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Limits to Knowledge
An Introduction

Are there limits to knowledge in evolutionary biology? The last 25 years have witnessed an explosion in biological knowledge. Much of this explosion has been driven by an unparalleled pace of technological innovation. Today we have the tools to answer questions that we could only speculate about a generation ago. It is not so much that new theoretical constructs have arisen as it is that our tools for empirical exploration have expanded enormously. If this history is any guide to the future, we can expect to see a continuing elaboration of empirical knowledge. Indeed, the current genomics enterprise represents one of the great descriptive phases of biology, perhaps akin to the age of discovery two centuries ago. So it is easy to question the notion of limits altogether. But that would be too facile. A deeper analysis suggests that there are classes of problems about which our knowledge is at best approximate and incomplete. To set the stage for an analysis of limits, the historian and philosopher of biology, Michael Ruse (Chapter 1) reminds us that evolutionary science has traditionally addressed three problems. The first, and largely completed problem, has been to establish the fact of evolution. This was done, beginning with Darwin, by using the consilience of different lines of evidence from disparate areas of investigation to establish an overwhelming case for the fact of evolution. The second problem area is historical inference with which we seek to understand the evolutionary pathways that led to today's biological world. It is clear that precise knowledge of historical pathways is limited and will remain limited. (Several of the chapters in later sections of this volume explore this question of historical inference from different perspectives.) The third area concerns the mechanisms of evolutionary change. This is an area where theoretical research is still exploring mechanisms involving, for example, models of social behavior, sexual selection, the evolution of recombination, and macroevolution.

To these three, I would add a fourth area, which is prediction. Evolutionary science is applied in plant and animal breeding, human health, and conservation biology for prediction. There are well-formulated statistical approaches to predict, for example, the response to selection in breeding populations or the minimum viable population size in conservation biology. It is clear that our ability to predict is limited by the same stochastic forces that limit historical inference. Ruse goes on to explore the influence of social forces on the kinds of questions we consider important in contemporary biology. Here, social context is seen as a kind of limitation on knowledge because what the community sees as being worthy of study may be a consequence of the social context of the times in which we live. The high-priority questions of a different era or a different society would likely diverge substantially from those that intrigue our contemporary western society. In Chapter 2, I take a more narrow approach and consider how the theoretical development of population genetics may have led to empirical questions that are misleading, either because the fundamental parameters of population genetics are not estimable, or because the simplifications of theory remove some of the essential details of evolutionary change. I also consider the problem of adaptation as a central empirical question that is difficult to penetrate because the process plays out over several different levels of biological organization. These two chapters set the stage for the ideas explored throughout this volume.