CRC Handbook of Microbiology

2nd Edition

Volume I
Bacteria

EDITORS:

Allen I. Laskin, Ph.D.

Hubert A. Lechevalier, Ph.D.

CRC Handbook of Microbiology

2nd Edition

Volume I
Bacteria

EDITORS:

Allen I. Laskin, Ph.D.

Exxon Research and Engineering Company

Hubert A. Lechevalier, Ph.D.

Waksman Institute of Microbiology
Rutgers University

CRC PRESS, Inc.
18901 Cranwood Parkway · Cleveland, Ohio 44128

Library of Congress Cataloging in Publication Data

Laskin, Allen I 1928–
Bacteria.

(CRC handbook of microbiology; v. 1)
Bibliography: p.
Includes index.
1. Bacteria. I. Lechevalier, Hubert A., joint author. II. Title. III. Series.
QR6.C2 1977 vol. 1 [QR412] 576'.08 [589.9]
ISBN 0-8493-7201-1 (v. 1) 77-12459

This book represents information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A wide variety of references are listed. Every reasonable effort has been made to give reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

All rights reserved. This book, or any parts thereof, may not be reproduced in any form without written consent from the publisher.

© 1977 by CRC Press, Inc.

International Standard Book Number 0-8493-7201-1

Library of Congress Card Number 77-12459
Printed in the United States

PREFACE

The first edition of the CRC HANDBOOK OF MICROBIOLOGY consisted of four volumes. The first of these, entitled *Organismic Microbiology*, was published in 1973 and dealt with information dealing with the organisms themselves. The revised, enlarged material dealing with this subject could not be conveniently bound within a single cover. Thus, we decided to include only information on bacteria in the first volume of the second edition of this handbook. The second volume of this series will contain information dealing with fungi, algae, protozoa, and viruses.

We wish to thank all those who directly or indirectly have made constructive criticisms of the first edition of the HANDBOOK OF MICROBIOLOGY. We have tried to present information on bacteria in an order that could easily be related to that followed in the 8th edition of *Bergey's Manual of Determinative Bacteriology*. We opted not to follow the order suggested by one of our critics, John Sieburth, but we think that our readers will be able to profit from his ideas as presented in the Introduction to this volume. Completely new subjects covered in this second edition include a chapter on paleomicrobiology by A. Knoll and one on bacterial cytology by B. K. and Arati Ghosh.

We extend our thanks to the members of the Advisory Board and to all our authors, who have worked so unselfishly to make this second edition possible. We also wish to express our gratitude to Mrs. Lisbeth Hammer and to Mrs. Verna Lepping for their excellent editorial work.

A. I. Laskin
H. A. Lechevalier
New Jersey, 1977

THE EDITORS

Allen I. Laskin, Head of Biosciences Research at Exxon Research and Engineering Company, Linden, N.J., received his B.S. degree in Biology from the City College of New York in 1950. His M.A. and Ph.D. degrees in Microbiology were obtained from the University of Texas in 1952 and 1955 respectively.

From 1955 to 1969 Dr. Laskin was at the Squibb Institute for Medical Research, first as Senior Research Microbiologist, then as Head of Microbial Biochemistry, and subsequently as Assistant Director of Microbiology. His research on microbial transformations of steroids led to several publications and more than twenty U.S. patents. Dr. Laskin then switched to molecular biology and studies on cell-free protein and cell wall synthesis, which led to work on the mode of action of tetracycline and several other antibiotics. In 1969 Dr. Laskin joined Exxon Research and Engineering Company to head the laboratory program concerned with single-cell protein. In 1971 he moved to his present position, heading the research on petroleum microbiology and enzymology.

Dr. Laskin is President-Elect of the Society for Industrial Microbiology, a Fellow of the American Academy of Microbiology, a Fellow of the New York Academy of Sciences, and recipient of the 1974 Selman A. Waksman Honorary Lectureship Award. At present he serves on the Panel on Microbial Degradation of Oil of the American Petroleum Institute and as Chairman of a subgroup for a National Academy of Sciences/National Research Council Panel on Underutilized Microbial Processes of Potential Value. Earlier Dr. Laskin was President of the Theobald Smith Society (New Jersey Branch, ASM) and National Councilor for many years. He was Vice-Chairman of the local committee for the 1965 ASM National Meeting and Chairman for the 1976 National Meeting. He also served as Chairman of the Environmental and General Applied Microbiology Division and of the Fermentation Division of ASM, as well as of the Microbiology Section of the New York Academy of Sciences.

