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Note

Synthesis of five diastereoisomers of the branched-chain deoxyinositol, DL-1-*C*-hydroxymethyl-1,2,3,4,5-cyclohexanepentol*

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During the course of synthetic studies[2] of valiolamine[3] (**1**), a branched-chain aminocyclitol inhibitor of α-D-glucosidase, the nucleophilic displacement reactions of DL-(1,2,4/3,5)- (**2**) and DL-(1,3,5/2,4)-1-*C*-acetoxymethyl-2,3,4-tri-*O*-acetyl-5-bromo-1,2,3,4-cyclohexanetetrol (**3a**) with acetate ion was studied and led to the preparation of some branched-chain cyclitols and their derivatives. We now describe a synthesis of four new diastereoisomers of the branched-chain deoxyinositol, DL-1-*C*-hydroxymethyl-1,2,3,4,5-cyclohexanepentol having the (1,2,4/3,5)- (**4a**), (1,3,5/2,4)- (**7a**), (1,2,4,5/3)- (**11a**), and (1,3/2,4,5)-configurations (**12a**), together with the known (1,2,5/3,4)-isomer (**5a**) as the penta- and hexa-acetate. The cyclitol **11a** is structurally related to **1**; **4a**, **7a**, and **12a** are deoxy derivatives of the biologically interesting *C*-hydroxymethyl-*myo*-inositol. In addition, the reaction of **2** and **3a** with methanolic sodium methoxide to give the anhydro derivatives of branched-chain cyclitols has been studied.

Treatment of **2** with 6 mol of sodium acetate in boiling 9:1 2-methoxyethanol–water for 16 h, followed by acetylation (acetic anhydride–pyridine), afforded, after column chromatography, two homogeneous branched-chain cyclitol penta-acetates [**4b** (43%) and the known[4] **5b** (46%)]. Acetylation of **4b** in the presence of 4-dimethylaminopyridine gave the hexa-acetate **4c**. The ^{1}H-n.m.r. spectrum (400 MHz) of **4b** contained a signal (δ 5.32, ddd, J 5.1, 10, and 11.6 Hz) attributed to H-5. The reaction involved an intermediate 4,5-acetoxonium ion, the opening of which was not regioselective.

Similar treatment of **3a** with acetate ion, followed by acetylation, afforded the known[2] crystalline anhydride **6** (40%) and the syrupy penta-acetate **7b** (56%) which was characterised as the crystalline hexa-acetate **7c**. The signals for H-2,3,4

*Pseudo-sugars, Part XVI. For Part XV, see ref. 1.
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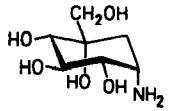

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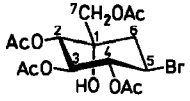

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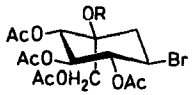

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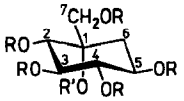

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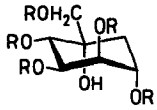

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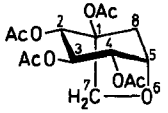

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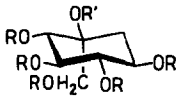

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7b R = Ac, R' = H
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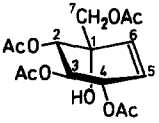

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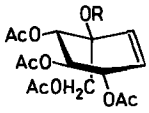
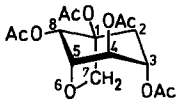


9a R = H
9b R = Ac



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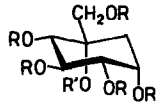
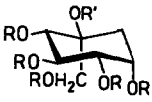
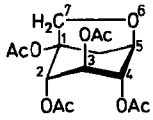


11a R = R' = H
11b R = Ac, R' = H
11c R = R' = Ac



12a R = R' = H
12b R = Ac, R' = H
12c R = R' = Ac



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in the ^{1}H-n.m.r. spectra (90 MHz) of **7c** and **3b** were similar. The 400-MHz spectrum of **7c** contained complex but symmetrical signals at δ 5.88 (1 H), 5.30 (2 H), and 5.03 (1 H) attributable to H-2, H-3,4, and H-5, respectively, indicating all ring protons to be axial. The intermediate 4,5-acetoxonium ion was cleaved at C-5 regioselectively, as observed in azidolysis[2]. The formation of **6** is explained by the intramolecular attack of HO-7 generated by migration of AcO-7 to HO-1. In fact, similar treatment of **3b** gave mainly **7b** (62%), together with **6** (7%) and **7c** (1.3%).

