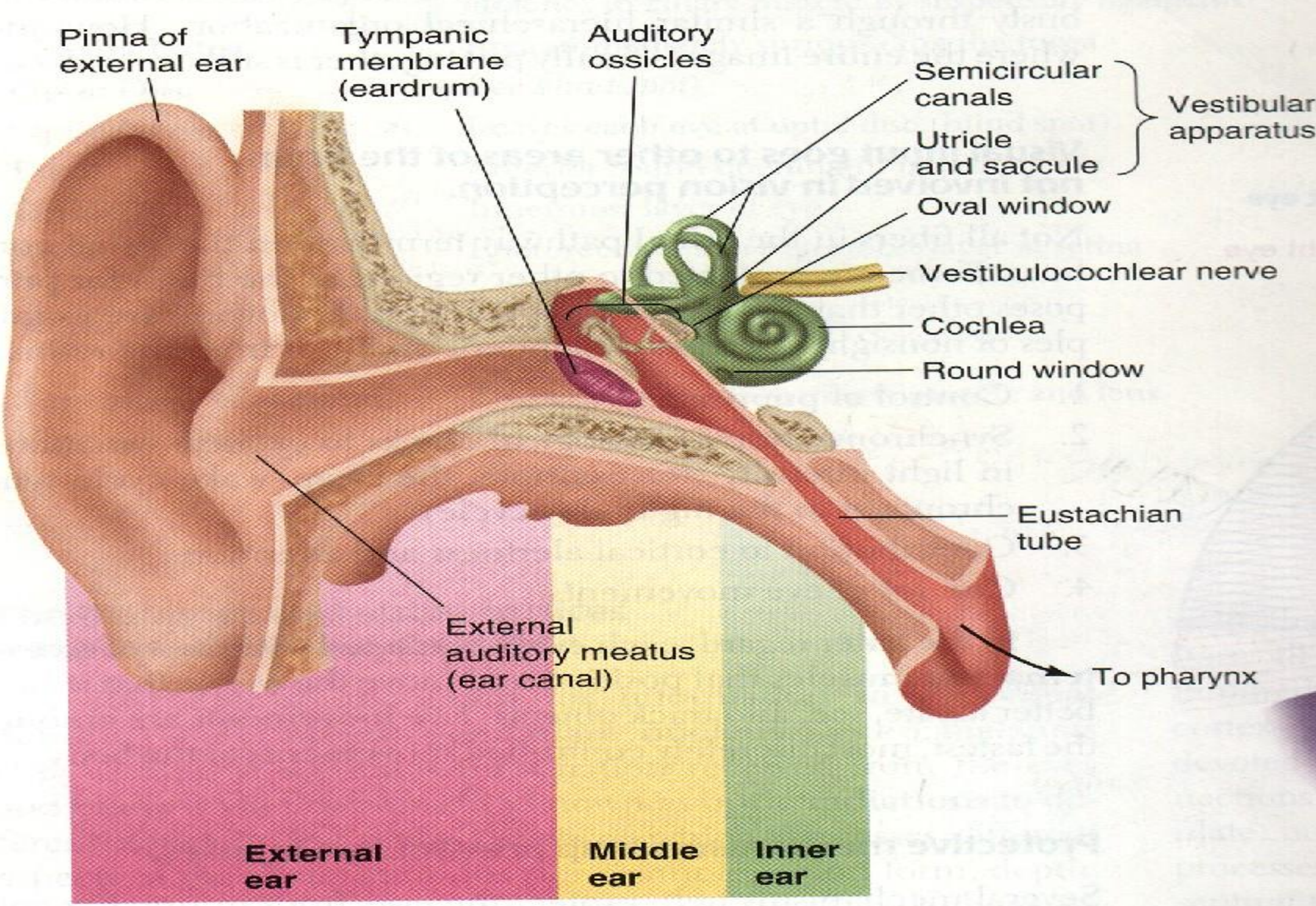
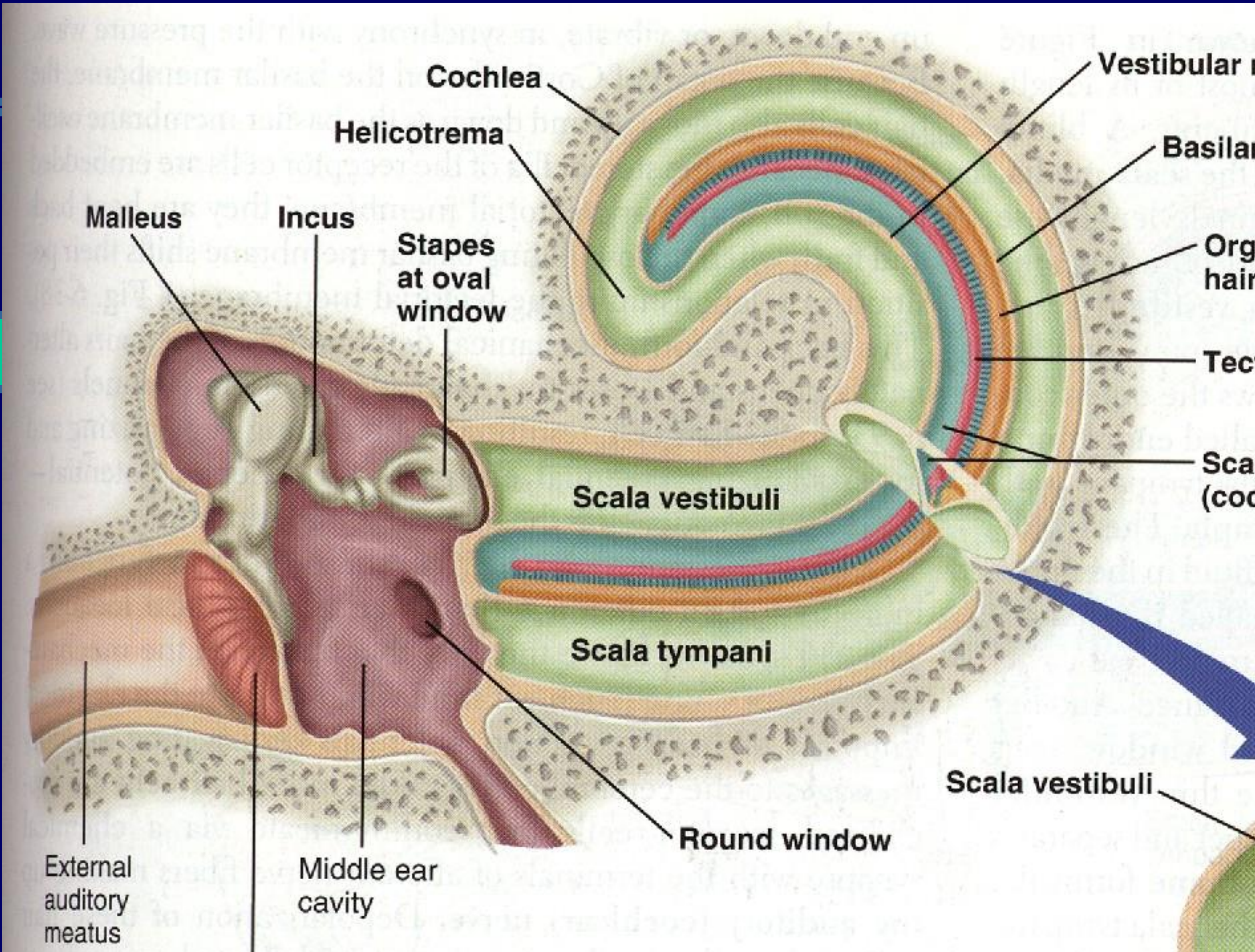


