Series Preface

Mycology, the study of fungi, originated as a subdiscipline of botany and was a descriptive discipline, largely neglected as an experimental science until the early years of this century. A seminal paper by Blakeslee in 1904 provided evidence for self-incompatibility, termed "heterothallism", and stimulated interest in studies related to the control of sexual reproduction in fungi by mating-type specificities. Soon to follow was the demonstration that sexually reproducing fungi exhibit Mendelian inheritance and that it was possible to conduct formal genetic analysis with fungi. The names Burgeff, Kniep and Lindegren are all associated with this early period of fungal genetics research.

These studies and the discovery of penicillin by Fleming, who shared a Nobel Prize in 1945, provided further impetus for experimental research with fungi. Thus began a period of interest in mutation induction and analysis of mutants for biochemical traits. Such fundamental research, conducted largely with *Neurospora crassa*, led to the one gene: one enzyme hypothesis and to a second Nobel Prize for fungal research awarded to Beadle and Tatum in 1958. Fundamental research in biochemical genetics was extended to other fungi, especially to *Saccharomyces cerevisiae*, and by the mid-1960s fungal systems were much favored for studies in eukaryotic molecular biology and were soon able to compete with bacterial systems in the molecular arena.

The experimental achievements in research on the genetics and molecular biology of fungi have benefited more generally studies in the related fields of fungal biochemistry, plant pathology, medical mycology, and systematics. Today, there is much interest in the genetic manipulation of fungi for applied research. This current interest in biotechnical genetics has been augmented by the development of DNA-mediated transformation systems in fungi and by an understanding of gene expression and regulation at the molecular level. Applied research initiatives involving fungi extend broadly to areas of interest not only to industry but to agricultural and environmental sciences as well.

It is this burgeoning interest in fungi as experimental systems for applied as well as basic research that has prompted publication of this series of books under the title *The Mycota*. This title knowingly relegates fungi into a separate realm, distinct from that of either plants, animals, or protozoa. For consistency throughout this Series of Volumes the names adopted for major groups of fungi (representative genera in parentheses) are as follows:

Pseudomycota

Division:	Oomycota (*Achlya*, *Phytophthora*, *Pythium*)
Division:	Hyphochytriomycota

Eumycota

Division:	Chytridiomycota (*Allomyces*)
Division:	Zygomycota (*Mucor*, *Phycomyces*, *Blakeslea*)
Division:	Dikaryomycota

Subdivision:	Ascomycotina
Class:	Saccharomycetes (*Saccharomyces, Schizosaccharomyces*)
Class:	Ascomycetes (*Neurospora, Podospora, Aspergillus*)
Subdivision:	Basidiomycotina
Class:	Heterobasidiomycetes (*Ustilago, Tremella*)
Class:	Homobasidiomycetes (*Schizophyllum, Coprinus*)

We have made the decision to exclude from *The Mycota* the slime molds which, although they have traditional and strong ties to mycology, truly represent nonfungal forms insofar as they ingest nutrients by phagocytosis, lack a cell wall during the assimilative phase, and clearly show affinities with certain protozoan taxa.

The Series throughout will address three basic questions: what are the fungi, what do they do, and what is their relevance to human affairs? Such a focused and comprehensive treatment of the fungi is long overdue in the opinion of the editors.

A volume devoted to systematics would ordinarily have been the first to appear in this Series. However, the scope of such a volume, coupled with the need to give serious and sustained consideration to any reclassification of major fungal groups, has delayed early publication. We wish, however, to provide a preamble on the nature of fungi, to acquaint readers who are unfamiliar with fungi with certain characteristics that are representative of these organisms and which make them attractive subjects for experimentation.

The fungi represent a heterogeneous assemblage of eukaryotic microorganisms. Fungal metabolism is characteristically heterotrophic or assimilative for organic carbon and some nonelemental source of nitrogen. Fungal cells characteristically imbibe or absorb, rather than ingest, nutrients and they have rigid cell walls. The vast majority of fungi are haploid organisms reproducing either sexually or asexually through spores. The spore forms and details on their method of production have been used to delineate most fungal taxa. Although there is a multitude of spore forms, fungal spores are basically only of two types: (i) asexual spores are formed following mitosis (mitospores) and culminate vegetative growth, and (ii) sexual spores are formed following meiosis (meiospores) and are borne in or upon specialized generative structures, the latter frequently clustered in a fruit body. The vegetative forms of fungi are either unicellular, yeasts are an example, or hyphal; the latter may be branched to form an extensive mycelium.

Regardless of these details, it is the accessibility of spores, especially the direct recovery of meiospores coupled with extended vegetative haploidy, that have made fungi especially attractive as objects for experimental research.

The ability of fungi, especially the saprobic fungi, to absorb and grow on rather simple and defined substrates and to convert these substances, not only into essential metabolites but into important secondary metabolites, is also noteworthy. The metabolic capacities of fungi have attracted much interest in natural products chemistry and in the production of antibiotics and other bioactive compounds. Fungi, especially yeasts, are important in fermentation processes. Other fungi are important in the production of enzymes, citric acid and other organic compounds as well as in the fermentation of foods.

