Photocyclisation of Enamides. Part 22.[1] Syntheses of the Despyrrole Analogues of some Ergot Alkaloids including Methyl Lysergate and Isofumigaclavine A[2]

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A general synthetic route to the benzo[*f*]quinolines (**21**)—(**27**), the despyrrole analogues of lysergic and isolysergic esters and isofumigaclavine A, is described. The route involves the reductive photocyclisation of the enamide (**2**) followed by glycol formation and oxidative ring opening of the dihydrofuran ring.

Although the potentiality of reductive photocyclisation of enamides for the construction of nitrogen-containing heterocyclic compounds has been convincingly demonstrated,[3] there yet remains the equally important task of application of this new methodology to the total synthesis of natural alkaloids. Within this context and also as an inevitable extension of our work[4] on the synthesis of ergot alkaloids which are relatively rarely investigated by synthetic chemists and which are also regarded as an important group of chemicals in clinical use, we report here the establishment of a simple and general synthetic route to the despyrrole analogues (**21**), (**22**), and (**27**) of methyl lysergate, methyl isolysergate, and isofumigaclavine A by the application of reductive photocyclisation of enamides.

Construction of Benzo[f]*quinolines as the Skeletal Nuclear Synthons of Despyrrole Analogues.*—In order to establish an effective synthetic route first to a key intermediate which has a basic skeletal nucleus of the despyrrole analogues of ergot alkaloids, that is, benzo[*f*]quinolines, we picked the enamides (**1**) and (**2**), which carry a readily cleavable heteroaromatic ring in the acyl portion, for their photocyclisation under reductive conditions. Acylation of the imine, prepared from 2-tetralone and methylamine, with isoxazole-4-carbonyl[5] and furan-3-carbonyl chlorides afforded the corresponding enamides (**1**) and (**2**) in good yield, both of which exhibited the spectral data [$\nu_{max.}$ 1 630 cm^{-1} (NCO); δ_H 6.33 (br s, HC=C–N)]. Irradiation of the enamide (**1**) in benzene–methanol (10:1) in the presence of excess of sodium borohydride at 4—10 °C with a high-pressure mercury lamp afforded a mixture of two hydrogenated lactams (**3**) and (**7**) in 32 and 31% yield respectively. The stereochemistry of these lactams (**3**) and (**7**) was deduced from their n.m.r. spectra as follows. The B/C-ring junctions of (**3**) and (**7**) were determined from the coupling constants between two protons at the 5a- and 11b-position which are 10 Hz in (**3**) and 5.5 Hz in (**7**), thus suggesting the B/C-*trans* structure for (**3**) and B/C-*cis* for (**7**). The *trans*-relationship of the two hydrogens 11b-H and 11c-H is also assigned from their coupling constants of 10 Hz in both compounds (**3**) and (**7**). On the other hand, reductive photocyclisation of the enamide (**1**) in acetonitrile–methanol (10:1) afforded the lactam (**9**) in 47% yield. The structure of compound (**9**) was assigned from its spectral data which had no olefinic proton signal in the n.m.r. spectrum but instead had a nitrile absorption in the i.r. spectrum, and a molecular ion at *m/z* 240 in the mass spectra. The equatorial configuration of the 2-nitrile group was suggested from the n.m.r. signal of 2-H at δ_H 3.78 (dd, *J* 11.5 and 5 Hz).

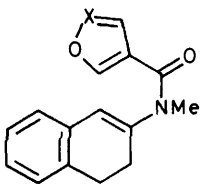
The formation of the lactam (**9**) can be explained as follows. Ring opening to the hydroxy nitrile (**A**) and the ensuing dehydration of the photocyclised lactam (**3**) would give the intermediate (**B**) which would then undergo reduction of a double bond by excess of sodium borohydride to form the lactam (**9**). The above explanation is also supported by the fact that both sodium borohydride reduction of the photocyclised lactam (**3**) and irradiation of the lactam (**3**) in the presence of sodium borohydride in acetonitrile–methanol (10:1) afforded the cyano lactam (**9**).

Of the photocyclised products (**3**), (**7**), and (**9**), the *trans*-lactam (**3**) was thought to be suitable for further conversion into the target despyrrole analogues of ergot alkaloids by ring opening to an intermediate (**A**) followed by dehydration of the hydroxy group at the 1-position and modification of substituents. Thus, we treated compound (**3**) with a base such as triethylamine and sodium methoxide in order to effect ring opening of the isoxazole ring. However, the product obtained was (**10**) as a result of further dehydrogenation and dehydration. Compound (**10**) was found to be too stable for further conversion into a desired and versatile intermediate such as (**A**) or (**B**).

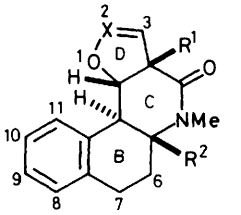
As the next approach, we investigated photocyclisation of the enamide (**2**), which carries a furan ring in the acyl portion, in view of the fact that synthesis of natural alkaloids has been successfully achieved by the judicious use of a furan ring and its ring opening.[6]

Irradiation of the enamide (**2**) under reductive conditions afforded a mixture of two hydrogenated lactams (**4**) and (**8**) with different ratios depending on the solvent used as summarised in the Table. The stereochemistry of these two lactams (**4**) and (**8**) was established from their n.m.r. spectra as in the cases of (**3**) and (**7**). The B/C-ring junctions in (**4**) and (**8**) were determined from the coupling constants between the 5a-H and 11b-H hydrogens as 11 Hz for (**4**) for the B/C-*trans*-fusion and 6 Hz for (**8**) for its *cis*-fusion. The *trans*-relationship between 11b-H and 11c-H was deduced from their coupling constants of 10 Hz for (**4**) and 11 Hz for (**8**). Furthermore, the C/D-*cis*-junction of the two lactams (**4**) and (**8**) was determined from the conversion of (**4**) into the 1,2-*cis*-disubstituted benzo[*f*]quinoline derivative (**20**), in addition to the observation of almost identical coupling patterns between 3a-H and 11c-H in the n.m.r. spectra of (**4**) and (**8**).

