INTRODUCTION:
The ear is a complex organ which converts vibrations of air (sound) into vibrations of liquid which stimulate the receptor cells for hearing, called hair cells. It also has the ability to modify the amplitude (strength) of the incoming vibrations before they reach the receptor cells, thus controlling the volume you actually hear.

The human ear consists of three parts:

a) An outer ear, filled with air, which directs sound waves into the ear and carries them to the tympanic membrane (eardrum). The outer ear consists of the auricle, or pinna, and the external auditory canal.

b) A middle ear, also filled with air but containing three small bones, or ossicles, which carry the vibrations to the inner ear.

c) An inner ear, filled with fluid, containing the hair cells enclosed within the spiraling cochlea. The inner ear also contains the receptors for another of the five special senses, balance or equilibrium, and the eighth cranial nerve (vestibulocochlear) carries information for both sound and equilibrium back to the brain.

The "sound" that your ears detect is actually vibrations of air molecules, and will be produced by any object which itself vibrates (moves back and forth). Speech occurs when the vocal cords in your larynx vibrate; a piano produces sound when its strings vibrate; thunder is produced when rapidly heated air molecules vibrate. These vibrations are measured in hertz, or vibrations per second. The human ear is capable of detecting a wide range of frequencies from 20 to 20,000 hertz, but it is most sensitive to frequencies between 1,500 and 4,000 hertz. The greater the frequency of vibrations, or hertz, the higher pitch the sound will have.

The volume of sound is measured in decibels - essentially how far back-and-forth each vibration moves. The farther back-and-forth, the louder it will be. Zero decibels is defined as the lowest volume which the ear can detect, and each increase of 10 decibels represents a ten-fold increase in volume. Thus, 40 decibels is ten times as loud as 30 decibels, one hundred times as loud as 20 decibels, and one thousand times as loud as 10 decibels. Sound over about 120 decibels is usually painful, but even 80 or 90 decibels can damage hair cells if your exposure to it is prolonged.

Deafness, in varying degrees, can occur through a number of different mechanisms. Conduction deafness occurs when sound waves are unable to pass through the outer or middle ears to reach the inner ear. Damage to the inner ear, including the hair cells, or the vestibulocochlear nerve results in sensory deafness.
ANATOMY OF THE EAR:
We will examine the structure of the ear using diagrams from your textbook, your lab partner, and models of the ear.

1: Identify each of the following parts of the pinna or auricle on Figure 16.10 of your Saladin textbook, on your lab partner, and on a model of the ear:

<table>
<thead>
<tr>
<th>Part</th>
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<tbody>
<tr>
<td>Helix</td>
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<tr>
<td>Antihelix</td>
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<td>Concha</td>
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<tr>
<td>Tragus</td>
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<tr>
<td>Antitragus</td>
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<tr>
<td>Earlobe</td>
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<tr>
<td>External auditory meatus (opening into the external auditory canal)</td>
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</table>

On your lab partner, bend the pinna gently. Notice that all parts except the earlobe contain elastic cartilage, which is flexible but which returns to its normal shape when released. Identify his/her mastoid process and temporomandibular joint. Notice that the external auditory meatus lies between these two landmarks. Place one finger (gently) into his/her external auditory meatus and have her/him open and close the jaw. You should be able to feel the movement of the mandible through the external auditory canal. The helix, tragus, antihelix, and antitragus may or may not have hair, and this hair usually grows within the external auditory meatus as well.

- Explain to other members of your lab group how it would affect your hearing (or would it?) if your pinna/auricle was removed?

All members of your lab group: It is your responsibility to be sure this explanation is correct.

2: Identify each of the following structures on a model of the human ear using Figure 16.11 of your Saladin text as a reference.

- Outer ear: Pinna / Auricle
  - External acoustic/auditory meatus
  - Auditory canal
  - Tympanic membrane

- Middle ear: Malleus
  - Incus
  - Stapes
  - Auditory tube leading to the nasopharynx
  - Oval window closed by the foot of the stapes
  - Round window

- Inner ear: Cochlea
  - Vestibule
  - Semicircular canals (ducts)
  - Vestibulocochlear nerve passing through the internal auditory meatus
Notice how the entire structure of the ear, with the exception of the auricle, is embedded within bone. Get a skull from the cupboards in the back of the lab and be sure you understand where the ear is located.

3: Explain to other members of your lab group how vibrations of air create vibrations of the tympanic membrane, ossicles, and oval window to reach the inner ear.

Explain to other members of your lab group how it would affect your hearing if the external auditory canal were blocked

Explain to other members of your lab group how it would affect your hearing if the tympanic membrane could not vibrate

Explain to other members of your lab group how it would affect your hearing if the ossicles could not vibrate

Explain to other members of your lab group the function of the auditory tube between the middle ear cavity and the pharynx

All members of your group: It is your responsibility to be sure these explanations are correct.

