

Sidney P. Colowick and Nathan O. Kaplan

Methods in ENZYMLOGY

Volume 92

Immunochemical Techniques

Part E

Monoclonal Antibodies
and General Immunoassay Methods

Edited by

John J. Langone
Helen Van Vunakis

Methods in Enzymology

Volume 92

Immunochemical Techniques

Part E

*Monoclonal Antibodies and
General Immunoassay Methods*

EDITED BY

John J. Langone

DEPARTMENT OF MEDICINE
BAYLOR COLLEGE OF MEDICINE
HOUSTON, TEXAS

Helen Van Vunakis

DEPARTMENT OF BIOCHEMISTRY
BRANDEIS UNIVERSITY
WALTHAM, MASSACHUSETTS

1983



ACADEMIC PRESS

A Subsidiary of Harcourt Brace Jovanovich, Publishers

New York London

Paris San Diego San Francisco São Paulo Sydney Tokyo Toronto

COPYRIGHT © 1983, BY ACADEMIC PRESS, INC.

ALL RIGHTS RESERVED.

NO PART OF THIS PUBLICATION MAY BE REPRODUCED OR
TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC
OR MECHANICAL, INCLUDING PHOTOCOPY, RECORDING, OR ANY
INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT
PERMISSION IN WRITING FROM THE PUBLISHER.

ACADEMIC PRESS, INC.

111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by

ACADEMIC PRESS, INC. (LONDON) LTD.

24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Main entry under title:

Monoclonal antibodies and general immunoassay methods.

(Methods in enzymology ; v. 92, pt. E)

Bibliography: p.

Includes indexes.

I. Antibodies, Monoclonal. 2. Immunoassay--
Methodology. I. Langone, John J. (John Joseph),
Date. II. Van Vunakis, Helen, Date.

III. Series.

QP601.M49 vol. 92, pt. E 574.19'25s 82-22786

[QR186.85] [591.19'285]

ISBN 0-12-281992-2

PRINTED IN THE UNITED STATES OF AMERICA

83 84 85 86 9 8 7 6 5 4 3 2 1

Contributors to Volume 92

Article numbers are in parentheses following the names of contributors.
Affiliations listed are current.

- N. LEIGH ANDERSON (16), *Molecular Anatomy Program, Division of Biological and Medical Research, Argonne National Laboratory, Argonne, Illinois 64039*
- GIULIA C. B. ASTALDI (5), *Istituto di Genetica Biochimica ed Evolutionistica C.N.R. di Pavia, 27100 Pavia, Italy*
- STRATIS AVRAMEAS (38), *Département d'Immunologie, Institut Pasteur, 75724 Paris, Cedex 15, France*
- WILLIAM F. BALE* (22), *School of Applied Biology, Georgia Institute of Technology, Atlanta, Georgia 30332*
- RICHARD B. BANKERT (15, 21), *Department of Molecular Immunology, Roswell Park Memorial Institute, Buffalo, New York 14263*
- ROBERT C. BAXTER (44), *Department of Endocrinology, Royal Prince Alfred Hospital, Sidney, New South Wales 2050, Australia*
- ELSA H. BERENSTEIN (2), *Clinical Immunology Section, Laboratory of Microbiology and Immunology, National Institute of Dental Research, National Institutes of Health, Bethesda, Maryland 20205*
- J. BRIGGS (36), *SYVA, Palo Alto, California 94303*
- JOSEPH P. BROWN (12), *Program in Tumor Immunology, Fred Hutchinson Cancer Research Center, Seattle, Washington 98104*
- ROBERT T. BUCKLER (32), *Ames Research and Development Laboratories, Miles Laboratories, Inc., Elkhart, Indiana 46515*
- GÉRARD BUTTIN (14), *Unité de Génétique Somatique, Bâtiment Metchnikoff, Institut Pasteur, 75724 Paris, Cedex 15, France*
- MICHAEL CAIS (25, 35), *Department of Chemistry, Technicon, Israel Institute of Technology, Haifa 32000, Israel*
- M. CHRÉTIEN (23), *Protein and Pituitary Hormone Laboratory, Clinical Research Institute of Montreal, Montreal H2W 1R7, Canada*
- M. ANGELES CONTRERAS (22), *School of Applied Biology, Georgia Institute of Technology, Atlanta, Georgia 30332*
- ANGEL L. DE BLAS (4), *Department of Neurobiology and Behavior, State University of New York at Stony Brook, Stony Brook, New York 11794*
- MARLENE DELUCA (33), *Department of Chemistry, University of California, San Diego, La Jolla, California 92093*
- J. Y. DOUILLARD (13), *Institut National de la Santé et de la Recherche Médicale (INSERM) U211, Unité d'enseignement et de Recherche (UER) Médecine, 44035 Nantes, Cedex, France*
- MATTHEW J. DOYLE (34), *Department of Chemistry, University of Cincinnati, Cincinnati, Ohio 45221*
- V. B. ELINGS (36), *Department of Physics, University of California, Santa Barbara, California 93106*
- J. FEINGERS (28), *Ames-Yissum Product Research and Development Laboratories, Jerusalem, Israel*
- HELMAR FIEBACH (18), *Department of Experimental and Clinical Immunology, Central Institute of Cancer Research, Academy of Sciences of the G.D.R., DDR-1115 Berlin-Buch, German Democratic Republic*
- PHILIP C. FOX (2), *Clinical Immunology Section, Laboratory of Microbiology and Immunology, National Institute of Dental Research, National Institutes of Health, Bethesda, Maryland 20205*
- G. M. FULLER (42), *Department of Human Biological Chemistry and Genetics, Division of Human Genetics, The University*