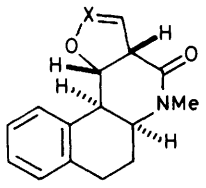
As shown in the Table of the solvent effects in the photocyclisation, the yield of the B/C-*trans*-lactam (**4**) was found to increase as the ratio of methanol in the reaction solution increased, while the by-product (**11**) was formed when benzene–methanol mixtures containing >50% by volume of methanol were used. Further, the use of acetonitrile as the solvent brought about the formation of the by-product (**11**), thus showing the unsuitability of strongly polar solvents in this photocyclisation. As a result, a mixed solvent of benzene–methanol (1:1) was found to be most suitable for this photocyclisation, giving a mixture of *trans*- and *cis*-lactam (**4**) and (**8**) in 84% combined



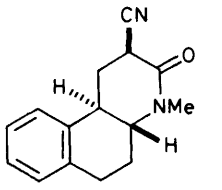
(1) X = N
(2) X = CH



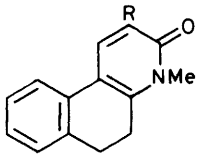
(3) X = N, $R^1 = R^2 = H$
(4) X = CH, $R^1 = R^2 = H$
(5) X = CH, $R^1 = D$, $R^2 = H$
(6) X = CH, $R^1 = H$, $R^2 = D$



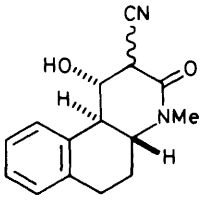
(7) X = N
(8) X = CH



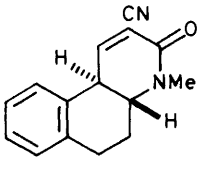
(9)



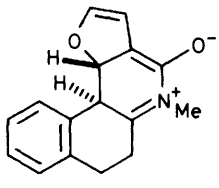
(10) R = CN
(11) R = CH_2CH_2OH



(A)



(B)



(C)

yield, of which the desired *trans*-lactam (**4**) was isolated in 76% yield. The mechanism of the formation of these two lactams (**4**) and (**8**) was deduced as follows.

Irradiation of the enamide (**2**) in the presence of sodium borohydride in benzene–methan[^{2}H]ol (1:1) yielded the photocyclised lactam (**5**) which was found to be deuteriated quantitatively at the 3a-position, while the photocyclised lactam (**6**), which was obtained by irradiation of the enamide (**2**) in the presence of sodium borodeuteride in benzene–methanol (1:1), was found to be quantitatively deuteriated at the 5a-position. Therefore, these results clearly suggest the mechanism[7] of the reductive photocyclisation of these enamides as follows: photochemical electrocyclic ring-closure of a 6π-electron system present in these enamides would bring about the formation of an 11b/11c-*trans* cyclic intermediate (**C**), which would then be subjected to reduction in the presence of a hydride reagent to yield the hydrogenated lactams by concomitant incorporation of a proton from the solvent into the 3a-position and of a hydride or a deuteride ion into the 5a-position.

Table. Solvent effect on the B/C *trans*:*cis* ratio of products of reductive photocyclisation of enamide (**2**)

	C_6H_6–MeOH (10:1)	C_6H_6–MeOH (1:1)	MeCN–MeOH (10:1)
B/C *trans*:*cis*	1:1	9:1	4:1
Combined yield (%)	82	84	72

Synthesis of The Despyrrole Analogues of Lysergic Acid and Isofumigaclavine A.—Though ring opening of the dihydroisoxazole ring of the photocyclised lactam (**3**) was unsuccessful, we succeeded in the smooth ring opening of the dihydrofuran ring of the lactam (**4**) and the successive conversion into despyrrole analogues of lysergic acid, isolysergic acid, and isofumigaclavine A.

First, oxidation of the lactam (**4**) with osmium tetraoxide in the presence of trimethylamine *N*-oxide[8] afforded the homogeneous glycol (**12**) in 46% yield, though the configurations of two hydroxy groups at the 2- and 3-position remained undetermined. Glycol cleavage of (**12**) did not give the desired compound (**D**) but instead gave the aromatised formyl lactam (**14**) as the sole product in 61% yield, probably due to dehydration and dehydrogenation of (**D**).

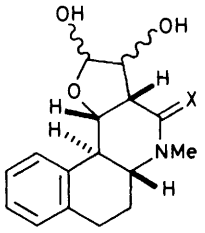
Therefore, the amine, obtained by lithium aluminium hydride reduction on the lactam (**4**), was treated with osmium tetraoxide in the presence of trimethylamine *N*-oxide to yield the desired glycols (**13a** and **b**) in 60% yield from (**4**). The structures of these glycols (**13a** and **b**) were determined from the n.m.r. spectrum of the mixture, and their ratio was 2:1 with the β-glycol (**13a**) the major isomer.

The glycol cleavage was performed on the above mixture with sodium metaperiodate in aqueous methanol followed by work-up with sodium carbonate to furnish complete isomerisation of the formyl group from an unstable α to a stable β-configuration. Owing to the instability of this hydroxy 2β-aldehyde (**15**), its structure was deduced from the following spectral data: $\nu_{max.}$ 1 720 cm^{-1} (CHO); δ_H 9.78 (s, CHO) and 4.16 (t, *J* 10 Hz, 1-H). The hydroxy aldehyde (**15**) was then dissolved in methanol–acetone and treated with chromium trioxide in sulphuric acid at 0 °C for 30 min to give the hydroxy ester (**17**) in 40% yield from the 1,3-glycols (**13a** and **b**).

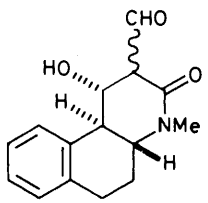
In contrast, glycol cleavage of the glycols (**13a** and **b**) and the ensuing work-up omitting sodium carbonate treatment afforded a mixture of two epimeric hydroxy aldehydes (**15**) and (**16**) in the ratio of *ca.* 1:1, which without further purification was oxidised with chromium trioxide as above to yield a mixture of two epimeric hydroxy esters (**17**) and (**18**), in *ca.* 20% yield each; these were separated.

The structures of these hydroxy esters (**17**) and (**18**) were determined mainly from their n.m.r. spectra which suggested the presence of a β-equatorial ester group at the 2-position from a signal for 1-H at δ_H 4.23 (t, *J* 10 Hz) in (**17**), while the ester group in an α-axial configuration in (**18**) was deduced from a signal for 2-H at δ_H 3.08 (q, *J* 3.5 Hz).

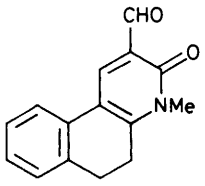
In accordance with the method described by Horii and co-workers,[9a] dehydration of these hydroxy esters (**17**) and (**18**) was achieved by heating with phosphorus trichloride oxide and phosphoric acid in pyridine. This afforded the epimeric unsaturated esters (**21**) and (**22**) in a ratio of 2:1, the β-ester (**21**) being the major isomer. The yields of (**21**) and (**22**) from their respective esters (**17**) and (**18**) were 68—76%. The unsaturated esters (**21**) and (**22**) were separated in pure form by high-performance liquid chromatography (h.p.l.c.).



