PREFACE

As the senior author of *Zoology*, I (Stephen Miller) am very pleased to present the eleventh edition of this textbook. I have been associated with this book from its inception. The initial planning, writing, and revision of *Zoology* through preparing this latest edition involved tasks that have spanned more than 30 years of my life. I am honored to have played a small part in the training of zoologists and other biologists, most of whom I will never know personally. Similarly, it has been an honor to feel a connection to the professors who use *Zoology* in their courses and who deserve the credit for mentoring future scientists. The processes of writing and revision have involved many joys, and some headaches, for me personally. I hope these efforts have helped inspire bright young minds to strive to make our planet a better place than Earth would have otherwise been.

I believe the comments of student users and reviewers of this textbook when they say that the strengths of this book lie in presentation of relevant, up-to-date zoological concepts in a friendly writing style. A book that is not read cannot inform and inspire. These strengths are carried on into the eleventh edition. Our goal has been to present zoology as a dynamic field that is critical to understanding and preserving of our planet and to present zoology in a format that is adaptable to a variety of one- or two-semester course formats.

As important as it has been for us to maintain the focus and goals of *Zoology*, change is inevitable. Two important changes faced us in this revision. The first change was the retirement of Dr. John Harley as coauthor. He has been with the book, nearly from the beginning. I wish him the best in his retirement. The second, and very welcome, change was the addition of Dr. Todd Tupper to the book team. Todd teaches general zoology at Northern Virginia Community College. He has earned both teaching and professional achievement awards. Todd involves students in his research and writing, has been a reviewer of the book, has served as an invited contributor to the tenth edition, and has used the book in his classes for many years. I have come to know Todd as someone who lives and breathes zoology and has a hunger for passing his devotion on to students. His expertise is in herpetological conservation, and you will see his ecologically minded fingerprints throughout this edition. Thank you, Todd.

Todd's involvement with zoology began with brief emailed feedback with John and me. His comments were honest and constructive, and they made the book better. We have had similar feedback from other users and students, and we welcome more of the same from you. We take all of your comments very seriously. As always, as soon as we close the cover on one revision, we begin thinking about the next. That planning begins now. Please feel free to contact us at zoology.miller@gmail.com or zoology.tupper@gmail.com.

CONTENT AND ORGANIZATION

Revision for the eleventh edition of *Zoology* has been a bigger than usual undertaking. Every chapter has been carefully scrutinized, and most chapters have had significant changes. The evolutionary and ecological perspectives that characterize this book have been retained. Both are extremely important for preserving the integrity of our discipline and the health of our planet. These perspectives are at the forefront of every chapter. A detailed explanation of the changes made to each chapter is presented in "New to the Eleventh Edition" later in this preface. The basic organization of the book is described in the following paragraphs.

Chapters 1 through 6 present cellular, evolutionary, and ecological concepts that unite zoology to biology as a whole. Chapter 2 (The Structure and Function of Animal Cells) has been completely rewritten, and the other chapters are updated with new population statistics, fresh examples, and new illustrations and photographs.

Chapters 7 through 22 cover animal taxonomy and phylogeny (chapter 7), animal origins and phylogenetic highlights (chapter 8), and survey the animal phyla (chapters 9 through 22). For those familiar with previous editions, you will note that chapter 8 is new. We believe that the addition of this chapter makes sense. It should help students move from understanding evolutionary principles (chapters 4 and 5), to knowing how zoologists organize life's diversity (chapter 7), to grasping the "big picture" of animal phylogeny (chapter 8), and to fitting animal phyla into the "big picture" (chapters 9 through 22). The trade-off that was made in presenting animal origins and diversification material in chapter 8 was to condense the coverage of the protists (chapter 8 in earlier editions) by moving it to a newly created appendix C. Instructors who want to cover these important nonanimal eukaryotes can still do so using appendix C. All of the chapters in this group, 7 through 22, include new explanations, photographs, and illustrations.

