Methods in Enzymology Volume 150

Immunochemical.Techniques

Part K
In Vitro Models of B and T Cell Functions and
Lymphoid Cell Receptors

EDITED BY

Giovanni Di Sabato

Methods in Enzymology

Volume 150

Immunochemical Techniques

Part K

In Vitro Models of B and T Cell Functions and Lymphoid Cell Receptors

EDITED BY

Giovanni Di Sabato

DEPARTMENT OF MOLECULAR BIOLOGY VANDERBILT UNIVERSITY NASHVILLE, TENNESSEE



ACADEMIC PRESS, INC.

Harcourt Brace Jovanovich, Publishers

San Diego New York Berkeley Boston London Sydney Tokyo Toronto COPYRIGHT © 1987 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. 1250 Sixth Avenue, San Diego, California 92101

United Kingdom Edition published by ACADEMIC PRESS INC. (LONDON) LTD. 24-28 Oval Road, London NW1 7DX

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 54-9110

ISBN 0-12-182051-3 (alk. paper)

PRINTED IN THE UNITED STATES OF AMERICA

87 88 89 90 9 8 7 6 5 4 3 2 1

Contributors to Volume 150

Article numbers are in parentheses following the names of contributors.

Affiliations listed are current.

- CLAUDIO ANASETTI (43), Division of Clinical Research, Fred Hutchinson Cancer Research Center, Seattle, Washington 98104
- CLARK L. ANDERSON (42), Department of Internal Medicine, The Ohio State University College of Medicine, Columbus, Ohio 43210
- M. AMIN ARNAOUT (48), Harvard Medical School and The Children's Hospital, Boston, Massachusetts 02115
- STRATIS AVRAMEAS (9), Unité d'Immunocytochimie, Département d'Immunologie, Institut Pasteur, 75724 Paris Cedex 15, France
- JACK R. BATTISTO (4), Department of Immunology and Cancer, The Research Institute, Cleveland Clinic Foundation, Cleveland, Ohio 44106
- MASATOSHI BEPPU (2), Tokyo College of Pnarmacy, 1432-1 Horinouchi, Hachioji, Tokyo 192-03, Japan
- JOCELYNE BOGHOSSIAN (11), Clayton Foundation Biochemical Institute, Austin, Texas 78712-1096
- MICHAEL BOOKMAN (29), Biological Response Modifiers Program, National Cancer Institute, National Institutes of Health, Bethesda, Maryland 20892
- WILIAM E. BOWERS (6), The Medical Research Institute, The Mary Imagene Bassett Hospital, Cooperstown, New York 13326
- MARCUS BRAUN (43), Department of Medicine, Oregon State University Hospital, Portland, Oregon 97201
- DOUGLAS R. CAVENER (55), Department of Molecular Biology, Vanderbilt University, Nashville, Tennessee 37235

- JULIO E. CELIS (12), Department of Medical Biochemistry, Aarhus University, DK-8000 Aarhus C. Denmark
- NICHOLAS CHIORAZZI (5), Cornell University Medical College, and Division of Rheumatology and Clinical Immunology, North Shore University Hospital, Manhasset, New York 11030
- RICHARD B. CLARK (39), Graduate School of Biomedical Sciences, University of Texas Health Science Center at Houston, Houston, Texas 77025
- LINDA K. CLAYTON (48), Harvard Medical School and Dana-Farber Cancer Institute, Boston, Massachusetts 02115
- MELVIN COHN (10), Developmental Biology Laboratory, The Salk Institute for Biological Studies, La Jolla, California 92037
- ROBERT E. CONE (33, 51), Department of Pathology, University of Connecticut Health Center, Farmington, Connecticut 06032
- DANIEL H. CONRAD (40), Subdepartment of Immunology, The Johns Hopkins University School of Medicine, Baltimore, Maryland 21205
- Neil R. Cooper (44), Department of Immunology, Scripps Clinic and Research Foundation, La Jolla, California 92037
- CYRIL C. CURTAIN (35), Division of Biotechnology, CSIRO, Clayton, Victoria 3168, Australia
- NAVA DANA (48), Harvard Medical School and The Children's Hospital, Boston, Massachusetts 02115
- GIOVANNI DI SABATO (1), Department of Molecular Biology, Vanderbilt University, Nashville, Tennessee 37235

