A JOURNAL OF THE AMERICAN DIABETES ASSOCIATION



EDITOR IN CHIEF

Martin G. Myers Jr., MD, PhD

SENIOR ASSOCIATE EDITORS

David A. D'Alessio, MD

Maureen A. Gannon, PhD

Randy J. Seeley, PhD

ASSOCIATE EDITORS

Karin Bornfeldt, PhD Frank C. Brosius, MD

Charles F. Burant, MD, PhD Alessandro Doria, MD, PhD

James Granneman, PhD

Maria B. Grant, MD, FARVO

Carey Nien-Kai Lumeng, MD, PhD

Ormond A. MacDougald, PhD Massimo Pietropaolo, MD Rodica Pop-Busui, MD, PhD

Leslie Satin, PhD

Doris A. Stoffers, MD, PhD Morris F. White, PhD

EDITORIAL BOARD

Steven F. Abcouwer, PhD Gail K. Adler, MD, PhD, FAHA

Laura C. Alonso, MD David A. Antonetti, PhD

Alan D. Attie, PhD

Julio E. Ayala, PhD

Manuela Bartoli, PhD

Bryan C. Bergman, PhD

Pengpeng Bi, PhD

Shawn C. Burgess, PhD

Julia V. Busik, PhD

Lu Cai, MD, PhD

Nigel A. Calcutt, PhD Jonathon Campbell, PhD

William P. Cawthorn, PhD

Sheila Collins, PhD

Robert V. Considine, PhD

Marc Y. Donath, MD

Lena Eliasson, PhD

Sven Enerback, MD, PhD

Carmela Evans-Molina, MD, PhD

Patrick Fueger, PhD

Paula Goforth, PhD

Bret H. Goodpaster, PhD

Laurie J. Goodyear, PhD

Struan F.A. Grant, PhD

Kevan C. Herold, MD

Jeffrey F. Horowitz, PhD

Jiandie D. Lin, PhD

Eric Hajduch, PhD

Alyssa Hasty, PhD

Mark A. Herman, MD

Pedro L. Herrera, PhD

James D. Johnson, PhD

Young-Bum Kim, PhD

Moshe Levi, MD, MS

Xiaoying Li, MD, PhD

Francis C. Lynn, PhD

Aaron W. Michels, MD

Bettina Mittendorfer, PhD

Daniel J. Moore, MD, PhD

David P. Olson, MD, PhD

Rama Natarajan, PhD

Edwards A. Park, PhD

Diego Perez-Tilve, PhD

Linda R. Peterson, MD

Vincent Poitout, DVM, PhD

Patrick E. MacDonald, PhD

Kieren J. Mather, MD, FRCPC

Franck Mauvais-Jarvis, MD, PhD

Rory J. McCrimmon, MD, MBChB

Viswanathan Mohan, MD, FRCP, PhD, DSc,

FNASc, FASc, FNA, FACP, FACE, FTWAS

Chih-Hao Lee, MD

Ken Inoki, MD, PhD

Matthew J. Potthoff, PhD

Alberto Pugliese, MD

Matthew Rodeheffer, PhD

Liangyou Rui, PhD

Guy A. Rutter, PhD

Alice S. Ryan, PhD

Darleen Sandoval, PhD

Gaetano Santulli, MD, PhD Philipp E. Scherer, PhD

Gary J. Schwartz, PhD

Show-Ling Shyng, PhD Scott Soleimanpour, MD

Andreas Stahl, PhD

Jacqueline M. Stephens,

BS, PhD

Craig S. Stump, MD, PhD,

FACE

Gianna Maria Toffolo, PhD Peter Tontonoz, MD, PhD

Vincenzo Trischitta, MD

Hubert M. Tse, PhD Fumihiko Urano, MD, PhD

Adrian Vella, MD

Matthew Watt, PhD

Li Wen, MD, PhD

Yang Kevin Xiang, PhD

AMERICAN DIABETES ASSOCIATION OFFICERS

CHAIR OF THE BOARD Karen Talmadge, PhD

PRESIDENT, MEDICINE & SCIENCE

Jane Reusch, MD

PRESIDENT, HEALTH CARE & EDUCATION

Felicia Hill-Briggs, PhD, ABPP

SECRETARY/TREASURER

Michael Ching, CPA

CHAIR OF THE BOARD-ELECT

David J. Herrick, MBA

PRESIDENT-ELECT, MEDICINE & SCIENCE Louis Philipson, MD

PRESIDENT-ELECT, HEALTH CARE & EDUCATION

Gretchen Youssef, MS, RD, CDE SECRETARY/TREASURER-ELECT

Brian Bertha, JD, MBA

CHIEF EXECUTIVE OFFICER

Tracey D. Brown, MBA, BChE

CHIEF SCIENTIFIC, MEDICAL & MISSION OFFICER William T. Cefalu, MD

American Diabetes Association_®

The mission of the American Diabetes Association is to prevent and cure diabetes and to improve the lives of all people affected by diabetes.

