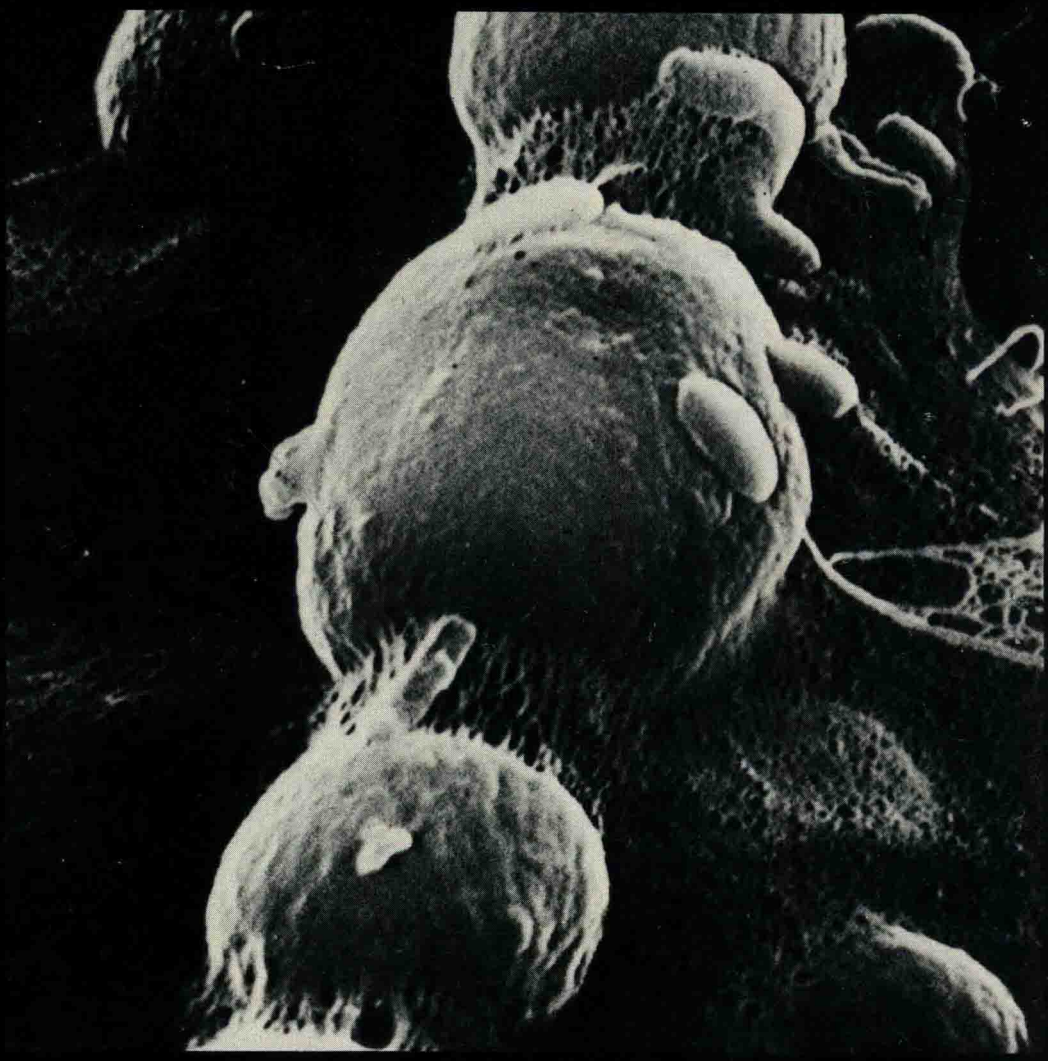
Bacterial Adhesion

MECHANISMS AND PHYSIOLOGICAL SIGNIFICANCE

Edited by
Dwayne C. Savage
and
Madilyn Fletcher



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PLENUM PRESS • NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

Main entry under title:

Bacterial adhesion.

Includes bibliographies and index.
1. Bacteria—Physiology. 2. Cell adhesion. I. Savage, Dwayne C. II. Fletcher, Madilyn M.
QR84.B15 1985 589.9'01 85-3434
ISBN 0-306-41941-6

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Preface

Study of the phenomena of bacterial adhesion to surfaces has accelerated considerably over the past 10 to 15 years. During this period, microbiologists have become increasingly aware that attachment to a substratum influences considerably the activities and structures of microbial cells. Moreover, in many cases attached communities of cells have important effects on their substratum and the surrounding environment. Such phenomena are now known to be important in plant and animal hosts, water and soil ecosystems, and man-made structures and industrial processes.

