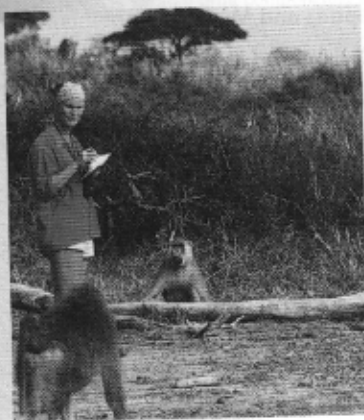


# TABLE OF CONTENTS

About the Authors ix

Preface x

## PART ONE



### Introduction to Living Animals

#### CHAPTER 1

##### Life: Biological Principles and the Science of Zoology 1

- 1.1 Fundamental Properties of Life 2
- 1.2 Zoology as a Part of Biology 9
- 1.3 Principles of Science 9
- 1.4 Theories of Evolution and Heredity 13
- Summary 17

#### CHAPTER 2

##### The Origin and Chemistry of Life 19

- 2.1 Water and Life 20
- 2.2 Organic Molecular Structure of Living Systems 22
- 2.3 Chemical Evolution 25
- 2.4 Origin of Living Systems 28
- 2.5 Precambrian Life 30
- Summary 32

#### CHAPTER 3

##### Cells as Units of Life 35

- 3.1 Cell Concept 36
- 3.2 Organization of Cells 38
- 3.3 Mitosis and Cell Division 49
- Summary 53

#### CHAPTER 4

##### Cellular Metabolism 55

- 4.1 Energy and the Laws of Thermodynamics 56
- 4.2 The Role of Enzymes 57
- 4.3 Enzyme Regulation 59
- 4.4 Chemical Energy Transfer by ATP 60
- 4.5 Cellular Respiration 61
- 4.6 Metabolism of Lipids 67
- 4.7 Metabolism of Proteins 68
- Summary 69

## PART TWO



### Continuity and Evolution of Animal Life

#### CHAPTER 5

##### Genetics: A Review 71

- 5.1 Mendel's Investigations 72
- 5.2 Chromosomal Basis of Inheritance 72
- 5.3 Mendelian Laws of Inheritance 76
- 5.4 Gene Theory 85
- 5.5 Storage and Transfer of Genetic Information 85
- 5.6 Gene Mutations 95
- 5.7 Molecular Genetics of Cancer 96
- Summary 96

#### CHAPTER 6

##### Organic Evolution 99

- 6.1 Origins of Darwinian Evolutionary Theory 100
- 6.2 Darwinian Evolutionary Theory: The Evidence 103
- 6.3 Revisions of Darwin's Theory 121

- 6.4 Microevolution: Genetic Variation and Change Within Species 122  
 6.5 Macroevolution: Major Evolutionary Events 128  
 Summary 130

## CHAPTER 7

### The Reproductive Process 133

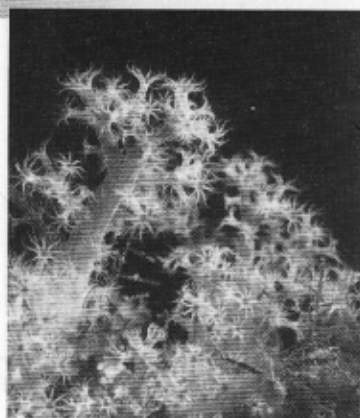
- 7.1 Nature of the Reproductive Process 134  
 7.2 The Origin and Maturation of Germ Cells 138  
 7.3 Reproductive Patterns 142  
 7.4 Structure of Reproductive Systems 143  
 7.5 Endocrine Events That Orchestrate Reproduction 145  
 Summary 152

## CHAPTER 8

### Principles of Development 154

- 8.1 Early Concepts: Preformation Versus Epigenesis 155  
 8.2 Fertilization 156  
 8.3 Cleavage and Early Development 159  
 8.4 An Overview of Development Following Cleavage 161  
 8.5 Mechanisms of Development 163  
 8.6 Gene Expression During Development 166  
 8.7 Developmental Patterns in Animals 169  
 8.8 Evolutionary Developmental Biology 174  
 8.9 Vertebrate Development 174  
 8.10 Development of Systems and Organs 177  
 Summary 180

## PART THREE



Diversity of Animal Life

## CHAPTER 9

### Architectural Pattern of an Animal 183

- 9.1 Hierarchical Organization of Animal Complexity 184  
 9.2 Animal Body Plans 185  
 9.3 Components of Animal Bodies 189

- 9.4 Complexity and Body Size 194  
 Summary 195

## CHAPTER 10

### Taxonomy and Phylogeny of Animals 197

- 10.1 Linnaeus and Taxonomy 198  
 10.2 Species 200  
 10.3 Taxonomic Characters and Phylogenetic Reconstruction 205  
 10.4 Theories of Taxonomy 207  
 10.5 Major Divisions of Life 213  
 10.6 Major Subdivisions of the Animal Kingdom 213  
 Summary 214

