Topic 10. Sense organs (part II)

Controll questions

1. Taste organ. Localization, functions and structure.
2. Three divisions of ear and their main components.
3. Structures of internal ear. Bony labyrinth.
4. Embryonic development of internal ear.
5. Structures of membranous labyrinth: cochlear labyrinth, vestibular labyrinth.
6. Sound transmission through the ear.
7. Corti organ. Localization, morphofunctional characteristic of Corti organ's cells.
8. Hair cells of the cochlear and vestibular labyrinth. Types, structure and functions.
9. Structure of the macula.
10. Structure of the crista ampullaris.

Question 1. Taste organ. Localization, functions and structure.

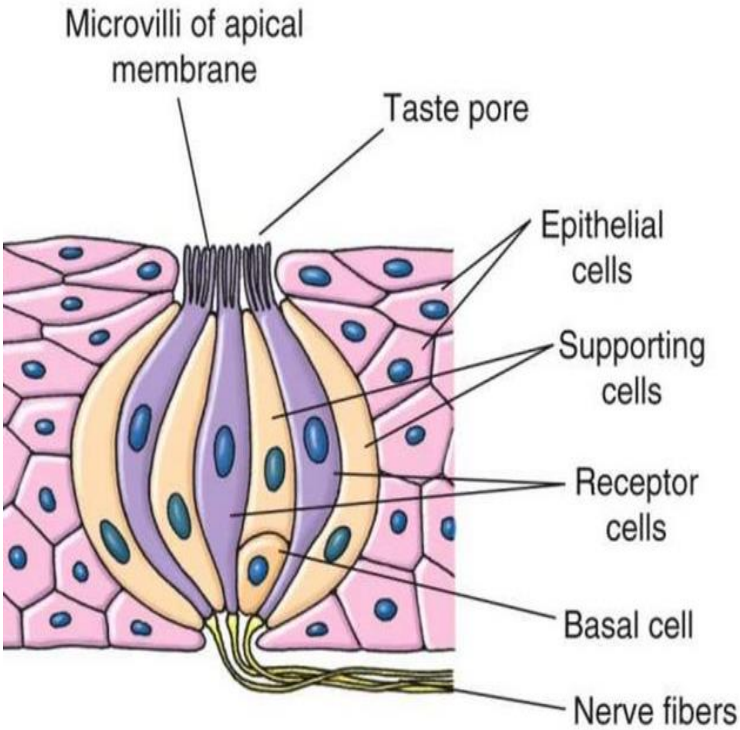

Figure 10.1. Diagram of taste bud.

Taste buds are present on fungiform, foliate, and circumvallate papillae of the tongue. The taste buds are oval bodies that extend through the thickness of the stratified nonkeratinaized squamous epithelium covering tongue. A small opening onto the epithelial surface at the apex of the taste bud is called the taste pore.

Three principal cell types are found in taste buds:

1) **Neuroepithelial (sensory) cells.** They are the most numerous receptor cells in the taste bud. These elongated cells extend from the basal lamina of the epithelium to the taste pore. Apical surface of each neuroepithelial cell contains microvilli. At their base, the neuroepithelial cells form the synapses with the processes of afferent sensory neurons. The neuroepithelial cells are sensitive to various taste-stimulating substances, containing in food that interact with taste receptors located at the apical surface of the neuroepithelial cells. These cells react to five basic stimuli: sweet, salty, bitter, sour, and umami.

2) **Supporting cells** are less numerous. They are also elongated cells that extend from the basal lamina to the taste pore. Like neuroepithelial cells, they contain microvilli on their apical surface;

3) **Basal cells** are small cells located in the basal portion of the taste bud, near the basal lamina. They are the stem cells for the two other cell types [13].

Foliate papillae of the tongue (slide)

Stain: hematoxylin-eosin

Using this slide you must perform the exercise 1 of album (topic "Sense organs" (part II))

