Detailed Contents



1 BIOLOGY: EXPLORING LIFE 1

Essay A Big-Billed Bird Rebounds 1

The Scope of Biology 2

- 1.1 Life's levels of organization define the scope of biology 2
- 1.2 Living organisms and their environments form interconnecting webs 3
- 1.3 Cells are the structural and functional units of life 4

Evolution, Unity, and Diversity 4

- 1.4 The unity of life: All forms of life have common features 4
- 1.5 The diversity of life can be arranged into three domains 6
- 1.6 Evolution explains the unity and diversity of life 8

The Process of Science 9

- 1.7 Scientists use two main approaches to learn about nature 9
- 1.8 With hypothesis-based science, we pose and test hypotheses 10

Biology and Everyday Life 12

1.9 Connection Biology is connected to our lives in many ways 12

Chapter Review 13

IINIT I

The Life of the Cell

2 THE CHEMICAL BASIS OF LIFE 16

Essay Nature's Chemical Language 16

Elements, Atoms, and Molecules 18

- 2.1 Living organisms are composed of about 25 chemical elements 18
- 2.2 Connection Trace elements are common additives to food and water 18
- 2.3 Elements can combine to form compounds 19

- Atoms consist of protons, neutrons, and 2.4 electrons 20
- Connection Radioactive isotopes can help or 2.5 harm us 21
- Electron arrangement determines the chemical 2.6 properties of an atom
- Ionic bonds are attractions between ions of opposite 2.7 charge
- Covalent bonds join atoms into molecules through 2.8 electron sharing 23
- Unequal electron sharing creates polar molecules 24 2.9 Hydrogen bonds are weak bonds important in the 2.10

Water's Life-Supporting Properties

chemistry of life 24

- Hydrogen bonds make liquid water cohesive 2.11
- 2.12 Water's hydrogen bonds moderate temperature 25
- Ice is less dense than liquid water 26 2.13
- 2.14 Water is the solvent of life
- The chemistry of life is sensitive to acidic and basic 2.15 conditions Connection Acid precipitation threatens the

environment **Chemical Reactions** 29

2.16

- 2.17 Chemical reactions change the composition of matter 29
- Chapter Review 30

THE MOLECULES OF CELLS 32 3

Essay Got Lactose? 32

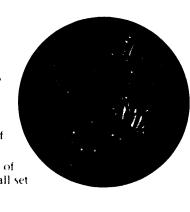
Introduction to Organic Compounds 34

- 3 1 Life's molecular diversity is based on the properties of
- carbon 34 3.2 Functional groups help
- determine the properties of organic compounds.
- 3.3 Cells make a huge number of large molecules from a small set

of small molecules 36

37 Carbohydrates

- Monosaccharides are the simplest carbohydrates 37 3.4 Cells link two single sugars to form disaccharides 38 3.5
- Connection How sweet is sweet? 3.6
- Polysaccharides are long chains of sugar units 3.7



Lip	ids 40
3.8	Fats are lipids that are mostly energy-storage molecules 40
3.9	Phospholipids, waxes, and steroids are lipids with a variety of functions 41
3.1	O Connection Anabolic steroids pose health risks 41
Pro	oteins 42
3.1	1 Proteins are essential to the structures and activities of life 42

ind activities 3.12 Proteins are made from amino acids linked by

peptide bonds 42 3.13 A protein's specific shape determines its function 43 A protein's shape depends on four levels of 3.14

structure 3.15 Talking About Science Linus Pauling contributed to our understanding of the chemistry of life **Nucleic Acids** 47 Nucleic acids are information-rich polymers of 3.16

4 A TOUR OF THE CELL 50

Essay The Art of Looking at Cells

nucleotides 47

Chapter Review

Introduction to the Cell

4.1 Microscopes provide windows to the world of the cell 52 4.2

Most cells are microscopic 4.3 Prokaryotic cells are structurally simpler than eukaryotic cells 55

4.4 Eukaryotic cells are partitioned into functional compartments 56

Organelles of the Endomembrane System

4.5 The nucleus is the cell's genetic control center 58 4.6 Overview: Many cell organelles are connected through the endomembrane system 4.7 Smooth endoplasmic reticulum has a variety of

4.8 Rough endoplasmic reticulum makes membrane and proteins 59 4.9 The Golgi apparatus finishes, sorts, and ships cell products 60

Lysosomes are digestive compartments within 4.10 a cell 60 Connection Abnormal lysosomes can cause fatal 4.11

61 4.12 Vacuoles function in the general maintenance of the cell 62

A review of the endomembrane system 4.13

Energy-Converting Organelles Chloroplasts convert solar energy to chemical 4.14

energy Mitochondria harvest chemical energy from 4.15 food 63

XX Contents

functions

58

The	Cv	toskeletor	and	Related	Structures	6
HIC	⊂ y	coskerecor	anu	Relateu	or actares	O

- 4.16 The cell's internal skeleton helps organize its structure and activities 64
- 4.17 Cilia and flagella move when microtubules bend 65

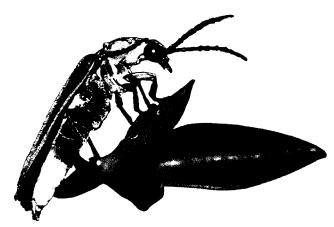
Cell Surfaces and Junctions 66

4.18 Cell surfaces protect, support, and join cells 66

Functional Categories of Organelles 63

4.19 Eukaryotic organelles comprise four functional categories 67

Chapter Review 68



5 THE WORKING CELL 70

Essay Cool "Fires" Attract Mates and Meals 70

Energy and the Cell 72

- 5.1 Energy is the capacity to perform work 72
- 5.2 Two laws govern energy transformations 73
- 5.3 Chemical reactions either store or release energy 74
- 5.4 ATP shuttles chemical energy and drives cellular work 75

How Enzymes Function 76

- 5.5 Enzymes speed up the cell's chemical reactions by lowering energy barriers 76
- 5.6 A specific enzyme catalyzes each cellular reaction 77
- 5.7 The cellular environment affects enzyme activity 77
- 5.8 Enzyme inhibitors block enzyme action 78
- 5.9 *Connection* Many poisons, pesticides, and drugs are enzyme inhibitors 78

Membrane Structure and Function 79

- 5.10 Membranes organize the chemical activities of cells 79
- 5.11 Membrane phospholipids form a bilayer 79
- 5.12 The membrane is a fluid mosaic of phospholipids and proteins 80
- 5.13 Proteins make the membrane a mosaic of function 80
- 5.14 Passive transport is diffusion across a membrane 81
- 5.15 Transport proteins may facilitate diffusion across membranes 82
- 5.16 Osmosis is the diffusion of water across a membrane 82

- 5.17 Water balance between cells and their surroundings is crucial to organisms 83
- 5.18 Cells expend energy for active transport 84
- 5.19 Exocytosis and endocytosis transport large molecules 84
- 5.20 *Connection* Faulty membranes can overload the blood with cholesterol 85
- 5.21 Chloroplasts and mitochondria make energy available for cellular work 86

