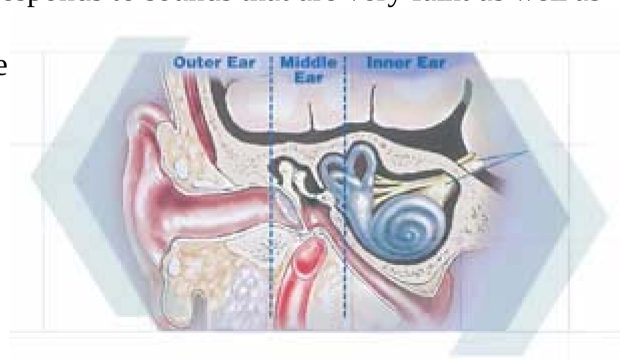
American Speech-Language-Hearing Association

Making effective communication, a human right, accessible and achievable for all.

How Hearing & Balance Work

Hearing is one of the five senses. It is a complex process of picking up sound and attaching meaning to it. The human ear is fully developed at birth and responds to sounds that are very faint as well as sounds that are very loud. Even in utero, infants respond to sound. The ability to hear is critical to the attachment of meaning to the world around us.



So, how does the ear and hearing mechanism work?

Five Sections of the Hearing Mechanism

1. Outer ear
2. Middle ear
3. Inner ear
4. Acoustic nerve
5. Brain' s auditory processing centers.

The **outer** ear consists of the *pinna*, *or auricle* and the ear canal (*external auditory meatus*). The pinna - the "ear" that we see on each side of our heads - is made of cartilage and soft tissue so that it maintains a particular shape but is also pliable. The pinna serves as a collector of sound vibrations around us and funnels the vibrations into the ear canal. It assists us in determining the direction and source of sound.

The ear canal is about an inch long and ¼ inch in diameter. It extends from the pinna to the eardrum (*tympanic membrane*). The outer foundation of the ear canal is cartilage covered with skin that contains hairs and glands that secrete wax (*cerumen*). The hairs and wax help to prevent foreign bodies, such as insects or dust, from entering the ear canal. Near the eardrum (*tympanic membrane*), the wall of the ear canal becomes bony and covered tightly by skin.

The **middle ear** begins with the eardrum at the end of the ear canal. The middle ear contains three tiny bones called the *ossicles* . These three bones form a connection from the eardrum to the inner ear. As sound waves hit the eardrum, it moves back and forth causing the ossicles to move. Thus the sound wave is changed to a mechanical vibration.

The first bone, the hammer (*malleus*) is connected to the eardrum. The hammer connects to the second ossicle, the anvil (*incus*), and then the anvil connects to the third bone, the stirrup (*stapes*). The mechanical energy transmitted through the three bones (*ossicular chain*) causes the in-and-out movement of the base of the stirrup (*stapes footplate*) in patterns that match those of the incoming sound waves. The stapes footplate fits into the oval window, the beginning point of the inner ear.

The middle ear is located in the *mastoid* section of the *temporal bone* (a skull bone on each side of the head) and is filled with air. A tube called the *eustachian tube* runs from the front wall of the middle ear down to the back of the nose and throat (the *nasopharynx*). This tube provides ventilation and access to outside air and equalizes air pressure on both sides of the eardrum -- the middle ear side and the outer ear side. We are aware of the eustachian tube at work when we feel air pressure changing in our ears as we yawn, chew, or swallow.

Because of the facial and skull structure of children, the eustachian tube is in a rather flat position between the middle ear and the nasopharynx rather than in the downward slanting position from the middle ear to the nasopharynx in adults. The flat positioning of the tube in children creates risk for infection traveling from the nasopharynx into the middle ear.

The **inner ear** contains the sensory organs for hearing and balance. The *cochlea* is the hearing part of the inner ear. The *semicircular canals* , the *utricle* and the *saccule* are the balance part of the inner ear.

The cochlea is a bony structure shaped like a snail and filled with fluid (*endolymph and perilymph*). The *Organ of Corti* is the sensory receptor inside the cochlea which holds the *hair cells* , the nerve receptors for hearing.

The mechanical energy from movement of the middle ear bones pushes in a membrane (*the oval window*) in the cochlea. This force moves the cochlea's fluids that, in turn, stimulate tiny hair cells. Individual hair cells respond to specific sound frequencies (pitches) so that, depending on the pitch (frequency) of the sound, only certain hair cells are stimulated.

Signals from these hair cells are translated into nerve impulses. The nerve impulses are transmitted to the brain by the cochlear portion of the acoustic nerve (VIII cranial nerve).

The **acoustic nerve** carries impulses from the cochlea to a relay station in the mid-brain, *the cochlear nucleus,* and on to other brain pathways that end in the auditory cortex of the brain. At the cochlear nucleus, nerve fibers from each ear divide into two pathways. One pathway ascends straight to the auditory cortex on one side (hemisphere) of the brain. The other pathway crosses over and ascends to the auditory cortex on the other side (hemisphere) of the brain. As a result, each hemisphere of the brain receives information from both ears.

The **central auditory system** deals with the processing of auditory information as it is carried up to the brain. Central auditory processes are the auditory processes responsible for the following behaviors:

- Sound localization and lateralization
- Auditory discrimination (hearing the differences between different sounds)
- Recognizing patterns of sounds
- Time aspects of hearing (temporal aspects of audition): temporal resolution, temporal masking, temporal integration, temporal ordering
- Reduction in auditory performance in the presence of competing acoustic signals
- Reduction in auditory performance in the presence of degraded (less than complete) acoustic signals

Balance

Balance, or one' s sense of equilibrium, is controlled through the *vestibular* system that is also contained in the inner ear. The vestibular organs share the temporal bone space with the cochlea. These organs also share the same fluid that is in the cochlea.

Balance and equilibrium help us stay erect when standing, know where we are in relation to gravity, and help us walk, run, and move without falling. The functioning of the vestibular system depends on information from many systems, hearing as well as vision and muscle feedback.

The vestibular system consists of three *semicircular canals* , the *utricle* , and the *saccule* . Each of the semicircular canals lies anatomically in a different plane, each plane at a right angle to each other. Thus, each deals with different movement: up and down, side to side, and tilting from one side to the other. All contain sensory hair cells that are activated by movement of inner ear fluid (endolymph). As the head moves, hair cells in the semicircular canals send nerve impulses to the brain by way of the vestibular portion of the acoustic nerve (VIII cranial nerve). These nerve impulses are processed in the stem of the brain and in the brain's cerebellum.

The ends of the semicircular canals connect with the utricle, and the utricle connects with the saccule. While the semicircular canals provide information about movement of the head, the sensory hair cells of the utricle and saccule provide information to the brain (again through the vestibular portion of the acoustic nerve) about head position when it is not moving.