

1.03 Glycosphingolipid Structures

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1.03.1 Introduction	73
1.03.2 General Structure	73
1.03.2.1 Ganglio-Series GSLs (Gg)	73
1.03.2.2 Lacto- (Neolacto-)Series GSLs (Lc and nLc)	74
1.03.2.3 Globo- (Isoglobo-)Series GSLs (Gb and iGb)	74

1.03.1 Introduction

Glycosphingolipids (GSLs) are located primarily, but not exclusively, in the outer leaflet of the plasma membrane. Their occurrence displays considerable cellular and subcellular specificity. Furthermore, they are known to undergo remarkable changes during development, cellular differentiation, and proliferation. The structural diversity of GSLs renders them ideally suited as candidates to participate in cellular recognition, adhesion, and signaling. For these reasons, interest has been focused on their biological functions.⁷ Thus, GSLs serve not only as markers for cells at specific developmental stages, but they also serve as molecules that modulate cellular events. In addition, GSLs are important components of the mammalian immune defense system, either as immunogens or antigens. Certain GSLs are involved in the antigenicity of blood group determinants. Antibodies to GSLs have been implicated in certain immune-mediated autoimmune diseases.¹ In addition, GSLs can modify the activity of membrane receptors, such as those for insulin, epidermal growth factor, and nerve growth factor. A large number of signaling molecules and GSLs are co-localized in specialized membrane domains, such as the lipid rafts or caveolae that are liquid-ordered membrane microdomains with specialized properties.⁵ Some of the biological functions of GSLs have been reviewed in recent literature.^{2,7} However, to understand their biological functions, it is of utmost importance to have a thorough understanding of their molecular structures.

1.03.2 General Structure

GSLs are composed of a hydrophobic ceramide (Cer) moiety and a hydrophilic carbohydrate portion. Since they share a common hydrophobic structure, they are generally classified according to the sequence, linkage, and anomeric configuration of the component monosaccharide residues. Heterogeneity and diversity of the carbohydrate molecular structure are hallmarks of GSLs. Most of the mammalian GSLs, including sialic acid-containing GSLs (gangliosides), are derived from glucosylceramide (GlcCer). However, some GSLs are derived from galactosylceramide (GalCer), which leads to the formation of a relatively small number of gala-series GSLs. Most of the major GSLs derived from GlcCer are divided into major three classes: the ganglio-series, the lacto- and neolacto-series, and the globo- and isoglobo-series; each of these groups is described below and members of the molecular structures are presented in [Table 1](#).

1.03.2.1 Ganglio-Series GSLs (Gg)

In this series, LacCer (lactosylceramide) is first derived from GlcCer and converted to GgOse₃Cer by the addition of a β 1-4-linked *N*-acetylgalactosamine (GalNAc) residue followed by the addition of a β 1-3-linked galactose (Gal), fucose (Fuc), and sialic acid (*N*-acetylneuraminic acid (NeuAc) or *N*-glycolylneuraminic acid (NeuGc)). The ganglio-series GSLs share the following common core structure: GalNAc β 1-4Gal β 1-4Glc β 1-1'Cer. An α 2-3-linked sialic acid residue can be attached directly to LacCer, catalyzed by a sialyltransferase (ST-I), to produce ganglioside GM3. Further extension of the GM3 structure results in the formation of hemato-series gangliosides that are devoid of the β 1-4-linked GalNAc residue.

Table 1 Representative series of carbohydrate structures of glycosphingolipids

<i>Series</i>	<i>Structure</i>	<i>Abbreviation</i>
Gala	Gal β 1-1' Cer	GalCer
Hemato	Gal β 1-4 Glc β 1-1' Cer	LacCer
Ganglio	GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	Gg ₃ Cer
	Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	Gg ₄ Cer
Isoganglio	GalNAc β 1-4 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	Gg ₅ Cer
	Gal β 1-3 GalNAc β 1-4 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	Gg ₆ Cer
	Gal β 1-3 GalNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	iGg ₄ Cer
	GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Lc ₃ Cer
	Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Lc ₄ Cer
Neolacto	Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Lc ₆ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	nLc ₄ Cer
Lactoganglio	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	nLc ₆ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	II ⁶ kladoLc ₆ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	IV ⁶ kladoLc ₆ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	IV ⁶ kladoLc ₈ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	IV ⁶ kladoLc ₈ Cer
	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	IV ⁶ kladoLc ₈ Cer
Lactoganglio	GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	LcGg ₄ Cer
	GlcNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	LcGg ₅ Cer
Globo	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Gb ₃ Cer
	Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	Gb ₄ Cer
	GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	Gb ₅ Cer
Isoglobo	Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	Gb ₅ Cer
	Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer	iGb ₃ Cer
Muco	GalNAc β 1-3 Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer	iGb ₄ Cer
	Gal β 1-3 GalNAc β 1-3 Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer	iGb ₅ Cer
	Gal β 1-4 Gal β 1-4 Glc β 1-1' Cer	Mc ₃ Cer
	Gal β 1-3 Gal β 1-4 Gal β 1-4 Glc β 1-1' Cer	Mc ₄ Cer

1.03.2.2 Lacto- (Neolacto-)Series GSLs (Lc and nLc)

The biosynthesis of the lacto-series GSLs begins when LacCer is converted to LcOse₃Cer. LcOse₃Cer is further extended by the addition of a β 1-3-linked galactose residue, followed by the addition of fucose, *N*-acetylglucosamine (GlcNAc), and sialic acid (NeuAc or NeuGc) to form the lacto-series GSLs that have the following basic core structure: GlcNAc β 1-3Gal β 1-4Glc β 1-1'Cer. On the other hand, a β 1-4-linked galactose (instead of β 1-3-linked galactose) residue can be attached to LcOse₃Cer to form the neolacto-series GSLs (nLc) with the following core structure: Gal β 1-4GlcNAc β 1-3Gal β 1-4Glc β 1-1'Cer). Although not included in this chapter, a group of huge GSLs containing 30–60 carbohydrates (macroglycolipids, megaloglycolipids, or poly(glycosyl)ceramides) belongs to the neolacto-series.^{3,6,8}

1.03.2.3 Globo- (Isoglobo-)Series GSLs (Gb and iGb)

LacCer is converted to GbOse₃Cer (P^k antigen) by the addition of an α 1-4-linked galactose residue, which can be extended by addition of galactose, GalNAc, GlcNAc, fucose, and sialic acid residues to form the globo-series GSLs (Gb) with the following core structure: Gal α 1-4Gal β 1-4Glc β 1-1'Cer. On the other hand, addition of an α 1-3-linked

Table 2 Carbohydrate structures of neutral glycosphingolipids

<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
Glc β 1-1' sphingosine	Psychosine	Glc-sphingosine	Gaucher disease	110
Glc β 1-1' Cer	Glucosylceramide, glucosylcerebroside	GlcCer	Human, bovine, equine spleen, Gaucher disease	101, 144, 110
(2- <i>O</i> -acyl)Glc β 1-1' Cer		GlcCer (Acyl- <i>O</i> -2)	Alaskan pollack brain	147
(3- <i>O</i> -acyl)Glc β 1-1' Cer		GlcCer (Acyl- <i>O</i> -3)	Porcine and human epidermis, Alaskan pollack brain	60, 147
(6- <i>O</i> -acyl)Glc β 1-1' Cer		GlcCer (Acyl- <i>O</i> -6)	Gaucher disease spleen, Alaskan pollack brain	103, 147
Fuc α 1-1' Cer	Fucosylceramide	FucCer	Human colon tumor	155
Xyl β 1-1' Cer	Xylosylceramide	XylCer	Herring gull salt gland	86
Gala series				
Gal β 1-1' sphingosine	Psychosine	Gal-sphingosine	Krabbe disease	108, 153
Gal β 1-1' (3- <i>O</i> Ac)sphingosine	Galactosyl 3- <i>O</i> -acetyl- sphingosine		Rat brain myelin	47
Gal β 1-1' (3- <i>O</i> -acyl)sphingosine	Galactosyl 3- <i>O</i> -acyl- sphingosine		Brain	90
(3,4-Cyclic acetal)Gal β 1-1' sphingosine	Psychosine (fatty aldehyde); plasmalopsychosine A		Human brain	116
(4,6-Cyclic acetal)Gal β 1-1' sphingosine	Psychosine (fatty aldehyde); plasmalopsycosine B		Human brain	116
Gal β 1-1' Cer	Galactosylceramide, galactocerebroside	GalCer	Brain, Myelin sheath, Mouse cerebellar cells	149, 119, 22
Gal β 1-1' (3- <i>O</i> -acyl)Cer	Galactosyl 3- <i>O</i> -acyl-Cer		Brain	90
Gal β 1-1' (3- <i>O</i> -alkyl)Cer	Galactosyl 3- <i>O</i> -alkyl-Cer		Bovine brain	92
(2- <i>O</i> -acyl)Gal β 1-1' Cer		GalCer (Acyl- <i>O</i> -2)	Whale brain, Alaskan pollack brain	158, 147
(3- <i>O</i> -acyl)Gal β 1-1' Cer		GalCer (Acyl- <i>O</i> -3)	Alaskan pollack brain	147
(4- <i>O</i> -acyl)Gal β 1-1' Cer		GalCer (Acyl- <i>O</i> -4)	Alaskan pollack brain	147

(continued)

Table 2 (continued)

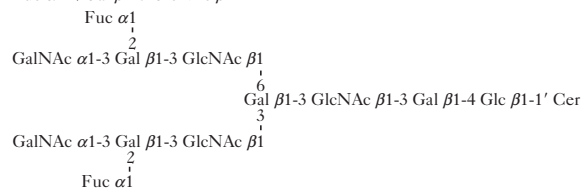
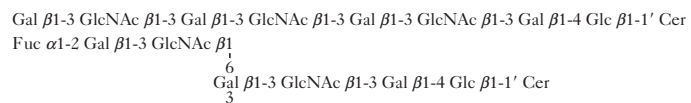
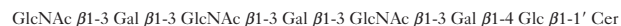
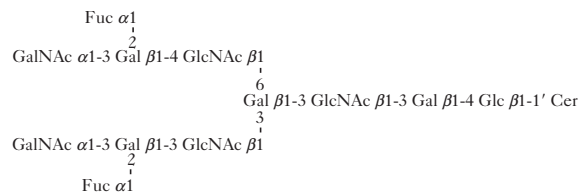
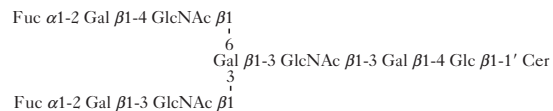
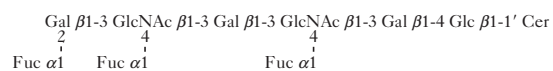
<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
(6- <i>O</i> -acyl)Gal β 1-1' Cer		GalCer (Acyl-O-6)	Whale brain, Alaskan pollack brain	158, 147
Gal α 1-4 Gal β 1-1' Cer	Digalactosyl ceramide, CDG	Gal ₂ Cer	Fabry disease	67, 107, 105
GalNAc α 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-1' Cer		II ³ (GalNAc α 1- 3GalNAc β)- Gal ₂ Cer	Hamster fibroblasts	58
Hemato series				
Gal β 1-4 Glc β 1-1' Cer	Lactosylceramide, cytolipin H	LacCer	Bovine spleen, human leukocytes	89, 76
Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Fuc-LacCer, blood group H	II ² Fucz-LacCer	Rat intestine	27
GalNAc α 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group A	II ³ GalNAc α , II ² Fucz-LacCer	Rat intestine	29
Ganglio series				
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' sphingosine	Lyso-GA2		GM2 gangliosidosis (Tay-Sachs disease and Sandhoff disease)	91
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' sphingosine	Asialo-GM2, GA2 Lyso-GA1	Gg ₃ Cer	Tay-Sachs disease GM2 gangliosidosis (Tay-Sachs disease and Sandhoff disease)	102 91
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	Asialo-GM1, GA1	Gg ₄ Cer	Lymphoma cells, human brain myelin, bovine brain	152, 96, 44
GalNAc β 1-4 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GalNAc-GA1	IV ⁴ GalNAc β -Gg ₄ Cer	Bovine brain	46
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group H	IV ² Fucz-Gg ₄ Cer	Rat hepatoma cells	145

