

CONTENTS

General Preface

v

Volume 1 Scientific Fundamentals of Biotechnology

1.01 Introduction M. Butler

1

The Biochemical Basis

1.02 Amino Acid Metabolism

P. Newsholme, L. Stenson, M. Sulvucci, R. Sumayao, and M. Krause

3

1.03 Enzyme Biocatalysis

D. Abedi, L. Zhang, M. Pyne, and C. Perry Chou

15

1.04 Immobilized Biocatalysts

A. Illanes

25

1.05 Lipids, Fatty Acids

J. Wynn

41

1.06 DNA Cloning in Plasmid Vectors

O.E. Tolmachov

53

1.07 Structure and Biosynthesis of Glycoprotein Carbohydrates

M. Crispin, C.N. Scanlan, and T.A. Bowden

73

1.08 Nucleotide Metabolism

J. Martinussen, M. Willemoës, and M. Kilstrup

91

1.09 Organic Acids

M. Papagianni

109

1.10 Peptides and Glycopeptides

N.W. Owens and F. Schweizer

121

1.11 Protein Structural Analysis

B.L. Mark, S.A. McKenna, and M. Khajepour

139

1.12 Secondary Metabolites

S. Sanchez and A.L. Demain

155

The Biological Basis

1.13 Cell Line Isolation and Design

T.P. Munro, W. Pilbrough, B.S. Hughes, and P.P. Gray

169

1.14 Cell Preservation Technology

J.G. Baust, W.L. Corwin, and J.M. Baust

179

1.15	Cytoskeleton and Cell Motility <i>G. Allsop and M. Peckham</i>	191
1.16	Design of Culture Media <i>S.F. Gorfien, A. Campbell, and M.C. Vemuri</i>	205
1.17	Protein Folding in the Endoplasmic Reticulum <i>N. Naidoo</i>	217
1.18	Extremophiles <i>R. Berlemont and C. Gerday</i>	229
1.19	Metabolic Design and Control for Production in Prokaryotes <i>S.R. Chhabra and J.D. Keasling</i>	243
1.20	Microbial Growth Dynamics <i>N.S. Panikov</i>	257
1.21	Modes of Culture/Animal Cells <i>X. Zhang, Y. Wen, and S.T. Yang</i>	285
1.22	Modes of Culture/Microbial <i>I.K. Blaby, V. de Crécy-Lagard, and T.J. Lyons</i>	303
1.23	Photosynthesis and Photoautotrophy <i>N.P.A. Hüner and B. Grodzinski</i>	315
1.24	Protein Expression in Insect Cells <i>R.B. Hitchman, R.D. Possee, and L.A. King</i>	323
1.25	Stem Cells <i>S.K.W. Oh and A.B.H. Choo</i>	341
1.26	Structural Organization of Cells – The Cytoskeleton <i>E. Frixione and M. Hernández</i>	367
1.27	Viruses Produced from Cells <i>K.M. Coombs</i>	383
The Genetic Basis		
1.28	Cell Transfection <i>P. Chahal, Y. Durocher, and A. Kamen</i>	395
1.29	mRNA Translation and Recombinant Gene Expression from Mammalian Cell Expression Systems <i>E.J. Mead and C.M. Smales</i>	403
1.30	Posttranslation Modifications Other Than Glycosylation <i>N. Jenkins</i>	411
1.31	Engineering Protein Folding and Secretion in Eukaryotic Cell Factories <i>J. McLeod and D.C. James</i>	419
Systems Biology		
1.32	Glycomics <i>E.F.J. Cosgrave, W.B. Struwe, M.P. Campbell, J.J. Kattila, M.R. Wormald, and P.M. Rudd</i>	427
1.33	Metabolomics – The Combination of Analytical Biochemistry, Biology, and Informatics <i>U. Roessner, A. Nahid, B. Chapman, A. Hunter, and M. Bellgard</i>	447
1.34	Theory and Applications of Proteomics <i>B.J. McConkey</i>	461

- 1.35 Systems Metabolic Engineering for the Production of Non-innate Chemical Compounds 471
D. Na, M.Y. Kim, J.Y. Park, and S.Y. Lee

The Metabolic Basis

- 1.36 Apoptosis: The Signaling Pathways and Their Control 483
T.M. Sauerwald, A. Lewis, H. Dorai, and M.J. Betenbaugh
- 1.37 Design Principles of Self-assembling Peptides and Their Potential Applications 495
P. Sadatmousavi, M. Soltani, R. Nazarian, T. Mamo, S. Lu, W. Xu, J. Wang, P. Chen, and M. Jafari
- 1.38 Rational Design of Strategies Based on Metabolic Control Analysis 511
E. Saavedra, S. Rodríguez-Enríquez, H. Quezada, R. Jasso-Chávez, and R. Moreno-Sánchez
- 1.39 Unfolded Protein Response 525
M. Taniguchi and H. Yoshida

The Biophysical Basis

- 1.40 Cell Migration 539
D. Wu and F. Lin
- 1.41 Biofilms 547
T. de Kievit
- 1.42 Flow Cytometry 559
B.-F. Alfonso and M. Al-Rubeai
- 1.43 Biological Imaging by Superresolution Light Microscopy 579
D. Lutz
- 1.44 Cell Isolation from Tissue 591
M.R. Mirbolooki, H. Bozorgmanesh, C. Foster III, W. Kuhtrieber, and J.R.T. Lakey
- 1.45 Nanobiotechnology 599
K.K. Jain
- 1.46 Effects of Shear Stress on Cells 615
K.E. McCloskey
- 1.47 Viruses and Virus-Like Particles in Biotechnology: Fundamentals and Applications 625
A. Roldão, A.C. Silva, M.C.M. Mellado, P.M. Alves, and M.J.T. Carrondo

The Computational Basis

- 1.48 Mathematical Models in Biotechnology 651
R.A. Tasseff and J.D. Varner

Analysis and Control

- 1.49 Immunoassays in Biotechnology 659
J.M. Van Emon
- 1.50 Mass Spectrometry 669
H. Perreault and E. Lattová
- 1.51 Bioprocessing Techniques 679
D. Cossar

