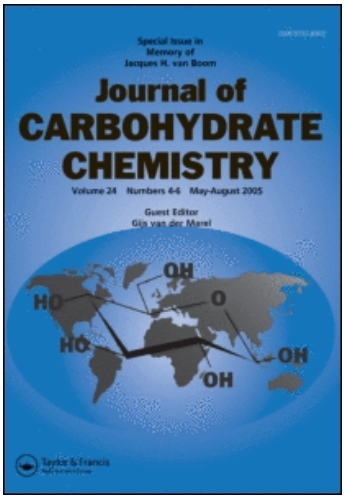

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A TOTAL SYNTHESIS OF SIALYL DIMERIC Le^x GANGLIOSIDE[1]

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ABSTRACT

The first total synthesis of tumor-associated glycolipid antigen, sialyl dimeric Le^x, is described. Regioselective glycosylation of the suitably protected Lewis X (Le^x) pentasaccharide derivative **6** with phenyl 4-*O*-acetyl-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-1-thio-β-D-glucopyranoside (**5**) gave the hexasaccharide **7**, which was converted, *via* removal of the phthaloyl groups and selective *N*-acetylation, into the hexasaccharide acceptor **9**. Dimethyl(methylthio)sulfonium triflate (DMTST) promoted glycosylation of **9** with methyl *O*-(methyl 5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-2,4,6-tri-*O*-benzoyl-1-thio-β-D-galactopyranoside (**10**) afforded regioselectively the expected octasaccharide **11**, which was converted into **13** *via* *O*-acetylation and removal of the methoxybenzyl group. Fucosylation of **13** with the methyl thioglycoside **14** was performed by use of *N*-iodosuccinimide (NIS)-trifluoromethanesulfonic acid(TfOH) as a promoter to give the desired nonasaccharide **15**. After replacing the benzyl groups of **15** by the acetyl groups, the 2-(trimethylsilyl)ethyl group at the reducing end was selectively transformed into the α-trichloroacetimidate **18**. Coupling of **18** with (2*S*, 3*R*, 4*E*)-2-azido-3-*O*-*tert*-butyldiphenylsilyl-4-octadecene-1,3-diol (**19**) gave the corresponding β-glycoside **20**, which was transformed, *via* selective reduction of the azide group, coupling with octadecanoic acid, *O*-desilylation, *O*-deacylation, and hydrolysis of the methyl ester group, into the title ganglioside **1** in good yield.

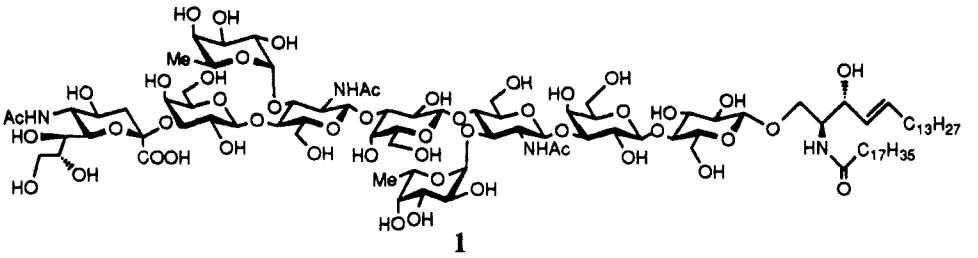
INTRODUCTION

The lacto-series gangliosides have been mainly detected by the monoclonal antibodies against tumor cells or tissues of lung, blood and digestive organ.[2] Recently, it has been demonstrated that the sialyl Lewis X (Le^x) ganglioside, one of the fucose-containing lacto-series gangliosides, is recognized by selectins,[3] a family of cell adhesion molecules involved in the initial stages of an inflammatory response. Although several sialyl Le^x relevant structures, such as VIM-II,[4] Le^x, sialyl dimeric Le^x and sialyl Le^x itself,[5] have been reported as the ligand for selectin binding, the structural requirements of the native ligand *in vivo* are still unclear. The interaction between these carbohydrate ligands and selectins may also be implicated in the process of hematogenous metastasis of cancer.

In the previous papers, we have reported[6] the total syntheses of sialyl Le^x and sialyl Le^a gangliosides, and their various analogs. As a part of our continuing efforts to elucidate the functions of tumor-associated lacto-series gangliosides, we describe here a facile, total synthesis of sialyl dimeric Le^x ganglioside **1**, which accumulates in human colonic adenocarcinoma but is absent in normal colonic mucosa, and found to be widespread as the tumor-associated glycolipid antigen of digestive organ and lung.[7]

RESULTS AND DISCUSSION

For the synthesis of sialyl dimeric Le^x ganglioside, three thioglycosides (**5**, **10**, and **14**) and the suitably protected Le^x pentasaccharide derivative **6**,[8] were selected as the building blocks. Compound **5** was prepared stepwise by 4-methoxybenzylation of phenyl 4,6-*O*-benzylidene-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside[9](**2**), reductive ring opening[10] of benzylidene acetal and subsequent 4-*O*-acetylation. The regioselective glycosylation of **6** with **5** was performed in dichloromethane in the presence of *N*-iodosuccinimide(NIS)-trifluoromethanesulfonic acid (TfOH) and molecular sieves 4Å (MS-4Å), to give the hexasaccharide **7** in 62% yield. Significant signals in ^1H NMR of the acetylated compound **8** were two one-proton doublets at δ 5.09 ($J_{1,2}$ = 8.0 Hz, H-1f) and δ 5.51 ($J_{3,4}$ = 3.7 Hz, H-4e), and a one-proton doublet of doublets at δ 4.66 ($J_{1,2}$ = 7.8 Hz, $J_{2,3}$ = 10.5 Hz, H-2e), indicating the newly formed glycosidic linkage to be β(1→3). Compound **7** was then converted into **9**, in