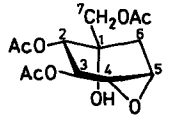
When the reaction of **2** with sodium acetate was carried out in anhydrous *N,N*-dimethylformamide at 90° for 6 days, 5,6-dehydrobromination occurred preferentially to give the known[5] olefin **8** (58%). In contrast, **3a** gave 52% of a

crystalline 1:2 mixture of the anhydrides **6** and **10**, together with the known[5] olefin **9a** (17%). The fully acetylated olefin **9b** was obtained quantitatively from **3b**. Compound **10**, the structure of which was tentatively assigned on the basis of the ^{1}H-n.m.r. spectrum, was assumed to have been formed by intramolecular attack of HO-7 on the 3,4-acetoxonium ion formed by migration from the initial 4,5-position. Under these conditions, acetate ion does not attack either the 4,5- or the 3,4-acetoxonium ion.

Reaction of **2** with a slight excess of silver acetate in boiling aqueous 10% acetic acid gave 82% of the crystalline penta-acetate **11b**, the ^{1}H-n.m.r. spectrum of which contained a quartet (δ 5.57, J 3 Hz) due to H-5. The configuration at C-5 of **2** was inverted by an S_N2 reaction of an acetate ion. On similar treatment, **3a** gave **6** (34%) and the new penta-acetate **12b** (33%). As expected, mainly **12b** (74%) was obtained from **3b**, together with **6** (12%) and the hexa-acetate **12c** (3%). The complex ^{1}H-n.m.r. spectra of **12b,c** made it impossible to assign their structures. However, the structures assigned were supported by the exclusive formation of **12b** (92%) on acetolysis of **6**. The attack of an acetate ion occurs at C-7 selectively[6].

Treatment of **2** with methanolic 0.2M sodium methoxide (2 mol) at room temperature for 1 h followed by acetylation gave, after column chromatography, the anhydrides **13** (13%), **14** (17%), and a 1:1 mixture (70%) of **15** and **16**. After reaction for 6 h, 52% of **13** was obtained together with **14** (7%) and a mixture (20%) of **15** and **16**. The structures of **13** and **14** were confirmed by the ^{1}H-n.m.r. spectra. Acetolysis of **13** afforded **4b** in good yield.

The initially formed epoxide **22** was attacked intramolecularly by HO-3 and HO-7 to produce **23**, and **25** or **26**. The results indicate that epoxide group migration between **22**, **23**, and **24** is possible, and the reaction giving **25** is irreversible. Molecular models show that the transition states for formation of the expected anhydrides **26** and **27** would markedly distort the cyclohexane ring.



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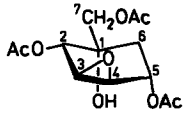

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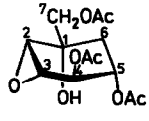

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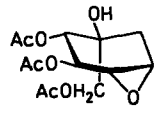

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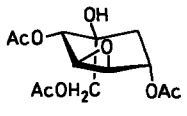

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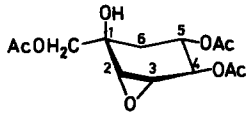

