

Chapter 21

Special Senses(Ear)

The ear can be divided up into three regions and serves to detect stimuli concerned with dynamic equilibrium, static equilibrium, and hearing.

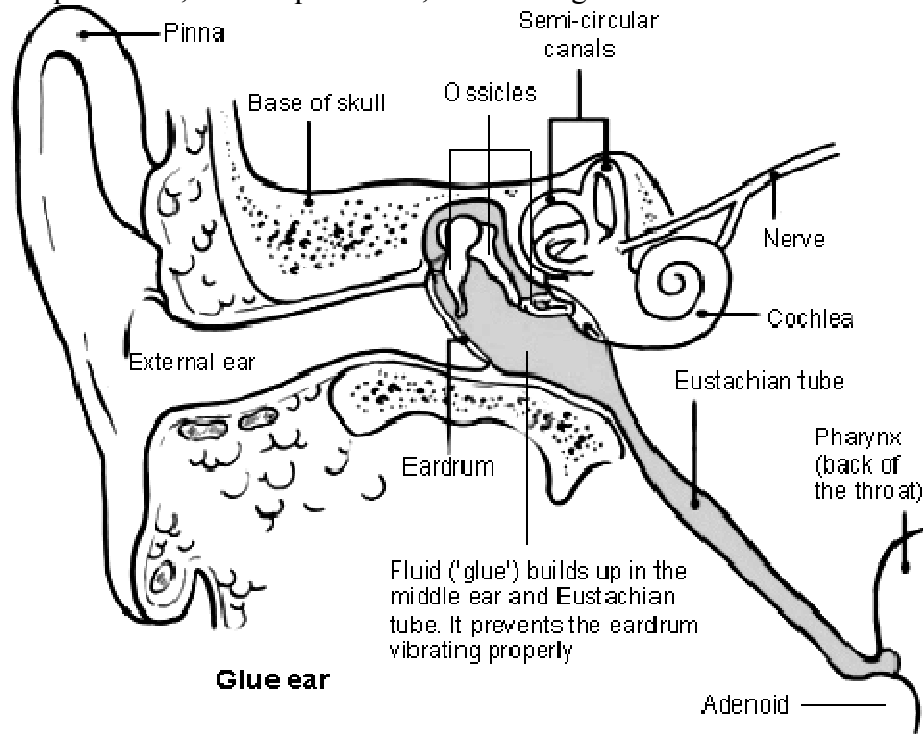


Fig.21.1. Structure of the Ear

21.1. The External/Outer Ear

21.1.1. The Pinna/Auricle is an elastic cartilaginous appendage covered by skin. It is designed for funneling sound waves into the external auditory canal.

21.1.2. The External Auditory Canal carries sound waves from the pinna to the deeper portions of the ear. This canal travels through the petrous portion of the temporal bone. It is lined by a stratified squamous epithelium containing ceruminous glands and having some hair follicles. These cutaneous appendages are more prominent closer to the pinna.

21.1.3. The Tympanic Membrane/External Tympanic Membrane is the most internal structure of the external ear. It serves to transmit sound waves to the middle ear. It can be thought to designate the border between the external and middle portions of the ear. It is a three layered structure: The external portion is covered by the same stratified squamous epithelium lining the external auditory canal. This epithelium is of ectodermal origin. The middle portion is made up of an elastic connective tissue. This connective tissue is of mesodermal origin. The inner portion, facing the middle ear, is composed of a low simple cuboidal epithelium. It is of endodermal origin.

21.2. The Middle Ear

The middle ear consists of a chamber containing three tiny bones, called Ossicles, arranged in a series spanning the distance between the external and internal ear. The ossicles are derived from three of the four bones making up the reptilian jaw.

a) Malleus - a hammer-shaped bone resting against the inner aspect of the tympanic membrane.

b) Incus - the middle ossicle located between the other two.

c) Stapes - a stirrup-shaped bone which attaches to the Oval Window (aka; the internal tympanic membrane).

Vibrations are carried from the tympanic membrane, through the series of ossicles, to the oval window of the inner ear. There are two skeletal muscles associated with the ossicles which are designed to reduce the chances of damage to the ear.

a) Tensor Tympani - inserts on the malleus.

b) Stapedius - inserts on the stapes.

The Eustachian Tube also opens into the middle ear. It connects the middle ear and the nasopharynx. It serves to stabilize internal air pressure. The chamber of the middle ear is lined by a mucus membrane. The connective tissue component fuses on to the periosteum of the surrounding bone.

21.3. The Inner/Internal Ear

The inner ear houses the sensory cells for audition, dynamic equilibrium, and static equilibrium. It is also located in the petrous portion of the temporal bone. The inner ear consists of a membranous structure located within a bony structure, both of which contain fluid. The Bony Labyrinth is the outer bony structure containing the membranous structure. It contains the fluid Perilymph. The Membranous Labyrinth is the inner, membranous, portion located within the bony labyrinth. It holds the sensory receptor structures. It holds the fluid Endolymph. The inner ear can be divided into three regions, each region containing a different group of sensory receptors: cochlea, semicircular canals, and vestibule.

The Cochlea houses the sensory structure for hearing called the Organ of Corti.

The membranous labyrinth is slightly off center and causes the cochlea to be divided into three canals: scala vestibula, scala tympani, and scala media. The scala media is also called the cochlear duct and holds the organ of Corti. The Vestibule houses the organ of static equilibrium called the Macula. The membranous labyrinth of the vestibule can be divided into two sac-like structures which are connected to one another. They are called the Utricule and the Sacculle.

