



Inner ear in balance and equilibrium



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- Important
- Further Explanation

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Recommended Videos!



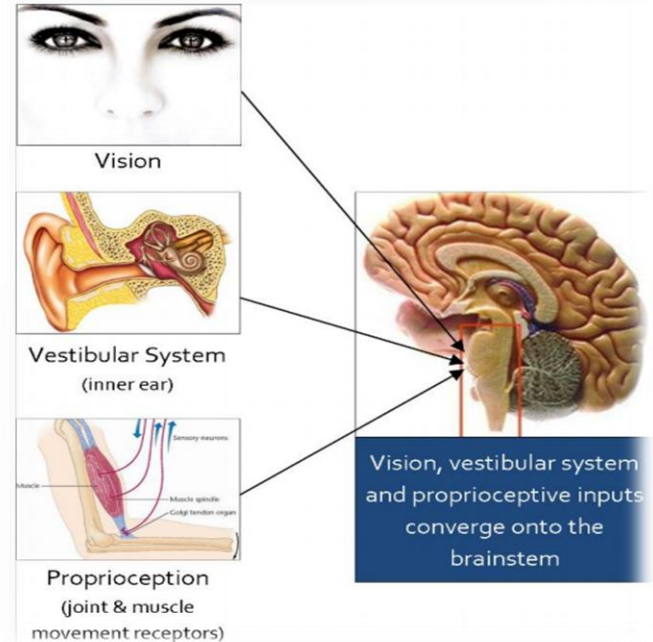
Please check out this link before viewing the file to know if there are any additions/changes or corrections. The same link will be used for all of our work [Physiology Edit](#)

Equilibrium

- ✧ It is Reflexes maintain body position at rest & movement.
- ✧ Through: Receptors of **postural reflexes**.

Receptors of postural reflexes are:

- 1- proprioceptors.
- 2- Visual (retinal) receptors. (cones and rods)
- 3- non-auditory membranous labyrinth.



Labyrinth (Inner ear)

Components :

1- Membranous labyrinth :

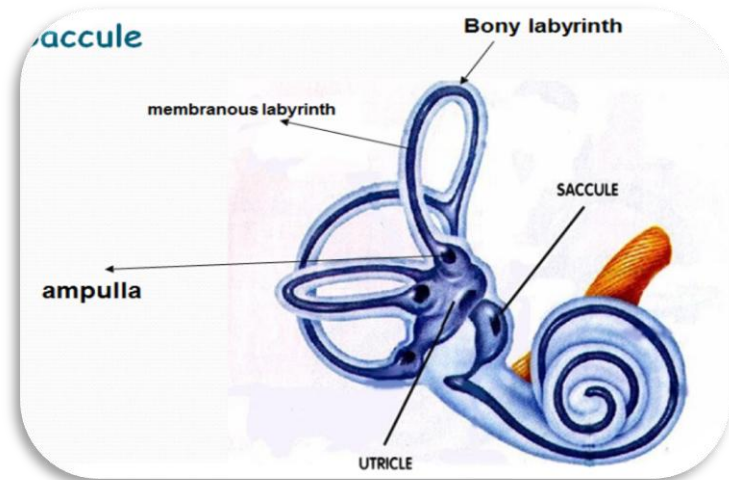
A- Auditory (cochlea for **hearing**).

B- Non- auditory (Vestibular apparatus for **equilibrium**).

Vestibular apparatus (Utricle Saccule & SCC)

2- Bony labyrinth : (bony cochlea & 3 bony semicircular canals)

enclose the membranous labyrinth for **protection**.



Vestibular apparatus

- Utricle & Sacculle :

Receptor: Macula

Function: **Linear acceleration** & Orientation

Movement by: statoconia (calcium carbonate)

* **Cilia of hair cells embedded in Gelatinous material of otolithes** (calcium carbonate crystals).