Chapter Review 86

6 HOW CELLS HARVEST CHEMICAL ENERGY 88

MILLER

Essay How Is a Marathoner Different from

Introduction to Cellular

Respiration 90

6.1 Photosynthesis and cellular respiration provide energy for life 90

a Sprinter? 88

- 6.2 Breathing supplies oxygen to our cells and removes carbon dioxide 90
- 6.3 Cellular respiration banks energy in ATP molecules 91
- 6.4 *Connection* The human body uses energy from ATP for all its activities 91
- 6.5 Cells tap energy from electrons "falling" from organic fuels to oxygen 92

Stages of Cellular Respiration and Fermentation 93

- 6.6 Overview: Cellular respiration occurs in three main stages 93
- 6.7 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate 94
- 6.8 Pyruvate is chemically groomed for the citric acid cycle 96
- 6.9 The citric acid cycle completes the oxidation of organic fuel, generating many NADH and FADH₂ molecules 96
- 6.10 Most ATP production occurs by oxidative phosphorylation 98
- 6.11 *Connection* Certain poisons interrupt critical events in cellular respiration 99
- 6.12 Review: Each molecule of glucose yields many molecules of ATP 100
- 6.13 Fermentation is an anaerobic alternative to cellular respiration 101

Interconnections Between Molecular Breakdown and Synthesis 102

- 6.14 Cells use many kinds of organic molecules as fuel for cellular respiration 102
- 6.15 Food molecules provide raw materials for biosynthesis 103
- 6.16 The fuel for respiration ultimately comes from photosynthesis 103

Chapter Review 104

7 PHOTOSYNTHESIS: USING LIGHT TO MAKE FOOD 106

Essay Plant Power 106

An Overview of Photosynthesis 108

- 7.1 Autotrophs are the producers of the biosphere 108
- 7.2 Photosynthesis occurs in chloroplasts 109
- 7.3 Plants produce O₂ gas by splitting water 110
- 7.4 Photosynthesis is a redox process, as is cellular respiration 110
- 7.5 Overview: Photosynthesis occurs in two stages linked by ATP and NADPH 111

The Light Reactions: Converting Solar Energy to Chemical Energy 112

- 7.6 Visible radiation drives the light reactions 112
- 7.7 Photosystems capture solar power 113
- 7.8 In the light reactions, electron transport chains generate ATP and NADPH 114
- 7.9 Chemiosmosis powers ATP synthesis in the light reactions 115

The Calvin Cycle: Converting CO₂ to Sugars 116

7.10 ATP and NADPH power sugar synthesis in the Calvin cycle 116

Photosynthesis Reviewed and Extended 117

- 7.11 Review: Photosynthesis uses light energy to make food molecules 117
- 7.12 C₄ and CAM plants have special adaptations that save water 118

Photosynthesis, Solar Radiation, and Earth's Atmosphere 119

- 7.13 *Connection* Photosynthesis moderates global warming 119
- 7.14 Talking About Science Mario Molina talks about Earth's protective ozone layer 120

Chapter Review 12:



UNITI

Cellular Reproduction and Genetics

8 THE CELLULAR BASIS OF REPRODUCTION AND INHERITANCE 124

Essay Rain Forest Rescue 124	ŀ
------------------------------	---

Connections Be	etween	Cell	Division	and
Reproduction	126			

- 8.1 Like begets like, more or less
- 8.2 Cells arise only from preexisting cells
- 8.3 Prokaryotes reproduce by binary fission 127

The Eukaryotic Cell Cycle and Mitosis

- 8.4 The large, complex chromosomes of eukaryotes duplicate with each cell division
- 8.5 The cell cycle multiplies cells
- 8.6 Cell division is a continuum of dynamic
- changes 130
- 8.7 Cytokinesis differs for plant and animal cells
- 8.8 Anchorage, cell density, and chemical growth factors affect cell division 133
- 8.9 Growth factors signal the cell cycle control
- Connection Growing out of control, cancer cells 8.10 produce malignant tumors 135
- 8.11 Review of the functions of mitosis: Growth, cell replacement, and asexual reproduction

Meiosis and Crossing Over 136

8.12

- Chromosomes are matched in homologous 136 pairs 8.13
- Gametes have a single set of chromosomes
- 8.14 Meiosis reduces the chromosome number from diploid to haploid
- 8.15 Review: A comparison of mitosis and meiosis
- 8.16 Independent orientation of chromosomes in meiosis and random fertilization lead to varied offspring 141
- 8.17 Homologous chromosomes carry different versions of genes 142
- 8.18 Crossing over further increases genetic variability 142

Alterations of Chromosome Number and Structure

- 8.19 A karyotype is a photographic inventory of an individual's chromosomes 144
- 8.20 Connection An extra copy of chromosome 21 causes Down syndrome

xxii Contents

- 8.21 Accidents during meiosis can alter chromosome number 146
- 8.22 *Connection* Abnormal numbers of sex chromosomes do not usually affect survival 147
- 8.23 *Connection* Alterations of chromosome structure can cause birth defects and cancer 148

Chapter Review 149



Essay Purebreds and Mutts—A Difference of Heredity

Mendel's Laws 154

- 9.1 The science of genetics has ancient roots 154
- 9.2 Experimental genetics began in an abbey garden 154
- 9.3 Mendel's law of segregation describes the inheritance of a single characteristic 156
- 9.4 Homologous chromosomes bear the two alleles for each characteristic 157
- 9.5 The law of independent assortment is revealed by tracking two characteristics at once 158
- 9.6 Geneticists use the testcross to determine unknown genotypes 159
- 9.7 Mendel's laws reflect the rules of probability 160
- 9.8 Connection Genetic traits in humans can be tracked through family pedigrees 161
- 9.9 *Connection* Many inherited disorders in humans are controlled by a single gene 162
- 9.10 *Connection* New technologies can provide insight into one's genetic legacy 164

Variations on Mendel's Laws 166

- 9.11 The relationship of genotype to phenotype is rarely simple 166
- 9.12 Incomplete dominance results in intermediate phenotypes 166
- 9.13 Many genes have more than two alleles in the population 167
- 9.14 A single gene may affect many phenotypic characteristics 168
- 9.15 A single characteristic may be influenced by many genes 169
- 9.16 The environment affects many characteristics 170
- 9.17 *Connection* Genetic testing can detect disease-causing alleles 170

The Chromosomal Basis of Inheritance 171

- 9.18 Chromosome behavior accounts for Mendel's laws 171
- 9.19 Genes on the same chromosome tend to be inherited together 172
- 9.20 Crossing over produces new combinations of alleles 172

9.21 Geneticists use crossover data to map genes 174

Sex Chromosomes and Sex-Linked Genes 175

- 9.22 Chromosomes determine sex in many species 175
- 9.23 Sex-linked genes exhibit a unique pattern of inheritance 176
- 9.24 Connection Sex-linked disorders affect mostly males 177

Chapter Review 178

10 MOLECULAR BIOLOGY OF THE GENE 180

Essay Sabotage Inside Our Cells 180

The Structure of the Genetic Material 182

- 10.1 Experiments showed that DNA is the genetic material 182
- 10.2 DNA and RNA are polymers of nucleotides 184
- 10.3 DNA is a double-stranded helix 186

DNA Replication 188

- 10.4 DNA replication depends on specific base pairing 188
- 10.5 DNA replication: A closer look 189