FIGURE 6-33
Anatomy of the ear

Anatomical consideration

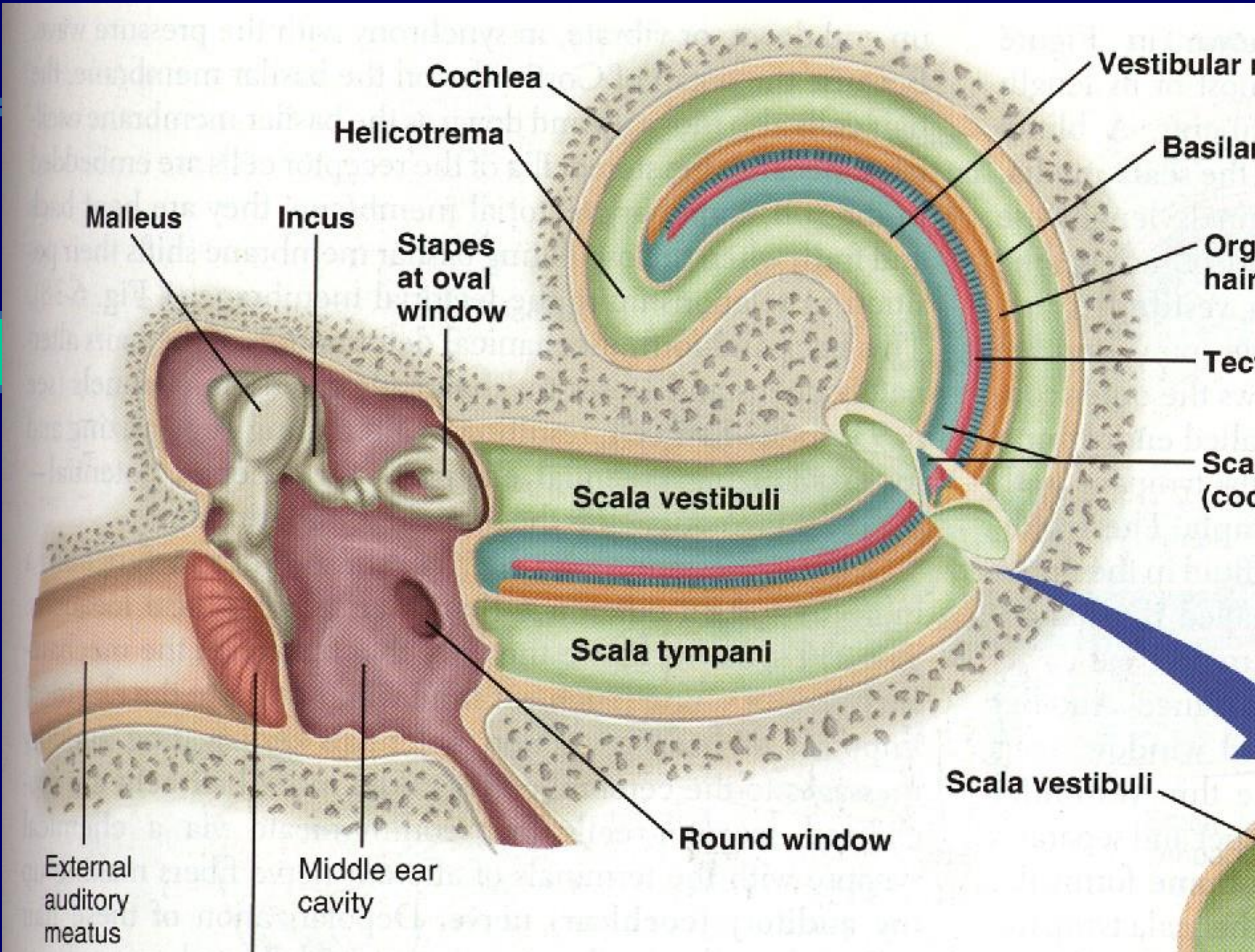
- Middle ear:
  - Air filled cavity
  - Three bones:
    - Mallaus
    - Incus
    - Stapes (with its foot sitting on the oval window of the inner ear)



Cochlea
Helicotrema
Vestibular
Basilar
Org
hair
Tec
Sca
(coc
Malleus
Incus
Stapes
at oval
window
Scala vestibuli
Scala tympani
Scala vestibuli
Round window
External
auditory
meatus
Middle ear
cavity

Anatomical consideration

- Inner ear:
  - Bony and membranous labyrinth


Cochlea
Vestibular
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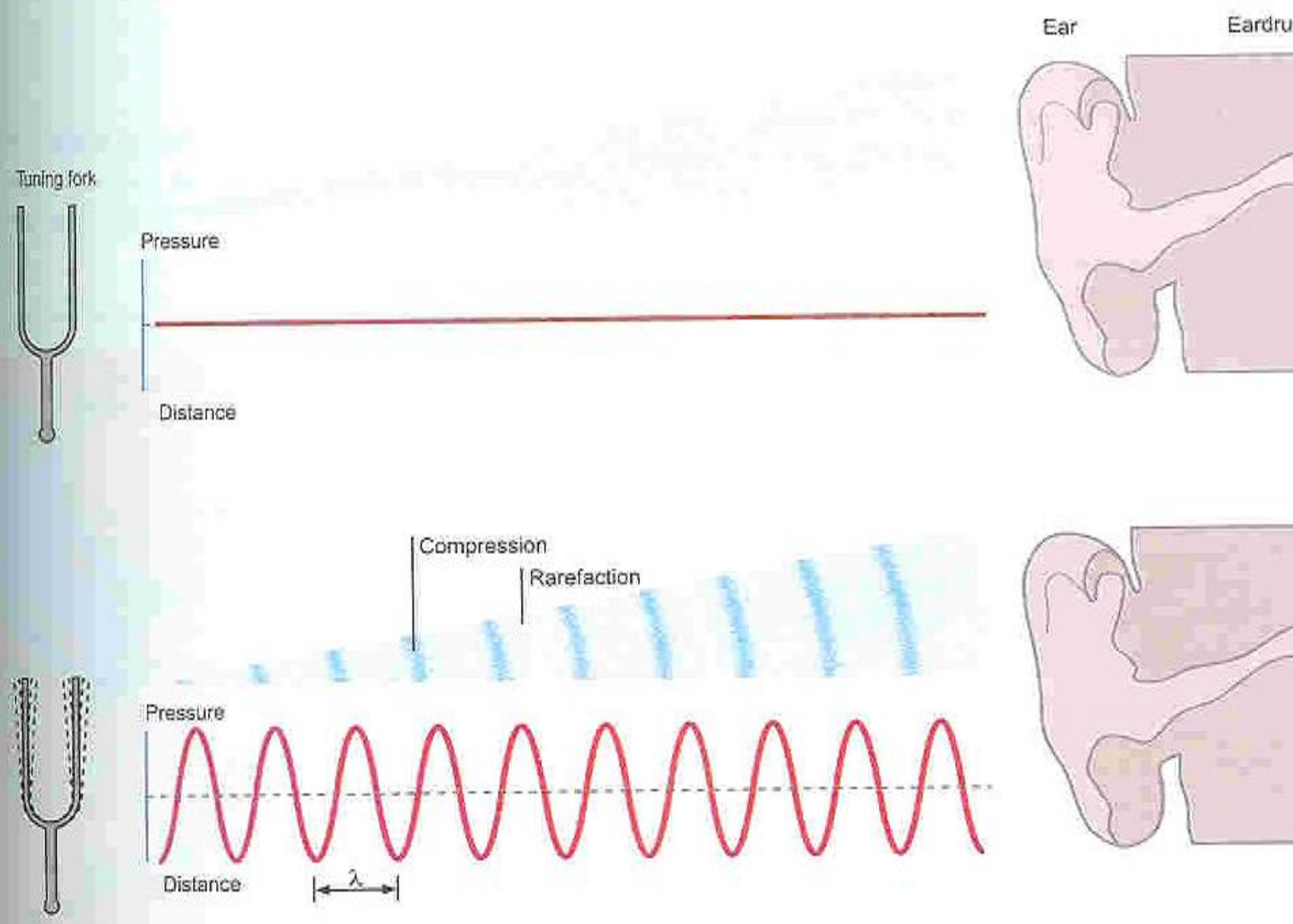
Basilar
Malleus
Incus
Stapes at oval window
Scala vestibuli
Scala tympani
Scala vestibuli
Round window
External auditory meatus
Middle ear cavity

