

Genetic Biotechnology

P. R. Gilbert

ANMOL PUBLICATIONS PVT. LTD.
NEW DELHI - 110 002 (INDIA)

ANMOL PUBLICATIONS PVT. LTD.

H.O.: 4374/4B, Ansari Road, Darya Ganj

New Delhi-110 002 (India)

Ph.: 23278000, 23261597

B.O.: 1015, Ist Main Road, BSK IIIrd Stage

IIIrd Phase, IIIrd Block

Bangalore - 560 085 (Karnataka)

Ph: 080-41723429, Tel/Fax: 080-2672 3604

Visit us at: www.anmolpublications.com

Genetic Biotechnology

© Reserved

First Published, 2008

ISBN 978-81-261-3275-1

PRINTED IN INDIA

Printed at Mehra Offset Press, Delhi.

Genetic Biotechnology

Preface

This book entitled “Genetic Biotechnology “ is designed to acquaint readers with the study area of modern genetic *biotechnology* at the global level. Genetic engineering (GE) is the manipulation of genetic material (i.e. DNA or genes) in a cell or an organism in order to produce desired characteristics and to eliminate unwanted ones. GE includes a range of different techniques with many different uses, and can be applied to plants, animals and humans. For example, the genetic modification of food is a form of GE that involves manipulating the cells of plants such as maize, to increase the yields, make it more nutritious and to make it drought- and disease-resistant. However, the most contentious type of GE is definitely related to its applications in humans. GE in humans has opened up a Pandora’s box of possibilities as it can be used for both the miraculous and the sinister. The cloning of Dolly the sheep in 1996 was a very important event. Until then, the cloning of a human was only possible in theory. Recent films and TV programmes such as *Gattaca*, *Mutant X*, *Dark Angel* and books such as *Brave New World* all focus on possible consequences of this technology – but what is the real deal?

Genetic engineering, genetic modification (GM), and the now-deprecated gene splicing are terms for the process of manipulating genes, usually outside the organism’s normal reproductive process. It often involves the isolation, manipulation and reintroduction of DNA into cells or model organisms, usually to express a protein. The aim is to

introduce new characteristics such as making a crop resistant to an herbicide, introducing a novel trait, or producing a new protein or enzyme. Examples include the production of human insulin through the use of modified bacteria, the production of erythropoietin in Chinese Hamster Ovary cells, and the production of new types of experimental mice such as the OncoMouse (cancer mouse) for research, through genetic redesign. Since a protein is specified by a segment of DNA called a gene, future versions of that protein can be modified by changing the gene's underlying DNA. One way to do this is to isolate the piece of DNA containing the gene, precisely cut the gene out, and then reintroduce (splice) the gene into a different DNA segment. Daniel Nathans and Hamilton Smith received the 1978 Nobel Prize in physiology or medicine for their isolation of restriction endonucleases, which are able to cut DNA at specific sites. Together with ligase, which can join fragments of DNA together, restriction enzymes formed the initial basis of recombinant DNA technology. Genetic engineering, the use of various methods to manipulate the DNA (genetic material) of cells to change hereditary traits or produce biological products. The techniques include the use of hybridomas (hybrids of rapidly multiplying cancer cells and of cells that make a desired antibody) to make monoclonal antibodies monoclonal antibody, an antibody that is mass produced in the laboratory from a single clone and that recognizes only one antigen. Monoclonal antibodies are typically made by fusing a normally short-lived, antibody-producing B cell to a fast-growing cell, such as a cancer cell (sometimes referred to as an "immortal" cell).; gene splicing or recombinant DNA, in which the DNA of a desired gene is inserted into the DNA of a bacterium, which then reproduces itself, yielding more of the desired gene; and polymerase chain reaction polymerase chain reaction (PCR), laboratory process in which a particular DNA segment from a mixture of DNA chains is rapidly

replicated, producing a large, readily analyzed sample of a piece of DNA; the process is sometimes called DNA amplification, which makes perfect copies of DNA fragments and is used in DNA fingerprinting DNA fingerprinting or DNA profiling, any of several similar techniques for analyzing and comparing DNA from separate sources, used especially in law enforcement to identify suspects from hair, blood, semen, or other biological materials found at the scene of a violent crime.

