

# Table of Contents

---

Contributors .....	xix
Foreword .....	
Preface .....	
<b>PART I—PRINCIPLES AND APPLICATION OF FOOD PRESERVATION TECHNIQUES .....</b>	<b>1</b>
<b>Chapter 1 The Production of Microbiologically Safe and Stable Foods .....</b>	<b>3</b>
<i>Tony C. Baird-Parker</i>	
1.1 History and background .....	3
1.2 Sources of foodborne pathogenic microorganisms .....	7
1.3 Control of foodborne pathogenic microorganisms .....	8
1.4 Assessment of microbiological risks .....	11
1.5 The role of legislation .....	13
1.6 The future .....	14
1.7 Concluding remarks .....	16
<b>Chapter 2 Strategies for Food Preservation .....</b>	<b>19</b>
<i>Grahame W. Gould</i>	
2.1 Introduction .....	19
2.2 Microbial targets for food preservation .....	21
2.3 Preservation and shelf life extension .....	25
2.4 Combination preservation techniques .....	26
2.5 Concluding remarks .....	31
<b>Chapter 3 Heat Treatment .....</b>	<b>36</b>
<i>Irving J. Pflug and Grahame W. Gould</i>	
3.1 Introduction .....	36
3.2 Kinetics of destruction of microorganisms by moist heat .....	38
3.3 Determination of resistance to moist heat .....	43
3.4 Selecting the $F_T$ -value for low-acid canned foods .....	46
3.5 Heat delivery .....	50
3.6 Concluding remarks .....	60
Appendix 3-A—Definitions .....	64

<b>Chapter 4</b>	<b>Irradiation .....</b>	
	<i>Margaret F. Patterson and Paisan Loaharanu</i>	
4.1	Introduction and historical perspective .....	
4.2	Irradiation processing .....	
4.3	Applications of food irradiation .....	
4.4	Biological effects .....	
4.5	Improvement in food safety .....	
4.6	Extension of shelf life .....	
4.7	Combination treatments .....	
4.8	Consumer concerns .....	
4.9	Concluding remarks .....	
	Appendix 4-A—Clearance of Item by Country ..	
<b>Chapter 5</b>	<b>Chill Storage .....</b>	<b>101</b>
	<i>Rod A. Herbert and Jane P. Sutherland</i>	
5.1	Introduction .....	101
5.2	Distribution of psychophilic and psychrotrophic microorganisms in natural environments .....	102
5.3	Effect of temperature on the growth of psychrophiles and psychrotrophs .....	103
5.4	Effects of temperature on solute uptake .....	104
5.5	Effects of temperature on membrane structure and function .....	105
5.6	Effect of temperature on protein synthesis and enzyme activity .....	108
5.7	Growth and survival of food-associated microorganisms at low temperatures .....	109
5.8	Concluding remarks .....	116
<b>Chapter 6</b>	<b>Freezing .....</b>	
	<i>Barbara M. Lund</i>	
6.1	Introduction .....	122
6.2	The production of frozen food .....	123
6.3	Physical changes during freezing .....	126
6.4	The effect of freezing on microorganisms .....	128
6.5	Examples of the effect of freezing on microorganisms associated with foods .....	132
6.6	The microbial flora of frozen foods .....	136
6.7	Outbreaks of disease associated with frozen foods .....	137
6.8	Microbiological spoilage of frozen foods .....	140
6.9	Concluding remarks .....	141
<b>Chapter 7</b>	<b>Drying and Reduction of Water Activity .....</b>	
	<i>John H.B. Christian</i>	
7.1	Introduction .....	146
7.2	The concept of water activity .....	147
7.3	Water activity and the water content of foods .....	148
7.4	Water relations of microbial growth .....	150
7.5	Water relations of microbial death and survival .....	154
7.6	Physiological basis of tolerance to low water activity ..	156
7.7	Interactions of $a_w$ with other environmental factors ....	157
7.8	Specific solute effects .....	158
7.9	Preservation of foods at reduced $a_w$ .....	159
7.10	Determination of water activity .....	165

