

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

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

Jeff Hoffman, MS, CCC-A

National Center for Hearing Assessment and Management



What are “Audiologists”?

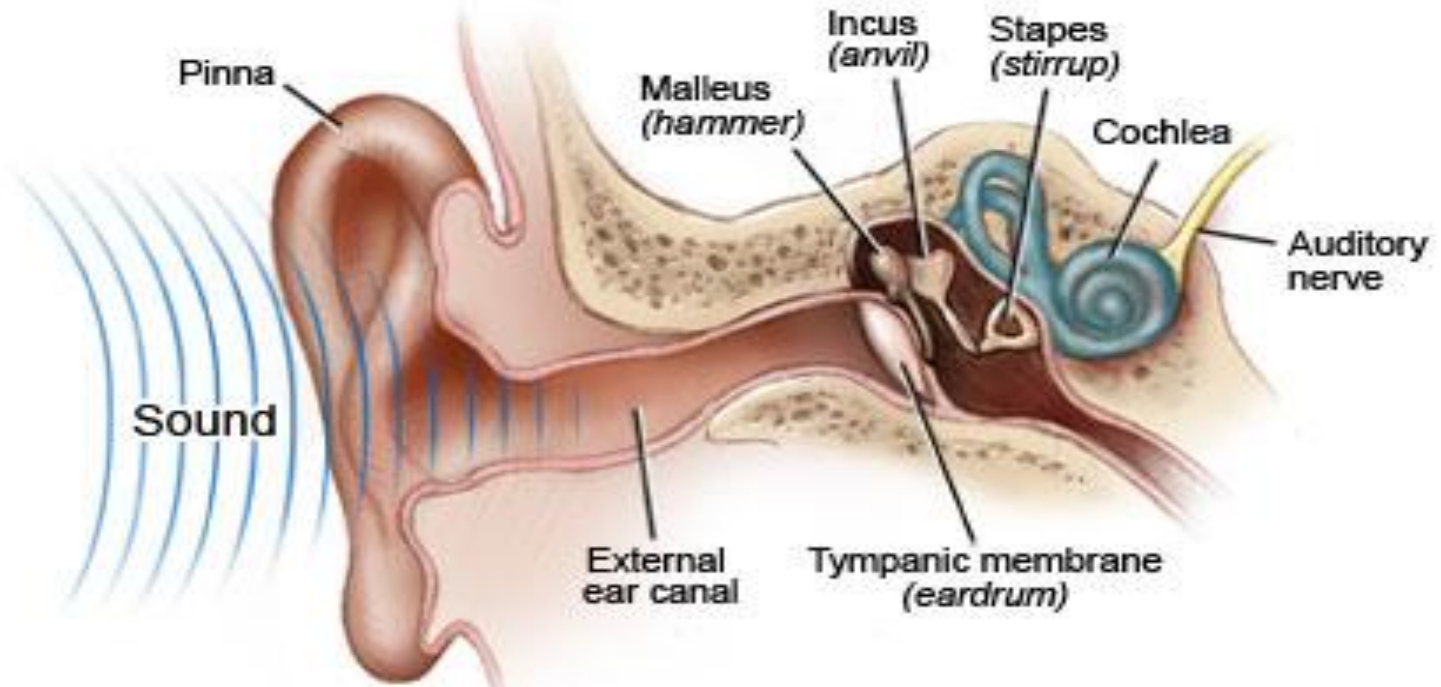
Specialists in Hearing and Balance

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





Ear



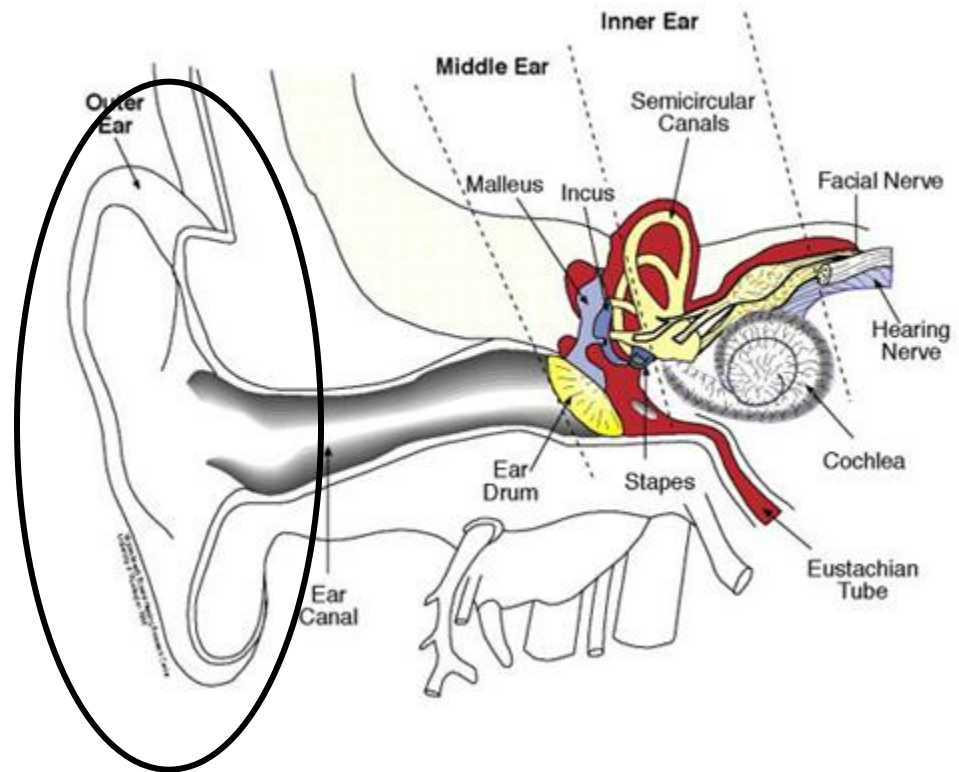
Parts of the Ear

- **Outer Ear**
- **Middle Ear**
- **Inner Ear**
- **Central Auditory Nervous System**

Outer Ear

Pinna

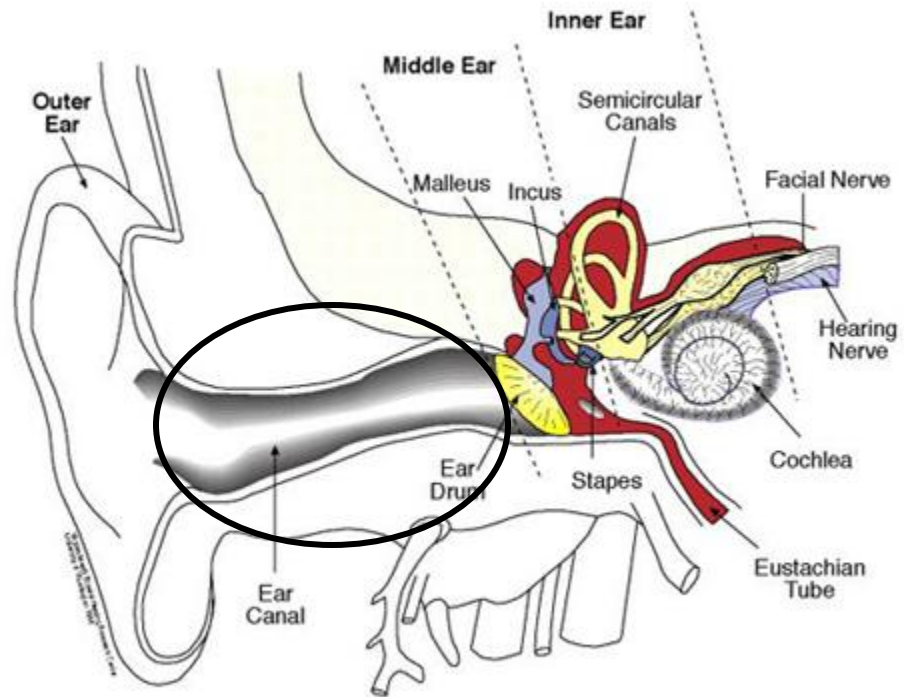
- Gathers sound waves
- Amplifies sound a little bit



Outer Ear

External Auditory Canal (Ear Canal)

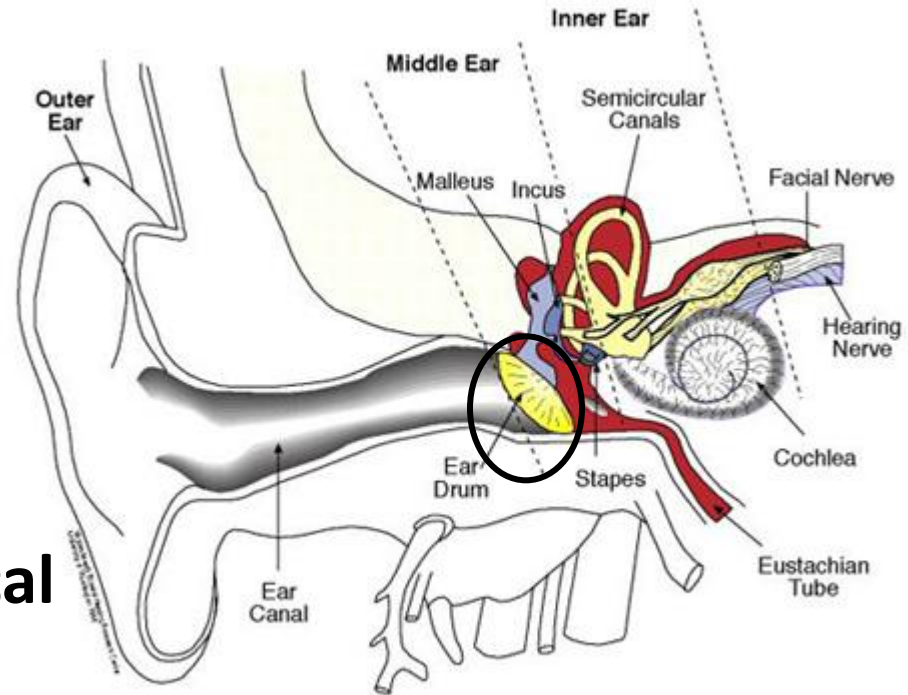
- About 1 inch long
- Surrounded by cartilage and bone
- Prevents some damage to the eardrum
- Cerumen glands moisten and soften skin



Outer Ear

Tympanic Membrane (Ear Drum)

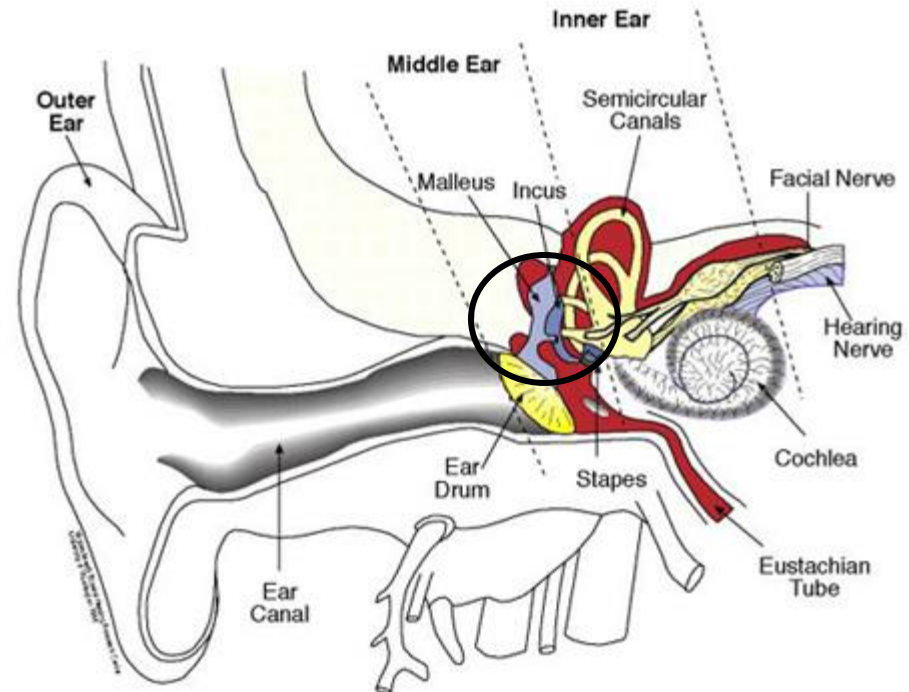
- Thin membrane
- Boundary between outer and middle ear
- Vibrates in response to sound waves
- Changes acoustical energy into mechanical energy



Middle Ear

Ossicles (bones)