The Flow of Genetic Information from DNA to RNA to Protein 190

- 10.6 The DNA genotype is expressed as proteins, which provide the molecular basis for phenotypic traits 190
- 10.7 Genetic information written in codons is translated into amino acid sequences 191
- 10.8 The genetic code is the Rosetta stone of life 192
- 10.9 Transcription produces genetic messages in the form of RNA 193
- 10.10 Eukaryotic RNA is processed before leaving the nucleus 194
- 10.11 Transfer RNA molecules serve as interpreters during translation 194
- 10.12 Ribosomes build polypeptides 196
- 10.13 An initiation codon marks the start of an mRNA message 196
- 10.14 Elongation adds amino acids to the polypeptide chain until a stop codon terminates translation 197
- 10.15 Review: The flow of genetic information in the cell is DNA → RNA → protein 198
- 10.16 Mutations can change the meaning of genes 199

Microbial Genetics 200

- 10.17 Viral DNA may become part of the host chromosome 200
- 10.18 *Connection* Many viruses cause disease in animals 201
- 10.19 *Connection* Plant viruses are serious agricultural pests 202
- 10.20 *Connection* Emerging viruses threaten human health 202

- 10.21 The AIDS virus makes DNA on an RNA template 203
- 10.22 Bacteria can transfer DNA in three ways 204
- 10.23 Bacterial plasmids can serve as carriers for gene transfer 205

Chapter Review 206



11 THE CONTROL OF GENE EXPRESSION 208

Essay To Clone or Not to Clone? 208

Gene Regulation 210

- 11.1 Proteins interacting with DNA turn prokaryotic genes on or off in response to environmental changes 210
- 11.2 Differentiation yields a variety of cell types, each expressing a different combination of genes 212
- 11.3 Differentiated cells may retain all of their genetic potential 212
- 11.4 DNA packing in eukaryotic chromosomes helps regulate gene expression 213
- 11.5 In female mammals, one X chromosome is inactive in each cell 214
- 11.6 Complex assemblies of proteins control eukaryotic transcription 214
- 11.7 Eukaryotic RNA may be spliced in more than one way 215
- 11.8 Translation and later stages of gene expression are also subject to regulation 216
- 11.9 Review: Multiple mechanisms regulate gene expression in eukaryotes 217

Animal Cloning 218

- 11.10 Nuclear transplantation can be used to clone animals 218
- 11.11 *Connection* Reproductive cloning has valuable applications, but human reproductive cloning raises ethical issues 218

11.12	Connection Therapeutic cloning can produce ste cells with great medical potential 219	em
The C	Genetic Control of Embryonic Development	22

20

11.13 Cascades of gene expression and cell-to-cell signaling direct the development of an animal 11.14 Signal transduction pathways convert messages

received at the cell surface to responses within the cell 221

11.15 Key developmental genes are very ancient

The Genetic Basis of Cancer 222

11.16 Cancer results from mutations in genes that control cell division 222

11.17 Oncogene proteins and faulty tumor-suppressor proteins can interfere with normal signal transduction pathways 224

11.18 Multiple genetic changes underlie the development of cancer 225 11.19 Talking About Science Mary-Claire King discusses mutations that cause breast cancer

11.20 Connection Avoiding carcinogens can reduce the risk

of cancer 227 Chapter Review 228

libraries

12 DNA TECHNOLOGY **AND GENOMICS 230**

Bacterial Plasmids and Gene Cloning

Essay DNA and Crime Scene Investigations 230

12.1 Plasmids are used to customize bacteria: An

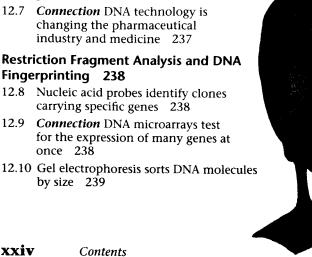
- overview 232 12.2 Enzymes are used to "cut and paste" DNA
- 12.3 Genes can be cloned in recombinant
- plasmids: A closer look 234 12.4 Cloned genes can be stored in genomic
- 12.5 Reverse transcriptase helps make genes for cloning 235

235

- 12.6 Connection Recombinant cells and organisms can mass-produce gene
- products 236 12.7 Connection DNA technology is

Restriction Fragment Analysis and DNA

- 12.8
- carrying specific genes 12.9 Connection DNA microarrays test
 - 238once
 - by size 239



12.11	Restriction fragment length polymorphisms can be used to detect differences in DNA sequences 240
12.12	Connection DNA technology is used in courts of law 242
12.13	Connection Gene therapy may someday help treat a variety of diseases 243
12.14	The PCR method is used to amplify DNA sequences 244
Geno	omics 244
12.15	Connection The Human Genome Project is an ambitious application of DNA technology 244
12.16	Most of the human genome does not consist of genes 245
12.17	Connection The science of genomics compares whole genomes 246
Gene	tically Modified Organisms 247
12.18	Connection Genetically modified organisms are transforming agriculture 247
12.19	Connection Could GM organisms harm human health or the environment? 248
12.20	Talking About ScienceGenomics researcher EricLander discusses the Human Genome Project249
Chapt	ter Review 249
Co	oncepts of Evolution POPULATIONS EVOLVE 254
	Essay Clown, Fool, or Simply Well Adapted? 254
	, , , , , , , , , , , , , , , , , , , ,
	Darwin's Theory of Evolution 256
	Darwin's Theory of Evolution 256 13.1 A sea voyage helped Darwin frame his theory of evolution 256
•	13.1 A sea voyage helped Darwin frame his theory of
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the mechanism of evolution 258 13.3 The study of fossils provides strong
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the mechanism of evolution 258 13.3 The study of fossils provides strong evidence for evolution 260 13.4 A mass of other evidence reinforces the
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the mechanism of evolution 258 13.3 The study of fossils provides strong evidence for evolution 260 13.4 A mass of other evidence reinforces the evolutionary view of life 262 13.5 <i>Connection</i> Scientists can observe
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the mechanism of evolution 258 13.3 The study of fossils provides strong evidence for evolution 260 13.4 A mass of other evidence reinforces the evolutionary view of life 262 13.5 Connection Scientists can observe natural selection in action 264 Population Genetics and The Modern
	13.1 A sea voyage helped Darwin frame his theory of evolution 256 13.2 Darwin proposed natural selection as the mechanism of evolution 258 13.3 The study of fossils provides strong evidence for evolution 260 13.4 A mass of other evidence reinforces the evolutionary view of life 262 13.5 Connection Scientists can observe natural selection in action 264 Population Genetics and The Modern Synthesis 265 13.6 Populations are the units of

- 13.9 In addition to natural selection, genetic drift and gene flow can contribute to evolution 268
- 13.10 *Connection* Endangered species often have reduced variation 269

Variation and Natural Selection 270

- 13.11 Variation is extensive in most populations 270
- 13.12 Mutation and sexual recombination generate variation 270
- 13.13 *Connection* The evolution of antibiotic resistance in bacteria is a serious public health concern 272
- 13.14 Diploidy and balancing selection preserve variation 272
- 13.15 The perpetuation of genes defines evolutionary fitness 273
- 13.16 Natural selection can alter variation in a population in three ways 274

13.18 Natural selection cannot fashion perfect

- 13.17 Sexual selection may produce sexual dimorphism 275
- organisms 275 Chapter Review 276

