

**431**

**CNS** System  
central Nervous

**Block**

**Physiology Team**

Female Side

Male side

**Done By: Yafa Alshamlan**

**Revised By: Nour Alkhawajah**

**Mohammad Asiri**

# CNS System central Nervous

## Block

Slide No.( 1 )



Team Notes :

Red is important

Blue is for explanation



# CNS System central Nervous

## Block

Slide No.( 2 )

### 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

Team Notes :

Postures are maintained by reflexes (subconsciously)

Visual receptors= rods and cones



# CNS System central Nervous

## Block


Slide No.( 3 )

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

Team Notes :

Vestibular apparatus is in the non-auditory membranous labyrinth

Sacule, utricule and semi circular canals (scc) are responsible for equilibrium



# CNS System central Nervous

## Block

Slide No.( 4 )

### Vestibular apparatus:-

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

2- SCC has ampulla.

### Team Notes :

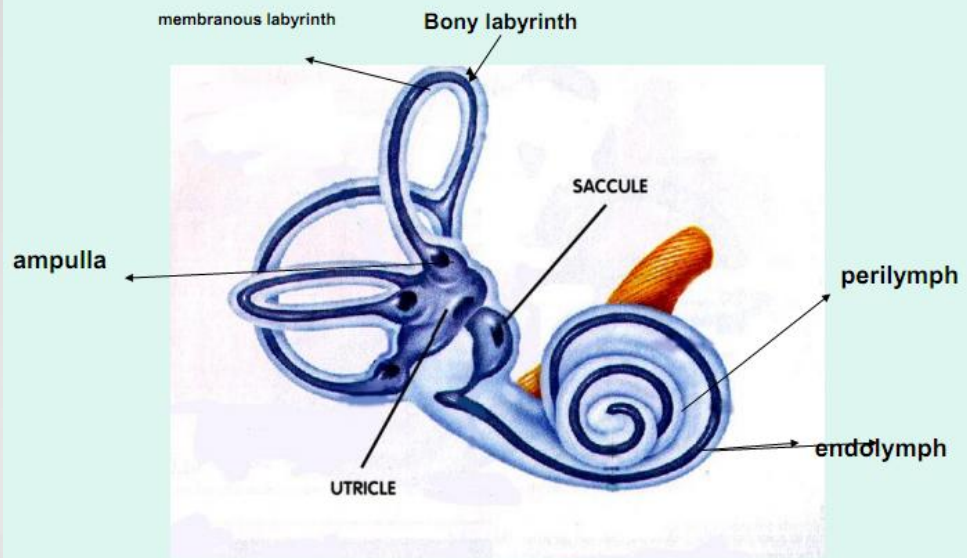
Macula (otolithic organ) is the balance receptor

Ampulla has receptor (sensitive organ) for balance called "crista ampullaris"

# CNS System central Nervous

## Block

Slide No.( 5 )



Team Notes :

Nothing else was mentioned



# CNS System central Nervous

## Block

### Slide No.( 6 )

- **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 subsended in gelatinous material.

### Team Notes :

Kinocilium is the tallest cilium

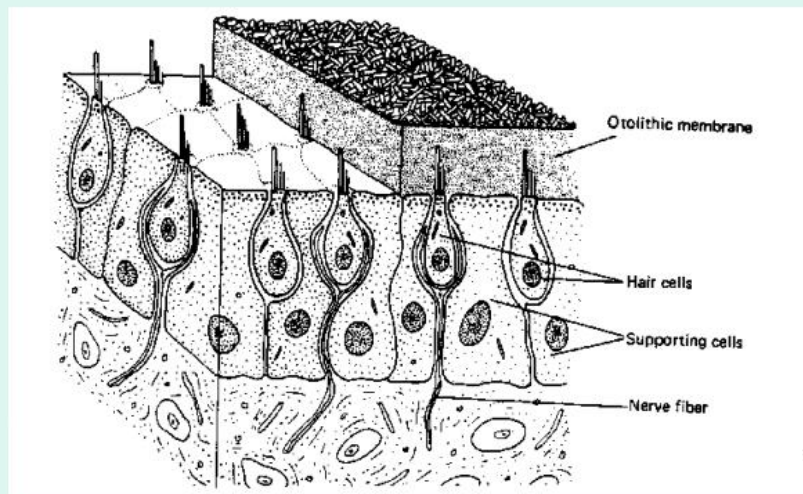
Filamentous attachment is a delicate membrane that holds the cilia together

