Physiology Team

LECTURE 19

Physiology of Inner Ear

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OBJECTIVES

At the end of this lecture, student should be able to describe:

NOT GIVEN !

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MIND MAP

Receptors of postural reflexes are :-

1-Proprioceptors. (muscle)

2-Visual(retinal) receptors.

3-non auditory (vestibular apparatus) membranous labyrinth

Vestibular apparatus:-

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

2-SCC(semicircular canals)has ampulla.

Macula (otolith organs)of utricle and saccule

Functions and Mechanism of action of macula (mainly utricle)

Function of SEMICIRCULAR CANALS

Nervous connections of vestibular apparatus

Effects of stimulation of S.C.C

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Posture & Equilibrium

- Reflexes maintain body position at rest & movement

Receptors of postural reflexes are :-

- 1-Proprioceptors. (muscle)
- 2-Visual(retinal) receptors.
- 3-non auditory (vestibular apparatus) membranous labyrinth.

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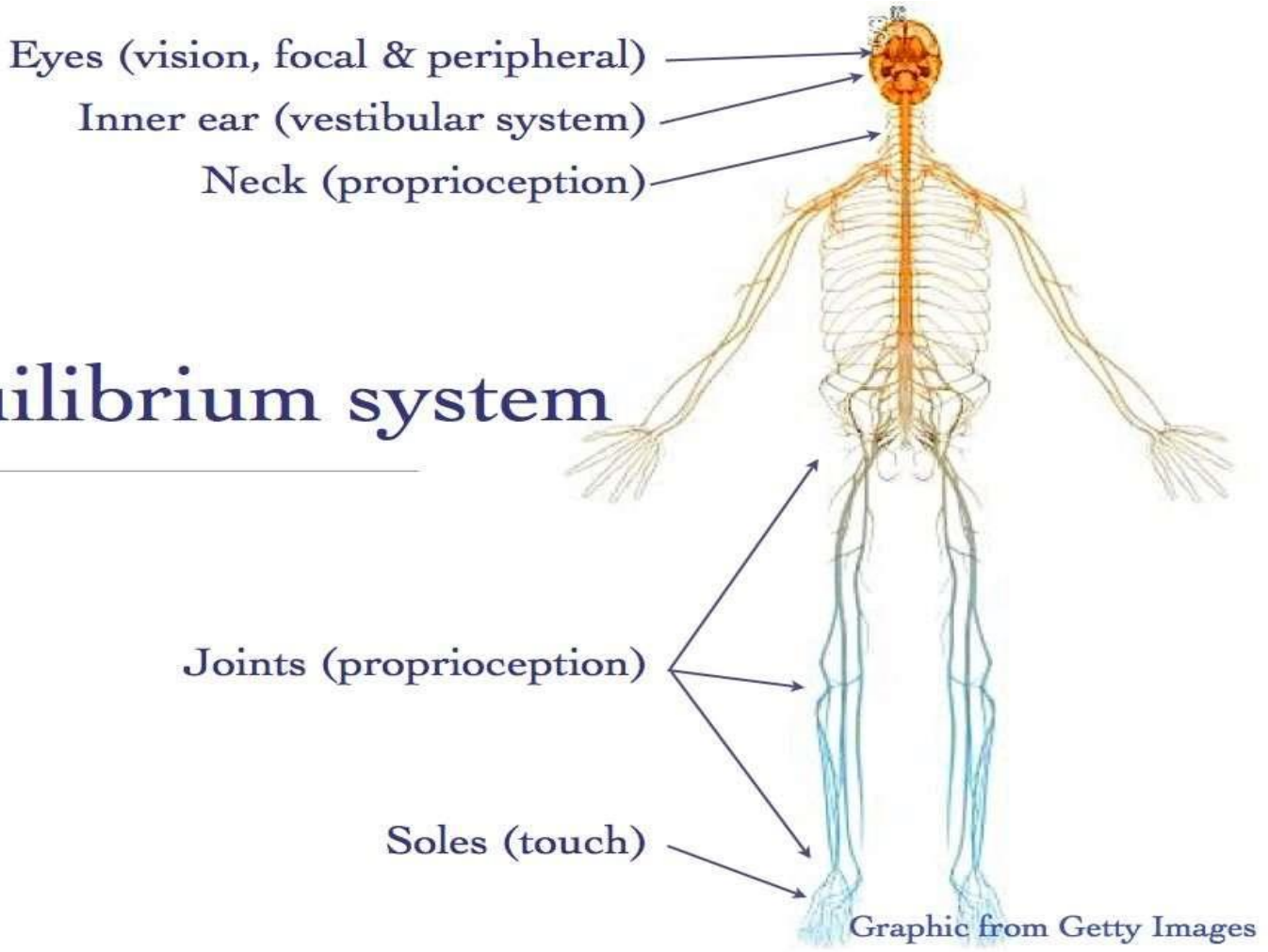
Equilibrium system



