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A NOVEL SYNTHESIS OF 2-DEOXY-α-GLYCOSIDES

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ABSTRACT

The key step of the synthesis involves the reaction of glycals [3,4,6-tri-*O*-acetyl-D-glucal (**1**), the new glycal derivative 4-*O*-acetyl-1,5-anhydro-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-L-*ribo*-hex-1-enitol (**2**), and 3-acetamido-4,6-di-*O*-acetyl-1,5-anhydro-2,3-dideoxy-D-*arabino*-hex-1-enitol (**3**)] with 1.5 molar equivalents of several alcohols in the presence of *N*-bromosuccinimide in acetonitrile to give mainly the corresponding 2-bromo-2-deoxy-α-glycopyranosides (**4–21**). The glycopyranosides (**4–8** and **16–21**) from **1** and **3** have the α-D-*manno* configuration and those (**10–15**) from **2** have the α-L-*altro* configuration. The yields are high from **1**, virtually quantitative from **2**, and moderate from **3**. Debromination of the 2-bromo-2-deoxy compounds with tributylstannane and a radical initiator gives the corresponding 2-deoxy-α-glycopyranosides (**22–38**) in quantitative yields. In particular, the branched-chain glycal **2** reacts with alcohols to give exclusively the corresponding α-glycopyranosides (**27–32**) of cladinose in strikingly high overall yields. The stereoselectivity and regiospecificity of the bromination reaction are described. 1,3-Dibromo-5,5-dimethylhydantoin and *N*-bromoacetamide are also found to be useful for the reaction.

INTRODUCTION

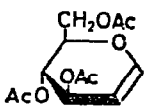
2-Deoxy-α-glycosides are well known to be biologically important as structural units in the field of natural products, particularly in sugar-containing antibiotics[1] including the macrolide and anthracycline groups. Although various methods for synthesis of 2-deoxy-α-glycosides have been investigated[2,3], most of them do not lead exclusively to α-glycosides. In recent years, 2-deoxy-disaccharides[4,5] having the α-linkage have been prepared in moderate yields by the method of Lemieux *et al.*[3]. With simple alcohols, this method also leads to 2-deoxy-β-glycosides. An efficient synthesis of a 3-amino-2,3-dideoxy-α-glycopyranoside has been achieved by using the acid-catalyzed addition of an alcohol to an acetylated glycal[6]. However, this reaction cannot be applied to acid-labile glycals such as branched-chain glycals and *O*-acetyl-glycals, because of their tendency to decompose or undergo allylic rearrangement.

On the other hand, it has been reported that halogenation of an alkene with *N*-bromosuccinimide in aqueous dimethyl sulfoxide results in the formation of a *trans*-halohydrin[7] Interest in this reaction led us to consider that glycals might react with an alcohol and *N*-bromosuccinimide to give alkyl 2-bromo-2-deoxy-α-glycosides which could then be converted into the corresponding 2-deoxy-α-glycosides

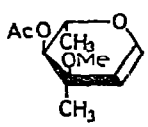
The present paper delineates a method for the synthesis of 2-bromo-2-deoxy-α-glycosides and for their conversion into 2-deoxy-α-glycosides The stereoselectivity and regiospecificity may be rationalized in terms of a reaction mechanism involving the diaxial opening of a cyclic bromonium ion in the transition state, and is influenced particularly by the anomeric effect All 2-bromo-2-deoxy-α-glycosides thus obtained were debrominated by using tributylstannane and α α′-azobis(isobutyronitrile) to give the corresponding 2-deoxy-α-glycosides in virtually quantitative yields

RESULTS AND DISCUSSION

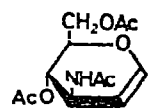
The starting glycals used were 3,4,6-tri-*O*-acetyl-D-glucal[8] (3,4,6-tri-*O*-acetyl-1,5-anhydro-2-deoxy-D-*arabino*-hex-1-enitol, **1**), the new glycal derivative 4-*O*-acetyl-1,5-anhydro-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-L-*ribo*-hex-1-enitol (**2**), and 3-acetamido-4,6-di-*O*-acetyl-1,5-anhydro-2,3-dideoxy-D-*arabino*-hex-1-enitol[9] (**3**), and the alcohols employed were methanol, ethanol, isopropyl alcohol, cyclohexanol, *tert*-butyl alcohol, 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose[10], and methyl 2,3,4-tri-*O*-benzyl-α-D-glucopyranoside (**47**)



1



2



3

The glycal **1** reacted with 1 5 molar equivalents of isopropyl alcohol and 1 2 molar equivalents of *N*-bromosuccinimide (NBS) in dry acetonitrile at room temperature to give mainly isopropyl 3,4,6-tri-*O*-acetyl-2-bromo-2-deoxy-α-D-mannopyranoside (**5**), obtained in 86% yield (Table I) The alternative *trans*-addition product, isopropyl 3,4,6-tri-*O*-acetyl-2-bromo-2-deoxy-β-D-glucopyranoside, was isolated in only 4% yield The structure of **5** was determined as follows Its p m r spectrum showed a sharp, narrow doublet at δ 5 15 ($J_{1,2}$ 1 5 Hz) and a quartet displaying small coupling constants ($J_{1,2}$ 1 5 and $J_{2,3}$ 3 5 Hz) at δ 4 38, which could be assigned to H-1 and H-2, respectively, indicating that **5** had either the α-*manno* or the β-*manno* configuration. Quantitative debromination of **5** by using tributylstannane with a radical initiator [α,α′-azobis(isobutyronitrile)] yielded the corresponding deoxy derivative **23**, the new methylene group (H-2a and 2e) of which gave two doubled quartets at δ 1 80 and 2 22, having $J_{1,2a}$ 4, $J_{1,2e}$ 1 5, $J_{2a,2e}$ 13, $J_{2a,3}$ 11, and $J_{2e,3}$

5 5 Hz in its p m r spectrum These coupling constants showed that **23** was isopropyl 3,4,6-tri-*O*-acetyl-2-deoxy-α-D-*arabino*-hexopyranoside[11] Therefore, **5** must have been the 2-bromo-2-deoxy-α-D-*manno* product

TABLE I

YIELDS OF BROMO ADDUCTS

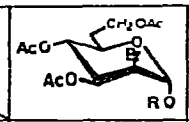
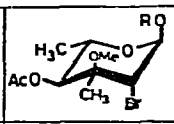
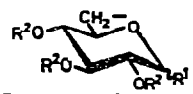
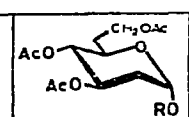
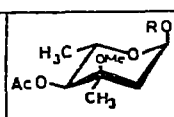
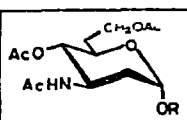
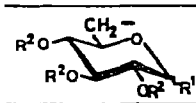
R			
Et—	4 78%	10 93%	16 78%
Me_2CH—	5 80%	11 96%	17 32%
	6 8.%	12 90%	18 19%
Me_3C—	7 70%	13 90%	19 23%
	8 R^1 β-OAc R^2=Ac 88%	14 R^1=β OAc, R^2=A 97%	20 R^1=α OMe R^2=CH_2Ph 15%
Me—	9 Mixture	15 91%	21 93%

TABLE II

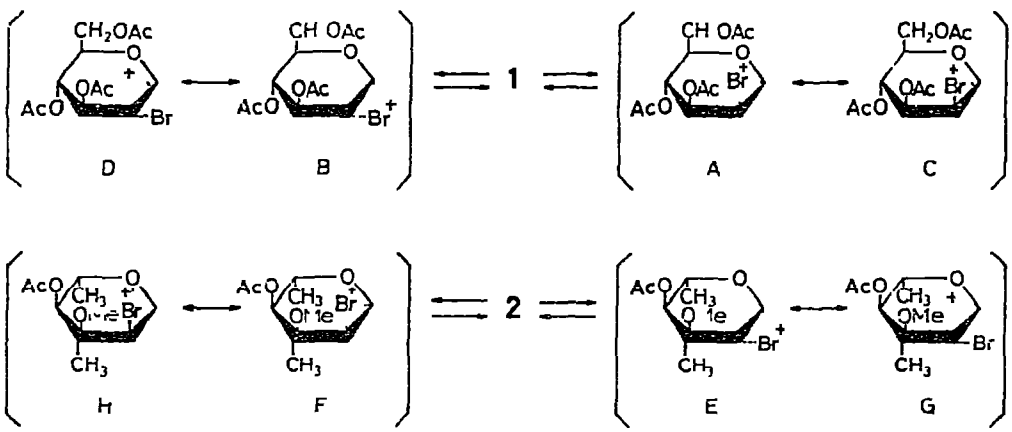
YIELDS OF 2-DEOXY GLYCOSIDES

R			
Et—	22 92%	27 94%	33 90%
Me_2CH—	23 90%	28 96%	34 8.%
	24 95%	29 99%	35 83%
Me_3C—	25 93%	30 9.%	36 90%
	26 R^1=β-OAc, R^2-Ac 94%	31 R^1=β-OAc, R^2=Ac 99%	37 R^1 α-OMe, R^2 CH_2Ph 97%
Me—	——	32 97%	38 91%

Similarly, the glycal **1** reacted with NBS and 1 5 molar equivalents of ethanol cyclohexanol, *tert*-butyl alcohol, or 1,2,3,4-tetra-*O*-acetyl-*β*-D-glucopyranose to give in high yields (Table I), the corresponding 3,4,6-tri-*O*-acetyl-2-bromo-2-deoxy-*α*-D-mannopyranosides (**4**, **6**, **7**, and **8**, respectively), these were also debrominated to the corresponding deoxy compounds (**22**, **24**, **25**, and **26**) in virtually quantitative yields, as shown in Table II Their structures were confirmed by p m r spectroscopy Moreover, the physical properties of the deacetylated deoxy products (**40**, **41**, and **42**) were found to be identical with those of the known compounds[3-5] The corresponding 2-bromo-2-deoxy-*β*-D-glucopyranosides, which could be detected by t l c, were not isolated but were estimated to be present to the extent of less than 5%

In contrast, the reaction of **1** and methanol in the presence of NBS at 5° gave a mixture (**9**) of methyl *α*-D-manno- and *β*-D-gluco-pyranosides, in the ratio of 4 1, as determined by p m r studies[1,2] Reaction at room temperature gave the mixture of *α*-manno- and *β*-glucopyranosides in 2 1 ratio

