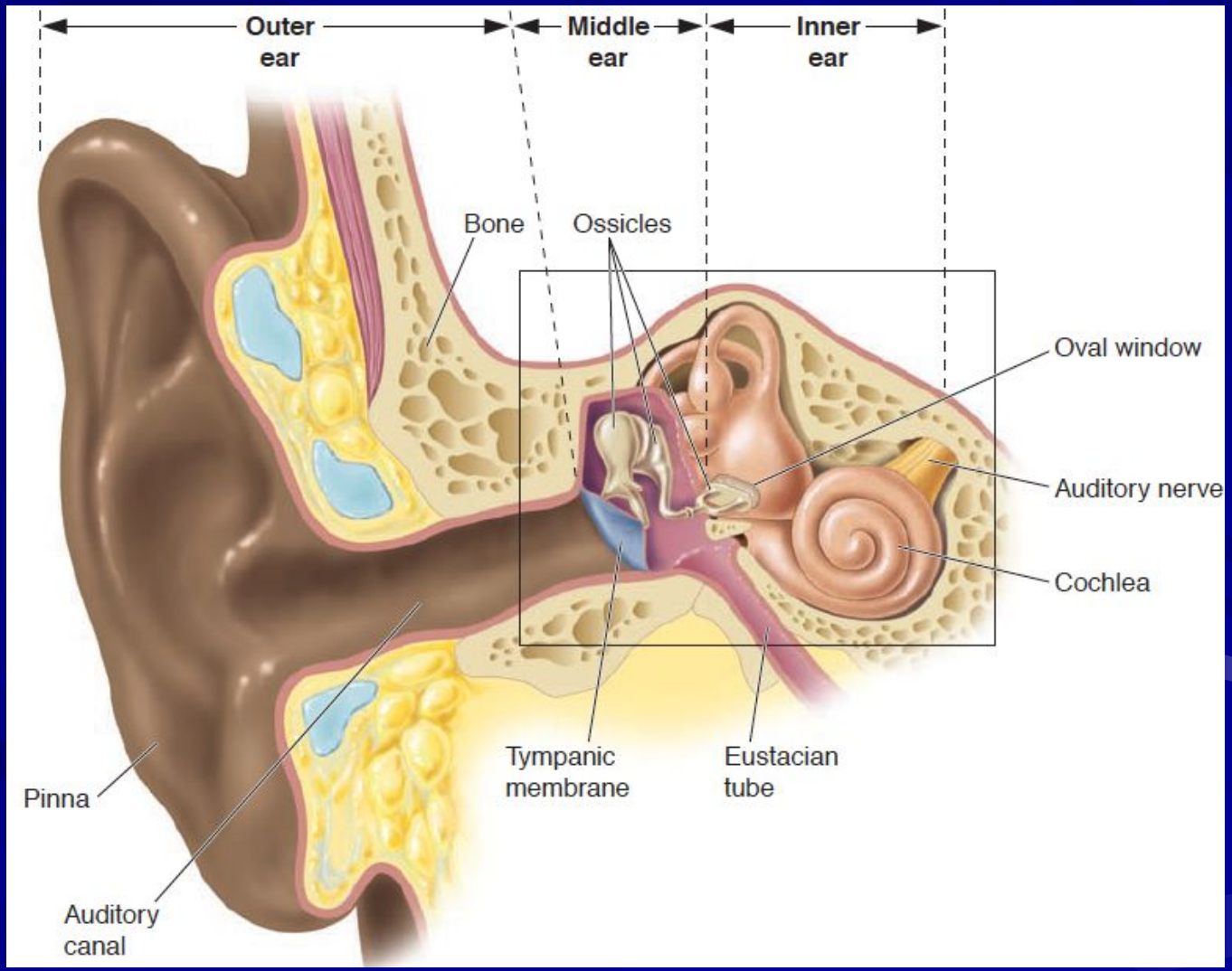
Auditory Processing

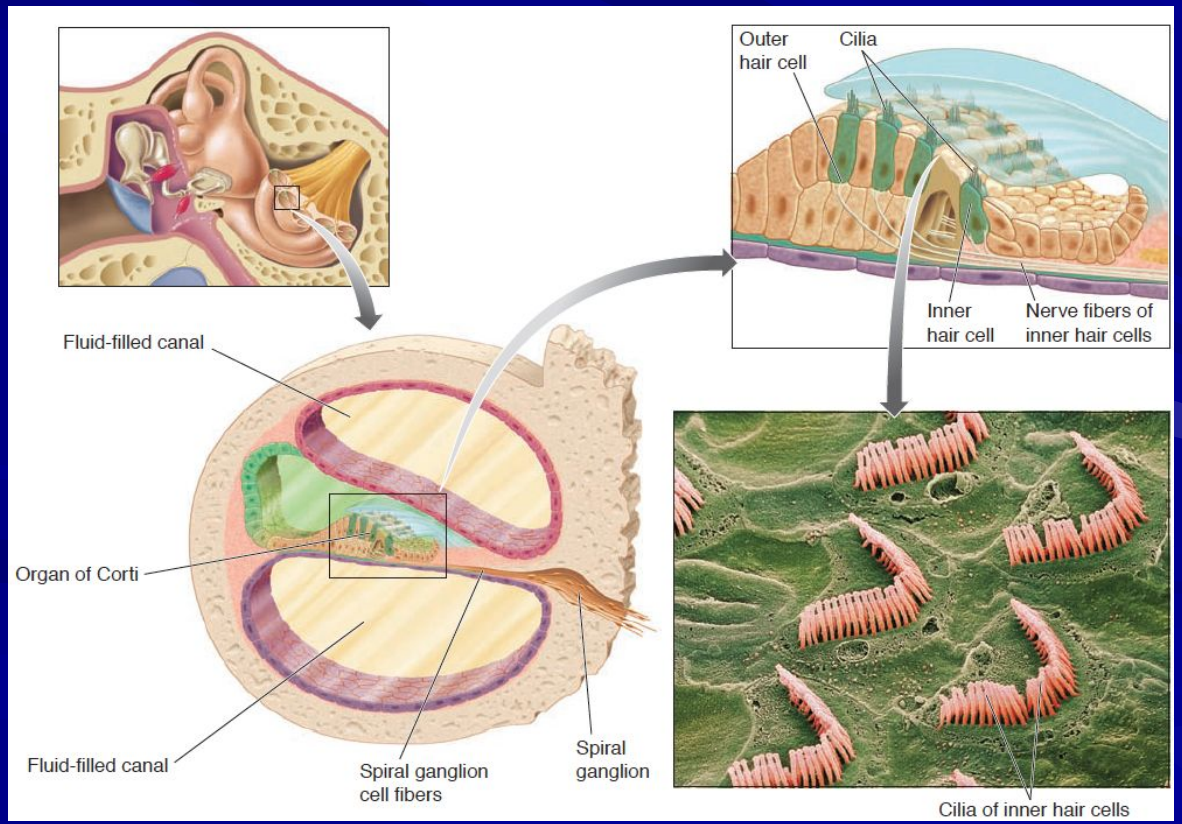
Organization of the Auditory Pathways

- Auditory processing begins in the ear.



