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THE EAR

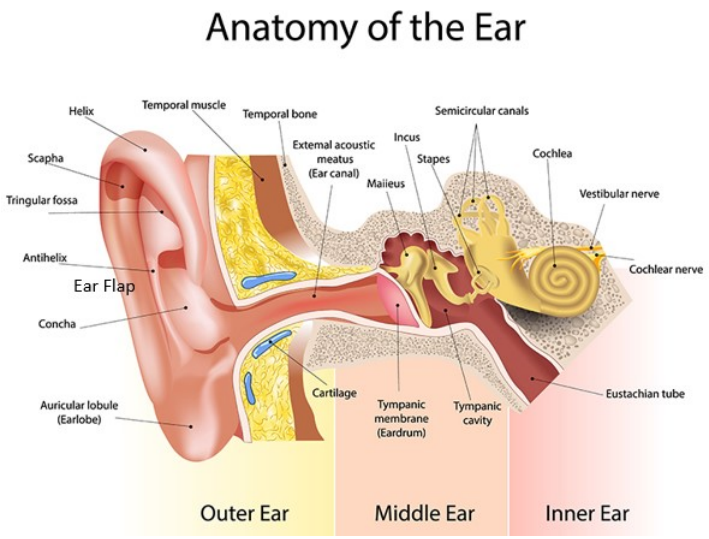
Unit Overview

This unit, as the title says, deals solely with the ears. You will learn how the ear operates, some common problems people face, and some proper care methods to maintain you hearing ability. Good luck!

The Human Ear

Understanding how humans hear is a complex subject involving the fields of physiology, psychology and acoustics. In this unit, we will focus on the acoustics (the branch of physics pertaining to sound) of hearing. We will attempt to understand how the human ear serves as an astounding transducer, converting sound energy to mechanical energy to a nerve impulse which is transmitted to the brain. The ear's ability to do this allows us to perceive the pitch of sounds by detection of the wave's frequencies, the loudness of sound by detection of the wave's amplitude and the timbre of the sound by the detection of the various frequencies which make up a complex sound wave.

The ear consists of three basic parts - the outer ear, the middle ear, and the inner ear. Each part of the ear serves a specific purpose in the task of detecting and interpreting sound. The outer ear serves to collect and channel sound to the middle ear. The middle ear serves to transform the energy of a sound wave into the internal vibrations of the bone structure of the middle ear and ultimately transform these vibrations into a compressional wave in the inner ear. The inner ear serves to transform the energy of a compressional wave within the inner ear fluid into nerve impulses which can be transmitted to the brain. The three parts of the ear are shown below.

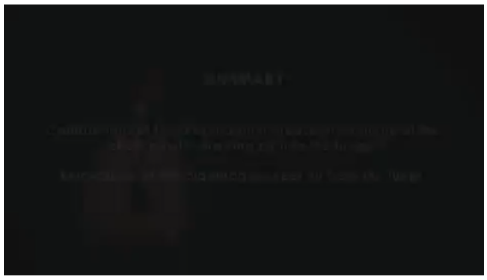


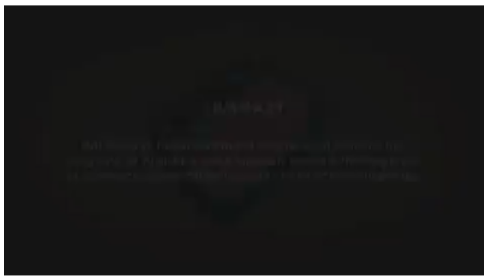
The outer ear consists of an ear flap and an approximately 2-cm long ear canal. The ear flap provides protection for the middle ear in order to prevent damage to the eardrum. The outer ear also channels sound waves which reach the ear through the ear canal to the eardrum of the middle ear. Because of the length of the ear canal, it is capable of amplifying sounds with frequencies of approximately 3000 Hz. As sound travels through the outer ear, the sound is still in the form of a pressure wave, with an alternating pattern of high and low pressure regions. It is not until the sound reaches the eardrum at the interface of the outer and the middle ear that the energy of the mechanical wave becomes converted into vibrations of the inner bone structure of the ear.

