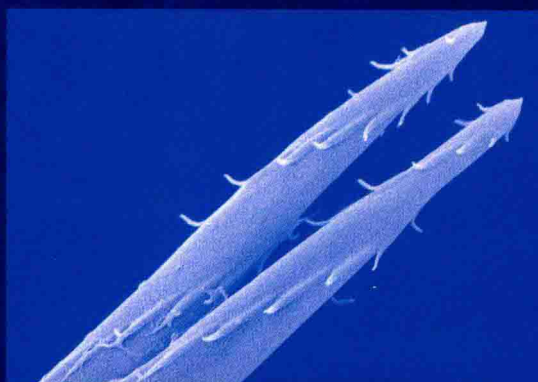
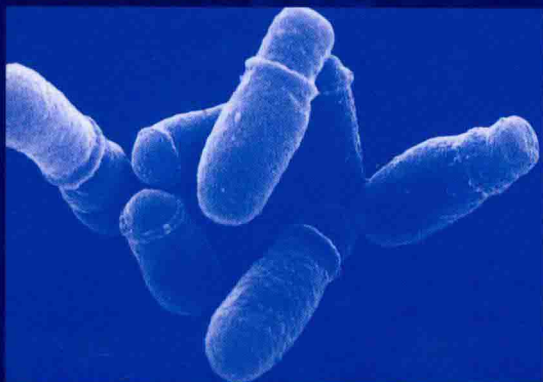
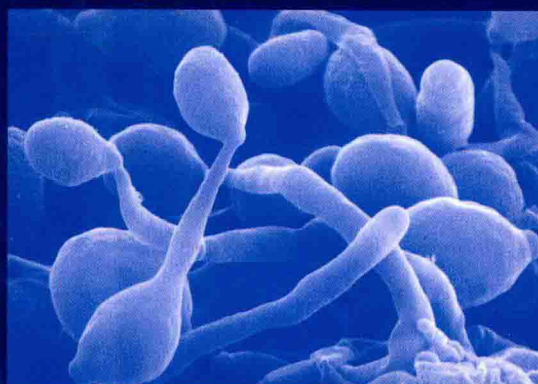
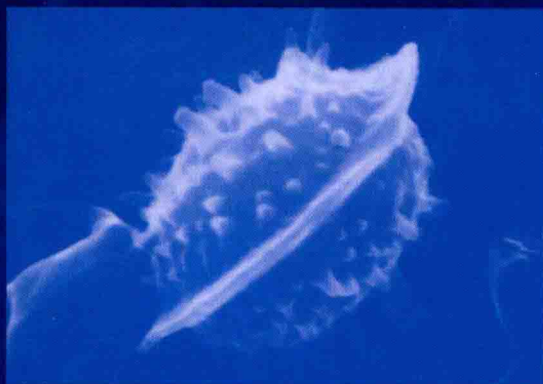


THE YEASTS

A TAXONOMIC STUDY

FIFTH EDITION



VOLUME 1

EDITED BY
C.P. KURTZMAN • J.W. FELL • T. BOEKHOUT

The Yeasts, a Taxonomic Study

Volume 1

Fifth Edition

Edited by

Cletus P. Kurtzman

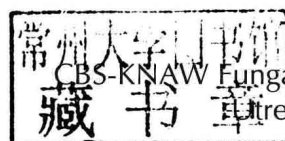
Bacterial Foodborne Pathogens and Mycology Research Unit
National Center for Agricultural Utilization Research
Agricultural Research Service, US Department of Agriculture
Peoria, Illinois, USA

Jack W. Fell

Rosenstiel School of Marine and Atmospheric Science
University of Miami
Key Biscayne, Florida, USA

and

Teun Boekhout



CBS-KNAW Fungal Biodiversity Centre
Utrecht, The Netherlands



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Elsevier
32 Jamestown Road, London NW1 7BY, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
525 B Street, Suite 1800, San Diego, CA 92101-4495, USA

First edition 1952
Second edition 1970
Third edition 1984
Fourth edition 1998
Fifth edition 2011

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Except chapters 13, 17, 18, 20, 33, 37, 38, 42, 44, 47, 48, 51, 53, 54, 55, 56, 57, 59, 60, 64, 65, 70, 72, 75, 78, 80, 81, 82, 85 and 99 which are in the Public Domain.

