ASSIGNMENT ON HISTOLOGY OF SPECIAL SENSES AND NEUROHISTOLOGY

HISTOLOGY OF EAR

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

The organ of Corti, or spiral organ, is the receptor organ for hearing and is located in the mammalian cochlea. It is an organ of the inner ear located within the cochlea which contributes to audition.

The Organ of Corti includes three rows of outer hair cells and one row of inner hair cells. This highly varied strip of epithelial cells allows for transduction of auditory signals into nerve impulses' action potential. Transduction occurs through vibrations of structures in the inner ear causing displacement of cochlear fluid and movement of hair cells at the organ of Corti to produce electrochemical signals that is transmitted to the central nervous system via the auditory nerve to facilitate audition.

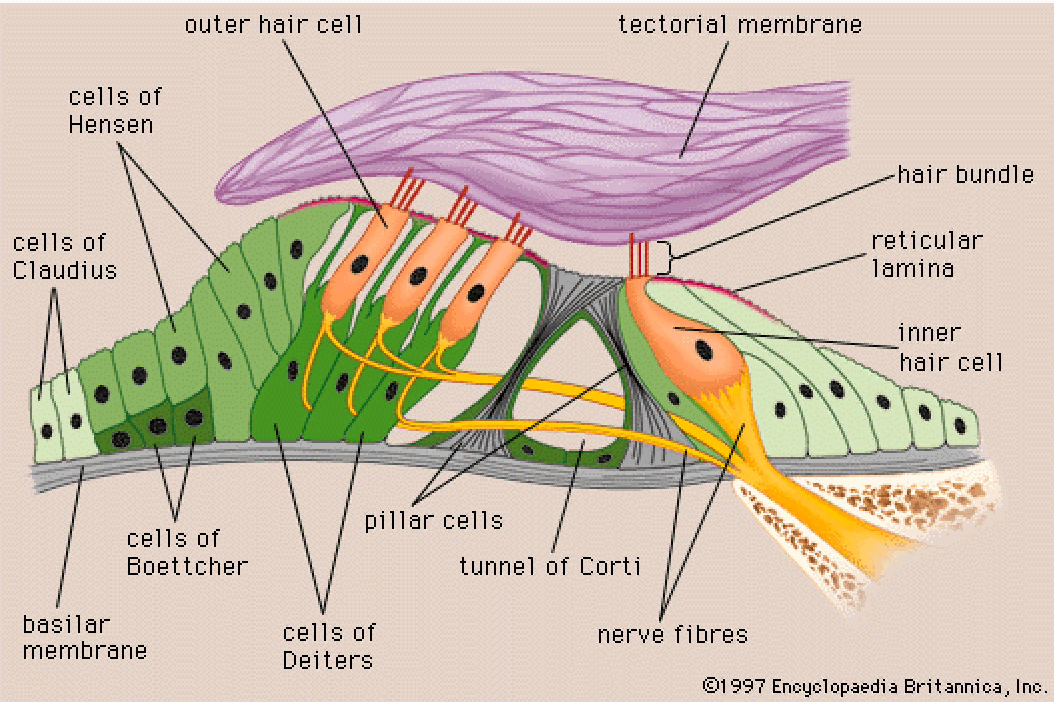


DIAGRAM SHOWING THE ORGAN OF CORTI

STRUCTURE

The organ of Corti is located in the scala media of the cochlea of the inner ear between the vestibular duct and the tympanic duct and is composed of mechanosensory cells, known as hair cells and supporting cells that sit on a flexible basilar membrane which is anchored to the bony shelf on the left and a ligament on the right.. The scala media is a cavity within the cochlea that contains endolymph which has a high (150 mM) K+ concentration. The endolymph helps to regulate the electrochemical impulses of the auditory hair cells.

Strategically positioned on the basilar membrane (a stiff membrane separating the scala tympani and scala media) of the organ of Corti are three rows of outer hair cells (OHCs) and one row of inner hair cells (IHCs). Separating these hair cells are supporting cells: Deiters cells, also called phalangeal cells, which separate and support both the OHCs and the IHCs.

