The background of the cover is a close-up photograph of a large, green, palmately lobed leaf, likely from a maple tree. The leaf's veins are clearly visible. To the left of the main leaf, a small branch with several bright red flowers and buds is visible. The overall image has a slightly textured, aged appearance with some white specks and scratches.

the **B**otanical World

second edition
Northington • Schneider

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the *B*otanical World

s e c o n d e d i t i o n

David K. Northington

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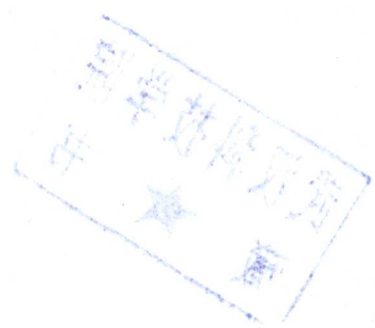
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Dedication

The second edition of The Botanical World is dedicated to Dr. J. R. Goodin who coauthored the first edition and worked with the two of us on the second edition until his death in 1991. Joe Goodin was an outstanding scholar who was extensively published and was known worldwide for his expertise in arid land plant physiology.

Joe was also an excellent teacher who dedicated over twenty years to improving the learning experience for the nonmajor student enrolled in his introductory botany course. His contributions to The Botanical World and, therefore, to the students who use this text, are considerable. Although his name is not listed as a coauthor per publisher policy, his mark on this book is very real and an important part of the philosophy and organization of the second edition.

With thanks and respect, we dedicate this to Joe Goodin, great teacher and good friend.



ANNOUNCING

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Preface

A

s with the first edition of *The Botanical World*, this second edition is written for the student. Our goal is to incorporate the strengths of the first edition with needed changes and updates to produce an

introductory text that provides the best balance and depth of coverage with the most applied and readable writing style. It has been our experience that the typical student taking an introductory level botany or plant biology course can develop a real understanding of and excitement for the world of plants if the day-to-day value of that world is an ongoing part of each subject in the book.

We consider the natural environment and the ecological balances of nature to be of at least equal importance as the daily application of plants to human society. Therefore, we incorporate an ecological message throughout each topic as well as stress the applications of plants to our daily lives. We want the student to learn the vocabulary and basic grammatical structure of the study of plants as a necessary activity to fully appreciate the poetry and depth of the language of the natural world and our place in that world. Simply memorizing the traditional botanical structure, function, and diversity without developing a deeper understanding of the integration and interdependency of nature and especially humans in the botanical world is not only less enjoyable but far less pertinent and useful—and, therefore, less worth learning. Our commitment to awaken students to the excitement and importance of botany in their daily lives, and to maintain their involvement from the first class remain prime objectives.

APPROACH AND ORGANIZATION

Just as science majors would be intimidated if marched into a voice class and asked to sing something on the first day, many non-science students are apprehensive about speaking about or even listening to lectures on science, biology, or botany. Introductory students appreciate a challenging but manageable menu in a course. Although chapters may be rearranged to tailor a course to the objectives of an instructor, there is much to be said for a front-to-back approach in an introductory course. Such a text is more likely to provide a logical, building sequence for the students as concepts gradually unfold. We have written *The Botanical World* in such a sequence. We have developed this text based on the approach we have found most successful in teaching introductory botany. That approach considers three basic elements: organization, balance, and depth of information.

Organization

We introduce the student to the most familiar topics first, and approach the subject by beginning not with the molecular level and building up to cells, tissues, organisms, diversity, and finally ecology (the traditional building block approach), but by starting with the most familiar subjects first. To the nonmajor, plant ecology, climatology, plant communities, and plant distribution are familiar topics that are often mentioned in the newspaper, on the evening news, and in other courses. There is also a greater comfort level with the macro versus the micro level of approaching any subject. With this approach, the

student can develop an interest in the subject by concentrating on the most familiar topics first and address the concept of their place in nature early on.

In the second edition, we have then taken a more traditional approach to the organization of topics with Parts II through V. Throughout these subjects, however, we regularly refer to ecological principals and bring out the application of the subject being covered to our daily lives.

Part VI, Plants and Society, provides a logical conclusion to the organization of the book, and students respond well to pulling it all together both ecologically and in terms of human society's interdependence with (not use of) the natural world.

Balance and Depth of Information

Providing an approximately equal level of coverage on each topic allows for a greater breadth of information, including the integration of applied information throughout and the four chapters in Part VI, Plants and Society.

