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IUPAC-IUB Joint Commission on Biochemical Nomenclature (JCBN)

Nomenclature of glycolipids *

Recommendations 1997

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Contents

GL-1. General considerations

Glycolipids are glycosyl derivatives of lipids such as acylglycerols, ceramides and prenols. They are collectively part of a larger family of substances known as glycoconjugates. The major types of glycoconjugates are glycoproteins, glycopeptides, peptidoglycans, proteoglycans, glycolipids and lipopolysaccharides. The structures of glycolipids are often complex and difficult to reproduce in the text of articles and certainly cannot be referred to in oral discussions without a nomenclature that implies specific chemical structural features.

The 1976 recommendations [1] on lipid nomenclature contained a section (Lip-3) on glycolipids, with symbols and abbreviations as well as trivial names for some of the most commonly occurring glycolipids. Since then, more than 300 new glycolipids have been isolated and characterized, some having carbohydrate chains with more than twenty monosaccharide residues and others with structural features such as inositol phosphate. The nomenclature needs to be convenient and practical, as well as extensible, to accommodate newly discovered structures. It should also be consistent with the nomenclature of glycoproteins, glycopeptides and peptidoglycans [2], oligosaccharides [3], and carbohydrates in general [4].

This document supersedes the glycolipid section in the 1976 Recommendations on lipid nomenclature [1].

GL-2. Generic terms

GL-2.1. Glycolipid. The term glycolipid designates any compound containing one or more monosaccharide residues bound by a glycosidic linkage to a hydrophobic moiety such as an acylglycerol, a sphingoid, a ceramide (*N*-acylsphingoid) or a prenyl phosphate.

GL-2.2. Glycoglycerolipid. The term glycoglycerolipid is used to designate glycolipids containing one or more glycerol residues.

GL-2.3. Glycosphingolipid. The term glycosphingolipid designates lipids containing at least one monosaccharide residue and either a sphingoid or a ceramide. The glycosphingolipids can be subdivided as follows:

A) Neutral glycosphingolipids:
  1) mono-, oligo-, and polyglycosylsphingoids
  2) mono-, oligo-, and polyglycosylceramides.

B) Acidic glycosphingolipids:
  1) sialoglycosphingolipids (gangliosides, containing one or more sialic acid residues)
  2) uronoglycosphingolipids (containing one or more uronic acid residues)
  3) sulfoglycosphingolipids (containing one or more carbohydrate-sulfate ester groups)

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4) phosphoglycosphingolipids (containing one or more phosphate mono- or diester groups)
5) phosphonoglycosphingolipids (containing one or more (2-aminoethyl)hydroxyphosphoryl groups).

GL-2.4. Glycophosphatidylinositol. The term glycophosphatidylinositol is used to designate glycolipids which contain saccharides glycosidically linked to the inositol moiety of phosphatidylinositols (*e.g.* diacyl-*sn*-glycero-3-phosphoinositol), inclusive of lyso- (Lip-2.6 in [1]) species and those with various *O*-acyl-, *O*-alkyl-, *O*-alk-1-en-1-yl- (*e.g.* plasmanylinositols; [5]) or other substitutions on their glycerol or inositol residues.

GL-2.5. Psychosine. Psychosine was coined historically to designate a monoglycosylsphingoid (*i.e.* not acylated). The use of this term is not encouraged (Lip-3.4 in [1]).

GL-2.6. Other names. Other terms such as fucoglycosphingolipid, mannoglycosphingolipid, xyloglycosphingolipid, etc., may be used when it is important to highlight a certain structural feature of the glycolipid.

GL-3. Principles of nomenclature

GL-3.1. Number of monosaccharide residues. The number of monosaccharide residues in an oligosaccharide is indicated by suffixes such as "diosyl", "triaosyl", "tetraosyl" etc. [1, 6]. Thus, the general name for the oligosaccharide residue of all glycosphingolipids containing ten monosaccharide residues is "glycodecaosyl"; it might be a glycodecaosylceramide or a 3-glycodecaosyl-1,2-diacyl-*sn*-glycerol.

