

LIST OF CHAPTERS and SPECIAL FEATURES

CHAPTER 1 Cells: The Fundamental Units of Life 1

- PANEL 1-1 Microscopy 12
- TABLE 1-1 Historical Landmarks in Determining Cell Structure 24
- PANEL 1-2 Cell Architecture 25
- How We Know: Life's Common Mechanisms 30
- TABLE 1-2 Some Model Organisms and Their Genomes 35

CHAPTER 2 Chemical Components of Cells 39

- TABLE 2-1 Length and Strength of Some Chemical Bonds 48
- TABLE 2-2 The Chemical Composition of a Bacterial Cell 52
- How We Know: The Discovery of Macromolecules 60
- PANEL 2-1 Chemical Bonds and Groups 66
- PANEL 2-2 The Chemical Properties of Water 68
- PANEL 2-3 The Principal Types of Weak Noncovalent Bonds 70
- PANEL 2-4 An Outline of Some of the Types of Sugars 72
- PANEL 2-5 Fatty Acids and Other Lipids 74
- PANEL 2-6 The 20 Amino Acids Found in Proteins 76
- PANEL 2-7 A Survey of the Nucleotides 78

CHAPTER 3 Energy, Catalysis, and Biosynthesis 81

- PANEL 3-1 Free Energy and Biological Reactions 94
- TABLE 3-1 Relationship Between the Standard Free-Energy Change, ΔG° , and the Equilibrium Constant 96
- How We Know: "High-Energy" Phosphate Bonds Power Cell Processes 102
- TABLE 3-2 Some Activated Carriers Widely Used in Metabolism 109

CHAPTER 4 Protein Structure and Function 117

- PANEL 4-1 A Few Examples of Some General Protein Functions 118
- PANEL 4-2 Making and Using Antibodies 140
- TABLE 4-1 Some Common Functional Classes of Enzymes 142
- How We Know: Measuring Enzyme Performance 144
- TABLE 4-2 Historical Landmarks in Our Understanding of Proteins 160
- PANEL 4-3 Cell Breakage and Initial Fractionation of Cell Extracts 164
- PANEL 4-4 Protein Separation by Chromatography 166
- PANEL 4-5 Protein Separation by Electrophoresis 167
- PANEL 4-6 Protein Structure Determination 168

CHAPTER 5 DNA and Chromosomes 173

- How We Know: Genes Are Made of DNA 193

CHAPTER 6 DNA Replication and Repair 199

How We Know: The Nature of Replication 202

TABLE 6-1 Proteins Involved in DNA Replication 213**TABLE 6-2** Error Rates 218**CHAPTER 7 From DNA to Protein: How Cells Read the Genome 227****TABLE 7-1** Types of RNA Produced in Cells 232**TABLE 7-2** The Three RNA Polymerases in Eukaryotic Cells 235

How We Know: Cracking the Genetic Code 246

TABLE 7-3 Antibiotics That Inhibit Bacterial Protein or RNA Synthesis 256**TABLE 7-4** Biochemical Reactions That Can Be Catalyzed by Ribozymes 261**CHAPTER 8 Control of Gene Expression 267**

How We Know: Gene Regulation—The Story of Eve 280

CHAPTER 9 How Genes and Genomes Evolve 297**TABLE 9-1** Viruses That Cause Human Disease 318**TABLE 9-2** Some Vital Statistics for the Human Genome 322

How We Know: Counting Genes 324

CHAPTER 10 Analyzing the Structure and Function of Genes 333

How We Know: Sequencing the Human Genome 348

CHAPTER 11 Membrane Structure 365**TABLE 11-1** Some Examples of Plasma Membrane Proteins and Their Functions 375

How We Know: Measuring Membrane Flow 384

CHAPTER 12 Transport Across Cell Membranes 389**TABLE 12-1** A Comparison of Ion Concentrations Inside and Outside a Typical Mammalian Cell 391**TABLE 12-2** Some Examples of Transmembrane Pumps 403

