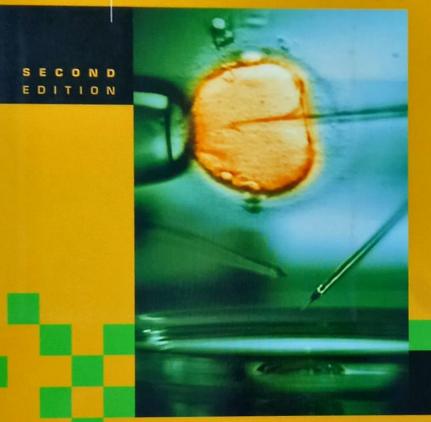
INTERNATIONAL STUDENT EDITION

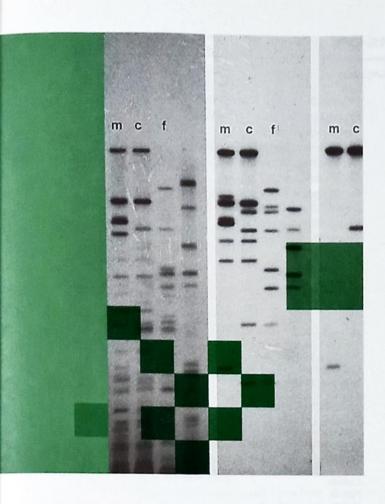
Biotechnology

AN INTRODUCTION



Susan R. Barnum

Not United States



BIOTECHNOLOGY

An Introduction

Edition 2

SUSAN R. BARNUM Miami University





Acquisitions Editor: Nedah Rose
Development Editor: Kari Hopperstead
Editorial Assistant: Sarah Lowe
Technology Project Manager: Travis Metz
Marketing Manager: Ann Caven
Marketing Assistant: Leyla Jowza
Advertising Project Manager: Linda Yip

Project Manager, Editorial Production: Belinda Krohmer

Art Director: Rob Hugel Print/Media Buyer: Kris Waller

COPYRIGHT © 2005 Brooks/Cole, a division of Thomson Learning, Inc. Thomson LearningTM is a trademark used herein under license.

ALL RIGHTS RESERVED. No part of this work covered by the copyright hereon may be reproduced or used in any form or by any means—graphic, electronic, or mechanical, including but not limited to photocopying, recording, taping, Web distribution, information networks, or information storage and retrieval systems—without the written permission of the publisher.

Printed in the United States of America 3 4 5 6 7 08 07 06 05

> For more information about our products, contact us at: Thomson Learning Academic Resource Center 1-800-423-0563

For permission to use material from this text or product, submit a request online at http://www.thomsonrights.com. Any additional questions about permissions can be submitted by email to thomsonrights@thomson.com.

Library of Congress Control Number: 2004100216

ISBN 0-534-49296-7

00077842

Permissions Editor: Kiely Sexton
Production Service: Graphic World
Text Designer: Andrew Ogus
Photo Researcher: Kathleen Olson
Copy Editor: Maryann Short
Cover Designer: Bill Stanton
Cover Image: ©Image Source/Superstock
Cover Printer: Phoenix Color Corp
Compositor: Graphic World
Printer: Banta Menasha

Thomson Brooks/Cole 10 Davis Drive Belmont, CA 94002 USA

Asia Thomson Learning 5 Shenton Way #01-01 UIC Building Singapore 068808

Australia/New Zealand Thomson Learning 102 Dodds Street Southbank, Victoria 3006 Australia

Canada Nelson 1120 Birchmount Road Toronto, Ontario M1K 5G4 Canada

Europe/Middle East/Africa Thomson Learning High Holborn House 50/51 Bedford Row London WC1R 4LR United Kingdom

Latin America Thomson Learning Seneca, 53 Colonia Polanco 11560 Mexico D.F. Mexico

Spain/Portugal Paraninfo Calle Magallanes, 25 28015 Madrid, Spain

CONTENTS

PREFACE xi		
BIOTECHNOLOGY: OLD AND NEW		
What Is Biotechnology? 2		
Ancient Biotechnology 2		
History of Domestication and Agriculture 2 Ancient Plant Germplasm 3		
History of Fermented Foods and Beverages 7		
Classical Biotechnology 9		
Biotech Revolution 12 Old Meets New		
Foundations of Modern Biotechnology 12 Early Microscopy and Observations 12 Development of Cell Theory 13 Role of Biochemistry and Genetics in Elucidating Cell Function 13		
Nature of the Gene 15		
Early Years of Molecular Biology 18 First Recombinant DNA Experiments 18		
 Biotech Revolution 19 Breaking the Genetic Code First DNA Cloning Experiment 21 		
■ Cause for Concern? 22 Public Reactions to Recombinant DNA Technology		
FROM DNA TO PROTFINS 25		