Chapters 23 through 29 have seen big changes. Although many of the excellent illustrations and photographs from the tenth edition have been retained, the text in these chapters has been largely rewritten, and in some cases reorganized. The goals of this reorganization and rewriting were to create a stronger evolutionary focus, to illustrate important unifying principles of structure and function without presenting excessive detail, and to enhance the readability of these chapters. We believe that we have accomplished these goals.

PEDAGOGY

Integrated Learning Outcomes and Critical Thinking

We have retained pedagogical elements useful to science faculty in identifying measurable learning outcomes. **Learning Outcomes** have been retained and enhanced in the eleventh edition for each major section of each chapter. Each major section ends with a **Thinking Beyond the Facts** question, which requires students to

apply the information presented in the section. Possible answers to these questions are available to instructors using Connect Zoology. These elements allow students to self-test and instructors to document student learning. In addition, instructors and students using Connect Zoology can access auto-gradable and interactive assessment material tied to learning outcomes from the text. These Connect features include the new LearnSmart and SmartBook adaptive learning tools and are described under "Teaching and Learning Resources."

Each chapter ends with a **Summary** of key concepts organized by section, a set of **Concept Review Questions,** and **Analysis and Application Questions**. These questions have been carefully reviewed and revised as needed. They allow students to test their understanding of chapter concepts and to apply concepts they have learned in each chapter. Suggested answers to these questions are available to instructors through Connect. In addition to being printed in the back of the book, the glossary is available electronically through Connect and in SmartBook.

An Evolutionary and Ecological Focus

Zoology emphasizes ecological and evolutionary concepts and helps students understand the process of science through elements of chapter organization and boxed readings. Each chapter in chapters 9 through 22 begins with a section entitled **Evolutionary Perspective**. This section discusses the relationship of the phylum or phyla covered in the current chapter to the animal kingdom as a whole and to animals discussed in previous chapters. Students are frequently reminded to consult appendices A and B to reorient themselves to phylogenetic relationships and geological time frames of evolutionary events. Similarly, each survey chapter ends with a section entitled **Further Phylogenetic Considerations**. This section discusses phylogenetic relationships of groups (subphyla or classes) within the phylum or phyla being studied and is a point of transition between chapters. The discussion in this section is usually supported by a cladogram illustrating important phylogenetic relationships.

To further explain and support evolutionary concepts, a set of themed boxed readings entitled **Evolutionary Insights** is present throughout the book. 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 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 speciation of Darwin's finches that illustrates how speciation can occur. Chapter 18 has a reading on the evolution of the vertebrate limb, and chapter 25 has a reading on the evolution of hormone receptors.

The ecological perspective of *Zoology* is stressed throughout chapters 1 to 22. Human population and endangered species statistics have been updated. Ecological problems are discussed including a newly written section entitled "Earth's Resources and Global Inequality" in chapter 6. The ecological perspective is reinforced by boxed readings entitled **Wildlife Alerts**. Wildlife Alerts first appeared in the fourth edition and have been very well received by students and professors. Each boxed reading depicts the plight of selected animal species or broader ecosystem issues relating to preserving animal species. These readings have been revised and updated. Apart from these boxed readings, numerous examples of threatened and endangered species are woven into chapters 4 through 22 that remind students of the delicate status of natural ecosystems of our planet. 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.

The Process of Science

To help students understand that science is a process, not just a body of facts, **How Do We Know** boxed readings are retained in this edition and they highlight research results that provide insight into biological processes. Chapter 9 has a boxed reading entitled "How Do We Know about Sponge Defenses?" This reading describes how zoologists investigated sponge defense mechanisms. Chapter 19 has a boxed reading entitled "How Do We Know about Amphibian Skin Toxins?" This reading describes how scientists are studying antibacterial and anticancer effects of amphibian skin toxins. Students learn that these studies have implications for studying naturally occurring compounds that may aid in the development of novel pharmaceutical drugs.

