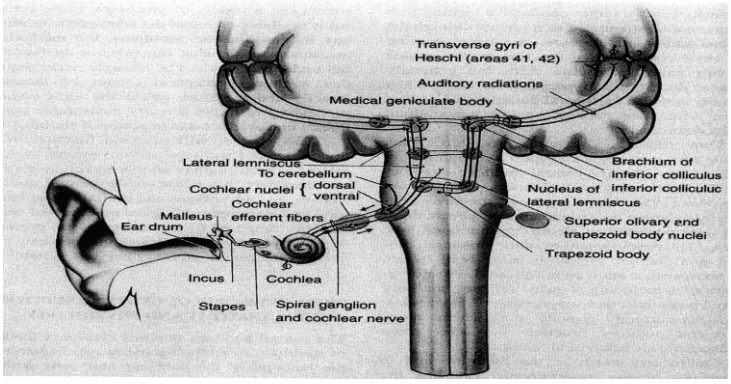
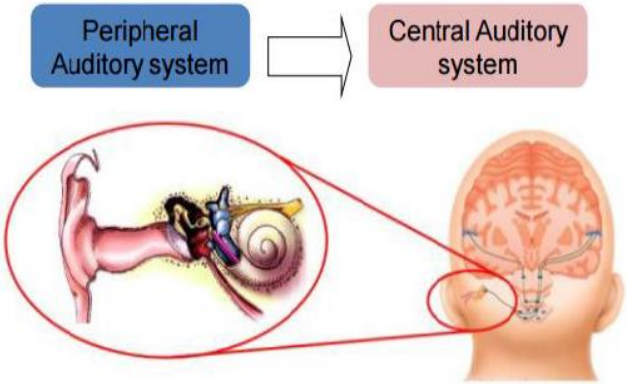
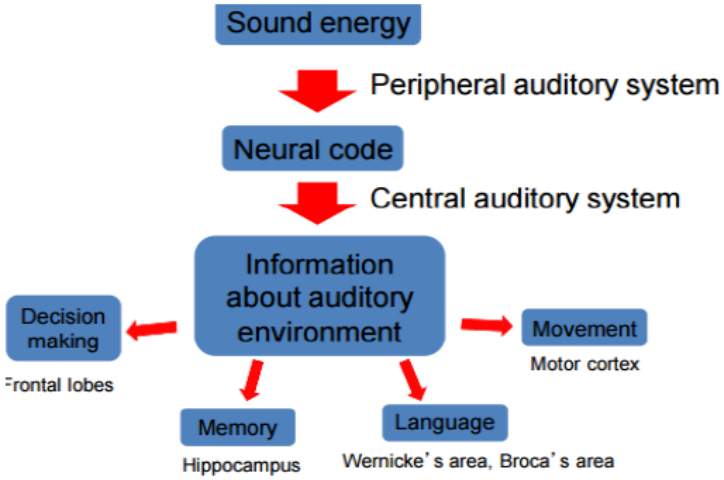
# The Auditory Nerve and Central Auditory Pathways




## OVERVIEW OF THE AUDIOTORY SYSTEM



# Auditory System Functions




# Auditory Environment

- Auditory object = sound source
- e.g. Car, Person, Horse
- The auditory environment is often made up of many auditory objects

## Problem

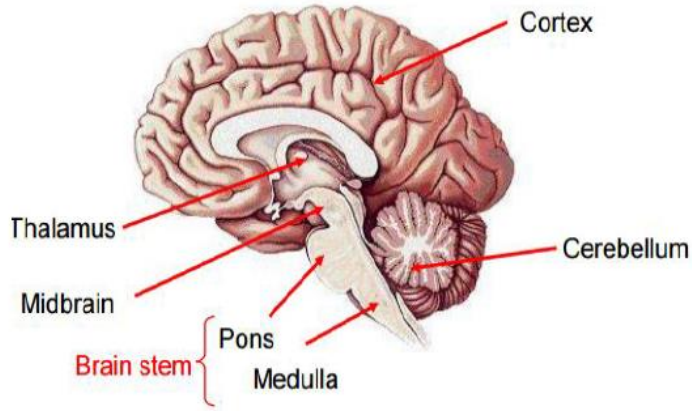
- We usually need to focus our attention on one auditory object, and ignore all of the others.
- E.g.

