# Neighbouring Group Participation in the Cleavage of Some Steroidal Acetoxy-epoxides

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Participation of a vicinal *trans*-axial acetoxy-group in the boron trifluoride-catalysed cleavage of steroidal epoxides, resulting in some cases in overall diequatorial opening of the oxiran ring, is described.

In general, steroidal epoxides react, both with nucleophiles and electrophiles, to afford mainly the product of diaxial cleavage of the oxiran ring.[1] A number of exceptions to the Fürst–Plattner Rule, arising from the operation of inductive, conjugative, and neighbouring group effects have been recorded,[2] and we have recently demonstrated[3] the *cis*-cleavage of certain vicinal steroidal hydroxy-epoxides by a mechanism involving epoxide migration. We now report that in the boron trifluoride-catalysed cleavage of steroidal epoxides, participation by a vicinal *trans*-axial acetoxy-group occurs, resulting in some cases in diequatorial scission of the oxiran ring.

Treatment of 5,6α-epoxy-3β-methoxy-5α-cholestan-4β-yl acetate (1)[4] with boron trifluoride–ether complex in benzene afforded two isomeric products which, on the basis of their spectra and the reactions described below, are assigned the structures (2a and b), arising by diequatorial cleavage of the oxiran ring.

Further acetylation of either isomer gave the same diacetate (2c), and saponification of a mixture of the two isomers gave a single triol (2d). The presence of a vicinal secondary–tertiary diol grouping in the more abundant isomer (2a) was established by its oxidation to a hydroxy-ketone (4a) with chromium trioxide in pyridine, and by oxidising it with lead tetra-acetate, when 1 mol. equiv. of oxidant was consumed to afford a compound formulated as the oxo-aldehyde (3). Treatment of the triol (2d) with trimethyl orthoformate gave the derived formate (2e).

In order to obtain definitive evidence for the structures of compounds (2a and b) it was planned to deoxygenate the triol monoacetate (2a) at position 4 to give the diol monoacetate (6d), a reference sample of which was prepared from 5-hydroxy-3β-methoxy-5α-cholestan-6-one (5a) as follows. The ketol (5a)[5] was heated under

[1] A. Fürst and P. A. Plattner, Abstracts of Papers of the 12th International Congress on Pure and Applied Chemistry, New York, 1951, p. 409; D. H. R. Barton, *J. Chem. Soc.*, 1953, 1027.

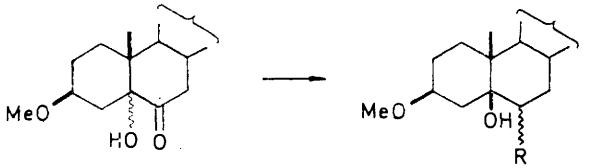
[2] D. H. R. Barton and G. A. Morrison, *Fortschr. Chem. org. Naturstoffe*, 1961, **19**, 202; E. L. Eliel, N. L. Allinger, S. J. Angyal, and G. A. Morrison, 'Conformational Analysis,' Wiley–Interscience, New York, 1965, pp. 294—300; J. G. Buchanan in 'Selective Organic Transformations,' ed. B. S. Thyagarajan, Wiley, New York, 1972, pp. 1—97.

[3] G. A. Morrison and J. B. Wilkinson, *Tetrahedron Letters*, 1975, 2713.

[4] T. H. Campion and G. A. Morrison, *Tetrahedron Letters*, 1968, 1; *Tetrhedron*, 1973, **29**, 239.

[5] Y. F. Shealy and R. M. Dodson, *J. Org. Chem.*, 1951, **16**, 1427.

reflux with methanolic potassium hydroxide to give mainly its 5β-epimer (5b), which was separated from starting material by chromatography. A similar reaction has been reported in the demethoxy series.[6]

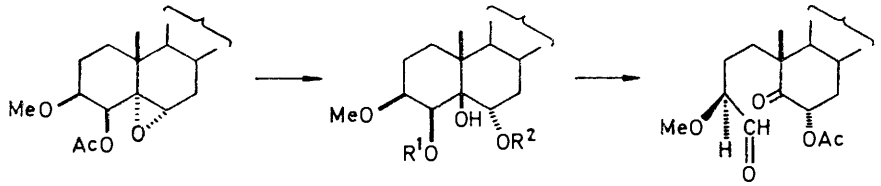


(5) a; 5α-OH
b; 5β-OH

(6) a; R = β-OH
b; R = β-OAc
c; R = α-OH
d; R = α-OAc

Treatment of the ketol (5b) with sodium and ethanol gave mainly the thermodynamically more stable reduction product (6c), whereas use of lithium aluminium aluminate ion. An attempt to replace the 4β-hydroxy-group of compound (2a) with a bromine atom (which might afterwards be removed reductively) also failed when treatment with carbon tetrabromide and triphenylphosphine [7] gave instead a ketonic product, assigned structure (4b) on the basis of its spectra and those of the ketol (4c) obtained by saponification.

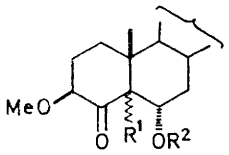
Structures (2a and b) were finally confirmed by an unambiguous preparation of the derived triol (2d), and of the monoacetate (2a) itself, from 3β-methoxycholest-5-en-4β-yl acetate (7).[4,8] The allylic acetate (7) was oxidised with osmium tetraoxide to afford the triol monoacetate (8), which upon further oxidation with chromium trioxide in pyridine gave the acetoxy-ketol (9a), which could be saponified to the corresponding dihydroxy-ketone (9b) by treatment with 1 equiv. of aqueous ethanolic sodium hydroxide. Both the acetoxy-ketol (9a) and the dihydroxy-ketone (9b) gave the 5-epimeric dihydroxy-ketone (9c) when treated with



(1)

(2) a; $R^1$ = H, $R^2$ = Ac
b; $R^1$ = Ac, $R^2$ = H
c; $R^1$ = $R^2$ = Ac
d; $R^1$ = $R^2$ = H
e; $R^1$ = H, $R^2$ = CHO
f; $R^1$ = Ts, $R^2$ = Ac

(3)



(4) a; $R^1$ = β-OH, $R^2$ = Ac
b; $R^1$ = α-H, $R^2$ = Ac
c; $R^1$ = α-H, $R^2$ = H

hydride afforded the diol (6a) possessing an axial 6β-hydroxy-group. The configurations of these products followed from their n.m.r. spectra and those of the derived mono-acetates (6b and d) (see Experimental section).

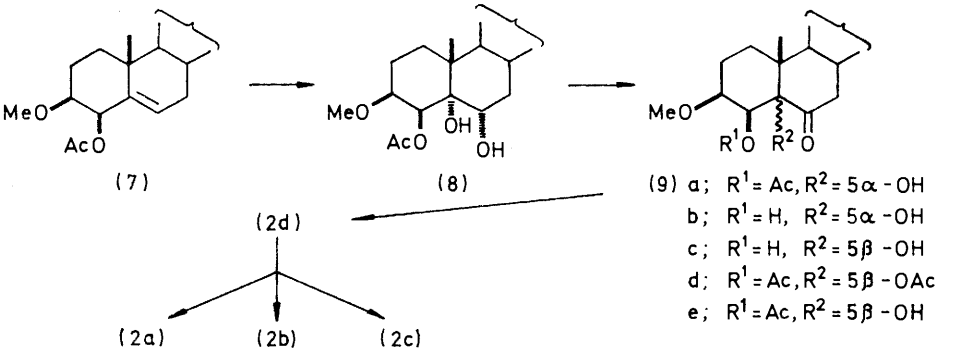
Attempted deoxygenation at position 4 of the triol monoacetate (2a) by reduction of the derived tosylate (2f) with lithium aluminium hydride, however, gave only the triol (2d), possibly because of steric hindrance to nucleophilic attack at C-4 by the bulky tetrahydro-methanolic potassium hydroxide. These configurational assignments are fully supported by n.m.r. spectra (see Experimental section). In particular the width of the signal assigned to the 3α-proton indicates that it is axial in compound (9b) and equatorial in compound (9c). Acetylation of the dihydroxy-ketone (9c) with acetic anhydride–pyridine gave the diacetate (9d) as the major product, together with the monoacetate (9e).