Small magnification

Large magnification

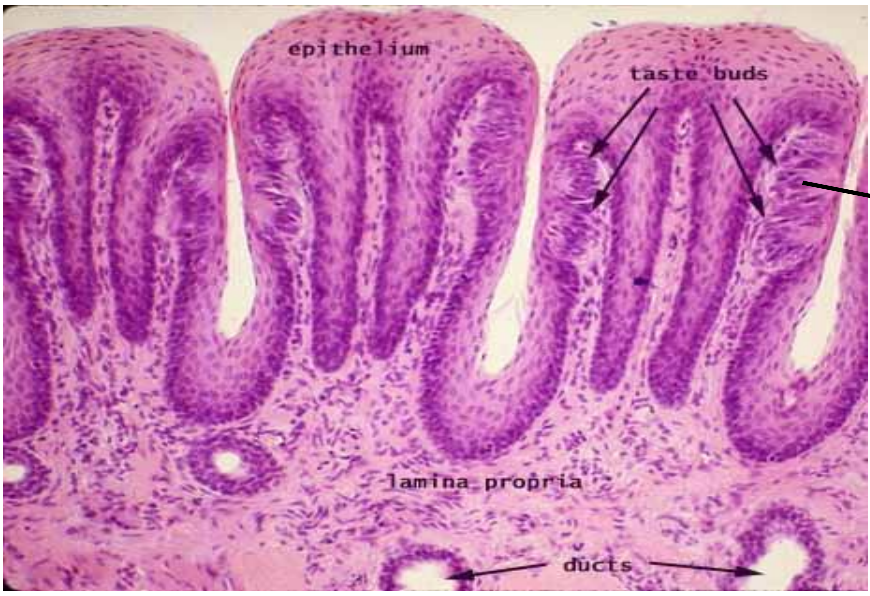

Figure 10.2. Photomicrograph of fungiform papillae.

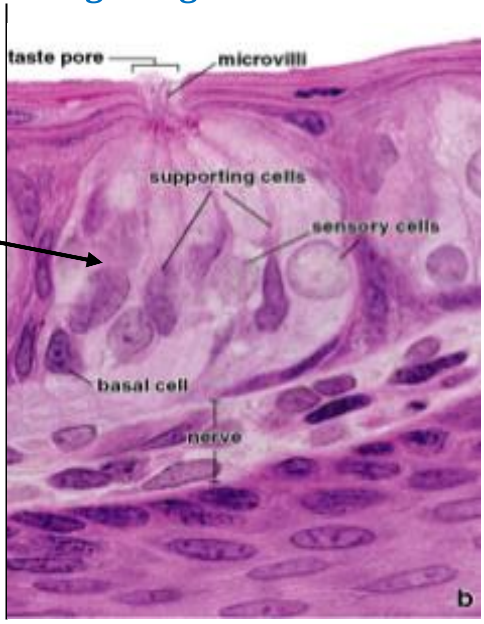

Figure 10.3. Photomicrograph of taste bud [13].

Question 2. Three divisions of ear and their main components.

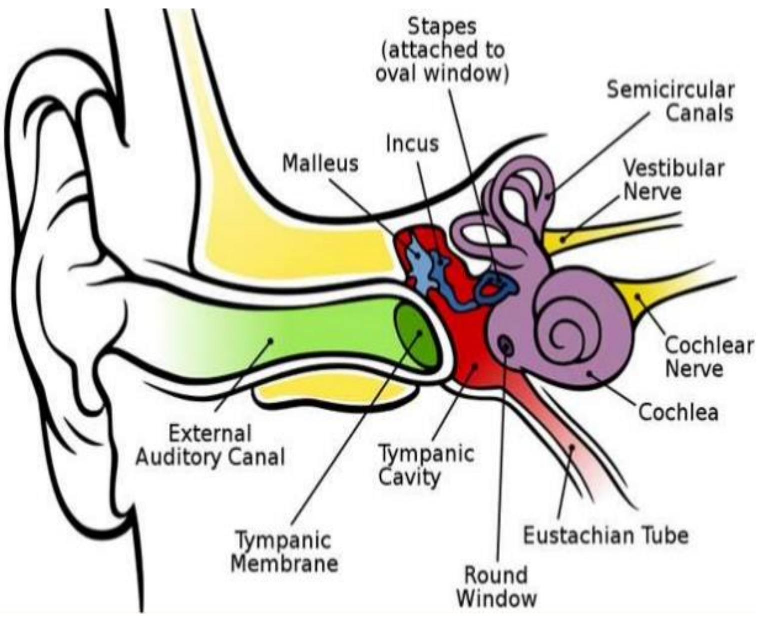

Figure 10.4. Diagram of the ear parts.

Ear is divided into three general regions: outer, middle and inner ear.

I. **Outer or external ear** includes:
1. Auricle (pinna);
2. External acoustic (auditory) meatus (canal);
3. Tympanic membrane (eardrum).

II. **Middle ear** includes:
1. Tympanic cavity;
2. Auditory ossicles:
   a) malleus;
   b) incus;
   c) stapes.
3. Auditory (Eustachiun) tube.

III. **Inner or internal ear** includes:
1. Cochlea;
2. Vestibule;
3. Three semicircular canals [14].

Question 3. Structures of internal ear. Bony labyrinth.

