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COURSE: HISTOLOGY OF SPECIAL SENSES

DEPARTMENT: MEDICINE AND SURGERY

LEVEL: 300

Question: **With the aid of a diagram, write an essay on the histology of the organ of Corti.**

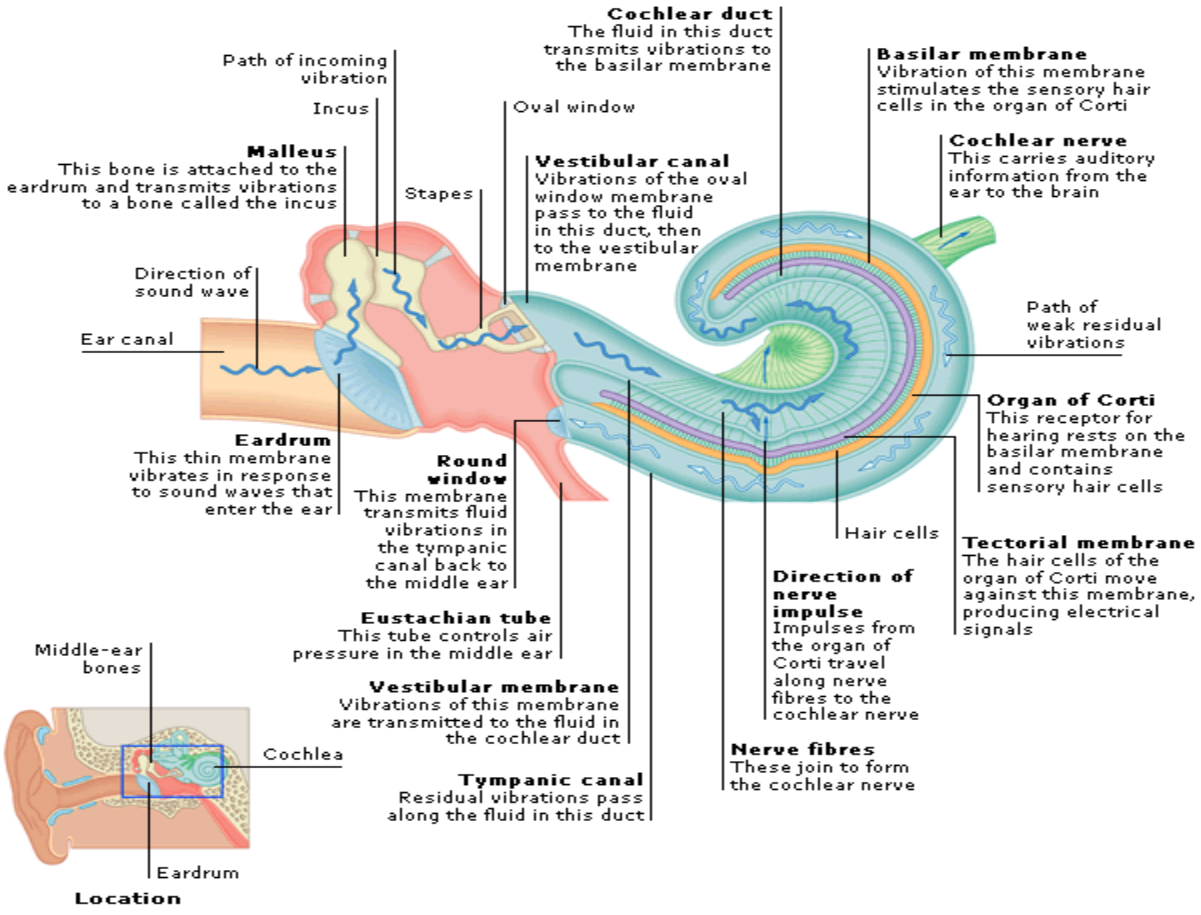


Diagram of the middle and inner ear with its structures

The organ of Corti is an organ of the inner ear located within the cochlea (scala media) which contributes to audition. It resides on the basilar membrane, a stiff membrane, separating the scala tympani and scala media.

