Intramolecular Functionalization of *N*-Cyanamide Radicals: Synthesis of 1,4- and 1,5-*N*-Cyanoepimino Compounds

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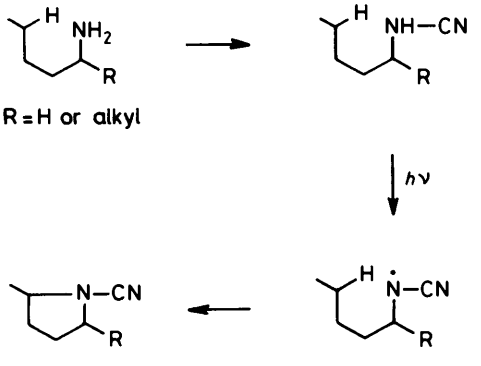
Photolysis of 3β-methoxymethoxy-5α-cholestan-6β-ylcyanamide (**6**), 29-methoxyfriedelan-3β-ylcyanamide (**15**), (22*R*,25*R*)-5α-furostan-26-ylcyanamide (**23**), 8α,12-(12*R*/12*S*)-epoxylabdan-15-ylcyanamides, (**32**) and (**33**), in the presence of iodine and lead tetra-acetate leads to neutral cyanimyl radicals which undergo intramolecular hydrogen abstraction to produce *N*-cyanoepimino compounds. Better results are obtained with the system iodine and diacetoxyiodobenzene. The starting cyanamides have been prepared by reduction of the oximes (**3**) and (**13**) and of the amides (**20**), (**28**), and (**29**), respectively, with lithium aluminium hydride followed by cyanation with cyanogen bromide or with sodium cyanate and subsequent dehydration of the urea derivative with methanesulphonyl chloride.

Intramolecular hydrogen abstraction from hetero radicals leading to remote functionalization of non-activated carbon centres can be achieved by generating reactive free-radical species in close proximity to the centre to be attacked. Although the reactions initiated by alkoxy radicals have been the subject of numerous studies,[1,2] comparatively little attention has been devoted to those associated with nitrogen radicals.[3] The sole reaction of this type which has proved of significant value for the preparation of cyclic amines is the thermal or photochemical fragmentation of *N*-haloamines (Hofmann-Loeffler-Freytag reaction). However, limited use of this reaction has been made in sensitive or complex molecules owing to the highly acid conditions required.[4]

Recently we have reported the functionalization of non-activated carbon atoms initiated by neutral aminyl radicals, intermediates which were produced by photolysis of the corresponding *N*-iodonitroamines,[5a,b] *N*-iodophosphoroamidates,[6] and one *N*-iodocyanamide.[5b]

Continuing our investigation in this field we described the synthesis of several steroidal and terpenic *N*-cyanoepimino compounds from the corresponding cyanamides. As occurs with the alkoxy radical, the mechanism for the hydrogen abstraction involves formation of a neutral radical which is obtained by photolysis of the corresponding *N*-iodo derivative generated *in situ* by reaction of the cyanamide with iodine and lead tetra-acetate (LTA) or diacetoxyiodobenzene (DIB) as oxidative agents (see Scheme 1).



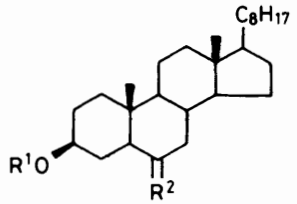
Scheme 1.

The cyanamide group is a convenient function for stabilizing the nitrogen radical intermediate required for the hydrogen abstraction and, furthermore, can be transformed into other functional groups such as isoureas,[7] ureas,[8] thioureas,[9] amines,[10] *etc.*

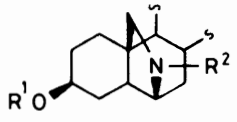
Preparation of the Substrates.—3β-Methoxymethoxy-5α-cholestan-6β-ylcyanamide (**6**) was prepared from 3β-hydroxy-5α-cholestan-6-one (**1**) whose hydroxy group was first protected as its methoxymethoxy derivative with dimethoxymethane and phosphorus pentaoxide[11] to give the ketone (**2**) (92%) which was then transformed into the oxime (**3**) (83%). Reduction of the oxime (**3**) with lithium aluminium hydride gave the unstable amine (**4**) which was treated with cyanogen bromide[12] or with sodium cyanate and subsequent dehydration of the resulting urea (**5**) with methanesulphonyl chloride[8] [34% and 37% respectively from the carbonyl compound (**2**)]. The identity of the cyanamide (**6**) was consistent with spectral data. The i.r. spectrum shows absorptions characteristic of the cyanamide group at 3 390 (NH) and 2 200 cm^{-1} (CN), and in the ^{13}C n.m.r. the C-6 signal appears at δ 57.53 and that for the cyano group at δ 115.77. Furthermore, the high-resolution mass spectrum confirms the presence of a cyanamide function, showing signals corresponding to M^+ at *m/z* 472.3958 ($C_{30}H_{52}N_2O_2$) and $M^+ - MeOCH_2OH - H_2NCN$ at *m/z* 368.3447 ($C_{27}H_{44}$).

29-Methoxyfriedelan-3-one (**12**) was obtained from the alcohol (**11**)[13] (95%) by treatment with diazomethane in the presence of fluoroboric acid.[14] 29-Methoxyfriedelan-3β-ylcyanamide (**15**) was prepared from the ketone (**12**) as indicated previously for (**6**), *via* the oxime (**13**) and subsequent reduction and treatment of the resulting amine (**14**) with BrCN [25% from the ketone (**12**)]. The spectroscopic data are in agreement with the structure proposed for this substance. Its mass spectrum showing the fragmentation pattern typical of the friedelane skeleton[15] [M^+ at *m/z* 482.4558 ($C_{32}H_{50}N_2O$)].

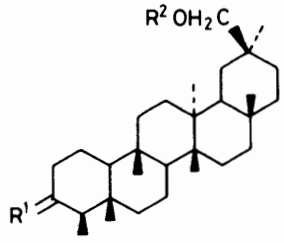
(22*R*,25*R*)-5α-Furostan-26-ylcyanamide (**23**) was conveniently prepared from the (25*R*)-5α-spirostan (**24**) by $LiAlH_4$–$AlCl_3$ reduction[16] to give (25*R*)-5α-furostan-26-ol (**18**); this was then oxidized with Jones' reagent and the resulting acid (**19**) transformed into the amide (**20**). Reduction of the amide (**20**) gave the amine (**21**) (*m/z* 471, M^+) which was treated with sodium cyanate to give the urea derivative (**22**) that shows the characteristic i.r. absorptions. Dehydration of the urea (**22**) was



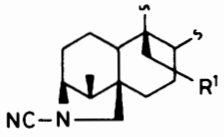
(1) R^1 = H, R^2 = O
(2) R^1 = MOM, R^2 = O
(3) R^1 = MOM, R^2 = N–OH
(4) R^1 = MOM, R^2 = α-H, β-NH_2
(5) R^1 = MOM, R^2 = α-H, β-$NHCONH_2$
(6) R^1 = MOM, R^2 = α-H, β-NHCN



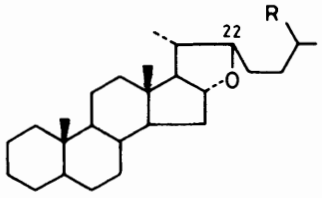
(7) R^1 = MOM, R^2 = CN
(8) R^1 = MOM, R^2 = C(NH)OMe
(9) R^1 = H, R^2 = $CONH_2$
(10) R^1 = Ac, R^2 = $CONH_2$



