Photoinduced Molecular Transformations. Part 153.[1] Long-Range Intramolecular Hydroxylation of C(25) of the Cholestane Side Chain[2]

Kazuhiko Orito, Shinji Sato and Hiroshi Suginome*
Organic Synthesis Division, Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

Alkoxyl radicals generated by photolysis of the hypoiodites of 5α-cholestan-7α-yl 4-(α-hydroxyphenylmethyl)phenylacetate and 5α-cholestan-7α-yl 3-[4-(α- hydroxyphenylmethyl)phenyl]-propanoate, respectively, abstracted hydrogen from C(25) of their cholestane side chain to give novel macrocyclic lactones. A reductive cleavage of the benzyl ether linkage of these lactones with sodium and liquid ammonia gave 5α-cholestane-7α,25-diol in good yields.

A great many studies have been carried out on the functionalization of unactivated C–H bonds *via* an intramolecular abstraction of hydrogen attached to a carbon atom by an alkoxyl radical since the importance of this process in organic synthesis was shown by Barton and his colleagues.[3] Intramolecular hydrogen abstraction by an alkoxyl radical that demands a 6-membered transition state has been repeatedly demonstrated ever since by numerous examples involving the nitrites[4] and hypoiodites[5] of a variety of substrates.

On the other hand, Breslow and colleagues have devised an ingenious extension of the intramolecular abstraction of hydrogen through a 6-membered cyclic transition state by an excited carbonyl group to a functionalization of remote unactivated methylene groups,[6] as part of their model study of the biomimetic control of chemical reactivity.[7] They used a series of esters derived from benzophenone-3- or -4-carboxylic acid and steroidal alcohols.

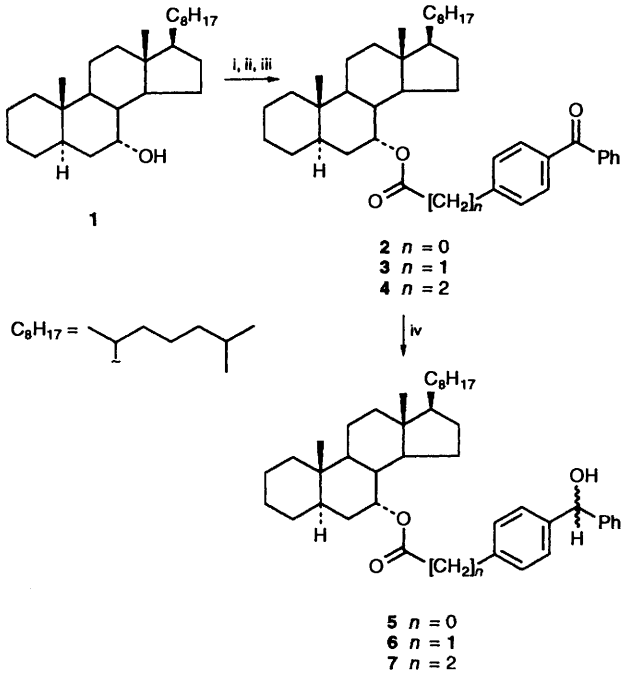
This paper describes a two-step, long-range hydroxylation of C(25) of a steroidal skeleton by alkoxyl radicals generated by the irradiation of the hypoiodites of esters carrying a benzhydryl group, derived simply by reducing Breslow-type esters with $NaBH_4$.

Steroidal 25-ols are of importance since there are several biologically active sterols belonging to this group.[8] The preparation of 25-hydroxycholesterol and the sterols hydroxylated in the side chain has therefore attracted attention.[9]

Results and Discussion

Preparation of 5α-Cholestan-7α-yl 4-(α-Hydroxyphenylmethyl)-benzoate, -phenylacetate or -phenylpropanoate **5–7** *and 3-(α-Hydroxyphenylmethyl)phenylacetate* **14**.—Four esters, **2–4** and **13**, derived from 5α-cholestan-7α-ol **1**[10] and 4-benzoylbenzoic acid, 4-benzoylphenylacetic acid,[11] and 3-(4-benzoylphenyl)propanoic acid and 3-benzoylphenylacetic acid,[12] respectively, were prepared by the standard method. The reduction of these esters with $NaBH_4$ at room temperature readily gave the corresponding alcohols, **5–7** and **14**. Each ester was a mixture of epimers with regard to the carbon atom carrying the hydroxy group (Scheme 1).