Treatment of the dihydroxy-ketone (9c) with sodium and propan-2-ol gave the non-crystalline thermodynamically more stable reduction product (2d), shown to be

[6] C. W. Davey, E. L. McGinnis, J. McKeown, G. D. Meakins, M. W. Pemberton, and R. N. Young, *J. Chem. Soc.* (*C*), 1968, 2674.

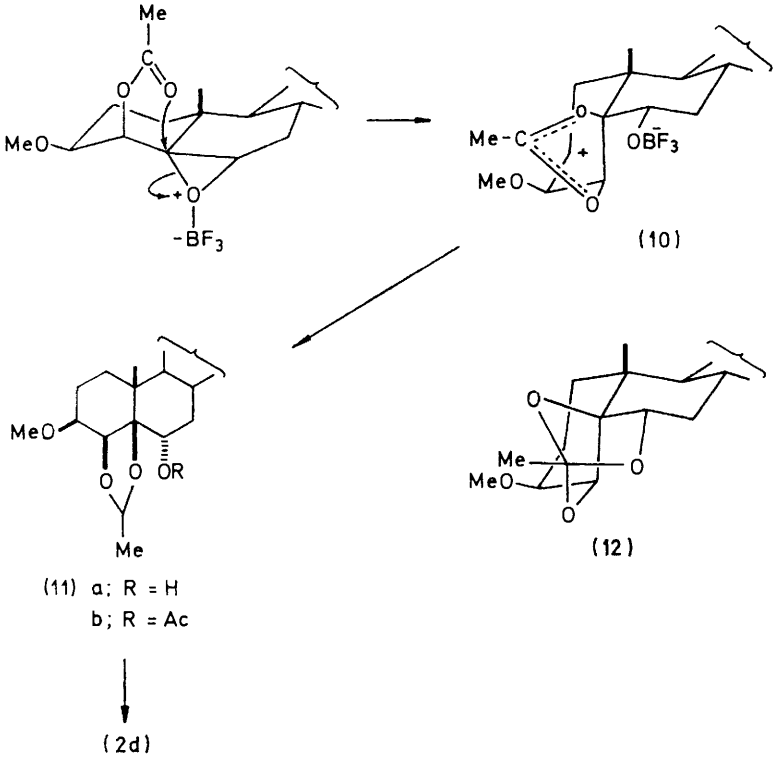
[7] J. Hooz and S. S. H. Gilani, *Canad. J. Chem.*, 1968, **46**, 86.

[8] B. R. Brown and D. M. L. Sandbach, *J. Chem. Soc.*, 1963, 5313.




identical with the saponification product of the triol monoacetates (2a and b) by comparison of i.r. and n.m.r. spectra, specific rotations, and t.l.c. behaviour. Final proof of structure was obtained by acetylation of the triol (2d) derived from the ketone (9c) to give a mixture of the diacetate (2c) and the two triol monoacetates (2a and b) from which a pure sample of the monoacetate (2a) was obtained by chromatography. These products exhibited the same $R_F$ values in t.l.c. as the samples previously derived by boron trifluoride-catalysed rearrangement of the acetoxy-epoxide (1). The identity of the two samples of the monoacetate (2a) was firmly established by direct comparison.

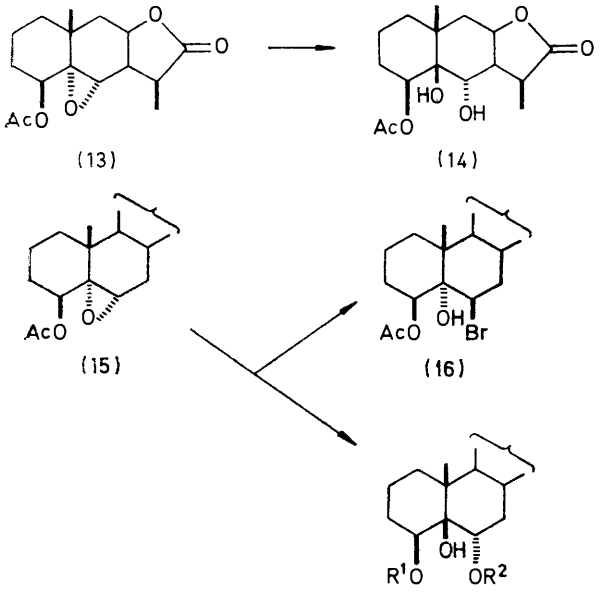
The diequatorial cleavage of the acetoxy-epoxide (1) thus established was shown to involve participation of the 4β-acetoxy-group by carrying out the reaction in the presence of sodium borohydride. Under these conditions, the intermediate 4β,5β-acetoxonium ion was reduced to the acetal (11a), which was isolated.[9] The structure of the acetal (11a) was evident from its n.m.r. spectrum and that of the derived acetate (11b), and from its hydrolysis with aqueous acetic acid to the triol (2d), identified by t.l.c. It is possible that hydrolysis of the acetoxonium ion (10) gives initially 3β-methoxy-5β-cholestane-4β,5,6α-triol 5-acetate, in which the ester function is axial on ring A,[10] subsequent equilibration then leading to a mixture of the triol monoacetates (2a and b). It is also possible, however, that the observed products (2a and b) arise by hydrolysis of an intermediate




[9] *Cf.* (*a*) J. M. Coxon, M. P. Hartshorn, and D. N. Kirk, *Tetrahedron*, 1964, **20**, 2547; (*b*) J. G. Buchanan and A. R. Edgar, *Chem. Comm.*, 1967, 29.

[10] J. F. King and A. D. Allbutt, *Canad. J. Chem.*, 1970, **48**, 1754.

orthoacetate (12), formed from the acetoxonium ion (10).[11]



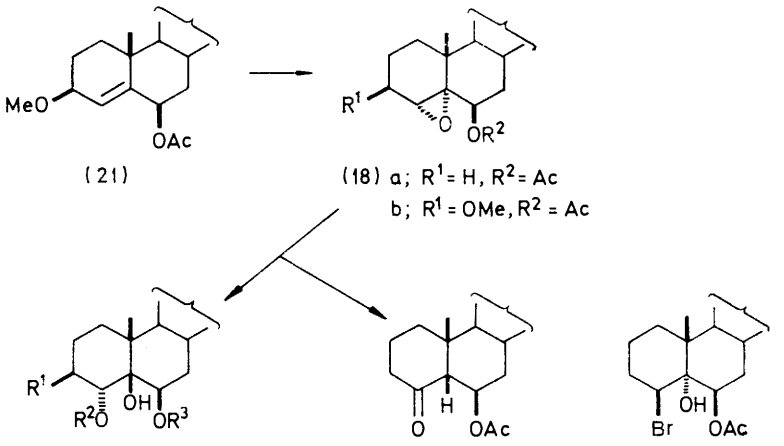

(13) (14) (15) (16)

(17) a; $R^1$=Ac, $R^2$=H
b; $R^1$=H, $R^2$=Ac
c; $R^1$=$R^2$=Ac
d; $R^1$=$R^2$=H

Other examples of participation by a neighbouring acetoxy-group in the cleavage of steroidal epoxides have been reported previously,[9a,12,13] but these have led to overall diaxial cleavage of the oxiran ring. The diequatorial cleavage which we now report is analogous to that observed[14] upon treatment of 4β-acetoxy-5α,6α-epoxy-15-noreudesman-8β,12-olide (13) with hydrobromic acid to give the triol monoacetate (14).

Participation by a vicinal *trans*-axial acetoxy-group in the boron trifluoride-catalysed cleavage of steroidal epoxides appears to be a general phenomenon. Thus, while scission of the acetoxy-epoxide (15) with hydrobromic acid proceeds unexceptionally to give the diaxial bromohydrin (16),[15] we now report that upon treatment of compound (15) with boron trifluoride–ether complex, acetate participation intervenes resulting in diequatorial epoxide cleavage to afford a mixture of the triol monoacetates (17a and b), identified by the n.m.r. spectrum of the mixture. Reduction of the mixture with lithium aluminium hydride gives a single triol (17d), and acetylation of the triol or of the original mixture gives the diacetate (17c).