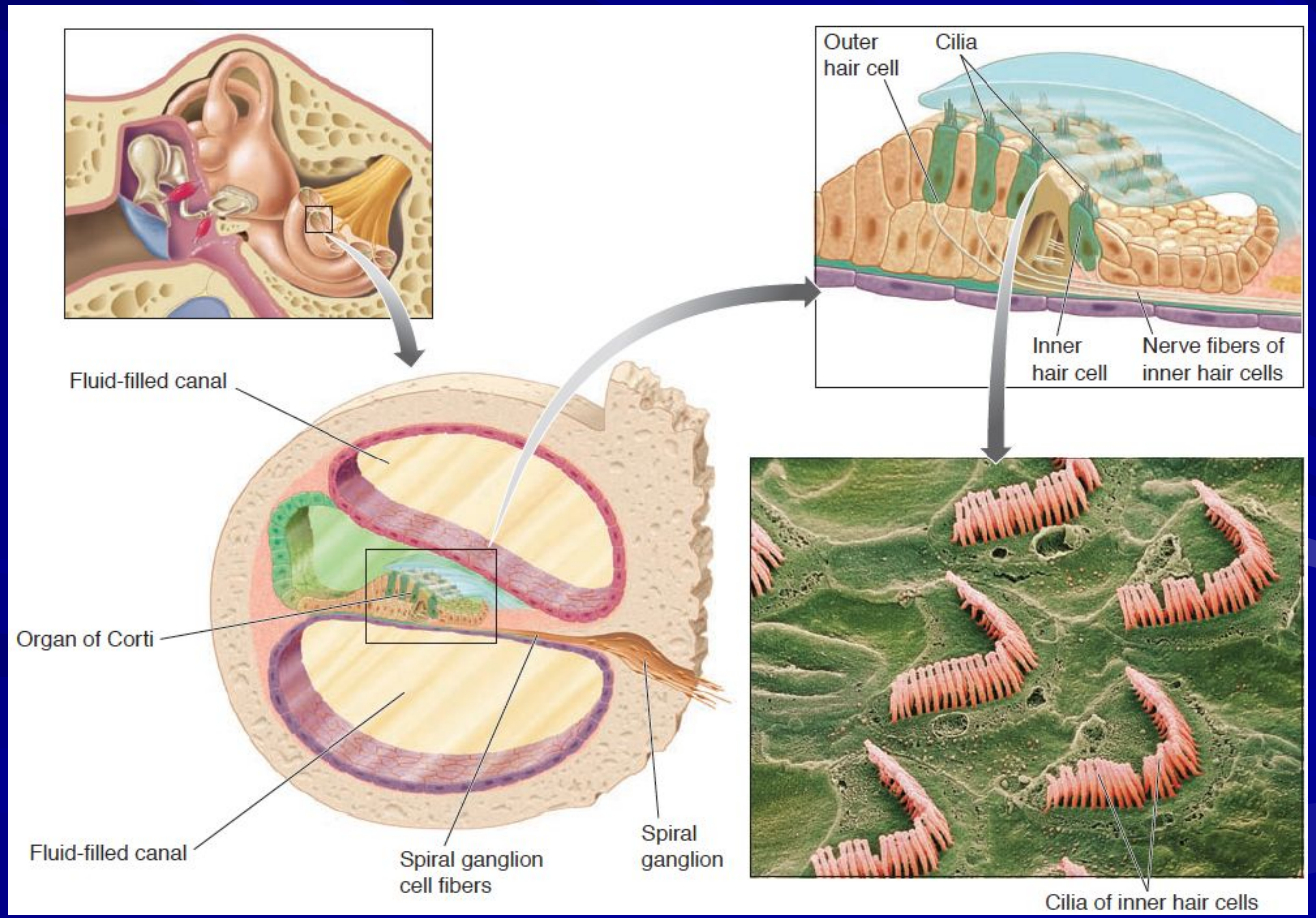
Auditory Processing

- Within the inner ear is the cochlea
- The cochlea contains the cells that translate sound energy into neural impulses.
- The cochlea is wound up into a spiral, and has a set of membranes that move in relation to one another when sound waves enter the ear.
