Hearing Loss

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Topics

- ✓ Five important characteristics of hearing loss
  1. Degree
  2. Configuration
  3. Type
  4. Age at acquisition
  5. Speech perception
- ✓ How to record hearing loss -- The audiogram
- ✓ Pure-tone audiometric testing -- air conduction vs bone conduction
- ✓ Effect of hearing loss on speech perception
- ✓ Causes of hearing loss
- ✓ Early identification

How to describe HEARING LOSS

1. Degree of loss
   - "How much"?
2. Configuration of loss
   - "Shape" – affect on each frequency range
3. Type of loss
   - Location of the problem
4. Time at onset of loss
   - Previous experience with sound
5. Auditory speech recognition performance

1. Degree of hearing loss

Some definitions

- **"Normal"**
  - Refers to the average healthy ear
  - The comparison group for measuring hearing
- **"Decibel"**
  - A unit to measure sound intensity
  - Abbreviation is dB
- **"Threshold"**
  - The softest level you can detect about half the time

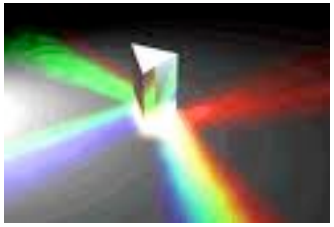
Hearing measurement scale

- Some physical events can be measured on more than one scale
  - Analogy: There are several scales for temperature--
    0° Celsius = 32° Farenheit
  - There are also several scales to measure hearing threshold
- The scale typically used to measure hearing threshold is called Hearing Level (HL)
- When we use HL, we can compare hearing ability for sounds that have very different acoustic characteristics
  - Low frequency vs. high frequency
  - Simple wave vs. complex wave
  - One word vs. another word (example: "yes" vs. "no")

Normal-hearing threshold

- Large groups of people were tested to determine normal-hearing threshold
  - Audiologists measured the minimum intensity levels required for detection of a series of tones
  - The average minimum intensity level for each tone was called 0 dB HL ("zero decibels Hearing Level")
- Results from these studies defined a range of normal hearing
- If an individual *needs more intensity than normal* to detect a tone, we say that person has a hearing loss

Demonstration #1



- Analogy
  - Light
    - A complex combination of frequencies across a wide spectrum
    - Can be analyzed into its component frequencies
  - Acoustic stimulus
    - Every sound is a unique combination of frequencies and waveforms
    - Can be analyzed into its component frequencies, called pure tones

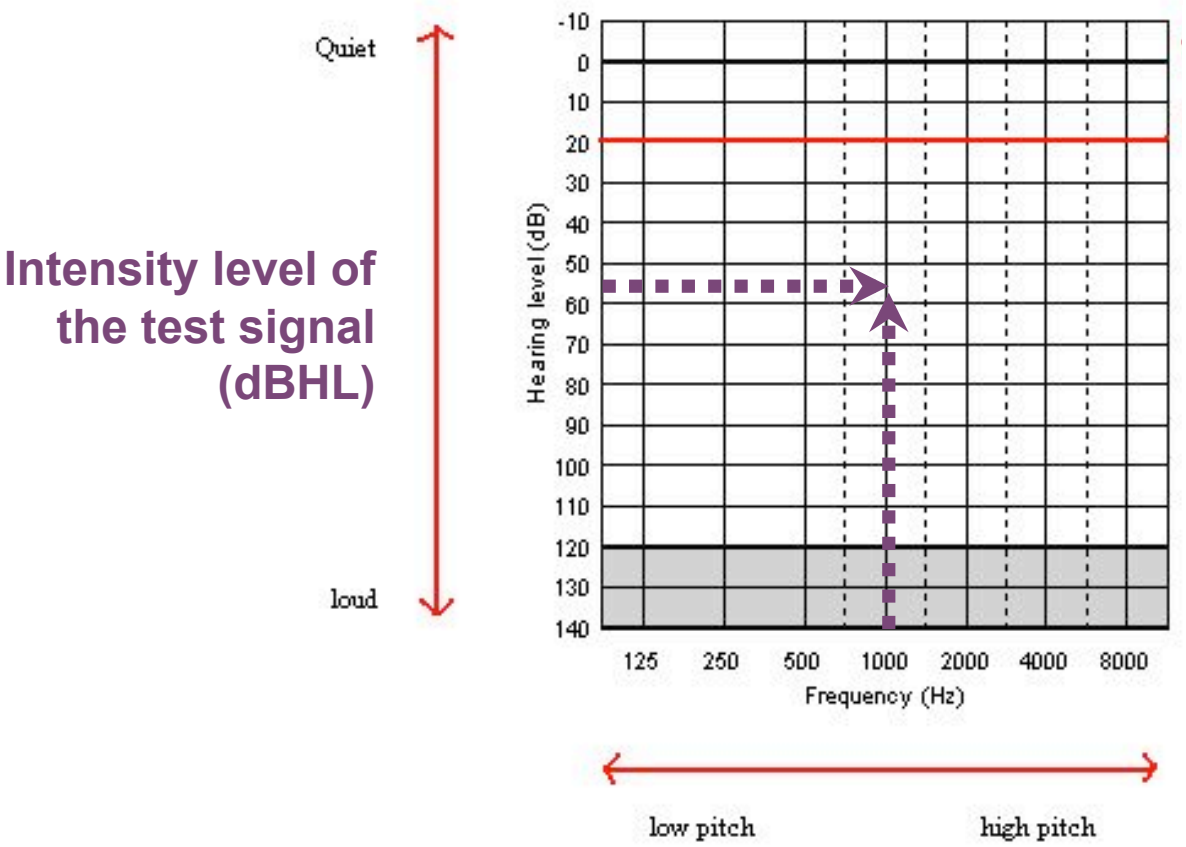
- To test hearing, we use individual pure tones
  - Demonstration of the audiometric frequency range
    http://www.phys.unsw.edu.au/jw/hearing.html
  - Demonstration of adjusting intensity level
  - The pure-tone-average threshold (PTA) is often used to summarize the level of hearing loss (using 500, 1000, & 2000 Hz)

Categories of Hearing Loss

Normal	≤ 10 dB HL
Minimal	10-25 dB HL
Mild	25-40 dB HL
Moderate	40-55 dB HL
Moderately-Severe	55-70 dB HL
Severe	70-90 dB HL
Profound	> 90 dB HL

How to record hearing loss:

The Audiogram



Select the test signal frequency.

