

# American Journal of Physiology- Endocrinology and Metabolism®

Editor: André Marette

---

## Associate Editors:

Patrice Carni  
Hari Hundal

Anna Krook  
Patrick MacDonald  
Gary J. Schwartz

Rebecca Simmons  
Cynthia Smas  
Matthew Watt

---

## Editorial Board:

Steven Abcouwer  
Matthew Anderson  
Younès Anini  
Russell V. Anthony  
Tracy Anthony  
Philip Atherton  
Keith Baar  
Eugene J. Barrett  
Rita Basu  
Stephen Benoit  
Ernesto Bernal-Mizrachi  
Philip J. Bilan  
Gustavo Blanco  
Stephen Borst  
George A. Brooks  
Holly Brown-Borg  
Christoph Buettner  
Ralph Burkhardt  
Dongsheng Cai  
Lu Cai  
Wenhong Cao  
Gregory Cartee  
Patrick Catalano  
Bandana Chatterjee  
Naibehya Chattopadhyay  
Alex F. Chen  
Alexander V. Chibalin  
Edward Chien  
Streamson C. Chua, Jr.  
Kirk P. Conrad  
Robert Considine  
Greg Cooney  
John A. Corbett  
David D'Alessio  
Sandra Davidge  
Nicolaas EP Deutz  
Henry Donahue  
Cumming Duan  
Charles A. Ducas  
Daniel Dumesic  
Jeffrey S. Elmendorf  
Sarah K. England  
Shereen Ezzat  
Asgerally Fazleabas  
Mark Febbraio  
William Festuccia  
Jorge P. Figueroa  
James D. Fluckey

Mao Fu  
Patrick T. Fueger  
J. David Furlow  
Adolfo Garcia-Ocaña  
Nori Geary  
Adria Giacca  
Benjamin Glaser  
Ira J. Goldberg  
Bret Goodpaster  
Laurie J. Goodyear  
George H. Greeley  
Lisa Halvorson  
Victor Han  
Chad Hancock  
Mark Hargreaves  
John A. Hawley  
William W. Hay, Jr.  
Jennifer W. Hill  
Carol Huang  
Mahmood Hussain  
Yumi Imai  
Jørgen Jensen  
Tianru Jin  
Caleb Kallen  
Gerard Karsenty  
Maureen Keller-Wood  
Jason K. Kim  
Jeong-a Kim  
Young-Bum Kim  
Scot R. Kimball  
Hilla Knobler  
Daniel Konrad  
Anjan Kowluru  
Graciela Krikun  
Anna Krook  
George Kunos  
Irwin Kurland  
Kyriakos E. Kypreos  
Sergio Lavandero  
Kuk-Wha Lee  
Todd Leff  
Gil Leibowitz  
Po Sing Leung  
Barry Levin  
Gary F. Lewis  
Hung-Mo Lin  
Dongmin Liu  
Feng Liu

Gary Lopaschuk  
Xin-Liang Ma  
Patrick MacDonald  
Robert G. MacKenzie  
Daniel J. MacPhee  
Daniel Marks  
Glenn McConell  
Owen McGuinness  
Joseph Messina  
Benjamin F. Miller  
Raghu Mirmira  
William E. Mitch  
Jane A. Mitchell  
Subburaman Mohan  
Patricia E. Molina  
Monica Montagnani  
Genie (Mary) Courtney Moore  
Christopher Morrison  
Heike Münzberg-Grüning  
Ranganath Muniyappa  
Amy Murtha  
Jan Nedergaard  
Margaret Neville  
Kevin Niswender  
Silvana Obici  
Robert O'Doherty  
Donal O'Gorman  
Youngman Oh  
Ann Louise Olson  
Kutluk Oktay  
David Olson  
Rudi Ortiz  
Jingsong Ou  
Michael Pagliassotti  
Kyong Soo Park  
Antonio Pellicer  
Gianluca Perseghin  
Kitt Falk Petersen  
Daniele Piomelli  
Scott Pletcher  
Stephen Plymate  
Lucilla Poston  
Marc Prentki  
Jerry Radziuk  
Sasanka Ramanadham  
Michael Roden  
Michael Rosenbaum  
Richard A. Roth

