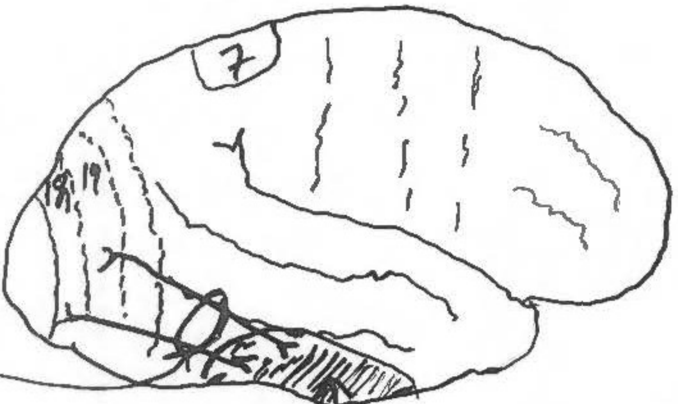
Left trochlear nerve paralysis

↓

the patient tilts the head to compensate for the slightly skewed gaze



inferior longitudinal fasciculus

↓

Bilateral lesions

↓

visual agnosia

inferotemporal area

← highest visual association area

It receives input from
- area 7 (serving visual attention)
- 18, 19

①

[redacted] [redacted] [redacted]

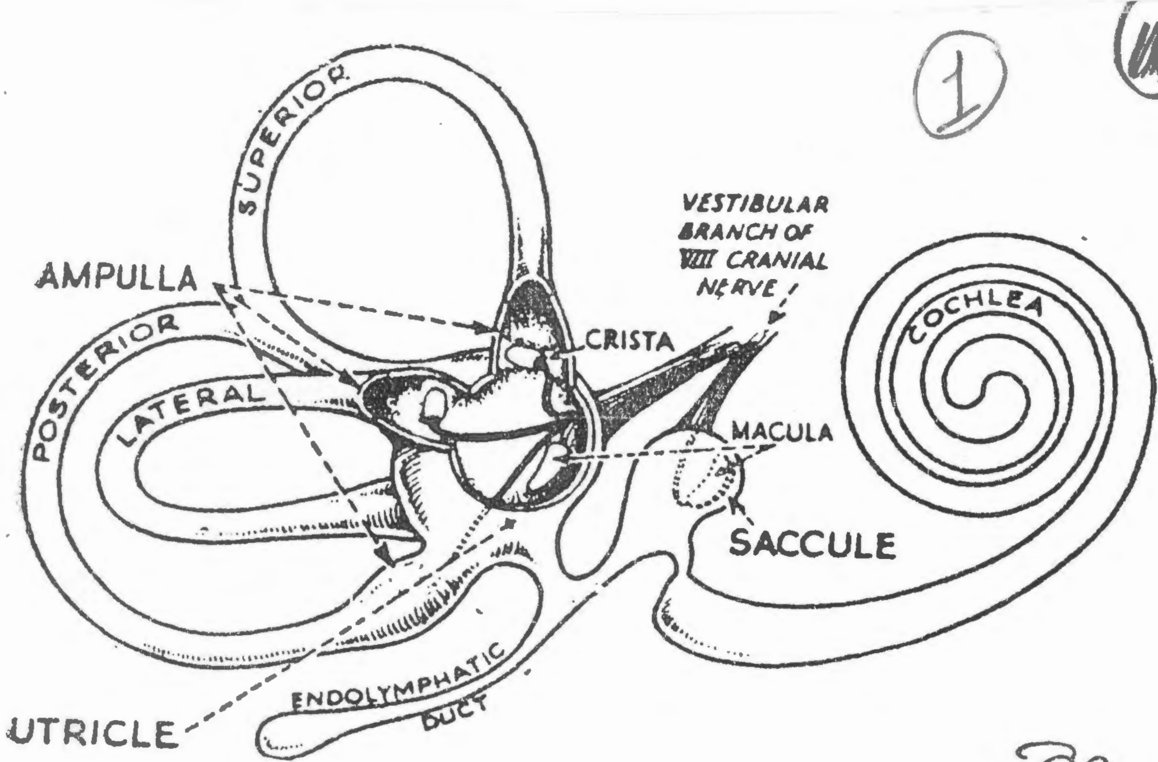


Figure 70 : The membraneous labyrinth.