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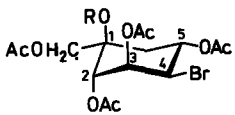
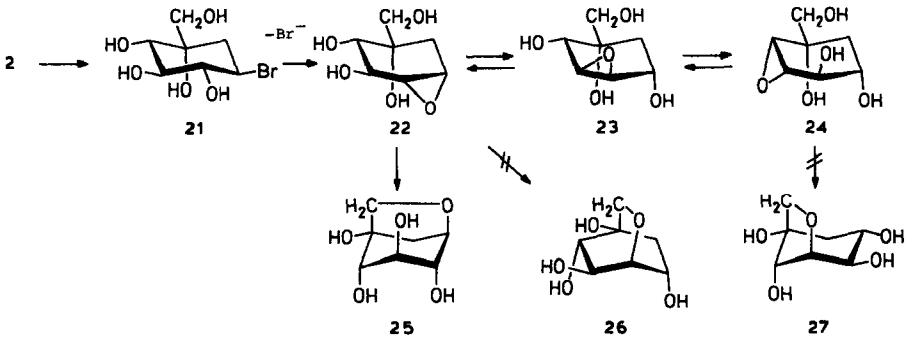
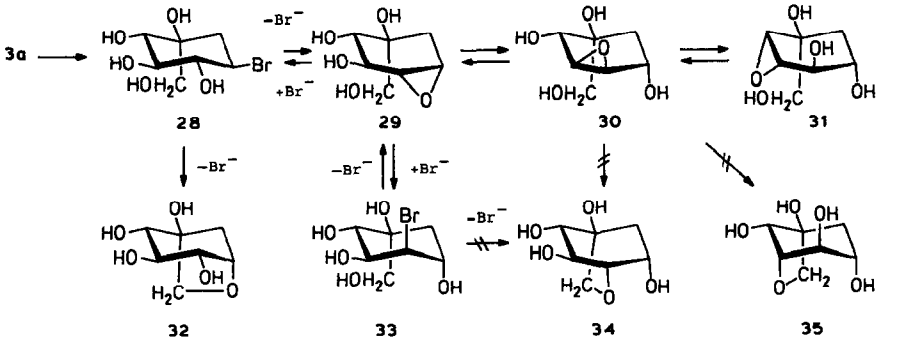


20a R = H
20b R = Ac



Treatment of **3a** with methanolic 0.2M sodium methoxide for 1 h, followed by acetylation, gave **3a** (8%), **6** (8%), and a 1:2 mixture (28%) of the epoxides **17** and **18**, together with the new bromide **20a** (17%). After reaction for 6 h, **6** (51%), a mixture (25%) of **17** and **18**, and the new epoxide **19** (7%) were isolated. Compound **20a** was converted into the penta-acetate **20b**, the ^{1}H-n.m.r. spectrum of which was first-order.

The presence of the bromides **28** and **33** under the above reaction conditions suggested that the epoxide **29** formed first may be susceptible to nucleophilic attack by bromide ion due to the hydrogen bonding involving HO-7. The anhydride **32** gradually accumulated through an irreversible intramolecular reaction of **28**. Formation of the epoxide **31** showed that it is thermodynamically the most stable of the three epoxides.



EXPERIMENTAL

General methods. — Melting points were determined with a MEL-TEMP capillary melting-point apparatus and are uncorrected. ^{1}H-N.m.r. spectra were recorded for solutions in $CDCl_3$ (internal Me_4Si) with Varian EM-390 (90 MHz) and Jeol FX-400 (400 MHz) instruments. T.l.c. was performed on Silica Gel 60 GF (Merck) with detection by charring with sulfuric acid. Column chromatography was conducted on Wakogel C-300 (300 Mesh, Wako Co., Osaka). Organic

solutions were dried over anhydrous Na_2SO_4 and concentrated at <50° under diminished pressure.

DL-*(1,2,4/3,5)-* (**4b**) *and* DL-*(1,2,5/3,4)-1-*C-*Acetoxymethyl-2,3,4,5-tetra-*O-*acetyl-1,2,3,4,5-cyclohexanepentol* (**5b**). — A mixture of DL-(1,2,4/3,5)-1-*C*-acetoxymethyl-2,3,4-tri-*O*-acetyl-5-bromo-1,2,3,4-cyclohexanetetrol[2] (**2**; 50 mg, 0.12 mmol), anhydrous sodium acetate (60 mg, 0.71 mmol), and 9:1 2-methoxyethanol–water (2 mL) was boiled under reflux for 16 h and then concentrated. The residue was treated with acetic anhydride (0.5 mL) and pyridine (0.5 mL) at room temperature overnight, the mixture was concentrated, and the residue was eluted from a column of silica gel (1.8 g) with 2-butanone–toluene (1:3) to give, first, **4b** (20 mg, 43%), m.p. 174–175° (from ethanol). ^{1}H-N.m.r. data (400 MHz): δ 5.45 (t, 1 H, $J_{2,3} = J_{3,4}$ = 9.9 Hz, H-3), 5.32 (ddd, 1 H, $J_{4,5}$ 10, $J_{5,6a}$ 11.6, $J_{5,6e}$ 5.1 Hz, H-5), 5.20 (t, 1 H, H-4), 5.14 (d, 1 H, H-2), 3.98 and 3.86 (2 d, each 1 H, $J_{7,7}$ 11.4 Hz, CH_2OAc), 2.63 (d, 1 H, *J* 1.7 Hz, OH), 2.29 (dd, 1 H, $J_{6,6}$ 13.8 Hz, H-6*e*), 2.09, 2.08, 2.03, 2.025, and 1.99 (5 s, 3, 3, 3, 3, and 3 H, 5 OAc).

