158. Synthesis of the 6-*C*-Methyl and 6-*C*-(Hydroxymethyl) Analogues of *N*-Acetylneuraminic Acid and of *N*-Acetyl-2,3-didehydro-2-deoxyneuraminic Acid

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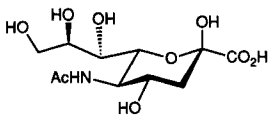
(13.VI.90)

The synthesis of 6-*C*-methyl-Neu2en5Ac (**4**), 6-*C*-(hydroxymethyl)-Neu2en5Ac (**5**), and 6-*C*-methyl-Neu5Ac (**6**) is described. The 4-methylumbellyferyl glycosides **8** and **9** were also prepared but proved unstable. Protection of the previously reported nitro ether **10** (→**11**) followed by a *Kornblum* reaction gave the branched-chain derivative **13** which was transformed into aldehyde **14** and hence *via* **16** into the protected 6-*C*-hydroxymethylated **20** and into the 6-*C*-methyl-substituted **18** (*Scheme 1*). Debenzylidenation of **20** and **18** afforded the diols **21** and **19**, respectively. Selective oxydation of **19** followed by esterification (→**22**), acetylation (→**23**), and elimination led to the protected 6-*C*-methyl-Neu2en5Ac derivative **24** (*Scheme 2*). Bromomethoxylation yielded mainly **25** and some **26**, which were reductively debrominated to **27** and **28**, respectively. Attempted deprotection of **27** did not lead to the corresponding acid, but to the 2,7- and 2,8-anhydro compounds **29** and **30** which were characterised as their peracetylated esters **31** and **32** (*Scheme 3*). The structure of **32** was established by X-ray analysis. Oxydation of **19** and **21**, followed by deprotection, esterification, and acetylation gave **37** and **38**, respectively (*Scheme 4*). The branched-chain Neu2en5Ac derivatives **4** and **5** were obtained by β-elimination (→**39** and **40**) and deprotection. Omission of the esterification after oxydation of **33** and **34** gave the lactones **35** and **36** which were transformed into **37** and **38**, respectively. Bromoacetoxylation of **39** gave **41**–**43** which were reductively debrominated to **44** (from **41** and **42**) and **45** (*Scheme 5*). Bromoacetoxylation of **40** yielded **46** which was debrominated to **47**. Glycosidation of the glycosyl chlorides obtained from **44** and **47** led to the α-D-glycosides **48** and **49** and to the elimination products **39** and **40**, respectively (*Scheme 6*). Transesterification of **48**, followed by saponification gave the unstable glycoside **8** and hence 6-*C*-methyl-Neu5Ac (**6**). The unstable glycoside **9** was obtained by similar treatment of **49** but yielded **50** under acidic conditions. The branched-chain **4** and **5** were weak inhibitors of *Vibrio cholerae* sialidase, and **8** and **9** were very poor substrates.

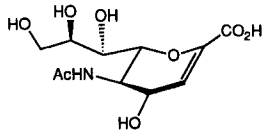
Introduction and Problem. – The biological role of conjugates of *N*-acetylneuraminic acid (Neu5Ac; **1**) and sialic acids in general has been extensively studied and is well documented [1] [2]. The relation between the activity, *i.e.* the inhibition, of several enzymes involved in the biosynthesis and degradation of these conjugates and the structure of sialic acids have also been examined in some detail [1] [2]. Neuraminidases (EC 3.2.1.18) have been studied in relation to their implication in the catabolism, with viral and bacterial infection, and tumor therapy [1–3]. One of the oldest known inhibitors of neuraminidases is *N*-acetyl-2,3-didehydro-2-deoxyneuraminic acid (Neu2en5Ac[1]), **2**; $K_i = 1.3\text{–}9.0 \cdot 10^{-5}$ M[2]) [5–9]. Several other inhibitors are known [1]. None of the analogues of Neu2en5Ac obtained by modifications such as changes of the side chain (length [10], nature of substituents [11] [12], and configuration [13]) and modification at C(4) [14] were stronger inhibitors than Neu2en5Ac. Only replacement of the *N*-acetyl group has led to

[1]) For proposals of pertaining abbreviations, see [4].

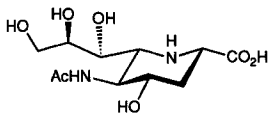
[2]) Depending upon the origin of the neuraminidase.



1 Neu5Ac



2 Neu2en5Ac



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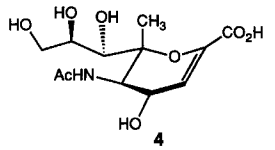

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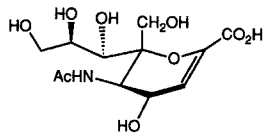

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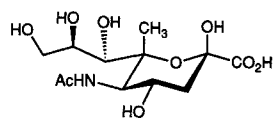

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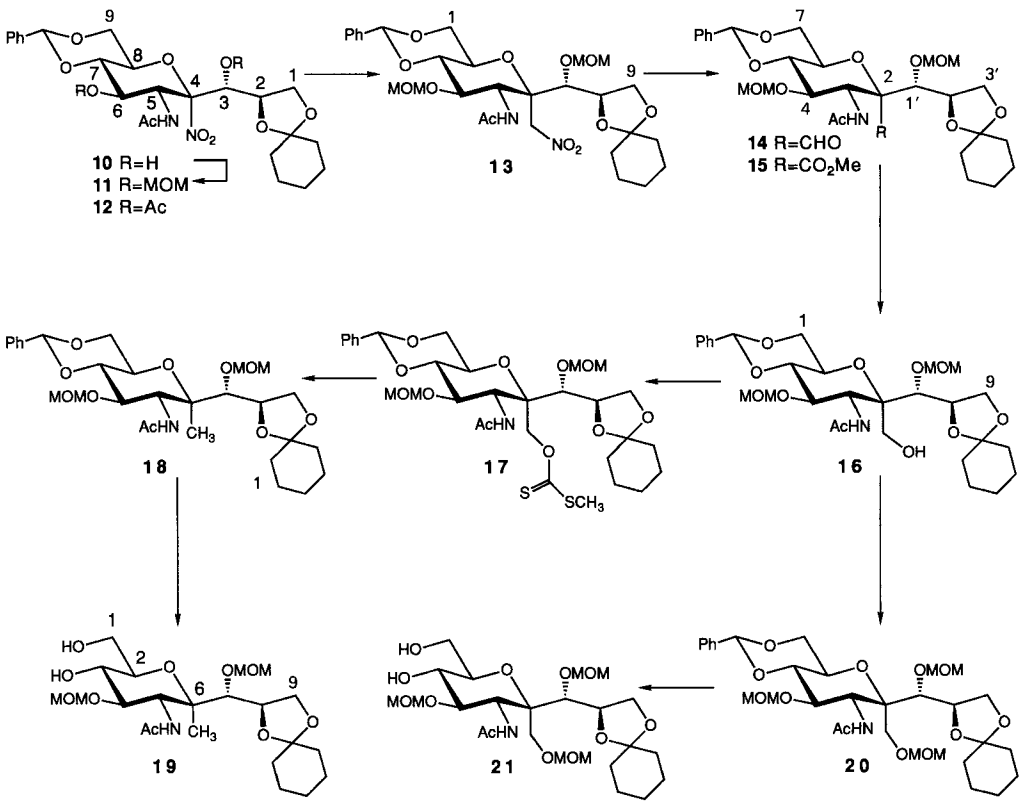
stronger inhibitors [9], and Neu2en5CF_3CO is the most potent neuraminidase inhibitor known so far (K_i values up to $1.9 \cdot 10^{-6}$ M). The 6-amino-6-deoxysialic acids were found to be another class of sialidase inhibitors [15] (see structure **3**, $K_i = 5.4 \cdot 10^{-5}$ M).

To study the effect of substituents on the upper side[3]) of the pyranose ring of sialic acids upon the inhibition of neuraminidases, we have prepared C(2)-branched derivatives [16] of 6-amino-6-deoxyneuraminic acids. To complement these investigations, we planned to prepare C(6)-branched analogues of Neu2en5Ac with a polar (hydroxymethyl) and a non-polar (methyl) substituent at C(6) (see **4** and **5**), based upon the approach used in our second synthesis of Neu5Ac [17]. The key step in the projected route to these branched-chain derivatives, is a *Kornblum* reaction [18] of the nitropyranose **11** (obtained from **10**; *Scheme 1*). We have reported an application of this reaction to a nitrofuranose [19], where a mixture of anomers was obtained in high yields. Equilibration allowed to accumulate the desired isomer. We anticipated that the *Kornblum* reaction will also proceed diastereoselectively in the pyranose series, since the reductive denitration of the diacetate **12** had given a single product with an equatorially oriented side chain [17].

Results and Discussion. – Protection [20] of the previously described **10** [17] (*Scheme 1*) as the bis acetal **11** (66%) and treatement of **11** with excess CH_3NO_2 and NaH in DMSO [18] gave exclusively **13** (94%) with formal retention of configuration. The axial orientation of the nitromethyl group was evidenced by a ^{1}H-NMR NOE between H–C(4) and H–CNO_2 (5.22 ppm). In **13**, H–C(6) (4.67 ppm) is no longer exposed to the shielding effect of the nitro group [17] (*cf.* H–C(4) of **11** at 3.90 ppm). The nitro compound **13** was converted into the aldehyde **14** by ozonolysis of the corresponding nitronate anion in MeOH [21]. Together with the aldehye **14**, various amounts of the methyl ester **15** were formed. Reduction of the crude product with $NaBH_4$ gave a mixture of the alcohol **16** and

[3]) 'Upper side' refers to the medium ring plane in the conventional orientation. By analogy to steroid nomenclature, this may be called the β-side in D-sugars [13].

Scheme 1

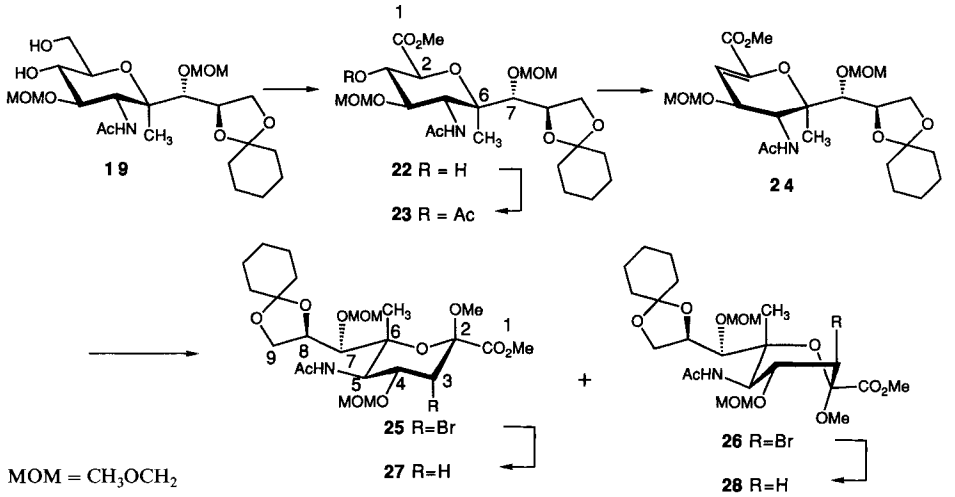


the methyl ester **15** which were separated. Reduction of the mixture **14**/**15** with $LiBH_4$ gave the alcohol **16** in 88% yield. The axial orientation of the formyl group in **14** was established by the ^{1}H-NMR data (long-range coupling of H–CO (9.79 ppm) with H–C(3) (J = 2.2 Hz); the conditions required for a W-coupling are not fulfilled by an equatorial formyl group). As in **11**, H–C(4) of the aldehyde **14** (at 3.7 ppm) and the methyl ester **15** (at 3.75 ppm) are exposed to a shielding effect of the formyl and the methoxycarbonyl group. The alcohol **16** was, on the one hand, deoxygenated [22] *via* the methyl xanthate **17** [23] to give the 6-*C*-methyl compound **18** (86%), and on the other hand transformed into the crystalline methoxymethyl ether **20** (91%) [20]. The benzylidene groups of **18** and **20** were removed by treatment with 4.5–5 equiv. of Na in liq. NH_3 [24] to afford the crystalline diols **19** and **21** in good yields[4]) (88% and 87%, respectively).

Selective oxydation of **19** according to a procedure of *Paulsen et al.* [25], followed by esterification with diazomethane gave **22** (85%; *Scheme 2*). The ^{1}H-NMR spectrum of **22** was devoid of signals of H–C(1), and the resonances of H–C(2) and H–C(3) were shifted downfield by 0.46 and 0.26 ppm, respectively, as compared to those of **19**. All other

[4]) Hydrogenolytic cleavage of the benzylidene group required harsh conditions ($Pd(OH)_2$/C, 8 atm) which led to significant amounts of by-products.

Scheme 2



signals remained almost unchanged. The β-acetoxyester **23** was obtained in quantitative yield and treated with MTBD[5]) to give the elimination product **24** (93%). Bromomethoxylation of **24** with *N*-bromosuccinimide (NBS) in MeOH gave the two diastereoisomeric bromides **25** and **26** which were separated by prep. HPLC (86%; **25**/**26** 94:6). The methyl glycosides **27** and **28** were obtained in high yields by reductive debromination of **25** and **26**. One expects a predominant attack of the bromonium ion opposite to the Me–C(6) of **24**; the major product would then be **25** and the minor one **26**, assuming a *trans*-addition. Interpretation of *Table 1* supports this assumption. The regioselectivity of the bromomethoxylation follows from the appearance of an additional methylene group in the ^{1}H- and ^{13}C-NMR spectra of both **27** and **28**, showing them to be anomers. The diastereoselectivity of the bromoalkoxylation of derivatives of Neu5Ac is known; the *trans*-addition products are obtained exclusively in a ratio of 1:1 [17] [27].

Table 1. *Selected ^{1}H-NMR Data of Neu5Ac6CMe Derivatives.* Coupling constants in Hz and shifts in ppm[a]).

	$J(3\alpha,3\beta)$	$J(3\alpha,4)$	$J(3\beta,4)$	$J(4,5)$	$\delta(H_\alpha\text{–}C(3))$	$\delta(H_\beta\text{–}C(3))$	$\delta(H\text{–}C(5))$	$[\alpha]_D^{25}$
25	–	–	3.2	11.4	–	4.81	4.18	–38.7
26	–	3.9	–	9.8	4.32	–	4.64	–9.3
27	13.1	11.2	4.5	11.0	1.67	2.63	3.79	–38.6
28	14.5	5.2	6.8	9.8	2.08	2.55	4.08	–4.0
41	–	10.7	–	10.7	4.08	–	4.60	–36.7
42	–	–	3.4	11.1	–	4.58	4.98	+22.4
43	–	1.9	–	10.4	4.30	–	5.16	+31.4
44	13.4	11.6	4.7	11.0	2.05	2.50	4.44	–9.9
45	15.8	2.5	8.3	9.5	2.3	2.65	4.97	+54.0
48	14.9	4.8	7.4	10.0	2.35	2.64	4.77	+79.6
49	15.4	3.3	8.0	10.2	2.43	2.69	5.03	+65.7

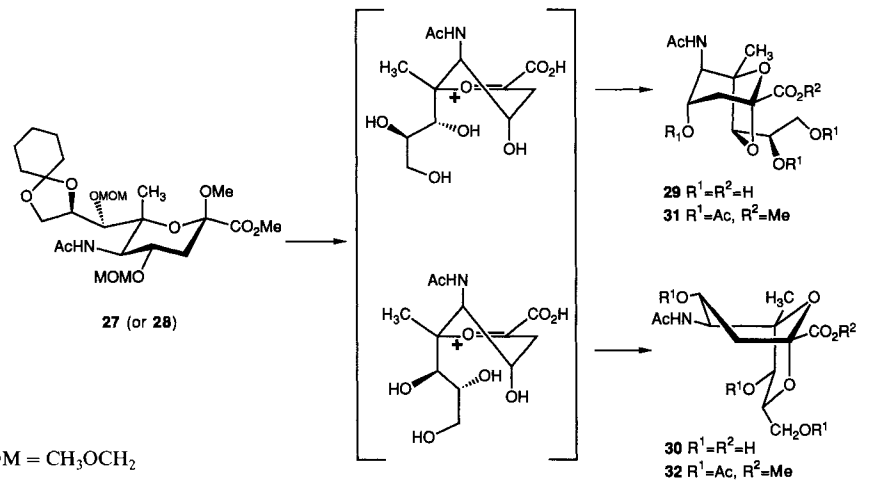
[a]) α and β refer to the lower and upper side of the pyranose ring *(cf. Footnote 3)*.

[5]) MTBD (= 7-Methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene [26]) gave better results than DBU: shorter reaction times and only 1.1 equiv. of the base were required.

The values of $J(3\beta,4)$, $J(3\alpha,4)$, and $J(4,5)$ for **27** (*Table 1*) indicate a *trans*-diaxal arrangement of H_α–C(3)/H–C(4) and H–C(4)/H–C(5) and a synclinal arrangement of H_β–C(3) and H–C(4). This is compatible with a $^2C_5$- or with a $^{O,4}B$-conformation which both show a 1,3-diaxial interaction; the former between the Me–C(6) and (depending upon the anomeric configuration) either the MeO–C(2) or the CO_2Me group, and the latter between CO_2Me or MeO–C(2) and the C_3-side chain. The bromide **25** probably assumes the same conformation as **27**, as the values of $J(3\beta,4)$ and $J(4,5)$ are quite similar to those of **27**. A $^{O,4}B$-form for **25** is even less probable than for **27**, as it entails an additional synperiplanar interaction between Br–C(3) and the CO_2Me or the MeO–C(2) group. The values of $J(3\beta,4)$, $J(3\alpha,4)$, and $J(4,5)$ for **28** indicate an antiperiplanar arrangement only for H–C(4) and H–C(5). Together with the similar values of $J(3\beta,4)$ and $J(3\alpha,4)$ for **28**, these data are only compatible with a $B_{2,5}$-form. The corresponding bromide **26** appears to adopt a similar conformation. These observations are best accomodated by assuming that **27** is the β-D-conformer. According to *A*-values[6]), a 1,3 interaction between a Me and a MeO group is less severe than a 1,3 interaction between a Me and a CO_2Me group. A $^2C_5$-conformation appears to be compatible with the former 1,3 interaction, while the latter one forces the pyranose ring into a boat conformation. In spite of the different conformations of the anomers, *Hudson*'s rule [29] is followed.

Treatment of **27** or **28** with 0.025M HCl was expected to lead to acid **6**, as hydrolysis of the α- and β-D-glycosides of Neu5Ac under similar conditions gives Neu5Ac in good yields. We obtained, however, the 2,7-anhydro product **29** and the 2,8-anhydro product **30** (63%; **29**/**30** = 4:1; *Scheme 3*) as the result of the interception of the intermediate

Scheme 3



MOM = CH_3OCH_2

Table 2. *Selected ^{1}H-NMR Data of the Anhydro Derivatives* **29**–**32** *of 6-C-Methylated Neu5Ac.* Chemical shifts in ppm and coupling constants in Hz[a]).

	$J(3\alpha,3\beta)$	$J(3\alpha,4)$	$J(3\beta,4)$	$J(4,5)$	$\delta(H_\alpha$–C(3))	$\delta(H_\beta$–C(3))	δ(H–C(4))	δ(H–C(7))	δ(H–C(8))	δ(H–C(9))	δ(H′–C(9))
29	15.3	1.2[b])	5.4	5.5	2.04	2.18	3.97	4.46	3.70	3.74	3.62
31				1.5	2.20	2.20	4.92	4.66	5.03	4.62	4.12
30	15.3	6.7	11.1	10.3	2.71	1.99	3.82	3.43	4.10	3.90	3.78
32	15.4	7.1	10.0	9.8	2.83	2.14	4.99	4.94	4.35	4.24	4.18
50	13.2	6.4	10.2	9.7	2.54	1.94	4.06	3.76	3.95	3.87	3.66
51	13.1	6.7	9.9	10.1	2.58	2.05	5.17	5.44	5.21	4.75	4.16

[a]) See *Footnote a* in *Table 1*. [b]) A long-range coupling ($J(3\alpha,5)$) of 1.2 Hz was observed.

