VESTIBULAR SYSTEM ANATOMY AND PHYSIOLOGY

Professor.Dr. M.K.Rajasekar MS., DLO.,

Life is hard for those who don't have a VOR

> *During a walk I found too much motion in my visual picture of the surroundings to permit recognition of fine detail. I learned that I must stand still in order to read the lettering on a sign*
>
> *--J.C, 1952*
>
> *M.D. with no vestibular system*

His vision was disturbed by head movements as small as those induced by the beat of his heart while at rest.

Introduction

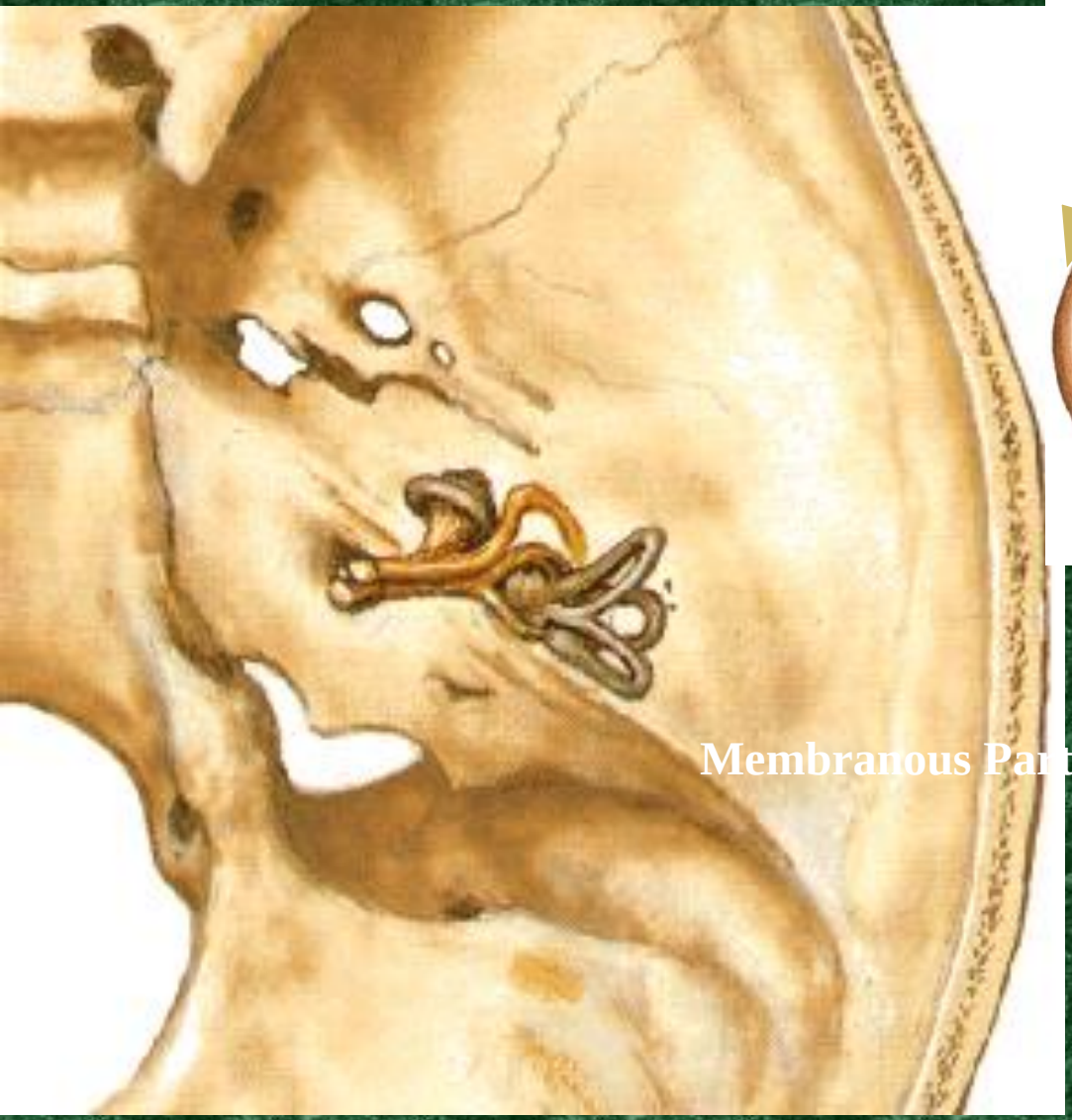
- The vestibular system has important sensory and motor functions contributing to the perception of self motion , head position and spatial orientation relative to gravity

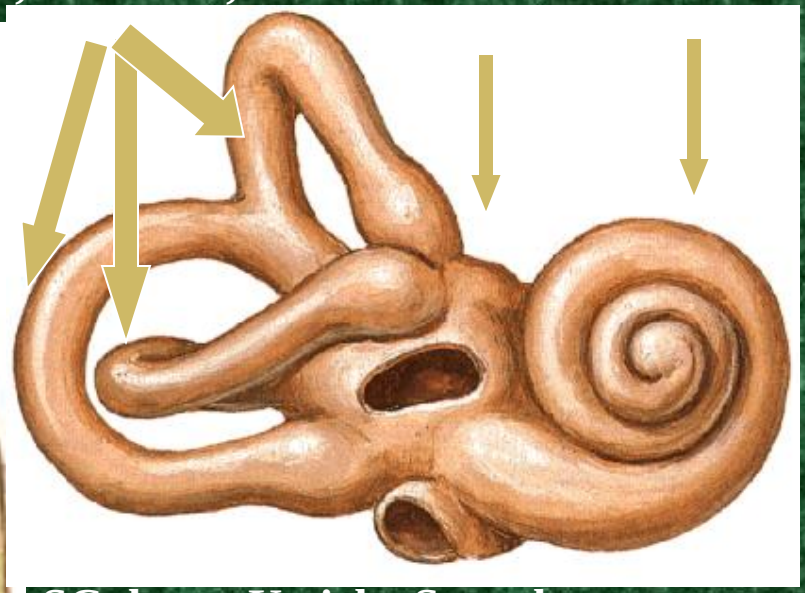
Vestibular Anatomy

- Peripheral sensory apparatus
  - detects & relays information about head angular & linear velocity to central processing system
  - orients the head with respect to gravity
- Central processing system
  - processes information in conjunction with other sensory inputs for position and movement of head in space
- Motor output system
  - generates compensatory eye movements and compensatory body movements during head & postural adjustments

Temporal bone & Inner Ear (Labyrinth)

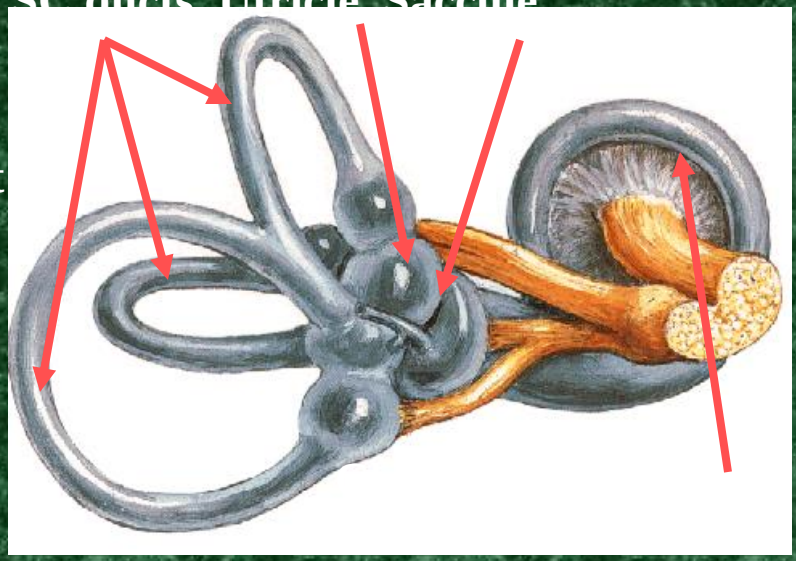
Bony Part: SemiCircular Canals, Vestibule, Cochlea





