

VESTIBULOCOCHLEAR NERVE

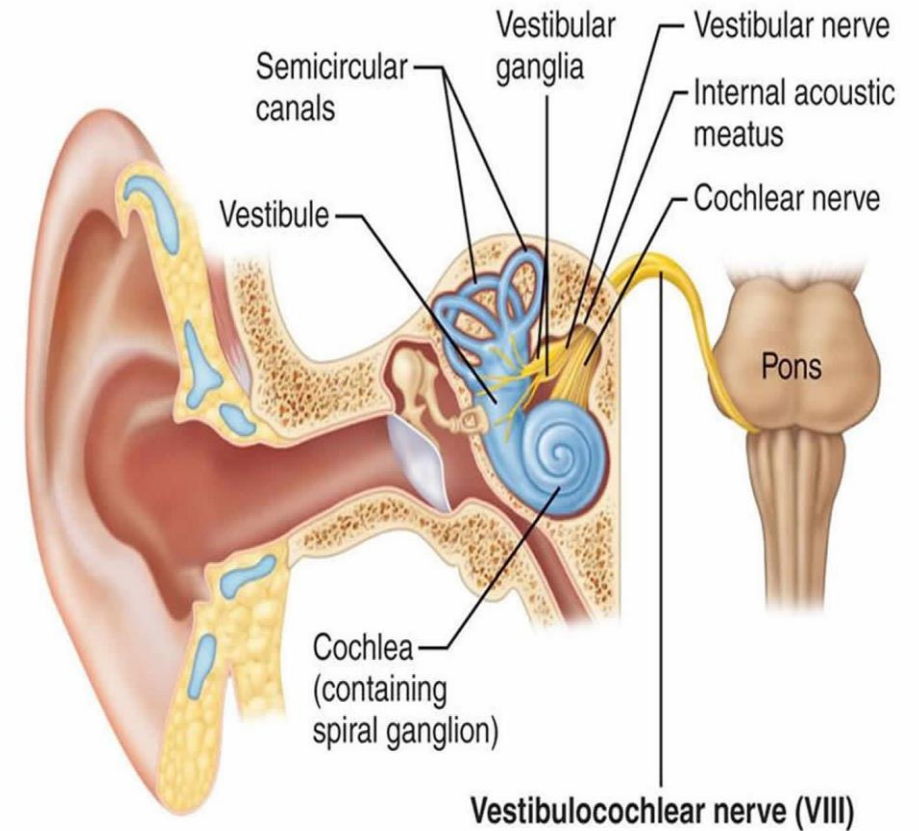
VESTIBULOCOCHLEAR NERVE (CRANIAL NERVE VIII)

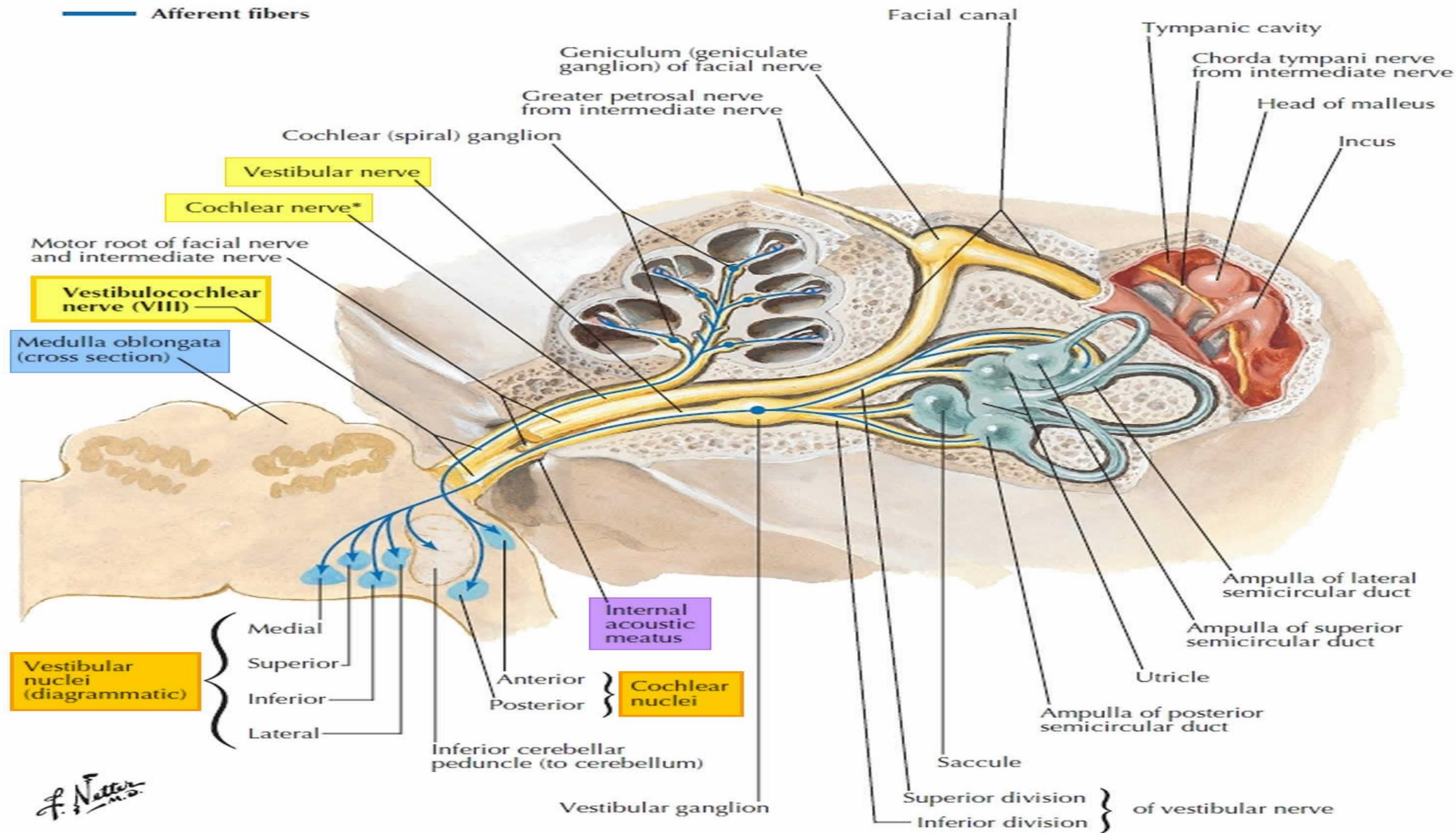
The eighth cranial nerve consists of two separate functional components concerned with transmitting afferent information from the internal ear to the central nervous system:

- The auditory (cochlear) nerve concerned with hearing
- The vestibular nerve concerned with balance and equilibrium

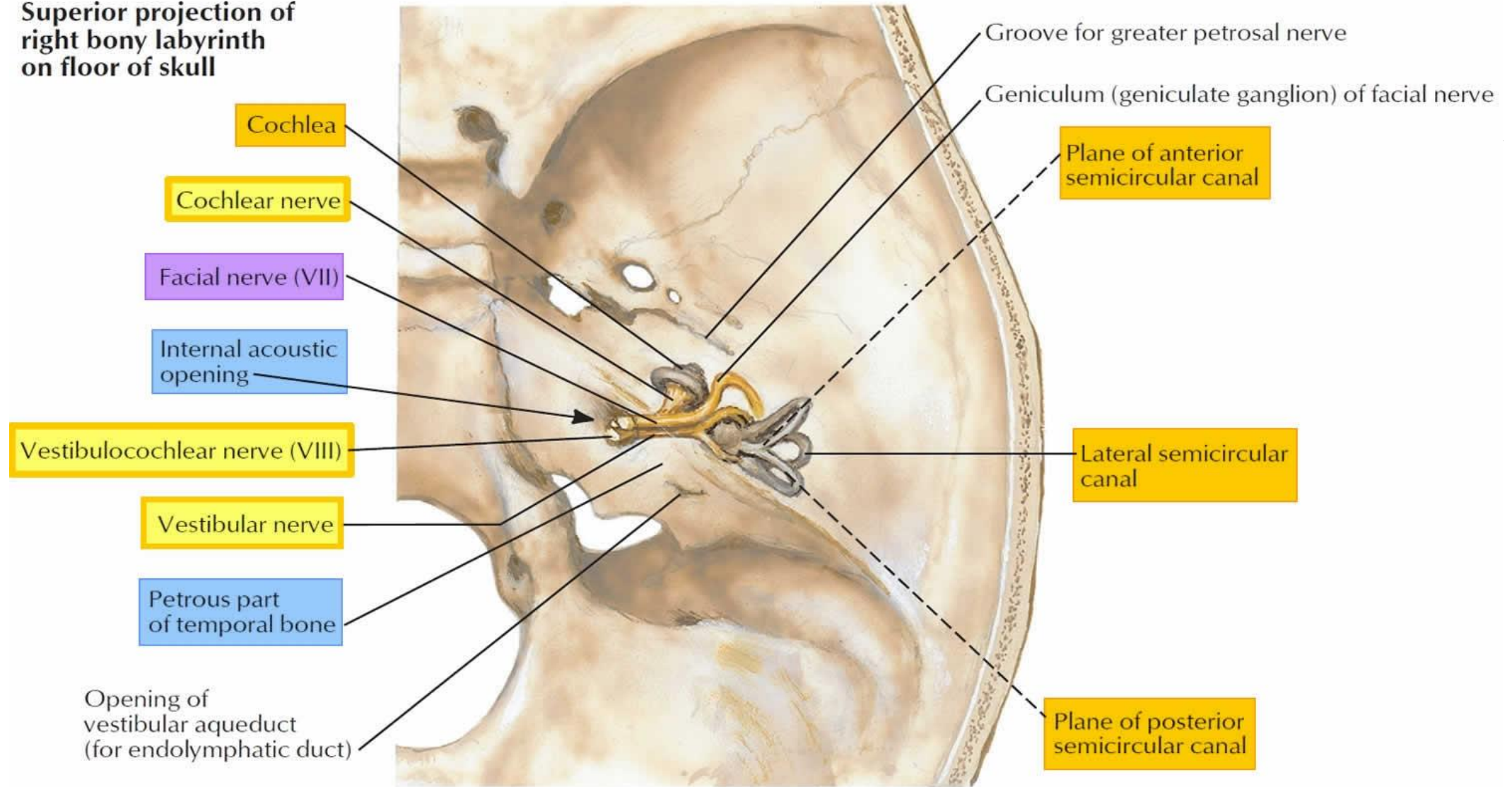
Vestibulocochlear Nerve Course

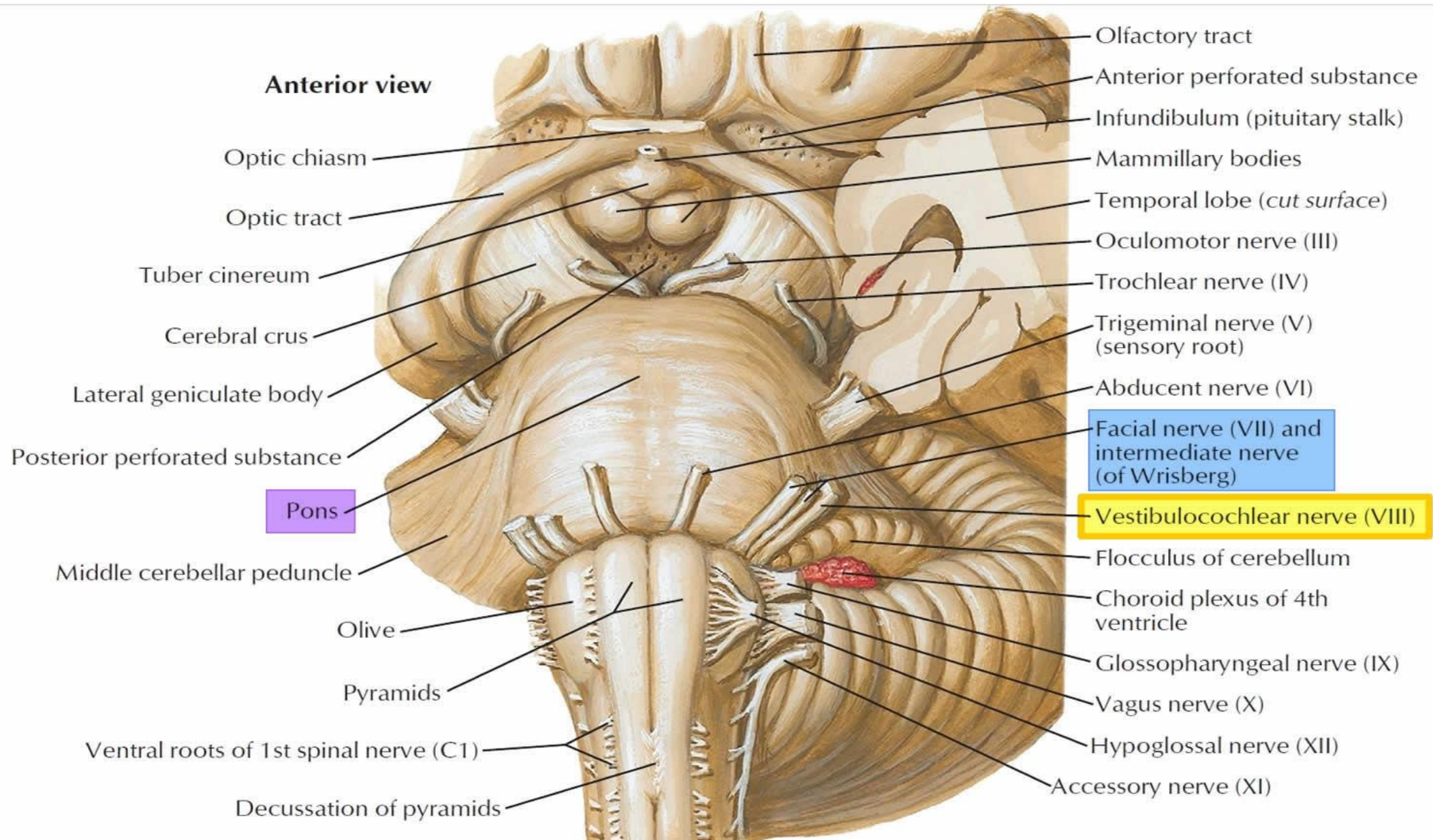
- The vestibulocochlear nerve (CN VIII) originates at the sensory receptors in the inner ear.
- Sensory nerve cell bodies for vestibular branch located in vestibular ganglia; for the cochlear branch, in the spiral ganglia within the cochlea.
- From the inner ear cavity, the vestibular nerve and the cochlear nerve fibers pass through the internal auditory canal, merge to form the vestibulocochlear nerve (CN VIII), and enter the brain stem at the groove between pons and medulla lateral to the facial nerve.

