IUPAC-IUB Combined Commission on Biochemical Nomenclature

Abbreviations and Symbols for Chemical Names of Special Interest in Biological Chemistry

Revised Tentative Rules (1965)¹

EXPLICATORY MEMORANDUM

The Commission on the Nomenclature of Biological Chemistry decided in 1958 that an attempt should be made to standardize the abbreviations and symbols used for chemical names of special interest in biological chemistry. A Sub委员会, consisting of L. Hellerman, W. Klyne (Chairman), and E. C. Slater, was set up early in 1959 to deal with this problem.

The original draft proposals were based on the notes given at the beginning of each number of the Journal of Biological Chemistry (1958 et seq.) and of the Suggestions to Authors of the Biochemical Journal (66, 1 (1957)). These drafts were circulated to members of the Nomenclature Commission, editors of chemical and biochemical journals, and interested specialists in many fields.

The problems were discussed fully at the meeting of the Commission in Munich in September, 1959—and also in joint sessions with the Organic Nomenclature Commission and the Enzyme Commission of the International Union of Biochemistry (IUB). A third draft, incorporating the results of the Munich discussions, was widely circulated in December 1959, and many useful comments on this were received.

A fourth draft, representing the "highest common factor" of all these comments and of many personal discussions, was prepared in August 1960, and circulated to members of the Commission on the Nomenclature of Biological Chemistry and to editors of some principal journals.

The meeting of editors of biochemical journals called together by the President of IUB in Cambridge in September 1960 invited W. Klyne to attend part of their meeting. He explained the history and purpose of the memorandum on abbreviations; he emphasized that this work lies on the borderline between the provinces of the two Unions, and that agreement of both Unions in principle was therefore very desirable.

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After discussion, the Secretary General of IUB, R. H. S. Thompson, proposed the following statement, which was unanimously approved. "The contents of this memorandum (i.e. the fourth Draft) were approved both by the Bureau of IUB and by the meeting of Editors of biochemical journals called together by the President of IUB under the Chairmanship of J. T. Edsall, at a meeting held in Cambridge on September 3, 1960."

¹ Changes made at the first revision (IUPAC Information Bulletin No. 20, July 1963, pp. 13-20) are indicated by the symbol ▲. Those made in this second revision, which are more extensive, are indicated by ■. The latter changes were made by the IUPAC-IUB Combined Commission on Biochemical Nomenclature (CBN), which came into being in January 1964, with W. Klyne as Chairman and E. C. Slater as Secretary.

Comments on these re-revised proposals should be sent to the present Chairman (O. Hoffmann-Ostenhof) or Secretary (W. E. Cohn) or to any member of CBN (A. F. Braunschein, J. S. Fruton, B. Keil, W. Klyne, C. Liebecq, F. G. Malmitröm, R. Schwyzzer, E. C. Slater), or corresponding member (N. Tamiya).

The Revised Tentative Rules (1963) were approved at the Zürich meeting. It has been impossible to meet all the comments and criticisms that colleagues have kindly offered on the various Drafts—since so many of the comments are mutually contradictory. However, these tentative proposals represent an honest attempt to give fair weight to all the diverse opinions that have been expressed.

TENTATIVE RULES

1. INTRODUCTION

1.1 It is sometimes convenient to use abbreviations or symbols for the names of chemical substances, particularly in equations, tables, or figures, which would otherwise require the repeated use of unwieldy terms. The limited use of abbreviations and symbols of specified meaning is therefore accepted. However, clarity and unambiguity are more important than brevity.

1.2 Some chemists deplore the use of any abbreviations or symbols for compounds. However, in the present state of biochemistry, increasing knowledge of the structure of large molecules such as proteins, polysaccharides, and polynucleotides makes it imperative to have some "shorthand" notation in which symbols are allotted to the monomeric units (monosaccharides, amino acids, and nucleosides), which are Nature’s building bricks in these complex structures. Opponents of abbreviations should consider how unwieldy the formula of insulin would appear if the “three-letter” symbols for amino acids had not been used.

