

# APPLIED AND ENVIRONMENTAL MICROBIOLOGY

VOLUME 39 • NUMBER 4 • APRIL 1980

## EDITORIAL BOARD

**Marvin P. Bryant, Editor-in-Chief (1981)**  
*University of Illinois, Urbana*

**Robert T. Belly, Editor (1984)**  
*Eastman Kodak Company*  
*Rochester, N. Y.*

**R. H. Deibel, Editor (1981)**  
*University of Wisconsin, Madison*

**A. L. Demain, Editor (1981)**  
*Massachusetts Institute of Technology, Cambridge*

**Martin S. Favero, Editor (1980)**  
*Center for Disease Control,*  
*Phoenix, Ariz.*

**James M. Tiedje, Editor (1984)**  
*Michigan State University, East Lansing*

Bernard J. Abbott (1980)  
Martin Alexander (1980)  
Milton J. Allison (1980)  
Ronald Atlas (1980)  
Richard Bartha (1982)  
Joan W. Bennett (1981)  
Merlin Bergdoll (1981)  
Martha D. Berliner (1980)  
Thomas L. Bott (1980)  
Charles Boylen (1982)  
Thomas Brock (1980)  
Lee A. Bulla, Jr. (1980)  
Lloyd B. Bullerman (1980)  
Victor Cabelli (1982)  
Paul E. Came (1982)  
Tom D. Y. Chin (1980)  
Alex Ciegler (1980)  
Richard T. J. Clarke (1981)  
Michael A. Cole (1982)  
Rita R. Colwell (1980)  
Richard A. Consigli (1982)  
Charles Cooney (1979)  
Joseph J. Cooney (1980)  
Frank Dazzo (1982)  
Steven W. Drew (1981)  
Richard Elander (1982)  
Beatrice England (1980)  
Jerald C. Ensign (1980)  
Douglas Eveleigh (1982)

Carl B. Fliermans (1981)  
Heinz G. Floss (1980)  
Dennis Focht (1982)  
Edwin E. Geldreich (1982)  
Charles Gerba (1982)  
Richard E. Goldstrand (1982)  
Reinaldo F. Gomez (1982)  
Leslie Grady (1982)  
Charles Hagedorn III (1982)  
Bruce Hamilton (1981)  
Paul A. Hartman (1980)  
Melvin T. Hatch (1981)  
Charles W. Hendricks (1980)  
Robert B. Hespell (1980)  
David H. Hubbell (1981)  
John J. Iandolo (1980)  
John Johnson (1982)  
David M. Karl (1982)  
Edward Katz (1982)  
Michael J. Klug (1980)  
Roger Knowles (1982)  
Paul Lemke (1982)  
Carol Litchfield (1980)  
Gordon A. McFeters (1981)  
Prakash Masurekar (1982)  
Joseph L. Melnick (1980)  
Richard Morita (1982)  
Claude H. Nash (1981)  
Ronald Oremland (1982)

Eldor A. Paul (1980)  
W. O. Pipes (1981)  
Hap Pritchard (1982)  
C. A. Reddy (1982)  
Douglas Ribbons (1982)  
Antonio H. Romano (1980)  
John P. Rosazza (1982)  
Dwayne Savage (1982)  
Robert D. Schwartz (1982)  
Oldrich K. Sebek (1980)  
John McN. Sieburth (1981)  
William H. Sperber (1980)  
James T. Staley (1980)  
Hiroshi Sugiyama (1981)  
Anne O. Summers (1982)  
Jon H. Tuttle (1980)  
Claude Vezina (1982)  
Edward Voss (1981)  
D. I. C. Wang (1981)  
David White (1982)  
William J. Wiebe (1980)  
Fred D. Williams (1980)  
R. P. Williams (1981)  
G. N. Wogan (1980)  
Alan G. Wolin (1980)  
Meyer J. Wolin (1982)  
William Yotis (1982)  
Stanley A. Zahler (1982)

**Robert A. Day, Managing Editor**  
**Gisella Pollock, Assistant Managing Editor**  
**Cheryl Cross, Production Editor**  
*1913 I St., NW, Washington, DC 20006*

## EX OFFICIO

**Willis A. Wood, President (1979-1980)**  
**J. Mehsen Joseph, Secretary**

**Albert Balows, President-Elect (1979-1980)**  
**Brinton M. Miller, Treasurer**

*Applied and Environmental Microbiology* (ISSN 0099-2240), a publication of the American Society for Microbiology, 1913 I St., N.W., Washington, D.C. 20006, is devoted to the advancement and dissemination of applied knowledge as well as ecological knowledge, both applied and fundamental, concerning microorganisms. Instructions to Authors are published in the January issue each year. *Applied and Environmental Microbiology* is published monthly, two volumes per year. The nonmember subscription price is \$70 per year. The member subscription price is \$17 per year. Single copies are \$6.00. Correspondence relating to subscriptions, nonreceipt of journals, reprints, defective copies, availability of back issues, and lost or late proofs should be directed to the ASM Publications Office, 1913 I St., N.W., Washington, D.C. 20006 (area 202-833-9680).

