أهلا وسهلا

الأستاذ الدكتور يوسف حسين

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دكتوراة من جامعة كولونيا المانيا

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Vestibular System

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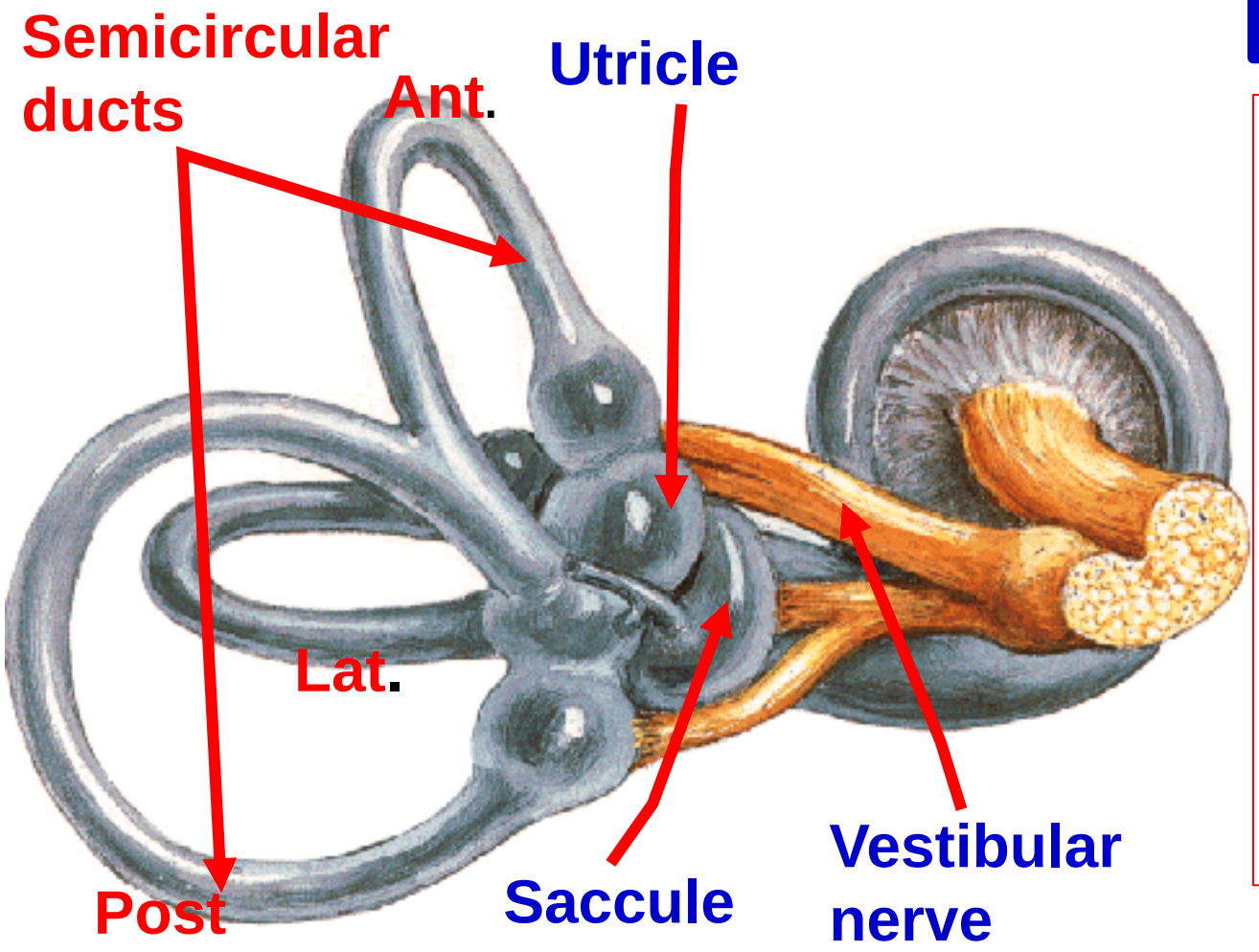
Vestibular apparatus

❖Vestibular apparatus



- **3 semicircular ducts (anterior, posterior and lateral)**
- **Otolith organ (utricle and saccule)**
- These cavities inside the bony labyrinth.

- These cavities are filled by **endolymph**.

- They are separated from the bony labyrinth by **perilymph**

❖ 3 semicircular ducts

- They lie within the corresponding semicircular canals.
- They open in the utricle.