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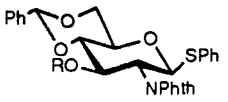
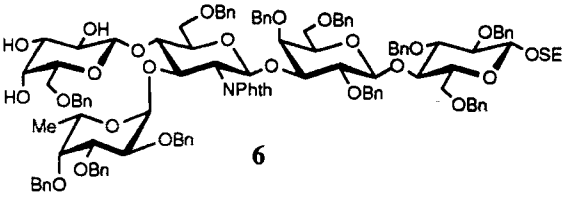


2 R = H
3 R = MPM



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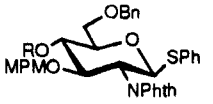
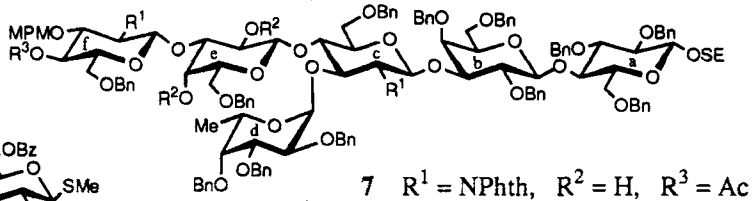
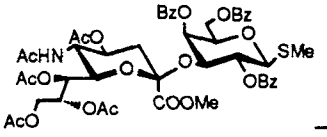


4 R = H
5 R = Ac

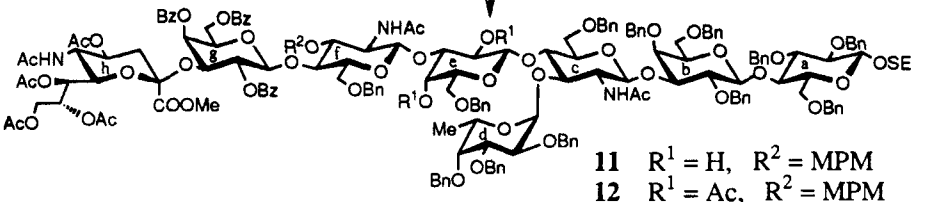
SE = 2-(trimethylsilyl)ethyl
MPM = 4-methoxybenzyl
Phth = phthaloyl