Dr. Laskin is not only Co-Editor of the *CRC Handbook of Microbiology* and of *CRC Critical Reviews in Microbiology*, but also of a series entitled *Methods in Molecular Biology* as well as of the books *Extracellular Microbial Polysaccharides* and *The Problems of Drug-Resistant Bacteria*. In addition, he serves as Editor for a series of books on microbiology. Dr. Laskin has also authored and co-authored reviews on the mode of action of tetracycline and on single-cell protein, as well as organized and chaired numerous symposia, seminars, and conferences.

Hubert A. Lechevalier, Professor of Microbiology at Rutgers University, New Brunswick, N.J., received a Licence ès Sciences Naturelles (*summa cum laude*) in 1947 and his M.S. degree (*cum laude*) in 1948 from Laval University, Quebec City, Canada. He obtained his Ph.D. from Rutgers University in 1951.

Dr. Lechevalier remained at Rutgers University as Assistant Professor of Microbiology from 1951 to 1956, and subsequently as Associate Professor, before advancing to his present position in 1966. Within this period he also was an exchange scientist at the Academy of Sciences of the U.S.S.R. in Moscow, Visiting Investigator at the Czechoslowak Academy of Sciences in Prague, and Visiting Investigator at the Pasteur Institute, Section of Mycology, in Paris. His research during those years led to U.S. patents for neomycin and candicidin as wlll as to sixteen foreign patents.

A recipient of Fellowships from the National Research Council of Canada, from Rutgers University, and from the U.S. Public Health Service, Dr. Lechevalier was also awarded membership in Sigma Xi and is an Associate Member of the Société Française de Microbiologie. In 1976 he received the Lindbach Award for Distinguished Research.

In addition to his membership in the American Society for Microbiology, in the Canadian Society for Microbiologists, and in the Mycological Society of America, Dr. Lechevalier has served as a participant on the Editorial Boards of *Applied Microbiology* and of *Annales de Microbiologie*, on the Subcommittee on the Taxonomy of the Actinomycetes of the International Committee on Bacteriological Nomenclature, on the Subcommittee on Tastes and Odors of the American Water Works Association, and on the ASM Archives Committee. He also served as Chairman of the AMS Subcommittee on Actinomycetes, as a Trustee of the American Type Culture Collection, and as consultant to various industrial and legal firms.

Dr. Lechevalier is not only Co-Editor of the *CRC Handbook of Microbiology* and of *CRC Critical Reviews in Microbiology*, but has also collaborated on a number of books – *A Guide to the Actinomycetes and Their Antibiotics, Neomycin – Nature, Formation, Isolation, and Practical Application, Neomycin – Its Nature and Practical Application, Antibiotics of Actinomycetes, Three Centuries of Microbiology*, and *The Microbes*. He has also authored or co-authored numerous papers.

此为试读，需要完整PDF请访问：www.ertongbook.com

ADVISORY BOARD

CHAIRMAN

Hans-Wolfgang Ackermann, M.D.
Department of Microbiology
Faculty of Medicine
Laval University
Quebec, P.Q., Canada

MEMBERS

Carl F. Clancy, Ph.D.
Department of Microbiology
Jefferson Medical College
Thomas Jefferson University
Philadelphia, Pennsylvania

Cecil. S. Cummins, Sc.D.
Anaerobe Laboratory
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Martin Dworkin, Ph.D.
Department of Microbiology
University of Minnesota
Minneapolis, Minnesota

Eugene R. L. Gaughran, Ph.D.
Research Center
Johnson & Johnson
North Brunswick, New Jersey

Nancy N. Gerber, Ph.D.
Waksman Institute of Microbiology
Rutgers University
Piscataway, New Jersey