[6]) A(COOR) = 1.27–1.31 kcal/mol; A(OAc) = 0.71 kcal/mol [28].

oxonium ion by OH–C(7) and OH–C(8), respectively. The facile anhydro ring formation of 6-*C*-methylated Neu5Ac **6** under acidic conditions is most probably the consequence of the facilitated (pseudo)axial orientation of the C_3 side chain. Similar 2,7-anhydro derivatives of Neu5Ac [30] have been isolated after acid hydrolysis of reduced ($NaBH_4$) internal esters of Neu5Ac residues in brain tissue gangliosides [31] or after methanolysis of sialic acid containing capsular polysaccharides [32]. Moreover, 2,7-anhydro derivatives of 4-epi-Neu5Ac have been found after prolonged treatment by acid of the methyl glycoside of 4-epi-Neu5Ac [33]. The structure of the anhydro derivatives **29** and **30** was deduced from their transformation into the crystalline triacetates **31** and **32** by acetylation and esterification and from the analytical data of **29–32** (*Table 2*). The structure of **32** was confirmed by an X-ray diffraction analysis[7]) (*Fig.*).

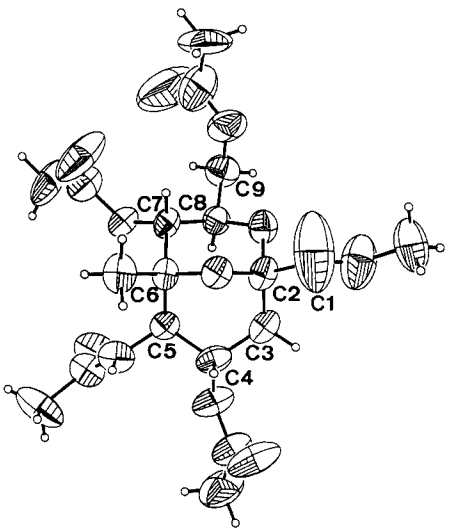


Figure. *Structure of the 2,8-anhydro derivative* **32**

The NMR spectra of **31** and **32** show the presence of an AcNH three AcO, and a CO_2Me group. The ^{1}H-NMR spectra of **29** and **31** show coupling constants in agreement with a $^5C_2$-conformation. The W-coupling between H_α–C(3) and H–C(5) in the spectrum of **29** confirms the $^5C_2$-conformation of the pyranose ring. Comparison of the chemical shifts of H–C(4), H–C(7), H–C(8), and the two H–C(9) in the triol **29** and in the triacetate **31** (*Table 2*) reveals significant shifts ($\Delta\delta$ = 0.5–1.3 ppm) to lower fields only for H–C(4), H–C(8), and the two H–C(9) of **31**, indicating that O–C(7) ($\Delta\delta$(H–C(7)) = 0.2 ppm) is involved in the anhydro ring formation. Comparison of the ^{1}H-NMR spectra of **30** and **32** shows that H–C(8) experiences the smallest downfield shift (0.25 ppm) upon acetylation, leading to the conclusion that H–C(8) is involved in the anhydro ring of **30** and **32**. The values of $J(3\beta,4)$, $J(3\alpha,4)$ and $J(4,5)$ for **30** and **32** are in agreement with a $^{O,4}B$-conformation.

Data Collection, Structure Determination, and Refinement for Compound **32**: Crystallized from CH_2Cl_2/Et_2O/hexane. $C_{19}H_{27}NO_{11}$ (445.42). Hexagonal $P6_5$ (# 170), non-centrosymmetric, a = 13.038(2), b = 13.038(2), c = 23.794(6) Å; volume = 3503 (1) Å^3; D_x = 1.267 Mg/m^3; Z = 6. Intensities were measured in the ω-scan mode on a *Nicolet-R3* diffractometer at 21° using MoK_α graphite-monochromated (λ = 0.71069 Å) radiation (no absorption correction), variable scan speed (2–29.3°/min), and subjected to the usual corrections. For the refine-

[7]) Coordinates and thermal parameters have been deposited with the *Cambridge Crystallographic Data Center*, Cambridge University, University Chemical Lab, Cambridge CB2 1EW, England.

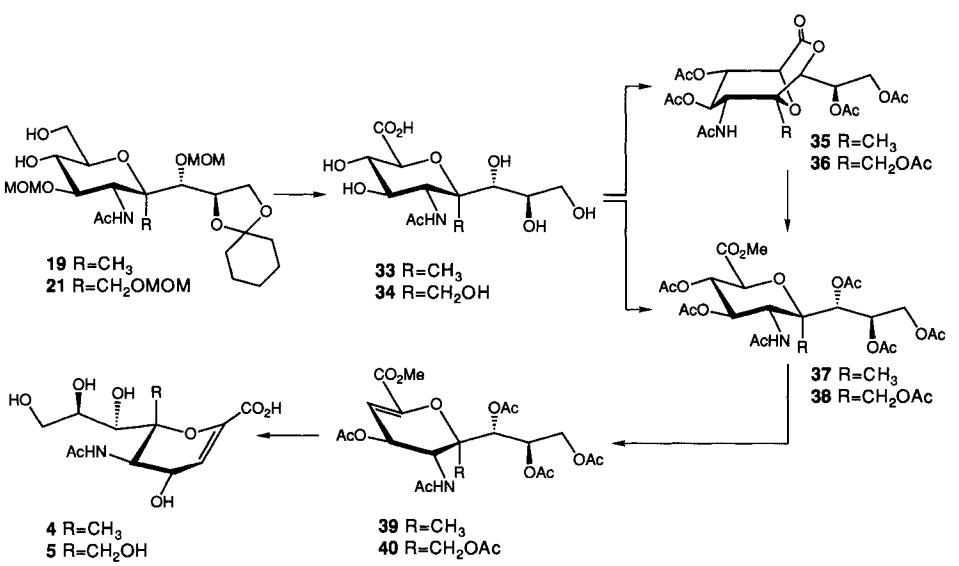
ment of the cell dimensions, 25 reflections were used in the range $20° < 2\theta < 23°$. Of the 8163 total reflections collected, 1289 were observed ($I > 2.5\sigma(I)$). Unique total reflections = 1664 ($R_{merg} = 0.054$). $2\theta_{max} = 46°$; $R = 0.064$; $R_w = 0.049$; $w = 1/(\sigma^2(F)+0.00004 \cdot F^2)$; $< \sigma(d_{c,c}) > = 0.09$–$0.013$ Å. The structure was solved with the direct methods routine of SHELXS86 [34] and the refinement performed with SHELXTL [35] (Version 5.1). All non-H-atoms were located in an *E*-map. All H-atoms were located in a difference *Fourier*, only the H–N was allowed to refine freely, all others were refined using a riding model. All non-H-atoms were refined with anisotropic thermal parameters and the H-atoms with individual isotropic temperature factors. A block-cascade refinement was employed with *ca.* 100 parameters per block. The CO_2Me group is apparently undergoing larger than normal motions in the crystal. There is a single, linear intermolecular H-bond between the N- and the carbonyl O-atom of the AcNH function.

Since we had not obtained the desired acid **6** by hydrolysis of the methyl glycoside containing acid-labile protective groups, we required a glycoside of **6** which can be hydrolysed under milder conditions so as to prevent the undesired anhydro ring formation. Replacement of all protective groups after the oxydation of **19** and of **21** by acetyl groups seemed appropriate, and the basic conditions required for their removal should allow the synthesis of the desired methylumbelliferyl glycosides **8** and **9**.

Thus, the diols **19** and **21** were first oxidised as described above. The resulting crude acids were hydrolysed with 0.025M HCl to the pentol **33** (78%) and to the hexol **34** (not characterised), respectively (*Scheme 4*). Esterification followed by acetylation gave the peracetates **37** (84%) and **38** (66% from **21**), respectively, while direct acetylation of **33** and **34** led to the lactones **35** (quant.) and **36** (73% from **21**).

Formation of 1,4-, 1,7-, 1,8-, or 1,9-lactones is possible[8]). As 5- or 6-membered lactones are preferred over 7- or 8-membered ones, we assume that **35** and **36** are either 1,4- or 1,7-lactones. The formation of 1,4-lactones would give a dioxa[3.2.1]bicyclooctane in which the pyranose ring would have to adopt a $^5C_2$- or a $^{3,6}B$-conformation. The

Scheme 4



[8]) The 1,4- and 1,7-lactones of a Neu5Ac derivative were prepared, but no NMR data for these structures were reported [36]. The 1,4-lactone of Neu5Ac has also been prepared [37].

Table 3. *Selected Coupling Constants* (in Hz) *of* **35–38**

	35	**36**	**37**	**38**
$J(2,3)$	0.8	0.7	9.6	10.2
$J(3,4)$	6.1	6.6	?	9.5
$J(4,5)$	10.9	11.5	10.5	10.9

$^{3,6}B$-conformation is improbable as it implies a severe 1,4-flagpole interaction of Me–C(6) and AcO–C(3). In the $^5C_2$-conformation, H–C(2), H–C(3), H–C(4), and H–C(5) must be in equatorial positions and, therefore, show very similar $J(2,3)$, $J(3,4)$, and $J(4,5)$ coupling constants. One also expects a $J(2,4)$ W-coupling. Neither of these conditions is fulfilled (*Table 3*). The formation of a 1,7-lactone would give a dioxa[3.3.1]bicyclononane in which the pyranose ring would have to adopt a $^5C_2$-, a $^{O,4}B$- or a $^OS_5$-conformation. The $^5C_2$- and the $^{O,4}B$-conformations should show very similar $J(2,3)$ and $J(3,4)$ coupling constants. This is not found, and only the $^OS_5$-conformation corresponds to the ^{1}H-NMR data (*Table 3*). Calculations with the *Alchemy* program (*Tripos Associates, Inc.*) also indicate that **35** and **36** possess a $^OS_5$-conformation which is consistent with the observed values of the coupling constants.

Treatment of the lactones **35** and **36** with NaOMe and then with Ac_2O/pyridine gave the previously obtained peracetates **37** (86%) and **38** (90%), respectively. The protected, branched chain Neu2en5Ac analogues **39** and **40** were obtained from **37** and **38** by elimination of AcOH with 7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene (MTBD) in yields of 88%. Deprotection of the key intermediates **39** and **40** with NaOH yielded quantitatively the 6-*C*-methylated Neu2en5Ac **4** and the 6-*C*-hydroxymethylated Neu2en5Ac **5**. Comparison of the coupling constants observed in the ^{1}H-NMR spectra of **4** and **5** with those of Neu2en5Ac (**2**; *Table 4*) show a significant difference for $J(7,8)$, indicating profound changes of the trihydroxypropyl-chain conformation due to the introduction of a substituent at C(6) (see *Table 4* and discussion in the paragraph on sialidase experiments).

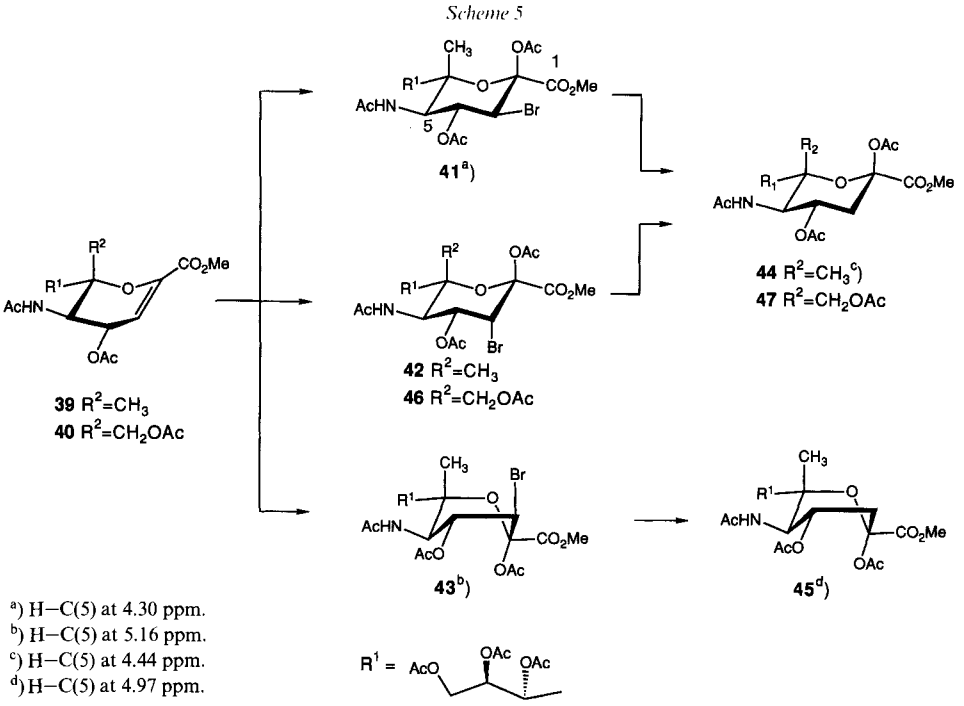
Table 4. *Coupling Constants* (in Hz) *in the Side Chain of Neu2en5Ac and Neu5Ac Analogues*

	$J(7,8)$	$J(8,9)$	$J(8,9')$	$J(9,9')$
1 (Neu5Ac)	8.9	2.6	6.4	–11.8
2 (Neu2en5Ac)	9.3	2.7	6.0	–11.9
4	4.8	3.6	6.8	–11.9
5	6.4	3.2	6.6	–12.0
6	3.6	3.4	7.3	–11.8
33	4.1	3.2	7,9	–11.9
50	6.9	3.0	6.5	–11.9

Bromoacetoxylation of **39** gave a 8:3:1 mixture of the three isomeric acetoxybromides **42**, **43**, and **41** (90%; *Scheme 5*), while olefin **40** yielded exclusively **46** (90%). Reductive debromination of **41** or **42**, **43**, and **46** led in high yields to the corresponding peracetates **44**, **45**, and **47**. The bromides **41** and **42** possess the same anomeric configuration, since they both led to **44**.

The coupling constants ($J(3\beta,4)$, $J(3\alpha,4)$, and $J(4,5)$) of **44** (*Table 1*) indicate a $^2C_5$-conformation of the pyranose ring. This is different for **45**, with coupling constants of 2.5 and 8.3 Hz for $J(3,4)$, pointing to a $B_{2,5}$-conformation which avoids the 1,3-diaxial interaction of Me–C(6) and CO_2Me (compare discussion of the structures **25–28**). The value of the geminal coupling constant $J(3\alpha,3\beta)$ (15.8 Hz) found in **45** is unusually high as

Scheme 5



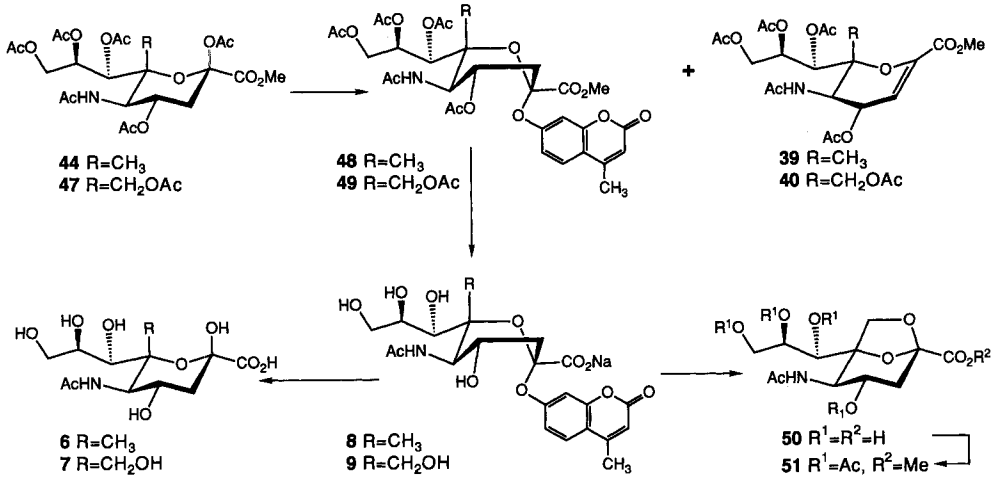
[a]) H–C(5) at 4.30 ppm.
[b]) H–C(5) at 5.16 ppm.
[c]) H–C(5) at 4.44 ppm.
[d]) H–C(5) at 4.97 ppm.

compared to values found for Neu5Ac derivatives (13–14 Hz) and also indicates a modified ring conformation. For the bromides **41**–**43** and **46**, the $J(3,4)$ coupling constants show the *trans*-diaxial orientation of H–C(3) and H–C(4) in **41** ($J(3\alpha,4) = 10.7$ Hz) and the equatorial orientation of H–C(3) in **42** ($J(3\beta,4) = 3.4$ Hz). The assumption of a $B_{2,5}$-conformation of **43** is in keeping with $J(3\alpha,4) = 1.9$ Hz and with a *trans*-orientation of H–C(3) and H–C(4). In agreement with the postulated conformation of **43**, one finds a NOE between H_α–C(3) and H–C(5) and between H_α–C(3) and H–C(4). The chemical shifts of H–C(5) correlate well with the ring conformation of compounds **41**–**45** (see *Scheme 5*). In **41** and **44** ($^2C_5$-conformation), H–C(5) resonates at relatively high fields (4.30 and 4.44 ppm, resp.). In **43** and **45** ($B_{2,5}$-conformation), the H–C(5) signal is shifted downfield[9]) to 5.16 and 4.97 ppm, respectively, due to the vicinity of H–C(5) and O–C(2). In these cases, the relative chemical shift values of the two H–C(3) are not altered, H_α–C(3) always being observed at higher field than H_β–C(3). The anomeric configuration of **44** and **45** is again in agreement with *Hudson*'s rule [29], irrespective of the conformational differences.

Finally the 4-methylumbelliferyl glycosides **48** and **49** (*Scheme 6*) were prepared following a known procedure [38]. Thus, the peracetates **44** and **47** were converted into the corresponding glycosyl chlorides which were immediately submitted to glycosylation with the tetrabutylammonium salt of methylumbelliferone in the presence of silver carbonate to give the α-D-configurated glycosides **48** (35%), **49** (37%), and the olefins **39** (60%) and **40** (40%), respectively. The $J(3,4)$ coupling constants observed for **48** and **49** (see *Table 1*) are similar to those found for **45** and in keeping with a $B_{2,5}$-conformation and an α-D-configuration. The anomeric configuration would then agree with the observation that glycosidation of the acetylated Neu5Ac2Cl with 4-methylumbelliferone yields

[9]) In the bromide **42**, H–C(5) is also found at a lower fields (4.98 ppm) but due to the influence of the axial Br-substiuent.

Scheme 6



exclusively α-D-glycosides (together with the acetylated Neu2en5Ac). Transacetylation of the peracetate **48** (NaOMe/MeOH), followed by saponification of the methyl ester and hydrolysis of the methylumbelliferyl glycoside **8** by rapid filtration of the crude salt through a short column of *Dowex 50WX4* (H^+-form) gave acid **6** (66%). The coupling constants deduced from the ^{1}H-NMR spectrum of **6** indicate a $^2C_5$-conformation[10]). In contrast to Neu5Ac which exists as an equilibrium of 92–95% of the β-D- and 5–8% of the α-D-anomer [1], **6** appears to exclusively exist as the β-D-anomer, due to the highly unfavorable 1,3-diaxial interaction (Me–C(6)/C(1)) in the α-D-anomer. When treated under the same conditions as **48**, **49** gave a mixture of the unstable glycoside **9** and of the 2,1′-anhydro compound **50**. Prolonged treatment of **9** with *Dowex 50WX4* resin or treatment with 0.025M HCl for 1 h led exclusively to **50** (65%). Acid **7** was not found. Attempts to isolate the unprotected methylumbelliferyl glycosides **8** and **9** were unsuccessful due to the high lability of these compounds in acidic as well as in basic solutions. The structure of **50** was mainly deduced from its ^{1}H-NMR spectrum and that of its tetra-*O*-acetyl methyl ester **51**.

