
بسم الله الرحمن الرحيم

Posture & Equilibrium

: Reflexes maintain body position at rest & movement

-Receptors of postural reflexes are :-

1-proprioceptors

2-Visual(retinal) receptors

3- non auditory membranous labyrinth

- **Labyrinth is :-**
- **1- Membranous labyrinth :-**
- **a- auditory (cochlea for hearing)**
- **b- non- auditory for equilibrium**
- **IT IS Vestibular apparatus = sacule & utricle & 3 semicircular canals.**

- **2- Bony labyrinyth (bony cochlea & 3 bony semicircular canals), which enclose the membranous labyrinth for protection.**
- **Fluids in the ear :-**
- **1- perilymph between bony & membranous labyrinth**
- **2- endolymph inside membranous labyrinth.**

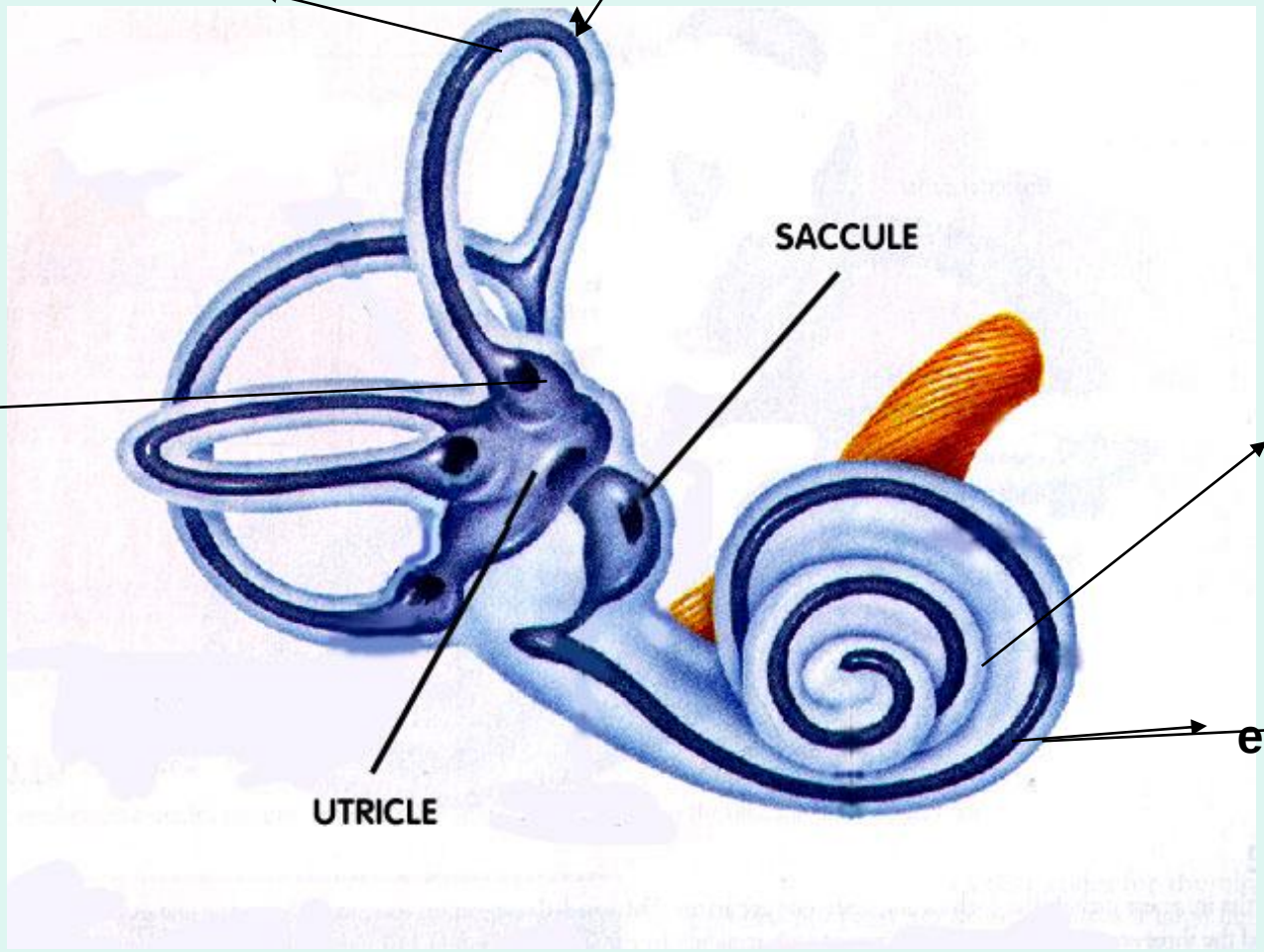
Vestibular apparatus:-

1- utricle & saccule has a sense organ called macula (otolith organ)