Nature of Sound

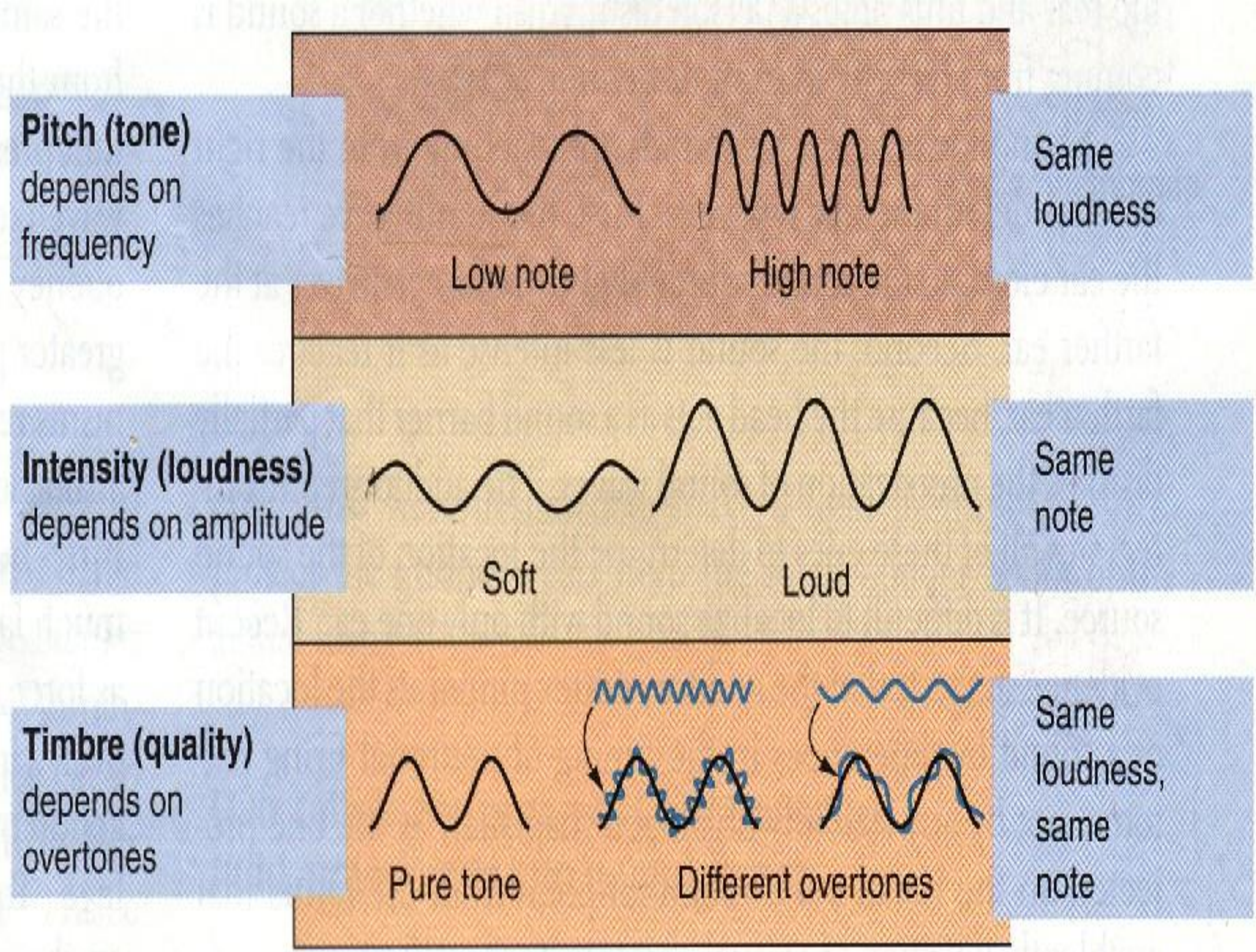
- Sound is produced from alternate compression and rarefaction of air molecules by vibrating body



Ear
Eardru
Tuning fork
Pressure
Distance
Compression
Rarefaction
Pressure
Distance
λ

Characteristics of sound

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


Pitch (tone) depends on frequency
Low note
High note
Same loudness
Intensity (loudness) depends on amplitude
Soft
Loud
Same note
Timbre (quality) depends on overtones
Pure tone
Different overtones
Same loudness, same note