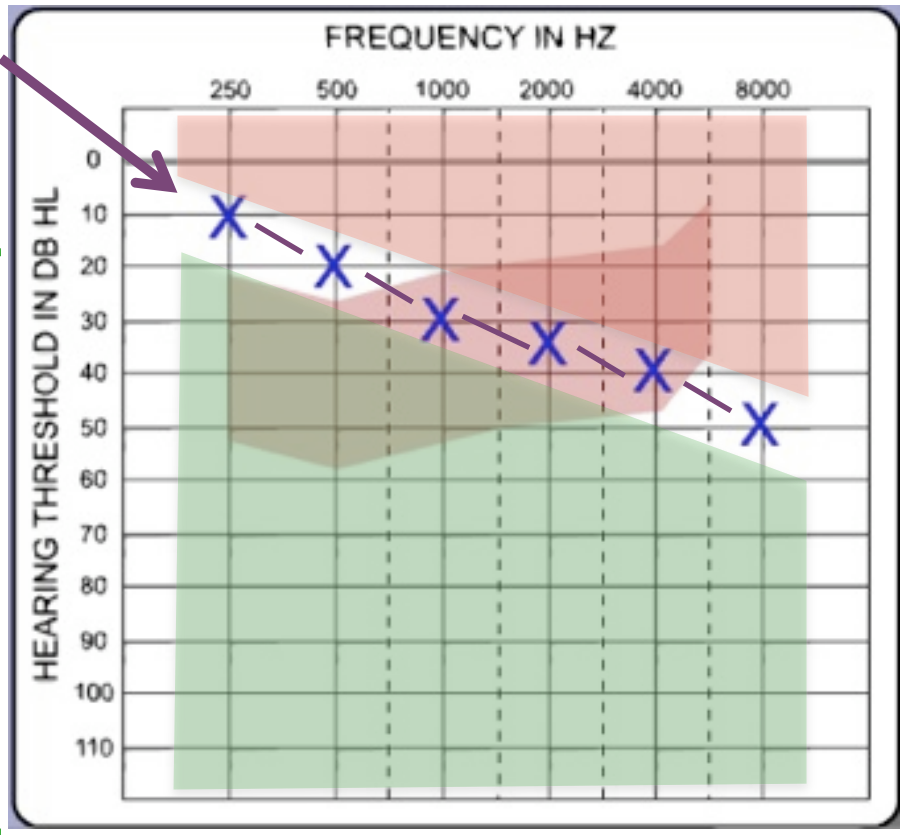
Adjust the signal level until it is "just detectable."

Right ear: Mark "o"

Left ear: Mark "x"

Example of an audiogram showing a hearing loss

Hearing threshold levels

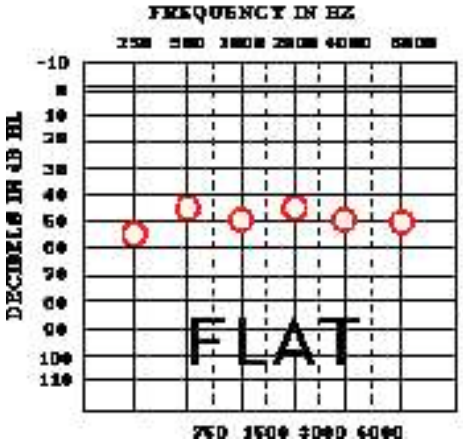


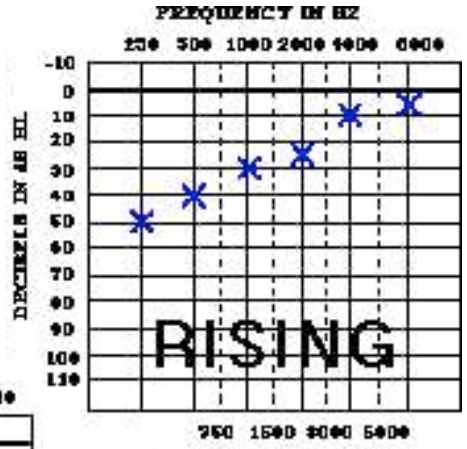
Below threshold
Inaudible

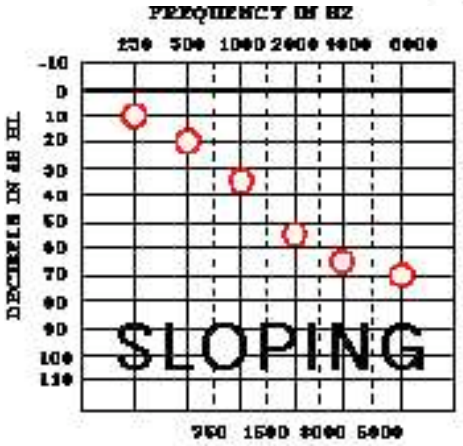
Above threshold
Audible

2. Configuration of hearing loss

- **"Flat"**
  - All frequencies are affected about the same
- **"Low-frequency" or "Rising"**
  - Hearing loss primarily at low frequencies
- **"High-frequency" or "Sloping"**
  - Hearing loss primarily at high frequencies







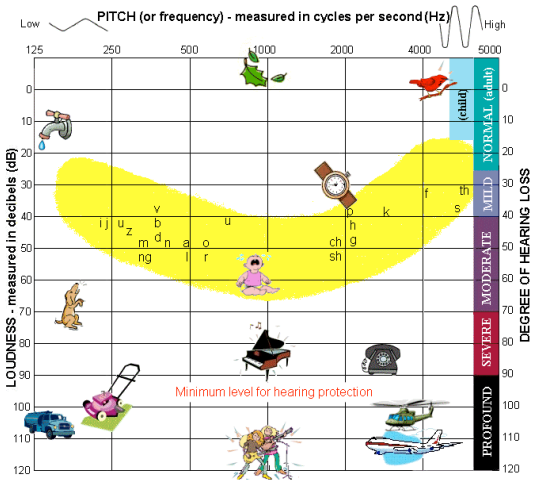
Demonstration #2

- Simulations of hearing loss
  - Illustrates the effects only of sound attenuation (sound is softer)
  - Sound quality remains adequate (not distorted)