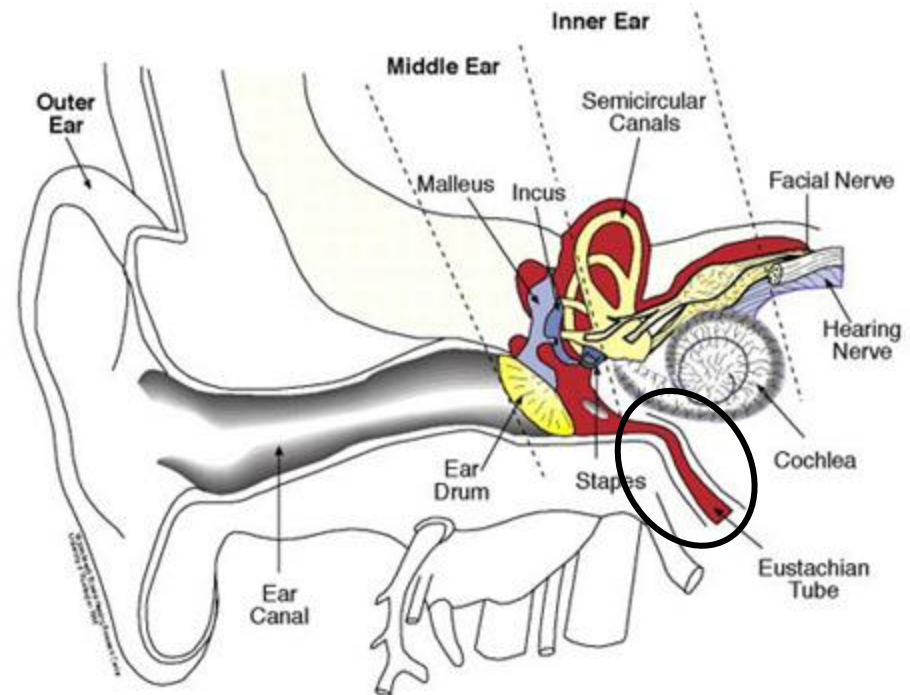
- Malleus (hammer)
 - Attaches to eardrum membrane
- Incus (anvil)
 - Connects to malleus and stapes
- Stapes (stirrup)
 - Smallest bone in the body
 - Footplate inserts in oval window of the cochlea
- Amplify vibration of eardrum to smaller area
- Enables vibration of cochlear fluids



Middle Ear

Eustachian Tube

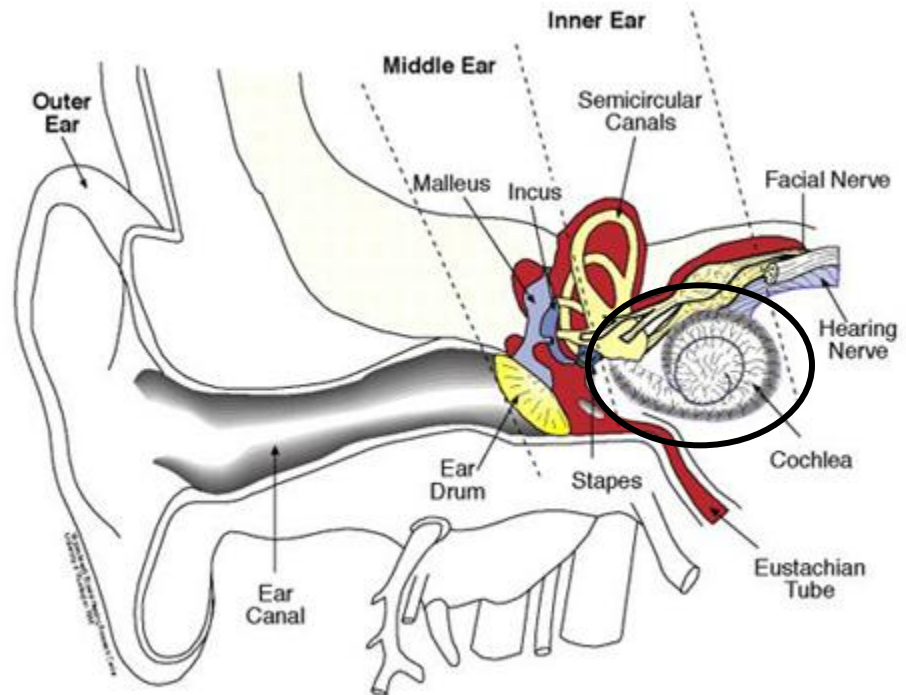
- Connects middle ear cavity to nasopharynx
- “Equalizes” air pressure in middle ear
- Normally closed but opens under certain conditions
- May allow a pathway for infection



Inner Ear

Cochlea

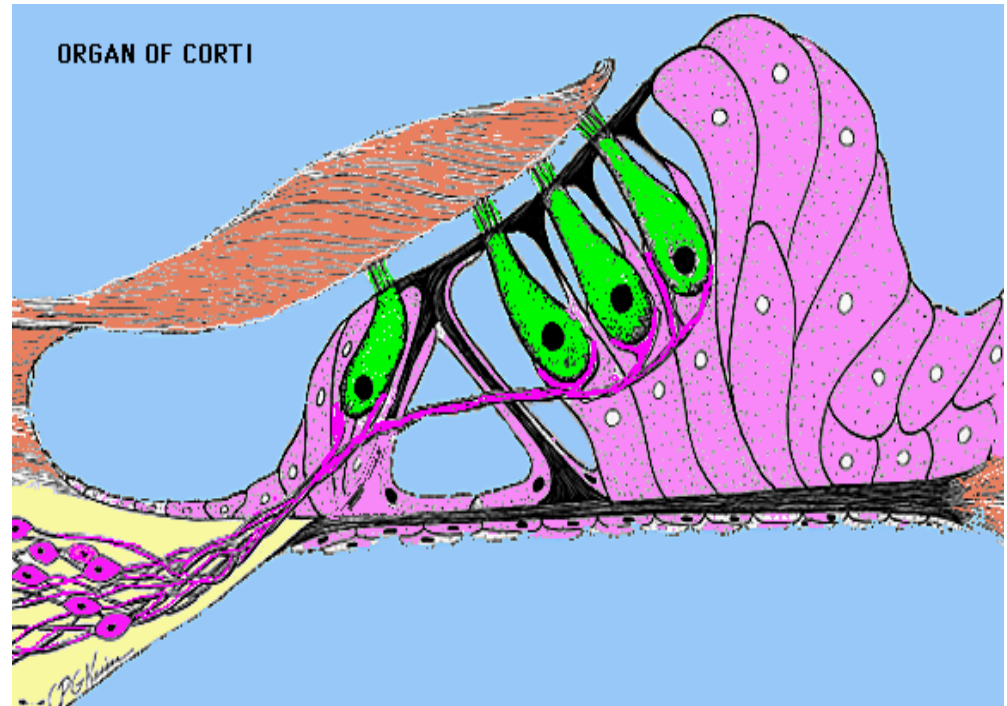
- Snail shaped cavity within mastoid bone
- 2 ½ turns
- 3 fluid-filled chambers
- Contains Organ of Corti
- Converts mechanical energy to electrical energy



Inner Ear

Organ Of Corti

- End organ of hearing
- 3 rows of Outer Hair Cells
- 1 row of Inner Hair Cells
- Cochlear fluids

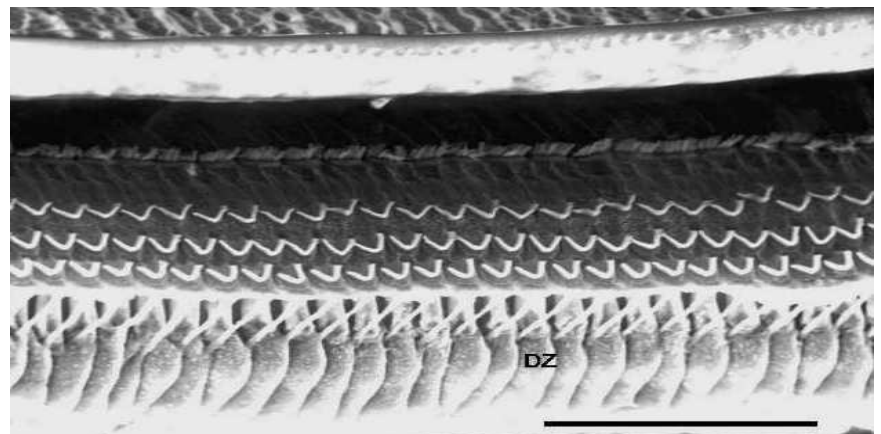
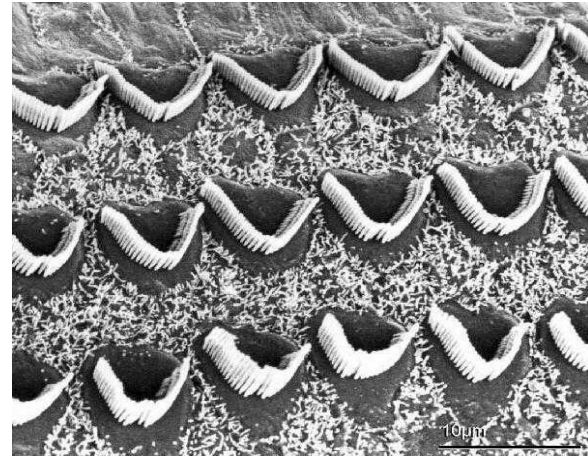


(From Augustana College, "Virtual Tour of the Ear")

Inner Ear

Hair Cells

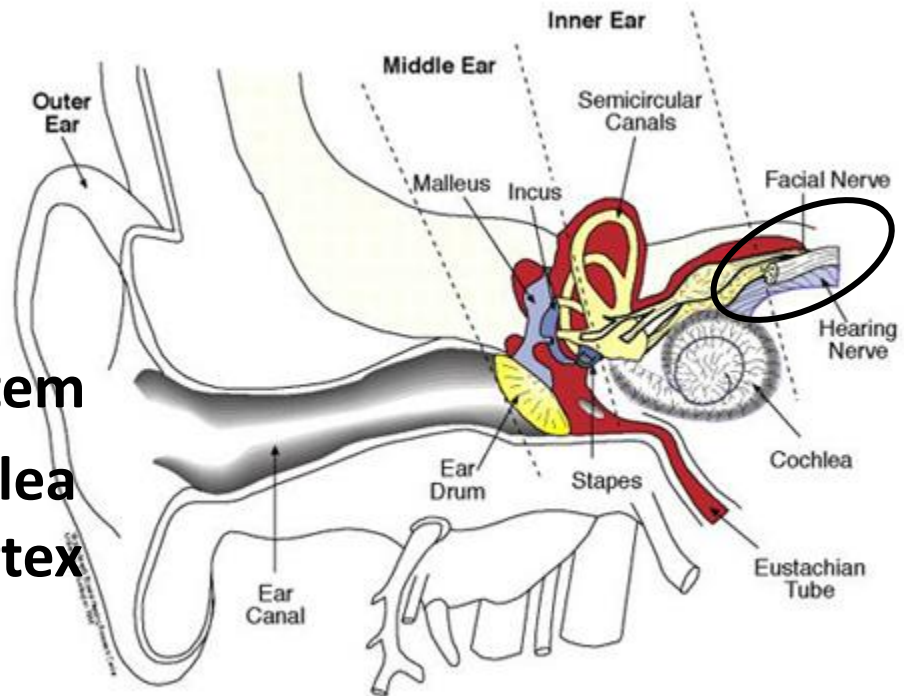
- Frequency-specific
- Fluid movement causes bending of nerve endings
- Nerve impulses (electrical energy) are generated and sent to the brain



Central Auditory System

VIIIth Cranial Nerve (Auditory Nerve)

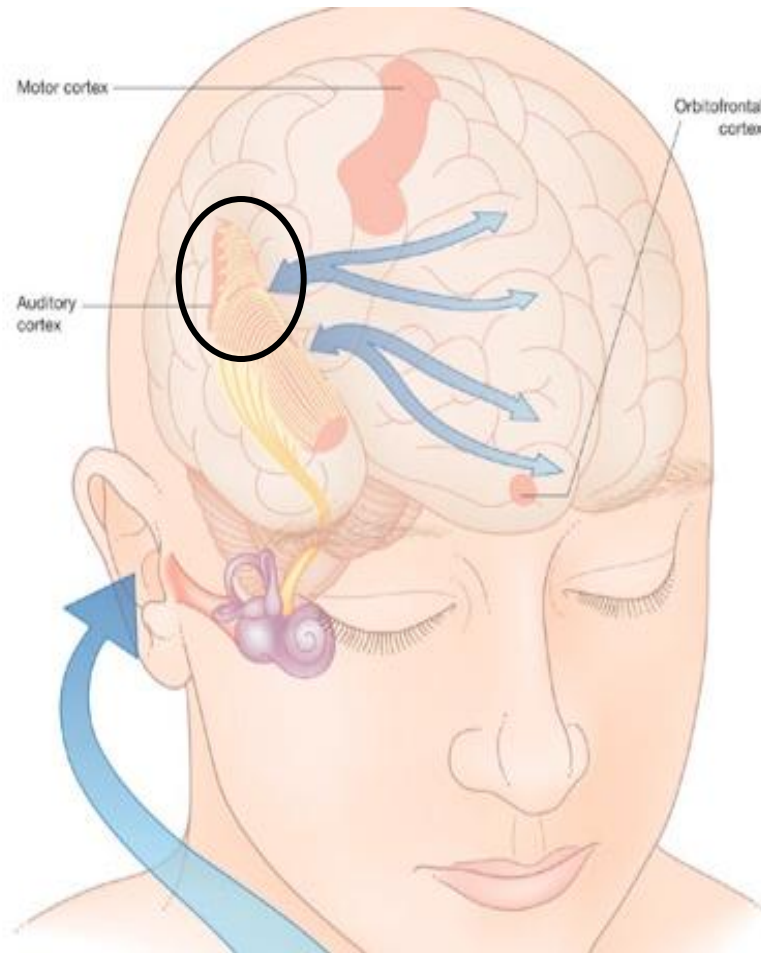
- Bundle of 25,000 nerve fibers
- Travels from cochlea to skull cavity and brain stem
- Carry signals from cochlea to primary auditory cortex
- Continuous processing along the way