Gal α 1-3 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	B-GA1	IV ³ Gal α , IV ² Fuc α -Gg ₄ Cer	Rat bone marrow cells, spleen, thymus, ascites hepatoma cells, rat gastric mucosa, rat RG2 glioma	146, 75, 140
GlcNAc β 1-3 Gal α 1-3 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1		IV ³ (GalNAc β 1-3Gal α), IV ² Fuc α -Gg ₄ Cer	Rat testis	148
Isoganglio series Gal α 1-3 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group B, glycolipid X	IV ³ Gal α , IV ² Fuc α -iGg ₄ Cer	Rat granuloma and abnormal macrophage	66
Lacto series GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Amino CTH lacto- <i>N</i> -triose II	Lc ₃ Cer	Human erythrocytes, human leukemia cells	11, 80
GlcNH ₂ β 1-3 Gal β 1-4 Glc β 1-1' Cer	Lacto- <i>N</i> -triose II (de- <i>N</i> -acetyl)	De- <i>N</i> -acetyl-Lc ₃ Cer	Human brain, Bovine brain white matter	77, 78
GalNAc α 1-3 Gal β 1-4 GalNAc β 1-3 Gal α 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group A		Human erythrocytes	35
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Type 1	Lc ₄ Cer	Human meconium	87
Gal α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group H	IV ³ Gal α -Lc ₄ Cer IV ² Fuc α -Lc ₄ Cer	Rabbit erythrocytes Human pancreas, human meconium, human small intestine	52 28, 88, 33
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Lewis ^a	III ⁴ Fuc α -Lc ₄ Cer	Human meconium	88
Gal α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group B	IV ³ Gal α , IV ² Fuc α -Lc ₄ Cer	Fabry disease spleen	157
GalNAc α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	A; ALewis ^a , type 1 mono-fucosyl, Le ^{a-b} ; AH21	IV ³ GalNAc α , IV ² Fuc α -Lc ₄ Cer	Hog gastric mucosa, rat intestine, human gastric cancer cell line, human erythrocytes	125, 30, 10, 38, 65

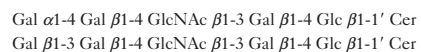
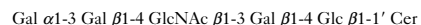
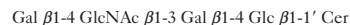
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Table 2 (continued)

Structure	Name	Abbreviation	Source	References
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^b	IV ² , III ⁴ Fuc α 2-Lc ₄ Cer	Human intestine, erythrocytes	36, 50
Gal α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	BLewis ^b	IV ³ Gal α , IV ² , III ⁴ Fuc α 2-Lc ₄ Cer	Human intestine	31
GalNAc α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Blood group A; ALe ^b , type 1 di-fucosyl; Le ^{a-b+} ; HH3	IV ³ GalNAc α , IV ² , III ⁴ Fuc α 2-Lc ₄ Cer	Human intestine, dog intestine, human erythrocytes	106, 39
GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		Lc ₅ Cer	Human leukemia cells	80
Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		V ⁴ Gal β -Lc ₅ Cer	Human meconium	88
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		IV ⁴ (Gal β 1-4GlcNAc β 1-3Gal β)-Lc ₅ Cer	Human meconium	88
Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Blood group H	V ⁴ (Fuc α 1-2Gal β)-Lc ₅ Cer	Human meconium	88
Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^x	V ⁴ Gal β , V ³ Fuc α -Lc ₅ Cer	Human meconium	88
Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^y	V ⁴ (Fuc α 1-2Gal β), V ³ Fuc α -Lc ₅ Cer	Human meconium	88
Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^y	V ⁴ (Fuc α 1-2Gal β), V ³ , III ⁴ Fuc α 2-Lc ₅ Cer	Human meconium	88
Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		Lc ₆ Cer	Human cancer tissues	137
Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^a	V ⁴ Fuc α -Lc ₆ Cer	Human cancer tissues	137
Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$		III ⁴ Fuc α -Lc ₆ Cer	Human cancer tissues	137
GalNAc α 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$	A ^b , type 1 repeat	VI ³ GalNAc α , VI ² Fuc α -Lc ₆ Cer	Human erythrocytes, rat intestine	94, 24
Gal β 1-3 GlcNAc β 1-3 Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 4 \\ \\ \text{Fuc } \alpha 1 \end{array}$	Lewis ^a , extended type 1 chain	V ⁴ , III ⁴ Fuc α 2-Lc ₆ Cer	Human colonic adenocarcinoma	137, 139



Neolacto series



Lewis ^b , extended type1 chain	VI ² , V ⁴ , III ⁴ Fucz ₃ . Lc ₆ Cer	Human colonic adenocarcinoma	138
Blood group H	VI ² Fucz, IV ⁶ (Fucz1-2Galβ1-4GlcNAcβ)-Lc ₆ Cer	Rat intestine	30
Blood group A	VI ³ GalNAcz, VI ² Fucz, IV ⁶ [GalNAcz1-3(Fucz1-2)Galβ1-4GlcNAcβ]-Lc ₆ Cer	Rat intestine	74
	Lc ₇ Cer	Human leukemia cells	80
	Lc ₈ Cer	Human meconium	88
Blood group H		Rat intestine	32
Blood group A		Rat intestine	74
Type 2, paragloboside	nLc ₄ Cer	Human erythrocytes, hamster NIPY tumor	12, 141
	IV ³ Galz-nLc ₄ Cer	Rabbit erythrocytes, human erythrocytes, rabbit erythrocytes	135, 159
P ₁ antigen	IV ⁴ Galz-nLc ₄ Cer IV ³ Galβ-nLc ₄ Cer	Human erythrocytes Human erythrocytes	109 136

(continued)

Table 2 (continued)

<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
Gal β 1-4 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		IV ⁴ Gal β -nLc ₄ Cer	Ostrich liver	26
GalNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		IV ³ GalNAc β -nLc ₄ Cer	Human erythrocytes	81
GalNAc β 1-3 Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		IV ³ (GalNAc β 1-3Gal α)-nLc ₄ Cer	Rat colon	150
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	H1 glycolipid	IV ² Fucz-nLc ₄ Cer	Human erythrocytes, dog small intestine, bovine erythrocytes	93, 134, 151, 9
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Lewis ^x , SSEA-1, X hapten	III ³ Fucz-nLc ₄ Cer	Human tumor, hog gastric mucosa, human and dog intestine, human cataract lenses, glioma cells	61, 125, 106, 18, 19
Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	B-I antigen	IV ³ Galz, IV ² Fucz-nLc ₄ Cer	Fabry disease pancreas, human erythrocytes, bovine erythrocytes, Fabry and Schindler disease skin fibroblasts	157, 93, 69, 151, 21
Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Gal-Lewis ^x	IV ³ Galz, III ³ Fucz-nLc ₄ Cer	Pig kidney	25
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Type 2, A ^a , blood group A; A ^a	IV ³ GalNAcz, IV ² Fucz-nLc ₄ Cer	Hog gastric mucosa, human erythrocytes, Fabry and Schindler disease skin fibroblasts	125, 62, 65, 95, 21
GalNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	GalNAc-Lewis ^x	IV ³ GalNAc β , III ³ Fucz-nLc ₄ Cer	Human cataractous lenses	18
Gal β 1-3 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1		IV ³ (Gal β 1-3GalNAcz), IV ² Fucz-nLc ₄ Cer	Human erythrocytes	43
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	Lewis ^y	IV ² , III ³ Fucz ₂ -nLc ₄ Cer	Human and dog intestine, human colonic cancer	106, 9

Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	Blood group B	IV ³ Galz, IV ² , III ³ Fucz-nLc ₄ Cer	Rat colon	15, 79
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	Blood group A	IV ³ GalNAcz, IV ² , III ³ Fucz ₂ -nLc ₄ Cer	Hog gastric mucosa	126
Gal β 1-3 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	Type 3 chain H	IV ³ (Fucz1-2Gal β 1-3GalNAcz), IV ² Fucz-nLc ₄ Cer	Human erythrocytes	41
GalNAc α 1-3 Gal β 1-3 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	Type 3 A	IV ³ [GalNAcz1-3(Fucz1-2)Gal β 1-3GalNAcz], IV ² Fucz-nLc ₄ Cer	Human erythrocytes	40
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	Le ^a type 1	V ³ Gal β -nLc ₅ Cer	Human cancer tissues	137
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Le ^a type 1	V ⁴ Fucz, III ³ Fucz β -nLc ₅ Cer	Human erythrocytes	93, 85
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1		V ³ Gal β , V ³ Gal β -nLc ₅ Cer	Human cancer tissues	137
Gal β 1-3 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 Fuc α 1	DifucosylLe ^a , x	V ⁴ Fucz, V ³ Gal β , III ³ Fucz-nLc ₅ Cer	Human squamous lung cancer	104
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	i antigen	nLc ₆ Cer	Bovine erythrocytes, human erythrocytes	151, 117
Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1		VI ³ Galz-nLc ₆ Cer III ³ Fuc-nLc ₆ Cer	Bovine erythrocytes Human gastric cancer cells	151 57, 114
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Lewis ^x , SSEA-1	V ³ Fucz-nLc ₆ Cer	Human erythrocytes	82, 56
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	H2	VI ² Fucz-nLc ₆ Cer	Human erythrocytes	93, 151, 65
Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	B-II antigen	VI ³ Galz, VI ² Fucz-nLc ₆ Cer	Human erythrocytes	93, 68
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Blood group A; A ^b	VI ³ GalNAcz, VI ² Fucz-nLc ₆ Cer	Human erythrocytes, rat intestine	62, 65, 35, 95, 24