	7.11 Moisture determination .....	167
	7.12 Concluding remarks .....	167
<b>Chapter 8</b>	<b>Control of pH and Use of Organic Acids .....</b>	
	<i>Barbara M. Lund and Trygve Eklund</i>	
	8.1 Introduction .....	
	8.2 The effect of pH, acidulants, and organic acid preservatives on growth of microorganisms .....	
	8.3 The effect of pH, acidulants, and organic acid preservatives on survival and death of microorganisms .....	187
	8.4 Mechanism of effect of pH, acidulants, and organic acid preservatives .....	192
	8.5 Factors influencing the effect of pH, acidulants, and organic acid preservatives .....	194
	8.6 Concluding remarks .....	196
<b>Chapter 9</b>	<b>The Use of Other Chemical Preservatives: Sulfite and Nitrite .....</b>	<b>200</b>
	<i>Grahame W. Gould</i>	
	9.1 Introduction .....	200
	9.2 Sulfite .....	200
	9.3 Nitrite .....	205
	9.4 Concluding remarks .....	210
<b>Chapter 10</b>	<b>Modified Atmospheres .....</b>	
	<i>Göran Molin</i>	
	10.1 Introduction .....	214
	10.2 The effect of oxygen on microorganisms .....	215
	10.3 The effect of carbon dioxide on microorganisms .....	216
	10.4 The use of modified atmospheres in preservation of fresh meat .....	219
	10.5 The use of modified atmospheres in preservation of fresh fish .....	223
	10.6 The use of modified atmospheres in preservation of processed meats .....	226
	10.7 The use of modified atmospheres in preservation of other foods .....	228
	10.8 Some safety aspects of modified atmospheres .....	228
	10.9 Concluding remarks .....	229
<b>Chapter 11</b>	<b>The Effect of Redox Potential .....</b>	
	<i>J. Gareth Morris</i>	
	11.1 Introduction: oxidation-reduction reactions and redox potentials .....	235
	11.2 In practice: redox potentials of biological systems .....	239
	11.3 Redox potentials and foodstuffs .....	243
	11.4 Concluding remarks .....	248
<b>Chapter 12</b>	<b>Microorganisms and Their Products in the Preservation of Foods .....</b>	
	<i>Dallas G. Hoover</i>	
	12.1 Introduction: Historical perspective .....	251
	12.2 The preservation of foods involving traditional methods of fermentation .....	252
	12.3 Bacteriocins .....	258
	12.4 Concluding remarks .....	268

**Chapter 13 New and Emerging Physical Methods of Preservation .....***Grahame W. Gould*

13.1	Introduction .....	
13.2	High hydrostatic pressure .....	
13.3	High voltage electric discharge .....	
13.4	High-intensity light .....	
13.5	High-intensity magnetic fields .....	
13.6	Manothermosonication .....	
13.7	Concluding remarks .....	

**Chapter 14 Use of Combined Preservative Factors in Foods of Developing Countries .....***Lothar Leistner*

14.1	Introduction .....	
14.2	Principles of food preservation in developing countries .....	
14.3	Recent applications of hurdle technology in developing countries .....	
14.4	Concluding remarks .....	

**Chapter 15 Injured Bacteria ..... 315***Bernard M. Mackey*

15.1	Introduction .....	315
15.2	Definitions of viability, death, and sublethal injury .....	316
15.3	The nature of sublethal injury .....	316
15.4	Viable but nonculturable cells .....	321
15.5	Spore injury .....	327
15.6	Recovery of injured spores .....	330
15.7	Recovery of injured vegetative cells .....	331
15.8	The role of sublethal injury in combined treatments for preserving food .....	334
15.9	Concluding remarks .....	335

**Chapter 16 Principles and Application of Predictive Modeling of the Effects of Preservative Factors on Microorganisms ..... 342***József Baranyi and Terry A. Roberts*

16.1	Introduction .....	342
16.2	Overview .....	342
16.3	Modeling microbial responses .....	343
16.4	Computational aspects of creating predictive models: a new modeling approach .....	347
16.5	Prospects .....	354

**PART II—MICROBIAL ECOLOGY OF DIFFERENT TYPES OF FOOD .....****Chapter 17 Fresh Red Meats ..... 361***Kathryn L. Kotula and Anthony W. Kotula*

17.1	Introduction .....	361
17.2	Composition .....	364
17.3	Slaughter/processing .....	366
17.4	Initial microflora of fresh raw meats .....	374
17.5	Effect of storage and packaging on the microflora of raw meats .....	380