S. H. Hutner, Ph.D.
Haskins Laboratories
Pace University
New York, New York

Karl Maramorosch, Ph.D.
Waksman Institute of Microbiology
Rutgers University
Piscataway, New Jersey

Yoshiro Okami, Ph.D.
Institute of Microbial Chemistry
Microbial Chemistry Research Foundation
Shinagawa-Ku, Tokyo, Japan

William M. O'Leary, Ph.D.
Department of Microbiology
Cornell University Medical College
New York, New York

David Pearlman, Ph.D.
School of Pharmacy
University of Wisconsin
Madison, Wisconsin

Frank Persico, Ph.D.
Biochemical Research
Ortho Pharmaceutical Corporation
Raritan, New Jersey

Herman J. Phaff, Ph.D.
Department of Food Science and Technology
College of Agricultural and Environmental Sciences
University of California
Davis, California

Thomas B. Platt, Ph.D.
Bioanalytical Section
The Squibb Institute of Medical Research
New Brunswick, New Jersey

Otto J. Plescia, Ph.D.
Waksman Institute of Microbiology
Rutgers University
Piscataway, New Jersey

Chase Van Baalen, Ph.D.
Marine Science Institute
University of Texas
Port Aransa, Texas

Claude Vezina, Ph.D.
Department of Microbiology
Ayerst Research Laboratories
St. Laurent, P.Q., Canada

L. C. Vining, Ph.D.
Department of Biology
Dalhousie University
Halifax, N.S., Canada

E. D. Weinberg, Ph.D.
Department of Microbiology
Indiana University
Bloomington, Indiana

CONTRIBUTORS

Carl F. Clancy, Ph.D.
Associate Professor of Microbiology (Retired)
Jefferson Medical College
Thomas Jefferson University
Philadelphia, Pennsylvania

Rita R. Colwell, Ph.D.
Professor of Microbiology
Director of the Sea Grant Program
University of Maryland
College Park, Maryland

Cecil S. Cummins, Sc.D.
Professor of Microbiology
Anaerobe Laboratory
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Martin Dworkin, Ph.D.
Professor, Department of Microbiology
University of Minnesota
Minneapolis, Minnesota

Paul Fiset, M.D., Ph.D.
Professor of Microbiology
School of Medicine
University of Maryland
Baltimore, Maryland

Emma C. Gergely, M.L.S.
Research and Development Division
Cooper Laboratories, Inc.
Cedar Knolls, New Jersey

Arati Ghosh, Ph.D.
Research Associate
College of Medicine and Dentistry
Rutgers Medical School
Piscataway, New Jersey

Bijan K. Ghosh, D.Sc.
Associate Professor
College of Medicine and Dentistry
Rutgers Medical School
Piscataway, New Jersey

Ian Gibson, Ph.D.
Senior Lecturer
School of Biology
University of East Anglia
Norwich, England

Michael Goodfellow, Ph.D.
Lecturer, Department of Microbiology
University of Newcastle
Newcastle upon Tyne, England

Ruth E. Gordon, Ph.D.
Professor of Microbiology
Waksman Institute of Microbiology
Rutgers University
Piscataway, New Jersey

Corinne L. Johnson, Ph.D.
Visiting Assistant Professor, Department of Microbiology
Vassar College
Poughkeepsie, New York

Andrew H. Knoll, Ph.D.
Assistant Professor of Geology
Oberlin College
Oberlin, Ohio

George Kwapinski, D.M., D.Sc.
Professor and Director
Institute of Immunodiagnosis
Brashear, Missouri

Hubert A. Lechevalier, Ph.D.
Professor of Microbiology
Waksman Institute of Microbiology
Rutgers University
Piscataway, New Jersey

William F. Myers, Ph.D.
Assistant Professor, Department of Microbiology
School of Medicine
University of Maryland
Baltimore, Maryland

Leslie Andrew Page, Ph.D.
Research Leader, Chlamydiosis Projects
National Animal Disease Center
Agricultural Research Service
U.S. Department of Agriculture
Ames, Iowa

