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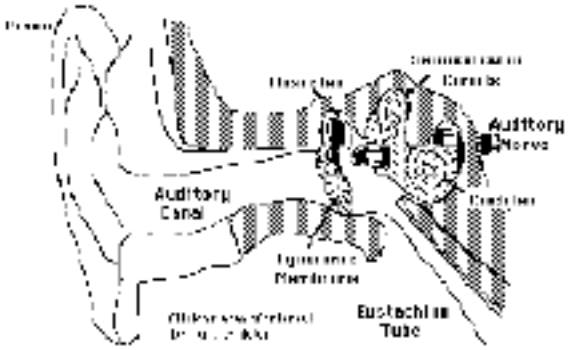
Do You Hear What I Hear? The Ear

by Matt Strauser, R & S Chair for Church Music

For the choral director, hearing is essential. Sometimes it is good to remember how wonderful hearing is. Let's consider our ears.

The three parts.

The ear has three parts: the outer, middle and inner ear. The outer ear is made of the visible ear and the ear canal. The outer ear ends at the eardrum. The middle ear contains the three bones or ossicles referred to as the hammer, anvil and stirrup. The bones of the inner ear attach to the eardrum of the outer ear and the oval window of the inner ear. The inner ear is the fluid filled cochlea and the nerve endings that transmit acoustic information to the brain.



The outer ear. How sensitive are our ears?

What happens when all acoustic stimulus is removed? An anechoic chamber is a room that is insulated from all outside sound. Complete silence fills the inside of the anechoic chamber. Yet, after a listener quietly rests in the anechoic chamber for an hour or so, sounds are heard! What are the sounds? The first sound is the beating of the listener's heart. Next is the sound of respiration and then the sound of the blood coursing through blood vessels. And then finally, between the heart beats, breathing and rushing blood, another sound is heard. It is a very soft hissing sound --- the sound of air particles beating against the eardrum! Amazingly, this sound is produced by the air particles displacing the eardrum a distance less than the diameter of a single hydrogen atom! (Everest, p26)

The middle ear. Amazing isn't it?

We know that sound travels well in water, but have you ever swam under water and tried to hear someone talking to you from the surface. It is almost impossible for the sound to refract through the air/water interface. This is

because the water is denser than air and so most of the sound is reflected back. So, if the outer ear is filled with air and the inner ear is filled with fluid, how does the sound get transferred from the air into the fluid? It turns out that the mechanical advantage of the middle ear ossicles (hammer, anvil and stirrup) along with the ratio of the sizes of the eardrum to the oval window (the counter-part of the eardrum into the inner ear) make a perfect transducer of sound from air to fluid. If it were not for this precise mechanical advantage the sound would be reflected off of the fluid-filled inner ear and nothing would be heard! (Everest, p30)

The inner ear. Measuring sound with a ruler.

The spiral shaped, fluid filled cochlea unrolls to about one inch in length. There are approximately 24,000 nerves along the length of the cochlea that transmit signals to the brain. Sound is transmitted into the inner ear by the vibration of the oval window attached to the ossicles of the middle ear. These vibrations set up a wave pattern in the fluid of the inner ear. A particular frequency will cause a peak amplitude at a particular location in the cochlea. Thus low frequency sounds stimulate the nerves at one end of the chochlea and high frequency sounds will stimulate the nerves at the other end with intermediate frequencies being sensed in between. Thus, the nerves of the inner ear work like an acoustic ruler to measure frequency. These 24,000 nerve approximate the 20 - 20,000 Hertz hearing range of the healthy ear. It is noteworthy that our ears can distinguish between a 440 Hertz 'A' and a 441 Hertz 'A'!

What a pleasure to hear beautiful music. What a privilege to be involved in making beautiful music. How wonderful is the mechanism of our hearing.

The Master handbook of Acoustics, F. Alton Everest, Tab Books, Inc., 1981
The Physics Classroom, http://www.glenbrook.k12.il.us/
Acoustical Society of America, http://www.olemiss.edu/working/clt/ASAPP
Ear sensitivity, http://hyperphysics.phy-astr.gsu.edu/hbase/sound/earsens.html

Editor's note:
As one who has lost just a few of those 24,000 nerves allowing for really sensitive hearing I've discovered that by cupping my hand behind my ear I could direct a bit more sound and thus pick up considerable acuity. So, shunning electronics, I've decided to design a device, not unlike a cross between earmuffs and Mickey Mouse ears that would fit in such a way as to increase the size of my already substantial outer ears (pinna, see

diagram above) and thus focus the sound in a natural way to both ears. I could place this device on my head during a concert and, thus, miss not a note of lovely pianissimo singing or playing.

For some reason, my wife has decided not to sit with me at the next concert. Besides, she says, it will bother those sitting behind me. I think not, for I'll build the ear pieces out of a translucent plastic so as not to impair the sightlines of those behind me. Does anyone want to go in on this with me? We could become rich! The rental fee at concert halls, alone, could bring phenomenal wealth!