

Vestibular apparatus

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Vestibular apparatus

The organ that detects the sensation of equilibrium

It is composed of:

- **Bony part (bony labyrinth)** which consisted of 3 bones **semicircular canals** & **vestibule**
 - Receptor
 - detector
- **Membranous part**
 - which consisted of **3 semicircular ducts** (canals) **ampullae**,
 - 2 sacs** **utricle** and **saccul**(**the Macula**) → ^{داخل:} [utricle, saccul]
 - Between the bony and membranous labyrinth, there is a fluid called **perilymph** and inside the membranous labyrinth there is another fluid **endolymph**.
 - ↓
extracellular

* 6 قنوات
 * 5 فتحات
 لأنه [Ant + Post]
 عاملين مع بعضنا end وحدة
 من الجهة البعيدة عن السائل

Ant + Post → Vertical

Anterior

Ampullae → dilated end

Utricle

Maculae and statoconia

Semicircular Canal
 هو الة علاقة مع

Semi-circular canals

Horizontal - lateral

Coccula

Posterior

Sacculle

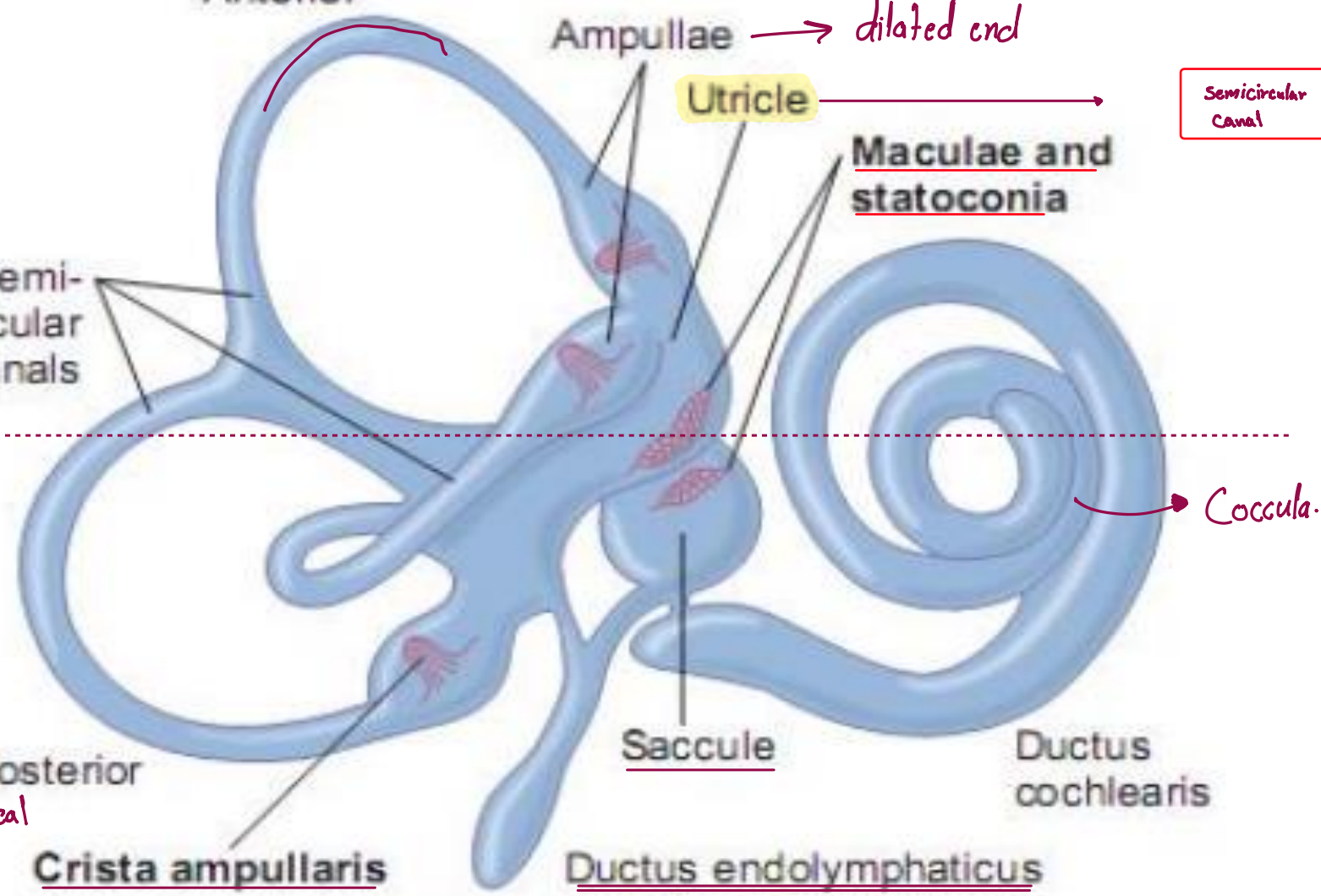
Ductus cochlearis

Ant + Post → Vertical

Crista ampullaris

Ductus endolymphaticus

MEMBRANOUS LABYRINTH

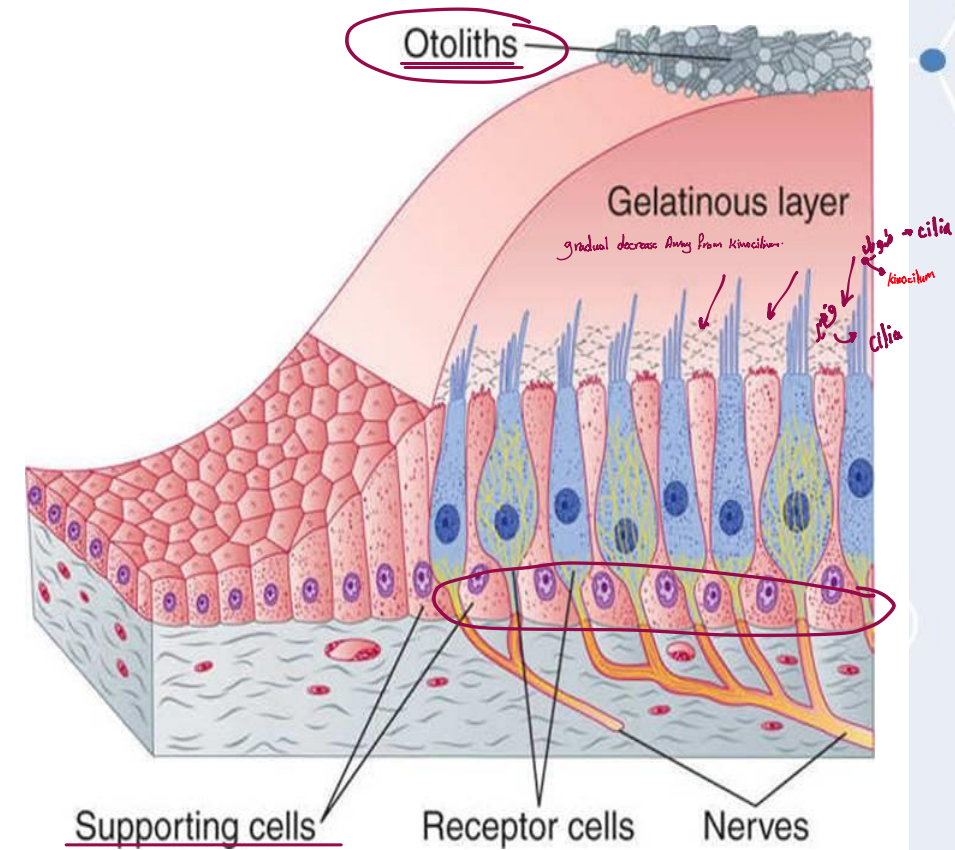


The non-auditory labyrinth in each side is composed of:

(A) The utricle and saccule (Two sacs inside the bony vestibule)

Contain sensory organ called the Macula

- **The macula** is formed of a ridge of columnar epithelium with hair cells having 50-70 stereocilia and one large kinocilium on one side. These cilia covered with gelatinous material, embedded on its top calcium carbonate called Otoliths or Otoconia.