The first clinical trial of human gene therapy began in 1990, but (as of 2006) gene therapy is still experimental. Other forms of human genetic engineering are still theoretical, or restricted to fiction stories. Recombinant DNA research is usually performed to study gene expression and various human diseases. Some drastic demonstrations of gene modification have been made with mice and other animals, however: testing on humans is generally considered off-limits. In some instances changes are usually brought about by removing genetic material from one organism, and transferring them into another species. This method is known as recombinant genetics. There are two main types of genetic engineering. Somatic modifications involve adding genes to cells other than egg or sperm cells. For example, if a person had a disease caused by a defective gene, a healthy gene could be added to the affected cells to treat the disorder. The distinguishing characteristic of somatic engineering is that it is non-inheritable, e.g. the new gene would not be passed to the recipient's offspring. Germline engineering would change genes in eggs, sperm, or very early embryos. This type of engineering is inheritable, meaning that the modified genes would appear not only in any children that resulted from the procedure, but in all succeeding generations. This application is by far the more consequential as it could open the door to the perpetual and irreversible alteration of

the human species. Genetic engineering is most easily accomplished by making changes just after the egg and sperm have melded but before first division. In this way, the gene will be expressed throughout and will affect the recipients children, grandchildren, and all subsequent generations. This type of germline engineering is highly controversial and deemed inappropriate by most scientists. As of now, this is likely to take the form of gene therapy. This is less controversial as the engineered person can give consent, unlike germline engineering where subsequent generations are brought into the world with a genetic modification made to their body without their consent. Each human cell contains a different set of genes, so different genes could be transferred to different parts of the body. Such changes will not be hereditary unless the sex cells are engineered.

This book consists of—Genetically Modified Organisms: An Overview; Gene Expression, Molecular Modelling and SNPs; and Practical Aspects of Genetic Biotechnology; etc. besides a large body of list of acronyms, glossary of relevant terms, extensive bibliography, list of websites and links, for further referencing and research.

—Editor

Contents

<i>Preface</i>	<i>vii</i>
<i>List of Acronyms</i>	1
<i>List of Glossary of Terms</i>	10
1. Genetically Modified Organisms: An Overview	33
2. Gene Expression, Molecular Modelling and SNPs	113
3. Practical Aspects of Genetic Biotechnology	176
<i>Bibliography</i>	283
<i>Index</i>	295

List of Acronyms

AAI	—	American Association of Immunologists
AANP	—	American Association of Neuropathologists
AAP	—	Association of American Physicians
ABA	—	Australian Biotechnol. Assoc.
ABI	—	Applied Biosystems, Inc.
ABIC	—	Agricultural Biotechnology Intl. Conf.
ABRF	—	Association of Biomolecular Resource Facilities
ACMG	—	American College of Medical Genet.
ACS	—	American Chemical Society
ADA	—	Americans with Disabilities Act
AEC	—	Atomic Energy Commission
AES	—	American Electrophoresis Society
AFMR	—	American Federation of Medical Research
AFIP/ARP	—	Armed Forces Inst. of Pathol./Am. Registry of Pathol.
AGSG	—	Alliance of Genetic Support Groups (now Genetic Alliance)
AGT	—	Association of Genetic Technologists
AHA	—	American Heart Association
AIBS	—	Am. Inst. of Biol. Soc.
AMIA	—	American Medical Informatics Association
ANGIS	—	Australian National Genomic Info. Service
ANL	—	Argonne National Laboratory
API	—	Application Programming Interface

2 Genetic Biotechnology

ARP	—	American Registry of Pathology
ASB	—	American Society for Biotechnology
ASCB	—	American Society for Cell Biology
ASCI	—	American Society for Clinical Investigation
ASHG	—	American Society for Human Genetics
ASIP	—	American Society for Investigative Pathologists
ASIS	—	American Society for Information Science
ASLME	—	American Society of Law, Medicine, and Ethics
ASM	—	American Society for Microbiology
ASPET	—	American Society for Pharmacology and Experimental Therapeutics
BER	—	Biological and Environmental Research
BIO	—	Biotechnology Industry Organization
BNL	—	Brookhaven National Laboratory
BSCS	—	Biological Sciences Curriculum Study
BS/SCF	—	Biological Sequence/Structure Computational Facility
BTCI	—	BioPharmaceutical Technology Center Institute
CATCMB	—	Center for Advanced Training in Cell and Molecular Biology
CCM	—	Chromosome Coordinating Meeting
CDC	—	Centers for Disease Control
cDNA	—	Complementary DNA
CE	—	Capillary Electrophoresis
CEPH	—	Centre d'Etude du Polymorphisme Humain
CF	—	Cystic Fibrosis
CFF	—	Cystic Fibrosis Foundation
CHH	—	Cartilage-hair Hypoplasia
CHI	—	Cambridge Healthtech Inst.