1.3 Titles and summaries of papers should be generally free of abbreviations. In the body of the paper, abbreviations and symbols should be used in the text sparingly, and only if advantage to the reader results. Chemical equations, which traditionally consist of symbols, may use a shorthand expression for a term that appears in full in the neighboring text.

1.4 If, in exceptional circumstances, symbols or abbrevia-
tions are used in a summary, they should be defined in the summary, as well as in the body of the paper.

1.5 It is hoped that editors will adopt in their journals as many of the following rules as possible in the light of individual circumstances.

1.6 Even if a journal permits the use of these abbreviations without definition, nonstandard abbreviations should always be defined in each paper.

1.7 Nonstandard (ad hoc) abbreviations and symbols should not conflict with known ones, or with the general principles proposed in these rules (see also Section 8).

1.8 The symbols and abbreviations discussed here fall into two distinct classes.

(a) Symbols for monomeric units in macromolecules; these symbols are used to make up abbreviated structural formulas (sometimes called “shorthand” formulas), e.g. Gly–Val–Thr for the tripeptide glycylvalylthreonine. These are generally used by structural organic chemists, and can be made fairly systematic.

(b) Abbreviations for semisystematic or trivial names, e.g. ATP for adenosine triphosphate; FAD for flavin-adenine dinucleotide.

The abbreviations of the second kind are generally formed of three or four capital letters. They are required chiefly by biochemists and are generally introduced as required; the need is for brevity rather than for system. It is the indiscriminate coining of such abbreviations that has aroused objections to the use of abbreviations in general.

Symbols for Natural Macromolecules

1.9 There are three main series of symbols for monomeric units, viz. those for amino acids, monosaccharides, and mononucleosides, of which the amino acid series is the oldest. An attempt has been made here to devise a standard treatment for all the three great groups of macromolecules, which are built up from these units. The standardization of treatment will involve certain unimportant changes in the (as yet partly developed) systems for individual groups. This standardization is desirable for two reasons.

(a) The work of authors, editors, and readers is made simpler if the same principles apply to polypeptides, polysaccharides, and polynucleotides.

(b) Standard treatment is essential for dealing with “hybrid” compounds, built up of units of different kinds, e.g. the nucleotide-peptides and glycopeptides.

1.10 It is much more difficult to be completely systematic in the planning of abbreviations and “shorthand” symbols for complex substances than in the construction of organic chemical formulas and physical symbols. Experience shows that it is not only difficult, but in some cases undesirable, to be rigidly consistent with these complex symbols.

The following example will illustrate these facts. For most purposes it is convenient to use the symbol Gly–Val–Thr to represent the tripeptide glycylvalylthreonine, as solid or in complex substances than in the construction of organic chemical cation, as anion, or as dipolar ion, but it is usually unnecessary purposes it is convenient to use the symbol Gly-Val-Thr to make separate shorthand symbols to represent these different formulas and physical symbols. Experience shows that it is not only difficult, but in some cases undesirable, to be rigidly consistent with these complex symbols.

The following example will illustrate these facts. For most purposes it is convenient to use the symbol Gly–Val–Thr to represent the tripeptide glycylvalylthreonine, as solid or in solution, whatever its state of ionization. We know that at certain defined pH values, the tripeptide will exist (mainly) as cation, as anion, or as dipolar ion, but it is usually unnecessary to make separate shorthand symbols to represent these different forms.

This deliberate lack of precision runs parallel with the convention by which biochemists talk about the “citric acid cycle” or “tricarboxylic acid cycle,” in spite of the fact that the acids exist almost entirely as their anions at physiological pH.

In several cases it is thought desirable to recommend for the same substance two different forms of abbreviation or symbol, one or other of which is more convenient for specific purposes.

Alternative Abbreviations and Symbols

1.11 For some important compounds, it is in practice necessary to have two symbols or abbreviations. For example, most biological chemists will continue to speak of “adenosine diphosphate,” or more often to abbreviate it as “ADP.” Organic chemists interested in the structure and synthesis of this and related compounds will wish to call this compound “adenosine-β’-pyrophosphate,” and to use a systematic symbol (Ado-β’-P–P’).