Statoconia= calcium carbonate crystals

# CNS System central Nervous

## Block

Slide No.( 7 )



**Team Notes :**

Otothic membrane= othoes that has the statoconia



# CNS System central Nervous

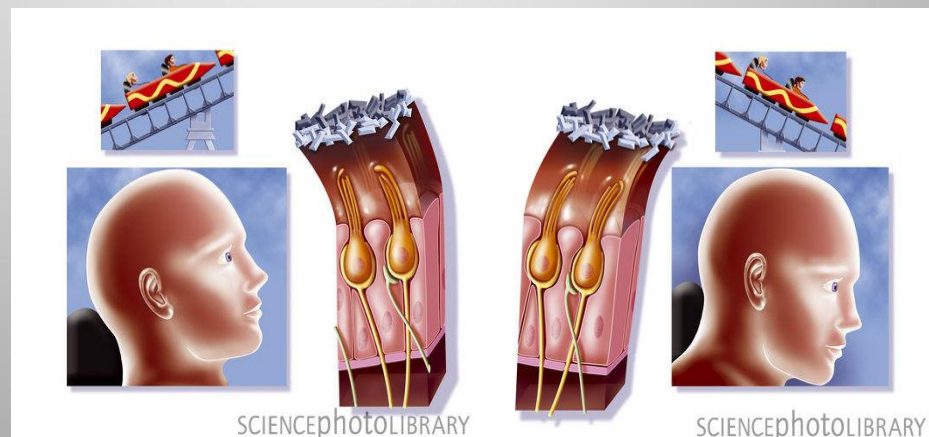
## Block

Slide No.( 8 )

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

Team Notes :

When the head is vertical, the macula is horizontal and cilia are vertical



Explanation:

When the head bends, statoconia and the gelatinous material act like weights and pull the hair cells to the same direction.

# CNS System central Nervous

## Block

Slide No.( 9 )

- **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.

### Team Notes :

MAO of macula:

1- at rest both utricles send basal discharges (with the same amount of impulses at the same time) to the brain, so it knows that the head is stable

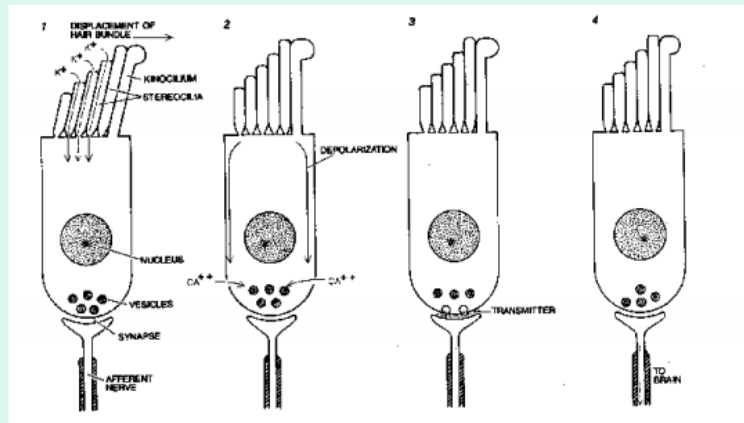
2-stereocilia bends towards kinocilium according to the head's position>.....> depolarization >opening of  $Ca^{++}$  channels in hair cells .....

# CNS System

central Nervous

## Block

Slide No.( 10 )



Team Notes :

Nothing else was mentioned

# CNS System central Nervous

## Block

Slide No.( 11 )

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

Team Notes :

Nothing else was mentioned



# CNS System central Nervous

## Block

Slide No.( 12 )

- 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

### Team Notes :

Linear acceleration: (movement in a straight line), includes walking and taking the elevator

Inertia: opposite movement (القصور الذاتي)

When a person is moving forwards, the statoconia are moving backwards pulling the hair cells backwards, that's why he feels that he is being pushed backwards



# CNS System central Nervous

## Block

Slide No.( 13 )

- - 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 & cilia posteriorly,

Team Notes :

Momentum= is the opposite of inertia

Slide No.( 14 )

## 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). ( cilia bending towards utricle by movement of endolymph)
- 
- - cilia embedded in a gelatinous mass called cupula).

