

Inner ear in balance and equilibrium



Proprioception

The Brain receives and interprets information from multiple inputs:

Vestibular organs in the inner ear send information about rotation, acceleration, and position.

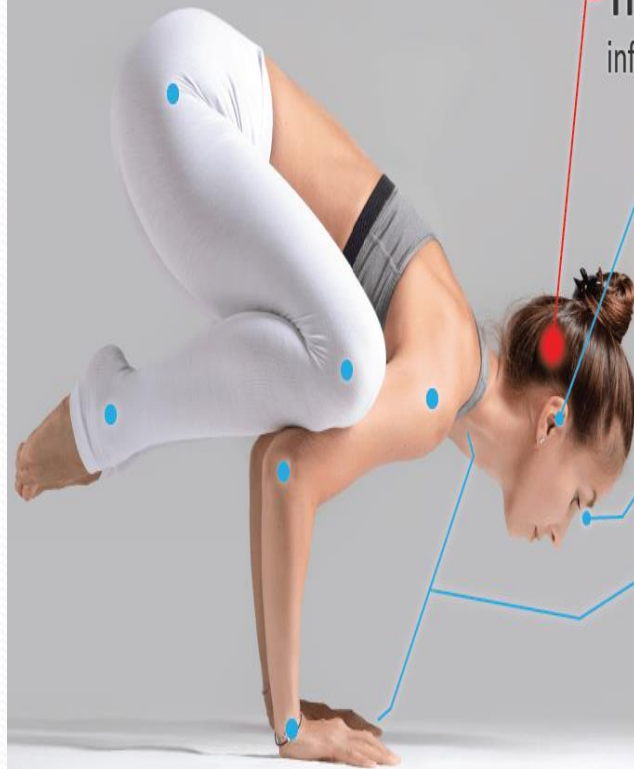
Eyes send visual information.

Stretch receptors in skin, muscles & joints send information about the position of body parts.

Equilibrium:
Reflexes maintain body position at rest & movement

Through: Receptors of postural reflexes

- 1 - Proprioceptors
- 2 - Visual (retinal) receptors
- 3 - Non auditory membranous labyrinth



• Labyrinth:-

1- Membranous labyrinth :-

a- Auditory (cochlea for hearing)

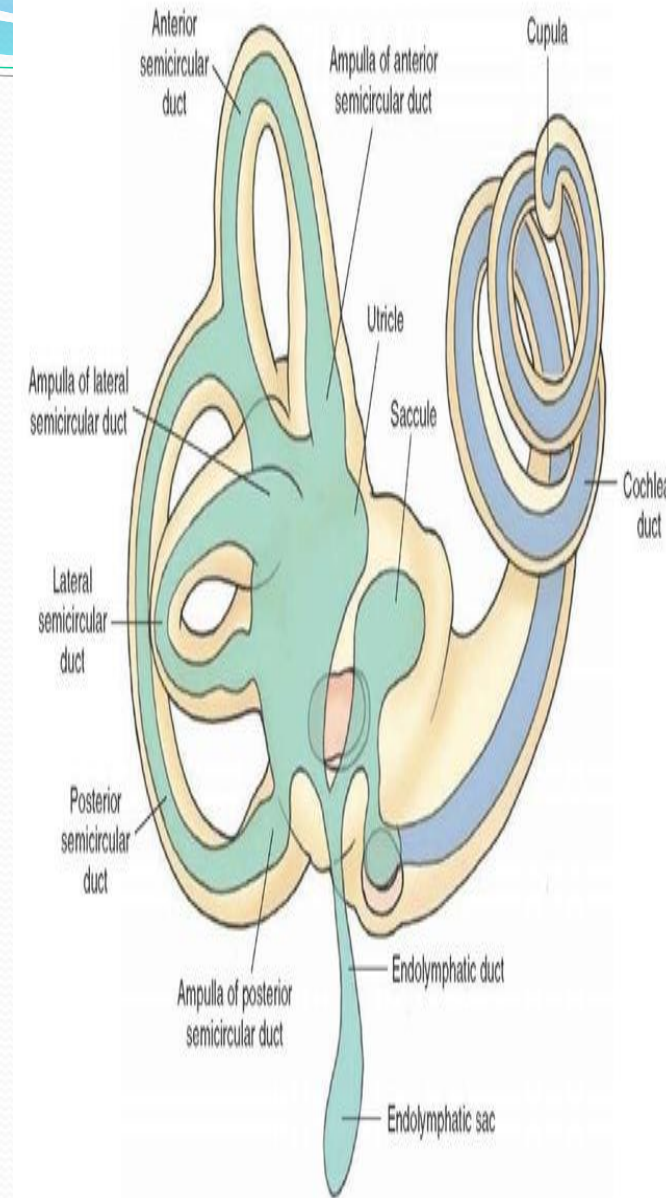
b- Non- auditory for equilibrium

(Vestibular apparatus)

