

## PRESIDENT OF THE ACADEMY

Marcia K. McNutt

## EDITOR-IN-CHIEF

May R. Berenbaum

## ASSOCIATE EDITORS

Huda Akil  
Richard Eisenberg  
Angela M. Gronenborn  
Philippa Marrack  
Dolores R. Piperno  
Natasha V. Raikhel  
Christine E. Seidman  
Neil H. Shubin  
B. L. Turner II  
Stephen T. Warren  
Mary C. Waters  
David A. Weitz

## EDITORIAL BOARD

### Animal, Nutritional, and Applied Microbial Sciences

Stephen M. Beverley  
David L. Denlinger  
John J. Eppig  
Caroline S. Harwood  
R. Michael Roberts  
Linda J. Saif

### Anthropology

Richard G. Klein  
C. Owen Lovejoy  
James F. O'Connell  
Elsa M. Redmond

### Applied Mathematical Sciences

Peter J. Bickel  
David L. Donoho  
Donald B. Rubin  
James A. Sethian  
Bin Yu

### Applied Physical Sciences

Gabriel Aeppli  
Zachary Fisk  
Angel Rubio  
John D. Weeks

### Astronomy

Neta A. Bahcall

### Biochemistry

Michael R. Botchan  
F. Ulrich Hartl  
Stephen C. Kowalczykowski  
Kiyoshi Mizuuchi  
Brenda A. Schulman  
James A. Wells

### Biophysics and Computational Biology

David Baker  
Adriaan Bax  
Axel T. Brunger  
William F. DeGrado  
Alan Fersht  
Yale E. Goldman  
Barry H. Honig  
Robert Langer  
Michael Levitt  
Susan Marqusee  
J. Andrew McCammon  
Peter B. Moore  
Joseph D. Puglisi  
John W. Sedat  
Michael F. Summers

### Cellular and Developmental Biology

Denis Duboule  
Brigid L. M. Hogan  
Satyajit Mayor  
Roeland Nusse  
Michael Rosbash  
Janet Rossant  
Gertrud M. Schüpbach

### Cellular and Molecular Neuroscience

David E. Clapham  
Nancy Y. Ip  
Yuh-Nung Jan  
Jeremy Nathans  
Solomon H. Snyder  
Charles F. Stevens  
Joseph S. Takahashi  
Gina Turrigiano

### Chemistry

Lia Addadi  
Stephen J. Benkovic  
Marcetta Y. Darensbourg  
Michael L. Klein  
Tobin J. Marks  
Chad A. Mirkin  
Catherine J. Murphy  
Amy C. Rosenzweig  
Peter J. Rossky

### Computer and Information Sciences

William H. Press

### Earth, Atmospheric, and Planetary Sciences

Donald E. Canfield  
Thure E. Cerling  
W. G. Ernst  
Jean Jouzel  
A. R. Ravishankara  
Lisa Tauxe  
Mark H. Thiemens

### Economic Sciences

Paul R. Milgrom  
Jose A. Scheinkman

### Engineering Sciences

Alexis T. Bell  
James J. Collins  
Pablo G. Debenedetti  
Evelyn L. Hu  
Rakesh K. Jain  
John A. Rogers  
John H. Seinfeld

### Environmental Sciences and Ecology

Edward F. DeLong  
Robert E. Dickinson  
James A. Estes  
Alan Hastings  
David M. Karl  
Nancy Knowlton  
Simon A. Levin  
François M. M. Morel  
Mary Power  
Andrea Rinaldo  
David W. Schindler

### Evolutionary Biology

W. Ford Doolittle  
Scott V. Edwards  
Douglas J. Futuyma  
Daniel L. Hartl  
David M. Hillis  
Hopi E. Hoekstra  
David Jablonski  
Richard E. Lenski  
Gene E. Robinson  
Nils C. Stenseth  
Joan E. Strassmann

### Genetics

Kathryn V. Anderson  
John Carlson  
Iva S. Greenwald  
Philip C. Hanawalt  
Mary-Claire King  
Douglas E. Koshland  
Jasper Rine  
Allan C. Spradling  
Anne M. Villeneuve

