

Inner ear in balance and equilibrium



17-inner ear in balance-student copy.lnk

Control of Equilibrium

Equilibrium: Reflexes maintain body position at rest & movement .

Sensory inputs from:

1. Vestibular system
2. Visual system
3. Proprioceptive system
4. Cutaneous sensations

• Labyrinth:-

1- Membranous labyrinth :-

a- Auditory (cochlea for hearing)

b- Non- auditory for equilibrium

(Vestibular apparatus)

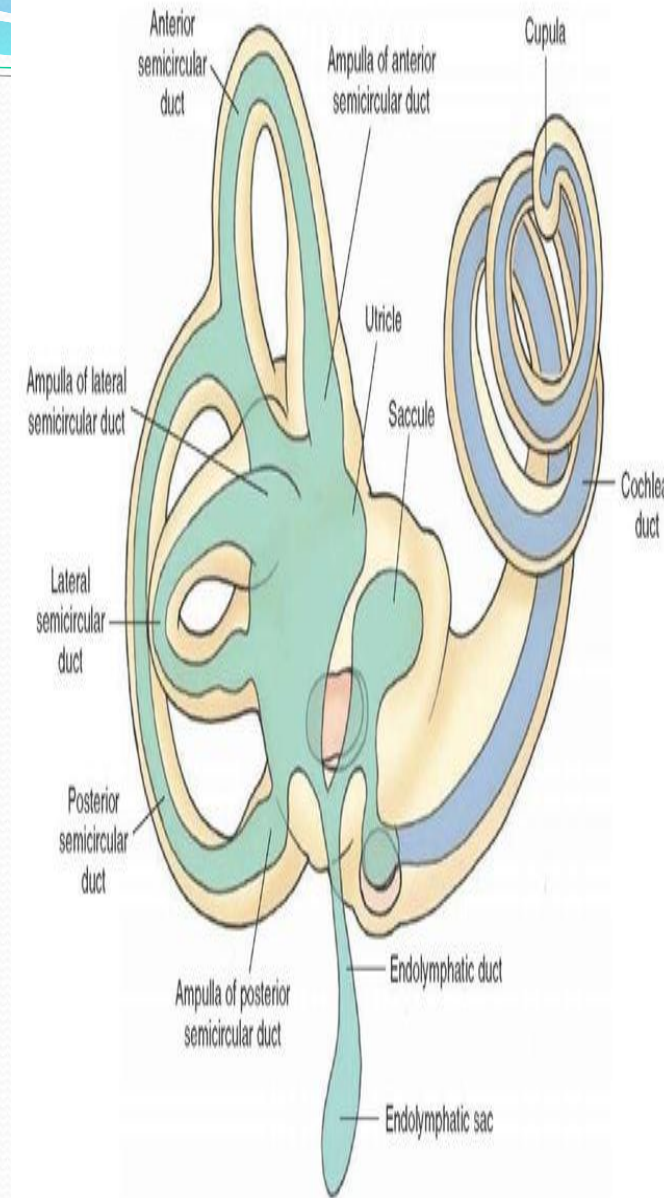
2- Bony labyrinth

(bony cochlea , vestibule & semicircular canals)

Enclose the membranous labyrinth.

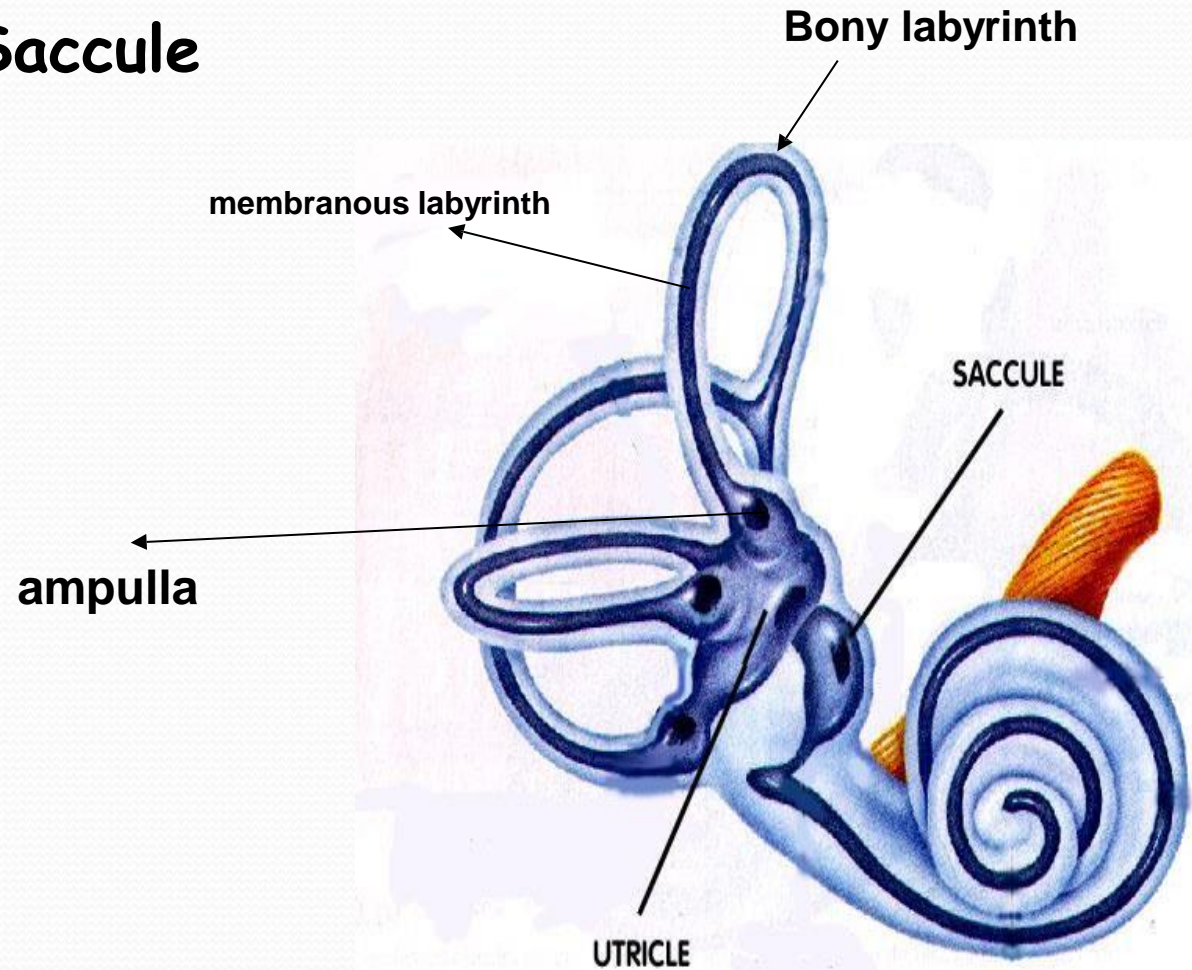
3 bony

labyrinth.