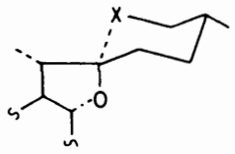
(11) R^1 = O, R^2 = H
(12) R^1 = O, R^2 = Me
(13) R^1 = N–OH, R^2 = Me
(14) R^1 = α-H, β-NH_2, R^2 = Me
(15) R^1 = α-H, β-NHCN, R^2 = Me



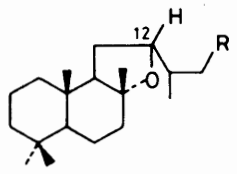
(16) R^1 = H, R^2 = Me
(17) R^1 = I, R^2 = Me



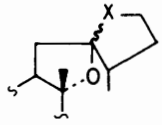
(18) R = CH_2OH
(19) R = COOH
(20) R = $CONH_2$
(21) R = CH_2NH_2
(22) R = $CH_2NHCONH_2$
(23) R = CH_2NHCN



(24) X = O
(25) X = N–CN



(26) R = I
(27) R = CN
(28) R = $CONH_2$ (12*R*)
(29) R = $CONH_2$ (12*S*)
(30) R = CH_2NH_2 (12*R*)
(31) R = CH_2NH_2 (12*S*)
(32) R = CH_2NHCN (12*R*)
(33) R = CH_2NHCN (12*S*)



(34) X = N–CN
(35) X = O

performed in pyridine with methanesulphonyl chloride to give the cyanamide (**23**) [82% from the amine (**21**)]. The structure of the latter was established on the basis of i.r. and mass spectral evidence.

(12*R*/12*S*)-8α,12-Epoxylabdan-15-amides (**28**) and (**29**) were prepared from (12*R*/12*S*)-14-iodo-8α,12-epoxy-15-norlabdane (**26**)[17] by treatment with sodium cyanide and subsequent reaction of the resulting nitrile (**27**) with potassium hydroxide in t-butyl alcohol.[18] The amides (**28**) and (**29**), separated by column chromatography, show significant differences in their ^{1}H n.m.r. spectra with respect to 12-H and in their ^{13}C n.m.r. spectra for the carbons 11, 12, 13, 16, and 17 (see Experimental section). The amide (**28**) was treated with $LiAlH_4$ and the crude reaction mixture, containing (**30**), was treated with BrCN to afford the cyanamide (**32**) (76%). The amide (**29**) was treated in a similar fashion to (**28**) to give the corresponding cyanamide (**33**) (61%). Although for compounds (**32**) and (**33**) the i.r. and mass spectral characteristics are those expected in their ^{1}H n.m.r spectra the compounds show markedly different signals for 12-H [δ 4.02 ($W_{\frac{1}{2}}$ 18 Hz) and 3.60 ($W_{\frac{1}{2}}$ 24 Hz) respectively]. Significant differences have also been observed in their ^{13}C n.m.r. spectra for carbons 11, 12, 13, 14, 16, and 17 (see Experimental section).

Photolysis of N-*Cyanamides*.—Intramolecular hydrogen abstractions were performed by photolysis of the *N*-iodocyanamides generated *in situ* by reaction of the corresponding *N*-cyanamides (in cyclohexane or cyclohexane and methylene dichloride when the solubility of the cyanamide was not total) with iodine and lead tetra-acetate. Recently we have found that the system iodine–diacetoxyiodobenzene (DIB) is more efficient than I_2–LTA in producing cyclic ethers from hydroxy compounds[19] and epimino compounds from amine derivatives.[5b] We have also found that better yields were obtained (see Table) when the reaction of the cyanamides (**6**), (**23**), (**32**), and (**33**) was performed with this system (see Table: compare entries 1—2, 4—5, 6—7, and 8—9).

When the reaction was performed with the cyanamides 3β-methoxymethoxy-5α-cholestan-6β-ylcyanamide (**6**) and 29-methoxyfriedelan-3β-ylcyanamide (**15**), as well as the expected epimino compounds (**7**) and (**16**) and (**17**), the carbonyl compounds (**2**) and (**12**) respectively were also obtained. Recently we have found that the cyanamides can be dehydrogenated with LTA as oxidative agent and the resulting cyanamides are easily hydrolysed to the corresponding carbonyl compounds. When the reaction is performed without iodine the carbonyl compound is obtained exclusively.[20]

The spectroscopic data are in agreement with the structure proposed for the *N*-cyanoepimino compounds (see Experimental section). The ^{1}H n.m.r. spectrum of compound *N*-cyano-3β-methoxymethoxy-6β,19-iminocholestane (**7**) has no signal corresponding to the 10-Me whilst showing an AB system at δ 3.16 and 3.33 (*J* 9.5 Hz) corresponding to the C-19 methylene; the ^{13}C n.m.r. spectrum furnished similar confirmatory evidence. The mass spectrum shows a fragment at *m/z* 207.1147 ($C_{11}H_{15}N_2O_2$) (fragment [**a**]: R = MOM, X = CN, Scheme

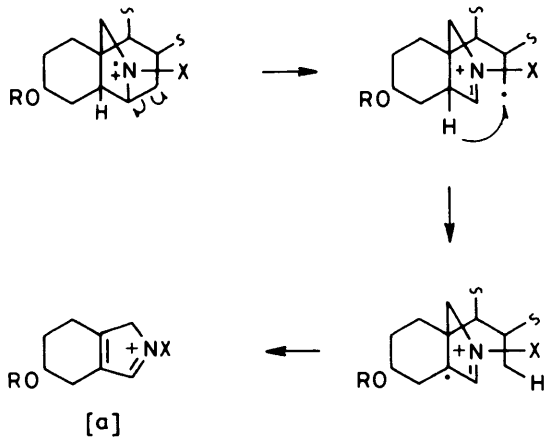
Table. Synthesis of 1,4- and 1,5-*N*-cyanoepimino compounds

Entry	Substrate	Reagent	Time (min.)	Temp. (°C)	Products (Yield %)
1	(**6**)	A	120	90	(**7**) (22), (**2**) (24)
2	(**6**)	B	120	50	(**7**) (64), (**2**) (31)
3	(**15**)	A	60	55	(**16**) (13), (**17**) (8), (**12**) (28)
4	(**23**)	A	45	40	(**25**) (71)
5	(**23**)	B	15	40	(**25**) (85)
6	(**32**)	A	60	20	(**34**) (82; 12*R*:12*S*, 3:2)
7	(**32**)	B	40	20	(**34**) (91; 12*R*:12*S*, 3:2)
8	(**33**)	A	60	20	(**34**) (77; 12*R*:12*S*, 2:1)
9	(**33**)	B	72	20	(**34**) (90; 12*R*:12*S*, 2:1)

A: 3 mol equiv. of LTA and 1 mol equiv. of iodine per mol of substrate. B: 1.1 mol equiv. of DIB and 1 mol equiv. of iodine per mol of substrate.

2), that we have observed to be typical of compounds with a heteroatom bridge between C-6 and C-19. This fragment, that corresponds to the base peak in many cases or generates it by subsequent loss of ROH and/or XH, is formed by α,β-fission of the C(6)–C(7) bond, followed by H transfer from C(5) and then cleavage of the C(9)–C(10) bond.

In the photolysis of 29-methoxyfriedelan-3β-ylcyanamide (**15**) the epimines (**16**) and (**17**) were obtained as well as the carbonyl compound (**12**).



Scheme 2.

The ^{1}H n.m.r. and mass spectral characteristics of (**16**) agreed with expectations. Two consecutive hydrogen abstractions are needed to produce (**17**) in a manner similar to that previously reported for friedelan-3β-ol.[21] Although the mass spectrum of (**17**) shows no molecular ion (the fragment of highest mass, *m/z* 478, corresponds to $M^+ - HI$), the ^{1}H n.m.r. spectrum clearly confirms the structure of this compound (see Experimental section).