(continued)

Table 2 (continued)

Structure	Name	Abbreviation	Source	References
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Lewis ^x , SSEA-1, type 2	V ³ , III ³ Fuc α ₂ -nLc ₆ Cer	Human adenocarcinoma, human cataract lenses and glioma cells	57, 64, 18, 19
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Lewis ^y	VI ² , V ³ Fuc α ₂ -nLc ₆ Cer	Human adenocarcinoma	99, 113
GalNAc α 1-3 Gal β 1-3 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Type 3; A ^b	VI ³ [GalNAc α 1-3 (Fuc α 1-2)Gal β 1-3GalNAc], VI ² Fuc α -nLc ₆ Cer	Human erythrocytes	42
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Lewis ^y	VI ² , V ³ , III ³ Fuc α ₃ -nLc ₆ Cer	Human adenocarcinoma	99, 113
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		nLc ₈ Cer	Human granulocytes	56
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div>	Lewis ^x , SSEA-1	VII ³ Fuc α -nLc ₈ Cer	Human erythrocytes	82, 56
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="text-align: center;"> $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div>	Blood group A; nor-A ^c	VIII ³ GalNAc α , VIII ² Fuc α -nLc ₈ Cer	Human erythrocytes	42, 65
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Lewis ^x , SSEA-1	VII ³ , V ³ Fuc α ₂ -nLc ₈ Cer	Human erythrocytes	82
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer <div style="display: flex; justify-content: space-around; width: 100%;"> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} 3 \\ \\ \text{Fuc } \alpha 1 \end{array}$ </div> </div>	Lewis ^x , SSEA-1, type 2	VII ³ , V ³ , III ³ Fuc α ₃ -nLc ₈ Cer	Human adenocarcinoma	57, 64
Gal β 1-4 GlcNAc β 1 <div style="text-align: center;"> $\begin{array}{c} 6 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ 3 \end{array}$ </div>	Blood groups I	IV ⁶ klado Lc ₈ Cer	Bovine erythrocytes, human adult and umbilical cord erythrocytes, human adenocarcinoma	156, 117, 115
Gal β 1-4 GlcNAc β 1 <div style="text-align: center;"> $\begin{array}{c} 6 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ 3 \end{array}$ </div>		VI ³ GalNAc α -IV ⁶ kladoLc ₈ Cer	Human erythrocytes	62
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1				

Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VII ³ , VI ³ Gal α 2-IV ⁶ kladoLc ₈ Cer	Rabbit erythrocytes	70
Gal α 1-3 Gal β 1-4 GlcNAc β 1 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VI ² Fucz-IV ⁶ kladoLc ₈ Cer	Human erythrocytes	117
Fuc α 1-2 Gal β 1-4 GlcNAc β 1 Fuc α 1-2 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	H3 antigen, H and I-active	VII ² , VI ² Fucz ₂ -IV ⁶ kladoLc ₈ Cer	Human erythrocytes	154, 156, 65
Fuc α 1-2 Gal β 1-4 GlcNAc β 1 Fuc α 1 2 Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	B-III antigen	VIII ³ , VI ³ Gal α 2, VIII ² , VI ² Fucz ₂ -IV ⁶ kladoLc ₈ Cer	Human erythrocytes	71
Gal α 1-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 2 Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	Blood group A; 'classical' A ^c (now A ^d)	VIII ³ , VI ³ GalNac α 2, VIII ² , VI ² Fucz ₂ -IV ⁶ kladoLc ₈ Cer	Human erythrocytes	62, 42, 95
Fuc α 1 2 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		nLc ₁₀ Cer	Human granulocytes	56
GalNAc α 1-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 2 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VII ³ Fucz-nLc ₁₀ Cer	Human gastric cancer cells	114
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer Fuc α 1 2 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	H ₄	X ² , VIII ² Fucz ₂ - IV ⁶ kladoLc ₁₀ Cer	Human erythrocytes	65
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 2				

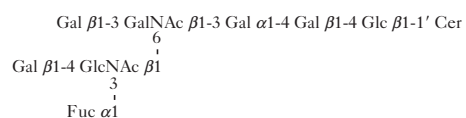
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Table 2 (continued)

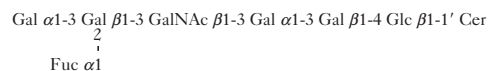
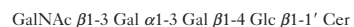
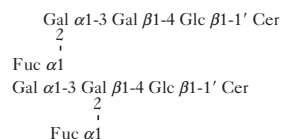
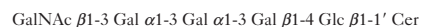
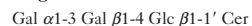
Structure	Name	Abbreviation	Source	References
$ \begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \end{array} $	B-IV antigen	X ² , VIII ² Gal α ₂ , Fuc α ₂ -IV ⁶ , kladoLc ₁₀ Cer	Human erythrocytes	71
$ \begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \end{array} $	Blood group A; classical A ^d (now A ^s)	X ³ , VIII ³ GalNAc α ₂ , XI ² , VIII ² , Fuc α ₂ -IV ⁶ , kladoLc ₁₀ Cer	Human erythrocytes	62, 55, 42
$ \begin{array}{c} \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \end{array} $			Human erythrocytes	51
$ \begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \end{array} $	B-V antigen	X ³ , XII ³ Gal α ₂ , X ² , XII ² Fuc α ₂ -VI ⁶ , kladoLc ₁₂ Cer	Human erythrocytes	71
$ \begin{array}{c} \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \end{array} $	BIrab-3 Blood group B-like and I-active		Rabbit erythrocytes	72

Table 2 (continued)

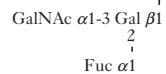
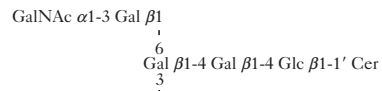
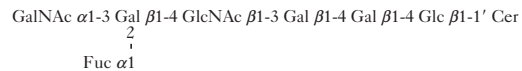
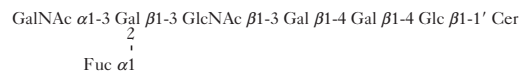
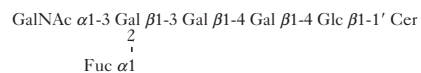
<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	Gb ₄ , Globoside, Cytolipin K, P antigen	Gb ₄ Cer	Tay–Sachs disease	102
Gal α 1-4 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer GalNAc α 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	GalNAc-Gb ₄ ; Forssman antigen	IV ⁴ Gal α -Gb ₄ Cer IV ³ GalNAc α -Gb ₄ Cer	Human erythrocytes Sheep erythrocytes, dog intestine and kidney, hamster fibroblasts	49 121, 142, 58
GalNAc β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	Para-Forssman antigen	IV ³ GalNAc β -Gb ₄ Cer	Human erythrocytes	13
GalNAc α 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer Gal β 1-3 GalNAc β 1	Branched Forssman antigen	IV ³ GalNAc α , III ⁴ (Gal β 1-3GalNAc β)-Gb ₄ Cer	Dog gastric mucosa	127
GalNAc α 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1-2 Gal β 1-3 GalNAc β 1		IV ³ GalNAc α , III ⁴ (Fuc α 1-2Gal β 1-3GalNAc β)-Gb ₄ Cer	Dog gastric mucosa	130
Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer	GalGb ₄ , SSEA-3	Gb ₅ Cer	Monkey kidney, human teratocarcinoma cells, fetal calf serum, human brain	23, 83, 45
Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer GlcNAc β 1		IV ⁶ GlcNAc β -Gb ₅ Cer	Mouse kidney	120
Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer Gal β 1-4 GlcNAc β 1		IV ⁶ (Gal β 1-4GlcNAc β)-Gb ₅ Cer	Mouse kidney	120
Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Type 4 chain H (globo-H), blood group H, SSEA-3	V ² Fuc α -Gb ₅ Cer	Human teratocarcinoma, human mammary gland, human embryonic carcinoma cells, human erythrocytes	83, 34, 54, 65
GalNAc α 1-3 Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer Fuc α 1	Type 4 chain A (globo-A)	V ³ GalNAc α , V ² Fuc α -Gb ₅ Cer	Human erythrocytes, human embryonic carcinoma cells	37, 54, 65



Isogloblo series



Muco series



SSEA-1 determinant	IV ⁶ [Galβ1-4(Fucz1-3)GlcNAcβ]-Gb ₅ Cer	Mouse kidney	120
iGb ₃	iGb ₃ Cer	Dog intestine, Burkitt lymphoma, rat hepatoma	143, 112, 20
Blood group H	III ³ (GalNAcβ-Galz)-iGb ₃ Cer III ² Fucz-iGb ₃ Cer	Rat intestine Hog gastric mucosa	14 123
B, BGb ₃	II ² Fucz-iGb ₃ Cer	Rat colon	73
iGb ₄ ; Cytolipin R	iGb ₄ Cer	Rat lymphosarcoma, pig edema, rat hepatoma	97, 48, 20
Forssman-like iGb ₄	IV ³ GalNAcα-iGb ₄ Cer	Rat adenocarcinoma	53
Blood group B	V ³ Galz, V ² Fucz-iGb ₅ Cer	Rat gastric mucosa	75
Blood group A	IV ³ GalNAcα, IV ² Fucz-Mc ₄ Cer	Hog gastric mucosa	122
Blood group A		Hog gastric mucosa	124
Blood group A		Hog gastric mucosa	124
Blood group A		Hog gastric mucosa	128

(continued)

Table 2 (continued)

<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
Unclassified				
Gal α 1-4 Gal β 1-4 GlcNAc β 1-4 Glc β 1-1' Cer	P ₁ antigen		Human erythrocytes	109
Gal α 1-3 Gal β 1-3 Gal β 1-4 Glc β 1-1' Cer	Blood group B		Xenopus blastula cells	111
$\begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$			Hog gastric mucosa	125
Gal β 1-4 GlcNAc β 1-4 Gal β 1-3 Gal β 1-4 Glc β 1-1' Cer	Lewis ^x		Human erythrocytes	64
$\begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-3 \text{ GlcNAc } \beta 1-4 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$			Rat intestine	29
$\begin{array}{c} \text{Gal } \beta 1 \\ \\ \text{Fuc } \alpha 1 \quad \text{Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	Blood group A		Hog gastric mucosa	129
$\begin{array}{c} \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ Gal } \beta 1 \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1 \\ \\ \text{Fuc } \alpha 1 \quad \text{Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	Blood group A		Hog gastric mucosa	128
$\begin{array}{c} \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ Gal } \beta 1 \\ \\ \text{GlcNAc } \beta 1-4 \text{ Gal } \beta 1 \\ \\ \text{Fuc } \alpha 1 \quad \text{Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	Blood group A		Hog gastric mucosa	128
$\begin{array}{c} \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ Gal } \beta 1 \\ \\ \text{GlcNAc } \beta 1-4 \text{ Gal } \beta 1 \\ \\ \text{Fuc } \alpha 1 \quad \text{Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	Lewis ^x		Hog gastric mucosa	129
Gal β 1-4 GlcNAc β 1-4 Gal β 1				
$\begin{array}{c} \text{Gal } \beta 1-3/4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \quad \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	Blood group A, H		Hog gastric mucosa	131
GalNAc α 1-3 Gal β 1-3/4 GlcNAc β 1				
$\begin{array}{c} \text{Fuc } \alpha 1 \\ \\ \text{GalNAc } \alpha 1-3 \text{ Gal } \beta 1-3/4 \text{ GlcNAc } \beta 1 \end{array}$				