- When membranes move back and forth, the motion stimulates hair cells



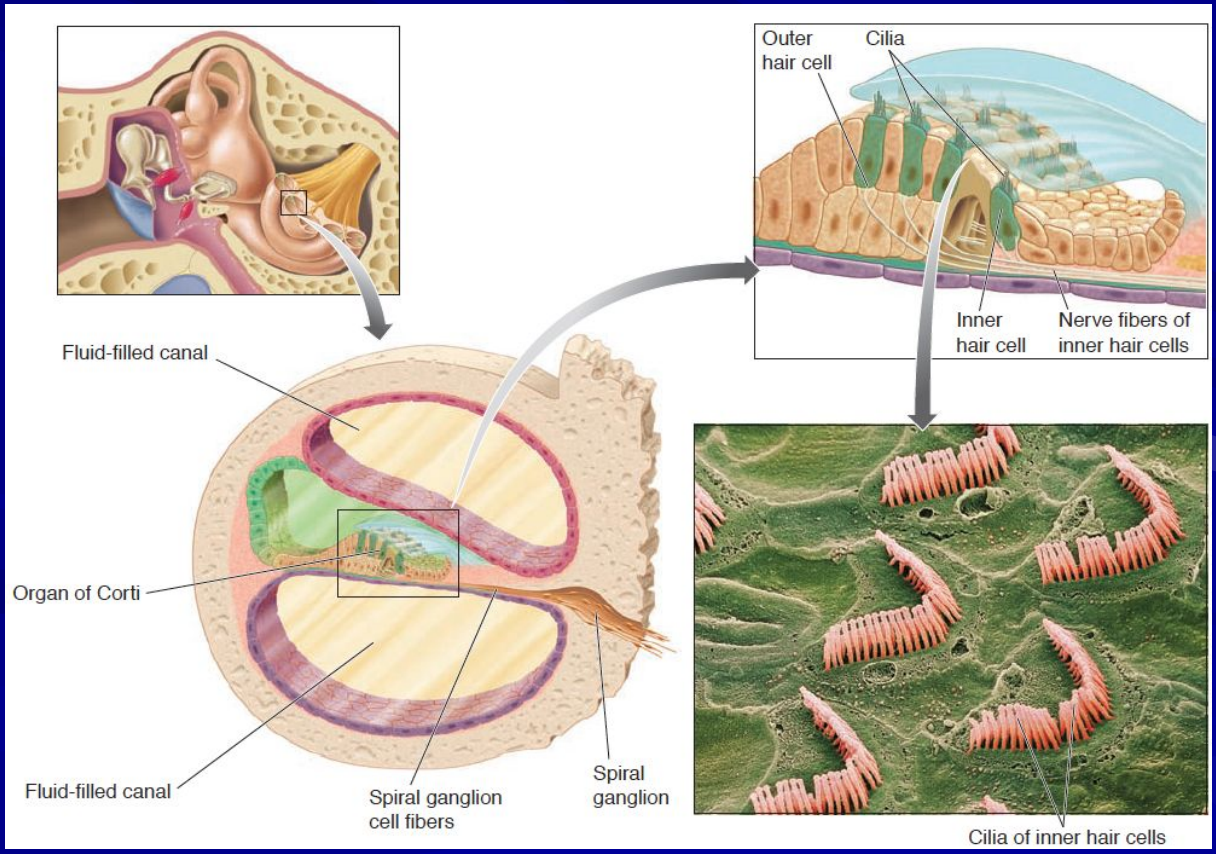
Auditory Processing

- Hair cells have little hairs - called cilia
- Movement of the cilia in response to sound vibrations causes the cell to emit action potentials.
- The axons of the hair cells synapse on spiral ganglion cells, which make up the auditory nerve