17.6	Effect of cooking .....	383
17.7	Concluding remarks	383
<b>Chapter 18</b>	<b>Processed Meat Products .....</b>	
	<i>Martyn H. Brown</i>	
18.1	Introduction .....	389
18.2	Factors affecting the microbiology of meat products	390
18.3	Production of meat products .....	395
18.4	Product types .....	396
18.5	Concluding remarks .....	409
<b>Chapter 19</b>	<b>Fermented Meats .....</b>	
	<i>Friedrich-Karl Lücke</i>	
19.1	Introduction .....	420
19.2	Traditional types of fermented meats and their manufacture .....	420
19.3	Microorganisms involved in meat fermentations, and factors affecting them .....	423
19.4	Microbiological, chemical, and physical changes during meat fermentations .....	425
19.5	Starter cultures .....	429
19.6	Application of HACCP to the production of fermented meat products .....	431
19.7	Mechanisms and control of spoilage of meats during and after fermentation .....	435
19.8	Recent and future developments .....	437
<b>Chapter 20</b>	<b>Fresh and Further-Processed Poultry .....</b>	445
	<i>Geoffrey C. Mead</i>	
20.1	Introduction .....	
20.2	Sources of product contamination with human pathogens and spoilage organisms .....	447
20.3	The processing plant .....	451
20.4	Raw poultry products .....	461
20.5	Further-processed products .....	464
20.6	Concluding remarks .....	466
<b>Chapter 21</b>	<b>Fresh and Processed Fish and Shellfish .....</b>	
	<i>Lone Gram and Hans Henrik Huss</i>	
21.1	Introduction .....	472
21.2	Chemical composition of fish and shellfish .....	473
21.3	Microbiology of freshly caught fish and shellfish .....	475
21.4	Microbiological hazards in fresh fish and shellfish .....	478
21.5	Microbiological hazards in fish and shellfish products	488
21.6	Concluding remarks .....	497
<b>Chapter 22</b>	<b>Milk and Unfermented Milk Products .....</b>	
	<i>Mansel W. Griffiths</i>	
22.1	Introduction .....	507
22.2	Milk composition .....	508
22.3	Unfermented products made from milk .....	510
22.4	Microflora of raw milk .....	511

22.5	Natural antimicrobial compounds in raw milk .....	518
22.6	Competitive effects between microorganisms found in milk .....	519
22.7	Other methods for prolonging the storage life of raw milk ...	520
22.8	Processing of raw milk .....	521
22.9	Other methods of pasteurization of milk .....	526
22.10	The future .....	527
<b>Chapter 23</b>	<b>Fermented Milk Products .....</b>	
	<i>Michael Teuber</i>	
23.1	Historical introduction .....	535
23.2	The substrate milk .....	536
23.3	Sources of microorganisms used in dairy fermentations .....	537
23.4	Fermented milk products .....	548
23.5	The bacteriophage problem in dairy fermentation .....	566
23.6	Fermented dairy products containing "probiotic" microorganisms .....	569
23.7	The microbiological safety of fermented dairy products .....	572
23.8	Concluding remarks .....	584
<b>Chapter 24</b>	<b>Eggs and Egg Products .....</b>	
	<i>Ronald G. Board</i>	
24.1	Introduction .....	590
24.2	The formation, structure and composition of eggs .....	591
24.3	Changes in the structure and composition with time .....	592
24.4	The antimicrobial defense systems in eggs .....	593
24.5	Microbial infection of eggs during passage through the oviduct ..	594
24.6	The microbiology of rotten eggs .....	597
24.7	Course of microbial infection of eggs .....	599
24.8	Egg products .....	606
24.9	The future .....	614
<b>Chapter 25</b>	<b>Fresh and Processed Vegetables .....</b>	
	<i>Christophe Nguyen-the and Frédéric Carlin</i>	
25.1	Introduction .....	
25.2	The microbiology of raw vegetables .....	
25.3	The microbiology of fresh vegetables during storage .....	
25.4	The effect of minimal processing on the microbiology of vegetables .....	
25.5	Control of microorganisms on fresh vegetables .....	
25.6	Microbiology of processed vegetables .....	
25.7	Concluding remarks .....	
<b>Chapter 26</b>	<b>Fermented and Acidified Plant Foods .....</b>	
	<i>M.J. Robert Nout and Frank M. Rombouts</i>	
26.1	Introduction .....	
26.2	Vegetables and olives .....	
26.3	Cereals, tubers, and roots (starchy plant foods) .....	
26.4	Legumes, oilseeds, and treeborne seeds (proteinaceous plant foods)	
26.5	Concluding remarks .....	

