Hearing

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General Anatomy

- Three components: Outer ear, middle ear, inner ear
- All three are involved in hearing, but only the inner ear is the organ that allows you to hear and it is also responsible for balance
- The complexity of the inner ear and balance is complex, so we will not go into the balancing part of the inner ear
The Outer Ear Anatomy

- The auricle offers a unique shape to direct sound deep into the ear.
- The auditory canal offers a direct passage to the middle ear.
- The outer ears function:
  - is to collect sound waves and channel them to the tympanic membrane aka the eardrum
  - Protects the entrance of the ear canal
Outer Ear Anatomy and Function cont.

- The tympanic membrane separates the outer ear from the middle ear.
- Auditory Canal: Is a tube running from the outer ear to the middle ear. In an adult human, the length of the tube is about 1 inch.
- Tympanic Membrane: thin layer of tissue that separates the outer ear from the middle ear. It functions by vibrating in response to percussions from compression waves.
The Middle Ear Anatomy & Function

- Eustachian minimizes the extremity of air pressure in order to avoid damage to the middle ear
- The Eustachian tube drains into the back of throat and nose (nasopharynx)
- Contains the tympanic membrane, which vibrates in the presence of sound waves
- There are three small bones, or ossicles, that are located adjacent to the tympanic membrane (Malleus, incus, and stapes)
Middle Ear Anatomy and Function

- Malleus is a small hammer-shaped bone, which is attached to the eardrum.
- The incus receives vibrations from the malleus, to which it is connected laterally, and transmits these to the stapes.
- The stapes is a bone that helps conduction of sounds to the inner ear.
- The stapes transmits sound vibrations from the incus to the oval window, a membrane-covered opening to the inner ear.
The Inner Ear

- Its primary function of the inner ear is hearing, and its secondary function is balance.
- It is a warren of tubes filled with fluid encased within the temporal bone of the skull.
- The bony tubes also contain a set of cell membrane lined tubes.
- These bony tubes are called the bony labyrinth filled with perilymph fluid, which the membranous labyrinth are filled with endolymph.
- This is where the cells responsible for hearing are located (the hairy cells of corti).
Inner Ear Anatomy and Function cont.

- The bony labyrinth has three sections: the cochlea, semicircular canals, and the vestibule.
- The cochlea is responsible for hearing.
- The semicircular canals have functions associated with balance.
- The vestibule connects the two and contains two more balance and equilibrium related structures, the saccule and utricle.
- The final structures of the inner ear are the round window and the eighth cranial nerve (cranial nerve VIII or the Vestibulocochlear Nerve) which is composed of the vestibular nerve (balance) and the cochlear (hearing) nerve.
Pathway to Stimulus

- Vibrations in the air (sound waves) enter through the outer ear (*pinna*) and travel through the ear canal to the eardrum.
- The eardrum then begins to vibrate (back & forth) and turns the vibrations into mechanical movement which is then transmitted to the auditory ossicles which help with
- Those vibrations are then passed onto the cochlea.
Hair Cells

- Hair cells are located inside the basilar membrane which is located inside the labyrinth in the Organ of Corti located in the cochlea.
- The hair cells get longer the further down they go.
- Hair cells near the base of the cochlea are short & stiff & pick up high frequencies.
- Hair cells that are further away from the base are longer & looser & pick up low frequency.
Stimulus

- The brain turns the impulses it gets into the sounds we hear
  - The “medium” of the vibrations turned into sounds is the air
  - This makes hearing a mechanical sense
- Hearing is the sense of sound perception
- The brain then erases out all of the background noises to make sure that the person is only hearing what it needs to hear
- The fluid in the ear -- Sound Organ (endolymph)
  - External ear: Goes mostly through the air
  - Middle ear: Goes through solid bone (ossicles)
  - Inner ear: Goes through the fluid - Endolymph (inside the cochlea)
INNER HAIR CELLS vs. OUTER HAIR CELLS

- The auditory system receives more afferent input from the inner hair cells.
- Function to detect the sound and transmit brain via the auditory nerve.
- One row of inner hair cells.

- The outer hair cells are more efferent since they end directly on the cell bodies.
- Function to amplify sound.
- Three rows on inner hair cells.
Depolarization of Hair Cells (Cochlear transduction)

- The hairs located in the inner hair cells consist of a series of cilia and one longer stereocilia (called the kinocilium) which is located off to one side of the hair cell.
- The hair cells' resting potential is approximately -65mV.
- The deformation of cilia towards the kinocilium (the longest hair cell) places tension on the filaments (this causes for the potassium channels to open, increasing afferent activity).
- The hair cells' threshold is approximately -50mV.

MECHANICAL MOVEMENT of endolymph turns into ELECTRICAL IMPULSES.

Image shows mechanical transduction.
Pathway to the Brain

- Once hairs cells have depolarized stimulates the cochlear branch of the vestibulocochlear nerve.
- There are two pathways:
  - Primary auditory pathway
  - Non-primary auditory pathway
Primary Auditory Pathway

1. The first major auditory pathways occurs in the **cochlear nuclei in the brain stem**
2. The second major relay in the brainstem is the **superior olivary cortex**
3. The third neuron carries this message to the **superior colliculus** (mesencephalus)
4. The fourth major relay occurs in the **medial geniculate body (thalamus)**
5. The final neuron **links the thalamus to the auditory cortex.**
Non-Primary Auditory Pathways

- Process all sorts of messages
- The core function of this pathways is to choose the type of sensory message that has to be treated first.
- Also passes through the brainstem but **passes through the reticular formation**.
- The message then goes to the thalamus and from there to the auditory cortex.
Hyperpolarization of Hair Cells

- The cilia bending in the opposite direction closes the potassium channels decreasing efferent activity.
Balance & Equilibrium

- Ear not only helps use with hearing but also helps maintain balance & equilibrium in our body.
- There are two structures that help maintain balance & equilibrium:
  - The three semicircular canals
  - The vestibule (connects the semicircular canals to the cochlea)
Semicircular Canals

- Are responsible for maintaining the dynamic equilibrium of the body.
- Dynamic Equilibrium lets us know the direction in which our head moves.
Vestibule

- The utricle & saccule are responsible for maintaining static equilibrium in the body.
- Static equilibrium helps us to detect the positioning of our head gravity (helps us know which way our head is tilted.)
Video

https://www.youtube.com/watch?v=eQEaiZ2j9oc
Homeostatic Imbalances

- Homeostatic Imbalances - interruptions to the homeostatic state become long-term or can't be easily corrected
- There are many possible homeostatic imbalances that could affect the ear
- Some possible homeostatic imbalances that you may encounter are otitis media, sensorineural deafness, otosclerosis, and conduction deafness
Otosclerosis

- Otosclerosis is a disease of the bones of the middle and inner ear
- The ossicles bones become knit together into an immovable mass, and do not transmit sound as well as when they are more flexible
- The sensory hearing loss is attributed to leakage of enzymes from bone into the inner ear
- Otosclerosis is believed to be an inherited disease
- There are four treatments for otosclerosis:
  - Surgical Treatments, Hearing Aid (for minor cases), amplification, or the most common one; nothing
Meniere's Syndrome

- The main cause is unclear; however, we know there is an abnormal amount of fluid (endolymph) in the inner ear in all patients with Meniere's Syndrome
- Commonly spread genetically
- Unclear what the cause of fluid backup is
- Vertigo, hearing loss, tinnitus, aural fullness.
- Anti-nausea, tobacco absence, hearing aid, vestibular rehabilitation
Activity
Sources

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