1. **(Amy)** Describe in detail the decibel scales used to measure sounds and hearing (dB HL, dB SPL and dB SL).

A decibel (dB) is one tenth of a bel, a unit named after Alexander Graham Bell that was originally developed to quantify the reduction in audio level over one mile of telephone cable. The decibel scale is logarithmic, and doubling sound pressure corresponds approximately to a 6 dB increase in level. A decibel is a unitless quantity, and decibels are expressed as a ratio to a reference level sound; dB SL, dB SPL, and dB HL are decibel scales with different reference sounds.

Decibel Sound Pressure Level (dB SPL) is relative to 20 micropascals, or 0.0002 dynes/cm$^2$, the quietest sound a human can hear at 1000 Hz. Hence, 0 dB SPL corresponds to 20 micropascals, which is roughly equivalent to the sound of a mosquito flying three miles away.

The Decibel Hearing Level (dB HL) scale was developed because the normal hearing person does not hear all tones from 125-8000 Hz equally well. The reference value is different for each frequency and corresponds to the average threshold of audibility in a large sample of adults with normal hearing tested at that same frequency. An audiogram uses the dB HL scale, and a completely normal hearing person should have hearing levels at 0 dB HL in all frequencies.

The Decibel Sensation Level (dB SL) is used to describe a signal relative to an individual’s auditory threshold at a particular signal frequency. For example, if at 1000 Hz a person’s threshold is 30 dB HL and a signal is at 50 dB HL, then the sensation level of this signal is 20 dB SL.

2. **(Kathy)** You practice in Timbuktu (no audiologists to be found). Tell us about tuning fork tests…how are they done and how should they be interpreted?

Evaluating hearing with a tuning fork, using combined information from the Weber and Rinne tests, can be a useful screening tool to differentiate between conductive and sensorineural hearing loss. However, these tests are associated with significant false-positive and false-negative responses and therefore should be utilized only as screening tools and not as a definitive evaluation of auditory function.

**Weber tuning fork test**- This may be performed with a 256- or 512-Hz fork. The stem of a vibrating tuning fork is placed on the head in the midline and the patient is asked whether the tone is heard in both ears, or in one better than the other. With a unilateral conductive hearing loss, the tone is perceived as louder in the affected ear. With a unilateral sensorineural hearing loss, the tone is perceived as louder in the unaffected ear. As a general rule, a 5 dB difference in hearing between the two ears is required for lateralization.

**Rinne tuning for test**- The Rinne tuning fork test is very sensitive in detecting mild conductive hearing losses if a 256-Hz fork is used. A Rinne test compares the ability to hear by air conduction with the ability to hear by bone conduction. The tines of a vibrating tuning fork are held near the opening of the EAC (AC), and then the stem is placed on the mastoid process (BC). The patient is asked to indicate whether the tone is louder by air or bone conduction. Normally and in the presence of sensorineural hearing loss, a tone is heard louder by air conduction than by bone conduction. However, with a 30dB or greater conductive hearing loss, the bone conduction stimulus is perceived as louder than the air conduction stimulus.

3. **(Rosow)** What is the speech reception threshold (SRT) and how is it measured?

A) Speech reception threshold is the lowest intensity at which a spondee (equally weighted two-syllable word, such as “baseball”) is understood by a subject approximately fifty per cent of the time.

B) In typical SRT testing, a subject is given a series of spondees through headphones or speakers. In between the playback of each spondee, the tester typically adjusts the sound intensity up or down until the subject’s responses are correct 50% of the time. The pure tone average and speech reception threshold should be within 7 dB of each other. Comparison of the speech reception threshold and the pure tone average serves as a check on the validity of the pure tone thresholds. Discrepancies between these measures may suggest a functional or non-organic hearing loss.

4. **(Rosow)** How would you test speech discrimination?

Speech discrimination assesses an individual’s ability to understand a speech signal at normal or above-normal conversational levels. Most commonly, a phonetically balanced word list of fifty one-syllable words is presented to the patient at a supra-threshold level. The patient’s score is represented as a percentage of the number of words correct. Generally, discrimination ability decreases proportionately with an increase of hearing impairment. However, there is an exception in conductive hearing loss where discrimination ability remains relatively good because the inner ear system is normal. Poor discrimination ability in the presence of relatively good hearing sensitivity may suggest retrocochlear pathology, such as acoustic neuroma.
Aug 23: Auditory Function Tests

5. (Josh) Masking...what is it, why do we do it? What is a masking dilemma?

**Crossover** occurs when a sufficiently loud signal is presented to the test ear crosses the skull and is perceived by the non-test ear. The attained responses represent the performance of the non-test ear rather than the test ear due to a large sensitivity difference between the ears.

