

Contents

INTRODUCTION	1
PART I. STRUCTURES AND FUNCTIONS OF BIOMOLECULES	4
Chapter 1 Structures and Functions of Nucleic Acids	5
Section 1.1 The Monomeric Units of Nucleic Acids—Nucleotides	5
1.1.1 Structure of Nucleotides	5
1.1.2 Properties of Nucleosides and Nucleotides	7
Section 1.2 Structure of DNA	7
1.2.1 Primary Structure of DNA	7
1.2.2 Secondary Structure of DNA	8
1.2.3 Superhelix of DNA	12
Section 1.3 Structure and Function of RNA	14
1.3.1 Structure of RNA	14
1.3.2 Types and Functions of RNAs	16
Section 1.4 Properties of Nucleic Acids	19
1.4.1 Denaturation and Renaturation of Nucleic Acids	19
1.4.2 Hybridization	21
Section 1.5 Catalytic RNA and DNA	22
1.5.1 Ribozymes	22
1.5.2 Deoxyribozymes	23
Section 1.6 Genomics and the Human Genome Project	24
1.6.1 Characteristics of Eukaryotic Genome DNA	24
1.6.2 The Human Genome Project	25
Summary	26
Chapter 2 Structures and Functions of Proteins	27
Section 2.1 Amino Acid Composition and Linkage in Proteins	27
2.1.1 Amino Acid Composition of Proteins	27
2.1.2 The Linkage Between Amino Acids in Protein Molecules	31
2.1.3 Biologically Active Peptides	32
Section 2.2 Molecular Structure of Proteins	33
2.2.1 The Primary Structure of Proteins	33
2.2.2 Three-dimensional Structure of Proteins	36
2.2.3 The Molecular Structure of Collagen	42
Section 2.3 Structure-Function Relationships of Protein	44
2.3.1 Relationships of Primary Structure and Function	44
2.3.2 Structure-Function Relationships of Myoglobin and Hemoglobin	46
2.3.3 Prion Protein and Protein Conformational Disease	49
Section 2.4 Protein Physicochemical Properties and Principles of Purification	50
2.4.1 Protein Physicochemical Properties	50

2.4.2 Protein Purification	53
Section 2.5 Proteome and Proteomics	58
2.5.1 Proteome	58
2.5.2 Proteomics	58
Summary	59
Chapter 3 Structures and Functions of Glycoconjugates	61
Section 3.1 Structures of Glycans	61
3.1.1 Classification and Structure of Monosaccharides	61
3.1.2 Linkage of Monosaccharide in Glycans	62
3.1.3 Primary Structure of Glycans and their Analysis	63
Section 3.2 Structures and Functions of Glycoproteins	64
3.2.1 Classification and Structure of Glycoproteins	64
3.2.2 Functions of Glycoproteins	67
3.2.3 Glycoproteins and Medicine	70
Section 3.3 Structures and Functions of Proteoglycans	71
3.3.1 Structures of Proteoglycans	71
3.3.2 Functions of Proteoglycans	73
Section 3.4 Structures and Functions of Glycolipids	74
3.4.1 Classification and Structure of GSLs	74
3.4.2 Functions of GSLs	74
Summary	76
Chapter 4 Vitamins	77
Section 4.1 The Fat-soluble Vitamins	77
4.1.1 Vitamin A	78
4.1.2 Vitamin D	80
4.1.3 Vitamin E	82
4.1.4 Vitamin K	83
Section 4.2 Water-soluble Vitamins	84
4.2.1 Vitamin B ₁ (Thiamine)	85
4.2.2 Vitamin B ₂ (Riboflavin)	85
4.2.3 Vitamin PP (Niacin)	86
4.2.4 Vitamin B ₆	88
4.2.5 Pantothenic Acid	89
4.2.6 Biotin	89
4.2.7 Folic Acid (Folacin)	89
4.2.8 Vitamin B ₁₂	91
4.2.9 Vitamin C (Ascorbic Acid)	92
4.2.10 Lipoic acid	93
Summary	95
Chapter 5 Enzymes	96
Section 5.1 Structure and Function of Enzymes	96
5.1.1 Structure of Enzymes	96
5.1.2 Active Site of an Enzyme	99

