

Preface

You're an interesting species. An interesting mix. You're capable of such beautiful dreams, and such horrible nightmares. You feel so lost, so cut off, so alone, only you're not. See, in all our searching, the only thing we've found that makes the emptiness bearable, is each other.

—fictional Extraterrestrial, speaking to Earthling,
in *Contact* (the film, 1997)^a

Rethinking Evolution breaks the mold for both popular and professional science books. The conceptual destination is nothing short of a wide-ranging Updated Evolutionary Synthesis (UES), and there are many challenges along the way. To see why it's worth embarking on this journey, please take a minute or two to jump ahead to the final chapter (Chapter 17) for a comprehensive list of the principles of the UES in its initial published form. Most readers will be surprised by at least some of the entries in this list. The UES includes many new aspects of which most readers are unaware. Today's evolutionary theory is stronger than ever, because it is thoroughly supported by literally thousands of wide-ranging empirical observations and experiments. The UES incorporates the lasting core principles of classical 1859 Darwinian theory but offers a more complete and plausible scientific explanation than ever before.

Theodosius Dobzhansky paid tribute to the "Modern Synthesis" when he famously declared that "Nothing in biology makes sense except in the light of evolution".

^a<http://www.imdb.com/title/tt0118884/>

That "Modern Synthesis" is, of course, no longer modern. The 21st century converse is equally illuminating: Nothing in evolution makes sense except in the light of biology.

In other words, a deep understanding of the sheer organizing power of the natural forces of evolution can be found in now well-established biological principles. These principles are based on numerous new discoveries in molecular, cellular and developmental biology.

The plausibility of the metaphorical "blind watchmaker" who creates an exquisite range of diverse structures and functions is persuasively revealed by exploring the biology of the inner-workings of living cells, and how they interact to reproduce complex organization from genetic determinants.

The stunning efficacy of complex adaptations that enable carbon-based life forms to capture energy and nutrients—and to store and reproduce hereditary information in each generation—is no longer a mystery. The UES goes far beyond Darwin's early, brilliant insights.

As with scientific theory in general, the UES is a social product. Most aspects of the UES are based on previously published, peer-reviewed scientific papers. Yet, despite numerous attempts to integrate these important new elements into a broader public awareness, evolutionary theory continues to be poorly understood among nonscientists. *Rethinking Evolution* consolidates these fragments and resolves needless confusion, while retaining both scientific rigor and improving accessibility for the general public.

Along with the contributions of other scientists, I add an important element of my own, which I call **Emergent Evolutionary Potential (EEP)**; see Chapter 2).^b

^bEEP was inspired by a new perspective that may resolve some of the paradoxes of quantum physics. Although theories that pertain to the quantum realm are *not* directly applicable to the macroscopic realm of biological evolution, they do emphasize an expanded scientific view of reality where *potential events* play an important role. Ruth Kastner presented this new perspective on quantum physics in her crystal-clear popular book, *Understanding Our Unseen Reality* [17].

There has never been an attempt at reconciliation that is quite like the one you are reading now. *Rethinking Evolution* transcends familiar science book categories, and is intended to reach a much broader readership that includes working scientists, educators and communicators, as well as nonscientists who are unfamiliar with biology in particular or science in general.

21st century evolutionary theory is arguably the most interdisciplinary topic in the natural sciences. For this reason, *Rethinking Evolution* casts a wide net to bring a broad range of disparate knowledge together in one place.

In terms of practical tools for accessibility, few popular science books have leveraged the extraordinary potential of new digital media. Nonscientists will find that the UES is presented in plain language, where practical and useful web links in the footnotes provide more in-depth explanations.

Additionally, technical terms are defined in the glossary which is linked to public-domain Internet resources such as Wikipedia. The glossary can be found in printed versions of *Rethinking Evolution* as also in hyperlinked web format on the Internet at rethinkingevolution.com. For the natural sciences in general and for biology in particular, Wikipedia represents a treasure-trove of accessible knowledge. This is an excellent way for readers with little or no background in biology to quickly gain a working knowledge of the relevant concepts that are of greatest personal interest. Students, teachers, and biomedical professionals will find that the contents of this book are thoroughly grounded in empirical facts but are presented in an accessible way with an engaging storyline.

