



Electron Transfer in Biology and the Solid State

Inorganic Compounds with Unusual Properties

This comprehensive volume brings together the latest information on electron transfer from two diverse scientific communities—those studying mechanisms of electron transfer in metalloproteins and those studying similar processes in solid state materials. Leading scientists in both fields contributed to this volume providing a balance of overview, theory, and experiment. Semiconductors and tunneling models are offered to explain many aspects of long-range biological electron transfer.

Recent research activities and significant advances are highlighted. Unifying concepts found here are applicable to electron transfer between metal centers in both solid state materials and biological systems. With 23 chapters, topics covered within this volume include:

- theoretical aspects of biological electron transfer
- experimental approaches to biological electron transfer: peptides and proteins and inorganic complexes
- theoretical aspects of solid state systems
- experimental aspects of solid state systems

This volume will serve as a valuable asset to the professional libraries of materials scientists, solid-state scientists, biochemists, and all whose interests span both biological and solid state materials.

Michael K. Johnson, R. Bruce King, Donald M. Kurtz, Jr., Charles Kutal, Michael L. Norton, Robert A. Scott, *Editors*, University of Georgia

Developed from a symposium sponsored by the Division of Inorganic Chemistry of the American Chemical Society

Advances in Chemistry Series 226
470 pages (1990) Clothbound
ISBN 0-8412-1675-4 LC 90-30119
\$89.95

O R D E R F R O O M

American Chemical Society
Distribution Office, Dept. 67
1155 Sixteenth St., N.W.
Washington, DC 20036

or CALL TOLL FREE

800-227-5558

(in Washington, D.C. 872-4363) and use your credit card!

Biochemistry

Biochemistry (ISSN 0006-2960) is published weekly except for the first week in January by the American Chemical Society at 1155 16th St., N.W., Washington, DC 20036. Second-class postage paid at Washington, DC, and additional mailing offices. POSTMASTER: Send address changes to *Biochemistry*, Member & Subscriber Services, P.O. Box 3337, Columbus, OH 43210. Canadian GST Reg. No. R127571347.

American Chemical Society

1155 16th St., N.W.
Washington, DC 20036
(202) 872-4600
TDD (202) 872-8733; FAX (202) 872-4615

Member & Subscriber Services

American Chemical Society
P.O. Box 3337, Columbus, OH 43210
(614) 447-3776; (800) 333-9511

Journals Department

American Chemical Society
2540 Olentangy River Road
P.O. Box 3330, Columbus, OH 43210
(614) 447-3600, Ext 3171
TELEX 6842086; FAX (614) 447-3745

Publications Division

Robert H. Marks, Director

Journals Department: Charles R. Bertsch, Head; Marianne C. Brogan, Associate Head

Editorial Office: Mary E. Scanlan, Manager; Kathleen E. Duffy and Joseph E. Yurvati, Journals Editing Managers; Deborah K. Miller, Senior Associate Editor; Heather W. Cammann, Daniel R. Kelsey, Beth A. Rogers, Barbara I. Taylor, and Brenda S. Wooten, Assistant Editors; Laure A. Needham, Staff Editor

Advertising Office: Centcom, Ltd., 1599 Post Road East, P.O. Box 231, Westport, CT 06881

© Copyright 1992 by the American Chemical Society. Copyright permission: An individual may make a single reprographic copy of an article in this publication for personal use. Reprographic copying beyond that permitted by Section 107 or 108 of the U.S. Copyright Law is allowed, provided that the appropriate per-copy fee is paid through the Copyright Clearance Center, Inc., 27 Congress St., Salem, MA 01970. For reprint permission, please write to the Copyright Administrator, Publications Division, at the ACS Washington address.

The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48-1984.

Editorial Information

Instructions to authors and copyright status form are printed in the first issue of each volume. Please conform to these instructions when submitting manuscripts.

