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 selfincompatibility, 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 100,000 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

Volume Preface to the First Edition

Hyphal growth, leading to the formation of a mycelium, is the most characteristic feature of fungi. Many fungi, however, propagate as yeasts or alternate between the yeast and mycelial form. Both growth forms have in common that they are manifestations of polarized cytoplasmic activities. A large part of this Volume of The Mycota therefore deals with growth and differentiation in both yeast-like and mycelial fungi and also the transition between them. Sexuality is the other main topic of this Volume.

Yeasts offer many methodological advantages, particularly with respect to applying microbiological and molecular techniques, and therefore have become major experimental objects for advanced research. Among processes studied in depth are the regulation of mitosis and the cell division cycle, the synthesis of wall components, the secretion of proteins, the regulation of meiosis and sporulation by the mating-type genes, the mating-type switch, and the nature and action of mating hormones. Apart from their relevance to general eukaryotic cell biology, these studies form a basis for exploring the nature of similar processes in mycelial fungi.

The rigid wall ultimately determines the shape of fungal structures and therefore attention is given to wall structure and biogenesis. The mechanisms by which the cells locate wall synthesis and exocytosis of proteins at denned sites are still problematic. Attention therefore focuses on the role of the cytoskeleton and plasma membrane proteins in the polarized activities of the cell, the role of turgor as a driving force for growth and the role of electrical currents that often accompany polarized growth.

Hyphae regularly branch according to a distinct pattern and form a mycelium that enables transport of water and nutrients. With the apically growing hyphae that release digestive enzymes, the mycelium is thus ideally adapted to colonize dead or living substrata. Vegetatively growing mycelia may eventually grow old and die, necessitating a sexual cycle for rejuvenescence.

Anastomosis of fungal mycelia occurs frequently in nature but heterogenic incompatibility systems often prevent the coexistence of genetically different nuclei in a common cytoplasm, whereas homogenic incompatibility often governs sexual interactions which lead to meiosis and the formation of meiospores.

The role of mating-type genes in homogenic incompatibility is best understood in some yeast species, but rapid progress is being made in elucidating the complex interactions between mating-type genes that govern sexual processes in mycelial fungi. Some of these mycelial fungi also offer excellent opportunities to study meiosis.

The mycelial growth habit allows for long-range intercellular communication and transport, permitting the emergence of aerial structures for dispersal of asexual and sexual spores. Extensive molecular-genetic studies are being carried out on conidiation and fruit body formation in a few selected species.

Differentiation in fungi also often involves signaling substances, indicated as hormones in the Chapter titles, although the authors may prefer different designations for these substances. Again, the yeast systems have yielded most to molecular studies while the mycelial systems offer a wealth of cases to be studied in depth.

Where possible we have selected authors who are actively engaged in advanced research on the topics mentioned. This means that the emphasis is on molecular research

probably with some neglect of important research that has not yet entered this arena. A comprehensive treatment of the topics would require more than one Volume of The Mycota. However, the contributors were asked to consider all relevant aspects and to stress future developments in their specific and related areas of research. We therefore hope that this Volume will not only provide a source of information for what has already been achieved but that it may also influence future research and developments in this field.

Groningen, The Netherlands
Münster, Germany
April 1994

Joseph G.H. Wessels
Friedhelm Meinhardt
Volume Editors

Volume Preface to the Second Edition

This volume is an update of Volume I of the series The Mycota, which appeared more than ten years ago. To us, the first edition of the book has been and, in some areas, still is a major source of ideas and knowledge concerning fungal development and reproduction. Since then, however, three major breakthroughs in molecular biology have caused fast progress in our understanding of fungal development and have also opened up new research fields. First, the improvement of PCR-based methods has facilitated faster access to genes and, in combination with reverse transcriptase, to transcripts. In addition, these methods have made it possible to investigate fungi which do not grow well on agar plates, such as obligate biotrophic fungi, and they have offered us the opportunity to analyse fungal populations in the field. Second, the advent of green and other fluorescent proteins in fungi in 1995 has caused a "green revolution", just like in many other fields of biology. Third, the publication of the full *Saccharomyces cerevisiae* genome in 1996, and of many more fungal genomes since then, has opened the way to genome-wide assessments and the widespread use of reverse genetics approaches.

We are very much indebted to Jos Wessels for his initial input in structuring this new Volume I, and his wealth of scientific and editorial experience has greatly helped to get the final design of the volume. Several of the authors of chapters in the first edition agreed to update their contributions, in many instances with a totally new focus. Others, however, had retired from science and, above all, we mourn the loss of Graham Gooday. New authors were asked to join the project, particularly in fast-progressing sectors and also in newly emerged fields dealing with novel developments in studies of growth, differentiation and sexuality. Due to space limitations, some subject matter, formerly treated in several chapters, has now been condensed, with the inevitable cost of loosing out on some knowledge and detailed information. An example is the field of meiosis, which formerly was presented in three chapters, now only in one. Likewise, in the first edition four chapters dealt with aspects of mating type genes, but in this second edition we have only two chapters specifically assigned to these genes. We therefore apologize to authors and readers if excellent parts of the former book have been left out of the current version, and we would like to draw attention to the older Volume I in The Mycota series, which in many cases still adds to the text presented here. Furthermore, we refer the reader to other books in The Mycota series, in particular to Volume 8, dealing with the related field of cell biology. Cross-references within the chapters of the present book will help in learning more about related topics in this and other books of the series.

Issues of vegetative processes and growth are nowadays not easily fully separated from those dealing with reproduction, and vice versa. As will be repeatedly found in this book, often the same cellular players are involved in growth and in reproduction. Grouping of chapters into general themes is thus not always that clear cut. This second edition of Volume 1 has been divided into three sections, according to the main foci of the chapters. The first ten chapters deal with vegetative processes and growth. There is one chapter on fungal cell types, and two chapters on organelle inheritance and mitosis. The following two contributions summarize our current knowledge about the fungal cell wall and its biogenesis. How fungal compartments are separated is described in Chapter 6. Chapters 7 and 8 deal with mechanisms of fungal cell fusion and incompatibility

reactions. These are followed by two chapters on programmed cell death and senescence. The second section comprises three chapters on signals in growth and development, with one chapter on autoregulatory signals, another on pheromones, and yet another on photomorphogenesis and gravitropism. The last section describes, in seven chapters, asexual and sexual reproductive processes in asco- and basidiomycetes, and ends with one chapter on meiosis. Reproductive processes in other groups of fungi are less well understood, and available information has been included mainly in the second section of chapters.

We hope that the book will give its readers the same joy as we had when learning all about new information and ideas in these rapidly evolving fields. We would like to express our gratitude to all the authors for their excellent input into this book, which hopefully will enjoy the same success as its predecessor.

Göttingen, Germany
Karlsruhe, Germany
July 2005

Ursula Kües
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Volume Editors