Bacterial Adhesion

ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY

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Bacterial Adhesion

Chemistry, Biology and Physics

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Introduction

Why a book on bacterial adhesion? Adhesion plays a major role in the bacterial lifestyle. Bacteria adhere to all surfaces and did so long before the first eukaryotes were around; stromatolites, which are calcium-based rocks in shallow seawaters formed and inhabited by cyanobacteria, are among the oldest fossils found (Battistuzzi et al., 2004). Bacteria can adhere to each other, a phenomenon referred to as autoagglutination, which is generally viewed as one of the first steps towards biofilm formation. Bacteria can also form more complex and defined structures, such as the *Myxococcus* fruiting bodies – *Myxococcus* is generally seen as a "social" bacterium with complex inter-cell interactions, and as a model for the early evolution of multicellularity (Konovalova et al., 2010). Last but not least, bacteria can adhere to other cells: different prokaryotic species in the formation of complex biofilms, or eukaryotic cells during disease. Adhesion to eukaryotic cells can serve different purposes in commensalism, symbiosis, and pathogenesis. The general principle, the expression of surface molecules to adhere to other structures, stays the same.

But why this particular book when reviews on bacterial pathogenesis are common, if not quite a dime a dozen? Our focus is: how are such adhesion phenomena best studied? Microbial genetics experiments have greatly enhanced our knowledge of what bacterial factors are involved in adhesion. For numerous reasons, though, biochemical and structural biology knowledge of the molecular interactions involved in adhesion is limited. Moreover, many of the most powerful biophysical methods available are not frequently used in adhesion research, meaning that the time dimension – the evolution of adhesion during biofilm formation remains poorly explored. The reason for this is, we believe, on the one hand microbiologists, who are experts at handling and manipulating the frequently pathogenic bacterial organisms in which adhesion is studied, lack detailed knowledge of the biophysical possibilities and have limited access to the frequently expensive instrumentation involved. On the other hand, the experts in these methods frequently do not have access to the biological materials, nor do they necessarily understand the biological questions to be answered. The purpose of this book is thus to overcome this gap in communication between researchers in biology, chemistry, and physics, and to display the many ways and means to address the topic of bacterial adhesion.

Thus, the book consists of three loosely connected parts. The first Chapters 1 to 7 deal, broadly speaking, with bacterial adhesion from a biological perspective, where different bacterial species and their repertoire of adhesion molecules are described. The chemistry section includes the biochemistry and structural biology knowledge which have been obtained on some of the adhesin systems. The physics section contains examples of biophysical methods that have been successfully applied to bacterial adhesion. For obvious reasons, we had to limit ourselves in the choice of systems and methods described in this book. The biological systems described are only examples, and mostly come from genera containing the better-studied human pathogens. We tried nonetheless to cover a broad spectrum of organisms, both Gram-positive and Gram-negative bacteria. Chapters 1 and 9 also put specific Gram-negative and Gram-positive systems into a historical perspective and describe the development of the field of infectious diseases. Many of the findings also apply to bacteria that are either non-pathogenic (Chapter 13) or pathogenic on different species and kingdoms, and Chapter 5 nicely shows that in plant pathogens, adhesins similar to those of human pathogens exist and serve comparable functions.

The chemistry section (Chapters 8 to 15), contains examples of molecular structures of the very different types of adhesins found. These are mostly from the human pathogens discussed in the biology section, again from both Gram-negative and Gram-positive bacteria. We have also included two chapters on carbohydrate structures (13 and 14), as these structures are at least as important as the proteins in bacterial pathogenesis. One pattern that emerges is that most of these adhesins contain repetitive elements, which make them long and fibrous, but which might also allow for easy recombination and thus evolution in the face of the host immune system.

The physics section (Chapters 16 to 22) originally seemed the hardest to fill: how should we identify methods useful in adhesion research, but infrequently used? Discussions with colleagues and literature searches led us to authors on such diverse methods as force measurements, electron microscopy, NMR, and optical tweezers, as well as a chapter on how bacteria adhere to medical devices and how this can be studied (Chapter 22). Moreover, the enthusiastic response of these authors showed to us that indeed, there is a need for a forum to display the panel of technical possibilities to the researchers who struggle with unsolved biological questions.

Now that the book is finished and out of our hands, we hope that it will achieve our goals – that it will be of broad interest to researchers from different fields all working on different aspects of bacterial adhesion. We hope it provides an advanced but jargon-free introduction to the state of adhesion research in 2010, one that will bring researchers together in new, exciting, and most importantly, interdisciplinary projects. The struggle for new therapies against bacterial infections is not made easier by the “Red Queen Principle” – the fact that pathogens evolve and adapt quickly in the face of new challenges (van Valen, 1973). We strongly believe that only interdisciplinary research can tackle the growing problems of multidrug resistance, hospital-acquired infections, and other adhesion- and biofilm-related topics in human health that require new drugs, disinfectants, or vaccines.

We thank all of our authors for their hard work and Thijs van Vlijmen of Springer for being always available to answer our questions.

Tübingen Dirk Linke
Helsinki Adrian Goldman
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