Synthesis of Sphingosine-1-phosphonate and Homosphingosine-1-phosphonate

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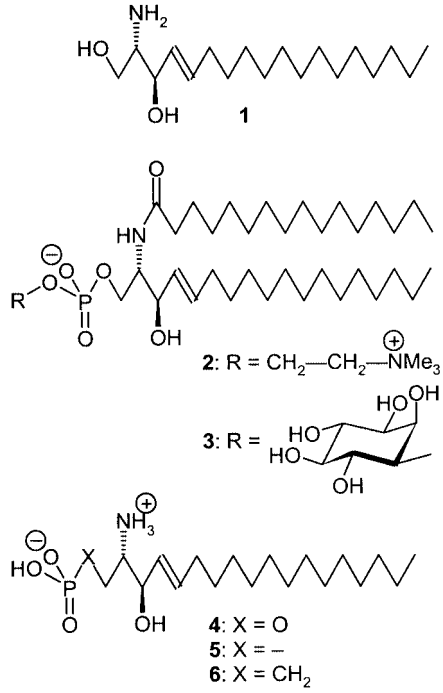
In the first approach to homosphingosine-1-phosphonate, D-glucofuranose was selectively deoxygenated at C-5. Bond cleavage between C-1 and C-2 afforded a 5-deoxy-D-*threo*-pentose intermediate. (*E*)-Selective Wittig reaction with a C_{14}-chain gave a C_{19}-intermediate, which was readily transformed into homosphingosine. Formation of a cyclic urethane containing the 3-amino and the 4-hydroxy group of the C_{19}-intermediate permitted regioselective introduction of the phosphonate group at C-1, thus affording the target molecule after deprotection. In a second and shorter route, C_{18}-sphingosine was converted to a cyclic urethane containing the 2-amino and the 3-hydroxy group of the C_{18}-chain. C_1-Chain extension by a hydroxymethyl group by introduction of cyanide led to the same C_{19} cyclic urethane as obtained in the first route. Similarly, the C_{18} cyclic urethane led to the other target molecule, namely sphingosine-1-phosphonate. The third and shortest route to homosphingosine-1-phosphonate could be based on regioselective 1-*O*-tosylation of 1,2,3-(trihydroxy)octadec-4-ene. Transformation into a 1,2-epoxide, then combination of C_1-chain extension and introduction of a phosphonate group with methylphosphonate as reagent, and finally azide introduction, led after functional group liberation to the target molecule. As shown, also truncated derivatives are readily accessible by this route.

Introduction

Phosphosphingolipids, derivatives of sphingosine (Scheme 1, **1**), are important membrane constituents. For instance, sphingomyelin (**2**) and ceramide-1-phosphoinositol (**3**), were found as constituents of a variety of different cell types.[1] The phosphorylated metabolites of sphingomyelin, as sphinogosine-1-phosphate (**4**), sphingosine-1-phosphocholine (= lysosphingomyelin), and ceramide-1-phosphate were found to participate in cell regulation and transmembrane signalling.[1–6] Sphingosine-1-phosphate (**4**) has received special attention because it possesses second messenger properties.[2,7,8] The levels of **4** increase rapidly, for instance, in response to platelet derived growth factor (PDGF) and tissue platelet activator (TPA).[8,9] **4** is a mitogen in several cell types, a strong inhibitor of cell motility and phagokinesis, and an inhibitor of chemoinvasion of tumour cells.[8,10,11,12] **4** also induces platelet shape changes, aggregation, and intracellular calcium mobilisation, thus having implications in thrombosis, haemostasis and wound healing.[13] Efficient syntheses of **4** have been reported.[14,15]

In order to clearly distinguish the biological effects of **4** from that of the dephosphorylated product, namely sphingosine (**1**), a hydrolytically stable analogue of **4** is required. Therefore, we planned to synthesize the corresponding phosphonate **5**, which is formally a derivative of 1-deoxysphingosine. Considering the distance between the functional groups in **4**, a better analogue of **4** should be homosphingosine-1-phosphonate **6**, which is a derivative of homosphingosine or 1-deoxyhomosphingosine. Efficient syntheses of compounds **5** and **6** are reported in this paper.[16–18] The sphinganine analogue of **5** has been previously synthesized as racemic mixture[19] and also the syn-



Scheme 1. Structure of compounds **1**–**6**.

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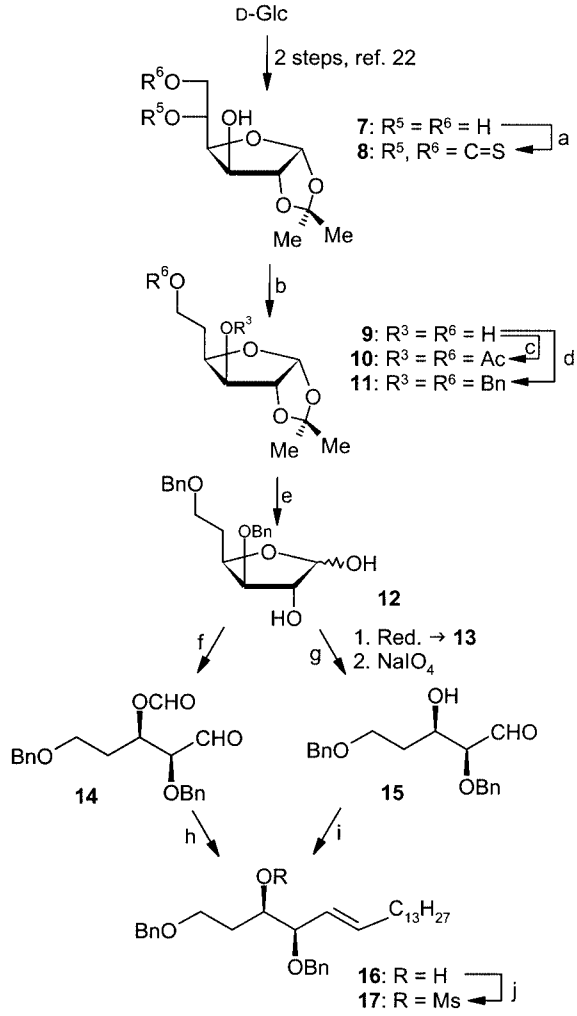
thesis of a protected derivative of **5** has been reported.[20] Syntheses of homosphinganine and homophytosphingosine analogs of **6** have also been recently reported.[21–23]

Results and Discussion

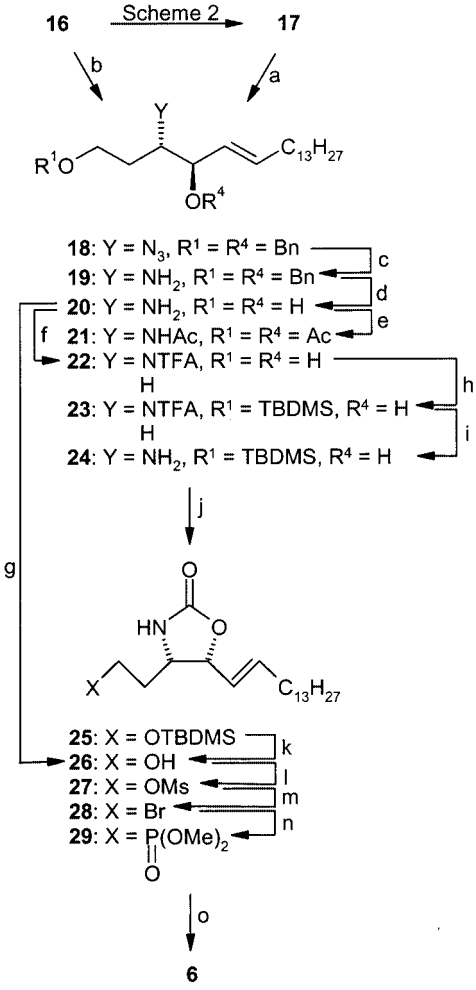
In our previously reported efficient sphingosine synthesis,[24,25] 2,4-di-*O*-protected D-threose was a decisive intermediate; hence, homosphingosine and presumably also its phosphonate **6**, should be readily available from 2,5-di-*O*-protected 4-deoxy-D-*threo*-pentose following (*E*)-selective chain extension by Wittig reaction.[16] To this end, known 1,2-*O*-isopropylidene-D-glucose **7**[26] (Scheme 2) was prepared in two steps from D-glucose. Transformation with thiocarbonyl diimidazole (TCDI) into thionocarbonate **8** and then deoxygenation with tributyltin hydride in the presence of azoisobutyronitrile (AIBN) afforded selectively the 5-deoxygenated intermediate **9** in good yield; the 6-deoxygenated isomer was not observed. The structural assignment of **9** was also confirmed by *O*-acetylation to **10**, which showed the expected downfield shifts for 6_a-H/6_b-H and 3-H. *O*-Benzylation of **9** with sodium hydride/benzyl bromide gave compound **11**, which on treatment with acid led to de-*O*-isopropylidenation (→ **12**). Formal 1,2-diol cleavage in **12** with sodium metaperiodate gave the 3-*O*-formyl-protected 4-deoxypentose **14**. However, it was found that first reduction of the aldehyde group in **12** (→ 5-deoxy-hexitol **13**) and then 1,2-diol cleavage, which provides 3-*O*-unprotected 4-deoxypentaose **15**, gives better results in the following chain extension. The (*E*)-selective Wittig reaction with **14** and (triphenyl)tetradecylphosphonium bromide with phenyllithium as base in the presence of lithium bromide gave C_{19}-intermediate **16**, though only in 39% yield. With **15** and the same reagents and reaction conditions, **16** was obtained in 50% yield.

Activation of the 3-OH group for azide introduction was carried out by *O*-mesylation (→ **17**). Treatment with sodium azide gave the 3-azido compound **18** (Scheme 3), which had the desired D-*erythro*-configuration of homosphingosine. The same compound could be directly obtained from 3-*O*-unprotected **16** in a Mitsunobu reaction[27] by activation with (triphenylphosphane)/diisopropyl azodicarboxylate (DIAD) and then reaction with the zinc azide–pyridine complex[28] in toluene at 50 °C, however, in lower overall yield. Liberation of the amino group in **18** by azide reduction with triphenylphosphane in pyridine/water[29] (→ **19**), and then *O*-debenzylation with lithium in liquid ammonia at low temperature, furnished unprotected homosphingosine **20**.[16,30] The structural assignment of **20** was supported by per-acetylation affording triacetyl derivative **21**, which showed the expected downfield shifts in the ^{1}H NMR spectrum for 1-H, 3-H, and 4-H.

For the synthesis of target molecule **6** from **20**, selective protection of the 4-OH group and the amino group was required. To this end, formation of a cyclic urethane was envisaged because any undesired intramolecular interaction with 1-*O*-activated C-1 should be precluded by steric constraints. Hence, the amino group of **20** was selectively protected with the trifluoroacetyl (TFA) group (→ **22**) and then the primary 1-OH group was protected with the sterically demanding *tert*-butyldimethylsilyl (TBDMS) group (→ **23**). Base-supported cleavage of the TFA group (→ **24**) and then treatment with carbonyldiimidazole (CDI) afforded the cyclic urethane **25** in high yield. 1-*O*-Desilylation under acid catalysis furnished the desired 1-*O*-unprotected homosphingosine derivative **26**, which could be directly obtained in low yield by the treatment of **20** with CDI. However, the main product in this reaction is the cyclic urethane incorporating 1-O and 3-N;[31] therefore, the synthesis via **22**–**25** is more efficient. 1-*O*-Mesylation of **26** (→ **27**), then mesylate/bromide exchange by reaction with lithium bromide in THF at 60 °C (→ **28**), and Arbuzov reaction[32] with neat trimethyl phosphite at elevated temperature, afforded the pro-



Scheme 2. Reagents and conditions: (a) TCDI, THF refl., 2 h (76%); (b) Bu_3SnH, AIBN, dioxane refl., 2 h, (71%); (c) Ac_2O, Pyr, 15 h (79%); (d) BnBr, NaH, DMF, room temp., 5 h (89%); (e) HCl in H_2O, THF, room temp., 60 h (82%); (f) $NaIO_4$, THF/H_2O, room temp., 5 h (90%); (g) $NaBH_4$, MeOH (81%); $NaIO_4$, THF/H_2O, room temp., 1 h (91%); (h) Triphenyl(tetradecyl)phosphonium bromide in Tol, PhLi and LiBr in Et_2O, THF, –40 °C → room temp. (39%); (i) see (h), 50% yield; (j) $MeSO_2Cl$, NEt_3, CH_2Cl_2, 6 h, room temp. (87%).



Scheme 3. Reagents and conditions: (a) NaN_3, DMF, 100 °C, 5 h (82%); (b) PPh_3, DIAD, $Zn(N_3)_2{\cdot}Pyr_2$, Tol, 50 °C (50%); (c) PPh_3, Pyr/H_2O, 50 °C, 15 h (80%); (d) Li, NH_3(l), THF, –78 °C → –45 °C, 3 h, (52%); (e) Ac_2O, Pyr, room temp., 30 h, (87%); (f) CF_3COSEt, NEt_3, MeOH, room temp., 4 h (90%); (g) CDI, THF, –78 °C (byprod. 10–15%); (h) TBDMS–Cl, Pyr, CH_2Cl_2, room temp., 1,5 h (89%); (i) K_2CO_3, $MeOH/H_2O$, refl. 1 h (75%); (j) CDI, THF, room temp., 5 h (85%); (k) pTsOH, THF/H_2O, room temp., 30 h (93%); (l) $MeSO_2Cl$, NEt_3, CH_2Cl_2, room temp., 3 h (99%); (m) LiBr, THF, 60 °C, 60 h (93%); (n) $(MeO)_3P$, refl., 50 h (97%); (o) LiOH, $EtOH/H_2O$, refl., 3 d (31%).

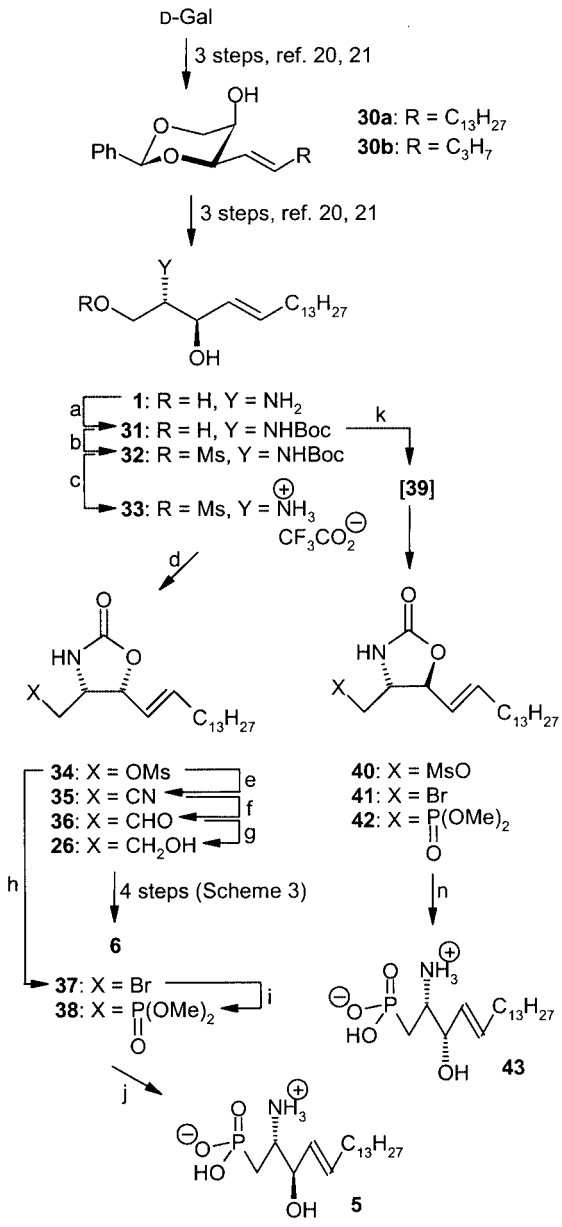
tected phosphonate **29** in high yield. Hydrolysis of **29** with lithium hydroxide furnished target compound **6**, the only step along this route in modest yield. The structural assignments of all intermediates and of the final product are supported by the NMR spectroscopic data.