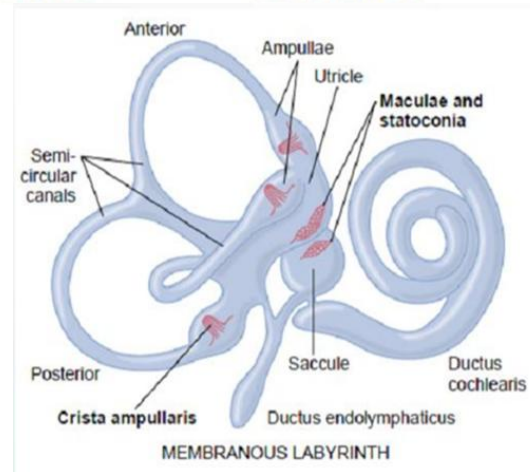
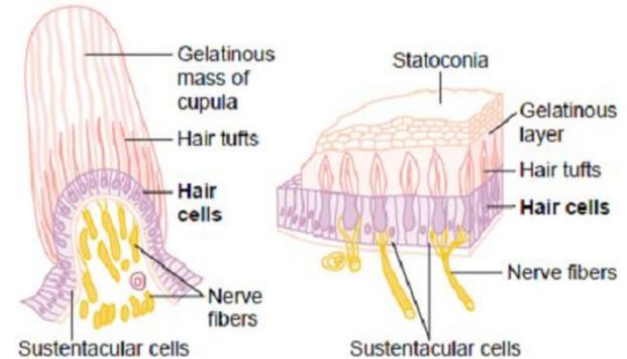
- Semicircular canals :

Receptor: Crista ampularis .

Function: **Angular acceleration** (rotation).

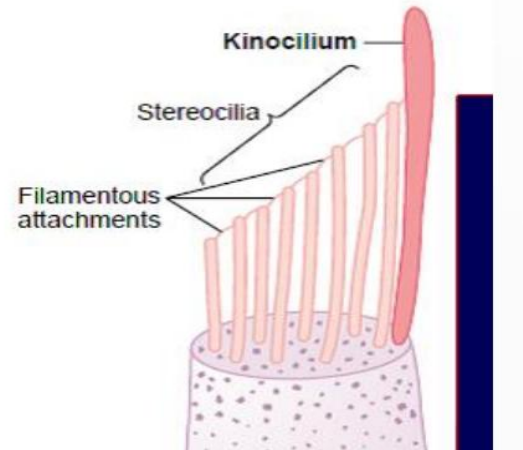
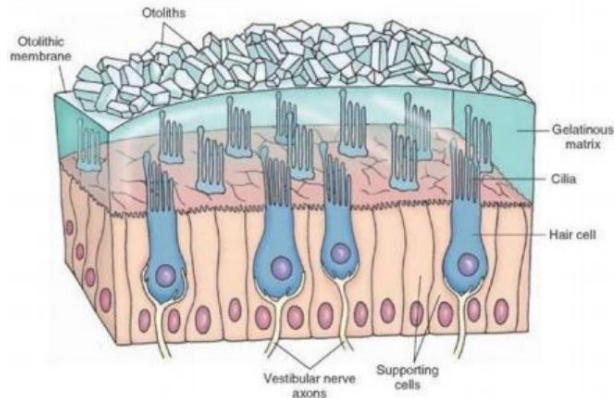
Movement by: Endolymph.