**Interaural attenuation** is the reduction of sound when it crosses from one ear to another. The normal interaural attenuation of air conducted tones is 40-80 dB depending on whether ear inserts (35-50 dB) or headphones (60-65 dB) are used. Inserts have less contact with the lateral temporal bone than headphones, therefore less sound energy is delivered contralaterally. The normal value for interaural attenuation for bone conduction is 0 dB. Interaural attenuation values tend to be smaller for lower frequencies than higher ones.

In the situation where the air conduction threshold of the test ear exceeds the bone conduction threshold of the non-test ear by a value greater than interaural attenuation, masking should be used.

**Masking** is the presentation of a signal to the ear that is not being tested to ensure that the responses obtained by the test ear are reliable and have not been influenced by the sensitivity of the non-test ear. Masking reduced the sensitivity of the non-test ear’s cochlea to prevent it from hearing the signal delivered to the test ear. It should be used routinely with bone conduction testing when the threshold levels between the ears are asymmetric. Masking should be used when determining the SRT whenever the SRT of the test ear and SRT, air conduction or bone conduction PTA of the non-test ear differ by 45 dB or more.

**Masking dilemma** occurs when masking is necessary but not possible. It usually occurs in cases of bilateral conductive or mixed hearing losses with 50 dB or greater air-bone gaps. It occurs when bone conduction thresholds are within normal limits, but the air thresholds equal or exceed interaural attenuation. Unmasked thresholds will likely reflect the responses of the non-test ear, and masked thresholds may appear worse than they actually are because of overmasking, where the masked noise crosses over and affects the responses obtained for the test ear.

The plateau method in clinical masking masks the non-test ear by progressively greater amounts of noise until the threshold of the test ear does not continue to increase.

6. (Caroline) Be prepared to draw and describe the classification of tympanograms.

**Type A** response - suggests normal ME function, can occur in some otosclerotic ears, Compliance peak is -150 to +100 daPa, and immittance is 0.2-2.5 millimhos (mmhos).

- **Type As** (A shallow) - stiffened middle ear system. Compliance peak is -150 to +100 daPa, and immittance is less than 0.2 mmhos. Ex. glue ear, a thickened or scarred eardrum, or otosclerosis.
- **Type Ad** (A deep) - flaccid TM, ME system, or a disarticulation of ossicles. Compliance peak is -150 to +100 daPa, and immittance is more than 2.5 mmhos

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type As</th>
<th>Type Ad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type B</td>
<td>Type C</td>
<td>Type D</td>
</tr>
</tbody>
</table>

- **Type B** is a flat trace with no observed compliance or immittance peak. Average ear canal volumes for children are 0.42-0.97 mL. Average adult volumes are 0.63-1.46 mL.
  - **Type B** (normal ear canal volume) usually suggests otitis media.
  - **Type B** (small ear canal volume) suggest cerumen impaction or that the immittance probe is pushed against the side of the ear canal.
  - **Type B** (large ear canal volume) suggests PET or perforation
Aug 23: Auditory Function Tests

Type B

- Type C - negative pressure in the ME system, ETD. Immittance peak is measurable, but compliance peak is less than -150.

7. (Caroline) Educate us on the acoustic reflex. What does it mean if there is "no response"?
The acoustic reflex is a contraction of the stapedius muscle of the middle ear in response to loud sound. The pathways for this reflex ascend from the peripheral auditory system to the brainstem and then descend both ipsilaterally and contralaterally, so presentation of a loud sound in one ear results in bilateral contraction of the stapedius muscles. This contraction stiffens the middle ear system, causing a reduction in the transfer of low-frequency energy.
The clinical procedure for assessing the acoustic reflex threshold involves presenting a low-frequency probe tone (i.e., 226 Hz) to one ear, presenting high-intensity signals to the same or the other (contralateral) ear, and monitoring a decrease in the acoustic admittance of the probe tone in response to the presentation of the high-level signal. The minimum stimulus level that results in an observable decrease in acoustic admittance is defined as the acoustic reflex threshold. Acoustic reflex thresholds are usually measured from 500-2000 Hz, in both ipsilateral and contralateral modes, for each ear.
The AR has both an ipsi and contra pathway. The majority of neurons run through the ipsi pathway which begins at the cochlea and proceeds through the 8th nerve, cochlear nucleus, trapezoid body, superior olivary complex and facial motor nucleus to the ipsi stapedial muscle. The contralateral pathway crosses the brainstem to go to the opposite stapedius muscle.

Absence of acoustic reflexes
In listeners with normal hearing, the acoustic reflex threshold is elicited at levels approximating 85 dB HL (+/- 10 dB). The acoustic reflex is absent if the signal doesn’t reach the cochlea with sufficient intensity, if there is damage affecting any of the structures along the acoustic reflex pathway, or if there is a stiff middle ear system in the probe ear. Examples: (1) CHL of 25 dB HL or greater in the stimulus ear (2) CHL of 10 dB HL or greater in the probe ear (3) SNHL exceeding 75 dB HL in the stimulus ear (4) a lesion of the facial nerve in the probe ear (5) a lesion in the auditory brainstem affecting the crossing pathway of the acoustic reflex arc (6) a lesion of the vestibulocochlear nerve in the stimulus ear, depending on the extent of the lesion.

