WORKINGKNOWLEDGE

COCHLEAR IMPLANTS

To Hear Again

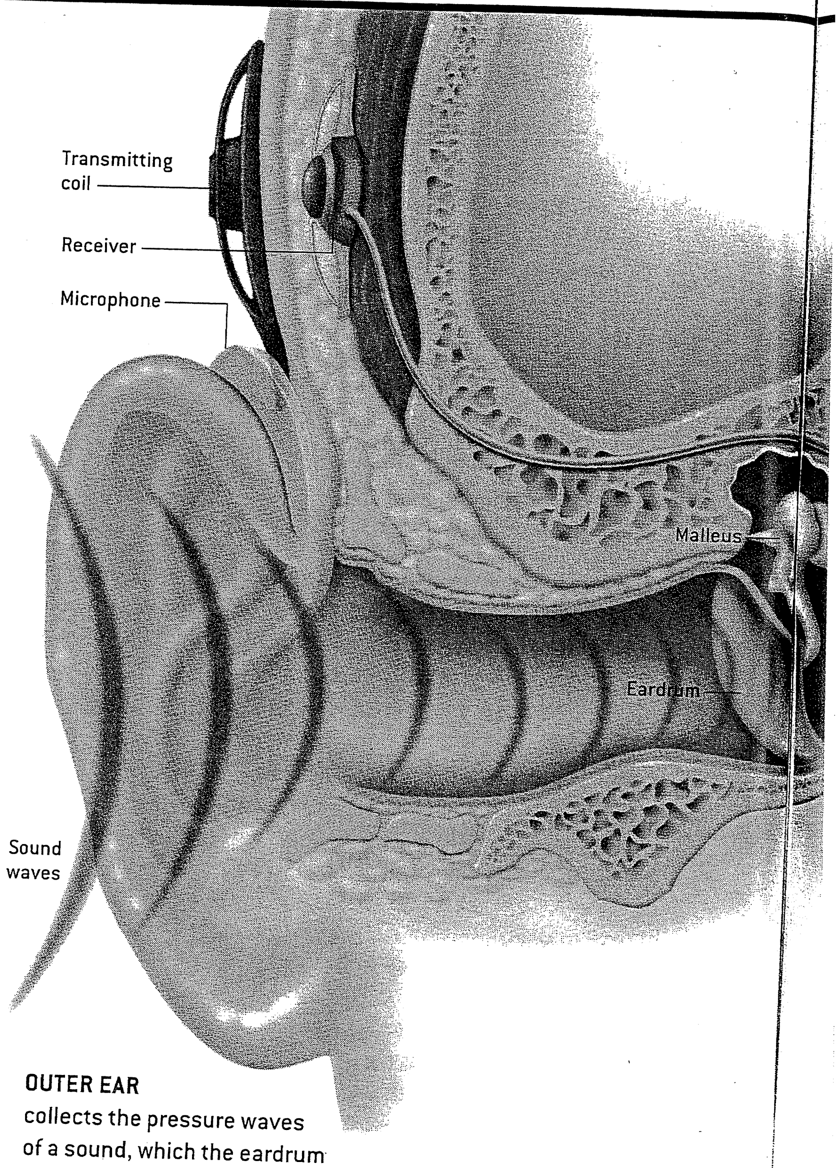
We hear when the cochlea, in the inner ear, stimulates the auditory nerve. Deafness occurs most commonly when tiny hair cells inside the cochlea are damaged as a result of a genetic defect, infection, loud noise or aging. Cochlear implants bypass the damage by receiving and converting sound into signals sent along electrodes to cells adjacent to the auditory nerve.

Worldwide, more than 40,000 children and adults depend on cochlear implants. Certain hair cells lining the cochlear ducts alongside auditory neurons are tuned to respond to specific frequencies. Therefore, implants such as the Nucleus or the Clarion have from eight to 22 electrodes that surgeons place at different positions to maximize the range of frequency stimuli forwarded to the brain. Recent research indicates that more electrodes won't improve performance as much as optimizing their placement; most implant wearers perceive loudness properly but can still have trouble sensing pitch correctly, making speech comprehension difficult. "Something is preventing the brain from extracting or assimilating all the coding information," says Philip Loizou, a professor of electrical engineering at the University of Texas at Dallas. "We don't know what yet."

The sooner a person receives an implant after becoming deaf, the more likely he will adapt to the new sound input; people who have been deaf for years do not respond as well because of degeneration in the cochlea or auditory nerve. Typically, success means the wearer can hear moderate and perhaps soft sounds, can communicate without lip reading or signing, and may be able to converse over the telephone. Completely normal hearing is still uncommon.

To help, engineers are trying, among other things, to tailor signal-processing algorithms for particular situations. People with implants often have trouble perceiving speech clearly in noisy environments and appreciating music, which has complex waveforms. Today's implant processors come with a general algorithm, but perhaps they could store specialized ones as well. "That way," Loizou says, "an individual could select an algorithm depending on whether he was talking at home, eating in a noisy restaurant or sitting at a concert."