***Cilia of hair cells embedded in Gelatinous material of Cupula .**

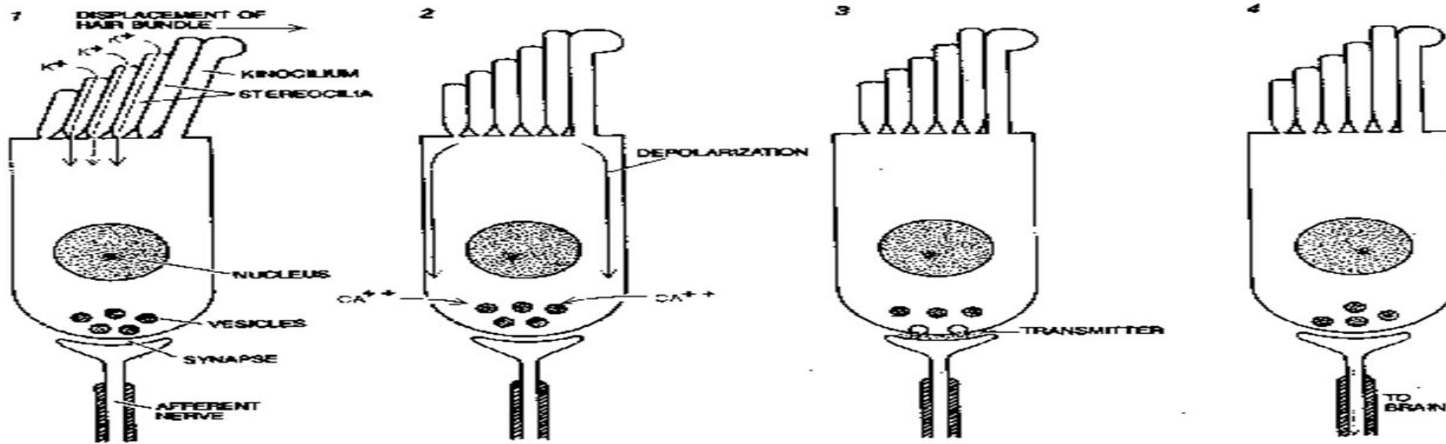


Hair cell

- * Hair cell **synapse** with endings of **the vestibular nerve**.
- Hair cell has 30-150 (**stereocilia**) and **one large** cilium called (**kinocilium**).
- Both connected with thin filamentous attachments.
- **Each cilium membrane** has: channels for **positive potassium ions**.
- **stimulated** when the head bends **forward & backward & laterally**



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.

- movement of hair cells by **calcium carbonate crystals of hair cells** by their weight

Mechanism of actions of macula in utricle:

1- orientation of head in space & maintenance of static equilibrium:-

A - in erect upright position (**vertical position**):




Right & Left utricle impulses balance each other , So no sensation of mal-equilibrium

Bending of head **increased or decreased** the impulses and lead to:

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 → **open potassium channels** → **depolarization** → **Ca entry** → neurotransmitter release → increase rate of impulses to 8th nerve fibers .

- At the same time stereocilia of the other side moves **away from** kinocilium → **close potassium Channels** → **hyperpolarization** → decrease rate of impulses to 8th nerve fibers .

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>			
<p>POLARIZATION OF HAIR CELL</p>	<p>NORMAL</p>	<p>DEPOLARIZED</p>	<p>HYPERPOLARIZED</p>
<p>FREQUENCY OF ACTION POTENTIALS</p>	<p>RESTING</p>	<p>HIGHER</p>	<p>LOWER</p>

Mechanism of actions of macula in utricle:

2- Detection of linear acceleration :

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

- At **beginning of movement** → statoconia **lag** behind movement by its inertia
القصور الذاتي → 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** (Bus tries to stop) → statoconia move forwards by its momentum
العزم → person feels falling anteriorly

Try to correct this by leaning backwards to shift statoconia & cilia **posteriorly** .

NO MOTION



**LINEAR
ACCELERATION**



**LINEAR
DECELERATION**

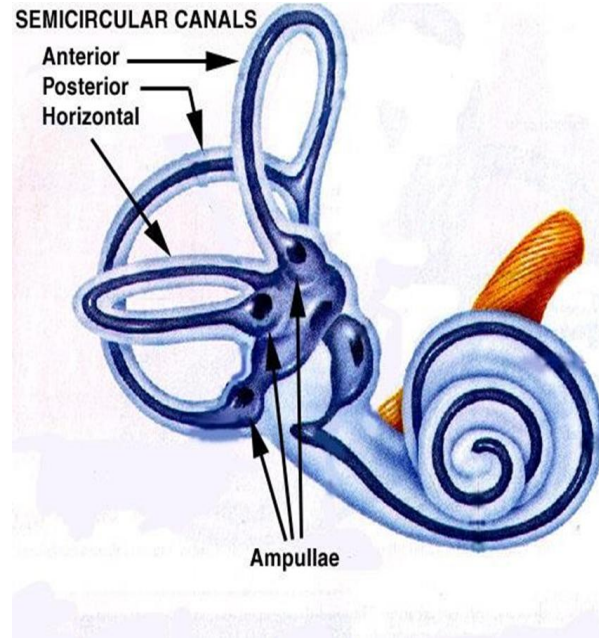


semicircular canal

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)
- cilia embedded in a gelatinous mass called **cupula** .



