Facile Preparation and Utilization of a Novel β-D-ManNAcA-Donor: Methyl 2-Benzoyloxyimino-1-bromo-2-deoxy-α-D-*arabino*-hexopyranuronate

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The title β-D-ManNAcA-donor, the α-bromide of methyl 2-benzoyloxyimino-2-deoxy-D-*arabino*-hexopyranuronate **9**, has been prepared from D-glucuronolactone in an overall yield of 21% for the seven steps required, all intermediates being securable in crystalline form. Key compounds were the 2-acetoxy-D-glucuronal ester **6** and its hydroxylaminolysis product, the 1,5-anhydro-D-fructuronate oxime **7**, the latter elaborating **9** on *O*-benzoylation (→**8**) and photobromination. —The utility of **9** as a suitable β-D-ManNAcA donor rests on two ensuing reactions: first, Koenigs-Knorr type glycosidations, with *N*-blocked 2-aminoethanols as spacer substrates, or with the 6-OH of an otherwise protected glucoside (**16**), produce β-selectivities of 20 : 1 or better, and second, the oxime reduction of the β-glycosides, thus obtained, proceeds in an essentially stereospecific manner to yield, upon *N*-acetylation, the 2-acetamido-2-deoxy-β-D-mannosiduronates. —The methodology elaborated was used to prepare some novel artificial glycolipids, e.g. the (myristoylamino)ethyl 6-*O*-(2-acetamido-2-deoxy-β-D-mannopyranosyluronic acid)-α-D-glucopyranoside (**25**) and its (stearoylamino)ethyl analog (**26**), that are being evaluated as recognition markers for liposomes.

2-Acetamido-2-deoxy-β-D-mannuronic acid (β-D-ManNAcA) is an important structural unit of various bacterial capsular polysaccharides[1] and lipopolysaccharides.[2] It is also found in the teichuronic acid,[3] a cell wall component from *Micrococcus luteus*, which is an acidic polysaccharide composed of a disaccharide repeating unit, β-D-Man*p*NAcA-(1→6)-α-D-Glc*p*, bound to a peptidoglycan (murein) through a phosphoric ester linkage (Chart 1):

Since a variety of mono- and oligosaccharides have been found to be highly useful recognition markers for targeting drug delivery systems (DDS),[4] and since teichuronic acid is an antigenic determinant active, conceivably, against immunological systems of living organisms, we became interested in the synthesis of artificial glycolipids in which β-D-ManNAcA or the above disaccharide unit are linked to fatty acids through a 2-aminoethanol spacer. In these glycolipids the carbohydrate portion may act as a recognition marker for targeting some of the cells or organs by incorporation of the lipid portion into any liposome.

At present, the methodology available for the construction of β-D-ManNAcA-containing oligosaccharides is far from being adequate in preparative terms. The disaccharide β-D-ManNAcA-(1→6)-α-D-Glc has been synthesized by elaboration of the mannuronic acid portion from the 2-azido-sugar **2**,[5] the acquisition of which requires six steps from D-glucose,[6] and, deplorably, shows no stereoselectivity in glycosidations (α : β-ratio: 1 : 1.1).[5] The more laboriously accessible donor **3** (11 steps from D-glucose)[6] allows stereospecific β-glycosidation with benzyl 2,3,4-tri-*O*-benzyl-β-D-glucoside, yet the resulting disaccharide **4** was found unsuited for conversion into the uronic acid.[5]

In consequence, other, more practical glycosyl donors are obviously needed for the straightforward construction of β-D-ManNAcA-containing oligosaccharides. In this paper we wish to disclose the simple preparation of the α-bromide of methyl 2-benzoyloxyimino-D-*arabino*-hexopyranuronate **9**,[7] and provide ample evidence for its utility as a most versatile "indirect" β-D-ManNAcA-donor substrate.

Results and Discussion

Preparation of 2-(Benzoyloxyimino)glycuronate 9. On the basis of the method we have developed for the synthesis of β-D-mannosamine-containing oligosaccharides,[8] **9** should be accessible on a preparative scale by a 4-step conversion from methyl 1-bromo-α-D-glucopyranuronate **5**[9] as formulated in Scheme 1. In fact, the uronate **5**, prepared in two steps from D-glucuronolactone in 75% yield, was reacted with diethylamine-tetrabutylammonium bromide (1.5 : 1.0 equiv) in DMF to give **6** in 54% yield. This compound is tentatively designated to 2-hydroxy-D-glucuronal ester. Other conditions, e.g. diethylamine–sodium iodide or 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) in various solvents, resulted in less effective dehydrobrominations. Exposure of the glucuronal **6** to excess hydroxylamine hydrochloride in pyridine afforded the oxime **7** in 56% yield. Subsequent benzoylation of **7** with benzoyl chloride–pyridine gave the *O*-benzoyl oxime **8** (98%), which accumulated in an *E* : *Z* ratio of 40 : 1 as shown by ^{1}H NMR: The H_R-1 of the *E* isomer is deshielded by the oxime-benzoyl group to 4.93 ppm (versus 4.53 ppm for *Z*-isomer); H-3, in turn, shows substantial deshielding in the *Z*-isomer (→6.35 ppm) versus a normal chemical shift (5.70 ppm) in the *E*-isomer. Additional evidence was secured by NOE experiments: A sizable effect was observed between H-3 and oxime-benzoyl group in the

α-D-Glc*p*-(1→4)-[β-D-Man*p*NAcA-(1→6)-α-D-Glc*p*]$_{\sim 40}$-O-P(=O)(OH)-O-Murein

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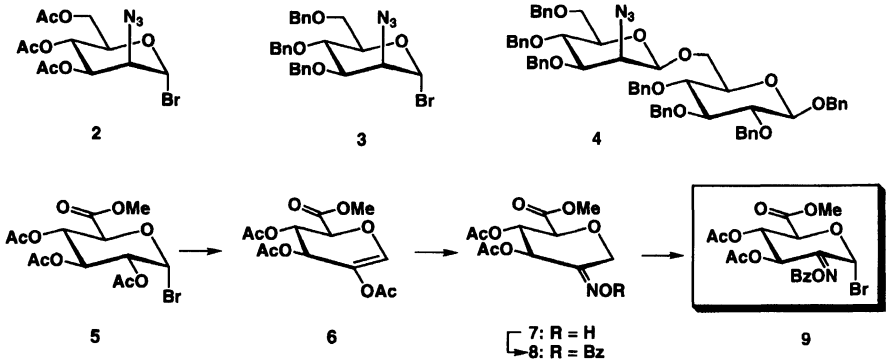
Chart 1.



2 **3** **4** **5** **6** **9**

Scheme 1.

Z-isomer.

Photobromination[10] of **8** was done smoothly by refluxing it with *N*-bromosuccinimide (NBS) in tetrachloromethane for 0.5 h under irradiation with a 250 W tungsten lamp, and gave the desired 2-(benzoyloxyimino)glycuronate **9**, isolable in 95% yield, as a stable, crystalline substance, storable in a refrigerator for months without decomposition.

Synthesis of 2-(Palmitoylamino)ethyl 2-Acetamido-2-deoxy-β-D-mannopyranosiduronic Acid (15). The utility of **9** as an effective, "indirect" β-D-ManNAcA-donor was demonstrated by the straightforward assembly of **15** through β-selective glycosidation with a spacer-linked palmitic acid, i.e. 2-(palmitoylamino)ethanol,[11] followed by stereoselective reduction of 2-benzoyloxyimino group and unmasking the protective groups (**9**→**10**→**14**→**15** in Scheme 2). Alternatively, a more circuitous route, introducing various fatty acids *a posteriori*, was examined by a set of reactions comprising β-glycosidation with 2-(benzyloxycarbonylamino)ethanol,[12] hydroboration, coupling with palmitic acid, and deblocking (i.e. **9**→**11**→**12**→**13**→**14**→**15** in Scheme 2).

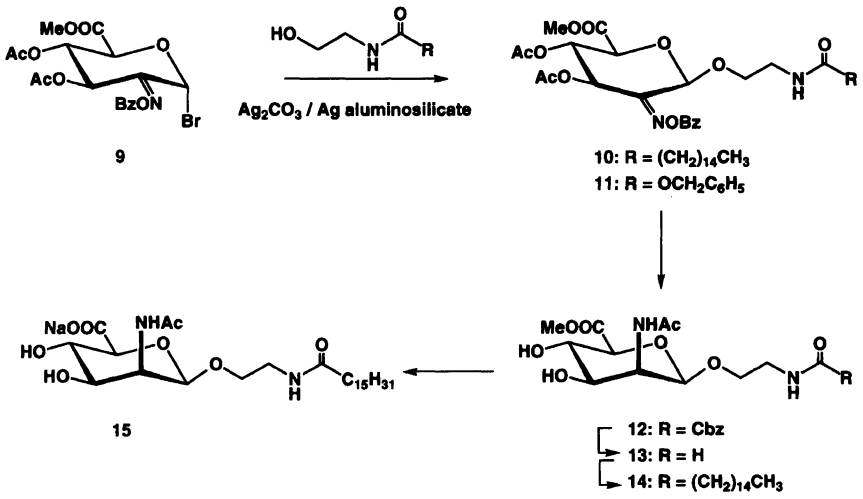
The glycosidations of **9** with *N*-blocked 2-aminoethanols, i.e. HO–$(CH_2)_2$–NHCOR; R=$(CH_2)_{14}CH_3$ or $OCH_2C_6H_5$, in the presence of several promoters are summarized in Table 1. Silver carbonate in dichloromethane effected high β-selectivity, but gave low to moderate yields (30—60%) for both acceptors (Entries 1 and 7, Table 1); more propitious proved to be the use of silver aluminosilicate (van Boeckel catalyst)[13] in dichromethane (2 h at 25°C), providing a β-selectivity of better than 20:1 (^{1}H NMR) and allowing the isolation of anomerically pure **11** in a yield of 71% (Entry 9). In contrast, the use of soluble silver catalysts such as silver triflate in glycosidation invariably resulted in no or partial predominance of β-anomers (Entries 4 and 8), while 2,4,6-trimethylpyridine in dioxane effected α-selective glycosidation, yet in low yield (Entry 5).

Although the 2-(benzoyloxyimino)glycuronate **9** is devoid of a participating group next to the anomeric center, the 2-acyloxyimino function, exerting a strong electron-withdrawing effect, appears to decisively influence the stereochemical outcome of glycosidation.[8] The high β-selectivity in these glycosidations may be deduced from van Boeckel's rationalization,[13,14] that electron-withdrawing substituents at C-2 and C-4 facilitate S_N2 type attacks of the alcohol component in insoluble silver salt-promoted glycosidations.

