

APPLIED AND ENVIRONMENTAL MICROBIOLOGY

VOLUME 67 • JUNE 2001 • NUMBER 6

Judy D. Wall, *Editor in Chief* (2005)
University of Missouri

Daniel J. Arp, *Minireview Editor* (2004)
Oregon State University

Richard Devereux, *Editor* (2003)
U.S. Environmental Protection Agency

Harold L. Drake, *Editor* (2001)
Universität Bayreuth

Caroline S. Harwood, *Editor* (2001)
University of Iowa

Eric A. Johnson, *Editor* (2005)
University of Wisconsin

Christian P. Kubicek, *Editor* (2002)
Technische Universität Wien

John F. Leslie, *Editor* (2001)
Kansas State University

Gary P. Roberts, *Editor* (2001)
University of Wisconsin

Michael J. Sadowsky, *Editor* (2003)
University of Minnesota

Michael E. Stiles, *Editor* (2002)
University of Alberta

Peter A. Williams, *Editor* (2004)
University of Wales

EDITORIAL BOARD

Keietsu Abe ('01)
Michael J. Adang ('03)
Jose A. Amador ('03)
Rudolf Amann ('02)
David Archer ('01)
Judith P. Armitage ('02)
Arthur Aronson ('01)
Brian Austin ('02)
Simon V. Avery ('02)
Charles W. Bacon ('01)
Hubert Bahl ('02)
Mark Bailey ('01)
Alan Bakalinsky ('03)
Katherine H. Baker ('03)
József Baranyi ('01)
Douglas H. Bartlett ('02)
J. Thomas Beatty ('03)
Colin Berry ('02)
Robert C. Blake II ('01)
Michael Blaut ('01)
Paul Blum ('01)
Paul L. E. Bodelier ('02)
Dulal Borthakur ('03)
Thomas L. Bott ('03)
Peter J. Bottomley ('03)
Botho Bowen ('01)
Axel Brakhage ('01)
Michael G. Bramucci ('02)
Gunnar Bratbak ('02)
Neil C. Bruce ('01)
Andreas Brune ('01)
Thomas D. Bruns ('01)
Douglas G. Capone ('02)
Jeffrey W. Cary ('01)
Enrique Cerdá-Olmedo ('03)
Darrrell P. Chandler ('03)
John D. Coates ('02)
Yehuda Cohen ('03)
Patricia J. S. Colberg ('01)
Keith E. Cooksey ('02)
Tim Coolbear ('03)
Michael A. Cotta ('01)

Sarah Covert ('01)
Daniel Cullen ('01)
Lori L. Daane ('02)
Thomas J. Daniels ('01)
Jeffrey F. D. Dean ('02)
Albert A. de Graaf ('02)
Edward F. DeLong ('02)
Edward DeMott ('01)
Sylvie Dequin ('01)
Thomas J. DiChristina ('02)
Martin Dickman ('02)
Jan Dolfing ('01)
Peter Dürre ('02)
Richard Eaton ('01)
Claudia Eggert ('02)
Henry L. Ehrlich ('01)
Lindsay Eltis ('01)
David Emerson ('03)
Brian Federici ('03)
Juan Ferré ('03)
Robert Findlay ('03)
Ulrich Fischer ('02)
Miroslav Flieger ('02)
Clay Fuqua ('02)
Gill G. Geesey ('02)
Bruce Geller ('01)
Katharine J. Gibson ('01)
Bonita Glatz ('01)
L. Anne Glover ('03)
Amanda E. Goodman ('03)
Friedrich Götz ('02)
Richard M. Greene ('02)
Max Häggblom ('03)
Dittmar Hahn ('01)
Kenneth E. Hammel ('01)
Jo Handelsman ('02)
Theo A. Hansen ('01)
Ian M. Head ('02)
Joan Henson ('01)
Mark E. Hines ('02)
Ayala Hochman ('03)
Christof Holliger ('01)

Laszlo Hornok ('02)
Michael R. Hyman ('02)
Karl-Erich Jaeger ('02)
Walter Jakubowski ('01)
Dick Janssen ('01)
Peter H. Janssen ('02)
Edward L. Jarroll ('01)
Diann Jordan ('01)
David Kaplan ('01)
Sophia Kathariou ('03)
Michael G. Kaufman ('01)
Jay D. Keasling ('02)
Lee Kerkhof ('03)
Ronald P. Kiene ('02)
Brian K. Kinkle ('01)
Keith K. Klein ('03)
Guy R. Knudsen ('02)
Tyler Kokjohn ('01)
Joseph A. Krzycki ('01)
John M. Kuchta ('01)
Jerome J. Kukor ('02)
Charles F. Kulp, Jr. ('01)
Kin S. Lam ('02)
Allen I. Laskin ('02)
Peter C. K. Lau ('02)
Mark W. LeChevallier ('01)
Laura G. Leff ('02)
John A. Leigh ('03)
Hiltrud Lenke ('03)
Thomas G. Leslie ('01)
Gunnar Lidén ('01)
Werner Liesack ('01)
James Ligon ('02)
John E. Linz ('01)
John Londesborough ('01)
Charles R. Lovell ('02)
Derek R. Lovley ('01)
Roderick I. Mackie ('01)
Eugene L. Madsen ('02)
Raina Maier ('01)
Walter F. O. Marasas ('01)
Robert E. Marquis ('02)