Long-Range Intramolecular Hydroxylation of C(25) *of Cholestane Skeleton*.—The epimeric esters **6** in CCl_4 were transformed into the corresponding hypoiodites by *in situ* treatment with 3 mol equiv. of both mercury(II) oxide and iodine. The solution was then irradiated with a 450 W high-pressure Hg arc for 7 h under nitrogen to give a mixture of products, from which products **8** (4.3%), **9** (3.8%), the benzophenone esters **3** (29%) and unchanged starting alcohol **6** (31% recovery) were isolated by means of preparative TLC (PLC) (Scheme 2).

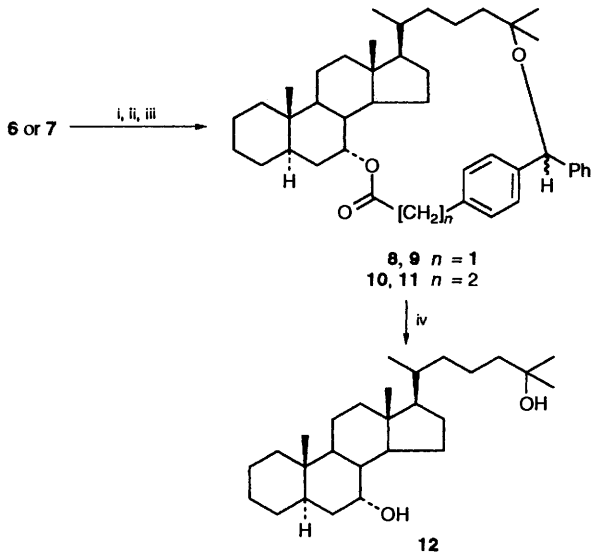


Scheme 1 *Reagents and conditions:* i, 4-benzoylbenzoyl chloride, benzene–pyridine, room temp.; ii, (4-benzoylphenyl)acetyl chloride, benzene–pyridine, room temp.; iii, 3-(4-benzoylphenyl)propanoyl chloride, benzene–pyridine, room temp.; iv, $NaBH_4$, MeOH, room temp.

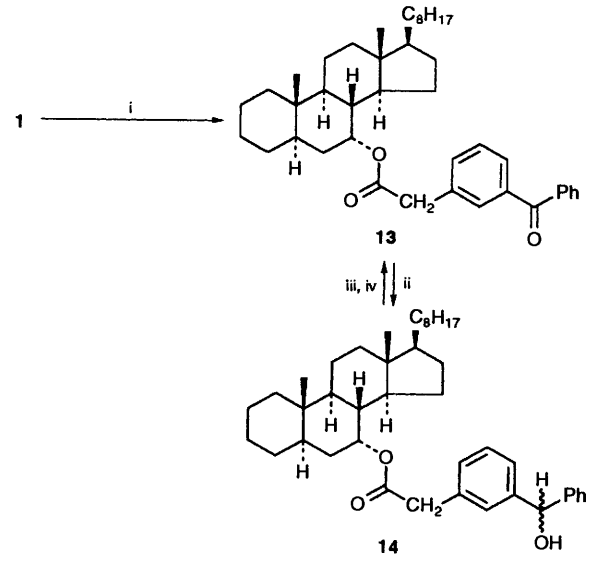
The molecular formula of crystalline products **8** and **9** was established to be $C_{42}H_{58}O_3$ by means of high-resolution mass spectrometry and combustion analysis. The IR spectra of compounds **8** and **9** showed absorption bands at 1722 and 1720 cm^{-1}, respectively, assignable to the lactone carbonyl groups. The ^1H NMR spectrum (400 MHz) of product **8** exhibited a 1 H singlet at δ 5.43 and two 3 H singlets, at δ 1.25 and 1.30, assignable to $C_6H_4CH(OR)Ph$ and the *gem* dimethyl group in addition to the signals due to 18-H_3, 19-H_3 and 7β-H. These spectral results indicated that the structure of the product is that of a macrocyclic ether lactone **8**.

The ^1H NMR of product **9** similarly exhibited a singlet at δ 5.56 (1 H) and two singlets (each 3 H), at δ 1.09 and 1.20, assignable to a proton attached to the carbon carrying an ether oxygen and the *gem* dimethyl group. These spectral results indicated that compound **9** is a macrocyclic ether lactone, and an epimer of the ether **8**.