Fungi have invaded every conceivable ecological niche. Saprobic forms abound, especially in the decay of organic debris. Pathogenic forms exist with both plant and animal hosts. Fungi even grow on other fungi. They are found in aquatic as well as soil environments, and their spores may pollute the air. Some are edible; others are poisonous. Many are variously associated with plants as copartners in the formation of lichens and mycorrhizae, as symbiotic endophytes or as overt pathogens. Association with animal systems varies; examples include the predaceous fungi that trap nematodes, the microfungi that grow in the anaerobic environment of the rumen, the many insect-associated fungi and the medically important pathogens afflicting humans. Yes, fungi are ubiquitous and important.

There are many fungi, conservative estimates are in the order of 100000 species, and there are many ways to study them, from descriptive accounts of organisms found in nature to laboratory experimentation at the cellular and molecular level. All such studies expand our knowledge of fungi and of fungal processes and improve our ability to utilize and to control fungi for the benefit of humankind.

We have invited leading research specialists in the field of mycology to contribute to this Series. We are especially indebted and grateful for the initiative and leadership shown by the Volume Editors in selecting topics and assembling the experts. We have all been a bit ambitious in producing these Volumes on a timely basis and therein lies the possibility of mistakes and oversights in this first edition. We encourage the readership to draw our attention to any error, omission or inconsistency in this Series in order that improvements can be made in any subsequent edition.

Finally, we wish to acknowledge the willingness of Springer-Verlag to host this project, which is envisioned to require more than 5 years of effort and the publication of at least nine Volumes.

Bochum, Germany
Auburn, AL, USA
April 1994

KARL ESSER
PAUL A. LEMKE
Series Editors

Addendum to the Series Preface

In early 1989, encouraged by Dieter Czeschlik, Springer-Verlag, Paul A. Lemke and I began to plan *The Mycota*. The first volume was released in 1994, three other volumes followed in the years 1995 and 1996. Also on behalf of Paul A. Lemke, I would like to take this opportunity to thank Dieter Czeschlik, his colleague Andrea Schlitzberger, and Springer-Verlag for their help in realizing the enterprise and for their excellent cooperation for many years.

Unfortunately, after a long and serious illness, *Paul A. Lemke* died in November 1995. Without his expertise, his talent for organization and his capability to grasp the essentials, we would not have been able to work out a concept for the volumes of the series and to acquire the current team of competent volume editors. He also knew how to cope with unexpected problems which occurred after the completion of the manuscripts. His particular concern was directed at Volume VII; in this volume, a posthumous publication of his will be included.

Paul A. Lemke was an outstanding scientist interested in many fields. He was extremely wise, dedicated to his profession and a preeminent teacher and researcher. Together with the volume editors, authors, and Springer-Verlag, I mourn the loss of a very good and reliable friend and colleague.

Bochum, Germany
January 1997

KARL ESSER

Volume Preface

In their concept of *The Mycota*, Karl Esser and Paul Lemke (Series Editors) determined that a volume was needed to examine research on fungal populations and communities. We were invited to organize Volume IV, *Environmental and Microbial Relationships*, and were instructed to concentrate on fungal responses to the physical environment, interactions with other fungi, microorganisms and invertebrates, and the role of fungi in ecosystem processes such as decomposition and nutrient cycling. Individual chapter authors were asked to concentrate on ecological themes that could be supported by selected studies in depth and to judge fungal systems for their promise as research tools. We were advised not to solicit exhaustive reviews to cover all ecological groups of fungi.

Several authors were asked to emphasize the technology transfer of ecological information, showing how specific knowledge of the ecology and biology of fungi has application in biological control, in enzymatic conversions of plant biomass, biodegradation of toxic organic pollutants, and the discovery of natural products. Here, we asked chapter authors to take into account the basic ecological underpinnings of such technologies. Initially, we intended to place chapters emphasizing biological control strategies or industrial mycology in a section entitled "Technology transfer of ecological information." However, it was found more desirable to integrate these specific chapters within the ecological framework of the volume. We hope that this approach will better unite aspects of ecological research classified as fundamental vs. applied mycology. The immediate challenge for mycological ecology is to identify those examples where ecological studies of fungi in nature provide basic information leading to the development of a particular technology.

The book begins with a section entitled "Fungal life history and genetic strategies." Here, J.H. Andrews and R.F. Harris examine the interconversion of different growth forms in a fungal life cycle, noting that the precise nature of the environmental signals which trigger these phases and how they are transduced by the organism are unknown. Fungal ecological genetics has become the most dynamic area of mycological research in the 1990s, largely due to the efforts of A.D.M. Rayner and colleagues at the University of Bath. In the present volume, M. Ramsdale and A.D.M. Rayner outline some of the highlights of progress made in recent years and also present their vision for the future of fungal ecological genetics.

