**Fundamentals of
Botany Series**

**Evolution and Plants
of the Past**

Fundamentals of Botany Series

edited by
William A. Jensen
University of California, Berkeley
Leroy G. Kavaljian
Sacramento State College

The Plant Cell
William A. Jensen, University of
California, Berkeley

Plant Variation and Classification
C. Ritchie Bell, University of North
Carolina

Reproduction, Heredity, and Sexuality
Stanton A. Cook, University of Oregon

Evolution and Plants of the Past
Harlan P. Banks, Cornell University

Nonseed Plants: Form and Function
William T. Doyle, University of California,
Santa Cruz

Vascular Plants: Form and Function
Frank B. Salisbury, Utah State University,
and Robert V. Parke,
Colorado State University

Plants, Man, and the Ecosystem
W. D. Billings, Duke University

Plants and Civilization
Herbert G. Baker, University of
California, Berkeley

Evolution and Plants of the Past

**Harlan P. Banks
Cornell University**

Macmillan Education

**Published by
THE MACMILLAN PRESS LTD**
London and Basingstoke
Associated companies in
New York Toronto Dublin
Melbourne Johannesburg
and Madras

SBN 333 14634 4

**© 1970 by Wadsworth Publishing
Company, Inc.**

**© 1964 by Wadsworth Publishing
Company, Inc., Belmont, California.**
All rights reserved. No part of this
publication may be reproduced or
transmitted, in any form or by any
means, without permission.

**First published in the United
Kingdom 1972**

ISBN 978-0-333-14634-7 ISBN 978-1-349-01818-5 (eBook)
DOI 10.1007/978-1-349-01818-5

The paperback edition of this book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, resold, hired out, or otherwise circulated without the publisher's prior consent, in any form of binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

Preface

This text introduces students of botany to several exciting aspects of plant evolution as it is revealed by remains (fossils) in rocks. In addition, it surveys in depth the earliest evidence of plant life on earth, the green plant invasion of dry land, and the development of the pine cone.

The material presented here answers questions that have been asked again and again by students of evolution. The answers provided, however, are hypotheses, subject constantly to revision when they fail to meet the tests posed by new data. Students are encouraged to view the text in this light, to question the interpretations, to refuse to accept them as fully established facts.

The study of plants of the past challenges the imagination and stimulates curiosity by its exacting demand for a variety of skills and its interdisciplinary approach. Even for the sophisticated modern biologist paleobotany is developmental biology in the truest sense. It must start with inorganic elements, evolve a complex organic system (a cell), and then evolve the myriad of organisms extinct and extant found on Earth's surface. In this sense the subject matter of Chapter 1 may demand a new definition of the word fossil. The suggestion of Barghoorn, Meinschein, and Schopf that the term fossil embraces "any evidence of ancient life" is particularly appropriate.

Thanks are due to many individuals and organizations for assistance in the production of this book. Only a few can be singled out. The photographic skill of Mrs. Renate Hodgson and Mrs. Jane Blanchard was invaluable. My election as a Fellow of Clare Hall, Cambridge University, provided the time required to assemble many of the basic

data. The Botany School of Cambridge, then headed by Professor Sir Harry Godwin, generously provided me with space and library facilities for a semester. Dr. Patrick Echlin stimulated many discussions of Precambrian life, and Dr. Dianne Edwards led me to many of the localities in Wales where the earliest land plants are found. Finally, the National Science Foundation and the John Simon Guggenheim Memorial Foundation have both provided research grants-in-aid which made possible some of the studies that are here drawn upon freely.

Series Foreword

Because of the immensity and complexity of the field of botany, the great diversity of plants, and the many methods of plant study, the problem of how to present to the student the highlights of botanical knowledge gained over centuries is not easy to solve. The authors and editors of the volumes in this series believe that an understanding of plants—their parts, their activities, and their relationship to man—is of fundamental importance in appreciating the significance of life. To stress this concept, the form and function of plants, tissues, and cells are treated together. At all levels of organization, in each volume, information gathered by morphologists, physiologists, cytologists, taxonomists, geneticists, biochemists, and ecologists is combined.

Thus, in the volume on *The Plant Cell* by William A. Jensen, the structure and function of the various cell parts are discussed together—for example, mitochondria and respiration, photosynthesis and chloroplasts. The volume by Stanton A. Cook, *Reproduction, Heredity, and Sexuality*, combines the principles of genetics with the means of reproduction in the various plant groups. *Nonseed Plants: Form and Function*, by William T. Doyle, and *Vascular Plants: Form and Function*, by Frank B. Salisbury and Robert V. Parke, cover the major plant groups and discuss the plants in terms of morphology, physiology, and biochemistry. The relation of plants, particularly vascular plants, to their environment, to each other, and to man is covered in *Plants, Man, and the Ecosystem* by W. D. Billings. The form and distribution of plants of the past and their relation to the concepts of evolution are considered in the present volume by Harlan Banks, *Evolution and Plants of the Past*. Herbert G. Baker, in *Plants and Civiliza-*

tion, discusses the importance of plants to man's social and economic development and the equally important consideration of man's role in the modification and distribution of plants.

In a series such as this, the editors are faced with the task of dividing a broad field into areas that can be presented in a meaningful way by the authors. There must be logic in the entire scheme, with few gaps and a minimum of overlap. Yet an instructor may not want to use the series of volumes in the sequence and manner preferred by the editors. Consequently, each volume must be usable alone and also in any sequence with the others. To achieve such a high degree of versatility is difficult, but we believe the series exhibits these features.

A concerted effort has been made by the authors and editors to maintain a consistent level of presentation. However, each author has been encouraged to approach his subject in his own way and to write in his own style in order to provide variety and to exploit the uniqueness of the individual author's viewpoint. Finally, while presenting the principles of botany we have tried to communicate the excitement of recent developments as well as the joy that comes with the extension of knowledge in any field.

Contents

1	Plants, Their Fossilization, and Techniques of Fossil Study, 1
2	In the Beginning, 17
3	Early Plant Life—the Thallophytes, 33
4	The Invasion of the Land, 55
5	Some Consequences, 77

6	The Next 65 Million Years— Coal Age Plants, 101
7	Evolution— an Overview, 115
8	The Riddle of the Pine Cones, 135
9	Angiosperms—the Culmination of Plant Evolution, 147
	Glossary, 161
	Index, 167