LING 2200

Introduction to Speech and Language Science

Week 8 Lecture 1

Audition

Anatomy of the ear

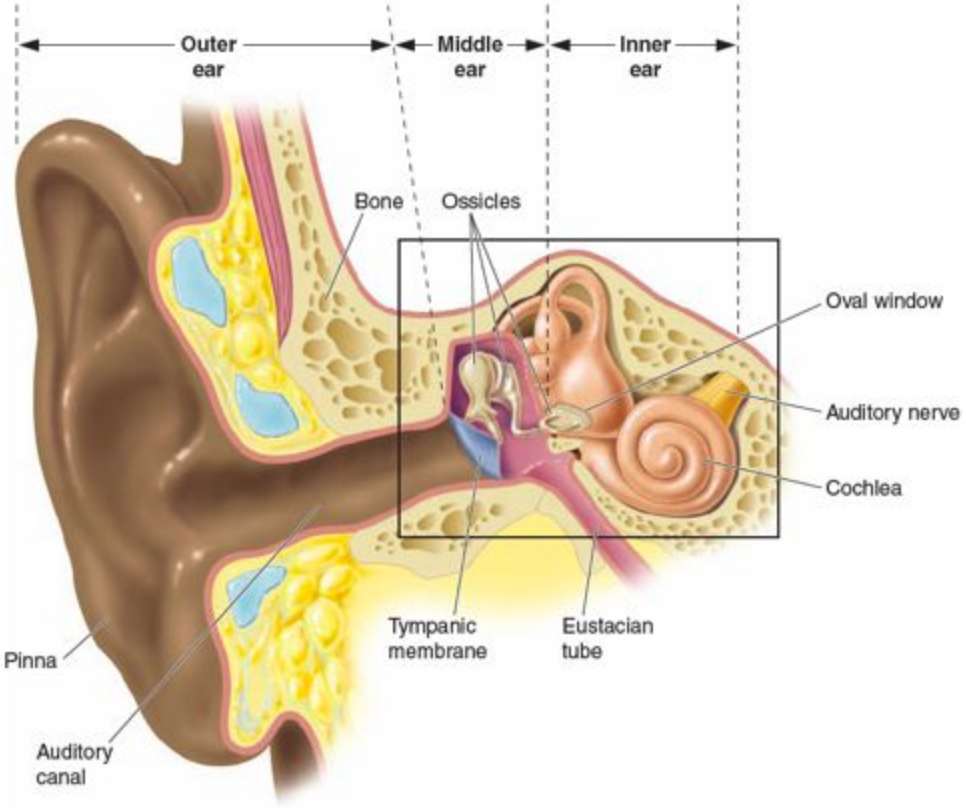
Outer, middle, and inner ear

Outer ear: Pinna, external auditory meatus (ear canal, half cartilage, half bone)

EAM contains cerumen and cilia; protects middle and inner ear; quarter-wave resonator with RF of 3400Hz→ boosts the amplitude of high-frequency sounds (like what?)

Transition of **Middle ear** is the **tympanic membrane** (ear drum), cone-like with the tip (umbo) facing the middle ear

One of the bones of the middle ear (the **malleus**) is embedded in the TM


Outer ear
Middle ear
Inner ear
Bone
Ossicles
Oval window
Auditory nerve
Cochlea
Pinna
Auditory canal
Tympanic membrane
Eustacian tube

Tympanic membrane

The primary function of the TM is to vibrate when there are acoustic pressure changes impinging on it

Vibration of the TM causes the malleus to move

The malleus is connected to the **incus** and the **stapes**

The TM is extremely sensitive to tiny variations in pressure and responds to a wide range of frequencies