$\begin{array}{c} \text{Gal } \beta 1\text{-}3/4 \text{ GlcNAc } \beta 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$	$\begin{array}{c} 6 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1\text{-}4 \text{ GlcNAc } \beta 1\text{-}3 \text{ Gal } \beta 1\text{-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$	Blood group A, H	Hog gastric mucosa	131
$\begin{array}{c} \text{GalNAc } \alpha 1\text{-}3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	$\begin{array}{c} \text{Gal } \beta 1\text{-}3/4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1 \\ \\ 6 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ Gal } \beta 1\text{-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$	Blood group A, H	Hog gastric mucosa	131
$\begin{array}{c} \text{GalNAc } \alpha 1\text{-}3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	$\begin{array}{c} \text{Gal } \beta 1\text{-}3/4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1 \\ \\ 6 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ Gal } \beta 1\text{-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$	Blood group A, H	Hog gastric mucosa	131
$\begin{array}{c} \text{GalNAc } \alpha 1\text{-}3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	$\begin{array}{c} \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1 \\ \\ 6 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ Gal } \beta 1\text{-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$	Blood group A, H	Hog gastric mucosa	132
$\begin{array}{c} \text{GalNAc } \alpha 1\text{-}3 \\ \\ \text{Fuc } \alpha 1 \end{array}$	$\begin{array}{c} \text{Gal } \beta 1\text{-}3/4 \text{ GlcNAc } \beta 1 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1 \\ \\ 6 \\ \\ \text{Gal } \beta 1\text{-}4 \text{ Gal } \beta 1\text{-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$	Blood group A, H	Hog gastric mucosa	133
$\begin{array}{c} \text{Fuc } \alpha 1\text{-}2 \\ \\ \text{Gal } \alpha 1\text{-}2 \end{array}$	$\begin{array}{c} \text{Gal } \beta 1\text{-}4 \text{ GlcNAc } \beta 1 \\ \\ 6 \\ \\ \text{Gal } 1\text{-}4 \text{ (GlcNAc } 1\text{-}3 \text{ Gal)}_7 \text{ 1-}4 \text{ Glc } \beta 1\text{-}1' \text{ Cer} \\ \\ 3 \\ \\ \end{array}$		Human erythrocytes	59

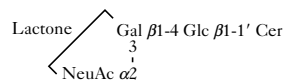
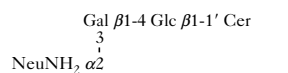
Table 3 Carbohydrate structures of sulfated glycosphingolipids

<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
HSO ₃ -3 Glc β1-1' Cer	Glucosyl sulfate, sulfoglucosylceramide	I ³ -sulfate, GlcCer	Rat kidney	166
Gala series				
HSO ₃ -3 Gal β1-1' Sphingosine	Lysosulfatide, sulfogalactosylsphingosine	I ³ -sulfate, Gal-sphingosine	Late infantile metachromatic leukodystrophy	171, 187, 188
HSO ₃ -3 Gal β1-1' Cer	Galactosyl sulfate, sulfogalactosylceramide	I ³ -sulfate, GalCer	Bovine brain	189, 164
(6- <i>O</i> -acyl)Gal β1-1' Cer 3 HSO ₃	6- <i>O</i> -acyl sulfate	I ³ -sulfate, (6- <i>O</i> -acyl)GalCer	Equine brain	168
Hemato series				
HSO ₃ -3 Gal β1-4 Glc β1-1' Cer	Sulfolactosylceramide, SM3	II ³ -sulfate, LacCer	Bovine brain, kidney, metachromatic leukodystrophy	163, 177, 178
Gal β1-4 Glc β1-1' Cer 3	SD3	II ³ (8-HSO ₃) NeuAcz2- 8NeuAcz-LacCer	Bovine gastric mucosa	175
HSO ₃ -8 NeuAc α2-8 NeuAc α2				
Ganglio series				
HSO ₃ 3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SM2a	II ³ -sulfate, Gg ₃ Cer	Rat kidney	180
HSO ₃ 3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SM2b	III ³ -sulfate, Gg ₃ Cer	Rat kidney	179, 185
HSO ₃ 3 Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SM1b	IV ³ -sulfate, Gg ₄ Cer	Mouse small intestine	167
HSO ₃ HSO ₃ 3 3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SB2	III ³ , II ³ -bis-sulfate, Gg ₃ Cer	Rat kidney	181
HSO ₃ 3 Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SM1a	II ³ -sulfate, Gg ₄ Cer	Rat kidney	186
HSO ₃ HSO ₃ 3 3 Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer	SB1a	IV ³ , II ³ -bis-sulfate, Gg ₄ Cer	Rat kidney, human hepatocellular carcinoma	182, 165

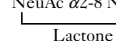
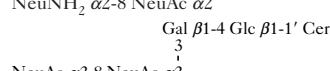
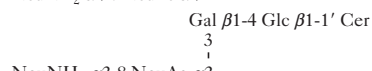
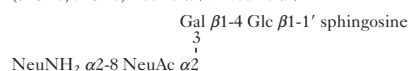
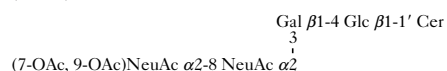
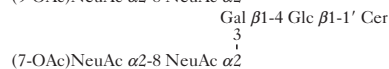
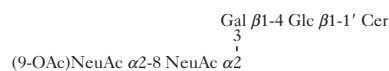
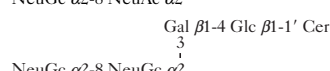
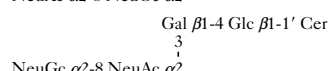
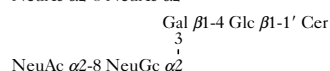
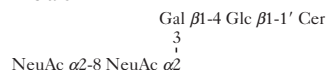
$\begin{array}{c} \text{HSO}_3 \\ \\ 3 \\ \text{Gal } \beta 1-3 \text{ GalNAc } \beta 1-4 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	SM1a (NeuGc)	IV ³ -sulfate, II ³ NeuGcz-Gg ₄ Cer	Rat kidney	186
$\begin{array}{c} \text{GalNAc } \beta 1-4 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ 3 \\ (8-O-SO_4)\text{NeuAc } \alpha 2 \end{array}$	SM2 (NeuAc)	II ³ (8-O-SO ₄)NeuAcz-Gg ₃ Cer	Bovine gastric mucosa	176
$\begin{array}{c} \text{GalNAc } \beta 1-4 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \\ \\ 3 \\ (8-O-SO_4)\text{NeuGc } \alpha 2 \end{array}$	SM2 (NeuGc)	II ³ (8-O-SO ₄)NeuGcz-Gg ₃ Cer	Bovine gastric mucosa	176
Lacto series				
$\begin{array}{c} \text{HSO}_3 \\ \\ 6 \\ \text{GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		III ⁶ -sulfate, Lc ₃ Cer	Hog gastric mucosa	172
Neolacto series				
$\begin{array}{c} \text{HSO}_3 \\ \\ 6 \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		III ⁶ -sulfate, nLc ₄ Cer	Hog gastric mucosa	173, 174
$\begin{array}{c} \text{HSO}_3 \\ \\ 3 \\ \text{GlcA } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	HNK-1 antigen, SGPG	IV ³ -GlcA-3-sulfate, nLc ₄ Cer	Human cauda equina	161, 160
$\begin{array}{c} \text{HSO}_3 \\ \\ 3 \\ \text{GlcA } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	HNK-1 antigen, SGLPG	VI ³ -GlcA-3-sulfate, nLc ₆ Cer	Human cauda equina	162, 160
Globo series				
HSO ₃ -3 GalNAc β1-3 Gal α1-4 Gal β1-4 Glc β1-1' Cer	SMGb ₄ Cer	IV ³ -sulfate, Gb ₄ Cer	Human kidney	169
HSO ₃ -3 Gal β1-3 GalNAc β1-3 Gal α1-4 Gal β1-4 Glc β1-1' Cer	SMGb ₅ Cer	V ³ -sulfate, Gb ₅ Cer	Human kidney	170
Isoglobo series				
$\begin{array}{c} \text{HSO}_3 \\ \\ 3 \\ \text{GalNAc } \beta 1-3 \text{ Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		IV ³ -sulfate, iGb ₄ Cer	Rat kidney	183
$\begin{array}{c} \text{HSO}_3 \\ \\ 3 \\ \text{Gal } \beta 1-3 \text{ GalNAc } \beta 1-3 \text{ Gal } \alpha 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		V ³ -sulfate, iGb ₅ Cer	Rat kidney	184
Unclassified				
HSO ₃ -3 Gal 1-4 Gal 1-4 Glc 1-1' Cer			Hog gastric mucosa	172

Table 4 Carbohydrate structures of gangliosides

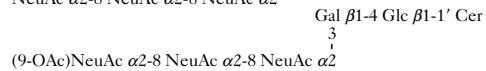
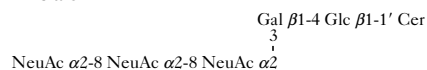
<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
Gala series				
NeuAc α 2-3 Gal β 1-1' Cer	GM4	I ³ NeuAcz-GalCer	Human brain, human myelin, egg yolk, avian myelin	267, 273, 278, 213
NeuGc α 2-3 Gal β 1-1' Cer	GM4 (NeuGc)	I ³ NeuGcz-GalCer	Frog liver, fish liver	304, 328
NeuAc α 2-3 Gal β 1-1' Cer └──────────┘ Lactone	GM4 (lactone)	I ³ NeuAcz(lactone)-GalCer	Minke whale brain	347
Hemato series				
Monosialo				
Gal β 1-4 Glc β 1-1' sphingosine ┆ 3 ┆ 1 ┆ NeuAc α 2	Lyso-GM3		A431 human epidermoid carcinoma cells	310
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ NeuAc α 2	GM3	II ³ NeuAcz-LacCer	Human brain, bovine liver, spleen, kidney, and adrenal medulla, human liver	267, 355, 332
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ NeuGc α 2	GM3 (NeuGc), hemoside	II ³ NeuGcz-LacCer	Horse erythrocytes, bovine adrenal medulla, liver, spleen and kidney	361, 263, 272, 355
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ (9-OAc)NeuAc α 2	GM3 (9-OAcNeuAc)	II ³ (9-OAc)NeuAcz-LacCer	Guinea pig kidney	245
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ (4-OAc)NeuGc α 2	GM3 (4-OAcNeuGc)	II ³ (4-OAc)NeuGcz-LacCer	Horse erythrocytes	235, 229
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ (9-OAc)NeuGc α 2	II ³ (9-OAcNeuGc)-Lac	II ³ (9-OAc)NeuGcz-LacCer	Equine erythrocytes	359
(6-OAc)Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ NeuGc α 2	GM3 (6-OAcGal, NeuGc)	I ⁴ [NeuGcz2-3 (6-OAc)Gal β]-GlcCer	Equine erythrocytes	359
(6-OAc)Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ (4-OAc)NeuGc α 2	GM3 (6-OAcGal, 4-OAcNeuGc)	I ⁴ [(4-OAc)NeuGcz2-3(6-OAc)Gal β]-GlcCer	Equine erythrocytes	360
Gal β 1-4 Glc β 1-1' Cer ┆ 3 ┆ 1 ┆ (4-OAc, 9-OAc)NeuGc α 2	GM3 (4,9-di-OAcNeuGc)	II ³ (4,9-diOAc)NeuGcz-LacCer	Equine erythrocytes	360
Kdn α 2-3 Gal β 1-4 Glc β 1-1' Cer	GM3 (Kdn)	II ³ Kdn-LacCer	Rainbow trout sperm	336