2- SCC has ampulla.

membranous labyrinth

Bony labyrinth



ampulla

perilymph

endolymph

- **Macula (otolith organs)of utricle and saccule:-**

- **1-thousands of hair cells (receptor) between a ridge of columnar epithelial cells.**

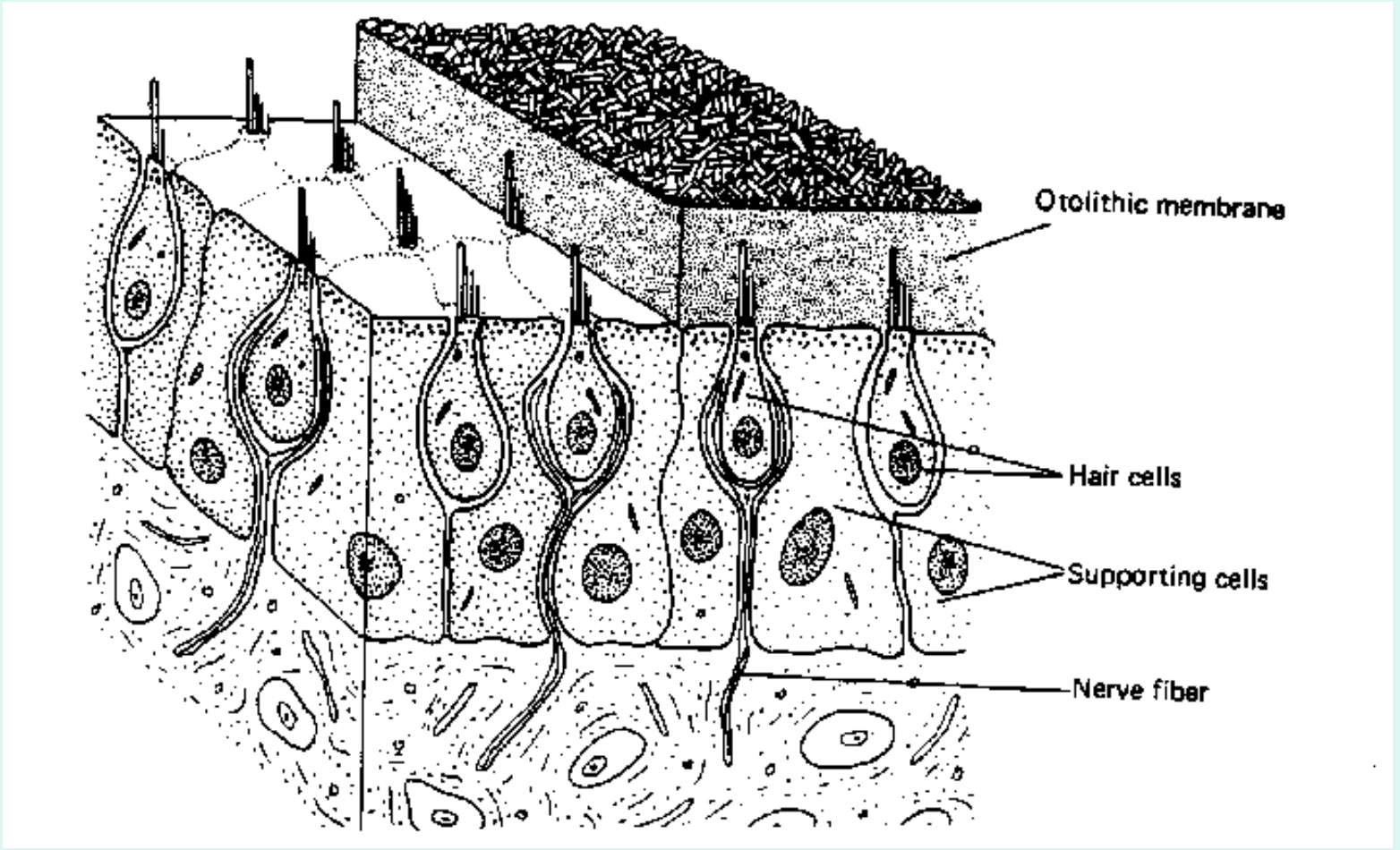
- **-hair cell synapse with endings of the vestibular nerve.**