Basic Unit of Life: The Cell 26

Macromolecules 27

Prokaryotes and Eukaryotes 26

Central Dogma of Molecular Biology 36 DNA Replication 36 Replication Process 38 Gene: Basic Unit of Genetic Information 42 Genetic Code 42 Transcription 44 Promoters and RNA Polymerase 44 RNA Processing 47 Translation 47 ■ Biotech Revolution 51 Translation in the Nucleus of Eukaryotic Cells? Regulation of Gene Expression 51 Prokaryotic Gene Expression 51 Eukaryotic Gene Expression 53 BASIC PRINCIPLES OF RECOMBINANT DNA TECHNOLOGY 57 Cause for Concern? 58 Recombinant DNA Technology: Promise and Controversy Cutting and Joining DNA 58 Separating Restriction Fragments and Visualizing DNA 61 DNA Cloning 61 Cloning Vectors 62 Bacterial Vectors 62 Vectors for Other Organisms 68 Cell Transformation 71 Constructing and Screening a DNA Library 72 Genomic Library 72

cDNA Library 73

Screening Libraries 74	Metabolites 127	
Expression Libraries 75	Enzymes 128	
Reporter Genes 76	Antibiotics 129	
Southern Blot Hybridization 76	Fuels 130	
Northern Blot Hybridization 79	Biopolymers 130	
Polymerase Chain Reaction 79	■ Cause for Concern? 132	
DNA Sequencing 80	Biotechnologies and Developing Countries	
Protein Methods 83	Bioconversions 132	
Protein Gel Electrophoresis 83	Use of Immobilized Cells 133	
Protein Engineering 84		
Protein Sequencing 86	■ Biotech Revolution 133 Microbial Cell-Surface Display	
DNA Microarray Technology 86		
	Microorganishis and Agricultura	
Biotech Revolution 90	Ice-Nucleating Bacteria 134	
RNA Interference Technology: Gene Silencing	Microbial Pesticides 135	
Applications of Recombinant	Bioremediation 138	
DNA Technology 90	Oil Spills 139	
D. 1010 DD. 1101 DD. 110 DD. 1101 DD. 1	Wastewater Treatment 140	
BASIC PRINCIPLES OF IMMUNOLOGY 93	Chemical Degradation 140	
	Heavy Metals 142	
Natural or Nonspecific Immunity 94	Oil and Mineral Recovery 142	
Antimicrobial Agents 95	Oil Recovery 143	
Phagocytic Cells 97	Metal Extraction 143	
Nonphagocytic Cells 98	Future of Bioremediation 144	
Natural Killer Cells 99	Microorganisms and the Future 144	
Inflammation and Fever 99	-	
Acquired or Adaptive Immunity 100	6 PLANT BIOTECHNOLOGY 147	
Lymphocytes 103		
Major Histocompatibility Complex 105	Plant Tissue Culture and Applications 148	
Antibodies 107	Plant Tissue Culture 148	
Overview of Cell- and Antibody-Mediated Immune Responses 111	Micropropagation 149	
Vaccines 112	Other Uses of Tissue Culture 153	
	Genetically Engineered Plants 155	
= Cause for Concern? 113	Plant Transformation and Agrobacterium	
New Vaccines for the Developing World?	tumefaciens 155	
Immune System Disorders 114	Challenges of Foreign Gene Expression 156	
Hypersensitivity 114	Applications of Plant Genetic Engineering 157	
Monoclonal Antibodies 116	Crop Improvement 157 Genetically Engineered Traits: The Big Six 157	
■ Biotech Revolution 118		
Future of Monoclonal Antibody Production	■ Biotech Revolution 162	
Tools of Immunology 119	Cold and Drought Tolerance and	
Western Blotting 119	WeatherGard Genes	
Fluorescent Antibody Technique 119	Genetically Engineered Foods 163	
Enzyme-Linked Immunosorbent Assay 120	Nutritionally Enhanced Plants—Golden Rice:	
	An International Effort 163	
MICROBIAL BIOTECHNOLOGY 123	■ Cause for Concern? 164	
	The Case of StarLink Corn	
Commercial Production of	■ Cause for Concern? 165	
Microorganisms 124	Genetically Engineered Foods and	
Industrial Fermenters 124	Public Concerns	
Single-Cell Protein 125	Molecular Farming 166	
Food Biotechnology 126	A Bright Future 167	

A Bright Future 167

Products from Microorganisms 127

5

Gene Transfer Methods in Animals 170 Microinjection 171 Embryonic Stem Cell Gene Transfer 172 Retrovirus and Gene Transfer 175

Transgenic Animals and Their Application 175 Mice 176 Cows 176 Pigs, Sheep, and Goats 177

Biotech Revolution 178
 Humanizing Pig Tissues and Organs
 Birds 178

Animal Health 179
Foot-and-Mouth Disease 180
Mad Cow Disease 180
Coccidiosis 180
Trypanosomiasis 181
Theileriosis 181

Animal Propagation 181
Artificial Insemination 181
Animal Clones 181
Conservation Biology 185
Embryo Transfer 185

Cause for Concern? 186 Animal Clones: Promise and Controversy

Regulation of Transgenic Animals 187
Patenting Genetically Engineered
Animals 188