Norberto J. Palleroni, Ph.D.
Research Fellow, Department of Microbiology
Hoffman-LaRoche Inc.
Nutley, New Jersey

Norbert Pfennig, Ph.D.
Department Head, Nutritional Physiology of Microorganisms
Institut für Mikrobiologie
Gesellschaft für Strahlen- und Umweltforschung m. b. H.
Göttingen, Germany

Leo Pine, Ph.D.
Chief, Products Development Branch
Center for Disease Control
Public Health Service
U.S. Department of Health, Education, and Welfare
Atlanta, Georgia

Shmuel Razin, Ph.D.
Professor of Microbiology
Biomembrane Research Laboratory
Hadassah Medical School
Hebrew University
Jerusalem, Israel

Antonio H. Romano, Ph.D.
Professor of Biology
Head, Microbiology Section
University of Connecticut
Storrs, Connecticut

John McN. Sieburth, Ph.D.
Professor of Oceanography/Microbiology
Graduate School of Oceanography
University of Rhode Island
Kingston, Rhode Island

V. B. D. Skerman, D.Sc.
Professor, Department of Microbiology
University of Queensland
St. Lucia, Queensland, Australia

Robert M. Smibert, Ph.D.
Professor of Microbiology
Anaerobe Laboratory
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Louis DS. Smith, Ph.D.
Visiting Professor
Department of Microbiology
University of Washington
Seattle, Washington

James T. Staley, Ph.D.
Associate Professor, Department of Microbiology
University of Washington
Seattle, Washington

Hans G. Trüper, Ph.D.
Professor, Department of Microbiology
University of Bonn
Bonn, Germany

Joseph G. Tully, Ph.D.
Head, Mycoplasma Section
Laboratory of Infectious Diseases
National Institute of Allergy and Infectious Diseases
National Institutes of Health
Bethesda, Maryland

Charles L. Wisseman, Jr., M.D.
Professor and Chairman, Department of Microbiology
School of Maryland
Baltimore, Maryland

TABLE OF CONTENTS

此为试读,需要完整PDF请访问: www.ertongbook.com

Introduction

Paleomicrobiology

Cytological Techniques

HOW CAN WE DIVIDE THE MICROBES?

J. McN. Sieburth

The importance of a reference book lies in the value of what it contains and on how it improves with each edition. Despite the patchwork nature of the first edition of Volume I of the *Handbook of Microbiology*, and despite the inadequate and redundant coverage of certain groups, it assembled under one cover much useful and previously scattered or unpublished information. It also seemed to me that the coverage of some multicellular groups was unnecessary. The book appeared while I was preparing a text on marine microorganisms, which discusses all the major groups of microorganisms studied by phycologists, bacteriologists, mycologists, and protozoologists.[3] In using Volume I as a guide to all the microbiological disciplines, some of its strengths and weaknesses became quite apparent. When I made my criticisms known to the Editors, they invited me to write an introduction to the organismic section of the second edition of the *Handbook*. The task of creating a head for a statue for which others will produce the body and appendages is a challenging and risky assignment. The purpose of this introduction is to show one way in which the entities studied by microbiologists can be organized to minimize redundancy, that is, by dividing them into pragmatic working groups according to their ultrastructure and feeding mode.