Why Me, and Why Now?

At the outset, such an unusual approach to the special challenges posed by the UES begs at least two questions: **First, why me? And second, why now?**

First, early in my career as a research biologist, I contributed some of the now widely-accepted discoveries concerning **DNA sequence variation** that call for rethinking the notion of “random mutations” that characterize

the **Modern Synthesis** that was forged in the 1940s. My 1987 doctoral thesis described the major mechanism—**slipped-strand mispairing**, also known as **replication slippage**—that generates repetitive sequences and—in concert with several other well-known processes—expands both **repetitive** and **nonrepetitive DNA sequences** throughout the **tree of life**.

Those are just a tiny fraction of the stunning recent discoveries made by the scientific community concerning the inner workings of cells. They call for a major upgrade to the classical and **neo-Darwinian** perspectives.

The subtitle of this book refers to the revolution that is hiding in plain sight. Despite numerous laboratory discoveries and exciting new perspectives, the outdated conceptual framework of the Modern Synthesis continues to persist in textbook accounts of evolution, with a tenacity that might be metaphorically compared to the **QWERTY keyboard layout**, which also persisted long after it outlived its usefulness.

Second, although my personal interests in developmental biology and evolution extend back to my earliest undergraduate days at UC Berkeley (UCB), I encountered the same obstacles that encourage most research scientists to focus more on peer-reviewed papers and practical applications, and less on broad theoretical discussions and communication with the general public. More recently, a number of scientific, social, and personal factors have come together in a sort of “perfect storm” that compelled me to write this book. I will briefly mention three contributing factors:

- (1) In addition to intriguing new perspectives on the sheer organizing power of EEP mentioned above, a number of important additions to Darwinian theory have come of age—such as **evolutionary developmental biology**^c [15] and **facilitated variation**^d [13, 122].
- (2) Just as biological evolution can be self-accelerating, increasingly rapid empirical discoveries in molecular, cellular, and developmental biology have been driven by technology—and these provide numerous indisputable facts consistent with an updated and expanded view that goes beyond classical Natural Selection.

^chttps://en.wikipedia.org/wiki/Evolutionary_developmental_biology

^dhttps://en.wikipedia.org/wiki/Facilitated_variation

- (3) Having spent much of my earlier career laboring under the same institutional constraints that limit communication with the nonscientists, as well as theoretical exploration by practicing research biologists, I am no longer subject to those constraints. Today, I have more freedom to share many years of quiet theoretical exploration—and numerous empirical discoveries by others—that have culminated in my current perspectives.

A Note on What is Missing

Although *Rethinking Evolution* offers an unusually wide-ranging and interdisciplinary view of biological evolution, I have deliberately stopped short of delving into **evolutionary psychology** (evo-psych) and its implications for human happiness and survival. I do hope to return to that subject in the future. For now, I recommend an excellent popular book on the subject by Robert Wright, titled *The Moral Animal* [32], written in 1994, and *Our Political Nature: The Evolutionary Origins of What Divides Us*, by Avi Tuschman, first written in 2013 [129].

Why would I choose to defer an updated discussion on evo-psych, when its principles of evo-psych are clearly relevant to understanding human nature, and arguably more important than ever, given recent political and social developments? After all, evo-psych informs us not only about the power and limitations of human nature, but also offers a path towards overcoming those limitations and surviving our own worst tendencies.

I have deferred this discussion for two reasons:

- (1) A solid understanding of the biological aspects of evolutionary theory makes it much easier to understand and appreciate evo-psych. *Rethinking Evolution* provides this prerequisite background.
- (2) Evo-psych is a blend of social science and natural science, whereas a discussion of the UES should focus on objective facts that are already well-supported by empirical evidence and basic principles of the natural sciences.

The human brain is perhaps the best example of an exquisitely powerful and complex adaptation with negative tendencies. That is why

evo-psych is so important, but any conclusions that we draw must be thoroughly grounded in empirical research and critical thinking. I do remain convinced that evolution has provided us with the means to overcome our own limitations. The prerequisite to making the right choices is understanding our own origins, while recognizing our potential to transform future probabilities.