The middle ear is an air-filled cavity which consists of an eardrum and three tiny, interconnected bones - the hammer, anvil, and stirrup. The eardrum is a very durable and tightly stretched membrane which vibrates as the incoming pressure waves reach it. As shown at the right, a compression forces the eardrum inward and a rarefaction forces the eardrum outward, thus vibrating the eardrum at the same frequency of the sound wave. Being connected to the hammer, the movements of the eardrum will set the hammer, anvil, and stirrup into motion at the same frequency of the sound wave. The stirrup is connected to the inner ear; and thus the vibrations of the stirrup are transmitted to the fluid of the middle ear and create a compression wave within the fluid. The three tiny bones of the middle ear act as levers to amplify the vibrations of the sound wave.

Due to a mechanical advantage, the displacements of the stirrup are greater than that of the hammer. Furthermore, since the pressure wave striking the large area of the eardrum is concentrated into the smaller area of the stirrup, the force of the vibrating stirrup is nearly 15 times larger than that of the eardrum. This feature enhances our ability of hear the faintest of sounds. The middle ear is an air-filled cavity which is connected by the Eustachian tube to the mouth. This connection allows for the equalization of pressure within the air-filled cavities of the ear. When this tube becomes clogged during a cold, the ear cavity is unable to equalize its pressure; this will often lead to earaches and other pains.

The inner ear consists of a cochlea, the semicircular canals, and the auditory nerve. The cochlea and the semicircular canals are filled with a water-like fluid. The fluid and nerve cells of the semicircular canals provide no roll in the task of hearing; they merely serve as accelerometers for detecting accelerated movements and assisting in the task of maintaining balance. The cochlea is a snail-shaped organ which would stretch to approximately 3 cm. In addition to being filled with fluid, the inner surface of the cochlea is lined with over 20,000 hair-like nerve cells which perform one of the most critical roles in our ability to hear. These nerve cells have a difference in length by minuscule amounts; they also have different degrees of resiliency to the fluid which passes over them. As a compressional wave moves from the interface between the hammer of the middle ear and the oval window of the inner ear through the cochlea, the small hair-like nerve cells will be set in motion. Each hair cell has a natural sensitivity to a particular frequency of vibration. When the frequency of the compressional wave matches the natural frequency of the nerve cell, that nerve cell will resonate with a larger amplitude of vibration. This increased vibrational amplitude induces the cell to release an electrical impulse which passes along the auditory nerve towards the brain. In a process which is not clearly understood, the brain is capable of interpreting the qualities of the sound upon reception of these electric nerve impulses.





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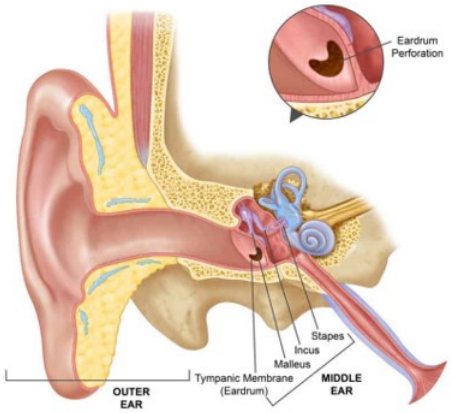
Common Ear Problems

Perforated Eardrum
A perforated eardrum is a hole or rupture in the eardrum, a thin membrane which separates the ear canal and the middle ear. The medical term for the ear drum is the tympanic membrane. The middle ear is connected to the nose by the Eustachian tube, which equalizes pressure in the middle ear. A perforated eardrum is often accompanied by decreased hearing and occasional discharge. Pain is usually not present.



The causes of perforated eardrum are usually from trauma or infection. Some examples of situations which can cause perforated ear drums are:

1) If the ear is struck squarely with an open hand.

2) With a skull fracture.

3) After a sudden explosion.

4) If an object such as a bobby pin or Q-tip is pushed too far into the ear canal.