Mechanism of actions of crista ampularis in SCC

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

- they are stimulated at **beginning** & at **end** by changing direction or rate of rotation .
during rest : equal discharge from SCC on both ears .

During movement :

- Bending cupula **towards**
utricle (bending kinocilium
towards utricle) → **stimulate**
hair cells

- Bending cupula **away from**
the utricle (bending
kinocilium away from
utricle) → **inhibit hair cells**

Semicircular ducts:

Anterior

Lateral

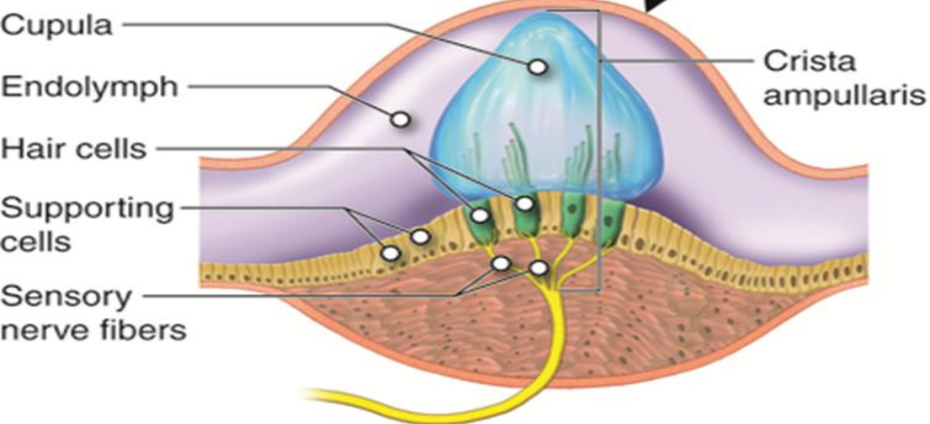
Posterior

Ampullae

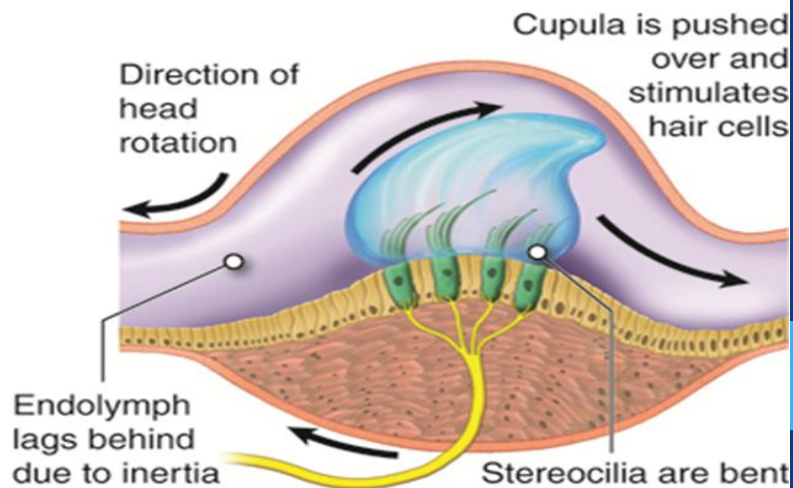
Crista ampullaris
and cupula



(a)

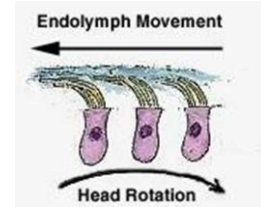


(b)



(c)