The abbreviation and the symbol must therefore coexist.

1.12 Abbreviations such as “ADP,” which are to the organic chemist trivial, are used to form the systematic names of enzymes in the patterns proposed by the Enzyme Commission of the International Union of Biochemistry (Elkevich, 1965).

Language Differences

1.13 It is desirable that where trivial abbreviations (such as ACTH) are necessary, they should be identical in all languages—as are chemical symbols (e.g. N for nitrogen, ozone, and Stickstoff). It would be unfortunate if the substance called in English “ribonucleic acid,” and abbreviated “RNA,” were to retain two separate abbreviations, ARN (acide ribonucléique) and RNS (Ribonukleinsäure), in French and German, to say nothing of other languages. It is suggested that the international abbreviations should be taken from that language in which a given abbreviation first became common. Abbreviations introduced in the future may conveniently be based on Greek or Latin forms.

Structural Analogues

1.14 Structural analogues of a given compound should not generally be abbreviated as if they were derivatives of that compound.

2. Polyamides and Proteins

This system is based on the original proposals of E. Brand and J. T. Edsall (Ann. Rev. Biochem., 16, 224 (1947)), as developed in the monograph of J. F. Greenstein and M. Winitz (The Chemistry of the Amino Acids, John Wiley and Sons, Inc., New York, 1961). However, some modifications have been introduced so that it is possible to designate all amino acids found in proteins, including the acid amides and the hydroxylated compounds, by three-letter symbols—a capital followed by two lower-case letters.

2.1 The following symbols denote the common amino acids and their residues (see also 2.5):

| Alanine      | Ala   | Hydroxylysine       | Hyl |
| Arginine     | Arg   | Hydroxyproline      | Hyp |
| Aspartic acid| Asp   | Isoleucine          | Ile |
| Asparagine   | Asn   | Leucine             | Leu |
| Lysine       | Lys   | Methionine          | Met |
| Ornithine    | Orn   | Phenylalanine       | Phe |
| Cysteine     | Cys   | Serine              | Ser |
| Glutamic acid| Glu   | Threonine           | Thr |
| Glutamine    | Gln   | Tryptophan          | Trp |
| Glycine      | Gly   | Tyrosine            | Tyr |
| Histidine    | His   | Valine              | Val |

* Modified amino acids, such as asparagine and glutamine, may also be represented as Asp(NH₂), Glu(NH₂) or Asp, Glu.

2.2 The abbreviations should not be used for the free amino acids in the text of papers, but only in tables, lists, and figures.
2.3 Where the sequence of residues in a peptide or protein is known, the symbols for the residues are written in order and joined by short lines (dashes, hyphens). Where the sequence is not known, the group of symbols, separated by commas, is enclosed in parentheses.3

In the formulation of linear polypeptides or proteins, the symbol written at the left-hand end of a known sequence is that of the amino acid carrying the free amino group, and the symbol written at the right-hand end is that of the residue of the amino acid carrying the free carboxyl group. Example: The condensed formula

\[ \text{Gly} - \text{Glu} - \text{Arg} - \text{Gly} - \text{Phe} - (\text{Phe}, \text{Tyr}, \text{Thr}, \text{Pro}) - \text{Lys} - \text{Ala} - \text{Trp} - \text{Tyr} - \text{Val} - \text{Ile} - \text{Hyp} - \text{Cys} - \text{Ala} \]

is that of a polypeptide in which the sequence of the first five amino acids has been established, the glycine at the left carrying the free amino group. The sequence of the next four amino acids is unknown, but the last nine amino acids are in known order with alanine carrying the free carboxyl group.

If the direction of the link must be specified, this may be done with an arrow thus (→), the point of the arrow indicating the nitrogen of the peptide bond. ..CO-NH.. The symbol written at the left-hand end is that of the amino acid carrying the free amino group, and the symbol written at the right-hand end is that of the residue of the amino acid carrying the free carboxyl group. Example: Gly → Ala → Val.

The symbol → is desirable particularly for dealing with cyclic peptides.