Note 1. "diosyl" not "biosyl" is the correct suffix.

Note 2. The "a" in "tetraosyl", etc. is not elided in order to differentiate a tetrasaccharide residue (tetraosyl) from a four carbon sugar (tetrose), etc. The "a" in "triaosyl" is added for a similar reason.

Recommendations have been made for the nomenclature of oligosaccharides [3, 4].

GL-3.2. Naming of monosaccharide residues. Monosaccharide residues are named and abbreviated (Table 1) according to the proposed nomenclature recommendations for carbohydrates [4] (see also the nomenclature of glycoproteins [2]). The D and L configurational symbols are generally omitted; all monosaccharides are D with the exception of fucose and rhamnose which are L unless otherwise specified.

GL-3.3. Use of symbols for defining oligosaccharide structures. Using the condensed system of carbohydrate nomenclature (Ref. [2], section 3.7; Ref. [4], 2-Carb-38.5), positions of glycosidic linkages and anomeric configurations are expressed in parentheses between the monosaccharide residues that are thus linked. This principle should be adhered to in full names as well as the abbreviated structures. A "short form" for representing sequences more briefly can be used for specifying large structures. Positions of glycosidic linkages are still given, but the number of the anomeric carbon is omitted, since this is invariable for each monosaccharide, *i.e.* C-1 for Glc, etc.; C-2 for Neu5Ac, etc.

Example:

α-D-Gal*p*-(1→3)-α-D-Gal*p*- (extended form)

or

Gal(α1−3)Gal(α- (condensed form)

or

Galα3Galα- or Galα-3Galα- (short form).

Table 1. Recommended abbreviations for some monosaccharides, derivatives and related compounds.

Name	Symbol
N-acetylgalactosamine	GalNAc
N-acetylglucosamine	GlcNAc
N-acetylneuraminic acid[1]	Neu5Ac or NeuAc
5,9-*N*,*O*-diacetylneuraminic acid[1]	Neu5,9Ac$_2$
fucose (6-deoxygalactose)	Fuc
galactitol	Gal-ol
galactosamine	GalN
galactopyranose 3-sulfate	Gal*p*3*S*
galactose	Gal
galacturonic acid	GalA
glucitol	Glc-ol
glucosamine	GlcN
glucose	Glc
glucose 6-phosphate	Glc6*P*
glucuronic acid	GlcA
N-glycoloylneuraminic acid[1]	Neu5Gc or NeuGc
myo-inositol[2]	Ins
mannose	Man
4-*O*-methylgalactose	Gal4Me
rhamnose	Rha
xylose	Xyl

[1] Acylated neuraminic acids and other derivatives of neuraminic acid may also be called sialic acids (abbreviated Sia) when the nature of the *N*-acyl substituent(s) is not relevant, or is unknown [7].

[2] *myo*-Inositol with the numbering of the 1D configuration [8].

GL-3.4. Ring size and conformation. Ring size and conformation should be designated only when firmly established from NMR or other experimental data. Previously published recommendations on the specification of conformation should be consulted [9, 10].

Example:

α-D-galactopyranosyl-$^{4}C_{1}$-(1→3)-α-D-galactopyranosyl-$^{4}C_{1}$-

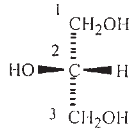
or

Gal*p*$^{1}C_{1}\alpha$3Gal*p*$^{4}C_{1}\alpha$-.

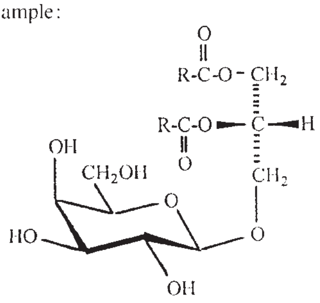
Subsequently, examples will usually be in the more traditional form with parentheses and both anomeric locants, as for example Gal(β1−4)Glc-, but it is understood that the short form (*i.e.* Galβ4Glc-) is also acceptable.

