



EDITOR

JACOB I. SZNAJDER, M.D.
Chicago, IL

DEPUTY EDITORS

LAURENT BROCHARD, M.D.
Geneva, Switzerland
G.R. SCOTT BUDINGER, M.D.
Chicago, IL
SERPIL C. ERZURUM, M.D.
Cleveland, Ohio
ELLIOT ISRAEL, M.D.
Boston, MA
PAUL SCHUMACKER, PH.D.
Chicago, IL

ASSOCIATE EDITORS

ALVAR AGUSTI, M.D., PH.D.
Barcelona, Spain
PETER J. BARNES, M.D., D.Sc.
London, United Kingdom

CHARLES L. DALEY, M.D.
Denver, CO
OLIVER EICKELBERG, M.D.
Munich, Germany
DAVID GOZAL, M.D.
Chicago, IL
TINA HARTERT, M.D., M.P.H.
Nashville, TN
NAFTALI KAMINSKI, M.D.
Pittsburgh, PA
JAY K. KOLLS, M.D.
Pittsburgh, PA
BRUCE D. LEVY, M.D.
Boston, MA
GÖKHAN M. MUTLU, M.D.
Chicago, IL
MASAHARU NISHIMURA, M.D.
Sapporo, Japan
MOISÉS SELMAN, M.D., M.Sc.
Mexico City, Mexico
B. TAYLOR THOMPSON, M.D.
Boston, MA
KEITH R. WALLEY, M.D.
Vancouver, BC, Canada

ASSOCIATE EDITORS FOR REVIEWS AND NEWS

NAVDEEP CHANDEL, Ph.D.
Chicago, IL
THOMAS CORBRIDGE, M.D.
Chicago, IL
JOHN E. HEFFNER, M.D.
Portland, OR
ROBERT KOTLOFF, M.D.
Philadelphia, PA
WERNER SEEGER, M.D.
Giessen, Germany
MARY E. STREK, M.D.
Chicago, IL

ATS DOCUMENTS EDITOR

KEVIN C. WILSON, M.D.
Boston, MA

PUBLISHER

Diane Gern

PEER REVIEW OFFICE

ATS Peer Review Office
Jacob I. Sznajder, M.D., Editor
AMERICAN JOURNAL OF RESPIRATORY
AND CRITICAL CARE MEDICINE
25 Broadway, 18th Floor
New York, NY 10004
Tel: 212-315-8623
FAX: 212-315-8613

Peer Review Manager

Marc Bendian

Peer Review Technical Manager

Fay Ling

EDITORIAL PRODUCTION OFFICE

ATS Editorial Office
25 Broadway, 18th Floor
New York, NY 10004
Tel: 212-315-6440
FAX: 212-315-6455
Internet: <http://www.thoracic.org>

Director, Editorial/Production

Eric Gumpert

Cover Art Design

Dorcas Gelabert

Business and Finance

Carl S. Aloi
Matthew Reid

Subscriptions

Mauricia Alexander

Advertising Representative

Cunningham Associates
180 Old Tappan Road
Old Tappan, NJ 07675
Tel: 201-767-4170
FAX: 201-767-8065

