

CONTENTS

FOREWORD-BIOTECHNOLOGY 1945-1985	V
Joshua Lederberg	
PREFACE	XIII
CONTRIBUTORS	XV
 1. BIOTECHNOLOGY: ITS POTENTIAL IMPACT ON TRADITIONAL FOOD PROCESSING	 1
Raymond Moshy	
Introduction	1
A Brief History of DNA	1
Agricultural Genetics	6
Biotechnology: Its Potential Impact ON Traditional Food	
Processing	7
Functional Attribute Crops	8
Corn	8
Wheat	11
Vegetable Oil	12
Tomato	13
Conclusions	13
References	14
 2. REGULATORY ISSUES IN THE FOOD BIOTECHNOLOGY ARENA 15	 15
Stephen McNamara	
Introduction	15
Regulation of New Food Substances Under the Federal Food, Drug, and Cosmetic Act	16
Regulation of GRAS Substances	17
Regulation of Food Additives	17
 Applying the FDC Act to Products of Modern Biotechnology	18
OSTP Publication	18
FDA Statement of Policy	19
Questions and Comments	20
May a New Product of Modern Biotechnology be GRAS?	20
If a New Product of Modern Biotechnology Is Identical to a Substance That Is Already Approved by a Food Additive	

Regulation, Is a New Food Additive Regulation Required?	22
Minor Differences in a Newly Produced Substance	23
PROBLEMS OF ENFORCEMENT AND IMPORTS	24
ENVIRONMENTAL ASSESSMENT CONSIDERATIONS	24
Goodwill: Official Expressions in Support of Biotechnology	24
Further FDA Action	25
Congressional Views	25
Conclusions	26
References	26
 3. FEDERAL REGULATION OF FOOD BIOTECHNOLOGY	 29
Richard Ronk	
Introduction	29
Nutrition Issues	30
Food Safety	30
Biotechnology	30
The Regulatory Issue	30
The Promise of Biotechnology	32
Gene Probes	32
Risk Assessment	33
FDA'S Position	33
The Future	34
 4. ENZYMOLOGY AND FOOD PROCESSING	 37
Saul Neidleman	
Purpose	37
Background	37
Enzymes In Food Processing: Introduction	38
Exogenous Enzymes In Food Processing	39
Endogenous Enzymes In Food Processing	39
Nontraditional Biocatalysis: Potential for the Food Processing Industry	43
Xenozymes From Chemical Modification	44
Xenozymes From Genetic (Protein) Engineering	46
Effect of Reaction Variables	47
Conclusions	51
References	52

5. PROTEIN ENGINEERING: POTENTIAL APPLICATIONS IN FOOD PROCESSING	57
Ronald Wetzel	
Introduction	57
Protein Engineering	58
Structure-Mechanism Approach	59
Random Mutagenesis/Selection-Screening	60
Examples of Protein Engineering	62
Subtilisin	62
T4 Lysozyme and Thermal Stability	63
Potential of Protein Engineering in Food processing	65
Enzymes	65
Protein Components of Foods	66
Conclusions	68
Acknowledgements	69
References	69
6. BIOPOLYMERS AND MODIFIED POLYSACCHARIDES	73
Anthony Sinskey, Spiros Jamas, David Easson Jr. and ChoKyun Rha	
Introduction	73
Review of Microbial Biopolymers in the Food Industry	75
Xanthan Gum	76
Alginate	77
Dextrans	79
Cellulose	79
Curdlan	80
Other Bacterial Exopolysaccharides	80
Biosynthesis of Bacterial Exopolysaccharides	81
New Generation of Engineered Biopolymers	82
Polysaccharide Structure-Function Relationships	82
Introduction	82
Conformation of Polysaccharide Chains in Solution	83
Chain Stiffness	88
Modification of Polysaccharide Structure	89
Strategies to Control Exopolysaccharide Biosynthesis	90
Introduction	90
Polysaccharide Characterization	92
Rheology	92
Cloning of The Polysaccharide Genes in E. coli	92
Cloning of Polysaccharide Genes in Z. ramigera	94

Conclusions	96
Control of The Structure-Function Properties of a Yeast	
Glucan Matrix	96
Introduction	96
Hydrodynamic and Functional Properties of Glucans	98
Rheological Analysis-Establishing Structure-Function	
Properties	99
Isolation of Glucan Mutants	103
Complementation and Tetrad Analysis	104
Cloning Strategies for β -Glucan Biosynthesis-Related	
Genes	105
Rheological Characterization of Altered Glucan Matrix	106
Conclusions of Work on Engineered Yeast Glucans	107
Conclusions	110
Acknowledgements	110
References	111
 7. USE OF MICROORGANISMS IN THE PRODUCTION OF UNIQUE INGREDIENTS	 115
Nayan Trivedi	
Introduction	115
Microbial Production of Flavor Compounds	116
PRODUCTION OF 5' NUCLEOTIDES	116
Direct Fermentation	117
Degradation of RNA by 5' Phosphodiesterase	117
Chemical Synthesis	118
Production of Esters	118
Production of Diacetyl	119
Production of Pyrazines	120
Production of Terpenes	122
Production of L-Menthol	123
Production of Lactones	124
Debittering Citrus Fruit Juice	125
Use of Microbes/Enzymes to Remove Bitterness	125
Selective Removal by Resins	126
Microbial Production of Color compounds	127
Phaffia Rhodozyma	127
Monascus Purpureus	129
Candida Utilis Red Beet Juice Fermentation	129
References	130

