

CANCER RESEARCH

Driving Innovation to Prevent and Cure Cancer

AN OFFICIAL JOURNAL OF THE **AACR** American Association
for Cancer Research



Editor-in-Chief

Chi Van Dang

Executive Editor

Harmony Turk

Advisory Editors

Joan S. Brugge
Joe W. Gray
Olufunmilayo I. Olopade
Bert Vogelstein
Karen H. Vousden

Breaking Insights

Deputy Editor

William A. Weiss

Editors

Marie Arsenian-Henriksson
Val Brunton
Timothy Burns
Michel Dupage
Paul B. Fisher
Rani George
Vijay Ramaswamy
David J. Robbins

Controversy and Consensus

Deputy Editor

Raghu Kalluri

Editor

Marcelo G. Kazanietz

Reviews

Deputy Editor

Danny R. Welch

Editors

Jeremy R. Graff
Harikrishna Nakshatri

Senior Editors

Genome and Epigenome

George A. Calin
Kojo S.J. Elenitoba-Johnson
Charis Eng
Jean-Pierre J. Issa
Daniel A. Lim
Bing Ren

Metabolism and Chemical Biology

Giulio F. Draetta
Eyal Gottlieb
Brendan D. Manning
William G. Nelson
Linda Z. Penn
Joseph Salvino
David B. Solit
Eileen White

Molecular Cell Biology

Mark W. Dewhirst
Eric R. Fearon
Brian C. Lewis
Masanobu Oshima
Ben Z. Stanger
Saraswati Sukumar

Tumor Biology and Immunology

Hellmut G. Augustin
Robert Clarke
Mario P. Colombo
Dean W. Felsher
Dmitry I. Gabrilovich
Silvia Giordano
Fumihiko Ishikawa
Kornelia Polyak
Jonathan D. Powell
Jeffrey C. Rathmell
Phuoc T. Tran

Translational Science

Kathleen R. Cho
Maura L. Gillison
Theodore S. Lawrence
Xin Lu
Anirban Maitra
Maureen E. Murphy
Yves Pommier
Hyunsuk Shim

Convergence and Technologies

Sarah E. Bohndiek
Claudia Fischbach-Teschl
Robert A. Gatenby
Benjamin Haibe-Kains
John Quackenbush
David W. Speicher

Population and Prevention Science

Robert A. Hiatt
Trevor Penning

Biostatistics

Qi Long

Editorial Staff

Associate Editor

Kevin Burton

Managing Editor

Catherine C. Wilson

Assistant Managing Editor

Joseph B. Schwartz

Special Content Manager

Chris Vesce

Editorial Staff

Rachel Alfiero
Eileen Echikson
Catherine Rachfalski

Production Manager

Brenda Roberson

Editorial Office: *Cancer Research* [ISSN: 0008-5472 (Print); ISSN: 1538-7445 (Online)] is published twice a month, one volume per year, by the American Association for Cancer Research, Inc.; 615 Chestnut Street, 17th Floor, Philadelphia, PA 19106-4404. Periodicals postage paid at Philadelphia, PA, and additional mailing offices. POSTMASTER: Send address changes to *Cancer Research*, Member Services, AACR, 615 Chestnut Street, 17th Floor, Philadelphia, PA 19106-4404 or E-mail: membership@aacr.org. Copyright 2021 the American Association for Cancer Research, Inc. © The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

CANCER RESEARCH

Editorial Board

Omar Abdel-Wahab
Kari Alitalo
Shrikant Anant
Andrea Anichini
Lionel Apetoh
Andrew E. Aplin
Manuela Baccarini
William T. Baumann
Fariba Behbod
Simon Bekker-Jensen
Rolf Brekken
Vincenzo Bronte
Nelson E. Brown
Kerry L. Burnstein
Peter T. Campbell
Timothy A. Chan
Alain Charest
Murali K. Cherukuri
Soumitra Kumar Choudhuri
Lena Claesson-Welsh
Michael Cole
Michele L. Cote
Olivier De Wever
Nicholas Denko
J. Alan Diehl
Dan Dixon
Ronny Drapkin
Bertrand Dubois
Jeanette E. Eckel-Passow
Wafik El-Deiry
Felix Y. Feng
Martin E. Fernandez-Zapico
Soldano Ferrone
Paul B. Fisher
Elsa Flores
David Frank
Simone Fulda
Joel R. Garbow
Kevin Gardner
Francois Ghiringhelli
David Gius
Jeremy R. Graff
Steven Grant
Florian Greten
Tim Greten
Heidi E. Greulich
Sergei Grivnickov
John Hanover

Mary J.C. Hendrix
Stephan Herzig
Haojie Huang
Kent Hunter
Tomoo Iwakuma
David M. Kaetzel
Joseph L. Kissil
Jorg Kleeff
Gou Young Koh
Mikhail G. Kolonin
Yutaka Kondo
Kenneth A. Krohn
Marieke L. Kuijjer
Natasha Kyprianou
James V. Lacey
Lucia R. Languino
Justin Lathia
Valerie LeBleu
Doron Levy
Claire E. Lewis
Da-Qiang Li
Jonathan Licht
Hui-Kuan Lin
Zhenkun Lou
David Lyden
Conor C. Lynch
Carlo C. Maley
Masao Matsuoka
Massimiliano Mazzone
Ignacio Melero
John D. Minna
Michael A. Morgan
Lindsay M. Morton
Hidayatullah G. Munshi
Junko Murai
Harikrishna Nakshatri
Yulia Nefedova
Kenneth P. Nephew
Daniel Normolle
Steffi Oesterreich
Hideho Okada
Gilbert S. Omenn
Arne Östman
Klaus Pantel
Gray W. Pearson
Gerd P. Pfeifer
Wayne A. Phillips
Kristian Pietras