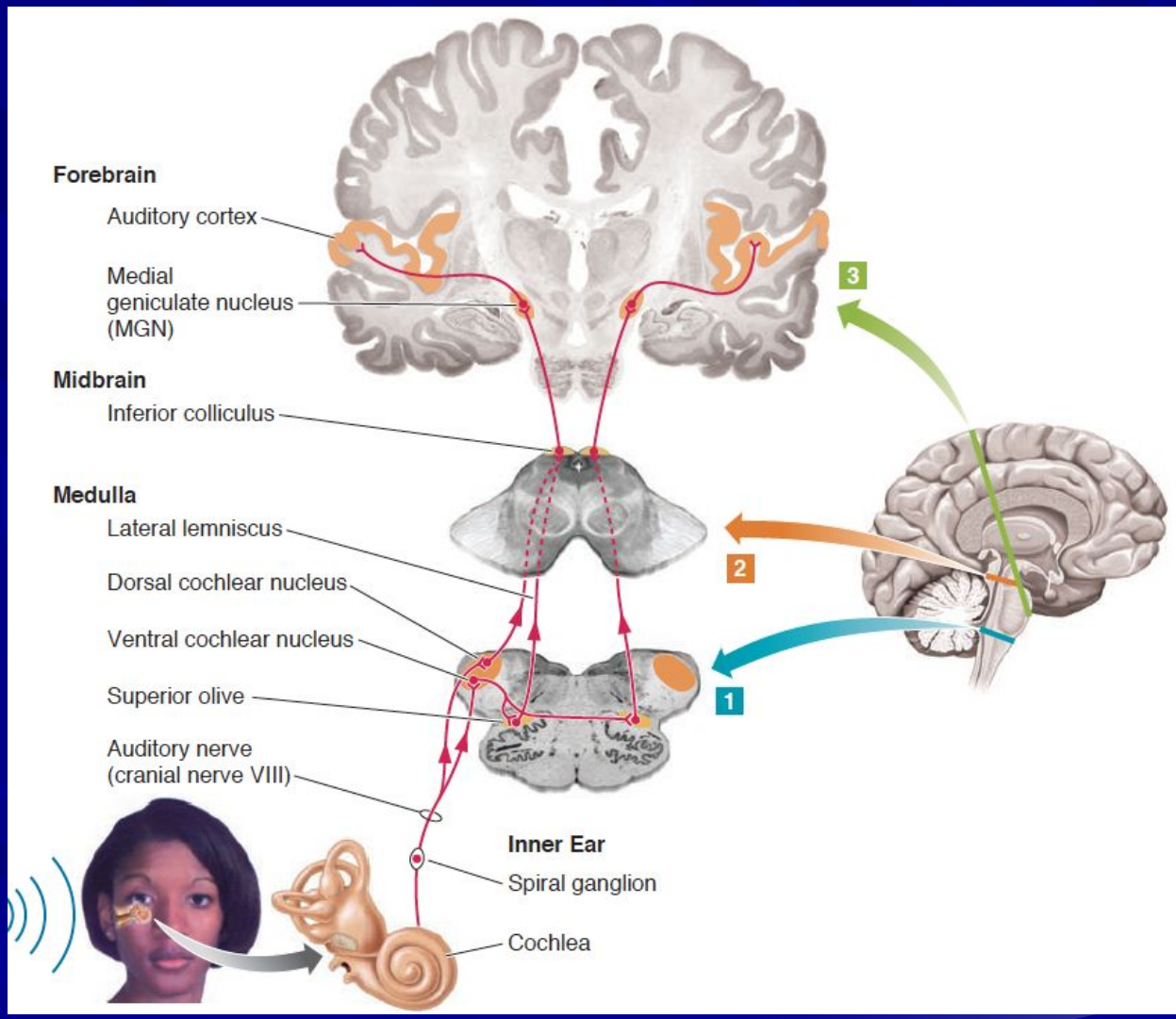
Auditory Processing

- Sound vibrations of different frequencies cause stimulation of different subsets of hair cells within the cochlea.
- Hair cells that are sensitive to high-frequency sound are located near the base of the cochlea, whereas those sensitive to low-frequency sound are located near the apex (tip) of the cochlea
- This organization creates a tonotopic map



