

## 🌟 Vestibular Apparatus (Organ of Equilibrium)

The vestibular apparatus is the organ responsible for balance and equilibrium.

### 1 Structure

It consists of:

#### A) Bony Labyrinth

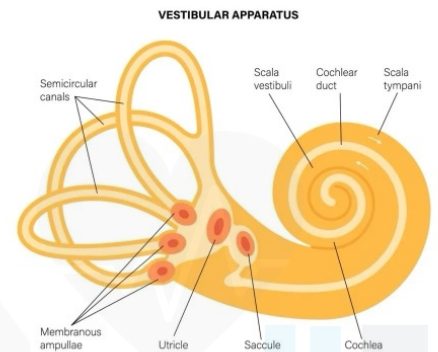
- 3 semicircular canals
- Vestibule

#### B) Membranous Labyrinth

- 3 semicircular ducts (with ampullae)
- Utricle
- Saccule

Fluids:

- Perilymph → between bony and membranous labyrinth
- Endolymph → inside membranous labyrinth



### 🌟 Part 1: Utricle & Saccule (Macula)

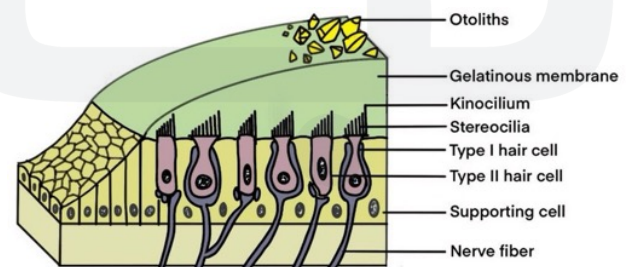
They are responsible for:

- Static equilibrium (head position)
- Linear acceleration

#### 🔬 Macula (Sensory Organ)

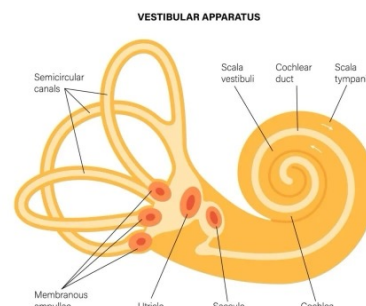
The macula contains:

- Hair cells with:
- 50–70 stereocilia
- 1 large kinocilium
- Covered by gelatinous layer
- On top → calcium carbonate crystals called otoliths (otoconia)



#### Orientation:

- Macula of utricle → horizontal plane
- Macula of saccule → vertical plane



## Mechanism of Action (Macula)

- Bending toward kinocilium → depolarization → ↑ discharge in vestibular nerve
- Bending away from kinocilium → hyperpolarization → ↓ discharge

Each group of hair cells has different orientation → so different head positions activate different groups.

## Functions of Macula

### 1) Static Equilibrium (Head Position)

- Normal head → equal impulses from right & left sides
- Tilt head right →
- Right utricle stimulated ↑
- Left utricle inhibited ↓
- Brain detects tilting to right

### 2) Linear Acceleration

Example: sudden forward movement

- Otoconia move backward (due to inertia)
- Hair cells stimulated
- False sensation of falling backward
- Body leans forward to maintain balance

### 3) Orientation During Swimming

Under water, proprioception is reduced (equal pressure everywhere).

People with inner ear disease may lose orientation and sink if eyes are closed.

## 🌟 Part 2: Semicircular Canals (SCC)

**Function: Detect angular acceleration (rotation)**

### 🦋 Sensory Organ: Crista Ampullaris

- Located in ampulla
- Hair cells embedded in gelatinous structure called cupula
- Each cell has:
  - 40–70 stereocilia
  - 1 kinocilium

### ⚙️ Mechanism of SCC

Stimulated by rotation.

- Bending toward kinocilium → depolarization
- Bending away → hyperpolarization

Important:

- In horizontal canal → kinocilium toward utricle
- In vertical canals → opposite direction

### 🔄 What Happens During Rotation?

During Rest:

Equal impulses from both sides.

Rotation to the Right:

#### 1 Beginning of rotation:

- Endolymph moves left (due to inertia)
- Right crista → stimulated ↑
- Left crista → inhibited ↓
- Brain senses rotation to right

#### 3 When Rotation Stops:

- Endolymph keeps moving (momentum)
- Opposite bending occurs
- False sensation of rotation to opposite side
- This causes vertigo

#### 2 After 20–30 seconds:

- Endolymph catches up with canal
- Cupula returns to normal
- Sensation disappears

## Results of SCC Stimulation

### 1) Vertigo

False sensation of rotation after stopping movement.

### 2) Nystagmus

Rhythmic oscillatory eye movement

Purpose: maintain fixation during rotation

### 3) Autonomic Reactions

Due to stimulation of autonomic centers:

- Nausea
- Vomiting
- Bradycardia
- Hypotension
- Sweating
- Pallor

### 4) Post-Rotatory Reaction (Barany's Test)

After right rotation → false sensation of left rotation

Person points to right side to compensate.

### 5) Changes in Muscle Tone

- Increased tone on same side
- Decreased tone on opposite side

Helps maintain posture.

## Meniere's Disease

Cause: Increased endolymph pressure (unknown cause)

Symptoms:

- Vertigo
- Nystagmus
- Vomiting
- Loss of equilibrium
- Tinnitus
- Hearing loss

Severe cases → surgical removal of vestibular nerve.

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 Very Important Exam Points

- ✓ Utricle → horizontal
- ✓ Sacculle → vertical
- ✓ Macula → static & linear acceleration
- ✓ SCC → angular acceleration
- ✓ Bending toward kinocilium → depolarization
- ✓ Vertigo occurs after stopping rotation