Cleavage of Steroidal α-Hydroxy Acetals with Methylmagnesium Iodide

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The four isomeric α-hydroxy acetals **17**, **19**, **21** and **22** undergo reaction with methylmagnesium iodide under forcing conditions to afford a variety of products, some arising by direct cleavage of the acetal ring, and some by processes which involve skeletal rearrangement with participation of the neighbouring hydroxy group. The structures of the products have been established and their mechanisms of formation are discussed.

We have recently reported[1] that when the ethylene acetals **1** and **2** derived from 5-hydroxy-3β-methoxy-5α-cholestan-6-one and its 5-epimer are treated with MeMgI under forcing conditions cleavage of the dioxolane ring is accompanied by skeletal rearrangements to give the 4a-homo-7-norsteroid **3**. Migration of C-10 may be concerted with cleavage of the acetal ring (as shown in **4** and **6**) or may occur as a second step after the dioxolane ring has undergone cleavage to form an oxonium ion (as shown in **7** and **8**). In either case, the C-10–C-5 and C-6–O bonds have the antiperiplanar relationship appropriate for 1,2-migration.

In the case of compounds **1** and **2** the migrating centre (C-10) is fully substituted. We now report the results we have obtained by subjecting each of the isomeric acetals **17**, **19**, **21** and **22**, in all of which the corresponding rearrangement would involve the migration of a primary centre (C-1 or C-4), to the same conditions.

The acetals **17** and **19** were obtained by treatment of the epimeric α-hydroxy ketones **10** and **12**[2] with ethanediol and toluene-*p*-sulfonic acid. The deuterated analogues **18** and **20** were similarly derived from the deuterio-compounds **11** and **13**, which were prepared by appropriate modification (see Experimental section) of the route previously described[2] for the preparation of compounds **10** and **12**. The acetals **21** and **22** were obtained by acetalisation of the corresponding ketones **14** and **16** which were prepared in good yield by appropriate oxidation of the enol acetate **9**.[3] Oxidation with a stoichiometric amount of osmium tetroxide in pyridine afforded compound **14** in a yield of 65%. The same reaction could be accomplished more rapidly and economically, albeit in a reduced yield, using trimethylamine *N*-oxide and a catalytic amount of osmium tetroxide. When peroxyformic acid was employed as the oxidising agent, the enol acetate **9** was converted into 2β-acetoxy-2α-methyl-5α-cholestan-3-one **15**, presumably by a process involving rearrangement of the intermediate acetoxy epoxide **23**.[4] Saponification of the acetate **15** afforded the hydroxy ketone **16**.

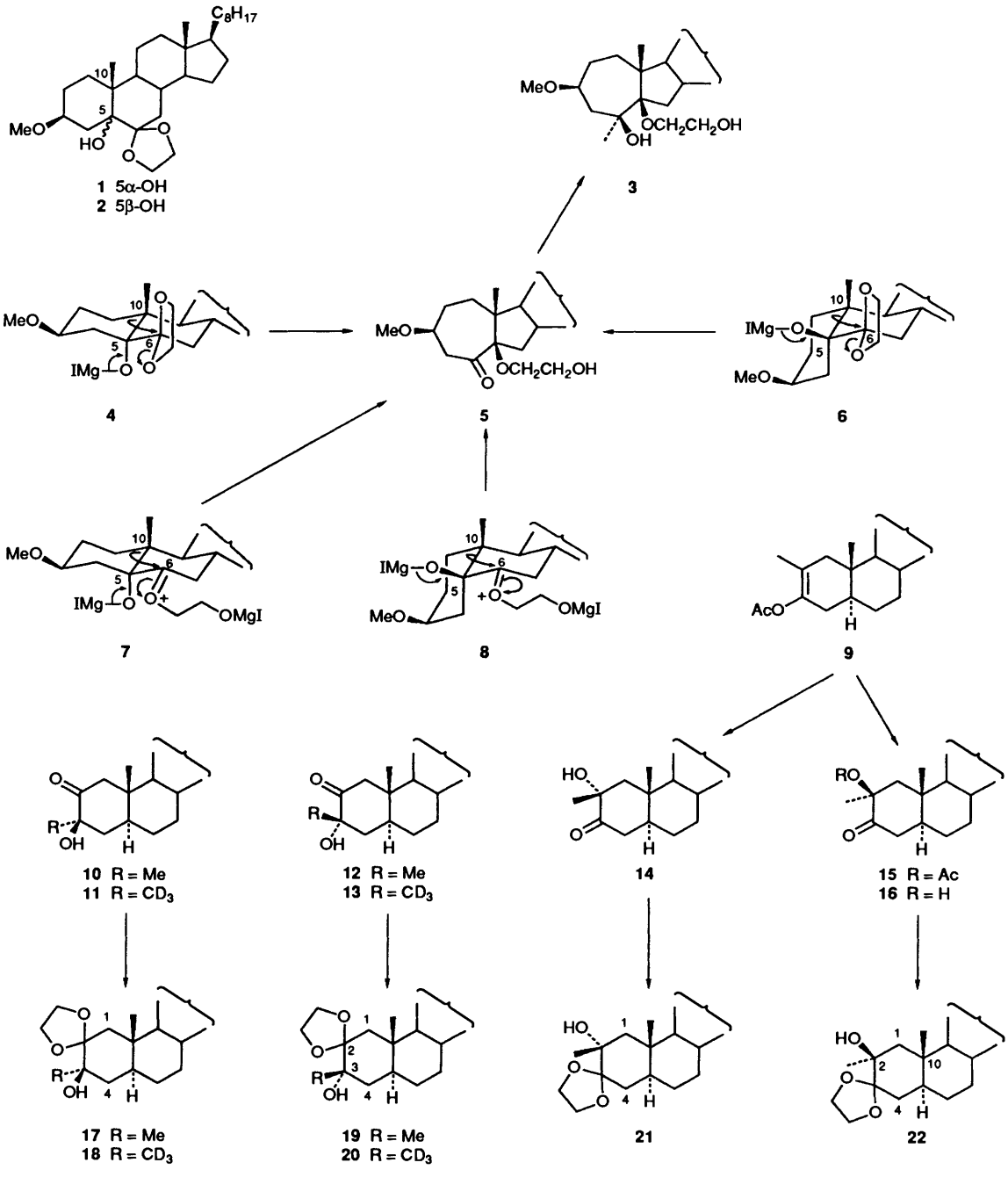
All four hydroxy acetals (**17**, **19**, **21** and **22**) could be hydrolysed back to the ketones from which they were derived by treatment with aq. methanolic hydrochloric acid.

When the hydroxy acetal **17** was treated with an excess of MeMgI in refluxing toluene, three products were isolated by chromatography. The least polar of these, obtained in a yield of 9% was the 4-norsteroid **24**, which was converted into the 1,4-dioxane **32** by treatment with toluene-*p*-sulfonyl chloride and pyridine at room temperature. The structures of these compounds were established by dehydration (using thionyl chloride and pyridine) of the acetate **25** derived from the diol **24** to give the olefin **33**, saponification of which gave the alcohol **34**, identical with the product obtained by the action of isopropenylmagnesium bromide on the acetal **41** derived from 4-nor-5α-cholestan-2-one **40**. Treatment with sodium iodide and zinc[5] of the toluene-*p*-sulfonate derived from the alcohol **34** gave the alcohol **35**, which was also formed by a Grignard reaction between 4-nor-5α-cholestan-2-one **40** and isopropenylmagnesium bromide. Final confirmation of the structural assignments was obtained by ozonolysis of compound **35** to afford the known[6] hydroxy ketone **42**.

The second compound isolated from cleavage of the dioxolane ring of the acetal **17** was 3β-hydroxy-2α-(2-hydroxyethoxy)-2β,3α-dimethyl-5α-cholestane **27** (5% yield), the structure of which followed from its conversion into the 1,4-dioxane **36** by treatment with toluene-*p*-sulfonyl chloride and pyridine. Structure **36** is the only possibility for the dioxane, since it is not identical with either of the isomeric *cis*-dioxanes **39** and **58** described below.

The most polar product arising by the action of MeMgI on the acetal **17** proved to be the diol **29** which was isolated in a yield of 81%. Its structure was established by correlation with the known[7] olefin **44**. Treatment of compound **29** with toluene-*p*-sulfonyl chloride and pyridine afforded a mixture of the toluene-*p*-sulfonate **30** and the dioxane **39**, which was separated by chromatography. The toluene-*p*-sulfonate underwent reaction with sodium iodide and zinc to afford the dioxane **39** and the 2β,3β-diol **37**, which was also obtained, together with the known[8] 2α,3α-diol **43**, as a minor product from the hydroxylation of 2,3-dimethyl-5α-cholest-2-ene **44** with osmium tetroxide.

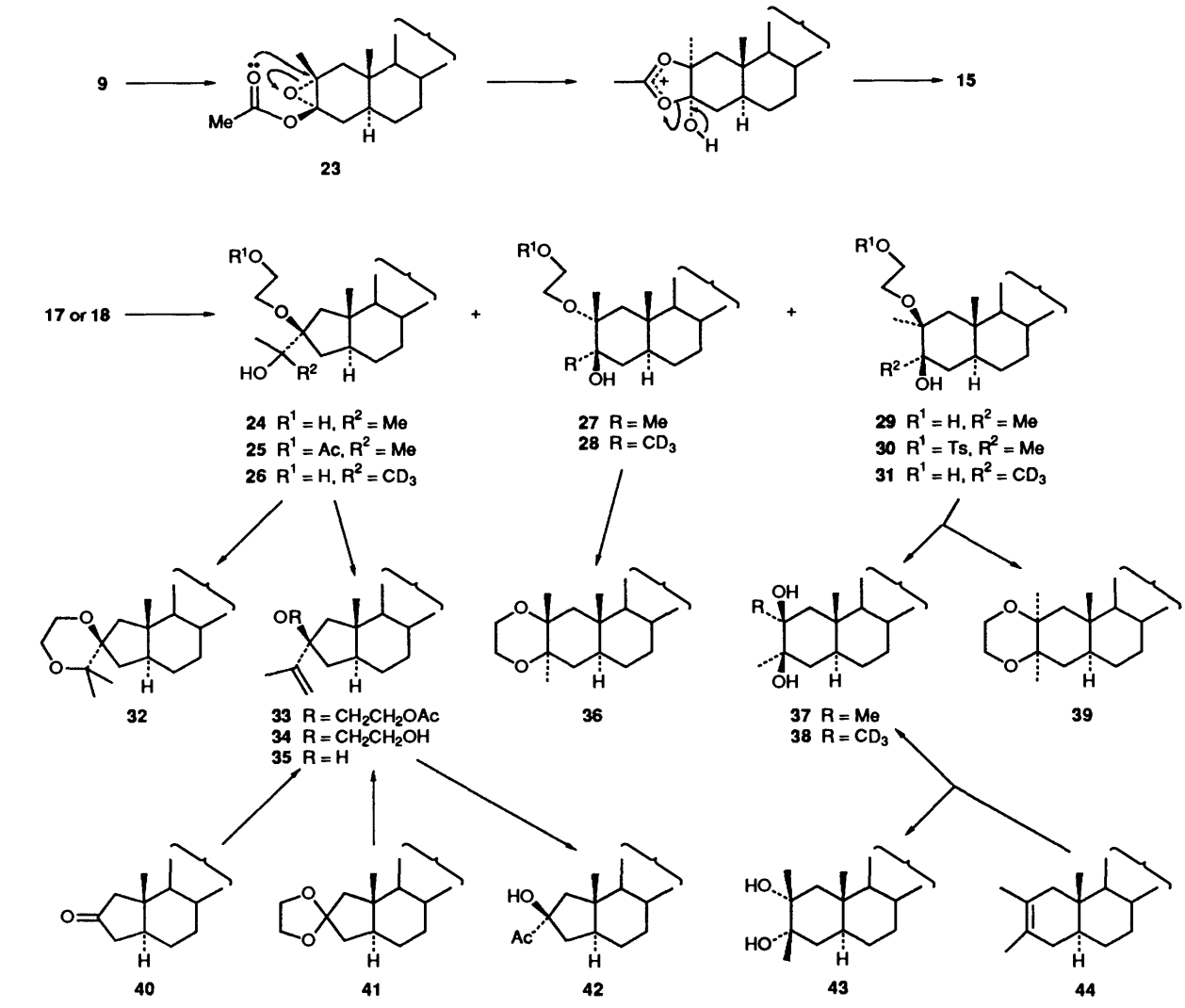
Formation of the 4-norsteroid **24** from the acetal **17** is analogous to the rearrangement of compounds **1** and **2** to the 4a-homo-7-norsteroid **3**; the low yield obtained is a reflection of the fact that ring contraction involves migration of a primary carbon atom (C-4). Compounds **27** and **29** are the products formed by direct nucleophilic attack of the Grignard reagent at C-2. The latter compound could, however, also arise by a mechanism involving an initial 1,2-shift of the axial 3α-Me to the 2α-position, with concomitant cleavage of the axial C-2–2β-O bond (see Fig. 1). That possibility was excluded by subjecting the deuterated acetal **18** to cleavage with MeMgI. The products obtained were the compounds **26** (16%), **28** (5%) and **31** (66%). The 3α-CD_3 was shown not to undergo migration since the ^1H NMR signal at δ 1.22 attributed to 3α-Me in compound **29** was absent in the deuterated analogue **31**, whilst the signal at δ 1.10, assigned to 2α-Me was of the same relative intensity in both compounds **29** and **31**. The ^1H NMR assignments were made by analogy with those made for the methyl groups in the structurally related 2α,3α-dimethyl-5α-cholestane-2β,3β-diol **37**. Thus, whilst the diol **37** exhibited ^1H NMR peaks at δ 1.12 (2α-CH_3) and 1.22 (3α-CH_3), the 2α-deuteriomethyl analogue, prepared by the action of CD_3MgI on the ketol **10**, gave only the signal at δ 1.22.