14 THE ORIGIN OF SPECIES 278

Essay Mosquito Mystery 278

14.1 The origin of species is the source of biological diversity 280

Concepts of Species 280

- 14.2 What is a species? 280
- 14.3 Reproductive barriers keep species separate 282

Mechanisms of Speciation 284

- 14.4 Geographic isolation can lead to speciation 284
- 14.5 Reproductive barriers may evolve as populations diverge 285
- 14.6 New species can arise within the same geographic area as the parent species 286
- 14.7 *Connection* Polyploid plants clothe and feed us 287
- 14.8 Adaptive radiation may occur in new or newly vacated habitats 288
- 14.9 *Talking About Science* Peter and Rosemary Grant study the evolution of Darwin's finches 289
- 14.10 The tempo of speciation can appear steady or jumpy 290

Macroevolution 291

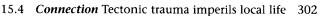
- 14.11 Evolutionary novelties may arise in several ways 291
- 14.12 Genes that control development are important in evolution 292
- 14.13 Evolutionary trends do not mean that evolution is goal directed 293
- Chapter Review 294

15 TRACING EVOLUTIONARY HISTORY 296

Essay Are Birds Really Dinosaurs with Feathers? 296

Macroevolution and Earth's History 298

- 15.1 The fossil record chronicles macroevolution 298
- 15.2 The actual ages of rocks and fossils mark geologic time 299
- 15.3 Continental drift has played a major role in macroevolution 300



15.5 Mass extinctions were followed by diversification of life-forms 302

Phylogeny and Systematics 304

- 15.6 Phylogenies are based on homologies in fossils and living organisms 304
- 15.7 Systematics connects classification with evolutionary history 304
- 15.8 Cladograms are diagrams based on shared characters among species 306
- 15.9 Molecular biology is a powerful tool in systematics 308
- 15.10 Arranging life into kingdoms is a work in progress 310

Chapter Review 311

UNIT IV

The Evolution of Biological Diversity

16 THE ORIGIN AND EVOLUTION OF MICROBIAL LIFE: PROKARYOTES AND PROTISTS 314

Essay How Ancient Bacteria Changed the World 314

Early Earth and the Origin of Life 316

- 16.1 Life began on a young Earth 316
- 16.2 How did life originate? 318
- 16.3 Talking About Science Stanley Miller's experiments showed that organic molecules could have arisen on a lifeless Earth 318
- 16.4 The first polymers may have formed on hot rocks or clay 320
- 16.5 The first genetic material and enzymes may both have been RNA 320



16.6	Membrane-enclosed molecular cooperatives may				
	have preceded the first cells 321				

Prokaryotes 322

prokaryotes 328

16.7

- Prokaryotes have inhabited Earth for billions of years 322 Bacteria and archaea are the two main branches of 16.8 prokaryotic evolution 322
- 16.9 Prokaryotes come in a variety of shapes 323 of prokaryotes 324
- 16.10 Various structural features contribute to the success 16.11 Prokaryotes obtain nourishment in a variety
- of ways 326 16.12 Archaea thrive in extreme environments-and in other habitats 327 16.13 Bacteria include a diverse assemblage of
- 16.14 Connection Some bacteria cause disease 16.15 Connection Bacteria can be used as biological
- weapons 330 16.16 Connection Prokaryotes help recycle chemicals and clean up the environment 330
- **Protists** 332 16.17 The eukaryotic cell probably originated as a
- community of prokaryotes 332 16.18 Protists are an extremely diverse assortment of eukaryotes 333

16.19 A tentative phylogeny of eukaryotes includes

- multiple clades of protists 334 16.20 Diplomonads and euglenozoans include some flagellated parasites 334 16.21 Alveolates have sacs beneath the plasma membrane
- and include dinoflagellates, apicomplexans, and ciliates 335 16.22 Stramenopiles are named for their "hairy" flagella and include the water molds, diatoms, and brown
- 16.23 Amoebozoans have pseudopodia and include amoebas and slime molds 337 16.24 Red algae and green algae are the closest relatives of
- land plants 338 16.25 Multicellularity evolved several times in
- eukaryotes 339 Chapter Review 340

17 PLANTS, FUNGI, AND THE COLONIZATION OF LAND 342

Essay Plants and Fungi-A Beneficial Partnership 342

Plant Evolution and Diversity

17.1 Plants evolved from green algae 344 17.2 Plants have adaptations for life on land 344

xxvi Contents

algae

336

17.3 Plant diversity reflects the evolutionary history of the plant kingdom 346

Alternation of Generations and Plant Life Cycles 348

- 17.4 Haploid and diploid generations alternate in plant life cycles 348
- 17.5 Mosses have a dominant gametophyte 348
- 17.6 Ferns, like most plants, have a dominant sporophyte 349
- 17.7 Seedless plants dominated vast "coal forests" 350
- 17.8 A pine tree is a sporophyte with tiny gametophytes in its cones 350
- 17.9 The flower is the centerpiece of angiosperm reproduction 352
- 17.10 The angiosperm plant is a sporophyte with gametophytes in its flowers 352
- 17.11 The structure of a fruit reflects its function in seed dispersal 354
- 17.12 *Connection* Agriculture is based almost entirely on angiosperms 354
- 17.13 Interactions with animals have profoundly influenced angiosperm evolution 35517.14 *Connection* Plant diversity is a nonrenewable

Fungi 357

resource 356

- 17.15 Fungi absorb food after digesting it outside their bodies 357
- 17.16 Fungi produce spores in both asexual and sexual life cycles 358
- 17.17 Fungi can be classified into five groups 358
- 17.18 Fungal groups differ in their life cycles and reproductive structures 360
- 17.19 Connection Parasitic fungi harm plants and animals 361
- 17.20 Lichens consist of fungi living mutualistically with photosynthetic organisms 362
- 17.21 Fungi also form mutualistic relationships with animals 362
- 17.22 *Connection* Fungi have enormous ecological benefits and practical uses 363

Chapter Review 364



18 THE EVOLUTION OF ANIMAL DIVERSITY 366



Essay What Am I? 366

Animal Evolution and Diversity 368

- 18.1 What is an animal? 368
- 18.2 The ancestor of animals was probably a colonial, flagellated protist 369
- 18.3 Animals can be characterized by basic features of their "body plan" 370
- 18.4 The body plans of animals can be used to build phylogenetic trees 371

Invertebrates 372

- 18.5 Sponges have a relatively simple, porous body 372
- 18.6 Cnidarians are radial animals with tentacles and stinging cells 373
- 18.7 Flatworms are the simplest bilateral animals 374
- 18.8 Nematodes have a pseudocoelom and a complete digestive tract 375
- 18.9 Diverse molluscs are variations on a common body plan 376
- 18.10 Annelids are segmented worms 378
- 18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton 380
- 18.12 Insects are the most diverse group of organisms 382
- 18.13 Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement 384
- 18.14 Our own phylum, Chordata, is distinguished by four features 385