- Listening to a friend in a café

- Penguin identifying the call of its own young amongst 100s of others

- Owl listening for the rustle of a mouse among the sound of wind in the trees

## Brain Anatomy



## General trends in central auditory processing

Low level brain areas → High level brain areas

- Complexity of stimulus coding increases
- Phase locking becomes poorer
- Cells respond less to simple stimuli such as pure tones
- Redundant information is discarded
- Integrate auditory information with that from other systems.
- Becomes more difficult to study!

## Major Components of the Central Auditory Nervous System (CANS)

- VIIIth cranial nerve
- Cochlear Nucleus
- Trapezoid body
- Superior Olivary Complex
- Lateral Lemniscus

Brainstem

- Inferior Colliculus

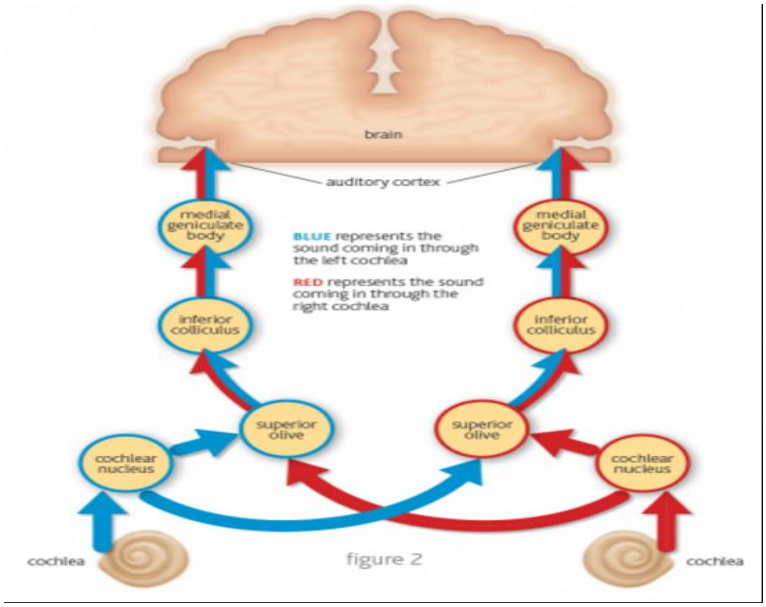
Mid-brain

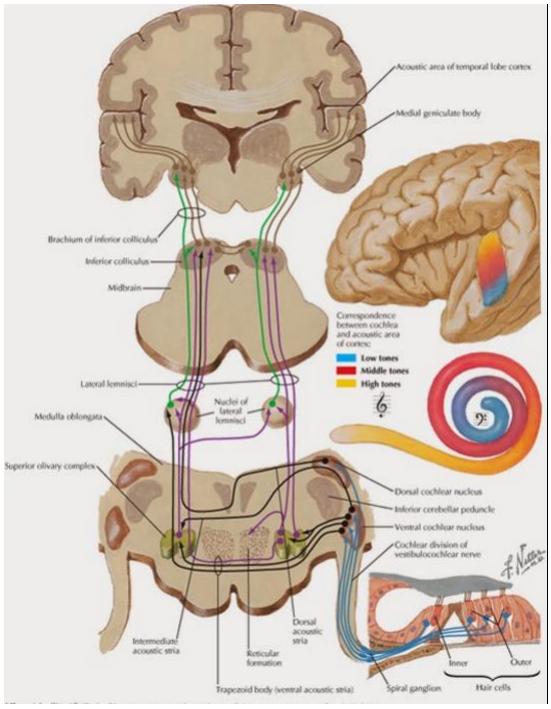
- Medial Geniculate Body

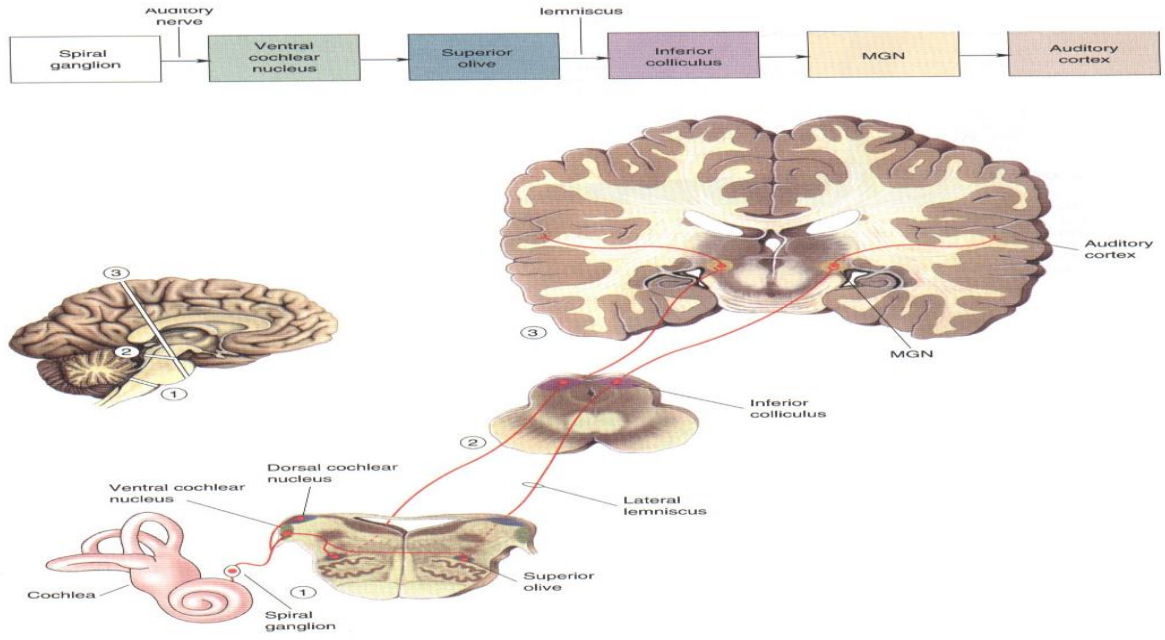
Thalamus

- Primary Auditory Cortex

Temporal Lobe

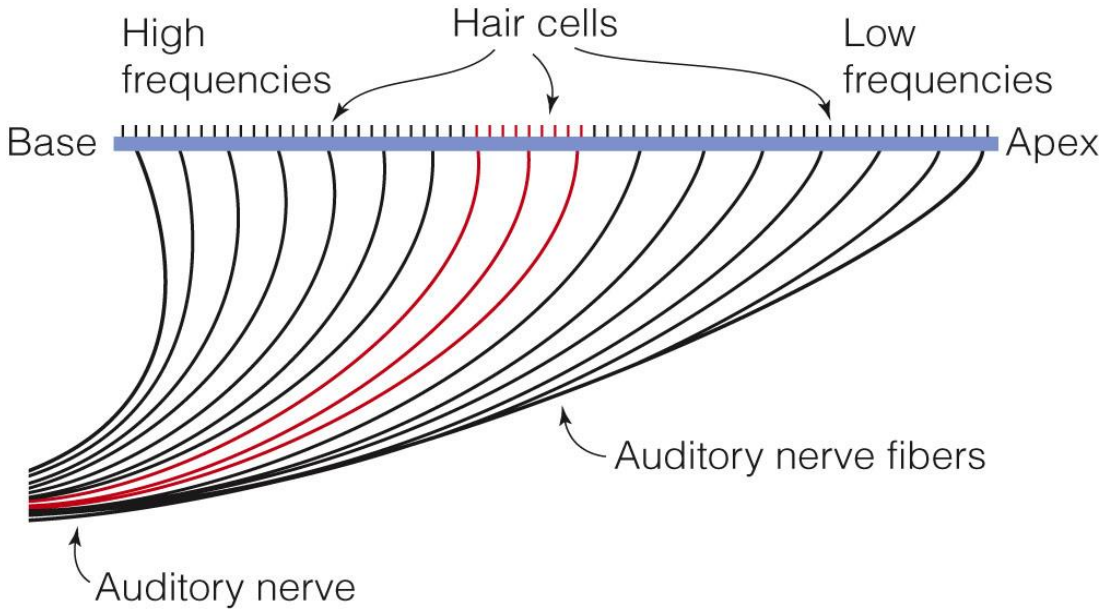

brain
auditory cortex
medial geniculate body
medial geniculate body
