Handbook of Biochemistry and Molecular Biology

3rd Edition

Nucleic Acids – Volume I

Handbook of Biochemistry and Molecular Biology

3rd Edition

Nucleic Acids – Volume I

EDITOR

Gerald D. Fasman, Ph. D.

Rosenfield Professor of Biochemistry
Graduate Department of Biochemistry
Brandeis University
Waltham, Massachusetts

（内部交流）

18901 Cranwood Parkway · Cleveland, Ohio 44128

Library of Congress Cataloging in Publication Data

Main entry under title:

Handbook of Biochemistry and Molecular Biology

Previous editions published under title:
Handbook of Biochemistry
Includes bibliographies and index.
Content: B. Nucleic acids. v. .–C.
Lipids, carbohydrates, steroids.
1. Biological chemistry. 2. Molecular biology.
I. Fasman, Gerald D. II. Sober, Herbert Alexander,
1918- [DNLM: 1. Nucleic acids – Tables. QU16
H234]
OT514.2.H34 1975 574.1*92 75-29514

International Standard Book Number (ISBN)

Complete Set 0-87819-503-3
Nucleic Acids, Volume I 0-87819-506-8

Library of Congress Card No. 75-29514

Handbook of Biochemistry and Molecular Biology

3rd Edition

Nucleic Acids
Volume I

Editor
Gerald D. Fasman, Ph. D.
Rosenfield Professor of Biochemistry
Graduate Department of Biochemistry
Brandeis University
Waltham, Massachusetts

The following is a list of the four major sections of the *Handbook*, each consisting of one or more volumes

Proteins – Amino Acids, Peptides, Polypeptides, and Proteins

Nucleic, Acids – Purines, Pyrimidines, Nucleotides, Oligonucleotides, tRNA, DNA, RNA

Lipids, Carbohydrates, Steroids

Physical and Chemical Data, Miscellaneous – Ion Exchange, Chromatography, Buffers, Miscellaneous, e.g., Vitamins

ADVISORY BOARD

ADVISORY BOARD (continued)

ADVISORY BOARD (continued)

CONTRIBUTORS

James L. Alderfer
Research Associate
Department of Biochemical and Biophysical Sciences
School of Hygiene and Public Health
The Johns Hopkins University
Baltimore, Maryland 21205

Robert M. Bock
Departments of Biochemistry and Molecular Biology
The University of Wisconsin
Madison, Wisconsin 53706

Philip N. Borer
Department of Chemistry
University of California
Irvine, California 92664

Girish B. Chheda
Principal Cancer Research Scientist
General Clinical Research Center
Roswell Park Memorial Institute
Buffalo, New York 14203

Waldo E. Cohn
Senior Biochemist, Biology Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Alex F. Drake
Department of Chemistry
King's College
University of London
London
England

David B. Dunn
Department of Virus Research
John Innes Institute
Colney Lane
Norwich
England

Ross H. Hall
Department of Biochemistry
McMaster University
Hamilton, Ontario
Canada

Lorne A. MacHattie
Department of Medical Genetics
University of Toronto
Toronto, Ontario
Canada

Manley Mandel
M.D. Anderson Hospital and Tumor Institute
Texas Medical Center
The University of Texas
Houston, Texas 77025

H. Todd Miles
Laboratory of Molecular Biology
National Institute of Arthritis and Metabolism, and Digestive Diseases
National Institutes of Health
Bethesda, Maryland 20014

Warner L. Peticolas
Professor, Department of Chemistry
College of Liberal Arts
University of Oregon
Eugene, Oregon 97403

E. G. Richards
Department of Biophysics
School of Biological Sciences
King's College
University of London
London
England

B. Singer
Virus Laboratory
Wendell M. Stanley Hall
University of California
Berkeley, California 94720

Elizabeth H. Szybalski
McArdle Laboratory for Cancer Research
University of Wisconsin
Madison, Wisconsin 53706

Waclaw Szybalski
Professor of Oncology
McArdle Laboratory for Cancer Research
University of Wisconsin
Madison, Wisconsin 53706

CONTRIBUTORS (continued)

Charles A. Thomas, Jr.
Department of Biological Chemistry
Harvard Medical School
Boston, Massachusetts 02115

Jane Nicolet Toal
Laboratory of Physiology
National Cancer Institute
National Institutes of Health
Bethesda, Maryland 20014

Leroy B. Townsend
Associate Professor of Medicinal Chemistry
Department of Biopharmaceutical Sciences
The University of Utah
Salt Lake City, Utah 84112

A. R. Trim
Department of Virus Research
John Innes Institute
Colney Land
Norwich
England

Paul O. P. Ts'o
Department of Biochemical and Biophysical Sciences
School of Hygiene and Public Health
The Johns Hopkins University
Baltimore, Maryland 21205

Myron M. Warshaw
Department of Chemistry
New York University Graduate School
Washington Square
New York, New York 10003

PREFACE

The rapid pace at which new data is currently accumulated in science presents one of the significant problems of today – the problem of rapid retrieval of information. The fields of biochemistry and molecular biology are two areas in which the information explosion is manifest. Such data is of interest in the disciplines of medicine, modern biology, genetics, immunology, biophysics, etc., to name but a few related areas. It was this need which first prompted CRC Press, with Dr. Herbert A. Sober as Editor, to publish the first two editions of a modern *Handbook of Biochemistry*, which made available unique, in depth compilations of critically evaluated data to graduate students, post-doctoral fellows, and research workers in selected areas of biochemistry.