Volume 2 Engineering Fundamentals of Biotechnology

- 2.01 Introduction 1
C. Webb

Underlying Principles

2.02	Bioengineering at the Interphase between Science and Society <i>W. Arber</i>	5
2.03	Cellular Systems <i>C. Du and C. Webb</i>	11
2.04	Cell Growth Dynamics <i>M.L. Shuler and J.D. Varner</i>	25
2.05	Reaction Kinetics and Stoichiometry <i>K. Miyanaga and H. Unno</i>	33
2.06	Bioreactor Fluid Dynamics <i>C. Sieblist, M.P.M. Jenzsch, and A. Lübbert</i>	47
2.07	Mixing in Bioreactor Vessels <i>K. van 't Riet and R.G.J.M. van der Lans</i>	63

Upstream Processing

2.08	Genetic Engineering <i>M. Pyne, K. Sukhija, and C.P. Chou</i>	81
2.09	Bio-Feedstocks <i>K. Muffler, S. Poth, T. Sieker, N. Tippkötter, R. Ulber, and D. Sell</i>	93
2.10	Substrate Hydrolysis: Methods, Mechanism, and Industrial Applications of Substrate Hydrolysis <i>V.J. Parekh, V.K. Rathod, and A.B. Pandit</i>	103
2.11	Medium Formulation and Development <i>H. Link and D. Weuster-Botz</i>	119
2.12	Sterilization in Biotechnology <i>M. Berovic</i>	135
2.13	Inoculum Preparation <i>S. Sood, S. Bhat, R. Singhal, and A. Kumar</i>	151

Bioreactors**A. Design**

2.14	Bioreactor Engineering <i>J.-J. Zhong</i>	165
2.15	Stirred Tank Bioreactors <i>F. Garcia-Ochoa, V.E. Santos, and E. Gomez</i>	179
2.16	Airlift Bioreactors <i>B. Guieysse, G. Quijano, and R. Muñoz</i>	199
2.17	Shake-Flask Bioreactors <i>W. Klöckner and J. Büchs</i>	213
2.18	Photobioreactors – Models of Photosynthesis and Related Effects <i>J.C. Merchuk, F. Garcia-Camacho, and E. Molina-Grima</i>	227
2.19	Disposable Bioreactors <i>N.M.G. Oosterhuis, T. Hudson, A. D'Avino, G.M. Zijlstra, and A. Amanullah</i>	249
2.20	Membrane Bioreactors <i>L. Giorno, L. De Bartolo, and E. Drioli</i>	263
2.21	Microbioreactors <i>P. Žnidaršič-Plazl and I. Plazl</i>	289
2.22	Biofilters <i>G. Cabrera, M. Ramírez, and D. Cantero</i>	303

B. Application

2.23	Enzyme Bioreactors <i>C. Zhang and X.-H. Xing</i>	319
2.24	Immobilized Cell Bioreactors <i>M. Nemati and C. Webb</i>	331
2.25	Bioreactors for Solid-State Fermentation <i>D.A. Mitchell, L.F. de Lima Luz, N. Krieger, and M. Berović</i>	347
2.26	Bioreactors for Plant Cell Culture <i>S. Furusaki and T. Takeda</i>	361
2.27	Bioreactors for Animal Cell Cultures <i>M. Taya and M. Kino-oka</i>	373
2.28	Bioreactors for Tissue Engineering: Design, Applications, and Monitoring <i>J. Dubois, Y. Martin, J.A. Chouinard, R. Lecomte, and P. Vermette</i>	383

Bioreactions and Bioreactor Operation

2.29	Recombinant Technology <i>D.L. Hacker and F.M. Wurm</i>	401
2.30	Metabolic Regulation Analysis and Metabolic Engineering <i>K. Shimizu</i>	407
2.31	Proteomics, Protein Engineering <i>A.G. Pereira-Medrano and P.C. Wright</i>	421
2.32	Heterologous Protein Expression <i>K.A. McDonald</i>	441
2.33	Biotransformations <i>C.C.C.R. de Carvalho and M.M.R. da Fonseca</i>	451
2.34	Immobilized Enzymes <i>L. Cao</i>	461
2.35	Immobilization Technology: Cells <i>F.W. Bai, X.-Q. Zhao, and J. Xu</i>	477
2.36	Immobilized Viable Cell Biocatalysts: A Paradoxical Development <i>G.-A. Junter and T. Jouenne</i>	491
2.37	Fermentation Processes: Quantitative Aspects <i>F. Acevedo</i>	507
2.38	Fed-Batch Fermentation – Design Strategies <i>A.K. Srivastava and S. Gupta</i>	515
2.39	Continuous Operation <i>M.T.A. Penia Kresnowati and X.D. Chen</i>	527
2.40	Multistage Continuous High Cell Density Culture <i>H.N. Chang</i>	537
2.41	Integrated Production and Separation <i>K. Hori and H. Unno</i>	579

Downstream Processing and Product Recovery

2.42	Product Recovery <i>R. Wohlgemuth</i>	591
2.43	Membrane Systems and Technology <i>C. Charcosset</i>	603

2.44	Cell Disruption <i>S.T.L. Harrison</i>	619
2.45	Autolysis of Yeasts <i>H. Alexandre</i>	641
2.46	Precipitation and Crystallization <i>P.A. Alcântara Pessoa Filho, G.A. Medeiros Hirata, É.O. Watanabe, and É.A. Miranda</i>	651
2.47	Adsorption and Chromatography <i>Y. Sun, Q.-H. Shi, L. Zhang, G.-F. Zhao, and F.-F. Liu</i>	665
2.48	Modeling Chromatographic Separation <i>A.R. Özdural</i>	681
2.49	Aqueous Two-Phase Systems <i>J. Benavides, M. Rito-Palomares, and J.A. Asenjo</i>	697
2.50	Foam Separations <i>P. Stevenson</i>	715
2.51	Drying <i>J.M. Domínguez</i>	727
2.52	Chiral Separations <i>B. Schuur, A.B. de Haan, M. Kaspereit, and M. Leeman</i>	737
2.53	Lab on a Chip – Future Technology for Characterizing Biotechnology Products <i>R.M. Guijt</i>	753
2.54	Protein Refolding/Renaturation <i>D. Kumar</i>	765
2.55	Biogas Production <i>R. Borja</i>	785
2.56	Purification Process Design and the Influence of Product and Technology Platforms <i>C.J. Dowd and B. Kelley</i>	799
2.57	The Proportion of Downstream Costs in Fermentative Production Processes <i>A.J.J. Straathof</i>	811
Process Considerations		
2.58	Biorefinery Engineering <i>T. Tan, J. Yu, and F. Shang</i>	815
2.59	Instrumentation and Analytical Methods <i>J.H.T. Luong, K.A. Mahmoud, and K.B. Male</i>	829
2.60	Life Cycle Assessment in Biotechnology <i>A. Laca, M. Herrero, and M. Díaz</i>	839
2.61	Metabolic Control <i>S.B. Sohn, T.Y. Kim, H.U. Kim, J.M. Park, and S.Y. Lee</i>	853
2.62	Fuzzy Control of Bioprocess <i>H. Honda and T. Kobayashi</i>	863
2.63	Online Control Strategies <i>A.P. Teixeira, R. Oliveira, P.M. Alves, and M.J.T. Carrondo</i>	875
2.64	Process Optimization <i>A.A. Koutinas and I.K. Kookos</i>	883
2.65	Micro-Biochemical Engineering: Using Small-Scale Devices to Predict Industry-Scale Downstream Performance <i>S. Chhatre and N.J. Titchener-Hooker</i>	891