With the head in the erect position, **the macula of the utricle** is in the **horizontal plane** while **that of the saccule is vertical**.

Bend → Forward And Backward.

linear circulation - horizontal



شعرية

[شعرية]

linear circulation - vertical



UPward -> downward.

Basic Rhythm \Rightarrow equilibrium discharge

Mechanism of action

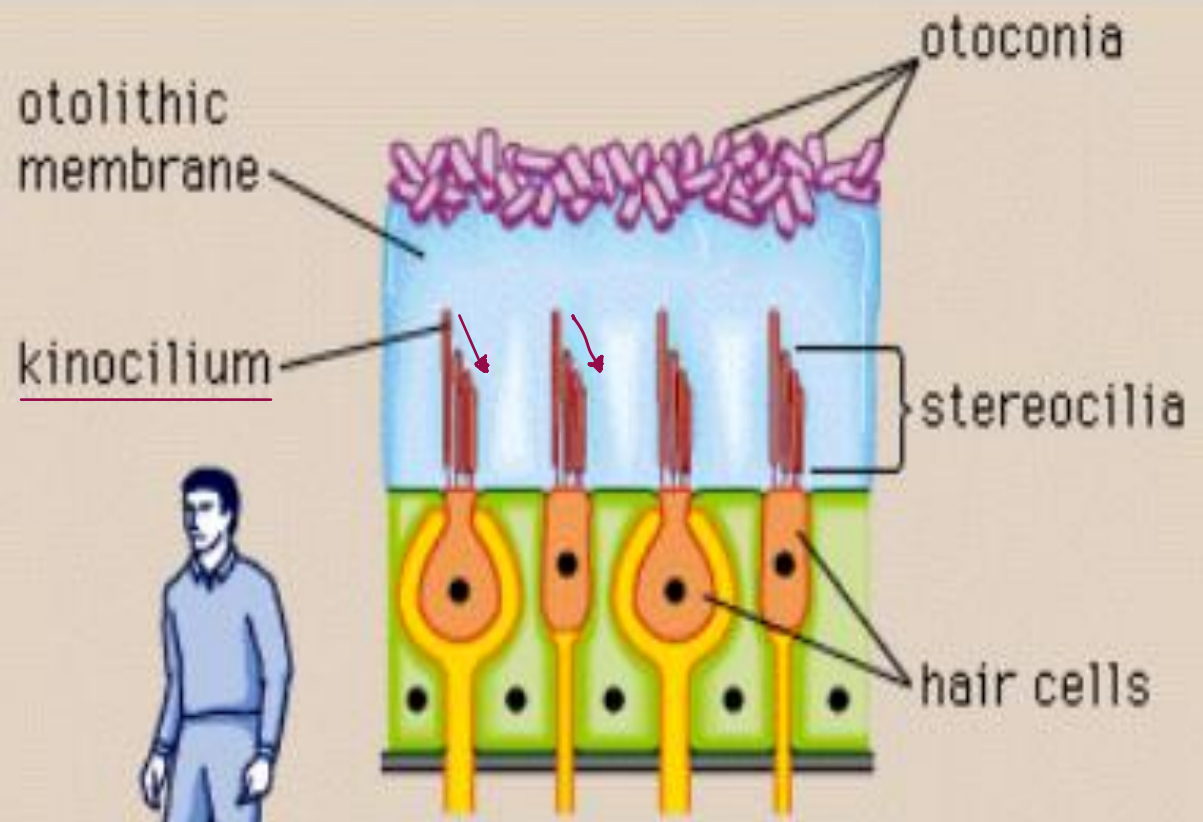
- Bending the cilia of hair cells to side of Kinocilium \rightarrow depolarization of hair cells and increase its discharge in the vestibular nerve. \star
- Bending the cilia to the opposite side causes hyperpolarization of hair cells and inhibition of afferent impulses.
- As the hair is stimulated when otoconia pull on them, each group of hair is oriented in a different direction so, each position of head detected by a particular group of hair .