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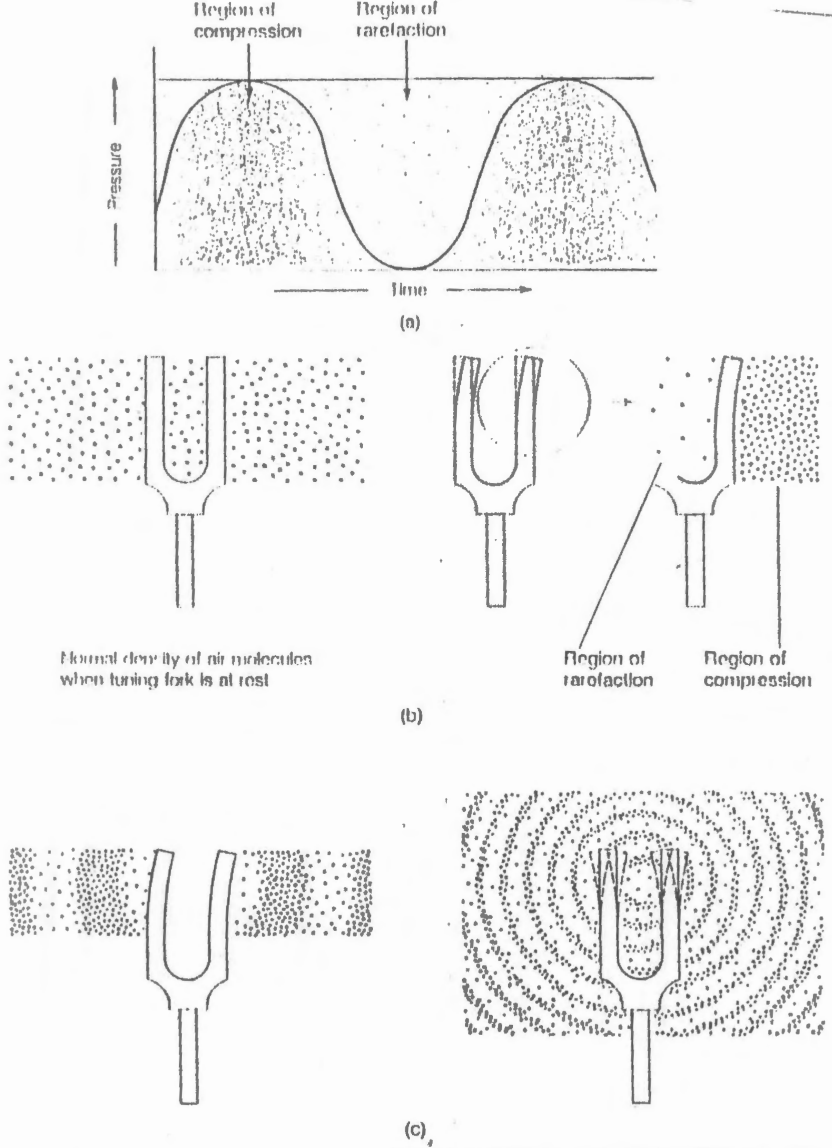
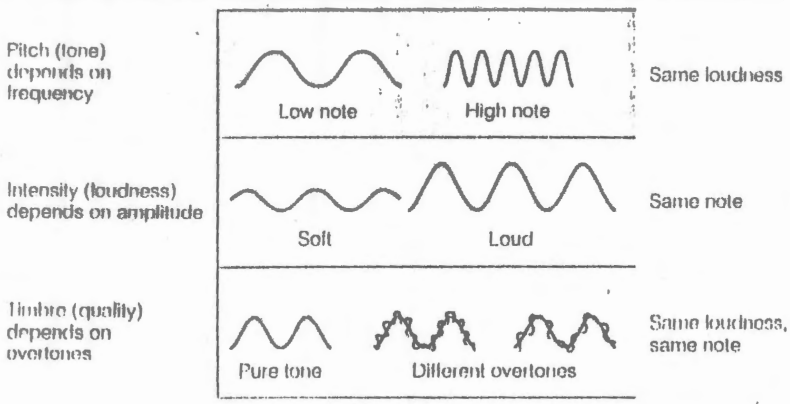


• **FIGURE 6–34 Properties of Sound Waves**



تتكون الامواج الصوتية
من مناطق ضغط تتبادل
مع مناطق تخلخل لجزيئات الهواء

↓

أي جسم قادر على إحداث
اضطراب في جزيئات الهواء بالشكل
السابق يكون مصدراً للصوت

↓

اهتزاز الشوكة الرنانة يولّد
مناطق ضغط لجزيئات الهواء أمام
الشوكة ومناطق تخلخل لجزيئات الهواء
خلف الشوكة وبالتالي تحدث اهتزاز
الصوت

↓

يمكن لامواج الصوت أن تنتقل
في أوساط غير الهواء (مثل الماء)

⇩

يمتاز الصوت بما يلي:

(١) نبرة أو نغمة الصوت (لحن الصوت)
Pitch (tone)

٢) علوّ الصّوت
intensity (loudness)

٣) طابع (رنّة) الصوت
Timbre (quality)

---

١) Pitch نغمة الصوت وتعتمد على
تردّد الاهتزازات = Frequency of vibrations
كلّما زاد التردّد زادت نغمة الصوت (ارتفعت)

↓

تستطيع أُذن الانسان أن تُميّز أمواج صوتية
ذات تردّد يتراوح بين ٢٠ - ٢٠,٠٠٠ دورة
في الثانية ولكنها تكون أكثر حساسيه للترددات
التي تتراوح بين ١,٠٠٠ - ٤,٠٠٠ دورة في الثانيه

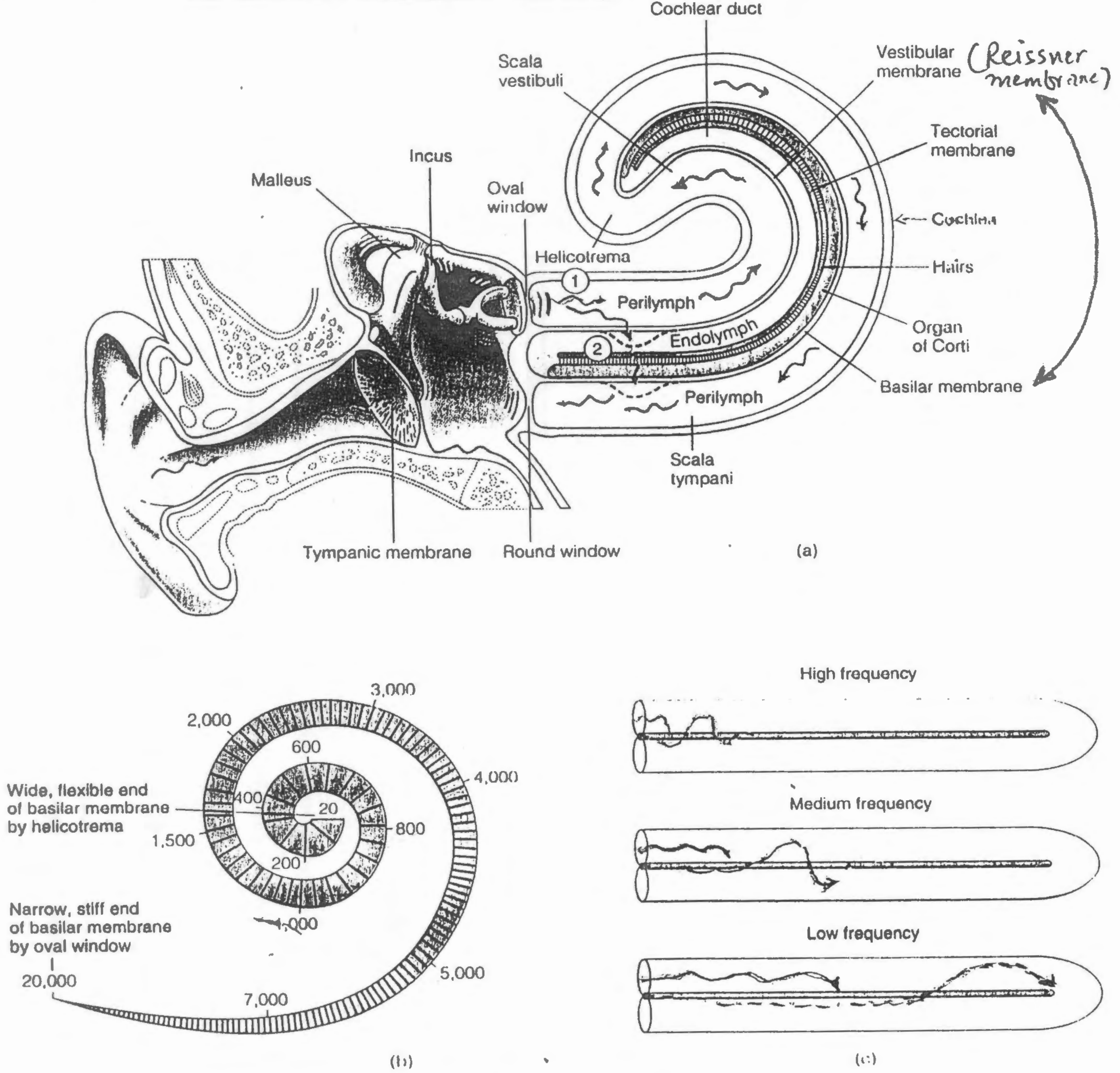
٢) علو الصوت أو شدّة الصوت intensity or loudness
تعتمد على حجم amplitude أمواج الصوت
الفرق في الضغط بين منطقة ضغط عالي لجزيئات الهواء ومنطقة تخلخل يقل فيها ضغط جزيئات الهواء