When the reaction was performed with (22*R*,25*R*)-5α-furostan-26-ylcyanamide (**23**) the derivative (**25**) was obtained in good yield; the spectroscopic data are in agreement with the structure proposed (see Experimental section). It seems likely that the process proceeds *via* a seven-membered transition state as indicated for the synthesis of spirostan sapogenins from 26-hydroxyfurostan compounds.[22] The two inseparable (12*R*/12*S*) epimeric epicyanamides (**34**) obtained from the (12*R*/12*S*)-8α,12-epoxylabdan-15-ylcyanamides (**32**) and (**33**), have similar i.r. and mass spectra, but may be distinguished by their ^{1}H n.m.r. spectra which show significant differences for the 8-Me signal (δ 1.33 and 1.11 respectively); this behaviour parallels that of the analogous spiroacetal compounds (**35**).[23]

The cyanamide group is a good starting point for the syntheses of isourea or urea derivatives. Thus, *N*-methoxyformimidoyl-3β-methoxymethoxy-6β,19-epimino-5α-cholestane (**8**) was prepared from the cyanoepimino compound (**7**) by treatment with potassium cyanide and methanol.[7] The spectroscopic data are in agreement with the structure proposed for this compound (see Experimental section). When the epimine (**8**) was treated under reflux with acetic acid and water the hydroxyurea derivative (**9**) was obtained; this was acetylated to give the urea (**10**). The spectral characteristics agreed with the structure assigned to it (see Experimental section).

Experimental

M.p.s were determined with a Kofler hot-stage apparatus and are uncorrected. Optical rotations were measured at room temperature for solutions in chloroform on a Perkin-Elmer 141 polarimeter. I.r. spectra were taken on a Perkin-Elmer 257 instrument in $CHCl_3$ solutions. ^{1}H N.m.r. spectra were recorded with a Perkin-Elmer R-12 (60 MHz), an R-32 (90 MHz), or a Bruker WP200sy (200 MHz) instrument and ^{13}C n.m.r. spectra on a Bruker WP200sy (50.3 MHz) spectrometer for solutions in $CDCl_3$ with Me_4Si as internal reference. Low- and high-resolution mass spectra were determined with a VG Micromass ZAB-2F spectrometer at 70 eV. Thin-layer chromatography (t.l.c.) was performed on Merck silica gel 60 and column chromatography on Merck silica gel (0.063—0.2 mm). The spray reagent for t.l.c. was vanillin (1 g) in H_2SO_4–EtOH (4:1; 200 ml).

Lead tetra-acetate (LTA) and diacetoxyiodobenzene (DIB) were purchased (Merck and Aldrich respectively).

3β-*Methoxymethoxy*-5α-*cholestan*-6-*one* (**2**).—To a stirred solution of 3β-hydroxy-5α-cholestan-6-one (**1**) (5.8 g, 14.4 mmol) in $CHCl_3$ (75 ml; dried over phosphorus pentaoxide) at room temperature, dimethoxymethane (72 ml, 814 mmol) and P_2O_5 (15 g, 105 mmol) were added and the resulting mixture was vigorously stirred for 2.5 h; it was then cautiously poured into ice–water, neutralized with aqueous sodium carbonate, and extracted with chloroform. The combined organic extracts were washed with brine and water, dried (Na_2SO_4), and evaporated under reduced pressure. Chromatography of the residue (hexane–ethyl acetate, 85:15) gave the ether (**2**) (5.95 g, 92%), m.p. 105—107 °C (MeOH); $[\alpha]_D$ −12° (*c* 0.52); $\nu_{max.}$ 1 700 cm^{-1} (CO); δ_H (90 MHz) 0.66 (3 H, s, 13-Me), 0.75 (3 H, s, 10-Me), 0.87 (6 H, d, *J* 7 Hz, 25-Me_2), 0.90 (3 H, d, *J* 7 Hz, 20-Me), 3.36 (3 H, s, OMe), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H), and 4.68 (2 H, s, OCH_2O); *m/z* 446 (M^+, 25%), 431 (12, M − Me), and 384 (100, M − $MeOCH_2OH$).

3β-*Methoxymethoxy*-5α-*cholestan*-6-*one Oxime* (**3**).—To a solution of the ketone (**2**) (5.84 g, 13.1 mmol) in dry pyridine

(75 ml), hydroxylamine hydrochloride (1.35 g, 19.4 mmol) was added and the solution was stirred at 90 °C for 2 h. After addition of water the mixture was extracted with $CHCl_3$ and the organic solution was washed with aqueous HCl (10%), saturated aqueous $NaHCO_3$, and water. Column chromatography of the residue (hexane–ethyl acetate, 4:1) gave the oxime (**3**) (5.0 g, 83%), amorphous; $\nu_{max.}$ 3 580 cm^{-1} (OH); δ_H (90 MHz) 0.64 (3 H, s, 13-Me), 0.75 (3 H, s, 10-Me), 0.86 (6 H, d, *J* 7 Hz, 25-Me_2), 0.89 (3 H, d, *J* 7 Hz, 20-Me), 3.37 (3 H, s, O-Me), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H), 4.70 (2 H, s, O-CH_2-O), and 8.95 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, N-OH); *m/z* 461 (M^+, 22%), 444 (18, M − OH), 399 (53, *M* − $MeOCH_2OH$), and 384 (100, *M* − $MeCH_2OH$ − Me).

3β-*Methoxymethoxy*-5α-*cholestan*-6β-*ylcyanamide* (**6**).—*Method A*. To a solution of the oxime (**3**) (5.0 g, 10.8 mmol) in tetrahydrofuran (150 ml) lithium aluminium hydride (2.5 g, 62.5 mmol) was added and the mixture was refluxed for 2 h. The excess of $LiAlH_4$ was quenched with saturated aqueous Na_2SO_4, the solution filtered, and the organic phase concentrated under reduced pressure. The residue was chromatographed (hexane–ethyl acetate, 3:7) to give the amorphous amine (**4**) (3.6 g, 74%). To a solution of the amine (**4**) (2.4 g, 5.4 mmol) in diethyl ether (70 ml), at −30 °C, cyanogen bromide (0.68 g, 6.4 mmol) was added and the mixture stirred, at room temperature, for 2 h. The solution was poured into aqueous HCl (5%) and extracted with $CHCl_3$. The organic solution was washed with saturated aqueous $NaHCO_3$ and water and then evaporated. Column chromatography of the residue (hexane–ethyl acetate, 4:1) gave the *cyanamide* (**6**) (1.39 g, 55%), m.p. 129—130 °C (MeOH); $[\alpha]_D$ −25° (*c* 0.3); $\nu_{max.}$ 3 390 (NH) and 2 200 cm^{-1} (CN); δ_H (200 MHz) 0.68 (3 H, s, 13-Me), 0.86 (6 H, d, *J* 6.7 Hz, 25-Me_2), 0.89 (3 H, d, *J* 6.7 Hz, 20-Me), 0.96 (3 H, s, 10-Me), 3.36 (4 H, br s, O-Me and 6-H), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H), and 4.67 (2 H, s, O-CH_2-O); δ_C 12.29 (C-18), 16.08 (C-19), 18.82 (C-21), 21.09 (C-11), 22.69 (C-26), 22.94 (C-27), 23.98 (C-15), 24.30 (C-23), 28.15 (C-25), 28.27 (C-16), 28.70 (C-2), 30.46 (C-8), 32.71 (C-4), 35.79 (C-10), 35.88 (C-20), 36.30 (C-22), 36.51 (C-7), 38.95 (C-1), 39.65 (C-24), 39.85 (C-12), 42.81 (C-13), 46.00 (C-5), 54.08 (C-9), 55.40 (O-Me), 55.85 (C-14), 56.42 (C-17), 57.53 (C-6), 76.54 (C-3), 94.86 (O-CH_2-O), and 115.77 (CN); *m/z* 472.3958 (M^+, $C_{30}H_{52}N_2O_2$ 472.4029, 42%), 457.7364 (13, $C_{29}H_{49}N_2O_2$ 457.7379, *M* − Me), 410.3700 (100, $C_{28}H_{46}N_2$ 410.3549, *M* − $MeOCH_2OH$), 368.3447 (**46**, $C_{27}H_{44}$ 368.3443 *M* − $MeOCH_2$-OH − H_2NCN).

