Inner ear in balance and equilibrium

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 :-

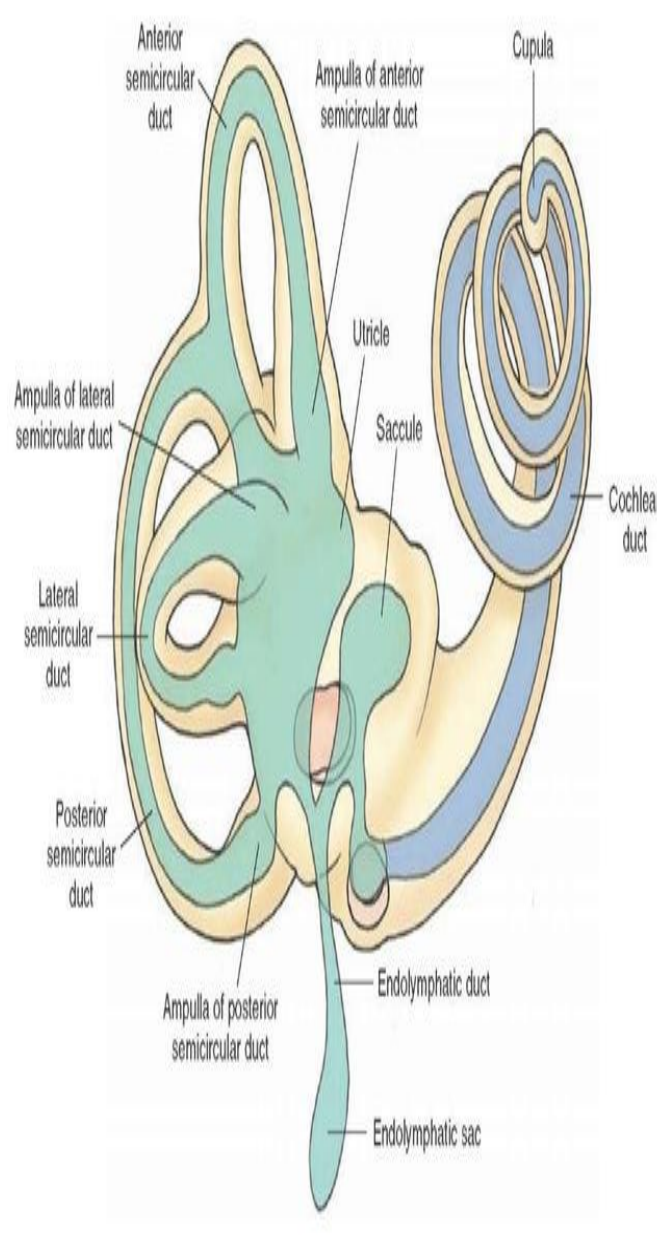
a- Auditory (cochlea for hearing)

b- Non- auditory for equilibrium

(Vestibular apparatus)

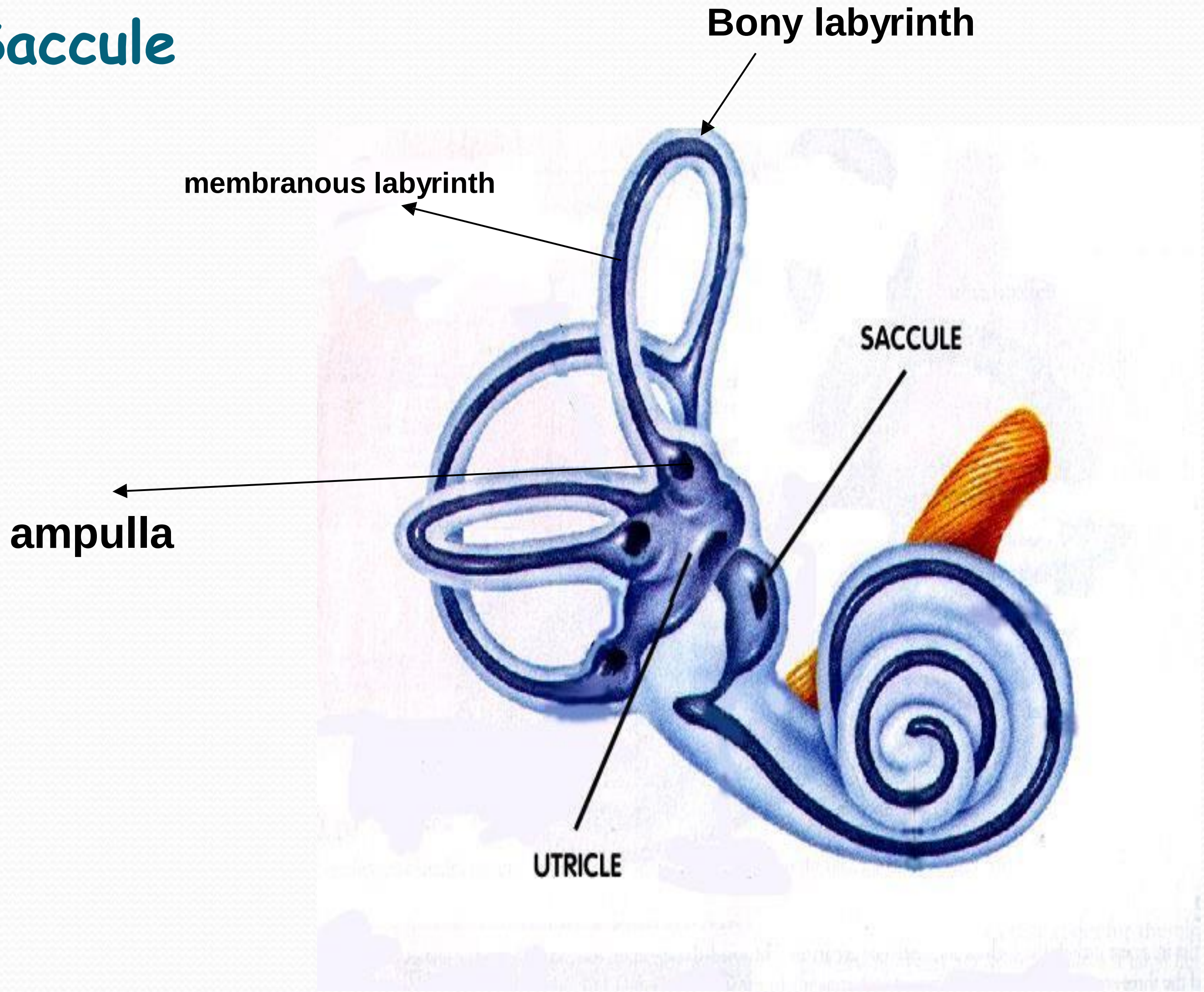
2- Bony labyrinyth (bony cochlea & 3 bony semicircular canals)