8. POTENTIAL APPLICATIONS OF PLANT CELL CULTURE	133
David Evans and William Sharp	
Introduction	133
Clonal Propagation	133
Somaclonal Variation	136
Gametoclonal Variation	138
Protoplast Fusion	139
Protection of New Developments	141
Conclusions	142
References	142
9. APPLICATION OF GENETIC ENGINEERING TECHNIQUES FOR DAIRY STARTER CULTURE IMPROVEMENT	145
Larry McKay	
Introduction	145
Strain Selection and Development	145
Plasmid Biology	146
Lactose Metabolism	146
Proteinase Activity	148
Citrate Metabolism	148
Production of Antagonistic Compounds	149
Bacteriophage Resistance	149
Other Potential Strains	151
Gene Transfer Systems	151
Conclusions	152
References	153
10. PRODUCTION OF L-ASCORBIC ACID FROM WHEY	157
Theodore Cayle, John Roland, David Mehnert, Robert Dinwoodie, Russell Larson, Jeremy Mathers, Maura Raines, Warren Alm, Samir Ma'ayeh, Sarah Kiang and Richard Saunder	
Introduction	157
Methods	158
Screening of Mutants	159
High Cell Density Bioconversions	162
Isolation of Mitochondria	162
Results	163
Discussion	168
References	169

11.THE GENETIC MODIFICATION OF BREWER’S YEAST AND OTHER INDUSTRIAL YEAST STRAINS	171
Igne Russell, Rena Jones and Graham Stewart	
Introduction	171
Industrial Yeast Strains	172
The Brewing Process	173
Brewer’s Yeast Strains	174
Genetic Manipulation Techniques	175
Rare Mating and Zymocidal Activity	176
Wort Sugar Uptake	180
Low Carbohydrate (Low Calorie) “Lite” Beer	183
Diastatic Yeasts for Distilled Ethanol Production	190
Conclusions	193
References	193
12. LACTOBACILLI IN FOOD FERMENTATIONS	197
BRUCE CHASSY	
INTRODUCTION	197
CURRENT APPLICATIONS OF LACTOBACILLI	197
MOLECULAR GENETICS OF LACTOBACILLI	199
CLASSICAL MUTAGENESIS AND SELECTION	200
TRANSDUCTION AND PHAGE	200
CONJUGATION AND CELL-FUSION	201
Transformation and Recombinant DNA Technology	201
Future Objectives for Biotechnology with Lactobacilli	203
Conclusions	205
References	205
13.FOOD FERMENTATION WITH MOLDS	209
Robert Buchanan	
Introduction	209
Transformation Systems	210
Current and Potential Applications	213
Strain Improvement	214
New Fermentation Products	216
Flavors	216
Pigments	218
Conclusions	219
References	219

14. UNITIZATION OF FERMENTED FOODS: AN APPLICATION OF FERMENTATION TECHNOLOGY	223
Michael Sfat	
Introduction and Concept	223
Market Potential	224
Applicable Fermentation Technology	225
Unitization	225
Optimization	228
Recombination	228
Fermentation Technology and Economics	228
Conclusion	235
References	236
15. SEPARATION TECHNOLOGY FOR BIOPROCESSES	237
Roy Grabner	
Introduction	237
Background	237
Separation Techniques	238
Unique Aspects of Bioprocesses	240
Downstream Processing	240
Recovery of Extracellular Products	242
Recovery of Intracellular Products	242
Chromatographic Techniques	244
Conclusions	246
References	246
16. SCALE UP OF A FERMENTATION PROCESS	249
Peter Senior	
Introduction	249
Economic Justification	249
Product Volume Decision	250
The Batch Versus Continuous Question	250
Scale	250
Methane Versus Methanol	251
Fermenter Configuration	252
Air Lift Pressure Cycle Fermenter (PCF)	253
Cell Harvesting	253
Corrasion	253
Undesirable Process Effects	254
Bubble Problems	254

Toxicological Considerations	255
Iron Problem	255
Yield	255
Conclusions	257
 17. THE USE OF ENZYMES FOR WASTE MANAGEMENT IN THE FOOD INDUSTRY	 259
Sharon Shoemaker	
Introduction	259
Enzymes and Their Applications to Food Waste	260
Polysaccharidases	261
Lactases	263
Proteases	264
Oxido-Reductases	265
Future Approaches to Waste Management	266
Acknowledgement	267
References	267
 18. BIOSENSORS FOR BIOLOGICAL MONITORING	 271
Renee fitts	
Introduction	271
Microbiological Assays for Microorganisms	271
Non- Microbiological Methods for Detecting the presence of	
Bacteria in Foods	273
DNA Probes	273
Monoclonal Antibodies	275
DNA Probes vs. Immunoassays	276
References	276
 19. STRATEGIES FOR COMMERCIALIZATION OF BIO- TECHNOLOGY IN THE FOOD INDUSTRY	 279
David Wheat	
Introduction	279
The Appropriate Response to Biotechnology in the Food	
Industry	279
Applications Now Emphasize Cost Reduction	279
Current Efforts to Apply Biotechnology	280
Impact of Biotechnology in Food Processing	283
Developing the Appropriate Response	283

20. COST REDUCTIONS IN FOOD PROCESSING USING BIO-TECHNOLOGY	285
David Jackson	
Introduction	285
Enzyme Use and Costs	286
Chymosin as an Example	286
Price of Genetically Engineered Proteins	287
Comparison of Product Costs	287
Immobilized Enzyme Technology	291
Summary of Bioreactor Advantages/Disadvantages	294
Conclusions	295
21. PROFIT OPPORTUNITIES IN BIOTECHNOLOGY FOR THE FOOD PROCESSING INDUSTRY	297
Nanette Newell and Susan Gordon	
Introduction	297
The Products	298
Processing Economics	298
Tomato solids	298
Enzymes	300
Consumer Trends	301
Natural Products	301
Low Calorie Foods	303
The U.S. Players	304
Competition from Japan	307
A Look to the Future: the Phenylalanine Story	309
References	310
INDEX	312