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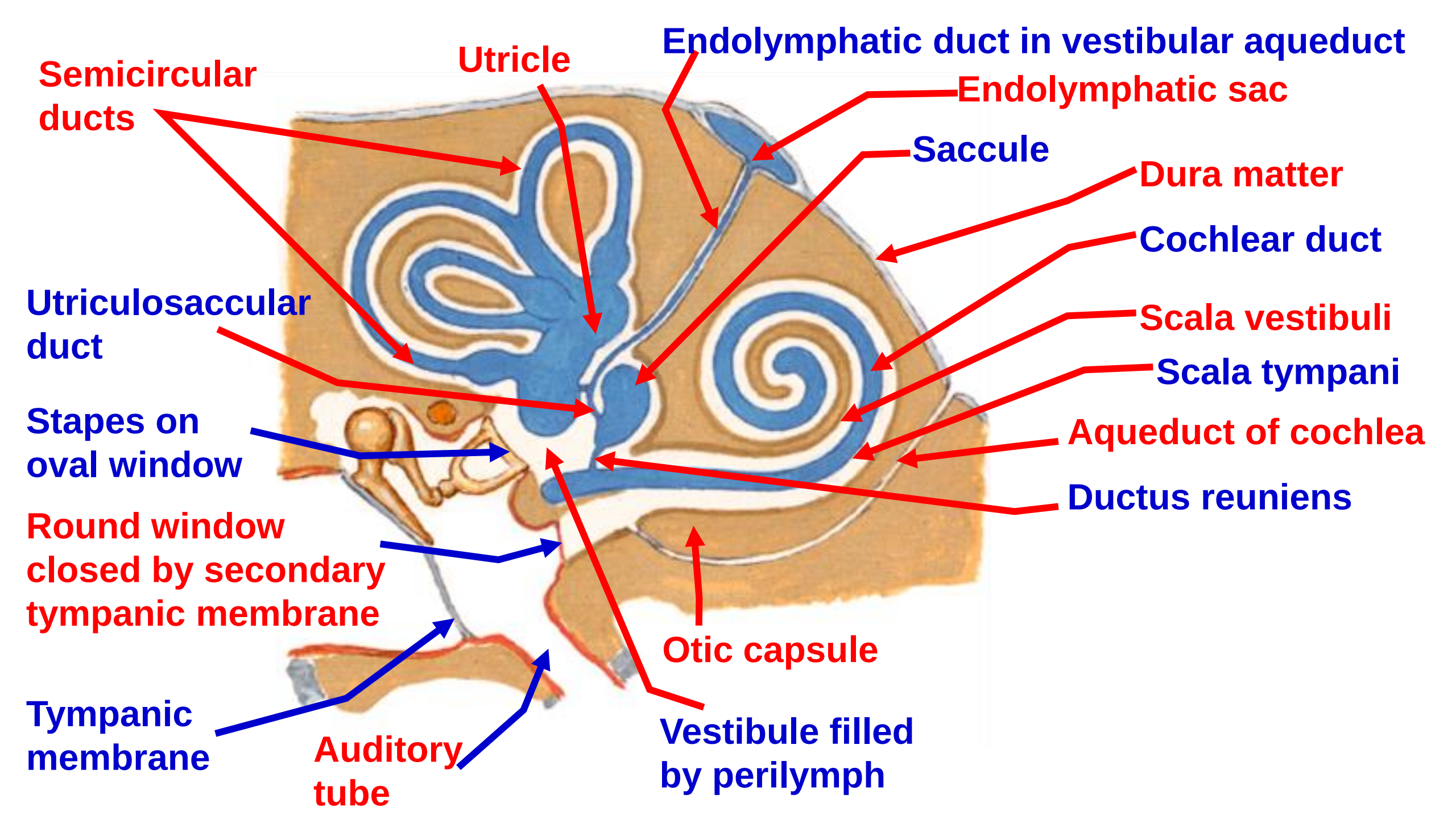
Semicircular ducts
Utricle
Endolymphatic duct in vestibular aqueduct
Endolymphatic sac
Saccule
Dura matter
Cochlear duct
Utriculosaccular duct
Scala vestibuli
Scala tympani
Stapes on oval window
Aqueduct of cochlea
Ductus reuniens
Round window closed by secondary tympanic membrane
Otic capsule
Tympanic membrane
Auditory tube
Vestibule filled by perilymph

❖ **Utricle and saccule:** small sacs filled by endolymph in **vestibule** filled by perilymph.

A- Utricle is larger than **saccule,** receives 3 semicircular ducts

- The utricle communicates with **saccule** via **Y-shaped utriculosaccular duct.**

- This utriculosaccular duct has a side branch to the endolymphatic duct which passes inside bony canal (called **vestibular aqueduct) in petrous part of temporal bone** to the **endolymphatic sac** that situated under the dura matter.

- Endolymph is resorbed into the **cerebrospinal fluid** from the endolymphatic sac (site for the drainage of endolymph)

- Its lateral wall in thickened to form a **macula.**

B- Saccule, close to base of cochlea.

- It is connected to cochlear duct by **ductus reunines**.
- Its anterior wall in thickened to form a **macula.**
- **The macula receives the fibres of the vestibular nerve.**

- Macula of the **utricle detect horizontal** linear acceleration
- Macula of **saccule** detect **Vertical** linear acceleration

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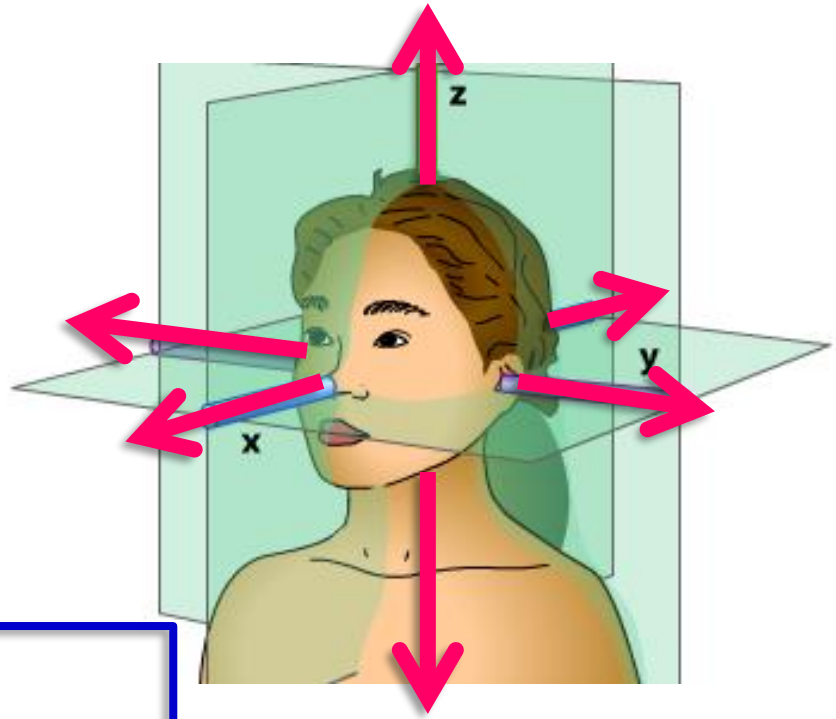
❖Vestibular apparatus

- Utricle senses acceleration in the horizontal plane: forward and backward, right and left movement or combination.