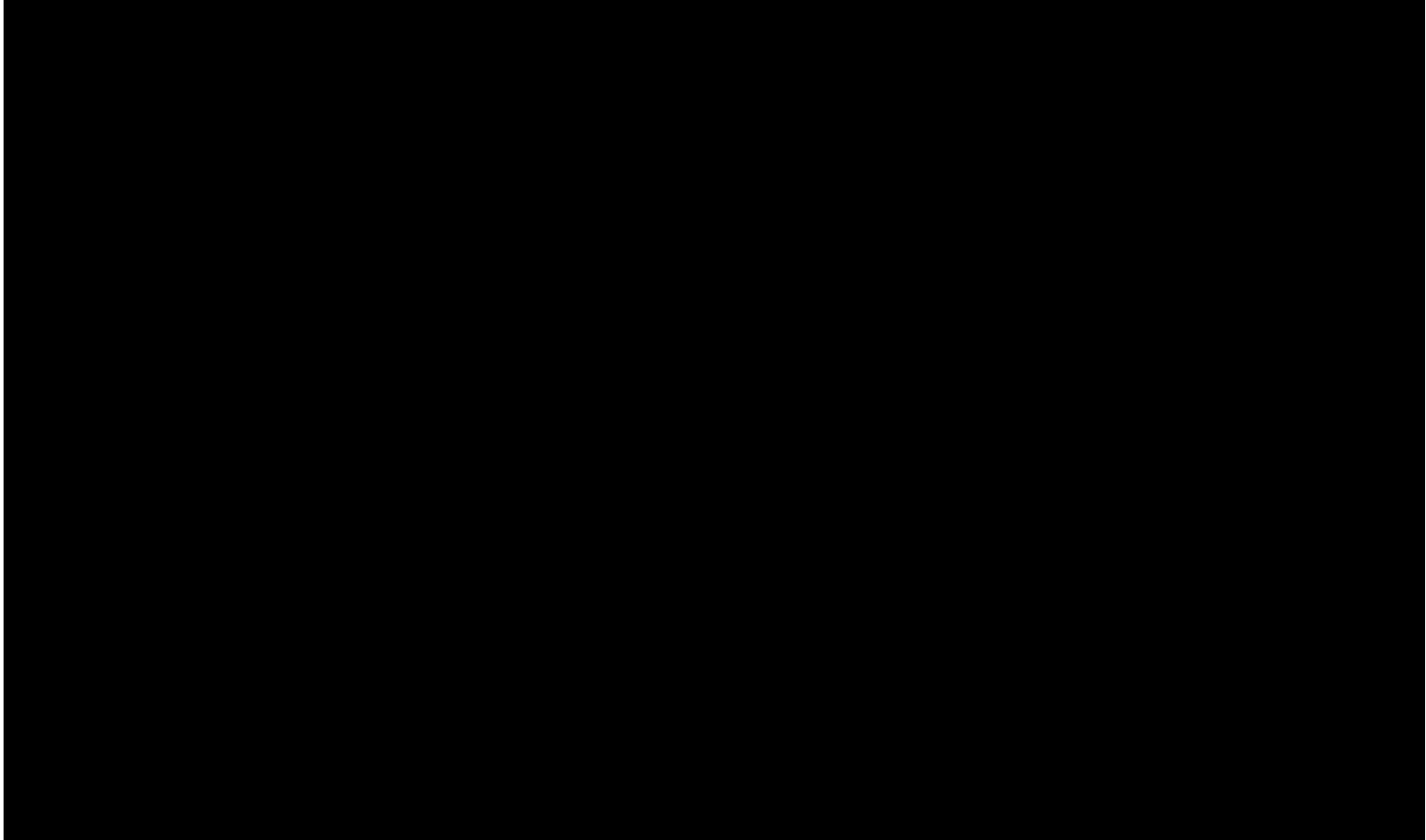


Structures of the Central Auditory System

Auditory Cortex

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





Types of Hearing Loss

Conductive = Outer and/or Middle Ear

Sensorineural = Inner Ear

Mixed = Outer and/or Middle and Inner Ear

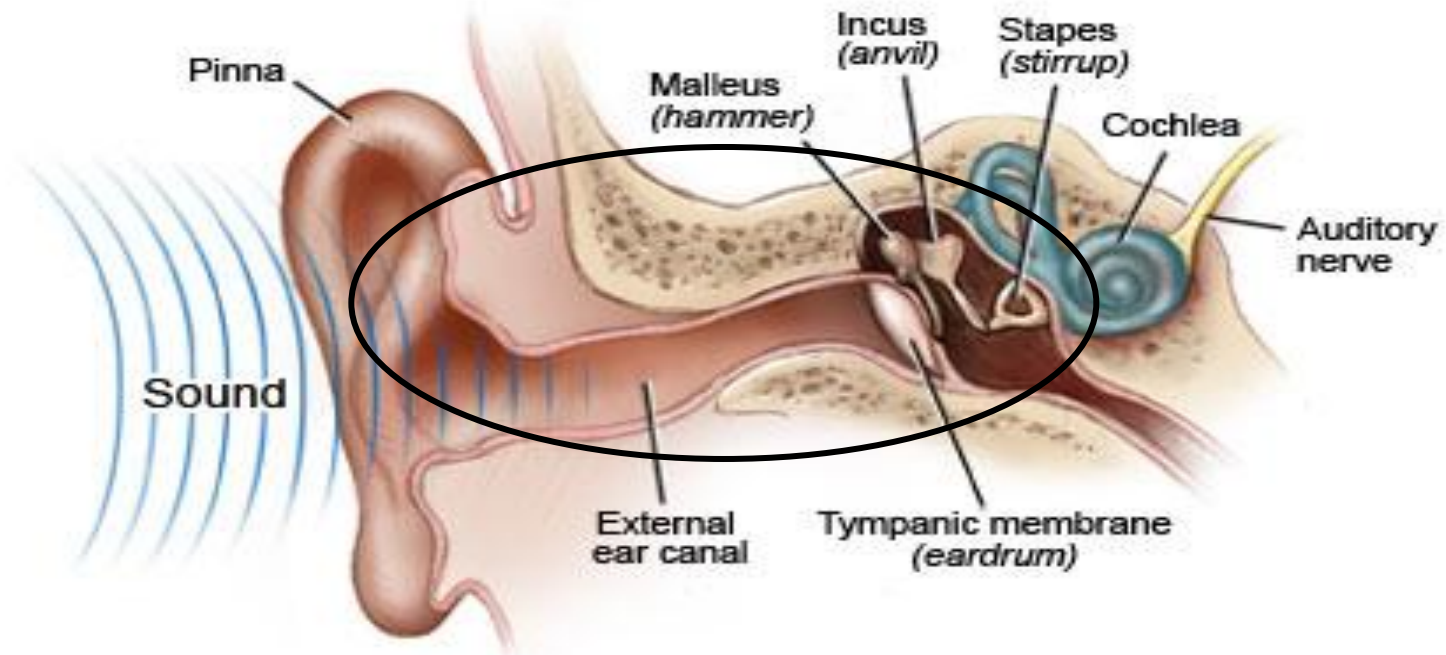
Auditory Neuropathy Spectrum Disorder (aka
Auditory Neuropathy / Dys-synchrony) = Central
Auditory System

Unilateral = one ear

Bilateral = two ears

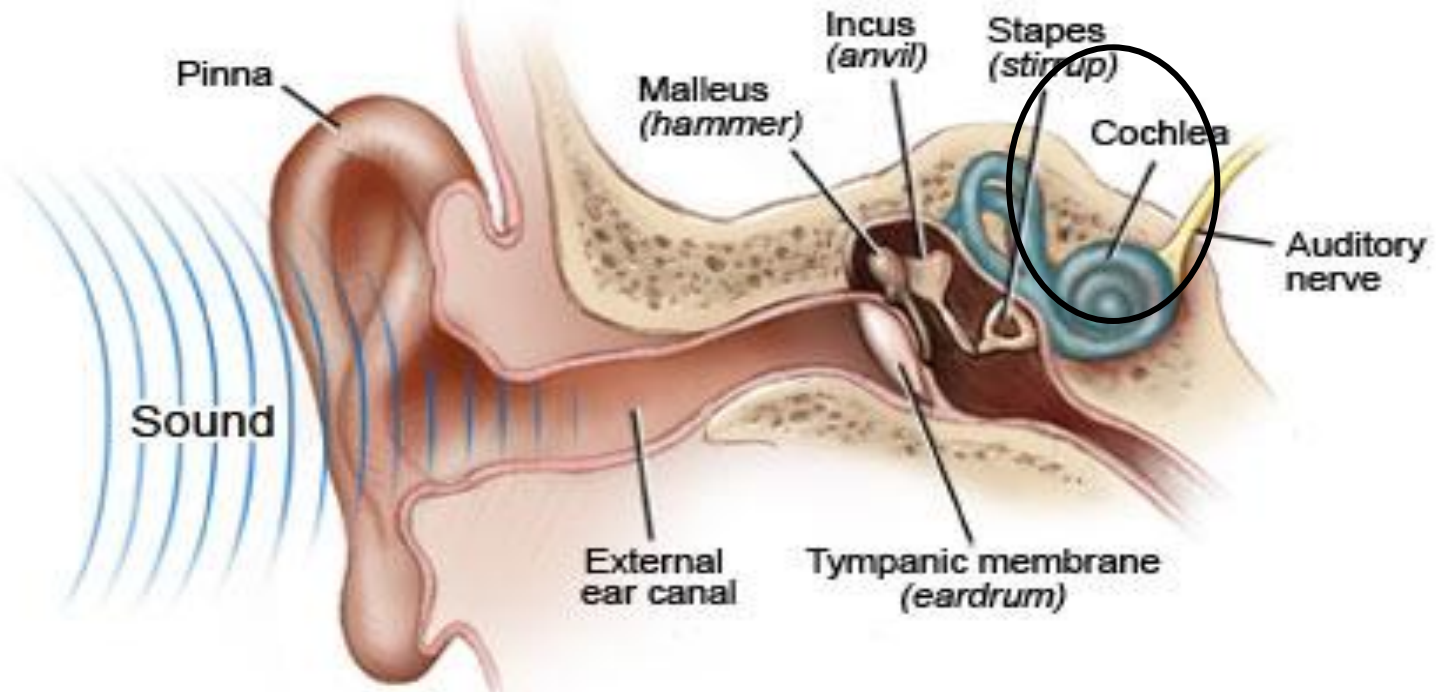
Permanent Congenital Hearing Loss: CDC HSFS, 2007

Conductive Hearing Loss – 12.5%



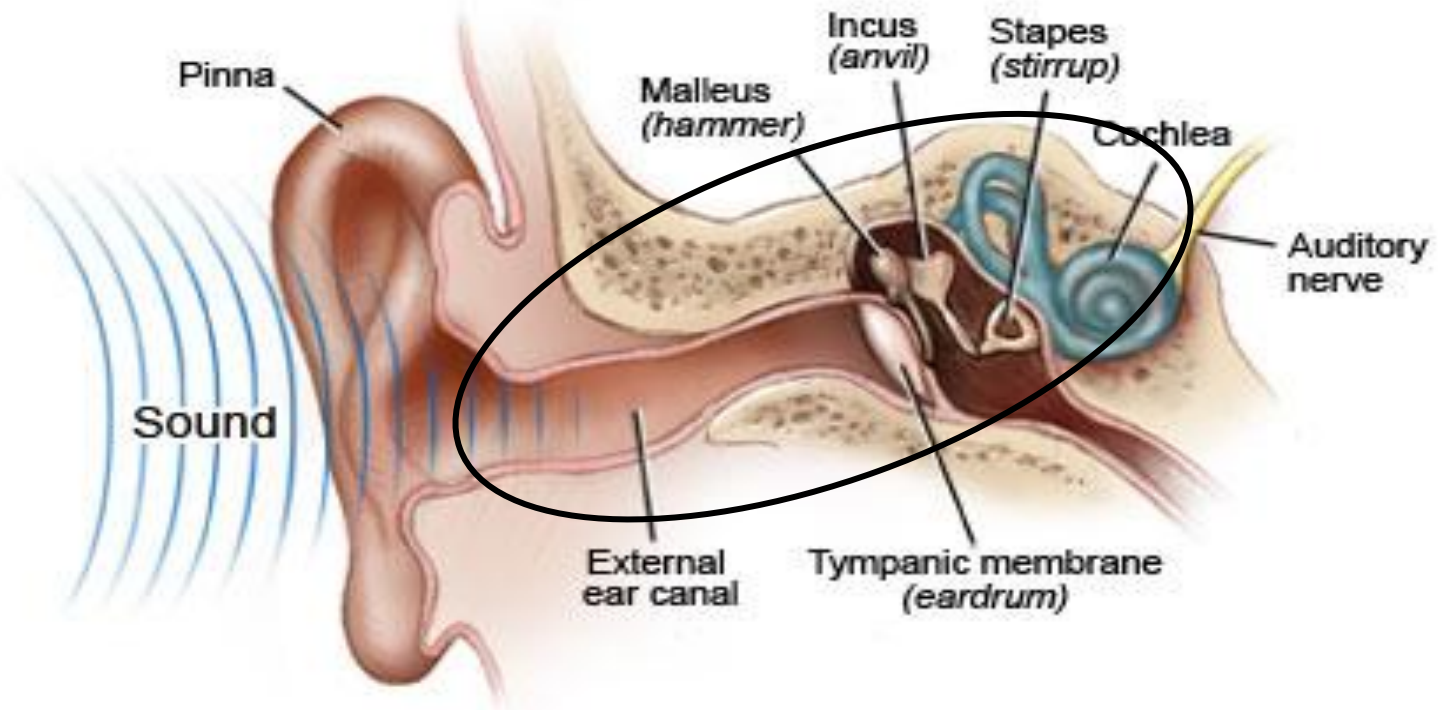
Permanent Congenital Hearing Loss: CDC HSFS, 2007