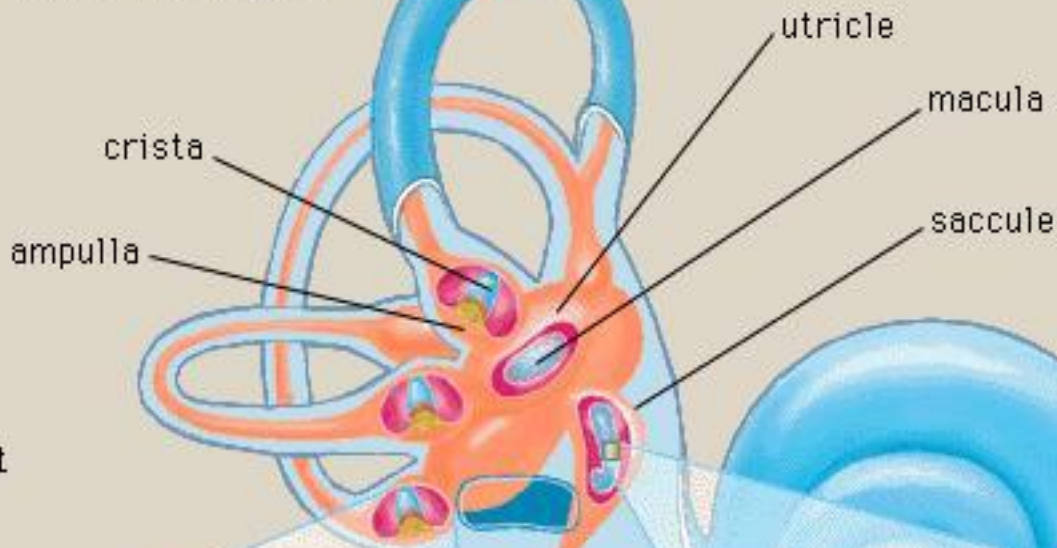


Vestibular apparatus:-

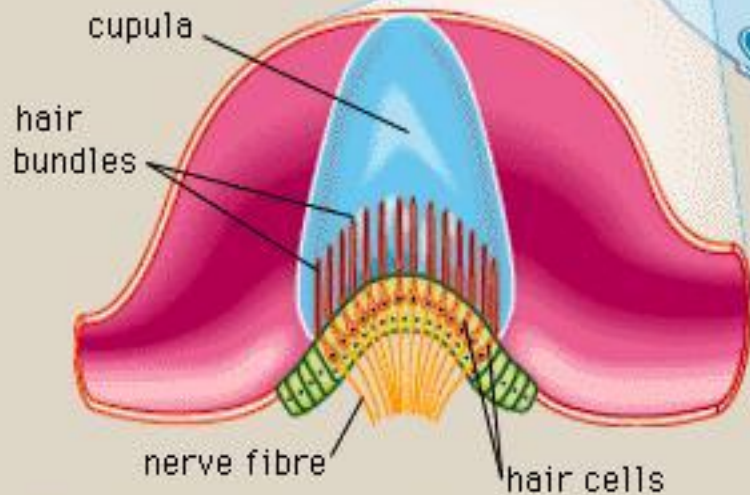
- 1- Utricle & Saccule
- 2- SCC



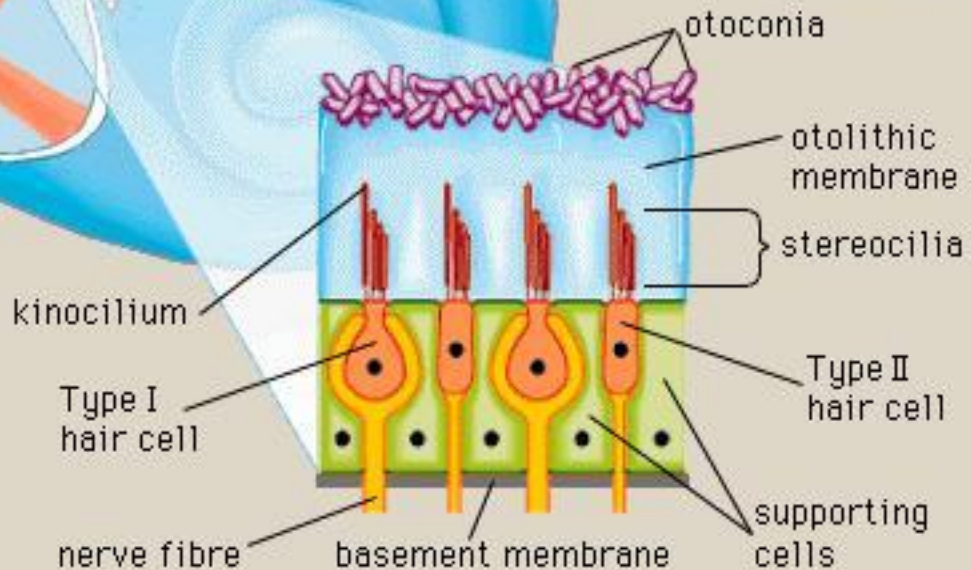
vestibular system

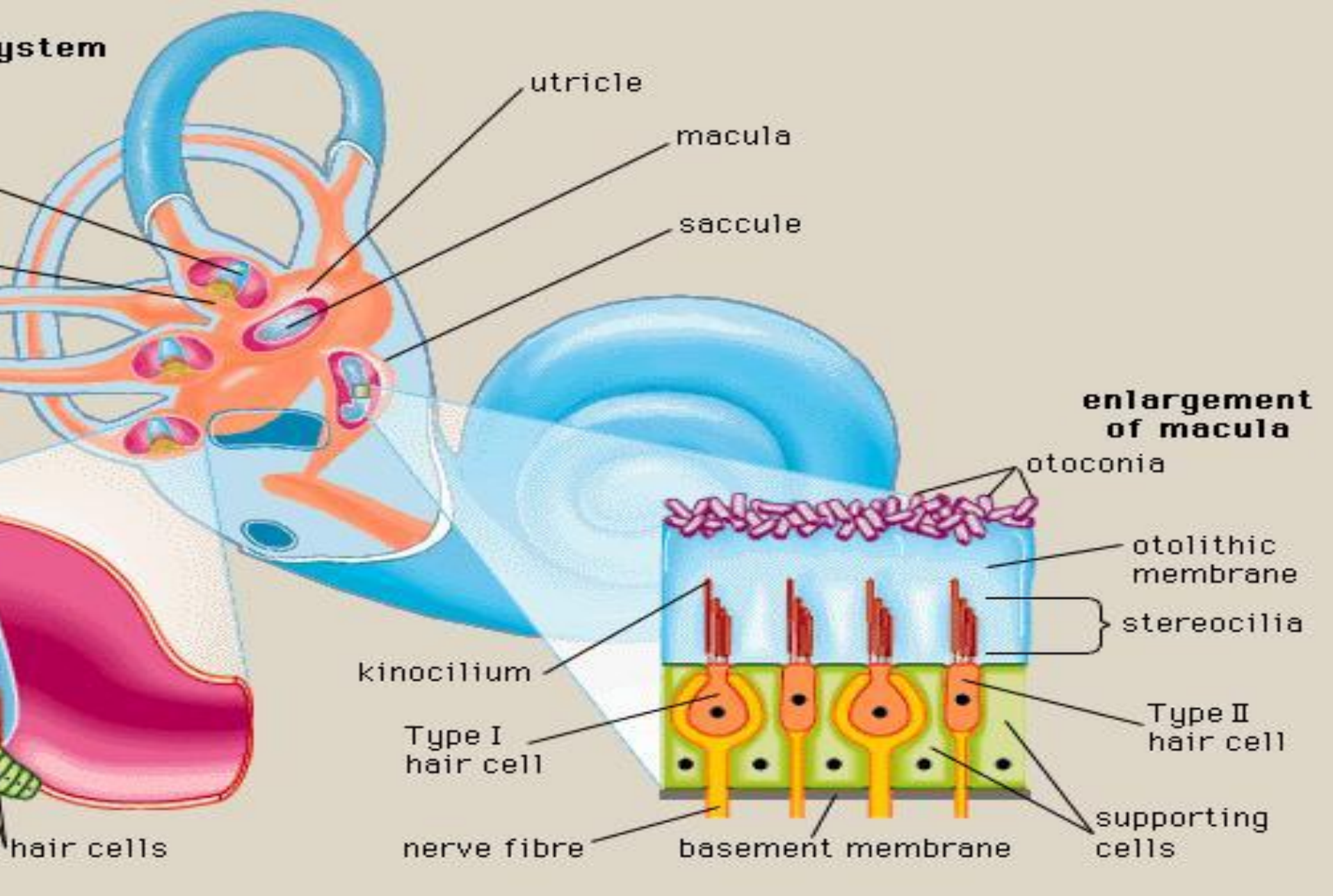


enlargement of crista



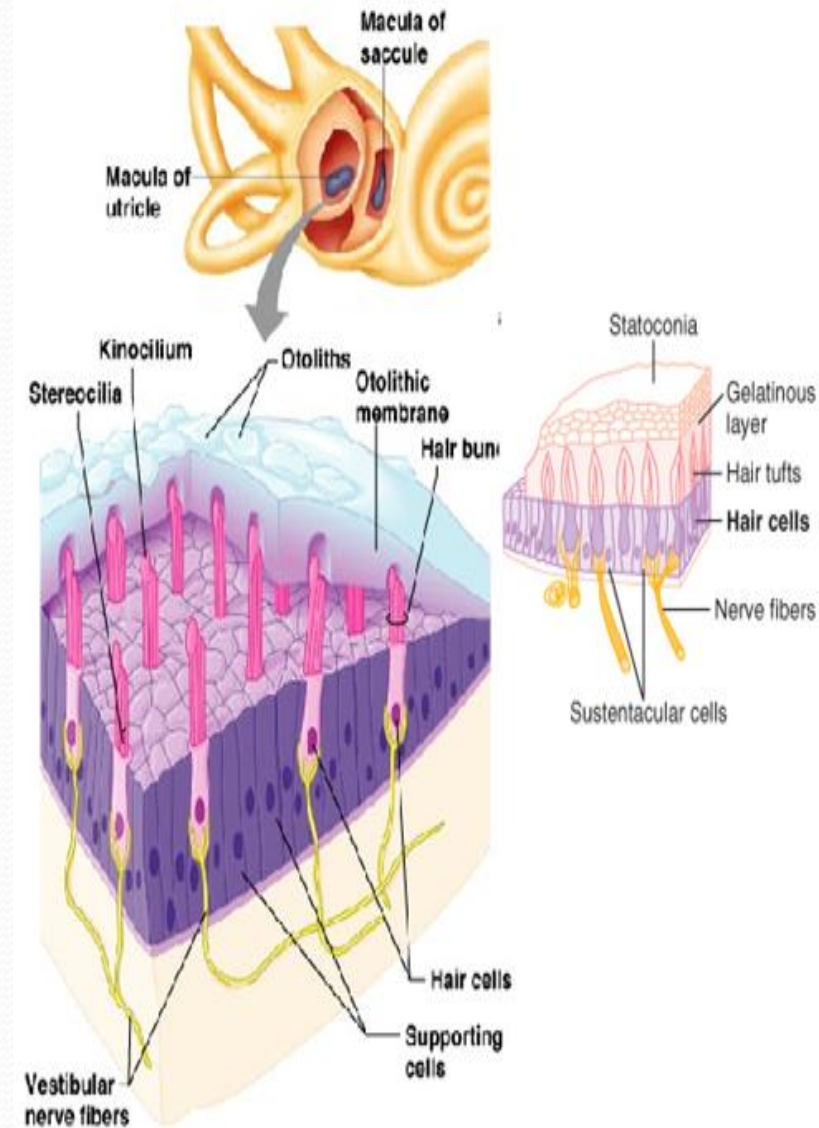
enlargement of macula





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 connectd 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



- Hair cells in utricle

Person in upright position: (Head vertical)

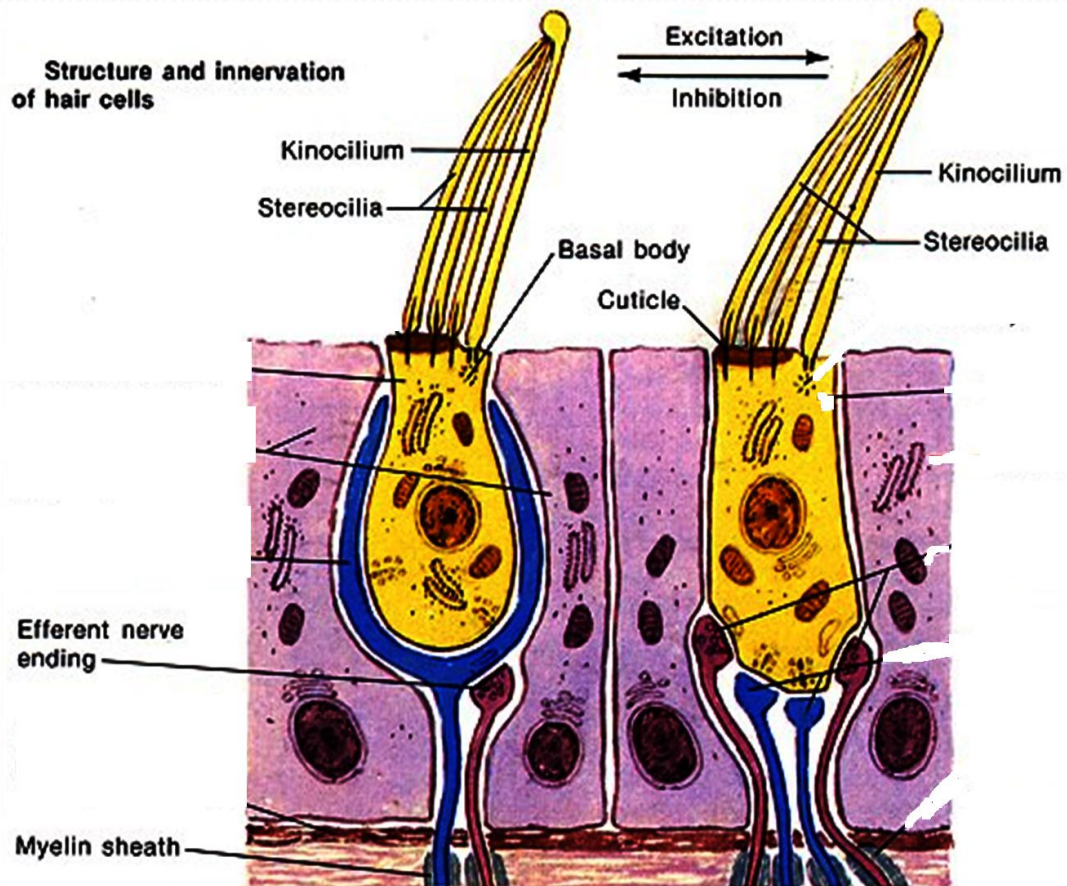
- Macula in horizontal plane
- Hairs pointing upwards
- Hair cells signal head movements in any direction >> >>