GL-4. Classification of glycolipids based on their lipid moieties

GL-4.1. Glycoglycerolipids. Esters, ethers and glucose derivatives of glycerol are designated by a prefix, denoting the substituent, preceded by a locant. As previously discussed in detail [1], the carbon atoms of glycerol are numbered stereospecifically, with carbon atom 1 at the top of the formula shown below. To differentiate this numbering system from others that have been used, the glycerol is always accompanied by the prefix *sn* (for *s*tereospecifically *n*umbered, Lip-1.13 in [1]) in systematic and abbreviated names.



Example:

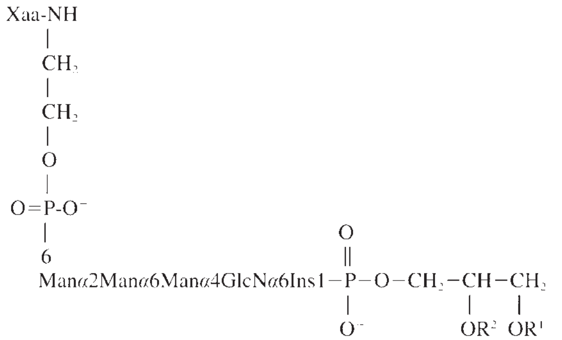


1,2-di-*O*-acyl-3-*O*-β-D-galactosyl-*sn*-glycerol

GL-4.2. Glycophosphatidylinositols

4.2.1. Glycophosphatidylinositol (GPI) nomenclature should incorporate the accepted IUPAC-IUB recommendations [1, 2] for the naming of phospholipids and the glycan portions of glycolipids or glycoproteins. While the diversity of glycophosphatidylinositol structures is only beginning to be realized (for reviews see [11, 12]), many appear to have a common "core".

"Core" structure of glycophosphatidylinositols



$$\text{Xaa-NH-CH}_2\text{-CH}_2\text{-O-P(=O)(O}^-\text{)-}6\,\text{Man}\alpha2\text{Man}\alpha6\text{Man}\alpha4\text{GlcN}\alpha6\text{Ins}1\text{-P(=O)(O}^-\text{)-O-CH}_2\text{-CH(OR}^2\text{)-CH}_2\text{OR}^1$$

Xaa = C-terminal residue
R = acyl, alkyl etc., side-chains

4.2.2. Glycophosphatidylinositols covalently attached to polypeptides are termed "GPI-anchors". Generally, such anchors are covalently attached to the C-terminus of a polypeptide *via* an amide linkage to 2-aminoethanol, which is linked to the terminal core mannose residue *via* a phosphodiester bond on O-6 of the mannose. A core Manα2Manα6Manα4GlcNα6 glycan structure is attached to the inositol (generally D-*myo*-inositol) of phosphatidylinositol. The non-acetylated GlcN is a characteristic feature of glycophosphatidylinositols. Anchor structures appear to vary considerably both in terms of modifications on the core glycan and with respect to additional modifications of the inositol residue. Free glycophosphatidylinositols have generically been termed "glycoinositolphospholipids" to distinguish them from those covalently attached to proteins or larger glycan structures.

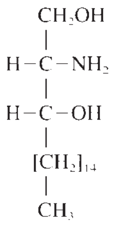
GL-4.3. Glycosphingolipids. 4.3.1. A glycosphingolipid is a carbohydrate-containing derivative of a sphingoid or ceramide. It is understood that the carbohydrate residue is attached by a glycosidic linkage to O-1 of the sphingoid.

4.3.2. Sphingoids are long-chain aliphatic amino alcohols. The basic chemical structure is represented by the compound originally called "dihydrosphingosine" [(2*S*,3*R*)-2-aminooctadecane-1,3-diol]. This sphingoid should now be referred to [1] as sphinganine (I).