In the formation of the aforementioned 2-bromo-2-deoxy-*α*-D-manno-pyranosides, it seems reasonable to suppose that the glycal **1** reacts with NBS to give an intermediate, cyclic bromonium ion (**A**) that is resonance-stabilized as the oxo-carbonium ion[13] **C** through ring-oxygen participation The bromonium ion **A** may undergo nucleophilic attack by an alcohol from the axial side at the anomeric center, the orientation of attack may be governed by the anomeric effect, promoting diaxial opening of the initial bromonium ion **A** and, consequently, giving mainly the 2-bromo-2-deoxy-*α*-D-mannopyranoside In the reaction of **1** with methanol, however, another cyclic bromonium ion (**B**) and oxocarbonium ion (**D**) appear to take part in the



reaction as intermediates, giving methyl 2-bromo-*β*-D-glycopyranoside by equatorial attack of methanol Perhaps the higher rate of reaction with methanol does not allow complete equilibration of the bromonium ion to the more-stable, *manno* bromonium ion (**A**) The *gluco* bromonium ion (**B**) would be destabilized by the reverse anomeric effect[14] Equatorial approach to the anomeric center of alcohols larger than methanol

may also be subject to steric hindrance This mechanism is compatible with that for methoxyhalogenation of glycals proposed by Lemieux *et al* [3,12]

Attention was next focused on the synthesis of branched-chain 2-deoxy-α-glycosides, which are important constituents especially in macrolide antibiotics The starting glycal chosen was the acid-labile 4-*O*-acetyl-1,5-anhydro-2 6-dideoxy-3-*C*-methyl-3-*O*-methyl-L-*ribo*-hex-1-enitol (**2**), which was prepared initially by treatment of 4-*O*-acetylcladinose (**46**) with mesyl chloride or tosyl chloride in pyridine

Treatment of **2** with 1 5 molar equivalents of the aforementioned alcohols in the presence of NBS gave the corresponding 2-bromo-α-L-altropyranosides **10–13** exclusively and even gave a disaccharide (**14**) in more than 90% yield, as shown in Table I Furthermore, it was noteworthy that even the reaction with methanol gave methyl 4-*O*-acetyl-2-bromo-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-α-L-altropyranoside (**15**) exclusively, isolated in 91% yield without formation of the β anomer The structures of the products were confirmed by p m r spectroscopy [$J_{1,2}$ (or $J_{1',2'}$) = 1–1 5 Hz and for the corresponding debrominated compounds **27–32** (Table II) $J_{1,2a}$ (or $J_{1',2'a}$) = 4 5 Hz and $J_{1,2e}$ (or $J_{1',2'e}$) = ~1 Hz]

The highly stereoselective and regiospecific reaction of the branched-chain glycal **2** appears mechanistically similar to that of **1**, however, the oxocarbonium ion **G** is presumably more favored than the ion **H** as the latter would be very unstable because of the sterically unfavorable, gauche-effect of the hindered bromine atom at C-2 between the geminal methyl and methoxyl groups at C-3 Consequently, the shift of the equilibrium strongly favors the one intermediate (**E**) over the other (**F**), making diaxial opening of the cyclic bromonium ion (**E**) exclusive, giving only 2-bromo-α-L-altropyranosides Thus, the gauche effect, together with the anomeric effect in the transition state evidently overcome the 1,3-diaxial interaction that would be created between the alcohol approaching the anomeric center from the axial side and the C-3 axial methoxyl group, and thereby govern the specific reactivity Acidic methanolysis of erythromycin gave a 1 4 mixture of methyl α- and β-cladinosides, and this ratio may reflect the operation of the aforementioned 1,3-diaxial interaction (see Experimental) Acidic ethanolysis likewise gave ethyl β-cladinoside, predominantly as the major product Acetates of methyl and ethyl β-cladinosides (**44** and **45**) were prepared by the foregoing alcoholysis reaction to provide references for the corresponding synthetic α-cladinosides (**32** and **27**)

Finally, the application of this synthetic method to the synthesis of 3-amino-2-deoxyglycosides was investigated Treatment of 3-acetamido-4,6-di-*O*-acetyl-1,5-anhydro-2,3-dideoxy-D-*arabino*-hex-1-enitol[9] (**3**) with alcohols in the presence of NBS gave the expected 3-acetamido-2-bromo-2-deoxy-α-D-mannopyranoside acetates (**16–20**) However, in comparison with the aforementioned glycals **1** and **2**, the yields (Table I) were not so high for some compounds Certain by-products have been isolated, and their structural elucidation may help in efforts to improve the yields However, in contrast to the reaction of **1**, the glycal **3** reacted with methanol to give exclusively methyl 3-acetamido-4 6-di-*O*-acetyl-2-bromo-2,3-dideoxy-α-D-mannopyranoside (**21**), isolated in 93% yield The stereoselective reaction of **3** may be

ascribed to participation by the 3-acetamido group Although no evidence was obtained and no by-product was identified, it seems probable that the nucleophilic acetamido group may attack the *gluco* bromonium ion (analog of **B**) from the top side of the sugar ring to form an oxazinium intermediate, giving an α-mannopyranoside in low yield, except with methanol and ethanol For methanol or ethanol, reaction of alcohol with the *manno* bromonium ion (analog of **A**) may be far faster than that of the aforementioned attack of the acetamido group, giving high yields of methyl or ethyl 2-bromo-2-deoxy-α-mannopyranoside (**21** or **16**) Witkop and coworkers[15] have described a related, intramolecular participation of an acetamido group

Debromination of the aforementioned 2-bromo derivatives gave the corresponding 3-acetamido-2-deoxy-α-D-*arabino*-hexopyranosides (**33–38**) in approximately 90% yields, as shown in Table II

In the p m r spectra of the ethyl 2-bromo-2-deoxy-α-glycosides (**4**, **10**, and **16**) and ethyl 2-deoxy-α-glycosides (**22**, **27**, and **33**), it was of interest that two protons (H and H′) of the methylene portion of the ethyl groups were not equivalent, thus leading to two doubled quartets (J_{CH_3,CH_2} 7, and $J_{H,H}$ 9 5–10 Hz) having different chemical shifts Also, the p m r spectrum of the β-anomer **44** showed two doubled quartets

In the reaction of the glycals with NBS and alcohols, change of the organic solvent (acetonitrile to ether) used did not greatly affect the yields of the resulting 2-bromo-2-deoxy-α-glycosides, use of a lower temperature gave more of the α-glycosides than β-glycosides, especially in the reaction with methanol, as described for **9**

As regards the molar ratio of alcohol to glycal, 1 2 molar equivalents of the former gave essentially the same yields as those obtained with 1 5 molar equivalents but the reactions with *tert*-butyl alcohol gave lower yields A reaction time of one hour was satisfactory for completion of the reaction with most of the alcohols, but reaction overnight or for 3 days was required for *tert*-butyl alcohol

1,3-Dibromo-5,5-dimethylhydantoin and *N*-bromoacetamide were also used, instead of NBS, without greatly affecting the yields Moreover, because they reacted to give more-polar products (dimethylhydantoin and acetamide) than succinimide, they were useful for synthesis of 2-bromo-2-deoxy-α-glycosides that were separated from succinimide only with difficulty by column chromatography

In summary, the glycals **1** and **2** reacted with alcohols in the presence of brominating reagents to give high yield of 2-bromo-2-deoxy-α-glycopyranosides which could be converted into the corresponding 2-deoxy-α-glycopyranosides in essentially quantitative yields The glycal **3** gave the corresponding 2-bromo-2-deoxy-α-glycopyranosides in variable yields, decreasing as the molecular size of the alcohols increased

In particular, the highly stereoselective and regiospecific reaction of the branched glycal **2**, followed by quantitative debromination, provides an efficient approach for the synthesis of branched-chain 2-deoxy-α-glycosides

EXPERIMENTAL

General — Melting points were determined on a Yanaco MP-S3 apparatus and are uncorrected Specific rotations were measured (0 2-dm tube) with a Carl Zeiss Photoelectric Precision polarimeter The p m r spectra were determined, unless otherwise state, for solutions in chloroform-*d* with Varian A60 and XL100 spectrometers Chemical shifts are given in δ units relative to internal tetramethylsilane (for $CDCl_3$) and sodium 4,4′-dimethyl-4-silapentane-1-sulfonate (for D_2O) Coupling constants were obtained by measuring spacings of spectra judged to be first-order Column chromatography was performed on silica gel (Wakogel C-300) developed with the following solvent systems A, 20 1 chloroform–ethyl acetate, B, 10 1 chloroform–ethyl acetate, C, 3 1 hexane–ethyl acetate, D, 4 1 chloroform–ethyl acetate, E, 5 1 hexane–ethyl acetate, F, 3 1 chloroform–ethyl acetate, G, 2 1 hexane–acetone, H, 2 1 chloroform–acetone, and others Thin layer chromatography (t l c) was performed on Wakogel B-5 with the same solvent system as described for column chromatography, and the chromatograms were developed by spraying with sulfuric acid

Tri-*O*-acetyl-D-glucal[8] (**1**), 3-acetamido-4,6-di-*O*-acetyl-1,5-anhydro-2,3-dideoxy-D-*arabino*-hex-1-enitol[9] [**3**, m p 157–158°, $[\alpha]_D^{16}$ +65° (*c* 1 0, chloroform)], 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose[10] [m p 127–129°, $[\alpha]_D^{14}$ +9 78° (*c* 6, chloroform)], and tributylstannane[16] were prepared according to published procedures

General method for the preparation of acetates of 2-bromo-2-deoxy-α-glycosides (**4–21**) — *Method A* (*used unless otherwise stated*) To an ice-cold, stirred solution of the glycal (**1**, **2**, or **3**, 0 5 mmol) in dry acetonitrile (approximately 1 ml) was added the alcohol (0 75 mmol) followed by NBS (107 mg, 0 6 mmol) The resulting solution was stirred at the same temperature (~5°) for 0 5 h and at room temperature for 1 h, and then concentrated *in vacuo* to afford a residue, which was chromatographed on a column of silica gel (10 g) with an appropriate solvent system The eluates containing the major product were combined and evaporated *in vacuo* to give the acetylated of 2-bromo-2-deoxy-α-glycoside as a solid or syrup Solids were recrystallized from an appropriate solvent