* Deceased.

- of Texas Medical Branch, Galveston, Texas 77550
- ADRIAN P. GEE (31), *Department of Pediatrics, University of Florida, Gainesville, Florida 32610*
- V. GHEȚIE (40), *Department of Immunology, Victor Babeș Institute, 76201 Bucharest, Romania*
- JEAN-LUC GUÉSDON (38), *Département d'Immunologie, Institut Pasteur, 75724 Paris, Cedex 15, France*
- H. BRIAN HALSALL (34), *Department of Chemistry, University of Cincinnati, Cincinnati, Ohio 45221*
- BRUNO HANSEN (24), *Hagedorn Research Laboratory, 2820 Gentofte, Denmark*
- P. HÄRING (20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- WILLIAM R. HEINEMAN (34), *Department of Chemistry, University of Cincinnati, Cincinnati, Ohio 45221*
- INGERGERD HELLSTRÖM (12), *Program in Tumor Immunology, Fred Hutchinson Cancer Research Center, and Department of Microbiology/Immunology, University of Washington, Seattle, Washington 98104*
- KARL ERIK HELLSTRÖM (12), *Program in Tumor Immunology, Fred Hutchinson Cancer Research Center, and Department of Pathology, University of Washington, Seattle, Washington 98104*
- STEVEN H. HERRMANN (8), *Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115*
- T. HOFFMAN (13), *Division of Biochemistry and Biophysics, Office of Biologics, FDA, National Center for Drugs and Biologics, Bethesda, Maryland 20205*
- D. INBAR (28), *Ames-Yissum Product Research and Development Laboratories, Jerusalem, Israel*
- YI-HER JOU (21), *Department of Molecular Immunology, Roswell Park Memorial Institute, Buffalo, New York 14263*
- DOMINIQUE JUY (14), *Unité d'Immunochimie Analytique, Bâtiment Metchnikoff, Institut Pasteur, 75724 Paris, Cedex 15, France*
- HENRY S. KAPLAN (1), *Department of Radiology, Cancer Biology Research Laboratory, Stanford University School of Medicine, Stanford, California 94305*
- UWE KARSTEN (18), *Department of Experimental and Clinical Immunology, Central Institute of Cancer Research, Academy of Sciences of the G.D.R., DDR-1115 Berlin-Buch, German Democratic Republic*
- KANEFUSA KATO (26), *Department of Biochemistry, Institute for Developmental Research, Aichi Prefectural Colony, Kasugai, Aichi 480-03, Japan*
- JOHN J. LANGONE (31), *Department of Medicine, Baylor College of Medicine, Houston, Texas 77030*
- PIERRE LEGRAIN (14), *Unité de Génétique Somatique, Bâtiment Metchnikoff, Institut Pasteur, 75724 Paris, Cedex 15, France*
- ÅKE LERNMARK (24), *Hagedorn Research Laboratory, 2820 Gentofte, Denmark*
- SUSANNE LINDE (24), *Hagedorn Research Laboratory, 2820 Gentofte, Denmark*
- BO MATTIASSON (39), *Pure and Applied Biochemistry, Chemical Center, University of Lund, S-220 07 Lund, Sweden*
- GEORGE L. MAYERS (21), *Department of Molecular Immunology, Roswell Park Memorial Institute, Buffalo, New York 14263*
- PARK K. MAZZAFERRO (21), *Department of Molecular Immunology, Roswell Park Memorial Institute, Buffalo, New York 14263*
- RONALD MCKAY (10), *Cold Spring Harbor Laboratory, Cold Spring Harbor, New York 11724*
- MATTHEW F. MESCHER (8), *Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115*
- BURKHARD MICHEEL (18), *Department of Experimental and Clinical Immunology,*