- Saccule senses acceleration in the sagittal vertical plane: up and down

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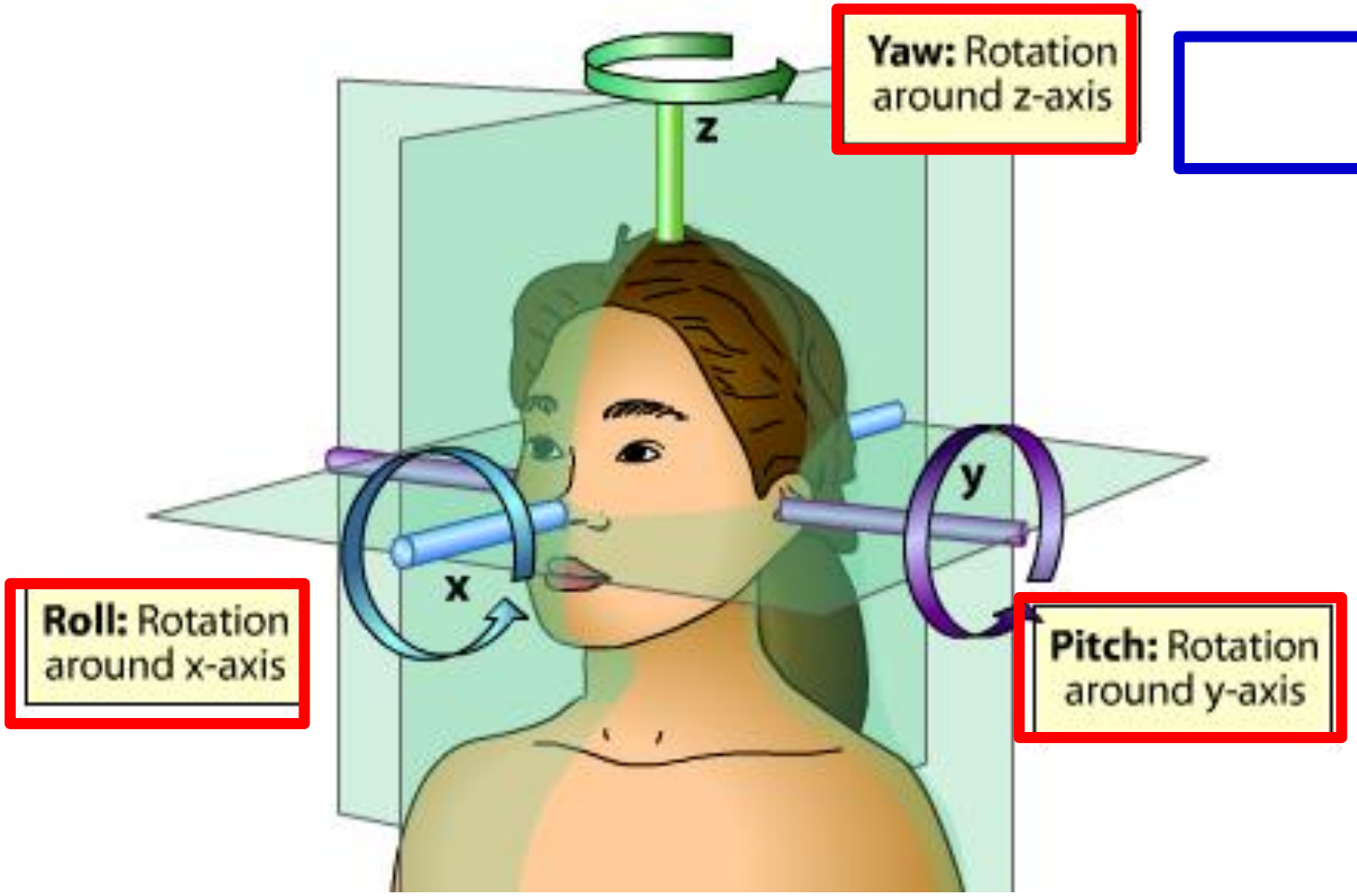
❖Vestibular apparatus



3 semicircular canals are sensitive to angular accelerations (head rotations) around 3 axes.

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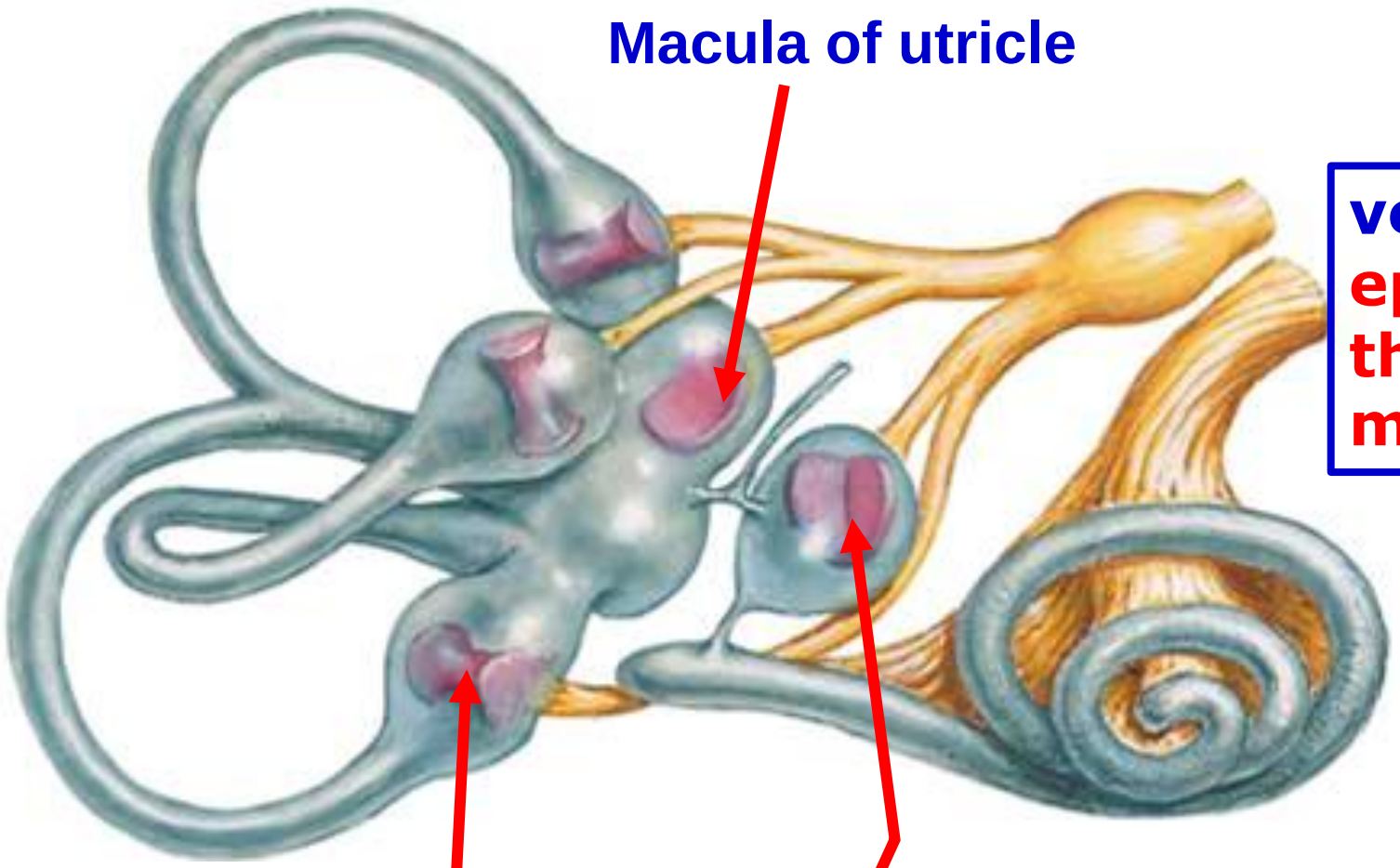
Receptors Vestibular apparatus