2- Bony labyrinth

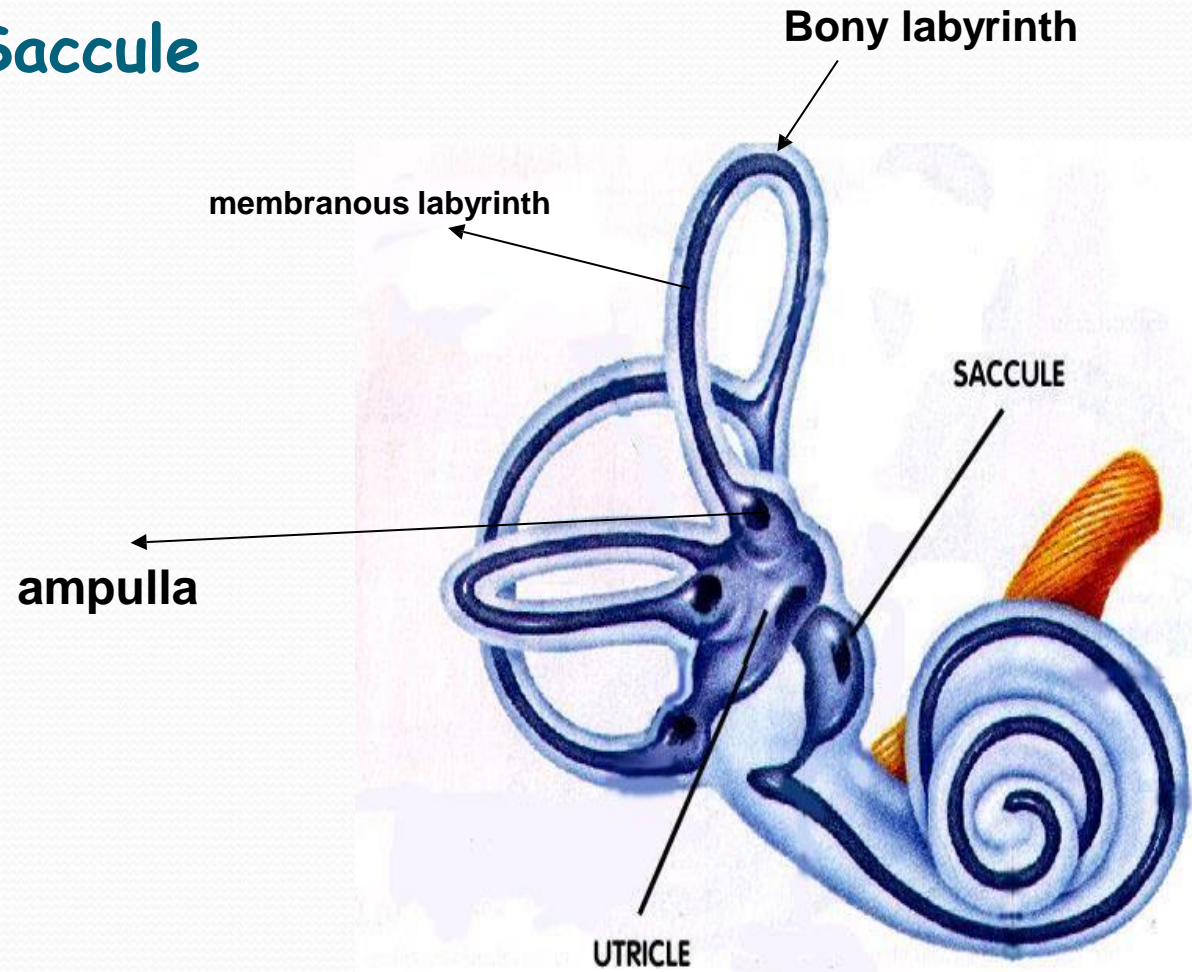
(bony cochlea & 3 bony semicircular canals)

Enclose the membranous labyrinth.

