Preface

The world exists holistically, wholly physics, chemistry, biology, and all their derived sciences (like geology and astronomy), all fused together in a single perfectly harmonized entity. By contrast, human minds are epsilons in both life span, physical ability, and capacity to know about the world they must live in. The amazing thing is that *the ability to build abstractions and reason with them* has given humans the ability to control a great deal of that world, at least on planet Earth. Divide and conquer has enabled them to understand the world, one slice (i.e. aspects of reality, like physics, chemistry, and biology) at a time. The latter sciences have developed in parallel, some long before biology started, as systematic sciences, like mathematics, physics, and chemistry, while others did after it, like statistics and computer science (including machine learning [ML] and data science [DS]). They have enabled the gathering and storing of volumes of data well beyond terabytes daily, without significant progress in deriving useful biological information from them. Yet, answers to fundamental questions in biology (like the concept of species, the nature of life, and whether evolution is really essentially an unpredictable random process) remain as challenging as ever.

Thus, biology has remained focused on a more empirical approach that seeks to explain an evident, humongous biological complexity that dwarfs the complexity of phenomena of interest in physics and chemistry, for example, as the result of the accumulation of interactions across scales, from nano to micro to organisms, both in space and time. Yet, no understanding of the world, particularly the holistic biome of life on Earth, would seem possible without putting these sciences back together again. Once this divide is understood, the next step should be to combine data with powerful mathematical and computational tools developed by ML and DSs to create a new kind of biology that is more than these parts just clumped together, an *analytical biology*. It would not be surprising then that biology could also develop abstractions and, consequently, theories that have conferred upon other sciences a predictive power, the source of much of human understanding of the world today.

This (text) book aims to take a bold first step in that direction by providing an integrated and systematic presentation of the subfields of genomics and evolution through the lenses of the classical challenging questions in biology, delving into fundamental physical processes. It seeks to facilitate necessary interactions and pave biologists' way to raise the level of abstraction to accrue a substantially deeper scientific understanding of the

enormous complexity of biological diversity. Each chapter summarizes the state-of-the-art conventional biological knowledge on one major biological question, then presents alternative concepts, approaches, and concrete case studies to apply them and address the problem at a deeper level. In addition, graduate students, researchers, and practitioners in biology, bioinformatics, and DS will find a number of problems suggested for further research. A companion website at bmc.memphis.edu/predBiology makes available data, software, and results of prior research to consolidate and facilitate work in these areas.

It is an exploration in progress.

Memphis, Tennessee, USA, and
Bogotá, Colombia, December 2024

Bon voyage
Max
Luis Fernando
Alex