

## Book Review

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### Electroreception (Springer Handbook of Auditory Research 21, series eds R.R. Fay and A.N. Popper)

Edited by T.H. Bullock, C. D. Hopkins, A. N. Popper and R. R. Fay

Springer, New York, 2005

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GBP 92.50, USD 139, EUR 119.95 (Hardback),  
acid-free paper, pp. xvi + 469, 13 tables, 120 figures  
(2 in colour); index (combined).

The idea that animals can produce electric discharges has been intimated ever since ancient Egyptian tomb hieroglyphics depicted lightning bolts emanating from electric catfish. This continuing fascination symbolizes the intriguing nature of the electric sense that has been lost and re-evolved several times in its history among fishes, amphibians and monotreme mammals. However, only in the last 50 or so years has a great body of work developed on the electric field production and sensing capabilities of electric fish. *Electroreception* is the second review of electrosensory systems, both edited by Theodore Bullock and colleagues. Without a doubt, Ted's contribution to this field has been unparalleled, because he has guided and enthused many colleagues all over the world to look deeply into the behavior, anatomy, and physiology of this interesting sense. This second review starts with a tribute and memorial to two other eminent scientists in the field, Walter Heiligenberg and Thomas Szabo, who created an enormous compendium of understanding about how this sensory system operates. A synergy resulted from all the interests and passions of these gifted individuals and produced a monumental body of knowledge, creating one of the most powerful neuroethological models in science today.

One difference between the first and second book on electroreception is that the field has matured in the almost 20 years that separate their publication dates. The 14 chapters are less a listing of

components, but more an exploration of how the systems conceptually work. The chapters are divided between descriptions of the high- and low-frequency electric systems, with two introductory/historical chapters and one chapter on systematics and biodiversity. The most exciting new areas of research described in this book concern the low-frequency systems, as the high-frequency systems have been described in more detail over the past 20 years. Jorgen Jorgensen's brief survey of electroreceptor morphology includes color drawings that are simple but provide an enlightening basic introduction to variation in receptor cell morphology. The physiology of the ampullary electroreceptors is selectively reviewed by Bodznick and Montgomery with a focus on receptors, noise and suppression, while Kawasaki gives a more complete review of tuberous electrosensory system physiology, pathways and time coding. Bell and Maler comprehensively and elegantly survey the central neuroanatomy of electric fish. However, because some chapters are so comprehensive, the reader is sometimes left wondering where the new frontiers lie. One exception is Glenn Northcutt's cogent and exciting chapter on the ontogeny of electroreceptors and their neural circuitry. This chapter is of particular relevance for new researchers coming into the field, because it highlights future areas for developmental research.

Animals are constantly challenged with understanding their own signals, those of conspecifics, and those of other organisms. During reproductive and other behaviors, these signals can change rapidly or over extended periods. In part, the nervous system handles these complex tasks through plasticity and a related concept, the 'adaptive filter'. Certain electrosensory systems cancel self-generated information by creating efference copy signals in a cerebellar-like system of the brainstem that helps reduce noise. Like the many electrosensory systems themselves, this remarkable noise-reduction system has evolved

several times and points to a second level of convergent evolution among fishes. These themes are discussed throughout many of the chapters that bind them conceptually.

Plasticity is thoroughly described by Bastian and Zakon, starting with peripheral receptors and continuing into central electrosensory systems, as well as the cerebellum. Coombs and Montgomery's integrative chapter clarifies the significance of a noise-reduction system by making their comparisons with mechanosensory and acoustic systems. Additionally, they conceptually integrate the electrosensory function with other octavolateralis senses — an exciting area with much research potential.

There are two means by which animals use electroreception to localize electric sources. Some use the passive electrosense to detect electric fields external to their own body, and others use the active electrosense to monitor self-generated signals. Wilkens and Hoffman present an exceptionally lucid chapter on passive electrosensory behavior in animals with ampullary electroreceptors, from lampreys to echidnas. Their work synthesizes both classic and more recent work, including their description of the remarkable planktivorous paddlefish. This is followed by an excellent and complementary presentation by Carl Hopkins on passive electrolocation of conspecifics by electrogenic *Gymnotus* and *Brachyhyopomus*, and the quantifiable behaviors when these animals orient towards electric dipole sources. Of particular interest to students of electrosensory systems in both sharks and electric fishes is his presentation and analysis of the

competing zero-error and constant-error algorithms. Mark Nelson's chapter on the active electrosense presents a basic conceptual, physical and mathematical examination of electric field sources and how the brain can derive targets, maps and features.

We have high praise for this book, and were able to find only a few negative aspects. Some chapters touch only superficially on the basic concepts in electrosensory encoding and processing, in part due to the maturity of the field and because few new labs are entering the field. Additionally, a future edition would benefit greatly from further consideration of *in situ* behavior and ecology of electric and electrosensory vertebrates. Physiology and anatomy needs to be grounded by the adaptive needs and behaviors of the animals in the field. Collectively, the chapters merge electrosensory fundamentals with current topics and identify several new research questions. *Electroreception* should be of general interest to researchers in electrosensory systems, but of particular interest to students, post docs and scientists new to the field.

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