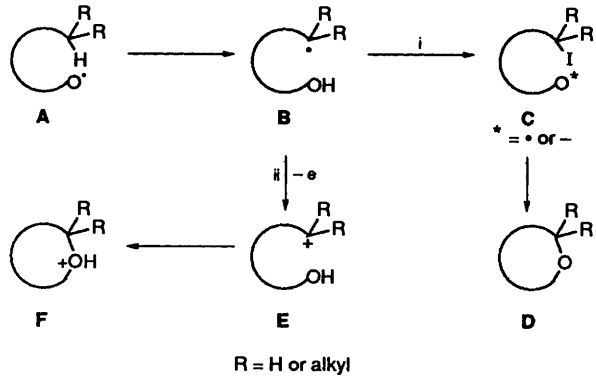
A similar remote functionalization of epimeric esters **6** with lead tetraacetate–iodine[13] or iodosylbenzene diacetate–iodine[14] as the reagent for the formation of the corresponding



Scheme 2 *Reagents and conditions:* i, $HgO–I_2$, CCl_4; ii, $Pb(OAc)_4–I_2$, CCl_4; iii, *hv* > 300 nm; iv, Na–liq. NH_3



Scheme 3 *Reagents and conditions:* i, 3-benzoylphenylacetyl chloride–benzene–pyridine, r.t.; ii, $NaBH_4$–MeOH, r.t.; iii, $HgO–I_2$, CCl_4; iv, *hv* > 300 nm



Scheme 4 *Reagents:* i, I_2 or ROI; ii, M^{2+}

hypoiodite was carried out. Thus, irradiation of the epimeric esters **6** in CCl_4 in the presence of 3 mol equiv. of lead tetraacetate and iodine for 4 h gave lactones **8** and **9** in 5.2 and 3.9% yield, respectively. However, a similar remote functionalization of epimeric esters **6** in CCl_4 in the presence of 3 mol equiv. of iodosylbenzene diacetate failed to give any lactone **8** or **9**.

Reduction of the macrocyclic lactones **8** and **9** with Na–liquid ammonia cleanly eliminated the non-steroidal portion of the lactones to give the hitherto undescribed 5α-cholestane-7α,25-diol **12** in 84 and 75% yield, respectively.

The long-range intramolecular functionalization through the hypoiodites of epimeric esters **7**, having a longer spacer generated with 3 mol equiv. of mercury(II) oxide and iodine in CCl_4, gave a mixture of homologous macrocyclic ether lactones **10** and **11**, in a lower yield (2%), together with homologous benzophenone ester **4** in 46% yield, and the recovered starting alcohol **7** (14% recovery). The reduction of ether lactones **10** and **11** with Na–liquid ammonia gave 5α-cholestane-7α,25-diol **12** in high yield.

Finally, an attempted long-range functionalization by the photolysis of the hypoiodites of epimeric esters **5**, carrying a shorter spacer, in the presence of mercury(II) oxide–iodine, failed to give any macrocyclic ether lactone corresponding to lactones **8**–**11**, resulting only in the formation of benzophenone ester **2**. Likewise, attempted functionalization by photolysis of the hypoiodites of epimeric esters **14**, which were isomeric with epimeric esters **6**, in the presence of mercury(II) oxide and iodine in CCl_4 did not give any products corresponding to macrocyclic ether lactones **8** and **9**, but gave only the parent ketone **13** (18%) and the starting alcohol (37% recovery) (Scheme 3).

Pathways for the Formation of Macrocyclic Ether Lactones **8**–**11**.—There are at least two principal paths for the formation of cyclic ethers in the long-range functionalization by photolysis of hypoiodites, as outlined in Scheme 4; the cyclic ethers can be formed *via* an S_H2 or S_N2 displacement of the iodine of iodides **C** formed by an intramolecular hydrogen abstraction (**A** ⟶ **B** ⟶ **C** ⟶ **D**).[5,13] Alternatively, the cyclic ethers can be formed *via* cyclization of a carbocation **E**, which is formed from one-electron oxidation of the carbon-centred radical **B** generated by intramolecular hydrogen abstraction (**A** ⟶ **B** ⟶ **E** ⟶ **F**).[5]

Macrocyclic ethers **8**–**11** should be formed through the latter path, since the formation of an iodide **C** (R = Me) through the tertiary carbon-centred radical **B** (R = Me) is very unlikely.

Conclusions.—The present long-range intramolecular functionalization involving a 1,20 or 1,21 hydrogen transfer is the first example in which an oxygen atom is directly introduced into a remote position as the result of a long-range intramolecular hydrogen abstraction. These results show that mercury(II) oxide–iodine and lead tetraacetate–iodine are powerful reagents that are applicable to even remote functionalization involving a many-membered cyclic transition state. Alkoxyl radicals are repeatedly generated here from the regenerated hypoidites in a solution containing an excess of reagent. In addition, the carbon-centred radicals, formed by a long-range hydrogen abstraction, are efficiently oxidized to the corresponding carbocation, thus allowing an intramolecular combination with ROI or ROH to form cyclic ethers **F**.