Inner hair cells: These cells are specialized in the mechanoelectrical transduction. There are almost 3500 cells disposed in one line along all the basilar membrane. They are connected to type I neuron peripheral fibers of spiral ganglion, these connections are very divergent (10/1). The luminal part of the cell is immerged in endolymph, the basal one is immerged in normal extracellular fluid. The luminal portion is formed by bundles of stereocilia (inner ear), whose tips are connected by filamentous structures called tip-links.

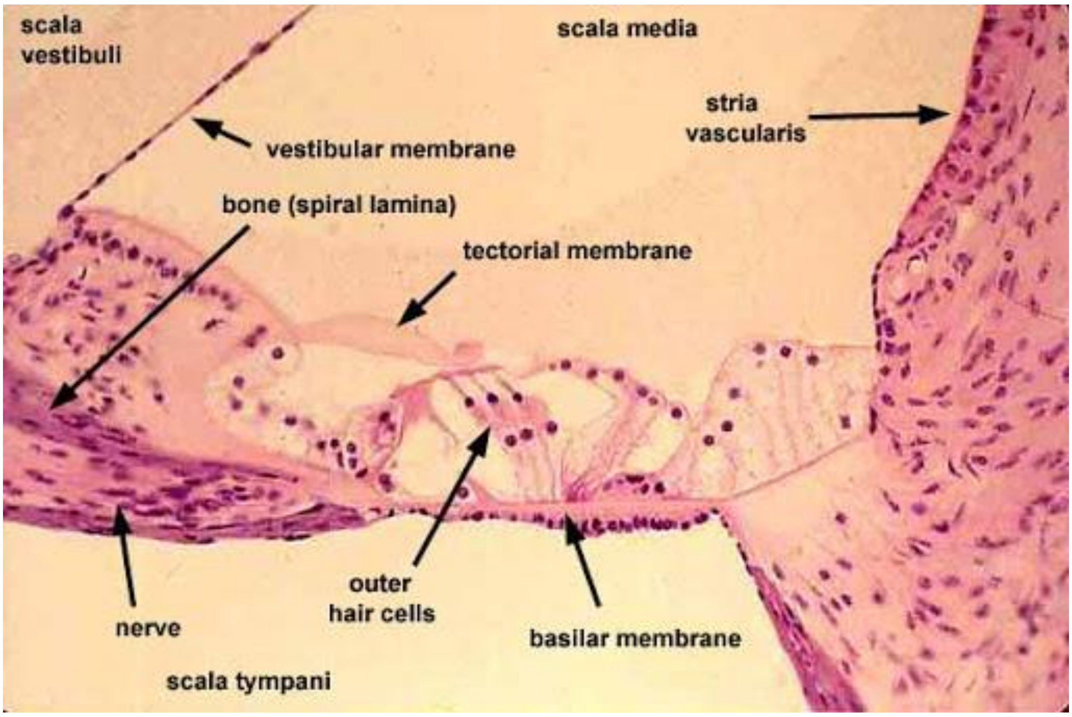
Outer hair cells: These cells are acoustical pre-amplifiers. They are almost 12000, disposed in three parallel lines. These cells are connected to type II amyelinic neurons, the connections are very convergent. They have also an afference from superior olivary nucleus. They have contractile activity.

Supporting cells: These cells are of four different types: Corti pillars, Hensen cells, Deiters cells and Claudius cells.

Projecting from the top of the hair cells are tiny finger like projections called stereocilia, which are arranged in a graduated fashion with the shortest stereocilia on the outer rows and the longest in the center. The tips of the outer hair cell stereocilia are imbedded in a gelatinous mass called the tectorial membrane which lies on top of the organ of Corti and is secreted from cells (not shown) on the left.
This gradation is thought to be the most important anatomic feature of the organ of Corti because this allows the sensory cells superior tuning capability. When sound is transmitted to the inner ear the organ of Corti begins to vibrate up and down. Since the basilar membrane is attached to bone and ligament at its two ends, the area of maximal vibration is near the third row of outer hair cells. The overlying tectorial membrane is not as flexible so the stereocilia are bent as the

organ of Corti moves up and down against it. The electrical potential inside the hair cells changes as the stereocilia are bent.