BLUE represents the sound coming in through the left cochlea
RED represents the sound coming in through the right cochlea
inferior colliculus
inferior colliculus
superior olive
superior olive
cochlear nucleus
cochlear nucleus
cochlea
cochlea
figure 2


Acoustic area of temporal lobe cortex
Medial geniculate body
Brachium of inferior colliculus
Inferior colliculus
Midbrain
Correspondence between cochlea and acoustic area of cortex:
Low tones
Middle tones
High tones
Lateral lemnisci
Nuclei of lateral lemnisci
Medulla oblongata
Superior olivary complex
Dorsal cochlear nucleus
Inferior cerebellar peduncle
Ventral cochlear nucleus
Cochlear division of vestibulocochlear nerve
Intermediate acoustic stria
Reticular formation
Dorsal acoustic stria
Trapezoid body (ventral acoustic stria)
Spiral ganglion
Inner
Outer
Hair cells




# THE AUDITORY NERVE

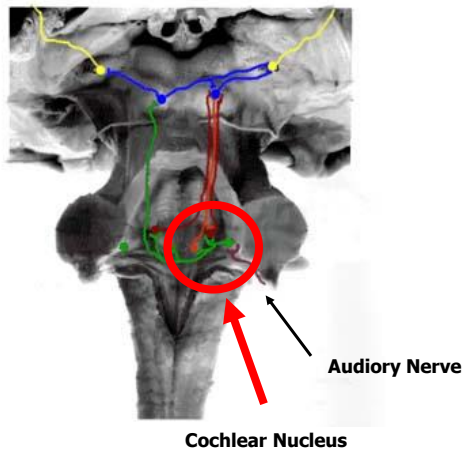
- The individual fibers pass from the modiolus of the cochlea through the internal auditory canal (IAC), which exits at the base of the brain
- *The IAC also carries the vestibular portion of the VIII nerve and fibers of the facial nerve.*