The β-configuration of **10** and **11** was unequivocally assigned from ^{1}H NMR data; the β-D-anomers of 2-(benzoyloxyimino)glycosides **10** and **11** have exceptionally small $J_{3,4}$ and $J_{4,5}$ coupling constants (4.5—6.5 Hz) originating from the steric congestion between 2-acyloxyimino group and aglycon, which distorts the pyran ring; the corresponding α-anomer **11**α has normal *J* values (9.5 and 9.8 Hz), as expected for the $^4C_1$ conformation of the pyran ring.[15—17]

Due to previous findings[8] that 2-(acyloxyimino)-β-D-glycosides favor hydride attack from the α-side, entailing the formation of 1,2-*cis*-amino sugars with β-D-*manno* configuration, we anticipated that 2-(benzoyloxyimino)-β-D-glycuronates are also endowed with high stereoselectivity for elaboration of 2-acetamido-2-deoxy-β-D-mannuronates. The 2-(benzoyloxyimino)-β-D-glycuronates **10** and **11** were thus hydroborated followed by *N*-acetylation according to our previous method.[15—17]

Indeed, the β-glycoside **11** was smoothly reduced with a twelve-fold molar excess of borane-tetrahydrofuran (BH_3·THF) complex in THF followed by *N*-acetylation with acetic anhydride to afford methyl 2-acet-



Scheme 2.

Table 1. Glycosidation of Methyl 2-Benzoyloxyimino-1-bromo-2-deoxy-α-D-*arabino*-hexopyranuronate (**9**) with 2-Aminoethanols: HO–$(CH_2)_2$–NHCOR

Entry	Acceptor R	Molar ratio Acceptor/Donor	Promoter	Solvent	Reaciton time/h at 25 °C	Yield %	α : β ratio[a]
1	$(CH_2)_{14}CH_3$	1.2	Ag_2CO_3/I_2	CH_2Cl_2	48	30	1 : 20
2	$(CH_2)_{14}CH_3$	1.5	Ag_2CO_3/I_2	CH_2Cl_2	48	28	1 : 20
3	$(CH_2)_{14}CH_3$	1.2	Ag_2CO_3/Ag-Zeolite	CH_2Cl_2	72	25	1 : 20
4	$(CH_2)_{14}CH_3$	1.2	AgOTf/TMU[b]	CH_2Cl_2	24	47	1 : 2
5	$(CH_2)_{14}CH_3$	1.5	2,4,6-Trimethylpyridine/I_2	Dioxane	48	12	10 : 1
6	$OCH_2C_6H_5$	1.5	Ag_2CO_3/I_2	CH_2Cl_2	48	53	1 : 20
7	$OCH_2C_6H_5$	2.0	Ag_2CO_3/I_2	CH_2Cl_2	48	60	1 : 20
8	$OCH_2C_6H_5$	1.5	AgOTf/TMU[b]	CH_2Cl_2	16	97	1 : 1
9	$OCH_2C_6H_5$	0.6	Ag-aluminosilicate	CH_2Cl_2	2	71	1 : 20

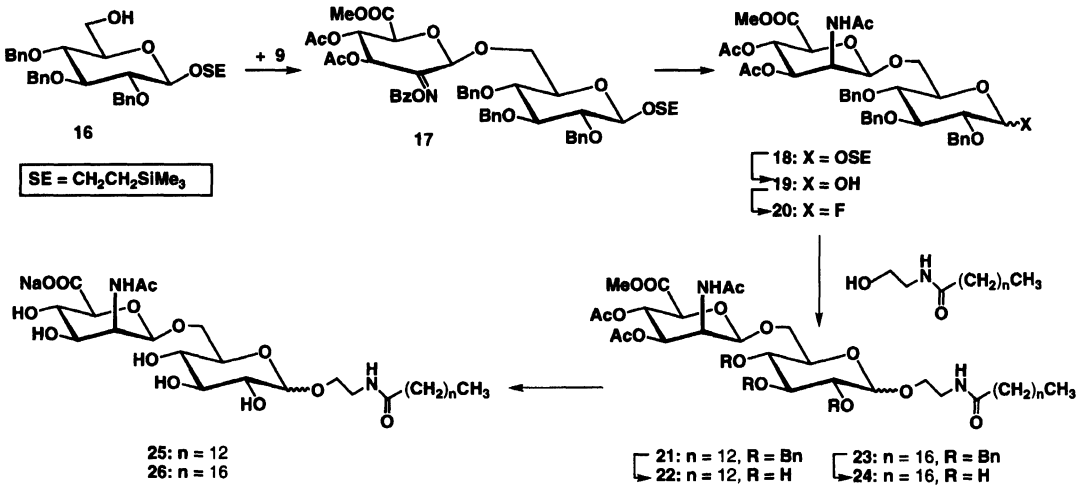
a) Determined by ^1H NMR of the reaction mixture. b) Silver trifluoromethanesulfonate/1,1,3,3-tetramethylurea.

amido-2-deoxy-β-D-mannuronate **12** in 56% yield. The hydroboration of 2-(palmitoylamino)ethyl glycoside **10**, however, resulted in the formation of a complex mixture of unidentified products. The β-D-*manno* configuration of **12** was proved by the respective couplings $J_{1,2}$, $J_{2,3}$, and $J_{3,4}$ of 1.2, 3.5, and 8.5 Hz, cogently reflecting the a,e-relationship of H-1 and H-2 as well as of H-2 and H-3, and an a,a-arrangement for H-3 and H-4.

After hydrogenolysis of the benzyloxycarbonyl group over palladium on carbon in the presence of *p*-toluenesulfonic acid (**12**→**13**, quant.), palmitic acid was attached to the 2-aminoethyl spacer of **13** with the aid of *N*,*N*′-carbonyldiimidazole and triethylamine to afford **14** in 57% yield. Saponification of the methyl ester function of **14** as well as deprotection of the *O*-acetyl group was achieved with 1 M methanolic NaOH (1 M = 1 mol dm^{-3}) to provide uneventfully, in 76% yield, the desired glycolipid **15**, unequivocally characterized by its spectral data.

Synthesis of Artificial Glycolipids Constituted with the Repeating Unit of a Teichuronic Acid of *Micrococcus luteus*. Construction of the repeating disaccharide unit, β-D-ManNAcA-(1→6)-α-D-Glc, was done by the reaction sequence shown in Scheme 3. The glycosyl donor **9** was glycosidated with partially blocked 2-(trimethylsilyl)ethyl β-D-glucopyranoside (**16**), which was readily prepared from 2-(trimethylsilyl)ethyl 2,3-di-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside[18] by reductive ring opening of the benzylidene acetal with $LiAlH_4$–$AlCl_3$ in 76% yield. Silver aluminosilicate-promoted β-glycosidation of **9** with **16** proceeded smoothly in dichloromethane (2 h at 25°C) to give anomerically pure **17** in a yield of 88%. Subsequent treatment of **17** with excess BH_3·THF complex in THF followed by *N*-acetylation led to the desired 2-acetamido-2-deoxy-β-D-mannuronate (**18**) in 84% yield. In this process, the reaction conditions must be such that the substrate **17** can react in fairly diluted THF solution (e.g. 12—14 mM), otherwise the 6-carboxylic ester function is reduced to the primary alcohol in addition to the desired reduction of the 2-acyloxyimino group. The β-D-*manno* configuration of the amino sugar portion was unambiguously identified as described above for the corresponding monosaccharide **12**.

Assembly of the spacer-linked glycolipids was done by activation of the reducing end of **18** (i.e. 1-OSE→



Scheme 3.

1-OH→1-F) and subsequent glycosidation with 2-(myristoylamino)ethanol[11] and 2-(stearoylamino)ethanol.[19] In adaptation of Magnusson's method,[18] the 2-(trimethylsilyl)ethyl group was smoothly removed with trifluoroacetic acid in dichloromethane (**18**→**19**, 83%), and the resulting 1-OH was fluorinated with diethylaminosulfur trifluoride (DAST) (**19**→**20**, 98%). The fluoride **20** was coupled with *N*-acylated 2-aminoethanols in the presence of either $SnCl_2$–$AgClO_4$[20] or Cp_2ZrCl_2–$AgClO_4$[21] in dichloromethane to afford **21** (62 or 51%) and **23** (53 or 64%), respectively. Both methods are of equal stereoselectivity, i.e., the α-glycosides are predominantly obtained in an α : β ratio of about 4 : 1. Subsequent de-*O*-benzylation was done with Pd–C/H_2 (**21**→**22**, and **23**→**24**, both quantitative). The concluding saponification of **22** and **24** with 1 M NaOH–MeOH (1 : 2) smoothly provided the target glycolipids **25** and **26** as 4 : 1 α/β-mixtures, in yields of 79 and 86%, respectively.

^{1}H and ^{13}C NMR spectra of the glycolipids **22**—**26** were fully analyzed with the aid of ^{1}H–^{1}H shift correlated two-dimentional spectra as well as HOHAHA and HMQC spectra. The anomeric configurations of the glucose portions were deduced from the $J_{1,2}$ coupling constants (3.5—4.0 Hz for the α-anomers), and the β-D-*manno* configuration were secured from $J_{1',2'}$ and $J_{2',3'}$ of 1.5—2.0 and 4.0—4.5 Hz, respectively. Mass spectrometric (MS) and combustion analyses clearly showed **25** and **26** to be the sodium 2-acetamido-2-deoxy-β-D-mannuronate derivatives. The biological evaluation of **15**,**25**, and **26** is in progress.

In summation, a concise, practical method has been developed for generating the suitably blocked 2-(benzoyloxyimino)glycuronate **9** from D-glucuronolactone in 20% yield over six simple steps. Its utility as an efficient, highly useful glycosyl donor for the assembly of β-D-ManNAcA-containing oligosaccharides was amply demonstrated by the fact that both, the glycosidation step as well as the reduction of the acyloxyimino function to 2-acetamido-2-deoxy-β-D-mannuronate, are proceeding in an essentially stereospecific manner. Thus, this approach has major advantages over previous ones, and is presently being applied to the synthesis of other immunologically relevant β-D-ManNAcA-containing oligosaccharides.

Experimental

General. Melting points were measured on a Yamato MP-1 apparatus and Yanagimoto micro melting point apparatus, and are uncorrected. Spectral measurements were recorded on JASCO DIP-150 digital polarimeter (rotations), JMS D-100 mass spectrometer (MS), Varian VXR-300 and XL-400 spectrometers (^{1}H and ^{13}C NMR). TLC was done on Merck silica gel 60 F_{254} with the same solvent systems as used for column chromatography. The spots were made visible by UV light (254 nm) or by charring with 10% aqueous H_2SO_4. Column chromatography was achieved on silica gel 60 (70—230 mesh, Merck).