Alternatively, the synthesis of the target compounds **5** and **6** should be directly accessible from one precursor, namely the readily available sphingosine (**1**).[24,25,33] Hence, for the synthesis of **6** a C_1-chain extension at C-1 is required. To this end, a synthesis of **1** via **30a**[24,25] and then a 2-*N*,3-*O*-protection again via urethane formation was envisaged. This could be readily gained by introduction of an *N*-*tert*-butoxycarbonyl (Boc) group (Scheme 4, → **31**) and selective mesylation (→ **32**) following previously reported procedures.[16,25,34] Acid-catalyzed cleavage of the Boc group (→ **33**), and then treatment with CDI afforded the cyclic urethane **34**. Reaction of this compound with cyanide in triethyleneglycol (TEG) at 60 °C led to the required C_{19}-intermediate **35** in high overall yield. Transformation of this compound into the protected homosphingosine **26** was best performed by reduction of the cyano group with diisobutylaluminum hydride (DIBAH) to the aldehyde **36**, which was then reduced with sodium borohydride to **26**, thus leading in four additional steps to **6**. In terms of number of steps and overall yield this D-galactose-based route to **6** is more efficient than the first route. In addition, readily available **34** is an ideal precursor for the synthesis of the phosphonate **5**. Treatment with lithium bromide in THF at 60 °C afforded the bromide **37** in quantitative yield. Heating in trimethyl phosphite furnished the dimethyl phosphonate **38**, which on base-catalyzed hydrolysis gave the unprotected sphingosine-1-phosphonate **5** in 80% yield.

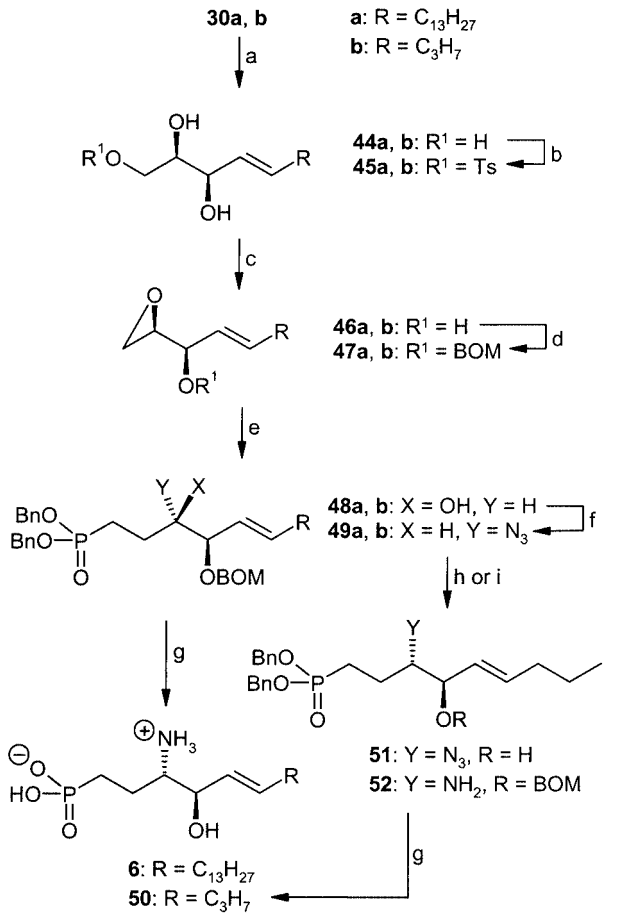
This reaction scheme could be also exploited, for instance, for the synthesis of the (L)-*threo*-isomer **43** of **5**. To this end, treatment of *N*-Boc-protected **31** with excess mesyl chloride in pyridine furnished the 1,3-di-*O*-mesyl compound **39** as intermediate, which in an S_N2-reaction between the Boc group and the highly reactive allylic C-3 carbon, having a mesylate leaving group, afforded immediately the cyclic urethane **40**. As described above, via bromide **41**, phosphonate **42**, and then hydrolysis, **43** was obtained in very good yield. This efficient transformation of **31** into a cyclic urethane could be employed for shortening the synthesis of **5** and **6** by selecting as corresponding carbohydrate precursor D-glucose; however, an even more efficient synthesis could be delineated from the results obtained so far.

Quite a few steps were required for the C_1-chain extension and the introduction of the phosphonate group. Therefore, C_1-chain extension and concomitant phosphonate group introduction was investigated with the help of methylphosphonate. To this end, the 1,3-*O*-benzylidene group in the readily available compound **30a**[24,25] (Scheme 5) was cleaved by acid catalysis and afforded the (D)-*threo*-triol **44a**. Chemoselective 1-*O*-tosylation at –15 °C afforded **45a** in 72% yield, which gave on base treatment the epoxide **46a**. In order to obtain regioselectivity in the following reactions, the 3-OH group was protected by treatment with benzyloxymethyl (BOM) chloride in the presence of Hünig's base (→ **47a**). The carbon chain extension with lithio methylphosphonate dibenzyl ester and boron trifluoride diethyl etherate, in order to support regioselective epoxide opening,[35] afforded the desired C_{19}-phosphonate **48a** in very good yield. The introduction of an azide group was again performed in a Mitsunobu reaction[27] and afforded cleanly **49a**. Treatment of **49a** with sodium in liquid ammonia at –60 °C led to *O*-debenzylation and azide group reduction. This directly afforded the target molecule **6**, which had physical data in accordance with those of the material obtained via the other routes. Thus, also the structural assignments were confirmed.

The same sequence of reactions was applied to the C_8-precursor **44b**, which was obtained from **30b**.[36,37] Via the intermediates **45b**, **46b**, **47b**, and **48b** the truncated homo-



Scheme 4. Reagents and conditions: (a) Boc_2O, NEt_3, dioxane/H_2O, room temp., 30 min (97%); (b) MsCl, Pyr, room temp., 15 min (71%); (c) TFA, CH_2Cl_2, room temp., 30 min (qu); (d) CDI, THF, room temp., 20 h (76%); (e) KCN, TEG, 60 °C, 5 h (79%); (f) DIBAH, Tol, –20 °C, 2 h (77%); (g) $NaBH_4$, MeOH, room temp., 30 min (95%); (h) LiBr, THF, 60 °C, 24 h (98%); (i) $P(OMe)_3$, refl., 50 h (95%); (j) LiOH, EtOH/H_2O, room temp., 5 h (80%); (k) $MeSO_2Cl$, Pyr, room temp., 1.5 h (71%); (l) LiBr, THF, 50 °C, 48 h (86%); (m) $P(OMe)_3$, refl., 50 h (96%); (n) LiOH, EtOH/H_2O, room temp., 5 h (69%).



Scheme 5. Reagents and conditions: (a) Ion exchange resin: H^+ form, MeOH, 50 °C, 10 h (**a**: 61%, **b**: 65%); (b) *p*TSCl, Pyr, –15 °C, 24 h (**a**: 72%, **b**: 67%); (c) NaH, THF/DMSO, room temp., 2 h (**a**: 73%, **b**: 64%); (d) BOMCl, DIPEA, CH_2Cl_2, room temp., 48 h (**a**:95%, **b**: 95%); (e) $MePO(OBn)_2$, BuLi, THF, –80 °C, 2 h; $BF_3{\cdot}OEt_2$, 2 h (**a**, **b** ~ 90%); (f) $Zn(N_3)_2{\cdot}Pyr_2$, PPh_3, DIAD, Tol, 50 °C, 5 h (**a**: 83%, **b**: 83%); (g) Na, NH_3(l), –60 °C, 5 min (qu); (h) *p*TsOH, *t*BuOH, refl., 6 h (47%); (i) PPh_3, H_2O, 50 °C, 16 h (73%).

sphingosine derivative **49b** was obtained. This was transformed into the target compound **50**. Such truncated compounds have proven useful in biological studies.[38] Also a slight variation of this scheme was investigated. The BOM group was selectively cleaved under acidic conditions giving access to the 4-*O*-unprotected derivative **51**. Also the 3-azido group in **49b** could be selectively reduced by the addition of triphenylphosphane to a solution in THF/water and furnished the 3-amino derivative **52**. On treatment with sodium in liquid ammonia both compounds afforded the target compound **50** in high yield.

Conclusions

In conclusion, sphingosine-1-phosphonate (**5**) can be readily obtained from sphingosine via the 2-*N*,3-*O*-urethane formation and then introduction of the phosphonate group by the use of an Arbuzov reaction. For the synthesis of homosphingosine-1-phosphonate (**6**) several routes were investigated. In the routes starting from D-glucose via a 4-deoxypentose and from D-galactose via sphingosine, most steps are very efficient. However, the total number of steps is high. Therefore, starting from D-galactose, an epoxide route was investigated, which combined the C_{18}-chain extension by one carbon atom with the introduction of the phosphonate group by selective opening of the epoxide group with lithio methylphosphonate. This way target mole-

cule **6** was obtained from D-galactose in ten steps in very good overall yield.

Experimental Section

General Remarks: Solvents were purified according to standard procedures. NMR spectra were recorded at 22 °C with a Bruker AC 250 Cryospec, JEOL JNM-GX 400 or Bruker DRX 600 spectrometer. Tetramethylsilane (TMS) or the resonance of the deuterated solvent was used as the internal standard; solvent $CDCl_3$, δ = 7.24; D_2O, δ = 4.63 ppm; [D_6]DMSO, δ = 2.49 ppm. For ^{31}P NMR, phosphoric acid was used as the external standard. ^{31}P NMR spectra were broadband ^1H-decoupled. MALDI-mass spectra were recorded with a Kratos Kompact Maldi 2 spectrometer and 2,5-dihydroxybenzoic acid (DHB) or 6-aza-2-thiothymine (ATT) were used as matrices. FAB-MS were recorded with a Finnigan MAT 312/AMD 5000. Thin layer chromatography was performed on Merck 60 F_{254} silica gel plastic plates or Merck RP-18 glass plates. Compounds were visualized by treatment with a solution of [$(NH_4)_6Mo_7O_{24}\cdot 4H_2O$] (20 g) and $Ce(SO_4)_2$ (0.4 g) in 10% sulphuric acid (400 mL). Flash chromatography was performed on J. T. Baker silica gel 60 (40–63 μm) at a pressure of 0.3 bar. Perparative HPLC separations were performed with an Autochrom System equipped with a Shimadzu LC8A preparative pump and a Rainin Dynamax UV 1 Detector at 260 nm. A LiChrosorb RP-18 column was used, (7 μm, 250 × 16 mm (Knauer, Germany). Optical rotations were measured at 21 °C with a Perkin–Elmer 241/MS polarimeter at the sodium D line.

1,2-*O*-Isopropylidene-5,6-*O*-thiocarbonyl-α-D-glucofuranose (8): Compound **7**[26] (56 g, 255 mmol) was dissolved in boiling tetrahydrofuran (2000 mL). Thiocarbonyldiimidazole (50 g, 281 mmol) was added after cooling and the reaction mixture was stirred at boiling temp. for 2 h. The crimson reaction mixture was successively washed with 1 N HCl, hydrogencarbonate solution and brine. The organic phase was dried and the solvents were evaporated in vacuo to afford **8** (51 g, 76%) as a colourless solid. TLC ($CHCl_3$/methanol, 6:1): R_f = 0.65, $[\alpha]_D$ = –15.8 (c = 1.0, CH_3OH); m.p. 162 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 1.30 (s, 3 H, CH_3), 1.46 (s, 3 H, CH_3), 4.42 (d, $^3J_{3,4}$ = 3.2 Hz, 1 H, 3-H), 4.46–4.55 (m, 2 H, 2-H, 4-H), 4.67 (dd, $^3J_{5,6a}$ = 8.9, $^2J_{6a,6b}$ = 8.9 Hz, 1 H, 6_a-H), 4.75 (dd, $^3J_{5,6b}$ = 7.6 Hz, 1 H, 6_b-H), 5.24 (ddd, $J_{4,5}$ = 2 Hz, 1 H, 5-H), 5.96 (d, 1 H, 1-H) ppm. $C_{10}H_{14}O_6S$ (262.3): calcd. C 45.80, H 5.38 found C 46.05, H 5.41.

1,2-*O*-Isopropylidene-5-deoxy-α-D-glucofuranose (9): Compound **8** (26.5 g, 101 mmol) was dissolved in dry dioxane (700 mL) and heated to boiling temp. Within 2 h a solution of tributyltin hydride (100 mL, 377 mmol) and AIBN (7.4 g, 45 mmol) in dry toluene (1000 mL) was added dropwise. The reaction mixture was evaporated under reduced pressure and purified by flash chromatography (toluene/acetone, 6:5) to afford **9** (14.6 g, 71%) as a colourless solid. TLC (toluene/acetone, 6:5): R_f = 0.33. $[\alpha]_D$ = –5.4 (c = 0.5, CH_3OH); m.p. 91.5–92.5 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 1.32 (s, 3 H, CH_3), 1.50 (s, 3 H, CH_3), 2.00 (m, 2 H, 5_a-H, 5_b-H), 2.55–2.75 (br. s, 1 H, OH), 3.30–3.50 (br. s. 1 H, OH), 3.74 (ddd, $^2J_{6a,6b}$ = 10.7, J = 7.9, J = 4.0 Hz, 1 H, 6_a-H), 3.89 (ddd, J = 4.0, J = 6.0 Hz, 1 H, 6_b-H), 4.14 (d, $^3J_{3,4}$ = 2.5 Hz, 1 H, 3-H), 4.26 (ddd, $^3J_{4,5a}$ = 7.2, $^3J_{4,5b}$ = 7.2 Hz, 1 H, 4-H), 4.55 (d, $^3J_{1,2}$ = 3.8 Hz, 1 H, 2-H), 5.91 (d, 1 H, 1-H) ppm. $C_9H_{16}O_5$ (204.2): calcd. C 52.93, H 7.90; found C 53.34, H 7.61.

3,6-Di-*O*-acetyl-5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranose (10): Compound **9** (50 mg, 0.245 mmol) was stirred in dry pyridine/Ac_2O, 1:1 (2.0 mL) for 15 h. The reaction mixture was evaporated under reduced pressure and purified by flash chromatography (petroleum ether/EtOAc, 3:1) to afford **10** (56 mg, 79%) as a colourless oil. TLC (petroleum ether/EtOAc, 3:1): R_f = 0.37. $[\alpha]_D$ = +1.5 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 1.31 (s, 3 H, CH_3), 1.52 (s, 3 H, CH_3), 1.90–1.98 (m, 2 H, 5_a-H, 5_b-H), 2.04 (s, 3 H, CH_3CO), 2.11 (s, 3 H, CH_3CO), 4.12 (m, 1 H, 6b-H), 4.24 (ddd, $^2J_{6a,6b}$ = 11.2, $^3J_{5a,6a}$ = 7.1, $^3J_{5b,6a}$ = 7.1 Hz, 1 H, 6_a-H), 4.37 (m, 1 H, 4-H), 4.52 (d, $^3J_{1,2}$ = 3.8 Hz, 1 H, 2-H), 5.17 (d, 1 H, 3-H), 5.89 (d, 1 H, 1-H) ppm. $C_{13}H_{20}O_7$ (288.3): calcd. C 54.16, H 6.99; found C 53.92, H 7.00.

3,6-Di-*O*-benzyl-5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranose (11): Compound **9** (26.8 g, 132 mmol) and benzyl bromide (46.9 mL, 393 mmol) were dissolved in dry DMF (400 mL) and sodium hydride added portionwise (8.2 g, 341 mmol) within five min, while the temp. was kept between 25 °C and 30 °C. The mixture was stirred for 5 h, poured into ammonium chloride solution, extracted with diethyl ether, dried and purified by flash chromatography (petroleum ether/EtOAc, 5:1) resulting in compound **11** (45.0 g, 89%) as a yellow oil. TLC (petroleum ether/EtOAc, 6:1): R_f = 0.30, $[\alpha]_D$ = –39.8 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 1.32 (s, 3 H, CH_3), 1.49 (s, 3 H, CH_3), 1.92–2.15 (m, 2 H, 5_a-, 5_b-H), 3.53–358 (m, 2 H, 6_a-, 6_b-H), 3.78 (d, $^3J_{3,4}$ = 3.1 Hz, 1 H, 3-H), 4.30–4.38 (m, 1 H. 4-H), 4.41–4.53 (m, 3 H, $C_6H_5CH_2$), 4.60 (d, $^3J_{1,2}$ = 3.9 Hz, 1 H, 2-H), 4.66 (d, 1 H, $C_6H_5CH_2$), 5.90 (d, 1 H, 1-H), 7.22–7.34 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{23}H_{28}O_5$ (384.5): calcd. C 71.85, H 7.34; found C 71.46, H 7.37.