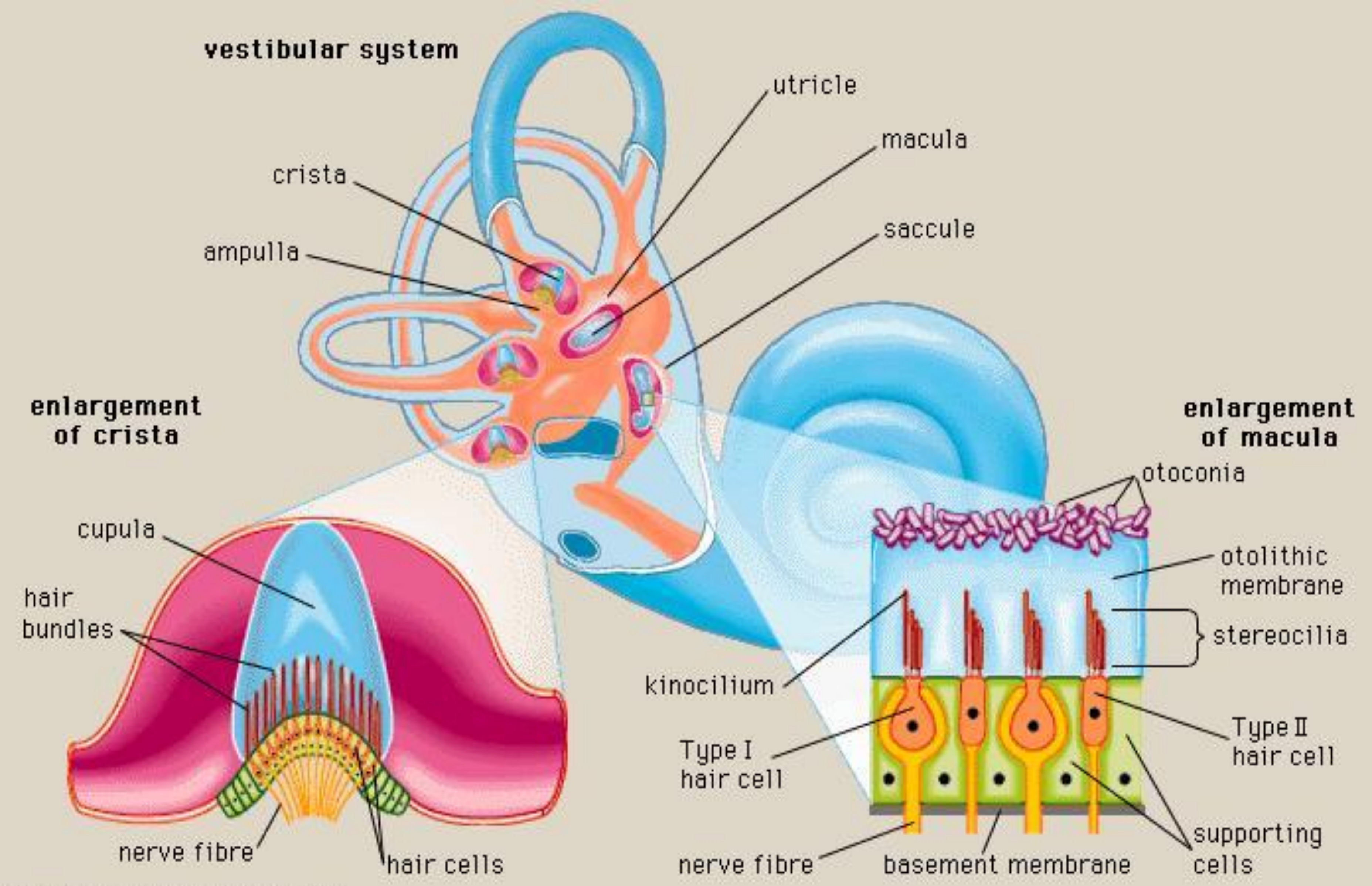
Enclose the membranous labyrinth.

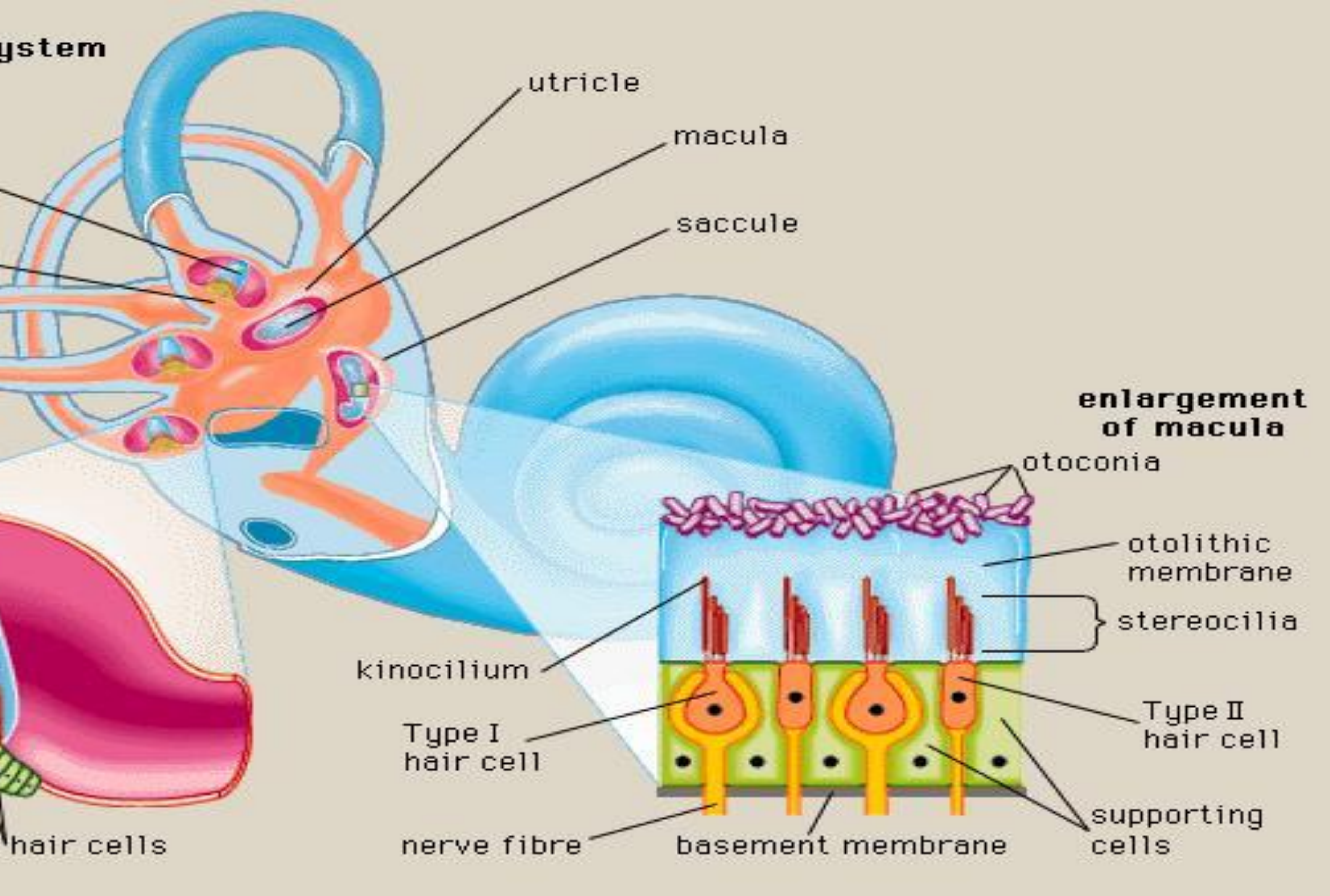


Vestibular apparatus:-

1- Utricle & Saccule
2- SCC




vestibular system
utricle
macula
crista
saccule
ampulla
enlargement of crista
enlargement of macula
otoconia
cupula
otolithic membrane
hair bundles
stereocilia
kinocilium
Type I hair cell
Type II hair cell
nerve fibre
hair cells
supporting cells
nerve fibre
basement membrane