Disialo



Trisialo

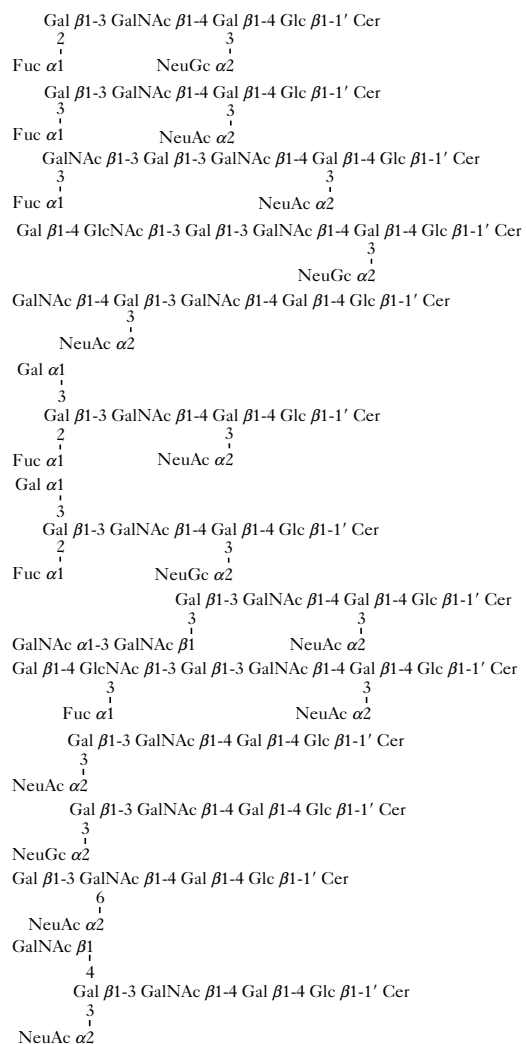


De- <i>N</i> -acetyl-GM3	II ³ NeuNH ₂ -LacCer	A431 human epidermoid carcinoma cells, B16 melanoma cells	239
GM3 lactone	II ³ NeuAcz(lactone)-LacCer	Melanoma cells	309
GD3	II ³ (NeuAcz) ₂ -LacCer	Human brain, bovine retina, bovine liver, spleen, kidney	267, 241, 355
GD3 (NeuAc/NeuGc)	II ³ (NeuAcz2-8NeuGcz)-LacCer	Bovine liver, spleen, kidney, bovine adrenal medulla	355, 194
GD3 (NeuGc/NeuAc)	II ³ (NeuGcz2-8NeuAcz)-LacCer	Bovine liver, spleen, kidney, rabbit thymus	355, 255
GD3 (NeuGc) ₂	II ³ (NeuGcz) ₂ -LacCer	Cat erythrocytes, bovine liver, spleen, kidney, bovine adrenal medulla	240, 355, 194
GD3 (9-OAc)	II ³ [(9-OAc)NeuAcz2-8NeuAcz]-LacCer	Human melanoma cells, bovine buttermilk	348, 327, 323
GD3 (7-OAc)	II ³ [(7-OAc)NeuAcz2-8NeuAcz]-LacCer	Bovine buttermilk, hamster melanoma, human T-lymphocytes	323, 324, 266
GD3 (7,9-diOAc)	II ³ [(7-OAc, 9-OAc)NeuAcz2-8NeuAcz]-LacCer	Bovine buttermilk	323
GD3 (lyso-de- <i>N</i> -acetyl)		Human melanoma cells	335
GD3 (de- <i>N</i> -acetyl)		Human melanoma cells	335
GD3 (lactone)	II ³ [NeuAcz(lactone)] ₂ -LacCer	Minke whale brain	347
GT3	II ³ (NeuAcz) ₃ -LacCer	Fish brain, pig kidney	318, 200, 363, 288
GT3 (9-OAc)	II ³ [(9-OAc)NeuAcz2-8NeuAcz2-8NeuAcz]-LacCer	Chicken brain, rat brain, bovine butter milk, codfish brain,	218, 323, 349

(continued)

Table 4 (continued)

<i>Structure</i>	<i>Name</i>	<i>Abbreviation</i>	<i>Source</i>	<i>References</i>
Ganglio series				
Monosialo				
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' sphingosine $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Lyso-GM2		GM2 gangliosidosis (Tay–Sachs disease and Sandhoff disease)	301, 91
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	GM2	II ³ NeuAcz-Gg ₃ Cer	Tay–Sachs brain, human brain	102, 267, 271,
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{NeuGc } \alpha 2 \end{array}$	GM2 (NeuGc)	II ³ NeuGcz-Gg ₃ Cer	Bovine spleen	355
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{Taurine-NeuAc } \alpha 2 \end{array}$	Tauro-GM2	II ³ (taurine-NeuAcz)-Gg ₃ Cer	Tay–Sachs brain	279
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' sphingosine $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Lyso-GM1		GM2 gangliosidosis (Tay–Sachs disease and Sandhoff disease)	91
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	GM1	II ³ NeuAcz-Gg ₄ Cer	Human brain, GM1 gangliosides, bovine spleen	355
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{NeuGc } \alpha 2 \end{array}$	GM1 (NeuGc)	II ³ NeuGcz-Gg ₄ Cer	Bovine spleen, kidney, liver	356
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{NeuNH}_2 \alpha 2 \end{array}$	GM1 (de- <i>N</i> -acetyl, NeuN)	II ³ NeuNH ₂ -Gg ₄ Cer	Bovine brain, human glioma	242, 222
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 4 \\ \\ \text{GalNAc } \beta 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	GalNAc-GM1	IV ⁴ GalNAc β , II ³ NeuAcz-Gg ₄ Cer	Human brain	256
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{Gal } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Gal-GM1	IV ³ Galz, II ³ NeuAcz-Gg ₄ Cer	Frog fat body	314
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{Gal } \beta 1-3 \text{ Gal } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Gal2-GM1	IV ³ (Gal β 1-3Galz), II ³ NeuAcz-Gg ₄ Cer	Frog fat body	314
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ \text{Gal } \beta 1-3 \text{ Gal } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Gal3-GM1	IV ³ (Galz1-3Gal β 1-3Galz), II ³ NeuAcz-Gg ₄ Cer	Frog fat body	314
Gal α 1-3 Gal β 1-3 Gal α 1 NeuAc α 2 $\begin{array}{c} 2 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ \text{NeuAc } \alpha 2 \end{array}$	Fuc-GM1	IV ² Fucz, II ³ NeuAcz-Gg ₄ Cer	Boar testis, bovine brain, pig adipose, mini-pig brain, PC12 cells	340, 230, 313, 220, 198

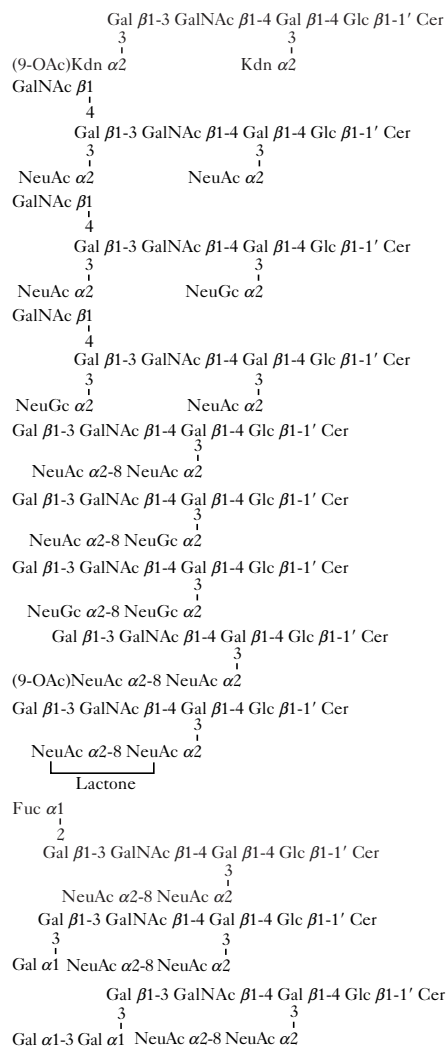


Fuc-GM1 (NeuGc)	IV ² Fucz, II ³ NeuGcz-Gg ₄ Cer	Bovine liver, boar testis, pig adipose, mini-pig brain	355, 340, 313, 220
	IV ³ Fucz, II ³ NeuAcz-Gg ₄ Cer	Pig adipose	313
Fucosyl-N-acetylgalactosaminyl-GM1	IV ³ (Fucz1-3GalNAc β), II ³ NeuAcz-Gg ₄ Cer	Salmon kidney	302
LacN-GM1	IV ³ (Gal β 1-4GlcNAc β), II ³ NeuGcz-Gg ₄ Cer	Rat spleen	305
GalNAc-isoGM1	IV ⁴ GalNAc β , IV ³ NeuAcz-Gg ₄ Cer	Human meconium	221
B-GM1, galactosylfucosyl-GM1	IV ³ Galz, IV ² Fucz, II ³ NeuAcz-Gg ₄ Cer	Rat hepatoma, rat stomach, PC12 cells	249, 203, 198
α Gal,Fuc-GM1 (NeuGc), B-GM1 (NeuGc)	IV ³ Galz, IV ² Fucz, II ³ NeuGcz-Gg ₄ Cer	Rat spleen	306
	IV ³ (GalNAc α 1-3GalNAc β), II ³ NeuAcz-Gg ₄ Cer	English sole liver	316
Le ^x -GM1	IV ³ [Gal β 1-4(Fuc α 1-3)GlcNAc β], II ³ NeuAcz-Gg ₄ Cer	Chicken intestinal tissues	246
GM1b	IV ³ NeuAcz-Gg ₄ Cer	Human erythrocytes, rat ascites, human brain	156, 244, 284, 199
GM1b (NeuGc)	IV ³ NeuGc-Gg ₄ Cer	Mouse spleen	293
GM1z	III ⁶ NeuAc-Gg ₄ Cer	Bovine brain	252
GalNAc-GM1b	IV ³ NeuAcz-Gg ₅ Cer	Tay-Sachs brain	254

