

## PREFACE

Hearing research is a vast and fascinating subject. This book focuses on the input mechanism of the auditory system, the cochlea, which receives and manipulates sound energy in order to translate the information it contains into nerve signals to be processed and interpreted by the brain. The cochlea is an exceptionally complex, sensitive and delicate mechanism which has attracted and challenged biologists, physicists, engineers and mathematicians for well over 100 years. It is also the site of the majority of sensory hearing loss. The incidence of cochlear dysfunction exceeds one in a thousand at birth and rises exponentially with more than half of people over 60 years of age suffering from significant levels of hearing loss which we are at present unable to prevent. A deeper understanding of the cochlea is essential if we are to reduce the incidence of deafness and its negative impacts on the individual, the family and society.

This book provides an account of present day attempts to understand how cochlear mechanisms function. It contains the proceedings of an international expert meeting, 'The Mechanics of Hearing Workshop', which took place at Keele University, in the UK, at the end of July, 2008. The book includes both theoretical and experimental research papers on cochlear mechanisms at the molecular, cellular and systems levels.

The workshop was the tenth in a triennial series which began in Delft, The Netherlands, in 1983. That first meeting was a direct response to a rapid succession of new cochlear observations, including sharp mechanical frequency tuning, mechanical nonlinearity, sound re-emission, and a vibration amplifying capability in the cochlea, all of which appeared to be incompatible with contemporary concepts of cochlear function. Guiding this first meeting was the conviction that the dramatic and disparate experimental findings of the previous 5 years could be best understood by developing new mathematical models to explain and unify the experimental evidence. This approach owes much to the foresight of Egbert de Boer, who not only organised the first meeting, but has contributed consistently to all subsequent meetings and to this volume.

The books arising from this series of workshops (see page ii) document both the tremendous progress that has been made and the enormous challenges which still face researchers of cochlear function. The 2008 workshop came exactly 20 years after the last such workshop to be held in Keele. Then as now the focus was on the structure, function and modelling of cochlear mechanisms. The 1988 Keele meeting was notable for the attendance of two giants in this field, Sir James Lighthill and Thomas Gold, both no longer with us. The 2008 meeting honoured Pat Wilson, the organiser of the 1988 workshop and a pioneer in the re-evaluation of cochlear function at Keele in the 1970s and 80s.

Subsequent workshops widened the scope of contributions to include the biophysics of hair cell sensory systems, the diversity in auditory mechanics, and the molecular biology of sensory mechanisms and processes. The 2008 workshop adopted a similar broad approach. Topics covered in this book include:- the transmission of stimulation

into, within and out of the inner ear; the role of sensory cell motilities in amplifying this stimulation; mechanisms involved in the modulation and control of cochlear sensitivity; the micro-mechanics of the basilar and tectorial membranes and the organ of Corti; and mechano-electrical and electromechanical transduction by the system's sensory cells and organelles. The great diversity of topics represented is an apt reflection of the complexity of the cochlea. It is impossible to say that any particular area is more important than others, but nevertheless we invited three participants to present keynote lectures. Jont Allen explored the role of the cochlea in human speech recognition. The intrinsic analytical properties of the cochlea must certainly have had a profound effect on which vocalic features could and could not be incorporated into a reliable communication code, and Allen's analysis leads to new challenges for cochlear researchers. Under the title of "Firing up the amplifier", Joe Santos-Sacchi's presentation gave deep insights into the molecular motors that drive electromotility in cochlear hair cells, focusing on the effects of temperature. Finally, Pascal Martin revealed a unity in the various incarnations of active hair-bundle motility that are exhibited by vertebrate hair cells.

It is a measure of the collective achievement of the participants of these meetings that most students of auditory science are now routinely taught about the cochlear amplifier and the role of hair cell motility and nonlinearity in the propagation of stimulation along the cochlea, and also of the reverse process which gives rise to otoacoustic emissions. These are concepts which were speculative, if not heretical, at the commencement of this series of workshops. It is a measure of the maturity and progress within the field of cochlear biophysics that some of these concepts are now themselves being challenged by new discoveries and models. The present workshop's Discussion session, which was led by Chris Shera and David Mountain, exposed these controversies to open debate, and this debate is fully transcribed in the final section of this book. Not only was the nature of and evidence for the 'cochlear amplifier' called into question, but even von Békésy's travelling wave was no longer considered wholly adequate to explain all propagation of energy inside the cochlea. The role of modelling was also constructively challenged. Experimentalists challenged modellers to identify more clearly the testable predictions arising from their theories, and modellers challenged experimentalists to specify useful goals for theoreticians to address. This section is essential reading for anyone wanting to see where our understanding of the cochlea is heading, and which cherished concepts may have to be relinquished.

The questioning of commonly held concepts about cochlear mechanisms at this workshop is a refreshing and positive outcome, and will perhaps herald a new generation of active cochlear models. The new and greatly refined technologies for observing the cochlea and its components described in this book are revealing information beyond the wildest dreams of the participants of the first workshop. This process can only take us closer to a complete understanding of the cochlea.