
This volume resulted from an international symposium, held at Kyoto in March of 1990, which set for itself the daunting task of surveying the evolution of life on earth. Contributions represent such highly divergent areas of evolutionary biology as molecular evolution, sociobiology, evolutionary ecology, and paleontology. Molecular evolution receives the most extensive coverage, and several of the contributions are outstanding. However, it is somewhat surprising, in a book that deals with evolutionary biology in its broadest sense, that interactions between molecular and phenotypic evolution are largely unexplored.

The major exception is in the section of the book dealing with human evolution. Here authoritative reviews of human paleontology (by Tobias and by Walker) nicely complement chapters dealing with the role that molecular evidence is beginning to play in unraveling our origins. These include a chapter by Kocher and Wilson on the mitochondrial DNA evidence and a chapter by Nei and Ota on evidence from numerous polymorphic loci. The latter paper, in particular, illustrates how paleontological, archaeological, and linguistic evidence must be balanced along with molecular evidence if we are to understand the history of human populations. Ueda’s contribution to this section draws attention to the generally neglected problem of species-specific DNA sequences and raises the question of how such sequences may relate to the uniqueness of a species such as our own. In the context of human uniqueness, even Aoki’s rather speculative review of the evolution of cultural transmission does not seem entirely out of place.

Other opportunities for cross-fertilization between the phenotypic and molecular levels are overlooked. For example, Hamilton considers the role of host-parasite interactions in evolution, drawing on a large body of observation and anecdote from ecology, anthropology, and human history. It would have been interesting to juxtapose some of the recent molecular-level work on the evolution of immune systems and of the strategies that parasites use to evade them. However, the only two contributions dealing with the molecular evolution of the immune system do not address the issue of host-parasite coevolution. Hood and Hunkapiller’s contribution is a solid review of the evolutionary relationships of the major groups of genes in the vertebrate immunoglobulin superfamily. Ohta’s paper presents a stimulating though rather artificial model of how polymorphism at major-histocompatibility-complex loci might evolve. Presumably the selection she envisages is parasite driven, but the molecular details of the host-parasite interaction do not really figure in her model.

To me the most exciting chapters in this volume are those in which molecular data are used to provide clues regarding the evolution of new protein function and to reconstruct early branchings in the phylogeny of life. Go reviews the idea that proteins have been assembled by shuffling of modular units, while Mori and co-workers examine the evolution of delta-crystallin by recruitment of the enzyme argininosuccinate lyase. Papers by both Hori and co-workers and by Miyata and co-workers examine the evolutionary relationships of prokaryotes, the former by means of rRNA sequences and the latter by means of a number of different proteins. Miyata’s group provide support for considering the Archaebacteria and Eukaryotes as a clade, elegantly over-
coming the lack of an outgroup for the urkingdoms of living things by using sequences that duplicated very early in the history of life.

Such quantitative data analysis contrasts with the still qualitative picture presented in chapters on the evolution of cell structure (Cavalier-Smith) and cell motility (Margulis). In spite of the fact that we have not yet hit on a way of studying such issues quantitatively, I suspect that Cavalier-Smith is correct when he writes that the study of cell evolution is important because “we have a much better understanding of the molecular basis of cell structure than we do of cell differentiation, morphogenesis, and pattern formation in multicells” (p. 300). Thus, application of the techniques of molecular evolution to this field may come in the not too distant future.

In his contribution to *The Evolution of Life*, the historian of science William B. Provine makes the curious comment that “evolutionary biology has already been bifurcated into molecular and phenotypic by Motoo Kimura’s neutral theory of molecular evolution” (p. 212). On the contrary, I should argue, this “bifurcation” has always been with us. It was evident as early as Morgan’s abandonment of descriptive embryology for the study of genetic mechanisms. Indeed, the bifurcation between phenotypes and the genetic mechanisms underlying them is not a consequence of any human theory but is fundamental to the nature of life. What is new is that molecular data give evolutionary biologists hope to understand the evolution of phenotypes because of the access to the fundamental process (evolution at the DNA level) underlying it.

Thus, I would argue that, rather than leading to disunity in biology, the field of molecular evolution (to which the neutral theory has made such an important contribution) has for the first time made it possible for us to glimpse a future in which biology really will be unified. When we understand the evolution of cellular specialization and of multicellular development at the molecular level, we will have achieved the kind of understanding that, in Cavalier-Smith’s words, “one day will unite the study of organismic evolution and molecular evolution into a unified discipline” (p. 300).

**AUSTIN L. HUGHES**
Department of Biology and Institute of Molecular Evolutionary Genetics
The Pennsylvania State University