2.66	Sustainability <i>M. Gavrilescu</i>	905
Other Considerations		
2.67	Nanostructured Biocatalysts <i>J. Ge, D. Lu, M. Yan, and Z. Liu</i>	925
2.68	Aseptic Operations <i>D. Pollard</i>	933
2.69	Oxygen Mass Transfer in Bioreactors <i>V.C. Srivastava, I.M. Mishra, and S. Suresh</i>	947
2.70	Cavitation in Biotechnology <i>P.R. Gogate</i>	957
2.71	Flow Cytometry: A High-Throughput Technique for Microbial Bioprocess Characterization <i>M. Díaz, M. Herrero, L.A. García, and C. Quirós</i>	967
2.72	Cleaning in Place <i>L.A. García and M. Díaz</i>	983
2.73	Ionic Liquids <i>A. Mell and U. Kragl</i>	999
2.74	Supercritical Fluids <i>E.D. Ramsey, W. Guo, J.Y. Liu, and X.H. Wu</i>	1007
2.75	Computational Fluid Dynamics <i>M. Eslahpazir, C. Wittmann, and R. Krull</i>	1027
Volume 3 Industrial Biotechnology and Commodity Products		
3.01	Introduction <i>A. Moreira</i>	1
Bulk Commodities		
A. Industrial Enzymes		
3.02	Industrial Enzymes <i>D. Zhu, Q. Wu, and N. Wang</i>	3
3.03	Multifunctional Enzyme Systems for Plant Cell Wall Degradation <i>Q. Xu, Y. Luo, S.-Y. Ding, M.E. Himmel, L. Bu, R. Lamed, and E.A. Bayer</i>	15
B. Biofuels and Bioenergy		
3.04	Ethanol Production from Sugar-Based Feedstocks <i>J.O.B. Carioca and M.R.L.V. Leal</i>	27
3.05	Ethanol from Starch-Based Feedstocks <i>W.M.M. Ingledew and Y.-H. Lin</i>	37
3.06	Biofuels from Cellulosic Feedstocks <i>N.W.Y. Ho, M.R. Ladisch, M. Sedlak, N. Mosier, and E. Casey</i>	51
3.07	Biodiesel <i>S. Tamalampudi and H. Fukuda</i>	63
3.08	Biofuels and Bioenergy: Acetone and Butanol <i>H. Dong, Y. Zhang, Y. Zhu, G. Luan, R. Wang, W. Tao, and Y. Li</i>	71
3.09	Microbial Production of 2,3-Butanediol <i>W. Sabra, H. Quitmann, A.-P. Zeng, J.-Y. Dai, and Z.-L. Xiu</i>	87

3.10	Biogas <i>X. Liu, Z. Yan, and Z.-B. Yue</i>	99
3.11	Biohydrogen <i>M.-S. Kim, D.-H. Kim, and J.K. Lee</i>	115
3.12	Biofuel from Microalgae <i>Z. Wen, J. Liu, and F. Chen</i>	127
C. Bio-Based Chemicals		
3.13	Citric Acid <i>K. Kirimura, Y. Honda, and T. Hattori</i>	135
3.14	Gluconic and Itaconic Acids <i>K. Kirimura, Y. Honda, and T. Hattori</i>	143
3.15	Organic Acids: Succinic and Malic Acids <i>J.W. Lee, M.-S. Han, S. Choi, J. Yi, T.W. Lee, and S.Y. Lee</i>	149
3.16	Fumaric Acid <i>S.T. Yang, K. Zhang, B. Zhang, and H. Huang</i>	163
3.17	Industrial Production of Lactic Acid <i>C. Miller, A. Fosmer, B. Rush, T. McMullin, D. Beacom, and P. Suominen</i>	179
3.18	Acetic and Propionic Acids <i>Z. Xu, Z. Shi, and L. Jiang</i>	189
3.19	Acrylic Acid <i>Z. Xu, L. Zhu, and H. Chen</i>	201
3.20	Butyric Acid <i>Z. Xu and L. Jiang</i>	207
D. Biomaterials		
3.21	PHA/PHB <i>G.-Q. Chen, Q. Wu, Y.K. Jung, and S.Y. Lee</i>	217
3.22	1,3-Propanediol and Polytrimethyleneterephthalate <i>D. Tjahjajari, T. Kaeding, and A.-P. Zeng</i>	229
Healthcare Products		
A. Small Molecules		
3.23	Antibiotics: The Miracle Menaced <i>D.M. Shlaes</i>	243
3.24	Penicillins and Cephalosporins <i>C. García-Estrada and J.-F. Martín</i>	255
3.25	Tetracyclines and Tetracycline Derivatives <i>M.L. Nelson and S.B. Levy</i>	269
3.26	Microbial Secondary Metabolites <i>F. Marinelli and G.L. Marcone</i>	285
3.27	Plant Secondary Metabolites <i>J.-J. Zhong</i>	299
3.28	Biocatalyzed Production of Fine Chemicals <i>A.R. Alcántara, M.-J. Hernaiz, and J.-V. Sinisterra</i>	309
B. Biologics		
3.29	Production of Recombinant Proteins by Microbes and Higher Organisms <i>A.L. Demain, and P. Vaishnav</i>	333