8. (Tali) What is the auditory brainstem response (ABR)? How is it measured and what are the limitations?

- (ABR) audiometry is a neurologic test of auditory brainstem function in response to a brief click or tone pip administered by earphone. The elicited waveform response is measured by surface electrodes typically placed at the vertex of the scalp and ear lobes. The amplitude (microvoltage) of the signal is averaged and charted against the time (millisecond).
- Waveforms normally occur within 10 ms after a click stimulus presented at high intensities (70-90 dB normal hearing level [nHL]). Characterized by 5-7 peaks.
- Peaks represent synchronous neural discharge at various pts along the auditory pathway.
  - Waves I and II arise primarily from the auditory nerve, wave I from the distal component and wave II from the more proximal component.
  - Intracranial generators more complicated but wave III may represent the cochlear nucleus, wave IV the superior olivary complex and wave V the lateral lemniscus.
- Evaluate and compared to normal findings: interwave latency (wave I-III and wave I-V), interaural latency difference (wave V), absolute latency, presence or absence of wave components, amplitude ratio (V/I) and overall morphology.
- Most valuable are measures of interwave latency and interaural latency difference of wave V. Interpeak latencies such as I-III or I-V are considered the most sensitive measures of retrocochlear involvement.
- Advantages:
  - Unaffected by sleep, pharmacologic agents, can be used to test infants or difficult-to-test children, can estimate hearing threshold within 20db, may give clue to nature of the hearing loss (conductive or sensorineural).
Aug 23: Auditory Function Tests

- Sensitive to CNVIII lesions and brainstem auditory pathways.

- Limitations:
  - Doesn't give frequency-specific information
  - Difficult to assess degree of loss when in severe-profound range
  - Infants neural pathways not completely myelinated
  - Subjective interpretation
  - Not a substitute for a formal hearing evaluation, and results should be used in conjunction with behavioral audiometry whenever possible.

9. (tali) Give us a mnemonic for the ABR wave forms.
   - Eighth Nerve
   - Cochlear Nucleus
   - Olivary Complex (Superior)
   - Lateral Lemniscus
   - Inferior Colliculi

10. (Scott) Describe special techniques used in the evaluation of hearing in the pediatric population.

Newborns and Infants: Non-invasive, objective physiologic measures are used including otoacoustic emissions (OAEs) and/or auditory brainstem response (ABR).

OAEs are inaudible sounds from the cochlea when audible sound stimulates the cochlea. The outer hair cells of the cochlea vibrate, and the vibration echoes back into the middle ear. Persons with normal hearing produce emissions. Those with hearing loss greater than 25-30 dB do not. OAEs can detect blockage in the outer ear canal, middle ear fluid, and damage to the outer hair cells in the cochlea.

ABR is an auditory evoked potential that originates from the auditory nerve. Brain wave activity in response to sound is recorded. ABR can detect damage to the cochlea, the auditory nerve and the auditory pathways in the stem of the brain.

Older Infants and Toddlers: For children 7 months to 3 years, visual reinforcement audiometry (VRA) and conditioned play audiometry (CPA) are used. Both of these methods are behavioral techniques that require involvement and cooperation of the child.

VRA is the method of choice for children between 6 months and 2 years of age. The child is trained to look toward (localize) a sound source. When the child gives a correct response, the child is "rewarded" through a visual reinforcement such as a toy that moves or a flashing light.

CPA can be used between 2 and 3 years of age. The child is trained to perform an activity each time a sound is heard. The activity may be putting a block in a box, placing pegs in a hole, putting a ring on a cone, etc. The child is taught to wait, listen, and respond.

If the child will allow earphones to be placed on his or her head, independent information can be obtained for each ear. If the child refuses, sounds are presented through speakers inside a sound booth. Since sound field screening does not give ear specific information, a unilateral hearing loss may be missed. Alternative procedures, such as OAEs or ABR may be used otherwise.

Preschoolers: Screening is to identify children most likely to have hearing loss that may interfere with communication, development, health, or future school performance. Hearing loss in this age range is so often associated with middle ear disease, it is also recommended that children in this age group be screened for outer and middle ear disorders. Conditioned play audiometry (CPA) is the most commonly employed procedure. Acoustic Immittance screening may include tympanometry, acoustic reflex, and static acoustic impedance.

School age (5-18 years): School age children should be screened at the following times: on first entry into school, every year from kindergarten through 3rd grade, in 7th grade, in 11th grade, upon entrance into special education, upon grade repetition, upon entering a new school system without evidence of having passed a previous hearing screening.

Conventional audiometry where students are instructed to raise their hand (or point to the appropriate ear) when they hear a tone is the commonly used procedure. Conditioned play audiometry (CPA) is also used.