EDITORIAL BOARD

KENNETH B. ADLER, PH.D. Raleigh, NC	AARON CIECHANOVER, M.D., D.Sc. Haifa, Israel	MARK W. GERACI, M.D. Denver, CO	ALAN JOBE, M.D., PH.D. Cincinnati, OH	DICK MENZIES, M.D. Montreal, PQ, Canada
LUIS A. NUNES AMARAL, PH.D. Chicago, IL	LAUREN E. COHN, M.D. New Haven, CT	SINA A. GHARIB, M.D. Seattle, WA	JEREMY M. KAHN, M.D., M.S. Pittsburgh, PA	MARY J. MORRELL, PH.D. London, United Kingdom
ALEJANDRO C. ARROLIGA, M.D. Temple, TX	BORJA G. COSIO, M.D., PH.D. Palma de Mallorca, Spain	MARK T. GLADWIN, M.D. Pittsburgh, PA	RAVI KALHAN, M.D. Chicago, IL	RORY E. MORTY, PH.D. Giessen, Germany
KOICHIRO ASANO, M.D. Tokyo, Japan	GERARD CRINER, M.D. Philadelphia, PA	ALLAN GLANVILLE, M.D. Sydney, Australia	DAVID KAUFMAN, M.D. Bridgeport, CT	MARC MOSS, M.D. Denver, CO
ELIE AZOULAY, M.D., PH.D. Paris, France	BRUCE H. CULVER, M.D. Seattle, WA	CHRISTOPHER GOSS, M.D., M.Sc. Seattle, WA	JOEL KAUFMAN, M.D., M.P.H. Seattle, WA	JOACHIM MÜLLER-QUERNHEIM, M.D. Freiburg, Germany
ZAHER AZZAM, M.D. Haifa, Israel	JEFF CURTIS, M.D. Ann Arbor, MI	BERTRAND GUIDET, M.D. Paris, France	STEVEN M. KAWUT, M.D. Philadelphia, PA	PATRICK NANA-SINKAM, M.D. Columbus, OH
GEORGE BALTOPOULOS, M.D., PH.D. Athens, Greece	JANE DEMATTE, M.D., M.B.A. Chicago, IL	JAMES S. HAGOOD, M.D. San Diego, CA	MICHAEL P. KEANE, M.D. Dublin, Ireland	MATTHEW NAUGHTON, M.D. Prahlan, Victoria, Australia
ESTHER BARREIRO, M.D., PH.D. Barcelona, Spain	JEFFREY DRAZEN, M.D. Boston, MA	JESSE HALL, M.D. Chicago, IL	LEILA KHEIRANDISH-GOZAL, M.D. Chicago, IL	DENNIS NIEWOEHNER, M.D. Minneapolis, MN
ROBERT BAUGHMAN, M.D. Cincinnati, OH	MASAHI TO EBINA, M.D., PH.D. Sendai, Japan	PAUL M. HASSOUN, M.D. Baltimore, MD	DONG SOON KIM, M.D., PH.D. Seoul, Korea	TORU OGA, PH.D., M.D. Kyoto, Japan
ELISABETH H.D. BEL, M.D., PH.D. Amsterdam, The Netherlands	JACK A. ELIAS, M.D. New Haven, CT	M. MARGARET S. HERRIDGE, M.D., M.P.H. Toronto, ON, Canada	LESTER KOBZIK, M.D. Boston, MA	STEVEN OPAL, M.D. Providence, RI
BRUCE BENDER, PH.D. Denver, CO	ARMIN ERNST, M.D. Boston, MA	MARIUS M. HOEPER, M.D. Hannover, Germany	MARTIN R.J. KOLB, M.D. Hamilton, ON, Canada	PAOLO PALANGE, M.D. Rome, Italy
FRANCESCO BLASI, M.D. Milan, Italy	ANDRÉS ESTEBAN, M.D., PH.D. Madrid, Spain	CORY HOGABOAM, PH.D. Ann Arbor, MI	CHI CHIU LEUNG, M.B. Hong Kong, China	SCOTT PALMER, M.D., M.H.S. Durham, NC
ANDERS BLOMBERG, M.D., PH.D. Umeå, Sweden	ELISA ESTENSSORO, M.D. La Plata, Buenos Aires, Argentina	FERNANDO HOLGUIN, M.D., M.P.H. Pittsburgh, PA	KATHLEEN O. LINDELL, PH.D., R.N. Pittsburgh, PA	ALBERTO PAPI, M.D. Ferrara, Italy
MARC J.M. BONTEN, M.D., PH.D. Utrecht, The Netherlands	TIMOTHY W. EVANS, M.D., PH.D. London, United Kingdom	ROLF D. HUBMAYR, M.D. Rochester, MN	GERALDO LORENZI-FILHO, M.D., PH.D. São Paulo, Brazil	ANNIE PARDO, PH.D. Mexico City, Mexico
ARTURO BRIVA, M.D., PH.D. Montevideo, Uruguay	ALAN M. FEIN, M.D. New York, NY	MARC HUMBERT, M.D., PH.D. Clamart, France	ROBERTO F. MACHADO, M.D. Chicago, IL	POLLY PARSONS, M.D. Burlington, VT
VITO BRUSASCO, M.D. Genoa, Italy	NIALL FERGUSON, M.D., M.Sc. Toronto, ON, Canada	JOHN R. HURST, PH.D., F.R.C.P. London, United Kingdom	BILL MacNEE, M.D. Edinburgh, Scotland	IAN PAVORD, M.B., B.S. Leicester, United Kingdom
GUY BRUSSELLE, M.D., PH.D. Ghent, Belgium	OGNEN GAJIC, M.D. Rochester, MN	MASAKAZU ICHINOSE, M.D., PH.D. Wakayama, Japan	ATUL MALHOTRA, M.D. Chestnut Hill, MA	MARIELLE PUNENBURG, M.D., PH.D. Rotterdam, The Netherlands
JUAN C. CELEDÓN, M.D., DR.P.H. Pittsburgh, PA	JOE G.N. GARCIA, M.D. Chicago, IL	STEVEN IDELL, M.D., PH.D. Tyler, TX	ASRAR B. MALIK, PH.D. Chicago, IL	CHRISTIAN F. POETS, M.D. Tübingen, Germany
AUGUSTINE M.K. CHOI, M.D. Boston, MA	BENJAMIN M. GASTON, M.D. Charlottesville, VA	STEVE N. GEORAS, M.D. Rochester, NY	RAMA K. MALLAMPALLI, M.D. Pittsburgh, PA	YSEVOLOD S. POLOTSKY, M.D., PH.D. Baltimore, MD
JASON CHRISTIE, M.D., M.S. Philadelphia, PA			FRANÇOIS MALTAIS, M.D. Québec, PQ, Canada	C. ARDEN POPE III, PH.D. Provo, UT