3,6-Di-*O*-benzyl-5-deoxy-α/β-D-glucofuranose (12): Compound **11** (32.0 g, 83.2 mmol) was dissolved in tetrahydrofuran (300 mL) and cooled. HCl (50%, 200 mL) was slowly added dropwise. The reaction mixture was stirred at room temp. for 60 h, neutralized with powdered $NaHCO_3$, diluted with water and the organic phase was dried. The solvents were evaporated in vacuo. Purification by flash chromatography (toluene/acetone, 4:1) afforded compound **12** (23.5 g, 82%) as a colourless oil. 12% of the starting material was recovered. TLC (toluene/acetone, 3:1): R_f = 0.30. ^1H NMR (250 MHz, $CDCl_3$): δ = 1.92–2.02 (m, 2 H, 5_a-, 5_b-H), 2.05–2.12 (m, 2 H, $5_a'$-, $5_b'$-H), 2.95–3.15 (br. s, 1 H, OH), 3.53–3.64 (m, 2 H, 6_a-, 6_b-/$6_a'$-, $6_b'$-H), 3.77–3.83 (m, 1 H, 3-/3′-H), 4.00–4.10 (br. s, 1 H, OH), 4.15–4.21 (m, 1 H, 2-/2′-H), 4.40–4.51 (m, 4 H, 4-/4′-H, $C_6H_5CH_2$), 4.60–4.68 (m, 1 H, $C_6H_5CH_2$), 5.08 (d, 1 H, 1′-H), 5.45 (d, 1 H, 1-H), 7.25–7.73 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{20}H_{24}O_5$ (344.4): calcd. C 69.75, H 7.02; found C 69.24, H 7.12.

3,6-Di-*O*-benzyl-5-deoxy-D-glucitol (13): Compound **12** (500 mg, 14.5 mmol) was dissolved in methanol (15 mL), and the reaction mixture was cooled. Within 30 min 1 M aqueous solution of sodium borohydride (2.0 mL, stabilized with 1 M NaOH solution) was added, stirred for 2 h (monitoring by TLC did not provide reproducible data), almost neutralized, diluted with diethyl ether and extracted with 50% ammonium chloride solution. The organic phase was dried and the solvents were evaporated in vacuo. Purification by flash chromatography (toluene/acetone, 1:1) afforded compound **13** (407 mg, 81%) as a colourless oil. TLC (toluene/acetone, 3:1): R_f = 0.31. $[\alpha]_D$ = –3.3 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 1.73–1.82 (m, 1 H, 5_a-H), 1.90–2.04 (m, 1 H, 5_b-H), 3.05–3.25 (br. s, 3 H, 3 OH), 3.42 (dd, $^3J_{2,3}$ = 4.8, $^3J_{3,4}$ = 2.9 Hz, 1 H, 3-H), 3.52–3.86 (m, 5 H, 1_a-, 1_b-, 2-, 6_a-, 6_b-H), 4.04 (ddd, $^3J_{4,5a}$ = 10, $^3J_{4,5b}$ = 2 Hz, 1 H, 4-H), 4.50 (s, 2 H, $C_6H_5CH_2$), 4.64 (s, 2 H, $C_6H_5CH_2$), 7.25–7.38 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{20}H_{26}O_5$ (346.4): calcd. C 69.34, H 7.57; found C 69.01, H 7.54.

(2*S*,3*R*)-2,5-Di-*O*-benzyl-3-*O*-formyl-2,3,5-trihydroxypentanal (14): Compound **12** (36.5 g, 106 mmol) was dissolved in tetrahydrofuran/

water, 4:1 (1500 mL) and sodium metaperiodate (45.0 g, 212 mmol) added. After 5 h of stirring the reaction mixture is diluted with diethyl ether, extracted with half-saturated $NaHCO_3$ solution, dried and evaporated under reduced pressure. The crude product (32.5 g, 90%) was used for the next step without further purification. TLC (toluene/acetone, 3:1): R_f = 0.71. $[\alpha]_D$ = +4.3 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 1.99–2.07 (m, 2 H, 4_a-, 4_b-H), 3.42–3.47 (m, 2 H, 5_a-, 5_b-H), 3.93 (dd, $^3J_{1,2}$ = 1.0, $^3J_{2,3}$ = 3.3 Hz, 1 H, 2-H), 4.43–4.79 (m, 4 H, $C_6H_5CH_2$), 5.53 (ddd, $^3J_{3,4a}$ = 6.5, $^3J_{3,4b}$ = 6.5 Hz, 1 H, 3-H), 7.26–7.39 (m, 10 H, $C_6H_5CH_2$), 8.01 (s, 1 H, HCOO), 9.62 (d, 1 H, 1-H) ppm. $C_{20}H_{22}O_5$ (342.4): calcd. C 70.16, H 6.48; found C 69.61, H 6.66.

(2*S*,3*R*)-2,5-Di-*O*-benzyl-2,3,5-trihydroxypentanal (15). (a) From 12: Compound **12** (0.83 g, 2.42 mmol) was dissolved in tetrahydrofuran/water, 2:1 (25 mL), cooled and within 10 min 1 M aqueous sodium borohydride solution (2.0 mL, stabilized with 1 M NaOH solution) added dropwise. The reaction mixture was stirred for 1 h holding the pH value at pH 9. After the reaction mixture was stirred at room temp. for 10 h, cooled, sodium metaperiodate (775 mg, 3.63 mmol) was added and stirred again for 5 h holding the pH value at pH 9. The reaction mixture was neutralized, diluted with diethyl ether and extracted with water. The organic phase was dried and the solvents were evaporated under reduced pressure. The crude product **15** (752 mg, 99%, colourless oil) was used for the next step without further purification. **(b) From 13:** Deoxyglucitol **13** (30 mg, 0.98 mmol) was dissolved in tetrahydrofuran/water, 2:1 (10 mL), sodium metaperiodate (250 mg, 1.18 mmol) added and extracted with half-saturated $NaHCO_3$ solution. The organic phase was dried and the solvents were evaporated under reduced pressure. The crude product **15** (281 mg, 91%, colourless oil) was used for the next step without further purification. TLC (toluene/acetone, 3:2): R_f = 0.69. ^1H NMR (250 MHz, $CDCl_3$): δ = 1.70–2.10 (m, 2 H, 4_a-, 4_b-H), 2.87 (bd, 1 H, OH), 3.53–3.71 (m, 2 H, 5_a-, 5_b-H), 3.77 (dd, $^3J_{1,2}$ = 1.4, $^3J_{2,3}$ = 3.9 Hz, 1 H, 2-H), 4.15–4.26 (m, 1 H, 3-H), 4.48–4.84 (m, 4 H, $C_6H_5CH_2$), 7.23–7.39 (m, 10 H, $C_6H_5CH_2$), 9.77 (d, 1 H, 1-H) ppm. $C_{19}H_{22}O_4$ (314.4).

(3*R*,4*R*,5*E*)-1,4-Di-*O*-benzylnonadec-5-ene-1,3,4-triol (16). (a) From 15: Wittig salt (triphenyl)tetradecylphosphonium bromide (680 mg, 1.62 mmol) was suspended in dry toluene (12 mL), cooled to –30 °C, and a suspension of phenyllithium and lithium bromide in dry diethyl ether (7.5 mL), which was obtained from bromobenzene (440 µL, 4.19 mmol) and lithium granulate (58 mg, 8.36 mmol), was added. The reaction mixture was stirred for 10 min and cooled to –40 °C. To the resulting orange suspension compound **15** (250 mg, 0.8 mmol) in dry tetrahydrofuran (3.0 mL) was added within 20 min. After complete addition, the cooling bath was removed, and the reaction mixture was stirred for 45 min and quenched with methanol. Water was added, diluted with diethyl ether/half-saturated brine, the organic phase was extracted with half-saturated ammonium chloride solution, dried, evaporated under reduced pressure and purified by flash chromatography (petroleum ether/EtOAc, 7:1) furnishing compound **16** (200 mg, 50%) as a colourless oil. **(b) From 14:** The Wittig salt (64.0 g, 119 mmol) was suspended in dry toluene (700 mL), cooled to –30 °C and a suspension of phenyllithium and lithium bromide in dry diethyl ether (170 mL) − obtained from bromobenzene (43 mL, 428 mmol) and lithium granulate (5.9 mg, 853 mmol) − added. The reaction mixture was stirred for 10 min and cooled to –40 °C. To the resulting orange suspension compound **14** (32.5 g, 95 mmol) in dry tetrahydrofuran (140 mL) was added within 20 min. After complete addition the cooling bath was removed, and the reaction mixture was stirred for 45 min and quenched with methanol. Water was added, and then diluted with diethyl ether/half-saturated brine. The organic phase was extracted with half-saturated ammonium chloride solution, dried, evaporated under reduced pressure and purified by flash chromatography (petroluem ether/EtOAc, 6:1) furnishing compound **16** (18.3 g, 39%) as a colourless oil. TLC (toluene/acetone, 6:1): R_f = 0.87, $[\alpha]_D$ = –14.5 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.90 (t, 3 H, 19-H), 1.23–1.45 (m, 22 H, 11 CH_2), 1.60–1.90 (m, 2 H, 2_a-, 2_b-H), 2.05–2.13 (m, 2 H, 7_b-H), 2.92 (br. s, 1 H, OH), 3.55–3.80 (m, 4 H, 1_a-, 1_b-, 3-, 4-H), 4.31–4.65 (m, 4 H, $C_6H_5CH_2$), 5.31 (ddt, $^3J_{4,5}$ = 8.0, $^3J_{5,6}$ = 15.5, $^3J_{5,7a}$ < 1.0, $^3J_{5,7b}$ < 1.0 Hz, 1 H, 5-H), 5.72 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 7.26–7.39 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{33}H_{50}O_3$ (494.8): calcd. C 80.11, H 10.19; found C 80.11, H 10.10.

(3*R*,4*R*,5*E*)-1,4-Di-*O*-benzyl-3-*O*-(methylsulfonyl)nonadec-5-ene-1,3,4-triol (17): Compound **16** (15.0 g, 30 mmol) was dissolved in dry dichloromethane (300 mL), dry triethylamine (21.0 mL, 151 mmol) added, cooled and dropwise methanesulfonyl chloride (3.0 mL, 39 mmol) in dry dichloromethane (30 mL) added within 15 min. The reaction mixture was then stirred for 6 h, quenched with methanol, diluted with diethyl ether and extracted with half-saturated brine. The organic phase was dried and evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 7:1) furnished compound **17** (15.0 g, 87%) as a yellow oil. TLC (petroluem ether/EtOAc, 7:1): R_f = 0.30, $[\alpha]_D$ = –10.6 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, 3 H, 19-H), 1.22–1.45 (m, 22 H, 11 CH_2), 1.79–2.12 (m, 4 H, 2_a-, 2_b-, 7_a-, 7_b-H), 2.91 (s, 3 H, CH_3SO_2), 3.57–3.62 (m, 2 H, 1_a-, 1_b-H), 3.91 (dd, $^3J_{3,4}$ = 7.3, $^3J_{4,5}$ = 8.4 Hz, 1 H, 4-H), 4.28–4.63 (m, 4 H, $C_6H_5CH_2$), 4.82 (ddd, $^3J_{2a,3}$ = 9.0, $^3J_{2b,3}$ = 3.2 Hz, 1 H, 3-H), 5.31 (ddt, $^3J_{5,6}$ = 15.5, $^4J_{5,7a}$ < 1.0, $^4J_{5,7b}$ < 1.0 Hz, 1 H, 5-H), 5.76 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6.7b}$ = 6.7 Hz, 1 H, 6-H), 7.27–7.36 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{34}H_{52}O_5S$ (572.9): calcd. C 71.29, H 9.15; found C 71.77, H 9.14.

(3*S*,4*R*,5*E*)-3-Azido-1,4-di-*O*-benzylnonadec-5-ene-1,4-diol (18). (a) From 16: To a solution of **16** (230 mg, 0.46 mmol) in dry toluene (2.5 mL) was added triphenylphosphane (246 mg, 0.93 mmol), $Zn(N_3)_2{\cdot}Pyr_2$ (86 mg, 0.28 mmol) and dropwise within 10 min diisopropyl azodicarboxylate (180 µL, 0.93 mmol). The reaction mixture was stirred for 1 h at room temp. and then for 1 h at 50 °C. After filtration through celite the reaction mixture was dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 15:1) furnished compound **18** (117 mg, 50%) as colourless oil. **(b) From 17:** To a solution of the mesylate **17** (14.5 g, 25.3 mmol) in dry DMF (200 mL) dried sodium azide (8.26 g, 127 mmol) was added and stirred at 100 °C for 5 h. The reaction mixture was diluted with diethyl ether and extracted with half-saturated brine. The organic phase was dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 25:1) furnished compound **18** (10.8 g, 82%) as a colourless oil. TLC (petroleum ether/toluene, 6:1): R_f = 0.78. $[\alpha]_D$ = –54.0 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.87 (t, 3 H, 19-H), 1.21–1.31 (m, 22 H, 11 CH_2), 1.53–1.67 (m, 1 H, 2_a-H), 1.78–1.89 (m, 1 H, 2_b-H), 1.93–2.14 (m, 2 H, 7_a-, 7_b-H), 3.52–3.57 (m, 2 H, 1_a-, 1_b-H), 3.68–3.80 (m, 2 H, 3-, 4-H), 4.48 (d, ^2J = 12.3 Hz, 1 H, $C_6H_5CH_2$), 4.48 (s, 2 H, $C_6H_5CH_2$), 4.61 (d, 1 H, $C_6H_5CH_2$), 5.42 (ddt, $^3J_{4,5}$ = 8.1, $^3J_{5,6}$ = 15.5, $^4J_{5,7a}$ < 1.0, $^3J_{5,7b}$ < 1.0 Hz, 1 H, 5-H), 5.69 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6.7b}$ = 6.7 Hz, 1 H, 6-H), 7.24–7.37 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{33}H_{49}N_3O_2$ (519.8): calcd. C 76.26, H 9.50, N 8.08; found C 76.72, H 9.62, N 8.20.

(3*S*,4*R*,5*E*)-3-Amino-1,4-di-*O*-benzylnonadec-5-ene-1,4-diol (19): Compound **18** (8.37 g, 16.1 mmol) and triphenylphosphane (7.60 g, 29 mmol) were dissolved in pyridine/water, 10:1 (200 mL), stirred

at room temp. for 3 h and then at 50 °C for 15 h. The reaction mixture was evaporated under reduced pressure. Purification by flash chromatography (toluene/acetone/triethylamine, 76:4:1) furnished compound **19** (6.36 g, 80%) as a yellow oil. TLC (toluene/acetone/triethylamine, 18:3:1): R_f = 0.36, $[\alpha]_D$ = –22.1 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, 3 H, 19-H), 1.23–1.43 (m, 22 H, 11 CH_2), 1.48–1.52 (m, 1 h, 2_a-H), 1.80–2.00 (m, 1 H, 2_b-H), 2.03–2.14 (m, 2 H, 7_a-, 7_b-h), 2.73 (br. s, 2 H, NH_2), 3.57–3.63 (m, 2 H, 3-, 4-H), 4.29–4.60 (m, 4 H, $C_6H_5CH_2$), 5.37 (ddt, $^3J_{4,5}$ = 8.1, $^3J_{5,6}$ = 15.5, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.71 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 7.22–7.38 (m, 10 H, $C_6H_5CH_2$) ppm. $C_{33}H_{51}NO_2$ (493.8): calcd. C 80.27, H 10.41, N 2.84; found C 79.89, H 10.36, N 2.80.

