

Audiology 101: Audiology for non-audiologists working in and supporting EHDI's activities

Terry E. Foust, Au.D., FAAA, CCC-A/SLP

Jeff Hoffman, MS, CCC-A

Jim Zeigler, Au.D., CCC-A

National Center for Hearing Assessment and Management

What are “Audiologists”?

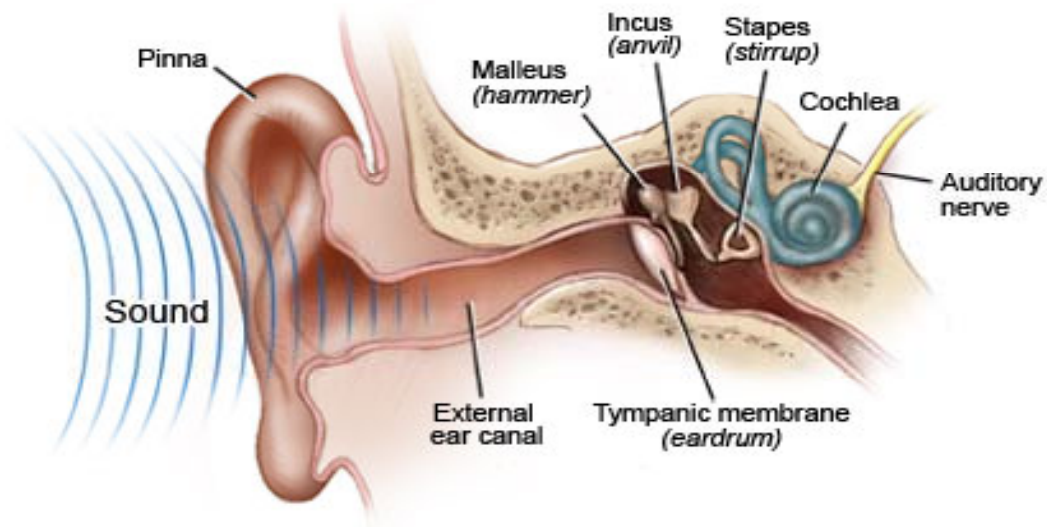
Specialists/experts in **Hearing and Balance**

We focus on :

- * Prevention of hearing loss
- * Identification and assessment of hearing and balance problems
- * Rehabilitation of persons with hearing and balance disorders



Anatomy and Physiology



Anatomy and Physiology

Divided into 4 parts

*** Outer Ear**

*** Middle Ear**

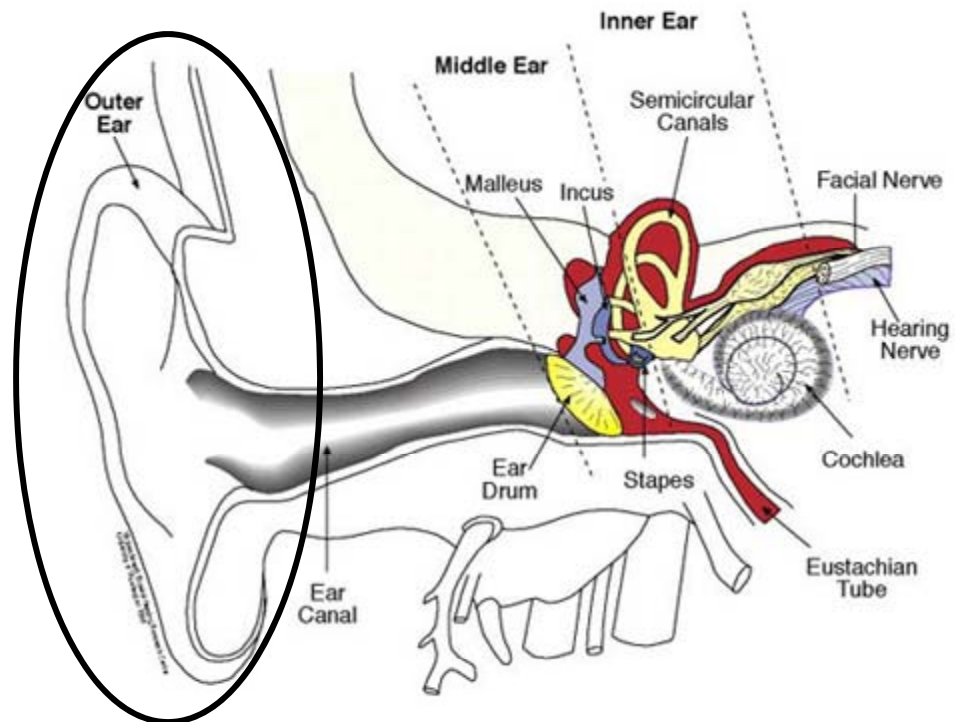
*** Inner Ear**

*** Central Auditory Nervous System**

Structures of the Outer Ear

Pinna

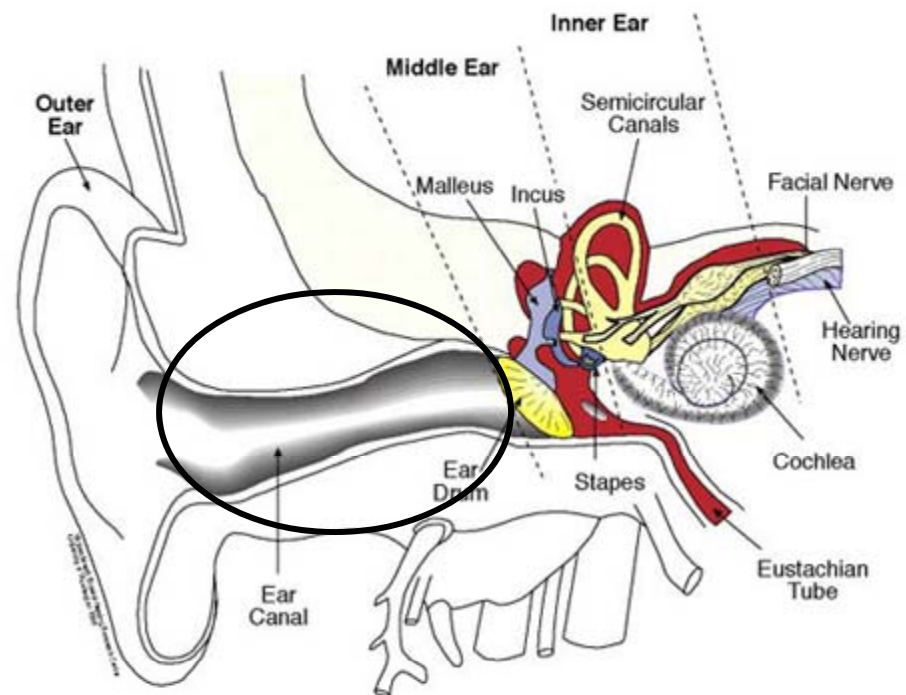
- * Gathers sound waves
- * Aids in localization
- * Amplifies sound approx. 5-6 dB



Structures of the Outer Ear

External Auditory Canal or Ear Canal

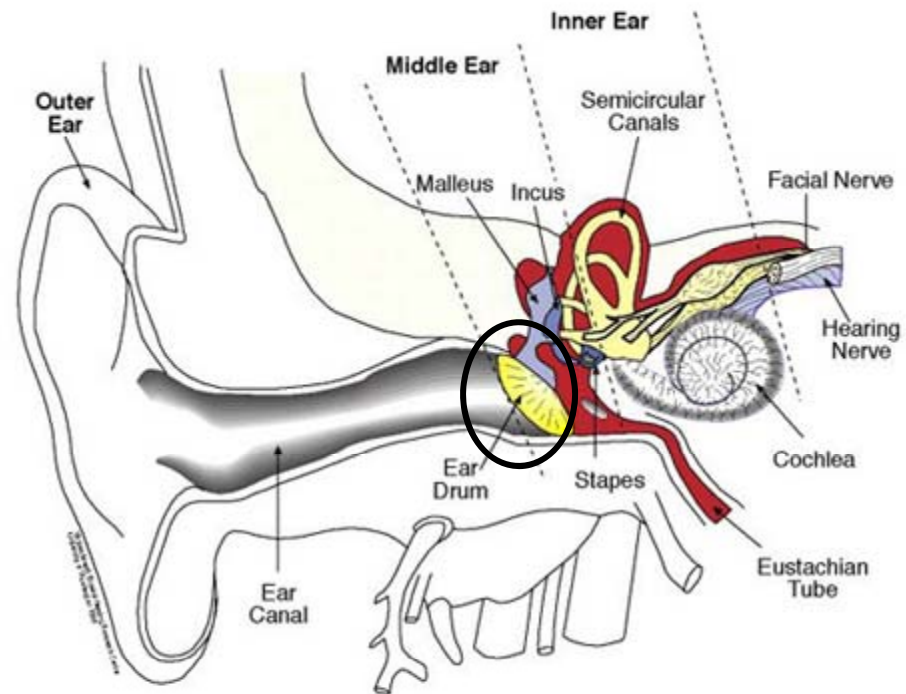
- * Approx. 1 inch long
- * “S” shaped
- * Outer 1/3 surrounded by cartilage
- * Inner 2/3 by mastoid bone
- * Isolates TM from physical damage
- * Cerumen glands moisten/soften skin
- * Presence of some cerumen is normal