4: Identify the saccule, utricle, and semicircular canals/ducts on the inner ear of the model, using Figures 16.13 and 16.14 in your Saladin text as a reference. These are actually a series of fluid-filled tubes which form part of the membranous labyrinth. The fluid they contain is called endolymph. These parts of the inner ear are not involved with hearing: they are the organs which allow you to detect the position and motion of your head. They are very important in maintaining your balance, or equilibrium.

Identify the cochlea on the model. This is the part of the inner ear which is involved in hearing. As shown in Figure 16.14 of your Saladin text, this consists of three side-by-side fluid-filled spaces which are coiled into a shape resembling the shell of a snail. The middle of these three spaces, called the cochlear duct, is part of the membranous labyrinth and is also filled with endolymph.

The membranous labyrinth fits loosely within hollow spaces in the petrous part of the temporal bone called the bony labyrinth, which is filled with a different fluid called perilymph, so the entire membranous labyrinth is floating within it. The central region of the bony labyrinth is called the vestibule, and it is to this that the oval window connects.

- Explain to other members of your lab group what fluid is caused to vibrate when the foot of the stapes at the oval window vibrates

All members of your group: It is your responsibility to be sure this explanation is correct.
5: Be sure you understand how the cochlea forms a spiral within the petrous part of the temporal bone, using Figures 16.11, 16.13 and 16.14 in your Saladin text as references. Notice how the cochlea is divided into three parallel tubes as it spirals, the scala vestibuli and scala tympani (part of the bony labyrinth and this filled with perilymph), between which is the cochlear duct (part of the membranous labyrinth and thus filled with endolymph).

Identify these three spaces on the large model. Notice further that the hair cells, which are the receptors for hearing, form part of a structure called the Spiral Organ (also called the Spiral organ of Corti) located within the cochlear duct.

FUNCTIONS OF THE EAR:
The human ear transmits sound waves through the outer ear, converts these to vibrations of the ossicles in the middle ear, then to vibrations of perilymph and endolymph within the inner ear which stimulate the hair cells of the spiral organ. Information from these receptors is then transmitted through the vestibulocochlear nerve to the medulla oblongata, from which it is relayed to the temporal lobe of the cerebrum. However, the bones of the skull will also vibrate in response to sound, and if this causes the perilymph and endolymph of the inner ear to vibrate we will also perceive sound. Thus, the inner ear and middle ear can be “bypassed” by causing the bones of the skull to vibrate directly. This is used clinically to differentiate between conduction deafness, caused by middle ear damage, and sensory deafness, caused by damage to the cochlea or vestibulocochlear nerve.

6: Close your eyes. Have your lab partner tap two pencils together two to three feet away from your head - you should be able to accurately point to where the sound is coming from. Keeping your eyes closed, have your partner continue to tap the pencils in various locations around your head. If you have normal hearing, you should always be able to accurately locate the sound regardless of where it is produced.

Repeat this test, but this time keep a finger firmly inserted in one ear to block sound from entering it. It is now much more difficult to locate the sound.

- Explain to other members of your lab group why this occurs
**All members of your group:** It is your responsibility to be sure this explanation is correct

7: Hold a tuning fork by its handle and strike it against your hand or your book to start it vibrating. Place the handle on the mid-sagittal line of your forehead (equal distance from each ear). If hearing is normal (or if you have the same type of deafness in both ears) you will perceive the tone as coming from the center of your forehead. If sensory deafness is present in one ear, the tone will be louder from the other ear. If conduction deafness is present in one ear the tone will be louder from that ear.

Repeat this test with the external auditory meatus of one ear plugged to simulate conduction deafness.
8: Hold a tuning fork by its handle and strike it against your hand or your book to start it vibrating. Always holding it only by its handle, place the tip of the handle against the mastoid process of your temporal bone with the vibrating arms facing away from the ear. You should easily be able to hear it by conduction of its vibrations through the bone of your skull.

When the sound has nearly died away, move the tuning fork so the vibrating arms are directly in front of the external auditory meatus. The sound should reappear. If hearing is normal, the tone is louder and heard longer after you move the tuning fork near the meatus. A conduction deafness is indicated if the tone is louder and longer through the mastoid process.

Repeat this test with the other ear. Then repeat it with the external auditory meatus plugged to simulate a conduction deficit.

- Explain to other members of your lab group if the tuning fork has the same pitch when you are hearing it through bone conduction or through the air. Why?

- Explain to other members of your lab group whether the sound is louder when the tuning fork is next to the ear or when it is touching your mastoid process. Why?

All members of your group: It is your responsibility to be sure these explanations are correct