Method B. To a solution of the amine (**4**) (1.0 g, 2.24 mmol) in EtOH (100 ml), water (3 ml), and acetic acid (0.27 ml), sodium cyanate (218 mg, 3.35 mmol) was added and the mixture refluxed for 1.5 h; it was then poured into brine and extracted with ethyl acetate. The organic solution was dried (Na_2SO_4) and evaporated and the residue (1.2 g) containing the urea (**5**) was used without purification in the next reaction. To a solution of the urea (**5**) in pyridine (10 ml), at 0 °C, methanesulphonyl chloride (0.55 ml, 0.71 mmol) was added. After 30 min, the solution was allowed to warm to room temperature, when it was stirred for 1 h. After this it was poured into water and extracted with $CHCl_3$. The organic layer was washed with aqueous $NaHCO_3$ and water and evaporated. Column chromatography of the residue gave the cyanamide (**6**) (650 mg, 61%).

29-*Methoxyfriedelan*-3-*one* (**12**).—To a solution of the ketone (**11**) (300 mg, 0.68 mmol) in methylene dichloride (30 ml) fluoroboric acid solution [HBF_4 *ca.* 16M (10 ml), Et_2O (180 ml), and CH_2Cl_2 (20 ml)] (1 ml) was added. This solution, at 0 °C, was treated with diazomethane generated from a solution of Diazald (*N*-methyl-*N*-nitrosotoluene-*p*-sulphonamide) (2.3 g) in CH_2Cl_2 (10 ml) which, at 5 °C, was treated with another solution of KOH (0.66 g) in water (1.1 ml) and diethylene glycol monomethyl ether (1.8 ml) and heated to 50 °C by means of a water-bath. After dilution with water, the mixture was neutralized with aqueous $NaHCO_3$ and extracted with CH_2Cl_2. The extract was evaporated and column chromatography of the residue (benzene–ethyl acetate, 95:5) afforded the title compound (**12**) (295 mg, 95%), m.p. 169—171 °C (MeOH); $[\alpha]_D$ −17° (*c* 0.25); $\nu_{max.}$ 1 705 cm^{-1} (CO); δ_H (200 MHz) 0.86 (3 H, d, *J* 6.6 Hz, 4-Me), 0.70, 0.85, 2 × 0.97, 1.03, and 1.18 (18 H, s, 6 × Me), 3.10 (2 H, s, 29-H_2), and 3.33 (3 H, s, O-Me); *m/z* 456 (M^+, 18%), 441 (6, *M* − Me), 371 (6), 302 (12), 273 (100), and 235 (42).

29-*Methoxyfriedelan*-3-*one Oxime* (**13**).—A solution of the ketone (**12**) (280 mg, 0.61 mmol) and hydroxylamine hydrochloride (140 mg, 2 mmol) in pyridine (15 ml) was treated as indicated previously for the ketone (**2**) to yield, after column chromatography (benzene–ethyl acetate, 95:5), the oxime (**13**) (270 mg, 91%), m.p. 234—236 °C ($CHCl_3$–MeOH); $[\alpha]_D$ +38° (*c* 0.3); $\nu_{max.}$ 3 580 cm^{-1} (OH); δ_H (200 MHz) 0.91 (3 H, d, *J* 6.7 Hz, 4-Me), 0.71, 0.82, 0.96, 0.97, 1.01, and 1.13 (18 H, s, 6 × Me), 3.10 (2 H, s, 29-H_2), and 3.33 (3 H, s, O-Me); *m/z* 471 (M^+, 30%), 456 (40, *M* − Me), 440 (100, *M* − MeO), 371 (11), 288 (6), 235 (39), and 155 (40).

29-*Methoxyfriedelan*-3β-*ylcyanamide* (**15**).—A mixture of the oxime (**13**) (250 mg, 0.53 mmol) and $LiAlH_4$ (125 mg, 3.1 mmol) in THF (60 ml) was treated as indicated previously for the oxime (**3**) to give the amine (**14**) which was treated without purification, in dry chloroform at 0 °C, with $NaHCO_3$ (49 mg, 0.58 mmol) and cyanogen bromide (62 mg, 0.58 mmol). The mixture was allowed to warm up to room temperature when it was stirred for 2 h. Work-up as indicated for (**6**) and column chromatography (benzene–ethyl acetate, 95:5) gave the cyanamide (**15**) (79 mg, 28%), m.p. 251—254 °C ($CHCl_3$–MeOH); $[\alpha]_D$ +44° (*c* 0.204); $\nu_{max.}$ 3 400 (NH) and 2 220 cm^{-1} (CN); δ_H (200 MHz) 0.92 (3 H, d, *J* 6.7 Hz, 4-Me), 0.81, 0.86, 0.94, 0.96, 0.98, and 1.12 (18 H, s, 6 × Me), 3.09 (2 H, s, 29-H_2), and 3.32 (3 H, s, OMe); *m/z* 482.4258 (M^+, $C_{32}H_{50}N_2O$ 482.4236, 12%), 467.3970 (15, $C_{31}H_{51}N_2O$ 467.3970, *M* − Me), 440.3900 (6, $C_{30}H_{54}NO$ 440.3892, *M* − Me − HCN), 299.2512 (49, $C_{20}H_{31}N_2$ 299.2487), 235.2047 (19, $C_{16}H_{27}O$ 235.2062), and 155.1455 (100, $C_{10}H_{19}O$ 155.1436).

(22R,25R)-5α-*Furostan*-26-*amide* (**20**).—$LiAlH_4$ (0.5 g, 12.5 mmol) was added to a solution of (25*R*)-5α-spirostan (**24**) (1.0 g, 2.5 mmol) in Et_2O (100 ml), and this was followed by a solution of $AlCl_3$ (6.0 g) in Et_2O (30 ml); the mixture was then refluxed for 1 h. The excess of reagent was quenched with saturated aqueous Na_2SO_4 and the solution filtered; the organic layer was then concentrated under reduced pressure. Column chromatography (hexane–ethyl acetate, 4:1) gave compound (**18**) (0.86 g, 86%), m.p. 110—111 °C (acetone); $[\alpha]_D$ +1° (*c* 0.26); $\nu_{max.}$ 3 625 cm^{-1} (OH); δ_H (60 MHz) 0.76 (6 H, s, 10-Me and 13-Me), 0.87 (3 H, d, *J* 6 Hz, 25-Me), 0.95 (3 H, d, *J* 6 Hz, 20-Me), 3.35 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), 3.44 (2 H, d, *J* 6 Hz, 26-H_2), and 4.28 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H); *m/z* 402 (M^+, 2%), 387 (1, *M* − Me), 384 (1, *M* − H_2O), and 257 (100). A solution of (**18**) (0.8 g, 1.99 mmol) in acetone (50 ml), at 0 °C, was treated dropwise with Jones' reagent. The excess of reagent was destroyed with MeOH and then the mixture was poured into water and extracted with $CHCl_3$. The organic layer was dried (Na_2SO_4) and concentrated under reduced pressure. Column chromatography of the residue (hexane–ethyl acetate, 7:3) gave (22*R*,25*R*)-5α-furostan-26-oic acid (**19**) (0.8 g, 98%), m.p. 146—148 °C (acetone); $[\alpha]_D$ −24° (*c* 0.26); $\nu_{max.}$ 3 600—2 500br (OH) and 1 705 cm^{-1} (CO); δ_H (60 MHz) 0.75 (6 H, s, 10-Me and 13-Me), 0.95 (3 H, d, *J* 6 Hz, 20-Me), 1.15 (3 H, d, *J* 6 Hz, 25-Me),

