The vestibular system is responsible for maintaining **balance, posture, and the body's orientation in space**. It senses both the **position** and **movement** of the head and body.

It involves **two types of equilibrium:**

**Static Equilibrium:** Senses the head’s position while at rest.

**Dynamic Equilibrium:** Senses sudden movements or rotations of the head and body.

### 📌 ****Vestibular Organs:****

The system includes **5 key structures:**

**3 Semicircular Canals:** Detect **angular/rotational acceleration**.

**2 Otolith Organs (Utricle & Saccule):** Detect **linear acceleration and head position relative to gravity**.

### 📌 ****Otolith Organs (Utricle & Saccule):****

**Utricle:** Oriented **horizontally**, senses **forward-backward, side-to-side (horizontal) movements**.

**Saccule:** Oriented **vertically**, senses **up-down (vertical) movements** and head tilt.

Provide information about **static equilibrium** and **linear accelerations** (e.g. riding in a car or elevator).

**Structure:**

Contain a sensory area called the **macula** made up of:

**Hair cells** (sensory receptors)

**Supporting cells**

Hair cell processes are embedded in a gelatinous **otolithic membrane** topped with **calcium carbonate crystals (otoliths)**.

Movement of the head causes the otoliths to shift, bending the hair cells, triggering action potentials in the **vestibular (VIII) nerve**.

### 📌 ****Semicircular Canals (Dynamic Equilibrium):****

**Three canals:**

**Lateral:** Detects **left-right head rotation (no-no motion)**

**Posterior:** Detects **tilting to right/left (head angulation)**

**Anterior (Ventral):** Detects **up-down (yes-yes motion)**

Filled with **perilymph**; contain **semicircular ducts** filled with **endolymph**.

Each duct has an enlarged end called the **ampulla**, containing the **crista ampullaris**:

**Crista ampullaris:** Contains **hair cells and supporting cells** covered by a gelatinous **cupula**.

Head movement moves the endolymph, bending the cupula and hair cells, causing a neural response.

### 📌 ****Hair Cells and Signal Transduction:****

Each hair cell has:

**50-70 stereocilia**

**1 large kinocilium**

Bending **toward kinocilium**: Depolarization → NT release (glutamate) → Stimulates vestibular nerve.

Bending **away**: Hyperpolarization.

Frequency of action potentials conveys information about **direction and speed** of motion.

**Signal Pathways:**

Signals transmitted via the **vestibulocochlear nerve (VIII)** to:

**Cerebellum**

**Vestibular nuclei (Medulla)**

**Thalamus and Cortex**

Central pathways integrate vestibular, visual, and proprioceptive input for coordinated motor output (head, eye, body adjustments).

### 📌 ****Clinical Relevance:****

**Vestibular Disorders** may cause:

**Vertigo (sense of spinning)**

**Motion sickness**

**Dizziness, nausea, vomiting**

Causes include:

**Labyrinthitis**

**Vestibular neuritis (herpes infection)**

**Cerebello-pontine tumors**

**Brainstem/cerebellar infarcts**

**Sensory mismatches (e.g. in boats, cars)**

**Systemic conditions (anemia, intoxication)**

## 📚 ****Summary:****

**Utricle & Saccule:** Sense **static equilibrium** and **linear motion**.

**Semicircular canals:** Sense **rotational/angular motion**.

**Hair cells:** Primary sensory receptors; bending of cilia alters action potential firing.

**Vestibulocochlear nerve (VIII):** Carries impulses to the **cerebellum, medulla, and cortex**.

**Vestibular dysfunction** leads to vertigo, motion sickness, imbalance, and nausea.