This third edition of the *Handbook* demonstrates the wealth of new information which has become available since 1970. The title has been changed to include molecular biology; as the fields of biochemistry and molecular biology exist today, it becomes more difficult to differentiate between them. As a result of this philosophy, this edition has been greatly expanded. Also, previous data has been revised and obsolete material has been eliminated. As before, however, all areas of interest have not been covered in this edition. Elementary data, readily available elsewhere, has not been included. We have attempted to stress the areas of today's principal research frontiers and consequently certain areas of important biochemical interest are relatively neglected, but hopefully not totally ignored.

This third edition is over double the size of the second edition. Tables used from the second edition without change are so marked, but their number is small. Most of the tables from the second edition have been extensively revised, and over half of the data is new material. In addition, a far more extensive index has been compiled to facilitate the use of the Handbook. To make more facile use of the Handbook because of the increased size, it has been divided into four sections. Each section will have one or more volumes. The four sections are titled:

Proteins – Amino Acids, Peptides, Polypeptides, and Proteins

Nucleic Acids – Purines, Pyrimidines, Nucleotides, Oligonucleotides, tRNA, DNA, RNA

Lipids, Carbohydrates, Steroids

Physical and Chemical Data, Miscellaneous – Ion Exchange, Chromatography, Buffers, Miscellaneous, e.g., Vitamins

By means of this division of the data, we can continuously update the *Handbook* by publishing new data as they become available.

The Editor wishes to thank the numerous contributors, Dr. Herbert A. Sober, who assisted the Editor generously, and the Advisory Board for their counsel and cooperation. Without their efforts this edition would not have been possible. Special acknowledgments are due to the editorial staff of CRC Press, Inc., particularly Ms. Susan Cubar Benovich, Ms. Sandy Pearlman, and Mrs. Gayle Tavens, for their perspicacity and invaluable assistance in the editing of the manuscript. The editor alone, however, is responsible for the scope and the organization of the tables.

We invite comments and criticisms regarding format and selection of subject matter, as well as specific suggestions for new data (and their sources) which might be included in subsequent editions. We hope that errors and omissions in the data that appear in the Handbook will be brought to the attention of the Editor and the publisher.

Gerald D. Fasman
Editor
August 1975

PREFACE TO NUCLEIC ACIDS, VOLUME 1

The section of the *Handbook of Biochemistry and Molecular Biology* on Nucleic Acids is divided into two volumes. The first volume contains information relating to purines, pyrimidines, nucleosides, nucleotides, oligonucleotides, polynucleotides, and their derivatives. Both ribo and deoxyribo compounds are listed, starting from their respective monomeric units and encompassing all materials up to and including RNA and DNA.

The following list is representative of the data for the above materials contained herein: Physical constants, spectral constants, ultraviolet absorption characteristics, optical properties (optical rotatory and circular dichroism), osmotic coefficients, proton chemical shifts, raman spectral bands, temperature melting profiles, and infrared spectra.

The second volume will contain the remaining material similar to Volume 1 and material more relative to genetic and biological aspects, such as enzymes involved in nucleic acid function, protein synthesis, linkage maps, etc.

Although the data, for which the editor alone is responsible, is far from complete, it is hoped these volumes will be of assistance to those working in the field of biochemistry and molecular biology.

Gerald D. Fasman
Editor
September 1975

THE EDITOR

Gerald D. Fasman, Ph.D., is the Rosenfield Professor of Biochemistry, Graduate Department of Chemistry, Brandeis University, Waltham, Massachusetts.

Dr. Fasman graduated from the University of Alberta in 1948 with a B.S. Honors Degree in Chemistry, and he received his Ph.D. in Organic Chemistry in 1952 from the California Institute of Technology, Pasadena, California. Dr. Fasman did postdoctoral studies at Cambridge University, England, Eidg. Technische Hochschule, Zurich, Switzerland, and the Weizmann Institute of Science, Rehovoth, Israel. Prior to moving to Brandeis University, he spent several years at the Children's Cancer Research Foundation at the Harvard Medical School. He has been an Established Investigator of the American Heart Association, a National Science Foundation Senior Postdoctoral Fellow in Japan, and recently was a John Simon Guggenheim Fellow.

Dr. Fasman is a member of the American Chemical Society, a Fellow of the American Association for the Advancement of Science, Sigma Xi, The Biophysical Society, American Society of Biological Chemists, The Chemical Society (London), the New York Academy of Science, and a Fellow of the American Institute of Chemists. He has published 180 research papers.

