

INTEGRATED PRINCIPLES OF ZOOLOGY

TWELFTH EDITION

HICKMAN

ROBERTS

LARSON

I'ANSON



INTEGRATED PRINCIPLES OF

ZOOLOGY

TWELFTH EDITION



Higher Education

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INTEGRATED PRINCIPLES OF ZOOLOGY, TWELFTH EDITION

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Over the years Dr. Hickman has led many field trips to the Galápagos Islands. His current research is on intertidal zonation and marine invertebrate systematics in the Galápagos. He has published three field guides in the Galápagos Marine Life Series for the identification of echinoderms, marine molluscs, and marine crustaceans. (To read more about these field guides, visit <http://www.galapagosmarine.com>.)

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PREFACE

Integrated *Principles of Zoology* is a college text adaptable to any introductory course in zoology. This twelfth edition, as with previous editions, describes the diversity of animal life and the fascinating adaptations that enable animals to inhabit nearly all conceivable ecological niches. We retain in this revision the basic organization of the eleventh edition and its distinctive features, especially emphasis on the principles of evolution and zoological science. Also retained are several pedagogical features that have made previous editions easily accessible to students: opening chapter dialogues drawn from the chapter's theme; chapter summaries and review questions to aid student comprehension and study; accurate and visually appealing illustrations; in-text derivations of generic names; chapter notes and essays that enhance the text by offering interesting sidelights to the narrative; and an extensive glossary providing pronunciation, derivation, and definition of terms used in the text.

NEW TO THE TWELFTH EDITION

Many changes in this edition were guided by suggestions of the 49 zoology instructors who read and commented on sections of the eleventh edition. For the eleventh edition, the vertebrate chapters of Part Three, and several chapters on functional systems (Part Four) were revised by invited contributors, all experienced zoologists who were solicited for their interest and expertise in the subject matter of specific chapters. This twelfth edition continues to benefit from their participation. In general, we revised all chapters to keep the text current while eliminating excessive detail, and placed emphasis on experimentation and comparative studies in zoology.

Chapter Organization

- Order of chapters in Parts One and Two has been maintained as in the eleventh edition. The presentation is streamlined by discussing basic chemistry in the context of the origin of life.
- Several chapters in Part Three have been reorganized. Because evidence is strong that lophophorate phyla and Chaetognatha are protostomes, separate chapters for each of these are not justified; therefore, material on these phyla has been moved to a single chapter covering all smaller phyla of coelomate protostomes (Chapter 21). Removal of chaetognaths from the chapter covering hemichordates made that chapter quite short, and accordingly, hemichordates are now covered in the same chapter as echinoderms, their closest relatives.

New Pedagogy

- Throughout the text we updated references, revised or replaced many illustrations, and rewrote many of the Review Questions to provoke thought and reduce emphasis on rote memorization.
- Suggested Internet topics are added at the end of each chapter; hyperlinks are available on this text's Online Learning Center website at www.mhhe.com/zoology.
- The art inside the front cover has been completely revised to depict phylogenetic relationships consistent with the Lophotrochozoa/Ecdysozoa hypothesis and other phylogenetic relationships based on sequence analysis of DNA.

The principal revisions in each chapter are explained here.

Part One: Introduction to Living Animals

- Chapter 2, The Origin and Chemistry of Life, now introduces the important concept of symbiogenesis in the context of the origin of eukaryotic cells. A review of basic chemistry (atoms, elements, and molecules; bonding theory; acids, bases, salts, and buffers) is available for reference; it will be found at our Online Learning Center website: www.mhhe.com/zoology.

Part Two: Continuity and Evolution of Animal Life

- Chapter 5, Genetics: A Review, features new art, including a revised meiosis figure that includes homologous chromosomes in synapsis during prophase of meiosis I and clarifications of 5' and 3' ends of RNA and DNA, indicating direction of synthesis. We have added new material on publication of the draft sequence of the human genome and its implications, as well as an explanation of proteomics.
- In Chapter 6, Organic Evolution, we have added information on new fossil discoveries from China. We relate the issue of gradualism to new work in developmental genetics.
- Chapter 7, The Reproductive Process, was revised extensively in the eleventh edition. Notes on contraception were updated to reflect new trends.

- Among many revisions and updates to Chapter 8, Principles of Development, the section on gene expression during development was completely rewritten to describe the three stages in epigenesis: pattern formation, determination of position in the body and involvement of the homeotic genes, and induction of limbs and organs appropriate for that position.

