GREEN GRACE IGBOGI

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PHARMACOLOGY

Phs 212 assignment

Special senses I

Question

Discuss the physiology of balance

# The Physiology Of [Balance:](https://www.britannica.com/science/proprioception) Vestibular Function

The [vestibular system](https://www.britannica.com/science/vestibular-system) is the sensory apparatus of the [inner ear](https://www.britannica.com/science/inner-ear) that helps the body maintain its postural [equilibrium](https://www.britannica.com/science/proprioception). The information furnished by the vestibular system is also essential for coordinating the position of the [head](https://www.britannica.com/science/head-anatomy) and the movement of the eyes. There are two sets of end organs in the inner ear, or labyrinth: the [semicircular canals](https://www.britannica.com/science/semicircular-canal), which respond to [rotational](https://www.britannica.com/science/rotation-physics) movements (angular acceleration); and the [utricle](https://www.britannica.com/science/utricle) and [saccule](https://www.britannica.com/science/saccule) within the [vestibule](https://www.britannica.com/science/vestibule-ear), which respond to changes in the position of the head with respect to gravity (linear acceleration). 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](https://www.britannica.com/science/sound-physics). Functionally these organs are closely related to the cerebellum and to the reflex centres of the [spinal cord](https://www.britannica.com/science/spinal-cord) and [brainstem](https://www.britannica.com/science/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](https://www.britannica.com/science/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](https://www.britannica.com/science/organ-biology) contains a [crista](https://www.britannica.com/science/crista-ampullaris), sensory hair cells, and a cupula, as found in the [ampullae of the semicircular ducts](https://www.britannica.com/science/ampulla-of-semicircular-duct). The cristae respond to waterborne vibrations and to pressure changes.

The anatomists of the 17th and 18th centuries assumed that the entire inner ear, including the vestibular apparatus, is devoted to [hearing](https://www.britannica.com/science/hearing-sense). They were impressed by the orientation of the semicircular canals, which lie in three planes more or less perpendicular to one another, and believed that the canals must be designed for localizing a source of sound in space. The first investigator to present evidence that the vestibular labyrinth is the organ of [equilibrium](https://www.merriam-webster.com/dictionary/equilibrium) was French experimental neurologist [Marie-Jean-Pierre Flourens](https://www.britannica.com/biography/Marie-Jean-Pierre-Flourens), who in 1824 reported a series of experiments in which he had observed abnormal head movements in pigeons after he had cut each of the semicircular canals in turn. The plane of the movements was always the same as that of the injured canal. Hearing was not affected when he cut the nerve fibres to these organs, but it was abolished when he cut those to the basilar papilla (the bird’s uncoiled cochlea). It was not until almost half a century later that the significance of his findings was appreciated and the semicircular canals were recognized as sense organs specifically concerned with the movements and position of the head.

## Detection of angular acceleration: dynamic equilibrium

Because the three [semicircular canals](https://www.britannica.com/science/semicircular-canal)—superior, posterior, and horizontal—are positioned at right angles to one another, they are able to detect movements in three-dimensional space. When the head begins to [rotate](https://www.britannica.com/science/rotation-physics) in any direction, the inertia of the endolymph causes it to lag behind, exerting pressure that deflects the [cupula](https://www.britannica.com/science/cupula) in the opposite direction. This deflection stimulates the [hair cells](https://www.britannica.com/science/hair-cell) by bending their stereocilia in the opposite direction. German physiologist [Friedrich Goltz](https://www.britannica.com/biography/Friedrich-Goltz) formulated the “hydrostatic concept” in 1870 to explain the working of the semicircular canals. He postulated that the canals are stimulated by the weight of the fluid they contain, the pressure it exerts varying with the head position. In 1873 Austrian scientists [Ernst Mach](https://www.britannica.com/biography/Ernst-Mach) and [Josef Breuer](https://www.britannica.com/biography/Josef-Breuer) and Scottish chemist Crum Brown, working independently, proposed the “[hydrodynamic concept](https://www.britannica.com/science/hydrodynamic-concept),” which held that head movements cause a flow of endolymph in the canals and that the canals are then stimulated by the fluid movements or pressure changes. German physiologist J.R. Ewald showed that the compression of the horizontal canal in a pigeon by a small pneumatic hammer causes endolymph movement toward the crista and turning of the head and eyes toward the opposite side. Decompression reverses both the direction of endolymph movement and the turning of the head and eyes. The [hydrodynamic concept](https://www.britannica.com/science/hydrodynamic-concept) was proved correct by later investigators who followed the path of a droplet of oil that was injected into the semicircular canal of a live fish. At the start of rotation in the plane of the canal, the cupula was deflected in the direction opposite to that of the movement and then returned slowly to its resting position. At the end of rotation it was deflected again, this time in the same direction as the rotation, and then returned once more to its upright stationary position. These deflections resulted from the inertia of the endolymph, which lags behind at the start of rotation and continues its motion after the head has ceased to rotate. The slow return is a function of the elasticity of the cupula itself.

These opposing deflections of the cupula affect the vestibular nerve in different ways, which have been demonstrated in experiments involving the labyrinth removed from a [cartilaginous fish](https://www.britannica.com/animal/chondrichthian). The labyrinth, which remained active for some time after its removal from the animal, was used to record vestibular nerve impulses arising from one of the [ampullar cristae](https://www.britannica.com/science/crista-ampullaris). When the labyrinth was at rest there was a slow, continuous, spontaneous discharge of nerve impulses, which was increased by rotation in one direction and decreased by rotation in the other. In other words, the level of excitation rose or fell depending on the direction of rotation