- **--Each hair cell has 30-150 varying size cilia called stereocilia**
- **& one large cilium called kinocilium, arranged, from shortest to tallest (towards kinocilium)**

- **- kinocilium connected to stereocilia , thin filamentous attachments**

- **-Each cilium membrane has channels for positive potassium ions.**

- **- stereocilia has otolithes (statoconia) of calcium carbonate susbended in gelatinous material.**

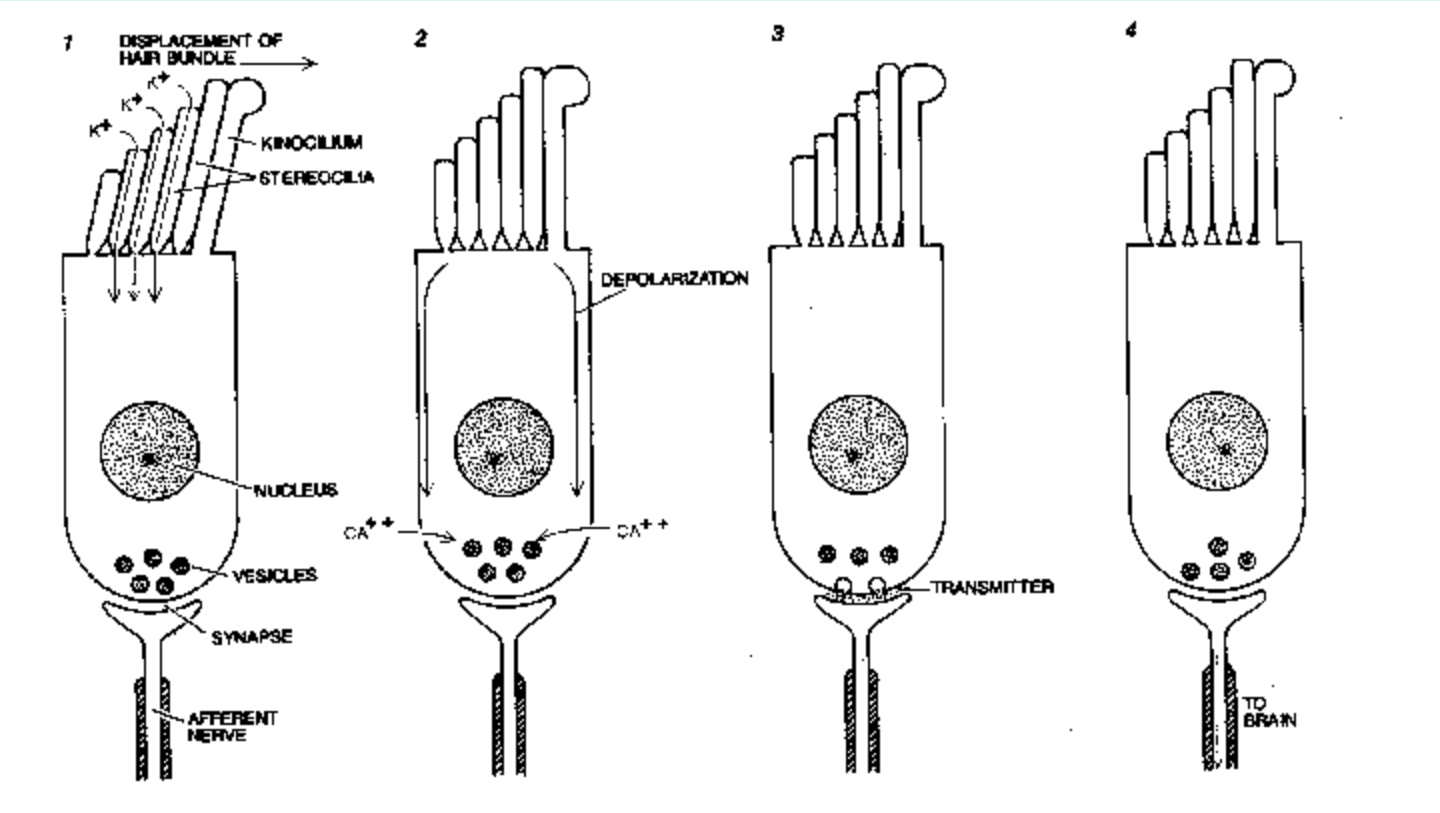

Otolithic membrane
Hair cells
Supporting cells
Nerve fiber

- **- macula of utricle is IN horizontal plane if the head is vertical , so cilia point upwards**
- **- stimulated when the head bends forward & backward & laterally**

- **Mechanism of action:-**
- **1- basal resting tonic discharge from nerve fibers of hair cells AT REST (increased or decreased by bending the head).**

- **2- bending of stereocilia towards kinocilium>>>>>.open potassium channels >>>>>>> depolarization & Ca entry & neurotransmitter release >>>>>>>>>- increase rate of impulses to 8th nerve fibers .**

- **3- bending of stereocilia away from kinocilium >>>>>>>-- close potassium channels>>>>>>hyperpolarization>>>>>>>decrease rate of impulses to 8th nerve fibers.**


1
DISPLACEMENT OF HAIR BUNDLE
K+
K+
K+
K+
KINOCILIUM
STEREOCILIA
NUCLEUS
VESICLES
SYNAPSE
AFFERENT NERVE
2
DEPOLARIZATION
Ca++
Ca++
3
TRANSMITTER
4
TO BRAIN

- **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) .**
- **Tilting to right , stimulate right utricle & inhibit left utricle >>>>>> sense of imbalance, sensation of tilting to the stimulated side(RIGHT).**

- **2- Detection of linear accleration :-**
- **- linear acceleration:- as at running & standing in a bus .**
- **- at beginning of movement statoconia lag behind movemnt 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 momentum عزم- دفع >>>> person feels falling anteriorly >>>>>> try to correct this by leaning backwards to shift statoconia & cillia posteriorly,**
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SEMICIRCULAR CANALS (SCC)

- **There are 3 SCC on each side:-**
- **1- Horizontal 2- anterior 3- posterior**
- **-All are perpendicular to each other, filled with endolymph,each has a dilated end called ampulla**

