The Synthesis of Some 32-Functionalised Lanostane Derivatives

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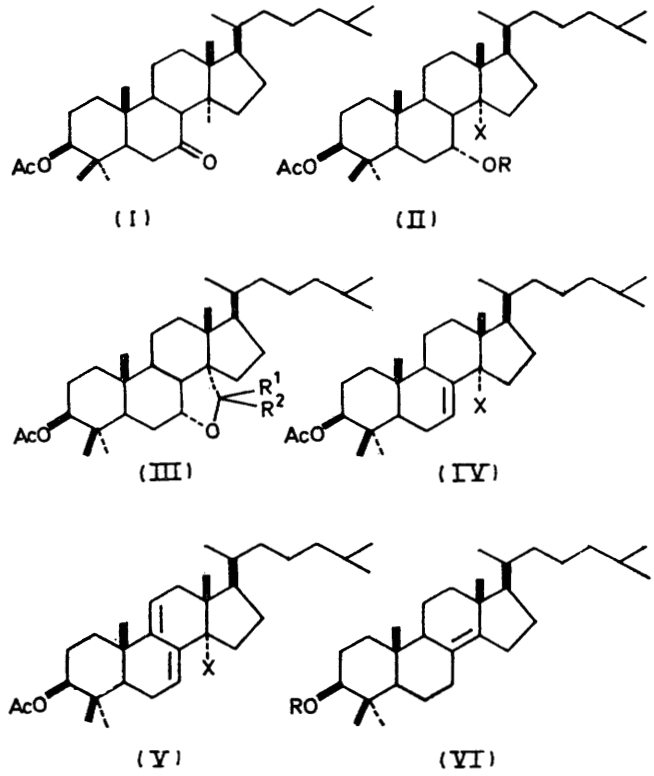
Lanosterol has been converted into 3β-acetoxylanost-7-en-32-onitrile and thence into 3β-acetoxylanost-7-en-32-al and 3β,32-diacetoxylanost-7-ene. 3β-Acetoxy-11-oxolanost-8-en-32-onitrile and methyl 3β-acetoxy-32-nitrilo-11-oxo-25,26,27-trinorlanost-8-en-24-oate have been synthesised by an analogous route. Unsuccessful attempts to prepare 3β-acetoxylanost-7-en-32-oic acid are reported, together with some novel methods for the oxidation of sterically hindered aldehydes as exemplified by using pivalaldehyde as a model compound.

CONSIDERABLE importance has been ascribed to 32-oxygenated derivatives of lanosterol as probable intermediates in the biosynthesis of cholesterol.[1] We report the synthesis of such compounds *via* the photolysis of the nitrite esters of a number of 7α-hydroxylanostane derivatives; preliminary accounts of part of this work have appeared.[2] Similar studies have been undertaken by two other groups of workers.[3,4] Further to their synthetic work, Fried and his co-workers demonstrated the efficient conversion of both lanost-7-ene-3β,32-diol and 3β-hydroxylanost-7-en-32-al into cholesterol by rat liver homogenates.[5]

3β-Acetoxylanostan-7α-ol (II; R = H, X = Me) was prepared by catalytic hydrogenation of 3β-acetoxylanostan-7-one (I).[6] Treatment of the product with nitrosyl chloride in anhydrous pyridine gave the crystaline 7α-nitrite (II; R = NO, X = Me). Photolysis [7] of the latter in benzene using a high-pressure mercury arc lamp with a Pyrex filter afforded the oxime (II; R = H, X = CH:N·OH) in 60% yield, together with minor amounts of the alcohol (II; R = H, X = Me) and the ketone (I).[8] Confirmation of the structure assigned to the oxime was obtained by its conversion into 3β,7α-diacetoxylanostan-32-onitrile (II; R = Ac, X = CN) using fused sodium acetate in refluxing acetic anhydride. Acetylation of the oxime under milder conditions (acetic anhydride–pyridine at room temperature for 1 h) gave the intermediate product, 3β-acetoxy-32-acetoxyiminolanostan-7α-ol (II; R = H, X = CH:N·OAc), which at its m.p. eliminated acetic acid to give 3β-acetoxy-7α-hydroxylanostan-32-onitrile (II; R = H, X = CN). This latter compound was more conveniently prepared by heating the acetoxy-imine (II; R = H, X = CH:N·OAc) in pyridine at 90° for 1 h.