Structures of the Outer Ear

Tympanic Membrane or Ear Drum

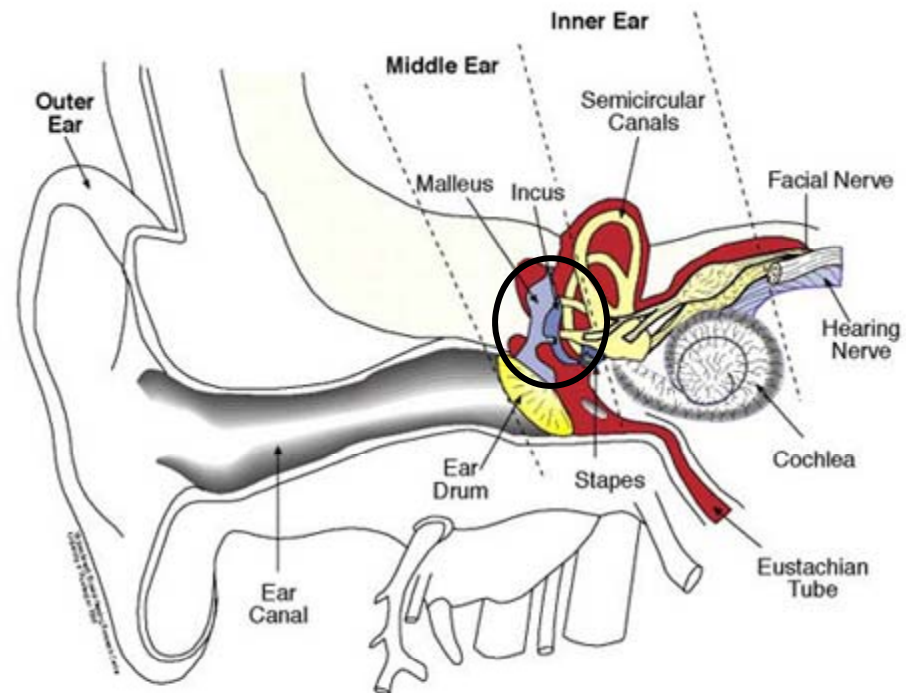
- * Thin membrane
- * Forms boundary between outer and middle ear
- * Vibrates in response to sound waves
- * Changes acoustical energy into mechanical energy



Structures of the Middle Ear

Ossicles

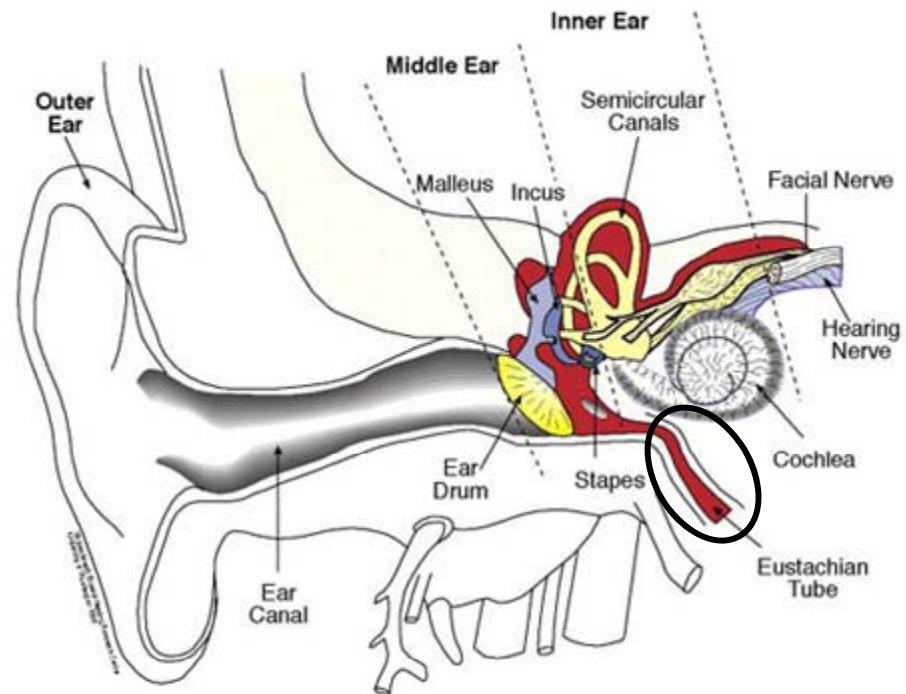
- * Ossicular chain = malleus, incus & stapes
- * Focus/amplify vibration of TM to smaller area
- * Enables vibration of cochlear fluids
- * **Malleus**
 - * Attaches to TM
- * **Incus**
 - * Connector
- * **Stapes**
 - * Smallest bone in the body
 - * Footplate inserts in oval window of the cochlea



Structures of the Middle Ear

Eustachian Tube

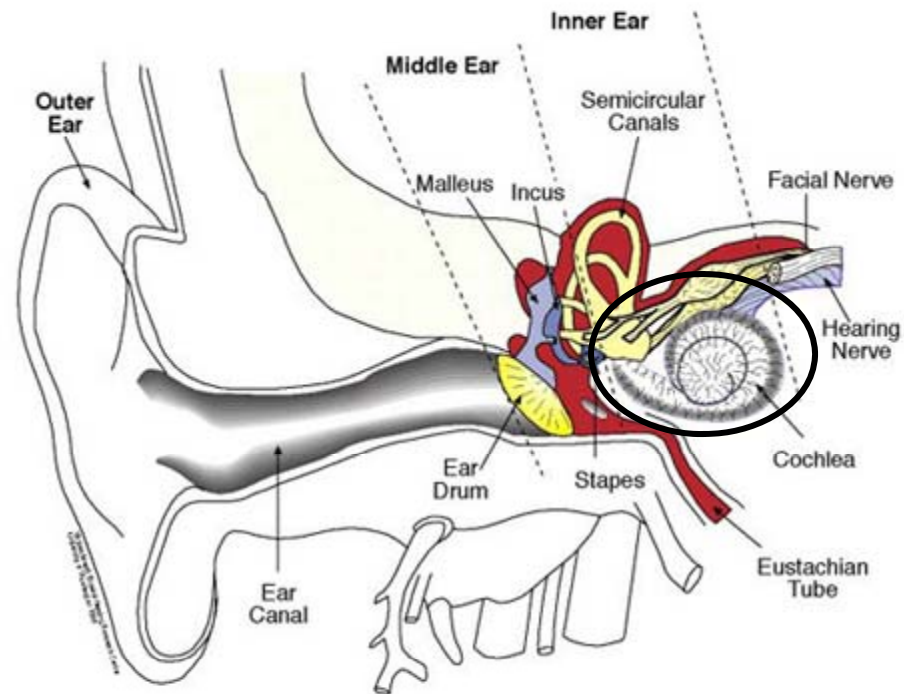
- * Mucous-lined
- * Connects middle ear cavity to nasopharynx
- * “Equalizes” air pressure in middle ear
- * Normally closed, opens under certain conditions
- * May allow a pathway for infection
- * Children “grow out of” most middle ear problems as this tube lengthens and becomes more vertical