2-Acetoxy-3,4-di-*O*-acetyl-D-glucuronal Methyl Ester [Methyl 3,4,5-Tri-*O*-acetyl-2,6-anhydro-D-*lyxo*-hex-5-enonate] (6). Diethylamine (0.200 ml, 1.89 mmol) was added dropwise to an ice-cooled stirred solution of methyl 2,3,4-tri-*O*-acetyl-1-bromo-α-D-glucopyranuronate (**5**)[9] (500 mg, 1.26 mmol) and tetrabutylammonium bromide (405 mg, 1.26 mmol) in DMF (10 ml). The mixture was stirred at room temperature for 20 h, neutralized with an acidic resin (IRC-50), and partitioned between ice-water (100 ml) and dichloromethane (100 ml). The organic phase was washed with 1 M HCl (50 ml), 5% aqueous $NaHCO_3$ (50 ml), and water (3×100 ml). Drying (Na_2SO_4) and evaporation of the solvent gave a residue, which was purified by elution from a column of silica gel with toluene–ethyl acetate (2 : 1). Concentration of the fraction containing **6** (TLC), followed by crystallization from diethyl ether gave 210 mg (54%) of **6** as colorless crystals: Mp 101—101.5 °C; $[\alpha]_D^{20}$ −51° (*c* 1.0, $CHCl_3$); cf. lit,[22] mp 76 °C; $[\alpha]_D^{20}$ −54° (*c* 0.5, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=2.00, 2.09, 2.13 (three 3H, s, 3×Ac-CH_3), 3.79 (3H, s, OCH_3), 5.37 (1H, dd, H-3), 5.45 (1H, dd, H-4), 4.82 (1H, dd, H-5), 6.81 (1H, s, H-1); $J_{3,4}=J_{4,5}=2.4$, $J_{3,5}=1.2$ Hz; ^{13}C NMR ($CDCl_3$) δ=20.50, 20.70, 20.70 (3×Ac-CH_3), 52.44 (OCH_3), 63.54

(C-3), 67.95 (C-4), 72.30 (C-5), 127.45 (C-2), 139.41 (C-1), 166.64 (COOCH$_3$), 169.20, 169.40 (Ac-CO); MS (EI) m/z 316 $[M]^+$. Found: C, 49.48; H, 5.10%. Calcd for $C_{13}H_{16}O_9$: C, 49.37; H, 5.10%.

Oxime of Methyl 3,4-Di-*O*-acetyl-1,5-anhydro-D-fructuronate (7). A mixture of glucuronal **6** (1.28 g, 4.05 mmol) and hydroxylamine hydrochloride (1.69 g, 24.3 mmol) in dry pyridine (45 ml) was stirred at room temperature for 20 h. After concentration of the mixture in vacuo the residue was diluted with dichloromethane (300 ml) and washed with water (300 ml). The organic phase was washed with 1 M HCl (100 ml), 5% aqueous $NaHCO_3$ (100 ml), and water (3×300 ml), dried (Na_2SO_4), and evaporated to dryness. The residue was purified by elution from a silica-gel column with toluene–ethyl acetate (2:1). Concentration of the appropriate fraction, crystallization of the syrupy residue from diethyl ether, and recrystallization from ethanol provided 655 mg (56%) of **7** as colorless crystals: Mp 141—142 °C; $[\alpha]_D^{20}$ +9.6° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=2.06, 2.11 (two 3H, s, 2×Ac-CH$_3$), 3.80 (3H, s, OCH$_3$), 4.33 (1H, d, H-5), 4.67 (1H, d, H$_R$-1), 4.87 (1H, d, H$_S$-1), 5.43 (1H, dd, H-4), 5.48 (1H, d, H-3), 8.59 (1H, s, NOH, disappearing on deuteration); $J_{1,1}$=16.0, $J_{3,4}$=4.8, $J_{4,5}$=4.5 Hz; ^{13}C NMR ($CDCl_3$) δ=20.64, 20.74 (2×Ac-CH$_3$), 52.58 (OCH$_3$), 59.08 (C-1), 68.21 (C-3), 69.79 (C-4), 74.37 (C-5), 149.91 (C-2), 168.49 (COOCH$_3$), 168.94, 169.39, (2×Ac-CO); MS (FAB) m/z 290 $[M+H]^+$, 312 $[M+Na]^+$, 579$[2M+H]^+$. Found: C, 45.64; H, 5.26; N, 4.89%. Calcd for $C_{11}H_{15}NO_8$: C, 45.68; H, 5.23; N, 4.84%.

***O*-Benzoyloxime of Methyl 3,4-Di-*O*-acetyl-1,5-anhydro-D-fructuronate (8).** Benzoyl chloride (4.00 ml, 34.7 mmol) was added dropwise to an ice-cooled, stirred solution of the oxime **7** (1.0 g, 3.46 mmol) in dry pyridine (20 ml). The mixture was stirred at ambient temperature for 3 h, poured into ice-water (100ml), and extracted with dichloromethane (100ml). The organic phase was washed with 1 M HCl (100 ml), 5% aqueous $NaHCO_3$ (100 ml), and water (3×100 ml), dried (Na_2SO_4), and concentrated to dryness. The resulting syrup was purified by elution from a silica-gel column with toluene–ethyl acetate (2:1). Evaporation of the eluate containing **8** (TLC) and trituration of the residue with diethyl ether induced crystallization: 1.33 g (98%) of **8** as colorless crystals (*E*:*Z*=40:1, ^{1}H NMR): Mp 127—127.5 °C; $[\alpha]_D^{20}$ −8.0° (*c* 0.50, $CHCl_3$); ^{1}H NMR ($CDCl_3$) *E-form*: δ=2.10, 2.14 (two 3H, s, 2×Ac-CH$_3$), 3.83 (3H, s, OCH$_3$), 4.45 (1H, d, H-5), 4.93 (1H, d, H$_R$-1), 5.03 (1H, d, H$_S$-1), 5.57 (1H, dd, H-4), 5.70 (1H, d, H-3), 7.49, 7.63, 8.03 (5H, C$_6$H$_5$), $J_{1,1}$=16.0, $J_{3,4}$=4.5, $J_{4,5}$=3.5 Hz; *Z-form*: δ=2.08, 2.10 (two 3H, s, 2×Ac-CH$_3$), 3.83 (3H, s, OCH$_3$), 4.53 (1H, d, H$_R$-1), 4.57 (1H, d, H-5), 5.03 (1H, d, H$_S$-1), 5.53 (1H, dd, H-4), 6.35 (1H, d, H-3), 7.49, 7.63, 8.07 (5H, C$_6$H$_5$); $J_{1,1}$=14.0, $J_{3,4}$=3.5, $J_{4,5}$=2.0 Hz; NOE was observed for protons between H-3 and oxime-benzoyl group; ^{13}C NMR ($CDCl_3$) *E-form*: δ=20.55, 20.75 (2×Ac-CH$_3$), 52.63 (OCH$_3$), 59.64 (C-1), 67.79 (C-3), 69.21 (C-4), 73.95 (C-5), 128.72, 129.73, 133.85 (C$_6$H$_5$), 157.64 (C-2), 162.80 (COPh), 168.26 (COOCH$_3$), 168.31, 169.17 (2×Ac-CO); MS (FAB) m/z 394 ($[M+H]^+$. Found: C, 54.87; H, 4.88; N, 3.39%. Calcd for $C_{18}H_{19}NO_9$: C, 54.96; H, 4.87; N, 3.56%.

Methyl 3,4-Di-*O*-acetyl-2-(benzoyloxyimino)-1-bromo-2-deoxy-α-D-*arabino*-hexopyranuronate (9). A mixture of benzoyloxime **8** (410 mg, 1.0 mmol) and *N*-bromosuccinimide (205 mg, 1.15 mmol) in tetrachloromethane (18 ml) was irradiated with a 250 W tungsten lamp such that gentle reflux was effected. After 30 min the resulting yellowish solution was cooled (0 °C), the precipitate (succinimide) was filtered off, and the filtrate was evaporated to dryness. The residue was partitioned between dichloromethane (50 ml) and water (50 ml). The organic phase was washed with water (2×50 ml), dried (Na_2SO_4), and concentrated in vacuo to give a syrup, which was crystallized from diethyl ether–pentane: 465 mg (95%) of **9** as coloress crystals; mp 90—91 °C; $[\alpha]_D^{23}$ +341° (*c* 0.500, $CHCl_3$); ^{1}H NMR ($CDCl_3$)δ=2.13, 2.21 (two 3H, s, 2×Ac-CH$_3$), 3.79 (3H, s, OCH$_3$), 4.67 (1H, d, H-5), 5.48 (1H, dd, H-4), 6.24 (1H, d, H-3), 7.43 (1H, s, H-1), 7.51, 7.65, 8.04 (5H, C$_6$H$_5$); $J_{3,4}=J_{4,5}$=9.5 Hz; ^{13}C NMR ($CDCl_3$) δ=20.45, 20.49 (2×Ac-CH$_3$), 53.32 (OCH$_3$), 66.87 (C-3), 68.37 (C-4), 72.05 (C-1), 72.44 (C-5), 127.57, 128.87, 129.83, 134.10 (C$_6$H$_5$), 154.61 (C-2), 161.78 (COPh), 166.02 (COOCH$_3$), 169.16, 169.47 (2×Ac-CO); MS (FAB) m/z 472 $[M+H]^+$. Found: C, 45.77; H, 3.59; N, 3.15; Br, 17.17%. Calcd for $C_{18}H_{18}NO_9Br$: C, 45.78; H, 3.84; N, 2.97; Br, 16.92%,

Methyl [2-(Palmitoylamino)ethyl 3,4-Di-*O*-acetyl-2-(benzoyloxyimino)-2-deoxy-β-D-*arabino*-hexopyranosid]uronate (10). A mixture of 2-(palmitoylamino)ethanol[11] (103 mg, 0.343 mmol), silver carbonate (394 mg, 1.43 mmol), iodine (75.5 mg, 0.286 mmol), and molecular sieves (3 Å, 350 mg, powder) in dry dichloromethane (7 ml) was stirred in the dark at room temeprature for 1 h. The 2-(benzoyloxyimino)glycuronate **9** (135 mg, 0.286 mmol) was then added and stirring was continued for 2 d, followed by dilution with dichloromethane (20 ml), and filtration through a pad of Celite. The filtrate was washed with 0.1 M aqueous $Na_2S_2O_3$ (20 ml), water (20 ml), 5% aqueous $NaHCO_3$ (20 ml), and water (3×20 ml). Drying (Na_2SO_4) and evaporation in vacuo gave a yellowish syrup, which was eluted through a silica-gel column with toluene–ethyl acetate (1:1). The major fraction was concentrated to give 59.5 mg (30%) of **10** as a syrup (α:β=1:20, ^{1}H NMR): $[\alpha]_D^{20}$ −46° (*c* 0.50, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=0.87 (3H, t, CH$_3$), 1.19—1.33 (24H, 12×CH$_2$), 1.66 (2H, broad, COCH$_2$CH$_2$), 2.04 (2H, t, COCH$_2$), 2.10, 2.12 (two 3H, s, 2×Ac-CH$_3$), ca. 3.5 (2H, broad m, CH$_2$N), 3.79 (3H, s, OCH$_3$), ca. 4.2 (2H, broad m, OCH$_2$), 4.54 (1H, d, H-5), 5.75 (1H, d, H-3), 5.85 (1H, dd, H-4), 5.92 (1H, s, H-1), 6.43 (1H, broad m, NH), 7.38—8.22 (5H, C$_6$H$_5$); $J_{3,4}$=6.5, $J_{4,5}$=4.7 Hz; ^{13}C NMR ($CDCl_3$) δ=14.10 (CH$_3$), 20.54, 20.72 (2×Ac-CH$_3$), 22.67 (CH$_2$CH$_3$), 25.63 (COCH$_2$CH$_2$), 29.23—29.67, 31.90 (11×CH$_2$), 36.52 (COCH$_2$), 39.08 (CH$_2$NH), 52.71 (OCH$_3$), 66.87 (C-3), 67.32 (C-4), 69.91 (OCH$_2$), 72.38 (C-5), 92.44 (C-1), 155.32 (C-2), 168.73 (COOCH$_3$), 169.05, 169.21 (2×Ac-CO), 173.41 (CONH); MS (FAB) m/z 691 $[M+H]^+$, 713 $[M+Na]^+$.