< وضمن مدى السمع لأُذن الإنسان كلما ازداد حجم أمواج الصوت كلما ازداد الصوت علواً .

< تستطيع أذن الانسان أن تُميّز بين مدى واسع لشدّة - علو - الصوت من درجة الهمس
الى صوت اقلاع الطائرة النفاثة .

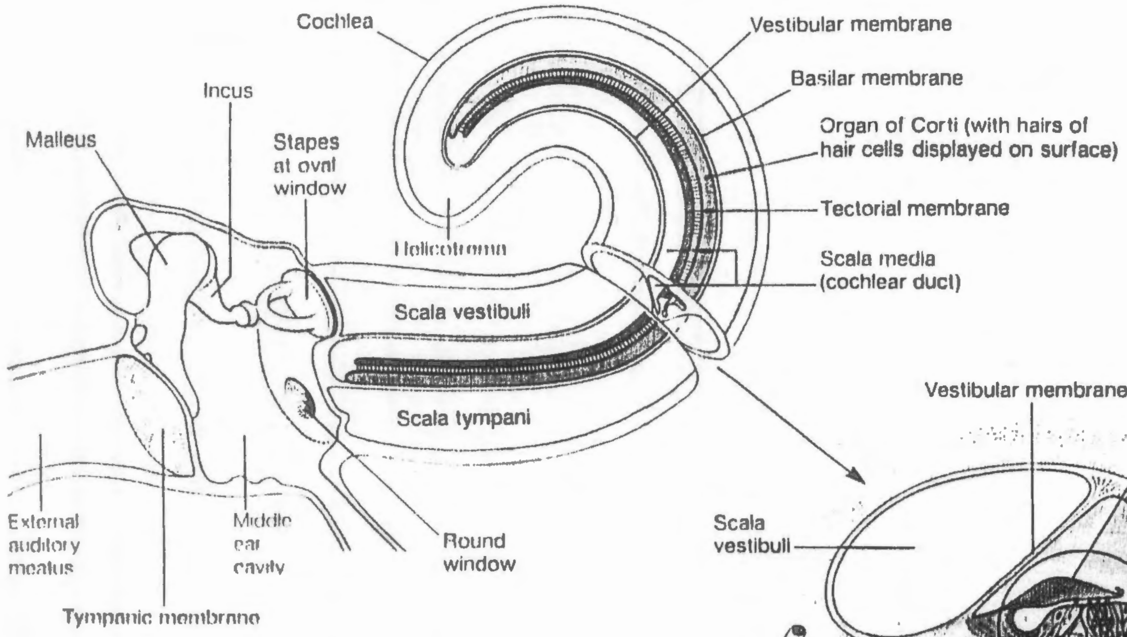
3 [redacted] Bustami [redacted] [redacted]

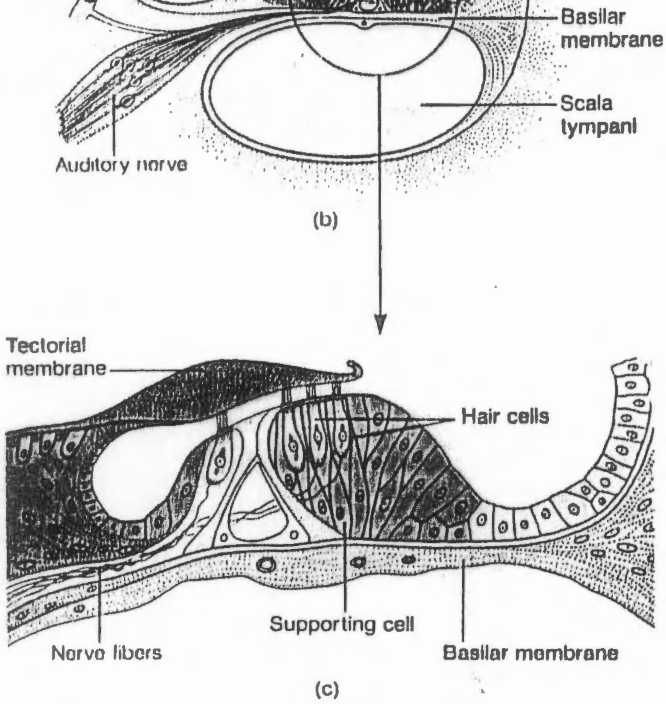
• FIGURE 6–36 Transmission of Sound Waves (a) Fluid movement within the perilymph set up by vibration of the oval window follows two pathways: (1) through the scala vestibuli, around the helicotrema, and through the scala tympani, causing the round window to vibrate; and (2) a "shortcut" from the scala vestibuli through the basilar membrane to the scala tympani. The first pathway just dissipates sound energy, but the second pathway triggers activation of the receptors for sound by bending the hairs of the hair cells as the organ of Corti on top of the vibrating basilar membrane is displaced in relation to the overlying tectorial membrane. (b) Different regions of the basilar membrane vibrate maximally at different frequencies. (c) The narrow, stiff end of the basilar membrane nearest the oval window vibrates best with high-frequency pitches. The wide, flexible end of the basilar membrane by the helicotrema vibrates best with low-frequency pitches.