Structures of the Inner Ear

Cochlea

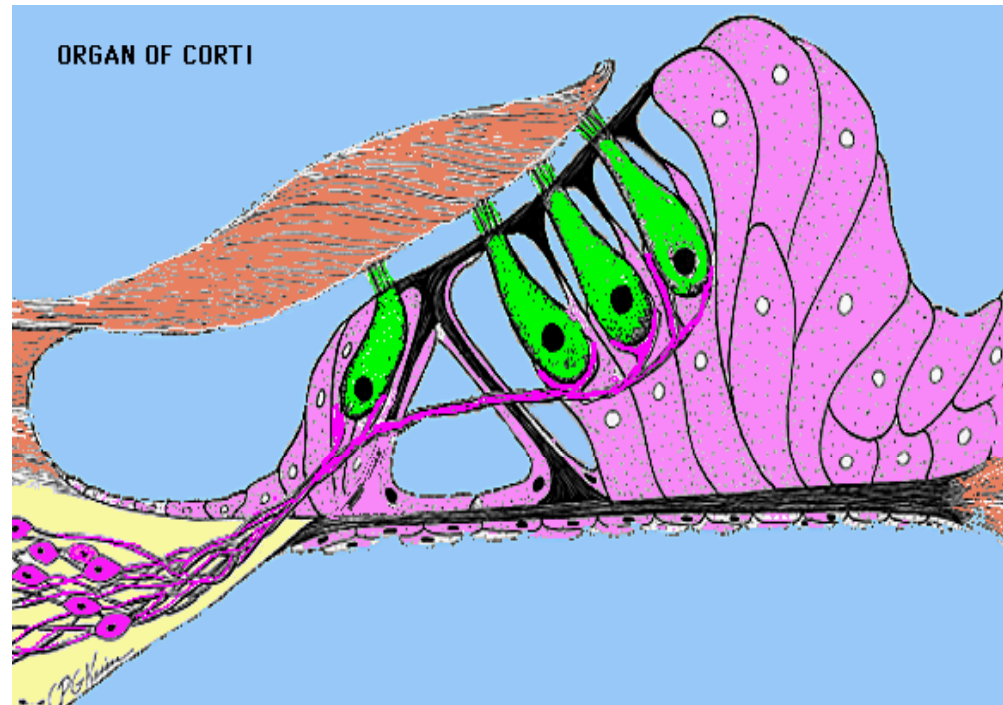
- * Snail shaped cavity within mastoid bone
- * 2 ½ turns
- * 3 fluid-filled chambers
- * Contains Organ of Corti
- * Converts mechanical energy to electrical energy



Structures of the Inner Ear

Organ Of Corti

- * End organ of hearing
- * 3 rows of Outer Hair Cells
- * 1 row of Inner Hair Cells
- * Tectorial and Basilar Membranes
- * Cochlear fluids

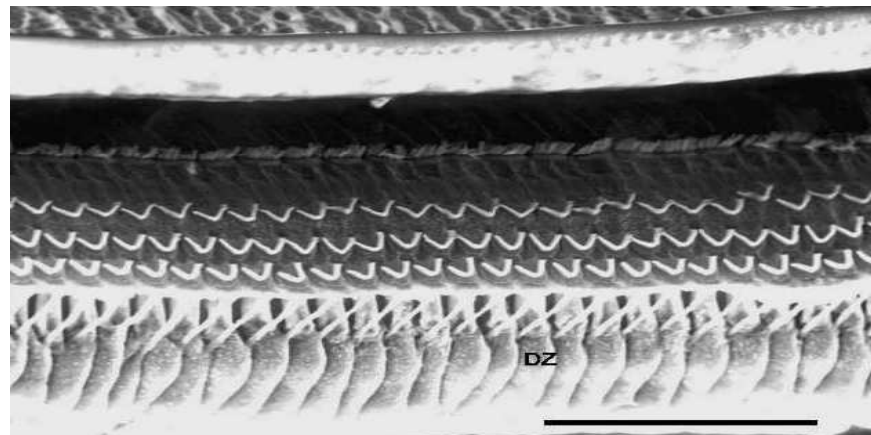
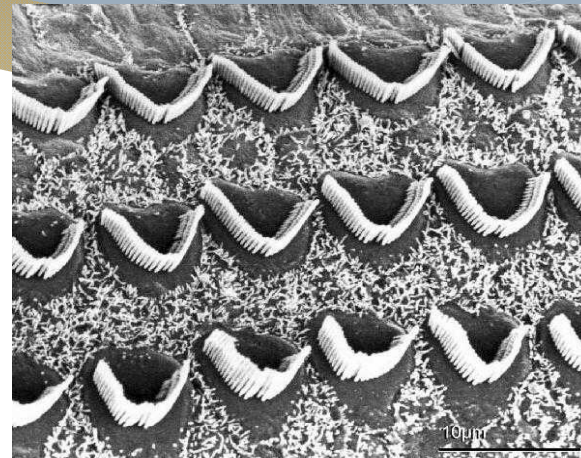


(From Augustana College, "Virtual Tour of the Ear")

Structures of the Inner Ear

Hair Cells

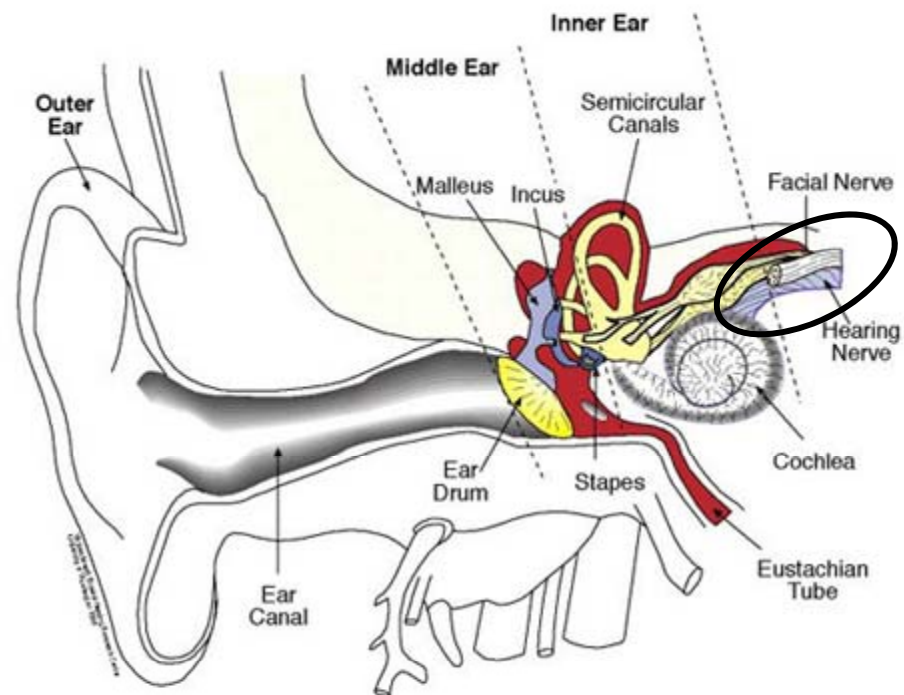
- * Frequency specific
 - * Low pitches = apex of cochlea
 - * High pitches = base of cochlea
- * Fluid movement causes deflection of nerve endings
- * Nerve impulses (electrical energy) are generated and sent to the brain



Structures of the Central Auditory System

VIIIth Cranial Nerve or Auditory Nerve

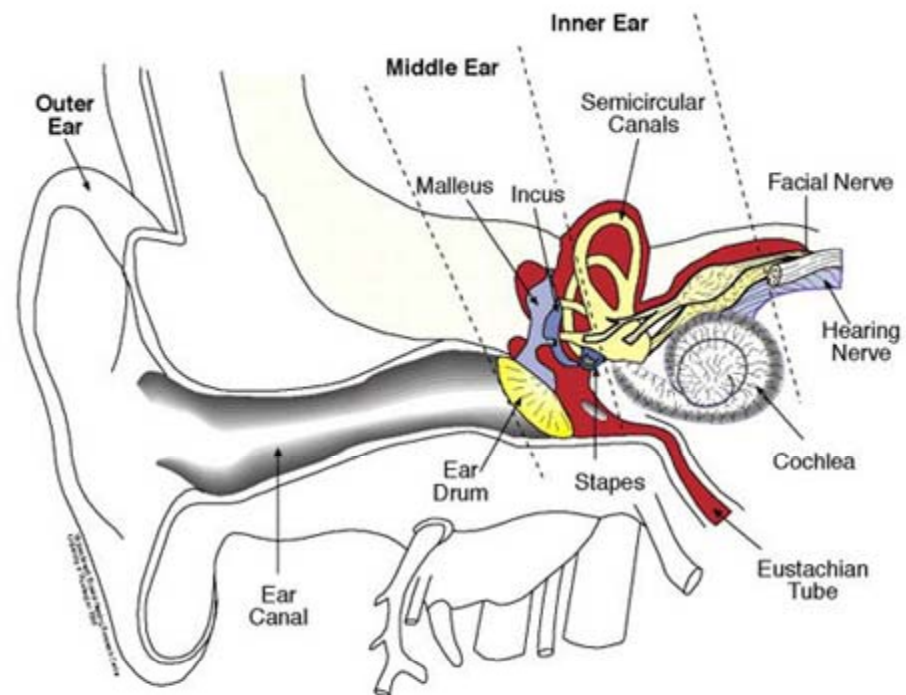
- * Bundle of nerve fibers (25-30K)
- * Travels from cochlea through internal auditory meatus to skull cavity and brain stem
- * Carry signals from cochlea to primary auditory cortex, with continuous processing along the way