- Central Institute of Cancer Research, Academy of Sciences of the G.D.R., DDR-1115 Berlin-Buch, German Democratic Republic*
- V. MIGGIANO (3, 20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- I. MORARU (40), *Department of Immunology, Victor Babeş Institute, 76201 Bucharest, Romania*
- DAVID L. MORRIS (32), *Ames Research and Development Laboratories, Miles Laboratories, Inc., Elkhart, Indiana 46515*
- JAMES E. MOSIMANN (4), *Laboratory of Statistical and Mathematical Methodology, Division of Computer Research and Technology, National Institutes of Health, Bethesda, Maryland 20205*
- ROLF MÜLLER (43), *Tumor Virology Laboratory, Salk Institute, San Diego, California 92138*
- PETER J. MUNSON (41), *Endocrinology and Reproduction Research Branch, National Institutes of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland 20205*
- J. M. NICKERSON (42), *Laboratory of Molecular Genetics, National Institutes of Health, Bethesda, Maryland 20205*
- J. C. NICOLAS (27), *INSERM Unité 58, Montpellier 34100, France*
- D. F. NICOLI (36), *Department of Physics, University of California, Santa Barbara, California 93106*
- KATHLEEN O'DAY (19), *School of Veterinary Medicine, Oregon State University, Corvallis, Oregon 97331*
- LENNART OLSSON (1), *Department of Medicine A, State University Hospital, Copenhagen 2100, Denmark*
- PETER PARHAM (9), *Department of Structural Biology, Stanford University School of Medicine, Stanford, California 94305*
- TERRY W. PEARSON (16), *Department of Biochemistry and Microbiology, University of Victoria, Victoria, British Columbia V8W 2Y2, Canada*
- JOSE M. PERALTA (29, 30), *Instituto de Microbiologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro 21491, Brasil*
- A. J. PICK (28), *Ames-Yissum Product Research and Development Laboratories, Jerusalem, Israel*
- M. A. PIZZOLATO (17), *Department of Clinical Chemistry, Faculty of Biochemistry, University of Buenos Aires, Buenos Aires 1113, Argentina*
- MAKARAND V. RATNAPARKHI (4), *Department of Mathematics and Statistics, Wright State University, Dayton, Ohio 45435*
- D. G. RITCHIE (42), *Department of Human Biological Chemistry and Genetics, Division of Cell Biology, The University of Texas Medical Branch, Galveston, Texas 77550*
- THOMAS J. ROGERS (19), *Department of Microbiology and Immunology, Temple University School of Medicine, Philadelphia, Pennsylvania 19104*
- N. G. SEIDAH (23), *Protein and Pituitary Hormone Laboratory, Clinical Research Institute of Montreal, Montreal H2W 1R7, Canada*
- ETHAN M. SHEVACH (7), *Laboratory of Immunology, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland 20205*
- A. RAY SIMONS (29), *Laboratory Training and Consultation Division, Centers for Disease Control, Atlanta, Georgia 30333*
- REUBEN P. SIRAGANIAN (2), *Clinical Immunology Section, Laboratory of Microbiology and Immunology, National Institute of Dental Research, National Institutes of Health, Bethesda, Maryland 20205*
- IRVING L. SPAR (22), *Department of Radiation Biology and Biophysics, University of Rochester, Rochester, New York 14627*
- TIMOTHY A. SPRINGER (11), *Laboratory of Membrane Immunochemistry, Sidney Farber Cancer Institute, Boston, Massachusetts 02115*

