Synopsis and Classification of Living Organisms

1

Synopsis and Classification of Living Organisms

Volume 1

Contributors

Lawrence G. Abele Department of Biological Science, Florida State University.

Omar M. Amin Associate Professor, University of Wisconsin – Parkside.

Jayapaul Azariah Reader, Department of Zoology, University of Madras.

William E. Balch Department of Biochemistry, Stanford University.

Donald J. S. Barr Mycologist, Biosystematics Research Institute, Agriculture Canada.

Margaret E. Barr (Bigelow) Professor of Botany, University of Massachusetts.

Richard W. Baumann Associate Professor, Department of Zoology, Brigham Young University.

Denton Belk Adjunct Assistant Professor, Biology Department, Our Lady of the Lake University of San Antonio.

Jesus Benito Hemichordata, Department of Zoology, University Complutense of Madrid.

Gerald L. Benny Department of Botany, University of Florida.

Daniel J. Bickel Teaching Assistant in Entomology, Department of Entomology, Cornell University.

Walter J. Bock Professor of Evolutionary Biology, Department of Biological Sciences, Columbia University.

Kenneth J. Boss Professor of Biology and Curator in Malacology, Museum of Comparative Zoology, Harvard University.

E. L. Bousfield Senior Scientist, National Museum of Natural Sciences, Ottawa.

Thomas E. Bowman Curator, Department of Invertebrate Zoology (Crustacea), Smithsonian Institution, Washington, DC.

Don J. Brenner Enteric Section, Centers for Disease Control, Atlanta.

R. O. Brinkhurst Chief Scientist, Ocean Ecology Laboratory, Institute of Ocean Sciences, Sidney, B. C., Canada

William L. Brown, Jr. Professor of Entomology, Department of Entomology, Cornell University; Associate in Entomology, Museum of Comparative Zoology, Harvard University.

Jean Cachon Actinopods, Laboratoire de Protistologie marine, Villefranche-sur-mer.

Monique Cachon Actinopods, Laboratoire de Protistologie marine, Villefranche-sur-mer.

C. Bradford Calloway Graduate Student, Museum of Comparative Zoology, Harvard University.

E. Canale-Parola Professor, Department of Microbiology, University of Massachusetts.

James M. Carpenter National Science Foundation Graduate Fellow, Department of Entomology, Cornell University.

B. Wesley Catlin Professor of Microbiology, Medical College of Wisconsin, Milwaukee.

Anne C. Cohen Museum Specialist, Department of Invertebrate Zoology, Smithsonian Institution, Washington, DC.

Rita R. Colwell Professor of Microbiology, Division of Agricultural and Life Sciences, Department of Microbiology, University of Maryland.

Leonard J. V. Compagno Adjunct Professor, Tiburon Center for Environmental Studies, San Francisco State University.

John O. Corliss Professor and Chairman, Department of Zoology, University of Maryland.

Bruce C. Coull Professor of Biology and Marine Science, University of South Carolina.

J. Leland Crane Mycologist and Curator of the Herbarium, Illinois Natural History Survey, Champaign.

Michael Crezee Senior Scientist, Jones, Edmunds & Assoc., Inc.

Arthur Cronquist Senior Scientist, The New York Botanical Garden.

Howard Crum Professor of Botany, University of Michigan.

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

Edward B. Cutler Professor of Biology, Utica College of Syracuse University.

Fay Kenoyer Daily Member of Herbarium Staff, Botany Department, Butler University.

D. Christopher Darling Teaching Assistant in Entomology, Cornell University.

Anthony F. DeBlase Research Associate, Field Museum of Natural History, Chicago.

Michael W. Dick Department of Botany, Plant Science Laboratories, The University of Reading.

Peter S. Dixon Professor of Ecology & Evolutionary Biology and Professor of Environmental Engineering, University of California, Irvine.

William E. Duellman Curator, Division of Herpetology, Museum of Natural History, University of Kansas.

Daphne Fautin Dunn Assistant Curator, Department of Invertebrate Zoology, California Academy of Sciences.

Rubén Durán Professor and Plant Pathologist, Department of Plant Pathology, Washington State University.

S. J. Edmonds South Australian Museum, Adelaide.

George F. Edmunds, Jr. Professor of Biology, Department of Biology, University of Utah.

George C. Eickwort Professor of Entomology, Cornell University.

K. C. Emerson Research Associate, Department of Entomology, Smithsonian Institution, Washington, DC.

Christian C. Emig Station Marine D'Endoume, Centre D'Oceanographie, Université D'Aix-Marseille.

John J. Engel Donald Richards Associate Curator of Bryology, Field Museum of Natural History, Chicago.

Bruce E. Felgenhauer Department of Biological Science, Florida State University.

F. Julian Fell Department of Zoology, University of Maine.

Merrill W. Foster Professor of Geology, Department of Geological Sciences, Bradley University.

Oscar F. Francke Assistant Professor, Texas Tech University.

E. Imre Friedmann Professor, Department of Biological Science, Florida State University.

Ronald A. Fritzsche Assistant Professor of Fisheries and Curator of the Fisheries Collection, Department of Fisheries, Humboldt State University.

Geoffrey Fryer Freshwater Biological Association, Ambleside, Cumbria, England.

Ray Gibson Reader in Marine Biology, Department of Biology, Liverpool Polytechnic.

I. M. Goodbody Professor, Department of Zoology, University of the West Indies.

Roger D. Goos Professor of Botany, Department of Botany, University of Rhode Island.

Karl Gottlieb Grell Professor Emeritus of Zoology, University of Tübingen; Honorary Member of the Society of Protozoologists.

Richard T. Hanlin Professor, Department of Plant Pathology, University of Georgia.

G. R. Harbison Ctenophora, Woods Hole Oceanographic Institution.

Willard D. Hartman Professor of Biology and Curator in Invertebrate Zoology, Department of Biology and Peabody Museum of Natural History, Yale University.

Joel W. Hedgpeth Professor of Oceanography Emeritus (Oregon State University), Santa Rosa, CA.

Charles S. Henry Associate Professor of Biology, Biological Sciences Group, University of Connecticut.

David J. Hibberd Culture Centre of Algae and Protozoa, Cambridge, England.

Robert P. Higgins Curator of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC.

Peter Hirsch Professor, Institut für Allgemeine Mikrobiologie, Universität Kiel.

Richard L. Hoffman Professor of Biology, Radford University.

William D. Hummon Professor of Zoology, Ohio University.

M. J. Isaac Honorary Lecturer, Zoology Department, University College of Swansea.

Norman F. Johnson Assistant Professor, Department of Entomology, Ohio State University.

Donald E. Johnston Acarology Laboratory, College of Biological Sciences, Ohio State University.

Donald B. Johnstone Professor of Microbiology, University of Vermont.

D. C. Jordan Professor, Department of Microbiology, College of Biological Science, University of Guelph, Ont., Canada.

Harold W. Keller Associate Professor, Department of Microbiology and Immunology, Wright State University.

John B. Kethley Associate Curator of Insects, Field Museum of Natural History, Chicago.

D. Keith McE. Kevan Professor of Entomology, Department of Entomology, Macdonald Campus of McGill University; Director, Lyman Entomological Museum & Research Laboratory.

Ke Chung Kim Professor of Entomology and Curator of the Frost Entomological Museum, Department of Entomology, Pennsylvania State University.

James W. Kimbrough Professor of Botany (Mycologist), Department of Botany, University of Florida.

Michael Kosztarab Professor of Systematic Entomology, Department of Entomology, Virginia Polytechnic Institute and State University.

Noel R. Krieg Professor of Microbiology, Virginia Polytechnic Institute and State University.

Jørgen Kristiansen Associate Professor, Institute of Plant Anatomy and Cytology, University of Copenhagen.

Charles Kugler Assistant Professor, Radford University.

Daisy A. Kuhn Professor of Biology, California State University, Northridge.

Cletus P. Kurtzman Zymologist, Northern Regional Research Center, U.S. Department of Agriculture, Peoria.