The second section is concerned with the role of selected environmental factors and ecosystem disturbance in determining the species structure of fungal communities. J.C. Zak and S.C. Rabatin begin by examining various experimental designs, approaches and methodologies for analyzing and describing fungal communities. They emphasize the importance of scale in community ecology and argue that disturbance may be the single most important process regulating the structure and functioning of fungal communities in nature. C.F. Friese, S.J. Morris and M.F. Allen evaluate disturbance dynamics over a wide array of scales and interacting factors, highlighted by a case linking site disturbance by harvester ants and the renewal of plant communities every 100 to 1000 years. R.M. Miller and D.J. Lodge identify research needed to understand how fungi respond to disturbance created by management practices in agriculture and forestry. Disruption of mycorrhizal hyphal networks and the response of saprophytic hyphae have impacts on soil structure and nutrient pools associated with the fungal hyphae. M. Wainwright and G.M. Gadd show how a more accurate assessment of the effects of pollutants on the growth and activity of fungi in the environment has been made possible by new methods for determining active fungal biomass and enlightened approaches to in vitro experimentation. In reviewing examples of fungi living in extreme environments, N. Magan argues a critical need for experiments which better simulate fluctuating abiotic parameters and their impact on the ecophysiology of these fungi. A knowledge of global, regional and endemic patterns of fungal distribution is important for the understanding of evolutionary processes and biodiversity patterns and E.J.M. Arnolds observes that such information may be applied to the control and spread of crop pests as well as in fungal conservation.

The interactions of fungi with one another, with other microbes, nematodes and arthropods have produced a wealth of ecological information with the potential for development of biological control strategies. This is considered in the third section, "Fungal interactions and biological control strategies." In reviewing fungal competition, P. Widden relates this knowledge to what is known about plant competition and the predictive value of competition theory. Because many decomposer fungi have to replace an existing microflora in order to colonize a substrate, interference competition can have an important impact on decomposition. P. Jeffries recognizes mycoparasitism as a widespread phenomenon and presents numerous examples of mycoparasitic interactions. Mycoparasitism is believed to have an important influence on competitive interactions involving fungi in nature, and in the biological control of phytoparasitic fungi. *Trichoderma harzianum* is presented as a model system of a typical mycoparasite. I. Chet, J. Inbar and Y. Hadar also examine research to improve plant resistance to fungal pathogens by integrating cloned fungal chitinase with antifungal polypeptides. Again, *Trichoderma* is shown to be a useful model system. While recognizing that mycoinsecticides have had little impact on insect pest control to date, A.K. Charnley suggests a promising future for these entomopathogenic fungi. This optimism is based on the current rate of progress in research on epizootology, mass production, formulation, application and mechanisms of pathogenesis. Fungal agents for controlling plant pathogenic nematodes often perform poorly or inconsistently because they have been released prematurely, without sufficient basic knowledge of their biology and ecology. B. Kerry and B. Jaffee explain the importance relating basic information on the mode of action and epidemiology of selected fungal biocontrol agents to methods of mass production, formulation and application. In his examination of the potential of mycoherbicides, D.A. Shisler emphasizes the importance of understanding phylloplane microbial dynamics in order to obtain consistent field efficacy of a mycoherbicide, including strategies for bolstering the pathogen at this same weak point. T. McGonigle shows how the selective grazing of soil and litter fungi by arthropods can have an impact on community structure. Fungi have responded in different ways to reduce the negative effects of predation. J.B. Gloer offers numerous examples showing how observations in fungal ecology have generated hypotheses about fungal antagonism and defense which, in turn, have led to the discovery of novel bioactive fungal metabolites.

The final section recognizes fungus-mediated decomposition and the nutrient mobilizing potentials of fungi in both aquatic (marine and freshwater) and terrestrial ecosystems. J. Dighton considers aspects of metal ion accumulation and enyzmatic competence of saprotrophic fungi. Such basic information can be applied to the degradation of toxic organic compounds and the uptake and accumulation of metal ions in contaminated soils. J.R. Leake and D.J. Read review evidence that mycorrhizae in decomposing litter have a direct role in recycling of organic nutrients. There is surprisingly little information on the extent to which processes of nutrient mobilization occur in nature. M.O. Gessner, K. Suberkropp and E. Chauvet examine the role of fungi in plant litter decomposition in aquatic environments (e.g. salt marshes, mangrove swamps and streams), and they observe that mechanisms controlling the allocation of resources between mycelium and reproductive structures are not yet understood. In an effort to encourage lateral thinking, M.J.R. Nout and co-authors examine different approaches for estimating fungal biomass in food fermentations and consider the appropriateness of various approaches for fungal ecologists investigating litter decomposition. Likewise, the bioconversion of plant fibres to fuel, feed or precursors for chemical syntheses is examined by R. Sinsabaugh and M.A. Liptak, scientists whose principal research interest is in the biochemistry of plant litter decomposition and the ecology of the decomposers in nature.

We hope that not only professional biologists who wish to learn research directions and opportunities in mycological ecology will find this volume interesting, but also that graduate students in mycology and microbial ecology will find it useful. Thanks are especially due to those individual contributors who produced outstanding original figures and to all for promptly responding to our various editorial requests.

Peoria, Illinois, USA
Lund, Sweden
January 1997

Donald Wicklow
Bengt Söderström
Volume Editors