The terms sphinganine, sphing-4-enine etc. imply a chain length of 18 carbon atoms. Chain-length homologs are named by the root chemical name of the parent hydrocarbon. For example, the sphingoid with 20 carbon atoms is icosasphinganine and the sphingoid with 14 carbon atoms is tetradecasphinganine.

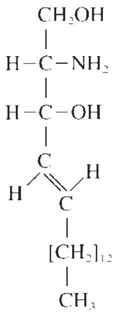
Unsaturated derivatives of sphinganine and other sphingoids should be defined in terms of the location and configuration of each olefinic center. The most commonly occurring unsaturated sphingoid was originally called "sphingosine" [(2*S*,3*R*,4*E*)-2-aminooctadec-4-ene-1,3-diol]. It should now be referred to as (*E*)-sphing-4-enine (II). The trivial name "sphingosine" can be retained. As a second example, a C_{18} sphingoid with two *trans* double bonds at 4,14 should be called (4*E*,14*E*)-sphinga-4,14-dienine.

Substituents such as hydroxy, oxo, methyl, etc. are referred to by appropriate suffixes that denote the position of each substituent. The sphingoid containing a hydroxyl group at C-4 of sphinganine was originally called phytosphingosine. According to the nomenclature adopted in 1976 [1], it should be called (2*S*,3*S*,4*R*)-2-aminooctadecane-1,3,4-triol. A trivial (but incorrect) name is (*R*)-4-hydroxysphinganine (III).



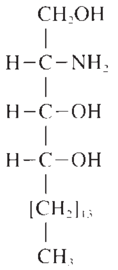
$$\text{CH}_2\text{OH-CH(NH}_2\text{)-CH(OH)-[CH}_2]_{14}\text{-CH}_3$$

I
sphinganine



$$\text{CH}_2\text{OH-CH(NH}_2\text{)-CH(OH)-CH=CH-[CH}_2]_{12}\text{-CH}_3$$

II
(*E*)-sphing-4-enine
(sphingosine)



$$\text{CH}_2\text{OH-CH(NH}_2\text{)-CH(OH)-CH(OH)-[CH}_2]_{13}\text{-CH}_3$$

III
(*R*)-4-hydroxy-sphinganine
(phytosphingosine)

4.3.3. Ceramides are *N*-acylated sphingoids. The fatty acids of naturally occurring ceramides range in chain length from about C_{16} to about C_{26} and may contain one or more double bonds and/or hydroxy substituents at C-2. The complete chemical name for a specific ceramide includes the sphingoid and fatty acyl substituents. For example, a ceramide containing 2-hydroxyoctadecanoic acid and sphing-4-enine should be called (*E*)-*N*-(2-hydroxyoctadecanoyl)sphing-4-enine.

GL-5. Neutral glycosphingolipids

GL-5.1. Monoglycosylceramides. The trivial name "cerebroside" was historically used for the substance from brain, β-galactosyl(1↔1)ceramide, and was later modified to include β-glucosyl(1↔1)ceramide from the spleen of a patient with Gaucher's disease. It has become a general term for these two kinds of monoglycosylceramides. However, since other monosaccharides are found in this class, the more structurally explicit terms such as glucosylceramide (GlcCer or better, Glcβ1Cer), galactosylceramide (GalCer), xylosylceramide (XylCer), etc. should be used.

GL-5.2. Diosylceramides. Diosylceramides may be named systematically, *e.g.* β-D-galactosyl-(1→4)-β-D-glucosyl-(1↔1)-ceramide. However, it is often more convenient to use the trivial name of the disaccharide and call the structure given above lactosylceramide (LacCer).

GL-5.3. Neutral glycosphingolipids with oligosaccharide chains

5.3.1. Systematic names for glycosphingolipids with larger oligosaccharide chains become rather cumbersome. It is therefore recommended to use semi-systematic names in which trivial names for "root" structures are used as a prefix. The recommended root names and structures are given in Table 2.