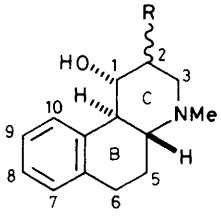
(12) X = O
(13a) X = H_2, β-glycol
(13b) X = H_2, α-glycol



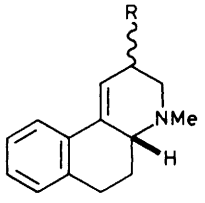
(D)



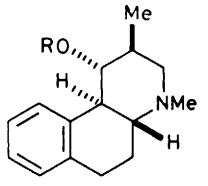
(14)



(15) R = β-CHO
(16) R = α-CHO
(17) R = β-CO_2Me
(18) R = α-CO_2Me
(19) R = β-CH_2OH
(20) R = α-CH_2OH



(21) R = β-CO_2Me
(22) R = α-CO_2Me
(23) R = β-CO_2Et
(24) R = α-CO_2Et
(25) R = β-$CONMe_2$



(26) R = H
(27) R = Ac

The stereochemistries of these were determined from their n.m.r. spectra which exhibited signals for the olefinic proton at δ_H 6.39 (br d, *J* 5 Hz) and 3-H_{eq} at δ_H 3.37 (br d, *J* 12 Hz) in (**22**), while the signals for the olefinic proton at δ_H 6.42 (br s), 3-H_{eq} at δ_H 3.22 (br dd, *J* 11.5 and 6 Hz), and 3-H_{ax} at δ_H 2.56 (t, *J* 11.5 Hz) were observed for (**21**). These n.m.r. data clearly suggested that the unsaturated ester (**22**) has an ester group at the 2-position in a pseudo-axial configuration while (**21**) has a pseudo-equatorial ester at the 2-position.

Further, each of these separated esters (**21**) and (**22**) was found to undergo smooth isomerisation even upon being kept neat or in methanol at room temperature to afford a 2:1 equilibrium mixture. When the n.m.r. spectrum of the reaction mixture was measured immediately after the above equilibrium mixture of (**21**) and (**22**) had been refluxed in methan[^{2}H]ol for 3 h, it was observed that a signal for 2-H at δ_H 3.66 disappeared while the signals for 3-H_{eq} at δ_H 3.22 and for 3-H_{ax} at δ_H 2.56 changed to doublets with *J* 11.5 Hz respectively in (**21**), and similarly a signal for 2-H at δ_H 3.21 disappeared in the n.m.r. spectrum of (**22**), thus suggesting that a hydrogen at the 2-position in both (**21**) and (**22**) was active and exchangeable even in methanol. Ethanolysis of the above mixture of (**21**) and (**22**) afforded an equilibrium mixture of the corresponding ethyl esters (**23**)[9] and (**24**) in the ratio of 5:2 [major isomer (**23**)].

The dimethylamide (**25**) was prepared from the above equilibrium mixture of (**21**) and (**22**) upon hydrolysis with 10% hydrochloric acid followed by amidation using imidazole and triphenyl phosphite in hexamethylphosphoric triamide (HMPT) according to the method reported by Nakahara and co-workers.[10] The amide (**25**) thus obtained was shown to be homogeneous both on by n.m.r. spectroscopy and h.p.l.c. In addition, no deuterium exchange at the 2-position was observed even upon refluxing in deuterium methoxide for 10 h.

The n.m.r. spectrum of the dimethylamide (**25**) showed an olefinic proton signal at δ_H 6.20 as a broad singlet, 3-H_{eq} at δ_H 3.04 (br dd, *J* 11 and 5 Hz), and 3-H_{ax} at δ_H 2.73 (t, *J* 11 Hz), suggesting that the 2-amide group of (**25**) was in a pseudo-equatorial orientation.

In conclusion, it is now believed that the despyrrole analogues (**21**)—(**24**) of methyl and ethyl lysergates exist as equilibrium mixtures in protic solvent as in the case of lysergic acid derivatives,[11] while the dimethylamide (**25**) exists only in one stable form (β).

Wolff–Kishner reduction of the above hydroxy aldehyde (**15**) afforded the 2-methyl derivative (**26**) in 57% yield and its structure was established from its n.m.r. spectrum which showed a signal for 1-H at δ_H 3.58 (t, *J* 10 Hz) and the 2-Me signal at δ_H 1.13 (d, *J* 6 Hz). The alcohol (**26**) was then converted by acetylation into the corresponding acetate (**27**), which is the despyrrole analogue of isofumigaclavine A[12] and showed the following spectral data: $\nu_{max.}$ 1 735 cm^{-1} (Ac); δ_H 5.14 (t, *J* 10 Hz, 1-H) and 0.98 (d, *J* 6 Hz, 2-Me); these closely resembled those of the alkaloid.

Thus, the synthetic route presented above for the synthesis of the despyrrole analogues (**21**)—(**27**) of the corresponding ergot alkaloids offers a potential total synthesis of the parent ergot alkaloids.

In addition to the above synthesis, we investigated sodium borohydride reduction of the key intermediate, the hydroxy 2β-aldehyde (**15**). The product obtained was the homogeneous 1,3-glycol (**19**) in 74% yield. On the other hand, lithium aluminium hydride reduction of the ozonised product obtained from the photocyclised lactam (**4**) by ozonolysis in methanol at −30 °C afforded the epimeric 1,3-glycol (**20**) in 65% yield. The structures of these 1,3-glycols (**19**) and (**20**) were established from their n.m.r. spectra. The configurations of the 2-hydroxymethyl groups were determined as 2β from the signal for 1-H at δ_H 3.95 (t, *J* 10 Hz) for (**19**), and 2α from the 1-H signal at δ_H 4.23 (dd, *J* 10.5 and 6 Hz) for (**20**). In the cleavage of the dihydrofuran ring of (**4**) by ozonolysis, which is known to bring about no isomerisation during the course of oxidation, the selective formation of the *cis*-1,3-glycol (**20**) demonstrated the C/D-*cis*-structure in the photocyclised lactam (**4**).

With the establishment of a selective synthesis of the stereoisomeric 1,3-glycols (**19**) and (**20**), their further conversion into other despyrrole analogues of ergot alkaloids, such as elymoclavine, lysergol, and others, is both possible and currently under investigation.

Experimental

^{1}H N.m.r. spectra were measured with JEOL PMX-60 and Varian XL-200 instruments for solutions in deuteriochloroform unless otherwise stated (tetramethylsilane as internal reference) and i.r. spectra for solutions in chloroform with a Hitachi 215 spectrophotometer. H.p.l.c. was carried out on a Waters Associates instrument with a u.v. detector at 254 nm. M.p.s were

determined with a Kofler-type hot-stage apparatus. Extracts from the reaction mixture were dried over anhydrous sodium sulphate. All the photochemical reactions were carried out by irradiation at 4—10 °C with a high-pressure (300 W) mercury lamp through a Pyrex filter (Eikosha PIH-300).