Sensorineural Hearing Loss – 63.5%



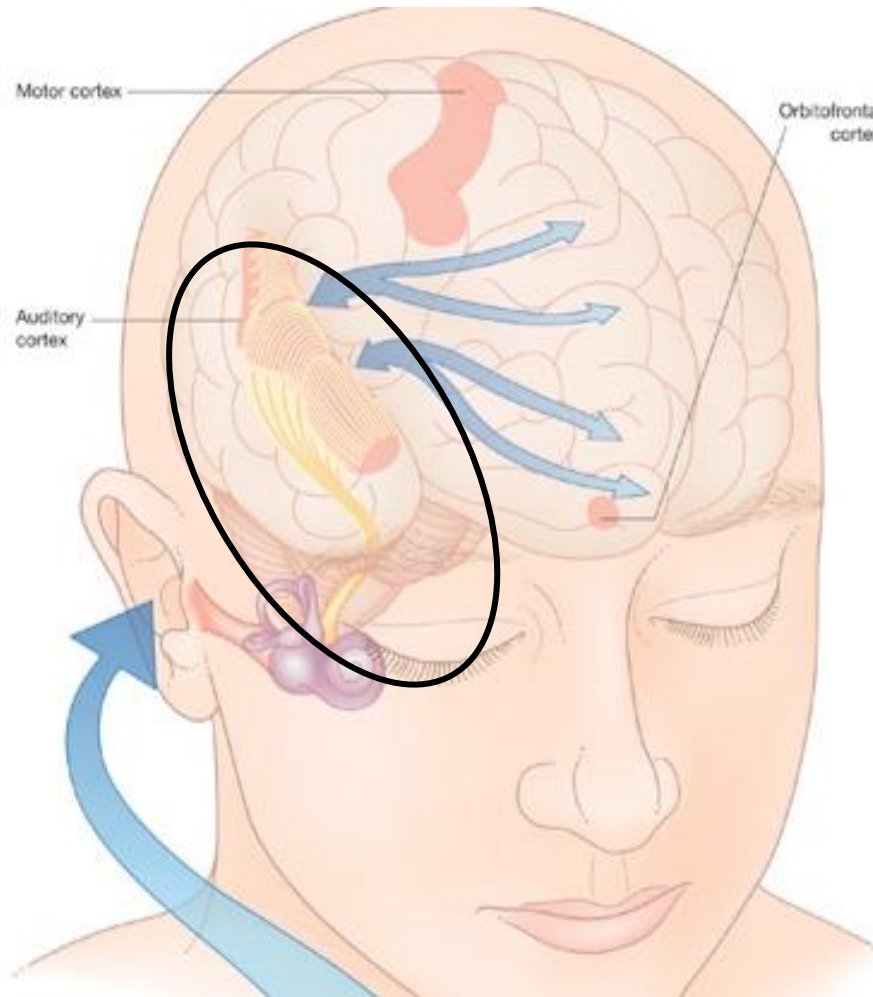
Permanent Congenital Hearing Loss: CDC HSFS, 2007

Mixed Hearing Loss – 7.7%



Permanent Congenital Hearing Loss: CDC HSFS, 2007

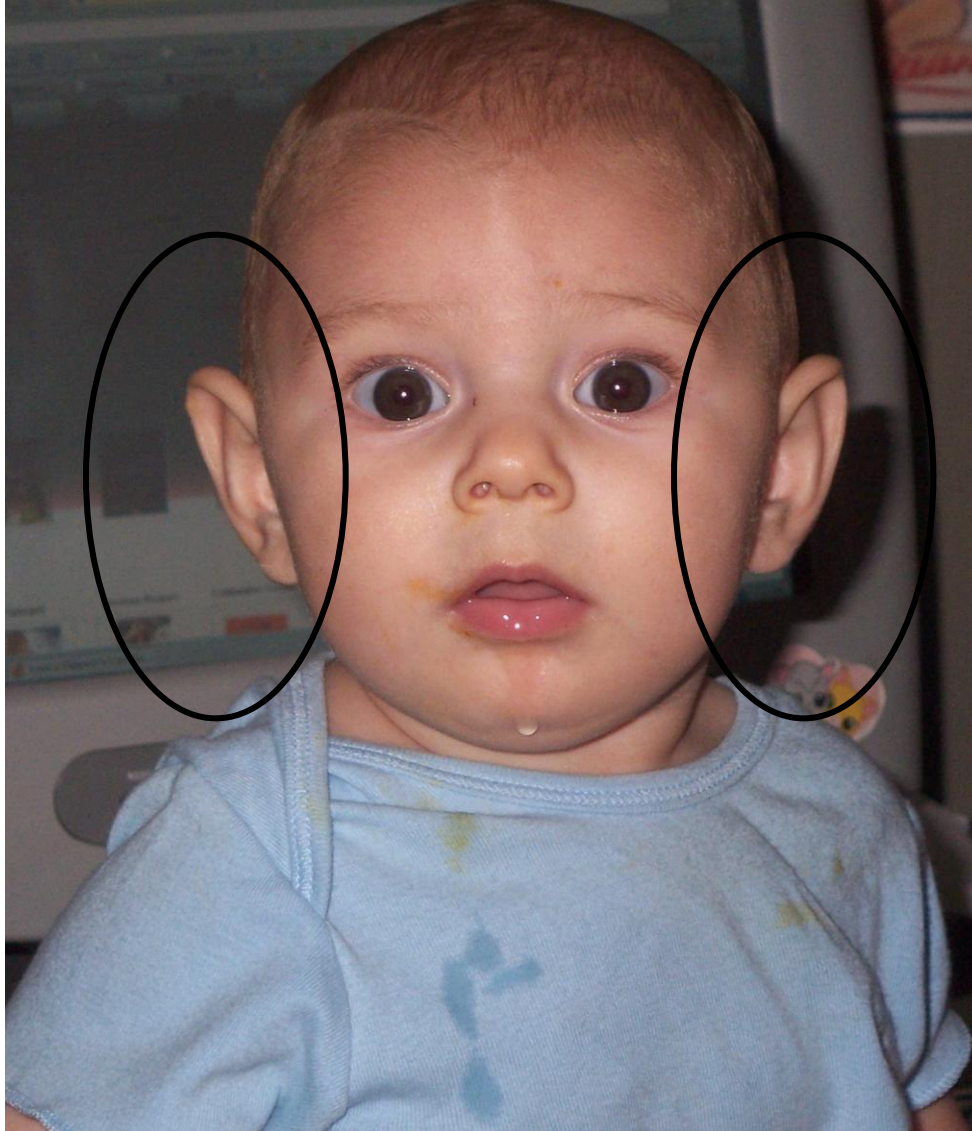
Auditory Neuropathy Spectrum Disorder – 2.5%



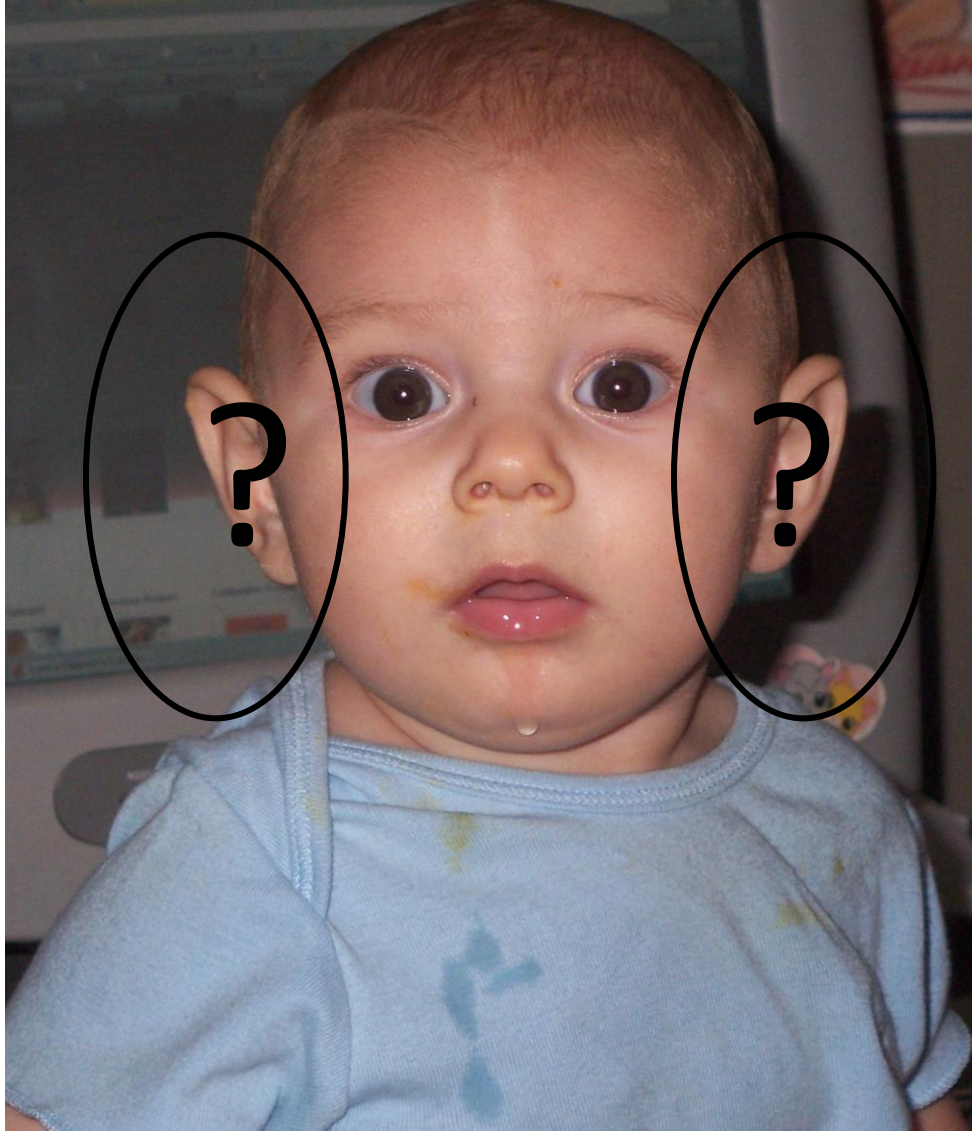
Permanent Congenital Hearing Loss: CDC HSFS, 2007
Unilateral Hearing Loss – 22.8%



