

P R E F A C E

The preparation of the ninth edition of *Zoology* involved careful evaluation of the previous editions and the features that contributed to the understanding of zoology as an exciting and dynamic scientific field. Every paragraph received careful scrutiny. Many illustrations have received minor changes and approximately 45 have been completely redrawn or substantially revised. We have added 20 new attractive and informative photographs. This edition of *Zoology* retains the manageable size, the informative and friendly writing style, and the up-to-date coverage that has attracted many loyal instructors and inspired many budding zoologists.

We are convinced that a book is only good if it is read, and reviewers and students have told us that this book really does get read by students. This book has come a long way since it was scratched out as a rough outline in 1986. We are honored that it has had a life that is now extended into its ninth edition. More important, we are honored to have had a role in communicating the science that we love, not just to the students we have known personally, but also to many we will never meet. We undertook this revision for the ninth edition with a sense of privilege and responsibility for content integrity for the instruction of future generations of zoologists, wildlife managers, ecologists, and other life scientists.

CONTENT AND ORGANIZATION

A New Pedagogy: Integrated Learning Outcomes and Critical Thinking

Colleges and universities throughout the country are now requiring science faculty to identify measurable learning outcomes in various assessment instruments. These learning outcomes are designed as a guide for students to understand the minimum material they are expected to learn in various units of study. To help instructors with these requirements, the ninth edition of *Zoology* provides **Learning Outcomes** for each major section in each chapter. **Learning Outcomes Reviews** at the end of each section reinforce important concepts students have just studied. A question at the end of each **Learning Outcomes Review** asks students to think critically about what they have read and learned. In addition, instructors using the new Connect *Zoology* can access auto-gradable and interactive assessment material tied to learning outcomes from the text—allowing instructors to document learning gains.

Analysis and Application Questions that have closed each chapter in previous editions have been carefully revised, and in some cases, completely rewritten. These questions ask students to think about, and apply, concepts they have learned in each chapter. The authors have provided suggested answers to these

questions and the Learning Outcomes Review questions. Instructors can download the answers from the book's website.

New Digital Assets and Media Integration

A significant new feature of the ninth edition of *Zoology* is the development of new digital resources through the **Connect Zoology** site, and a better integration of animation, video, and audio assets. Many of the sections within each chapter are linked to animations of biological processes, MP3 files, and National Geographic and ScienCentral videos. This media integration is indicated within the printed text by the icons shown below. In the interactive eBook version of the text available through ConnectPlus *Zoology*, these icons are live links to the media assets. These media assets are also available through the book's website.

 **MP3 files.** These short, three-to-five minute audio files serve as a review of material in certain sections of the book and help the student with the pronunciation of scientific terms and processes.

 **Animations.** The authors have selected animations from McGraw-Hill's library of animations that will enhance the student's understanding of the material within each chapter.

 **Videos.** Two types of videos are integrated within select sections of this edition of *Zoology*. Specifically, the ScienCentral videos are short clips on recent advances in the biological sciences. The National Geographic videos provide the student with an overview of the complexity of various life processes that would not be possible in a classroom setting.

For more information on Connect *Zoology* and ConnectPlus *Zoology*, please see pp. xii–xiv.

We have maintained from the inception of this text that evolutionary and ecological perspectives captivate students and are fundamental to understanding the unifying principles of zoology. These perspectives are incorporated into *Zoology* in a number of ways. For example, animal structure and function are considered in the context of the environment, the animal phyla are described in the context of their roles in ecosystems, and most of the “Wildlife Alerts” that first appeared in the fourth edition, and were expanded in the fifth and sixth editions, have been retained and updated as the status of the animals covered has changed. These boxed readings depict the plight of selected animal species or broader ecosystem issues relating to preserving various animal species.

We believe that the ninth edition of *Zoology* presents evolution as an exciting and dynamic field of study—a field of study that is vital for understanding all of biology. In addition,

the continuing and expanding pseudoscientific attacks on biology make it a necessity that evolutionary concepts be presented clearly and convincingly throughout the biology curricula.