3.30	Vaccines A.Y. Elliott	347
3.31	Manufacturing Recombinant Proteins in kg-ton Quantities Using Animal Cells in Bioreactors M. De Jesus and F.M. Wurm	357
3.32	Recent and Emerging Trends and Concerns Related to the Manufacturing and Testing of Monoclonal Antibodies Intended for Clinical Use B.L. Rellahan, K. Brorson, L. Graham, D. Hirsch, S. Kennett, R. Rawat, and J. Swisher	363
3.33	Therapeutic Enzymes and Biomimetic Substrates: A Case Study of Recombinant Human Arylsulfatase B (Naglazyme®) Substrate Selection and Application W.S. Prince, E. Pungor, V. Sluzky, and R.A. Baffi	377
3.34	Cell-Free Production of Pharmaceutical Proteins J.F. Zawada	391
3.35	Combination Products Are Not Solely Biological Products, Drugs, or Devices: A Regulatory Perspective A.D. Kaiser	399
3.36	Cellular Therapies C.T. Carson, N. Emre, C. McIntyre, and T.C. Fong	411
3.37	Gene Therapies W.E. Tente	425
3.38	Regulatory Aspects of Chemistry Manufacturing and Controls for Investigational New Drug Applications and Biologic License Applications to the United States Food and Drug Administration K. Lee	439
3.39	Raw Materials in the Manufacture of Biotechnology Products R. Cordoba-Rodriguez	453
3.40	Characterization of Biotechnological/Biological/Biosimilar Products N.M. Ritter	459
3.41	Protein Glycosylation J.J. Katila, W.B. Struwe, P.M. Rudd, M. Doherty, B. Adamczyk, and M.P. Campbell	467
3.42	Immunogenicity Assay Development and Validation A. Clements-Egan, G.R. Gunn, III, and G. Shankar	487
3.43	Process Analytical Technology in Bioprocess Development and Manufacturing J.C. Menezes	501
3.44	Process Validation D.H. Reifsnyder, N.L. McKnight, and B. Kelley	511
3.45	Follow-On Protein Products: Scientific Issues, Developments, and Challenges A.S. Rathore	521
Food Ingredients		
3.46	Amino Acid Production L. Eggeling and H. Sahm	531
3.47	Lysine: Industrial Uses and Production T. Brautaset and T.E. Ellingsen	541
3.48	Food-Grade Enzymes O.S. Ramos and F.X. Malcata	555
3.49	Proteases O.P. Ward	571

3.50	Application of Enzymes and Microbes for the Industrial Production of Vitamins and Vitamin-Like Compounds <i>D. Laudert and H.-P. Hohmann</i>	583
3.51	Fungal Biotechnology in Food and Feed Processing <i>S. Ghorai, S.P. Banik, D. Verma, S. Chowdhury, S. Mukherjee, and S. Khowala</i>	603
Other Considerations		
3.52	Metabolic Engineering <i>D.M. Wuest, S. Hou, and K.H. Lee</i>	617
3.53	Synthetic Biology: An Overview <i>L. Dress, A. Hessel, Y. Cai, J.V. Meyers, and A. Moreira</i>	629
3.54	Industrial Biotechnology and Commodity Products: Single-Use Technologies for Biomanufacturing <i>M.W. Jornitz, J.-M. Cappia, and G. Rao</i>	641
3.55	Bioreactors for Commodity Products <i>L.E. Erickson</i>	653
3.56	Integrating Process Scouting Devices (PSDs) With Bench-Scale Devices: Challenges and Opportunities for Mammalian Cell Culture <i>J.R. Vallejos, A. Moreira, G. Rao, and K. Brorson</i>	659
3.57	Overview of Downstream Processing in the Biomanufacturing Industry <i>U. Gottschalk</i>	669
3.58	Nanotechnology <i>D.W. Hobson</i>	683
3.59	Biosurfactants <i>D.L. Gutnick and H. Bach</i>	699
3.60	Bioleaching and Biomining for the Industrial Recovery of Metals <i>C.A. Jerez</i>	717
3.61	Biological Control <i>N. Moazami</i>	731
Volume 4 Agricultural and Related Biotechnologies		
4.01	Introduction <i>B. Grodzinski, W.A. King, and R. Yada</i>	1
Plant Systems		
4.02	Plant Biotechnology and GMOs <i>K. Gellatly and D.T. Dennis</i>	9
4.03	Bioactivity of Herbicides <i>S.O. Duke and F.E. Dayan</i>	23
4.04	Starch Biosynthesis in Higher Plants: The Starch Granule <i>I.J. Tetlow and M.J. Emes</i>	37
4.05	Starch Biosynthesis in Higher Plants: The Enzymes of Starch Synthesis <i>I.J. Tetlow and M.J. Emes</i>	47
4.06	Metabolic Engineering of Higher Plants to Produce Bio-Industrial Oils <i>D.C. Taylor, M.A. Smith, P. Fobert, E. Mietkiewska, and R.J. Weselake</i>	67
4.07	Biodiesel – An Integrated Approach for a Highly Efficient Biofuel <i>J.M. Berghthorson, L. Kunst, D.B. Levin, P.B.E. McVetty, D.L. Smith, and J.K. Vessey</i>	87
4.08	Matching Crops for Selected Bioproducts <i>A.K. Mohanty, M.O. Seydibeyoglu, S. Sahoo, and M. Misra</i>	101