Permanent Congenital Hearing Loss: CDC HSFS, 2007
Bilateral Hearing Loss – 72.7%



Permanent Congenital Hearing Loss: CDC HSFS, 2007
Laterality Unknown – 2.9%



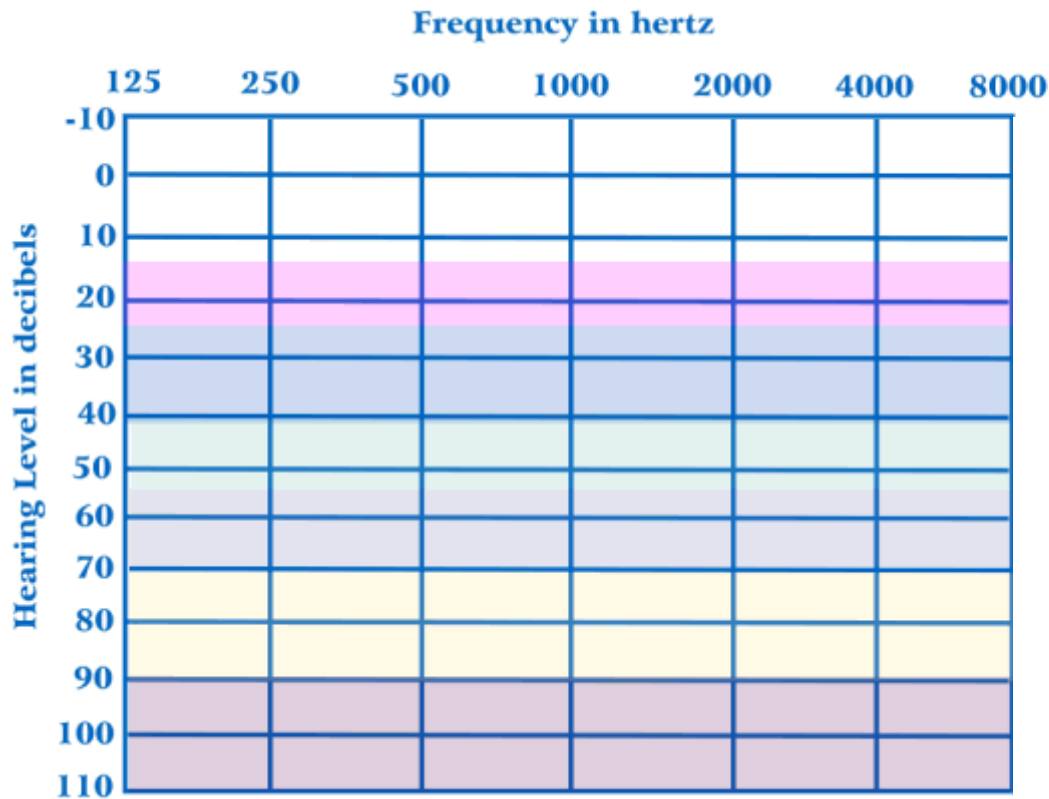
Incidence of Congenital Hearing Loss

CDC EHDI Survey – 2007 (n=5,994)

- Conductive = 12.5 %
 - Sensorineural = 63.5 %
 - Mixed = 7.7 %
 - Auditory Neuropathy Spectrum Disorder = 2.5 %
 - Unknown = 13.7 %
-
- Unilateral = 22.8 %
 - Bilateral = 72.7 %
 - Laterality Unknown = 2.9 %

The Audiogram

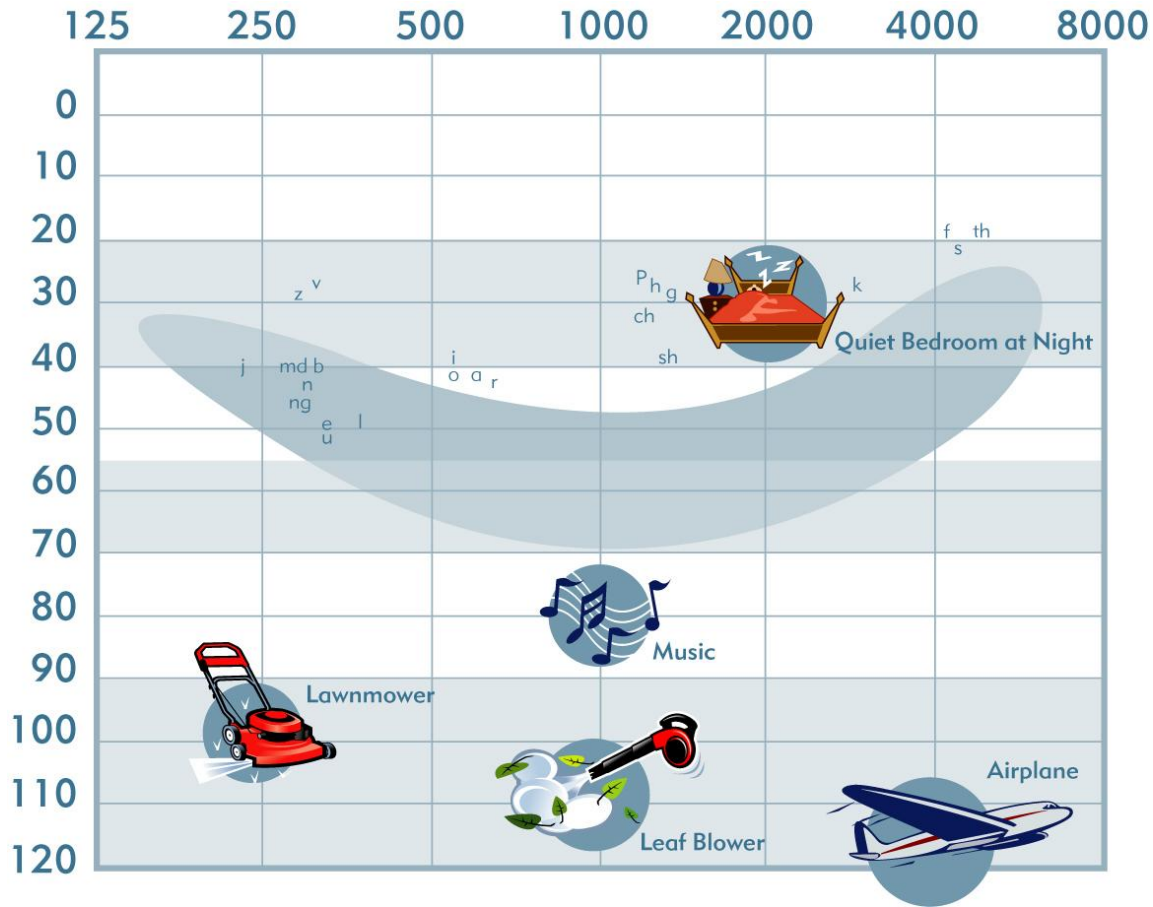
Audiogram – A graph of an individual's hearing sensitivity, including type and degree of hearing loss