inform the brain of orientation of head in space

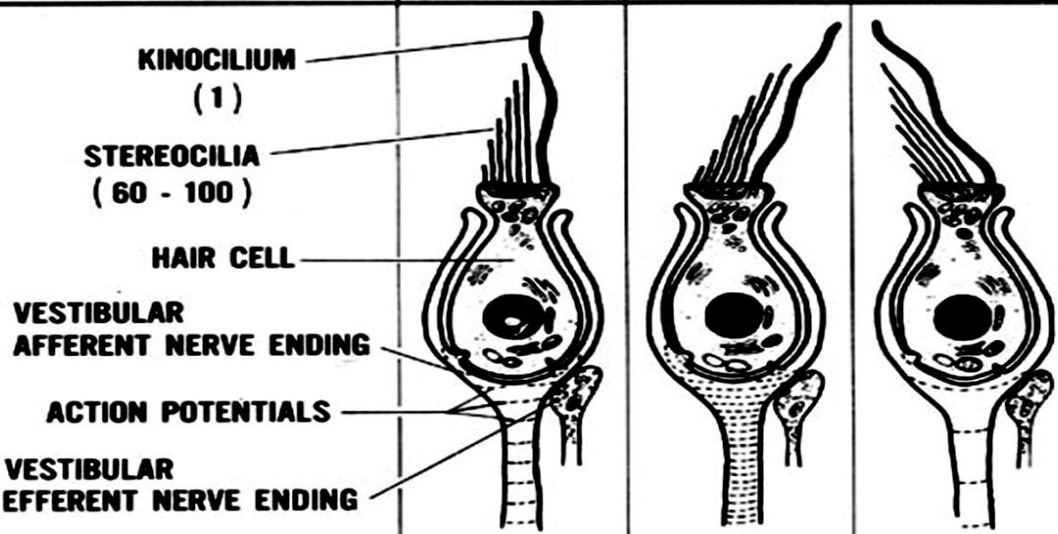



Hair cells in Sacculle

Person in upright position: (Head vertical)

- Macula in vertical plane
- Hairs pointing laterally
- Hair cells operate when one is lying down

**Structure and innervation
of hair cells**



POSITION OF CILIA	NEUTRAL	TOWARD KINOCILIUM	AWAY FROM KINOCILIUM
<p>KINOCILIUM (1)</p> <p>STEREOCILIA (60 - 100)</p> <p>HAIR CELL</p> <p>VESTIBULAR AFFERENT NERVE ENDING</p> <p>ACTION POTENTIALS</p> <p>VESTIBULAR EFFERENT NERVE ENDING</p> 			
POLARIZATION OF HAIR CELL	NORMAL	DEPOLARIZED	HYPERPOLARIZED
FREQUENCY OF ACTION POTENTIALS	RESTING	HIGHER	LOWER