Treatment of the hydroxy acetal **19** with an excess of MeMgI in refluxing toluene afforded three products, which were separated by chromatography. The most polar of these was the enol ether **45**, obtained in 30% yield, the structure of which followed from its IR and ^{1}H NMR spectra, and from the fact that it was hydrolysed with hot methanolic hydrochloric acid to 3α-hydroxy-3β-methyl-5α-cholestan-2-one **12**. The least polar product, isolated in a yield of 41%, was the tertiary alcohol **51**, which underwent dehydration with thionyl chloride and pyridine to give a disubstituted olefin **52**. Ozonolysis of the olefin **52** afforded the methyl ketone **53**, the structure of which was established by synthesising it from the aldehyde **54** by successive Grignard reaction with MeMgI and oxidation with pyridinium chlorochromate. The aldehyde **54** (which was characterised as the derived semi-carbazone **55**) was obtained, together with 3β-methyl-5α-cholestan-2-one **49**, by treatment of 2β,3β-epoxy-3α-methyl-5α-cholestane **50**[9] with boron trifluoride–diethyl ether. In contrast with its epimer **61** (described below) the ketone **53** would not undergo a Baeyer–Villiger reaction with *m*-chloroperoxybenzoic acid, presumably as a consequence of steric interaction between β-Ac and the angular 10-Me. It did, however, react with MeMgI to afford the tertiary alcohol **51**, identical with the compound obtained by cleavage of the acetal **19**.

The third compound formed in the cleavage of the acetal **19** was the diol **46**, an epimer of compound **24** described above. The two compounds gave very similar ^{1}H NMR and mass spectra. In parallel with its epimer, the diol **46** afforded a monoacetate **47** with acetic anhydride and pyridine, and gave a 1,4-dioxane **48** with toluene-*p*-sulfonyl chloride and pyridine.

Of the four hydroxy acetals subjected to cleavage with MeMgI in the present work only compound **19** afforded an enol ether. The acetal **19** differs from its epimer **17** in that it possesses an axial hydroxy group and it is possible that abstraction of 1α-H is assisted by complexation of the hydroxy with a molecule of the Grignard reagent (Fig. 2). The failure of the hydroxy acetal



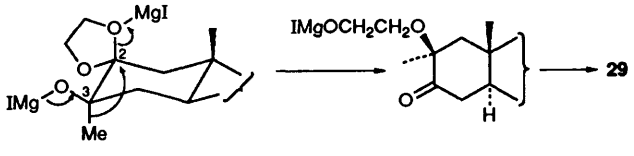


Fig. 1

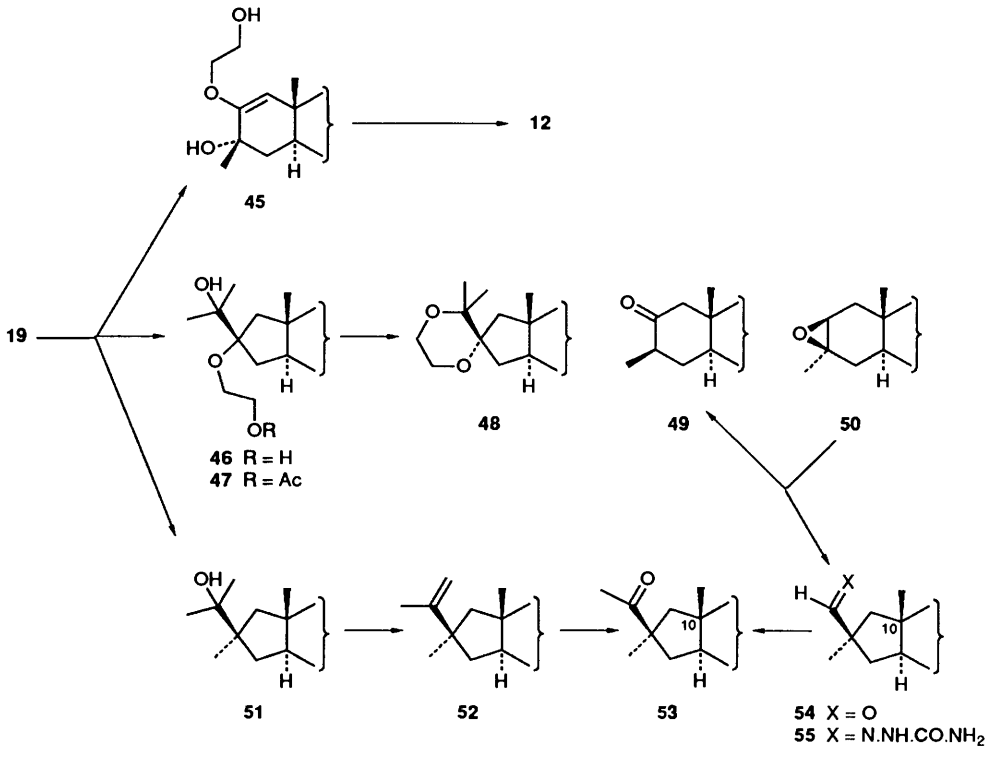
22, which also possesses an axial hydroxy group, to undergo cleavage to an analogous enol ether may be ascribed to the steric effect of the angular 10-Me which inhibits complexation of the hydroxy group with the Grignard reagent.

Formation of the diol **46** from the acetal **19** is surprising since in the chair conformation of ring A the C-3–C-4 and C-2–2α-O bonds have the antiperiplanar relationship appropriate for a 1,2-migration of C-4 from C-3 to C-2 with concerted cleavage of the C-2–2α-O bond leading to the epimeric structure **24**. It may be that the rearrangement proceeds through a flexible conformation of ring A, in which the magnesium atom of the 3-OMgI can complex with both the oxygen atoms of the acetal group (Fig. 3).

Cleavage of the acetal **19** to give the tertiary alcohol **51** may also involve participation of the neighbouring 3α-OH. A possible mechanism is outlined in Fig. 4.

When 3,3-ethylenedioxy-2α-hydroxy-2β-methyl-5α-cholestane **21** was cleaved with MeMgI two compounds were obtained. The major product (55% yield) was the diol **56**, presumably formed by nucleophilic β-attack of the Grignard reagent at C-3 of compound **21** (or the related oxonium ion **67** arising by prior cleavage of the acetal ring). Its structure was established by treating the derived toluene-*p*-sulfonate (formed, together with the 1,4-dioxane **58**, by the action of toluene-*p*-sulfonyl chloride and pyridine on the diol **56**) with sodium iodide and zinc to give 2α,3α-dihydroxy-2β,3β-dimethyl-5α-cholestane **43**. The absence of the C-3 epimer of compound **56** from the reaction mixture may be ascribed to the steric hindrance to approach to the α-face of the acetal **21** (or the oxonium ion **67**) presented by the bulky 2α-OMg. In that respect, the corresponding ketone **14** behaves similarly; it reacts with MeMgI to give mainly (55% yield) the previously reported diol **43**,[8] together with an 8% yield of 2α,3β-dihydroxy-2β,3α-dimethyl-5α-cholestane **65**. In contrast, 3α-hydroxy-3β-methyl-5α-cholestan-2-one **12** reacts with MeMgI to give 2β,3α-dihydroxy-2α,3β-dimethyl-5α-cholestane **66**, the structure of which follows from the fact that it differs from the other three isomeric 2,3-dihydroxy-2,3-dimethyl-5α-cholestanes **37**, **43** and **65**. In this case the steric hindrance of the angular 10-Me dictates the steric outcome of the reaction.