The name of a given glycosphingolipid is then composed of (root name)(root size)osylceramide. Thus, lactotetraosylceramide designates the second structure listed in Table 2 linked to a ceramide. When referring to particular glycose residues Roman numerals are used (Lip-3.9 in [1]), counting from the ceramide (see Table 2).

Table 2. Root names and structures.

Root	Symbol	Root structure
		`IV       III  II   I`
ganglio	Gg	Galβ3GalNAcβ4Galβ4Glc-
lacto[1]	Lc	Galβ3GlcNAcβ3Galβ4Glc-
neolacto[2]	nLc	Galβ4GlcNAcβ3Galβ4Glc-
globo	Gb	GalNAcβ3Galα4Galβ4Glc-
isoglobo[2]	iGb	GalNAcβ3Galα3Galβ4Glc-
mollu	Mu	GlcNAcβ2Manα3Manβ4Glc-
arthro	At	GalNAcβ4GlcNAcβ3Manβ4Glc-

[1] Lacto as used here should not be confused with lactose.

[2] *Note:* The prefix "iso" is used here to denote a (1→3) *vs* (1→4) difference in the linkage position between the monosaccharide residues III and II, while the term "neo" denotes such a difference [(1→4) *vs* (1→3)] between residues IV and III. This scheme should be used also in other cases where such positional isomers occur, and only in such cases.

The use of the prefix "nor" for unbranched oligosaccharide chains should be abandoned since this prefix has a well-defined meaning ("one carbon atom less") in organic chemistry nomenclature.

5.3.2. The root name applies also to structures that are shorter than the root given in Table 2. Thus, gangliotriaosylceramide is the name for the structure GalNAcβ4Galβ4GlcCer, where the fourth, terminal residue is missing. The trisaccharides obtained from the lacto and neolacto series are identical and in this case the former (shorter) name should be used.

5.3.3. In the lacto series, the residues III and IV can form a repeating unit. Thus, names like neolactohexaosylceramide (not recommended) have been used, even though the chemical nature of the two glycose residues at the non-reducing end are not explicit in the name.

β-D-Gal*p*-(1→4)-β-Glc*p*NAc-(1→3)-β-D-Gal*p*-(1→4)-β--Glc*p*NAc-(1→3)-β-D-Gal*p*-(1→4)-β-D-Glc*p*-(1↔1)Cer

or

Galβ4GlcNAcβ3Galβ4GlcNAcβ3Galβ4GlcCer

or

Galβ-4GlcNAcβ-3Galβ-4GlcNAcβ-3Galβ-4GlcCer.

The correct name is β-(*N*-acetyllactosaminyl)-(1→3)-neolactotetraosylceramide, where *N*-acetyllactosaminyl is β-D-Gal*p*-(1→4)-D-GlcNAc-.

5.3.4. Substances containing glycose residues that are not part of a root structure should be named by referral to the root oligosaccharide and locating the additional substituents by a Roman numeral designating the position of the substituent in the root oligosaccharide (counting from the ceramide end) to which the substituent is attached, with an arabic numeral superscript indicating the position on that residue which is substituted. The anomeric configuration should also be specified.

Examples:

(i) III^{2}-α-fucosylglobotriosylceramide

or

Fucα2Galα4Galβ4GlcCer

or

III^{2}-α-Fuc-Gb$_{3}$Cer

(ii) II^{2}-β-xylosylmollutetraosylceramide

or

GlcNAcβ2Manα3(Xylβ2)Manβ4GlcCer

or

II^{2}-β-Xyl-Mu$_{4}$Cer

5.3.5. Branched structures should be designated in a systematic manner, locating substituents in correlation with the Haworth structure of the multiply substituted monosaccharide. This principle should be applied in full structures as well as linear formulations, wherein substituents are in one or more sets of square brackets. Such names and abbreviations should refer to the substituent on the highest carbon number of the branched monosaccharide first, and proceed toward the substituent on the lowest carbon number. This recommendation is consistent with the nomenclature of glycoproteins, glycopeptides and peptidoglycans [2] although not explicitly stated therein.