Method B As method A, except that 0 3 mmol of 1,3-dibromo-5,5-dimethylhydantoin (86 mg) was used in the place of NBS

Method C As method A, except that 0 6 mmol of *N*-bromoacetamide (83 mg) was used instead of NBS

Ethyl 3,4,6-tri-O-acetyl-2-bromo-2-deoxy-α-D-mannopyranoside (**4**) — Compound **1** (173 mg, 0 63 mmol) was treated with ethanol by the general method described Purification by column chromatography (solvent A) gave syrupy **4**, $[\alpha]_D^{16}$ +21 3° (*c* 1 0, chloroform), p m r δ 1 27 (t, 3 H, J_{CH_3,CH_2} 7 Hz, CH_3 of Et), 2 07, 2 10, and 2 12 (s, 3 H each, OAc), 3 59 and 3 83 (dq, 1 H each, $J_{H,H'}$ 10 Hz, H and H′ of CH_2 of Et), 3 9–4 3 (m, 3 H, H-5,6, and 6′), 4 49 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ ~3 5 Hz, H-2), 5 13 (d, 1 H, H-1), 5 29 (q, 1 H, $J_{3,4}$ ~9 5 Hz, H-3), and 5 5 (t, 1 H, $J_{4,5}$ 9 5 Hz, H-4)

Anal Calc for $C_{14}H_{21}BrO_8$ C, 42 33, H, 5 33, Br, 20 12 Found C, 42 19, H, 5 18, Br, 20 09

Isopropyl 3,4,6-tri-O-acetyl-2-bromo-2-deoxy-α-D-mannopyranoside (**5**) — Compound **1** (111 mg 0 41 mmol) was treated with isopropyl alcohol by the general method described Purification by column chromatography (solvent C) gave the α-D-*manno* product **5** (145 mg, 86%) as a faster-moving component (R_F 0 35) on t l c The product was a syrup, $[\alpha]_D^{16}$ +27 5° (*c* 1 0, chloroform), p m r δ 1 20 and 1 26 (d 3 H each, $J_{CH_3\,CH}$ 6 Hz, Me_2C), 2 06 ,2 09, and 2 10 (s, 3 H each, OAc), 3 7–4 35 (m 4 H, H-5,6,6′, and CH of isopropyl group), 4 38 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ 3 5 Hz H-2), 5 15 (d, 1 H, H-1), 5 22 (q, 1 H, $J_{3,4}$ ~9 5 Hz, H-3), and 5 38 (t, 1 H, $J_{4,5}$ ~9 Hz, H-4)

Anal Calc for $C_{15}H_{23}BrO_8$ C, 43 81, H, 5 64, Br, 19 43 Found C, 44 01, H 5 61, Br 19 64

Isopropyl 3,4,6-tri-O-acetyl-2-bromo-2-deoxy-β-D-glucopyranoside (7 mg, 4%) was isolated as the slower-moving product (R_F 0 30 on t l c) and gave needles (ether–hexane), m p 112–112 5°, $[\alpha]_D^{16}$ +42 5° (*c* 1 0, chloroform), p m r δ 1 24 and 1 28 (d, 3 H each, $J_{CH\,CH_3}$ 6 Hz, (Me_2C), 2 02, 2 08, and 2 09 (s, 3 H each, OAc), 3 6–3 8 (m, 1 H, H-5), 3 75 (q, 1 H, $J_{1,2}$ 8 5, $J_{2,3}$ ~10 Hz H-2), 3 9–4 4 (m, 3 H, H-6,6′, and CH of isopropyl group), 4 60 (d, 1 H, H-1), 4 95 (t, 1 H, $J_{3,4} = J_{4,5} = 9$ Hz, H-4), and 5 29 (q, 1 H H-3)

Anal Calc for $C_{15}H_{23}BrO_8$ C, 43 81, H, 5 64, Br, 19 43 Found C, 44 04, H, 5 61, Br, 19 63

Preparation by methods B and C also gave **5**, in 83 and 75% yields, respectively

Cyclohexyl 3,4,6-tri-O-acetyl-2-bromo-2-deoxy-α-D-mannopyranoside (**6**) — Compound **1** (142 mg, 0 52 mmol) was treated with cyclohexanol by the general method described Purification by column chromatography (solvent B) gave syrupy **6**, $[\alpha]_D^{16}$ +40° (*c* 1 0, chloroform), p m r δ 1–2 (m, 10 H, 5 × CH_2 of cyclohexyl group), 3 6 (m, 1 H, CH of cyclohexyl group), 4 39 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ 3 5 Hz, H-2), and 5 18 (d, 1 H, H-1)

Anal Calc for $C_{18}H_{27}BrO_8$ C, 47 90, H, 6 03, Br, 17 70 Found C, 47 66 H 5 92 Br, 17 96

tert-*Butyl 3,4,6-tri-O-acetyl-2-bromo-2-deoxy-α-D-mannopyranoside* (**7**) — Compound **1** (196 mg, 0 72 mmol) was treated with *tert*-butyl alcohol by the general method described except that reaction was extended to 3 days Purification by column chromatography (solvent C) gave **7** as a syrup, $[\alpha]_D^{16}$ +22 5° (*c* 1 0, chloroform), p m r δ 1 30 (s, 9 H, Me_2C), 2 07 (s, 3 H, OAc), 2 10 (s, 6 H, 2 × OAc), 4 36 (q, 1 H $J_{1,2}$ 1 5 $J_{2,3}$ 3 5 Hz H-2), and 5 36 (d, 1 H, H-1)

Anal Calc for $C_{16}H_{25}BrO_8$ C 45 19, H 5 93, Br, 18 79 Found C, 45 36, H, 5 88 Br, 18 83

6-O-(3,4,6-Tri-O-acetyl-2-bromo-2-deoxy-α-D-mannopyranosyl)-1,2,3,4-tetra-O-acetyl-β-D-glucopyranose (**8**) — Compound **1** (119 mg, 0 44 mmol) was treated with 1,2 3,4-tetra-*O*-acetyl-β-D-glucopyranose in a mixture (1 ml) of acetonitrile and ether (1 1) by the general method described Purification by column chromatography

(solvent D) and recrystallization from ether gave rosettes of **8**, m p 154–156°, $[\alpha]_D^{13}$ +32.5° (*c* 1.0, chloroform), p m r δ 2.03, 2.04, 2.06, 2.07, 2.09, 2.11, and 2.13 (s, 3 H each, OAc), 3.5–4.3 (m, 6 H, CH_2-6, CH_2-6′, H-5, and H-5′), 4.50 (q 1 H $J_{1,2}$ 1.5, $J_{2,3}$ 4 Hz, H-2), 4.9–5.5 (m, 5 H, H-2,3,3′,4, and 4′), 5.06 (d, which collapsed to a singlet on irradiation at δ 4.50, 1 H, H-1′), and 5.69 (d, 1 H $J_{1,2}$ 7 Hz, H-1)

Anal Calc for $C_{20}H_{33}BrO_{17}$ C, 44.65, H, 5.04, Br, 11.42 Found C, 44.81 H, 5.02, Br, 11.64

Mixture (**9**) *of methyl 3,4,6-tri-*O*-acetyl-2-bromo-2-deoxy-*α*-*D*-manno- and -*β*-*D*-gluco-pyranosides* — Compound **1** (90 mg, 0.33 mmol) was treated with methanol at room temperature by the general method described Purification by column chromatography (1:1 hexane–ethyl acetate) gave syrupy mixture **9**, p m r δ 3.45 and 3.60 (s, 3 H in total relative intensity ~2:1, MeO of *α-manno* and *β-gluco* isomers[11] respectively), 4.55 (d, $J_{1,2}$ 8 Hz, H-1 of *β*-D-*gluco* isomer), and 5.0 (d, $J_{1,2}$ 1.5 Hz, H-1 of α-D-*manno* isomer)

Reaction at 5° gave the mixture of α-D-*manno* and *β*-D-*gluco* isomers with relative intensities of ~4:1 of their *O*-methyl signals

*Ethyl 4-*O*-acetyl-2-bromo-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-*α*-L-altro-pyranoside* (**10**) — Compound **2** (100 mg, 0.5 mmol) was treated with ethanol by the general method described Purification by column chromatography (10:1 hexane–ethyl acetate) gave **10** as a syrup, $[\alpha]_D^{16}$ −65° (*c* 1.0, chloroform) p m r δ 1.18 (d, 3 H, J_{5,CH_3} 6.5 Hz, CH_3-5), 1.23 (t, 3 H, $J_{CH_3,CH}$ 7 Hz, CH_3 of Et), 1.40 (s, 3 H, CH_3-3) 2.15 (s, 3 H, OAc), 3.32 (s, 3 H CH_3O-3), 3.50 and 3.80 (dq 1 H each, $J_{H,H}$ 10 Hz, H and H′ of CH_2 of Et), 4.32 (d, 1 H, $J_{1,2}$ 1.5 Hz, H-2), 4.35 (dq, 1 H, $J_{4,5}$ ~9.5 Hz, H-5), 5.06 (d, 1 H, H-1), and 5.23 (d, 1 H, H-4)

Anal Calc for $C_{12}H_{21}BrO_5$ C, 44.32 H, 6.51, Br, 24.57 Found C, 44.08, H, 6.31, Br, 24.33

*Isopropyl 4-*O*-acetyl-2-bromo-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-*α*-L-altro-pyranoside* (**11**) — Compound **2** (64 mg, 0.32 mmol) was treated with isopropyl alcohol by the general method described Purification by column chromatography (solvent A) gave **11** as a syrup that gradually crystallized m p 64–67° $[\alpha]_D^{16}$ −72.5° (*c* 1.0, chloroform), p m r δ 1.15 (d, 6 H, $J_{CH_3,CH}$ 6 Hz, Me_2C), 1.22 (d, 3 H, J_{5,CH_3} 6 Hz, CH_3-5), 1.38 (s, 3 H, CH_3-3), 2.10 (s 3 H, OAc), 3.26 (s, 3 H, CH_3O-3), 3.88 (septet, 1 H, CH of isopropyl group), 4.23 (d, 1 H, $J_{1,2}$ 1.5 Hz, H-2), 4.34 (dq, 1 H, $J_{4,5}$ 9.5 Hz, H-5), 5.09 (d, 1 H, H-1), and 5.20 (d, 1 H, H-4)