Participation by a neighbouring acetoxy-group was also evident in the boron trifluoride-catalysed cleavage of the epoxide (18a), which gave a mixture of the triol monoacetates (19a and b), a pure sample of one of which was obtained by chromatography. Acetylation of the mixture gave a single triol diacetate (19c). Once again, the structures assigned to these compounds rest upon spectroscopic evidence (see Experimental section). It is to be noted that, because ring A of the 4α,5α-epoxide (18a) can exist in either of two half-chair conformations, a diaxial product arises by nucleophilic attack at either C-4 or C-5. However, it has already been reported that when the compound is treated with hydrobromic acid, the product is the bromohydrin (22) arising by nucleophilic attack by bromide ion at C-4 of the protonated



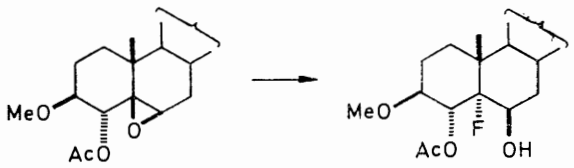

(21) (18) a; $R^1$= H, $R^2$= Ac
b; $R^1$ = OMe, $R^2$ = Ac

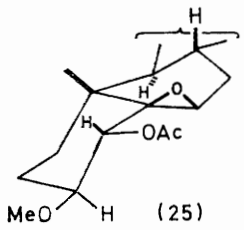
(19) a; $R^1$ = $R^2$ = H, $R^3$ = Ac
b; $R^1$ = $R^3$ = H, $R^2$ = Ac
c; $R^1$ = H, $R^2$ = $R^3$ = Ac
d; $R^1$ = OMe, $R^2$ = H, $R^3$ = Ac

(20) (22)

[11] *Cf.* J. M. Coxon, M. P. Hartshorn, and W. H. Swallow, *J. Org. Chem.*, 1974, **39**, 1142.
[12] *Cf.* J. Atkin, R. E. Gall, and A. M. Slee, *J.C.S. Perkin II*, 1972, 1185.
[13] S. Julia and J.-P. Lavaux, *Bull. Soc. chim. France*, 1963, 1238; S. Julia and B. Fürer, *ibid.*, 1966, 1106.
[14] P. Vita-Finzi, Y. Kashman, E. Glotter, and D. Lavie, *Tetrahedron*, 1968, **24**, 5847.
[15] D. Lavie, Y. Kashman, and E. Glotter, *Tetrahedron*, 1966, **22**, 1103.

oxiran.[16] The different mode of scission observed in the present work is interpreted in terms of intramolecular nucleophilic attack at C-5 by the 6β-acetoxy-group, which can compete successfully with fluoride, but not with the more nucleophilic bromide ion. In addition to the triol monoacetates (19a and b) a ketone, thought to be 6β-acetoxy-5β-cholestan-4-one (20) on the basis of its i.r. and n.m.r. spectra, was also isolated. This product, which arises by an unexceptional hydride shift from C-4 to C-5, exhibits a signal for the C-10 angular methyl group at δ 1.16, a value consistent with




that calculated from additivity tables[17] and which distinguishes it from the known 5α-epimer.[18]

The behaviour of the epoxy-acetate (18a) was paralleled by that of its 3β-methoxy-analogue (18b) [prepared by oxidation of 3β-methoxycholest-4-en-6β-yl acetate (21)[5] with *m*-chloroperbenzoic acid], which with boron trifluoride–ether gave the dihydroxy-acetate (19d).

In contrast with those examples of oxiran cleavage involving acetate participation, treatment of the vicinal *trans*-acetoxy-epoxide (23)[3] with boron trifluoride–ether complex gives the diaxial fluorohydrin (24), the structure and configuration of which follow from its $^1H$ and $^{19}F$ n.m.r. spectra. The absence of neighbouring acetoxy-group participation in this case is in accord with the 'non-steroid' conformation (25)[19] adopted by rings A and B, resulting in the 4α-acetoxy-group being equatorially disposed.

## EXPERIMENTAL

M.p.s were measured on a Kofler hot-stage apparatus. I.r. spectra (Nujol mulls, unless stated otherwise) were recorded on a Unicam SP 1000 G spectrophotometer or a Perkin-Elmer 157 G instrument. N.m.r. spectra were measured on a Perkin-Elmer R 12 or a Varian A 60A instrument, with deuteriochloroform as solvent, except for the fluorine spectrum and the double irradiation experiments which were carried out on a Bruker HFX 90 MHz instrument. Mass spectra were recorded on an A.E.I. MS902 spectrometer. Optical rotations were measured on a Perkin-Elmer 141 polarimeter for solutions in chloroform (unless stated otherwise) in a 1 dm cell. Merck Kieselgel G or $GF_{254}$ was used for t.l.c. and column chromatography. Solutions in organic solvents were dried with anhydrous sodium sulphate or magnesium sulphate.

*Reaction of 5,6α-Epoxy-3β-methoxy-5α-cholestan-4β-yl Acetate* (1) *with Boron Trifluoride–Ether*.—Boron trifluoride–ether complex (7.5 ml) was added to a solution of the epoxide (1)[4] (392 mg) in ether (7.5 ml), and the mixture was left at room temperature for 18 h, then poured into water, and extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo* to give a gum (435 mg) which was chromatographed on a column of Kieselgel G (60 g) with benzene–chloroform (1 : 1) as eluant. The earliest fractions gave, after crystallisation from aqueous acetone, *3β-methoxy-5β-cholestane-4β,5,6α-triol 4-acetate* (2b) (61 mg), m.p. 148—149°, $[\alpha]_D$ +29.3° (*c* 0.75 in $Me_2CO$) (Found: C, 73.1; H, 10.8. $C_{30}H_{52}O_5$ requires C, 73.1; H, 10.65%); $\nu_{max.}$ 3 450, 1 720, and 1 235 $cm^{-1}$; δ 0.97 (3 H, s, 10-Me), 2.08 (3 H, s, 4β-OAc), 2.45 (1 H, m, exchangeable with $D_2O$, OH), 3.47 (3 H, s, OMe), 3.52—4.10 (2 H, m, 6β- and 3α-H), 4.53 (1 H, m, exchangeable with $D_2O$, OH), and 5.69 (1 H, d, *J* 3 Hz, collapses to a singlet on irradiation at δ 3.67, 4α-H); *m/e* 432 ($M^+$ — HOAc).

The final fractions gave *3β-methoxy-5β-cholestane-4β,5,6α-triol 6-acetate* (2a), which crystallised from methanol as needles (203 mg), m.p. 146—147°, $[\alpha]_D$ +51.7° (*c* 0.92 in $Me_2CO$) (Found: C, 72.8; H, 10.35. $C_{30}H_{52}O_5$ requires C, 73.1; H, 10.65%); $\nu_{max.}$ 3 470, 1 735, and 1 520 $cm^{-1}$; δ 1.04 (3 H, s, 10-Me), 2.13 (3 H, s, 6α-OAc), 3.53 (3 H, s, OMe), 3.75 (2 H, m, $W_{\frac{1}{2}}$ 7 Hz, reduced to a 1 H signal on shaking with $D_2O$, 3α-H and OH), 4.32 (2 H, m, 4α-H and OH; simplifies to 1 H, d, *J* 3 Hz upon addition of $D_2O$, and collapses to a singlet on irradiation at δ 3.75), and 5.30 (1 H, dd, *J* 4 and 12 Hz, 6β-H); *m/e* 432 ($M^+$ — HOAc).

An intermediate mixed fraction of the acetates (2a and b) was shown by t.l.c. to consist mainly of the acetate (2a).

