Preface

This book started as a series of notes, overheads, and digital slides that comprised a course in molecular evolution. The course was designed as an integrated approach to this field. It draws from concepts in evolution, geology, chemistry, biochemistry, molecular biology, genetics, taxonomy, and, of course, molecular evolution. Because it discusses aspects of each of these disciplines, students with broad backgrounds (as well as very focused backgrounds) should be able to grasp the concepts, principles, and details of this book. It presents some of the usual information regarding various aspects of cell function, but also details the variety of mechanisms that have evolved in various organisms. This has been done to present a broader view of evolution that is meant to show that some processes have been approached in very different ways by the diversity of organisms during evolution on Earth.

The book is organized into 18 chapters. Chapter 1 is an overview of life on Earth as well as the possible origins of life. The definitions of life are discussed in detail. At the end of the chapter, there is an exercise designed to help the reader imagine and visualize the components of a cell in their true dimensions. Chapter 2 details the evolution of organisms on Earth. It also presents a history of the study of evolution. Chapter 3 covers the basic structures of DNA (deoxyribonucleic acid), RNA (ribonucleic acid), proteins, and other biological molecules, and the syntheses of each. Chapter 4 begins with the central dogma of molecular biology, but then goes into detail about the complexities of all of the central processes of this basic principle. Chapter 5 discusses the largest ribozyme in the cell, the ribosome. This includes details about the structure and function of ribosomes as well as a discussion about its evolution. Also discussed are the mechanisms for assuring that enough rRNA (ribosomal RNA) is produced to supply each cell with all of the ribosomes it needs. Ribosomes have been one of the key structures in cells that have led to the success of life on Earth. Chapter 6 discusses the various forms of DNA replication, and how they have been important in evolution. Chapter 7 presents the common, as well as many of the uncommon, modes of separating chromosomes, from separation of chromosomes in bacteria to mitosis and meiosis in a variety of eukaryotes. Chapter 8 summarizes the ways in which DNA can be changed to produce mutations as well as the ways in which DNA can be repaired by several repair pathways. Chapter 9 details the infectious causes of mutation in DNA, including viruses, transposons, plasmids, and introns. Some of these have led to rapid evolutionary changes, many of which made possible the evolution of complex organisms. Chapter 10 is meant to integrate some of the ideas presented in the previous chapters. It discusses the various definitions of a species as well as speciation and gene flow in populations. Chapter 11 presents details about the definitions, evolution, and importance of multigene families. These have led to rapid evolution and some have been shown to parallel the development of entire lineages of organisms. For example, without the globin multigene family, mammals would not exist. Chapter 12 is a brief description of phylogenetic analysis. It was needed at this point in the book to bring together some

of the information presented in the previous chapters in order to show how researchers use the raw sequence data to reconstruct portions of evolutionary processes. It provides a perspective to the study of molecular evolution.

Chapters 13 through 18 detail the genomes of a variety of organisms from RNA viruses to eukaryotes. The genomes are presented in order of their sizes. In this way, some of the details of genome organization and expression are discussed for the smallest genomes (RNA viruses in Chapter 13 and DNA viruses in Chapter 14). These principles of organization and expression then are used as a basis for discussing the larger genomes, including those of Bacteria and Archaea (Chapter 15). Before discussing the genomes of Eukarya specifically, genome interactions are discussed in two chapters (Chapters 16 and 17). This is because eukaryotic genomes have evolved due to the interactions between different organisms and their genomes. Chapter 16 discusses interactions in mutualistic and pathogenic relationships. Organisms and their genomes do not exist in isolation, but are in constant contact with other organisms and genomes. Chapter 16 discusses some of these interactions. Chapter 17 details genomic interactions involved in endosymbiotic relationships that lead to the formation of organelles. This characterizes one of the hallmarks of eukaryotic evolution. Finally, genomes of Eukarya are discussed in Chapter 18. Several genomes are discussed in detail, including those of plants, fungi, and animals.

A companion CD is located at the back of the book.