HEARING

Anatomy of the Ear

- The human ear can be divided into two parts:
  - The peripheral ear (includes the outer, middle, and the inner ear)
  - The neural system (sensory nerves and the temporal lobe)
- Both of them work in conjunction to transform acoustic vibrations to neural signals for the cortex.
- During this process of transformation, the ear acts as a filter, permitting certain acoustic features to fully pass through, while distorting and blocking away other features.

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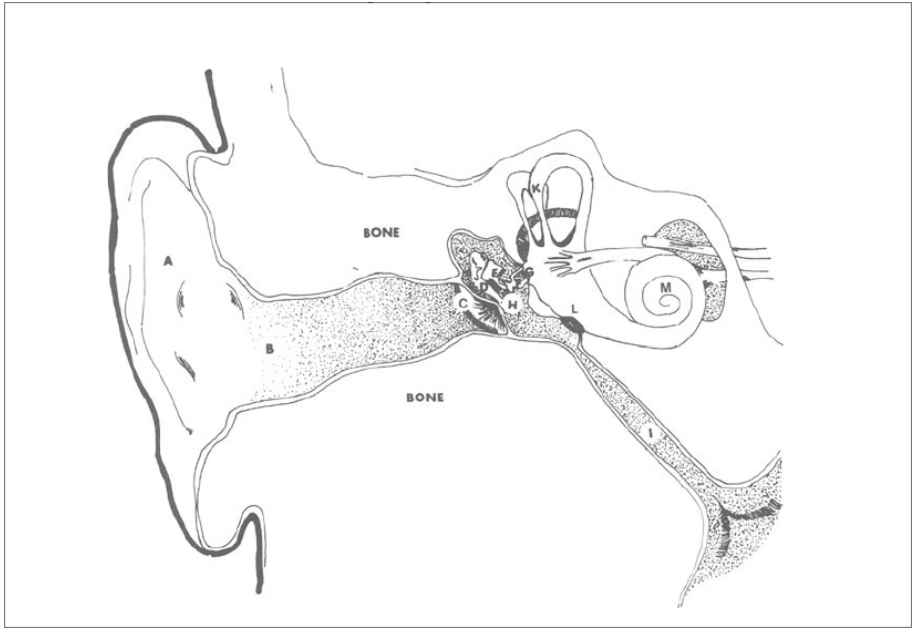


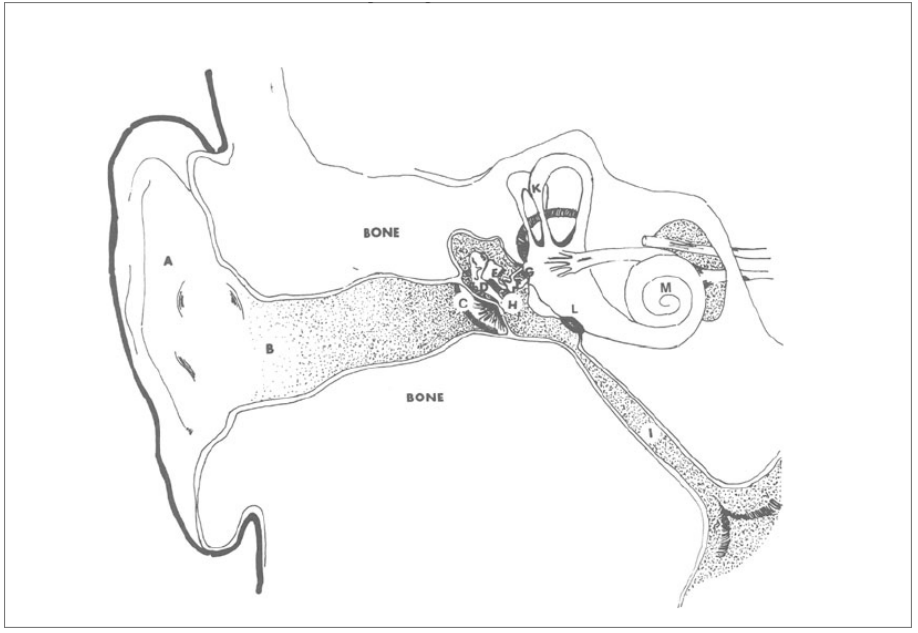
OUTER EAR (A+B)

- (A) depicts the auricle, which consists of a cup shaped pinna, and, a lobe. The pinna collects sounds and amplifies them to an extent of 3 dB.

- This section allows for sound localisation

- (B) is the external auditory meatus, a canal which connects the outer ear to the ear-drum (C).