10

7 R^1 = NPhth, R^2 = H, R^3 = Ac
8 R^1 = NPhth, R^2 = Ac, R^3 = Ac
9 R^1 = NHAc, R^2 = H, R^3 = H

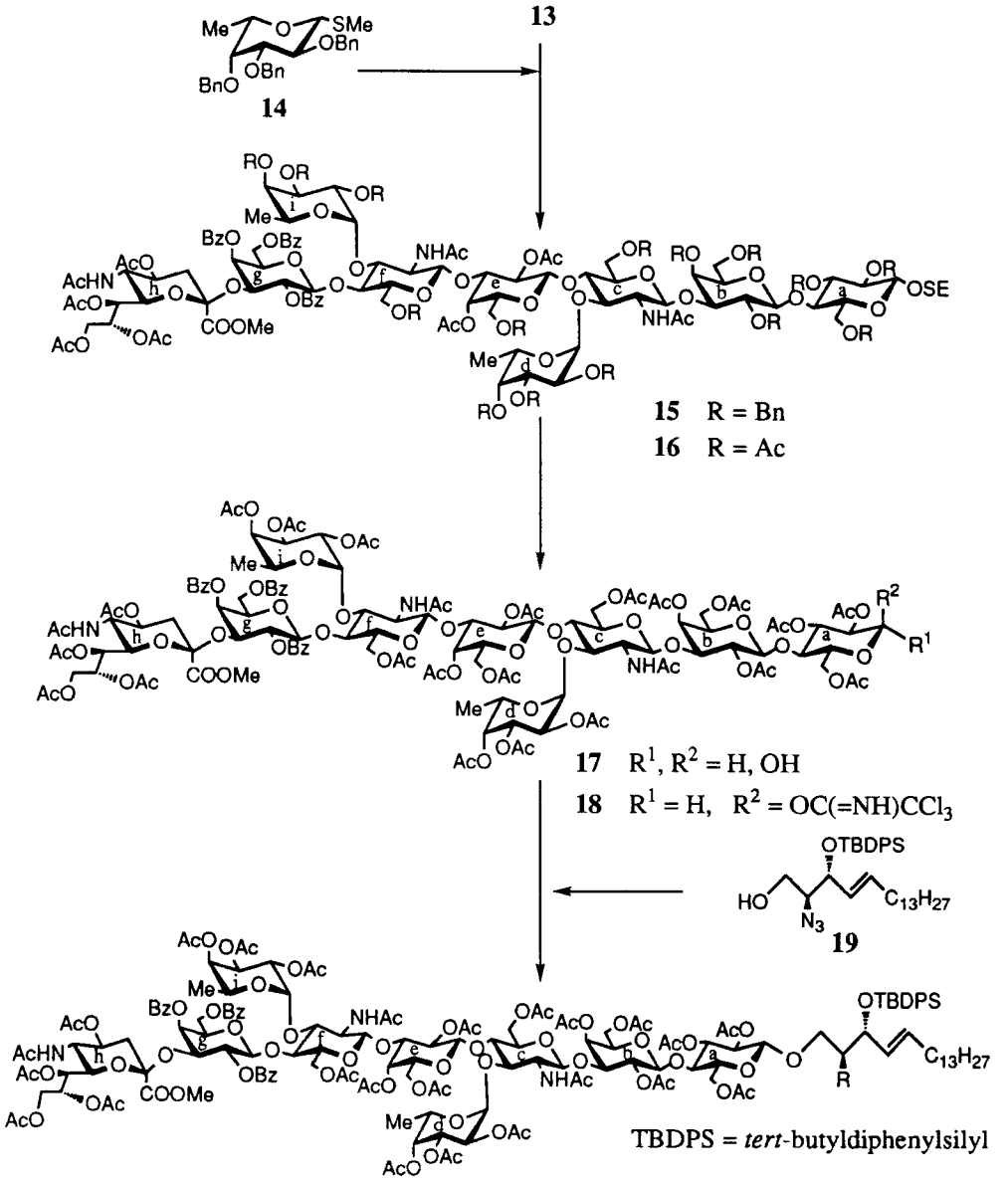


11 R^1 = H, R^2 = MPM
12 R^1 = Ac, R^2 = MPM
13 R^1 = Ac, R^2 = H

which three OH groups (OH-2e, 4e, 4f) are unprotected, by succesive treatments with hydrazine monohydrate and acetic anhydride in MeOH. The glycosylation of **9** with sialyl-α(2→3)Gal donor **10**[11] was performed in dichloromethane for 16 h at -15 °C in the presence of dimethyl(methylthio)sulfonium trifluoromethanesulfonate[12] (DMTST) and MS-4Å, to give the desired octasaccharide **11** in 55% yield, regioselectively. The ^{1}H NMR signals at δ 4.96 (dd, $J_{1,2}$ = 7.2 Hz, $J_{2,3}$ = 10.6 Hz, H-2) and 5.36 (d, $J_{3,4}$ = 3.5 Hz, H-4) for the Gal moiety (e) in the acetylated compound **12**, indicated that the sialyl galactose unit is linked to O-4 of the GlcN moiety (f). Other ^{1}H NMR data are given in Experimental Section, and are consistent with the structure assigned.

Removal of the methoxybenzyl group in **12** by ceric ammonium nitrate[13] gave compound **13** in 95% yield. Coupling of **13** with methyl 2,3,4-tri-*O*-benzyl-1-thio-β-L-fucopyranoside (**14**) in the presence of NIS-TfOH as the glycosyl promoter and powdered MS-4Å in toluene at -15 °C, afforded the corresponding nonasaccharidic sialyl dimeric Le^x derivative **15** in 60% yield. Significant signals in the ^{1}H NMR spectrum of **15** were two three-proton doublets at δ 1.01 ($J_{5,6}$ = 6.9 Hz, H-6d or 6i) and 1.03 ($J_{5,6}$ = 6.1 Hz, H-6d or 6i), and ninety aromatic protons due to eighteen phenyl groups, showing the difucosylated structure **15**. In a previous paper,[6] we have achieved an α-stereoselective fucosylation under the same condition. Thus, the newly formed glycosidic linkage of fucose in **15** was determined as α from the ^{1}H MNR data of **21** and **1**.

Catalytic hydrogenolysis (10% Pd/C) of the benzyl groups of **15** in methanol for 5 days and subsequent *O*-acetylation, gave the per-*O*-acyl compound **16** in 69% yield. Treatment[14] of **16** with trifluoroacetic acid in dichloromethane for 4 h at room temperature gave the corresponding hemiacetal derivative **17** in 97% yield, which was subsequently treated with trichloroacetonitrile in the presence of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) for 3 h at 0 °C to give the α-trichloroacetimidate **18** in 83% yield. Significant signals in the ^{1}H NMR spectrum were at δ 6.48 ($J_{1,2}$ = 3.8 Hz, H-1a) and 8.67 (C=NH), which showed the imidate to be α. Glycosylation of (2*S*, 3*R*, 4*E*)-2-azido-3-*O*-*tert*-butyl-diphenylsilyl-4-octadecene-1,3-diol[15] (**19**) with **18** was carried out in the presence of boron trifluoride etherate for 8 h at 0 °C, affording the desired β-glycoside **20** in 33% yield. Selective reduction[16] of the azide group in **20** with triphenylphosphine in benzene gave the amine, which on condensation with octadecanoic acid using 2-chloro-1,3-dimethylimidazolium chloride[17] (DMC) in



dichloromethane, afforded the fully protected sialyl dimeric Le^x ganglioside **21** in 57 % yield. Finally, **21** was transformed *via* *O*-desilylation with tetrabutylammonium fluoride in acetonitrile, *O*-deacylation with sodium methoxide in methanol and subsequent saponification of the methyl ester, into the desired sialyl dimeric Le^x ganglioside in good yield after chromatography on a column of Sephadex LH-20. The ^1H NMR data of the product thus obtained are consistent with the structure assigned.

In conclusion, an efficient, first total synthesis of sialyl dimeric Le^x ganglioside was achieved by employing the thioglycosides **5**, **10**, and **14** as the glycosyl donors, and the suitably protected Le^x pentasaccharide **6**, hexa- and octasaccharides (**9** and **13**) as the key glycosyl acceptors.

EXPERIMENTAL

General Procedures. Specific rotations were determined with a Jasco DIP-370 digital polarimeter at 25 °C, and IR spectra were recorded with a Jasco IR-700 infrared spectrometer. ^1H NMR spectra were recorded at 300 MHz with General Electric QE-plus spectrometer. Preparative chromatography was performed on silica gel (Wako Chemical Co., 300 mesh) with the solvent systems specified. Concentrations were conducted *in vacuo*.

Phenyl 4,6-*O*-Benzylidene-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-1-thio-β-D-glucopyranoside (3). To a solution of **2** (ref. 9; 3.0 g, 6.1 mmol) in dry *N*,*N*-dimethylformamide (30 mL) was added sodium hydride in oil suspension (270 mg; 60% of sodium hydride by weight), and the mixture was stirred for 30 min at 0 °C, and then 4-methoxybenzyl chloride (1.0 mL, 7.3 mmol) was added at -15 °C. After the stirring was continued for 12 h, methanol (1.0 mL) and citric acid were added. The precipitates were filtered off, and washed with ethyl acetate. The filtrate and washings were combined, and the solution was washed with water, dried (Na_2SO_4) and concentrated to a syrup that was chromatographed on a column of silica gel (300 g) with 1:3 ethyl acetate-hexane to give **3** (2.66 g, 71%) as a syrup, which crystallized from ethyl acetate-hexane: mp 169-170 °C; $[\alpha]_D$ +101.8° (*c* 1.04, chloroform); ^1H NMR ($CDCl_3$) δ 3.61 (s, 3H, MeO), 5.61 (d, 1H, $J_{1,2}$ = 10.5 Hz, H-1), 5.63 (s, 1H, PhC*H*), 6.34-7.86 (m, 18H, aromatic).