vestibular sensory epithelium is located in the walls of the membranous labyrinth

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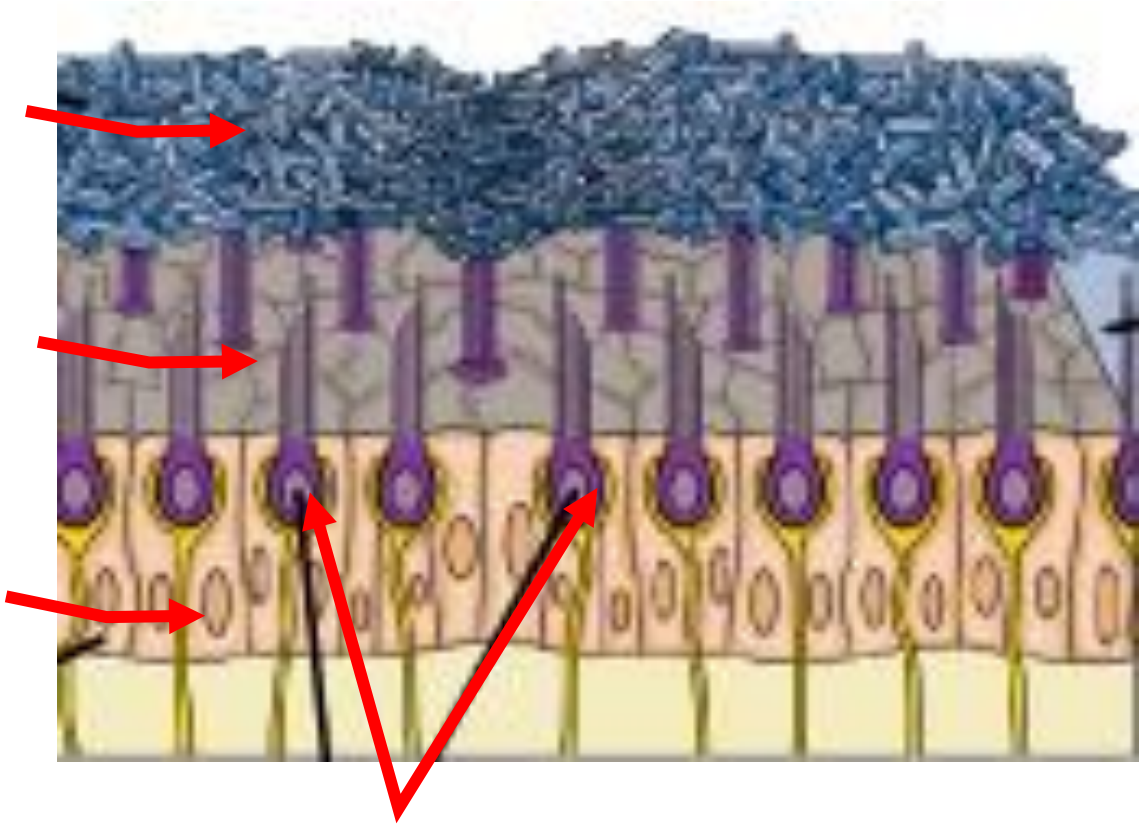
Vestibular Sensory Epithelium



Otolithic membrane

macula is a specialized area of neurosensory epithelium lining the membranous wall of **utricle and saccule**

- The epithelial surface is covered by a **gelatinous layer**
- **A**bove this layer is a **fibrous structure**, in which many small crystals of **calcium carbonate**, are embedded (**otoconia**)