Anal. Calc. for $C_{17}H_{24}O_{11}$: C, 50.49; H, 5.98. Found: C, 50.40; H, 5.83.

Eluted second was **5b** (22 mg, 47%), the ^{1}H-n.m.r. spectrum of which was superimposable on that of an authentic sample[4].

Compound **4b** (50 mg, 0.12 mmol) was treated with acetic anhydride (0.5 mL) and pyridine (0.5 mL) in the presence of 4-dimethylaminopyridine (3.4 mg, 0.03 mmol) at 70° for 4 h. The product was eluted from a column of silica gel (4 g) with 2-butanone–toluene (1:5) to give the hexa-acetate **4c** (47 mg, 86%), m.p. 113–114° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.61–4.91 (m, 4 H, H-2,3,4,5), 4.59 and 4.32 (2 d, each 1 H, $J_{7,7}$ 12 Hz, CH_2OAc), 2.19, 2.06, 2.03, and 1.98 (4 s, 3, 6, 6, and 3 H, 6 OAc).

Anal. Calc. for $C_{19}H_{26}O_{12}$: C, 51.12; H, 5.87. Found: C, 51.01; H, 5.83.

*(1*RS*,2*SR*,3*RS*,4*SR*,5*RS*)-1,2,3,4-Tetra-acetoxy-6-oxabicyclo[3.2.1]octane* (**6**) *and* DL-*(1,3,5/2,4)-1-*C-*acetoxymethyl-2,3,4,5-tetra-*O-*acetyl-1,2,3,4,5-cyclohexanepentol* (**7b**). — (*a*) A mixture of **3a**[2] (100 mg, 0.24 mmol), anhydrous sodium acetate (116 mg, 1.42 mmol), and 9:1 2-methoxyethanol–water (4 mL) was boiled under reflux for 18 h and then concentrated. The mixture was then processed as described above. The products were eluted from a column of silica gel (4.7 g) with 2-butanone–toluene (1:4) to give, first, **6** (33 mg, 41%), m.p. 148–149° (from ethanol), the ^{1}H-n.m.r. spectrum of which was superimposable on that of an authentic sample[2]. Eluted second was **7b** (54 mg, 57%), isolated as a syrup contaminated with a trace of **6**. This compound was acetylated as described for the preparation of **4c**, to give the hexa-acetate **7c** (50 mg, 47% based on **3a**), m.p. 105–106° (from ethanol). ^{1}H-N.m.r. data (400 MHz): δ 5.88 (sextet, 1 H, H-2), 5.34–5.26 (m, 2 H, H-3,4), 5.06–4.99 (m, 1 H, H-5), 4.50 and 4.43 (2 d, each 1 H, $J_{7,7}$ 12.3 Hz, CH_2OAc), 2.73 (dd, 1 H, $J_{5,6e}$ 5.2, $J_{6,6}$ 13.2 Hz, H-6*e*), 2.61 (bt, 1 H, $J_{5,6a}$ 11.7 Hz, H-6*a*), 2.20, 2.06, 2.02, 2.015, 2.00, and 1.98 (6 s, each 3 H, 6 OAc).

Anal. Calc. for $C_{19}H_{26}O_{12}$: C, 51.12; H, 5.87. Found: C, 50.91; H, 5.85.

(*b*) A mixture of DL-(1,3,5/2,4)-1-*C*-acetoxymethyl-1,2,3,4-tetra-*O*-acetyl-5-

bromo-1,2,3,4-cyclohexanetetrol (**3b**; 50 mg, 0.11 mmol), anhydrous sodium acetate (53 mg, 0.64 mmol), and 9:1 2-methoxyethanol–water (2 mL) was boiled under reflux for 17 h. The products were acetylated and then eluted from a column of silica gel (2.2 g) with 2-butanone–toluene (1:4), to give **6** (2.5 mg, 7%) and **7b** (27 mg, 62%) contamined with a trace of **6**.