Assaf Rudich  
Liangyou Rui  
Mario J.A. Saad  
Kei Sakamoto  
Toshiyasu Sasaoka  
Leslie Satin  
David Savage  
Rosario Scalia  
Jonathan Schertzer  
James Segars  
Utpal Sen  
Colin Sibley  
Cynthia Smas  
Gregory R. Steinberg  
Jacqueline Stephens  
Naftali Stern  
XiaoJian Sun  
Gary Sweeney  
J. David Symons  
Nobuhiko Takahashi  
André Tchernof  
Karen Teff  
Debbie Thurmond  
Amir Tirosch  
Michael J. Toth  
Frederic Tremblay  
Matthias H. Tschöp  
Robert Tsushima  
Rupangi Vasavada  
Allen Volchuk  
Anton Wagenmakers  
Hong Wang  
Qinghua Wang  
Rennian Wang  
Matthew J. Watt  
Ram Weiss  
Monte S. Willis  
William Winder  
Minna Woo  
Toru Yamaguchi  
Peixin Yang  
Kevin E. Yarasheski  
Jianping Ye  
Yiyang Zhang  
Yeheil Zick  
Teresa Zimmers  
Antonio Zorzano

---

## Publications Committee

Curt D. Sigmund, *Chair*  
Hershel Raff, *Vice Chair*  
Catherine E. Carr  
David Ellison  
Andrew Greene  
Paul Insel  
Alicia A. McDonough  
Lynette K. Rogers  
Susan M. Wall  
Loren Wold

Rita Scheman  
*Director of Publications*  
and *Executive Editor*  
Jane F. Reckelhoff, *President*  
Dennis Brown, *President-Elect*  
Patricia E. Molina, *Past President*  
Martin. Frank, *Executive Director*

Audra E. Cox  
*Editorial Manager*  
Stephanie Demma  
*Journal Supervisor*  
T. Christensen  
L. Kanaskie  
J. Marquez  
D. Udoff  
*Copy Editors*

Gilbert Ebner  
*Peer Review Manager*  
Eric Pesanelli  
*Editorial Art Manager*  
Karen Dodson  
*Editor's Assistant*

---

The *American Journal of Physiology-Endocrinology and Metabolism* (ISSN-0193-1849) is published online at [www.ajpendo.org](http://www.ajpendo.org) (ESSN 1522-1555) monthly (two volumes a year) by the American Physiological Society, 9650 Rockville Pike, Bethesda, MD 20814-3991. *Subscription Prices (postpaid)*: For institutional print and online pricing, please see <http://www.the-aps.org/publications/subs>. Non-member individuals (online only): \$415.00, APS members: online is free. Subscriptions from outside the United States are payable in US currency or full equivalent. Subscriptions are accepted on a calendar-year basis only. Print back issues, when available, through December 2011: Subscriber, \$45 each; Nonsubscriber, \$90. Periodicals postage paid at Bethesda, MD and at additional mailing offices.

The *American Journal of Physiology-Endocrinology and Metabolism*® is a registered trademark of the American Physiological Society.

Copyright © 2017 by the American Physiological Society. Printed in the United States of America by Cadmus Communications—Lancaster Division, Lancaster, PA 17601. The code at the bottom of the first page of an article indicates the copyright owner's consent that copies of that article may be made beyond that permitted by sections 107 and 108 of the US Copyright Law—unless the copies are for general distribution, for advertising, for creating new works, or for resale—provided the per-copy fee is paid through the Copyright Clearance Center, Inc., 222 Rosewood Dr., Danvers, MA 01923.

*Editorial and Business Correspondence*: AJP-Endocrinology and Metabolism, 9650 Rockville Pike, Bethesda, MD 20814-3991.

**Disclaimer**: The statements and opinions contained in the articles of the *American Journal of Physiology-Endocrinology and Metabolism* are solely those of the individual authors and contributors and not of the American Physiological Society. The appearance of advertisements in the journal is not a warranty, endorsement, or approval of the products or their safety. The American Physiological Society disclaims responsibility for any injury to persons or property resulting from any ideas or products referred to in any article or advertisement.