The minor product (32% yield) from cleavage of the acetal **21** with MeMgI was the tertiary alcohol **60**. The identity of this compound was verified by its preparation from 2α-acetyl-2β-methyl-4-nor-5α-cholestane **61** by the action of MeMgI. The ketone **61** was obtained from the olefin **44** by epoxidation to give compound **59** followed by rearrangement with boron trifluoride–diethyl ether; and also by oxidation with pyridinium



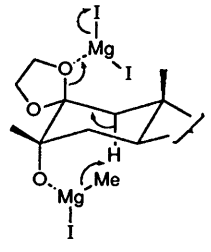


Fig. 2

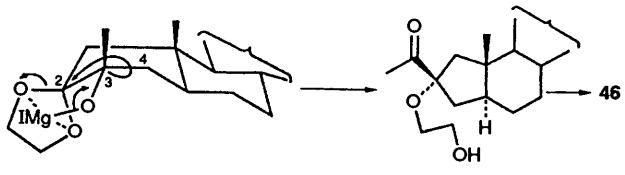


Fig. 3

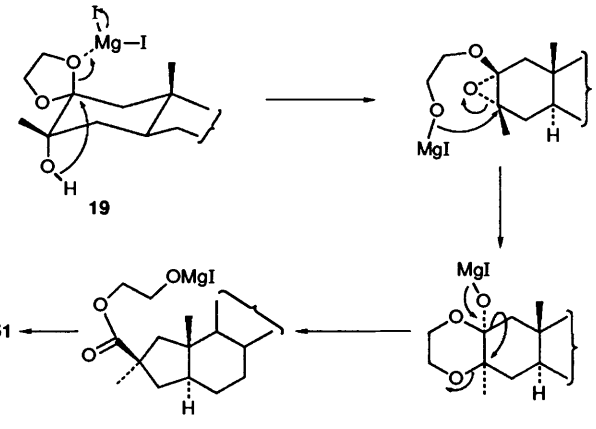


Fig. 4

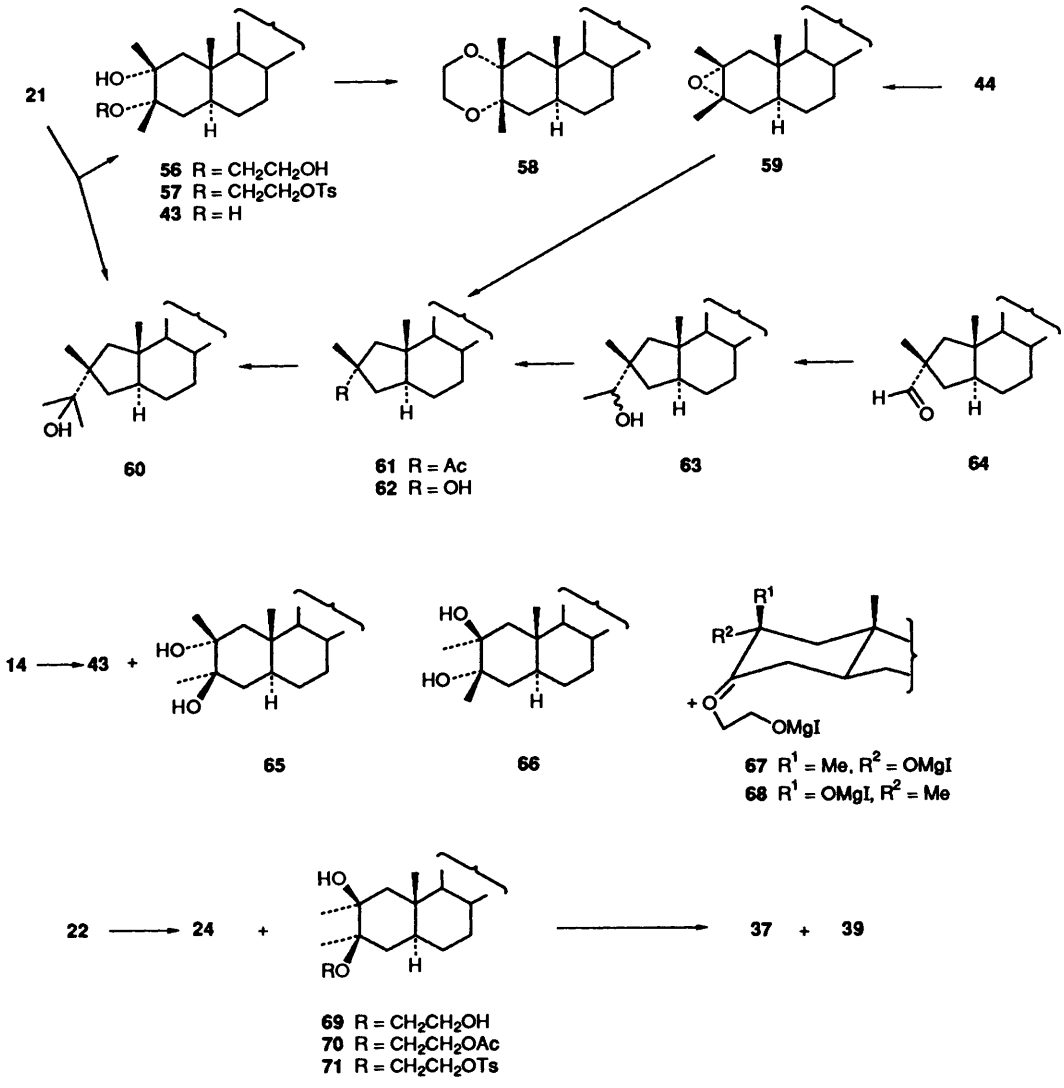
chlorochromate of the epimeric alcohols **63** formed by reaction of the aldehyde **64**[10] with MeMgI. The configuration of the ketone **61** at C-2 followed from its conversion into the known[7] alcohol **62** by Baeyer–Villiger oxidation followed by saponification of the resulting ester.

Treatment of the acetal **22** with MeMgI under the same conditions as were applied to the other acetals afforded two cleavage products, which were separated by chromatography. The minor product (6% yield) was the 4-norsteroid **24**, previously obtained from the acetal **17**. As in the rearrangement of the acetal **19** leading to the isomeric 4-norsteroid **46** (Fig. 3), the favoured antiperiplanar arrangement of the bonds undergoing migration and cleavage can be achieved only if ring A adopts a flexible conformation. Such a conformation would remove the 1,3-diaxial interaction between 10-Me and the 2β-OMgI present in the chair conformation of ring A, and would allow the 2β-OMg to complex with both of the acetal oxygen atoms, as shown in Fig. 5.

The major cleavage product, obtained in a yield of 66%, was the diol **69** resulting from direct nucleophilic attack of the Grignard reagent at C-3 of the acetal **22** (or the oxonium ion **68** formed by prior cleavage of the dioxolane ring). As in the case of compound **21**, discussed above, the approach of the nucleophile to C-3 is *trans* to the 2-OMgI. Compound **69** afforded a monoacetate **70** and a mono-toluene-*p*-sulfonate **71**, and its structure was established by cleavage of the toluene-*p*-sulfonate with sodium iodide and zinc to give the dioxane **39** and 2β,3β-dihydroxy-2α,3α-dimethyl-5α-cholestane **37**.

Experimental

M.p.s were measured on a Kofler hot-stage apparatus. IR spectra (solutions in $CHCl_3$) were recorded on Perkin-Elmer 157G and 297 spectrophotometers. NMR spectra were recorded on a Perkin-Elmer R32A instrument, with deuteriochloroform as solvent. *J* values are given in Hz. Mass spectra were measured on A.E.I. MS902 and Kratos MS25S spectrometers. Optical rotations were measured on a Perkin-Elmer 141 polameter or on a Thorn NPL automatic polarimeter type 243 for solutions in $CHCl_3$ and values are recorded in 10^{-1} deg cm^2 g^{-1}. Merck Kieselgel G (type 60) was used for column chromatography unless stated otherwise, and TLC was carried



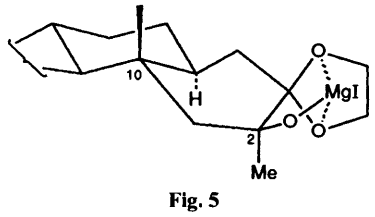


Fig. 5

out using plates prepared from Merck Kieselgel GF_{254}. Light petroleum refers to the fraction of boiling range 60–80 °C. Ether refers to diethyl ether. Solutions in organic solvents were dried with anhydrous sodium sulfate or magnesium sulfate unless otherwise stated. Grignard reagents were prepared by the dropwise addition of the alkyl halide in ether to a stirred suspension of dry magnesium turnings in ether at 0 °C under nitrogen.

2,2-*Ethylenedioxy*-3β-*hydroxy*-3α-*methyl*-5α-*cholestane* **17**.—A mixture of 3β-hydroxy-3α-methyl-5α-cholestan-2-one **10** (1.93 g), toluene-*p*-sulfonic acid (85 mg) and ethylene glycol (5 cm^3) was heated under reflux in toluene (240 cm^3), for 24 h with removal of water by means of a Dean–Stark apparatus. After the mixture had cooled, ether was added and the organic layer was separated, washed successively with aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. The residue was chromatographed (chloroform as eluent) to afford the starting ketol **10** (510 mg, 26%) followed by the *title compound* **17** (1.095 g, 51%), m.p. 139–140 °C (ex methanol); $[\alpha]_D^{20}$ +13 (*c* 0.13) (Found: C, 78.05, H, 11.4%; M^+, 460.3920. $C_{30}H_{52}O_3$ requires C, 78.2; H, 11.4% *M*, 460.3916); ν_{max}/cm^{-1} 3560 and 1120; δ_H 0.65 (3 H, s, 18-H_3), 0.90 (3 H, s, 19-H_3), 1.30 (3 H, s, 3α-CH_3), 2.15 (1 H, s, exch. D_2O, OH) and 3.95 (4 H, m, OCH_2CH_2O).

Similar treatment of 3α-deuteriomethyl-3β-hydroxy-5α-cholestan-2-one **11*** afforded the *deuterated acetal* **18** (68% yield), m.p. 139–140 °C (ex methanol); $[\alpha]_D^{20}$ +13 (*c* 0.19) (Found: M^+, 463.4103. $C_{30}H_{49}D_3O_3$ requires *M*, 463.4105); δ_H 0.65 (3 H, s, 18-H_3), 0.90 (3 H, s, 19-H_3) and 3.95 (4 H, m, OCH_2CH_2O).

2,2-*Ethylenedioxy*-3α-*hydroxy*-3β-*methyl*-5α-*cholestane* **19**.—Treatment of a mixture of 3α-hydroxy-3β-methyl-5α-cholestan-2-one **12** (2.25 g), toluene-*p*-sulfonic acid (90 mg), ethylene glycol (5 cm^3) and toluene (250 cm^3) as described in the preceding experiment afforded the *title compound* **19** (1.43 g, 57%), m.p. 130–131 °C (ex methanol); $[\alpha]_D^{20}$ +18 (*c* 0.43) (Found: C, 78.5; H, 11.45%; M^+, 460.3906. $C_{30}H_{52}O_3$ requires C, 78.2; H, 11.4%; *M*, 460.3916); ν_{max}/cm^{-1} 3575 and 1115; δ_H 0.65 (3 H, s, 18-H_3), 0.87 (3 H, s, 19-H_3), 1.11 (3 H, s, 3β-CH_3) and 4.0 (4 H, m, OCH_2CH_2O).

Similar treatment of 3β-deuteriomethyl-3α-hydroxy-5α-cholestan-2-one **13*** afforded the deuterated acetal **20** (82% yield),

* Compounds **11** and **13** were prepared from 2α-acetoxy-5α-cholestan-3-one by the method described for the ketones **10** and **12**[2] but using deuteriomethylmagnesium iodide instead of methylmagnesium iodide.

m.p. 129–131 °C (ex methanol); δ_H 0.65 (3 H, s, 18-H_3), 0.87 (3 H, s, 19-H_3), 2.14 (1 H, br s, exch. D_2O, OH) and 4.0 (4 H, s, OCH_2CH_2O).