Structures of the Central Auditory System

Auditory Cortex

- * Wernicke's Area within Temporal Lobe of the brain
- * Sounds interpreted based on experience/association



Types of Hearing Loss

- * Conductive = Outer and/or Middle Ear
 - * Sensorineural = Inner Ear
 - * Mixed = Outer and/or Middle Ear and Inner Ear
 - * Auditory Neuropathy Spectrum Disorder (AKA Auditory Neuropathy / Dys-synchrony) = Central Auditory System
-
- * Unilateral
 - * Bilateral

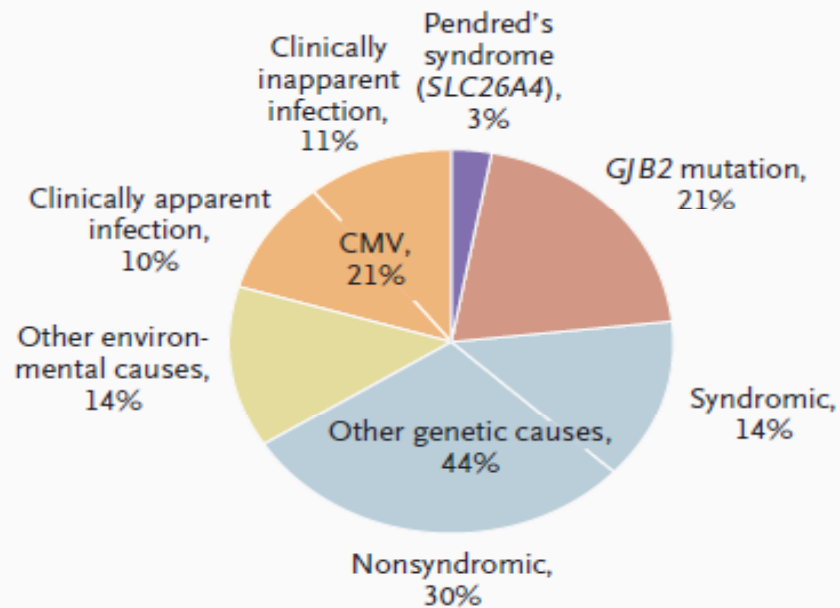
Incidence of Congenital Hearing Loss CDC EHDI Survey - 2006

- * Conductive = 18 %
 - * Sensorineural = 72 %
 - * Mixed = 7 %
 - * Auditory Neuropathy Spectrum Disorder = 3 %
-

- * Unilateral = 22 %
- * Bilateral = 73 %
- * Laterality Unknown = 5 %

Causes of Sensorineural Hearing Loss

**Incidence at Birth
(186 per 100,000)**



Newborn Hearing Screening — A Silent Revolution

Cynthia C. Morton, Ph.D., and Walter E. Nance, M.D., Ph.D.

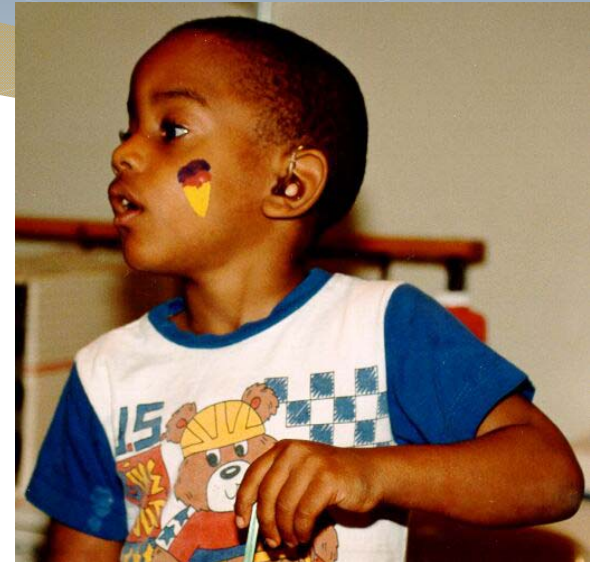
What Does It Sound Like to Have a Hearing Loss?