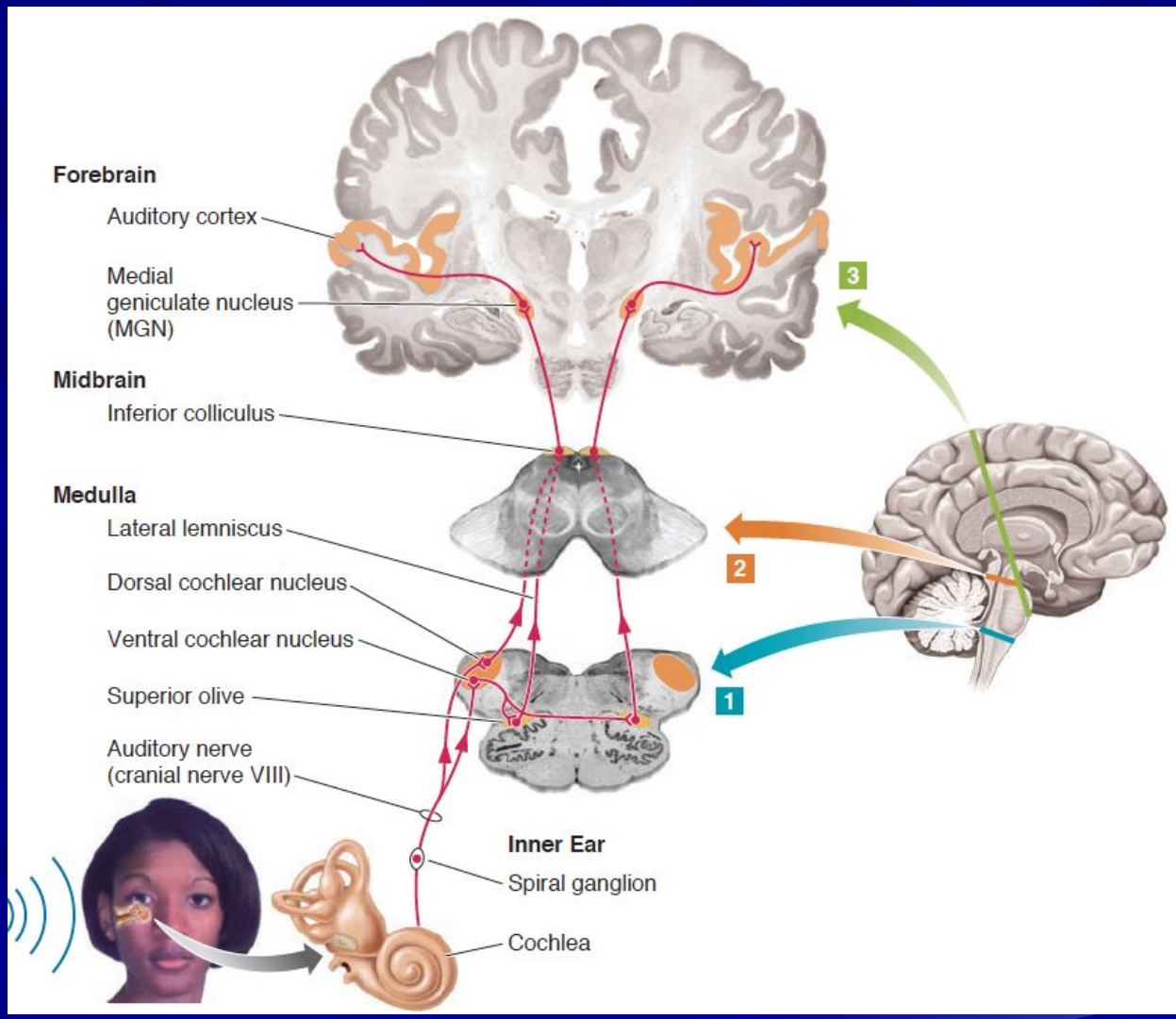
Auditory Processing

- Auditory information passes through several stopover points on its way from the ear to the auditory cortex
- Two of these locations are in the brainstem.
- First, the auditory nerve synapses in the cochlear nucleus (in the medulla)
- From there a pathway sends the information onward to the superior olivary nucleus (also in the medulla).