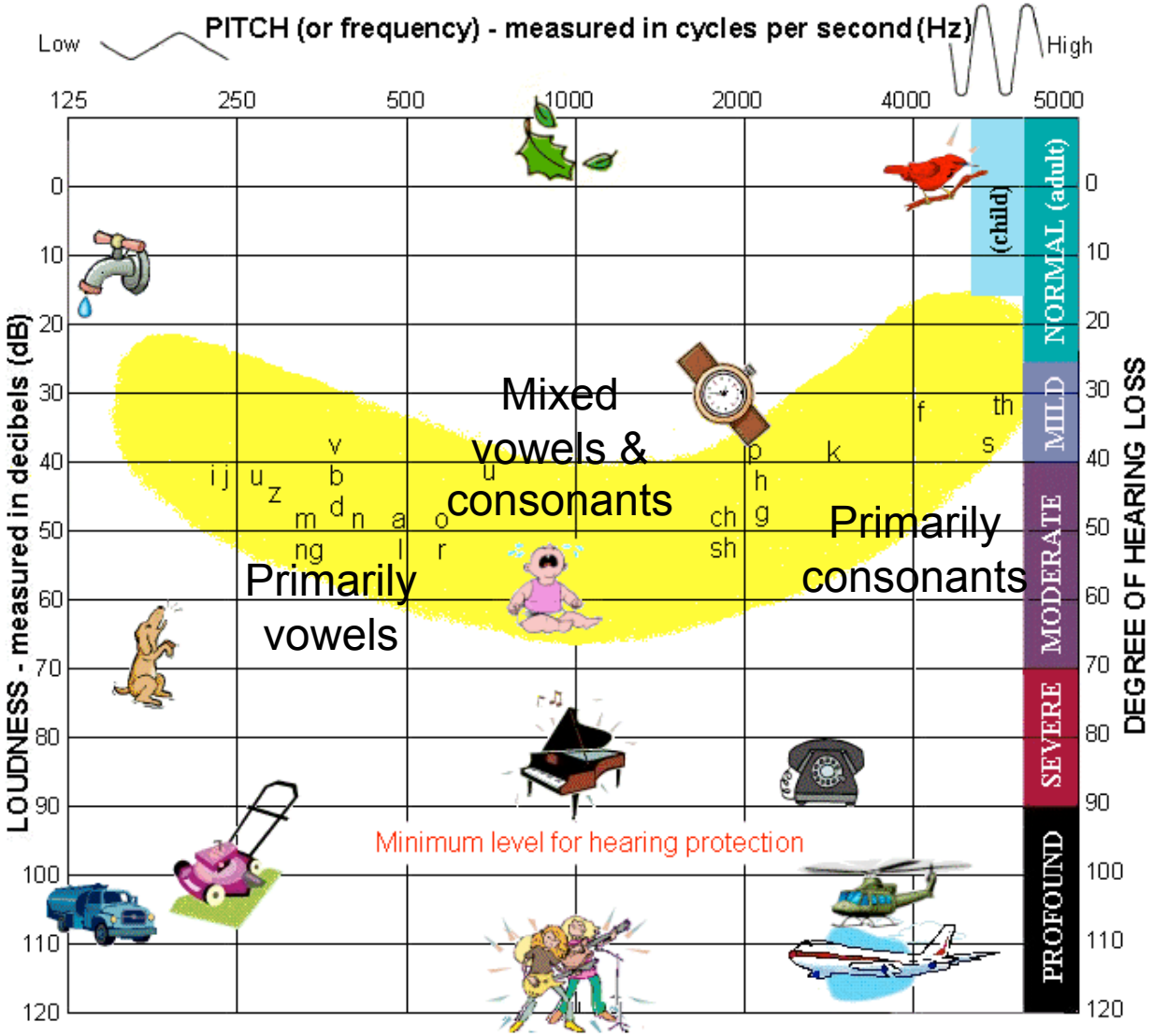
    http://facstaff.uww.edu/bradleys/radio/hlsimulation/

  a) Profound
  b) Moderate (example: "presbycusis")
  c) Mild (example: "otitis media")
- Why are some parts of the message more clear or less clear?
  - Some *speech sounds* depend on low-frequency hearing; others depend on high-frequency hearing
  - Some speech sounds are naturally soft; others are strong
  - Degree of hearing loss determines how many speech sounds are below threshold

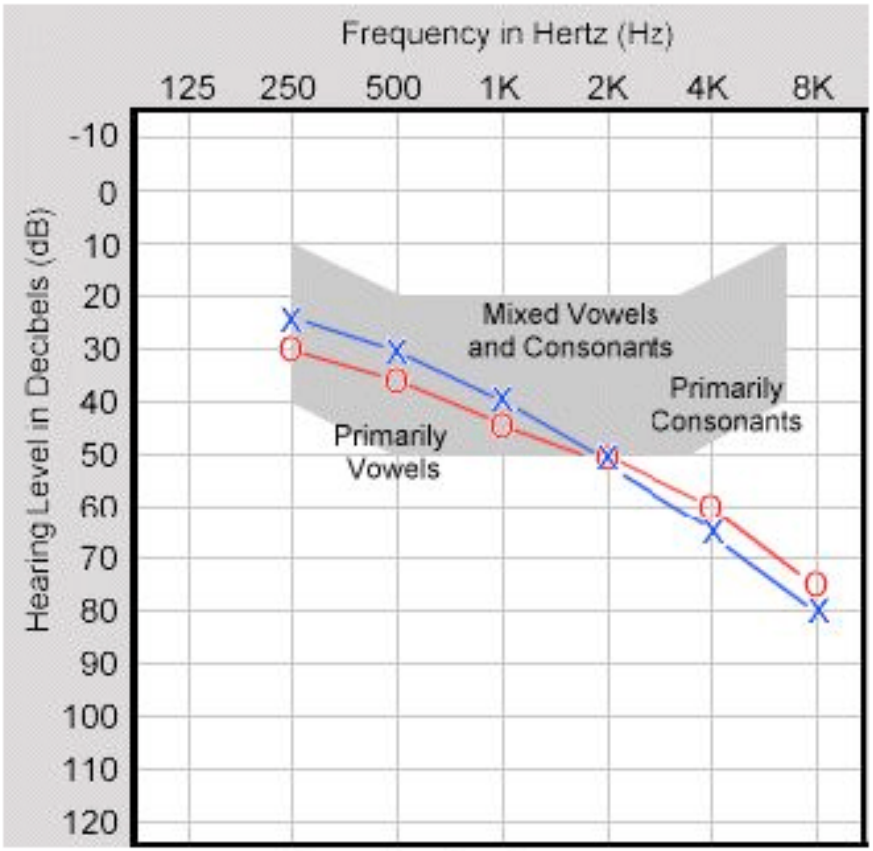
The “speech banana”



- We can graph the frequency and intensity level of speech sounds in our language (examples here are for English)
- When we draw a line around these levels, the outline has a banana shape – The Speech Banana
- The speech banana makes it easy to see how many speech sounds are audible for a person, and how many sounds the person will miss because of a hearing loss