DL-*(1,2,4/3)-1*-C-*Acetoxymethyl-2,3,4-tri*-O-*acetyl-5-cyclohexene-1,2,3,4-tetrol* (**8**). — A mixture of **2** (50 mg, 0.12 mmol), anhydrous sodium acetate (58 mg, 0.71 mmol), and *N,N*-dimethylformamide (2 mL) was stirred at 90° for 9 days and then concentrated. The residue was extracted with ethyl acetate (10 mL), the extract was filtered and concentrated, and the residue was eluted from a column of silica gel (1.8 g) with 2-butanone–toluene (1:3) to give **8** (19 mg, 56% based on **2** consumed), isolated as a syrup, together with **2** (6 mg). The ^{1}H-n.m.r. spectrum (90 MHz) of **8** was superimposable on that of an authentic sample[5].

DL-*(1,3/2,4)-1*-C-*Acetoxymethyl-2,3,4-tri*-O-*acetyl-5-cyclohexene-1,2,3,4-tetrol* (**9a**) *and (1*RS,*3*RS,*4*RS,*5*SR,*8*SR*)-1,3,4,8-tetra-acetoxy-6-oxabicyclo[3.2.1]-octane* (**10**). — A mixture of **3a** (50 mg, 0.12 mmol), anhydrous sodium acetate (58 mg, 0.71 mmol), and *N,N*-dimethylformamide (2 mL) was stirred at 90° for 6 days and then concentrated. The residue was processed as described in the preparation of **8**. The products were eluted from a column of silica gel (2 g) with 2-butanone–toluene (1:4) to give, first, a ~1:2 mixture (21 mg, 52%) of **6** and **10**, m.p. 129.5–136° (from ethanol). ^{1}H-N.m.r. data (90 MHz) for **10**: δ 5.29–5.15 (m, 1 H, H-3), 4.85 (d, 1 H, $J_{4,8}$ 7.4 Hz, H-4), 4.84 (s, 1 H, H-8), 4.65 (d, 1 H, $J_{7,7}$ 11.7 Hz, H-7*exo*), 4.45 (d, 1 H, H-5), 4.24 (d, 1 H, H-7*endo*), 2.10, 2.05, 2.04, and 2.01 (4 s, each 3 H, 4 OAc).

Anal. Calc. for $C_{15}H_{20}O_9$: C, 52.33; H, 5.85. Found: C, 52.03; H, 5.79.

Eluted second was **9a** (7 mg, 17%), isolated as a syrup, the ^{1}H-n.m.r. spectrum of which was superimposable on that of an authentic sample[4].

DL-*(1,3/2,4)-1*-C-*Acetoxymethyl-1,2,3,4-tetra*-O-*acetyl-5-cyclohexene-1,2,3,4-tetrol* (**9b**). — Compound **3b** (50 mg, 0.11 mmol) was treated with anhydrous sodium acetate (53 mg, 0.64 mmol) in *N,N*-dimethylformamide (2 mL) at 90° for 69 h, and the mixture was processed as described for the preparation of **8**. The product was eluted from a column of silica gel (2 g) with 2-butanone–toluene (1:6) to give **3b** (3.6 mg, 7%) and **9b** (28 mg, 68%), m.p. 94–96° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.95 (dt, 1 H, $J_{2,7} = J_{2,7'} = 5.7$, $J_{2,3}$ 10.5 Hz, H-2), 5.80–5.51 (m, 4 H, H-3,4,5,6), 4.29 (s, 2 H, CH_2OAc), 2.12, 2.08, 2.04, 2.00, and 1.99 (5 s, each 3 H, 4 OAc).

Anal. Calc. for $C_{17}H_{22}O_{10}$: C, 52.85; H, 5.74. Found: C, 52.89: H, 5.63.