Severe hearing loss 

Moderate hearing loss 

Mild hearing loss 

Normal hearing 

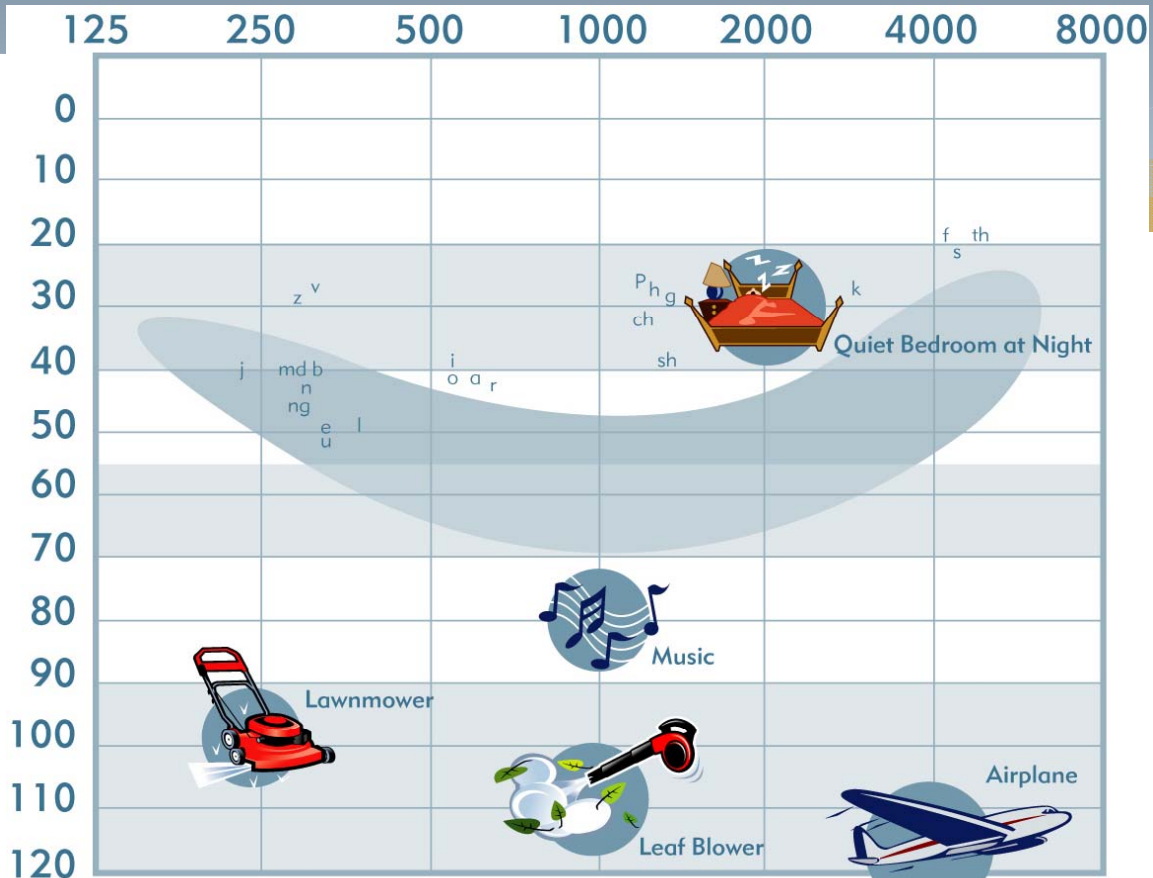


The Audiogram

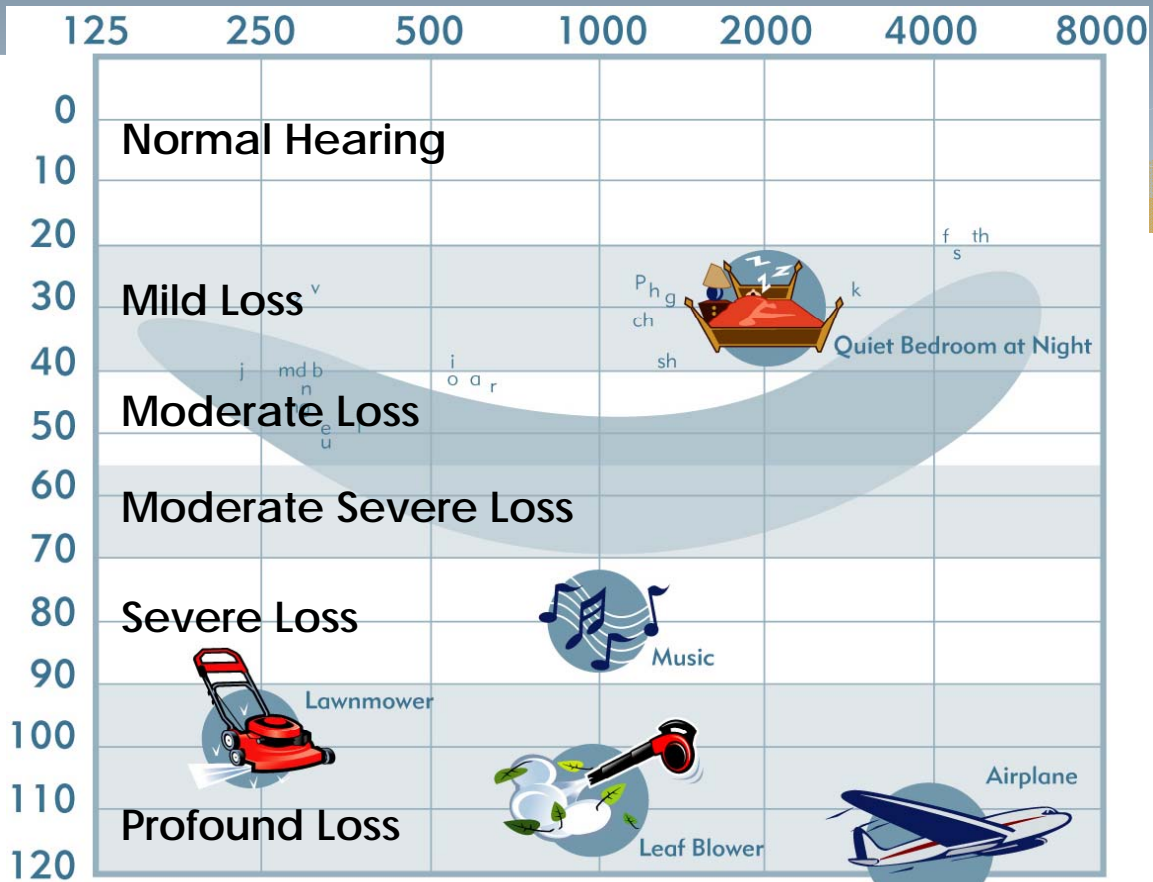
Frequency Low Pitch to High Pitch



Loudness
Soft to Loud



The Audiogram



Take Home Message

- * Hearing loss is described by the parts of the ear affected and can be temporary, permanent and/or fluctuating
- * Even mild and moderate hearing loss significantly affects ability to hear speech which affects speech and language development
- * An audiogram is how we graph hearing sensitivity and it is very important to develop an understanding of what it means

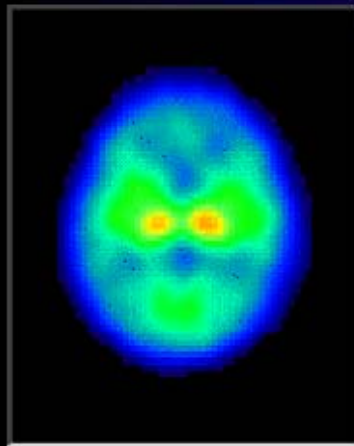


Screening and Diagnostics

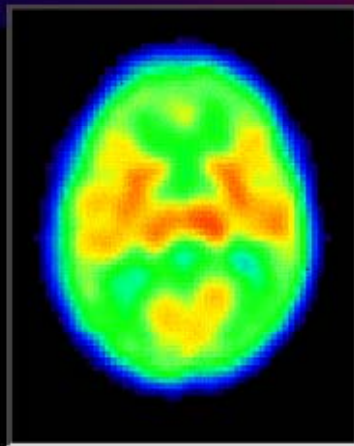
JCIH Newborn Hearing Screening Guidelines

- 1-3-6 Model
 - By 1 month Screen hearing
 - By 3 months Evaluate hearing; complete diagnostic audiology and otolaryngology examinations
Fit hearing aids if necessary
 - By 6 months Enroll in Early Intervention Services

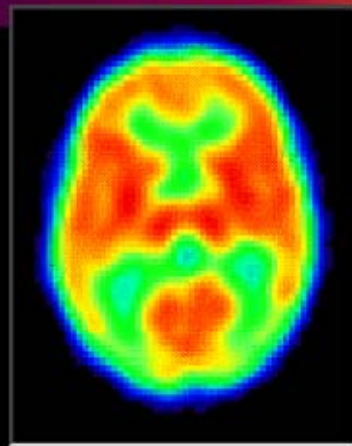
Why the rush??



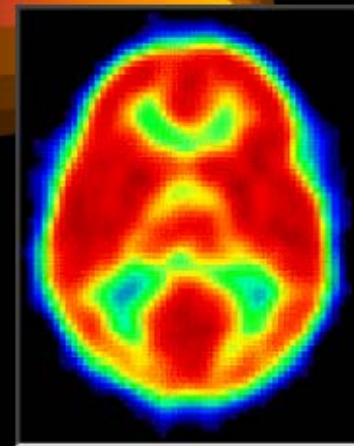
1 month



3 months



6 months



1 year

Laxmi.nuc.ucla.edu

Objective Test

- * Requires no behavioral response
- * Determine status of auditory system
 - * Middle ear function
 - * Inner Ear Function
 - * Function of central pathways in the brainstem and cortex

Three Main Tests

- Tympanometry-
 - evaluate middle ear pressure
 - status of middle ear system
 - confirm/rule out conductive or temporary hearing loss
- Otoacoustic emissions- OAE
 - echo of Outer Hair Cells from inner ear
 - recorded in ear canal
 - integrity of inner ear
- Auditory Evoked responses- record brain waves in response to sound
 - ABR auditory Brainstem response
 - response from brainstem