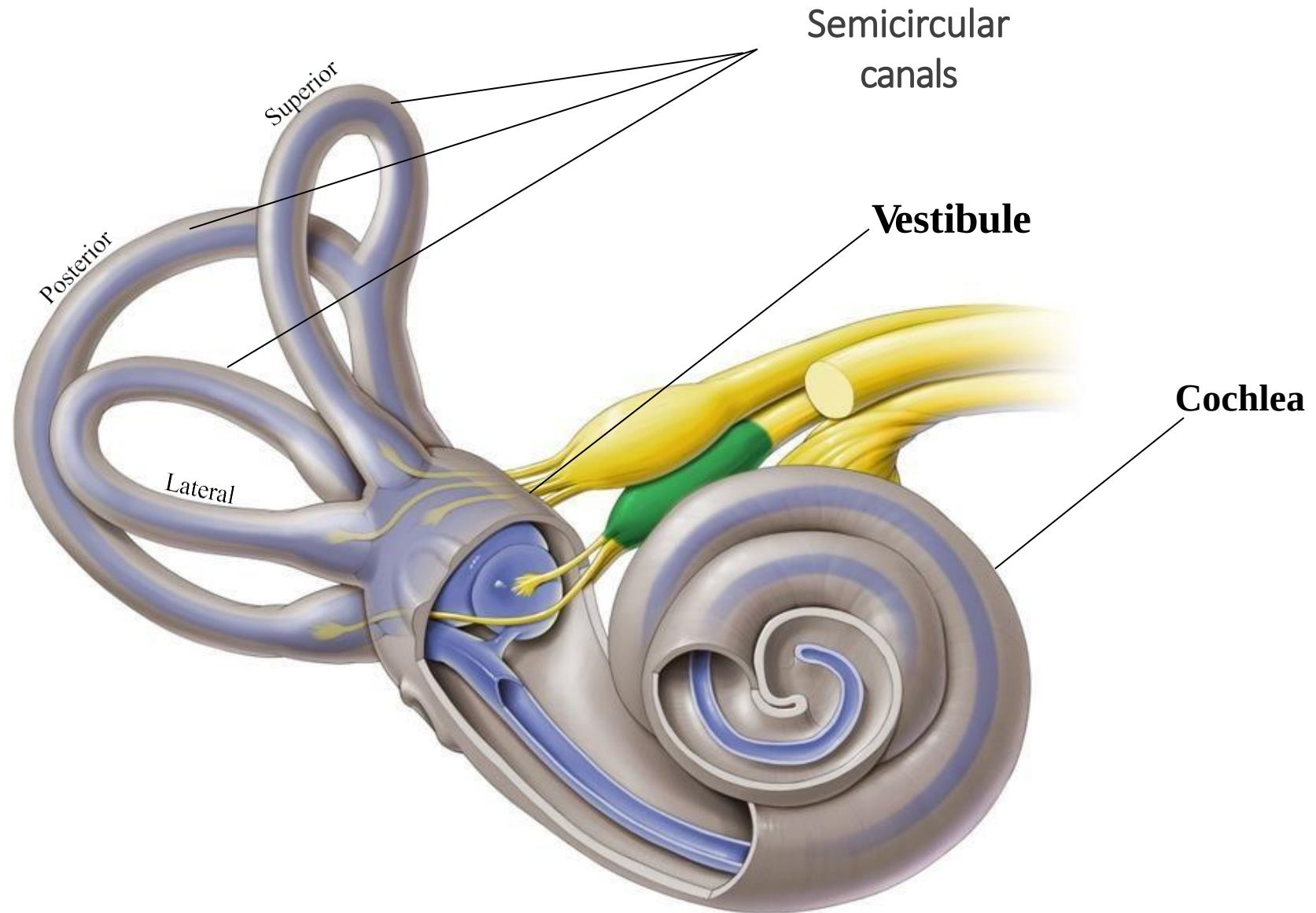




**Superior projection of
right bony labyrinth
on floor of skull**







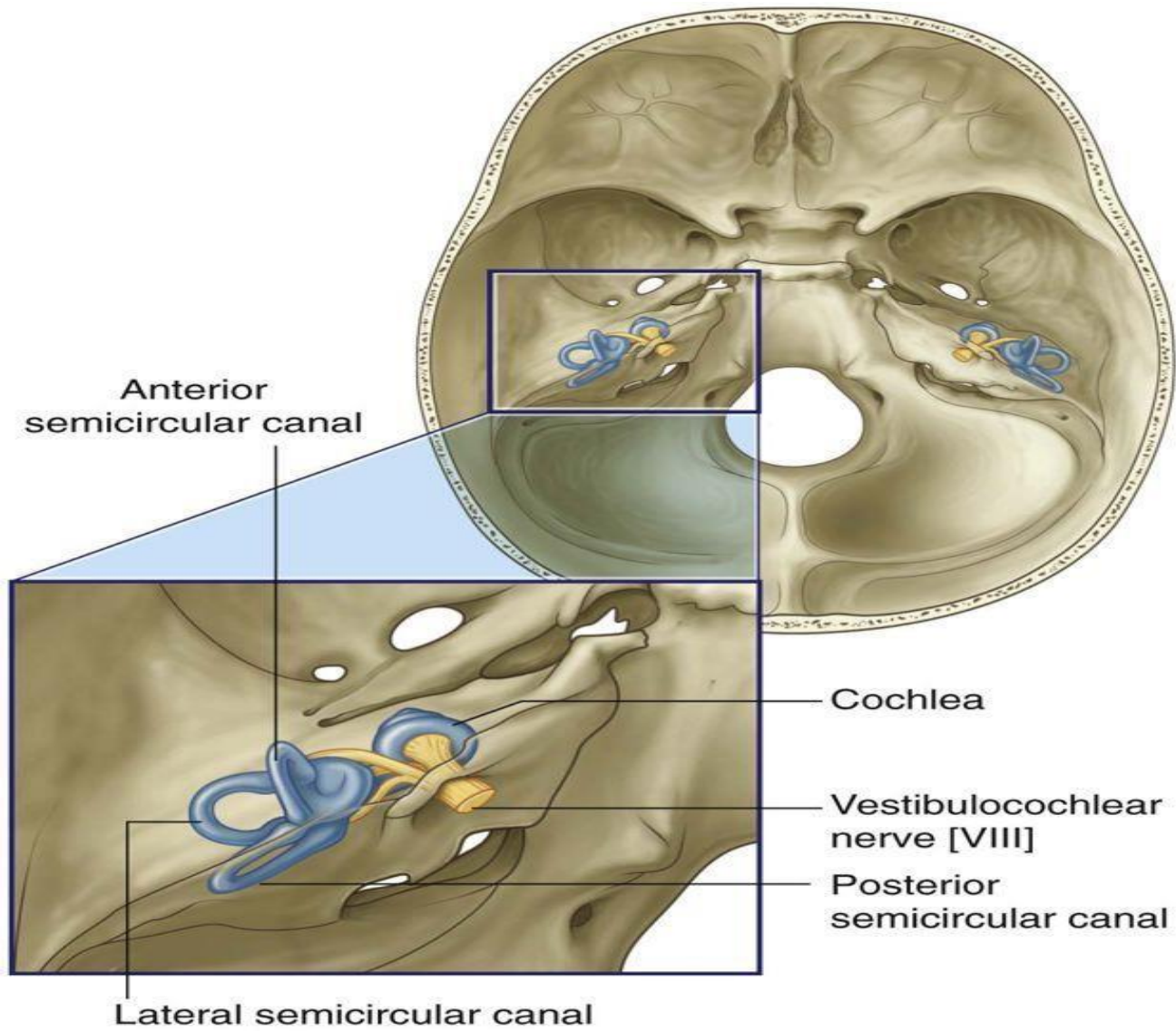
The cochlear and cochlear nerve

The cochlear nerve is responsible for transmitting auditory signals from the inner ear to the cochlear nuclei within the brainstem and ultimately to the primary auditory cortex within the temporal lobe.

The cochlea resembles a snail shell. It opens into the anterior part of the vestibule.

Basically, it consists of a central pillar, **the modiolus**, around which a hollow bony tube makes two and-one-half spiral turns. Each successive turn is of decreasing radius so that the whole structure is conical.

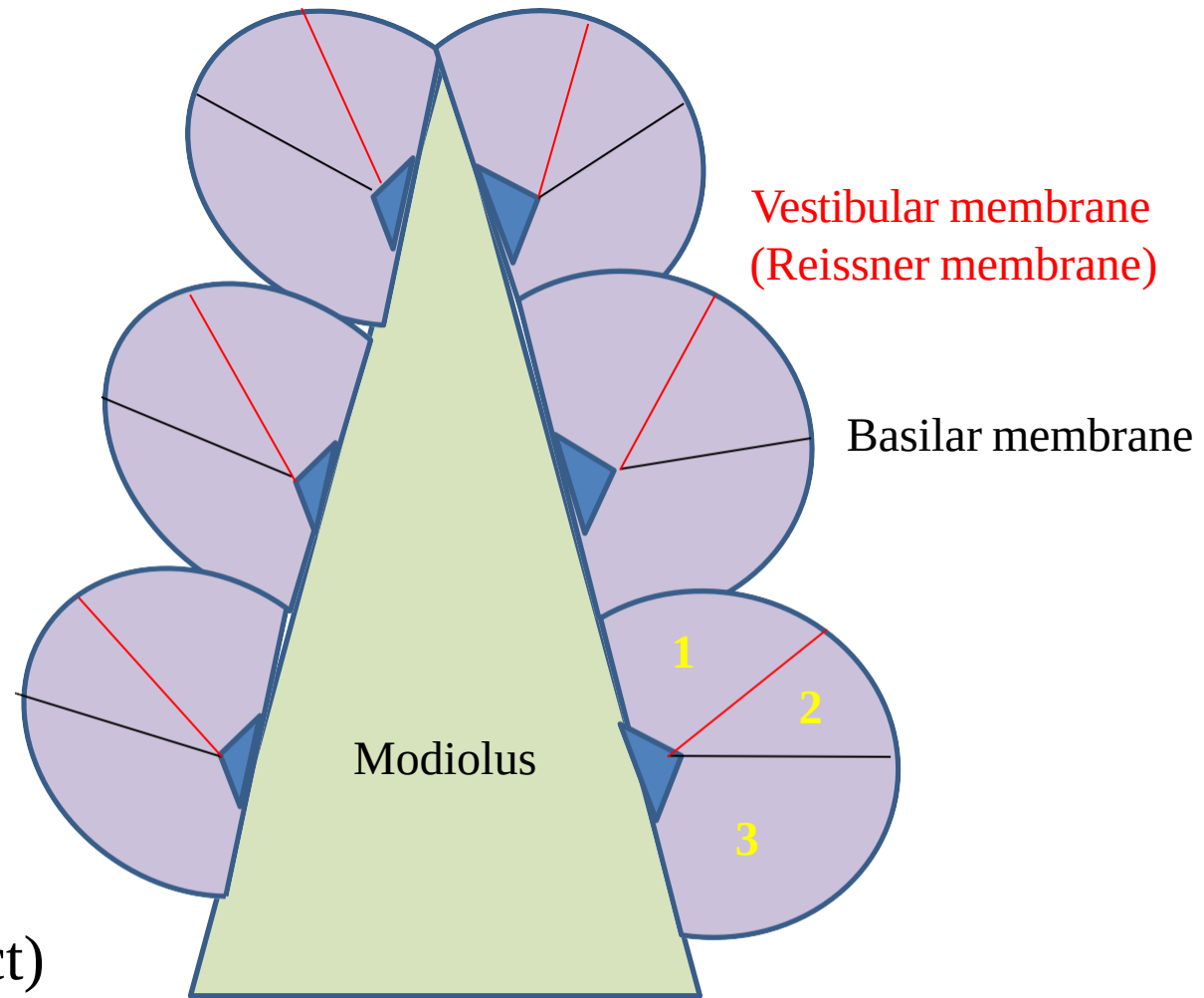
The apex faces anterolaterally and the base faces posteromedially.



The **modiolus** has a broad base, which is situated at the bottom of the internal acoustic meatus.

Branches of the cochlear nerve perforate it. A spiral ledge, the spiral lamina, winds around the modiolus and projects into the interior of the canal and partially divides it. The basilar membrane stretches from the free edge of the spiral lamina to the outer bony wall, thus dividing the cochlear canal into the **scala vestibuli** above and the **scala tympani** below.

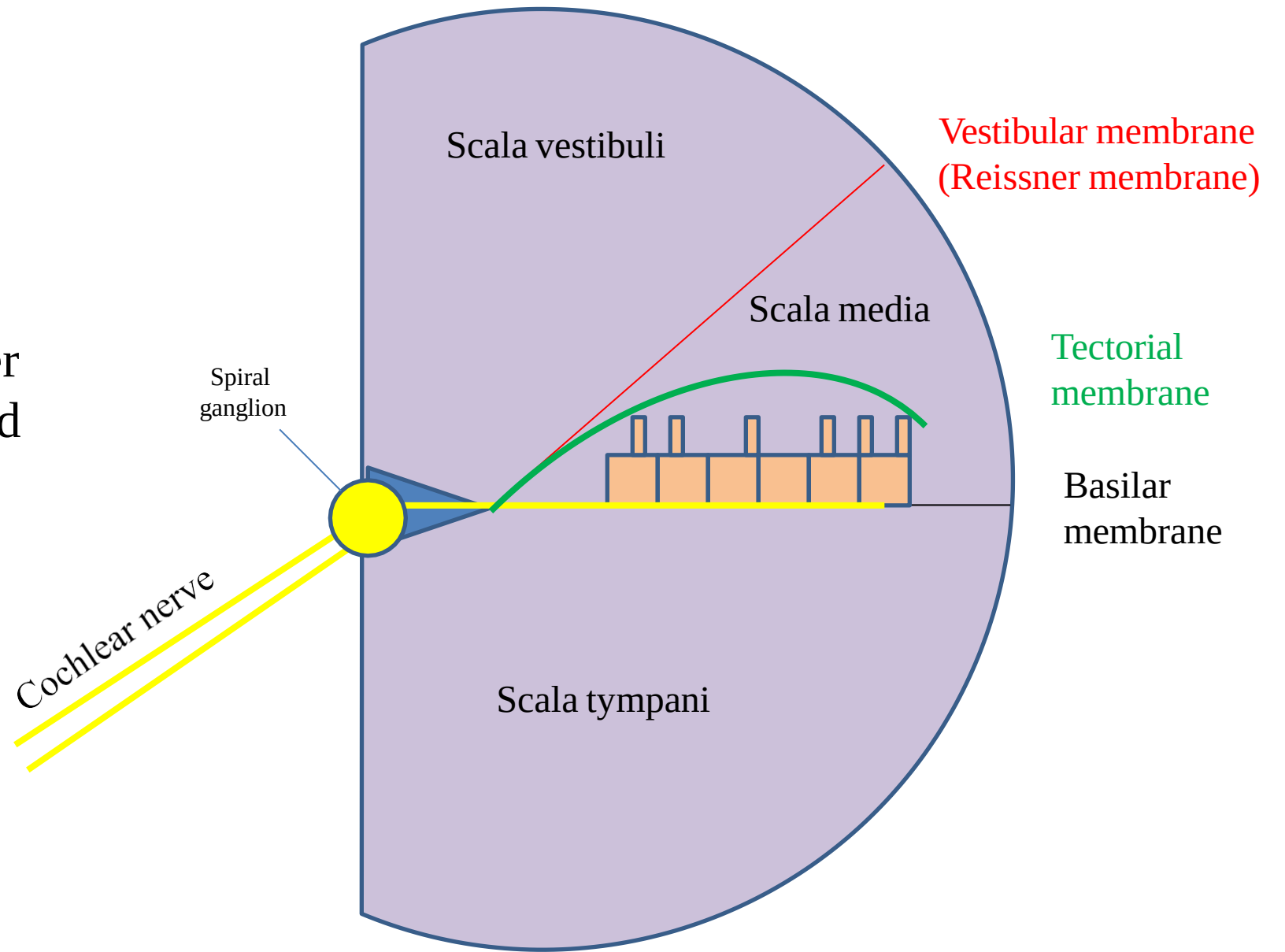
The perilymph within the scala vestibuli is separated from the middle ear by the base of the stapes and the annular ligament at the fenestra vestibuli. The perilymph in the scala tympani is separated from the middle ear by the secondary tympanic membrane at the fenestra cochleae.