Functions of the ear

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

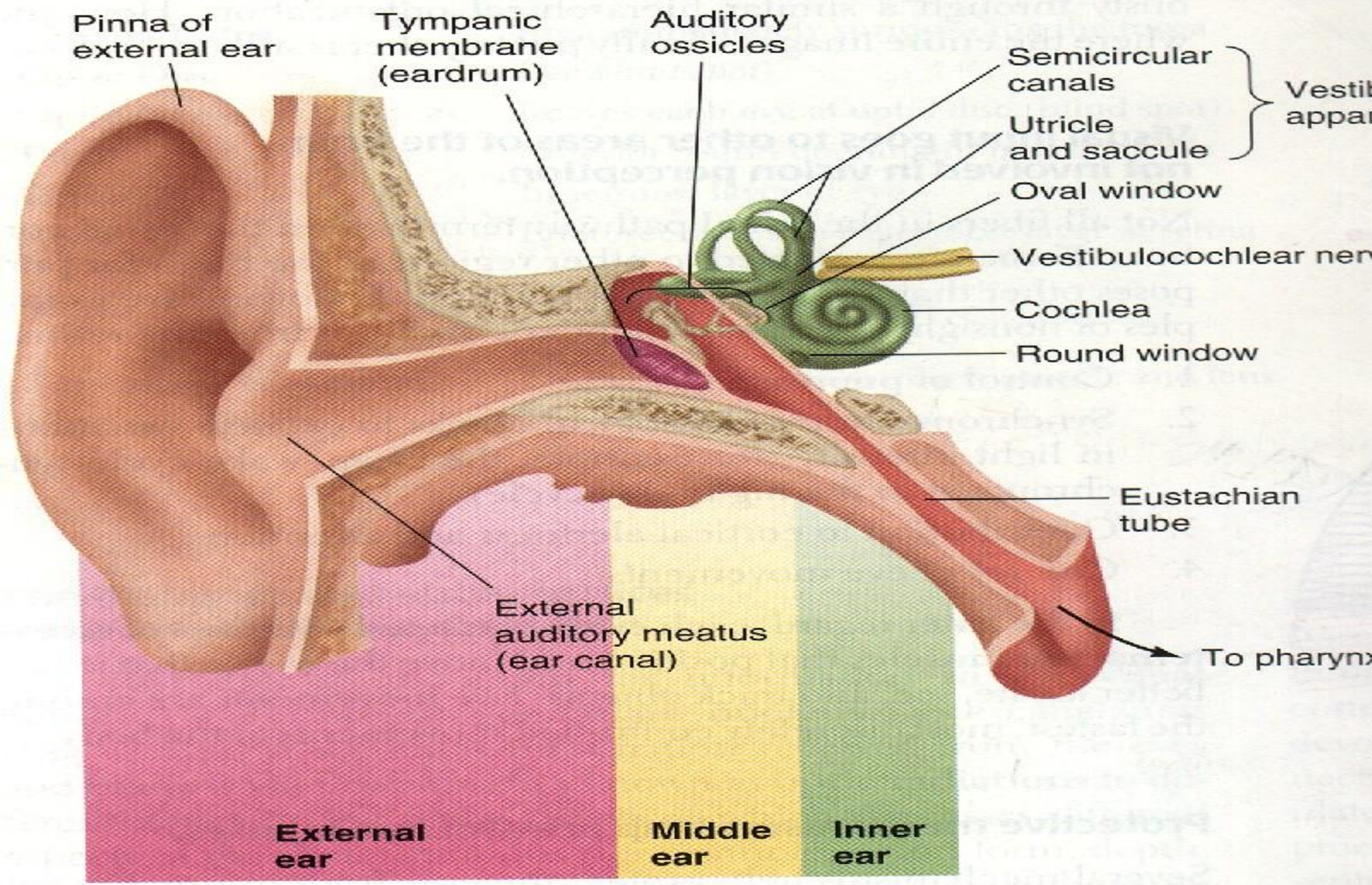


FIGURE 6-33
Anatomy of the ear

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

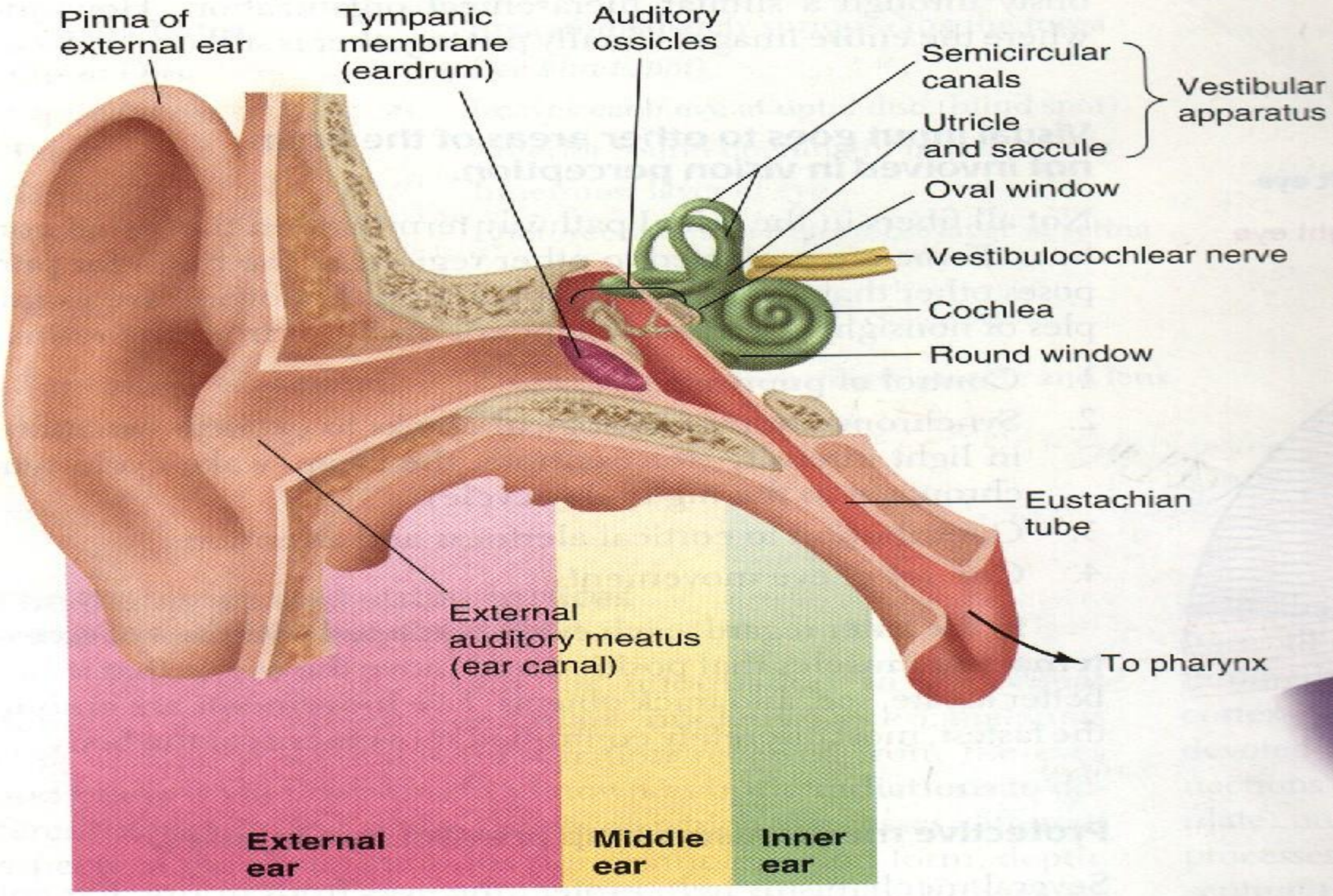


FIGURE 6-33
Anatomy of the ear

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 are 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

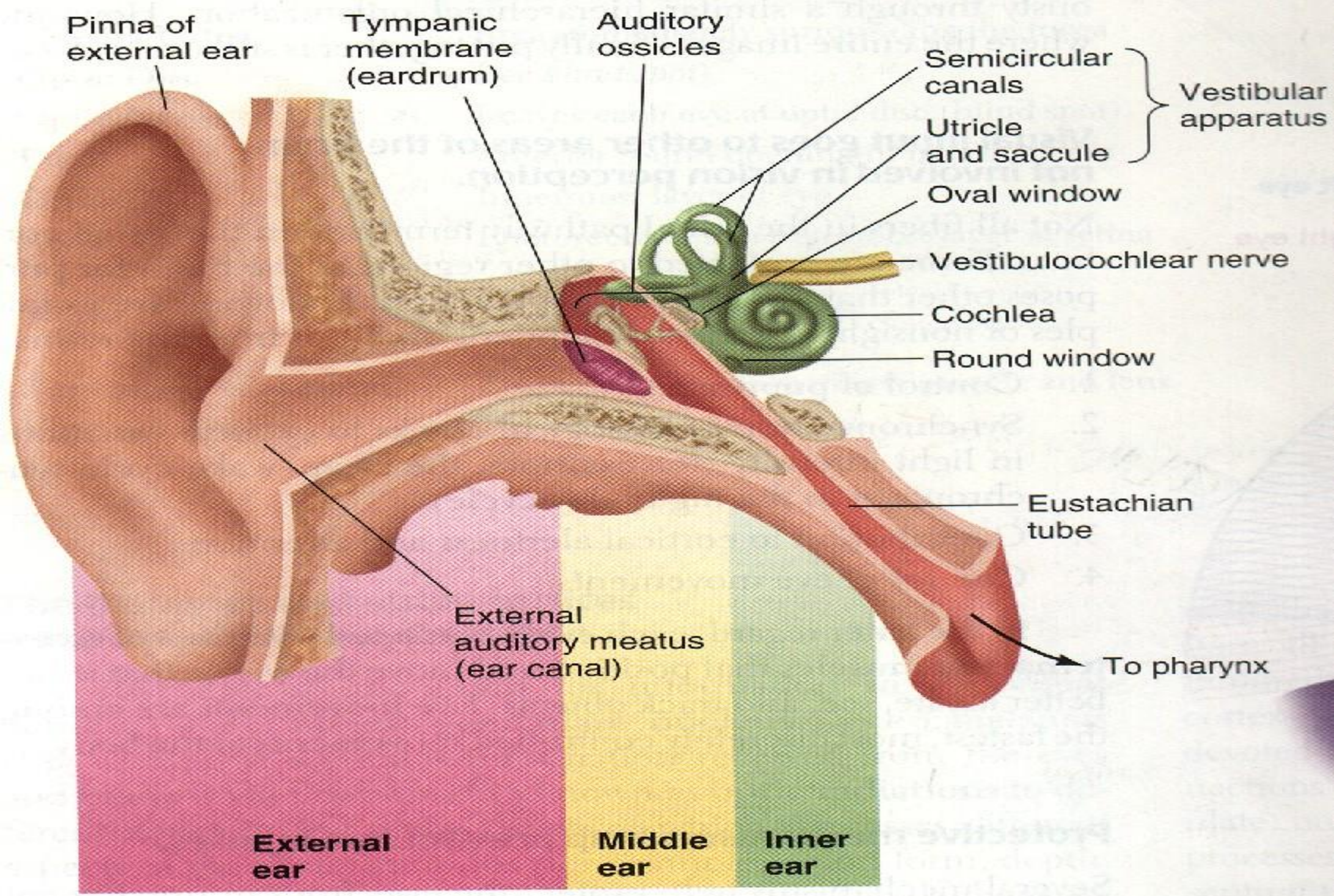


FIGURE 6-33

Anatomy of the ear

Middle ear magnifying effect

- 1- The force from a large surface area (Tympanic m.) are concentrated to a small (oval window) the ratio is 17=1
- 2- Lever action of ossicles = the lever action of ossicles increase the force of movement 1.3 times
- ▲ the total increase 17 X 1.3 = 22 times

