PREFACE

The second edition of a life science text usually gets written in response to two factors: (1) the first edition was received well by teachers and students; and (2) new research findings make the first edition slightly outdated. As to the former, I am humbled and honored by the widespread use of *The Biology of Aging*. It has exceeded all my expectations. As to the latter, I cannot say that new research added to the second edition, and the amount is significant, alters the conclusions in the first edition. The new findings confirm pervious knowledge on the mechanisms of aging and longevity. So, why a second addition if the first edition is not outdated?

The answer to this question comes down to one word – complexity. That is, the collective research in biogerontology since the first edition has shown that the mechanisms of aging and longevity are extremely complex. These mechanisms are so complex that a new research model will be required to understand them in their entirety. This new research model, *quantitative biology*, is the reason for a second edition. Quantitative biology tests hypotheses by comparing experimental data to theoretical models using computational methods. That is, biology has begun to use similar mathematical and computational methods that have allowed the physical sciences to understand the universe. We believe strongly that quantitative biology represents the future of biogerontology research and that all students of biology should be introduced to its basic concepts. The second edition of *The Biology of Aging* emphasizes how the emerging field of quantitative biology will bring a new and deep understanding to the complex mechanisms of aging and longevity.

The organization of the second edition has not changed significantly from that of the first edition. We continue to affirm that human biological aging can be best explained by first gaining a thorough understanding of the cellular and molecular mechanisms underlying time-dependent changes. As such, Chapters 1–6 focus on the cellular, molecular, and now the quantitative findings that help explain biological aging and longevity. Chapters 7–10 focus exclusively on human aging and disease. In these chapters, and especially in Chapter 10, you will learn that interventions now exist to slow the rate of aging and extend the healthy life span. The second edition concludes with Chapter 11, a brief look at how the extension of a healthy life span might change our perception of growing old and one's place in society.

PREFACE TO THE FIRST EDITION

Why do we age? And what determines how long we—or any other species—will live? Sir Peter Medawar, biologist and Nobel laureate, suggested in 1952 that biological aging was one of the great unsolved mysteries of the time—and it would take another 40 years for this baffling mystery to be solved. We now know the underlying cause of aging and why a species lives as long as it does. In brief, *aging* is a random process; it is not a process that evolved. *Longevity* did evolve, through the selection of genes that promote reproductive success. With a better understanding of the differences between aging and longevity came a different approach to the study of biological aging: the science of biogerontology. This led to exciting new research that is providing a greater understanding of the cellular and molecular mechanisms underlying aging and longevity. *Biology of Aging* is the first textbook on the subject of biological aging since the causes of aging and longevity were elucidated.

Over the past 15–20 years, a general consensus has arisen among scientists on the evolutionary explanation of why we age and why we live as long as we do, resulting in an explosion of research on the basic mechanisms underlying aging and longevity. The results of this research have rapidly transformed biogerontology from a primarily observational and biomedical science into a more experimental and rigorous discipline within the general biological sciences. This new and exciting direction for biogerontology created a need for courses on the biology of aging. However, the pace of course development has been hampered by the lack of a textbook that approaches biogerontology from the biological rather than the biomedical perspective. *Biology of Aging* fills that gap. It is a biology textbook written for the biology student.

This book adheres to the fundamental principle that the key to fully understanding the biological process of aging is to first understand the basic concepts in biochemistry and physiology that apply to all life and all life stages. Each chapter begins with an overview of basic biological principles of non-aged systems. With this knowledge, the student is more fully prepared to understand how time-dependent alterations in molecular and cellular functions lead to aging. Working within a framework of basic biology also provides students with the background necessary to consider what interventions might lead to a slowdown in the rate of aging and an extension of life span.

The sequence of chapters follows a standard biology textbook organization, with each chapter providing the concepts and principles needed for understanding subsequent chapters. The 10 chapters are divided into three broad organizational groups. Chapters 1 and 2 present the basic concepts of biogerontology that are common to both experimental and clinical applications. Chapters 3 through 6 explore findings in evolutionary, cellular, and genetic biogerontology that have led to our current understanding of why and how we age. And Chapters 7 through 10 focus on how the basic sciences described in earlier chapters apply to human aging and longevity. We also establish the relationship between aging and disease and discuss what can be done now to slow the rate of human aging.

Chapter 1, Basic Concepts in the Biology of Aging, lays the foundation for all the chapters that follow. It introduces and explains the terminology of biogerontology, discusses the rise of biogerontology as a subdiscipline of biology, and describes the types of model systems that researchers use to study aging and longevity. In Chapter 2, Measuring Biological Aging, we take a closer look at the basic methods used by biogerontologists to measure the rate of aging in the individual and in populations. The principles of measuring mortality rate, concepts important for understanding the evolution of longevity, are thoroughly discussed in the context of life tables. Here, the student is introduced to the field of demography and learns how studies in demography help to predict trajectories in the rate of aging and longevity and how this prediction can be used to better understand how and why we age.

Chapter 3, Evolutionary Theories of Longevity and Aging, is the heart of the book. Only through an understanding of *why* we age—that is, an understanding of aging and evolution—have biogerontologists been able to more precisely construct and test hypotheses for *how* we age. Chapter 3 traces the development of evolutionary theories on longevity and aging from the early observational postulations to the mathematics and laboratory experimentation of the contemporary evolutionist.