3.30 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), 4.28 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H), and 9.80 (1 H, m, $W_{\frac{1}{2}}$ 24 Hz, COOH); *m/z* 416 (M^+, 5%), 398 (4, $M - H_2O$), 370 (1, $M - HCO_2H$), and 257 (100). To a solution of compound (**19**) (0.75 g, 1.8 mmol) in Et_2O (25 ml) and pyridine (0.1 ml), thionyl chloride (0.23 ml, 3.1 mmol) was added and the mixture was stirred at room temperature for 1 h. The Et_2O was evaporated under reduced pressure and the residue treated with ammonium hydroxide (*ca.* 28%; 10 ml) and then poured into water, neutralized with HCl (5%), and extracted with Et_2O. The ether extract was evaporated and the residue subjected to column chromatography (hexane–ethyl acetate, 7:3) to give the amide (**20**) (0.636 g, 85%), 145—148 °C (acetone); $[\alpha]_D$ −24° (*c* 0.41); $\nu_{max.}$ 3 515, 3 400 (NH_2), 1 670, and 1 590 cm^{-1} (CO); δ_H (60 MHz) 0.74 and 0.77 (6 H, s, 2 × Me), 0.95 (3 H, d, *J* 6 Hz, 20-Me), 1.13 (3 H, d, *J* 6 Hz, 25-Me), 3.30 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), 4.30 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H), 5.70, and 6.10 (2 H, m, $W_{\frac{1}{2}}$ 24 Hz, $CONH_2$); *m/z* 415 (M^+, 8%), 398 (3, $M - NH_3$), 370 (2, $M - HCONH_2$), and 257 (100).

(22R,25R)-5α-*Furostan*-26-*amine* (**21**).—To a solution of (22*R*,25*R*)-5α-furostan-26-amide (**20**) (500 mg, 1.2 mmol) in Et_2O (60 ml), $LiAlH_4$ (250 mg, 6.25 mmol) was added and the mixture refluxed for 3 h. The mixture was quenched and worked up, and column chromatography of the residue ($CHCl_3$–acetone, 1:1) gave the amine (**21**) (469 mg, 97%), amorphous; $\nu_{max.}$ 3 540—3 000br cm^{-1} (NH_2); δ_H (200 MHz) 0.78 (6 H, s, 10-Me and 13-Me), 0.90 (3 H, d, *J* 7 Hz, 25-Me), 0.97 (3 H, d, *J* 7 Hz, 20-Me), 3.20 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), and 4.25 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H); *m/z* 401 (M^+, 15%), 386 (12, M − Me), 384 (12, $M - NH_3$), and 257 (100).

(22R,25R)-5α-*Furostan*-26-*ylcyanamide* (**23**).—A solution of the amine (**21**) (250 mg, 0.62 mmol) and sodium cyanate (61 mg, 0.093 mmol) in EtOH (37 ml), water (0.73 ml), and acetic acid (0.55 ml) was treated as indicated for the amine (**4**) (Method B). Column chromatography of the residue (ethyl acetate) gave the urea derivative (**22**) (246 mg, 89%), m.p. 136—138 °C (acetone–pentane); $[\alpha]_D$ +3° (*c* 0.208); $\nu_{max.}$ 3 500, 3 460, 3 400 (NH), 1 670, 1 590, and 1 525 cm^{-1} (CO); δ_H (200 MHz) 0.75, and 0.77 (6 H, s, 2 × Me), 0.88 and 0.95 (6 H, d, *J* 6.6 Hz, 2 × Me), 3.00 (2 H, m, $W_{\frac{1}{2}}$ 40 Hz, 26-H_2), 3.27 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), 4.25 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H), 4.50, and 4.90 (2 H, m, m, $W_{\frac{1}{2}}$ 20 Hz, NH_2); *m/z* 444 (15 eV, M^+, 1%), 427.3488 (21, $C_{28}H_{45}NO_2$ 427.3451, $M - NH_3$), 384.3441 (22, $C_{27}H_{44}O$ 384.3392, $M - H_2NCONH_2$), and 257.2271 (100, $C_{19}H_{29}$ 257.2270). To a stirred solution of the urea (**22**) (150 mg, 0.34 mmol) in pyridine (6 ml), at 0 °C, methanesulphonyl chloride (0.1 ml, 1.3 mmol) was added and the mixture stirred, at room temperature, for 1 h. After work-up, as indicated previously, the residue was purified by column chromatography (benzene–ethyl acetate, 9:1) to afford the cyanamide (**23**) (133 mg, 92%), m.p. 146—148 °C (acetone); $[\alpha]_D$ +10° (*c* 0.282); $\nu_{max.}$ 3 400 (NH) and 2 220 cm^{-1} (CN); δ_H (200 MHz) 0.75 and 0.77 (6 H, s, 2 × Me), 0.93 and 0.96 (6 H, d, *J* 6.8 Hz, 2 × Me), 2.93 (2 H, m, $W_{\frac{1}{2}}$ 22 Hz, 26-H_2), 3.28 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 22-H), 3.98 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, N–H), and 4.26 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H); δ_C 12.32 (C-19), 16.68 (C-18), 17.29 (C-27), 18.86 (C-21), 20.49 (C-11), 22.24 (C-2), 26.85 (C-3), 29.03 (C-4 or C-6), 29.10 (C-6 or C-4), 30.10 (C-23 or C-24), 30.68 (C-24 or C-23), 32.17 (C-15), 32.35 (C-7), 33.64 (C-25), 35.36 (C-8), 36.40 (C-10), 37.98 (C-20), 38.76 (C-1), 39.82 (C-12), 41.06 (C-13), 47.14 (C-5), 52.11 (C-26), 54.88 (C-9), 57.00 (C-14), 65.24 (C-17), 83.44 (C-16), and 90.13 (C-22); *m/z* 426.3637 (M^+, $C_{28}H_{46}N_2O$ 426.3609, 11%), 411.3818 (21, $C_{27}H_{43}N_2O$ 411.3372, M − Me), 384.3314 (4, $C_{27}H_{44}O$ 384.3390, $M - H_2NCN$), and 257.2267 (100, $C_{19}H_{29}$ 257.2268).