- *There are approximately 30000 cochlear nerve fibers in each ear.*




# THE AUDITORY NERVE

- **Tonotopic organization** The VIII nerve fibers form a cylindrically arranged bundle, with fibers from the apical (low frequencies ) areas forming the center and fibers form the basal turn of the cochlea(high frequencies ) form outer portion.
- The vestibular and auditory portions of the VIII N. separate at the cerebellopontine angle
- One part of the auditory portion descends to the **dorsal cochlear nucleus** and the other ascends to the **ventral cochlear nucleus**.

## The cochlear nucleus




## Anatomy of the Cochlear nucleus (CN)

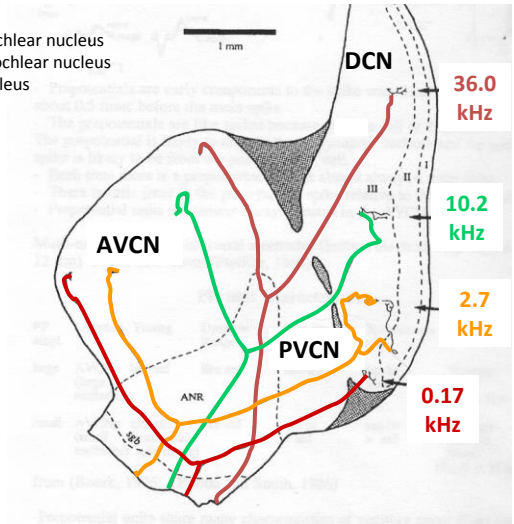
- Spans junction of pons and medulla
- Receives mainly *ipsilateral* afferent input from the cochlear via auditory nerve
- Two distinct anatomical divisions (each with different innervations):
  - Ventral Cochlear Nucleus (VCN)
    - split into anterior- and posterior-
    - Projects to ipsi and contralateral Superior Olivary Complexes (through *Trapezoid Body*)
  - Dorsal Cochlear Nucleus (DCN)
    - Projects into the **contralateral** Inferior Colliculus (IC)

