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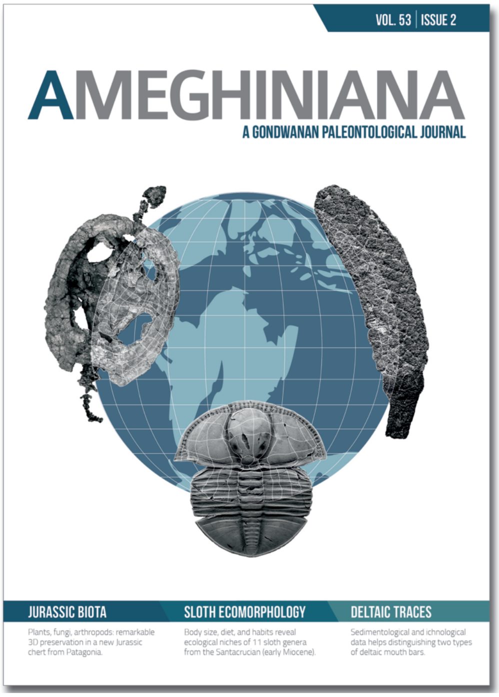


# FOSSIL FUNGI

*Thomas N. Taylor, Michael Krings, Edith L. Taylor*. 2015, 382 p. Academic Press, London, UK. ISBN: 978-0-12-387731-4

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**FOSSIL FUNGI.** *Thomas N. Taylor, Michael Krings, Edith L. Taylor*. 2015, 382 p. Academic Press, London, UK. ISBN: 978-0-12-387731-4.

While most of us probably have a visual image of dinosaur bones or the remains of mammoths that once roamed the Earth, invertebrate shells, or plant leaves, what about fossil fungi and other types of microorganisms? The book, "Fossil Fungi" by Taylor, Krings, and Taylor addresses this question on 382 pages, subdivided into 13 chapters and accompanied by more than 400 images.

Fungi today are instrumental to the health and success of virtually every ecosystem in the world, and they certainly played similarly important roles in the ecosystems of the geologic past. We know that there is an extraordinary abundance of fungal remains in the fossil record; however, systematic studies of fungi and their roles in ancient ecosystems based on fossils are rare, owing primarily to several inherent problems and limitations connected to the fossil record of the fungi. This book chronicles the fossil record of fungi through the geologic ages, places them within a systematic context where possible, and describes various types of fungal associations and interactions that existed in ancient ecosystems. Paleomycology is defined as a research area, and is discussed within the historical context of both extant and fossil fungi, and linked to other closely related disciplines. The book is structured and outlined similar to the Taylor *et al*. (2009) paleobotany textbook in that it addresses in the early chapters (1–3) "what exactly are fossil fungi", the historical context of the discipline, and the various modes of preservation of fossil fungi. The following chapters survey the fossil record for each of the fungal phyla in current systematic order, *i.e.*, lower to higher fungi, then lichens, biotic and abiotic interactions with fungi, and bacteria as well as fungus-like organisms. There are also numerous portraits of mycologists and paleobotanists, who have contributed to paleomycology, including historical figures such as Robert Kidston and William H. Lang. One of the many highlights of this textbook are the series of open questions and current hypotheses in paleomycology that serve in garnering interest as research foci for future investigators in the study of fossil fungi.

Chapter 4 focuses on the Chytridiomycota and introduces the Rhynie chert as a model ancient ecosystem. While reading this chapter, one might think about the phrase "not all that glitters is gold" in terms of "not all microfungi that look like chytrids actually are chytrids" because the authors are quick to point out that there are many fossils that superficially appear to be chytrids. However, structures produced by other groups of organisms, especially Hyphochytridiomycetes and certain Peronosporomycetes, may be very similar to, and thus as fossils indistinguishable from, structures seen in chytrids. The authors note that the abundance of these organisms in the fossil record might make it possible to reconstruct life cycles, as well as to decipher interactions of chytrids and chytrid-like organisms with other ecosystem constituents, especially land plants. One interesting question is found on pg. 67: "...will it be possible to examine the effects of chytrid parasites on the germination of glomeromycotan spores that are a biological component of endomycorrhizas in relation to effects on the population of early land plants?" Perhaps these microorganisms had profound impacts on population control of early land plants through their mycorrhizal fungi.

The next chapter (Chapter 5) focuses on the Blastocladiomycota and in contrast to the other chapters is relatively short, attesting to the exceedingly sparse record of this group of zoosporic fungi. Persuasive fossil evidence of this group exclusively comes from the Rhynie chert. The authors offer the hypothesis that fossils of these fungi have perhaps not been recognized because Blastocladiomycota today are defined primarily on ultrastructural and molecular features, as well as by a life cycle showing alternation of generations.

Chapter 6 describes the complex fossil history of the zygomycetes. Fossils of zygomycetes are generally rare, but there are a number of interesting fossils dating back to the Devonian. One interesting question introduced in this chapter concerns the use of the terms sporocarp and "sporocarp" for certain peculiar spherical microfossils from the Devonian through Triassic. The authors do a nice job of explaining how


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many of these fossils might not represent sporocarps, but rather mantled chlamydospores of glomeromycotan fungi or zygosporangia of a zygomycete. One thing the reader can take away from this chapter is the morphological plasticity of fossil members of the zygomycetes, and how difficult it is to accurately place these organisms in a systematic context.