Part Three: Diversity of Animal Life

- Chapter 10, Classification and Phylogeny of Animals, has been reorganized. We present species concepts and diagnosis and then proceed to higher-level taxonomy, rather than vice versa, as in the eleventh edition. We revised coverage of subspecies and added the process of species recognition. A boxed essay has been added to describe how phylogenies are constructed from DNA sequences, and a new taxonomic system called PhyloCode is explained.
- Chapter 11, Protozoan Groups, was completely reorganized in an effort to make it consistent with current classification of unicellular eukaryotes. Traditional taxa such as Sarcomastigophora, Sarcodina, Mastigophora, Zoomastigophora, and Phytomastigophora are all discarded. Flagellated forms that we discuss are distributed among separate phyla: Retortamonada, Axostylata, Chlorophyta, Euglenozoa, and Dinoflagellata. Protozoologists now disperse ameboid forms into numerous lineages, and it is impractical for us to place them all in formal taxa; therefore, we simply use an informal heading “Amebas” to introduce some of the most important ones. The section on phylogeny was rewritten to reflect current evidence, including the likelihood of secondary symbiogenesis in origins of several groups.
- In discussing the phylogeny of Mesozoa in Chapter 12, we note that molecular evidence supports a relationship with flatworms. The description of Hexactinellida was completely rewritten, and a new figure depicting their structure is included.
- Chapter 13, Radiate Animals, underwent several important revisions. Most noticeable to users of earlier editions is a preference for use of Octocorallia over Alcyonaria for this anthozoan subclass. Because members of the subclass always have eight tentacles, we believe that Octocorallia is easier for students to remember. In addition, the discussion of cnidarian phylogeny was rewritten to include evidence from *Hox* genes and sequence data that Anthozoa is basal for the phylum. A new cladogram reflects this relationship.
- In Chapter 14, Acoelomate Animals, the description of both form and function in Nemertea and phylogeny of flatworms were rewritten.
- Chapter 15, Pseudocoelomate Animals, was completely reorganized. We hope that placing all animals with a common body plan in the same chapter will be helpful for students, rather than separating pseudocoelomate lophotrochozoans from pseudocoelomate ecdysozoans in separate chapters. Thus, phyla in each superphylum were grouped together under appropriate headings (see also Chapter 21). Furthermore, because Nematoda is the largest and most important of all pseudocoelomate phyla, their coverage was moved to the beginning of the chapter. Recognizing molecular evidence of a rotifer-acanthocephalan affinity, coverage of Acanthocephala was moved to follow immediately after Rotifera.
- In Chapter 16, Molluscs, a note on the evolution of eyes in animals was added, with the observation that all animals with eyes apparently share two conserved genes: *Pax 6*, the “master control gene for eye morphogenesis,” and the gene encoding rhodopsin, a visual pigment. The eyes of cephalopod molluscs are amazingly similar to those of vertebrates. Although this has long been considered an astonishing example of convergence, both groups must have inherited the genes from a common ancestor, and thus their eyes would be homologous.
- Chapter 18, Arthropods, is an introduction to Arthropoda and a more detailed coverage of Chelicerata. In this chapter, many sections on spiders, scorpions, and harvestmen were rewritten and revised.
- Chapter 19, Aquatic Mandibulates, benefits from much new art. The phylogeny section in this chapter was rewritten and includes a discussion of how biramous limbs in Crustacea probably arose by a mutation resulting in a modulation of *Distal-less* gene expression.
- Chapter 20, Terrestrial Mandibulates, is a large chapter because insects are a large group. There were many small rewrites and additions, including the discussion and illustration of sucking mouthparts. The phylogeny discussion was heavily rewritten, including roles of *Hox* genes and *Distal-less* gene and the evolution of flight.
- Chapter 21, Smaller Protostome Phyla, was extensively reorganized, as in Chapter 15, grouping lophotrochozoan and ecdysozoan phyla under their appropriate headings. Lophophorate phyla and Chaetognatha were brought into this chapter because present evidence lends little justification to covering them in separate chapters. Significant changes in the phylogeny discussion were required.
- Chapter 22, Echinoderms and Hemichordates, now includes all deuterostomes other than chordates. After removal of chaetognaths from the chapter covering hemichordates, a very short chapter resulted; therefore, hemichordates were moved to join Echinodermata.
- Chapter 23, Chordates, underwent many changes throughout, incorporating new ideas about chordate origins and character evolution, primarily from new fossil finds in China, molecular phylogenetics, and studies of developmental biology. Specifically, we modified and added figures, revised characteristics of chordates and vertebrates, revised discussion of hypotheses of origins of chordates and vertebrates, and added a discussion on *Hox*

genes. Discussions of conodonts, ostracoderms, origin of jaws, and origin of paired appendages were revised to better emphasize critical concepts and include more recent information.

- Coverage of the ecology of amphibian declines in the world is increased in Chapter 25, Early Tetrapods and Modern Amphibians.
- The title of Chapter 26, Amniote Origins and Reptilian Groups, was changed to better reflect expanded coverage of derived features of amniotes, including the amniote egg. Relationships of major groups were updated, especially showing that snakes and amphisbaenians evolved from a lizardlike ancestor. Discussions of dinosaur behavior and extinction, snake feeding methods, snakebite statistics, and ectothermy were revised. A new illustration of a snake skull was added to show the extreme mobility of their head bones.
- Chapter 27, Birds, incorporates material on new fossil dinosaur-bird finds and their significance to flight. The section on mating systems was also modified.
- In Chapter 28, Mammals, coverage on synapsid evolution has been expanded and supporting artwork is modified. We added a section on whale evolution, revised the section on the fermentation system, and updated coverage of human evolution, incorporating information from recent fossil finds and analyses. Coverage of evolution of reproductive systems was changed extensively, including evidence that the chorioallantoic placenta of placental mammals evolved in a common ancestor of marsupials and placentals, and was secondarily lost in marsupials.