Experimental

M.p.s. were determined using a Yanagimoto micro melting-point apparatus and are uncorrected. IR spectra were determined for Nujol mulls using a JASCO IR-810 spectrophotometer (unless otherwise indicated). ^1H NMR spectra were determined in $CDCl_3$ ($SiMe_4$ as internal reference) using either an Hitachi R-90 H spectrometer operating at 90 MHz, or a JEOL JNM-GX 270 spectrometer operating at 270 MHz, or a Bruker MSL-400 spectrometer operating at 400

MHz. The *J*-values are in Hz. Mass spectra were measured with a JEOL JMS-01SG-2 spectrometer for FD/FI-MS and FI-HR-MS, and a JEOL JMS-D-300 spectrometer (70 eV) for EI-MS and EI-HR-MS. HPLC was performed with a Waters model 45 pump with MeOH containing appropriate amounts of water as the mobile phase and a Waters Radial Pack Cartridge silica gel column 8Si10μ as the stationary phase. Column chromatography was carried out with Merck Kieselgel 60 (70–230 mesh, No. 7734) and PLC was carried out with Merck Kieselgel 60 PF_{254} (No. 7749). Light petroleum refers to the fraction with distillation range 30–70 °C.

5α-Cholestan-7α-yl 4-Benzoylbenzoate **2**.—5α-Cholestan-7α-ol **1**[7] (0.78 g, 2.0 mmol), 4-benzoyl chloride (1.00 g, 4.1 mmol) and pyridine (0.33 g, 4.1 mmol) were stirred in dry benzene (30 cm^3) for 5 h at 50–60 °C. The solution was poured into ice–water and the organic layer was separated. The aqueous layer was extracted with benzene. The combined benzene solution was washed successively with dil. hydrochloric acid, aq. sodium hydroxide, and water, and dried over anhydrous Na_2SO_4. Usual work-up of the solution gave an oily crude ester **2** (1.47 g), which was subjected to PLC with benzene to give a glassy 4-*benzoylbenzoate* **2** (0.91 g, 76%); ν_{max}/cm^{-1} 1710 (ester C=O), 1640 (benzoyl C=O) and 1270 (ester C–O); δ_H(270 MHz) 0.68 (3 H, s, 18-H_3), 0.85 (3 H, s, 19-H_3), 5.18 (1 H, br s, 7β-H) and 7.51–8.19 (9 H, m, ArH); *m/z* 596 (M^+, 41.7), 370 [(M − $C_6H_5COC_6H_4CO_2H)^+$, 46] and 369 [(M − $C_6H_5COC_6H_4CO_2H$ − H)$^+$, 100%] (Found: M^+, 596.4222. $C_{41}H_{56}O_3$ requires M, 596.4229).

5α-Cholestan-7α-yl 4-(α-Hydroxyphenylmethyl)benzoate **5**.—Sodium boranuide (31 mg) was added to a stirred solution of the benzoylbenzoate **2** (861 mg) in tetrahydrofuran (THF) (20 cm^3)–methanol (2 cm^3). Removal of the solvent gave a residue, to which water was added. The mixture was then extracted with dichloromethane. The organic layer was washed with water and dried over anhydrous Na_2SO_4. Removal of the solvent gave an oily product, which was purified by PLC with dichloromethane. The fraction from silica gels was dissolved in dichloromethane. The solution was then washed with water, and dried over anhydrous Na_2SO_4. Removal of the solvent gave *5α-cholestan-7α-yl 4-(α-hydroxyphenylmethyl)benzoate* **5** as a glassy material (712 mg, 82.4%); ν_{max}/cm^{-1} 3400br (OH), 1710 (ester C=O) and 1275 (ester C–O); δ_H(270 MHz) 0.66 (3 H, s, 18-H_3), 0.83 (3 H, s, 19-H_3), 5.12 (1 H, br s, 7β-H), 5.90 (1 H, s, C*H*OH), 7.25–7.52 (5 H, m, Ph) and 8.03 (4 H, d, *J* 8.42, ArH); FD-MS *m/z* 598 (M^+, 93.0), 597 [(M − H)$^+$, 100] and 372 {[M − $C_6H_5CH(OH)C_6H_4CO_2H]^+$, 38.4%} (Found: M^+, 598.4384. $C_{41}H_{58}O_3$ requires M, 598.4386).