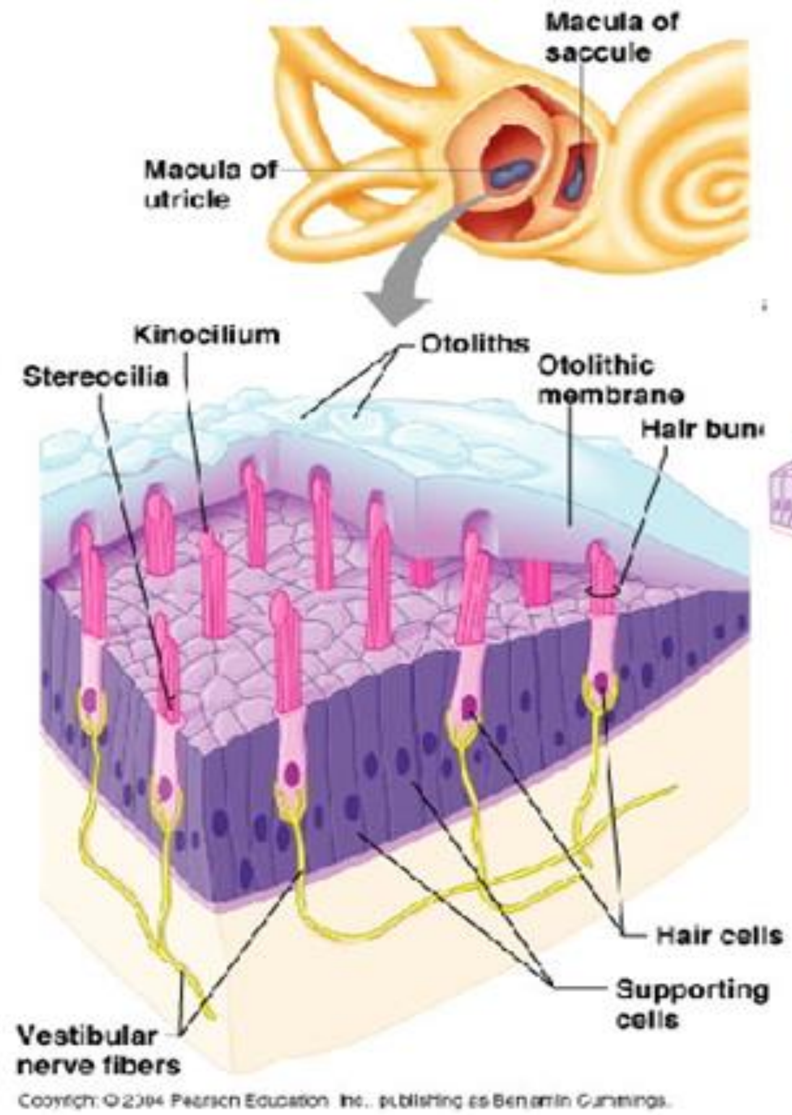

ystem
utricle
macula
saccule
enlargement of macula
otoconia
otolithic membrane
stereocilia
kinocilium
Type I hair cell
Type II hair cell
supporting cells
hair cells
nerve fibre
basement membrane

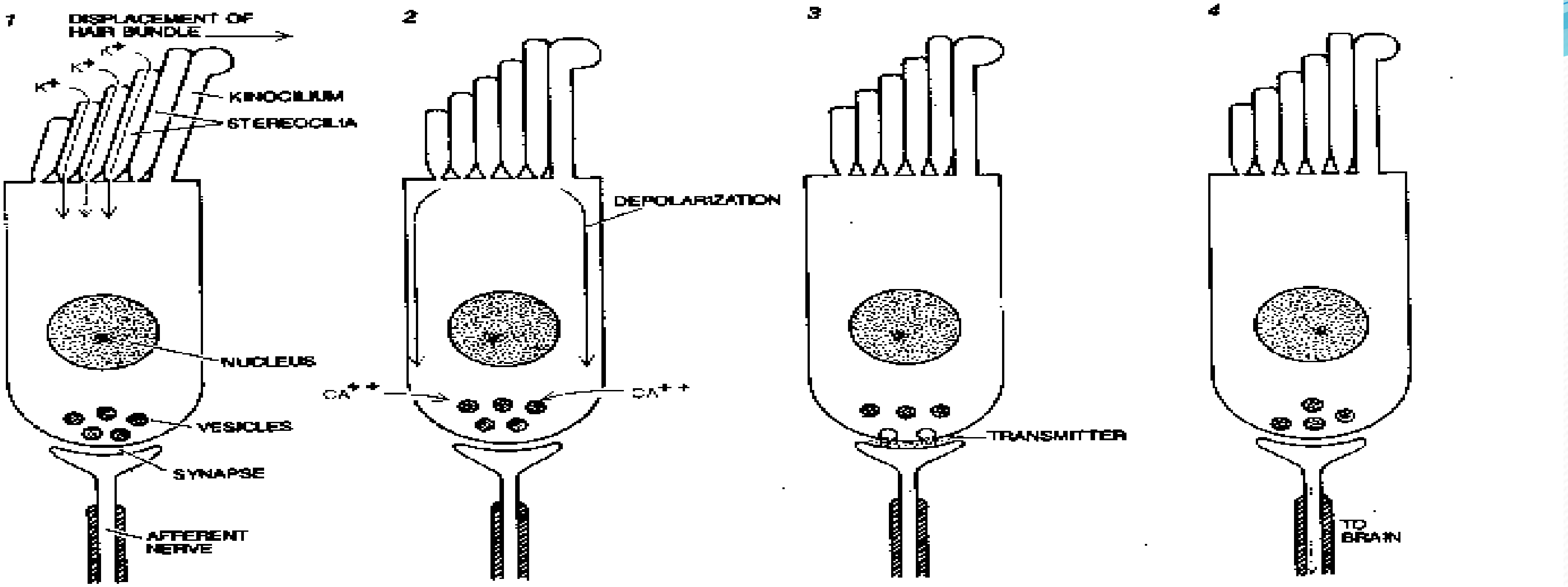
Macula (otolith organs) of utricle and saccule:-

- -hair cell synapse with endings of the vestibular nerve.
- -Hair cell has 30-150 (stereocilia)

&

- one large cilium called (kinocilium)
- Both connectdd with thin filamnet attachments
- -All cilium membrane has positive potass channels
- -Otolithes (statoconia) of calcium carbon suspended in gelatinous material.
- - macula of utricle is IN horizontal plane the head is vertical , so cilia point upwards
- - stimulated when the head bends forwar & backward & laterally





- <u>**Mechanism of action:-**</u>
- 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

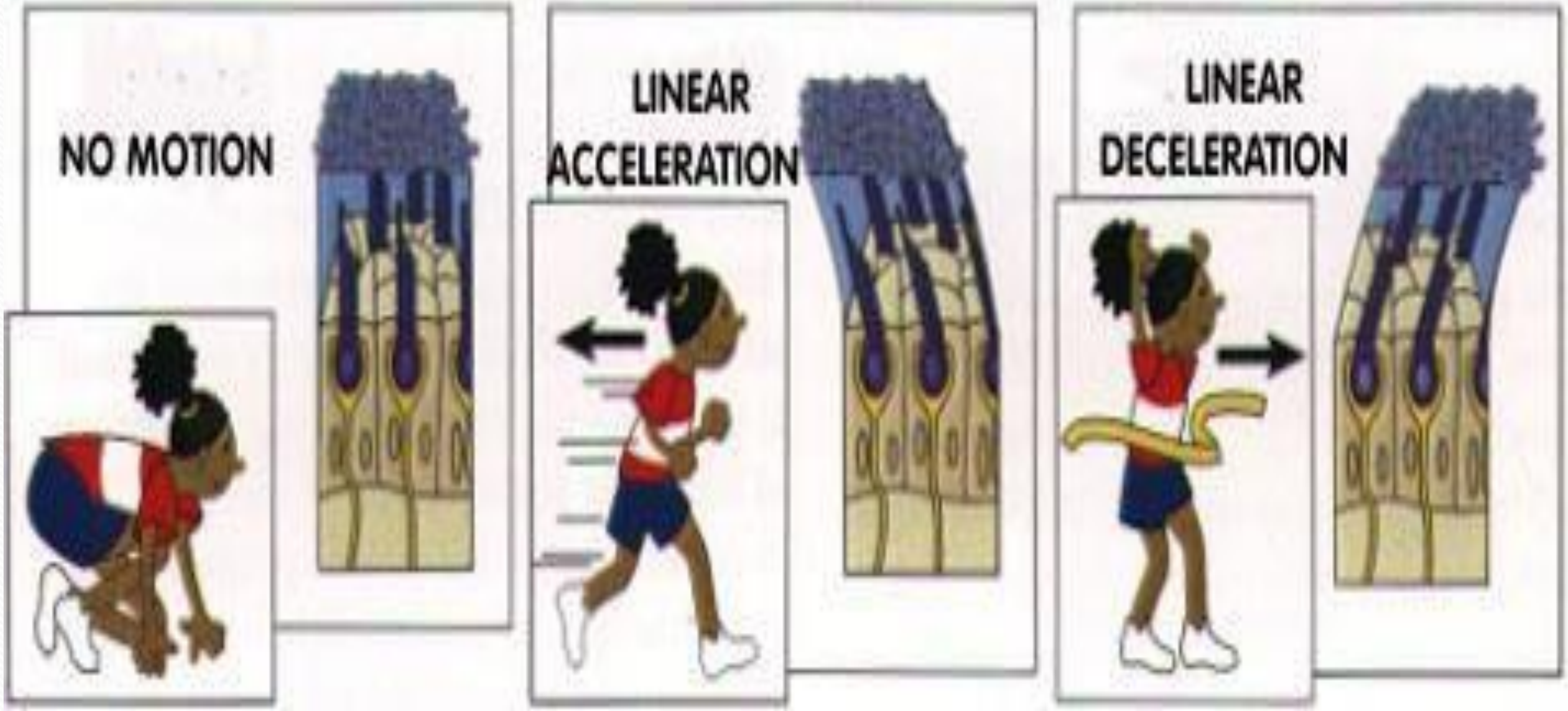
- b- bending the head to one side ;
- - statoconia crystals of hair cells fall to that side by their weight>>>>>>pull steriocilia to move towards kinocilium>>>>>depolarization (stimulation)
- -steriocilia of the other side moves away from kinocilium--------hyper-polarization (inhibition)

