Preface

The cochlear implant is a device that bypasses a nonfunctional inner ear and stimulates the hearing nerves with patterns of electrical currents so that speech and other sounds can be experienced by profoundly deaf people. It is the culmination of investigations that started in the 19th century, and as such it is the first major advance in helping profoundly deaf children to communicate since the sign language of the deaf was developed at the Paris Deaf School 200 years ago. It is also the first direct interface to the central nervous system to restore sensory function for use on a regular clinical basis.

I became interested in helping deaf people hear when I was 10 years old, because my father had a severe hearing loss and I knew how difficult it was for him to cope as a pharmacist and as a family man. In 1966 I left my practice as an ear, nose, and throat surgeon in Melbourne to do research and to learn how it might be possible to help people with a profound hearing loss. These were the patients I had to turn away from my clinic, saying that a hearing aid would be of little help but that one day medical research might provide an alternative. For me this meant first undertaking basic studies to learn about the differences between acoustic and electrical stimulation of the auditory neural pathways.

When it became clear from these and other basic studies that the best chance of providing speech understanding was through multiple electrode stimulation, many scientific challenges were to lie ahead. As previous attempts to produce speech understanding with electrical stimulation had been unsuccessful, and as reproducing the coding of sound was not seen as feasible, the research faced rigorous scientific criticism. The first criticism came from auditory neuroscience, where research had shown the complexity of the inner ear and central brain pathways. Not surprisingly it was believed that inserting a relatively small number of electrodes into the inner ear to stimulate groups of nerve fibers would fail to produce sufficient information for speech understanding. The second criticism came from the biological and clinical disciplines. Here the concern was that implantation would damage the very nerves it was intended to stimulate. In addition, it was thought the electrode could be a pathway for middle ear infection to induce dangerous infection in the inner ear. These biological and clinical criticisms were also well founded. The delicacy of the inner ear had been appreciated in ear surgery, and the risk of infection was ever present in young children. The above two major criticisms required answers before clinical studies could be done on patients.

It was also essential to determine from a small group of volunteers how the complex signals of speech could be presented as patterns of electrical stimulation that could be understood. This seemed at the time an almost insurmountable challenge. Research that followed established that speech processing could in fact be achieved safely for profoundly deaf adults, who had hearing before going deaf. After the benefits were shown for adults, it was appropriate to initiate research to see if children born deaf or deafened early in life could obtain sufficient speech understanding to enable them to manage successfully in a hearing world. Would deaf children be able to develop the right central neural connections, as they had received no auditory stimulation during the plastic phase of brain development? Indeed children who were born deaf were shown to develop speech at a level comparable to that in adults who had prior exposure to sound. Furthermore, it was discovered that if they were operated on at a young age, they could develop good speech sounds as well as language.

Providing hearing and speech understanding for children born deaf then led to an intense ethical debate. The signing deaf community had developed an effective communication system and support network to help one another. Community members were upheld by a strong belief in their self-worth, which is so necessary to manage in a world of sound where people with good hearing did not fully appreciate the great difficulty they had. For a time the implant was seen as an ideological threat to their beliefs and as undermining this well-knit group, and for a number of years the efficacy of the procedure was questioned. It required many controlled studies and the opinion of educators who had experience with the achievements of children with hearing aids before the benefits of the implant for children were fully appreciated.

The cochlear implant has been the result of research in many disciplines, including surgical anatomy, surgical pathology, biology, biophysics, neurophysiology, psychophysics, speech science, engineering, surgery, audiology, rehabilitation, and education. Few medical advances have required the integration of so many disciplines. The scientific questions in these disciplines had to be addressed in a logical, systematic, and sequential manner, and are discussed in this book.

As a result of this research, cochlear implantation has grown from a small number of isolated experimental studies done by a few, to a diverse discipline investigated by many. Its scientific credibility has been recognized through its inclusion in international physiological, acoustical, surgical, otolaryngological, audiological, education, speech science and technology, and engineering society meetings. In addition, there are many international meetings devoted solely to the topic of cochlear implants. The growth in knowledge in the last 30 years has been rapid. This can be seen in the number of papers that include cochlear implants in the title, abstract, or subject heading: in the 1960s, one; in the 1970s, 72; in the

1980s, 679; in the 1990s, 1,935. There have been many other relevant publications. Not only have there been a very large number of scientific papers, but there also have been monographs and book chapters.

Initially the field drew on basic sciences for its development, and then gradually established its own body of scientific and clinical knowledge. This has continued to the point that now electrical simulation of the auditory system can justly claim to be making scientific contributions to the disciplines that helped establish it, in particular neurophysiology, biology, psychophysics, speech science, and the clinical disciplines of surgery, audiology, and rehabilitation.

One aim of this book is to show how the numerous disciplines have contributed and how they have interrelated. This book presents the fundamentals of the research as well as the clinical outcomes so that the reader will have a more complete understanding of the discipline. It is intended for a general reader, and those with a more specialized background can refer to the references. In presenting the fundamentals, research at the University of Melbourne/Bionic Ear Institute and elsewhere is cited. Clinical studies cannot be divorced from the basic research. The two must guide each other and the main aim should be to help people. This requires excellent basic research, but it should be focused and not an end in itself. In this book this interaction is presented at all opportunities.

Finally, the basic and clinical research would not have reached the wider community without the biomedical and engineering expertise of industry. The work has been much more demanding than developing a pacemaker, as more complex electronics have had to be encapsulated in a smaller implanted package. Furthermore, the interface with the auditory nervous system is a very intricate bioengineering achievement. For this reason this book not only presents the basic and clinical research, but also discusses how these have supported the industrial achievement.

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