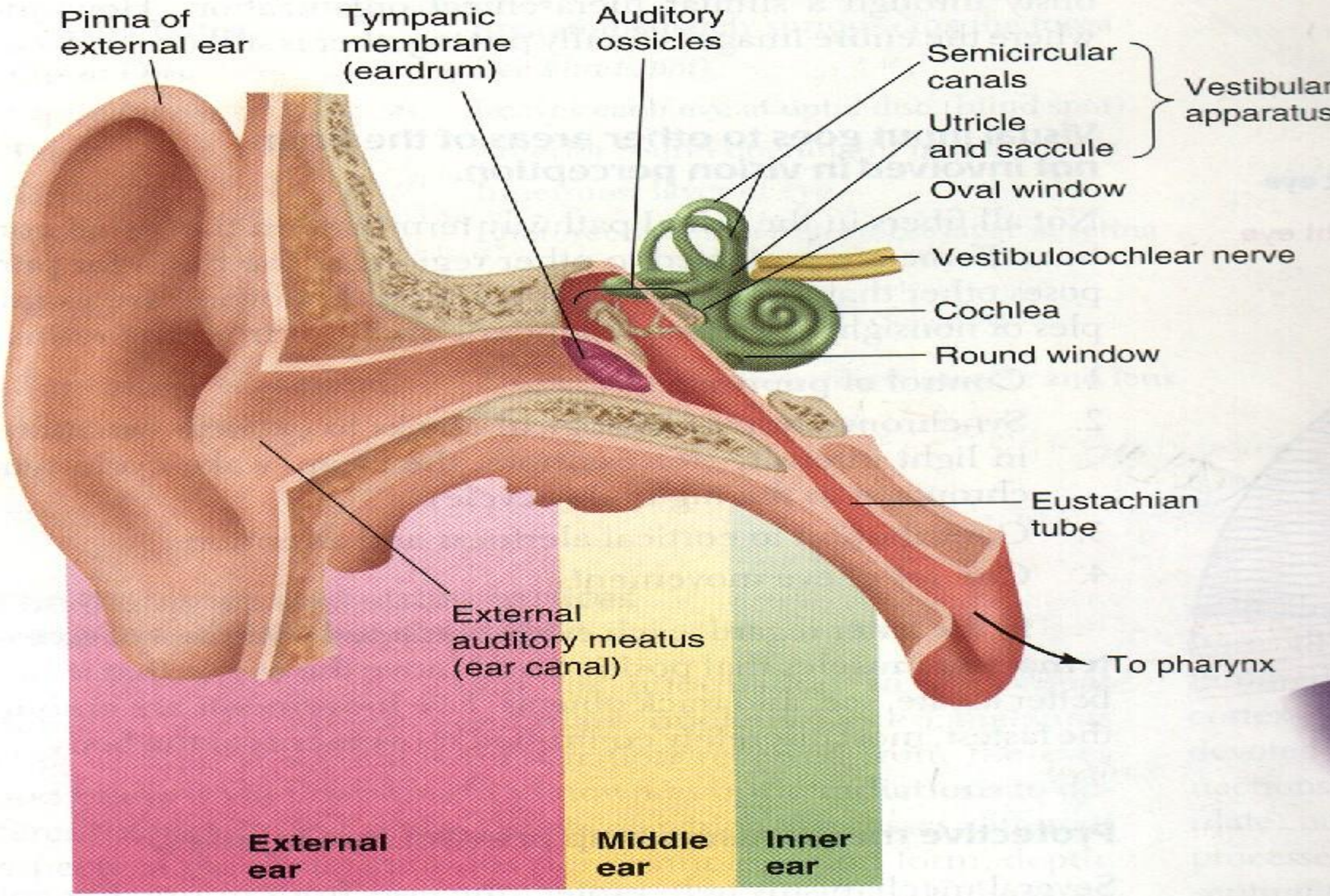


FIGURE 6-33

Anatomy of the ear

Inner ear

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

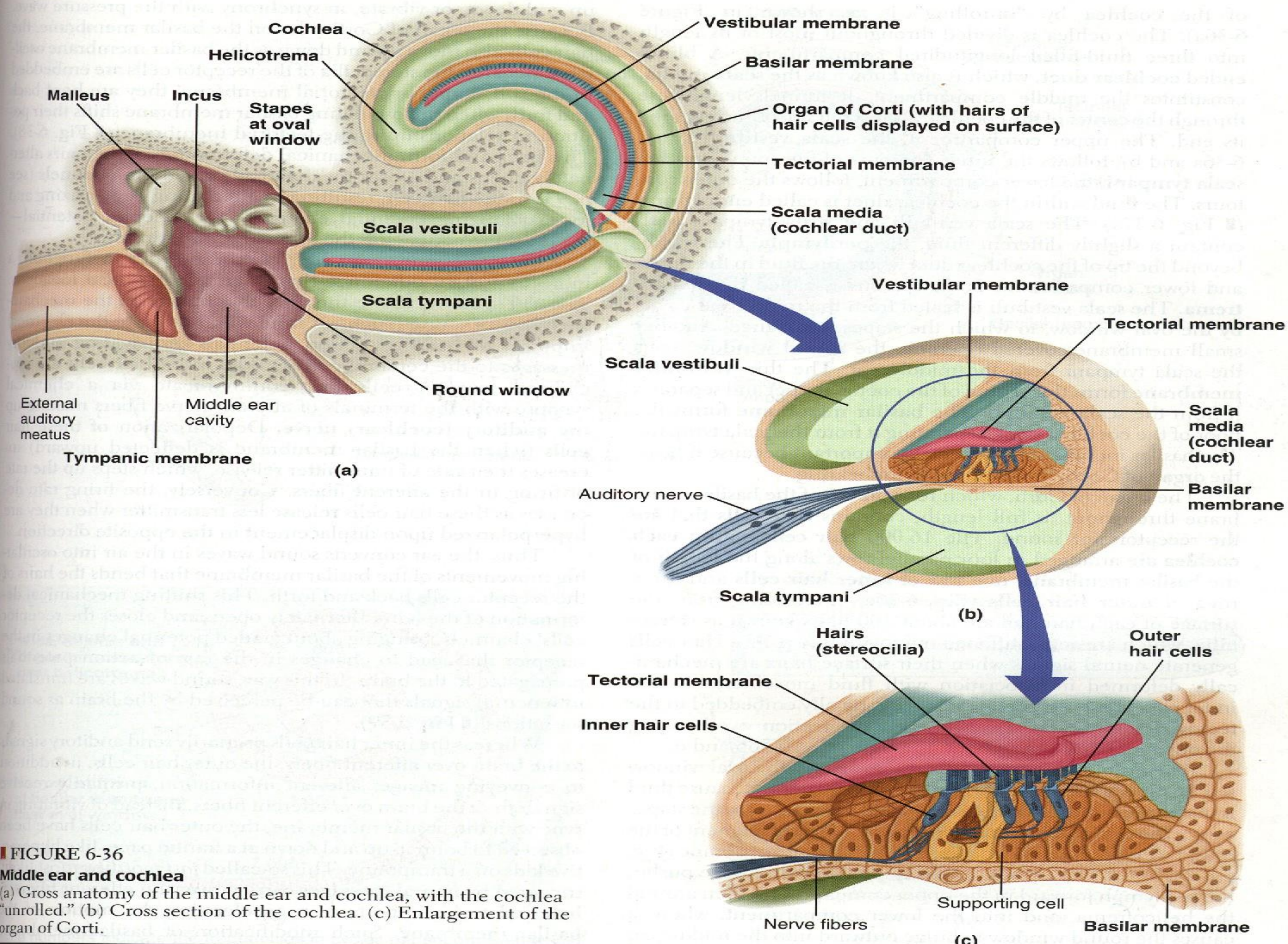


FIGURE 6-36

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.