(12R)- *and* (12S)-8α,12-*Epoxylabdan*-15-*amides* (**28**) *and* (**29**).—To a solution of (12*R*/*S*)-14-iodo-8α,12-epoxy-15-norlabdane (**26**) (800 mg, 1.98 mmol) in EtOH (50 ml), sodium cyanide (291 mg, 5.94 mmol) was added and the mixture refluxed overnight; it was then poured into water and extracted with Et_2O. The organic solution was dried (Na_2SO_4) and evaporated under reduced pressure and column chromatography of the residue (benzene–ethyl acetate, 95:5) gave the epimeric (12*R*/*S*)-8α,12-epoxy-15-norlabdane-14-nitrile (**27**) (390 mg, 65%), amorphous; $\nu_{max.}$ 2 240 cm^{-1}; δ_H (200 MHz) 2 × 0.84 and 0.88 (9 H, s, 3 × Me), 1.01 and 1.03 (both d, *J* 6.5 Hz, 13-Me), 1.11 and 1.13 (both s, 8-Me), and 3.60 and 4.10 (both m, $W_{\frac{1}{2}}$ 18 and 24 Hz, 12-H); *m/z* 303 (M^+, 7%) and 288 (100, m − Me). To a solution of the nitrile (**27**) (347 mg) in t-butyl alcohol (3 ml), potassium hydroxide (616 mg) was added and the mixture refluxed for 1 h; it was then poured into brine and extracted with $CHCl_3$. Column chromatography of the residue (benzene–ethyl acetate, 1:1) gave (12*R*) and (12*S*)-8α,12-epoxylabdan-15-amides (**28**) (208 mg, 57%) and (**29**) (143 mg, 39%): (**28**), m.p. 154—155 °C (acetone–hexane); $[\alpha]_D$ −26° (*c* 0.312); $\nu_{max.}$ 3 480, 3 400 (NH), and 1 665 cm^{-1} (CO); δ_H (200 MHz) 0.82 (6 H, s, 4β-Me and 10-Me), 0.87 (3 H, s, 4α-Me), 0.96 (3 H, d, *J* 6.6 Hz, 13-Me), 1.13 (3 H, s, 8-Me), 4.08 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 12-H), and 5.33 and 5.99 (2 H, m, $W_{\frac{1}{2}}$ 20 Hz, N–H_2); δ_C 14.89 (C-16 or C-20), 15.06 (C-20 or C-16), 18.50 (C-2), 20.66 (C-6), 21.26 (C-17 or C-19), 21.48 (C-19 or C-17), 25.49 (C-11), 33.23 (C-4), 33.66 (C-18), 35.34 (C-13), 36.46 (C-10), 39.73 (C-7 or C-14), 39.87 (C-14 or C-7), 40.09 (C-1), 42.59 (C-3), 57.53 (C-5), 60.20 (C-9), 78.63 (C-12), 81.11 (C-8), and 175.59 (C-15); *m/z* 321.2651 (M^+, $C_{20}H_{35}NO_2$ 321.2667, 2%), 306.2433 (23, $C_{19}H_{32}NO_2$ 306.2433, M − Me), and 191.1772 (100, $C_{14}H_{23}$ 191.1799); amide (**29**), m.p. 60—63 °C (acetone–hexane); $[\alpha]_D$ +1° (*c* 0.34); $\nu_{max.}$ 3 480, 3 400 (NH), and 1 660 cm^{-1} (CO); δ_H 0.82 (3 H, s, 10-Me), 0.84 (3 H, s, 4β-Me), 0.87 (3 H, s, 4α-Me), 0.93 (3 H, d, *J* 6.6 Hz, 13-Me), 1.13 (3 H, s, 8-Me), 3.60 (1 H, m, $W_{\frac{1}{2}}$ 24 Hz, 12-H), and 5.23 and 5.90 (2 H, m, $W_{\frac{1}{2}}$ 20 Hz, NH_2); δ_C 15.66 (C-20), 16.73 (C-16), 18.55 (C-2), 21.02 (C-6), 21.21 (C-19), 24.83 (C-17), 28.79 (C-11), 33.25 (C-4), 33.68 (C-18), 36.43 (C-10), 39.16 (C-13), 40.15 (C-1), 40.68 (C-7), 41.30 (C-14), 42.61 (C-3), 57.28 (C-5), 61.21 (C-9), 80.96 (C-8), 83.07 (C-12), and 175.51 (C-15); *m/z* 321.2668 (M^+, $C_{20}H_{35}NO_2$ 321.2667, 4%), 306.2458 (74, $C_{19}H_{32}NO_2$ 306.2432, M − Me), and 191.1787 (100, $C_{14}H_{23}$ 191.1800).

(12R)-8α,12-*Epoxylabdan*-15-*ylcyanamide* (**32**).—To a solution of the amide (**28**) (110 mg, 0.34 mmol) in Et_2O (50 ml), $LiAlH_4$ (45 mg, 1.13 mmol) was added and the mixture refluxed for 2 h. After work-up the residue, containing (**30**), without purification was dissolved in CH_2Cl_2 (15 ml) and to this solution, at 0 °C, $NaHCO_3$ (32 mg, 0.38 mmol) and cyanogen bromide (40 mg, 0.38 mmol) were added; the reaction mixture was then stirred at room temperature for 1 h. After work-up ($CHCl_3$), the residue was purified by column chromatography (benzene–ethyl acetate, 4:1) to afford the cyanamide (**32**) [(86 mg, 76% from (**28**)], amorphous; $\nu_{max.}$ 3 400 (NH) and 2 220 cm^{-1} (CN); δ_H (200 MHz) 0.83 (6 H, s, 4β-Me and 10-Me), 0.87 (3 H, s, 4α-Me), 0.91 (3 H, d, *J* 6.7 Hz, 13-Me), 1.13 (3 H, s, 8-Me), 3.12 (2 H, m, $W_{\frac{1}{2}}$ 24 Hz, 15-H_2), 4.02 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 12-H), and 4.75 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, N–H); δ_C 14.84 (C-16), 15.10 (C-20), 18.48 (C-2), 20.62 (C-6), 21.24 (C-17 or C-19), 21.44 (C-19 or C-17), 25.49 (C-11), 32.72 (C-14), 33.20 (C-4), 33.64 (C-18), 35.34 (C-13), 36.48 (C-10), 39.60 (C-7), 40.07 (C-1), 42.54 (C-3), 44.75 (C-15), 57.48 (C-5), 60.27 (C-9), 78.90 (C-12), 81.35 (C-8), and 116.96 (CN); *m/z* 332.2831 (M^+, $C_{21}H_{36}N_2O$ 332.2828, 3%), 317.2598 (80, $C_{20}H_{33}N_2O$ 317.2593, M − Me), and 191.1782 (100, $C_{14}H_{23}$ 191.1800).

(12S)-8α,12-*Epoxylabdan*-15-*ylcyanamide* (**33**).—A solution of the amide (**29**) (100 mg, 0.31 mmol) in Et_2O (45 ml), was treated with $LiAlH_4$ (40 mg, 1 mmol) as described previously

and the resulting residue, containing the amine (**31**), was dissolved in CH_2Cl_2 (10 ml) and treated with $NaHCO_3$ (29 mg, 0.34 mmol) and BrCN (36 mg, 0.34 mmol). After work-up, column chromatography of the residue (benzene–ethyl acetate, 4:1) gave the cyanamide (**33**) [(63 mg, 61% from the amide (**29**)], m.p. 119—121 °C (acetone–hexane); $[\alpha]_D$ +1° (*c* 0.31); $\nu_{max.}$ 3 400 (NH) and 2 220 cm^{-1} (CN); δ_H (200 MHz) 0.82 (3 H, s, 10-Me), 0.83 (3 H, s, 4β-Me), 0.86 (3 H, d, *J* 6.7 Hz, 13-Me), 0.87 (3 H, s, 4α-Me), 1.11 (3 H, s, 8-Me), 3.18 (2 H, m, $W_{\frac{1}{2}}$ 24 Hz, 15-H_2), 3.60 (1 H, m, $W_{\frac{1}{2}}$ 24 Hz, 12-H), and 5.09 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, NH); δ_C 15.71 (C-20), 17.46 (C-16), 18.55 (C-2), 21.00 (C-6), 21.19 (C-19), 24.93 (C-17), 28.98 (C-11), 33.25 (C-4), 33.65 (C-18), 36.40 (C-10 and C-14), 39.82 (C-13), 40.15 (C-1), 40.65 (C-7), 42.59 (C-3), 45.57 (C-15), 57.24 (C-5), 60.66 (C-9), 81.23 (C-8), 83.80 (C-12), and 117.32 (CN); *m/z* 332.2808 (M^+, $C_{21}H_{36}N_2O$ 332.2828, 6%), 317.2631 (100, $C_{20}H_{33}N_2O$ 317.2593, *M* − Me), and 191.1719 (77, $C_{14}H_{23}$ 191.1799).