<b>Chapter 27</b>	<b>Fresh and Processed Fruits .....</b>	<b>738</b>
	<i>Barbara M. Lund and Anna L. Snowdon</i>	
27.1	Introduction .....	738
27.2	Composition and properties .....	738
27.3	Major groups of microorganisms associated with fresh fruits .....	740
27.4	Microbiological spoilage of fresh fruits .....	740
27.5	Microbiological safety of fresh fruits .....	743
27.6	Control of microbiological spoilage of fresh fruits .....	746
27.7	Control of the microbiological safety of fresh fruits .....	748
27.8	Frozen fruits .....	750
27.9	Dried fruits .....	750
27.10	Canned fruits .....	752
27.11	Concluding remarks .....	754
<b>Chapter 28</b>	<b>Cereals and Cereal Products .....</b>	<b>759</b>
	<i>J. David Legan</i>	
28.1	Introduction—the importance of cereals .....	759
28.2	Microflora on cereals in the field .....	760
28.3	Harvest, drying, transport, and storage .....	763
28.4	Primary processing at the mill .....	766
28.5	Further processing .....	766
28.6	Concluding remarks .....	777
<b>Chapter 29</b>	<b>Yellow Fat Products (Butter, Margarine, Dairy and Nondairy Spreads) .....</b>	<b>784</b>
	<i>Maddy M. van Zijl and Pieter M. Klapwijk</i>	
29.1	Introduction .....	784
29.2	Butter .....	785
29.3	Margarine .....	792
29.4	Dairy and nondairy spreads .....	798
29.5	Preservation .....	800
29.6	Concluding remarks .....	803
<b>Chapter 30</b>	<b>Mayonnaise, Dressings, Mustard, Mayonnaise-Based Salads, and Acid Sauces .....</b>	<b>807</b>
	<i>Martin J.M. Michels and Wil Koning</i>	
30.1	Introduction .....	807
30.2	Mayonnaise, dressings and other emulsified sauces .....	808
30.3	Ketchup, vinaigrette and other nonemulsified sauces .....	820
30.4	Mustard .....	822
30.5	Mayonnaise-based salads .....	824
30.6	Pasteurized acid sauces .....	828
30.7	Concluding remarks .....	830
<b>Chapter 31</b>	<b>Fruit Juices, Fruit Drinks, and Soft Drinks .....</b>	<b>836</b>
	<i>Malcolm Stratford, Paul D. Hofman, and Martin B. Cole</i>	
31.1	Introduction .....	836
31.2	Composition and characteristics of fruit juices and soft drinks .....	837

- 31.3 The microbiology of the manufacturing process
- 31.4 Microbial spoilage of fruit juices and soft drinks
- 31.5 Preservation and preservation procedures .....
- 31.6 Microbiological safety: risks to human health ...
- 31.7 Concluding remarks and future trends .....

## **Chapter 32 Bottled Water .....**

*Donald W. Warburton and John W. Austin*

- 32.1 Introduction .....
- 32.2 Microbiology of the water sources .....
- 32.3 Microbiological contamination of bottled water .....
- 32.4 Production of bottled water .....
- 32.5 The effect of storage on the microbiology of bottled water
- 32.6 Microbiological testing and criteria for bottled water .....
- 32.7 Concluding remarks .....

## **Chapter 33 Spices and Herbs .....**

*József Farkas*

- 33.1 Introduction: definitions and importance .....
- 33.2 Relations of spices and herbs to microbiological quality and safety of foods
- 33.3 Spice essential oils and oleoresins .....
- 33.4 Antimicrobial effects and antimicrobial constituents .....
- 33.5 Stimulation of microbial activities .....
- 33.6 Microbiological contamination of spices and herbs .....
- 33.7 Effect of primary processing, packaging, and storage on the  
microflora of spices and herbs .....
- 33.8 Application of good hygienic practice and the hazard analysis  
critical control points concept .....
- 33.9 Microbial spoilage of spices and foods by microorganisms from spices .....
- 33.10 Methods of microbiological decontamination .....
- 33.11 Microbiological criteria for, and monitoring of, microbiological  
quality of spices and herbs .....
- 33.12 Concluding remarks .....