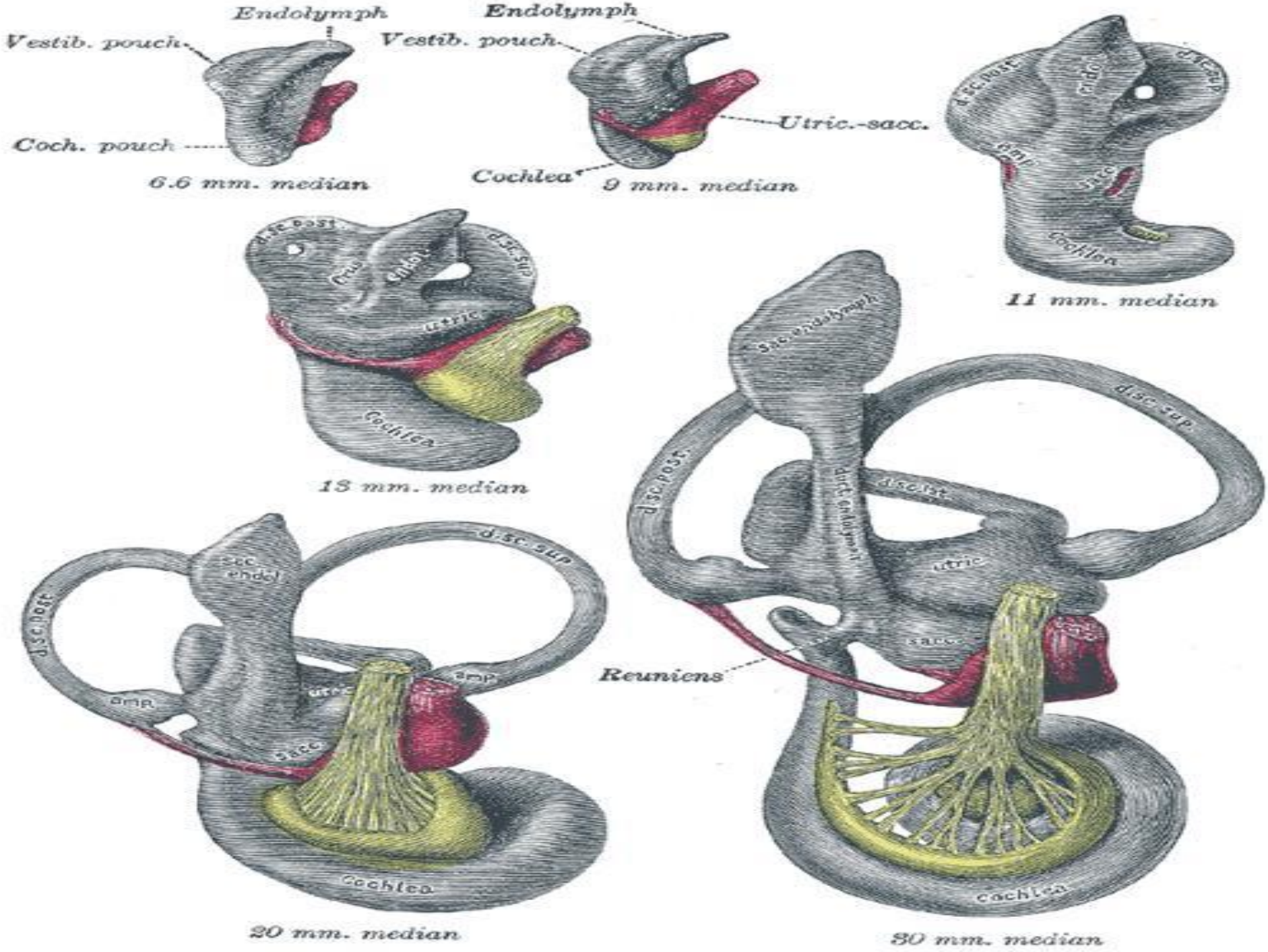
SC ducts, Utricle, Saccule

Membranous Part



- Buried deep in the temporal bone the main peripheral component of the vestibular system the elaborate set of interconnected chambers, the labyrinth in continuous with the cochlea

- The labyrinth consists of two otolith organs the utricle and the saccule and three semicircular canals the vestibular haircells like the cochlear hair cells produce minute displacements into relevant receptor potentials are located in the utricle and saccule and three jug like swellings called the ampulla located at the base of the semicircular canals next to the utricle.


Endolymph
Vestib. pouch
Coch. pouch
6.6 mm. median
Endolymph
Vestib. pouch
Utric.-sacc.
Cochlea
9 mm. median
d.sc.post
d.sc.sup
Cochlea
11 mm. median
d.sc.post
d.sc.sup
utric
Cochlea
13 mm. median
d.sc.sup
d.sc.post
sac. endol
amp
utric
sacc
Cochlea
20 mm. median
d.sc.sup
d.sc.post
d.sc.lat.
utric
sacc
Reuniens
cochlea
30 mm. median

Embryology

3rd week of embryonic development

Otic placode formed from neuroectoderm .