(3*S*,4*R*,5*E*)-3-Aminononadec-5-ene-1,4-diol (20): To liquid ammonia (40 mL, dried over sodium) a mixture of **19** (1.85 g, 3.67 mmol) and dry tetrahydrofuran was added dropwise within 10 min at −78 °C and then lithium granulate (600 mg, 89.6 mmol). The reaction mixture was stirred for 1.5 h increasing the temp. slowly to –45 °C. At this temp. stirring was continued for 1.5 h. The reaction mixture was quenched with solid ammonium chloride and tetrahydrofuran added, diluted with diethyl ether, washed with 1 N NaOH and brine, dried and evaporated under reduced pressure. Purification by flash chromatography ($CHCl_3$/methanol/20% ammonia, 60:10:1) furnished compound **20** (598 mg, 52%) as colourless solid. TLC ($CHCl_3$/methanol/25% ammonia, 40:10:1): R_f = 0.38. $[\alpha]_D$ = +4.6 (c = 1.0, $CHCl_3$); m.p. 80 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, 3 H, 19-H), 1.23–1.42 (m, 22 H, 11 CH_2), 1.50 (dddd, $^2J_{2a,2b}$ = 14.7, $^3J_{2a,3}$ = 10.0, $^3J_{1a,2a}$ = 6.7, $^3J_{1b,2a}$ = 6.7 Hz, 1 H, 2_a-H), 1.70 (ddt, $^2J_{2b,3}$ = 3.1, $^3J_{1a,2b}$ = 3.7, $^3J_{1b,2b}$ = 3.7 Hz, 1 H, 2_b-H), 2.02-2.10 (m, 2 H, 7_a-, 7_b-H), 2.20–2.60 (br. s, 4 H, 2 OH, NH_2), 2.94 (ddd, $^3J_{3,4}$ = 4.7 Hz, 1 H, 3-H), 3.81–3.85 (m, 2 H, 1_a-, 1_b-H), 3.92 (dd, $^3J_{4,5}$ = 6.9 Hz, 1 H, 4-H), 5.43 (ddt, $^3J_{5,6}$ = 15.4, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.74 (ddd, $^3J_{6,7a}$ = 6.6, $^3J_{6,7b}$ = 6.6 Hz, 1 H, 6-H) ppm. $C_{19}H_{39}NO_2$ (313.5): calcd. C 72.79, H 12.54, N 4.46; found C 72.53, H 12.54, N 4.71.

(3*S*,4*R*,5*E*)-3-Acetamido-1,4-di-*O*-acetylnonadec-5-ene-1,4-diol (21): A mixture of compound **20** (20 mg, 63.8 μmol) and dry pyridine/acetic anhydride, 1:1 (1.0 mL) was stirred for 30 h. The reaction mixture was evaporated under reduced pressure and purified by flash chromatography (toluene/acetone, 3:1), which furnished compound **21** (24 mg, 87%) as a colourless solid. TLC (toluene/acetone, 3:1): R_f = 0.23. $[\alpha]_D$ = –33.6 (c = 1.0, $CHCl_3$); m.p. 73 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 19-H), 1.18–1.40 (m, 22 H, 11 CH_2), 1.56–1.73 (m, 2 H, 2_a-, 2_b-H), 1.90–2.07 (m, 11 H, 7_a-, 7_b-H, 3 CH_3CO), 3.42–4.18 (m, 2 H, 1_a-, 1_b-H), 4.30 (dddd, $^3J_{3,NH}$ = 9.9, $^3J_{2b,3}$ = 4.0, $^3J_{3,4}$ = 4.0 Hz, 1 H, 3-H), 5.21 (dd, $^3J_{4,5}$ = 7.0 Hz, 1 H, 4-H), 5.33–5.46 (m, 2 H, 5-H, NH), 5.77 (ddd, $^3J_{6,7a}$ = 6.9, $^3J_{6,7b}$ = 6.9 Hz, 1 H, 6-H) ppm. $C_{25}H_{45}NO_2$ (439.6): calcd. C 68.30, H 10.32, N 3.18; found C 68.48, H 10.42, N 3.01.

(3*S*,4*R*,5*E*)-3-(Trifluoroacetamido)nonadec-5-ene-1,4-diol (22): To a solution of **20** (500 mg, 1.59 mmol) in dry methanol (30 mL) was added triethylamine (260 μL, 1.96 mmol) followed by *S*-ethyl trifluorothioacetate (260 μL, 1.96 mmol) in dry methanol (10 mL). The reaction mixture was stirred for 4 h, evaporated under reduced pressure and purified by flash chromatography ($CHCl_3$/methanol, 15:1) furnishing compound **22** (585 mg, 90%) as colourless solid. TLC ($CHCl_3$/methanol/25% ammonia, 60:10:1): R_f = 0.54. $[\alpha]_D$ = –26.2 (c = 1.0, $CHCl_3$/methanol, 1:1), m.p. 113.6–114.0 °C. ^1H NMR (250 MHz, $CDCl_3/CD_3OD$): δ = 0.89 (t, 3 H, 19-H), 1.20–1.41 (m, 22 H, 11 CH_2), 1.72 (dddd, $^3J_{2a,3}$ = 9.8, J = 5.0, J = 9.8, J = 9.8 Hz, 1 H, 2_a-H), 1.94–2.08 (m, 3 H, 2_b-, 7_a-, 7_b-H), 3.59–3.65 (m, 2 H, 1_a-, 1_b-H), 3.98 (ddd, $^3J_{2b,3}$ = 3.6, $^3J_{3,4}$ = 6.0 Hz, 1 H, 3-H), 4.09 (dd, $^3J_{4,5}$ = 6.8 Hz, 1 H, 4-H), 5.44 (ddt, $^3J_{5,6}$ = 15.4, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.73 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H) ppm. ^{13}C NMR (62.9 MHz, $CDCl_3$): δ = 13.9 (C-19), 52.42 (C-3), 58.33 (C-1), 73.33 (C-4), 115.80 (q, ^1J = 287.3 Hz, CF_3), 127.99 (C-5), 134.49 (C-6), 157.6 (q, ^1J = 37.2 Hz, CO) ppm. $C_{21}H_{38}NO_3$ (409.5): calcd. C 61.59, H 9.35, N 3.42; found C 61.94, H 9.42, N 3.46.

(3*S*,4*R*,5*E*)-1-*O*-(*tert*-Butyldimethylsilyl)-3-(trifluoroacetamido)nonadec-5-ene-1,4-diol (23): To a solution of **22** (630 mg, 1.54 mmol) and dry pyridine (30 mL) TBDMS chloride (1.51 g, 10 mmol) in dry dichloromethane (15 mL) was added dropwise within 5 min, then stirred for 1.5 h, quenched with methanol and evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 6:1) furnished compound **23** (720 mg, 89%) as a colourless solid. TLC (petroleum ether/EtOAc, 6:1): R_f = 0.34. $[\alpha]_D$ = –2.6 (c = 1.0, $CHCl_3$); m.p. 63 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.09 (s, 6 H, $SiMe_2$), 0.85–0.97 (m, 12 H, 19-H, *t*Bu), 1.21–1.49 (m, 22 H, 11 CH_2), 1.87–1.93 (m, 2 H, 2_a-, 2_b-H), 1.99–2.08 (m, 2 H, 7_a-, 7_b-H), 3.03 (br. s, 1 H, OH), 3.70 (ddd, $^2J_{1a,1b}$ = 10.8, J = 4.7, J = 6.0 Hz, 1 H, 1_a-H), 3.83 (ddd, J = 4.8, J = 6.1 Hz, 1 H, 1_b-H), 4.07–4.22 (m, 2 H, 3-, 4-H), (dd, $^3J_{4,5}$ = 6.4, $^3J_{5,6}$ = 15.4 Hz, 1 H, 5-H), 5.74 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 7.30 (s, 1 H, NH) ppm. ^{13}C NMR (62.9 MHz, $CDCl_3$): δ = –5.61 ($SiMe_2$), 14.05 (C-19), 53.53 (C-3), 59.93 (C-1), 73-67 (C-4), 114.40 (q, J = 288.0 Hz, CF_3), 128.36 (C-5), 134–79 (C-6), 157.00 (q, J = 36.8 Hz, CO) ppm. $C_{27}H_{52}F_3NO_3Si$ (523.8): calcd. C 61.91, H 10.01, N 2.68; found C 61.93, H 9.99, N 2.78.

(3*S*,4*R*,5*E*)-3-Amino-1-*O*-(*tert*-butyldimethylsilyl)nonadec-5-ene-1,4-diol (24): To a mixture of **23** (334 mg, 0.637 mmol) and methanol/water, 15:1 (25 mL) was added K_2CO_3 (440 mg, 3.19 mmol) and stirred for 1 h at boiling temp. The reaction mixture was diluted with diethyl ether and extracted with brine. The organic phase was dried, evaporated under reduced pressure and coevaporated three times with toluene and then three times with CH_2Cl_2. The colourless crude product **24** (204 mg, 75%) was used for the next step without further purification. TLC ($CHCl_3$/methanol/25% ammonia, 60:10:1): R_f = 0.60. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.05 (s, 6 H, $SiMe_2$), 0.81–0.90 (m, 12 H, 19-H, *t*Bu), 1.21–1.39 (m, 22 H, 11 CH_2), 1.95–2.08 (m, 5 H, 7_a-, 7_b-H, NH_2, OH), 2.92–2.99 (m, 1 H, 3-H), 3.71–3.76 (m, 2 H, 1_a-, 1_b-H), 3.91 (dd, $^3J_{3,4}$ = 8.1, $^3J_{4,5}$ = 8.1 Hz, 1 H, 4-H), 5.42 (ddt, $^3J_{5,6}$ = 15.4, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.71 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H) ppm. $C_{25}H_{53}NO_2Si$ (427.8).

(3*S*,4*R*,5*E*)-3-Amino-1-*O*-(*tert*-butyldimethylsilyl)-3,4-*N*,*O*-(carbonyl)nonadec-5-ene-1,4-diol (25): To a solution of crude **24** (204 mg, 0.478 mmol) and dry tetrahydrofuran (15 mL) was added carbonyl diimidazole (133 mg, 0.822 mmol) and stirred for 5 h. The reaction mixture was quenched by the addition of methanol and evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 3:1) furnished compound **25** (186 mg, 85%) as a colourless oil. TLC (petroleum ether/EtOAc, 3:2): R_f = 0.59. $[\alpha]_D$ = –3.7 (c = 1.0, $CHCl_3$). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.05 (s, 6 H, $SiMe_2$), 0.83–0.90 (m, 12 H, 19-H, *t*Bu), 1.19–1.40 (m, 22 H, 11 CH_2), 1.52–1.72 (m, 2 H, 2_a-, 2_b-H), 2.02–2.10 (m, 2 H, 7_a-, 7_b-H), 3.66 (ddd, $^2J_{1a,1b}$ = 10.5, J = 8.4, J = 4.3 Hz, 1 H, 1_a-H), 3.78 (ddd, J = 4.8, J = 4.6 Hz, 1 H, 1_b-H), 3.89–3.98 (m, 1 H, 3-H), 4.98 (dd, $^3J_{3,4}$ = 8.1, $^3J_{4,5}$ = 8.1 Hz, 1 H, 4-H), 5.42 (s, 1 H, NH), 5.47 (ddt, $^3J_{5,6}$ = 15.3, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.81 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = –5.53 ($SiMe_2$), –5.44 ($SiMe_2$), 14.12 (C-19), 32.22 (C-7), 33.10 (C-2), 55.79 (C-3), 61.66 (C-1), 80.62 (C-4), 122.88 (C-5), 137.95 (C-6), 158.08 (CO)

ppm. $C_{26}H_{51}NO_3Si$ (453.8): calcd. C 68.82, H 11.33, N 3.09; found C 68.78, H 11.20, N 3.10.

(3*S*,4*R*,5*E*)-3-Amino-3,4-*N*,*O*-(carbonyl)nonadec-5-ene-1,4-diol (26). (a) From 25: To a solution of **25** (186 mg, 0.41 mmol) and tetrahydrofuran/water, 9:1 (15 mL) was added *p*-toluenesulfonic acid (16 mg, 0.82 mmol). The reaction mixture was stirred for 30 h, quenched with pyridine and evaporated under reduced pressure. Purification by flash chromatography ($CHCl_3$/methanol, 15:1) furnished compound **26** (130 mg, 93%) as colourless solid. **(b) From 36:** To a solution of **36** (25 mg, 0.074 mmol) and methanol (1 mL) was added 1 drop of an aqueous 1 M sodium borohydride solution and stirred for 30 min. The reaction mixture was then diluted with diethyl ether and extracted with water. The organic phase was dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography ($CHCl_3$/methanol, 15:1) furnished compound **26** (24 mg, 95%) as colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.28, $[\alpha]_D$ = –2.7 (*c* = 1.0, $CHCl_3$), m.p. 82.0–82.3 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, 19-H), 1.19–1.39 (m, 22 H, 11 CH_2), 1.60–1.78 (m, 2 H, 2_a-, 2_b-H), 1.89 (br. s, 1 H, OH), 2.20–2.10 (m, 2 H, 7_a-, 7_b-H), 3.66–3.75 (m, 2 H, 1_a-, 1_b-H), 3.95–4.04 (m, 1 H, 3-H), 5.00 (dd, $^3J_{3,4}$ = 8.1, $^3J_{4,5}$ = 8.1 Hz, 1 H, 4-H); 5.48 (ddt, $^3J_{5,6}$ = 15.3, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.82 (ddd, $^3J_{6,7a}$ = 6.8, $^3J_{6,7b}$ = 6.8 Hz, 1 H, 6-H), 6.03 (br. s, 1 H, NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.12 (C-19), 32.24 (C-7), 32.85 (C-2), 55.39 (C-3), 60.79 (C-1), 80.90 (C-4), 122.71 (C-5), 138.25 (C-6), 159.27 (CO) ppm. $C_{20}H_{37}NO_3$ (339.5): calcd. C 70.75, H 10.98, N 4.13; found C 71.05, H 10.73, N 4.00.

(3*S*,4*R*,5*E*)-3-Amino-3,4-*N*,*O*-carbonyl-1-*O*-(methylsulfonyl)nonadec-5-ene-1,4-diol (27): To a solution of **26** (220 mg, 0.648 mmol) in dry CH_2Cl_2 (33 mL) was added triethylamine (220 μL) and then dropwise mesyl chloride (76 μL, 0.978 mmol) in dry CH_2Cl_2 (1.2 mL). The reaction mixture was stirred for 3 h, quenched with methanol and the solvents were evaporated under reduced pressure. Purification by flash chromatography ($CHCl_3$/methanol, 15:1) furnished compound **27** (269 mg, 99%) as a colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.42. $[\alpha]_D$ = –10.1 (*c* = 1.0, $CHCl_3$); m.p. 64.5–64.8 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 19-H), 1.19–1.42 (m, 22 H, 11 CH_2), 1.71–2.01 (m, 2 H, 2_a-, 2_b-H), 2.04–2.12 (m, 2 H, 7_a-, 7_b-H), 3.04 (s, 3 H, CH_3SO_2), 3.96–4.05 (m, 1 H, 3-H), 4.29–4.34 (m, 2 H, 1_a-, 1_b-H), 5.06 (dd, $^3J_{3,4}$ = 8.0, $^3J_{4,5}$ = 8.0 Hz, 1 H, 4-H), 5.46 (ddt, $^3J_{5,6}$ = 15.4, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.89 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 6.04 (s, 1 H, NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.12 (C-19), 30.91 (C-2), 37.56 (C-7), 52.69 (C-3), 66.48 (C-1), 80.46 (C-4), 121.88 (C-5), 139.09 (C-6), 158.68 (CO) ppm. $C_{21}H_{39}NO_5S$ (417.6): calcd. C 60.40, H 9.41, N 3.35; found C 60.56, H 9.49, N 3.65.