The ^{1}H-NMR spectrum of **51** shows signals for 1 MeO and 4 AcO groups, and the MS indicate the correct mass for **50** and **51**. Comparison of the chemical shifts of H–C(4), H–C(7), H–C(8), 2 H–C(9), and 2 H–C(1′) of **50** and **51** show that the $\Delta\delta$ values of the 2 H–C(1′) signals are considerably smaller ($\Delta\delta < 0.05$ ppm) than the corresponding values for H–C(4), H–C(7), H–C(8), and 2 H–C(9) ($\Delta\delta = 0.5$–1.68 ppm), indicating that O–C(1′) is involved in the anhydro ring. Further evidence for the structure of **50** and **51** derives from the observation of a W-type long-range coupling ($J = 1.4$ Hz) between H–C(5) and 1 H–C(1′) of **51**. A dioxa[3.2.1]bicyclooctane system such as **51** fulfills the conditions for such a coupling. The value of the geminal coupling constant $J(1',1')$ (8.4 and 8.8 Hz, resp.) in **50** and **51** is much lower than in the compounds where the CH_2OR group is not part of a ring (> 10 Hz) and confirms the formation of a dioxolane ring involving $OCH_2(1')$ (*cf.* [16]).

Sialidase Experiments. – Both **4** and **5** were found to be weak competitive inhibitors of the *Vibrio Cholerae* sialidase with K_i values of $6.9 \cdot 10^{-3}$ and $9.4 \cdot 10^{-3}$ M, respectively. By comparison, the K_i value of Neu2en5Ac (**2**) under the same conditions was found to be

[10]) See *Table 4* and discussion of the conformation of the trihydroxypropyl chain.

$1.6 \cdot 10^{-5}$ M. The methylumbelliferyl glycosides **8** and **9** were tested as substrates for the *V. Cholerae* sialidase. The glycoside **8** was a poor substrate, showing only 4% of the hydrolysis rate of Neu5Ac2(methylumbelliferyl). It was rapidly hydrolysed simply by standing in aqueous solutions even at pH 10 (blank values represented 85% of the total observed hydrolysis). The glycoside **9** was not a substrate for the enzyme.

Inhibition and Conformation of the Trihydroxypropyl Chain. The above mentioned results show that the introduction of additional substituents at C(6) of Neu2en5Ac diminishes the affinity of these analogues for the enzyme. The reason for this loss of activity might be due either to unfavorable steric interactions with the enzyme and (or) to the modification of the C_3 side chain conformation. It was shown that such changes have dramatical influence upon binding of an inhibitor to the enzyme [39]. One major difference between the conformation of the C_3 side chain of Neu2en5Ac (**2**) and Neu5Ac (**1**) and of **4**–**6**, **33**, and **50** is seen in the values of the $J(7,8)$ coupling constants, which are much lower for **4**–**6**, **33**, and **50** than for Neu2en5Ac and Neu5Ac derivatives (see above and *Table 4*). This change is understandable if one assumes with *Brown et al.* [40] and others [39] [41] that the conformation of the trihydroxypropyl chain in solution is about the same as the one in the solid state [42], since introduction of the Me group at C(6) entails a 1,3-parallel interaction with OH–C(8). No conformer generated by 60° rotations around C(7)–C(8) is, however, more favorable. Compounds **4**–**6**, **33**, and **50** exist almost certainly as mixtures of conformers; one with a value of +60° for the C(9)–C(8)–C(7)–C(6) dihedral angle and the other with a value of 180°. The latter conformation is the one found in Neu5Ac and Neu2en5Ac. The percentage of this conformer would then be higher in the C(6)-hydroxymethylated **5** ($J(7,8) = 6.4$ Hz) than in **4** ($J(7,8) = 3.6$ Hz), in agreement with the possibility to form a H-bond between OH–C(8) and OH–C(1′). The somewhat weaker inhibition by **5** would then mean that steric hindrance and/or polar effects (depending upon the direction of the H-bond[11])) are mainly responsible for the weaker inhibition rather than an altered conformation of the trihydroxypropyl chain.

We thank the *Swiss National Science Foundation, F. Hoffmann-La Roche AG,* and *Sandoz AG,* Basle, for generous support and Dr. *B. Vincent* for the X-ray analysis. We thank Prof. Dr. *R. Schauer,* Kiel, for the detailed protocol for the enzymatic measurements.

Experimental Part

General. see [16].

*5-Acetamido-7,9-*O*-benzylidene-1,2-*O*-cyclohexylidene-4,5-dideoxy-3,6-bis-*O*-(methoxymethyl)-4-nitro-*D*-gluco-*L*-erythro-nonulopyranose* (**11**). A mixture of 24.8 g (48.7 mmol) of **10**, 140 ml of CH_2Cl_2, 70 g (540 mmol) of $Et(i\text{-}Pr)_2N$ and 40 g (480 mmol) of $MeOCH_2Cl$ was stirred for 1 h at 0° and for 48 h at r.t. The solvent was evaporated. Column chromatography (SiO_2, AcOEt/hexane 1:1) gave 19.2 g (66%) of **11**. R_f (AcOEt) 0.58. $[\alpha]_D^{25} = +85.7$ ($c = 1.03$, $CHCl_3$). IR (KBr): 3430*m*, 2930*s*, 2860*m*, 1670*m*, 1550*m*, 1500*w*, 1450*w*, 1370*m*, 1280*w*, 1210*w*, 1150*m*, 1095*s*, 1030*s*, 920*m*, 850*w*, 750*w*, 700*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 6.47 (*d*, $J = 10.3$, NH); 5.54 (*s*, PhC*H*); 5.05 (*t*, $J = 10.2$, H–C(5)); 4.86 (*d*, $J = 6.9$, OCHO); 4.67 (*d*, $J = 6.9$, OCHO); 4.63 (*d*, $J = 6.6$, OCHO); 4.59 (*d*, $J = 6.5$, OCHO); 4.37 (*m*, 1 H–C(9)); 4.25 (*dt*, $J = 6.5$, 5.8, H–C(2)); 4.12 (*d*, $J = 6.7$, H–C(3)); 4.07 (*dd*, $J = 8.8$, 6.0, 1 H–C(1)); 4.03 (*dd*, $J = 8.8$, 5.7, 1 H–C(1)); 3.90 (*t*, $J = 9.3$, H–C(6)); 3.8 (*m*, H–C(7), H–C(8), 1 H–C(9)); 3.34, 3.33 (2*s*, CH_3O); 2.07 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 169.95 (*s*); 136.51 (*s*); 129.07 (*d*); 128.12 (2*d*); 125.90 (2*d*); 115.50 (*s*); 109.95 (*s*); 101.47 (*d*); 99.43

[11]) The larger value of $J(7,8)$ both for **5** and **50** shows that a C(8)OH···OCH_2–C(6) interaction is possible, but does not exclude a C(8)O···$HOCH_2$–C(6) interaction in **5**.

(*d*); 97.25 (*t*); 81.34 (*d*); 80.17 (*d*); 74.76 (*d*); 73.84 (*d*); 68.48 (*d*); 67.88 (*t*); 66,26 (*t*); 56.41 (*q*); 55.75 (*q*); 50.80 (*d*); 35.83 (*t*); 34.20 (*t*); 25.01 (*t*); 24.05 (*t*); 23.72 (*t*); 23.43 (*q*). Anal. calc. for $C_{28}H_{40}N_2O_{12}$ (596.64): C 56.37, H 6.76, N 4.70; found: C 56.17, H 6.59, N 4.60.

*5-Acetamido-2,6-anhydro-1,3-*O*-benzylidene-8,9-*O*-cyclohexylidene-5-deoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-(nitromethyl)-*D-arabino-L-gulo-*nonitol* (**13**). Under N_2, 7.2 ml (134 mmol) of CH_3NO_2 was added dropwise to a suspension of 13 g (542 mmol) of NaH in 100 ml of DMSO. After the foaming had subsided (30 min), a soln. of 20.0 g (33.5 mmol) of **11** in 100 ml of DMSO was added. The yellow mixture was irradiated with a 60-W lamp and stirred for 5 h at r.t. The soln. was acidified with 10 ml of AcOH, stirred for 15 min, and partitioned between AcOEt and brine. Usual workup afforded an oil. Chromatography on SiO_2 (600 g, AcOEt/hexane 2:1) afforded 19.6 g (94%) of **13** as a foam. R_f (AcOEt) 0.35. $[\alpha]_D^{25} = +42.2$ ($c = 0.99$, $CHCl_3$). IR ($CHCl_3$): 3340*w*, 2980 (sh), 2930*s*, 2860*m*, 1725*w*, 1680*s*, 1555*s*, 1450*w*, 1370*m*, 1310*w*, 1280*w*, 1150*m*, 1100*s*, 1025*s*, 970*w*, 940*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 6.55 (*d*, $J = 7.8$, NH); 5.54 (*s*, PhC*H*); 5.22 (*d*, $J = 12.6$, $CHNO_2$); 4.85 (*m*, $CHNO_2$, OCH_2O); 4.80 (*d*, $J = 6.3$, OCHO); 4.76 (*d*, $J = 6.3$, OCHO); 4.67 (*t*, $J = 9.7$, H–C(4)); 4.28 (*dd*, $J = 10.3$, 5.0, H_{eq}–C(1)); 4.24 (*dt*, $J = 3.4$, 7.0, H–C(8)); 4.10 (*d*, $J = 3.4$, H–C(7)); 4.05 (*t*, $J = 9.1$, H–C(5)); 3.9–4.0 (*m*, 2 H–C(9)); 3.65 (*t*, $J = 10.0$, H_{ax}–C(1)); 3.56 (*t*, $J = 9.5$, H–C(3)); 3.45, 3.33 (2*s*, 2 CH_3O); 1.99 (*s*, CH_3CO); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.67 (*s*); 136.90 (*s*); 128.92 (*d*); 128.08 (2*d*); 125.98 (2*d*); 108.75 (*s*); 101.22 (*d*); 99.86 (*t*); 97.48 (*t*); 81.42 (*d*); 81.17 (*d*); 81.17 (*s*); 74.89 (*d*); 74.88 (*t*); 73.92 (*d*); 68.34 (*t*); 65.54 (*d*); 65.17 (*t*); 56.24 (*q*); 55.83 (*q*); 53.91 (*d*); 35.78 (*t*); 34.22 (*t*); 25.00 (*t*); 23.93 (*t*); 23.68 (*t*); 23.54 (*q*). Anal. calc. for $C_{29}H_{42}N_2O_{12}$ (610.66): C 57.04, H 6.93, N 4.59; found: C 57.00 H 7.10, N 4.34.

*3-Acetamido-2,6-anhydro-5,7-*O*-benzylidene-2-*C*-[2,3-*O*-cyclohexylidene-1-*O*-(methoxymethyl)-*D-erythro-*1,2,3-trihydroxypropyl]-3-deoxy-4-*O*-(methoxymethyl)-*D-glycero-D-ido-*heptose* (**14**), *Methyl 3-Acetamido-2,6-anhydro-5,7-*O*-benzylidene-2-*C*-[2,3-*O*-cyclohexylidene-1-*O*-(methoxymethyl)-*D-erythro-*1,2,3-trihydroxypropyl]-3-deoxy-4-*O*-(methoxymethyl)-*D-glycero-D-ido-*heptonate* (**15**), *and 5-Acetamido-2,6-anhydro-1,3-*O*-benzylidene-8,9-*O*-cyclohexylidene-5-deoxy-6-*C*-(hydroxymethyl)-4,7-bis-*O*-(methoxymethyl)-*D-arabino-L-gulo-*nonitol* (**16**). a) *Formation of* **16**. To a soln. of 300 mg (13.04 mmol) of Na in anh. MeOH, 7.96 g (13.035 mmol) of **13** were added. Ozone was bubbled through the soln. at −78° for 15 min. After warming to r.t., 250 ml of H_2O were added, and the soln. was extracted with 4 × 200 ml AcOEt. The org. layer was dried ($MgSO_4$) and evaporated. The residue was dissolved in 100 ml of anh. THF, and 350 mg of $LiBH_4$ were added. MeOH (5 ml) was added dropwise and the soln. stirred for 1 h at r.t. After the addition of 50 ml of AcOEt, the soln. was evaporated. Column chromatography of the residue (SiO_2, AcOEt) gave 6.7 g (88%) of **16**.

b) *Isolation of* **14** *and* **15**. Chromatography (SiO_2, AcOEt) of the product of ozonolysis gave anal. pure **14** and **15**.

c) *Isolation of* **15** *and* **16**: As decribed under *a*), 5.00 g (8.19 mmol) of **13** were ozonolyzed. After addition of 1.0 g of $NaBH_4$ and workup, chromatography of the crude product (SiO_2, AcOEt/hexane 1:1 to AcOEt) gave 686 mg (14%) of **15** and 3.32 g (70%) of **16**.

Data of **16**: R_f(AcOEt) 0.18. $[\alpha]_D^{25} = +12.8$ ($c = 1.08$, $CHCl_3$). IR ($CHCl_3$): 3680*w*, 3620*w*, 3370*m*, 3000*s*, 2940*s*, 2400*w*, 1720*w*, 1670*m*, 1515*w*, 1370*m*, 1200*s*, 1150*m*, 1100*s*, 1025*s*, 975*w*, 875*w*, 850*w*, 770*s*, 710*s*, 665*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 6.86 (*d*, $J = 8.3$, NH); 5.51 (*s*, PhCH); 4.87 (*d*, $J = 6.5$, OCHO); 4.85 (*d*, $J = 6.5$, OCHO); 4.76 (*d*, $J = 6.5$, OCHO); 4.74 (*t*, $J = 9.8$, H–C(5)); 4.74 (*d*, $J = 6.5$, OCHO); 4.68 (*dd*, $J = 9.5$, 5.2, OH); 4.20 (*m*, 1 H–C(1), H–C(3), H–C(8)); 3.95–4.05 (*m*, 4 H, 2 H–C(9), 1 H–C(1′), 1 H–C(1)); 3.83 (*dd*, $J = 12.9$, 5.1, 1 H–C(1′)); 3.78 (*d*, $J = 4.0$, H–C(7)); 3.62 (*m*, H–C(2)); 3.52 (*t*, $J = 9.1$, H–C(4)); 3.48, 3.33 (2*s*, 2 CH_3O); 2.04 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.29 (*s*); 137.23 (*s*); 128.82 (*d*); 128.05 (2*d*); 125.93 (2*d*); 108.70 (*s*); 101.20 (*d*); 100.12 (*t*); 97.25 (*t*); 82.76 (*d*); 81.73 (*s*); 78.51 (*d*); 75.26 (*d*); 74.81 (*d*); 69.24 (*t*); 65.73 (*t*); 65.57 (*d*); 65.15 (*t*); 56.49 (*q*); 55.66 (*q*); 53.33 (*d*); 35.76 (*t*); 35.02 (*t*); 24.99 (*t*); 23.88 (*t*); 23.73 (*t*); 23.73 (*q*). CI-MS 582 (100, $[M + 1]^+$), 564 (32), 550 (74), 452 (20). Anal. calc. for $C_{29}H_{43}NO_{11}$ (581.67): C 59.88, H 7.45, N 2.41; found: C 59.69, H 7.49, N 2.65.

Data of **14**: M.p. 144° (from Et_2O/hexane). R_f (AcOEt) 0.42. $[\alpha]_D^{25} = +110.5$ ($c = 1.04$, $CHCl_3$). IR ($CHCl_3$): 3420*m*, 3000*m*, 2940*s*, 2920*m*, 2860*w*, 1720*m*, 1680*s*, 1500*s*, 1450*w*, 1370*m*, 1280*w*, 1150*m*, 1100*s*, 1030*s*, 970*m*, 920*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 9.79 (*d*, $J = 2.2$, CH=O); 7.3–7.5 (*m*, 5 arom. H); 7.00 (*d*, $J = 10.0$, NH); 5.53 (*s*, PhC*H*); 4.87 (*d*, $J = 6.9$, OCHO); 4.78 (*d*, $J = 7.4$, OCHO); 4.64 (*d*, $J = 6.9$, OCHO); 4.61 (*d*, $J = 7.4$, OCHO); 4.57 (*dt*, $J = 2.1$, 10.0, H–C(3)); 4.43 (*dd*, $J = 10.5$, 4.2 H_{eq}–C(7)); 4.32 (*ddd*, $J = 8.7$, 6.0, 5.4, H–C(2′)); 4.16 (*dd*, $J = 9.1$, 5.2, 1 H–C(1′)); 4.11 (*d*, $J = 9.1$, 6.2, 1 H–C(3′)); 3.88 (*t*, $J = 9.9$, H_{ax}–C(7)); 3.70 (*m*, H–C(6), H–C(5), H–C(4)); 3.65 (*d*, $J = 8.7$, H–C(3′)); 3.36, 3.31 (2*s*, 2 CH_3O); 2.07 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 205.01 (*d*); 169.91 (*s*); 136.93 (*s*); 129.05 (*d*); 128.20 (2*d*); 125.97 (2*d*); 110.98 (*s*); 101.38 (*d*); 100.22 (*t*); 97.34 (*t*); 85.16 (*s*); 82.95 (*d*); 81.52 (*d*); 76.34 (*d*); 72.76 (*d*); 68.64 (*t*); 68.07 (*d*); 66.77 (*t*); 56.28 (*q*); 55.82 (*q*); 51.40 (*d*); 35.82 (*t*); 34.62 (*t*); 24.99 (*t*); 23.83 (2*t*); 23.82 (*q*). CI-MS: 580 (100, $[M + 1]^+$), 548 (36). Anal. calc. for $C_{29}H_{41}N_2O_{11}$ (579.65): C 60.09, H 7.13, N 2.42; found: C 59.93, H 7.08, N 2.47.

Data of **15**: R_f (AcOEt) 0.35. $[\alpha]_D^{25} = +40.4$ ($c = 1.06$, $CHCl_3$). IR ($CHCl_3$): 3420*w*, 2960*m*, 1720*m*, 1680*m*, 1500*m*, 1370*m*, 1310*m*, 1150*m*, 1095*s*, 1025*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, arom. H); 6.95 (*d*, $J = 10.1$, NH); 5.52 (*s*, PhC*H*); 4.88 (*d*, $J = 6.9$, OCHO); 4.75 (*d*, $J = 6.4$, OCHO); 4.68 (*d*, $J = 6.9$, OCHO); 4.66 (*d*, $J = 6.4$, OCHO); 4.53 (*t*, $J = 10.1$, H–C(3)); 4.32 (*dd*, $J = 9.8, 2.4$, H_{eq}–C(7)); 4.25 (*q*, $J = 6.2$, H–C(2′)); 4.03 (*m*, 2H–C(3′)); 3.94 (*d*, $J = 5.8$, H–C(1′)); 3.84 (*s*, $COOCH_3$); 3.7–3.8 (*m*, H_{ax}–C(7), H–C(6), H–C(5), H–C(4)); 3.39, 3.32 (2*s*, 2 CH_3O); 2.03 (*s*, CH_3CON); 1.3–1.6 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.68 (*s*); 169.37 (*s*); 136.83 (*s*); 128.71 (*d*); 127.90 (2*d*); 125.70 (2*d*); 109.10 (*s*); 101.20 (*d*); 99.62 (*t*); 96.96 (*t*); 83.49 (*s*); 81.30 (*d*); 81.02 (*d*); 75.59 (*d*); 73.98 (*d*); 68.44 (*t*); 67.89 (*d*); 65.50 (*t*); 56.32 (*q*); 55.48 (*q*); 52.65 (*q*); 51.44 (*d*); 35.75 (*t*); 34.48 (*t*); 24.87 (*t*); 23.73 (*t*); 23.52 (*t*); 23.52 (*q*). Anal. calc. for $C_{30}H_{43}NO_{12}$ (609.68): C 59.10, H 7.11, N 2.30; found: C 59.36, H 7.31, N 2.30.