### Human Environmental Sciences

Arun Agrawal  
Anthony J. Bebbington  
Ruth S. DeFries  
Susan Hanson  
Emilio F. Moran  
Robert J. Scholes  
B. L. Turner II  
Arild Underdal

### Immunology and Inflammation

Robert L. Coffman  
Peter Cresswell  
K. Christopher Garcia  
Tak Wah Mak  
Ruslan Medzhitov  
Carl F. Nathan  
Lawrence Steinman  
Tadatsugu Taniguchi  
Arthur Weiss

### Mathematics

Robion C. Kirby  
Kenneth A. Ribet  
Srinivasa S. R. Varadhan

### Medical Genetics, Hematology, and Oncology

Anton J. Berns  
Dennis A. Carson  
C. Thomas Caskey  
James E. Cleaver  
Joseph L. Goldstein  
Tony Hunter  
Carol L. Prives  
Owen N. Witte

### Medical Physiology and Metabolism

Christopher K. Glass  
Barbara B. Kahn  
Robert J. Lefkowitz  
David J. Mangelsdorf  
Andrew R. Marks

### Microbial Biology

Yuan Chang  
John M. Coffin  
R. John Collier  
Jorge E. Galan  
Stephen P. Goff  
E. Peter Greenberg  
Diane E. Griffin  
Ralph R. Isberg  
Michael B. A. Oldstone  
Peter Palese  
Lalita Ramakrishnan

Thomas E. Shenk  
Thomas J. Silhavy  
Peter K. Vogt

### Physics

Curtis G. Callan Jr.  
Anthony Leggett  
Herbert Levine

### Physiology and Pharmacology

Richard W. Aldrich  
Susan G. Amara  
Francisco Bezanilla  
Gail Mandel

### Plant Biology

David Baulcombe  
Philip N. Benfey  
Joseph R. Ecker  
June B. Nasrallah  
Krishna K. Niyogi  
Julian I. Schroeder

### Plant, Soil, and Microbial Sciences

Julia Bailey-Serres  
Vicki L. Chandler  
Sheng Yang He  
Donald R. Ort  
Craig S. Pikaard  
Brian J. Staskawicz

### Psychological and Cognitive Sciences

Renee Baillargeon  
Susan T. Fiske  
Michael S. Gazzaniga  
Susan Gelman  
Dale Purves  
Jennifer Richeson

### Social and Political Sciences

Adrian Raftery  
Stephen W. Raudenbush  
Kenneth W. Wachter

### Sustainability Science

Arun Agrawal  
Gregory P. Asner  
Anthony J. Bebbington  
William C. Clark  
Ruth S. DeFries  
Carl Folke  
Susan Hanson  
Bonnie J. McCay  
Emilio F. Moran  
Hans Joachim Schellnhuber  
B. L. Turner II  
Arild Underdal

### Systems Neuroscience

Thomas D. Albright  
Emery N. Brown  
Robert Desimone  
Fred H. Gage  
Charles D. Gilbert  
Tony Movshon  
Marcus E. Raichle  
Peter L. Strick  
Leslie G. Ungerleider

## Submission to PNAS

Authors (members and nonmembers) may submit their manuscripts directly to PNAS at [www.pnascentral.org](http://www.pnascentral.org). Authors must recommend three appropriate Editorial Board members, three NAS members who are expert in the paper's scientific area, and five qualified referees. No Academy member sponsor is required.

**PNAS** is published weekly by the National Academy of Sciences, 500 Fifth Street, NW, NAS 338, Washington, DC 20001.

ISSN 1091-6490 (Online)  
ISSN 0027-8424 (Print)

**Correspondence:** PNAS, 500 Fifth Street, NW, NAS 338, Washington, DC 20001 USA. Email: PNAS@nas.edu.

**Copyright:** Volumes 90–105, copyright © 1993–2008 by the National Academy of Sciences of the United States of America, all rights reserved. Volumes 1–89 and 106–116, copyright as a collective work only; author(s) retains copyright to individual articles. **Requests for Permission:** See [www.pnas.org/page/about/rights-permissions](http://www.pnas.org/page/about/rights-permissions) for details. Address requests to reproduce material published in Volumes 1–89 to the original author(s); email other requests to PNASpermissions@nas.edu, fax 202-334-2739, or PNAS Permissions Editor, 500 Fifth Street, NW, NAS 338, Washington, DC 20001 USA. Please cite the exact material to be reprinted and state specifically where it will be used.