- TH. STAEHELIN (3, 20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- C. STÄHLI (3, 20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- KATHRYN C. STALLCUP (8), *Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115*
- J. STOCKER (20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- CATHLEEN P. SULLIVAN (8), *Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115*
- B. TAKÁCS (20), *Research Department, F. Hoffmann-La Roche and Co., Ltd., CH-4200 Basel, Switzerland*
- Y. TAMIR (28), *Ames-Yissum Product Research and Development Laboratories, Jerusalem, Israel*
- B. TEROUANNE (27), *INSERM Unité 58, Montpellier 34100, France*
- VICTOR C. W. TSANG (29, 30), *Helminthic Diseases Branch, Division of Parasitic Diseases, Centers for Disease Control, Atlanta, Georgia 30333*
- AMAR S. TUNG (6), *Department of Immunology, Merck Sharp and Dohme Research Laboratories, Rahway, New Jersey 07065*
- AARON P. TURKEWITZ (8), *Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115*
- D. B. WAGNER (28), *Becton Dickinson Research Center, Research Triangle Park, North Carolina 27709*
- JON WANNLUND (33), *Analytical Luminescence Laboratory, San Diego, California 92121*
- KENNETH R. WEHMEYER (34), *Department of Chemistry, University of Cincinnati, Cincinnati, Ohio 45221*
- O. WEISS (28), *Ames-Yissum Product Research and Development Laboratories, Jerusalem, Israel*
- BRITT C. WILSON (30), *2238 Lyle Road, College Park, Georgia 30337*
- LEON WOFSY (37), *Department of Microbiology and Immunology, University of California, Berkeley, California 94720*
- STEPHEN E. ZWEIG (7), *Department of Pharmacology, Baylor University College of Medicine, Houston, Texas 77030*

Preface

Several papers in this volume deal with advances in hybridoma technology and complement the chapter by Galfrè and Milstein that appeared in Volume 73 of this series. Methods to enhance the efficiency of producing desired fusion products, to simplify the basic procedures involved, and to assess the specificity and other properties of monoclonal antibodies are discussed. Representative examples illustrate how a battery of monoclonal antibodies with different specificities can be used to study various immunochemical and biochemical problems. Other chapters cover additional procedures that can be used to label antigens and antibodies, separate antigen-antibody complexes, and process data. Some papers classified under one heading or contained in another volume of the series include methods that can be applied in other specific areas. For example, cytotoxicity tests described in Volume 93 may be used to screen supernatant fluids in hybridoma experiments if cytotoxic activity is a desirable property of the monoclonal antibody.

The contents of these volumes continue to reflect our intention of presenting useful methods as they are developed. Thus, several section headings may be similar to those in other Immunochemical Techniques volumes. We believe that such a system makes it easier to follow recent advances. It can be particularly advantageous to investigators whose major interests may lie outside the realm of immunology but who realize that answers to their scientific problems can often be obtained by the judicious use of innovative immunochemical techniques.

Again we thank the contributors whose consistently fine efforts make these volumes possible; Carla Langone for managing the correspondence; and Nathan Kaplan, Sidney Colowick, and our colleagues at Academic Press for their continued enthusiastic support and invaluable assistance.

JOHN J. LANGONE
HELEN VAN VUNAKIS

METHODS IN ENZYMOLOGY

EDITED BY

Sidney P. Colowick and Nathan O. Kaplan

VANDERBILT UNIVERSITY
SCHOOL OF MEDICINE
NASHVILLE, TENNESSEE

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
AT SAN DIEGO
LA JOLLA, CALIFORNIA

- I. Preparation and Assay of Enzymes
- II. Preparation and Assay of Enzymes
- III. Preparation and Assay of Substrates
- IV. Special Techniques for the Enzymologist
- V. Preparation and Assay of Enzymes
- VI. Preparation and Assay of Enzymes (*Continued*)
Preparation and Assay of Substrates
Special Techniques
- VII. Cumulative Subject Index