Anal. Calcd for $C_{35}H_{31}NO_7S$(609.7): C, 68.95; H, 5.13; N, 2.30. Found: C, 68.77; H, 4.90; N, 2.16.

Phenyl 6-*O*-Benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-1-thio-β-D-glucopyranoside (4). To a solution of **3** (374 mg, 0.61 mmol) in dry tetrahydrofuran (4 mL) were added molecular sieves 4Å (MS-4Å, 2.0 g), the mixture was stirred for 4 h at room temperature, and sodium cyanoborohydride (578 mg, 9.19 mmol) was gradually added. After the reagent had dissolved, hydrogen chloride in ether was added dropwise at room temperature until the evolution of gas ceased. TLC indicated that the reaction was complete after 5 min. The mixture was diluted with dichloromethane (30 mL) and water (30 mL), filtered, washed with M sodium hydrogen carbonate and water, dried (Na_2SO_4), and concentrated. Column chromatography (2:5 ethyl acetate-hexane) of the residue on silica gel (50 g) gave **4** (364 mg, 97%) as an amorphous mass: $[\alpha]_D$ +73.1° (*c* 1.06, chloroform); ^1H NMR ($CDCl_3$) δ 1.00 (m, 2H, $Me_3SiCH_2CH_2O$), 1.47 (s, 3H, AcN), 3.77 (s, 3H, *Me*O), 6.81-7.31 (m, 39H, 7Ph, MeO*Ph*).

Anal. Calcd for $C_{35}H_{33}NO_7S$ (611.7): C, 68.72; H, 5.44; N, 2.29. Found: C, 68.68; H, 5.21; N, 2.07.

Phenyl 4-*O*-Acetyl-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-1-thio-β-D-glucopyranoside (5). To a solution of **4** (2.2 g, 3.60 mmol) in pyridine (15 mL) was added acetic anhydride (5 mL), and the mixture was stirred for 16 h at room temperature. After completion of the reaction, methanol (10 mL) was added, and the mixture was stirred for 20 min at room temperature, concentrated, and extracted with dichloromethane. The extract was washed with 2 M hydrochloric acid, M sodium carbonate, and water, dried (Na_2SO_4), and concentrated to give **5** (2.1 g, 89%) as an amorphous mass: $[\alpha]_D$ +103.1° (*c* 0.83, chloroform); ^1H NMR ($CDCl_3$) δ 1.99 (s, 3H, AcO), 3.58 (s, 3H, MeO), 4.27 (t, 1H, $J_{1,2} = J_{2,3} = 10.4$ Hz, H-2), 4.42 (dd, 1H, $J_{3,4} = 8.9$ Hz, H-3), 5.10 (dd, 1H, $J_{4,5} = 10.0$ Hz, H-4), 5.55 (d, 1H, H-1), 6.39-7.81 (m, 18H, aromatic).

Anal. Calcd for $C_{37}H_{35}NO_8S$ (653.7): C, 67.98; H, 5.40; N, 2.14. Found: C, 67.95; H, 5.10; N, 2.03.

2-(Trimethylsilyl)ethyl *O*-[4-*O*-Acetyl-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-β-D-glucopyranosyl]-(1→3)-*O*-(6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-

benzyl-β-D-glucopyranoside (7). To a solution of **6** (ref. 8; 300 mg, 147 μmol) and **5** (78 mg, 119 μmol) in dry dichloromethane (3 mL) was added MS-4Å (1.2 g), and the mixture was stirred for 24 h at room temperature. *N*-Iodosuccinimide (NIS; 47 mg, 209 μmol) was added to the mixture, and it was cooled to -60 °C. Trifluoromethanesulfonic acid (TfOH; 5 μL, 20 μmol) was added to the cooled mixture, and this was stirred for 24 h at -60 °C. The precipitate was filtered off and washed with dichloromethane. The filtrate and washings were combined, and the solution was successively washed with M $Na_2S_2O_3$ and water, dried (Na_2SO_4), and concentrated to a syrup which was chromatographed on a column of silica gel (60 g) with 2:3 ethyl acetate-hexane to give amorphous **7** (181 mg, 62%): $[\alpha]_D$ -2.1° (*c* 0.99, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.77 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d), 0.99 (m, 2H, $Me_3SiCH_2CH_2O$), 1.99 (s, 3H, AcO), 3.57 (s, 3H, MeO), 5.11 (dd, 1H, $J_{3,4} = 9.3$ Hz, $J_{4,5} = 9.9$ Hz, H-4f), 5.28 (d, 1H, $J_{1,2} = 8.3$ Hz, H-1f), 5.38 (d, 1H, $J_{1,2} = 8.5$ Hz, H-1c), 6.44-7.62 (m, 72H, aromatic).

Anal. Calcd for $C_{151}H_{162}N_2O_{34}Si$ (2577.0): C, 70.38; H, 6.34; N, 1.09. Found: C, 70.37; H, 6.24; N, 1.02.

2-(Trimethylsilyl)ethyl *O*-[4-*O*-Acetyl-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-2-phthalimido-β-D-glucopyranosyl]-(1→3)-*O*-(2,4-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (8). Acetylation of **7** (100 mg, 3.60 mmol), as described for **5**, gave amorphous **8** (97 mg, 94%): $[\alpha]_D$ -12.6° (*c* 1.41, chloroform); ^{1}H NMR ($CDCl_3$): δ 0.91 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d), 0.98 (m, 2H, $Me_3SiCH_2CH_2O$), 1.71, 1.90, 2.00 (3s, 9H, 3AcO), 3.62 (s, 3H, MeO), 4.66 (dd, 1H, $J_{1,2} = 7.8$ Hz, $J_{2,3} = 10.5$ Hz, H-2e), 5.08 (t, 1H, $J_{3,4} = J_{4,5} = 10.1$ Hz, H-4f), 5.09 (d, 1H, $J_{1,2} = 8.0$ Hz, H-1f), 5.26 (d, 1H, $J_{1,2} = 8.4$ Hz, H-1c), 5.51 (d, 1H, $J_{3,4} = 3.7$ Hz, H-4e), 6.45-7.74 (m, 72H, aromatic).