- **Ampulla: has crista ampularis (as macula)**
- **-with cilia (stereocilia & a large kinocilium directed to the utricle in which the ampulla open). (cillia bending towards utricle by movement of endolymph)**
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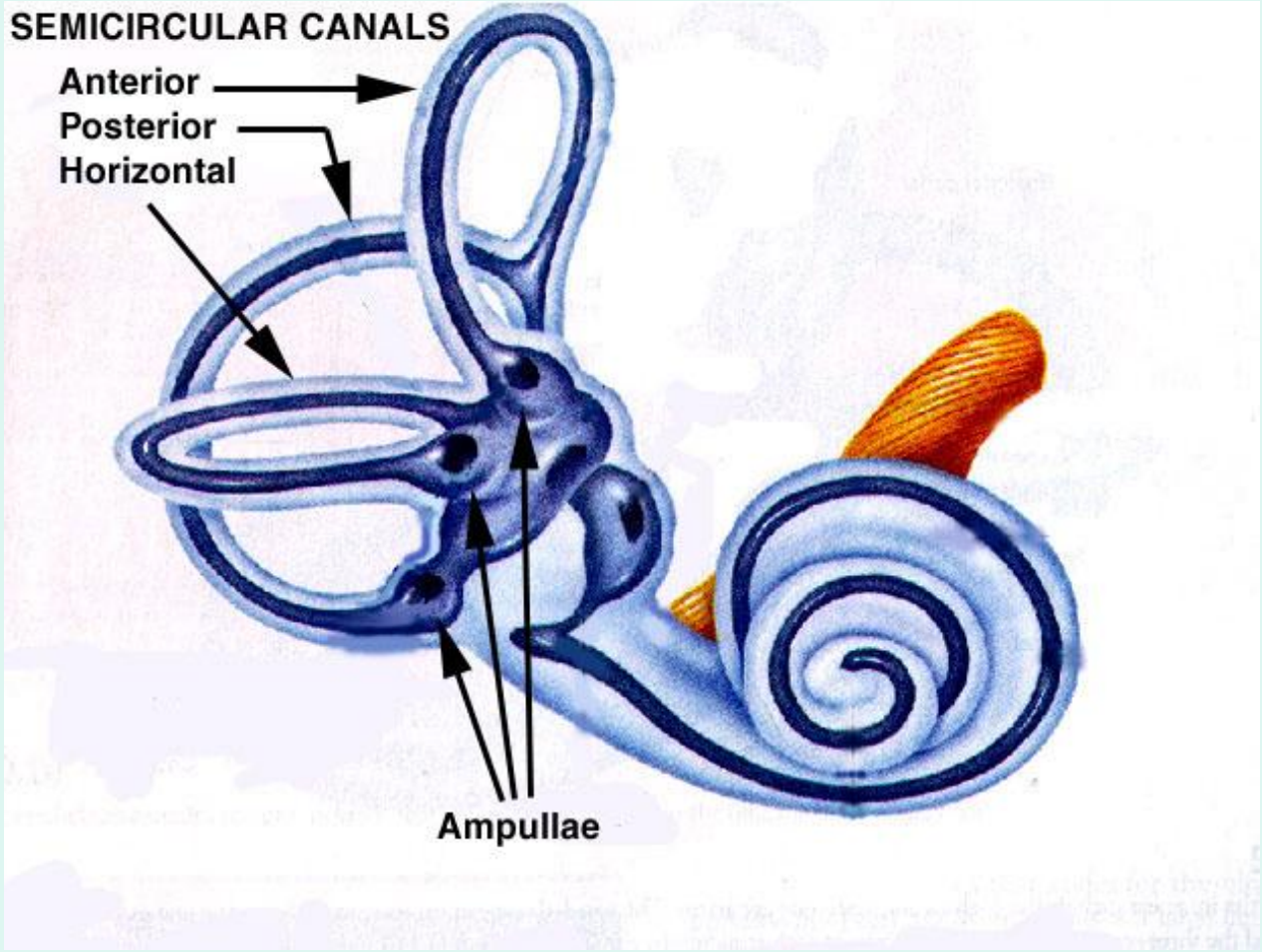
- **- cilia embedded in a gelatinous mass called cupula).**


SEMICIRCULAR CANALS
Anterior
Posterior
Horizontal
Ampullae

Mode of action & functions

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

-transmit from their cristae about 200 impulses/sec as basal tonic discharge.

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

a- they are stimulated at beginning & at end & by changing direction or rate of rotation(not stimulated by maintained constant rotation as earth rotation)

-**In horizontal SCC:-** **_bending kinocilium towards utricle means cupula towards utricle>>>>>>stimulate hair cells**

-while bending cupula away from the utricle >>>>>>inhibit hair cells.

-e.g/- Rotation to RT>>>> the cilia of right side bent by endolymph towards the kinocilium >>>>> cupula moves 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.

Nervous connections of vestibular apparatus:-

Nerve fibers from maculae & cristae ampularis >>>>>>Vestibular nerve->>>>>>>epsilateral vestibular nucleus to :-

1- cerebellum:- floculonodular lobe & dentate nucleus>>>>>>thalamus of the opposite side>>>>>cortex of the opposite side (motor areas, superior temporal gyrus for vertigo).

2- spinal cord (vestibulospinal tracts)

3- Reticular formation

4- Medial longitudinal bundle(for eye movements)(nystagmus)

Effects of stimulation of S.C.C:-

-Stim by rotation or caloric test

(stim of SCC by water hotter or colder than body temp in external auditory canal>>>>convection currents in endolymph>>>>>motion of cupula)

1- Vertigo:- - this false sensation of counter-rotation at end of rotation (or angular acceleration)

2- Nystagmus:- jerky eye movements at the beginning & end of rotation to fix objects in the eye field.

- **3- bradycardia & hypotension.**

  4- increased muscle tone on same side of rotation to support the body & decreased muscle tone on the opposite side