Synthesis of D-*erythro*-Ceramide-1-phosphoinositol and Its Aminoglucosylated Derivative − Intermediates in GPI-Anchor Biosynthesis

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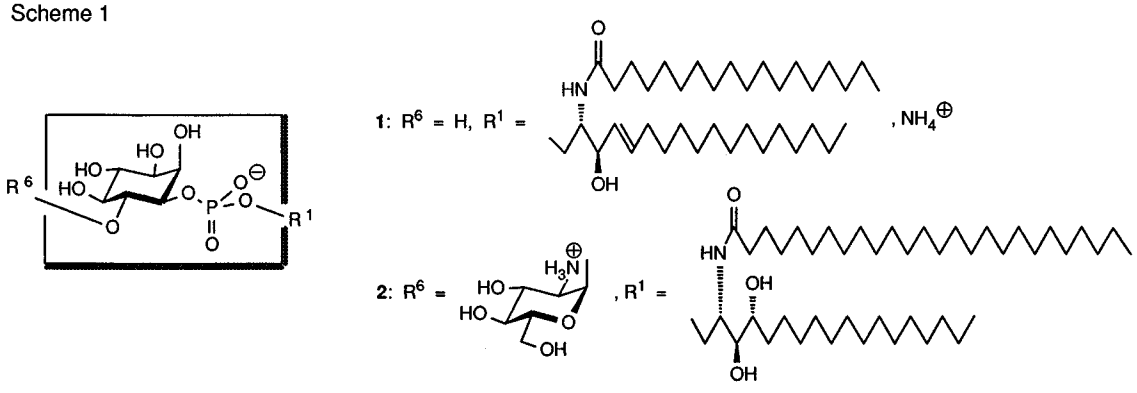
The readily available 2,3:4,5-di-*O*-cyclohexylidene-D-*myo*-inositol derivative **3** was converted into the 1-*O*-unprotected D-*myo*-inositol derivative **6**. Reaction with the phosphite derivative **7** of 3-*O*-*tert*-butyldimethylsilyl-protected ceramide furnished the target molecule D-*erythro*-ceramide-1-phosphoinositol (**1**). Reaction of *O*-(3,4,6-tri-*O*-acetyl-2-azido-β-D-glucopyranosyl)trichloroacetimidate (**20**) with **3** gave exclusively α(1→6)-connected glycoside **21** which was converted into the 1α-*O*-unprotected derivative **24**. Reaction with the D-*erythro*-azidophytosphingosine-derived ceramide-1-phosphite derivative **17** led, after oxidation and removal of the cyanoethyl group, to protected 2-azido-D-glucopyranosyl-α(1→6)-D-*myo*-inositol-1-phospho-ceramide (**25**) which could be fully deprotected in two steps to afford the target molecule, the ceramide derivative of 2-amino-2-deoxy-D-glucopyranosyl-α(1→6)-D-*myo*-inositol-1-phosphate (**2**).

Phosphosphingolipids play an important role as membrane constituents. For instance, sphingomyelin, the choline ester of D-*erythro*-ceramide-1-phosphate, is found in a variety of different cell types[1]. In addition, D-*erythro*-ceramide-1-phosphoinositol (Scheme 1, **1**) and structural variants have recently been detected in plants, yeasts, and fungi[2]; in particular, compound **1** was detected in the fungus *Phytophthora capsici*, thus leading to the development of a specific defence mechanism in some plants and eventually to their protection[2]. D-*erythro*-ceramide-1-phosphoinositols have also been recognized as serving in glycosylphosphoinositol-mediated anchoring of proteins (GPI anchors)[3].To this end, in nature, α-glycosidic linkage of a D-glucosamine residue to the 6-*O* of the D-*myo*-inositol residue generally occurs, resulting in compound **2**. Compounds **1** and **2** are basic building blocks in ceramide-based GPI-anchor (bio)synthesis, and we therefore report here a versatile approach for their chemical synthesis[4][5].

For the synthesis of **1** a 1-*O*-unprotected D-isomer and for the synthesis of **2** a D-isomer of *myo*-inositol permitting selective access to 1-*O* and 6-*O,* respectively were required. These demands were met by 2,3:4,5-di-*O*-cyclohexylidene-1-*O*-menthyloxycarbonyl derivative **3** (Scheme 2) which could readily be obtained from *myo*-inositol in optically pure form[6]. Treatment with *p*-toluenesulfonic acid (*p*-TsOH) in a mixture of MeOH/THF/H_2O gave the known 2,3,4,5,6-*O*-unprotected D-*myo*-inositol derivative **4**[7] which on treatment with methoxymethyl chloride (MOM-Cl) in the presence of Hünig′s base at 0°C and then slowly raising the temperature to 20°C furnished the *O*-MOM-protected derivative **5**; **5** was fully characterized by ^{1}H-NMR spectroscopy. Treatment with K_2CO_3/MeOH afforded the desired 1-*O*-unprotected D-isomer of *myo*-inositol **6**. The linkage with the ceramide-1-phosphate residue was based on the phosphitamide methodology[8] which also proved successful in efficient sphingomyelin and lysosphingomyelin

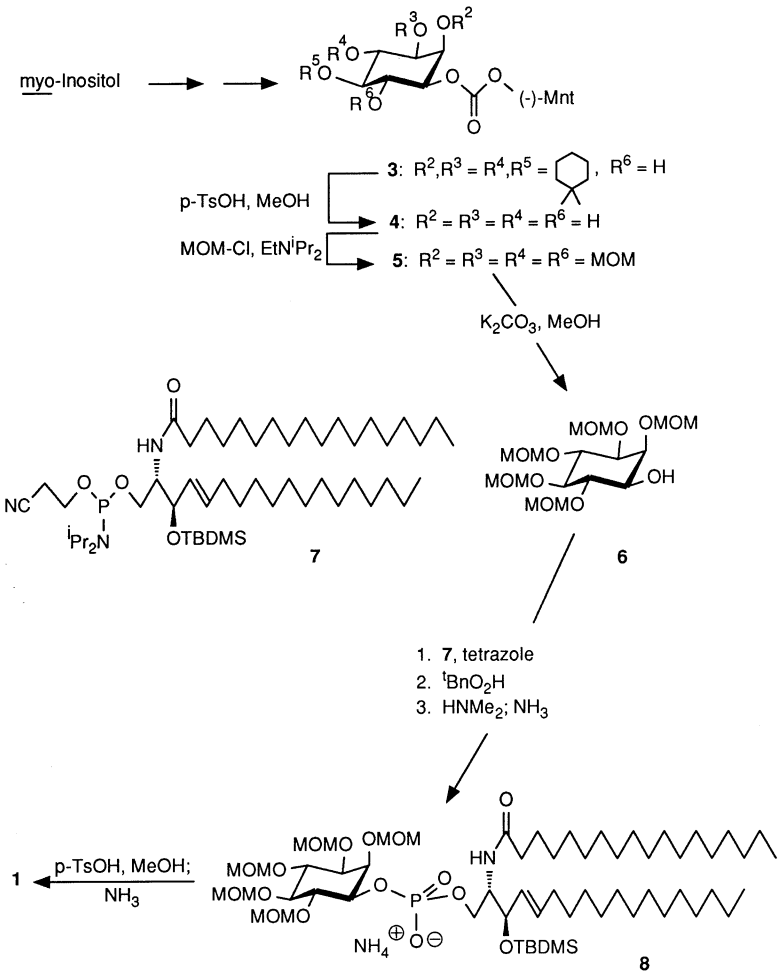
Scheme 1



  1434−193X/98/0202−0291 $ 17.50+.50/0

synthesis[4][9]. The phosphite derivative **7**[9] was particularly useful because it enabled the synthesis of mixed phosphorous diesters. Thus, reaction with **6** in the presence of tetrazole and then oxidation with *tert*-butylhydroperoxide gave the corresponding phosphotriester which after treatment with dimethylamine in ethanol and then silica-gel chromatography with $CHCl_3$/MeOH/aqueous NH_3 as the eluent furnished *O*-protected diester **8** as an ammonium salt. Treatment of **8** with *p*-TsOH in MeOH at 40°C led to removal of all protective groups, thus providing the desired target molecule **1** which was obtained by silica gel chromatography ($CHCl_3$/MeOH/2 N NH_3, 65:35:8 as eluent) in pure form.