Part Four: Activity of Life

- In Chapter 29, Support, Protection, and Movement, we clarified the role of exercise in differential stimulation of fast and slow fiber types, and we updated the microanatomy and physiology of skeletal muscle contraction.
- We elaborated on the concept of homeostatic setpoint in Chapter 30, Homeostasis, and sections on the role of urea in osmoregulation of elasmobranchs and in urine concentration by mammals were revised. Also revised were coverage of aldosterone secretion, glomerular tubular secretion, ADH mechanism of action, and countercurrent multiplication.
- Chapter 31, Internal Fluids and Respiration, includes revisions on excitation and control of heart function, structure and function of the arterial system, respiration in birds, regulation of respiration, and transport of respiratory gases in mammals.
- In Chapter 32, Digestion and Nutrition, we added a consideration of the brainstem as a hunger center and of obesity as a lifestyle problem in developed countries. New information on leptin resistance and obesity, and on the role of inflammation in development of atherosclerosis was added.

- Chapter 33, Nervous Coordination, includes new information on the vomeronasal organ as a pheromonal sense organ in terrestrial vertebrates and the possibility of pheromonal communication in humans. Coverage of taste discrimination was updated, including discovery of a new taste, umami.
- Chapter 34, Chemical Coordination, includes new information on steroid hormone membrane receptors, steroid abuse by young people, insulin action in the brain, and the importance of leptin during periods of decreased food intake.
- Within Chapter 35, Immunity, we significantly updated the section on innate immunity by addition of material on the exciting discoveries of antimicrobial peptides produced by many invertebrates and vertebrates, responding on first exposure to broad categories of invaders such as gram-positive bacteria, gram-negative bacteria, and fungi.
- Chapter 36, Animal Behavior, covers advances in application of phylogenetic approaches to study of animal behavior, which highlights an important recent advancement in the field. Material was added on the important concepts of reciprocal altruism and evolutionarily stable strategies.

Part Five: Animals and Their Environment

- Chapter 37, The Biosphere and Animal Distribution, features new information on Wallace's Line and its illustration of the importance of plate tectonics in biogeography. Connections between material in this chapter and that in Chapters 6 and 10 are strengthened.
- In Chapter 38, Animal Ecology, we elaborate the niche concept and have made it more consistent with current leading ecology texts. The discussion of interactions among species in a community (for example, commensalism and mimicry) has been extended.

TEACHING AND LEARNING AIDS

To help students in **vocabulary development**, key words are boldfaced, and derivations of technical and zoological terms are provided, along with generic names of animals where they first appear in the text. In this way students gradually become familiar with the more common roots that comprise many technical terms. An extensive glossary of almost 1,100 terms provides pronunciation, derivation, and definition of each term. Many new terms were added to the glossary or rewritten for this edition.

A distinctive feature of this text is a **prologue** for each chapter that draws out some theme or fact relating to the subject of the chapter. Some prologues present biological, particularly evolutionary, principles; others (especially those in the survey sections) illuminate distinguishing characteristics of the group treated in the chapter. Each is intended to present an important concept drawn from the chapter in an interesting manner that

will facilitate learning by students, as well as engage their interest and pique their curiosity.

Chapter notes, which appear throughout the book, augment the text material and offer interesting sidelights without interrupting the narrative. We prepared many new notes for this edition and revised several existing notes.

To assist students in chapter review, each chapter ends with a **concise summary**, a list of **review questions**, and **annotated selected references**. The review questions enable a student to self-test retention and understanding of the more important chapter material.

The **historical appendix**, unique to this textbook, lists key discoveries in zoology, and separately describes books and publications that have greatly influenced the development of zoology. Many readers have found this appendix an invaluable reference to be consulted long after their formal training in zoology. The historical appendix will be found on this textbook's Online Learning Center website at www.mhhe.com/zoology.

Again, William C. Ober and Claire W. Garrison have enhanced the **art program** for this text with many new full-color paintings that replace older art, or that illustrate new material. Bill's artistic skills, knowledge of biology, and experience gained from an earlier career as a practicing physician have enriched this text through eight of its editions. Claire practiced pediatric and obstetric nursing before turning to scientific illustration as a full-time career. Texts illustrated by Bill and Claire have received national recognition and won awards from the Association of Medical Illustrators, American Institute of Graphic Arts, Chicago Book Clinic, Printing Industries of America, and Bookbuilders West. They are also recipients of the Art Directors Award.

SUPPLEMENTS

The **Instructor's Testing and Resource CD-ROM** provides both an Instructor's Manual and a test bank to support the textbook. The Instructor's Manual includes annotated chapter outlines, chapter-specific changes for this edition, lecture enrichment suggestions, commentaries and lesson plans, questions for advanced classes, and a listing of resource references for each chapter. The Instructor's Manual also includes a listing of transparencies and slides available with the book. A comprehensive **test bank** offers 35 to 50 objective questions per chapter within a computerized test generation system for IBM and Macintosh computers. Using this system, instructors can create tests or quizzes quickly and easily. Questions can be sorted by type or level of difficulty, and instructors also can add their own material to the bank of questions provided. We trust this will be of particular value to first-time users of the text, although experienced teachers may also find much of value.

The **Laboratory Manual** by Cleveland P. Hickman, Jr., and Lee B. Kats, *Laboratory Studies in Integrated Principles of Zoology*, now in its twelfth edition, includes exercises on molecular techniques. This manual can be customized conveniently for two semester, one semester, or term courses by judicious selection of exercises.

A set of 150 full-color **transparency acetates** of important textual illustrations are available with this edition of *Integrated Principles of Zoology*. Labeling is clear, dark, and bold for easy reading.