4.09	Nanotechnologies for Agricultural Bioproducts <i>M. Misra, S. Vivekanandhan, A.K. Mohanty, and J. Denault</i>	111
4.10	Transgenic Crops with Producer-Oriented Traits: Development, Application, and Impact <i>L.R. Erickson and C. Atanaseo</i>	121
4.11	Plant Genetic Techniques: Plant Breeder's Toolbox <i>I. Rajcan, J.G. Boersma, and E.J. Shaw</i>	133
4.12	Plant Bioinformatics and Microarray Technologies <i>L. Lukens and S. Zhan</i>	149
4.13	Increasing Photosynthesis/RuBisCO and CO ₂ -Concentrating Mechanisms <i>H. Ashida and A. Yokota</i>	165
4.14	Photosynthesis and Productivity of Vascular Plants in Controlled and Field Environments <i>E.D. Leonardos and B. Grodzinski</i>	177
4.15	Roles of Dark Respiration in Plant Growth and Productivity <i>S.M. Weraduwege, B.J. Micallef, B. Grodzinski, D.C. Taylor, and E.-F. Marillia</i>	191
4.16	Improving Plant Nitrogen-Use Efficiency <i>R.R. Pathak, S. Lochab, and N. Raghuram</i>	209
4.17	Circadian Clocks/Photoperiodism and Crop Quality <i>B.J. Micallef</i>	219
4.18	Breadfruit: An Old Crop with a New Future <i>A.M.P. Jones, W.A. Lane, S.J. Murch, D. Ragone, and I.B. Cole</i>	235
4.19	Wines <i>V. De Luca</i>	241
4.20	Sulfur Metabolism in Plants and Related Biotechnologies <i>S.P. Singh and A.L. Schwan</i>	257
4.21	Emerging Roles for Plant Terpenoids <i>I. Szucs, M. Escobar, and B. Grodzinski</i>	273
4.22	Antibody Production in planta <i>A.J. Meyers, B.M. Grohs, and J.C. Hall</i>	287
4.23	Microalgae as Bioreactors for Production of Pharmaceutical Proteins <i>S. Ma, A.M. Jevnikar, and N.P.A. Hüner</i>	301
4.24	Algal Chemostats <i>C.G. Trick</i>	309
4.25	Improvement of Ginseng by <i>In Vitro</i> Culture: Challenges and Opportunities <i>E.E. Uchendu, M.R. Shukla, B.M. Reed, D.C.W. Brown, and P.K. Saxena</i>	317
4.26	Can Plants Really Improve Indoor Air Quality? <i>D. Llewellyn and M. Dixon</i>	331
4.27	Regulating the Ripening Process <i>E. Fox and J. Giovannoni</i>	339
4.28	Pre- and Postharvest Treatments Affecting Nutritional Quality <i>C. Sitbon and G. Paliyath</i>	349
Animal Systems		
4.29	Embryo Genomics State of the Art <i>C. Robert</i>	359
4.30	Aquaculture Genomics: A Case Study with Catfish <i>Z. Liu</i>	371

4.31	Epigenetics and Animal Health <i>N.A. Karrow, B.S. Sharma, R.E. Fisher, and B.A. Mallard</i>	381
4.32	Quest for Novel Muscle Pathway Biomarkers by Proteomics in Beef Production <i>B. Picard, I. Cassar-Malek, N. Guillemin, and M. Bonnet</i>	395
4.33	From Stem Cell to Gamete <i>K. Linher and J. Li</i>	407
4.34	Stem Cells and Animal Therapies <i>R.J. Figueroa, T.G. Koch, and D.H. Betts</i>	417
4.35	Flow Cytometric Sorting of Mammalian Sperm for Predetermination of Sex <i>S.L. Underwood, C. Vigneault, and P. Blondin</i>	429
4.36	Animal Cloning: State of the Art and Applications <i>V. Bordignon</i>	441
4.37	Transgenesis <i>H. Niemann, W.A. Kues, B. Petersen, and J.W. Carnwath</i>	457
4.38	Arrest or Survive: A Decision of the Early Preimplantation Embryo That Influences Fertility <i>P. Madan</i>	469
4.39	Heat Stress and Climate Change <i>P.J. Hansen</i>	477
Food Systems		
4.40	Analytical Methods – Functional Foods and Dietary Supplements <i>A. Schieber and D. Lopes-Lutz</i>	487
4.41	Plant Derived Bioactives <i>R.E. Aluko</i>	501
4.42	Functional Properties of Dietary Fiber <i>S.W. Cui, S. Nie, and K.T. Roberts</i>	517
4.43	Resistant Starches in Foods <i>H.-J. Chung, E. Donner, and Q. Liu</i>	527
4.44	Plant Sterols: Nutritional Aspects <i>P.J.H. Jones and T.C. Rideout</i>	535
4.45	Soy Protein Functionality: Emulsion and Gels <i>M. Keerati-u-rai and M. Corredig</i>	543
4.46	Egg Components for Heart Health: Promise and Progress for Cardiovascular Protective Functional Food Ingredient <i>Y. Mine and M.K. Roy</i>	553
4.47	Enzyme Technology – Dairy Industry Applications <i>H.S. Garcia, A. López-Hernandez, and C.G. Hill Jr.</i>	567
Integration of Biotechnologies		
4.48	Gut Microbiology – A Relatively Unexplored Domain <i>S.P.J. Brooks, J. Green-Johnson, G. Douglas Inglis, R.R.E. Uwiera, and M. Kalmokoff</i>	575
4.49	Probiotics <i>D. Roy</i>	591
4.50	Novel Lipid Substitutes <i>M.A. Rogers</i>	603
4.51	Microwave Dehydration of Food and Food Ingredients <i>T. Durance and P. Yaghmaee</i>	617

4.52	Active and Intelligent Packaging Materials <i>L.-T. Lim</i>	629
4.53	Antimicrobials from Plants – Food Preservation and Shelf-Life Extension <i>S. Shao, T. Zhou, and R. Tsao</i>	645
4.54	Biosensors for Foodborne Pathogen Detection <i>K. Warriner and A. Namvar</i>	659
4.55	Microemulsions as Nanoscale Delivery Systems <i>D. Rousseau, R.R. Rafanan, and R. Yada</i>	675
4.56	Origins and Compositional Analysis of Novel Foods: <i>Kopi Luwak</i> Coffee and Bird's Nest Soup <i>M.F. Marcone</i>	683
4.57	Nutrigenomics: A Possible Road to Personalized Nutrition <i>L.E. Cahill and A. El-Sohemy</i>	703
4.58	Plant and Endophyte Relationships: Nutrient Management <i>D. Johnston-Monje and M.N. Raizada</i>	713
4.59	Disease Resistance/Pathology/Fusarium <i>P. Kant, Y. Reinprecht, C.J. Martin, R. Islam, and K.P. Pauls</i>	729
4.60	Plant Biochemistry: Antifungal Proteins Protecting Plants from Fungal Pathogens <i>J.H. Wong and T.B. Ng</i>	745
4.61	Biological Control and Biotechnological Amelioration in Managed Ecosystems <i>P. Kevan and L. Shipp</i>	757
4.62	Genetic Basis of Disease Resistance in the Honey Bee (<i>Apis mellifera</i> L.) <i>E. Guzman-Novoa</i>	763