5.1.3	Structure and Function of Enzymes	101
Section 5.2	Nomenclature and Classification of Enzyme	102
5.2.1	Oxidoreductases	102
5.2.2	Transferases	102
5.2.3	Hydrolases	102
5.2.4	Lyases	103
5.2.5	Isomerases	103
5.2.6	Ligases	103
Section 5.3	Properties and Catalytic Mechanisms of Enzymes	104
5.3.1	Properties of Enzyme Catalyzed Reaction	103
5.3.2	Catalytic Mechanisms of Enzymes	105
Section 5.4	Kinetics of Enzyme-Catalyzed Reactions	108
5.4.1	The Effect of Substrate on the Rate of Enzyme-catalyzed Reactions	108
5.4.2	The Effect of Enzyme on the Rate of Enzyme-catalyzed Reactions	112
5.4.3	The Effect of Temperature on the Rate of Enzyme-catalyzed Reactions	112
5.4.4	The Effect of pH on the Rate of Enzyme-catalyzed Reactions	113
5.4.5	The Effect of Inhibitors on the Rate of Enzyme-catalyzed Reactions	113
5.4.6	Activators of Enzyme	118
Section 5.5	Regulation of Enzyme Activity	118
5.5.1	Allosteric Regulation	118
5.5.2	Covalent Modification	120
5.5.3	Zymogen	120
5.5.4	Isoenzymes	121
5.5.5	Genetic Control	122
Section 5.6	Clinical Applications of Enzymes	123
5.6.1	Enzymes and Pathogenesis	123
5.6.2	Enzymes and Diagnosis of the Diseases	124
5.6.3	Enzymes and Therapy of Diseases	126
Summary		126
PART II	METABOLISM	128
Chapter 6	Carbohydrate Metabolism	129
Section 6.1	Introduction	129
6.1.1	Digestion and Absorption of Carbohydrates	129
6.1.2	The Fate of Absorbed Glucose	130
Section 6.2	Anaerobic Degradation of Glucose	131
6.2.1	Basic Process of Glycolysis	131
6.2.2	Regulation of Glycolysis	132
6.2.3	The Significance of Glycolysis	134
Section 6.3	Aerobic Oxidation of Glucose	135
6.3.1	Basic Process of Aerobic Oxidation of Glucose	135
6.3.2	ATP Generated in the Aerobic Oxidation of Glucose	138
6.3.3	The Regulation of Aerobic Oxidation of Glucose	139
Section 6.4	Pentose Phosphate Pathway	141

6.4.1	Basic Process	141
6.4.2	The Significance of Pentose Phosphate Pathway	142
Section 6.5	Glycogen Formation and Degradation	143
6.5.1	Glycogen Formation (Glycogenesis)	143
6.5.2	Glycogen Degradation (Glycogenolysis)	145
6.5.3	The Regulation of Glycogenesis and Glycogenolysis	145
6.5.4	The Significance of Glycogenesis and Glycogenolysis	147
6.5.5	Glycogen Storage Diseases	147
Section 6.6	Gluconeogenesis	148
6.6.1	The Basic Process of Gluconeogenesis	148
6.6.2	Cori Cycle	149
6.6.3	Regulation of Gluconeogenesis	150
6.6.4	The Significance of Gluconeogenesis	152
Section 6.7	Blood Sugar and Its Regulation	152
6.7.1	Blood Sugar Level	152
6.7.2	Regulation of Blood Glucose Concentration	153
6.7.3	Abnormal Blood Sugar Level	154
Summary		154
Chapter 7	Biological Oxidation	156
Section 7.1	Principle of Reduction/Oxidation (Redox) Reactions	156
Section 7.2	Respiratory Chain and Oxidative Phosphorylation	157
7.2.1	Respiratory Chain and Complexes	157
7.2.2	Oxidative Phosphorylation	162
7.2.3	ATP and Other Energy-rich Compounds	166
Section 7.3	Energy from Cytosolic NADH	169
Section 7.4	Other Biological Oxidations	170
7.4.1	Monooxygenases	170
7.4.2	Free Radical Scavenging Enzymes	171
Summary		172
Chapter 8	Metabolism of Lipids	173
Section 8.1	Digestion and Absorption of Lipids	173
8.1.1	Digestion of Lipids	173
8.1.2	Absorption of Lipids	174
Section 8.2	Metabolism of Triacylglycerols	174
8.2.1	Degradation of Triacylglycerols	174
8.2.2	FA Biosynthesis	181
8.2.3	Regulation of Triacylglycerol Metabolism	185
Section 8.3	Important Derivatives of Unsaturated Fatty Acids — Arachidonic Acid	186
8.3.1	Structural Features of PGs, TXs and LTs	186
8.3.2	Biosynthesis of Eicosanoids	187
8.3.3	Physiological Function	187
Section 8.4	Metabolism of Phospholipids	188
8.4.1	Metabolism of Glycerolphospholipid	188