CHOP	—	Children's Hospital of Philadelphia
CIMB	—	Center for International Meeting on Biology
CIOMS	—	Council for International Organizations of Medical Sciences
CIRB	—	Colorado Institute for Research in Biotechnology
CLMA	—	Clinical Laboratory Management Association
CMT	—	Charcot-Marie-Tooth
CONTIG	—	Consortium of Teachers in Genetics
CORN	—	Council of Regional Networks for Genetic Services
CRADA	—	Cooperative Research and Development Agreement
DM	—	Myotonic Dystrophy
DMD	—	Duchenne Muscular Dystrophy
DOE	—	Department of Energy
EEOC	—	Equal Employment Opportunity Commission
EL.B.A.	—	ELectronics and Biotechnology Advanced
EMBL	—	European Mol. Biol. Lab.
EMBO	—	European Molecular Biology Organisation
EMG	—	Encyclopedia of the Mouse Genome
EMS	—	Environmental Mutagen Society
EORTC	—	European Organization for Research and Treatment of Cancer
ERDA	—	Energy Research and Development Administration
ERI	—	Eleanor Roosevelt Institute
ES	—	Embryonic Stem
ESF	—	European Science Foundation
ESHG	—	European Society of Human Genetics

4 Genetic Biotechnology

ESI	—	Electrospray Ionization
EST	—	Expressed Sequence Tag
FCM	—	Flow Cytometry
FEBS	—	Fed. of Eur. Biochem. Soc.
FMF	—	Familial Mediterranean Fever
FRAXA	—	Fragile X locus
FVEA	—	Fundacion Valenciana de Estudios Avanzados
GBASE	—	Genome Database of the Mouse
GBR	—	Global Business Research
GDB	—	Genome Database
GDB/OMIM	—	Genome Database/Online Mendelian Inheritance in Man
GESTEC	—	Genome Science and Technology Center
GIST	—	Genome Informatics System of Transputers
GLaRGG	—	Great Lakes Regional Genetics Group
GMCRF	—	General Motors Cancer Res. Foundation
GMD	—	Genomic Map Design
GPI	—	Genetics and Public Issues Program
GRAIL	—	Gene Recognition and Analysis Internet Link
GRC	—	Gordon Res. Conf.
HERAC	—	Health and Environmental Research Advisory Committee
HGCC	—	Human Genome Coordinating Committee
HGM	—	Human Genome Meeting
HGMIS	—	Human Genome Management Information System
HGP	—	Human Genome Project
HHMI	—	Howard Hughes Medical Institute
HICSS	—	Hawaii Intl. Conf. on Systems Sci.
HLA	—	Human Leukocyte Antigen

HMDP	—	Homology Database
HNPCC	—	Hereditary Nonpolyposis Colorectal Cancer
IBC	—	International Business Communications
IBEX	—	International Biotechnology EXpo
IBF	—	International Business Forum
IBI	—	Institute for Biotechnology Information
ICES	—	International Council of Electrophoresis Societies
ICGEB	—	International Centre for Genetic Engineering and Biotechnology
ICHG	—	International Congress of Human Genetics
ICPEMC	—	International Commission on Protection Against Environmental Mutagens and Carcinogens
ICRF	—	Imperial Cancer Research Fund
IEEE	—	Institute of Electrical and Electronics Engineers
IG	—	IntelliGenetics
IGES	—	International Genetics Epidemiology Societies
IJCAI	—	International Joint Conference on Artificial Intelligence
IMA	—	Institute for Mathematics and its Applications
IMACS	—	International Association for Mathematics and Computers In Simulation
IMAGE	—	Integrated Molecular Analysis of Gene Expression
IMGS	—	Intl. Mammalian Genome Society
INRIA	—	French Natl. Inst. for Research in Computer Science and Control
IOM	—	Institute of Medicine