Unless otherwise indicated, it is assumed that polypeptide bonds or links formed through functional groups, may be indicated by methods such as the following:

\[ \text{Cys} - \text{Gly} \]

\[ \text{Cys} - \text{Gly} \]

\[ \text{Glu} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{Gly} - \text{Val} - \text{Thr} - \text{O}^- \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{O}^- \]

Comment

The links between residues have been shown previously by peptide chemists as full points (periods, dots; ·) and by carbohydrate chemists (generally) as short strokes (dashes, hyphens; —). At times, special symbols have been used (> or ←) to show the direction of what is in all cases an unsymmetrical link (peptide or glycoside).

For consistency and ease of printing, a short rule or dash (—), which is what we normally use for a chemical bond, should be the standard connecting symbol.

The usual usage by which Gly-Gly-Gly stands for glycylglycine appears to involve the employment of the same conventions.5

\[ \text{Glu} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{Gly} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{O}^- \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{OH} \]

\[ \text{H} - \text{Gly} - \text{Val} - \text{Thr} - \text{O}^- \]

Derivatives

2.7 Symbols for the functional groups of derivatives have been devised by specialists in the field (cf. reference in paragraph 2.5).

3. CARBOHYDRATES

A system of three-letter symbols for monosaccharide units and their residues, similar to that already in use for peptides, was introduced by the Carbohydrate Nomenclature Committees of the Chemical Society and the American Chemical Society (cf. J. Chem. Soc., 5121 (1952); Chem. Eng. News, 1776 (1953); J. Org. Chem., 28, 281 (1963)). The following rules are based on this system. 

3.1 The following symbols are used to indicate monosaccharide units and their residues in oligosaccharides and polysaccharides.

- Glucose Glc
- Fructose Fru
- Galactose Gal
- Ribose Rib
- Mannose Man

Other monosaccharides are represented similarly by the first three letters of their names, unless this would lead to confusion.6

A Atoms, groups, or derivatives not shown in this system are indicated by appropriate symbols (or by numbers).

A Where no ambiguity can arise, the single-letter symbol G may be used.
fusion with an existing symbol (e.g. Gly and Thr in the amino acid series).

3.2 Pyranose and furanose forms are designated where necessary by the suffixes p and j.

3.3 Configurational symbols d and L (small Roman capital letters) and anomeric prefixes are shown where necessary as prefixes. Examples: (i) an α-D-glucopyranose unit, α-D-Glp or GlcP; (ii) a β-D-fructofuranose unit, β-D-Fru or Fru.

3.4 Symbols thus formed are joined by short rules to indicate the links between units. The position and nature of the links are shown by numerals and the anomeric symbols α and β. Examples:

- Maltose, Glcp-1→4Glc
- Lactose, Galp1→4GlcP
- Stachyose, Galp1→6Galp1→6Galp1→2Fru

A branched chain tetrasaccharide:

\[
\text{GlcP1-3(4)GalP1-4Glc}
\]

Arrows may be used to indicate the direction of the glycosidic link, the arrow pointing away from the hemiacetal carbon of the link; e.g. lactose may be represented as Galp1→4Glc.

3.5 A 2-deoxy sugar is designated by the symbol for its most common parent sugar with the prefix “de.” Other deoxy sugars may be designated similarly with a positional numeral. Examples: 2-deoxyribose, deRib; 3-deoxyglucose, 3-deGlc.

Arrows may be used to indicate the direction of the glycosidic link; e.g. lactose may be represented as Galp1→4Glc.

4.1 Phosphorylated compounds may be designated by the name (or abbreviation) of the parent compound with a capital italic P as a prefix or suffix.7

P is used as prefix where it symbolizes “phospho-” at the beginning of a name. P is used as a suffix where it symbolizes “phosphoric acid” or “phosphate” at the end of a name.8

For compounds containing more than one position available for phosphorylation, the position of the phosphate group should always be indicated by number or Greek letter.

4.2 The capital P when linked to one radical indicates —PO(OH)2 or any ion derived from it; when linked to two radicals it indicates —PO(OH) —, or the ion derived from it.