The Semicircular Canals are three C-shaped extensions of the inner ear designed to detect the stimuli for dynamic equilibrium. These canals are arranged along three planes so as to detect movement of the head along those planes. At the base of each canal is a swollen portion called the Ampulla. Within the ampulla is the sensory structure for dynamic equilibrium called the Crista Ampullaris. Along with the oval window, the inner ear has a second "window" of elastic connective tissue called the Round Window.

21.4. The Auditory Ear

21.4.1. The Structure of the Cochlea

The bony labyrinth of the cochlea spirals 2.5 times around the center of a spongy bone, called the Modiolus, during development. This gives it its "snail shell" appearance. The

membranous labyrinth lines the bony labyrinth and has two extensions which divide the inner cochlea into three chambers/canals. The three canals are: scala media, scala tympani, and scala vestibuli. The extensions of the membranous labyrinth are:

a) Basilar Membrane - separates the scala media from the scala tympani. The organ of Corti sits on the basilar membrane.

b) Vestibular Membrane/Reissner's membrane - separates the scala media from the scala vestibuli. The cochlea is innervated by the cochlear branch of cranial nerve VIII.

21.4.2. The Scala Media/The Cochlear Duct

The cochlear duct contains the organ of Corti. The floor of the scala media is formed by the basilar membrane. The basilar membrane is composed a dense connective tissue which is rich in elastic and collagen fibers. The basilar membrane extends from a periosteal thickening on the outer edge of the duct, called the Spiral Ligament, to a thin shelf of bone on the inner edge of the cochlear duct, called the Osseous Spiral Lamina. The roof of the cochlear duct is formed by the vestibular membrane. The vestibular membrane is a double layer of squamous epithelium. The vestibular membrane extends from the osseous spiral lamina to the outer wall of the cochlea. The cochlear duct is filled with endolymph. Whereas the scala tympani and scala vestibuli are filled with perilymph. This perilymph is continuous with the perilymph of the vestibule. It carries sound waves from the oval window to the cochlear duct.

21.5. The Organ of Corti

The organ of Corti is a ribbon of innervated neuroepithelial and supporting cells resting on the basilar membrane. The neuroepithelial cells are called Hair Cells/Auditory Receptor Cells. They have very long microvilli, called stereocilia, located on their apical surface which are sometimes called "hairs".

These stereocilia are embedded in an acellular, proteinaceous membrane called the Tectorial Membrane. The tectorial membrane is anchored at the inner angle of the cochlear duct at the Limbus and extends over the auditory receptor cells. When sound vibrations are transferred across the cochlea from the scala vestibuli to the scala tympani the basilar membrane vibrates. This causes the tectorial membrane to vibrate which stimulates the "hairs". As a result the neuroepithelial cells produce an impulse which is picked up by a sensory neuron. Different portions of the organ of Corti respond to different vibrations accounting for different sound frequencies detected. There are two recognized types of auditory cells located within the organ of Corti.

a) Inner Hair Cells - a single row of goblet-shaped auditory receptor cells. They have neurotransmitter containing vesicles in their basal cytoplasm. They are the class located closer to the limbus.

b) Outer Hair Cells - three to five rows of columnar-shaped cells. They also have neurotransmitter containing vesicles in their basal cytoplasm. They are the class located further from the limbus. The supporting cells, or sustentacular cells, are columnar-shaped epithelial cells which surround and support the auditory cells. There are five types recognized: outer phalangeal cells, inner phalangeal cells, Claudius cells, Hensen cells, and the stria vascularis. The stria vascularis may secrete endolymph.

21.6. The Balancing Ear

21.6.1. The Balancing Ear for Static Equilibrium

The cells which detect static equilibrium are located in the vestibule. Within the vestibule

the membranous labyrinth is broken up into two contiguous sack-like structures called the Utricle and Saccule. This portion of the inner ear receives innervation from the vestibular branch of CN VIII. The neuroepithelial cells for the detection of static equilibrium are located within the utricle and the saccule. They are found in a small area on the inner aspect of these membranous structures. This small area is called the Macula. There are two recognized neuroepithelial cells found in the macula. They are differentiated by shape.

1] Flask Cells

2] Columnar Hair Cells

Like the auditory receptor cells these cells are surrounded by sustentacular cells. These will also be columnar epithelial cells. Also like the auditory hair cells these cells have stereocilia. The stereocilia are embedded in the Otolith Membrane. The otolith membrane is an acellular, gelatinous, mucopolysaccharide containing numerous calcium carbonate crystals called Otoliths. The otoliths give mass to the otolith membrane giving it a greater specific gravity. When the head tilts the otoliths slowly move in that direction causing stimulation of the receptor cells.

21.6.2. The Balancing Ear for Dynamic Equilibrium

The balancing ear for equilibrium is located in the semicircular canals. The actual sensory structure is called the Crista Ampullaris and is located in an expansion at the base of the semicircular canal called the Ampulla. The semicircular canals receive innervation from the vestibular branch of CN VIII. The crista ampullaris consists of a ridge-like arrangement of hair cells located among sustentacular cells. There are two types of receptor cells recognized based on their appearance:

1] Flask Shaped Hair Cells

2] Columnar Shaped Hair Cells

These receptor cells will also have stereocilia. The stereocilia are embedded in an acellular, gelatinous membrane called the Cupola. The cupola extends into the lumen of the semicircular canal. During angular movements endolymph strikes the cupola, which will compress the stereocilia, which will send an impulse to the sensory neurons.

Remember: there are three semicircular canals at right angles to one another in each ear to detect movement along three planes. The cupola has the same specific gravity as does endolymph.