8.4.2	Metabolism of Sphingolipid	192
Section 8.5	Metabolism of Cholesterols	193
8.5.1	Cholesterol Biosynthesis	194
8.5.2	Cholesterol Biotransformation and Excretion	196
Section 8.6	Metabolism of Plasma Lipoproteins	197
8.6.1	Plasma Lipids	197
8.6.2	Classification, Constitution and Structures of Plasma Lipoprotein	198
8.6.3	Apoproteins	198
8.6.4	Metabolism of Lipoproteins	199
8.6.5	Abnormal Metabolism of Lipoprotein	203
Summary		204
Chapter 9	Catabolism of Proteins	206
Section 9.1	Nutritional Function of Proteins	206
9.1.1	Nutritional Requirement of Proteins	206
9.1.2	Nutritional Quality of Proteins	206
Section 9.2	Digestion, Absorption and Putrefaction	207
9.2.1	Digestion of Dietary Protein	207
9.2.2	Absorption and Transportation of Amino Acids	208
9.2.3	Putrefaction	209
Section 9.3	Degradation of Protein in Cells	210
9.3.1	Lysosomal Pathway	211
9.3.2	Cytosol Pathway	211
Section 9.4	Amino Acid Catabolism; General	212
9.4.1	Deamination of Amino Acids	212
9.4.2	Metabolism of Ammonia	216
9.4.3	Metabolism of the Carbon Skeleton of Amino Acids	222
Section 9.5	Amino Acid Catabolism; Individual	223
9.5.1	Decarboxylation of Amino Acids	223
9.5.2	Metabolism of One Carbon Units	224
9.5.3	Metabolism of Methionine, Cysteine and Cystine	227
9.5.4	Metabolism of Aromatic Amino Acids	230
9.5.5	Degradation of Branched-chain Amino Acids	233
Summary		234
Chapter 10	Nucleotide Metabolism	236
Section 10.1	Functions of Nucleotides	236
Section 10.2	Nucleotide Synthesis and Degradation	237
10.2.1	Metabolism of Purine Nucleotides	237
10.2.2	Metabolism of Pyrimidine Nucleotides	241
10.2.3	Deoxyribonucleotide Biosynthesis	244
10.2.4	Biosynthesis of Nucleoside Diphosphate and Nucleoside Triphosphate	246
Section 10.3	Dysmetabolism of Nucleotides and Antimetabolites	247
10.3.1	Dysmetabolism of Nucleotides	247
10.3.2	Antimetabolites	247

Summary	249
Chapter 11 Regulation of Metabolism	251
Section 11.1 Metabolism Regulation in Cell Level	251
11.1.1 Basic Manner of Metabolism Regulation in Cells	251
11.1.2 Regulation of Enzymatic Activity in Cells	255
11.1.3 Regulation of Enzyme Content in Cells	259
Section 11.2 Hormone Regulation of Metabolism	261
11.2.1 Regulation of Hormone Associating Transmembrane Receptor	261
11.2.2 Regulation of Hormone Associating Intracellular Receptor	262
Section 11.3 Regulation of Metabolism in Relation to the Whole	262
11.3.1 Metabolism Regulation in Stress	263
11.3.2 Change of Metabolism in Starvation	263
Summary	265
PART III EXPRESSION AND TRANSMISSION OF GENETIC INFORMATION	267
Chapter 12 DNA Biosynthesis	268
Section 12.1 Overlook of DNA Replication	268
12.1.1 DNA Semiconservative Replication	268
12.1.2 The General Character of DNA Replication	268
Section 12.2 DNA Replication in Eukaryotic Cells	269
12.2.1 Eukaryotic Enzymes of DNA Replication	269
12.2.2 Process of DNA Replication in the Eukaryotes	273
12.2.3 Telomere DNA Replication	276
12.2.4 Mitochondrial DNA Replication	276
12.2.5 Reverse Transcription	277
Section 12.3 Prokaryotic DNA Replication	278
12.3.1 Prokaryotic Enzymes and Proteins Involved in the DNA Replication	278
12.3.2 Process of Proeukaryotic Replication	279
Section 12.4 Recombination and Repair	181
12.4.1 Recombination of DNA	281
12.4.2 Gene Mutation	281
12.4.3 DNA Damage	282
12.4.4 Repair of DNA Damage	283
Summary	286
Chapter 13 Transcription; Synthesis of RNA	288
Section 13.1 Introduction	288
Section 13.2 RNA Synthesis in Prokaryotes	289
13.2.1 RNA Polymerase	290
13.2.2 Initiation of RNA Synthesis	292
13.2.3 Elongation of RNA Synthesis	295
13.2.4 Termination of RNA Synthesis	296
13.2.5 Post-transcriptional Modification	297
13.2.6 Inhibitors of Transcription	298
Section 13.3 RNA Synthesis in Eukaryotes	299