Inner ear or labyrinth is situated in the temporal bone and it is a peripheral part of acoustic and vestibular sensory systems.

Inner ear is a bony labyrinth, which contains three parts:

1) vestibule;

2) snail shaped canal called cochlea;
3) three semicircular canals.

Vestibule, cochlea and three semicircular canals are filled with the fluid called perilymph. It is a clear fluid with a composition similar to that of the cerebrospinal fluid. Within the bony labyrinth there is the second membrane-enclosed cavity called membranous labyrinth.

The membranous labyrinth consists of a series of communicating sacs and ducts containing fluid called endolymph. Endolymph is similar to perilymph, but contains more high concentration of potassium [3].

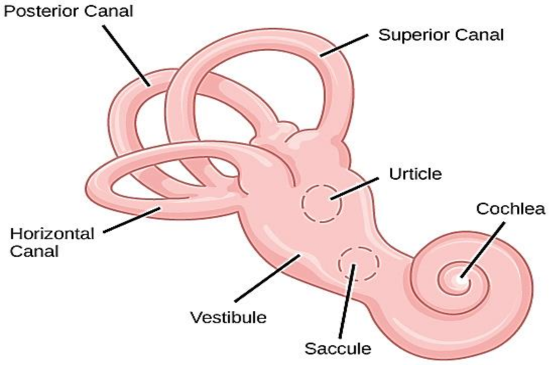

Figure 10.5. Diagram of bony labyrinth.

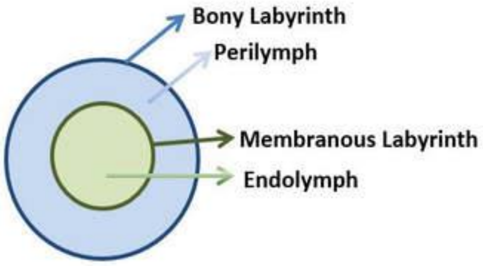

Figure 10.6. Diagram of bony and membranous labyrinth in cross section.

Question 4. Embryonic development of internal ear.

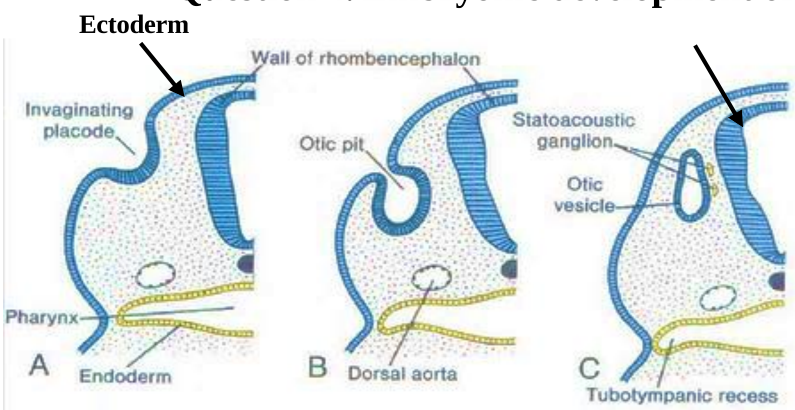

Figure 10.7. Diagram of the ear development.

Inner ear is produced from the optic placodae. Placode is a thickening ectoderm lying on both sides of the nervous tube. After placode becomes invaginated, to produce the otic pit that then finally pinches off from the ectoderm to become otic vesicle, surrounding by mesenchyme. The otic vesicle develops into the membranous labyrinth of internal ear [9].

Question 5. Structures of membranous labyrinth: cochlear labyrinth, vestibular labyrinth.

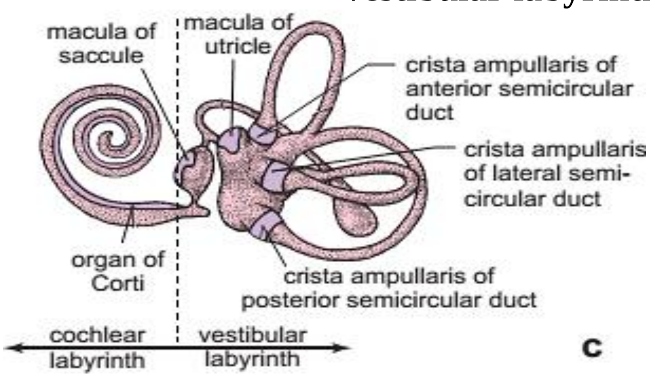

Figure 10.8. Diagram of membranous labyrinth [13].