Photolysis of the Hypoiodite of 5α-Cholest-7α-yl 4-(α-Hydroxyphenylmethyl)benzoate **5** *in the Presence of Mercury*(II) *Oxide and Iodine*.—The 4-(α-hydroxyphenylmethyl)benzoate **5** (649 mg, 1.08 mmol) in tetrachloromethane (100 cm^3) containing HgO (red; 710 mg, 3.28 mmol) and I_2 (1.12 g, 4.43 mmol) was irradiated for 7 h in a manner described for ester **6** to give only recovered starting alcohol **5** (37 mg, 6% recovery) and 4-benzoylbenzoate **2** (363 mg, 56%).

Preparation of 5α-Cholestan-7α-yl 4-Benzoylphenylacetate **3**.—5α-Cholestan-7α-ol **1** (1.24 g, 3.21 mmol), 4-benzoylphenylacetyl chloride (1.67 g, 6.43 mmol) and pyridine (0.52 g, 6.58 mmol) were stirred in benzene (60 cm^3) for 16 h at room temperature. The solution was then poured into ice–water. The organic layer was separated and the aq. layer was extracted with benzene. The combined benzene layers were washed successively with dil. aq. sodium hydroxide and water, and dried over anhydrous Na_2SO_4. Usual work-up gave a crude product, which was subjected to PLC with benzene. A fraction with R_f 0.4 was extracted with ethyl acetate to give 4-*benzoylphenylacetate* **3**. Recrystallization of the benzoylphenylacetate from light petroleum gave pure crystals (1.46 g, 75%), m.p. 129–130 °C; ν_{max}/cm^{-1} 1710 (ester C=O), 1660 (benzoyl C=O) and 1270 (ester C–O); δ_H(270 MHz) 0.58 (3 H, s, 18-H_3), 0.76 (3 H, s, 19-H_3), 3.71 (2 H, s, OCH_2), 4.86 (1 H, br s, 7β-H), 7.42–7.61 (5 H, m, Ph) and 7.80–7.81 (4 H, m, ArH); FD-MS *m/z* 610 (M^+, 100%) (Found: C, 82.6; H, 9.65. $C_{42}H_{58}O_3$ requires C, 82.57; H, 9.57%).

5α-Cholestan-7α-yl 4-(α-Hydroxyphenylmethyl)phenylacetate **6**.—To a stirred solution of the ester **3** (1.40 g) in THF (30 cm^3)–methanol (3 cm^3) was added sodium boranuide (50 mg). The solution was stirred for 5 h at room temperature. The solvent was then evaporated off on a rotary evaporator at room temperature. The residue was dissolved in a mixture of dichloromethane and water. The aqueous layer was extracted with dichloromethane. Combined organic layers were washed with water and dried over anhydrous Na_2SO_4. Usual work-up of the solution gave the title alcohol, which was recrystallized from light petroleum to give *pure alcohol* **6** (1.34 g, 96%), m.p. 107 °C; ν_{max}/cm^{-1} 3450 (OH), 1700 (ester C=O) and 1270 (ester C–O); δ_H(270 MHz) 0.59 (3 H, s, 18-H_3), 0.74 (3 H, s, 19-H_3), 3.59 (2 H, s, $COCH_2$), 4.82 (1 H, br s, 7β-H), 5.82 (1 H, s, C*H*OH) and 7.25–7.38 (9 H, m, ArH); FD-MS, *m/z* 612 (M^+, 100) and 595 [(M − OH)$^+$, 16%] (Found: C, 82.4; H, 10.0. $C_{42}H_{60}O_3$ requires C, 82.30; H, 9.87%).