# THE COCHLEAR NUCLEUS

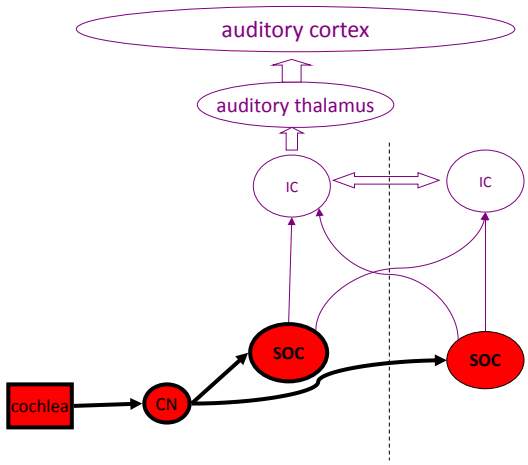
- Tonotopic organization
- "must-synapse" station--second order fibers
- Preserves, but does not enhance, information received from the auditory nerve

## AN fibers terminate in a "tonotopic" or "cochleotopic" pattern

AVCN = anterior ventral cochlear nucleus
PVCN = posterior ventral cochlear nucleus
DCN = dorsal cochlear nucleus



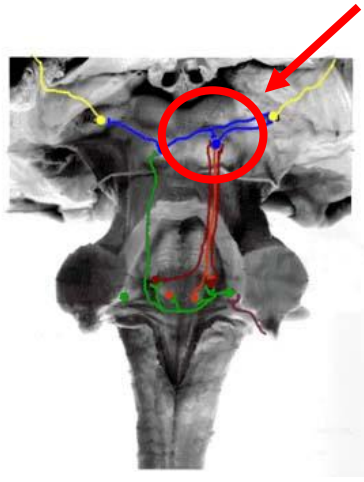
## simplified overview of afferent auditory system




CN = Cochlear nucleus
SOC= Superior Olivary Complex
IC= Inferior Colliculus

cochlea -> CN -> SOC -> IC -> Thalamus -> Cortex

## Superior olivary complex (SOC)



# Superior Olivary Complex (SOC)

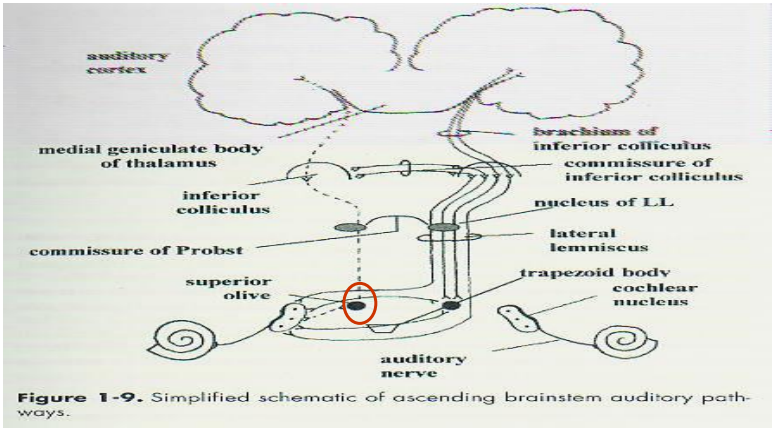



**Figure 1-9.** Simplified schematic of ascending brainstem auditory pathways.

- Medial to the CN in the caudal pons.
- Receives info from both ipsi & contra nuclei.