## CHAPTER 11

### Unicellular Eukaryotes 216

- 11.1 Naming and Identifying Unicellular Eukaryotic Taxa 217  
 11.2 Form and Function 221  
 11.3 Major Unicellular Eukaryotic Taxa 227  
 11.4 Phylogeny and Adaptive Diversification 241  
 Summary 244

## CHAPTER 12

### Sponges and Placozoans 246

- 12.1 Origin of Animals (Metazoa) 247  
 12.2 Phylum Porifera: Sponges 247  
 12.3 Phylum Placozoa 257  
 Summary 258

## CHAPTER 13

### Cnidarians and Ctenophores 260

- 13.1 Phylum Cnidaria 261  
 13.2 Phylum Ctenophora 282  
 13.3 Phylogeny and Adaptive Diversification 286  
 Summary 287

## CHAPTER 14

### Acoelomorpha, Platyzoa, and Mesozoa 289

- 14.1 Phylum Acoelomorpha 290  
 14.2 Clades Within Protostomia 291  
 14.3 Phylum Platyhelminthes 293  
 14.4 Phylum Gastrotricha 306  
 14.5 Clade Gnathifera 308  
 14.6 Phylum Gnathostomulida 309  
 14.7 Phylum Micrognathozoa 309  
 14.8 Phylum Rotifera 309  
 14.9 Phylum Acanthocephala 313  
 14.10 Phylum Mesozoa 314  
 14.11 Phylogeny 316  
 Summary 316

## CHAPTER 15

### Polyzoa and Kryptozoa 319

- 15.1 Clade Polyzoa 321
- 15.2 Phylum Cycliophora 321
- 15.3 Phylum Entoprocta 321
- 15.4 Phylum Ectoprocta (Bryozoa) 322
- 15.5 Clade Kryptozoa 325
- 15.6 Clade Brachiozoa 325
- 15.7 Phylum Brachiopoda 325
- 15.8 Phylum Phoronida 326
- 15.9 Phylum Nemertea (Rhynchocoela) 327
- 15.10 Phylogeny and Adaptive Diversification 329
- Summary 330

## CHAPTER 16

### Molluscs 332

- 16.1 Molluscs 333
- 16.2 Form and Function 335
- 16.3 Classes of Molluscs 338
- 16.4 Phylogeny and Adaptive Diversification 358
- Summary 361

## CHAPTER 17

### Annelids and Allied Taxa 363

- 17.1 Phylum Annelida, Including Pogonophorans (Siboglinids) and Echiurans 364
- 17.2 Phylum Sipuncula 381
- 17.3 Evolutionary Significance of a Coelom and Metamerism 382
- 17.4 Phylogeny and Adaptive Diversification 382
- Summary 383

## CHAPTER 18

### Smaller Ecdysozoans 385

- 18.1 Phylum Nematoda: Roundworms 386
- 18.2 Phylum Nematomorpha 394
- 18.3 Phylum Loricifera 395
- 18.4 Phylum Kinorhyncha 395
- 18.5 Phylum Priapulida 396
- 18.6 Clade Panarthropoda 397
- 18.7 Phylum Onychophora 397
- 18.8 Phylum Tardigrada 398
- 18.9 Phylogeny and Adaptive Diversification 399
- Summary 400

## CHAPTER 19

### Trilobites, Chelicerates, and Myriapods 402

- 19.1 Phylum Arthropoda 403
- 19.2 Subphylum Trilobita 406
- 19.3 Subphylum Chelicerata 407
- 19.4 Subphylum Myriapoda 414
- 19.5 Phylogeny and Adaptive Diversification 417
- Summary 419

## CHAPTER 20

### Crustaceans 421

- 20.1 Subphylum Crustacea 423
- 20.2 A Brief Survey of Crustaceans 431
- 20.3 Phylogeny and Adaptive Diversification 437
- Summary 441

## CHAPTER 21

### Hexapods 443

- 21.1 Class Insecta 444
- 21.2 Insects and Human Welfare 462
- 21.3 Phylogeny and Adaptive Diversification 468
- Summary 469

## CHAPTER 22

### Chaetognaths, Echinoderms, and Hemichordates 471

- 22.1 Phylum Chaetognatha 473
- 22.2 Form and Function 473
- 22.3 Phylum Xenoturbellida 474
- 22.4 Clade Ambulacraria 474
- 22.5 Phylum Echinodermata 474
- 22.6 Phylogeny and Adaptive Diversification 489
- 22.7 Phylum Hemichordata 491
- 22.8 Phylogeny and Adaptive Diversification 494
- Summary 495