### Team Notes :

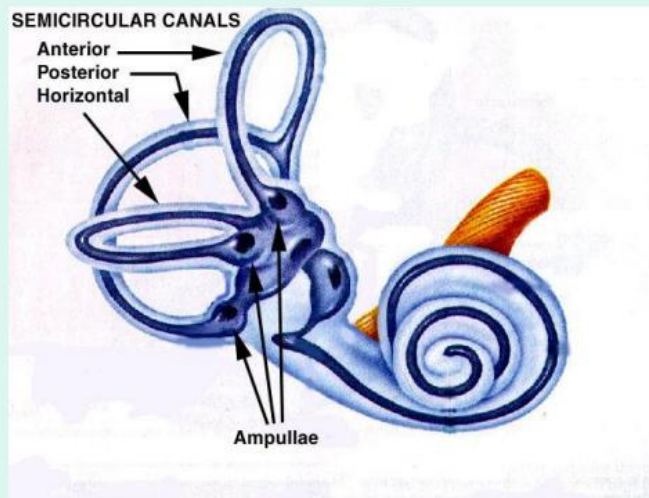
The endolymph will pull the cilia when it moves.

# CNS System

central Nervous

## Block


Slide No.( 15 )



Team Notes :

Nothing else was mentioned





# CNS System central Nervous

## Block

Slide No.( 16 )

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)

**Team Notes :**

Rotation= complete body rotation (like sitting in a rotating chair)

Semicircular canals do not detect linear acceleration only rotated acceleration.

Semicircular canals are stimulated at the beginning and at the end of the rotation but never in the middle

# CNS System central Nervous

## Block

Slide No.( 17 )

**-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.**

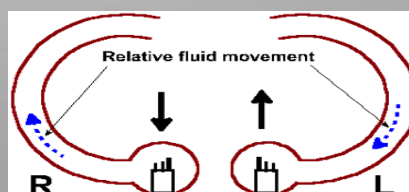
### Team Notes :

Explanation: rotation from left to right

At the beginning: endolymph moves to opposite direction (inertia) > cilia are bent towards kinocilium> kinocilium bend towards utricle> increased impulses from the right to the brain> sense of movement to the right. But in the left side, the cilia are bent away from kinocilium> away from utricle> decreased impulses from the left to the brain > no sense of movement to the left.

Constant rotating (middle): tonic discharge from right and left > no sense of rotation

At the end (stopping): endolymph moves from left to right (momentum)>cilia of the left side moves towards kinocilium> towards utricle>increased impulses from the left to the brain>sense of movement to the left (opposite= vertigo)



# CNS System central Nervous

## Block

Slide No.( 18 )

### Nervous connections of vestibular apparatus:-

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 **for vertigo**).

**2- spinal cord (vestibulospinal tracts)**

**3- Reticular formation**

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

### Team Notes :

Vestibular nucleus: is the distributing area

Vestibulospinal tract is for coordination of postural reflexes

Reticulospinal formation sends the reticulospinal tract for adjustment of posture

Nystagmus= rapid eye ball movement



# CNS System central Nervous

## Block

Slide No.( 19 )

### 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.

Team Notes :

Nothing else was mentioned



# CNS System central Nervous


## Block

Slide No.( 20 )

- **3- bradycardia & hypotension.**
- 4- increased muscle tone on same side of rotation to support the body & decreased muscle tone on the opposite side**

### Team Notes :

Bradycardia and hypotension are due to increase in parasympathetic activity, head rotation will attenuate (reduce) the baroreflex response (which is responsible for increasing the blood pressure)>hypotension



# CNS System central Nervous Block

Slide No.( )

## Summary

- Vestibular apparatus is responsible for equilibrium and contains {sacculle, utricle, semicircular canals}
- Utricle of the macula is stimulated or inhibited by bending the head
- Macula maintains equilibrium and detects linear acceleration
- Scc maintain equilibrium during angular acceleration (rotation)
- Movement towards kinocilium>stimulation
- Movement away from kinocilium>inhibition
- Stimulation of scc effects nervous, cardiovascular and muscular systems

**Team Notes :**

## Questions:

Q. What is the effect of stimulation of semicircular canals?

- a) Coma
- b) Vertigo
- c) Hearing loss
- d) increase muscle tone of the opposite side of rotation

Q. When tilting your head to the left what happens?

- a) Depolarization of the left side
- b) Hyperpolarization of the left side
- c) Tonic basal discharge from both sides
- d) Sensation of tilting to the right

Answers: b,a