To further explain and support evolutionary concepts, a second set of themed boxed readings (in addition to "Wildlife Alerts") entitled "Evolutionary Insights" was added to the sixth edition and has been expanded in this new edition. These boxes provide detailed examples of principles covered in a chapter and provide insight into how evolutionary biology works. For example, chapter 4 includes a reading on big-cat biogeography that illustrates how a variety of sources of evidence are used to paint a picture of the history of one group of animals. Chapter 5 has a reading on the speciation of Darwin's finches that illustrates how and why speciation occurs. Chapter 18 has a reading on the evolution of the vertebrate limb, and chapter 25 has a reading on the evolution of hormone receptors. Other readings describe ideas regarding animal origins, the debates that occur among taxonomists who try to sort out evolutionary relationships within animal groups, and the evolution of animal organ systems. Other pedagogical elements designed to reinforce evolutionary concepts have been retained. These include the "Evolutionary Perspective" and the "Further Phylogenetic Perspective" that begins and end each of the animal survey chapters.

Users will recognize that the ninth edition includes phylogenetic revisions, some are major revisions and some are minor. These revisions are depicted in cladograms and discussed in the text. The protists, Platyhelminthes, Annelida, Arthropoda, Echinodermata, Hemichordata, and Vertebrata all required substantial changes in phylogenetic descriptions. As students read and study, they should begin to appreciate the lively and dynamic field of phylogenetics.

Ecological concepts are stressed throughout the first two sections of the book. Not only are human population and endangered species statistics updated, but also the coverage of ecological problems has been completely rewritten. We have included an assessment of the condition of eight critical environmental processes: biodiversity loss, nitrogen cycling, phosphorus cycling, climate change, land use, ocean acidification, freshwater use, and ozone depletion. Students are provided practical steps they can take to help alleviate our ecological problems. Students who read and study this book should have an enhanced understanding of ecological principles and how human ignorance and misplaced values have had detrimental effects on our environment in general and on specific animal groups in particular. An entire section of chapter 19 is devoted to "Amphibians in Peril."

To help students understand that science is a process, not just a body of facts, "How Do We Know" boxes are used to highlight research results that provide insight into biological processes. For example, chapter 3 has a box entitled "How Do We Know about the Function of Genes—Mutagenesis Screening?" This box discusses how biologists use mutations as a tool for investigating the function of genes. Chapter 14 has a box entitled "How Do We Know about Spider Silk?" This box discusses methods for measuring the tensile strength and elasticity of spider silk and the

possible uses of engineered silk. The boxed readings in each chapter are listed following the table of contents.

Zoology is organized into three parts. Part One covers the common life processes, including cell and tissue structure and function, the genetic basis of evolution, and the evolutionary and ecological principles that unify all life.

Part Two is the survey of protists and animals, emphasizing evolutionary and ecological relationships, aspects of animal organization that unite major animal phyla, and animal adaptations. All of the chapters in Part Two have been updated. The presentation of taxonomic principles in chapter 7, and the taxonomic relationships in chapters 8 through 22, have been carefully revised and incorporate some of the flavor of the exciting changes occurring in the field of taxonomy. You will see some of these changes listed under "New to the Ninth Edition." Cladograms have been updated and, as in previous editions, full-color artwork, photographs, and lists of phylum characteristics are used to highlight each phylum.

Part Three covers animal form and function using a comparative approach. This approach includes descriptions and full-color artwork depicting evolutionary changes in the structure and function of selected organ systems. Part Three includes an appropriate balance between invertebrate and vertebrate descriptions.

NEW TO THE NINTH EDITION

As with earlier revisions of *Zoology*, the focus for this revision has been on presenting evolutionary and ecological concepts clearly and accurately, using examples from current literature as convincingly as possible, and presenting how new evidence is changing the exciting and dynamic field of zoology. In this revision, we have taken a conservative yet up-to-date position on taxonomic and other challenges to traditional interpretations of zoological data. The following are major additions to this edition:

- The cladograms have been updated for all chapters in Part Two of the textbook.
- A new pedagogy including "Learning Outcomes," "Learning Outcomes Review," and media integration was described earlier.
- Answers for all review activities including the "Learning Outcomes Review" questions, "Concept Review Questions" and "Analysis and Application Questions" are provided.
- All chapters and boxed readings have been carefully edited by outside reviewers and the authors. The revisions include minor to substantial changes in wording, artwork, photographs, content, and pedagogy. The following is a list of changes by chapter.
 - **Chapter 1 (Zoology: An Evolutionary and Ecological Perspective).** Population statistics have been updated in the section on ecological problems.
 - **Chapter 2 (Cells, Tissues, Organs, and Organ Systems of Animals).** The various cell organelles have

been color-coded so that their color is uniform throughout the chapter.