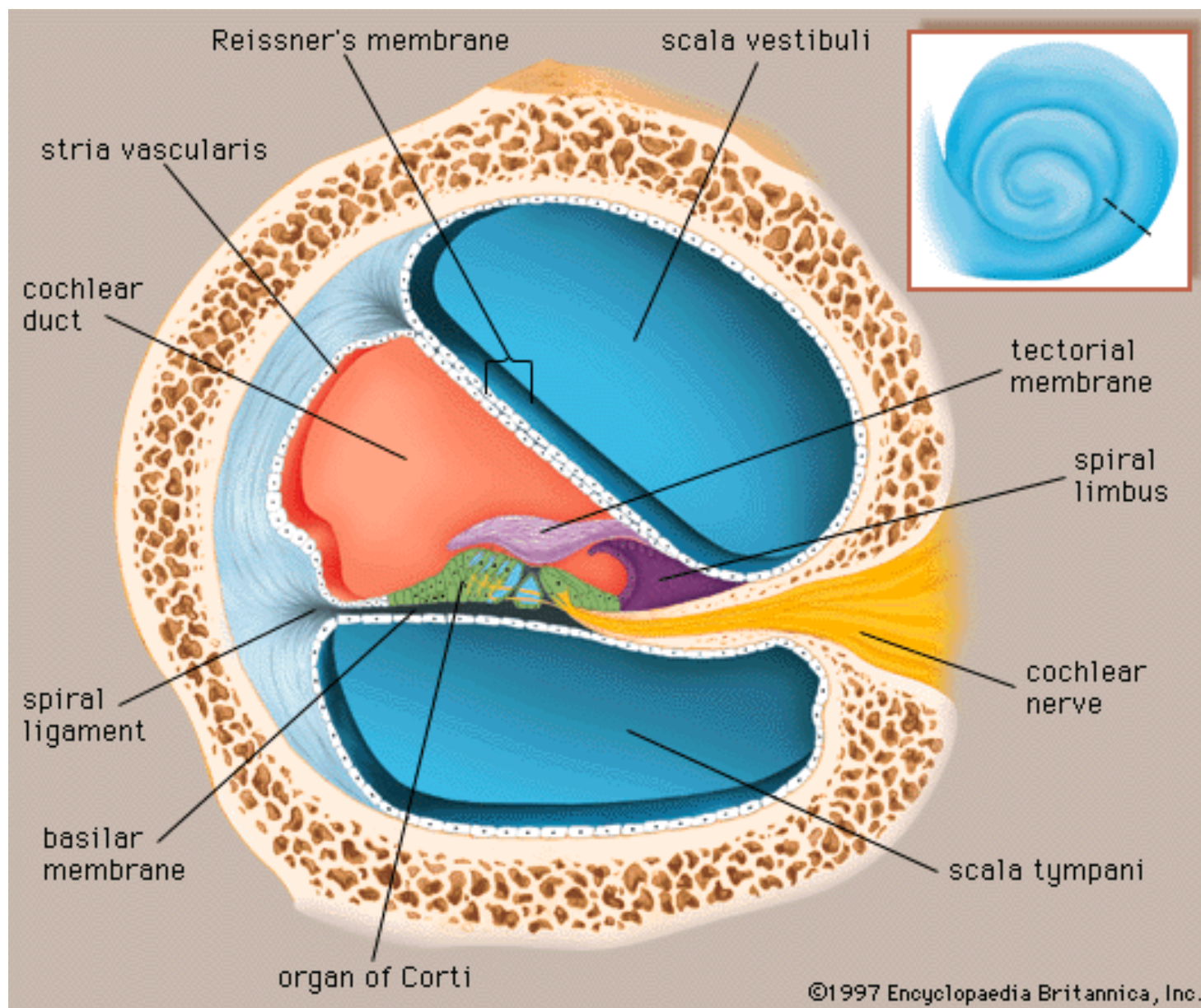


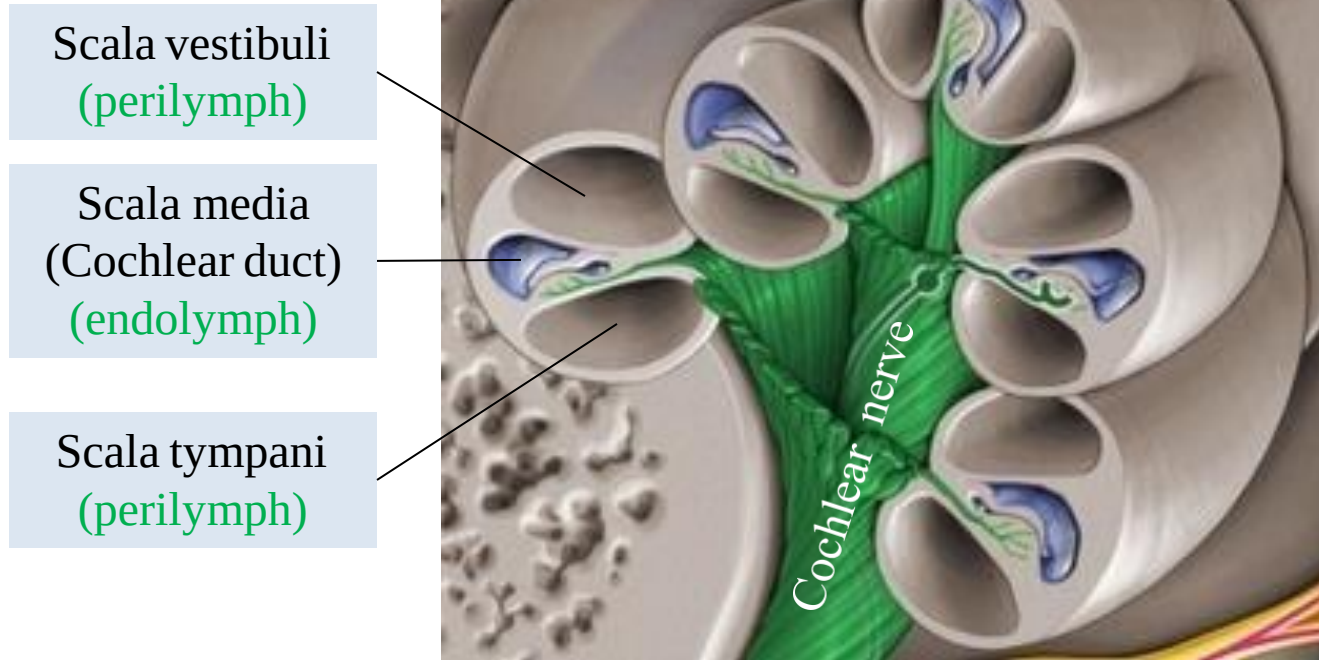
- 1: Scala vestibuli
- 2: Scala media (Cochlear duct)
- 3: Scala tympani

The **organ of Corti**, or spiral organ, where sound vibrations of different frequencies are detected, consists of hair cells and other epithelial structures supported by the basilar membrane

**Sensory receptor
for hearing
(organ of Corti)**







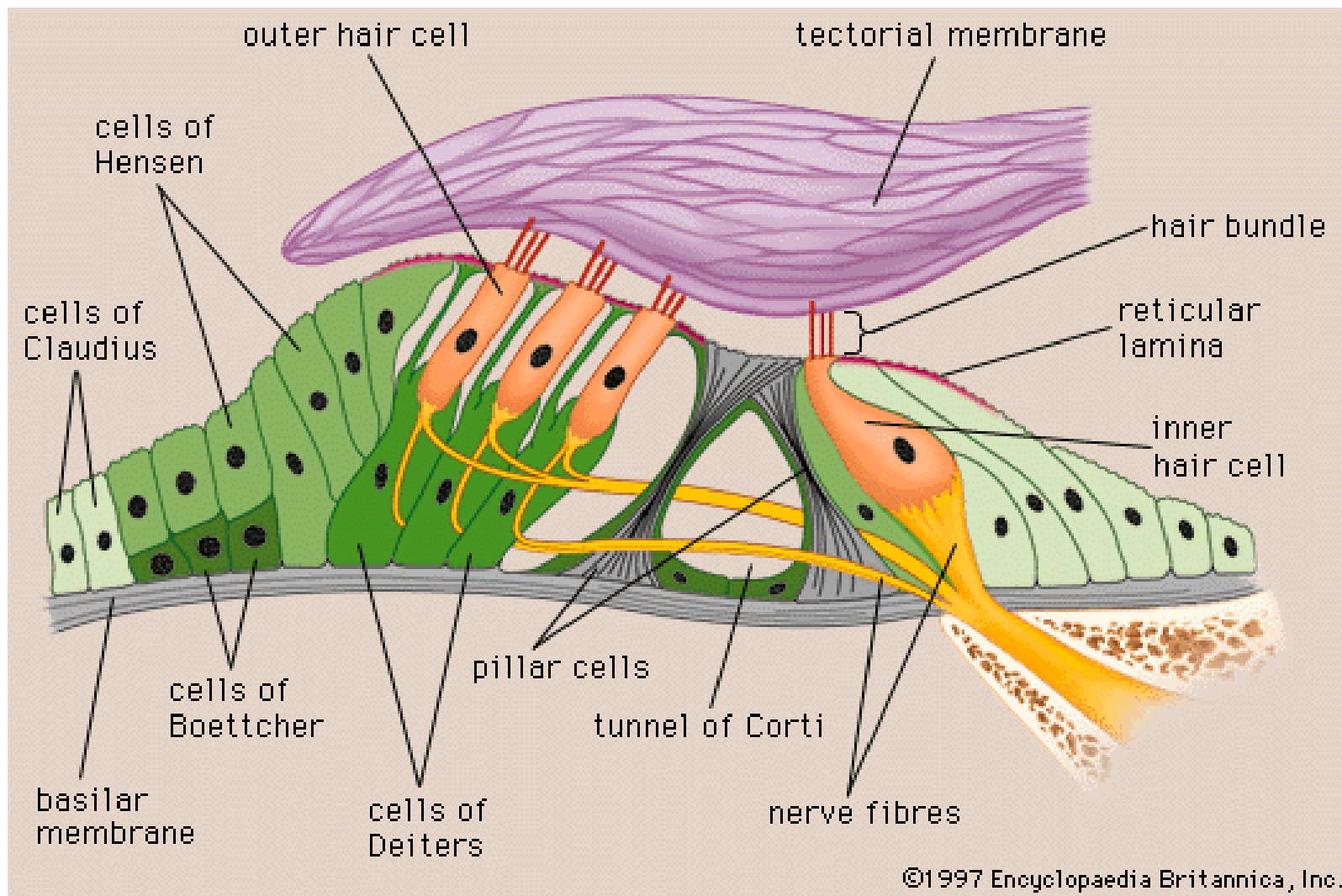
- ✓ The cochlear duct itself forms the middle compartment, or scala media, filled with endolymph. It is continuous with the saccule and ends at the apex of the cochlea.
- ✓ The larger scala vestibuli contains perilymph and is separated from the scala media by the very thin vestibular membrane (Reissner membrane)
- ✓ The scala tympani also contains perilymph and is separated from the scala media by the basilar membrane

Organ of Corti

- The organ of Corti is the sensory receptor of hearing contained within the scala media of the cochlea, rests on the basilar membrane.
- It is composed of both supporting cells and mechanosensory hair cells.
- The auditory hair cells are: inner and outer hair cells.
- Stereocilia (hair bundles) protrude from the apical surface of the hair cell into the fluid-filled cochlear duct.
- Stereocilia attach to the tectorial membrane.

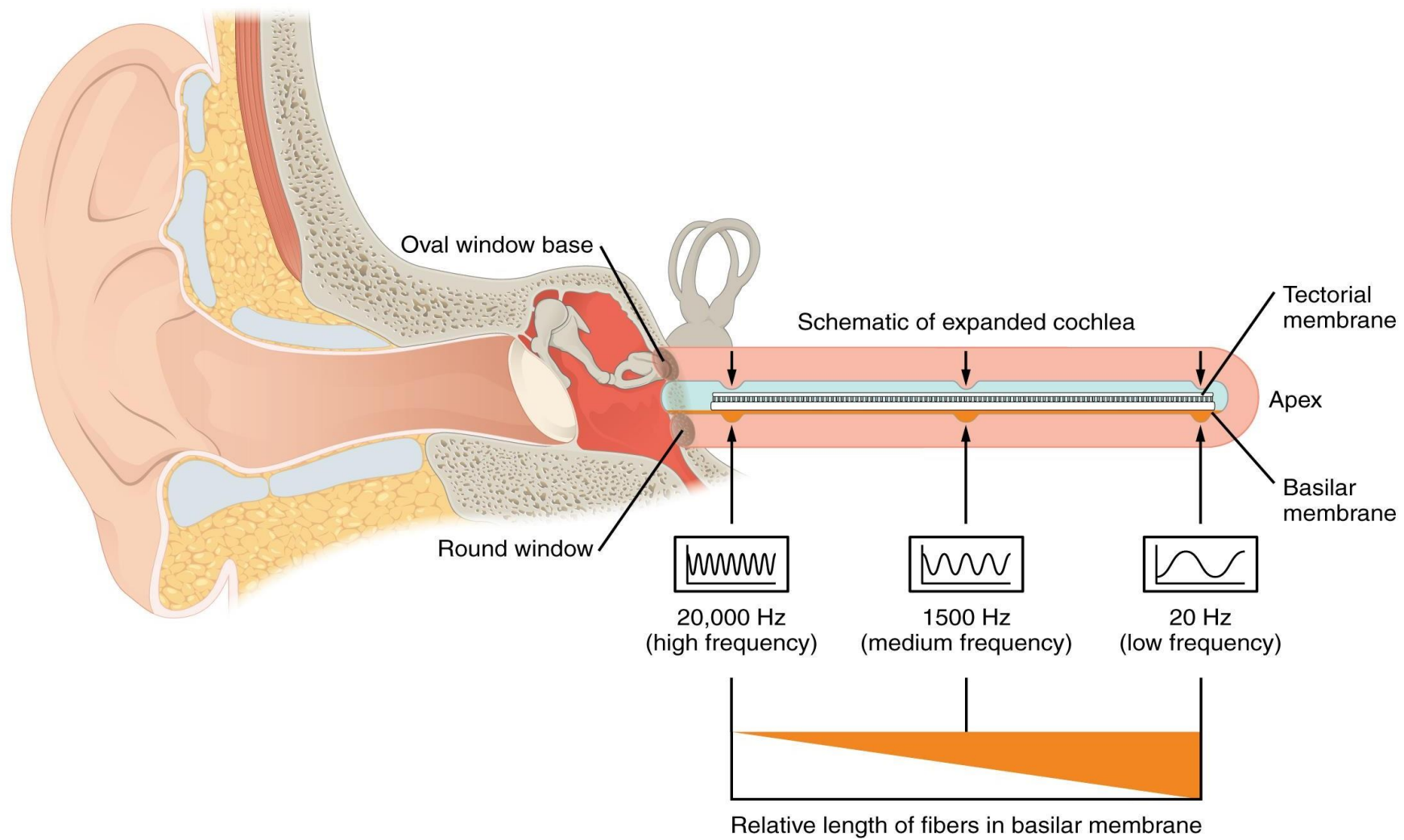
Organ of Corti

- The inner hair cells transform the sound vibrations in the fluids of the cochlea into electrical signals that are then relayed via the auditory nerve to the auditory brainstem and to the auditory cortex.
- The deflection of the hair-cell stereocilia opens mechanically gated ion channels that allow positively charged ions (primarily potassium) to enter the cell.
- The influx of positive ions from the endolymph in the scala media depolarizes the cell, resulting in a receptor potential.
- Damage to these hair cells results in decreased hearing sensitivity, and because the inner ear hair cells cannot regenerate, this damage is permanent