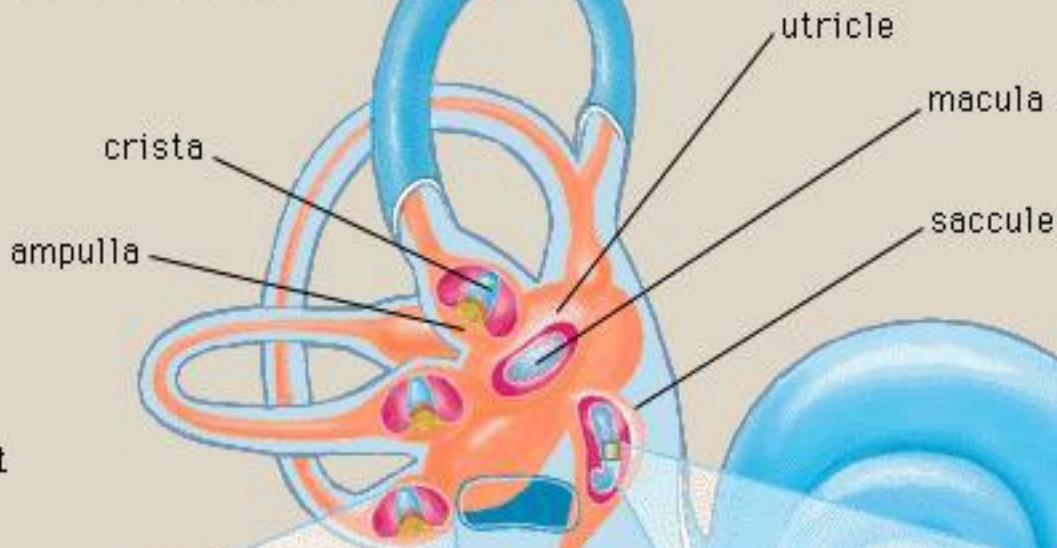


Vestibular apparatus:-

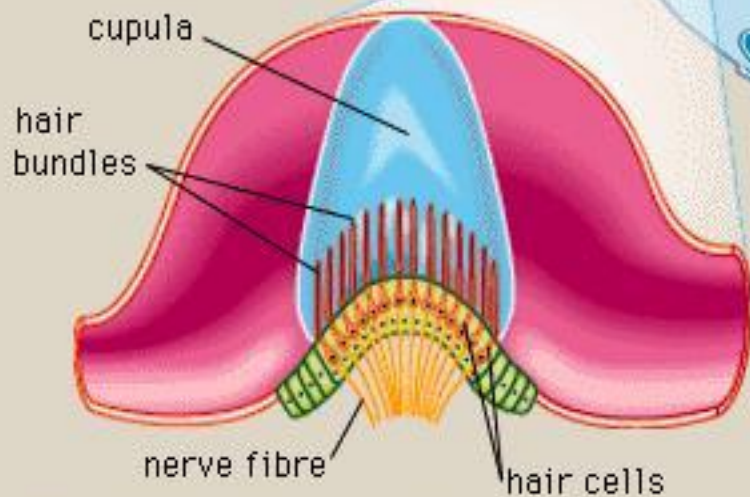
- 1- Utricle & Sacculle
- 2- SCC



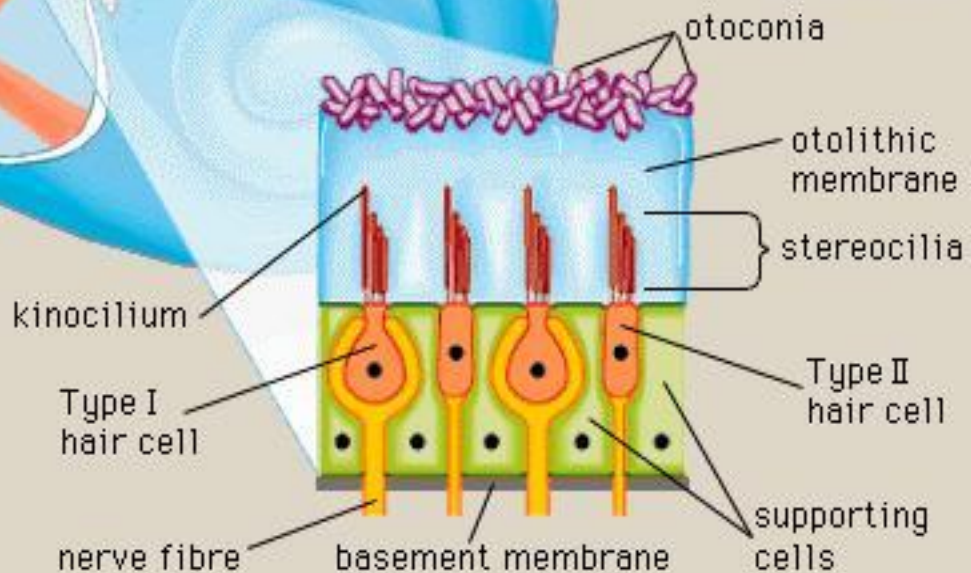
vestibular system

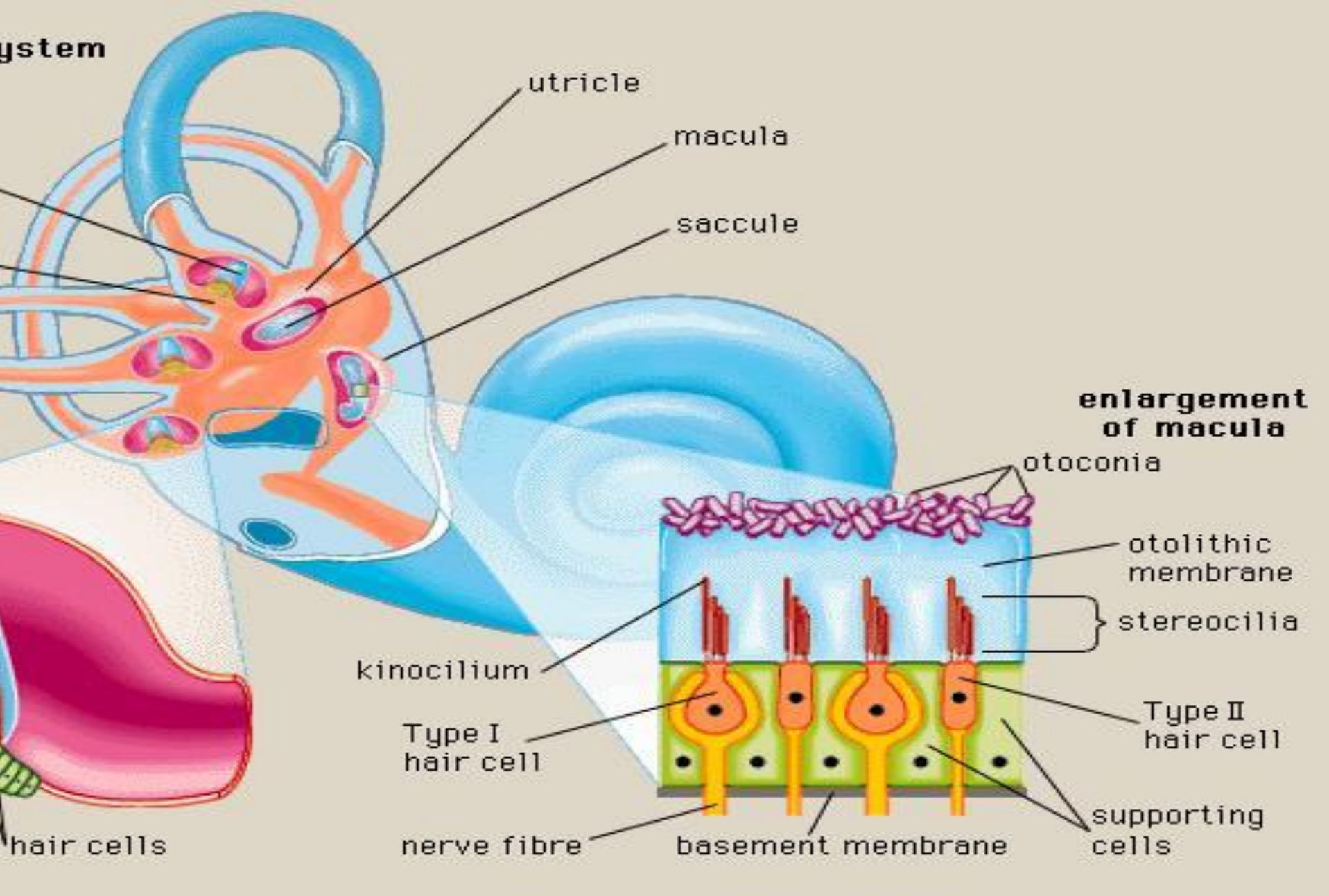


enlargement of crista



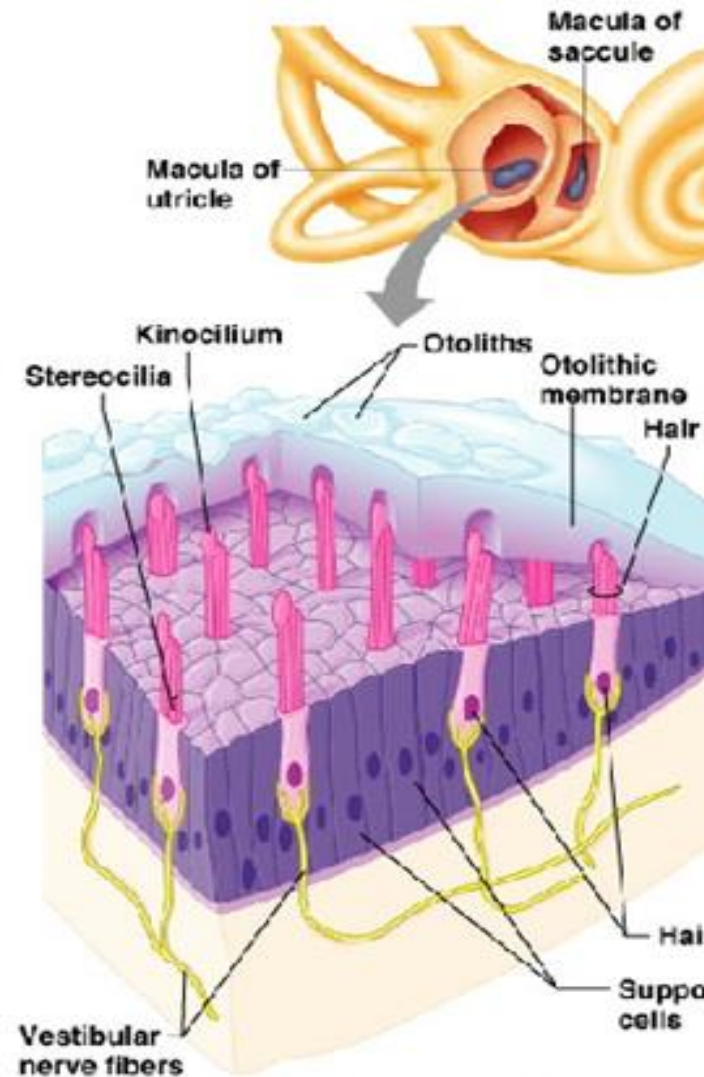
enlargement of macula






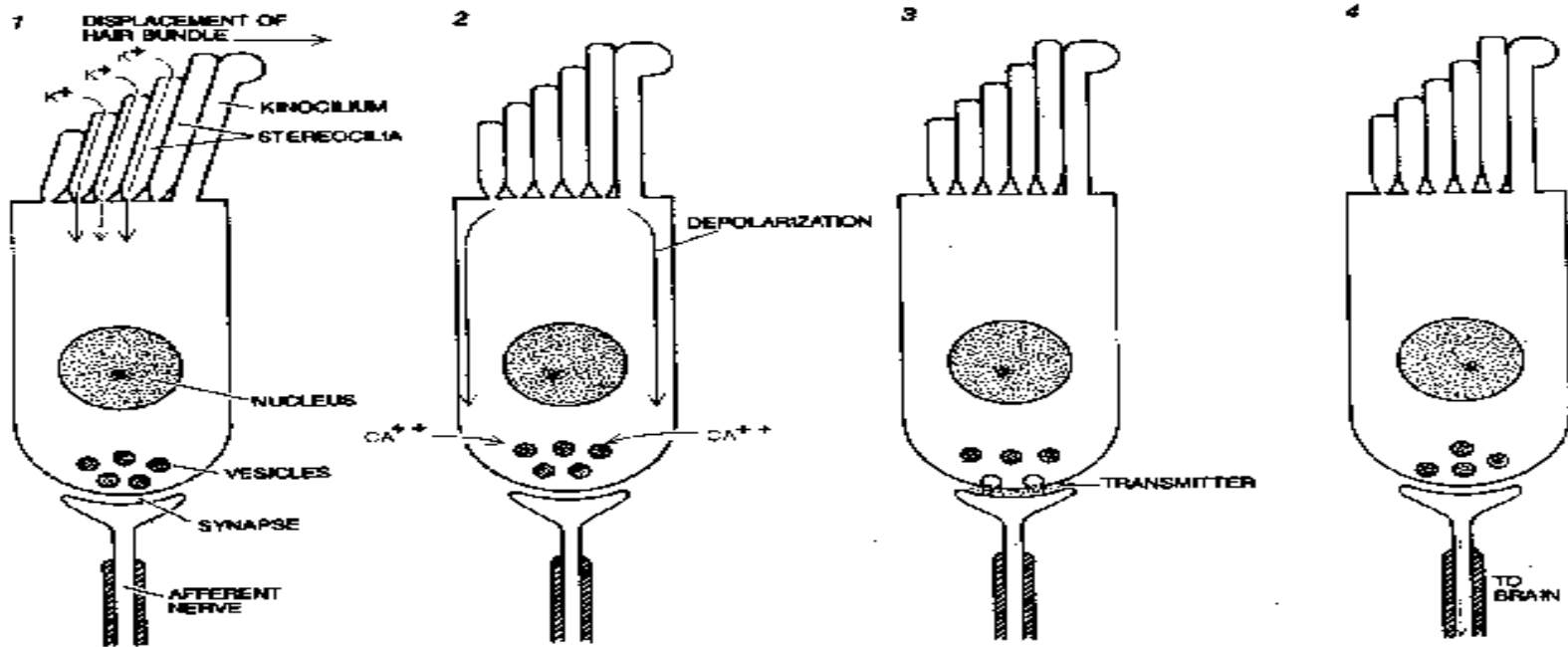
Macula (otolith organs) of utricle and saccule:-

- -hair cell synapse with endings of the vestibular nerve
- -Hair cell has 30-150 (stereocilia)
- one large cilium called & (kinocilium)
- Both connectdd with thin filamnetous attachments
- -All cilium membrane has positive potassium channels
- -Otolithes (statoconia) of calcium carbonate suspended in gelatinous material.
- - macula of utricle is IN horizontal plane if the head is vertical , so cilia point upwards
- - stimulated when the head bends forward & backward & laterally



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- **Macula of:**
 - **Utricules detect balance in horizontal direction**
 - **Sacculle detect balance in horizontal and vertical direction**



- Mechanism of action:-

- 1- bending of stereocilia towards kinocilium >>>>> depolarization & Ca entry & neurotransmitter release >>>>>- increase rate of impulses to 8th nerve fibers
- 2- bending of stereocilia away from kinocilium
- >>>>- hyperpolarization >>>> decrease rate of impulses to 8th nerve fibers

• 2 - Detection of linear acceleration :-

- - linear acceleration:- as at running & standing in a bus .
- - at beginning of movement statoconia lag behind movement by its inertia >>>> fall backwards
- >>>>cilia moves backward >>>> person feels he is falling backwards
- >>>> try to correct this by leaning forwards to shift statoconia & cilia anteriorly



- - at deceleration (runner try to stop) >>>>>
- statoconia move forwards by its momentum
- >>>> person feels falling anteriorly