The numbers indicate the frequencies with which different regions of the basilar membrane maximally vibrate

4





• **FIGURE 6–35 Middle Ear and Cochlea** (a) Gross anatomy of the middle ear and cochlea, with the cochlea "unrolled." (b) Cross section of cochlea. (c) Enlargement of organ of Corti.

fluid filled cochlea. As the tympanic membrane vibrates in response to sound waves, the chain of bones is set into motion at the same frequency, transmitting this frequency of movement from the tympanic membrane to the oval window. The resultant pressure on the oval window with each vibration produces wavelike movements in the inner ear fluid at the same frequency as the original sound waves. However, as noted earlier, greater pressure is required to set fluid in motion. Two mechanisms related to the ossicular system amplify the pressure of the airborne sound waves to set up fluid vibrations in the cochlea. First, because the surface area of the tympanic membrane is much larger than that of the oval window, pressure is increased as force exerted on the tympanic membrane is conveyed to the oval window (pressure = force/unit area). Second, the lever action of the ossicles provides an additional mechanical advantage. Together, these mechanisms increase the force exerted on the oval window by twenty times what it would be if the sound wave struck the oval window directly. This additional pressure is sufficient to set the cochlear fluid in motion.

Several tiny muscles in the middle ear contract reflexly in response to loud sounds (over 70 dB), causing the tympanic membrane to tighten and limiting movement of the ossicular chain. This reduced movement of middle ear structures diminishes the transmission of loud sound waves to the inner ear to protect the delicate sensory apparatus from damage. This reflex response is relatively slow, however, happening at least 40 msec after exposure to a loud sound. It thus provides protection only from prolonged loud sounds, not from sudden loud sounds like an explosion.

Hair cells in the organ of Corti transduce fluid movements into neural signals.

The snail-shaped cochlear portion of the **inner ear** is a coiled tubular system lying deep within the temporal bone (Fig. 6–32). It is easier to understand the functional components of the **cochlea** by "unrolling" it, as shown in Figure 6–35a. The cochlea is divided throughout most of its length into three fluid-filled longitudinal compartments. A blind-ended **cochlear duct**, which is also known as the **scala media**, constitutes the middle compartment. It tunnels lengthwise

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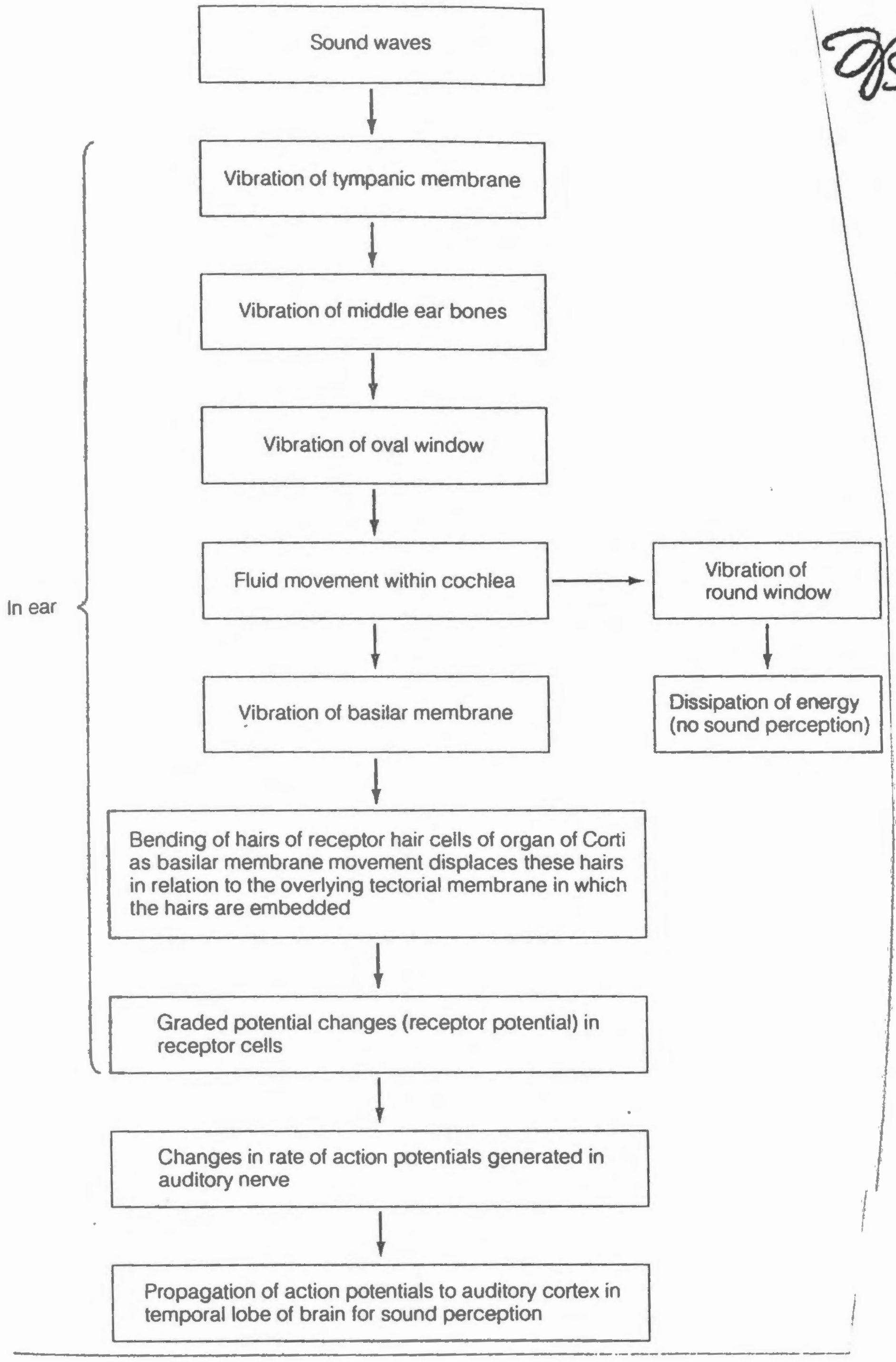
[redacted]