Vertebrates 386

- 18.15 Derived characters define the major clades of chordates 386
- 18.16 Lampreys are vertebrates that lack hinged jaws 387
- 18.17 Jawed vertebrates with gills and paired fins include sharks, ray-finned fishes, and lobe-fins 388
- 18.18 Amphibians were the first tetrapods-vertebrates with two pairs of limbs 389
- 18.19 Reptiles are amniotes-tetrapods with a terrestrially adapted egg 390
- 18.20 Birds are feathered reptiles with adaptations for flight 391
- 18.21 Mammals are amniotes that have hair and produce milk 392

Animal Phylogeny and Diversity Revisited 393

- 18.22 An animal phylogenetic tree is a work in progress 393
- 18.23 Connection Humans threaten animal diversity by introducing non-native species 394

Chapter Review 395

19 HUMAN EVOLUTION 398

Essay How Are We Related to the Neanderthals? 398

Primate Diversity 400

- 19.1 The human story begins with our primate heritage 400
- 19.2 Hominoids include humans and four other groups of apes 402

Hominid Evolution 403

- 19.3 The human branch of the primate tree is only a few million years old 403
- 19.4 Upright posture evolved well before an enlarged brain in hominids 404
- 19.5 Larger brains and reduced sexual dimorphism mark the evolution of *Homo* 404
- 19.6 When and where did Homo sapiens arise? 405
- 19.7 *Connection* Human skin colors reflect adaptations to varying amounts of sunlight 406
- 19.8 *Connection* A genetic difference helped humans start speaking 406

Our Cultural History and Its Consequences 407

- 19.9 Culture gives humans enormous power to change the environment 407
- 19.10 Scavenging, gathering, and hunting were the earliest human endeavors 407
- 19.11 Agriculture was a major development in human history 408
- 19.12 Development of complex tools affects human culture and the world 408

Chapter Review 409

UNIT V

Animals: Form and Function

20 UNIFYING CONCEPTS OF ANIMAL STRUCTURE AND FUNCTION 412

Essay Climbing the Walls 412

The Hierarchy of Structural Organization in an

Animal 414

20.1 Structure fits function in the animal body 414

20.2 Animal structure has a hierarchy 415



20.3	Tissues are groups of cells with a common structure
	and function 415
20.4	Epithelial tissue covers the body and lines its organs

- 20.4 Epithelial tissue covers the body and lines its organs and cavities 416
- 20.5 Connective tissue binds and supports other tissues 417
- 20.6 Muscle tissue functions in movement 418
 20.7 Nervous tissue forms a communication network 418
- network 418
 20.8 *Connection* Artificial tissues have medical uses 419
- 20.9 Organs are made up of tissues 41920.10 Organ systems work together to perform life's functions 420
- functions 420
 20.11 *Connection* New imaging technology reveals the inner body 422

Exchanges with the External Environment 424 20.12 Structural adaptations enhance exchange between animals and their environment 424

animals and their environment 424
20.13 Animals regulate their internal environment 425
20.14 Homeostasis depends on negative feedback 426

21 NUTRITION AND DIGESTION 428

Chapter Review 426

Essay Getting Their Fill of Krill 428

Obtaining and Processing Food 430

- 21.1 Animals ingest their food in a variety of ways 430
 21.2 Overview: Food processing occurs in four stages 431
- 21.3 Digestion occurs in specialized compartments 432

Human Digestive System 433

- 21.4 The human digestive system consists of an alimentary canal and accessory glands 433
- 21.5 Digestion begins in the oral cavity 434
- 21.6 The food and breathing passages both open into the pharynx 434
- 21.7 *Connection* The Heimlich maneuver can save lives 435
- 21.8 The esophagus squeezes food along to the stomach by peristalsis 435
- 21.9 The stomach stores food and breaks it down with acid and enzymes 436
- 21.10 *Connection* Bacterial infections can cause ulcers 437
- 21.11 The small intestine is the major organ of chemical digestion and nutrient absorption 438
- 21.12 The large intestine reclaims water and compacts the feces 440



Diets and Digestive Adaptations 440

21.13 Adaptations of vertebrate digestive systems reflect diet 440

Nutrition 442

- 21.14 Overview: A healthy diet satisfies three needs 442
- 21.15 Chemical energy powers the body 442
- 21.16 An animal's diet must supply essential nutrients 443
- 21.17 *Connection* Vegetarians must be sure to obtain all eight essential amino acids 443
- 21.18 A healthy diet includes 13 vitamins 444
- 21.19 Essential minerals are required for many body functions 445
- 21.20 *Connection* Do you need to take vitamin and mineral supplements? 446
- 21.21 Connection What do food labels tell us? 446
- 21.22 *Connection* Obesity is a human health problem 447
- 21.23 Connection What are the health risks and benefits of fad diets? 448
- 21.24 *Connection* Diet can influence cardiovascular disease and cancer 449

Chapter Review 450



22 GAS EXCHANGE 452

Essay Surviving in Thin Air 452

Mechanisms of Gas Exchange 454

- 22.1 Overview: Gas exchange involves breathing, transport of gases, and exchange of gases with tissue cells 454
- 22.2 Animals exchange O₂ and CO₂ across moist body surfaces 454
- 22.3 Gills are adapted for gas exchange in aquatic environments 456
- 22.4 The tracheal system of insects provides direct exchange between the air and body cells 457
- 22.5 Terrestrial vertebrates have lungs 458
- 22.6 *Connection* Smoking is a deadly assault on our respiratory system 459
- 22.7 Breathing ventilates the lungs 460
- 22.8 Breathing is automatically controlled 461

Transport of Gases in the Body 462

- 22.9 Blood transports respiratory gases 462
- 22.10 Hemoglobin carries O_2 and helps transport CO_2 and buffer the blood 462
- 22.11 *Connection* The human fetus exchanges gases with the mother's bloodstream 463

Chapter Review 464

23 CIRCULATION 466

Essay How Does Gravity Affect Blood Circulation? 466

23.1 The circulatory system connects with all body tissues 468

Mechanisms of Internal Transport 468

- 23.2 Several types of internal transport have evolved in animals 468
- 23.3 Vertebrate cardiovascular systems reflect evolution 470

The Mammalian Cardiovascular System 471

- 23.4 The human heart and cardiovascular system are typical of mammals 471
- 23.5 The structure of blood vessels fits their functions 472
- 23.6 The heart contracts and relaxes rhythmically 472
- 23.7 The pacemaker sets the tempo of the heartbeat 473
- 23.8 Connection What is a heart attack? 474
- 23.9 Blood exerts pressure on vessel walls 475
- 23.10 *Connection* Measuring blood pressure can reveal cardiovascular problems 476
- 23.11 Smooth muscle controls the distribution of blood 477
- 23.12 Capillaries allow the transfer of substances through their walls 478

Structure and Function of Blood 479

- 23.13 Blood consists of red and white blood cells suspended in plasma 479
- 23.14 *Connection* Too few or too many red blood cells can be unhealthy 480
- 23.15 Blood clots plug leaks when blood vessels are injured 480
- 23.16 *Connection* Stem cells offer a potential cure for blood cell diseases 481

Chapter Review 482

24 THE IMMUNE SYSTEM 484

Essay An AIDS Uproar 484

Innate Defenses Against Infection 486

- 24.1 Innate defenses against infection include the skin and mucous membranes, phagocytic cells, and antimicrobial proteins 486
- 24.2 The inflammatory response mobilizes nonspecific defense forces 487
- 24.3 The lymphatic system becomes a crucial battleground during infection 488

