# Cochlear Implant Brings Sound And Language To Thousands

University of California, San Francisco (UCSF)

An electronic hearing device developed by neuroscientists at the University of California, San Francisco gives the gift of sound to thousands of people who have lost their hearing and brings normal language to people who have been deaf since birth.

One of the most remarkable technologies ever developed for people with hearing loss is the cochlear implant. An amazingly complex, micro-machined electronic device that stimulates the acoustic nerve to replace the excitatory function of a pathologically destroyed ear, the cochlear implant has led to restored hearing in people with advanced hearing loss and established normal language use in people who have been deaf since birth. Though the device has been somewhat controversial within the deaf community, it is nothing short of a miracle for people who use it.

Michael Merzenich, Ph.D., and his colleagues at the University of California, San Francisco led research on the development of cochlear implants in the1970s and 80s. Merzenich, a neuroscientist, has spent his career investigating the neural origin of higher brain functions and the remediation of human neurological dysfunction and disability. His lab focuses on defining the neural bases of learning, recognition and memory, defining the mechanisms that underlie functional disabilities, and developing strategies for remediating learning-disabled children and adults. The cochlear

implant is one of a number of commercial products that has emerged from those varied interests and pursuits.

> *It is one of the most sophisticated electronic devices that's implanted into humans.*
>
> Michael Merzenich

The university licensed the technology in 1988 to a cardiac pacemaker manufacturer, which created a subsidiary called Advanced Bionic, now a subsidiary of Boston Scientific, to develop and market the technology.

Merzenich and his team developed novel strategies to electrically stimulate the auditory nerve array in the inner ear with patterned stimulation that generated sensory inputs designed to simulate those generated in a normal, intact ear. Though the Merzenich team was the worldleading research group in this area, they didn't patent their inventions until they began to search for a company that could manufacture the device.

**Studies Began in the 1950s**

Researchers had been working on the problem since the 1950s, wondering whether it might be possible to replace the electric signals from the missing hair cells in people who had hearing loss, especially those who had intact auditory nerves. Initial efforts to create a cochlear implant were met with a great deal of skepticism and daunting technical obstacles.

In parallel, the communication industry had been working to reduce the information in a speech signal without losing its intelligibility. Spearheaded largely by AT&T's Bell Laboratories, these early voice coders simplified the designs of the coding stages for the cochlear implant. Merzenich's inventions were based in part on that technology.

Merzenich says that the first patent was very general, covering the basic idea behind the technology: the patterned replacement of sound that would simulate the activation that occurs in an intact ear. The ear of a non-hearing person lacks the tiny hairs that act as transducers to stimulate the auditory nerve, creating sound. The cochlear implant directs the electrical simulation input of complex sounds. Later patents described specific features that were critical to the successful application of the device.

**Distinct From Hearing Aids**

Cochlear implants are not the same as hearing aids. Surgically implanted to replace the function of the ear, they are used in patients whose deafness is complete, or almost so. Hearing aids amplify sounds and are created to target specific areas of the auditory nerve to make up for hearing loss.

In contrast, the cochlear implant  stimulates the whole auditory nerve array with patterned electrical signals to simulate normal nerve input in a way that would be expected to generate sound in an intact ear. It is more sophisticated, complex and costly than a hearing aid; it also is extremely difficult to manufacture, requiring complex micromachining, microfabrication and engineering.

"Each implant has hand-fabricated components and very complicated electronics," Merzenich says. "The engineering development in this product has been substantial." Merzenich estimates that each device costs $5,000 to $10,000 to manufacture with appropriate quality assurance. "Quality assurances are crucial," he says, "because these devices are designed to last a lifetime."

The implant was developed for those with the most severe hearing loss, but it is being applied more and more frequently to patients with marginal hearing. One of the most famous people to receive a cochlear implant is radio talk show host Rush Limbaugh, whose career was on the line because his hearing loss was so severe.

The cochlear implant technology, while embraced by the medical community, has met with some resistance in the deaf community. Merzenich says it is difficult for deaf families — especially those who have always been deaf — to deal with a hearing child, or even to understand why anyone would want to treat the nonhearing child.

"It isn't surprising that deaf individuals can be a little insulted by the notion that deafness is an unacceptable condition that demands treatment," he says. "It's not an entirely unjustified fear that deaf children implanted with the device can become aliens in their own families and communities."

**Understanding Sounds**

The "ah-ha" moment for Merzenich and his colleagues came in 1979 or 80, when patients equipped with the technology, sitting in a sound room, "began to understand everything the scientists were saying to them through the cochlear implant-mediated hearing alone."

When a deaf person with a cochlear implant is first exposed to speech, they usually cannot understand what they're hearing, according to Merzenich. "Speech sounds distorted or robotic," he says. "But, in time, about 90 percent of the patients come to understand almost everything that's said to them."

More than 20,000 patients have received Cochlear implants since the technology was patented in 1980.

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