(continued)

Table 4 (continued)

Structure	Name	Abbreviation	Source	References
GalNAc β 1 4 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GalNAc-GM1b (NeuGc)	IV ³ NeuGcz-Gg ₅ Cer	Mouse spleen, mouse T lymphocytes	294, 291
NeuGc α 2 Gal α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	α Gal-LacN-GM1	IV ³ (Gal α 1-3Gal β 1-4GlcNAc β), II ³ NeuGcz-Gg ₄ Cer	Rat spleen	305
Gal β 1-3 GalNAc β 1 4 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer		IV ³ NeuAcz-Gg ₆ Cer	Mouse spleen	294
NeuAc α 2				
Disialo				
GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD2	II ³ (NeuAcz) ₂ -Gg ₅ Cer	Human brain	267, 264
NeuAc α 2-8 NeuAc α 2 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD2 (9-OAc)	II ³ [(9-OAc)NeuAcz ₂ -8 NeuAcz]-Gg ₅ Cer	Human melanoma cells	334
(9-OAc)NeuAc α 2-8 NeuAc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a	IV ³ , II ³ NeuAcz ₂ -Gg ₄ Cer	Human brain, bovine adrenal medulla	267, 265, 318, 194
NeuAc α 2 NeuAc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (NeuAc/NeuGc)	IV ³ NeuAcz, II ³ NeuGcz- Gg ₄ Cer	Bovine brain, bovine adrenal medulla	230, 318
NeuAc α 2 NeuGc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (NeuGc/NeuAc)	IV ³ NeuGcz, II ³ NeuAcz- Gg ₄ Cer	Bovine brain	230
NeuGc α 2 NeuAc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (NeuGc/NeuGc)	IV ³ , II ³ NeuGcz ₂ -Gg ₄ Cer	Bovine spleen, kidney, bovine adrenal medulla	355, 194
NeuGc α 2 NeuGc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (9-OAc NeuAc/ NeuAc)	IV ³ (9-OAc)NeuAcz, II ³ NeuAcz-Gg ₄ Cer	Rat erythrocytes	233
(9-OAc)NeuAc α 2 NeuAc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (NeuAc/ Kdn)	IV ³ NeuAcz, II ³ Kdnz- Gg ₄ Cer	Rainbow trout testis	338
NeuAc α 2 Kdn α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (Kdn/NeuAc)	IV ³ Kdnz, II ³ NeuAcz- Gg ₄ Cer	Rainbow trout testis	338
Kdn α 2 NeuAc α 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1a (Kdn/Kdn)	IV ³ , II ³ Kdnz ₂ -Gg ₄ Cer	Rainbow trout testis	337, 338
Kdn α 2 Kdn α 2				



GD1a (9-OAc Kdn/Kdn)	IV ³ (9-OAc)Kdnz, II ³ Kdnz-Gg ₄ Cer	Rainbow trout testis	337
GalNAc-GD1a	IV ³ α , II ³ NeuAc α 2-Gg ₅ Cer	Human brain, Tay-Sachs brain	341, 257, 364
GalNAc-GD1a (NeuAc/ NeuGc)	IV ³ NeuAcz, II ³ NeuGcz, Gg ₅ Cer	Bovine brain	206
GalNAc-GD1a (NeuGc/ NeuAc)	IV ³ NeuGcz, II ³ NeuAcz, Gg ₅ Cer	Bovine brain	206
GD1b	II ³ (NeuAcz) ₂ -Gg ₄ Cer	Human brain, bovine adrenal medulla	267, 265, 318
GD1b (NeuAc/NeuGc)	II ³ (NeuGcz-NeuAcz)- Gg ₄ Cer	Pig skeletal muscle	195
GD1b (NeuGc) ₂	II ³ (NeuGcz) ₂ -Gg ₄ Cer	Bovine adrenal medulla	197
GD1b (9-OAc)	II ³ [(9-OAc) NeuAcz2- 8NeuAcz]-Gg ₄ Cer	Bovine brain	248
GD1b (lactone)	II ³ Neucz2-8NeuAcz (lactone)-Gg ₄ Cer	Human brain	325
Fuc-GD1b	IV ² Fucz, II ³ (NeuAcz) ₂ - Gg ₄ Cer	Pig cerebellum, mini- pig brain, PC12 cells	339, 220, 198
	IV ³ Galz, II ³ (NeuAcz) ₂ - Gg ₄ Cer	Rat basophilic leukemia cell line	234
	IV ³ (Galz) ₂ , II ³ (NeuAcz) ₂ - Gg ₄ Cer	Rat basophilic leukemia cell line	234

(continued)

Table 4 (continued)

Structure	Name	Abbreviation	Source	References
Fuc α ₁ 2 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer		IV ² Fucz, IV ³ Galz, II ³ (NeuAcz) ₂ -Gg ₄ Cer	PC12 cells	198
Gal α ₁ NeuAc α 2-8 NeuAc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1c	IV ³ (NeuAcz) ₂ -Gg ₄ Cer	Mouse thymoma	201
NeuAc α 2-8 NeuAc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1c (NeuAc/NeuGc)	IV ³ (NeuAcz2-8NeuGcz)- Gg ₄ Cer	Mouse thymoma and thymocytes	317, 296
NeuAc α 2-8 NeuGc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1c (NeuGc/NeuAc)	IV ³ (NeuGcz2-8NeuAcz)- Gg ₄ Cer	Mouse thymoma and thymocytes	296
NeuGc α 2-8 NeuAc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1c (NeuGc/NeuGc)	IV ³ (NeuGcz) ₂ -Gg ₄ Cer	Mouse thymoma and thymocytes, rat spleen lymphocytes	296, 307
NeuGc α 2-8 NeuGc α ₂ NeuAc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1z	IV ³ , III ⁶ NeuAcz ₂ -Gg ₄ Cer	Frog brain, rat ascites, hepatoma cells, mouse lymphoma cell line	315, 343, 290
NeuAc α ₂ NeuAc α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1z (Kdn/NeuAc)	IV ³ Kdnz, III ⁶ NeuAcz- Gg ₄ Cer	Rainbow trout testis	338
Kdn α ₂ Kdn α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1z (Kdn/Kdn)	IV ³ , III ⁶ Kdnz ₂ -Gg ₄ Cer	Rainbow trout testis	338
Kdn α ₂ Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GD1az	III ⁶ , II ³ NeuAcz ₂ -Gg ₄ Cer	Bovine brain	252
NeuAc α ₂ NeuAc α ₂ Gal β 1-4 GlcNAc β 1-3 Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer		IV ³ (NeuGcz2-3Gal β 1- 4GlcNAc β), II ³ NeuGcz- Gg ₄ Cer	Rat spleen	308
NeuGc α ₂ NeuGc α ₂				
Trisialo GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer	GT2	II ³ (NeuAcz) ₃ -Gg ₃ Cer	Fish brain, pig adipose tissue	251, 363, 313
NeuAc α 2-8 NeuAc α 2-8 NeuAc α ₂				

GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer (9-OAc)NeuAc α 2-8 NeuAc α 2-8 NeuAc α 2	GT2 (9-OAc)	II ³ (9-OAcNeuAcz2-8 NeuAcz2-8NeuAcz)-Gg ₃ Cer	Codfish brain	350
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2-8 NeuAc α 2 NeuAc α 2	GT1a	IV ³ (NeuAcz) ₂ , II ³ NeuAcz-Gg ₄ Cer	Human brain	191
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuAc α 2-8 NeuAc α 2	GT1b	IV ³ NeuAcz, II ³ (NeuAcz) ₂ -Gg ₄ Cer	Human brain	267, 264
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuGc α 2 NeuAc α 2-8 NeuAc α 2	GT1b (NeuGc/NeuAc/NeuAc)	IV ³ NeuGcz, II ³ (NeuAcz) ₂ -Gg ₄ Cer	Bovine adrenal medulla	196
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuAc α 2-8 NeuGc α 2	GT1b (NeuAc/NeuAc/NeuGc)	IV ³ NeuAcz, II ³ (NeuAcz2-8NeuGcz)-Gg ₄ Cer	Bovine adrenal medulla, bovine brain	196, 299
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuGc α 2-8 NeuGc α 2	GT1b (NeuAc/NeuGc/NeuGc)	IV ³ NeuAcz, II ³ (NeuGcz) ₂ -Gg ₄ Cer	Bovine adrenal medulla	196
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer (9-OAc)NeuAc α 2-8 NeuAc α 2	GT1L GT1b (9-OAc)	IV ³ NeuAcz, II ³ (9-OAcNeuAcz2-8NeuAcz)-Gg ₄ Cer	Mouse brain	231
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2-8 NeuAc α 2-8 NeuAc α 2	GT1c	II ³ (NeuAcz) ₃ -Gg ₄ Cer	Fish brain	363
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuAc α 2-8 NeuAc α 2		IV ³ NeuAcz, III ⁶ (NeuAcz) ₂ -Gg ₄ Cer	Frog adipose tissue	315
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuAc α 2-8 NeuAc α 2		IV ³ (NeuAcz) ₂ , III ⁶ NeuAcz-Gg ₄ Cer	Frog adipose tissue	315
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuAc α 2 NeuAc α 2 NeuAc α 2	GTx, GT1az	IV ³ , III ⁶ , II ³ NeuAcz ₃ -Gg ₄ Cer	Dogfish brain, bovine brain	295, 297, 193
Gal β 1-3 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer NeuGc α 2-8 NeuAc α 2	GT1bz (NeuGc)	III ⁶ NeuAcz, II ³ NeuGcz2-8NeuAcz-Gg ₄ Cer	Bovine brain	252