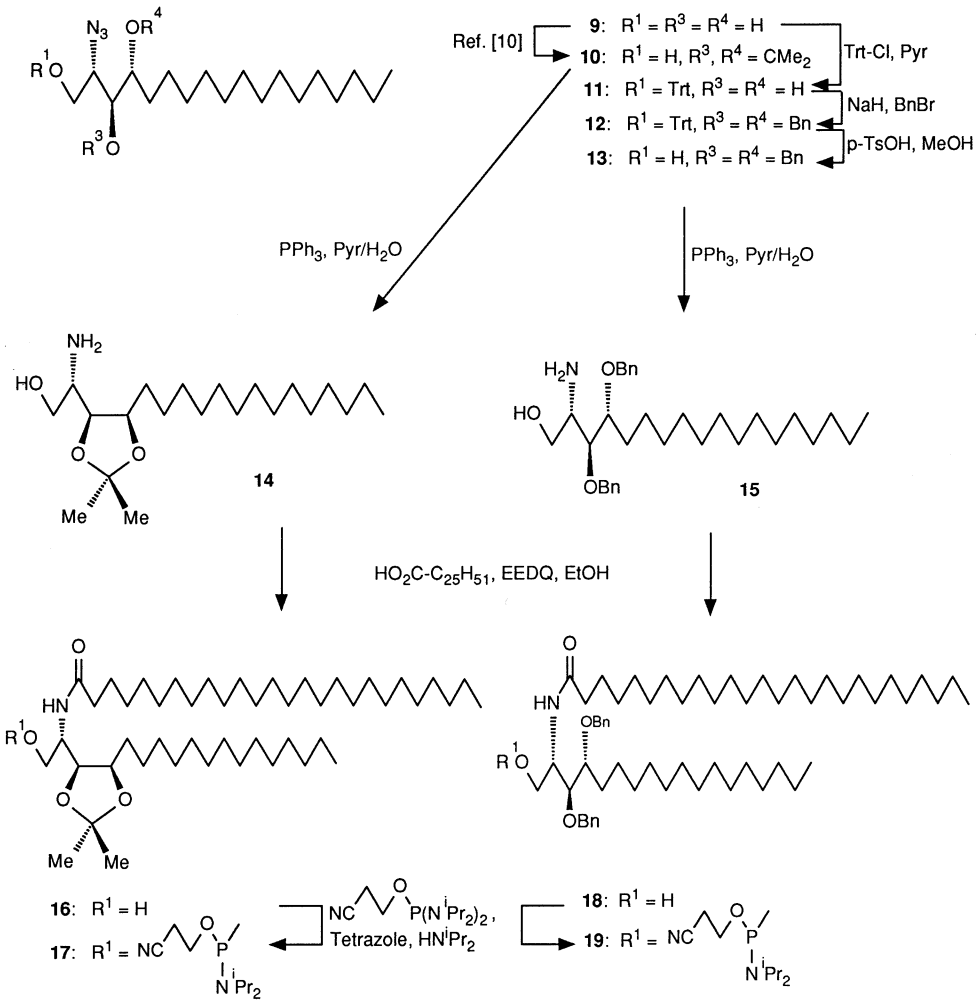
Scheme 2



Phytosphingosine is found as an amino alcohol in GPI anchors with a ceramide constituent. Thus for the synthesis of **2**, the corresponding ceramide-1-phosphate residue is required, in addition to a 2-amino-α-glucosyl-(1→6)-inositol building block. To this end, the known 3,4-*O*-isopropylidene derivative **10**[10] was prepared starting from readily available azido-phytosphingosine **9**[10][11] (Scheme 3) and 2,2-dimethoxypropane in the presence of *p*-TsOH as a catalyst. Azide reduction according to the method used by Staudinger et al.[12] (→ **14**) and *N*-acylation with cerotic acid (hexacosanic acid) in the presence of 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline (EEDQ) as a condensing agent afforded 1-*O*-unprotected ceramide **16** in high yield. The desired phosphite intermediate **17** was obtained by reaction with the bifunctional phosphitylation reagent cyanoethoxy-bis(diisopropylamino)phosphane[13] in the presence of tetrazole as the activator. Alternatively, **9** was selectively *O*-tritylated with trityl chloride in pyridine at the primary position furnishing **11**. Following per-*O*-benzylation with benzyl bromide using NaH as the base (→ **12**), detritylation with *p*-TsOH as the catalyst (→ **13**) and azide reduction with triphenylphosphane[2] gave the amino derivative **15** which corresponded to **14**. Attachment of the fatty acyl residue (→ **18**) and phosphitylation were therefore performed as described above, furnishing phosphite intermediate **19**.

In addition to **3**, readily available 2-azido-2-deoxy-3,4,6-tri-*O*-acetyl-β-D-glucosyl trichloroacetimidate (**20**)[14] was selected for the synthesis of the 2-amino-α-glucosyl-(1→6)-inositol building block. Use of the β-configured imidate, together with ether as the cosolvent, and a strong catalyst at

Scheme 3



room temperature all favor α-linkage[15]. It was therefore not surprising that only the α-glucopyranoside **21** was obtained in high yield. In addition to support by the donor configuration, by the solvent, and/or through thermodynamic control, participation of the 6-*O*-acetyl group at the anomeric position has been suggested[15][16] as a possible explanation for this favorable result. Earlier unsatisfactory α selectivities and/or yields in the synthesis of this α-glycoside[17][18][19][20][21][22] were thus overcome. The 1α-*O*-unprotected compound **24** was obtained by selective cleavage of the acetyl protecting groups with NaOM/MeOH (→ **22**), *O*-benzylation with benzyl bromide/NaH in the presence of tetra-butylammonium iodide (TBAI) (→ **23**), and cleavage of the carbonate residue with K_2CO_3/MeOH at 40°C. Reaction of **24** with **17** in the presence of tetrazole followed by oxidation with *tert*-butylhydroperoxide gave the corresponding phosphotriester which gave with dimethylamine in ethanol the *O*-protected diester **25**. Simultaneous cleavage of the *O*-isopropylidene and *O*-cyclohexylidene groups with glycol in the presence of camphorsulfonic acid (CSA) as the catalyst (→ **26**) followed by hydrogenolysis of the *O*-benzyl protecting groups and the azido group with Pearlman's catalyst[23] yielded the target molecule **2** which was characterized using NMR and MS data.

