PREFACE TO SECOND EDITION

Eight years have passed since the first edition of this text was published. Eight years in which the subject matter of sensory biology has seen huge developments. In particular, the molecular revolution of our times has continued apace and culminated in the publication of not only the human genome but also those of many other living forms. Although to the innocent eye the living world seems to be populated by an almost infinite variety of forms possessing an equally unimaginable variety of sensory systems, the explosive development of molecular biology shows that there is a deep underlying unity. In revising this book I have attempted to bring out this unity to an even greater extent than in the first edition. Not only has each chapter been thoroughly revised with this in mind but an additional chapter, Chapter 5, on genes and genomics has been inserted. Otherwise the overall organization of the book remains largely unchanged. The major themes remain as before: foundations in molecular biology and biophysics; a strong emphasis on evolutionary development and comparative anatomy; a focus on human systems; reference to the 'hard problem' of the relation of our sensory experience to the anatomy and physiology of sensory systems.

Although the overall structure of the volume remains much as it was in the first edition, each page has been subjected to detailed revision and updating and over forty new illustrations have been added. Several new sections have been inserted. Amongst these are sections on transient receptor potential channels (TRP channels), synaptic transmission, evolution of nervous systems, arachnid mechanosensitive sensilla and photoreceptors, electroreception in the Monotremata, language and the *FOXP2* gene; the molecular biology of pain, mirror neurons and so on. One of the most interesting developments since the first edition was published has been the Nobel-Prize-winning work on olfaction in mammals and insects and the chapters on olfaction have been expanded to take this work into account. In addition a number of new Boxes have been incorporated into the text: on the genetics of hearing loss; on macular degeneration; on the nomenclature of genes and proteins; on the reality of cortical columns.

As I wrote in the preface to the first edition, the study of sensory systems can form a bridge between the worlds of biophysics, molecular biology and neurophysiology and the worlds of cognitive science and psychology. My hope remains that the overview presented in the pages of this second edition, as in the first, can form a basis on which special studies can be built. Although the book provides a wide sweep through the world of animal sensory systems the major focus remains on mammalian and especially on human systems. The ubiquity of the underlying molecular biology often means that the molecular disorders responsible for human disease and disability can be studied in infrahuman species. Wherever possible the opportunity is taken to bring out these connections and to outline the molecular bases of human sensory disorders and pathology. In spite of this focus on human sensory systems and their pathologies I hope that the wide coverage of other animals brings with it another message: that in studying sensory systems and their functioning we should bear in mind that human systems are but one among many.

In concluding, I can only reiterate the thanks offered in the preface to the first edition to all those

who helped in the production of this book and, in particular, the many scientists and others who gave permission to reproduce their diagrams and illustrations. Finally, I cannot end without reference to the invaluable help and support of my wife, Jenny, who wanted to know, and to whom this book is dedicated.

C.U.M.S.
January 2008

PREFACE TO FIRST EDITION

'All men by nature desire to know. An indication of this is the delight we take in our senses; for even apart from their usefulness they are loved for themselves. . . ' Aristotle, *Metaphysics,* Book 1, 980a

This book arises from the experience of teaching undergraduate classes in the biology of sensory systems over many years. It differs from the many other excellent texts in the subject in that, in addition to the neurobiology, it emphasises evolution, molecular biology and the wider philosophical implications of the subject. Humans are not the only beings with sensory systems on the surface of this planet. We are deeply interwoven with all the other biological forms which populate the biosphere. Some of these other forms, the other chordates, are related, albeit frequently quite distantly, by a common basic design plan; others, the mollusca, the arthropoda and so on have evolved separately for more than half a billion years. Comparisons between these forms often show how similar sensory problems have elicited sometimes different and sometimes remarkably similar solutions. At the basis of all these solutions are the sensory cells and the molecular mechanisms which make them especially sensitive to particular forms of environmental energy. One of the most interesting developments of recent years has been the dawning recognition that these molecular mechanisms are often much the same from nematode to man. Underlying the unimaginable variety of sensory systems in the biosphere is a remarkable unity. Finally, sensory systems provide each of us with our private subjective world. As we study sensory systems in ourselves and in the animals with which we share the planet we should not lose sight of the problem posed by the mysterious transition (is it a transition?) between the world of molecules and cells and fibre tracts, with all its fascinating detail, and the very different world of scents and sounds and colours which all of us experience every day. This remains the major philosophical problem of modern times. It appears and reappears at intervals throughout the following pages.

The study of sensory systems forms a bridge between the world of biophysics, molecular biology, neurophysiology and the world of cognitive science and psychology. I hope that the overview provided in the following pages can form a basis upon which special studies can be built. The subject of sensory systems, like all aspects of contemporary science, is vast. All that has been attempted in the following pages is to present a basis, a framework, for further studies. In order to pursue these studies recourse has to be made to the libraries and to the various electronic databases nowadays available. To this end a reasonably full bibliography has been included. For ease of reading references have not been included in the text but are, instead, collected at the end of each the six parts of the book with short bibliographical introductions.

Finally, a number of self-assessment questions are also grouped at the end of each of the six parts. These questions are keyed into the text. After reading a chapter, a student should turn to these questions

and make sure that answers spring readily to mind. If they do not, reference should be made to the relevant section of the text to refresh the memory.

No book, and certainly no book on so vast a subject as the biology of sensory systems, springs forth fully armed, as Athene is said to have sprung forth from the forehead of Zeus. All, as Isaac Newton said long ago, are founded on the work of countless predecessors and contemporaries. In this book the reference lists stretch back from mid 1999 to Aristotle and beyond, two and a half millennia ago. My thanks are accordingly due to innumerable workers, both past and present. In particular, those thanks must go to the many contemporary workers who have given permission to reproduce their diagrams and figures. It is said that one well-judged illustration is worth a thousand words and the books and papers of contemporary science abound with high-quality line drawings and half-tones. I am most grateful to the authors and their publishers for permission to reproduce them.

It is impossible in these acknowledgments to mention more than a very few of those who have helped me. In alphabetical order they would include Professor Allison for up to date information about face-sensitive regions in the human brain, Professor Paul Bach-y-Rita for help with the section on sensory substitution, Professor John E.Brugge for figures showing the positions of the auditory cortices in cat and monkey, Professor Alan J. Benson for a revised diagram of cochlear hair cells, Professor Oleg Orlov for valuable correspondence on visual systems and vision, Professor Adrian Horridge for information about arthropod eyes, Professor Jim Pickles for scanning electronmicrographs of cochlear hair cells. I would also like to thank the two anonymous reviewers of the first draft manuscript who provided expert feed-back. This has been incorporated where possible. The usual disclaimers are, of course, operative. All mistakes and misapprehensions are the author's own, not those of his advisors.

As indicated at the beginning of this preface, this book arises from the experience of teaching undergraduate students in biology and, latterly, in optometry at Aston University. My acknowledgements would not be complete without reference to their critical response to my courses: as is always the case in any teaching situation the teacher learns as much as (if not more than) the student. I would also like to thank my colleagues amongst the academic staff for support and discussion and for providing the time and facilities for carrying through this project. Technical assistance has also proved invaluable and I have not only benefited from the computer and IT expertise of others but also from the expert photographic talents of our visual aids technician, Mr Barry Brooks. Finally, in these acknowledgements, I cannot fail to include my publishers who, as with my previous books, have managed to put together illustrations, questions, bibliographies, tables, appendices, boxes and text to create a volume which (hopefully) will find favour amongst students and others at the beginning of our new century.

C.U.M.S.
November 1999