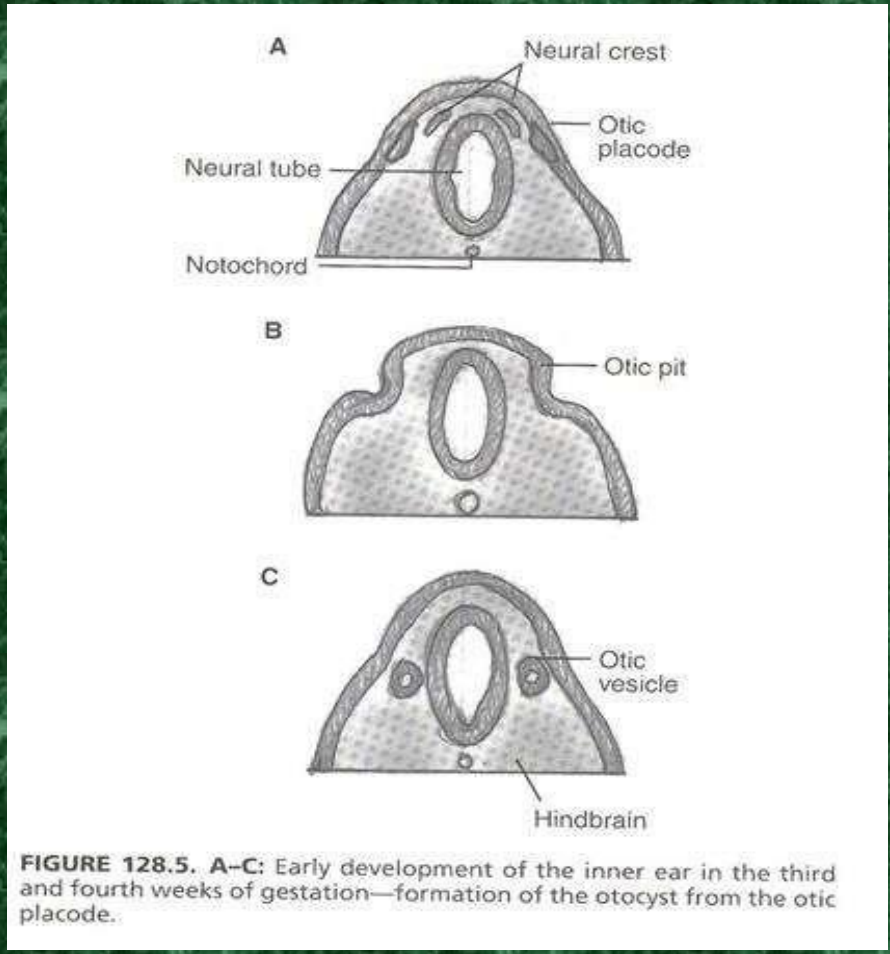
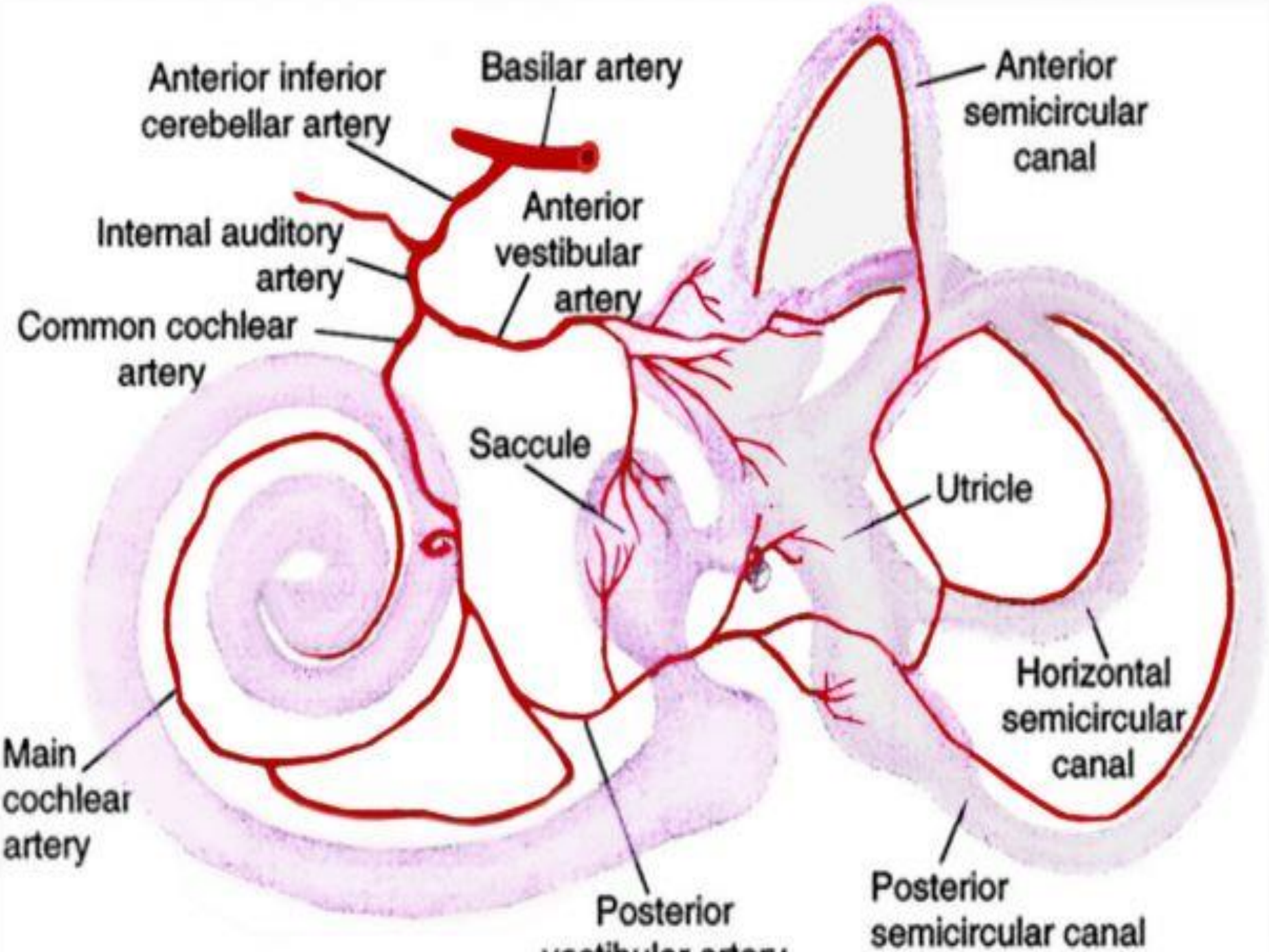


FIGURE 128.5. A–C: Early development of the inner ear in the third and fourth weeks of gestation—formation of the otocyst from the otic placode.


Anterior inferior cerebellar artery
Basilar artery
Anterior semicircular canal
Internal auditory artery
Anterior vestibular artery
Common cochlear artery
Saccule
Utricle
Horizontal semicircular canal
Main cochlear artery
Posterior
Posterior semicircular canal

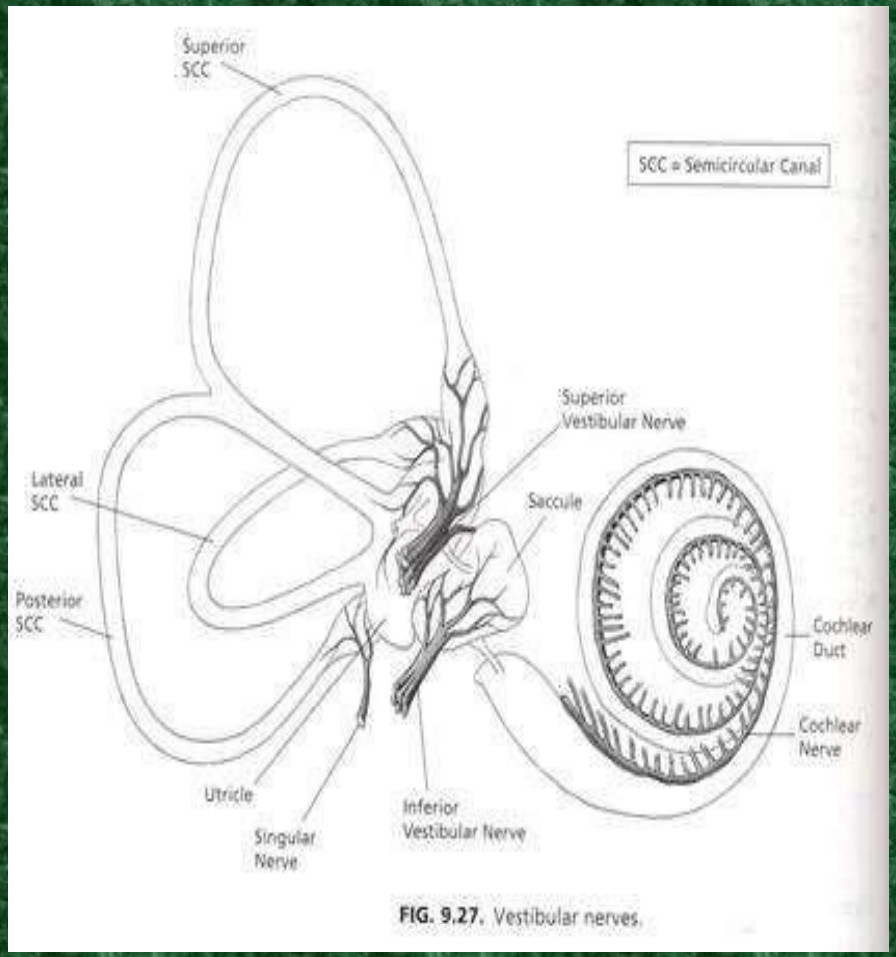
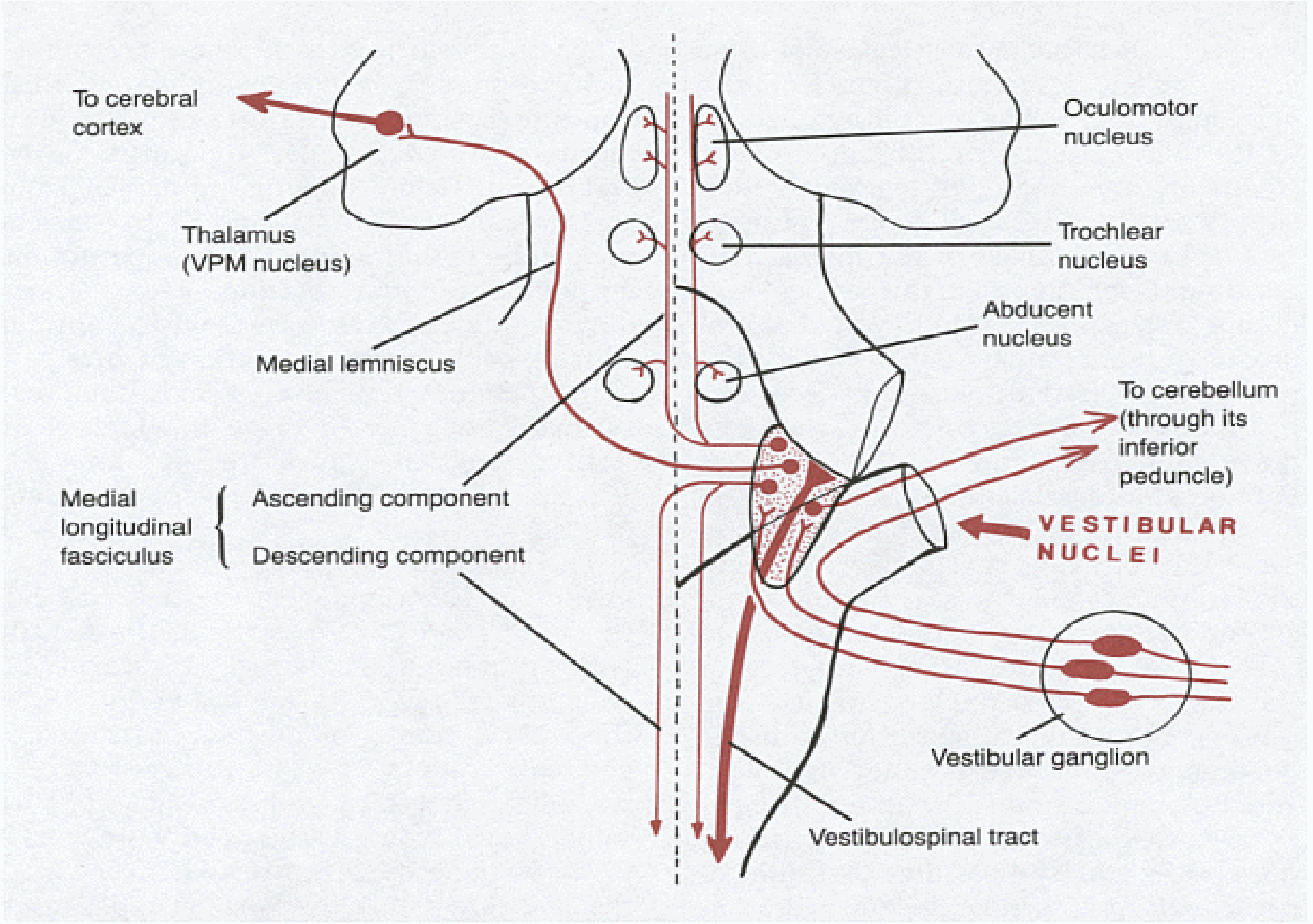


