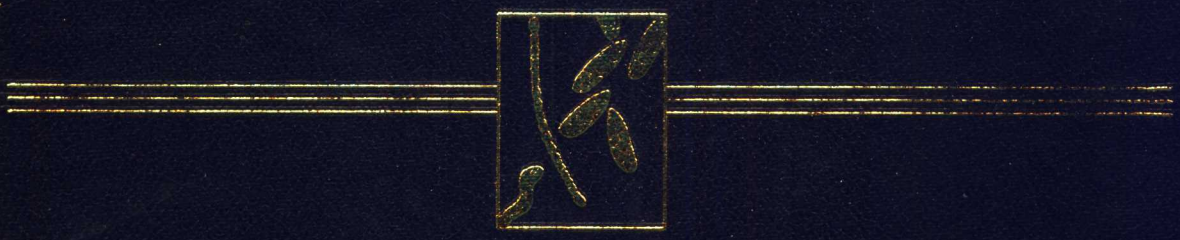
Encyclopedia of MICROBIOLOGY



Second Edition

Volume 4 Q–Z

Encyclopedia of MICROBIOLOGY

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Joshua Lederberg

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Preface

The scientific literature at large is believed to double about every 12 years. Though less than a decade has elapsed since the initiation of the first edition of this encyclopedia, it is a fair bet that the microbiology literature has more than doubled in the interval, though one might also say it has fissioned in the interval, with parasitology, virology, infectious disease, and immunology assuming more and more independent stature as disciplines.

According to the *Encyclopaedia Britannica*, the encyclopedias of classic and medieval times could be expected to contain "a compendium of all available knowledge." There is still an expectation of the "essence of all that is known." With the exponential growth and accumulation of scientific knowledge, this has become an elusive goal, hardly one that could be embraced in a mere two or three thousand pages of text. The encyclopedia's function has moved to becoming the first word, the initial introduction to knowledge of a comprehensive range of subjects, with pointers on where to find more as may be needed. One can hardly think of the last word, as this is an ever-moving target at the cutting edge of novel discovery, changing literally day by day.

For the renovation of an encyclopedia, these issues have then entailed a number of pragmatic compromises, designed to maximize its utility to an audience of initial look-uppers over a range of coherently linked interests. The core remains the biology of that group of organisms we think of as microbes. Though this constitutes a rather disparate set, crossing several taxonomic kingdoms, the more important principle is the unifying role of DNA and the genetic code and the shared ensemble of primary pathways of gene expression. Also shared is access to a "world wide web" of genetic information through the traffic of plasmids and other genetic elements right across the taxa. It is pathognomonic that the American Society for Microbiology has altered the name of *Microbiological Reviews* to *Microbiology and Molecular Biology Reviews*. At academic institutions, microbiology will be practiced in any or all of a dozen different departments, and these may be located at schools of arts and sciences, medicine, agriculture, engineering, marine sciences, and others.

Much of human physiology, pathology, or genetics is now practiced with cell culture, which involves a methodology indistinguishable from microbiology: it is hard to define a boundary that would demarcate microbiology from cell biology. Nor do we spend much energy on these niceties except when we have the burden of deciding the scope of an enterprise such as this one.

Probably more important has been the explosion of the Internet and the online availability of many sources of information. Whereas we spoke last decade of CDs, now the focus is the Web, and the anticipation is that we are not many years from the general availability of the entire scientific literature via this medium. The utility of the encyclopedia is no longer so much "how do I begin to get information on Topic X" as how to filter a surfeit of claimed information with some degree of dependability. The intervention of editors and of a peer-review process (in selection of authors even more important than in overseeing their papers) is the only foreseeable solution. We have then sought in each article to provide a digest of information with perspective and

provided by responsible authors who can be proud of, and will then strive to maintain, reputations for knowledge and fairmindedness.

The further reach of more detailed information is endless. When available, many specific topics are elaborated in greater depth in the ASM (American Society of Microbiology) reviews and in *Annual Review of Microbiology*. These are indexed online. Medline, Biosis, and the Science Citation Index are further online bibliographic resources, which can be focused for the recovery of review articles.

The reputation of the authors and of the particular journals can further aid readers' assessments. Citation searches can be of further assistance in locating critical discussions, the dialectic which is far more important than "authority" in establishing authenticity in science.

Then there are the open-ended resources of the Web itself. It is not a fair test for recovery on a specialized topic, but my favorite browser, google.com, returned 15,000 hits for "microbiology"; netscape.com gave 46,000; excite.com a few score structured headings. These might be most useful in identifying other Web sites with specialized resources. Google's 641 hits for "luminescent bacteria" offer a more proximate indicator of the difficulty of coping with the massive returns of unfiltered verbiage that this wonderful new medium affords: how to extract the nuggets from the slag.

A great many academic libraries and departments of microbiology have posted extensive considered listings of secondary sources. One of my favorites is maintained at San Diego State University:

http://libweb.sdsu.edu/scidiv/microbiologyblr.html

I am sure I have not begun to tap all that would be available.