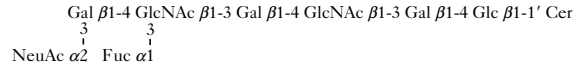
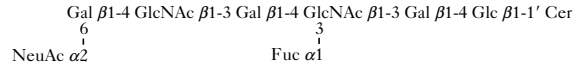
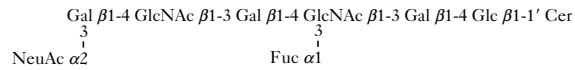
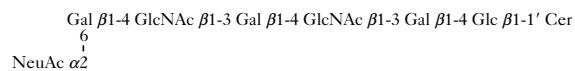
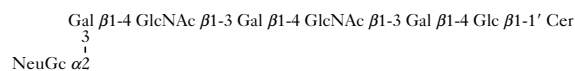
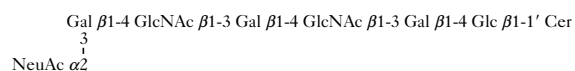
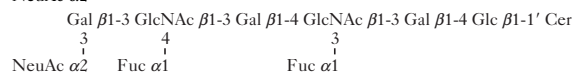
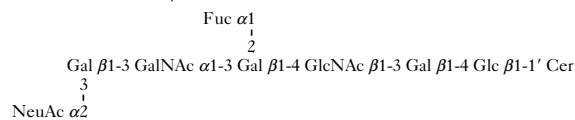
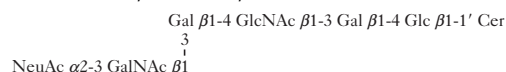
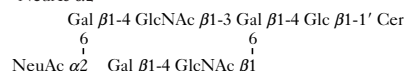
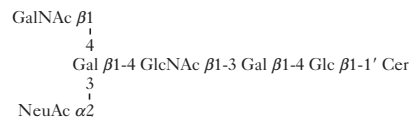
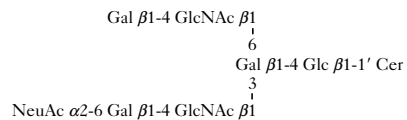
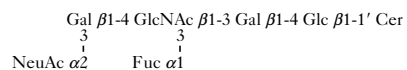
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Table 4 (continued)

Structure	Name	Abbreviation	Source	References
<p>Tetrasialo</p> <p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ (9-OAc)NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>	GQ1b	IV ³ (NeuAc) ₂ , II ³ (NeuAcz) ₂ -Gg ₄ Cer	Human, bovine, skate brain	192, 298
<p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ (9-OAc)NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>	9-OAcGQ1b	IV ³ (NeuAcz) ₂ , II ³ [(9-OAc) NeuAcz2-8NeuAcz]- Gg ₄ Cer	Mouse brain	209
<p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>	GQ1c	IV ³ NeuAcz, II ³ (NeuAcz) ₃ - Gg ₄ Cer	Human, bovine, chicken brains	192
<p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>	GQ1az	IV ³ NeuAcz ₂ , III ⁶ NeuAcz, II ³ NeuAcz-Gg ₄ Cer	Skate brain	298
<p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>	GQ1bz	IV ³ NeuAcz, III ⁶ NeuAcz, II ³ NeuAcz ₂ -Gg ₄ Cer	Bovine brain	247
<p>Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₆ ₁ NeuAc α2-8 NeuAc α2</p>		IV ³ (NeuAcz) ₂ , III ⁶ (NeuAcz) ₂ -Gg ₄ Cer	Adipose tissues, <i>Xenopus laevis</i> brain	315, 326
<p>Pentasialo</p> <p>NeuAc α2-8 NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2</p>	GP1b	IV ³ (NeuAcz) ₃ , II ³ (NeuAcz) ₂ -Gg ₄ Cer	Human brain	285
<p>NeuAc α2-8 NeuAc α2 ₃ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2 NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2</p>	GP1c	IV ³ (NeuAcz) ₂ , II ³ (NeuAcz) ₃ -Gg ₄ Cer	Fish brain	251
<p>NeuAc α2 NeuAc α2 ₃ ₆ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer ₃ NeuAc α2-8 NeuAc α2-8 NeuAc α2</p>	GP1cz	IV ³ , III ⁶ NeuAcz ₂ , II ³ (NeuAcz) ₃ -Gg ₄ Cer	Skate brain	298

<p>Hexasialo NeuAc α2-8 NeuAc α2 NeuAc α2 $\begin{array}{c} 1 \\ 3 \\ 6 \\ 3 \\ 1 \end{array}$ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer NeuAc α2-8 NeuAc α2-8 NeuAc α2</p>	GH1cz	$IV^3(NeuAc\alpha)_2, III^6NeuAc\alpha,$ $II^3(NeuAc\alpha)_3-Gg_4Cer$	Skate brain	298
<p>Heptasialo NeuAc α2-8 NeuAc α2-8 NeuAc α2-8 NeuAc α2 $\begin{array}{c} 1 \\ 3 \\ 3 \\ 3 \\ 1 \end{array}$ Gal β1-3 GalNAc β1-4 Gal β1-4 Glc β1-1' Cer NeuAc α2-8 NeuAc α2-8 NeuAc α2</p>	GS1c	$IV^3(NeuAc\alpha)_4,$ $II^3(NeuAc\alpha)_3-Gg_4Cer$	Chicken brain	329
<p>Lacto series Monosialo Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuAc α2</p>	Precursor of sialyl-Le ^a , 3'-isoLM1	$IV^3NeuAc\alpha-Lc_4Cer$	Human carcinomas, embryonic carcinoma cells, human meconium, infant brain gliomas	303, 224, 320, 287, 358
<p>Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuGc α2</p>		$IV^3NeuGc\alpha-Lc_4Cer$	Murine xenografts of human glioma cells	283
<p>Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuAc α2 Fuc α1</p>	Sialyl-Le ^a , Fuc-3'-isoLM1, sialyl lacto-N-fucopentaose II	$IV^3NeuAc\alpha, III^4Fuc\alpha-Lc_4Cer$	Gastrointestinal cancer, human milk	281, 357
<p>GalNAc β1-4 Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuAc α2</p>	GalNAc-3'-isoLM1	$IV^4GalNAc\beta, IV^3NeuAc\alpha-Lc_4Cer$	Human meconium	221
<p>GalNAc β1-4 Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuAc α2 GalNAc β1</p>	Ganglioside X1	$IV^4, II^4GalNAc\beta_2, IV^3NeuAc\alpha-Lc_4Cer$	Amyotrophic lateral sclerosis-like disorder	300
<p>GalNAc β1-4 Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 3 \\ 1 \end{array}$ NeuAc α2 Gal β1-3 GalNAc β1</p>	Ganglioside X2	$IV^4GalNAc\beta, IV^3NeuAc\alpha, II^4(Gal\beta 1-3GalNAc\beta)-Lc_4Cer$	Amyotrophic lateral sclerosis-like disorder	300
<p>Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 6 \\ 1 \end{array}$ NeuAc α2</p>		$III^6NeuAc\alpha-Lc_4Cer$	Human SW1116 colorectal carcinoma cells	270
<p>Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 2 \\ 1 \end{array}$ $\begin{array}{c} 6 \\ 1 \end{array}$ Fuc α1 NeuAc α2</p>	Sialyl lacto-N-fucopentaose I	$IV^2Fuc\alpha, III^6NeuAc\alpha-Lc_4Cer$	Human milk	357
<p>Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc β1-1' Cer $\begin{array}{c} 1 \\ 4 \\ 6 \\ 1 \end{array}$ NeuAc α2</p>	Sialyl Le ^a type	$III^6NeuAc\alpha, III^4Fuc\alpha-Lc_4Cer$	Human adenocarcinoma	113

(continued)



Fuc-3'-LM1,
sialosyllactofucopentaosyl
(III)ceramide, sialyl Le^x

IV³NeuAcz, III³Fucz-
nLc₄Cer

Human kidney,
pancreatic adeno-
carcinoma, human
cataract lenses

321, 282, 18

IV⁶NeuAcz-II⁶kladoLc₆Cer

Human hepato-cellular
carcinoma

345

Cad antigen, nLc (GalNAc-
NeuAc)

IV⁴GalNAcβ, IV³NeuAcz-
nLc₄Cer

Human erythrocytes,
mullet roe, gastric
cancer

202, 216,
232, 217

I-type

IV⁶NeuAcz-
II⁶kladonLc₆Cer

Bovine buttermilk

342

P-antigen

IV³(NeuAcz2-3GalNAcβ)-
nLc₄Cer

Human erythrocytes

353

Sialosylgalactosyl-A

IV³(NeuAcz2-3Galβ1-
3GalNAcz), IV²Fucz-
nLc₄Cer

Human erythrocytes

43

Sialyl Le^atype

VI³NeuAcz,V⁴, III³Fucz₂-
nLc₆Cer

Human rectal adeno-
carcinoma

262

VI³NeuAcz-nLc₆Cer

Human spleen, bovine
erythrocytes, human
placenta

356, 207,
344

VI³NeuGcz-nLc₆Cer

Bovine erythrocytes,
Marek disease, rabbit
thymus

207, 243,
286

IV⁶NeuAc-nLc₆Cer

Human erythrocytes

352

VI³NeuAcz, III³
Fucz-nLc₆Cer

Human leukemia cells

225

VI⁶NeuAcz, III³
Fucz-nLc₆Cer

Adenocarcinoma

237, 274

Sialyl Le^x

VI³NeuAcz, V³
Fucz-nLc₆Cer

Human granulocyte

292

(continued)

Table 4 (continued)

Structure	Name	Abbreviation	Source	References
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$		VI ³ NeuAcz, V ³ , III ³ Fucz ₂ -nLc ₆ Cer	Human colonic adenocarcinoma	226
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$		VIII ³ NeuAcz-nLc ₈ Cer	Rabbit skeletal muscle, human erythrocytes, human granulocytes	258, 268, 56
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuGe } \alpha 2 \end{array}$		VIII ³ NeuGez-nLc ₈ Cer	Bovine erythrocytes	214
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 6 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$		VIII ⁶ NeuAcz-nLc ₈ Cer	Human granulocytes	56
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$		VIII ³ NeuAcz, V ³ Fucz-nLc ₈ Cer	Chronic myelogenous leukemia cells	280
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$	X3 ganglioside	VIII ³ NeuAcz, V ³ , III ³ Fucz ₂ -nLc ₈ Cer	Human granulocytes	292
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$	X3 ganglioside	VIII ³ NeuAcz, VII ³ , III ³ Fucz ₂ -nLc ₈ Cer	Human granulocytes	292
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{NeuAc } \alpha 2 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Fuc } \alpha 1 \end{array}$	X4 ganglioside	VIII ³ NeuAcz, VII ³ , V ³ , III ³ Fucz ₃ -nLc ₈ Cer	Human granulocytes	292
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 6 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		VI ³ NeuAcz-IV ⁶ kladoLc ₈ Cer	Human erythrocytes	352
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 6 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		VI ³ NeuGez-IV ⁶ kladoLc ₈ Cer	Bovine erythrocytes	215
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 6 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1 \end{array}$ $\begin{array}{c} 3 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$	I-type	VI ⁶ NeuAcz-IV ⁶ kladoLc ₈ Cer	Human meconium	346
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 6 \\ \\ 1 \\ \\ \text{Gal } \beta 1-4 \text{ GlcNAc } \beta 1-3 \text{ Gal } \beta 1-4 \text{ Glc } \beta 1-1' \text{ Cer} \end{array}$		VIII ³ Galz, VI ³ Siaz-IV ⁶ kladoLc ₈ Cer	Bovine erythrocytes	156
Sia α 2-3 Gal β 1-4 GlcNAc β 1				