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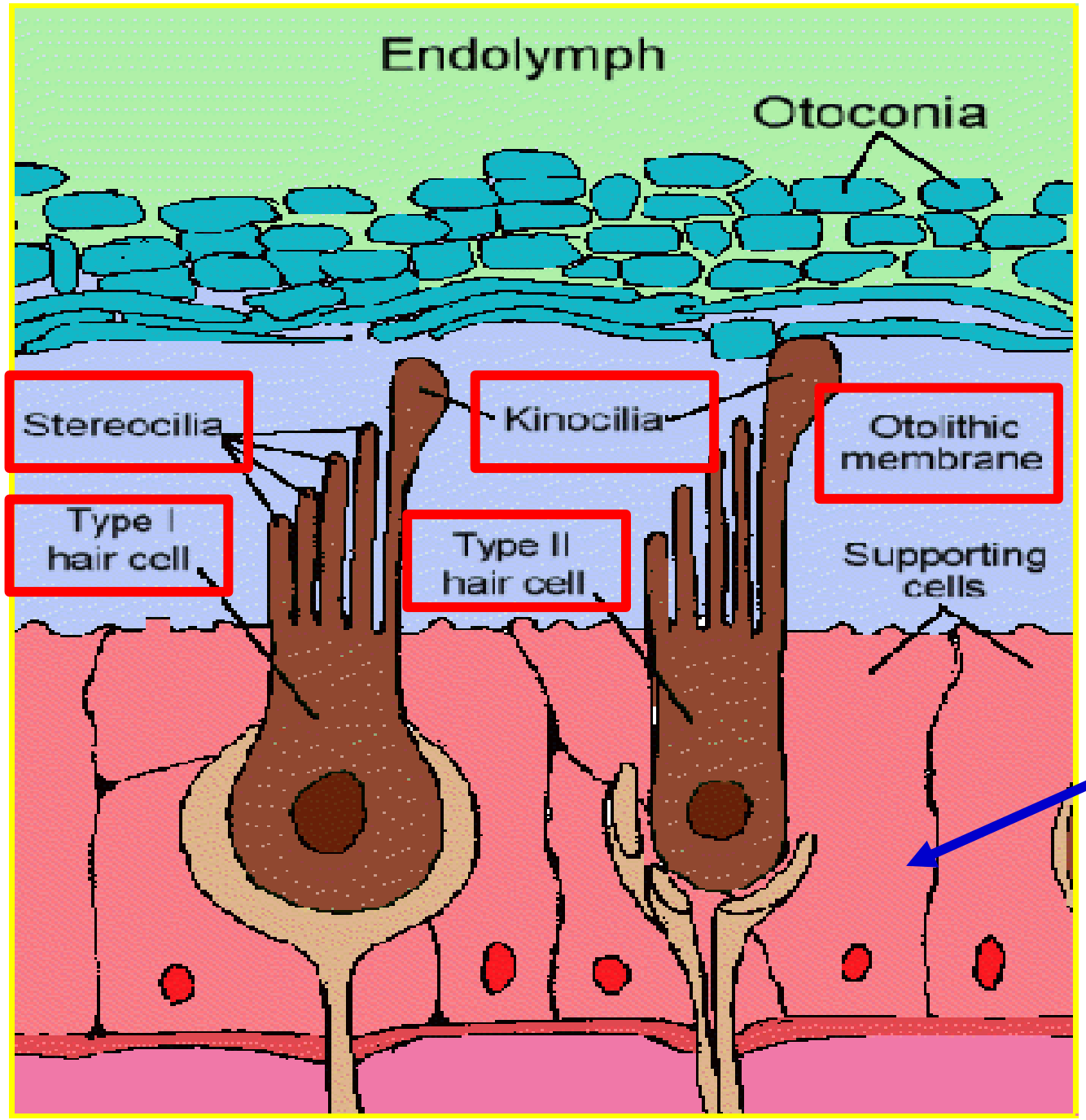
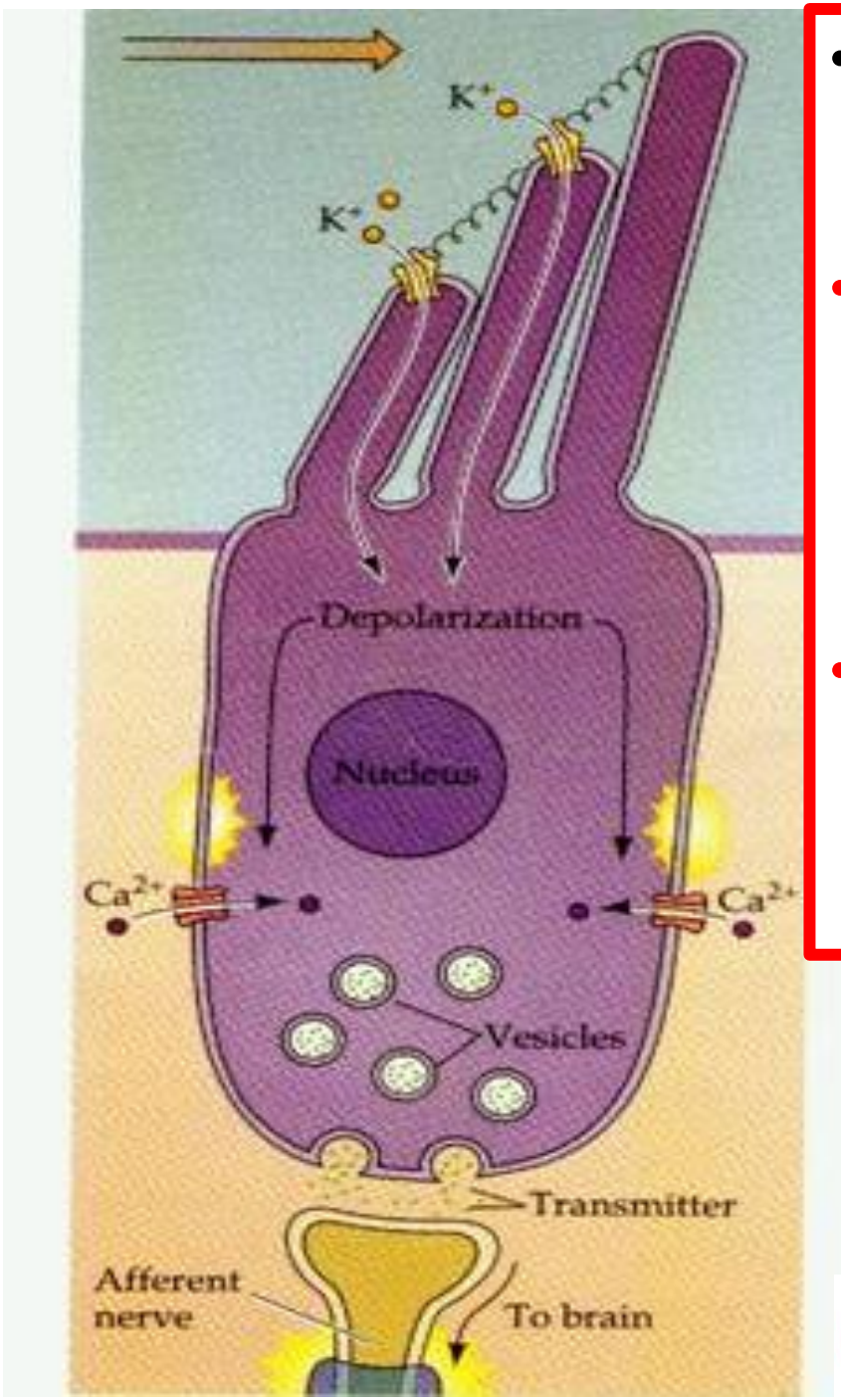