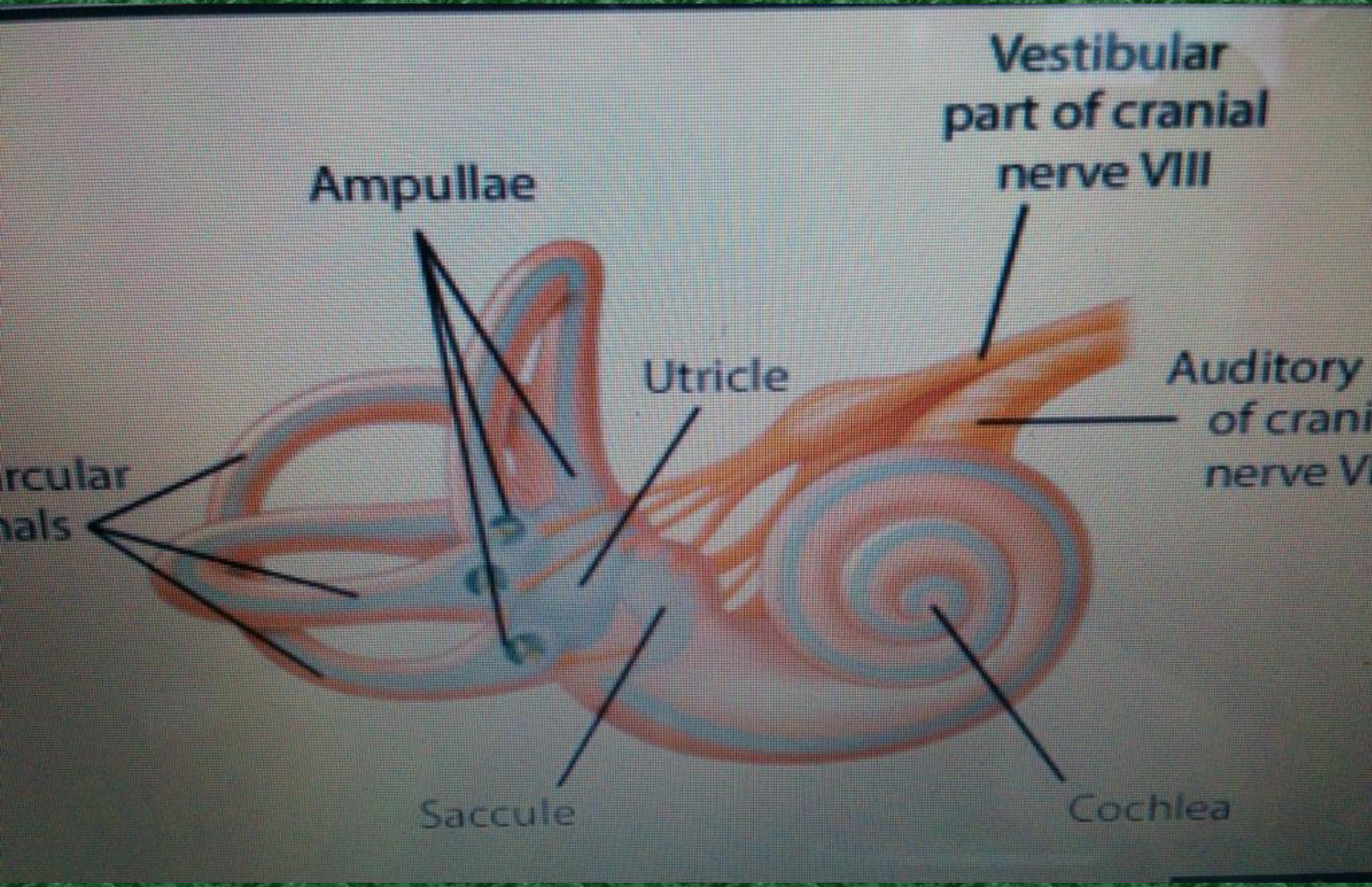
FIG. 9.27. Vestibular nerves.

Superior vestibular Nerve: superior canal,lateral canal, utricle.

