

Series Preface



The following preface is the one that we published in volume 1 of the Springer Handbook of Auditory Research back in 1992. As anyone reading the original preface, or the many users of the series, will note, we have far exceeded our original expectation of eight volumes. Indeed, with books published to date and those in the pipeline, we are now set for over 60 volumes in SHAR, and we are still open to new and exciting ideas for additional books.

We are very proud that there seems to be consensus, at least among our friends and colleagues, that SHAR has become an important and influential part of the auditory literature. While we have worked hard to develop and maintain the quality and value of SHAR, the real value of the books is very much because of the numerous authors who have given their time to write outstanding chapters and to our many co-editors who have provided the intellectual leadership to the individual volumes. We have worked with a remarkable and wonderful group of people, many of whom have become great personal friends of both of us. We also continue to work with a spectacular group of editors at Springer. Indeed, several of our past editors have moved on in the publishing world to become senior executives. To our delight, this includes the current president of Springer US, Dr. William Curtis.

But the truth is that the series would and could not be possible without the support of our families, and we want to take this opportunity to dedicate all of the SHAR books, past and future, to them. Our wives, Catherine Fay and Helen Popper, and our children, Michelle Popper Levit, Melissa Popper Levinsohn, Christian Fay, and Amanda Fay Seirra, have been immensely patient as we developed and worked on this series. We thank them and state, without doubt, that this series could not have happened without them. We also dedicate the future of SHAR to our next generation of (potential) auditory researchers—our grandchildren—Ethan and Sophie Levinsohn, Emma Levit, and Nathaniel, Evan, and Stella Fay.

Preface 1992

The Springer Handbook of Auditory Research presents a series of comprehensive and synthetic reviews of the fundamental topics in modern auditory research. The volumes are aimed at all individuals with interests in hearing research including advanced graduate students, post-doctoral researchers, and clinical investigators. The volumes are intended to introduce new investigators to important aspects of hearing science and to help established investigators to better understand the fundamental theories and data in fields of hearing that they may not normally follow closely.

Each volume presents a particular topic comprehensively, and each serves as a synthetic overview and guide to the literature. As such, the chapters present neither exhaustive data reviews nor original research that has not yet appeared in peer-reviewed journals. The volumes focus on topics that have developed a solid data and conceptual foundation rather than on those for which a literature is only beginning to develop. New research areas will be covered on a timely basis in the series as they begin to mature.

Each volume in the series consists of a few substantial chapters on a particular topic. In some cases, the topics will be ones of traditional interest for which there is a substantial body of data and theory, such as auditory neuroanatomy (Vol. 1) and neurophysiology (Vol. 2). Other volumes in the series deal with topics that have begun to mature more recently, such as development, plasticity, and computational models of neural processing. In many cases, the series editors are joined by a co-editor having special expertise in the topic of the volume.

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Volume Preface

The evolution of the vertebrate inner ear is a topic that holds great interest for all students of auditory neuroscience. When and in which vertebrate groups did the ear arise and how has it changed over the tens of millions of years since the first vertebrate? While some insight into this history comes from comparing the ears of extant vertebrates, the best view of the origin and evolution of the vertebrate middle and inner ears comes from the growing fossil record. This volume focuses on that record to provide unique insights into this evolution.

This kind of overview is possible because the middle and inner ears of vertebrates are represented by the best and most readily traceable record for a sensory system among fossils. Each major group of bony vertebrates tells its own story of the evolution of its auditory system and, in recent years, more and more information has become available. A combination of traditional paleontological methods of fossil preparation has been employed to great effect, including serial grinding, mechanical and chemical preparation, and advanced methods of virtual reconstruction. Detailed phylogenetic analyses increasingly have refined knowledge of vertebrate phylogeny from both extinct and extant groups, allowing the evolution of the ear region to be traced. This volume presents the most recent findings about the ear region in each of the major bony vertebrate clades.

The clear patterns that emerge are those of convergent evolution and variations on a theme. Based on the same original building blocks, each vertebrate group has refined and utilized them for the differing needs and habits of the animals. Constrained by the physical facts of transmission of sound through air, water, or body tissues, it is no surprise that similar solutions to the problem have evolved several times. Ideas about these processes have been similarly refined as a result of advances in understanding as our knowledge has grown. The similarities observed can be and have been deceptive: a single evolutionary origin for hearing in air has been inferred in the past, whereas deeper knowledge has revealed subtle anatomical differences among the ears of vertebrate groups that are a testament to their divergent history.