## **Chapter 34 Nuts and Nut Products .....**

*Peter W. Wareing, Linda Nicolaides, and David R. Twiddy*

- 34.1 Introduction .....
- 34.2 Production .....
- 34.3 Processing/preservation .....
- 34.4 Initial microflora .....
- 34.5 Effects of processing and storage on nut microflora ...
- 34.6 Bacterial toxins .....
- 34.7 Mycotoxins .....
- 34.8 Microbiological quality and safety .....
- 34.9 Legislation .....
- 34.10 Concluding remarks .....



<b>Chapter 35</b>	<b>Sugars, Honey, Cocoa, Chocolate, and Confectionery Products .....</b>	
	<i>Jean-Louis Cordier</i>	
35.1	Introduction .....	941
35.2	Sugars .....	942
35.3	Syrups .....	948
35.4	Honey .....	949
35.5	Cocoa, Chocolate, and Confectionery .....	951
<b>Chapter 36</b>	<b>Teas, Herbal Teas, and Coffee .....</b>	
	<i>Martin J.M. Michels</i>	
36.1	Introduction .....	960
36.2	Tea .....	960
36.3	Herbal Teas .....	964
36.4	Coffee .....	967
36.5	Concluding remarks .....	970
<b>Index</b> .....		<b>I:1</b>

## VOLUME II

### PART III—FOODBORNE PATHOGENS...

<b>Chapter 37</b>	<b>Surveillance of Foodborne Disease .....</b>	
	<i>J. Clark M. Sharp and W. (Bill) J. Reilly</i>	
37.1	Introduction .....	975
37.2	Reporting and collection of data .....	976
37.3	Collation and analysis of data .....	988
37.4	Dissemination of information .....	989
37.5	The use of surveillance data .....	990
37.6	The role of reference laboratories .....	997
37.7	The analysis of trends and introduction of control measures .....	998
37.8	Concluding remarks .....	1003
<b>Chapter 38</b>	<b>The <i>Aeromonas hydrophila</i> Group .....</b>	
	<i>Samuel Palumbo, Gerard N. Stelma, Jr., and Carlos Abeyta</i>	
38.1	Introduction .....	1011
38.2	Taxonomy and characteristics .....	1011
38.3	Epidemiology and characteristics of the disease .....	1013
38.4	Mechanisms of pathogenicity .....	1015
38.5	Incidence of the bacteria in the environment and foods .....	1017
38.6	Factors affecting survival and growth, particularly in foods .....	1018
38.7	Principles of detection and isolation .....	1022
38.8	Control .....	1023
38.9	Concluding remarks .....	1023

**Chapter 39 *Bacillus* species .....**

*Per Einer Granum and Tony C. Baird-Parker*

- 39.1 Introduction .....
- 39.2 Taxonomy and typing of food-poisoning *Bacillus* species .....
- 39.3 Characteristics of human disease .....
- 39.4 Epidemiology .....
- 39.5 Mechanisms of disease .....
- 39.6 Incidence in the environment and in foods .....
- 39.7 Growth, survival, and destruction in foods .....
- 39.8 Detection and enumeration .....
- 39.9 Prevention and control of *Bacillus* food-poisoning .....
- 39.10 Concluding remarks .....

**Chapter 40 *Campylobacter* .....**

*Norman J. Stern and J. Eric Line*

- 40.1 Introduction .....
- 40.2 Taxonomy and characteristics of the organisms .....
- 40.3 Characteristics of the disease .....
- 40.4 Mechanism of pathogenicity .....
- 40.5 Incidence of the organisms in the environment and in foods .....
- 40.6 Epidemiology .....
- 40.7 Factors affecting survival, growth, and contamination of foods .....
- 40.8 Principles of detection, isolation, identification, and typing .....
- 40.9 Control in poultry operations .....
- 40.10 Concluding remarks .....

**Chapter 41 *Clostridium botulinum* .....**

*Barbara M. Lund and Michael W. Peck*

- 41.1 Introduction .....
- 41.2 Taxonomy and properties of the organisms .....
- 41.3 Characteristics of botulism .....
- 41.4 Mechanism of pathogenicity .....
- 41.5 Incidence of *Clostridium botulinum* in the environment and in foods .....
- 41.6 Epidemiology of foodborne botulism .....
- 41.7 Factors affecting survival, growth, and toxin formation, particularly in foods .....
- 41.8 Principles of detection and isolation .....
- 41.9 Controls to prevent growth of and toxin formation by *C. botulinum*  
in foods .....
- 41.10 Concluding remarks .....

