ORIGIN AND EVOLUTION OF NEW GENE FUNCTIONS

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Origin and Evolution of New Gene Functions

Edited by
M. LONG

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Preface

Although interest in evolutionary novelties can be traced back to the time of Darwin, the appreciation and systematical experimental pursuit of the origin and evolution of new gene functions did not appear until the early years of last decade. Since the 1970s, Susumu Ohno, Walter Gilbert, and others from the area of evolutionary genetics have made pioneer efforts to elaborate possibilities for major biological mechanisms, for example, gene duplication and exon shuffling, by which new gene functions could arise. However, the problem of new gene evolution did not catch significant attention among biologists generally even recently. One of the reasons was the lack of experimental or observational systems for investigating factual details of the 'birth' process of new genes. As a consequence, a stationary genome, a stationary coding portion of the genome, a stationary gene structure, and a stationary set of functions encoded in a genome – all these were part of the mind-set of biology researchers and laymen alike not long ago.

In the first half of the 1990s, the results of the various genome projects began to show explicitly the great difference in the number of genes encoded in various genomes. This variation suggests the existence of one general process in molecular evolution: the birth and death of genes. Thus, the origin of new genes becomes an obvious problem for one to attack. Meanwhile, several discoveries of young genes in *Drosophila* and humans in the past 10 years delivered a clear and inspiring message: the early process of new gene evolution is observable. By examining young genes created by various mechanisms, one can infer the general process of new gene evolution.

Apparently to address origins of new genes we have to deal with two kinds of problems first. What kinds of molecular process are involved in the *de novo* creation of the new gene structure? What population genetic and molecular evolutionary processes drive the fixation of new genes across species and their subsequent changes for a more efficient novel function?

There is ample evidence for diverse molecular mechanisms for the *de novo* creation process: exon shuffling, retroposition, gene duplication with diverged functions, and recruitment of new modules from transposable elements. Yet, it is frequently found

that these different mechanisms cooperate in the making of new genes. In the second phase of new gene evolution, conventional models of new gene evolution, for example by gene duplication, held that the mutations fixed in the early stages of the new genes are assumed to be neutral or nearly neutral. However, it appears that the force of Darwinian positive selection has been detectably strong from the outset in available population genetic studies of young genes created through the process of exon recombination. This may account for a common phenomenon in phylogenetic analyses of genes with changed functions: the early stages of such genes are usually associated with accelerated substitution rates. Nonetheless, a more general and complete conclusion may appear from analyses of an adequate number of new genes in the future.

We see the dawn of a new era in studying new gene evolution revealed in this volume comprising 16 contributions, offering glimpses of the early life of genes and uncovering further unanswered questions and challenges. For example, it is yet to be known how rapidly new genes are created in a genome and whether or not there are any general patterns for new gene origination. Although scientists are not prophets to predict the answers to all known or unknown problems, new significant problems arising in a new area provide an enchanting perspective to pursue.

The editor appreciates the great efforts of all the contributors, who were invited to present their new results and overviews of studies of their subjects of interest. Without their efforts and patience during the editorial process, this volume would not have come into being. In addition, the editor is indebted to many contributors who also spent their valuable time peer-reviewing the papers from other contributors. The editor wishes to show his gratitude to several outside reviewers for their critical and constructive reviews. The critiques of all peer reviewers helped maintain the scientific standard of this volume, as a special issue of both *Genetica* and the *Contemporary Issues in Genetics and Evolution*.

MANYUAN LONG
University of Chicago
Chicago, IL