EDITORIAL BOARD (continued)

CHARLES POWELL, M.D. New York, NY	IVAN ROSAS, M.D. Boston, MA	STEVEN D. SHAPIRO, M.D. Pittsburgh, PA	VICTOR J. THANNICKAL, M.D. Birmingham, AL	ATHOL WELLS, M.D. London, United Kingdom
KLAUS F. RABE, M.D., Ph.D. Leiden, The Netherlands	BRUCE K. RUBIN, M.D. Richmond, VA	DEAN SHEPPARD, M.D. San Francisco, CA	ANTONIO TORRES, M.D. Barcelona, Spain	DAVID P. WHITE, M.D. Boston, MA
BENJAMIN A. RABY, M.D., M.P.H. Boston, MA	JAMES A. RUSSELL, M.D. Vancouver, BC, Canada	DONALD D. SIN, M.D. Edmonton, AB, Canada	RUBIN M. TUDER, M.D. Denver, CO	ERIC WHITE, M.D. Ann Arbor, MI
MARCO RANIERI, M.D. Torino, Italy	MARINA SAETTA, M.D. Padua, Italy	ARTHUR S. SLUTSKY, M.D. Toronto, ON, Canada	ISTVÁN VADÁSZ, M.D., Ph.D. Giessen, Germany	DAVID S. WILKES, M.D. Indianapolis, IN
USHA RAJ, M.D. Chicago, IL	CATHERINE S.H. SASSOON, M.D. Irvine, CA	ALAN SMYTH, M.B.B.S., M.D. Nottingham, United Kingdom	VICTOR C. VAN HEE, M.D., M.P.H. Seattle, WA	PRESCOTT G. WOODRUFF, M.D., M.P.H. San Francisco, CA
FELIX A. RATJEN, M.D., Ph.D. Toronto, ON, Canada	NEIL W. SCHLUGER, M.D. New York, NY	RONALD L. SORKNESS, Ph.D., R.Ph. Madison, WI	JEAN-LOUIS VINCENT, M.D., Ph.D. Brussels, Belgium	EMIEL WOUTERS, M.D., Ph.D. Maastricht, The Netherlands
JOHN T. REILLY, M.D. Boston, MA	GREGORY A. SCHMIDT, M.D. Iowa City, IA	AVRUM SPIRA, M.D., M.Sc. Boston, MA	PETER D. WAGNER, M.D. La Jolla, CA	RICHARD WUNDERINK, M.D. Chicago, IL
RANDALL REVES, M.D. Denver, CO	LYNN M. SCHNAPP, M.D. Seattle, WA	ROBIN H. STEINHORN, M.D. Chicago, IL	GRANT WATERER, M.B.B.S. Perth, Australia	MARK WURFEL, M.D., Ph.D. Seattle, WA
LUCA RICHELDI, M.D., Ph.D. Modena, Italy	RICHARD V. SCHULZ, M.D. Giessen, Germany	KURT R. STENMARK, M.D. Denver, CO	CHRISTOPHER M. WATERS, Ph.D. Memphis, TN	ROGER D. YUSEN, M.D., M.P.H., St. Louis, MO
KAREN RIDGE, Ph.D. Chicago, IL	FRANK C. SCIURBA, M.D. Pittsburgh, PA	PETER STERK, M.D., Ph.D. Amsterdam, The Netherlands	JADWIGA A. WEDZICHA, M.D. London, United Kingdom	JOSEPH ZABNER, M.D. Iowa City, IA
JESSE ROMAN, M.D. Louisville, KY	NITIN SEAM, M.D. Washington, DC	ERIK R. SWENSON, M.D. Seattle, WA	SCOTT T. WEISS, M.D. Boston, MA	GUY A. ZIMMERMAN, M.D. Salt Lake City, UT

EDITORS EMERITI

EDWARD R. BALDWIN, M.D. 1917–1922	ESMOND R. LONG, M.D. 1948–1951	JOHN F. MURRAY, M.D. 1973–1979	ROBERT A. KLOCKE, M.D. 1989–1994	EDWARD ABRAHAM, M.D. 2004–2009
ALLEN K. KRAUSE, M.D. 1922–1939	WALSH McDERMOTT, M.D. 1952–1972	GARETH M. GREEN, M.D. 1980–1984	ALAN R. LEFF, M.D. 1994–1999	
MAX PINNER, M.D. 1940–1947	DANIEL S. LUKAS, M.D. (acting) Jan–June 1973	REUBEN M. CHERNIACK, M.D. 1985–1989	MARTIN J. TOBIN, M.D. 1999–2004	