**Chapter 42 *Clostridium perfringens* .....**

*Ronald G. Labbé*

- 42.1 Introduction .....
- 42.2 Taxonomy and characteristics of the organism .....
- 42.3 Characteristics of the disease .....
- 42.4 Mechanisms of pathogenicity .....
- 42.5 Incidence of the organism .....
- 42.6 Epidemiology .....
- 42.7 Factors affecting survival in food .....

42.8 Isolation of <i>C. perfringens</i> and detection of enterotoxin .....	1124
42.9 Control .....	1127
42.10 Concluding remarks .....	1127

### Chapter 43 *Escherichia coli* .....

*Geraldine A. Willshaw, Thomas Cheasty, and Henry R. Smith*

43.1 Introduction .....	1136
43.2 Taxonomy and typing .....	1137
43.3 Characteristics of the disease .....	1139
43.4 Epidemiology of <i>E. coli</i> causing diarrheal disease .....	1140
43.5 Pathogenesis mechanisms .....	1145
43.6 Principles of detection .....	1151
43.7 Role of food, water and the environment as sources of diarrheagenic <i>E. coli</i> ....	1153
43.8 Factors affecting survival and growth of diarrheagenic <i>E. coli</i> in foods .....	1157
43.9 Control and prevention of infection .....	1161
43.10 Concluding remarks .....	1164

### Chapter 44 *Listeria monocytogenes* .....

*Jeffrey M. Farber and Pearl I. Peterkin*

44.1 Introduction .....	1178
44.2 Taxonomy and properties of <i>L. monocytogenes</i> .....	1179
44.3 Characteristics of the disease .....	1180
44.4 Virulence .....	1187
44.5 Incidence of <i>L. monocytogenes</i> in food and the environment .....	1190
44.6 Epidemiology .....	1195
44.7 Factors affecting growth and survival, particularly in foods ...	1199
44.8 Principles of detection and isolation .....	1208
44.9 Control .....	1211
44.10 Concluding remarks .....	1216

### Chapter 45 *Salmonella* .....

*Jean-Yves D'Aoust*

45.1 Introduction .....	1233
45.2 Taxonomy and characteristics of the organism .....	1234
45.3 Characteristics of disease .....	1235
45.4 Mechanism of pathogenicity .....	1240
45.5 Incidence of the organism in the environment and in foods .....	1246
45.6 Epidemiology .....	1257
45.7 Factors affecting growth and survival in foods .....	1262
45.8 Principles of detection and isolation .....	1267
45.9 Control .....	1276

### Chapter 46 *Shigella* species .....

*Keith A. Lampel, Joseph M. Madden, and I. Kaye Wachsmuth*

46.1 Introduction .....	1300
46.2 Taxonomy and characteristics of the organism .....	1301
46.3 Characteristics of the disease .....	1302
46.4 Mechanism of pathogenicity .....	1302
46.5 Incidence of the organism in the environment and in foods .....	1305

46.6	Epidemiology .....	1306
46.7	Factors affecting survival and growth in foods ...	1307
46.8	Principles of detection and isolation from foods	1308
46.9	Control .....	1311
46.10	Concluding remarks .....	1312
<b>Chapter 47</b>	<b><i>Staphylococcus aureus</i> .....</b>	
	<i>Tony C. Baird-Parker</i>	
47.1	Introduction .....	1317
47.2	Taxonomy and typing .....	1317
47.3	Characteristics of disease .....	1319
47.4	Mechanism of pathogenicity .....	1320
47.5	Incidence of the organism in the environment and in food .....	1321
47.6	Epidemiology .....	1321
47.7	Factors affecting growth and survival of <i>S. aureus</i> and production and destruction of enterotoxin .....	1322
47.8	Principles of detection and enumeration .....	1326
47.9	Control .....	1329
47.10	Concluding remarks .....	1330
<b>Chapter 48</b>	<b><i>Vibrio</i> species .....</b>	
	<i>Charles A. Kaysner</i>	
48.1	Introduction .....	1336
48.2	Taxonomy and characteristics of <i>Vibrio</i>	1338
48.3	Characteristics of diseases .....	1340
48.4	Mechanisms of pathogenicity .....	1343
48.5	Incidence in the environment and food	1346
48.6	Epidemiology .....	1348
48.7	Factors affecting survival and growth ...	1350
48.8	Principles of detection in food .....	1352
48.9	Control of <i>Vibrio</i> species .....	1355
48.10	Concluding remarks .....	1357
<b>Chapter 49</b>	<b><i>Yersinia</i> species .....</b>	
	<i>Truls Nesbakken</i>	
49.1	Introduction .....	1363
49.2	Taxonomy and characteristics of <i>Yersinia</i> spp. ....	1364
49.3	Features of the diseases caused by foodborne <i>Yersinia</i> spp.	1368
49.4	Mechanisms of pathogenicity of <i>Y. enterocolitica</i> .....	1369
49.5	Incidence in the environment and in foods .....	1370
49.6	Epidemiology .....	1373
49.7	Factors affecting survival and growth of <i>Y. enterocolitica</i> , particularly in foods .....	1377
49.8	Principles of detection and isolation .....	1379
49.9	Control .....	1380
49.10	Concluding remarks .....	1385