Anal Calc for $C_{13}H_{23}BrO_5$ C, 46.03, H, 6.83, Br, 23.55 Found C, 46.14, H, 6.73, Br, 23.31

*Cyclohexyl 4-*O*-acetyl-2-bromo-2,6-dideoxy-3-*C*-methyl-3-*O*-methyl-*α*-L-altro-pyranoside* (**12**) — Compound **2** (56 mg, 0.28 mmol) was treated with cyclohexanol by the general method described Purification by column chromatography (8:1 hexane–ethyl acetate) gave crystals of **12**, m p 63–66°, $[\alpha]_D^{15}$ −70 (*c* 1.0, chloroform), p m r δ 3.65 (m, 1 H, CH of cyclohexyl group), 4.31 (d, 1 H, $J_{1,2}$ 1 Hz, H-2), 4.40 (dq, 1 H, $J_{4,5}$ 9.5, J_{5,CH_3} 6.5 Hz, H-5), 5.15 (d, 1 H, H-1), and 5.25 (d, 1 H, H-4)

Anal Calc for $C_{16}H_{27}BrO_5$ C, 50 67, H, 7 18 Br, 21 07 Found C, 50 85, H 7 08, Br, 21 15

tert-*Butyl 4-O-acetyl-2-bromo-2,6-dideoxy-3-C-methyl-3-O-methyl-α-L-altropyranoside* (**13**) — Compound **2** (84 mg, 0 42 mmol) was treated with *tert*-butyl alcohol by the general method described except for reaction overnight Purification by column chromatography (solvent E) gave syrupy **13**, $[\alpha]_D^{14}$ −66 3° (*c* 1 0, chloroform), p m r δ 1 13 (d, 3 H, $J_{5\ CH_3}$ 6 5 Hz, CH_3-5), 1 26 (s, 9 H, Me_3C), 1 37 (s, 3 H, CH_3-3), 4 23 (d, 1 H, $J_{1,2}$ 1 5 Hz, H-2), 4 45 (dq, 1 H, $J_{4,5}$ 9 5 Hz, H-5), 5 22 (d, 1 H, H-4), and 5 27 (d, 1 H, H-1)

Anal Calc for $C_{14}H_{25}BrO_5$ C, 47 60, H, 7 13, Br, 22 62 Found C, 47 36 H, 7 01, Br, 22 49

6-O-(4-O-Acetyl-2-bromo-2,6-dideoxy-3-C-methyl-3-O-methyl-α-L-altropyranosyl)-1,2,3,4-tetra-O-acetyl-β-D-glucopyranose (**14**) — Compound **2** (76 mg 0 38 mmol) was treated with 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose in a 1 1 mixture (1 ml) of acetonitrile and ether by the general method described Purification by column chromatography (4 1 chloroform–ethyl acetate) and recrystallization from ether gave needles of **14**, m p 173–174°, $[\alpha]_D^{13}$ −26 3° (*c* 1 0, chloroform), p m r δ 1 12 (d, 3 H, $J_{5\ CH_3}$ 6 5 Hz, CH_3-5′), 1 37 (s, 3 H, CH_3-3′), 2 01, 2 03, 2 04, 2 12, and 2 14 (s, 3 H each, OAc), 3 32 (s, 3 H, CH_3O-3′), 3 3–3 9 (m, 3 H, H-5 and CH_2-5), 4 30 (dq, 1 H, $J_{4\ 5}$ 10 Hz, H-5′), 4 33 (d, 1 H, $J_{1',2'}$ 1 Hz, H-2′), 4 90 (sharp d, 1 H H-1′), 4 95–5 35 (m, 4 H, H-2,3,4, and 4′), and 5 65 (d, 1 H, $J_{1,2}$ 7 5 Hz, H-1)

Anal Calc for $C_{24}H_{35}BrO_{14}$ C, 45 94, H, 5 62, Br, 12 74 Found C, 46 13, H, 5 59, Br, 12 76

Methyl 4-O-acetyl-2-bromo-2 6-dideoxy-3-C-methyl-3-O-methyl-α-L-altropyranoside (**15**) — Compound **2** (50 mg, 0 25 mmol) was treated with methanol by the general method described Purification by column chromatography (4 1 hexane–ethyl acetate) gave syrupy **15**, $[\alpha]_D^{15}$ −61 3° (*c* 1 0, chloroform), p m r δ 1 02 (d, 3 H, $J_{5\ CH_3}$ 6 5 Hz, CH_3-5), 1 33 (s, 3 H, CH_3-3), 2 07 (s, 3 H, OAc), 3 21 (s, 3 H, CH_3O-1) 3 31 (s, 3 H, CH_3O-3), 4 19 (d, 1 H, $J_{1,2}$ 1 Hz, H-2), 4 2 (m, 1 H, H-5), 4 82 (d, 1 H, H-1), and 5 09 (d, 1 H, $J_{4,5}$ 9 5 Hz, H-4)

Anal Calc for $C_{11}H_{19}BrO_5$ C, 42 46, H, 6 15, Br, 25 68 Found C, 42 28, H, 5 93, Br, 25 48

Ethyl 3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-mannopyranoside (**16**) — Compound **3** (100 mg, 0 37 mmol) was treated with ethanol by the general method described Purification by column chromatography (solvent F) and recrystallization from chloroform–ether–hexane gave needles of **16**, m p 118–120°, $[\alpha]_D^{16}$ +50° (*c* 1 0, chloroform), p m r δ 1 27 (t, 3 H, $J_{CH_3\ CH_2}$ 7 Hz, CH_3 of Et), 1 99 (s, 3 H, NAc), 2 08 and 2 11 (s, 3 H each, OAc), 3 60 and 3 83 (dq, 1 H each, $J_{H\ H}$ 10 Hz, H and H′ of CH_2 of Et), 3 9–4 4 (m, 3 H, H-5,6, and 6′), 4 40 (q, 1 H, $J_{1,2}$ 1 5, $J_{2\ 3}$ 3 5 Hz, H-2), 4 71 (dq, 1 H, $J_{3,4}$ 10 $J_{3,NH}$ 8 5 Hz, H-3), 5 12 (d, 1 H, H-1), 5 20 (q, 1 H, $J_{4\ 5}$ 9 5 Hz, H-4), and 5 9 (broad d, 1 H, NH)

Anal Calc for $C_{14}H_{22}BrNO_7$ C, 42 44, H, 5 60, Br, 20 17, N, 3 54 Found C, 42 61, H, 5 52, Br, 20 40, N, 3 56

Isopropyl 3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-manno-pyranoside (**17**) — Compound **3** (100 mg, 0 37 mmol) was treated with isopropyl alcohol by the general method described Purification by column chromatography (solvent F) and recrystallization from chloroform–ether–hexane gave needles of **17**, m p 152–153°, $[\alpha]_D^{16}$ +52 5° (*c* 1 0, chloroform), p m r δ 1 21 and 1 28 (d, 3 H each, $J_{CH_3,CH}$ 6 Hz, Me_2C), 4 38 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ 3 5 Hz, H-2), and 5 21 (d, 1 H, H-1)

Anal Calc for $C_{15}H_{24}BrNO_7$ C, 43 91, H, 5 90 Br, 19 48, N, 3 41 Found C, 44 00, H, 5 94, Br, 19 26, N, 3 26

Preparation by methods B and C also gave **17**, in 55 and 62% yields, respectively

Cyclohexyl 3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-manno-pyranoside (**18**) — Compound **3** (118 mg, 0 44 mmol) was treated with cyclohexanol by the general method described Purification by column chromatography (solvent F) and recrystallization from chloroform–ether–hexane gave needles of **18**, m p 133–134°, $[\alpha]_D^{16}$ +50° (*c* 1 0, chloroform) p m r δ 3 7 (m, 1 H, CH of cyclohexyl group), 4 36 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ 3 5 Hz, H-2), and 5 23 (d, 1 H, H-1)

Anal Calc for $C_{18}H_{28}BrNO_7$ C, 48 01, H, 6 27, Br, 17 74 N, 3 11 Found C, 47 78, H, 6 15 Br, 17 60, N, 3 22

tert-*Butyl 3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-manno-pyranoside* (**19**) — Compound **3** (113 mg, 0 42 mmol) was treated with *tert*-butyl alcohol by the general method described, except for reaction overnight Purification by column chromatography (solvent F) and recrystallization from chloroform–ether–hexane gave needles of **19**, m p 149–150°, $[\alpha]_D^{16}$ +47 5° (*c* 1 0, chloroform) p m r δ 1 33 (s, 9 H, Me_3C), 4 28 (q, 1 H, $J_{1,2}$ 1 5, $J_{2,3}$ 3 Hz, H-2), and 5 27 (d, 1 H, H-1)

Anal Calc for $C_{16}H_{26}BrNO_7$ C, 45 29, H, 6 18, Br, 18 83, N, 3 30 Found C, 45 07, H, 5 96, Br, 18 98, N, 3 17

Methyl 6-O-(3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-manno-pyranosyl)-2,3,4-tri-O-benzyl-α-D-glucopyranoside (**20**) — Compound **3** (144 mg, 0 53 mmol) was treated with methyl 2 3,4-tri-*O*-benzyl-α-D-glucopyranoside (**47**) by method B except for a 2-h reaction time in 1 1 acetonitrile–ether Purification by column chromatography with solvent G followed by rechromatography with 7 1 chloroform–acetone gave **20** as a solid, m p 44–48°, $[\alpha]_D^{13}$ +67 5° (*c* 1 0, chloroform), p m r δ 1 97 (s, 3 H, NAc), 2 04 (s, 6 H, 2 × OAc), 3 39 (s, 3 H, CH_3O-1), 4 37 (q, 1 H, $J_{1',2'}$ 1 5, $J_{2',3'}$ 3 5 Hz H-2'), 5 09 (d, 1 H, H-1'), 5 80 (d, 1 H, $J_{3,NH}$ 8 5 Hz, NH), and ~7 3 (sharp signals, 15 H, phenyl of benzyl groups) Irradiation at δ 4 37 caused a doublet at δ 5 09 to collapse to a sharp singlet

Anal Calc for $C_{40}H_{48}BrNO_{12}$ C, 58 97, H, 5 94, Br, 9 81, N, 1 72 Found C, 58 76, H, 5 98, Br, 10 04, N, 1 60

Methyl 3-acetamido-4,6-di-O-acetyl-2-bromo-2,3-dideoxy-α-D-mannopyranoside (**21**) — Compound **3** (153 mg, 0 56 mmol) was treated with methanol by the general method described Purification by column chromatography (solvent F) and recrystallization from ether gave rods of **21**, m p 99–100°, $[\alpha]_D^{17}$ +47 5° (*c* 1 0, chloroform),

p.m.r. δ 1.99 (s, 3 H, NAc), 2.07 and 2.11 (s, 3 H each, OAc), 3.44 (s, 3 H, CH_3O-1), 3.9–4.3 (m, 3 H, H-5,6, and 6'), 4.36 (q, 1 H, $J_{1,2}$ 1.5, $J_{2,3}$ 3.5 Hz, H-2), 4.62 (dq, 1 H, $J_{3,4}$ 10, $J_{3,NH}$ 8.5 Hz, H-3), 4.95 (sharp d, 1 H, H-1), 5.11 (t, 1 H, $J_{4,5}$ 10 Hz, H-4), and 6.02 (d, 1 H, NH). On irradiation at δ 6.02, a doubled quartet at δ 4.62 changed to a quartet. Irradiation at δ 4.95 caused a quartet at δ 4.36 to change to a doublet.