Diana R. Laubitz Associate Curator of Crustaceans, National Museum of Natural Sciences, National Museums of Canada.

John F. Lawrence Principal Research

Scientist and Curator of Coleoptera, Entomology Division, Commonwealth Scientific and Industrial Research Organization.

Gordon F. Leedale Professor of Botany, Department of Plant Sciences, University of Leeds.

Herbert W. Levi Museum of Comparative Zoology, and Agassiz Professor of Zoology and Curator in Arachnology, Harvard University.

Norman D. Levine Professor, College of Veterinary Medicine, University of Illinois, Urbana.

Robert W. Lichtwardt Professor of Botany, University of Kansas.

Alfred R. Loeblich, Jr. Professor, Department of Earth & Space Sciences, University of California, Los Angeles.

Alfred R. Loeblich, III Director, Marine Science Program, Department of Biology, University of Houston.

Jack London Research Microbiologist, Laboratory of Microbiology and Immunology, National Institute of Dental Research, National Institutes of Health.

Bernard Lowy Professor Emeritus, Botany Department, Louisiana State University.

H. D. McCurdy Head, Biology Department, University of Windsor, Ontario, Canada.

John D. McEachran Associate Professor, Texas A&M University.

Laurence P. Madin Associate Scientist, Woods Hole Oceanographic Institution.

Armand R. Maggenti Nematologist, Division of Nematology, University of California, Davis.

Manley Mandel Professor, Department of Molecular Biology, University of Texas System Cancer Center, M. D. Anderson Hospital and Tumor Institute, Houston.

Raymond B. Manning Curator, Crustacea, National Museum of Natural History, Smithsonian Institution, Washington, DC.

John C. Markham Zoologist, Arch Cape Marine Laboratory, Arch Cape, OR.

John Mauchline Dunstaffnage Marine Research Laboratory, Oban, Argyll, Scotland.

Joseph L. Melnick Distinguished Service Professor of Virology, Baylor College of Medicine.

Harding B. Michel Professor, Division of Biology and Living Resources, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

John T. Mickel Curator of Ferns, The New York Botanical Garden.

W. E. C. Moore Professor, Department of Anaerobic Microbiology, Virginia Polytechnic Institute and State University.

Clive I. Morgan Department of Biological Sciences, Glasgow College of Technology.

William B. Muchmore Professor of Biology, University of Rochester.

Martin H. Muma Entomologist Emeritus (University of Florida); Research Associate, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, and Western New Mexico University.

J. Orvin Mundt Professor of Microbiology, University of Tennessee.

Eugene Munroe Research Associate, Lyman Entomological Museum and Research Laboratory, McGill University.

Barbara M. Murray Research Associate, Institute of Arctic Biology, University of Alaska.

Claus Nielsen Lecturer, Marine Biological Laboratory (University of Copenhagen), Helsingør, Denmark.

Thomas Nogrady Professor of Biochemistry, Concordia University, Montreal.

Richard E. Norris Professor, Department of Botany, University of the Witwatersrand, Johannesburg.

Barry M. OConnor Curator of Insects, Museum of Zoology, University of Michigan.

Lindsay S. Olive University Distinguished Professor of Botany, University of North Carolina.

G. F. Orr Mycologist (Retired), Sandy, UT.

Frederick C. Page Senior Protozoologist, Culture Centre of Algae and Protozoa, Institute of Terrestrial Ecology, Cambridge, England.

Leslie Andrew Page Microbiologist (Retired), U.S. Department of Agriculture, Science and Education Administration, National Animal Disease Center, Ames, IA.

Norberto J. Palleroni Senior Research Fellow, Department of Microbiology, Hoffmann-La Roche, Nutley, NJ.

John A. Parmelee Mycologist and Curator, National Mycological Herbarium, Biosystematics Research Institute, Ottawa.

Robert A. Paterson Professor of Botany, Virginia Polytechnic Institute and State University.

David L. Pawson Curator of Echinoderms, National Museum of Natural History, Smithsonian Institution, Washington, DC.

Stewart B. Peck Associate Professor, Department of Biology, Carleton University.

Marian H. Pettibone Curator Emeritus, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC.

Norbert Pfennig Professor, Faculty of Biology, University of Konstanz.

Elliot C. G. Pinhey Doctor (Science), Retired; formerly Research Associate, National Museum, Bulawayo, Zimbabwe.

Patricio Ponce de Leon Associate Curator, Department of Botany, Field Museum of Natural History, Chicago.

Thomas G. Pridham Research Leader, Culture Collection Research, Fermentation Laboratory, Northern Regional Research Center, U.S. Department of Agriculture, Peoria.

Shmuel Razin Professor and Chair-

man, Department of Membrane and Ultrastructure Research, Hebrew University–Hadassah Medical School, Jerusalem.

Mary E. Rice Curator, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC.

Edward S. Ross Curator, California Academy of Sciences, San Francisco.

Robert Ross British Museum (Natural History), London.

Louis M. Roth Research Associate, Museum of Comparative Zoology, Harvard University.

John S. Ryland Professor, Department of Zoology, University College of Swansea.

Stewart C. Schell Professor Emeritus (Zoology), Department of Biological Sciences, University of Idaho.

Ulf Scheller Biologist, Lundsberg, Sweden.

Gerald D. Schmidt Professor of Parasitology, University of Northern Colorado.

Horst Kurt Schminke Fachbereich IV, Universität Oldenburg.

George A. Schultz Isopodologist, Hampton, NJ.

J. Teague Self Regents Professor of Zoology Emeritus, University of Oklahoma.

Robert L. Shaffer Curator of Fungi and Professor of Botany, University of Michigan.

William A. Shear Professor of Biology, Hampden-Sydney College; Research Associate, Department of Entomology, American Museum of Natural History, New York.

James M. Shewan Senior Principal Scientific Officer (Retired), Torry Research Station, Aberdeen.

C. T. Shih Curator of Crustaceans, National Museums of Canada, Ottawa.

Jürgen Sieg Universität Osnabrück/Abt. Vechta, Germany.

Paul C. Silva Research Botanist, University of California, Berkeley.

R. W. Sims Head of Annelida Section, Department of Zoology, British Museum (Natural History), London.

James A. Slater Professor of Biology, Section of Systematic and Evolutionary Biology, University of Connecticut.

F. G. A. M. Smit Custodian of the Rothschild Collection of Siphonaptera, British Museum (Natural History), London.

Courtenay N. Smithers Principal Curator, The Australian Museum, Sydney.

Henry R. Spivey Department of Biological Science, Florida State University.

Victor Sprague Professor, Chesapeake Biological Laboratory of the Center for Environmental and Estuarine Studies, University of Maryland.

James T. Staley Associate Professor, Department of Microbiology and Immunology, University of Washington.

Lewis J. Stannard Professor Emeritus, University of Illinois, and Taxonomist Emeritus, Illinois Natural History Survey, Urbana.

Wolfgang Sterrer Director, Bermuda Biological Station for Research, Inc., St. George.

Jan H. Stock Professor of Zoology, Institute of Taxonomic Zoology, University of Amsterdam.

Julia Stuart Eastbourne, New Zealand.

Horace W. Stunkard Research Associate, American Museum of Natural History, New York.

C. J. Swanson Associate Professor, Division of Physiology & Biophysics, Department of Biological Sciences, Wayne State University.

Helen Tappan Professor, Department of Earth & Space Sciences, University of California, Los Angeles.

Isabelle I. Taveres Mycologist, Herbarium, Department of Botany, Uni of California, Berkeley.

Keith Vickerman Professor of Zoology, Department of Zoology, University of Glasgow.

Dale H. Vitt Professor, Department of Botany, University of Alberta.

Les Watling Associate Professor of Oceanography, Darling Center, University of Maine.

Stanley W. Watson Senior Scientist, Woods Hole Oceanographic Institution.

Emilio Weiss Chair of Science, Naval Medical Research Institute, Bethesda.

Glenn B. Wiggins Curator, Department of Entomology, Royal Ontario Museum.