DL-*(1,2,4,5/3)-1*-C-*Acetoxymethyl-2,3,4,5-tetra*-O-*acetyl-1,2,3,4,5-cyclohexanepentol* (**11b**). — A mixture of **2** (50 mg, 0.12 mmol), silver acetate (24 mg, 0.14 mmol), and aqueous 10% acetic acid (2 mL) was boiled under reflux for 7 days, then filtered, and concentrated, and the residue was acetylated in the usual way. The product was eluted from a column of silica gel (2.3 g) with 2-butanone–toluene (1:2) to give **11b** (39 mg, 82%), m.p. 101.5–103.5° (from ethanol). ^{1}H-N.m.r. data

(90 MHz): δ 5.72 (t, 1 H, $J_{2,3} = J_{3,4} = 10.5$ Hz, H-3), 5.51 (q, 1 H, $J_{4,5} = J_{5,6} = J_{5,6'} = 3$ Hz, H-5), 5.14 (d, 1 H, H-2), 5.01 (dd, 1 H, H-4), 4.05 and 3.71 (2 d, each 1 H, $J_{7,7}$ 11.7 Hz, CH_2OAc), 2.91 (bs, 1 H, OH), 2.17, 2.10, and 2.02 (3 s, 3, 6, and 6 H, 5 OAc).

Anal. Calc. for $C_{17}H_{24}O_{11}$: C, 50.49; H, 5.98. Found: C, 50.30; H, 5.98.

Acetylation of **11b** (20 mg, 0.05 mmol) in the presence of 4-dimethylaminopyridine gave the hexa-acetate **11c** (16 mg, 72%), m.p. 172–174° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.69 (t, 1 H, $J_{2,3} = J_{3,4} = 10.5$ Hz, H-3), 5.57 (q, 1 H, $J_{4,5} = J_{5,6} = J_{5,6'} = 3$ Hz, H-5), 5.17 (d, 1 H, H-2), 5.08 (dd, 1 H, H-4), 4.46 and 4.26 (2 d, each 1 H, $J_{7,7}$ 10.8 Hz, CH_2OAc), 2.13, 2.07, 2.05, 1.99, and 1.92 (5 s, 3, 3, 6, 3, and 3 H, 6 OAc).

Anal. Calc. for $C_{19}H_{26}O_{12}$: C, 51.12; H, 5.87. Found: C, 51.12; H, 5.81.

DL-*(1,3,5/2,4)-1-C-Acetoxymethyl-2,3,4,5-tetra-O-acetyl-1,2,3,4,5-cyclohexanepentol* (**12b**). — (*a*) Treatment of **3a** (50 mg, 0.12 mmol) with silver acetate for 5 days as described for the preparation of **11b**, with elution of the products from a column of silica gel (2.2 g) with 2-butanone–toluene (1:3), gave **6** (14 mg, 34%) and **12b** (17 mg, 33%), m.p. 192.5–195.5° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.51–4.95 (m, 4 H, H-2,3,4,5), 4.40 (s, 2 H, CH_2OAc), 4.14–3.49 (m, 1 H, OH), 2.15, 2.06, and 2.02 (3 s, 12, 3, and 3 H, 6 OAc).

Anal. Calc. for $C_{17}H_{24}O_{11}$: C, 50.49; H, 5.98. Found: C, 50.69; H, 6.07.

Acetylation of **12b** (25 mg, 0.06 mmol) in the presence of 4-dimethylaminopyridine gave the hexa-acetate **12c** (25 mg, 92%), m.p. 141–141.5° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.95 (d, 1 H, $J_{2,3}$ 8.7 Hz, H-2), 5.55–5.28 (m, 1 H, $J_{4,5}$ 3.3 Hz, H-4), 4.54 (s, 2 H, CH_2OAc), 2.10, 2.09, 2.08, 2.05, 2.01, and 1.99 (6 s, each 3 H, 6 OAc).

Anal. Calc. for $C_{19}H_{26}O_{12}$: C, 51.12; H, 5.87. Found: C, 51.12; H, 5.81.

(*b*) Treatment of **3b** (50 mg, 0.11 mmol) as in (*a*), with elution of the products from a column of silica gel (2.5 g) with 2-butanone–toluene (1:3), gave **6** (4.3 mg, 12%), **12c** (1.4 mg, 3%), and **12b** (32 mg, 74%).

(*c*) Compound **6** (28 mg, 0.08 mmol) was treated with acetic acid–acetic anhydride–conc. sulfuric acid (40:40:1, 1.0 mL) at 0–5° for 1 h, and then the mixture was poured into ice–water. The solution was extracted with ethyl acetate, and the extract was washed with aqueous sodium hydrogencarbonate, dried, and concentrated to give **12b** (30 mg, 92%).