Anal. Calc. for $C_{13}H_{20}BrNO_7$: C, 40.85; H, 5.27; Br, 20.91; N, 3.66. Found: C, 40.63; H, 5.18; Br, 20.73; N, 3.51.

General method for the preparation of acetates of 2-deoxy-α-glycosides (**22–38**). — To a solution of the aforementioned acetate of 2-bromo-2-deoxy-α-glycoside (**4–21**, 0.2 mmol) in dry benzene (approximately 1 ml) under an argon atmosphere was added tributylstannane (70 mg, 0.24 mmol) and α,α'-azobisisobutyronitrile (2 mg). The solution was stirred for 1 h at 60° and then concentrated *in vacuo* to afford a residue, which was chromatographed with an appropriate solvent system on a column of about a 100-fold weight of silica gel in relation to the amount of starting glycoside. The eluate containing the product was evaporated *in vacuo* to yield the solid or syrupy 2-deoxy-α-glycoside. Solids were recrystallized or sublimed.

Ethyl 3,4,6-tri-O-acetyl-2-deoxy-α-D-arabino-hexopyranoside (**22**). —Compound **4** (150 mg, 0.37 mmol) was debrominated by the general method described. Purification by column chromatography (solvent B) gave **22** as a syrup, $[\alpha]_D^{16}$ +112° (*c* 1.0, chloroform), p.m.r. δ 1.22 (t, 3 H, J_{CH_3,CH_2} 7 Hz, CH_3 of Et), 1.8 (dq, 1 H, $J_{1,2a}$ 4, $J_{2a,3}$ 11.5, $J_{2a,2e}$ 13 Hz, H-2a), 2.22 (dq, 1 H, $J_{1,2e}$ 1.5, $J_{2e,3}$ 5.5 Hz, H-2e), 3.45 and 3.68 (dq, which collapsed to an AB quartet on irradiation at δ 1.24, 1 H each, $J_{H,H}$ 10 Hz, H and H' of CH_2 of Et), 3.95 (m, 1 H, H-5), 4.05 and 4.30 (q, 1 H each, $J_{5,6}$ 2, $J_{5,6'}$ 4.5, $J_{6,6'}$ 12.5 Hz, H-6 and 6'), 4.94 (q, 1 H, H-1), 4.97 (t, 1 H, $J_{3,4} = J_{4,5} = 9.5$ Hz, H-4) and 5.33 (dq, 1 H, H-3).

Anal. Calc. for $C_{14}H_{22}O_8$: C, 52.82; H, 6.97. Found: C, 52.74; H, 6.86.

Isopropyl 3,4,6-tri-O-acetyl-2-deoxy-α-D-arabino-hexopyranoside (**23**). — Compound **5** (120 mg, 0.29 mmol) was debrominated by the general method described. Purification by column chromatography (solvent B) gave **23** as an analytically pure syrup $[\alpha]_D^{15}$ +117° (*c* 1.0, chloroform) that crystallized on standing. Recrystallization from pentane gave needles of **23**, m.p. 72°, $[\alpha]_D^{20}$ +119° (*c* 1.0, chloroform) [lit.[11] m.p. 73–74°, $[\alpha]_D^{23}$ +127° (*c* 1.0, chloroform)], p.m.r. δ 1.17 and 1.23 (d, 3 H each, $J_{CH_3,CH}$ 6 Hz, Me_2C), 1.80 (dq, 1 H, $J_{1,2a}$ 4, $J_{2a,3}$ 11, $J_{2a,2e}$ 13 Hz, H-2a), 2.02, 2.05, and 2.09 (s, 3 H each, OAc), 2.22 (dq, 1 H, $J_{1,2e}$ 1.5, $J_{2e,3}$ 5.5 Hz, H-2e), 3.7–4.6 (m, 3 H, H-5,6, and 6'), 5.02 (t, 1 H, $J_{3,4} = J_{4,5} = 9.5$ Hz, H-4), 5.12 (q, 1 H, H-1), and 5.42 (dq, 1 H, H-3).

Anal. Calc. for $C_{15}H_{24}O_8$: C, 54.21; H, 7.28. Found: C, 54.27; H, 7.30.

Cyclohexyl 3,4,6-tri-O-acetyl-2-deoxy-α-D-arabino-hexopyranoside (**24**). — Compound **6** (250 mg, 0.55 mmol) was debrominated by the general method described. Purification by column chromatography (solvent C) gave syrupy **24**, $[\alpha]_D^{13}$ +107° (*c* 1.0, chloroform), p.m.r. δ 1–2 (m, 10 H, 5 × CH_2 of cyclohexyl group), 1.8 (dq, 1 H, $J_{1,2a}$ 4, $J_{2a,3}$ 11, $J_{2a,2e}$ 13 Hz, H-2a), 2.23 (dq, 1 H, $J_{1,2e}$ 1.5, $J_{2e,3}$ 5.5 Hz

H-2e), 3 6 (m, 1 H, CH of cyclohexyl group), 5 02 (t, 1 H $J_{3,4} = J_{4,5} = 9$ 5 Hz, H-4) 5 18 (q, 1 H H-1), and 5 43 (dq, 1 H, H-3)

Anal Calc for $C_{18}H_{28}O_8$ C, 58 05, H, 7 58 Found C, 57 85, H, 7 37

tert-*Butyl 3,4,6-tri-O-acetyl-2-deoxy-α-*D-arabino-*hexopyranoside* (**25**) — Compound 7 (158 mg, 0 37 mmol) was debrominated by the general method described Purification by column chromatography (solvent C) gave syrupy **25**, $[\alpha]_D^{16}$ +110° (*c* 1 0, chloroform), p m r δ 1 26 (s, 9 H Me_3C), 1 80 (dq, 1 H, $J_{1,2a}$ 3 5 $J_{2a,3}$ 10 5, $J_{2a,2e}$ 12 5 Hz, H-2a), ~2 13 (dq 1 H, $J_{1,2e}$ 1 5, $J_{2e,3}$ 5 5 Hz, H-2e), 5 0 (t 1 H, $J_{3,4} = J_{4,5} = 9$ 5 Hz, H-4), 5 32 (q, 1 H H-1), and 5 45 (dq, 1 H, H-3)

Anal Calc for $C_{16}H_{26}O_8$ C, 55 48 H, 7 57 Found C, 55 62, H, 7 41

*6-O-(3,4,6-Tri-O-acetyl-2-deoxy-α-*D-arabino-*hexopyranosyl)-1,2,3,4-tetra-O-acetyl-β-*D-*glucopyranose* (**26**) — Compound **8** (100 mg, 0 14 mmol) was debrominated by the general method described Purification by column chromatography (10 1 chloroform–acetone) and recrystallization from ether gave rosettes of **26**, m p 127–129°, $[\alpha]_D^{16}$ +63 8° (*c* 1 0 chloroform), p m r δ 1 78 (dq, 1 H, $J_{1',2'a}$ 4, $J_{2'a,3'}$ 11 5, $J_{2'a,2'e}$ 13 5 Hz, H-2'a), 2 29 (dq 1 H, $J_{1',2'e}$ 1 5 $J_{2'e,3'}$ ~5 5 Hz, H 2'e), and 5 69 (d, 1 H, $J_{1',2'}$ 7 Hz H-1)

Anal Calc for $C_{26}H_{36}O_{17}$ C 50 32 H 5 85 Found C, 50 22, H 5 75

*Ethyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L-*ribo-hexopyranoside* (**27**) — Compound **10** (98 mg 0 30 mmol) was debrominated by the general method described Purification by column chromatography (solvent A) and sublimation (~15 mm 60°) gave crystals of **27** m p 37 5–38 5°, $[\alpha]_D^{15}$ −164° (*c* 1 0, chloroform) p m r δ 1 12 (d, 3 H J_{5,CH_3} 6 5 Hz CH_3-5) 1 12 (s 3 H CH_3-3) 1 21 (t, 3 H, $J_{CH_3,CH}$ 7 Hz, CH_3 of Et) 1 59 (q 1 H $J_{1,2a}$ 4 5 $J_{2a,2e}$ 15 Hz H-2a) 2 16 (s, 3 H, OAc), 2 29 (q, 1 H, $J_{1,2e}$ ~1 Hz), 3 30 (s 3 H CH_3O-3) 3 37 and 3 71 (dq, which collapsed to an AB quartet on irradiation at δ 1 26 1 H each, $J_{H,H}$ 9 5 Hz H and H' of CH_2 of Et) 4 28 (dq, 1 H $J_{4,5}$ 9 5 Hz, H-5), 4 70 (d, 1 H, H-4), and 4 75 (q 1 H, H-1)

Anal Calc for $C_{12}H_{22}O_5$ C, 58 52, H, 9 00 Found C 58 44 H 8 80

*Isopropyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L-*ribo-hexopyranoside* (**28**) — Compound **11** (104 mg 0 30 mmol) was debrominated by the general method described Purification by column chromatography (solvent A) and sublimation (~15 mm, 60) gave crystals of **28**, m p 24–25°, $[\alpha]_D^{16}$ −185° (*c* 1 0, chloroform) p m r δ 1 12 and 1 13 (d, 3 H each, J_{CH,CH_3} 6 Hz, Me_2C), 1 62 (q, 1 H, $J_{1,2a}$ 4 5, $J_{2a,2e}$ 15 5 Hz, H-2a) 2 33 (q, 1 H, $J_{1,2e}$ 1 Hz H-2e), 3 97 (septet, 1 H, CH of isopropyl group), 4 44 (dq 1 H, $J_{4,5}$ 10, J_{5,CH_3} 6 Hz, H-5), 4 83 (d 1 H, H-4), and 4 99 (q, 1 H H-1)