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Labyrinth is:-

- 1-Membranous labyrinth:-
  - a-auditory(cochlea for hearing)
  - b-non-auditory(vestibular apparatus) for equilibrium (sacule& utricle & 3 semicircular canals).

- 2-Bony labyrinth(bony cochlea & 3 bony semicircular canals), which enclose the membranous labyrinth for protection.

Fluids in the ear:- (for protection)

- 1-perilymph →between bony & membranous labyrinth.
- 2-endolymph →inside membranous labyrinth.

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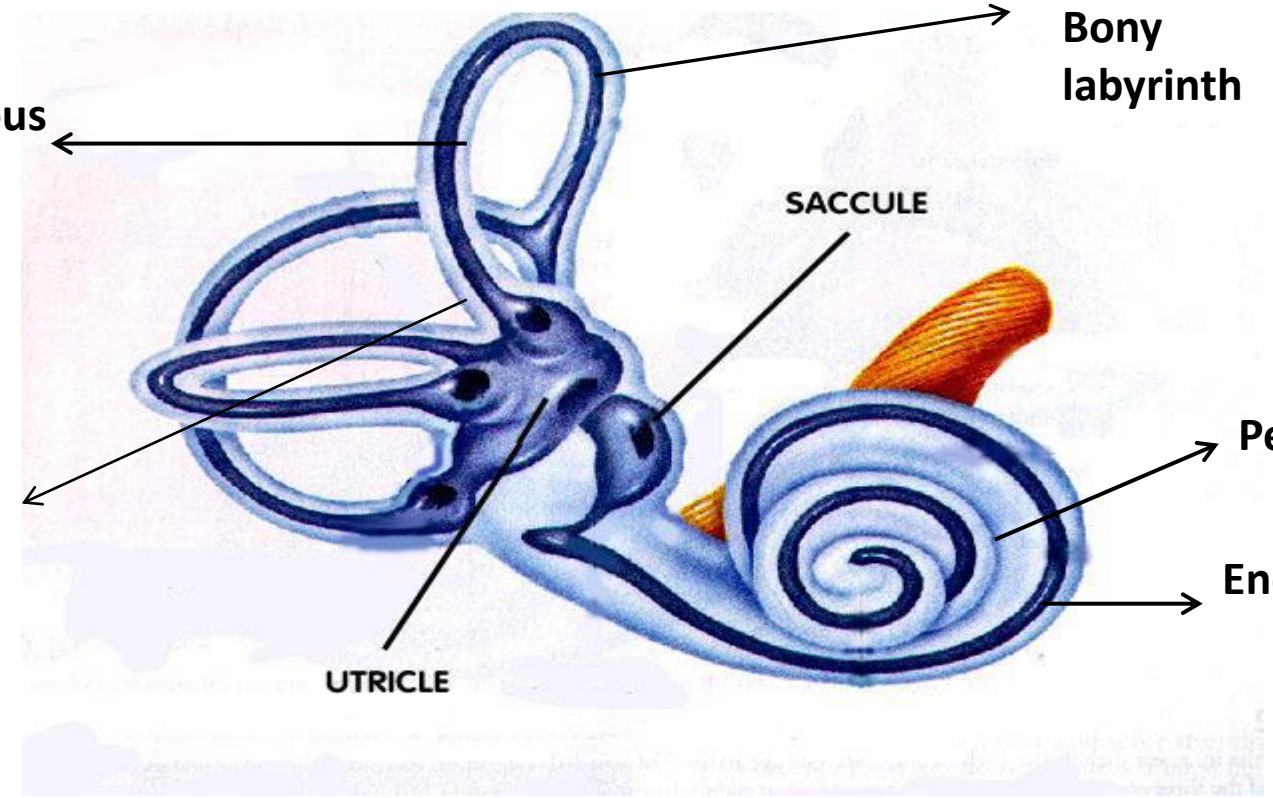
Vestibular apparatus