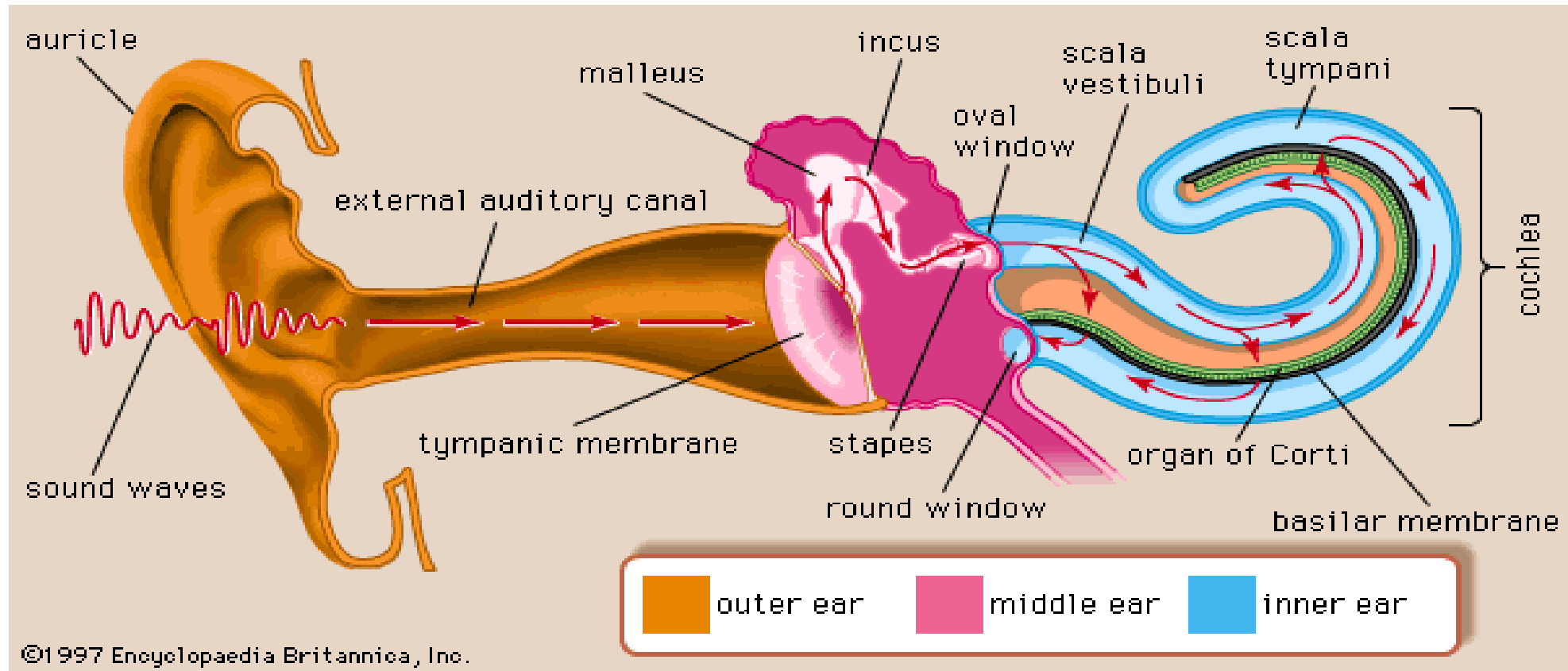


Spiral Ganglion

- The bipolar neurons making up the spiral (cochlear) ganglion create the link between the central nervous system and the organ of Corti.
- The spiral ganglion is located at the spiral canal of the modiolus.
- Neurons in the spiral ganglion send peripheral processes to the ciliated hair cells of the organ of Corti and central processes that join together to form the cochlear nerve.

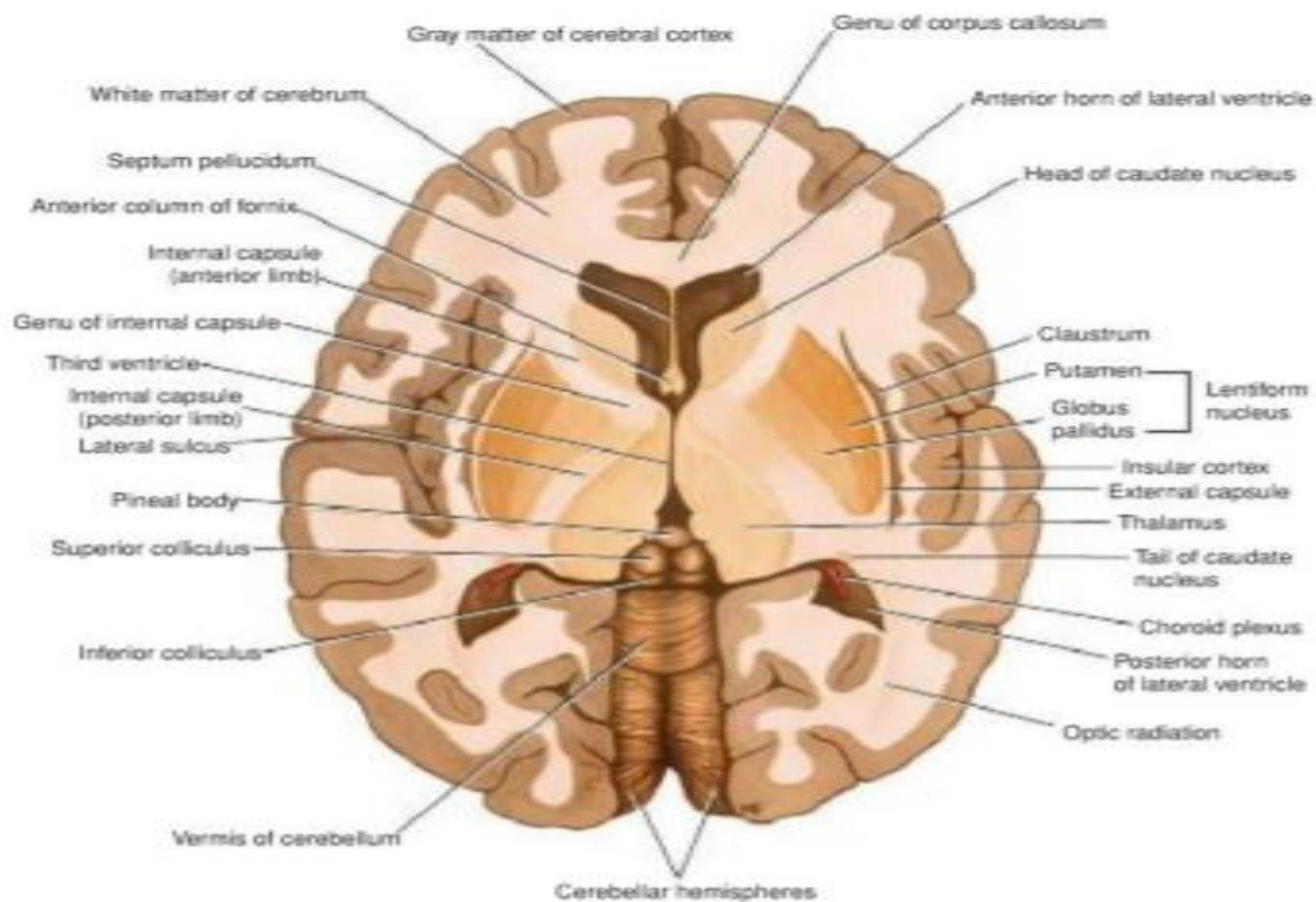


SOUND TRANSMISSION



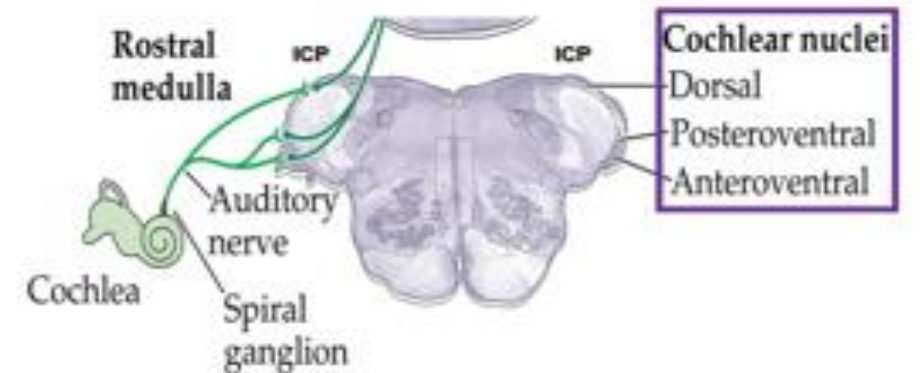
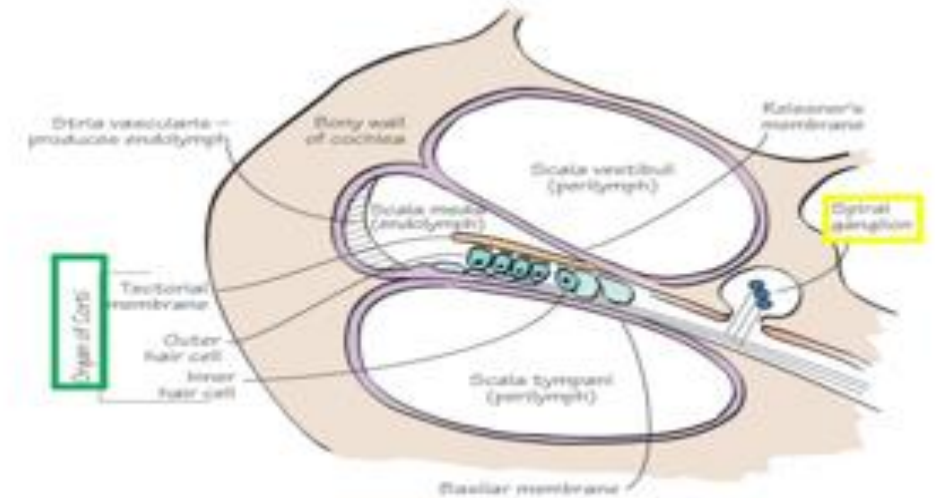
Auditory Pathway





Auditory Pathway

- 1- The Peripheral processes make *dendritic contact* with hair cells of the **organ of Corti** within the cochlear duct of the inner ear.
- 2- The cell bodies (**1st order neurons**) are located in the **spiral ganglion** within the **cochlea** (organ of Corti in inner ear) axons form cochlear nerve.
- 3- The **central processes** (cochlear nerve fibers) terminate in the **dorsal and ventral cochlear nuclei** (**2nd order neurons**), which lie close to the **inferior cerebellar peduncle (ICP)** in open rostral medulla.



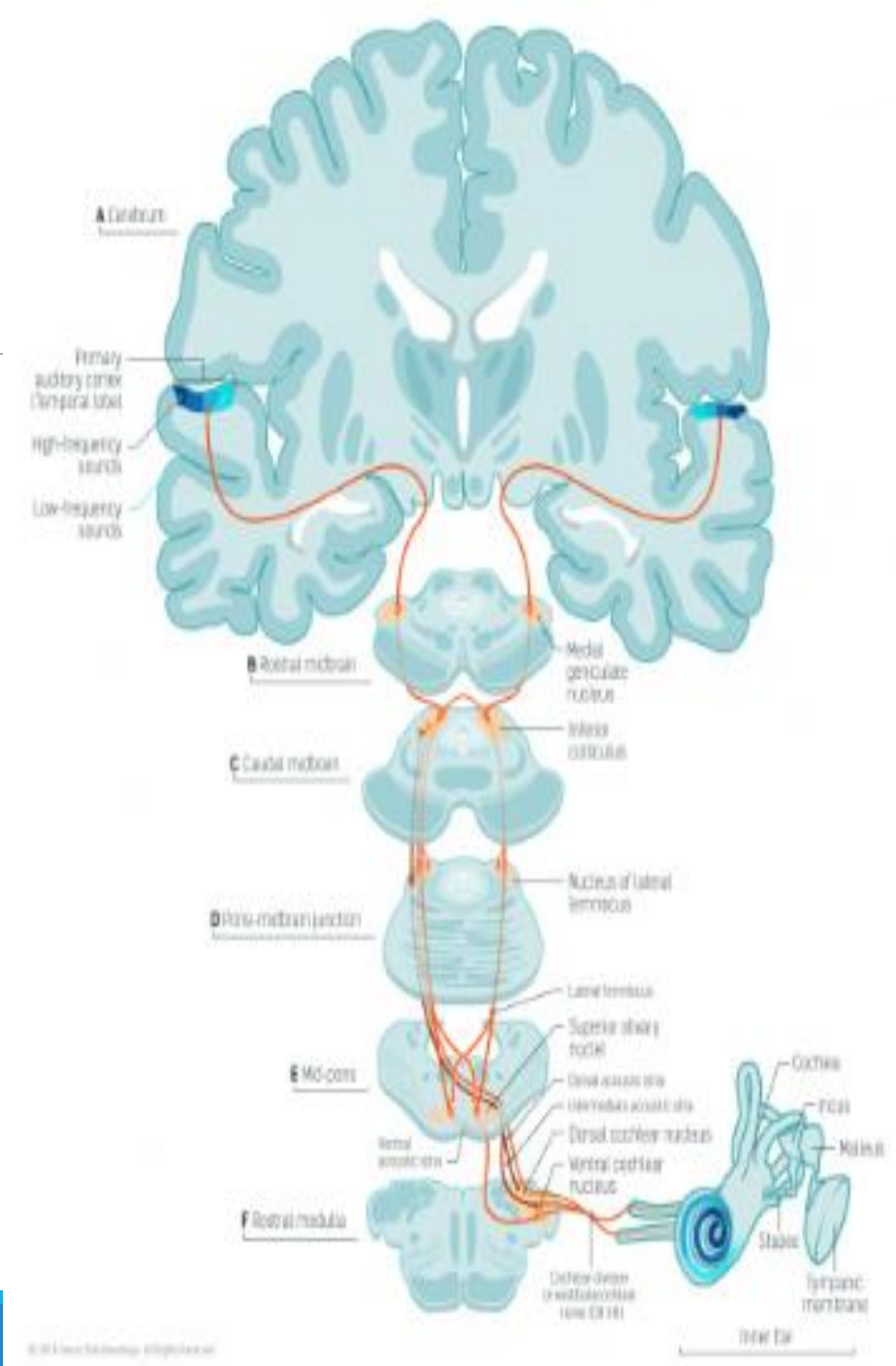
Auditory Pathway

4- From the ventral and dorsal cochlear nuclei, fibers ascend to the pons.

5- Most fibers cross the midline to terminate in nuclei of **trapezoid body** and **contralateral superior olivary nucleus**.

6- Some fibers pass to the **ipsilateral** superior olivary nucleus.