Digital Assets and Media Integration

Beginning with the ninth edition of *Zoology,* digital resources were integrated into the book through the Connect Zoology site. Many of the sections within most chapters are linked to animations from

McGraw Hill's library of animations. These animations will enhance students' understanding of material within the chapter and are available through Connect.

NEW TO THE ELEVENTH 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. The revisions highlighted below should impress students with the excitement experienced in zoology as new information clarifies zoological concepts and informs our understanding of phylogenetic relationships.

- **Chapter 1 (Zoology: An Evolutionary and Ecological Perspective)**

  A new introduction emphasizes the importance of zoological studies in our modern world. Population, world resources, and threatened and endangered species statistics have been updated with 2018 data. Table 1.4 is new and presents information on the major contributors of anthropogenic greenhouse gas emissions.

- **Chapter 2 (The Structure and Function of Animal Cells)**

  This chapter has been completely rewritten. It begins with the properties and common origin of cells. Coverage of cells is organized by common functions. It begins with cellular membranes and membrane transport, followed by energy processing. Five new figures (2.11–2.13 and 2.15–2.16) and new text art support an introduction to enzymes, ATP, glycolysis, the citric acid cycle, electron transport and chemiosmosis. This coverage provides important background for material that comes later, on energy flow in ecosystems, animal temperature regulation, nutrition, and related topics. The descriptions of the nucleus, ribosomes, and vaults are followed by coverage of functions of the endomembrane system, which are supported by the newly rendered figure 2.19. Peroxisomes, the cytoskeleton, and an introduction to tissues, organs, and organ systems follow. Detailed descriptions of tissue types have been moved to the appropriate system in chapters 23 through 29.

- **Chapter 3 (Cell Division and Inheritance)**

  A new section on cell-cycle control has been added to this chapter.

- **Chapter 4 (Evolution: History and Evidence)**

  The introduction to chapter 4 has been rewritten. In an era in which the validity of science is under attack, students need to be reminded of what a scientific theory is and the work involved with establishing scientific theories. We believe that the beginning of this chapter is the right place to present such a reminder. The revival of the epigenetics movement is briefly addressed. A new section entitled "Geological Time and Mass Extinctions" has been added to this chapter. This content is referenced throughout the book, and it is presented visually in appendix B, where it can be easily accessed. The "Evolutionary Insights" reading on cat phylogeny has been updated and illustrates how data from multiple disciples contribute to our understanding of evolutionary pathways. The cat phylogeny in box figure 4.1 has also been updated.

- **Chapter 5 (Evolution and Gene Frequencies)**

  In chapter 5, we have included an expanded discussion of neutral theory and genetic drift. A new example of founder effect (the brown anole lizard) is presented. The discussion of the effects of limiting gene flow through human influences is expanded with new examples that describe the loss of genetic diversity in bighorn sheep through highway construction and in polar bear populations as a result of sea-ice melting.

- **Chapter 6 (Ecology: Preserving the Animal Kingdom)**

  In chapter 6, the discussions of community stability and ecosystem trophic structure have been revised, including a discussion of biomagnification in the latter. Statistics on human population growth have been updated. We have added a new section entitled "Earth's Resources and Global Inequality," where students are challenged to consider overconsumption in western cultures. The material on biodiversity is revised with additional discussion on its preservation and five reasons it is threatened.

- **Chapter 7 (Animal Taxonomy, Phylogeny, and Organization)**

  Chapter 7 is updated with a newly written section on taxonomic methods. It compares the usefulness of analyses of genomic DNA, mitochondrial DNA, ribosomal RNA, and noncoding DNA sequences in phylogenetic studies. It emphasizes the importance of both molecular and traditional taxonomic data in these studies. There is a new discussion, and supporting figures, illustrating the construction of simple cladograms from phenotypic characters. A new "How Do We Know" boxed reading does the same using data from DNA base sequences.