- **Chapter 3 (Cell Division and Inheritance).** Figures have been redrawn to better illustrate concepts related to chromatin packing into chromosomes, chromosome structure, synapsis, and crossing-over.
- **Chapter 4 (Evolution: History and Evidence).** Coverage of Hox genes has been updated.
- **Chapter 5 (Evolution and Gene Frequencies).** The discussion of the phylogenetic concept of the species is now included in chapter 5 as well as chapter 7 to emphasize the importance of this view of the species. Additional information on, and examples pertaining to, rates of evolution has been added. More detail on the usefulness of molecular data in helping to understand evolutionary relationships has been added.
- **Chapter 6 (Ecology: Preserving the Animal Kingdom).** New information and a new figure clarify the concepts of the niche and niche partitioning. The section on ecological problems has been completely rewritten. It includes updated population statistics and an assessment of the condition of eight critical environmental processes: biodiversity loss, nitrogen cycling, phosphorus cycling, climate change, land use, ocean acidification, freshwater use, and ozone depletion.
- **Chapter 7 (Animal Classification, Phylogeny, and Organization).** New coverage of the limitations of the traditional taxonomic hierarchy is included. The concepts of horizontal and vertical gene transfer and the implications of horizontal gene transfer for the evolution of early life forms are presented. Figure 7.2 is revised to show horizontal gene transfer.
- **Chapter 8 (Animal-Like Protists: The Protozoa).** The table on the classification of the animal-like protists (protozoa) has been revised according to new phylogenetic data presented in a recent issue of *Systematic Biology*. The life-cycle figure of *Plasmodium* has been completely revised to be clearer and more colorful with respect to schizogony and gametogony. Conjugation in *Paramecium* has been up-dated with new artwork. The tentative phylogeny of the protist-like Eukaryotes based on 18S rRNA sequence comparisons has been revised and up-dated based on recent molecular phylogenetic data.
- **Chapter 9 (Multicellular and Tissue Levels of Organization).** The coverage of animal origins has been updated and expanded. The history of multicellular life has been traced to between 800 and 1,000 mya. The cladogram depicting the relationships among the Cnidaria has been updated.
- **Chapter 10 (The Triploblastic, Acoelomate Body Plan).** Throughout, the importance of the evolutionary relationships and controversies of the major phylum (Platyhelminthes) in this chapter to other phyla is emphasized. In addition to morphological data, a new synthesis of animal phylogeny has been proposed using ribosomal RNA sequences supporting the three major clades of bilaterally symmetrical animals.
- **Chapter 11 (Molluscan Success).** This chapter's artwork has been extensively revised. There are 16 new or revised pieces of line art and new photographs. Taxonomy and the discussion of phylogenetic relationships have been updated.
- **Chapter 12 (Annelida: The Metameric Body Form).** The taxonomy of the Annelida continues to be problematic. The controversies regarding the use of Polychaeta as a class name and the inclusion of Sipuncula, Siboglinidae, and Echiura in the phylum are discussed as an example of the lively discussions occurring in phylogenetics.
- **Chapter 13 (The Pseudocoelomate Body Plan: Aschelminthes Lophotrochozoan and Ecdysozoan Phyla).** Since the dog heartworm (*Dirofilaria immitis*) is the most common filarial worm in the United States, a photo of an infected dog heart full of worms opens this chapter.
- **Chapter 14 (The Arthropods: Blueprint for Success).** This chapter's artwork has received major revisions, including new photographs.
- **Chapter 15 (Hexapods and Myriapods: Terrestrial Triumphs).** New molecular phylogenetic information has been added that discusses the probable ties between the Crustacea and Hexapoda, including the term "pancrustacea" to refer to the hexapod/crustacean clade. Figure 15.19 has been redrawn to reflect this relationship.
- **Chapter 16 (The Echinoderms).** Phylogenetic information and the echinoderm cladogram (Figure 16.16) have been updated.
- **Chapter 17 (Hemichordata and Invertebrate Chordates).** Hemichordate/Chordate phylogeny has been updated. The term "Ambulacraria" is introduced to signify the close ties that have recently been revealed between the Echinodermata and Hemichordata. The chordate cladogram in Figure 17.10 has been redrawn to reflect this new information. The chordate endostyle/thyroid gland is now included as a fifth unique chordate characteristic. Artwork for this chapter has had significant revisions.
- **Chapter 18 (The Fishes: Vertebrate Success in Water).** A discussion of tetrapods as members of the sarcopterygian taxon is presented, and the cladogram in Figure 18.2 has been redrawn to reflect the monophyly of this lineage. Osteichthyes is dropped as a class name and is no longer used in reference to any bony fish. The discussion of the transition from land to water by tetrapodomorph sarcopterygians is updated, including new artwork featuring the "fishapod" *Tiktaalik*.
- **Chapter 19 (Amphibians: The First Terrestrial Vertebrates).** Figure 19.3 has been redrawn to more clearly distinguish the "stem tetrapoda," tetrapoda, Temnospondyli, and Lissamphibia. The text explains the significance of these terms. The coverage of amphibian orders has been reorganized to better reflect relationships among the Lissamphibia.