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British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

ISBN: 978-0-444-52149-1 (Set)
ISBN: 978-0-123-84708-9 (Volume 1)
ISBN: 978-0-123-84707-2 (Volume 2)
ISBN: 978-0-123-84868-0 (Volume 3)

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Typeset by MPS Limited, a Macmillan Company, Chennai, India
www.macmillansolutions.com

Printed and bound in United States of America

10 11 12 13 14 15 10 9 8 7 6 5 4 3 2 1

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The Yeasts, a Taxonomic Study

Volume 1

This book is dedicated to the memory of

Robert J. Bandoni

Helen R. Buckley

Nellie J. W. Kreger-van Rij

Martin W. Miller

Herman J. Phaff

Wilhelmina Ch. Slooff

Isabel Spencer-Martins

Preface

The importance of yeasts is underscored by our often daily consumption of bread and fermented beverages. Recent advances in biotechnology have increased our reliance on yeasts for pharmaceuticals and for bulk biochemicals such as citric acid. Furthermore, clinically important yeasts are commonplace, especially as numbers of immunosuppressed patients increase, and biologists are continuing to discover the importance of yeasts in the ecosystem and their application in the biocontrol of plant pests. All of these areas of science and technology have a common need: the rapid and accurate identification of yeasts. The goal of this book is to provide that information.

This book, the fifth edition of *The Yeasts, a Taxonomic Study*, represents a continuation of the monographic series begun by J. Lodder and N.J.W. Kreger-van Rij (1st edn, 1952), J. Lodder (2nd edn, 1970), N.J.W. Kreger-van Rij (3rd edn, 1984) and C.P. Kurtzman and J.W. Fell (4th edn, 1998). In the fourth edition (1998), 100 genera and over 700 species were described. In the present edition, there are 149 genera and nearly 1500 species. The application of gene sequence analysis is largely responsible for the increase in the number of taxa presented in this edition. In 1998 and in 2000, diagnostic gene sequences were published for essentially all known yeasts. This advance allowed rapid, accurate species identification for the first time, and the method has been widely adopted by the yeast com-

munity to catalogue new species. Sequence analysis has also demonstrated that genera were often polyphyletic, and from such analyses many genera are now phylogenetically circumscribed. There is still much to do to understand phylogenetic relationships among species and genera, but a good start has been made.

In this edition, a large array of fermentation and growth tests is reported for each species. These tests can be used for species identification, but as this is now commonly done from gene sequences, their major value is to provide information for the selection of biotechnologically important species, to understand how metabolism affects species ecology and for the selective isolation of taxa. Many of the species are illustrated by photographs or line drawings because it is important to know the species morphology and the method of growth.

This edition includes chapters on the importance of yeasts and the current methods used for their identification and classification. We hope readers will find these chapters useful, and that they will provide a starting point for more extensive studies with a fascinating group of fungi that we know as the yeasts.

Cletus P. Kurtzman
Jack W. Fell
Teun Boekhout

Feng-Yan Bai, Key Laboratory of Systematic Mycology and Lichenology, Institute of Microbiology, Chinese Academy of Sciences, Datun Road, Chaoyang District, Beijing 100101, China

Robert J. Bandoni, Prof. Emeritus, Botany Department, University of British Columbia, Vancouver, BC, Canada V6T 1Z4, Deceased

Roma Batra, Theodores Cove, Pewaukee, Wisconsin 53072, USA

Meredith Blackwell, Department of Biological Sciences, Louisiana State University, Baton Rouge, Louisiana 70803, USA

Teun Boekhout, CBS-KNAW Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands

Kyria Boundy-Mills, Department of Food Science and Technology, University of California Davis, California 95616, USA

Stanley Brul, Swammerdam Institute for Life Sciences, University of Amsterdam, Nieuwe Achtergracht 166, 1018WV Amsterdam, The Netherlands

Neza Cadez, Biotechnical Faculty, University of Ljubljana, Ljubljana, Slovenia

Chee-Jen Chen, Department of Biotechnology, Southern Taiwan University, Tainan 71043, Taiwan, ROC

Chester R. Cooper, Department of Biological Sciences, Youngstown State University, One University Plaza, Youngstown, Ohio 44555, USA

Melanie T. Cushion, University of Cincinnati, College of Medicine, 231 Albert Sabin Way, Cincinnati, Ohio 45267-0560, USA