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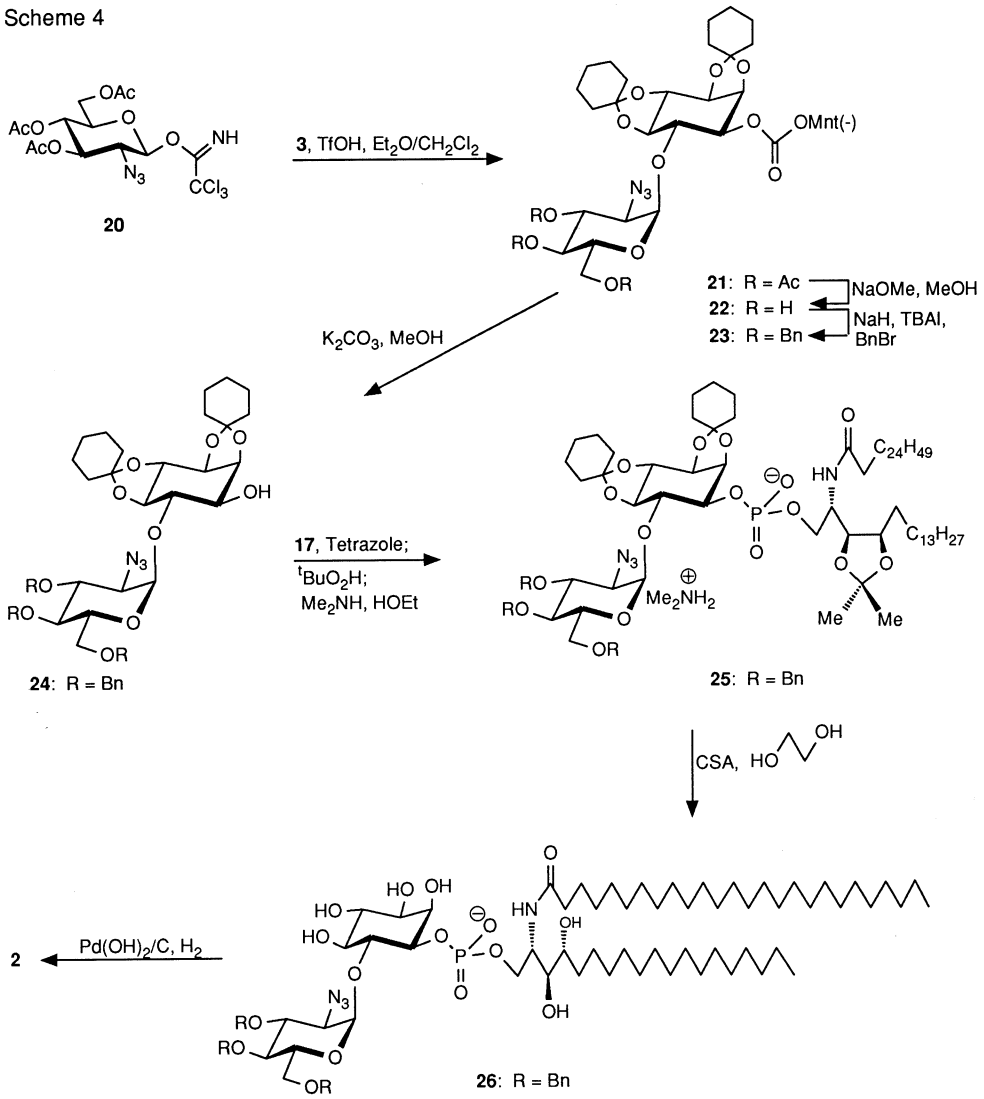
Experimental Section

General: Solvents were purified in the usual way; boiling range of petroleum ether: 35−60°C. − Melting points are uncorrected. − Optical rotations: Perkin-Elmer polarimeter 241 MC; 1-dm cell. Thin-layer chromatography (TLC): Plastic sheets, silica gel 60 F_{254} (Merck; layer thickness 0.2 mm). − Column chromatography: Kieselgel 60 (Merck; 0.063−0.200 mm). − Flash chromatography: Silica gel (J. T. Baker, particle size 40 mm). − ^{1}H NMR: Bruker AC 250 (250 MHz) Cryospec, Bruker DRX 600 (600 MHz), internal standard tetramethylsilane (TMS). − ^{31}P NMR: Jeol JNM-GX 400; external standard 85% phosphoric acid. − Elemental analyses: Heraeus CHN-O-Rapid.

1-O-(1R)-Menthyloxycarbonyl-D-myo-inositol (**4**): To a solution of **3**[6] (8.0 g, 15.3 mmol) in methanol/tetrahydrofuran/water (5:2:1,

Scheme 4



150 ml) was added *p*-toluenesulfonic acid (0.5 g). The mixture was refluxed for 6 h (monitoring by TLC). Evaporation of the solvent in vacuo and subsequent crystallization from ethyl acetate/ethanol (2:1) gave **4** (4.98 g, 90%) as a white powder. Physical data are in agreement with values described previously[7]. – TLC (chloroform/methanol, 8:2): R_f = 0.20. – ^{1}H NMR (250 MHz, CD_3OD): δ = 0.79–0.82 (d, J = 6.9 Hz, 3 H, CH_3), 0.85–1.18 (2 d, m, 9 H, 2 CH_3, 3 H_{Mnt}), 1.34–1.55 (m, 2 H, 2 H_{Mnt}), 1.65–1.75 (m, 2 H, 2 H_{Mnt}), 1.94–2.11 (m, 2 H, 2 H_{Mnt}), 3.21 (dd, $J_{4,5}$ = $J_{5,6}$ = 9.2 Hz, 1 H, 5-H), 3.39 (dd, $J_{2,3}$ = 2.7, $J_{3,4}$ = 9.6 Hz, 1 H, 3-H), 3.63 (dd, $J_{3,4}$ = $J_{4,5}$ = 9.5 Hz, 1 H, 4-H), 3.82 (dd, $J_{5,6}$ = 9.4, $J_{1,6}$ = 10.1 Hz, 1 H, 6-H), 4.09 (dd, $J_{1,2}$ = $J_{2,3}$ = 2.7 Hz, 1 H, 2-H), 4.46 (dd, $J_{1,6}$ = 10.2, $J_{1,2}$ = 2.7 Hz, 1 H, 1-H), 4.53 (ddd, 1 H, H_{Mnt}).

1-O-(1R)-Menthyloxycarbonyl-2,3,4,5,6-penta-O-methoxymethyl-D-myo-inositol (**5**): Compound **4** (0.35 g, 1.02 mmol) was suspended in tetrahydrofuran/*N,N*-(diisopropyl)ethylamine (10 ml, 1:1), the suspension cooled to 0°C and methoxymethyl chloride (1.0 ml, 1.3 mmol) added while stirring. After stirring for 48 h at room temp. the reaction mixture was again cooled to 0°C and methoxymethyl chloride (0.5 ml, 0.65 mmol) was added. The reaction mixture was stirred for a further 12 h at room temp., poured into a satd. ammonium chloride solution (30 ml) and extracted with ethyl acetate (30 ml). The organic layer was washed a further time with a satd. ammonium chloride solution (20 ml), and after drying ($MgSO_4$) concentrated under reduced pressure. The residue obtained was purified by flash chromatography (petroleum ether/ethyl acetate, 7:3) to yield **5** (0.39 g, 60%) as a colorless oil. – TLC (petroleum ether/ethyl acetate, 6:4): R_f = 0.51. – $[\alpha]_D^{20}$ = –58.9 (c = 1, chloroform). – ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.74–2.05 (m, 18 H, Mnt-H), 3.35–3.37 (3 s, 9 H, 3 OCH_3), 3.41–3.42 (2 s, 6 H, 2 OCH_3), 3.40–3.47 (t, $J_{4,5}$ = $J_{5,6}$ = 9.6 Hz, 1 H, 5-H), 3.50–3.59 (dd, $J_{2,3}$ = 2.4, $J_{3,4}$ = 9.6 Hz, 1 H, 3-H), 3.87–3.99 (m, $J_{3,4}$ = $J_{4,5}$ = $J_{5,6}$ = $J_{6,1}$ = 9.6 Hz, 2 H, 4-H, 6-H), 4.14–4.16 (t, $J_{1,2}$ = $J_{2,3}$ = 2.4 Hz, 1 H, 2-H), 4.43–4.59 (m, $J_{1,2}$ = 2.4, $J_{1,6}$ = 9.6 Hz, 2 H, 1-H, Mnt-H), 4.62-4.87 (m, 10 H, 5 OCH_2O). – $C_{27}H_{50}O_{13}$ (582.68): calcd. C 55.65, H 8.64; found C 55.68, H 8.70.