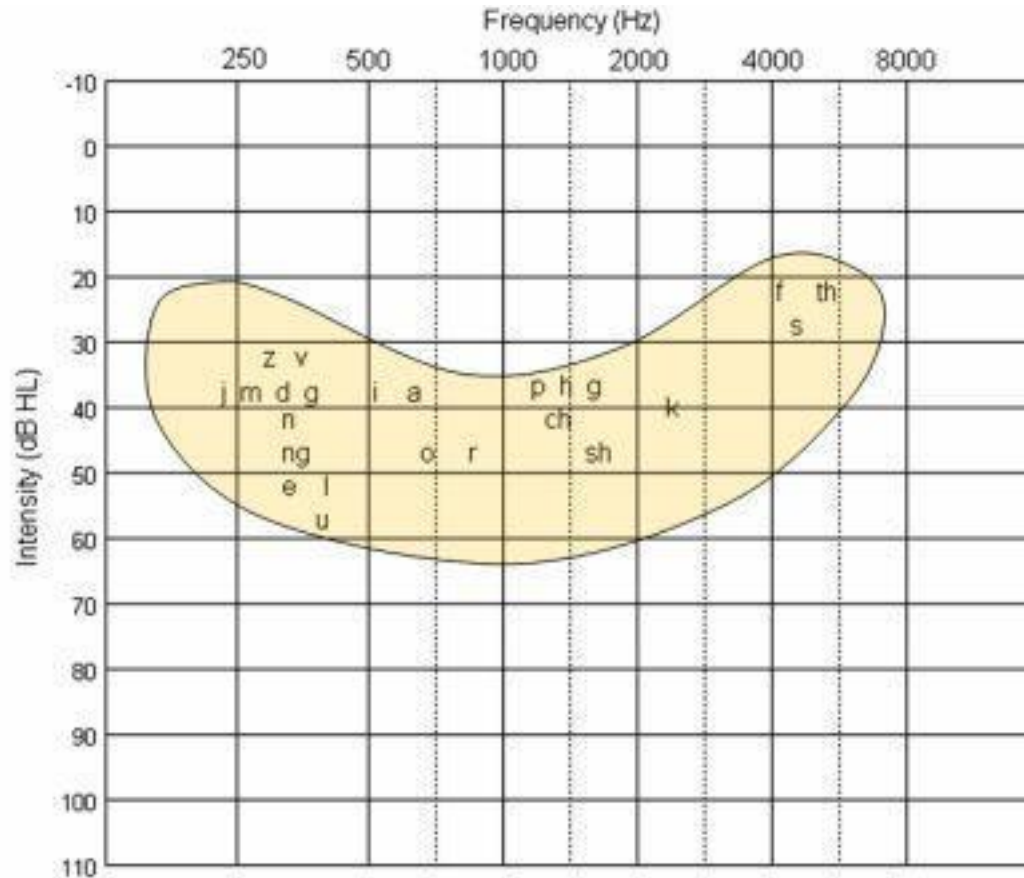
Frequency Low Pitch to High Pitch

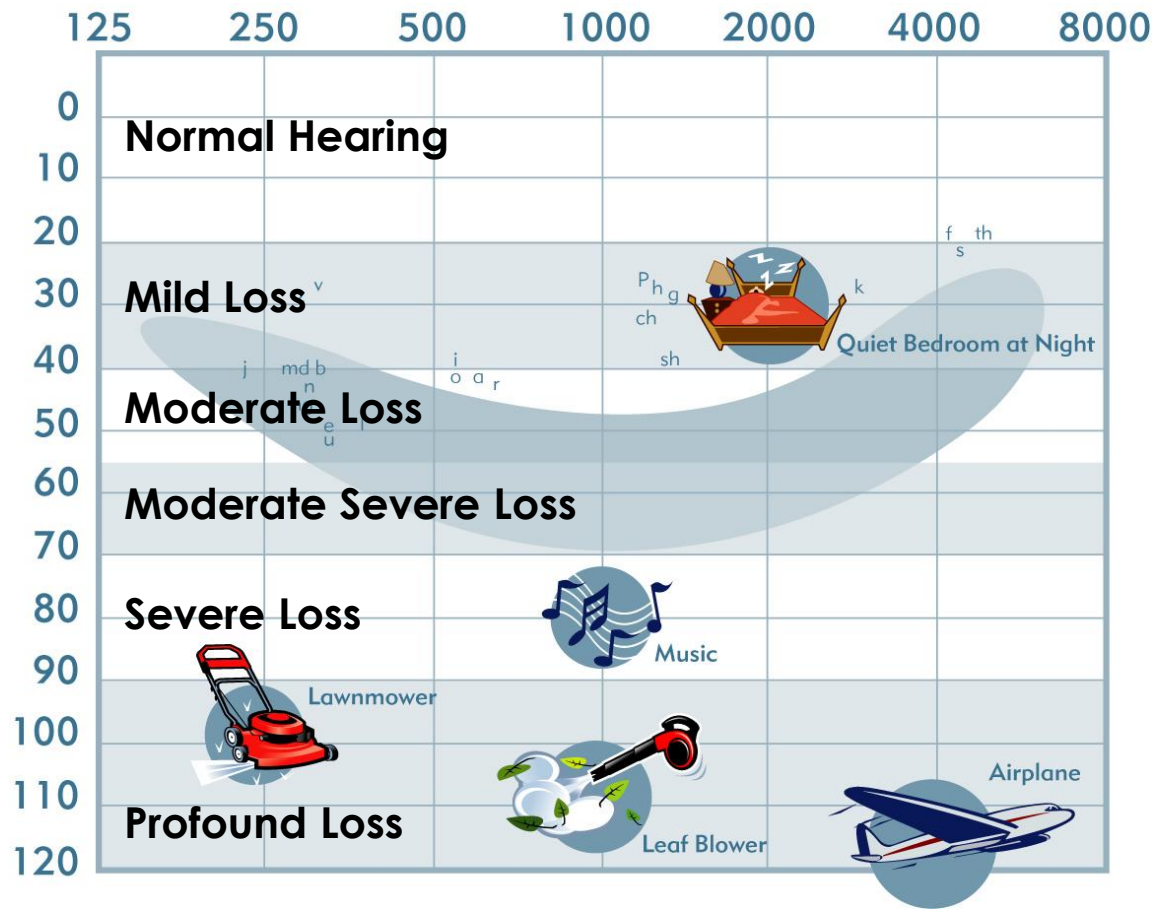


Loudness
Soft to Loud

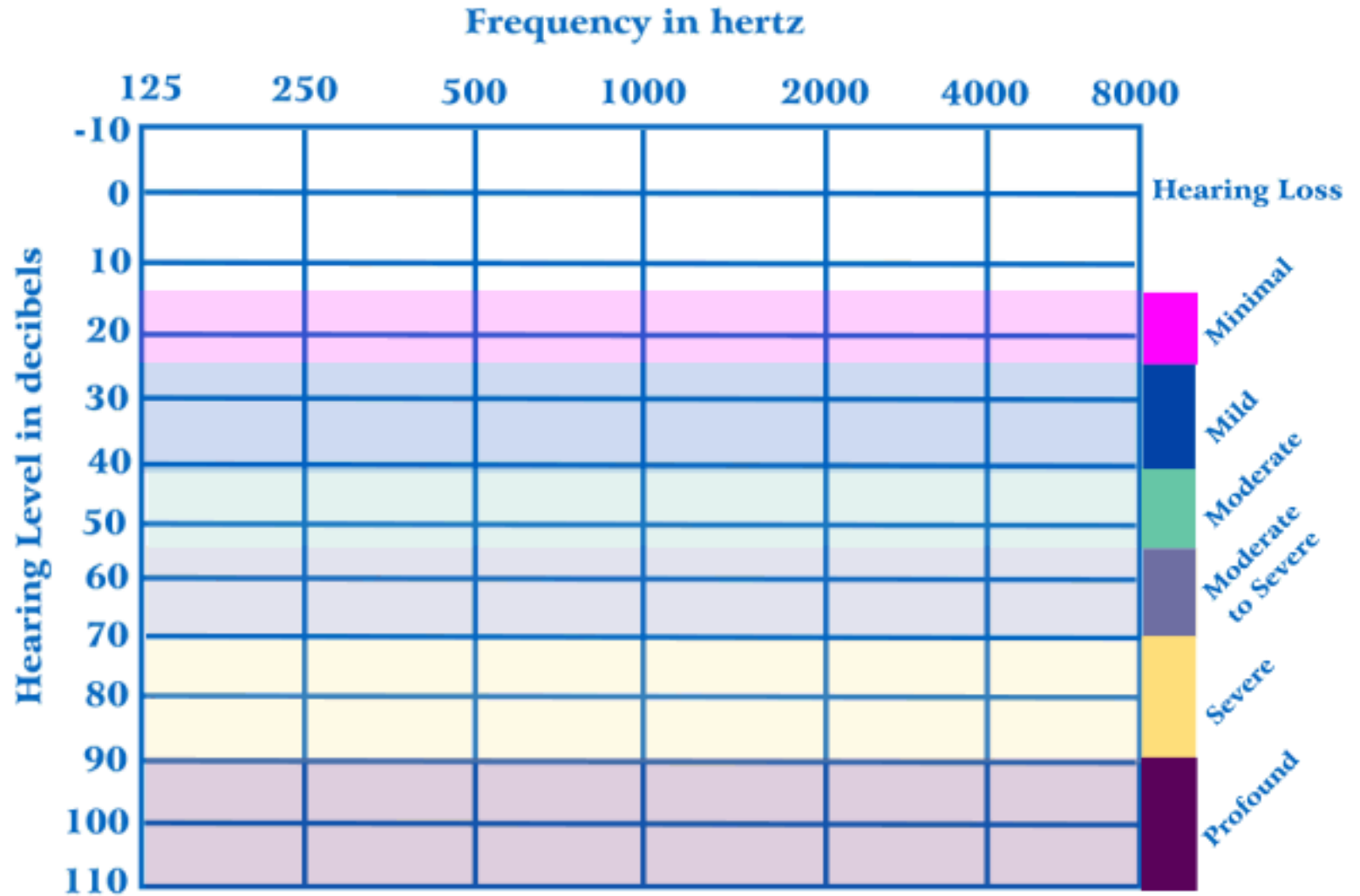


Speech Sounds

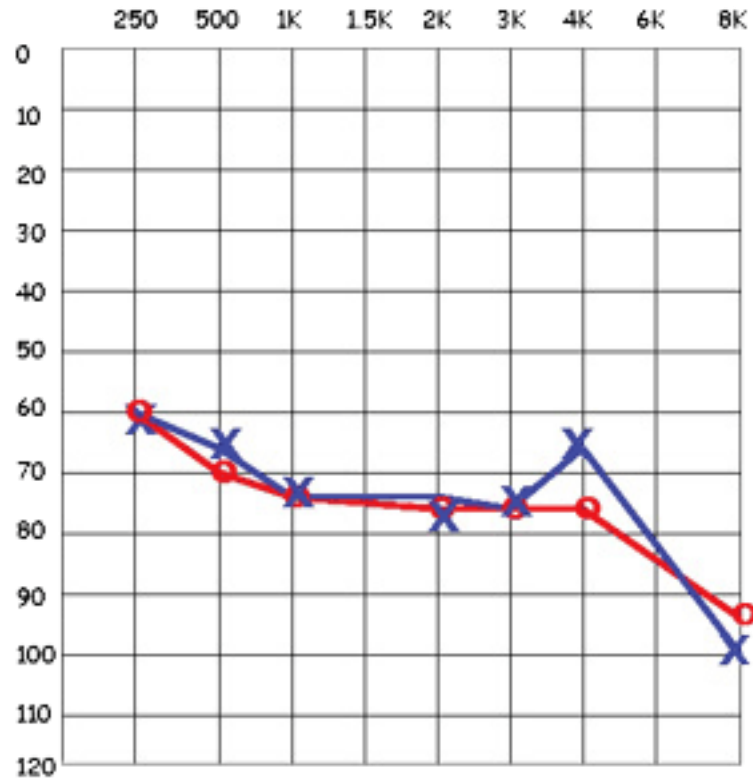




The Audiogram



Moderate to Profound Bilateral Hearing Loss



What Does It Sound Like to Have a Hearing Loss?

Severe hearing loss



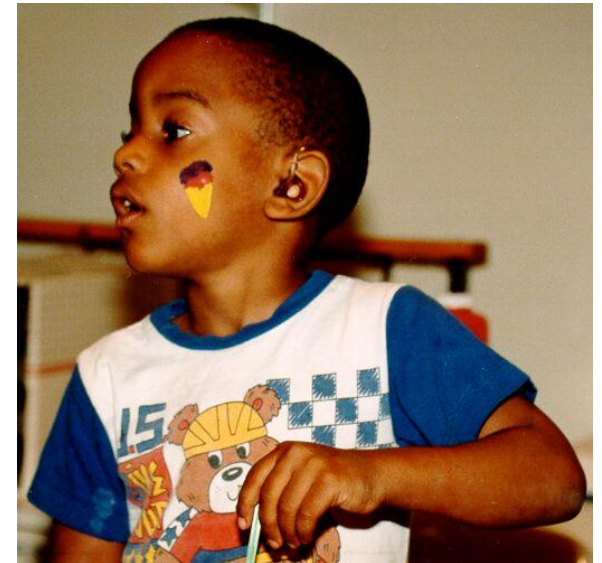
Moderate hearing loss



Mild hearing loss



Normal hearing



Take Home Message

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



Screening and Diagnostics

JCIH Newborn Hearing Screening Guidelines

1-3-6 Model

By 1 month

Screen hearing

By 3 months:

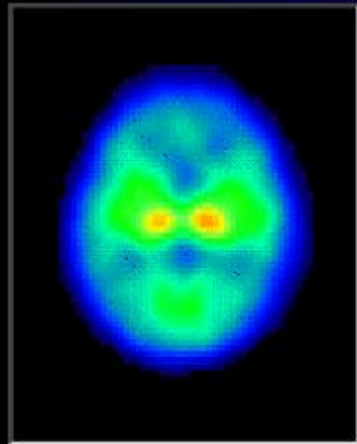
Evaluate hearing and complete diagnostic audiology
and otolaryngology examinations

Fit hearing aids if necessary

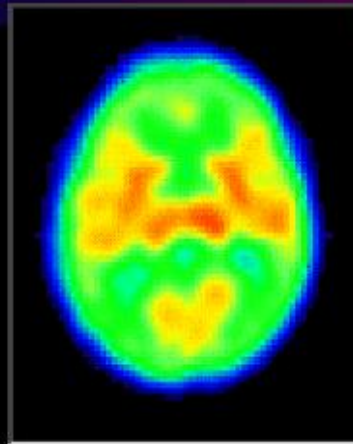
By 6 months:

Enroll in Early Intervention Services

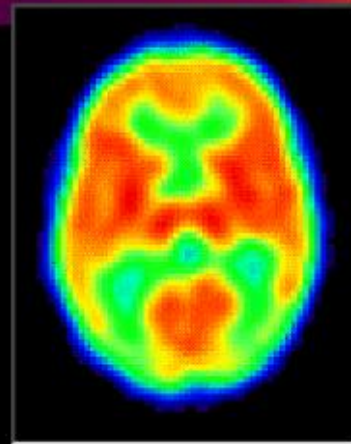
Why the rush??



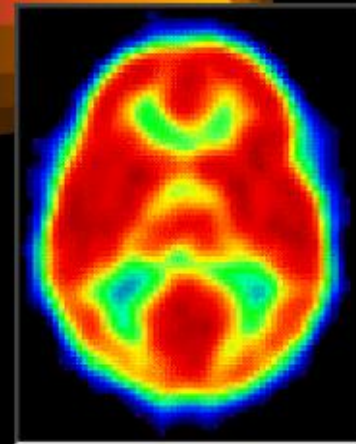
1 month



3 months



6 months



1 year

Laxmi.nuc.ucla.edu

Four 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
- Behavioral

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

Tympanometry

Measured at the plane of the ear drum or Tympanic Membrane

Record how much acoustic energy is transferred into the middle ear

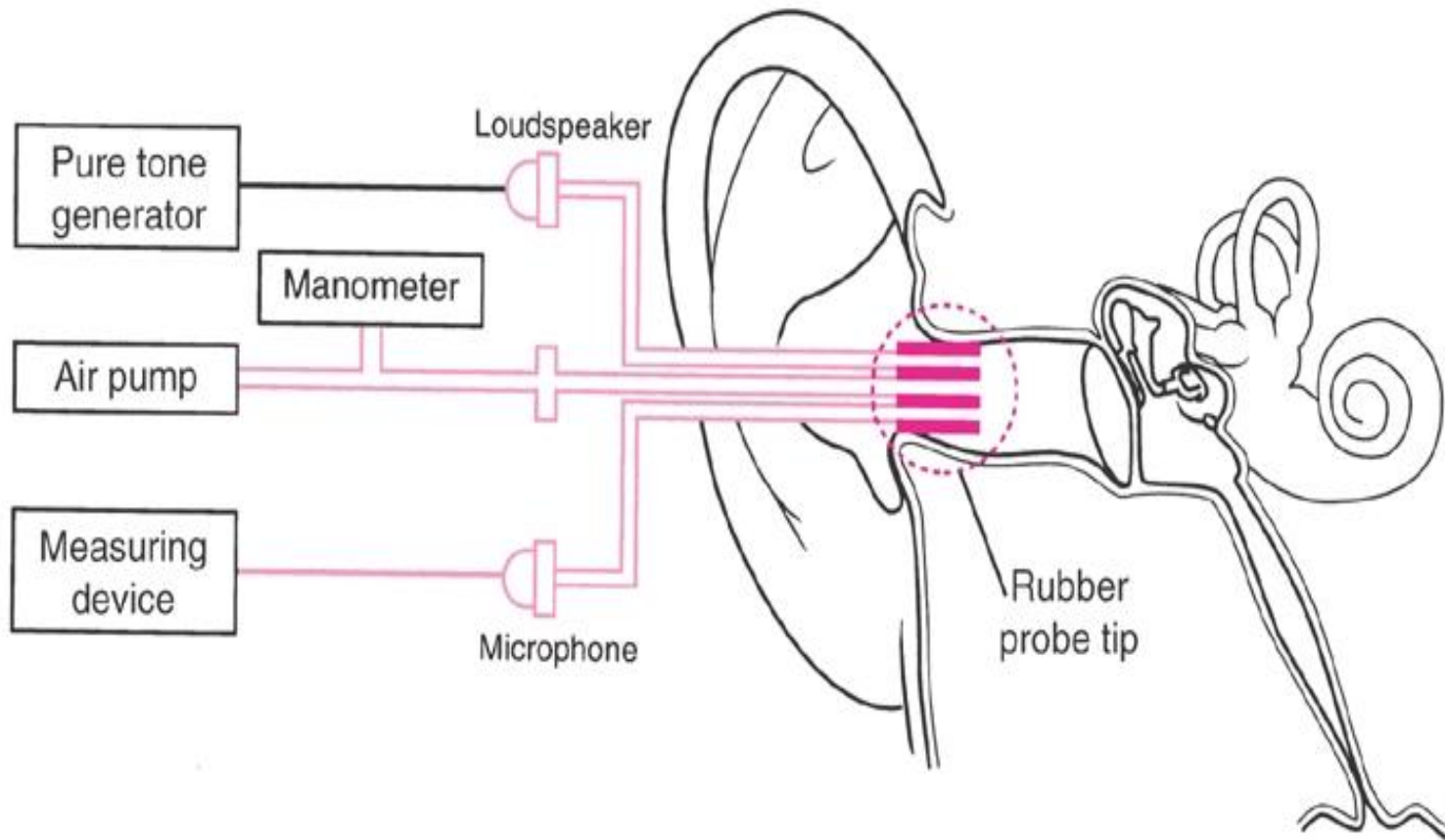
Determine the condition of the middle ear from this measurement