In a simpler time, naturalists like Ehrenberg[1] studied and described microorganisms in their environment without too much worry about what kind of microorganism each was. It is a joy to study Ehrenberg's plates and see microalgae, bacteria, and protozoa side by side as they occurred in his samples. As microbiologists in succeeding decades of the 19th century advanced to the culture of many microbial forms with different nutrient requirement and morphological properties, the division between plants and animals became obscure, and the microorganisms were separated into the kingdoms Monera and Protista. Only with the advent of transmission electron microscopy and techniques for thin-sectioning and staining were the tools provided to allow ultrastructural confirmation of the similarities and differences between what we now call prokaryotes and eukaryotes and the differences between the various trophic groups. When the absorptive mode of nutrition was taken into account by Whittaker,[4] the fungi fell into a group of their own, and the divergence of the three trophic modes and that between the three levels of cellular complexity (prokaryote, unicellular eukaryote, and multicellular eukaryote) became clear. The Five Kingdom concept is a pleasing way to show the relationships of the major groups of organisms. Figure 1 shows the now famous Whittaker Five Kingdom scheme and my attempts to divide the microorganisms (Figure 1B) on the basis of discipline (Figure 1C), ultrastructure (Figure 1D), and trophic modes (Figure 1E). When the microorganisms are divided into fiefs according to disciplines, there are too many territorial disputes. None is worse than deciding which protists fall within the province of the phycologist and which belong to the protozoologist. It seems absurd to find flagellates (both chloroplast-containing and chloroplast-lacking species) being claimed by both sides. To be sure, true mixotrophs – such as the marine dinoflagellate *Gyrodinium pavillardi*, containing functional chloroplasts while actively grazing on the holotrichous ciliate *Strombidium* – will continue to raise problems, as well the atrophy of the photosynthetic apparatus in photosynthetic euglenoids and its absence in apochlorotic diatoms. However, there are too many clear-cut photosynthetic flagellates (even called phytoflagellates by the protozoologists) to warrant pulling them away from the microalgae; conversely, the existence of one possible photosynthetic choanoflagellate is not enough to pull the whole group of these phagotrophic flagellates into the phytoflagellates. There will always be exceptions to general rules, since many bizarre forms resulting from offbeat experimental approaches to life persist.