2,3,4,5,6-Penta-O-methoxymethyl-D-myo-inositol (**6**): Potassium carbonate (0.35 g) was added to a solution of compound **5** (0.35 g, 0.6 mmol) in methanol (10 ml) and the reaction mixture stirred for 12 h at 60°C. The reaction mixture was then poured into a satd. ammonium chloride solution (30 ml) and extracted with ethyl acetate (40 ml). After drying ($MgSO_4$) the organic layer was concentrated under reduced pressure and the residue purified by flash

chromatography (petroleum ether/ethyl acetate, 1:2) to yield **6** (0.23 g, 95%) as a colorless oil. − TLC (petroleum ether/ethyl acetate, 1:2): R_f = 0.19. − $[\alpha]_D^{20}$ = −42.5 (*c* = 1, chloroform). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 3.37−3.44 (m, 17 H, 1-H, 5-H, 5 OCH_3), 3.45−3.50 (dd, $J_{2,3}$ = 2.4, $J_{3,4}$ = 9.6 Hz, 1 H, 3-H), 3.61−3.68 (t, $J_{1,6}$ = $J_{5,6}$ = 9.6 Hz, 1 H, 6-H), 3.87−3.96 (m, 2 H, OH, 4-H), 4.06 (t, $J_{1,2}$ = $J_{2,3}$ = 2.4 Hz, 1 H, 2-H), 4.70−4.86 (m, 10 H, 5 OCH_2O). − $C_{16}H_{32}O_{11}$ (400.42): calcd. C 47.99, H 8.05; found: C 48.06, H 7.95.

Ammonium {[2S,3R,4E)-3-(tert-Butyldimethylsilyloxy)-2-(octadecanoylamino)-4-octadecen-1-yl](2,3,4,5,6-Penta-O-methoxymethyl-D-myo-inositol-1) Hydrogen Phosphate} (**8**): To a solution of compound **7**[9] (0.21 g, 0.24 mmol) and compound **6** (0.11 g, 0.3 mmol) in dry acetonitrile/dichloromethane (6 ml, 2:1) was added freshly sublimated tetrazole (0.017 g, 0.24 mmol) under nitrogen. After stirring for 1 h, *tert*-butylhydroperoxide [0.081 ml of a 3 M solution in dry toluene (0.244 mmol)] was added. After further stirring (15 min) the reaction mixture was poured into a satd. sodium chloride solution (10 ml), extracted with dichloromethane (15 ml) and the organic layer was dried ($MgSO_4$). The solvent was evaporated under reduced pressure, the obtained residue dried under high vacuum and finally dissolved in dimethylamine (33%) in dry ethanol (5 ml). The solution was stirred for 12 h, the solvent then removed under reduced pressure and the remaining residue purified by chromatography. Elution with chloroform/methanol/2 N ammonia (90:10:1) yielded **8** (0.12 g, 45%) as an amorphous solid. − TLC (chloroform/methanol/2 N ammonia, 90:10:1): R_f = 0.24. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.00, 0.01 [2 s, 6 H, $Si(CH_3)_2$], 0.82−0.87 [m, 15 H, $SiC(CH_3)_3$, 2 CH_3], 1.22−1.34 (m, 50 H, 25 CH_2), 1.52−1.55 (m, 2 H, 3′a-H, 3′b-H), 1.95−1.98 (m, 2 H, 6a-H, 6b-H), 2.12−2.15 (m, 2 H, 2′a-H, 2′b-H), 3.36−3.43 (m, 16 H, 5 OCH_3, 5″-H), 3.45−3.51 (dd, $J_{2'',3''}$ = 2.5, $J_{3'',4''}$ = 9.8 Hz, 1 H, 3″-H), 3.61−4.98 (m, 18 H, 1a-H, 1b-H, 2-H, 3-H, 2″-H, 4″-H, 6″-H, 1″-H, 5 OCH_2O), 5.31−5.40 (dd, $J_{3,4}$ = 6.7, $J_{4,5}$ = 15.5 Hz, 1 H, 4-H), 5.54−5.65 (dt, $J_{4,5}$ = 15.5, $J_{5,6}$ = 6.7 Hz, 1 H, 5-H), 6.00−6.40 (bs, 1 H, NH). − ^{31}P NMR [250 MHz, $CDCl_3$/[D$_4$]methanol (1:1)]: δ = −2.14.

Ammonium {[(2S,3R,4E)-3-Hydroxy-2-(octadecanoylamino)-4-octadecen-1-yl](D-myo-Inositol-1) Hydrogen Phosphate} (**1**): To a solution of compound **8** (0.04 g, 0.035 mmol) in dry methanol (5 ml) 4-toluenesulfonic acid (0.015 g) was added and the reaction mixture stirred for 12 h at 45°C (monitoring by TLC). Sodium hydroxide (1 N aqueous solution) was then added to neutralize the reaction mixture. The resulting precipitate was separated from the liquid layer in a centrifuge and finally purified by chromatography (chloroform/methanol/2 N ammonia, 80:20:2 → 70:30:4 → 65:35:8) to yield **1** (0.012 g, 41%) as an amorphous solid. − TLC (chloroform/methanol/2 N ammonia, 65:35:8): R_f = 0.33. − $[\alpha]_D^{20}$ = −3.6 (*c* = 0.25, chloroform/methanol/water, 20:10:2). − ^{1}H NMR [250 MHz, $CDCl_3$/[D$_4$]methanol/D_2O (20:10:2)]: δ = 0.81−0.86 (t, *J* = 6.3 Hz, 6 H, 2 CH_3); 1.22−1.40 (m, 50 H, 25 CH_2), 1.52 (m, 2 H, 3′a-H, 3′b-H), 1.97 (m, 2 H, 6a-H, 6b-H), 2.10−2.16 (t, $J_{2',3'}$ = 7.9 Hz, 2 H, 2′a-H, 2′b-H), 3.16−3.23 (t, $J_{4'',5''}$ = $J_{5'',6''}$ = 9.5 Hz, 1 H, 5″-H), 3.35−3.40 (dd, $J_{2'',3''}$ = 2.8, $J_{3'',4''}$ = 9.5 Hz, 1 H, 3″-H), 3.56−3.63 (t, $J_{3'',4''}$ = $J_{4'',5''}$ = 9.5 Hz, 1 H, 4″-H), 3.68−3.75 (t, $J_{5'',6''}$ = $J_{1'',6''}$ = 9.5 Hz, 1 H, 6″-H), 3.82−3.88 (m, 3 H, 1a-H, 1b-H, 2-H), 4.01−4.07 (t, $J_{2,3}$ = $J_{3,4}$ = 7.8 Hz, 1 H, 3-H), 4.15 (t, $J_{1'',2''}$ = $J_{2'',3''}$ = 2.8 Hz, 1 H, 2″-H), 4.22−4.59 (m, 1 H, 1″-H, overlapped by signals from H_2O), 5.33−5.43 (dd, $J_{3,4}$ = 7.8, $J_{4,5}$ = 15.3 Hz, 1 H, 4-H), 5.61−5.72 (dt, $J_{4,5}$ = 15.3, $J_{5,6}$ = 6.7 Hz, 1 H, 5-H). − ^{31}P NMR [161.7 MHz, $CDCl_3$/[D$_4$]methanol/D_2O (20:10:2)]: δ_P = 1.31. − FAB MS (negative mode, matrix: glycerol/3-nitrobenzyl alcohol, 1:1); *m/z* (%): 807 (100) [(M − H)$^-$], 645 (38) [(M − $C_6H_{11}O_5$)$^-$].