METHODS IN ENZYMOLOGY

EDITORS-IN-CHIEF

Sidney P. Colowick Nathan O. Kaplan

VOLUME VIII. Complex Carbohydrates

Edited by ELIZABETH F. NEUFELD AND VICTOR GINSBURG

VOLUME IX. Carbohydrate Metabolism

Edited by WILLIS A. WOOD

VOLUME X. Oxidation and Phosphorylation

Edited by RONALD W. ESTABROOK AND MAYNARD E. PULLMAN

VOLUME XI. Enzyme Structure

Edited by C. H. W. HIRS

VOLUME XII. Nucleic Acids (Parts A and B)

Edited by LAWRENCE GROSSMAN AND KIVIE MOLDAVE

VOLUME XIII. Citric Acid Cycle

Edited by J. M. LOWENSTEIN

VOLUME XIV. Lipids

Edited by J. M. LOWENSTEIN

VOLUME XV. Steroids and Terpenoids

Edited by RAYMOND B. CLAYTON

VOLUME XVI. Fast Reactions

Edited by KENNETH KUSTIN

VOLUME XVII. Metabolism of Amino Acids and Amines (Parts A and B)

Edited by HERBERT TABOR AND CELIA WHITE TABOR

VOLUME XVIII. Vitamins and Coenzymes (Parts A, B, and C)

Edited by DONALD B. MCCORMICK AND LEMUEL D. WRIGHT

VOLUME XIX. Proteolytic Enzymes

Edited by GERTRUDE E. PERLMANN AND LASZLO LORAND

VOLUME XX. Nucleic Acids and Protein Synthesis (Part C)*Edited by KIVIE MOLDAVE AND LAWRENCE GROSSMAN***VOLUME XXI. Nucleic Acids (Part D)***Edited by LAWRENCE GROSSMAN AND KIVIE MOLDAVE***VOLUME XXII. Enzyme Purification and Related Techniques***Edited by WILLIAM B. JAKOBY***VOLUME XXIII. Photosynthesis (Part A)***Edited by ANTHONY SAN PIETRO***VOLUME XXIV. Photosynthesis and Nitrogen Fixation (Part B)***Edited by ANTHONY SAN PIETRO***VOLUME XXV. Enzyme Structure (Part B)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF***VOLUME XXVI. Enzyme Structure (Part C)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF***VOLUME XXVII. Enzyme Structure (Part D)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF***VOLUME XXVIII. Complex Carbohydrates (Part B)***Edited by VICTOR GINSBURG***VOLUME XXIX. Nucleic Acids and Protein Synthesis (Part E)***Edited by LAWRENCE GROSSMAN AND KIVIE MOLDAVE***VOLUME XXX. Nucleic Acids and Protein Synthesis (Part F)***Edited by KIVIE MOLDAVE AND LAWRENCE GROSSMAN***VOLUME XXXI. Biomembranes (Part A)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME XXXII. Biomembranes (Part B)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME XXXIII. Cumulative Subject Index Volumes I-XXX***Edited by MARTHA G. DENNIS AND EDWARD A. DENNIS*

VOLUME XXXIV. Affinity Techniques (Enzyme Purification: Part B)*Edited by WILLIAM B. JAKOBY AND MEIR WILCHEK***VOLUME XXXV. Lipids (Part B)***Edited by JOHN M. LOWENSTEIN***VOLUME XXXVI. Hormone Action (Part A: Steroid Hormones)***Edited by BERT W. O'MALLEY AND JOEL G. HARDMAN***VOLUME XXXVII. Hormone Action (Part B: Peptide Hormones)***Edited by BERT W. O'MALLEY AND JOEL G. HARDMAN***VOLUME XXXVIII. Hormone Action (Part C: Cyclic Nucleotides)***Edited by JOEL G. HARDMAN AND BERT W. O'MALLEY***VOLUME XXXIX. Hormone Action (Part D: Isolated Cells, Tissues, and Organ Systems)***Edited by JOEL G. HARDMAN AND BERT W. O'MALLEY***VOLUME XL. Hormone Action (Part E: Nuclear Structure and Function)***Edited by BERT W. O'MALLEY AND JOEL G. HARDMAN***VOLUME XLI. Carbohydrate Metabolism (Part B)***Edited by W. A. WOOD***VOLUME XLII. Carbohydrate Metabolism (Part C)***Edited by W. A. WOOD***VOLUME XLIII. Antibiotics***Edited by JOHN H. HASH***VOLUME XLIV. Immobilized Enzymes***Edited by KLAUS MOSBACH***VOLUME XLV. Proteolytic Enzymes (Part B)***Edited by LASZLO LORAND***VOLUME XLVI. Affinity Labeling***Edited by WILLIAM B. JAKOBY AND MEIR WILCHEK***VOLUME XLVII. Enzyme Structure (Part E)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF*