A set of 148 **animal diversity slides**, photographed by the authors and Bill Ober on their various excursions, are offered in this unique textbook supplement. Both invertebrates and vertebrates are represented. Descriptions, including specific names of each animal and brief overview of the animal's ecology and/or behavior, accompany the slides.

The **Digital Content Manager CD-ROM** is a multimedia collection of visual resources that allows instructors to create powerful presentations for the classroom. The Digital Content Manager CD-ROM contains many photos and all of the illustrations from this textbook, along with 200 additional animal diversity images, 26 animations of key biological concepts, and a collection of underwater video clips displaying a variety of ocean life, habitats, and behaviors. See page xx for additional details.

The **Zoology Essential Study Partner CD-ROM** is an interactive student study tool that features activities, animations, drag-and-drop exercises, self-testing tools, full-color art and graphs, and more, and can be packaged to go with any McGraw-Hill zoology title. For further details, see page xxii, or contact your McGraw-Hill sales representative.

An **Online Learning Center website** is available with this edition and contains additional readings, animations, quizzing, key term flashcards, cladogram exercises, Animal Diversity PowerPoint slides, Zoology Essential Study Partner, and much more (see page xx for specific information). Check it out at www.mhhe.com/zoology.

Digital Zoology

Digital Zoology Version 2.0 Interactive CD-ROM and Student Workbook by Jon Houseman is an interactive guide to the specimens and materials covered in zoology laboratory and lecture sessions. Laboratory modules contain illustrations, photographs, annotations of the major structures of organisms, interactive quizzes, and video clips. Interactive cladograms within lab modules provide links to interactive synapomorphies of the various animal groups. Key terms throughout the program link to an interactive glossary. This CD-ROM is the perfect student study tool to promote learning both in and outside of the zoology laboratory, and also comes with an accompanying student workbook and website to provide additional study tips, exercises, and phyla characteristics. (For further information, see page xxi.)

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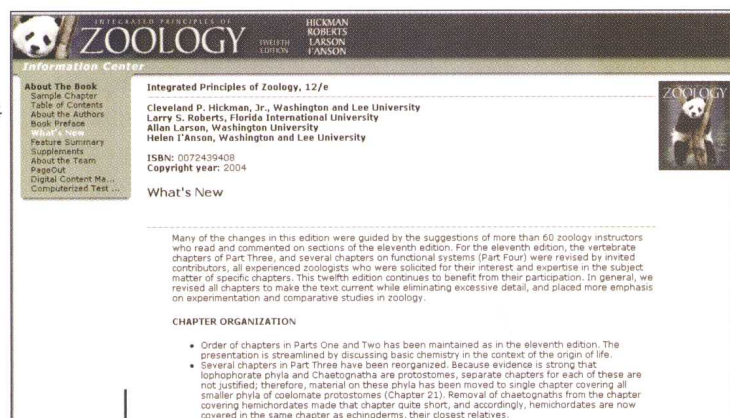
Although we make every effort to bring to you an error-free text, errors of many kinds inevitably find their way into a textbook of this scope and complexity. We will be grateful to readers who have comments or suggestions concerning content to send their remarks to Fran Schreiber, Developmental Editor, 2460 Kerper Boulevard, Dubuque, IA 52001. Fran may also be contacted by e-mail: fran_schreiber@mcgraw-hill.com, or through this textbook's website: www.mhhe.com/zoology.

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THE ONLINE LEARNING CENTER

Your Password to Success

www.mhhe.com/zoology
(click on cover)

This text-specific website allows students and instructors from all over the world to communicate. Instructors can create a more interactive course with the integration of this site, and students will find tools such as practice quizzing, key term flashcards, and animations that will help them improve their grades and learn that zoology can be fun.

Student Resources

Quizzing with immediate feedback
Hyperlinks to chapter-related websites
Key Term Flashcards
Animations
Interactive Cladogram Exercise
“Development of Zoology” timeline
“Basic Structure of Matter” appendix
Zoology Essential Study Partner

Instructor Resources

Instructor's Manual

- Annotated chapter outlines
- Twelfth edition changes
- Lecture enrichment suggestions
- Commentary/lesson plan
- Advanced class questions
- Source material listings

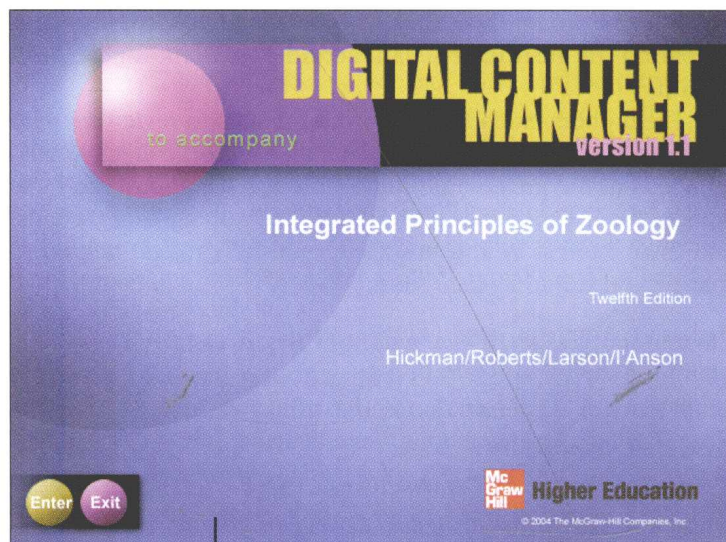
Links to related websites to expand on particular topics