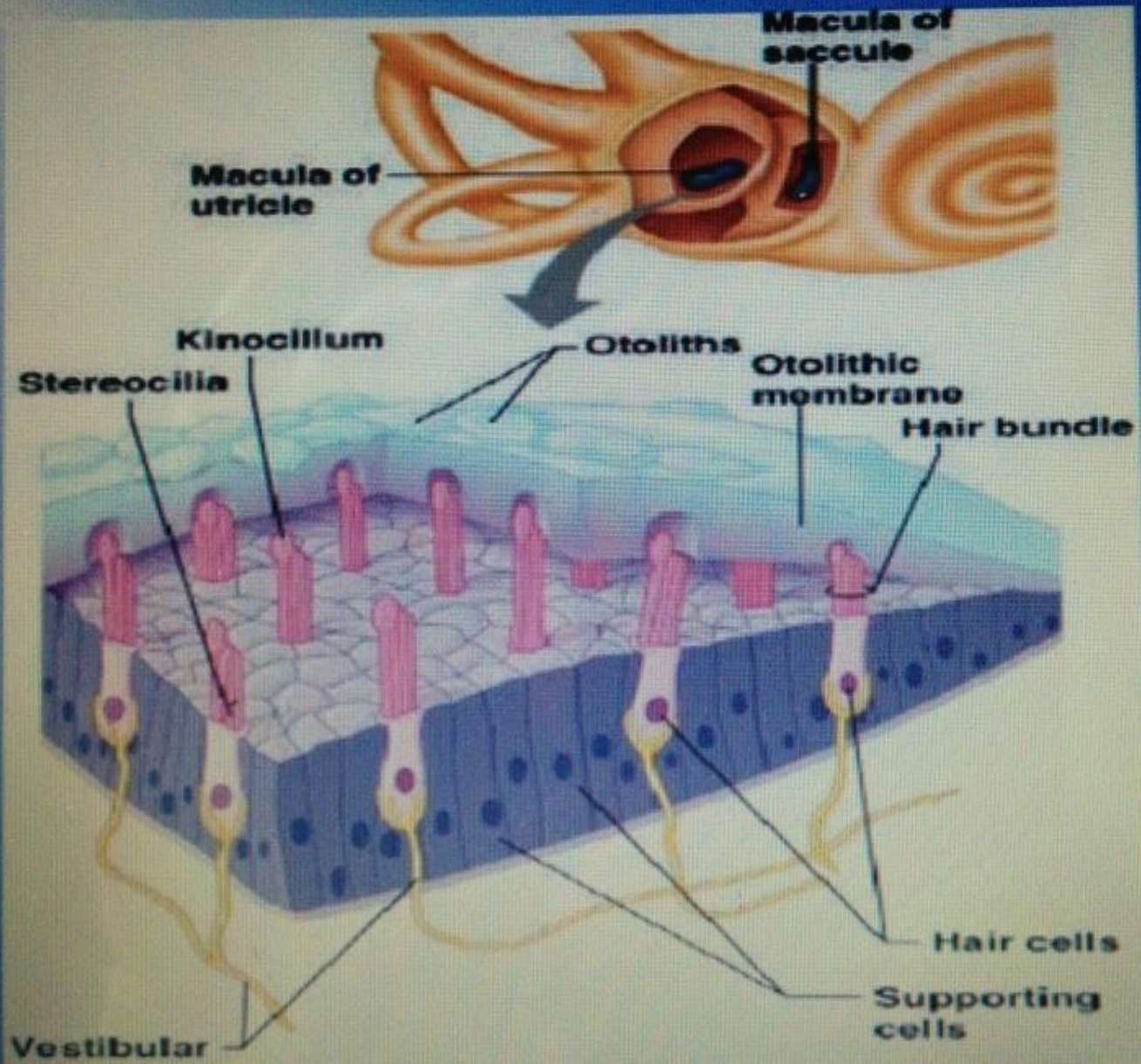
Inferior vestibular nerve: posterior canal and saccule

Central connections of the vestibular system

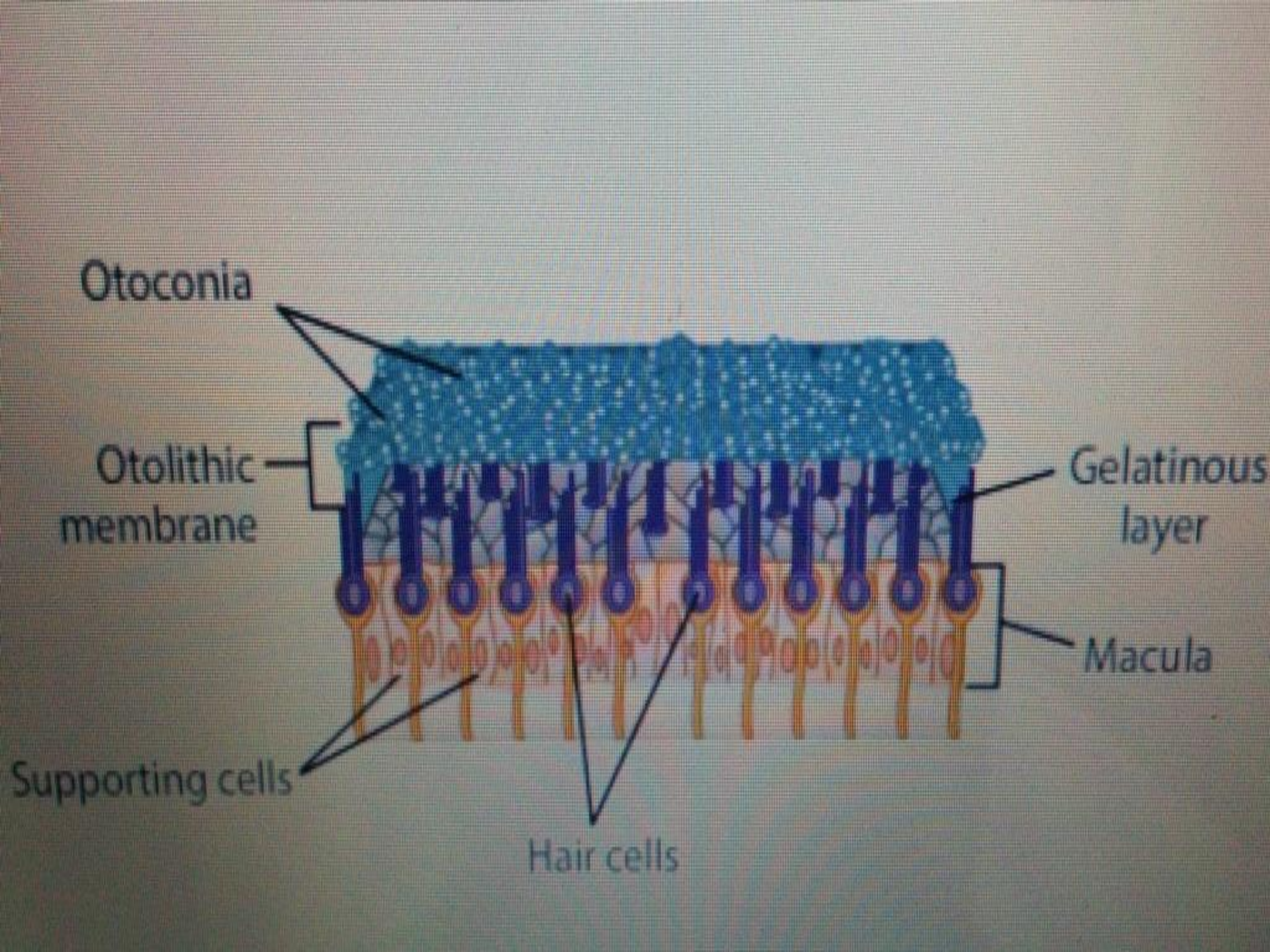



Vestibular part of cranial nerve VIII
Ampullae
Utricle
Auditory
of crani
nerve VI
rcular
nals
Saccule
Cochlea

Maculae


Macula of saccule
Macula of utricle
Kinocilium
Stereocilia
Otoliths
Otolithic membrane
Hair bundle
Hair cells
Supporting cells
Vestibular

- In the utricle and saccule the sensory epithelium , the macula consists of hair cells and associated supporting cells overlying the haircells and their stereocilia is a gelatinous layer, above this layer is a fibrous structure the otolith membrane in which are embedded crystals of calcium carbonate called otoconia the crystals give the otolith organ the name(otolith in greek for ear stones)