Note. When root names (see GL-5.3.1) are used, the branches should be treated as side chains and named accordingly even when linked to a carbon atom with a higher number than the member of the root oligosaccharide. In oligosaccharide nomenclature [4] the longest chain is the parent structure. If two chains are of equal length the one with lower locants at the branch points is preferred, although some oligosaccharides are traditionally depicted otherwise – frequently NeuAc and Fuc derivatives.

Example:

```
GalNAcβ4Galβ4Glc-
         |
  Neu5Acα3
```

or

GalNAcβ4(Neu5Acα3)Galβ4Glc-.

Otherwise in [4]: Neu5Acα3(GalNAcβ4)Galβ4Glc-

or

II3-α-Neu5Ac-Gg$_{3}$-

GL-6. Acidic glycosphingolipids

GL-6.1. Gangliosides. Gangliosides are sialoglycosphingolipids. They are named as *N*-acetyl- or *N*-glycoloyl-neuraminosyl derivatives of the corresponding neutral glycosphingolipid, using the nomenclature given in GL-5.3. The position of the sialic acid residue(s) is indicated in the same way as is the case of a branched structure.

Example:

IV^{3}-α-*N*-glycoloylneuraminosyl-II^{3}-α-*N*-acetylneuraminosylgangliotetraosylceramide

or

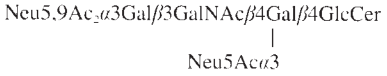
```
Neu5Gcα3Galβ3GalNAcβ4Galb4GlcCer
                          |
                  Neu5Acα3
```

or

IV^{3}-α-Neu5Gc,II^{3}-α-Neu5Ac-Gg$_{4}$Cer.

Gangliosides containing neuraminic acid residues (with *O*-acyl or other substituents) should be named accordingly, with the positions of the substituents given.

Example:
$\mathrm{IV^3}$-*α*-*N*-acetyl-9-*O*-acetylneuraminosyl,$\mathrm{II^3}$-*α*-*N*-acetylneuraminosylgangliotetraosylceramide
or



$$\mathrm{Neu5{,}9Ac_2\alpha3Gal\beta3GalNAc\beta4}\underset{\underset{\mathrm{Neu5Ac\alpha3}}{|}}{\mathrm{Gal}}\mathrm{\beta4GlcCer}$$

or
$\mathrm{IV^3}$-*α*-Neu5,9Ac2,$\mathrm{II^3}$-*α*-Neu5Ac-Gg4Cer.

GL-6.2. Glycuronoglycosphingolipids. These are best named according to the guidelines of GL-5.2 and GL-5.3. Special root names have not yet been assigned.

GL-6.3. Sulfoglycosphingolipids. These are glycosphingolipids carrying a sulfate ester group, formerly called "sulfatides". They are sometimes termed sulfatoglycosphingolipids.

Sulfoglycosphingolipids may also be named as sulfate esters (sulfates) of the neutral glycosphingolipids (see GL-5).

Example:
$\mathrm{II^3}$-sulfo-LacCer
or
lactosylceramide $\mathrm{II^3}$-sulfate.

GL-6.4. Phosphoglycosphingolipids. Two types of glycosphingolipids containing phosphodiester bonds are known: (i) those containing a 2-aminoethyl phosphate residue esterified to a monosaccharide residue, and (ii) those with a phosphodiester bridge between an inositol residue and the ceramide moiety.

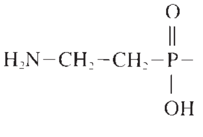
Those of the first type can be easily named by analogy to the sulfoglycosphingolipids.