The internal ear is in the form of a complex system of cavities lying within the petrous temporal bone. It has a central part called the **vestibule**. Continuous with the front of the vestibule there is a spiral shaped cavity called the **cochlea**. Posteriorly, the vestibule is continuous with three **semicircular canals**. The inner ear located within the bony labyrinth, contains sense organs serving both balance and hearing.

- Head position/linear acceleration is sensed by the otolith organs of the saccule and utricle.
- Head rotation (angular acceleration) is sensed by the cristae ampularis of the semicircular canals.
- Hearing is sensed by the organ of Corti within the scala media of the cochlea.

BONY LABYRINTH and MEMBRANOUS LABYRINTH

The inner ear residues within a space called the bony labyrinth. The **oval window** forms a potential opening from the middle ear into the bony labyrinth. Suspended within the bony labyrinth and approximating its shape, is an interconnected set of membrane-lined chambers and passageways called the membranous labyrinth.

The vestibule (entry room) of the bony labyrinth contains saccule and utricle of the membranous labyrinth. 3 semicircular canals comprise looping tubules which leave and return to the vestibule.

COCHLEA

The cochlea houses an elaborate configuration of membranous labyrinth and hair cells, called the organ of Corti, designed for auditory reception. The shape of the cochlea is like that of a snail-shell or tapering helix.

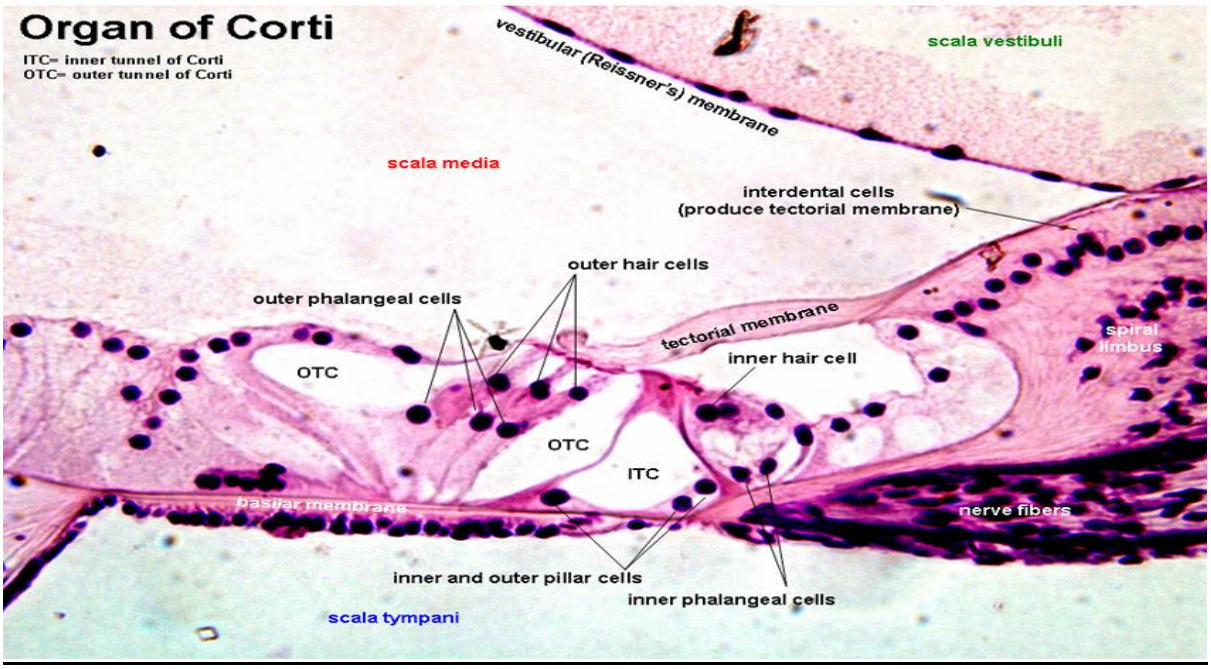
The central column (THE MODIOLUS) of the helical cochlea contains axons serving the organ of Corti on their way to the auditory nerve. A bony ridge, the SPIRAL LAMINA, extends out from the modiolus and provides support for the organ of Corti. A tubular cavity within the spiral lamina contains the cell bodies of

the axons of the auditory nerve. Because this collection of nerve cell bodies has a helical shape paralleling the cochlear scalae, it is called the SPIRAL GANGLION.

