Preface

How well do we understand bacteria? How true is the hypothesis of Jacques Monod that if we understand *Escherichia coli*, we will be able to understand elephant? It is striking that the more we learn regarding bacteria the less we can be convinced of this hypothesis. For a long time, scientists thought that bacteria were just simple single-celled organisms that could be used as model systems for higher, complex, and multi-celled eukaryotic organisms. In a rather simplified view, bacteria were considered as self-contained packets of enzymes that had little interaction with each other or the surrounding environments. Conversely, it is now appreciated that bacteria can show community features of communication between individual cells and interaction with surrounding environments. As with higher organisms, a community of bacteria can display individual phenotypic variations; this is the case even within a clonal population of identical genetic composition (see Chap. 12). Such individual diversity seems to promote communication between cells that aids adaptation in the environment (see Chap. 9). The tremendous diversity between different bacterial species is also striking; suffice it to say that the genetic distance between two bacterial groups may be of a similar order to the average genetic distance between plants and animals.

Although the significance of the early contributions of pioneering microbiologists cannot be overemphasised, it is unquestionable that the study of bacteria has been revolutionized by the application of molecular methodologies. These methods allowed direct manipulation and monitoring of bacterial cells' components rather than hypothesizing on them. This was not an option for an old bacteriologist, given the limitation of traditional methodology in microbiology, and it has been the massive advancement in genetics, biochemistry, biophysics, bioinformatics, etc. that made molecular techniques available. The use of molecular methods including the "omics" (genomics, transcriptomics, proteomics) and fluorescence-based techniques not only allowed new discoveries, but has also changed our way of researching and thinking of bacteria. Modern bacteriologists do now adopt "a molecular approach," in which cell structure, function, and behaviour are interpreted on molecular basis. This approach has broadened and deepened the level of study of bacterial cells, but also raised concerns regarding a number of the past's theories.

Within this context comes the present book, which presents the impact of applying the molecular approach to the study of bacterial physiology. The first chapter discusses recent discoveries of subcellular organisation that have been made possible by the use of molecular techniques. The author exploits such sophisticated structural findings in reforming our ideas regarding the basic physiological processes of transcription, translation, cell division, etc. The second chapter reports on the presence of cytoskeletal elements in bacteria, a structural property that was thought to be restricted to eukaryotic cells. This is an interesting and significant discovery, given the involvement of bacterial cytoskeleton in shaping cells, cell division, chromosome segregation, and cell motility. The third chapter is also on newly discovered structural phenomena related to the cytoplasmic membrane. The authors provide comprehensive review of the presence of mechanosensitive channels that form large pores in the cytoplasmic membrane that switch between open and closed states, aiding cell survival during environmental stress. In relation to this, the authors also describe recent findings showing the dynamic structural nature of bacterial cell wall. The fourth chapter considers an interesting aspect of one of the basic physiological processes: respiration. The author discusses the phenomenon of respiratory flexibility in bacteria, where cells use a range of different electron donors and acceptors in response to different environmental pressures. Chapter 5 describes protein secretion systems, a novel research area with particularly potential medical applications. Chapter 6 discusses the regulation of gene expression by DNA supercoiling. This is an unorthodox view of gene regulation, usually thought to be mediated by primary DNA sequences, activators, repressors, etc. Here, the author shows that DNA topology is significantly important for regulating gene expression. Chapters 7 through 9 provide reports on different systems used by bacteria to sense changes in the surrounding environment. These chapters emphasize the ability of bacterial cells to interact with each other and with surrounding environments, a trait that enables adaptation and survival under different environmental conditions. Chapters 10 and 11 further describe other cellular mechanisms to cope with environmental stress. Chapter 10 reports on ribosome modulation factor, whose binding to bacterial ribosomes has been shown to aid cell survival during stress, whereas Chapter 11 demonstrates diverse aspects of the so-called "stress master regulator," RpoS, which is a sigma factor protein mediating the transcription of stress-responsive genes. Apart from structural and functional issues discussed in the previous chapters, the last chapter explains the striking phenomena of phenotypic switching and bistability in bacteria. The authors provide an account of the molecular basis of these phenomena, in which individual cells with identical genotypes may display different phenotypes under identical conditions within the same clonal population.

As mentioned above, bacteria display a high degree of structural and functional diversity. Since much of our knowledge of bacteria has been gained through the study of relatively few species, such as *E. coli* and *Bacillus subtilis*, this raises the question of how applicable our current understanding is to the physiology of the rest of bacterial species. It is interesting to see in this book several examples of knowledge generated with bacterial species other than the previous model ones. This will certainly help provide better and thorough understanding of the physiology of bacterial cells. As we will also see in most chapters, there is a concluding section showing potential applications of the aspects discussed in each chapter. It could be realized from these sections that significant applications in biotechnology and drug discovery can be made effective using the wealth of basic knowledge in bacterial physiology.

This book has been developed to suit readers of diverse backgrounds. While the text serves as a reference for researchers pursuing work in areas highlighted by the book chapters, it is also intended to be useful to undergraduates and postgraduates majoring in microbiology and to microbiologists who wish to be familiar with advances in other areas of microbiology. I am very grateful to the colleagues who contributed chapters to this book, dedicating time and sincere effort for such a project. I would also like to thank all of them for their patience with me during the review process. My greatest appreciation to the following professors who kindly contributed to reviewing the book chapters: Peter Graumann, Frank Mayer, Paul Williams, Wolfgang Schumann, Regin Hengge, Eberhard Klauck, Tracy Palmer, and Mattew Hicks. I would like also to thank Dr. Christina Eckey, Ms. Ursula Gramm, Ms. Alice Blanck, and the rest of the editorial team at Springer for their support and help during the development of this book.

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Aga, July 2007 Walid M. El-Sharoud

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