Anal Calc for $C_{13}H_{24}O_5$ C, 59 98, H, 9 29 Found C, 60 06 H, 9 07

*Cyclohexyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L-*ribo-hexopyranoside* (**29**) — Compound **12** (56 mg, 0 14 mmol) was debrominated by the general method described Purification by column chromatography (solvent A) gave syrupy **29**, $[\alpha]_D^{16}$ −159° (*c* 1 0, chloroform) p m r δ 1 63 (q, 1 H, $J_{1,2a}$ 4 5, $J_{2a,2e}$ 15 5 Hz H-2a), 2 35 (q 1 H $J_{1,2e}$ 1 Hz, H-2e), 3 7 (m, 1 H CH of cyclohexyl group),

4 50 (dq, 1 H, $J_{4,5}$ 10 Hz, J_{5,CH_3} 6 Hz, H-5), 4 85 (d, 1 H, H-4), and 5 04 (q, 1 H, H-1)

Anal Calc for $C_{10}H_{18}O_5$ C, 63 97, H, 9 40 Found C, 63 74, H, 9 15

tert-*Butyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L*-ribo-hexopyranoside* (**30**) — Compound **13** (93 mg, 0 26 mmol) was debrominated by the general method described Purification by column chromatography (solvent A) gave **30** as a solid, m p 73–74°, $[\alpha]_D^{15}$ −155° (*c* 1 0, chloroform), p m r δ 1 09 (d, 3 H, J_{5,CH_3} 6 Hz, CH_3-5), 1 11 (s, 3 H, CH_3-3), 1 26 (s, 9 H, Me_3C), 1 62 (q, 1 H, $J_{1,2a}$ 4 5, $J_{2a,2e}$ 15 5 Hz, H-2a), 2 23 (q, 1 H, $J_{1,2e}$ 1 Hz, H-2e), 4 52 (dq, 1 H, $J_{4,5}$ 10 Hz, H-5), 4 80 (d, 1 H, H-4), and 5 19 (q, 1 H, H-1)

Anal Calc for $C_{14}H_{26}O_5$ C, 61 29, H, 9 56 Found C, 61 14, H, 9 40

*6-O-(4-O-Acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L*-ribo-hexopyranosyl)-1,2,3,4-tetra-O-acetyl-β-*D*-glucopyranose* (**31**) — Compound **14** (123 mg, 0 19 mmol) was debrominated by the general method described Purification by column chromatography (solvent G) and recrystallization from ether gave needles of **31**, m p 129–130°, $[\alpha]_D^{16}$ −62 5° (*c* 1 0, chloroform), p m r δ 1 07 (d, 3 H, J_{5,CH_3} 6 5 Hz, CH_3-5'), 1 10 (s, 3 H, CH_3-3'), 1 54 (q, 1 H $J_{1',2'a}$ 4 5, $J_{2'a,2'e}$ 15 5 Hz, H-2'a), 2 01, 2 10, and 2 15 (s, 3 H each, OAc), 2 03 (s, 6 H, 2 × OAc), 2 35 (q, 1 H, $J_{1',2'e}$ ~1 Hz, H-2'e), 3 32 (s, 3 H, CH_3O-3'), 3 3–3 9 (m, 3 H, H-5 and CH_2-5), 4 25 (dq, 1 H, $J_{4',5'}$ 9 5 Hz, H-5'), 4 63 (q, 1 H, H-1'), 4 67 (d, 1 H, H-4'), 4 9–5 35 (m, 3 H, H-2,3, and 4), and 5 66 (d, 1 H, $J_{1,2}$ 7 5 Hz, H-1)

Anal Calc for $C_{24}H_{36}O_{14}$ C, 52 55, H, 6 62 Found C, 52 37, H, 6 40

*Methyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-α-*L*-ribo-hexopyranoside* (**32**) — Compound **15** (61 mg, 0 19 mmol) was debrominated by the general method described Purification by column chromatography (solvent B) and sublimation (~15 mm, 60°) gave crystals of **32**, m p 51–52°, $[\alpha]_D^{15}$ −179° (*c* 1 38, chloroform), p m r δ 1 11 (d, 3 H, J_{5,CH_3} 6 5 Hz, CH_3-5), 1 11 (s, 3 H, CH_3-3), 1 60 (q, 1 H, $J_{1,2a}$ 4 5, $J_{2a,2e}$ 15 5 Hz, H-2a), 2 14 (s, 3 H, OAc), 2 32 (q, 1 H, $J_{1,2e}$ 1 Hz, H-2e), 3 30 (s, 3 H, CH_3O-3), 3 34 (s, 3 H, CH_3O-1), 4 28 (dq, 1 H, $J_{4,5}$ 10 Hz, H-5), 4 67 (q, 1 H, H-1), and 4 74 (d, 1 H, H-4)

Anal Calc for $C_{11}H_{20}O_5$ C, 56 88, H, 8 68 Found C, 56 76, H, 8 56

*Ethyl 3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-*D*-arabino-hexopyranoside* (**33**) — Compound **16** (80 mg, 0 20 mmol) was debrominated by the general method described Purification by column chromatography (solvent H) and recrystallization from ether gave plates of **33**, m p 137–138°, $[\alpha]_D^{15}$ +125° (*c* 1 0, chloroform), p m r δ 1 23 (t, 3 H, J_{CH_3,CH_2} 7 Hz, CH_3 of Et), 1 63 (dq, 1 H, $J_{1,2a}$ 3 5, $J_{2a,3}$ 12, $J_{2a,2e}$ 13 5 Hz, H-2a), 1 93 (s, 3 H, NAc), 2 08, and 2 10 (s, 3 H each, OAc), 2 21 (dq, 1 H, $J_{1,2e}$ 1, $J_{2e,3}$ 4 5 Hz, H-2e), 3 46 and 3 70 (dq, 1 H each, $J_{H,H}$ 10 Hz, H and H' of CH_2 of Et), 3 95–4 15 (m, 2 H, H-5, and 6), 4 36 (q, 1 H, $J_{5,6}$ 5, $J_{6,6}$ 12 5 Hz, H-6'), 4 55 (m, 1 H, H-3), 4 74 (q, 1 H, $J_{3,4}$ 9 5, $J_{4,5}$ 10 Hz, H-4), 4 90 (q, 1 H, H-1), and 5 68 (broad d, 1 H, NH) Irradiation at δ 1 29 caused doubled quartets at δ 3 46 and 370 to collapse to an AB quartet

Anal Calc for $C_{14}H_{23}NO_7$ C, 52 99, H, 7 31, N, 4 41 Found C, 53 19, H, 7 29, N, 4 23

Isopropyl 3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-D-arabino-hexopyranoside (**34**) — Compound **17** (25 mg, 0 06 mmol) was debrominated by the general method described Purification by column chromatography (solvent H) and recrystallization from ether gave needles of **34**, m p 132–133° $[\alpha]_D^{15}$ + 135° (*c* 1 0, chloroform), p m r δ 1 18 and 1 25 (d, 3 H each, $J_{CH_3\,CH}$ 6 5 Hz, Me_3C), 1 65 (dq, 1 H, $J_{1\,2a}$ 3 5, $J_{2a,3}$ 12, $J_{2a,2e}$ 13 5 Hz, H-2a), 2 25 (dq, 1 H, $J_{1\,2e}$ 1, $J_{2e\,3}$ 4 5 Hz, H-2e), and 5 15 (q, 1 H H-1)

Anal Calc for $C_{15}H_{25}NO_7$ C, 54 37, H, 7 60, N, 4 23 Found C, 54 25, H, 7 47, N, 4 18

Cyclohexyl 3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-D-arabino-hexopyranoside (**35**) — Compound **18** (14 mg, 0 05 mmol) was debrominated by the general method described Purification by column chromatography (solvent H) and recrystallization from ether gave needles of **35** that melted at 113–114°, resolidified, and then remelted at 124–128°, $[\alpha]_D^{15}$ + 128° (*c* 1 0, chloroform), p m r δ 1 0–2 0 (m, 10 H, 5 × CH_2 of cyclohexyl group), 1 66 (dq, 1 H, $J_{1\,2a}$ 3 5, $J_{2a\,3}$ 11 5, $J_{2a\,2e}$ 13 Hz, H-2a), 2 27 (dq, 1 H, $J_{1,2e}$ 1, $J_{2e\,3}$ 4 Hz, H-2e), 3 65 (m, 1 H, CH of cyclohexyl group), and 5 19 (q, 1 H, H-1)

Anal Calc for $C_{18}H_{29}NO_7$ C, 58 21, H, 7 87, N, 3 77 Found C, 58 43, H, 7 85, N, 3 55

tert-*Butyl 3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-D-arabino-hexopyranoside* (**36**) — Compound **19** (22 mg, 0 05 mmol) was debrominated by the general method described Purification by column chromatography (solvent H) and recrystallization from ether gave needles of **36**, m p 116–117°, $[\alpha]_D^{15}$ + 120 (*c* 1 0, chloroform), p m r δ 1 28 (s, 9 H, Me_3C), 1 66 (dq, 1 H, $J_{1,2a}$ 3 5, $J_{2a\,3}$ 12, $J_{2a,2e}$ 13 Hz, H-2a), 2 22 (dq, 1 H, $J_{1,2e}$ 1 5, $J_{2e\,3}$ 4 5 Hz, H-2e), and 5 36 (q, 1 H, H-1)

Anal Calc for $C_{10}H_{23}NO_7$ C, 55 64, H, 7 88, N, 4 06 Found C, 55 47, H, 7 67, N, 3 82