Piet W.J. de Groot, Biomolecular Mass Spectrometry, Swammerdam Institute for Life Sciences, University of Amsterdam, Nieuwe Achtergracht 166, 1018WV Amsterdam, The Netherlands

G. Sybren de Hoog, CBS-KNAW Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands

Carlos Echavarri-Erasun, Instituto Madrileño de Estudios Avanzados (IMDEA) Energía, Madrid 28023, Spain

Jack W. Fell, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, 4600 Rickenbacker Causeway, Key Biscayne, Florida 33149, USA

Graham H. Fleet, School of Chemical Sciences and Engineering, University of New South Wales, Sydney, New South Wales, Australia, 2052

Álvaro Fonseca, Centro de Recursos Microbiológicos (CREM), Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal

Markus Göker, Universität Tübingen, Lehrstuhl Spezielle Botanik und Mykologie, Auf der Morgenstelle 1, D-72076 Tübingen, Germany

Wladyslav I. Golubev, Russia Collection of Microorganisms (VKM), Institute for Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, Pushchino, Russia

Eveline Guého-Kellermann, INSERM, 5 rue de la Huchette, 61400 sur Huisne, France

Makiko Hamamoto, Department of Life Sciences, School of Agriculture, Meiji University, Kawasaki, Kanagawa, Japan

Yasuko Hannafusa, Department of Infectious Diseases, National Institute of Animal Health, Kannondai, Tsukuba, Ibaraki, Japan

João Inácio, Centro de Recursos Microbiológicos (CREM), Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal

Stephen James, National Collection of Yeast Cultures, Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA, UK

Wojciech J. Janisiewicz, Appalachian Fruit Research Station, ARS/USDA, Kearneysville, West Virginia 25430, USA

Eric A. Johnson, Department of Bacteriology, Food Research Institute, University of Wisconsin, Madison, Wisconsin 53706, USA

Scott P. Keely, University of Cincinnati College of Medicine, 231 Albert Sabin Way, Cincinnati, Ohio 45267-0560, USA

Julia Kerrigan, Department of Entomology, Soils, and Plant Sciences, Clemson University, Clemson, South Carolina 29634-0315, USA