- The canal amplifies and dampens signals selectively



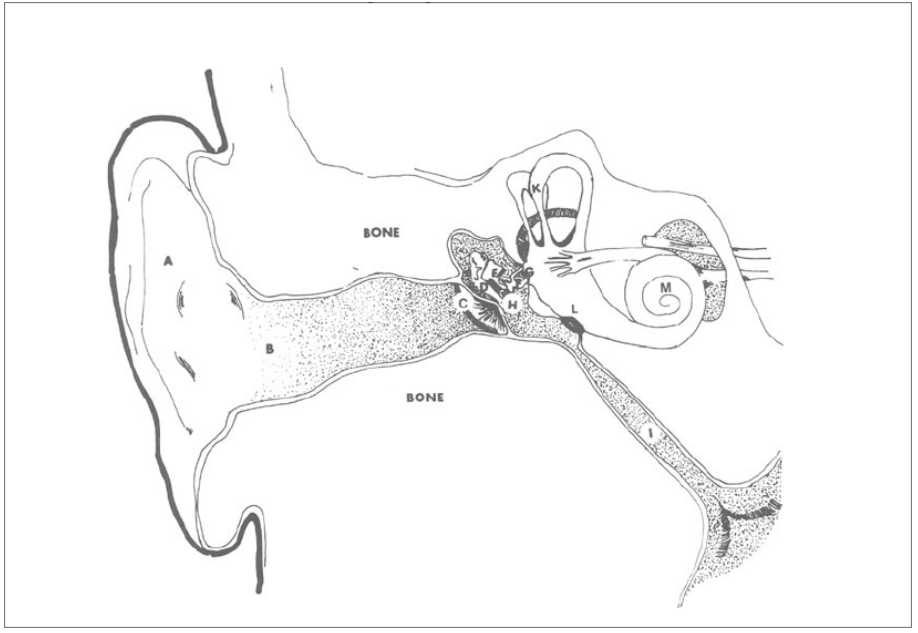
Middle Ear (H) - Overview

- The middle ear (H) is separated from the outer ear by the ear drum (C).

- Semi-isolated air chamber

- Connected via the eustachian tube (I) to the nose.

- Since the eustachian tube is closed, the middle drum is sensitive to variations in pressure traveling through the external auditory meatus



OSSICLES (D,E,F) – Middle Ear

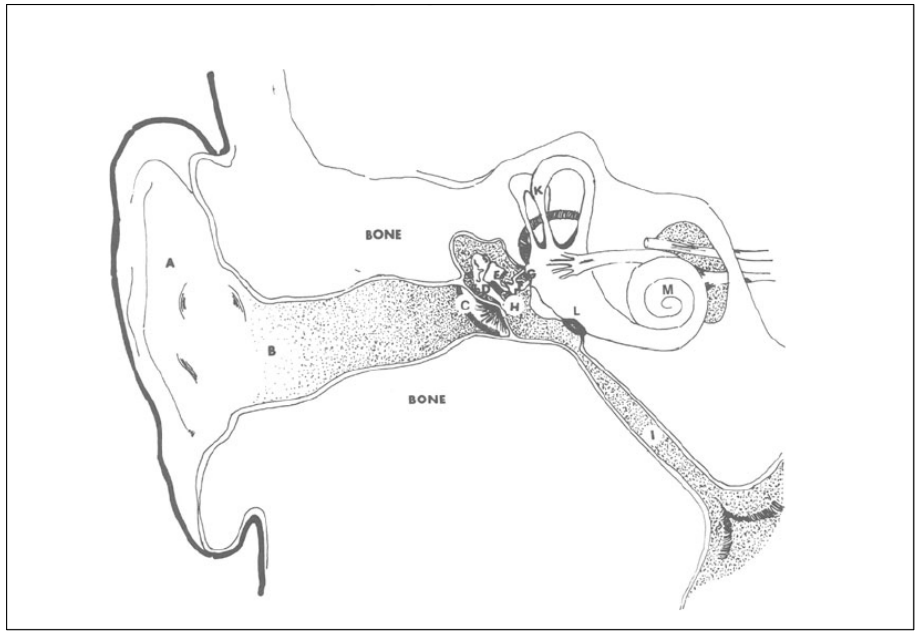
- D,E,F are attached to the eardrum

- Vibrations passing through the ear drum are passed mechanically, via the ossicular chain, to the oval window.

- D is called maleus, E, incus and F, stapes.

- These bones are meant to match the impedance of the air at the eardrum with the fluid behind the oval window;
it even provides some amplification