List of Digital Content Manager images

List of slides

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Teaching Animal Molecular Phylogenetics tutorial



DIGITAL CONTENT MANAGER

CD-ROM (ISBN 0-07-254700-6)

This powerful and easy-to-use tool is designed to help instructors easily incorporate text-specific illustrations, photos, and tables, plus animations and other related assets, into lecture presentations and printed classroom materials. Organized by chapter, this cross-platform CD-ROM contains a collection of visual and multimedia resources that can be imported and reproduced in multiple formats to create customized lectures, visually based tests and quizzes, dynamic course website content, or attractive printed support materials. The *Integrated Principles of Zoology* Digital Content Manager features:

- An **art library** of JPEG files featuring EVERY ILLUSTRATION from the twelfth edition (720 images, organized by chapter).
- A **textbook photo library**—218 JPEG files featuring photos from the twelfth edition (organized by chapter).
- A **table library** of JPEG files featuring EVERY TABLE from the text (organized by chapter).
- An **additional photo library of 200 animal diversity images**—comprised of additional photographs not found in the text (labeled by topic, with search function).
- **PowerPoint art slides**—art, photos, and tables from each chapter that have been preinserted into PowerPoint slides.
- **Animations library**—26 full-color animations illustrating key biological concepts. Harness the visual impact of processes in motion by importing these files into classroom presentations or online course materials.
- **Video clips library**—74 underwater video clips showing the ocean's animal diversity, habitats, and behaviors.

DIGITAL ZOOLOGY CD-ROM AND STUDENT WORKBOOK

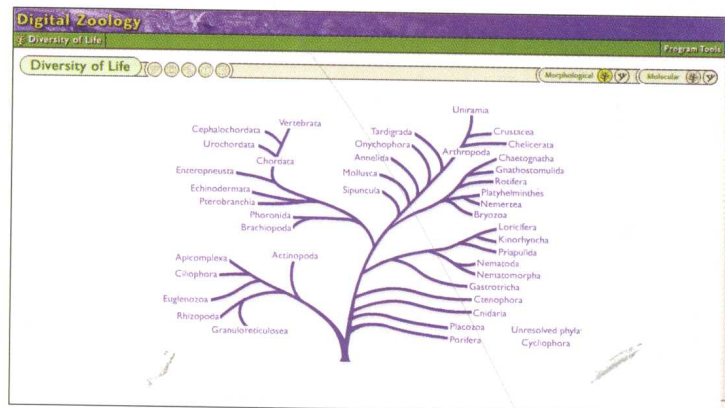
Digital Zoology is an interactive guide that will help reinforce what students are learning in their zoology lecture and laboratory sessions. Here is what you will find on this easy-to-use CD-ROM:

- Laboratory modules containing illustrations, photographs, annotations of the major structures of organisms, interactive quizzes, and over 70 video clips of animal diversity, habitats, and behaviors
- Interactive cladograms and dendrograms within lab modules, along with links to interactive synapomorphies of the various animal groups
- Key terms with links to an interactive glossary of over 750 definitions
- Taxon "Read Abouts" that include information on over 100 taxa, the number of living and extinct species, habitats, and how they function
- Updated taxonomy of the animal phyla that allow for easy comparison of the differences between traditional morphological phylogenies and those created with molecular data
- Image galleries available for many of the major phyla, providing photos that detail diversity within the phyla
- An accompanying student workbook with self-tests, crossword puzzles, and a website to provide additional study tips, exercises, and phyla characteristics

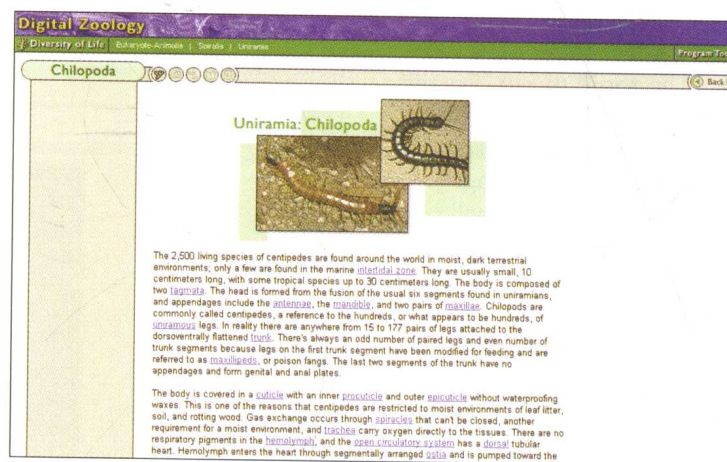
INSTRUCTORS: CUT CLASS PREP TIME IN HALF!

