Fungi Pathogenic for Humans and Animals

(IN THREE PARTS)

PART A
Biology

EDITED BY
Dexter H. Howard

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Biology

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MARCEL DEKKER, INC. New York and Basel

Library of Congress Cataloging in Publication Data

Main entry under title:

Fungi pathogenic for humans and animals.

(Mycology series ; v. 3)
Includes indexes.
Contents: pt. A. Biology.
1. Fungi, Pathogenic. I. Howard, Dexter H., [date]
II. Howard, Lois F. III. Series.

QR245.F86 589.2'0469 82-18240
ISBN 0-8247-1875-5 (pt. A)

MARCEL DEKKER, INC.

270 Madison Avenue, New York, New York 10016

Current printing (last digit):
10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

Introduction to the Series

Mycology is the study of fungi, that vast assemblage of microorganisms which includes such things as molds, yeasts, and mushrooms. All of us in one way or another are influenced by fungi. Think of it for a moment—the good life without penicillin or a fine wine. Consider further the importance of fungi in the decomposition of wastes and the potential hazards of fungi as pathogens to plants and to humans. Yes, fungi are ubiquitous and important.

Mycologists study fungi either in nature or in the laboratory and at different experimental levels ranging from descriptive to molecular and from basic to applied. Since there are so many fungi and so many ways to study them, mycologists often find it difficult to communicate their results even to other mycologists, much less to other scientists or to society in general.

This Series establishes a niche for publication of works dealing with all aspects of mycology. It is not intended to set the fungi apart, but rather to emphasize the study of fungi and of fungal processes as they relate to mankind and to science in general. Such a series of books is long overdue. It is broadly conceived as to scope, and should include textbooks and manuals as well as original and scholarly research works and monographs.

The scope of the Series will be defined by, and hopefully will help define, progress in mycology.

Paul A. Lemke

Foreword

The current interest in the field of medical mycology is shown by the steadily increasing number of workshops, symposia, review articles, and research papers on medically important fungi. The growth in interest is not restricted to research scientists, for lectures concerned with medically important fungi are becoming an important part of the teaching curricula in biomedical sciences.

Although several fine textbooks and extensive literature on various aspects of fungal disease have accumulated, there is a lack of texts to which students can go for detailed accounts of biology and up-to-date research accomplishments on medically important fungi. This book, in a series of three parts, is devoted exclusively to meet this need.

The authors are all highly qualified, and many of them are internationally renowned scientists in the field. Professor Howard is a distinguished mycologist whose research efforts made important contributions to our knowledge of host-fungi interactions. He is also a noted teacher who has trained numerous young scientists in the field.

Part A contains the latest and most authoritative information on classification, nomenclature, morphology, and physiology of fungi pathogenic for man and animal. Publication of this volume is timely because classification and the continuous changes in the nomenclature of medically important fungi created enormous confusion among workers in this field.

Microbiologists and clinicians alike will find the taxonomic discussions of extreme interest and appreciate the kindly guidance for the identification of pathogens in each order or class. Microbiologists and biochemists will appreciate the comprehensive coverage of the morphological and physiological aspects in this volume.

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Preface

In 1947, Walter J. Nickerson edited a volume on the *Biology of Pathogenic Fungi* which covered some aspects of the biology, physiology, and biochemistry of the fungi pathogenic for man. Since then several fine textbooks have appeared, in which are described the essential features of the clinical manifestation, epidemiology, and pathology of fungous infections together with the identifying characteristics of their etiologic agents. In addition, individual mycoses or single aspects of all of the major mycoses have received abundant monographic treatment. However, a comprehensive consideration of the biology of the fungi pathogenic to man and animals has not recently been offered. These volumes are an effort to do so. It was not my object to present a series of "selected topics" or "recent advances" but rather a thorough review of basic biology, host-parasite interactions, and current methods of detection and characterization of the zoopathogenic fungi.

Part A of this series deals with the basic biology of medically important fungi. The first section comprises a discussion of the taxonomy and classification of the zoopathogens. This section is followed by individual chapters on ultrastructural cytology, dimorphism, sporulation, blastoconidium germination, and the transport of metabolites. Some additional topics which suggested themselves for coverage could not be included in Part A because of size limitations. Other basic biology topics will be included in subsequent parts of the series. (Members of the bacterial order Actinomycetales, often included in various types of works on medical mycology, will not be considered in this series.)