Acquired Immunity 489

24.4 The immune response counters specific invaders 489





- 24.5 Lymphocytes mount a dual defense 490
- 24.6 Antigens have specific regions where antibodies bind to them 491
- 24.7 Clonal selection musters defensive forces against specific antigens 492
- 24.8 Antibodies are the weapons of humoral immunity 494
- 24.9 Antibodies mark antigens for elimination 495
- 24.10 *Connection* Monoclonal antibodies are powerful tools in the lab and clinic 496
- 24.11 Helper T cells stimulate humoral and cell-mediated immunity 497
- 24.12 *Connection* HIV destroys helper T cells, compromising the body's defenses 498
- 24.13 Cytotoxic T cells destroy infected body cells 499
- 24.14 Cytotoxic T cells may help prevent cancer 499
- 24.15 The immune system depends on our molecular fingerprints 500

Disorders of the Immune System 500

- 24.16 *Connection* Malfunction or failure of the immune system causes disease 500
- 24.17 *Connection* Allergies are overreactions to certain environmental antigens 501

Chapter Review 502

25 CONTROL OF THE INTERNAL ENVIRONMENT 504

Essay Let Sleeping Bears Lie 504

Thermoregulation 506

- 25.1 Heat is gained or lost in four ways 506
- 25.2 Thermoregulation involves adaptations that balance heat gain and loss 506
- 25.3 Reducing metabolic rate and body temperature saves energy 507

Osmoregulation and Excretion 508

- 25.4 Osmoregulation: Animals balance the gain and loss of water and solutes 508
- 25.5 *Connection* Do we need to drink eight glasses of water each day? 509
- 25.6 Animals must dispose of nitrogenous wastes 510
- 25.7 The liver performs many functions, inclduing the production of urea 511
- 25.8 *Connection* Alcohol consumption can damage the liver 511
- 25.9 The excretory system plays several major roles in homeostasis 512
- 25.10 Overview: The key processes of the excretory system are filtration, reabsorption, secretion, and excretion 513

25.11 From blood filtrate to urine: A closer look 51425.12 *Connection* Kidney dialysis can be a lifesaver 515Chapter Review 516

26 CHEMICAL REGULATION 518

Essay Testosterone and Male Aggression: Is There a Link? 518

The Nature of Chemical Regulation 520

- 26.1 Chemical signals coordinate body functions 520
- 26.2 Hormones affect target cells by two main signaling mechanisms 521

The Vertebrate Endocrine System 522

- 26.3 Overview: The vertebrate endocrine system 522
- 26.4 The hypothalamus, closely tied to the pituitary, connects the nervous and endocrine systems 524

Hormones and Homeostasis 526

- 26.5 The thyroid regulates development and metabolism 526
- 26.6 Hormones from the thyroid and the parathyroids maintain calcium homeostasis 526
- 26.7 Pancreatic hormones regulate blood glucose levels 528
- 26.8 *Connection* Diabetes is a common endocrine disorder 529
- 26.9 The adrenal glands mobilize responses to stress 530
- 26.10 *Connection* Glucocorticoids offer relief from pain, but not without serious risks 531
- 26.11 The gonads secrete sex hormones 532

Chapter Review 532



27 REPRODUCTION AND EMBRYONIC DEVELOPMENT 534

Essay Baby Bonanza 534

Asexual and Sexual Reproduction 536

27.1 Sexual and asexual reproduction are both common among animals 536

XXX Contents

Hum	an Reproduction 538
27.2	Reproductive anatomy of the human female 538
27.3	Reproductive anatomy of the human male 540
27.4	The formation of sperm and ova requires meiosis 542

- 27.5 Hormones synchronize cyclic changes in the ovary and uterus 544
- 27.6 The human sexual response occurs in four phases 546
- 27.7 *Connection* Sexual activity can transmit disease 546
- 27.8 *Connection* Contraception can prevent unwanted pregnancy 547

Principles of Embryonic Development 548

- 27.9 Fertilization results in a zygote and triggers embryonic development 548
- 27.10 Cleavage produces a ball of cells from the zygote 55027.11 Gastrulation produces a three-layered embryo 550
- 27.12 Organs start to form after gastrulation 552
- 27.13 Changes in cell shape, cell migration, and programmed cell death give form to the developing animal 554
- 27.14 Embryonic induction initiates organ formation 554
- 27.15 Pattern formation organizes the animal body 555

Human Development 556

- 27.16 The embryo and placenta take shape during the first month of pregnancy 556
- 27.17 Human development from conception to birth is divided into three trimesters 558
- 27.18 Childbirth is hormonally induced and occurs in three stages 560
- 27.19 *Connection* Reproductive technology increases our reproductive options 561

Chapter Review 562

28 NERVOUS SYSTEMS 564

Essay Can an Injured Spinal Cord Be Fixed? 564

Nervous System Structure and Function 566

- 28.1 Nervous systems receive sensory input, interpret it, and send out appropriate commands 566
- 28.2 Neurons are the functional units of nervous systems 567

Nerve Signals and Their Transmission 568

- 28.3 A neuron maintains a membrane potential across its membrane 568
- 28.4 A nerve signal begins as a change in the membrane potential 568
- 28.5 The action potential propagates itself along the neuron 570
- 28.6 Neurons communicate at synapses 571
- 28.7 Chemical synapses make complex information processing possible 572
- 28.8 A variety of small molecules function as neurotransmitters 572

28.9 *Connection* Many drugs act at chemical synapses 573

An Overview of Animal Nervous Systems 574

- 28.10 Nervous system organization usually correlates with body symmetry 574
- 28.11 Vertebrate nervous systems are highly centralized and cephalized 575
- 28.12 The peripheral nervous system of vertebrates is a functional hierarchy 576
- 28.13 Opposing actions of sympathetic and parasympathetic neurons regulate the internal environment 576
- 28.14 The vertebrate brain develops from three anterior bulges of the neural tube 578

The Human Brain 578

- 28.15 The structure of a living supercomputer: The human brain 578
- 28.16 The cerebral cortex is a mosaic of specialized, interact ive regions 580
- 28.17 *Connection* Injuries and brain operations provide insight into brain function 581
- 28.18 Several parts of the brain regulate sleep and arousal 582
- 28.19 The limbic system is involved in emotions, memory, and learning 583
- 28.20 *Connection* Changes in brain physiology can produce neurological disorders 584

Chapter Review 586

29 THE SENSES 588

Essay An Animal's Senses Guide Its Movement 588

29.1 Sensory inputs become sensations and perceptions in the brain 590

Sensory Reception 590

- 29.2 Sensory receptors convert stimulus energy to action potentials 590
- 29.3 Specialized sensory receptors detect five categories of stimuli 592

Vision 594

- 29.4 Several types of eyes have evolved among invertebrates 594
- 29.5 Vertebrates have single-lens eyes 594
- 29.6 To focus, a lens changes position or shape 595
- 29.7 Connection Artificial lenses or surgery can correct focusing problems 596
- 29.8 Our photoreceptors are rods and cones 597