Methyl 6-O-(3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-D-arabino-hexopyranosyl)-2,3,4-tri-O-benzyl-α-D-glucopyranoside (**37**) — Compound **20** (42 mg, 0 05 mmol) was debrominated by the general method described Purification by column chromatography with 5 1 chloroform–acetone and recrystallization from chloroform–ether gave needles of **37**, m p 197–198°, $[\alpha]_D^{16}$ + 90° (*c* 1 0, chloroform), p m r δ 1 58 (dq, 1 H, $J_{1'\,2'a}$ 3 5, $J_{2'a\,3'}$ 12, $J_{2'a\,2'e}$ 13 Hz, H-2'a), 1 91 (s, 3 H, NAc), 2 02 and 2 04 (s, 3 H each, OAc), 2 26 (dq, 1 H, $J_{1'\,2'e}$ ~ 1, $J_{2'e\,3'}$ ~ 4 5 Hz, H-2'e), 3 39 (s, 3 H, CH_3O-1), 5 55 (d, 1 H, $J_{3'\,NH}$ 8 Hz, NH), and 7 3 (sharp signals, 15 H, phenyls of benzyl groups)

Anal Calc for $C_{40}H_{49}NO_{12}$ C, 65 29, H, 6 71, N, 1 90 Found C, 65 16, H, 6 69, N, 1 84

Methyl 3-acetamido-4,6-di-O-acetyl-2,3-dideoxy-α-D-arabino-hexopyranoside (**38**) — Compound **21** (137 mg, 0 36 mmol) was debrominated by the general method described Purification by column chromatography (solvent H) and recrystallization

from chloroform–ether gave needles of **38**, m p 181–182°, $[\alpha]_D^{14}$ +135° (*c* 1 0, chloroform) p m r δ 1 63 (dq 1 H, $J_{1,2a}$ 3 5, $J_{2a,3}$ 12, $J_{2a,2e}$ 13 Hz, H-2a), 1 93 (s, 3 H, NAc), 2 08, and 2 10 (s, 3 H each, OAc), 2 24 (dq, 1 H, $J_{1,2e} \sim 1$ $J_{2e,3}$ 4 5 Hz H-2e), 3 37 (s, 3 H, CH_3O-1), 3 9–4 2 (m, 2 H, H-5, and 6), 4 37 (q, 1 H, $J_{5,6'}$ 4 5 $J_{6,6'}$ 12 Hz, H-6'), 4 5 (m 1 H, H-3), 4 75 (t, 1 H, $J_{3,4} = J_{4,5} = 10$ Hz, H-4), 4 79 (q, 1 H, H-1), and 6 55 (broad d 1 H, $J_{3,NH}$ 8 5 Hz, NH) Irradiation at δ 1 68 changed the quartet at δ 4 79 to a very sharp doublet

Anal Calc for $C_{13}H_{21}NO_7$ C, 51 48, H, 6 98, N, 4 62 Found C, 51 72, H, 6 88, N, 4 50

*Ethyl 2-deoxy-α-*D-arabino-*hexopyranoside* (**39**) — A solution of **22** (96 mg, 0 30 mmol) in dry methanol (1 5 ml) containing M methanolic sodium methoxide (0 15 ml) was kept overnight at room temperature The solution was neutralized by Amberlite CG-50 (H^+ type) resin and evaporated, and the residue was chromatographed on a column of silica gel (10 g) with 4 1 chloroform–ethanol The eluate containing the product was evaporated to a solid that was recrystallized from methanol–benzene to give needles (56 mg, 97%) of **39**, m p 126–127° $[\alpha]_D^{15}$ +150° (*c* 1 0, methanol), p m r (D_2O) δ 1 21 (t, 3 H, J_{CH_3,CH_2} 7 Hz, CH_3 of Et), 1 68 (dq, 1 H, $J_{1,2a}$ 4, $J_{2a,3}$ 11 5, $J_{2a,2e}$ 13 5 Hz, H-2a), 2 14 (dq, 1 H $J_{1,2a}$ 1 5, $J_{2e,3}$ 5 5 Hz, H-2e), and 5 04 (q, 1 H, H-1)

Anal Calc for $C_8H_{16}O_5$ C 49 99, H, 8 39 Found C, 50 02, H, 8 22

*Cyclohexyl 2-deoxy-α-*D-arabino-*hexopyranoside* (**40**) — Compound **24** (170 mg, 0 46 mmol) was treated as described for **39** to give needles (104 mg, 93%) of **40**, m p 123–124°, $[\alpha]_D^{14}$ +130° (*c* 1 0, methanol) [lit [3] m p 123–124°, $[\alpha]_D$ +129 3 (*c* 1 1, methanol)] p m r (D_2O) δ 1 70 (dq 1 H $J_{1,2a}$ 4, $J_{2a,3}$ 11 5, $J_{2a,2e}$ 13 5 Hz, H-2a), 2 15 (dq, 1 H, $J_{1,2e}$ 1 5, $J_{2e,3}$ 5 5 Hz, H-2e), and 5 23 (q, 1 H, H-1)

Anal Calc for $C_{12}H_{22}O_5$ C 58 52, H, 9 00 Found C, 58 68 H, 8 79

tert-*Butyl 2-deoxy-α-*D-arabino-*hexopyranoside* (**41**) — Compound **25** (115 mg, 0 33 mmol) was treated as described for **39** to give plates (67 mg, 92%) of **41**, m p 144–145°, $[\alpha]_D^{14}$ +125° (*c* 1 0, methanol) [lit [3] m p 136–138° and 144–145°, $[\alpha]_D$ +123° (*c* 0 7, methanol)], p m r (D_2O) δ 1 27 (s 9 H, Me_3C), 1 70 (dq, 1 H, $J_{1,2a}$ 4 $J_{2a,3}$ 11 5, $J_{2a,2e}$ 13 5 Hz, H-2a), 2 05 (dq, 1 H, $J_{1,2e}$ 2, $J_{2e,3}$ 5 5 Hz, H-2e), and 5 38 (q, 1 H, H-1)

Anal Calc for $C_{10}H_{20}O_5$ C, 54 53, H, 9 15 Found C, 54 44, H, 9 03

*6-O-(2-Deoxy-α-*D-arabino-*hexopyranosyl)-*D-*glucose* (**42**) — A solution of **26** (25 mg, 0 04 mmol) in 90% aqueous methanol (1 ml) containing triethylamine (0 1 ml) was kept overnight at 37° and then neutralized by Amberlite CG-50 (H^+) resin The solvent was evaporated off and the residue chromatographed on a column of silica gel (4 g) with 2 1 1 ethyl acetate–ethanol–water to give a solid Reprecipitation from water–acetone gave **42** as an amorphous solid (12 6 mg, 96%), m p 98–104° (with foaming), $[\alpha]_D^{15}$ +82 5° (*c* 1 0, water, 24 h) [lit [5] syrup, $[\alpha]_D^{20}$ +85 2° (*c* 1 4, water, 24 h) and $[\alpha]_D^{30}$ +90 6° (*c* 0 6, water, 24 h)], p m r (D_2O) δ 1 67 (dq, 1 H, $J_{1,2a}$ 3 5, $J_{2a,3}$ 11 5, $J_{2a,2e}$ 13 5 Hz, H-2'a), and 2 19 (dq, 1 H, $J_{1,2e}$ 1 5, $J_{2e,3}$ 5 0 Hz, H-2'e)

Anal Calc for $C_{12}H_{22}O_{10}$ C, 44 17, H, 6 80 Found C, 43 95 H, 6 86

*Methyl 3-acetamido-2 3-dideoxy-α-*D-arabino-*hexopyranoside* (**43**) — Compound **38** (47 mg, 0 1555 mmol) was treated as described for **39** Recrystallization from methanol–hexane gave rods (32 mg, 94%) of **43** m p 141 5–142 5°, $[\alpha]_D^{16}$ +159° (*c* 1 0, methanol) [lit [9] m p 135–137°, $[\alpha]_D$ +145° (*c* 1 2, methanol)], p m r (D_2O) δ 1 68 (dq, 1 H, $J_{1,2a}$ 3 5, $J_{2a,3}$ 12, $J_{2a,2e}$ 14 Hz, H-2a), 2 01 (s, 3 H, NAc), 2 10 (dq, 1 H, $J_{1,2e}$ 1 5, $J_{2e,3}$ ~5 5 Hz, H-2e), 3 41 (s, 3 H, CH_3O-1), 3 5–4 0 (m, 4 H, H-4,5,6, and 6′) ~4 2 (m, 1 H, H-3), and 4 91 (q, 1 H, H-1)

Anal Calc for $C_9H_{17}NO_5$ C, 49 31, H, 7 82, N, 6 39 Found C, 49 49, H, 7 65 N, 6 23

*Ethyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-β-*L-ribo-*hexopyranoside* (**44**) — A solution of erythromycin A (2 0 g, 2 72 mmol) in 0 5% ethanolic hydrogen chloride solution (20 ml) was kept overnight at room temperature and then evaporated *in vacuo* to give a residue which was co-evaporated with toluene The residue was treated with acetic anhydride (15 ml) and pyridine (30 ml) overnight at room temperature After addition of ethanol (15 ml), the resulting solution was concentrated to a residue that was chromatographed on a column of silica gel (50 g) with 5 1 hexane–butanone The eluate (containing the major product, which had R_F 0 5 by t l c with the same solvent system) was evaporated to a syrup that was rechromatographed on a column of silica gel to give **44** as a pure liquid (280 mg, 42%), $[\alpha]_D^{25}$ −3 46° (*c* 2 17, chloroform), p m r δ 1 14 (s, 3 H, CH_3-3), 1 15 (d, 3 H, J_{5,CH_3} 6 Hz, CH_3-5) 1 23 (t, 3 H, J_{CH_3,CH_2} 7Hz, CH_3 of Et), 1 49 (q, 1 H, $J_{1,2a}$ ~10, $J_{2a,2e}$ 14 Hz, H-2a) 2 14 (s 3 H, OAc), 2 21 (q, 1 H, $J_{1,2e}$ 2 Hz, H-2e), 3 30 (s, 3 H, CH_3O-3), 3 51, and 3 92 (dq, 1 H each, $J_{H,H}$ 9 5 Hz, H and H′ of CH_2 of Et), ~3 95 (m, 1 H, H-5) 4 65 (d 1 H, $J_{4,5}$ 10 Hz, H-4), and 4 69 (q, 1 H, H-1) Irradiation at δ 1 26 caused doubled quartets at δ 3 51 and 3 92 to change to an AB quartet