- 1-Utricle & saccule has a sense organ called macula(otolith organ)
- 2-SCC(semicircular canals)has ampulla.



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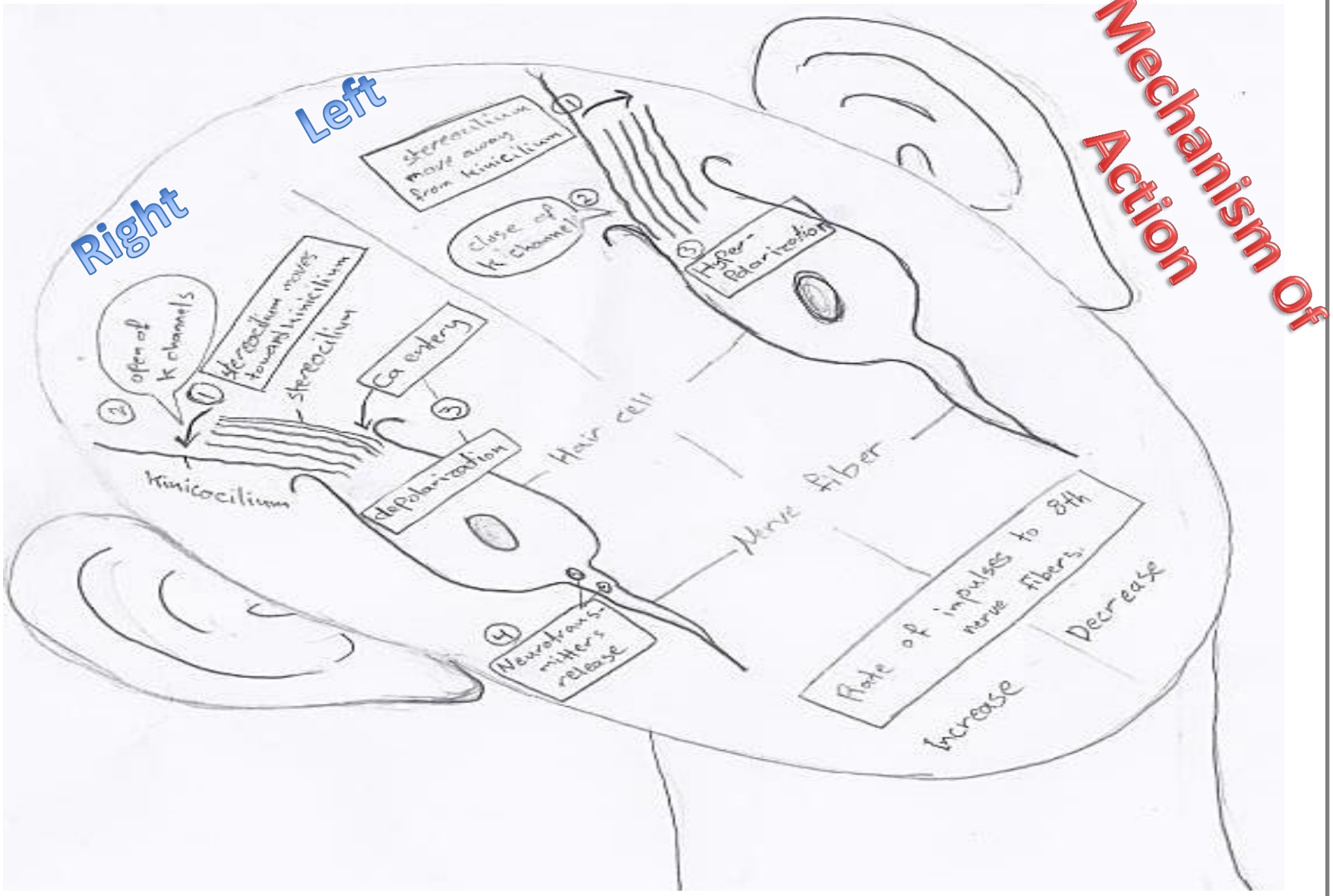
Macula (otolith organs)of utricle and saccule