The best strategy is a parallel attack: to use the encyclopedia and the major review journals as a secure starting point and then to try to filter Web-worked material for the most up-to-date or disparate detail. In many cases, direct enquiry to the experts, until they saturate, may be the best (or last) recourse. E-mail is best, and society or academic institutional directories can be found online. Some listservers will entertain questions from outsiders, if the questions are particularly difficult or challenging.

All publishers, Academic Press included, are updating their policies and practices by the week as to how they will integrate their traditional book offerings with new media. Updated information on electronic editions of this and cognate encyclopedias can be found by consulting www.academicpress.com/.

Joshua Lederberg

From the Preface to the First Edition

(Excerpted from the 1992 Edition)

For the purposes of this encyclopedia, microbiology has been understood to embrace the study of "microorganisms," including the basic science and the roles of these organisms in practical arts (agriculture and technology) and in disease (public health and medicine). Microorganisms do not constitute a well-defined taxonomic group; they include the two kingdoms of Archaebacteria and Eubacteria, as well as protozoa and those fungi and algae that are predominantly unicellular in their habit. Viruses are also an important constituent, albeit they are not quite "organisms." Whether to include the mitochondria and chloroplasts of higher eukaryotes is a matter of choice, since these organelles are believed to be descended from free-living bacteria. Cell biology is practiced extensively with tissue cells in culture, where the cells are manipulated very much as though they were autonomous microbes; however, we shall exclude this branch of research. Microbiology also is enmeshed thoroughly with biotechnology, biochemistry, and genetics, since microbes are the canonical substrates for many investigations of genes, enzymes, and metabolic pathways, as well as the technical vehicles for discovery and manufacture of new biological products, for example, recombinant human insulin. . . .

The *Encyclopedia of Microbiology* is intended to survey the entire field coherently, complementing material that would be included in an advanced undergraduate and graduate major course of university study. Particular topics should be accessible to talented high school and college students, as well as to graduates involved in teaching, research, and technical practice of microbiology.

Even these hefty volumes cannot embrace all current knowledge in the field. Each article does provide key references to the literature available at the time of writing. Acquisition of more detailed and up-to-date knowledge depends on (1) exploiting the review and monographic literature and (2) bibliographic retrieval of the preceding and current research literature. . . .

To access bibliographic materials in microbiology, the main retrieval resources are MEDLINE, sponsored by the U.S. National Library of Medicine, and the Science Citation Index of the ISI. With governmental subsidy, MEDLINE is widely available at modest cost: terminals are available at every medical school and at many other academic centers. MEDLINE provides searches of the recent literature by author, title, and key word and offers online displays of the relevant bibliographies and abstracts. Medical aspects of microbiology are covered exhaustively; general microbiology is covered in reasonable depth. The Science Citation Index must recover its costs from user fees, but is widely available at major research centers. It offers additional search capabilities, especially by citation linkage. Therefore, starting with the bibliography of a given encyclopedia article, one can quickly find (1) all articles more recently published that have cited those bibliographic reference starting points and (2) all other recent articles that share bibliographic information with the others. With luck, one of these articles may be identified as another comprehensive

review that has digested more recent or broader primary material.

On a weekly basis, services such as Current Contents on Diskette (ISI) and Reference Update offer still more timely access to current literature as well as to abstracts with a variety of useful features. Under the impetus of intense competition, these services are evolving rapidly, to the great benefit of a user community desperate for electronic assistance in coping with the rapidly growing and intertwined networks of discovery. The bibliographic services of Chemical Abstracts and Biological Abstracts would also be potentially invaluable; however, their coverage of microbiology is rather limited.

In addition, major monographs have appeared from time to time—*The Bacteria, The Prokaryotes,* and many others. Your local reference library should be consulted for these volumes.

Valuable collections of reviews also include *Critical Reviews for Microbiology, Symposia of the Society for General Microbiology, Monographs of the American Society for Microbiology,* and *Proceedings of the International Congresses of Microbiology.*

The articles in this encyclopedia are intended to be accessible to a broader audience, not to take the place of review articles with comprehensive bibliographies. Citations should be sufficient to give the reader access to the latter, as may be required. We do apologize to many individuals whose contributions to the growth of microbiology could not be adequately embraced by the secondary bibliographies included here.

The organization of encyclopedic knowledge is a daunting task in any discipline; it is all the more complex in such a diversified and rapidly moving domain as microbiology. The best way to anticipate the rapid further growth that we can expect in the near future is unclear. Perhaps more specialized series in subfields of microbiology would be more appropriate. The publishers and editors would welcome readers' comments on these points, as well as on any deficiencies that may be perceived in the current effort.

My personal thanks are extended to my coeditors, Martin Alexander, David Hopwood, Barbara Iglewski, and Allen Laskin; and above all, to the many very busy scientists who took time to draft and review each of these articles.

Joshua Lederberg

Guide to the Encyclopedia

The *Encyclopedia of Microbiology, Second Edition* is a scholarly source of information on microorganisms, those life forms that are observable with a microscope rather than by the naked eye. The work consists of four volumes and includes 298 separate articles. Of these 298 articles, 171 are completely new topics commissioned for this edition, and 63 others are newly written articles on topics appearing in the first edition. In other words, approximately 80% of the content of the encyclopedia is entirely new to this edition. (The remaining 20% of the content has been carefully reviewed and revised to ensure currency.)