Otoconia
Otolithic membrane
Gelatinous layer
Macula
Supporting cells
Hair cells

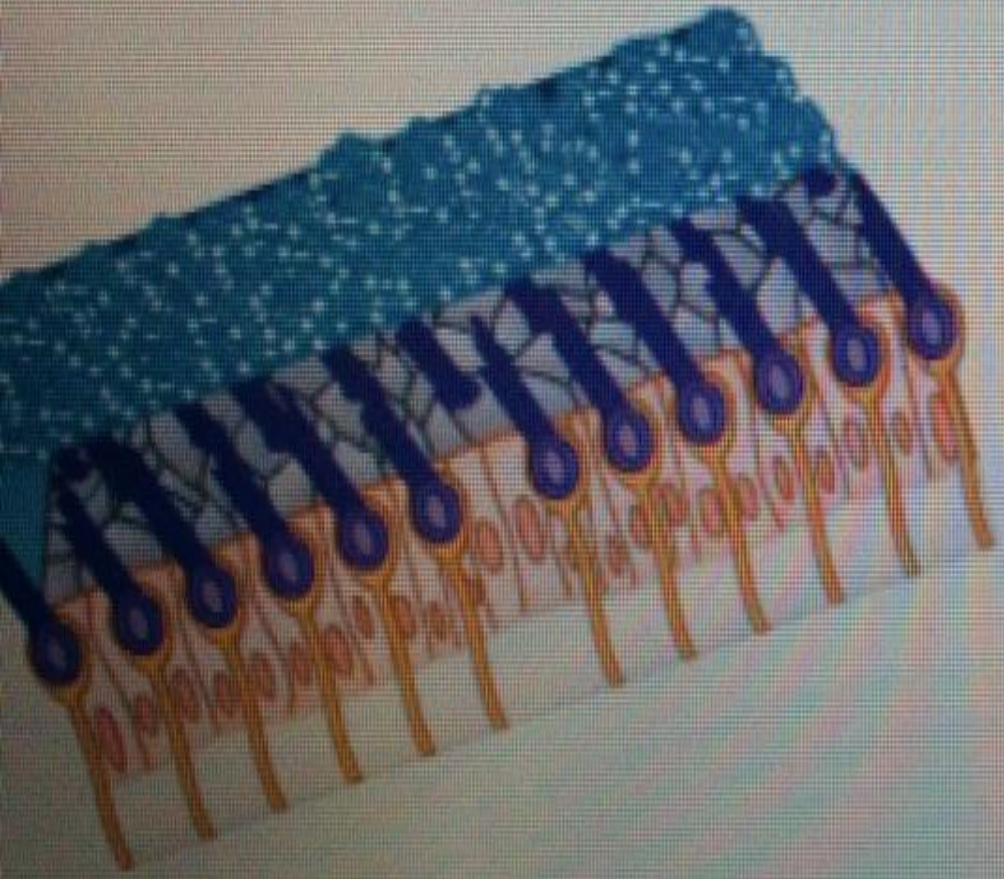
- The otolith make the otoconial membrane considerably heavier than the structures and fluids surrounding it thus when the head tilts gravity causes the membrane to shift relative to the sensory epithelium.

Semicircular canals sense angular Acceleration.

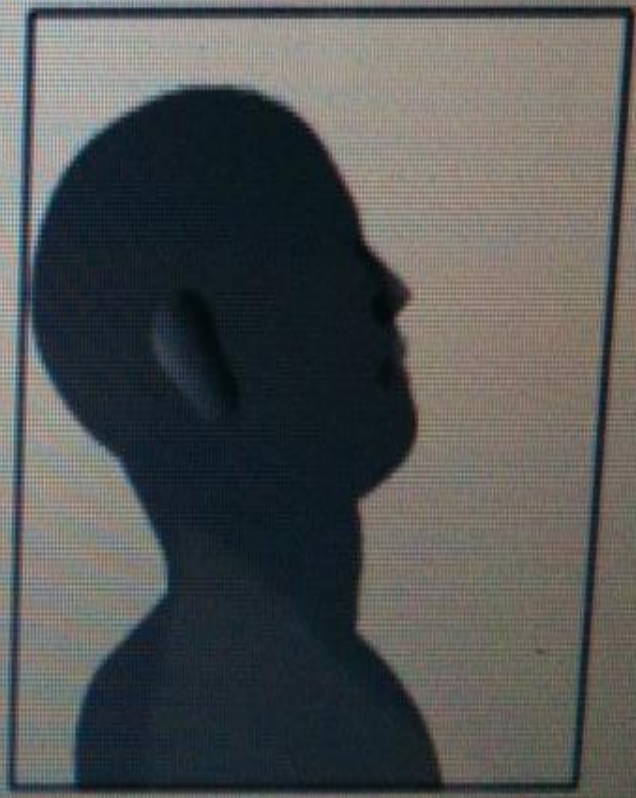
Otolithic organs (utricle and saccule)sense linear acceleration

Utricle in horizontal axis

Saccule in the vertical axis.