Michael J. Wynne Associate Professor, Division of Biological Sciences, University of Michigan.

Thomas A. Zanoni Taxonomist, Jardin Botanico Nacional, Santo Domingo, Republica Dominicana; Honorary Research Associate, The New York Botanical Garden.

Victor A. Zullo Professor of Geology, Department of Earth Sciences, University of North Carolina at Wilmington.

Preface

The great system of classification developed by C. Linnaeus in the 18th century remains in many ways the primary system of classification and is central to all other classifications of biological variation (see the Appendix). Despite the importance of Linnaean classification to biological research, there exists no single, comprehensive reference to the classification of living organisms with descriptions of taxa above the generic level. With this in mind, *Synopsis and Classification of Living Organisms* was conceived to treat higher-level taxonomy. In these volumes, the systematic positions and affinities of all living organisms are presented in synoptic articles for all taxa down to the family level. This reference also provides Linnaean classifications and citations which serve as a guide to the specialized literature. Much of the information has previously been available only in obscure journals; in many cases, this information is presented in English for the first time; and, for a few groups, the classification is published here for the first time.

This reference is restricted to Recent organisms, that is, those observed alive by scientists or recorded in some form compatible with scientific methods. Exclusion of purely fossil groups was necessary in order to restrict the size of the work; of course, this results in little or no discussion of the primitive groups of most major taxa.

The concept of living organism, as delimited here, includes viruses. The decision to place viruses as a kingdom in the classification system was based on knowledge that viruses have evolved from more complicated free-living organisms and have become secondarily simplified as parasites—a well-known pattern of evolutionary change.

The classification used in these volumes recognizes four kingdoms (Virus, Monera, Plantae, and Animalia) arranged in two superkingdoms—the Prokaryotae and the Eukaryotae. Almost all workers agree that these two superkingdoms reflect a basic difference in organization of living organisms. Decision on this arrangement is based on a compromise between the most useful groups and the highest degree of monophyly of these taxa. The kingdoms recognized herein and some of the subkingdoms are still minimally monophyletic. Many workers will disagree with certain aspects of this classification, especially not recognizing the Protista. Although the four-kingdom system advocated herein has the greatest advantage, the differences between it and some other systems, such as a five-kingdom system recognizing the Protista, are not significant.

Synoptic articles (totaling 8200) constitute the major portion of this reference. They are designed to give an idea of the biology of each group and are presented in the same order as the classification in the Appendix. All recognized taxa are listed in the classification, even though articles are not included for monotypic groups or those groups whose classification has not been sufficiently clarified. Each article provides a brief overview of the characteristics, biology, ecology, and distribution of the taxon. For family treatments, there is mention of the number of included genera, and major genera are named. These articles are limited in scope and therefore are not intended to serve as a means of identifying unknown specimens, to supply a thorough diagnosis for each taxon, or to treat the complete diversity of each group.

The classification for each section was the responsibility of the author. In cases where the classification has not been worked out completely, the one that is given reflects the best current knowledge of the group. Authors were asked to avoid unaccepted classifications but were encouraged to express their views as to the validity of alternate schemes. There has been no attempt to force all groups into a rigid standard system since this would have produced artificial results.

The literature citations at the end of a synoptic article are an extremely useful feature. Criteria for selection of these citations were: to include the principal English and/or foreign language publication; to include recent publications as well as those of historical significance; and to include research papers in addition to comprehensive references. Very often, however, the best references for a particular taxon are the same as the references for the taxon immediately superior. To avoid repetition in such cases, references were deleted in the inferior taxon. Therefore, when a taxon is not cited with references, the reader should look in the taxon immediately superior. Also, even if a taxon is listed with references, the references of the taxon immediately superior may also be relevant.

Illustrations selected by the authors include both line drawings and photographs since all groups are not well represented in the same way. Photographs are presented in a series of plates, identified by number, and listed by group name in the front matter of volume 1. Each subject in a plate is labeled with a specific name followed by the family (in a few cases, a higher taxon) name in parentheses. The plates are not referenced in the text because photographs generally have only intrinsic interest. Line drawings are similarly labeled (species, family), sometimes supplemented by captions. These appear on folioed pages and are called out at appropriate points in the text by page number.

Articles are signed by authors, who retain full responsibility for content. In general, each author contributed a group of articles and the writer's name is given following the article title that identifies the group. If a large group was prepared by several authors, the names are repeated as individual contributions are interspersed. For a group which was handled principally by one author but which includes isolated entries by a second author, the second name is given at the end of appropriate articles.

The Appendix has a brief article on biological nomenclature with sources for additional information; an article on biological classification, including a discussion of systems of kingdoms and a bibliography; and the classification listing of living organisms. Although nomenclature is not an integral part of this reference, it is an essential aspect of systematics and is of primary importance to biologists. No matter how carefully it is worked out, classification for living organisms would not work unless definite rules of nomenclature were followed by all biologists.

Access to the information in this reference is achieved most efficiently via the Index which contains the names of all taxa, including genera and species, mentioned in the text of the synoptic articles. Also listed are common names, synonyms, and names used in other or older systems of classification. There are more than 35,000 entries in the Index.

To publish a work of such magnitude required the dedicated efforts of hundreds of specialists working together over several years. We are indebted to the authors, who were committed to the completion of this project; without them it would have been impossible. A special acknowledgment is also due the consultants, who extended themselves in planning the work and finding the authors.

SYBIL P. PARKER
Editor in Chief

Credits for Plates and Illustrations

Volume 1 Plates

Plates 1, 2 Courtesy of J. L. Melnick, Baylor College of Medicine.

Plate 3 *Stigmatella:* From G. T. Quails, K. Stephens, and D. White, Light stimulated morphogenesis in the fruiting myxobacterium *Stigmatella aurantiaca*, *Science*, 201(4354):444–445, © 1978 by the American Association for the Advancement of Science.

Plate 4 *Simonsiella:* From J. Pangborn, D. A. Kuhn, and J. R. Woods, Dorsal-ventral differentiation in *Simonsiella* and other aspects of its morphology and ultrastructure, *Arch. Microbiol.*, 113:197–204, 1977.

Plate 6 *Rhizobium:* From C. R. MacKenzie, W. J. Vail, and D. C. Jordan, Ultrastructure of free-living and nitrogen fixing forms of *Rhizobium melitoti* as revealed by freeze-etching, *J. Bacteriol.*, 113:387–393, 1973.

Plate 8 Top (phase contrast micrograph): From S. Razin, B. J. Cosenza, and M. E. Tourtellotte, Filamentous growth of mycoplasma, *Ann. N.Y. Acad. Sci.*, 143:66–72, 1967.
Top (scanning electron micrograph): From G. Biberfeld and P. Biberfeld, Ultrastructural features of *Mycoplasma pneumoniae*, *J. Bacteriol.*, 102:855–861, 1970.
Bottom *(Spiroplasma):* From R. M. Cole et al., Morphology, ultrastructure, and bacteriophage infection of the helical mycoplasma-like organism *Spiroplasma citri* gen. nov., sp. nov., cultured from "stubborn" disease of atrus, *J. Bacteriol.*, 115:367–386, 1973.
Bottom (mycoplasma colonies): From S. Razin and O. Oliver, Morphogenesis of mycoplasma and bacterial L-form colonies, *J. Gen. Microbiol.*, 24:225–237, 1961.

Plates 9, 10 Courtesy of E. I. Friedman.

Plate 11 Courtesy of J. Kristiansen.

Plate 15 Courtesy of Michael J. Wynne.

Plates 17, 18 Biophoto Associates.

Plates 19, 20 Courtesy of Ray Simons.

Plate 25 *Cordyceps* arising from beetle: Courtesy of T. Herrera.

Plate 26 *Eusynaptomyces:* Photograph by A. Blaker, *Colonomyces*, *Herpomyces*, *Misgomyces:* Photographs by J. Hendel.

Plate 27 Courtesy of J. Parmelee.