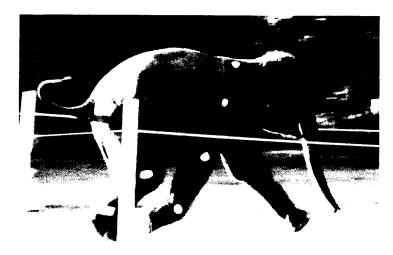
Hearing and Balance 598

- 29.9 The ear converts air pressure waves to action potentials that are perceived as sound 598
- 29.10 The inner ear houses our organs of balance 600
- 29.11 Connection What causes motion sickness? 600

Taste and Smell 601

- 29.12 Taste and odor receptors detect chemicals present in solution or air 601
- 29.13 *Connection* Our sense of taste may change as we age 601
- 29.14 Review: The central nervous system couples stimulus with response 602

Chapter Review 602



30 HOW ANIMALS MOVE 604

Essay Elephants Do the "Groucho Gait" 604

Movement and Locomotion 606

30.1 Diverse means of animal locomotion have evolved 606

Skeletal Support 608

- 30.2 Skeletons function in support, movement, and protection 608
- 30.3 The human skeleton is a unique variation on an ancient theme 610
- 30.4 Bones are complex living organs 611
- 30.5 Connection Broken bones can heal themselves 612
- 30.6 *Connection* Weak, brittle bones are a serious health problem, even in young people 612

Muscle Contraction and Movement 613

- 30.7 The skeleton and muscles interact in movement 613
- 30.8 Each muscle cell has its own contractile apparatus 614
- 30.9 A muscle contracts when thin filaments slide across thick filaments 614
- 30.10 Motor neurons stimulate muscle contraction 616
- 30.11 *Connection* Athletic training increases strength and endurance 617
- 30.12 The structure-function theme underlies all the parts and activities of an animal 618

Chapter Review 619

UNIT VI

Plants: Form and Function

31 PLANT STRUCTURE, REPRODUCTION, AND DEVELOPMENT 622

Essay A Gentle Giant 622

31.1 *Talking About Science* Plant scientist Natasha Raikhel studies the *Arabidopsis* plant as a model biological system 624

Plant Structure and Function 625

31.2 The two main groups of angiosperms are the monocots and the dicots 625

- 31.3 A typical plant body consists of roots and shoots 626
- 31.4 Many plants have modified roots, stems, and leaves 627
- 31.5 Plant cells and tissues are diverse in structure and function 628
- 31.6 Three tissue systems make up the plant body 630

Plant Growth 632

- 31.7 Primary growth lengthens roots and shoots 632
- 31.8 Secondary growth increases the girth of woody plants 634

Reproduction of Flowering Plants 636

- 31.9 Overview: The sexual life cycle of a flowering plant 636
- 31.10 The development of pollen and ovules culminates in fertilization 636
- 31.11 The ovule develops into a seed 638
- 31.12 The ovary develops into a fruit 639
- 31.13 Seed germination continues the life cycle 640
- 31.14 Asexual reproduction produces plant clones 641
- 31.15 *Connection* Asexual reproduction is a mainstay of modern agriculture 642

Chapter Review 642

32 PLANT NUTRITION AND TRANSPORT 644

Essay Plants That Clean Up Poisons 644

The Uptake and Transport of Plant Nutrients 646

- 32.1 Plants acquire their nutrients from soil and air 646
- 32.2 The plasma membranes of root cells control solute uptake 647



32.3	Transpiration	pulls	water	up	xylem	vessels	648
------	---------------	-------	-------	----	-------	---------	-----

- 32.4 Guard cells control transpiration 649
- 32.5 Phloem transports sugars 650

Plant Nutrients and the Soil 652

- 32.6 Plant health depends on a complete diet of essential inorganic nutrients 652
- 32.7 *Connection* You can diagnose some nutrient deficiencies in your own plants 653
- 32.8 Fertile soil supports plant growth 654
- 32.9 *Connection* Soil conservation is essential to human life 655
- 32.10 *Connection* Organic farmers must follow ecological principles 656
- 32.11 *Connection* Agricultural research is improving the yields and nutritional values of crops 656

Plant Nutrition and Symbiosis 657

- 32.12 Fungi help most plants absorb nutrients from the soil 657
 - 32.13 Most plants depend on bacteria to supply nitrogen 658
 - 32.14 Legumes and certain other plants house nitrogen-fixing bacteria 658
 - 32.15 The plant kingdom includes parasites and carnivores 659

Chapter Review 660

33 CONTROL SYSTEMS IN PLANTS 662

Essay What Are the Health Benefits of Soy? 662

Plant Hormones 664

- 33.1 Experiments on how plants turn toward light led to the discovery of a plant hormone 664
- 33.2 Five major types of hormones regulate plant growth and development 666
- 33.3 Auxin stimulates the elongation of cells in young shoots 666
- 33.4 Cytokinins stimulate cell division 668
- 33.5 Gibberellins affect stem elongation and
- have numerous other effects 668
 33.6 Abscisic acid inhibits many plant processes 669
- 33.7 Ethylene triggers fruit ripening and other aging processes 670
- Connection Plant hormones have many agricultural uses 671

Growth Responses and Biological Rhythms in Plants 672

- 33.9 Tropisms orient plant growth toward or away from environmental stimuli 672
- 33.10 Plants have internal clocks 673

33.8

- 33.11 Plants mark the seasons by measuring photoperiod 674
- 33.12 Phytochrome is a light detector that may help set the biological clock 675
- 33.13 *Talking About Science* Joanne Chory studies the effects of light and hormones in the model plant *Arabidopsis* 676

Plant Defenses 676

- 33.14 Defenses against herbivores and infectious microbes have evolved in plants 676
- 33.15 *Talking About Science* Plant biochemist Eloy Rodriguez studies how animals use defensive chemicals made by plants 678

Chapter Review 678

UNIT VII

Ecology

34 BIOSPHERE: AN INTRODUCTION TO EARTH'S DIVERSE ENVIRONMENTS 682

Essay A Mysterious Giant of the Deep 682

34.1 Ecologists study how organisms interact with their environment at several levels 684

The Biosphere 684

- 34.2 The biosphere is the total of all of Earth's ecosystems 684
- 34.3 *Connection* Environmental problems reveal the limits of the biosphere 685
- 34.4 Physical and chemical factors influence life in the biosphere 686
- 34.5 Organisms are adapted to abiotic and biotic factors by natural selection 687
- 34.6 Regional climate influences the distribution of biological communities 688

Aquatic Biomes 690

- 34.7 Oceans occupy most of Earth's surface 690
- 34.8 Freshwater biomes include lakes, ponds, rivers, streams, and wetlands 692

Terrestrial Biomes 693

- 34.9 Terrestrial biomes reflect regional variations in climate 693
- 34.10 Tropical forests cluster near the equator 694
- 34.11 Savannas are grasslands with scattered trees 694
- 34.12 Deserts are defined by their dryness 695
- 34.13 Spiny shrubs dominate the chaparral 696

- 34.14 Temperate grasslands include the North American prairie 696
- 34.15 Broadleaf trees dominate temperate forests 697
- 34.16 Coniferous forests are often dominated by a few species of trees 698
- 34.17 Long, bitter-cold winters characterize the tundra 698
- 34.18 *Talking About Science* Ecologist Ariel Lugo studies tropical forests in Puerto Rico 699