2-Azido-1-(triphenylmethyloxy)-D-ribo-3,4-octadecanediol (**11**): Compound **9**[11] (0.6 g, 1.74 mmol) and triphenylmethyl chloride (0.53 g, 1.91 mmol) were dissolved in pyridine/tetrahydrofuran/dichloromethane (6 ml, 1:1:1) and stirred for 12 h. The reaction mixture was then poured into a satd. sodium hydrogen carbonate solution (15 ml) and extracted with ethyl acetate (20 ml). After drying ($MgSO_4$) the organic layer was concentrated under reduced pressure and the residue purified by flash chromatography (petroleum ether/ethyl acetate 9:1 → 8:2 → 7:3) to yield **11** (0.77 g, 76%) as a colorless oil. − TLC (petroleum ether/ethyl acetate, 9:1): R_f = 0.19. − $[\alpha]_D^{20}$ = +8.9 (*c* = 1, chloroform). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.81−0.86 (t, *J* = 6.3 Hz, 3 H, CH_3), 1.22−1.39 (m, 24 H, 12 CH_2), 1.45−1.53 (m, 2 H, 5a-H, 5b-H), 1.78−1.80 (d, $J_{4,OH}$ = 5.5 Hz, 1 H, 4-OH), 2.32−2.34 (d, $J_{3,OH}$ = 4.9 Hz, 3-OH), 3.34−3.41 (dd, $J_{1a,1b}$ = 9.9, $J_{1a,2}$ = 5.7 Hz, 1 H, 1a-H), 3.47−3.63 (m, 4 H, 1b-H, 2-H, 3-H, 4-H), 7.17−7.45 (m, 15 H, 3 C_6H_5). − $C_{37}H_{51}N_3O_3$ (585.82): calcd. C 75.85, H 8.77, N 7.17; found: C 75.87, H 8.78, N 7.20.

2-Azido-3,4-di-O-benzyl-1-(triphenylmethoxy)-D-ribo-3,4-octadecanediol (**12**): To a solution of compound **11** (0.69 g, 1.18 mmol) and benzyl bromide (0.62 ml, 5.2 mmol) in dry dimethylformamide (7 ml) under nitrogen, was added sodium hydride (0.13 g, 5.4 mmol). After stirring for 4 h (monitoring by TLC) methanol (1 ml) was added and the reaction mixture was then poured into a satd. sodium chloride solution (15 ml) and extracted with petroleum ether (2 × 20 ml). The organic layer was dried ($MgSO_4$), concentrated under reduced pressure and the residue purified by flash chromatography (petroleum ether/ethyl acetate, 95:5) to yield **12** (0.73 g, 80%) as a colorless oil. − TLC (petroleum ether/ethyl acetate): R_f = 0.62. − $[\alpha]_D^{20}$ = +6.4 (*c* = 1, chloroform). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.80−0.85 (t, *J* = 6.3 Hz, 3 H, CH_3), 1.20−1.39 (m, 24 H, 12 CH_2), 1.46−1.59 (m, 2 H, 5a-H, 5b-H), 3.28−3.35 (dd, $J_{1a,1b}$ = 9.9, $J_{1a,2}$ = 8.2 Hz, 1 H, 1a-H), 3.41−3.51 (m, 3 H, 1b-H, 3-H, 4-H), 3.69−3.74 (m, 1 H, 2-H), 4.36−4.54 (m, 4 H, 2 $CH_2C_6H_5$), 7.01−7.41 (m, 25 H, 5 C_6H_5). − $C_{51}H_{63}N_3O_3$ (766.08): calcd. C 79.96, H 8.28, N 5.48; found: C 79.89, H 8.21, N 5.50.

2-Azido-3,4-di-O-benzyl-D-ribo-1,3,4-octadecanetriol (**13**): Compound **12** (0.8 g, 1.04 mmol) and 4-toluenesulfonic acid (0.05 g) were dissolved in dry dichloromethane/methanol (20 ml, 3:1) and stirred at room temp. for 12 h. The reaction mixture was washed with a satd. sodium hydrogen carbonate solution (20 ml) and extracted with ethyl acetate (20 ml). The organic layer was dried ($MgSO_4$), concentrated under reduced pressure and the residue purified by flash chromatography (petroleum ether/ethyl acetate, 9:1) to yield **13** (0.53 g, 98%) as a colorless oil which slowly solidified. − TLC (petroleum ether/ethyl acetate, 9:1): R_f = 0.25. − $[\alpha]_D^{20}$ = −5.7 (*c* = 1, chloroform). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.83−0.89 (t, *J* = 6.8 Hz, 3 H, CH_3), 1.22−1.67 (m, 26 H, 13 CH_2), 2.49 (bs, 1 H, OH), 3.59−3.70 (m, 3 H, 2-H, 3-H, 4-H), 3.73−3.80 (dd, $J_{1a,1b}$ = 11.6, $J_{1a,2}$ = 4.7 Hz, 1 H, 1a-H), 3.84−3.91 (dd, $J_{1a,1b}$ = 11.6, $J_{1b,2}$ = 4.9 Hz, 1 H, 1b-H), 4.52−4.72 (m, 4 H, 2 $CH_2C_6H_5$), 7.26−7.37 (m, 10 H, 2 C_6H_5). − $C_{32}H_{49}N_3O_3$ (523.75): calcd. C 73.38, H 9.42, N 8.02; found: C 73.49, H 9.21, N 8.00.

2-Amino-3,4-O-isopropylidene-D-ribo-1,3,4-octadecanetriol (**14**): Compound **10**[10] (0.43 g, 1.12 mmol) and triphenylphosphane (0.59 g, 2.24 mmol) were dissolved in pyridine/water (30 ml, 9:1) and stirred for 12 h at 40°C. The solvent was removed under reduced pressure and after codistillation with toluene (2 × 15 ml)

the residue was purified by chromatography (chloroform/methanol, 95:5 → 9:1 → 8:2) to yield **14** (0.39 g, 98%) as a colorless oil which slowly solidified. − TLC (chloroform/methanol, 8:2): R_f = 0.63. − $[\alpha]_D^{20}$ = +24.9 (*c* = 1, chloroform), m.p. 63°C. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.82−0.87 (t, *J* = 6.8 Hz, 3 H, CH_3), 1.22 (m, 24 H, 12 CH_2), 1.30 (s, 3 H, CCH_3), 1.39 (s, 3 H, CCH_3), 1.43−1.52 (m, 2 H, 5a-H, 5b-H), 1.77 (s, 3 H, NH_2, OH), 2.88 (m, $J_{1a,2}$ = 5.7, $J_{1b,2}$ = 5, $J_{2,3}$ = 8.7 Hz, 1 H, 2-H), 3.51−3.58 (dd, $J_{1a,1b}$ = 10.9, $J_{1a,2}$ = 5.7 Hz, 1 H, 1a-H), 3.68−3.74 (dd, $J_{1a,1b}$ = 10.9, $J_{1b,2}$ = 5 Hz, 1 H, 1b-H), 3.82−3.88 (dd, $J_{2,3}$ = 8.7, $J_{3,4}$ = 5.6 Hz, 1 H, 3-H), 4.10−4.18 (m, 1 H, 4-H). − $C_{21}H_{43}NO_3 \times 0.1\ H_2O$ (359.37): calcd. C 70.18, H 12.11, N 3.89; found: C 70.01, H 11.88, N 3.68.

2-Amino-3,4-di-O-benzyl-D-ribo-1,3,4-octadecanetriol (**15**): Compound **13** (0.25 g, 0.47 mmol) and triphenylphosphane (0.25 g, 0.95 mmol) were dissolved in pyridine/water (20 ml, 9:1) and stirred for 12 h at 40°C. The solvent was removed under reduced pressure and after codistillation with toluene (2 × 15 ml) the residue was purified by chromatography (chloroform/methanol, 95:5 → 9:1 → 8:2) to yield **15** (0.19 g, 81%) as a colorless oil. − TLC (chloroform/methanol, 9:1): R_f = 0.36. − $[\alpha]_D^{20}$ = −18.5 (*c* = 0.56, chloroform). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.83−0.88 (t, *J* = 6.3 Hz, 3 H, CH_3), 1.22−1.70 (m, 26 H, 13 CH_2), 2.06 (bs, 3 H, NH_2, OH), 2.99−3.05 (m, 1 H, 2-H), 3.51−3.74 (m, 4 H, 1a-H, 1b-H, 3-H, 4-H), 4.52−4.75 (m, 4 H, 2 $CH_2C_6H_5$), 7.25−7.36 (m, 10 H, 2 C_6H_5). − $C_{32}H_{51}NO_3 \times 0.2\ H_2O$ (501.35): calcd. C 76.66, H 10.33, N 2.79; found: C 76.52, H 10.24, N 2.70.

