THE DEPARTMENT OF OTOLARYNGOLOGY at The University of Melbourne commenced on the 1st of January 1970. It was established because otolaryngology had become a major specialty and one of importance to medical students: 15 per cent of referrals in family medicine can be attributed to conditions of the ear, nose and throat. The Chair was the first in Australasia and was also meant to have a significant role outside The University of Melbourne.

Teaching, in the case of undergraduate medical students, has focused on special formal lectures at different stages during the course, clinical training associated with the Clinical Schools, and examination for the Hedley F Summons Prize in Otolaryngology. The Department of Otolaryngology has also encouraged undergraduate medical students to take a year off during their course and carry out research or a Bachelor of Medical Science degree. This has been a successful venture and Melbourne University's medical students have played a major role in research relating to the development of a cochlear implant (Bionic Ear) for profoundly deaf children and adults. The postgraduate educational activities of the Department have primarily been concerned with the training of professionals in audiology. The Department established the first course in audiology in this country and it still runs the major training course in this discipline in Australia: 42 students have graduated over the last twenty years and a proportion returned to Europe and South East Asia. The training leads to a postgraduate Diploma in Audiology. The units in this postgraduate diploma are: acoustics, anatomy and physiology, otology, perception of sound and speech, general audiology, paediatric audiology, aural rehabilitation, hearing aids and other sensory devices, and audiology and the hearing impaired child. Advanced studies can be undertaken for a Master's degree by coursework in audiology, in which case special studies take place. Postgraduates in medicine can receive training through a postgraduate Diploma in Laryngology and Otology, and more recently, a Master's degree in Audiology and Otoneurology or Otolaryngology. The Department has been active for twenty years in training postgraduate students for Master of Science and Doctorate of Philosophy degrees. It has approval from the Faculty of Science to conduct research for both Bachelor of Science Honours and Master's degrees within the Faculty of Science.

The research of the Department has focused primarily on the development of a multiple-channel cochlear implant, or Bionic Ear, for profoundly-to-totally deaf people. This work started when the department was first established in 1970. At the time it was generally considered that it was not possible to give people hearing by direct electrical stimulation of residual hearing nerves, and therefore funding for the research was extremely difficult. The initial research received significant support from the Telethon undertaken by Channel 0 (10) from 1973 to 1976. The Department was also awarded a National Health and Medical Research Council Project Grant in the 1970s that enabled basic research to be done. The development of prototypes and work leading to its industrialisation was then supported by a Commonwealth Government Public Interest Grant in 1978.

After a series of biological and surgical studies, as well as engineering work in collaboration with the Department of Electrical Engineering at The University of Melbourne, a prototype Bionic Ear was achieved and implanted in the first patient in 1978. This patient had been totally deaf for two years following a head injury. A series of studies was undertaken on this patient to see what he perceived when stimulating different electrodes. The first important finding was that he experienced different pitch sensations depending on the site or rate of stimulation; but initially it seemed difficult to find a suitable code to convey speech information. Further studies on the patient, however, led to the clues that resulted in a successful speech processing strategy being achieved. This extracted particular speech frequencies of importance for intelligibility, particularly for consonants - these are called second formants. Voicing was conveyed by rate of stimulation and the speech amplitude by current strength.

In 1979, we established for the first time that it was possible for a profoundly deaf person to understand running speech when electrical stimulation was combined with lipreading, and also when electrical stimulation was used alone. This was a major advance at the time, and it raised the possibility of taking this research through to industry and having devices developed commercially. This was achieved through the Public Interest Grant awarded to the Department of Otolaryngology. Tenders were sought to develop the device commercially and the Australian pacemaker firm, Teletronics, was the successful tenderer. Its parent, the biomedical firm, Nucleus, and its subsidiary, Cochlear Pty Limited, developed the cochlear implant for clinical trial for the United States Food and Drug Administration (FDA), and this was first implanted by The University of Melbourne team at The Royal Victorian Eye and Ear Hospital in 1982. It was shown to be effective and successfully implemented the initial research findings from the Department of Otolaryngology. This was trialled in a number of centres in the United States, West Germany, Melbourne and Sydney and was shown to be both safe and effective and approved by the US Food and Drug Administration in 1985. This was the first time the US Food and Drug Administration had approved a multiple-channel device for use in adults, and it is still the only multiple-channel device to have received approval to this day.

At about this time it was realised there was a need to carry out further research to improve the cochlear implant so that as wide a range of people as possible could benefit. The Department of Otolaryngology was awarded a NHMRC Program Grant in 1985 to help undertake the necessary research. In addition, it received a US National Institutes of Health (NIH) Grant in 1984 to carry out cochlear...
implant research. This was the first time the NIH had awarded a grant in this area outside the United States. In 1985 the Department of Otolaryngology received an NIH contract to further develop speech processing for the cochlear implant, and in 1986 an NIH contract to study biological safety for implantation in young children.

The success of the cochlear implant has also led to the possibility of other hearing prostheses for deaf people. One of these possibilities is the use of a cochlear implant in one ear, combined with information transmitted via a special speech processing hearing aid in the other ear. Another possibility is the use of two Bionic Ears so that a two-ear advantage for improving the signals in noisy backgrounds can be experienced. The development of a Tickle Talker, or electrotactile method of presenting speech to the digital nerve bundles on the non-dominant hand is in progress. The development of speech processing hearing aids for people who have some residual hearing but do not get adequate help with their conventional hearing aids is being initiated. A central brainstem implant for direct implantation into the cochlear nucleus in the case of people who have lost the hearing nerves and cannot be stimulated by a cochlear implant has commenced. There is also important research being undertaken in the Department which has led to the development of a means of analyzing evoked potentials from the scalp in response to complex acoustic stimuli, and is a great help in accurately diagnosing a hearing loss at all speech frequencies.