Comment

It may sometimes be necessary to enclose such a symbol in parentheses to avoid confusion between the numeral indicating the “deoxy position” and numerals indicating the position of linkages.

3.6 Derived monosaccharide units—such as glyconic acids, glucuronic acids, 2-amino-2-deoxy sugars, and their N-acetyl derivatives—may be designated by reasonable modified symbols, defined in each paper. Examples of symbols that have been used are as follows (all in the glucose, Glc, series):

<table>
<thead>
<tr>
<th>Monosaccharide</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucitol</td>
<td>GlcA</td>
</tr>
<tr>
<td>Gluconic acid</td>
<td>GlcA</td>
</tr>
<tr>
<td>Glucosamine</td>
<td>GlcN</td>
</tr>
<tr>
<td>N-Acetylglucosamine</td>
<td>GlnAc</td>
</tr>
</tbody>
</table>

3.7 Symbols should not be used for the monosaccharides themselves, except in tables, lists, and figures.

5. NUCLEOTIDES AND NUCLEIC ACIDS

5.1 Two systems are recognized, one (5.3) using three-letter symbols for the more common nucleosides (like those used for amino acids and monosaccharides in Sections 2 and 3) and a capital italic P or its abbreviation for the phosphate residue, the other (5.4) using single capital letters for the more common nucleosides and a lower-case p for the phosphate residue.

5.2 In either system, glycosyl linkages are assumed to be β and to involve only ν-ribose or ν-deoxyribose, and the phosphodiester linkage is assumed to be 3’-5’ from left to right unless otherwise specified by appropriate ad hoc symbols or numerals.

5.3 Three-Letter Symbols

5.3.1 The phosphate group is designated by an italic capital P (cf. Section 4), to distinguish it from Roman capital P for phosphorus.

5.3.2 The (ribo) nucleosides are designated by the following three-letter symbols, chosen to avoid confusion with the corresponding bases:

- Ado adenosine
- Guo guanosine
- Ino inosine
- Xao xanthosine

5.3.3 The 2’-deoxyribonucleosides are designated by the symbols for the corresponding ribose-derivatives (5.3.2) with the prefix d. Examples are dAdo for 2’-deoxyadenosine, dThd for 2’(deoxy)thymidine (2’-deoxyribosylthymine).

The letter d may also be used as a prefix to a series (an oligonucleotide) to indicate that all the sugars in the series are 2’-deoxyribosyl units.

5.3.4 The points of attachment of phosphate residues to a

Comment

This type of partial abbreviation (e.g. glucose-6-P) is convenient in biochemical papers where there is much discussion of phosphorylated metabolites and intermediates. It is not commonly used in organic chemical papers.

Because thymidine has traditionally been used for 2’-deoxyribosylthymine, arising at a time when the ribosyl analogue was not known, it is recommended that the prefix r (for ribo) or d (for deoxyribosyl) be used with Thd or T whenever there is a possibility of misunderstanding which substance is intended.
5.4 One-Letter Symbols

5.4.1 The phosphate group is designated by a lower case p (to separate what would otherwise be a solid mass of capital letters).  
5.4.2 The common (ribo)nucleosides are designated by single capital letters, thus:

- A adenine  
- G guanine  
- I inosine  
- T thymine  
- X xanthosine

The following general symbols are also useful: P, unspecified purine nucleoside; Y, unspecified pyrimidine nucleoside; N, unspecified nucleoside.

5.4.3 The 2'-deoxyribonucleosides are designated by the same symbols (5.4.2) preceded by d (cf. 5.3.3). Thus, dA = deoxyadenosine, dT = deoxythymidine (= thymidine).  

5.4.4 The points of attachment of phosphate residues, if other than 3'P-5', may be indicated as in 5.3.4. A regular 3'-5' sequence (read left to right), as in the natural nucleic acids, need not be specified by positional numerals (5.2).

In this system, the substance in 5.3.4 becomes: A2'p; pA; d(pApT).