Tympanometry

Measured at the plane of the of the ear drum or Tympanic Membrane

Record how much acoustic energy is transferred into the middle ear

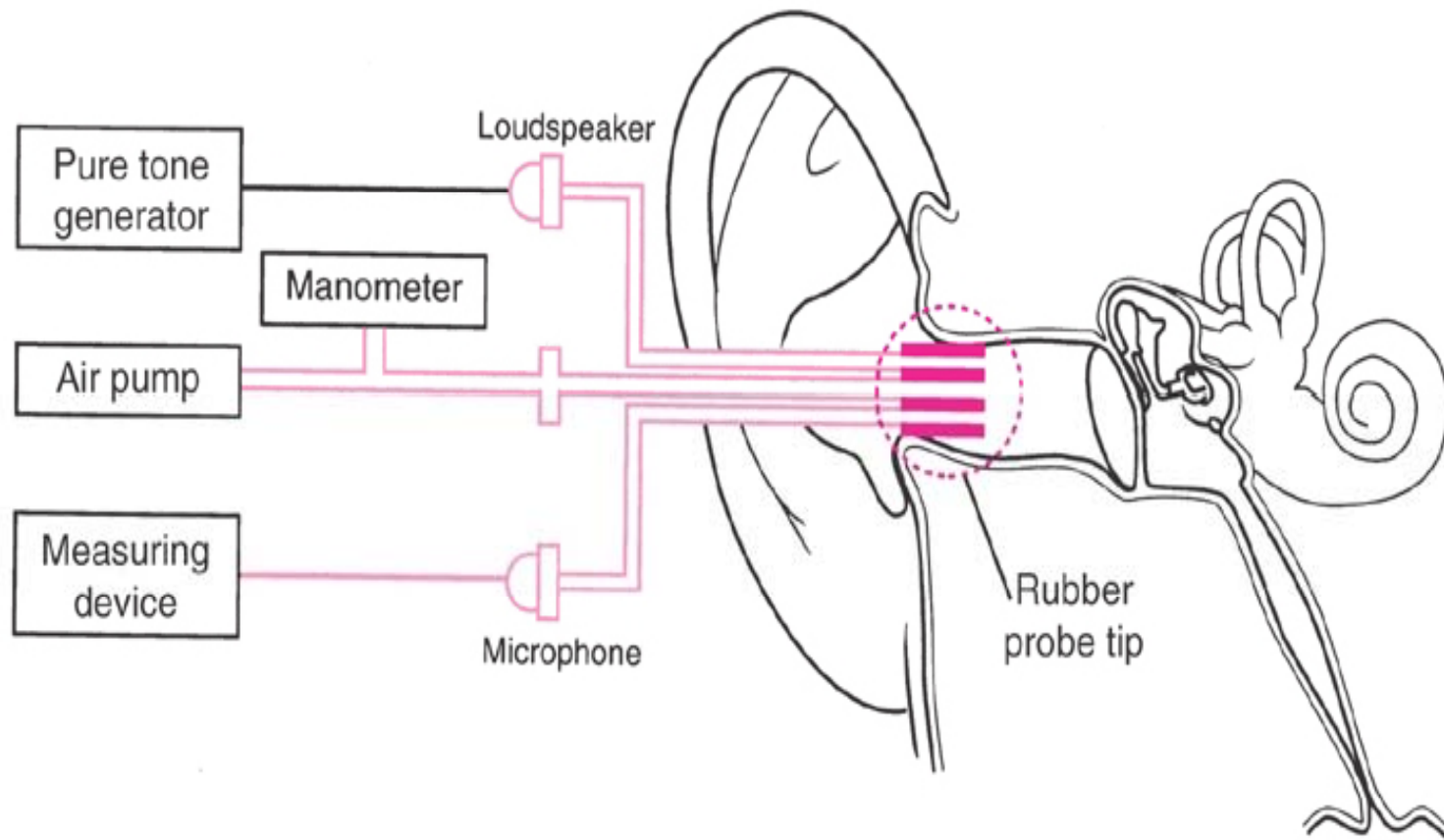
Determine the condition of the middle ear from this measurement

- hole or perforation of the eardrum
- fluid behind the ear drum
- air pressure behind the ear drum
- normal ear drum movement

Equipment for middle ear measurements

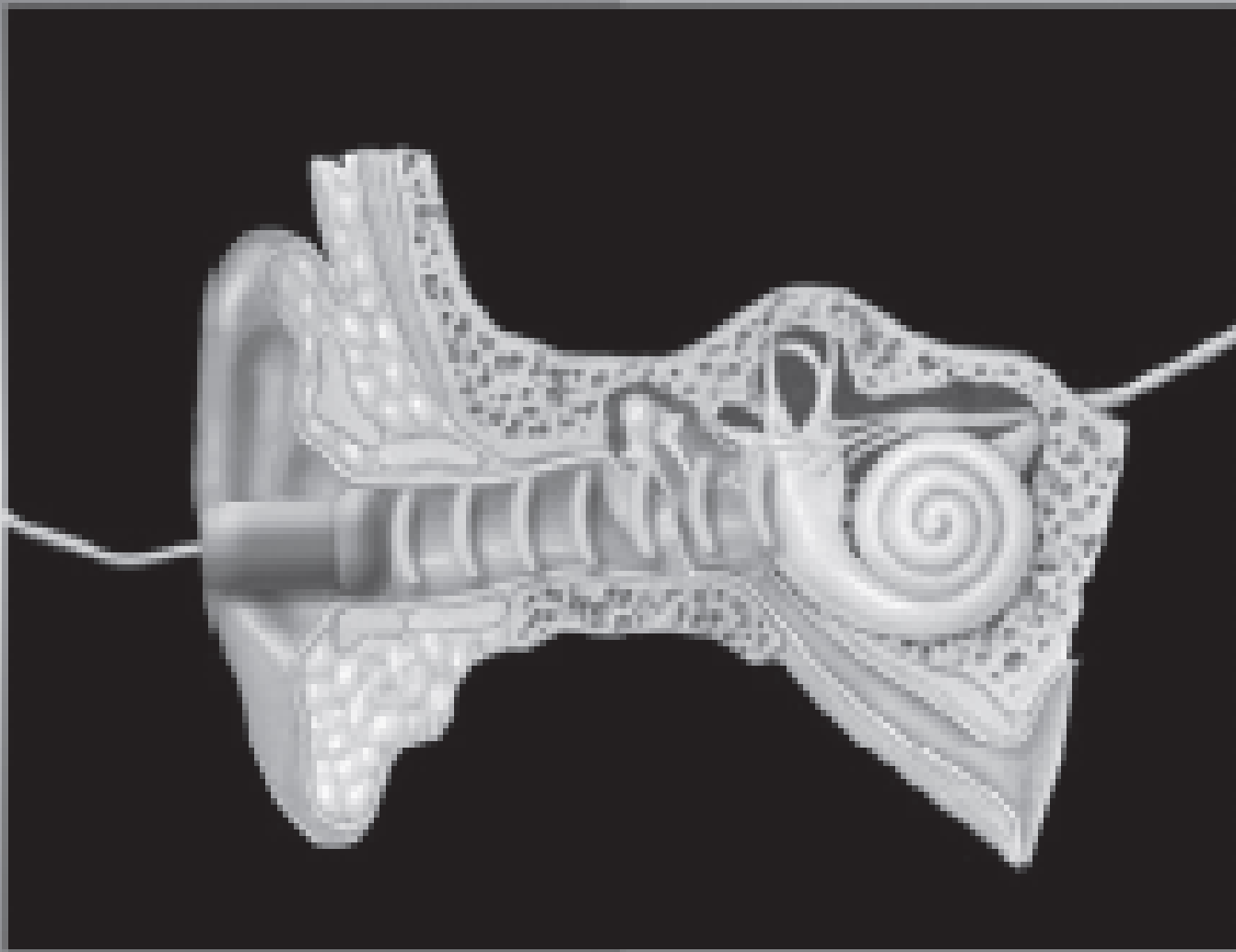
- * Probe for seal in ear canal
- * Speaker to generate tone sound wave
- * Microphone to measure reflected sound in the ear canal
- * Air pump to deliver positive and negative pressure to the sealed ear canal
- * Earphone for other ear for reflex measures

Tympanometry



OAE Overview

- * Sound stimulus goes into the ear canal
- * *If* the eardrum and middle ear system is healthy AND the Inner Ear is normal
- * *Then* a response (echo) from the movement of the outer hair cells can be measured
- * Babies are the easiest to test when they are:
 - * Younger
 - * Quiet or distracted



