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Paleopalynology

second edition

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The series editors also welcome any comments or suggestions for future volumes;

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'He picked up the manila envelope, and got out of the car, slamming the door. He headed for the entrance, shaking his head. Dodgson had been paying him five hundred dollars a day for weeks now, to follow a bunch of scientists around. At first, James had assumed it was some sort of industrial espionage. But none of the scientists worked for industry; they held university appointments, in pretty dull fields. Like that paleobotanist Sattler whose specialty was prehistoric pollen grains. James had sat through one of her lectures at Berkeley, and had barely been able to stay awake. Slide after slide of little pale spheres that looked like cotton balls, while she nattered on about polysaccharide bonding angles and the Campanian-Maastrichtian boundary . . . it was boring.' Quotation from: *The Lost World*, by Michael Crichton, 1995, Ballantine, NY.

Preface to the Second Edition

As soon as the first edition of this book was published, I began thinking of a second edition, in which I planned especially to correct various errors of omission and commission that immediately started being called to my attention. Critical colleagues found things that even the careful editorial process had missed, and dozens of students in my palynology courses found it understandably heartening to discover that the professor was very capable of making even amusing blunders. I started keeping large three-hole binders for the notes about such errors and regarding various suggestions for improvement. By the time the project for this edition finally got into high gear several years ago, there were four binders, crammed with pages well beyond the normal 8 cm. thickness for such books. The revision process has carefully treated every single suggestion, and most of them have resulted in changes.

The first edition had some critics, of course, but it also had some devoted fans, and I have paid close attention to a repeated theme in their communications: what was wanted was a revision of the first edition, not a completely new book. I have therefore concentrated on corrections and revisions in all chapters, and have confined extensive new material to areas where the first edition had become seriously outdated. Specifically, there has been considerable expansion and change of the material about dinoflagellates, acritarchs and cryptospores, as well as about the subjects of palynodebris, palynofacies, paleoecology, thermal alteration of palynomorphs, and the application of palynology to sequence stratigraphy. The glossary has also been extensively revised. I remain convinced that this book provides most of the information necessary to teach a good university/college course on palynology, although I am also aware that it will continue to serve frequently as a handy one-volume reference to palynological subjects.

Preface to the First Edition

This book is intended to fulfill a need which I have recognized through nearly two decades of teaching paleopalynology. My approach in teaching the subject has always been laboratory-centered and has emphasized learning by seeing and doing. This seems natural to me, as paleopalynology is not really a unified subject with an easily definable core of subject matter and a unified approach to its study. Rather, it is the application of a wide variety of techniques to the study of a hard-to-define, extremely diverse set of subjects. Inevitably a professor has favorite approaches and favorite aspects of a subject. Therefore my book obviously does not entirely cover all the possible areas of subject matter, nor does it cover the areas it does treat with an equal degree of thoroughness. Nevertheless, students from my courses have fairly often managed to commence practicing palynology with only my introductory, one-term course, followed by a term of rather independent laboratory work in my problems course. I believe that this book alone will enable even college teachers with little previous experience in the subject to present an adequate course in paleopalynology.

The shape of the book follows that of my course, definition and discussion of the subject matter of paleopalynology, followed by a stratigraphically based survey of palynofloras, and finally by a closer look at "non-pollen" palynomorphs such as dinoflagellate cysts, at "satellite" matters such as carbonization (= "maturation" or coalification) studies, and at some applicable techniques.

Bibliographies are not presented chapter-by-chapter as is often done in this sort of text, because I have frequently been annoyed by this. When one wants to find a certain reference, it is often maddening to have to figure out after which chapter to look. I really see no advantage to the piecemeal bibliography. The reader will find all references together in the back of the book.