2α-Hydroxy-2β-methyl-5α-cholestan-3-one **14**.—(a) A mixture of 3-acetoxy-2-methyl-5α-cholest-2-ene **9** (2.1 g) and osmium tetroxide (1.7 g) in pyridine (100 cm^3) was allowed to stand at room temp in the dark for 8 days. A solution of sodium metabisulfite (5 g) in water (30 cm^3) was added and the mixture was stirred for 1 h then poured into water and extracted with ether. The ether extracts were washed successively with dil. hydrochloric acid, aq. sodium metabisulfite, dil. aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. Chromatography [chloroform–light petroleum (7:3)] afforded the ketone **14** (1.28 g, 65%), m.p. 163–165 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +84 (*c* 0.6) (lit.,[11] m.p. 164–166 °C $[\alpha]_D^{20}$ +85) (Found: M^+, 416.3656. Calc. for $C_{28}H_{48}O_2$: *M*, 416.3654); ν_{max}/cm^{-1} 3500 and 1715; δ 0.65 (3 H, s, 18-H_3), 1.06 (3 H, s, 19-H_3), 1.41 (3 H, s, 2β-CH_3) and 3.87 (1 H, br s, exch. D_2O, OH).

(b) A mixture of the cholest-2-ene **9** (1.72 g), trimethylamine *N*-oxide dihydrate (1.5 g) and osmium tetroxide (300 mg) in *tert*-butyl alcohol (100 cm^3), pyridine (50 cm^3) and water (10 cm^3) was heated under reflux in an atmosphere of nitrogen for 24 h. Aq. sodium metabisulfite (50 cm^3, 20%) was added and after 30 min the *tert*-butyl alcohol was removed by distillation under reduced pressure. The reaction mixture was worked up as described in (a) to afford the enol acetate **9** (250 mg, 15%) and the ketone **14** (830 mg, 51%) identical (m.p., NMR, TLC) with the sample described above.

2β-Acetoxy-2α-methyl-5α-cholestan-3-one **15**.—A mixture of 3-acetoxy-2-methyl-5α-cholest-2-ene **9** (1.1 g), formic acid (200 cm^3), aq. hydrogen peroxide (20 cm^3, 28%), and chloroform (10 cm^3) was warmed to 50 °C then stirred at room temp. for 5 h, poured into water, and extracted with chloroform. The chloroform extract was washed successively with aq. sodium metabisulfite, dil. aq. sodium hydrogen carbonate, and saturated brine, then dried, evaporated under reduced pressure and chromatographed [chloroform–light petroleum (7:3) as eluent] to afford the enol acetate **9** (350 mg, 32%) and the acetoxy ketone **15** (680 mg, 60%), m.p. 161–162 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +17 (*c* 0.48) (lit.,[12] m.p. 163–165 °C, $[\alpha]_D$ +8) (Found: C, 78.3; H, 10.95. Calc. for $C_{30}H_{50}O_3$: C, 78.55; H, 11.0%); ν_{max}/cm^{-1} 1735 and 1715; δ_H 0.65 (3 H, s, 18-H_3), 1.11 (3 H, s, 19-H_3), 1.38 (3 H, s, 2α-CH_3) and 2.05 (3 H, s, OAc).

2β-Hydroxy-2α-methyl-5α-cholestan-3-one **16**.—Aq. sodium hydroxide (2 mol dm^{-3}; 50 cm^3) was added to a solution of the acetate **15** (560 mg) in methanol (50 cm^3) and aq. tetrahydrofuran (100 cm^3, 20%). After 24 h the mixture was poured into water and extracted with ether. The ether extract was washed with saturated brine, dried and evaporated under reduced pressure. Chromatography [chloroform–light petroleum (4:1) as eluent] afforded the hydroxy ketone **16** (420 mg, 83%), m.p. 184–185 °C (ex methanol); $[\alpha]_D^{20}$ +44 (*c* 1.2) (lit.,[12] m.p. 185 °C, $[\alpha]_D^{20}$ +44) (Found: M^+, 416.3652. Calc. for $C_{28}H_{48}O_2$ *M*, 416.3654); ν_{max}/cm^{-1} 3490 and 1708; δ_H 0.65 (3 H, s, 18-H_3), 0.72 (3 H, s, 19-H_3) and 1.4 (3 H, s, 2α-CH_3).

3,3-Ethylenedioxy-2α-hydroxy-2β-methyl-5α-cholestane **21**.—2α-Hydroxy-2β-methyl-5α-cholestan-3-one **14** (1.08 g), toluene-*p*-sulfonic acid (100 mg) and ethylene glycol (5 cm^3) were heated under reflux in benzene (250 cm^3) for 48 h, with removal of water by means of a Dean–Stark apparatus. The reaction mixture was worked up as described in the preparation of compound **17** to give the *title compound* **21** (655 mg, 55%), m.p. 135–136 °C (ex aq. ethanol); $[\alpha]_D^{20}$ + 29 (*c* 0.15) (Found: C, 77.85; H, 11.45%; M^+, 460.3911. $C_{30}H_{52}O_3$ requires C, 78.2; H, 11.4%; *M*, 460.3916); ν_{max}/cm^{-1} 3575 and 1140; δ_H 0.66 (3 H, s, 18-H_3), 0.84 (3 H, s, 19-H_3), 1.34 (3 H, s, 2β-CH_3) and 4.02 (4 H, m, OCH_2CH_2O).

3,3-Ethylenedioxy-2β-hydroxy-2α-methyl-5α-cholestane **22**.—Treatment of a mixture of 2β-hydroxy-2α-methyl-5α-cholestan-3-one **16** (1.78 g), toluene-*p*-sulfonic acid (75 mg), ethylene glycol (5 cm^3) and toluene (250 cm^3) as described in the preparation of compound **17** afforded the *hydroxy acetal* **22** (1.25 g, 64%), m.p. 131–133 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +48 (*c* 0.1) (Found: C, 78.15; H, 11.4%; M^+, 460.3911. $C_{30}H_{52}O_3$ requires C, 78.2; H, 11.4%; *M*, 460.3916); ν_{max}/cm^{-1} 3565 and 1110; δ_H 0.64 (3 H, s, 18-H_3), 1.01 (3 H, s, 19-H_3), 1.07 (3 H, s, 2α-CH_3), 2.0 (1 H, br s, exch. D_2O, OH) and 3.95 (4 H, m, OCH_2CH_2O).

Reaction of the Hydroxy Acetal **17** *with Methylmagnesium Iodide*.—A solution of the acetal **17** (1.06 g) in toluene (60 cm^3) was added dropwise to a stirred ethereal solution of methylmagnesium iodide (6.7 mol dm^{-3}; 15 cm^3) at 0 °C under nitrogen. Ether was removed by distillation until the internal temperature reached 105 °C. More toluene (20 cm^3) was added and the mixture was heated under reflux in an atmosphere of nitrogen for 24 h. The mixture was then cooled to 0 °C, saturated aq. ammonium chloride was added, followed by dil. hydrochloric acid and the mixture was extracted with ether. The ether extract was washed successively with dil. aq. sodium hydrogen carbonate and brine, then dried, evaporated under reduced pressure and chromatographed. Elution with ethyl acetate–benzene (1:1) gave 2β-(*2-hydroxyethoxy*)-2α-(*1-hydroxy-1-methylethyl*)-*4-nor*-5α-*cholestane* **24** (100 mg, 9%), m.p. 154–156 °C (ex methanol); $[\alpha]_D^{20}$ +14 (*c* 0.08) (Found: C, 77.95; H, 11.95%; M^+, 476.4220. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%; *M*, 476.4229); ν_{max}/cm^{-1} 3500 and 1085; δ_H 0.65 (3 H, s, 18-H_3), 0.88 (3 H, s, 19-H_3), 1.2 and 1.24 [each 3 H, s, $(CH_3)_2C$], 2.5 (2 H, br s, exch. D_2O, OH) and 3.72 (4 H, s, $HOCH_2CH_2O$); *m/z* 417, 59.

Further elution with the same solvent afforded 3β-*hydroxy*-2α-(*2-hydroxyethoxy*)-2β,3α-*dimethyl*-5α-*cholestane* **27** (55 mg, 5%), m.p. 154–156 °C (ex methanol); $[\alpha]_D^{20}$ +9 (*c* 0.29) (Found: C, 78.25; H, 11.9%; M^+, 476.4229. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%; *M*, 476.4229); ν_{max}/cm^{-1} 3670, 3400 and 1090; δ_H 0.65 (3 H, s, 18-H_3), 1.04 (3 H, s, 19-H_3), 1.20 (3 H, s, 3α-CH_3), 1.21 (3 H, s, 2β-CH_3) and 3.69 (4 H, br s, $HOCH_2CH_2O$).

Continued elution afforded 3β-*hydroxy*-2β-(*2-hydroxyethoxy*)-2α,3α-*dimethyl*-5α-*cholestane* **29** (885 mg, 81%), m.p. 132–134 °C (ex methanol); $[\alpha]_D^{20}$ +28 (*c* 0.4) (Found: C, 78.55; H, 11.95%; M^+, 476.4220. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%; *M*, 476.4229); ν_{max}/cm^{-1} 3650, 3400 and 1095; δ_H 0.65 (3 H, s, 18-H_3), 0.95 (3 H, s, 19-H_3), 1.10 (3 H, s, 2α-CH_3), 1.22 (3 H, s, 3α-CH_3), 2.46 (2 H, exch. D_2O, OH), 3.55 (2 H, m, $HOCH_2CH_2O$) and 3.75 (2 H, m, $HOCH_2CH_2O$).

Reaction of 3α-Deuteromethyl-2,2-ethylenedioxy-3β-hydroxy-5α-cholestane **18** *with Methylmagnesium Iodide*.—A solution of the deuterated acetal **18** (300 mg) in toluene (60 cm^3) was treated with an ethereal solution of MeMgI (0.52 mol dm^{-2}; 20 cm^3) under the conditions described in the preceding experiment to give, after work-up, an oil which was chromatographed. Elution with ethyl acetate–benzene (1:1) gave 2α-(1-deuteromethyl-1-hydroxyethyl)-2β-(2-hydroxyethoxy)-4-nor-5α-cholestane **26** (50 mg, 16%), m.p. 153–155 °C (ex methanol); δ_H 0.65 (3 H, s, 18-H_3), 0.89 (3 H, s, 19-H_3), 1.20 (3 H, s, CH_3COH), 2.50 (2 H, br s, exch. D_2O, OH) and 3.74 (4 H, s, OCH_2CH_2O).

Continued elution gave 3α-deuteromethyl-3β-hydroxy-2β-(2-

hydroxyethoxy)-2α-methyl-5α-cholestane **31** (205 mg, 66%), m.p. 134–135 °C (ex methanol); $[\alpha]_D^{20}$ +28 (*c* 0.31); δ_H 0.65 (3 H, s, 18-H_3), 0.96 (3 H, s, 19-H_3), 1.10 (3 H, s, 2α-CH_3), 2.46 (2 H, s, exch. D_2O, OH), 3.55 (2 H, m, $HOCH_2CH_2O$) and 3.75 (2 H, m, $HOCH_2CH_2O$).

(2R)-3,3-*Dimethylspiro*[p-*dioxane*-2,2'(4-*nor*-5'α-*cholestane*)] **32**.—A solution of the 5α-cholestane **24** (65 mg) in pyridine (20 cm^3) containing toluene-*p*-sulfonyl chloride (100 mg) was stirred at room temp. for 48 h, then poured into water and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, dil. aq. sodium hydrogen carbonate and brine, then dried and evaporated to dryness under reduced pressure. The residue was chromatographed (chloroform as eluent) to afford the *title compound* **32** (50 mg, 80%), m.p. 96–98 °C (ex methanol); $[\alpha]_D^{20}$ −14 (*c* 0.2) (Found: C, 81.15; H, 11.9%. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.85%); δ_H 0.65 (3 H, s, 18'-H_3), 1.10 (3 H, s, 19'-H_3), 1.25 and 1.30 [each 3 H, s, $C(CH_3)_2$], 3.45 and 3.87 (each 2 H, m, ethylenedioxy protons).