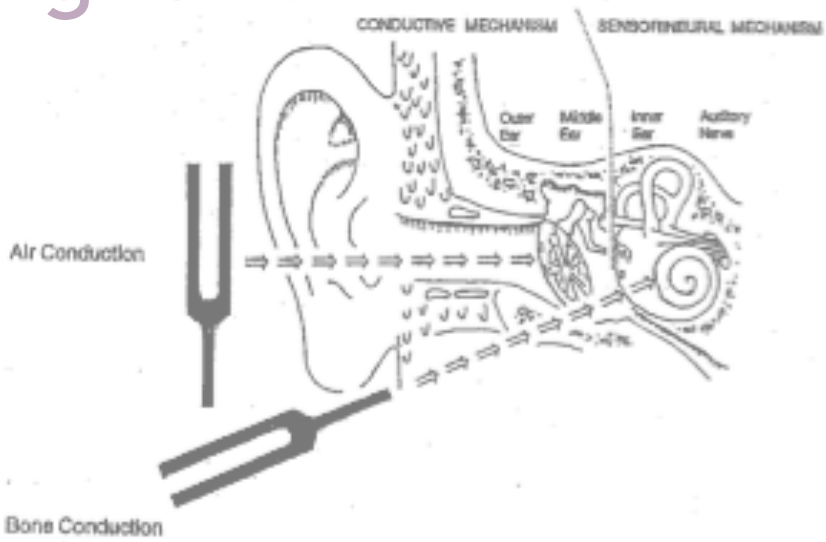
For a person with normal hearing, all of the sounds of speech, and most environmental sounds, are **audible**.



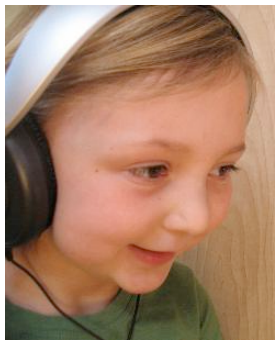
For a person with hearing loss, some speech sounds and environmental sounds are **inaudible**.

Mark Ross
http://www.healthyhearing.com/articles/7841-audiogram-explanation-and-significance

3. Type of hearing loss



- **Indicates location of the problem**
  - Conductive mechanism
    - Outer ear
    - Middle ear
  - Sensorineural mechanism
    - Sensory cells in the cochlea
    - Neural system (in the cochlea or along the 8th nerve)

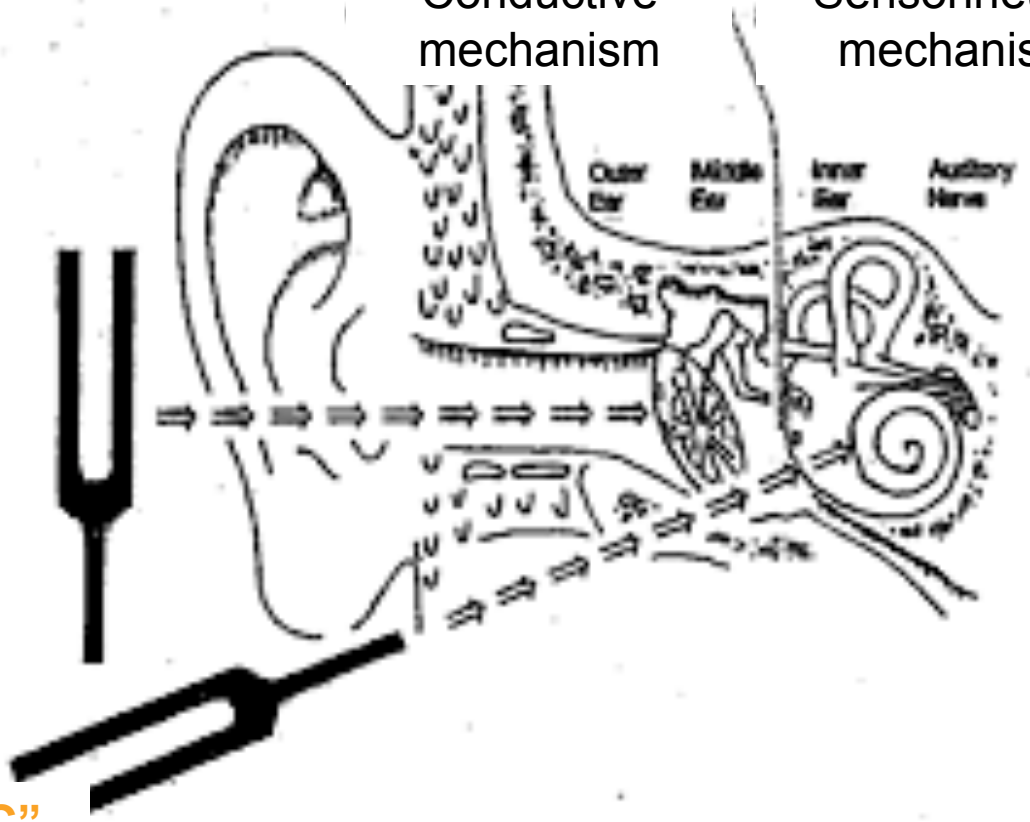


Air Conduction **"AC"**

Tests the whole system

Conductive mechanism

Sensorineural mechanism



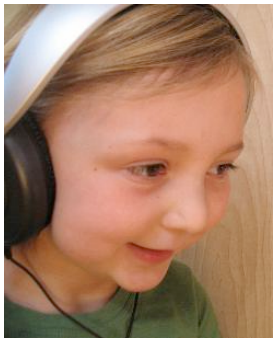
Bone Conduction **"BC"**

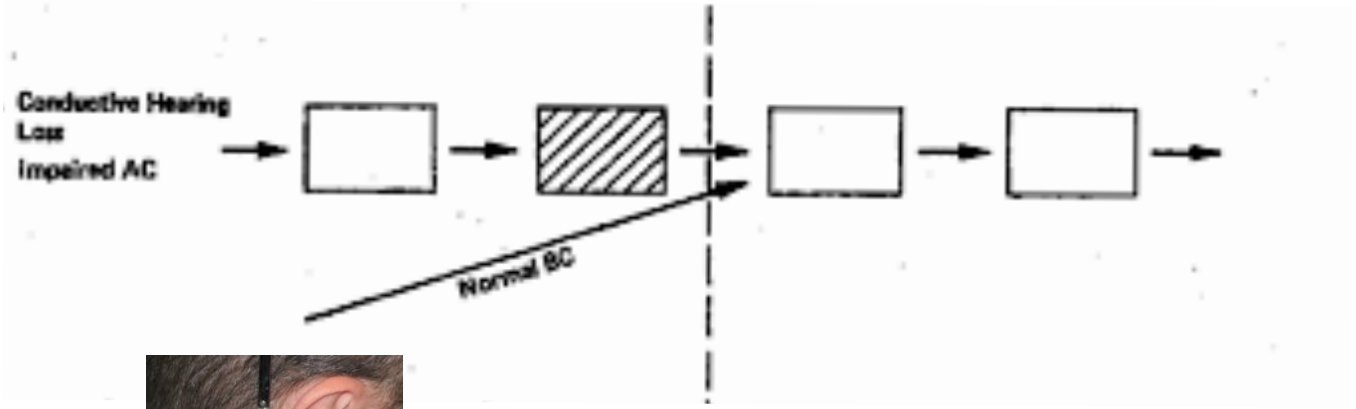
Tests sensorineural system only

Martin, F., & Clark, J. (2008). Introduction to Audiology (p. 13). Allyn & Bacon.