Methyl [2-(Benzyloxycarbonylamino)ethyl 3,4-Di-*O*-acetyl-2-(benzoyloxyimino)-2-deoxy-β-D-*arabino*-hexopyranosid]uronate (11). ***Method A (Promotion by Ag_2CO_3–I_2):*** 2-(Benzyloxycarbonylamino)ethanol[12] (508 mg, 2.60 mmol) was treated with 2-(benzoyloxyimino)glycuronate **9** (614 mg, 1.30 mmol) in the presence of silver carbonate (1.79 g, 6.5 mmol) as described for **9**→**10**. After workup, the crude product was eluted from a silica-gel column with toluene–ethyl acetate (3:2): 455 mg (60%) of **11** as a yellowish syrup (α:β=1:20, ^{1}H NMR): $[\alpha]_D^{20}$ −91°

(c 0.40, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=2.04, 2.12 (two 3H, s, 2×Ac-CH_3), ca. 3.4, 3.5 (2H, broad m, C$\underline{H}_2$NH), 3.74 (3H, s, OCH_3), 3.8, 4.3 (two 1H, m, OCH_2), 4.51 (1H, d, H-5), 4.93, 5.04 (two 1H, d, CH_2Ph), 5.44 (1H, broad, NHCO), 5.71 (1H, d, H-3), 5.83 (1H, dd, H-4), 5.94 (1H, s, H-1), 7.3—8.0 (2×C_6H_5); $J_{3,4}$=6.5, $J_{4,5}$=4.5 Hz; ^{13}C NMR ($CDCl_3$) δ= 20.46, 20.73 (2×Ac-CH_3), 40.73 ($\underline{C}H_2$NH), 52.67 (OCH_3), 66.59 (CH_2Ph), 66.89 (C-3), 67.43 (C-4), 69.44 (OCH_2), 72.16 (C-5), 92.28 (C-1), 128.0—136.4 (C_6H_5), 155.09 (C-2), 156.33, 162.40 (NHCO, COPh), 168.77 ($\underline{C}OOCH_3$), 168.93, 169.00 (2×Ac-CO); MS (FAB) m/z 587 $[M+H]^+$.

***Method B (Promotion by Silver Aluminosilicate)*:** 2-(Benzoyloxyimino)glycuronate **9** (71 mg, 0.15 mmol) was added to a stirred mixture of 2-(benzyloxycarbonylamino)-ethanol (20 mg, 0.10 mmol) and silver aluminosilicate[13] (63 mg, 0.20 mmol) in dry dichloromethane (2 ml) with molecular sieves (3 Å, 200 mg, powder). The mixture was stirred in the dark under nitrogen at room temperature for 1 h, whereafter all the educt had been consumed (TLC), followed by dilution with dichloromethane (20 ml) and filtration through Celite. The filtrate was washed with 5% aqueous $NaHCO_3$ (20 ml), and water (3×20 ml). Drying (Na_2SO_4) and concentration to dryness gave a syrup, which was eluted through a silica-gel column with toluene–ethyl acetate (3:2). The major fraction was concentrated to furnish 42 mg (71%) of **11** as a colorless syrup ($\alpha:\beta$=1:20, ^{1}H NMR).

***Method C (Promotion by Silver Triflate-Tetramethylurea)*:** 2-(Benzoyloxyimino)glycuronate **9** (47 mg, 0.10 mmol) and tetramethylurea (18 μl, 0.15 mmol) were added to a stirred solution of 2-(benzyloxycarbonylamino)ethanol (29 mg, 0.15 mmol) and silver triflate (31 mg, 0.12 mmol) in dry dichloromethane (2 ml) with molecular sieves (3 Å, 100 mg, powder). The mixture was stirred in the dark at room temperature for 16 h. Dilution with dichloromethane, washing with 5% aqueous $NaHCO_3$ and water, drying (Na_2SO_4), and evaporation to dryness gave a syrup, which was purified by column chromatography as described above. An anomeric mixture of **11** and its α-anomer (**11**α) was obtaiend in the ratio of 1:1 (^{1}H NMR): 57 mg (97%) as a colorless syrup; $[\alpha]_D^{28}$ −43° (c 1.3, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=4.53 (1H, d, H-5), 5.43 (1H, dd, H-4), 5.98 (1H, d, H-3), 6.12 (1H, s, H-1); $J_{3,4}$=9.5, $J_{4,5}$=9.8 Hz; ^{13}C NMR ($CDCl_3$) δ=68.30 (C-3), 69.01 (C-5), 70.08 (C-4), 91.64 (C-1), 155.10 (C-2); MS (FAB) m/z 587 $[M+H]^+$.

Methyl [2-(Benzyloxycarbonylamino)ethyl 2-Acetamido- 3, 4- di- *O*- acetyl- 2- deoxy- β- D- mannopyranosid]uronate (12). A 1 M solution of BH_3·THF complex in THF (2.4 ml) was added to a solution of the β-glycoside **11** (117 mg, 0.200 mmol) in THF (2.4 ml) at −10°C under atmosphere of nitrogen. The mixture was stirred at −10 °C for 0.5 h and at ambient temperature for 2 h. Excess reductant was quenched with methanol (1.6 ml) followed by addition of acetic anhydride (0.8 ml) for N-acetylation. After it was stirred for 1 h at ambient temperature, the mixture was passed through a basic resin (Amberlite IR-45), and washed with methanol. The eluate was concentrated in vacuo and the residue was purified by elusion from a silica-gel column with toluene–ethyl acetate (1:3)→chloroform–methanol (15:1). The major fraction was concentrated and the residue was crystallized from ethyl acetate–diethyl ether (1:2) and excess pentane: 57 mg (56%) of **12**; mp 62—65 °C; $[\alpha]_D^{22}$ −20° (c 0.30, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=1.97 (3H, s, NAc-CH_3), 2.02, 2.07 (two 3H, s, 2×OAc-CH_3), 3.3—3.5 (2H, broad, C$\underline{H}_2$NH), 3.62, 3.98 (two 1H, m, OCH_2), 3.71 (3H, s, OCH_3), 4.05 (1H, d, H-5), 4.72 (1H, dd, H-2), 4.73 (1H, d, H-1), 4.98 (1H, dd, H-3), 5.09 (2H, s, C$\underline{H}_2$Ph), 5.29 (1H, dd, H-4), ca. 5.3 (1H, broad, NHCO), 7.3—7.4 (C_6H_5); $J_{1,2}$= 1.0, $J_{2,3}$=3.5, $J_{3,4}$=8.5, $J_{4,5}$=8.0 Hz; ^{13}C NMR ($CDCl_3$) δ=20.67 (2×Ac-CH_3), 23.24 (NAc-CH_3), 40.84 (CH_2NH), 48.63 (C-2), 52.79 (OCH_3), 66.66 (C-4), 66.77 (CH_2Ph), 69.40 (OCH_2), 70.12 (C-3), 72.30 (C-5), 98.82 (C-1), 128.12, 128.15, 128.50, 136.42 (C_6H_5), 156.44 (NH$\underline{C}$OOBn), 167.89 ($\underline{C}OOCH_3$), 169.67, 170.10 (2×OAc-CO), 170.67 (NAc-CO); MS (FAB) m/z 511 $[M+H]^+$, 533 $[M+Na]^+$. Found: C, 53.70; H, 6.09; N, 5.28%. Calcd for $C_{23}H_{30}N_2O_{11}$: C, 54.11; H, 5.92; N, 5.49%.

Methyl[2-(Palmitoylamino)ethyl 2-Acetamido-3, 4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosid]uronate (14). A solution of **12** (188 mg, 0.368 mmol) in dry methanol (35 ml) was hydrogenolyzed in the presence of p-toluenesulfonic acid (70.0 mg, 0.368 mmol) with 5% palladium on carbon (50 mg) under atmosphere of hydrogen (2.76×10^5 Pa) for 2 h. The mixture was filtered through a pad of Celite and the filtrate was concentrated in vacuo to give the 2-aminoethyl glycoside as the p-toluenesulfonic acid salt (**13**) (colorless syrup, 215 mg, quantitative), which was used for the next step without further purification.

A solution of palmitic acid (123 mg, 0.478 mmol) and N,N'-carbonyldiimidazole (85.3 mg, 0.526 mmol) in dry DMF (2 ml) was stirred at room temperature for 0.5 h, whereupon a solution of **13** (202 mg, 0.368 mmol) in dry DMF (0.5 ml) and a solution of triethylamine (67.0 μl, 0.478 mmol) in dry DMF (0.5 ml) were added. The mixture was stirred at room temperature for 20 h, and subsequently diluted with dichloromethane (20 ml). After this was washed with water (2×15 ml), 0.2 M HCl (10 ml), 5% aqueous $NaHCO_3$ (20 ml), and brine (2×20 ml), the solvent was removed at diminished pressure to give a residue, which was eluted through a silica-gel column with chloroform–methanol (20:1). The major fraction was concentrated to furnish 129 mg (57%) of **14** as a colorless syrup: $[\alpha]_D^{21}$ −13° (c 0.30, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=0.87 (3H, t, CH_3), 1.2—1.3 (24H, 12×CH_2), 1.61 (2H, broad, $COCH_2C\underline{H}_2$), 2.01 (3H, s, NAc-CH_3), 2.05, 2.07 (two 3H, s, 2×Ac-CH_3), 2.17 (2H, t, $COCH_2$), 3.34, 3.53 (two 1H, m, C$\underline{H}_2$NH), 3.64, 3.93 (two 1H, m, OCH_2), 3.75 (3H, s, OCH_3), 4.05 (1H, d, H-5), 4.74 (1H, td, H-2), 4.75 (1H, d, H-1), 5.01 (1H, dd, H-3), 5.27 (1H, dd, H-4), 5.99 (1H, d, 2-NH), 6.06 (1H, broad t, $CH_2N\underline{H}$); $J_{1,2}$=2.0, $J_{2,3}$=4.0, $J_{2,NH}$=8.5, $J_{3,4}$=8.8, $J_{4,5}$=8.5 Hz; ^{13}C NMR ($CDCl_3$) δ= 14.09 (CH_3), 20.62, 20.70 (2×Ac-CH_3), 22.66 ($\underline{C}H_2CH_3$), 23.31 (NAc-CH_3), 25.72 ($COCH_2\underline{C}H_2$), 29.33—29.67, 31.90 (11×CH_2), 36.65 ($CO\underline{C}H_2$), 39.07 ($\underline{C}H_2$NH), 49.05 (C-2), 52.84 (OCH_3), 66.68 (C-4), 69.77 (OCH_2), 70.27 (C-3), 72.49 (C-5), 99.02 (C-1), 167.85 ($\underline{C}OOCH_3$), 169.70, 170.04 (2×Ac-CO), 170.82 (NAc-CO), 173.42 (NH$\underline{C}$OCH_2); MS (FAB) m/z 615$[M+H]^+$, 637$[M+Na]^+$.