Reduction of 3β-acetoxy-32-hydroxyiminolanostan-7α-ol (II; R = H, X = CH:N·OH) with zinc in glacial acetic acid afforded 3β-acetoxy-7α,32-epoxylanostane (III; $R^1 = R^2 = H$), identical with a sample prepared by the thermal reaction of 3β-acetoxylanostan-7α-ol with lead tetra-acetate.[3b] A correlation between 32-functionalised compounds obtained by the two alternative routes was thereby obtained. The close proximity of the 7α-hydroxy-group to the 32-hydroxyimino-function in (II; R = H, X = CH:N·OH) was also evident from other reactions of this compound. Thus, oxidation of the oxime (II; R = H, X = CH:N·OH) with Kiliani's chromic acid gave the γ-lactone (III; $R^1R^2 = O$) in good yield. Treatment of the oxime (II; R = H, X = CH:N·OH) with boron trifluoride–ether complex in glacial acetic acid afforded the imidolactone (III; $R^1R^2 = NH$). The latter was recovered unchanged after refluxing with ethanolic hydrochloric acid; however,

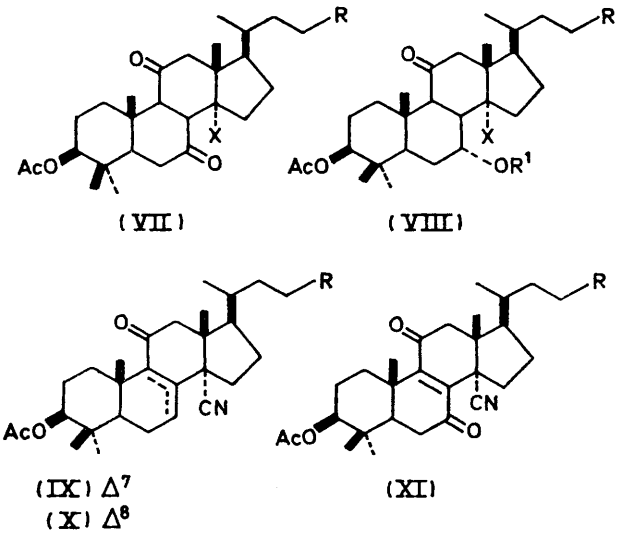


[1] (*a*) F. Gautschi and K. Bloch, *J. Amer. Chem. Soc.*, 1957, **79**, 684; *J. Biol. Chem.*, 1958, **233**, 1343; (*b*) R. B. Clayton, *Quart. Rev.*, 1965, **19**, 168.
[2] D. H. R. Barton, T. J. Bentley, and J. F. McGhie, *Tetrahedron Letters*, 1965, 2497; D. H. R. Barton, A. Hameed, and J. F. McGhie, *ibid.*, p. 4343.
[3] (*a*) J. Fried, J. W. Brown, and M. Applebaum, *Tetrahedron Letters*, 1965, 849; (*b*) J. Fried, J. W. Brown, and L. Borkenhagen, *ibid.*, p. 2499; (*c*) J. Fried and J. W. Brown, *ibid.*, 1966, 1677; (*d*) *ibid.*, 1967, 925.
[4] C. W. Shoppee, N. W. Hughes, and R. E. Lack, *J. Chem. Soc.* (*C*), 1966, 2359; *Tetrahedron Letters*, 1966, 5235.
[5] J. Fried, A. Dudowitz, and J. W. Brown, *Biochem. Biophys. Res. Comm.*, 1968, **32**, 568.
[6] D. H. R. Barton, P. L. Batten, and J. F. McGhie, *J. Chem. Soc.* (*C*), 1970, 1033.
[7] D. H. R. Barton, J. M. Beaton, L. E. Geller, and M. M. Pechet, *J. Amer. Chem. Soc.*, 1961, **83**, 4076.
[8] R. H. Hesse, *Adv. Free Radical Chem.*, 1968, **3**, 83.

treatment with nitrous acid readily furnished the γ-lactone (III; R^1R^2 = O). Alternatively, hydrolysis of the imidolactone (III; R^1R^2 = NH) with ethanolic potassium hydroxide gave 3β,7α-dihydroxylanostan-32-onitrile, characterised as the diacetate (II; R = Ac, X = CN).

The next step in our synthesis of compounds of biosynthetic interest involved the conversion of 3β-acetoxy-32-hydroxyiminolanostan-7α-ol (II; R = H, X = CH:N·OH) into 3β-acetoxylanost-7-en-32-onitrile (IV; X = CN). Attempted dehydration with thionyl chloride in pyridine was unsuccessful. However, the desired compound was obtained in high yield by treating the oxime (II; R = H, X = CH:N·OH) with methanesulphonyl chloride in pyridine to furnish the mesylate nitrile (II; R = SO_2Me, X = CN). This afforded the olefin (IV; X = CN) when heated in collidine for 21 h. It is well known that 3β-acetoxylanost-7-ene and 3β-acetoxylanost-8-ene enter into an acid-catalysed equilibrium,[9] and we hoped to utilise this to convert 3β-acetoxylanost-7-en-32-onitrile (IV; X = CN) into 3β-acetoxylanost-8-en-32-onitrile. However, treatment of the former (IV; X = CN) under a variety of conditions (anhydrous hydrogen chloride in chloroform, anhydrous hydrogen chloride, or hydrogen bromide in refluxing glacial acetic acid) failed to effect the desired isomerisation. In an alternative approach we utilised the observation of Halsall and his co-workers [10] that reduction of 3β-acetoxylanosta-7,9(11)-diene (V; X = Me) with lithium in liquid ammonia results in a mixture of lanost-7-en-3β-ol and lanost-8-en-3β-ol. Accordingly, 3β-acetoxylanost-7-en-32-onitrile (IV; X = CN) was oxidised with selenium dioxide to 3β-acetoxylanosta-7,9(11)-dien-32-onitrile (V; X = CN), which was reduced with lithium in liquid ammonia. The crude product showed no nitrile absorption in the i.r. spectrum, and appeared to be a mixture of the isomeric 32-norlanosten-3β-ols. In keeping with this supposition, treatment of the total product with a platinum catalyst in acetic acid in an atmosphere of hydrogen gave the known [1a] 32-norlanost-8(14)-en-3β-ol (VI; R = H), further identified as the corresponding acetate (VI; R = Ac).