15.3.2	Transcription Activation in Eukaryotes	352
	Summary	355
Chapter 16	Oncogene, Tumor Suppressor Gene and Growth Factor	356
Section 16.1	Oncogenes	356
16.1.1	Viral and Cellular Oncogenes	356
16.1.2	The Function of Oncogene Expression Products	358
16.1.3	Mechanisms of Oncogene Activation	360
Section 16.2	Tumor Suppressor Gene	362
16.2.1	The Concept	362
16.2.2	Some Important Tumor Suppressor Genes and Their Functions	363
16.2.3	Oncogene, Tumor Suppressor Gene and the Generation of Cancer	365
Section 16.3	Growth Factors	366
16.3.1	The Concept	366
16.3.2	The Function Mechanism of the Growth Factor	368
	Summary	368
Chapter 17	Gene Technology	370
Section 17.1	Genetic Engineering	370
17.1.1	Common Tools Used in Genetic Engineering	370
17.1.2	Processes of Genetic Engineering	373
Section 17.2	Molecular Hybridization	375
17.2.1	Nucleic Acid Probes	375
17.2.2	Types of Molecular Hybridization	376
Section 17.3	Polymerase Chain Reaction (PCR)	378
17.3.1	Principles of PCR	378
17.3.2	Procedures of PCR	378
17.3.3	Applications of PCR	379
Section 17.4	DNA Sequencing	380
17.4.1	Chemical Cleavage Sequencing	381
17.4.2	Dideoxy Chain Terminator Sequencing	381
Section 17.5	Transgenesis, Animal Cloning and Gene Knockout Technologies	383
17.5.1	Transgenesis	383
17.5.2	Animal Cloning Technology	383
17.5.3	Gene Knockout Technology	384
17.5.4	Biomedical Applications	384
Section 17.6	Gene Diagnosis	385
17.6.1	Common Techniques Used in Gene Diagnosis	385
17.6.2	Applications of Gene Diagnosis	387
Section 17.7	Gene Therapy	388
17.7.1	The Concept of Gene Therapy	388
17.7.2	The Procedures of Gene Therapy	389
17.7.3	Applications of Gene Therapy	390
	Summary	391

PART IV COMPREHENSIVE TOPICS	393
Chapter 18 Biomembranes	394
Section 18.1 The Molecular Compositions of Biomembranes	394
18.1.1 Lipids	394
18.1.2 Proteins	396
18.1.3 Saccharides	397
Section 18.2 The Structures of Biomembranes	397
18.2.1 The Asymmetry of the Structure of Biomembranes	397
18.2.2 The Fluidity of Biomembranes	398
18.2.3 The Models of Molecular Structures in Biomembranes	400
Section 18.3 The Transportation Functions of Biomembranes	401
18.3.1 Passive Transport	401
18.3.2 Active Transportation	403
18.3.3 Endocytosis and Exocytosis	408
Section 18.4 Biomembranes and Medicine	410
18.4.1 Erythrocyte Membranes	410
18.4.2 Diseases Related to Biomembranes	411
18.4.3 Applications of Liposomes in Medicine	412
Summary	412
Chapter 19 Cellular Signal Transduction	415
Section 19.1 Main Concept of Signaling Transduction	415
19.1.1 Signal Molecules and Forms of Communication between the Cells	415
19.1.2 Components of Intracellular Signaling Pathways	416
Section 19.2 Receptors	417
19.2.1 G Protein-coupled Receptors	417
19.2.2 Enzyme-linked Receptors	419
19.2.3 Ion Channel Receptors	421
19.2.4 Intracellular Receptor Superfamily	422
Section 19.3 Signal Transduction Pathways	422
19.3.1 Cyclic AMP (cAMP)/Protein kinase A and Cyclic GMP (cGMP)/Protein Kinase G Pathways	422
19.3.2 Phospholipid Signaling Pathway	424
19.3.3 Growth Factor and Cytokine Signal Transduction	427
19.3.4 Intracellular Receptors Involved in Signal Transduction	431
Summary	432
Chapter 20 Blood Biochemistry	434
Section 20.1 Composition and Function of Blood	434
20.1.1 Composition	434
20.1.2 Functions	434
20.1.3 Non-Protein Nitrogen (NPN)	435
Section 20.2 The Plasma Proteins	435
20.2.1 Classification and Characters of Plasma Proteins	435
20.2.2 The Function of the Plasma Proteins	437