Auditory Processing

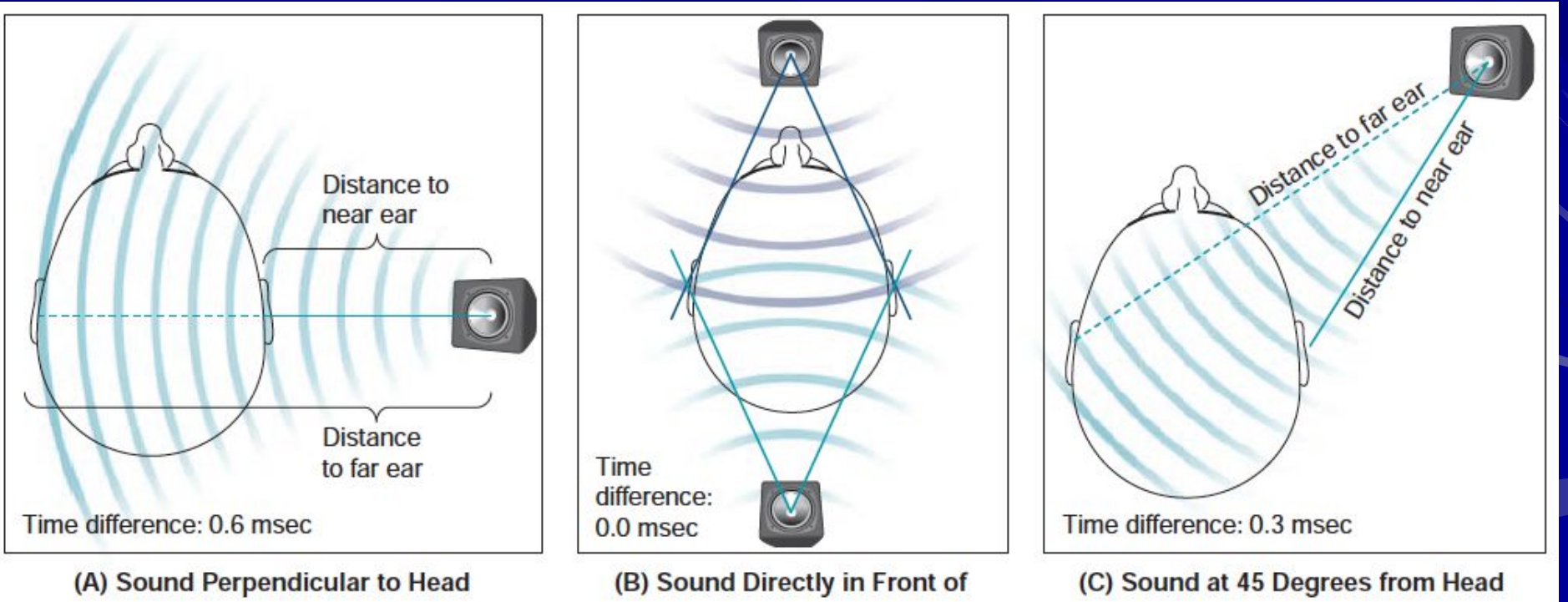
- From superior olivary nucleus, the information travels to the inferior colliculus in the midbrain
- Then onward to the medial geniculate nucleus of the thalamus.
- From medial geniculate nucleus, the information is finally sent to the primary auditory cortex.



Auditory Processing

Brainstem Computation of Spatial Location

- By comparing interaural ("between the ears") time differences and interaural intensity differences, the auditory system can deduce the spatial location of a sound source.
- Brainstem areas compute spatial location in part by using delay lines and cells called coincidence detectors that take into account the different arrival times of a sound at the left and right ears



