

ARCHIVES

of Pathology & Laboratory Medicine

Vol. 144

No. 1

January 2020

Interim Editor in Chief: Donna E. Hansel, MD, PhD

Deputy Editors in Chief: Sanja Dacic, MD, PhD; Jerad M. Gardner, MD;
Gregory Y. Lauwers, MD; Fan Lin, MD, PhD; Ross A. Miller, MD; Raouf E. Nakhleh, 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
Alain Borczuk, MD
Patricia Chavez-Barrios, MD
Lucian R. Chirieac, MD
Terence J. Colgan, MD
Gregory J. Davis, MD
Michael T. Deavers, MD
Megan K. Dishop, MD
Adel K. El-Naggar, MD, PhD
Patrick L. Fitzgibbons, MD
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
Mark A. Rubin, MD
David A. Schwartz, MD
Mary R. Schwartz, MD
Lynette M. Sholl, MD
Fattaneh A. Tavassoli, MD
M. Kay Washington, MD, PhD
Rhonda K. Yantiss, MD
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
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
Anthony A. Gal, MD
Richard J. Hausner, MD
J. Thomas Molina, MD, PhD
Michael L. Talbert, MD
Maren Y. Fuller, MD

SECTION EDITORS

ANATOMIC PATHOLOGY

Autopsy Pathology

Kim A. Collins, MD
Larry Nichols, MD

Bone and Soft Tissue Pathology

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

Breast Pathology

D. Craig Allred, MD
Edi Brogi, MD, PhD

Omar Hameed, MD, MBChB
Timothy W. Jacobs, MD
Xiaoxian (Bill) Li, MD, PhD
Syed K. Mohsin, MD
Aysegul Sahin, MD
Dennis Sgroi, MD
Kalliopi P. Siziopikou, MD, PhD
Nour Sneige, MD

Cardiovascular Pathology

Debra L. Kearney, MD
Bruce M. McManus, MD, PhD
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

Editorial Boards cont. next page

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: \$450 United States and Canada, \$690 other countries. No agency discount. Prepayment required in U.S. dollars drawn upon a U.S. bank. Individual copy prices: \$50 United States and Canada, \$70 other countries. Direct all orders, payments, claims, and inquires 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 2020 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.

Cytopathology continued

Roseann I. Wu, MD, MPH
Nancy A. Young, MD

Dermatopathology

Scott R. Granter, MD
Jon A. Reed, MD
Artur Zembowicz, MD

Endocrine Pathology

Sylvia L. Asa, MD, PhD
Virginia LiVolsi, MD

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

Gastrointestinal Pathology

Olca Basturk, MD
Ian Brown, MBBS, FRCPA
Lawrence J. Burgart, MD
Zongming Eric Chen, MD, PhD
Domenico Coppola, MD
Vikram Deshpande, MD
Jeffrey D. Goldsmith, MD
Blythe Gorman, MD
David S. Klimstra, MD
Laura W. Lamps, MD
Robert M. Najarian, MD
Nicole C. Panarelli, MD
Giacomo Puppa, MD
Marie E. Robert, MD
Antonia R. Sepulveda, MD, PhD
Amitabh Srivastava, MD
Catherine J. Streutker, MD
T. T. Wu, MD, PhD
Mamoun Younes, MD

Gynecologic Pathology

Donna Coffey, MD
Suzanne Crumley, MD
Anais Malpica, MD
Anne M. Mills, MD
Ekene Okoye, MD
Anna E. Sienko, MD

Hepatopathology

Sadhna Dhingra, MD
Wendy L. Frankel, MD
Joseph Misdraji, MD
Asif Rashid, MD, PhD
Dongfeng Tan, MD
Swan N. Thung, MD

Immunohistochemistry

Kumarasen Cooper, MBChB
Andrew L. Folpe, MD
Rodolfo Laucirica, 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

Matthew D. Cykowski, MD
Bette K. DeMasters, MD
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
M. John Hicks, MD, DDS, PhD
Aliya N. Husain, MD
Jason A. Jarzembowski, MD, PhD

Placental Pathology

Janice M. Lage, MD
Edwina Popek, DO

Pulmonary Pathology

Israh Akhtar, MD
Douglas B. Flieder, MD
Teri J. Franks, MD
Andras Khor, 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