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

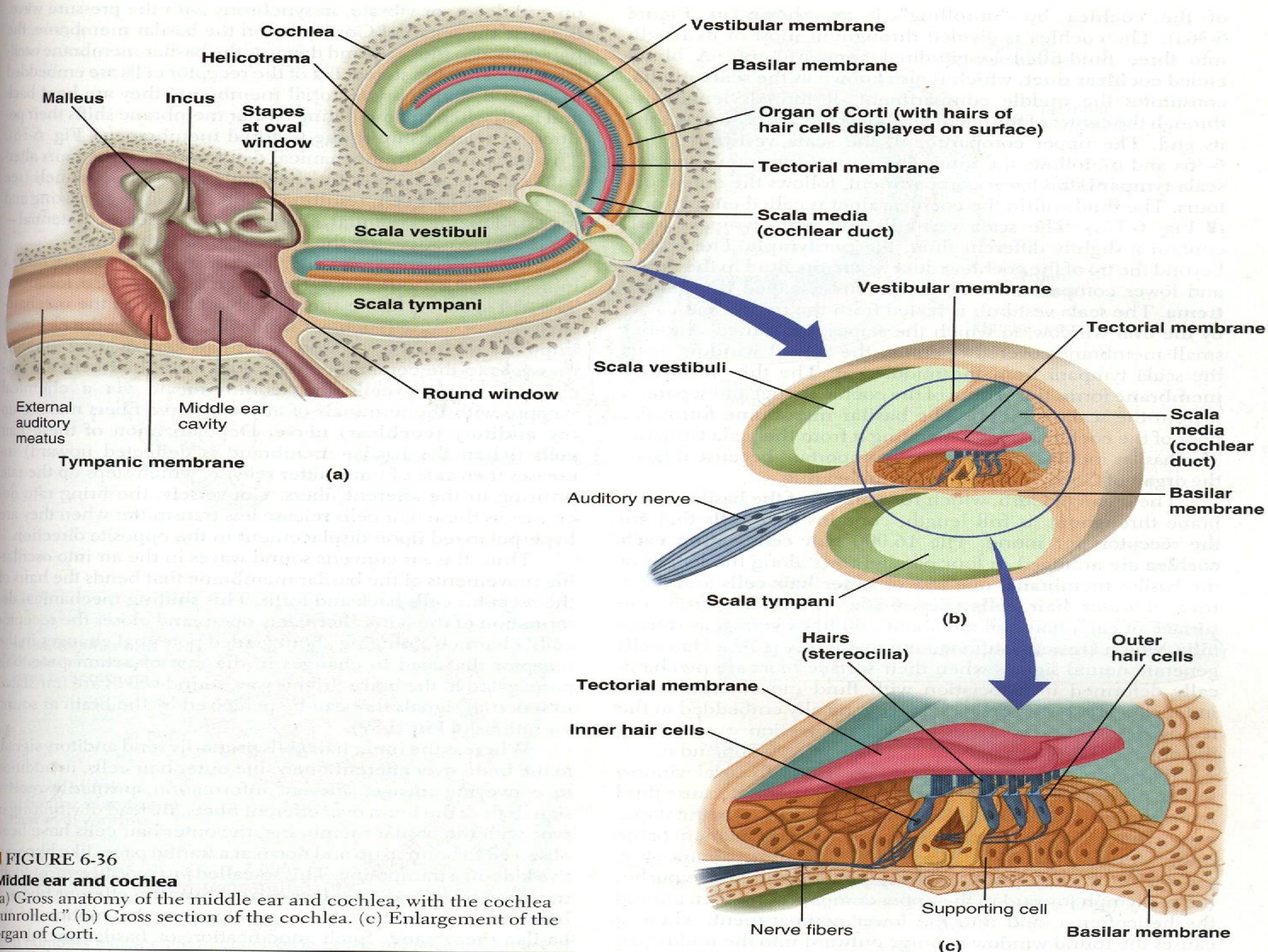


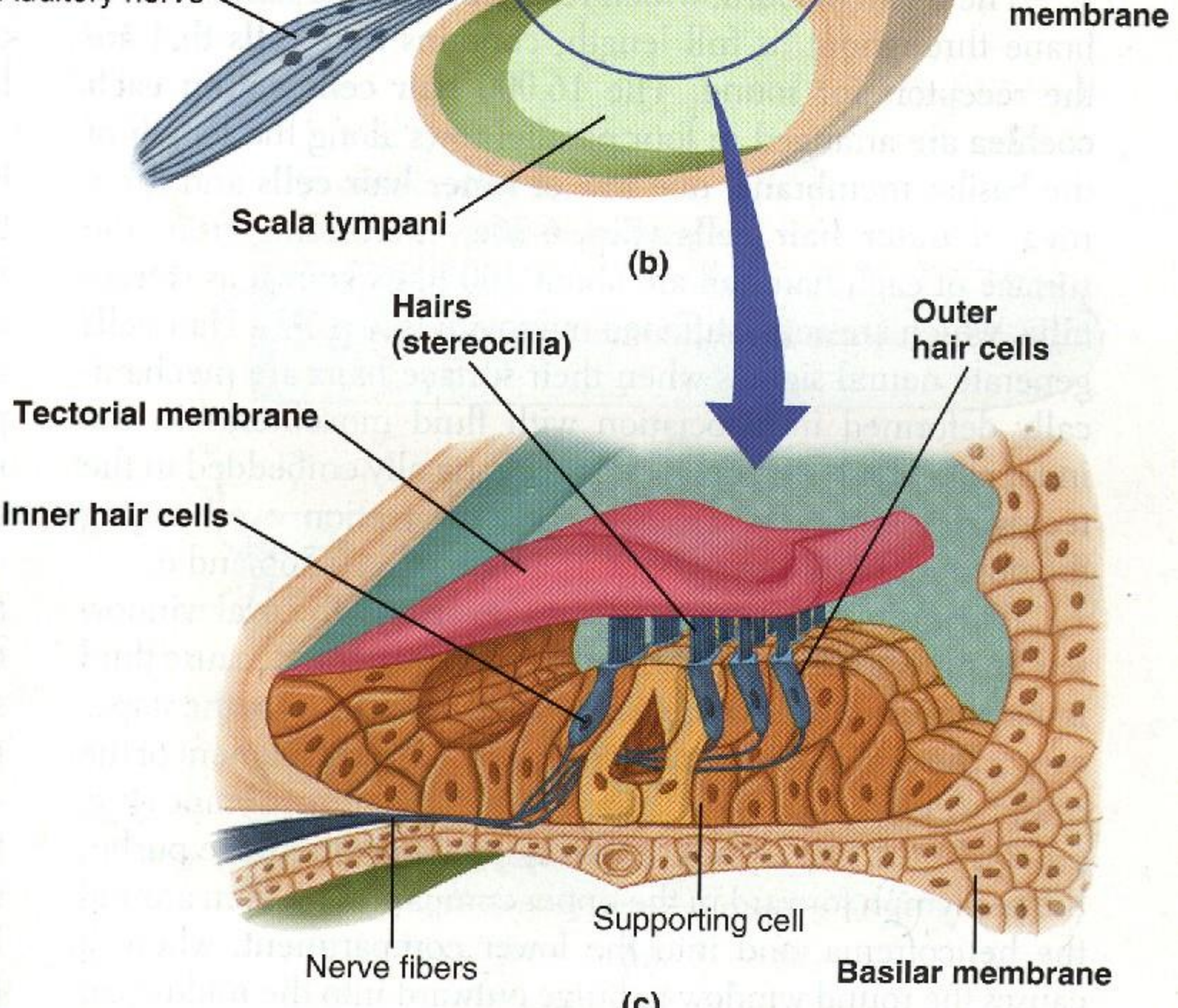
FIGURE 6-36

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.

Composition

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



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Organ of Corti

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

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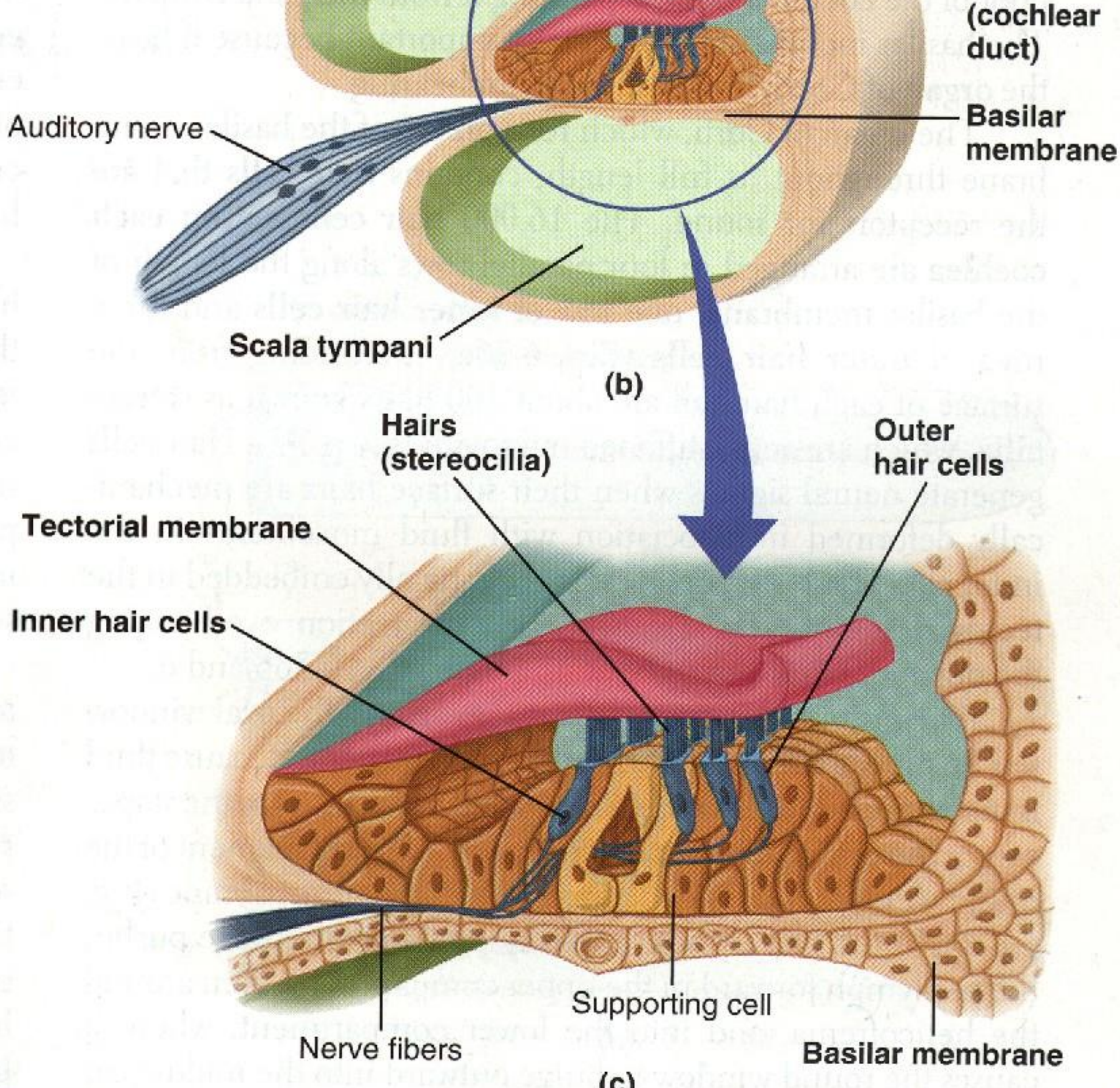

ochlea, with the cochlea
a. (c) Enlargement of the

Hair cells

- Steroclia extend from the top
- 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.)