- 2- Detection of linear acceleration :-

- - linear acceleration:- as at running & standing in a bus .

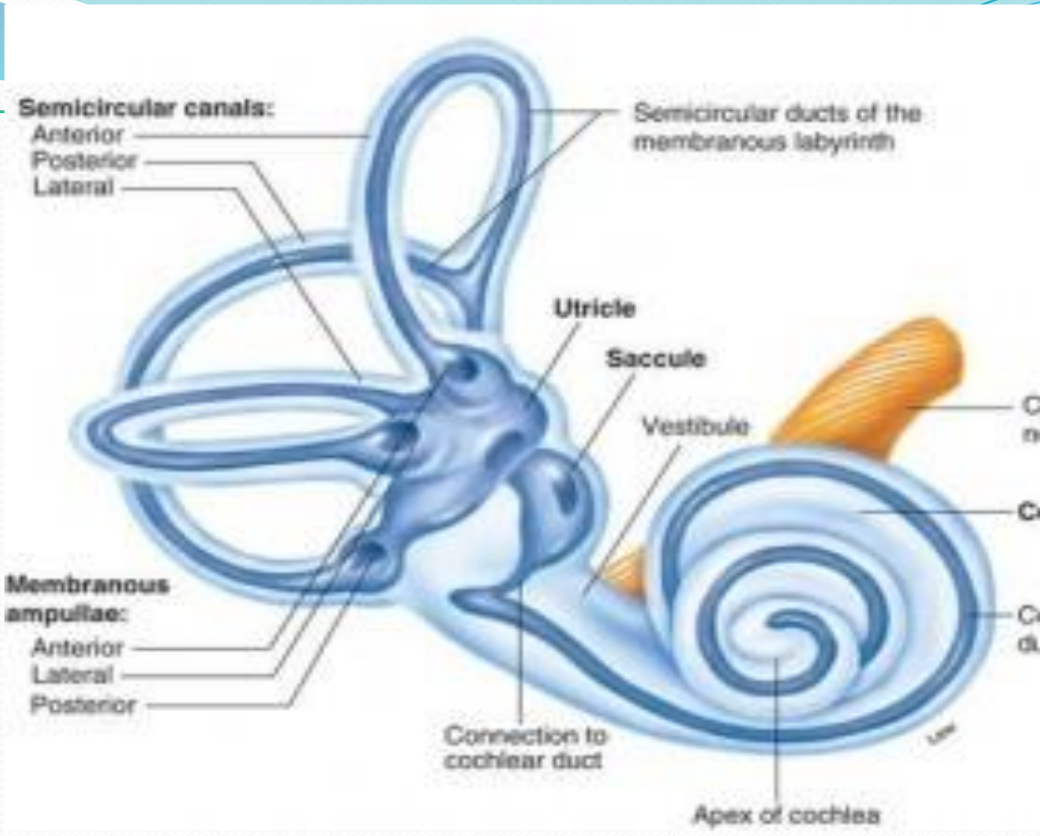
- - at beginning of movement statoconia lag behind movement by its inertia >>>>> fall backwards
- >>>>cilia moves backward >>>>> person feels he is falling backwards
- >>>> try to correct this by leaning forwards to shift statoconia & cillia anteriorly

