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Enzyme Handbook

Supplement I

Springer-Verlag Berlin Heidelberg NewYork 1974

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ISBN 3-540-06761-2 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-06761-2 Springer-Verlag New York Heidelberg Berlin

Library of Congress Catalog Card Number 69-19293. Printed in Germany.

Offset printing: Julius Beltz, Hemsbach/Bergstr.
Bookbinding: Konrad Triltsch, Graphischer Betrieb, Würzburg

Preface

In the five years since the appearance of the *Enzyme Handbook* several hundred new enzymes have been described. The *Supplement* includes molecular and kinetic data on about half of these and also on several enzymes omitted from the *Handbook;* information on many of the remainder will be found in *Enzyme Nomenclature (1972).* An incomplete search of the literature may have resulted in the omission of a number of enzymes from the *Supplement* and I apologize to the authors whose contributions I have missed.

The labour involved in compiling the data for the *Supplement* was greatly reduced by the kindness of Professor E. C. Webb who sent me a draft copy of *Enzyme Nomenclature (1972)* prior to publication. Dr. E. A. Jones and Dr. G. S. Knaggs reviewed the entire text of the *Supplement* and I am grateful for their criticisms and suggestions. I also thank the many people who offered constructive criticisms of the earlier *Enzyme Handbook.* Several of these suggestions have been incorporated into the *Supplement.* I am grateful to Mrs. Anna Knaggs for her expert typing and for making the manuscript ready for photomechanical reproduction, to Mrs. Lucia Barman for preparing the lists of references and the index and to the staff of Springer-Verlag for giving me every possible assistance in seeing the *Supplement* to completion. I am indebted to Professor E. C. Webb, the IUPAC-IUB and the Elsevier Publishing Company for permission to reproduce the Key to the Numbering and Classification of Enzymes which appears on pages 7–12.

Shinfield, Reading
January 1974

Thomas E. Barman

Contents

SYMBOLS AND ABBREVIATIONS

General

ADP, CDP, GDP, IDP, dTDP, UDP	the 5'-diphosphates of adenosine, cytidine, guanosine, inosine, thymidine and uridine
Ammediol	2-amino-2-methyl-1,3-propanediol
AMP, CMP, GMP, IMP, dTMP, UMP	the 5'-monophosphates of adenosine, cytidine, guanosine, inosine, thymidine and uridine
Cyclic AMP	adenosine 3':5'-cyclic phosphate
ATP, CTP, GTP, ITP, dTTP, UTP	the 5'-triphosphates of adenosine, cytidine, guanosine, inosine, thymidine and uridine
dATP, dCTP, etc.	deoxy ATP, deoxy CTP etc.
ATPP	adenosine tetraphosphate
Bicine	N,N-bis(2-hydroxyethyl)glycine
C	competitive
CoA	coenzyme A
Coenzyme I	NAD
Coenzyme II	NADP
Cozymase	NAD
DNA	deoxyribonucleic acid
DPN	NAD
EDTA	ethylenediaminetetraacetate
FAD	flavin - adenine dinucleotide
FMN	flavin mononucleotide
Glc	glucose
GlyGly	glycylglycine
HEPES	N-2-hydroxyethylpiperazine-N'-2-ethane-sulphonic acid
I	inhibitor
LAD	light absorption data
M	gm molecule (1 mole) per litre
mM	10^{-3}M
µM	10^{-6}M
nM	10^{-9}M
MES	2-(N-morpholino)ethanesulphonic acid
NAD	nicotinamide-adenine dinucleotide

NADP	nicotinamide-adenine dinucleotide phosphate
NC	non-competitive
NDP	nucleoside diphosphate
NMN	nicotinamide mononucleotide
NTP	nucleoside triphosphate
P_i	inorganic orthophosphate
PP_{ii}	inorganic pyrophosphate
RNA	ribonucleic acid
tRNA	transfer ribonucleic acid
S	substrate
$S_{20,w}$	sedimentation coefficient in Svedbergs (in water at 20°). One Svedberg = 1×10^{-13} sec.
SDS	sodium dodecyl sulphate (≡sodium lauryl sulphate)
TAES	tris (hydroxymethyl)-methyl-2-aminoethane sulphonic acid
TEA	triethanolamine
TPN	NADP
Tris	2-amino-2-hydroxymethylpropane-1,3-diol
TPP	thiamine pyrophosphate
Tricine	2-N-glycine-2-hydroxymethylpropane-1,3-diol
UC	uncompetitive
ε	molar extinction coefficient (units = $M^{-1}cm^{-1}$)
λ	wavelength
nm	millimicrons (1nm = 10Å = 10^{-9}m)
°	degree centigrade

Symbols for amino acids

Unless otherwise stated all amino acids are of the L-configuration.