$K^+ \rightarrow$
endolymph

\rightarrow + [gelatinous material]

بالعادة لما كان يغير depolarization
كنا نفتح قنوات البوروم
كنا هوننا نفتح قنوات
البو فاسيوم (K) .endolymph.

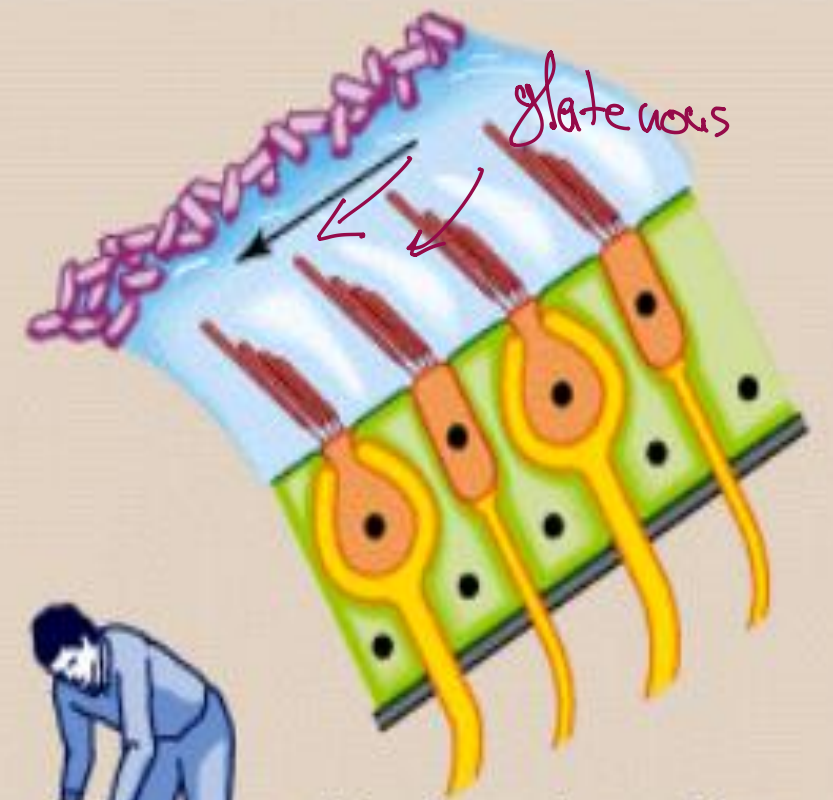
B



upright section of the utricular macula



head upright



displaced section of the utricular macula



head bent forward

Function of the Macula

1. **Orientation of the head in space** (static equilibrium):

If the head in normal erect position δ equal impulses from Rt. & Lt. maculae.

- Titling the head to Rt. → the otoliths of Rt. side displaced by gravity and bending the hair cells → \uparrow rate of discharge from Rt. utricle and \downarrow discharge from Lt. utricle → sensation of tilting of head to right.

Rt → depolarization
Lt → hyperpolarization.

2. **Receptors for linear acceleration:**

- When the body is suddenly **forward** accelerated, the **otoconia** (which have **greater inertia** than surrounding fluid) **displaced backwards** → bending of cilia → stimulation of hair cells → false sensation of falling backwards → **automatic leaning the body forwards** for proper equilibrium.


لو كنت واقفاً في باص:
وفجأة الباص تحرك للأمام.
ستشعر أن:
جسمك يندفع للخلف
ثم تميل للأمام حتى لا تسقط
هذا بالضبط ما تصفه الجملة.

3 main systems for equilibrium:

- 1) - Proprioception [Cerebellum]
- 2) - Vestibule
- 3) - vision

Function of the Macula

3. Receptors for orientation during swimming under deep water:

proprioceptive impulses are absent in this condition. Because, water press all over the body by equal pressure. So, any one with inner ear disease must avoid swimming. Because, if he closes his eyes he will immediately sink. 

