Evolution of Vertebrate Sensory Systems

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Preface

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The seven papers in this Karger workshop take as their theme the evolution of vertebrate sensory systems. Since there is only the most limited fossil record of sensory systems, much of the evolutionary history of vertebrate sensory systems has to be extrapolated from a thorough knowledge of comparative sensory biology. These papers illustrate the two contrasting themes of conservation and innovation in the evolution of structures and functions of sensory systems.

The charge to the authors in this Karger workshop was to use their knowledge of comparative sensory biology in an attempt to add to our understanding of the evolution of vertebrate sensory systems. This charge was adhered to closely by all participants, and as a result, the papers from the workshop provide new ideas and fresh insights into how vertebrate sensory systems may have evolved.

It is clear that *ih*o sensory systems of all animals are adapted to acquiring information about objects and events through the reception of various forms of mechanical, electromagnetic, and chemical energy and then processing this information through computations by the central nervous system. However, while it is relatively easy to look at an extant sensory system and understand its functions, it is much harder to extrapolate from extant systems to understand the evolutionary history that led to what we find in living animals. With the exception of the hard parts of the ear, as described by J.A. Clack (The Evolution of Tetrapod Ears and the Fossil Record'), there is virtually no fossil EreSjSd for sensory systems. Thus, developing insight into the evolution of vertebrate sensory systems requires a detailed understanding of, and extrapolation from, comparative sensory biology.

Comparative studies on extant species reveal wide interspecific variation in the structures of sensory endorgans and their more peripheral accessory structures. This peripheral variation often appears to be 'matched' to the opportunities and constraints of the species' usual environment, leading to the notion that structural variations are adaptations to particular environmental features of importance to a species. For example, the spectral sensitivity of the eyes of fishes closely matches the rather specific Ught-transmitting properties of water, as discussed by R.D. Fernald ('The Evolution of Eyes'). However, some sensory characteristics occur that are not readily understood as adaptations to the environmental constraints facing a particular species. Fernald has also noted, for example, that terrestrial vertebrates tend to transduce light in essentially the same bandwidth as fishes. Thus, evolutionary choices may tBIist.

At the same time, some of the wide variation in the structures of sensory endorgans may not reflect any particular demands in the stimulus domain. For example, Clack notes that the wide familial diversity among lizards in the structures of the auditory papillae is not correlated with any known variation in the sound fields enC^mtered by these groups. A.N.

Popper and R.R. Fay ('Evolution of the Ear and Hearing: Issues and Questions') further note that this structural diversity among lizards appears to have little impact on the neural representations of sound transmitted to the brain via the auditory nerve. Thus, it is not clear how many of the structural features of sensory systems could be explained as adaptations to particular environmental demands.

In the following papers, two general themes in the evolution of sensory systems recur: conservation and innova-

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tion. Conservation is most clearly evident in central nervous system pathways (e.g., W. Hodos and A.B. Butler, 'Evolution of Sensory Pathways in Vertebrates'; H.L. Eisthen, 'Evolution of Vertebrate Olfactory Systems'; T.E. Finger, 'Evolution of Taste and Solitary Chemoreceptor Cell Systems'), transduction mechanisms (e.g., Fernald), and receptor encoding and neural processing mechanisms (e.g., Popper and Fay). Innovation is documented in all the symposium papers. Perhaps the most striking examples of innovation are the multiple, independent developments of electrosensory organs (J.G. New, 'The Evolution of Vertebrate Electrosensory Systems'), tympanic ears (Clack), and eyes (Fernald). Reconciling the contrasting themes of conservation and innovation will be a key to a more complete understanding of sensory system evolution. It is hoped that these papers will increase investigation on the evolution of sensory systems and that 10 years from now, in another Karger workshop, more answers will be forthcoming.

In the meantime, we are grateful to the authors of all of these papers for their fine presentations at the Karger symposium, their willingness to meet a tight schedule, and the uniformly excellent job they did in writing the papers. We also want to thank R. Glenn Northcutt and Mary Sue Northcutt for their advice throughout the planning and execution of the workshop and Catherine Fay for editorial work. Finally, we want to express our gratitude, and that of all of our participants, to Dr. Thomas Karger for providing the encouragement and support that enables members of the J.B. Johnston club to delve deeply, each year, into an exciting and stimulating aspect of comparative neurobiology.

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