The research to develop a variety of hearing prostheses was supported in 1988 by the award of a Special Research Centre for Human Communication Research to the Department of Otolaryngology from the Australian Research Council and Commonwealth Department of Employment, Education and Training. This Special Research Centre has been actively involved in a number of areas of research, and this has led to improvements in speech processing for the cochlear implant that has kept the Australian cochlear implant the leading device in international markets. The Australian firm, Cochlear, has 90 per cent of the world market. As at July 1993 over 7,000 people, including 2,750 children, have been implanted worldwide in 38 counties and more than 30 languages.

A bimodal speech processor, or Combionic aid, has been taken to the prototype stage for initial clinical trial. This aid, which combines an implant in one ear and a hearing aid in the other, has been tested now through the Melbourne University’s clinic at The Royal Victorian Eye and Ear Hospital as well as at the Denver Ear Institute. Furthermore, a means of diagnosing hearing loss accurately, even in one-day-old babies, has been researched and is now being developed commercially by industry.

More recently, the Department of Otolaryngology’s work led to the award of a Co-operative Research Centre from the Department of Prime Minister and Cabinet for Cochlear Implant Speech and Hearing Research. The core parties for this Co-operative Research Centre are The University of Melbourne, in particular the Department of Otolaryngology, the Australian Cochlear Implant Hearing Research Institute, Australian Hearing Services and Cochlear Pty Limited. The supporting parties are The Royal Victorian Eye and Ear Hospital, Taralye, St Mary’s School for Deaf Children, The Royal Prince Alfred Hospital, Sydney, The Royal Alexandra Hospital, Sydney, and The University of Sydney. The aim of this centre is to further develop the products that have already arisen from the basic research at The University of Melbourne, and carry out research leading to other devices. The particular devices being researched and developed at the moment are an advanced Bionic Ear, a Combionic Aid, a new generation of speech processing hearing aids, the Tickle Talker and brainstem implants for comprehension speech and language program.

As far as future directions are concerned, much has been accomplished with the Bionic Ear and other hearing prostheses, but much remains to be done. Our goal is to see that most people (children and adults with severe to profound hearing loss) can communicate normally and understand environmental sounds. To achieve this goal we will be necessary to learn more about how the brain codes sounds and how this can be transmitted by direct electrical stimulation of the hearing nerve. To know how best to help children, basic studies are also required to determine when the auditory brain is plastic, how it develops neural links to speech sounds and how this ability is affected by different modes of electrical stimulation with the Bionic Ear.

Not only is it necessary to have a greater understanding of how the brain functions at a physiological level, but it is important to know how the complex patterns of electrical stimulation produced by the Bionic Ear are perceived. The perception of simple and complex stimuli can lead to a knowledge of how the brain processes speech, particularly for electrical stimulation. Along with this research on further improving the Bionic Ear, there is also a need to learn why there is variation in patient results, and how patients with below average performance can benefit.

With children, present trends indicate that they should receive a Bionic Ear at a young age, and research will need to focus on issues that are relevant to this special group. This includes biological safety, assessment and training procedures. It will also be important to learn how children best learn language and to speak with a good quality voice. Finally, we must learn how these children are most effectively integrated into the hearing world.

As most people with a hearing loss have difficulty understanding speech in the presence of background noise, a significant part of our research will need to be directed to improving this situation. This may involve improvements in microphone design, ‘intelligent’ speech processing to ‘listen’ selectively to certain sounds, and the use of Bionic Ears in each ear. Two normal hearing ears are a big advantage when listening in noise, as they enable the noise to be cancelled out when signals reach the brain, with the signals of importance still processed. Bionic Ears in each ear may also allow us to improve overall speech perception in quiet, by presenting some parts of the speech signal to one ear and different parts of the signal to the other ear. This may require some ‘intelligent’ decision making by the electronic circuitry.

As the results with the Bionic Ear for profoundly deaf people can be better than those obtained by severely deaf people with hearing aids, there is now a need to operate on people with some residual hearing. To give these people the best results there will be a need to carry out research to combine electrical stimulation in one ear with processed speech sounds presented to an aid in the better ear. Research will also examine how best to use residual hearing in the implanted ear.

Not only must our research aim to give people the clearest possible speech signal, but we must teach them how best to use it. While it remains an approximation to normal sound there will be a need for training. This applies, in particular, to children, who will be learning language for the first time.

Some unfortunate patients cannot receive the benefit of a Bionic Ear because their hearing nerves have been destroyed, for example, by tumours. Speech processing advances with the Bionic Ear now mean that some of these patients can now be given artificial ears implanted directly into the brain. More research is needed before this will be as safe and effective as the Bionic Ear.

As an adjunct to electrical stimulation of the hearing nerve, we have been carrying out research with a Tickle Talker, and now know that some children can also lipread better when speech elements are presented as patterns of stimulation to the skin. They can learn to incorporate touch sensations as speech. The challenge for the future research is to enable these children to understand speech without the help from lip-reading, which is the case for some when using the Bionic Ear.

It is not enough to help only severely-to-profoundly deaf people, but those with a moderate-to-severe hearing loss need assistance, as they often do not obtain optimal help with present hearing aid designs. For this reason we are extending our speech processing research to this group of people and hope to develop a new generation of hearing aids which process the speech to specially suit the person by using a form of ‘intelligence’ in the electronic circuitry.

Finally, future research directions are not complete without extending the work of the Department which led to the development of an effective computer-based system for analysing brain waves from the scalp of infants in response to sounds. This research has the potential to determine how children’s brains work when decoding complex sounds and what happens with malfunction.

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