Anal Calc for $C_{12}H_{22}O_5$ C, 58 52, H, 9 00 Found C, 58 61, H, 8 88

*Methyl 4-O-acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-β-*L-ribo-*hexopyranoside* (**45**) — A solution of erythromycin A (530 mg, 0 722 mmol) in 0 5% methanolic hydrogen chloride (5 3 ml) was kept overnight at room temperature and then neutralized by addition of solid sodium hydrogencarbonate The mixture was evaporated and the residue chromatographed on a column of silica gel (50 g) with 5 1 chloroform–ethyl acetate The eluate containing the product (R_F ~0 35 by t l c with the same solvent system) was evaporated to give a syrupy mixture of methyl α- and β-cladinosides (110 mg) The ratio of the α- and β-anomers was determined to be 1 4 by the relative intensities of the methyl signals of the anomeric *O*-methyl groups (at δ 3 32 and 3 46, respectively) in the p m r spectrum ($CDCl_3$) The corresponding acetylated mixture also showed two singlets attributable to the anomeric *O*-methyl groups of the α anomer (**32**) and the β anomer (**45**), at δ 3 34 and 3 49, respectively, with the same ratio of intensities as just described

The foregoing syrup (110 mg) which showed two spots having R_F 0 42 (minor, α-anomer) and 0 40 (major, β-anomer) on t l c with the other solvent system (3 1 hexane–butanone), was chromatographed on a column of silica gel (50 g) with the

same solvent system as that used for t l c The eluate containing the product having R_F 0 40 was evaporated to a syrup (90 mg) that was rechromatographed on a column of silica gel to give the chromatographically homogeneous, syrupy β anomer (75 mg) The syrup (75 mg) was treated with acetic anhydride (1 ml) and pyridine (2 ml) overnight at room temperature After addition of methanol (1 ml), the resulting solution was evaporated and the residue chromatographed on a column of silica gel (10 g) with 8 1 hexane–butanone to give pure, syrupy **45** (82 mg, 49%), $[\alpha]_D^{16}$ −1 87° (*c* 2 01, chloroform), p m r δ 1 14 (s, 3 H, CH_3-3), 1 16 (d, 3 H, $J_{5\ CH_3}$ 6 Hz, CH_3-5), 1 46 (q, 1 H, $J_{1\ 2a}$ 9 5, $J_{2a\ 2e}$ 14 Hz, H-2a), 2 13 (s, 3 H, OAc), 2 23 (q, 1 H, $J_{1\ 2e}$ 2 Hz, H-2e), 3 30 (s, 3 H, CH_3O-3), 3 49 (s, 3 H, CH_3O-1), 3 99 (dq, 1 H, $J_{4\ 5}$ 9 5 Hz, H-5), 4 62 (q, 1 H, H-1), and 4 68 (d, 1 H, H-4)

Anal Calc for $C_{11}H_{20}O_5$ C, 56 88, H, 8 68 Found C, 57 02, H, 8 58

*4-O-Acetyl-2,6-dideoxy-3-C-methyl-3-O-methyl-*L*-ribo-hexopyranose* (*4-O-acetylcladinose*) (**46**) — The starting cladinose was prepared as a syrup from erythromycin according to the procedure reported[17] A solution of cladinose (237 mg) in a mixture of acetic anhydride (1 ml) and pyridine (2 ml) was kept overnight at room temperature and, after addition of ethanol (1 ml), was concentrated *in vacuo* to a residue that was chromatographed on a column of silica gel (15 g) with solvent B to give syrupy di-*O*-acetylcladinose (304 mg) The syrup, which crystallized on standing, was used without further purification for the next reaction Recrystallization from hexane gave analytically pure cubes of di-*O*-acetylcladinose, m p 67–68°, $[\alpha]_D^{30}$ −47 5° (*c* 1 0, chloroform), p m r δ 1 17 (s, 3 H, CH_3-3), 1 17 (d, 3 H, $J_{5\ CH_3}$ 6 Hz, CH_3-5), 1 58 (q, 1 H, $J_{1\ 2a}$ 10, $J_{2a,2e}$ 14 Hz, H-2a), 2 10 and 2 15 (s, 3 H each, OAc), 2 32 (q, 1 H, $J_{1\ 2e}$ 2 5 Hz, H-2e), 3 33 (s, 3 H, CH_3O-3), 4 17 (dq, 1 H, $J_{4,5}$ 10 Hz, H-5), 4 72 (d, 1 H, H-4), and 5 96 (q, 1 H, H-1) The n m r spectrum showed that the β-anomeric acetate was markedly preponderant

Anal Calc for $C_{12}H_{20}O_6$ C, 55 37, H, 7 75 Found C, 55 51, H, 7 66

A suspension of di-*O*-acetylcladinose (179 mg), obtained as just described, in 0 1M hydrochloric acid (20 ml) was stirred for 3 h at room temperature until it had completely dissolved The resulting solution was neutralized with solid sodium hydrogencarbonate, evaporated, and the residue extracted with chloroform (20 ml × 5) The extracts were combined and evaporated *in vacuo* to a syrup that gradually crystallized The crystals were chromatographed on a short column of silica gel with 10 1 chloroform–isopropyl alcohol to give crystals that were further purified by sublimation at 80° under diminished pressure (~ 15 mm) to give needles of **46** (136 mg, 91%), m p 97–98°, $[\alpha]_D^{30}$ −40° (*c* 1 0, chloroform), p m r δ 1 19 (d, 3 H, J_{5,CH_3} 6 Hz, CH_3-5), 1 18 and 1 23 (s, 3 H total, CH_3-3), 1 3–1 9 and 2 1–2 6 (m, 1 H each, H-2a and 2e), 2 13 and 2 15 (s, 3 H total, OAc), 3 30 and 3 45 (s, 3 H total, CH_3O-3 of α- and β-anomers respectively, the relative intensities were 2 3), ~4 25 (m, 1 H, H-5), 4 69 and 4 73 (d, 1 H total, $J_{4\ 5}$ 10 Hz, H-4 of α and β anomers), 4 9–5 25 (m, which changed to a mixture of quartets on addition of D_2O, 1 H total, H-1), and 5 43 (d, which disappeared on addition of D_2O, 1 H, *J* 11 Hz, HO-1) The n m r data showed **46** to be a mixture (~2 3) of α and β anomers T l c showed two spots for the α- and

β-anomers near R_F 0 65 with the same solvent system as that used for column chromatography

Anal Calc for $C_{10}H_{18}O_5$ C, 55 03 H, 8 31 Found C, 54 91, H, 8 16

4-O-Acetyl-1 5-anhydro-2,6-dideoxy-3-C-methyl-3-O-methyl-L-*ribo-hex-1-enitol* (*4-O-acetylcladinal*, **2**) — A solution of **46** (400 mg, 1 83 mmol) in dry pyridine (10 ml) containing methanesulfonyl chloride (231 mg, 1 1 molar equivalents) was stirred for 1 5 h at 80° After cooling, the resulting brown solution was poured into agitated ice–water (25 ml) and the mixture was extracted with ethyl acetate (50 ml × 3) The combined extracts were successively washed with water (25 ml), aqueous potassium hydrogensulfate (25 ml × 2), aqueous sodium hydrogencarbonate (25 ml × 2), and water (25 ml), dried (sodium sulfate), and evaporated The residue was chromatographed on a column of silica gel (20 g) with 5 1 hexane–ethyl acetate to give **2** as a liquid (154 mg, 42%) that showed a single spot (R_F 0 4) on t l c This liquid was used for the next reaction

Distillation of the liquid at room temperature under diminished pressure (0 1 mm) gave analytically pure crystals of **2**, which were trapped by cooling with liquid nitrogen The crystals were further sublimed at 50° with an aspirator to give needles of **2**, m p 29–30°, $[\alpha]_D^{16}$ −265° (*c* 1 0, chloroform), p m r δ 1 20 (s 3 H, CH_3-3), 1 22 (d, 3 H, $J_{5\ CH_3}$ ~6 5 Hz, CH_3-5), 2 19 (s, 3 H, OAc), 3 31 (s, 3 H, CH_3O-3), 4 30 (dq, 1 H, $J_{4\ 5}$ ~10 5 Hz, H-5), 4 75 and 6 41 (d 1 H each, $J_{1,2}$ 6 Hz, H-2 and H-1 respectively), and 4 91 (d, 1 H, H-4)

Anal Calc for $C_{10}H_{16}O_4$ C, 59 98, H, 8 05 Found C, 60 05, H, 7 93

This glycal **2** was also obtained by similar treatment of **46** with *p*-toluenesulfonyl chloride (1 7 molar equivalents) in pyridine for 3 h at 80°

Methyl 2,3,4-tri-O-benzyl-α-D-glucopyranoside (**47**) — The starting material was methyl 6-*O*-trityl-α-D-glucopyranoside, which was prepared from methyl α-D-glucopyranoside according to a reported procedure[18] To a stirred solution of methyl 6-*O*-trityl-α-D-glucopyranoside (14 6 g, 33 4 mmol) in dry *N,N*-dimethylformamide (220 ml) was added ground potassium hydroxide (28 3 g, 0 504 mol) followed by α-chlorotoluene (31 9 g, 0 252 mol) The mixture was vigorously stirred for 4 h at room temperature and then filtered After addition of ethanol, the filtrate was evaporated *in vacuo* and the residue extracted with chloroform (400 ml) The extract was washed with water (100 ml × 4), dried (sodium sulfate), and evaporated *in vacuo* to yield a syrup containing methyl 2,3,4-tri-*O*-benzyl-6-*O*-trityl-α-D-glucopyranoside

A solution of the syrup in 80% acetic acid (300 ml) was stirred overnight at room temperature and for 1 h at 60°, and then evaporated *in vacuo* The residue was chromatographed on a column of silica gel (450 g) with 3 1 hexane–acetone to give a solid that was recrystallized from cyclohexane to give needles (12 2 g, 78 7%) of **47**, m p 54–55°, $[\alpha]_D^{15}$ +23 8° (*c* 1 0, chloroform), p m r δ 1 88 (broad s, 1 H, HO-6), 3 35 (s, 3 H, CH_3O-1), 3 4–4 2 (m, 6 H, H-2,3,4,5,6, and 6′), 4 5–5 15 (m, 7 H, H-1 and 3 × CH_2 of benzyl groups), and 7 3 (m, 15 H, 3 × phenyls of benzyl groups)

Anal Calc for $C_{28}H_{32}O_6$ C, 72 39, H, 6 94 Found C, 72 23, H, 7 01

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