TABLE OF CONTENTS

TABLE OF CONTENTS

Nomenclature

BIOCHEMICAL NOMENCLATURE

This synopsis of the recommendations of the IUPAC-IUB Commission on Biochemical Nomenclature (CBN) was prepared by Waldo E. Cohn, Director, NAS-NRC Office of Biochemical Nomenclature (OBN, located at Biology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830), from whom reprints of the CBN publications listed below and on which the synopsis is based are available.

The synopsis is divided into three sections: Abbreviations, symbols, and trivial names. Each section contains material drawn from the documents (A1 to C1, inclusive) listed below, which deal with the subjects named.

Additions consonant with the CBN Recommendations have been made by OBN throughout the synopsis.

RULES AND RECOMMENDATIONS AFFECTING BIOCHEMICAL NOMENCLATURE AND PLACES OF PUBLICATION (AS OF FEBRUARY 1975)

I. IUPAC-IUB Commission on Biochemical Nomenclature
- A1. Abbreviations and Symbols [General; Section 5 replaced by A6]
- A2. Abbreviated Designation of Amino-acid Derivatives and Peptides (1965) [Revised 1971; Expands Section 2 of A1]
- A3. Synthetic Modifications of Natural Peptides (1966) [Revised 1972]
- A4. Synthetic Polypeptides (Polymerized Amino Acids) (1967) [Revised 1971]
- A5. A One-letter Notation for Amino-acid Sequences (1968)
- A6. Nucleic Acids, Polynucleotides, and their Constituents (1970)

- B1. (Nomenclature of Vitamins, Coenzymes, and Related Compounds)
  - a. Miscellaneous [A, B's, C, D's, tocols, niacins; see B2 and B3]
  - b. Quinones with Isoprenoid Side-chains: E, K, Q [Revised 1973]
  - c. Folic Acid and Related Compounds
  - d. Corrinoids: B-12's [Revised 1973]
- B2. Vitamins B-6 and Related Compounds [Revised 1973]
- B3. Tocopherols (1973)

- C1. Nomenclature of Lipids (1967) [Amended 1970; see also II, 2]
- C2. Nomenclature of α-Amino Acids (1974) [See also II, 5]

- D1. Conformation of Polypeptide Chains (1970) [See also III, 2]

- E1. Enzyme Nomenclature (1972)[a] [Elsevier (in paperback); Replaces 1965 edition.]
- E2. Multiple Forms of Enzymes (1971) [Chapter 3 of E1]
- E3. Nomenclature of Iron-sulfur Proteins (1973) [Chapter 6.5 of E1]
- E4. Nomenclature of Peptide Hormones (1974)

II. Documents Jointly Authored by CBN and CNOC [See III]
1. Nomenclature of Cyclitols (1968) [Revised 1973]
2. Nomenclature of Steroids (1968) [Amended 1971; Revised 1972]
3. Nomenclature of Carbohydrates-I (1969)
4. Nomenclature of Carotenoids (1972) [Revised 1975]
5. Nomenclature of α-Amino Acids (1974) [Listed under I, C2 in the following table]

III. IUPAC Commission on the Nomenclature of Organic Chemistry (CNOC)
1. Section A (Hydrocarbons), Section B (Heterocyclics): *J. Am. Chem. Soc.*, 82, 5545;[a] Section C (Groups containing N, Hal, S, Se/Te): *Pure Appl. Chem.*, 11, Nos. 1–2[a] [A, B, and C Revised 1969:[a] Butterworth's, London (1971)]
2. Section E (Stereochemistry):[b] *J. Org. Chem.*, 35, 2489 (1970); *Biochim. Biophys. Acta*, 208, 1 (1970); *Eur. J. Biochem.*, 18, 151 (1970) [See also I, D1]

[a]No reprints available from OBN; order from publisher.
[b]Reprints available from OBN (in addition to all in IA to ID and II).

RULES AND RECOMMENDATIONS AFFECTING BIOCHEMICAL NOMENCLATURE AND PLACES OF PUBLICATION (AS OF FEBRUARY 1975)(continued)

IV. Physiochemical Quantities and Units (IUPAC)[a] *J. Am. Chem. Soc.*, 82, 5517 (1960) [Revised 1970: *Pure Appl. Chem.*, 21, 1 (1970)]

V. Nomenclature of Inorganic Chemistry (IUPAC) *J. Am. Chem. Soc.*, 82, 5523[a] [Revised 1971: *Pure Appl. Chem.*, 28, No. 1 (1971)][a]

VI. Drugs and Related Compounds or Preparations

1. U.S. Adopted Names (USAN) No. 10 (1972) and Supplement [U.S. Pharmacopeial Convention, Inc., 12601 Twinbrook Parkway, Rockville, Md.]
2. International Nonproprietary Names (INN) [WHO, Geneva]