Organizing your class materials has never been so easy! Visit www.digitalzoology.com to take advantage of all the tools available to you on the *Digital Zoology* website. Here is what you will find:

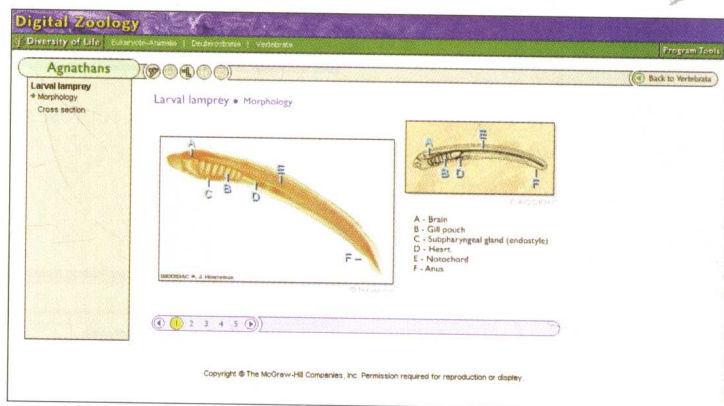
- PowerPoint slides with cladograms and dendrograms illustrating the relationships between the different major taxa, as well as many additional images to show the diversity of each group
- Test bank, sorted by taxonomic group
- *Teaching Animal Molecular Phylogenetics* website



Main dendrogram (tree) for *Digital Zoology*.



Taxon "Read About."

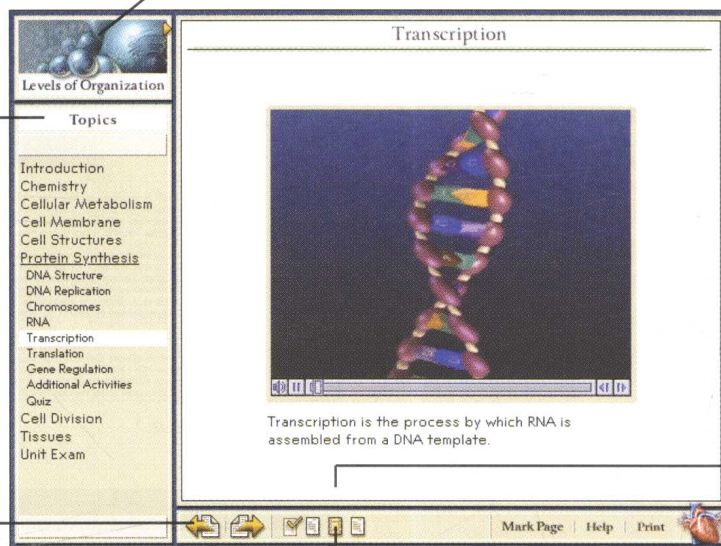


Laboratory module.

ZOOLOGY ESSENTIAL STUDY PARTNER

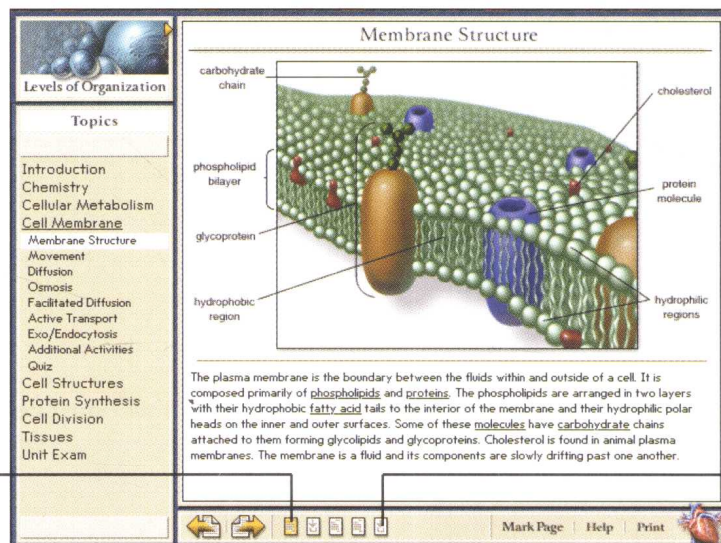
This study partner engages, investigates, and reinforces what you are learning in your zoology course. You'll find the **Zoology Essential Study Partner** to be a complete, interactive student study tool packed with hundreds of learning activities and animations. From quizzes to interactive diagrams, you'll find that there has never been a better study partner to ensure the mastery of core concepts. This innovative study tool can be accessed through the Online Learning Center for this textbook, or it is also available on CD-ROM, and can be packaged with your zoology textbook. Contact your McGraw-Hill sales representative for further details.

- The **unit pop-up menu** is accessible at any time within the program. Clicking on the current unit will bring up a menu of other units available in the program.
- The **topic menu** contains an interactive list of the available topics. Clicking on any of the listings within this menu will open your selection and will show the specific concepts presented within this topic.
- Various navigational aids appear along the bottom of the screen. At the left are **arrows** that allow you to page forward and backward through text screens or interactive exercise screens. You can also use the LEFT and RIGHT arrows on your keyboard to perform the same function.



- To the right of the arrows is a row of icons that represent the number of screens in a concept. There are three different icons, each representing different functions that a screen in that section will serve. The screen that is currently displayed will highlight in yellow and visited ones will be checked.

- The **film icon** represents an animation screen.