N-(3,4-*Dihydro*-2-*naphthyl*)-N-*methylisoxazole*-4-*carboxamide* (**1**).—Anhydrous methylamine gas was bubbled into a boiling solution of 2-tetralone (1.2 g) in benzene (100 ml) for 5 h; water was removed as it formed. The mixture was then refluxed further while dry nitrogen was bubbled through to remove the excess of methylamine. To the resulting solution was added *NN*-diethylaniline (1.13 g). Subsequently, a solution of freshly prepared isoxazole-4-carbonyl chloride[5] (1 g) in anhydrous benzene (30 ml) was added dropwise to the stirred, ice-cooled mixture. After being refluxed for 2 h, the solution was cooled and diluted with benzene, washed with water, and dried. The solvent was removed and the residue was recrystallised from ether to afford the *enamide* (**1**) (1.93 g, 93%), m.p. 126—127 °C; $\nu_{max.}$ 1 630 cm^{-1} (NCO); δ 8.63 and 8.40 (each 1 H, s, together 3- and 5-H), 6.33 (1 H, br s, HC=C–N), and 3.23 (3 H, s, NMe) (Found: M^+, 254.104. $C_{15}H_{14}N_2O_2$ requires *M*, 254.105).

Reductive Photocyclisation of the Enamide (**1**).—(a) *In benzene–methanol* (10:1). A solution of the enamide (**1**) (400 mg) and sodium borohydride (400 mg) in benzene–methanol (10:1) (440 ml) was irradiated for 1.5 h. The reaction solution was washed with water, dried, and evaporated to give a solid, which was chromatographed on silica gel. Elution with benzene gave (3aβ,5aβ,11bα,11cβ)-3a,5a,6,7,11b,11c-*hexahydro*-5-*methylbenz*[f]*isoxazolo*[4,5-c]*quinolin*-4(5H)-*one* (**3**) (130 mg, 32%), m.p. 136—138 °C (from methanol–ether); $\nu_{max.}$ 1 650 cm^{-1} (NCO); δ 7.85 (1 H, m, 11-H), 7.50 (1 H, m, 3-H), 4.87 (1 H, dd, *J* 12 and 10 Hz, 11c-H), 4.24 (1 H, br d, *J* 12 Hz, 3a-H), 3.48 (1 H, td, *J* 10 and 3 Hz, 5a-H), 3.10 (3 H, s, NMe), 2.55 (1 H, m, 6-H_{eq}), and 1.80 (1 H, m, 6-H_{ax}) (Found: C, 70.2; H, 6.3; N, 10.85. $C_{15}H_{16}N_2O_2$ requires C, 70.3; H, 6.3; N, 10.95%). Further elution by benzene gave (3aβ,5aα,11bα,11cβ)-3a,5a,6,7,11b,11c-*hexahydro*-5-*methylbenz*[f]*isoxazolo*[4,5-c]*quinolin*-4(5H)-*one* (**7**) (123 mg, 31%), m.p. 206—208 °C (from methanol); $\nu_{max.}$ 1 650 cm^{-1} (NCO); δ 7.45 (1 H, d, *J* 2 Hz, 3-H), 4.80 (1 H, dd, *J* 11 and 10 Hz, 11c-H), 4.18 (1 H, dd, *J* 11 and 2 Hz, 3a-H), 3.54 (1 H, ddd, *J* 13, 5.5, and 3.5 Hz, 5a-H), 3.10 (3 H, s, NMe), 2.22 (1 H, m, 6-H_{eq}), and 1.76 (1 H, ddd, *J* 13, 12, and 6 Hz, 6-H_{ax}) (Found: C, 70.05; H, 6.25; N, 10.75%).

(b) *In acetonitrile–methanol* (10:1). Similarly, irradiation of the enamide (**1**) (180 mg) in the presence of sodium borohydride (180 mg) in acetonitrile–methanol (10:1) (198 ml), followed by evaporation of the solvent, left a residue which was dissolved in benzene and the solution was washed with water. The benzene layer was dried and evaporated to give a residue which was purified by chromatography on silica gel to afford (2β,4aβ,10bα)-1,2,3,4,4a,5,6,10b-*octahydro*-4-*methyl*-3-*oxobenzo*[f]*quinoline*-2-*carbonitrile* (**9**) (80 mg, 47%), m.p. 145—147 °C (from ethyl acetate); $\nu_{max.}$ 2 200 (CN) and 1 640 cm^{-1} (NCO); δ 3.78 (1 H, dd, *J* 11.5 and 5 Hz, 2-H), 3.32 (1 H, td, *J* 11.5 and 3 Hz, 4a-H), 3.07 (3 H, s, NMe), and 2.10 (1 H, q, *J* 11.5 Hz, 1-H_{ax}) (Found: M^+, 240.128. $C_{15}H_{16}N_2O$ requires *M*, 240.126).

Alternatively, the lactam (**9**) was prepared from the lactam (**3**) by irradiation in acetonitrile–methanol (10:1), in the presence of sodium borohydride, in good yield, or simply by treatment with sodium borohydride in refluxing methanol in low yield.

3,4,5,6-*Tetrahydro*-4-*methyl*-3-*oxobenzo*[f]*quinoline*-2-*carbonitrile* (**10**).—A solution of the *trans*-lactam (**3**) (70 mg) and triethylamine (0.1 ml) in benzene (10 ml) was refluxed for 3 h and then evaporated. The resulting residual solid was recrystallised from methanol to give the *lactam* (**10**) (30 mg, 47%) as yellow crystals, m.p. 220—221 °C; $\nu_{max.}$ 2 240 (CN) and 1 650 cm^{-1} (NCO); δ 8.24 (1 H, s, 1-H), 3.70 (3 H, s, NMe), and 3.01 (4 H, s, 5- and 6-H_2) (Found: M^+, 236.097. $C_{15}H_{12}N_2O$ requires *M*, 236.095).

Alternatively, the lactam (**10**) was prepared from the lactam (**3**) in 45% yield by treatment with sodium methoxide.

N-(3,4-*Dihydro*-2-*naphthyl*)-N-*methylfuran*-3-*carboxamide* (**2**).—According to the procedure given for the preparation of (**1**), acylation of the imine prepared from 2-tetralone and methylamine with furan-3-carbonyl chloride in the presence of triethylamine afforded the *enamide* (**2**) (71%) as crystals, m.p. 79.5—80.5 °C (from ether); $\nu_{max.}$ 1 630 cm^{-1} (NCO); δ 6.33 (1 H, br s, HC=C–N) and 3.27 (3 H, s, NMe) (Found: C, 76.0; H, 5.9; N, 5.65. $C_{16}H_{15}NO_2$ requires C, 75.85; H, 5.95; N, 5.55%).