- **Chapter 20 (Reptiles: Nonavian Diapsid Reptiles).** Additional detail has been added on the kinetic skull of members of the order Squamata. The suborder level taxonomy of Squamata is updated.
- **Chapter 21 (Birds: Reptiles by Another Name).** Order-level taxonomy has been updated. Additional discussion of bird migration has been added.
- **Chapter 22 (Mammals: Synapsid Amniotes).** Recent information from molecular, morphological, and biogeographical data is redefining eutherian taxonomy. This new information is incorporated into the text and into figure 22.3. There is new coverage of mammalian dentition and hibernation. Hominin taxonomy has been updated.
- **Chapter 23 (Protection, Support, and Movement).** The section on the limitations an exoskeleton imposes on terrestrial invertebrates has been expanded.
- **Chapter 24 (Communication I: Nervous and Sensory Systems).** New artwork on the types of vertebrate neurons and transmission of the electrical impulses across the synapse in the peripheral and central nervous systems has been rendered to better clarify the electrical and chemical flow of information.
- **Chapter 25 (Communication II: The Endocrine System and Chemical Messengers).** Many of the figure legends in this chapter have been expanded to reflect more detail in the figures. The Chapter Outline has been modified so that the material in the chapter flows more smoothly in manageable amounts. The most recent terminology from the *Society of Endocrinology* is used for the various hormones.
- **Chapter 26 (Circulation and Gas Exchange).** This is a very large chapter since it covers the comparative anatomy and physiology of the circulatory and respiratory systems. Therefore, the chapter content and the outline have been completely reorganized so that the material flows more smoothly and in manageable amounts.
- **Chapter 27 (Nutrition and Digestion).** Color has been added to the illustrations containing teeth to differentiate the incisors, canines, premolars, and molars. New figures on ruminant mammals and the extensive cecum of nonruminant herbivores have been added.
- **Chapter 28 (Temperature and Body Fluid Regulation).** The various flow diagrams utilizing positive and negative feedback have been colorized for greater clarity. A new section and figure on how marine birds cope with excess salt in their diets has been added.
- **Chapter 29 (Reproduction and Development).** A new photo and discussion on mating in hermaphroditic earthworms have been added to this chapter. The evolution of internal fertilization and livebirth in vertebrates has been updated based on phylogenetic analysis from fish to placental mammals. A new figure illustrates this evolution. The various flow diagrams that illustrate reproductive control in both the human male and female based on positive and negative feedback have been redrawn for better clarity.

ACKNOWLEDGMENTS

We wish to thank the reviewers who provided detailed analysis of the text during its development. In the midst of their busy teaching and research schedules, they took time to read our manuscript and offer constructive advice that greatly improved the ninth edition.