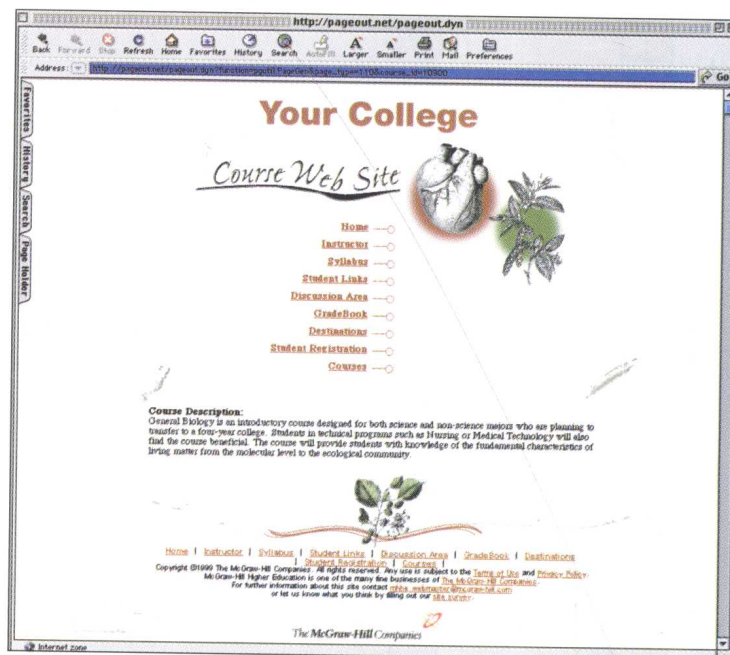
- The **page icon** represents a page of informational text.
- The **activity icon** represents an interactive learning activity.

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CONTENTS IN BRIEF

About the Authors xiii

Preface xv

PART ONE

Introduction to Living Animals

- 1 Life: Biological Principles and the Science of Zoology 2
- 2 The Origin and Chemistry of Life 21
- 3 Cells as Units of Life 36
- 4 Cellular Metabolism 56

PART TWO

Continuity and Evolution of Animal Life

- 5 Genetics: A Review 74
- 6 Organic Evolution 102
- 7 The Reproductive Process 131
- 8 Principles of Development 151

PART THREE

Diversity of Animal Life

- 9 Architectural Pattern of an Animal 176
- 10 Classification and Phylogeny of Animals 190
- 11 Protozoan Groups 207
- 12 Mesozoa and Parazoa 233
- 13 Radiate Animals 247
- 14 Acoelomate Bilateral Animals 274
- 15 Pseudocoelomate Animals 295
- 16 Molluscs 316
- 17 Segmented Worms 345
- 18 Arthropods 364

- 19 Aquatic Mandibulates 377
- 20 Terrestrial Mandibulates 397
- 21 Smaller Protostome Phyla 426
- 22 Echinoderms and Hemichordates 442
- 23 Chordates 467
- 24 Fishes 486
- 25 Early Tetrapods and Modern Amphibians 514
- 26 Amniote Origins and Reptilian Groups 534
- 27 Birds 555
- 28 Mammals 582

PART FOUR

Activity of Life

- 29 Support, Protection, and Movement 612
- 30 Homeostasis 634
- 31 Internal Fluids and Respiration 655
- 32 Digestion and Nutrition 677
- 33 Nervous Coordination 695
- 34 Chemical Coordination 721
- 35 Immunity 738
- 36 Animal Behavior 752

PART FIVE

Animals and Their Environment

- 37 The Biosphere and Animal Distribution 772
- 38 Animal Ecology 789

Glossary 807

Credits 845

Index 851

TABLE OF CONTENTS

About the Authors xiii
Preface xv

PART ONE



Introduction to Living Animals

CHAPTER 1

Life: Biological Principles and the Science of Zoology 2

Fundamental Properties of Life 3
Zoology as a Part of Biology 10
Principles of Science 10
Theories of Evolution and Heredity 14
Summary 19

CHAPTER 2

The Origin and Chemistry of Life 21

Organic Molecular Structure of Living Systems 22
Chemical Evolution 26
Origin of Living Systems 30
Precambrian Life 32
Summary 34

CHAPTER 3

Cells as Units of Life 36

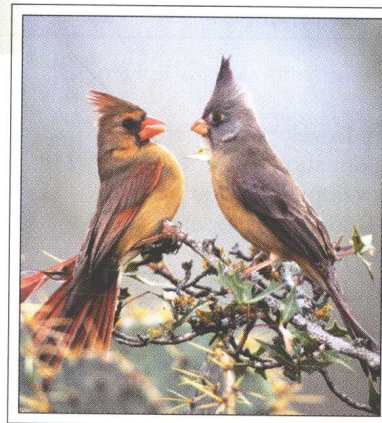
Cell Concept 37
Organization of Cells 39
Mitosis and Cell Division 48
Summary 54

CHAPTER 4

Cellular Metabolism 56

Energy and the Laws of Thermodynamics 57
The Role of Enzymes 58
Chemical Energy Transfer by ATP 60
Cellular Respiration 61
Metabolism of Lipids 68
Metabolism of Proteins 69
Management of Metabolism 70
Summary 71

PART TWO



Continuity and Evolution of Animal Life

CHAPTER 5

Genetics: A Review 74

Mendel's Investigations 75
Chromosomal Basis of Inheritance 75
Mendelian Laws of Inheritance 79
Gene Theory 88
Storage and Transfer of Genetic Information 88
Sources of Phenotypic Variation 97
Molecular Genetics of Cancer 98
Summary 99

CHAPTER 6

Organic Evolution 102

- Origins of Darwinian Evolutionary Theory 103
- Darwinian Evolutionary Theory: The Evidence 106
- Revisions of Darwin's Theory 120
- Microevolution: Genetic Variation and Change within Species 120
- Macroevolution: Major Evolutionary Events 126
- Summary* 128