Socio-Economic Considerations

4.63	Food Safety, Genetically Engineered Foods and Perception <i>D. Powell</i>	769
4.64	Socio-Environmental Factors Influencing Food Behavior <i>E.C. Witchell and J. Sheeshka</i>	775
4.65	Policy and Novel Foods from Animal Sources <i>W.A. King, R. Yada, and B. Grodzinski</i>	781

Volume 5 Medical Biotechnology and Healthcare

5.01	Introduction <i>Z. Cui</i>	1
------	-------------------------------	---

Enabling Technologies

5.02	Functional Biomaterials <i>D.E. Clarke, S.D. McCullen, A.G.Y. Chow, and M.M. Stevens</i>	3
5.03	Biomaterials/Cryogels <i>S.V. Mikhailovsky, I.N. Savina, M. Dainiak, A.E. Ivanov, and I.Y. Galaev</i>	11
5.04	Biomaterials: Electrospinning <i>P.-A. Mouthuy and H. Ye</i>	23
5.05	Mesoscale Engineering of Collagen as a Functional Biomaterial <i>H. Jawad and R.A. Brown</i>	37
5.06	Biomaterials: Temperature-Responsive Polymer <i>J. Kobayashi, Y. Akiyama, M. Yamato, and T. Okano</i>	51
5.07	Surface Modification to Improve Biocompatibility <i>M. Yaseen, F. Pan, X. Zhao, and J.R. Lu</i>	65

5.08	Cryopreservation: Organ Preservation <i>X. Ma, Y. Liu, W. Fan, and Z. Cui</i>	83
5.09	The Artificial Organ: Cell Encapsulation <i>Y. Zhang, W. Yu, G. Lv, J. Zhu, W. Wang, X. Ma, and X. Liu</i>	99
5.10	Isolation of Mesenchymal Stem Cells from Bone Marrow Aspirate <i>T.W.E. Chippendale, A.J. El Haj, K. Coopman, Q. Rafiq, and C.J. Hewitt</i>	115
5.11	Nanoimprint Lithography and Its Application in Tissue Engineering and Biosensing <i>K. Li, K. Morton, T. Veres, and B. Cui</i>	125
5.12	Microfluidic Technology and Its Biological Applications <i>Y.-H. Lin, T.-M. Pan, and M.-H. Wu</i>	141
5.13	Multifunctional Biosensor Development and Manufacture <i>P. Vadgama</i>	159
5.14	Treating Intracranial Aneurysms – A Review of Existing and Emerging Methods <i>Z. You and X. Zhou</i>	173
5.15	RNA Interference (RNAi) Technology <i>Z. Liang and P. Zhang</i>	179
5.16	Rheology and Its Applications in Biotechnology <i>A.S. Lubansky</i>	189
5.17	Biological Fluid Mechanics: Integrative and Multiscale Computational Modeling <i>E.C. Holland, P.N. Watton, and Y. Ventikos</i>	203
5.18	Mechanobiology of Bone <i>A.C.E. Dahl and M.S. Thompson</i>	217
5.19	Biofluids Microcirculation <i>Y. Lu and W. Wang</i>	237
Tissue Engineering and Stem Cell Therapy		
5.20	Emerging Trends in Tissue Engineering <i>R. Gauvin, A. Khadem hosseini, M. Guillemette, and R. Langer</i>	251
5.21	Cartilage Tissue Engineering Using Embryonic Stem Cells <i>T. Painter and W. Kafienah</i>	265
5.22	Tissue Engineering: Bone <i>J.I. Dawson, J. Kanczler, A. Aarvold, J. Smith, and R.O.C. Oreffo</i>	275
5.23	Tendon Tissue Engineering: The Potential Application of Stem Cells, Biological Factors, and Repair Scaffolds to Improve Rotator Cuff Tendon Tears <i>S. Chaudhury, R.J. Murphy, and A.J. Carr</i>	291
5.24	Complexity in Modeling of Cartilage Tissue Engineering <i>S. Zhou, H. Ye, and Z. Cui</i>	311
5.25	Tissue Engineering of Fibrocartilaginous Tissues: The Intervertebral Disc and the Meniscus <i>S. Roberts and J. Menage</i>	321
5.26	Tissue Engineering of Normal and Abnormal Bone Marrow <i>T. Mortera-Blanco, N. Panoskaltsis, and A. Mantalaris</i>	331
5.27	Evaluation of Silk as a Scaffold for Musculoskeletal Regeneration – the Path from the Laboratory to Clinical Trials <i>O. Hakimi, F. Vollrath, and A.J. Carr</i>	341
5.28	Tissue-Engineering Technology for Tissue Repair and Regeneration <i>W. Liu and Y. Cao</i>	353