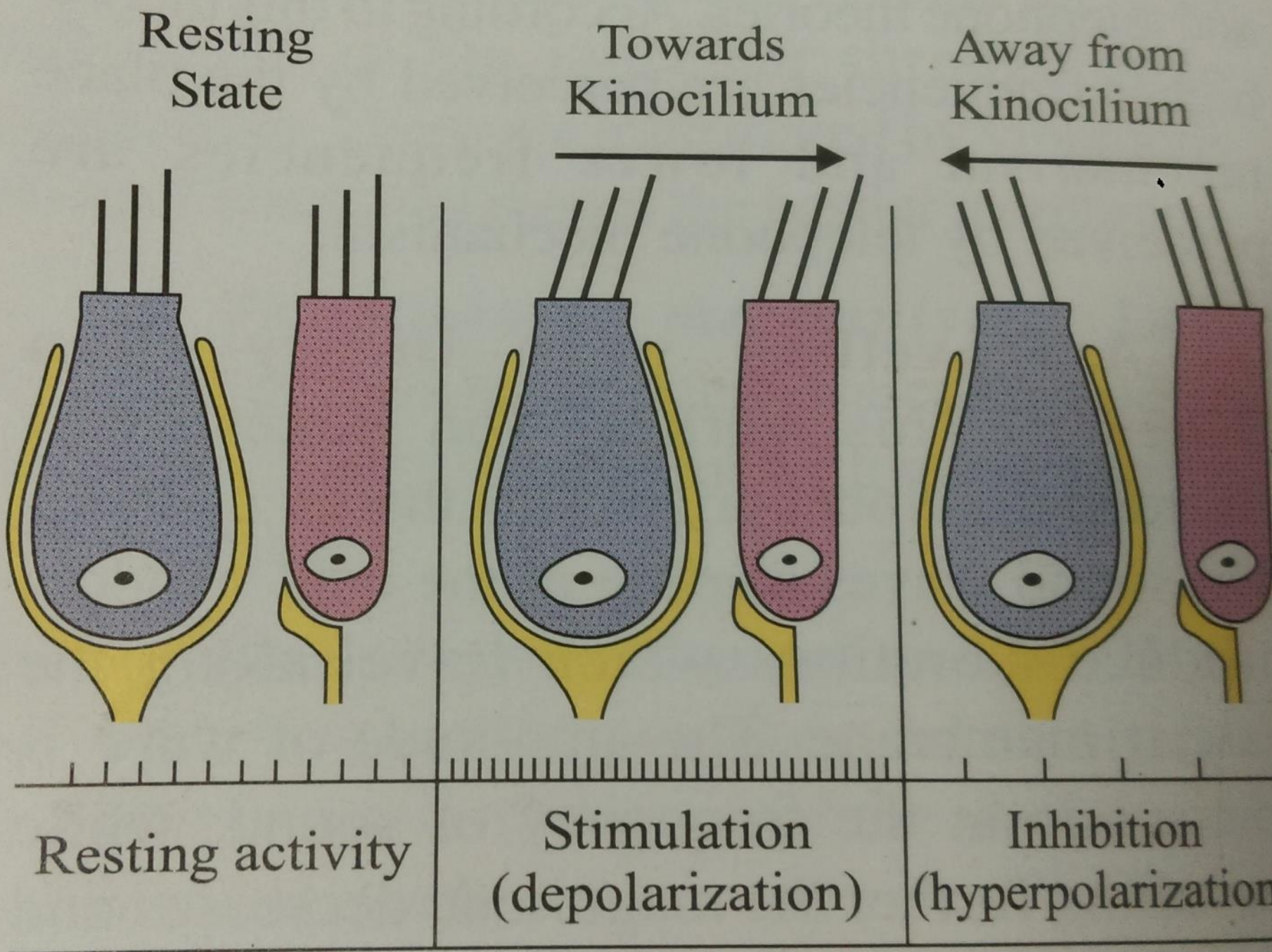


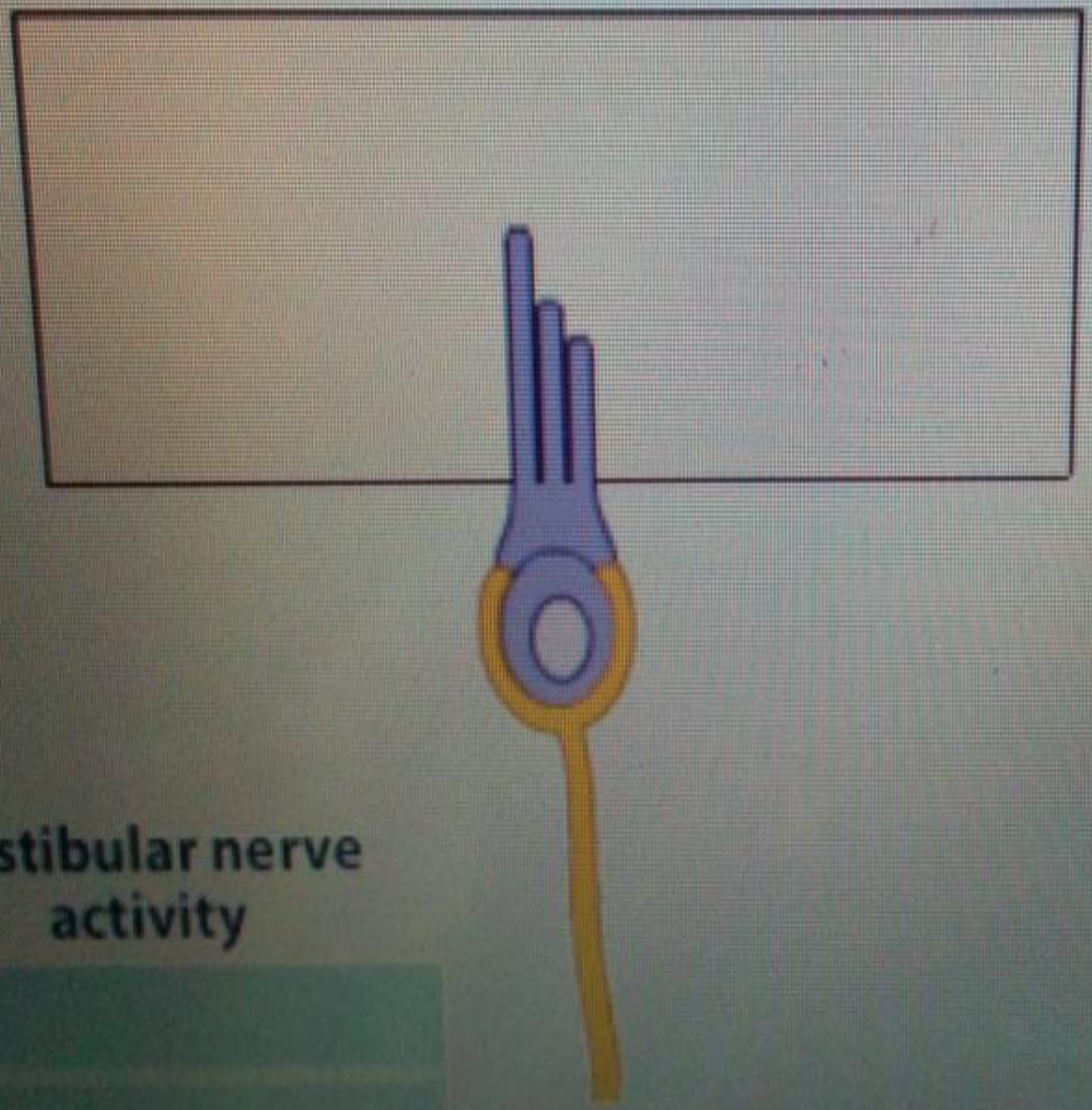
Backward tilt

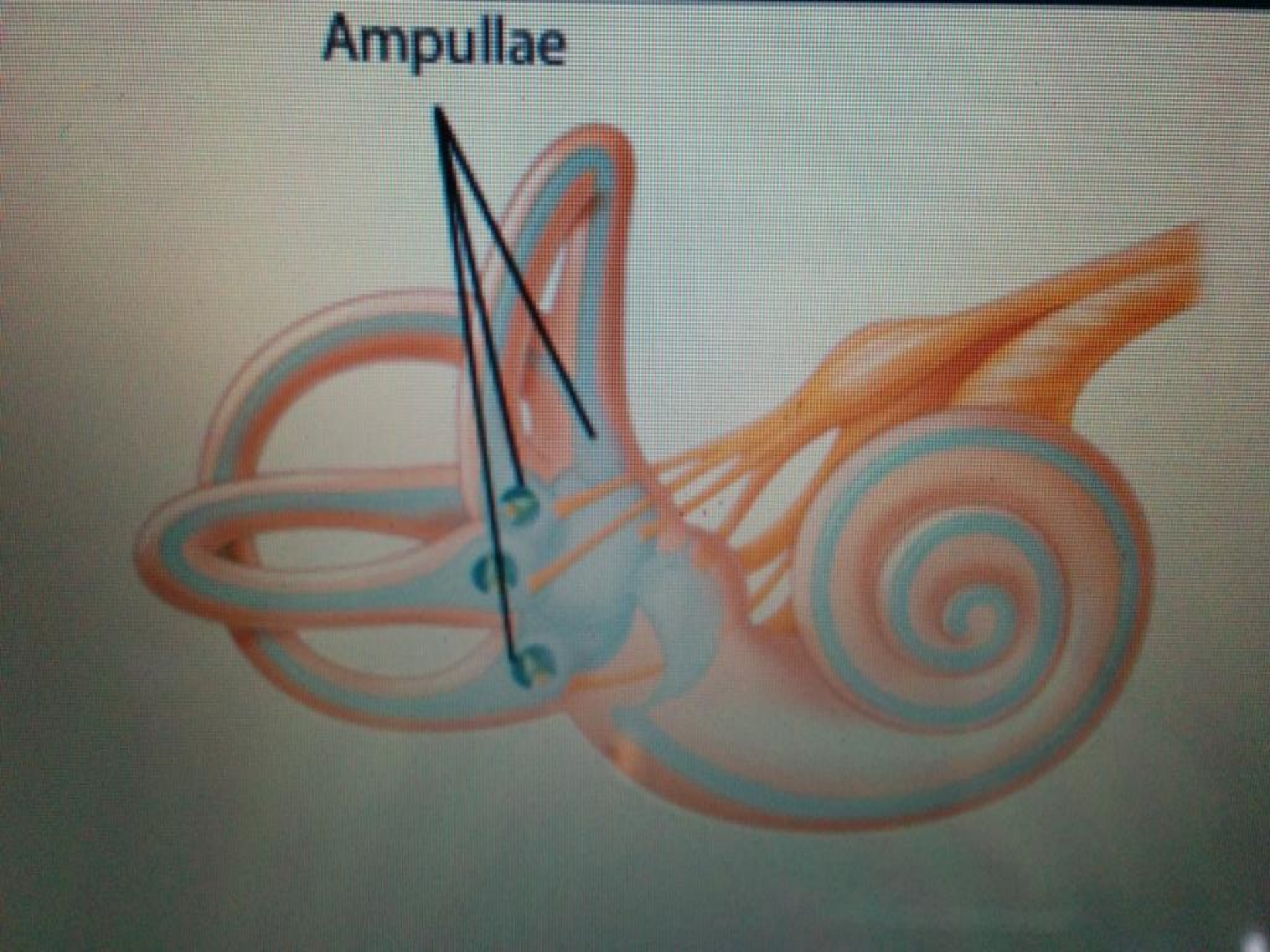


- The resulting shearing motion between the otolith membrane and the macula displaces the hair bundle which are embedded in the lower gelatinous surface of the membrane this generates a receptor potential in the hair cells , that is dependent on the direction of the tilt.