The cochlea is also tonotopically organized, meaning that different frequencies of sound waves interact with different locations on the structure. The base of the cochlea, closest to the outer ear, is the most stiff and narrow and is where the high frequency sounds are transduced. The apex, or top, of the cochlea is wider and much more flexible and loose and functions as the transduction site for low frequency sounds.



<u>HISTOLOGY SLIDE OF THE ORGAN OF CORTI</u>

In no other organ in the body is it as easy to see the precise organization of the principal cells. The supporting cells of the organ of Corti are not found immediately adjacent to the outer hair cells so that for most of the length of these cylindrically shaped cells are surrounded by a relatively large fluid filled space.

FUNCTION

The function of the organ of Corti is to change (transduce) auditory signals and minimise the hair cells' extraction of sound energy. It is the auricle and middle ear that act as mechanical transformers and amplifiers so that the sound waves end up with amplitudes 22 times greater than when they entered the ear.

Auditory transduction

In normal hearing, the majority of the auditory signals that reach the organ of Corti in the first place come from the outer ear. Sound waves enter through the auditory canal and vibrate the tympanic membrane, also known as the eardrum, which vibrates three small bones called the ossicles. As a result, the attached oval window moves and causes movement of the round window, which leads to displacement of the cochlear fluid.
However, the stimulation can happen also via direct vibration of the cochlea from the skull. The latter is referred to as Bone Conduction (or BC) hearing, as complementary to the first one described, which is instead called Air Conduction (or AC) hearing. Both AC and BC stimulate the basilar membrane in the same way.

The basilar membrane on the tympanic duct presses against the hair cells of the organ as perilymphatic pressure waves pass. The stereocilia atop the IHCs move with this fluid displacement and in response their cation, or positive ion selective, channels are pulled open by cadherin structures called tip links that connect adjacent stereocilia. The organ of Corti, surrounded in potassium rich fluid endolymph, lies on the basilar membrane at the base of the scala media. Under the organ of Corti is the scala tympani and above it, the scala vestibuli. Both structures exist in a low potassium fluid called perilymph. Because those stereocilia are in the midst of a high concentration of potassium, once their cation channels are pulled open, potassium ions as well as calcium ions flow into the top of the hair cell. With this influx of positive ions, the IHC becomes depolarized, opening voltage-gated calcium channels at the basolateral region of the hair cells and triggering the release of the neurotransmitter glutamate. An electrical signal is then sent through the auditory nerve and into the auditory cortex of the brain as a neural message.

Cochlear amplification

The organ of Corti is also capable of modulating the auditory signal. The outer hair cells (OHCs) can amplify the signal through a process called electromotility where they increase movement of the basilar and tectorial membranes and therefore increase deflection of stereocilia in the IHCs.

A crucial piece to this cochlear amplification is the motor protein prestin, which changes shape based on the voltage potential inside of the hair cell. When the cell is depolarized, prestin shortens, and because it is located on the membrane of OHCs it then pulls on the basilar membrane and increasing how much the membrane is deflected, creating a more intense effect on the inner hair cells (IHCs). When the cell hyperpolarizes prestin lengthens and eases tension on the IHCs, which decreases the neural impulses to the brain. In this way, the hair cell itself is able to modify the auditory signal before it even reaches the brain.

The organ of Corti is larger and the basilar membrane on which it sits is longer as it gets further away from the base of the cochlea. This difference in size is consistent with the fact that different frequencies of sound result in greater vibrations of the organ of Corti depending on where along the length of the cochlea you are measuring. The shorter, smaller structures near the base of the cochlea respond best to high frequencies, while the longer, larger structures near the top of cochlea respond best to low frequencies.