Reactions with methanolic sodium methoxide. — (*a*) A mixture of **2** (200 mg, 0.47 mmol) and methanolic 0.2M sodium methoxide (5 mL) was stirred at room temperature for 1 h, then neutralised with M hydrochloric acid, and concentrated, and the residue was acetylated in the usual way. The mixture of products was eluted from a column of silica gel (6.8 g) with 2-butanone–toluene (1:4) to give, first, (1*SR*,2*SR*,3*RS*,4*RS*,5*RS*)-1,2,3,4-tetra-acetoxy-6-oxabicyclo[3.2.1]octane (**13**; 28 mg, 13%), m.p. 111–112.5° (from ethanol). ^{1}H-N.m.r. data (400 MHz): δ 5.54 (d, 1 H, $J_{3,5}$ 1.3 Hz, H-3), 4.90 (s, 1 H, H-2), 4.78 (d, 1 H, $J_{4,5}$ 4.3 Hz, H-4), 4.74 (d, 1 H, $J_{7,7}$ 9.4 Hz, H-7), 4.36 (ddd, 1 H, $J_{5,8}$ 5.6 Hz, H-6), 3.77 (d, 1 H, H-7′), 2.15, 2.14, 2.10, and 1.98 (4 s, each 3 H, 4 OAc).

Anal. Calc. for $C_{15}H_{20}O_9$: C, 52.33; H, 5.85. Found: C, 52.18; H, 5.82.

Eluted second was DL-(1,2,4,5/3)-1-*C*-acetoxymethyl-2,3-di-*O*-acetyl-4,5-anhydro-1,2,3,4,5-cyclohexanepentol (**14**; 24 mg, 17%), isolated as a syrup. ^{1}H-N.m.r. data (90 MHz): δ 5.35 and 5.11 (2 d, each 1 H, $J_{2,3}$ 8.7 Hz, H-2,3), 4.17 and 3.65 (2 d, each 1 H, $J_{7,7}$ 11.9 Hz, CH_2OAc), 3.54–3.42 (m, 1 H, H-5), 3.30 (d, 1 H, $J_{4,5}$ 4.2 Hz, H-4), 3.21 (s, 1 H, OH), 2.42–2.24 (m, 2 H, H-6,6'), 2.09, 2.08, and 2.05 (3 s, each 3 H, 3 OAc).

Anal. Calc. for $C_{13}H_{18}O_8$: C, 51.65; H, 6.00. Found: C, 51.54; H, 6.06.

Eluted third was a 1:1 mixture (94 mg, 70%) of DL-(1,2,5/3,4)-1-*C*-acetoxymethyl-2,5-di-*O*-acetyl-3,4-anhydro-1,2,3,4,5-cyclohexanepentol (**15**) and DL-(1,2,3,5/4)-1-*C*-acetoxymethyl-4,5-di-*O*-acetyl-2,3-anhydro-1,2,3,4,5-cyclohexanepentol (**16**), isolated as a homogeneous syrup. ^{1}H-N.m.r. data (90 MHz): δ 4.01 and 3.78 (2 d, *J* 10.8 Hz), and 3.94 (s) (4 H, CH_2OAc), 3.48 (s), 3.41–3.28 (m), and 3.14 (d, *J* 3.5 Hz) (4 H, epoxide protons), 2.18, 2.15, 2.10, and 2.06 (4 s, total 18 H, 6 OAc).

Anal. Found: C, 50.97; H, 6.14.

(*b*) Treatment of **2** (200 mg, 0.47 mmol) with methanolic 0.2M sodium methoxide as in (*a*), but for 6 h, gave **13** (83 mg, 52%), **14** (10 mg, 7.2%), and a mixture (29 mg, 20%) of **15** and **16**.