(3*S*,4*R*,5*E*)-3-Amino-3,4-*N*,*O*-carbonyl-4-hydroxynonadec-5-en-1-yl Bromide (28): A solution of **27** (250 mg, 0.599 mmol) and lithium bromide (1.04 g, 11.9 mmol) in dry tetrahydrofuran (30 mL) was stirred at 60 °C for 16 h, diluted with diethyl ether and extracted with half-saturated brine. The organic phase was dried, the solvents were evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 3:2), furnished compound **28** (224 mg, 93%) as a colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.60, $[\alpha]_D$ = –10.3 (*c* = 1.0, $CHCl_3$), m.p. 62.5–62.8 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 19-H), 1.23–1.44 (m, 22 H, 11 CH_2), 1.95–2.12 (m, 4 H, 2_a-, 2_b-, 7_a-, 7_b-H), 3.31–3.51 (m, 2 H, 1_a-, 1_b-H), 4.00–4.09 (m, 1 H, 3-H), 5.04 (dd, $^3J_{3,4}$ = 8.1, $^3J_{4,5}$ = 8.1 Hz, 1 H, 4-H), 5.47 (ddt, $^3J_{5,6}$ = 15.3, $^4J_{5,7a} < 1.0$, $^4J_{5,7b} < 1.0$ Hz, 1 H, 5-H), 5.87 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 6.32 (s, 1 H, NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-19), 29.66 (C-1), 33.25 (C-7), 33.71 (C-2), 54.50 (C-3), 80.54 (C-4), 122.00 C-5), 138.88 (C-6), 159.08 (CO) ppm. $C_{20}H_{36}BrNO_3$ (402.4): calcd. C 59.69, H 9.02, N 3.48; found C 60.00, H 9.03, N 3.79.

Dimethyl (3*S*,4*R*,5*E*)-(3-Amino-3,4-*N*,*O*-carbonyl-4-hydroxynonadec-5-en-1-yl)phosphonate (29): A solution of **28** (242 mg, 0.601 mmol) and freshly under argon distilled trimethyl phosphite (20 mL) was refluxed for 50 h under argon. The solvent was then distilled off under high vacuum. Purification by flash chromatography ($CHCl_3$/methanol, 15:1) furnished **29** (253 mg, 97%) as a colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.31. $[\alpha]_D$ = –13.7 (*c* = 1.0, $CHCl_3$); m.p. 63 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, 19-H), 1.221.40 (m, 22 H, 11 CH_2), 1.64–1.92 (m, 4 H, 1_a-, 1_b-, 2_a-, 2_b-H), 2.02–2.10 (m, 2 H, 7_a-, 7_b-H), 3.71 (d, $^3J_{MeO,P}$ = 10.8 Hz, 3 H, CH_3O), 3.72 (d, $^3J_{MeO,P}$ = 10.8 Hz, 3 H, CH_3O), 3.80–3.88 (m, 1 H, 3-H), 4.98 (dd, $^3J_{3,4}$ = 8.0, $^3J_{4,5}$ = 8.0 Hz, 1 H, 4-H), 5.48 (dd, $^3J_{5,6}$ = 15.4 Hz, 1 H, 5-H), 5.85 (ddd, $^3J_{6,7a}$ = 6.8, $^3J_{6,7b}$ = 6.8 Hz, 1 H, 6-H), 6.70 (s, 1 H, NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.08 (C-19), 21.35 (d, $^1J_{1,P}$ = 142.4 Hz, C-1), 24.40 (C-2), 31.88 (C-8), 32.28 (C-7), 52.51-56.09 (CH_3O), 56.04 (d, $^3J_{3,P}$ = 12.0 Hz, C-3), 80.64 (C-4), 122.05 (C-5), 138.77 (C-6), 159.02 (CO) ppm. ^{31}P NMR (243 MHz, $CDCl_3$): δ = 37.17 ppm. $C_{22}H_{42}NO_5P$ (431.6): calcd. C 61.22, H 9.81, N 3.25; found C 61.23, H 9.73, N 3.48.

(2*R*,3*S*,4*E*)-(2-Amino-3-hydroxynonadec-4-en-1-yl)phosphonic Acid (6). (a) From 29: To a solution of **29** (74 mg, 0.171 mmol) in ethanol (7.5 mL) was slowly added water (2.5 mL) under vigorous stirring and then $LiOH \times H_2O$ (216 mg, 5.14 mmol). The reaction mixture was stirred at room temp. for 5 h and then refluxed for 3 d, concentrated acetic acid (2.0 mL) added and the volatiles were evaporated under reduced pressure. The residue was dissolved in hot acetic acid (5.0 mL) and then water (2.0 mL) added until clouding. After leaving the mixture in the refrigerator for 3 d the precipitate was filtered off and washed with acetic acid/water, 1:1, water and tetrahydrofuran. Recrystallisation of the product from acetic acid/water furnished compound **6** (20 mg, 31%) as a colourless solid. **(b) From 49a:** Compound **6** was obtained from **49a** in practically quantitative yield as reported for the transformation of **49b** into **50**. TLC (*n*-butanol/acetic acid/water, 5:1:1): R_f = 0.41. $[\alpha]_D$ = –1.0 (*c* = 0.2, acetic acid); m.p. 150 °C (decomposition). ^{1}H NMR (250 MHz, CD_3COOD): δ = 0.79 (t, 3 H, 19-H), 1.15–1.39 (m, 22 H, 11 CH_2), 1.70–2.06 (m, 6 H, 1_a-, 1_b-, 2_a-, 2_b-, 7_a-, 7_b-H), 3.42–3.52 (m, 1 H, 3-H), 4.29–4.33 (m, 1 H, 4-H), 5.43 (dd, $^3J_{4,5}$ = 6.6, $^3J_{5,6}$ = 15.7 Hz, 1 H, 5-H), 5.79 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H) ppm. ^{13}C NMR (151 MHz, CD_3COOD): δ = 14.41 (C-19), 27.50 (d, $^2J_{1,P}$ = 136.0 Hz, C-1), 32.94 (C-7), 58.06 (C-3), 73.21 (C-4), 126.67 (C-5), 137.25 (C-6) ppm. ^{31}P NMR (243 MHz, CD_3COOD): δ = 30.78 ppm. FAB-MS (negative mode): Matrix: DMSO/nitrobenzyl alcohol/glycerol, 1:1:1): *m*/*z* (%) = 376 (50) [M – H$^+$], 753 (5) [2M – H$^+$]. $C_{19}H_{40}NO_4P$ (377.5): calcd. C 60.45, H 10.68, N 3.71; found C 60.16, H 10.36, N 3.80.

(2*S*,3*R*,4*E*)-2-(*tert*-Butyloxycarbonylamino)-4-octadecene-1,3-diol (31): Compound **30** (425 mg, 1.42 mmol) was dissolved in dioxane/water (10 mL, 4:1) and triethylamine (0.2 mL) added. Under stirring di-*tert*-butyl dicarbonate (370 mg, 1.70 mmol) dissolved in dioxane (10 mL) was slowly added. After 30 min (TLC monitoring) the mixture was evaporated and then coevaporated with toluene. Purification of the product was performed by filtration through silica gel with $CHCl_3$/methanol, (9:1) as eluent, leading to **31** (550 mg, 97%) as colourless oil. TLC ($CHCl_3$/methanol, 9:1): R_f = 0.61. $[\alpha]_D$ = +2.4 (*c* = 1.0, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$):

δ = 0.88 (t, $J_{17,18}$ = 6.6 Hz, 3 H, CH_3), 1.22–1.40 (m, 22 H, 11 CH_2), 1.45 (s, 9 H, C_4H_9), 2.05 (m, 2 H, 6-H_a, 6-H_b), 3.21 (br. s, 2 H, 2 OH), 3.58 (m, 1 H, 2-H), 3.68 (m, 1 H, 1-H_a), 3.91 (m, 1 H, 1-H_b), 4.28 (m, 1 H, 3-H), 5.37 (d, $J_{2,NH}$ = 8.2 Hz, 1 H, NH), 5.51 (dd, $J_{3,4}$ = 6.4, $J_{4,5}$ = 15.4 Hz, 1 H, 4-H), 5.76 (dt, $J_{4,5}$ = 15.4, $J_{5,6}$ = 6.8 Hz, 1 H, 5-H) ppm. $C_{23}H_{45}NO_4$ (399.6): calcd. C 69.13, H 11.35, N 3.50; found C 69.28, H 11.32, N 3.47.

(2*S*,3*R*,4*E*)-2-(*tert*-Butyloxycarbonylamino)-1-methylsulfonyloxy-4-octadecen-3-ol (32): Compound **31** (960 mg, 2.40 mmol) was dissolved in dry pyridine (20 mL). Under stirring methanesulfonyl chloride (550 mg, 4.80 mmol) was added at room temp. and the reaction monitored by TLC. After 15 min the reaction was stopped by adding water (100 mL). Extraction with ethyl acetate (2 × 80 mL) and silica gel chromatography ($CHCl_3$/methanol, 97:3) afforded compound **32** (812 mg, 71%). TLC (petroleum ether/ethyl acetate, 1:1): R_f = 0.59. $[a]_D$ = +3.4 (*c* = 1.0, $CHCl_3$) ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, $J_{17,18}$ = 6.6 Hz, 3 H, CH_3), 1.22–1.41 (m, 22 H, 11 CH_2), 1.44 (s, 9 H, C_4H_9), 2.04 (m, 2 H, 6-H_a, 6-H_b), 2.22 (br. s, 1 H, OH), 3.04 (s, 3 H, S–CH_3), 3.86 (m, 1 H, 2-H), 4.17 (m, 1 H, 3-H), 4.34 (dd, $J_{1a,1b}$ = 10.4, $J_{1a,2}$ = 3.5 Hz, 1 H, 1-H_a), 4.48 (dd, $J_{1a,1b}$ = 10.4, $J_{1b,2}$ = 4.8 Hz, 1 H, 1-H_b), 4.91 (br. d, 1 H, NH), 5.49 (dd, $J_{3,4}$ = 7.1, $J_{4,5}$ = 15.4 Hz, 1 H, 4-H), 5.78 (dt, $J_{4,5}$ = 15.4, $J_{5,6}$ = 6.7 Hz, 1 H, 5-H) ppm. $C_{24}H_{47}NO_6S$ (477.7): calcd. C 60.34, H 9.92, N 2.93; found C 60.38, H 9.86, N 2.90.

(2*S*,3*R*,4*E*)-2-Amino-1-methylsulfonyloxy-4-octadecen-3-ol (33): Compound **32** (180 mg, 377 μmol) and trifluoroacetic acid (5 mL) were dissolved in CH_2Cl_2 (15 mL). After 30 min at room temp. the mixture was evaporated and then coevaporated with toluene. Purification by flash chromatography ($CHCl_3$/methanol, 95:5) afforded **33** (143 mg, qu), which was immediately used in the next step. TLC ($CHCl_3$/methanol, 9:1): R_f = 0.41. $[a]_D$ = +3.1 (c = $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, $J_{17,18}$ = 6.6 Hz, 3 H, CH_3), 1.17–1.39 (m, 22 H, 11 CH_2), 2.03 (m, 2 H, 6-H_a, 6-H_b), 2.88 (br. s, 3 H, NH_2, OH), 3.04 (s, 3 H, S–CH_3), 3.15 (m, 1 H, 2-H), 4.10 (m, 1 H, 3-H), 4.22 (dd, $J_{1a,1b}$ = 10.2, $J_{1a,2}$ = 7.3 Hz, 1 H, 1-H_a), 4.32 (dd, $J_{1a,1b}$ = 10.2, $J_{1b,2}$ = 3.7 Hz, 1 H, 1-H_b), 5.41 (dd, $J_{3,4}$ = 7.0, $J_{4,5}$ = 15.4 Hz, 1 H, 4-H), 5.77 (dt, $J_{4,5}$ = 15.4, $J_{5,6}$ = 6.6 Hz, 1 H, 5-H) ppm.

(2*S*,3*R*,4*E*)-2-Amino-2,3-*N*,*O*-carbonyl-1-*O*-(methylsulfonyl)octadec-4-ene-1,3-diol (34): A solution of **33**[16,25,34] (771 mg, 1.57 mmol) and dry tetrahydrofuran (100 mL) was added carbonyl diimidazole (300 mg, 1.88 mmol) and stirred for 20 h. The reaction mixture was then quenched with methanol, evaporated under reduced pressure and purified by flash chromatography (petroleum ether/EtOAc, 3:1), which furnished compound **34** (480 mg, 76%) as colourless solid. TLC ($CHCl_3$/methanol, 9:1): R_f = 0.53. $[a]_D$ = –25.8 (*c* = 1.0, $CHCl_3$); m.p. 103 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, 18-H), 1.21–142 (m, 22 H, 11 CH_2), 2.04–2.12 (m, 2 H, 6$_a$-, 6$_b$-H), 3.07 (s, 3 H, CH_3SO_2), 4.05–4.79 (m, 3 H, 1$_a$-, 1$_b$-, 2-H), 5.10 (dd, $^3J_{2,3}$ = 7.8, $^3J_{3,4}$ = 7.8 Hz, 1 H, 3-H), 5.47 (ddt, $^3J_{4,5}$ = 15.3, $^4J_{4,6a}$ = 1.3, $^4J_{4,6b}$ = 1.3 Hz, 1 H, 4-H), 5.96 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H), 6.07 (br. s, 1 H, NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-18), 37.72 (CH_3SO_2), 54.54 C-2), 67.42 (C-1), 78.78 (C-3), 120.66 (C-4), 140.12 (C-5), 158.65 (CO) ppm. EI-MS (70 eV, 190 °C): *m*/*z* (%) = 403 (10) [M^+], 307 (15) [(M – CH_3SO_3H)$^+$], 294 (10) [(M – $CH_3SO_3CH_2$)$^+$], 250 (100) [(M – $CH_3SO_3CH_2$ – CO_2)$^+$]. $C_{20}H_{37}NO_5S$ (403.6): calcd. C 59.51, H 9.24, N 3.47; found C 59.24, H 9.21, N 3.43.

(3*S*,4*R*,5*E*)-3-Amino-3,4-*N*,*O*-carbonyl-4-hydroxynonadec-5-enenitrile (35): A solution of **34** (1.0 g, 2.47 mmol) and potassium cyanide (410 mg, 6.31 mmol) in dry triethylene glycol (120 mL) was stirred at 60 °C for 5 h. The reaction mixture was diluted with diethyl ether and extracted with half-saturated brine. The organic phase was washed with water, dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 1:1) furnished compound **35** (650 mg, 79%) as colourless solid. TLC (petroleum ether/EtOAc, 1:1): R_f = 0.23. $[a]_D$ = –23.2 (*c* = 1.0, $CHCl_3$); m.p. 68 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 19-H), 1.19–1.42 (m, 22 H, 11 CH_2), 2.07–2.15 (m, 2 H, 7$_a$-, 7$_b$-H), 2.52–2.55 (m, 2 H, 2$_a$-, 2$_b$-H), 4.13 (ddd, $^3J_{3,4}$ = 7.5 Hz, 1 H, 3-H), 5.13 (dd, $^3J_{4,5}$ = 7.5 Hz, 1 H, 4-H), 5.48 (ddt, $^3J_{5,6}$ = 15.4, $^4J_{5,7a}$ = 1.4, $^4J_{5,7b}$ = 1.4 Hz, 1 H, 5-H), 5.99 (ddd, $^3J_{6,7a}$ = 6.7, $^3J_{6,7b}$ = 6.7 Hz, 1 H, 6-H), 6.58 (s, 1 H, NH) ppm. ^{13}C NMR (62.9 MHz, $CDCl_3$): δ = 14.10 (C-19), 20.75 (C-2), 32.34 (C-7), 52.61 (C-3), 79.30 (C-4), 116.29 (C-1), 120.29 (C-5), 140.37 (C-6), 157.73 (CO) ppm. $C_{20}H_{34}N_2O_5$ (334.5): calcd. C 71.81, H 10.25, N 8.37; found C 71.69, H 10.40, N 8.31.

