



Preface

Our knowledge of the biology of animal life continues to increase at a rapid pace. New scientific discoveries are made possible through the development of new experimental methods and new approaches by modern scientists. Important advances in our understanding of the specific roles of genes in development, the role of the nervous system in animal behavior, chemical communication between cells, and ecological interactions among species and populations are only a few of the areas in which important new knowledge has been accumulated. Zoology, like all other areas of science, is cumulative and builds upon the work of previous workers. As new knowledge is added, prior findings are confirmed, revised, or refuted.

Zoology is the scientific body of knowledge about the classification and structure of animals and how they live, function, and interact with their environment. A good working knowledge of basic zoology is essential to understand the biology of animals. A solid foundation in the structure, function, and diversity of animals is critical for understanding the central issues in biology, such as the molecular mechanisms of cellular structure and function, mathematical analyses and modeling of animal processes, and the functioning of the nervous system.

Meaningful laboratory experiences are a vital part of learning zoology, and this book is designed to facilitate laboratory study of selected animals. In the laboratory, students learn the importance of careful observation, of following specific instructions, and of seeing relationships of structure and function. By carrying out well-designed scientific observations and experiments in the laboratory, students learn to **do** science instead of merely listening to someone **talk** about science.

In writing this book, we have tried to remember our own days as students and the kinds of questions we had while studying various kinds of animals for the first time. We have attempted to provide descriptions, illustrations, and appropriate guidance for meaningful laboratory study of animals. Although we agree with the spirit of Louis Agassiz' admonition, "Study nature, not books," we believe that students can benefit most in their study of nature when guided by a good instructor and aided by appropriate instructions and illustrations.

We can remember some of our own frustrations in zoology labs when we attempted to follow some vague verbal

description of anatomical structures with no illustrations or other visual aids to help us locate important structures or to give us some appropriate orientation. We have written the exercises in this book with the intention of reducing such frustration and with the intention of making student experiences in the zoology laboratory interesting, rewarding, and meaningful.

We continue to emphasize the study of living and anesthetized animals whenever feasible because students should learn that zoology is the study of animal life rather than the study of dead animals. Live animals give students the opportunity to observe and experiment with behavior and to do simple physiological experiments as well as to see the natural color and texture of body parts. Preserved specimens serve well for many anatomical studies, but students should always have the opportunity to observe and to work with living animals whenever possible. Few of us would choose a stuffed or embalmed dog or cat for a pet if given the option.

This book is written to aid students and teachers in many colleges and universities operating with different schedules, resources, and preferences, so we have intentionally included more material than can reasonably be covered in the time available in a two-semester general zoology course. We expect instructors to select those parts of the guide and those animals they deem most appropriate for their own classes. With judicious selection of chapters and of animal types, this book can also be used for one-semester and one-quarter zoology classes.



Changes in This Edition

We have revised and updated several sections for this edition to reflect new information and new interpretations of animal structures and relationships. Several illustrations have been revised or replaced following the suggestions of users and reviewers and some descriptions have been revised to improve clarity. We added new sections on the collection and preservation of various kinds of animals to several of the chapters to aid in the collection and study of locally available species. A series of Fact Files have been added to several chapters to provide interesting information about various species and groups of animals. To aid the

understanding of animal relationships, we have added a section, Systematics and Classification, to the front matter in the book and we have included cladograms in certain chapters to illustrate the possible evolutionary relationships within most of the animal phyla covered in the book. Information has been added on the properties of, and the appropriate safety measures for, handling specimens treated with various preservatives.



Basic Features of This Manual

In this edition we have continued the basic organization and pedagogical features of the previous edition. Important pedagogical features of the book include **boldface headings** within each chapter to indicate the major divisions of each exercise.

We also use **boldface** in the text to identify important terms (ideas, structures, processes) that students should remember and understand. The most important of these boldface terms are included in the list of **key terms** at the end of the chapter in which they are first introduced.

Several chapters provide space for students to add their own drawings of particular animals or structures to aid them in learning and remembering things observed during their laboratory study. The book also provides several blank tables and pages of graph paper for students to record and plot data from their laboratory observations and experiments.

Each chapter begins with a list of specific **objectives** that identifies important principles, concepts, and facts that students should learn as a result of their laboratory study. We have found that a specific list of laboratory objectives helps students focus their attention on the important material in each lab. We also suggest that instructors modify and add to these lists of objectives as appropriate for their own classes. Such lists of objectives can be most helpful in ensuring that students understand what they will be tested on and that the tests actually focus on students' understanding of the important principles, concepts, and processes.

Most chapters in this book start with a brief **introduction** with pertinent background material to help orient students for the exercises to follow. A **materials list** is provided showing the specimens and other materials needed for each exercise. Most chapters have one or more lists of suggested **demonstrations**, which are suggested to supplement the main studies of each exercise.