7- Ascending fibers from superior olivary nucleus (mostly contralateral and some ipsilateral) comprise the **lateral lemniscus**

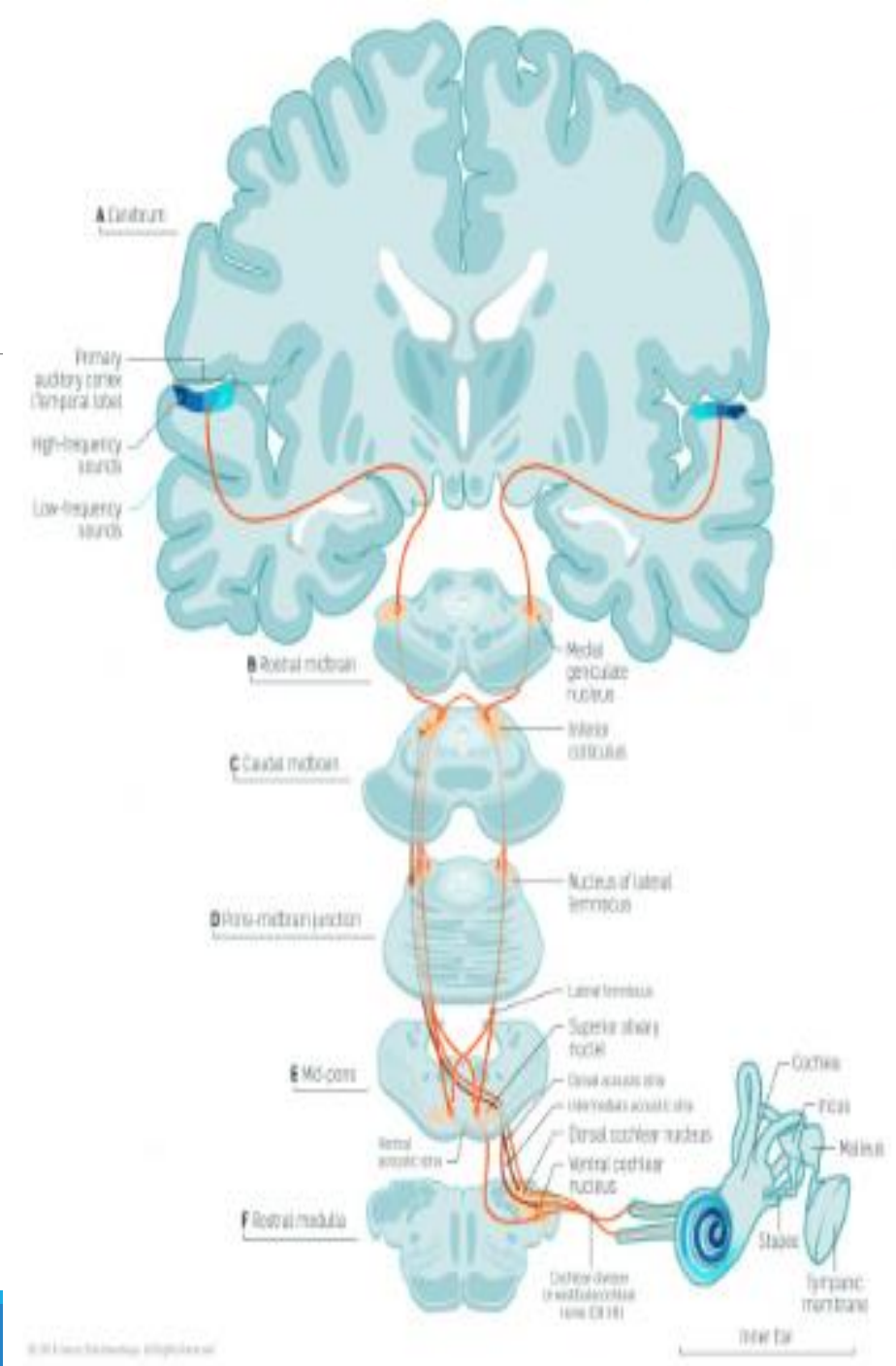


Auditory Pathway

8- some fibers pass to nucleus of lateral lemniscus, the rest pass through tegmentum of pons and terminate in inferior colliculus of midbrain (**3rd order neuron**).

Both colliculi are interconnected by commissural fibers.

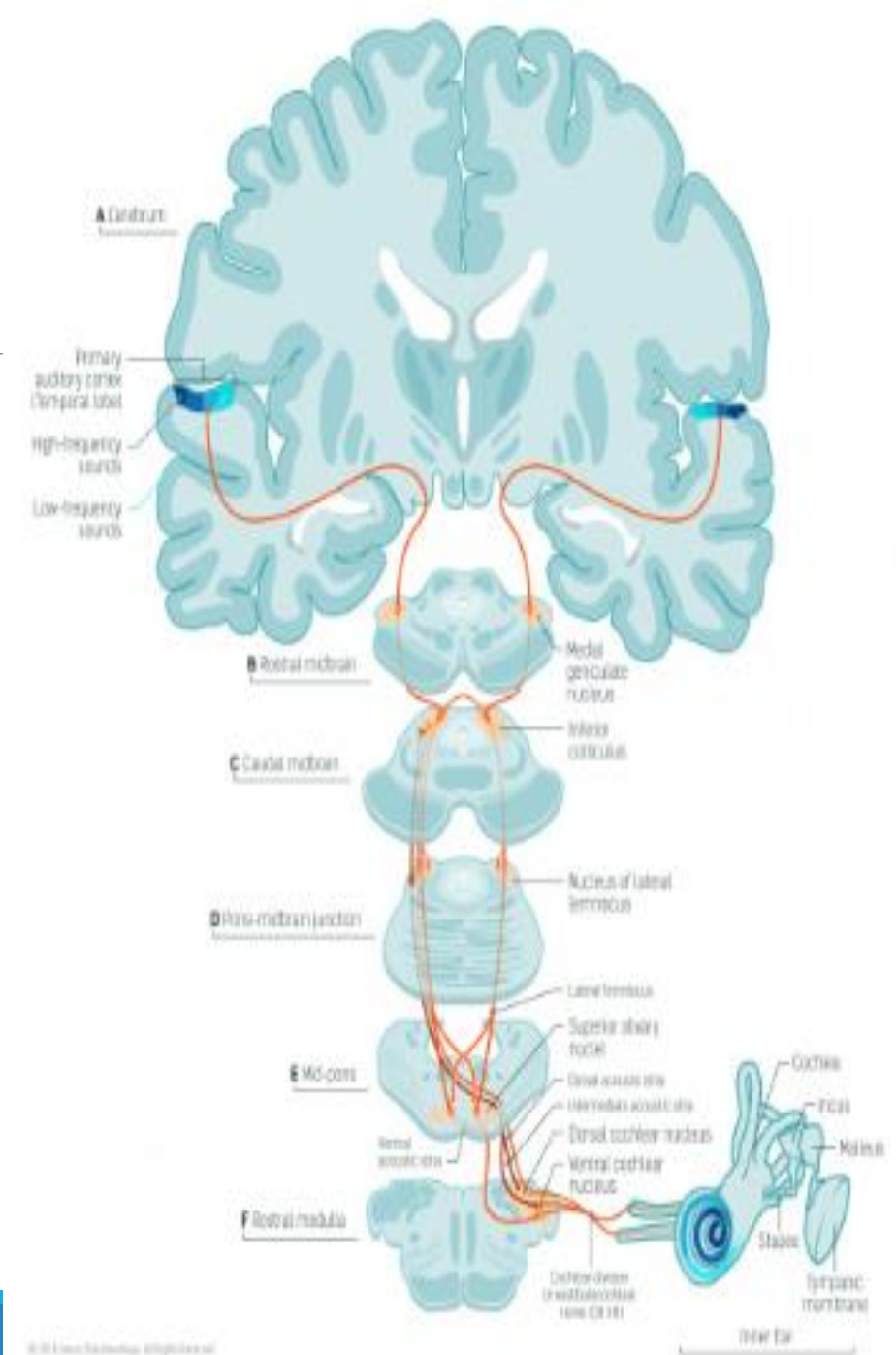
9- Inferior colliculi project to **medial geniculate body** of the thalamus (**4th order neuron**)

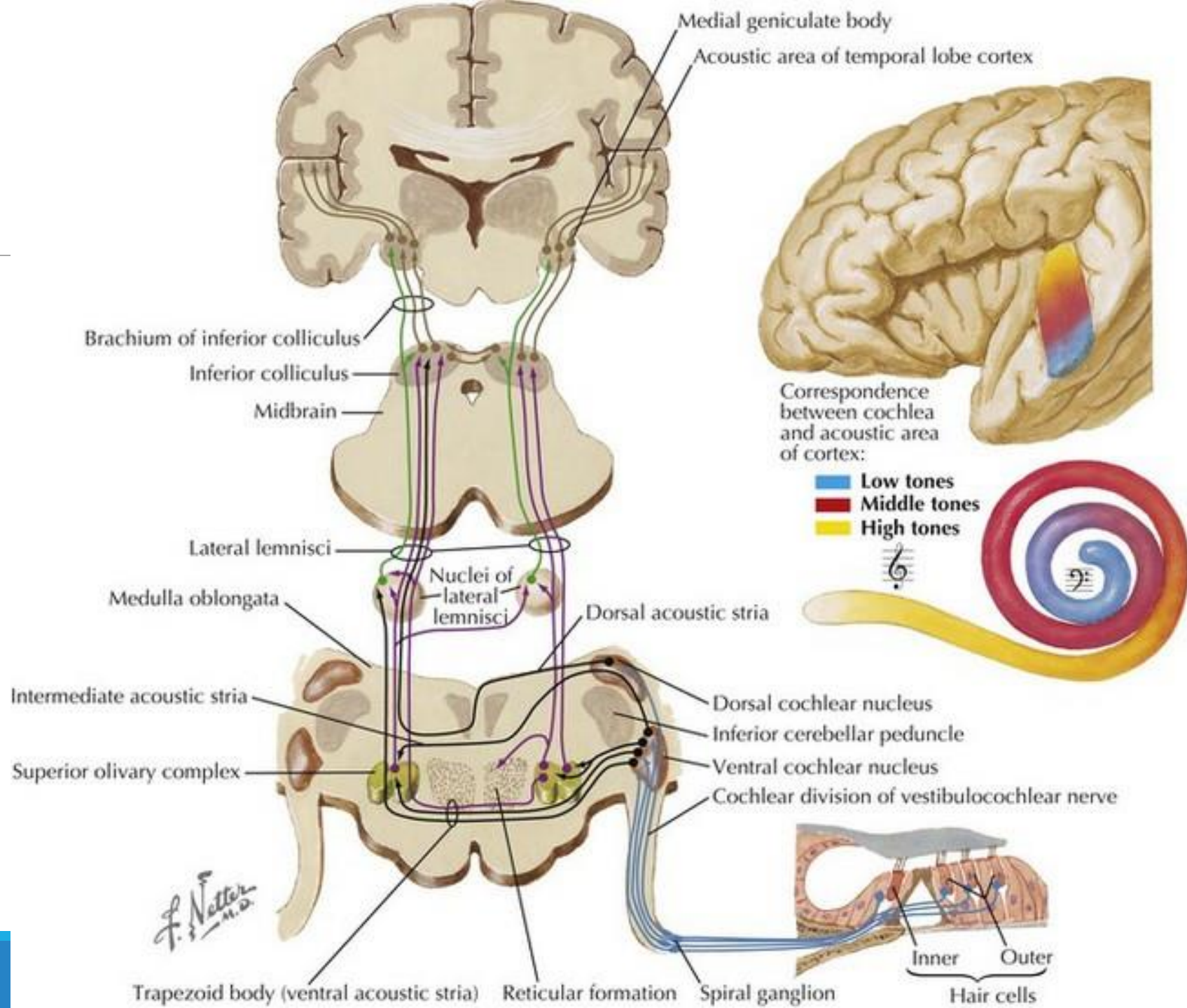


Auditory Pathway

10- The axons originating from the medial geniculate nucleus (auditory radiation) pass through **sublenticular part of internal capsule** to **primary auditory cortex** (area 41, 42) located in the dorsal surface of the superior temporal gyrus (gyrus of Heschl).

11- The secondary auditory area (area 22) is thought to be necessary for the interpretation of sounds and for the association of the auditory input with other sensory information.



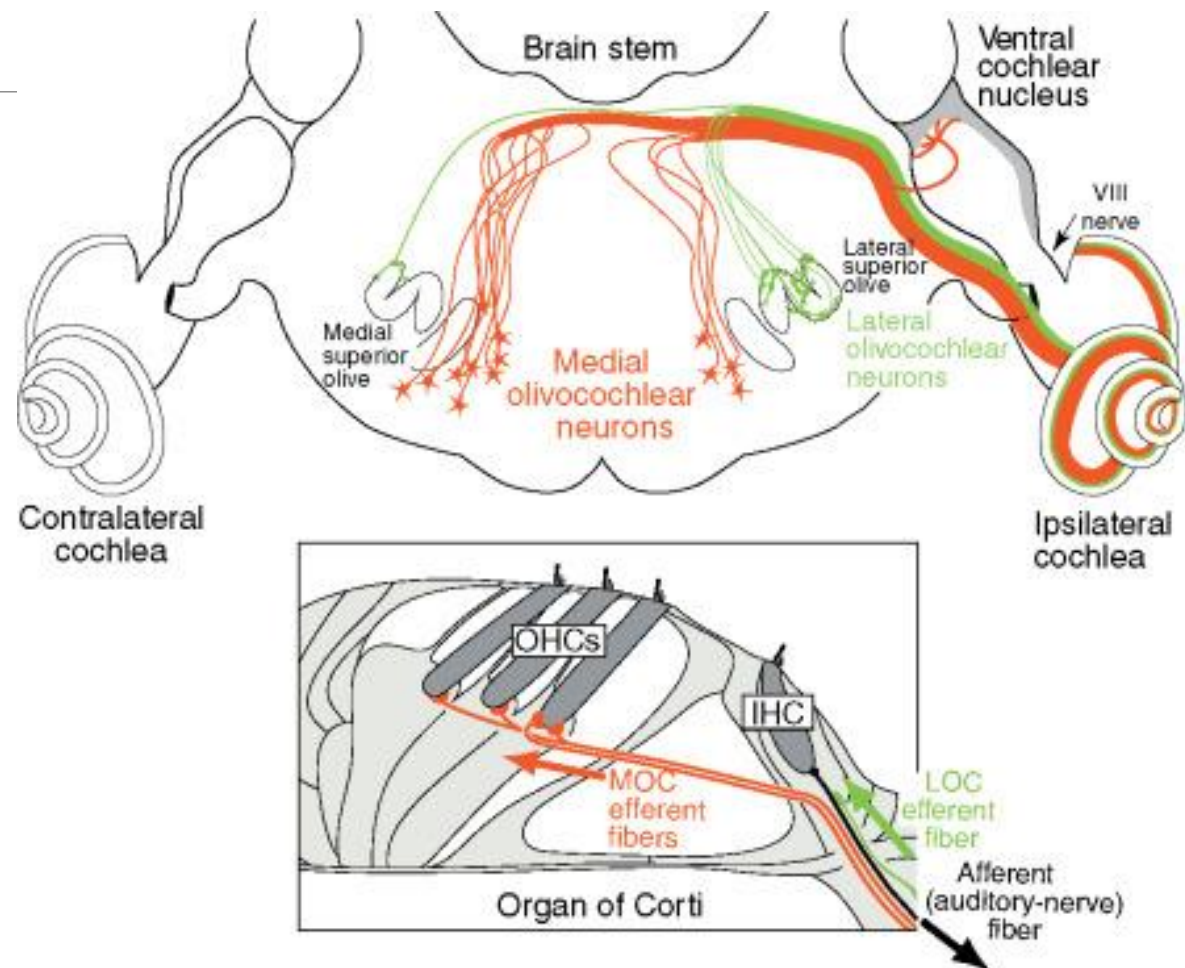


Descending Auditory Pathways

- Descending fibers originating in the auditory cortex and in other nuclei in the auditory pathway accompany the ascending pathway.
- These fibers are bilateral and end on nerve cells at different levels of the auditory pathway and on the hair cells of the organ of Corti.
- These fibers are believed to serve as a feedback mechanism and inhibit the reception of sound.
- They may also have a role in the process of auditory sharpening, suppressing some signals, and enhancing others.