Photolysis of 29-*Methoxyfriedean*-3β-*ylcyanamide* (**15**).—To a solution of the cyanamide in cyclohexane (or cyclohexane and CH_2Cl_2 until dissolution of the cyanamide), lead tetra-acetate (LTA) (3 mol equiv.) and I_2 (1 mol equiv.) were added and the mixture was irradiated with two 100 W tungsten-filament lamps. The reaction (time and temperature) was monitored for each example by t.l.c., and the mixture was then poured into water and extracted with CH_2Cl_2. The organic layer was washed with aqueous sodium thiosulphate and water, dried (Na_2SO_4), and evaporated under reduced pressure.

Method B. (Diacetoxyiodo)benzene (DIB) (1.1 mol equiv.) was used as the oxidizing agent. The reaction conditions and work-up were as described for Method A.

N-*Cyano*-3β-*Methoxymethoxy*-6β,19-*epimino*-5α-*cholestane* (**7**).—*Method A.* The cyanamide (**6**) (142 mg), LTA (400 mg), and I_2 (76 mg) was irradiated, at 90 °C, for 2 h. Column chromatography (benzene–ethyl acetate, 9:1) furnished the ketone (**2**) (31 mg, 24%) and the imine (**7**) (31 mg, 22%), amorphous; $\nu_{max.}$ 2 200 cm^{-1}; δ_H (200 MHz) 0.75 (3 H, s, 13-Me), 0.85 (6 H, d, *J* 6.6 Hz, 25-Me_2), 0.88 (3 H, d, *J* 6.6 Hz, 20-Me), 3.16 and 3.33 (2 H, AB, *J* 9.5 Hz, 10-H_2), 3.35 (3 H, s, OMe), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H), 3.56 (1 H, m, $W_{\frac{1}{2}}$ 10 Hz, 6α-H), and 4.66 (2 H, s, OCH_2O); δ_C 12.61 (C-18), 18.75 (C-21), 22.51 (C-11), 22.68 (C-26), 22.92 (C-27), 23.67 (C-15), 23.97 (C-23), 27.77 (C-2), 28.14 (C-25), 28.35 (C-16), 28.62 (C-4 or C-7), 33.18 (C-1), 34.59 (C-8), 35.74 (C-7 or C-4), 35.85 (C-20), 36.29 (C-22), 39.63 (C-24), 39.92 (C-12), 43.30 (C-10 or C-13), 43.87 (C-13 or C-10), 50.89 (C-5), 51.76 (C-19), 54.59 (C-9), 55.29 (C-14), 55.38 (OMe), 56.34 (C-17), 66.14 (C-6), 74.22 (C-3), 94.84 (OCH_2O), and 117.44 (CN); *m/z* 470.3826 (M^+, $C_{30}H_{50}N_2O_2$ 470.3872, 19%), 455.3628 (26, $C_{29}H_{47}N_2O_2$ 455.3637, *M* − Me), 425.3557 (100, $C_{28}H_{45}N_2O$ 435.3532, *M* − $MeOCH_2$), 408.3362 (16, $C_{24}H_{44}N_2$ 408.3404, *M* − $MeOCH_2OH$), 207.1147 (4, $C_{11}H_{15}N_2O_2$ 207.1133, [**a**]) (fragment [**a**]: R = MOM, X = CN).

Method B. The cyanamide (**6**) (103 mg), DIB (77 mg), and I_2 (55 mg) in cyclohexane (40 ml), was irradiated, at 50 °C, for 2 h. Column chromatography gave the ketone (**2**) (30 mg, 31%) and the imine (**7**) (66 mg, 64%).

Photolysis of 29-*Methoxyfriedelan*-3β-*ylcyanamide* (**15**).—*Method A.* To a solution of the cyanamide (**15**) (96 mg) in cyclohexane (80 ml), I_2 (51 mg) and LTA (266 mg, in three portions each 15 min) were added and the mixture irradiated, at 55 °C, for 1 h. Column chromatography (benzene–ethyl acetate, 98:2) gave the ketone (**12**) (25 mg, 28%), N-*cyano*-29-*methoxy*-3β,24-*epiminofriedelane* (**16**) (12 mg, 13%), and N-*cyano*-25-*iodo*-25-*methoxy*-3β,24-*epiminofriedelane* (**17**) (10 mg, 8%). Compound (**16**), m.p. 201—204 °C (MeOH); $\nu_{max.}$ 2 210 cm^{-1} (CN); δ_H (200 MHz) 0.87 (3 H, d, *J* 6.9 Hz, 4-Me), 2 × 0.94, 0.96, 0.98, 1.12 (15 H, s, 5 × Me), 3.09 (2 H, s, 29-H_2), 3.32 (3 H, s, O–Me), 3.06 and 3.74 (2 H, AB, *J* 9.5 Hz, 24-H_2), and 3.43 (1 H, m, $W_{\frac{1}{2}}$ 7 Hz, 3α-H); *m/z* 480.4091 (M^+, $C_{32}H_{52}N_2O$ 480.4080, 18%), 435.3777 (100, $C_{30}H_{47}N_2$ 435.3739, *M* − $MeOCH_2$), 326.2715 (94, $C_{22}H_{34}N_2$ 326.2722), and 235.2087 (19, $C_{16}H_{27}O$ 235.2061). Compound (**17**), m.p. 171 °C (decomp., $CHCl_3$); $\nu_{max.}$ 2 210 cm^{-1} (CN); δ_H (200 MHz) 0.93 (3 H, d, *J* 6.9 Hz, 4-Me), 0.96, 1.00, 1.01, and 1.14 (12 H, s, 4 × Me), 3.10 (2 H, s, 29-H_2), 3.33 (3 H, s, O–Me), 3.43 (1 H, m, $W_{\frac{1}{2}}$ 7 Hz, 3α-H), 3.17 and 3.77 (2 H, AB, *J* 9.6 Hz, 24-H_2), and 3.45 and 3.85 (2 H, AB, *J* 11.7 Hz, 25-H_2); *m/z* 478.3910 (M^+ − IH, $C_{32}H_{50}N_2O$ 478.3923, 20%), 433.3566 (51, $C_{30}H_{45}N_2$ 433.3583, *M* − IH − $MeOCH_2$), 235.2102 (100, $C_{16}H_{27}O$ 235.2062), and 155.1454 (63, $C_{10}H_{19}$ 155.1436).

