PREFACE

Not all microorganisms that infect insects and other animals are pathogens. Evidence accumulated over more than a century has shown that healthy insects bear microorganisms and that many insect species require their microbial partners for sustained growth and reproduction. For much of the last century, entomologists—being thoroughly practical people—recognized two things: that these associations had great potential to control insect pests; and that they were largely intractable to study because most of the microbial partners could not be cultured. While the study of insect-pathogen interactions was a mainstream discipline in entomology and microbiology, the study of beneficial microbes associated with insects was a fringe topic, pursued by relatively few researchers.

Everything changed in the opening years of this century. Novel sequencing and microscopical technologies have made it possible to identify microorganisms and investigate their functional traits without cultivation. The discipline of microbiology was transformed, and the new discipline of microbiome science was founded. A major goal of microbiome research is biomedical, to develop microbial therapeutics that ameliorate and cure chronic human diseases. Nevertheless, many of the new technologies are readily applicable to insects, reshaping our capacity to study insect interactions with their communities of resident microorganisms. This in turn has created new opportunities to harness these insect-microbial associations for novel strategies to manage insect pests and disease vectors, and also to use insects as models for human microbiome research. We have an unparalleled scope for fundamental discovery and application for the public good.

The rapid expansion of research on insect associations with beneficial microorganisms over the last decade has been exciting, perhaps even overwhelming. The primary literature has ballooned, and every month brings more mini reviews, perspectives, and opinion pieces on individual associations or specific

aspects of insect-microbial interactions. Making sense of this burgeoning information is demanding and made more difficult by mutual incomprehension among colleagues approaching this subject area from different disciplines. Entomologists recognize that the biomedical microbiome literature is important but often struggle to follow it, while many microbiologists and biomedical microbiome researchers find much of the entomological literature opaque. It is from many conversations with colleagues and students that I came to understand that a book about the relationships between insects and beneficial microbes could contribute to solving these difficulties.

The specific purpose of this book is to provide a framework of the basic concepts and key studies in the field of insect interactions with beneficial microorganisms, and to explore how recent advances can be applied in insect pest management and biomedicine. My goal is to present the fundamentals of this field to assist colleagues and students in their research, teaching, and learning. I assume that readers have a university-level education in the life sciences.

The focus of this book is insects and their bacterial, archaeal, and eukaryotic microorganisms. I set myself these taxonomic limits as a "rule" when I started this project and, despite many temptations, I have not deviated, to ensure consistency in my subject material. After all, not all rules are there to be broken. This book does not consider noninsect arthropods, such as acarines, millipedes and centipedes, or crustaceans. Similarly, it does not address insect interactions either with animal endosymbionts, such as nematodes, or with beneficial viruses, such as polydnaviruses. These various systems illuminate our understanding of symbiotic systems in diverse and fascinating ways; but if I included them, this book would quickly have lost its focus. Even with my rule obeyed, I have not been able to include some fascinating topics and to describe the studies of many colleagues within the word limit wisely set by the publisher. Some of these decisions have been hard to make. I recognize fully how much of the primary literature that goes unmentioned in this book has enriched my understanding of insect-microbial associations.

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