Anal. Calcd for $C_{148}H_{166}N_2O_{40}Si$ (2641.0): C, 69.96; H, 6.29; N, 1.05. Found: C, 69.68; H, 6.09; N, 0.88.

2-(Trimethylsilyl)ethyl *O*-[2-Acetamido-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-β-D-glucopyranosyl]-(1→3)-*O*-(6-*O*-benzyl-β-D-galacto-pyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-

(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (9). To a solution of **7** (250 mg, 97 μmol) in aq 95% ethanol (10 mL) was added hydrazine hydrate (0.2 mL), the mixture was refluxed for 2 days. After cooling the mixture in ice bath, the precipitate was filtered off, and washed with methanol. The filtrate and washings were combined, and concentrated. The residue thus obtained was then treated with acetic anhydride (1 mL) in methanol (7 mL) for 16 h at room temperature. The reaction mixture was then concentrated to a syrup which was chromatographed on a column of silica gel (100 g) with 40:1 dichloromethane-methanol, to give **9** (161 mg, 66%) as an amorphous mass: $[\alpha]_D$ -23.4° (*c* 0.84, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.98 (m, 2H, $Me_3SiCH_2CH_2O$), 1.03 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d), 1.24, 1.25 (2s, 6H, 2AcN), 3.66 (s, 3H, MeO), 6.78-7.47 (m, 64H, aromatic).

Anal. Calcd for $C_{137}H_{160}N_2O_{31}Si$ (2358.9): C, 69.76; H, 6.84; N, 1.19. Found: C, 69.46; H, 6.61; N, 1.19.

2-(Trimethylsilyl)ethyl *O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-*O*-[2-acetamido-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-β-D-glucopyranosyl]-(1→3)-*O*-(6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (11). To a solution of **9** (78 mg, 119 μmol) and **10** (ref. 11; 300 mg, 147 μmol) in dry dichloromethane (3 mL) was added MS-4Å (1.2 g), and the mixture was stirred for 16 h at room temperature and cooled to -15 °C. Dimethyl(methylthio)sulfonium triflate (DMTST; 25 mg, 96.7 mmol) was added to the stirred mixture, and the stirring was continued for 24 h at -15 °C. The precipitate was removed by filtration and washed with dichloromethane. The filtrate and washings were combined, and the solution was successively washed with M $NaHCO_3$ and water, dried (Na_2SO_4), and concentrated to a syrup which was chromatographed on a column of silica gel (20 g) with 12:8:0.9 dichloromethane-ethyl acetate-methanol to give amorphous **11** (181 mg, 55%): $[\alpha]_D$ -9.3° (*c* 1.14, chloroform); ^{1}H NMR ($CDCl_3$) δ 1.00 (m, 2H, $Me_3SiCH_2CH_2O$), 1.08 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d), 1.48-2.17 (7s, 21H, 4AcO, 3AcN), 2.45 (dd, 1H, $J_{gem} = 12.6$ Hz, $J_{3eq,4} = 4.6$ Hz, H-3h*eq*),

3.71 (s, 3H, MeO), 3.84 (s, 3H, *Me*OOC), 5.21 (dd, 1H, $J_{6,7}$ = 2.7 Hz, $J_{7,8}$ = 9.7 Hz, H-7h), 5.38 (d, 1H, $J_{3,4}$ = 3.2 Hz, H-4g), 5.49 (dd, 1H, $J_{1,2}$ = 7.9 Hz, $J_{2,3}$ = 10.0 Hz, H-2g), 5.66 (m, 1H, H-8h), 6.73-8.21 (m, 79H, aromatic).

Anal. Calcd for $C_{184}H_{209}N_3O_{51}Si$ (3306.8): C, 66.83; H, 6.37; N, 1.27. Found: C, 66.56; H, 6.32; N, 1.08.

2-(Trimethylsilyl)ethyl *O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-*O*-[2-acetamido-6-*O*-benzyl-2-deoxy-3-*O*-(4-methoxybenzyl)-β-D-glucopyranosyl]-(1→3)-*O*-(2,4-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (12). To a solution of **11** (69 mg, 20.9 μmol) in pyridine (1 mL) were added acetic anhydride (0.5 mL) and a catalytic amount of 4-dimethylaminopyridine, and the mixture was stirred for 16 h at room temperature. After completion of the reaction, methanol (1 mL) was added, and the mixture was stirred for 20 min at room temperature then concentrated to a syrup which was chromatographed on a column of silica gel (30 g) with 30:1 dichloromethane-methanol to give amorphous **12** (67 mg, 95%): $[\alpha]_D$ -11.2° (*c* 0.91, chloroform); ^1H NMR ($CDCl_3$) δ 1.00 (m, 2H, $Me_3SiCH_2CH_2O$), 1.07 (d, 3H, $J_{5,6} = J_{5,6'}$ = 6.4 Hz, H-6d), 1.41-2.20 (9s, 27H, 6AcO, 3AcN), 2.45 (dd, 1H, J_{gem} = 12.7 Hz, $J_{3eq,4}$ = 4.4 Hz, H-3h*eq*), 3.68 (s, 3H, *Me*O), 3.84 (s, 3H, *Me*OOC), 4.96 (dd, 1H, $J_{1,2}$ = 7.2 Hz, $J_{2,3}$ = 10.6 Hz, H-2e), 5.10 (d, 1H, $J_{1,2}$ = 3.5 Hz, H-1d), 5.15 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1g), 5.20 (dd, 1H, $J_{6,7}$ = 2.8 Hz, $J_{7,8}$ = 9.7 Hz, H-7h), 5.36 (d, 1H, $J_{3,4}$ = 3.5 Hz, H-4e), 5.38 (d, 1H, $J_{3,4}$ = 3.3 Hz, H-4g), 5.47 (dd, 1H, $J_{2,3}$ = 10.0 Hz, H-2g), 5.72 (m, 1H, H-8h), 6.66-8.25 (m, 79H, aromatic).