6 Genetic Biotechnology

IOR	—	Institute of Religion
ISAG	—	Intl. Society for Animal Genetics
ISMB	—	Intelligent Systems for Molecular Biology
ISONG	—	Intl. Soc. of Nurses in Genet.
ISQL	—	Interactive Standard Query Language
ISTR	—	Institute for Science Training and Research
IUBMB	—	Intl. Union of Biochemistry and Molecular Biology
IU	—	Indiana University
LBNL	—	Lawrence Berkeley National Laboratory
LLNL	—	Lawrence Livermore National Laboratory
LTI	—	Life Technologies, Inc.
MBC	—	Massachusetts Biotechnology Council
MBL	—	Marine Biological Laboratory
MCD	—	Mouse Cytogenetic Database
MDA	—	Muscular Dystrophy Assoc.
MEMS	—	Microelectromechanical Systems
MGC	—	Mouse Genome Conference
MGD	—	Mouse Genome Database
MGI	—	Microbial Genome Initiative
MHC	—	Major Histocompatibility Complex
MIMBD	—	Meet. on the Interconnection of Mol. Biol. Databases
MIT	—	Massachusetts Institute of Technology
MMRF	—	Marshfield Medical Research Foundation
MNBWS	—	Miami Nature Biotechnology Winter Symposium
MOD	—	March of Dimes
MOU	—	Memorandum of Understanding
MRC	—	Medical Research Council
NAPBC	—	Natl. Action Plan on Breast Cancer

NAS	—	Natl. Academy of Sciences
NASA	—	Natl. Aeronautics and Space Administration
NBAC	—	Natl. Bioethics Advisory Commission
NCGR	—	National Center for Genome Resources
NCI	—	Natl. Cancer Institute
NCSA	—	National Center for Supercomputing Applications
NCSL	—	National Conference of State Legislatures
NCSU	—	North Carolina State University
NEH	—	National Endowment for the Humanities
NFCR	—	National Foundation for Cancer Research
NFID	—	National Foundation for Infectious Diseases
NHGRI	—	Natl. Human Genome Res. Inst.
NICHD	—	National Institute of Child Health and Human Development
NIGMS	—	National Institute of General Medical Sciences
NIH	—	National Institutes of Health
NIGMS	—	Natl. Institute of General Medical Sciences
NIST	—	Natl. Inst. of Standards and Technology
NLGLP	—	National Laboratory Gene Library Project
NLM	—	National Library of Medicine
NMHCC	—	National Managed Health Care Congress
NORD	—	National Organization for Rare Disorders
NRC	—	National Research Council
NRSA	—	National Research Service Award
NSF	—	Natl. Sci. Foundation
NSGC	—	National Society of Genetic Counselors
OSHER	—	Office of Health and Environmental Research

8 Genetic Biotechnology

OMIM	—	Online <i>Mendelian Inheritance in Man</i>
OPRR	—	Office of Protection from Res. Risks
ORAU	—	Oak Ridge Associated Universities
ORISE	—	Oak Ridge Inst. for Science and Education
ORF	—	open reading frame
ORNL	—	Oak Ridge National Laboratory
OSU	—	Oregon State University
PCR	—	Polymerase Chain Reaction
PFGE	—	Pulsed-field gel electrophoresis
PG	—	Plant Genome
PIR	—	Protein Info. Resource
PNNL	—	Pacific Northwest National Laboratory
PRIM&R	—	Public Responsibility in Medicine & Research
RAPD	—	Random Amplified Polymorphic DNA
RARA	—	Retinoic Acid Receptor
RECOMB	—	Conference on Computational Molecular Biology
RFLP	—	Restriction Fragment Length Polymorphism
SCAN	—	Sequence Comparison ANalysis Program
SCE	—	School of Continuing Education
SCI	—	Society of Chemical Industry
SCW	—	Single-chromosome Workshop
SDC	—	San Diego Conference
SERGG	—	Southeast Regional Genetics Group
SHOM	—	Sequencing by Hybridization on Matrices
SIAM	—	Society for Industrial and Applied Mathematics
SIB	—	Society for Industrial Biology
SIM	—	Society for Industrial Microbiology