(3*S*,4*R*,5*E*)-3-Amino-3,4-*N*,*O*-carbonyl-4-hydroxynonadec-5-enal (36): A solution of **35** (450 mg, 1.34 mmol) in dry toluene (7.5 mL) was added dropwise within 15 min to a solution of diisobutylaluminium hydride (1 M in toluene, 3.4 mL, 3.40 mmol) in dry toluene (10 mL) cooled to –20 °C. The reaction mixture was stirred for 2 h, ethyl acetate (5 mL) added, stirred for 1 h, diluted with diethyl ether, stirred for a few min with 1 N HCl and extracted with 1 N HCl (adding brine to separate the phases). The organic phase was washed with half-saturated hydrogencarbonate solution, dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography ($CHCl_3$/methanol, 30:1) furnished compound **36** (348 mg, 77%) as colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.26. $[a]_D$ = –14.2 (*c* = 0.5, $CHCl_3$); m.p. 75 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 19-H), 1.18–1.39 (m, 22 H, 11 CH_2), 2.01–2.15 (m, 2 H, 7$_a$-, 7$_b$-H), 2.71–2.74 (m, 2 H, 2$_a$-, 2$_b$-H), 4.21–4.30 (m, 1 H, 3-H), 5.05 (dd, $^3J_{3,4}$ = 7.9, $^3J_{4,5}$ = 7.9 Hz, 1 H, 4-H), 5.41 (ddt, $^3J_{5,6}$ = 15.3, $^4J_{5,7a}$ = 1.4, $^4J_{5,7b}$ = 1.4 Hz, 1 H, 5-H), 5.57 (s, 1 H, NH), 5.87 (ddd, $^3J_{6,7a}$ = 6.6, $^3J_{6,7b}$ = 6.6 Hz, 1 H, 6-H), 9.74 (m, 1 H, 1-H) ppm. $C_{20}H_{35}NO_3$ (337.5): calcd. C 71.18, H 10.45, N 4.15; found C 70.80, H 10.38, N 4.36.

(2*S*,3*R*,4*E*)-2-Amino-2,3-*N*,*O*-carbonyl-3-hydroxyoctadec-4-en-1-yl Bromide (37): A solution of **34** (330 mg, 0.818 mmol) and lithium bromide (1.42 g. 16.4 mmol) in dry tetrahydrofuran (40 mL) was stirred at 60 °C for 24 h. The reaction mixture was diluted with diethyl ether, extracted with water and the organic phase was dried and the solvents were evaporated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 2:1) furnished **37** (310 mg, 98%) as colourless solid. TLC ($CHCl_3$/methanol, 15:1): R_f = 0.58. $[a]_D$ = –14.4 (*c* = 1.0, $CHCl_3$); m.p. 57 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 18-H), 1.22–1.42 (m, 22 H, 11 CH_2), 2.04–2.12 (m, 2 H, 6$_a$-, 6$_b$-H), 3.25–3.40 (m, 2 H, 1$_a$-, 1$_b$-H), 4.06–4.14 (m, 1 H, 2-H), 5.06 (dd, $^3J_{2,3}$ = 7.9, $^3J_{3,4}$ = 7.9 Hz, 1 H, 3-H), 5.56 (ddt, $^3J_{4,5}$ = 15.3, $^4J_{4,6a}$ < 1.0, $^4J_{4,6b}$ < 1.0 Hz, 1 H, 4-H), 5.58 (s, 1 H, NH), 5.94 (ddd, $^3J_{5,6a}$ = 6.8, $^3J_{5,6b}$ = 6.8 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-18), 32.27 (C-6), 32.40 (C-1), 57.05 (C-2), 79.68 (C-3), 120.63 (C-4), 139.48 (C-5), 158.00 (CO) ppm. $C_{19}H_{34}BrNO_2$ (388.4): calcd. C 58.76, H 8.82, N 3.61; found C 58.72, H 8.66, N 3.73.

Dimethyl (2*R*,3*R*,4*E*)-(2-Amino-2,3-*N*,*O*-carbonyl-3-hydroxyoctadec-4-en-1-yl)phosphonate (38): A solution of **37** (161 mg, 0.414 mmol) and trimethyl phosphite (15 mL) was stirred for 50 h under reflux. The solvent was distilled off under high vacuum. Purification by flash chromatography ($CHCl_3$/methanol, 25:1) furnished **38** (164 mg, 95%) as colourless solid. TLC ($CHCl_3$/methanol, 20:1): R_f = 0.31. $[a]_D$ = –20.4 (*c* = 1.0, $CHCl_3$); m.p. 77 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, 18-H), 1.10–1.49

(m, 22 H, 11 CH_2), 1.79–1.89 (m, 2 H, 1_a-, 1_b-H), 2.03–2.11 (m, 2 H, 6_a-, 6_b-H), 3.75 (d, $^3J_{H,P}$ = 11.0 Hz, 3 H, CH_3O), 4.05–4.17 (m, 1 H, 2-H), 5.01 (dd, $^3J_{2,3}$ = 7.7, $^3J_{3,4}$ = 7.7 Hz, 1 H, 3-H), 5.39 (dd, $^3J_{4,5}$ = 15.4 Hz, 1 H, 4-H), 5.74–5.93 (m, 2 H, 5-H), NH) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-18), 27.40 (C-1), 32.28 (C-6), 51.24 (d, $^2J_{2,P}$ = 3.5 Hz, C-2), 52–75–52.83 (m, MeO), 79.93 (d, $^3J_{3,P}$ = 13.0 Hz, C-3), 121.76 (C-4), 139.20 (C-5), 157.88 (CO) ppm. ^{31}P NMR (243 MHz, $CDCl_3$): δ = 34.47 ppm. $C_{21}H_{40}NO_5P$ (417.5): calcd. C 60.41, H 9.66, N 3.35; found C 60.15, H 9.61, N 3.20.

(2*R*,3*R*,4*E*)-(2-Amino-3-hydroxyoctadec-4-en-1-yl)phosphonic Acid (5): To a solution of **38** (40 mg, 0.0958 mmol) in ethanol (1.3 mL) was slowly added water (0.5 mL) under vigorous stirring and then $LiOH \times H_2O$ (120 mg, 2.87 mmol). The reaction mixture was stirred for 5 h and then for 18 h under reflux, concentrated acetic acid (2.0 mL) added and evaporated under reduced pressure. The residue was dissolved in hot acetic acid (5.0 mL) and then water (2.0 mL) added until clouding. After leaving this mixture in the refrigerator it was filtered and the precipitate washed with acetic acid/water, 1:1, water and tetrahydrofuran furnishing **5** (28 mg, 80%) as a colourless solid. TLC (*n*-butanol/acetic acid/water, 5:1:1): R_f = 0.42. $[\alpha]_D$ = –2.6 (*c* = 0.5, acetic acid); m.p. 190 °C (decomposition). ^1H NMR (250 MHz, CD_3COOD): δ = 0.79 (t, 3 H, 18-H), 1.18–1.35 (m, 22 H, 11 CH_2), 1.90–2.05 (m, 4 H, 1_a-, 1_b-, 6_a-, 6_b-H), 3.73–3.81 (m, 1 H, 2-H), 4.32–4.38 (m, 1 H, 3-H), 5.40 (dd, $^3J_{3,4}$ = 6.3, $^3J_{4,5}$ = 15.5 Hz, 1 H, 4-H), 5.79 (ddd, $^3J_{5,6a}$ = 6.8, $^3J_{5,6b}$ = 6.8 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, CD_3COOD): δ = 14.40 (C-18), 27.00 (d, $^1J_{1,P}$ = 135.5 Hz, C-1), 33.20 (C-6), 53.47 (C-2), 73.13 (d, $^3J_{3,P}$ = 16.2 Hz, C-3), 126.59 (C-4), 137.36 (C-5) ppm. ^{31}P NMR (161.7 MHz, CD_3COOD): δ = 26.25 ppm. FAB-MS (negative mode): Matrix: DMSO/nitrobenzyl alcohol/glycerol, 1:1:1): *m*/*z* (%) = 362 (40) [M – H^+]. $C_{18}H_{38}NO_4P$ (363.5): calcd. C 59.48, H 10.54, N 3.85; found C 59.02, H 10.24, N 4.08.

(2*S*,3*S*,4*E*)- 2-Amino-2,3-*N*,*O*-carbonyl-1-*O*-(methylsulfonyl)octadec-4-ene-1,3-diol (40): To a solution of **31** (25 mg, 0.063 mmol) in dry pyridine (1.0 mL) was injected methanesulfonyl chloride (25 µL, 0.313 mmol) affording **39** as intermediate, which was directly transformed into **40**. The reaction mixture was stirred for 1.5 h, quenched with methanol, concentrated, diluted with diethyl ether, extracted with half-saturated brine and the organic phase dried. Then the solvents were evaporated in vacuo. Purification by flash chromatography (toluene/acetone, 4:1) furnished compound **40** (18 mg, 71%) as a colourless solid. TLC ($CHCl_3$/methanol, 14:1): R_f = 0.32, $[\alpha]_D$ = –41.5 (*c* = 1.0, $CHCl_3$); m.p. 101 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, 3 H, 18-H), 1.22–1.45 (m, 22 H, 11 CH_2), 2.05–2.13 (m, 2 H, 6_a-, 6_b-H), 3.10 (s, 3 H, CH_3SO_2), 3.86 (ddd, $^3J_{1a,2}$ = 6.2, $^3J_{1b,2}$ = 3.9, $^3J_{2,3}$ = 6.1 Hz, 1 H, 2-H), 4.19 (dd, $^2J_{1a,1b}$ = 10.8 Hz, 1 H, 1_a-H), 4.30 (dd, 1 H, 1_b-H), 4.69 (dd, $^3J_{3,4}$ = 7.6 Hz, 1 H, 3-H), 5.55 (ddt, $^3J_{4,5}$ = 15.5, $^4J_{4,6a}$ < 1.0, $^4J_{4,6b}$ < 1.0 Hz, 1 H. 4-H), 5.71 (br. s, 1 H, NH), 5.90 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.15 (C-18), 37.76 (CH_3SO_2), 57.23 (C-2), 68.20 (C-1), 79.14 (C-3), 124.94 (C-4), 138.52 (C-5), 158.63 (CO) ppm. $C_{20}H_{37}NO_5S$ (403.6): calcd. C 59.52, H 9.24, N 3.47; found C 60.25, H 9.31, N 3.56.

(2*R*,3*S*,4*E*)-2-Amino-2,3-*N*,*O*-carbonyl-3-hydroxyoctadec-4-en-1-yl Bromide (41): A solution of **40** (259 mg, 0.642 mmol) and lithium bromide (1.12 g, 12.8 mmol) in dry tetrahydrofuran (25 mL) was stirred at 50 °C for 48 h. The reaction mixture was diluted with diethyl ether, extracted with water and the organic phase dried. The solvents were evaporated in vacuo. Purification by flash chromatography (petroleum ether/EtOAc, 2:1) furnished compound **41** (214 mg, 86%) as a colourless solid. TLC ($CHCl_3$/methanol, 20:1): R_f = 0.28. $[\alpha]_D$ = –34.4 (*c* = 1.0, $CHCl_3$); m.p. 58 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, 18-H), 1.21–1.44 (m, 22 H, 11 CH_2), 2.04–2.12 (m, 2 H, 6_a-, 6_b-H), 3.34–3.47 (m, 2 H, 1_a-, 1_b-H), 3.82 (ddd, $^3J_{2,3}$ = 5.5 Hz, 1 H, 2-H), 4.68 (dd, $^3J_{3,4}$ = 7.4 Hz, 1 H, 3-H), 5.54 (ddt, $^3J_{4,5}$ = 15.4, $^4J_{4,6a}$ < 1.0, $^4J_{4,6b}$ < 1.0 Hz, 1 H, 4-H), 5.79 (br. s, 1 H, NH), 5.90 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-18), 33.35 (C-1), 59.50 (C-2), 81.60 (C-3), 125.30 (C-4), 137.86 (C-5), 158.15 (CO) ppm. $C_{19}H_{34}BrNO_5$ (338.4): calcd. C 58.76, H 8.82, N 3.61; found C 58.81, H 8.77, N 3.86.

Dimethyl (2*R*,3*S*,4*E*)-(2-Amino-2,3-*N*,*O*-carbonyl-3-hydroxyoctadec-4-en-1-yl)phosphonate (42): A solution of **41** (66 mg, 0.17 mmol) and trimethyl phosphite (2.0 mL) was stirred for 50 h under reflux. The solvent was distilled off under high vacuo. Purification by flash chromatography ($CHCl_3$/methanol, 20:1) furnished **42** (68 mg, 96%) as a colourless solid. TLC ($CHCl_3$/methanol, 20:1): R_f = 0.23. $[\alpha]_D$ = –31.0 (*c* = 1.0, $CHCl_3$); m.p. 57 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = (t, 3 H, 18-H), 1.22–1.43 (m, 22 H, 11 CH_2), 1.87–2.12 (m, 4 H, 1_a-, 1_b-, 6_a-, 6_b-H), 3.76–3.85 (m, 7 H, 2-H, 2 CH_3O), 4.50 (dd, $^3J_{2,3}$ = 7.5, $^3J_{3,4}$ = 7.5 Hz, 1 H, 3-H), 5.50 (ddt, $^3J_{4,5}$ = 15.4, $^4J_{4,6a}$ = 1.3, $^4J_{4,6b}$ = 1.3 Hz, 1 H, 4-H), 5.78 (s, 1 H, NH), 5.89 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H). ^{13}C NMR (151 MHz, $CDCl_3$): δ = 14.10 (C-18), 29.90 (C-1), 52.74 (d, $^2J_{MeO,P}$ = 6.6 Hz, MeO), 52.82 (d, $^2J_{MeO,P}$ = 6.6 Hz, MeO), 53.74 (d, $^3J_{3,P}$ = 21.4 Hz, C-3), 124.56 (C-4), 138.78 (C-5), 157.68 (CO). ^{31}P NMR (161.7 MHz, CD_3COOD): δ = 29.71. $C_{21}H_{40}NO_5P$ (417.5): calcd. C 60.41, H 9.66, N 3.35; found C 60.30, H 9.51, N 3.57.

(2*R*,3*S*,4*E*)-(2-Amino-3-hydroxyoctadec-4-en-1-yl)phosphonic Acid (43): To a solution of **42** (45 mg, 0.108 mmol) in ethanol (1.3 mL) was slowly added water (0.5 mL) under vigorous stirring and then $LiOH \times H_2O$ (136 mg, 3.23 mmol). Stirring was continued at room temp. for 5 h and then refluxed for 12 h. Acetic acid was added and the reaction mixture evaporated in vacuo. The residue was then diluted in hot acetic acid (3.0 mL) and then water added until clouding. After leaving this mixture in the refrigerator the precipitate was filtered off and washed with water and ethanol. Recrystallisation from acetic acid/water furnished compound **43** (27 mg, 69%) as colourless solid. TLC (*n*-butanol/acetic acid/water, 5:1:1): R_f = 0.49. $[\alpha]_D$ = –5.8 (*c* = 0.5, acetic acid); m.p. 180 °C (decomposition). ^1H NMR (250 MHz, CD_3COOD): δ = 0.81 (t, 3 H, 18-H), 1.18–1.35 (m, 22 H, 11 CH_2), 1.94–2.05 (m, 4 H, 1_a-, 1_b-, 6_a-, 6_b-H), 3.51–3.66 (m, 1 H, 2-H), 4.15 (dd, $^3J_{2,3}$ = 7.7, $^3J_{3,4}$ = 7.7 Hz, 1 H, 3-H), 5.39 (ddt, $^3J_{4,5}$ = 15.4, $^4J_{4,6a}$ < 1.0, $^4J_{4,6b}$ < 1.0 Hz, 1 H, 4-H), 5.83 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, CD_3COOD): δ = 14.50 (C-18), 32.86 (C-6), 53.78 (d, $^2J_{2,P}$ = 6.1 Hz, C-2), 74.27 (d, $^3J_{3,P}$ = 17.0 Hz, C-3), 128.20 (C-4), 138.50 (C-5) ppm. ^{31}P NMR (161.7 MHz, CD_3COOD): δ = 22.89 ppm. FAB-MS (negative mode): Matrix: DMSO/nitrobenzyl alcohol/glycerine, 1:1:1): *m*/*z* (%) = 362 (40) [M – H^+], 725 (5) [(2M) – H^+]. $C_{18}H_{38}NO_4P$ (363.5): calcd. C 59.48, H 10.54, N 3.88; found C 59.41, H 10.28, N 4.23.