So much has been accomplished in each of these fields that it would be impossible for any single author to give an in-depth presentation. Accordingly, a compilation by many individuals was attempted despite the recognized difficulties of variation and potential redundancy. The scope of these volumes is such as to attract the attention of all engaged in research on fundamental aspects of the fungi pathogenic to man and animals. However, the coverage will be of interest to students who wish an up-to-date consideration of the frontiers of investigation on these pathogens.

A special acknowledgment is required. All responsibility for necessary editing with regard to uniformity of format, proper references, and retyping of heavily altered copy was assumed by my wife, Mrs. Lois F. Howard. She was, indeed, the primary copyeditor of this work. She merits recognition for her unswerving pursuit of excellence of presentation and the indefatigable insistence on perfection of textural detail which I had hoped from the outset would characterize these volumes. Her efforts, in no small measure, and those of several of the authors, have been supported by research grant AI 16252 from the National Institute of Allergy and Infectious Diseases, National Institutes of Health, which is used to fund the Collaborative California Universities-Mycology Research Unit (CCU-MRU).

I am, of course, grateful to the splendid group of authors collaborating with me to produce these volumes.

Dexter H. Howard

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Other Volumes in Preparation

Part One

CLASSIFICATION AND NOMENCLATURE

1

An Introduction to the Taxonomy and Nomenclature of Zoopathogenic Fungi

Dexter H. Howard / UCLA School of Medicine, Los Angeles, California

I. GENERAL COMMENTS

Medical mycology has long been encumbered with the great number of names that have been given to medically important fungi, a fact commented on by Nickerson in an early review on medical mycology [8]. Moreover, taxonomic developments have necessitated many nomenclatural changes over the years which have resulted in a bewildering synonymy for some pathogens. Since taxonomic considerations involve judgments and opinions, nomenclatural changes are often frustrating to the nonexpert and not infrequently controversial among the authorities. Thus, in planning this treatise on the biology of zoopathogenic fungi it seemed appropriate to begin with a consideration of their nomenclature and taxonomy.

The contributors to this portion of the book have chosen to approach their subjects in rather different ways. Undoubtedly, this reflects various opinions as to the type of treatment required by different groups of fungi as well as the individualism often noted among taxonomists.

II. NOMENCLATURE

The nomenclature of medically important fungi has long been a problem to scientists interested in various aspects of these microorganisms. One well-known example, frequently quoted [4], is the fact that there are over 100 synonyms for the single species *Candida albicans* [6]. This situation has been aggravated by the inexperience of investigators who were interested in aspects of the behavior of zoopathogens other than their classification.

But the problem is also related to the fact that, for the most part, these pathogens were, at the outset, known only in their imperfect states and the classification of imperfect fungi has always been subject to more uncertainty than has that of other groups. The discovery of the sexual phases of certain pathogens together with other sorts of taxonomic developments have led to many changes in nomenclature over the years.

As a starting place for a proper nomenclature of fungi pathogenic to humans and animals, I chose a recent monograph [7] on the subject compiled by a select subcommittee of the British Society for Mycopathology convened by D. W. R. Mackenzie and comprised of G. C. Ainsworth, P. K. C. Austwick, A. J. E. Barlow, C. N. D. Cruickshank, J. C. Gentles, and P. M. Stockdale. The Introduction to this monograph is an excellent account of the bases for nomenclature of the zoopathogens and other mycological matters of central importance.

III. TAXONOMIC ARRANGEMENTS

The recent overview by Ainsworth [1] of the classification of fungi presented in the introductory chapter to the two-volume treatment of fungal taxonomy which he coedited was adopted as a guide when I first began to plan these chapters on the classification of zoopathogens. Ajello [2] also followed Ainsworth's general scheme in his recent succinct consideration of the location of animal pathogens among the divisions of the fungi. More recent monographic treatments on taxonomy of the Fungi Imperfecti [3] have raised many issues for consideration, e.g., the anamorph expression of growth of teleomorphs, and these excellent volumes should be consulted for further information. Recognition of the fact that anamorphs are form-genera and form-species has been emphasized repeatedly by Carmichael [3,5].