While the foregoing work was in progress we also investigated two analogous series of reactions starting from 3β-acetoxylanostane-7,11-dione [11] (VII; R = Bu^i, X = Me) and methyl 3β-acetoxy-7,11-dioxo-25,26,27-trinorlanostan-24-oate [12] (VII; R = CO_2Me, X = Me). Thus, catalytic hydrogenation of the diketone (VII; R = CO_2Me, X = Me) afforded 3β-acetoxy-7α-hydroxy-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = H, R^2 = CO_2Me, X = Me) (58%) together with the corresponding 7β-hydroxy-compound and methyl 3β-acetoxy-25,26,27-trinorlanosta-7,9(11)-dien-24-oate. The 7α-alcohol, with nitrosyl chloride in pyridine, gave the crystalline 7α-nitrite (VIII; R^1 = NO, R^2 = CO_2Me, X = Me), which on photolysis in benzene solution gave methyl 3β-acetoxy-7α-hydroxy-32-hydroxyimino-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH) (55%). The alcohol (VIII;



R^1 = H, R^2 = CO_2Me, X = Me) and the ketone (VII; R = CO_2Me, X = Me) were detected as minor products of this reaction. By controlled acetylation of the oxime (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH) under progressively more forcing conditions we were able to prepare selectively methyl 3β-acetoxy-32-acetoxyimino-7α-hydroxy-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OAc), methyl 3β,7α-diacetoxy-32-acetoxyimino-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = Ac, R^2 = CO_2Me, X = CH:N·OAc), or methyl 3β,7α-diacetoxy-32-nitrilo-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = Ac, R^2 = CO_2Me, X = CN). Similarly, 3β-acetoxylanostane-7,11-dione (VII; R = Bu^i, X = Me) was converted into the oxime (VIII; R^1 = H, R^2 = Bu^i, X = CH:N·OH), which afforded an analogous range of acetoxy-derivatives.

Treatment of either oxime (VIII; R^1 = H, X = CH:N·OH, R^2 = CO_2Me or Bu^i) with methanesulphonyl chloride in pyridine gave the respective mesylate nitriles (VIII; R^1 = SO_2Me, X = CN, R^2 = CO_2Me or Bu^i). When heated in collidine for 90 h the mesylate nitrile (VIII; R^1 = SO_2Me, X = CN, R^2 = Bu^i) gave 3β-acetoxy-11-oxolanost-7-en-32-onitrile (IX; R = Bu^i) and 3β-acetoxy-11-oxolanost-8-en-32-onitrile (X; R = Bu^i) in a ratio of approximately 6 : 4 (u.v. spectroscopy). Attempts to isomerise this mixture to the desired conjugated isomer (X; R = Bu^i) were unsuccessful.

In a more convenient procedure the mesylate nitrile (VIII; R^1 = SO_2Me, X = CN, R^2 = Bu^i) was treated with potassium t-butoxide in refluxing t-butyl alcohol for

[9] R. E. Marker, E. L. Wittle, and L. W. Mixon, *J. Amer. Chem. Soc.*, 1937, **59**, 1368; J. F. Cavalla, J. F. McGhie, and M. K. Pradhan, *J. Chem. Soc.*, 1951, 3142.

[10] S. Brewis, T. G. Halsall, and G. C. Sayer, *J. Chem. Soc.*, 1962, 2763.

[11] C. Dorée, J. F. McGhie, and F. Kurzer, *J. Chem. Soc.*, 1948, 988.

[12] W. Voser, O. Jeger, and L. Ruzicka, *Helv. Chim. Acta*, 1952, **35**, 497.

