An Introduction to Genetic Engineering

Fourth Edition

The fourth edition of this popular textbook retains its focus on the fundamental principles of gene manipulation, providing an accessible and broad-based introduction to the subject for beginning undergraduate students. It has been brought thoroughly up to date with new chapters on the story of DNA and genome editing, and new sections on bioethics, significant developments in sequencing technology and structural, functional and comparative genomics and proteomics, and the impact of transgenic plants. In addition to chapter summaries, learning objectives, concept maps, glossary and key word lists, the book now also features new concluding sections, further reading lists and websearch activities for each chapter to provide a comprehensive suite of learning resources to help students develop a flexible and critical approach to the study of genetic engineering.

Desmond S. T. Nicholl was Senior Lecturer in Biological Sciences, Head of Bioscience, Head of Quality Enhancement and Assistant Dean for Education at the University of the West of Scotland. As well as three previous editions of *An Introduction to Genetic Engineering*, he also authored *Cell and Molecular Biology* (Learning & Teaching Scotland, 2000).

'Genetic engineering represents a toolbox that all students within the basic and applied biology fields must get acquainted with. The fourth edition of *An Introduction to Genetic Engineering* is an excellent up-to-date version of a classic textbook. This ambitious book excellently balances the molecular biology knowledge required to grasp the comprehensive gene technology toolbox with a discussion of its impact on society.'

Per Amstrup Pedersen, University of Copenhagen

'As a biomedical engineering professor teaching an undergraduate Genetic Engineering course for close to 10 years, I use Dr Nicholl's *An Introduction to Genetic Engineering* as my go-to textbook. It is not one of those overly thick textbooks that overwhelm students. Its comprehensiveness captures readers' attention with succinct fundamental concepts that truly promote one's interest in exploring the wonder of many genetic engineering techniques and applications. To facilitate that further, the material provided at the end of each chapter encourages readers to expand their learning with relevant resources … Many of my students become so interested that they pursue graduate degrees and have a career in this field. Dr Nicholl's textbook has a long-term influence on its readers.'

M. Ete Chan, State University of New York at Stony Brook

'Dr Nicholl's book covers all the basic material that one would expect from its title, but what particularly impressed me was how it isn't afraid to move into political and socio-economic arenas. In Chapter 16, for example, balanced arguments are presented for and against the development of transgenic organisms, and these don't always come out in favour of the science.'

Neil Crickmore, University of Sussex

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Preface

Advances in genetics continue to be made at an ever increasing rate, which presents something of a dilemma when writing an introductory text on the subject. In the years since the third edition was published, many new applications of gene manipulation technology have been developed; genome sequencing has become available at bench-top scale and cost, and gene editing can be achieved using very modest laboratory infrastructure. Personal genome profiling is available from a range of companies, and genetic technology has played a major role in managing many aspects of the COVID-19 pandemic, from diagnostic testing to rapid development of safe and effective vaccines.

Information technology resources, coupled with the internet and World Wide Web, have been critical parts of all these developments, providing tools for the analysis of DNA sequences and instant sharing of data across the globe. At the same time, a level of mistrust has developed among some sections of society, largely driven by misinformation on social media channels, which has illustrated the power of the internet in a less positive way. It is against this background that some themes began to emerge for the fourth edition, reflecting the aim of encouraging students to use the excellent resources on the web, whilst retaining a level of critical assessment of the information. Aspects around the ethics of using genetic technology are perhaps now even more important than before, so these are discussed early in the text to enable the applications to be placed within an appreciation of the ethical framework.

Whilst aiming for a slight broadening in scope, I remain convinced that a basic technical introduction to the subject should be the major focus of the text. Thus, some of the original methods used in gene manipulation have been kept as examples of how the technology developed, even though some of these have become little used or even obsolete. From the educational point of view, this should help the reader cope with more advanced information about the subject, as a sound grasp of the basic principles is an important part of any introduction to genetic engineering. I have been gratified by the many positive comments about the third edition of the text, and I hope that this new edition continues to serve a useful purpose as part of the introductory literature on this fascinating subject.

This book is organised as four parts. *Part 1* (*Genetic Engineering in Context*; Chapters 1–3) sets the scene and brings the discussion of the ethical issues around DNA technology to the start of the book. *Part 2* (*The Basis of Genetic Engineering*; Chapters 4–6) provides an introduction to molecular biology and outlines the tools available to the genetic engineer, and *Part 3* (*The Methodology of Gene Manipulation*; Chapters 7–12) extends this theme further by examining how these tools enable

sophisticated experiments and procedures to be carried out. Finally, in *Part 4* (*Genetic Engineering in Action*; Chapters 13–17), we look at the impact of DNA technology across a range of key areas.

In the fourth edition, I have expanded the range of features that should be useful as study aids where the text is used to support a particular academic course. In the book, there are *text boxes* sprinkled throughout the chapters. These highlight key points on the way through the text, and can be used as a means of summarising the content. At the start of each chapter, the *aims* of the chapter are presented, along with a *chapter summary* in the form of *learning objectives*. These have been written quite generally, so that an instructor can modify them to suit the level of detail required. A list of the *key words* in each chapter is also provided for reference. These are shown as bold in the text; terms in blue can also be found in the Glossary. A new addition to the end of each chapter is a *websearch* page that provides some structured web-based search exercises that help to set the chapter in context and act as a start point for further study using the resources available online. As in previous editions, a *concept map* has been generated for each chapter, showing how the main topics are linked. The concept maps provided here are essentially summaries of the chapters, and may be examined either before or after reading the chapter.

As this remains an introductory text, no in-text reference has been made to the primary (research) literature, but some suggestions for *further reading* are given at the end of each chapter. Most of these are available in open-access format or may be available through an institution's library subscription service. A *glossary* of terms used has also been provided.

A new development for the fourth edition is a set of *online resources* at www.cambridge.org/nicholl4. This provides access to a range of materials from the book (and additional information) that I hope will be useful in building a learning system to suit your preferred learning style. The resources have been provided in electronic format as a *study guide* to enable collation into a set of student-generated notes.

My thanks go to the anonymous (but appreciated) reviewers of the proposal and the early versions of the manuscript. Their comments and suggestions have made the book better; any errors of fact or interpretation of course remain my own responsibility. Special thanks to Megan Keirnan, Susan Francis, Helen Shannon and Rachel Norridge at Cambridge University Press, and to Joyce Cheung, for their cheerful advice, support, encouragement and patience, which helped bring the project to its conclusion.

My final and biggest thank you goes as ever to my wife Linda and to Charlotte, Thomas and Anna, who have grown up along with the various editions of 'IGE'. I dedicate this new edition to them.