The membranous labyrinth is composed of two divisions: **the cochlear labyrinth and the vestibular labyrinth.**

The vestibular labyrinth contains the following components:

1) Three semicircular ducts lying within the semicircular canals and are continuous with the utricle.
2) The utricle and the saccule lying in the vestibule and are connected by the membranous utriculosaccular duct.

The cochlear labyrinth is represented by cochlear duct, lying within the bony cochlea and is continuous with the saccule [13].

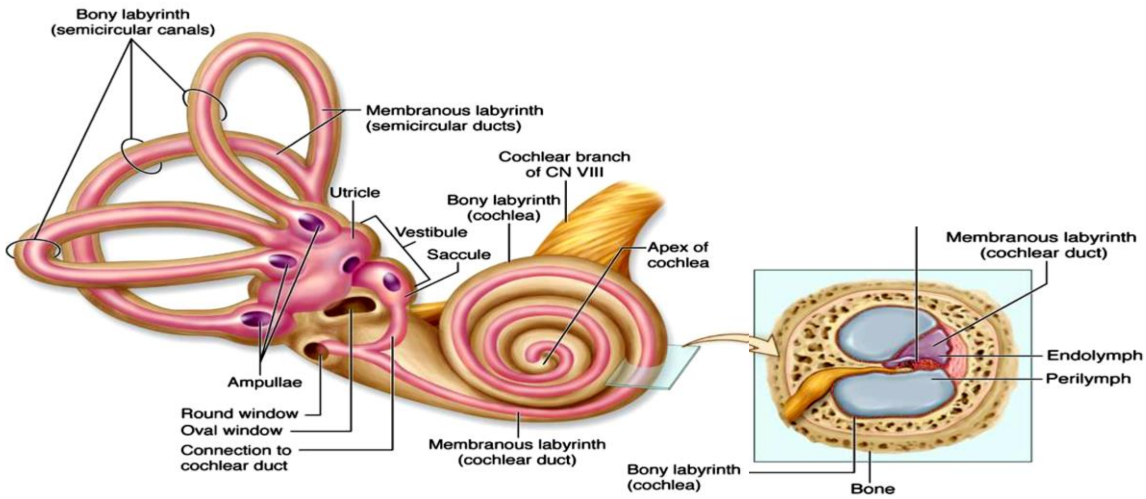

Figure 10.9. Diagram of membranous labyrinth [9].

Question 7. Corti organ. Localization, morphofunctional characteristic of Corti organ's cells.

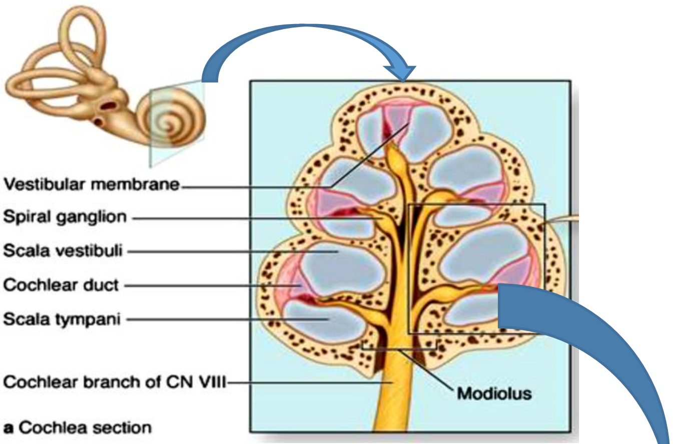

Figure 10.10. Diagram of cochlea in vertical section [9].

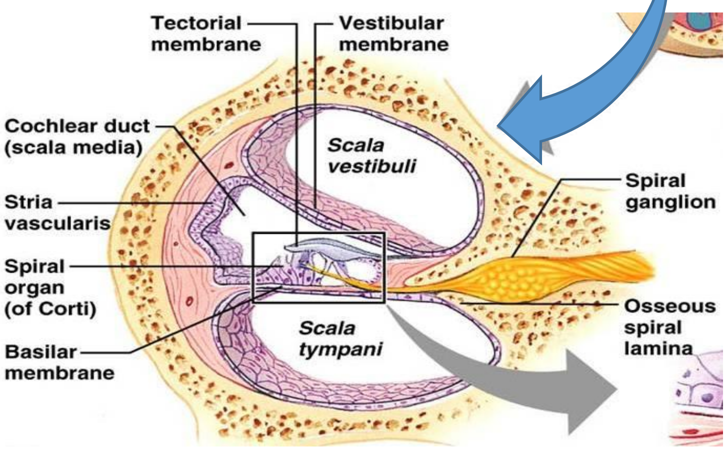

Figure 10.11. Diagram of cochlea in cross section.