2β-(2-*Acetoxyethoxy*)-2α-(1-*hydroxy*-1-*methylethyl*)-4-*nor*-5α-*cholestane* **25**.—The diol **24** (80 mg) was treated overnight at room temp. with pyridine (10 cm^3) and acetic anhydride (2 cm^3). The mixture was poured into water and extracted with ether, and the ether extract was washed successively with dil. hydrochloric acid, dil. aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure to afford the *monoacetate* **25** (80 mg, 92%), m.p. 107–109 °C (ex methanol); $[\alpha]_D^{20}$ +4 (*c* 0.65) (Found: C, 76.6; H, 11.25%; M^+, 518.4352. $C_{33}H_{58}O_4$ requires C, 76.4; H, 11.25%; *M*, 518.4335); ν_{max}/cm^{-1} 3540, 1740 and 1115; δ_H 0.65 (3 H, s, 18-H_3), 0.89 (3 H, s, 19-H_3), 1.21 [6 H, s, $C(CH_3)_2$], 2.06 (3 H, s, OAc), 3.8 (2 H, t, *J* 5, OCH_2CH_2OAc) and 4.28 (2 H, t, *J* 5, OCH_2CH_2OAc).

2β-(2-*Acetoxyethoxy*)-2α-*isopropenyl*-4-*nor*-5α-*cholestane* **33**.—Thionyl chloride (1.5 cm^3) was added dropwise to a solution of the 4-nor-5α-cholestane **25** (120 mg) in pyridine (10 cm^3) at 0 °C. After 2 h the reaction was quenched by dropwise dil. hydrochloric acid (5 cm^3), and the mixture was poured into dil. hydrochloric acid and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, dil. aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. The residue was chromatographed [chloroform–light petroleum (3:2 as eluent)] to afford the *alkene* **33** (75 mg, 65%), m.p. 57–59 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +3 (*c* 1.4) (Found: C, 79.1; H, 11.15%; M^+, 500.4223. $C_{33}H_{56}O_3$ requires C, 79.15; H, 11.25%; *M*, 500.4229); ν_{max}/cm^{-1} 1740, 1645, 1105 and 905; δ_H 0.65 (3 H, s, 18-H_3), 0.93 (3 H, s, 19-H_3), 1.74 (3 H, s, CH_3C=), 2.05 (3 H, s, OAc), 3.3 (2 H, t, *J* 4, OCH_2CH_2Ac), 4.15 (2 H, t, *J* 4, CH_2OAc) 4.83 and 4.90 (each 1 H, br s, $=CH_2$).

2,2-*Ethylenedioxy*-4-*nor*-5α-*cholestane* **41**.—Treatment of a mixture of 4-nor-5α-cholestan-2-one **40**[13] (2 g), toluene-*p*-sulfonic acid (100 mg), ethylene glycol (5 cm^3) and toluene (200 cm^3) as described in the preparation of compound **18** afforded the *acetal* **41** (2.01 g, 90%), m.p. 117–118 °C (ex methanol); $[\alpha]_D^{20}$ +22 (*c* 0.94) (Found: C, 80.8; H, 11.4%; M^+, 416.3656. $C_{28}H_{48}O_2$ requires C, 80.75; H, 11.6%; *M*, 416.3654); ν_{max}/cm^{-1} 1110; δ_H 0.65 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3) and 3.85 (4 H, m, OCH_2CH_2O).

2β-(2-*Hydroxyethoxy*)-2α-*isopropenyl*-4-*nor*-5α-*cholestane* **34**.—(a) A solution of isopropenyl bromide (3.2 cm^3) in tetrahydrofuran (15 cm^3) was added to a stirred suspension of magnesium turnings (900 mg) in tetrahydrofuran (15 cm^3). The reaction mixture was heated gently to initiate the reaction, then cooled to maintain the internal temperature below 50 °C. A solution of the 5α-cholestane **41** (1.02 g) in toluene (70 cm^3) was added dropwise, and tetrahydrofuran was then removed by distillation until the internal temperature reached 105 °C. The reaction mixture was heated under reflux for 24 h under nitrogen, then cooled to 0 °C and saturated aq. ammonium chloride (50 cm^3), followed by dil. hydrochloric acid (50 cm^3), was added dropwise. The reaction mixture was extracted with ether, and the ether extract was washed successively with aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. Chromatography of the residue [chloroform–light petroleum (3:2) as eluent] afforded the starting acetal **42** (240 mg. 24%), followed by the *alcohol* **34** (345 mg, 31%), m.p. 92–94 °C (ex methanol); $[\alpha]_D^{20}$ +3 (*c* 0.8) (Found: C, 81.2; H, 11.7%. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.9%); ν_{max}/cm^{-1} 3590, 3450, 1645, 1090 and 900; δ_H 0.65 (3 H, s, 18-H_3), 0.90 (3 H, s, 19-H_3), 1.73 (3 H, br s, CH_3C=), 2.05 (1 H, s, exch. D_2O, OH), 3.20 and 3.70 (each 2 H, t, *J* 4, OCH_2CH_2O), 4.86 and 4.94 (each 1 H, br s, $=CH_2$).

(b) A solution of the 5α-cholestane **33** (90 mg) in aq. tetrahydrofuran (20 cm^3, 20%) and methanol (5 cm^3) was treated with dil. sodium hydroxide (10 cm^3) for 18 h at room temp. then poured into water and extracted with ether. The ether extract was washed with water, dried and evaporated under reduced pressure. Chromatography of the residue [chloroform–light petroleum (3:2) as eluent] gave the alcohol **34**, identical (m.p., mixed m.p., TLC, IR, NMR and $[\alpha]_D$) to the sample obtained as described in (a).

2β-*Hydroxy*-2α-*isopropenyl*-4-*nor*-5α-*cholestane* **35**.—(a) Treatment of a solution of 4-nor-5α-cholestan-2-one **40** (400 mg) in tetrahydrofuran (50 cm^3) with isopropenylmagnesium bromide [derived from isopropenyl bromide (0.6 cm^3) and magnesium turnings (160 mg)] in tetrahydrofuran (20 cm^3) under the conditions described in the preparation of compound **34** from the acetal **22** gave, after chromatography [chloroform–light petroleum (1:1) as eluent], some unchanged ketone **40** (160 mg, 40%) followed by the *allylic alcohol* **35** (90 mg, 20%), m.p. 117–119 °C (ex methanol–acetone), $[\alpha]_D^{20}$ +18 (*c* 0.71) (Found: C, 83.8; H, 11.9%. $C_{29}H_{50}O$ requires C, 84.0; H, 12.15%); ν_{max}/cm^{-1} 3585, 3430, 1640 and 895; δ_H 0.65 (3 H, s, 18-H_3), 1.00 (3 H, s, 19-H_3), 1.80 (3 H, s, CH_3–C=), 4.70 and 4.95 (each 1 H, br s, $=CH_2$).

(b) A solution of the 4-nor-5α-cholestane **34** (180 mg) in pyridine (10 cm^3) was treated with toluene-*p*-sulfonyl chloride (300 mg) at room temp. for 72 h. The mixture was poured into water and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, aq. sodium hydrogen carbonate, and brine, then dried, and evaporated under reduced pressure. The resulting crude toluene-*p*-sulfonate was dissolved in 1,2-dimethoxyethane (150 cm^3) and heated under reflux for 4 h with sodium iodide (300 mg) and zinc powder (300 mg). When cool, the mixture was filtered into aq. sodium thiosulfate (5%, 100 cm^3) and extracted with ether. The ether extract was washed with brine, dried and evaporated under reduced pressure. Chromatography of the residue [chloroform–light petroleum (1:1) as eluent] yielded the 4-nor-5α-cholestane **35** (80 mg, 49%), identical (m.p., mixed m.p., $[\alpha]_D$, IR, NMR) with the material described in (a).

2α-*Acetyl*-2β-*hydroxy*-4-*nor*-5α-*cholestane* **42**.—Ozone was bubbled through a solution of the allylic alcohol **35** (65 mg) in dichloromethane (100 cm^3) and methanol (50 cm^3) until a faint blue colour persisted. Oxygen was then bubbled through the solution until the blue colour disappeared. The cooling bath was removed, dimethyl sulfide (2 cm^3) was added, and after 2 h the solution was evaporated under reduced pressure and the residue was chromatographed [chloroform–light petroleum

(1:1) as eluent] to give unchanged allylic alcohol **35** (15 mg 23%), followed by the α-hydroxy ketone **42** (30 mg, 46%), m.p. 107–109 °C (ex methanol–acetone); $[\alpha]_D^{20}$ −6 (*c* 0.3) (lit.,[6] m.p. 117–119 °C, $[\alpha]_D^{20}$ −6) (Found: C, 80.9; H, 11.85%. Calc. for $C_{28}H_{48}O_2$: C, 80.7; H, 11.6%); ν_{max}/cm^{-1} 3470 and 1705; δ_H 0.65 (3 H, s, 18-H_3), 0.98 (3 H, s, 19-H_3), 2.20 (3 H, s, CH_3CO) and 3.93 (1 H, s, exch. D_2O, OH).

2α,3β-*Ethylenedioxy*-2β-3α-*dimethyl*-5α-*cholestane* **36**.—A solution of 2β,3α-dimethyl-3β-hydroxy-2α-(2-hydroxyethoxy)-5α-cholestane **27** (55 mg) in pyridine (15 cm^3) was treated with toluene-*p*-sulfonyl chloride (100 mg) at room temp. for 72 h, then poured into water and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, aq. sodium hydrogen carbonate, and saturated brine, then dried and evaporated under reduced pressure. Chromatography of the residue (chloroform as eluent) gave *the dioxane* **36** (45 mg, 85%), m.p. 132–134 °C (ex methanol), $[\alpha]_D^{20}$ −3 (*c* 0.6) (Found: C, 81.15; H, 11.75%. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.85%); δ_H 0.65 (3 H, s, 18-H_3), 1.06 (3 H, s, 19-H_3), 1.09 (3 H, s, 3α-CH_3), 1.25 (3 H, s, 2β-CH_3), 3.35 and 3.80 (each 2 H, m, OCH_2CH_2O).

Reaction of the Diol **29** *with Toluene*-p-*sulfonyl Chloride and Pyridine*.—A solution of the diol **29** (335 mg) in pyridine (20 cm^3) was treated with toluene-*p*-sulfonyl chloride (500 mg) at room temp. for 24 h, then poured into water and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, aq. sodium hydrogen carbonate and brine then dried and evaporated under reduced pressure. Chromatography of the residue (chloroform as eluent) gave, from the early fractions, 2β,3β-*ethylenedioxy*-2α,3α-*dimethyl*-5α-*cholestane* **39** (130 mg, 40%), m.p. 144–145 °C, followed by re-solidification and a second m.p. 155–156 °C (ex chloroform–methanol); $[\alpha]_D^{20}$ +39 (*c* 0.18) (Found: C, 81.05; H, 11.8%; M$^+$, 458.4101. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.85%; *M*, 458.4124); δ_H 0.65 (3 H, s, 18-H_3), 1.01 (3 H, s, 19-H_3), 1.14 (3 H, s, 2α-CH_3), 1.26 (3 H, s, 3α-CH_3), 3.47 and 3.99 (each 2 H, m, OCH_2CH_2O).