*3β-Methoxy-5β-cholestane-4β,5,6α-triol 4,6-Diacetate* (2c).—(*a*) The 4β-acetate (2b) (32 mg) was acetylated with acetic anhydride (3 ml) and pyridine (6 ml) at room temperature for 2 days to give, after chromatography on a column of Kieselgel G (4 g) (1 : 4 ethyl acetate–light petroleum as eluant), the *4β,6α-diacetate* (2c) as a gum, $[\alpha]_D$ +9.2° (*c* 0.95 in $CCl_4$) (Found: C, 71.85; H, 10.5. $C_{32}H_{54}O_6$ requires C, 71.85; H, 10.2%); $\nu_{max.}$ (film) 3 470, 1 730, and 1 250 $cm^{-1}$; δ 1.05 (3 H, s, 10-Me), 2.08 (3 H, s, OAc), 2.20 (3 H, s, OAc), 3.45 (3 H, s, OMe), 3.61 (1 H, m, $W_{\frac{1}{2}}$ 9 Hz, 3α-H), 4.25br (1 H, s, OH), 5.26 (1 H, dd, *J* 4 and 12 Hz, 6β-H), and 5.72 (1 H, d, *J* 3.5 Hz, collapses to a singlet on irradiation at δ 3.61, 4α-H).

(*b*) Acetylation of the 6α-acetate (2a) (63 mg) under similar conditions gave the diacetate (2c) (51 mg), identical (n.m.r., i.r., t.l.c., $[\alpha]_D$) with a sample obtained as described in (*a*).

*3β-Methoxy-5β-cholestane-4β,5,6α-triol* (2d).—(*a*) A mixture (297 mg) of the acetates (2a and b) was dissolved in ether (10 ml) and heated under reflux for 6 h with lithium aluminium hydride (200 mg). The excess of reducing agent was destroyed by adding ethyl acetate, then water, and the mixture was extracted with ether. The extract was dried

[16] S. Greenfield, E. Glotter, D. Lavie, and Y. Kashman, *J. Chem. Soc.* (*C*), 1967, 1460.

[17] N. S. Bhacca and D. H. Williams, 'Application of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry,' Prentice–Hall, San Francisco, 1964.

[18] J.-P. Pete and M.-L. Viriot-Villaume, *Bull. Soc. chim. France*, 1971, 3699.

[19] *Cf.* T. G. Halsall, E. R. H. Jones, E. L. Tan, and G. R. Chaudhry, *J. Chem. Soc.* (*C*), 1966, 1374; P. Morand and M. Kaufman, *Canad. J. Chem.*, 1971, **49**, 3185.

and evaporated *in vacuo*, and the residue (257 mg) was chromatographed on a column of Kieselgel G (11 g) (3 : 7 ethyl acetate–benzene as eluant) to give 3β-*methoxy*-5β-*cholestane*-4β,5,6α-*triol* (2d) (242 mg) as a gum, $[\alpha]_D$ +33.7° (*c* 4.65) (Found: C, 74.65; H, 10.9. $C_{28}H_{50}O_4$ requires C, 74.6; H, 11.2%); $\nu_{max.}$ (film) 3 400 $cm^{-1}$; δ 0.93 (3 H, s, 10-Me), 3.46 (3 H, s, OMe), 3.65 (1 H, m, $W_{\frac{1}{2}}$ 6 Hz, 3α-H), 3.93 (2 H, m, $W_{\frac{1}{2}}$ 16 Hz, reduced to a 1 H signal on shaking with $D_2O$, 6β-H and OH), 4.30 (1 H, m, $W_{\frac{1}{2}}$ 5 Hz, 4α-H), 4.42 (1 H, s, exchangeable with $D_2O$, OH), and 4.81 (1 H, m, exchangeable with $D_2O$, OH).

(*b*) A solution of the toluene-*p*-sulphonate (2f) (45 mg) in ether (2.5 ml) was treated with lithium aluminium hydride (50 mg) at room temperature for 24 h. The mixture was worked up as in (*a*), and the resulting gum (29 mg) was chromatographed on a column of silica gel (15 g) (5 : 95 ethyl acetate–chloroform as eluant) to give the triol (2d) (20 mg) identical (t.l.c., i.r.) with the material obtained in (*a*).

(*c*) A solution of 4β,5-dihydroxy-3β-methoxy-5β-cholestan-6-one (9c) (118 mg) in benzene (20 ml) was stirred with sodium shavings (1 g) at room temperature while propan-2-ol (30 ml) was slowly added. After the addition was complete the mixture was heated under reflux for 1 h. Ether was added to the cooled mixture, which was then washed with brine (three times), dried, and evaporated *in vacuo*. Chromatography on a column of Kieselgel G (10 g) (3 : 7 ether–benzene as eluant) gave from the early fractions a mixture (28 mg) of starting material (9c) and the triol (2d) (identified by t.l.c.); the later fractions afforded a pure sample of the triol (2d) (78 mg), identical (t.l.c., i.r., n.m.r., $[\alpha]_D$) with the material obtained in (*a*).

(*d*) A solution of 4β,5-ethylidenedioxy-3β-methoxy-5β-cholestan-6α-ol (11a) (5 mg) in aqueous acetic acid (1 ml; 20% $H_2O$) was heated at 100 °C for 1 h. Ether was added to the cooled mixture, and the solution was washed successively with dilute aqueous sodium hydroxide and water, then dried. T.l.c. with ether as eluant showed the products to be unchanged acetal (11a) and the triol (2d).

*Oxidation of* 3β-*Methoxy*-5β-*cholestane*-4β,5,6α-*triol* 6-*Acetate* (2a) *with Lead Tetra-acetate*.—A stirred solution of 3β-methoxy-5β-cholestane-4β,5,6α-triol 6-acetate (2a) (120 mg) in methylene chloride (5 ml) was treated with lead tetra-acetate (115 mg) at room temperature. After 1 h (when titration of portions with 0.1N-$Na_2S_2O_3$ had shown that 1.05 mol. equiv. of oxidant had been consumed, and no further uptake was occurring) the solution was decanted, and the residue extracted with chloroform. The combined organic solutions were washed successively with aqueous sodium sulphite, aqueous sodium hydrogen carbonate, and water, then dried and evaporated *in vacuo*. Chromatography of the residue on a column of Kieselgel G (12 g) (1 : 1 ether–benzene as eluant) gave the *formyl ketone* (3) (90 mg) as a gum, $[\alpha]_D$ −9.7° (*c* 2.95) (Found: C, 73.3; H, 10.1. $C_{30}H_{50}O_5$ requires C, 73.45; H, 10.3%); $\nu_{max.}$ 1 750—1 720 and 1 240 $cm^{-1}$; δ 2.17 (3 H, s, OAc), 3.50 (3 H, s, OMe), 3.45—3.80 (1 H, m, 3α-H), 5.35—5.70 (1 H, m, 6β-H), and 9.83 (1 H, d, *J* 2 Hz, CHO).

6α-*Acetoxy*-5-*hydroxy*-3β-*methoxy*-5β-*cholestan*-4-*one* (4a).—Chromium trioxide (1 g) was added to a stirred solution of dry pyridine (2 ml) in dry methylene chloride (30 ml) at room temperature, and stirring was continued for 15 min. A solution of the triol monoacetate (2a) (71 mg) in methylene chloride (5 ml) was added, and stirring was continued for a further 15 min. The methylene chloride solution was decanted, and the residue was extracted with ether. The combined organic solutions were washed successively with dilute aqueous sodium hydroxide (three times), dilute hydrochloric acid, aqueous sodium hydrogen carbonate, and brine, then dried, and evaporated under reduced pressure to give, after recrystallisation from aqueous ethanol, the *acetoxy-ketone* (4a) (66 mg), m.p. 131—132°, $[\alpha]_D$ +37.4° (*c* 1.45) (Found: C, 73.55; H, 10.15. $C_{30}H_{50}O_5$ requires C, 73.45; H, 10.3%); $\nu_{max.}$ 3 420, 1 745, and 1 266 $cm^{-1}$; δ 1.09 (3 H, s, 10-Me), 2.09 (3 H, s, OAc), 3.48 (3 H, s, OMe), 3.67 (1 H, s, OH), and 4.92—5.29 (1 H, m, 6β-H).