1-Thousands of hair cells (receptor) between a ridge of columnar epithelial cells.
(hair cell is the basic tonic dischage)

- -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.
- -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



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Right

1. Stereocilium moves towards kinicocilium
2. Open of K channels
3. Ca entry
4. Depolarization
5. Neurotransmitters release

Left

1. Stereocilium moves away kinicocilium
2. Close of K channels
3. Hyperpolarization

Rate of impulses to 8th nerve fibers

INCREASE | DECREASE

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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.

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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(calcium carbonate) 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).

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2-Detection of linear acceleration (in straight line)

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

- Example: marathon runner:

at beginning of movement:

1- **statoconia lag behind movemnt by its inertia = قصور ذاتي (opposite movement)**

➡ **fall backwards** ➡ **cilia moves backward**

Due to the fast movement the granules lag behind in the gelatinous material.
Cilia move back ward due to the movement of the granules.

2- person feels he is falling backwards .

3-try to correct this by leaning forwards to shift statoconia & cillia anteriorly.

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At the end deceleration (runner try to stop)

1-statoconia move forwards by its momentum = is the opposite of inertia قوة الدفع

2- cilia move forward person feels falling anteriorly

3-try to correct this by leaning backwards to shift statoconia & cillia posteriorly

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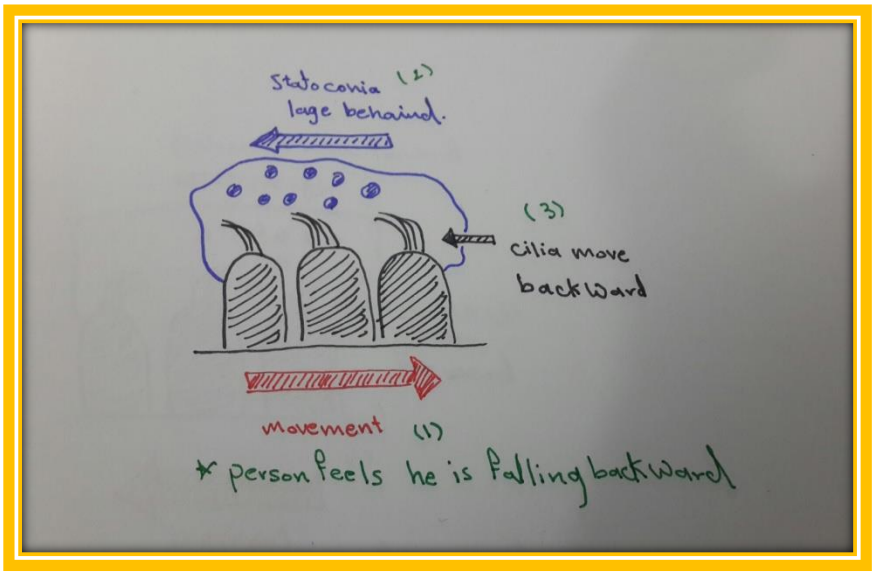
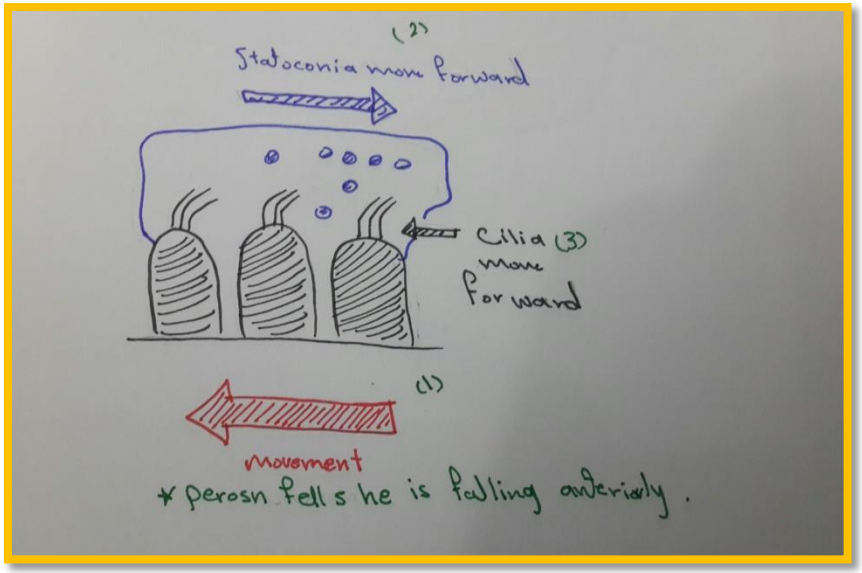
1- in beginning (acceleration) :



2- when your running became regular:
It take the speed and direction
of movement.



3- in the end (deceleration) :

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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 = macula (area with receptors)

- stereocilia & a large kinocilium directed to the utricle in which the ampulla open.
(cillia bending towards utricle by movement of endolymph)

- cilia embedded in a gelatinous mass called cupula

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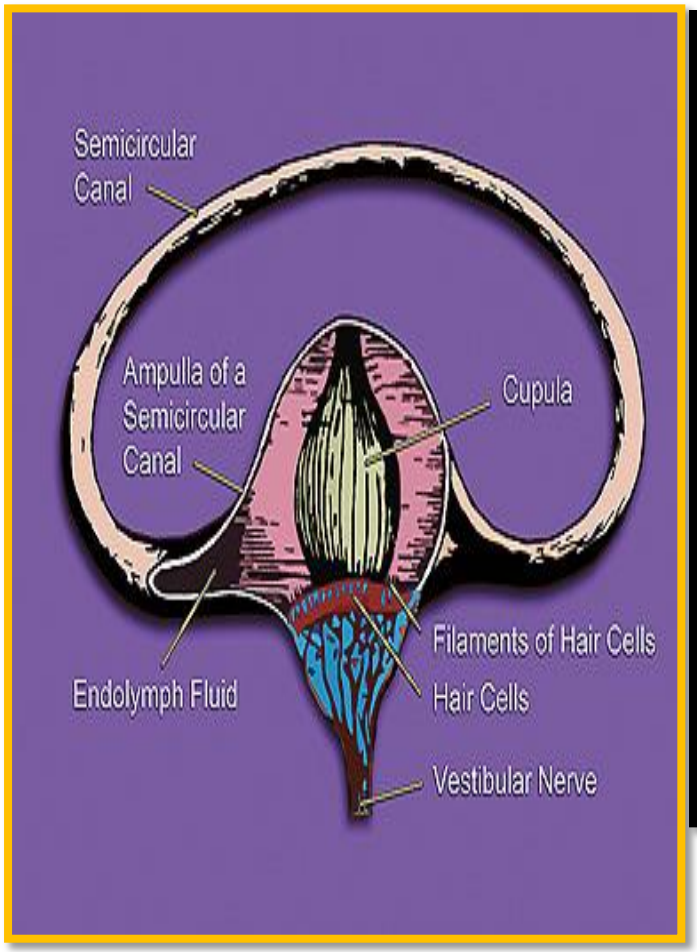