**Chapter 50 Less Recognized and Suspected Foodborne Bacterial Pathogens .....***Michael E. Stiles*

50.1	Introduction .....	1394
50.2	Enterobacteriaceae .....	1395
50.3	Spiral bacteria of the human stomach .....	1399
50.4	Sporeforming bacteria .....	1401
50.5	Lactic acid bacteria .....	1402
50.6	Human diseases (and related bacteria) transmitted through foods .....	1406
50.7	Zoonoses transmitted through foods .....	1408
50.8	Concluding remarks .....	1412

**Chapter 51 Protozoa ..... 1420***Michael A. Taylor*

51.1	Introduction .....	1420
51.2	Apicomplexan (coccidian) protozoa .....	1421
51.3	Flagellate protozoa (mastigophora) .....	1436
51.4	Amoeboid protozoa (sarcodina) .....	1440
51.5	Blastocysta .....	1442
51.6	Ciliated protozoa (cilophora) .....	1444
51.7	Microspora .....	1446

**Chapter 52 Foodborne Viruses ..... 1457***E. Owen Caul*

52.1	Introduction .....	1457
52.2	Taxonomy of foodborne viruses .....	1458
52.3	Viral gastroenteritis .....	1458
52.4	Viral hepatitis .....	1468
52.5	Biophysical properties and virus inactivation .....	1470
52.6	Modes of transmission .....	1471
52.7	Laboratory diagnosis .....	1475
52.8	Virus isolation .....	1479
52.9	Diagnostic serology .....	1480
52.10	Prevention and control .....	1480
52.11	Concluding remarks .....	1482

**Chapter 53 Toxigenic Fungi and Mycotoxins ... 1490***Maurice O. Moss*

53.1	Introduction .....	1490
53.2	The aflatoxins .....	1493
53.3	The ochratoxins .....	1499
53.4	Patulin .....	1503
53.5	The <i>Fusarium</i> toxins .....	1504
53.6	Analysis .....	1506
53.7	Significance and legislation .....	1509
53.8	Concluding remarks .....	1510

<b>Chapter 54</b>	<b>Fish and Shellfish Poisoning .....</b>
	<i>John Liston</i>
54.1	Introduction .....
54.2	Shellfish poisoning .....
54.3	Fish poisoning .....
54.4	Concluding remarks .....
<b>Chapter 55</b>	<b>Long-Term Consequences of Foodborne Disease .....</b>
	<i>James L. Smith and Pina M. Fratamico</i>
55.1	Introduction .....
55.2	Reactive arthritis and Reiter's syndrome .....
55.3	Guillain-Barré syndrome .....
55.4	Hemolytic uremic syndrome .....
55.5	Other complications and long-term consequences of foodborne disease .....
<b>Chapter 56</b>	<b>The Economic Costs of Foodborne Disease .....</b>
	<i>Paul N. Sockett and Ewen C.D. Todd</i>
56.1	Introduction .....
56.2	Approaches to economic evaluation in public health .....
56.3	Factors affecting interest in economic evaluation of foodborne disease .....
56.4	Categories of costs associated with foodborne disease .....
56.5	Estimated cases and deaths due to foodborne disease .....
56.6	National economic studies of foodborne disease .....
56.7	National estimates of salmonellosis costs .....
56.8	Costs and benefits of preventing foodborne infection .....
56.9	Estimated costs and benefits of food irradiation .....
56.10	Competitive exclusion (CE) .....
56.11	Concluding remarks .....
<b>Chapter 57</b>	<b>Transmissible Spongiform Encephalopathies .....</b>
	<i>J. Gerald Collee</i>
57.1	Introduction .....
57.2	Bovine spongiform encephalopathy .....
57.3	Scrapie .....
57.4	Transmissible spongiform encephalopathies in other animals .....
57.5	Models of human prion diseases .....
57.6	Disputed inter-relationships .....
57.7	Basic principles .....
57.8	What has been done to bring the UK cattle outbreak of BSE under control? ....
57.9	Will things now get worse for the cows? .....
57.10	BSE in man .....
57.11	Concluding remarks .....