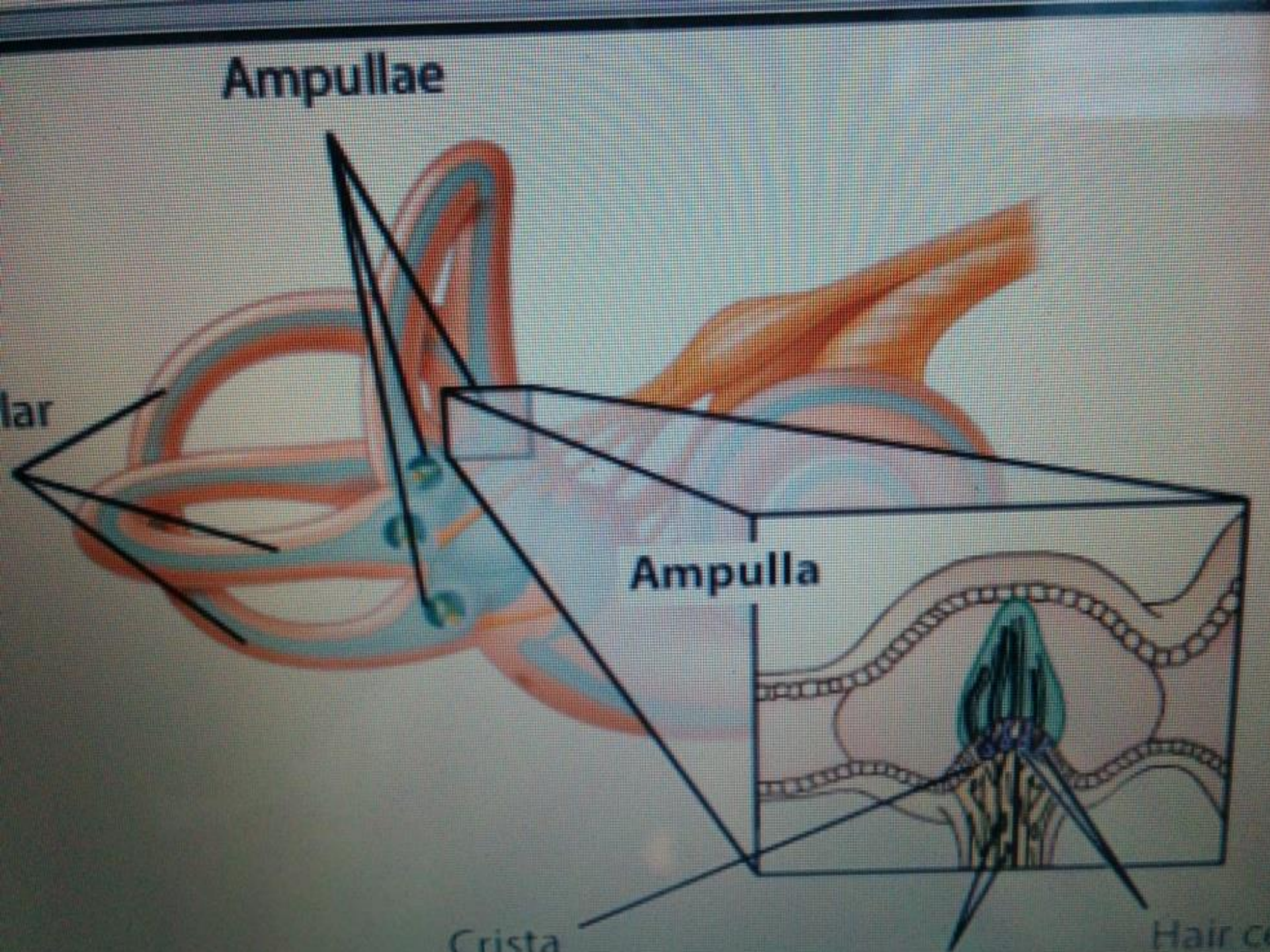
- Movement of the stereocilia towards the kinocilia causes the potassium channels to open depolarizing the hair cells this results in neurotransmitter release and excitation of vestibular nerve fibers . Movement of the stereocilia away from the kinocilia causes closing of the potassium channels causing hyperpolorisation of the cell thus reducing vestibular nerve activity.


Resting State
Towards Kinocilium
Away from Kinocilium
Resting activity
Stimulation (depolarization)
Inhibition (hyperpolarization

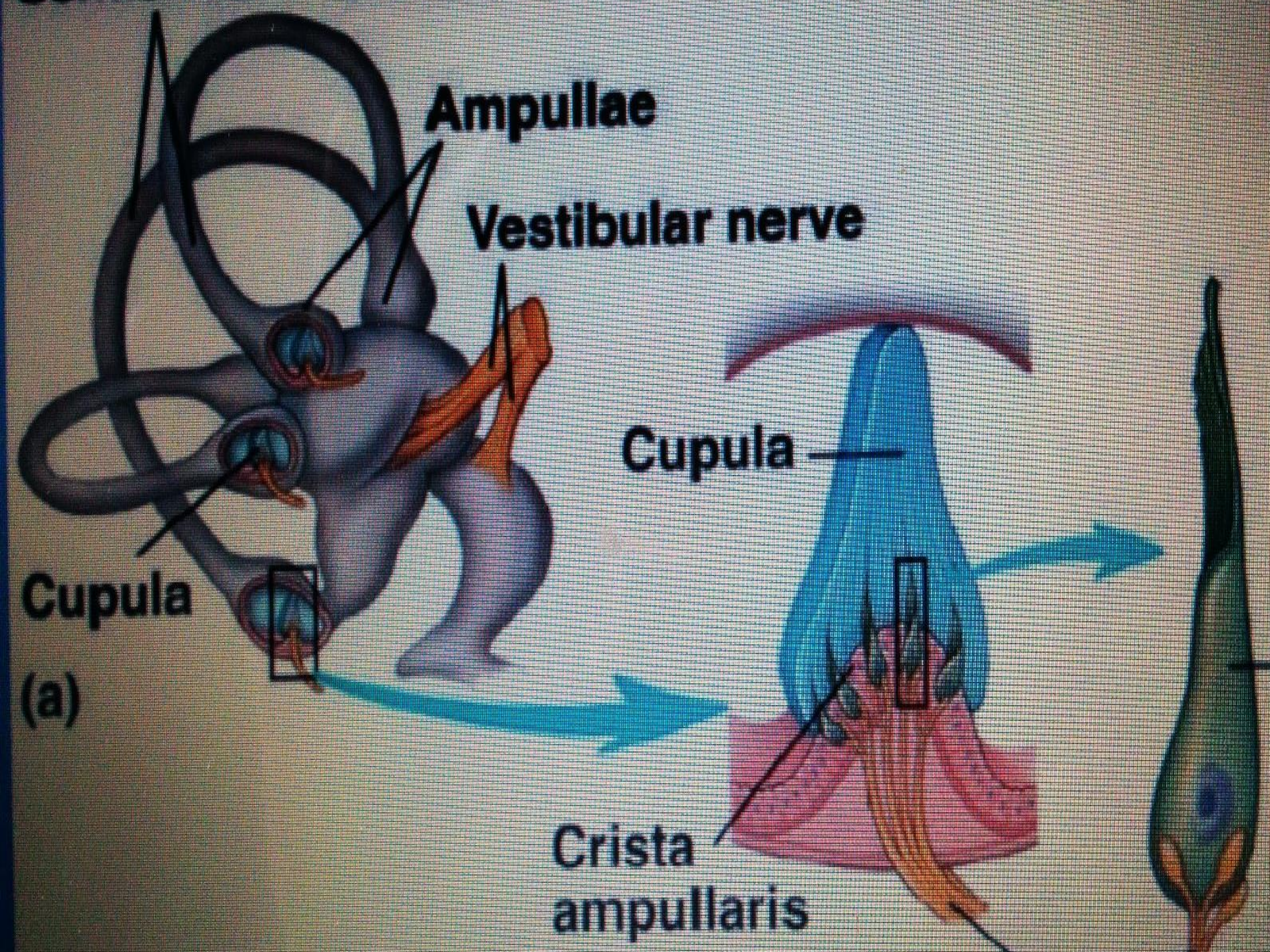

Vestibular nerve
activity


Ampullae

- Each of the scc has a base expansion called the ampulla which houses the sensory epithelium or the crista that contain the hair cells, the structure of the canal suggest how they detect the angular acceleration that arise thro rotation of the head.


Ampullae
lar
Ampulla
Crista
Hair c

- The hair bundles extend out of the crista into the gelatinous mass,the cupula that bridges the width of the gelatinous mass forming a viscous barrier through which endolymph cannot circulate. as a result the compliant cupula is distorted by movements of the endolymphatic fluid.


Ampullae
Vestibular nerve
Cupula
Cupula
(a)
Crista
ampullaris

- When the head turns in the direction of the one of the plane of scc the inertia of endolymph produces force along the cupula distending it away from the direction of head movement causing the displacement of hair bundles within the crista in contrast the linear acceleration of the head produces force equal on both sides, so hair bundles are not displaced.

- The orientation of the hscc makes it selectively sensitive to rotation in the horizontal plane more specifically the hair cells in the canal on which side the head is turning is depolarized while those on the other side is hyperpolarized.


Thank you.