Chapter Review 700



35 BEHAVIORAL ADAPTATIONS TO THE ENVIRONMENT 702

Essay Leaping Herds of Herbivores 702

The Scientific Study of Behavior 704

- 35.1 Behavioral ecologists ask both proximate and ultimate questions 704
- 35.2 Early behaviorists used experiments to study fixed action patterns 705
- 35.3 Behavior is the result of both genes and environmental factors 706

Learning 707

- 35.4 Learning ranges from simple behavioral changes to complex problem solving 707
- 35.5 Imprinting is learning that involves innate behavior and experience 708
- 35.6 Connection Imprinting poses problems and opportunities for conservation programs 70
- 35.7 Animal movement may be a simple response to stimuli or involve spatial learning 710
- 35.8 Movements of animals may depend on internal maps 711
- 35.9 Animals may learn to associate a stimulus or behavior with a response 712
- 35.10 Social learning involves observation and imitation of others 712
- 35.11 Problem-solving behavior relies on cognition 713

Foraging and Mating Behaviors 714

- 35.12 Behavioral ecologists use cost-benefit analysis in studying foraging 714
- 35.13 Mating behaviors enhance reproductive success 713 35.14 Mating behavior often involves elaborate courtship

Social Behavior and Sociobiology 717

716

rituals

- 35.15 Sociobiology places social behavior in an
- evolutionary context 717
- 35.16 Territorial behavior parcels space and resources 717 35.17 Rituals involving agonistic behavior often resolve
- confrontations between competitors 718
 35.18 Dominance hierarchies are maintained by agonistic
- behavior 718
 35.19 *Talking About Science* Behavioral biologist Jane
- Goodall discusses dominance hierarchies and reconciliation behavior in chimpanzees 719
 35.20 Social behavior requires communication between
- animals 720
 35.21 Altruistic acts can often be explained by the concept
- of inclusive fitness 721
 35.22 *Connection* Both genes and culture contribute to human social behavior 722
- 35.23 *Talking About Science* Edward O. Wilson promoted the field of sociobiology and is a leading conservation activist 723

Chapter Review 724

36 POPULATION DYNAMICS 726

Essay The Spread of Shakespeare's Starlings 726

36.1 Population ecology studies how and why populations change 728

Population Structure and Dynamics 728

- 36.2 Density and dispersion patterns are important population variables 728
- 36.3 Life tables track mortality and survivorship in populations 729
- 36.4 Idealized models help us understand population growth 730
- 36.5 Multiple factors may limit population growth 732
 36.6 Some populations have "boom-and-bust" cycles 733
- 36.6 Some populations have "boom-and-bust" cycles

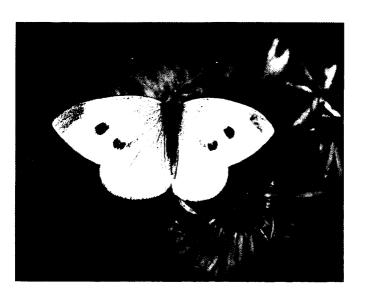
Life Histories and Their Evolution 734

- 36.7 Evolution shapes life histories 734
- 36.8 *Connection* Principles of population ecology have practical applications 735

The Human Population 736

- 36.9 *Connection* Human population growth has started to slow after centuries of exponential increase 736
- 36.10 Birth and death rates and age structure affect population growth 738
- Chapter Review 740

XXXIV Contents



37 COMMUNITIES AND ECOSYSTEMS 742

Essay Dining In 742

Structural Features of Communities 744

- 37.1 A community includes all the organisms inhabiting a particular area 744
- 37.2 Competition may occur when a shared resource is limited 745
- 37.3 Predation leads to diverse adaptations in both predator and prey 746
- 37.4 Predation can maintain diversity in a community 747
- 37.5 Herbivores and the plants they eat have various adaptations 748
- 37.6 Symbiotic relationships help structure communities 748
- 37.7 Disturbance is a prominent feature of most communities 750
- 37.8 *Talking About Science* Fire specialist Max Moritz discusses the role of fire in ecosystems 751
- 37.9 Trophic structure is a key factor in community dynamics 752
- 37.10 Food chains interconnect, forming food webs 753

Ecosystem Structure and Dynamics 754

- 37.11 Ecosystem ecology emphasizes energy flow and chemical cycling 754
- 37.12 Primary production sets the energy budget for ecosystems 754
- 37.13 Energy supply limits the length of food chains 755
- 37.14 *Connection* A production pyramid explains why meat is a luxury for humans 756
- 37.15 Chemicals are recycled between organic matter and abiotic reservoirs 756
- 37.16 Water moves through the biosphere in a global cycle 757

- 37.17 The carbon cycle depends on photosynthesis and respiration 758
- respiration 758

 37.18 The nitrogen cycle relies heavily on bacteria 758
- 37.19 The phosphorus cycle depends on the weathering of rock 759

Ecosystem Alteration 760

- 37.20 *Connection* Ecosystem alteration can upset chemical cycling 760
- 37.21 *Talking About Science* David Schindler talks about the effects of nutrients on freshwater ecosystems 761

Chapter Review 762

38 CONSERVATION BIOLOGY 764

766

Essay Saving the Tiger 764

The Biodiversity Crisis: An Overview 766

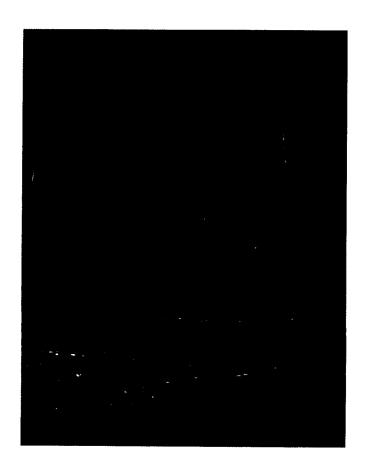
- 38.1 Human activities threaten Earth's biodiversity
- 38.2 Biodiversity is vital to human welfare 767
- 38.3 Habitat destruction, introduced species, and overexploitation are the major threats to biodiversity 768
- 38.4 *Connection* Pollution of the environment compounds our impact on other species 769
 38.5 *Connection* Rapid global warming could alter the
- entire biosphere 770

Conservation of Populations and Species 772 38.6 Two ways to study endangered populations at

- 38.6 Two ways to study endangered populations are the small-population approach and the declining-population approach 772
- 38.7 Identifying critical habitat factors can guide conservation efforts 773

Managing and Restoring Ecosystems 774

- 38.8 Sustaining ecosystems and landscapes is a conservation priority 774
- 38.9 Protected areas are established to slow the loss of biodiversity 775
- 38.10 *Connection* The Yellowstone to Yukon Conservation Initiative seeks to preserve biodiversity by connecting protected areas 776
- 38.11 The study of how to restore degraded habitats is a developing science 778
- 38.12 *Connection* The Kissimmee River project is a case study in restoration ecology 779



38.13 Zoned reserves are an attempt to reverse ecosystem disruption 78038.14 Sustainable development is an ultimate goal 781

APPENDIX 1 Metric Conversion Table

APPENDIX 2 The Amino Acids
of Proteins

APPENDIX 3 Chapter Review Answers

APPENDIX 3 Chapter Review Answers

APPENDIX 4 Credits

GLOSSARY

Chapter Review 782

INDEX