Other examples are:

- ApGpUp (3'-5'-trinucleotide, ending at right in a 3'-phosphate).
- ApGpU-cyclic p (the same, but ending in a 2':3'-cyclic phosphate).
- pApApA (3'-5'-trinucleotide, starting with a 5'-phosphate at left, ending with unsubstituted 2' and 3' hydroxyl groups at right).

5.5 More Complex Structures

5.5.1 Sequence Designation—For more complex structures (large oligonucleotides or polynucleotides), in which known and unknown sequences may be involved, the p for phosphate be-

The symbol > for “cyclic” is useful in the one-letter system. Thus this example can be represented as ApGpU > p. Unless otherwise stated, this symbol indicates a 2':3'-cyclic phosphate residue.

5.5.4 Association between Chains—Associations between two or more nucleotide chains may be designated by the center dot—

The absence of association is indicated by the plus sign, as in p (A) + p (C). The absence of definite information on association is indicated by the comma (again meaning “unknown”), as in (A), (A-U).

Special Abbreviations

5.5.6 The 5'-monophosphate, d-, and triphosphates of the common nucleosides may be designated by the customary special abbreviations, e.g. AMP, ADP, and ATP for the derivatives of adenine. The corresponding derivatives of cytidine, guanine, inosine, uridine, and pseudouridine may be designated by similar abbreviations in which the initial letters are C, G, I, U, and P, respectively. Thus, for example, IMP = inosine 5'-monophosphate; UDP = uridine 5'-diphosphate. Uridine diphosphate glucose may be designated by UDPG.

These compounds should, however, be designated in more “chemical” papers by systematic symbols as indicated in paragraph 5.3.4, e.g. Ado 5' P, Ado 5' P P, Ado 5'-P-P-P, when required for consistency with the other nucleotides.

5.5.7 Flavin mononucleotide (riboflavin 5'-phosphate) may be designated by the special abbreviation FMN.

5.8.1 The two types of nucleic acid are designated by their customary abbreviations:

- RNA, ribonucleic acid or ribonucleate
- DNA, deoxyribonucleic acid or deoxyribonucleate
6. COENZYMES

There has been much controversy about names and symbols for the nucleotide coenzymes (DPN, DPN+, etc.). The Enzyme Commission of the International Union of Biochemistry decided in August 1959 to recommend the following names, for the reasons briefly stated in the comment below.

Nicotinamide adenine dinucleotide (the compound hitherto commonly called diphosphopyridine nucleotide or Coenzyme I).

Nicotinamide adenine dinucleotide phosphate (the compound hitherto commonly called triphosphopyridine nucleotide or Coenzyme II).

The IUPAC Commission on the Nomenclature of Biological Chemistry after discussion accepted these recommendations of the Enzyme Commission, which were formally adopted by the IUB Council at Moscow in August 1961.


The two main systems of nomenclature of the nicotinamide nucleotide coenzymes (the CoI and the DPN systems) are both unsatisfactory. The first gives no indication of the chemical structure; the second indicates a chemical structure that is incorrect.

Since no compromise between the two systems is possible, the only satisfactory solution is to abandon both and to adopt a name that indicates the correct chemical structure. The name adopted should be consistent with the existing names of three closely related compounds, namely the corresponding mononucleotide (nicotinamide mononucleotide, NNN) and the two flavin nucleotides (flavin adenine dinucleotide, FAD, and flavin mononucleotide, FMN).

The name the Enzyme Commission of IUB, after careful consideration of possible alternatives, has decided to recommend in place of CoI or DPN, namely nicotinamide adenine dinucleotide (NAD), not only indicates the structure satisfactorily, but forms a logical system with the three that are already generally accepted.

CoII or TPN is a phosphorylated derivative of NAD, and may be called nicotinamide adenine dinucleotide phosphate, conveniently abbreviated to NADP.