- **Macula** showing Type I and Type II hair cells
- Their hair bundles which are embedded in **otolithic membrane** called **stereocilia.**
- The large cilium in each bundle is called **kinocilia.**

Macula



- **Depolarized (stimulation) or Hyperpolarized (inhibition) depending upon movements of the stereocilia**
- **Movement of stereocilia towards kinocilium open potassium channels** and **depolarization** of hair cells thus causing neurotransmitter release and so increasing vestibular activity afferents to brainstem
- **Movement of stereocilia away from kinocilium closes potassium channels** with **hyperpolarization** of hair cell and thus reducing vestibular activity

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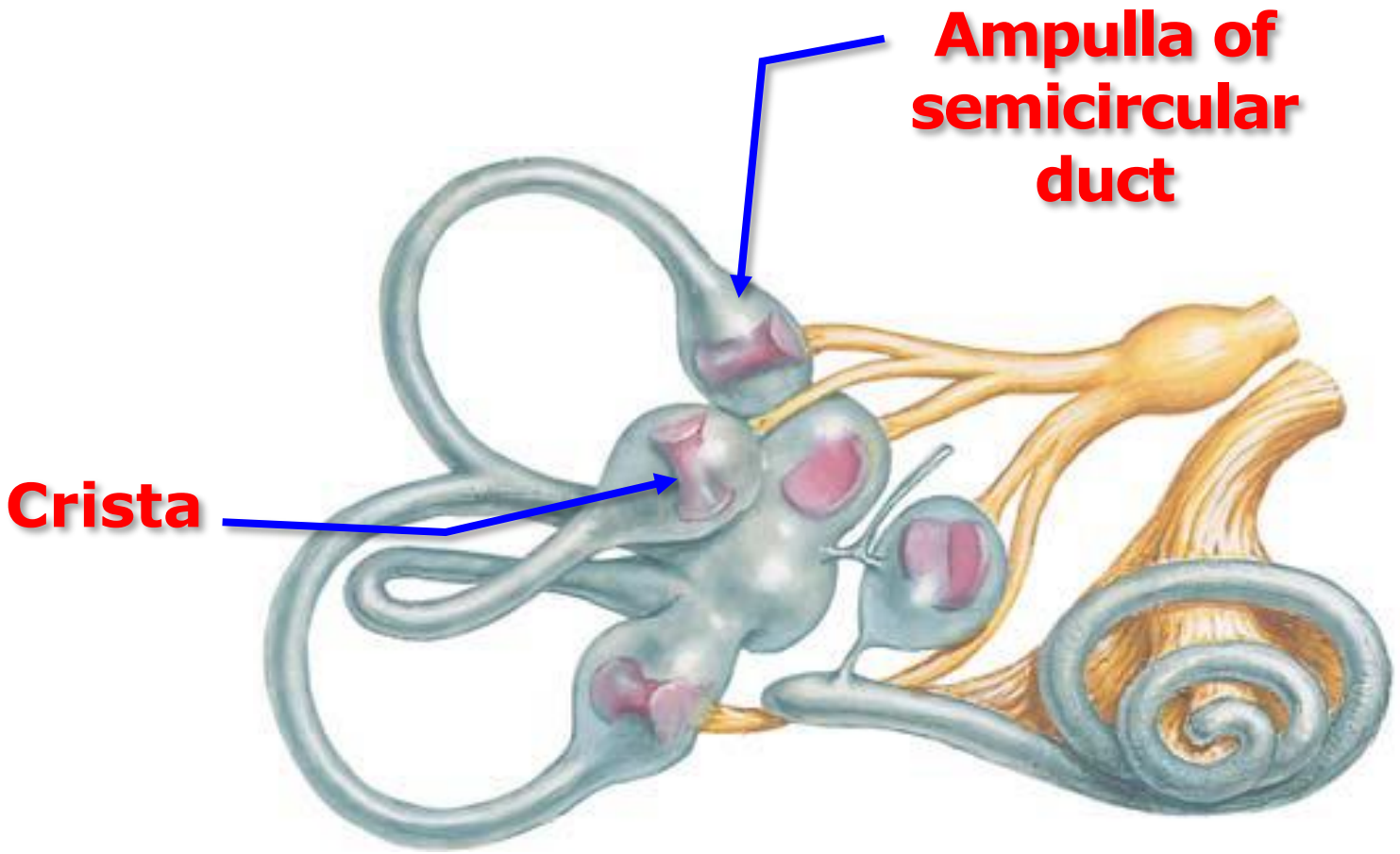

- The lateral end of each semicircular ducts dilated to form an **ampulla**
- **The crista** lies within the ampulla of each duct