The cochlea consists of a canal that forms 2-3 spiral turns around the bony conical pillar called modiolus. The modiolus contains the spiral ganglions with cells bodies of bipolar sensory neurons. The peripheral processes (dendrites) of these neurons pass to the cochlear hear cells to innervate them. Axons of bipolar sensory neurons form the nervous cochlearis [3].

Two spiral membranes, vestibular and basilar, divide the cochlear canal into 3 canals (or cavities on the section). They are:
1) scala vestibuli (upper one);
2) scala tympani (lower one);
3) scala media or cochlear duct (middle one).

Scala vestibule and scala tympani both are perilymphcontaining spaces. Scala media is endolymphcontaining space.

The scala media is a triangular space containing 3 walls with its acute angle attached to the osseous spiral lamina of modiolus.

The upper wall of the scala media is the vestibular (Reissner's) membrane. It is thin connective tissue, covering by the flattened epithelium.

The lateral or outer wall of the scala media is bordered by stria vascularis. The stria vascularis is a pseudostratified epithelium containing blood vessels. This is responsible for production and maintenance of endolymph [13].

Lateral to stria vascularis, the endosteum is much thickend to produce the spiral ligament.

The lower wall or floor of the scala media is formed by a basilar membrane that is fibrous connective tissue, covering by the flattened epithelium and extending from the spiral lamina to the spiral ligament [13].

Spiral organ of Corti

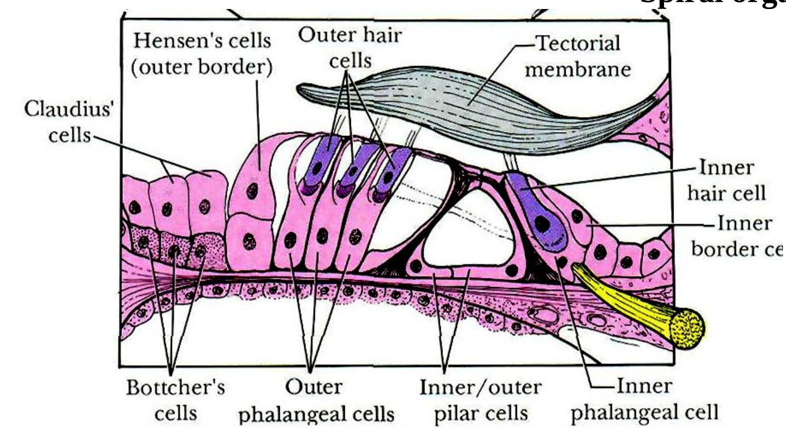

Figure 10.12. Diagram of the spiral organ of Corti [13].

The spiral organ of Corti is an epithelial layer on the basilar membrane of cochlear duct. It is formed by the following cells:

1) Hair cells (inner and outer);
2) Phalangeal (supporting) cells (inner and outer);
3) Pillar cells (inner and outer).

The border between inner and outer cells forming the spiral organ of Corti is a triangular shaped cavity called tunnel producing by the pillar cells.

Phalangeal cells are supporting cells for hair cells. The phalangeal cells associated with the inner hair cells surround the cells completely. The phalangeal cells associated with the outer hair cells surround only the basal portion of the hair cell completely and send apical processes toward the endolymphatic space.

Hair cells are sensory auditory cells for hearing. All hair cells have a bundle of stereocilia (hairs) on their apical domain. Inner hair cells are arranged in a single row, outer hair cells are arranged in three rows.

Hair cells are overlain by the structure called tectorial membrane. The tectorial membrane is originated from the connective tissue structure called spiral limbus [13].

Spiral organ of Corti (slide)

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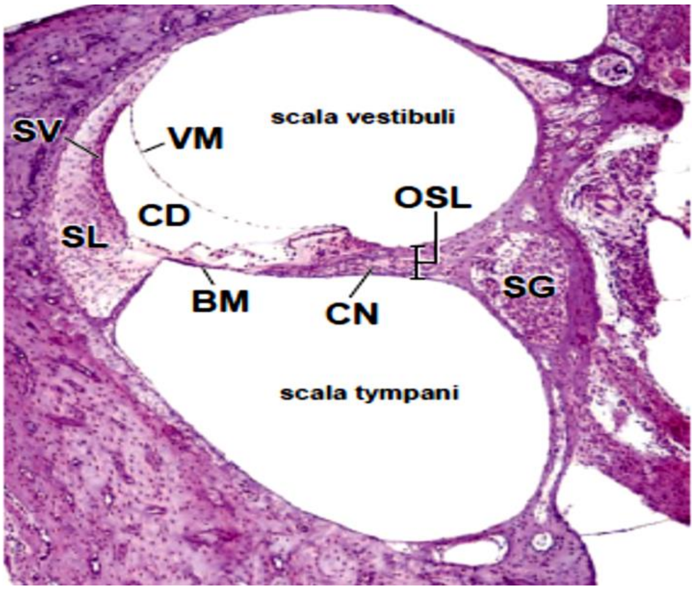