Much work on microbial adhesion in the early 1970s was descriptive. Those studies were important for detecting and describing the phenomena of bacterial adhesion to substrata in various environments; the findings have been presented in numerous recently published, excellent books and reviews. In some studies, attempts were made to elucidate some fundamental principles controlling adhesion processes in different environments containing a variety of microorganisms. Common threads have been observed occasionally in different studies. Taken as a whole, however, the information has revealed that many disparate factors are involved in adhesion processes. Whether a particular microorganism can adhere to a certain substratum depends on the properties of the microbial strain itself and on characteristics of the substratum and of the environment. For example, the capacity of a bacterial strain to adhere to a substratum may depend on whether the cell is fimbriated, encapsulated, or a rough mutant; whether the substratum is a nonbiological or biological surface; and on the pH, temperature and ionic strength of the environment. Such conditions may affect adhesion directly, by influencing the physicochemistry of the process, or indirectly, by modifying the physiological processes of the bacteria. Moreover, when biological surfaces are involved, many additional, complex physiological factors can come into play.

When bacterial cells adhere to a given substratum, significant changes can take place in those cells and in the substratum. If the surface is a nonbiological one, then the attached cells may be deformed physically and undergo numerous poorly defined physiological changes. Concomitantly, products of the metabolism of the microorganisms may begin to alter the substratum, such as by dissolving pits in it. Such phenomena may be particularly prominent when the substratum to which the organism is attached contains, or is, its nutritional substrate. When the substratum is a biological one, such as a plant or animal surface, then the attached microbial cells may not only undergo physiological changes themselves, but may secrete substances or be involved in processes, such as those involving genetic or invasive

activities, that may have profound consequences for the host. Thus, understanding of microbial adhesion processes must go beyond mere description of the processes themselves and extend to sophisticated study of their mechanisms and consequences.

Such research must be concerned with the subcellular mechanisms by which the bacterial cells adhere to the substratum and, in many cases, the genetics of the process in the adhering cells. Investigators must guard, however, against confusing mechanisms in separate adhesive events. A danger exists for such misinterpretation because of the chemical and structural heterogeneity of bacterial populations and the bacterial surface itself.

The purpose of this book is to examine in one volume what is presently known about the physicochemical and molecular bases of the processes of bacterial adhesion to surfaces, and the influences of attached bacterial communities on their substrata. In most chapters, the emphasis is on the results of experimental studies of various aspects of such processes.

The book is divided into three sections. The first, introductory section begins with a description of some of the phenomena of bacteria adhering to various substrata in different environments (Chapter 1). This is followed by descriptions of the structural and chemical properties of the surfaces involved in the adhesion processes, i.e., bacterial (Chapter 2), animal (Chapter 3), plant (Chapter 4), and nonbiological (Chapter 5) surfaces.

The second section is concerned with the mechanisms by which bacteria adhere to surfaces. The first three chapters deal with adhesive interactions at nonbiological interfaces in different environments, i.e., solid–water (Chapter 6) and air–water (Chapter 7) interfaces, and soil particle surfaces (Chapter 8). The next three chapters deal with bacterial adhesion to surfaces of higher organisms, i.e., plant–bacterium (Chapter 9) and animal–bacterium interactions. The latter topic is developed in two chapters, one on adhesive interactions involving complex macromolecular mechanisms (Chapter 10), and one on interactions known to be mediated by pili (Chapter 11).

The third section deals with the consequences of the phenomena of bacteria adhering to surfaces. The consequences for the bacterial cells themselves are discussed in two chapters. In Chapter 12, emphasis is placed on how the physiological activity of a bacterium can change when its cells are in proximity to a surface. Chapter 13 discusses how a surface can influence the properties of an attached bacterium in an extremely complex way when the surface is another organism which can act as a source of nutrients or inhibitors. The final two chapters deal with how bacteria attached to surfaces of plants (Chapter 14) and animals (Chapter 15) may influence their hosts, such as by invading tissues, inducing resistance responses and otherwise altering host physiology, sometimes to the advantage, but often to the disadvantage of the animal or plant involved.

A reading of these chapters will reveal readily that bacteria adhere to surfaces by a variety of mechanisms and that the consequences of such adhesion may be many and varied. It is seen that, at this time, it is generally not possible to elucidate fundamental processes underlying the phenomena. The chapters reveal, as well, however, that methods now exist for elucidating the mechanisms at the molecular level. The reader is encouraged to look for similarities in biochemical interactions or responses in various ecosystems, which may offer clues to underlying and dominant molecular mechanisms or the evolutionary history of interactions involving adhesion. We hope that this book will prove to be useful in the planning and execution of future experimental attempts to understand the mechanisms of bacterial adhesion and their physiological consequences. We will be especially satisfied should the book prove to be a strong stimulant for further research on these important subjects.

We wish to express our great appreciation to the authors of the chapters who labored so

hard and well to produce their fine manuscripts. We also thank them for their patience during the long editorial process. We wish as well to express gratitude to Mr. Kirk Jensen, who inspired us to edit this book.

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