Conductive hearing loss

Only AC results show loss





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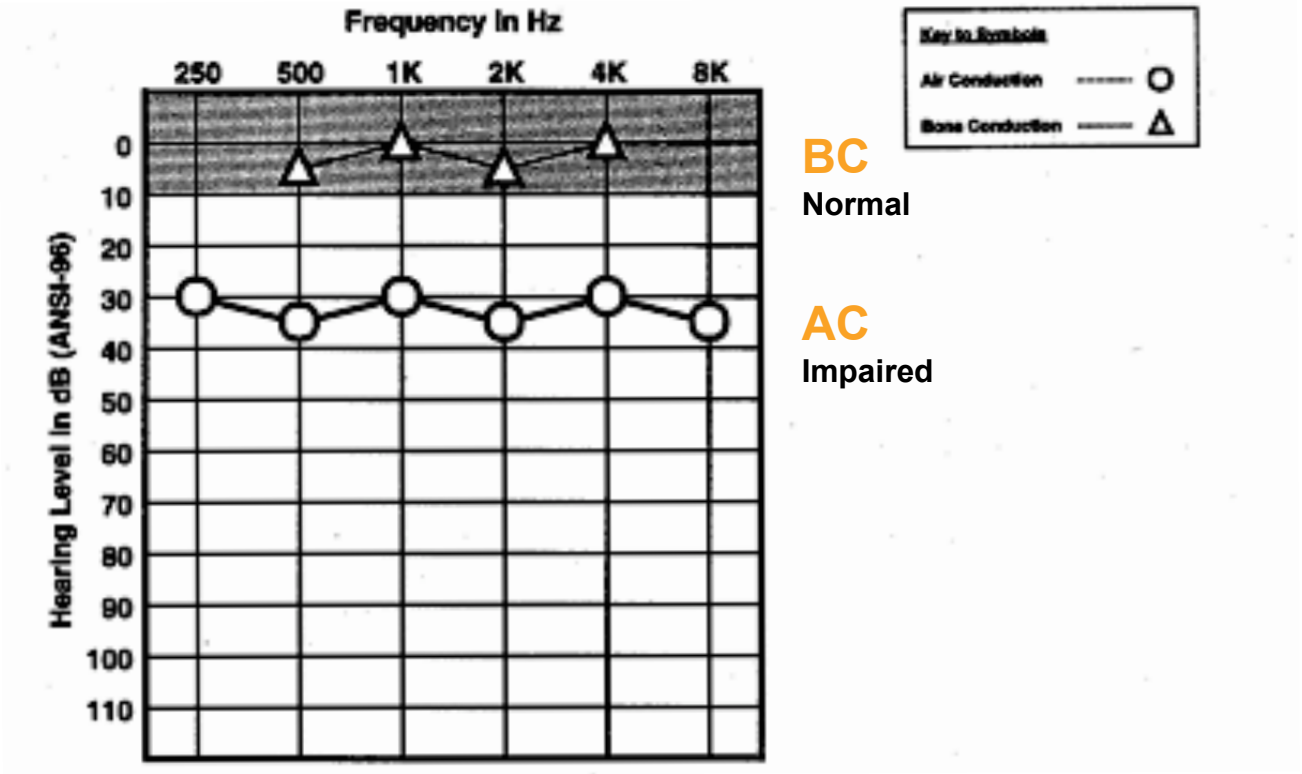
Audiogram for a Conductive Hearing Loss



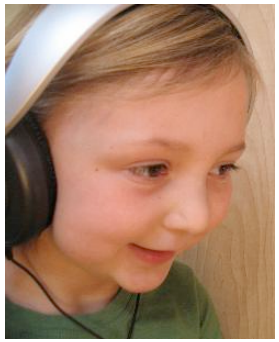
Stach, B. (1998). *Clinical audiology: An introduction* (p. 95). Singular.

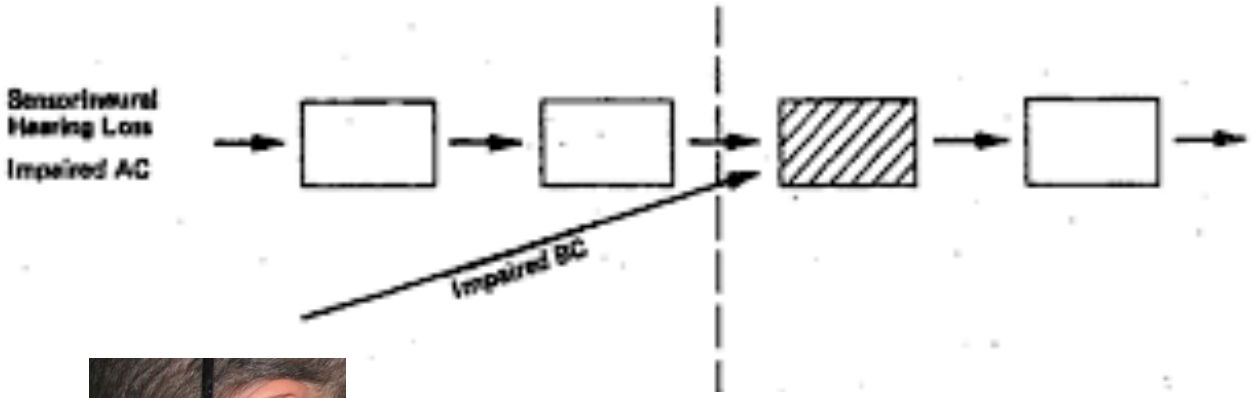
Conductive

- A problem of loudness
- Maximum level of conductive loss is about 55 dB
- Structural or medical problems are effectively treated with medicine or surgery
- Hearing aids provide a high degree of benefit