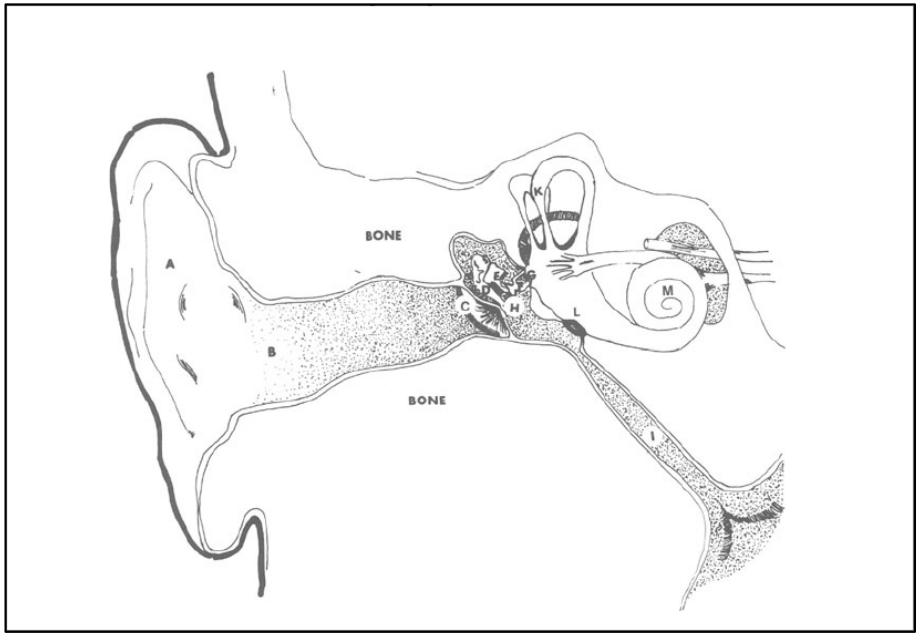
OSSICLES (D,E,F) – II



- The entire peripheral hearing mechanism also serves to transform the high-amplitude, low-force sound energy transduced through air into a high-force, low-amplitude form that can be introduced into the heavy, viscous fluid of the cochlea.

- The third bone, i.e stapes, is characterised by a rocking motion that that permits the sound vibrations to be introduced into the dense fluid of the inner ear. This allows for the transmission a fairly accurate presentation of the acoustic energy from eardrum to cochlea (M)

INNER EAR



- The inner ear contains the cochlea, a spiral-shaped structure filled with fluid that transforms vibrations into neural signals through hair cells.

- The cochlea consists of three parallel tubes: scala vestibuli, scala tympani, and the cochlear duct, separated by Reissner's membrane and Bassilar's membrane.

- Hair cells in the organ of Corti are distributed throughout the cochlea, with cells at the base responding to high frequencies and cells at the apex responding to low frequencies.

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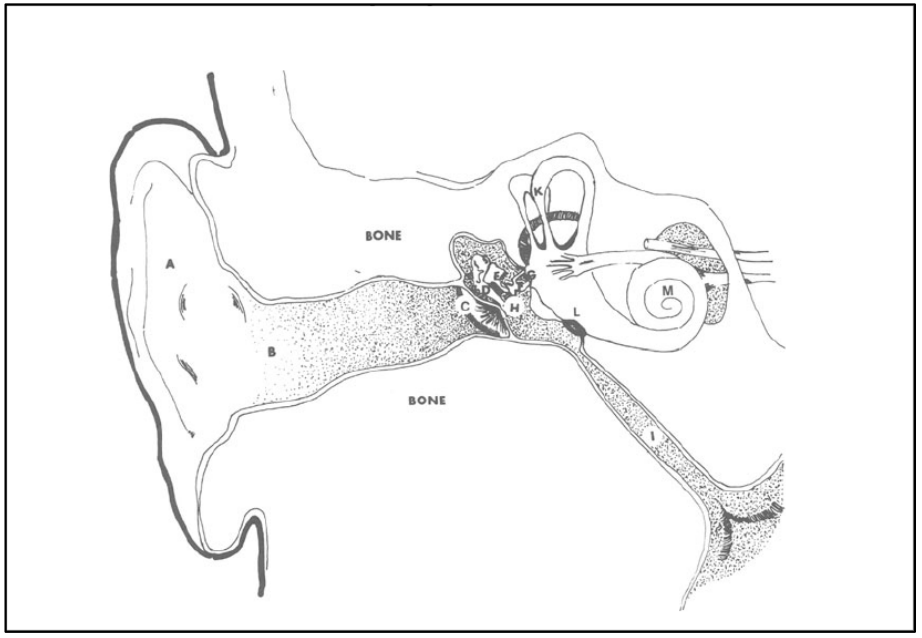

- Signal intensity is likely determined by the number of hair cells firing, and these neural impulses travel through the eighth cranial nerve to the brain's temporal lobe.

- The cochlea connects to the semicircular canal system (which controls balance), and its efficiency is enhanced by pressure compensation from the round window.

Hearing Acuity

- Frequency Range: Normal hearing spans roughly 16-16,000 Hz, with young healthy people hearing up to 20,000 Hz or slightly higher
- Low Frequency Perception: Below 16-20 Hz, sounds lose tonal character and become individually perceptible pulses
- Age-Related Changes: High-frequency sensitivity decreases progressively with age; older adults typically lose higher frequencies first
- Intensity Limitations: Upper intensity limit is around 120-140 dB SPL (threshold of pain)
- 120 dB SPL creates a sensation of touch
- A few decibels higher reaches threshold of tickle

Hearing Acuity

- 140-150 dB SPL reaches threshold of pain (relatively uniform across frequencies)
- Frequency Sensitivity Curve: Middle frequencies (1-3 kHz) are detected more easily than high (>4000 Hz) or low (<500 Hz) frequencies
- More energy is required to detect sounds at the extremes of our hearing range
- Reference pressure levels are typically to 0.0002 dynes/cm^2