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

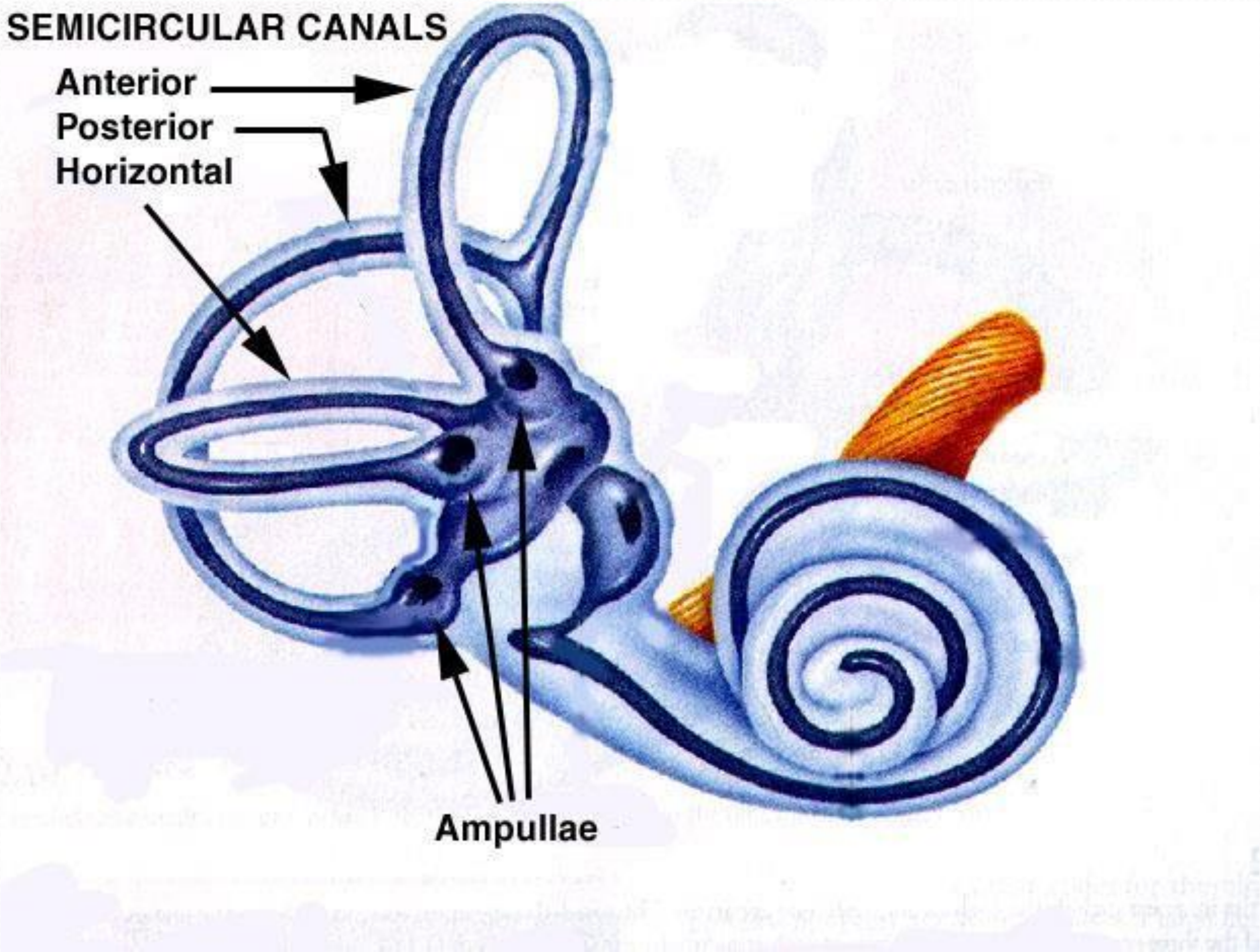

NO MOTION
LINEAR ACCELERATION
LINEAR DECELERATION

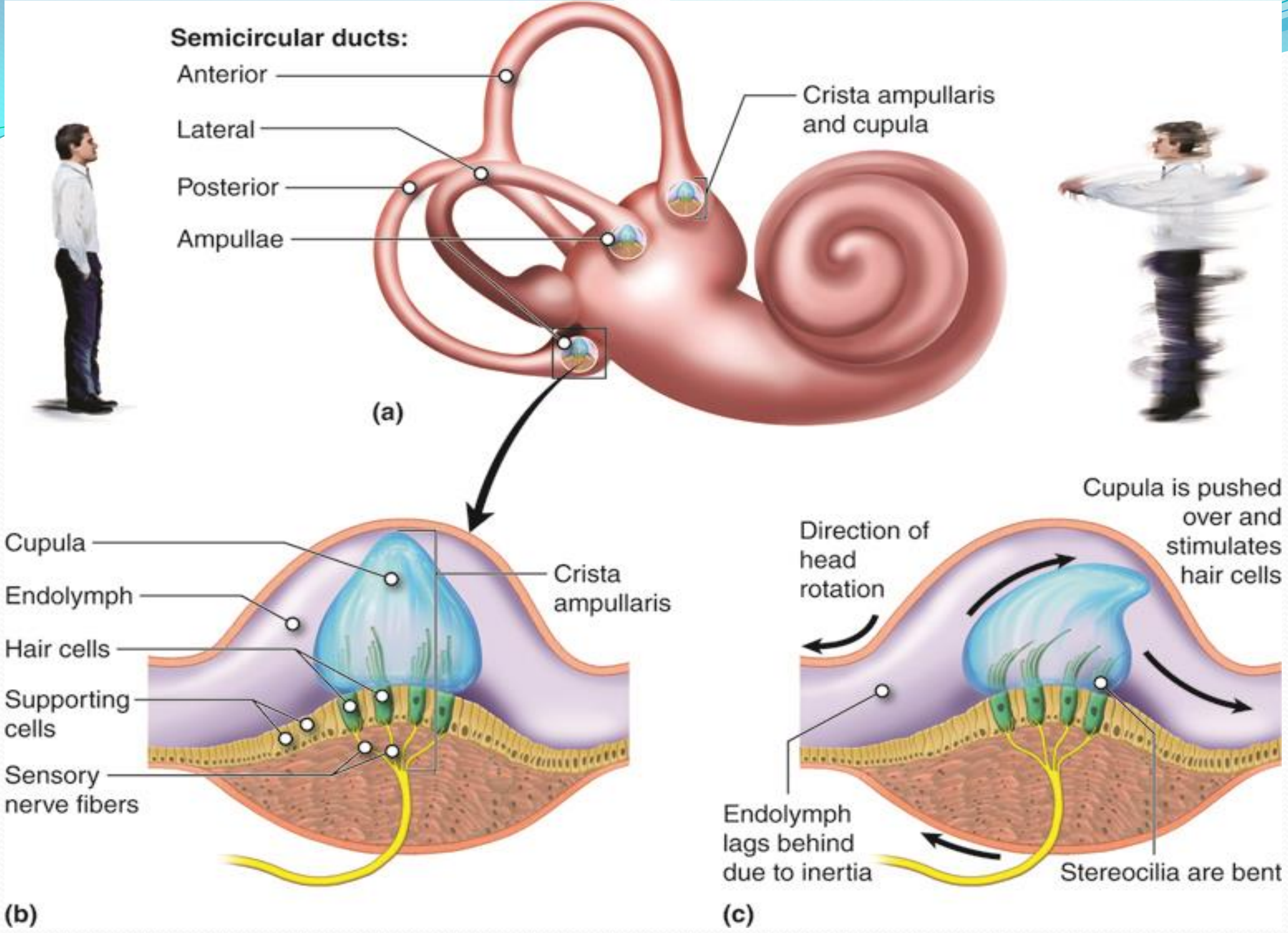
Semicelrcula canals

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).