(22R,25R)-N-*Cyano*-5α-*tomatanine* (**25**).—*Method A.* To a solution of (**23**) (52 mg) in cyclohexane (17 ml) and CH_2Cl_2 (1.2 ml), I_2 (31 mg) and LTA (163 (mg) were added and then the mixture irradiated, at 40 °C, for 45 min. Column chromatography (hexane–ethyl acetate, 98:2) gave the title compound (**25**) (37 mg, 71%), m.p. 253—256 °C (acetone); $[\alpha]_D$ −44° (*c* 0.396); $\nu_{max.}$ 2 200 cm^{-1} (CN); δ_H (200 MHz) 0.75 and 0.78 (6 H, s, 2 × Me), 0.88 (3 H, d, *J* 6.4 Hz, 25-Me), 1.27 (3 H, d, *J* 7.2 Hz, 20-Me), 3.08 (2 H, d, *J* 8.6 Hz, 26-H_2), and 4.80 (1 H, m, $W_{\frac{1}{2}}$ 22 Hz, 16-H); δ_C 12.36 (C-19), 13.41 (C-21), 16.49 (C-18), 18.57 (C-27), 20.81 (C-11), 22.31 (C-2), 26.89 (C-3), 28.79 (C-24), 29.07 (C-4 or C-6), 29.17 (C-6 or C-4), 30.22 (C-25), 32.16 (C-15), 32.45 (C-7), 34.61 (C-23), 35.29 (C-8), 36.48 (C-10), 38.73 (C-1), 40.12 (C-12), 41.18 (C-13), 43.05 (C-20), 47.10 (C-25), 54.50 (C-26), 54.79 (C-9), 56.39 (C-14), 60.88 (C-17), 83.17 (C-16), 100.66 (C-22), and 118.88 (CN); *m/z* 424.3353 (M^+, $C_{28}H_{44}N_2O$ 424.3452, 20%), 409.3338 (6, $C_{27}H_{41}N_2O$ 409.3217, *M* − Me), 382.3244 (2, $C_{27}H_{42}O$ 382.3234, *M* − H_2NCN), and 257.2236 (100, $C_{19}H_{29}$ 257.2267).

Method B. A solution of (**23**) (53 mg), I_2 (32 mg), and DIB (43 mg) in cyclohexane (18 ml) and CH_2Cl_2 (1.2 ml) was irradiated at 40 °C for 15 min. Column chromatography gave (**25**) (45 mg, 85%).

(12R/12S)-N-*Cyano*-12,15-*epimino*-8α,12-*epoxylabdane* (**34**).—*Method A.* A mixture of the cyanamide (**32**) (33 mg), I_2 (25 mg), and LTA (133 mg) in cyclohexane (10 ml) at 20 °C was irradiated for 1 h. Column chromatography (hexane–ethyl acetate, 9:1) gave a chromatographically irresolvable mixture (3:2) of the title compounds (**34**) (27 mg, 82%), amorphous; $\nu_{max.}$ 2 215 cm^{-1} (CN); δ_H (200 MHz) 0.82, 0.83, 2 × 0.87 (s, 3 × Me), 0.96 and 1.06 (d, *J* 6.0 and 7.1 Hz, 13-Me), 1.11 and 1.33 (s, 8-Me), and 3.57 (2 H, m, $W_{\frac{1}{2}}$ 40 Hz, 15-H_2); *m/z* 330.2677 (M^+, $C_{21}H_{34}N_2O$ 330.2671, 18%), 315.2438 (31, $C_{20}H_{31}N_2O$ 315.2437, *M* − Me), and 191.1814 (100, $C_{14}H_{23}$ 191.1800).

Method B. A mixture of the cyanamide (**32**) (30 mg) I_2 (21 mg), and DIB (29 mg) in cyclohexane (10 ml) at 20 °C was irradiated for 40 min to give (**34**) (*ca.* 3:2; 24 mg, 91%).

Photolysis of (12S)-8α,12-*Epoxylabdan*-15-*ylcyanamide* (**33**).—*Method A.* The cyanamide (**33**) (30 mg), I_2 (22 mg), and LTA (120 mg) in cyclohexane (10 ml) at 20 °C irradiated for 1 h, gave (**34**) (*ca.* 2:1; 23 mg, 77%).

Method B. Compound (**33**) (27 mg), I_2 (21 mg), and DIB (29 mg) in cyclohexane (9 ml), at 20 °C for 1.2 h, gave (**34**) (*ca.* 2:1; 24 mg, 90%).

N-*Methoxyformimidoyl*-3β-*methoxymethoxy*-6β,19-*epimino*-5α-*cholestane* (**8**).—To a solution of (**7**) (90 mg, 0.18 mmol) in MeOH (40 ml), potassium cyanide (13 mg, 0.2 mmol) was added and the mixture refluxed for 24 h; it was then poured into water and extracted with Et_2O. The extract was evaporated and the

residue on column chromatography ($CHCl_3$–MeOH, 1:1) gave the title compound (**8**) (95 mg, 95%), amorphous; $\nu_{max.}$ 3 340 (NH) and 1 660 cm^{-1} (C=N); δ_H (200 MHz) 0.66 (3 H, s, 13-Me), 0.85 (6 H, d, *J* 6.6 Hz, 25-Me_2), 0.87 (3 H, d, *J* 6.7 Hz, 20-Me), 2.97 and 3.19 (2 H, AB, *J* 9.7 Hz, 19-H_2), 3.34 (3 H, s, OMe), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H), 3.74 [3 H, s, C(NH)OMe], and 4.65 (2 H, s, OCH_2O); *m/z* 502.4141 (M^+, $C_{31}H_{54}N_2O_3$ 502.4133, 73%), 441.3836 (66, $C_{29}H_{49}N_2O$ 441.3844, M – $MeOCH_2O$), 239.1357 (41, $C_{12}H_{19}N_2O_3$ 239.1395, [**a**]), and 120.0834 (100, $C_8H_{10}N$ 120.0812, [**a**] – ROH – X + H) {fragment [**a**], R = MOM, X = C(NH)OMe}.

3β-*Acetoxy*-N-*carbamoyl*-6β,19-*epimino*-5α-*cholestane* (**10**).—A solution of the iminocholestane (**8**) (90 mg, 0.18 mmol) in acetic acid (29 ml) and water (7 ml) was refluxed for 24 h, after which it was poured into water, neutralized with $NaHCO_3$, and extracted with $CHCl_3$. The extract was dried and evaporated to dryness and the residue containing (**9**) acetylated. Column chromatography ($CHCl_3$–MeOH, 97:3) of the product gave the title compound (**10**) (57 mg, 63%), amorphous; $\nu_{max.}$ 3 500, 3 400 (NH), 1 720, 1 645, and 1 580 cm^{-1} (CO); δ_H (200 MHz) 0.66 (3 H, s, 13-Me), 0.85 (6 H, d, *J* 6.1 Hz, 25-Me_2), 0.88 (3 H, d, *J* 6.2 Hz, 20-Me), 2.01 (3 H, s, OAc), 2.96 and 3.20 (2 H, m, $W_{\frac{1}{2}}$ 16 Hz, 19-H_2), 3.40 (1 H, m, $W_{\frac{1}{2}}$ 18 Hz, 6α-H), 4.55 (2 H, m, $W_{\frac{1}{2}}$ 20 Hz, N–H_2), and 4.62 (1 H, m, $W_{\frac{1}{2}}$ 20 Hz, 3α-H); δ_C 12.65 (C-18), 18.77 (C-21), 21.44 (OCOMe), 22.54 (C-11), 22.70 (C-26), 22.94 (C-27), 23.77 (C-15), 24.01 (C-23), 27.60 (C-2), 28.04 (C-7), 28.18 (C-25), 28.38 (C-16), 32.25 (C-1), 35.11 (C-8), 35.49 (C-4), 35.89 (C-20), 36.35 (C-22), 39.68 (C-24), 40.08 (C-12), 43.36 (C-13), 47.51 (C-19), 54.83 (C-9), 55.49 (C-14), 56.42 (C-17), 71.79 (C-3), 157.16 ($CONH_2$), and 170.67 (COMe); only 27 signals are observed; *m/z* 443.3740 (M^+ – CONH, $C_{29}H_{49}NO_2$ 443.3761, 4%), 223.1096 (2, $C_{11}H_{15}N_2O_3$ 223.1082, [**a**]), 180.1003 (37, $C_{10}H_{14}NO_2$ 180.1024, [**a**] – X + H), and 120.0811 (100, $C_8H_{10}N$ 120.0812, [**a**] – ROH – X + H); (fragment [**a**], R = Ac, X = $CONH_2$).

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