Photolysis of the Hypoiodite of 5α-Cholestan-7α-yl 4-(α-Hydroxyphenylmethyl)phenylacetate **6** *in the Presence of* HgO *and* I_2.—The alcohol **6** (574 mg, 0.938 mmol), HgO (red; 610 mg, 2.81 mmol), and I_2 (717 mg, 281 mmol) in dry tetrachloromethane (100 cm^3) were irradiated through a Pyrex filter with a Ushio 450 W high-pressure mercury arc for 7 h under nitrogen. After the solution had been filtered, the filtrate was washed with aq. Na_2SO_4. Usual work-up of the solution gave a mixture of the products (630 mg), which was subjected to PLC (Merck silica gel No. 7749) with benzene to give three fractions. The most mobile fraction was an oily mixture of the two epimers **8** and **9** of a cyclic ether (56 mg). The next mobile fraction (167 mg, 29%) was the crystalline benzoylphenylacetate **3**. The most polar fraction (179 mg, 31% recovery) was the starting alcohol **6**. The most mobile fraction was again subjected to PLC with the same solvent as above to give two fractions. The more mobile fraction (25 mg, 4.3%) (R_f 0.75) was a crystalline solid, which was recrystallized from light petroleum to give an analytical specimen of *ether lactone* **8** (14 mg, 2.4%), m.p. 292–293 °C; ν_{max}/cm^{-1} 1722 (ester C=O) and 1265 (ester C–O); δ_H(400 MHz) 0.50 (3 H, s, 18-H_3), 0.76 (3 H, s, 19-H_3), 3.43 and 3.49 (each 1 H, d, *J* 11.72, $COCH_2$), 4.73 (1 H, br s, 7β-H) and 5.43 (1 H, s, CHO); *m/z* 610 (M^+, 100) and 592 [(M − 18)$^+$, 30%] (Found: C, 82.4; H, 9.7. $C_{42}H_{58}O_3$ requires C, 82.57; H, 9.57%).

A less mobile fraction (R_f 0.65) was a crystalline solid (22 mg, 3.8%), which was recrystallized from light petroleum to give an analytical sample of isomeric *ether lactone* **9** (16 mg, 2.8%), m.p. 262–270 °C; ν_{max}/cm^{-1} 1720 (ester C=O) and 1275 (ester C=O); δ_H(400 MHz) 0.52 (3 H, s, 18-H_3), 0.77 (3 H, s, 19-H_3), 0.93 (3 H, d, *J* 6.8, 21-H_3) 1.09 and 1.20 (each 3 H, s, 26- and 27-H_3), 3.43 and 3.57 (each 1 H, each *J* 12.2, $CH_2C_6H_4$), 4.81 (1 H, br d, *J* 2.73, 7β-H), 5.56 [1 H, s, C_6H_4CH(O)Ph] and 7.14–7.33 (9 H, m, ArH); FD-MS *m/z* 610 (M^+, 100) and 592 [(M − 18)$^+$, 6%] (Found: C, 82.5; H, 9.6%).

Preparation of 5α-Cholestane-7α,25-diol **12** *by Treatment of Lactones* **8** *and* **9** *with Sodium and Liquid Ammonia*.—To liq. ammonia (100 cm^3) cooled in a solid CO_2–acetone bath was added sodium metal (200 mg). This mixture was stirred for 20

min, then a solution of the lactone **8** (9 mg) in dry THF (3 cm^3) was added. The mixture was stirred at −78 °C for 1 h and then NH_4Cl (500 mg) was added dropwise. The white suspension thus obtained was allowed to warm to room temperature under exposure to air to remove NH_3 gas in a hood. The residue was dissolved in a mixture of water and dichloromethane. The organic layer was then washed with water and dried over anhydrous Na_2SO_4. Evaporation of the solvent gave an oil (8 mg), which was purified by PLC (1 : 1 benzene–diethyl ether as the developing solvent). A band with R_f 0.4 gave an oil, which was crystallized from light petroleum to give the hitherto unknown *5α-cholestane-7α,25-diol* **12** (5 mg, 84%), m.p. 146–148 °C; ν_{max}/cm^{-1} 3380 (OH); δ_H(270 MHz) 0.66 and 0.78 (each 3 H, s, 18- and 19-H_3), 0.92 (3 H, d, *J* 6.6, 21-H_3), 1.21 (6 H, s, 26- and 27-H_3) and 3.81 (1 H, br s, 7β-H); *m/z* FD-MS (relative intensity) 404 (M^+, 44), 386 ($M^+ - H_2O$, 34), 369 [$(M - H_2O - OH)^+$, 71] and 59 {$[(CH_3)_2C{=}O + H]^+$, 100%} (Found: C, 79.9; H, 11.9. $C_{27}H_{48}O_2$ requires C, 80.14; H, 11.96%).

In the same manner, the lactone **9** (12 mg) was treated with sodium metal in liquid ammonia to afford the crystalline diol **12** (6 mg, 75%).

