PRINCIPLES OF

Microbial Diversity
This book is dedicated to the memory of Elizabeth Haas.
You are missed by all who knew you.
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Contents
Preface

Although it has been recommended that undergraduate curricula for microbiology majors require a core course on microbial diversity, microbiology programs most often lack such a course. One reason for this lack is that, unlike the other recommended core microbiology courses, there has been no appropriate textbook on microbial diversity for students at the undergraduate level. Principles of Microbial Diversity is intended to fill this gap.

This textbook is intended primarily for junior and senior undergraduate students who are majoring in microbiology or a related field. Students should already have studied a general microbiology course and should have familiarity with genetics and either biochemistry or microbial physiology. The perspective in this book is phylogenetic and organismal, from the Carl Woese school (in contrast to the approach of most general microbiology textbooks) (1). This textbook arose from an existing senior-level lecture/lab course on microbial diversity and so has been in use with success already.

The book comprises four main sections. The first section is introductory, laying out the scope of the text, defining the perspective, and providing a historical context. This is followed by a practical guide to molecular phylogenetic analysis, focusing on how to create and interpret phylogenetic trees, and an overview of “the Tree of Life.” The second section is a tour through each of the major familiar phylogenetic groups of Bacteria and Archaea (microbial eukaryotes and viruses are also covered briefly), discussing the general properties of the organisms in each group, describing some representatives in more detail, and concluding with one or two specific topics on the unique properties of these organisms.
The third section of the book is conceptually and experimentally defined (based on primary literature), beginning with identification of unknown and potentially uncultivable organisms and leading to molecular surveys of populations, linking processes with specific organisms. This sequence leads to the final section, brief discussions of various aspects of microbial genomics and origins.

The most straightforward approach for covering the two large middle sections of the textbook in class is to start with the survey of phylogenetic groups and follow this with the concept/literature chapters. An alternative approach, which I have used with great success, is to intertwine them. In my experience, each lecture begins with the discussion of a particular microbial phylum (a portion of a chapter in section two), with some discussion of general topics raised about these organisms, leading into one of the papers from sections three and four of the textbook (or a more recent paper chosen by the instructor) that highlights organisms in the group discussed in that lecture. For example, a chapter might start out with a discussion of the Chlamydiae, describing the members of the group, their phenotype, pathogenicity, and life cycle, and be followed by a discussion of reductive evolution in parasites. It would then shift gears to an introduction to genomics, exemplified by the paper describing the Protochlamydia amoebophila genome and what it teaches us about the origin of obligate pathogens. The order of topics, as would be taught in the course, would be defined by the conceptual thread (section four of the text), building in complexity.

Acknowledgments

As the sole listed author of this text, I would be negligent if I did not make it absolutely clear that it is the result of a community effort on many levels. The folks listed below all deserve the lion’s share of the credit for this work; any errors and shortcoming I claim only for myself.

This book was initiated over the course of a couple of years by the persistent encouragement of Greg Payne at the ASM Press. Once started, Ken April, Production Manager, and John Bell, Senior Production Editor, at the ASM Press made this book happen. Special thanks are also owed to the book’s interior and cover designer, Susan Brown Schmidler; Dianna Logan and Peggy Rupp at Dedicated Book Services, Clarinda, Iowa, who assembled this high-quality book from a collection of text files and images; Lindsay Williams, the diligent ASM Press Editorial and Rights Coordinator, who shepherded permissions; and the art renderer, Tom Webster of Lineworks, Inc., who created professional illustrations from what were, in some cases, little more than vague sketches.

This text is based on a course I was hired (in part) to develop and teach in the Department of Microbiology at North Carolina State University. The success of this course is owed to those who recognized its importance before my arrival and encouraged and fostered its development afterwards—especially Leo Parks, Hosni Hassan, and Gerry Luginbuhl, but also the entire faculty of the department.

This book, and the phylogenetic perspective on which it is based, owes everything to Carl Woese, the intellectual father of modern microbiology. The course on which this text is based has its origin not just in Carl’s work generally but also very specifically in his fabulously important review article from 1987
Woese CR. 1987. Bacterial evolution. Microbiol Rev 51:221–271). The importance and utility of the phylogenetic perspective have no better advocate than my postdoctoral mentor, Norm Pace, for whom no amount of thanks can suffice for his mentorship over the years.

Enormous credit goes to those who captured the images of organisms used in this text. A picture is worth at least a thousand words. Photo credits are given with the images, but special thanks are warranted to a few who provided numerous images well beyond anything for which I had the right to ask: Michael Thomm and Reinhard Rachel, John Fuerst and Margaret Lindsay, and D. J. Patterson. A special thanks also goes to Howard Spero for allowing us to use his spectacular image of G. bulloides on the cover of this text.

This book also owes its existence to another James W. Brown, my father, for his patient yet persistent encouragement, and to my mother, Phyllis Brown, who nurtured my scientific interests from the earliest possible age. Finally, and most importantly, I am forever grateful for the encouragement and patience of my wife, colleague, and collaborator, Melanie Lee-Brown.
About the Author

From the beginning, Jim Brown had a keen interest in nature, including anything slow or unwary enough to be captured or observed in the woods, rivers, beach, or ocean that was always nearby. A single lecture on microbial diversity in a General Microbiology class while Jim was an undergraduate at Ball State University, and the announcement in that class of the discovery of an entirely new kind of living thing (the “archaebacteria”), sparked his lasting interest in microbiology. That led to undergraduate research examining *Beggiatoa* in a southern Indiana sulfur spring. He later earned his M.S. in Microbiology.
at Miami University and joined the MCD Biology Ph.D. program at The Ohio State University, where he worked on the molecular biology of methanogenic archaea with Professor John Reeve. He then moved to Indiana University for a postdoc in Professor Norm Pace’s lab, working on the comparative analysis of ribonuclease P RNA in Bacteria. Afterwards, Jim joined the Department of Microbiology at North Carolina State University (NCSU) and continued to work on RNase P in Archaea and the comparative analysis of RNA. Jim developed and teaches senior-level undergraduate lecture and lab courses in microbial diversity, which are the genesis of this textbook. Jim was awarded the NCSU and Alumni Outstanding Teacher awards in 2005 and the Alumni Association Distinguished Undergraduate Professor award in 2014. He has been a member of the ASM since Graduate School and is a long-time officer of the North Carolina branch of the ASM.
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