Plates 29, 30 From M. F. Brown and H. G. Brotzman, *Phytopathogenic Fungi: A Scanning Electron Stereoscopic Survey*, 1979; reproduced courtesy of University of Missouri–Columbia Extension Division.

Plates 35, 36, 38 *Cannabis, Cypripedium, Monotropa, Yucca:* Courtesy of Arthur Cronquist.
Clematis, Erythronium, Viola: Courtesy of Valoie Albrecht.

Plate 43 *Acrasis sorocarp:* From L. S. Olive and C. Stoianovitch, Two new members of the Acrasiales, *Bull. Torrey Bot. Club*, 87: 1–20, 1960.
Cavostelium sorocarp: From L. S. Olive and C. Stoianovitch, A new two-spored species of *Cavostelium* (Protostelida), *Mycologia*, 58: 440–451, 1966.
Ceratiomyxa: From L. S. Olive, *The Mycetozoans*, Academic Press, New York, 1975.
Copromyxa: From F. W. Spiegel and L. S. Olive, New evidence for the validity of *Copromyxa protea*, *Mycologia*, 70:843–874, 1978.
Copromyxella: From K. B. Raper et al., *Copromyxella:* A new genus of Acrasidae, *Amer. J. Bot.*, 65:1011–1026, 1978.
Guttulinopsis: From L. S. Olive, A developmental study of *Guttulinopsis vulgaris* (Acrasiales), *Amer. J. Bot.*, 52:513–519, 1965.

Plate 44 *Acytostelium:* From K. B. Raper and M. S. Quinlan, *Acytostelium leptosomum:* A unique cellular slime mold with an acellular stalk, *J. Gen. Microbiol.*, 18:16–32, 1958.
Echinosteliopsis: From D. J. Reinhardt and L. S. Olive, *Echinosteliopsis*, a new genus of the Mycetozoa, *Mycologia*, 58:966–970, 1966.
Nematostelium: From L. S. Olive and C. Stoianovitch, *Schizoplasmodium*, a mycetozoan genus intermediate between *Cavostelium* and *Protostelium;* a new order of Mycetozoa, *J. Protozool.*, 13:164–171, 1966.
Protostelium sporocarp: From L. S. Olive and C. Stoianovitch, Monograph of the genus *Protostelium*, *Amer. J. Bot.*, 56:979–988, 1969.

Plate 45 *Dictyostelium* pseudoplasmodia: From K. B. Raper, The environment and morphogenesis in cellular slime molds, *Harvey Lecture Series 57*, pp. 111–141, Academic Press, New York, 1963.
Echinostelium protoplasmodium: From L. S. Olive, *The Mycetozoans*, Academic Press, New York, 1975.
Echinostelium sporangia: From L. S. Olive and C. Stoianovitch, A minute new *Echinostelium* with protostelid affinities, *Mycologia*, 63:1051–1062, 1971.
Polysphondylium: From K. B. Raper, Levels of cellular interaction in amoeboid populations, *Proc. Amer. Phil. Soc.*, 104:579–604, 1960.
Stemonitis aphanoplasmodium: From C. W. Mims, A light and electron microscope study of sporulation in the myxomycete *Stemonitis virginiensis*, *Protoplasma*, 77:35–54, 1973.
Stemonitis sporangia: Courtesy of R. L. Blanton.

Plate 46 *Dictydiaethalium, Hemitrichia, Trichia:* From L. S. Olive, *The Mycetozoans*, Academic Press, New York, 1975.
Physarum: Courtesy of R. L. Blanton.

Plate 60 Courtesy of Dr. Frank O. Perkins.

Plate 62 *Haplosporidium:* Courtesy of Dr. Frank O. Perkins.
Urosporidium: From Frank O. Perkins, Sporulation in the trematode hyperparasite *Urosporidium crescens* DeTurk, 1940 (Haplosporida: Haplosporidiidae)–An electron microscope study, *J. Parasitol.*, 57:9–23, 1971.

Plate 67 From K. G. Grell, Ober den Ursprung der Metazoen, *Mikrokosmos*, 60:97–102, 1971.

Plate 68 *Aulococtena:* Photograph by R. Gilmer.
Lampea, Thalassocalyce: Photographs by L. Madin.
Mertensia: Photograph by W. Cross.
Pleurobrachia: Photograph by A. Brosius.
Vallicula: Photograph by M. Reeve.

Plate 69 *Mnemiopsis:* Photograph by N. Swanberg.
All other genera: Photographs by L. Madin.

Plate 70 *Taenia* sp.: Photographs of hook and mature proglottids by Jay Georgi.

Plate 71 *Diphyllobothrium* sp.: Photograph by Jay Georgi.
Hymenolepis: Photograph by John Ubelaker.

Plate 86 *Priapulus:* Courtesy of C. B. Calloway.
Tubiluchus: From C. B. Calloway, Morphology of the introvert and associated structures of the priapulid *Tubiluchus corallicola* from Bermuda, *Mar. Biol.*, 31:161–174, 1975.

Plate 87 Courtesy of C. B. Calloway.

Volume 2 Plates

Plate 90 Courtesy of J. Wilkialis.

Plate 91 All except *Peloscolex:* Photographs courtesy of Peter Chapman.

Plate 94 *Mastigoproctus* and palpigradid: Courtesy of P. Weygoldt.

Plate 95 *Hypochilus:* Courtesy of Otto Kraus.
Loxosceles: Courtesy of Allen Brady.

Plate 96 *Dinopis* sp.: Courtesy of R. Silberglied.
Hersiliidae sp.: Courtesy of M. Kjell Sandved.
Stegodyphus sp.: Courtesy of J. A. L. Cooke.

Plate 98 *Cupiennus:* Courtesy of M. Melchers.

Plates 99, 100 Courtesy of H. H. Muma.

Plate 109 *Acridoxena:* Photograph by D. K. McE. Kevan.
Amblycorypha: Photograph by M. S. Ulagaraj.
Diaphanogryllus: Photograph by C. J. M. Willemse.
Cyphoderris: Photograph by D. T. Gwynne.
Certhothilus, Preussia: Courtesy of Lyman Entomological Museum, McGill University.
Ephippiger: Photograph by Z. R. Adamović.

Plate 110 Apteropedetinae: Photograph by R. A. Ronderos.
Ruspolia: Photograph by D. K. McE. Kevan.
Saga: Photograph by F. Willemse.
Zabalius: Photograph by A. deBarros Machado.

Plate 111 *Acheta:* Courtesy of Shell Photographic Unit, London.
Gryllotalpa: Photograph by C. J. M. Willemse.
Gryllus, Schizodactylus: Courtesy of Lyman Entomological Museum, McGill University.
Orocharis: Photograph by D. K. McE. Kevan.

Plate 112 *Erianthus, Erucius, Mastacides, Tetanorhynchus:* Courtesy of Lyman Entomological Museum, McGill University.
Orchetypus, Paramnesides: Photograph by C. J. M. Willemse.

Plate 113 *Borneacris, Trachypterella:* Photograph by C. J. M. Willemse.
Lobosceliana, Physeuracis, Systella: Courtesy of Lyman Entomological Museum, McGill University.

Plate 114 *Cranaella, Pycnosarcus:* Photograph by D. K. McE. Kevan.
Locusta: Courtesy of Shell Photographic Unit, London.
Phymateus, Tropidolophus: Courtesy of Lyman Entomological Museum, McGill University.

Plates 115, 116 Courtesy of Lyman Entomological Museum, McGill University.

Plate 117 Aleyrodidae: Courtesy of A. B. Hamon, Florida Department of Agriculture, Division of Plant Industry.
Aphididae: Courtesy of Department of Entomology, Virginia Polytechnic Institute and State University.
Ceropidae adult and nymph, Fulgoridae, Membracidae, Psyllidae: Courtesy of F. W. Mead.
Cicadellidae, Cicadidae: Courtesy of E. S. Ross.