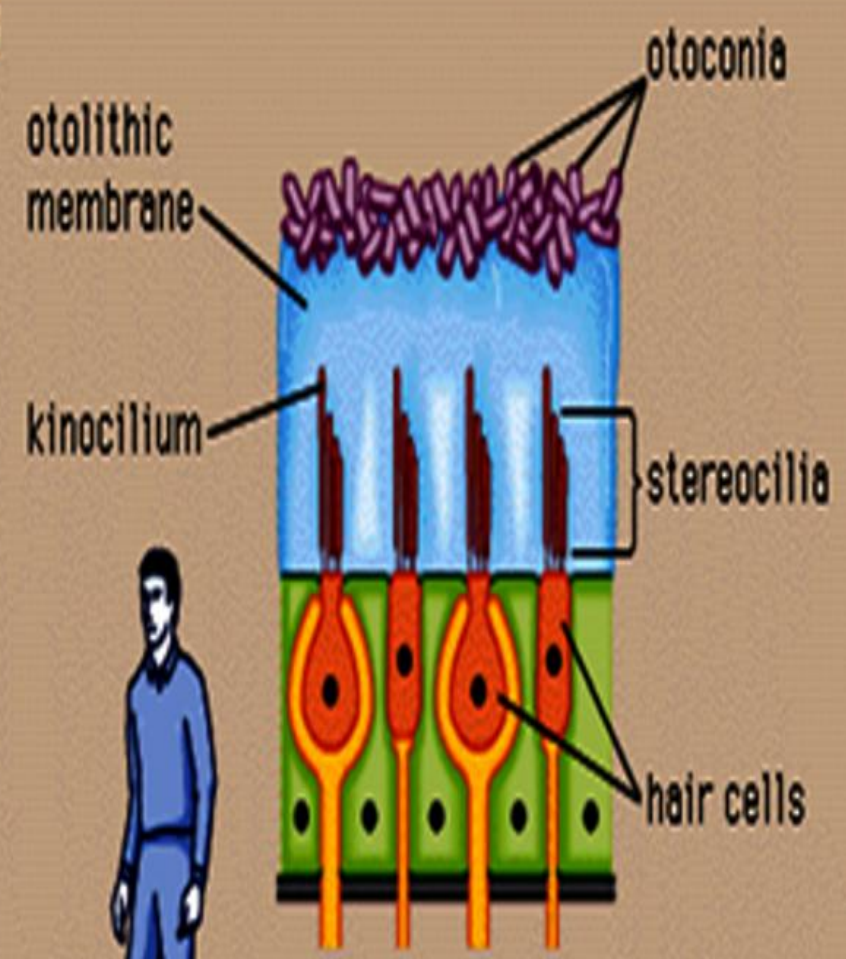


displaced section of the utricular macula



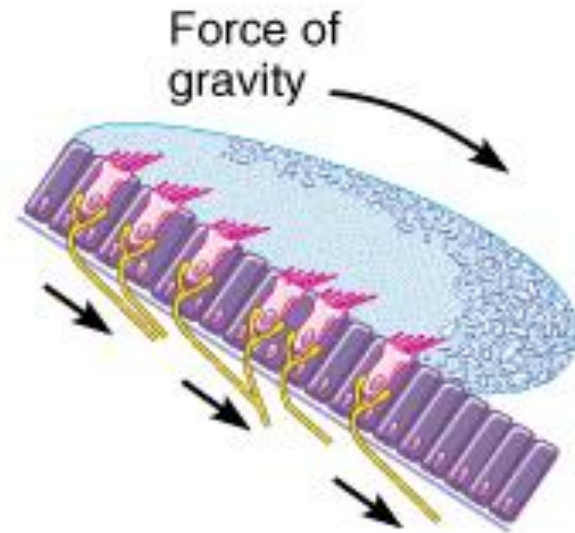
head bent forward

B



head upright

upright section of the utricular macula

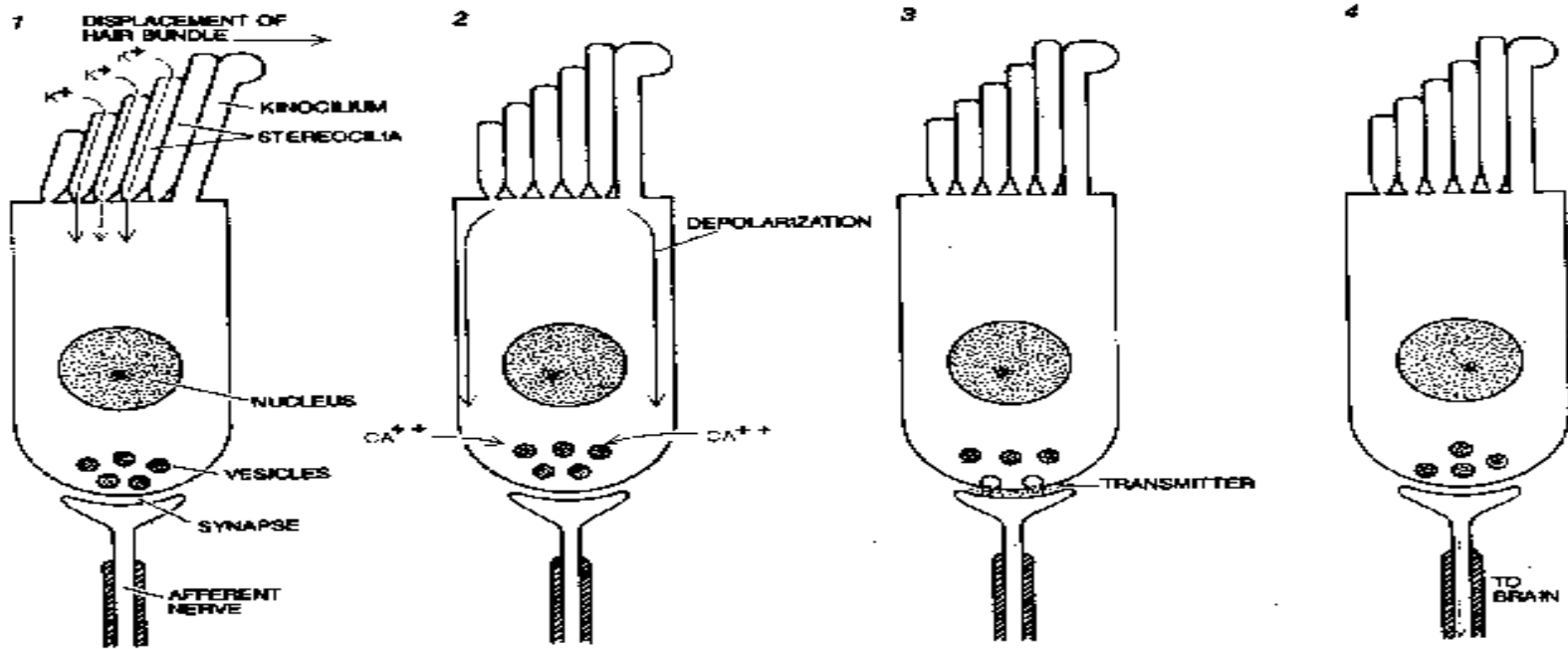


Head upright



Head tilted

(c)



- 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

Functions of macula (mainly utricle):-

- 1- orientation of head in space & maintenance of static equilibrium:-
 - a-in erect upright position (vertical position) :
 - RT & LT utricle impulses balance each other
 - No sensation of male-equilibrium
 - b- bending the head to one side ;
 - - statoconia crystals of hair cells fall to that side by their weight>>>>>pull stereocilia to move towards kinocilium>>>>>depolarization (stimulation)
 - -stereocilia of the other side moves away from kinocilium-----hyper-polarization (inhibition)