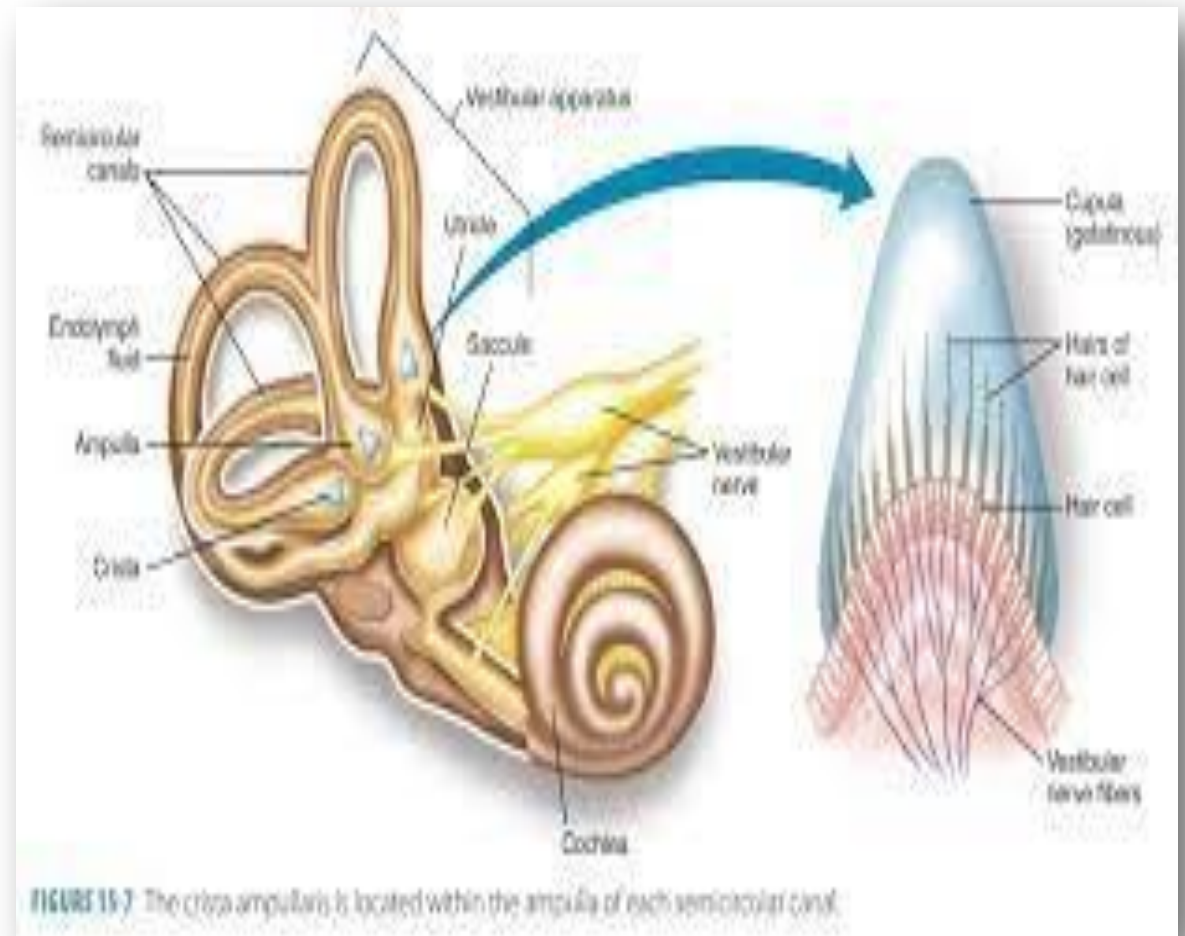
تخيل أنه عندك 3 أجهزة توازن وسلامة ..

- (1) Proprioceptive X in deep water
- (2) Vestibular X → inner ear disease
- (3) vision X → close eye ⇒ عي العيون

The non-auditory labyrinth in each side is composed of:

(B) Semicircular canals: sensory organ (Crista ampullaris)

- The crista composed of ridge of columnar hair cells. The hair is embedded in gelatinous material called cupula, and each cell contains 40-70 stereocilia and one large kinocilium.



Mechanism of action

SCC are stimulated by angular acceleration (rotation)

لزوجة →

Bending of cilia in Direction of Kinocilium causing Depolarization of hair cells & Discharge of impulses in the vestibular nerve on same side.