CHAPTER 7

The Reproductive Process 131

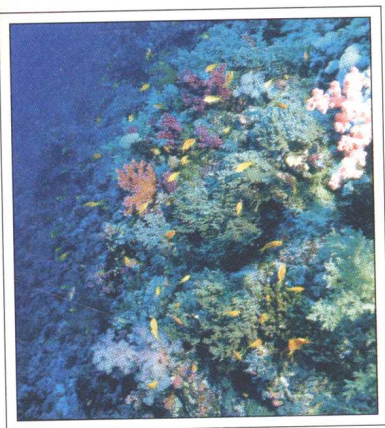
- Nature of the Reproductive Process 132
- The Origin and Maturation of Germ Cells 136
- Reproductive Patterns 140
- Plan of Reproductive Systems 141
- Endocrine Events That Orchestrate Reproduction 143
- Summary* 148

CHAPTER 8

Principles of Development 151

- Early Concepts: Preformation Versus Epigenesis 152
- Fertilization 153
- Cleavage and Early Development 155
- Gastrulation and Formation of Germ Layers 158
- Mechanisms of Development 160
- Gene Expression During Development 162
- Vertebrate Development 165
- Development of Systems and Organs 168
- Summary* 171

PART THREE



Diversity of Animal Life

CHAPTER 9

Architectural Pattern of an Animal 176

- Hierarchical Organization of Animal Complexity 177
- Extracellular Components of Metazoan Bodies 178
- Types of Tissues 179
- Animal Body Plans 182
- Summary* 189

CHAPTER 10

Classification and Phylogeny of Animals 190

- Linnaeus and the Development of Classification 191
- Species 193
- Taxonomic Characters and Phylogenetic Reconstruction 195
- Theories of Taxonomy 197
- Major Divisions of Life 202
- Major Subdivisions of the Animal Kingdom 203
- Summary* 204

CHAPTER 11

Protozoan Groups 207

- Form and Function 209
- Phyla Retortamonada and Axostylata 216
- Phylum Chlorophyta 216
- Phylum Euglenozoa 218
- Superphylum Alveolata 219
- Phylum Apicomplexa 219
- Phylum Ciliophora 222
- Phylum Dinoflagellata 226
- Amebas 226
- Phylogeny and Adaptive Radiation 229
- Summary* 231

CHAPTER 12

Mesozoa and Parazoa 233

- Origin of Metazoa 234
- Phylum Mesozoa 234
- Phylum Placozoa 236
- Phylum Porifera: Sponges 236
- Summary* 245

CHAPTER 13

Radiate Animals 247

- Phylum Cnidaria 248
- Phylum Ctenophora 267
- Phylogeny and Adaptive Radiation 270
- Summary* 272

CHAPTER 14**Acoelomate Bilateral Animals 274**

- Phylum Platyhelminthes 275
- Phylum Nemertea (Rhynchocoela) 289
- Phylum Gnathostomulida 291
- Phylogeny and Adaptive Radiation 292
- Summary* 293

CHAPTER 15**Pseudocoelomate Animals 295**

- Pseudocoelomates 296
- Ecdysozoan Phyla 296
- Lophotrochozoan Phyla 306
- Phylogeny and Adaptive Radiation 312
- Summary* 314

CHAPTER 16**Molluscs 316**

- Molluscs 317
- Form and Function 318
- Classes of Molluscs 321
- Phylogeny and Adaptive Radiation 340
- Summary* 343

CHAPTER 17**Segmented Worms 345**

- Body Plan 346
- Class Polychaeta 347
- Class Oligochaeta 353
- Class Hirudinea: Leeches 357
- Evolutionary Significance of Metamerism 360
- Phylogeny and Adaptive Radiation 360
- Summary* 362

CHAPTER 18**Arthropods 364**

- Phylum Arthropoda 365
- Subphylum Trilobita 367
- Subphylum Chelicerata 367
- Phylogeny and Adaptive Radiation 374
- Summary* 375

CHAPTER 19**Aquatic Mandibulates 377**

- Subphylum Crustacea 378
- A Brief Survey of Crustaceans 386
- Phylogeny and Adaptive Radiation 393
- Summary* 396

CHAPTER 20**Terrestrial Mandibulates 397**

- Class Chilopoda 398
- Class Diplopoda 398
- Class Pauropoda 399
- Class Symphyla 399
- Class Insecta 400
- Insects and Human Welfare 416
- Phylogeny and Adaptive Radiation 420
- Summary* 424

CHAPTER 21**Smaller Protostome Phyla 426**

- Lophotrochozoan Phyla 427
- Ecdysozoan Phyla 434
- Phylogeny 438
- Summary* 440

CHAPTER 22**Echinoderms and Hemichordates 442**

- Phylum Echinodermata 443
- Phylogeny and Adaptive Radiation 458
- Phylum Hemichordata 460
- Phylogeny and Adaptive Radiation 464
- Summary* 464

CHAPTER 23**Chordates 467**

- The Chordates 468
- Five Chordate Hallmarks 469
- Ancestry and Evolution 472
- Subphylum Urochordata (Tunicata) 473
- Subphylum Cephalochordata 475
- Subphylum Vertebrata (Craniata) 477
- Summary* 483