Within each chapter, student-directed questions have been placed in boldface type to trigger students to stop and think about the animal structure or procedure being discussed.

At the end of each chapter is a list of **key terms** introduced in that chapter, as well as Internet Resources and Suggested Readings for further study. Each chapter also ends with a list of **Questions for Critical Thinking** to help stu-

dents review the important concepts and processes of the chapter. Most chapters also have blank space provided for students to add their own notes and sketches. If students use these pages to record their observations, they will have a consolidated record of their laboratory work bound in a single place instead of a scattered bunch of papers and drawings likely to be lost.

We have tried to make this laboratory manual a convenient, user-friendly companion for laboratory study. We hope every student has as much fun and satisfaction in zoology lab as we have had.



Anatomy Films

From our many years of teaching zoology laboratories, we have learned that it is very helpful to give students an overview of the anatomy of an animal to be studied and/or dissected before they undertake the anatomical study on an actual specimen themselves. It's a lot like football players viewing game films before facing a major rival football team. They might do all right without knowing what kinds of plays the opposition typically runs and who their key players are, but they are not likely to win the championship without some good scouting information.

An excellent way to prepare for a serious anatomical study of an animal is to view a good film or video of the anatomy of that animal prior to beginning work with an actual specimen. Such preparation for the lab study gives students a better perspective and orientation and greatly increases their confidence. It also aids in their identification of anatomical structures, facilitates their recognition of relationships among various organs, and assists them in relating structure and function. Good films or videos also help students review their laboratory work in preparation for a test and in comparing the anatomy of different animals.

We have collaborated with the staff of Carolina Biological Supply Company in the development of a series of videos specifically designed to aid in the study of nine of the more complex animals included in this manual. These videos illustrate the anatomy and dissection of these nine animals and parallel the descriptions of those animals in this book.

Each video illustrates the anatomy of the animal in detail, discusses the functions of various organs and systems, and demonstrates good dissection techniques. Each video is divided into sections according to organ system so that each system can be located easily and viewed separately if desired. Several of the longer videos are too long to be productively viewed in a single session.

The videos are available from Carolina Biological Supply Company, 2700 York Road, Burlington, North Carolina, 27215. The videos and the corresponding chapters in this manual containing the exercises for the study of these animals are listed in the following table.

Chapter	Video
11. Mollusca	The Anatomy of the Freshwater Mussel (49-2365V)
12. Annelida	The Anatomy of the Earthworm (49-2372V)
13. Arthropoda and Onychophora	The Anatomy of the Crayfish (49-2403V) The Anatomy of the Grasshopper (49-2404V)
14. Echinodermata	The Anatomy of the Starfish (49-2369V)
16. Shark Anatomy	The Anatomy of the Shark (49-2655V)
17. Perch Anatomy	The Anatomy of the Perch (49-2662V)
18. Frog Anatomy	The Anatomy of the Frog (49-2704V)
19. Fetal Pig Anatomy	The Anatomy of the Fetal Pig (49-3075V)



Acknowledgments

We are grateful to several people who provided assistance in the preparation of this edition of the book. Dr. Betty Black of North Carolina State University provided facilities and equipment for numerous new anatomical illustrations, Mrs. Toni Onks, Ms. Susan Carter, and Mr. Brad Kuebler helped with many of the dissections and photographs. Mr. Dan James, Mr. Roger Phillips, Mr. Bill West,

Mr. Clyde White, and others at Carolina Biological Supply frequently assisted us with information, materials, and photographs. Dr. Robert Higgins, a long-time friend retired from the Smithsonian Institution, provided valuable information and comments on several matters. Mrs. Carol Majors of Publications Unlimited provided additional new drawings.

The following reviewers of the thirteenth edition provided excellent suggestions and feedback for this new edition:

Steve K. Alexander, *University of Mary Hardin–Baylor*
Barry G. Campbell, *Delta State University*
Gary W. Hunt, *Tulsa Community College*
Michael L. McMahan, *Union University*
Tina Miller-Way, *University of Mobile*
Anna Mleczko, *Mississippi State University*
Gale Oaks, *University of Wisconsin–Madison*
Mark Sheridan, *North Dakota State University*
Danny Wann, *Carl Albert State College*
Robert W. Yost, *Indiana University*



Introducing a New Coauthor

We are pleased to introduce Dr. John Meyer as a coauthor with this fourteenth edition of this book. Dr. Meyer is an experienced research scientist and teacher with many years of college teaching experience in biology and entomology. He has participated actively in all phases of the preparation of this edition and has contributed many important ideas. In this edition, we continue the tradition of more than 60 years of excellence in providing students with a comprehensive introduction to the fundamentals of animal structure and function.