(2*R*,3*R*,4*E*)-Octadec-4-ene-1,2,3-triol (44a): To a solution of **30a**[24,25] (8.56 g, 22 mmol) and methanol (100 mL) was added ion exchange resin (IR-120, H^+ form) and stirred at 50 °C for 10 h. The reaction mixture was filtered and extracted with pyridine. Crystallisation from *n*-hexane furnished compound **44a** (4.0 g, 61%) as colourless crystals. TLC ($CHCl_3$/methanol, 14:1): R_f = 0.28. $[\alpha]_D$ = +0.2 (*c* = 1.0, $CHCl_3$); m.p. 62 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 0.86 (t, 3 H, 18-H), 1.22–1.41 (m, 22 H, 11 CH_2), 1.99–2.07 (m, 2 H, 6_a-, 6_b-H), 2.46–2.50 (m, 3 H, OH), 3.52–3.75

(m, 3 H, 1_a-, 1_b-, 2-H), 4.08 (dd, $^3J_{2,3}$ = 5.2, $^3J_{3,4}$ = 7.3 Hz, 1 H, 3-H), 5.46 (ddt, $^3J_{4,5}$ = 15.4, $^4J_{4,6a}$ = 1.3, $^4J_{4,6b}$ = 1.3 Hz, 1 H, 4-H), 5.76 (ddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 63.85 (C-1), 73.92 (C-3), 74.24 (C-2), 128.37 (C-4), 135.57 (C-5) ppm. $C_{18}H_{36}O_3$ (300.5): calcd. C 70.95, H 12.08; found C 71.27, H 11.55.

(2*R*,3*R*,4*E*)-Oct-4-ene-1,2,3-triol (44b): To a solution of **30b**[36,37] (14.16 g, 57 mmol) and methanol (250 mL) was added ion exchange resin (IR-120, H^+ form) and stirred at 50–60 °C for 24 h. The ion exchange resin was filtered off and washed with methanol. The reaction mixture was evaporated in vacuo and purified by flash chromatography (petroleum ether/EtOAc/methanol, 5:4:1) furnishing compound **44b** (5.92 g, 65%) as a colourless oil. TLC (petroleum ether/EtOAc/methanol, 5:4:1): R_f = 0.25. $[\alpha]_D$ = +2.2 (c = 0.5, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.87–0.93 (t, $^3J_{7,8}$ = 7.4 Hz, 3 H, 8-H), 1.33–1.47 (se, $^3J_{6,7} \approx {}^3J_{7,8}$ = 7.4 Hz, 2 H, 7-H), 1.98–2.07 (tdd, $^4J_{4,6}$ = 1.2, $^3J_{5,6}$ = 6.7, $^3J_{6,7}$ = 7.4 Hz, 2 H, 6-H), 3.52–3.71 (bm, 3 H, 1_a-, 1_b-, 2-H), 4.01–4.07 (bm, $^3J_{3,4}$ = 7.3, $^4J_{3,5}$ < 1.0 Hz, 1 H, 3-H), 5.41–5.51 (ddt, $^3J_{3,4}$ = 7.3, $^3J_{4,5}$ = 15.4, $^4J_{4,6}$ = 1.2 Hz, 1 H, 4-H), 5.70–5.81 (ddt, $^4J_{3,5}$ < 1.0, $^3J_{4,5}$ = 15.4, $^3J_{5,6}$ = 6.7 Hz, 1 H, 5-H) ppm. $C_8H_{16}O_3$ (160.2): calcd. C 59.98, H 10.07; found C 59.76, H 10.04.

(2*R*,3*R*,4*E*)-1-*O*-(*p*-Tolylsulfonyl)octadec-4-ene-1,2,3-triol (45a): A solution of **44a** (8.32 g, 27.7 mmol) and dry pyridine (100 mL) was cooled to –10 °C and tosyl chloride (6.07 g, 31.8 mmol) in dry pyridine (40 mL) added dropwise within 15 min. The reaction mixture was stirred for 24 h, quenched with methanol, concentrated and worked up with diethyl ether/half-saturated brine. The organic phase was dried and the solvents were evaporated in vacuo. Purification by flash chromatography ($CHCl_3$/MeOH, 20:1) gave **45a** (9.03 g, 75%) as a colourless solid. TLC ($CHCl_3$/MeOH, 8:1): R_f = 0.75. $[\alpha]_D$ = +8.3 (c = 1.0, $CHCl_3$); m.p. 54 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85 (t, 3 H, CH_3), 1.25–1.38 (m, 22 H, 11 CH_2), 1.97–2.05 (m, 2 H, 6_a-, 6_b-H), 2.46 (s, 3 H, CH_3C$_6$H$_4$), 3.72 (ddd, $^3J_{1a,2}$ = 6.1, $^3J_{1b,2}$ = 4.0, $^3J_{2,3}$ = 5.9 Hz, 1 H, 2-H), 4.01 (dd, $^2J_{1a,1b}$ = 10.4 Hz, 1 H, 1_a-H), 4.14 (dd, 1 H, 1_b-H), 5.42 (dd, $^3J_{4,5}$ = 15.4, $^4J_{4,6a}$ < 1.0, $^4J_{4,6b}$ < 1.0 Hz, 1 H, 4-H), 5.74 (ddd, $^3J_{5,6a}$ = 6.6, $^3J_{5,6b}$ = 6.6 Hz, 1 H, 5-H), 7.34–7.82 (m, 4 H, CH_3C$_6$H$_4$). $C_{25}H_{42}O_5S$ (454.7): calcd. C 66.04, H 9.31; found C 65.83, H 9.19.

(2*R*,3*R*,4*E*)-1-*O*-(*p*-Tolylsulfonyl)oct-4-ene-1,2,3-triol (45b): A solution of **44b** (5.8 g, 36 mmol) in dry pyridine (100 mL) was cooled to –12 °C. *p*-Toluenesulfonyl chloride in 40 mL dry pyridine was slowly added dropwise and stirred at –12 °C for 3 h. Stirring was continued at room temp. overnight, and then the reaction mixture was diluted with water and extracted with diethyl ether. The organic phase was dried with sodium sulphate and the solvents were evaporated in vacuo. Purification of the residue by flash chromatography (petroleum ether/EtOAc, 3:2) furnished compound **45b** (7.62 g, 67%) as colourless oil. TLC (toluene/acetone, 4:1): R_f = 0.27. $[\alpha]_D$ = +12.9 (c = 1.0, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85–0.91 (t, $^3J_{7,8}$ = 7.4 Hz, 3 H, 8-H), 1.29–1.42 (se, $^3J_{6,7} \approx {}^3J_{7,8}$ = 7.4 Hz, 2 H, 7-H), 1.96–2.04 07 (tdd, $^4J_{4,6}$ = 1.4, $^3J_{6,7}$ = 7.3, $^3J_{5,6}$ = 6.7 Hz, 2 H, 6-H), 2.45 (s, 1 H, C_6H_4–CH_3), 3.69–3.75 (m, 1 H, 2-H), 3.98–4.16 (m, $^3J_{2,3}$ = n.z., $^3J_{3,4}$ = 7.2, $^4J_{3,5}$ < 1.0 Hz, 3 H, 1_a-, 1_b-H, 3-H), 5.37–5.48 (ddt, $^3J_{3,4}$ = 7.2, $^3J_{4,5}$ = 15.5, $^4J_{4,6}$ = 1.4 Hz, 1 H, 4-H), 5.68–5.80 (dtd, $^4J_{3,5}$ < 1.0, $^3J_{4,5}$ = 15.5, $^3J_{5,6}$ = 6.7 Hz, 1 H, 5-H), 7.34–7.82 (m, 4 H, C_6H_4–CH_3) ppm. $C_{15}H_{22}O_5S$ (314.4): calcd. C 57.30, H 7.05; found C 57.35, H 7.11.

(2*R*,3*R*,4*E*)-1,2-Anhydrooctadec-4-ene-1,2,3-triol (46a): A solution of **45a** (1.02 g, 2.24 mmol) in dry tetrahydrofuran (20 mL) and dry dimethyl sulfoxide (1.0 mL) was cooled, and a suspension of sodium hydride (50–60%, 110 mg, 2.48 mmol) added. After removing the cooling, the reaction mixture was stirred for 2 h, filtered and worked up with diethyl ether/half-saturated brine. The organic phase was dried and the solvents were evaporated in vacuo. Purification by flash chromatography (petroleum ether/EtOAc, 3:1) furnished compound **46a** (460 mg, 73%) as a colourless solid. TLC (toluene/acetone, 4:1): R_f = 0.59. $[\alpha]_D$ = +0.8 (c = 1.0, $CHCl_3$); m.p. 39 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.88 (t, 3 H, 18-H), 1.20–1.41 (m, 22 H, 11 CH_2), 1.92 (bd, 1 H, OH), 2.02–2.10 (m, 2 H, 6_a-, 6_b-H), 2.73 (dd, $^2J_{1a,2b}$ = 4.9, $^3J_{1a,2}$ = 2.7 Hz, 1 H, 1_a-H), 2.82 (dd, $^3J_{1b,2}$ = 4.2 Hz, 1 H, 1_b-H), 3.05 (ddd, $^3J_{2,3}$ = 4.9 Hz, 1 H, 2-H), 3.90–3.98 (m, 1 H, 3-H), 5.55 (dddd, $^3J_{4,5}$ = 15.5, $^4J_{4,6a}$ = 1.3, $^4J_{4,6b}$ = 1.3 Hz, 1 H, 4-H), 5.81 (dddd, $^3J_{5,6a}$ = 6.7, $^3J_{5,6b}$ = 6.7 Hz, 1 H, 5-H) ppm. $C_{18}H_{34}O_2$ (282.4): calcd. C 76.54, H 12.13; found C 76.48, H 12.07.

(2*R*,3*R*,4*E*)-1,2-Anhydrooct-4-ene-1,2,3-triol (46b): A solution of **45b** (7.5 g, 23.8 mmol) in dry DMF was cooled to –20 °C, then sodium hydride (687 mg, 28.6 mmol) added and slowly heated to room temp. After 7 h the reaction was stopped by the addition of water. The reaction mixture was extracted three times with diethyl ether. The organic phase was dried with sodium sulfate and the solvents were evaporated in vacuo. Purification by flash chromatography (petroleum ether/EtOAc, 8:2.5) furnished compound **46b** (2.17 g, 15.2 mmol) as a yellow liquid. TLC (toluene/acetone, 4:1): R_f = 0.52. $[\alpha]_D$ = +2.6 (c = 1.0, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.88–0.94 (t, $^3J_{7,8}$ = 7.3 Hz, 3 H, 8-H), 1.35–1.68 (se, $^3J_{6,7} \approx {}^3J_{7,8}$ = 7.4 Hz, 2 H, 7-H), 2.00–2.10 (m, $^4J_{4,6}$ = 1.2, $^3J_{5,6}$ = 6.7, $^3J_{6,7}$ = 7.5 Hz, 2 H, 6-H), 2.72–2.75 (dd, $^2J_{1a,1b}$ = 4.9, $^3J_{1a,2}$ = 2.8 Hz, 1 H, 1_a-H), 2.80–2.84 (t, $^2J_{1a,1b} \approx {}^3J_{1a,2}$ = 4.9 Hz, 1 H, 1_b-H), 3.03–3.07 (ddd, $^3J_{1a,2}$ = 2.8, $^3J_{1b,2}$ = 4.9, $^3J_{2,3}$ = 5.4 Hz, 1 H, 2-H), 3.90–3.98 (ddd, $^3J_{2,3}$ = 5.4, $^3J_{3,4}$ = 6.4, $^3J_{3,5}$ = 1.1 Hz, 1 H, 3-H), 5.51–5.61 (ddt, $^3J_{3,4}$ = 6.4, $^3J_{4,5}$ = 15.5, $^4J_{4,6}$ = 1.2 Hz, 1 H, 4-H), 5.75–5.87 (ddt, $^4J_{3,5}$ = 1.1, $^3J_{4,5}$ = 15.5, $^3J_{5,6}$ = 6.7 Hz, 1 H, 5-H).

(2*R*,3*R*,4*E*)-1,2-Anhydro-3-*O*-(benzyloxymethyl)octadec-4-ene-1,2,3-triol (47a): Compound **47a** was prepared as reported for **47b**. Flash chromatography (petroleum ether/EtOAc, 16:1). TLC (petroleum ether/EtOAc, 9:1): R_f = 0.54. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.84–0.93 (t, $^3J_{17,18}$ = 7.4 Hz, 3 H, 18-H), 1.22–1.34 (s, $^3J_{17,18}$ = 7.4 Hz, 22 H, 7-, 8-, 9-, 10-, 11-, 12-, 13-, 14-, 15-, 16-, 17-H), 2.00–2.10 (q, $^3J_{5,6} \approx {}^3J_{6,7}$ = 7.4 Hz, 2 H, 6-H), 2.59–2.63 (dd, $^2J_{1a,1b}$ = 4.9, $^3J_{1a,2}$ = 2.8 Hz, 1 H, 1_a-H), 2.76–2.81 (t, $^2J_{1a,1b} \approx {}^3J_{1b,2}$ = 4.9 Hz, 1 H, 1_b-H), 3.05–3.11 (ddd, $^3J_{1a,2}$ = 2.8, $^3J_{1b,2}$ = 4.9, $^3J_{2,3}$ = 5.9 Hz, 1 H, 2-H), 3.85–3.92 (ddd, $^3J_{2,3}$ = 5.9, $^3J_{3,4}$ = 6.0, $^3J_{3,5}$ < 1.0 Hz, 1 H, 3-H), 4.51–4.90 (m, 4 H, O–CH_2–O–CH_2–C$_6$H$_5$), 5.33–5.45 (ddt, $^3J_{3,4}$ = 6.0, $^3J_{4,5}$ = 14.2, $^4J_{4,6}$ = 1.1 Hz, 1 H, 4-H), 5.70–5.82 (ddt, $^4J_{3,5}$ < 1.0, $^3J_{4,5}$ = 14.2, $^3J_{5,6}$ = 7.4 Hz, 1 H, 5-H), 7.30–7.40 (m, 5 H, O–CH_2–O–CH_2–C_6H_5) ppm.

(2*R*,3*R*,4*E*)-1,2-Anhydro-3-*O*-(benzyloxymethyl)oct-4-ene-1,2,3-triol (47b): Compound **46b** (124 mg, 870 μmol) was dissolved in dry dichloromethane (10 mL) under argon and Hünig's base (*N*,*N*-diisopropylethylamine 500 μL, 376 mg, 2.9 mmol) added. To the reaction mixture was added benzyloxymethyl chloride (550 μL, 620 mg corresponding to 2.4 mmol pure BOM–Cl), stirred at room temp. for 48 h, quenched with methanol, poured on water and extracted twice with diethyl ether. The organic phase was dried with sodium sulphate. Purification by flash chromatography (petroleum ether/EtOAc, 16:1) furnished compound **47b** (217 mg, 827 μmol, 95%). TLC (petroleum ether/EtOAc, 9:1): R_f = 0.53. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85–0.96 (t, $^3J_{7,8}$ = 7.4 Hz, 3 H, 8-H), 1.33–1.49 (se, $^3J_{6,7} \approx {}^3J_{7,8}$ = 7.4 Hz, 2 H, 7-H), 1.98–2.12 (dq, $^4J_{4,6}$ = 1.2, $^3J_{5,6} \approx {}^3J_{6,7}$ = 7.4 Hz, 2 H, 6-H), 2.59–2.63 (dd, $^2J_{1a,1b}$ =

4.9, $^3J_{1a,2}$ = 2.8 Hz, 1 H, 1_a-H), 2.77–2.81 (t, $^2J_{1a,1b} \approx {}^3J_{1b,2}$ = 4.9 Hz, 1 H, 1_b-H), 3.07–3.12 (ddd, $^3J_{1a,2}$ = 2.8, $^3J_{1b,2}$ = 4.9, $^3J_{2,3}$ = 5.9 Hz, 1 H, 2-H), 3.85–3.94 (ddd, $^3J_{2,3}$ = 5.9, $^3J_{3,4}$ = 6.0, $^3J_{3,5}$ = 1.0 Hz, 1 H, 3-H), 4.52–4.93 (m, 4 H, O–CH_2–O–CH_2–C_6H_5), 5.35–5.49 (ddt, $^3J_{3,4}$ = 6.0, $^3J_{4,5}$ = 14.2, $^4J_{4,6}$ = 1.2 Hz, 1 H, 4-H), 5.68–5.82 (ddt, $^4J_{3,5}$ = 1.0, $^3J_{4,5}$ = 14.2, $^3J_{5,6}$ = 7.4 Hz, 1 H, 5-H), 7.30–7.39 (m, 4 H, O–CH_2–O–CH_2–C_6H_5) ppm. $C_{16}H_{22}O_3$ (262.4): calcd. C 73.25, H 8.45; found C 72.78, H 8.30.