Example:
$\mathrm{III^6}$-(2-aminoethanolphospho)arthrotriaosylceramide
or
6(Etn*P*)-GlcNAcβ3Manβ4GlcCer
or
$\mathrm{III^6}$-Etn-*P*-At3Cer.

The second type can be named as inositolphosphoceramide derivatives

Example:
α-(*N*-acetyllactosaminyl)-(1→4)-*α*-glucuronosyl-(1→2)-inositolphosphoceramide
or
Galβ4GlcNAcα4GlcAα2Ins-1-*P*-Cer.

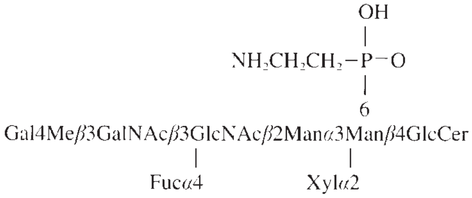
GL-6.5. Phosphonoglycosphingolipids. These are glycolipids esterified with an alkylphosphono acid, *i.e.* a compound containing a C-P bond. Their nomenclature is best derived using the prefix phosphoryl that denotes the trivalent radical O=P←. The residue



$$\mathrm{H_2N{-}CH_2{-}CH_2{-}}\overset{\overset{\mathrm{O}}{\|}}{\underset{\underset{\mathrm{OH}}{|}}{\mathrm{P}}}{-}$$

may be termed (2-aminoethyl)hydroxyphosphoryl. The location of this group is given in the same way as other ester groups.

Example:
(4-*O*-methyl-*β*-D-galactopyranosyl)-(1→3)-(2-acetamido-2-deoxy-*β*-D-galactopyranosyl)-(1→3)-[*α*-L-fucopyranosyl-(1→4)]-(2-acetamido-2-deoxy-*β*-D-glucopyranosyl)-(1→2)-*α*-D-mannopyranosyl-(1→3)-[*α*-D-xylopyranosyl-(1→2)]-6-[(2-aminoethyl)hydroxyphosphoryl]-*β*-D-mannopyranosyl-(1→4)-*β*-D-glucopyranosyl-(1↔1)-ceramide
or
$\mathrm{Gal4Me\beta3GalNAc\beta3(Fuc\alpha4)GlcNAc\beta2Man\alpha3(Xyl\alpha2)\text{-}6[NH_2{-}CH_2CH_2{-}P(OH){=}O]Man\beta4GlcCer}$
or



$$\mathrm{Gal4Me\beta3GalNAc\beta3}\underset{\underset{\mathrm{Fuc\alpha4}}{|}}{\mathrm{GlcNAc}}\mathrm{\beta2Man\alpha3}\overset{\overset{\overset{\overset{\mathrm{OH}}{|}}{\mathrm{NH_2CH_2CH_2{-}P{-}O}}}{|}}{6}{\underset{\underset{\mathrm{Xyl\alpha2}}{|}}{\mathrm{Man}}}\mathrm{\beta4GlcCer}$$

GL-7. Short abbreviations

There are no easy solutions to the dilemma that has arisen from the discovery of so many (nearly 300) glycosphingolipids of diverse structures. Short abbreviations are so attractive that a logical system, with broad application to more complex compounds, is desirable.

GL-7.1. Recommended abbreviations. A system already used (GL-5.3) is based on the abbreviated root names of the oligosaccharide structures. The full root structures are tetrasaccharides, and sequential removal of terminal monosaccharide residues gives smaller, precisely defined structures. Elongation of root tetrasaccharides is on the other hand undefined and hence ambiguous. The root name may be used, followed by an arabic number indicating the total number of monosaccharide residues. A lower case letter can be added to differentiate between particular compounds.

Examples:
(i) Galβ3GalNAcβ3Galα4Galβ4GlcCer
or
$\mathrm{IV^3}$-*β*-Gal-$\mathrm{Gb_4Cer}$
(ii) GalNAcα3GalNAcβ3Galα4Galβ4GlcCer
or
$\mathrm{IV^3}$-*α*-GalNAc-$\mathrm{Gb_4Cer}$.

