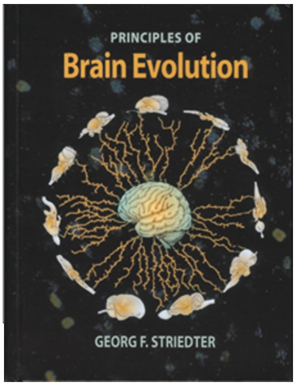
Understanding brain evolution



Principles of Brain Evolution

By Georg F Striedter

Sinauer Associates, Inc., 2004
436 pp, hardcover, $59.95
ISBN 0878938206

Reviewed by Jon H Kaas

Early efforts to describe brain evolution, such as Herrick's 1926 *Brains in Rats and Men,* were fun to read, but they were based on a very limited data set. Since then, there has been an explosion in our knowledge of brain organization from comparative studies on a broad range of vertebrate species. Systematic approaches have been developed for reconstructing evolutionary history from observations on extant species, and theories of brain evolution have been enriched by historical data on brain sizes and shapes from the endocasts of skulls in an accumulating fossil record. Many of the structural and functional implications of evolutionary changes in brain size are now understood, but until recently, there was little to say on this topic. Thus, Schmidt-Nielsen wisely avoided any discussion of the impact of brain size on brain organization in his landmark 1984 book *Scaling: Why Is Animal Size So Important?* Now, finally, we are in an 'evo-devo' age where great advances have been made in understanding how gene expression influences brain development and evolution. Georg Striedter has produced a wonderful book that discusses current understandings of brain evolution. It nicely reflects all these recent advances, although some more than others.

Striedter avoids the trap of an encyclopedic approach that would bury the reader in detail. Instead, he focuses on general principles of brain evolution that should withstand an anticipated avalanche of new information, thereby providing a guide to the interpretation of new observations. An important principle is that brain features have been conserved from distant ancestors across members of a taxonomic group. Of course, the degree of similarity across members of a group depends on how much evolutionary time has passed. Thus, the lateral geniculate nucleus of the visual thalamus has been conserved in all mammals, but it varies in laminar pattern. A lateral geniculate nucleus can be recognized as belonging to a primate or a carnivore by its laminar pattern. Striedter also discusses the evolution of changes in brain organization, raising the question of how new structures are formed. One possibility is that new structures are differentiated parts of old structures. For example, there are many instances where a layered brain part evolved from a brain part without layers. Cortical areas may be added in a manner similar to the way regions within an area become specialized. Alternatively, new structures may emerge in development as duplications of old structures as a result of changes in gene expression and gene duplication.

Another important part of the book is a discussion of the consequences of brain enlargement. A general trend that has been recognized by Barbara Finlay and co-workers is that as bigger brains evolve, 'late makes large'. Structures that are created late in embryonic development become disproportionately large in bigger brains. Thus, humans have much bigger forebrains relative to their brainstem than do rats. This rule is frequently modulated by adaptive enlargement of useful brain parts: so-called mosaic evolution. Because of mosaic evolution, the superior colliculus might be ten times larger in a highly visual rodent than in a weakly visual rodent, even though their brains are the same size. However, most deviations from the rule are much smaller.

Brain size influences brain organization in another way as well. As neurons do not change very much in cell body size, large brains have many more neurons than small brains. This usually means that neurons in bigger brains do not connect with the same proportion of other neurons. In addition, as brains get bigger, connection lengths between neurons, as well as transmission times, get longer, and more of the brain must be devoted to connections unless brain organization is modified. Thus, large brains require a design different from small brains. These design problems are best addressed by increasing the number of brain parts and emphasizing local over distributed processing.

Although human brains have conserved many features from our primate ancestors, Striedter concludes from brain scaling issues that the large human brains have been significantly reorganized. There is, of course, much evidence for this from comparative studies of monkey and human brains. Most notably, human brains are structurally and functionally much less symmetrical, with the right and left cerebral hemispheres differently specialized. This reduces the need for ancestral proportions of the long connections between the hemispheres.

The book is written for the beginning and advanced student. One does not need an extensive understanding of brain anatomy and terminology to understand the text. Experienced investigators will find the book interesting and informative, but they are also likely to disagree with some of the statements and conclusions. This would not surprise Striedter, as he realizes that there is still much to learn. He concludes, "If you disagree with statements I have made, I trust that you will set the record straight." Clearly, Striedter expects that the book will motivate researchers to learn more and guide the writing of a future second edition. Overall, this is a volume that most neuroscientists will enjoy reading, and some of them, myself included, will find it useful as a textbook for graduate students and advanced undergraduates. ■

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