(*c*) Treatment of **3a** (200 mg, 0.47 mmol) with methanolic 0.2M sodium methoxide as described in (*a*) and elution of the mixture of products from a column of silica gel (5.9 g) with 2-butanone–toluene (1:4) gave **6** (13 mg, 7.7%), **3a** (16 mg, 8.2%), and DL-(1,3/2,4,5)-1-*C*-acetoxymethyl-2,3,5-tri-*O*-acetyl-4-bromo-1,2,3,5-cyclohexanetetrol (**20a**; 35 mg, 17%), m.p. 142–144° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.39 (td, 1 H, $J_{4,5} = J_{5,6} = 8.3$, $J_{5,6'}$ 4.5 Hz, H-5), 5.33–5.21 (m, 2 H, H-2,3), 4.31–4.24 (m, 1 H, H-4), 4.26 and 3.97 (2 d, each 1 H, $J_{7,7}$ 12 Hz, CH_2OAc), 3.10 (s, 1 H, OH), 2.17, 2.12, and 2.08 (3 s, 3, 6, and 3 H, 4 OAc).

Anal. Calc. for $C_{15}H_{21}BrO_9$: C, 42.37; H, 4.98. Found: C, 42.48; H, 4.86.

Eluted fourth was a ~2:1 mixture (39 mg, 28%) of DL-(1,3/2,4,5)-1-*C*-acetoxymethyl-2,3-di-*O*-acetyl-4,5-anhydro-1,2,3,4,5-cyclohexanepentol (**17**) and DL-(1,3,4/2,5)-1-*C*-acetoxymethyl-2,5-di-*O*-acetyl-3,4-anhydro-1,2,3,4,5-cyclohexanepentol (**18**), isolated as a homogeneous syrup. ^{1}H-N.m.r. data (90 MHz): δ 4.39 and 3.97 (2 d, *J* 11.3 Hz), and 4.19 (s) (4 H, CH_2OAc), 3.30 (s), 3.30–3.20 (m), and 3.08 (d, *J* 3.8 Hz) (total 4 H, epoxide protons), 2.14, 2.08, 2.06, 2.04, 2.00, and 1.91 (6 s, total 18 H, 6 OAc).

Anal. Calc. for $C_{13}H_{18}O_8$: C, 51.65; H, 6.00. Found: C, 51.45; H, 6.25.

Acetylation of **20a** (18 mg, 0.04 mmol) in the presence of 4-dimethylaminopyridine gave the penta-acetate **20b** (18 mg, 90%), m.p. 154–155° (from ethanol). ^{1}H-N.m.r. data (90 MHz): δ 5.79 (bdd, 1 H, $J_{2,3}$ 5.3, $J_{2,7}$ 1.5 Hz, H-2), 5.37 (td, $J_{4,5} = J_{5,6} = 9.5$, $J_{5,6'}$ 4.5 Hz, H-5), 5.30 (dd, 1 H, $J_{3,4}$ 4.5 Hz, H-3), 4.47 (bs, 2 H, CH_2OAc), 4.31 (dd, 1 H, H-4), 2.14, 2.12, 2.10, 2.08, and 2.05 (5 s, each 3 H, 5 OAc).

Anal. Calc. for $C_{17}H_{23}BrO_{10}$: C, 43.70; H, 4.96; Br, 17.10. Found: C, 43.77; H, 4.75; Br, 16.44.

(*b*) Treatment of **3a** (200 mg, 0.47 mmol) with methanolic 0.2M sodium methoxide as described above for 6 h and elution of the products from a column of silica gel (7.2 g) gave **6** (82 mg, 51%) and DL-(1,4/2,3,5)-1-*C*-acetoxymethyl-4,5-di-*O*-acetyl-2,3-anhydro-1,2,3,4,5-cyclohexanepentol (**19**; 13 mg, 7.4%), isolated as a syrup. ^{1}H-n.m.r. data (90 MHz): δ 5.23 (ddd, 1 H, $J_{4,5}$ 7.5, $J_{5,6a}$ 12, $J_{5,6e}$ 4.5 Hz, H-5), 4.99 (d, 1 H, H-4), 4.20 (s, 2 H, CH_2OAc), 3.16 (s, 3 H, H-2,3 and OH), 2.12, 2.10, and 2.00 (3 s, each 3 H, 3 OAc).

Anal. Calc. for $C_{13}H_{18}O_8$: C, 51.65; H, 6.00. Found: C, 51.84; H, 6.14.

Eluted third was a mixture (36 mg, 25%) of **17** and **18**. Acetolysis of **13** (30 mg, 0.09 mmol) for 2 h, as described for the preparation of **11a**, gave **4b** (27 mg, 77%) as crystals.

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