Reductive Photocyclisation of the Enamide (**2**).—Solutions of the enamide (**2**) (600 mg) and sodium borohydride (600 mg) in benzene–methanol (10:1) (600 ml), benzene–methanol (1:1) (600 ml), or acetonitrile–methanol (10:1) (600 ml) was irradiated for 1—2 h. Work-up afforded a solid which was a mixture of the B/C-*trans*-lactam (**4**) and *cis*-lactam (**8**), and their ratios and yields are shown in the Table.

The stereoisomers were separated by chromatography on silica gel. (3aβ,5aβ,11bα,11cβ)-3a,5a,6,7,11b,11c-*Hexahydro*-5-*methylbenzo*[f]*furo*[3,2-c]*quinolin*-4(5H)-*one* (**4**), m.p. 121—123 °C (from methanol–ether); $\nu_{max.}$ 1 650 cm^{-1} (NCO); δ 7.83 (1 H, m, 11-H), 6.46 (1 H, t, *J* 2.5 Hz, 2-H), 5.38 (1 H, t, *J* 2.5 Hz, 3-H), 4.85 (1 H, dd, *J* 11 and 10 Hz, 11c-H), 3.76 (1 H, br d, *J* 11 Hz, 3a-H), 3.48 (1 H, ddd, *J* 12, 11, and 3 Hz, 5a-H), 3.08 (3 H, s, NMe), 2.51 (1 H, m, 6-H_{eq}), and 1.85 (1 H, m, 6-H_{ax}) (Found: C, 75.1; H, 6.8; N, 5.5. $C_{16}H_{17}NO_2$ requires C, 75.25; H, 6.7; N, 5.5%). (3aβ,5aα,11bα,11cβ)-3a,5a,6,7,11b,11c-*Hexahydro*-5-*methylbenzo*[f]*furo*[3,2-c]*quinolin*-4(5H)-*one* (**8**), viscous oil (unstable); $\nu_{max.}$ 1 650 cm^{-1} (NCO); δ 6.42 (1 H, t, *J* 2.5 Hz, 2-H), 5.33 (1 H, t, *J* 2.5 Hz, 3-H), 4.77 (1 H, dd, *J* 11 and 10 Hz, 11c-H), 3.87 (1 H, dt, *J* 10 and 2.5 Hz, 3a-H), 3.51 (1 H, ddd, *J* 13, 6, and 4 Hz, 5a-H), 3.08 (3 H, s, NMe), 2.23 (1 H, m, 6-H_{eq}), and 1.78 (1 H, m, 6-H_{ax}) (Found: M^+, 255.126. $C_{16}H_{17}NO_2$ requires *M*, 255.126).

In the case of reductive photocyclisation of the enamide (**2**) in acetonitrile–methanol (10:1), 5,6-*dihydro*-2-(2-*hydroxyethyl*)-4-*methylbenzo*[f]*quinolin*-3(4H)-*one* (**11**) was obtained as a by-product in 10% yield, m.p. 139—140 °C (from chloroform–ether); $\nu_{max.}$ 3 350 (OH) and 1 635 cm^{-1} (NCO); δ 7.58 (1 H, s, 1-H), 3.65 (2 H, t, *J* 6 Hz, CH_2CH_2OH), 3.53 (3 H, s, NMe), 2.83 (2 H, m, CH_2CH_2OH), and 2.81 (4 H, s, 5- and 6-H_2) (Found: C, 75.35; H, 6.65; N, 5.5. $C_{16}H_{17}NO_2$ requires C, 75.25; H, 6.7; N, 5.5%).

Reductive Photocyclisation of the Enamide (**2**) *in Methan*-[^{2}H]*ol*.—Irradiation of the enamide (**2**) (30 mg) in benzene–CH_3OD (1:1) (60 ml) in the presence of sodium borohydride (30 mg) afforded the trans-*lactam* (**5**) (15 mg, 50%). The n.m.r. spectrum of the *trans*-lactam (**5**) showed no 3a-H signal; δ 7.83 (1 H, m, 11-H), 6.46 (1 H, d, *J* 2.5 Hz, 2-H), 5.38 (1 H, d, *J* 2.5 Hz, 3-H), 4.85 (1 H, d, *J* 10 Hz, 11c-H) 3.48 (1 H, ddd, *J* 12, 11, and 3 Hz, 5a-H), 3.08 (3 H, s, NMe), 2.51 (1 H, m, 6-H_{eq}), and 1.85 (1 H, m, 6-H_{ax}) (Found: M^+, 256.132. $C_{16}H_{16}DNO_2$ requires *M*, 256.132).

Reductive Photocyclisation of the Enamide (**2**) *in the Presence of Sodium Borodeuteride*.—Irradiation of the enamide (**2**) (30 mg) in benzene–methanol (1:1) (60 ml) in the presence of sodium borodeuteride (30 mg) afforded the trans-*lactam* (**6**) (15 mg, 50%). The n.m.r. spectrum of this *trans*-lactam (**6**) showed no 5a-H signal; δ 7.83 (1 H, m, 11-H), 6.46 (1 H, t, *J* 2.5 Hz, 2-H),

5.38 (1 H, t, *J* 2.5 Hz, 3-H), 4.85 (1 H, dd, *J* 11 and 10 Hz, 11c-H), 3.76 (1 H, br d, *J* 11 Hz, 3a-H), 3.08 (3 H, s, NMe), 2.51 (1 H, ddd, *J* 12, 5, and 3 Hz, 6-H_{eq}), and 1.85 (1 H, m, 6-H_{ax}) (Found: M^+, 256.134).