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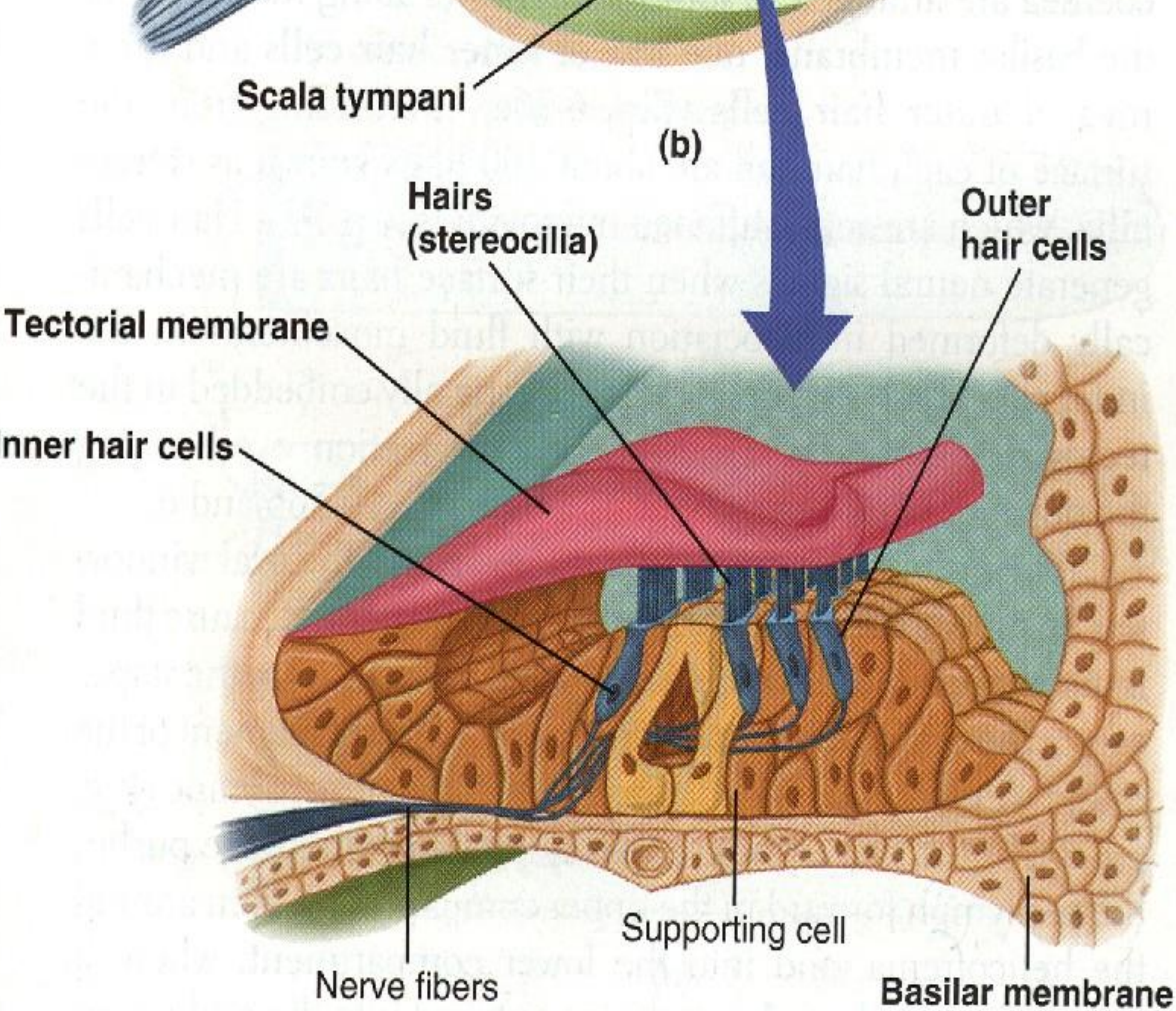
ment of the



(c)

Function of inner hair cells

- Striocellia not embedded in tectorial m. but bent by fluid movement under the tectorial m.
- They are primary receptors for sound, transducing fluid movement in cochlea into action potential in the auditory nerve

Function of the outer hair cells

- Large number, but stimulate only small fraction of nerve fibres in the cochlear nerve
- If damaged, significant loss of hearing (they control the sensitivity of inner hair cells to particular sound frequency)

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

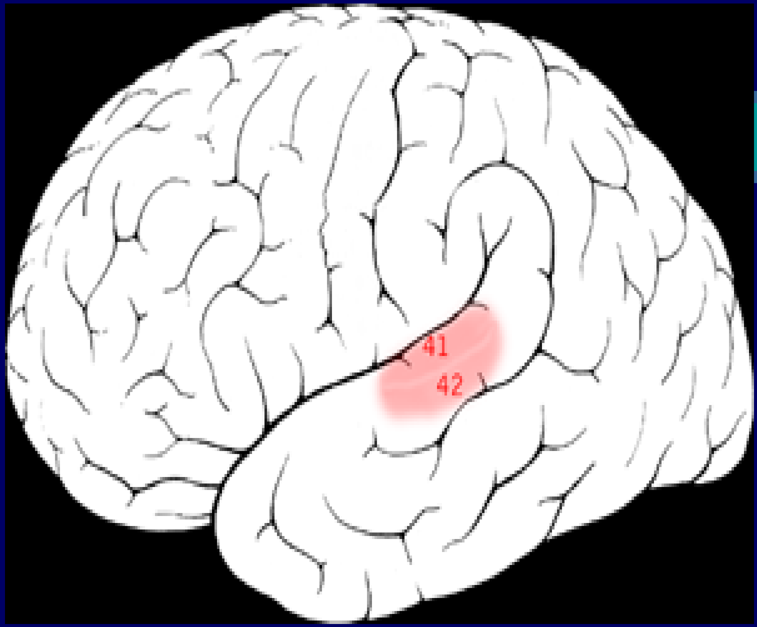
- »»»»»» (inward current) depolarization »»»»»» (outward current) hyperpolarisation
- »»»»»» the net results is depolarization

- Production of cells receptors potentials
- »»»»»» release of neurotransmitter
- »»»»»» production of action potentials

The Central Auditory pathway

- 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)

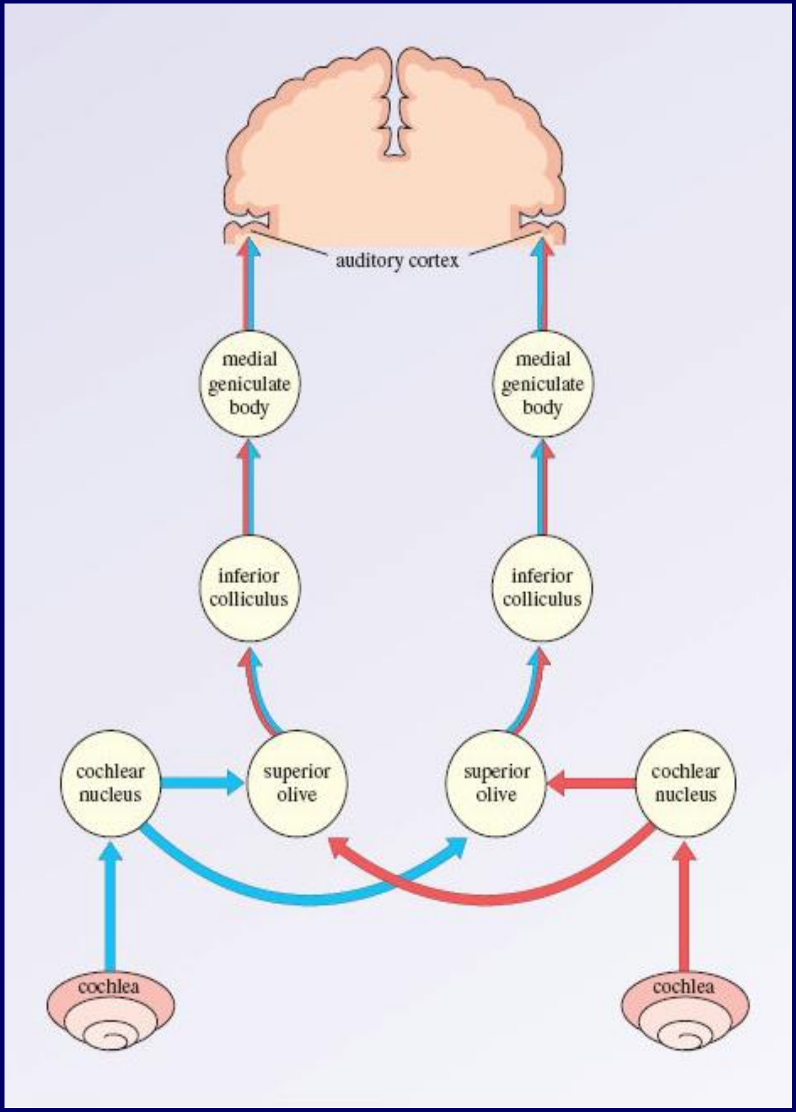
- Fibres end in the auditory area, where it is heard, then interpretation occurs in the auditory association areas (wernikes area)