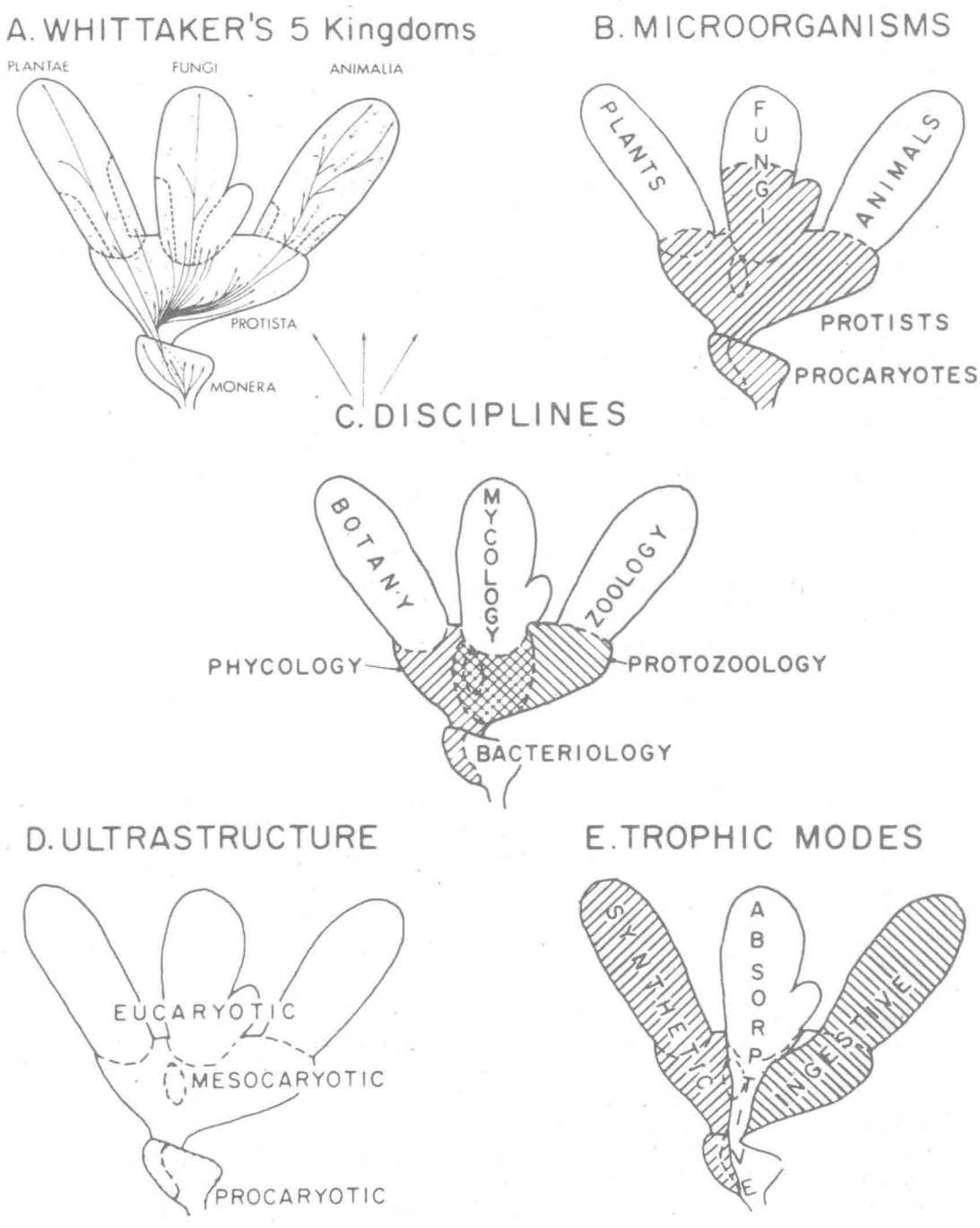

FIGURE 1. The division of the Five Kingdoms of Whittaker into microbial, disciplinary, ultrastructural, and trophic divisions. (Figure 1A taken from Whittaker, R. H., *Science*, 163, 150–160, 1969. Copyright 1969 by the American Association of Science.)

Microorganisms evolved together live together and depend upon each other, as well as on the higher forms of life, for their existence. The examination of natural populations, such as described in *Microbial Seascapes*,[2] shows the necessity of an interdisciplinary approach. The environmental and ecological problems of today require an interdisciplinary approach so that we will be able to jump the borders, knowing not only where we are, but also able to speak a common language. As I, a naive bacteriologist, tried to unravel what ultrastructural studies have done to the taxonomy of the phytoflagellates, tried to get a clearer idea of what the major groups of microscopic fungi are, and attempted to figure out which protozoa occur as free-living marine forms, I felt as though I were traveling through Europe without a road map or a phrase book. If this and other interdisciplinary texts on microorganisms are going to fulfill their function, they must be more than a compilation of uncoordinated summaries with overlapping and contradictory coverage. Of course, one has to make an arbitrary decision on how to divide the microorganisms in order to best minimize territorial disputes and serious overlaps. It would also help to speak a common and simple language. The use of jargon, such as the terms "lignicolous" or "xylophilous" for wood-digesting and wood-inhabiting microorganisms, is ridiculous.

Territorial disputes can be minimized by the simple philosophy of recognizing that, although mixotrophy occurs, most organisms have one dominant mode of nutrition. Therefore, primary division can be made according to this dominant nutritional mode, with further divisions according to ultrastructure. Although two ultrastructural kingdoms are usually recognized, a third kingdom, the Mesokaryota, has been proposed by Dodge[5] for dinoflagellates on the basis of their intermediate nuclear organization. Even including this dubious kingdom, division only by ultrastructure or only by trophic mode (Figures 1D and 1E) is insufficient to yield manageable groups. A division according to both criteria, however, results in seven convenient working groups, as shown in Table 1. The practicality of such a division is shown by further dividing the seven working groups into some 33 arbitrary vernacular groupings, as shown in Table 2, which covers the microorganisms considered in this volume and in Volume II. (For the convenience of the reader, volume and – where known – page numbers are given in parentheses for each grouping.) The size of each grouping varies greatly, but it puts the microbial realm into a manageable framework. I will not attempt here to show the reasoning behind the lumping and divisions that are made. This information will eventually be published.[3] Due to the multiple authorship of this *Handbook*, and due to the reluctance of the Editors to force the divorces, marriages, and rearrangements necessary to accomplish my suggested arrangement, the contents of the first two volumes of the second edition are presented in a different sequence than the one suggested.

These two volumes show many areas of improvement and updating over Volume I of the first edition. Their appeal is still the wide coverage of the forms studied by microbiologists. As with the microorganisms described, it will take succeeding generations to select the qualities that are needed for survival.