3 h. Reacetylation (pyridine–acetic anhydride; room temperature, overnight) followed by chromatography gave approximately equal amounts of the required 3β-acetoxy-11-oxolanost-8-en-32-onitrile (X; R = Bu^i) and an autoxidation product, 3β-acetoxy-7,11-dioxolanost-8-en-32-onitrile (XI; R = Bu^i). The latter was readily converted into the former by reduction with sodium borohydride to give 3β-acetoxy-7β-hydroxy-11-oxolanost-8-en-32-onitrile, which on further reduction with zinc in glacial acetic acid gave (X; R = Bu^i). The structure assigned to compound (XI; R = Bu^i) was confirmed by its reduction with zinc in glacial acetic acid to 3β-acetoxy-7,11-dioxolanostan-32-onitrile (VII; R = Bu^i, X = CN), identical with an authentic sample prepared by oxidation of 3β-acetoxy-7α-hydroxy-11-oxolanostan-32-onitrile (VIII; R^1 = H, R^2 = Bu^i, X = CN) (see following paper). Similar experiments starting from the mesylate nitrile (VIII; R^1 = SO_2Me, X = CN, R^2 = CO_2Me) made available methyl 3β-acetoxy-32-nitrilo-11-oxo-25,26,27-trinorlanost-8-en-24-oate (X; R = CO_2Me) and methyl 3β-acetoxy-32-nitrilo-7,11-dioxo-25,26,27-trinorlanost-8-en-24-oate (XI; R = CO_2Me).

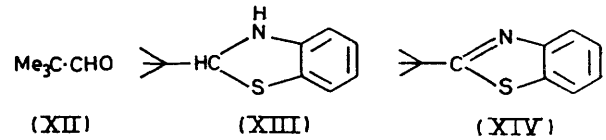
With a practicable synthesis of lanostan-32-onitrile derivatives well established, its logical extension to compounds possessing a hydroxymethyl, a formyl, or a carboxy-group in position 32 was next investigated, employing 3β-acetoxylanost-7-en-32-onitrile (IV; X = CN) as a model compound. All attempts to hydrolyse the nitrile group of (IV; X = CN) failed to give the corresponding carboxylic acid (IV; X = CO_2H), an indication of the steric protection afforded to substituents at this position in the lanosterol skeleton. Several examples have been recorded of the partial reduction of sterically hindered nitriles with lithium aluminium hydride.[13] Accordingly, the nitrile (IV; X = CN) in dry tetrahydrofuran was shaken at room temperature with an excess of lithium aluminium hydride for 3 days. Hydrolysis and crystallisation of the crude product from methanol yielded 3β-hydroxylanost-7-en-32-al (43%), characterised as the acetate (IV; X = CHO). Acetylation of the mother liquors followed by column chromatography gave, in order of elution, 3β-acetoxy-4,4-dimethylcholest-8(14)-ene (VI; R = Ac), a mixture of the required aldehyde (IV; X = CHO) and 3β-acetoxylanost-7-en-32-onitrile (IV; X = CN), and 3β-acetoxy-32-acetylaminolanost-7-ene (IV; X = CH_2·NHAc). A variety of reaction conditions were investigated in attempts to improve the yield of the aldehyde (IV; X = CHO); however only the conditions described gave acceptable yields.

Reduction of the aldehyde (IV; X = CHO) with lithium aluminium hydride gave lanost-7-ene-3β,32-diol, further characterised as the diacetate (IV; X = CH_2·OAc). This completed the synthesis of the second of the desired 32-oxygenated lanostanes.

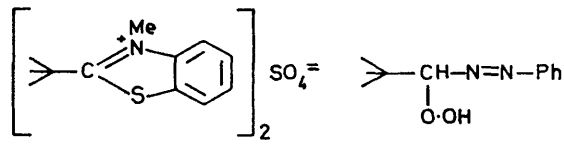
[13] T. Jen and M. E. Wolff, *J. Org. Chem.*, 1963, **28**, 1573.
[14] J. M. Metzger and H. Plank, *Bull. Soc. chim. France*, 1956, 1692.

Despite the use of a wide spectrum of reagents normally effective for the conversion of aldehydes into carboxylic acids we were unsuccessful in our attempts to convert (IV; X = CHO) into the acid (IV; X = CO_2H). In continued efforts towards this goal we devised a number of novel methods for the oxidation of sterically hindered aldehydes, using pivalaldehyde (XII) as a model compound. Although none of these methods proved successful when applied to the synthesis of the acid (IV; X = CO_2H), we record some of the more interesting aspects of this work.

Condensation of pivalaldehyde with 2-aminobenzenethiol gave 2-t-butylbenzothiazoline (XIII), which was readily oxidised by aqueous iron(III) chloride to 2-t-butylbenzothiazole (XIV).[14] With dimethyl sulphate the latter gave bis-(*N*-methyl-2-t-butylbenzothiazolium) sulphate (XV). This was expected to afford pivalic acid on basic hydrolysis. In the event use of ethanolic potassium hydroxide regenerated compound (XIV), and it was only by the use of alkaline hydrogen peroxide under vigorous conditions that an appreciable yield (30%) of pivalic acid was obtained.



(XII) (XIII) (XIV)



(XV) (XVI)

In a further approach we utilised the known tendency of aldehyde phenylhydrazones to undergo autoxidation.[15] Reaction of pivalaldehyde phenylhydrazone with oxygen gave 1-hydroperoxy-2,2-dimethylpropane-1-azobenzene (XVI), which when subjected either to basic hydrolysis or to oxidation afforded pivalic acid (see Table 1).