In the traditional coverage of the diversity of plants, the amount of space and the depth of detail are usually at that of a text designed for botany majors. In addition, depending on the particular interest of the author(s), other traditional subjects such as genetics, physiology, or morphology and anatomy often receive accordingly exhaustive coverage. This depth of detail and the number of pages dedicated to such coverage prevent the inclusion of applied information such as climatology, plant distribution, industrial plant products, the history of agriculture, horticulture, plants of medicine and culture, and a thorough coverage of environmental and

ecological subjects as they relate to the successful balance of human needs and the protection of the natural world.

By balancing the depth of coverage, especially in the area of diversity, we have tried to treat each topic with the student in mind. We feel there is thorough coverage, even for a student who might decide to take upper-level courses in botany, but without the overabundance found in most texts.

Summary

The organization of topics, the depth and breadth of coverage, and the incorporation of applied material throughout the book are all aimed at helping the student learn. We have found in our courses that both majors and nonmajors are more successful with this approach than with a hierarchical organization: molecules, cells, tissues, organisms, ecology.

We do not subscribe to the philosophy which states that the capable students will learn the information and our only job is to cover everything thoroughly and carefully. Rather, we feel an obligation to help every student develop an understanding of how plants interact, grow, reproduce, and function. That understanding will promote informed decision making concerning the role of plants in a functional world. Our goal is to present the basic botanical information in a depth appropriate for beginning college students, while providing enough application to keep the students interested. We have tried to find a balance of these two components.

The overall theme of this book encompasses botany's ecological and applied components. The need for the enlightened management of plant resources is a large part of our message. Another is that humans need to function *within* the natural framework of all biological species.

DISTINCTIVE FEATURES

Although the first edition of *The Botanical World* was well received for its ecological and applied emphasis, several students, colleagues, reviewers, and adopters felt, and we concurred, that the second edition would benefit from a strengthening of the structural, evolutionary, and biodiversity coverage, while retaining our commitment to the original goals and objectives. It is

our intent in this second edition to provide an enhanced balance of coverage, yet still retain our focus on informing students of the importance of plants in the world by providing a readable, stimulating, and compelling text. The outstanding production efforts made by our publisher have made this possible. Some of these enhancements are listed below.

REORGANIZATION

With the rewriting of any new edition comes reorganization of the existing chapters and the creation of new chapters. The second edition of *The Botanical World* is no exception. Part III, The Plant Body, includes three new chapters (6, 7, and 8), and all the others have been updated with new information since the appearance of the first edition ten years ago. In addition, many new photographs have been added, accompanied with new legends. Several of the previous photographs have also been upgraded together with their legends. These are important tools that allow instructors to teach complex concepts and enhance student interest and learning.

The addition of new chapters, photographs, and line art has resulted in an entirely new design and illustration program for the second edition of *The Botanical World*. The new design elements include:

Color

The generous use of full-color photographs throughout the text adds significantly to the clarity of the line drawings and provides vivid examples of the many specific topics discussed. A conscientious effort was made to include full-color photographs that would add instructional value.

New Photos

Numerous new color photographs have been selected with the purpose of enhancing the students' desire to learn more about the structure, function, evolution, and importance of plants.

Original Drawings

Almost all of the line art in the second edition is original. Done under the close supervision of the authors, each drawing was planned to illustrate specific points in the text.

Chapter Outlines

Presented at the beginning of each chapter, these outlines provide an overall perspective of the major topics to be covered.

Chapter Overview

Each chapter opens with a brief summary of its content.

Concept Checks

Appropriately placed throughout all chapters are short topic and discussion questions. Students will benefit immensely from these, ensuring their understanding of the major concepts.

Cross-references

One of the pedagogical design aids in this text is cross-referencing where topics are discussed more than once. The intent is to indicate purposeful repetition of certain subjects and to allow the student to turn quickly to another explanation of the topic if desired.

Key Terms

Key terms are printed in **boldface type** the first time they occur in the text. Most of these terms can be found in the glossary. The student should use the glossary as often as needed, since not all terms are thoroughly defined the first time they are used.

Discussion Questions

At the end of each chapter, a list of discussion questions test student knowledge of the chapter's key content.

Boxed Essays

Examples of interesting botanical topics include the importance of seed banks (chapter 11), mycorrhizae (chapter 7), and a special boxed essay written by Dr. Sherwin Carlquist on the evolutionary history of island plants (chapter 16).

Enumerated Summaries

At the end of each chapter, these summaries provide a quick review of major concepts and serve as a study aid.

New Selected Readings

At the end of each chapter, we have provided an updated list of additional resource materials that may be assigned by

the instructor or selected by the student when additional information on the subject material in the chapter is needed.

Glossary

A comprehensive glossary defines most boldface key terms found in the text, as well as several additional terms.

