

Preface

Bacteriology can be traced back to Anton van Leuwenhooek in the late seventeenth century, who first saw the magnitude of the bacterial colonisation of the planet Earth. However, it was in the nineteenth century that bacteriology, as we know it, was created by the towering figures of scientists such as Louis Pasteur and Robert Koch of bacterial disease fame and Serge Winogradsky, who pioneered the characterisation of the activity of bacteria in natural habitats. Bacteriology begat immunology, and the twentieth century saw the development of antibacterial vaccines and then the discovery of antibiotics. These naturally occurring drugs created the false illusion that we had "beaten the bugs," and bacteriology as a scientific discipline went into decline. Nevertheless, the study of bacteria, such as *Escherichia coli*, and of bacteriophage was at the foundation of modern molecular biology. The emergence of widespread antibiotic resistance in the late twentieth century was the spur to reactivate bacteriology, which is now a flourishing discipline in its many guises, such as molecular microbiology, cellular microbiology, and environmental microbiology.

Throughout the twentieth century, there was a growing realisation that bacteria did more than simply cause disease, and evidence began to mount that most animals contained their own populations of bacteria that were variously termed: commensal bacteria, indigenous microbiota, microflora, and so on. It was not until the advent of techniques allowing molecular phylogenetic analysis of the life forms in environmental samples (including those from animals) that the magnitude of the diversity of the prokaryotic world became realised. We now understand that microbial life forms, particularly bacteria, are the predominant organisms on our planet, with a staggering diversity. What has been even more astonishing is the discovery that the

majority of multicellular creatures on our planet live with many specific bacterial partners. In this volume, we describe these organisms as cooperative bacteria. Humans, most of whom fear bacterial infection, may be the acme of bacterial cooperation as ninety percent of the cells in the average human are bacteria, and the number of bacterial species living happily with us is estimated to be between 1,000 and 3,000. Compare this with the 50 or so bacteria (many of which form part of the cooperative assembly) that have the potential to cause human disease. This suggests that for the last century or more, we have been looking at bacteria through the wrong end of the telescope.

This volume arose from a meeting held in the beautiful lake resort of Bellagio, Italy, and funded by the Rockefeller Foundation. Scientists from diverse disciplines but with a common interest in bacteria-host interactions came together to discuss the biology of animal-bacterial cooperation and what it means for both partners.

This volume is divided into four sections. Part I discusses the evolution of cooperation and addresses key questions about the role of cooperation as an evolutionary pressure on both prokaryotes and eukaryotes, as well as the influence of bacterial cooperation in the evolution of the complex vertebrate acquired immune response. Biological evolution is generally viewed on the scale of millions of years. However, as the last two chapters in this section describe, rapid changes in phenotype can arise in bacterial populations in response to selection factors in their environment, such as antibiotics. In Part II attention focuses on the ecological interactions between bacteria and their multicellular hosts, and the reader is introduced to the roles of bacteria in such diverse activities as coral bleaching and the control of insect reproduction. A major problem in the study of cooperative bacteria is the complexity of the "system" that is created between bacteria and their hosts. The final chapters in this section deal with methods of analysis of cooperative systems using metagenomics and mathematical modelling. Part III discusses our emerging knowledge of how cooperative bacteria interact with their hosts at the molecular level in a variety of systems ranging from intracellular bacteria in insects to the complex systems found in mammalian tissues such as the gut, genitourinary system, and respiratory tract. The final section, Part IV, considers how cooperative bacteria interact with innate and acquired immunity, and discusses our rapidly advancing knowledge of the innate immune responses of invertebrates and the mechanisms by which vertebrates immunologically recognise and cope with bacteria, including their cooperative partners. The final chapter reviews how much we have gained control over our cooperative bacteria in the last 50 years.

This volume will be of interest to a wide range of biological scientists, including basic microbiologists, medical microbiologists, epidemiologists, cell biologists, virologists, parasitologists, ecologists, and zoologists, and should be useful to undergraduate, postgraduate, and postdoctoral scientists working at the frontier of a new understanding of the role of cooperative bacteria in animal host biology.