Anal. Calcd for $C_{188}H_{213}N_3O_{53}Si$ (3390.8): C, 66.59; H, 6.33; N, 1.24. Found: C, 66.31; H, 6.29; N, 1.21.

2-(Trimethylsilyl)ethyl *O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopy-

ranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (13). To a solution of **12** (83 mg, 24.5 μmol) in dry methanol (8 mL) was added ceric ammonium nitrate (CAN; 134 mg, 245 μmol), and the mixture was stirred for 4 h at room temperature. Sodium hydrogen carbonate (200 mg) was then added and the mixture was stirred for 5 min. The solids were separated on a celite-pad and washed with dichlorometane. The combined filtrate and washings were successively washed with water, dried (Na_2SO_4), and concentrated. Column chromatography (30:1 dichloromethane-methanol) of the residue on silica gel (30 g) gave **13** (76 mg, 95%) as an amorphous mass: $[\alpha]_D$ -22.7° (*c* 1.32, chloroform); ^1H NMR ($CDCl_3$) δ 1.00 (m, 2H, $Me_3SiCH_2CH_2O$), 1.08 (d, 3H, $J_{5,6} = J_{5,6'} = 6.3$ Hz, H-6d), 1.36-2.20 (9s, 27H, 6AcO, 3AcN), 2.45 (dd, 1H, $J_{gem} = 12.5$ Hz, $J_{3eq,4} = 4.7$ Hz, H-3h*eq*), 3.84 (s, 3H, *Me*OOC), 5.34 (d, 1H, $J_{3,4} = 3.1$ Hz, H-4e), 5.44 (d, 1H, $J_{3,4} = 2.7$ Hz, H-4g), 5.52 (dd, 1H, $J_{1,2} = 8.2$ Hz, $J_{2,3} = 9.9$ Hz, H-2g), 5.67 (m, 1H, H-8h), 7.05-8.29 (m, 75H, aromatic).

Anal. Calcd for $C_{180}H_{205}N_3O_{52}Si$ (3270.7): C, 66.10; H, 6.32; N, 1.28. Found: C, 65.93; H, 6.13; N, 1.26.

2-(Trimethylsilyl)ethyl *O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (15). To a solution of **13** (72 mg, 22.0 μmol) and methyl 2,3,4-tri-*O*-benzyl-1-thio-β-L-fucopyranoside[6] (**14**; 17 mg, 32.3 μmol) in dry toluene (1 mL) was added MS-4Å (200 mg), the mixture was stirred for 4 h at room temperature. *N*-Iodosuccinimide (NIS; 15 mg, 67.0 μmol) was added, and the mixture was cooled to -15 °C. Trifluoromethanesulfonic acid (TfOH; 1 μL) was added to the cooled mixture, and this was stirred for 24 h at -5 °C. The precipitate was removed by filtration and washed with dichloromethane. The filtrate and washings were combined, and the solution was successively washed with M $Na_2S_2O_3$ and water, dried (Na_2SO_4), and concentrated to a

syrup which was chromatographed on a column of silica gel (30 g) with 40:20:1 dichloromethane-ethyl acetate-methanol to give amorphous **15** (48.8 mg, 60%); $[\alpha]_D$ -24.8° (*c* 0.78, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.97 (m, 2H, $Me_3SiCH_2CH_2O$), 1.01 (d, 3H, $J_{5,6} = J_{5,6'} = 6.9$ Hz, H-6d or 6i), 1.03 (d, 3H, $J_{5,6} = J_{5,6'} = 6.1$ Hz, H-6d or 6i), 1.24-2.19 (8s, 27H, 6AcO, 3AcN), 2.41 (dd, 1H, $J_{gem} = 12.2$ Hz, $J_{3eq,4} = 4.3$ Hz, H-3h*eq*), 3.78 (s, 3H, *Me*OOC), 5.30 (d, 1H, $J_{3,4} = 3.6$ Hz, H-4g), 5.47 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.0$ Hz, H-2g), 5.74 (m, 1H, H-8h), 7.03-8.25 (m, 90H, aromatic).

Anal. Calcd for $C_{207}H_{233}N_3O_{56}Si$ (3687.2): C, 67.43; H, 6.37; N, 1.14. Found: C, 67.36; H, 6.20; N, 0.91.

2-(Trimethylsilyl)ethyl *O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-β-D-glucopyranoside (16). A solution of **15** (256 mg, 69.4 μmol) in methanol (30 mL) and acetic acid (1 mL) was hydrogenolysed in the presence of 10% Pd-C (350 mg) for 6 days at room temperature, then filtered, and concentrated. The residue was acetylated in the presence of a catalytic amount of 4-dimethylaminopyridine with acetic anhydride (3 mL)-pyridine (5 mL) for 24 h. The product was purified by chromatography on a column of silica gel (80 g) with 25:1 dichloromethane-methanol, to give **16** (142 mg, 69%) as an amorphous mass: $[\alpha]_D$ -29.0° (*c* 0.70, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.91 (m, 2H, $Me_3SiCH_2CH_2O$), 1.14 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d or 6i), 1.21 (d, 3H, $J_{5,6} = J_{5,6'} = 6.5$ Hz, H-6d or 6i), 1.54-2.17 (24s, 72H, 21AcO, 3AcN), 2.40 (dd, 1H, $J_{gem} = 12.5$ Hz, $J_{3eq,4} = 4.5$ Hz, H-3h*eq*), 3.07 (m, 1H, H-2c), 3.48 (dd, 1H, $J_{2,3} = 9.2$ Hz, $J_{3,4} = 3.8$ Hz, H-3b), 3.68 (dd, 1H, $J_{2,3} = 10.1$ Hz, $J_{3,4} = 3.3$ Hz, H-3e), 3.80 (s, 3H, *Me*OOC), 4.33 (d, 1H, $J_{1,2} = 8.0$ Hz, H-1e), 4.39 (d, 1H, $J_{1,2} = 8.8$ Hz, H-1a), 5.30 (d, 1H, $J_{3,4} = 3.6$ Hz, H-4g), 4.47 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1b), 5.16 (t, 1H, $J_{3,4} = J_{2,3} = 9.3$ Hz, H-3a), 5.23 (dd, 1H, $J_{6,7} = 11.4$ Hz, $J_{7,8} = 2.8$ Hz, H-7h), 5.38 (nd, 1H, $J_{3,4} = 3.8$ Hz, H-4g), 5.42 (dd, 1H, $J_{1,2} = 8.3$ Hz, $J_{2,3} = 9.8$ Hz, H-2g), 5.66 (m, 1H, H-8h), 7.45-8.22 (m, 15H, aromatic).

