Modular Evolution
How Natural Selection Produces Biological Complexity

Natural selection is more than the survival of the fittest: it is a force engendering higher biological complexity. Presenting a new explanation for the tendency of life to become more complex through evolution, this book offers an introduction to the key debates in evolutionary theory, including the role of genes and sex in evolution, the adaptive reasons for senescence and death and the origin of neural information. The author argues that biological complexity increased through the process of 'modularity transfer': modular phenotypes (proteins, somatic cells, learned behaviours) evolved into new modular information carriers (regulatory proteins, neural cells, words), giving rise to new information systems and higher levels of biological organisation.

Modular Evolution makes sense of the unique place of humans in evolution, both as the pinnacle of biological complexity and as inventors of non-biological evolution.

Lucio Vinicius is a Postdoctoral Fellow at the Leverhulme Centre for Human Evolutionary Studies in Cambridge, UK. He has published articles in various fields including life history evolution, *Drosophila* genetics, brain evolution and human growth.

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LUCIO VINICIUS
Leverhulme Centre for Human Evolutionary Studies, Cambridge

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Thus we cannot say that evolution consists simply in the development of higher from lower forms of life; it consists in raising the upper level of organization reached by living matter, while still permitting the lower types of organization to survive. This general direction to be found in evolution, this gradual rise in the upper level of control and independence to be observed in living things with the passage of time, may be called *evolutionary* or *biological progress*. It is obviously of great importance, and can be seen, on reflection, to be another necessary consequence of the struggle for existence.

Haldane and Huxley (1927: 234), *Animal Biology*

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Preface

This book deals with a classic problem in macroevolution: how do we reconcile the Darwinian 'tree of life', which implies that every single branch or living species is historically and adaptively unique, with apparent differences in levels of complexity between organisms such as bacteria and humans? The first author to deal with the issue was Darwin himself, at the same time a believer in the power of natural selection to create biological diversity and in evolutionary 'progress', or the emergence of complex organisms from humbler beginnings. Besides Darwin, I was also inspired by Erwin Schrödinger and his insightful definition of life; by J. B. S. Haldane, Julian Huxley, John Maynard Smith and Eörs Szathmáry and their aggregation model; by Marcello Barbieri, Eva Jablonka and Marion Lamb and the study of biological codes of inheritance. This book is an attempt at melding together those ideas so as to present one possible answer to the problem of evolutionary complexity.

My intention was to offer at the same time an update on classic themes (including the evolution of sex and the role of genes in adaptive evolution) and an introduction to new debates (in particular the controversies surrounding the comparisons between social behaviour in humans and other species). Many important topics could not be addressed: plants are rarely mentioned, as emphasis was given to animals, behaviour and communication; Price's equation and Kimura's neutral theory were not discussed; and the chapter on evolution and development is necessarily tentative due to the constant transformation of the field. However, the biases can be justified: my aim was not to present a thorough review of evolutionary theory but to develop a thesis: namely that the evolution of complexity should be understood as the transformation of Schrödinger 's Principle of Order from Order. This thesis is meant to harmonise Darwinian evolution by natural

selection with the concept of a dynamical Chain of Being in which organisms are characterised by different levels of complexity.

This monograph resulted from a few years of study and work at Cambridge and grew out of an undergraduate course that I offer in the Department of Biological Anthropology. I would like to thank St John's College and the Department of Zoology at Cambridge for their support during my PhD, and the Leverhulme Trust for funding my research at postdoctoral level. I am especially grateful to LCHES (the Leverhulme Centre for Human Evolutionary Studies) that has hosted me for the past few years. I am indebted to Professor Robert Foley for discussing some of the ideas in the book and for continuous support. Dr Marta Mirazon Lahr has inspired me as a teacher and convinced me that the book should be written in the first place, and I cannot express my gratitude highly enough. I am also grateful to Andrea Migliano and Rudy Schlaepfer and especially Philip Schlaepfer for useful suggestions. I am indebted to Dominic Lewis at the Cambridge University Press for his patience and assistance. Finally, I could not have finalised this project without the support of Hannah Mumby, and I am counting on her help in future endeavours.