Ancillaries

A comprehensive package of supplementary materials has been developed for the second edition of *The Botanical World* to aid student learning and facilitate course management by the instructor. This package includes:

- The Botanical World* Laboratory Manual
- The Botanical World* Student Study Guide
- The Botanical World* Instructor's Manual and Test Item File
- Overhead Transparency Acetates
- Art Study Notebook
- Color Slides (additional images not found in the text)
- Computerized Testing Software

ABOUT THE AUTHORS

Professors Northington and Schneider combine over forty years of teaching experience in introductory botany.

David K. Northington, Ph.D.

Dr. Northington received his Ph.D. in systematic botany at the University of Texas, Austin in 1971 and accepted a faculty position in the Department of Biological Sciences at Texas Tech University in Lubbock, Texas. During thirteen years at Texas Tech, he received several teaching awards and served as curator of the E. L. Reed Herbarium, associate chairman in the Department of Biological Sciences, and director of the Texas Tech Center at Junction, Texas, a 400-acre campus and biology field station. During his academic career at Texas Tech, he published in regional, national, and international journals, edited two books on arid land plant resources and, with Dr. J. R. Goodin, wrote the first edition of *The Botanical World*. In 1984, Dr. Northington returned to Austin as executive director of the National Wildflower Research Center, a nonprofit research and educational organization

dedicated to the preservation and reestablishment of the native flora of North America. He is also an adjunct associate professor in the Department of Botany of the University of Texas, Austin and the Biology Department of Southwest Texas State University. Dr. Northington has studied and traveled professionally for cooperative projects in Egypt, Australia, Mexico, and England.

Edward L. Schneider, Ph.D.

After earning a Ph.D. in structural and evolutionary botany at the University of California, Santa Barbara in 1974, he began an academic career at Southwest Texas State University, serving as professor, chairman of the Biology Department and dean of the School of Science before returning in 1992 to Santa Barbara to assume a new role as director of the Santa Barbara Botanic Garden, a scientific and educational institution dedicated to the study, display, and conservation of native California flora. Dr. Schneider is an adjunct professor of botany at the University of California, Santa Barbara. He is widely published and has presented numerous invited lectures on the structure, reproduction, and evolution of aquatic plants. His research, supported by the National Science Foundation, and cooperative projects have taken him to Japan, China, Malaysia, Australia, Mexico, and throughout much of Europe.

Scholarship

Because education was so important to Joe Goodin, a memorial scholarship has been established in his name and will be awarded to students who are engaged in botanical study. Complete information about the scholarship is available on page xii.

ACKNOWLEDGMENTS

Many people help make a text such as *The Botanical World* possible. We appreciate the valuable input, patience, and support of family, friends, colleagues, reviewers, and especially students. We enjoy teaching the introductory course and feel it should be an important part of any college student's education. We sincerely hope this book will convey the excitement and importance of the botanical world.

We would like to acknowledge the continued patience and support of Wm. C.

Brown Publishers, especially that of our editors, the production staff, and the marketing coordinators. In particular, the incredible patience and encouragement of Marge Kemp, the Project Editor, and the guidance of Kathy Loewenberg, Lori Hancock, and Jane Matthews. They have been involved in every aspect of bringing this second edition to fruition, improving its quality, and ensuring its accuracy.

We would also like to acknowledge the endless hours of our copy editor, Cathy DiPasquale. Her care and talent have contributed an immeasurable amount to the style, flow, accuracy, and clarity of the text. If a misspelled word or dangling participle has slipped through, we apologize to her; she has displayed boundless talent in keeping us in line.

Obviously, the talents of our illustrator, Yevon Wilson-Ramsey, have added a great deal to enhancing the text. As with the first edition, it is a true delight to be able to work with a talented, patient, and dedicated person.

We would like to give particular thanks to the many people who provided the outstanding photographs, photomicrographs, and micrographs in this book. Each of these contributors has been cited in the photo credit listing, individually crediting their skill and collectively emphasizing that the science of botany grows through the application of the talents of many.

Those who contributed indirectly, although substantially, to this book include the botany professors who introduced us to the fascinating botanical world and the many, many students that have not only challenged us to excel as teachers, but who have instilled in us the rewards that come with quality instruction and the excitement of fostering successful student learning.

We could not have completed this text without the assistance of many colleagues. We wish to thank especially Dr. Paula S. Williamson and Dr. Arthur Elliot, who read portions of the manuscript and have offered many suggestions for improvement.

To our wives, Pat Northington and Sandy Schneider, we owe a tremendous debt. Without their understanding, support, and forgiveness of time spent preparing the text, it would not have been possible to complete this revision.

Reviewers

The authors and publisher would like to express appreciation to the botanists who provided critical reviews during the development of the second edition. Their support, advice, opinions, and criticisms concerning the content, organization, and philosophy of the book were instrumental in its revision. Since not all suggestions were incorporated, the authors accept full responsibility for any factual errors that might exist.

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