

ARCHIVES

of Pathology & Laboratory Medicine

Vol. 149

Editor in Chief: Alain C. Borczuk, MD

Deputy Executive Editor: Donna E. Hansel, MD, PhD

Deputy Editors in Chief: Sanja Dacic, MD, PhD; Jerad M. Gardner, MD;
Fan Lin, MD, PhD; David A. Schwartz, MD; Lynette M. Sholl, MD

Executive Managing Editor: Patrick H. Kearns **Managing Editor:** Katie Giesen

Associate Managing Editor: Hilary Price

Editorial Office: College of American Pathologists, 325 Waukegan Rd, Northfield, IL 60093-2750
847-832-7400; Fax: 847-832-8400; E-mail: archivesofpathology@cap.org

ASSOCIATE EDITORS

Anatomic Pathology

Adekunle M. Adesina, MD, PhD
Timothy Craig Allen, MD, JD
Richard L. Attanoos, MD
Mary Beth Beasley, MD
Patricia Chevez-Barrios, MD
Lucian R. Chirieac, MD
Gregory J. Davis, MD
Michael T. Deavers, MD
Adel K. El-Naggar, MD, PhD
Gregory N. Fuller, MD, PhD
Kirk D. Jones, MD
Keith M. Kerr, BSc, MB, ChB,
FRCPath, FRCPE
Ashraf Khan, MD
Haiyan Liu, MD
Dina R. Mody, MD
Anil V. Parwani, MD, PhD
Victor G. Prieto, MD, PhD
David L. Rimm, MD, PhD
Sinchita Roy-Chowdhuri, MD, PhD
Mary R. Schwartz, MD
M. Kay Washington, MD, PhD
Maureen Zakowski, MD
Lanjing "L.J." Zhang, MD, MS

Clinical Pathology

David W. Bernard, MD, PhD
Chung-Che (Jeff) Chang, MD, PhD
L. Jeffrey Medeiros, MD
Jan A. Nowak, MD, PhD
Randall J. Olsen, MD, PhD
Jorge Sepulveda, MD
Deborah Sesok-Pizzini, MD, MBA
Nikoletta Sidiropoulos, MD
Ila R. Singh, MD, PhD
Youli Zu, MD, PhD

Administrative and Regulatory Affairs

R. Marshall Austin, MD, PhD
W. Stephen Black-Schaffer, MD
Richard W. Brown, MD
Alexis B. Carter, MD
Maren Y. Fuller, MD
Richard J. Hausner, MD
Michael L. Talbert, MD

SECTION EDITORS

ANATOMIC PATHOLOGY

Autopsy Pathology

Kim A. Collins, MD
Larry Nichols, MD

Bone and Soft Tissue Pathology

Marilyn M. Bui, MD, PhD
John D. Reith, MD
Nicole D. Riddle, MD
Andrew E. Rosenberg, MD
Gene P. Siegal, MD, PhD

Breast Pathology

Edi Brogi, MD, PhD
Sabina Hajiyeve, MD
Omar Hameed, MD, MBChB
Timothy W. Jacobs, MD
Shabnam Jaffer, MD
Xiaoxian (Bill) Li, MD, PhD
Dennis Sgroi, MD
Kalliopi P. Siziopikou, MD, PhD

Cardiovascular Pathology

E. Rene Rodriguez, MD
Carmela D. Tan, MD

Cytopathology

Diane D. Davey, MD
Yun Gong, MD
Andre L. Moreira, MD, PhD
Ritu Nayar, MD

N. Paul Otori, MD
Michelle D. Reid, MD, MSc
Anjali Saqi, MD, MBA
Marina Vivero, MD
Roseann I. Wu, MD, MPH
Nancy A. Young, MD

Dermatopathology

Paul W. Harms, MD, PhD
Artur Zembowicz, MD

Endocrine Pathology

Sylvia L. Asa, MD, PhD

ENT Pathology

William C. Faquin, MD, PhD
Raja R. Seethala, MD
Aaron M. Udager, MD, PhD
Michelle D. Williams, MD
Qihui "Jim" Zhai, MD

