specialized pathogens, especially the obligate parasites (rusts, powdery mildews, downy mildews), told clearer, more compelling stories. To choose one example, the chapter on *Blumeria graminis* (by Pietro D. Spanu) began by succinctly describing the peculiarities of the powdery mildew lifestyle: obligate biotrophy despite a close relationship to necrotrophs, a limited host range combined with an ability to rapidly overcome host resistance genes, and the explosive spread of disease from secondary cycles of conidia disseminated in dry air with no liquid water needed for infection. The chapter went on to describe the unexpectedly large genome of *B. graminis* (ca. 120 MB) largely consisting of repetitive DNA (greater than 90%) from retrotransposons. Strains of *B. graminis* differed more in these repetitive areas than in gene sequences, suggesting that most of the genetic variation may derive from recombination by retrotransposition during clonal propagation. Since effectors are associated with repetitive regions of DNA, the ability to rapidly break down host resistance was suggested as a possible advantage to powdery mildews maintaining such a large genome. In contrast to this, the number of coding genes was half the number found in related fungi, with the genes lost being associated with functions that are possibly less necessary for a phylloplane-inhabiting obligate parasite, such as polysaccharide-degrading enzymes, enzymes for anaerobic respiration, and those for utilization of inorganic nitrogen and sulfates. The author suggested that there is a tradeoff for large genome size in powdery mildews: "the cost of large genomes full of active retrotransposons is paid with 'evolutionary currency' of more swiftly adaptable effectors . . . [a]nd the cost of large genomes with many active retrotransposons includes gene loss" (p. 168). It is a good story: all of the evidence taken together supported a logical and coherent understanding of an organism and the selection pressures on it.

In a world where everything is online, there may seem to be no need to own a book. Volumes such as these are, however, more than compendia of data, they show an organizing intelligence. They allow each pathogen the chance to be as interesting as a cheetah or a saber-tooth tiger.

NINA SHISHKOFF, *Foreign Disease/Weed Science Research Unit, Agricultural Research Service, United States Department of Agriculture, Frederick, Maryland*

MICROBIOLOGY

PRINCIPLES OF MICROBIAL DIVERSITY.

By James W. Brown. Washington (DC): ASM Press. $90.00 (paper). xvi + 390 p.; ill.; index. ISBN: 978-1-55581-442-7 (pb); 978-1-55581-851-7 (eb). 2015.

Microorganisms are the most abundant and diverse forms of life on Earth. Over the past decade, our understanding of microbial diversity has dramatically expanded due in large part to advances in sequencing technology, which have facilitated the identification and classification of bacteria, microeukaryotes, archaea, and viruses. To showcase this diversity, James W. Brown's *Principles of Microbial Diversity* provides a clear and approachable overview of the major microbial taxonomic groups spanning the tree of life.

In this volume, the author emphasizes a phylogenetic approach to the study of microbial diversity. In the opening sections, he demonstrates the usefulness of this approach while providing a typical workflow that is used for constructing phylogenetic trees. Brown then begins a tour of what he refers to as the "microbial zoo": a survey of the taxonomic, morphological, and metabolic diversity contained within the major groups of Bacteria, Archaea, and Eukarya. After outlining methods for assessing microbial diversity in environmental or uncultivable populations, the author wraps up by discussing (meta-)genomics and hypotheses for the origin of life.

Principles of Microbial Diversity succeeds as a broad survey of microbial diversity while uniquely adopting a phylogenetic framework. Furthermore, Brown alerts curious readers to more advanced topics, such as treeing algorithms, long branch attraction, and non-16S rRNA gene-based approaches for differentiating microbial species. He smartly highlights nonmodel organisms as taxonomic representatives from each group and accompanies them with supporting images. There are subsections that briefly describe the metabolism, morphology, and habitat requirements for each of the major groups of microorganisms being discussed. The figures throughout are clear, purposeful, and well positioned on the page. To initiate classroom discussion, the author poses a few thought-provoking questions to conclude each chapter.