NO MOTION



LINEAR ACCELERATION



LINEAR DECELERATION



Semicircular canals

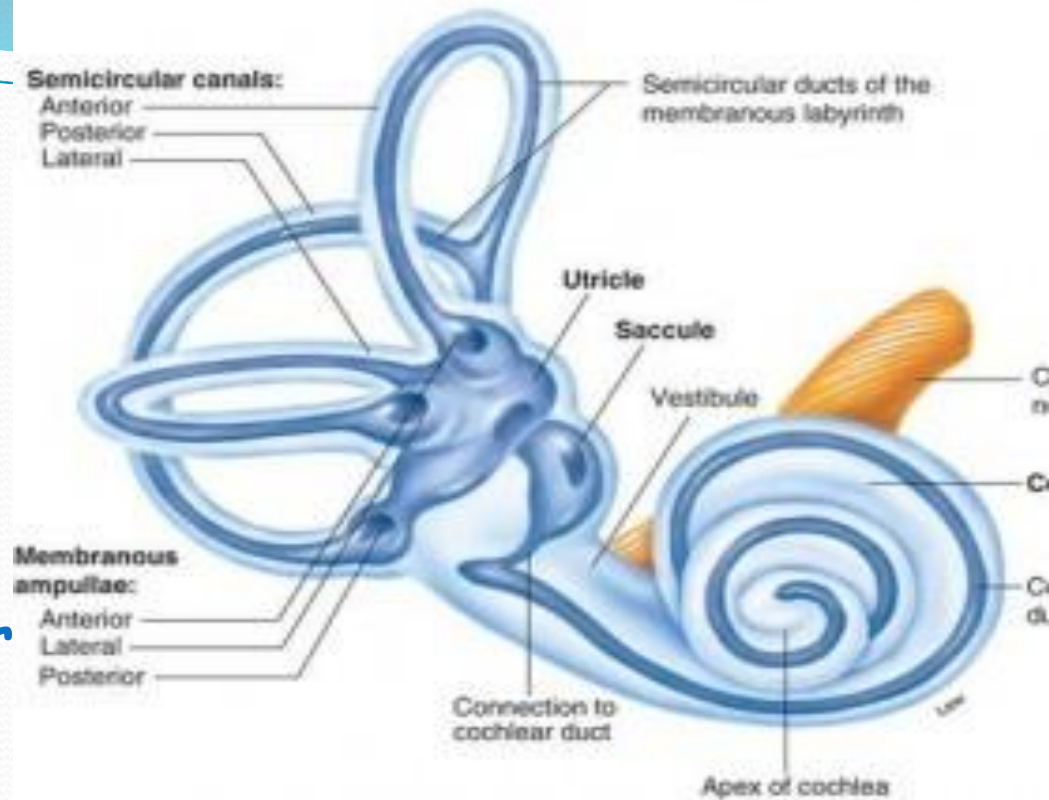
Horizontal

Anterior

Posterior

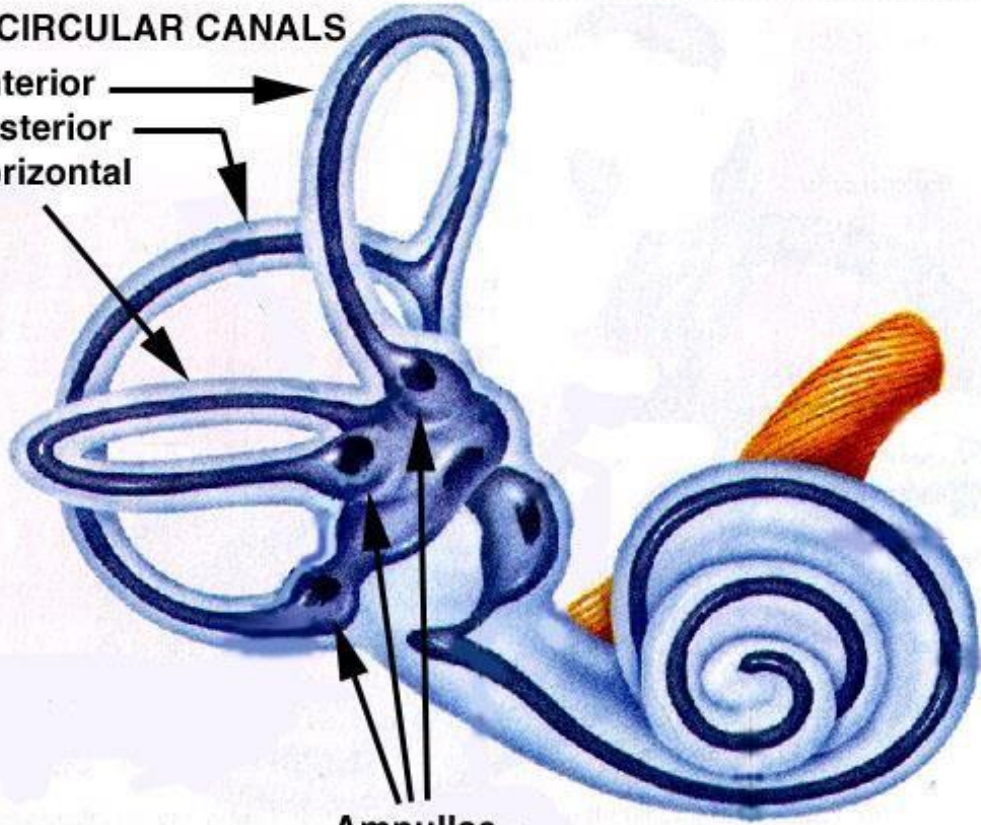
Perpendicular to each other
Filled with endolymph
Dilated end called ampulla
crista ampularis (as macula)
cilia embedded in a
gelatinous mass called
cupula)

Detect angular changes



SEMICIRCULAR CANALS

Anterior →
Posterior ↘
Horizontal ↙



Ampullae

Semicircular ducts:

Anterior

Lateral

Posterior

Ampullae

Crista ampullaris and cupula

(a)

Cupula

Endolymph

Hair cells

Supporting cells

Sensory nerve fibers

Crista ampullaris

(b)