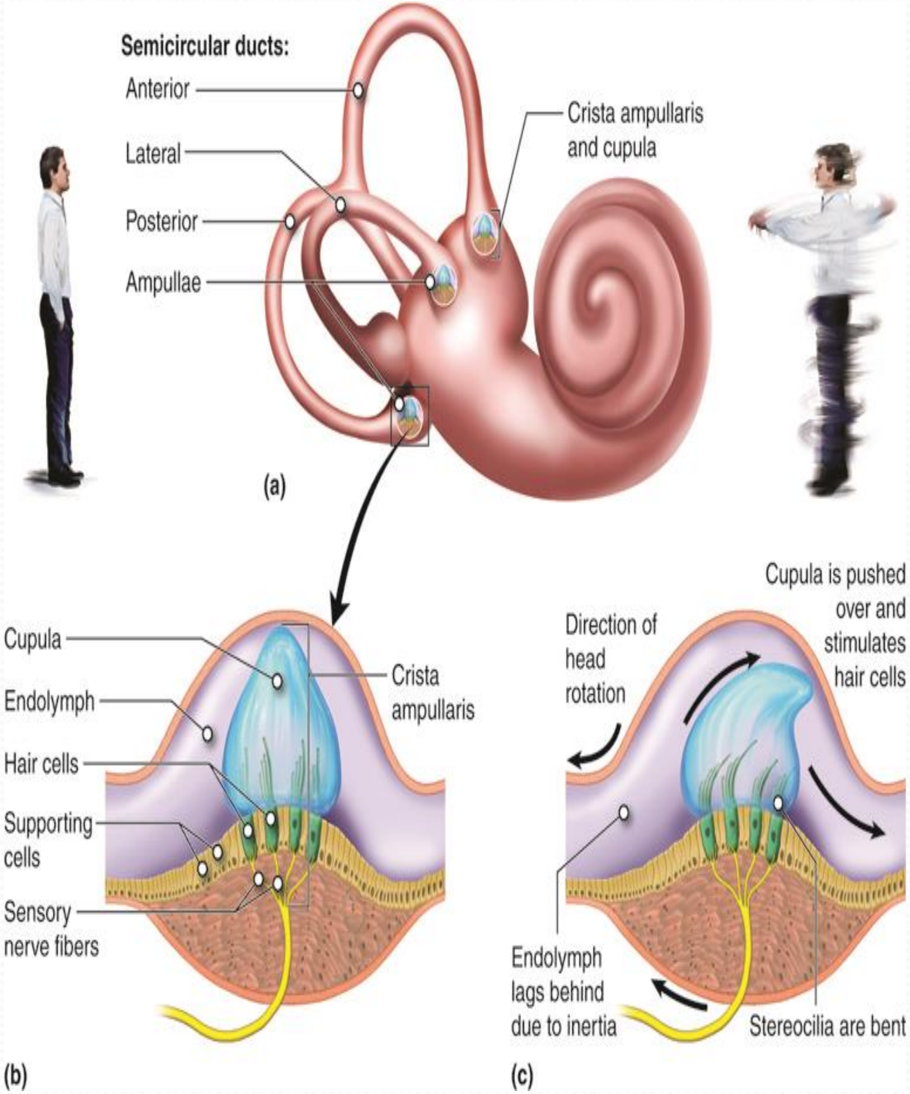

SEMICIRCULAR CANALS
Anterior
Posterior
Horizontal
Ampullae


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**

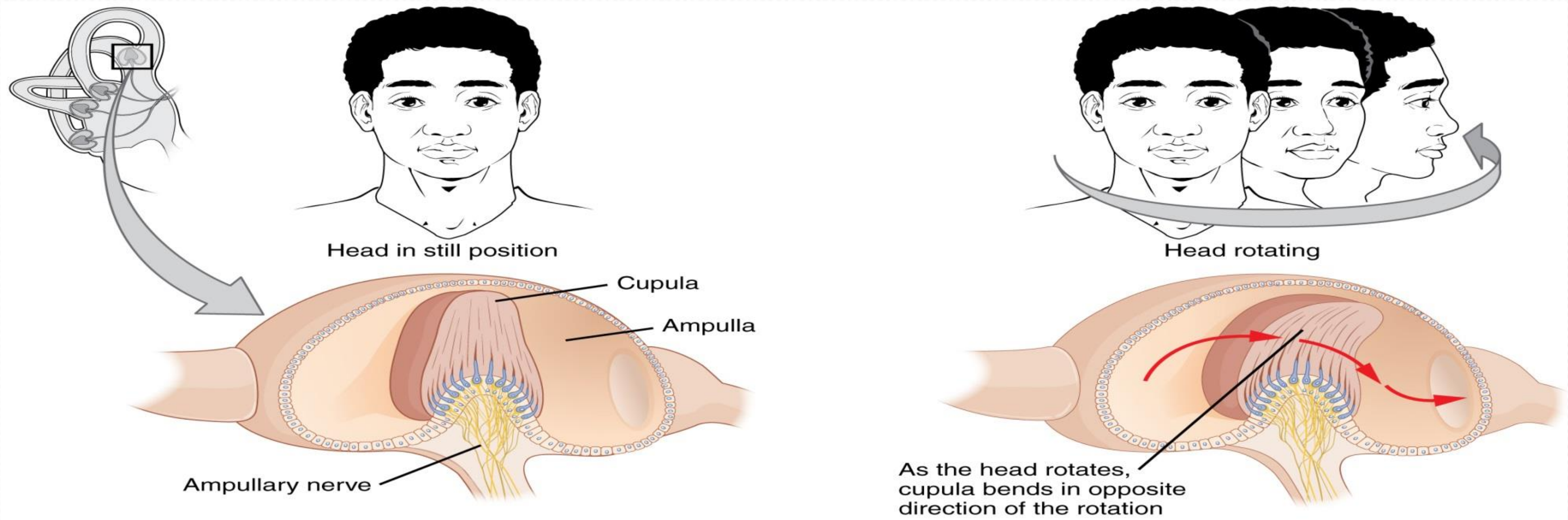
- 1- during rest : equal discharge from SCC on both

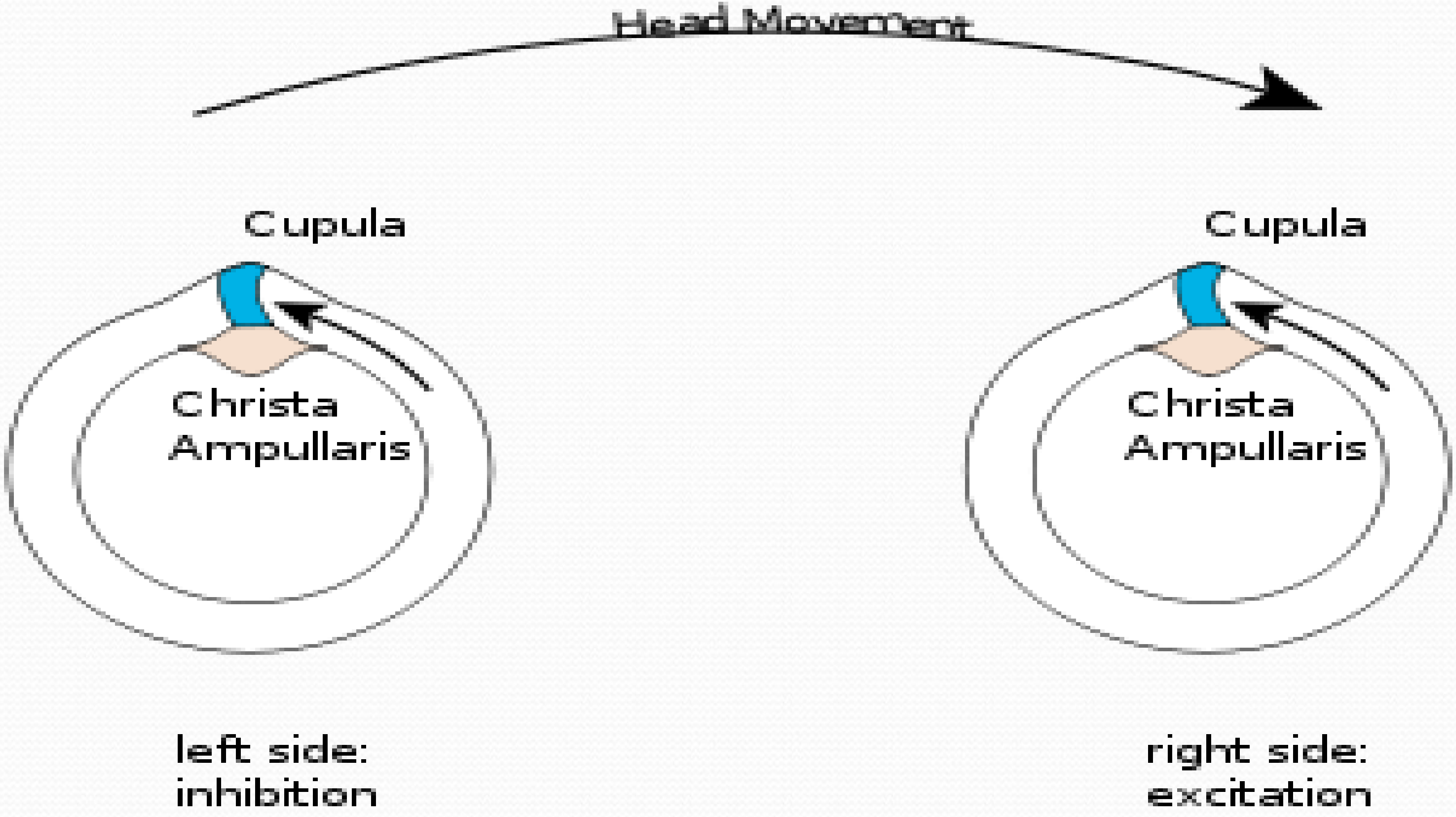
- 2- Detect & maintain posture during head rotation in any direction
- (angular acceleration) rotation