[redacted]

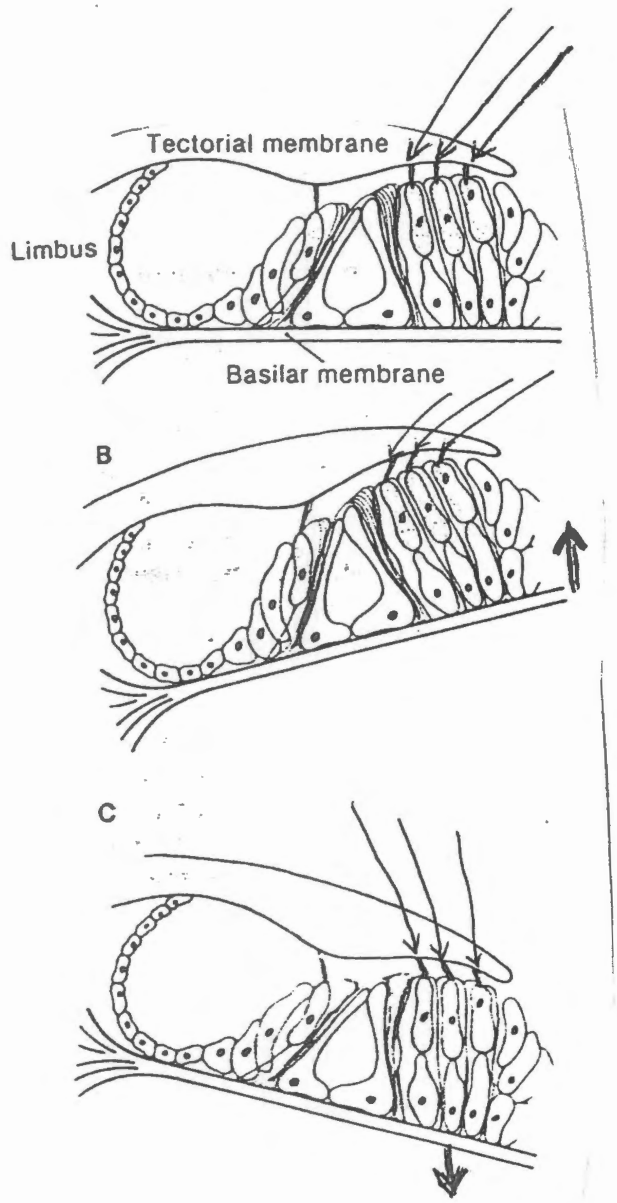
5



Pressure waves of frequencies associated with sound reception take a "shortcut." Pressure waves in the upper compartment are transferred through the thin vestibular membrane, into the cochlear duct, and then through the basilar membrane into the lower compartment, where they cause the round window to alternately bulge outward and inward. The main difference in this pathway is that transmission of pressure waves through the basilar membrane causes this membrane to move up and down, or vibrate, in synchrony with the pressure wave. Since the organ of Corti rides on the basilar membrane, the hair cells also move up and down as the basilar membrane oscillates. Because the hairs of the receptor cells are embedded in the stiff, stationary tectorial membrane, they are bent back and forth when the oscillating basilar membrane shifts their position in relationship to the tectorial membrane (• Fig. 6–37). This back-and-forth mechanical deformation of the hairs alternately opens and closes mechanically gated ion channels (see p. 81) in the hair cell, resulting in alternating depolarizing and hyperpolarizing potential changes—the receptor potential—at the same frequency as the original sound stimulus.

Thus, the ear converts sound waves in the air into oscillating movements of the basilar membrane that bend the hairs of the receptor cells back and forth. This shifting mechanical deformation of the hairs alternately opens and closes the receptor cells' channels, which bring about graded potential changes in the receptor that lead to changes in the rate of action potentials propagated to the brain. In this way, sound waves are translated into neural signals that can be perceived by the brain as sound sensations (• Fig. 6–38).

Up-and-down movement of the basilar membrane & tectorial membrane causes the stereocilia extending from the hair cells to bend BACK & FORTH



Depolarize

hyperpolarize

B – When the organ of corti moves upward (with the basilar membrane) → the stereocilia bend AWAY from the limbus & depolarize

C – When the organ ⇓ of corti moves downward the stereocilia bend toward the limbus & they hyperpolarize