3β-*Methoxy*-5β-*cholestane*-4β,5,6α-*triol* 6-*Formate* (2e).—A solution of the triol (2d) (160 mg) in methanol (3 ml) was treated with methanolic hydrogen chloride (1.5 ml) and trimethyl orthoformate (2 ml) at 0 °C. After 4 h sodium hydrogen carbonate (5 g) was added, and the mixture was extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo*, and the resulting gum was chromatographed on a column of Kieselgel G (10 g) (1 : 1 ether–benzene as eluant) to give the *formate* (2e) (47 mg), m.p. 80—82° (from methanol), $[\alpha]_D$ +54.1° (*c* 8.0) (Found: C, 73.1; H, 10.4. $C_{29}H_{50}O_5$ requires C, 72.75; H, 10.55%); $\nu_{max.}$ 3 460, 1 730, and 1 195 $cm^{-1}$; δ 1.01 (3 H, s, 10-Me), 3.46 (3 H, s, OMe), 3.70 (1 H, m, $W_{\frac{1}{2}}$ 10 Hz, 3α-H), 4.30 (2 H, m, 4α-H and OH; simplifies to 1 H, d, *J* 4 Hz at δ 4.20 upon addition of $D_2O$), 5.25 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 6β-H), and 8.15 (1 H, s, OCHO).

3β-*Methoxy*-5β-*cholestane*-4β,5,6α-*triol* 6-*Acetate* 4-*Toluene*-p-*sulphonate* (2f).—A solution of the triol monoacetate (2a) (73 mg) in pyridine (2 ml) at 0 °C was treated with toluene-*p*-sulphonyl chloride (108 mg), and allowed to warm to room temperature. After 4 days, water was added, and the mixture was extracted with ether. The extract was washed successively with dilute hydrochloric acid, aqueous sodium hydrogen carbonate, and water, then dried and evaporated *in vacuo*. Chromatography of the residue on a column of silica gel (15 g), with chloroform as eluant, gave, from the early fractions, the *toluene*-p-*sulphonate* (2f) (62 mg), which gave crystals, m.p. 154—155° [from light petroleum (b.p. 30—60 °C)], $[\alpha]_D$ −11.2° (*c* 4.15) (Found: C, 69.1; H, 9.1. $C_{37}H_{55}SO_7$ requires C, 68.7; H, 9.05%); $\nu_{max.}$ 3 940, 1 733, 1 600, 1 245, 1 185, and 1 175 $cm^{-1}$; δ 1.02 (3 H, s, 10-Me), 1.91 (3 H, s, OAc), 2.49 (3 H, s, ArMe), 3.25 (3 H, s, OMe), 3.73 (1 H, m, $W_{\frac{1}{2}}$ 10 Hz, 3α-H), 4.24 (1 H, m, exchangeable with $D_2O$, OH), 5.10—5.38 (1 H, m, 6β-H), 5.31 (1 H, d, *J* 3 Hz, 4α-H), 7.49 (2 H, d, *J* 8 Hz, Ar-H), and 8.07 (2 H, d, *J* 8 Hz, Ar-H). The later fractions gave starting material (2a) (40 mg).

6α-*Acetoxy*-3β-*methoxy*-5α-*cholestan*-4-*one* (4b).—A solution of 3β-methoxy-5β-cholestane-4β,5,6α-triol 6-acetate (2a) (130 mg), and carbon tetrabromide (206 mg) in dry ether (3.5 ml) was stirred at room temperature for 24 h with triphenylphosphine (167 mg), then poured into 1 : 1 methanol–brine, and extracted with pentane. The extract was washed with brine, dried, and evaporated *in vacuo*. Chromatography of the residue on a column of Kieselgel G (10 g) (1 : 9 ether–benzene as eluant) gave the *ketone* (4b) (70 mg), m.p. 158—160° (from methanol), $[\alpha]_D$ +24.5° (*c* 2.30) (Found: C, 75.3; H, 10.45%; $M^+$, 474.369 4. $C_{30}H_{50}O_4$ requires C, 75.9; H, 10.6%; *M*, 474.370 9); $\nu_{max.}$ 1 720 and 1 240 $cm^{-1}$; δ 0.76 (3 H, s, 10-Me), 1.94 (3 H, s, OAc), 2.32 (1 H, d, *J* 10.5 Hz, collapses to a singlet on irradiation at δ 5.12, 5α-H), 3.41 (3 H, s, OMe), 3.80 (1 H, dd, *J* 12 and 7 Hz, 3α-H), and 5.12 (1 H, dt, *J* 10.5 and 4 Hz, simplifies to a dd, *J* 11 and 4 Hz on irradiation at δ 2.32, 6β-H).

6α-*Hydroxy*-3β-*methoxy*-5α-*cholestan*-4-*one* (4c).—The acetate (4b) (62 mg) was saponified by treatment with methanolic potassium hydroxide (10 ml; 1.2%) at room temperature for 3 days to give, after work up in the usual way, the *ketone* (4c) (50 mg), m.p. 140—142° (from acetone), $[\alpha]_D$ +14.8° (*c* 3.30) (Found: $M^+$, 432.360 3. $C_{28}H_{48}O_3$ requires *M*, 432.361 6); $\nu_{max.}$ 3 500 and 1 708 $cm^{-1}$; δ 0.76 (3 H, s, 10-Me), 3.47 (3 H, s, OMe), and 3.50—4.10 (2 H, m, 3α- and 6β-H).

5-*Hydroxy*-3β-*methoxy*-5β-*cholestan*-6-*one* (5b).*—A solution of 5-hydroxy-3β-methoxy-5α-cholestan-6-one (5a) [5] (153 mg) in methanolic potassium hydroxide (10%; 30 ml) was heated under reflux for 2 days, then poured into brine and extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo* to leave a yellow oil (145 mg). Chromatography on a column of Kieselgel G (12 g) (chloroform as eluant) gave, in addition to starting material (5b) (35 mg), the 5β-*cholestanone* (5b) (90 mg) as a gum which, although homogeneous by t.l.c., could not be induced to crystallise. It was purified by distillation (bath temp. 156 °C; pressure 3 × $10^{-3}$ mmHg) (Found: C, 78.0; H, 11.3%; $M^+$, 432.359 1. $C_{28}H_{48}O_3$ requires C, 77.7; H, 11.2%; *M*, 432.360 3); $\nu_{max.}$ (film) 3 440 and 1 700 $cm^{-1}$; δ 0.80 (3 H, s, 10-Me), 3.34 (3 H, s, OMe), 3.61 (1 H, m, $W_{\frac{1}{2}}$ 9 Hz, 3α-H), and 4.23 (1 H, s, OH).

3β-*Methoxy*-5β-*cholestane*-5,6β-*diol* (6a).—Lithium aluminium hydride (60 mg) was added to a stirred solution of the ketol (5b) (55 mg) in ether (4 ml) at room temperature. After 24 h water was added and the mixture was extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo* to give the *diol* (6a) (43 mg), which crystallised from aqueous ethanol as plates, m.p. 68—69° (Found: C, 77.3; H, 11.45. $C_{28}H_{50}O_3$ requires C, 77.35; H, 11.6%); $\nu_{max.}$ 3 460 $cm^{-1}$; δ 1.13 (3 H, s, 10-Me), 2.50—2.90 (1 H, m, exchangeable with $D_2O$, OH), 3.39 (3 H, s, OMe), 3.63 (2 H, m, $W_{\frac{1}{2}}$ 10 Hz, 3α- and 6α-H), and 4.20—4.60 (1 H, m, exchangeable with $D_2O$, OH); *m/e* 434 ($M^+$), 416 ($M^+ - H_2O$), and 398 ($M^+ - 2H_2O$).