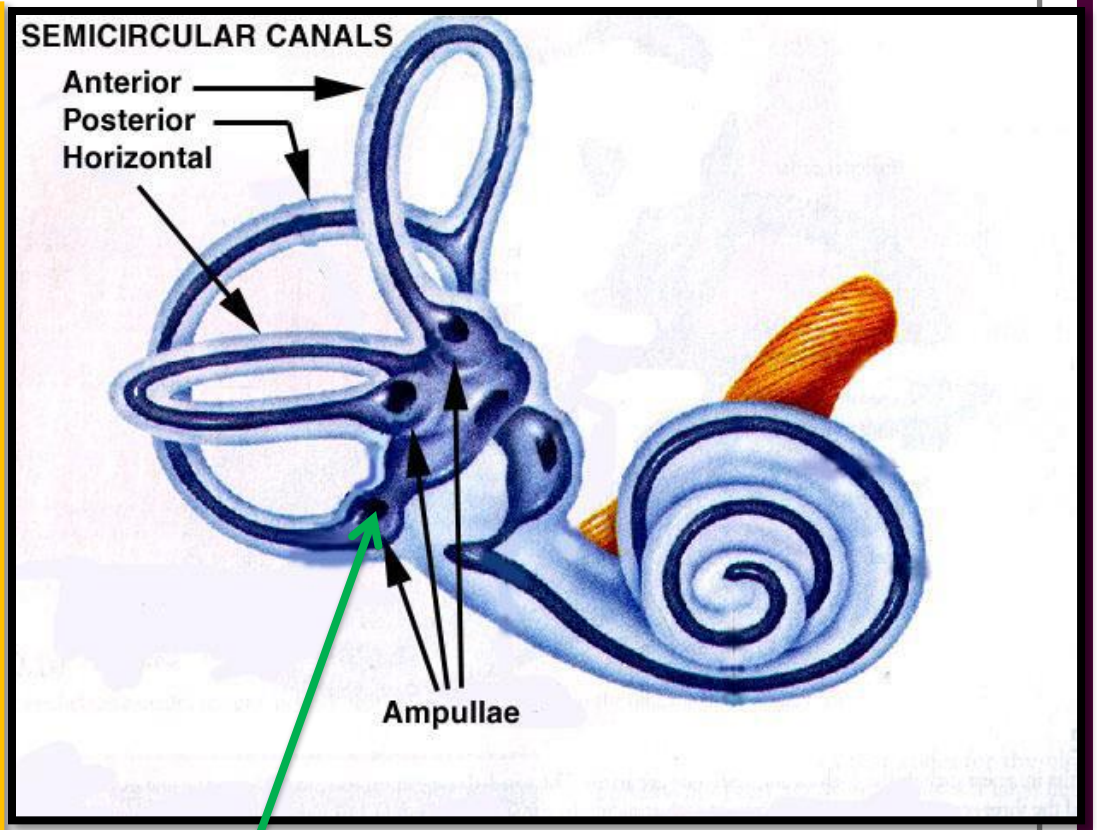

crista ampularis

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Function of SEMICIRCULAR CANALS

1- during rest:	2- Detect & maintain posture
A- equal discharge from SCC on both sides (balance).	A- during head rotation in any direction (angular acceleration)= rotation (Roller coaster)
B- transmit from their cristae about 200 impulses/sec as basal tonic discharge.	B- they are stimulated at beginning & at end & by changing direction or rate of rotation (not stimulated by maintained constant rotation as earth rotation) Its not stimulated during the rotation it self .