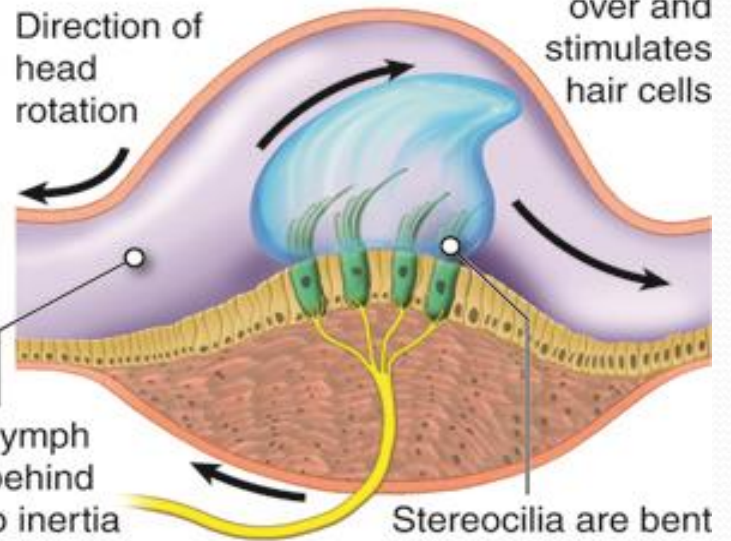
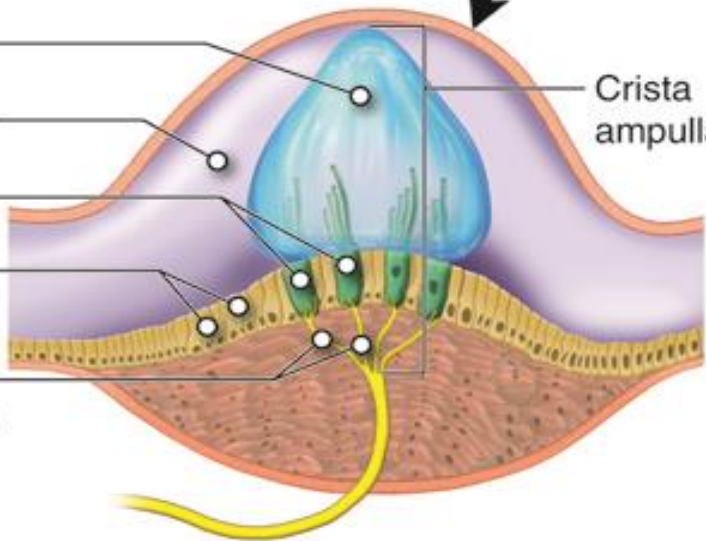
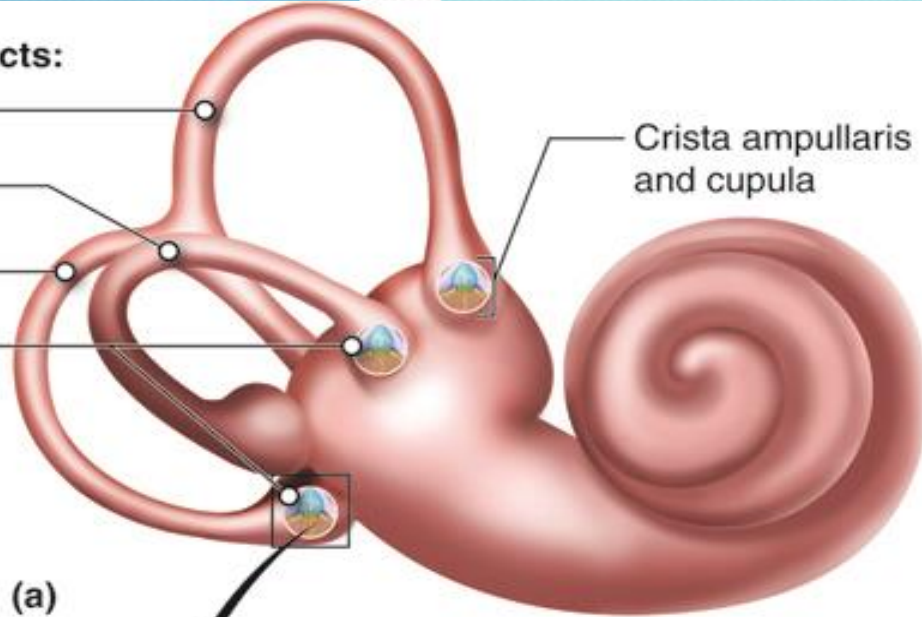
Direction of head rotation

