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## **PHYSIOLOGY OF BALANCE**

The ear is a sensory organ that picks up sound waves, allowing us to hear. It is also essential to our sense of balance: the organ of balance (the vestibular system) is found inside the inner ear. It is made up of three semicircular canals and two otolith organs, known as the utricle and the saccule. The semicircular canals and the otolith organs are filled with fluid.

The vestibular system is the sensory apparatus of the inner ear that helps the body maintain its postural equilibrium. The information furnished by the vestibular system is also essential for coordinating the position of the head and the movement of the eyes. There are two sets of end organs in the inner ear, or labyrinth: the semicircular canals, which respond to rotational movements (angular acceleration); and the utricle and saccule within the vestibule, which respond to changes in the position of the head with respect to gravity (linear acceleration). Each of the three semicircular canals is responsible for a specific direction of head movement: One of the canals responds to the head

- tilting upwards or downwards,
- one responds to it tilting to the right or to the left, and
- one responds to it turning sideways.

The otolith organs are found diagonally under the semicircular canals and have a similar function: There are also thin sensory hair cells in both organs. The difference is that, unlike in the semicircular canals, there are small crystals on the hair cells – like pebbles on a carpet. These crystals are called otoliths or “ear rocks.” The otolith organs detect acceleration, for instance when you take an elevator, fall, or gather speed or brake in a car.

The information these organs deliver is proprioceptive in character, dealing with events within the body itself, rather than exteroceptive, dealing with events outside the body, as in the case of the responses of the cochlea to sound. Functionally these organs are closely related to the cerebellum and to the reflex centres of the spinal cord

and brainstem that govern the movements of the eyes, neck, and limbs.

Although the vestibular organs and the cochlea are derived embryologically from the same formation, the otic vesicle, their association in the inner ear seems to be a matter more of convenience than of necessity. From both the developmental and the structural point of view, the kinship of the vestibular organs with the lateral line system of the fish is readily apparent. The lateral line system is made up of a series of small sense organs located in the skin of the head and along the sides of the body of fishes. Each organ contains a crista, sensory hair cells, and a cupula, as found in the ampullae of the semicircular ducts. The cristae respond to waterborne vibrations and to pressure changes. The brain senses the direction and speed of rotation of the head by the movement of fluid in the semicircular canals. Balance is maintained by the interactions between the labyrinth and other systems in the body, such as the visual and skeletal systems. The main inputs into the balance system are the:

- vestibular labyrinths
- visual system (eyes)
- somatosensory system, especially proprioception

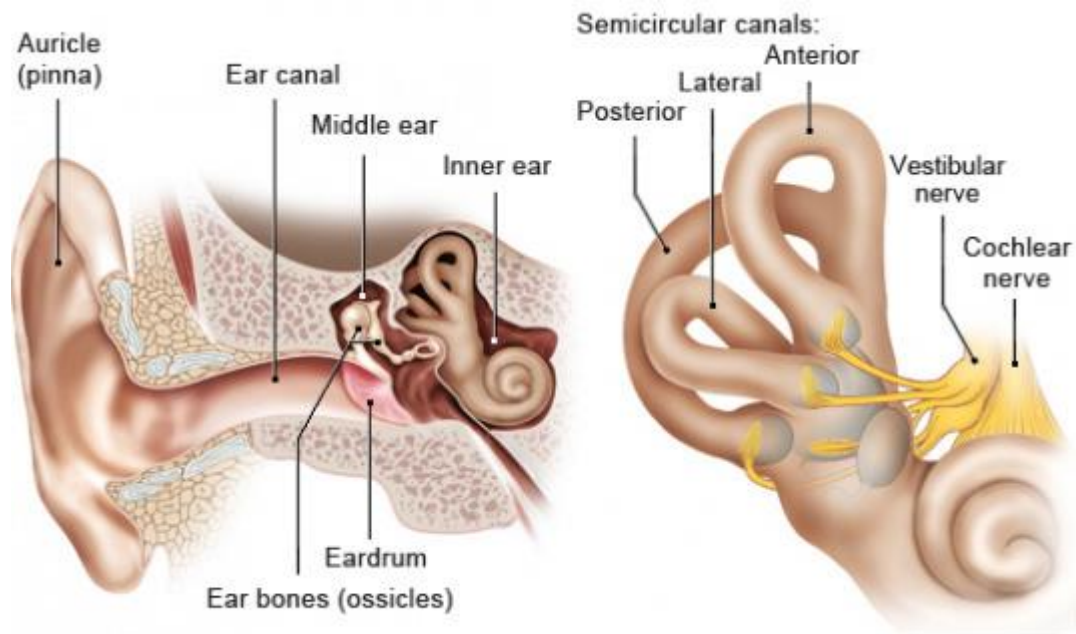
The main outputs from the vestibular nuclei are:

- vestibulo-ocular: permitting reflex eye movements related to posture
- vestibulo-spinal which supply: anti-gravity muscles in the lower limbs and reflex arcs which control gait

Information coming from the vestibular system is processed in the brain and then sent on to other organs that need this information, such as the eyes, joints or muscles. This allows us to keep our balance and know what position our body is in.

In some situations, for example on a ship or airplane, different sensory organs (e.g. the eyes and the organ of balance) send contradictory messages to the brain. This can cause us to feel unwell, dizzy or nauseous.

The vestibular system is especially sensitive in children, and reacts more slowly to movements as we grow older. Inner ear infections and other problems may also affect how well our sense of balance works.



**Structure of ear and the vestibular system**