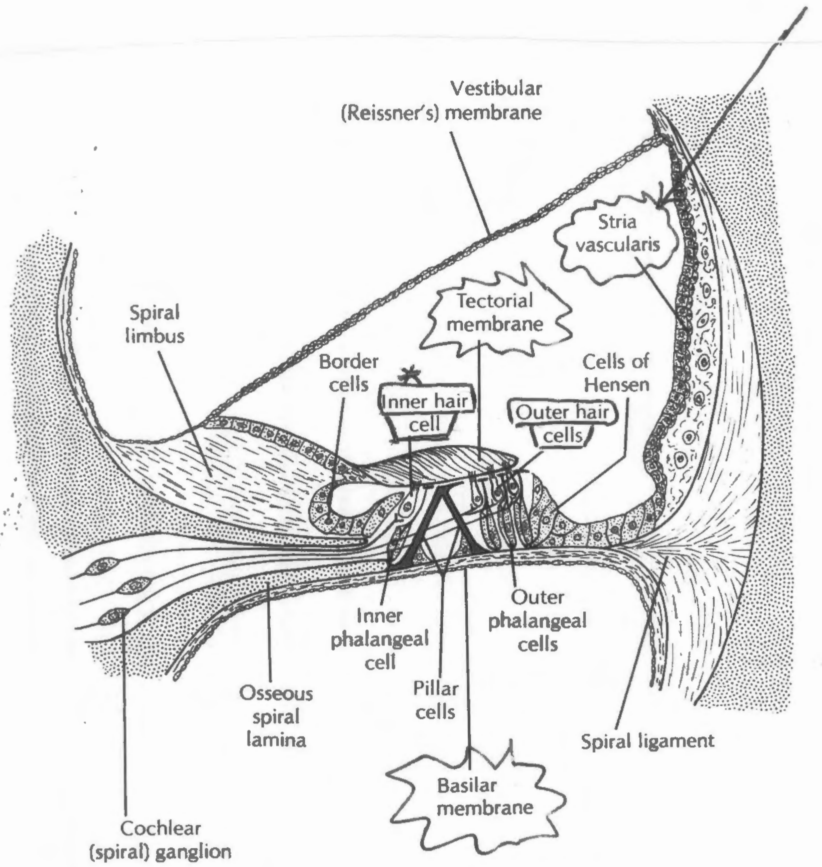


Figure 21-5. Structure of the cochlear duct and spiral organ (organ of Corti).

Receptors for hearing

↓

Sensory Hair cells of the spiral organ (of Corti) disposed as:

1) single row of inner hair cells
2) 3 rows of outer hair cells

- 2 types of neurons in the spiral ganglion

bipolar 25000 ← → unipolar 5000 ?

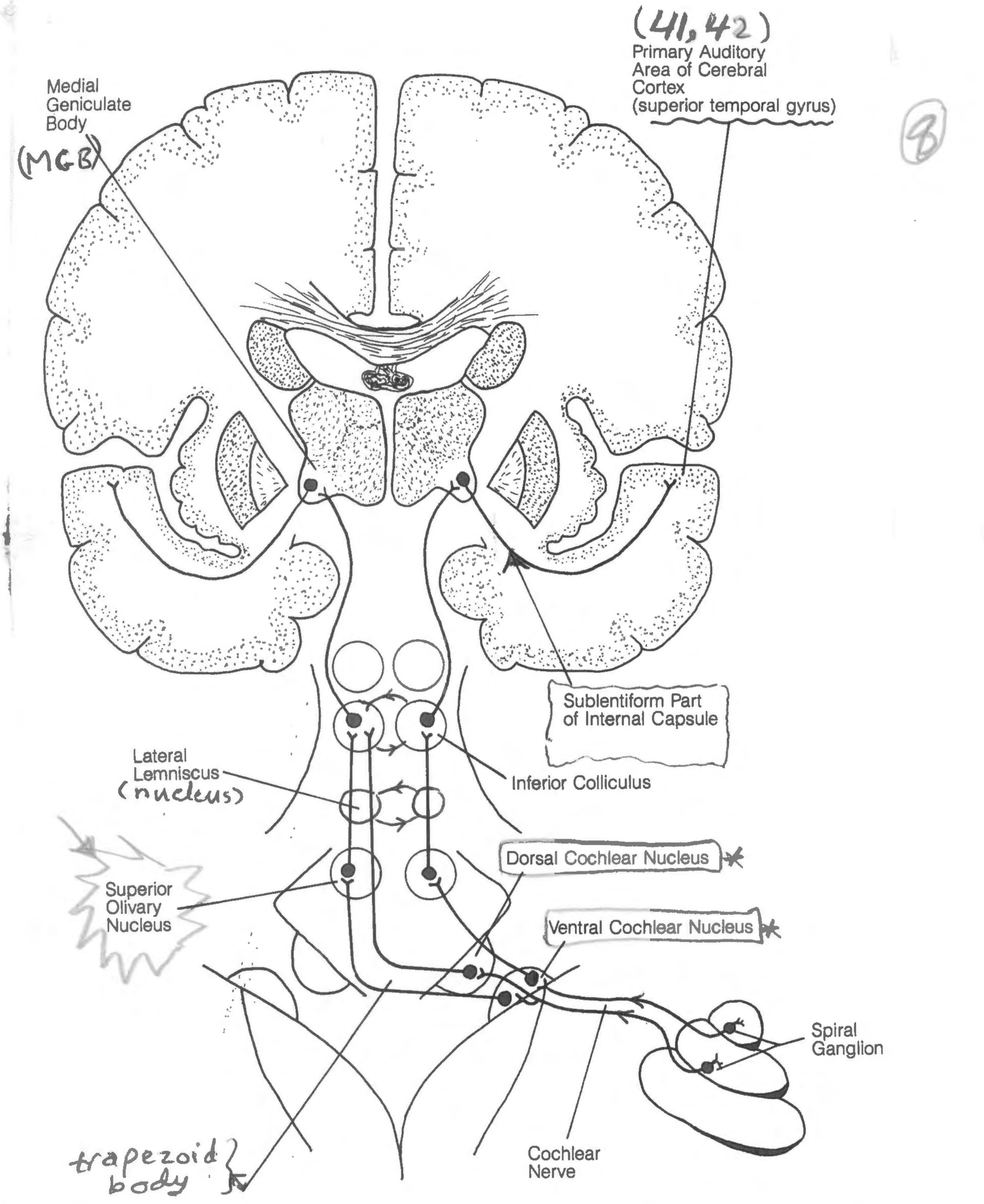
↓

Their peripheral processes come in contact with INNER hair cells

- Action potential recorded from the main cochlear nerve appear to be derived from neurons supplying inner hair cells

- Endolymph has a high concentration of K^+
- In contrast perilymph has high concentration of Na^+
- ion Pumps in the hair cell membrane produce a resting membrane potential of about -70 mv
- As the basilar membrane is displaced UP in response to fluid movement in the scala tympani → the taller stereocilia are displaced against the tectorial membrane

→ This causes ion channels at the tips of the stereocilia to open allowing K^+ flow along electrical gradient to DEPOLARIZE the cell → when a hair cell depolarize → voltage-gated Ca^{2+} channels at the base of the cell open and the resulting influx of Ca^{2+} causes release of neurotransmitter → depolarize afferent fibres of Cochlear nerve → action Potential transmitted along the „ „ fibres



- Cochlear Nerve (central processes of spiral ganglion cells) bifurcates at pontomedullary junction & enters cochlear nuclei { dorsal (posterior) / ventral (anterior)