Either of these compounds could, after definition, be referred to as $\mathrm{Gb_5Cer}$. In the presence of both structures the abbreviations $\mathrm{Gb_{5a}}$ and $\mathrm{Gb_{5b}}$ may be defined and used. It is recommended that the use of "Ose", as in $\mathrm{GbOse_4Cer}$, be discontinued. Since this short form sometimes leads to ambiguities, the full structure should be given once in a paper or in a footnote, using the abbreviated form according to GL-5.3.

GL-7.2. The Svennerholm abbreviations for brain gangliosides. In this system, the fact that we are dealing with gangliosides is indicated by the letter G, the number of sialic acid residues is stated by M for mono-, D for di-, T for tri- and Q for tetra-sialoglycosphingolipids. A number is then assigned to the individual compound which referred initially to its migration order in a certain chromatographic system [13].

Though these designations are far from being systematic, and it is impossible to derive the structure from them, they have the advantage of being short and well understood since they have been in use for a long time. A list of these abbreviations is given in Table 3.

Table 3. Some abbreviations using the Svennerholm system.

Structure	Abbreviation*
Neu5Acα3Galβ4GlcCer	GM3
GalNAcβ4(Neu5Acα3)Galβ4GlcCer	GM2
Galβ3GalNAcβ4(Neu5Acα3)Galβ4GlcCer	GM1a
Neu5Acα3Galβ3GalNAcβ4Galβ4GlcCer	GM1b
Neu5Acα8Neu5Acα3Galβ4GlcCer	GD3
GalNAcβ4(Neu5Acα8Neu5Acα3)Galβ4GlcCer	GD2
Neu5Acα3Galβ3GalNAcβ4(Neu5Acα3)Galβ4GlcCer	GD1a
Galβ3GalNAcβ4(Neu5Acα8Neu5Acα3)Galβ4GlcCer	GD1b
Neu5Acα8Neu5Acα3Galβ3GalNAcβ4(Neu5Acα3)- -Galβ4GlcCer	GT1a
Neu5Acα3Galβ3GalNAcβ4(Neu5Acα8Neu5Acα3)- -Galβ4GlcCer	GT1b
Galβ3GalNAcβ4(Neu5Acα8Neu5Acα8Neu5Acα3)- -Galβ4GlcCer	GT1c
Neu5Acα8Neu5Acα3Galβ3GalNAcβ4- -(Neu5Acα8Neu5Acα3)Galβ4GlcCer	GQ1b

* Previously written using subscripts, e.g. G$_{M3}$, etc.

Since there is no clear-cut system in these abbreviations, it is not recommended to extend the list by coining new symbols of this kind. As a result, the following two cases are examples of abbreviations that should not be used.

1) A disialoganglioside, Neu5Acα3Galβ3(Neu5Acα6)GalNAc-β4Galβ4GlcCer, has been abbreviated GD1α. This practice should be discontinued. The recommended abbreviation for this compound is IV^3-α-Neu5Ac,III^6-α-Neu5Ac-Gg$_4$Cer.
2) The system has been extended to gangliosides of other "root" types, such as those derived from lactotetraosylceramide. An example of this kind is the widely distributed ganglioside called sialoparagloboside, Neu5Acα3Galβ4GlcNAcβ3-Galβ4GlcCer, which has at times been abbreviated LM1, but should be referred to as IV^3-α-Neu5Ac-nLc$_4$Cer.

Attempts to abbreviate more complex glycosphingolipids derived from these examples have resulted in other illogical abbreviations, such as Fuc-3′-LM1 for Neu5Acα3Galβ4-(Fucα3)GlcNAcβ3Galβ4GlcCer (IV^3-α-Neu5Ac,III^3-α-Fuc-nLc$_4$Cer).

More information on the structures of various glycolipids and the biological material from which they were obtained may be found in several reviews [14−16].

GL-8. References

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