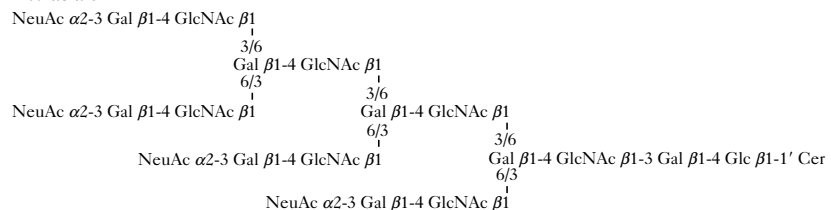
Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VIII ³ Galz, VI ³ NeuAcz- IV ⁶ kladoLc ₈ Cer	Bovine erythrocytes	215
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VIII ³ Galz, VI ³ NeuGcz- IV ⁶ kladoLc ₈ Cer	Bovine erythrocytes	215
NeuGc α 2-3 Gal β 1-4 GlcNAc β 1 Fuc α 1-2 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VIII ² Fucz, VI ³ NeuAcz- IV ⁶ kladoLc ₈ Cer	Human erythrocytes	351, 260
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 2 Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3		VIII ³ Galz, VIII ² Fucz, VI ³ NeuAcz- IV ⁶ kladoLc ₈ Cer	Human erythrocytes	260
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 3 Gal α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	SM1	VIII ³ Galz, VII ³ Fucz, VI ³ NeuAcz- IV ⁶ kladoLc ₈ Cer	Porcine kidney	204
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 2 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3	Type A-active	VIII ³ GalNAcz, VIII ² Fucz, VI ³ NeuAcz- IV ⁶ kladoLc ₈ Cer	Human erythrocytes	260, 269
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 Fuc α 1 Fuc α 1 2 3 GalNAc α 1-3 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1 6 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer 3 NeuAc α 2-3 Gal β 1-4 GlcNAc β 1	Type A-active	X ³ GalNAcz, X ² , IX ³ Fucz ₂ , VI ³ NeuAcz- IV ⁶ kladoLc ₁₀ Cer	Human erythrocytes	269

(continued)

Table 4 (continued)

Structure	Name	Abbreviation	Source	References
Disialo Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$	Disialyl paragloboside	IV ³ (NeuAcz) ₂ -nLc ₄ Cer	Human kidney	322
NeuAc α 2-8 NeuAc α 2 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$		IV ³ (NeuGcz) ₂ -nLc ₄ Cer	Cat erythrocytes, sheep erythrocytes	228
NeuGc α 2-8 NeuGc α 2 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$		IV ³ (NeuAcz ₂ -8NeuGcz)-nLc ₄ Cer	Cat erythrocytes, sheep erythrocytes	228
NeuAc α 2-8 NeuAc α 2 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$	nLc4 (OAc, NeuAc-NeuAc)	IV ³ [(OAc)NeuAcz ₂ -8NeuAcz]-nLc ₄ Cer	Fish genus <i>Xiphophorus</i> , mouse cerebellum	219, 211
(OAc)NeuAc α 2-8 NeuAc α 2 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$		VI ³ (NeuAcz) ₂ -nLc ₆ Cer	Bovine nasal cartilage	238
NeuAc α 2-8 NeuAc α 2 NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 $\begin{array}{c} 6 \\ \\ 3 \\ \\ 1 \end{array}$	Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer	DG-6 I-type	Human placenta, erythrocytes, human hepatoma	268, 260, 345
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 NeuAc α 2 $\begin{array}{c} 3 \\ \\ 3 \\ \\ 1 \end{array}$	Gal β 1-4 GlcNAc β 1 $\begin{array}{c} 3/6 \\ \\ 6/3 \\ \\ 1 \end{array}$	X ³ ,VI ³ NeuAcz ₂ -IV ⁶ kladoLc ₁₀ Cer, or X ³ ,VIII ³ NeuAcz ₂ -IV ⁶ kladnLc ₁₀ Cer	Human colonic adenocarcinoma	115
Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 GlcNAc β 1 $\begin{array}{c} 3 \\ \\ 1 \end{array}$	NeuAc α 2			
Trisialo Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer $\begin{array}{c} 3 \\ \\ 1 \end{array}$		IV ³ (NeuAcz) ₃ -nLc ₄ Cer	Hog kidney, cortex	289
NeuAc α 2-8 NeuAc α 2-8 NeuAc α 2 NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 $\begin{array}{c} 3 \\ \\ 6 \\ \\ 3/6 \\ \\ 6/3 \\ \\ 1 \end{array}$	Gal β 1-4 GlcNAc β 1 Gal β 1-4 GlcNAc β 1-3 Gal β 1-4 Glc β 1-1' Cer		Human colonic adenocarcinoma, human placenta	115, 275
NeuAc α 2-3 Gal β 1-4 GlcNAc β 1 NeuAc α 2-3 Gal β 1-4 GlcNAc β 1				

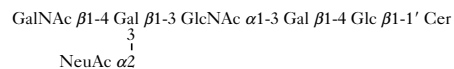
Tetrasialo



Human placenta 275

Isonolacto series

Monosialo



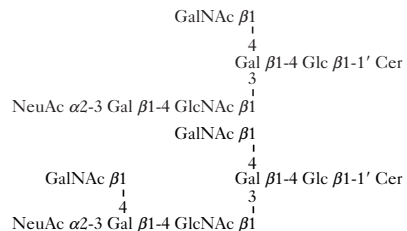
GalNAc-3'-isoLM1

IV⁴ GalNAc α , IV³ NeuAc α -inLc₄Cer

Human meconium 221

Lactoganglio series

Monosialo



IV³ NeuAc α -LcGg₅Cer

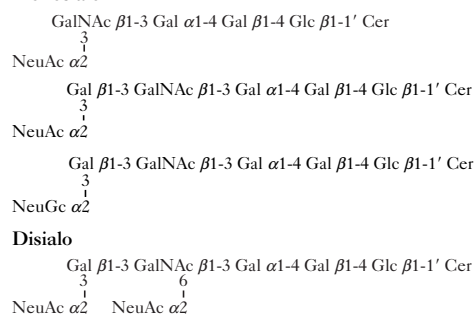
Mullet roe 216

IV⁴ GalNAc β , IV³ NeuAc α -LcGg₅Cer

Mullet roe 216

Globo series

Monosialo



IV³ NeuAc α -Gb₄Cer

Human terato-carcinoma cell line 331

SSEA-4 antigen

V³ NeuAc α -Gb₅Cer

Chicken muscle, human teratocarcinoma cells 208, 261

V³ NeuGe α -Gb₅Cer

Mouse kidney 330

V³ NeuAc, IV⁶ NeuAc-Gb₅Cer

Chicken skeletal muscle, human erythrocytes 276

(continued)

Table 4 (continued)

Structure	Name	Abbreviation	Source	References
Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer 3 1		V ³ (NeuAc α) ₂ -Gb ₅ Cer	Chicken muscle	250
NeuAc α 2-8 NeuAc α 2 Gal β 1-3 GalNAc β 1-3 Gal α 1-4 Gal β 1-4 Glc β 1-1' Cer 3 1		V ³ (NeuGc α) ₂ -Gb ₅ Cer	Mouse kidney	330
NeuGc α 2-8 NeuGc α 2				
Isoglobo series				
Monosialo				
Gal β 1-3 GalNAc β 1-3 Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer 3 1		V ³ NeuAc α -iGb ₅ Cer	Rat tissue	205
NeuAc α 2				
Gal β 1-3 GalNAc β 1-3 Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer 6 1		V ⁶ NeuAc α -iGb ₅ Cer	Rat small intestine	205
NeuAc α 2				
GalNAc α 1-3 GalNAc β 1-3 Gal α 1-3 Gal β 1-4 Glc β 1-1' Cer 6 1		IV ³ GalNAc α , II ⁶ [GalNAc β 1-4 (NeuAc α 2-3)Gal β 1- 4GlcNAc β 1]-iGb ₄ Cer	Equine kidney, spleen	363
GalNAc β 1-4 Gal β 1-4 GlcNAc β 1 3 1				
NeuAc α 2				
Unclassified				
Monosialo				
Gal β 1-3 GalNAc β 1-4 Glc β 1-1' Cer 3 1			Human erythrocytes	352
NeuAc α 2				
GalNAc β 1-4 Gal β 1-3 Gal β 1-4 Glc β 1-1' Cer 3 1	Cad antigen		Human erythrocytes	232
NeuAc α 2				
NeuAc α - Gal β - Gal β - Gal α - Gal β - Glc β 1-1' Cer			Mouse hematopoietic cells	332
Gal α 1-3 Gal β 1-4 GalNAc β 1-4 Gal β 1-4 Glc β 1-1' Cer 2 3 1			Rat hepatoma	236
Fuc α 1				
NeuAc α 2				

Kdn, 2-keto-3-deoxy-D-glycero-D-galacto-nononic acid.

galactose (instead of β 1-4-linked galactose) residue to LacCer results in the formation of the isoglobo-series of GSLs (iGb) with the core structure Gal α 1-3Gal β 1-4Glc β 1-1'Cer.

Some GSLs include hybrid types of carbohydrate chains, for example, lactoganglio-series. In addition, the addition of a β 1-4 galactose residue to LacCer results in the formation of muco-series GSLs with the following core structure: Gal β 1-4Gal β 1-4Glc β 1-1'Cer. Certain GSLs are further modified by the addition of a sulfated group. In invertebrates, mollu-(MI; Manz1-3Man β 1-4Glc β 1-1'Cer), arthro-(Ar; GlcNAc β 1-3Man β 1-4Glc β 1-1'Cer), neogala-(nGa; Gal β 1-6Gal β 1-6Gal β 1-1'Cer), and spirometo-(Sp; Gal β 1-4Glc β 1-3Gal β 1-1'Cer) series of GSLs have been identified.

Here in this chapter, we review 172 neutral GSLs (Table 2), 24 sulfated GSLs (Table 3), and 187 gangliosides (Table 4) that have been reported in the literatures. For consistency, the IUPAC–IUB recommendations regarding the nomenclature of GSLs are cited in the text.^{4,4a,4b} With the advent of modern methodologies for GSL isolation and characterization, it is expected that the list will grow at an accelerated pace.

Glossary

Cer ceramide.
Gal galactose.
GalNAc *N*-acetylgalactosamine.
Glc glucose.
GlcCer glucosylceramide.
GlcNAc *N*-acetylglucosamine.
GSL glycosphingolipid.
Fuc fucose.
Lac lactose.
LacCer lactosylceramide.
NeuAc *N*-acetylneuraminic acid.
NeuGc *N*-glycolylneuraminic acid.
KDN 2-keto-3-deoxy-D-*glycero*-D-galactonic acid.
Xyl xylose.

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Biographical Sketch



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