PHYCOLOGY

FIFTH EDITION

Phycology is the study of algae, the primary photosynthetic organisms in freshwater and marine food chains. Since the publication of the first edition in 1981, this textbook has established itself as a classic resource on this subject. Aimed at upper-level undergraduate and graduate students in phycology, limnology, and biological oceanography, this revised edition maintains the format of previous editions, whilst incorporating the recent developments in the field such as: the potential and challenges of producing algal biofuel; the proliferation of algal toxins; and the development of new molecular tools and technologies on ancestry, phylogeny, and taxonomy of algae.

Robert Edward Lee was educated at Cornell University (BS, 1960–4) and the University of Massachusetts, Amherst (PhD, 1966–71) and served as a Platoon leader in the US Army First Infantry Division (1964–6). He was Lecturer at the University of the Witwatersrand, Johannesburg (1971–7), Associate Professor at Shiraz (Pahlavi) University, Shiraz, Iran (1977–9), Fellow of Schepens Eye Research Institute and Harvard Medical School, Boston (1979–81), and is currently Coordinator of Biomedical Sciences at Colorado State University, a post he has held since 1981. For 50 years, and five editions of *Phycology*, Lee has been interested in the systematics, evolution, and ecology of the algae as well as the important economic aspects of the organisms.

Phycology

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ROBERT EDWARD LEE
Colorado State University

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For Patricia, my wife of 50 years. My children Nicole, Alana, and Christian. My grandchildren Colin, Daniel, Grayson, Gannon, and Grian

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PREFACE TO THE FIFTH EDITION

It has been 45 years since I spent a considerable amount of time among the extensive collections in the old Cullen and the new Wartenweiler libraries at the University of the Witwatersrand in Johannesburg, writing and illustrating most of the first edition of *Phycology*. The illustrations were pen and ink, the photographs were done in the wet trays in the darkroom, and the text was written using a Smith Corona typewriter. The Smith Corona typewriter is presumably still in Iran as my family left with only three suitcases and could not carry the typewriter after sitting out the revolution in Shiraz and living under the clerical regime of Khomeini for a few months. We were probably one of the last American families to leave Shiraz. I had been a US Army platoon leader in Vietnam and the family had lived under UDI in Rhodesia, apartheid in South Africa, and had experienced the Portuguese African wars, so we weren't too rattled by the Iranian Revolution. However, after getting past the cordon of Soviet BTR-60 eight-wheeled armored cars and light Scorpion tanks surrounding the Shiraz airport, we were pleased to be getting on an airplane for Bahrain with the first edition of *Phycology* in hand.

A lot has, of course, changed since then. No more typewriter, everything is done using Microsoft Word on the computer. No more pen and ink, drawings are now done with Adobe Illustrator. No more darkroom, photographs are digitally manipulated with Adobe Photoshop.

The science of phycology has moved on also. In the first edition, the hot research papers were about life cycles and cytology using electron microscopes. These areas of research have now matured and do not generate anywhere near the levels of interest in the field. While the fifth edition of *Phycology* has generally updated the field, certain areas have received more attention. Specifically:

- The evolution of the chloroplast from cyanobacteria has rightly been extensively investigated since the process of photosynthesis is integral to the production of food stuffs for the world population. It has been known for some time that algal chloroplasts evolved from endosymbiotic cyanobacteria. However, it is only recently that many of the transport issues involving control of division and metabolism of chloroplasts has been elucidated, essential information in the understanding of photosynthesis. During evolution, the host cell has taken over much of the control of the chloroplast with very little nucleic acids left in the chloroplast. The question of transport of information from the host into the chloroplast is crucial to photosynthesis. These areas are covered in Chapters 1 and 3 and the introductions to Parts III, IV, and V.
- An important ecological and economic impact of algae has been in the production of phycotoxins that results in the destructive "red tides" in the marine environment and cyanobacterial poisoning of livestock, and degradation of municipal water supplies in the freshwater environment. This edition focuses on the biochemistry and production of these phycotoxins and how their production is metabolically controlled by the algae cells. The description of the toxic algae is enhanced with illustrations and life cycle diagrams that enable the student to better identify the harmful taxa. These areas are covered in Chapters 2, 18, 22, and 23.

- From the time of the last edition of *Phycology* (2008) until 2015, the production of biofuels from algae received a great deal of attention in the media. This resulted in an explosion in the number of investigations into the use of algae as biofuels and the establishment of pilot plants to demonstrate the commercialization of the concept. However, with the subsequent plunge in the price of oil since 2015, much of the enthusiasm for the production of biofuels from algae has been lost. This edition of *Phycology* discusses how many of the oil deposits in the world originated from algal blooms and gives a frank appraisal of the future of biofuels from algae. This topic is covered in Chapter 23.

PREFACE TO THE FIRST EDITION

It was that eccentric British soldier of fortune Col. Meinertzhagen, in his *Birds of Arabia*, who expressed the sentiment that prefaces should be kept short because few people ever read them. Accordingly, I would like to take a brief opportunity to express my gratitude to the people who offered encouragement and assistance during the preparation of this book. I would like to thank Adele Strauss Wolbarst, Robert Cnoops, Charmaine Slack, Sophia Skiordis, Caroline Mondel, Jill Keetley-Smith, Heather Edwards, Gail Arbeter, and the Lending Library at Boston Spa, England, for help while most of this manuscript was being prepared at the University of the Witwatersrand. For general encouragement while at Pahlavi (Shiraz) University and for providing assistance during the last turbulent and chaotic year of imperial rule in Iran, while the manuscript was being finished, I would like to thank Mark Gettner, Brian Coad, and Mumtaz Bokhari. When photographs or drawings have been taken directly from the original material, this is indicated by stating in the legend that it is *from* the original work. Most of the drawings have been redrawn to suit my tastes, and these drawings are indicated by stating that the work is *after* the original.

In some cases I have made drawings from photographs or have incorporated a number of drawings in one, in which case I state that the finished drawing is *adapted* from the original work or works. I have used the metric system in this book, and the fine-structural illustrations are expressed in micrometers (μm) and nanometers (nm).