Sensorineural hearing loss

AC *and* BC results show equal loss





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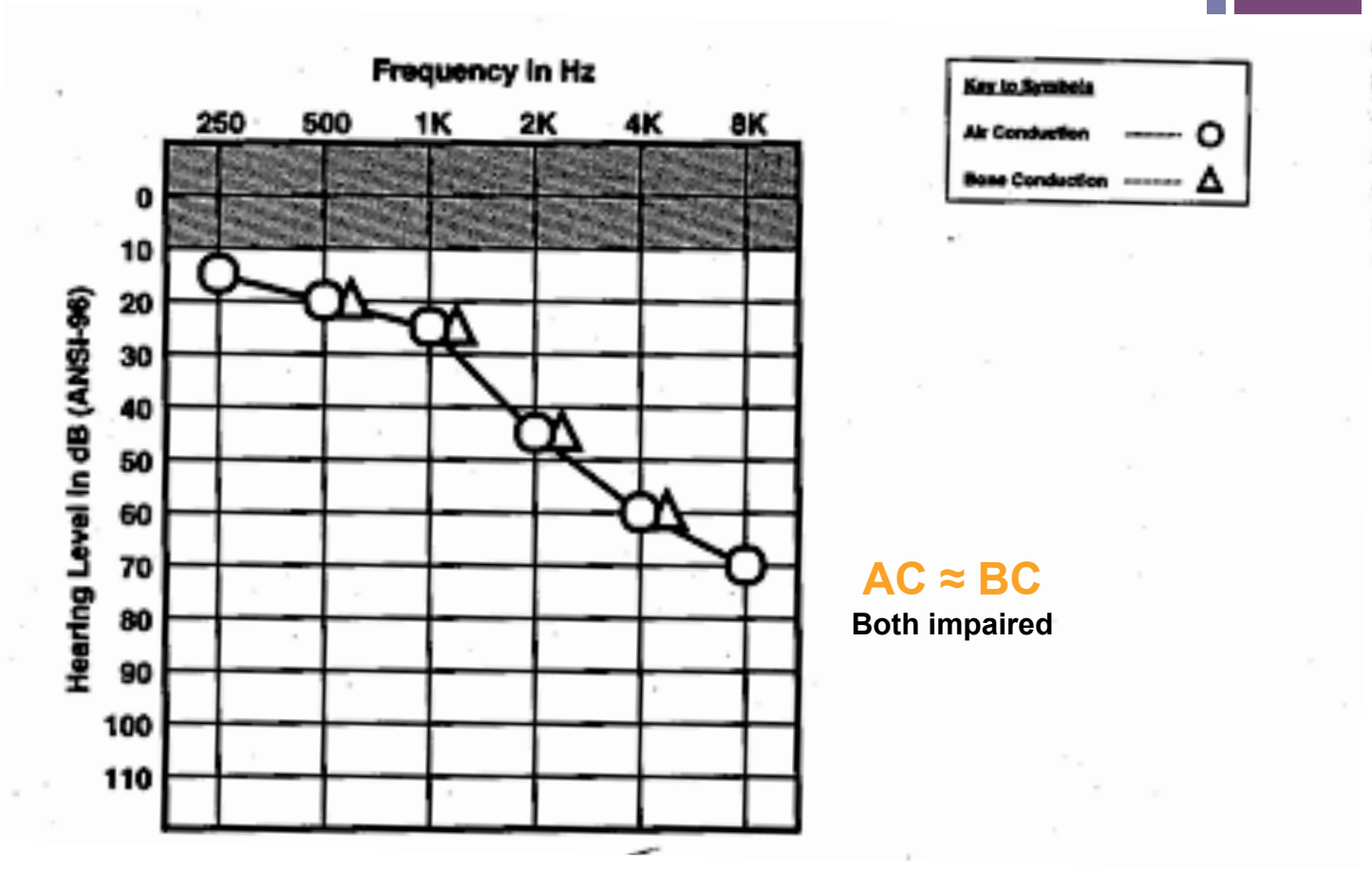
Audiogram for a Sensorineural hearing loss



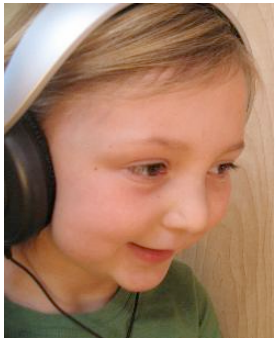
AC ≈ BC
Both impaired

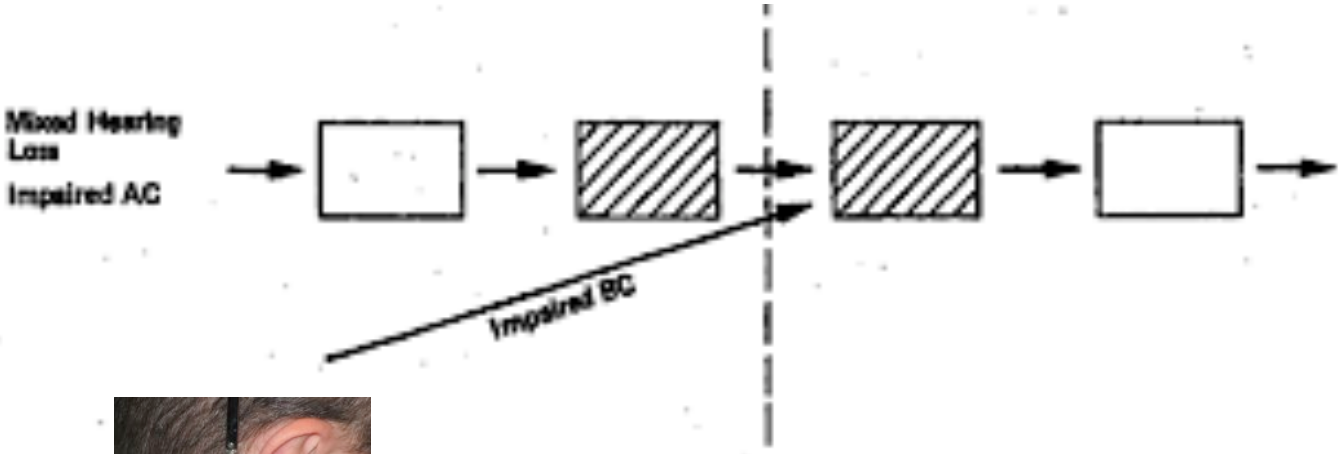
Stach, B. (1998). *Clinical audiology: An introduction* (p. 93). Singular.