David G. Bostwick, MD
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

John R. Strigley, MD

Satish Tickoo, MD

SECTION EDITORS**CLINICAL PATHOLOGY****Clinical Chemistry**

Dean C. Carlow, MD, PhD
Amitava Dasgupta, PhD
Sridevi Devaraj, PhD, DABCC
David G. Grenache, PhD
Erin J. Kaleta, PhD, DABCC
Frederick L. Kiechle, MD, PhD
Stephen R. Master, MD, PhD
Michael C. Milone, MD, PhD
Ping Wang, PhD, DABCC, FACB
Xin Yi, PhD, DABCC

Clinical Immunology

M. Qasim Ansari, MD
Smaroula Dilioglou, PhD
Todd N. Eagar, PhD
Henry A. Homburger, MD
Semyon Risin, MD, PhD

Coagulation

Paul M. Allison, MD
Wayne L. Chandler, MD
Jessica Jacobson, MD
Nghia D. Nguyen, MD
Jun Teruya, MD, DSc
Elizabeth M. Van Cott, MD
X. Long Zheng, MD, PhD

Hematopathology

Amy Chadburn, MD
John Kim Choi, MD, PhD
Genevieve M. Crane, MD, PhD
Suyang Hao, MD
Eric D. Hsi, MD
S. David Hudnall, MD
Jerry Hussong, MD
Jeffrey L. Jorgensen, MD, PhD
Todd W. Kelley, MD
Tara Miller, MD
Sergio Pina-Oviedo, MD

Microbiology

Matthew J. Bankowski, PhD
Kathleen G. Beavis, MD
S. Wesley Long, MD, PhD
Sandra S. Richter, MD
Audrey N. Schuetz, MD, MPH
Lisa M. Stempak, MD
Gail L. Woods, MD

Molecular Pathology

Vera Luiza Capelozzi, MD, PhD
William B. Coleman, PhD
Jennifer Laudadio, MD
Dolores H. Lopez-Terrada, MD, PhD
Satdarshan Paul Monga, MD
Federico A. Monzon, MD
Dwight H. Oliver, MD
Gary W. Procop, MD
Gregory J. Tsongalis, PhD
Yasushi Yatabe, MD, PhD
Wei Zhang, PhD

Transfusion Medicine

Jill Adamski, MD, PhD
Aleksandar Babic, MD, PhD
Charlene Bierl, MD, PhD
Melissa M. Cushing, MD
Elizabeth A. Hartwell, MD
Tina Ipe, MD, MPH
Kevin J. Land, MD
Christopher M. Leveque, MD
Susan Rossmann, MD, PhD
David H. Yawn, MD

ADMINISTRATIVE AND REGULATORY AFFAIRS**Artificial Intelligence**

James H. Harrison, Jr., MD, PhD
Andrew Quinn, MD

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
Ilene Harris, MD
Amy Y. Lin, MD

Quality Assurance

Bruce A. Jones, 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
David A. Cohen, MD

Editorial Boards cont. next page

Clinical Effectiveness and Economics continued

Michael B. Datto, MD, PhD
Michael C. Dugan, MD
Brian R. Jackson, MD
Jeffrey W. Prichard, DO
Emily E. Volk, MD
Monte S. Willis, MD, PhD

Digital Pathology

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

Emerging Technologies and Techniques

Shane F. Battye, MBBS, FRCPA
Paul A. Christensen, MD
Junya Fukuoka, MD, PhD
Raul S. Gonzalez, MD
Mark Gustavson, PhD
Xiaoyin "Sara" Jiang, MD
Keith J. Kaplan, MD
Nathan E. Lee, 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

Lois B. Travis, MD, ScD

Global Health

Hallgrimur Benediktsson, MD
Samreung Rangdaeng, MD
Indrojit Roy, 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
Mark A. Valasek, MD, PhD

Molecular Cytopathology

Gilda da Cunha Santos, MD, PhD
Deepali Jain, MD
Sarah E. Kerr, MD
Sara E. Monaco, MD
Natasha Rekhman, MD, PhD
Michael H. Roh, MD, PhD
Philippe Vielh, MD

Precision Medicine

Dara L. Aisner, MD, PhD
Angela N. Bartley, MD
Eric Bernicker, 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
Chen Liu, MD, PhD
Anirban Maitra, MBBS
Dipen Maru, MD
Juan Miguel Mosquera, MD, MSc
Bryce P. Portier, MD, PhD
Arundhati Rao, MD, PhD
Brian D. Robinson, MD
Jason N. Rosenbaum, MD
Jessica S. Thomas, MD, PhD, MPH
Cindy L. Vnencak-Jones, PhD