Later fractions afforded 3β-*hydroxy*-2α,3α-*dimethyl*-2β-(2-*toluene*-p-*sulfonyloxyethoxy*]-5α-*cholestane* **30** (145 mg, 33%), m.p. 119–121 °C (ex methanol); $[\alpha]_D^{20}$ +18.5 (*c* 1.07) (Found: C, 72.65; H, 9.95; S, 5.05%. $C_{38}H_{62}O_5S$ requires C, 72.35; H, 9.9; S, 5.05%); ν_{max}/cm^{-1} 3540, 1600, 1170, 1100 and 918; δ_H 0.65 (3 H, s, 18-H_3), 0.88 (3 H, s, 19-H_3), 1.04 (3 H, s, 2α-CH_3), 1.17 (3 H, s, 3α-CH_3), 2.45 (3 H, s, aromatic CH_3), 2.71 (1 H, br s, exch. D_2O, OH), 3.56 (2 H, t, *J* 5, OCH_2CH_2OTs), 7.33 and 7.80 (each 2 H, d, *J* 8, aromatic H).

2β,3β-*Dihydroxy*-2α,3α-*dimethyl*-5α-*cholestane* **37**.—A solution of the 5α-cholestan-2-one **10** (580 mg) in ether (50 cm^3) was added dropwise to a stirred ethereal solution of MeMgI (0.57 mol dm^{-3}; 15 cm^3) at 0 °C under nitrogen. The mixture was heated under reflux for 45 min, then cooled to 0 °C, and saturated aq. ammonium chloride (50 cm^3) was added, followed by dil. HCl (50 cm^3). The reaction mixture was extracted with ether, and the ether extract was washed successively with aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. The residue was chromatographed [benzene–ethyl acetate (7:3) as eluent] to give *the diol* **37** (415 mg, 74%), m.p. 209–211 °C (ex methanol–chloroform); $[\alpha]_D^{20}$ +36 (*c* 0.5) (Found: C, 80.4; H, 11.95; M$^+$, 432.3963. $C_{29}H_{52}O_2$ requires C, 80.5; H, 12.1%; *M*, 432.3967); ν_{max}/cm^{-1} 3540 and 3410; δ_H 0.65 (3 H, s, 18-H_3), 1.01, (3 H, s, 19-H_3), 1.12 (3 H, s, 2α-CH_3), 1.22 (3 H, s, 3α-CH_3) and 1.86–2.05 (2 H, br s, exch. D_2O, OH).

When the ketone **10** (200 mg) was treated with CD_3MgI (0.3 mol dm^{-3}; 15 cm^3) under the same conditions, 2α-deuteromethyl-2β,3β-dihydroxy-3α-methyl-5α-cholestane **38** (150 mg, 72%) was obtained, m.p. 209–211 °C (ex methanol–chloroform); δ_H 0.65 (3 H, s, 18-H_3), 1.01 (3 H, s, 19-H_3) and 1.22 (3 H, s, 3α-CH_3).

Reaction of 3β-*Hydroxy*-2α,3α-*dimethyl*-2β-(2-*toluene*-p-*sulfonyloxyethoxy*)-5α-*cholestane* **30** *with Sodium Iodide and Zinc*.—A solution of the monotoluene-*p*-sulfate **30** (110 mg) in 1,2-dimethoxyethane (20 cm^3) was heated under reflux for 4 h with sodium iodide (110 mg) and zinc powder (120 mg). When cool the mixture was filtered into aq. sodium thiosulfate (5%, 20 cm^3) and extracted with ether. The ether extract was washed successively with aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. Chromatography of the residue [benzene–ethyl acetate (7:3) as eluent] afforded, from the early fractions, 2β,3β-ethylenedioxy-2α,3α-dimethyl-5α-cholestane **39** (30 mg, 38%), identical (m.p., mixed m.p., NMR, TLC) with the material described above.

Later fractions gave the diol **37** (50 mg, 66%), identical ($[\alpha]_D^{20}$, IR, NMR, TLC) with the material described in the preceding experiment.

Reaction of 2,3-*Dimethyl*-5α-*cholest*-2-*ene* **44** *with Osmium Tetroxide*.—A solution of the 5α-cholest-2-ene[7] **44** (470 mg) in pyridine (100 cm^3) was treated with osmium tetroxide (400 mg) in the dark at room temp. for 5 days. The reaction mixture was worked up as described in the preparation of compound **15**, and the products isolated by chromatography (chloroform as eluent). Early fractions gave 2α,3α-dihydroxy-2β,3β-dimethyl-5α-cholestane **43** (380 mg, 74%), m.p. 162–164 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +38.5 (*c* 0.8) (lit.,[8] m.p. 159–161 °C; $[\alpha]_D$ +21.5); ν_{max}/cm^{-1} 3605, 3550 and 3430; δ_H 0.65 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 1.18 (3 H, s, 3β-CH_3), 1.27 (3 H, s, 2β-CH_3) and 2.28 (2 H, br s, exch. with D_2O, OH).

Further elution with chloroform afforded the diol **37** (15 mg, 3%), identical (m.p., mixed m.p., IR, TLC) to the material described above.

Reaction of 2,2-*Ethylenedioxy*-3α-*hydroxy*-3β-*methyl*-5α-*cholestane* **19** *with Methylmagnesium Iodide*.—A solution of the hydroxy-acetal **19** (1.74 g) in toluene (80 cm^3) was treated with an ethereal soluion of methylmagnesium iodide (0.65 mol dm^{-3}; 30 cm^3) as described above for the reaction of compound **18** with MeMgI. Chromatography (benzene as eluent) afforded 2β-(1-*hydroxy*-1-*methylethyl*)-2α-methyl-4-*nor*-5α-*cholestane* **51** (660 mg, 41%), m.p. 134–135 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +26 (*c* (0.25) (Found: C, 83.65; H, 12.95%; M$^+$, 430.4189. $C_{30}H_{54}O$ requires C, 83.65; H, 12.65%; *M*, 430.4174); ν_{max}/cm^{-1} 3590 and 3430; δ_H 0.65 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 1.12 (3 H, s, 2α-CH_3) and 1.15 [6 H, s, $(CH_3)_2C$]; *m*/*z* 371.59. Elution with ethyl acetate–benzene (1:9) gave the acetal **19** (310 mg, 18%).

Elution with ethyl acetate–benzene (1:1) gave 2α-(2-*hydroxyethoxy*)-2β-(1-*hydroxy*-1-*methylethyl*)-4-*nor*-5α-*cholestane* **46** (115 mg, 6%), m.p. 142–144 °C (ex methanol); $[\alpha]_D^{20}$ +16 (*c* 0.2) (Found: C, 77.75; H, 11.85%; M$^+$, 476.4230. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%; *M*, 476.4230); ν_{max}/cm^{-1} 3540, 3400 and 1095; δ_H 0.65 (3 H, s, 18-H_3), 0.78 (3 H, s, 19-H_3), 1.24 [6 H, s, $(CH_3)_2C$-O] and 3.24 (4 H, m, OCH_2CH_2O); *m*/*z* 417. Acetylation of compound **46** (140 mg) with acetic anhydride (2 cm^3) and pyridine (10 cm^3) at room temp. overnight afforded the derived *acetate* **47** (130 mg, 85%) as a gum, $[\alpha]_D$ +27 (*c* 0.3) (Found: C, 76.1; H, 11.25%; M$^+$, 518.4335. $C_{33}H_{58}O_4$ requires C, 76.4; H, 11.25%; *M*, 518.4335); ν_{max}/cm^{-1} 3540, 1735 and 1100; δ_H 0.65 (3 H, s, 18-H_3), 0.79 (3 H, s, 19-H_3), 1.10 and 1.23 [each 3 H, s, $(CH_3)_2COH$], 2.07 (3 H, s, OAc), 3.16 (1 H, br s, exch. D_2O, OH), 3.60 (2 H, t, *J* 4, OCH_2CH_2OAc) and 4.20 (2 H, t, *J* 4, OCH_2CH_2OAc).

Further elution with the same solvent afforded 3α-*hydroxy*-2-

(2-*hydroxyethoxy*)-3β-*methyl*-5α-*cholest*-1-*ene* **45** (530 mg, 30%), m.p. 135–137 °C (ex methanol); $[\alpha]_D^{20}$ −14.5 (*c* 0.7) (Found: C, 78.2; H, 11.6%; M^+, 460.3920. $C_{30}H_{52}O_3$ requires C, 78.2; H, 11.4%; *M*, 460.3916); ν_{max}/cm^{-1} 3670, 3580, 3430–3300 and 1645; δ_H 0.65 (3 H, s, 18-H_3), 0.87 (3 H, s, 19-H_3), 1.27 (3 H, s, 3β-CH_3), 2.65 (2 H, br s, exch. D_2O, OH), 3.65–3.95 (4 H, m, OCH_2CH_2O) and 4.94 (1 H, s, 1-H).

Hydrolysis of the Enol Ether **45**.—A solution of the enol ether **45** (90 mg) in methanol (20 cm^2) was heated under reflux with aq. hydrochloric acid (2 mol dm^{-3}; 20 cm^3) for 30 min, then poured into water and extracted with ether. The ether extract was washed with dil. sodium hydrogen carbonate, dried, and evaporated under reduced pressure. Chromatography (chloroform as eluent) afforded 3α-hydroxy-3β-methyl-5α-cholestan-2-one **12**, identical with an authentic specimen.[2]

(2S)-3,3-*Dimethylspiro*[p-*dioxane*-2,2′-(4-*nor*-5′α-*cholestane*)] **48**.—A solution of the diol **46** (80 mg) in pyridine (10 cm^3) was treated with toluene-*p*-sulfonyl chloride (100 mg) as described in the preparation of compound **32** to give, after chromatography [chloroform–light petroleum (7:3) as eluent], the *title compound* **48** (30 mg, 39%), m.p. 93–95 °C (ex methanol–ether) (Found: C, 81.0; H, 12.1%. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.85%); δ_H 0.65 (3 H, s, 18′-H_3), 0.74 (3 H, s, 19′-H_3) 1.17 and 1.28 [each 3 H, s, $C(CH_3)_2$] and 3.4–4.0 (4 H, m, ethylenedioxy protons).

2β-*Isopropenyl*-2α-*methyl*-4-*nor*-5α-*cholestane* **52**.—Thionyl chloride (4 cm^3) was added dropwise to a solution of 2β-(1-hydroxy-1-methylethyl)-2α-methyl-4-nor-5α-cholestane **51** (350 mg) in pyridine (20 cm^3) at 0 °C. After stirring for 2 h at 0 °C, the reaction mixture was acidified with dil. hydrochloric acid, poured into water and extracted with ether. The ether extract was washed successively with water and dil. hydrochloric acid, then dried and evaporated under reduced pressure. Chromatography (light petroleum as eluent) afforded the *alkene* **52** (190 mg, 57%), m.p. 109–111 °C; $[\alpha]_D^{20}$ +8 (*c* 0.58) (Found: C, 87.15; H, 12.5%; M^+, 412.4061. $C_{30}H_{52}$ requires C, 87.3; H, 12.7%; *M*, 412.4069); ν_{max}/cm^{-1} 1635 and 890; δ_H 0.68 (3 H, s, 18-H_3), 0.88 (3 H, s, 19-H_3), 1.05 (3 H, s, 2α-CH_3), 1.78 (3 H, s, CH_3–C=C) 4.64 and 4.76 (each 1 H, br s, olefinic protons).