Sensorineural

- A problem of loudness and distortion
- Hearing aids are effective in restoring loudness
- Hearing aids cannot improve sound perception
- Hearing aid technology *can* improve the acoustic signal
- Listening experience and language knowledge facilitate auditory speech perception

Mixed hearing loss
BC better than AC





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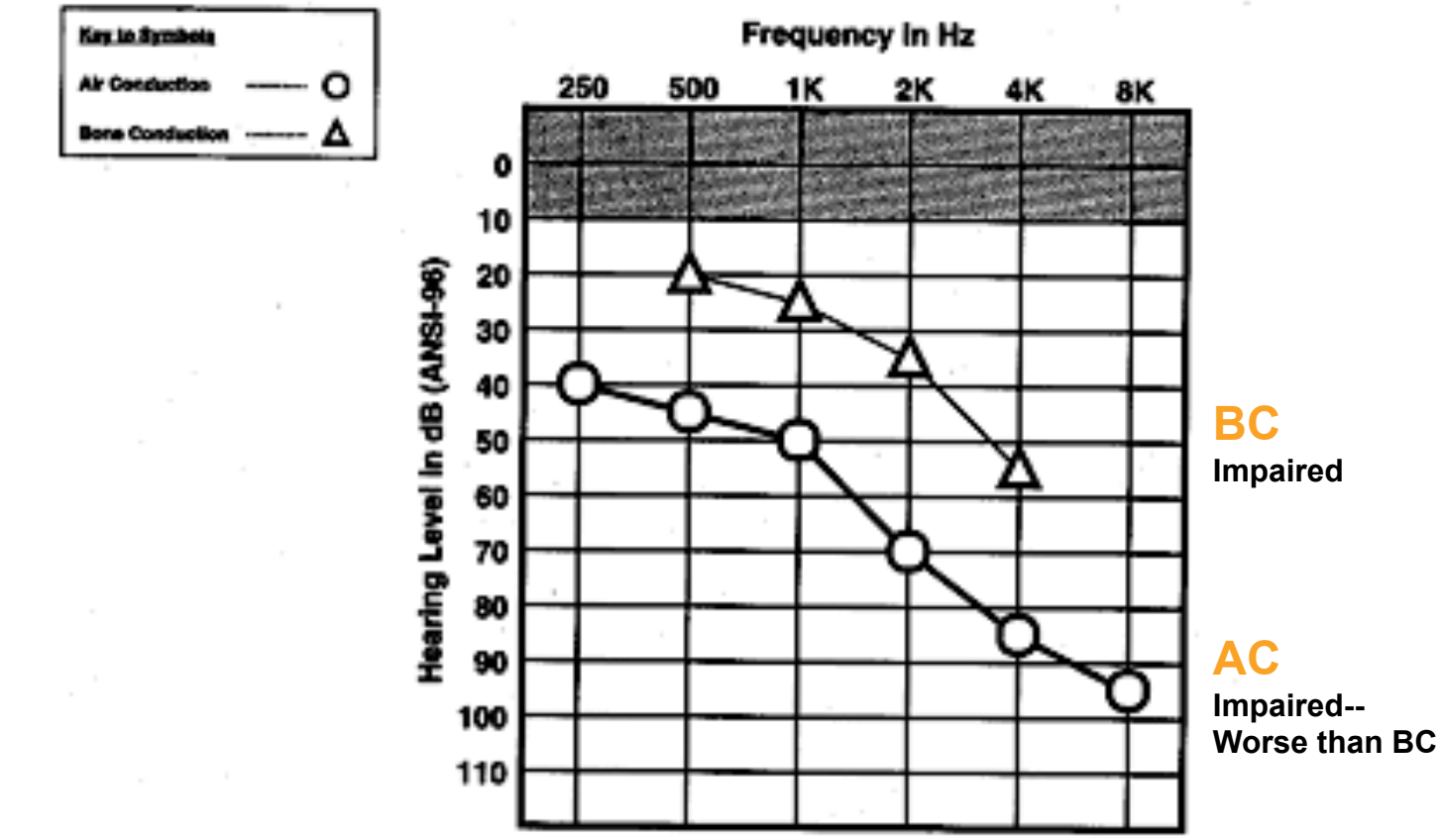
Audiogram for a Mixed Hearing Loss



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Other hearing loss variables

Unilateral ---------- Bilateral

Symmetrical ---------- Asymmetrical

Sudden ---------- Progressive

Fluctuating ---------- Stable

4. Age at onset of hearing loss

- **After auditory speech and language have developed**
  - Acquired
  - Adventitious
  - Postlingual
- **During early auditory speech and language development**
  - Perilingual
- **Before auditory speech and language development**
  - Prelingual
  - Congenital

Listening and spoken language depend on early access to sound

- Degree of hearing loss is not a reliable predictor of outcome
  - Profoundly deaf individuals *can* be successful communicators with spoken language (listening and speaking)
- Ease of acquisition increases with early identification and early intervention (with a hearing aid or cochlear implant)
- Degree of hearing loss becomes a much stronger predictor of outcome when there is delayed identification or intervention

5. Speech recognition performance

- Conditions are selected according to the objectives of the test
  - With earphones or best-fit hearing aids
  - In quiet or in noise
  - Live voice or recorded voice
  - Speech or environmental sounds
- Speech recognition tests use a variety of stimuli
  - Speech sounds in syllables (examples: "aba", "ada," "aga")
  - One-syllable words (examples: "tie," "pig," "cat")
  - Two-syllable words (examples: "mailbox," "ice cream")
  - Sentences

5. Speech recognition performance

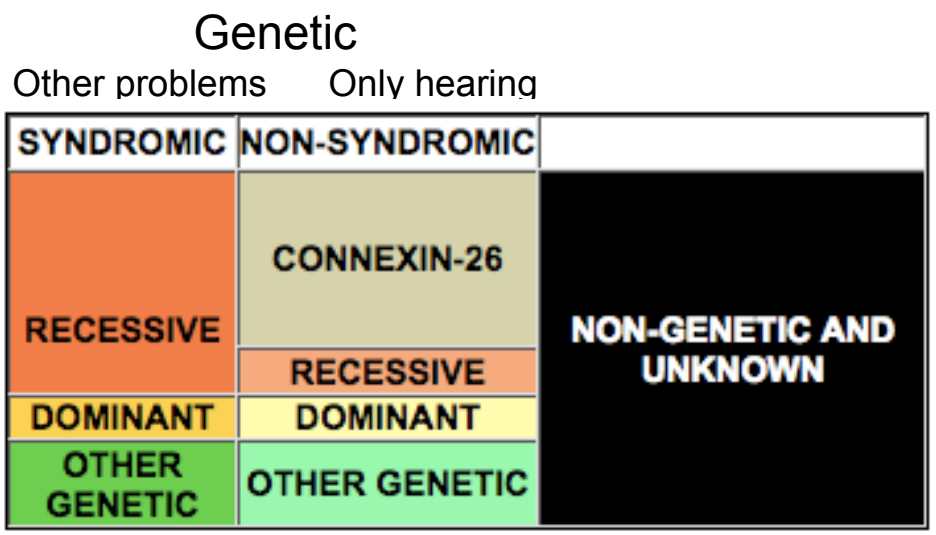
- Speech recognition tests use a variety of responses
  - Recognition ("Say the word _____ .")
  - Closed-set identification (Choose from these words: "Mailbox, baseball, ice cream, sunset")
  - Discrimination ("same" or "different")
- Often measured in percent correct
- **Performance cannot be predicted from audiogram alone**

