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Biotechnology
The Biological Principles

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Biotechnology: The Biological Principles

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Biotechnology: The Biological Principles

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Foreword

As the authors of this text rightly point out, biotechnology is an activity that has engaged the human race for a very long time—five or six thousand years at least. It is only since the advent of 'genetic engineering' however, that it has been clearly recognised as a key operation in human living. In this it is a prime example of how an activity with which we are all familiar but which has sunk into the background can be brought back to the forefront of attention by a new and exciting discovery. The ensuing flurry of activity is likely to start a whole new series of developments within the older areas of the subject. In the present instance, genetic engineering is not only the cause of the present realisation of the widespread importance of biotechnology but is, as John Higgins has pointed out, itself 'a dramatic example of the difficulty of predicting those areas of basic science which are most likely to lead to important applications. The discovery of recombinant DNA technology is a consequence of the large amount of support given to research into molecular biology for more than forty years. Yet even as late as the late sixties, a common criticism of giving relatively so much support to this 'glamour' area of chemistry and biology was that nothing directly useful had come from it. Now, however, it is clear that it has lead to discoveries that will radically affect humanity.

In the late fifties, a few pioneers, encouraged by the development of large scale fermentation by the antibiotic manufacturers, began to establish large scale biochemistry—'Biochemical Engineering' as it was then called since the term 'Biotechnology' was not then in use. However, not much notice was taken of these efforts until the understanding of the genetics of microorganisms had reached a stage where this knowledge could be exploited commercially. Based upon the fundamental understanding of bacterial genetics which resulted from the work of Monod and backed up by research on DNA replication, protein synthesis, the genetic code, restriction enzymes and bacterial plasmids, there emerged in the course of forty years an entirely new outlook in the biological sciences and one fraught with problems—scientific, ethical and industrial. The excitement engendered by this revolution and the power of the techniques that emerged encouraged many of the leading workers in the field to oversell and industrialists to overestimate the immediate commercial potential of the discoveries. Chiefly lacking was a clear appreciation that the genetics was only

the preliminary stage to the production of a commercial product and that the intermediate steps were not only difficult but were in many instances unknown.

This text is designed to assist students and industrial people who are having to or who will have to grapple with these areas of biotechnology. Most existing texts of 'biotechnology' so far have tended to be either highly specialised or general surveys of the field—'what is Biotechnology'? We have so far lacked an intermediate level book dealing with the main background science relevant to biotechnology and which is suitable for middle year undergraduates and workers in other fields who find their activities impinging on biotechnology. Because of the wide range of the potential subject matter, the authors have had to be selective. They have very sensibly concentrated on their own areas of expertise so that the text is reliable and their enthusiasm comes over—always an enlivening aspect of a book. This one is a winner and is surely going to be well received.

Eric M. Crook
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Preface

Publishing would seem presently to many the most lucrative activity under the umbrella of biotechnology, so why yet another book? This particular book is written with students of biotechnology firmly in mind. It has arisen out of the author's own experience of teaching in the biological disciplines underpinning current developments in biotechnology, both at undergraduate and postgraduate level. We have aimed to write a book which takes the student on from his basic knowledge of biochemistry, microbiology and molecular biology and helps to develop that understanding of the rationale and problems in the specific areas of microbial metabolism, the growth and culturing of microrganisms, genetic manipulation and biocatalyst technology. Thus the book is divided into four major sections covering each of these topics. In subdividing the book in this way, we were aware of the multidisciplinary nature of biotechnology, but also keenly cogniscent of the need for an integrated approach and have thus attempted, wherever sensible, to cross-reference the text and to write the book as a coherent whole, ensuring an even level of treatment throughout. Time alone will tell how successful we have been. In order to achieve this, each section is prefaced by a list of concepts of which a basic understanding is assumed, together with a few suggestions of appropriate standard texts to which the reader may refer.

Thus we would have a continuous theme; microbial metabolism, how and why microbes grow and on what; how microbes can be cultured; the products which can be derived from them; how productivity can be improved by both conventional methods and genetic engineering; how genetic engineering is performed and what else it can do; the value of enzymes as a group of biological compounds which are both important microbial products and ameanable to the techniques of genetic engineering; how enzymes may be isolated and purified; how their catalytic activity may be harnessed and enhanced; and the uses to which enzymes may be put, including enhancing microbial productivity and in the techniques of genetic engineering.

To aid the readers' understanding, we have used pictorial and tabular presentation of the material as often as possible to supplement the text, and have also included brief summaries at the end of each chapter. We also hope that this book will prove useful to the practising biotechnologist who requires an introduction to a subject outside his own area of expertise.

In this particular presentation we have deliberately chosen to exclude two important biological aspects of biotechnology, plant cell and animal cell tissue culture. We have done this both because of the rather more specialist nature of these subjects, rarely tackled effectively at undergraduate level, and also in order to keep the text to a reasonable length.

More controversially, we have deliberately taken an intuitive approach to those areas which usually involve mathematical formulae, attempting to develop an innate understanding onto which can be grafted a detailed knowledge of the necessary mathematical manipulations. For reasons of clarity of the text, we have also chosen to leave out the EC. numbers for enzymes and have instead included a glossary of systematic enzyme names and numbers.

Finally we would like to record our thanks to all those of our friends and colleagues who have made helpful comments during the preparation of this book, to the editorial staff of Open University Press without whose encouragement and threats this book might never have been completed and to our families without whose sufferance and understanding this project would have been impossible. We hope that this book lives up to its aims; any mistakes or misconceptions remain the fault of the authors and we would welcome any comments or criticisms from our readers.

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Contents

SECTION I

Introduction

M. D. Trevan

Chapter 1

What is biotechnology?

'Superbugs for the third industrial revolution' is the kind of media headline, prevalent in recent years, that is guaranteed to send a chill down the spine of any biotechnologist. The problem is one of perspective. The common view of biotechnology is often distorted both in the appreciation of what it is and what it might achieve. It is the purpose of this brief introductory chapter to provide an overview of biotechnology, who (or what) biotechnologists are, and what biotechnology is worth.

1.1 What?

Biotechnology has been defined in various ways, mostly rather unsatisfactorily, but if pressed a biotechnologist would probably recite 'The application of biological organisms, systems or processes to manufacturing and service industries'. This rather vague definition in practice means 'biology applied for profit, either financial or, less often, humanitarian'. In fact biotechnology does not exist as a scientific discipline, nor is it an emerging interdisciplinary field, rather it is multidisciplinary, involving a wide variety of distinct subject areas. Indeed, such is the breadth of knowledge and skills encompassed by the term that a meeting of biotechnologists can be reminiscent of a scene from the Tower of Babel, such is the diversity of language and jargon employed.

The term 'biotechnology' was most recently brought into popular usage in the mid-1970s as a result of the increased potential for the application of the emerging techniques of molecular biology. The word itself first seems to have been employed by Leeds City Council in the United Kingdom in the early 1920s, when they set up an Institute of Biotechnology. In fact, biotechnological process precede even that date by some 5000 years with the discovery of the production of alcoholic beverages by fermentation.

The ancient Egyptians went several stages further than even this time-honoured art, with the use of mouldy bread as poultices for infected wounds (the forerunner of antibiotics), and the introduction of a pregnancy testing service based on the effect of urine on the germination rate of wheat and barley (but that story is sadly beyond the scope of this present text). Thus biotechnology can claim to be a modern technology