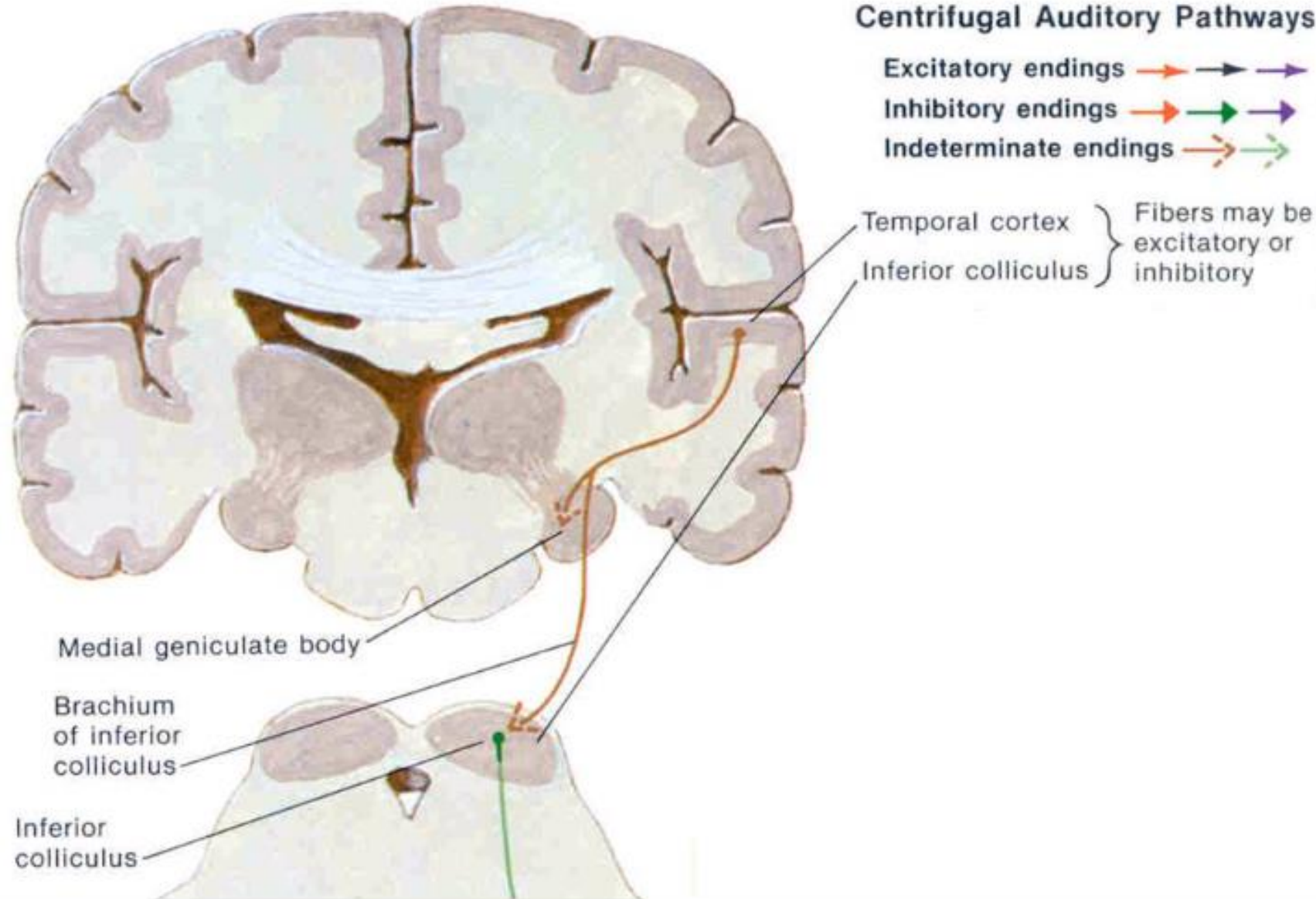
Descending Auditory Pathways

- Olivo-cochlear Neurons
- Cortical Neurons
- Innervation of Middle Ear Musculature



Centrifugal Auditory Pathways

- Excitatory endings → → →
- Inhibitory endings → → →
- Indeterminate endings → → →

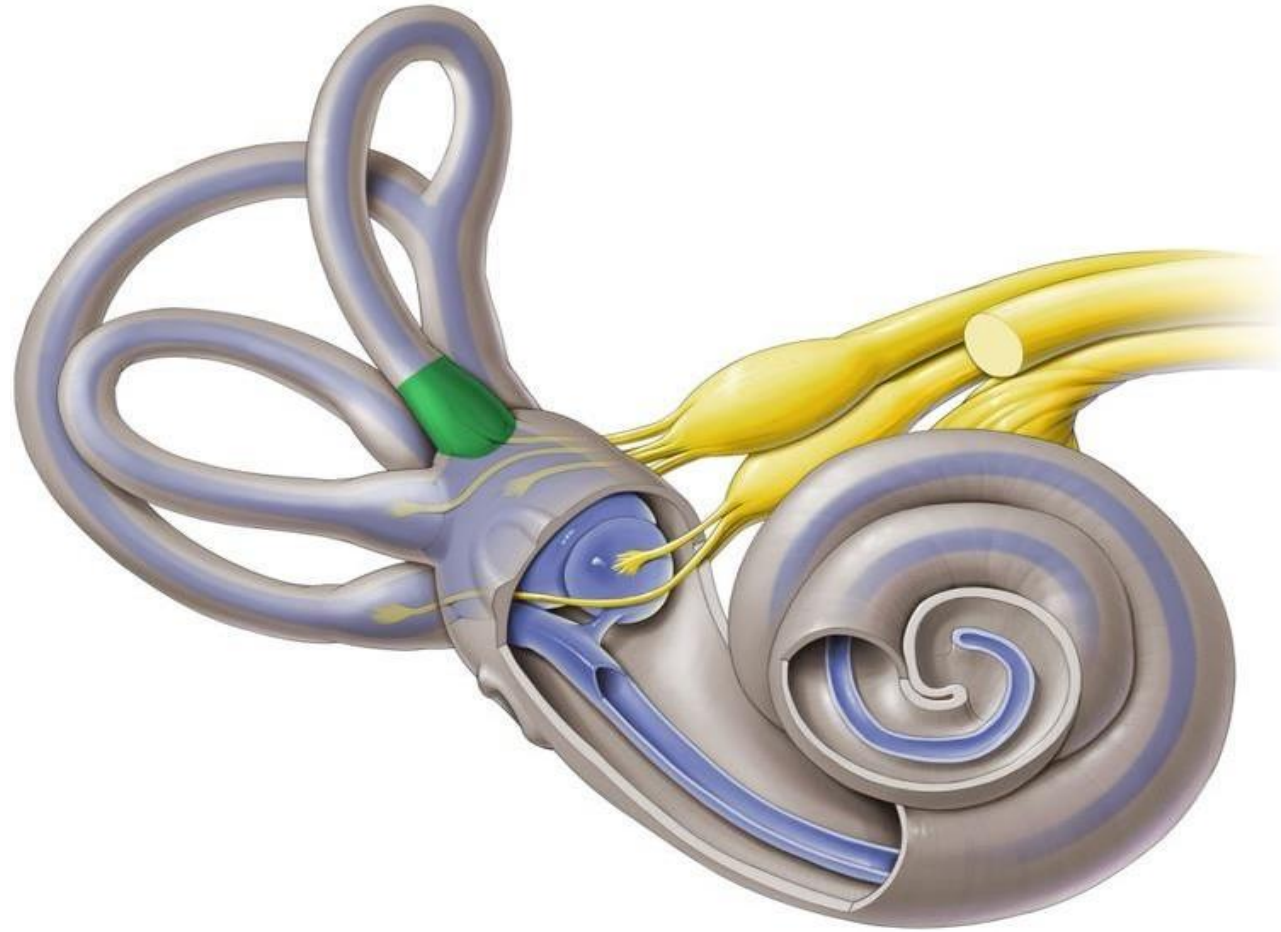


CLINICAL CONSIDERATIONS

- Conductive deafness: is a hearing loss where the ear's ability to conduct sound from the outer ear and middle ear into the inner ear is blocked or reduced
- Nerve deafness: lesion in the cochlear nerve or the nucleus
- Word deafness: you can hear without understanding
- Lesion in the lateral lemniscus or the primary auditory area: bilateral partial deafness greater on the contralateral ear

Vestibular System





The Vestibular System

- ✓ It lies in the otic capsule of the petrous portion of the temporal bone.
- ✓ It consists of 5 distinct end organs:
 - 1- three semicircular canals that are sensitive to angular acceleration (head rotations).
 - 2- Otolith organs (utricle and saccule) that are sensitive to linear acceleration.

Fluids of the vestibular system

✓ Perilymph

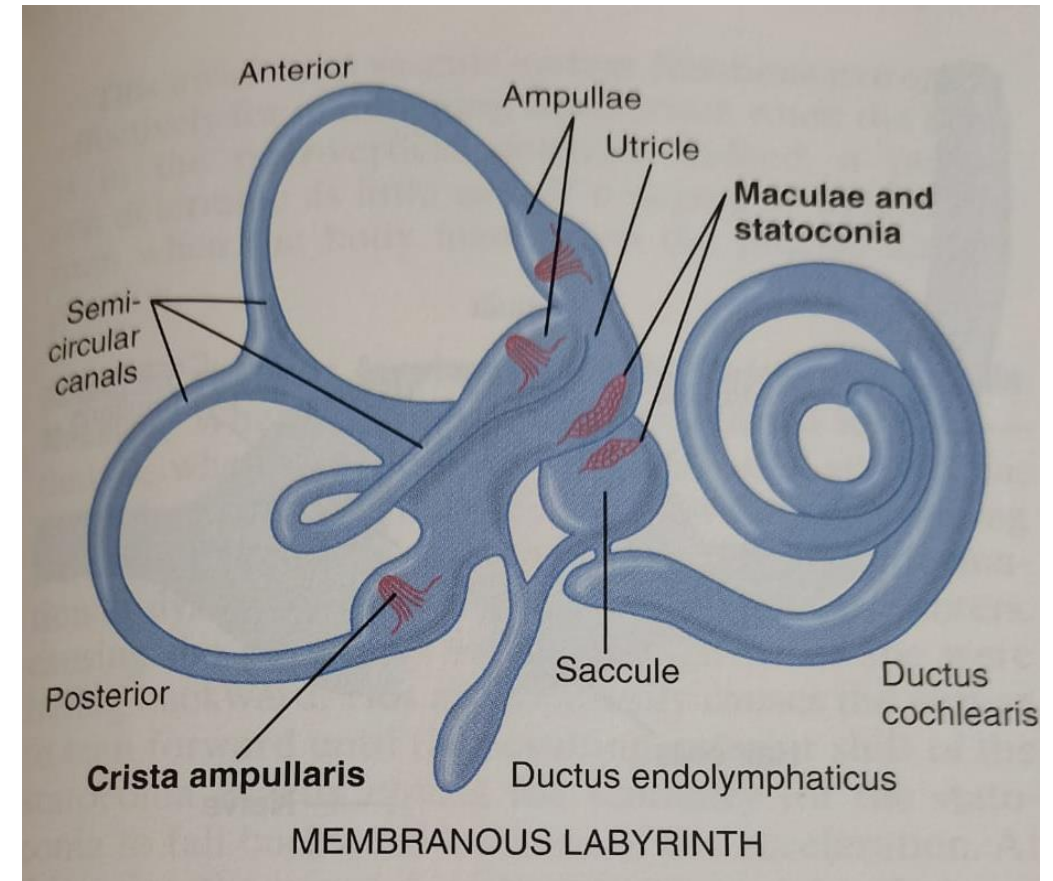
- In the bony labyrinth.
- Similar to the extracellular fluid.
- Low content of potassium, high sodium

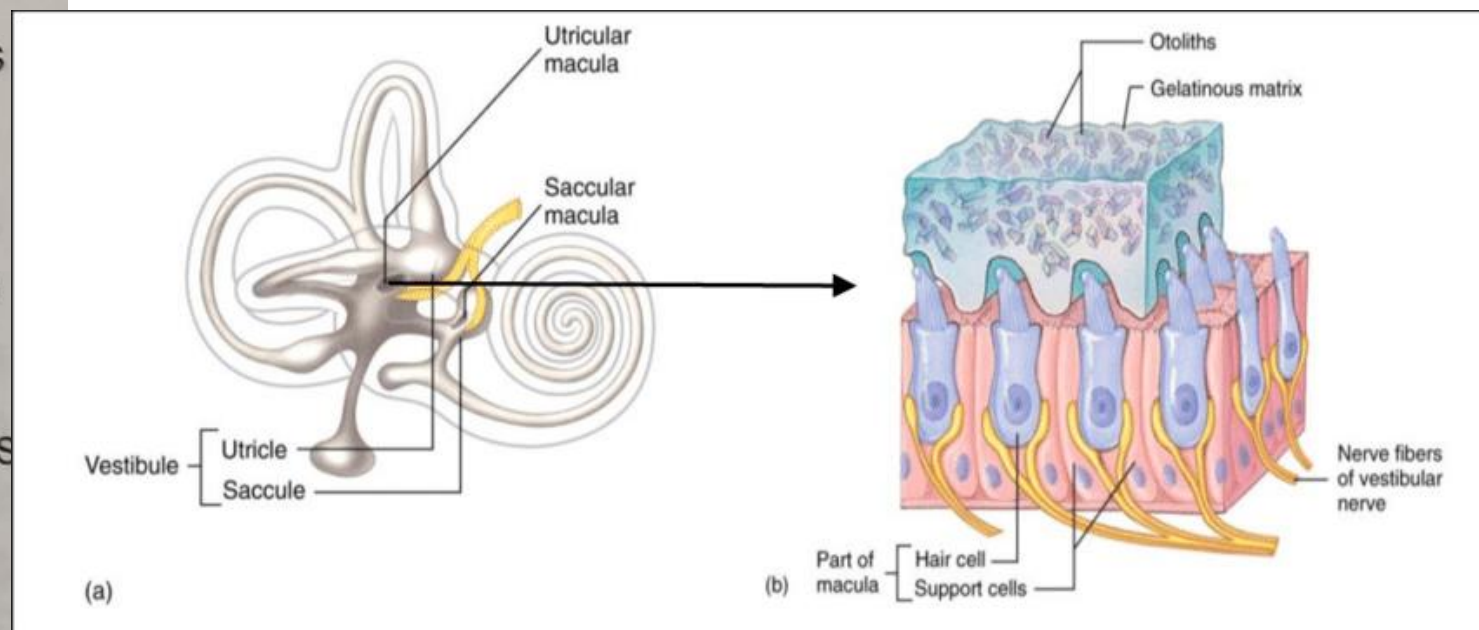
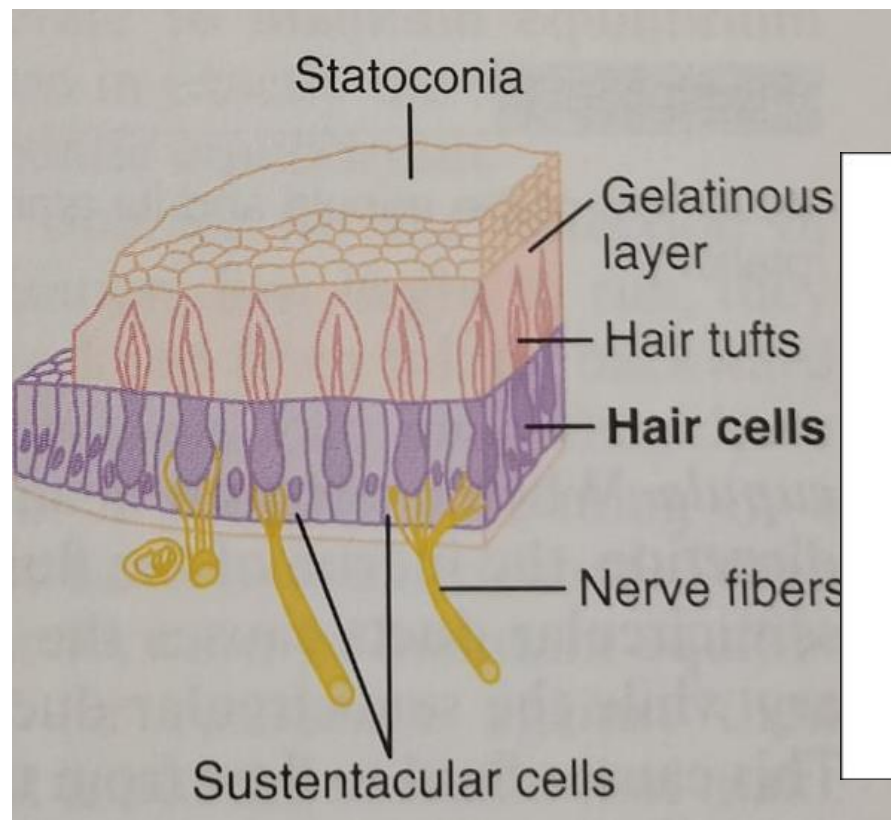
✓ Endolymph

- In the membranous labyrinth.
- Similar to intracellular fluid.
- High potassium and low sodium.
- It is secreted continuously by epithelial cells and drains from the inner ear to the venous sinuses in the dura matter of the brain.