- **Chapter 8 (Animal Origins and Phylogenetic Highlights)**

  Chapter 8 is new in the eleventh edition of *Zoology*. It begins with a discussion of Earth's beginning and evidence of early life. It continues by presenting what is known of events occurring within the first 3 billion years of Earth's history. It surveys hypotheses regarding life's origin and the evolution of the three domains, including the importance of horizontal gene transfer in early evolutionary events. The role of endosymbiosis in the origin of eukaryons is discussed. This presentation is followed by a discussion of the origins of multicellularity and animal origins within the eukaryotic clade Opisthokonta. The name "Apoikozoa" is introduced to designate the monophyletic choanoflagellate/animal lineage within Opisthokonta. A discussion of the Cambrian explosion follows. Chapter 8 ends with phylogenetic highlights of Animalia, including an introduction to the basal phyla, Protostomia, and Deuterostomia. We believe that this new chapter establishes a firm connection between the discussion of evolutionary theory in chapters 4 and 5, phylogenetics in chapter 7, and the survey of the animal phyla in chapters 9 through 22.

- **Chapters 9 through 17**

  Chapters 9 through 17 survey the animal phyla through the invertebrate chordates. They have been carefully revised and include smaller changes that clarify phylogenetics and natural history. We have included additional examples, often focusing on anthropogenic changes that threaten members of each group of animals. Wildlife Alerts have been rewritten in chapter 11 (freshwater bivalves) and chapter 16 (sea cucumbers). Boxed readings on sponge defenses (chapter 9) and early deuterostome evolution (chapter 17) have also been significantly revised.

- **Chapter 18 (The Fishes: Vertebrate Success in Water)**

  Chapter 18's coverage of early craniate evolution has been rewritten. The evolutionary history of early bony fishes has been revised, including new information on the evolution of paired appendages and jaws within the placoderms.

- **Chapter 19 (Amphibians: The First Terrestrial Vertebrates)**

  Revision of chapter 19 includes updated information on amphibian origins and origins of the Lissamphibia. Descriptions of all the extant amphibian orders have been rewritten with expanded coverage of the natural history of members of each order. The "Evolutionary Pressures" section has been updated and enhanced with expanded coverage and additional examples of amphibian adaptations. The section describing the endangered status of many amphibians has been rewritten and expanded. This section includes both anthropogenic threats like habitat destruction and "enigmatic" threats, including the spread of the chytrid fungus and climate change.

- **Chapter 20 (Nonavian Reptiles: Diapsid Amniotes)**

  Chapter 20 includes a new introduction to the two extant amniote lineages. We have consistently used the designations "nonavian reptiles" to refer to the traditional vertebrate class "Reptilia" and "avian reptiles" to refer to the traditional vertebrate class "Aves." These designations are intended as constant reminders of the accepted makeup of the reptilian lineage. Information on the evolution of Testudines and shell adaptations has been added. There are expanded descriptions of the natural history of the nonavian reptilian orders and squamate suborders. The "Evolutionary Pressures" section has been updated and enhanced with new examples.

- **Chapter 21 (Birds: The Avian Reptiles)**

  In chapter 21, the theropod origin of avian reptiles has been rewritten and expanded, as has the coverage of the evolution of the early birds. The discussion of the appearance of feathers and the evolution of flight has been enhanced. Figures 21.4 and 21.5 on feather structure and development are new, and the "Evolutionary Pressures" section is updated and includes additional examples to illustrate important concepts.

- **Chapter 22 (Mammals: Synapsid Amniotes)**

  Mammalian evolution within the therapsid lineage has been updated, as has mammalian classification. The "Evolutionary Pressures" section has been enhanced, and new information on human evolution has been added.

