

PREFACE: THE EVOLUTION OF THE EVOLUTION OF THE GENOME

It has been said that the preface is the most important part of a book, because even the reviewers will read it. That strikes me as a lot of pressure to put on such a small fraction of a book, made no less disconcerting by the fact that the preface can actually be rather challenging to write. How does one encapsulate, in only a few pages, a book that covers (and integrates) as many topics, involved the input of as many people, and has taken as much work to prepare as this one? The only strategy that comes to mind is to follow the old adage that one should stick to writing what one knows best. As such, it seems reasonable (and actually quite appropriate) to discuss this book in biological terms.

A central theme of this volume is that genomes represent a distinct and legitimate level of biological organization, with their own inherent properties and unique evolutionary histories. Books about genomes, too, are organized entities that evolve in sometimes unpredictable ways, and are subject to the same general processes as biological individuals. What is editing, really, but an example of "intellectual selection," whereby the author proposes and the editor disposes (or at least ruthlessly modifies)? As with life at large, the evolution of this book also involved healthy doses of morphological constraint (especially in regard to length), the necessary coordination of parts, hybridization of data from the study of very different taxonomic groups, horizontal transfer and exaptation of concepts among disciplines, and more than a little quirky historical contingency.

The evolution of any entity, living or literary, is a combination of general principles (acting at several levels of organization) and unique historical particulars. The convoluted particulars of this book's genesis are as follows. In 2002, I ventured to Washington, DC to attend a conference. While there, I was kindly hosted by my friend and colleague Grace Wyngaard, whose husband, Roy McDiarmid, is a curator of herpetology at the Smithsonian Institution. Also at the conference was

Chuck Crumly, then a senior editor at Academic Press, who had also trained as a herpetologist and was an old acquaintance of Roy's. Through this connection, Chuck approached me with the notion of preparing a book on genome evolution for Academic Press.

Lacking any comparative data, I can only speculate as to how typical the rest of the book's history is: Rookie editorial hopeful manages to assemble an all-star list of authors and gets a book contract; original publisher is phagocytosed by another company; there ensues a chaotic series of comings and goings on the publishing team involved with the book (including the departure of Chuck Crumly); some authors who planned to contribute are unable to; the chapter list is juggled and reshuffled, and other equally stellar contributors graciously agree to join the revised project; and in the end, a book emerges that bears at least a modest resemblance to the one discussed over a lunchtime meeting more than two years earlier.

Now that the book has come into being, it is worthwhile to consider some aspects of its ecology and morphology—that is to say, the niche it is meant to occupy and the ways in which it is adapted to do so.

Speaking from experience, I can attest that the primary literature of genome biology is, shall we say, less than readily accessible. It can be a significant challenge to follow developments in one's own specialized subdiscipline, and a near impossibility to obtain a broad view of genome evolution at large. The chasms separating researchers working on different genomic questions or with different taxa are as wide as ever, and those dividing the various branches of the life sciences seem to be getting wider. This can be a major barrier to understanding the context and importance of genome evolution, a problem that is particularly acute for newcomers.

The chapters in this book are meant to provide comprehensive summaries of the underlying concepts, histories, current statuses, and future prospects of the major fields of genomic inquiry. Too often, these conceptual and historical underpinnings are overlooked as new discoveries come to dominate discussions of these topics. Overall, this book is aimed at the up-and-coming "genome generation"—advanced graduate students, postdocs, and young faculty members—although it should also serve as a valuable resource for existing experts in these and related fields. Put explicitly, it is written for the people who are, and will be, shaping the future of genome biology. It therefore provides a map to the otherwise bewildering maze of literature on genome evolution, seeks to build much-needed bridges between divergent disciplines, and, perhaps most importantly, stresses the big picture. In some cases, the subject of a given chapter has never been reviewed before, and, as such, is treated as comprehensively as possible. In others, the subject could be (and in some cases is) reviewed every few months, though seldom in the broad context emphasized here.

All of this means that this book also is *not* several things. Notably, it is not a comprehensive textbook for undergraduates, meaning that a strong basic background

in biology and genetics will be required to get the most out of these chapters. However, neither is it a typical collection of highly technical reviews accessible only to other specialists. By keeping discipline-specific jargon to a minimum (and making all attempts to define it when unavoidable), the chapters provided here are meant to be accessible to anyone with *only* a strong basic biological background. In a phrase, this is the book that I wish had been available when I was first starting out as a student of genome evolution.

Although the various chapters have been written by several different authors and each can stand on its own, the book is designed as a cohesive whole rather than a collection of independent reviews. The volume begins with a discussion of the evolution of genome size (Chapters 1 and 2), which has remained a puzzle in genome biology since before the elucidation of the double helix 50 years ago (and, not coincidentally, is my own primary subject of study). This is followed by a discussion of genomic parasites, first in the form of transposable elements (Chapter 3), and then of B chromosomes (Chapter 4). Next comes a series of chapters dealing with duplications—of individual genes (Chapter 5), of large fragments and entire genomes in the ancient past (Chapter 6), and of whole chromosome sets in more recent times (Chapters 7 and 8). The following two chapters treat the topics of comparative genome sequencing in eukaryotes and prokaryotes (Chapters 9 and 10, respectively), and include information on genome structure and evolution in the two groups. Finally, the new insights derived from genomic analyses in all these areas are placed in the context of evolutionary theory (Chapter 11). Here the policy of integration is taken to the extreme by drawing links between opposite ends of the evolutionary spectrum, from the study of sub-genomic elements to the macroevolutionary theory developed by paleontologists.