Otolith Organs (Utricle & Saccule)

- The sensory organs of the utricle and saccule are the maculae.
- Each macula consists of hair cells and supporting cells.
- The ciliary bundles project into the overlying gelatinous matrix known as the otolith membrane.
- Otoliths are minerals and protein particles embedded in the otolith membrane (Calcium carbonate crystals).





Macula

- ✓ It consists of hair cells and supporting cells.
- ✓ It detects and responds to the position of the head with respect to linear acceleration and pull of gravity.
- ✓ Each macula consists of thousands of hair cells that synapse with sensory endings of the vestibular nerve.
- ✓ Each hair cell has 60-80 small cilia called stereocilia and one large cilium called kinocilium.
- ✓ The kinocilium is always
 - 1- three semicircular canals that are sensitive to angular acceleration (head rotations).
 - 2- Otolith organs (utricle and saccule) that are sensitive to linear acceleration.

Macula

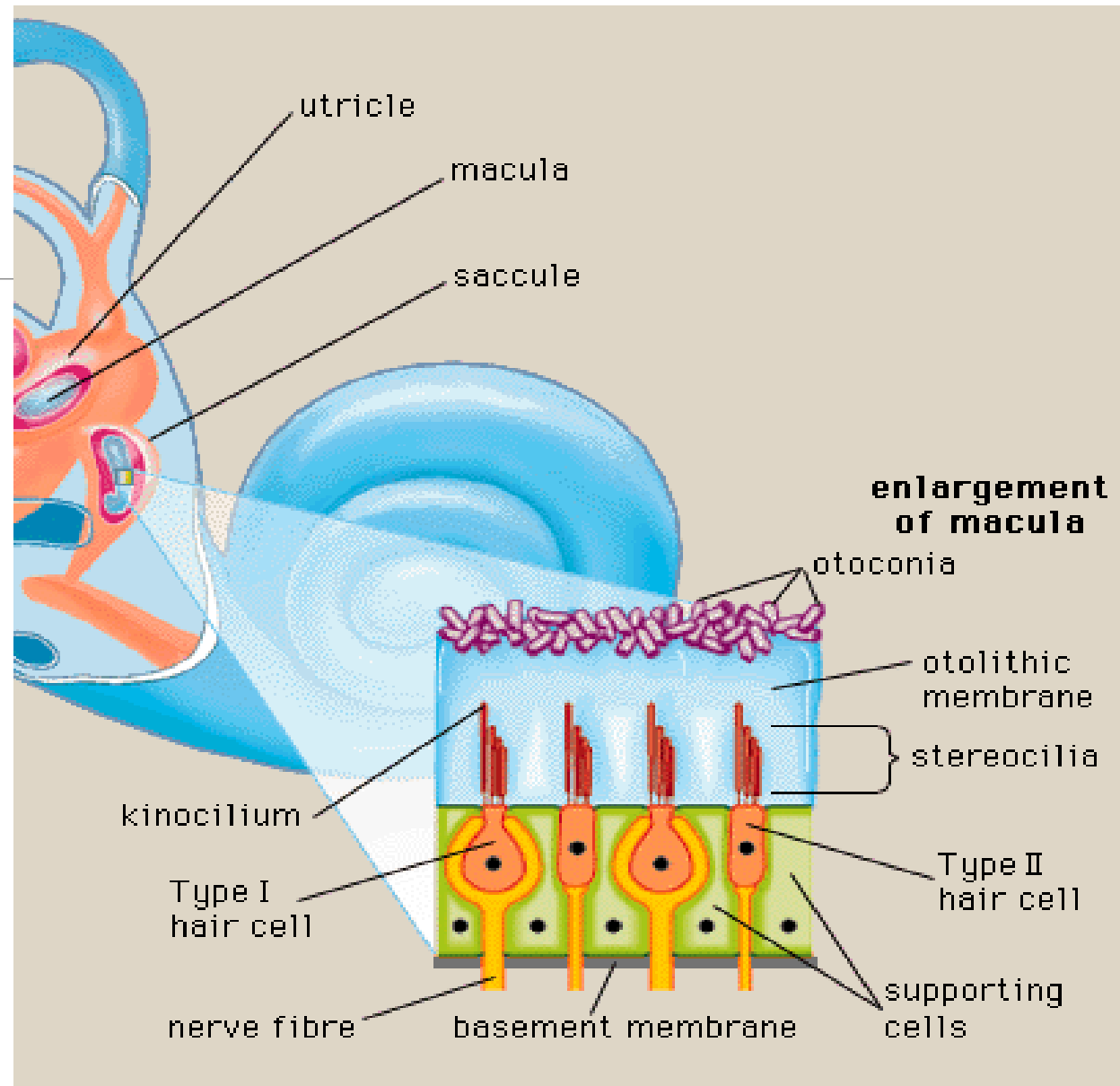
- ✓ When the stereocilia bend to the direction of kinocilium, it results in the opening of K^+ channels at the tip of stereocilia, allowing K^+ to enter and depolarize the hair cell.
- ✓ In response to depolarization, voltage-gated Ca^{+2} channels are activated allowing for Ca^{+2} influx and subsequent liberation of neurotransmitters to produce an action potential.
- ✓ Conversely, bending of the stereocilia in the opposite direction (backward to the kinocilium) reduces the tension on the attachments and this closes the ion channels causing receptor hyperpolarization and inhibition of the cell.

Macula

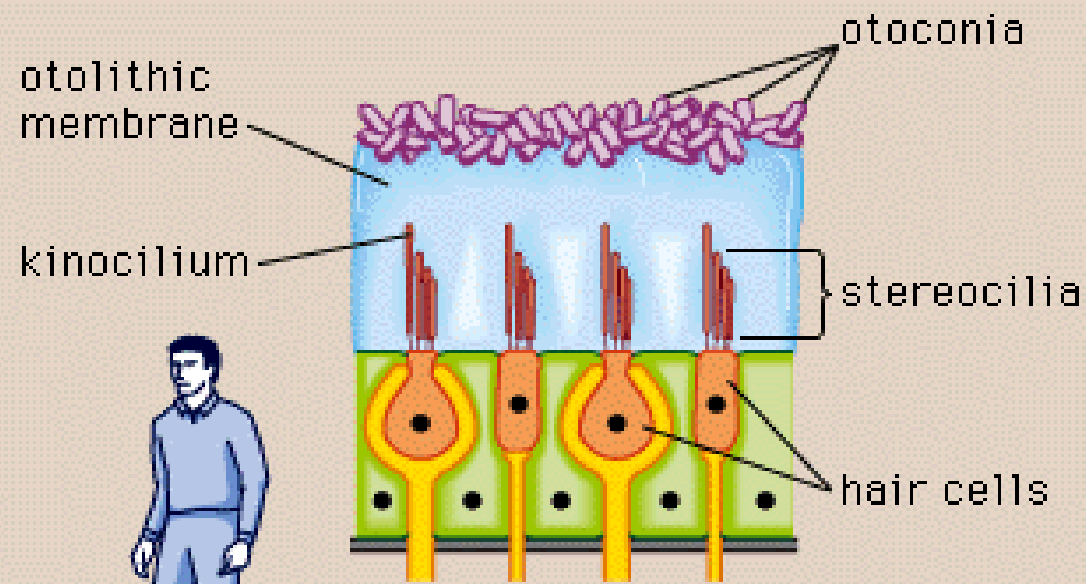
- ✓ When the head is upright, the hair projects upward in the gelatinous material.
- ✓ When the head bends forward, backward, or to one side the hair cells are stimulated as the gelatinous material of the macula sag in response to gravity causing the hair to bend.
- ✓ Stimulated hair cells signal nerve fibers resulting in impulses traveling to the CNS on the vestibular branch of the vestibulocochlear nerve and informing the brain of the head's new position.
- ✓ Brain responds by sending motor impulses to skeletal muscles to contract or relax to maintain balance.

Macula

- ✓ Macula of the utricle lies mainly in the **horizontal** plane on the inferior surface of the utricle, so plays a role in determining the orientation of the head when the head is Upright.
 - Senses motion in the horizontal plane (forward, backward, left, right movement or combination)
- ✓ In saccule, the macula is located in the **vertical** plane and signals head orientation when the person is lying down (up and down movement).

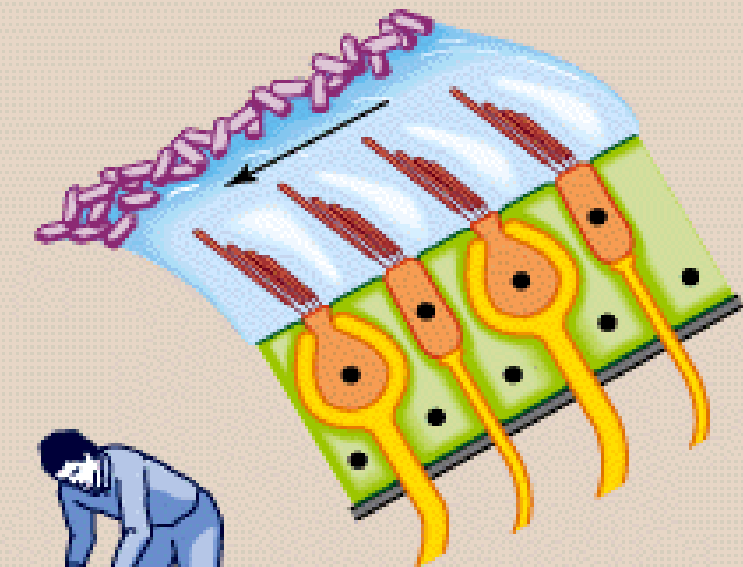


B



**upright section
of the
utricular macula**

head upright



**displaced section
of the
utricular macula**

head bent forward

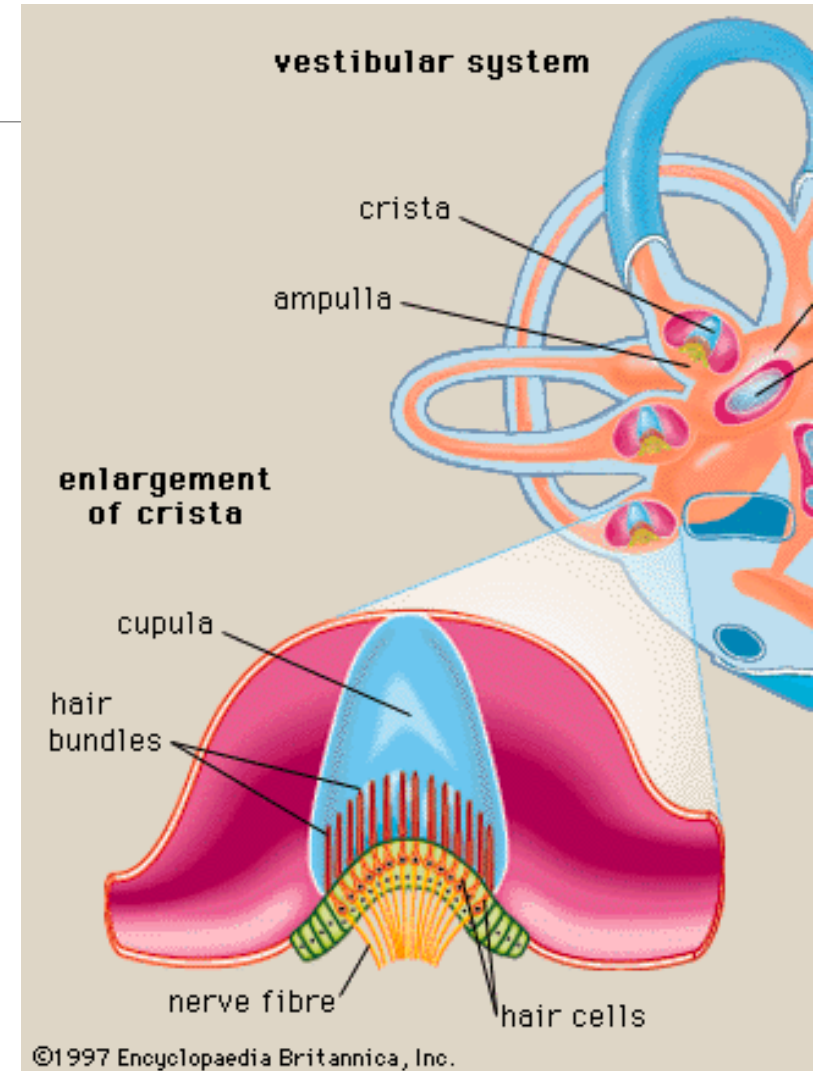
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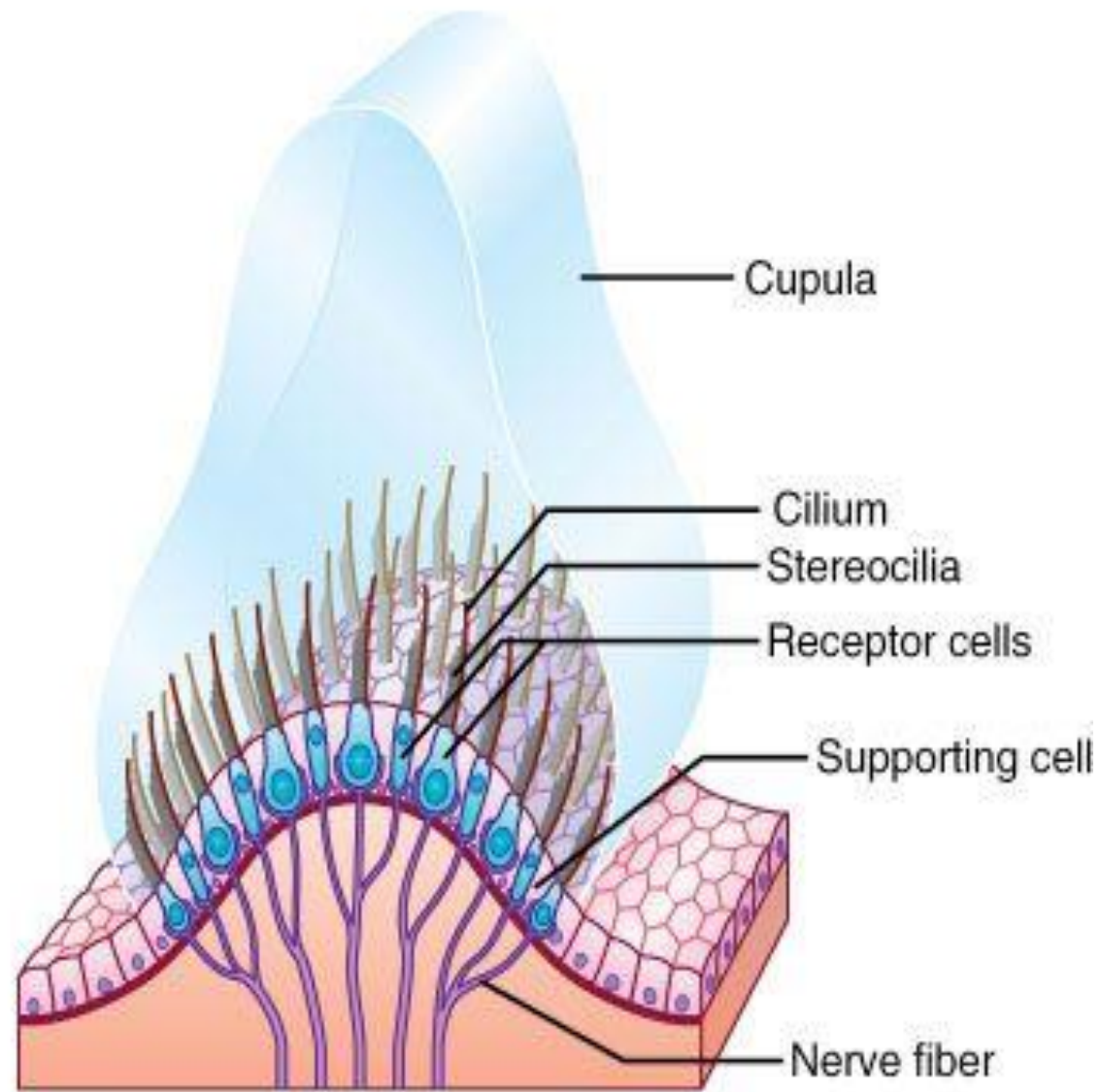
The semicircular canals

- ✓ Lateral or horizontal, Anterior or superior, and Posterior.
- ✓ The semicircular canals are connected to the utricle at their bases.
- ✓ Oriented at a right angle to one another.
- ✓ At the end of each canal is an enlarged chamber, the **Ampulla**.
- ✓ The ampulla contains a sensory receptor called Crista ampullaris.
- ✓ Crista ampullaris is the sensory organ of the semicircular ducts.