رکزت عليه ، موضع أسئلة ↓

In horizontal (lateral) canals the kinocilium is present towards the utricle. So, crista is stimulated when it bends towards the utricle. In the vertical canals the opposite occur

Ant ↓
Post

شرح الصورة ↓

In the semicircular canals, there are hair cells that detect rotation of the head.

Each hair cell has:

- Stereocilia
- One kinocilium

The direction in which the hair bends determines whether the cell is stimulated or inhibited.

Horizontal (Lateral) Semicircular Canal

Key rule

In the horizontal canal:

→ Kinocilium ⁼ faces the utricle

So:

Bending TOWARD the utricle → stimulation

Bending AWAY from the utricle → inhibition

Simple sentence

In the horizontal canal, hair cells are excited when the cilia bend toward the utricle.

Vertical Canals (Anterior & Posterior)

Here the rule is reversed.

→ Bending AWAY from the utricle → stimulation

→ Bending TOWARD the utricle → inhibition

Simple sentence

In the vertical canals, hair cells are excited when the cilia bend away from the utricle.

Semicircular ducts:

Anterior

Lateral

Posterior

Ampullae

Crista ampullaris and cupula



(a)

Cupula

Endolymph

Hair cells

Supporting cells

Sensory nerve fibers

Crista ampullaris

(b)