Long-range Functionalization of the Alcohol **6** *with* $Pb(OAc)_4$ *and* I_2.—A mixture of the ester alcohol **6** (153 mg, 0.23 mmol), $Pb(OAc)_4$ (Wako, 325 mg, 0.75 mmol) and I_2 (190 mg, 0.75 mmol) in dry CCl_4 (25 cm^3) was irradiated for 4 h in the same manner as described above. Work-up of the solution gave an oily residue (175 mg), which was subjected to PLC. Recrystallization of the amorphous fraction 1 (R_f 0.75, 12 mg) from light petroleum afforded the crystalline lactone **8** (8 mg, 5.2%), m.p. 292–298 °C. Fraction 2 (R_f 0.65) was an oil (6 mg, 3.9%) which gave isomeric lactone **9**, m.p. 264–270 °C. Fraction 3 (R_f 0.4) gave the keto ester **3** (49 mg, 32%). Fraction 4 (R_f 0.2) gave the starting alcohol **6** (20 mg, 13% recovery).

Irradiation of the Alcohol **6** *in the Presence of* $PhI(OAc)_2$ *and* I_2.—A stirred suspension of the ester alcohol **6** (153 mg, 0.25 mmol), iodosylbenzene diacetate (242 mg, 0.75 mmol) and I_2 (190 mg, 0.75 mmol) in dry CCl_4 (25 cm^3) was irradiated for 4 h in the same manner as described above to give only an unidentified mixture (13 mg) (R_f 0.8–0.7), the ketone **3** (R_f 0.4; 92 mg, 60%) and the starting material **6** (R_f 0.2; 11 mg, 7.2% recovery). Irradiation in benzene or cyclohexane as solvent gave neither lactone **8** nor its stereoisomer **9**.

Preparation of 5α-Cholestan-7α-yl 3-(4-Benzoylphenyl)propanoate **4**.—A mixture of 5α-cholestan-7α-ol **1** (1.25 g, 3.21 mmol), 3-(4-benzoylphenyl)propanoyl chloride [1.09 g, 4.0 mmol, prepared from 3-(4-benzoylphenyl)propanoic acid[11] and $SOCl_2$] and pyridine (0.48 g, 6.0 mmol) in dry benzene (40 cm^3) was stirred at room temperature for 15 h and then at 50 °C for 5 h. The mixture was then washed successively with water (20 cm^3), dil. HCl, aq. NaOH, and water and dried over anhydrous Na_2SO_4. Evaporation of the mixture gave an oil (2.47 g), which was purified by PLC (silica gel) with benzene as the solvent. A band with R_f 0.6 gave an oil, which was recrystallized from light petroleum to give *5α-cholestan-7α-yl 3-(4-benzoylphenyl)propanoate* **4** (1.88 g, 96%), m.p. 97–101 °C; ν_{max}/cm^{-1} 1725, 1650 and 1610; δ_H(270 MHz) 0.62 (3 H, s, Me), 0.77 (3 H, s, Me), 2.73 and 2.81 (each 2 H, each t, *J* 7.3, $OCOCH_2CH_2$), 4.90 (1 H, br s, 7β-H) and 7.25–7.82 (9 H, m, ArH); *m/z* (FD-MS) 625 [$(M + H)^+$, 100] and 624 (M^+, 93%) (Found: C, 82.9; H, 9.7. $C_{43}H_{60}O_3$ requires C, 82.46; H, 9.68%).

5α-Cholestan-7α-yl 3-[4-(α-Hydroxyphenylmethyl)phenyl]propanoate **7**.—The ester **4** (580 mg) was dissolved in a mixed solvent of THF (15 cm^3) and MeOH (3 cm^3). To this solution was added sodium boranuide (100 mg) in portions (25 mg × 4) in the course of 3 h. After being stirred at room temperature for 6 h, the mixture was evaporated and the residue was extracted with water (10 cm^3) and dichloromethane (10 cm^3 × 2). The extracts were washed with water (15 cm^3) and dried. Evaporation of the mixture gave an oil (575 mg), which was purified by means of PLC (benzene) to give oily 5α-cholestan-7α-yl [3-(α-hydroxyphenylmethyl)phenyl]propanoate **7** (R_f 0.2; 547 mg, 94%); ν_{max}(neat)/cm^{-1} 3450 and 1720; ν_{max}/cm^{-1} 3450, 1700 and 1270; δ_H(270 MHz) 0.59 (3 H, s, 18-H_3), 0.74 (3 H, s, 19-H_3), 0.87, 0.88 and 0.89 (each 3 H, d, *J* 6.6, 21-, 26- and 27-H_3), 4.82 (1 H, br s, 7β-H), 5.83 [1 H, s, C*H*(OH)Ph] and 7.20–7.40 (9 H, m, ArH); *m/z* (FD-MS) 626 (M^+, 100) and 609 [$(M - OH)^+$, 22%].