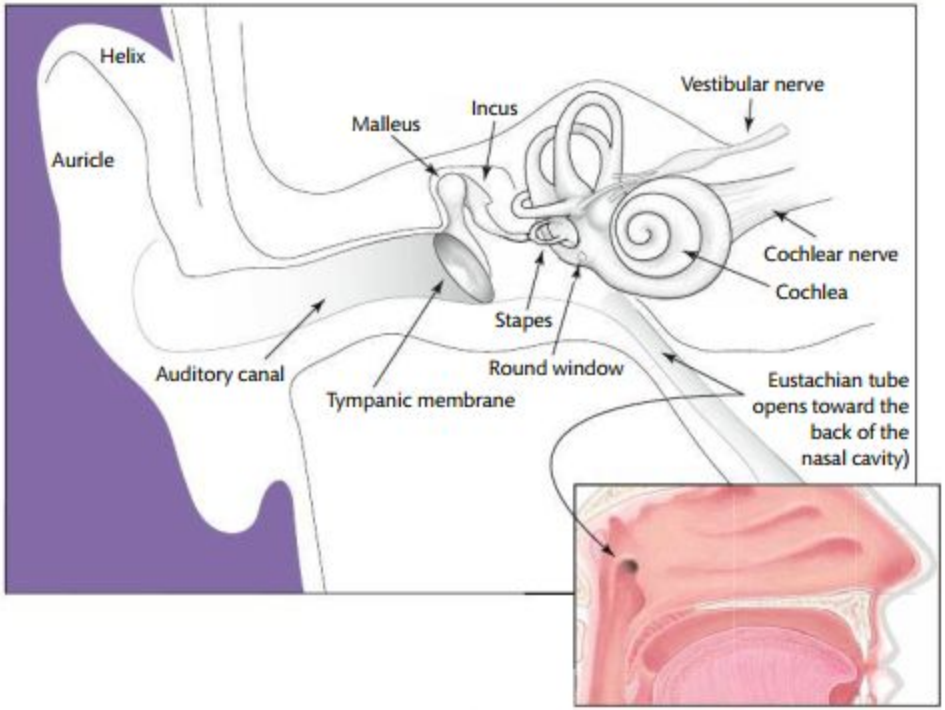
The TM is involved in *transducing* pressure waves into mechanical vibration

Middle ear

The middle ear, directly behind the TM , is a very small space divided into two sections

- Tympanic cavity
- Attic: lies superior to the tympanic cavity

Middle ear is ventilated and drained by the Eustachian tube


Helix
Auricle
Malleus
Incus
Vestibular nerve
Cochlear nerve
Cochlea
Stapes
Round window
Auditory canal
Tympanic membrane
Eustachian tube
opens toward the
back of the
nasal cavity)

Eustachian tube

About 35mm long, two-thirds cartilage, one-third bony; runs from the nasopharynx to the middle ear

The pharyngeal opening is 8mm long, and is normally closed except when swallowing or yawning

The tube acts to equalize air pressure between the closed middle ear and the atmosphere, if the opening stays closed then the pressure builds up in the middle ear

The tube also helps clear mucus from the middle ear by draining it to the pharynx

Ossicles

The three ossicles are the smallest bones in the body

Malleus is connected to the TM and is then attached to the **Incus,** which in turn is connected to the **stapes**

The footplate of the stapes is connected to the **oval window** of the inner ear and is held in place by a ligament

Muscles of the middle ear

Tensor tympani: connects to the malleus and when contracted pulls the malleus inward

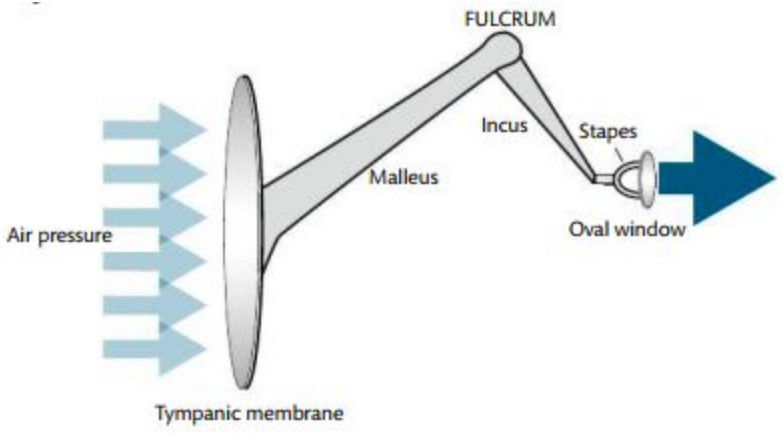
Stapedius: connects to the head of the stapes, when contracted pulls the stapes to a posterior position

Involved in the “acoustic reflex”; contracts strongly in response to loud sound→ reduces the pressure to the oval window, decreasing the sound intensity by 10dB