## CHAPTER 23

### Chordates 498

- 23.1 The Chordates 499
- 23.2 Five Chordate Hallmarks 502
- 23.3 Ancestry and Evolution 503
- 23.4 Subphylum Urochordata (Tunicata) 504
- 23.5 Subphylum Cephalochordata 506
- 23.6 Subphylum Vertebrata 506
- Summary 513

## CHAPTER 24

### Fishes 516

- 24.1 Ancestry and Relationships of Major Groups of Fishes 517
- 24.2 Living Jawless Fishes 517
- 24.3 Chondrichthyes: Cartilaginous Fishes 522
- 24.4 Osteichthyes: Bony Fishes and Tetrapods 526
- 24.5 Structural and Functional Adaptations of Fishes 531
- Summary 541

## CHAPTER 25

### Early Tetrapods and Modern Amphibians 543

- 25.1 Devonian Origin of Tetrapods 544
- 25.2 Modern Amphibians 546
- Summary 559



**CHAPTER 26****Amniote Origins and Nonavian Reptiles 562**

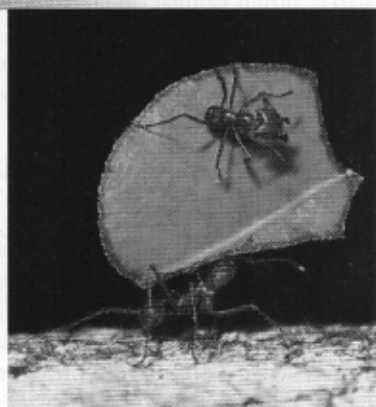
- 26.1 Origin and Early Evolution of Amniotes 563
- 26.2 Characteristics and Natural History of Reptilian Groups 568
- Summary 582

**CHAPTER 27****Birds 584**

- 27.1 Origin and Relationships 585
- 27.2 Structural and Functional Adaptations for Flight 588
- 27.3 Flight 596
- 27.4 Migration and Navigation 599
- 27.5 Social Behavior and Reproduction 601
- 27.6 Bird Populations and Their Conservation 604
- Summary 605

**CHAPTER 28****Mammals 610**

- 28.1 Origin and Evolution of Mammals 611
- 28.2 Structural and Functional Adaptations of Mammals 614
- 28.3 Humans and Mammals 627
- 28.4 Human Evolution 628
- Summary 636

**PART FOUR****Activity of Life****CHAPTER 29****Support, Protection, and Movement 639**

- 29.1 Integument 640
- 29.2 Skeletal Systems 643
- 29.3 Animal Movement 648
- Summary 658

**CHAPTER 30****Homeostasis: Osmotic Regulation, Excretion, and Temperature Regulation 660**

- 30.1 Water and Osmotic Regulation 661
- 30.2 Invertebrate Excretory Structures 665
- 30.3 Vertebrate Kidney 667
- 30.4 Temperature Regulation 672
- Summary 677

**CHAPTER 31****Homeostasis: Internal Fluids and Respiration 680**

- 31.1 Internal Fluid Environment 681
- 31.2 Composition of Blood 682
- 31.3 Circulation 684
- 31.4 Respiration 691
- Summary 700

**CHAPTER 32****Digestion and Nutrition 702**

- 32.1 Feeding Mechanisms 703
- 32.2 Digestion 706
- 32.3 Organization and Regional Function of Alimentary Canals 708
- 32.4 Regulation of Food Intake 713
- 32.5 Nutritional Requirements 715
- Summary 717

**CHAPTER 33****Nervous Coordination: Nervous System and Sense Organs 720**

- 33.1 Neurons: Functional Units of Nervous Systems 721
- 33.2 Synapses: Junctions Between Nerves 725
- 33.3 Evolution of Nervous Systems 727
- 33.4 Sense Organs 733
- Summary 744

**CHAPTER 34****Chemical Coordination: Endocrine System 746**

- 34.1 Mechanisms of Hormone Action 747
- 34.2 Invertebrate Hormones 749
- 34.3 Vertebrate Endocrine Glands and Hormones 751
- Summary 761

**CHAPTER 35****Immunity 764**

- 35.1 Susceptibility and Resistance 765
- 35.2 Innate Defense Mechanisms 765

- 35.3 Immunity in Invertebrates 769  
 35.4 Acquired Immune Response in Vertebrates 769  
 35.5 Blood Group Antigens 775  
 Summary 775

## CHAPTER 36

### Animal Behavior 778

- 36.1 Describing Behavior: Principles of Classical Ethology 780  
 36.2 Control of Behavior 781  
 36.3 Social Behavior 784  
 Summary 794

## PART FIVE



## Animals and Their Environments

## CHAPTER 37

### Animal Distributions 797

- 37.1 Principles of Historical Biogeography 798  
 37.2 Distribution of Life on Earth 804  
 Summary 814

## CHAPTER 38

### Animal Ecology 816

- 38.1 The Hierarchy of Ecology 817  
 38.2 Extinction and Biodiversity 829  
 Summary 832

Glossary G-1

Index I-1