*5-Acetamido-2,6-anhydro-1,3-*O*-benzylidene-8,9-*O*-cyclohexylidene-5-deoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-{[(thiomethyl)thiocarbonyloxy]methyl}-*D*-arabino-*L*-gulo-nonitol* (**17**). A soln. of 6.8 g (11.7 mmol) of **16**, 30 ml of DMSO, 12 ml of CS_2 and 12 ml of 5N NaOH was stirred for 5 min at 10°. After the addition of 21 ml of CH_3I, stirring was continued for 1 h at r.t. and H_2O (200 ml) was added. The aq. layer was extracted with AcOEt (4 × 150 ml) and the org. layers dried ($MgSO_4$) and evaporated. Column chromatography (SiO_2, AcOEt/hexane 2:1) gave 6.97 g (89%) of **17**. R_f(AcOEt) 0.52. $[\alpha]_D^{25} = +42.2$ ($c = 1.01$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3000*m*, 2940*s*, 2900*m*, 2860*m*, 1690*s*, 1500*m*, 1450*m*, 1370*m*, 1280*w*, 1150*s*, 1060*s*, 1030*s*, 930*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 5.91 (*d*, $J = 8.9$, NH); 5.55 (*s*, PhCH); 5.03 (*d*, $J = 12.6$, 1 H–C(1′)); 4.97, 4.88 (2*d*, $J = 6.0$, OCHO); 4.88 (*d*, $J = 12.4$, 1 H–C(1′)); 4.87, 4.72 (2*d*, $J = 6.6$, OCHO); 4.43 (*t*, $J = 9.5$, H–C(5)); 4.36 (*t*, $J = 9.5$, H–C(4)); 4.24 (*m*, H–C(8), H_{eq}–C(1)); 4.00 (*d*, $J = 7.1$, 2H–C(9)); 3.86 (*d*, $J = 4.1$, H–C(7)); 3.72 (*m*, H–C(2), H_{ax}–C(1)); 3.61 (*t*, $J = 9.4$, H–C(3)); 3.50, 3.34, (2*s*, 2 CH_3O); 2.64 (*s*, CH_3S); 2.01 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 214.69 (*s*); 170.29 (*s*); 136.98 (*s*); 128.71 (*d*); 127.91 (2*d*); 125.77 (2*d*); 108.59 (*s*); 101.00 (*d*); 99.84 (*t*); 97.34 (*t*); 81.61 (*d*); 80.98 (*s*); 78.75 (*d*); 74.61 (*d*); 73.93 (*t*); 68.74 (*t*); 65.55 (*d*); 65.28 (*t*); 56.37 (*q*); 55.93 (*q*); 52.39 (*d*); 35.70 (*t*); 34.71 (*t*); 24.92 (*t*); 23.72 (*t*); 23.64 (*t*); 23.50 (*q*); 19.30 (*q*). CI-MS: 672 (5, $[M + 1]^+$), 640 (11), 564 (100), 532 (33). Anal. calc. for $C_{31}H_{45}NO_{11}S$ (671.82): C 55.42, H 6.75, N 2.08, S 9.54; found: C 55.64, H 6.65, N 1.92, S 9.65.

*5-Acetamido-2,6-anhydro-1,3-*O*-benzylidene-8,9-*O*-cyclohexylidene-5-deoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-arabino-*L*-gulo-nonitol* (**18**). A soln. of 4.01 g (5.97 mmol) of **17**, 4.7 ml of Bu_3SnH, and 490 mg of 2,2′-dimethyl-2,2′-azobis[propanenitrile] (AIBN) in 100 ml of PhH was heated under reflux for 1 h. The solvent was evaporated, and chromatography of the residue (SiO_2, AcOEt/hexane 1:1 to AcOEt) gave 2.91 g (86%) of **18**. R_f(AcOEt) 0.22. $[\alpha]_D^{25} = +3.5$ ($c = 1.01$, $CHCl_3$). IR ($CHCl_3$): 3480*w*, 3000*m*, 2940*s*, 2900*m*, 2860*m*, 1680*s*, 1510*m*, 1450*m*, 1370*m*, 1280*w*, 1150*m*, 1100*s*, 1030*s*, 925*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 6.17 (*d*, $J = 8.1$, NH); 5.53 (*s*, PhC*H*); 4.92 (*d*, $J = 5,9$, OCHO); 4.83 (*d*, $J = 6.3$, OCHO); 4.80 (*d*, $J = 5.8$, OCHO); 4.80 (*d*, $J = 6.3$, OCHO); 4.58 (*dd*, $J = 10.3, 9.2$, H–C(4)); 4.33 (*ddd*, $J = 8.4, 6.5, 2.1$, H–C(8)); 4.16 (*dd*, $J = 10.0, 4.5$, H_{eq}–C(1)); 3.97 (*dd*, $J = 10.5, 8.2$, H–C(5)); 3.96 (*t*, $J = 8.4$, 1 H–C(9)); 3.89 (*dd*, $J = 8.6, 6.5$, 1 H–C(9)); 3.82 (*d*, $J = 2.1$, H–C(7)); 3.71 (*t*, $J = 9.9$, H_{ax}–C(1)); 3.62 (*dt*, $J = 4.5, 9.5$, H–C(2)); 3.53 (*t*, $J = 9.2$, H–C(3)); 3.50, 3.34 (2*s*, 2 CH_3O); 1.99 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2); 1.41 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.07 (*s*); 137.16 (*s*); 128.76 (*d*); 128.01 (2*d*); 125.85 (2*d*); 108.07 (*s*); 101.11 (*d*); 99.69 (*t*); 97.33 (*t*); 82.61 (*d*); 80.42 (*s*); 80.03 (*d*); 75.08 (*d*); 74.20 (*d*); 68.92 (*t*); 64.44 (*d* + *t*), 56.40 (*q*); 55.75 (*q*); 54.09 (*d*); 35.69 (*t*); 34.89 (*t*); 25.01 (*t*); 23.83 (2*t*); 23.72 (*q*); 18.21 (*q*). CI-MS: 566 (18, $[M + 1]^+$), 534 (100), 436 (43). Anal. calc. for $C_{29}H_{43}NO_{10}$ (565.67): C 61.58, H 7.66, N 2.48; found: C 61.59, H 7.84, N 2.24.

*5-Acetamido-2,6-anhydro-8,9-*O*-cyclohexylidene-5-deoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-arabino-*L*-gulo-nonitol* (**19**). To a soln. of 3.18 g (5.62 mmol) of **18** in 300 ml of liq. NH_3 at −35°, 630 mg (4.9 equiv.) of freshly cut Na were added (soln. remains blue). After stirring for 30 min, 100 ml of MeOH were slowly added, and the soln. was evaporated. Chromatography of the residue (SiO_2, CH_2Cl_2/MeOH 96:4 to 94:6) gave 2.37 g (88%) of **19**. M.p. 76° (CH_2Cl_2/hexane). R_f (CH_2Cl_2/MeOH 9:1) 0.40. $[\alpha]_D^{25} = -45.3$ ($c = 1.02$, $CHCl_3$). IR ($CHCl_3$): 3470*s* (br.), 3000*m*, 2940*s*, 2900*m*, 2860*m*, 1675*s*, 1530*m*, 1450*m*, 1380*m*, 1370*m*, 1280*w*, 1150*m*, 1105*s*, 1080*s*, 1070*s*, 1030*s*, 960*w*, 930*m*, 910*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 670 (*d*, $J = 6.7$, NH); 4.93 ((*d*, $J = 6.2$, OCHO); 4.84 (br. *s*, OH); 4.79 (*d*, $J = 7.0$, OCHO); 4.74 (*dd*, $J = 11.1, 8.5$, H–C(4)); 4.72 (*d*, $J = 6.2$, OCHO); 4.65 (*d*, $J = 7.0$, OCHO); 4.35 (*dt*, $J = 1.7, 7.3$, H–C(8)); 3.93 (*m*, 2H–C(9)); 3.89 (*d*, $J = 1.7$, H–C(7)); 3.79 (*dd*, $J = 11.4, 4.1$, 1 H–C(1)); 3.71 (*dd*, $J = 11.4, 4.3$, 1 H–C(1)); 3.50 (*dt*, $J = 9.6, 4.3$, H–C(2)); 3.48 (*dd*, $J = 11.1, 6.7$, H–C(5)); 3.45, 3.43 (2*s*, 2 CH_3O); 3.30 (*dd*, $J = 9.5, 8.6$, H–C(3)); 1.92 (*s*, CH_3CON); 1.5–1.8 (*m*, 5 CH_2); 1.33 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.33 (*s*); 107.97 (*s*); 99.68 (*t*); 97.89 (*t*); 81.53 (*d*); 80.81 (*d*); 79.37 (*s*); 75.23 (*d*); 73.28 (*d*); 71.01 (*d*); 64.27 (*t*); 62.87 (*t*); 56.18 (*q*); 55.59 (*q*); 54.27 (*d*); 35.67 (*t*); 34.80 (*t*); 24.96 (*t*); 23.94 (*t*); 23.78 (*t*); 23.65 (*q*); 17.28 (*q*). Anal. calc. for $C_{22}H_{39}NO_{10}$ (477.56): C 55.33, H 8.23, N 2.93; found: C 55.39, H 8.21, N 3.18.

5-Acetamido-4,8-anhydro-7,9-O-benzylidene-1,2-O-cyclohexylidene-5-deoxy-6-C-(methoxymethoxymethyl)-4,7-bis-O-(methoxymethyl)-D-arabino-L-gulo-*nonitol* (**20**). To a soln. of 4.00 g (6.88 mmol) of **16** in 10 g (80 mmol) of Et(i-Pr$_2$)N at 0°, excess MeOCH$_2$Cl (5.6 ml, 70 mmol) was added. After stirring for 15 h at r.t., the soln. was evaporated. Chromatography of the residue (SiO_2, AcOEt) gave 3.90 g (91%) of crystalline **20**. M.p. 152–154° (from CH_2Cl_2/hexane). R_f(CH_2Cl_2/MeOH 9:1) 0.72. $[\alpha]_D^{25}$ = +40.3 (*c* = 1.1, $CHCl_3$). IR ($CHCl_3$): 3420*m*, 3380*m*, 2930*s*, 1740*w*, 1680*s*, 1505*w*, 1450*m*, 1370*m*, 1280*w*, 1150*s*, 1100*s*, 1020*s*, 930*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.3–7.5 (*m*, 5 arom. H); 6.42 (*d*, *J* = 9.8, NH); 5.54 (*s*, PhCH); 4.90 (*m*, 3 OCHO); 4.73 (*d*, *J* = 6.2, OCHO); 4.68 (*d*, *J* = 6.9, OCHO); 4.64 (*d*, *J* = 6.2, OCHO); 4.56 (*t*, *J* = 9.8, H–C(5)); 4.26 (*t*, *J* = 9.5, H–C(6)); 4.21 (*dd*, *J* = 10.3, 4.9, H_{eq}–C(9)); 4.15 (*ddd*, *J* = 8.1, 6.2, 3.0, H–C(2)); 4.01 (*t*, *J* = 8.3, 1 H–C(1)); 3.93 (*dd*, *J* = 8.6, 6.3, 1 H–C(1)); 3.91 (*m*, 2H–C(1′)); 3.88 (*dt*, *J* = 9.9, 4.9, H–C(8)); 3.73 (*d*, *J* = 3.1, H–C(3)); 3.68 (*t*, *J* = 10.2, H_{ax}–C(9)); 3.60 (*t*, *J* = 9.4, H–C(7)); 3.52, 3.46, 3.33 (3*s*, 3 OCH_3); 2.00 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 169.79 (*s*); 137.29 (*s*); 128.81 (*d*); 128.08 (2*d*); 125.91 (2*d*); 108.53 (*s*); 101.08 (*d*); 99.84 (*t*); 97.24 (*t*); 97.21 (*t*); 81.87 (*d*); 81.65 (*s*); 77.54 (*d*); 77.34 (*d*); 74.93 (*d*); 72.83 (*t*); 69.14 (*t*); 65.68 (*d*); 65.14 (*t*); 56.70 (*q*); 56.20 (*q*); 55.63 (*q*); 51.79 (*d*); 35.78 (*t*); 35.02 (*t*); 25.08 (*t*); 23.91 (*t*); 23.82 (*t*); 23.67 (*q*). Anal. calc. for $C_{31}H_{47}NO_{12}$ (625.72): C 59.51, H 7.57, N 2.24; found: C 59.31, H 7.47, N 2.41.

5-Acetamido-2,6-anhydro-8,9-O-cyclohexylidene-5-deoxy-6-C-(methoxymethoxymethyl)-4,7-bis-O-(methoxymethyl)-D-arabino-L-gulo-*nonitol* (**21**). As described for **19**, **21** was obtained from **20** in 87% yield. R_f(CH_2Cl_2/MeOH 9:1) 0.43. $[\alpha]_D^{25}$ = +4.8 (*c* = 1.00, $CHCl_3$). IR ($CHCl_3$): 3600*w*, 3380 (br.), 2990*m*, 2940*s*, 2900*m*, 2860*m*, 2830*w*, 1680*s*, 1520*m*, 1450*m*, 1370*m*, 1280*w*, 1150*s*, 1100*s*, 1025*s*, 930*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.54 (*d*, *J* = 8.2, NH); 4.92 (*d*, *J* = 5.9, OCHO); 4.78 (*d*, *J* = 5.9, OCHO); 4.73 (*s*, OCH_2O); 4.64 (*d*, *J* = 6.3, OCHO); 4.61 (br. *s*, OH); 4.60 (*d*, *J* = 6.3, OCHO); 4.36 (*dt*, *J* = 2.7, 7.3, H–C(8)); 4.32 (*dd*, *J* = 10.4, 7.8, H–C(4)); 4.02 (*dd*, *J* = 10.5, 8.3, H–C(5)); 3.95–4.00 (*m*, 2H–C(9), H–C(7)); 3.88 (*s*, 2H–C(1′)); 3.81 (*dd*, *J* = 11.5, 3.8, 1 H–C(1)); 3.72 (*dd*, *J* = 11.6, 4.4, 1 H–C(1)); 3.59 (*dt*, *J* = 9.7, 4.2, H–C(2)); 3.46, 3.45, 3.40 (3*s*, 3 CH_3O); 3.41 (*t*, *J* = 9.4, H–C(3)); 2.0–2.5 (*m*, OH); 1.94 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.04 (*s*); 108.03 (*s*); 99.64 (*t*); 97.80 (*t*); 96.88 (*t*); 83.49 (*d*); 79.59 (*s*); 77.91 (*d*); 75.08 (*d*); 74.21 (*s*); 70.33 (*d*); 69.74 (*t*); 64.64 (*t*); 62.63 (*t*); 56.26 (*q*); 55.79 (*q*); 55.55 (*q*); 51.96 (*d*); 35.57 (*t*); 34.72 (*t*); 24.87 (*t*); 23.68 (*t*); 23.51 (*t*), 23.50 (*q*). CI-MS: 538 (70, $[M + 1]^+$), 506 (53), 408 (100). Anal. calc. for $C_{24}H_{43}NO_{12}$ (537.61): C 53.62, H 8.06, N 2.61; found: C 53.48, H 8.15, N 2.54.

Methyl 5-Acetamido-2,6-anhydro-8,9-O-cyclohexylidene-5-deoxy-4,7-bis-O-(methoxymethyl)-6-C-methyl-D-arabino-L-gulo-*nononate* (**22**). To a soln. of 1.143 g (2.39 mmol) of **19** and 400 mg of $NaHCO_3$ in 100 ml of H_2O, a suspension of Pt(0) in H_2O (prepared by hydrogenation of 1.0 g of PtO_2) was added. O_2 (4 l/h) was bubbled through the rigorously agitated (vibromixer) soln. at 90–100°. After 20 h, the soln. was decanted from the catalyst and the supernatant freeze-dried. The residue was dissolved in MeOH, cooled to 0°, acidified to pH 1–2 with 0.5M HCl and immediately treated with an excess of a CH_2N_2 soln. in Et_2O. Evaporation and chromatography of the residue (SiO_2, CH_2Cl_2/MeOH 96:4) gave 1.027 g (85%) of **22**. R_f (CH_2Cl_2/MeOH 9:1) 0.43. $[\alpha]_D^{25}$ = –45.4 (*c* = 1.07, $CHCl_3$). IR ($CHCl_3$): 3360*m*, 2990*m*, 2940*s*, 2860*m*, 1750*s*, 1680*s*, 1540*m*, 1440*m*, 1385*w*, 1370*m*, 1280*w*, 1200*s*, 1150*s*, 1110*s*, 1070*s*, 1030*s*, 930*m*, 910*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.80 (*d*, *J* = 6.5, NH); 4.94 (*d*, *J* = 6.1, OCHO); 4.82 (*d*, *J* = 7.0, OCHO); 4.82 (*d*, *J* = 0.5, OH); 4.81 (*dd*, *J* = 11.1, 8.6, H–C(4)); 4.75 (*d*, *J* = 6.0, OCHO); 4.68 (*d*, *J* = 6.9, OCHO); 4.33 (*ddd*, *J* = 8.1, 6.6, 1.5, H–C(8)); 3.97 (*t*, *J* = 8.5, 1 H–C(9)); 3.96 (*d*, *J* = 9.8, H–C(2)); 3.91 (br. *s*, H–C(7)); 3.90 (*dd*, *J* = 8.9, 6.6, 1 H–C(9)); 3.79 (*s*, $COOCH_3$); 3.56 (*dt*, *J* = 0.5, 9.0, H–C(3)); 3.55 (*dd*, *J* = 11.1, 6.5, H–C(5)); 3.46, 3.44 (2*s*, 2, CH_3O); 1.94 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2); 1.36 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.26 (*s*); 169.50 (*s*); 107.74 (*s*); 99.66 (*t*); 97.80 (*t*); 81.15 (*d*); 80.42 (*s*); 80.34 (*d*); 75.25 (*d*); 73.01 (*d*); 71.65 (*d*); 64.15 (*t*); 55.99 (*q*); 55.60 (*q*); 54.24 (*d*); 52.17 (*q*); 35.58 (*t*); 34.77 (*t*); 24.91 (*t*); 23.94 (*q*); 23.71 (*t*); 23.59 (*t*); 16.97 (*q*). Anal. calc. for $C_{23}H_{39}NO_{11}$ (505.97): C 54.64, H 7.78, N 2.77; found: C 54.44, H 7.99, N 2.82.

Methyl 5-Acetamido-3-O-acetyl-2,6-anhydro-8,9-O-cyclohexylidene-5-deoxy-4,7-bis-O-(methoxymethyl)-6-C-methyl-D-arabino-L-gulo-*nononate* (**23**). Acetylation of **22** (Ac_2O/pyridine 1:2) and evaporation of the solvents gave **23** in 100% yield. M.p. 192°. R_f (CH_2Cl_2/MeOH 9:1) 0.50. $[\alpha]_D^{25}$ = –22.0 (*c* = 1.02, $CHCl_3$). IR ($CHCl_3$): 3370*m*, 2990*m*, 2940*s*, 2900*m*, 2860*m*, 2820*w*, 1745*s*, 1680*s*, 1530*m*, 1440*m*, 1370*m*, 1230(br.), 1150*s*, 1100*s*, 1070*s*, 1030*s*, 920*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.74 (*d*, *J* = 6.7, NH); 4.90–5.02 (*m*, H–C(3), H–C(4)); 4.94 (*d*, *J* = 6.3, OCHO); 4.77 (*d*, *J* = 6.2, OCHO); 4.75 (*d*, *J* = 6.7, OCHO); 4.63 (*d*, *J* = 6.7, OCHO); 4.32 (*ddd*, *J* = 8.0, 6.5, 1.5, H–C(8)); 4.03 (*t*, *J* = 8.5, 1 H–C(9)); 4.02 (*d*, *J* = 9.8, H–C(2)); 3.93 (*dd*, *J* = 9.0, 6.6, 1 H–C(9)); 3.90 (*d*, *J* = 1.5, H–C(7)); 3.70 (*s*, $COOCH_3$); 3.63 (*dd*, *J* = 10.5, 6.9, H–C(5)); 3.48, 3.30 (2*s*, 2 CH_3O); 2.07 (CH_3CO); 1.94 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2); 1.38 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.36 (*s*); 169.64 (*s*); 168.25 (*s*); 107.84 (*s*); 99.84 (*t*); 98.04 (*t*); 81.45 (*d*); 80.38 (*s*); 76.00 (*d*); 75.25 (*d*); 72.00 (*d*); 72.00 (*d*); 70.68

(*d*); 64.32 (*t*); 56.19 (*q*); 55.77 (*q*); 55.10 (*d*); 52.27 (*q*); 35.65 (*t*); 34.79 (*t*); 24.99 (*t*); 23.98 (*q*); 23.78 (*t*); 23.65 (*t*); 20.66 (*q*). Anal. calc. for $C_{25}H_{41}NO_{12}$ (547.61): C 54.83, H 7.55, N 2.56; found: C 54.75, H 7.37, N 2.41.