Manuscripts for publication should be submitted to the Editor, Gordon G. Hammes, Duke University Medical Center, P.O. Box 3673, 081 Yellow Zone, Duke South, Durham, NC 27710. Correspondence regarding accepted papers and proofs should be directed to the Journals Department at the address above. Page charges of \$30.00 per page may be paid for papers published in this journal. Payment does not affect acceptance or scheduling of papers. Bulk reprints of individual articles are available. For information write to Distribution Office at the ACS Washington address.

The American Chemical Society and its Editors assume no responsibility for the statements and opinions advanced by contributors.

Registered names and trademarks, etc., used in this publication, even without specific indication thereof, are not to be considered unprotected by law.

Subscription and Business Information

Subscriptions are available only on a calendar year basis. (For membership information, contact Office of Member Services at the ACS Washington address.)

New and renewal subscriptions should be sent with payment to American Chemical Society, Department L-0011, Columbus, OH 43268-0011. Rates do not apply to non-member subscribers in Japan, who must enter subscription orders with Maruzen Company Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211.

1992 subscription prices including postage.

	U.S.	Canada, Mexico	Europe*	All Other Countries*
Printed				
Members—1 yr	\$ 98	\$ 194	\$ 334	\$ 426
2 yr	\$ 176	\$ 368	\$ 648	\$ 832
Nonmembers	\$1040	\$1136	\$1276	\$1368
Microfiche				
Members—1 yr	\$ 98	\$ 98	\$ 146	\$ 146
2 yr	\$ 176	\$ 176	\$ 272	\$ 272
Nonmembers	\$1040	\$1040	\$1088	\$1088
Supplementary material on microfiche	\$ 35	\$ 55	\$ 55	\$ 55

* Air service included.

Printed edition single issue prices: current year, \$21.00; 1990–91, \$23.00; prior year, \$44.00. Back volume price: \$1129.00. Foreign postage additional. Mail orders should be sent to Microforms & Back Issues Office at the ACS Washington address.

Phone orders can be placed for printed, microfiche, and microfilm editions by calling the ACS TOLL FREE at (800) 333-9511 from anywhere in the United States and Canada. Phone orders can be charged to Visa, MasterCard, or American Express accounts.

Changes of address must include both old and new addresses with ZIP code and a recent mailing label. Send all address changes to Member & Subscriber Services. Please allow 6 weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America, more than 90 days beyond issue date; (b) all other foreign, more than 180 days beyond issue date. Hard copy claims are handled by Member & Subscriber Services.

Supplementary material is noted in the table of contents with a ■. It is available as photocopy (\$10.00 for up to 3 pages and \$1.50 per page for additional pages, plus \$2.00 for foreign postage) or as 24X microfiche (\$10.00, plus \$1.00 for foreign postage). Canadian residents should add 7% GST. See supplementary material notice at end of journal article for number of pages. Orders must state whether for photocopy or for microfiche and give complete title of article, names of authors, journal, issue date, and page numbers. Prepayment is required and prices are subject to change. Order from Microforms & Back Issues Office at the ACS Washington address. Supplementary material except structure factors also appears in the microfilm edition and may be ordered by subscription (in microfiche only).

Cover: Based on apohemoglobin β subunit—courtesy of Jane S. Richardson.

Biochemistry

EDITOR: GORDON G. HAMMES

Duke University Medical Center, P.O. Box 3673, 081 Yellow Zone, Duke South, Durham, North Carolina 27710
[Phone (919) 681-3250; FAX (919) 681-8344]

ASSOCIATE EDITORS:

MARC G. CARON, DUKE UNIVERSITY

EARL W. DAVIE, UNIVERSITY OF WASHINGTON

PERRY A. FREY, UNIVERSITY OF WISCONSIN

PAUL L. MODRICH, DUKE UNIVERSITY

WILLIAM W. PARSON, UNIVERSITY OF WASHINGTON

JOSEPH J. VILLAFRANCA, THE PENNSYLVANIA STATE UNIVERSITY

LESLIE WILSON, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

EDITORIAL ADVISORY BOARD

ROBERT H. ABELES
Brandeis University

DAVID S. AULD
Harvard Medical School

JOSEPH AVRUCH
Massachusetts General Hospital

GERALD T. BABCOCK
Michigan State University

STEPHEN J. BENKOVIC
The Pennsylvania State University

GUNTER BLOBEL
The Rockefeller University

E. MORTON BRADBURY
University of California, Davis

BILL R. BRINKLEY
Baylor College of Medicine

MINOR J. COON
The University of Michigan

JACKIE CORBIN
Vanderbilt University

DAVID DAVIES
NIADDK, National Institutes of Health

RUSSELL F. DOOLITTLE
University of California at San Diego

RAYMOND A. DWEK
University of Oxford

MICHAEL EDIDIN
Johns Hopkins University

MAURICE EFTINK
University of Mississippi

JAMES H. FREISHEIM
Medical College of Ohio

IRWIN FRIDOVICH
Duke University

CARL FRIEDEN
Washington University

PAUL A. FRIEDMAN
Merck Sharp & Dohme

MARTIN GELLERT
National Institutes of Health

JOHN GERGELY
Boston Biomedical Research Institute

IRVING H. GOLDBERG
Harvard Medical School

JACK GORSKI
University of Wisconsin

WILLIAM F. HARRINGTON
Johns Hopkins University

ROBERT HASELKORN
University of Chicago

CARL-HENRIK HELDIN
Ludwig Institute for Cancer Research,
Uppsala

CLAUDE HÉLÈNE
Muséum National d'Histoire Naturelle,
Paris

JOHN W. B. HERSHEY
University of California, Davis

GEORGE P. HESS
Cornell University, Ithaca

PETER C. HINKLE
Cornell University, Ithaca

BARRY HONIG
Columbia University

FRANK M. HUENNEKENS
Scripps Clinic & Research Foundation

TONY E. HUGLI
Scripps Clinic & Research Foundation

RAINER JAENICKE
University of Regensburg

HANS JÖRNVALL
Karolinska Institute, Stockholm

H. RONALD KABACK
Howard Hughes Medical Institute, UCLA

NEVILLE R. KALLENBACH
New York University

YOSHITO KAZIRO
University of Tokyo

CLAUDE B. KLEE
National Cancer Institute

JOSEPH KRAUT
University of California at San Diego

JACK E. KYTE
University of California at San Diego

ROBERT J. LEFKOWITZ
Duke University

TOMAS LINDAHL
Imperial Cancer Research Fund, London

GERHARD MEISSNER
University of North Carolina

HENRY METZGER
NIAMS, National Institutes of Health

ELIZABETH NEUFELD
University of California, Los Angeles

DEXTER B. NORTHROP
University of Wisconsin

JAMES OFENGAND
Roche Institute of Molecular Biology

BERT O'MALLEY
Baylor College of Medicine

DEMETRIOS PAPAHAJIOPOULOS
University of California, San Francisco

MARY LOU PARDUE
Massachusetts Institute of Technology

DAVID C. PHILLIPS
University of Oxford

JAMES C. POWERS
Georgia Institute of Technology

JAMES H. PRESTEGARD
Yale University

JAMES F. RIORDAN
Harvard Medical School

MICHAEL ROSSMANN
Purdue University

DAVID W. RUSSELL
University of Texas Southwestern
Medical Center

CLARENCE A. RYAN, JR.
Washington State University

RANDY W. SCHEKMAN
University of California, Berkeley

HAROLD A. SCHERAGA
Cornell University, Ithaca

PAUL R. SCHIMMEL
Massachusetts Institute of Technology

JOACHIM SEELIG
University of Basel

G. GRAHAM SHIPLEY
Boston University

ANTERO G. SO
University of Miami

JOANNE STUBBE
Massachusetts Institute of Technology

BRIAN SYKES
University of Alberta

IGNACIO TINOCO, JR.
University of California, Berkeley

BERT L. VALLEE
Harvard Medical School

MARTHA VAUGHAN
National Institutes of Health

SALIH J. WAKIL
Baylor College of Medicine

ERNST-L. WINNACKER
Universitat Munchen

SAVIO WOO
Baylor College of Medicine

PETER E. WRIGHT
Scripps Clinic & Research Foundation