8 MARINE BIOTECHNOLOGY 191

Aquaculture 192 Gastropod, Bivalve, and Crustacean Production 193 Marine Animal Health 194 Algal Products 196 Fuels from Algae 202 Algal Cell Culture 203 Medical Applications 204 Marine Natural Products and Their Medical Potential 204 Anticancer and Antiviral Compounds 205 Antibacterial Agents 207 Marine Toxins 207 Probing the Marine Environment 208 Conservation 208 Terrestrial Agriculture 209 Transgenic Fish 209

Biotech Revolution 211
 Fluorescent Fish Pets

Cause for Concern? 212
The Commercialization and Release of Transgenic Fish

9 GENOMICS AND BEYOND 215

Genetic, Cytological, and Physical Maps 216 Human Genome Project 223 Goals of the Human Genome Project 223 Public and Private First Drafts of the Human Genome Sequence 226 Comparative Genomics 228 Human Genome Project and Disease 228 Other Genome Projects 232 Mouse and Other Animals 234 Invertebrates 234 Plants 234 Microorganisms 235 Functional Genomics 235 Proteome and Proteomics 236 Other --- omes 236 Biotech Revolution 237 Pharmacogenomics Bioinformatics 237 Databases 238 Tools of Bioinformatics 238

Ethical, Legal, and Social Implications

10 MEDICAL BIOTECHNOLOGY 243

Stem Cells 254

Stem Cells 256

Cause for Concern? 239

Gene Therapy 244 Genetic Disorders 244 Gene Target Selection 244 Gene Delivery Methods 245 Viral Vectors 245 Nonviral Delivery Methods 246 Gene Therapy Examples 247 Clinical Trials 249 Issues in Gene Therapy 249 Recent Gene Therapy Success 249 New Approaches to Gene Therapy 250 Cause for Concern? 251 Is Gene Therapy Safe? Spliceosome-Mediated RNA Trans-splicing 251 Triplex-Helix-Forming Oligonucleotide Therapy 251 Antisense Therapy 252 Ribozyme Therapy 254 Virotherapy 254

Therapeutic Cloning and Embryonic

	No. 1
	Vaccines 257
	Tissue Engineering 258
	Xenotransplantation 259
	Drug Delivery 260
	Biosensors 260
	Biotech Revolution 261
	Nanotechnology
11	DNA DDOCU INO FORENCIOS AND OTHER
	DNA PROFILING, FORENSICS, AND OTHER
	APPLICATIONS 263
	Satellite DNA 264
	Repetitive DNA 264
	Microsatellites 266
	Minisatellites 266
	Macrosatellites 266
	Population Genetics and Alleles 266
	Multilocus Minisatellite VNTR 266
	Single-Locus VNTR for STR 268
	Restriction Fragment Length
	Polymorphisms 271
	Methods of DNA Profiling 271
	Technical Considerations 271 DNA 274
	Polymerase Chain Reaction 275
	Digital DNA Typing 276
	Population Comparisons 276
	Admissibility of Scientific Evidence in a Court of Law 276
	Frye Standard 277
	Daubert Standard 277
	Databases 278
	= Cause for Concern? 278
	What About Privacy?
	Other Methods of Profiling DNA and Their Applications 279
	Random Amplification of Polymorphic DNA 279
	Amplified Fragment Length Polymorphism 279
	Single-Strand Conformation Polymorphism 281
	Single Nucleotide Polymorphism 282
	Mitochondrial DNA and the Y Chromosome 282
	Forensic Archaeology 283
	Biotech Revolution 284
	DNA Profiling and Human Remains
12	
12	REGULATION, PATENTS, AND SOCIETY 287

Revision of the NIH Guidelines 291 Regulatory Agencies in the United States 291 United States Department of Agriculture 291 Environmental Protection Agency 291 Food and Drug Administration 291 Coordinated Biotechnology Framework 292 Problems with the Coordinated Framework 293 Biotech Revolution 294 More Effective Coordinated Framework? Release of Genetically Engineered Organisms 295 Ice-Minus Bacteria 295 First Genetically Engineered Food 296 Approval for Release and Marketing 297 Risk Assessment 297 How Much Risk? 298 Patents and Biotechnology 298 Patent Process 299 History of Patenting Living Organisms 300 Cause for Concern? 301 DNA Patents What About the Future? 302 APPENDIX A 304 Summary of NIH Guidelines, July 1976 APPENDIX B 306 Revisions of NIH Guidelines 1978-1982 APPENDIX C 308 The Immune Response: An Overview APPENDIX D 309 Expamples of Industrial Chemicals Produced by Fermentation 311 Regulatory Agencies and Laws for Product Regulation

APPENDIX E

GLOSSARY 314

CREDITS 319

INDEX 320

INTERNATIONAL STUDENT EDITION

Not for Sale in the United States

This edition is intended for use outside of the U.S. only, with content that may be different from the U.S. edition.



Visit Brooks/Cole online at www.brookscole.com

For your learning solutions: www.thomsonlearning.com