Residents Affairs

Alyssa M. Krasinskas, MD
Suzanne Z. Powell, MD
JaeY. Ro, MD, PhD
Huamin Wang, MD, PhD

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-Lerner, MD, PhD
Lisa Yerian, MD

Virology

Eileen M. Burd, PhD, D(ABMM)
Jeannette Guamer, 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
Gene N. Herbek, 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
Samuel A. Yousem, MD
Peter Paul Yu, MD
Richard J. Zarbo, MD, DMD

CONTRIBUTING EDITORS

Hussam Abu-Farsakh, MD
Mojgan Amrikachi, MD
Rose C. Anton, MD
Susan C. Baer, MD
Franco Bertoni, MD
Kevin M. Burns, MD
James L. Connolly, MD
Christopher P. Crum, MD
Louis P. Dehner, MD
Christopher Doem, PhD, D(ABMM)
Ronald E. Domen, MD
George W. English, III, MD
Jonathan I. Epstein, MD
April Ewton, MD
Susan L. Haley, MD
Michelle M. Hebert, MD
Donald Earl Henson, MD
David G. Hicks, MD
J. Charles Jennette, MD
Nirag C. Jhala, MD
Zahid Kaleem, 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
Jason Y. Park, MD, PhD
Michael R. Pins, MD
Andrew Renshaw, MD
Michio Shimizu, MD, PhD
Gabriel L. Sica, MD, PhD
Shi Wei, MD, PhD
Eva M. Wojcik, MD
Rebecca F. Yorke, MD
Handan Zeren, MD

COLLEGE OF AMERICAN PATHOLOGISTS

President: Patrick Godbey, MD
President-Elect: Emily E. Volk, MD, MBA
Secretary-Treasurer: Richard R. Gomez, MD
Immediate Past President: R. Bruce Williams, MD

Governors: Timothy Craig Allen, MD, JD; Alfred Wray Campbell, MD, MBA; Rajesh C. Dash, MD;
Mary Elizabeth Fowkes, MD, PhD; Eric F. Glassy, MD; Jennifer L. Hunt, MD, MEd; Donald Steven Karcher, MD;
Jonathan Louis Myles, MD; Raouf E. Nakhleh, MD; Richard M. Scanlan, MD; Nancy A. Young, MD; Qihui "Jim" Zhai, MD
Speaker, House of Delegates: Kathryn Theresa Knight, MD
Vice Speaker, House of Delegates: Sang Wu, MD
President, CAP Foundation Board: Guillermo G. Martinez-Torres, MD
Residents Forum Chair: Adam Lee Booth, MD
Chief Executive Officer: Stephen Myers

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.

Publication Staff

Bob McGonnagle, Publisher, 847-832-7476
Keith Eilers, Ad Materials Manager, 847-832-7528, Fax: 847-832-8528
Kimberly A. Gilfillan, Circulation Director, 847-832-7456, Fax: 847-832-8153

Advertising Offices

Publisher: Bob McGonnagle, College of American Pathologists, 325 Waukegan Rd, Northfield, IL 60093, 847-832-7476
East: Hally Birnbaum, 914-218-1943, Fax: 847-832-8153, captodayeast@gmail.com
Midwest: Alex Prochaska, 402-290-8203, Fax: 847-832-8153, alex@captoday.org
West: Lori Prochaska, 402-290-7670, Fax: 847-832-8153, lori@captoday.org
Classified Advertising: KERH Group, 888-489-1555, sales@kerhgroup.com

Production Staff

Allen Press, 810 E. 10th St, Lawrence, KS 66044, 785-843-1234, Fax: 785-843-1244
Audrey McDonald, Managing Editor, 785-843-1234 ext. 189
Alley Ulrich, Account Manager, 785-843-1234 ext. 114

To Submit a Manuscript to ARCHIVES, Go to:

<http://archivesofpathology.allentrack.net>

To View Current and Past Issues, Go to:

www.archivesofpathology.org

**For All Subscription-Related Questions and
to Report a Missing Issue, Send an E-mail to:**

subscription@cap.org

Use your mobile device to scan this QR code for instant access to
the ARCHIVES Web site (www.archivesofpathology.org)

