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Bacterial and Bacteriophage Genetics

An Introduction

With 111 Figures

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For Lynn and Colin

Preface

This book is intended for the student who is taking a first course in bacterial and bacteriophage genetics, rather than as a reference tool for the specialist. It presumes a knowledge of basic biology as well as familiarity with general genetics. Extensive knowledge of microbiology, although helpful, is not essential for a good understanding of the material presented herein.

In order to develop the basic concepts of bacterial and bacteriophage genetics in a volume of reasonable size, I have endeavored to avoid the strictly molecular approach as well as the thoroughly comprehensive treatment characteristic of review articles. For simplification and continuity, therefore, I have dealt primarily with *Escherichia coli* and its phages, except where other bacteria can better illustrate a particular point. This should not, however, be construed to imply that only *E. coli* is worthy of study. Rather, it is my hope that students will be able to generalize from the principles presented in this book to the specific bacterial systems which may be of more direct interest to them.

This book is not intended to cover the individual aspects of bacterial genetics in great depth. To do so would require such an excess of detail as to make the book unwieldy. Rather, it is my hope that the student who has carefully read this book will be prepared to read, with insight and comprehension, the current literature in whatever area of specific interest. Toward this end, I have tried to present bacterial genetics as a logical development of concepts. In so doing, it has occasionally been necessary to omit or defer until later chapters certain topics for which the theoretical framework has not been prepared. Cross references to such topics within the text are made by a series of numbers and letters indicating chapter, section, and part, respectively (e.g., 1.IV.A refers to Chapter 1, Section IV, Part A).

At the end of each chapter, references are provided which will assist the serious student in finding more information on individual topics. These are grouped into two classes: those articles which can be used as general background, and those which have been selected as examples of research articles which amplify the specific topics covered in the chapter. The selection of a limited number of references must of necessity be highly arbitrary, and it should be understood that there are many excellent research scientists whose works simply could not be cited because of space limitations. Indexes such as the *Science Citation Index* will assist the reader to enlarge upon the lists of references provided.

Two books may be noted as being particularly useful sources of detailed information. One is the classic book in the field, William Hayes's *Genetics of Bacteria and Their Viruses*. Although somewhat dated now, its breadth of coverage has never been equaled. The other book which may prove to be a useful descriptive reference for certain types of procedures used in bacterial genetics is David Freifelder's *Physical Biochemistry*.

If the reader of this book develops some of the same fascination which I have long found in bacterial genetics, the task of writing it will have been well worthwhile.

Tempe, Arizona, 1980

EDWARD A. BIRGE

Acknowledgments

A book such as this would not be possible without the cooperation of many people. It is a pleasure to acknowledge the support and encouragement of Dr. Mortimer P. Starr, for without his stimulus this book would never have been written. The style of writing and the presentation of the subject matter have benefited greatly from the efforts of Drs. Elizabeth M. Haines and Lynn E. Birge. The early chapters were facilitated by the congenial habitat provided by Bernard and Ruth Weber and by the comments of Drs. William F. Burke and Winifred Doane. Many of the figures in the text are taken from the research literature, and the cooperation of the authors in supplying these figures has been greatly appreciated. Preparation of the manuscript has been made easier by the efforts of Regina Derosé, who typed much of the rough draft; by Valley Autographics, who prepared the finished product; and by Dr. Mark Licker, Ute Bujard, Roger Kasunic, and Marie Donovan of Springer-Verlag, who patiently dealt with the inevitable problems. However, despite all of these contributors, the ultimate responsibility for any errors of commission or omission must be mine.

Linkage Maps

Inside the front cover The illustrations on the front inside cover are linear scale drawings representing the circular linkage map of *E. coli* K-12. The time scale of 100 minutes, beginning arbitrarily with zero at the *thr* locus, is based on the results of interrupted-conjugation experiments. Major genetic symbols used in this figure are defined in Table 1-2. Parentheses around a gene symbol indicate that the position of that marker is not well known and may have been determined only within 5 to 10 minutes. An asterisk indicates that a marker has been mapped more precisely but that its position with respect to nearby markers is not known. The small vertical arrows indicate the directions of transcription of certain well-studied loci. Note that the *rrnD* loci should have been placed at 71.7 minutes instead of at 70.5 minutes. A similar map for *Salmonella typhimurium* may be found inside the back cover. From Bachmann, B.J., Low, K.B. 1980. Linkage map of *E. coli* K-12, edition 6. Microbiological Reviews 44: 1–56.

Inside the back cover The illustrations on the back inside cover are linear scale drawings representing the circular linkage map of *Salmonella typhimurium*. The scale of one hundred units has been chosen to emphasize the similarities to the *E. coli* map (inside the front cover). A length of one unit represents the amount of DNA carried by P22, KB1, or ES18 transducing phage particles, while a length of two units represents the amount of DNA carried by a P1 transducing phage particle (see Chapter 7). The segmented lines to the right of the cistron symbols indicate cistrons which are jointly transduced and the linear distances determined by this method. Major genetic symbols used in this figure are defined in Table 1-2. Parentheses around a cistron symbol indicate that the location of the cistron is known only approximately, usually from conjugation studies. An asterisk indicates that a marker has been mapped more precisely, usually by phage-mediated transduction, but that its position relative to adjacent markers is not known. Arrows to the extreme right of cistrons and operons indicate the direction of mRNA transcription at these loci. A line without an arrowhead to the extreme right of a cistron or operon indicates that the orientation of the cistrons on the linkage map is not known. From Sanderson, K.E., Hartman, P.E. 1978. Linkage map of *Salmonella typhimurium*, edition V. Microbiological Reviews 42:471–519.

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