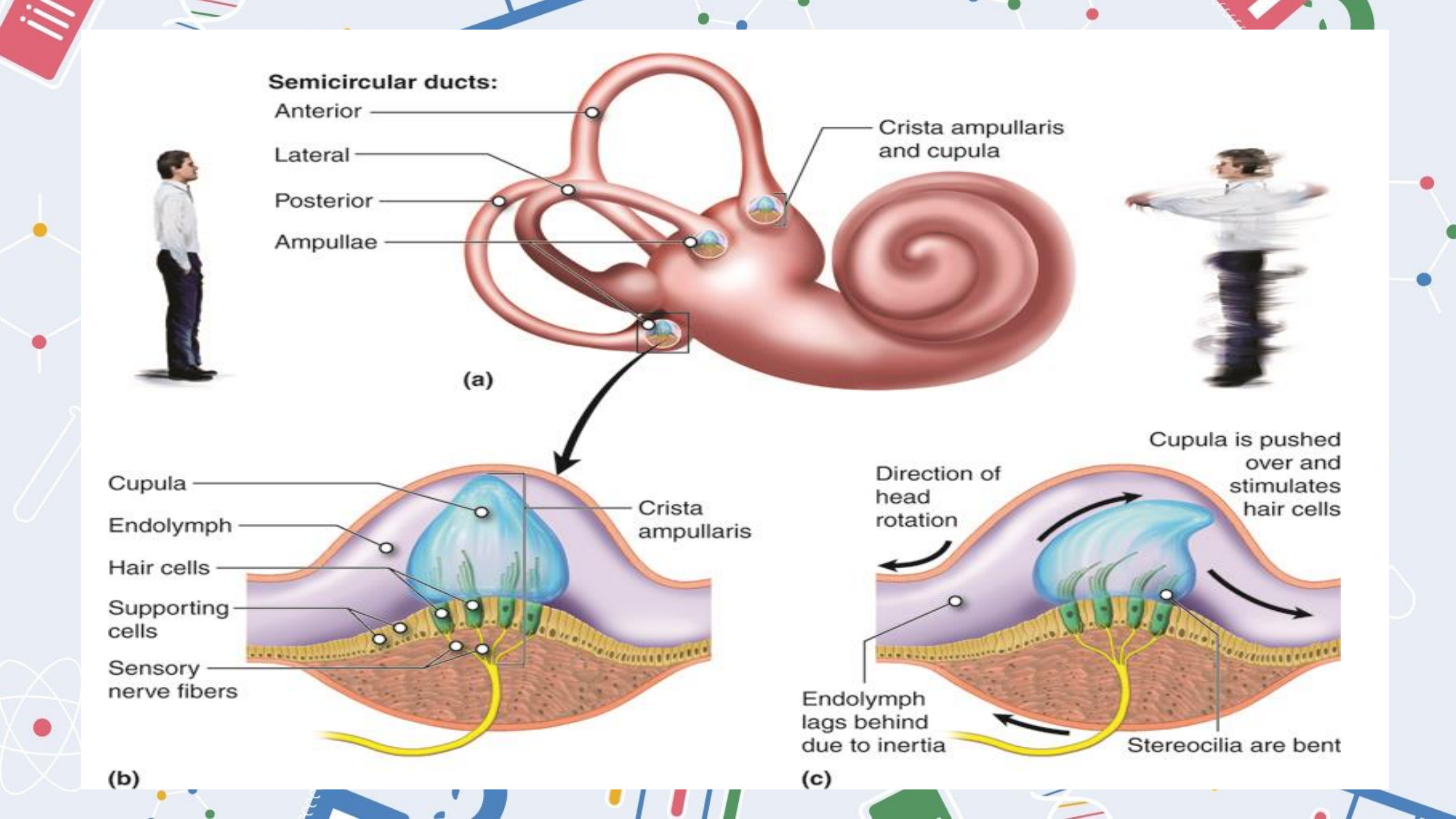
Direction of head rotation

Cupula is pushed over and stimulates hair cells

Endolymph lags behind due to inertia

Stereocilia are bent

(c)



Function of the Crista ampullaris

Mode of action of SCC in angular acceleration:

- **During rest:** these is equal impulses are discharged from SCC of both sides.
- **During rotation to right** the following occurs:
 - 1) *At the beginning of rotation:* ✖
- ✖ • The endolymph by its inertia rotates to Lt (opposite to side of rotation) → bending both cristae to left.
- The Rt. crista bends towards the utricle so it is stimulated → ↑ impulse frequency.
- The Lt. crista bends away from the utricle so it is inhibited (hyperpolarized) → ↓ impulse frequency.
- This unbalanced discharge gives the CNS the sensation of rotation to the Rt.

Function of the Crista ampullaris

انتهى العصور الذاتية

- 1) After 20-30 seconds of rotation: as the rotation continues the [inertia is overcome] and the endolymph moves at the same rates as its bony canal so the cupula return to their normal position by their elasticity → the sensation of rotation disappear.
- 2) At the stoppage of rotation: the endolymph due to its momentum (force keeping it moving) continue to move to the Rt. after stoppage of rotation → bending the cristae to right → stimulation of left crista → false sensation of rotation to left (vertigo).
- 3) After 20-30 seconds of stoppage: The movements of endolymph stop and cupula return to its resting position due to their elasticity → sense of rotation stops.

After stopping rotation:

Endolymph keeps moving → opposite signal → brain senses rotation in the opposite direction.

Results of stimulation of SCC

1) Vertigo:

Definition: It is a false sensation of counter rotation felt on stoppage of rotation → disturbance in equilibrium.

2) Nystagmus:

- **Definition:** It is a rhythmic oscillatory movement of the eye according to direction of rotation.
- **Aim:** to fix objects in the field of vision for long period. → Focus!

Results of stimulation of SCC

3) Autonomic reactions: due to impulses from SCC to autonomic centers in reticular formation causing nausea, vomiting, bradycardia, hypotension, sweating & pallor.

4) Post-rotatory reaction (past-pointing Barany's test): after end of rotation to right the person feels false sensation of rotation to left.

So ,if he is asked to touch a point on the wall "he determined it previously before closing the eye" he will point to the right of the point to compensate false sensation of rotation to left.

Results of stimulation of SCC

5) Changes in muscle tone:

stimulation of SCC causes increase in muscle tone on the same side and decrease in opposite side to support the body posture.

Results of stimulation of SCC

Meniere's disease:

- it is due to increased pressure in the endolymph of unknown causes. It is characterized by attacks of vertigo, nystagmus, vomiting, loss of equilibrium, and tinnitus or even defective hearing acuity.
- In severe cases surgical removal of the vestibular nerve becomes the only treatment to avoid severe, vertigo and loss of equilibrium.

one of treatment:

↓ decrease secretion of endolymph => by Carbonic Anhydrase enzyme



THANK
YOU