- 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

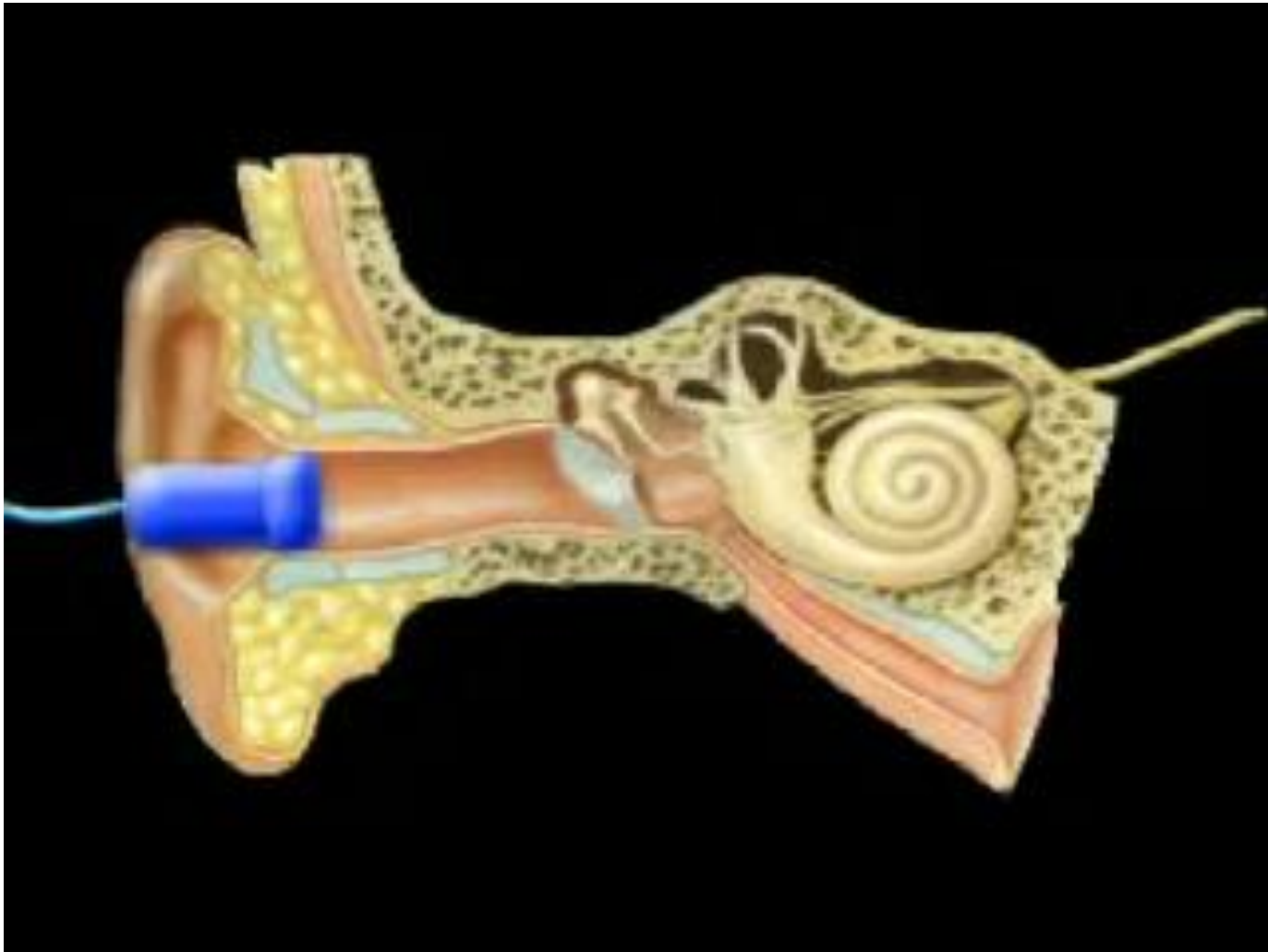
- Probe for seal in ear canal
- Speaker to generate tone sound wave
- Microphone to measure reflected sound in the ear canal
- Air pump to deliver positive and negative pressure to the sealed ear canal
- Earphone for other ear for reflex measures

Tympanometry



OAE Overview

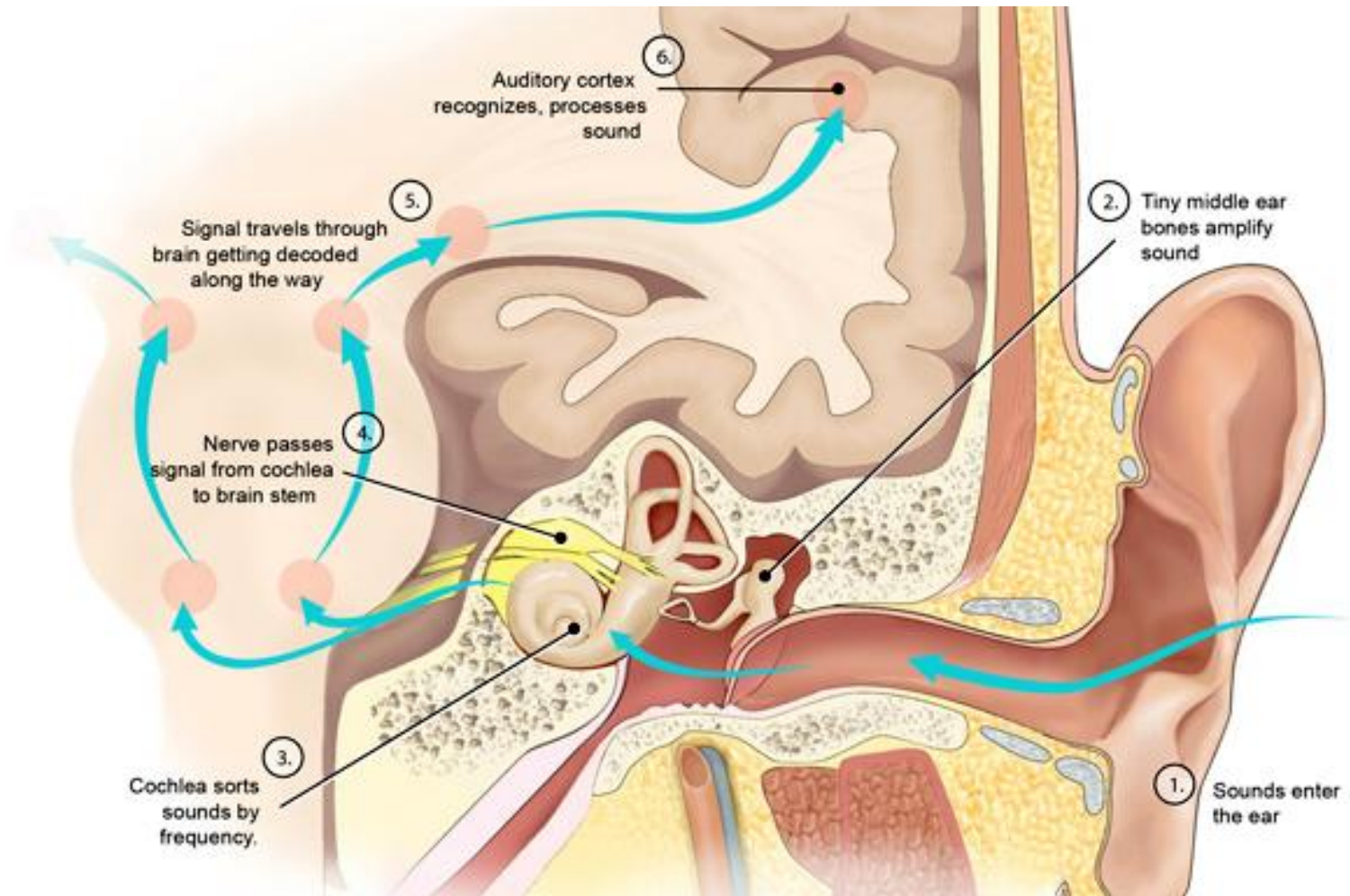
- Sound stimulus goes into the ear canal
- *If* the eardrum and middle ear system is healthy AND the Inner Ear is normal
- *Then* a response (echo) from the movement of the outer hair cells can be measured
- Babies are the easiest to test when they are:
 - Younger
 - Quiet or distracted



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

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

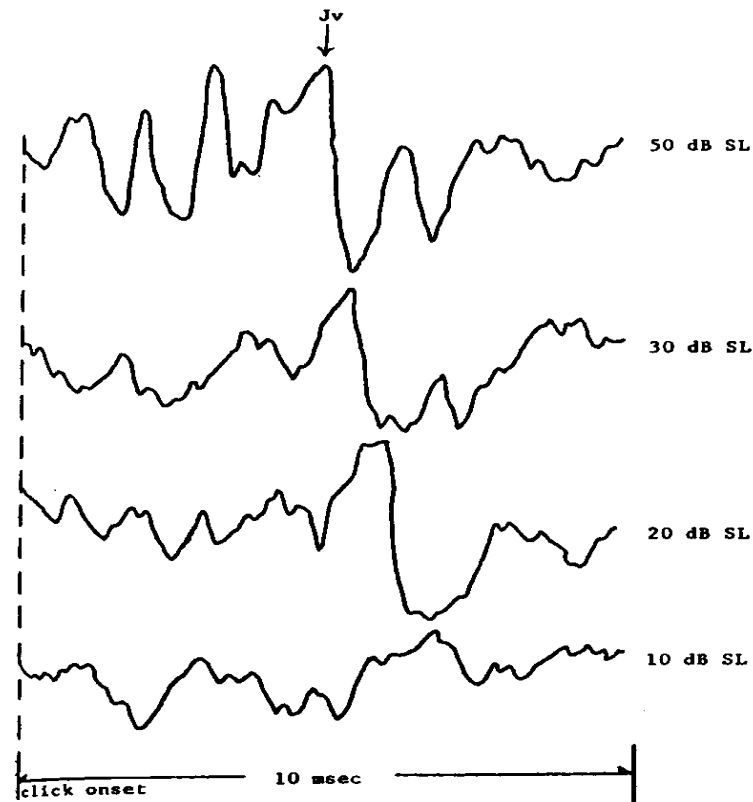
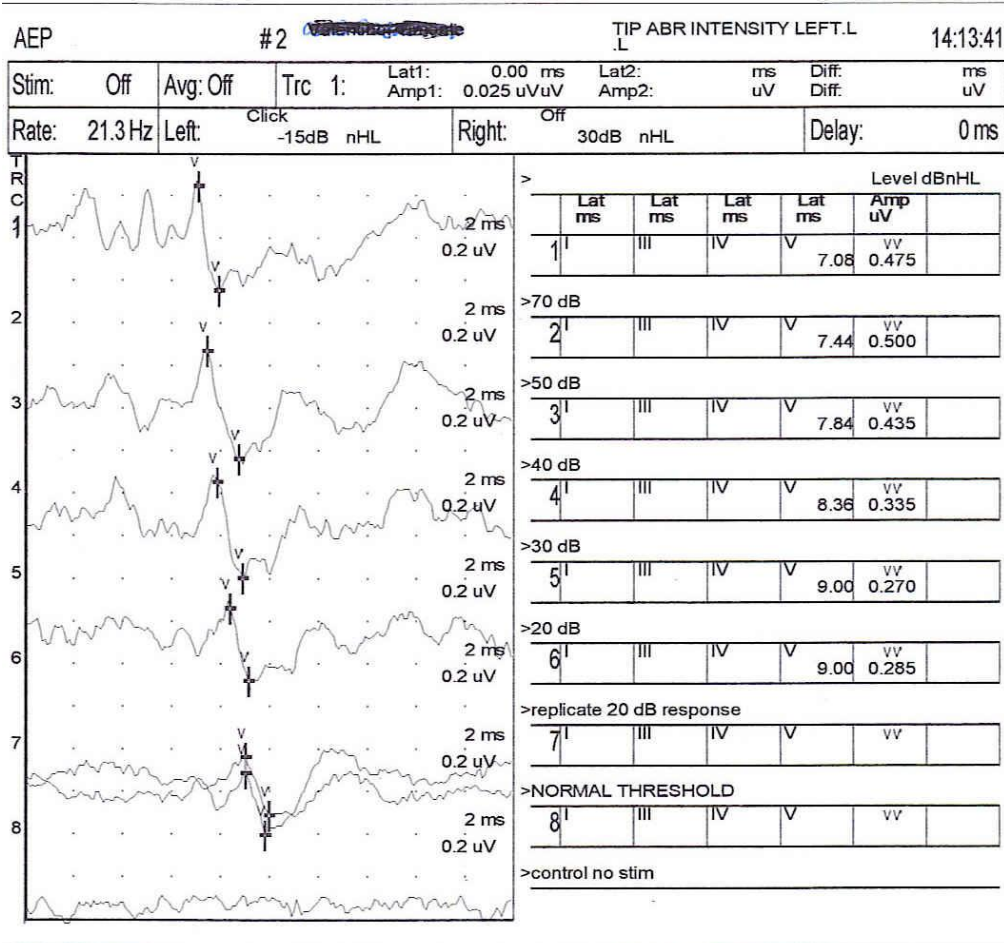