Each article in the encyclopedia provides a comprehensive overview of the selected topic to inform a broad spectrum of readers, from research professionals to students to the interested general public. In order that you, the reader, will derive the greatest possible benefit from your use of the *Encyclopedia of Microbiology*, we have provided this Guide. It explains how the encyclopedia is organized and how the information within it can be located.

ORGANIZATION

The *Encyclopedia of Microbiology* is organized to provide maximum ease of use. All of the articles are arranged in a single alphabetical sequence by title. Articles whose titles begin with the letters A to C are in Volume 1, articles with titles from D through K are in Volume 2, then L through P in Volume 3, and finally Q to Z in Volume 4. This last volume also includes a complete subject index for the entire work, an alphabetical list of the contributors to the encyclopedia, and a glossary of key terms used in the articles.

Article titles generally begin with the key noun or noun phrase indicating the topic, with any descriptive terms following. For example, the article title is "Bioluminescence, Microbial" rather than "Microbial Bioluminescence," and "Foods, Quality Control" is the title rather than "Quality Control of Foods."

TABLE OF CONTENTS

A complete table of contents for the *Encyclopedia of Microbiology* appears at the front of each volume. This list of article titles represents topics that have been carefully selected by the Editor-in-Chief, Dr. Joshua Lederberg, and the nine Associate Editors. The Encyclopedia provides coverage of 20 different subject areas within the overall field of microbiology. Please see p. v for the alphabetical table of contents, and p. xix for a list of topics arranged by subject area.

INDEX

The Subject Index in Volume 4 indicates the volume and page number where information on a given topic can be found. In addition, the Table of Contents by Subject Area also functions as an index, since it lists all the topics within a given area; e.g., the encyclopedia includes eight different articles dealing with historic aspects of microbiology and nine dealing with techniques of microbiology.

ARTICLE FORMAT

In order to make information easy to locate, all of the articles in the *Encyclopedia of Microbiology* are arranged in a standard format, as follows:

- Title of Article
- Author's Name and Affiliation
- Outline
- Glossary
- Defining Statement
- Body of the Article
- Cross-References
- Bibliography

OUTLINE

Each entry in the Encyclopedia begins with a topical outline that indicates the general content of the article. This outline serves two functions. First, it provides a brief preview of the article, so that the reader can get a sense of what is contained there without having to leaf through the pages. Second, it serves to highlight important subtopics that will be discussed within the article. For example, the article "Biopesticides" includes subtopics such as "Selection of Biopesticides," "Production of Biopesticides," "Biopesticide Stabilization," and "Commercialization of Biopesticides."

The outline is intended as an overview and thus it lists only the major headings of the article. In addition, extensive second-level and third-level headings will be found within the article.

GLOSSARY

The Glossary contains terms that are important to an understanding of the article and that may be unfamiliar to the reader. Each term is defined in the context of the article in which it is used. Thus the same term may appear as a glossary entry in two or more articles, with the details of the definition varying slightly from one article to another. The encyclopedia has approximately 2500 glossary entries.

In addition, Volume 4 provides a comprehensive glossary that collects all the core vocabulary of microbiology in one A–Z list. This section can be consulted for definitions of terms not found in the individual glossary for a given article.

DEFINING STATEMENT

The text of each article in the encyclopedia begins with a single introductory paragraph that defines the topic under discussion and summarizes the content of the article. For example, the article "Eyespot" begins with the following statement:

> EYESPOT is a damaging stem base disease of cereal crops and other grasses caused by fungi of the genus *Tapsia*. It occurs in temperate regions world-wide including Europe, the USSR, Japan, South Africa, North America, and Australasia. In many of these countries eyespot can be found on the majority of autumn-sown barley and wheat crops and may cause an average of 5–10% loss in yield, although low rates of infection do not generally have a significant effect. . . .

CROSS-REFERENCES

Almost all of the articles in the Encyclopedia have cross-references to other articles. These cross-references appear at the conclusion of the article text. They indicate articles that can be consulted for further information on the same topic or for information on a related topic. For example, the article "Smallpox" has references to "Biological Warfare," "Polio," "Surveillance of Infectious Diseases," and "Vaccines, Viral."

BIBLIOGRAPHY

The Bibliography is the last element in an article. The reference sources listed there are the author's recommendations of the most appropriate materials for further research on the given topic. The bibliography entries are for the benefit of the reader and do not represent a complete listing of all materials consulted by the author in preparing the article.

COMPANION WORKS

The *Encyclopedia of Microbiology* is one of a series of multivolume reference works in the life sciences published by Academic Press. Other such titles include the *Encyclopedia of Human Biology*, *Encyclopedia of Reproduction*, *Encyclopedia of Toxicology*, *Encyclopedia of Immunology*, *Encyclopedia of Virology*, *Encyclopedia of Cancer*, and *Encyclopedia of Stress*.

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