*Methyl 5-Acetamido-2,6-anhydro-8,9-*O*-cyclohexylidene-5-deoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-glycero-*D*-galacto-non-2-enonate* (**24**). A soln. of 1060 mg (1.94 mmol) of **23** and 420 µl (2.90 mmol, 1.5 equiv.) of MTBD (7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene) in 20 ml of toluene was heated under reflux for 10 h. After cooling, the solvent was evaporated. Chromatography of the residue (SiO_2, CH_2Cl_2/MeOH 97:3) gave 877 mg (93%) of **24**. R_f (CH_2Cl_2/MeOH 9:1) 0.52. $[\alpha]_D^{25} = +10.1$ (*c* = 1.00 $CHCl_3$). IR ($CHCl_3$): 3430*m*, 2990*m*, 2940*s*, 2900*m*, 2860*m*, 1730*s*, 1675*s*, 1550(sh), 1495*w*, 1440*m*, 1365*w*, 1280*m*, 1240*m*, 1145*w*, 1100*s*, 1030*s*, 940*m*, 915*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.16 (*dd*, *J* = 4.2, 0.9, H–C(3)); 5.99 (br. *d*, *J* = 8.5, NH); 4.84 (*d*, *J* = 6.7, OCHO); 4.80 (*d*, *J* = 6.5, OCHO); 4.66 (*d*, *J* = 6.7, OCHO); 4.62 (*d*, *J* = 6.5, OCHO); 4.53 (br. *s*, H–C(4)); 4.40 (*d*, *J* = 2.9, H–C(7)); 4.38 (br. *dd*, *J* = 8.5, 4.4, H–C(5)); 4.29 (*ddd*, *J* = 8.3, 6.2, 3.0, H–C(8)); 4.07 (*dd*, *J* = 8.0, 6.3, 1 H–C(9)); 3.94 (*t*, *J* = 8.2, 1 H–C(9)); 3.80 (*s*, $COOCH_3$); 3.40, 3.37 (2*s*, 2 CH_3O); 1.97 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2); 1.34 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 169.82 (*s*); 162.57 (*s*); 142.64 (*s*); 108.81 (*d*); 108.55 (*s*); 98.95 (*t*); 95.32 (*t*); 81.72 (*s*); 76.37 (*d*); 75.40 (*d*); 68.79 (*d*); 65.10 (*t*); 56.17 (*q*); 55.64 (*q*); 52.39 (*q*); 51.39 (*d*); 35.90 (*t*); 34.70 (*t*); 25.13 (*t*); 23.90 (*t*); 23.81 (*t*); 23.51 (*q*); 17.68 (*q*). Anal. calc. for $C_{23}H_{37}NO_{10}$ (487.55): C 56.66, H 7.65, N 2.87; found: C 56.57, H 7.91, N 3.14.

*Methyl (Methyl 5-Acetamido-2,6-anhydro-3-bromo-8,9-*O*-cyclohexylidene-3,5-dideoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-erythro-β-*L*-manno-nonulopyranosid)onate* (**25**) *and Methyl (Methyl 5-Acetamido-2,6-anhydro-3-bromo-8,9-*O*-cyclohexylidene-3,5-dideoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-erythro-α-*L*-gluco-nonulopyranosid)onate* (**26**). A soln. of 785 mg (1.61 mmol) of **24** and 345 mg (1.94 mmol, 1.2 equiv.) of NBS in 30 ml of anh. MeOH was stirred at r.t. After 1 h, the solvent was evaporated, and the 2 isomers present in the residue were separated by prep. HPLC (*Zorbax-Sil*, AcOEt/hexane 85:15, injection of 100-mg portions) to give 51 mg (5%) of **26** and 775 mg (81%) of **25**.

Data of **25**: R_f (AcOEt) 0.30 $[\alpha]_D^{25} = -38.7$ (*c* = 1.07, $CHCl_3$). IR ($CHCl_3$): 3380*m*, 3000*m*, 2940*s*, 2910*m*, 2860*m*, 1765*s*, 1740*s*, 1680*s*, 1530*m*, 1450*m*, 1385*w*, 1370*m*, 1240(br.), 1150*s*, 1110*s*, 1060*s*, 1045*s*, 1025*s*, 995*w*, 925*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.50 (*d*, *J* = 7.0, NH); 5.13 (*dd*, *J* = 11.4, 3.3, H–C(4)); 4.95 (*d*, *J* = 7.2, OCHO); 4.94 (*d*, *J* = 6.8, OCHO); 4.81 (*d*, *J* = 6.9, OCHO); 4.81 (*d*, *J* = 3.0, H–C(3)); 4.63 (*d*, *J* = 7.0, OCHO); 4.42 (*ddd*, *J* = 8.4, 6.8, 1.8, H–C(8)); 4.22 (*t*, *J* = 8.6, 1 H–C(9)); 4.20 (*dd*, *J* = 9.3, 6.7, 1 H–C(9)); 4.18 (*dd*, *J* = 11.4, 7.0, H–C(5)); 3.79 (*d*, *J* = 1.8, H–C(7)); 3.80 (*s*, $COOCH_3$); 3.51, 3.45, 3.19 (3*s*, 3 CH_3O); 1.93 (*s*, CH_3CON); 1.47 (*s*, CH_3); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.32 (*s*); 166.23 (*s*); 107.87 (*s*); 101.44 (*s*); 100.03 (*t*); 97.80 (*t*); 82.91 (*s*); 82.48 (*d*); 75.46 (*d*); 69.87 (*d*); 64.89 (*t*); 57.63 (*d*); 56.42 (2*q*); 52.60 (*q*); 52.37 (*q*); 51.69 (*d*); 35.68 (*t*); 35.14 (*t*); 25.02 (*t*); 23.94 (*q*); 23.79 (*t*); 23.75 (*t*); 20.42 (*q*). Anal. calc. for $C_{24}H_{40}BrNO_{11}$ (598.49): C 48.17, H 6.74, N 2.34, Br 13.35; found: C 48.17, H 6.91, N 2.51, Br 13.18.

Data of **26**: R_f (AcOEt) 0.34. $[\alpha]_D^{25} = -9.3$ (*c* = 1.03, $CHCl_3$). IR ($CHCl_3$): 3380*m*, 3030*w*, 2990*m*, 2940*s*, 2900*m*, 2860*m*, 1745*s*, 1680*s*, 1510*m*, 1445*w*, 1365*w*, 1240*s*, 1100*s*, 1025*s*, 920*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.14 (*d*, *J* = 8.6, NH); 5.02 (*dd*, *J* = 9.8, 3.9, H–C(4)); 4.93 (*d*, *J* = 5.8, OCHO); 4.82 (*d*, *J* = 5.6, OCHO); 4.82 (*d*, *J* = 7.0, OCHO); 4.75 (*d*, *J* = 6.9, OCHO); 4.64 (*dd*, *J* = 9.7, 8.7, H–C(5)); 4.42 (*ddd*, *J* = 8.6, 6.1, 2.1, H–C(8)); 4.32 (*d*, *J* = 3.9, H–C(3)); 4.21 (*dd*, *J* = 8.6, 6.1, 1 H–C(9)); 4.02 (*t*, *J* = 8.7, 1 H–C(9)); 3.82 (*d*, *J* = 2.2, H–C(7)); 3.79 (*s*, $COOCH_3$); 3.49, 3.41, 3.40 (3*s*, 3 CH_3O); 1.99 (*s*, CH_3CON); 1.47 (*s*, CH_3); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.10 (*s*); 167.48 (*s*); 108.21 (*s*); 100.75 (*s*); 99.70 (*t*); 97.12 (*t*); 81.61 (*s*); 80.22 (*d*); 78.35 (*d*); 75.35 (*d*); 64.82 (*t*); 56.62 (*q*); 56.08 (*q*); 52.75 (*q*); 52.64 (*d*); 52.05 (*q*); 50.92 (*d*); 35.89 (*t*); 35.34 (*t*); 25.17 (*t*); 24.10 (*q*); 23.99 (*t*); 23.89 (*t*); 21.66 (*q*). Anal. calc. for $C_{24}H_{40}BrNO_{11}$ (598.49): C 48.17, H 6.74, N 2.34, Br 13.35; found: C 48.29, H 6.91, N 2.13, Br 13.20.

*Methyl (Methyl 5-Acetamido-2,6-anhydro-8,9-*O*-cyclohexylidene-3,5-dideoxy-4,7-*bis-O-*(methoxymethyl)-6-*C*-methyl-*D*-glycero-β-*D*-galacto-nonulopyranosid)onate* (**27**). A soln. of 760 mg (1.27 mmol) of **25**, 670 µl (2.54 mmol, 2 equiv.) of Bu_3SnH, and 104 mg (0.63 mmol, 0.5 equiv.) of AIBN in 15 ml of toluene was heated to 100° for 20 min. After cooling, the solvent was evaporated. Chromatography of the residue (SiO_2, AcOEt/hexane 1:1, then AcOEt) gave 620 mg (94%) of **27**. R_f(AcOEt) 0.19. $[\alpha]_D^{25} = -38.6$ (*c* = 1.00, $CHCl_3$). IR ($CHCl_3$): 3470*m*, 3000*s*, 2940*s*, 2900*s*, 2860*m*, 1745*s*, 1680*s*, 1510*m*, 1450*m*, 1370*m*, 1270*m*, 1150*s*, 1100*s*, 1030*s*, 1000*s*, 930*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.29 (*d*, *J* = 7.4, NH); 4.94 (*d*, *J* = 5.8, OCHO); 4.80 (*dt*, *J* = 4.8, 11.9, H–C(4)); 4.79 (*d*, *J* = 6.7, OCHO); 4.79 (*d*, *J* = 5.7, OCHO); 4.63 (*d*, *J* = 6.8, OCHO); 4.43 (*ddd*, *J* = 7.9, 6.8, 1.6, H–C(8)); 4.13 (*t*, *J* = 8.6, 1 H–C(9)); 4.09 (*dd*, *J* = 9.1, 6.7 1 H–C(9)); 3.80 (*d*, *J* = 1.6, H–C(7)); 3.79 (*dd*, *J* = 10.9, 7.4, H–C(5)); 3.77 (*s*, $COOCH_3$); 3.47, 3.34, 3.17 (3*s*, 3 CH_3O); 2.63 (*dd*, *J* = 13.1, 4.5, H_{eq}–C(3)); 1.96 (*s*, CH_3CON); 1.67 (*dd*, *J* = 13.1, 11.2, H_{ax}–C(3)); 1.44 (*s*, CH_3); 1.3–1.7 (*m*, 5 CH_2). ^{13}C-NMR (50 MHz, $CDCl_3$): 169.99 (*s*); 168.21 (*s*); 107.68 (*s*); 99.34 (*s* + *t*); 96.21 (*t*); 81.34 (*s*); 80.89 (*d*); 75.31 (*d*); 69.39 (*d*); 64.68 (*t*); 56.04 (*q*); 55.20

(*q*); 54.58 (*d*); 52.07 (*q*); 51.32 (*q*); 40.04 (*t*); 35.59 (*t*); 34.67 (*t*); 24.94 (*t*); 23.73 (*t*); 23.67 (*q*); 23.59 (*t*); 20.03 (*q*). Anal. calc. for $C_{24}H_{41}NO_{11}$ (519.59): C 55.48, H 7.95, N 2.70; found: C 55.28, H 7.91, N 2.51.

*Methyl (Methyl 5-Acetamido-2,6-anhydro-8,9-*O*-cyclohexylidene-3,5-dideoxy-4,7-bis-*O*-(methoxymethyl)-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosid)onate* (**28**). As described for **27**, **28** was obtained from **26** in 92% yield. R_f(AcOEt) 0.15. $[\alpha]_D^{25} = -4.0$ ($c = 0.8$, $CHCl_3$). IR ($CHCl_3$): 3370*m*, 2990*m*, 2940*m*, 2900 (sh), 2850*m*, 1740*s*, 1675*s*, 1510*m*, 1440*m*, 1365*m*, 1275*m*, 1145*s*, 1100*s*, 1065*s*, 1030*s*, 930*m* 905*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.44 (*d*, $J = 7.5$, NH); 4.99 (*ddd*, $J = 9.8$, 6.8, 5.2, H–C(4)); 4.97 (*d*, $J = 6.1$, OCHO); 4.79 (*d*, $J = 6.0$, OCHO); 4.73 (*d*, $J = 6.9$, OCHO); 4.68 (*d*, $J = 6.9$, OCHO); 4.41 (*ddd*, $J = 8.6$, 6.2, 1.7, H–C(8)); 4.14 (*dd*, $J = 8.6$, 6.2, 1 H–C(9)); 4.08 (*dd*, $J = 9.8$, 7.5, H–C(5)); 4.04 (*t*, $J = 8.6$, 1 H–C(9)); 3.89 (*d*, $J = 1.7$, H–C(7)); 3.76 (*s*, $COOCH_3$); 3.49, 3.37, 3.35 (3*s*, 3 CH_3O); 2.55 (*dd*, $J = 14.5$, 6.8, 1 H–C(3)); 2.08 (*dd*, $J = 14.5$, 5.2, 1 H–C(3)); 1.95 (*s*, CH_3CON); 1.3–1.7 (*m*, 5 CH_2); 1.27 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.20 (*s*); 169.52 (*s*); 107.98 (*s*); 99.74 (*t*); 98.00 (*t*); 96.17 (*t*); 80.87 (*d*); 80.64 (*s*); 75.57 (*d*); 68.88 (*d*); 64.56 (*t*); 56.31 (*q*); 55.46 (*q*); 54.71 (*d*); 52.46 (*q*); 50.95 (*q*); 37.02 (*t*); 35.82 (*t*); 35.27 (*t*); 25.12 (*t*); 24.26 (*q*); 23.94 (*t*); 23.84 (*t*); 20.55 (*q*). Anal. calc. for $C_{24}H_{41}NO_{11}$ (519.59): C 55.48, H 7.95, N 2.70; found: C 55.27, H 8.06, N 2.72.

*5-Acetamido-2,6:2,7-dianhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosonic Acid* (**29**) *and 5-Acetamido-2,6-anhydro-2,8:2,8-dianhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosonic Acid* (**30**). A soln. of 670 mg (1.289 mmol) of a mixture of **27** and **28** in 30 ml of 0.025M HCl/THF 1:1 was stirred at 80° for 2 h, and THF was distilled off. After addition of 15 ml of 0.025M HCl stirring was continued for 18 h at 80–90°, and the soln. was loaded on an ion-exchange resin column (85 cm^3 of *Dowex 1X8*, $HCOO^-$ form). The column was washed with 150 ml of H_2O, and elution with a linear gradient of HCOOH (0.3–0.7M, 200 ml) gave 198 mg (50%) of **29** and 52 mg (13%) of **30** after freeze-drying.

Data of **29**: R_f(PrOH/H_2O 7:3) 0.41. $[\alpha]_D^{25} = +52.2$ ($c = 0.99$, H_2O). IR (KBr): 3700–2300 (br.), 1740*s*, 1635*s*, 1550*s*, 1430*m*, 1380*m*, 1310*m*, 1245*w*, 1210*m*, 1180*m*, 1102*m*, 1100*s*, 1080*s*, 1040*m*, 1015*w*, 940*w*, 920*w*, 880*w*, 845*w*, 770*w*, 720*w*. ^{1}H-NMR (400 MHz, D_2O): 4.46 (*d*, $J = 7.7$, H–C(7)); 3.97 (*dt*, $J = 5.5$, 1.5, H–C(4)); 3.95 (br. *s*, H–C(5)); 3.74 (*dd*, $J = 11.4$, 2.8, 1 H–C(9)); 3.70 (*m*, H–C(8)); 3.62 (*dd*, $J = 11.4$, 5.6, 1 H–C(9)); 2.18 (*dd*, $J = 15.3$, 5.4, 1 H–C(3)); 2.04 (*s*, CH_3CON); 2.04 (*dt*, $J = 15.3$, 1.2, 1 H–C(3)); 1.39 (*s*, CH_3). ^{13}C-NMR (50 MHz, D_2O): 174.16 (*s*); 170.83 (*s*); 103.83 (*s*); 83.88 (*s*); 79.62 (*d*); 70.65 (*d*); 68.40 (*d*); 63.40 (*t*); 55.51 (*d*); 34.21 (*t*); 22.19 (*q*); 16.22 (*q*). FAB-MS: 306 (100, $[M + 1]^+$). Anal. calc. for $C_{12}H_{19}NO_8$ (305.29): C 47.21, H 6.27, N 4.59; found: C 47.10, H 6.47, N 4.60.

Data of **30**: R_f(PrOH/H_2O 7:3) 0.41. $[\alpha]_D^{25} = +93.8$ ($c = 1.00$, H_2O). IR (KBr): 3700–2300 (br.), 1745*s*, 1630*s*, 1560*s*, 1450*m*, 1430*m*, 1385*w*, 1340*w*, 1290*m*, 1250*w*, 1220*m*, 1195*w*, 1150*s*, 1120*m*, 1095*w*, 1075*s*, 1055*w*, 1035*s*, 1100*m*, 960*w*, 935*w*, 905*w*, 860*w*, 820*w*, 770*w*, 740*w*. ^{1}H-NMR (400 MHz, D_2O): 4.10 (*ddd*, $J = 10.3$, 5.2, 2.2, H–C(8)); 4.10 (*d*, $J = 10.2$, H–C(5)); 3.90 (*dd*, $J = 12.4$, 2.2, 1 H–C(9)); 3.82 (*dt*, $J = 6.6$, 10.4, H–C(4)); 3.78 (*dd*, $J = 12.5$, 5.2, 1 H–C(9)); 3.43 (*d*, $J = 103$, H–C(7)); 2.71 (*dd*, $J = 15.3$, 6.7, H_{eq}–C(3)); 2.04 (*s*, CH_3CON); 1.99 (*dd*, $J = 15.2$, 11.1, H_{ax}–C(3)); 1.28 (*s*, CH_3). ^{13}C-NMR (50 MHz, D_2O): 174.59 (*s*); 172.08 (*s*); 95.38 (*s*); 79.42 (*s*); 72.10 (*d*); 69.38 (*d*); 65.17 (*d*); 61.22 (*t*); 52.96 (*d*); 35.63 (*t*); 22.38 (*q*); 22.13 (*q*). FAB-MS: 306 (100, $[M + 1]^+$). Anal. calc. for $C_{12}H_{21}NO_9 \cdot H_2O$ (323.30): C 44.58, H 6.55, N 4.33; found: C 44.49, H 6.76, N 4.40.

*Methyl 5-Acetamido-4,8,9-tri-*O*-acetyl-2,6:2,7-dianhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosonate* (**31**). A soln. of 80 mg (0.262 mmol) of **29** in 1 ml of Ac_2O/pyridine 1:2 was kept at r.t. overnight. Chromatography (SiO_2, AcOEt) gave 99 mg (85%) of **31**. M.p. 165–166° (CH_2Cl_2/hexane). R_f(AcOEt) 0.35. $[\alpha]_D^{25} = +87.3$ ($c = 1.02$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3040*m*, 3000*m*, 2960*m*, 1745*s*, 1680*s*, 1500*m*, 1440*m*, 1380*s*, 1310*m*, 1240 (br.), 1130*m*, 1090*s*, 1070*s*, 1045*s*, 1020*m*, 970*w*, 935*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.92 (*d*, $J = 9.8$, NH); 5.03 (*ddd*, $J = 8.1$, 4.7, 2.3, H–C(8)); 4.90–4.93 (*m*, H–C(4)); 4.66 (*d*, $J = 8.1$, H–C(7)); 4.62 (*dd*, $J = 12.3$, 2.3, 1 H–C(9)); 4.21 (*dd*, $J = 9.9$, 1.5, H–C(5)); 4.17 (*dd*, $J = 12.4$, 4.8, 1 H–C(9)); 3.84 (*s*, $COOCH_3$); 2.18–2.22 (*m*, 2H–C(3)); 2.11, 2.07, 2.06, 2.05 (4*s*, 4 CH_3CO); 1.31 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.48 (*s*); 169.71 (*s*); 169.53 (*s*); 169.29 (*s*); 166.68 (*s*); 103.09 (*s*); 84.43 (*s*); 76.90 (*d*); 69.91 (*d*); 69.72 (*d*); 62.52 (*t*); 53.03 (*q*); 51.76 (*d*); 32.07 (*t*); 22.86 (*q*); 21.05 (*q*); 20.78 (*q*); 20.59 (*q*); 15.72 (*q*). CI-MS: 446 (100, $[M + 1]^+$), 386 (3). Anal. calc. for $C_{19}H_{27}NO_{11}$ (445.43): C 51.23, H 6.11, N 3.14; found: C 51.48, H 6.13, N 3.32.