Plate 118 Cerococcidae: Courtesy of R. G. Baer.
Coccidae: Courtesy of Department of Entomology, Virginia Polytechnic Institute and State University.
Kermesidae, Kerridae: Courtesy of R. J. Gill, California Department of Agriculture.
Lecanodiaspididae, Margarodidae: Courtesy of J. O. Howell.
Pseudococcidae: Courtesy of A. B. Hamon, Florida Department of Agriculture, Division of Plant Industry.

Plates 119, 120 Courtesy of R. Silberglied.

Plates 126, 127 Courtesy of C. C. Emig.

Plates 128, 129 Courtesy of D. P. Gordon.

Plate 136 *Ceto:* Courtesy of N. Coleman.
Heterothyone, Ocnus brevidentis: From D. L. Pawson, *N. Z. Depart. Sci. Ind. Res. Bull.*, no. 201, 1970.
Ocnus sp.: Courtesy of K. Sandved.
Ypsilothuria: Courtesy of E. J. Batham.

Plate 137 *Holothuria* (2 species), *Euapta:* Courtesy of K. Sandved.
Paracaudina: From D. L. Pawson, *N. Z. Depart. Sci. Ind. Res. Bull.*, no. 201, 1970.
Stichopus, Chiridota: Courtesy of N. Coleman.

Plate 138 *Ambystoma, Bolitoglossa, Rhinophrynus:* Courtesy of William E. Duellman.
Ranodon, Salamandra: Courtesy of Joseph T. Collins.

Plate 139 *Hamptophryne, Ichthyophis:* Courtesy of Joseph T. Collins.
Litoria, Phyllobates, Phyllomedusa: Courtesy of William E. Duellman.

Plate 140 *Hemidactylus, Enyalioides, Amphibolurus:* Courtesy of William E. Duellman.
Sphenodon, Sternotherus, Terrapene: Courtesy of Joseph T. Collins.

Plate 141 *Ameiva, Amphisbaena:* Courtesy of William E. Duellman.
Anniella, Coluber, Heloderma: Courtesy of Joseph T. Collins.

Volume 1 Illustrations

Page 6 Forms of virions: From B. D. Davies et al., *Microbiology*, Harper and Row, New York, 1967.
DNA and RNA viruses: From F. Fenner and D. White, *Medical Virology*, Academic Press, New York, 1976.

Pages 233, 234 Illustrations by Wendy Zomlefer.

Page 243 Life cycle: From D. B. O. Savile, Evolution of the rust fungi (Uredinales) as reflected by their ecological problems, in M. K. Hecht, W. C. Steere, and B. Wallace (eds.), *Evolutionary Biology*, vol. 9, Plenum Publishing, New York, 1976.
Phragmidium occidentale: Adapted from D. B. O. Savile, *Fungi Canadensis*, no. 80, 1975; reproduced courtesy of the Research Branch, Department of Agriculture, Government of Canada. Also, *Phragmidium potentillae* (no. 41, 1974); *Puccinia arnicalis* (no. 3, 1978); *Puccinia codyi* (no. 46, 1974).

Page 266 *Pestalotia versicolor:* From E. A. Bessey, *Morphology and Taxonomy of Fungi*, Blakiston–McGraw-Hill, Philadelphia, 1950.
All others: From H. L. Barnett and B. B. Hunter, *Illustrated Genera of Imperfect Fungi*, Burgess Publishing, Minneapolis, 1972.

Page 267 *Phyllosticta ilicicola:* From J. A. Von Arx, *The Genera of Fungi Sporulating in Pure Culture*, J. Cramer, Vaduz, 1974.
Phyllosticta tabifica: From E. A. Bessey, *Morphology and Taxonomy of Fungi*, Blakiston–McGraw-Hill, Philadelphia, 1950.
Septoria and *Phoma:* From H. L. Barnett and B. B. Hunter, *Illustrated Genera of Imperfect Fungi*, Burgess Publishing, Minneapolis, 1972.
Septoria apii: From P. H. B. Talbot, *Principles of Fungal Taxonomy*, St. Martin's Press, New York, 1971.

Page 306 From original drawings by Charles Clare, reproduced by permission of W. C. Steere and B. M. Murray.

Page 351 *Cupressus macrocarpa:* From G. B. Sudworth, U.S. Department of Agriculture, Forest Service, *Forest Trees of the Pacific Slope*, 1908.
Ginkgo biloba: From R. A. Vines, *Trees, Shrubs and Woody Vines of the Southwest*, University of Texas Press, Austin, 1960.
Juniperus ashei: From G. B. Sudworth, *The Cypress and Juniper trees of the Rocky Mountain Region*, U.S. Dept. Agr. Bull. no. 207, 1915.

Page 352 *Picea engelmanni:* From G. B. Sudworth, *The Spruce and Balsam Fir Trees of the Rocky Mountain Region*, U.S. Dept. Agr. Bull. no. 327, 1916.

Podocarpus falcatus: From L. E. Codd, B. deWinter, and H. B. Rycroft (eds.), *Flora of Southern Africa*, vol. 1, published in the Republic of South Africa, 1966.
Pseudotsuga menziesii: From G. B. Sudworth, U.S. Department of Agriculture, Forest Service, *Forest Trees of the Pacific Slope*, 1908.

Page 353 *Ephedra trifurca:* From R. A. Vines, *Trees, Shrubs and Woody Vines of the Southwest*, University of Texas Press, Austin, 1960.
Tumion californicum and *T. distichum:* From C. S. Sargent, *Manual of the Trees of North America (Exclusive of Mexico)*, vol. 1, Dover Publications, New York, 1965.

Page 354 *Welwitschia bainesii:* From L. E. Codd, B. deWinter, and H. B. Rycroft (eds.), *Flora of Southern Africa*, vol. 1, published in the Republic of South Africa, 1966.

Pages 432–435 Drawings by Robin A. Jess.

Page 570 Apicomplexan structures: From Levine, 1978.

Page 581 *Eimeria:* From N. D. Levine, *Protozoan Parasites of Domestic Animals and of Man*, 2d ed., Burgess, Minneapolis, 1973.

Page 583 From N. D. Levine, *Protozoan Parasites of Domestic Animals and of Man*, 2d ed., Burgess, Minneapolis, 1973.

Page 584 *Babesia* and *Theileria:* From Levine, 1978.

Page 706 After L. H. Hyman, *The Invertebrates: Protozoa through Ctenophora*, McGraw-Hill, New York, 1940.

Page 709 *Lyrocteis:* From T. Komai, The structure and development of the sessile ctenophore *Lyrocteis imperatoris* Komai, *Memoirs of the College of Science, Kyoto Imperial University*, ser. B, vol. 17, no. 1, 1942.
Tinerfe: From A. G. Mayer, Ctenophores of the Atlantic coast of North America, *Carnegie Inst. Wash. Publ.*, no. 162, 1912.

Page 710 *Deiopea:* From C. Chun, Die Ctenophoren des Gulfes von Neapel, *Fauna und Flora des Gulfes von Neapel*, 1:1–313, 1880.
Ganesha: From C. Dawydoff, Contribution à la connaissance des ctenophores pélagiques des eaux de l'Indochine, *Bull. Biol. Fr. Belg.*, 80:113–170, 1946.

Page 711 *Beroë:* From A. G. Mayer, Ctenophores of the Atlantic coast of North America, *Carnegie Inst. Wash. Publ.*, no. 162, 1912.
Cestum: From C. Chun, Die Ctenophoren des Gulfes von Neapel, *Fauna und Flora des Gulfes von Neapel*, 1:1–313, 1880.

Pages 849, 850 From W. E. Sterrer, Systematics and evolution within the Gnathostomulida, *Syst. Zool.*, 21(2):151–173, 1972.

Page 867 From L. H. Hyman, *The Invertebrates*, vol. 3, McGraw-Hill, New York, 1951.

