

Preface

The 21st century is an incredibly exciting time to be a biologist. Animal biologists now have access to data from a range of complete animal genomes, including those of humans, mice, fish, tunicates, insects, and nematode worms—taxa covering a broad spectrum of the diversity of animals. But the fundamental questions about how the genes in these genomes work together to allow animals to perform their diverse physiological functions and go about their daily lives are still largely unanswered. Physiologists are at the forefront of integrating this new genome sequence information into a functional and evolutionary framework as part of their efforts to understand how animals work. Our goal in writing this textbook is to convey a sense of this excitement to students who are approaching the study of animal physiology for the first time.

One of the challenges that students face when they approach their first course in physiology is the great breadth and diversity of the subject matter. Physiology is among the most integrative of the life sciences, drawing on ideas from chemistry, physics, mathematics, molecular biology, and cell biology for its conceptual underpinnings. In addition, to fully appreciate the physiological diversity of animals, students must have a working knowledge of environmental biology, ecology, and evolutionary biology. We have written this book to give students a well-organized and engaging treatment of the fundamental principles of animal physiology. Throughout the book, we integrate concepts from all levels of biological organization to explore the nature of diversity in cells, physiological systems, and whole animals. We think that this approach will spark the interest of all students, whatever their background preparation.

Key Themes

We have organized this textbook around the key themes presented in Chapter 1:

- Physiological processes have their basis in the laws of chemistry and physics.
- Physiological processes are homeostatically regulated.
- Physiological processes are the product of both the genotype and the environment.

- Physiological diversity among animals is the result of evolutionary processes.

These key themes are revisited in every chapter of the book, providing a unifying thread that ties together our concept of animal physiology. Within each chapter, we begin by addressing the fundamental principles of the topic under discussion, using judiciously chosen examples as illustrations of these ideas. This emphasis on key themes and fundamental principles is particularly critical because students are sometimes so focused on remembering the “facts” of physiology that they are unable to place these facts into a well-developed conceptual framework.

We hope that this textbook will provide the core organizing principles that students can use as a jumping-off point as they explore the wealth of information about animal physiology that is available to them in the primary literature and through resources such as the Internet. We have included a number of features to highlight our key themes and provide students with an effective learning tool.

A Focus on Integration

Throughout the book we emphasize the integrative nature of physiology, and this theme is highlighted in a number of ways. Each chapter begins with an opening essay that places the system under discussion into its environmental or evolutionary framework. To reinforce this theme of integration, each chapter in Part Two concludes with a section entitled “Integrating Systems” in which we examine how the physiological system covered in the chapter interacts with one or more other systems in response to an environmental challenge. Together, these features help to build student understanding of how physiological systems interrelate and depend on each other.

In addition to the importance of integration across physiological systems, physiology also integrates with other disciplines. Our understanding of animal physiology has changed dramatically in the last 10 years because of the advances in genomic analyses, cell biology, and molecular biology on one end of the spectrum of biological organization, and an increased understanding of the dynamics of

evolutionary processes at the other end of the spectrum. Undergraduates are increasingly aware of cellular and molecular processes but not in the context of animal physiology. We have chosen a depth of discussion that is appropriate to understand their relevance to animal physiology.

At the same time, the vast comparative physiology literature, coupled with a greater appreciation of the role of evolutionary processes in physiology, has led to a change in the way animal physiology is studied and taught. We believe that a textbook must address the sophistication of both the discipline and the students within it. A number of special topics boxes throughout the text, including "Genetics and Genomics" and "Evolution and Diversity," allow us to highlight areas of particular interest where physiology intersects with other disciplines.

An Emphasis on Animal Diversity

We are strongly committed to the importance of teaching about the physiological diversity of animals, because we feel that this diversity is a fundamental property of the natural world. As a result, we have included extensive discussion of physiological processes in both vertebrates and invertebrates throughout the book and have attempted to fully interweave evolutionary thinking into these discussions.

We also believe that books focusing only on humans can cause students to form the erroneous impression that physiological processes in humans are typical of those in all animals, and thus we have striven to provide diverse examples in their evolutionary context.

Our commitment to diversity is emphasized by our inclusion of the phylogenies of the major animal taxa at the front and back of this book.

From Cells to Systems

Because of the varied organization of undergraduate biology programs among universities, students enter animal physiology courses with a wide range of background preparation. This book has been carefully structured to suit this diverse student body.

We have divided this book into two main sections. In Part One, we discuss the cellular basis of animal physiology. The goal of Part One is to provide students with a general context for understanding animal physiology and to show how, at a cellular level, animals are both similar to and different from other organisms. We hope that this treatment will help students begin to see how the somewhat abstract processes that they study in other courses have direct relevance to the understanding of animal physiology.

In Part Two of the book we discuss how cells and tissues interact to form the integrative physiological systems of animals. We consider each of the major physiological systems in turn, building on the twin themes of conservation and diversity to address the question: how do different animals use fundamentally similar building blocks to construct unique physiological systems to meet the challenges imposed by the environment?

One unique element in the organization of this book is our treatment of the endocrine system. Rather than relegating this system to a single isolated chapter, we discuss endocrinology in the first part of the book in the context of the various means of cellular signaling and communication and then integrate the presentation of its various physiological roles throughout the chapters in the second part of the book. We find that students better understand how hormones control systems once they have been introduced to all the diverse ways in which cells send and receive signals. By establishing the foundation of cellular control early in the text, we are able to discuss the impact of specific hormones and glands in the context of each physiological system, increasing the integrative nature of the discussion. We feel that this approach places the endocrine system in its appropriate evolutionary framework—as one of several means of intercellular communication that are available to multicellular organisms—and clearly demonstrates how communication and coordination are critical for the functioning of essentially every organ system.

Accessible Presentation

Because of the many concepts, large amounts of information, and new vocabulary that students must master in order to understand physiology, we think it is absolutely critical that a physiology textbook be written in a clear, accessible, and organized style.

We hope that students will find this book easy to read and that it will help them to understand complex physiological processes. In each chapter, we first develop the fundamental principles and then, once these concepts are fully explained, move on to a discussion of diversity. Each chapter opens with an illustrated overview that emphasizes the “big picture,” laying the groundwork for a closer look at the physiological processes to be discussed. These orientation sections provide a pathway for students to follow as they read the chapter.

An Innovative Art Program

Our experience with our own students suggests that the illustrations and photographs in a textbook are a critical component in determining how well students grasp the material—particularly for complex, multistep processes that may require several paragraphs of text to describe. Illustrations in this textbook have been carefully designed to highlight the fundamental principles of physiology and walk students through each step of complex processes. We have included a large number of flowcharts, which help students understand the dynamic and multilayered nature of physiological processes.

You will also find numerous anatomical drawings and photographs of a wide range of animals, which allow students to place physiological processes in the context of whole-animal function. With the help of our art development team, we think we have achieved an art program that rivals the best in any physiology textbook and that will contribute greatly to student learning.

For more information about this text, see the following pages for a visual presentation of the complete array of special topics boxes, the art program, text features, and the supplements package.

We hope that you enjoy using this textbook. Please feel free to contact us at the email addresses below if you have any comments or suggestions on how we could make this book an even better tool to help you learn or teach animal physiology.

Chris Moyes
Queen's University
moyesc@biology.queensu.ca

Trish Schulte
University of British Columbia
pschulte@zoology.ubc.ca