Hydroxylation of the Lactam (**4**).—A solution of osmium tetraoxide (0.4 mg) in t-butyl alcohol (0.02 ml) was added to a mixture of the lactam (**4**) (174 mg), trimethylamine *N*-oxide dihydrate (75 mg), pyridine (0.04 ml), water (0.3 ml), and t-butyl alcohol (1 ml). The resulting solution was refluxed under a stream of nitrogen for 5 h, cooled to room temperature, and treated with 20% aqueous sodium hydrogen sulphite (20 ml). The mixture was concentrated under reduced pressure to remove t-butyl alcohol, then was saturated with sodium chloride, and extracted repeatedly with methylene dichloride. The combined extracts were dried and evaporated to give a solid which was recrystallised from chloroform to give (3aβ,5aβ,11bα,11cβ)-2,3,3a,5a,6,7,11b,11c-*octahydro*-2,3-*dihydroxy*-5-*methylbenzo*-[f]*furo*[3,2-c]*quinolin*-4(5H)-*one* (**12**) (90 mg, 46%), m.p. 201—203 °C; $\nu_{max.}$(Nujol) 3 400 (OH) and 1 610 cm^{-1} (NCO); δ ($CDCl_3$–CD_3OD) 7.92 (1 H, m, 11-H), 5.33 (1 H, s 2-H), 4.79 (1 H, s, 3-H), 4.66 (1 H, t, *J* 9 Hz, 11c-H), 3.48 (1 H, td, *J* 11 and 3 Hz, 5a-H), 3.10 (3 H, s, NMe), 2.51 (1 H, m, 6-H_{eq}), and 1.85 (1 H, qd, *J* 11 and 6 Hz, 6-H_{ax}) (Found: M^+, 289.131. $C_{16}H_{19}NO_4$ requires *M*, 289.131).

3,4,5,6-*Tetrahydro*-4-*methyl*-3-*oxobenzo*[f]*quinoline*-2-*carbaldehyde* (**14**).—An ice-cooled solution of the 1,2-glycol (**12**) (40 mg) and sodium metaperiodate (40 mg) in methanol–water (1:1) (20 ml) was stirred for 1 h, diluted with methylene dichloride, and washed with water. The organic layer was dried and evaporated to give a solid which was recrystallised from methanol to afford the *aldehyde* (**14**) (20 mg, 61%) as yellow crystals, m.p. 280—283 °C (decomp.); $\nu_{max.}$ 1 680 (CHO) and 1 655 cm^{-1} (NCO); δ 10.27 (1 H, s, CHO), 3.63 (3 H, s, NMe), and 2.97 (4 H, s, 5- and 6-H_2) (Found: M^+, 239.092. $C_{15}H_{13}NO_2$ requires *M*, 239.094).

Conversion of the Lactam (**4**) *into the* 1,2-*Glycols* (**13a** *and* **b**).—To an ice-cooled solution of the lactam (**4**) (500 mg) in anhydrous ether–tetrahydrofuran (THF) (1:1) (100 ml) was added lithium aluminium hydride (500 mg) in small portions. The mixture was refluxed for 1 h. Work-up afforded the corresponding amine which was, without further purification, hydroxylated with osmium tetraoxide (1.5 mg) and trimethylamine *N*-oxide dihydrate (283 mg) in t-butyl alcohol, pyridine, and water according to the procedure given for compound (**12**). The product was recrystallised from methylene dichloride to give a mixture of (2β,3β,3aβ,5aβ,11bα,11cβ)-2,3,3a,4,5,5a,6,7,11b,11c-decahydro-2,3-dihydroxy-5-methylbenzo[*f*]furo-[3,2-*c*]quinoline (**13a**) and (2α,3α,3aβ,5aβ,11bα,11cβ)-2,3,3a,4,5,5a,6,7,11b,11c-decahydro-2,3-dihydroxy-5-methylbenzo[*f*]furo[3,2-*c*]quinoline (**13b**) in the ratio of 2:1 [major isomer (**13a**)] (323 mg, 60%); $\nu_{max.}$(Nujol) 3 250 cm^{-1} (OH); δ 8.03 ($\frac{1}{3}$ H, m, 11-H), 7.96 ($\frac{2}{3}$ H, m, 11-H), 5.38 ($\frac{2}{3}$ H, d, *J* 4.5 Hz, 2-H), 5.28 ($\frac{1}{3}$ H, d, *J* 4.5 Hz, 2-H), 3.01 ($\frac{1}{3}$ H, t, *J* 11 Hz, 11b-H), 2.66 ($\frac{2}{3}$ H, t, *J* 11 Hz, 11b-H), and 2.40 (3 H, s, NMe); *m/z* 275 (M^+). This mixture was used in the next step without further purification.

Methyl (1α,2β,4aβ,10bα)-1,2,3,4,4a,5,6,10b-*Octahydro*-1-*hydroxy*-4-*methylbenzo*[f]*quinoline*-2-*carboxylate* (**17**).—An ice-cooled mixture of the glycols (**13a** and **b**) (200 mg) and sodium metaperiodate (200 mg) in methanol–water (1:1) (100 ml) was stirred for 1 h, and then sodium carbonate (200 mg) was added to the reaction mixture and the mixture was stirred for another 1 h. The reaction mixture was then diluted with methylene dichloride and washed with water. The organic layer was dried and evaporated to give the 2β-aldehyde (**15**) [$\nu_{max.}$ 1 720 cm^{-1} (CHO); δ 9.78 (1 H, s, CHO) and 4.16 (1 H, t, *J* 10 Hz, 1-H)] which was, without further purification, dissolved in methanol–pure acetone (10:1) (33 ml) and to the resulting stirred, ice-cooled solution was added 4.0M chromium trioxide in sulphuric acid–water (0.3 ml) dropwise. The mixture was stirred at 0 °C for 30 min. The precipitate thus formed was filtered off and washed with methylene dichloride. The filtrate was washed successively with aqueous sodium carbonate and water. Upon removal of the solvents, the solid obtained was recrystallised from methanol–ether to give the *ester* (**17**) (80 mg, 40%), m.p. 170—172 °C; $\nu_{max.}$ 3 550 (OH) and 1 710 cm^{-1} (CO_2Me); δ 7.87 (1 H, m, 10-H), 4.23 (1 H, t, *J* 10 Hz, 1-H), 3.80 (3 H, s, OMe), 3.19 (1 H, dd, *J* 12 and 4 Hz, 3-H_{eq}), 2.96 (1 H, m, 2-H), 2.68 (1 H, t, *J* 10 Hz, 10b-H), 2.32 (3 H, s, NMe), and 2.26 (1 H, t, *J* 12 Hz, 3-H_{ax}) (Found: C, 69.5; H, 7.6; N, 5.1. $C_{16}H_{21}NO_3$ requires C, 69.8; H, 7.7; N, 5.1%).