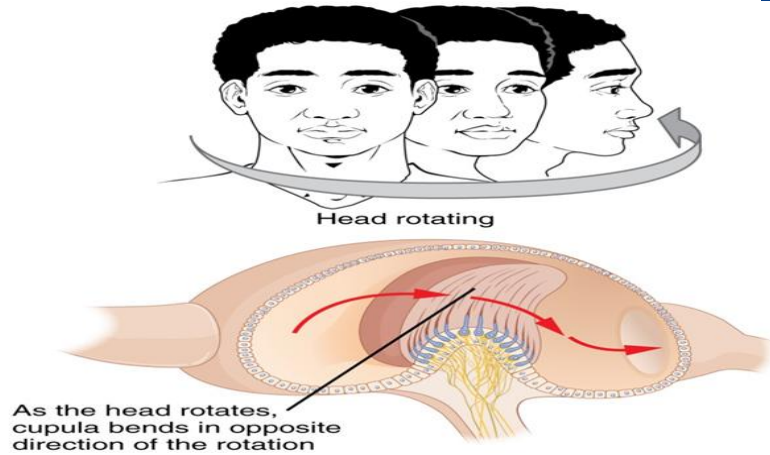
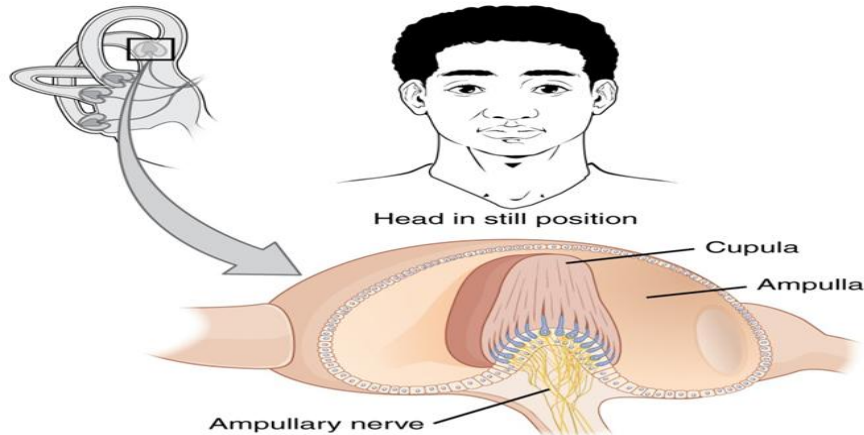
Mechanism of actions of crista ampularis in SCC



Rotation from left to right in horizontal plane:-

Rotation to right :

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 → In the other hand left side cilia bent **away from kinocilium** → **Impulses decrease** from left side → sensation of rotation to right.



Caloric test: stim of SCC by water hotter or colder than body temp in external auditory Canal → convection currents in Endolymph → motion of cupula.

Neural connections

Nerve fibers from maculae & cristae ampularis → Vestibular nerve → ipsilateral vestibular nucleus to :-

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

2- spinal cord (vestibulospinal tracts).

3- Reticular formation

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

Effects of stimulation of S.C.C by rotation :

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.

1- If the stereocilia move away from kinocilium what happen ?

- A. Hyperpolarization
- B. Depolarization

2-At the beginning of the liner acceleration ?

- A. the statoconia lag behind and the person feels he is falling inferiorly
- B. the statoconia move forward and he try to correct this by leaning forward
- C. statoconia lag behind by its momentum
- D. - the statoconia lag behind and try to correct this by leaning forward

3-false sensation of counter-rotation at end of rotation

- A. Nystagmus
- B. increased muscle tone
- C. Vertigo

1-What are the receptors of postural reflexes ?

- . 1- proprioceptors.
- 2- Visual (retinal) receptors. (cones and rods)
- 3- non-auditory membranous labyrinth.

2-What is Nystagmus ?

- . involuntary jerky eye movements .

3- What cause movement of hair cells?

- . calcium carbonate crystals of hair cells by their weight

4- Hair cell synapse with

- . endings of the vestibular nerve

THANK YOU FOR CHECKING OUR WORK!

BEST OF LUCK

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