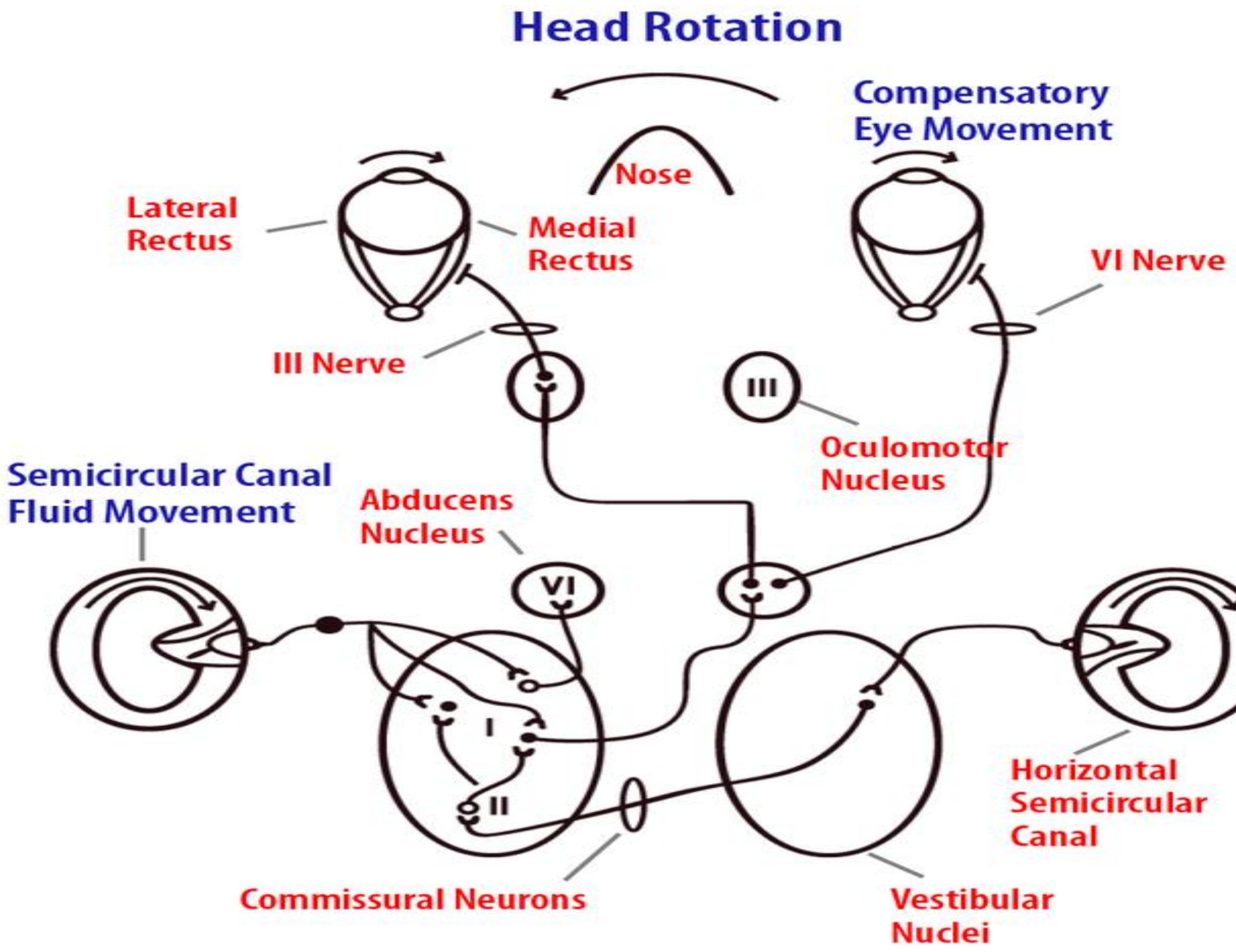


Rotation from left to right in horizontal plane:-

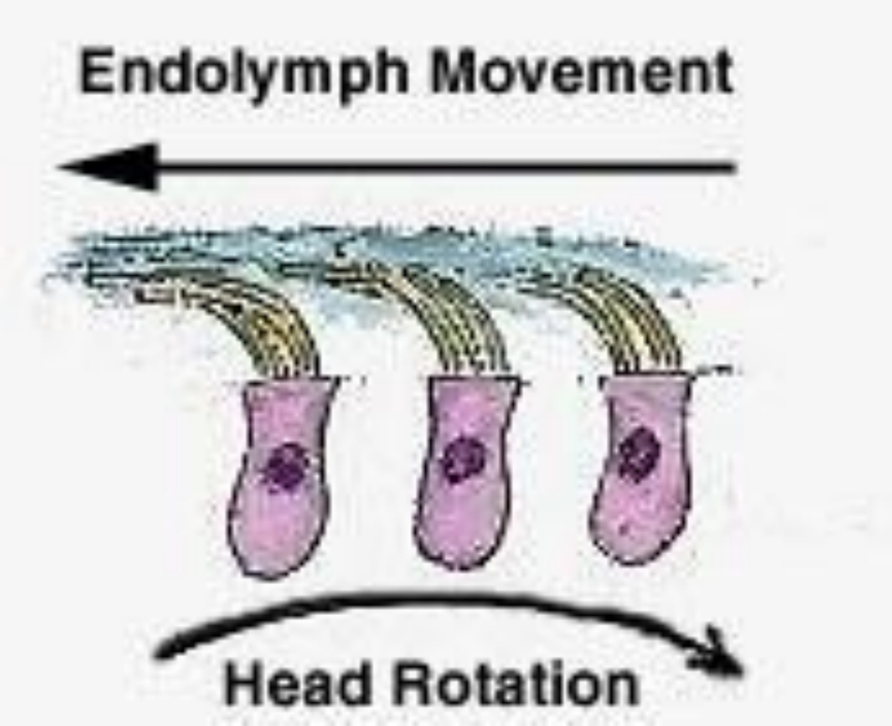
- Endolymph -->>>opposite direction by
- inertia --from right to left,
- -> the cilia of right side bent by endolymph towards the kinocilium >towards the utricle--
- depolarizationà--impulses from right side increase.
- --impulses fom left side decrease as cilia bent away from kinocilium.>>>>>
- - sensation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

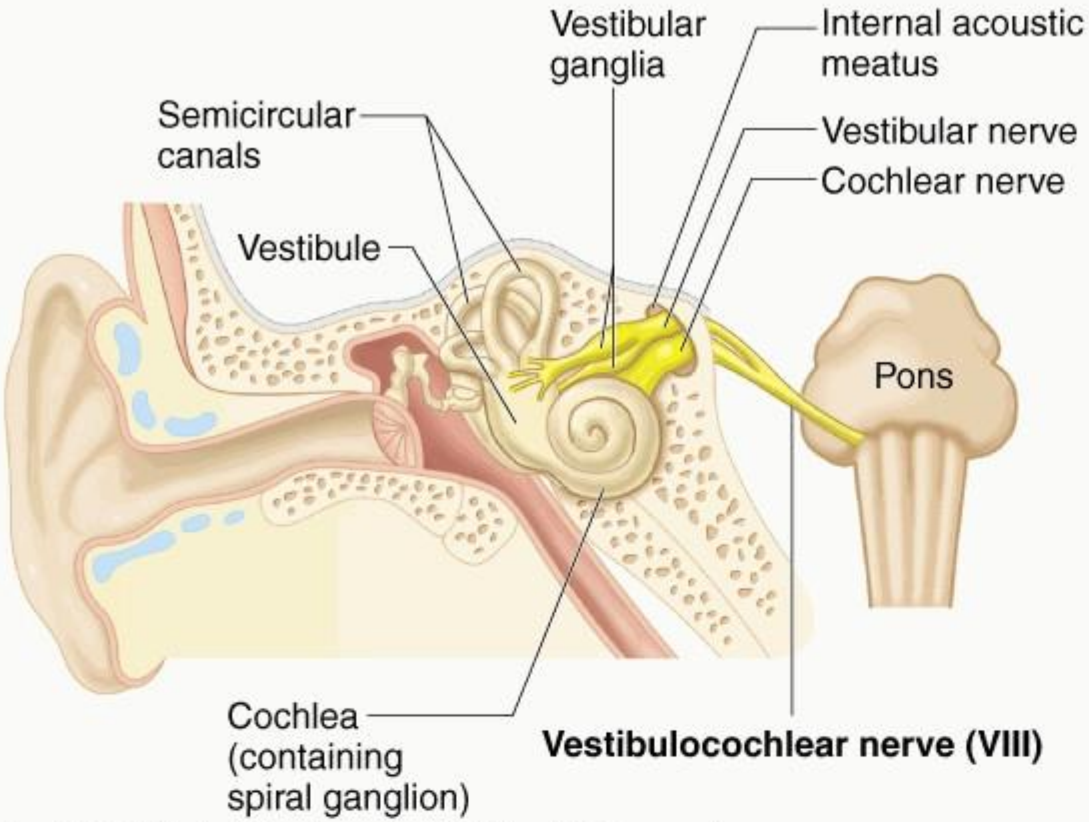



Head Movement
Cupula
Christa Ampullaris
left side: inhibition
Cupula
Christa Ampullaris
right side: excitation


Head Rotation
Compensatory
Eye Movement
Nose
Lateral
Rectus
Medial
Rectus
VI Nerve
III Nerve
III
Oculomotor
Nucleus
Semicircular Canal
Fluid Movement
Abducens
Nucleus
VI
I
II
Horizontal
Semicircular
Canal
Commissural Neurons
Vestibular
Nuclei