Oxidation of an Epimeric Mixture of the Hydroxy Aldehydes (**15**) *and* (**16**).—A mixture of the hydroxy aldehydes (**15**) and (**16**), which was prepared from the 1,2-glycols (**13a** and **b**) (200 mg) by metaperiodate oxidation as above without treatment with sodium carbonate, was oxidised in a similar way with chromium trioxide as above to give a residue. Purification of the crude product by p.l.c. on silica gel [chloroform–methanol (19:1) as eluant] afforded *methyl* (1α,2α,4aβ,10bα)1,2,3,4,4a,5,-6,10b-*octahydro*-1-*hydroxy*-4-*methylbenzo*[f]*quinoline*-2-*carboxylate* (**18**) (20 mg, 20%), m.p. 161—162 °C (from methanol–ether); $\nu_{max.}$ 3 500 (OH) and 1 720 cm^{-1} (CO_2Me); δ 7.91 (1 H, m, 10-H), 4.03 (1 H, m, 1-H), 3.81 (3 H, s, OMe), 3.34 (1 H, dd, *J* 12 and 3.5 Hz, 3-H_{eq}), 3.08 (1 H, q, *J* 3.5 Hz, 2-H), 3.02 (1 H, br t, *J* 10 Hz, 10b-H), 2.28 (1 H, dd, *J* 12 and 3.5 Hz, 3-H_{ax}), and 2.22 (3 H, s, NMe) (Found: C, 68.95; H, 7.65; N, 5.1. $C_{16}H_{21}NO_3 \cdot \frac{1}{5}MeOH$ requires C, 69.05; H, 7.8; N, 4.95%), and the hydroxy ester (**17**) (20 mg, 20%).

Dehydration of the Hydroxy Ester (**17**).—A solution of the hydroxy ester (**17**) (110 mg) in anhydrous pyridine (2 ml), 85% phosphoric acid (0.02 ml), and phosphorus trichloride oxide (0.3 ml) was warmed at 80 °C under a stream of nitrogen for 2 h. The reaction mixture was poured into ice–water, acidified with 10% hydrochloric acid, and washed with ether. The aqueous layer was made alkaline with sodium carbonate and extracted with ether. The ethereal extract was washed with water, dried, and evaporated to give a residue. Purification of the crude product by p.l.c. on silica gel [chloroform–methanol (97:3) as eluant] afforded a mixture of methyl (2β,4aβ)-2,3,4,4a,5,6-hexahydro-4-methylbenzo[*f*]quinoline-2-carboxylate (methyl despyrrololysergate (**21**) and methyl (2α,4aβ)-2,3,4,4a,5,6-hexahydro-4-methylbenzo[*f*]quinoline-2-carboxylate (methyl despyrroloisolysergate) (**22**) (78 mg, 76%) in the ratio of 2:1 as an oil; $\nu_{max.}$ 1 735 cm^{-1} (CO_2Me) (Found: M^+, 257.139. $C_{16}H_{19}NO_2$ requires *M*, 257.141). This mixture was separated by h.p.l.c. [μ-Porasil; 30 cm × 7.8 mm i.d.; 800 p.s.i.; 3% MeOH–$CHCl_3$ (0.8 ml min^{-1})] to give the 2α-ester (**22**), R_t 16.5 min; δ 7.59 (1 H, m, 10-H), 6.39 (1 H, br d, *J* 5 Hz, 1-H), 3.74 (3 H, s, OMe), 3.37 (1 H, br d, *J* 12 Hz, 3-H_{eq}), 3.21 (1 H, $w_{\frac{1}{2}}$ 13 Hz, 2-H), 2.77 (1 H, br d, *J* 13 Hz, 4a-H), and 2.50 (3 H, s, NMe), and the 2β-ester (**21**), R_t 18 min: δ 7.64 (1 H, m, 10-H), 6.42 (1 H, br s, 1-H), 3.78 (3 H, s, OMe), 3.66 (1 H, m, 2-H), 3.22 (1 H, br dd, *J* 11.5 and 6 Hz, 3-H_{eq}), 2.80 (1 H, dq, *J* 12 and 3 Hz, 4a-H), 2.56 (1 H, t, *J* 11.5 Hz, 3-H_{ax}), and 2.53 (3 H, s, NMe). The purified 2α-ester (**22**) was partly converted into the 2β-ester on being kept in methanol at room temperature and this mixture reached an equilibrium after 2 days, the equilibrium ratio (**21**):(**22**) being 2:1. In addition, the purified 2β-ester (**21**) gave a mixture of the two epimeric esters (**21**) and (**22**) with an identical ratio (2:1) on being kept in methanol at room temperature for 2 days.

A solution of a 2:1 mixture of (**21**) and (**22**) (10 mg) in

CH_3OD (2 ml) was refluxed for 3 h. The n.m.r. spectrum, measured immediately after evaporation of the solvent, showed the disappearance of the 2-H signal of the ester (**21**), the broad double-doublet signals at δ 3.22 due to 3-H_{eq}, and the triplet signal at δ 2.56 due to 3-H_{ax} of the ester (**21**) changed to a simple doublet (*J* 11.5 Hz) respectively. Similarly, the 2-H signal of the ester (**22**) disappeared.

Dehydration of the Hydroxy Ester (**18**).—A solution of the hydroxy ester (**18**) (25 mg), anhydrous pyridine (1 ml), 85% phosphoric acid (0.01 ml), and phosphorus trichloride oxide (0.15 ml) was worked up in the same manner as given for the preparation of (**17**) to give a mixture of (**21**) and (**22**) (16 mg, 68%) in the ratio of 2:1 [major isomer (**21**)].

Ethanolysis of a Mixture of the Methyl Esters (**21**) *and* (**22**).—A solution of a 2:1 mixture of (**21**) and (**22**) (20 mg) in 10% hydrochloric acid was warmed to 90 °C and stirred for 2 h. The solvent was removed and the residue was dissolved in anhydrous ethanol (5 ml). To the resulting solution was added a 2M solution of hydrochloric acid and ethanol (1 ml). After being stirred at room temperature under a stream of nitrogen for 24 h, the solvent was removed and the residue was dissolved in saturated aqueous sodium carbonate and extracted with benzene. The extract was washed with water, dried, and evaporated to give an oil which was purified by p.l.c. [chloroform–methanol (97:3) as eluant] to afford a mixture of the 2β-ethyl ester (**23**) and 2α-ethyl ester (**24**) (10 mg, 50%) as an oil in the ratio of 5:2 [(**23**):(**24**)]. The oxalate, which was prepared from the above mixture of two esters (**23**) and (**24**), was recrystallised from ethanol, m.p. 162—164 °C (decomp.) (lit.,[9a] 161—162 °C).