* - Fibres from VENTRAL cochlear nucleus → ipsilateral superior olivary nucleus → Lateral lemniscus
majority → trapezoid body
↓
contralateral sup. oliv. nucleus
↓
contralateral lateral lemniscus

* - Fibres from DORSAL cochlear nucleus
↓
contralateral superior olivary nuc. nucleus
↓
contralateral lateral lemniscus

Notice the following:

Informations from both ears converges on [redacted] each superior olive & AT ALL HIGHER LEVELS most of the neurons respond to inputs from both sides

- Cochlear nuclei → the only auditory nuclei that do not receive binaural input (i.e input from both ears)
  → damage results in unilateral deafness
- Dorsal cochlear nucleus → receives input from the cochlear nerve
  → projects Contralaterally to the lateral lemniscus
- Ventral Cochlear nucleus → receives input from the cochlear nerve
  → Projects — bilaterally to the superior olivary nuclei
  — contralaterally to the lateral lemniscus through the trapezoid body
- superior olivary nucleus — located in the Pons at the level of the facial nucleus
  → Receives input from Ventral cochlear nuclei
  → Projects bilaterally to the lateral lemniscus
  → Plays a role in Sound localization & binaural hearing
  → gives rise to the efferent olivocochlear bundle which suppresses auditory activity when stimulated
- lateral lemniscus
  → receives input from < contralateral cochlear nuclei (mostly) / superior olivary nuclei (both ears)
  → Projects to the nucleus of the inferior colliculus
  → Connected to the contralateral lateral lemniscus via commissural fibres
- Nucleus of inferior colliculus
  → receives input from the lateral lemniscus
  → Projects via the brachium of the inferior colliculus to the medial geniculate body (MGB) which is the thalamic centre for hearing

MGB → receives input from the nucleus of the inferior colliculus
→ projects via the **auditory radiation** → (in the sublentiform part of internal capsule) to the **Primary auditory cortex** → the transverse gyri of Heschl (area 41 & 42 in the depth of the lateral sulcus) ⟹ Projects to the auditory association cortex (area 22)

* Although fibres conveying auditory input decussate at several levels → the sound is carried out by 2 ways:

① **Monaural information** i.e information about sounds at a Single ear
↓
conducted to the Contralateral side

② **Binaural information** i.e (information about differences between sounds to both ears) is handled by central pathways that receive compare & transmit this input.

⇓

* **Unilateral damage** to → cochlea (Receptors)
→ cochlear nerve
" nucleus
} Results in monaural i.e Unilateral deafness

* In contrast **Unilateral damage** AT or ABOVE the superior olivary complex leaves intact fibres from either ear so monaural deafness DOES NOT occur

⇓

The auditory decussations, particularly the trapezoid body are functionally similar to the optic chiasma

↓

* Unilateral lesion at or above the superior olive
→ impaired hearing especially on contralateral ear
→ inattention to stimuli on the " "

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~~15~~ ~~13~~ 11

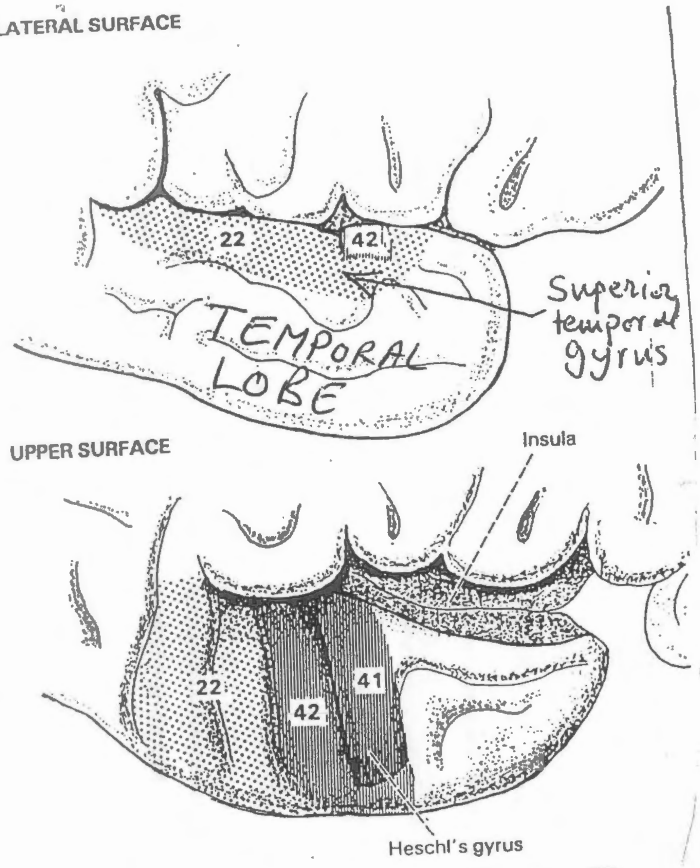


Fig. 30-9 Two views of the primary (41, 42) and secondary (22) auditory cortex.

Auditory cortex (Fig. 30-9)

The *primary auditory cortex* (areas 41 and 42 of Brodmann) includes the gyrus of Heschl on the upper surface of the superior temporal gyrus, and the adjoining part of the temporal operculum of the insula. 'Columnar organization' is obvious, the 'columns' being in fact stripes disposed mediolaterally. Each stripe is an isofrequency band, and the cortical arrangement is tonotopic: high tones excite the posterior stripes and low tones excite the anterior ones. The stripes are maximally excited from the *contralateral sound field*. Virtually all of the neurons are binaural.