2-Hexacosanoylamino-3,4-O-isopropylidene-D-ribo-1,3,4-octadecanetriol (**16**): To a solution of compound **14** (0.39 g, 1.1 mmol) in dry ethanol (90 ml) were added hexacosanic acid (0.43 g, 1.1 mmol) and 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline (EEDQ, 0.34 g, 1.4 mmol). The suspension was stirred at 50°C for 12 h and was then cooled to 0°C. The resulting precipitate was separated from the reaction mixture by filtration and for further purification crystallized from a minimum amount of ethanol to yield **16** (0.76 g, 94%) as an amorphous solid. − TLC (chloroform/methanol, 95:5): R_f = 0.64. − $[\alpha]_D^{20}$ = +2.8 (*c* = 0.5, chloroform), m.p. 92.3−93°C. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.82−0.87 (t, *J* = 6.7 Hz, 6 H, 2 CH_3), 1.22 (m, 68 H, 34 CH_2), 1.31 (s, 3 H, CCH_3), 1.44 (s, 3 H, CCH_3), 1.52−1.60 (m, 4 H, 5a-H, 5b-H, 3′a-H, 3′b-H), 2.13−2.19 (t, $J_{2',3'}$ = 7.1 Hz, 2 H, 2′a-H, 2′b-H), 2.5 (bs, 1 H, OH), 3.63−3.68 (m, $J_{1a,1b}$ = 11.3, $J_{1a,2}$ = 2.7 Hz, 1 H, 1a-H), 3.84-3.89 (m, $J_{1a,1b}$ = 11.3, $J_{1b,2}$ = 2.7 Hz, 1 H, 1b-H), 4.07−4.12 (m, 3 H, 2-H, 3-H, 4-H), 5.94−5.97 (d, $J_{2,NH}$ = 7.5 Hz, 1 H, NH). − FAB MS (positive mode, matrix: chloroform/3-nitrobenzyl alcohol, 1:1), *m/z* (%): 737 (32) [MH^+], 679 (100) [$(M - OC_3H_6)]H^+$]. − $C_{47}H_{93}NO_4 \times 0.5\ H_2O$ (745.25): calcd. C 75.74, H 12.57, N 1.87; found: C 75.43, H 12.57, N 2.05.

(2-Cyanoethoxy)(diisopropylamino)[2-(hexacosanoylamino)-3,4-(isopropylidenoxy)-D-ribo-1-(octadecyloxy)]phosphane (**17**): To a solution of (2-cyanoethoxy)bis(diisopropylamino)phosphane[13] (0.15 g, 0.51 mmol) in dry tetrahydrofuran/dichloromethane (12 ml, 1:1) under nitrogen were added compound **16** (0.25 g, 0.34 mmol) and diisopropylammonium tetrazolide[13] (0.05 g, 0.3 mmol) while stirring. After 24 h (monitoring by TLC) dichloromethane (20 ml) was added to the suspension and the reaction mixture was then washed with a satd. sodium hydrogen carbonate solution (20 ml). The organic layer was dried ($MgSO_4$) and the solvent removed under reduced pressure. Chromatography (short silica-gel column) of the residue with petroleum ether/ethyl acetate/triethylamine (80:20:1) yielded the diastereomeric mixture **17** (0.26 g, 82%) as a colorless solid. − TLC (petroleum ether/ethyl acetate, 3:1): R_f = 0.66. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.82−0.87 (t, *J* = 6.3 Hz, 6 H, 2 CH_3), 1.12−1.66 [m, 90 H, 2 $CH(CH_3)_2$, $C(CH_3)_2$, 36 CH_2], 2.07−2.16 (m, 2 H, 2′a-H, 2′b-H), 2.58−2.64 (t, *J* = 6.3 Hz, 2 H, CH_2CN), 3.50−4.28 [m, 9 H, CH_2CH_2CN, 1a-H, 1b-H, 2-H, 3-H, 4-H, 2 $CH(CH_3)_2$], 5.84−5.88 (d, $J_{2,NH}$ = 9.0 Hz, 1 H, NH). − ^{31}P NMR (161.7 MHz, $CDCl_3$): δ_P = 148.57, 148.67 (10:7).

3,4-Di-O-benzyl-2-hexacosanoylamino-D-ribo-1,3,4-octadecanetriol (**18**): To a solution of compound **15** (0.16 g, 0.32 mmol) in dry ethanol (35 ml) were added 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline (EEDQ; 0.1 g, 0.41 mmol) and hexacosanic acid (0.13 g, 0.32 mmol). The suspension was stirred at 50°C for 12 h followed by cooling the reaction mixture to 0°C. The resulting precipitate was separated from the reaction mixture by filtration and subsequently purified by chromatography. Elution with petroleum ether/ethyl acetate (5:2) yielded **15** (0.24 g, 86%) as an amorphous solid. − TLC (petroleum ether/ethyl acetate, 5:2): R_f = 0.21. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.83−0.88 (t, *J* = 6.3 Hz, 6 H, 2 CH_3), 1.23−1.67 (m, 72 H, 36 CH_2), 1.93−1.99 (m, $J_{2',3'}$ = 7 Hz, 2 H, 2′a-H, 2′b-H), 3.05 (bs, 1 H, OH), 3.56−3.69 (m, 3 H, 1a-H, 3-H, 4-H), 3.95−4.00 (m, 1 H, 1b-H), 4.10−4.14 (m, 1 H, 2-H), 4.40−4.72 (m, 4 H, 2 $CH_2C_6H_5$), 5.99−6.03 (d, $J_{2,NH}$ = 8.2 Hz, 1 H, NH), 7.25−7.36 (m, 10 H, 2 C_6H_5). − MS (70 eV), *m/z*: 875 [M^+].

(2-Cyanoethoxy)[3,4-(dibenzyloxy)-2-(hexacosanoylamino)-D-ribo-1-(octadecyloxy)](diisopropylamino)phosphane (**19**): To a solution of (2-cyanoethoxy)bis(diisopropylamino)phosphane[13] (0.06 g, 0.19 mmol) in dry dichloromethane/acetonitrile (6 ml, 2:1) were added under nitrogen compound **18** (0.11 g, 0.13 mmol and diisopropylammonium tetrazolide[13] (0.016 g, 0.092 mmol) while stirring. After 12 h dichloromethane (15 ml) was added to the suspension and the reaction mixture was then washed with a satd. sodium hydrogen carbonate solution (15 ml). The organic layer was dried ($MgSO_4$) and the solvent removed under reduced pressure. Chromatography (short silica-gel column) of the residue with petroleum ether/ethyl acetate/triethylamine (80:20:1) yielded the diastereomeric mixture **19** (0.12 g, 85%) as a waxy solid. − TLC (petroleum ether/ethyl acetate, 3:1): R_f = 0.87. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.83−0.88 (t, *J* = 6.3 Hz, 6 H, 2 CH_3), 1.11−1.65 [m, 84 H, 2 $CH(CH_3)_2$, 36 CH_2], 1.99−2.05 (t, $J_{2',3'}$ = 7.3 Hz, 2 H, 2′a-H, 2′b-H), 2.47−2.57 (m, 2 H, CH_2CN), 3.50−4.00 [m, 8 H, 2 $CH(CH_3)_2$, CH_2CH_2CN, 1a-H, 1b-H, 3-H, 4-H], 4.19−4.25 (m, 1 H, 2-H), 4.48−4.88 (m, 4 H, 2 $CH_2C_6H_5$), 5.85−5.98 (d, $J_{2,NH}$ = 9.1 Hz, 0.5 H, NH), 5.90−5.93 (d, $J_{2,NH}$ = 9.1 Hz, 0.5 H, NH), 7.25−7.33 (m, 10 H, 2 C_6H_5). − ^{31}P NMR (161.7 MHz, $CDCl_3$): δ_P = 148.53, 148.80 (1:1).