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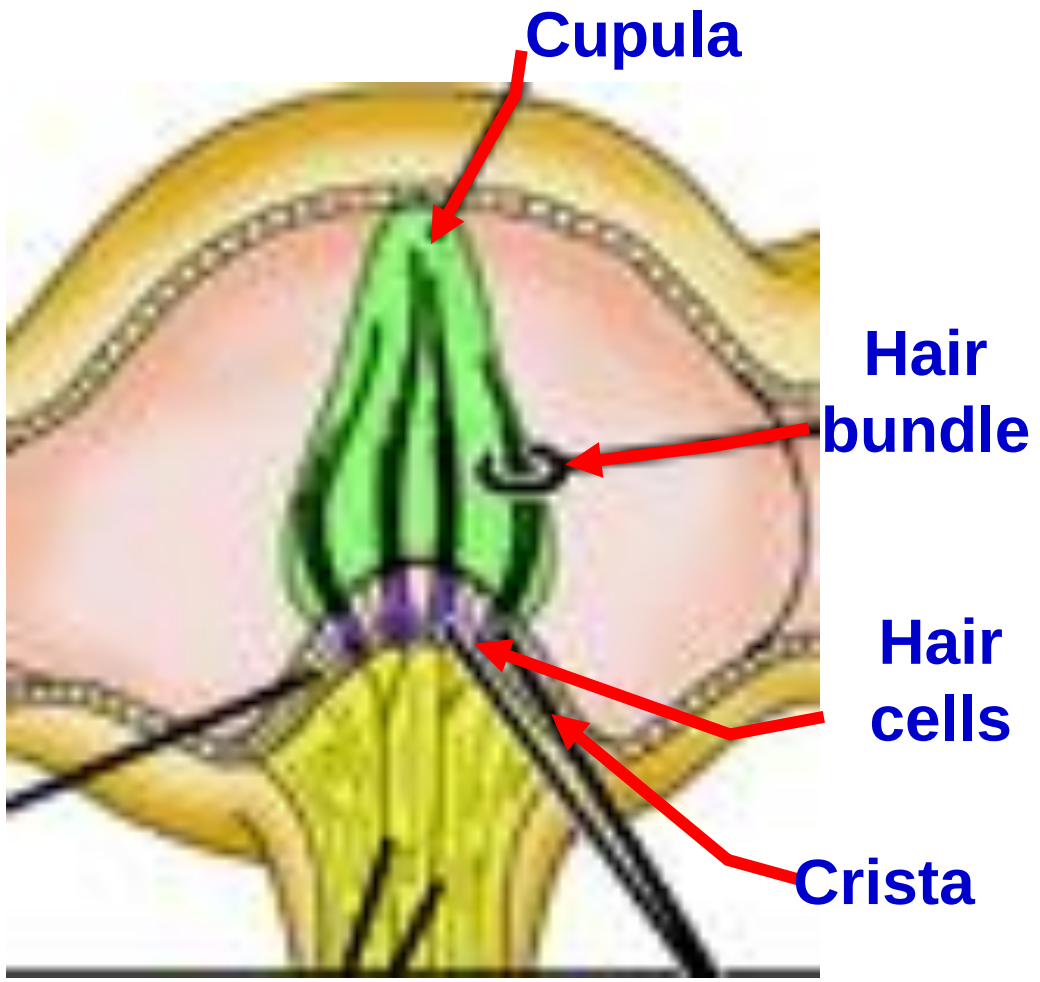
- **The Crista** has many **hair cells**
- **Hair bundles** are covered by a gelatinous structure, **cupula**.
- **The cupula** forms a viscous barrier through which the endolymph cannot circulate.
- **When the head turns to the left, For example:** the **cupula** is **pushed toward the kinocilia in the left** lateral (horizontal) canal, So **depolarization** occurs and the firing rate of left vestibular nerve increases. In contrast, the cupula in the **right** lateral canal is pushed **away** from **kinocilia**, So **hyperpolarization** occurs
- If the head turns to the right, the result is the opposite.



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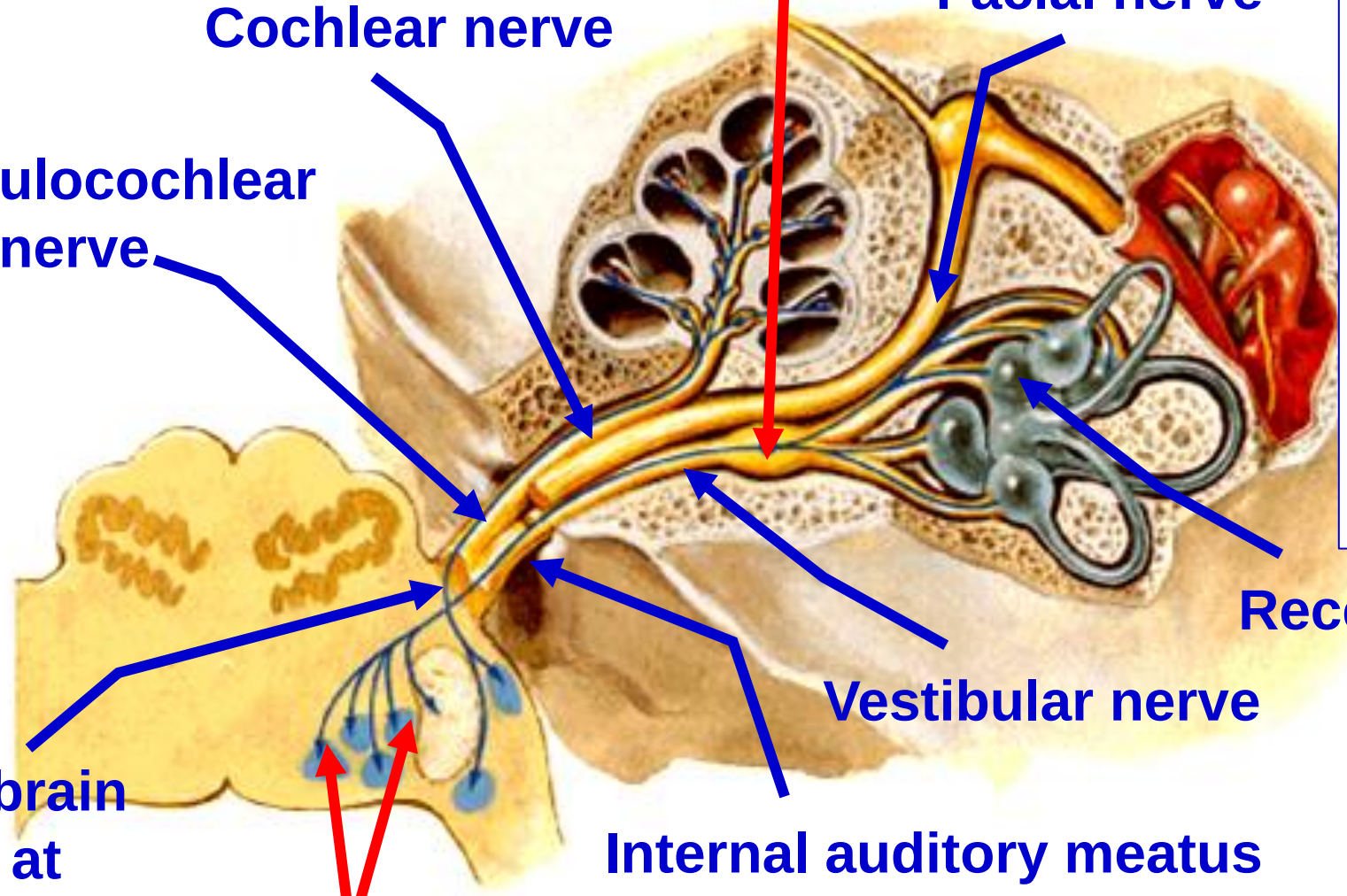
Vestibular Pathway