**Photocopies:** PNAS is registered with the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923 USA, fax 978-750-4470, or [www.copyright.com](http://www.copyright.com). Authorization to photocopy items for the internal or personal use of specific clients is granted by the National Academy of Sciences provided that the proper fee is paid directly to CCC.

**Subscriptions:** Send payments to PNAS, P.O. Box 936110, Atlanta, GA 31193-6110 USA. For subscription help, email [pnas.subs@sheridan.com](mailto:pnas.subs@sheridan.com), phone 717-632-3535, or visit [www.pnas.org/page/subscriptions/subscribers](http://www.pnas.org/page/subscriptions/subscribers).

**2019 Rates:** Individual online only, \$235; institutional online only, \$535–9,060. Subscriptions are entered on a calendar-year basis. **International Subscribers:** Sales agent information can be found online at [www.pnas.org/page/subscriptions/subs-faq#contact](http://www.pnas.org/page/subscriptions/subs-faq#contact).

**Change of Address:** PNAS, Subscriber Services, PO Box 465, Hanover, PA 17331 USA. Phone 717-632-3535, email [pnas.subs@sheridan.com](mailto:pnas.subs@sheridan.com). Please send notification 6 weeks in advance and list the old and new addresses.

**PNAS is published online at [www.pnas.org](http://www.pnas.org).**

## PNAS STAFF

### Publisher

Kenneth R. Fulton

### Executive Editor

Diane M. Sullenberger

### Deputy Executive Editor

Daniel H. Salsbury

### Senior Recruiting Editor

David Stopak

### Recruiting Editor

Jennifer Robinson

### Front Matter Editor

Gene Russo

### Editorial Manager

Etta Kavanagh

### Assistant Editorial Managers

Josiah W. Armour

Kathryn Murphy DeTura

### Editorial Staff

James B. Allison

Daniela Torres Checo

Pablo Luis Clemente

Brianna Costache

Abigail Fox

Samantha Fuller

Jenny Geyer

Julia Glueck

Jeffrey King

Rachel Laney

Matt Longabaugh

Amy McDermott

Kiefer McDowell

Melanie Michel

Tom Myers

Andrew Schroeder

Megan E. Shuler

Jacob D. Svobodny

Rocio Vidal-Ronchas

### Director of Publication

Midori Baer

### Editorial Production

#### Manager

Sharon Jane Chua

### Production Staff

Delaney Cruickshank

Elizabeth Griffith

Jennifer H. Nguyen

Danielle Robbins

Kat Rodenhizer

Audrey Springer

### Subscription Specialist

Kay McLaughlin

### Marketing Associate

Kirsten Ronald

### Media and Communications

#### Manager

Prashant Nair

### Media Staff

Brian M. Doctrow

Taylor Gedeon

Melissa Suran

### Senior Financial and

#### Administrative Officer

Anton L. Bandy

### Business Staff

Kim Mann

Vilija B. Teel

## Authorship

Authorship should be limited to those who have contributed substantially to the work. Authors must indicate their specific contributions to the published work; this information will be published as a footnote to the paper. The corresponding author must have obtained permission from all authors for the submission of each version of the paper and for any change in authorship.

## Conflict of Interest

All authors, members, referees, and editors must disclose any association that poses a conflict of interest in connection with the manuscript. Authors must acknowledge all funding sources supporting the work. See [www.pnas.org/site/authors/coi.xhtml](http://www.pnas.org/site/authors/coi.xhtml) for details.

## Supporting Information

Authors may use supporting information to enhance their papers in PNAS by providing additional substantive material for online posting, but the main text of the paper must stand on its own merits.

## Cover Images

Authors are encouraged to submit scientifically interesting and visually arresting images for the cover.

## Information for Authors

Please see the complete Information for Authors, available online at [www.pnas.org](http://www.pnas.org).

## PNAS Online

PNAS articles are published daily at [www.pnas.org](http://www.pnas.org) in PNAS Latest Articles.

The articles in PNAS report original research by independent authors and have not been endorsed by the National Academies.