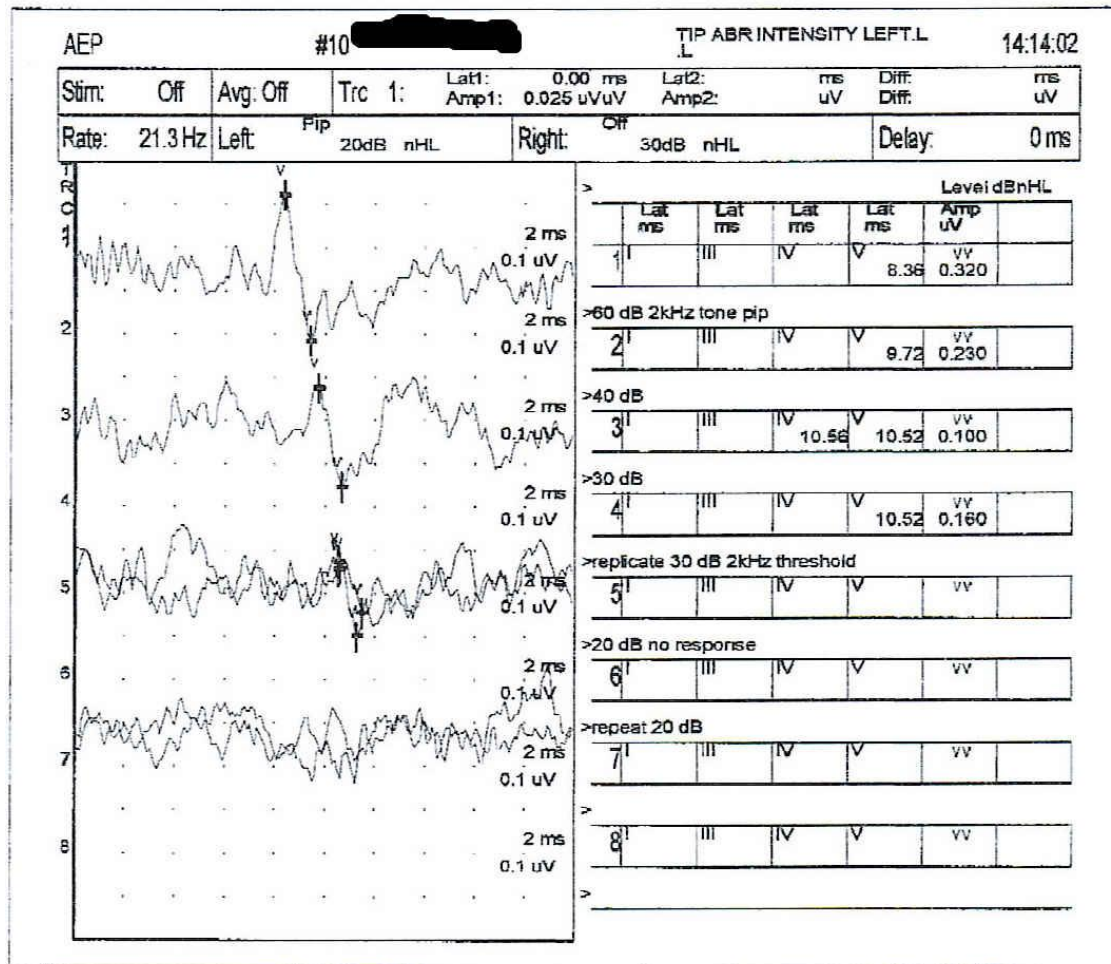
Figure 7-20. Summed brainstem evoked responses at decreasing intensities. Each response represents 2048 click presentations. (Courtesy of Steven Staller, PhD, Cochlear Corporation.)

ABR Normal Threshold

Wyoming Valley Healthcare System--Neurophysiology



ABR Threshold Mild hearing loss



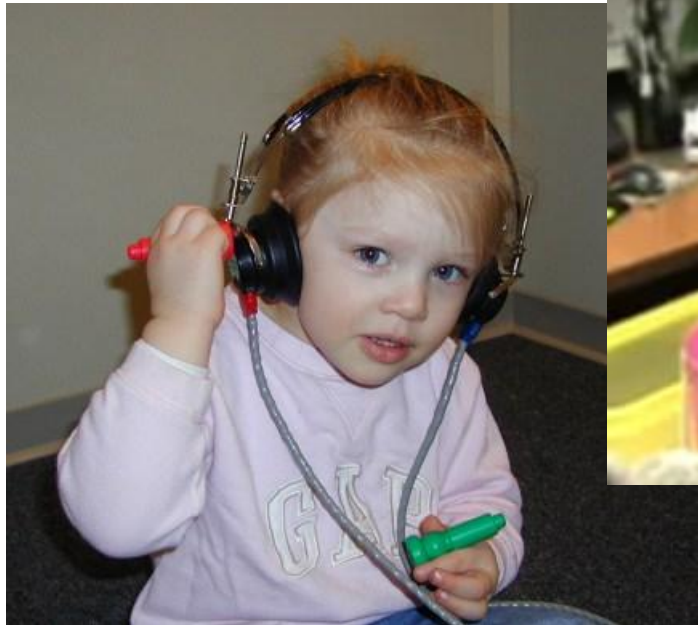
Why use ABR?

- 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

Behavioral Tests

Visual Reinforcement Audiometry (VRA)

Conditioned Play Audiometry (CPA)



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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; if OAE fails receive ABR. If Pass ABR = Pass Screening (NIH 1993)



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- 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

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Hearing Screening Protocols - NICU

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



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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

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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

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Audiologic Evaluation – Birth to 6 months (Developmental Age)

- Child and family history
- Frequency-specific AC (air conduction) ABR
- Frequency specific BC (bone conduction) 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

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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

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 deaf or hard of hearing

Treatment and intervention

Medical intervention

- surgical treatment
- treatment for chronic middle ear disorder

Hearing aids

Cochlear implants

FM systems



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Amplification

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

Hearing Aids

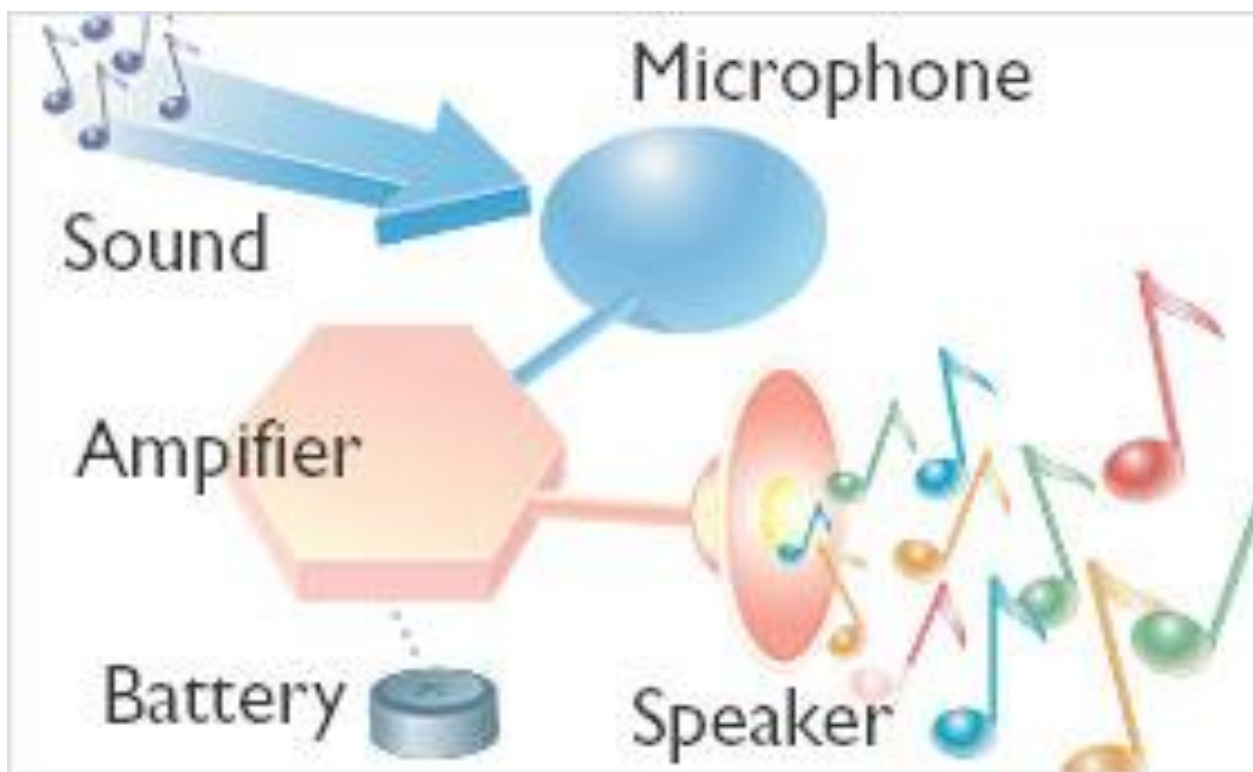
- Hearing aids can be fitted as young as 1 month of age



Hearing Aids



Hearing Aids

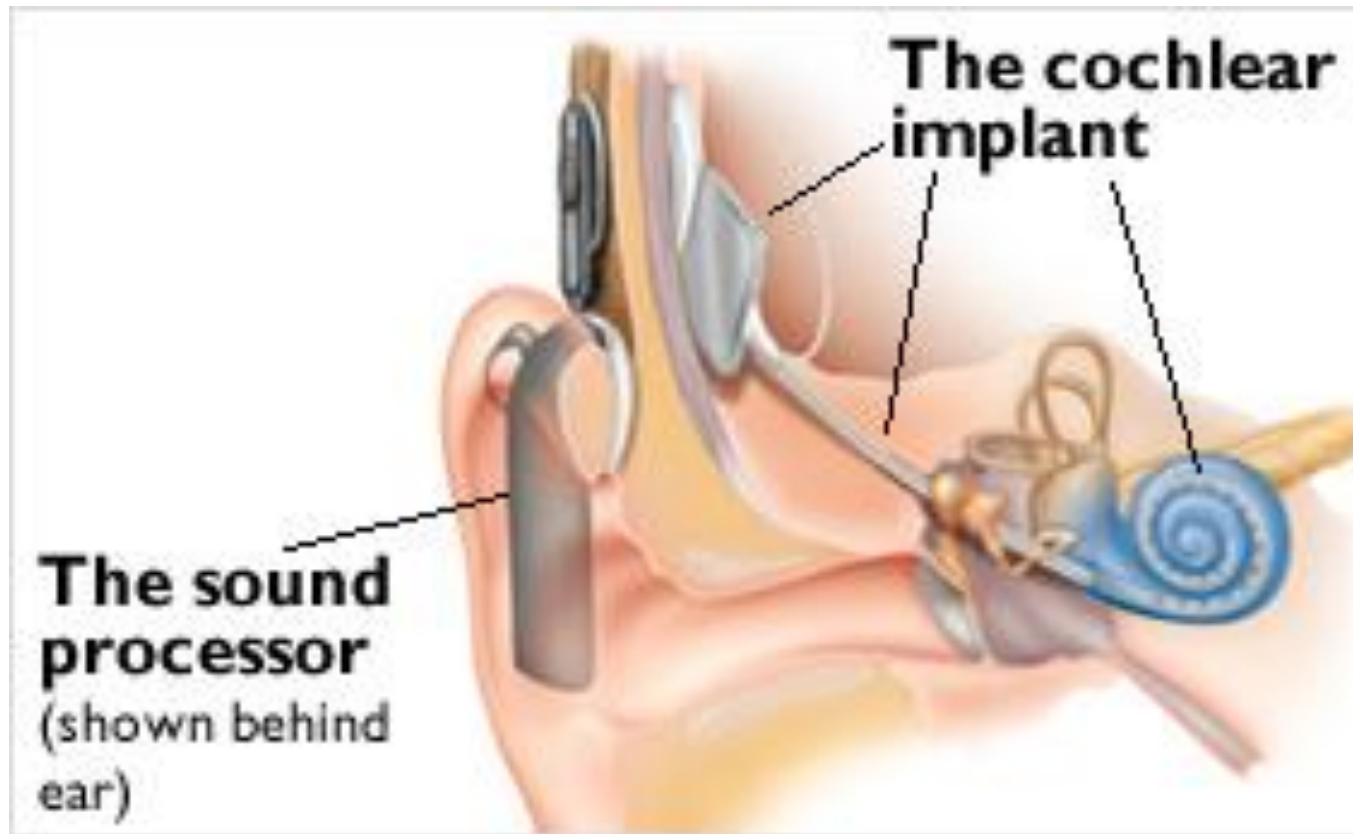


Cochlear Implant Candidacy Criteria

- Lack of benefit from amplification
- Age: 12 months (FDA, insurance) but sometimes younger
- Degree of hearing loss: bilateral severe to profound
- No medical contraindications
- Education environments and services appropriate for post-CI aural re/habilitation
- Family factors (motivation, expectations)



Cochlear Implant



Cochlear Implant



FM Systems



Monitoring and managing hearing loss

- Hearing can change and get worse
- Plan for future needs - amplification flexibility
- Monitor hearing aid/cochlear implant function – trouble shoot
- Provide educational input and consultation
 - classroom modifications
 - FM
 - 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



NCHAM

National Center for Hearing
Assessment and Management
Utah State University™