SCOP Hearing and Vision

Hearing

Sound waves are created by **vibration in matter**. That is, sound waves are **mechanical waves**; they require matter as a medium to travel through. In particular, sound waves are **longitudinal**: they propagate in the same direction as their displacement. Human hearing is designed, on average, to detect sounds with **frequencies** (number of vibrations per second) between 20 Hertz (Hz) and 20,000 Hz. This is one of the widest ranges among animals.

The **ear** is designed to convert vibration into a bioelectric signal which is sent to the brain for analysis. In this sense, the ear is a natural **transducer**, a device that converts a signal from one form of energy into another. The ear can be divided into three areas.

The **outer ear**'s most notable feature is the **pinna**, which is the visible portion of the ear. It is designed to act more or less as a "funnel" for sound waves, directing them toward the **auditory canal**, the passage that leads to the middle ear.
The **middle ear** starts with the **tympanic membrane**, or **eardrum**. When sound waves reach this membrane, it begins to vibrate. Behind the tympanic membrane are three small bones, the smallest ones in the body. First is the **malleus** ("hammer"), then the **incus** ("anvil"), and last is the **stapes** ("stirrup"). As the tympanic membrane vibrates, so do these three bones.
The **inner ear** consists essentially of a single organ called the **cochlea**, which resembles a snail's shell. The stapes attaches to the cochlea at an interface called the **oval window**, where the vibration passes from the stapes into the cochlea. The interior of the cochlea is filled with fluid, and lined with several hair cells called the **organs of Corti**. As the vibration passes through the fluid, it causes some combination of these hairs to vibrate and initiate nerve impulses to the brain.

The cochlea serves one other important function unrelated to hearing. On top are three **semicircular canals** arranged along three different planes. The fluid in these canals moves different hair cells, which in turn sends signals to the brain about the orientation of the head. Thus, a person who spins may experience dizziness because the fluid sloshes around differently than the actual movement of the head.

Hearing Disorders

Deafness can result from damage to the auditory center to the brain, or to the auditory nerve that connects the cochlea to the brain. It can also be caused by the over-calcification of the three small bones. This can be corrected surgically, or in some cases with a hearing aid. If the cochlea is damaged, a cochlear implant near the ear may be helpful. Over time, people tend to lose the acuity in hearing higher frequency sounds. Exposure to loud sounds over time can destroy the cochlea's ability to hear low frequency sounds.

Tinnitus is the very common perception of a high-pitched ringing sound when there is none, generally caused by overexposure to loud noise or infection.

Vision

The **eye** is considered by some to be a part of the brain. It is designed to detect light waves and convert these light waves into signals sent to the visual center of the brain; thus, it too is a transducer.

Light enters the eye by passing through the transparent outer covering called the **cornea**. The eyeball is completely covered by a membrane called the **sclera**, which is transparent only in the front and white elsewhere. The light then enters the eyeball by passing through an opening called the **pupil**, which can be opened or closed by the muscular **iris**, which is the part of the eye that is colored.. When the eye is exposed to bright light, the iris contracts, making the pupil smaller; in low light, the iris relaxes, making the pupil wider. Once light passes through the pupil, it is refracted by the clear **lens** of the eye.
The eyeball itself is filled with a fluid called the **vitreous humor**. Past the vitreous humor, the back and sides of the eyeball are coated in light receptor cells called the **retina**, a bed of capillaries that forms unique patterns in each person. Hence, a computerized scan of the retina through the pupil can act as a fingerprint that is not easily copied. The only part of the back of the eyeball that is not covered with light-sensing cells is the point where the optic nerve attaches to the retina. In the field of vision, this causes a "blind spot".

Two different types of cells act as light receptors. **Rods** are light-sensitive and detect only in "black-and-white"; their activation is only based on whether or not light is present. When light strikes a rod, a chemical reaction takes place inside the rod, and a nerve impulse is initiated. **Cones** come in three varieties and are responsible for color vision. Each type of cone has maximum reactivity to light waves with frequencies corresponding to the colors red, blue, and green.

Vision Disorders

As with hearing, damage to the visual center of the brain or the optic nerve can result in **blindness**.
Color blindness is due to an X chromosome-linked recessive gene, making this disorder more common in males. One of the cones is not coded for, and hence individuals see that color as a shade of gray. Blue color blindness is extremely rare, but green and red colorblindness each occur in about 2% of the population.

Myopia, or **nearsightedness**, results from the eyeball being misshapen, causing distant objects to be out of focus. This can be corrected with concave lenses.
Hyperopia, or **farsightedness**, results from the opposite defect in the eyeball, causing near objects to appear out of focus. This is corrected with convex lenses.
Astigmatism is a lack of focus in vision caused by a misshapen lens or cornea; it is aided with corrective lenses.

Cataracts are a clouding of the cornea, and the leading cause of blindness in the world. The major cause, other than as a side effect of other diseases, is increased exposure to ultraviolet and other high-energy radiation. Today, donor corneas can be transplanted to correct the problem, though partial removal of the lens is also a possible treatment.
Glaucoma is a condition which results from the death of the retina because of the collapse of the artery that feeds it after increases in pressure in the vitreous humor. High blood pressure can lead to this condition in some individuals.