

The American Journal of PATHOLOGY

Discoveries in Basic and Translational Pathobiology

Editor-in-Chief

Martha B. Furie, *Stony Brook University*

Senior Associate Editors

William B. Coleman, *The American Society for Investigative Pathology*
Richard N. Mitchell, *Brigham and Women's Hospital and Harvard Medical School*

Associate Editors

Chris Albanese, *Georgetown University Medical Center*
Steven L. Carroll, *Medical University of South Carolina*
Stanley Cohen, *Perelman School of Medicine, University of Pennsylvania*
Zoran Culig, *Medical University of Innsbruck*
Patricia A. D'Amore, *Schepens Eye Research Institute — Massachusetts Eye and Ear*
Lora Hedrick Ellenson, *Cornell University*
Carol F. Farver, *University of Michigan*
Philippe G. Frank, *The University of Tours*
Philip Furmanski, *Rutgers University*
Nisha Jain Garg, *University of Texas Medical Branch*
Michael S. Goligorsky, *New York Medical College*
Meera Hameed, *Memorial Sloan-Kettering Cancer Center*
David M. Hockenbery, *Fred Hutchinson Cancer Research Center*
Yoshifumi Itoh, *University of Oxford*
Christopher G. Kevil, *Louisiana State University Health Sciences Center*
Satdarshan (Paul) Singh Monga, *University of Pittsburgh School of Medicine*
David J. Nikolic-Paterson, *Monash Medical Center*
Charles A. Parkos, *University of Michigan*
Drucilla Roberts, *Massachusetts General Hospital*
Shin'ichi Takeda, *National Center of Neurology and Psychiatry*
Jouni Uitto, *Thomas Jefferson University*
Xiao-Ming Yin, *Indiana University School of Medicine*

Managing Editor

Emily H. Essex

Assistant Managing Editor

Henry L. Carter, Jr.

Director of Scientific Outreach

Chhavi Chauhan, PhD, ELS

Senior Editorial Assistant

Michael Dustin

The official journal of the American Society for Investigative Pathology, published by Elsevier, Inc., seeks high-quality original research reports, reviews, and commentaries related to the molecular and cellular basis of disease. The editors will consider basic, translational, and clinical investigations that directly address mechanisms of pathogenesis or provide a foundation for future mechanistic inquiries. Examples of such foundational investigations include data mining, identification of biomarkers, molecular pathology, and discovery research. Foundational studies that incorporate deep learning and artificial intelligence are also welcome. High priority is given to studies of human disease and relevant experimental models using molecular, cellular, and organ-ismal approaches.

<http://ajp.amjpathol.org>

Editorial Board

Rosalyn Adam	Kevan L. Hartshorn	Yuri Persidsky
Malcolm Alison	Jeffrey C. Horowitz	Sem H. Phan
Charles E. Alpers	Renato V. Iozzo	Charalabos Pothoulakis
Gianfranco Alpini	Andrei Ivanov	Raju C. Reddy
Udayan Apte	Hartmut Jaeschke	Daniel Remick
Gloria Bonuccelli	Elaine S. Jaffe	Kevin A. Roth
Arnold R. Brody	Aaron W. James	Magali Saint-Geniez
Kyle Brown	Motoi Kanagawa	David S. Salomon
John Calvert	Alpdogan Kantarci	Joel Saltz
Christiane Charriaud-	C. Dirk Keene	Michael Schnoor
Marlangue	Celina G. Kleer	Lalita R. Shevde-Samant
Sean Colgan	Karen E. Knudsen	Darryl Shibata
Lee A.D. Cooper	Stefan Koch	Ie Ming Shih
Nicholas Davidson	Olivier Kocher	David Shima
George S. Deepe, Jr.	Laurie T. Krug	Nicholas Siblinga
Gabriel E. DiMattia	Hans Lassmann	Gene P. Siegal
Wen-Xing Ding	Andrew Leask	Douglas B. Stairs
Motomi Enomoto-Iwamoto	Richard M. Levenson	Patricia S. Steeg
Melanie B. Feany	Ricardo V. Lloyd	William G. Stetler-Stevenson
Agnes Fogo	Robin G. Lorenz	Gary E. Striker
Matthew P. Frosch	Nicholas W. Lukacs	Victor J. Thannickal
Thomas J. Fuchs	Benjamin R. Mitchell	John E. Tomaszewski
Chandrashekhar R. Gandhi	George F. Murphy	Warren G. Tourtellotte
Allan Gao	Asma Nusrat	David H. Walker
Kevin L. Gardner	Shuji Ogino	Alan Wells
Godfrey S. Getz	Yasunori Okada	Elizabeth M. Whitley
Andrew Gewirtz	A. Wayne Orr	Monte S. Willis
Jeffrey A. Golden	Liron Pantanowitz	Tesshi Yamada
Steven Gonias	William C. Parks	Cecelia Yates
Avrum I. Gotlieb	Tristram Parslow	Dani S. Zander
Anna Greka	Rakesh P. Patel	Jianhua Zhang
Donna Hansel	Mercio A. PereiraPerrin	Jing Zhang



The American Society for
Investigative Pathology

EXECUTIVE OFFICER: William B. Coleman

PRESIDENT: Dani S. Zander; **Past President:** Asma Nusrat; **President-Elect:** Richard Mitchell; **Vice President:** Patricia A. D'Amore; **Secretary-Treasurer:** Satdarshan (Paul) Singh Monga; **Program Chair:** David Williams; **Education Committee Chair:** Diane Bielenberg; **Committee for Career Development and Diversity Chair:** Cecelia Yates; **Research and Science Policy Chair:** William A. Muller; **Councilors:** Monte S. Willis, Pilar Alcaide.