A JOURNAL OF THE AMERICAN DIABETES ASSOCIATION



Mission Statement for **Diabetes**

Diabetes publishes original research about the physiology and pathophysiology of diabetes mellitus. Submitted manuscripts can report any aspect of laboratory, animal, or human research. Emphasis is on investigative reports focusing on areas such as the pathogenesis of diabetes and its complications, normal and pathological pancreatic islet function and intermediary metabolism, pharmacological mechanisms of drug and hormone action, and biochemical and molecular aspects of normal and abnormal biological processes. Studies in the areas of diabetes education or the application of accepted therapeutic and diagnostic approaches to patients with diabetes are not published. More information about the journal can be found online at diabetes.diabetesjournals.org.

Copyright © 2018 by the American Diabetes Association, Inc. All rights reserved. Printed in the USA. Requests for permission to reuse content should be sent to Copyright Clearance Center at www.copyright.com or 222 Rosewood Dr., Danvers, MA 01923; phone: (978) 750-8400; fax: (978) 646-8600. Requests for permission to translate should be sent to Permissions Editor, American Diabetes Association, at permissions@diabetes.org.

The American Diabetes Association reserves the right to reject any advertisement for any reason, which need not be disclosed to the party submitting the advertisement.

Commercial reprint orders should be directed to Sheridan Content Services, (800) 635-7181, ext. 8065.

Single issues of *Diabetes* can be ordered by calling toll-free (800) 232-3472, 8:30 A.M. to 5:00 P.M. EST, Monday through Friday. Outside the United States, call (703) 549-1500. Rates: \$75 in the United States, \$95 in Canada and Mexico, and \$125 for all other countries.

PRINT ISSN 0012-1797 ONLINE ISSN 1939-327X PRINTED IN THE USA Diabetes is available online at diabetes.diabetesjournals.org. Please call the numbers listed above, email membership@diabetes.org, or visit the online journal for more information about submitting manuscripts, publication charges, ordering reprints, subscribing to the journal, becoming an ADA member, advertising, permission to reuse content, and the journal's publication policies.

Periodicals postage paid at Arlington, VA, and additional mailing offices.

AMERICAN DIABETES ASSOCIATION PERSONNEL AND CONTACTS

SENIOR VICE PRESIDENT, PUBLISHER

Michael Eisenstein

ASSOCIATE PUBLISHER, SCHOLARLY JOURNALS Christian S. Kohler

EDITORIAL OFFICE DIRECTOR

Lyn Reynolds

PEER REVIEW MANAGER Jane Castner

ASSOCIATE MANAGER, PEER REVIEW

Joan Garrett

DIRECTOR, SCHOLARLY JOURNALS Heather Norton Blackburn CONTENT PRODUCTION MANAGER

Kelly Newton

EDITORIAL CONTENT MANAGER

Oedipa Rice

TECHNICAL EDITOR
Theresa Cooper
Donna J. Reynolds

DIRECTOR, MEMBERSHIP/ SUBSCRIPTION SERVICES Donald Crowl

SENIOR ADVERTISING MANAGER

Julie DeVoss Graff jgraff@diabetes.org (703) 299-5511 ADVERTISING REPRESENTATIVES

AMERICAN DIABETES ASSOCIATION
Paul Nalbandian
Associate Publisher, Advertising &
Sponsorships

pnalbandian@diabetes.org (703) 549-1500, ext. 4806

Tina Auletta Senior Account Executive tauletta@diabetes.org (703) 549-1500, ext. 4809

PHARMACEUTICAL/DEVICE DIGITAL ADVERTISING

The Walchli Tauber Group Maura Paoletti National Sales Manager

maura.paoletti@wt-group.com (443) 512-8899, ext. 110