Problem 1: Starting with the auricle, trace a sound wave into the inner ear to the point at which action potentials are generated at the vestibulocochlear nerve.

Draw or describe the auditory system from the external ear to inner ear:
Auricle -> ear canal -> ear drum -> middle ear (3 pieces of bones) -> oval window -> basilar membrane vibration (there’s more to that, including outer hair cell motility) -> hair cells -> synapses -> 8th nerve action potentials.

Problem 2) Describe and discuss one of the major functions for the middle ear, i.e., matching mechanical impedance minimizes power loss.

The middle ear, through 3 pieces of the smallest bones in the body, connects the eardrum on one end and the cochlea (oval window) on the other end. The eardrum vibration has large amplitude but low force, whereas the fluid-filled cochlea’s vibration has small amplitude but large force, creating a mismatch in mechanical impedance. The middle ear serves like a leverage or impedance matcher to transfer the energy from the air to the fluid with minimal loss.

Problem 3:  Discuss how intensity is encoded by the auditory system:
   a) How compression is achieved in the cochlea?
   b) What cells have contributed to this compression?
   c) How cochlear compression affects loudness coding?
   d) How different types of hearing loss may affect this compression?

   a. The compression is achieved by providing different degrees of amplification dependent on the input level: the softest sound will be amplified by 40-60 dB whereas the loudest sound received no amplification.
   b. Outer hair cells.
   c. Cochlear compression reduces the input dynamic range to match that of the nerve transmission.
   d. Conductive hearing loss and auditory neuropathy do not affect the compression, whereas the outer hair cell (sensory) loss reduces or removes it.

Problem 4: Describe and discuss tuning curves (a plot of threshold vs. frequency curves) for neurons from different places of the cochlea, specifically:
   a) discuss tonotopic organization;
   b) discuss nonlinearity;
   c) discuss the origin of the tuning;
   d) show how outer hair cell damage may change the tuning curve.

   a. base = high frequency; apex=low frequency; from the cochlea to the brain
b. outer hair cells are the source of nonlinearity, which does two things including the sharp tuning and the amplitude compression

c. tuning has two parts: passive tuning and active tuning. Passive one is originated at the basilar membrane level while the active one is originated at the outer hair cell level. Both are mechanical; no neural tuning!

d. outer hair cell damage typically makes the tuning curve less sharply tuned