Sodium [2-(Palmitoylamino)ethyl 2-Acetamido-2-deoxy-β-D-mannopyranosid]uronate (15). To a cooled, stirred solution of **14** (42.0 mg, 68.3 μmol) in methanol (2 ml) was added 1 M aqueous sodium hydroxide (1 ml). The mixture was stirred at room temperature for 20 h, diluted with methanol (2 ml), and neutralized with acidic

resin (Dowex 50W-X8, H^+ type, 0.40 g). The solid phase was filtered off, and the filtrate was concentrated to dryness to give a residue, which crystallized from methanol–diethyl ether. Centrifugation and washing with diethyl ether provided 28 mg (76%) of **15** as colorless powder: Mp ca. 200 °C (decomp); $[\alpha]_D^{23}$ −54° (*c* 0.40, MeOH); ^{1}H NMR (D_2O) δ=0.78 (3H, t, CH_3), ca. 1.2 (24H, 12×CH_2), 1.44 (2H, broad, $COCH_2C\underline{H}_2$), 1.98 (3H, s, NAc-CH_3), 2.14 (2H, broad m, $COCH_2$), 3.28 (3H, broad m, H-1 and $C\underline{H}_2NH$), 3.56 (3H, broad m, H-4 and OCH_2), 3.64 (1H, H-5), 3.76 (1H, H-3), 4.40 (1H, H-2); ^{13}C NMR (D_2O) δ=14.87 (CH_3), 23.27 ($\underline{C}H_2CH_3$), 23.67 (NAc-CH_3), 26.84 ($COCH_2\underline{C}H_2$), 30.39—31.06, 33.02, (11×CH_2), 37.01 ($CO\underline{C}H_2$), 39.93 (CH_2NH), 53.99 (C-2), 68.98 (OCH_2), 70.26 (C-4), 73.00 (C-3), 78.09 (C-5), 99.94 (C-1), 175.73, 176.75 (3×CO); MS (FAB) *m/z* 539 $[M+H]^+$, 561 $[M+Na]^+$. Found: C, 53.16; H, 8.47; N, 4.69%. Calcd for $C_{26}H_{47}N_2O_8Na\cdot2.5\,H_2O$: C, 53.50; H, 8.98; N, 4.80%.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-*O*-benzyl-β-D-glucopyranoside (16). Lithium aluminum hydride (31.4 mg, 0.828 mmol) was added to a solution of 2-(trimethylsilyl)ethyl 2,3-di-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside[18] (110 mg, 0.200 mmol) in dry diethyl ether–dichloromethane (1:1) (2 ml), and the mixture was refluxed at external 60 °C. A solution of $AlCl_3$ (94.3 mg, 0.707 mmol) in dry diethyl ether (1 ml) was added to the mixture, which was further refluxed for 0.5 h. The resulting mixture was cooled, treated with ethyl acetate (0.4 ml) and water (0.5 ml), and diluted with diethyl ether (10 ml). The organic phase was washed with water (3×10 ml), dried (Na_2SO_4), and evaporated to dryness to give a residue, which was eluted through a silica-gel column with toluene–ethyl acetate (5:1). The major fraction was concentrated to furnish 83 mg (76%) of **16** as a colorless syrup: $[\alpha]_D^{23}$ +3.0° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=0.04 [11H, s, $(CH_3)_3SiCH_2$], 1.05 (broad 2H, m, OCH_2), 3.37 (1H, m, H-5), 3.41 (1H, dd, H-2), 3.58 (1H, t, H-4), 3.65 (1H, t, H-3), 3.73 (1H, td, H-6a), 3.99 (1H, dd, H-6b), 4.46 (1H, d, H-1), 4.69—5.00 (6H, 3×CH_2Ph), 5.30 (1H, s, OH), 7.2—7.4 (C_6H_5); $J_{1,2}$=8.0, $J_{2,3}=J_{3,4}=J_{4,5}$=9.0, $J_{5,6a}$=5.0, $J_{5,6b}$=8.0, $J_{6,6}$=10.0 Hz; ^{13}C NMR ($CDCl_3$) δ=−1.42 (Si-C), 18.63 (OCH_2), 67.85 (C-6), 74.96 (C-5), 74.88, 75.10, 75.67 (3×CH_2Ph), 77.65 (C-4), 82.46 (C-2), 84.53 (C-3), 103.26 (C-1); MS (FAB) *m/z* 549 $[M-H]^+$, 551 $[M+H]^+$, 573 $[M+Na]^+$.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-*O*-benzyl-6-*O*-[methyl 3,4-*di*-*O*-acetyl-2-(benzoyloxyimino)-2-deoxy-β-D-*arabino*-hexopyranosyluronate]-β-D-glucopyranoside (17). A mixture of 2-(trimethylsilyl)ethyl glucoside **16** (111 mg, 0.200 mmol), 2-(benzoyloxyimino)-glycuronate **9** (141 mg, 0.300 mmol), silver aluminosilicate (125 mg, 0.400 mmol), molecular sieves (3 Å, 400 mg, powder), and dry dichloromethane (4 ml) was stirred at room temperature for 2 h, followed by processing as described for **11** (*Method B*). Elution of the crude product from a silica-gel column with toluene–ethyl acetate (5:1) and concentration of the major fraction gave 165 mg (88%) of **17** as a colorless syrup; $[\alpha]_D^{22}$ −77° (*c* 0.70, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=−0.10 [11H, s, $(CH_3)_3SiCH_2$], 0.89 (2H, t, OCH_2), 2.09, 2.11 (two 3H, s, 2×Ac-CH_3), ca. 3.4 (2H, m, H-2, H-4), 3.48 (1H, td, H-5), 3.65 (1H, t, H-3), 3.66 (3H, s, OCH_3), 3.7—3.8 (broad 2H, m, H-6a,b), 4.36 (1H, d, H-1), 4.45 (1H, d, H-5′), 4.55—5.0 (6H, 3×CH_2Ph), 5.74 (1H, d, H-3′), 5.89 (1H, s, H-1′), 5.91 (1H, dd, H-4′), 7.3—8.1 (4×C_6H_5); $J_{1,2}$=8.0, $J_{2,3}=J_{3,4}=J_{4,5}=J_{5,6b}$=9.0, $J_{5,6a}$=5.5, $J_{3',4'}$=6.5, $J_{4',5'}$=4.8 Hz; ^{13}C NMR ($CDCl_3$) δ=−1.62 (Si-C), 14.03 (OCH_2), 20.62, 20.76 (2×Ac-CH_3), 52.62 (OCH_3), 67.36 (C-3′), 67.66 (C-4′), 70.27 (C-6), 72.30 (C-5′), 74.01 (C-5), 74.58, 75.02, 75.63 (3×CH_2Ph), 78.26 (C-4), 82.33 (C-2), 84.73 (C-3), 92.95 (C-1′), 102.77 (C-1), 127.6—138.5 (C_6H_5). 155.60 (C-2′), 162.72 ($\underline{C}OOCH_3$), 168.69, 169.04 (2×Ac-CO); MS (FAB) *m/z* 954 $[M+Na]^+$.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-*O*-benzyl-6-*O*-(methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-β-D-glucopyranoside (18). A solution of the β-glycoside **17** (94.2 mg, 0.100 mmol) in THF (7.2 ml) was treated with a 1 M solution of BH_3·THF complex in THF (1.2 ml) as described for **11**→**12**. Subsequent exposure to acetic anhydride (0.5 ml) followed by processing of the mixture as described for **12** gave a syrup, which was eluted from a silica-gel column with chloroform–methanol (40:1). The faster-eluted fraction was concentrated to dryness to give 48 mg (55%) of **18** as a colorless syrup, which crystallized from ethyl acetate–diethyl ether (1:2) and excess pentane; mp 49—51 °C; $[\alpha]_D^{22}$ −6.5° (*c* 0.30, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ=0.05 [11H, s, $(CH_3)_3SiCH_2$], ca. 1.05 (2H, m, OCH_2), 1.99, 2.00 (two 3H, s, 2×Ac-CH_3), 2.06 (3H, s, NAc-CH_3), 3.34 (1H, t, H-4), 3.37 (1H, dd, H-2), 3.44 (1H, td, H-5), 3.59 (1H, dd, H-6a), 3.71 (1H, t, H-3), 3.94 (1H, d, H-5′), 4.01 (1H, dd, H-6b), 4.38 (1H, d, H-1), 4.5—4.9 (6H, 3×CH_2Ph), 4.66 (1H, dd, H-2′), 4.70 (1H, d, H-1′), 4.93 (1H, dd, H-3′), 5.23 (1H, t, H-4′), 5.93 (1H, d, NHCO), 7.2—7.4 (3×C_6H_5); $J_{1,2}$=8.0, $J_{2,3}=J_{3,4}=J_{4,5}=J_{5,6b}$=9.0, $J_{5,6a}$=5.5, $J_{6,6}$=11.0, $J_{1',2'}$=2.0, $J_{2',NH}$=8.5, $J_{2',3'}$=3.1, $J_{3',4'}=J_{4',5'}$=9.0 Hz; ^{13}C NMR ($CDCl_3$) δ=−1.36 (Si-C), 18.48 (OCH_2), 20.62, 20.76 (2×OAc-CH_3), 23.31 (NAc-CH_3), 49.55 (C-2′), 52.75 (OCH_3), 66.78 (C-4′), 69.05 (C-6), 70.78 (C-3′), 72.65 (C-5′), 74.56 (C-5), 74.81, 74.92, 75.64 (3×CH_2Ph), 77.97 (C-4), 82.35 (C-2), 84.62 (C-3), 99.17 (C-1′), 103.08 (C-1), 126.9—138.5 (C_6H_5), 167.74 ($\underline{C}OOCH_3$), 169.72, 170.07 (2×Ac-CO), 170.66 (NCO); MS (FAB) *m/z* 866 $[M+H]^+$, 888 $[M+Na]^+$.