5.29	Induced Pluripotent Stem Cells and Their Application to Personalized Therapy <i>S.A. Cowley</i>	377
5.30	Expansion of Hematopoietic Stem/Progenitor Cells <i>T. Liu</i>	389
5.31	Umbilical Cord Blood Stem Cell Banking <i>S.M. Watt</i>	397
5.32	Stem Cell Therapy to Treat Heart Failure <i>G. Földes and S.E. Harding</i>	407
5.33	Expansion of hMSCs and Their Application <i>Z. Xia and J. Bishop</i>	425
5.34	Cell Therapy for Parkinson's Disease <i>L. Li, Y. Bai, and Y. Liu</i>	437
5.35	Stem Cell Therapy Facility Design <i>J. Liu, D. Lv, Y. Xu, L. Song, Y. Liu, and P. Liu</i>	443
5.36	Stem Cell Research and Molecular Markers in Medicine <i>A. Casado-Díaz, G.D. Pérez, and J.M. Quesada-Gómez</i>	455
5.37	Stem Cell Therapy – MRI for <i>In Vivo</i> Monitoring of Cell and Tissue Function <i>D. Stuckey</i>	467
5.38	Cryopreservation of Stem Cells <i>X. Xu</i>	481
Biopharmaceuticals, <i>in vitro</i> Drug Testing and Drug Delivery		
5.39	Biopharmaceutical Development <i>C.M. Smales and R.J. Masterton</i>	489
5.40	Bioseparations: Membrane Processes <i>A.L. Zydney and R. van Reis</i>	499
5.41	Pharmaceutical Proteins – Structure, Stability, and Formulation <i>H.A. Schiffter</i>	521
5.42	<i>In Vitro</i> Cancer Model for Drug Testing <i>X. Liu and P. Raju</i>	543
5.43	<i>In Vitro</i> Micro-tissue and -Organ Models for Toxicity Testing <i>Z. Li</i>	551
5.44	Development of <i>In Vitro</i> Neural Models for Drug Discovery and Toxicity Screening <i>G. Shui</i>	565
5.45	<i>In Vitro</i> Chronic Neurotoxicity Assays: Present and Future Developments <i>D.A. Nagel, E.J. Hill, and M.D. Coleman</i>	573
5.46	The Delivery of Drugs – Peptides and Proteins <i>H.A. Schiffter</i>	587
5.47	Enzyme-Sensitive Biomaterials for Drug Delivery <i>Y. Chau and J. Zhong</i>	605
5.48	Drug Delivery Using Microneedles <i>O. Olatunji and D.B. Das</i>	625
5.49	Carbon Nanotube for Drug Delivery and Controlled Release <i>D.F. Chowdhury</i>	643
5.50	Drug Delivery Across the Blood–Brain Barrier <i>A. Lalatsa, A.G. Schätzlein, and I.F. Uchebun</i>	657

Artificial Organs and Life Support Devices

5.51	Organ Transplant: Strategies for Prevention of Antibody-Mediated Allograft Rejection <i>H. Wang</i>	669
5.52	Artificial Organs: Kidney <i>S. Stewart-Clark and X. Wen</i>	685
5.53	Artificial Organs Pancreas <i>A. Sambanis</i>	699
5.54	Hemoglobin-Based Blood Substitutes – Preparation Technologies and Challenges <i>X. Lu, G. Ma, and Z. Su</i>	713
5.55	Blood Detoxication <i>J. Ren, H.-L. Wei, L. Xu, and L.-Y. Jia</i>	729
5.56	Novel and Current Techniques to Produce Endotoxin-Free Dialysate in Dialysis Centers <i>I.E. De Napoli, G. Catapano, M. Ebrahimi, and P. Czermak</i>	741

Volume 6 Environmental Biotechnology and Safety

6.01	Introduction <i>S.N. Agathos</i>	1
------	-------------------------------------	---

Industrial and Toxic Wastes

6.02	Biodegradation: Principles, Scope, and Technologies <i>R.L. Crawford</i>	3
6.03	Systems Biology Approaches to Bioremediation <i>V. de Lorenzo</i>	15
6.04	Molecular Approaches for the Analysis of Natural Attenuation and Bioremediation <i>A. Kouzuma and K. Watanabe</i>	25
6.05	New Developments and Applications of Microarrays for Microbial Community Analysis in Natural and Impacted Ecosystems <i>J.D. Van Nostrand, Z. He, and J. Zhou</i>	37
6.06	Metagenomics for Bioremediation <i>I.F. George, E. Bouhajja, and S.N. Agathos</i>	47
6.07	<i>In Situ</i> Bioremediation <i>K.S. Jørgensen</i>	59
6.08	Bioaugmentation as a Strategy for the Treatment of Persistent Pollutants <i>D.Y. Lyon and T.M. Vogel</i>	69
6.09	Bioavailability and Bioaccessibility as Key Factors in Bioremediation <i>H. Harms</i>	83
6.10	Biodegradability of Recalcitrant Aromatic Compounds <i>E.L. Madsen</i>	95
6.11	Proteomic Applications to Elucidate Bacterial Aromatic Hydrocarbon Metabolic Pathways <i>S.-J. Kim, O. Kweon, and C.E. Cerniglia</i>	105
6.12	Rieske-Type Dioxygenases: Key Enzymes in the Degradation of Aromatic Hydrocarbons <i>R.E. Parales and K.-S. Ju</i>	115
6.13	Dehalogenation of Polychlorinated Dibenzo- <i>p</i> -Dioxins and Dibenzofurans, Polychlorinated Biphenyls, and Brominated Flame Retardants, and Potential as a Bioremediation Strategy <i>D.E. Fennell, S. Du, F. Liu, H. Liu, and M.M. Häggblom</i>	135

6.14	Microbial Degradation of Polychlorinated Biphenyls <i>B. Van Aken and R. Bhalla</i>	151
6.15	Biodegradation and Bioremediation of TNT and Other Nitro Explosives <i>B.A. Stenuit and S.N. Agathos</i>	167
6.16	Oxidative Fungal Enzymes for Bioremediation <i>M. Tuomela and A. Hatakka</i>	183
6.17	Biotechnological Strategies Applied to the Decontamination of Soils Polluted with Heavy Metals <i>V.N. Kavamura and E. Esposito</i>	197
6.18	Phytofiltration of Heavy Metals: Assessment of the Key Factors Involved in the Design of a Sustainable Process <i>E.J. Olguín and G. Sánchez-Galván</i>	207
6.19	Phycoremediation: Current Challenges and Applications <i>E.J. Olguín and G. Sánchez-Galván</i>	215
6.20	Transgenic Plants and Associated Bacteria for Phytoremediation of Organic Pollutants <i>B. Van Aken</i>	223
6.21	Potential for Enhanced Phytoremediation of Landfills Using Biosolids – A Review <i>K.-R. Kim and G. Owens</i>	239
6.22	Methanotrophs: Multifunctional Bacteria with Promising Applications in Environmental Bioengineering <i>H. Jiang, Y. Chen, J.C. Murrell, P. Jiang, C. Zhang, X.-H. Xing, and T.J. Smith</i>	249
6.23	Petroleum Spill Control with Biological Means <i>M. Nikolopoulou and N. Kalogerakis</i>	263
Municipal Wastes		
6.24	Biological Wastewater Treatment Systems <i>M. Pell and A. Wörman</i>	275
6.25	Ecological Models: Wastewater Treatment Models <i>K.V. Gernaey and G. Sin</i>	291
6.26	Activated Sludge Model-Based Modeling of Membrane Bioreactor Processes: A Critical Review with Special Regard to MBR Specificities <i>A. Fenu, C. Thoeve, G. Guglielmi, J. Jimenez, M. Spèrandio, D. Saroj, B. Lesjean, C. Brepols, and I. Nopens</i>	305
6.27	Biological Nitrogen Removal from Domestic Wastewater <i>M. Rusalleda Beylier, M.D. Balaguer, J. Colprim, C. Pellicer-Nàcher, B.-J. Ni, B.F. Smets, S.-P. Sun, and R.-C. Wang</i>	329
6.28	Biotechnological Methods for Nutrient Removal from Wastewater with Emphasis on the Denitrifying Phosphorus Removal Process <i>A.G. Kapagiannidis, I. Zafiriadis, and A. Aivasidis</i>	341
6.29	Constructed Wetlands for Water Treatment <i>G.M. Naja and B. Volesky</i>	353
6.30	Attached Growth Biological Systems in the Treatment of Potable Water and Wastewater <i>D.V. Vayenas</i>	371
6.31	Kinetics and Modeling of Anaerobic Treatment and Biotransformation Processes <i>S.G. Pavlostathis</i>	385
6.32	Anaerobic Treatment of Organic Sulfate-Rich Wastewaters <i>S.I.C. Lopes and P.N.L. Lens</i>	399