Copula in head rotation



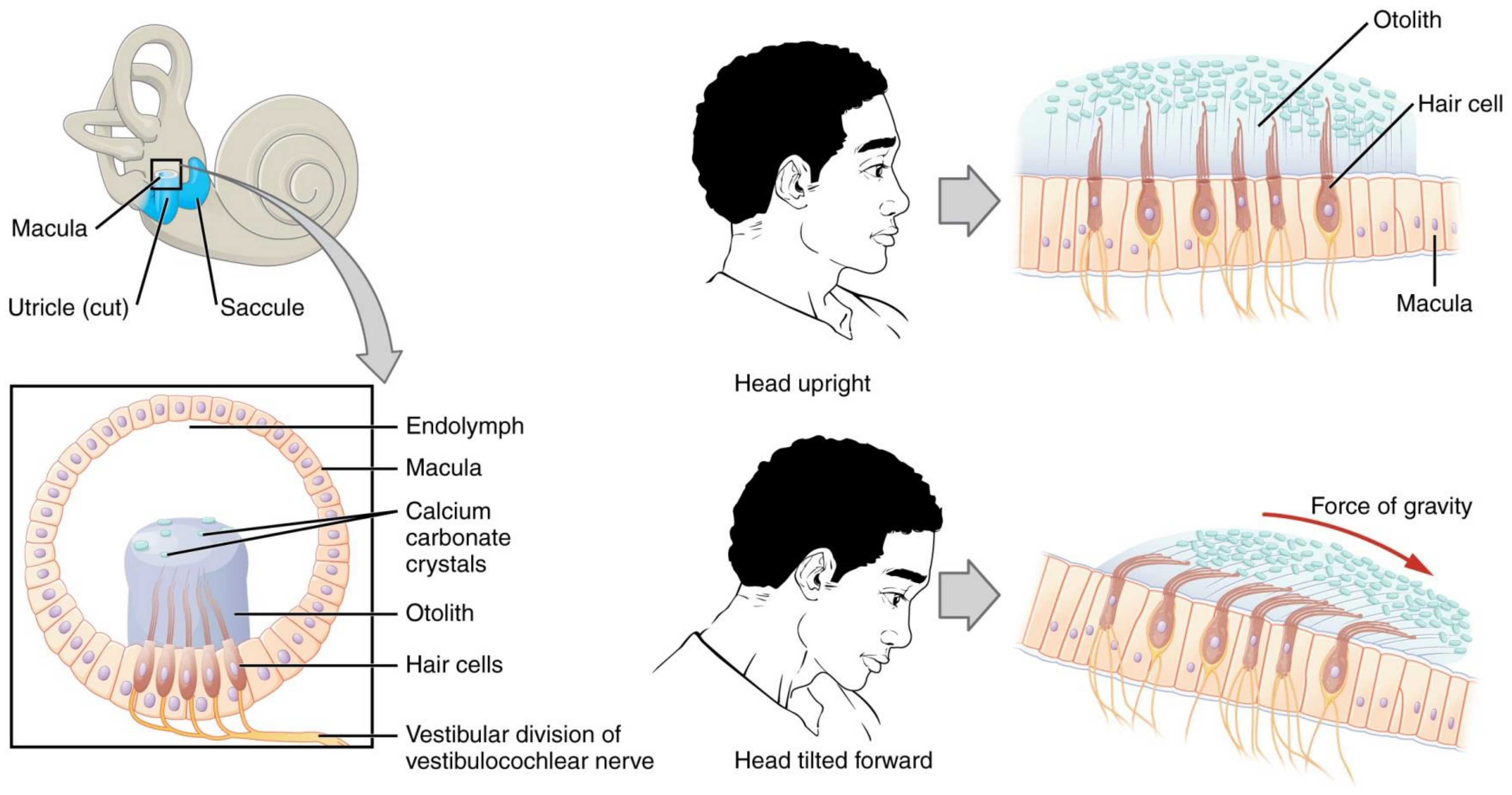

Vestibular ganglia
Internal acoustic meatus
Semicircular canals
Vestibular nerve
Cochlear nerve
Vestibule
Pons
Cochlea (containing spiral ganglion)
Vestibulocochlear nerve (VIII)

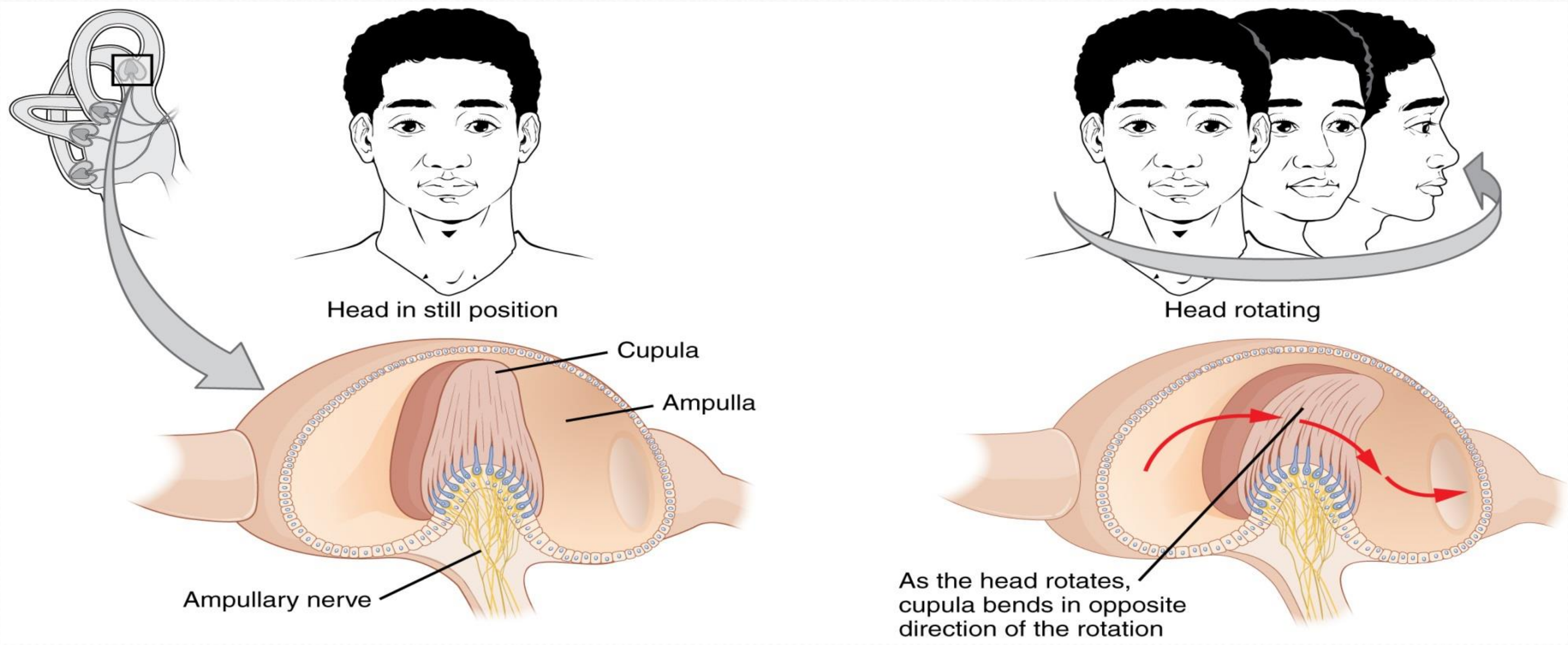
Neural connections

- 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


Macula
Utricle (cut)
Saccule
Endolymph
Macula
Calcium carbonate crystals
Otolith
Hair cells
Vestibular division of vestibulocochlear nerve
Head upright
Otolith
Hair cell
Macula
Force of gravity
Head tilted forward



As the head rotates, cupula bends in opposite direction of the rotation