Series Preface

Mycology, the study of fungi, originated as a sub discipline 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) areas 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 — Karl Esser
Auburn, AL, USA — Paul A. Lemke
April 1994 — *Series Editors*

Volume Preface

In their concept of *The Mycota*, Karl Esser and Paul Lemke (Series Editors) determined that there was a need for a volume that emphasizes research on fungal populations and communities and their biotic and abiotic interactions with environments. Two volumes written in this line have so far been published. We were invited to prepare a third edition of Volume IV that continues concentrating on fungal responses to physical environments, interactions with other fungi, but also bacteria, plants, and invertebrates, and their role in ecosystem processes.

The dramatic progresses in genetic manipulation of fungi, genome-wide analytical tools, and bioinformatics have also revolutionized research in the above-described area. Consequently, while several authors of the third edition were asked to rework and update their chapters for this volume, we also felt the need to also incorporate new chapters to emphasize important findings and trends in this area.

The first section highlights two important aspects of the fungal population: Sun and Heitman discuss the fundamental roles that recombination plays in fungal evolution by generating novel allele combinations, as well as by increasing the genetic diversity and facilitating natural selection. They thereby particularly focus on the diverse mating systems and mating-type determination mechanisms in fungi, which provide a rich resource to study the effects of recombination on mechanisms of sex determination and sexual development, as well as the evolution of sex determination systems and sex chromosomes in general. Leavitt and Lumbsch illuminate new insights into the geographical distributions of lichen-forming fungi and the factors that shape these distributions. Besides discussing general perspectives of biogeography of lichen-forming fungi, they focus on major themes directly related to ecological biogeography, such as dispersal and establishment of lichens, landscape genetics and gene flow, and the role of photobionts in determining distributional ranges.

The second section is dedicated to the determinants of fungal communities. Among these, sunlight is definitely one of the most important cues for all living organisms on earth. Casas-Flores and Herrera-Estrella describe how light regulates several physiological and developmental processes, including phototropism, synthesis of pigments, circadian rhythms, sexual and asexual development, and primary and secondary metabolism, among other processes. They also explain the fungal components involved in sensing light and how this signal is transduced downstream. Morris and coauthors deal with the impact of events that disrupts ecosystem, community, or population structure such as changes in resources, substrate availability, or the physical environment on fungal communities. They

show that such disturbances that alter the fungal community have major consequences for ecosystem dynamics by changing nutrient cycles and affect plant diversity. However, also the type of fungal community that reestablishes on a given site is affected by the reestablishing plant community structure and nutrient dynamics across the landscape.

Fungi are capable of the degradation, utilization, and/or transformation of a wide variety of organic and inorganic substances, including xenobiotics, metals, radionuclides, and minerals. Fungal populations are therefore intimately involved in element cycling at local and global scales and such processes have major implications for living organisms, notably plant productivity and human health. Geoffrey Gadd outlines in his chapter some important interactions of fungi with organic and inorganic pollutants and highlights the interdisciplinary approach that is necessary to further understand the important roles that fungi play in pollutant transformations, the chemical and biological mechanisms that are involved, and their environmental and applied significance.

Fungi are also the major organisms for the recycling of biomass on this planet and thus essentially contribute to the global carbon cycle. Ramoni and Seiboth illustrate how the plant cell wall that is composed of cellulose, different hemicelluloses, pectins, and the polymer lignin and represents material extremely recalcitrant to degradation and decomposition can be used as a nutrient by different fungi via different strategies and describe the enzymes involved in this process.

The largest section of this volume is dedicated to the field of fungal interactions which today is one of the hotspot of fungal research. Pawlowska starts this section by describing the accumulated data about newly discovered bacterial–fungal symbioses. Particularly, the heritable alliances formed by early divergent lineages of *Mucoromycotina* and *Glomeromycota* with beta-proteobacteria and Mollicutes yielded novel insights into the forms of evolutionary trajectories in mutualisms and into mechanisms of symbiont genome evolution. Tarrka and Deveau continue on this topic by discussing the interactions of fungi and bacteria, which are frequent because they coexist in various environments and often share niches. They consequently often undergo physical associations that have beneficial effects for both partners. They highlight recent contributions to the understanding of bacteria–fungi interactions and focus on the rapid methodological development in this area.

Fungal plant interactions have been known for a long while. "Mycorrhiza"—the beneficial and mutualistic associations between plant roots and fungi—thereby has a major impact on earth's plant growth. Marmeisse and Girlanda summarize the recent advances in the field of mycorrhizal ecology, particularly prompted by "omic" approaches, which have offered insights into the genome signatures of different fungal trophic strategies and the roles of mycorrhizal fungi in the functioning of terrestrial ecosystems. In addition, root endophytes—while not being mycorrhizal fungi—have only recently been recognized to have a significant impact on plant nutrition. Yuan and coauthors describe the ecological significances of fungal root endophytes, particularly those termed class 4 endophytes which represent the main root associates. They particularly introduce a new model system for studying this process—*Harpophora oryzae*—that is a root endophyte of wild rice. Interestingly, *H. oryzae* is a close relative of the most

devastating pathogen of rice, *Magnaporthe oryzae*, and the authors highlight the metabolomic and transcriptomic differences that have been found in the two binary fungal-root systems which reveal details about the key elements leading to either mutualistic or pathogenic interactions.

Moving on the further interactions performed by fungi, Chenthamara and Druzhinina focus on mycotrophic fungi and—on the basis of genome-wide investigations—reveal unique features in the intracellular mycoparasite *Cryptomycota* and outline similar and apparently convergent mechanisms employed by a diversity of fungicolous Asco- and Basidiomycota. Herrera-Estrella and coauthors deal with the ancient and diverse group of nematophagous fungi that use refined mycelial structures or their conidia to capture their preys. They review the current state of knowledge of their biology and molecular physiology and particularly highlight the recent genomic insights into the virulence factors of nematophagous fungi. Schigel illustrates the ecological complexity of fungus–beetle interactions from European boreal forests. Larvae or adults of the fungivorous species of the genus *Coleoptera* selectively feed on a primarily fungal diet, fruit bodies, mycelia, and spores. He describes how the evolutionary success and diversity of both fungi and the beetles result in complex patterns of co-occurrence and interactions, culminating in diverse species assemblage patterns and varying degrees of trophic specialization of beetles.

We hope that this volume will prove useful to both scientists who wish to update themselves in any of the research areas outlined above and students for a first overview before entering these areas in depth. We are grateful to all the authors who took the time and effort to collaborate with us on the updating of this volume and particularly that they all helped us getting this task finished within the expected time schedule.

Vienna, Austria
December 2015

Irina S. Druzhinina
Christian P. Kubicek

http://www.springer.com/978-3-319-29530-5

Environmental and Microbial Relationships
Druzhinina, I.S.; Kubicek, C.P. (Eds.)
2016, XIX, 291 p. 40 illus., 25 illus. in color., Hardcover
ISBN: 978-3-319-29530-5