The fraction eluted second containing 3′,4′-de-*O*-acetylated **18** was concentrated and reacetylated with acetic anhydride (1 ml) in pyridine (1 ml) for 1 h at room temperature. Addition of methanol (3 ml) to the mixture and evaporation of the solvent gave a syrup, which was purified by elution from a silica-gel column with chloroform–ethyl acetate (1:1). Concentration of the eluate afforded 25 mg (29%) of **18** as a syrup, thus raising the total yield to 84%.

2,3,4-Tri-*O*-benzyl-6-*O*-(methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-D-glucopyranose (19). Trifluoroacetic acid (1 ml, 13 mmol) was added to a cooled (0 °C), stirred solution of **18** (87mg, 0.10 mmol) in dry dichloromethane (0.5 ml) under nitrogen atmosphere. Stirring at 0 °C was continued for 2 h, by which time **18** had been consumed (TLC). Propyl acetate (3 ml) and toluene (6 ml) were added to the mixture, from which the solvent was removed in vacuo to dryness. The residue was eluted through a silica-gel column with chloroform–ethyl acetate (1:2). Concentration of the major fraction gave a syrup which crystallized from acetone–hexane: 64 mg (83%) of **19** as colorless crystals ($\alpha:\beta$=4:1, ^{1}H NMR): Mp 208—210 °C; $[\alpha]_D^{22}$ +15° (*c* 0.44, $CHCl_3$); ^{1}H NMR ($CDCl_3$) *α-anomer*: δ=2.00, 2.01, 2.05

(three 3H, s, 3×Ac-CH_3), 3.29 (1H, dd, H-4), 3.46 (1H, dd, H-2), 3.51 (1H, dd, H-6a), 3.65 (1H, t, H-3), 3.71 (3H, s, OCH_3), 3.83 (1H, d, H-5'), 4.01 (1H, td, H-5), 4.12 (1H, dd, H-6b), 4.54 (2H, d, H-1' and 1H for CH_2Ph), 4.73 (1H, ddd, H-2'), 4.70—4.99 (5H for 3×CH_2Ph), 4.89 (1H, dd, H-3'), 5.17 (1H, t, H-4'), 5.20 (1H, d, H-1), 6.18 (1H, d, NH); $J_{1,2}$=4.0, $J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=10.0, $J_{5,6a}$=7.0, $J_{5,6b}$=2.0, $J_{6,6}$=11.5, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2',NH}=J_{3',4'}=J_{4',5'}$=9.0 Hz; *β-anomer*: δ=1.92, 2.00, 2.05 (three 3H, s, 3×Ac-CH_3), 3.29 (1H, dd, H-4), 3.39 (1H, t, H-2), ca. 3.44 (1H, m, H-5), 3.52 (1H, dd, H-6a), 3.73 (3H, s, OCH_3), 3.92 (1H, d, H-5'), 4.14 (1H, dd, H-6b), 4.50, 4.74, 4.94, 5.03 (6H, 3×CH_2Ph), 4.70 (1H, d, H-1'), 4.73 (1H, d, H-1), 4.90 (1H, t, H-3'), 5.22 (1H, dd, H-4'), 6.14 (1H, d, NH), H-2' is overlapped with other signals; $J_{1,2}=J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=10.0, $J_{5,6a}$=7.5, $J_{5,6b}$=2.0, $J_{6,6}$=11.5, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2',NH}=J_{3',4'}=J_{4',5'}$=9.0 Hz; ^{13}C NMR ($CDCl_3$) *α-anomer*: δ=20.64, 20.77 (2×OAc-CH_3), 23.14 (NAc-CH_3), 49.53 (C-2'), 52.77 (OCH_3), 66.62 (C-4'), 69.97 (C-6), 70.64 (C-3'), 72.57 (C-5'), 72.90, 74.84, 75.61 (CH_2Ph), 77.78 (C-4), 79.81 (C-2), 81.77 (C-5), 84.60 (C-3), 90.79 (C-1), 100.03 (C-1'), 167.69 (<u>C</u>$OOCH_3$), 170.28, 170.82, 171.47, (3×CO); *β-anomer*: 20.62, 20.85 (2×OAc-CH_3), 23.20 (NAc-CH_3), 49.74 (C-2'), 52.83 (OCH_3), 66.41 (C-4'), 70.44 (C-6), 71.28 (C-3'), 72.90 (C-5'), 74.54, 74.77, 75.64 (CH_2Ph), 82.88 (C-2), 97.39 (C-1), 100.28 (C-1'), 167.61 (<u>C</u>$OOCH_3$), 169.94, 170.82, 171.44 (3×CO); MS (FAB) *m/z* 766 $[M+H]^+$, 788 $[M+Na]^+$. Found: C, 62.86; H, 6.24; N, 1.72%. Calcd for $C_{40}H_{47}NO_{14}$: C, 62.74; H, 6.19; N, 1.83%.

2,3,4-Tri-*O*-benzyl-6-*O*-(methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranosyl Fluoride (20). (Diethylamino)sulfur trifluoride (76.0 μl, 0.620 mmol) was added to a cooled (−30 °C), stirred solution of **19** (238 mg, 0.310 mmol) under nitrogen atmosphere. The mixture was stirred at room temperature for 2 h, treated with methanol (60 μl) at −30 °C, and concentrated to dryness. The residue was dissolved in dichloromethane (20 ml), washed with 5% aqueous $NaHCO_3$ (20 ml) and water (3×20 ml), dried (Na_2SO_4), and evaporated to give a syrup. Elution through a silica-gel column with chloroform–ethyl acetate (1:2), and concentration of the fraction containing **20** gave 233 mg (98%) as a colorless syrup (α:β=1:5, ^{1}H NMR): $[\alpha]_D^{20}$ +7.5° (*c* 1.43 $CHCl_3$); ^{1}H NMR ($CDCl_3$) *β-anomer*: δ=1.99, 2.02, 2.07 (three 3H, s, 3×Ac-CH_3), 3.52 (1H, dd, H-4), 3.56 (1H, dd, H-2), 3.59 (1H, dd, H-6a), 3.61 (1H, td, H-5), 3.68 (1H, dd, H-3), 3.71 (3H, s, OCH_3), 3.99 (1H, d, H-5'), 4.12 (1H, dd, H-6b), 4.56—4.90 (3×CH_2Ph), 4.57 (1H, d, H-1'), 4.66 (1H, dd, H-2'), 4.96 (1H, dd, H-3'), 5.27 (1H, dd, H-1), 5.29 (1H, t, H-4'), 6.09 (1H, d, NH); $J_{1,2}$=6.5, $J_{2,3}$=7.0, $J_{3,4}$=8.0, $J_{4,5}$=10.0, $J_{5,6a}$=6.0, $J_{5,6b}$=2.0, $J_{6,6}$=10.0, $J_{1',2'}$=2.5, $J_{2',3'}$=4.0, $J_{2',NH}$=8.5, $J_{3',4'}=J_{4',5'}$=8.0, $J_{H,F}$=52.5 Hz; *α-anomer*: δ=1.98, 1.99, 2.06 (three 3H, s, 3×Ac-CH_3), 3.93 (1H, d, H-5'), 6.00 (1H, d, NH), 5.47 (1H, d, H-1); $J_{1,2}$=3.0, $J_{H,F}$=53.0, $J_{2',NH}$=9.0, $J_{4',5'}$=8.0; ^{13}C NMR ($CDCl_3$) *β-anomer*: δ=20.56, 20.67 (2×Ac-CH_3), 23.08 (NAc-CH_3), 48.74 (C-2'), 52.59 (OCH_3), 66.69 (C-4'), 68.55 (C-6), 70.07 (C-3'), 72.19 (C-5'), 74.17, 74.73, 75.15 (CH_2Ph), 74.47 (C-5), 76.57 (C-4), 81.15 (C-2), 83.17 (C-3), 99.83 (C-1'), 109.45 (C-1); $J_{C1,F}$=216.7, $J_{C2,F}$=22.9, $J_{C3,F}$=10.7, $J_{C5,F}$=4.6 Hz; *α-anomer*: δ=48.61 (C-2'), 98.70 (C-1'), 105.02 (C-1); $J_{C1,F}$=227.4 Hz; MS (FAB) *m/z* 768 $[M+H]^+$, 790 $[M+Na]^+$.

2-(Myristoylamino)ethyl 2,3,4-Tri-*O*-benzyl-6-*O*-(methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (21). ***Method A (Promotion by $SnCl_2$–$AgClO_4$).*** A solution of the fluoride **20** (115 mg, 0.150 mmol) in dry dichloromethane (3 ml) was added to a mixture of 2-(myristoylamino)ethanol[11] (49.0 mg, 0.180 mmol), tin(II) chloride (31.5 mg, 0.165 mmol), and silver perchlorate (34.2 mg, 0.165 mmol) in dry dichloromethane (3 ml) with molecular sieves (3 Å, 300 mg, powder). After stirring in the dark at room temperature overnight, the reaction mixture was diluted with dichloromethane (20 ml), filtered through a pad of Celite. The filtrate was washed with 5% aqueous $NaHCO_3$ (20 ml) and water (3×20 ml), dried (Na_2SO_4), and evaporated to dryness. The residue was eluted through a silica-gel column with chloroform–ethyl acetate (1:4). Concentration of the major fraction and crystallization of the residue from diethyl ether–ethyl acetate (1:1) and excess pentane afforded 95 mg (62%) of **21** as an amorphous powder (α:β=4:1, ^{1}H NMR): $[\alpha]_D^{23}$ +10.6° (*c* 1.15 $CHCl_3$); ^{1}H NMR ($CDCl_3$) *α-anomer*: δ=0.87 (3H, t, CH_3), 1.26 (20H, 10×CH_2), 1.60 (2H, m, $COCH_2C\underline{H}_2$), 1.99, 2.00, 2.04 (three 3H, s, 3×Ac-CH_3), 2.09 (2H, t, $COCH_2$), 3.30 (1H, dd, H-4), 3.42, 3.53 (2H, m, CH_2N), 3.47 (1H, dd, H-6a), 3.49 (1H, dd, H-2), 3.53, 3.66 (2H, m, OCH_2), 3.73 (3H, s, OCH_3), 3.76 (1H, ddd, H-5), 3.88 (1H, d, H-5'), 3.96 (1H, t, H-3), 4.03 (1H, dd, H-6b), 4.48 (1H, d, H-1'), 4.52—4.98 (CH_2Ph), 4.66 (1H, ddd, H-2'), 4.69 (1H, d, H-1), 4.92 (1H, dd, H-3'), 5.19 (1H, t, H-4'), 6.12 (1H, d,N<u>H</u>Ac), 6.32 (1H, t, $CH_2N\underline{H}$); $J_{1,2}$=3.5, $J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=10.0, $J_{5,6a}$=7.0, $J_{5,6b}$=2.0, $J_{6,6}$=11.0, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2'NH}=J_{3',4'}=J_{4',5'}$=9.0 Hz; *β-anomer*: δ=2.19 (2H, t, $COCH_2$), 3.34 (1H, dd, H-4), 3.40 (1H, dd, H-2), 3.57 (1H, dd, H-6a), 3.63 (1H, t, H-3), 3.66, 3.90 (two 1H, m, OCH_2), 3.71 (1H, ddd, H-5), 3.74 (3H, s, OCH_3), 3.94 (1H, d, H-5'), 4.07 (1H, dd, H-6b), 4.37 (1H, d, H-1), 4.51—4.93 (CH_2Ph), 4.65 (1H, m, H-2'), 4.67 (1H, d, H-1'), 4.90 (1H, t, H-3'), 5.21 (1H, dd, H-4'), 6.14 (1H, d, N<u>H</u>Ac), 6.21 (1H, t, $CH_2N\underline{H}$); $J_{1,2}$=8.0, $J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=10.0, $J_{5,6a}$=7.0, $J_{5,6b}$=2.0, $J_{6,6}$=11.0, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2',NH}=J_{3',4'}=J_{4',5'}$=9.0 Hz; ^{13}C NMR ($CDCl_3$) *α-anomer*: δ=14.08 ($CH_3$), 20.58, 20.73 (2×OAc), 22.66—31.89 (10×CH_2), 23.19 (NHAc), 25.68 ($COCH_2\underline{C}H_2$), 36.52 ($CO\underline{C}H_2$), 38.65 (CH_2NH), 49.73 (C-2'), 52.79 (OCH_3), 66.69 (C-4'), 66.84 (OCH_2), 69.39 (C-6), 70.39 (C-5), 70.80 (C-3'), 72.81 (C-5'), 73.38—75.72 (CH_2Ph), 77.84 (C-4), 79.92 (C-2), 81.95 (C-3), 96.73 (C-1), 99.54 (C-1'), 167.54—173.44 (CO); *β-anomer*: δ=20.79, 23.23 (2×Ac-CH_3), 36.65 ($COCH_2$), 39.19 (CH_2NH), 49.75 (C-2'), 52.86 (OCH_3), 62.54 (C-5), 66.60 (C-4'), 68.81 (OCH_2), 71.15 (C-3'), 72.74 (C-5'), 73.38—75.68 (CH_2Ph), 77.96 (C-4), 82.05 (C-2), 84.57 (C-3), 99.46 (C-1'), 103.58 (C-1); MS (FAB) *m/z* 1019 $[M+H]^+$, 1041 $[M+Na]^+$.