Forensic Pathology

John R. Parker, MD
Glenn Rudner, MD

The ARCHIVES OF PATHOLOGY & LABORATORY MEDICINE (ISSN: 0003-9985) is published monthly by the College of American Pathologists, 325 Waukegan Rd, Northfield, IL 60093, and is an official publication of the College of American Pathologists. Periodicals postage paid at Winnetka, IL, and at additional mailing office. SUBSCRIPTION RATES: The annual subscription rates for the ARCHIVES OF PATHOLOGY & LABORATORY MEDICINE are as follows: \$850 United States and Canada, \$1,100 other countries. No agency discount. Prepayment required in U.S. dollars drawn upon a U.S. bank. Individual copy prices: \$75 United States and Canada, \$95 other countries. Direct all orders, payments, claims, and inquiries to: Archives of Pathology & Laboratory Medicine, College of American Pathologists, 325 Waukegan Rd, Northfield, IL 60093. Phone: 800-323-4040. Fax: 847-832-8153. CHANGE OF ADDRESS: POSTMASTER, send all address changes to ARCHIVES OF PATHOLOGY & LABORATORY MEDICINE, 325 Waukegan Rd, Northfield, IL 60093. Notification of address change must be made at least 6 weeks in advance. Include both old and new addresses, and a recent mailing label. All articles published, including editorials, letters, and book reviews, represent the opinions of the authors and do not reflect official policy of the College of American Pathologists, the Editorial Board, or the institution with which the author is affiliated, unless this is clearly specified. Advertising: The appearance of display or classified advertising in this publication is not a CAP guarantee or endorsement of the product or the claims made for the product by the manufacturer. Copyright 2025 College of American Pathologists. All rights reserved. None of the contents 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 the prior written permission of the publisher. Printed in the USA.

COLLEGE OF AMERICAN PATHOLOGISTS

The College of American Pathologists, the leading organization of board-certified pathologists, serves patients, pathologists, and the public by fostering and advocating excellence in the practice of pathology and laboratory medicine worldwide.

President: Qihui "Jim" Zhai, MD

President-Elect: Kalisha Ashara Hill, MD, MBA

Secretary-Treasurer: Alfred Wray Campbell, MD, MBA

Immediate Past President: Donald S. Karcher, MD

Governors: Aaron Auerbach, MD, MPH; Diana Marcella Cardona, MD, MBA; Earle "Smitty" Collum, MD; Raj C. Dash, MD; M. E. (Doc) de Baca, MD; Matthew R. Foster, MD; Aaron C. Han, MD, PhD; Rebecca L. Johnson, MD; Bradley S. Karon, MD, PhD; Guillermo G. Martinez-Torres, MD; Joel Todd Moncur, MD, PhD; A. Joe Saad, MD, CPE

Speaker, House of Delegates: Sang Wu, MD

Vice Speaker, House of Delegates: Marilyn M. Bui, MD, PhD

President, CAP Foundation Board: Bharati S. Jhaveri, MD

Residents Forum Chair: Cullen M. Lilley, MD, MS, MA

Chief Executive Officer: Michael R. Fraser, PhD

Publication Staff

Bob McGonnagle, Publisher, 847-832-7476, Fax: 847-832-8153

Keith Eilers, Ad Materials Manager, 847-832-7528

Kimberly A. Gilfillan, Circulation Director, 847-832-7456

Advertising Offices

Publisher: Bob McGonnagle, College of American Pathologists,
325 Waukegan Rd, Northfield, IL 60093, 847-832-7476

Sales Office: Bob McGonnagle, 847-832-7476, bmcgonn@cap.org;