5) As a result of hot slag from welding or acid entering the ear canal.

Middle ear infections may cause pain, hearing loss and spontaneous rupture (tear) of the eardrum, resulting in a perforation. In this circumstance, there may be infected or bloody drainage from the ear. In medical terms, this is called otitis media with perforation. On rare occasions a small hole may remain in the eardrum after a previously placed pressure equalization tube either falls out or is removed by the physician.

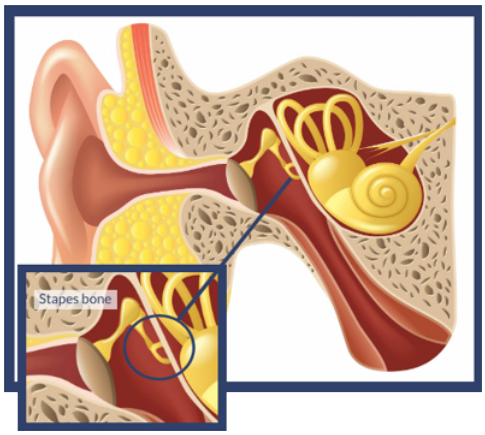
Usually, the larger the perforation, the greater the loss of hearing. The location of the hole (perforation) in the eardrum also affects the degree of hearing loss. If severe trauma (e.g. skull fracture) disrupts the bones in the middle ear which transmit sound or causes injury to the inner ear structures, the hearing loss may be quite severe. If the perforated eardrum is due to a sudden traumatic or explosive event, the loss of hearing can be great and ringing in the ear (tinnitus) may be severe. In this case the hearing usually returns partially, and the ringing diminishes in a few days. Chronic infection as a result of the perforation can cause major hearing loss.

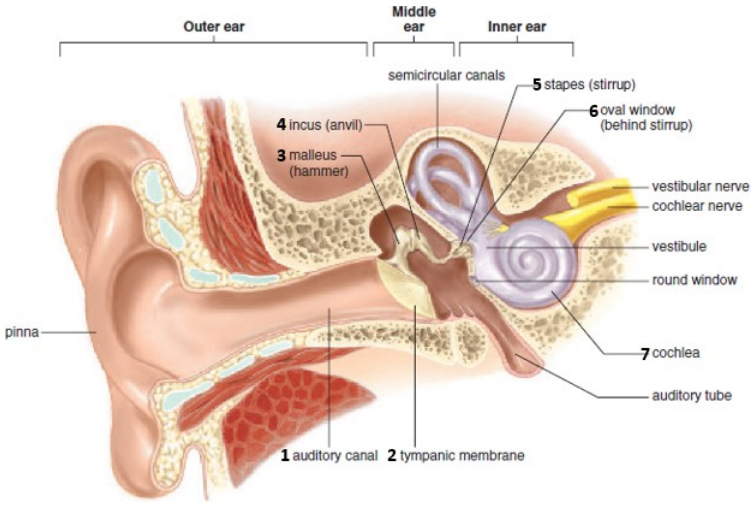
Otosclerosis
Otosclerosis is a common cause of gradual hearing loss in adults. The hearing loss is usually conductive, that is, affecting the ossicles (bones of the middle ear) that conduct sound to the inner ear. Some sensorineural, or nerve loss, may also occur. The diagram provides a representation of the parts of the ear to help understand what is affected by Otosclerosis.

Otosclerosis is a condition that affects the tiny middle ear bone known as the stapes.

The stapes can become stuck, limiting its ability to vibrate.

These vibrations are crucial for hearing





1) Ear canal, leading out to the ear.

2) Ear drum (tympanic membrane). Sound cau
head of a drum.

3), 4), and 5) The malleus (hammer), incus (ar
(stirrup), which are ossicles, or bones of the m
causes them to move, and in a chain reaction
window. Problems in the middle ear cause con

6) The oval window, a drum-like membrane se
from the inner ear. It causes fluid in the inner e
cochlea.

7) The cochlea, which changes the movement
impulses for the auditory nerve which goes to
the cochlea or along the nerve cause sensorin
loss.