Page 868 *Asplanchna priodonta, Floscularia ringens,* and *Tetrasiphon hydrocora:* From W. T. Edmondson, in *Ward and Whipple's Freshwater Biology*, ed. by W. T. Edmondson, 2d ed., John Wiley and Son, New York, 1959.
Hexarthra intermedia, Macrochaetus longipes, Polyarthra vulgaris, and *Squatinella rostrum:* From A. Ruttner-Kolisko, Plankton Rotifera, biology, taxonomy, *Die Binnengewasser*, 26/1, Supplement, Schweizerbart, Stuttgart, 1974.
Philodina roseola: From L. H. Hyman, *The Invertebrates*, vol. 3, McGraw-Hill, New York, 1951.
Stephanoceros fimbriatus: From M. Voigt and W. Koste, *Rotatoria, die Radertiere Mitteleuropas*, 2d ed., Borntraeger, Berlin, 1978.

Page 875 From R. P. Higgins, A historical overview of kinorynch research, in N. C. Hulings (ed.), Proceedings of the 1st International Conference on Meiofauna, *Smithson. Contrib. Zool.*, 76: 25–31, 1971.

Page 943 From J. van der Land, Systematics, zoogeography, and ecology of the Priapulida, *Zool. Verh., Leiden*, 112:1–118, 1970.

Pages 946, 947 From L. V. Salvini-Plawen, Zur Morphologie und Phylogenie der Mollusken: Die Beziehungen der Caudofoveata und der Solenogastres als Aculifera, als Mollusca und als Spiralia, *Z. Wiss. Zool., Leipzig*, 184:3/4, S. 205–394, 1972.

Pages 956, 957 (c), 967, 968, 969, 1084, 1085, 1086 From L. H. Hyman, *The Invertebrates*, Mollusca I, vol. 4, McGraw-Hill, New York, 1967.

Pages 957 (a and b), 965 (top and middle), 966, 1087 (bottom), 1088 From R. C. Moore (ed.), *Treatise on Invertebrate Paleontology*, (I) Mollusca 1, 1960; (N) Mollusca 6 vol. 1, 1969, Geological Society of America and University of Kansas Press, Lawrence.

Pages 964, 965 (bottom), 1087 (top), 1089 (Opercula), 14 (shell characteristics), 16: From R. R. Shrock and W. H. Twenhofel, *Principles of Invertebrate Paleontology*, McGraw-Hill, New York, 1953.

Volume 2 Illustrations

Page 45 *Acanthobdella, Pontobdella amara, Pontobdella muricata:* From K. H. Mann, *Leeches*, Pergamon Press, Elmsford, NY, 1962.
Stephanodrilus: From R. D. Barnes, *Invertebrate Zoology*, W. B. Saunders, Philadelphia, 1963.

Page 46 From K. H. Mann, *Leeches*, Pergamon Press, Elmsford, NY, 1962.

Page 47 *Glossiphonia heteroclita:* Courtesy of Julia Stuart.
Hirudo medicinalis: From T. I. Storer et al., *General Zoology*, 6th ed., McGraw-Hill, New York, 1979.

Page 53 *Ripistes parasita:* From R. D. Barnes, *Invertebrate Zoology*, W. B. Saunders, Philadelphia, 1963.

Page 68 *Phascolosoma, Themiste:* From R. I. Smith and J. T. Carlton (eds.), *Light's Manual: Intertidal Invertebrates of the Central California Coast*, 3d ed., University of California Press, Berkeley, 1975.
Sipunculus: From M. E. Rice and M. Todorovic (eds.), *Proceedings of the International Symposium on the Biology of the Sipuncula and Echiura*, Kotor, Yugoslavia (June 18–25, 1970), 1975.

Page 189 *Cypridina:* From H. G. Cannon, On the anatomy of a marine ostracod, *Cypridina (Doloria) levis, Discovery Reports*, vol. 2, 1931.
Thaumatoconcha: From L. S. Kornicker and I. G. Sohen, Phylogeny, ontology, and morphology of living fossil Thaumatocypridacea (Myodocopa: Ostracoda), *Smithson. Contrib. Zool.*, no. 219, 1976.

Pages 190, 191 From R. C. Moore (ed.), *Treatise on Invertebrate Paleontology*, part Q, Geological Society of America and University of Kansas Press, Lawrence, 1961.

Page 192 From R. Benson, *Smithson. Contrib. Paleobiol.*, no. 12, 1972.

Page 221 *Baccalaureus:* From H. Brattström, *On the Organization of the Genus Baccalaureus (Ascothoracica) with Description of a New South African Species*, 1956.
Kochlorine: From J. Tomlinson, *The Burrowing Barnacles (Cirripedia: Order Acrothoracica)*, Smithsonian Institution Press, Washington, DC, 1969.
Scalpellum: From V. A. Zullo, Thoracic Cirripedia from the continental shelf off South Carolina, U.S.A., *Crustaceana*, vol. 11, pt. 3, 1966.

Page 222 *Balanus, Lepas, Semibalanus:* From V. A. Zullo, Marine flora and fauna of the Northeastern United States. Arthropoda: Cirripedia, *NOAA Tech. Rep. NMFS Cir.*, no. 425, April 1979.
Verruca: From V. A. Zullo, Catalog of the Cirripedia named by Henry A. Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 120(5):209–235, 1968.

Page 230 *Chthamalophilus delagei:* From O. Bocquet-Vedrine, Rhizocephale parasite de *Chthamalus stellatus* (Poli), *Cahiers Biol. Mar.*, 2:455–593, 1961.
Clistosaccus paguri, Sylon hippolytes, Triangulus galatheae: From H. Boschma, Rhizocephala of the North Atlantic region, *The Danish Ingolf-Expedition*, 3(10):1–49, 1928.
Heterosaccus: From H. Boschma, Notes on Sacculinidae, chiefly in the collection of the United States National Museum, *Zoologische Verhandelingen*, Rijksmuseum Natuurlijke Historie, Leiden, 7:3–55, 1950.

Mycetomorpha vancouverensis: From F. A. Potts, *Mycetomorpha*, a new rhizocephalan (with a note on the sexual condition of *Sylon*), *Zool. Qahrb. Abt. Syst.*, 33:575–594, pls. 15, 16, 1912.
Sylon hippolytes (Spirontocaris spinus): From P. P. C. Hoek, Description of *Sylon challengeri* n. sp., a parasitic cirriped, *Report Scientific Results Voyage H. M. S. Challenger 1873–76*, Zoology vol. 24, App. A, pp. 919–926, pls. 149, 150, 106 of C. S. Bate, 1888.
Tortugaster fistulatus: From E. G. Reinhard, *Tortugaster fistulatus* n. gen., n. sp., a rhizocephalan parasite of *Munidopsis robusta*, *Proc. Helminthol. Soc. Wash.*, 15(1):33–37, 1948.

Page 297 *Amphionides:* From D. L. Williamson, *Amphionides reynaudii* (H. Milne Edwards), representative of a proposed new order of eucaridan Malacostraca, *Crustaceana*, 25:35–50, 1973.
Penaeus: From A. B. Williams, Marine decapod crustaceans of the Carolinas, *Fishery Bull.*, vol. 65, no. 1, 1965.

Page 298 *Hepomadus:* From I. P. Farfante, Morphological study of diagnostic characters in Western Atlantic *Hepomadus* (Crustacea, Decapoda, Penaeidae), *Fishery Bull.*, vol. 71, no. 2, 1973.
Selenocera: From I. P. Farfante and H. R. Bullis, Jr., Western Atlantic shrimps of the genus *Solenocera* with description of a new species (Crustacea: Decapoda: Penaeidae), *Smithson. Contrib. Zool.*, no. 153, 1973.

Page 299 *Procaris:* From F. A. Chace, Jr., and R. B. Manning, Two new caridean shrimps, one representing a new family, from marine pools on Ascension Island (Crustacea: Decapoda: Natantia), *Smithson. Contrib. Zool.*, no. 13, 1972.
Stenopus: From C. Limbaugh, H. Pederson, and F. A. Chace, Jr., Shrimps that clean fishes, *Bull. Mar. Sci. Gulf Carib.*, 11(2):237–257, June 1961.