日本：価格は外貨表示とは関係なく円建。

Second-class postage paid at Washington, DC 20006, and at

additional mailing offices. Made in the United States of America. Copyright © 1980, American Society for Microbiology. All Rights Reserved.

The code at the top of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal use, or for personal use of specific clients. This consent is given on the condition, however, that the copier pay the stated per-copy fee through the Copyright Clearance Center, Inc., P.O. Box 765, Schenectady, New York 12301, for copying beyond that permitted by Sections 107 and 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale.

# Author Index

- Abshire, Robert L., 695  
Andrews, Robert E., Jr., 932  
Antoine, A. D., 777  
Asher, Rodney A., 686
- Bain, Beverly, 695  
Bazylnski, Dennis A., 934  
Bennett, J. W., 835  
Berg, Gerald, 850  
Biguet, J., 770  
Boise, Jean R., 840  
Bollag, Jean-Marc, 845  
Bölter, M., 797  
Boudreaux, G. H., 835  
Burge, Harriet A., 840  
Burke, John A., 872
- Cato, Elizabeth P., 900
- Dahling, Daniel R., 850  
Davis, N. D., 882  
Dawson, R., 797  
Dean, A. V., 777  
De Jonckheere, Johan F., 681  
Derelanko, P., 720, 727  
Deshpande, M. V., 935  
Diener, U. L., 882
- Eagon, R. G., 831
- Federle, Thomas W., 888  
Felix, A., 720, 727  
Finkelman, Malcolm A. J., 923  
Fredell, Dale L., 743
- Gabrielson, R. L., 803  
Gatenbeck, Sten, 828  
Gerba, Charles P., 749  
Gilbert, S. G., 777  
Grimes, D. Jay, 782  
Güde, Hans, 756
- Harada, Tokuya, 812  
Harvey, R. W., 894
- Hash, D. E., 900  
Hespell, Robert B., 709  
Hitokoto, Hiroshi, 818  
Hökby, Elvy, 828  
Holdeman, Lillian V., 900  
Hou, C. T., 720, 727  
Hult, Karl, 828  
Huss, Hans Henrik, 764  
Hutchinson, D. B., 702
- Jaska, James M., 743  
Jones, William J., 864
- Kempler, G. M., 926  
King, Gary M., 877  
Knudsen, R. C., 823  
Kurata, Hiroshi, 818  
Kurek, Ewa J., 845
- LaBelle, Raymond L., 749  
Lablache-Combiér, A., 770  
Lafon-Lafourcade, S., 808  
Lamka, Karla G., 734  
Larue, F., 808  
Laskin, A. I., 720, 727  
LeChevallier, Mark W., 734, 739  
Lee, L. S., 835  
Leedle, Jane A. Zeigler, 709  
Liebezeit, G., 797
- Mays, Edward L., 686  
McKay, L. L., 926  
Meyer-Reil, L.-A., 797  
Miehl, Rosemarie, 854  
Miller, Lois K., 932  
Moore, W. E. C., 900  
Moran, James W., 928  
Moreau, S., 770  
Morozumi, Satoshi, 818  
Mountfort, Douglas O., 686  
Mulanax, M. W., 803  
Mulcahy, Dan, 872  
Murooka, Yoshikatsu, 812
- Okushima, Minoru, 908
- Patel, Ramesh N., 720, 727  
Paynter, Malcolm J. B., 864  
Perry, M. J., 913  
Polatnick, J., 823
- Rake, J. B., 831  
Ribereau-Gayon, P., 808  
Richmond, J. Y., 823  
Rosenberg, F. A., 934  
Rutqvist, Lars, 828
- Sadana, J. C., 935  
Sakai, Senzo, 818  
Sakai, Takuo, 908  
Schaad, N. W., 803  
Schwartz, Robert D., 702  
Seidler, Ramon J., 734, 739  
Shewale, J. G., 935  
Shoss, S. M., 835  
Solomon, William R., 840  
Spence, Kemet D., 932  
Szwernski, H., 797
- Tiedje, James M., 686
- Vardanis, Alex, 923  
Vestal, J. Robie, 888
- Wagener, R. E., 882  
Ward, B. B., 913  
Wauke, Tomoaki, 818  
Wiebe, W. J., 877  
Williams, A. L., 702  
Williams, Thelma, 695  
Witter, Lloyd D., 928  
Witzel, Karl-Paul, 790  
Wojciechowicz, Maria, 919  
Wolter, K., 797
- Yamin, Michael A., 859  
Yarbrough, J. M., 831  
Yasbin, Ronald E., 854  
Yim, Moo-Hyun, 812  
Young, L. Y., 894
- Zajic, James E., 923  
Ziotecki, Aleksander, 919