- **Chapters 23 through 29**

  Chapters 23 through 29 have been largely rewritten. The organization of all subjects in this block of chapters has been carefully examined to streamline their presentations, to ensure that they accurately portray evolutionary changes in animal systems, and to make them as reader friendly as possible. The organ-system histology formerly presented in chapter 2 is now appropriately placed in these chapters. In addition to these organizational revisions, the following content changes are present.

- **Chapter 23 (Protection, Support, and Movement)**

  The discussion of the mechanism of skeletal muscle contraction has been expanded, including new and revised figures. The comparative histology and physiology of fast and slow twitch skeletal muscle fibers, insect flight muscle, cardiac muscle, and vertebrate and invertebrate smooth muscles are explained.

- **Chapter 24 (Communication I: Nervous and Sensory Systems)**

  The presentation of concepts concerning resting membrane potentials, graded potentials, and action potentials has been clarified and enhanced. The presentation of invertebrate nervous systems has been revised to clearly reflect trends toward centralization and cephalization. Similarly, coverage of the evolution of the vertebrate brain has been rewritten with the same goal. A new "Evolutionary Insights" box describes surprising new roles for bitter taste receptors.

- **Chapter 25 (Communication II: The Endocrine System and Chemical Messengers)**

  Chapter 25 has been rewritten to provide clearer descriptions of the evolution and diversity of chemical messengers and the principles of negative and positive feedback control of hormonal functions. Both invertebrate and vertebrate endocrine systems are discussed in a phylogenetically meaningful organization.

- **Chapter 26 (Circulation and Gas Exchange)**

  In addition to clearer and more accurate descriptions of the evolution of vertebrate hearts, chapter 26 has a new discussion of oxygen and carbon dioxide transport, including discussions and illustrations of oxyhemoglobin dissociation curves.

- **Chapter 27 (Nutrition and Digestion)**

  Chapter 27 has a new discussion of the evolution of heterotrophy and a new "Evolutionary Insights" boxed reading on gut microbiomes.

- **Chapter 28 (Temperature and Body Fluid Regulation)**

  Chapter 28 includes a new presentation of temperature regulation, including a new figure 28.3 depicting strategies for animal thermoregulation. The sections on osmoregulation and excretion have been updated. The descriptions of invertebrate nephridia are presented with an evolutionary focus. More detail is provided on the evolution of vertebrate kidneys and the physiology of the metanephric kidney.

- **Chapter 29 (Reproduction and Development)**

  This chapter has been streamlined throughout, and the section on vertebrate reproduction has been enhanced; it now includes a stronger evolutionary focus and a clearer description of hormonal regulation of the human reproductive function.

- **Appendices**

  The eleventh edition of *Zoology* has moved some material into three appendices. Appendix A presents one interpretation of animal phylogeny that is developed and used in the textbook. Appendix B provides an expanded view of Earth's geological history and some major biological events occurring in each eon, era, and period. Frequent references are made to both of these appendices throughout the textbook. Placing this

information in appendices provides students easy access to this important information. We recommend that students tab these appendices for quick referral. Appendix C covers the Protozoa. The content of appendix C has been revised and condensed from its appearance in chapter 8 of the tenth edition. While protists are not animals, they are still very important subjects in many general zoology courses. Appendix C will allow instructors who wish to cover these organisms to do so.

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We wish to thank reviewers who provided feedback and analysis of the revision plan for the eleventh edition. In the midst of their busy teaching and research schedules, they took time to consider our proposed revisions and offered constructive advice that greatly improved the eleventh edition. We also appreciate the help of individuals who reviewed portions of the eleventh edition manuscript. Dr. Chris Barnhart from Missouri State University provided valuable feedback on the content of the Wildlife Alert on endangered freshwater mussels (chapter 11). His remarkable photographs greatly enhance our understanding of the plight of these animals. Lastly, we'd like to sincerely thank the students and biology faculty at NOVA, Alexandria, for helping to prompt meaningful inquiry and discussion that ultimately led to many of the revisions present in the eleventh edition.

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SPECIAL THANKS AND DEDICATIONS

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