- HANS-MICHAEL DOSCH (17), Department of Paediatrics, Division of Immunology/ Rheumatology, The Hospital For Sick Children, Toronto, Ontario, Canada M5G 1X8
- MEHER M. DUSTOOR (4), Department of Artificial Organs, The Research Institute, Cleveland Clinic Foundation. Cleveland, Ohio 44106
- C. GARRISON FATHMAN (24, 27, 28), Department of Medicine, Division of Immunology, Stanford University Medical Center, Stanford, California 94305
- DOUGLAS T. FEARON (46), Department of Medicine, Division of Molecular and Clinical Rheumatology, The Johns Hopkins University School of Medicine, Baltimore, Maryland 21205
- Ross D. Feldman (39), Department of Internal Medicine and Pharmacology, University of Iowa College of Medicine, Ames. Iowa 52242
- BARBARA G. FROSCHER (14), Department of Immunology, Scripps Clinic and Research Foundation, La Jolla, California 92037
- ROBERT M. GALBRAITH (32), Department of Basic and Clinical Immunology and Microbiology, Medical University of South Carolina, Charleston, South Carolina 29425
- RAIF S. GEHA (25), Division of Immunology, Children's Hospital, Boston, Massachusetts 02115
- ERWIN W. GELFAND (17), National Jewish Center for Immunology and Respiratory Medicine, Denver, Colorado 80206
- MERRIL J. GERSTEN (10), Developmental Biology Laboratory, The Salk Institute for Biological Studies, La Jolla, California 92037
- BERHANE GHEBREHIWET (45), Department of Medicine, State University of New York, Stony Brook, New York 11794-8161
- ROLAND H. GISLER (19), Basel Institute for Immunology, CH-4005 Basel, Switzerland

- IRVING GOLDSCHNEIDER (31), Department of Pathology, School of Medicine, University of Connecticut Health Center, Farmington, Connecticut 06032
- PHILLIP GORDEN (53), National Institute of Diabetes, and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland 20892
- LARRY M. GORDON (35), Biochemical Division, Rees-Stealy Research Foundation, San Diego, California 92101
- JORG GORONZY (28), Department of Medicine, Division of Immunology, Stanford University Medical Center, Stanford, California 94305
- WARNER C. GREENE (52), Howard Hughes Medical Institute, Department of Internal Medicine, Duke University School of Medicine, Durham, North Carolina 27710
- GEORGE GRUNBERGER (53), Diabetes Program, Wayne State School of Medicine, Detroit. Michigan 48201
- Janice M. Hall (1), Department of Molecular Biology, Vanderbilt University, Nashville, Tennessee 37235
- JOHN A. HANSEN (43), Histocompatibility Laboratory, Puget Sound Blood Center, and Fred Hutchinson Cancer Research Center, Department of Medicine, University of Washington, Seattle, Washington 98104
- Jose A. Hedo (53), Departmento de Metabolismo, Nutrición y Hormonas, Fiundación Jimenez Diaz, 2 Madrid 28040, Spain
- GEOFFREY J. HOWLETT (36), Russell Grimwade School of Biochemistry, University of Melbourne, Parkville, Victoria 3052, Australia
- R. HUEY (49), Teacher Education Program, University of California—San Diego, La Jolla, California 92093
- T. E. HUGLI (49), Department of Immunology, Scripps Clinic and Research Foundation, La Jolla, California 92037
- Toshiki Ishihara (24), Division of Immunology, Department of Medicine, Stanford University Medical Center, Stanford, California 94305

- JUDITH P. JOHNSON (30), Institute for Immunology, University of Munich, D-8000 Munich 2, Federal Republic of Germany
- GARNETT KELSOE (23), Department of Microbiology, University of Texas Medical Branch, Galveston, Texas 77550
- H. KIRCHNER (8), Institute of Virus Research, German Cancer Research Center, 6900 Heidelberg, Federal Republic of Germany
- DAGMAR KLEIN (13), Abteilung Immungenetik, Max-Planck-Institut für Biologie, 7400 Tübingen, Federal Republic of Germany
- JAN KLEIN (13), Abteilung Immungenetik, Max-Planck-Institut für Biologie, 7400 Tübingen, Federal Republic of Germany
- NORMAN R. KLINMAN (14), Department of Immunology, Research Institute of Scripps Clinic, La Jolla, California 92037
- WILLIAM T. LEE (40), Department of Microbiology, University of Texas Health Science Center, Dallas, Texas 75235
- IVAN LEFKOVITS (15, 18), Basel Institute for Immunology, CH-4005 Basel, Switzerland
- WARREN J. LEONARD (52), Cell Biology and Metabolism Branch, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland 20892
- MAXINE A. LESNIAK (53), Diabetes Branch, National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland 20892
- ALEXANDRA LIVINGSTONE (27), Department of Medicine, Division of Immunology, Stanford University Medical Center, Stanford, California 94305
- FRANK D. LOONEY (35), Division of Biotechnology, CSIRO, Clayton, Victoria 3168, Australia
- R. JOHN LOONEY (42), Department of Medicine, University of Rochester Medical Center, Rochester, New York 14642
- JOHN J. MARCHALONIS (32, 34, 37, 50), Department of Biochemistry and Molecular Biology, Medical University of South