- Roland Kirschner**, Botanisches Institut, J.W. Goethe-Universität Frankfurt am Main, Siesmayerstr. 70, D-60323 Frankfurt/Main, Germany
- Frans M. Klis**, Swammerdam Institute for Life Sciences, University of Amsterdam, BioCentrum Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands
- Johan L.F. Kock**, Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
- Cletus P. Kurtzman**, Bacterial Foodborne Pathogens and Mycology Research Unit, National Center for Agricultural Utilization Research, ARS, USDA, 1815 N University Street, Peoria, Illinois 61604-3999, USA
- Kyung J. Kwon-Chung**, Molecular Microbiology Section, Laboratory of Clinical Infectious Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland, USA
- Marc-André Lachance**, Department of Biology, University of Western Ontario, London, Ontario, Canada N6A 5B7
- Ksenija Lopandic**, Austrian Center of Biological Resources and Applied Mycology, Institute of Applied Microbiology, University of Natural Resources and Applied Life Sciences, Muthgasse 18, 1190 Vienna, Austria
- David Malloch**, New Brunswick Museum, 277 Douglas Avenue, Saint John, NB, Canada E2K 1E5
- Rosa Margesin**, Institute of Microbiology, University of Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria
- Alessandro Martini**, Industrial Yeasts Collection DBVPG, Università degli Studi, 06121 Perugia, Italy
- Martin W. Miller**, Department of Food Science and Technology, University of California Davis, California 95616, USA, Deceased
- Wally H. Müller**, Department of Molecular Cell Biology, Electron Microscopy, Utrecht University, Padualaan 8, NL-3584 CH Utrecht, The Netherlands
- Takashi Nakase**, NITE Biological Resource Center, Department of Biotechnology, National Institute of Technology and Evaluation, Chiba, 292-0818, Japan
- Nhu H. Nguyen**, Department of Plant and Microbial Biology, University of California, Berkeley, California 94720-3102, USA
- Hiromi Nishida**, Agricultural Bioinformatics Research Unit, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan
- Franz Oberwinkler**, Universität Tübingen, Institut für Biologie I, Lehrstuhl Spezielle Botanik und Mykologie, Auf der Morgenstelle, 1, D-72076 Tübingen, Germany
- Roger W. Payne**, Statistics Department, IACR-Rothamsted, Harpenden, Hertfordshire AL5 2JQ, UK
- Gabor Péter**, National Collection of Agricultural and Industrial Microorganisms, Faculty of Food Sciences, Corvinus University of Budapest, Hungary
- Herman J. Phaff**, Department of Food Science and Technology, University of California, Davis, California 95616, USA, Deceased
- David N. Phalen**, The Schubot Exotic Bird Health Center, Department of Veterinary Pathobiology, Texas A&M University, College Station, Texas, USA
- Jure Piškur**, Cell and Organism Biology, Lund University, Solvegatan 35, 22362 Lund, Sweden
- R. Scott Pore**, West Virginia University School of Medicine, Morgantown, West Virginia, 26506, USA
- Gandham S. Prasad**, Microbial Type Culture Collection and Gene Bank (MTCC), Institute of Microbial Technology (IMTECH), Council of Scientific and Industrial Research (CSIR), Sector-39A, Chandigarh 160036, India
- Hansjörg Prillinger**, Institut für Angewandte Mikrobiologie, Universität für Bodenkultur, Vienna, Austria
- Vincent Robert**, CBS-KNAW Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands
- Miguel G. Rodrigues**, Biopremier – Innovation and Services in Biotechnology, S.A., Edif. ICAT, Campus da Faculdade de Ciências de Lisboa, 1749-016 Lisboa, Portugal
- Carlos A. Rosa**, Universidade Federal de Minas Gerais, Departamento de Microbiologia, Belo Horizonte, Brazil
- E. Rozpędowska**, Cell and Organism Biology, Lund University, Solvegatan 35, 22362 Lund, Sweden
- José Paulo Sampaio**, Centro de Recursos Microbiológicos (CREM), Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
- David A. Schisler**, Crop Bioprotection Research Unit, National Center for Agricultural Utilization Research, ARS, USDA, 1815 N University Street, Peoria, Illinois 61604-3999, USA
- Gloria Scorzetti**, Rosenstiel School Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Key Biscayne, Florida 33149, USA
- Maudy Th. Smith**, CBS Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands
- William T. Starmer**, Biology Department, Syracuse University, Syracuse, New York 13244, USA
- Adele Statzell-Tallman**, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600

Rickenbacker Causeway, Key Biscayne, Florida 33149, USA

Malcolm Stratford, School of Biology, B64 Biology Building, University of Nottingham, Nottingham WG7 2RD, UK

Takashi Sugita, Department of Microbiology, Meiji Pharmaceutical University, 2-522-1 Noshio, Kiyose, Tokyo 204-8588, Japan

Junta Sugiyama, TechnoSuruga Laboratory Co. Ltd, Chiba Branch Office & Lab, 2102-10, Dainichi, Yotsukaido-shi, Chiba-ken 284-0001, Japan

Sung-Oui Suh, Mycology Program, American Type Culture Collection (ATCC), 10801 University Blvd., Manassas, Virginia 20110, USA

Motofumi Suzuki, Microbe Division, Japan Collection of Microorganisms (JCM) RIKEN, BioResource Center, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan

Masako Takashima, Microbe Division, Japan Collection of Microorganisms (JCM) RIKEN, BioResource Center, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan

Elizabeth K. Tomazewski, The Schubot Exotic Bird Health Center, Department of Veterinary Pathobiology, Texas A&M University, College Station, Texas, USA

Ida van der Klei, Molecular Cell Biology, Groningen Biomolecular Sciences and Biotechnology Institute (GBB), University of Groningen, PO Box 14, 9750 AA Haren, The Netherlands

Ann Vaughan-Martini, Industrial Yeasts Collection, DBVPG, Università degli Studi, 06121 Perugia, Italy

Kenneth G.A. van Driel, CBS-KNAW Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands

Marten Veenhuis, Molecular Cell Biology, Groningen Biomolecular Sciences and Biotechnology Institute (GBB), University of Groningen, PO Box 14, 9750 AA Haren, The Netherlands

Michael Weiss, Universität Tübingen, Lehrstuhl Spezielle Botanik und Mykologie, Auf der Morgenstelle 1, D-72076 Tübingen, Germany

Ken Wolfe, Smurfit Institute of Genetics, Trinity College Dublin, Dublin 2, Ireland

Michael Wuczkowski, Austrian Center of Biological Resources and Applied Mycology, Institute of Applied Microbiology, University of Natural Resources and Applied Life Sciences, Muthgasse 18, 1190 Vienna, Austria

Acknowledgments

The Editors are grateful to Dr Walter Gams for his expert advice on nomenclatural issues.