Auditory association cortex (area 22)

* occupies the lateral surface of the superior temporal gyrus
* It receives short association fibres from the primary cortex & INTEGRATES INCOMING SOUNDS WITH AUDITORY MEMORY STORES

* Area (22) → has been subdivided into six cytoarchitectural areas → The most important is Wernick's sensory speech area

Lesion of the ① Cochlea ② Cochlear Nerve cochlear nuclei → Complete ipsilateral deafness

* Lesion of the lateral lemniscus up to → 1ry auditory cortex → Bilateral partial deafness greatest in the contralateral ear

* Lesion of the auditory association cortex → Word deafness? → the person fails to understand sounds or spoken words even though they are heard

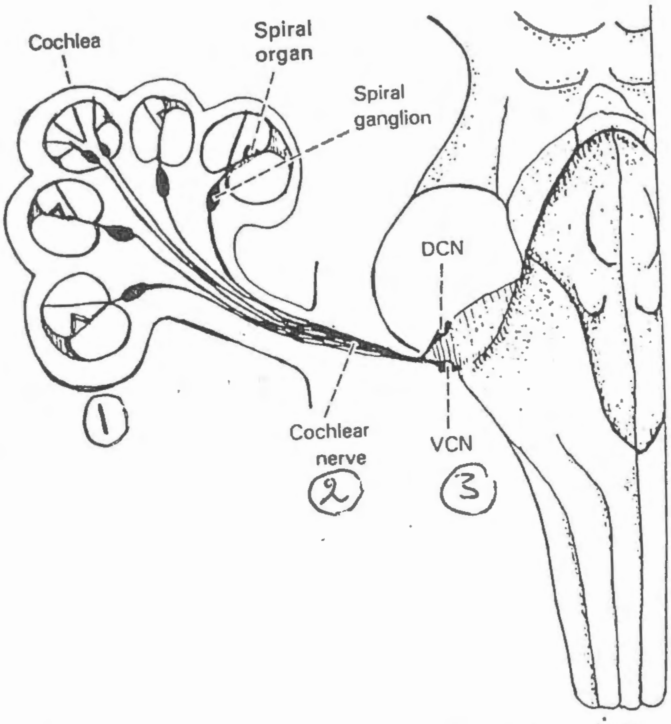
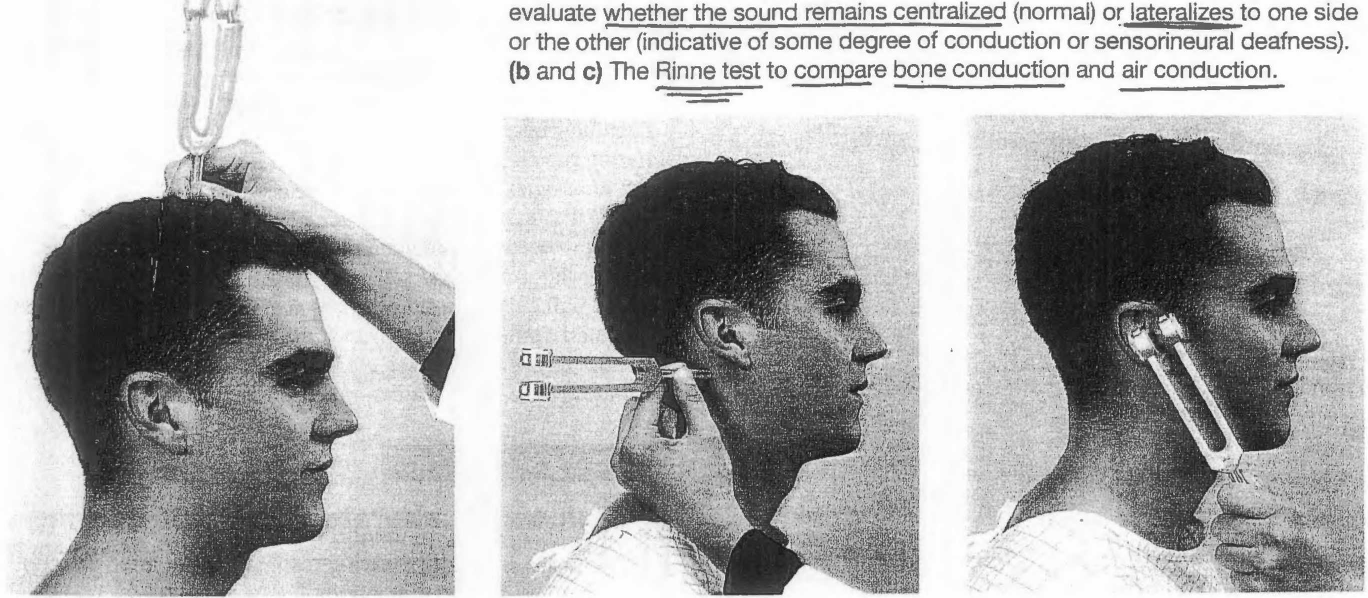


Fig. 30-2 Spiral ganglion and cochlear nerve. The nerve terminates in dorsal (DCN) and ventral (VCN) cochlear nuclei.

(12) [redacted]

FIGURE 25.6 The Weber and Rinne tuning fork tests. (a) The Weber test to evaluate whether the sound remains centralized (normal) or lateralizes to one side or the other (indicative of some degree of conduction or sensorineural deafness). **(b and c)** The Rinne test to compare bone conduction and air conduction.



(a) Weber Test (b) Rinne test (c)

Weber Test to Determine Conduction and Sensorineural Deafness (Nerve deafness)

Strike a tuning fork and place the handle of the tuning fork medially on your partner's head (see Figure 25.6a). Is the tone * equally loud in both ears, or is it louder in one ear? *

⊛ If it is equally loud in both ears → You have EQUAL HEARING or EQUAL LOSS OF HEARING in both ears

⊛ If nerve deafness is present in the Rt. ear → the tone will be heard in the Lt. ear but not the Rt. ear

⊛ If conduction deafness is present in the Rt. ear (ear wax in ext. ear / disease of middle ear) → the sound will be heard more strongly in Rt. ear due to sound conduction by the bone of skull.

⊛ Rinne test for comparing Bone- and Air- conduction hearing

1. Strike the tuning fork, and place its handle on your partner's mastoid process (Figure 25.6b).

2. When your partner indicates that the sound is no longer audible, hold the still-vibrating prongs close to his auditory canal (Figure 25.6c). If your partner hears the fork again (by air conduction) when it is moved to that position, hearing is not impaired and the test result is to be recorded as positive (+). (Record below step 5.)

3. Repeat the test on the same ear, but this time test air-conduction hearing first.

4. After the tone is no longer heard by air conduction, hold the handle of the tuning fork on the bony mastoid process. If the subject hears the tone again by bone conduction after hearing by air conduction is lost, there is some conduction deafness and the result is recorded as negative (−).

5. Repeat the sequence for the opposite ear.

Right ear: ________________ Left ear: ________________

Does the subject hear better by bone or by air conduction?