Ludmila Prokunina-Olsson
Derek C. Radisky
V. Ashutosh Rao
Jeremy Rich
Jann N. Sarkaria
Dieter Saur
Edward Sausville
Matthew B. Schabath
Andrew E. Schade
Clemens A. Schmitt
Santiago Schnell
Katia Scotlandi
Oliver John Semmes
Natalie J. Serkova
Louise C. Showe
Xiao-Ou Shu
Jill M. Siegfried
Pierre Sonveaux
Douglas Spitz
M. Sharon Stack
John Stagg
Patricia Steeg
Hiromu Suzuki
Kristin R. Swanson
Joann B. Sweasy
Kai Tan
Jeremy M.G. Taylor
Beverly A. Teicher
Anna Teti
Anish Thomas
Claudio Tripodo
Kenneth Tsai
Viktor Umansky
Toshikazu Ushijima
Guus A.M.S. van Dongen
Jo A. Van Ginderachter
Thierry Walzer
Jeffrey S. Weber
Ashani T. Weeraratna
Wenyi Wei
Yasuhiro Yamada
David S. Yu
Xiaochun Yu
Lin Zhang
Rugang Zhang
Lee Zou
Weiping Zou

CANCER RESEARCH

Publishing Information

AN OFFICIAL JOURNAL OF THE **AACR** American Association for Cancer Research

AACR Officers

David A. Tuveson, President
Lisa M. Coussens,
President-Elect
Antoni Ribas,
Past President
William N. Hait, Treasurer
Margaret Foti,
Chief Executive Officer

Publications Committee

Victor E. Velculescu, Chairperson
Adriana Albini
Laura Fejerman
Masanori Hatakeyama
Catriona H.M. Jamieson
Jos Jonkers
Virginia G. Kaklamani
Andrew Kung
Jonathan D. Licht
Ira Mellman
Gordon B. Mills
Kunle Odunsi
Kenneth J. Pienta
Joshua D. Rabinowitz
Timothy R. Rebbeck
David L. Rimm
Mack Roach III
Sheila K. Singh
Sheila A. Stewart
Miguel A. Villalona-Calero
Michael B. Yaffe

Publishing Staff

Publisher

Christine Battle

Director, Journal

Operations and Systems

Daniel S. Evankov

Director, Journal Sales and Marketing

Nicola L. Hill

Director, Digital Publishing

Mark Jacobson

Associate Director, Production

Charlene Squibb

Assistant Director, Journal Marketing

Joanna Arnold

Assistant Director, Institutional Sales & Outreach

Karola Rac

Marketing and Creative Services

Senior Director

Paul Driscoll

Design Staff

Susan Moore

Scope

Cancer Research publishes original studies, reviews, and opinion pieces offering significance and broad impact to a diverse audience.

Cancer Research seeks manuscripts that offer pathobiological and translational impact to inform the personal, clinical, and societal problems posed by cancer. The main scope of the Journal is captured in its primary subsections: Genome and Epigenome, Metabolism and Chemical Biology, Molecular Cell Biology, Tumor Biology and Immunology, Translational Science, Convergence and Technologies, and Population and Prevention Science.

Cancer Research is abstracted and/or indexed in Current Contents/Clinical Medicine, MEDLINE, Science Citation Index, Scopus, and Web of Science.

Submission of Manuscripts

Online submission of manuscripts is welcomed at <http://can.msubmit.net>. Before submitting a manuscript, please read the Instructions for Authors, which are available from the Journal's home page at <http://cancerres.aacrjournals.org>.

Publication Charges

Articles will be published with the understanding that the author(s) will pay both a publication fee plus a display item fee. For more details, please see the Publication Fees and Reprints page, which is available at <https://aacrjournals.org/content/authors/publication-fees-and-reprints>.

Subscription Information

Nonmember Individuals

Subscriptions include online access only. Contacts listed below are for nonmember individual subscriptions.

USA and Rest of World (excluding Japan)
American Association for Cancer Research, 615 Chestnut Street, Philadelphia, PA 19106;
1-855-744-4667; pubsales@aacr.org

Japan

e-support@maruzen.co.jp;
journal@kinokuniya.co.jp; usaco@usaco.co.jp

International print subscriptions include cost of surface mail. Expedited mailing is available. Contact the American Association for Cancer Research for rates.

Site Licenses

For information about institutional site licenses, contact pubsales@aacr.org.

AACR Members

AACR members may opt to receive either a print subscription with online access to content or an online-only subscription. Contact membership@aacr.org or visit the membership page at www.aacr.org for more information.

Single Issue Sales

Due to the impact of COVID-19, the AACR has discontinued single issue orders and fulfillment of claims through December 31, 2021.

Claims

One-time claims for missing issues made within 120 days of the issue's publication will be honored, subject to availability. No credit or refund will be given if an issue is out of print at the time of claim.

AACR Members

membership@aacr.org

Nonmembers and Institutions

pubsales@aacr.org

Advertising Information

For information about advertising in ACR journals, contact The Walchli Tauber Group, Inc., 2225 Old Emmorton Road, Suite 201, Bel Air, MD 21015; 443-512-8899; maura.paoletti@wt-group.com.

Copyright and Permissions

Content printed in or disseminated by *Cancer Research* is protected by copyright. Authors publishing in *Cancer Research* may either formally transfer copyright to the AACR or may select the Open Access option and publish the article under one of two Creative Commons Attribution licenses—Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) or Attribution 4.0 International (CC BY 4.0)—depending on funder requirements. Please visit <http://aacrjournals.org/content/authors/copyright-permissions-and-access>.