As Stephen Jay Gould noted in his last tome on evolutionary theory, “[a] book’s timescale of production must be labeled as geological compared with a pace of discovery that can only be measured in ecological time.” This disconnect in evolutionary rates is especially acute in genomic science, where major discoveries are being made at an ever-accelerating tempo. In fact, the field of genome biology is moving so quickly that even looking over our shoulders as we typed would not guarantee a fully up-to-date review for the reader. Nor can all of the information presently available be treated in complete detail within the constraints of a single book. The net result is that these chapters are, of necessity, both snapshots and sketches of dynamic and wide-ranging subjects. However, even though much new information continues to accrue as we move deeper into the 21st century, the basic historical and conceptual background, the inroads to the existing literature, and the cross-disciplinary bridges provided in these chapters should remain useful for some time. In fact, one of the goals of the book is to help shape the future development of genome biology by highlighting exciting current and potential research and, hopefully, by stimulating young researchers to pursue their own novel avenues of investigation.

A book like this comes to exist only through the encouragement, support, and hard work of many people. So many, in fact, that it is probably prudent to simply apologize in advance to anyone I may fail to list here by name. Believe me, you are appreciated nonetheless.

To start, let me extend sincere thanks to Beth Callaway, David Cella, Bonnie Falk, Sarah Hager, and especially Chuck Crumly and Kelly Sonnack, along with everyone else at Academic Press/Elsevier and Graphic World Publishing Services who helped to guide this project from a rough idea concocted over mediocre Chinese food to a detailed, comprehensive, accessible collection of chapters that makes quite a satisfying thud when dropped on a desk.

Thanks are also owed (and happily given) to Jim Bogart, Thomas D'Souza, Milton Gallardo, Sara Islas, Spencer Johnston, Antonio Lazcano, Steve Le Comber, Serge Morand, Bob Ricklefs, and others for providing access to unpublished information and other assistance. Juan Pedro Camacho thanks J. Cabrero, M.D. López-León, F. Perfectti, and M. Bakkali for fruitful discussions, and Neil Jones and Robert Trivers for helpful comments. John Taylor and Jeroen Raes thank Martine De Cock for help with the retrieval of older papers. Yves Van de Peer and Axel Meyer gratefully acknowledge the numerous graduate students responsible for carrying out much of the analysis described in their chapter. A heartfelt thank you also goes to the various colleagues who read earlier drafts of particular chapters, including Leo Beukeboom, Robert Carroll, Niles Eldredge, and Robert Trivers, with extra-special thanks extended to Jürgen Brosius, Margaret Kidwell, Mike Monaghan, Howard Ochman, Sarah Otto, and Paul Planet, who provided very helpful comments and constructive criticisms.

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through the end of my postdoc (and hopefully well beyond!), and for giving me the freedom to pursue unorthodox projects such as this one.

I must thank the University of Guelph, the American Museum of Natural History, and the Natural History Museum, London, for hosting me while work was being carried out on this book. I would also like to thank my friends and labmates at each of these fine institutions for putting up with me. A special thank you goes to my former advisor in each lab, Paul Hebert (Guelph), Rob DeSalle (AMNH), and Alfried Vogler (NHM), for always being supportive and for graciously tolerating my rather eccentric work habits (which typically involved prolonged periods of at-home sequestration during the major writing and editing phases).

I owe an enormous debt to the various authors who contributed to this volume. Their hard work, dedication, and expertise have, I believe, made this book something of which we can all be very proud. Thank you!

To my various sets of parents, Bob and Marilyn Gregory, Michele Davis and Frank Brewster, and Steve and Carol Adamowicz, and to my oldest and closest friend (who also happens to be my younger brother), Sean Gregory: thank you for your love, generosity, encouragement, and, well—thank you for everything. And finally, the biggest thank you of all to my wonderful partner and friend, counselor and caretaker, confidant and fellow explorer, Sarah Adamowicz: thank you so much—again, for everything.

I dedicate this book with love to all the members of my family, genetic and otherwise.

T. Ryan Gregory
London, England
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THE EVOLUTION OF THE GENOME

Edited by T. Ryan Gregory

The Evolution of the Genome provides a much needed overview of genomic study through clear, detailed, expert-authored discussions of the key areas in genome biology. This includes the evolution of genome size, genomic parasites, gene and ancient genome duplications, polyploidy, comparative genomics, and the implications of these genome-level phenomena for evolutionary theory. In addition to reviewing the current state of knowledge of these fields in an accessible way, the various chapters also provide historical and conceptual background information, highlight the ways in which the critical questions are actually being studied, indicate some important areas for future research and build bridges across traditional, professional, and taxonomic boundaries.

The Evolution of the Genome will serve as a critical resource for graduate students, postdoctoral fellows, and scientists interested in the issue of genome evolution.



"This book is one of the most exciting books on large-scale evolutionary phenomena I have read in the past decade."

— Robert L. Carroll, Redpath Museum, McGill University, Montreal, Canada

"The Evolution of the Genome is an indispensable source on current understanding of genomic evolution." — Niles Eldredge, The American Museum of Natural History, New York, U.S.A.

"This book is very timely in the age of genomic biology. It provides an impressive coverage of information on genome evolution and brings us a step closer to solving the mystery of genome size variation in nature."

— France Dufresne, Université du Québec à Rimouski, Canada



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