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**



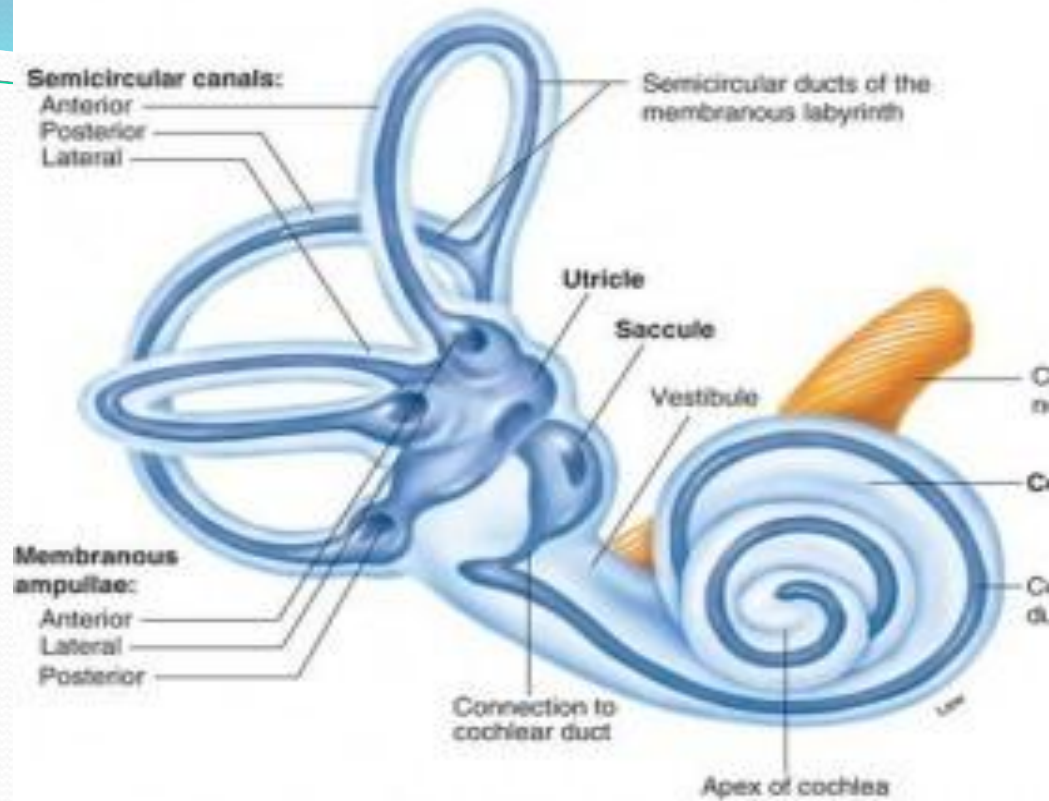
**LINEAR
DECELERATION**

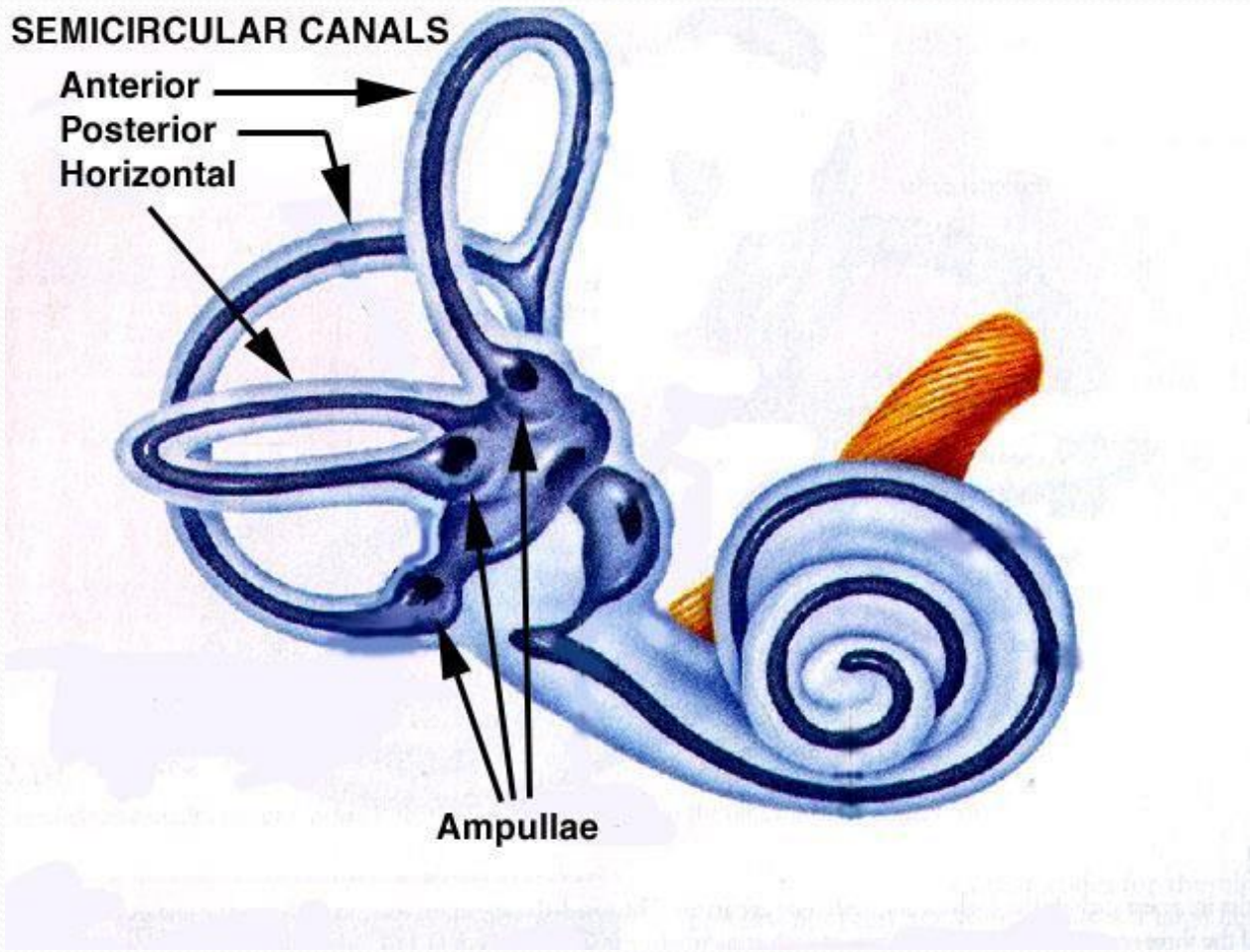


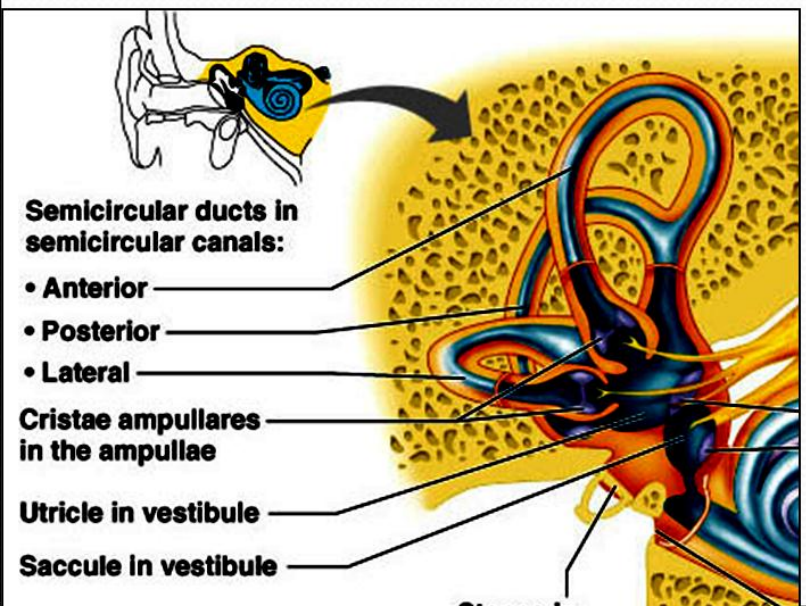
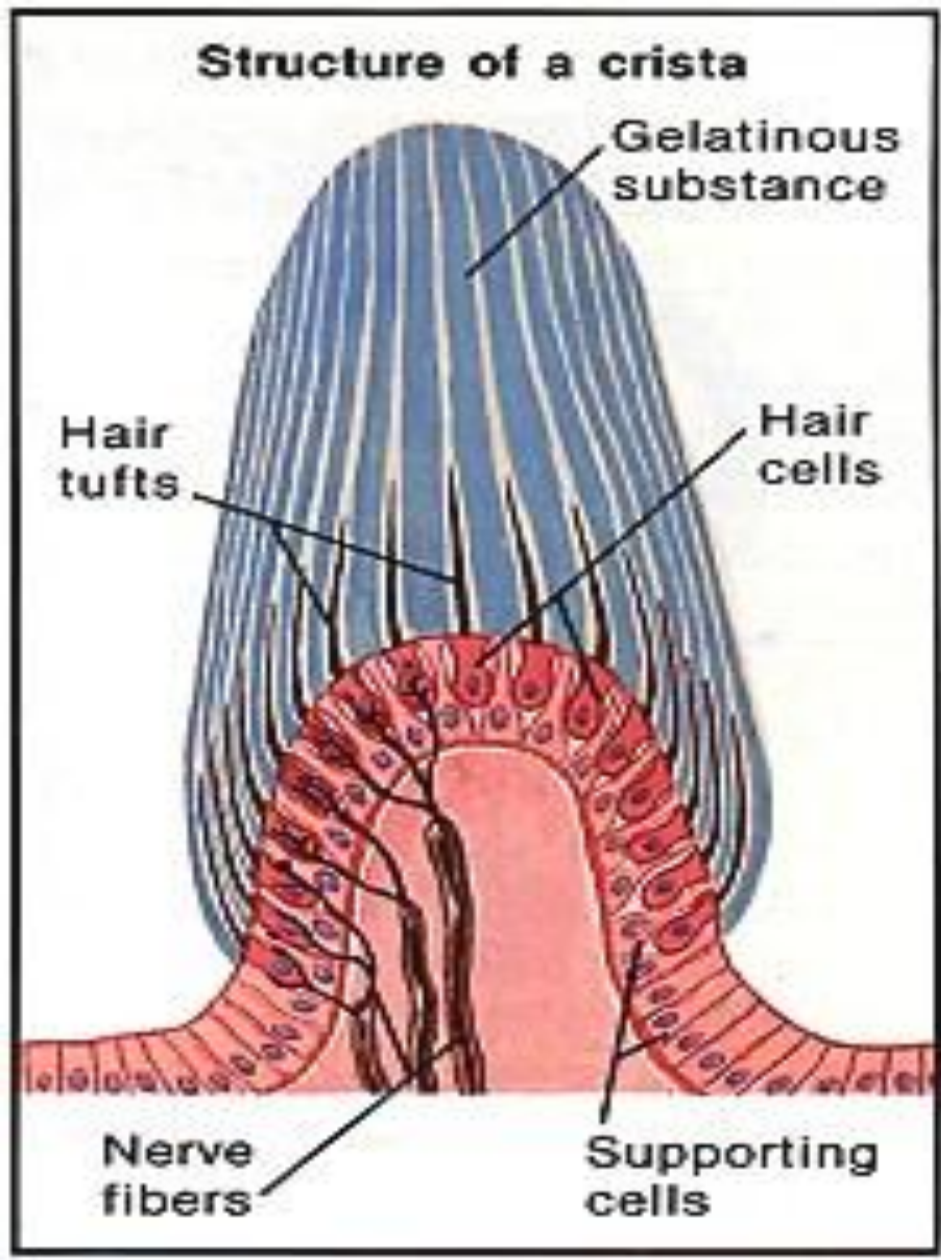
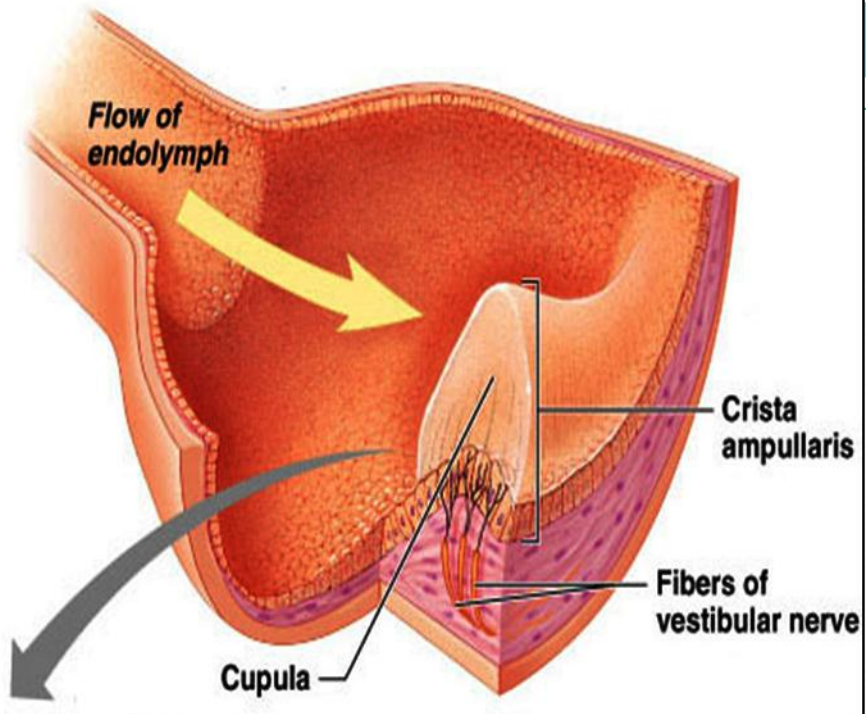