Middle ear muscles also contract during vocalization

Functions of middle ear

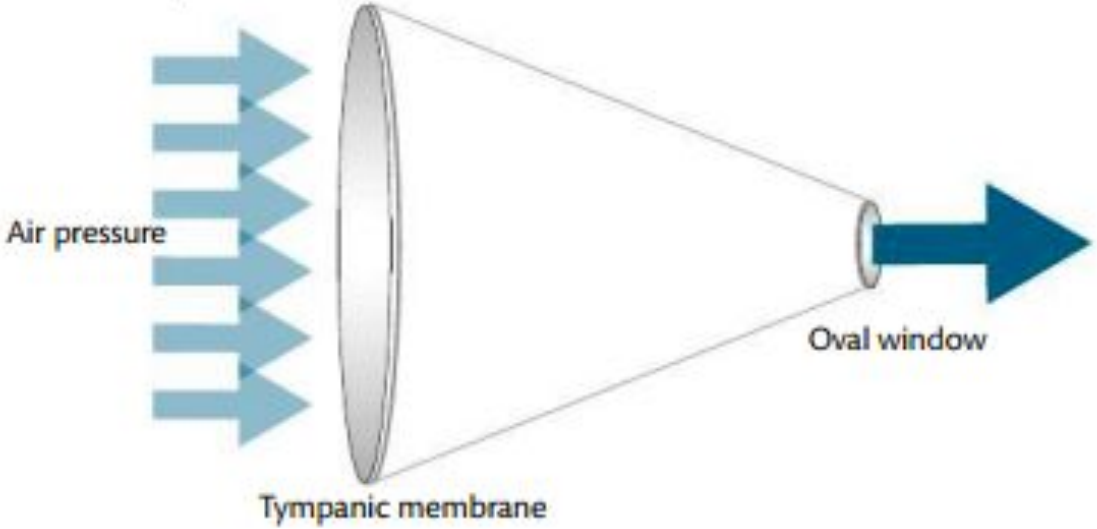
1. Increases acoustic energy by overcoming impedance mismatch between middle and inner ear→ Impedance is a measure of the difficulty of transmitting a signal through a medium



Due to the difference in impedance between the air filled middle ear and the fluid filled inner ear, acoustic energy is reflected, and very little energy is transmitted to the fluid→ increase the amplitude of the pressure changes at the oval window, which for many reasons is increased by 30dB

Only about half of the acoustic energy arriving at the tympanic membrane is transmitted to the inner ear

The energy of the air pressure that moves the tympanic membrane is concentrated on the much smaller oval window, creating an amplification effect.



2. Attenuate loud sounds via the acoustic reflex

3. Keep air pressure in middle ear and ear canal equal via the Eustachian tube

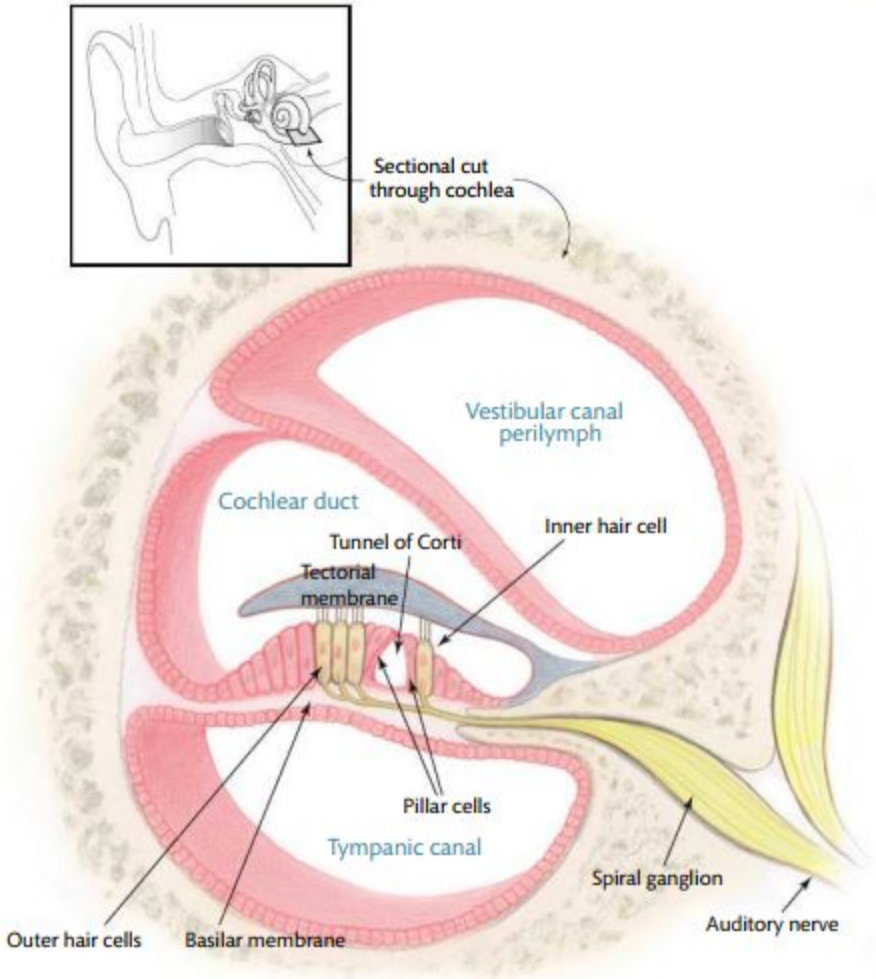
Inner ear

Lies deep within the temporal bone and composed of:

Cochlea: hearing

Semicircular canals: balance

Vestibule connecting cochlea and semicircular canal: balance



Organ of Corti

Cochlea

The cochlea is housed in the temporal bone, just behind the tympanic membrane

The majority of the cochlea consists of a snail shaped bony spiral canal, uncoiled would measure about 5cm long; there are three canals within the cochlea: the membranous canal (**cochlear duct**) and two bony canals (**tympanic canal and vestibular canal**)

The bony canal is filled with **perilymph** and the cochlear duct with **endolymph**

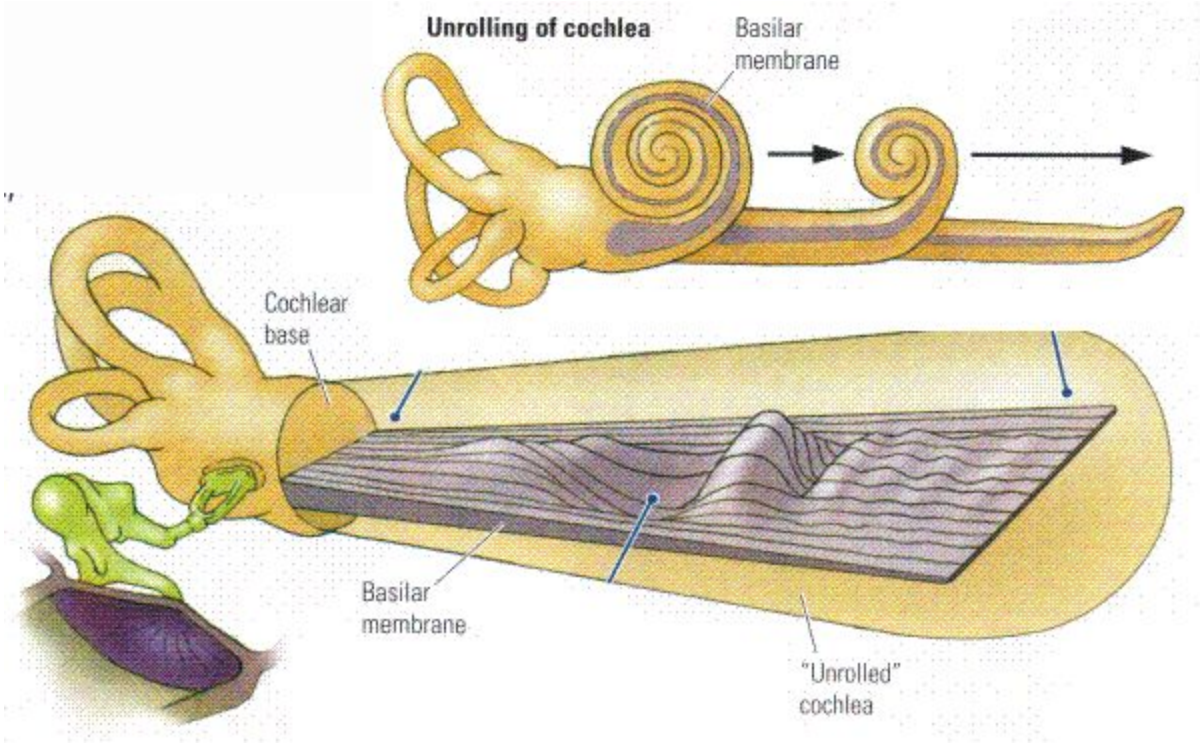
- The **apex** is the point furthest from the middle ear
- The **base** is closest to the middle ear

Cochlea

The base of the cochlear duct is the **Basilar membrane,** the roof of the cochlear duct is the **vestibular membrane**, with the canal above being the **Vestibular canal (scala vestibuli),** and the canal below being the **tympanic canal (scala tympani)**

The scala vestibuli terminates at the **round window** which connects to the **stapes**

The scala tympani terminates at the **oval window,** which is covered with a membrane


Unrolling of cochlea
Basilar membrane
Cochlear base
Basilar membrane
"Unrolled" cochlea

Cochlear duct

Lying within the cochlear duct, sitting on the basilar membrane is the **Organ of Corti,** which has roughly 12000 hair cells **(stereocilia)**, whose tips make contact with the **tectorial membrane,** stimulating the auditory nerve to fire

- http://www.youtube.com/watch?v=PeTriGTENoc

Basilar membrane

The basilar plays a crucial role in the cochlea's ability to perform frequency and intensity analysis of all incoming sounds

The BM is not equally wide along its entire length→ increases in width from base (**basal end**) to apex (farthest from BM)

Stiffest at the basal end and 100x more compliant/flexible at the apex

Tonotopic organization

The basal portion of the BM responds to all frequencies, but due to its stiffness it’s most responsive to high freqs

Apex most responsive to low freqs due to its compliance