TABLE 1

Cleavage of 1-hydroperoxy-2,2-dimethylpropane-1-azobenzene

Reagent	% Yield of Pivalic acid [a]
Ethanolic potassium hydroxide	65
Manganese dioxide in benzene	8
Molecular oxygen; platinum catalyst	11
Neutral silver oxide	12
Potassium permanganate	28
Kiliani's chromic acid	85

[a] Yields were estimated by titration against standard sodium hydroxide solutions. Appropriate blank titrations were performed. In appropriate cases the pivalic acid was also characterised as the anilide.

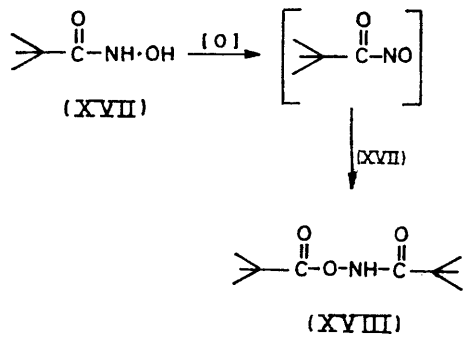
[15] A. J. Bellamy and R. D. Guthrie, *J. Chem. Soc.*, 1965, 2788; H. C. Yao and P. Resnick, *J. Org. Chem.*, 1965, **30**, 2832.

The success of these experiments encouraged us to attempt the oxidation of the aldehyde (IV; X = CHO) by a similar reaction sequence. The phenylhydrazone of the aldehyde (IV; X = CHO) in light petroleum was shaken in oxygen. The product, a yellow solid, appeared to be the desired phenylazo-hydroperoxide [IV; X = CH(O·OH)·N=NPh]. However its instability prevented a full spectral analysis. When this hydroperoxide was treated with either ethanolic potassium hydroxide or Kiliani's chromic acid neither the acid (IV; X = CO_2H) nor its decarboxylation product (VI; R = Ac) could be detected.

The basis of the Angeli–Rimini test [16] involves the reaction of an aldehyde with benzenesulphonohydroxamic acid (Piloty's acid); the resulting hydroxamic acid may be detected by its characteristic colour reactions with iron(III) chloride solution. The cleavage of a hydroxamic acid to the corresponding carboxylic acid with periodic acid is an efficient process.[17] We envisaged a combination of these two reactions. First we ascertained that the sodium benzenesulphinate, formed in the reaction, did not interfere with the periodic acid cleavage of hydroxamic acids. Benzaldehyde reacted with benzenesulphonohydroxamic acid in the presence of sufficient ethanolic potassium hydroxide to maintain the solution at approximately pH 8. Excess of benzenesulphonohydroxamic acid was destroyed by adjusting the solution to pH 11, a necessary precaution since benzenesulphonohydroxamic acid reacts with periodic acid to form intractable ether-soluble products. Acidification, followed by the addition of periodic acid, gave an 84% yield of benzoic acid. Similarly, pivalaldehyde afforded pivalic acid (42%). However, the aldehyde (IV; X = CHO) did not react under these conditions. Consequently an alternative synthesis of the desired hydroxamic acid (IV; X = CO·NH·OH) was investigated. The oxime of 3β-acetoxylanost-7-en-32-al (IV; X = CHO) was oxidised with lead tetra-acetate to the nitrile oxide (IV; X = $C\equiv\overset{+}{N}-O^-$).[18] This was isolated as a stable, crystalline solid, a further indication of the severely hindered nature of substituents at position 32.

Reaction of the nitrile oxide (IV; X = $C\equiv\overset{+}{N}-O^-$) with glacial acetic acid afforded the required *O*-acetyl-3β-acetoxylanost-7-en-32-ohydroxamic acid (IV; X = CO·NH·OAc) in high yield. This compound, on hydrolysis followed by treatment with periodic acid, gave a non-acidic oil which t.l.c. showed to be 70% one compound. This compound was slightly more polar on t.l.c. than 4,4-dimethylcholest-8(14)-en-3β-ol (VI; R = H). Since it was clearly not the desired acid (IV; X = CO_2H), this reaction was not investigated further.

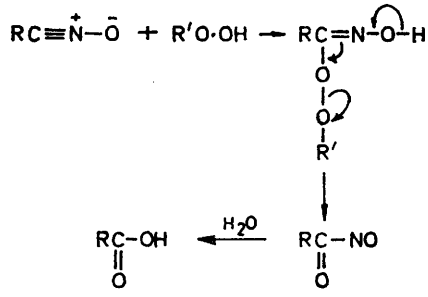
We then examined alternative methods for the cleavage of hydroxamic acids, employing pivalohydroxamic acid (XVII) as a model compound. Treatment of compound (XVII) with neutral silver oxide or with manganese dioxide, or with aqueous potassium ferricyanide at pH 9, gave not the desired pivalic acid, but pivaloyl pivalohydroxamate (XVIII) in high yield (see Scheme 1). Similarly, oxidation with lead tetra-acetate



SCHEME 1

or thallium(III) acetate yielded a mixture of pivaloyl pivalohydroxamate (XVIII) and acetyl pivalohydroxamate. The required cleavage of (XVII) to pivalic acid was however accomplished in 76% yield using potassium t-butoxide in t-butyl alcohol in an atmosphere of oxygen. Again the sequence proved unsuccessful when applied to the case of the carboxylic acid (IV; X = CO_2H).