The conductive hearing loss is caused by the growth of a spongy bone-like tissue that prevents the ossicles from moving well. Because of the spongy nature of this tissue, otosclerosis has also been known as "otospongiosis". Middle ear surgery can restore the conductive component of the hearing loss in many people, but it will not eliminate the sensorineural loss. Hearing aids can also be beneficial in cases when surgery is not recommended or when an individual does not wish to accept the risks of surgery. The cause of otosclerosis is not yet known, but researchers have some good clues which hopefully will provide a way to prevent the loss of hearing.

Caring for your Ears

Cleaning
Your ear produces wax (called cerumen) to protect itself. Wax and tiny hairs inside the ear canal prevent small objects getting down inside the ear.

The ear has a clever mechanism for cleaning itself. There is a natural movement of old skin, wax and dirt away from the eardrum toward the outer end of the ear canal. This means that all you need to do to clean your ears is to regularly wipe around the outside of the ear with a damp cloth.

If a build up of wax blocks the ear canal, special ear drops (available from a pharmacy) may soften the wax. Sometimes a visit to your doctor may be necessary in order to physically remove the blockage.

The old saying that you should never put anything in your ear smaller than you elbow is true! That's because placing anything into the ear has the potential to cause damage.

However, if something does somehow become lodged in the ear, seek expert advice about having it removed. You, a parent or well meaning friends should never attempt to remove it.
So the rule is don't poke around in your ear yourself. If there's a problem, get professional advice.

Protecting
Noise is vibration that causes a response in the human ear. Scientifically speaking, noise and sound are the same thing. One person's noise can be another person's symphony. Excessive exposure to loud noise can damage the delicate mechanism of the ear. In a short time you can develop a temporary loss of hearing which can become permanent over an extended period of noise exposure.

You could be damaging your hearing if it's so noisy that you need to shout to talk to someone an arm's length away, of if your hearing seems dull or your ears are ringing after leaving a noisy situation.

The best action to take if you are exposed to loud noise is to either remove the noise or remove yourself from the noise. The use of earplugs or ear muffs is not the best solution, although they can reduce the risk of hearing damage. If you use hearing protectors, be sure to follow all instructions carefully to ensure best protection.

Sources of loud noise can be:

- Mechanical plant or machinery
- Power tools
- Lawnmowers
- Compressed air sources
- Loud music at concerts or entertainment venues
- Personal music players (e.g. Walkmans)
- Shooting
- Engines

If you think a noise is too loud, it probably is!

Water
If you have grommets (vibration tubes), a perforated eardrum or an ear infection, you will need to keep water out of your ears when swimming or bathing. The doctor will advise you about what precautions you should take. If any doubt, discuss the matter with your doctor.

Drugs and Chemicals
Some medications have the potential to harm hearing if used over an extended period of time or in high doses. Tell your doctor immediately if, on taking prescribed drugs, your ears start to ring. If you use chemicals at work or for a hobby at home, take a few minutes to study the Material Safety Data Sheet that should be supplied with the chemical. Some chemicals interact with noise to make the overall effect worse.

Infections
Ear infection is very common in young children and can cause considerable pain and temporary hearing loss.

The outer ear can easily pick up infection while swimming, particularly in unclean water, while the middle ear can become infected as a result of upper respiratory tract infections or colds or flu. If there is any sign of infection in or around the ear, do not try and treat it yourself. See your doctor.

Diseases

There are many diseases that can result in a hearing loss such as measles, mumps, rubella (German measles), meningitis and sometimes even a bad case of the flu.

If rubella is contracted during the first three months of pregnancy, the unborn baby has a 90% chance of having significant hearing loss (and many other complications). This is why rubella immunization is very important

Trauma
Some physical injuries have the potential to cause a hearing loss, such as a blow to the head while playing football, damage to the neck in a car accident, or damage to the eardrum while scuba diving.

Hearing Tests
If you are concerned about your hearing, discuss them with your family doctor, or seek the advice of a hearing professional such as an audiologist who can assess your hearing and offer you advice.