

Preface and Acknowledgments

Although originally a systematic term associated with speciation by hybridization, this book exemplifies “reticulate evolution” as it occurs by mechanisms and processes of symbiosis, symbiogenesis, lateral gene transfer, hybridization or divergence with gene flow, and infectious heredity. These phenomena are currently taking up a prominent role in the evolutionary sciences. Almost on a daily basis, new and fascinating data are presented that prove that evolution can result not merely from natural selection which brings forth a vertical pattern of linear descent with modification, but also from various types of reticulate evolution whereby evolutionary lineages connect, merge, and dissolve into one another.

A vast majority of these data are coming in from molecular biology, molecular systematics, and molecular phylogenetics. These fields developed after the foundation of the Modern Synthesis, and they currently enable a unification of bacteriology, virology, medicine, cell biology, exo-, and astrobiology. Together, these fields are building the new and fascinating research area of reticulate evolution. Many of the means whereby reticulate evolution can occur, however, were already identified before the foundation of the Modern Synthesis. Research on hybridization first developed in pre-evolutionary times and reaches as far back as the seventeenth century. Symbiosis and symbiogenesis has mostly been associated with ecological disciplines as well as with research on (a) biogenesis, developmental biology, and cell cytology. These disciplines originated in the late nineteenth century, during a period that has been characterized by Julian Huxley as the “eclipse of Darwin” because the then rising fields favored non-selectionist evolutionary explanations. Infectious heredity and the mechanisms of lateral gene transfer in prokaryotic organisms were first identified in the beginning of the twentieth century, within the bacterial and biomedical sciences, and today associated with virology, bacteriology, and genetic engineering and with attempts to personalize medicine. None of these fields belong to the classic Modern Synthesis that combined theoretical population genetics with Mendelian hereditary laws and aspects of diverse mutation theories. Today, scholars are therefore more and more pleading for an Extended Synthesis that integrates these research fields and their important data into a larger and richer theoretical framework whereby we can understand the evolution of life.

There is a general recognition that reticulate evolutionary mechanisms are stirring up and overthrowing many tenets of the standard neo-Darwinian framework, but how the new findings can become integrated with the standard paradigm, and how a new evolutionary biology might look like, is nonetheless still very much in the open. Natural selection, for example, is traditionally defined as a slow and gradual process, while symbiogenesis and lateral gene transfer are argued to occur rapidly in time. Research today is adding to the complexity, by demonstrating that the various evolutionary mechanisms are often simultaneously active within the various domains of life. Symbiotically acquired organelles, for example, or ontogenetically acquired viruses, can exchange genes laterally with the nuclear genes. Horizontally transferred genes in turn become integrated into the germ line where they evolve via natural and sexual selection mechanisms. When both vertical and reticulate mechanisms are active within the same individual or population, then how do we define the pace(s) and mode(s) of overall evolution? At present, we do not have the epistemic frameworks that synthesize vertical with reticulate evolutionary theories. The mechanisms of reticulate evolution are currently (1) awaiting synthesis into a standard reticulate evolutionary paradigm, and (2) that paradigm in turn is awaiting integration with the classic, neo-Darwinian one.

Though knowledge on the various means by which reticulate evolution occurs has never been so vast, a wider recognition and dissemination of these ideas toward the public sphere as well as within and across the general evolutionary sciences continues to lag behind. Almost all founders of the Modern Synthesis, and many leading neo-Darwinian scholars, brought natural selection to a wider academic and non-academic audience by publishing accessible books on their findings. It brought forth a general recognition that, regardless of our private or public institutional affiliations, the study of evolution by means of natural selection concerns us all and therefore needs integration in all scientific and public domains. Whether we are biologists or not, and academics or not, reticulate evolution equally impacts how we are to understand life's natural history, and it has a vast array of applications in the study of human health and disease, genetic engineering, or agriculture. Today, few experts unfortunately feel chosen to bring their work outside their field-specific disciplines, and instead, they report their results in technical journals. Field-specific handbooks that have as goal to train future expert-scientists are equally inaccessible to non-experts because of the necessary technical language.

The goal of this book is to provide an introduction on reticulate evolution to scholars and students working outside the fields, but it is not an encyclopedia of the numerous advocates. Such encyclopedias will eventually be edited by the biologists themselves. For this book, I chose to focus on the mechanisms that underlie reticulate evolution. Here too, choices had to be made, because there are many ways in which reticulate evolutionary mechanisms can be explained and exemplified. One can choose to provide a dictionary or glossary of new scientific jargon; one can give a state of the art on a selection of current data; one can dive into history and examine the original context of discovery wherein the mechanisms were first identified and perform an epistemic, philosophical analysis on how these

ideas were and are received as well as what their consequences are for scientific theory in general; one can exemplify one reticulate evolutionary mechanism by providing examples of how it occurs within diverse lineages; or one can exemplify the relation between the various reticulate evolutionary mechanisms by exemplifying how they together bring forth the evolution of one or a couple of species. In agreement with the theme, the authors in this work have merged these various approaches, and their works focus either on theory formation or on particular case studies, or they either provide historical and philosophical contextualization or introductions to the state of the art.

This book also draws the line under a one-year long project funded by the Templeton Foundation that set out to investigate how reticulate evolutionary theories, and also macroevolutionary theories, are currently expanding evolutionary thought and how they can be implemented into the sociocultural domain. With the project, my collaborators, Marcia Belchior, Francisco Carrapiço, Luís Correia, Larissa Mendoza Straffon, Marco Pina, Olga Pombo, and Emanuele Serrelli, and I organized evolution schools for pre- and postdoctoral research scholars that featured courses on reticulate evolution taught by Michael Arnold, Frédéric Bouchard, Francisco Dionisio, Luis Villarreal, and Douglas Zook (<http://evolutionschool.fc.ul.pt/videos>); a symposium session on how symbiogenesis, lateral gene transfer, and virolution extend the synthesis for the 2013 meeting of the American Association for the Advancement of Science (<http://appeel.fc.ul.pt/sub/eve/dir/aaas/aaas2013.html>); a public conference on evolution that featured talks for a general audience and classes for teenagers on topics of reticulate evolution (<http://evolutionconference.fc.ul.pt>); and a conference on *Evolutionary Patterns: Horizontal and Vertical, Micro- and Macroevo-lutionary Patterns of Biological and Sociocultural Sciences* (<http://evolutionarypatterns.fc.ul.pt/videos>). Along the way, we captured several video interviews with the scholars involved, which can be viewed either on the respective video channels mentioned above, or directly on Appeel's YouTube channel (<https://www.youtube.com/user/appeellisboa>).

Many of the scholars that partook in the project and its associated events are also featured in this volume. I am very grateful to the authors who were willing to disseminate their and other people's work on reticulate evolution to a larger academic community, and I am quite confident that this book will provide an excellent entry point to interested scholars outside the field. Cordial thanks furthermore go out to Andreas Bohn, Frédéric Bouchard, Jorge Carneiro, Maurizio Casiraghi, Claudine Chaouiya, Eveline Kolijn, Alan Cooper, Cristina Cruz, Tal Dagan, Lee Dugatkin, Ricardo Guerrero, Frank Kressing, Paulo Madruga, William Martin, Ana Noronha, Frank Ryan, Jan Sapp, Rosalia Vargas, Davide Vecchi, Luis Villarreal, Tyler Volk, Richard Watson, and Slava V.I. Yukalov. Finally, my gratitude, as always, goes out to the entire Springer team, especially Anette Lindqvist, Sabine Schwarz, and the team in India.

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