Cupula is pushed over and stimulates hair cells

Endolymph lags behind due to inertia

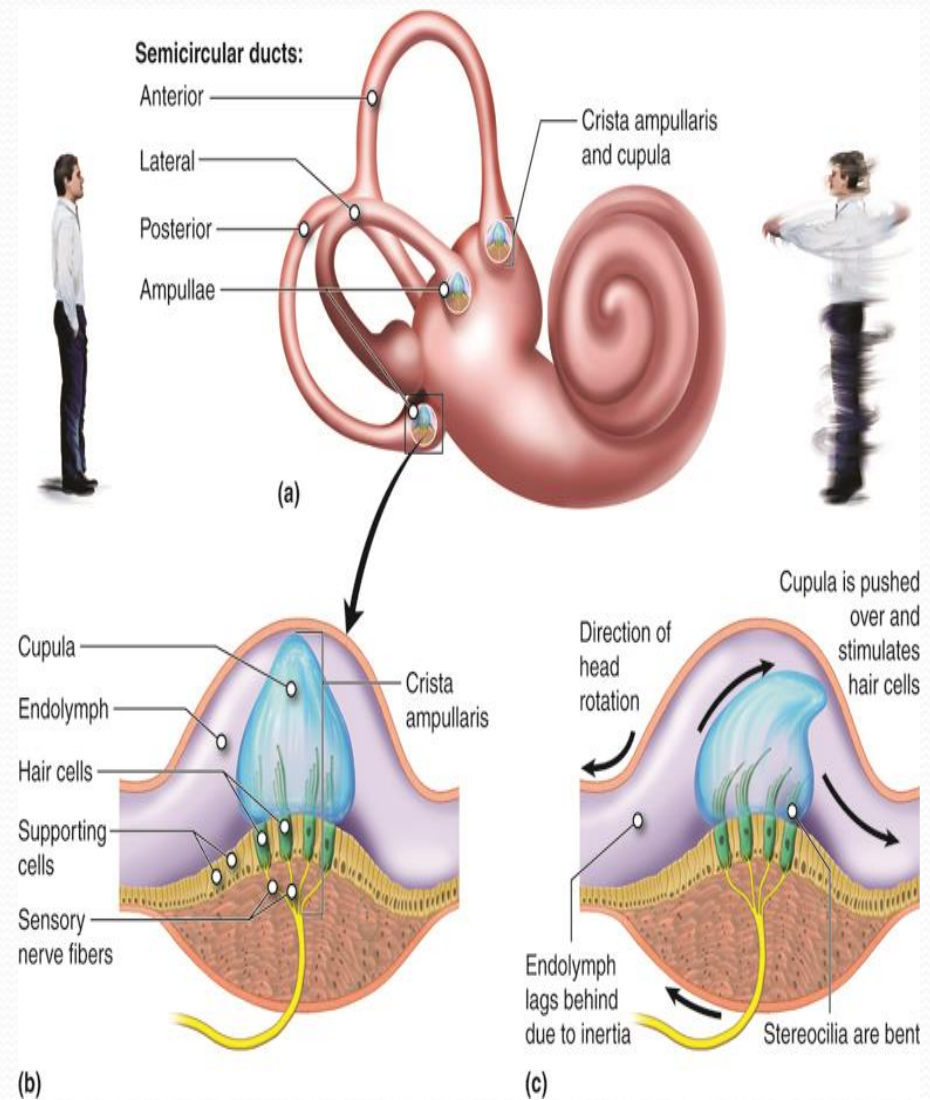
Stereocilia are bent

(c)



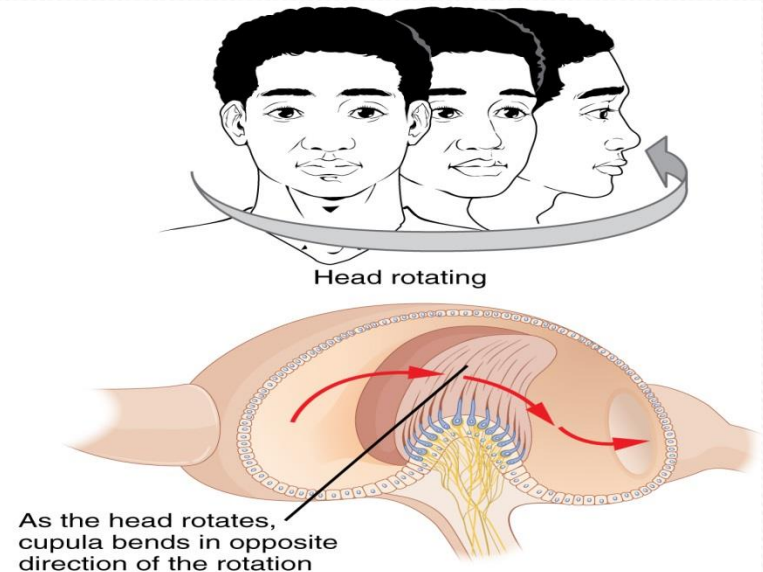
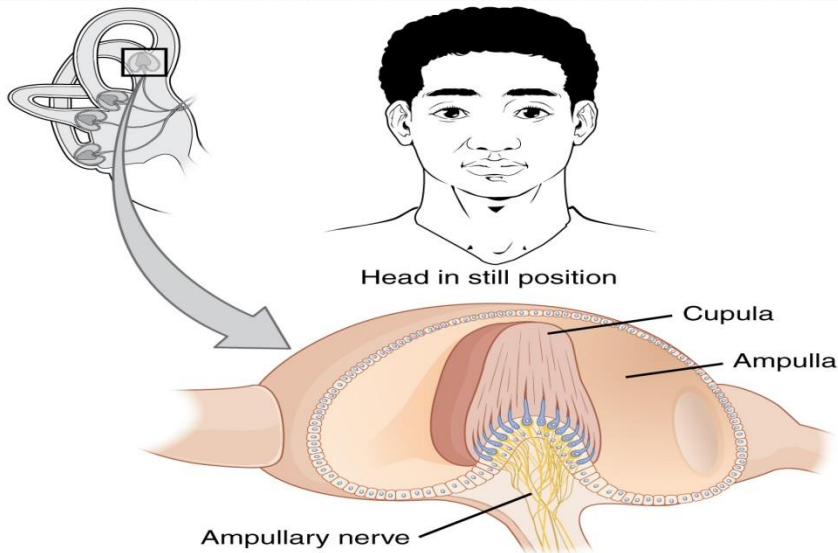
• Mode of action & functions

- 1- during rest : equal discharge from SCC on both
- 2- Detect & maintain posture during head rotation in any direction
- (angular acceleration) rotation



Rotation from left to right in horizontal plane:-

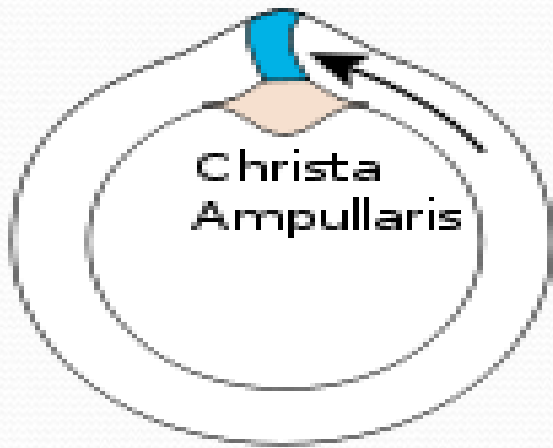
- Endolymph -->>>opposite direction by
- inertia --from right to left,
- -> the cilia of right side bent by endolymph towards the kinocilium
>towards the utricle--
- depolarization--impulses from right side increase.
- --impulses fom left side decrease as cilia bent away from kinocilium.>>>>>
- - sensation of rotation to right.