—Mark Fischetti



ALICE Y. CHEN

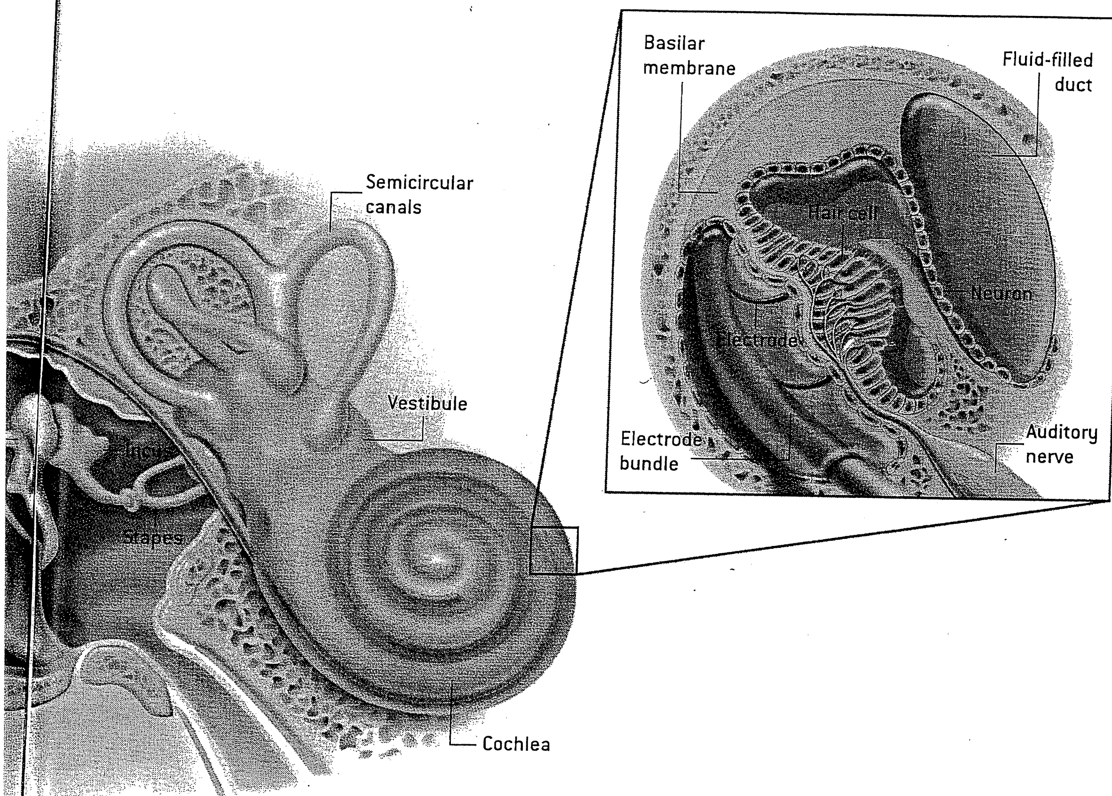
OUTER EAR collects the pressure waves of a sound, which the eardrum converts into mechanical vibrations in tiny bones in the middle ear. The oscillating stapes sets off pressure waves within the fluid in the cochlea, which in turn stimulate nerve cells on the auditory nerve that leads to the brain.

DID YOU KNOW . . .

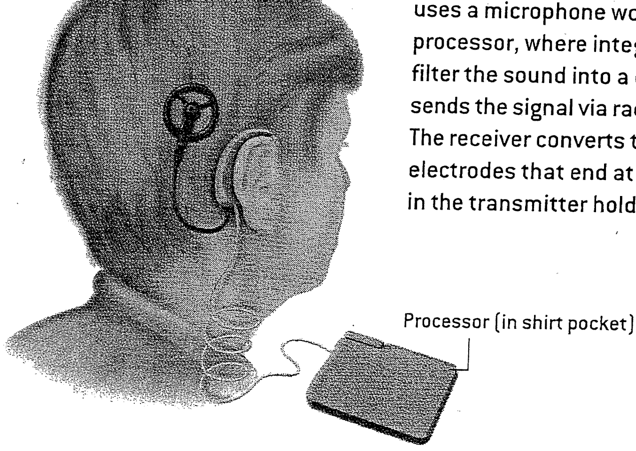
➢ LOUD! Audiologists measure how loud a test signal must become before a person can hear it. The normal threshold is anything up to 15 decibels. People who have "moderate" hearing loss require a signal of 41 to 55 dB; "severe" loss, 71 to 90 dB; and "profound" loss, 91 dB or greater. Typical conversation rings in at 40 to 50 dB; freeway traffic at 50 feet, 70 dB; and a blender, 90 dB. Only people with severe or profound loss in both ears qualify for cochlear implants.

➢ HAIRPIN TURN: Tipping the head forward, back or to the side tilts a gelatinous substance inside the vestibule, beside the cochlea. The shifting gel bends hair cells that tell attached nerve fibers which way the head is headed, so the brain can keep the body upright. Similarly, hair cells inside three fluid-filled semicircular canals, at right angles to one another just above the cochlea, respond to sudden changes in the head's velocity, to maintain balance.

➢ HARD ON HEARING: In its "Position Statement on Cochlear Implants," the U.S. National Association of the Deaf notes that the technology doesn't always work. It also discourages the use of implants in children who are born deaf or become deaf before learning language, because even with the technology, it is very hard for them to develop the cognition for spoken language. Meanwhile the children are often not taught visual, or sign, languages, which "can result in developmental delays that can be extremely difficult to reverse."



COCHLEA transmits pressure waves through its duct fluid, displacing the basilar membrane, which bends hair cells to various degrees. The cells release neurotransmitters that cause attached neurons to fire, telling the brain where along the duct the bending has occurred (which corresponds to the frequency of the original sound) as well as the amplitude of the bending (which indicates the loudness).



COCHLEAR IMPLANT uses a microphone worn behind the ear to pick up sound and send it to a processor, where integrated circuits and algorithms amplify, digitize and filter the sound into a coded signal sent to the transmitter coil. The coil sends the signal via radio waves through the skin to an implanted receiver. The receiver converts the waves into electrical impulses that travel along electrodes that end at cells at certain points along the cochlea. A magnet in the transmitter holds it against the implanted receiver.

This month's column was suggested by reader Thomas Boehm. Have a topic for a future column? Send it to workingknowledge@sciam.com