Figure 10.13. Photomicrograph of turn of the cochlear canal in cross section [13].

CD - cochlear duct
OSL - osseous spiral lamina
BM - basilar membrane
VM - vestibular membrane
SV - stria vascularis
SL - spiral ligament
SG - spiral ganglion

Using this slide you have to perform exercise 5 and 6 of album (topic "Sense organs" (part II))

Stain: hematoxylin-eosin **Large magnification**

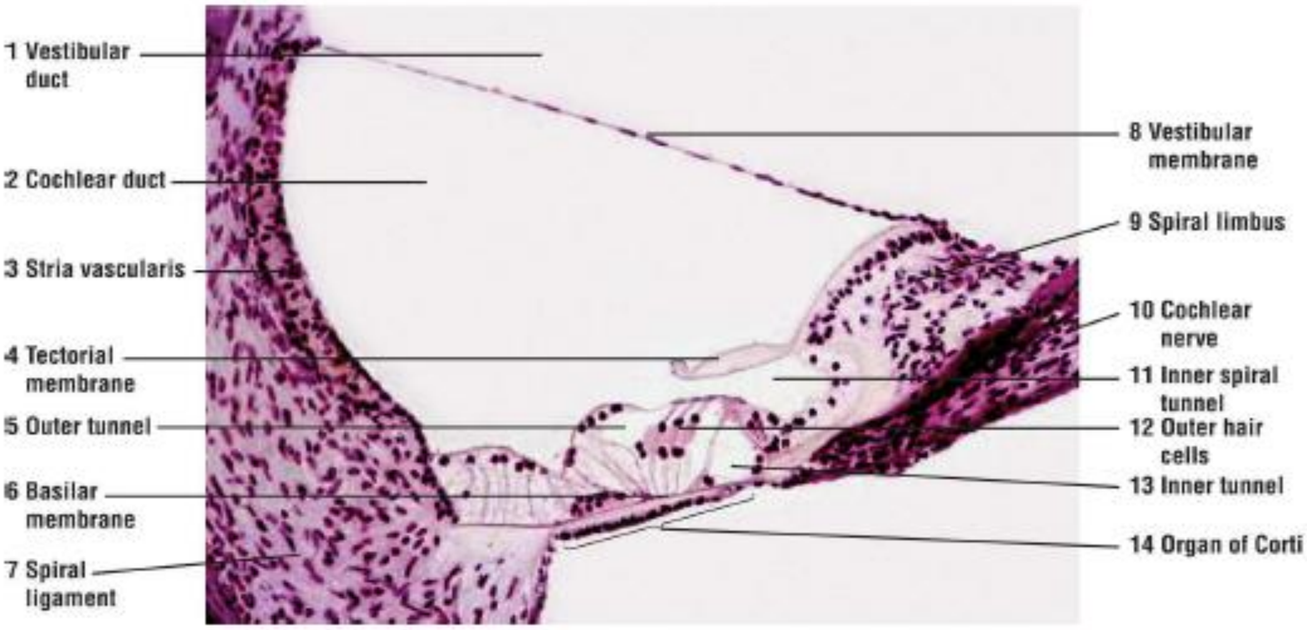

Figure 10.14. Photomicrograph of one turn of the cochlear canal in cross section [4].

Question 6. Sound transmission through the ear.