Section 20.3	Blood Coagulation and Fibrinolysis	438
20.3.1	The Factors Involved in Blood Coagulation	439
20.3.2	The Pathways of Blood Coagulation	439
20.3.3	The Factors Involved in Anticoagulants	443
20.3.4	Dissolution of Blood Clot (Fibrinolysis)	443
Section 20.4	Metabolism of the Blood Cells	444
20.4.1	Biochemical Features of Red Blood Cells	444
20.4.2	Biochemical Features of White Blood Cells	448
Summary		449
Chapter 21	Liver Biochemistry	451
Section 21.1	The Important Role of Liver in Material Metabolism	451
21.1.1	In Carbohydrate Metabolism	451
21.1.2	In Lipid Metabolism	451
21.1.3	In Protein Metabolism	452
21.1.4	In Removal of Drugs and Hormones	452
Section 21.2	Hepatic Biotransformation	452
21.2.1	The Basic Reaction of Biotransformation	452
21.2.2	The Significance of Biotransformation	458
Section 21.3	The Metabolism of Bile and Bile Acid	459
21.3.1	Composition of Bile	459
21.3.2	Bile Acids	459
21.3.3	The Enterohepatic Circulation	461
21.3.4	Function of Bile	462
Section 21.4	Bile Pigment Metabolism and Jaundice	463
21.4.1	Formation and Transport of Bile Pigments	463
21.4.2	Bile Pigment Conversion in Liver	465
21.4.3	Metabolism of Bilirubin in the Intestine and Enterohepatic Cycle of Urobilinogen	466
21.4.4	Serum Bilirubin and Jaundice	467
Summary		468
Chapter 22	Brain Biochemistry	470
Section 22.1	Neurons and Neuroglial Cells	470
22.1.1	Neurons	470
22.1.2	Neuroglial Cells	471
Section 22.2	The Biochemical Components of the Brain	472
22.2.1	The Component Features of the Brain	472
22.2.2	Lipids of the Brain	472
22.2.3	Specific Proteins	473
22.2.4	Important Specific Enzymes and Proteins of the Brain	474
Section 22.3	Substance Metabolism and Energy Metabolism of the Brain	474
22.3.1	Carbohydrate Metabolism	475
22.3.2	Lipid Metabolism	475
22.3.3	Amino Acid and Protein Metabolism	477
22.3.4	Nucleotide, Nucleic Acid Metabolism	477

Section 22.4 Neurotransmitters and Their Receptors	477
22.4.1 Acetylcholine Receptor	478
22.4.2 Monoamine Neurotransmitters and Its Receptors	479
22.4.3 Amino acid Neurotransmitters	479
22.4.4 Nitric Oxide and Purine Neurotransmitters	480
Summary	481
Chapter 23 Biochemistry of Inorganic Molecules	482
Section 23.1 Water and Inorganic Molecules: Importance and Function	482
23.1.1 Biological Function of Water	482
23.1.2 General Biological Function of Some Major Inorganic Molecules	482
Section 23.2 Metabolism of Water and Electrolytes	483
23.2.1 Metabolism of Water	483
23.2.2 Metabolism of Sodium and Potassium	484
Section 23.3 Calcium, Phosphorus, and Magnesium Metabolism	485
23.3.1 Calcium, Phosphorus Metabolism	485
23.3.2 The Metabolism of Magnesium	488
Section 23.4 Trace Element	489
23.4.1 Iron	490
23.4.2 Copper	492
23.4.3 Zinc	493
23.4.4 Iodine	494
23.4.5 Manganese	496
23.4.6 Selenium	496
Summary	497
Appendix A Greek Alphabets	498
Appendix B Some Prefixes Used in the International System of Units	499
Appendix C The Numeral Prefix of Chemical Compounds	499
Appendix D Some Common Biochemical Abbreviations	500
Appendix E English-Chinese Index	505
Appendix F The Major References	514

lar biology, which studies the structures and functions and their control of biomacromolecules, seeks to explain the nature of life. In 1953, James D. Watson and Francis H. Crick deduced the double-helical structure of DNA. In that same year, Frederick Sanger worked out the sequence of amino acids in the polypeptide chains of the hormone insulin. These discoveries were momentous events in science. The establishment of the DNA structure gave rise to entirely new disciplines and influenced the course of many others. Our present understanding of the storage, replication, and expression of genetic information is based on the work of this discovery. Molecular biology is the study in the structures, functions, and the regulation of biomacromolecules, and is the discipline for exposing the nature of life. Scientists advanced the central dogma of molecular biology, the transmission of genetic information DNA $\rightarrow$ RNA $\rightarrow$ proteins. The genetic code was revealed. The study on the regulation of genetic expression made great progress. The techniques of gene recombinant, molecular bi-