Cochlear nerve



1- First neuron: Scarpa's ganglion.

- Peripheral processes receive the sensation from the receptors.
- Their axons form **vestibular nerve** which ends vestibular nuclei in pons.

• Vestibular pathway

❖ **The first order neuron: Scarpa's ganglia** in the internal auditory canal

- The peripheral processes divided into

A- Superior division innervates the **cristae of the anterior and lateral semicircular canals**, the anterosuperior part of the **macula of utricle and saccule**

B- Inferior division innervates the **crista of the posterior canal** and the **main portion of the macula of utricle and saccule.**

- Their axons form **vestibular nerve** that unites with cochlear nerve forming vestibulocochlear nerve that exits from internal auditory meatus with facial nerve, enters brainstem in the pontomedullary junction to vestibular nuclei

❖ **The second-order neuron:** four **vestibular nuclei**.

- These nuclei are located on the floor of the fourth ventricle.
- **From the vestibular nuclei,** fibers travel to

- Motor nuclei of anterior horn cells of spinal cord (medial and lateral vestibulospinal tracts)
- Motor nuclei of the 3rd, 4th & 6th cranial nerves
- Cerebellum

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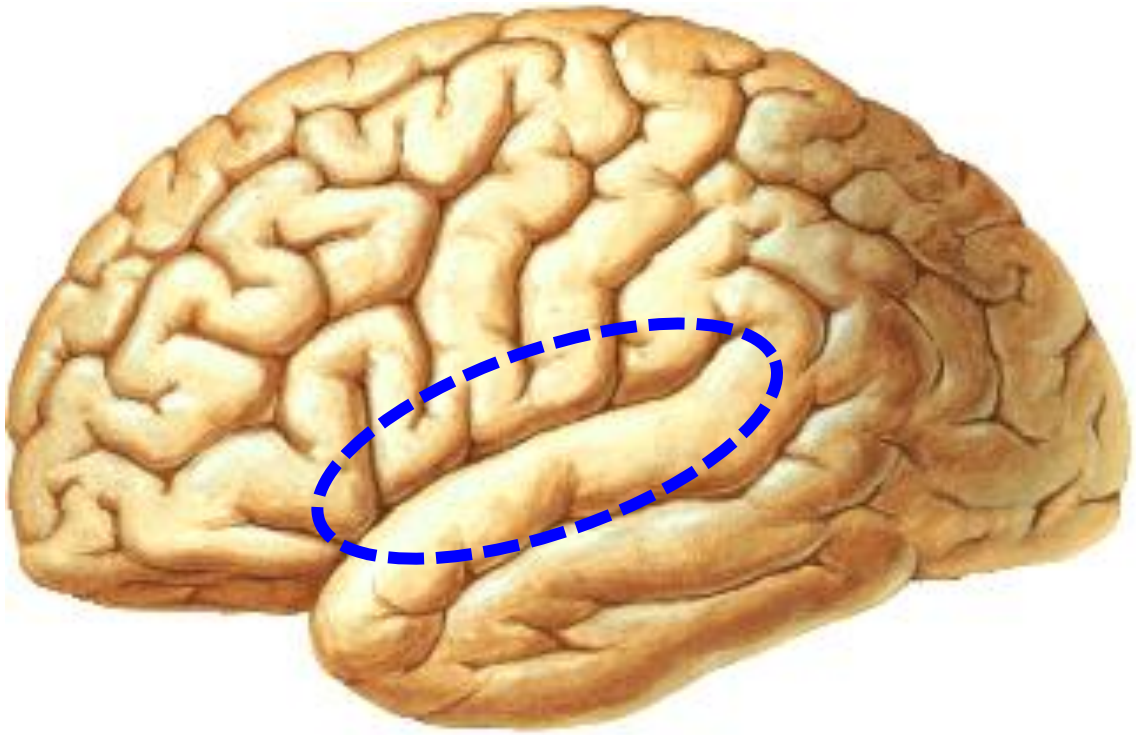

❖ **The third order neuron: thalamus**

- **Terminal vestibular pathway** through **lateral lemniscus or reticular formation** extend to temporal lobe near auditory area **above and below lateral sulcus (Sylvian fissure) and insula (**at the bottom of the deep lateral sulcus)**.**

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- **3 Vestibular reflexes through medial longitudinal bundle**

- **Vestibulo-ocular reflex:** coordinates position of the **eyes** during movements of the **head**
- **Vestibulo-colic reflex:** stabilizes **head** position during movement of **body**
- **Vestibulo-spinal reflex:**
  - Stabilizes position of the **limbs** in response to movement of **head on trunk**
  - Control body position
  - Help us walk upright in relation to gravity.

- **Vestibulocerebellar connection:** The cerebellum coordinates the movements that maintain balance.

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