O-(3,4,6-Tri-O-acetyl-2-azido-2-deoxy-α/β-D-glucopyranosyl)-trichloroacetimidate (**20**): Compound **20** was prepared as described previously[14].

O-(3,4,6-Tri-O-acetyl-2-azido-2-deoxy-α-D-glucopyranosyl)-(1→6)-2,3:4,5-di-O-cyclohexylidene-1-O-(1R)-menthyloxycarbonyl-D-myo-inositol (**21**): A suspension of trichloroacetimidate **20** (11.8 g, 24.8 mmol), acceptor **3** (10 g, 19.1 mmol), and powdered molecular sieves (3 Å) in dry diethyl ether (120 ml) and dry dichloromethane (20 ml) was vigorously stirred for 15 min at room temp. A solution of triflic acid in dry diethyl ether (150 µl, 1.7 mmol triflic acid in 0.5 ml dry diethyl ether) was added. After stirring for 10 min at room temp. the solution was neutralized by addition of solid $NaHCO_3$ and concentrated in vacuo. The residue was dissolved in toluene/petroleum ether (1:1), filtered, and evaporated in vacuo. Flash chromatography (toluene/ethyl acetate, 25:1) of the sirup yielded **21** (13.8 g, 86%) as a colorless foam. Crystalli-

zation from methanol gave white crystals. − TLC (petroleum ether/ethyl acetate, 8:2): R_f = 0.35. − $[\alpha]_D^{20}$ = +59 (*c* = 1, chloroform), m.p. 157°C. − ^{1}H NMR (600 MHz, $CDCl_3$): δ = 0.76−0.78 (d, *J* = 6.9 Hz, 3 H, CH_3), 0.88−0.95 (2 d, m, 7 H, 2 CH_3, H_{Mnt}), 1.03−1.12 (m, 2 H, 2 H_{Mnt}), 1.37−1.74 (m, 24 H, 20 $H_{cycloh.}$, 4 H_{Mnt}), 1.91−1.97 (m, 1 H, H_{Mnt}), 2.05−2.12 (3 s, m, 10 H, 3 $COCH_3$, H_{Mnt}), 4.52 (ddd, *J* = 4.3 Hz, *J* = *J* = 11.0 Hz, 1 H, H_{Mnt}). − $C_{41}H_{61}N_3O_{15}$ (835.94): calcd. C 58.91, H 7.35, N 5.03; found: C 58.97, H 7.34, N 5.20.

O-(2-Azido-2-deoxy-α-D-glucopyranosyl)-(1→6)-2,3:4,5-di-O-cyclohexylidene-1-O-(1R)-menthyloxycarbonyl-D-myo-inositol (**22**): To a solution of **21** (5.0 g, 5.98 mmol) in dry methanol (40 ml) and dry dichloromethane (10 ml) was added satd. sodium methoxide solution in methanol (0.2 ml). After stirring at room temp. for 1 h the reaction was complete [monitoring by TLC (chloroform/methanol, 9:1): R_f = 0.35]. The solution was then neutralized with Amberlite IR 120 (H^+) and concentrated in vacuo. The colorless foam (3.7 g, 88%) obtained was of sufficient purity for the preparation of **23**. A pure sample was obtained by flash chromatography (toluene/ethyl acetate, 1:1). − TLC (chloroform/methanol, 9:1): R_f = 0.35 (toluene/ethyl acetate, 1:1): R_f = 0.15. − $[\alpha]_D^{20}$ = +54 (*c* = 0.5, methanol). − ^{1}H NMR (250 MHz, CD_3OD): δ = 0.77−0.80 (d, *J* = 6.9 Hz, 3 H, CH_3), 0.89−1.18 (2 d, m, 9 H, 2 CH_3, 3 H_{Mnt}), 1.36−1.77 (m, 24 H, 20 $H_{cycloh.}$, 4 H_{Mnt}), 1.89−2.13 (m, 2 H, 2 H_{Mnt}), 3.14 (dd, $J_{1b,2b}$ = 3.6, $J_{2b,3b}$ = 10.4 Hz, 1 H, 2b-H), 3.49 (dd, *J* = 8.9, *J* = 9.9 Hz, 1 H), 3.61 (dd, *J* = 8.7, *J* = 10.5 Hz, 1 H), 3.71−3.91 (m, 5 H), 4.04 (dd, *J* = 4.0, *J* = 8.7 Hz, 1 H), 4.40 (dd, $J_{2a,3a}$ = 6.5, $J_{3a,4a}$ = 7.6 Hz, 1 H, 3a-H), 4.48−4.63 (m, 2 H, H_{Mnt}, 2a-H), 4.92 (dd, $J_{1a,2a}$ = $J_{1a,6a}$ = 4.1 Hz, 1 H, 1a-H), 5.20 (d, $J_{1b,2b}$ = 3.6 Hz, 1 H, 1b-H). − $C_{35}H_{55}N_3O_{12}$ (709.83).

O-(2-Azido-3,4,6-tri-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1→6)-2,3:4,5-di-O-cyclohexylidene-1-O-(1R)-menthyloxycarbonyl-D-myo-inositol (**23**): To a solution of **22** (0.75 g, 1.06 mmol) in dry tetrahydrofuran (7.5 ml) benzyl bromide (0.75 ml, 6.34 mmol), and tetrabutylammonium iodide (0.1 g, 0.27 mmol) were added. The mixture was cooled to 0°C and sodium hydride (80 mg, 3.49 mmol) was added. After stirring at room temp. for 2 d, the solution was diluted by addition of ethyl acetate and concentrated in vacuo. Flash chromatography (petroleum ether → petroleum ether/ethyl acetate, 10:1) of the residue yielded **23** (0.69 g, 66%) as a colorless foam. − TLC (petroleum ether/ethyl acetate, 8:2): R_f = 0.65. − $[\alpha]_D^{20}$ = +41 (*c* = 0.2, ethyl acetate). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.73−0.76 (d, *J* = 6.9 Hz, 3 H, CH_3), 0.81−1.14 (2 d, m, 9 H, 2 CH_3, 3 H_{Mnt}), 1.30−1.75 (m, 24 H, 20 $H_{cycloh.}$, 4 H_{Mnt}), 1.89−2.01 (m, 1 H, H_{Mnt}), 2.09−2.17 (m, 1 H, H_{Mnt}), 3.39 (dd, $J_{1b,2b}$ = 3.7, $J_{2b,3b}$ = 10.1 Hz, 1 H, 2b-H), 3.51 (dd, $J_{4a,5a}$ = 10.9, $J_{5a,6a}$ = 8.4 Hz, 1 H, 5a-H), 3.67 (dd, $J_{5b,6b'}$ = 1.8, J_{gem} = 10.9 Hz, 1 H, 6b-H), 3.74−3.81 (m, 2 H), 3.92−4.07 (m, 4 H), 4.37 (dd, $J_{2a,3a}$ = $J_{3a,4a}$ = 7.2 Hz, 1 H, 3a-H), 4.44−4.55 (m, 4 H, CH_2Ph, H_{Mnt}, 2a-H), 4.62−4.85 (m, 4 H, 2 CH_2Ph), 4.97 (dd, *J* = 2.5, *J* = 3.9 Hz, 1 H, 1a-H), 5.26 (d, $J_{1b,2b}$ = 3.6 Hz, 1 H, 1b-H), 7.11−7.35 (m, 15 H, 3 Ph). − $C_{56}H_{73}N_3O_{12}$ (980.21): calcd. C 68.62, H 7.51, N 4.29; found: C 68.29, H 7.49, N 4.33.