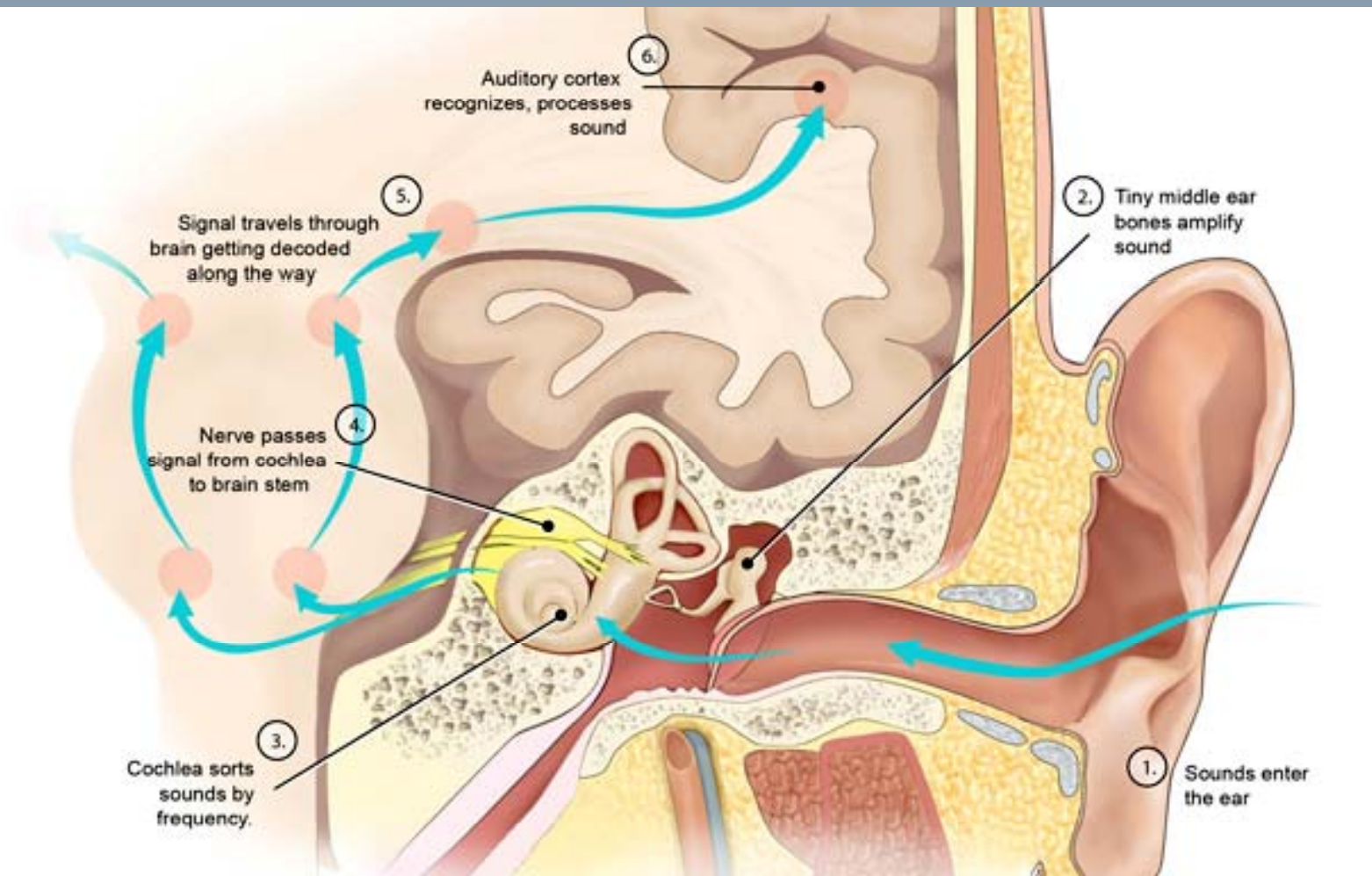
Auditory Evoked Potentials

- * Labeled based on origin of response in system
further “up” the system, the longer the latency
- * ABR- auditory BRAINSTEM response 10-15 msec
- * AMLR- auditory middle latency 15-60 msec
- * ALR- auditory late response 75- 200 msec
- * ERP- Event related potentials 220-389 msec

Auditory Evoked Potentials

- ABR- auditory brainstem response occurs in the first 10-15 msec after a sound enters the ear
- “Waves” generated by synchronous nerve firing-volley
 - Waves I and II VIII nerve
 - Wave III Superior Olivary Nucleus
level of pons
 - Wave IV Lateral Lemniscus—pons
 - Wave V Inferior Colliculus- level of
mid-brain

ABR Pathways



ABR

- * Evaluate nerve conduction delays- timing
- * Estimate hearing threshold
 - * Electro-physiologic response 10-20 dB above behavioral threshold

ABR Threshold search

from Hearing in Children, Northern and Downs, C7 pp 238to 257

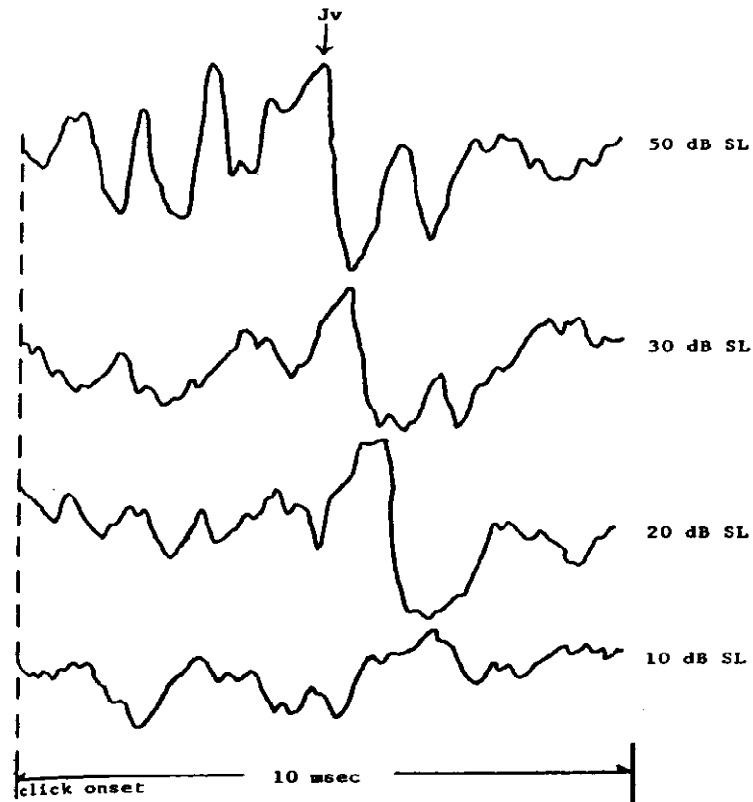


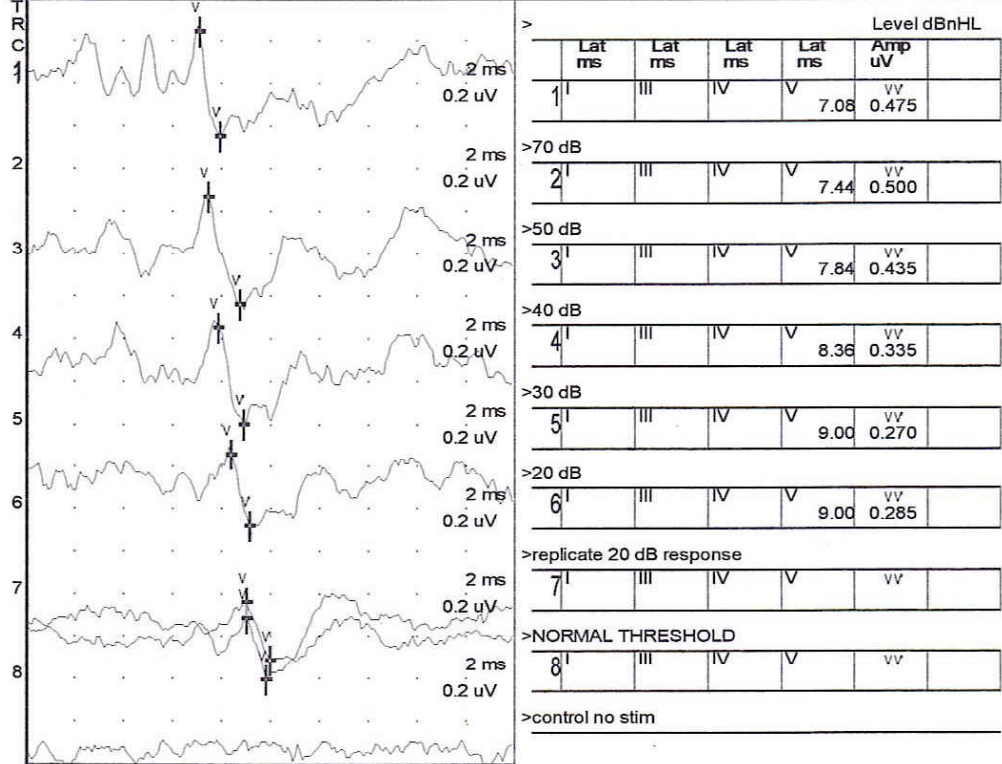
Figure 7-20. Summed brainstem evoked responses at decreasing intensities. Each response represents 2048 click presentations. (Courtesy of Steven Staller, PhD, Cochlear Corporation.)