- Carolina, Charleston, South Carolina 29425
- Bernice Marcus-Samuels (53), Diabetes Branch, National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland 20892
- PAUL J. MARTIN (43), Department of Medicine, University of Washington, Seattle, Washington 98104
- LOUIS A. MATIS (29), Molecular Immunology Laboratory, Division of Biochemistry and Biophysics, Center for Drugs and Biologics, Food and Drug Administration, Bethesda, Maryland 20892
- KATHLEEN SHIVE MATTHEWS (11), Department of Biochemistry, Rice University, Houston, Texas 77251
- EUGENE S. MEDLOCK (31), Department of Exploratory Research, AMGEN Corporation, Thousand Oaks, California 91320
- FRITZ MELCHERS (16), Basel Institute for Immunology, CH-4058 Basel, Switzerland
- C. D. Myers (26), Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas, Texas 75235
- BARRY L. MYONES (47), Division of Rheumatology/Immunology, Departments of Medicine and Pediatrics, University of North Carolina, Chapel Hill, North Carolina 27514
- GLEN R. NEMEROW (44), Scripps Clinic and Research Foundation, Department of Immunology, La Jolla, California 92037
- ROLAND A. NEWMAN (54), Cancer Center, University of California—San Diego, La Jolla, California 92093
- KENJI OGATA (12), Scripps Clinic and Research Foundation, La Jolla, California 92037
- K. G. OLIVER (26), Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas, Texas 75235
- TOSHIAKI OSAWA (2), Division of Chemical Toxicology and Immunochemistry, Faculty of Pharmaceutical Sciences, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan

- CHRISTOPHER J. PAIGE (19, 20), Basel Institute for Immunology, CH-4005 Basel, Switzerland
- CHARLES W. PARKER (3, 41), Division of Allergy and Immunology, Department of Medicine, Howard Hughes Medical Institute at Washington University School of Medicine, St. Louis, Missouri 63110
- FLORA PETTIT (11), Clayton Foundaton Biochemical Institute, Austin, Texas 78712-1096
- MARK W. PIERCE (48), Harvard Medical School, Massachusetts General Hospital, and The Howard Hughes Institute, Boston, Massachusetts 02114
- BEVERLEY L. PIKE (21), The Walter and Eliza Hall Institute of Medical Research, Royal Melbourne Hospital, Victoria 3050, Australia
- THOMAS PORTSMANN (9), Institute of Medical Immunology, Faculty of Medicine (Charité), Humbold University of Berlin, 1040 Berlin, German Democratic Republic
- ABBAS RASHIDBAIGI (39), Department of Molecular Genetics and Microbiology, University of Medicine and Dentistry of New Jersey, Piscataway, New Jersey 08854
- STEVEN A. ROSENBERG (29), Surgical Oncology Branch, National Cancer Institute, National Institutes of Health, Bethesda, Maryland 20892
- GORDON D. Ross (47), Division of Rheumatology/Immunology, Departments of Medicine and Microbiology/Immunology, University of North Carolina, Chapel Hill, North Carolina 27514
- JESSE ROTH (53), National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland 20892
- ARNOLD E. RUOHO (39), Department of Pharmacology, University of Wisconsin Medical School, Madison, Wisconsin 53706