6.33	Biotechnological Aspects of the Use of Methane as Electron Donor for Sulfate Reduction <i>G. Gonzalez-Gil, R.J.W. Meulepas, and P.N.L. Lens</i>	419
6.34	Sulfate Reduction for Inorganic Waste and Process Water Treatment <i>M.F.M. Bijmans, C.J.N. Buisman, R.J.W. Meulepas, and P.N.L. Lens</i>	435
6.35	Anaerobic Biotreatment of Municipal Sewage Sludge <i>U. Tezel, M. Tandukar, and S.G. Pavlostathis</i>	447
6.36	Anaerobic Digestion of the Organic Fraction of Municipal Solid Waste for Methane Production: Research and Industrial Application <i>F. Cecchi, D. Bolzonella, P. Pavan, S. Macé, and J. Mata-Alvarez</i>	463
6.37	Occurrence, Toxicity, and Biodegradation of Selected Emerging Priority Pollutants in Municipal Sewage Sludge <i>K. Stamatelatou, C. Pakou, and G. Lyberatos</i>	473
6.38	Biodegradation of Micropollutants and Prospects for Water and Wastewater Biotreatment <i>I. Forrez, N. Boon, W. Verstraete, and M. Carballa</i>	485
6.39	Microbial Sensors for Monitoring and Control of Aerobic, Anoxic, and Anaerobic Bioreactors in Wastewater Treatment <i>E. Vaioopoulou, P. Melidis, V. Diamantis, and A. Aivasidis</i>	495
6.40	Efficiency and Sustainability of Urban Wastewater Treatment with Maximum Separation of the Solid and Liquid Fraction <i>V. Diamantis, P. Melidis, A. Aivasidis, W. Verstraete, and S.E. Vlaeminck</i>	507
6.41	Biotreatment of Drinking Water <i>F. Hammes, S. Velten, T. Egli, and T. Juhna</i>	517
Wastes from Agriculture, Forestry and Food Processing		
6.42	Agriculture and Agro-Industrial Wastes, Byproducts, and Wastewaters: Origin, Characteristics, and Potential in Bio-Based-Compounds Production <i>M. Petruccioli, M. Raviv, R. Di Silvestro, and G. Dinelli</i>	531
6.43	Production of Fine Chemicals by (Bio)Transformation of Agro-Food Byproducts and Wastes <i>F. Molinari, D. Romano, R. Villa, and J. Clark</i>	547
6.44	Management and Processing of Food Wastes <i>M.R. Kosseva</i>	557
6.45	Application of White-Rot Fungi in Transformation, Detoxification, or Revalorization of Agriculture Wastes: Role of Laccase in the Processes <i>M. Jurado, A.T. Martínez, M.J. Martínez, and M.C.N. Saparrat</i>	595
6.46	A Microbial Perspective on Ethanolic Lignocellulose Fermentation <i>N.S. Parachin, B. Hahn-Hägerdal, and M. Bettiga</i>	605
6.47	Techno-Economic Aspects of Ethanol Production from Lignocellulosic Agricultural Crops and Residues <i>M. Galbe, O. Wallberg, and G. Zacchi</i>	615
6.48	Biohydrogen Production from Agricultural Agrofood-Based Resources <i>N. Azbar and D.B. Levin</i>	629
6.49	Microbial Fuel Cells and Bioelectrochemical Systems: Industrial and Environmental Biotechnologies Based on Extracellular Electron Transfer <i>F. Harnisch, F. Aulenta, and U. Schröder</i>	643
6.50	Vanillin Production from Agro-Industrial Wastes <i>D. Di Gioia, F. Fava, F. Luziatelli, and M. Ruzzi</i>	661

6.51	Mixed Culture Processes for Polyhydroxyalkanoate Production from Agro-Industrial Surplus/Wastes as Feedstocks <i>M. Reis, M. Albuquerque, M. Villano, and M. Majone</i>	669
Other Considerations		
6.52	Biosorption for Industrial Applications <i>G.M. Naja and B. Volesky</i>	685
6.53	BT Technology for the Control of Methane Emissions from Permafrost and Natural Gas Hydrates <i>G. Hamer</i>	701
6.54	Molecular Aspects of Microbial Dissimilatory Reduction of Radionuclides: A Review <i>B.R. Mohapatra, O. Dinardo, W.D. Gould, and D.W. Koren</i>	709
6.55	Today's Wastes, Tomorrow's Materials for Environmental Protection <i>L.E. Macaskie, I.P. Mikhchenko, P. Yong, K. Deplanche, A.J. Murray, M. Paterson-Beedle, V.S. Coker, C.I. Pearce, R. Cutting, R.A.D. Patrick, D. Vaughan, G. van der Laan, and J.R. Lloyd</i>	719
Nomenclature Guidelines		727
Index		731