In Chap. 1, Clack provides an exciting and important overview of evolution of the vertebrate ear: a guide to the vertebrates in general and to the ear in particular.

She provides an important discussion of the terminology used by anatomists and paleontologists with respect to the latest understanding of the vertebrate lineage. This chapter also describes some of the latest discoveries from fossils that often are preserved poorly and usually do not provide much data on the ear region. These include fossils of the jawless vertebrates, placoderms, and chondrichthyans. The rest of the chapters cover the bony vertebrates or osteichthyans.

In Chap. 2, Friedman and Giles explain how the fossil record of ray-finned fishes shows the main modifications to the otic region and surrounding parts of the braincase. Clack and Ahlberg (Chap. 3) then cover the sarcopterygians, apart from the limbed forms that are known as tetrapods. With the rise of limbed stem tetrapods from the Devonian, the earliest complement of a stapes, fenestra vestibuli, and its supporting structures developed, as described by Clack and Anderson in Chap. 4.

Three chapters consider the evolution of the unique construction of the mammalian ear, detailing the origins of its three-ossicle series of malleus, incus, and stapes, and the coiled cochlea. In the first of these, Kemp (Chap. 5) describes the most basal sector of the mammalian lineage, the synapsids, starting with the late Carboniferous and Early Permian forms sometimes informally called pelycosaurs. In Chap. 6, Luo, Schultz, and Ekdale follow on from the descriptions of basal synapsids in Chap. 5 and show the increasingly mammal-like conditions found in later members of the synapsid clade. The gradual acquisition of mammalian features and the convergent development of some of the mammalian ear's components are key to this chapter. The story of mammalian ears finishes with Chap. 7 in which Ekdale discusses the evidence from fossil representatives of mammals belonging to modern groups. Ekdale shows how the mammalian ear was refined and adapted for different environments.

The next three chapters deal with reptiles (in the phylogenetic sense, which includes birds). In contrast to mammals, reptiles have only the single stapes as a middle ear ossicle. Chapter 8 by Sobral, Reisz, Neenan, Müller, and Scheyer treats the early representatives of the clade. Some of these have no living representatives, such as pareiasaurs and procolophonids, as well as the extinct marine reptiles, such as ichthyosaurs and plesiosaurs. The chapter describes the earliest members of the diapsid clade, which provided the foundation for most living reptiles. These fall into two groups, the lepidosaurs and the archosaurs. Turtles may belong to one of these two groups, and current thinking suggests the archosaurs. Chapter 9 by Evans provides a review of the lepidosaur clade, which includes lizards and snakes, as well as the rhynchocephalian clade that culminates in its only living representative, the extant *Sphenodon*. The archosaurs are covered in Chap. 10 by Sobral and Müller. The group is a large one, containing modern representatives of crocodiles and birds and the extinct members of each. The extinct members of the avian lineage include all the dinosaurs. One other constituent member is entirely extinct: the flying pterosaurs.

The final chapter by Schoch and Anderson (Chap. 11) follows the evolution of the Amphibia. It is treated last to distinguish the group from those animals described in Chap. 4 (Clack and Anderson on early tetrapods). Fossil members of the Lissamphibia arrived quite late on the scene, around the time of the first

dinosaurs, and they are similar in many respects to extant lissamphibians. Although the amphibian ear region is superficially similar to that of lizards, it arose quite independently, first among the Paleozoic tetrapods known as temnospondyls, which are considered to be the stem from which modern forms arose.

This volume of the Springer Handbook of Auditory Research (SHAR) is unique in that it is the only book ever to consider the evolution of the vertebrate ear from the perspective of the fossil record. At the same time, evolution of the ear and hearing has been a frequent topic in SHAR through individual chapters and through a series of books on comparative hearing for insects, fishes, amphibians, reptiles and birds, and mammals. Moreover, *Evolution of the Vertebrate Auditory System* (vol. 22, 2004, edited by Manley, Popper, and Fay) focused on principles of the evolution of hearing. This volume focuses on the associated bony anatomy.

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Evolution of the Vertebrate Ear

Evidence from the Fossil Record

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