

PREFACE

The duplication of genes and genomes was postulated to be an important process for the evolution of functional and organismal diversity long before we entered the genome sequencing era. Many of the groundbreaking intellectual concepts for this hypothesis come from the work of Susumu Ohno. However, only with the recent availability of many genome sequences are we able to gather supporting data to develop hypotheses and test them on a large scale. Current research on the topic spans scientific disciplines from bioinformatics to organismal biology and touches on different aspects of gene and genome duplication, ranging from the molecular mechanics of the duplication process to the fate of duplicated genomes. Naturally, a variety of approaches goes hand in hand with differences in opinion, and presently, a prolific and at times overwhelming body of research has accumulated. Thus, it was our idea to provide a systematic examination of current thought on gene duplication and its importance to biological diversification across multiple levels.

This edited volume began with a review article published in the *Journal of Experimental Zoology*. With the expansion of concepts into full book chapters, we hoped to cover approaches from a range of fields, starting with molecular and structural biology, leading to computer science and statistics to cellular and, ultimately, organismal-level biology. It is our intention to lay out a hierarchy of chapters extending from evolutionary principles and molecular details out to increasingly higher levels of biological organization. This setup is designed to make the reader appreciate the interconnectedness of these levels.

It is important to us to present this work as a platform for diverse scientific approaches and reasoning. One clear point that will emerge in reading the book is that chapters come from authors in diverse disciplines, some of whom disagree with each other on underlying evolutionary forces, on experimental procedures, and on data interpretation. Occasionally, authors use terms in different ways. In particular, concepts of redundancy (and its maintenance) differ: Genes that one set of authors consider to have been selected for retention due to redundant function others consider to have diverged and to no longer be redundant.

The first section of the book deals with models of gene duplication and retention. Five chapters provide an overview (with some overlap in description, but involving different interpretations) of the mechanisms for the retention of duplicate genes. This includes diverse perspectives on mutational opportunities, dosage compensation, evolutionary processes, and their interrelationship with molecular processes and resulting selection. These fine-scale aspects of interpreting genomic data lay the foundation for the cell/systems level of biology of duplication as well as effects on speciation and biodiversity.

The second section, on gene/protein structure and duplication, includes two chapters. Chapter 6 links the evolutionary process associated with gene duplication through

structure to function, paying particular attention to adaptive processes in proteins that have not yet undergone duplication. Chapter 7 describes the link between the process of gene duplication and protein structure, concentrating on a review of the genetic mechanisms creating fused tandem duplicates.

Comparative genomic methodologies for characterizing gene duplicates are treated in the third section. Chapter 8 overviews methodology for characterizing the functional divergence of duplicate genes, Chapter 9 presents a procedure for linking changes in gene copy number through evolution to functional and gene expression evolution, and Chapter 10 presents an overview of model and parsimony-based approaches for gene tree/species tree reconciliation coupled to a detailed presentation of most parsimonious reconciliation.

The fourth section, involving systems biology considerations of gene duplication, includes three chapters. Chapter 11 describes the energetic costs of gene duplication, arguing for a nonneutral process of fixation. The next two chapters describe the interplay between systems-level constraints and duplicate gene retention as well as the complementary interplay between duplication and the structure of biological networks.

The last section builds up to species-level characterizations of gene duplication. The first two chapters in this section treat research on duplication in birds and plants, addressing their roles in the speciation process, as well as developmental and morphological novelty. Chapter 16 concludes this work with a portrayal of the role of duplication in vertebrate speciation.

As editors, we would like to extend our thanks to all the researchers who contributed to this volume. First and foremost, we thank them for their timely delivered scientific insights, but also for their good humor and patience as we worked through the publishing process. We also thank all the colleagues, students, and friends who joined our discussions on this topic. Finally, we would like to thank Karen Chambers, at John Wiley, who was enthusiastic and supportive of our idea, and thankfully, a very patient editor in the long and at times exhausting process of assembling this volume.

We hope the book will be a useful tool for researchers and students alike to learn about current research on duplication and inspire continued discussion about this important topic.

DAVID LIBERLES
KATHARINA DITTMAR