How to describe HEARING LOSS

1. Degree of loss
   - "How much"?
2. Configuration of loss
   - "Shape" – affect on each frequency range
3. Type of loss
   - Location of the problem
4. Time at onset of loss
   - Previous experience with sound
5. Auditory speech recognition performance

Causes of hearing loss in children

- **Genetic factors** in congenital hearing loss
  - Cause of about half of all congenital hearing loss
  - Autosomal dominant -- one parent (deaf) carries the dominant gene for hearing loss and passes it along to the child
  - Autosomal recessive -- both parents (hearing) carry a recessive gene for hearing loss
  - X-linked hearing loss -- mother carries the recessive trait for hearing loss on the sex chromosome and passes it on to males, but not to females
  - Genetic syndromes that include hearing loss
    - Down
    - Neurofibromatosis (NF)
    - Waardenburg
    - Treacher-Collins
    - Crouzon
    - Alport
    - Pendred



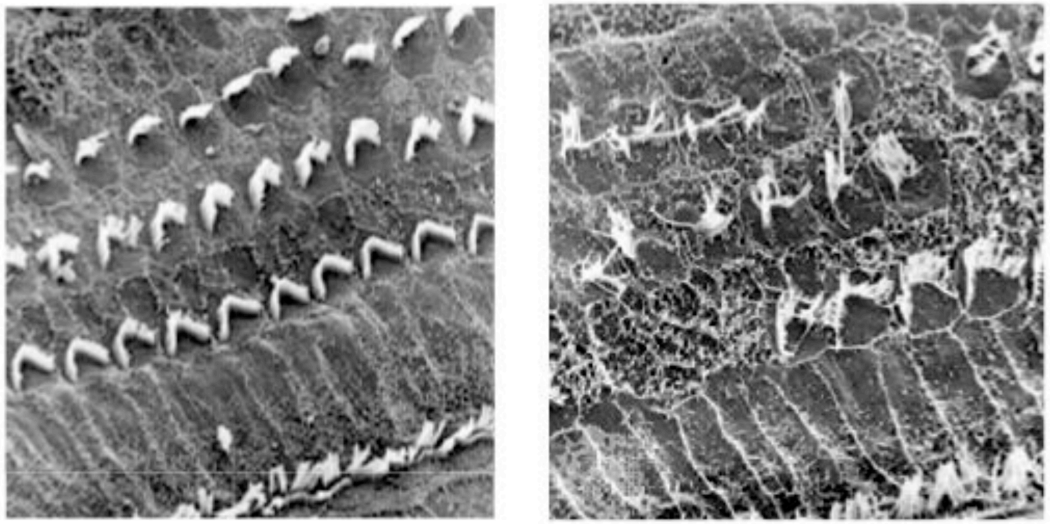
http://www.babyhearing.org/HearingAmplification/Causes/genetics.asp

Nonhereditary causes of congenital hearing loss in children

- Prenatal or perinatal infections, illnesses, toxins consumed by the mother
  - Usually sensorineural
  - Can be mild to profound
  - Examples
    - Rubella, cytomegalovirus (CMV), herpes simplex virus
    - Rh complications
    - Prematurity
    - Maternal diabetes
    - Toxemia during pregnancy
    - Anoxia (lack of oxygen)

Acquired causes of hearing loss in children

- Noise exposure



- Ototoxic drugs
- Head injury (eardrum perforation; temporal bone fracture)
- Radiation treatment

Acquired causes of hearing loss in children

- Meningitis
- Measles
- Encephalitis
- Chicken pox
- Mumps
- Impacted cerumen
- Developmental defects (microtia, atresia)

http://www.microtia.us.com/

Otitis Media (OM)

- Inflammation of the middle ear, often with fluid, which may or may not be infected.
- Severity, duration, and frequency of inflammation vary between children. If child does not show pain or fever, OM may go unnoticed and untreated.

http://www.entusa.com/eardrum_and_middle_ear.htm

Otitis Media (OM)

http://www.pedisurg.com/ptEducENT/tubes.htm

- Symptoms can include:
  - Severe pain, fever
  - Tugging at the ears
  - Hearing loss
    - Mild or moderate conductive hearing loss, particularly in the low frequencies
    - Conductive loss can add to an existing sensorineural hearing loss
    - Repeated bouts can result in glue-like fluid and permanent hearing loss
  - Difficulty understanding speech
  - Inattentiveness
  - Language and speech delay
  - Fatigue
- Chronic OM may be treated with ear tubes to aid pressure equalization and drainage

Central Auditory Processing Disorder (CAPD)

- Disruption in transmission of sound from the brain stem to the cerebrum
- Information received by the temporal cortex may be incorrect or may be processed incorrectly
- Signs include difficulty with these skills:
  - Understanding speech that is degraded, fast, or spoken with an accent
  - Listening in noise
  - Associating meaning to sound
  - Memory for sound sequences
  - Localizing and lateralizing sound
  - Discriminating sounds
  - Recognizing sound patterns
  - Following the rhythm and melody of music

Early identification

- Universal newborn hearing screening
  - Otoacoustic emissions test (OAEs)
    - Measures internally generated sound from the cochlea in response to a stimulus
    - Depends on healthy external and middle ear
    - Child must be asleep
  - Auditory Brain Stem Response test (ABR)
    - Measures brain's response to sound
    - Uses scalp electrodes
    - Child must be quiet
- Expected referral rate in U.S. < 4%
  - 2-10% of babies do not pass the screen
  - Less than 1% will have a hearing loss
- Concerns
  - Parents may not follow up
  - Family may be worried unnecessarily, especially if there is a false positive

Early identification

- Tests for older infants and children
  - Behavioral observation audiometry (BOA) for young infants
  - Visual reinforcement audiometry (VRA) for children from 6 mos to 2-1/2 years of age
  - Conditioned play audiometry (CPA) for children aged about 2-1/2 years or older

www.hearingtune.com/images/vra.jpg