Finally, we envisaged the conversion of a nitrile oxide into the corresponding carboxylic acid. Benzonitrile oxide [19] and mesitonitrile oxide [20] served as model compounds for our initial investigations. Alkaline hydrogen peroxide and t-butyl hydroperoxide were selected as oxidants, according to the hypothesis of Scheme 2.



SCHEME 2

Preliminary experiments indicated that the desired reaction was taking place but that the efficiency of the process was pH-dependent (see Table 2).

The rate of consumption of mesitonitrile oxide (determined by i.r. spectroscopy) increased rapidly over the pH range of the above experiments; the time for complete reaction varied from 2—3 days at pH 8 to 10—15 min at pH 14. It was evident that at high pH values alternative reactions of the nitrile oxide were taking

[16] P. A. S. Smith and G. E. Hein, *J. Amer. Chem. Soc.*, 1960, **82**, 5731.
[17] T. Emery and J. B. Neilands, *J. Amer. Chem. Soc.*, 1960, **82**, 4903.
[18] G. Just and K. Dahl, *Tetrahedron Letters*, 1966, 2441.
[19] H. Wieland, *Ber.*, 1907, **40**, 1667.
[20] C. Grundmann and J. M. Dean, *J. Org. Chem.*, 1965, **30**, 2809.

place. In preparative runs employing mesitonitrile oxide and benzonitrile oxide in solutions buffered to pH 11, the yields of mesitoic acid and benzoic acid were 35 and 49%, respectively. The need for strict pH control

TABLE 2

Conversion of mesitonitrile oxide into mesitoic acid as a function of pH

pH [a]	8	9	10	11	12	13	14
Yield of mesitoic acid using hydrogen peroxide (%)	15	15	43	47	44	8	2
Yield of mesitoic acid using t-butyl hydroperoxide (%)	3	4	10	9	7	7	0

[a] Sodium hydroxide–potassium dihydrogen phosphate buffer.

made this oxidative method unattractive in the lanosterol series.

Biosynthetic experiments complementary to the foregoing work are being undertaken in collaboration with Dr. M. A. Akhtar, Southampton University.[21]

EXPERIMENTAL

M.p.s were determined with a Kofler hot-stage apparatus. N.m.r. data refer to solutions in deuteriochloroform with tetramethylsilane as internal standard; they were recorded on a Perkin-Elmer R10 or a Varian A60 instrument. Unless otherwise stated rotations refer to solutions in chloroform, and i.r. spectra to Nujol mulls. U.v. spectral data are for ethanol solutions. Column chromatography was performed on Spence alumina (grade H or O as specified). Ether refers to diethyl ether and light petroleum to the fraction b.p. 40—60°. Organic extracts were washed thoroughly with water, dried over anhydrous magnesium sulphate, and evaporated under reduced pressure. Kiliani's chromic acid was prepared by adding concentrated sulphuric acid (6·5 ml) to a solution of sodium dichromate (9·0 g) in water (40 ml).

3β-*Acetoxylanostan*-7α-*ol* (II; R = H, X = Me).—3β-Acetoxylanostan-7-one [6] (10 g) was dissolved in ethyl acetate (100 ml) with warming. Acetic acid (100 ml) was added and the solution cooled to room temperature. Perchloric acid (72%; 5 drops) and Adams platinum oxide (500 mg) were added, and the mixture was hydrogenated until the uptake of gas had ceased (3—6 h). Any precipitate was redissolved by the addition of ethyl acetate and the catalyst was then removed by filtration. The filtrate was poured into water (500 ml) and extracted with ether. The combined extracts were washed thoroughly with sodium hydrogen carbonate solution, then water, dried, and evaporated. Crystallisation of the residue from ethyl acetate–methanol gave needles of 3β-acetoxylanostan-7α-ol (6·9 g, 69%), m.p. 205—206°, $[\alpha]_D$ +13·8° (*c* 1·00) (lit.,[22] m.p. 205—206°, $[\alpha]_D$ +14°). Chromatography of the mother liquors on type O alumina gave 3β-acetoxylanost-7-ene, m.p. 144—146°, $[\alpha]_D$ +31° (lit.,[23] m.p. 145—146°, $[\alpha]_D$ +28°) and 3β-acetoxylanostan-7-one, m.p. 170—172°, $[\alpha]_D$ +34·5° (lit.,[22] m.p. 172°, $[\alpha]_D$ +36°).