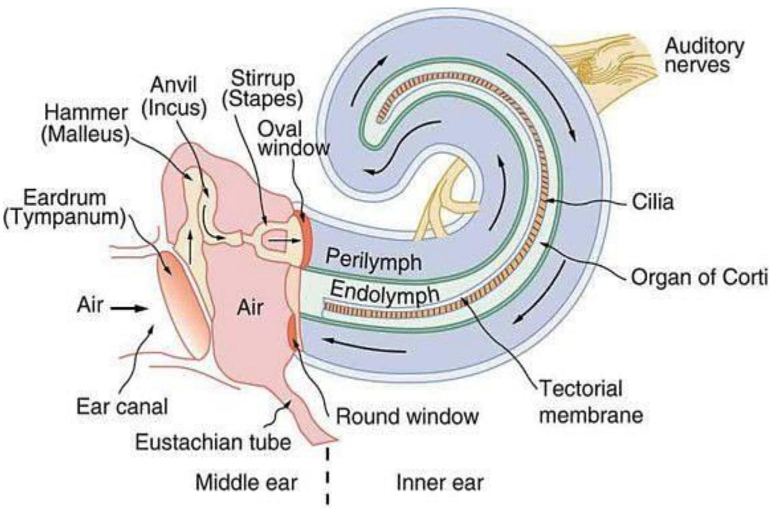

Figure 10.15. Diagram of sound transmission.

Sound waves cause the tympanic membrane of external ear to vibrate, and these vibrations are transmitted through the chain of three ouditory ossicles that link the external ear to the internal ear. The auditory ossicles connect the tympanic membrane to the oval window. Movement of the stapes in the oval window of the vestibule sets up vibrations or traveling waves in the perilymph of the scala vestibule. These waves pass through scala vestibule to rich the apex of the cochlea where there is helicotrema. Through helicotrema the scala vestibule is continuous with the scala tympani and here the waves pass into the scala tympani and traverse along the whole cochlea length to end on the membrane that covers the round window in the base of the cochlea.

In this way, vibrations are set up in the perilymph and through it in the basilar membrane. High-frequency sounds cause maximal vibration of the basilar membrane near the base of the cochlea. Low-frequency sounds cause maximal displacement of the basilar membrane near the apex of the cochlea [13].

Vibration of the basilar membrane leads to friction between hair cells and overlaying tectorial membrane to bend stereocilia of the hair cells. This bending generates nerve impulses that travel through the cochlea nerve to the brain.

Question 8. Hair cells of the cochlear and vestibular labyrinth. Their types, structure and functions.

Hair cells are sensory cells of both the cochlear and vestibular labyrinth.

Cochlear hair cells

Cochlear hair cells are divided into inner and outer. Inner columnar shaped hair cells are arranged in a single row, outer pear shaped hair cells are arranged in three rows. All hair cells have a bundle of stereocilia (hairs) on their apical domain. Stereocilia are modified microvilli. The stereocilia of inner hair cells are arranged in a straight line, whereas the stereocilia of outer hair cells are arranged in a "V" shape.

Inner hair cells are completely surrounded by inner phalangeal cells, whereas outer hair cells are partially (only lower third of them) surrounded by inner phalangeal cells.

The basal parts of every cochlear hair cells have a contact with dendrites of the sensory bipolar neurons, whose cell bodies localize in spiral ganglions [13].

Vestibular labyrinth hair cells

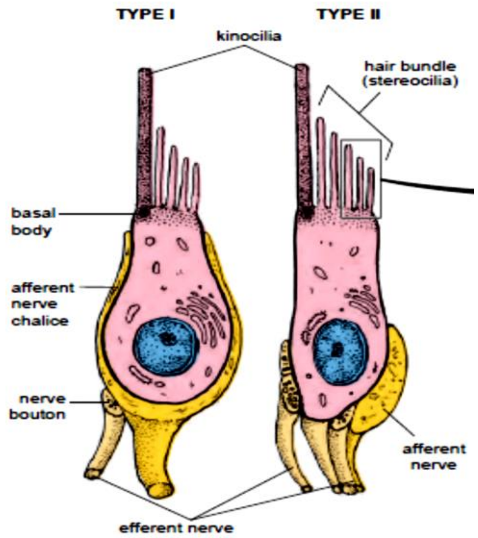

Figure 10.16. Diagram of two types of sensory hair cells of the vestibular labyrinth [13].

In vestibular labyrinth there are 2 types of sensory epithelial hair cells: type I hair cells and type II hair cells.

Type I hair cells have flask structure with a rounded base and a thin neck. Type I hair cells are surrounded by an afferent nerve producing a chalice like nerve ending and a few efferent nerve fibers forming synaptic boutons with basal part of the type I hair cells.

Type II hair cells are cylindrical shape cells. They have bouton, like afferent and efferent nerve endings at the base of the cell.

Apical part of both type I and type II hair cells contains single kinocilium and a bundle of stereocilia [13].

Question 9. Structure of the macula.