Anal. Calcd for $C_{132}H_{173}N_3O_{71}Si$ (2965.9): C, 53.46; H, 5.88; N, 1.42. Found: C, 53.17; H, 5.67; N, 1.32.

***O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-D-glucopyranose (17).** To a solution of **16** (140 mg, 47.2 μmol) in dry dichloromethane (1 mL) was added trifluoroacetic acid (2 mL), and the mixture was stirred for 4 h at room temperature. Ethyl acetate (6 mL) was added to the mixture, and it was concentrated to a syrup that was chromatographed on a column of silica gel (30 g) with 20:1 dichloromethane-methanol, to give **17** (131 mg, 97%) as an amorphous mass: $[\alpha]_D$ -12.5° (*c* 0.93, chloroform); IR (KBr) 3380 (NH, OH), 1745 and 1230 (ester), 1690 and 1540 (amide), and 720 cm^{-1} (Ph).

Anal. Calcd for $C_{127}H_{161}N_3O_{71}$ (2865.6): C, 53.23; H, 5.66; N, 1.47. Found: C, 52.98; H, 5.49; N, 1.20.

***O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-α-D-glucopyranosyl trichloroacetimidate (18).** A solution of **17** (131 mg, 46.0 μmol) and trichloroacetonitrile (0.2 mL) in dichloromethane (1 mL) was cooled to -5 °C, and to the solution was added 1,8-diazabicyclo[5.4.0.]undec-7-ene (DBU; 10 mg). The mixture was stirred for 4 h at 0 °C and then concentrated. Column chromatography of the residue on silica gel (30 g) with 30:1 dichloromethane-methanol afforded **18** (114 mg, 83%) as an amorphous mass: $[\alpha]_D$ -13.5° (*c* 1.14, chloroform); ^1H NMR ($CDCl_3$) δ 1.14 (d, 3H, $J_{5,6}$ = 6.5 Hz, H-6d or 6i), 1.21 (d, 3H, $J_{5,6}$ = 6.5 Hz, H-6d or 6i), 1.54-2.18 (23s, 72H, 3AcN,

21AcO), 2.40 (dd, 1H, J_{gem} = 12.6 Hz, $J_{3eq,4}$ = 4.4 Hz, H-3h*eq*), 3.08 (m, 1H, H-2c), 3.61 (dd, 1H, $J_{5,6}$ = 10.7 Hz, $J_{6,7}$ = 2.8 Hz, H-6h), 3.81 (s, 3H, MeO), 5.65 (m, 1H, H-8h), 6.48 (d, 1H, $J_{1,2}$ = 3.8 Hz, H-1a), 7.45-8.20 (m, 15H, 3Ph), 8.67 (s, 1H, C=N*H*).

Anal. Calcd for $C_{129}H_{161}N_4O_{71}Cl_3$ (3010.0): C, 51.48; H, 5.39; N, 1.86. Found: C, 51.38; H, 5.31; N, 1.82.

***O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-α-D-glucopyranosyl)-(1→1)-(2*S*,3*R*,4*E*)-2-azido-3-*O*-*tert*-butyldiphenylsilyl-4-octadecene-1,3-diol (20).** To a solution of **18** (114 mg, 38.0 μmol) and (2*S*,3*R*,4*E*)-2-azido-3-*tert*-butyldiphenylsilyl-4-octadecene-1,3-diol[15] (**19**; 53 mg, 94.0 μmol) in dry dichloromethane (1 mL) was added MS-4Å (AW-300; 1.2 g), and the mixture was stirred for 30 min at room temperature, and cooled to 0 °C. To the cooled mixture was added boron trifluoride etherate (30 μL), and the mixture was stirred for 8 h at 0 °C, and then filtered. The insoluble material was washed with dichloromethane, and the combined filtrate and washings were successively washed with M sodium hydrogen carbonate and water, dried (Na_2SO_4), and concentrated. Column chromatography (30:1 dichloromethane-methanol) of the residue on silica gel (20 g) gave **12** (43 mg, 33%) as an amorphous mass: $[\alpha]_D$ -34.2° (*c* 0.74, chloroform); ^1H NMR ($CDCl_3$) δ 0.90 (t, 3H, J_{Me,CH_2} = 6.6 Hz, *Me*CH_2), 1.06 (s, 9H, *t-Bu*), 1.15 (d, 3H, $J_{5,6}$ = 6.3 Hz, H-6d or 6i), 1.22 (d, 3H, $J_{5,6}$ = 6.3 Hz, H-6d or 6i), 1.28 (s, 22H, 11CH_2), 1.64 (t, 1H, J_{gem} = $J_{3ax,4}$ = 12.6 Hz, H-3h*ax*), 1.56-2.18 (18s, 72H, 3AcN, 21AcO), 2.42 (dd, 1H, $J_{3eq,4}$ = 4.6 Hz, H-3h*eq*), 3.82 (s, 3H, MeO), 5.67 (m, 1H, H-8h), 7.34-8.21 (m, 25H, 5Ph).