*Methyl 5-Acetamido-4,7,9-tri-*O*-acetyl-2,6:2,8-dianhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosonate* (**32**). A soln. of 42 mg (0.130 mmol) of **30** in 1 ml of Ac_2O/pyridine 1:2 was kept at r.t. over night. Chromatography (SiO_2, AcOEt) gave 50 mng (83%) of **32**. M.p. 194° (CH_2Cl_2/Et_2O/hexane). R_f(AcOEt) 0.21. $[\alpha]_D^{25} = +81.8$ ($c = 1.03$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3390*w*, 3040*m*, 3000*m*, 2960*m*, 1745*s*, 1685*s*, 1510*m*, 1440*m*, 1370*s*, 1240 (br.), 1150*s*, 1050*s*, 985*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.70 (*d*, $J = 9.3$, NH); 4.99 (*dt*, $J = 7.0$, 9.9, H–C(4)); 4.94 (*d*, $J = 10.0$, H–C(7)); 4.56 (*t*, $J = 9.6$, H–C(5)); 4.35 (*ddd*, $J = 10.0$, 4.6, 2.7, H–C(8)); 4.24 (*dd*, $J = 12.3$, 4.7, 1 H–C(9)); 4.18 (*dd*, $J = 12.3$, 2.6, 1 H–C(9)); 3.83 (*s*, $COOCH_3$); 2.83 (*dd*, $J = 15.4$, 7.1, H_{eq}–C(3)); 2.14 (*dd*, $J = 15.4$, 10.0, H_{ax}–C(3)); 2.13, 2.10, 2.07 (3*s*, 3 CH_3CO); 1.96 (*s*, CH_3CON); 1.27 (*s*, CH_3).

^{13}C-NMR (50 MHz, $CDCl_3$): 170.71 (*s*); 170.63 (*s*); 169.90 (*s*); 169.26 (*s*); 167.53 (*s*); 94.96 (*s*); 77.47 (*s*); 68.81 (*d*); 68.21 (*d*); 67.31 (*d*); 62.78 (*t*); 53.27 (*q*); 50.51 (*d*); 32.44 (*t*); 23.38 (*q*); 23.00 (*q*); 20.90 (*q*); 20.71 (2*q*). CI-MS: 446 (100, $[M + 1]^+$), 386 (82). Anal. calc. for $C_{19}H_{27}NO_{11}$ (445.43): C 51.23, H 6.11, N 3.14; found: C 51.18, H 5.95, N 3.19.

*5-Acetamido-2,6-anhydro-5-deoxy-6-*C*-methyl-*D-arabino-L-gulo-*nononic Acid* (**33**). To a soln. of 1.0 g (2.09 mmol) of **19** and 400 mg of $NaHCO_3$ in 100 ml of H_2O, Pt(0) (from 1.0 g of PtO_2) was added. O_2 (4 l/h) was bubbled through the vigorously agitated (vibromixer) soln. at 90–100°. After 20 h, the catalyst was filtered off and a second portion of **19** (1.0 g) was oxidized as described (using the same catalyst). To the combined filtrates, 10 ml of 0.5M HCl were added, and the soln. was stirred for 2 h at 80–90°. The soln. was loaded on an ion-exchange chromatography column (*Dowex 1X8*, $HCOO^-$ form). Elution of **33** with HCOOH (linear gradient from 0.2–0.7M) gave 1.056 g (78%) of **33** after freeze-drying. R_f(PrOH/H_2O 7:3) 0.32. $[\alpha]_D^{25} = +10.2$ (*c* = 0.97, H_2O). IR (KBr): 3700–2200 (br.), 1730*s*, 1635*s*, 1560*s*, 1430*m*, 1380*m*, 1325*w*, 1265*w*, 1240*m*, 1200*m*, 1100*s*, 1060*s*, 970*w*, 905*w*, 860*w*, 830*w*. ^{1}H-NMR (400 MHz, H_2O): 4.19 (*d*, *J* = 10.5, H–C(2)); 4.05 (*d*, *J* = 10.1, H–C(5)); 3.93 (*dt*, *J* = 7.9, 3.8, H–C(8)); 3.87 (*dd*, 11.9, 3.2, 1 H–C(9)); 3.75 (*dd*, *J* = 10.4, 9.1, H–C(3)); 3.56 (*dd*, *J* = 12.0, 7.9, 1 H–C(9)); 3.52 (*dd*, *J* = 10.0, 9.1, H–C(4)); 3.46 (*d*, *J* = 4.1, H–C(7)); 2.03 (*s*, CH_3CON); 1.29 (*s*, CH_3). ^{13}C-NMR (50 MHz, H_2O): 175.52 (*s*); 173.65 (*s*); 80.03 (*s*); 75.36 (*d*); 72.98 (*d*); 72.45 (*d*); 71.94 (*d*); 71.26 (*d*); 62.99 (*t*); 53.59 (*d*); 22.29 (*q*); 15.33 (*q*). Anal. calc. for $C_{12}H_{21}NO_9$ (323.30): C 44.58, H 6.55, N 4.33; found: C 44.29, H 6.83, N 4.05.

*5-Acetamido-3,4,8,9-tetra-*O*-acetyl-2,6-anhydro-5-deoxy-6-*C*-methyl-*D-arabino-L-gulo-*nonono-1,7-lactone* (**35**). A soln. of 940 mg (2.9 mmol) of **33** in 3 ml of Ac_2O/pyridine 1:2 was kept at r.t. over night. The soln. was evaporated, and chromatography of the residue (SiO_2, AcOEt) gave **35** in 100% yield. R_f (AcOEt) 0.30. $[\alpha]_D^{25} = +64.3$ (*c* = 1.02, $CHCl_3$). IR ($CHCl_3$): 3430*m*, 3040*m*, 3000*m*, 1750*s*, 1690*s*, 1510*s*, 1440*w*, 1370*s*, 1240*s*, 1100*s*, 1050*s*, 960*w*, 910*w*, 860*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.00 (*d*, *J* = 8.6, NH); 5.37 (*ddd*, *J* = 6.1, 4.4, 2.9, H–C(8)); 5.24 (*dd*, *J* = 6.1, 0.9, H–C(3)); 5.10 (*dd*, *J* = 10.9, 6.1, H–C(4)); 4.91 (*d*, *J* = 4.4, H–C(7)); 4.73 (*dd*, *J* = 12.1, 2.9, 1 H–C(9)); 4.55 (*d*, *J* = 0.7, H–C(2)); 4.48 (*dd*, *J* = 10.8, 8.6, H–C(5)); 4.08 (*dd*, *J* = 12.2, 6.1, 1 H–C(9)); 2.13, 2.10, 2.10, 2.05, 2.00 (5*s*, 5 CH_3CO); 1.36 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.63 (*s*); 170.59 (*s*); 170.27 (*s*); 169.97 (*s*); 168.99 (*s*); 164.49 (*s*); 83.43 (*d*); 74.63 (*d*); 74.29 (*d*); 74.16 (*d*); 69.90 (*d*); 69.05 (*d*); 62.04 (*t*); 50.59 (*d*); 22.85 (*q*); 20.88 (*q*); 20.75 (2*q*); 20.65 (*q*); 18.16 (*q*). CI-MS: 474 (100, $[M + 1]^+$). Anal. calc. for $C_{20}H_{27}NO_{12}$ (473.44): C 50.74, H 5.75, N 2.96; found: C 50.71, H 5.92, N 2.89.

*5-Acetamido-6-*C*-(acetoxymethyl)-3,4,8,9-tetra-*O*-acetyl-2,6-anhydro-5-deoxy-*D-arabino-L-gulo-*nonono-1,7-lactone* (**36**). As described for **35**, **36** was obtained from **21** in 73% yield. R_f(AcOEt) 0.29. $[\alpha]_D^{25} = +86.4$ (*c* = 1.07, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3020*w*, 2870*w*, 1750*s*, 1690*s*, 1510*m*, 1370*s*, 1230*s*, 1220*w*, 1045*s*, 970*w*, 910*w*, 870*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.06 (*d*, *J* = 8.9, NH); 5.37 (*dd*, *J* = 11.5, 6.6, H–C(4)); 5.28 (*dt*, *J* = 2.9, 5.4, H–C(8)); 5.25 (*dd*, *J* = 6.6, 0.8, H–C(3)); 4.93 (*d*, *J* = 5.2, H–C(7)); 4.70 (*dd*, *J* = 12.4, 2.9, 1 H–C(9)); 4.64 (*dd*, *J* = 11.5, 8.9, H–C(5)); 4.62 (*d*, *J* = 0.5, H–C(2)); 4.40 (*d*, *J* = 12.1, 1 H–C(1′)); 4.16 (*d*, *J* = 12.1, 1 H–C(1′)); 4.09 (*dd*, *J* = 12.3, 5.4, 1 H–C(9)); 2.26, 2.14, 2.13, 2.11, 2.06 (5*s*, 5 CH_3CO); 1.99 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.75 (*s*); 170.52 (2*s*); 169.82 (*s*); 169.73 (*s*); 169.12 (*s*); 163.72 (*s*); 81.27 (*d*); 75.29 (*d*); 74.97 (*d*); 74.36 (*d*); 70.63 (*d*); 68.87 (*d*); 62.80 (*t*); 61.93 (*t*); 49.67 (*d*); 22.89 (*q*); 20.74 (2*q*); 20.70 (*q*); 20.60 (2*q*). CI-MS: 532 (100, $[M + 1]^+$). Anal. calc. for $C_{22}H_{29}NO_{14}$ (531.47): C 49.72, H 5.50, N 2.64; found: C 49.62, H 5.72, N 2.71.

*Methyl 5-Acetamido-3,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-5-deoxy-6-*C*-methyl-*D-arabino-L-gulo-*nononate* (**37**). To a soln. of 1.328 g of **35** in 20 ml of anh. MeOH, 2 ml of a soln. of NaOMe in MeOH (0.5M) were added. After stirring for 1 h at r.t., the soln. was treated with *Dowex 50WX4* (H^+ form) and acetylated over night at r.t. in 5 ml of Ac_2O/pyridine 1:2. Evaporation and chromatography of the residue gave 1.321 g (86%) of **37**. The product was also obtained by esterification of **33** with excess CH_2N_2 soln. in Et_2O, followed by acetylation. By this method, 600 mg of **33** gave 851 mg (84%) of **37**. M.p. 195–196°. R_f(AcOEt) 0.35 $[\alpha]_D^{25} = +36.3$ (*c* = 1.04, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3000*m*, 2960*w*, 1740*s*, 1695*s*, 1505*w*, 1440*m*, 1370*s*,1203*s*, 1115*w*, 1070*m*, 1045*s*, 1020*m*, 955*w*, 890*w*. ^{1}H-NMR (400 (MHz, $CDCl_3$): 5.26 (*dq*, *J* = 9.1, 2.0, H–C(8)); 5.22–5.16 (*m*, H–C(3), H–C(4)); 5.14 (*d*, *J* = 10.7, NH); 5.13 (*d*, *J* = 1.5, H–C(7)); 4.87 (*d*, *J* = 12.3, 2.1, 1 H–C(9)); 4.54 (*t*, *J* = 10.5, H–C(5)); 4.13 (*d*, *J* = 9.6, H–C(2)); 4.08 (*dd*, *J* = 12.3, 9.2, 1 H–C(9)); 3.75 (*s*, CH_2O); 2.18, 2.05, 2.04, 2.03, 2.01 (5*s*, 5 CH_3CO); 1.85 (*s*, CH_3CON); 1.57 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.26 (*s*); 170.90 (*s*); 170.29 (*s*); 170.06 (2*s*); 169.01 (*s*); 167.39 (*s*); 78.92 (*s*); 72.45 (*d*); 71.83 (*d*); 71.35 (*d*); 70.23 (*d*); 69.36 (*d*); 62.67 (*t*); 52.44 (*d*); 49.73 (*d*); 22.43 (*q*); 20.71 (*q*); 20.60 (*q*); 20.51 (*q*); 20.31 (*q*); 20.25 (*q*); 15.57 (*q*). CI-MS: 548 (100, $[M + 1]^+$). Anal. calc. for $C_{23}H_{33}NO_{14}$ (547.52): C 50.46, H 6.08, N 2.56; found: C 50.51, H 6.13, N 2.47.

*Methyl 5-Acetamido-6-*C*-(acetoxymethyl)-3,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-5-deoxy-*D-arabino-L-gulo-*nononate* (**38**). As described for **37** from **35**, **38** was obtained from **36** in 90% yield. R_f(AcOEt) 0.33. $[\alpha]_D^{25} = +42.2$

($c = 1.03$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3380*w*, 3040*m*, 3000*m*, 2960*m*, 1750*s*, 1695*s*, 1500*m*, 1440*m*, 1370*s*, 1240*s*, 1105*w*, 1050*s*, 990*w*, 910*w*, 890*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.68 (*d*, $J = 10.7$, NH); 5.39 (*dd*, $J = 10.9, 9.5$, H–C(4)); 5.27 (*d*, $J = 1.7$, H–C(7)); 5.22 (*t*, $J = 9.9$, H–C(3)); 5.17 (*dt*, $J = 8.7, 1.9$, H–C(8)); 4.86 (*dd*, $J = 12.4, 2.2$, 1 H–C(9)); 4.81 (*d*, $J = 13.2$, 1 H–C(1′)); 4.67 (*t*, $J = 10.8$, H–C(5)); 4.49 (*d*, $J = 13.2$, 1 H–C(1′)); 4.33 (*d*, $J = 10.2$, H–C(2)); 4.09 (*dd*, $J = 12.4, 8.9$, 1 H–C(9)); 3.76 (*s*, $COOCH_3$); 2.27, 2.19, 2.04, 2.03, 2.02, 2.00 (6*s*, 6 CH_3CO); 1.85 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.25 (*s*); 171.10 (*s*); 170.34 (*s*); 170.26 (*s*); 170.06 (*s*); 169.93 (*s*); 169.20 (*s*); 167.29 (*s*); 80.62 (*s*); 72.18 (*d*); 71.48 (2*d*); 70.61 (*d*); 69.08 (*d*); 63.98 (*t*); 62.67 (*t*); 52.66 (*q*); 49.37 (*d*); 22.67 (*q*); 20.81 (*q*); 20.75 (2*q*); 20.64 (*q*); 20.41 (*q*). CI-MS: 606 (100, $[M + 1]^+$). Anal. calc. for $C_{25}H_{35}NO_{16}$ (605.55): C 49.59, H 5.83, N 2.31; found: C 49.60, H 5.92, N 2.18.

*Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-2,6-anhydro-5-deoxy-6-*C*-methyl-*D*-glycero-*D*-galacto-non-2-enonate* (**39**). A soln. of 1070 mg (1.95 mmol) of **37** and 420 µl (2.93 mmol, 1.5 equiv.) of MTBD in 30 ml of toluene was heated under reflux for 5 h under N_2. After cooling, the soln. was evaporated. Chromatography of the residue (SiO_2, CH_2Cl_2/MeOH 97:3) gave 836 mg (88%) of **39**. M.p. 190°. R_f(CH_2Cl_2/MeOH 9:1) 0.60. $[\alpha]_D^{25} = +81.8$ ($c = 1.02$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3000*m*, 2960*w*, 1740*s*, 1690*s*, 1670 (sh), 1500*m*, 1440*m*, 1370*s*, 1330*m*, 1150*m*, 1110*m*, 1070*m*, 1050*m*, 1030*m*, 975*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.95 (*d*, $J = 3.0$, H–C(3)); 5.44 (*d*, $J = 3.4$, H–C(7)); 5.40 (*dd*, $J = 8.0, 2.9$, H–C(4)); 5.39 (*ddd*, $J = 8.4, 3.4, 2.5$, H–C(8)); 5.24 (*d*, $J = 10.7$, NH); 4.84 (*dd*, $J = 12.4, 2.3$, 1 H–C(9)); 4.68 (*dd*, $J = 10.7, 7.9$, H–C(5)); 4.21 (*dd*, $J = 12.4, 8.4$, 1 H–C(9)); 3.80 (*s*, CH_3O); 2.12, 2.10, 2.09, 2.06 (4*s*, 4 CH_3CO); 1.91 (*s*, CH_3CON); 1.46 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.02 (*s*); 170.74 (*s*); 170.43 (*s*); 170.21 (*s*); 169.98 (*s*); 161.67 (*s*); 143.33 (*s*); 106.47 (*d*); 81.45 (*s*); 71.21 (*d*); 70.40 (*d*); 67.77 (*d*); 62.51 (*t*); 52.36 (*q*); 47.84 (*d*); 22.71 (*q*); 20.76 (*q*); 20.70 (*q*); 20.62 (2*q*); 15.64 (*q*). CI-MS: 428 (100, $[M + 1 - AcOH]^+$). Anal. calc. for $C_{21}H_{29}NO_{12}$ (487.46): C 51.74, H 6.00, N 2.87; found: C 51.74, H 6.01, N 2.98.

*Methyl 5-Acetamido-6-*C*-(acetoxymethyl)-4,7,8,9-tetra-*O*-acetyl-2,6-anhydro-5-deoxy-*D*-glycero-*D*-galacto-non-2-enonate* (**40**). As described for **39**, **40** was obtained from **38** in 88% yield. R_f(CH_2Cl_2/MeOH 9:1) 0.60. $[\alpha]_D^{25} = +75.0$ ($c = 1.04$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3020*w*, 1740*s*, 1690*s*, 1505*s*, 1440*m*, 1370*s*, 1250*m*, 1105*w*, 1050*s*, 990*w*, 975*w*, 930*m*, 850*w*, 830*s*, 765*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.05 (*d*, $J = 3.7$, H–C(3)); 5.84 (*d*, $J = 5.8$, H–C(7)); 5.62 (*d*, $J = 10.6$, NH); 5.36 (*dd*, $J = 6.1, 3.7$, H–C(4)); 5.30 (*dt*, $J = 2.2, 6.4$, H–C(8)); 4.98 (*dd*, $J = 10.5, 6.2$, H–C(5)); 4.57 (br. *d*, $J = 12.3$, 1 H–C(9)); 4.43 (*d*, $J = 12.2$, 1 H–C(1′)); 4.38 (*d*, $J = 12.2$, 1 H–C(1′)); 4.30 (*dd*, $J = 12.6, 6.6$, 1 H–C(9)); 3.80 (*s*, $COOCH_3$); 2.14, 2.13, 2.11, 2.09, 2.05 (5*s*, 5 CH_3CO); 1.90 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.40 (*s*); 170.25 (*s*); 170.16 (*s*); 169.74 (*s*); 169.61 (*s*); 169.47 (*s*); 161.26 (*s*); 143.71 (*s*); 106.42 (*s*); 80.55 (*s*); 70.54 (*d*); 66.64 (*d*); 66.35 (*d*); 62.32 (*t*); 60.96 (*t*); 52.52 (*q*); 46.31 (*d*); 22.98 (*q*); 20.80 (2*q*); 20.66 (*q*); 20.55 (*q*); 20.49 (*q*). CI-MS: 546 (10, $[M + 1]^+$), 486 (100). Anal. calc. for $C_{23}H_{31}NO_{14}$ (545.50): C 50.64, H 5.73, N 2.57; found: C 50.58, H 5.70, N 2.76.

*5-Acetamido-2,6-anhydro-5-deoxy-6-*C*-methyl-*D*-glycero-*D*-galacto-non-2-enonic Acid* (**4**). A soln. of 60 mg (0.123 mmol) of **39** and 1 ml of 1M NaOH was stirred for 2 h at 40°. After treatment with *Dowex 50WX4* (H^+ form), the soln. was freeze-dried to give **4** in 100% yield. R_f(PrOH/H_2O 7:3) 0.50. $[\alpha]_D^{25} = +121.7$ ($c = 0.99$, D_2O). IR (KBr): 3700–2500 (br.), 1720*s*, 1650*s*, 1550*s*, 1430*m*, 1380*m*, 1250*m*, 1155*w*, 1110*m*, 1050*m*, 1005*w*, 935*w*, 900*w*, 820*w*. ^{1}H-NMR (400 MHz, D_2O): 6.03 (*d*, $J = 2.5$, H–C(3)); 4.39 (*dd*, $J = 8.9, 2.6$, H–C(4)); 4.25 (*d*, $J = 8.9$, H–C(5)); 4.05 (*ddd*, $J = 6.8, 4.8, 3.6$, H–C(8)); 4.00 (*dd*, $J = 11.9, 3.6$, 1 H–C(9)); 3.66 (*d*, $J = 4.8$, H–C(7)); 3.63 (*d*, $J = 11.9, 6.8$, 1 H–C(9)); 2.07 (*s*, CH_3CON); 1.27 (*s*, CH_3). ^{13}C-NMR (100 MHz, D_2O): 175.50 (*s*); 165.86 (*s*); 142.01 (*s*); 110.75 (*d*); 82.69 (*s*); 73.42 (*d*); 70.79 (*d*); 65.05 (*d*); 62.81 (*t*); 52.36 (*d*); 21,88 (*q*); 14.22 (*q*). FAB-MS: 306 (56, $[M + 1]^+$), 288 (29), 277 (100). Anal. calc. for $C_{12}H_{19}NO_8$ (305.29): C 47.21, H 6.27, N 4.59; found: C 46.97, H 6.54, N 4.35.