Keith Eilers, 847-832-7528, keilers@cap.org

Midwest and East: Alex Pacheco, 402-290-8203,

Fax: 847-832-8153, alex@captoday.org

West and East: Lori Prochaska, 402-290-7670,

Fax: 847-832-8153, lori@captoday.org

Classified Advertising: KERH Group, 888-489-1555,

sales@kerhgroup.com

Production Staff

Sheridan NH, 69 Lyme Road, Hanover, NH 03755, 785-843-1234

MaryBeth Pinard-Brace, Journal Production Manager, coap.me@kwcglobal.com

Gastrointestinal Pathology

Olca Basturk, MD

Ian Brown, MBBS, FRCPA

Lawrence J. Burgart, MD

Zongming Eric Chen, MD, PhD

Vikram Deshpande, MD

Jeffrey D. Goldsmith, MD

Melanie Johnncilla, MD

David S. Klimstra, MD

Laura W. Lamps, MD

Robert M. Najarian, MD

Nicole C. Panarelli, MD

Deepa T. Patil, MBBS, MD

Giacomo Puppa, MD

Marie E. Robert, MD

Antonia R. Sepulveda, MD, PhD

Amitabh Srivastava, MD

Catherine J. Streutker, MD

Huamin Wang, MD, PhD

T. T. Wu, MD, PhD

Mamoun Younes, MD

Lei Zhao, MD, PhD

Gynecologic Pathology

Natalia Buza, MD

Suzanne Crumley, MD

Ian S. Hagemann, MD, PhD

Ekene Okoye, MD

Sudarshana Roychoudhury, MD

Hepatopathology

Daniela S. Allende, MD, MBA

Sadhna Dhingra, MD

Wendy L. Frankel, MD

Asif Rashid, MD, PhD

Dongfeng Tan, MD

Immunohistochemistry

Andrew M. Bellizzi, MD

Kumarasen Cooper, MBChB

Andrew L. Folpe, MD

Mediastinal Pathology

Cesar A. Moran, MD

Saul M. Suster, MD

Nephropathology

Guillermo A. Herrera, MD

Surya V. Seshan, MD

Luan D. Truong, MD

Neuropathology

Kar-Ming Fung, MD, PhD

Roger E. McLendon, MD

Richard A. Prayson, MD

Andreana L. Rivera, MD

G. Jackson Snipes, MD, PhD

Hidehiro Takei, MD

Tarik Tihan, MD, PhD

David Zagzag, MD, PhD

Ophthalmic Pathology

Mukul K. Divatia, MD

Oral and Maxillofacial Pathology

Catherine M. Flaitz, DDS, MS

Pediatric Pathology

Michael A. Arnold, MD, PhD

Aliya N. Husain, MD

Jason A. Jarzembowski, MD, PhD

Placental Pathology

Chrystalle Katte Carreon, MD

Daniel Levitan, MD

Alex K. Williamson, MD

Pulmonary Pathology

Israh Akhtar, MD

Douglas B. Flieder, MD

Teri J. Franks, MD

Andras Khoo, MD

Brandon T. Larsen, MD, PhD

Leslie A. Litzky, MD

Alberto M. Marchevsky, MD

Sanjay Mukhopadhyay, MD

Kirtee Raparia, MD

Anja C. Roden, MD

Frank Schneider, MD

Haijun (Steve) Zhou, MD, PhD

Urologic Pathology

Bogdan A. Czerniak, MD, PhD

Michael Ittmann, MD, PhD

Zhong Jiang, MD

Lakshmi Priya Kunju, MD

Adeboye O. Osunkoya, MD

Gladell P. Paner, MD

Steven S. Shen, MD, PhD

Satish Tickoo, MD

SECTION EDITORS

CLINICAL PATHOLOGY

Clinical Chemistry

Melissa M. Budelier, PhD, DABCC

Dean C. Carlow, MD, PhD

Amitava Dasgupta, PhD

Sridevi Devaraj, PhD, DABCC

Erin J. Kaleta, PhD, DABCC

Stephen R. Master, MD, PhD

Xin Yi, PhD, DABCC

Clinical Immunology

M. Qasim Ansari, MD

Smaroula Dilioglou, PhD

Todd N. Eagar, PhD

Semyon Risin, MD, PhD

Coagulation

Paul M. Allison, MD

Jessica Jacobson, MD

Jun Teruya, MD, DSc

X. Long Zheng, MD, PhD

To submit a manuscript to ARCHIVES, go to:

<https://archivesofpathology.msubmit.net/cgi-bin/main.plex>

**To view current and past issues,
scan this QR code or go to:**

www.archivesofpathology.org



**For all subscription-related questions and
to report a missing issue, send an e-mail to:**
subscription@cap.org

Hematopathology

Amy Chadburn, MD
John Kim Choi, MD, PhD
Genevieve M. Crane, MD, PhD
Eric D. Hsi, MD
S. David Hudnall, MD
Jerry Hussong, MD
Jeffrey L. Jorgensen, MD, PhD
Michael J. Kluk, MD, PhD
Tara Miller, MD
Sergio Pina-Oviedo, MD

Microbiology

S. Wesley Long, MD, PhD
Audrey N. Schuetz, MD, MPH
Lisa M. Stempak, MD
Gail L. Woods, MD

Molecular Pathology

Anjen Chenn, MD, PhD
Ninette Cohen, PhD
Fei Dong, MD
Jennifer Laudadio, MD
Dolores H. Lopez-Terrada, MD, PhD
Federico A. Monzon, MD
Dwight H. Oliver, MD
Gary W. Procop, MD
Gregory J. Tsongalis, PhD
Yasushi Yatabe, MD, PhD

Transfusion Medicine

Jill Adamski, MD, PhD
Aleksandar Babic, MD, PhD
Vishesh Chhibber, MD
Elizabeth A. Hartwell, MD
Kevin J. Land, MD

ADMINISTRATIVE AND REGULATORY AFFAIRS

Artificial Intelligence

James H. Harrison, Jr., MD, PhD
Fedaa Najdawi, MD
Andrew Quinn, MD
Ajit Singh, PhD

Informatics

Ulysses G.J. Balis, MD
Michael J. Becich, MD, PhD
Jordan Olson, MD
Zhenhong Qu, MD, PhD

Pathology Education

Sarah M. Bean, MD
Ralph Green, MD
Amy Y. Lin, MD

Quality Assurance

Arzu Buyuk, MD
Stephen S. Raab, MD
Stephen Ruby, MD

SPECIAL SECTIONS

Advanced Imaging in Pathology

Michael Feldman, MD, PhD
Lida P. Hariri, MD, PhD
Richard Levenson, MD
Stephen TC Wong, PhD

Clinical Effectiveness and Economics

Diana M. Cardona, MD
Michael C. Dugan, MD
Brian R. Jackson, MD
Jeffrey W. Prichard, DO
Emily E. Volk, MD

Digital Pathology

David S. McClintock, MD
Liron Pantanowitz, MD
Michael Thrall, MD
Yukako Yagi, PhD

Emerging Technologies and Techniques

Paul A. Christensen, MD
Junya Fukuoka, MD, PhD
Raul S. Gonzalez, MD
Xiaoyin "Sara" Jiang, MD
Sean R. Williamson, MD

Environmental Pathology

Andrew Churg, MD, PhD
Francoise Galateau-Salle, MD
Allen Gibbs, MD
Sylvie Lantuejoul, MD, PhD
Victor L. Roggli, MD
Anjana V. Yeldandi, MD

Epidemiology and Biostatistics

Jan Krumsiek, PhD
Matt Vassar, PhD

Global Health

Hallgrimur Benediktsson, MD
Samreung Rangdaeng, MD

Immune Therapy

Deborah A. R. Dillon, MD
Oluwole Fadare, MD
Brooke E. Howitt, MD
Alvaro C. Laga, MD
Mari Mino-Kenudson, MD
Erik Thunnissen, MD, PhD
Scott A. Tomlins, MD, PhD
Ming S. Tsao, MD, FRCPC

Molecular Cytopathology

Gilda da Cunha Santos, MD, PhD
Deepali Jain, MD
Sarah E. Kerr, MD
Sara E. Monaco, MD
Natasha Rekhtman, MD, PhD