The outline given here was constructed in May 1978 as I was outlining the chapter headings for this part of the book. I modified it in July of that year when I came across Ajello's paper on the subject [2]. His contribution is more comprehensive than mine and should be consulted for details. I further modified the key as the various chapters arrived in manuscript form. Carmichael encouraged the use of "Fungi Imperfecti" rather than "Deuteromycotina" so that the fact that the latter were form-genera and form-species would be emphasized (personal communication). I hope the presentation will be of some interest and will provide a glimpse of the position of zoopathogens in the scheme of things.

*Outline of the Zoopathogenic Fungi**

Kingdom: Fungi
Division
I. Myxomycota (no pathogens known)
II. Eumycota
A. Mastigomycotina
1. Chytridiomycetes — *Rhinosporidium seeberi* (?)

*Restricted for the most part to those genera included in Chaps. 2 to 8 (see individual chapters for lists of species). The divisions of the outline were chosen to suggest general location. Details are not presented. The divisions shown are those thought to contain pathogens of humans and animals. Prominent pathogens or potential pathogens are indicated at a generic level.

- 2. Oomycetes
  - a. Saprolegniales — *Saprolegnia*
  - b. Peronosporales — *Pythium (Hyphomyces) destruens*
  - c. Blastocladiales — *Coelomyces*
- B. Zygomycotina
  - 1. Trichomycetes
  - 2. Zygomycetes
    - a. Mucorales
      - i. Mucoraceae — *Absidia*, *Mucor*, *Rhizomucor*, *Rhizopus*
      - ii. Cunninghamellaceae — *Cunninghamella*
      - iii. Mortierellaceae — *Mortierella*
      - iv. Saksenaeaceae — *Saksenaea*
      - v. Syncephalastraceae — *Syncephalastrum*
    - b. Entomophthorales — *Basidiobolus*, *Conidiobolus*
- C. Ascomycotina
  - 1. Hemiascomycetes
    - a. Endomycetales
      - i. Spermophthoraceae — *Metschnikowia*
      - ii. Endomycetaceae — *Endomyces*
      - iii. Saccharomycetaceae — *Kluyeromyces*, *Lodderomyces*, *Pichia*, *Saccharomyces*
  - 2. Ascoloculomycetes
    - a. Dothideales
      - i. Testudinaceae — *Neotestudina*
      - ii. Pleosporaceae — *Leptosphaeria*
      - iii. Piedraiaceae — *Piedraia*
  - 3. Ascohymenomycetes
    - a. Eurotiales
      - i. Eurotiaceae — *Emericella*, *Eurotium*, *Neosartorya*
      - ii. Gymnoascaceae — *Ajellomyces*, *Arthroderma*, *Emmonsiella*, *Nannizzia*
    - b. Sphaeriales
      - i. Microascaceae — *Microascus*, *Petriellidium*, *Pithoascus*
      - ii. Ophiostomataceae — *Ceratocystis*

D. Basidiomycotina	
1. Teliomycetes	
a. Ustilaginales	
i. Filobasidiaceae	*Filobasidiella*
ii. Ustilaginaceae	*Ustilago*
2. Hymenomycetes	
a. Agaricales	
i. Coprinaceae	*Coprinus cinereus*
b. Aphyllophorales	
i. Schizophyllaceae	*Schizophyllum commune*
3. Gasteromycetes	
E. Fungi Imperfecti	
1. Blastomycetes	*Candida*
	Cryptococcus
	Loboa
	Pityrosporum
	Rhodotorula
	Torulopsis
2. Hyphomycetes	*Trichosporon*
a. "Moniliaceous"	
	Acremonium
	Arthrographis
	Aspergillus
	Beauveria
	Blastomyces
	Chrysosproium
	Coccidioides
	Epidermophyton
	Fusarium
	Fusidium
	Geotrichum
	Histoplasma
	Indiella
	Madurella
	Microsporum
	Paecilomyces
	Paracoccidioides
	Penicillium
	Prototheca
	Rhinosporidium
	Scopulariopsis
	Sporothrix
	Trichophyton
b. "Dematiaceous"	*Acrotheca*
	Alternaria
	Aureobasidium
	Cladosporium

Curvularia
Dactylaria
Drechslera
Exophiala
Ochroconis
Phialophora
Ramichloridium
Rhinocladiella
Sarcinomyces
Torula
Trichocladium
Tritirachium
Wallemia

3. Coelomycetes
   a. Sphaeropsidales

Hendersonula
Macrophoma
Madurella
Phoma
Pyrenochaeta

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