Page 300 *Acanthephyra, Nematocarcinus:* From S. I. Smith, *Report on the Decapod Crustacea of the Albatross Dredgings off the Coast of the United States during the Summer and Autumn of 1884*, 1886.
Potimirim: From L. G. Abele, Introductions of two freshwater decapod crustaceans (Hymenosomatidae and Atyidae) into Central and North America, *Crustaceana*, vol. 23, pt. 3, pp. 210–218, 1972.
Pseudocheles: From F. A. Chace, Jr., and D. E. Brown, A new polychelate shrimp from the Great Barrier Reef of Australia and its bearing on the family Bresiliidae (Crustacea: Decapoda: Caridea), *Proc. Biol. Soc. Wash.*, 91(3):756–766, 1978.

Page 307 *Gnathophyllum:* From F. A. Chace, Jr., and S. L. H. Fuller, A new shrimp of the genus *Gnathophyllum* (Decapoda, Caridea) from Puerto Rico, *Proc. Biol. Soc. Wash.*, 83(44):493–504, 1971.
Macrobrachium: From F. A. Chace, Jr., and H. H. Hobbs, Jr., The freshwater terrestrial decapod crustaceans of the West Indies with special reference to Dominica, *Smithson. Inst. Bull.*, no. 292, 1969.
Psalidopus: From F. A. Chace, Jr., and L. B. Holthuis, *Psalidopus:* The scissor-foot shrimps (Crustacea: Decapoda: Caridea), *Smithson. Contrib. Zool.*, no. 277, 1978.

Page 308 *Alpheus:* From G. Y. Hendrix and R. H. Gore, Studies on decapod Crustacea from the Indian River region of Florida, I. *Alpheus thomasi*, new species, a new snapping shrimp from the subtropical east coast of Florida (Crustacea: Decapoda: Caridea), *Proc. Biol. Soc. Wash.*, 86(35):413–422, 1973.
Ambidexter: From L. G. Abele, A review of the genus *Ambidexter* (Crustacea: Decapoda: Processidae) in Panama, *Bull. Mar. Sci.*, 22(2):365–380, 1972.

Page 309 *Callianassa, Nepropsis, Thaumastocheles:* From W. T. Calman, *The Life of Crustacea*, Macmillan, New York, 1911.
Calocaris: From A. B. Williams, Two new axiids (Crustacea: Decapoda: Thalassinidea: *Calocaris*) from North Carolina and the Straits of Florida, *Proc. Biol. Soc. Wash.*, 87(39):451–464, 1974.
Glyphocragnon: From S. I. Smith, *Report on the Decapod Crustacea of the Albatross Dredgings off the Coast of the United States during the Summer and Autumn of 1884*, 1886.
Laomedia: From J. C. Yaldwyn and R. G. Wear, Preliminary description of a new burrowing mud-shrimp from eastern Australia (Crustacea, Macrura, Reptantia, Laomediidae), *Austral. Zool.*, 15(3):384–385, 1970.
Procambarus: From F. A. Chace, Jr., and H. H. Hobbs, Jr., The freshwater terrestrial decapod crustaceans of the West Indies with special reference to Dominica, *Smithson. Inst. Bull.*, no. 292, 1969.

Page 311 *Pagurus:* From J. E. Benedict, The hermit crabs of the *Pagurus bernhardus* type, *Proc. U.S. Nat. Mus.*, 23(1216):451–466, 1901.
Pentacheles: From S. I. Smith, *Report on the Decapod Crustacea of the Albatross Dredgings off the Coast of the United States during the Summer and Autumn of 1884*, 1886.
Pylocheles: From J. E. Benedict, Four new symmetrical hermit crabs (pagurids) from the West India region, *Proc. U.S. Nat. Mus.*, 23(1236):771–776, 1901.

Page 312 *Aegla:* From W. L. Schmitt, The species of *Aegla*, endemic South American freshwater crustaceans, *Proc. U.S. Nat. Mus.*, 91:431–520, 1942.
Lithodes: From S. I. Smith, *Report on the Decapod Crustacea of the Albatross Dredgings off the Coast of the United States during the Summer and Autumn of 1884*, 1886.
Probeebei: From T. Wolff, Description of a remarkable deep-sea hermit crab with notes on the evolution of the Paguridea, *Galathea Report*, vol. 4, pp. 11–32, 1961.
Uroptychus: From J. E. Benedict, Description of a new genus and forty-six new species of crustaceans of the family Galatheidae, with a list of the known marine species, *Proc. U.S. Nat. Mus.*, 26(1311):243–334, 1902.

Page 317 *Ethusina, Latreilla:* From S. I. Smith, *Decapod Crustacea of the Albatross Dredgings off the East Coast of the United States*, 1883.
Neorhynchoplax: From L. G. Abele, A review of the genus *Ambidexter* (Crustacea: Decapoda: Processidae) in Panama, *Bull. Mar. Sci.*, 22(2):365–380, 1972.
Petrolisthes: From F. A. Chace, Jr., and H. H. Hobbs, Jr., The freshwater terrestrial decapod crustaceans of the West Indies with special reference to Dominica, *Smithson. Inst. Bull.*, no. 292, 1969.

Page 318 *Mimilambrus:* From A. B. Williams, A new crab family from shallow waters of the West Indies (Crustacea: Decapoda: Brachyura), *Proc. Biol. Soc. Wash.*, 92(2):399–413, 1979.
Pseudocryptochirus: From J. K. Shaw and T. S. Hopkins, The distribution of the family Hapalocarcinidae (Decapoda, Brachura) on the Florida middle ground with a description of *Pseudocryptochirus hypostegus* new species, *Proceedings of the 3d International Coral Reef Symposium*, University of Miami, May 1977.
Sesarma: From L. G. Abele, A new species of *Sesarma, S. (Holometopus) rubinofforum*, from the Pacific coast of Panama (Crustacea, Decapoda, Grapsidae), *Proc. Biol. Soc. Wash.*, 86(27):333–338, 1973.
Sirpus: From I. Gordon, On *Sirpus*, a genus of pigmy cancroid crabs, *Bull. Brit. Mus. (Nat. Hist.)*, vol. 2, no. 3, 1953.

Page 319 *Coenobita, Gecarcinus, Guinotia, Ocypode:* From F. A. Chace, Jr., and H. H. Hobbs, Jr., The freshwater and terrestrial decapod crustaceans of the West Indies with special reference to Dominica, *Smithson. Inst. Bull.*, no. 292, 1969.
Dromia, Paromola: From M. E. Christiansen, *Crustacea Decapoda Brachyura*, The Norwegian Research Council for Science and the Humanities, 1969.

Page 320 From M. E. Christiansen, *Crustacea Decapoda Brachyura*, The Norwegian Research Council for Science and the Humanities, 1969.

Page 335 *Baetis* larva: From M. Grandi, *Boll. 1st Entomol. Univ. Bologna*, 11:2, 1940.
Drunella larva: From R. K. Allen and G. F. Edmunds, *Misc. Publ. Entomol. Soc. Amer.*, 3:148, 1962.
Hexagenia larva: From W. P. McCafferty, *Trans. Amer. Entomol. Soc.*, 101:447–504, 1975.
Paraleptophlebia larva: From B. D. Burks, *Bull. Ill. Nat. Hist. Surv.*, 26(Art. 1):91, 1953.

Page 336 *Baetisca* larva: From G. F. Edmunds, *Pan-Pac. Entomol.*, 36:103, 1960.
Caenis imago, male: From M. Grandi, *Boll. 1st Entomol. Univ. Bologna*, 12:138, 1942.

Caenis larva: From M. Grandi, *Boll. 1st Entomol. Univ. Bologna*, 13:153, 1942.
Choroterpes imago, male: From M. Grandi, *Boll. 1st Entomol. Univ. Bologna*, 13:191, 1941.
Copera, Neurobasis: From J. Stephenson (ed.), *The Fauna of British India, Including Ceylon and Burma*, Odonata, vol. 1 by F. C. Fraser, Taylor and Francis, London, 1933.
All others: From J. A. L. Watson, *The Insects of Australia*, Melbourne University Press, Carlton, 1970.