Ala	alanine	Leu	leucine
Arg	arginine	Lys	lysine
Asn	asparagine	Met	methionine
Asp	aspartic acid	Phe	phenylalanine
Cys	cysteine	Pro	proline
Gln	glutamine	Ser	serine
Glu	glutamic acid	Thr	threonine
Gly	glycine	Trp	tryptophan
His	histidine	Tyr	tyrosine
Ile	isoleucine	Val	valine

Kinetic symbols

Symbol	Definition	Unit
v	velocity of reaction catalyzed by an enzyme	-
V	maximum velocity: the value of v when the enzyme is saturated with substrate	-
K_D	dissociation constant	-
K_m	Michaelis constant; concentration of substrate at which $v = V/2$.	M
K_s	substrate constant; equilibrium (dissociation) constant of the reaction $E + S = ES$	M
K_i	inhibitor constant; equilibrium (dissociation) constant of the reaction $E + I = EI$	M
k_o	overall or observed rate constant - the number of molecules of substrate transformed per second per molecule of enzyme, sometimes called turnover number	sec^{-1}

Literature abbreviations

Other abbreviations such as those accepted without definition by the Journal of Biological Chemistry appear in the Handbook without further identification.

AB	Archives of Biochemistry
ABB	Archives of Biochemistry & Biophysics
ACS	American Chemical Society
Advances in Enzymology	ed. Nord, F. F. Interscience (John Wiley & Sons): New York
Ann. Rev. Biochem.	Annual Review of Biochemistry. Annual Reviews Inc: Palo Alto, California
B	Biochemistry
BBA	Biochimica & Biophysica Acta
BBRC	Biochemical & Biophysical Research Communications
BJ	Biochemical Journal
Brookhaven Symposia in Biology	Biology Department, Brookhaven National Laboratory, Upton, New York
BZ	Biochemische Zeitschrift
EJB	European Journal of Biochemistry
The Enzymes (second edition, 1959-1963)	eds. Boyer, P.D., Lardy, H.A. & Myrbäck, K. Academic Press Inc.: New York
The Enzymes (third edition, 1970-)	ed. Boyer, P.D. Academic Press Inc.: New York
FEBS lett.	the Federation of European Biochemical Societies letters
FP	Federation Proceedings
JACS	Journal of the American Chemical Society
JBC	Journal of Biological Chemistry
JMB	Journal of Molecular Biology
Methods in Enzymology	eds. Colowick, S.P. & Kaplan, N.O. Academic Press Inc.: New York
PNAS	Proceedings of the National Academy of Sciences (U.S.)
The Proteins (first edition)	eds. Neurath, H. & Bailey, K. Academic Press Inc.: New York
The Proteins (second edition)	ed. Neurath, H. Academic Press Inc.: New York

EXPLANATORY NOTES

The data in the Supplement are arranged in the same way as in the Enzyme Handbook and below is a summary of the way in which this has been done. The reader is referred to the Handbook for a more detailed discussion of the enzyme properties considered in the Supplement.

Enzyme classification

The enzyme list in Enzyme Nomenclature (1972) differs in several important respects from the 1964 list (especially subgroups 1.13, 1.14 and 3.4). The new key to the numbering and classification of enzymes will be found on pages 7 – 12 . The enzymes in the Supplement have been arranged according to the 1972 list.

Equilibrium constant

When a reaction is described as "essentially irreversible" the direction catalyzed by the enzyme in question is indicated by [F] (forward reaction) or [R] (reverse reaction).

Molecular properties

The Supplement includes more molecular data than the Enzyme Handbook and wherever possible details of the following are given: molecular weight [number of subunits]; carbohydrate or lipid content; multiplicity; prosthetic group (including metal ion content); stable enzyme-substrate complexes; active site directed irreversible inhibitors (e.g. diisopropyl-fluorophosphate. These are occasionally included under *Specificity and kinetic properties* or *Inhibitors*) and references to amino acid compositions. Details of the way in which a particular molecular weight was obtained are given under conditions. This information is given in a concise form and when several methods were used, these are separated by semicolons. For example, the entry

"pH 8.2; Sephadex G 100, pH 7.5; amino acid composition"

is an abbreviation of

"the molecular weight was obtained by an ultracentrifugation method at pH 8.2 and by gel filtration on a column of Sephadex G 100 at pH 7.5. The amino acid composition of the enzyme has been determined."

Specific activity

The specific activity of an enzyme is defined as units per mg of enzyme protein where one unit is that amount of enzyme which will catalyze the transformation of 1 µmole of substrate per minute under specified conditions.

Specific activities are only given for enzymes which have been highly purified and which are thought to be homogeneous. The figure in brackets immediately following the source of the enzyme of interest is the purification factor - i.e. the ratio of the specific activity of the purified enzyme to the specific activity of the source material. Specific activities are occasionally included under *Specificity and kinetic properties*.