ABR Normal Threshold

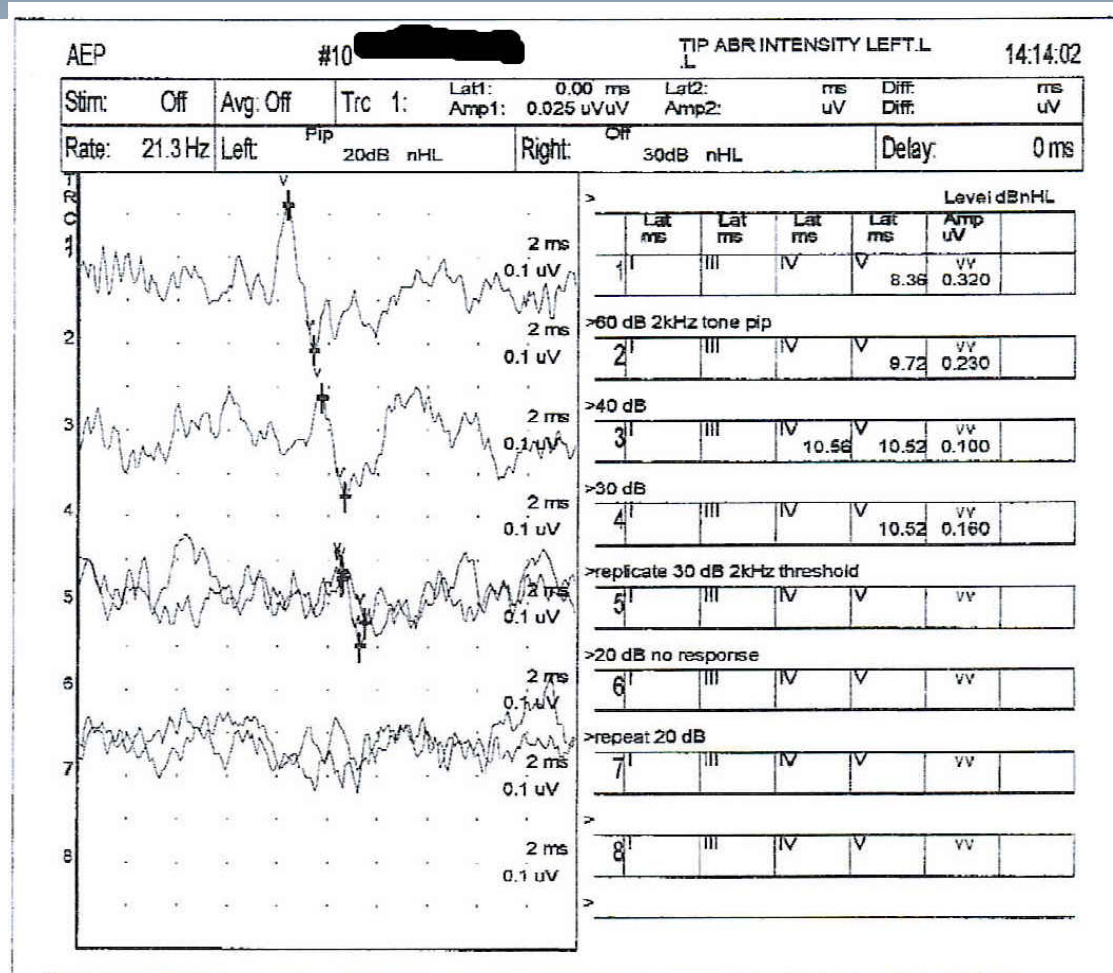
Wyoming Valley Healthcare System--Neurophysiology

AEP #2 ~~XXXXXXXXXX~~ TIP ABR INTENSITY LEFT.L 14:13:41

Stim: Off Avg: Off Trc 1: Lat1: 0.00 ms Lat2: ms Diff: ms
 Amp1: 0.025 uVuV Amp2: uV Diff: uV
 Rate: 21.3 Hz Left: Click -15dB nHL Right: Off 30dB nHL Delay: 0 ms




ABR Threshold Mild hearing loss



Why use ABR?

- * ABR not affected by patient state or anesthesia-brainstem level response
- * Natural sleep or sedation to estimate threshold in infants and children
- * Later waves from Higher centers
 response affected by alertness/state
- * Sedation or some medications will
 suppress the middle and late responses



JCIH 2007

Hearing Screening Protocols

Separate protocols for Well-Baby
Nursery and NICU

Newborn Hearing Screening – Well-Baby

- * Physiologic (‘objective’) measure (pass/fail interpretative criteria available; evidence-based; automated):
 - * Auditory Brainstem Response (ABR) automated technology
 - * Otoacoustic Emissions (OAE) automated technology
 - * 2-technology screen; screen first OAE; OAE fails receive ABR. Pass ABR = Pass Screening (NIH 1993)



JCIH 2007

Limit number of repeated inpatient tests
(increases probability of 'passing' by chance alone)

In absence of national calibration standards or uniform performance standard, *“audiologists must obtain normative data for the instruments and protocols they use”*

Rescreen of both ears even if only one ear fails initial screening

JCIH 2007

Hearing Screening Protocols - NICU

Automated-ABR technology recommended as the primary screening tool for use in the NICU for infants admitted for > 5 days



JCIH 2007

Re-Screening Protocols - NICU

- NICU infants not passing AABR screening referred immediately to an Audiologist for audiologic rescreening/diagnostic assessment
 - Any 'rescreening' must include ABR
 - (first diagnostic testing may occur prior to NICU discharge)

JCIH - Changes in 2007

Audiologic Evaluation

Should be performed by audiologists experienced in pediatric hearing assessment

Initial audiologic test battery to confirm hearing loss must include:

- physiologic measures

- when developmentally appropriate, behavioral methods

- Completed in both ears regardless of the results of screening tests

JCIH 2007

A

Audiologic Evaluation – Birth to 6 months (Devel. Age)

Child and family history

Frequency-specific AC (air conduction) ABR;

Bone conduction, frequency specific ABR, when indicated

Click-evoked ABR

if infant has risk indicators for neural HL,

any infant demonstrating no response on FS-ABR requires click-evoked ABR

some infants with neural HL have no risk indicators

OAE (DPOAE or TEOAE)

Tympanometry using 1000-Hz probe tone

Observation of auditory behavior

As cross-check; not for assessment or amplification fitting

JCIH 2007

Audiologic Evaluation – 6 months to 36 months

Child and family history

Parent report of auditory and visual behaviors and communication milestones

Behavioral audiometry (VRA, CPA), including:

- Pure-tone audiometry across the frequency range for each ear

- Speech detection and speech recognition measures

OAE testing

Acoustic immittance measures: Tympanometry & Acoustic Reflex Thresholds

ABR testing if responses to behavioral audiometry are not reliable, OR if ABR testing has not been performed previously

JCIH 2007

Amplification

Infants diagnosed with permanent hearing loss should be fit with amplification within one month of confirmation of HL

Treatment and intervention for hearing loss

Medical intervention

surgical treatment

treatment for chronic middle ear disorder

Hearing aids

Cochlear implants

FM systems

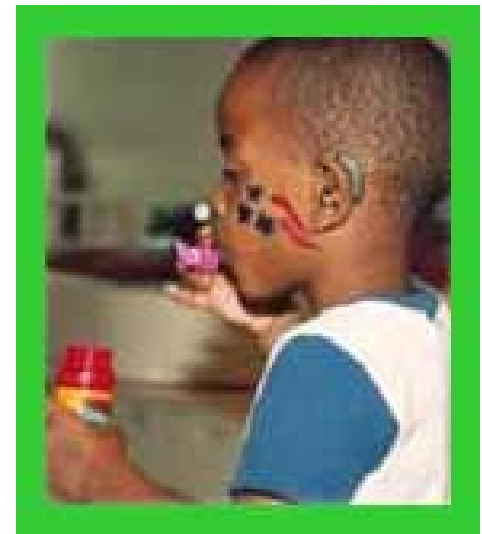


Treatment and intervention

- * Early intervention for overall development
 - * Communication modalities
 - * Emotional
 - * Social
 - * Cognitive
- * Audiologist work with and refer to
 - * Early interventionists
 - * Speech-language therapists – specialized in hearing impairment
 - * Educators for the hearing impaired

Monitoring and managing hearing loss

- * Hearing can change and get worse
- * Plan for future needs - amplification flexibility
- * Monitor hearing aid/cohclear implant function – trouble shoot
- * Provide educational input and consultation (classroom modifications, FMs, educational strategies)



How to work collaboratively with audiologists

1. Make out reach efforts - individual or group
2. Encourage mutual information sharing
3. Invite participation
4. Keep asking questions



Take Home Message

- * Infants can and should be assessed as soon as possible to maximize development of maturing auditory skills; sets the stage for language development
- * Family choices for intervention often includes hearing aids/Cochlear Implants AND early intervention (communication strategies)
- * Questions about hearing? Ask your Audiologist