The 6-*acetate* (6b) (34 mg) was obtained by treatment of the diol (6a) (44 mg) with acetic anhydride (2 ml) and pyridine (4 ml) on a steam-bath for 7 h; m.p. 122—124° (from aqueous methanol), $[\alpha]_D$ +6.5° (*c* 1.85) (Found: C, 75.7; H, 10.85. $C_{30}H_{52}O_4$ requires C, 75.6; H, 11.0%); $\nu_{max.}$ 3 485, 1 745, and 1 250 $cm^{-1}$; δ 1.06 (3 H, s, 10-Me), 2.05 (3 H, s, OAc), 3.29 (3 H, s, OMe), 3.58 (1 H, m, $W_{\frac{1}{2}}$ 8 Hz, 3α-H), 4.17 (1 H, s, exchangeable with $D_2O$, OH), and 4.83 (1 H, t, *J* 2 Hz, 6α-H).

3β-*Methoxy*-5β-*cholestane*-5,6α-*diol* (6c).—Sodium (14 g) was added slowly to a solution of the ketol (5b) (387 mg) in ethanol (160 ml) at 0 °C. The resulting clear solution was poured into brine and extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo*, and the residue was chromatographed on a column of kieselgel G (30 g) (5 : 95 ether–benzene as eluant) to give the 5,6β-diol (6a) (26 mg), identical with the product of the previous experiment, and the 5,6α-*diol* (6c) (195 mg), m.p. 91—92° (from aqueous methanol), $[\alpha]_D$ +27.9° (*c* 4.85) (Found: C, 77.3; H, 11.5. $C_{28}H_{50}O_3$ requires C, 77.35; H, 11.6%); $\nu_{max.}$ 3 460 $cm^{-1}$; δ 0.90 (3 H, s, 10-Me), 3.30 (3 H, s, OMe), 2.33br (1 H, s, exchangeable with $D_2O$, OH), 3.76 (1 H, dd, *J* 11 and 5 Hz, 6β-H), 3.66 (1 H, m, $W_{\frac{1}{2}}$ 9 Hz, 3α-H), and 4.33br (1 H, s, exchangeable with $D_2O$, OH); *m/e* 434 ($M^+$), 416 ($M^+ - H_2O$).

* We thank Mr. A. W. Bridge for technical assistance in the characterisation of this compound.

The 6-*acetate* (6d) (83 mg) was obtained by treatment of the diol (6a) (80 mg) with acetic anhydride (2.5 ml) and pyridine (5 ml) at 100 °C for 1.5 h followed by 20 h at room temperature; m.p. 130—131° (from methanol), $[\alpha]_D$ +55° (*c* 3.22) (Found: C, 75.5; H, 11.05. $C_{30}H_{52}O_4$ requires C, 75.6; H, 11.0%); $\nu_{max.}$ 3 480, 1 725, and 1 260 $cm^{-1}$; δ 0.97 (3 H, s, 10-Me), 2.05 (3 H, s, OAc), 3.32 (3 H, s, OMe), 3.63 (1 H, m, $W_{\frac{1}{2}}$ 9 Hz, 3α-H), 4.00br (1 H, s, exchangeable with $D_2O$, OH), and 5.00 (1 H, dd, *J* 12 and 5 Hz, 6β-H).

3β-*Methoxy*-5α-*cholestane*-4β,5,6α-*triol* 4-*Acetate* (8).—Osmium tetraoxide (700 mg) was added to a stirred solution of 3β-methoxycholest-5-en-4β-yl acetate (7) [4,8] (1.16 g) in pyridine (10 ml) and the mixture was left at room temperature for 7 days. A solution of sodium hydrogen sulphite (1.8 g) in water (30 ml) and pyridine (20 ml) was then added, and after 1 h the mixture was extracted with chloroform. The extract was washed successively with water, dilute hydrochloric acid, and aqueous sodium hydrogen carbonate, dried, and evaporated under reduced pressure. Chromatography of the residue on a column of Kieselgel G (60 g) (15 : 85 ether–benzene as eluant) gave the 4β,5,6α-*triol* 4-*acetate* (8) (1.11 g), m.p. 127—128° (from methanol), $[\alpha]_D$ +8.0° (*c* 2.95) (Found: C, 73.0; H, 10.6. $C_{30}H_{52}O_5$ requires C, 73.1; H, 10.65%); $\nu_{max.}$ 3 480, 1 710, and 1 260 $cm^{-1}$; δ 1.00 (3 H, s, 10-Me), 2.14 (3 H, s, OAc), 2.43br (1 H, s, exchangeable with $D_2O$, OH), 3.31 (3 H, s, OMe), 3.40—4.00 (3 H, m, 6β- and 3α-H, and OH), and 5.12 (1 H, d, *J* 3.5 Hz, 4α-H).

4β-*Acetoxy*-5-*hydroxy*-3β-*methoxy*-5α-*cholestan*-6-*one* (9a).—3β-Methoxy-5α-cholestane-4β,5,6α-triol 4-acetate (8) (256 mg) was oxidised with chromium trioxide (3 g) and pyridine (5 ml) in methylene chloride (80 ml) as described for the preparation of the ketone (4a) to give the 6-*one* (9a) (175 mg), m.p. 189—190° (from ethanol), $[\alpha]_D$ −22.9° (*c* 3.20) (Found: C, 73.1; H, 10.25. $C_{30}H_{50}O_5$ requires C, 73.45; H, 10.3%); $\nu_{max.}$ 3 340, 1 730, 1 712, and 1 260 $cm^{-1}$; δ 0.97 (3 H, s, 10-Me), 2.03 (3 H, s, OAc), 3.33 (3 H, s, OMe), 3.53 (1 H, s, exchangeable with $D_2O$, OH), 3.50—3.95 (1 H, m, 3α-H), and 5.48 (1 H, d, *J* 3.5 Hz, 4α-H).

4β,5-*Dihydroxy*-3β-*methoxy*-5α-*cholestan*-6-*one* (9b).—A solution of the acetate (9a) (134 mg) in ethanol (20 ml) was heated under reflux for 2 days with aqueous sodium hydroxide (0.1N; 2.75 ml), then poured into water and extracted with chloroform. Chromatography of the residue on a column of Kieselgel G (8 g) (3 : 7 ether–benzene as eluant) gave starting material (42 mg) (identified by t.l.c., i.r., m.p., and mixed m.p.) and the *diol* (9b) (62 mg), m.p. 181—183° (from ethanol), $[\alpha]_D$ −12.3° (*c* 2.05) (Found: C, 74.6; H, 10.7. $C_{28}H_{48}O_4$ requires C, 74.95; H, 10.8%); $\nu_{max.}$ 3 380 and 1 690 $cm^{-1}$; δ 1.04 (3 H, s, 10-Me), 2.58 (2 H, m, exchangeable with $D_2O$, OH), 3.36 (3 H, s, OMe), 3.25—3.70 (1 H, m, $W_{\frac{1}{2}}$ 15 Hz, 3α-H), and 4.21 (1 H, d, *J* 3 Hz, 4α-H).

4β,5-*Dihydroxy*-3β-*methoxy*-5β-*cholestan*-6-*one* (9c).—(*a*) A solution of the acetate (9a) (122 mg) in methanolic potassium hydroxide (6%; 40 ml) was heated under reflux for 6 h, then poured into brine and extracted with chloroform. The extract was washed with water, dried, and evaporated *in vacuo* to give the *diol* (9c) (120 mg), m.p. 161—162° (from methanol), $[\alpha]_D$ +12.9° (*c* 1.50) (Found: C, 74.8; H, 10.85. $C_{28}H_{48}O_4$ requires C, 74.95; H, 10.8%); $\nu_{max.}$ 3 440 and 1 705 $cm^{-1}$; δ 0.78 (3 H, s, 10-Me), 2.85 (1 H, m, exchangeable with $D_2O$, OH), 3.39 (3 H, s, OMe), 3.57 (1 H, m, $W_{\frac{1}{2}}$ 9 Hz, 3α-H), 4.20 (1 H, m, exchangeable with $D_2O$, OH), and 4.14 (1 H, d, *J* 4 Hz, 4α-H).