Method B (Promotion by Cp_2ZrCl_2–$AgClO_4$): A solution of the fluoride **20** (76.8 mg, 0.100 mmol) in dry dichloromethane (2 ml) was added to a mixture of 2-(myristoylamino)ethanol (32.6 mg, 0.120 mmol), dichlorobis(η^5-cyclopentadienyl)zirconium (29.2 mg, 0.100 mmol), and silver perchlorate (41.4 mg, 0.200 mmol) in dry dichloromethane (2 ml) with molecular sieves (3 Å, 200 mg, powder). The mixture was processed and worked up as described for **21** (*Method A*) to provide 52 mg (51%) of **21** (α:β=4:1,

^{1}H NMR).

2-(Myristoylamino)ethyl 6-*O*-(Methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (22). A solution of **21** (102 mg, 0.100 mmol) in methanol–water (4:1, 50 ml) and acetic acid (2.5 ml) was hydrogenolyzed with 10% palladium on carbon (130 mg) under atmosphere of hydrogen (3.10×10^5 Pa) for 24 h. The mixture was filtered through a pad of Celite, and the filtrate was eluted through a column of basic resin (IR-45), followed by concentration to dryness. The residue was purified by column chromatography [SiO_2, $CHCl_3$–MeOH (6:1)] and concentration of the major fraction gave 84 mg (96%) of **22** as a colorless syrup (α:β=4:1, ^{1}H NMR); $[\alpha]_D^{26}$ −0.20° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) *α-anomer*: δ=0.87 (CH_3), 1.26 (20H, 10×CH_2), 1.58 (2H, m, $COCH_2C\underline{H}_2$), 1.99, 2.05 (3H, and 6H, s, 3×Ac-CH_3), 2.15 (2H, t, $COCH_2$), 3.28 (1H, dd, H-4), 3.31, ca. 3.6 (two 1H, m, CH_2N), 3.42 (1H, dd, H-2), 3.53, 3.72 (two 1H, td, OCH_2), 3.58—3.69 (2H, m, H-5 and H-6a), 3.70 (1H, dd, H-3), 3.75 (3H, s, OCH_3), 4.03 (1H, d, H-5′), 4.15 (1H, dd, H-6b), 4.77 (1H, dd, H-2′), 4.80 (1H, d, H-1), 4.91 (1H, d, H-1′), 5.01 (1H, dd, H-3′), 5.20 (1H, dd, H-4′); $J_{1,2}$=4.0, $J_{2,3}$=8.0, $J_{3,4}$=10.0, $J_{4,5}$=9.0, $J_{5,6b}$=2.0, $J_{6,6}$=10.0, $J_{1',2'}$=1.5, $J_{2',3'}$=4.0, $J_{3',4'}$=10.0, $J_{4',5'}$=9.0 Hz; *β-anomer*: δ=3.74 (3H, s, OCH_3), 3.89 (1H, td, OCH_2), 4.06 (1H, d, H-5′), 4.14 (1H, dd, H-6b), 4.29 (1H, d, H-1), 5.21 (1H, t, H-4′); $J_{1,2}$=8.0, $J_{5,6b}$=2.0, $J_{6,6}$=10.0, $J_{3',4'}=J_{4',5'}$=9.0 Hz; ^{13}C NMR ($CDCl_3$) *α-anomer*: δ=14.08 (CH_3), 20.55, 20.75 (2×OAc-CH_3), 22.66—31.89 (10×CH_2), 23.10 (NAc-CH_3), 25.86 ($COCH_2\underline{C}H_2$), 36.55 ($COCH_2$), 38.88 (CH_2N), 50.07 (C-2′), 52.98 (OCH_3), 66.68 (C-4′), 67.37 (OCH_2), 69.93 (C-6), 70.32 (C-4), 70.96 (C-3′), 71.86 (C-5), 71.98 (C-2), 72.69 (C-5′), 74.05 (C-3), 98.42 (C-1), 99.74 (C-1′), 168.11—174.76 (5×CO); *β-anomer*: δ=20.58, 20.81 (2×OAc-CH_3), 23.05 (NAc-CH_3), 25.76 ($COCH_2\underline{C}H_2$), 36.49 ($CO\underline{C}H_2$) 69.03 (OCH_2), 69.40 (C-6), 99.41 (C-1′), 103.00 (C-1), 168.30—174.23 (CO): MS (FAB) *m/z* 749 $[M+H]^+$, 771 $[M+Na]^+$.

2-(Stearoylamino)ethyl 2,3,4-Tri-*O*-benzyl-6-*O*-(methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (23). ***Method A (Promotion by $SnCl_2$–$AgClO_4$)*:** A solution of 2-(stearoylamino)ethanol[19] (58.9 mg, 0.180 mmol) in dry dichloromethane (3 ml) was treated with the fluoride **20** (115 mg, 0.150 mmol) in the presence of tin(II) chloride (31.5 mg, 0.165 mmol) and silver perchlorate (34.2 mg, 0.165 mmol) as described for **20**→**21** (*Method A*). General workup and column chromatography (SiO_2, chloroform–ethyl acetate 1:4) afforded 86 mg (53%) of **23** as a colorless amophous powder; $[\alpha]_D^{26}$ +14° (*c* 0.52, $CHCl_3$); ^{1}H NMR ($CDCl_3$) revealed it to be an approximate 4:1 mixture of α:β anomers: *α-anomer*: δ=0.88 (3H, t, CH_3), 1.25 (28H, 14×CH_2), 1.59 (2H, m, $COCH_2C\underline{H}_2$), 1.99, 2.01, 2.05 (three 3H, s, 3×Ac-CH_3), 2.19 (2H, t, $COCH_2$), 3.30 (1H, dd, H-4), 3.38 (2H, t, CH_2N), 3.43 (1H, ddd, H-5), 3.49 (1H, dd, H-2), 3.55 (1H, dd, H-6a), ca. 3.6 (2H, m, OCH_2), 3.72 (3H, s, OCH_3), 3.88 (1H, d, H-5′), 3.96(1H, t, H-3), 4.03 (1H, dd, H-6b), 4.49 (1H, d, H-1′), 4.64 (1H, dd, H-2′), 4.69 (1H, d, H-1), 4.92 (1H, dd, H-3′), 4.52—4.98 (CH_2Ph), 5.19 (1H, dd, H-4′), 6.08 (1H, d, N$\underline{H}$Ac), 6.30 (1H, t, $CH_2N\underline{H}$); $J_{1,2}$=4.0, $J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=10.0, $J_{5,6a}$=4.0, $J_{5,6b}$=2.0, $J_{6,6}$=11.0, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2',NH}$=9.0, $J_{3',4'}$=10.0, $J_{4',5'}$=9.0; *β-anomer*: δ=2.01, 2.02, 2.06 (three 3H, s, 3×Ac-CH_3), 2.20 (2H, t, $COCH_2C\underline{H}_2$), 3.74 (3H, s, OCH_3), 4.37 (1H, d, H-1), 5.21 (1H, dd, H-4′), 6.09 (1H, d, NH); $J_{1,2}$=8.0, $J_{3',4'}$=9.0, $J_{4',5'}$=11.0 Hz; ^{13}C NMR ($CDCl_3$) *α-anomer*: δ=14.11 (CH_3), 20.60, 20.75 (2×OAc-CH_3), 22.67—31.91 (14×CH_2), 23.21 (NAc-CH_3), 36.57 ($CO\underline{C}H_2$), 38.65 (OCH_3), 49.73 (C-2′), 66.69 (C-4′), 66.85 (OCH_2), 69.39 (C-6), 70.81 (C-3′), 72.82 (C-5′), 73.39—75.70 (3×CH_2Ph), 74.90 (C-5), 77.83 (C-4), 79.91 (C-2), 81.95 (C-3), 96.74 (C-1), 99.60 (C-1′), 167.55—173.44 (5×CO); *β-anomer*: δ=99.46 (C-1′), 103.58 (C-1); MS (FAB) *m/z* 1075 $[M+H]^+$, 1097 $[M+Na]^+$.

***Method B(Promotion by Cp_2ZrCl_2–$AgClO_4$)*:** A solution of 2-(stearoylamino)ethanol (39.4 mg, 0.120 mmol) in dry dichloromethane (2 ml) was treated with the fluoride **20** (76.8 mg, 0.100 mmol) in the presence of dichlorobis(η^5-cyclopentadienyl)zirconium (29.2 mg, 0.100 mmol) and silver perchlorate (41.4 mg, 0.2 mmol) as described for **20**→**21** (*Method B*). Workup and column chromatography as above afforded 69 mg (64%) of **23** (α:β=4:1, ^{1}H NMR).

