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Preface

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Behavioral and neural diversity comprise one of evolution's major outcomes. As a result, the origin and evolution of nervous systems – and particularly that of the human brain – has long attracted interest and debate [Striedter, 2004; Healy and Rowe, 2008]. While progress has been made in our understanding of how brain structure and function change over evolutionary time scales, progress also has been impeded by several obstacles. First, there is still no common agreement on appropriate brain measures [c.f. Deaner et al., 2007]. Various authors have pursued fractions, residuals, encephalization quotients, a progression index, whole brain volumes, and neocortex volumes. Secondly, our mechanistic insights into the functional consequences of observed size differences continue to be inadequate. Thirdly, we have a limited understanding of any differences beyond size. And finally, we have few behavioral assays available that allow unbiased comparisons across species.

However, the field is now entering an exciting new stage where novel approaches can be utilized within a comparative context. By moving beyond neuroanatomy, the comparative method still provides the most powerful framework for understanding the evolution of brain and behavior. The 19th Karger Workshop, held in San Diego in October, 2007, highlighted the latest advances in several vertebrate and invertebrate systems, drawing broad lessons learned from these studies. The topics ranged from sensory to motor, from ecology to social aspects, from molecular to physiological to genomic approaches. The workshop was dedicated to the memory of Ted Bullock, whose relentless push to understand neural and behavioral complexity was a great inspiration to us and many other neurobiologists.

In the first paper, Linda Holland and Stephen Short [2008] explore developmental similarities and differences between vertebrates and invertebrates. They show how two rounds of whole genome duplication and the creation of new splice forms in the vertebrate lineage led to the emergence of the neural crest. They present evidence that the genetic machinery underlying the neural crest was already present in the ancestral chordate-like *Amphioxus* (which lacks a neural crest). They emphasize that gene duplication allows the preservation of old functions by some duplicates and the acquisition of new ones by others. They argue that it is chiefly the increase in flexibility of old genes, rather than the evolution of entirely new genes, that allowed the evolution of new structures such as neural crest.

In her review, Sarah Farris [2008] compares higher-order centers in vertebrates and invertebrates. She shows that the centralized nervous system of bilaterally symmetrical animals originated only once in evolution and exposes the fundamental groundplan consisting of a tripartite brain and a nerve cord divided into distinct antero-posterior and medio-lateral zones. The paper links comparative studies on parallelism and convergence in vertebrates that have associated evolutionary changes in brain structure and function with ecology to similar studies in invertebrates, which have independently evolved higher brain centers.

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Caroly Shumway [2008] reviews how habitat complexity influences both brain and behavior in African cichlid fishes, drawing on examples from primates and birds where appropriate. The paper demonstrates that environmental and social forces affect cichlid brains differently. She highlights the importance of quantifying complexity, addressing phylogenetic confounds, and using closely-related species and new experimental paradigms for testing the cognitive and survival value of brain and brain structure changes, both in the laboratory and in the wild.

The Special Invited Guest of the workshop, Louis Lefebvre, together with his co-author, Daniel Sol, focus on convergent evolution of different types of cognitive abilities based on similar lifestyles [Lefebvre and Sol, 2008]. These authors have previously demonstrated the survival value of bigger brains. They highlight a few common principles that appear to have influenced the evolution of brains and cognition in widely divergent taxa, including the unpredictability of resources in time and space. They also emphasize the need for more work in the field if we are to understand the evolution of animal cognition.

Alexander Pollen and Hans Hofmann [2008] outline four conceptual approaches that they believe will advance the field of brain evolution emerge from a historical focus on descriptive comparative neuroanatomy. They emphasize the need for (and provide examples of) reliable and efficient behavioral assays; the application of the comparative approach to developmental and physiological processes underlying species differences in brain and behavior; genome wide comparisons to identify the genetic basis for phenotypic differences; and identifying signatures of selection at the level of DNA sequence to uncover adaptive genetic changes that affect the nervous system. Finally, they also emphasize the importance of well-resolved phylogenies for comparative studies.

Samuel Wang [2008] presents a biophysical approach to comparative and evolutionary neurobiology, focusing on the costs of the construction and operation of neurons and the tradeoff between speed and energetic efficiency and volume. He applies biophysical reasoning to quantitative comparative data to identify candidate functional principles and uses cell and developmental biology to help distinguish functional principles from obligate principles.

Finally, Eric Vallender [2008] describes the molecular evolution of genes involved in brain development. He explores the evolutionary forces that gave rise to the human brain by utilizing the genomic sequences of a several primates and other mammals in the search for signs of positive selection acting on DNA sequences. The review illuminates the strengths and weaknesses of these approaches and the dependence of the results on differing methodologies. He outlines a possible synthesis that would allow a more complete understanding of the genetic correlates behind the human brain and the selective events that have acted upon them.

Taken together, these seven contributions to the 19th Karger Workshop provided an exciting forum for truly comparative neurobiology. Emphasizing the need for phylogenetically sound approaches and highlighting how novel methodologies can open up exciting new avenues of research created a lot of discussion and enthusiasm among participants and audience. We are confident that this volume will help pave the way towards integrative insights into the evolution of brain and behavior at many levels of biological organization. This workshop would not have been possible without the longstanding and continued support from the Karger Family. We believe we can speak for the entire community of comparative and evolutionary neurobiologists that Karger's vision for our field has had a tremendous impact. We also want to thank the J.B. Johnston Club Program Committee for selecting this topic, and Walt Wilczynski and Blinda McClelland for expert support in both organizing the workshop and editing this volume.

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