Chapters 4 and 5 present the basic cellular and genetic findings that reveal how we age. Chapter 4, Cellular Aging, elucidates how the basic forces of the universe that affect all matter also provide the explanation for the underlying principle of aging. Here, we explore how the laws of thermodynamics explain what has become the fundamental principle underlying cellular aging: cellular aging reflects the accumulation of damaged proteins. We describe two mechanisms, oxidative damage and telomere shortening, in demonstrating the biochemistry and physiology behind the accumulation of damaged proteins and the finite life span of the cell.

Chapter 5, Genetics of Longevity, expands on the concepts presented in Chapter 3—that the longevity of a species is related to genes selected for reproductive success. We discuss the results of elegant laboratory research on yeast and worms that has identified specific genes affecting longevity. Because these genes are known to have similar effects in higher-order animals such as mice and rats, the student will get a sense of how biogerontology is on the verge of major discoveries that will allow the genetic manipulation of the rate of aging and longevity.

Chapter 6, Plant Senescence, contains material unique to this textbook: this is the first book on the biology of aging to discuss plant senescence and its importance to aging in humans and other animals. Plant sciences are an important part of biology, and plant senescence is an important part of the biology of aging.

The exploration of human aging begins in Chapter 7, Human Longevity, with a look into an exciting new area of aging and longevity research: gerontological biodemography. Biodemography is a computational science combining biology with demography. Results from this emerging field are providing evidence that the origin of aging and longevity in humans may differ significantly from that in other species, including nonhuman primates. In the second half of the chapter, we explore the reasons behind the unprecedented increase in human life expectancy during the twentieth century.

Chapter 8, The Physiology of Human Aging, and Chapter 9, Age-Related Disease In Humans, provide a detailed look at time-dependent changes in the major physiological systems: age-related changes in physiological systems that do not, in general, increase the risk of disease or mortality

(Chapter 8) and those that are more likely to develop into diseases that lead to an increased mortality rate or morbidity (Chapter 9). As with other chapters, we cover basic physiology before describing age-related alterations.

The book concludes with Chapter 10, Modulating Human Aging and Longevity, a brief discussion of the current state of scientific knowledge about the modulation of aging and longevity. We begin by considering why modulation of biological aging might not be possible, then discuss the only two interventions that have been scientifically established as capable of modulating the rate of aging or life span: (1) reducing caloric intake and (2) maintaining physical activity throughout life. The chapter ends with a discussion of the possible implications of halting aging and/or extending the human life span.

This textbook provides an accessible introduction to biogerontology. The material is presented as an engaging, story-like narrative, with no loss of the accuracy essential to a biological science text. The illustrations are easy to follow and are accompanied by expanded legends that supplement the text description, rather than just repeating information. All chapters contain key terms (in bold type throughout the text) that are included in the book's extensive Glossary and available as flash-cards online; boxed text, providing further detail or interesting asides on a chapter topic; Essential Concepts, summarizing the main points of the chapter; Discussion Questions, to aid with studying (with answers provided on the student and instructor's site at www.garlandscience.com); and Further Reading, a list of sources and references, grouped by the chapter's section titles. An appendix explaining the mathematical derivations of life tables will assist the student in understanding Chapters 2 and 7. The appendix is an excerpt from the article E. Arias, United States life tables, 2006, Natl Vital Stat. Rep. 58:1-40, 2010. The full report can be accessed on the US Centers for Disease Control website (www.cdc.gov).

Biogerontology is a relatively young science. And it is an area of science that is of intense interest to us all—whether planning a career in biological research and teaching or in other areas of science, health, or medicine, or simply planning, while growing older, to understand as much about the process as possible. We hope this textbook serves the biology student well, and we look forward to feedback from both students and teachers.

Online Resources

While the book is the centerpiece of the course, we provide students and instructors with access to online resources to aid in the teaching and learning process. Accessible from http://garlandscience.com/ aging, Student and Instructor Resource websites provide learning and teaching tools created for *Biology of Aging*. The Student Resources site is open to everyone, and users have the option to register in order to use book-marking and note-taking tools. The Instructor's Resource site requires registration; access is available to instructors who have assigned the book to their course. To access the instructor's resources, please contact your local sales representative or email science@garland.com. Below is an overview of the resources available for this book. Resources may be browsed by individual chapters and there is a search engine.

For students:

- A selection of animations and movies illustrating relevant concepts from the book.
- Answers to end-of-chapter problems.
- Glossary terms available as online flashcards.

For instructors:

- All of the images from the book are available in two convenient formats: Microsoft PowerPoint® and JPEG. Figures are searchable by figure number, figure name, or by keywords used in the figure legend from the book.
- The animations and movies that are available to students are also available on the Instructor's Resource site in two formats. The WMV-formatted movies are created for instructors who wish to use the movies in PowerPoint presentations on computers running Windows; the QuickTime-formatted movies are for use in PowerPoint* for Apple computers or Keynote presentations. The movies can easily be downloaded to your personal computer using the "download" button on the movie preview page.
- Answers to end-of-chapter problems.
- Qualified instructors will be able to access a Question Bank comprising of multiple choice and open-ended questions.
- Lecture outlines are available to aid in framing a course around *Biology of Aging*.
- Access to resources from all of the Garland Science textbooks.

* PowerPoint is a registered trademark of the Microsoft Corporation in the United States and/or other countries.