Page 400 *Amphigerontia:* From A. Badonnel, Psocopteres, *Faune Fr.*, 42:1–164, 1943.
Archipsocus: From A. B. Gurney, Nomenclatural notes on Corrodentia, with descriptions of two new species of *Archipsocus*, *J. Wash. Acad. Sci.*, 29(11):501–515, 1939.
Badonnelia: From K. K. Gunther, Uber einige interessante Psocoptera Funde in Berlin (DDR), *Deutsch. Entomol. Z.*, 21:317–329, 1974.
Caecilius: From G. Enderlein, The Percy Sladen Trust Expedition to the Indian Ocean in 1905 . . . VIII. Die Copeognathenfauna der Seychellen, *Trans. Linn. Soc. Lond. (Zool.)*, (2)19:207–240, 1931.
Liposcelis: From S. Tada, Studies on the Japanese psocid insects as stored products pest, II, *Jap. J. San Zool.*, 10(1):35–40, 1959.
Mesopsocus: From G. Enderlein, Psociden aus Deutsch Ostafricas, *Mitt. Zool. Mus. Berlin*, 2(2):7–16, 1902.
Psocatropos: From A. Badonnel, Contribution á l'étude de la faune du Mozambique. Voyage de M. P. Lesne (1928–1929) 4e note. Copeognathes, *Ann. Sci. Nat. Zool.*, (10)14(16):229–260, 1931.
Trogium: From A. Badonnel, Complements á l'étude des Psocopteres de Madagascar. *Bull. Mus. Nat. Hist.–Natur.*, (3) Zool., 287: 1143–1197, 1936.

Page 408 *Antarctopthirus, Hoplopleura, Pediculus, Polyplax, Pthirus:* From G. F. Ferris, *Atlas of the Scale Insects of North America*, AMS Press, 1951.
Haematopinus: From W. P. Meleney and Ke Chung Kim, A comparative study of cattle-infesting *Haematopinus*, Fahrenholz, 1916 (Anoplura: Haematopinidae), *J. Parasitol.*, 60(3):507–522, 1974.
Solenopotes: From C. F. Weisser and Ke Chung Kim, Rediscovery of *Solenopotes tarandi* (Mjoberg, 1915) (Linognathidae: Anoplura), with ectoparasites of the Barren Ground Caribou, *Parasitology*, 66:123–132, 1973.

Page 412 *Franciscoloa magnifici:* From R. D. Price, A new species of *Franciscoloa* (Mallophaga: Menoponidae) from Australia, *Pacific Insects*, 11(3–4):541–543, 1969.
Strigiphilus acadicus: From K. C. Emerson and R. D. Price, A new species of *Strigiphilus* from the saw-whet owl, *Aegolius acadicus*, *Proc. Entomol. Soc. Wash.*, 75(1):45–48, March 1973.

Page 413 *Damalinia maai:* From K. C. Emerson and R. D. Price, A new species of *Damalinia* (Mallophaga: Trichodectidae) from the formosan sika deer *(Cervus nippon taiouanus)*, *Proc. Biol. Soc. Wash.*, 86(26):329–332, Sept. 28, 1973.
Felicola liberiae: From K. C. Emerson and R. D. Price, A new species of *Felicola* (Mallophaga: Trichodectidae) from the Liberian mongoose *(Liberiictis kuhni)*, *Proc. Biol. Soc. Wash.*, 85(33):399–404, Dec. 30, 1972.

Page 448 Wing drawings by P. L. Firth.

Pages 462–465 Drawings by J. O. Howell and M. L. Williams.

Pages 484, 485, 495, 530 From Division of Entomology, Commonwealth Scientific and Industrial Research Organization, Australia.

Pages 605, 606 Illustrations by Anker Odum; reproduced with permission of the Royal Ontario Museum.

Page 826 For all sections (except *Symplegma*), after Berrill, 1950.

List of Plates

Contents

PROKARYOTAE

JOHN O. CORLISS

Predominantly unicellular microorganisms or infectious agents of cells (the viruses), prokaryotic, with reproduction asexual and chromonemal and with recombination unidirectional. The Prokaryotae sensu lato may be considered to include a kingdom for viruses, although such "organisms" are considered acellular or noncellular (even nonliving) by many authorities, and one for the typical moneran forms, the many kinds of "true" bacteria plus the aphragmobacteria (the "nonwalled" mycoplasmas), the myxobacteria (gliding forms), the cyanobacteria (the "blue-green algae"), and the curious chloroxybacteria (the recently discovered Prochloron).

The 2 kingdoms constituting this superkingdom possess little in common, besides such superficial characters as microscopic (or ultramicroscopic) size and frequent involvement in causing diseases in other organisms, including human beings, and such negative characters as not being eukaryotic, not possessing any mouth opening, and not being multicellular (or, in the case of viruses, even cellular) in their organization. In the smallest dimension, prokaryotes measure from 0.2 to 10 μm; viruses show a diameter of 10 to 300 nm, the largest, therefore, just barely overlapping in width with the smallest bacterium.

Monerans (above the virus level) are generally solitary, unicellular forms; but some species are filamen-

tous, colonial, or mycelial. Some are also motile, either by gliding or by the action of bacterial flagella containing the protein flagellin. Modes of nutrition are diverse: absorptive, chemosynthetic, photoheterotrophic, and photoautotrophic. Respiration is anaerobic or aerobic, or facultatively either one. Respiratory and photosynthetic functions are both generally associated with the plasma membrane system: there are no specialized organelles such as mitochondria or plastids, although thylakoids are present in cyanobacteria and in Prochloron.

Virus particles can survive in a dried, crystalline, metabolically inert state. Bacteria may produce endospores of great resistance to a variety of environmental stresses; the trophic forms occur ubiquitously in aquatic or moist habitats, including cells and tissues of hosts belonging to all other groups of organisms. Complex viruses have an envelope surrounding the nucleocapsid; many bacteria possess rigid cell walls, and some produce outer sheaths.

Viruses replicate only in (other living) cells: that is, they are obligate intracellular parasites in the cytoplasm or nuclei of unicellular organisms or in the cells of tissues or organs of multicellular organisms. Viral nucleic acid (RNA or DNA) contains the proper genetic information to cause the infected host cell to synthesize the materials needed for making more viruses of the same kind as the invader. In the monerans, reproduction of the haploid cell is essentially asexual, by fission or budding. But mechanisms of gene transfer and recombination occur, though without involvement of the processes so common in even the lower eukaryotes, namely, gametogenesis and zygote formation. The nucleoplasm is not enclosed by a nuclear membrane, no microtubular spindle is formed, no centrioles are present, and genic material is associated with single chromonemata rather than chromosomes. Recombination is either unidirectional or mediated by viruses present.

Fewer than 50 families have been recognized by taxonomic students of the kingdom Virus, and most of these have been formally proposed only recently. With respect to the combined 3 divisions (Bacteria, Cyanophycota, Prochlorophycota) of the kingdom Monera, scores of families (or equivalent taxonomic groups) have been described.

References. T. D. Brock, "Biology of Microorganisms," 3d ed., Prentice-Hall, Englewood Cliffs, NJ, 1979; F. Fenner, Classification and nomenclature of viruses: Second report of the International Committee on Taxonomy of Viruses, "Intervirology," 7:1–116, 1976; L. Margulis, The classification and evolution of prokaryotes and eukaryotes, in R. C. King (ed.), "Handbook of Genetics," vol. 1, pp. 1–41, Plenum Press, New York, 1974; L. Margulis and K. Schwartz, "Phyla of the Five Kingdoms: An Illustrated Guide to the Kinds of Life on Earth," W. H. Freeman, San Francisco, 1981; R. E. F. Matthews, Classification and nomenclature of viruses: Third report of the International Committee on Taxonomy of Viruses, "Intervirology," 12:129–296, 1979; R. Y. Stanier, E. A. Adelberg, and J. Ingraham, "The Microbial World," 4th ed., Prentice-Hall, Englewood Cliffs, NJ, 1976.