

Contents

Chapter 1	Introduction and Background to Microbiome Research	1
	<i>Joseph F. Pierre</i>	
1.1	Introduction to the Gut Microbiota	1
1.2	Approaches in Microbiome Research	2
1.2.1	Fingerprinting the Microbial Community	3
1.2.2	Identification and Classification of Microbial Membership and Their Functions	5
1.3	<i>In Vivo</i> Models for Investigating Microbial Causality in Nutrition and Metabolism	8
1.4	<i>In Vitro</i> Models to Study the Microbiome	9
1.4.1	Microbial Culture-based Technologies to Study Host–Microbe Interactions	9
1.4.2	Cell Culture Model Systems to Study Host–Microbe Interactions	10
1.5	Heterogeneity of Mammalian Gut Microbes – Implications for Nutritional Science	10
1.6	Summary	12
	References	12
Chapter 2	Metabolism of Dietary Carbohydrates by Intestinal Bacteria	18
	<i>Ebru Ece Gulshan, Farrhin Nowshad, Arul Jayaraman and Kyongbum Lee</i>	
2.1	Introduction	18
2.2	Dietary Fiber	21
2.2.1	Cellulose	22

2.2.2	Hemicellulose	22
2.2.3	Pectin	24
2.2.4	Oligosaccharides	25
2.2.5	Resistant Starch	30
2.2.6	Lignin	31
2.3	Polyphenols	31
2.4	Amino Sugars	36
2.5	Tools for Identifying Products of Microbiota Metabolism	38
2.6	Future Directions	40
	Acknowledgements	42
	References	42
Chapter 3	The Microbiome and Amino Acid Metabolism	48
	<i>N. E. Diether and B. P. Willing</i>	
3.1	Introduction	48
3.2	Microbes and Protein in the Gut Compartments	49
3.2.1	Microbes and Protein in the Small Intestine	49
3.2.2	Microbes and Protein in the Large Intestine	50
3.3	Metabolic Pathways of Proteolytic Fermentation	51
3.3.1	Deamination	52
3.3.2	Decarboxylation	52
3.3.3	Stickland Reaction	52
3.4	Metabolites Produced by Proteolytic Fermentation	53
3.4.1	Ammonia	53
3.4.2	Amines	54
3.4.3	Branched Chain Fatty Acids	54
3.4.4	Phenols and Indoles	54
3.5	Fermentation of Aromatic Amino Acids	55
3.5.1	Tryptophan	55
3.5.2	Tyrosine	57
3.5.3	Phenylalanine	58
3.6	Proteolytic Fermentation and Health	58
3.6.1	Proteolytic Metabolites and the Gut–Brain Axis	58
3.6.2	Irritable Bowel Syndrome (IBS) and Inflammatory Bowel Disease (IBD)	59
3.6.3	Colorectal Cancer	61
3.6.4	Metabolic Syndrome	62
3.7	Conclusions	62
	References	63
Chapter 4	Fat Absorption, Metabolism, and Global Regulation	68
	<i>Nayaab Rana, Peymaun Mozaffari, Danial Asim and Kristina Martinez-Guryun</i>	
4.1	Introduction	68
4.2	Obesity and the Gut Microbiota	70

<i>Contents</i>	xi
4.3 Dietary Modulation of the Gut Microbiota	72
4.3.1 Diet-mediated Shifts in Gut Microbiota Community Composition	72
4.3.2 Direct Microbial Metabolism of Dietary Components	74
4.4 Local Effects of Gut Microbes on the Gastrointestinal Tract	76
4.4.1 Lipid Digestion and Absorption	76
4.5 Microbial Regulation of Peripheral Metabolic Organs	78
4.5.1 Gut Microbiota–Liver Interactions	78
4.5.2 Gut Microbiota–Adipose Interactions	80
4.5.3 Gut Microbiota–Muscle Interactions	81
4.6 Conclusion	81
Conflicts of Interest	82
Acknowledgements	82
References	82
Chapter 5 Probiotics, Prebiotics, and Synbiotics in Human Health	86
<i>Olivia L. Wells, Sidharth Mishra and Hariom Yadav</i>	
5.1 Introduction	86
5.1.1 Probiotics	87
5.1.2 Prebiotics	87
5.1.3 Synbiotics	89
5.2 The Gut Microbiome and Human Health	90
5.3 Role of Probiotics, Prebiotics, and Synbiotics in Illnesses Related to Gut Dysbiosis	92
5.3.1 Introduction	92
5.3.2 Intra-intestinal Disorders	92
5.3.3 Extra-intestinal Disorders	99
5.4 Conclusion	105
Abbreviations	106
References	107
Chapter 6 Microbial Drug Interactions and Human Health	120
<i>Zehra Esra Ilhan and Melissa M. Herbst-Kralovetz</i>	
6.1 Introduction	120
6.2 Drugs Perturb Gut Microbiota Structure, Function, and Host Health	121
6.3 Gut Microbiome as a Modulator of Pharmokinetics	125
6.4 Microbial Biochemistry of Drug Metabolism	129
6.5 Approaches and Model Systems to Study Gut Pharmacomicrobiomics	131
6.6 Personalized Pharmacomicrobiomics and the Future of Microbiome-centric Therapies	135
6.7 Summary	137
References	137

Chapter 7	Early Life Microbiome Colonization and Human Health	150
	<i>Tahliyah S. Mims, Jun Miyoshi and Joseph F. Pierre</i>	
7.1	Introduction	150
7.2	Microbiome Acquisition and Factors Shaping Composition	151
7.2.1	During Gestation	151
7.2.2	Following Birth or Delivery	152
7.2.3	The Effect of Birth Route	153
7.2.4	The Role of Infant Nutrition	155
7.2.5	Exposure to Antibiotics	156
7.3	Early Life Microbiome and Normal Organ System Development	158
7.3.1	Digestive Organ Development	158
7.3.2	Brain Growth and Development	159
7.3.3	Bone Mass	160
7.4	Early Life Microbiome and Obesity Risk	161
7.5	Early Life Microbiome and Immunological Disturbance	162
7.5.1	Inflammatory Bowel Disease (IBD)	162
7.5.2	Asthma and Food Allergy	163
7.5.3	Vaccine Efficacy	164
7.6	Conclusions	164
	References	165
Chapter 8	The Gut Microbiome and Metabolic Surgery	173
	<i>Mehdi Chaib, Matthew J. Davis, Stacey Kubovec, Liza Makowski and Joseph F. Pierre</i>	
8.1	Introduction and History of Bariatric Surgery	173
8.2	Types of Bariatric Surgery	176
8.3	Mechanisms of Metabolic Improvement	177
8.3.1	Role of the Endocrine System	177
8.3.2	Role of the Nervous System	179
8.4	Microbiome and Bile Acid Changes Following Metabolic Surgery	180
8.4.1	The Microbiome in Obesity	180
8.4.2	The Microbiome and Metabolic Surgery	182
8.4.3	Bile Acid Metabolism and Signaling	184
8.5	Effects of Metabolic Surgery, Microbiome, and Bile Acids on Host Immunity	186
8.5.1	The Microbiome and Host Immunity	186
8.5.2	Bile Acids and Host Immunity	187
8.5.3	Metabolic Surgery and Host Immunity	187
8.6	Areas of Current and Future Research	188
8.7	Conclusion	188
	References	189
	Subject Index	196