PUBLICATIONS COMMITTEE: Magali Saint-Geniez (Interim Chair), William B. Coleman, Steven Carroll, Prathana Dalal, Yava Jones-Hall, Satdarshan (Paul) Singh Monga, Morgan Preziosi, Daniel G. Remick, William G. Stetler-Stevenson, Cecelia Yates.

Journal Information

The American Journal of Pathology (ISSN 0002-9440) is published monthly by Elsevier, 230 Park Avenue, Suite 800, New York, NY 10169-0901, USA. Periodicals Postage Paid at New York, NY and at additional mailing offices (not valid for journal supplements).

Business Office: 1600 John F. Kennedy Boulevard, Suite 1800, Philadelphia, PA 19103-2899. Accounting and Circulation Offices: 3251 Riverport Lane, Maryland Heights, MO 63043. Periodicals postage paid at New York, NY and additional mailing offices.

Postmaster: Send address changes to *The American Journal of Pathology*, Elsevier, Journal Returns, 1799 Highway 50 East, Linn, MO 65051, USA.

Customer Service (orders, claims, online, change of address): Please visit our Support Hub page <https://service.elsevier.com> for assistance.

Address changes must be submitted four weeks in advance.

Yearly Subscription Rates: Further information on this journal is available from the Publisher or from this journal's website (<http://ajp.amjpathol.org>). Information on other Elsevier products is available through Elsevier's website (<http://www.elsevier.com>).

Advertising Information: Advertising and classified advertising orders and inquiries can be sent to: Bill Hipple, Elsevier Inc., 230 Park Avenue, Suite 800, New York, NY 10169-0901, USA; e-mail: b.hipple@elsevier.com; phone: 214-592-4467. Classified Advertising: Michael Kelley; phone: 212-633-3198; e-mail: m.kelley@elsevier.com.

Author Inquiries: For inquiries relating to the submission of articles, contact the Editorial Office at 301-634-7959. You can track your accepted article at <http://www.elsevier.com/trackarticle>. You are also welcome to contact Customer Support via <http://support.elsevier.com>. Please see Information for Authors for individual journal. Contact details for questions arising after acceptance of an article, especially those relating to proofs, are provided after registration of an article for publication.

Instructions for Authors can be found online at: <http://ajp.amjpathol.org/authorinfo>.

Journal Scientific Integrity Policy can be found online at: <http://ajp.amjpathol.org/content/integrity>.

The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

English Language Service: Upon request, Elsevier will direct authors to an agent who can check and improve the English of their paper (before submission). Please contact authorsupport@elsevier.com for further information.

Reprints: For queries about author offprints, e-mail authorsupport@elsevier.com. To order 100 or more reprints for educational, commercial, or promotional use, contact the Commercial Reprints Department, Elsevier Inc, 360 Park Ave South, New York, NY 10010-1710. Fax: 212-462-1935; e-mail: reprints@elsevier.com.

© 2019 American Society for Investigative Pathology. All rights reserved.

This journal and the individual contributions contained in it are protected under copyright by the American Society for Investigative Pathology, and the following terms and conditions apply to their use:

Photocopying: Single photocopies of single articles may be made for personal use as allowed by national copyright laws. Permission of the Publisher and payment of a fee is required for all other photocopying, including multiple or systematic copying, copying for advertising or promotional purposes, resale, and all forms of document delivery. Special rates are available for educational institutions that wish to make photocopies for non-profit educational classroom use.

Permissions may be sought directly from Elsevier's Rights Department in Oxford, UK: phone +1 800 523 4069 x3808, fax +44 (0) 1865 853333. Requests may also be completed online via the Elsevier site (<http://www.elsevier.com/authors/obtaining-permission-to-re-use-elsevier-material>).

In the USA, users may clear permissions and make payments through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA; phone: (978) 750-8400, fax: (978) 750-4744, and in the UK through the Copyright Licensing Agency Rapid Clearance Service (CLARCS), 90 Tottenham Court Road, London W1P 0LP, UK; phone: (+44) 20 7631 5555; fax: (+44) 20 7631 5500. Other countries may have a local reprographic rights agency for payments.

Derivative Works: Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution.

Permission of the Publisher is required for all other derivative works, including compilations and translations.

Electronic Storage or Usage: Permission of the Publisher is required to store or use electronically any material contained in this journal, including any article or part of an article.

Except as outlined above, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior written permission of the Publisher.

Address permissions requests to: Elsevier Rights Department, at the fax and e-mail addresses noted above.

Notice: Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds or experiments described herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made. To the fullest extent of the law, no responsibility is assumed by the publisher or the American Society for Investigative Pathology for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein.

Although all advertising material is expected to conform to ethical (medical) standards, inclusion in this publication does not constitute a guarantee or endorsement of the quality or value of such product or of the claims made of it by its manufacturer.