II

The Philosophy of Biology, Paradigms, and Paradigm Shifts

The philosopher of science, Alex Rosenberg (Chapter 3), begins this section with a provocative chapter that makes two major claims. The first is that prediction in biology is severely limited, and the second is that the only law in biology is the law of natural selection. These two claims are related. Rosenberg argues that selection is blind to structure and selects only on function, because any functional solution to a particular adaptive challenge is sufficient. It is thus not possible to predict the structural solutions to biological problems of future adaptation. What of the mathematical models of population genetics that appear to capture general deductive truths about genetic transmission? Rosenberg argues that these deductive systems are largely unconnected to empirical reality because they are built from a highly simplified version of biological processes. So we cannot expect accurate prediction from models that are mere parodies of reality.

Rosenberg goes on to consider the role of historical inference in evolutionary biology. In this context, I need to add a word of explanation for one passage where he cites a statement of mine that begins with "our strategy in exploring limits to knowledge is to study the particular . . ." This passage did not survive into the final version of the chapter that I authored for the volume. The passage was included in an earlier version circulated to the conference participants, and it reflects my strategy for proposed research. However, the passage seemed inappropriate for the final chapter and was removed, but Rosenberg's critique of this passage is relevant and is included here. In this critique, Rosenberg takes on the larger question of the value of historical inference in biology. He asks, "Why do we want to know history?" He answers this question by noting that many biological theories can only be tested retrospectively, and further that the law of natural selection, while transtemporarily exceptionless, produces outcomes that are dependent on initial conditions. Hence, our current position can only be understood through reference to some initial starting point.

The biologist Ward Watt (Chapter 4) rejects the notion of ultimate limits to knowledge in evolutionary biology. He argues that the modern synthesis produced an "amechanistic" view in evolutionary biology, in which the study of biological mechanisms is subordinated to the statistical view of genetic change encapsulated in the theory of population genetics. Watt observes that the amechanistic paradigm represented by the modern synthesis emphasizes simple additive relationships between phenotype and genotype and deemphasizes the study of biological interaction. In contrast, careful experimental research with well-defined but complex phenotypes, such as bristle number in *Drosophila*, reveal instead a rich field of interaction among the relatively small number of genes that underlie the bristle number phenotype. On the basis of these examples, Watt calls for a new experimental paradigm of phenotypic analysis built on the central tenet of adaptation, and he provides case studies to bolster his argument.

Jody Hey (Chapter 5) also rejects the notion of limits to knowledge in evolutionary biology. Hey notes that imprecision of language can be the basis for limits to understanding in many areas, and he argues that our linguistic precision improves as a problem is elaborated. He goes on to consider scientific revolutions and uses the development of the theory of electromagnetism by James Clerk Maxwell as an example. Hey argues that even though Maxwell's work revolutionized the physics of his time, Maxwell was unable to predict and appreciate the many ways his theories would unfold in the future. On the basis of this analogy, Hey cautions us to be wary of accepting our current knowledge as secure. He then speculates that a revolution in evolutionary genetics may be in progress, owing to the frequent statistical rejection of neutrality when population samples of DNA sequence data are analyzed. One especially intriguing rejection arises in the study of codon bias, where very weak selection intensities must be effective. Hey argues that contemporary data are consistent with weak selection affecting most segregating nucleotide sites, owing to the confounding of linkage, selection, and effective population size. The end result is a reduction in the efficacy of natural selection. Hey concludes that the selection–drift dichotomy of classic population genetics theory is misleading, and he suggests that a mature theory will emerge to reconcile this dichotomy.

It is interesting to contrast the views of the biologists Watt and Hey. Both see evolutionary genetics as being restricted by theoretical constructs that do not engage the interesting problems presented by contemporary data. Both are optimistic and believe that new theory and a broader experimental paradigm will be elaborated to accommodate the growth of evolutionary genetics. Neither see current or future limits to knowledge in evolutionary biology. In contrast, the philosopher Rosenberg sees the structure of the science as limiting. Why the difference? Biologists are concerned with the particular. How did a particular adaptation arise, what is its genetic basis, what features of the environment selected for this adaptation? The philosopher is interested in the general. What is the structure of the science and how does its structure limit explanatory power?