The Central Auditory pathway

- There is a bilateral cortical connection of auditory area

- Thus damage to one side only slightly reduces hearing



Sound localization

- Differences in the time arrival of the sound wave at the ears (time-lag)
- Differences in the loudness

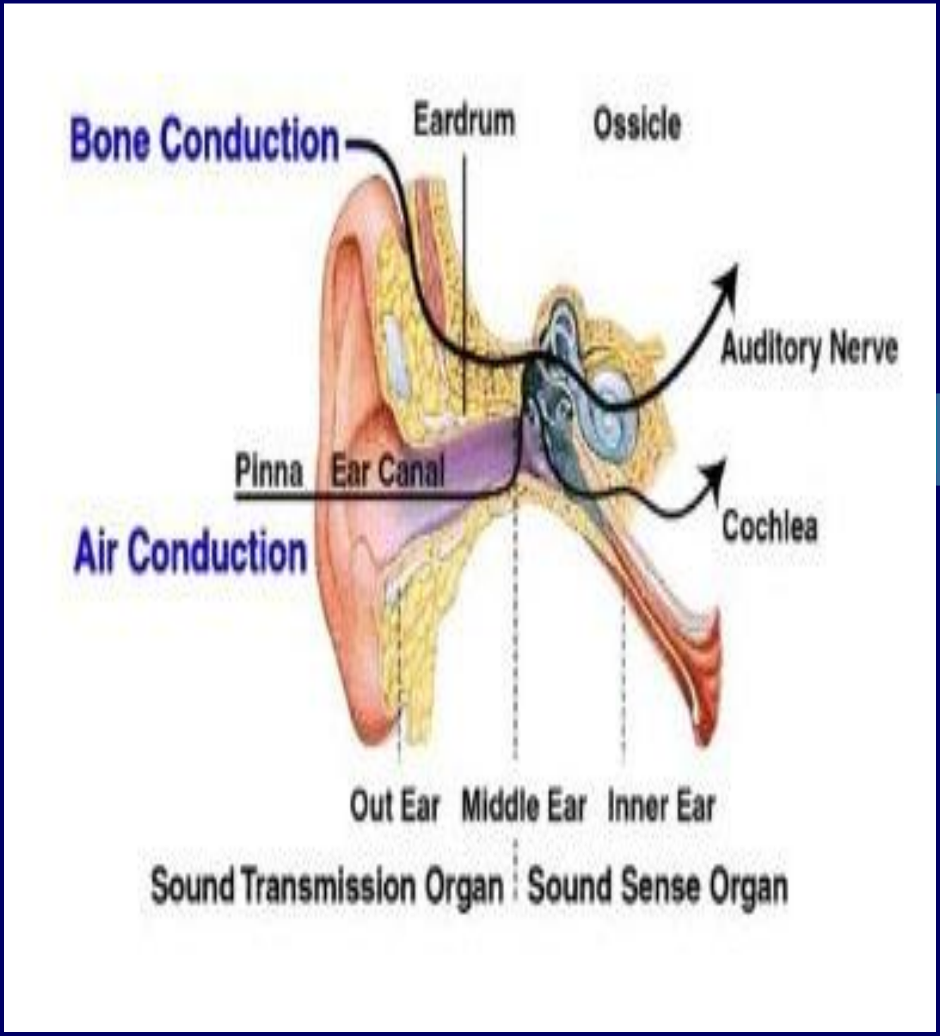
Masking effect

- 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 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)

Conductive deafness

- 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

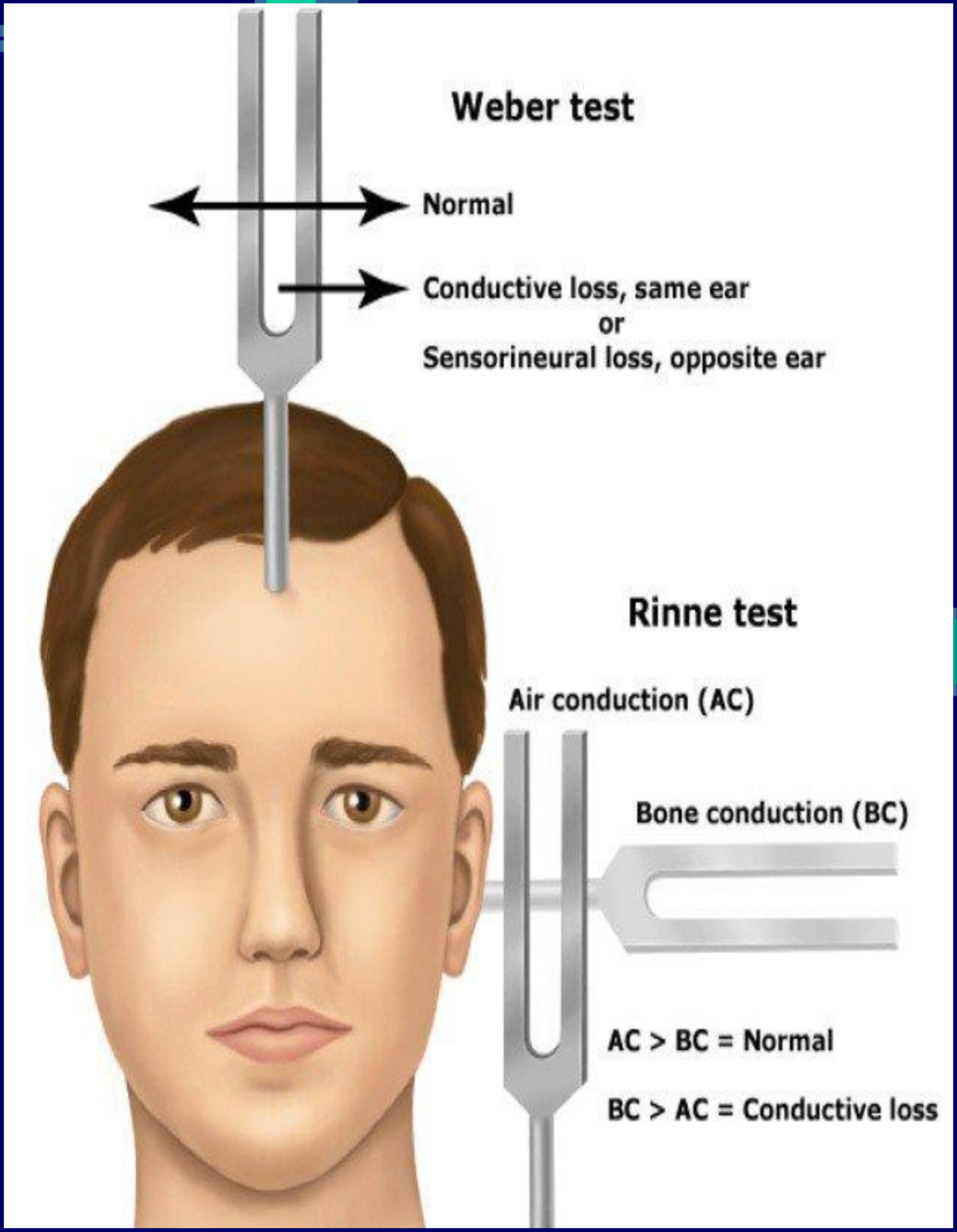
Test of hearing

- Audiometer
- Weber test
- Rinnes test

- Audiometer

Weber test

- tuning fork is placed on the patient's forehead (or in the middle line)



Rinnes test:

- The base of the tuning fork placed on mastoid process until the sound is not heard
- Then the prongs of the fork held in air near the ear

Rinnes test

- Normal subject continue to hear near ear (positive test)
- If not reveres the test (if heard near the mastoid process, negative test)