Because mine is a laboratory-based approach to the subject, I present in the Appendix applicable laboratory techniques, a flowsheet for processing, and so forth. Ideally, my whole paleopalynology course should be two terms, or a year where the semester system exists. Ideally, also, students taking the course should have a basic understanding of both biology and geology. However, under the circumstances applying at our university, if I were to attempt to realize all of the above-mentioned "ideals," there would not be enough qualified, interested students, with enough spare semester slots for such an elective course, to satisfy the minimum enrollment requirement in force here.

Acknowledgments for the Second Edition

The second edition, as the first, has been a joint project with my wife, Dr. Elizabeth I. Traverse, who since the first edition has earned her Ph. D. in a totally unrelated field, medieval German literature, and in recent years has published more pages in her specialty than I have in mine. Her contributions in helping me convert this palynological work to modern form, via computer programs, scanners, word-processing, etc., and her encouragement, have been critical to whatever success the project has. Personnel in the Earth and Mineral Sciences Library of the Pennsylvania State University have been very generous with their help in tracking down various pieces of literature. William Ammerman, of the Camera Shop, State College, PA, has been generous far beyond the call of duty with his time in helping me get new illustrations, as well as those from the first edition, into suitable electronic form for this edition. Concerning my colleagues in palynology, so many have helped me so much that it is difficult to whittle the list down to one that one can reasonably include in this book. Jan Jansonius began the whole revision process in 1988–89 with a many-page contribution regarding mistakes in the first edition, and he has continued to be a source of wisdom over the years since, right down to a day or two ago. Paul K. Strother, a former student of mine, has assisted me greatly with updating parts of the book dealing with ancient acritarchs and cryptospores. Martin B. Farley, another former student, has also helped me with various matters from time to time, even suggesting wording for several sections. Gordon D. Wood has been helpful in connection with many palynological subjects at various stages of the project, and it is appropriate that one of his chitinozoans is displayed on the book's cover. Speaking of that reminds me of Rodolfo Dino, whose marvelous collage of palynomorphs makes up the main panel of the cover. David J. Batten was extremely generous with his time in helping me bring the palynofacies and thermal alteration sections up to date, especially with preparation of plates of color photomicrographs. Robert A. Fensome and James B. Riding helped me greatly with illustrations and information about dinoflagellates and other matters. W. G. Chaloner, one of the principal editors of, contributor to and fan of, the first edition, continued his assistance into the second edition, especially by allowing me to use his interesting stratigraphic key to fossil palynomorphs. Reed Wicander contributed acritarch illustrations and advice about revising my treatment of the group. Geoffrey Playford, always a booster for the first edition, also provided acritarch and other illustrations. V. A. Krassilov obtained several important illustrations for me. Stewart Molyneux gave me access to early Paleozoic acritarch photomicrographs.

Poul Schiøler permitted use of many of his pictures of Cenozoic dinoflagellate cysts. Oscar A. Abbink permitted me to republish his paleoecology/sequence stratigraphy chart, as did Jorunn Vigran for a chart of palynofacies vs. stratigraphy. Robert K. Booth, a former student, helped me with information about testate amoebae. N. J. Butterfield allowed me to use an illustration of a delicate non-palynomorph ancient microfossil. Carlos A. Jaramillo permitted use of his illustration of the coordinated use of various modern statistical, stratigraphic and geochemical tools in conjunction with palynological analyses. Catherine Duggan helped me adapt her graphical presentation of thermal alteration of Paleozoic acritarchs for my section on T. A. Edith Taylor helped me repeatedly with questions about the literature and about various palynological matters impinging on megafossil paleobotany. John M. McNeill was very helpful with questions relating to my revision and expansion of the section on nomenclatural matters. I am certain that combing my memory at this juncture has failed to turn up a "card" for others who contributed to this project. In some instances it will probably be obvious from captions or statements in the text that I had help from various colleagues I have neglected to list. I apologize in advance to everyone I should have mentioned here but have failed to do so. Finally, I must mention that this project has been underway for so many years that the responsible publishers have changed names and locations several times. I am grateful to all of the editors for their indulgence, but I would especially like to acknowledge the patience and helpfulness in the final stages of the responsible editorial person at Springer, Judith Terpos.