VOLUME XLVIII. Enzyme Structure (Part F)*Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF***VOLUME XLIX. Enzyme Structure (Part G)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF***VOLUME L. Complex Carbohydrates (Part C)***Edited by VICTOR GINSBURG***VOLUME LI. Purine and Pyrimidine Nucleotide Metabolism***Edited by PATRICIA A. HOFFEE AND MARY ELLEN JONES***VOLUME LII. Biomembranes (Part C: Biological Oxidations)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME LIII. Biomembranes (Part D: Biological Oxidations)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME LIV. Biomembranes (Part E: Biological Oxidations)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME LV. Biomembranes (Part F: Bioenergetics)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME LVI. Biomembranes (Part G: Bioenergetics)***Edited by SIDNEY FLEISCHER AND LESTER PACKER***VOLUME LVII. Bioluminescence and Chemiluminescence***Edited by MARLENE A. DeLUCA***VOLUME LVIII. Cell Culture***Edited by WILLIAM B. JAKOBY AND IRA H. PASTAN***VOLUME LIX. Nucleic Acids and Protein Synthesis (Part G)***Edited by KIVIE MOLDAVE AND LAWRENCE GROSSMAN***VOLUME LX. Nucleic Acids and Protein Synthesis (Part H)***Edited by KIVIE MOLDAVE AND LAWRENCE GROSSMAN***VOLUME 61. Enzyme Structure (Part H)***Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF*

VOLUME 62. Vitamins and Coenzymes (Part D)*Edited by* DONALD B. MCCORMICK AND LEMUEL D. WRIGHT**VOLUME 63. Enzyme Kinetics and Mechanism (Part A: Initial Rate and Inhibitor Methods)***Edited by* DANIEL L. PURICH**VOLUME 64. Enzyme Kinetics and Mechanism (Part B: Isotopic Probes and Complex Enzyme Systems)***Edited by* DANIEL L. PURICH**VOLUME 65. Nucleic Acids (Part I)***Edited by* LAWRENCE GROSSMAN AND KIVIE MOLDAVE**VOLUME 66. Vitamins and Coenzymes (Part E)***Edited by* DONALD B. MCCORMICK AND LEMUEL D. WRIGHT**VOLUME 67. Vitamins and Coenzymes (Part F)***Edited by* DONALD B. MCCORMICK AND LEMUEL D. WRIGHT**VOLUME 68. Recombinant DNA***Edited by* RAY WU**VOLUME 69. Photosynthesis and Nitrogen Fixation (Part C)***Edited by* ANTHONY SAN PIETRO**VOLUME 70. Immunochemical Techniques (Part A)***Edited by* HELEN VAN VUNAKIS AND JOHN J. LANGONE**VOLUME 71. Lipids (Part C)***Edited by* JOHN M. LOWENSTEIN**VOLUME 72. Lipids (Part D)***Edited by* JOHN M. LOWENSTEIN**VOLUME 73. Immunochemical Techniques (Part B)***Edited by* JOHN J. LANGONE AND HELEN VAN VUNAKIS**VOLUME 74. Immunochemical Techniques (Part C)***Edited by* JOHN J. LANGONE AND HELEN VAN VUNAKIS

VOLUME 75. Cumulative Subject Index Volumes XXXI, XXXII, and XXXLV-LX

Edited by EDWARD A. DENNIS AND MARTHA G. DENNIS

VOLUME 76. Hemoglobins

Edited by ERALDO ANTONINI, LUIGI ROSSI-BERNARDI, AND EMILIA CHIANCONE

VOLUME 77. Detoxication and Drug Metabolism

Edited by WILLIAM B. JAKOBY

VOLUME 78. Interferons (Part A)