Semicircular canals

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).







Semicircular ducts:

Anterior

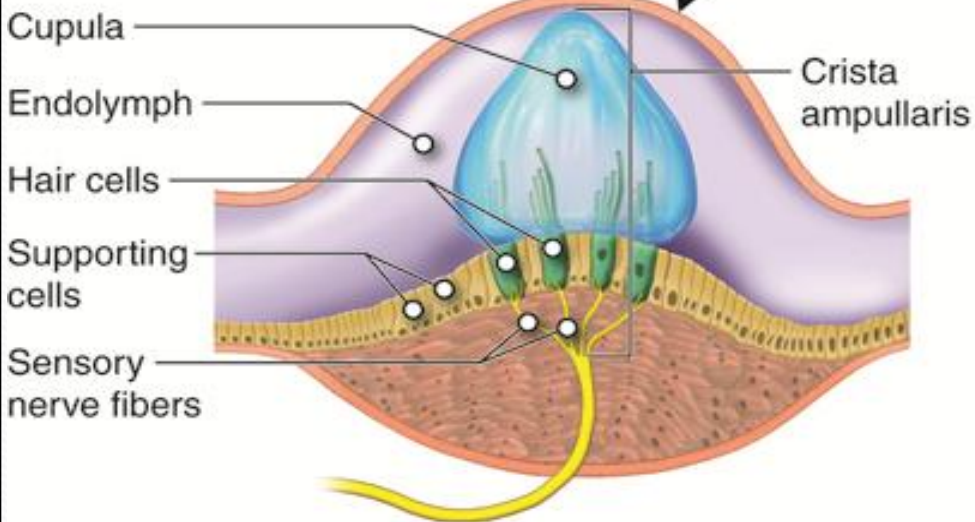
Lateral

Posterior

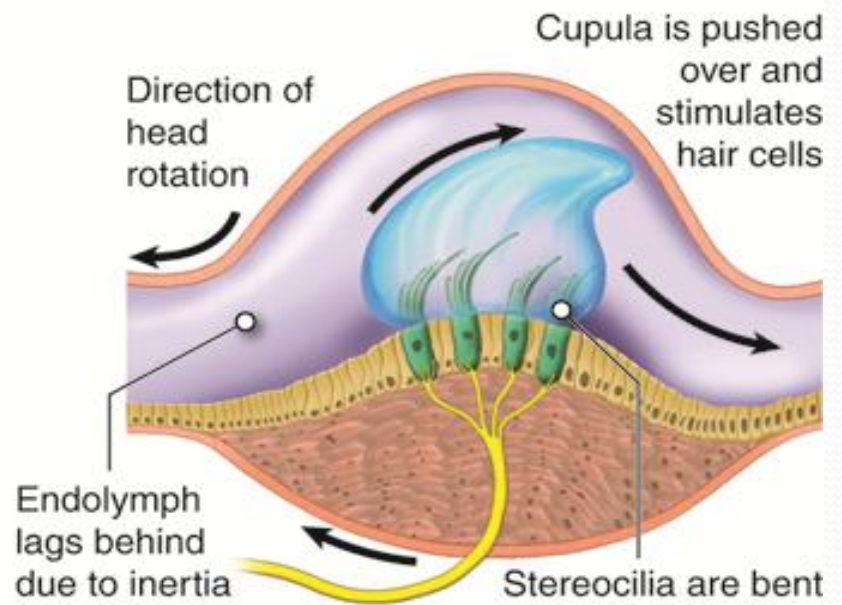
Ampullae

Crista ampullaris and cupula

(a)