*5-Acetamido-2,6-anhydro-5-deoxy-6-*C*-(hydroxymethyl)-*D*-glycero-*D*-galacto-non-2-enonic Acid* (**5**). As described for **4**, **5** was obtained from **40**. R_f(PrOH/H_2O 7:3) 0.38. $[\alpha]_D^{25} = +105.9$ ($c = 0.46$, H_2O). ^{1}H-NMR (400 MHz, D_2O): 6.04 (*d*, $J = 2.2$, H–C(3)); 4.53 (*dd*, $J = 8.9, 2.2$, H–C(4)); 4.49 (*d*, $J = 8.8$, H–C(5)); 4.06 (*dt*, $J = 3.2, 6.5$, H–C(8)); 3.97 (*dd*, $J = 12.0, 3.2$, 1 H–C(9)); 3.89 (*s*, 2 H–C(1′)); 3.85 (*d*, $J = 6.4$, H–C(7)); 3.68 (*dd*, $J = 12.0, 6.6$, 1 H–C(9)); 2.09 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, D_2O): 175.47 (*s*); 165.80 (*s*); 142.60 (*s*); 111.86 (*d*); 83.89 (*s*); 71.56 (*d*); 71.05 (*d*); 65.57 (*d*); 63.55 (*t*); 60.35 (*t*); 52.11 (*q*); 22.51 (*q*). FAB-MS: 344 (76, $[M + 23]^+$), 322 (100, $[M + 1]^+$), 304 (66). Anal. calc. for $C_{12}H_{19}NO_9 \cdot H_2O$ (339.30): C 42.48, H 6.24, N 4.13; found: C 42.26, H 6.26, N 3.98.

*Methyl 5-Acetamido-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3-bromo-3,5-dideoxy-6-*C*-methyl-*D*-erythro-β-*L*-gluco-nonulopyranosonate* (**41**), *Methyl 5-Acetamido-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3-bromo-3,5-dideoxy-6-*C*-methyl-*D*-erythro-β-*L*-manno-nonulopyranosonate* (**42**), *and Methyl 5-Acetamido-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3-bromo-3,5-dideoxy-6-*C*-methyl-*D*-erythro-α-*L*-gluco-nonulopyranosonate* (**43**). A soln. of 798 mg (1.64 mmol) of **39**, 360 mg (2.02 mmol, 1.24 equiv.) of NBS, and 800 mg of AcONa in 8 ml of AcOH was stirred at r.t. After 6 h, the solvent was evaporated, the residue taken up in MeOH and poured on a short SiO_2 column. Elution

with AcOEt and evaporation gave a mixture of 3 isomers which were separated by prep. HPLC (*Zorbax-Sil;* AcOEt/hexane 85:15; injection of 100 mg portions) to give 76 mg (7%) of **41**, 607 mg (59%) of **42**, and 241 mg (24%) of **43**.

Data of **41**: R_f (AcOEt) 0.34. $[\alpha]_D^{25} = -36.7$ ($c = 0.89$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3020*w*, 2960*m*, 1745*s*, 1695*w*, 1510*m*, 1430*m*, 1370*s*, 1205*s*, 1145*w*, 1050*s*, 930*m*, 820*s*, 765*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.40 (*t*, $J = 10.7$, H–C(4)); 5.32 (*d*, $J = 10.7$, NH); 5.22 (*ddd*, $J = 9.0, 2.3, 1.5$, H–C(8)); 5.05 (*d*, $J = 1.5$, H–C(7)); 4.77 (*dd*, $J = 12.4, 2.3$, H–C(9)); 4.60 (*t*, $J = 10.7$, H–C(5)); 4.17 (*dd*, $J = 12.3, 9.0$, 1 H–C(9)); 4.08 (*d*, $J = 10.7$, H–C(3)); 3.86 (*s*, CH_3O); 2.19, 2.18, 2.10, 2.03, 2.02 (5*s*, 5 CH_3CO); 1.87 (*s*, CH_3CON); 1.61 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.31 (*s*); 170.88 (*s*); 170.61 (*s*); 170.07 (2*s*); 168.37 (*s*); 164.47 (*s*); 96.85 (*s*); 81.40 (*s*); 73.50 (*d*); 71.92 (*d*); 69.88 (*d*); 62.74 (*t*); 53.64 (*q*); 51.47 (*d*); 47.73 (*d*); 22.92 (*q*); 21.39 (*q*); 20.97 (*q*); 20.79 (2*q*); 18.88 (*q*). CI-MS: 628 (12, $[M + 1]^+$), 626 (12, $[M + 1]^+$), 568 (100), 566 (98), 508 (42), 506 (40), 428 (15). Anal. calc. for $C_{23}H_{32}BrNO_{14}$ (626.41): C 44.10, H 2.24, N 2.24, Br 12.76; found: C 44.03, H 5.35, N 2.21, Br 12.63.

Data of **42**: R_f (AcOEt) 0.28. $[\alpha]_D^{25} = +22.4$ ($c = 1.04$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3020*m*, 3000*m*, 2860*m*, 1740*s*, 1695*s*, 1500*m*, 1440*m*, 1370*s*, 1320*m*, 1240*s*, 1130*m*, 1110*m*, 1075*w*, 1050*m*, 985*w*, 940*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 548 (*dd*, $J = 11.1, 3.4$, H–C(4)); 5.29 (*ddd*, $J = 9.3, 2.4, 1.4$, H–C(8)); 5.13 (*d*, $J = 10.4$, NH); 5.00 (*d*, $J = 1.4$, H–C(7)); 5.00 (*dd*, $J = 12.5, 2.4$, 1 H–C(9)); 4.98 (br. *t*, $J = 10.7$, H–C(5)); 4.58 (*d*, $J = 3.3$, H–C(3)); 4.27 (*dd*, $J = 12.5, 9.3$, 1 H–C(9)); 3.84 (*s*, CH_3O); 2.22, 2.13, 2.10, 2.05, 2.04 (5*s*, 5 CH_3CO); 1.91 (*s*, CH_3CON); 1.59 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.34 (*s*); 170.86 (*s*); 170.73 (*s*); 170.22 (*s*); 170.01 (*s*); 167.69 (*s*); 165.81 (*s*); 97.46 (*s*); 81.96 (*s*); 73.72 (*d*); 71.64 (*d*); 65.84 (*d*); 63.02 (*t*); 53.22 (*q*); 51.09 (*d*); 46.94 (*d*); 23.06 (*q*); 21.05 (*q*); 21.01 (*q*); 20.82 (*q*); 20.75 (*q*); 20.69 (*q*); 20.10 (*q*). CI-MS: 628 (2, $[M + 1]^+$), 626 (3, $[M + 1]^+$), 568 (100), 566 (100), 508 (71), 506 (69), 428 (27). Anal. calc. for $C_{23}H_{32}BrNO_{14}$ (626.41): C 44.10, H 2.24, N 2.24, Br 12.76; found: C 44.36, H 5.36, N 2.15, Br 12.69.

Data of **43**: R_f(AcOEt) 0.22. $[\alpha]_D^{25} = +31.4$ ($c = 0.96$, $CHCl_3$). IR ($CHCl_3$): 3440*m*, 3000*m*, 2860*m*, 1745*s*, 1690*s*, 1500*m*, 1440*m*, 1370*s*, 1320*m*, 1230*s*, 1180*m*, 1105*w*, 1070*s*, 1045*w*, 1010*m*, 990*m*, 970*m*, 940*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.53 (*dd*, $J = 10.3, 1.9$, H–C(4)); 5.44 (*dt*, $J = 8.9, 2.4$, H–C(8)); 5.29 (*d*, $J = 10.3$, NH); 5.16 (*t*, $J = 10.5$, H–C(5)); 5.16 (*d*, $J = 2.2$, H–C(7)); 4.89 (*dd*, $J = 12.6, 2.7$, 1 H–C(9)); 4.30 (*d*, $J = 1.9$, H–C(3)); 4.11 (*dd*, $J = 12.6, 9.3$, 1 H–C(9)); 3.81 (*s*, CH_3O); 2.23, 2.12, 2.11, 2.03, 2.02 (5*s*, 5 CH_3CO); 1.87 (*s*, CH_3CON); 1.77 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.28 (*s*); 170.49 (*s*); 170.41 (*s*); 170.36 (*s*); 169.65 (*s*); 167.34 (*s*); 156.60 (*s*); 97.30 (*s*); 80.64 (*s*); 75.36 (*d*); 72.37 (*d*); 71.37 (*d*); 61.88 (*t*); 53.21 (*q*); 47.75 (*d*); 47.68 (*d*); 22.77 (*q*); 21.29 (*q*); 20.93 (2*q*); 20.77 (*q*); 20.61 (*q*); 20.44 (*q*). CI-MS: 628 (18, $[M + 1]^+$), 626 (19, $[M + 1]^+$), 568 (99), 566 (100), 508 (79), 506 (68). Anal. calc. for $C_{23}H_{32}BrNO_{14}$ (626.41): C 44.10, H 2.24, N 2.24, Br 12.76; found: C 44.33, H 5.31, N 2.39, Br 12.57.

*Methyl 5-Acetamido-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-β-*D*-galacto-nonulopyranosonate* (**44**). A soln. of 566 mg (0.90 mmol) of **42**, 480 µl (1.80 mmol, 2 equiv.) of Bu_3SnH, and 74 mg (0.45 mmol, 0.5 equiv.) of AIBN in 10 ml of toluene was heated to 100° for 30 min. After cooling, the solvent was evaporated. Chromatography of the residue (SiO_2, AcOEt) gave 475 mg (96%) of **44**. Treatment of **41** under similar conditions also gave **44** (85%; identified by its ^{1}H-NMR). R_f(AcOEt) 0.24. $[\alpha]_D^{25} = -9.9$ ($c = 0.94$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3010*m*, 2960*w*, 1740*s*, 1695*s*, 1550*m*, 1440*m*, 1370*s*, 1320*w*, 1240*s*, 1130*m*, 1120*m*, 1090*w*, 1070*m*, 1050*s*, 1010*m*, 1000*m*, 960*m*, 930*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.37 (*dt*, $J = 4.7$, 11.2, H–C(4)); 5.27 (*ddd*, $J = 9.1, 2.2, 1.4$, H–C(8)); 5.10 (*d*, $J = 10.7$, NH); 5.06 (*d*, $J = 1.4$, H–C(7)); 4.86 (*dd*, $J = 12.3, 2.3$, 1 H–C(9)); 4.44 (*t*, $J = 10.5$, H–C(5)); 4.18 (*dd*, $J = 12.3, 9.1$, 1 H–C(9)); 3.80 (*s*, CH_3O); 2.50 (*dd*, $J = 13.4, 4.7$, H_{eq}–C(3)); 2.18, 2.11 (2*s*, 2 CH_3CO); 2.05 (*dd*, $J = 13.4, 11.6$, H_{ax}–C(3)); 2.03 (*s*, 3 CH_3CO); 1.88 (*s*, CH_3CON); 1.59 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.31 (*s*); 171.06 (*s*); 170.64 (*s*); 170.30 (*s*); 170.17 (*s*); 168.48 (*s*); 167.15 (*s*); 97.01 (*s*); 81.36 (*s*); 73.68 (*d*); 71.97 (*d*); 65.69 (*d*); 62.94 (*t*); 53.17 (*q*); 50.76 (*d*); 37.16 (*t*); 23.00 (*q*); 22.16 (*q*); 20.98 (*q*); 20.84 (*q*); 20.80 (*q*); 20.75 (*q*); 19.71 (*q*). CI-MS: 548 (22, $[M + 1]^+$), 488 (36), 428 (100). Anal. calc. for $C_{23}H_{33}NO_{14}$ (547.52): C 50.46, H 6.08, N 2.56; found: C 50.51, H 6.04, N 2.42.

*Methyl 5-Acetamido-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosonate* (**45**). Treatment of **43** under the conditions described for **42** gave **45** in 91% yield. R_f (AcOEt) 0.15. $[\alpha]_D^{25} = +54.0$ ($c = 1.09$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3000*m*, 2960*w*, 1740*s*, 1690*s*, 1550*m*, 1440*m*, 1370*s*, 1240*s*, 1140*m*, 1105*s*, 1070*m*, 1045*s*, 1010*s*, 960*m*, 930*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.35 (*dt*, $J = 8.9, 2.3$, H–C(8)); 5.26 (*d*, $J = 10.7$, NH); 5.21 (*ddd*, $J = 9.5, 8.3, 2.5$, H–C(4)); 5.12 (*d*, $J = 2.0$, H–C(7)); 4.97 (*dd*, $J = 10.5, 9.6$, H–C(5)); 4.83 (*dd*, $J = 12.5, 2.5$, 1 H–C(9)); 4.11 (*dd*, $J = 12.5, 9.2$, 1 H–C(9)); 3.78 (*s*, CH_3O); 2.65 (*dd*, $J = 15.8, 8.3$, H_{eq}–C(3)); 2.32 (*dd*, $J = 15.8, 2.5$, H_{ax}–C(3)); 2.19, 2.14, 2.04, 2.03, 2.02 (5*s*, 5 CH_3CO); 1.88 (*s*, CH_3CON); 1.49 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.44 (*s*); 171.86 (*s*); 170.49 (2*s*); 169.97 (*s*); 168.75 (*s*); 167.41 (*s*); 96.29 (*s*); 79.76 (*s*); 72.29 (*d*); 71.58 (*d*); 67.56 (*d*); 62.25 (*t*); 53.06 (*q*); 48.27 (*d*); 34.77 (*t*); 22.85 (*q*); 21.15 (*q*); 20.92 (2*q*); 20.82 (*q*); 20.75 (*q*); 19.17 (*q*). CI-MS: 548 (24, $[M + 1]^+$), 488 (32), 428 (100). Anal. calc. for $C_{23}H_{33}NO_{14}$ (547.52): C 50.46, H 6.08, N 2.56; found: C 50.23, H 6.11, N 2.59.

*Methyl 5-Acetamido-6-*C*-(acetoxymethyl)-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3-bromo-3,5-dideoxy-*D*-erythro-β-*L*-manno-nonulopyranosonate* (**46**). Bromoacetoxylation of **40** under identical conditions as described for **39** gave **46** as the only product in 89% yield. R_f(AcOEt) 0.22. $[\alpha]_D^{25} = +27.4$ ($c = 1.1$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3000*m*, 1740*s*, 1690*s*, 1500*m*, 1435*w*, 1370*s*, 1240 (br.), 1130*m*, 1100*m*, 1045*s*, 990*m*, 910*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.60 (*dd*, $J = 11.2, 3.4$, H–C(4)); 5.57 (*d*, $J = 10.4$, NH); 5.30 (*d*, $J = 1.8$, H–C(7)); 5.27 (*dt*, $J = 8.7, 2.1$, H–C(8)); 5.11 (*t*, $J = 10.8$, H–C(5)); 4.96 (*dd*, $J = 12.5, 2.4$, 1 H–C(9)); 4.58 (*d*, $J = 3.3$, H–C(3)); 4.54 (*d*, $J = 12.6$, 1 H–C(1′)); 4.41 (*d*, $J = 12.6$, 1 H–C(1′)); 4.29 (*dd*, $J = 12.5, 9.0$, 1 H–C(9)); 3.85 (*s*, $COOCH_3$); 2.23, 2.21, 2.12, 2.10, 2.04, 2.03 (6*s*, 6 CH_3CO); 1.90 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.79 (*s*); 170.50 (2*s*); 170.33 (*s*); 169.93 (*s*); 169.80 (*s*); 167.35 (*s*); 165.35 (*s*); 97.13 (*s*); 81.98 (*s*); 71.45 (2*d*); 65.61 (*d*); 64.85 (*t*); 62.83 (*t*); 53.22 (*q*); 50.85 (*d*); 46.06 (*d*); 22.84 (*q*); 20.78 (*q*); 20.68 (2*q*); 20.61 (2*q*); 20.51 (*q*). CI-MS: 686 (100, $[M + 1]^+$), 684 (98, $[M + 1]^+$).

*Methyl 5-Acetamido-6-*C*-(acetoxymethyl)-2,4,7,8,9-penta-*O*-acetyl-2,6-anhydro-3,5-dideoxy-*D*-glycero-*D*-galacto-nonulopyranosonate* (**47**). Similarily to **42**, **46** gave **47** in 85% yield. R_f(AcOEt) 0.21. $[\alpha]_D^{25} = +2.4$ ($c = 1.09$, $CHCl_3$). IR ($CHCl_3$): 3450*w*, 3000*m*, 1740*s*, 1690*s*, 1510*m*, 1440*m*, 1370*s*, 1240 (br.), 1130*m*, 1100*m*, 1040*s*, 1010*m*, 1000*m*, 960*m*, 930*m* ^{1}H-NMR (400 MHz, $CDCl_3$): 5.66 (*d*, $J = 10.4$, NH); 5.45 (*dt*, $J = 4.6, 11.2$, H–C(4)); 5.45 (*d*, $J = 1.8$, H–C(7)); 5.23 (*dt*, $J = 8.8, 2.0$, H–C(8)); 4.82 (*dd*, $J = 12.4, 2.3$, 1 H–C(9)); 4.58 (*d*, $J = 12.4$, 1 H–C(1′)); 4.54 (*t*, $J = 10.7$, H–C(5)); 4.48 (*d*, $J = 12.6$, 1 H–C(1′)); 4.20 (*dd*, $J = 12.4, 9.0$, 1 H–C(9)); 3.81 (*s*, $COOCH_3$); 2.54 (*dd*, $J = 13.6, 4.7$, 1 H–C(3)); 2.21, 2.19, 2.12 (3*s*, 3 CH_3CO); 2.10 (*dd*, $J = 13.7, 11.6$, 1 H–C(3)); 2.03 (*s*, 2 CH_3CO); 2.01 (*s*, CH_3CO); 1.88 (*s*, CH_3CON). ^{13}C-NMR (50 MHz, $CDCl_3$): 170.74 (*s*); 170.63 (*s*); 170.50 (*s*); 170.10 (*s*); 170.05 (*s*); 169.86 (*s*); 168.18 (*s*); 166.59 (*s*); 96.84 (*s*); 81.45 (*s*); 71.55 (*d*); 70.83 (*d*); 65.37 (*d*); 63.34 (*t*); 62.70 (*t*); 53.19 (*q*); 50.11 (*d*); 36.71 (*t*); 22.86 (*q*); 20.86 (*q*); 20.73 (2*q*); 20.67 (2*q*); 20.60 (*q*). CI-MS: 606 (25, $[M + 1]^+$), 546 (100), 486 (63). Anal. calc. for $C_{25}H_{35}NO_{16}$ (605.55): C 49.59, H 5.83, N 2.31; found: C 49.83, H 5.86, N 2.42.