The next chapter, Chapter 7: Glomeromycota, focuses on a group of fungi that arguably forms one of the most important fungal interactions on Earth, *i.e.* the mycorrhizal symbiosis. The chapter provides a comprehensive literature survey of fossil arbuscular mycorrhizas, but also discusses reports on glomeromycotan spores and especially the co-evolution of mycorrhizal fungi and early land plants. At the end of the chapter the authors state that the evolution of the arbuscule cannot at present be directly reconstructed from the fossil record. However, they propose that another fossil fungus can be used as a model to study this membrane-fungus interface. Page 128 "One idea... uses the Carboniferous fossil root endophyte *Cashhickia acuminata* (see Chapter 8) as a model system (Taylor *et al.*, 2012). Perhaps a fungus similar to *C. acuminata* initially extended through the apoplast and intercellular spaces of the host cortex and later gained the capacity to penetrate the cell wall but was unable to breach the cell membrane..." Integrating topics and reports of fossil fungi across geologic time periods to address these evolutionary questions may be a point of ongoing inquiry for future investigators.

The Ascomycota, addressed in Chapter 8, are the most diverse and largest group of fungi. Taylor et al. provide a comprehensive overview of structurally preserved Paleozoic through Cenozoic ascomycetes, but the vast majority of this chapter discusses the diversity of Mesozoic and Cenozoic epiphyllous ascomycetous fungi. The last sections of the chapter address the use of the term 'endophyte' when describing fungi, noting the inconsistency of the term in modern studies and in fossil fungi. Moreover, the authors elaborate on the paucity of documented fossil evidence of fungi inhabiting leaves, a niche widely exploited by ascomycetous fungi today and one of the most common interactions in modern ecosystems. The authors also suggest several avenues of new research relating to the fossil record of leaf-colonizing fungi, pg. 171 "...are there any differences in host preference? Does a particular leaf type always have the same epiphylls or endophytes? [...] Is there any evidence in fossils for this type of tissue preference? These and many other areas will also be important sources of new information as paleomycology increases its contribution to our understanding of ecosystem dynamics in the fossil record..."

The final chapter in the systematic survey of the fungal lineages, Chapter 9, deals with the Basidiomycota, perhaps the most familiar group of fungi. The chapter is structured similar to chapter 8 in providing a nice overview of reports of fossil clamp connections, as well as mushrooms, smuts, and rusts in amber, and the reports of fungal wood decay. The text leaves the reader with more questions than fossils to answer the questions, attesting to the scarcity of fossil evidence of this major fungal lineage. The group is probably ancient, but the early fossil record is difficult to interpret because of the lack of diagnostic features; the oldest clamp connection dates to the Mississippian (Lower Carboniferous). The vast majority of fungal phyla have been found in the Rhynie Chert, so where are the basidiomycetes prior to the Carboniferous? Where is the pre-Cenozoic record of mushrooms, smuts, and rusts? Especially curious, where are the pre-Cenozoic examples of ectomycorrhizal fungi? More so than with the other groups of fungi, the possibility exists that the earliest Basidiomycota looked markedly different from their younger fossil and modern relatives and lacked the diagnostic features that define the lineage today.

Despite the title, the book also addresses several other groups of organisms (Chapters 10–13) such as lichens, bacteria, fungus-like organisms (*e.g.*, slime molds and water molds). One of these chapters also includes information on the enigmatic nematophytes, especially *Prototaxites,* a towering, 8-meter tall organism for which the most commonly accepted interpretation today it is likely a lichen. Moreover, several types of fungal interactions with other organisms such as animals, plants, other fungi and even certain abiotic interactions such as the interaction with rock substrates are addressed. On pg. 268, the authors state "...identifying microorganisms such as bacteria, actinobacteria, and slime molds in the fossil record will always pose a challenge until sufficient techniques have developed to record some type of biomarker or other molecular signature..."

Fossil Fungi is welcomed because it is the first and only book on the fossil record of fungi and microorganisms, and achieves the fine balance of being equally interesting for paleobiologists interested in fungi and neo-mycologists interested in fossils. The images accompanying the text represent a crucial aspect for anyone studying fossil fungi since they can serve as search images for paleobiologists or to neo-mycologists to familiarize themselves with fossil fungi. Unlike the Paleobotany book by Taylor *et al*. (2009) that had a chapter dedicated to basic plant anatomy, there is no chapter on fungal morphology, but the authors do a good job in describing the most important terms throughout the text and in an extensive glossary at the end of the book. For those, however, who might need additional information on fungal structure and biology, I would suggest to the use Ulloa and Hanlin (2012) and/or Webster and Weber (2007) as a companion to the text. The study of paleomycology is a cross-disciplinary field, and therefore this textbook should be on the bookshelves of anyone who studies or is interested in paleobiology, biology, geology, and many other fields or, as the authors put it (pg. xi), "...see the contents of this volume only as a starting point on a continuum of incorporating the geological history of fungal lineages..." As integral as fungi are to our lives today, paleomycology is poised to be as integral for paleobiologists and mycologists alike.

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## REFERENCES

Taylor, T.N., Taylor, E.L., and Krings M. 2009. Paleobotany: The Biology and Evolution of Fossil Plants. Academic Press, New York, NY. 1230 p.

Taylor, T.N., Krings, M., Galtier, J., and Dotzler, N. 2012. Fungal endophytes in *Astromyelon*-type (Sphenophyta, Equisetales, Calamitaceae) roots from the Upper Pennsylvanian of France. Review of Palaeobotany and Palynology 171: 9–18.

Ulloa, M., and Hanlin, R.T. 2012. Illustrated Dictionary of Mycology (Second Edition). APS (American Phytopathological Society) Press, St. Paul, MN. 784 p.

Webster, J., and Weber, R. 2007. Introduction to fungi. (Third Edition). Cambridge University Press, Cambridge, UK. 855 p.