Dibenzyl (3*R*,4*R*,5*E*)-(4-*O*-Benzyloxymethyl-3,4-dihydroxynonadec-5-en-1-yl)phosphonate (48a): Compound **48a** was prepared as reported for **48b**. TLC (toluene/acetone, 2:1): R_f = 0.68. $[\alpha]_D$ = –41.9 (c = 1.0, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85–0.91 (t, $^3J_{18,19}$ = 7.2 Hz, 3 H, 19-H), 1.24–1.36 (s, $^3J_{18,19}$ = 7.2 Hz, 22 H, 8-, 9-, 10-, 11-, 12-, 13-, 14-, 15-, 16-, 17-, 18-H), 1.57–2.10 (m, 6 H, 1-, 2-, 7-H), 3.46–3.55 (m, $^3J_{2,3}$ = n.z., $^3J_{3,4}$ = 8.5 Hz, 1 H, 3-H), 3.80–3.86 (ddd, $^3J_{3,4}$ = 8.5, $^3J_{4,5}$ = 6.9, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.47–4.83 (m, $^2J_{1'a,1'b}$ = 6.8, $^2J_{2'a,2'b}$ = 11.7 Hz, 4 H, O–C(1′)H_2–O–C(2′)H_2–C_6H_5), 4.92–5.10 (m, 4 H, 2 O–CH_2–C_6H_5), 5.15–5.28 (ddt, $^3J_{4,5}$ = 6.9, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ = 1.1 Hz, 1 H, 5-H), 5.65–5.78 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.7 Hz, 1 H, 6-H), 7.28–7.36 (m, 15 H, O–CH_2–O–CH_2–C_6H_5, 2 O–CH_2–C_6H_5) ppm. MALDI-MS (positive mode, Matrix DHB, THF): m/z = 702 [M + Na]$^+$, 717 [M +K]$^+$.

Dibenzyl (3*R*,4*R*,5*E*)-(4-*O*-Benzyloxymethyl-3,4-dihydroxynon-5-en-1-yl)phosphonate (48b): A solution of dibenzyl methylphosphonate (4.3 g, 15.6 mmol) in dry tetrahydrofuran (55 mL) was cooled to –80 °C, then butyllithium (1.6 M in hexane, 10 mL, 16 mmol) added and stirred for 2 h. Borontrifluoride diethyl etherate (1 mL, 1.13 g, 8 mmol) in dry tetrahydrofuran (8 mL) was added quickly and the reaction mixture stirred for 30 min. Then a solution of **47 b** (1.15 g, 4.38 mmol) in dry tetrahydrofuran (10 mL) was slowly added dropwise, stirred for 2 h and then added again undiluted borontrifluoride diethyl etherate (0.6 mL, 4.8 mmol). After 2 h triethylamine (6 mL) and then hydrogencarbonate solution (16 mL) were added. The mixture was defrosted, diluted with water and extracted three times with diethyl ether. The organic phase was dried with sodium sulphate, the solvents were evaporated under reduced pressure. Purification of the crude material by flash chromatography (toluene/acetone, 4:1) furnished **48b** (2.14 g, 3.98 mmol, 90% assigned by NMR), which was contaminated with traces of dibenzyl methylphosphonate. MPLC (toluene/acetone, 4:1) furnished pure **48b**. TLC (toluene/acetone, 2:1): R_f = 0.66. $[\alpha]_D$ = –49.9 (c = 1.0, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.84–0.90 (t, $^3J_{8,9}$ = 7.3 Hz, 3 H, 9-H), 1.32–1.41 (m, $^3J_{7,8} \approx {}^3J_{8,9}$ = 7.3 Hz, 2 H, 8-H), 1.64–2.06 (m, $^4J_{5,7}$ = 1.42, $^3J_{6,7}$ = 6.7, $^3J_{7,8}$ = 7.3 Hz, 6 H, 1-, 2-, 7-H), 3.48–3.50 (bm, $^3J_{3,4}$ = 8.5 Hz, 1 H, 3-H), 3.80–3.86 (ddd, $^3J_{3,4}$ = 8.5, $^3J_{4,5}$ = 6.9, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.47–4.82 (m, $^2J_{1'a,1'b}$ = 6.8, $^2J_{2'a,2'b}$ = 11.7 Hz, 4 H, O–C(1′)H_2–O–C(2′)H_2–C_6H_5), 4.91–5.09 (m, 4 H, 2 O–CH_2–C_6H_5), 5.18–5.28 28 (ddt, $^3J_{4,5}$ = 6.9, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ = 1.4 Hz, 1 H, 5-H), 5.64–5.76 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.7 Hz, 1 H, 6-H), 7.28–7.36 (m, 15 H, O–CH_2–O–CH_2–C_6H_5, 2 O–CH_2–C_6H_5) ppm. MALDI-MS (positive mode, Matrix DHB, THF): m/z = 561 [M + Na]$^+$, 577 [M + K]$^+$. $C_{31}H_{39}O_6P$ (538.6): calcd. C 69.13, H 7.29; found C 68.38, H 7.40.

Dibenzyl (3*S*,4*R*,5*E*)-(3-Azido-4-*O*-benzyloxymethyl-4-hydroxynonadec-5-en-1-yl)phosphonate (49a): Compound **49a** was prepared as reported for **49b**. TLC (petroleum ether/EtOAc, 3:2): R_f = 0.46. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85–0.92 (t, $^3J_{18,19}$ = 7.3 Hz, 3 H, 19-H), 1.34–1.40 (s, $^3J_{18,19}$ = 7.3 Hz, 22 H, 8-, 9-, 10-, 11-, 12-, 13-, 14-, 15-, 16-, 17-, 18-H), 1.50–2.09 (m, 6 H, 1-, 2-, 7-H), 3.39–3.47 (m, $^3J_{2,3}$ = n.z., $^3J_{3,4}$ = 8.5 Hz, 1 H, 3-H), 3.98–4.06 (ddd, $^3J_{3,4}$ = 8.5, $^3J_{4,5}$ = 6.9, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.48–4.79 (m, $^2J_{1'a,1'b}$ = 6.8, $^2J_{2'a,2'b}$ = 11.7 Hz, 4 H, O–C(1′)H_2–O–C(2′)H_2–C_6H_5), 4.90–5.12 (m, 4 H, 2 O–CH_2–C_6H_5), 5.23–5.47 (ddt, $^3J_{4,5}$ = 6.9, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ < 1.0 Hz, 1 H, 5-H), 5.63–5.78 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.7 Hz, 1 H, 6-H), 7.30–7.36 (m, 15 H, O–CH_2–O–CH_2–C_6H_5, 2 O–CH_2–C_6H_5) ppm. MALDI-MS (positive mode, Matrix DHB, THF): m/z = 727 [M + Na]$^+$, 744 [M + K]$^+$.

Dibenzyl (3*S*,4*R*,5*E*)-(3-Azido-4-*O*-benzyloxymethyl-4-hydroxynon-5-en-1-yl)phosphonate (49b): A solution of $Zn(N_3)_2$·Pyr_2 (1.05 g, 3.4 mmol) and triphenylphosphane (1.77 g, 6.8 mmol) was suspended under argon in dry toluene (20 mL), then crude **48b** (362 mg, 0.67 mmol) in dry toluene (10 mL) was added quickly. The reaction was started by adding diisopropyl azodicarboxylate (1.3 mL, 1.36 g, 6.73 mmol), then stirred at 50 °C for 5 h and then left to cool. Excess of starting material and byproducts were precipitated by adding dry hexane (20 mL). The reaction mixture was filtered, the remaining solid washed with little hexane and then the solvent evaporated in vacuo. Purification by flash chromatography (toluene/acetone, 14:1) furnished **49b** (313 mg, 0.56 mmol, 83%). TLC (toluene/acetone, 9:1): R_f = 0.59. $[\alpha]_D$ = –36.9 (c = 1.0, $CHCl_3$), IR: azide specific absorption at $\tilde{\nu}$ = 2103 cm^{-1}. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.84–0.90 (t, $^3J_{8,9}$ = 7.3 Hz, 3 H, 9-H), 1.32–1.41 (m, $^3J_{7,8}$, $^3J_{8,9}$ = 7.3 Hz, 2 H, 8-H), 1.64–2.06 (m, $^3J_{7,8}$ = 7.3 Hz, 6 H, 1-, 2-, 7-H), 3.38–3.40 (m, $^3J_{3,4}$ = 8.5 Hz, 1 H, 3-H), 3.80–3.86 (ddd, $^3J_{3,4}$ = 8.5, $^3J_{4,5}$ = 6.9, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.47–4.82 (m, $^2J_{1'a,1'b}$ = 6.8, $^2J_{2'a,2'b}$ = 11.7 Hz, 4 H, O–C(1′)H_2–O–C(2′)H_2–C_6H_5), 4.91–5.09 (m, 4 H, 2 O–CH_2–C_6H_5), 5.18–5.28 (ddt, $^3J_{4,5}$ = 6.9, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ = 1.4 Hz, 1 H, 5-H), 5.64–5.76 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.7 Hz, 1 H, 6-H), 7.28–7.36 (m, 15 H, O–CH_2–O–CH_2–C_6H_5, 2 O–CH_2–C_6H_5) ppm. MALDI-MS (positive mode, Matrix DHB, THF): m/z = 586 [M + Na]$^+$, 602 [M + K]$^+$. $C_{31}H_{38}O_5P$ (563.6): calcd. C 66.06, H 6.80, N 7.46; found C 66.67, H 6.97, N 7.43.

(3*S*,4*R*,5*E*)-(3-Amino-4-hydroxynon-5-en-1-yl)phosphonic Acid (50): Gaseous ammonia was condensed in a flask cooled to –60 °C (5–10 mL). Sodium (20 equiv.) was added and stirred for 3 min. Compound **49b** (225 mg, 0.4 mmol) in dry tetrahydrofuran (1 mL) was slowly added dropwise and the reaction mixture was stirred for 5 min, then defrosted, diluted with little water, and the ammonia evaporated. The solution was then lyophilized and purified by RP-flash chromatography (water/methanol, 3:1), which furnished compound **50** as a white solid (93 mg) in almost quantitative yield. RP-TLC (water/methanol, 3:1): R_f = 0.42. $[\alpha]_D$ = –8.2 (c = 0.5, $CHCl_3$). ^{1}H NMR (250 MHz, D_2O): δ = 0.75–0.78 (t, $^3J_{8,9}$ = 7.3 Hz, 3 H, 9-H), 1.26–1.31 (m, $^3J_{7,8}$ „ $^3J_{8,9}$ = 7.3 Hz, 2 H, 8-H), 1.50–1.84 (m, 4 H, 1-,2-H), 1.94–1.98 (m, $^4J_{5,7}$ < 1.0, $^4J_{6,7}$ = 6.8, $^3J_{7,8}$ = 7.3 Hz, 2 H, 7-H), 3.20–3.22 (m, 1 H, 3-H), 4.21–4.23 (m, $^3J_{4,5}$ = 7.1, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 5.36–5.39 (ddt, $^3J_{4,5}$ = 7.1, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ < 1.0 Hz, 1 H, 5-H), 5.79–5.84 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.8 Hz, 1 H, 6-H) ppm. ^{13}C NMR (151 MHz, D_2O): δ = 12.90 (C-9), 21.41 (C-8), 22.77 (C-2), 24.23–25.10 ($^2J_{P,1-C}$ = 132.4 Hz, C-1), 33.71 (C-7), 56.47-56.55 ($^3J_{P,3-C}$ = 13.0 Hz, C-3), 71.32 (C-4), 124.70 (C-5), 137.50 (C-6) ppm. ^{31}P NMR (243 MHz, D_2O): δ = 26.20 ppm. FAB-MS (negative mode, glycerol/DMSO/1% trifluoroacetic acid, 2:2:1): m/z = 113 [CF_3COOH – H$^+$]$^-$, 236 [M – H$^+$]$^-$, 350 [M + CF_3COOH – H$^+$]$^-$, 372 [M – CF_3COONa – H$^+$]$^-$, 473 [2M – H$^+$]$^-$.

Dibenzyl (3*S*,4*R*,5*E*)-(3-Azido-4-hydroxynon-5-en-1-yl)phosphonate (51): To a solution of **49b** (30 mg, 53 µmol) and *tert*-butyl alcohol (5 mL) was added pyridinium *p*-toluenesulfonate (170 mg, 0.68 mmol) and refluxed for 6 h. After cooling, the reaction mixture was diluted with water (5 mL) and extracted twice with diethyl ether. The organic phase was dried with sodium sulphate. Purifica-

tion by flash chromatography (toluene/acetone, 4:1) furnished compound **51** (11 mg, 24.8 μmol, 47%) as a colourless oil. TLC (toluene/acetone, 3:2): R_f = 0.69. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.86–0.93 (t, $^3J_{8,9}$ = 7.4 Hz, 3 H, 9-H), 1.32–1.47 (se, $^3J_{7,8}$, $^3J_{8,9}$ = 7.4 Hz, 2 H, 8-H), 1.58–2.06 (m, $^3J_{6,7}$ = 6.7, $^3J_{7,8}$ = 7.4 Hz, 6 H, 1-, 2-, 7-H), 3.44–3.50 (m, 1 H, 3-H), 4.03–4.07 (m, $^3J_{3,4}$ = n.z., $^3J_{4,5}$ = 7.4, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.91–5.10 (m, 4 H, 2 O–CH_2–C_6H_5), 5.42–5.51 (ddt, $^3J_{4,5}$ = 7.4, $^3J_{5,6}$ = 15.4, $^4J_{5,7}$ < 1.0 Hz, 1 H, 5-H), 5.68–5.79 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.4, $^3J_{6,7}$ = 6.7 Hz, 1 H, 6-H), 7.29–7.35 (m, 10 H, 2 O–CH_2–C_6H_5) ppm.

Dibenzyl (3*S*,4*R*,5*E*)-(3-Amino-4-*O*-benzyloxymethyl-4-hydroxynon-5-en-1-yl)phosphonate (52): A solution of **49b** (33 mg, 59 μmol) in tetrahydrofuran (8 mL) was diluted with water (1 mL), triphenylphosphane (54 mg, 0.2 mmol) was added and then stirred at 50 °C for 16 h and left to cool. After evaporation in vacuo the residue was extracted three times with $CHCl_3$. The solution was then evaporated under reduced pressure and purified by flash chromatography ($CHCl_3$/methanol, 19:1). Compound **52** (23 mg, 43 μmol, 73%) was furnished as a yellow oil. TLC (toluene/acetone, 9:1): R_f = 0.59. $[a]_D$ = –73.4 (c = 0.44, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 0.85–0.90 (t, $^3J_{8,9}$ = 7.4 Hz, 3 H, 9-H), 1.31–2.09 (m, $^3J_{7,8} \approx {}^3J_{8,9}$ = 7.4 Hz, 8 H, 1-, 2-, 7-, 8-H), 2.72–2.79 (br. m, $^3J_{3,4}$ = 5.1 Hz, 1 H, 3-H), 3.81–3.87 (m, $^3J_{3,4}$ = 5.1, $^3J_{4,5}$ = 8.3, $^4J_{4,6}$ < 1.0 Hz, 1 H, 4-H), 4.46–4.78 (m, $^2J_{1'a,1'b}$ = 6.8, $^2J_{2'a,2'b}$ = 11.9 Hz, 4 H, O–C(1′)H_2–O–C(2′)H_2–C_6H_5), 4.91–5.09 (m, 4 H, 2 O–CH_2–C_6H_5), 5.22–5.31 (br. m, $^3J_{4,5}$ = 8.3, $^3J_{5,6}$ = 15.5, $^4J_{5,7}$ < 1.0 Hz, 1 H, 5-H), 5.63–5.74 (ddt, $^4J_{4,6}$ < 1.0, $^3J_{5,6}$ = 15.5, $^3J_{6,7}$ = 6.6 Hz, 1 H, 6-H), 7.28–7.35 (m, 15 H, O–CH_2–O–CH_2–C_6H_5, 2 O–CH_2–C_6H_5) ppm. MALDI-MS (positive mode, Matrix DHB, THF): m/z = 538 $[M + H]^+$.

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