The spiraling tunnel that forms the cochlea of the bony labyrinth is divided into 3 distinct channels by portions of the membranous labyrinth attached to bony ridges. Each of these channels is called a “scala” meaning ramp.

- The scala vestibuli ascends from the vestibule to the tip pf the cochlea. The scala vestibuli contains perilymph.
- The scala tympani descends from the tip off the cochlea to the round window. The scala tympani like the scala vestibule contains perilymph and at the tip of the cochlea, the scala vestibule and scala tympani are connected through the helicotrema.
- The scala media also called the cochlear duct, lies along the length of spiral cochlea, in a medial position between the scala vestibule and scala tympani. The scala media contains endolymph (with a high k+ concentration, which help regulate electrochemical impulses of the auditory hair cells) and the organ of Corti lies within this scala.
  The scala media is separated from the scala vestibuli by a very thin membrane, Reissner’s Membrane.

ORGAN OF CORTI



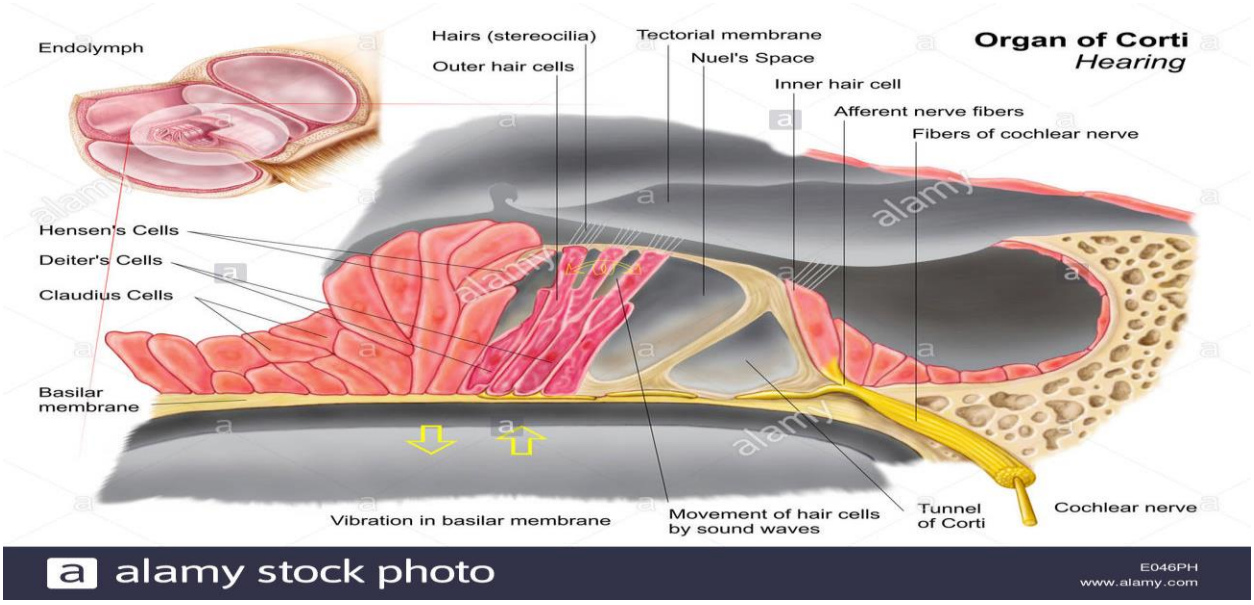


Diagram of the organ of Corti showing its cells

The organ of Corti is part of the cochlea (scala media) and it mediates the sense hearing transducing pressure waves to action potentials. The primary function of the organ of Corti is the transduction of auditory sounds.

In sections, the organ of Corti is seen to be placed on the basilar membrane and to be made up of epithelial cells that are arranged in a complicated manner. The organ of Corti is composed of both supporting cells and mechanoreceptors hair cell. In the arrangement of mechanosensory hair cells, there is a single row of inner hair cells and 3 rows of outer hair cells, which are separated by the supporting cells.