(b)

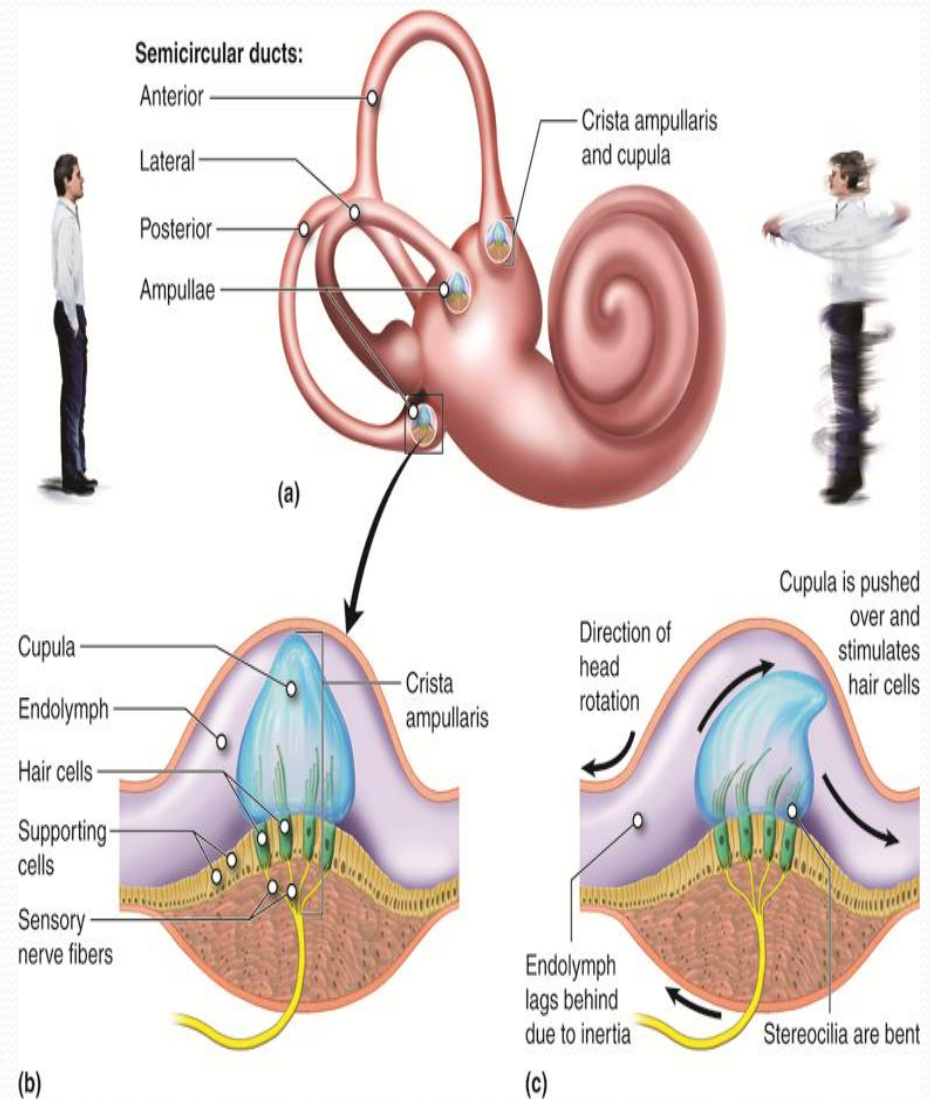


(c)



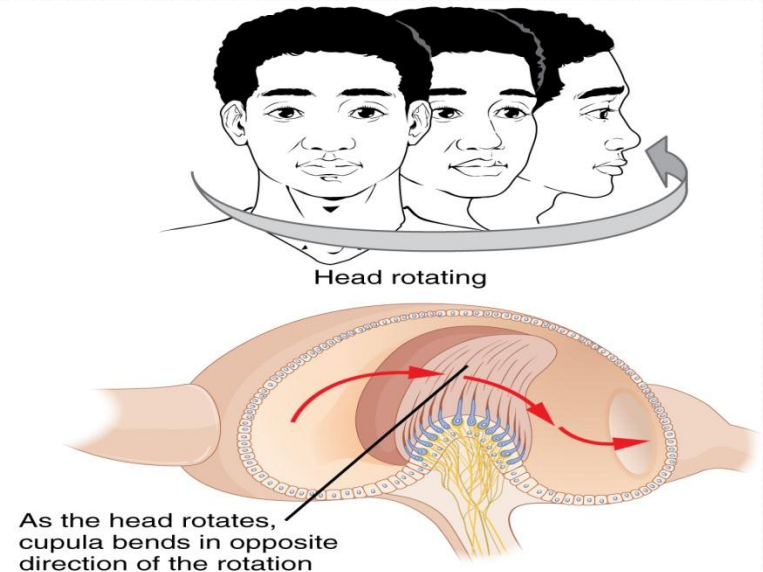
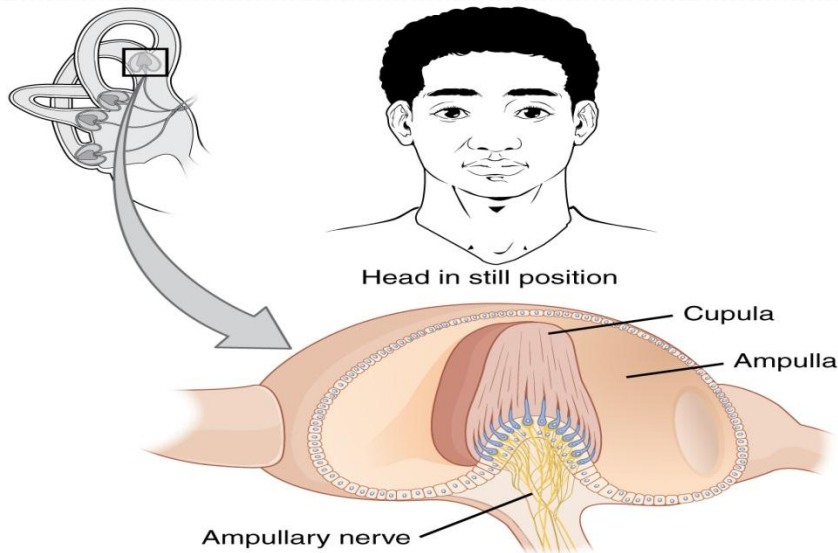
• Mode of action & functions

- 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:-

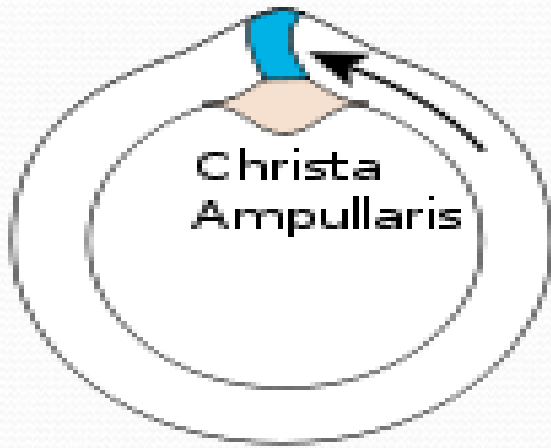
- Endolymph -->>>opposite direction by
- inertia --from right to left,
- -> the cilia of right side bent by endolymph towards the kinocilium >towards the utricle--
- depolarization--impulses from right side increase.
- --impulses fom left side decrease as cilia bent away from kinocilium.>>>>>
- - sensation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