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# Superior olivary complex (SOC)

- Group of nuclei in pons
- Receives input from ventral cochlear nuclear complexes on *both* sides (through *Trapezoid Body*)
- First stage in auditory pathway to receive binaural input
- Sense the direction of sound localisation
- Two major nuclei:
  - **Medial Superior Olive, (MSO)**
    - Neurons sensitive to difference in arrival time of sound at each ear (ITD)
  - **Lateral Superior Olive (LSO)**
    - Neurons sensitive to difference in level of sound at each ear (ILD)

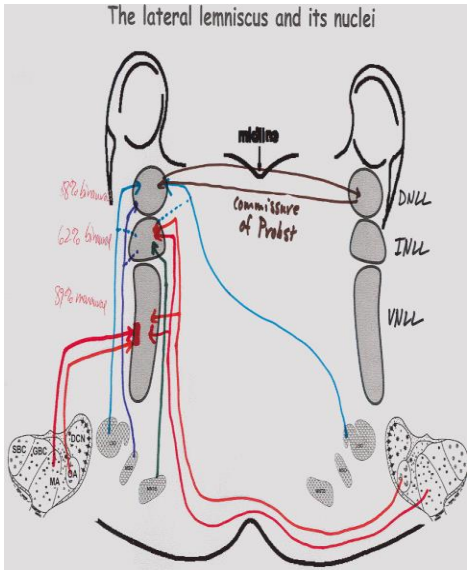
- Mediate the reflex activity of the tensor tympani and stapedius muscles of the middle ear.

## Superior Olivary Complex (SOC)

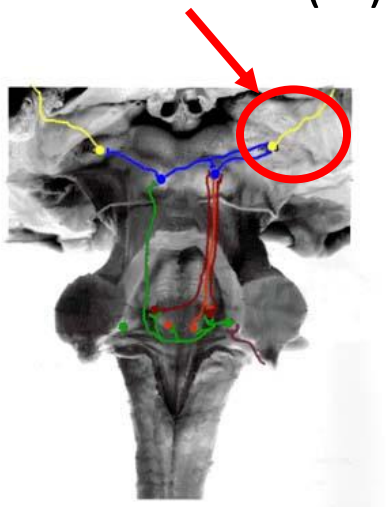
- SOC is the first place in the auditory system where the inputs form the two ears converge.
- SOC plays a key role in localisation.
- SOC analyzes differences in the neural impulses that represent information about the time of arrival and intensity levels of the auditory signals that have arrived at the two ears.

## Lateral Lemniscus(LL)

- **Bilat representation** of auditory stimulus



# Inferior colliculus (IC)



# Inferior colliculus (IC)

- Largest (and most active) auditory brainstem nucleus
- Vast majority of axons from SOC (forming *lateral lemniscus)* terminate in ipsilateral IC
- A few axons terminate in contralateral IC
- Most axons of IC cells travel to ipsilateral thalamus