Head Movement



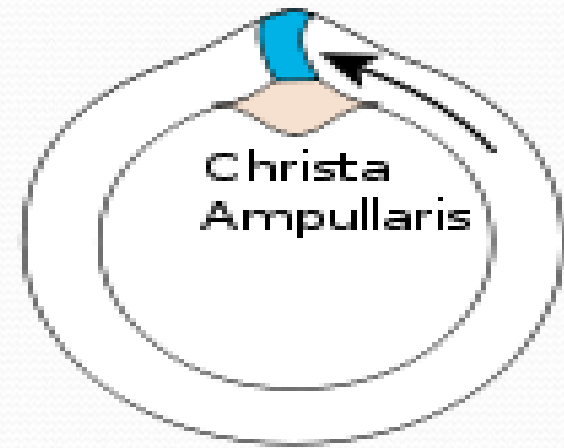
Cupula



Christa
Ampullaris

left side:
inhibition

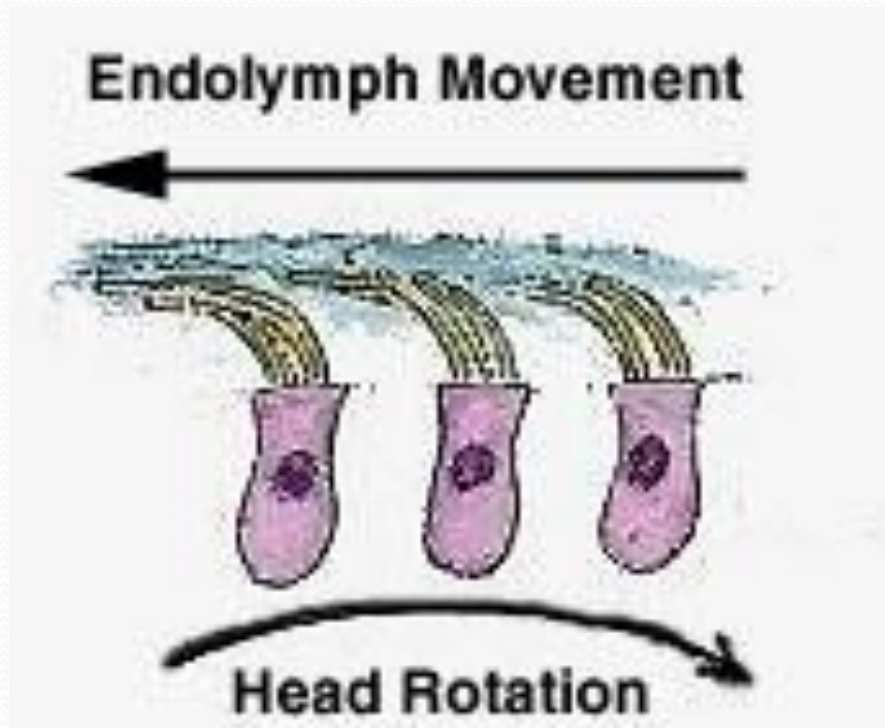
Cupula



Christa
Ampullaris

right side:
excitation

Copula in head rotation

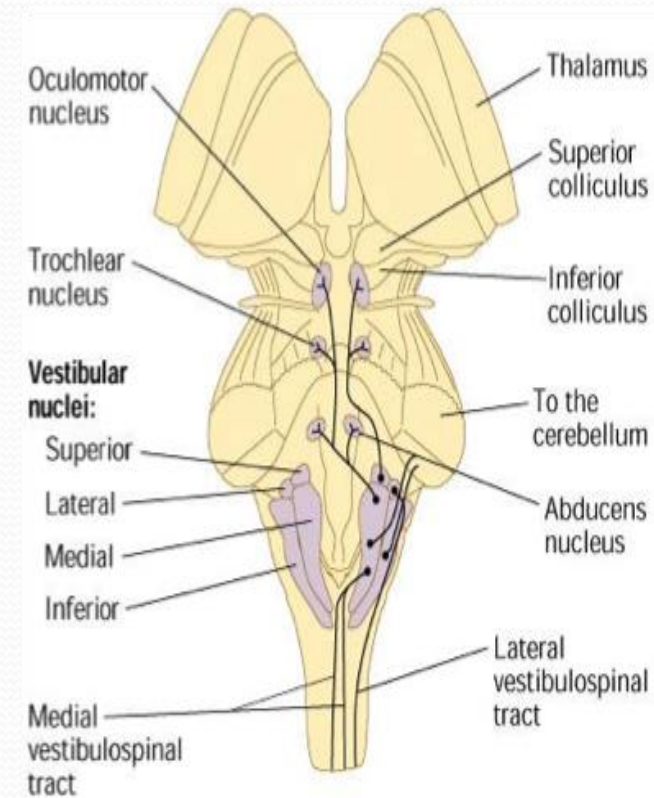
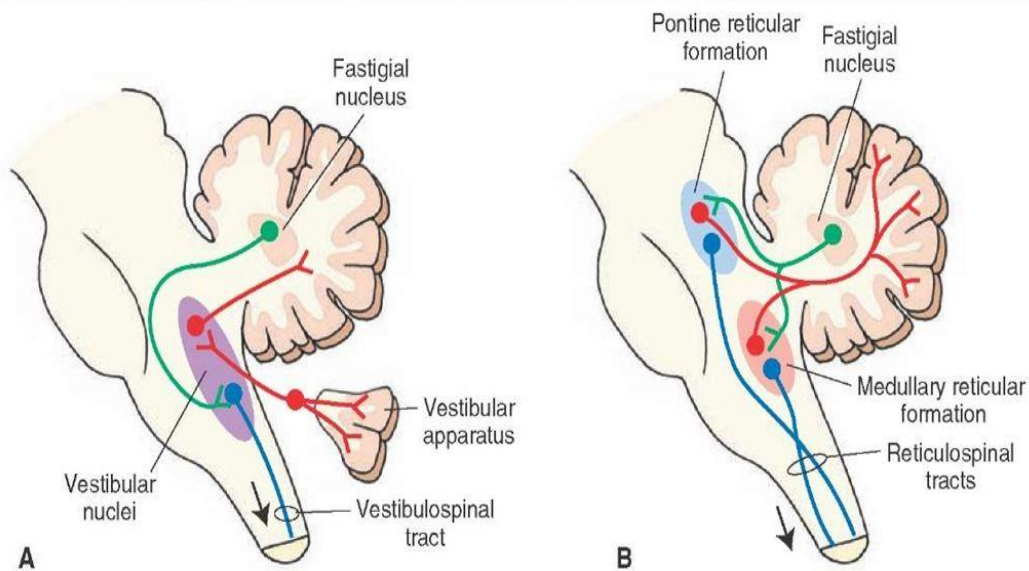


• Nervous connections of vestibular apparatus:-

Nerve fibers from maculae & cristae ampularis

- >> Vestibular nerve >> ipsilateral vestibular nucleus to :-

- 1- Cerebellum: flocculonodular lobe
- 2- Spinal cord (vestibulospinal tracts)
- 3- Reticular formation



Effects of stimulation of S.C.C (rotation)

- Vertigo: this false sensation of counter-rotation at end of rotation
- Nystagmus
- Bradycardia & hypotension
- Increased muscle tone on same side of rotation to support the body & decreased muscle tone on the opposite side