Cletus P. Kurtzman thanks Dianna Halcumb for manuscript processing and the preparation of tables, Don Fraser for graphics, and Christie J. Robnett and Eleanor Basehoar-Powers for technical assistance.

For the *Ecology of Yeasts* chapter, the authors would like to thank and recognize their colleague in research, Virginia Aberdeen, for her insights and assistance in their studies on yeast ecology and evolution over the last few decades. They acknowledge grants from the Natural Science and Engineering Research Council of Canada as well as the National Science Foundation of the United States.

Julia Kerrigan thanks Jack D. Rogers for introducing her to the fascinating genus *Botryozyma*.

The *Spathaspora* chapter was supported in part by National Science Foundation Grants DEB-0072741 and NSF DEB-0417180 and REU supplements. The authors acknowledge the use of the DNA sequencing facility supported by NSF Multiuser Equipment Grant (DBI-0400797) to Robb Brumfield.

Stephen A. James and Malcolm Stratford would like to extend their thanks to James and Linda Barnett for kindly providing them with the photomicrographs used in the *Zygosaccharomyces* chapter.

Wadyslaw I. Golubev thanks Jack W. Fell for providing the Figure 121.1.

The research by Jack W. Fell, Adele Statzell-Tallman and Gloria Scorzetti was funded by the National Science Foundation (USA) Biotic Surveys and Inventories Grant DEB-0206521.

Eveline Guého-Kellerman and Teun Boekhout are particularly grateful to Dr Bernard Papierok (Fungal Collection in Pasteur Institute, Paris France) and his collaborators Martine Kiredjian and Marie-Ange Rouffaud who allowed E. Guého-Kellerman to investigate the phenotypic characteristics of some recently described *Malassezia* species. They also thank Anne-Françoise Miegerville

(Medical School, Antibiology Laboratory, Nantes, France) for the SEM micrographs of most *Malassezia* species.

Teun Boekhout acknowledges Bart Theelen and Marizeth Groenewald of CBS for help with some physiological tests, preparation of phylogenetic trees and making available some yeast strains.

Frans Klis acknowledges the support of the EU (FP6, STREP Program FungWall, LSHB-CT-2004-511952). Ida van der Klei and Marten Veenhuis thank Arjen Krikken and Ron Booij for skillful help in preparing the micrographs.

The authors of *Taphrina* wish to thank Cletus P. Kurtzman (ARS, Illinois, USA), Vincent Robert (CBS, The Netherlands), Hansjörg Prillinger (IAM, Austria) and Robert Bandoni (UBC, Canada) for providing most of the cultures studied. They thank Kamila Bacigálová (Institute of Botany, Slovakia) for providing reprints of her publications and João Inácio (CREM, Portugal) for assistance in the preparation of figures.

The phylogenetic trees presented in *Filobasidium* and *Chionosphaera* were kindly prepared by Jack Fell.

The authors of *Trichomonascus* would like to thank Bert Gerrits van den Ende and Gé A. Poot for their technical assistance.

The authors of *Cryptococcus* thank João Inácio (Univ. Nova de Lisboa, Portugal) and Bart Theelen (CBS, The Netherlands) for assistance in the preparation of some of the figure files.

Makiko Hamamoto thanks Masaki Itoi, Momoko Takahashi, Takashi Kuramoto, Mihoko Saitou and Masaru Serizawa for their assistance with the photomicrography of *Sporobolomyces* species, and Yusuke Nakamura, Nobuhiro Kokubun and Junya Suzuki for nucleotide sequencing.

André Lachance would like to offer a special acknowledgement to Allison Kwan, distinguished pianist and yeast photographer.

Roger Payne provided the comprehensive taxonomic keys to the genera *Trichosporon* and *Rhodotorula*.