(*b*) The dihydroxy-ketone (9b) (34 mg) was heated under

reflux in methanolic potassium hydroxide (10%; 10 ml) for 10 h. The mixture was worked up as in the preceding experiment to give the dihydroxy-ketone (9c) (32 mg), identical (m.p., mixed m.p., i.r., and t.l.c.) with the product obtained in (*a*).

*Acetylation of* 4β,5-*Dihydroxy*-3β-*methoxy*-5β-*cholestan*-6-*one* (9c).—The dihydroxy-ketone (9c) (129 mg) was treated with acetic anhydride (2 ml) and pyridine (2 ml) for 2 days at room temperature and the product (139 mg) was chromatographed on a column of Kieselgel G (9 g) (1 : 4 ether–benzene as eluant). The early fractions afforded 4β,5-*diacetoxy*-3β-*methoxy*-5β-*cholestan*-6-*one* (9d) (74 mg) which, although chromatographically homogeneous, could not be crystallised; $[\alpha]_D$ −71.6° (*c* 3.25) (Found: C, 72.35; H, 9.9. $C_{32}H_{52}O_6$ requires C, 72.15; H, 9.85%); $\nu_{max.}$ (film) 1 745, 1 712, and 1 245 $cm^{-1}$; δ 1.16 (3 H, s, 10-Me), 2.03 and 2.06 (each 3 H, s, OAc), 3.35 (3 H, s, OMe), 3.70 (1 H, m, $W_{\frac{1}{2}}$ 14 Hz, 3α-H), and 6.02 (1 H, d, *J* 3 Hz, 4α-H); *m/e* 532 ($M^+$), 490 ($M^+ - CH_2CO$), 472 ($M^+$ − AcOH), 448 ($M^+ - 2CH_2CO$), and 430 (490 − AcOH).

The later fractions gave 4β,5-*dihydroxy*-3β-*methoxy*-5β-*cholestan*-6-*one* 4-*acetate* (9e) (29 mg) as an oil, $[\alpha]_D$ −24° (*c* 1.95), which could not be crystallised (Found: C, 72.95; H, 10.1. $C_{30}H_{50}O_5$ requires C, 73.45; H, 10.3%); $\nu_{max.}$ (film) 3 460, 1 720, and 1 240 $cm^{-1}$; *m/e* 490 ($M^+$).

*Acetylation of* 3β-*Methoxy*-5β-*cholestane*-4β,5,6α-*triol* (2d).—The triol (2d) (60 mg) [prepared by reduction of the ketone (9c) with sodium and propan-2-ol, as described above] was treated with acetic anhydride (10 ml) and pyridine (10 ml) at room temperature for 5 h to give, after work-up in the usual way, a mixture (65 mg). Chromatography on a column of Kieselgel G (10 g) (19 : 1 : 180 ether–methanol–benzene as eluant) gave, from the early fractions, a mixture (29 mg) of 3β-methoxy-5β-cholestane-4β,5,6α-triol 4-acetate (2b) and 3β-methoxy-5β-cholestane-4β,5,6α-triol 4,6-diacetate (2c), identified by t.l.c. comparison with the same compounds derived ultimately from the boron trifluoride-catalysed rearrangement of the acetoxy-epoxide (1). The later fractions afforded pure 3β-methoxy-5β-cholestane-4β,5,6α-triol 6-acetate (2a) (28 mg), identical (t.l.c., i.r., n.m.r., m.p., and mixed m.p.) with the sample obtained by boron trifluoride-catalysed rearrangement of the acetoxy-epoxide (1).

4β,5-*Ethylidenedioxy*-3β-*methoxy*-5β-*cholestan*-6α-*ol* (11a).—Boron trifluoride–ether complex (0.2 ml) was added to a stirred mixture of 5,6α-epoxy-3β-methoxy-5α-cholestan-4β-yl acetate (1) (310 mg) and sodium borohydride (1 g) in dry ether (2.5 ml) at room temperature. After 24 h, aqueous sodium hydrogen carbonate was added, and the mixture was extracted with ether. The extract was washed with water, dried, and evaporated *in vacuo*. Chromatography of the residue on a column of Kieselgel G (16 g) (1 : 1 ether–benzene as eluant) gave 4β,5-*ethylidenedioxy*-3β-*methoxy*-5β-*cholestan*-6α-*ol* (11a) (230 mg), m.p. 182—184° (from methanol), $[\alpha]_D$ +25.3° (*c* 8.35) (Found: C, 75.45; H, 11.05. $C_{30}H_{52}O_4$ requires C, 75.6; H, 11.0%); $\nu_{max.}$ 3 450 $cm^{-1}$; δ 0.87 (3 H, s, 10-Me), 1.39 [3 H, d, *J* 4.5 Hz, *Me*CH(O–)O–], 3.42 (3 H, s, OMe), 3.65—4.20 (2 H, m, 3α- and 6β-H), 4.66 (1 H, d, *J* 3 Hz, 4α-H), and 5.29 [1 H, q, *J* 4.5 Hz, MeC*H*(O–)O–]; *m/e* 476 ($M^+$), 475, and 461.

Treatment of the acetal (11a) (122 mg) with acetic anhydride (5 ml) and pyridine (5 ml) overnight at room temperature gave the *acetate* (11b) (131 mg), m.p. 169—170° (from methanol), $[\alpha]_D$ +47.8° (*c* 8.05) (Found: C, 74.55; H, 10.25%; $M^+$, 518.394 6. $C_{32}H_{54}O_5$ requires C, 74.1; H, 10.5%; *M*, 518.397 1); $\nu_{max.}$ 1 732 and 1 260 $cm^{-1}$; δ 0.92 (3 H, s, 10-Me), 1.38 [3 H, d, *J* 4.5 Hz, *Me*CH(O–)O–], 2.07 (3 H, s, OAc), 3.45 (3 H, s, OMe), 3.91 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 3α-H), 4.64 (1 H, d, *J* 3 Hz, 4α-H), 5.13 [1 H, q, *J* 4.5 Hz, MeC*H*(O–)O–], and 5.16 (1 H, dd, *J* 4 and 12 Hz, 6β-H); *m/e* 518 ($M^+$), 517, 503 ($M^+ - CH_3$), and 458 ($M^+$ − HOAc).

*Boron Trifluoride-catalysed Cleavage of* 5,6α-*Epoxy*-5α-*cholestan*-4β-*yl Acetate* (15).—Boron trifluoride–ether complex (7.75 ml) was added to a solution of the epoxide (15) (163 mg) in ether (11 ml). The mixture was left at room temperature for 2 days, then poured into water and extracted with ether to give a gum (150 mg), shown by t.l.c. (chloroform as eluant) to be essentially a mixture of the triol monoacetates (17a and b), $\nu_{max.}$ ($CHCl_3$) 3 590, 1 720, and 1 240 $cm^{-1}$; δ 2.02 and 2.08 (total 3 H, two singlets, ratio 2 : 1, OAc), 2.95 (2 H, m, exchangeable with $D_2O$, OH), 3.9 and 4.4 (total 1 H, broad multiplets, C*H*·OH), and 5.25 and 5.7 (total 1 H, broad multiplets, C*H*·OAc). A portion (63 mg) of the mixture was heated under reflux for 40 min with lithium aluminium hydride (63 mg) in ether (20 ml) to give, after the usual work-up, a single product (40 mg), formulated as the triol (17d), $[\alpha]_D$ +22.3° (*c* 0.58), $\nu_{max.}$ ($CCl_4$) 3 400 $cm^{-1}$.

Treatment of the triol (17d) (40 mg) with acetic anhydride and pyridine at room temperature gave the *diacetate* (17c) (40 mg), which crystallised from methanol as needles, m.p. 188—190°, $[\alpha]_D$ −2.1° (*c* 0.72) (Found: C, 73.75; H, 10.15. $C_{31}H_{52}O_5$ requires C, 73.75; H, 10.4%); $\nu_{max.}$ ($CHCl_3$) 3 600, 1 730, and 1 260 $cm^{-1}$; δ 1.01 (3 H, s, 10-Me), 2.04 and 2.08 (each 3 H, s, OAc), 2.78br (1 H, s, exchangeable with $D_2O$, OH), 5.20 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 4α- or 6β-H), and 5.72 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 4α- or 6β-H). The same diacetate (identified by m.p., mixed m.p., and t.l.c.) was also obtained by acetylation of the binary mixture (17a and b) described above.