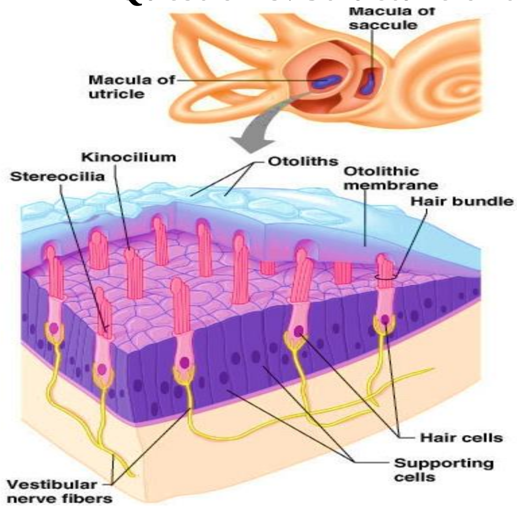

Figure 10.17. Diagram of the macula.

The vestibular or equilibrium organ is represented by the maculae and crista ampullaris.

Maculae there are in the utricle and the saccule of inner ear vestibule. They are represented by the specialized epithelium laying on basement. The epithelium of maculae consists of 2 types of cell:

1) Supporting cells;
2) Hair cells (type I and type II).

Hair cells of utricle macula are receptors for linear acceleration and static head position.

Hair cells of saccule macula are receptors for vertical acceleration (vibration) and static head position [3].

Question 10. Structure of the crista ampullaris.

Crista ampullaris there are in ampulae of the semicircular ducts. Each ampulla is dilated part of semicircular duct where it continues with utricle. Crista ampullaris have the same organization characteristic to that in the maculae of utricle and saccule. However, the structure overlaying epithelium in crista ampullaris is named cupula, which is a gelatinous protein-polysaccharide rich mass. In crista ampullaris the kinocilium and stereocilia of each hear cells are embedded in the cupula that projects into the lumen of ampullar and is surrounded by endolymph.

Hair cells of crista ampullaris are receptors for angular acceleration (rotational movement) of the head [13].

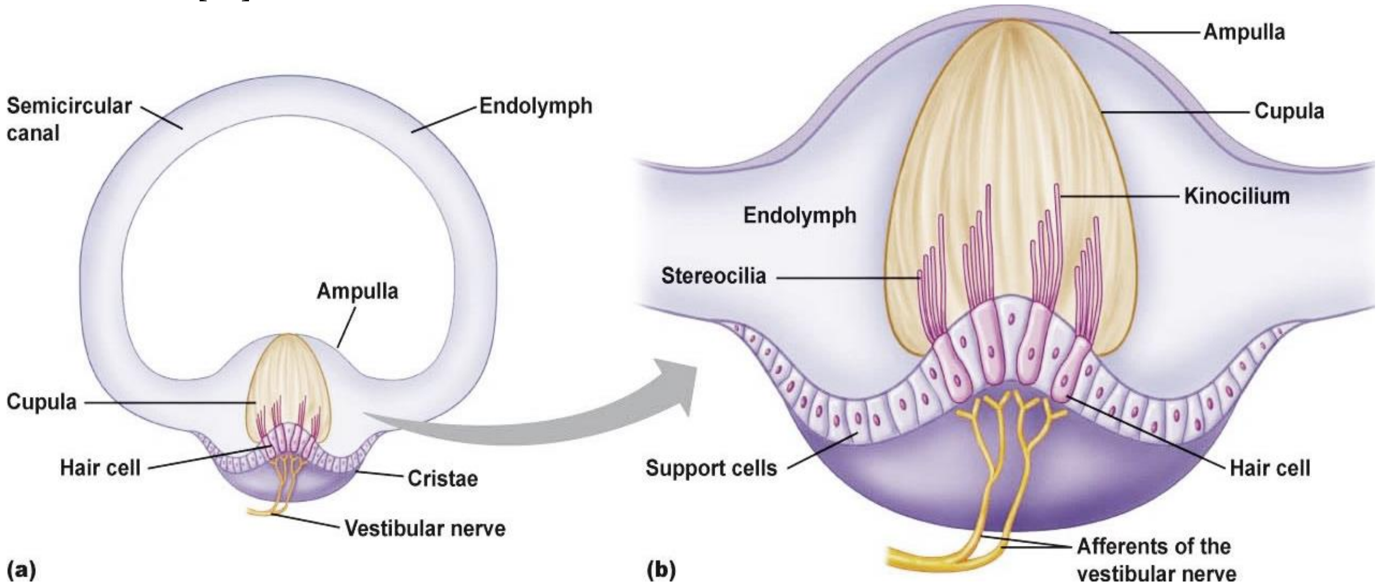

Figure 10.18. Diagram of the crista ampullaris.