NOTICE TO SUBSCRIBERS AND CONTRIBUTORS

ATS Membership: Subscription to the *American Journal of Respiratory and Critical Care Medicine*® (AJRCCM) is one of the benefits of membership in the American Thoracic Society (ATS). Further information is available from the ATS Office, 25 Broadway, 18th Floor, New York, NY 10004, or from the ATS website: <http://www.thoracic.org>

Subscription Rates: Subscriptions are available at the following rates: U.S.: Individuals, \$650 for combined online and print subscriptions and \$300 for print-only; library and institutional subscriptions start at \$700 for combined online and print (\$665 online-only)—prices vary depending on the size of the institution and number of users (contact the ATS subscriptions department, 212-315-8687 or subscriptions@thoracic.org). Outside U.S.: Individuals, \$700 for combined online and print subscription and \$360 for print-only; library and institutional subscriptions start at \$750 for combined online and print and \$665 for online-only—prices vary depending on the size of the institution and number of users (contact the ATS subscriptions department, 212-315-8687 or subscriptions@thoracic.org). Please contact the ATS for individual online-only subscription rates. *Single copies:* U.S., \$40; outside U.S., \$45. Checks should be made payable to the AJRCCM and sent to the ATS, P.O. Box 9016, GPO New York, NY 10087-9016. *Missing issues:* Replacements will be processed at no charge for claims received within 90 days of the issue cover date.

Mission Statement: To publish the highest quality and most innovative science, reviews, practice guidelines, and statements in the pulmonary, critical care, and sleep-related fields. The AJRCCM is available online at <http://www.atsjournals.org>, or <http://intl.atsjournals.org>.

The ATS publishes the AJRCCM in furtherance of its educational and scientific purposes as a nonprofit and tax-exempt organization. All articles published in the Journal are subject to copyrights owned by the ATS or other individual(s) or entity(ies). Reproduction of any article by any means without the express prior authorization of the ATS is prohibited. The statements and opinions expressed in the Journal only represent those of individual author(s) and do not reflect the policies or opinions of the ATS. Statements and claims concerning the effectiveness, quality, or safety of the products or procedures advertised in the Journal are solely those of the advertiser and do not represent any endorsement or approval by the ATS. The ATS assumes no responsibility for the content of the Journal and expressly disclaims all liability for any damages arising out of use, reference to, or reliance on the contents of the Journal.

Manuscripts: Contributors are requested to read the Instructions for Contributors, posted on (<http://www.thoracic.org/journals/ajrccm/instructions-for-contributors.php>) or obtained from the Peer Review Office upon request. Failure to follow these instructions may cause delay in publication. Manuscripts must

be submitted online using ScholarOne at (<http://atsjournals.manuscriptcentral.com>). Submission forms and copyright forms are to be downloaded at the same site and mailed, with original signatures to ATS Peer Review Office, Jacob I. Sznajder, M.D., Editor, American Journal of Respiratory and Critical Care Medicine, 25 Broadway, 18th Floor, New York, NY 10004. Authors are billed for submission fees at the time of the submission of a manuscript. The submitting author is charged \$50 per submission. Submission fees are not refundable. Please write to the Publisher if there is a hardship or special circumstances. If you have questions or encounter problems with online submission, please contact Marc Bendian, Peer Review Manager (mbendian@thoracic.org) or Fay Ling, Peer Review Technical Manager (fling@thoracic.org). Authors are billed for page charges at different rates depending on their ATS membership status. AJRCCM bills the corresponding author of an article for page charges at the rate of \$100 per printed page. Corresponding authors who are members of the ATS receive discounts on page charges. For information on membership please visit the Become a Member page at www.thoracic.org or contact subscriptions@thoracic.org or 212-315-8687. Offprints may be ordered via the links that are e-mailed to corresponding authors in advance of publication.

PERMISSION REQUESTS

For permission requests, please, contact the Publisher (dgerm@thoracic.org) or permissions@thoracic.org. The ATS solely reserves the right to decline any request for any reason.

REPRINTS AND E-PRINTS

Requests for quotations will be provided based on the language and area of distribution. For English-language prints distributed in the U.S. and Canada, contact Hope Robinson from Sheridan Reprints at 800-635-7181 or e-mail to hrobinson@tsp.sheridan.com

For translated and English-language prints distributed outside the U.S. and Canada, contact the Publisher (dgerm@thoracic.org), who will forward your request to an agent of the ATS. The ATS solely reserves the right to decline any request for any reason.

ADVERTISERS

Rates will be furnished by Cunningham Associates (address listed on top of previous page). The publisher reserves the right to decline any advertising submitted. Billing directed to the advertising agency is approved on condition that the advertiser will accept full responsibility for payment if the agency does not remit within 90 days.