(A) Sound Perpendicular to Head

(B) Sound Directly in Front of

(C) Sound at 45 Degrees from Head

Auditory Processing

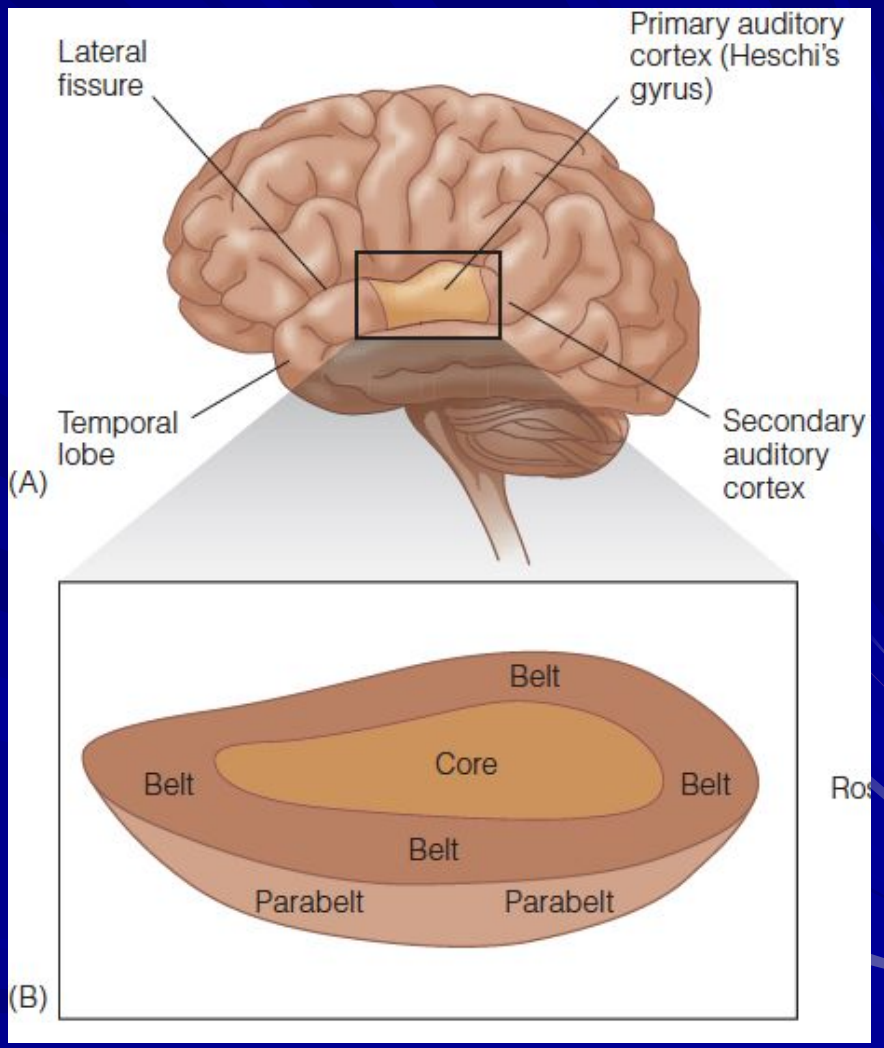
Organization of Auditory Cortex

- The auditory cortex lies just beneath the Sylvian fissure in the temporal lobe.
- The auditory cortex can be subdivided into a few regions:

1. the core
2. the belt (which surrounds the core)
3. the parabelt (which surrounds the belt)

- The core can be further subdivided into

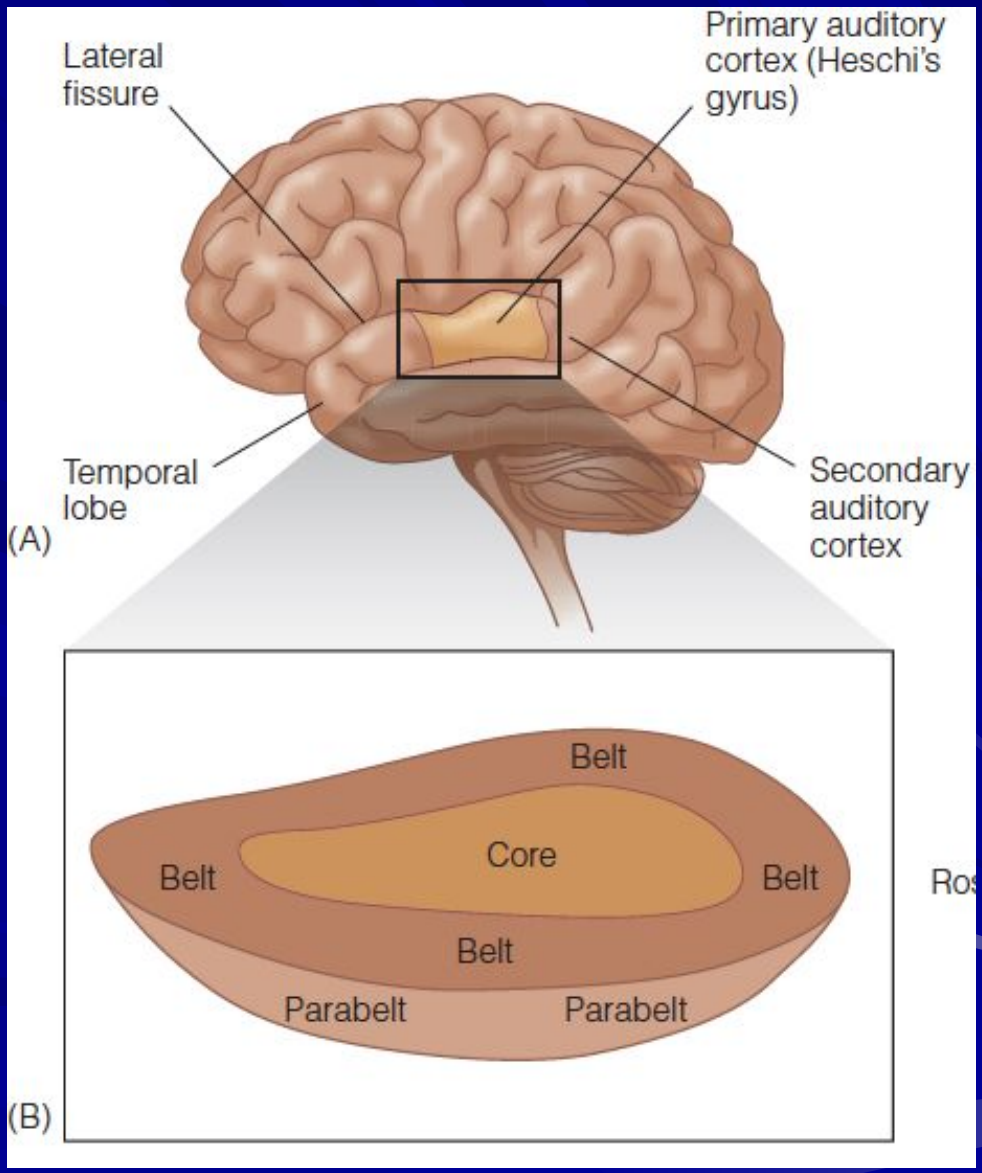
1. areas A1 (primary auditory cortex)
2. regions anterior to A1 (the rostral and rostrotemporal fields).



