



Contents

Preface	<i>page</i> xv
Acknowledgments	xix
Abbreviations and Acronyms	xxi
1 Introduction: What Is Biomedical Engineering?	1
1.1 Prelude	1
1.2 Engineering in modern medicine	4
1.3 What is biomedical engineering?	8
1.4 Biomedical engineering in the future	23
1.5 How to use this book	26
PROFILES IN BME: THE AUTHOR, W. MARK SALTZMAN	28
PART 1 MOLECULAR AND CELLULAR PRINCIPLES	
2 Biomolecular Principles	37
2.1 Prelude	37
2.2 Bonding between atoms and molecules	39
2.3 Water: The medium of life	43
2.4 Biochemical energetics	45
2.5 Importance of pH	50
2.6 Macromolecules: Polymers of biological importance	58
2.7 Lipids	72
PROFILES IN BME: TIFFANEE GREEN MACKEY	80
3 Biomolecular Principles: Nucleic Acids	94
3.1 Prelude	94
3.2 Overview: Genetics and inheritance	99
3.3 Molecular basis of genetics	106
3.4 The central dogma: Transcription and translation	116
3.5 Control of gene expression	123
3.6 Recombinant DNA technology	128
PROFILES IN BME: LAURA LIPTAI	143

4 Biomolecular Principles: Proteins	160
<hr/>	
4.1 Prelude	160
4.2 Protein structure	162
4.3 Modification and processing of polypeptides	171
4.4 Enzymes	175
PROFILES IN BME: BRENDA K. MANN	182
5 Cellular Principles	190
<hr/>	
5.1 Prelude	190
5.2 Cell structure and function	192
5.3 ECM	196
5.4 Molecules in the cell membrane	198
5.5 Cell proliferation	206
5.6 Cell differentiation and stem cells	210
5.7 Cell death	213
5.8 Cell culture technology	214
PROFILES IN BME: E.E. "JACK" RICHARDS II	219
PART 2 PHYSIOLOGICAL PRINCIPLES	
6 Communication Systems in the Body	231
<hr/>	
6.1 Prelude	231
6.2 Signaling fundamentals	237
6.3 The nervous system	242
6.4 The endocrine system	251
6.5 The adaptive immune system	256
6.6 Connections to biomedical engineering	265
PROFILES IN BME: DOUGLAS LAUFFENBURGER	268
7 Engineering Balances: Respiration and Digestion	280
<hr/>	
7.1 Prelude	280
7.2 Introduction to mass balances	281
7.3 Respiratory physiology	295
7.4 Digestion and metabolism	313
PROFILES IN BME: DAN LUO	331

8 Circulation	341
8.1 Prelude	341
8.2 The circulating fluid	342
8.3 The blood vessels	345
8.4 The heart	361
PROFILES IN BME: CURTIS G. NEASON	368
9 Removal of Molecules from the Body	377
9.1 Prelude	377
9.2 Examples of elimination of molecules from the body	379
9.3 Biotransformation and biliary excretion	383
9.4 Elimination of molecules by the kidneys	385
PART 3 BIOMEDICAL ENGINEERING	
10 Biomechanics	413
10.1 Prelude	413
10.2 Mechanical properties of materials	415
10.3 Mechanical properties of tissues and organs	424
10.4 Cellular mechanics	433
PROFILES IN BME: WALT BAXTER	438
11 Bioinstrumentation	448
11.1 Prelude	448
11.2 Overview of measurement systems	451
11.3 Types of sensors	453
11.4 Instruments in medical practice	463
11.5 Instruments in the research laboratory	478
11.6 Biosensors	482
11.7 Biomicroelectromechanical systems and lab-on-a-chip devices	484
PROFILES IN BME: BILL HAWKINS	488
12 Bioimaging	497
12.1 Prelude	497
12.2 X-rays and CT	501
12.3 Ultrasound imaging	508
12.4 Nuclear medicine	513

12.5	Optical bioimaging	520
12.6	MRI	524
12.7	Image processing and analysis	527
	PROFILES IN BME: REBECCA RICHARDS-KORTUM	535
13	Biomolecular Engineering I: Biotechnology	544
13.1	Prelude	544
13.2	Drug delivery	546
13.3	Tissue engineering	559
13.4	Nanobiotechnology	567
13.5	Other areas of biomolecular engineering	574
	PROFILES IN BME: ROBERT LANGER	577
14	Biomolecular Engineering II: Engineering of Immunity	588
14.1	Prelude	588
14.2	Antigens, Abs, and mAbs	590
14.3	What are Abs?	592
14.4	How can specific Abs be manufactured?	597
14.5	Clinical uses of Abs	600
14.6	Vaccines	603
	PROFILES IN BME: ELIAH R. SHAMIR	618
15	Biomaterials and Artificial Organs	626
15.1	Prelude	626
15.2	Biomaterials	627
15.3	Hemodialysis	634
15.4	Membrane oxygenators	643
15.5	Artificial heart	645
15.6	Biohybrid artificial organs	650
	PROFILES IN BME: ELIAS QUIJANO	659
16	Biomedical Engineering and Cancer	666
16.1	Prelude	666
16.2	Introduction to cancer	667
16.3	Surgery	669
16.4	Radiation therapy	671
16.5	Chemotherapy	680

16.6	Hormonal and biological therapies	686
16.7	Systems biology, biomedical engineering, and cancer	691
	PROFILES IN BME: KATIE SERRANO	699
	Appendix A Physiological Parameters	705
	Appendix B Chemical Parameters	715
	Appendix C Units and Conversion Factors	721
	Index	723

Color plate section is between pages 360 and 361.