1. INTRODUCTORY CHAPTERS

With the widespread use of gene sequences for yeast identification, the number of known species has doubled since publication of the fourth edition of this book in 1998. As a result, the book has grown from one to three volumes. As in previous editions, the book begins with introductory chapters that discuss the definition of yeasts, their importance and the means for their characterization and classification. Thus in Volume 1, Part I discusses the current definition of yeasts, their classification and the rules for their nomenclature. Part II focuses on yeasts that are human and plant pathogens, those that cause food and beverage spoilage, species used for biocontrol of plant pests, their applications in biotechnology, and an overview of yeast ecology. Part III provides chapters on phenotypic characterization, chemotaxonomy, ultrastructure and molecular biological characters that are used to identify yeasts and to develop a phylogenetic framework for their classification. Volume 2 is devoted to the ascomycetous yeasts, and Volume 3 includes the basidiomycetous yeasts, along with the genus *Prototheca*.

The format of this edition differs from previous editions in the placement of the all-species key, summary table of species characteristics, glossary, and indexes to taxa and literature references in Volume 1 with the introductory chapters, rather than at the back of the book as was done previously. Because we now have three volumes, we reasoned that it would be more convenient, while looking for taxa and their references or keying species, to have these sections in a separate volume from the species descriptions, thus avoiding the need to flip between the front to back of a single volume while looking for the information. We hope that readers will find this format to be a convenient choice for a multi-volume taxonomic work.

2. DESCRIPTIONS OF GENERA AND SPECIES

Genera are arranged alphabetically within four groups: teleomorphic ascomycetes, anamorphic ascomycetes, teleomorphic basidiomycetes and anamorphic basidiomycetes. The introductory chapters for both ascomycetes and basidiomycetes include discussions of genera and their phylogenetic placement. These discussions also note relationships between teleomorphic and anamorphic genera. Each chapter begins with a narrative description of the genus, a phylogenetic tree that depicts species relationships within the genus, and a key to species based on growth characteristics, which is followed by a table that includes the key characters. Each species description begins with a designation of the anamorph or teleomorph, where known, followed by a listing of synonyms. The characterization proceeds to morphological and physiological descriptions. Representative species for each genus are illustrated by either drawings or photographs, which include a scale bar and growth conditions. Noteworthy information for the species is given in sections entitled Systematics, Ecology, Biotechnology, Agriculture and food, and Clinical importance.

Abbreviations used throughout the text are standard. For mol% G+C of nuclear DNA, the method for determination is included and abbreviated as follows: T_m , thermal melt; BD, buoyant density; HPLC, high-pressure liquid chromatography.

The following symbols are used for the fermentation and assimilation reactions given with species descriptions:

+	positive
l	latent (rapid development of a positive reaction after a lag period)
+/l	positive or latent
s	positive but slow
w	weak
ws	weak and slow
+/w	positive or weak
w/-	weak or negative
lw	latent but weak (rapid development of a weak reaction after a lag period)
-/l	negative or latent
v	variable
-	negative
n	no data

3. YEAST-LIKE TAXA

Some microbial taxa that could be mistaken as yeasts are briefly discussed. For example, species of the dimorphic euascomycete genus *Aureobasidium* are commonly isolated, and often appear white to light pink in color and yeast-like on isolation plates. Consequently, *Aureobasidium pullulans* is included in the all-species key. Similarly, the achlorophyllic algal genus *Prototheca* is often misidentified as a yeast, and for this reason a chapter on the genus is included.

4. SPECIES SUMMARY TABLE AND KEY TO ALL TAXA

A summary table of fermentation and assimilation reactions and certain key biochemical characteristics is placed near the end of Volume 1. Taxa are listed alphabetically, first by genus and then by species. A key using the physiological data in the table includes all species of ascomycetes, basidiomycetes and the genus *Prototheca* for which data are available. The following abbreviated symbols are used in the table and for the key:

+	+, s, l, +/l, +/w, w, ws, lw
-	-
v	v, w/-, -/l
n	no data or not applicable

5. GLOSSARY

A glossary has been provided that includes morphological, genetic and molecular biological terms.

6. INDEXES TO TAXA

There are two indexes to taxa. The first lists genera followed by assigned species and their synonyms. Validly accepted combinations

are in bold type. The second index alphabetically lists all species and variety names followed by all genera to which the species and varieties were assigned. Validly accepted genera are in bold type.

7. REFERENCES

The references for all chapters have been consolidated into a single list. This saved sufficient space to allow inclusion of titles which would have been omitted if each chapter had a reference list.

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