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In horizontal SCC

- bending kinocilium towards utricle = cupula towards utricle
- → **stimulate hair cells.**
- While bending kinocilium away from the utricle = cupula away from the utricle
  .. → **inhibit hair cells.**

Example: sensation of rotation to right.

1-Rotation to **right**	1-what happen in the left side.
2-cilia of right side bent by endolymph **towards the kinocilium**.	2-cilia of left side bent by endolymph away from the kinocilium
3-cupula moves **towards the utricle** (Stimulate the hair cell)	3-cupula moves **away from the utricle** (inhibit the hair cell)
4-depolarization	4-hyperpolarization
5-impulses from right side **increase**.	5-impulses from left side **decrease**.

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The doctor said that the mechanism is not required

- angular acceleration = rotation.

1- at begening:	2- during maintained rotation:	3- at end:
In the **same** direction of rotation	Equal (no sensation of rotation)	false sensation of counter-rotation (fells of rotation in **opposite** side)

Nervous connections of vestibular apparatus

Nerve fibers from maculae & cristae ampularis → Vestibular nerve → Epsilateral vestibular nucleus

1-cerebellum:

floculonodularlobe & dentate nucleus → thalamus of the **opposite** side → cortex of the **opposite** side → 1- motor areas **(muscles)**
2- superior temporal gyrus for(vertigo)

2-spinal cord (vestibulospinal tracts): posture maintain.

3-Reticular formation (brain stem): reticulospinal tract for muscle tone and posture.

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

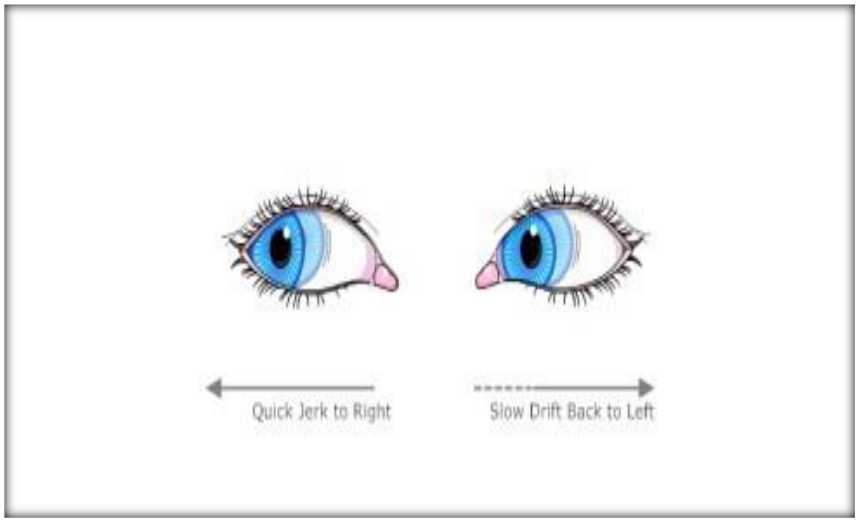
Effects of stimulation of S.C.C

- 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. http://www.youtube.com/watch?v=H4iQkFUgG6k

1-Vertigo: this false sensation of counter-rotationat **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

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Question

Q1- if the stereocilia move away from kinocilium what happen ?

A- hyperpolarization.

B- depolarization.

C- hair cells will remain constant action potential.

Q2- at the beginning of the liner acceleration ?

A- the statoconia lag behind and the person fells he is falling interiorly

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 he try to correct this by leaning forward.

Q2- at the beginning of angular acceleration :

A-statoconia move forwards by its momentum

B- false sensation of counter-rotation.

C- person feels he is falling backwards.

D- Nystagmus.

Q1 = A
Q2 = D
Q3 = D

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THE END

If there are any Problems or Suggestions,
Feel free to contact:

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THANK YOU