6.1 The dinucleotide coenzymes may be designated by the following abbreviations:

Nicotinamide adenine dinucleotide (formerly DPN, CoI)

Nicotinamide adenine dinucleotide phosphate (formerly TPN, CoII)

6.2 The abbreviations do not specify the state of oxidation of the coenzyme.

6.3 Other coenzymes may be designated as follows:

FAD, FMNH₂  Flavin adenine dinucleotide, and its reduced form
FMN, FMNH₃  Flavin mononucleotide, and its reduced form
GSH, GSSG  Glutathione, and its oxidized form
CoA, acetyl-CoA Coenzyme A and its acetyl derivative (alternative forms)

6.4 Systematic symbols may be built up for some of these coenzymes as shown in paragraphs 5.3.4 and 5.3.6. Example:

\[
NAD = \text{Nir-5',-5'-P'-Ado}
\]

\[
NADP = \text{Nir-5',-5'-P'-Ado-2'-P}
\]

7. MISCELLANEOUS COMPOUNDS

7.1 The following abbreviations are permitted; although they are fairly common, they should be defined in any paper if it is thought that readers might be unfamiliar with them. Some abbreviations are taken from the list published by Annual Review of Biochemistry.

ACTH  adrenocorticotropic hormone, or corticotropin
BAL  β-adrenergic receptor
CM-cellulose  0-(carboxymethyl)cellulose
DDT  1,1,1,3,3-pentachloro-2-bis(p-chlorophenyl)ethane
DEAE-cellulose  O-(diethylaminoethyl)cellulose
DFP  diisopropyl phosphorofluoridate
DNP  2,4-dinitrophenyl
DOC  11-deoxy corticosterone
DCA  11-deoxy corticosterone acetate
DPT  4,4-dihydroxyphenylalanine
EDTA  ethylenediaminetetraacetic acid (or -acetate)
FDNB  1-fluoro-2,4-dinitrobenzene
Hb  hemoglobin (deoxygerated)
HbCO  "carboxy" hemoglobin (i.e. hemoglobin plus carbon monoxide)
HbO₂  oxyhemoglobin
MetHb  methemoglobin
Mb  deoxygenated myoglobin (may be modified in the same way as Hb)
MSH  melanocyte-stimulating hormone
P₂  orthophosphate (inorganic)
PP₁  pyrophosphate (inorganic)
TEAE-cellulose  0-(triethylaminoethyl)cellulose
Tris  tris(hydroxymethyl)aminoethane, 2-amino-2-hydroxymethylpropane-1,3-diol

7.2 If one-letter symbols for steroids (Compound F, Substance S) are used, the systematic name of the compound should be given at least once in each paper. Derivatives, such as "tetrahydro-F" and "11-qi-F," should also be clearly defined by systematic names.

8. STANDARDS FOR NEW ABBREVIATIONS

8.1 Abbreviations other than those listed or defined above should be constructed in accordance with the following principles.

8.2 The number should be limited; none should be introduced except where repeated use is required. Three-letter abbreviations are most convenient. Use in another sense of an accepted abbreviation must be avoided.

Where a number of derivatives, salts, or addition compounds may be formed, the name of the common fundamental structure...
should be the one abbreviated, so that other symbols may be attached to it.