The semicircular canals

- ✓ The crista consists of a gelatinous mass called **Cupula**.
- ✓ Embedded in the cupula are the cilia of hair cells.
- ✓ The basal membrane of the hair cells synapses on the sensory neurons of the vestibular nerve.





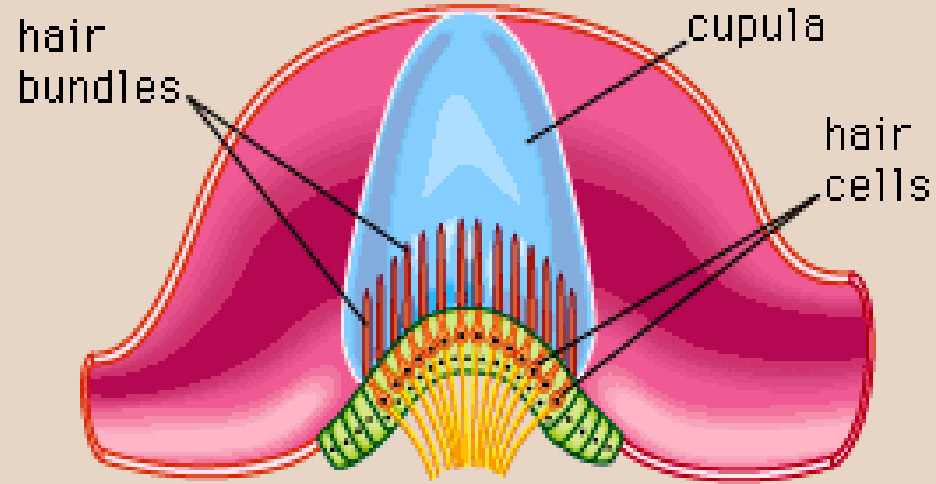
Crista Ampullaris

- ✓ Detects and responds to angular acceleration and deceleration of the head.
- ✓ Rapid turns of the head or body stimulates the hair cells of the crista ampullaris.
- ✓ Appropriate rotation of the head in one direction bend cilia in the opposite, depolarizing the cells.
- ✓ Nerve fibers send impulses to the brain—cerebellum.
- ✓ Analysis of information allows the brain to predict the consequences of rapid body movements and signal the appropriate skeletal muscle to maintain balance.

Crista Ampullaris

- ✓ Each semicircular canal works in concert with a partner located on the other side of the head, which had its hair cells aligned oppositely.
- ✓ The head rotation deforms the cupula in opposing directions for the two partners, resulting in opposite changes in their firing rates.
- ✓ For example, the orientation of the horizontal canals makes them selectively sensitive to rotation in the horizontal plane. More specifically the hair cells in the canal towards which the head is turning are depolarized, while those on the other side are hyperpolarized.
- ✓ When the head turns to the left, the cupula is pushed toward the kinocilium in the left horizontal canal and the firing rate of the relevant axons in the left vestibular nerve increases.
- ✓ In contrast, cupula in right horizontal canal is pushed away from the kinocilium, with concomitant decrease in the firing rate of the related neurons. If the head is to the right, the result is just the opposite.

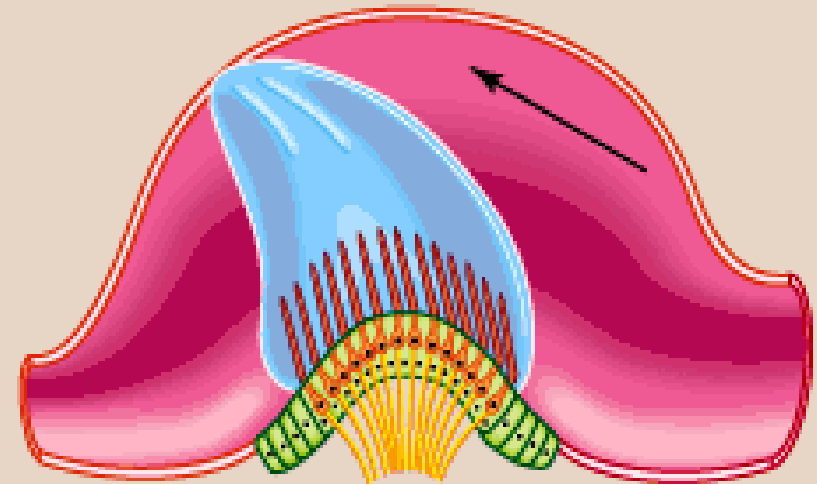
A



**stationary section
of the crista
of the horizontal canal**



stationary



**rotating section
of the crista
of the horizontal canal**



rotating

Vestibular Pathway

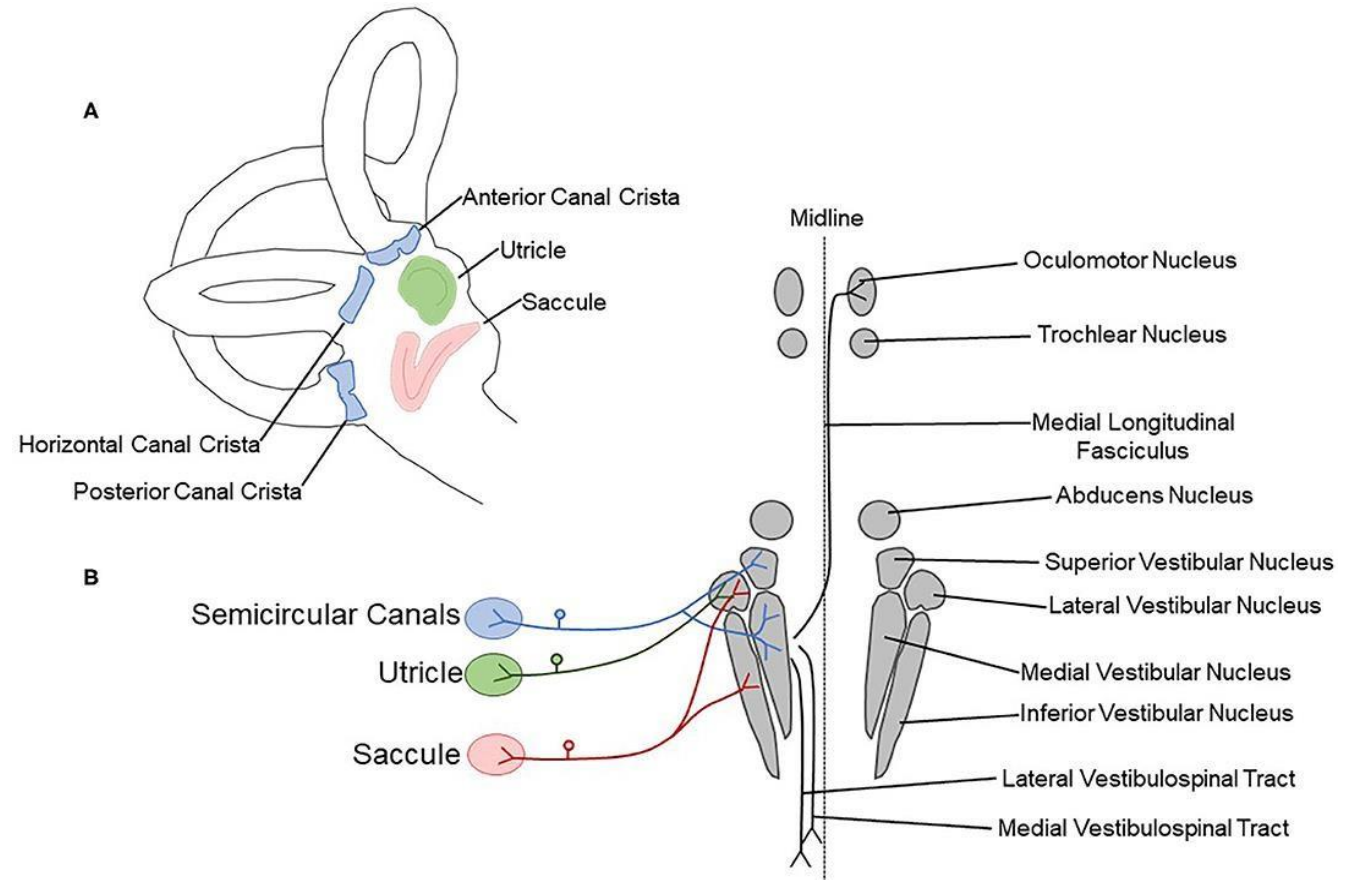


Vestibular Nerve

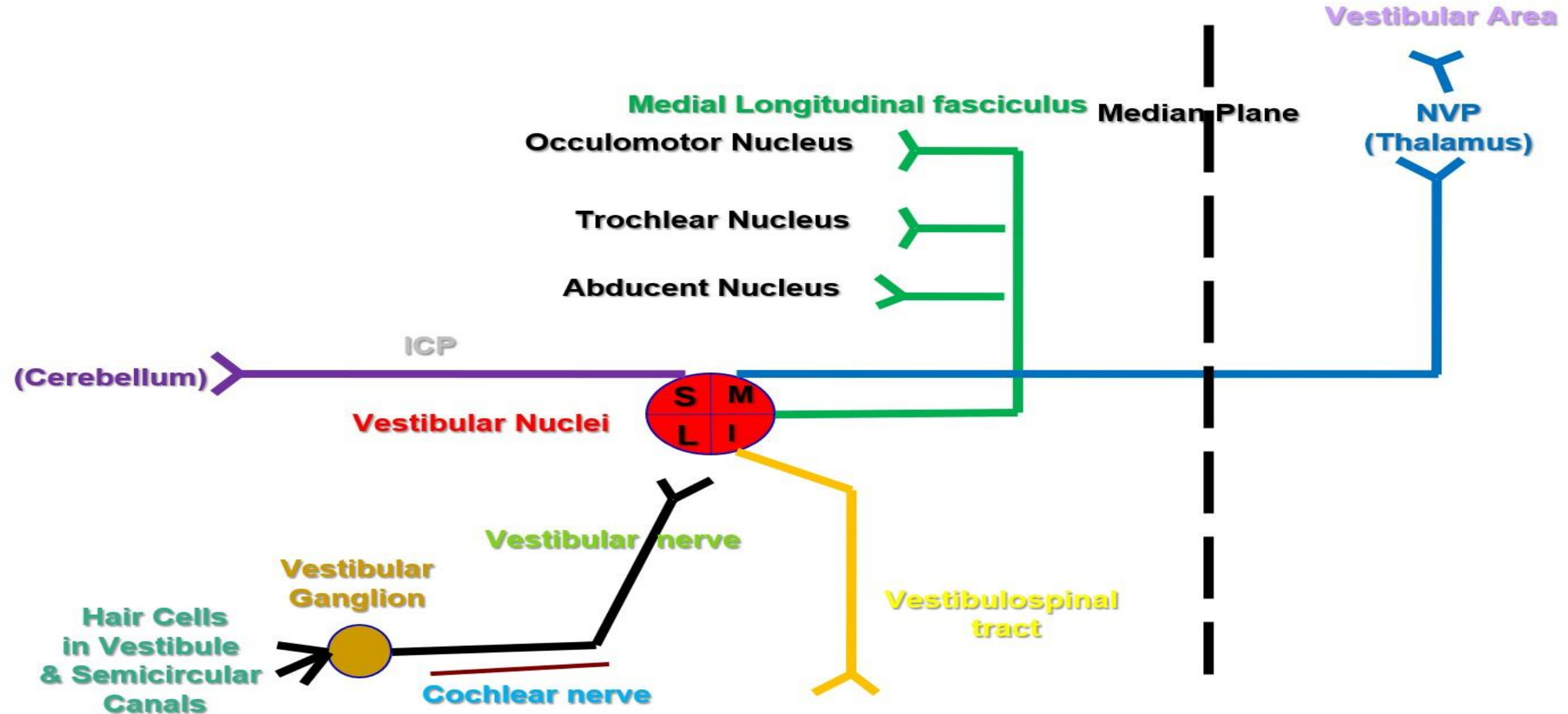
- The nerve fibers of the vestibular nerve are the central processes of nerve cells located in the **vestibular ganglion**, which is situated in the **internal acoustic meatus**.
- They enter the anterior surface of the brainstem in a groove between the lower border of the pons and the upper part of the medulla oblongata.
- When they enter the vestibular nuclear complex, the fibers divide into **short ascending** and **long descending fibers**; a small number of fibers pass directly to the cerebellum through the inferior cerebellar peduncle, bypassing the vestibular nuclei

VESTIBULAR NUCLEAR COMPLEX

- This complex consists of a group of nuclei situated beneath the floor of the fourth ventricle.
- Four nuclei may be recognized:
 - (1) **The lateral vestibular**
 - (2) **The superior vestibular**
 - (3) **The medial vestibular**
 - (4) **The inferior vestibular**



Vestibular Pathway



Vestibular Pathway

- The **vestibular nuclei** receive **afferent** fibers from the utricle and saccule and the semicircular canals through the vestibular nerve and fibers from the cerebellum through the inferior cerebellar peduncle.
- Efferent fibers from the nuclei pass to the cerebellum through the **inferior cerebellar peduncle**.
- Efferent fibers also descend uncrossed to the spinal cord from the lateral vestibular nucleus and form the **vestibulospinal tract**.

Vestibular Pathway

- Efferent fibers pass to the nuclei of the oculomotor, trochlear, and abducens nerves through the medial longitudinal fasciculus. These connections enable the movements of the head and the eyes to be coordinated so that visual fixation on an object can be maintained. (vestibulo-ocular pathway)
- In addition, information received from the internal ear can assist in maintaining balance by influencing the muscle tone of the limbs and trunk.
- Ascending fibers also pass upward from the vestibular nuclei to the cerebral cortex, to the vestibular area in the postcentral gyrus just above the lateral fissure. These fibers are thought to relay in the ventral posterior nuclei of the thalamus. The cerebral cortex probably serves to orient the individual consciously in space.

THANK YOU