Head Movement



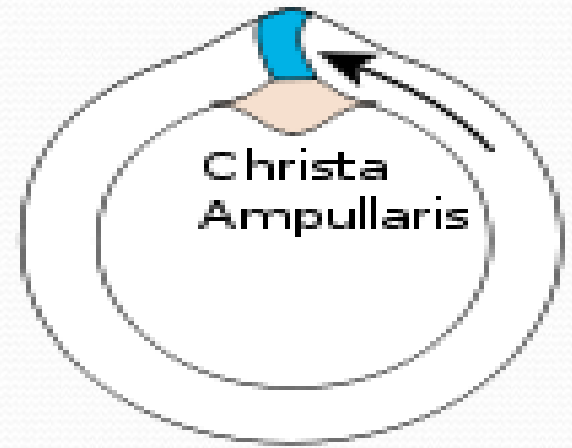
Cupula



Christa Ampullaris

left side:
inhibition

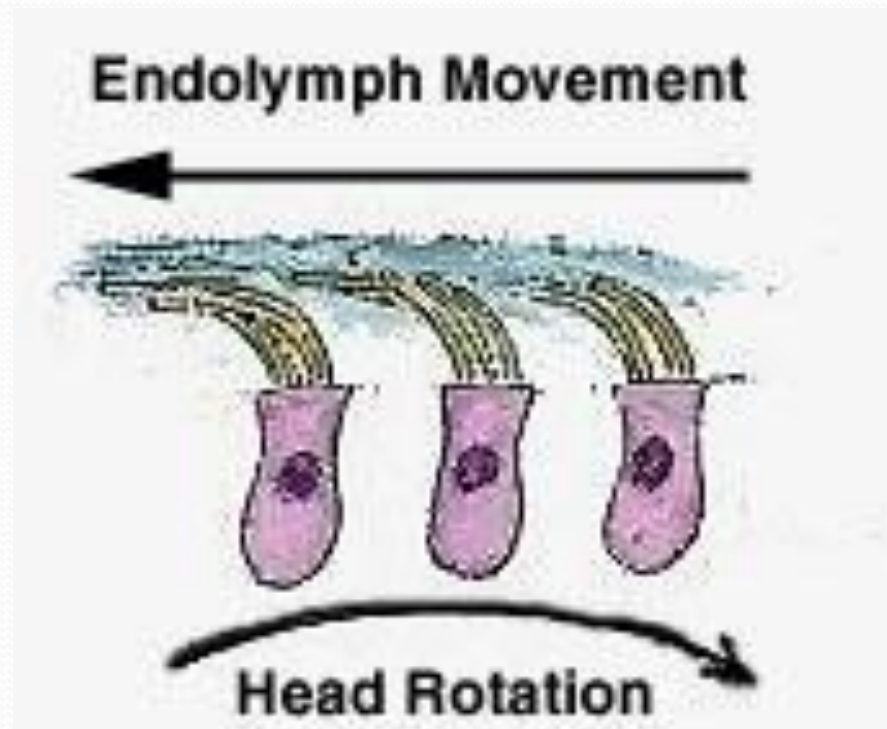
Cupula



Christa Ampullaris

right side:
excitation

Copula in head rotation



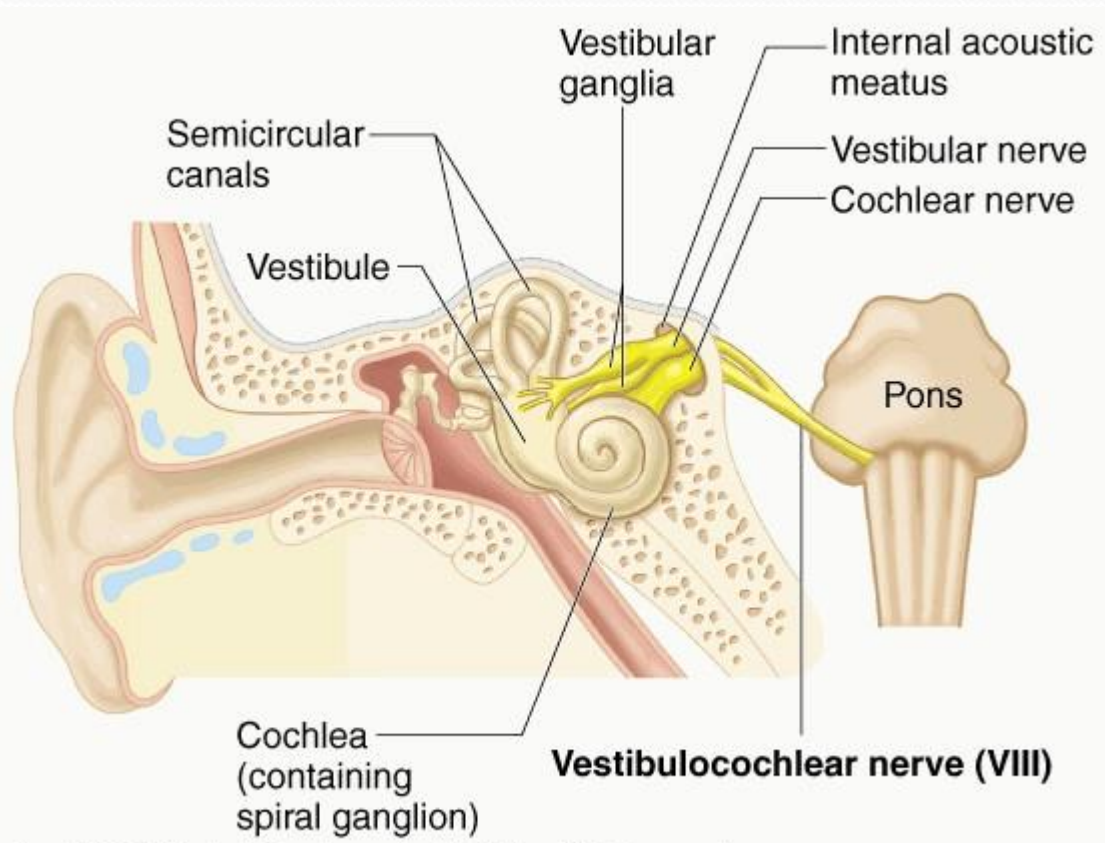
VESTIBULAR FUNCTION

Predictive function of SCC in the maintenance of equilibrium:

i.e. Predict ahead of time that mal-equilibrium is going to occur



Send impulses to CNS for corrective measures before the start of the fall



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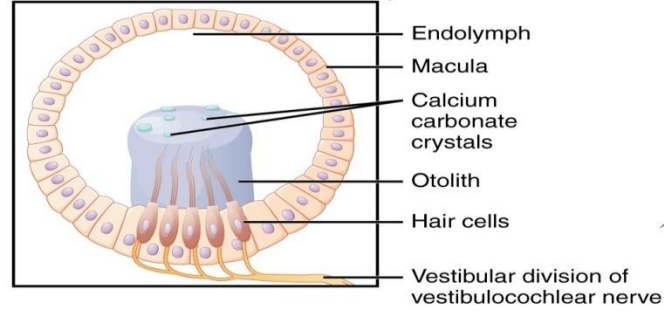
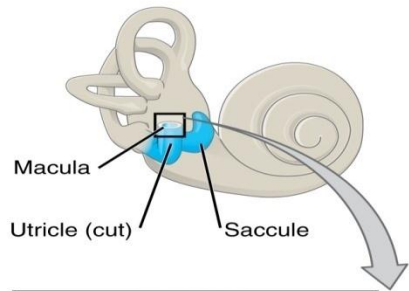
VESTIBULAR PATHWAY

Neural Connections:

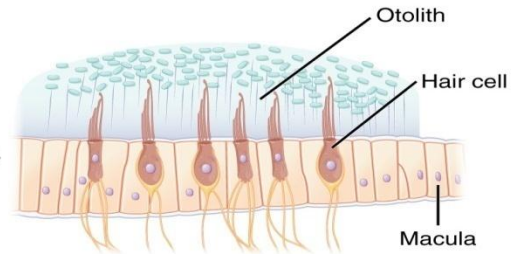
- The vestibular nuclei on either sides of the brain stem send signal to:
- Cerebellum.
- Nuclei of cranial nerves III, IV, and VI
- Reticular formation
- Spinal cord (vestibulospinal tracts)
- Thalamus

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

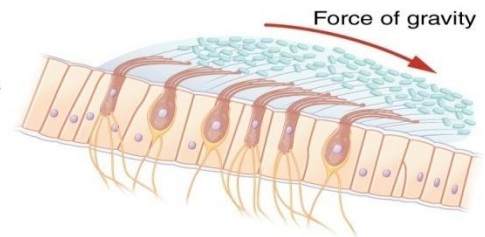
- Vertigo: this false sensation of counter-rotation at end of rotation
- Nystagmus
- Bradycardia & hypotension
- Increased muscle tone on same side of rotation to support the body & decreased muscle tone on the opposite side



Head upright



Head tilted forward



Head Rotation