Table 1
DIVISION OF THE MICROBIOLOGISTS' REALM INTO WORKING GROUPS ACCORDING TO FEEDING AND ULTRASTRUCTURE TYPES

	Ultrastructural type		
Feeding type	Prokaryotes	Eukaryotes	Virions
Chemolithotrophic	+		
Phototrophic	+	+	
Osmotrophic	+	+	
Phagotrophic		+	
Ribosomotrophic			+

Table 2
SUGGESTED DIVISION OF THE SEVEN WORKING GROUPS OF MICROORGANISMS INTO VERNACULAR SUBGROUPS

I. CHEMOLITHOTROPHIC PROKARYOTES
- A. Bacteria oxidizing ammonia and nitrite (Vol. I, pp. 288, 293–296)
- B. Bacteria oxidizing sulfur and sulfur compounds (Vol. I, pp. 286, 288, 290–292)

II. PHOTOTROPHIC PROKARYOTES
- A. Cyanophytes (Vol. II)
- B. Rhodospirlla (Vol. I, pp. 119–130)

III. PHOTOTROPHIC EUKARYOTES
- A. Diatoms (Vol. II)
- B. Dinoflagellates (Vol. II)
- C. Haptophytes (Vol. II)
- D. Prasinophytes (Vol. II)
- E. Chrysophytes (Vol. II)
- F. Cryptophytes (Vol. II)
- G. Euglenophytes (Vol. II)
- H. Chlorophytes (Vol. II)
- I. Xanthophytes (Vol. II)
- J. Eustigmatophytes (Vol. II)
- K. Rhapidophytes (Vol. II)
- L. Rhodophytes (Vol. II)

IV. OSMOTROPHIC PROKARYOTES
- A. Aerobic/facultative, nondistinctive, Gram-negative:
  1. Azotobacteria (Vol. I, p. 239)
  2. Rhizobias (Vol. I, p. 240)
  3. Halobacters (Vol. I, p. 242)
  4. Enterobacters (Vol. I, pp. 259, 263–272)
  5. Vibrios (Vol. I, pp. 229–234)
  6. Neisserias (Vol. I, pp. 277, 279–282)
  7. Pseudomonads (Vol. I, pp. 237, 247–258)
- B. Aerobic/facultative, distinctive, Gram-negative:
  1. Gliding bacteria (Vol. I, p. 145)
  2. Sheathed bacteria (Vol. I, pp. 147–151)
  3. Prosthecate bacteria (Vol. I, pp. 173–185)
  4. Spirals and curved bacteria (Vol. I, pp. 237, 240, 241)
  5. Methylamonads
- C. Aerobic/facultative, Gram-positive:
  1. Cocci (Vol. I, pp. 305–307)
  2. Endospore-forming bacteria (Vol. I, pp. 317, 318)
  3. Asporogenous bacteria (Vol. I, pp. 347–350)
  4. Actinomycetes (Vol. I, pp. 361–380)
- D. Obligately anaerobic:
  1. Clostridia (Vol. I, pp. 337–345)
  2. Spirochetes (Vol. I, pp. 195–227)
  3. Gram-negative rods (Vol. I, pp. 259, 260, 262, 273–275)
  4. Gram-negative cocci (Vol. I, p. 261)
  5. Methanogenic bacteria (Vol. I, p. 301)
  6. Sulfate-reducing bacteria (Vol. I, pp. 229, 337)
- E. Mycoplasmas (Vol. I, pp. 405–459)
- F. Rickettsias (Vol. I, pp. 381–395)
- G. Chlamydias (Vol. I, pp. 397–404)

V. OSMOTROPHIC EUKARYOTES
- A. Filamentous fungi:
  1. Ascomycetous (Vol. II)
  2. Basidiomycetous (Vol. II)
  3. Deuteromycetous (Vol. II)
- B. Yeasts:
  1. Ascomycetous (Vol. II)
  2. Basidiomycetous (Vol. II)
  3. Deuteromycetous (Vol. II)
- C. Zygomycetes (Vol. II)

此为试读,需要完整PDF请访问: www.ertongbook.com