The cells of the spiral organ of Corti enclose a triangular cavity called the tunnel of Corti (or cuniculum internum). The base of the tunnel lies over the basilar membrane. It has a sloping inner wall that is formed by internal rod cells; and a sloping outer wall that is formed by external rod cells. To the internal side of the inner rod cells there is a single row of inner hair cells. The inner hair cell is supported by tall cells lining the tympanic lip of the internal spiral sulcus.

On the outer side of each external rod cell there are three or four outer hair cells. The outer hair cells do not lie directly on the basilar membrane, but are supported by the phalangeal cells (of Dieters) which rest on the basilar membrane. To the outer side of the outer hair cells and the phalangeal cells, there are tall supporting cells (cells of Hensen). Still more externally the outer spiral sulcus is lined by cubical cells (cells of Claudius). A narrow space the cuniculum externum intervenes between the outer-most hair cells and the cells of Hensen. A third space, the cuniculum medium (or space of Nuel) lies between the outer rod cell and the outer hair cells. The spaces are filled with perilymph (or cortilymph).

The Hair Cells

The hair cells have a free apical ends which bear a number of hair/stereocilia. Each hair cell is columnar or piriform. The hair cells are distinctly shorter than the rod cells. Their apices are at the level of the reticular lamina. Their lower ends do not reach the basilar membrane.

The apical surface of each hair cell is thickened to form a **cuticular plate** the edges of which are attached to neighbouring cells. The hair on each hair cell are arranged in a definite V manner. Each limb of the ‘V’ has three rows of hairs.

- Inner Hair Cell: These cells are specialized in the mechanoelectrical transduction. There are almost 3500 cells disposed in one line along all the basilar membrane. The luminal part of the cell is immersed in endolymph (which fills the scala media and is produced by the stria vascularia), the basal one is immersed in normal extracellular fluid. The luminal portion is formed by bundles of stereocilia.
  These cells account for approximately 90-95% of the sensory input into the auditory system and they may possess more than one nucleus.
- Outer hair cells: these cells are surrounded by outer pharyngeal cells and account for approximately 5-10% of the sensory input into the auditory system. There are three rows of outer hair cells. The apices of these cells and their pharyngeal cells are joined together to form the reticular membrane/ reticular lamina/ apical cuticuar plate.
  The function of these cells is to contract when stimulated, thereby stimulating the inner hair cells.

The Supporting cells

The supporting cells are also called *phalangeal cells*. These cells are of four different types: Corti pillars, Hensen cells, Deiters cells and Claudius cells.

The Rod Cells

Each rod cell (or pillar cell) has a broad base (or foot plate, or crus) that rests on the basilar membrane, an elongated middle part (rod or scapus) and an expanded upper end called the head or caput. The bases of the rod cells are greatly expanded and contain their nuclei. The bases of the inner and outer rod cells meet each other forming the base of the tunnel of Corti. The heads of these cells also meet at the apex of the tunnel. The uppermost parts of the heads are expanded into horizontal plates called the phalangeal processes. These processes join similar processes of neighbouring cells to form a continuous membrane called the reticular lamina.

The Outer Phalangeal Cells

They lie lateral to the outer rod cells. Their bases rest on the basilar membrane. Their apical parts have a complicated configuration. The greater part of the apex

forms a cup-like depression into which the base of an outer hair cell fits. Arising from one side (of the apical part) of the cell there is a thin rod-like *phalangeal process*.

At the apex, the phalangeal process expands to form a transverse plate called the *phalanx*. Still located apically, the edges of the phalanges of adjoining phalangeal cells unite with each other to form a membrane called the *reticular lamina* (The reticular lamina also receives contributions from the heads of hair cells). The apices of hair cells protrude through apertures in this lamina.

Adjacent cell margins are united by desmosomes, occluding junctions and gap junctions. The reticular lamina forms a barrier impermeable to ions except through the cell membranes. It also forms a rigid support between the apical parts of hair cells.

Medical Application

1) Exposure to loud noises cause the shift between the tectorial and basilar membrane to increase. This shift can damage the stereocilia of the outer hair cells. Damage to the outer hair cells decreases the protection of inner hair cells and causes them to become more sensitive and over time the inner hair cells will become damaged and audition affected.
2) Aminoglycoside antibiotics are ototoxic drugs which are k^+ channel blocker. As such, they block the ability of both inner and outer hair cells to depolarize.