Precision Medicine

Angela N. Bartley, MD
Kenneth J. Bloom, MD
Jonathan L. Curry, MD
Fred R. Hirsch, MD, PhD
A. John Iafrate, MD, PhD
Diana N. Ionescu, MD
Sarika P. Jain, MD
Alexander J. Lazar, MD, PhD
Neal I. Lindeman, MD
Anirban Maitra, MBBS
Dipen Maru, MD

Juan Miguel Mosquera, MD, MSc
Arundhati Rao, MD, PhD
Jessica S. Thomas, MD, PhD, MPH

Residents Affairs

Suzanne Z. Powell, MD

Social Media

Christina A. Arnold, MD
Adam L. Booth, MD
Yasmeen M. Butt, MD
Marcos Lepe, MD
Elizabeth L. McKinnon, MD
Pembe Oltulu, MD
Vishwas Parekh, MD
Raghavendra Pillappa, MD
Saranya Singaravel, DCP,
DipNB (Path)
Daniel C. Skipper, DO

Transplantation Pathology

Roberto J. Barrios, MD
Anthony Chang, MD
Michael C. Fishbein, MD
Lillian Gaber, MD
Maxwell L. Smith, MD
Heather Stevenson-Lemer, MD, PhD
Lisa Yerian, MD

Virology

Eileen M. Burd, PhD, D(ABMM)
Jeannette Guarnier, MD
Marie Louise Landry, MD

EXECUTIVE

ADVISORY BOARD

Mahul B. Amin, MD
Daniel A. Arber, MD
Barbara F. Atkinson, MD
David L. Booker, MD
Jenny Chang, MD
Barbara S. Ducatman, MD
Harry L. Evans, MD
Robert Folberg, MD
Richard C. Friedberg, MD, PhD
Eric F. Glassy, MD
Allen M. Gown, MD
Stanley R. Hamilton, MD
M. Elizabeth H. Hammond, MD
James S. Hernandez, MD
William F. Hickey, MD
Jason L. Hornick, MD, PhD
Jennifer L. Hunt, MD
Robert L. Hunter Jr., MD, PhD
Elaine S. Jaffe, MD
Peter E. Jensen, MD
Rebecca L. Johnson, MD
Donald S. Karcher, MD
Karen L. Kaul, MD, PhD
Marsha C. Kinney, MD
Daniel M. Knowles, MD
Peter Kragel, MD
Marc Ladanyi, MD
Debra G. B. Leonard, MD, PhD
Ricardo V. Lloyd, MD, PhD
David N. Louis, MD
Eugene J. Mark, MD
George Michalopoulos, MD, PhD

Krzysztof Moroz, MD
William A. Muller, MD, PhD
Jeffrey L. Myers, MD
Tristram G. Parslow, MD, PhD
Deborah E. Powell, MD
Michael B. Prystowsky, MD, PhD
Robert L. Reddick, MD
Stanley J. Robboy, MD
A. Joe Saad, MD
Henry D. Tazelaar, MD
William D. Travis, MD
Edward O. Uthman, MD
Gail H. Vance, MD
David H. Walker, MD
Thomas M. Wheeler, MD
Myra L. Wilkerson, MD
R. Bruce Williams, MD
Ignacio I. Wistuba, MD
Peter Paul Yu, MD
Richard J. Zarbo, MD, DMD

CONTRIBUTING EDITORS

Hussam Abu-Farsakh, MD
Susan C. Baer, MD
Kevin M. Burns, MD
James L. Connolly, MD
Christopher P. Crum, MD
Christopher Doern, PhD, D(ABMM)
Jonathan I. Epstein, MD
April Ewton, MD
Susan L. Haley, MD
Michelle M. Hebert, MD
David G. Hicks, MD
J. Charles Jennette, MD
Nirag C. Jhala, MD
Kristine Konopka, MD
Gerald J. Kost, MD, PhD
Grace Y. Lin, MD, PhD
Cindy B. McCloskey, MD
Andrew G. Nicholson, MD
Mauro Papotti, MD
Michael R. Pins, MD
Andrew Renshaw, MD
Gabriel L. Sica, MD, PhD
Shi Wei, MD, PhD
Eva M. Wojcik, MD
Rebecca F. Yorke, MD