This volume does not delve into the eco-evolutionary processes that are responsible for the generation and maintenance of the vast diversity on display in the "microbial zoo." And although Brown introduces readers to high throughput sequencing technology, less attention is devoted to the visualization and quantification of biodiversity that is common in the primary literature. For example, core biodiversity concepts related to α- and β-diversity (e.g., richness, evenness, turnover) are not discussed. Perhaps more emphasis could have been placed on the critical role that microorganisms have in global biogeochemical cycles, along with the effects that microbial diversity has on the stability and functioning of natural and managed ecosystems.

In summary, Brown's book will serve as a useful guide to an upper-division course on microbial diversity. The phylogenetic introduction is an effective foundation for subsequent sections outlining the biology of major microbial lineages. For a typical course in microbial ecology, this volume would compliment other textbooks or literature on population, community, and ecosystem ecology.

NATHAN I. WISNOSKI and JAY T. LENNON, *Biology, Indiana University, Bloomington, Indiana*

PHILOSOPHY OF MICROBIOLOGY.

By Maureen A. O'Malley. Cambridge and New York: Cambridge University Press. $95.00 (hardcover); $31.99 (paper). x + 269 p.; ill.; index. ISBN: 978-1-107-02425-0 (hc); 978-1-107-62150-3 (pb). 2014.

In his memoir *Naturalist*, E. O. Wilson writes, "The key to taking the measure of biodiversity lies in a downward adjustment of scale. The smaller the organism, the broader the frontier and the deeper the unmapped terrain" (1994. Washington (DC): Island Press. Pages 363–364). In *Philosophy of Microbiology*, Maureen O'Malley argues that microbiology—the study of the smallest organisms—is changing how we conceive of biological phenomena in general. With central chapters on the philosophical implications of high-level and species-level classification of microbes, microbial evolution and ecology, and the use of microbes as model systems, O'Malley's book is well worth reading for philosophers of science and biologists.

The author argues that accounting for the essentially microbial nature of life should shift our emphasis away from the 20th-century obsession with heredity (genetics) and more toward metabolism (biochemistry). She notes that ideas about "major transitions" in evolution have emphasized changes in levels of selection on hereditary information (e.g., the origin of multicellularity), whereas key biogeochemical events in the history of life (e.g., the pre-Cambrian oxygen revolution) involved microbial metabolic innovation. Because such metabolic transitions provided the necessary preconditions for future hereditary transitions, they should indeed occupy a more central place in accounts of the history of life.

Microbial ribosomal RNA gene comparisons pioneered by Carl Woese in the late 20th century established the domains Archaea, Bacteria, and Eukarya as the largest divisions of life, overturning previous systems that gave equal weight to plants, animals, and microbes: microbes—single-celled organisms—are found in all three domains, whereas macrobial life occupies a subset of branches within the Eukarya. The history and philosophical implications of the ongoing microbial revolution in classification are comprehensively discussed by O'Malley in the first of two interesting chapters. The second of these chapters provides a broad philosophical and historical perspective on the challenges that Archaea and Bacteria, which reproduce asexually yet can transfer genes between distant lineages, pose for traditional ways of thinking about species and speciation.

In recent decades, microbes have moved from the periphery to a central place in investigations of ecology and evolution, both in natural settings and in experimental, laboratory-based settings. Questions about scale and extrapolation arise in both contexts. Does evolution and ecology in microbes follow the same rules—insofar as we know them—as in multicellular organisms? Are studies of simple microbial populations, communities, and ecosystems in the laboratory suitable proxies for long-term evolutionary and ecological processes in nature? Biologists and philosophers of science will find much that is worthwhile on these and other questions in O'Malley's chapters on microbial ecology and evolution and the use of microbial model systems.

Philosophy of Microbiology is a thought-provoking and comprehensive look at the influence of microbiology on how we conceive of and study the living world. This book may not convince you that all life is fundamentally microbial, but it will certainly change your perspective.

PAUL SNIEGOWSKI, *Biology, University of Pennsylvania, Philadelphia, Pennsylvania*

LIFE'S ENGINES: HOW MICROBES MADE EARTH HABITABLE. *Science Essentials.*

By Paul G. Falkowski. Princeton (New Jersey): Princeton University Press. $24.95. xi + 205 p.; ill.; index. ISBN: 978-0-691-15537-1. 2015.

Paul Falkowski is a marine biologist and oceanographer at Rutgers University. His specialty has been phytoplankton. This book is an outstanding attempt to popularize the role of microbes,