Auditory Processing

Organization of Auditory Cortex

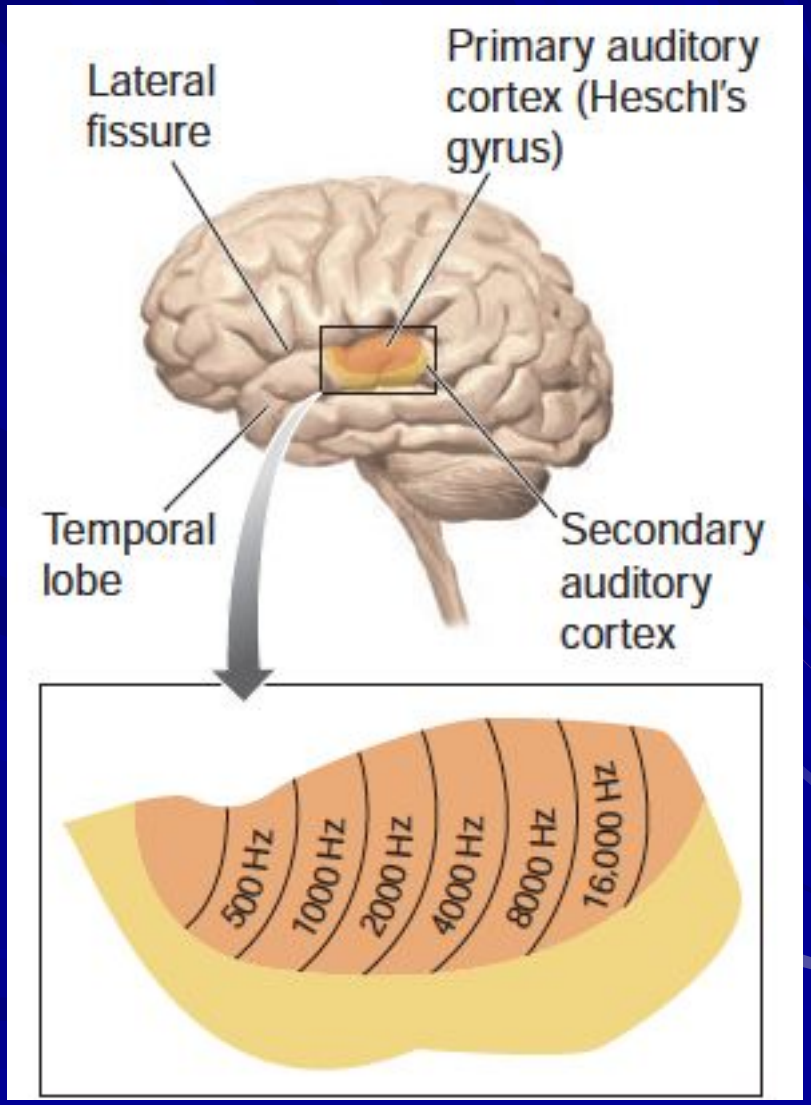
- The core region receives input from the medial geniculate nucleus,
- The belt region receives most of its input from the core,
- The parabelt receives input from the belt.



Auditory Processing

Organization of Auditory Cortex

- All areas within the core contain tonotopic maps.
- The tonotopic map is a map of sound frequencies.
- The lateral belt and parabelt regions are thought to correspond to the planum temporale, an anatomical region that is known to be especially important in speech perception.
- The planum temporale on the left side of the brain is activated by speech sounds, while this region of the brain in both the left and right hemispheres is also activated in response to other complex auditory stimuli like sound patterns, music, and environmental sounds



Auditory Processing

Auditory-Visual Interactions

- Auditory and visual processing is taking place in largely separate streams within the brain.
- But at some point sounds and sights must be associated with one another.
- In a traditional hierarchical model, this multisensory integration was thought to take place at higher-level association regions of the brain, such as the association cortex in the temporal and parietal lobes.
- Auditory and visual inputs are first processed in their separate cortical areas, and then those areas converge upon higher level association areas.