Reaction of 2β,3β-*Epoxy*-3α-*methyl*-5α-*cholestane* **50** *with Boron Trifluoride–Diethyl Ether*.—A solution of the epoxide **50** (510 mg) in benzene (20 cm^3) was treated at room temp. with boron trifluoride–diethyl ether (2 cm^3) for 1.5 h; ether was then added and the mixture was washed successively with brine and aq. sodium hydrogen carbonate, then dried and evaporated under reduced pressure. Chromatography of the residue [benzene–light petroleum (2:3) as eluent] gave 2β-*formyl*-2α-*methyl*-4-*nor*-5α-*cholestane* **54** (120 mg, 24%), m.p. 116–119 °C (Found, M^+, 400.3705. $C_{28}H_{48}O$ requires *M*, 400.3705); ν_{max}/cm^{-1} 2710 and 1720; δ_H 0.65 (3 H, s, 18-H_3) 0.66 (3 H, s, 19-H_3), 1.15 (3 H, s, 2α-CH_3) and 9.53 (1 H, s, HC=O). Treatment of the aldehyde **54** (100 mg) with semicarbazide hydrochloride (50 mg) in pyridine (5 cm^3) and water (1 cm^3) gave the derived *semicarbazone* **55** (105 mg, 92%), m.p. 211–213 °C (ex methanol–chloroform); $[\alpha]_D^{20}$ −9 (*c* 0.48) (Found: C, 76.1; H, 10.95; N, 9.0. $C_{29}H_{51}N_3O$ requires C, 76.1; H, 11.25; N, 9.2%).

Further elution with the same solvent gave 3β-methyl-5α-cholestan-2-one **49** (360 mg, 71%), m.p. 149–151 °C (ex. methanol–acetone), $[\alpha]_D^{20}$ +47 (*c* 1.9) (lit.,[9] m.p. 149–150 °C, 152–153 °C, $[\alpha]_D$ +47, +49); λ_{max}/nm 290 (ε 31); ν_{max}/cm^{-1} 1705; δ_H 0.65 (3 H, s, 18-H_3), 0.70 (3 H, s, 19-H_3), 1.01 (3 H, d, *J* 7, 3β-CH_3), 1.99 (1 H, d, *J* 13, 1α-H) and 2.43 (1 H, d, *J* 13, 1β-H).

2β-*Acetyl*-2α-*methyl*-4-*nor*-5α-*cholestane* **53**.—(a) A solution of 2β-isopropenyl-2α-methyl-4-nor-5α-cholestane **52** (210 mg) in dichloromethane (50 cm^3) and methanol (20 cm^3) was treated with ozone as described above in the preparation of compound **43** to give, after chromatography [chloroform–light petroleum (1:2) as eluent] unchanged starting material **52** (55 mg, 26%), followed by the *title compound* **53** (150 mg, 71%), m.p. 108–110 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +23 (*c* 0.4) (Found: C, 83.8; H, 12.35%; M^+, 414.3877. $C_{29}H_{50}O$ requires C, 84.0; H, 12.15%; *M*, 414.3861); ν_{max}/cm^{-1} 1700; δ_H 0.55 (3 H, s, 19-H_3), 0.65 (3 H, s, 18-H_3), 1.23 (3 H, s, 2α-CH_3) and 2.14 (3 H, s, CH_3C=O).

(b) A solution of 2β-formyl-2α-methyl-4-nor-5α-cholestane **54** (200 mg) in ether (30 cm^3) was added dropwise, with stirring, to ethereal MeMgI (0.33 mol dm^{-3}; 15 cm^3) at 0 °C. The reaction mixture was heated under reflux for 1.5 h, then cooled, quenched by the addition of saturated aq. ammonium chloride followed by dil. hydrochloric acid, and extracted with ether. The ether extract was washed successively with aq. sodium hydrogen carbonate and brine, then dried, and evaporated under reduced pressure. The residue was dissolved in dichloromethane (50 cm^3) and stirred at room temp. for 4 h with Celite (300 mg) and pyridinium chlorochromate (300 mg). Ether was added and the reaction mixture was filtered, evaporated under reduced pressure and chromatographed [chloroform–light petroleum (1:1) as eluent] to give the ketone **53** identical with the material obtained in (a).

Reaction of the Hydroxy Acetal **21** *with Methylmagnesium Iodide*.—A solution of the hydroxy-acetal **21** (1.1 g) in toluene (120 cm^3) was treated with an ethereal solution of methylmagnesium iodide (1.1 mol dm^{-3}; 30 cm^3) as previously described above for the reaction of compound **17** with MeMgI. Chromatography [ethyl acetate–benzene (1:9) as eluent] gave 2α-(1-*hydroxy*-1-*methylethyl*)-2β-*methyl*-4-*nor*-5α-*cholestane* **60** (330 mg, 32%), m.p. 43–45 °C (ex methanol–ether); $[\alpha]_D^{20}$ +26.5 (*c* 0.8) (Found: C, 83.75; H, 12.65. $C_{30}H_{54}O$ requires C, 83.65; H, 12.65%); ν_{max}/cm^{-1} 3600 and 3440; δ_H 0.65 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 1.12 (3 H, s, 2β-CH_3) and 1.18 and 1.20 [each 3 H, s, $(CH_3)_2C$], followed by the acetal **21** (130 mg, 12%).

Elution with ethyl acetate–benzene (1:1) gave 2α-*hydroxy*-3α-(2-*hydroxyethoxy*)-2β,3β-*dimethyl*-5α-*cholestane* **56** (625 mg, 55%), m.p. 132–133 °C (ex methanol); $[\alpha]_D^{20}$ +40 (*c* 0.37) (Found: C, 78.05; H, 11.8. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%); ν_{max}/cm^{-1} 3660, 3400 and 1130; δ_H 0.64 (3 H, s, 18-H_3), 0.82 (3 H, s, 19-H_3), 1.09 (3 H, s, 3β-CH_3), 1.22 (3 H, s, 2β-CH_3), 2.88–3.30 (2 H, br s, exch. D_2O, OH), 3.44 (2 H, t, *J* 5, $HOCH_2CH_2O$) and 3.74 (2 H, t, *J* 5, $HOCH_2CH_2O$).

Reaction of the Diol **56** *with Toluene*-p-*sulfonyl Chloride*.—A solution of the diol **56** (340 mg) in pyridine (15 cm^3) was treated with toluene-*p*-sulfonyl chloride (400 mg) at room temperature for 48 h. The reaction mixture was poured into water and extracted with ether, and the ether extract was washed successively with dil. hydrochloric acid, aq. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. Chromatography [chloroform–light petroleum (4:1) as eluent] gave, from the early fractions 2α,3α-*ethylenedioxy*-2β,3β-*dimethyl*-5α-*cholestane* **58** (60 mg, 18%), m.p. 89–90 °C (ex methanol–ether); $[\alpha]_D^{20}$ +47 (*c* 0.3) (Found: C, 81.15; H, 12.1. $C_{31}H_{54}O_2$ requires C, 81.15; H, 11.85%); ν_{max}/cm^{-1} 1100; δ_H 0.65 (3H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 1.15 (3 H, s, 3β-CH_3), 1.28 (3 H, s, 2β-CH_3), 3.57 and 3.85 (each 2 H, m, ethylenedioxy protons).

Later fractions afforded 2α-*hydroxy*-3α-(2-*toluene*-p-*sulfonyloxyethoxy*)-2β,3β-*dimethyl*-5α-*cholestane* **57** (165 mg, 37%), m.p. 117–118 °C (ex methanol–acetone), $[\alpha]_D^{20}$ +25.5 (*c* 0.14) (Found: C, 72.3; H, 9.75; S, 5.25. $C_{38}H_{62}O_5S$ requires C,

72.35; H, 9.9; S, 5.05%); ν_{max}/cm^{-1} 3555,1355, 1165 and 1095; δ_H 0.65 (3 H, s, 18-H_3), 0.79 (3 H, s, 19-H_3), 1.04 (3 H, s, 3β-CH_3), 1.18 (3 H, s, 2β-CH_3), 2.56 (3 H, s, ar-CH_3), 3.52 (2 H, t, *J* 4, OCH_2CH_2OTs), 4.18 (2 H, t, *J* 4, OCH_2CH_2OTs), 7.35 (2 H, d, *J* 9, 3′ and 5′-H) and 7.83 (2 H, d, *J* 9, 2′ and 6′-H).

*Reaction of the Diol Monotoluene-*p*-sulfonate* **57** *with Sodium Iodide and Zinc.*—A solution of the monotoluene-*p*-sulfonate **57** (160 mg) in 1,2-dimethoxyethane (50 cm^3) was heated under reflux for 4 h with sodium iodide (150 mg) and zinc powder (150 mg). A second portion of zinc powder (200 mg) was added and heating was continued for a further 8 h. The reaction mixture was worked up as described above for the corresponding reaction of compound **30** to give 2α,3α-dihydroxy-2β,3β-dimethyl-5α-cholestane **43** (75 mg, 68%), identical with the sample described above, obtained by hydroxylation of the alkene **44**.

Reaction of 2α-Formyl-2β-methyl-4-nor-5α-cholestane **64** *with Methylmagnesium Iodide.*—A solution of the aldehyde **64**[10] (650 mg) in ether (50 cm^3) was treated with an ethereal solution of MeMgI (1 mol dm^2; 20 cm^3) as described above in the preparation of the diol **37**. Chromatography [chloroform–light petroleum (3:2) as eluent] gave 2α-[1(R or S)-*hydroxyethyl*]-2β-*methyl*-4-*nor*-5α-cholestane **63** (300 mg, 44%), m.p. 103–104 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +18 (*c* 0.97) (Found: C, 83.75; H, 12.6%; M$^+$, 416.4024. $C_{29}H_{52}O$ requires C, 83.6; H, 12.6%, *M*, 416.4018); ν_{max}/cm^{-1} 3628 and 3460; δ_H 0.65 (3 H, s, 18-H_3), 0.82 (3 H, s, 19-H_3), 1.04 (3 H, s, 2β-CH_3), 1.12 (3 H, d, *J* 7, CH_3CHOH) and 3.54 (1 H, q, *J* 7, CH_3CHOH).

Further elution afforded the *epimeric alcohol* **63** (250 mg, 37%), m.p. 103–104 °C (ex methanol–acetone); $[\alpha]_D$ +44 (*c* 0.53) (Found: C, 83.55; H, 12.5%; M$^+$, 416.4008. $C_{29}H_{52}O$ requires C, 83.6; H, 12.6%; *M*,416.4018); ν_{max}/cm^{-1} 3618 and 3460; δ_H 0.65 (3 H, s, 18-H_3), 0.82 (3 H, s, 19-H_3), 1.06 (3 H, s, 2β-CH_3), 1.11 (3 H, d, *J* 7, CH_3CHOH) and 3.49 (1 H, q, *J* 7, CH_3CHOH).