How We Know: Squid Reveal Secrets of Membrane Excitability 412

TABLE 12-3 Some Examples of Ion Channels 419**CHAPTER 13 How Cells Obtain Energy from Food 427****TABLE 13-1** Some Types of Enzymes Involved in Glycolysis 431**PANEL 13-1** Details of the 10 Steps of Glycolysis 436**PANEL 13-2** The Complete Citric Acid Cycle 442

How We Know: Unraveling the Citric Acid Cycle 444

CHAPTER 14 Energy Generation in Mitochondria and Chloroplasts 455**TABLE 14-1** Product Yields from Glucose Oxidation 469**PANEL 14-1** Redox Potentials 472

How We Know: How Chemiosmotic Coupling Drives ATP Synthesis 476

CHAPTER 15 Intracellular Compartments and Protein Transport 495**TABLE 15-1** The Main Functions of Membrane-enclosed Organelles of a Eukaryotic Cell 497**TABLE 15-2** The Relative Volumes and Numbers of the Major Membrane-enclosed Organelles in a Liver Cell (Hepatocyte) 498

TABLE 15-3	Some Typical Signal Sequences	502
TABLE 15-4	Some Types of Coated Vesicles	513
How We Know:	Tracking Protein and Vesicle Transport	520

CHAPTER 16 Cell Signaling 533

TABLE 16-1	Some Examples of Signal Molecules	536
TABLE 16-2	Some Foreign Substances That Act on Cell-Surface Receptors	544
TABLE 16-3	Some Cell Responses Mediated by Cyclic AMP	550
TABLE 16-4	Some Cell Responses Mediated by Phospholipase C Activation	552
How We Know:	Untangling Cell Signaling Pathways	563

CHAPTER 17 Cytoskeleton 573

TABLE 17-1	Drugs That Affect Microtubules	584
How We Know:	Pursuing Microtubule-associated Motor Proteins	588
TABLE 17-2	Drugs That Affect Filaments	594

CHAPTER 18 The Cell-Division Cycle 609

TABLE 18-1	Some Eukaryotic Cell-Cycle Durations	611
How We Know:	Discovery of Cyclins and Cdks	615
TABLE 18-2	The Major Cyclins and Cdks of Vertebrates	617
PANEL 18-1	The Principal Stages of M Phase in an Animal Cell	628

CHAPTER 19 Sexual Reproduction and Genetics 651

PANEL 19-1	Some Essentials of Classical Genetics	675
How We Know:	Using SNPs to Get a Handle on Human Disease	684

CHAPTER 20 Cell Communities: Tissues, Stem Cells, and Cancer 691

TABLE 20-1	A Variety of Factors Can Contribute to Genetic Instability	721
TABLE 20-2	Examples of Cancer-critical Genes	728
How We Know:	Making Sense of the Genes That Are Critical for Cancer	730

The Nucleus Is the Information Store of the Cell 16

Mitochondria Generate Usable Energy from Food Molecules 17

Chloroplasts Capture Energy from Sunlight 18

Internal Membranes Create Intracellular Compartments with Different Functions 19

The Cytosol Is a Concentrated Aqueous Gel of Large and Small Molecules 21

The Cytoskeleton Is Responsible for Directed Cell Movements 22

The Cytosol Is Far from Static 23

Eukaryotic Cells May Have Originated as Predators 24

MODEL ORGANISMS 27

Molecular Biologists Have Focused on *E. coli* 27

Brewer's Yeast Is a Simple Eukaryote 28

Arabidopsis Has Been Chosen as a Model Plant 28

Model Animals Include Flies, Worms, Fish, and Mice 29

Biologists Also Directly Study Humans and Their Cells 32

Comparing Genome Sequences Reveals Life's Common Heritage 33

Genomes Contain More Than Just Genes 35

ESSENTIAL CONCEPTS 36

QUESTIONS 37