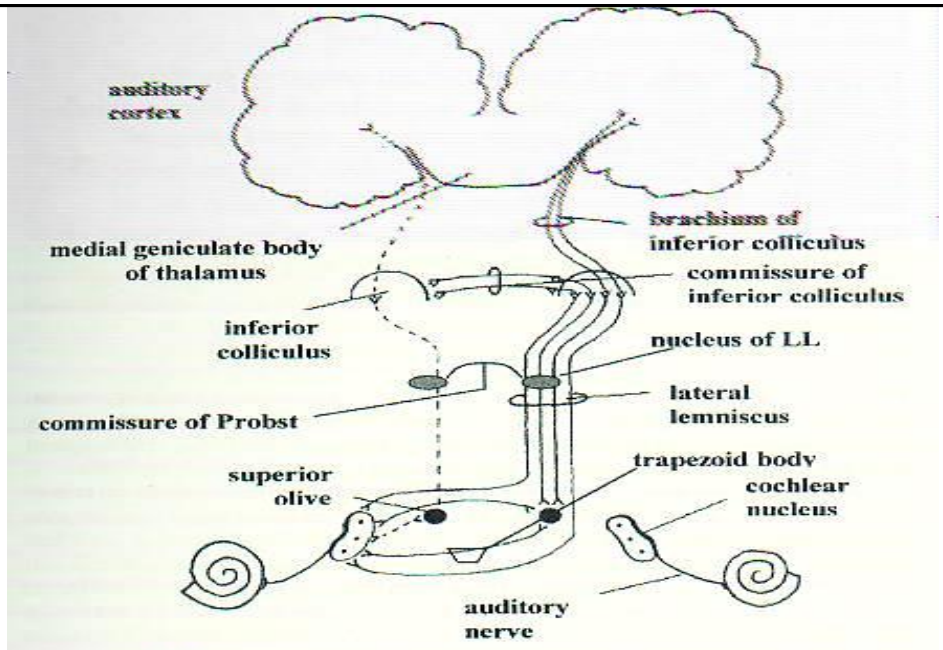
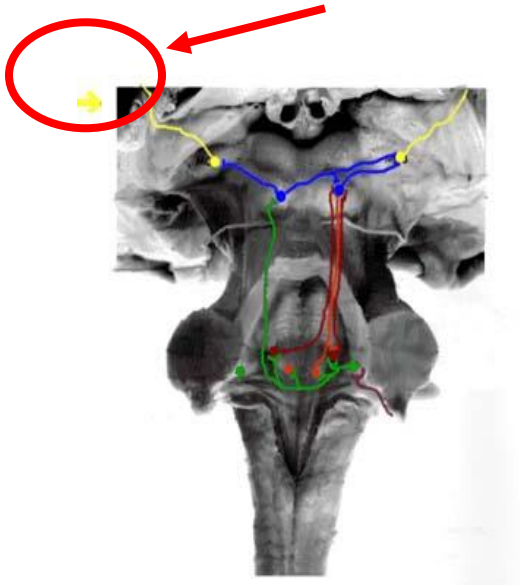



**Figure 1-9.** Simplified schematic of ascending brainstem auditory pathways.

# Medial Geniculate Body (MGB)



## Medial Geniculate Body (MGB)

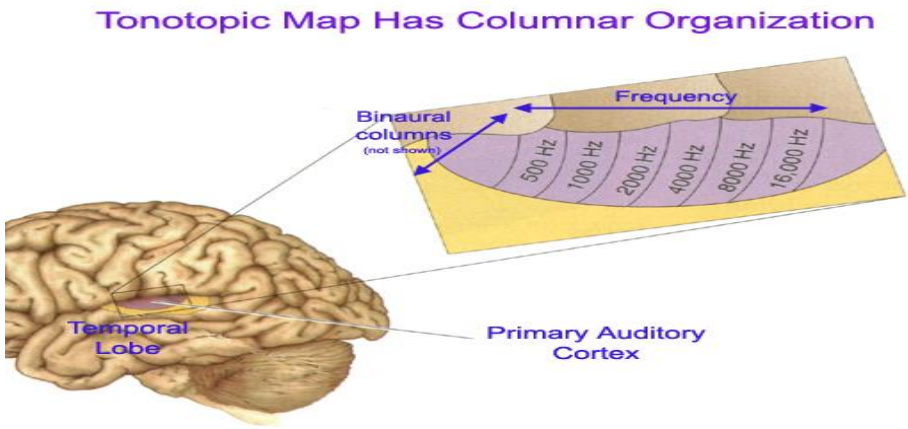
- Lies within the area of the Thalamus, thus also called the "Auditory Thalamus"
- Receives input mainly from IC
- Last subcortical relay in the pathway
- relays to cerebral cortex (Auditory cortex A1 and association auditory cortices)