2-(Stearoylamino)ethyl 6-*O*-(Methyl 2-acetamido-3,4-di-*O*-acetyl-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (24). A solution of **23** (140 mg, 0.130 mmol) in methanol–water (4:1, 50 ml) was hydrogenolyzed as described for **22**. Workup and column chromatography [SiO_2, chloroform–methanol (6:1)] gave 102 mg (98%) of **24** as a colorless syrup (α:β=4:1, ^{1}H NMR); $[\alpha]_D^{26}$ +6.1° (*c* 0.75, $CHCl_3$); ^{1}H NMR ($CDCl_3$) *α-anomer*: δ=0.87 (3H, t, CH_3), 1.24 (28H, 14×CH_2), 1.56 (2H, m, $COCH_2C\underline{H}_2$), 2.00, 2.04, 2.05 (three 3H, s, 3×Ac-CH_3), 2.14 (2H, t, $COCH_2$), 3.26, 3.59 (two 1H, m, CH_2N), 3.29 (1H, t, H-4), 3.56 (1H, dd, H-2), 3.63 (1H, dd, H-3), 3.5—3.7 (4H, m, OCH_2, H-5, and H-6a), 3.76 (3H, s, OCH_3), 4.02 (1H, d, H-5′), 4.16 (1H, dd, H-6b), 4.77 (1H, dd, H-2′), 4.81 (1H, d, H-1), 4.89 (1H, d, H-1′), 5.01 (1H, dd, H-3′), 5.21 (1H, dd, H-4′), 6.61 (1H, d, NH); $J_{1,2}$=3.5, $J_{2,3}$=8.5, $J_{3,4}=J_{4,5}$=8.0, $J_{5,6b}$=3.0, $J_{6,6}$=10.0, $J_{1',2'}$=1.5, $J_{2',3'}$=4.0, $J_{2',NH}$=9.0, $J_{3',4'}$=10.0, $J_{4',5'}$=9.0 Hz; *β-anomer*: δ=2.04, 2.06 (two 3H, s, 2×Ac-CH_3), 3.32 (1H, t, H-2), 4.05 (1H, d, H-5′), 4.16 (1H, dd, H-6b), 4.27 (1H, d, H-1), 4.74 (1H, dd, H-2′), 4.79 (1H, d, H-1′), 5.23 (1H, t, H-4′), 6.70 (1H, d, NH); $J_{1,2}=J_{2,3}$=8.0, $J_{5,6b}$=3.0, $J_{6,6}$=10.0, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{2',NH}$=8.0, $J_{3',4'}=J_{4',5'}$=9.0 Hz; ^{13}C NMR ($CDCl_3$) *α-anomer*: δ=14.11 (CH_3), 20.59, 20.76 (2×OAc-CH_3), 22.68—31.92 (14×CH_2), 23.14 (NAc-CH_3), 25.86 ($COCH_2\underline{C}H_2$), 36.55 ($CO\underline{C}H_2$), 38.89 (CH_2N), 50.07 (C-2′), 52.94 (OCH_3), 66.67 (C-4′), 67.41 (OCH_2), 69.98 (C-6), 70.36 (C-4), 70.93 (C-3′), 71.90 (C-5), 71.95 (C-2), 72.72 (C-5′), 74.13 (C-3), 98.36 (C-1), 99.77 (C-1′), 167.91—174.75 (5×CO); *β-anomer*: δ=49.61 (C-2′), 52.94 (OCH_3), 69.11 (C-3), 72.49 (C-3′), 73.42 (C-2), 74.92 (C-5), 99.46 (C-1′), 102.98 (C-1), 168.12—174.21 (CO); MS (FAB) *m/z* 805 $[M+H]^+$, 827 $[M+Na]^+$.

2-(Myristoylamino)ethyl 6-*O*-(Sodium 2-acetamido-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (25). To a cooled (0 °C), stirred solution of **22** (37.2 mg, 50.0 μmol) in methanol (1.45 ml) was added 1 M aqueous NaOH (0.72 ml), and the mixture was stirred at room temperature for 20 h. After dilution with methanol (1.5 ml), the resulting mixture was neutralized with acidic resin (Dowex 50W X8, 230 mg), and filtered. The filtrate was concentrated to dryness to give a residue, which was eluted through a silica-gel column with chloro-

form–methanol (1 : 2). The major fraction was concentrated and the residue crystallized from methanol–diethyl ether to give 28.5 mg (79%) of **25** as a colorless amorphous powder ($\alpha:\beta$=4 : 1, ^{1}HNMR); $[\alpha]_D^{21}$ −9.3° (*c* 0.40, MeOH); ^{1}H NMR (CD_3OD) *α-anomer*: δ=0.89 (CH_3), 1.29 (20H, 10×CH_2), 1.60 (2H, m, $COCH_2C\underline{H}_2$), 2.02 (3H, s, NAc-CH_3), 2.19 (2H, t, $COCH_2$), 3.19 (1H, dd, H-4), 3.27, 3.54 (two 1H, m, CH_2N), 3.38 (1H, dd, H-2), 3.46, 3.77 (each 1H, td, OCH_2), 3.57 (1H, d, H-5′), 3.58 (1H, t, H-4′), 3.59 (1H, t, H-3), 3.65 (1H, dd, H-3′), 3.67 (1H, td, H-5), 3.69 (1H, dd, H-6a), 4.11 (1H, dd, H-6b), 4.48 (1H, dd, H-2′), 4.69 (1H, d, H-1′), 4.74 (1H, d, H-1); $J_{1,2}$=4.0, $J_{2,3}=J_{3,4}$=9.0, $J_{4,5}$=8.0, $J_{5,6a}$=7.5, $J_{5,6b}$=2.0, $J_{6,6}$=10.0, $J_{1',2'}$=1.5, $J_{2',3'}$=4.5, $J_{3',4'}=J_{4',5'}$= 9.0 Hz; *β-anomer*: δ=1.91 (3H, s, NAc-CH_3), 3.16 (1H, dd, H-2), 3.88 (1H, td, OCH_2), 4.13 (1H, dd, H-6b), 4.26 (1H, d, H-1), 4.72 (1H, d, H-1′); $J_{1,2}$=8.0, $J_{2,3}$=9.0, $J_{5,6b}$=2.0, $J_{6,6}$=11.0, $J_{1',2'}$=1.5 Hz; ^{13}C NMR (CD_3OD) *α-anomer*: δ=14.73 (CH_3), 23.22 (NAc-CH_3), 24.02—33.36 (10×CH_2), 27.33 ($COCH_2\underline{C}H_2$), 37.53 ($CO\underline{C}H_2$), 40.46 (CH_2N), 54.80 (C-2′), 68.11 (OCH_2), 70.84 (C-6), 71.44 (C-5′), 72.38 (C-4), 73.14 (C-5), 73.79 (C-2), 74.46 (C-3′), 75.42 (C-4′), 78.71 (C-3), 100.29 (C-1), 101.68 (C-1′), 174.91 (COONa), 176.74, 177.80 (2×CO); *β-anomer*: δ=101.66 (C-1′), 104.65 (C-1); MS (FAB) *m/z* 673 $[M+H]^+$, 695 $[M+Na]^+$. Found: C, 49.35; H, 8.15; N, 3.44%. Calcd for $C_{30}H_{53}N_2O_{13}Na\cdot 3H_2O$: C, 49.58; H, 8.18; N, 3.85%.

2-(Stearoylamino)ethyl 6-*O*-(Sodium 2-acetamido-2-deoxy-β-D-mannopyranosyluronate)-α/β-D-glucopyranoside (26). Methyl uronate **24** (32.2 mg, 40.0 μmol) was hydrolyzed with 1 M aqueous NaOH as described for **22**→**25**. General workup, purification by column chromatography [SiO_2, chloroform–methanol (1 : 2)], and crystallization from methanol-diethyl ether gave 27 mg (86%) of **26** as a colorless amorphous powder ($\alpha:\beta$=4 : 1, ^{1}H NMR); $[\alpha]_D^{26}$ −5.3° (*c* 1.0, MeOH); ^{1}H NMR (CD_3OD) *α-anomer*: δ=0.89 (3H, t, CH_3), 1.29 (28H, 14×CH_2), 1.60 (2H, m, $COCH_2C\underline{H}_2$), 2.02 (3H, s, NAc-CH_3), 2.20 (2H, t, $COCH_2$), 3.20 (1H, dd, H-4), 3.28, 3.54 (two 1H, m, CH_2N), 3.39 (1H, dd, H-2), 3.45, 3.78 (two 1H, td, OCH_2), 3.57 (1H, d, H-5′), 3.58 (1H, t, H-4′), 3.59 (1H, dd, H-3), 3.64 (1H, m, H-3′), 3.66 (1H, td, H-5), 3.68 (1H, dd, H-6a), 4.12 (1H, dd, H-6b), 4.48 (1H, dd, H-2′), 4.69 (1H, d, H-1′), 4.75 (1H, d, H-1); $J_{1,2}$=4.0, $J_{2,3}$=10.0, $J_{3,4}$=8.0, $J_{4,5}$=10.0, $J_{5,6a}$=8.0, $J_{5,6b}$=2.0, $J_{6,6}$=10.0, $J_{1',2'}$=2.0, $J_{2',3'}$=4.0, $J_{3',4'}=J_{4',5'}$=9.0 Hz; *β-anomer*: δ=1.91 (3H, s, NAc-CH_3), 3.17 (1H, dd, H-2), 3.87 (1H, td, OCH_2), 4.26 (1H, d, H-1), 4.72 (1H, d, H-1′); $J_{1,2}$=8.0, $J_{2,3}$=9.0, $J_{1',2'}$=2.0 Hz; ^{13}C NMR (CD_3OD) *α-anomer*: δ=14.76 (CH_3), 23.25 (NAc-CH_3), 24.04—33.37 (14×CH_2), 27.35 ($COCH_2\underline{C}H_2$), 37.54 ($CO\underline{C}H_2$) 40.46 (CH_2N), 54.80 (C-2′), 68.14 (OCH_2), 70.82 (C-6), 71.42 (C-5′), 72.34 (C-4), 73.14 (C-5), 73.78 (C-2), 74.47 (C-3′), 75.41 (C-4′), 78.62 (C-3), 100.31 (C-1), 101.67 (C-1′), 174.95 (COONa), 176.74 (NAc-CO), 177.68 ($N\underline{C}OCH_2$); *β-anomer*: δ=23.21 (NAc-CH_3), 69.84 (OCH_2), 75.35 (C-2), 101.67 (C-1′), 104.67 (C-1); MS (FAB) *m/z* 729 $[M+H]^+$, 751 $[M+Na]^+$. Found: C, 51.98; H, 8.24; N, 3.27%. Calcd for $C_{34}H_{61}N_2O_{13}Na\cdot 3H_2O$: C, 52.16; H, 8.62; N, 3.57%.

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