Anal. Calcd for $C_{161}H_{212}N_6O_{72}Si$ (3411.5): C, 56.68; H, 6.26; N, 2.46. Found: C, 56.63; H, 6.01; N, 2.26.

***O*-(Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate)-(2→3)-*O*-(2,4,6-tri-*O*-benzoyl-**

β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-α-D-glucopyranosyl)-(1→1)-(2*S*,3*R*,4*E*)-3-*O*-*tert*-butyldiphenylsilyl-2-octadecanamido-4-octadecene-1,3-diol (21). To a solution of **20** (43 mg, 12.6 μmol) in benzene (1 mL) were added triphenylphosphine (6.6 mg; 25.2 μmol) and water (30 μL), and the mixture was stirred at 50 °C for 4 h and concentrated to dryness. The amine thus obtained and octadecanoic acid (7.2 mg, 25.3 μmol) were dissolved in benzene. To the stirred solution were added 2-chloro-1,3-dimethylimidazolium chloride[17] (3.2 mg, 18.9 μmol) and triethylamine (5.3 μL, 38.0 μmol), and the mixture was stirred for 4 h at room temperature. Methanol (1 mL) was added, and the mixture was concentrated to a syrup which was chromatographed on a column of silica gel (20 g) with 30:1 dichloromethane-methanol to gave **21** (26.3 mg, 57%) as an amorphous mass: $[\alpha]_D$ -28.9° (*c* 1.31, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.90 (t, 6H, J_{Me,CH_2} = 6.6 Hz, 2*Me*CH2), 1.02 (s, 9H, *t-Bu*), 1.15 (d, 3H, $J_{5,6}$ = 6.5 Hz, H-6d or i), 1.21 (d, 3H, $J_{5,6}$ = 6.5 Hz, H-6d or i), 1.27 (s, 52H, 26CH2), 1.65 (t, 1H, J_{gem} = $J_{3ax,4}$ = 12.1 Hz, H-3h*ax*), 1.56-2.19 (23s, 72H, 3AcN, 21AcO), 2.42 (dd, 1H, $J_{3eq,4}$ = 4.0 Hz, H-3h*eq*), 3.62 (dd, 1H, $J_{5,6}$ = 10.8 Hz, $J_{6,7}$ = 2.6 Hz, H-6h), 3.83 (s, 3H, MeO), 4.33 (d, 1H, $J_{1,2}$ = 8.0 Hz, H-1g), 5.07 (d, 2H, $J_{1,2}$ = 2.8 Hz, H-1d and i), 5.17 (t, 1H, $J_{2,3}$ = $J_{3,4}$ = 9.3 Hz, H-3a), 5.67 (m, 1H, H-8h), 7.34-8.21 (m, 25H, 5Ph).

Anal. Calcd for $C_{179}H_{248}N_4O_{73}Si$ (3652.0): C, 58.87; H, 6.85; N, 1.53. Found: C, 58.82; H, 6.70; N, 1.40.

Sialyl α(2→3) dimeric Le^x ganglioside (1). To a solution of **21** (25.8 mg, 7.1 μmol) in acetonitrile (1 mL) was added 1.0 M tetrabutylammonium fluoride solution in tetrahydrofuran (20 mL), and the mixture was stirred for 24 h at room temperature. The mixture was concentrated, and the residue was dissolved in methanol (1 mL). Sodium methoxide (6 mg) was added to the solution, and the mixture was stirred for 48 h at 40 °C, and then water (0.1 mL) was added. The mixture was stirred for 8 h at room temperature, neutralized with Amberlite IR-120 (H+) resin and filtered. The resin was washed with 5:4:1 chloroform-methanol-water, and the combined filtrate

and washings were concentrated to a syrup that was chromatographed on a column of Sephadex LH-20 (40 g) with 5:4:1 chloroform-methanol-water, to give **1** (13.4 mg, 86%) as an amorphous mass: $[\alpha]_D$ -37.9° (*c* 0.65, 5:4:1 chloroform-methanol-water); ^1H NMR [49:1 $(CD_3)_2SO$-D_2O] (ceramide part) δ 0.86 (t, 6H, J = 6.7 Hz, $2CH_3CH_2$), 1.26 (s, 52H, $26CH_2$), 2.04 (t, 2H, J = 7.4 Hz, $COCH_2CH_2$), 5.37 (dd, 1H, $J_{3,4}$ = 6.9 Hz, $J_{4,5}$ = 15.4 Hz, H-4), 5.56 (m, 1H, $J_{5,6}$ = $J_{5,6'}$ = 6.5 Hz, H-5); (oligosaccharide part) δ 1.01 (d, 3H, $J_{5,6}$ = 6.4 Hz, H-6d or 6i), 1.02 (d, 3H, $J_{5,6}$ = 6.5 Hz, H-6d or 6i), 1.82, 1.83, 1.89 (3s, 9H, 3AcN), 2.72 (dd, 1H, J_{gem} = 13.1 Hz, $J_{3eq,4}$ = 4.4 Hz, H-3h*eq*), 4.18 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1a), 4.28 (d, 1H, $J_{1,2}$ = 7.6 Hz, H-1b), 4.32 (d, 1H, $J_{1,2}$ = 8.4 Hz, H-1e or 1g), 4.34 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1e or 1g), 4.61 (m, 2H, H-5d and 5i), 4.75 (d, 2H, $J_{1,2}$ = 7.9 Hz, H-1c and 1f), 4.88 (d, 2H, $J_{1,2}$ = 3.6 Hz, H-1d and 1i).

Anal. Calcd for $C_{99}H_{174}N_4O_{49}$ (2204.5): C, 53.94; H, 7.96; N, 2.54. Found: C, 53.89; H, 7.94; N, 2.42.

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