*Boron Trifluoride-catalysed Cleavage of* 4α,5-*Epoxy*-5α-*cholestan*-6β-*yl Acetate* (18a).—Boron trifluoride–ether complex (0.5 ml) was added to a solution of the epoxide (18a) [16] (160 mg) in ether (5 ml) at room temperature. After 15 h more ether was added, and the mixture was washed with water, dried, and evaporated *in vacuo* to give a brown gum (163 mg). Chromatography on a column of Kieselgel G (10 g) (15 : 85 ether–benzene as eluant) gave, from the early fractions, 6β-*acetoxy*-5β-*cholestan*-4-*one* (20) (28 mg), m.p. 160—162° (from methanol), $[\alpha]_D$ +16.1° (*c* 1.40) (Found: C, 78.65; H, 10.55. $C_{29}H_{48}O_3$ requires C, 78.3; H, 10.9%); $\nu_{max.}$ 1 725, 1 700, and 1 255 $cm^{-1}$; δ 1.16 (3 H, s, 10-Me), 2.01 (3 H, s, OAc), 2.57 (1 H, m, $W_{\frac{1}{2}}$ 5 Hz, 5β-H), and 5.50 (1 H, m, $W_{\frac{1}{2}}$ 8 Hz, 6α-H).

The main fraction was a 1 : 1 mixture (81 mg) of 5β-cholestane-4α,5,6β-triol 6-acetate (19a) and the isomeric 4α-acetate (19b); δ 1.00 (3 H, s, 10-Me), 2.08 (3 H, s, OAc), 2.95 (1 H, m, exchangeable with $D_2O$, OH), 3.71 (1 H, m, $W_{\frac{1}{2}}$ 6 Hz, C*H*·OH), and 4.96 (1 H, m, $W_{\frac{1}{2}}$ 7 Hz, C*H*·OAc).

The final fractions contained one of the pure monoacetates (19a or b) (14 mg), which crystallised from methanol; m.p. 139—141° (Found: C, 75.05; H, 10.85. Calc. for $C_{29}H_{50}O_4$: C, 75.3; H, 10.9%); $\nu_{max.}$ 3 500, 1 725, and 1 250 $cm^{-1}$; n.m.r. spectrum identical with that of the mixture of monoacetates (19a and b).

5β-*Cholestane*-4α,5,6β-*triol* 4,6-*Diacetate* (19c).—The mixture (60 mg) of monoacetates (19a and b) obtained in the preceding experiment was treated with acetic anhydride (3 ml) and pyridine (3 ml) at 100 °C for 3 h. After work-up in the usual manner the product was chromatographed on a

column of silica (5 : 95 ether–benzene as eluant) to give 5β-*cholestane*-4α,5,6β-*triol* 4,6-*diacetate* (19c) (54 mg), m.p. 148—150° (from methanol), $[\alpha]_D$ −29.6° (*c* 3.20) (Found: C, 73.7; H, 10.6. $C_{31}H_{52}O_5$ requires C, 73.75; H, 10.4%); $\nu_{max.}$ 3 500, 1 745, and 1 715 $cm^{-1}$; δ 1.02 (3 H, s, 10-Me), 2.10 (6 H, s, OAc), 2.30 (1 H, m, exchangeable with $D_2O$, OH), and 4.86 (2 H, m, $W_{\frac{1}{2}}$ 6 Hz, C*H*·OAc).

4α,5-*Epoxy*-3β-*methoxy*-5α-*cholestan*-6β-*yl Acetate* (18b).—A solution of 3β-methoxycholest-4-en-6β-yl acetate (21) [5] (1.82 g) in benzene (23 ml) was treated with *m*-chloroperbenzoic acid (0.8 g) at room temperature for 24 h. Ether was added, and the mixture was washed successively with aqueous sodium sulphite, dilute aqueous sodium hydroxide, and water, then dried and evaporated *in vacuo* to afford the *epoxide* (18b) (1.92 g), m.p. 101—103° (from methanol), $[\alpha]_D$ +8.5° (*c* 6.49) (Found: C, 75.9; H, 10.4. $C_{30}H_{50}O_4$ requires C, 75.9; H, 10.6%); $\nu_{max.}$ 1 732 and 1 235 $cm^{-1}$; δ 1.20 (3 H, s, 10-Me), 2.06 (3 H, s, OAc), 3.22br (1 H, s, 4β-H), 3.41 (3 H, s, OMe), 3.45 (1 H, m, $W_{\frac{1}{2}}$ 17 Hz, 3α-H), and 4.31 (1 H, t, *J* 3 Hz, 6α-H).

3β-*Methoxy*-5β-*cholestane*-4α,5,6β-*triol* 6-*Acetate* (19d).—Boron trifluoride–ether complex (2.5 ml) was added to a stirred solution of the epoxide (18b) (155 mg) in ether (3 ml) at room temperature. After 1 h more ether was added and the mixture was washed with water, dried, and evaporated *in vacuo* to give a gum (164 mg), from which, by chromatography on a column of Kieselgel G (12 g) (1 : 4 ether–benzene as eluant), was obtained 3β-*methoxy*-5β-*cholestane*-4α,5,6β-*triol* 6-*acetate* (19d) (128 mg), m.p. 133—134° (from methanol), $[\alpha]_D$ −9.2° (*c* 7.06) (Found: C, 73.25; H, 10.65. $C_{30}H_{52}O_5$ requires C, 73.1; H, 10.65%); $\nu_{max.}$ 3 550, 3 480, 1 720, and 1 275 $cm^{-1}$; δ 1.03 (3 H, s, 10-Me), 2.04 (3 H, s, OAc), 3.33 (3 H, s, OMe), 3.4 (2 H, m, 1 H exchangeable with $D_2O$, OH, 3α-H), 3.80 (1 H, d, *J* 3.5 Hz, 4β-H), 3.91 (1 H, s, exchangeable with $D_2O$, OH), and 5.09 (1 H, m, $W_{\frac{1}{2}}$ 6 Hz, 6α-H).

5-*Fluoro*-3β-*methoxy*-5α-*cholestane*-4α,6β-*diol* 4-*Acetate* (24).—A solution of 5,6β-epoxy-3β-methoxy-5β-cholestan-4α-yl acetate (23) [3] (461 mg) in ether (7 ml) was treated with boron trifluoride–ether complex (0.5 ml) at room temperature for 15 h. The mixture was worked up in the usual way to afford, after chromatography on a column of Kieselgel G (30 g) (2 : 98 methanol–benzene as eluant), the *fluoroalcohol* (24) (187 mg), which crystallised from aqueous acetone as needles, m.p. 150—152°, $[\alpha]_D$ +63.9° (*c* 5.87) (Found: C, 72.85; H, 10.45; F, 3.9. $C_{30}H_{51}FO_4$ requires C, 72.7; H, 10.05; F, 3.85%); $\nu_{max.}$ 3 560, 1 725, and 1 260 $cm^{-1}$; δ 1.20 (3 H, s, 10-Me), 2.16 (3 H, s, OAc), 3.20 (1 H, m, exchangeable with $D_2O$, OH), 3.36 (3 H, s, OMe), 3.30—3.75 (1 H, m, 3α-H), 3.63 (1 H, m, $W_{\frac{1}{2}}$ 11 Hz, 6α-H), and 5.20 (1 H, d, *J* 28 and 9.5 Hz, collapsing to a doublet, *J* 9.5 Hz, on irradiation at $^{19}F$ signal frequency, 4β-H), δ ($^{19}F$) 11.6 p.p.m (d, *J* 28 Hz) from $C_6F_6$; *m/e* 494 ($M^+$).

We thank the S.R.C. for research studentships (to T. H. C. and J. B. W.).

[6/906 *Received*, 12*th May*, 1976]