Acknowledgments for the First Edition

Obviously the author of a book such as this has been aided by a great array of people. This particular project has first of all been in many senses a joint effort shared by my wife, Elizabeth Insley Traverse. She has been research assistant, typist, word-processor operator, consultant, adviser, and much more. I am very grateful to her for all of this. The "official" reviewers selected by the publisher, W. G. Chaloner and A. C. Scott, have assisted me immeasurably with suggestions for changes, additions, deletions, and in finding errors. I have incorporated almost all of their recommended alterations. The same is true of C. W. Barnosky, who "unofficially" but very thoroughly reviewed the Cenozoic material and the subsequent chapters on pollen sedimentation and so forth, and the Appendix. Nevertheless, errors that remain are not to be laid to these reviewers' account, as most of them probably stem from either my failure to respond adequately to their criticism, or to material I have added since their reviews. I am grateful to K. J. Hsü for his encouragement of the project while I was at the Swiss Federal Technical Institute ("E.T.H.") Zürich, in 1980–8l. Colleagues at E.T.H., R. Hantke and P. Hochuli, also have been helpful. Dozens of colleagues assisted by providing illustrative material and by reviewing the drafts of resulting figures. These persons are mentioned below in connection with credits for various figures. That sort of mention stands as admittedly far too meagre acknowledgment and expression of thanks for their inestimable help. All of my graduate students during this period have helped me in one way or another, especially by being sounding boards: D. K. Choi, V. S. Ediger, M. B. Farley, N. G. Johnson, R. J. Litwin, E. I. Robbins, D. J. Rue and A. Schuyler. Former students, B. Cornet and D. J. Nichols, helped in a similar way. Dozens of people gave advice over the telephone or by letter (the file of such correspondence runs to many hundreds of items). It is not possible to acknowledge all such valuable help except by this general statement of hearty thanks! However, the patience and goodwill of Roger Jones, Director of Academic Publishing for Unwin Hyman, at all stages of this work, simply must be mentioned. Also, the assistance of D. G. Benson with some troublesome figures of phytoplankton, not one of my areas of expertise, is gratefully acknowledged, as is similar help with fungal spores by W. C. Elsik, and with sporopollenin and chitin diagenesis by K. J. Dorning. For the liberal use of the various excellent facilities in the Department of Geosciences at Penn State, I am also very thankful. (Eight pages of "Specific Acknowledgments to Figures and Tables," being citation

of sources for all illustrations was also placed here in the first edition, but that was an egregious blunder that confused many. One of my esteemed colleagues even asserted in print that I did not acknowledge my sources. In the second edition, all such matter is transferred to the captions, where it belongs.)

Cover Illustration

Main block (1) is a collage of all major categories of palynomorphs: pollen, spores, dinoflagellate cysts, acritarchs, chitinozoans, scolecodont. Prepared by Dr. Rodolfo Dino, Petrobras/UERJ, Brazil. Smaller photomicrographs at the top, from the left, are: (2) *Ramochitina guilloryi* Wood, Devonian chitinozoan, Bolivia. Published by Wood (2004) as a new species. Published by permission of the Assoc. Australasian Palaeontologists.; (3) Ubisch bodies from the pollen of morning glory, *Ipomoea* sp. The principal picture is a mass of ubisch bodies, as released by an acetolysed anther. Lower left is one isolated body, and upper left is a "pseudo-ubisch body," being a detached globose sculpturing element. All of the bodies are in the 10 μm range; (4) Foraminiferal test lining ("micro-foraminifera") from Recent sediment, Great Bahama Bank. The fossil is about 200 μm from top to bottom; (5) *Retispora lepidophyta* (Kedo) Playford, arguably the stratigraphically most important single species of sporomorph ever discovered. This specimen is 75 μm in max. dimension and is from Catskill Fm., uppermost Devonian, Centre Co., PA, USA.

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