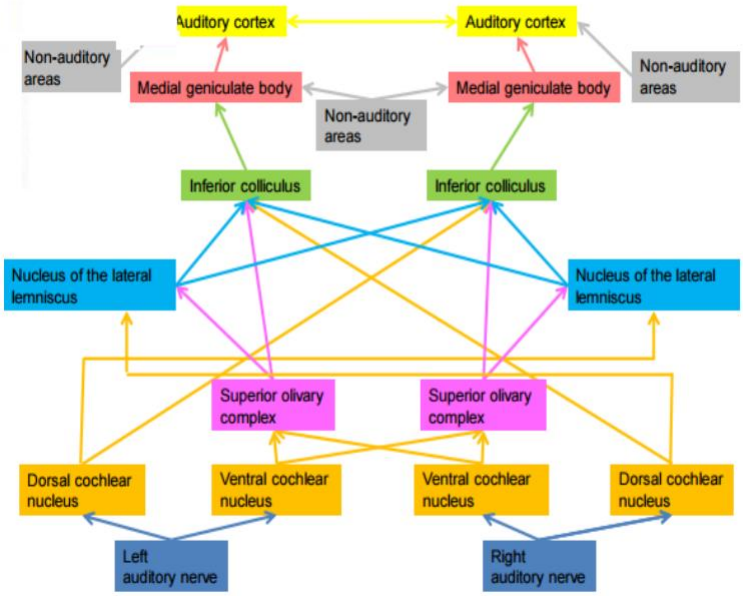
## Areas 41 and 42

- Primary auditory cortex
- involved in tasks such as identifying and segregating auditory "objects" and identifying the location of a sound in space.
- Receives & processes auditory information from MGB
- Lies along superior surface of temporal lobe on *Heschl's gyrus*
- Passes information on to Area 22

# Auditory Cortex

- There is a **tonotopic organization** in auditory cortex



## Disorders of the auditory nerve

- Lesions of the 8th nerve results in hearing losses classified as sensory/neural.
- There is usually nothing in the general audiometric configuration that could differentiate cochlear from 8th nerve disorders.
- Two common early signs of auditory nerve disorders are tinnitus and high frequency loss.
- There is discrepancy between the amount of hearing loss and the speech scores.

## Lesions of the 8th nerve

- Lesion may occur in the internal auditory canal or in the cerebellopontine angle.
- May occur due to:

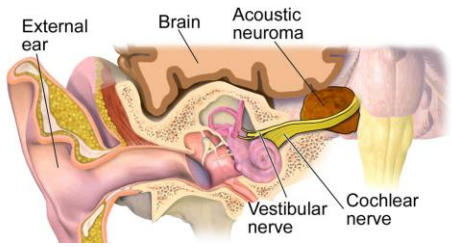
- Disease.

*VIII nerve tumor * Auditory Neuropathy

- Demyelinating Diseases
- Trauma to the head.
- Pressure on the nerve trunk

# Acoustic neuroma

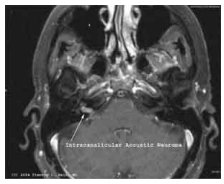
- Tumor of the auditory nerve
- Known as acoustic neuroma or vestibular shwannoma
- Most are benign and vary in size.
- Arise from the sheaths that cover the vestibular branch of the VIII nerve.




# Acoustic neuroma

- As the tumor increases in size, VIII nerve symptoms such as tinnitus, dizziness, hearing loss, and speech difficulty become apparent.
- The increase in the size of the tumor shows as progressive unilateral loss accompanied by facial weakness or numbness and alterations in the senses of taste and vision.

# Acoustic neuroma



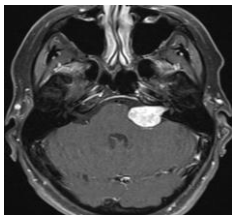

- classification

❑ Interacanicular

When the tumor occurs within the internal auditory canal.

❑ Extracanicular

When the tumor occurs outside the internal auditory canal.



# Case study

- Patient is a 58-year-old female with a complaint of hearing loss in her right ear. The difficulty was first noticed about five years earlier and has been gradually progressive to the point where she relies entirely on her left ear for communication. She does not experience true vertigo, but frequently she has attacks of unsteadiness and occasional headaches. She also complains of a constant noise in her right ear, which she describes as "bacon frying". Her family physician has told her that the hearing loss is related to several episodes of middle-ear infection that she had as a child. Her main communication problem is in groups or noisy backgrounds, which she attempts to avoid

# Acoustic neuroma

- Treatment
  - ❑ Radiotherapy ; Gamma Knife
  - ❑ Surgical removal