*Methyl [(4′-Methyl-2′-oxo-2′*H*-1′-benzopyran-7′-yl) 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-2,6-anhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-α-*D*-galacto-nonulopyranosid]onate* (**48**). A soln. of 598 mg (0.988 mmol) of **44** and 2.2 ml of freshly distilled AcCl in 33 ml of anh. Et_2O was saturated with HCl gas at −40°. After the soln. was kept at 0° for 6 h, the solvent was evaporated and the residue co-evaporated several times with AcOEt. A mixture of the dried residue (15 min at 0.1 mbar), 30 ml of anh. MeCN, 1.3 g of the tetrabutylammonium salt of methylumbelliferone (= *7-hydroxy-4-methyl-2*H*-1-benzopyran-2-one)*, 1.3 g of freshly prepared Ag_2CO_3, and 1.8 g of molecular sieves (3 Å) was stirred in the dark for 36 h and filtered through *Celite*. The *Celite* was washed with $CHCl_3$. The filtrates were evaporated and 50 ml of AcOEt added. After stirring for 10 min, the precipitate was filtered off and the clear soln. evaporated. Chromatography of the residue (SiO_2, AcOEt) gave 324 mg (60%) of **39** and 250 mg (35%) of **48**. R_f(AcOEt) 0.11. $[\alpha]_D^{25} = +79.6$ ($c = 0.91$, $CHCl_3$). IR ($CHCl_3$): 3440*w*, 3030*w*, 3000*m*, 1740*s*, 1690 (sh), 1615*s*, 1560*w*, 1500*m*, 1440*m*, 1385*w*, 1370*s*, 1230*s*, 1170*s*, 1140*s*, 1100*s*, 1040*s*, 1015*s*, 990*m*, 955*w*, 855*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.54 (*d*, $J = 8.8$, H–C(5′)); 7.18 (*d*, $J = 2.4$, H–C(8′)); 7.06 (*d*, $J = 8.8$, 2.4, H–C(6′)); 6.21 (*d*, $J = 1.2$, H–C(3′)); 5.42 (*dt*, $J = 9.7, 2.7$, H–C(8)); 5.28 (*ddd*, $J = 9.9, 7.3, 4.8$, H–C(4)); 5.25 (*d*, $J = 11.1$, NH); 5.12 (*d*, $J = 2.9$, H–C(7)); 5.00 (*dd*, $J = 12.2, 2.6$, 1 H–C(9)); 4.77 (*dd*, $J = 11.0, 10.0$, 1 H–C(9)); 3.82 (*s*, CH_3O); 2.64 (*dd*, $J = 14.8, 7.4$, 1 H–C(3)); 2.42 (*d*, $J = 1.2$, CH_3–C(4′)); 2.35 (*dd*, $J = 14.9, 4.8$, 1 H–C(3)); 2.07, 2.05, 2.02, 1.88, 1.77 (5*s*, 5 CH_3CO); 1.51 (*s*, CH_3). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.21 (*s*); 171.15 (*s*); 170.73 (*s*); 170.35 (*s*); 169.86 (*s*); 168.24 (*s*); 160.83 (*s*); 156.55 (*s*); 154.40 (*s*); 152.10 (*s*); 152.24 (*d*); 115.79 (*d*); 115.51 (*s*); 113.24 (*d*); 107.28 (*d*); 98.98 (*s*); 80.18 (*s*); 71.57 (*d*); 70.60 (*d*); 67.50 (*d*); 62.04 (*t*); 53.46 (*q*); 49.44 (*d*); 36.31 (*t*); 22.97 (*q*); 20.93 (2*q*); 20.78 (*q*); 20.21 (*q*); 18.59 (*q*); 18.06 (*q*). CI-MS: 664 (11, $[M + 1]^+$), 488 (8), 428 (100). Anal. calc. for $C_{31}H_{37}NO_{15} \cdot H_2O$ (663.64): C 54.62, H 5.77, N 2.05; found: C 54.80, H 5.91, N 2.06.

*5-Acetamido-2,6-anhydro-3,5-dideoxy-6-*C*-methyl-*D*-glycero-β-*D*-galacto-nonulopyranosonic Acid* (**6**). A soln. of 130 mg (0.196 mmol) of **48** in 0.15 ml of 0.5M NaOMe/MeOH and 5 ml of MeOH was stirred at r.t. for 1 h. Evaporation and chromatography of the residue (SiO_2, AcOEt/MeOH/H_2O 7:2:1) gave 87 mg (89%) of the deacetylated glycoside. Treatment of 20 mg (0.04 mmol) of this ester with 1 ml of 1M NaOH for 1 h at r.t. and quick filtration through *Dowex 50WX4* gave the free acid **6**. Chromatography (*Dowex1X8* ($HCOO^-$ form), HCOOH gradient from 0 to 0.7M) and freeze-drying gave 9.7 mg (74% from ester) of **6**. R_f (PrOH/H_2O 7:3) 0.41. $[\alpha]_D^{25} = +92.4$ ($c = 0.31$, H_2O). IR (KBr): 3700–2500 (br.), 1725*m*, 1670*s*, 1550*m*, 1420 (sh), 1370*m*, 1325*m*, 1290*m*, 1230*m*, 1140*s*, 1110*s*, 1080*s*, 1050*s*, 1030*s*, 990*m*, 945*m*, 895*w*. ^{1}H-NMR (400 MHz, D_2O): 4.20 (*dt*, $J = 4.3, 10.5$, H–C(4)); 4.15 (*d*, $J = 10.3$, H–C(5)); 3.94 (*dt*, $J = 7.3, 3.5$, H–C(8)); 3.90 (*dd*, $J = 11.8, 3.3$, 1 H–C(9)); 3.59 (*dd*, $J = 11.8, 7.3$, 1 H–C(9)); 3.40 (*d*, $J = 3.6$, H–C(7)); 2.26 (*dd*, $J = 12.5, 4.3$, H_{eq}–C(3)); 2.04 (*s*, CH_3CON); 1.88 (*dd*, $J = 12.5, 10.9$, H_{ax}–C(3)); 1.39 (*s*, CH_3). ^{13}C-NMR (100 MHz, D_2O): 177.77 (*s*); 175.00 (*s*); 83.30 (*s*); 78.92 (*d*); 73.64 (*d*); 66.00 (*d*); 65.24 (*t*); 57.25 (*d*); 42.35 (*t*); 24.46 (*q*); 22.52 (*q*). FAB-MS: 324 (100, $[M + 1]^+$). Anal. calc. for $C_{12}H_{21}NO_9$ (323.30): C 44.58, H 6.55, N 4.33; found: C 44.41, H 6.65, N 4.23.

*Methyl [(4′-Methyl-2′-oxo-2′*H*-1′-benzopyran-7′-yl) 5-Acetamido-6-*C*-(acetoxymethyl)-4,7,8,9-tetra-*O*-acetyl-2,6-anhydro-3,5-dideoxy-*D*-glycero-α-*D*-galacto-nonulopyranosid]onate* (**49**). Similarily to **44**, **47** gave the olefin **40** and **49** in yields of 37 and 40%, resp. Data of **49**: R_f(AcOEt): 0.16. $[\alpha]_D^{25} = +65.7$ ($c = 0.85$, $CHCl_3$). IR ($CHCl_3$): 3450*w*, 3030*w*, 3000*m*, 2960*w*, 1740*s*, 1695 (sh), 1615*s*, 1560*w*, 1505*w*, 1435*w*, 1390*m*, 1370*s*, 1295*w*, 1240 (br.), 1140*s*, 1070*s*, 1045*s*, 1015*s*, 990*m*, 955*w*, 855*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.56 (*d*, $J = 8.8$, H–C(5′)); 7.11 (*d*, $J = 2.4$, H–C(8′)); 7.05 (*dd*, $J = 8.8, 2.4$, H–C(6′)); 6.20 (*d*, $J = 1.3$, H–C(3′)); 5.67 (*d*, $J = 10.6$, NH); 5.36 (*d*, $J = 3.4$, H–C(7)); 5.30–5.35 (*m*, H–C(4), H–C(8)); 5.03 (*t*, $J = 10.2$, H–C(5)); 4.84 (*dd*, $J = 12.2, 2.5$, 1 H–C(9)); 4.74 (*d*, $J = 12.6$, 1 H, CH_2–C(6)); 4.23 (*d*, $J = 12.6$, 1 H, CH_2–C(6)); 4.01 (*dd*, $J = 12.2, 9.0$, 1 H–C(9)); 3.78 (*s*, $COOCH_3$); 2.69 (*dd*, $J = 15.4, 8.0$, 1 H–C(3)); 2.43 (*dd*, $J = 15.4, 3.3$, 1 H–C(3)); 2.42 (*d*, $J = 1.2$, CH_3–C(4′)); 2.24, 2.09, 2.05, 2.00, 1.87, 1.64 (6*s*, 6 CH_3CO). ^{13}C-NMR (50 MHz, $CDCl_3$): 171.08 (*s*); 170.93 (*s*); 170.55 (*s*); 170.06 (2*s*); 169.59 (*s*); 167.45 (*s*); 160.77 (*s*); 156.71 (*s*); 154.47 (*s*); 152.05 (*s*); 125.34 (*d*); 115.32 (*s*); 114.66 (*d*); 113.23 (*d*); 106.43 (*d*); 99.01 (*s*); 80.24 (*s*); 70.72 (*d*); 69.39 (*d*); 67.46 (*d*); 63.11 (*t*); 61.98 (*t*); 53.51 (*q*); 48.29 (*d*); 36.84 (*t*); 23.03 (*q*); 20.95 (*q*); 20.82 (2*q*); 20.72 (*q*); 20.10 (*q*); 18.59 (*q*). CI-MS: 722 (50, $[M + 1]^+$), 546 (15), 486 (100). Anal. calc. for $C_{33}H_{39}NO_{17}$ (721.68): C 54.92, H 5.45, N 1.94; found: C 54.67, H 5.71, N 1.87.

*5-Acetamido-2,6:2,1′-dianhydro-3,5-dideoxy-6-*C*-(hydroxymethyl)-*D*-glycero-β-*D*-galacto-nonulopyranosonic Acid* (**50**). A soln. of 25 mg (0.035 mmol) of **49** in 1 ml of 1M NaOH was stirred at r.t. for 1 h. The soln. was loaded on a short *Dowex 50WX4* column and left on this column for 1 h. Elution with H_2O gave crude **50**. Purification by chromatography (*Dowex 1X8* ($HCOO^-$ form), HCOOH gradient from 0 to 0.7M) gave 7.6 mg (65%) of **50**. R_f(PrOH/H_2O 7:3) 0.42. $[\alpha]_D^{25} = 0.0$ ($c = 0.17$, H_2O). ^{1}H-NMR (400 MHz, D_2O): 4.24 (br. *d*, $J = 9.4$, H–C(5)); 4.15 (*d*, $J = 8.6$, 1 H–C(1′)); 4.06 (*dt*, $J = 6,4, 9.9$, H–C(4)); 4.05 (br. *d*, $J = 8.2$, 1 H–C(1′)); 3.95 (*dt*, $J = 3.0, 6.7$, H–C(8)); 3.87 (*dd*, $J = 11.9, 3.0$, 1 H–C(9)); 3.76 (*d*, $J = 6.9$, H–C(7)); 3.66 (*dd*, $J = 11.9, 6.5$, 1 H–C(9)); 2.54 (*dd*, $J = 13.2, 6.4$, H_{eq}–C(3)); 2.09 (*s*, CH_3CON); 1.94 (*dd*, $J = 13.2, 10.2$, H_{ax}–C(3)). ^{13}C-NMR (100 MHz, D_2O): 174.84 (*s*); 171.01 (*s*); 104.95 (*s*); 85.19 (*s*); 69.87 (*d*); 69.60 (*d*); 67.60 (*d*); 66.72 (*t*); 62.69 (*t*); 54.03 (*d*); 39.73 (*t*); 21.55 (*q*). FAB-MS: 344 (39, $[M + Na]^+$), 322 (100, $[M + 1]^+$). Anal. calc. for $C_{12}H_{19}NO_9 \cdot H_2O$ (339.30): C 42.48, H 6.24, N 4.13; found: C 42.60, H 6.28, N 3.87.

*Methyl 5-Acetamido-4,7,8,9-tetra-*O*-acetyl-2,6:2,1′-dianhydro-3,5-dideoxy-6-*C*-(hydroxymethyl)-*D*-glycero-β-*D*-galacto-nonulopyranosonate* (**51**). A soln. of 1.6 mg (3.2 μmol) of **50** in MeOH was treated with an Et_2O soln. of diazomethane. After evaporation, the residue was stirred at r.t. in Ac_2O/pyridine 1:2 for 15 h. Evaporation and chromatography (SiO_2, AcOEt) gave 2.3 mg (92%) of **51**. R_f(AcOEt) 0.28. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.44 (*d*, $J = 2.3$, H–C(7)); 5.31 (*d*, $J = 10.7$, NH); 5.21 (*dt*, $J = 8.4, 2.2$, H–C(8)); 5.17 (*dt*, $J = 6.6, 9.9$, H–C(4)); 4.75 (*dd*, $J = 12.2, 2.2$, 1 H–C(9)); 4.54 (*dt*, $J = 1.3, 10.2$, H–C(5)); 4.22 (*dd*, $J = 8.8, 1.5$, 1 H–C(1′)); 4.16 (*dd*, $J = 12.3, 8.4$, 1 H–C(9)); 4.10 (*d*, $J = 8.9$, 1 H–C(1′)); 3.83 (*s*, $COOCH_3$); 2.58 (*dd*, $J = 13.1, 6.7$, H_{eq}–C(3)); 2.14, 2.05, 2.03 (3*s*, 4 CH_3CO); 2.05 (*m*, H_{ax}–C(3)); 1.86 (*s*, CH_3CON). CI-MS: 504 (100, $[M + 1]^+$), 444 (33).

Methods for the Sialidase Experiments (see also [13]). The sialidase *(Vibrio cholerae)* was purchased from *Calbiochem*. Prior to use, a 100 mU soln. of the enzyme was prepared in 10 ml of 0.1M acetate buffer of pH 5.5 containing 0.5 mM $CaCl_2$ and 0.1 mg/ml bovine serum albumine *(Merck)*. The substrate (MU-Neu5Ac) was prepared and purified by known procedures [38] [43]. The incubations were carried out at 37° in a total volume of 100 μl containing 0.20 mU of enzyme (20 μl of the above soln.), 0.5 mM $CaCl_2$, $2.0 \cdot 10^{-4}$ M MU-Neu5Ac and a final acetate-buffer concentration of 0.1M of pH 5.5. After 15 min, the reaction was stopped by the addition of 900 μl of glycine buffer of pH 10 (0.042M Na_2CO_3, 0.06M NaCl, and 0.133M glycine). The amounts of liberated methylumbelliferone was determined fluorimetrically at 365 nm for excitation and 450 nm for emission on a *Shimadzu* spectrofluorophotometer *RF-510*. Blank values (from experiments without enzyme) were substracted from the enzyme values before calculation of the number of mmol of Neu5Ac released. For the calculation of the K_i values of the inhibitors **4** and **5**, various concentrations of MU-Neu5Ac (ranging from 0.5 to $2.0 \cdot 10^{-4}$ M) were incubated in the presence of various inhibitor concentrations (1 mM, 5 mM, 10 mM). The reciprocal reaction rates were plotted against the reciprocal MU-Neu5Ac (substrate) concentrations (*Linweaever-Burk* plot). In a second plot, the slopes of the first plot were reported against the inhibitor concentration. Extrapolation of the linear regression curve obtained gives the K_i value (intercept on the horizontal axis).

REFERENCES

[1] 'Sialic Acids. Metabolism and Function', Ed. R. Schauer, Springer-Verlag, Vienna and New York, 1982.
[2] R. Schauer, *Adv. Carbohydr. Chem. Biochem.* **1982,** *40,* 131.
[3] H. H. Sedlacek, 'Tumor Therapy with Tumor Cells and Neuaminidase', Karger-Verlag, Basel and Munich, 1987.
[4] R. Schauer, in 'Sialic Acids', Proc. of the Japanese-German symposium on sialic acids, Eds. R. Schauer and T. Yamakawa, 1988, p. 100; IUPAC/IUB, *Pure Appl. Chem.* **1982,** *54,* 1517.
[5] P. Meindl, H. Tuppy, *Monatsh. Chem.* **1969,** *100,* 1295.
[6] P. Meindl, H. Tuppy, *Hoppe-Seyler's Z. Physiol. Chem.* **1969,** *350,* 1088.
[7] C. A. Miller, P. Wang, M. Flashner, *Biochem. Biophys. Res. Commun.* **1978,** *83,* 1479.
[8] M. Flashner, J. Kessler, S. W. Tanenbaum, 'Drug Action and Design': Mechanism Based Inhibitors, Ed. Kalman, Elsevier, Amsterdam, 1979, Vol. 6, p. 27.
[9] P. Meindl, G. Bodo, P. Palese, J. Schulman, H. Tuppy, *Virology* **1974,** *58,* 457.
[10] P. Meindl, H. Tuppy, *Monatsh. Chem.* **1970,** *101,* 639.
[11] M. M. Salunkhe, E. Schreiner, E. Zbiral, G. Schultz, R. G. Kleincidam, R. Schauer, in 'Sialic Acids', Proc. of the Japanese-German Symposium on Sialic Acids, Eds. R. Schauer and T. Yamakawa, 1988, p. 42.
[12] E. Zbiral, E. Schreiner, R. Christian, R. G. Kleineidam, R. Schauer, see [11], p. 58.
[13] E. Zbiral, H. H. Brandstetter, R. Christian, R. Schauer, *Liebigs Ann. Chem.* **1987,** 781.
[14] M. Flashner, J. Kessler, S. W. Tanenbaum, *Arch. Biochem. Biophys.* **1983,** *221,* 188.
[15] F. Baumberger, A. Vasella, R. Schauer, *Helv. Chim. Acta* **1988,** *71,* 429.
[16] B. Bernet, A. R. C. Bulusu Murty, A. Vasella, *Helv. Chim. Acta* **1990,** *73,* 947.
[17] R. Julina, I. Müller, A. Vasella, R. Wyler, *Carbohydr. Res.* **1987,** *164,* 415.
[18] N. Kornblum, A. S. Erickson, *J. Org. Chem.* **1981,** *46,* 1037.
[19] R. Meuwly, A. Vasella, *Helv. Chim. Acta* **1986,** *69,* 751.
[20] G. Stork, T. Takahashi, *J. Am. Chem. Soc.* **1977,** *99,* 1275.
[21] J. E. Mc Murry, J. Melton, H. Padgett, *J. Org. Chem.* **1974,** *39,* 259.
[22] W. Hartwig, *Tetrahedron* **1983,** *39,* 2609.
[23] J. Thiem, H. Karl, *Chem. Ber.* **1980,** *113,* 3039.
[24] M. Zaoral, J. Jezek, R. Straka, K. Masek, *Collect. Czech. Chem. Commun.* **1978,** *43,* 1797.
[25] H. Paulsen, J. P. Lorentzen, W. Kutschker, *Carbohydr. Res.* **1985,** *136,* 153.
[26] R. Schwesinger, *Chimia* **1985,** 269.
[27] K. Okamoto, T. kondo, T. goto, *Bull. Chem. Soc. Jpn.* **1987,** *60,* 631.
[28] F. R. Jensen, C. H. Bushweller, *Adv. Alicycl. Chem.* **1971,** *3,* 139.
[29] C. S. Hudson, *J. Am. Chem. Soc.* **1909,** *31,* 66.
[30] M. Suzuki, A. Suzuki, T. Yamakawa, E. Matsunaga, *J. Biochem.* **1985,** *97,* 509.
[31] S. K. Gross, M. A. Wiliams, R. H. McLuer, *J. Neurochem.* **1980,** *34,* 1351.
[32] R. Lifely, F. H. Cottee, *Carbohydr. Res.* **1982,** *107,* 187.
[33] R. Julina, Dissertation, Universität Zürich, 1988.
[34] G. M. Sheldrick, 'SHELXS86' University of Göttingen, 1986.
[35] G. M. Sheldrick, 'SHELXTL 5.1' 1986.
[36] R. Yu, R. Ledeen, *J. Biol. Chem.* **1969,** *244,* 1306.
[37] V. A. Derevitskaya, V. M. Kalinevich, N. K. Kochetkov, *Dokl. Akad. Nauk SSSR* **1966,** *169,* 1087.
[38] F. Baumberger, A. Vasella, R. Schauer, *Helv. Chim. Acta* **1986,** *69,* 1927.
[39] R. Christian, G. Schultz, H. H. Brandstetter, E. Zbiral, *Carbohydr. Res.* **1987,** *162,* 1.
[40] E. B. Brown, W. S. Brey, W. Jr. Welter, *Biochim. Biophys. Acta* **1975,** *399,* 124.
[41] J. Breg, L. M. J. Krown-Batenburg, G. Strecker, J. Montreuil, J. F. G. Vliegenthart, *Eur. J. Biochem.* **1989,** *178,* 727.
[42] J. L. Flippen, *Acta Crystallogr., Sect. B* **1973,** *29,* 1881.
[43] T. G. Warner, J. S. O'Brien, *Biochemistry* **1979,** *18,* 2783.