(2β,4aβ)-2,3,4,4a,5,6-*Hexahydro*-4,N,N-*trimethylbenzo*[f]-*quinoline*-2-*carboxamide* (**25**).—A 2:1 mixture of (**21**) and (**22**) (25 mg) was hydrolysed as above. The solvent was evaporated and the residue was dissolved in HMPT (1 ml). To this solution was added a mixture of imidazole (14 mg), triphenyl phosphite (62 mg), and absolute acetonitrile (0.4 ml) which was freshly prepared before use, and the mixture was left at room temperature for 1 h. To this mixture was added absolute acetonitrile (1 ml) containing excess of dimethylamine and the resulting solution was kept at room temperature for 4 h. The mixture was diluted with benzene and extracted with 1% tartaric acid; the aqueous extract was washed with benzene, and then was saturated with sodium carbonate and again extracted with benzene. The benzene extract was dried and evaporated to give an oil, which was purified by p.l.c. [chloroform–methanol (9:1) as eluant] to afford the *amide* (**25**) (15 mg, 57%) as an oil, $\nu_{max.}$ 1 630 cm^{-1} (NCO); δ 7.62 (1 H, m, 10-H), 6.20 (1 H, br s, 1-H), 3.94 (1 H, m, 2-H), 3.18 and 3.02 (each 3 H, s, together $CONMe_2$), 3.04 (1 H, br dd, *J* 11 and 5 Hz, 3-H_{eq}), 2.73 (1 H, t, *J* 11 Hz, 3-H_{ax}), and 2.54 (3 H, s, NMe) (Found: M^+, 270.174. $C_{17}H_{22}N_2O$ requires *M*, 270.173).

(1α,2β,4aβ,10bα)-1,2,3,4,4a,5,6,10b-*Octahydro*-1-*hydroxy*-2,4-*dimethylbenzo*[f]*quinoline* (*Despyrroloisofumigaclavine B*) (**26**).—A solution of the 2β-aldehyde (**15**), which was prepared by epimerisation with sodium carbonate after glycol cleavage of the 1,2-glycols (**13a** and **b**) (150 mg), sodium hydroxide (80 mg), and hydrazine hydrate (1 ml) in ethylene glycol (10 ml) was refluxed for 3 h under a stream of nitrogen. To the resulting solution was added water and the mixture was extracted repeatedly with benzene. The combined extracts were dried and evaporated to give a solid which was recrystallised from ethyl acetate to afford the *alcohol* (**26**) (67 mg, 57%), m.p. 162—163 °C; $\nu_{max.}$ 3 620 cm^{-1} (OH); δ 7.76 (1 H, m, 10-H), 3.58 (1 H, t, *J* 10 Hz, 1-H), 2.68 (1 H, t, *J* 10 Hz, 10b-H), 2.34 (3 H, s, NMe), and 1.13 (3 H, d, *J* 6 Hz, CMe) (Found: C, 77.75; H, 9.25; N, 6.1. $C_{15}H_{21}NO$ requires C, 77.9; H, 9.15; N, 6.05%).

(1α,2β,4aβ,10bα)-1-*Acetoxy*-1,2,3,4,4a,5,6,10b-*octahydro*-2,4-*dimethylbenzo*[f]*quinoline* (*Despyrroisofumigaclavine A*) (**27**).—A solution of the alcohol (**26**) (50 mg) and acetic anhydride (0.2 ml) in pyridine (0.5 ml) was kept at room temperature overnight. Methylene dichloride was then added and the solution was washed with water, dried, and evaporated to give a solid which was recrystallised from light petroleum (b.p. 30—60 °C) to afford the *acetate* (**27**) (50 mg, 83%), m.p. 92—93 °C; $\nu_{max.}$ 1 735 cm^{-1} (Ac); δ 5.14 (1 H, t, *J* 10 Hz, 1-H), 2.91 (1 H, t, *J* 10 Hz, 10b-H), 2.34 (3 H, s, NMe), 2.12 (3 H, s, Ac), and 0.98 (3 H, d, *J* 6 Hz, CMe) (Found: M^+, 273.174. $C_{17}H_{23}NO_2$ requires *M*, 273.173).

(1α,2β,4aβ,10bα)-1,2,3,4,4a,5,6,10b-*Octahydro*-1-*hydroxy*-2-*hydroxymethyl*-4-*methylbenzo*[f]*quinoline* (**19**).—The 2β-aldehyde (**15**), which was prepared from the 1,2-glycols (**13a** and **b**) (200 mg) upon metaperiodate oxidation followed by treatment with sodium carbonate, was reduced with sodium borohydride (200 mg) in methanol (10 ml). Work-up in the usual way gave a solid which was recrystallised from methanol–ether to give the 1,3-glycol (**19**) (133 mg, 74%), m.p. 169—170 °C; $\nu_{max.}$ (Nujol) 3 430 and 3 200—3 100 cm^{-1} (OH); δ 7.81 (1 H, m, 10-H), 3.95 (1 H, t, *J* 10 Hz, 1-H), 3.81 (2 H, br d, *J* 6 Hz, CH_2OH), 2.66 (1 H, t, *J* 10 Hz, 10b-H), and 2.28 (3 H, s, NMe) (Found: C, 72.5; H, 8.55; N, 5.65. $C_{15}H_{21}NO_2$ requires C, 72.85; H, 8.6; N, 5.65%).

(1α,2α,4aβ,10bα)-1,2,3,4,4a,5,6,10b-*Octahydro*-1-*hydroxy*-2-*hydroxymethyl*-4-*methylbenzo*[f]*quinoline* (**20**).—Into a solution of the lactam (**4**) (600 mg) in anhydrous methanol (40 ml) was slowly bubbled ozone gas at −30 °C for 30 min. Removal of the solvent at room temperature under reduced pressure left a crystalline solid, which was dissolved in anhydrous ether–THF (1:1) (200 ml), and lithium aluminium hydride (1.4 g) was added in small portions to the cooled solution. The mixture was refluxed for 5 h, and treatment in the usual way gave a solid residue which was recrystallised from methanol–ether to afford the 1,3-glycol (**20**) (375 mg, 65%), m.p. 175—177 °C; $\nu_{max.}$ (Nujol) 3 350 cm^{-1} (OH); δ 7.74 (1 H, d, *J* 8 Hz, 10-H), 4.23 (1 H, dd, *J* 10.5 and 6 Hz, 1-H), 4.10 (2 H, m, CH_2OH), 3.05 (1 H, dd, *J* 12 and 3 Hz, 3-H_{eq}), 3.02 (1 H, t, *J* 10.5 Hz, 10b-H), 2.47 (1 H, br d, *J* 12 Hz, 3-H_{ax}), and 2.21 (3 H, s, NMe) (Found: C, 72.95; H, 8.75; N, 5.65%).

Alternatively, the 1,3-glycol (**20**) was prepared from a mixture of the 2β- and 2α-aldehyde (**15**) and (**16**) by sodium borohydride reduction. The products were a mixture of two glycols (**19**) and (**20**), which were separated by p.l.c. to give (**19**) in 40% and (**20**) in 44% yield respectively.

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