# Gene Function

## *E. coli* and its heritable elements

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# Preface

My aim in writing *Gene Function* has been to present an up-to-date picture of the molecular biology of *Escherichia coli*. I have not attempted a chronological description, believing that a mechanistic account is more useful for such a highly developed field.

I have divided the book into four parts. Part I is a general introduction to bacterial systems, their genetic material, structure, composition and growth. It has seemed desirable to include herein a brief preview of the remaining text, to introduce the nomenclature and to help place subsequent chapters in perspective. The expression of genetic material and its perturbation through mutation is considered in Part II. Part III discusses how the transfer of prokaryotic genetic material can be mediated by plasmids and bacteriophages. It describes the DNA transactions involved (replication, recombination and repair) and ends with a description of the genetic and biochemical techniques employed in the study of gene organisation. Finally, Part IV considers the control of expression of bacterial, plasmid and phage genes. Key reviews are listed at the end of each chapter.

I should like to express my gratitude to the following: Richard Hayward, Michael Hunter, Robert Lloyd, David McConnell, Vishvanath Nene and Terek Schwartz for invaluable advice and criticism of the text; Michael Billett, Ray McKee and Philip Strange for comments on certain areas; Tony Brown for good counsel; Bryan Clarke for a 'sensible' title; Colin Wilde for constructing the index; Gill Burgess and Rosalyn Chapman for patiently typing the manuscript; Sally Smith for her superb graphic work; Ray McKee for supplying material for photographing; Kate Kirwan and the audio-visual department of the Queen's Medical Centre for photographic work.

Robert E. Glass
Nottingham

To my father,
in memory.

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# Part I
# Introduction

# 1 The Bacterial Cell

What is a bacterium? Of the multitude of different cellular organisms present on our earth, all can be conveniently divided into two main groups: *eukaryotes*, those that carry their genetic material physically retained within a membrane, separate from the cytosol; and *prokaryotes*, those that lack a distinct nuclear membrane. Bacteria are microscopic, predominantly unicellular species, ubiquitous in nature, belonging to this latter class. They come in many shapes and sizes: spherical, rod-shaped (straight or curved); some form a mycelium. They have in common the ability to divide asexually by fission (certain species, such as *Bacillus subtilis*, also survive by the generation of spores that are aerially dispersed).

Why *Escherichia coli?* Prominent in any list of the advantages of research on bacteria must be the rapid growth and limited nutritional requirements of these organisms. This allows the ready production of large quantities of cells — a homogeneous population, moreover. Also important is that results are obtained in a matter of hours (certainly no more than one or two days). Bacteria are easily handled — they require minimal sterile techniques, being fast growers. Since the strains of *E. coli* generally used are non-pathogenic, little (if any) containment is necessary. The fact that *E. coli* grows on a defined medium is cruical for genetic studies and for the investigation of biochemical pathways. It seems fortuitous that this harmless gut bacterium was initially chosen for study since *E. coli* (unlike *Salmonella typhimurium*) carries a functional system for lactose utilisation, study of which led to formulation of the operon model for regulation of expression of prokaryotic genetic material. Moreover, comparison of the conjugative plasmids — extrachromosomal genetic elements able to transfer between bacteria — present in different species suggests that the high transfer efficiency of the F plasmid of *E. coli* was instrumental in its discovery.

The present discussion, indeed the remaining text, is restricted to *E. coli* and its heritable elements. This is a reflection of the mass of research that has gone into a single organism. Already, we know the complete structure of the genetic material of certain of its simple viruses. The processes responsible for their replication and propagation are likely to be elucidated completely in the near future. The next level of challenge is, surely, a whole bacterium. Perhaps half of the *E. coli* genetic material has been characterised in terms of coding potential, and a number of regions have been sequenced. A unified, frontal attack on a single species, albeit at many different levels, therefore has its advantages. Critics of such prokaryotic studies have cited the clear disparity with higher