- MARGARITA SALAS (8), Department of Biochemistry, School of Medicine, Avenida de Madrid, 18012 Granada, Spain
- V. M. SANDERS (26), Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas, Texas 75235
- HELMUT SAUTER (20), Basel Institute for Immunology, CH-4005 Basel, Switzerland
- SAMUEL F. SCHLUTER (50), Department of Biochemistry and Molecular Biology, Medical University of South Carolina, Charleston, South Carolina 29425
- DAVID M. SEGAL (38), Immunology Branch, National Cancer Institute, National Institutes of Health, Bethesda, Maryland 20892
- WILLIAM SHIVE (11), Department of Chemistry and Clayton Foundation Biochemical Institute, The University of Texas at Austin, Austin, Texas 78712-1096
- James V. Staros (40), Department of Biochemistry, Vanderbilt University, School of Medicine, Nashville, Tennessee 37232
- DAVID A. STEPHANY (38), Biological Research Branch, National Institute of Allergy and Infectious Disease, Bethesda, Maryland 20892
- ENG M. TAN (12), Scripps Clinic and Research Foundation, La Jolla, California 92037
- THÉRÈSE TERNYNCK (9), Unité d'Immunocytochimie, Département d'Immunologie, Institut Pasteur, 75724 Paris Cedex 15, France
- LUANN THOMPSON (1), Department of Molecular Biology, Vanderbilt University, Nashville, Tennessee 37235
- JULIE A. TITUS (38), Immunology Branch, National Cancer Institute, National Institutes of Health, Bethesda, Maryland 20892
- J. W. UHR (26), Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas, Texas 75235
- DALE T. UMETSU (25), Division of Immu-

- nology, Children's Hospital, Boston, Massachusetts 02115
- THOMAS L. VISCHER (7), Division of Rheumatology, Department of Medicine, University Hospital, CH-1211 Geneva, Switzerland
- E. S. VITETTA (26), Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas, Texas 75235
- GREGORY W. WARR (34), Department of Biochemistry and Molecular Biology, Medical University of South Carolina, Charleston, South Carolina 29425
- CORNELIA WEYAND (28), Department of Medicine, Division of Immunology, Stanford University Medical Center, Stanford, California 94305

- C. A. WHITLOCK (22), Department of Pathology, Stanford University, Stanford, California 94305
- O. N. WITTE (22), Molecular Biology Institute, University of California, Los Angeles, California 90024
- WINNIE W. WONG (46), Department of Rheumatology and Immunology, Brigham & Women's Hospital, and Department of Rheumatology and Immunology, Harvard Medical School, Boston, Massachusetts 02115
- GILLIAN E. WU (20), Basel Institute for Immunology, CH-4005 Basel, Switzerland
- E. YEFENOF (26), Department of Immunology, Hadassah Medical School, Jerusalem 91010, Israel

Preface

This is the last of a set of volumes in the Immunochemical Techniques series of *Methods in Enzymology* dealing with methods for the study of the biology of lymphoid cells. The other two volumes (108 and 116) dealt with the separation and characterization of lymphoid cells and with the effectors and mediators of lymphoid cell functions, respectively. In this volume *in vitro* models for the study of lymphoid cell functions and methods for the study of lymphoid cell receptors are presented.

The area of lymphocyte in vitro transformation has received considerable attention in recent years. This subject is discussed in the first section that describes methods for the in vitro stimulation of lymphocytes. Some special media for the study of lymphocyte transformation are also discussed.

In vitro methods have been very useful for the understanding of the differentiation of lymphoid cells. The more commonly used of these methods are presented in the second section.

Finally, the third section deals with the receptors of lymphoid cells. This area of immunology has developed dramatically recently. It would have been difficult to include the methods for the study of all the known receptors of lymphoid cells. Thus, only those receptors that are characteristic of these cells and/or are specifically involved in some functions of lymphoid cells have been discussed.

I acknowledge the help and advice of the late Drs. Sidney Colowick and Nathan Kaplan in the organization and preparation of this volume of Immunochemical Techniques.

GIOVANNI DI SABATO

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 and 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 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 Lemue 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, XXXIV-LX

Edited by EDWARD A. DENNIS AND MARTHA G. DENNIS

VOLUME 76. Hemoglobins

Edited by Eraldo Antonini, Luigi adssi-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

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)

Edited by John J. Langone and Helen Van Vunakis

VOLUME 94. Polyamines

Edited by Herbert Tabor and Celia White Tabor

VOLUME 95. Cumulative Subject Index Volumes 61-74, 76-80 Edited by EDWARD A. DENNIS AND MARTHA G. DENNIS

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

Edited by Sidney Fleischer and Becca Fleischer