<b>PART IV- ASSURANCE OF THE MICROBIOLOGICAL SAFETY AND QUALITY OF FOODS .....</b>	<b>1625</b>
<b>Chapter 58 Good Manufacturing Practice, HACCP, and Quality Systems .....</b>	<b>1627</b>
<i>Jean-Louis Jouve</i>	
58.1 Introduction .....	1627
58.2 An integrated approach to control microbiological quality and safety .....	1628
58.3 Application of Good Manufacturing Practice .....	1630
58.4 The HACCP System .....	1635
58.5 Application of quality systems .....	1648
58.6 Concluding remarks .....	1652
<b>Chapter 59 Hygienic Design of Factories and Equipment .....</b>	<b>1656</b>
<i>Huub L.M. Lelieveld</i>	
59.1 Introduction .....	1656
59.2 Factory design .....	1658
59.3 Equipment design .....	1666
59.4 Design of process lines .....	1681
59.5 Legislation .....	1687
59.6 Concluding remarks .....	1688
<b>Chapter 60 Sampling for Microbiological Analysis .....</b>	
<i>Basil Jarvis</i>	
60.1 Introduction .....	1691
60.2 Statistical basis of sampling plans .....	1702
60.3 Choice of sampling plans .....	1713
60.4 Statistical process control charts .....	1718
60.5 Some practical aspects of sampling and analysis .....	1722
60.6 Concluding remarks .....	1730
Appendix 60-A Terms used in statistical analysis and sampling .....	1732
<b>Chapter 61 Detection of Microorganisms in Foods: Principles of Physical Methods for Separation and Associated Chemical and Enzymological Methods of Detection ...</b>	<b>1734</b>
<i>Anthony N. Sharpe</i>	
61.1 Preparation of samples for analysis .....	1734
61.2 Detecting microbial cells or their activity .....	1741
61.3 Chemical and biochemical tests .....	1744
61.4 Concluding remarks .....	1751
<b>Chapter 62 Detection of Microorganisms in Foods—Principles of Culture Methods</b>	
<i>Roy Holbrook</i>	
62.1 Introduction .....	1761
62.2 Background .....	1761

<i>Principles of media formulation</i> .....	
Culture media components .....	
Chemically defined media .....	
62.7 Selective agents .....	
62.8 Diluents .....	
62.9 Microbial growth media .....	
62.10 Preparation, storage, and use of culture media .....	
62.11 Quality assurance of culture media .....	
12 Accreditation, validation, and proficiency testing .....	
12 Concluding remarks .....	

**Chapter 63 Detection of Microorganisms in Food—Principles and Application of Immunological Techniques** ..... 17

*David M. Radcliffe and Roy Holbrook*

Introduction .....	17
Microbial antigens .....	17
Antibody production .....	17
The application of immunological techniques in food microbiology .....	17
Examples of immunoassays .....	17
The use of immunomagnetic separation (IMS) techniques in food microbiology .....	18
Standards .....	18
Factors affecting immunological techniques .....	18
Concluding remarks .....	

**Chapter 64 Principles and Applications of Genetic Techniques for Detection, Identification, and Subtyping of Food-Associated Pathogenic Microorganisms** ..... 18

*David E. Hill and Karen C. Jinneman*

Introduction .....	18
Gene probes .....	18
The basic polymerase chain reaction (PCR) .....	18
General aspects of application of the PCR to detection of microorganisms in food samples .....	18
Modifications of the basic PCR method .....	18
Non-PCR-based amplification methods .....	18
Detection of foodborne microbes .....	18
Typing of foodborne microbes .....	18
Concluding remarks .....	

**Chapter 65 Risk Assessment and Microbiological Criteria** .....

*C. Baird-Parker and R. Bruce Tompkin*

Introduction .....	
Risk assessment .....	
Microbiological and related criteria .....	
Concluding remarks .....	