9. ALPHABETICAL LISTS

For convenience the symbols and abbreviations are collected in the following two alphabetical lists.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Symbols for monomeric units in macromolecules (or in phosphorylated compounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol</td>
<td>Monomeric unit in macromolecule</td>
</tr>
<tr>
<td>A, Ado</td>
<td>adenosine</td>
</tr>
<tr>
<td>Ala</td>
<td>alanine</td>
</tr>
<tr>
<td>Arg</td>
<td>arginine</td>
</tr>
<tr>
<td>Asp(NH2), Asp</td>
<td>aspartic acid, asparagine</td>
</tr>
<tr>
<td>C, Cyd</td>
<td>cytidine</td>
</tr>
<tr>
<td>Cys</td>
<td>cysteine</td>
</tr>
<tr>
<td>Fru</td>
<td>fructose</td>
</tr>
<tr>
<td>Gal</td>
<td>galactose</td>
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<tr>
<td>G, GloA</td>
<td>glucosamine</td>
</tr>
<tr>
<td>Glu</td>
<td>glutamic acid</td>
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<tr>
<td>Gly</td>
<td>glycine</td>
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<tr>
<td>His</td>
<td>histidine</td>
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<td>Ile</td>
<td>isoleucine</td>
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<tr>
<td>Leu</td>
<td>leucine</td>
</tr>
<tr>
<td>Lys</td>
<td>lysine</td>
</tr>
<tr>
<td>Met</td>
<td>methionine</td>
</tr>
<tr>
<td>Orn</td>
<td>ornithine</td>
</tr>
<tr>
<td>P, P</td>
<td>phosphate</td>
</tr>
<tr>
<td>Trp</td>
<td>tryptophan</td>
</tr>
<tr>
<td>Tyr</td>
<td>tyrosine</td>
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<tr>
<td>Val</td>
<td>valine</td>
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<tr>
<td>Val</td>
<td>valine</td>
</tr>
<tr>
<td>Xao</td>
<td>xanthosine</td>
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<table>
<thead>
<tr>
<th>Symbol</th>
<th>Monomeric unit in macromolecule</th>
</tr>
</thead>
<tbody>
<tr>
<td>H, Hy</td>
<td>hydroxylysine</td>
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<tr>
<td>Hypro</td>
<td>hydroxyproline</td>
</tr>
<tr>
<td>I, Ino</td>
<td>inosine</td>
</tr>
<tr>
<td>Ile</td>
<td>isoleucine</td>
</tr>
<tr>
<td>Leu</td>
<td>leucine</td>
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<td>P</td>
<td>phosphate</td>
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<td>P</td>
<td>phosphate</td>
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<tr>
<td>Thr</td>
<td>threonine</td>
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<td>T, Thd</td>
<td>threo-thymine</td>
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<td>Tyr</td>
<td>tyrosine</td>
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<tr>
<td>Val</td>
<td>valine</td>
</tr>
<tr>
<td>Val</td>
<td>valine</td>
</tr>
<tr>
<td>Xao</td>
<td>xanthosine</td>
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</table>

a With vertical bond above or below "s" (see Section 2).

b The one-letter symbol G must not be used if confusion between its two meanings can arise.

<table>
<thead>
<tr>
<th>Table II</th>
<th>Abbreviations for semisystematic or trivial names</th>
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<tbody>
<tr>
<td>ACTH</td>
<td>adrenocorticotropin, adrenocorticotropin hormone, or corticotropin</td>
</tr>
<tr>
<td>ADP</td>
<td>adenosine 5'-diphosphate (pyro)</td>
</tr>
<tr>
<td>AMP</td>
<td>adenosine 5'-phosphate</td>
</tr>
<tr>
<td>ATP</td>
<td>adenosine 5'-triphosphate (pyro)</td>
</tr>
<tr>
<td>AMP</td>
<td>adenosine 5'-phosphate</td>
</tr>
<tr>
<td>P</td>
<td>inorganic orthophosphate</td>
</tr>
<tr>
<td>RNA</td>
<td>ribonucleic acid</td>
</tr>
<tr>
<td>TEAE-cellulose</td>
<td>triphosphopyridine nucleotide (pyro)</td>
</tr>
<tr>
<td>TPN</td>
<td>triphosphopyridine nucleotide (pyro)</td>
</tr>
<tr>
<td>Tris</td>
<td>triglycerol (2-amino-2-hydroxyethylpropane-1,3-diol)</td>
</tr>
<tr>
<td>UDP</td>
<td>uridine diphosphate</td>
</tr>
<tr>
<td>UTP</td>
<td>uridine triphosphate</td>
</tr>
<tr>
<td>UTP</td>
<td>uridine triphosphate</td>
</tr>
<tr>
<td>UTP</td>
<td>uridine triphosphate</td>
</tr>
</tbody>
</table>

a Replaced by NAD (see Section 6).

b Replaced by NADP (see Section 6).
Abbreviations and Symbols for Chemical Names of Special Interest in Biological Chemistry: Revised Tentative Rules (1965)
IUPAC-IUB Combined Commission on Biochemical Nomenclature


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