REVIEWERS

Donald Dorfman, *Monmouth University*
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 Stephen Sumithran, *Eastern Kentucky University*
 Leslie Kelso Winemiller, *Texas A & M University*

The publication of a textbook requires the efforts of many people. We are grateful for the work of our colleagues at McGraw-Hill, who have shown extraordinary patience, skill, and commitment to this textbook: Rebecca Olson, our Sponsoring Editor, has helped shape *Zoology* from its earliest planning stages. Her wisdom and skill are evident in the ninth edition. Wendy Langerud, Developmental Editor, worked with this textbook on the latest revision. We are grateful for her skill in coordinating many of the tasks involved with publishing this edition of *Zoology*. Wendy kept us on schedule and kept the production moving in the plethora of directions that are nearly unimaginable to us. Lisa A. Brufordt served as Project Editor for this edition. We appreciate her efficiency and organization.

Finally, but most important, we wish to extend appreciation to our families for their patience and encouragement. Janice A. Miller lived with this text through many months of planning and writing. She died suddenly two months before the first edition was released. Our wives, Carol A. Miller and Donna L. Harley, have been supportive throughout the revision process. We appreciate the sacrifices that our families have made during the writing and revision of this text. We dedicate this book to the memory of Jan and to our families.

STEPHEN A. MILLER

JOHN P. HARLEY

SUPPLEMENTARY RESOURCES

 McGraw-Hill Connect® *Zoology* is a web-based assignment and assessment platform that gives students the means to better connect with their coursework, with their instructors, and with the important concepts that they will need to know for success now and in the future.

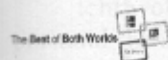
With McGraw-Hill Connect *Zoology*, instructors can deliver interactive assignments, quizzes, and tests online. Nearly all the questions from the text are presented in an autogradable format and tied to the text's learning objectives.

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ZOOLOGY WEBSITE

[www.mhhe.com/millerharley9e]

The text-specific website offers an extensive array of resources for both students and instructors. Students will find:

- multiple choice quizzing
- animations
- videos
- MP3 audio reviews
- web links
- boxed readings

Instructors can access a password-protected Instructor's Manual, which contains lecture outlines and enrichment, teaching suggestions, and suggested readings for each chapter.

Presentation Center

Accessed from the instructor side of your textbook's website, as well as from Connect Zoology, the Presentation Center's dynamic search engine allows you to explore by discipline, course, textbook chapter, asset type, or keyword. Simply browse, select, and download the files you need to build engaging course materials. All assets are copyrighted by McGraw-Hill Higher Education, but can be used by instructors for classroom purposes. Instructors will find the following digital assets for *Zoology*, Ninth Edition at: www.mhhe.com/millerharley9e:

- **Color Art** Full-color digital files of ALL illustrations in the text can readily be incorporated into lecture presentations, exams, or custom-made classroom materials.
- **Photos** Digital files of ALL photographs from the text can be reproduced for multiple classroom uses.
- **Animations and Videos** Full-color animations and videos that illustrate many different concepts covered in the study of ecology are available for use in creating classroom lectures, testing materials, or online course communication.
- **PowerPoint Lecture Outlines** Ready-made presentations that combine art, photos, and lecture notes are provided for each of the 23 chapters of the text. These outlines can be used as they are, or tailored to reflect your preferred lecture topics and sequences.
- **PowerPoint Figure Slides** For instructors who prefer to create their lectures from scratch, all illustrations, photos, and tables are preinserted by chapter into blank PowerPoint slides for convenience.

Computerized Test Bank

The test bank contains a variety of questions. This computerized test bank uses testing software to quickly create customized exams, and is available on the text website. The user-friendly program allows instructors to search for questions by topic or format, edit existing questions or add new ones, and scramble questions for multiple versions of the same test. Word files of the test bank questions are provided for those instructors who prefer to work outside test generator software.

GENERAL ZOOLOGY LABORATORY MANUAL ISBN: 0-07-747929-7

Seventh Edition, by Stephen A. Miller, is an excellent corollary to the text. This laboratory manual includes photographs and illustrations, activities on the scientific method, cladistics, ecological and evolutionary principles, and animal structure and function. The newly revised Seventh Edition includes major content updates in animal taxonomy and evolution. The pedagogy has been revised to include learning outcomes

and numbered section headings. Learning outcomes are correlated with Learning Outcome Reviews and Analytical Thinking questions in worksheets. The revised pedagogy makes this laboratory manual more interactive and student learning more easily assessed. The art program has also received major revisions. A **Laboratory Resource Guide** with information on materials and procedures as well as answers to worksheet questions accompanying the lab exercises can be found in the *Zoology* website.

ADDITIONAL RESOURCES

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