2α,3α-*Epoxy*-2β,3β-*dimethyl*-5α-*cholestane* **59**.—A solution of the alkene **44** (600 mg) in benzene (100 cm^3) was treated with *m*-chloroperoxybenzoic acid (700 mg) for 16 h at room temp. Ether was added and the mixture was washed successively with aq. sodium metabisulfite and dil. sodium hydrogen carbonate, then dried and evaporated under reduced pressure. The residue was recrystallised from acetone to give the *title compound* **59** (580 mg, 93%), m.p. 122–124 °C; $[\alpha]_D^{20}$ +36.5 (*c* 0.55); (Found: C, 84.3; H, 11.95%; M$^+$, 414.3861. $C_{29}H_{50}O$ requires C, 84.0; H, 12.15%; *M*, 414.3861); δ_H 0.65 (3 H, s, 18-H_3), 0.71 (3 H, s, 19-H_3) and 1.28 (6 H, s, 2β-CH_3 and 3β-CH_3).

2α-*Acetyl*-2β-*methyl*-4-*nor*-5α-*cholestane* **61**.—(a) A solution of the epoxide **59** (120 mg) in ether (15 cm^3) was treated with boron trifluoride–diethyl ether (2 cm^3) at room temp. for 2 h. Ether was added and the mixture was washed successively with brine and dil. sodium hydrogen carbonate, then dried and evaporated under reduced pressure. Chromatography [chloroform–light petroleum (1:1) as eluent] afforded 2α-*acetyl*-2β-*methyl*-4-*nor*-5α-*cholestane* **61** (85 mg, 71%), m.p. 95–96 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +16 (*c* 0.93) (Found: C, 84.0; H, 12.25%; M$^+$, 414.3861. $C_{29}H_{50}O$ requires C, 84.0; H, 12.15%; *M*, 414.3861); ν_{max}/cm^{-1} 1705; δ_H 0.65 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 1.33 (3 H, s, 2β-CH_3) and 2.14 (3 H, s, CH_3CO).

(b) A mixture of the epimeric 2α-(1ζ-hydroxyethyl)-2β-methyl-4-nor-5α-cholestanes **63** (250 mg) was dissolved in dichloromethane (50 cm^3) and stirred at room temp for 4 h with pyridinium chlorochromate (300 mg) and Celite (500 mg). Ether was then added, the mixture was filtered through Celite, evaporated under reduced pressure, and chromatographed [chloroform–light petroleum (1:1) as eluent] to give the ketone **61**, identical with material obtained as described in (a).

2α-*Hydroxy*-2β-*methyl*-4-*nor*-5α-*cholestane* **62**.—A solution of the ketone **61** (450 mg) in benzene (100 cm^3) was treated with *m*-chloroperoxybenzoic acid (500 mg) at room temp. for 6 days. Ether was added, and the solution was washed successively with aq. sodium metabisulfite, dil. sodium hydrogen carbonate and brine, then dried and evaporated under reduced pressure. The residue was taken up in tetrahydrofuran (50 cm^3) and methanol (20 cm^3). Dil. sodium hydroxide (50 cm^3) was added and the mixture was left at room temp. for 16 h, then poured into water and extracted with ether. The ether extract was washed with brine, dried and evaporated under reduced pressure. Chromatography [chloroform–light petroleum (7:3) as eluent] gave unchanged starting material **61** (65 mg, 14%), followed by 2α-hydroxy-2β-methyl-4-nor-5α-cholestane **62** (315 mg, 75%), m.p. 127–128 °C (ex methanol), $[\alpha]_D^{20}$ +23 (*c* 0.15) (lit.,[6] m.p. 126–128 °C, $[\alpha]_D$ +23) (Found: C, 83.1; H, 12.6%; M$^+$, 388.3700. Calc. for $C_{27}H_{48}O$: C, 83.45; H, 12.45%; *M*, 388.3705); ν_{max}/cm^{-1} 3620 and 3450; δ_H 0.65 (3 H, s, 18-H_3), 0.72 (3 H, s, 19-H_3), 1.38 (3 H, s, 2β-CH_3) and 1.85 (1 H, s, exch. D_2O, OH).

Reaction of the Ketone **61** *with Methylmagnesium Iodide.*—A solution of the ketone **61** (165 mg) in ether (50 cm^3) was reacted with an ethereal solution of MeMgI (0.16 mol dm^{-3}; 15 cm^3) as described above in the preparation of the diol **37**. Chromatography [chloroform–light petroleum (3:2) as eluent] gave 2α-(1-hydroxy-1-methylethyl)-2β-methyl-4-nor-5α-cholestane **60** (155 mg, 90%), identical with a specimen obtained as described above by the action of MeMgI on the hydroxy-acetal **21**.

Reaction of the Ketone **14** *with Methylmagnesium Iodide.*—A solution of the ketone **14** (750 mg) in ether (70 cm^3) was treated with an ethereal solution of MeMgI (1.1 mol dm^{-3}; 20 cm^3) as described above in the preparation of the diol **37**. Chromatography [benzene–ethyl acetate (2:1) as eluent] gave unchanged starting material **14** (25 mg, 3%), followed by 2α,3α-dihydroxy-2β,3β-dimethyl-5α-cholestane **43** (425 mg, 55%), identical with the sample obtained as described above by hydroxylation of 5α-cholest-2-ene **44**.

Further elution afforded 2α,3β-*dihydroxy*-2β,3α-*dimethyl*-5α-*cholestane* **65** (60 mg, 8%), m.p. 199–201 °C (ex methanol); $[\alpha]_D^{20}$ +42 (*c* 0.4) (Found: C, 80.65; H, 12.25. $C_{29}H_{52}O_2$ requires C, 80.5; H, 12.1%); ν_{max}/cm^{-1} 3600 and 3450; δ_H 0.65 (3 H, s, 18-H_3), 0.89 (3 H, s, 19-H_3), 1.32 (3 H, s, 3α-CH_3), 1.37 (3 H, s, 2β-CH_3) and 1.87 (2 H, br s, exch. D_2O, OH).

2β,3α-*Dihydroxy*-2α,3β-*dimethyl*-5α-*cholestane* **66**.—A solution of the ketone **12** (310 mg) in ether (50 cm^3) was treated with an ethereal solution of MeMgI (0.62 mol dm^{-3}; 20 cm^3) as described above in the preparation of the diol **37**. Chromatography [benzene–ethyl acetate (4:1) as eluent] gave unchanged starting material **66** (45 mg, 15%), followed by the *title compound* **66** (245 mg, 76%), m.p. 154–156 °C (ex methanol); $[\alpha]_D^{20}$ + 29 (*c* 0.27) (Found: C, 80.4; H, 12.3%; M$^+$, 432.3963. $C_{29}H_{52}O_2$ requires C, 80.5; H, 12.1%; *M*, 432.3967); ν_{max}/cm^{-1} 3605 and 3485; δ_H 0.65 (3 H, s, 18-H_3), 0.99 (3 H, s, 19-H_3) 1.20 and 1.24 (each 3 H, s, 2α- and 3β-CH_3).

Reaction of the Hydroxy Acetal **22** *with Methylmagnesium Iodide.*—A solution of the hydroxy-acetal **22** (990 mg) in toluene (125 cm^3) was treated with an ethereal solution of MeMgI (1.65 mol dm^{-3}; 20 cm^3) as previously described above for the reaction of compound **17** with MeMgI. Chromatography

[chloroform–methanol (49:1) as eluent] gave, from the early fractions, 2β-*hydroxy*-3β-(2-*hydroxyethoxy*)-2α,3α-*dimethyl*-5α-*cholestane* **69** (675 mg, 66%), m.p. 175–176 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +33 (*c* 1.1) (Found: C, 77.95; H, 11.55%; M^+, 476.4225. $C_{31}H_{56}O_3$ requires C, 78.1; H, 11.85%; *M*, 476.4229); ν_{max}/cm^{-1} 3540, 3380 and 1065; δ_H 0.65 (3 H, s, 18-H_3), 1.02 (3 H, s, 19-H_3), 1.09 (3 H, s, 2α-CH_3), 1.23 (3 H, s, 3α-CH_3), 2.46 (2 H, br s, exch. D_2O, OH), 3.53 (2 H, d, *J* 4, OCH_2CH_2OH) and 3.70 (2 H, d, *J* 4, OCH_2CH_2OH).

Later fractions afforded the diol **24** (60 mg, 6%), identical with the material obtained by reaction of the hydroxyacetal **17** with MeMgI.

Treatment of intermediate chromatographic fractions containing a mixture of the diols **24** and **69** with acetic anhydride and pyridine at room temperature gave, after chromatography, the acetate **25**, identical with material described in an earlier experiment, and 3β-(2-*acetoxyethoxy*)-2β-*hydroxy*-2α,3α-*dimethyl*-5α-*cholestane* **70**, m.p. 114–115 °C (ex methanol); $[\alpha]_D^{20}$ +17 (*c* 0.52) (Found: C, 76.25; H, 10.95%; M^+, 518.4331. $C_{33}H_{58}O_4$ requires C, 76.4; H, 11.25%; *M*, 518.4335); ν_{max}/cm^{-1} 3550, 1740 and 1110; δ_H 0.65 (3 H, s, 18-H_3), 1.03 (3 H, s, 19-H_3), 1.08 (3 H, s, 2α-CH_3), 1.21 (3 H, s, 3α-CH_3), 2.05 (3 H, s, OAc), 3.00 (1 H, s, exch. D_2O, OH), 3.60 (2 H, t, *J* 5, OCH_2CH_2OAc) and 4.20 (2 H, t, *J* 5, OCH_2CH_2OAc).

2β-*Hydroxy*-2α,3α-*dimethyl*-3β-(2-*toluene*-p-*sulfonyloxyethoxy*)-5α-*cholestane* **71**.—A solution of the diol **69** (340 mg) and toluene-*p*-sulfonyl chloride (230 mg) in pyridine (40 cm^3) was left at room temp., under nitrogen, for 18 h. Aq. lactic acid (2%, 1.5 cm^3) was added and after 15 min the reaction mixture was poured into water and extracted with ether. The ether extract was washed successively with dil. hydrochloric acid, aq. sodium hydrogen carbonate and brine, then dried, and evaporated under reduced pressure. Chromatography of the residue [chloroform–light petroleum (7:3) as eluent] afforded the *toluene*-p-*sulfonate* **71** (325 mg, 72%), m.p. 134–136 °C (ex methanol–acetone); $[\alpha]_D^{20}$ +8 (*c* 0.17) (Found: C, 72.4; H, 9.75; S, 5.35%. $C_{38}H_{62}O_5S$ requires C, 72.35; H, 9.9; S, 5.05%); δ_H 0.65 (3 H, s, 18-H_3), 1.00 (6 H, s, 19-H_3 and 2α-CH_3), 1.16 (3 H, s, 3α-CH_3), 2.45 (3 H, s, $ArCH_3$), 3.60 (2 H, t, *J* 4, OCH_2CH_2OTs), 4.15 (2 H, t, *J* 4, OCH_2CH_2OTs), 7.34 (2 H, d, *J* 9, 3′- and 5′-H) and 7.80 (2 H, d, *J* 9, 2′- and 6′-H).

Reaction of the Diol Monotoluene-p-*sulfonate* **71** *with Sodium Iodide and Zinc*.—A solution of the monotoluene-*p*-sulfonate **71** (235 mg) in 1,2-dimethoxyethane (100 cm^3) was heated under reflux for 4 h with sodium iodide (200 mg) and zinc powder (240 mg). The reaction mixture was worked up as described above for the corresponding reaction of compound **30** to give, after chromatography (chloroform as eluent), the 1,4-dioxane **39** (45 mg, 26%) and the diol **37** (105 mg, 65%), both identical with samples of the same compounds described above in earlier experiments.

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