Edited by SIDNEY PESTKA

VOLUME 79. Interferons (Part B)

Edited by SIDNEY PESTKA

VOLUME 80. Proteolytic Enzymes (Part C)

Edited by LASZLO LORAND

VOLUME 81. Biomembranes (Part H: Visual Pigments and Purple Membranes, I)

Edited by LESTER PACKER

VOLUME 82. Structural and Contractile Proteins (Part A: Extracellular Matrix)

Edited by LEON W. CUNNINGHAM AND DIXIE W. FREDERIKSEN

VOLUME 83. Complex Carbohydrates (Part D)

Edited by VICTOR GINSBURG

VOLUME 84. Immunochemical Techniques (Part D: Selected Immunoassays)

Edited by JOHN J. LANGONE AND HELEN VAN VUNAKIS

VOLUME 85. Structural and Contractile Proteins (Part B: The Contractile Apparatus and the Cytoskeleton)

Edited by DIXIE W. FREDERIKSEN AND LEON W. CUNNINGHAM

VOLUME 86. Prostaglandins and Arachidonate Metabolites

Edited by WILLIAM E. M. LANDS AND WILLIAM L. SMITH

VOLUME 87. Enzyme Kinetics and Mechanism (Part C: Intermediates, Stereochemistry, and Rate Studies)

Edited by DANIEL L. PURICH

VOLUME 88. Biomembranes (Part I: Visual Pigments and Purple Membranes, II)

Edited by LESTER PACKER

VOLUME 89. Carbohydrate Metabolism (Part D)

Edited by WILLIS A. WOOD

VOLUME 90. Carbohydrate Metabolism (Part E)

Edited by Willis A. Wood

VOLUME 91. Enzyme Structure (Part I)

Edited by C. H. W. HIRS AND SERGE N. TIMASHEFF

VOLUME 92. Immunochemical Techniques (Part E: Monoclonal Antibodies and General Immunoassay Methods)

Edited by JOHN J. LANGONE AND HELEN VAN VUNAKIS

VOLUME 93. Immunochemical Techniques (Part F: Conventional Antibodies, Fc Receptors, and Cytotoxicity) (in preparation)

Edited by JOHN J. LANGONE AND HELEN VAN VUNAKIS

VOLUME 94. Polyamines (in preparation)

Edited by HERBERT TABOR AND CELIA WHITE TABOR

VOLUME 95. Cumulative Subject Index Volumes 61–74 and 76–80 (in preparation)

Edited by EDWARD A. DENNIS AND MARTHA G. DENNIS

VOLUME 96. Biomembranes (Part J: Membrane Biogenesis: Assembly and Targeting (General Methods; Eukaryotes)) (in preparation)

Edited by SIDNEY FLEISCHER AND BECCA FLEISCHER

VOLUME 97. Biomembranes (Part K: Membrane Biogenesis: Assembly and Targeting (Prokaryotes, Mitochondria, and Chloroplasts)) (in preparation)

Edited by SIDNEY FLEISCHER AND BECCA FLEISCHER

VOLUME 98. Biomembranes (Part L: Membrane Biogenesis (Processing and Recycling)) (in preparation)

Edited by **SIDNEY FLEISCHER AND BECCA FLEISCHER**

VOLUME 99. Hormone Action (Part F: Protein Kinases) (in preparation)

Edited by **JACKIE D. CORBIN AND JOEL G. HARDMAN**

VOLUME 100. Recombinant DNA (Part B) (in preparation)

Edited by **RAY WU, LAWRENCE GROSSMAN, AND KIVIE MOLDAVE**

VOLUME 101. Recombinant DNA (Part C) (in preparation)

Edited by **RAY WU, LAWRENCE GROSSMAN, AND KIVIE MOLDAVE**

VOLUME 102. Hormone Action (Part G: Calmodulin and Calcium-Binding Proteins) (in preparation)

Edited by **ANTHONY R. MEANS AND BERT W. O'MALLEY**