Irradiation of the Hypoiodite of 5α-Cholestan-7α-yl 3-[4-(α-Hydroxyphenylmethyl)phenyl]propanoate **7** *in the Presence of* HgO *and* I_2.—A stirred suspension of the alcohol **7** (371 mg, 0.592 mmol), HgO (red; 384 mg, 1.77 mmol) and I_2 (467 mg, 1.77 mmol) in dry CCl_4 (100 cm^3) was irradiated for 7 h to give a mixture of isomeric cyclic ethers **10** and **11** (8 mg, 2%), ν_{max}(neat)/cm^{-1} 1720; δ_H(90 MHz) 0.53 and 0.66 (each 3 H, *ca.* 1 : 1, s, 18-H_3); the precursor keto ester **4** (170 mg, 46%) and the starting alcohol **7** (53 mg, 14% recovery).

5α-Cholestane-7α,25-diol **12** *from Lactones* **10** *and* **11**.—The above mixture (12 mg) of lactones **10** and **11** in dry THF (5 cm^3) was treated with sodium metal (200 mg) in liq. ammonia (20 cm^3) to give an oily mixture (8 mg), PLC of which gave crystalline diol **12** (4 mg).

5α-Cholestan-7α-yl (3-Benzoylphenyl)acetate **13**.—A solution of 5α-cholestan-7α-ol **1** (473 mg, 1.2 mmol), (3-benzoylphenyl)-acetyl chloride [466 mg, 1.8 mmol, prepared from (3-benzoylphenyl)acetic acid,[12] $SOCl_2$] and pyridine (143 mg, 1.18 mmol) in dry benzene (10 cm^3) was stirred at room temperature for 1 h and was then washed with dil. HCl, aq. NaOH, and water, and dried over anhydrous Na_2SO_4. Evaporation of the mixture gave an oil (1.016 g), which was purified by PLC with benzene. A band with R_f 0.4 gave oily 5α-cholestan-7α-yl (3-benzoylphenyl)acetate **13** (727 mg, 99%), ν_{max}(neat)/cm^{-1} 1732, 1664, 1599 and 1580; δ_H(270 MHz) 0.57 (3 H, s, 18-H_3), 0.74 (3 H, s, 19-H_3), 0.89 (9 H, d, *J* 6.6, 21-, 26- and 27-H_3), 3.70 (2 H, s, $CH_2C_6H_4$), 4.84 (1 H, br s, 7β-H), 7.40–7.85 (9 H, m, ArH); *m/z* (FD-MS) 611 [$(M + H)^+$, 53] and 610 (M^+, 100%).

5α-Cholestan-7α-yl 3-(α-Hydroxyphenylmethyl)phenylacetate **14**.—Keto ester **13** (680 mg, 1.11 mmol) was treated with sodium boranuide (50 mg) in THF (15 cm^3)–MeOH (3 cm^3) at room temperature for 30 min. The solvent was evaporated off at room temperature and the oily residue was extracted with dichloromethane (20 cm^3) and water (20 cm^3). The organic layer was dried (Na_2SO_4) and evaporated to give a crude alcohol, which was subjected to PLC with benzene to give 5α-cholestan-7α-yl 3-(α-hydroxyphenylmethyl)phenylacetate **14** as an oil (668 mg, 98%; R_f 0.4); ν_{max}/cm^{-1} 1730; δ_H(270 MHz) 0.57 (3 H, s, 18-H_3), 0.74 (α-3 H, s, 19-H_3), 0.87 and 0.88 (3 H and 6 H, each d, *J* 6.6, 21-, 26- and 27-H_3), 2.23 (1 H, br s, OH), 3.59 (2 H, s, $CH_2C_6H_4$), 4.81 (1 H, br s, 7β-H), 5.83 [1 H, s, C*H*(O)C_6H_4] and 7.17–7.40 (9 H, m, ArH); *m/z* (FD-MS) 612 (M^+, 100), 610 [$(M - 2)^+$, 57), 596 [$(M - 18)^+$, 49] and 371 [$(M - OCOR)^+$, 16%].

Irradiation of the Hypoiodite of 5α-Cholestan-7α-yl 3-(α-Hydroxyphenylmethyl)phenylacetate **14** *in the Presence of* HgO *and* I_2.—A stirred suspension of the alcohol **14** (612 mg), HgO

(red, 651 mg) and I_2 (762 mg) in dry CCl_4 (100 cm^3) was irradiated as described above to give only keto ester **13** (115 mg) and starting alcohol **14** (231 mg recovery).

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