O-(2-Azido-3,4,6-tri-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1→6)-2,3:4,5-di-O-cyclohexylidene-D-myo-inositol (**24**): A mixture of **23** (0.5 g, 0.51 mmol) and potassium carbonate (0.5 g) in dry methanol/dichloromethane (10:2, 12 ml) was vigorously stirred for 2 d at 40°C. After concentration in vacuo, water was added and the mixture was extracted two times with ethyl acetate. The combined organic extract was dried ($MgSO_4$) and concentrated in vacuo. Flash chromatography (petroleum ether/ethyl acetate, 9:1) of the residue yielded **24** (387 mg, 95%) as a colorless foam. − TLC (petroleum ether/ethyl acetate, 8:2): R_f = 0.36. − $[\alpha]_D^{20}$ = +71 (*c* = 0.5, chloroform). − ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.25−1.70 (m, 20 H, 20 $H_{cycloh.}$), 2.75 (d, $J_{1a,OH}$ = 2.8 Hz, 1 H, OH), 3.35 (dd, $J_{1b,2b}$ = 3.7, $J_{2b,3b}$ = 5.9 Hz, 1 H, 2b-H), 3.38 (dd, $J_{4a,5a}$ = 11.0, $J_{5a,6a}$ = 8.8 Hz, 1 H, 5a-H), 3.61 (dd, $J_{5b,6b}$ = 2.2, J_{gem} = 11.0 Hz, 1 H, 6b-H), 3.72−3.77 (m, 2 H, 4b-H, 5b-H), 3.89−3.94 (m, 2 H, 1a-H, 3b-H), 3.98−4.03 (m, 3 H, 6b′-H, 6a-H, 4a-H), 4.25 (dd, $J_{2a,3a}$ = $J_{3a,4a}$ = 7.3 Hz, 1 H, 3a-H), 4.40 (dd, $J_{1a,2a}$ = 3.7, $J_{2a,3a}$ = 6.7, 1 H, 2a-H), 4.41−4.83 (m, 6 H, 3 CH_2Ph), 5.10 (d, $^3J_{1b,2b}$ = 3.7 Hz, 1 H, 1b-H), 7.08−7.30 (m, 15 H, 3 Ph). − $C_{45}H_{55}N_3O_{10}$ (797.94): calcd. C 67.74, H 6.95, N 5.27; found: C 67.25, H 6.82, N 5.39.

O-(2-Azido-3,4,6-tri-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1→6)-2,3:4,5-di-O-cyclohexylidene-1-[(2S,3S,4R)-2-N-hexacosanoylamino-3,4-O-isopropylidene-octadecane-3,4-diol-1-yl-dimethylammoniumphosphate]-D-myo-inositol (**25**): To a solution of **24** (78 mg, 98 mmol) and phosphitamide **17** (137 mg, 147 μmol) in dry dichloromethane/acetonitrile (5:2, 2.5 ml) 1*H*-tetrazole (10 mg, 143 μmol) was added. After stirring for 1 h at room temp. *tert*-butylhydroperoxide (3 M solution in toluene, 0.2 ml) was added. The progress of the oxidation was monitored by TLC [phosphite: (petroleum ether/ethyl acetate, 8:2): R_f = 0.47; phosphate: (petroleum ether/ethyl acetate, 6:4): R_f = 0.64]. After 1.5 h the reaction mixture was concentrated in vacuo, redissolved in dimethyl amine (33% in ethanol, 5 ml), stirred at room temp. for 30 min, and evaporated in vacuo. Chromatography of the residue over silica gel (chloroform → chloroform/methanol, 95:5) yielded **25** (115 mg, 72%) as dimethylammonium salt. − TLC (chloroform/methanol, 9:1): R_f = 0.40. − $[\alpha]_D^{20}$ = +60 (*c* = 1, chloroform). − ^{1}H NMR [250 MHz, $CDCl_3/CD_3OD$ (2:1), chloroform as internal standard (δ = 7.23)]: δ = 0.87−0.93 (t, *J* = 6.2 Hz, 6 H, 2 CH_3), 1.23−1.89 (m, 98 H, CMe_2, 36 CH_2, 20 $H_{cycloh.}$), 2.11−2.20 (m, 2 H, $COCH_2$), 3.35 (dd, $J_{1b,2b}$ = 3.8, $J_{2b,3b}$ = 10.1 Hz, 1 H, 2b-H), 3.50−3.58 (m), 3.67−3.87 (m, 3 H), 3.95−4.66 (m), 4.81 (d, J_{gem} = 10.8 Hz, 1 H, 0.5 CH_2Ph), 4.89 (s, 2 H, CH_2Ph), 5.45 (d, $J_{1b,2b}$ = 3.7 Hz, 1 H, 1b-H), 7.16−7.36 (m, 15 H, 3 Ph). − ^{31}P NMR [161.7 MHz, $CDCl_3/CD_3OD$ (2:1)]: δ = −1.4 to 0.8, broad signal. − FAB MS (negative mode, matrix: 3-nitrobenzyl alcohol): *m/z* = 1595 [M^-]. − $[C_{92}H_{146}N_4O_{16}P]^-$ (1595.17).

O-(2-Azido-3,4,6-tri-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1→6)-1-[(2S,3S,4R)-2-N-(hexacosanoyl)amino-3,4-dihydroxy-octadecan-1-yl-triethylammonium-phosphate]-D-myo-inositol (**26**) *and O-(2-Amino-2-deoxy-α-D-glucopyranosyl)-(1→6)-1-[(2S,3S,4R)-2-N-(hexacosanoyl)amino-3,4-dihydroxy-octadecan-1-yl-hydrogen-phosphate]-D-myo-inositol* (**1**): To a solution of **25** (22 mg, 13.4 μmol) and ethyleneglycol (0.1 ml) in dry acetonitrile/dichloromethane (2:3, 5 ml) was added (1*S*)-camphor-10-sulphonic acid to adjust the pH to 1. After stirring for 4 h at room temp. the solution was neutralized by addition of triethylamine and concentrated in vacuo (0.1 mbar). After addition of brine and water the mixture was extracted three times with chloroform. The combined organic extract was dried (Na_2SO_4) and concentrated in vacuo. The residue was separated by chromatography over silica gel (chloroform/methanol/triethylamine, 90:10:1 → 80:20:1) to yield crude **26** [TLC (chloroform/methanol, 8:2): R_f = 0.21] as a triethylammonium salt. **26** was of sufficient purity for the preparation of **1**. **26** was dissolved in chloroform/methanol/water (45:35:1, 2 ml). After addition of Pearlman-catalyst [$Pd(OH)_2$ on charcoal, 5 mg] the mixture was stirred for 3 h under a hydrogen atmosphere (1 bar) and then filtered through Celite. The filtrate was evaporated to dryness and the residue was chromatographed over a silica-gel column (chloroform/methanol/water, 10:6:1) to give betaine **1** (8 mg, 54%) as a noncrys-

talline solid. – **26**: FAB MS (negative mode, matrix: 3-nitrobenzyl alcohol): *m/z*: = 1393 [M^-] – [$C_{77}H_{126}N_4O_{16}P]^-$ (1394.38). – **1**: TLC (chloroform/methanol/water, 8:5:1): R_f = 0.31. – ^{1}H NMR [250 MHz, $CDCl_3/CD_3OD/D_2O$ (1:1:0.15), chloroform as internal standard (δ = 7.23)]: δ = 0.53–0.59 (t, *J* = 6.3 Hz, 6 H, 2 CH_3), 0.89–1.33 (m, 72 H, 36 CH_2), 1.88–1.94 (t, *J* = 7.6 Hz, 2 H, $COCH_2$), 2.87 (dd, $J_{1b,2b}$ = 3.8, $J_{2b,3b}$ = 10.3 Hz, 1 H, 2b-H), 2.98–3.98 (m), 5.19 (d, $J_{1b,2b}$ = 3.9 Hz, 1 H, 1b-H). – ^{31}P NMR [161.7 MHz, $CDCl_3/CD_3OD/D_2O$ (1:1:0.15)]: δ = 0.99. – FAB MS [positive mode, matrix: 3-nitrobenzyl alcohol/glycerol (1:1)]: *m/z* = 1100 [M + H^+]. – [$C_{56}H_{111}N_2O_{16}P$] (1099.47).

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