Phyllis Martin ('01)
Luke Masson ('02)
Ann G. Matthysse ('01)
Timothy R. McDermott ('02)
Robert J. C. McLean ('01)
Phillip G. Meaden ('02)
Aubrey F. Mendonca ('03)
Eric S. Miller ('02)
Robert V. Miller ('02)
Terry L. Miller ('02)
Donald A. Morrison ('02)
Mark Morrison ('02)
Jim Mueller ('01)
Volker Müller ('01)
Gerard Muyzer ('01)
Charles R. Myers ('03)
David Myrold ('01)
Kenneth Nickerson ('01)
Peter A. Noble ('01)
Jeanette Norton ('01)
Klaus Nuesslein ('03)
Mark R. O'Brien ('03)
Andrew Ogram ('03)
Oladele A. Ogunseitan ('02)
Gregory Olson ('01)
William J. Page ('01)
Brian Palenik ('01)
Matthew R. Parsek ('03)
John H. Paul ('03)
Gary Payne ('01)
Philip Pienkos ('01)
Leland S. Pierson III ('02)
Joseph Piesman ('01)
James F. Preston ('01)
Isak S. Pretorius ('02)
Fredrick A. Rainey ('02)
Douglas E. Rawlings ('03)
Bibek Ray ('01)
Donald J. Reasoner ('01)
Gregor Reid ('02)
Ian D. Reid ('03)
Eugene W. Rice ('01)

John F. Robyl ('02)
Tony Romeo ('02)
Thomas Ross ('01)
Edward G. Ruby ('01)
Isabel Sá-Correia ('02)
Francis Schmidt ('03)
Kate M. Scow ('02)
Simon D. Silver ('02)
Gregory R. Siragusa ('03)
Jim C. Spain ('03)
Dirk Springael ('03)
Lucas J. Stal ('03)
Thad B. Stanton ('01)
Herbert Strobel ('02)
Keller Suberkropp ('01)
John B. Sutherland ('01)
John R. Tagg ('02)
Maija Tenkanen ('02)
Ulf Thrane ('02)
Eva M. Top ('03)
Jack T. Trevors ('03)
Tony Trinci ('01)
Eric W. Triplett ('02)
Peter van Berkum ('02)
Jan Roelof van der Meer ('01)
Tina K. Van Dyk ('01)
Jan Dirk van Elsas ('03)
Pieter T. Visscher ('03)
Andrew J. Weightman ('03)
Marleen Wekell ('01)
Graham F. White ('03)
Brian Wilkinson ('01)
Joanne Willey ('02)
Charles Woloshuk ('01)
Michael Wyman ('03)
Luying N. Xun ('02)
Kimiko Yabe ('02)
Jonathan P. Zehr ('03)
Daniel R. Zeigler ('02)
Jizhong Zhou ('03)

Samuel Kaplan, *Chairman, Publications Board*
John N. Bell, *Production Editor*

Linda M. Illig, *Director, Journals*
Margaret S. Milhous, *Assistant Production Editor*

Applied and Environmental Microbiology (ISSN 0099-2240), a publication of the American Society for Microbiology (ASM), 1752 N St., N.W., Washington, DC 20036-2904, 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; reprints are available from the editors and the Journals Department. *Applied and Environmental Microbiology* is published monthly, one volume per year. Nonmember print subscription prices (per year) are: \$421, U.S.; \$448, Canada (plus 7% GST, or 7% GST + 8% HST where applicable); \$484, Europe; \$489, Latin America; \$503, rest of world. Member print subscription prices (per year) are: \$64, U.S.; \$92, Canada (plus 7% GST, or 7% GST + 8% HST where applicable); \$123, Europe; \$136, Latin America; \$151, rest of world. Single copies are: \$50, nonmember; \$20, member (Canadians add 7% GST, or 7% GST + 8% HST where applicable). For prices of electronic versions, contact the Subscriptions Unit, ASM. Correspondence relating to subscriptions, defective copies, missing issues, and availability of back issues should be directed to the Subscriptions Unit, ASM; correspondence relating to reprint orders should be directed to the Reprint Order Unit, ASM; and correspondence relating to disposition of submitted manuscripts, proofs, and general editorial matters should be directed to the Journals Department, American Society for Microbiology, 1752 N St., N.W., Washington, DC 20036-2904. Phone: (202) 737-3600.

Claims for missing issues from residents of the United States, Canada, and Mexico must be submitted within 3 months after publication of the issues; residents of all other countries must submit claims within 6 months of publication of the issues. Claims for issues missing because of failure to report an address change or for issues "missing from files" will not be allowed.

Periodicals postage paid at Washington, DC 20036, and at additional mailing offices.

POSTMASTER: Send address changes to *Applied and Environmental Microbiology*, ASM, 1752 N St., N.W., Washington, DC 20036-2904.

Made in the United States of America. Printed on acid-free paper. DOI: 10.1128/AEM.67.6.2001 CODEN: AEMIDF

Copyright © 2001, 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., 222 Rosewood Drive, Danvers, MA 01923, 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.