3β-*Acetoxylanostan*-7α-*yl Nitrite* (II; R = NO, X = Me).—3β-Acetoxylanostan-7α-ol (10 g) in dry pyridine (250 ml) was cooled to −15°. Nitrosyl chloride was passed into the solution for 10 min. The dark brown solution was poured into water and the crude product filtered off. Crystallisation from methanol–pyridine gave the *nitrite* (9·5 g, 92%), m.p. 157—158°, $[\alpha]_D$ −74° (*c* 0·67 in pyridine), $\nu_{max.}$ 1730, 1630, 1245, and 775 cm^{-1} (Found: C, 74·0; H, 10·4; N, 2·6. $C_{32}H_{55}NO_4$ requires C, 74·2; H, 10·7; N, 2·7%).

3β-*Acetoxy*-32-*hydroxyiminolanostan*-7α-*ol* (II; R = H, X = CH:N·OH).—3β-Acetoxylanostan-7α-yl nitrite (4 g) in dry benzene (500 ml) was photolysed using a 125 W high-pressure mercury-vapour lamp (Phillips type MBL/7) in an atmosphere of dry, oxygen-free nitrogen. Photolysis was continued until no nitrite remained (t.l.c. or i.r. control; *ca.* 2 h). The solvent was evaporated off and the yellow residue crystallised from a small volume of methanol to give the *oxime* (2·4 g, 60%), m.p. 159 and 177—179°, $[\alpha]_D$ −15° (*c* 0·9), $\nu_{max.}$ 3600, 3450, 1720, 1635, and 1255 cm^{-1} (Found: C, 74·15; H, 10·5; N, 2·7. $C_{32}H_{55}NO_4$ requires C, 74·2; H, 10·7; N, 2·7%).

3β,7α-*Diacetoxylanostan*-32-*onitrile* (II; R = Ac, X = CN).—3β-Acetoxy-32-hydroxyiminolanostan-7α-ol (520 mg) was added to a mixture of acetic anhydride (5 ml) and fused sodium acetate (1·0 g). The solution was refluxed for 1 h and then poured into ice–water. Extraction with ether gave an oil (480 mg) which crystallised from ethyl acetate–methanol to give needles of 3β,7α-*diacetoxylanostan*-32-*onitrile* (300 mg, 55%), m.p. 234—235°, $[\alpha]_D$ +4·5° (*c* 1·00), $\nu_{max.}$ 2225, 1725, and 1240 cm^{-1} (Found: C, 75·5; H, 10·2; N, 2·6. $C_{34}H_{55}NO_4$ requires C, 75·4; H, 10·2; N, 2·6%).

3β-*Acetoxy*-32-*acetoxyiminolanostan*-7α-*ol* (II; R = H, X = CH:N·OAc). 3β-Acetoxy-32-hydroxyiminolanostan-7α-ol (100 mg) in dry pyridine (10 ml) and acetic anhydride (1·0 ml) was left at room temperature for 1 h. The solution was poured into ice–water and extracted with ether to give an oil (91 mg). Crystallisation from aqueous methanol gave 3β-*acetoxy*-32-*acetoxyiminolanostan*-7α-*ol* (74 mg, 69%), m.p. 131—132° (decomposing to give 3β-acetoxy-7α-hydroxylanostan-32-onitrile, m.p. 212—213°, mixed m.p. with an authentic sample 213—216°), $[\alpha]_D$ −55° (*c* 1·00), $\nu_{max.}$ 3490, 1765, 1720, 1610, 1260, and 1200 cm^{-1} (Found: C, 72·8; H, 10·4; N, 2·7. $C_{34}H_{57}NO_5$ requires C, 72·9; H, 10·3; N, 2·5%).

3β-*Acetoxy*-7α-*hydroxylanostan*-32-*onitrile* (II; R = H, X = CN).—3β-Acetoxy-32-acetoxyiminolanostan-7α-ol (50 mg) in dry pyridine (2·5 ml) was heated on a steam-bath for 1 h. The solution was poured into ice–water and extracted with ether to give the *nitrile* (38 mg, 85%), m.p. (from aqueous methanol) 215—217°, $[\alpha]_D$ +11° (*c* 1·00), $\nu_{max.}$ 3580, 2220, 1730, and 1250 cm^{-1} (Found: C, 76·5; H, 11·0; N, 3·0. $C_{32}H_{53}NO_3$ requires C, 76·9; H, 10·7; N, 2·8%).

3β-*Acetoxy*-7α,32-*epoxylanostane* (III; $R^1 = R^2 = H$).—3β-Acetoxy-32-hydroxyiminolanostan-7α-ol (47 mg) in glacial acetic acid (20 ml) was heated under reflux during the addition of AnalaR zinc dust (1·2 g) (1 h). The mixture was filtered and the residual zinc dust was washed with acetic acid (2 × 10 ml). The combined filtrates were poured into water and extracted with ether. The extracts were washed with 2N-sodium hydroxide solution, then water, dried, and evaporated. The residue was recrystallised twice from methanol to give the ether, m.p. 181—183°,

[21] M. A. Akhtar, K. T. W. Alexander, D. H. R. Barton, R. B. Boar, and J. F. McGhie, *Chem. Comm.*, 1971, 1479.

[22] D. H. R. Barton and B. R. Thomas, *J. Chem. Soc.*, 1953, 1842.