Specificity and kinetic properties

The Supplement includes more information on cofactor and activator requirements than the Enzyme Handbook. In most cases purification factors are included, regardless of the purity of the enzyme. Relative activities are included wherever possible - usually this information is tabulated but often relative activities are indicated in brackets immediately following the compound listed in the text. In both cases the reference compound (i.e. that of relative activity 1.00) is usually thought to be physiologically the most important.

Inhibitors

Information on inhibitors is in many cases included under *Specificity and kinetic properties*. The data are condensed. For instance, the entry

"a number of amino acids [C(L-lysine); UC(reduced NAD)] are inhibitors"

is an abbreviation of

"a number of amino acids are inhibitory. The type of inhibition is competitive (with respect to the substrate L-lysine) or uncompetitive (with respect to the substrate reduced NAD)".

Active site irreversible inhibitors are usually included under *Molecular properties*.

References

The literature survey for the Supplement was concluded September 30 1973. Certain references were inserted after the typing of the manuscript; these are not numbered. References to review articles are underlined.

KEY TO NUMBERING AND CLASSIFICATION OF ENZYMES

From ENZYME NOMENCLATURE: *Recommendations (1972) of the Commission on Biochemical Nomenclature on the Nomenclature and Classification of Enzymes together with their Units and the Symbols of Enzyme Kinetics.* Published by Elsevier, Amsterdam; pages 17-22.

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ENZYME COMMISSION NUMBERS (1972) OF INCOMPLETELY NUMBERED ENZYMES IN THE ENZYME HANDBOOK (1969)

Numbers in brackets are tentative. The numbers of several enzymes included in the *Handbook (1969)* have recently been revised (especially subgroups 1.13, 1.14 and 3.4) and the reader is referred to *Enzyme Nomenclature (1972)* for details of these changes.

Enzyme Handbook	EC Number	Enzyme Handbook	EC Number
1.1.1.a	1.1.1.77	2.3.1.c	4.1.3.12
1.1.1.b	1.1.1.88	2.3.1.d	2.3.1.36
1.1.1.c	1.1.1.140	2.4.1.a	2.4.1.21
1.1.1.d	1.1.1.103	2.4.1.b	2.4.1.21
1.1.1.e	1.1.1.129	2.4.2.a	2.4.2.19
1.1.1.f	1.1.1.138	2.4.2.b	2.4.2.22
1.1.1.g	1.1.1.130	2.4.2.c	2.4.2.17
1.1.1.h	1.1.1.126	2.6.1.a	2.6.1.30
1.1.1.k	1.1.1.127	2.6.1.b	2.6.1.21
1.1.1.m	1.1.1.125	2.6.1.c	2.6.1.33
1.1.1.n	1.1.1.150	2.6.1.d	2.6.1.31
1.1.1.p	1.1.1.85	2.6.1.e	2.6.1.6 or 42
1.1.1.q	1.1.1.137	2.7.1.a	2.7.1.63
1.1.1.r	1.1.1.132	2.7.1.b	2.7.1.60
1.1.1.s	1.1.1.95	2.7.1.c	2.7.1.54
1.1.3.a	1.1.3.15	2.7.1.d	2.7.1.53
1.1.99.a	(1.1.99.10)	2.7.1.e	2.7.1.62
1.2.1.a	1.5.1.12	2.7.1.f	2.7.1.59
1.3.1.a	1.3.1.12	2.7.1.g	2.7.1.61
1.3.1.b	1.3.1.7	2.7.1.h	2.7.5.5
1.3.99.a	1.3.99.6	2.7.1.k	2.7.1.7
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1.4.3.a	1.4.3.8	2.7.3.a	2.7.3.7
1.4.3.b	1.13.12.1	2.7.5.a	-
1.5.1.a	1.5.1.11	2.7.7.a	2.7.7.29
1.5.3.a	1.5.3.4	2.7.7.b	2.7.7.27
1.6.2.a	1.6.2.4	2.7.7.c	2.7.7.43
1.6.4.a	1.6.4.5	2.7.7.d	2.7.7.37
1.7.99.a	(1.7.3.4)	2.7.7.e	2.7.7.32
1.11.1.a	1.11.1.10	2.7.7.f	2.7.7.33
1.14.1.a	1.14.13.1		
1.14.3.a	1.14.16.2	3.1.3.a	3.1.3.29
		3.1.4.a	3.1.4.13
2.1.1.a	2.1.1.27	3.1.4.b	3.1.4.26
2.1.1.b	-	3.1.4.c	3.1.4.17
2.1.1.c	2.1.1.17	3.1.4.d	3.1.4.16
2.1.2.a	2.1.2.7	3.2.2.a	3.2.2.7
2.1.2.b	2.1.2.8	3.4.4.a	3.4.99.26
2.1.3.a	-	3.4.4.b	3.4.21.2
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2.3.1.b	2.3.1.32	3.5.1.a	3.5.1.19