[23] D. H. R. Barton, J. S. Fawcett, and B. R. Thomas, *J. Chem. Soc.*, 1951, 3147.

$[\alpha]_D$ +24°, $\nu_{max.}$ 1730, 1250, and 825 cm^{-1}, identical with an authentic sample prepared by the action of lead tetra-acetate on 3β-acetoxylanostan-7α-ol.[3b]

3β-*Acetoxylanostan*-32,7α-*olactone* (III; R^1R^2 = O).—3β-Acetoxy-32-hydroxyiminolanostan-7α-ol (100 mg) in acetone (20 ml) was shaken with Kiliani's chromic acid (2 ml) for 10 min at room temperature. Excess of oxidant was destroyed with sodium disulphite solution and the mixture was poured into water. Extraction with ether gave a solid (89 mg) which was crystallised from ethyl acetate–methanol. 3β-*Acetoxylanostan*-32,7α-*olactone* had m.p. 287—290°, [α] +51° (*c* 0·36), $\nu_{max.}$ 1760, 1730, and 1240 cm^{-1} (Found: C, 76·7; H, 10·4. $C_{32}H_{52}O_4$ requires C, 76·75; H, 10·5%). Similarly, 3β-acetoxy-7α-hydroxy-32-hydroxyiminolanostan-11-one (500 mg) gave 3β-acetoxy-11-oxolanostan-32,7α-olactone (417 mg, 87%), m.p. (from methanol) 276—277° (lit.,[4] 277—278°), $[\alpha]_D$ +83·3° (*c* 0·48), and methyl 3β-acetoxy-7α-hydroxy-32-hydroxyimino-11-oxo-25,26,27-trinorlanostan-24-oate (400 mg) gave *methyl* 3β-*acetoxy*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* 32,7α-*lactone* (300 mg, 78%), m.p. (from methanol) 277—278°, $[\alpha]_D$ +69·1° (*c* 0·5), $\nu_{max.}$ 1755, 1735, 1720, 1715, and 1245 cm^{-1} (Found: C, 69·9; H, 8·65. $C_{30}H_{44}O_7$ requires C, 69·7; H, 8·6%).

3β-*Acetoxy*-7α,32-*epoxy*-32-*iminolanostane* (III; R^1R^2 = NH).—3β-Acetoxy-32-hydroxyiminolanostan-7α-ol (100 mg) in refluxing glacial acetic acid (5 ml) was treated with redistilled boron trifluoride–ether complex (1 ml). After 2 min the mixture was poured into water and extracted with ether. The extracts were washed with 2N-sodium hydroxide solution, then water, dried, and evaporated. The brown product (85 mg) was crystallised from methanol to give needles of the *imidolactone* (48 mg, 50%), m.p. 180—183°, $[\alpha]_D$ +44° (*c* 2·1), $\nu_{max.}$ 1730, 1680, and 1240 cm^{-1} (Found: C, 77·8; H, 10·7; N, 2·7. $C_{32}H_{53}NO_3$ requires C, 76·9; H, 10·7; N, 2·8%).

Reaction of 3β-*Acetoxy*-7α-32-*epoxy*-32-*iminolanostane with Nitrous Acid*.—To a solution of the imidolactone (10 mg) in dioxan (4 ml) were added acetic acid (1·4 ml), water (0·25 ml), and a solution of sodium nitrite (33 mg) in water (0·5 ml). During 4 h at room temperature crystals of 3β-acetoxylanostan-32,7α-olactone separated (5 mg, 50%), m.p. 280—283°, mixed m.p. with an authentic sample 282—284°.

Reaction of 3β-*Acetoxy*-7α,32-*epoxy*-32-*iminolanostane with Ethanolic Potassium Hydroxide*.—A solution of the imidolactone (48 mg) and potassium hydroxide (500 mg) in ethanol (10 ml) was refluxed for 1 h, poured into water, and extracted with ether. The product thus obtained was dissolved in pyridine (5 ml) containing acetic anhydride (0·5 ml) and left at room temperature overnight. Normal work-up then gave 3β,7α-diacetoxylanostan-32-onitrile (38 mg, 73%), m.p. 225—228°, mixed m.p. with an authentic sample 226—229°.

3β-*Acetoxy*-32-*nitrilolanostan*-7α-*yl Methanesulphonate* (II; R = SO_2Me, X = CN).—A solution of 3β-acetoxy-32-hydroxyiminolanostan-7α-ol (500 mg) in dry pyridine (20 ml) was cooled to 0°. Redistilled methanesulphonyl chloride (1 ml) was added dropwise with shaking. The solution was allowed to warm to room temperature and was then left for a further 5 h. The mixture was poured into water. Extraction with ether and crystallisation from chloroform–methanol gave the *methanesulphonate* (496 mg, 89%), m.p. 173—174° (but variable with rate of heating), $[\alpha]_D$ +3° (*c* 0·83), $\nu_{max.}$ 2250, 1740, 1340, 1260, 1170, and 895 cm^{-1} (Found: C, 68·2; H, 9·8; N, 2·4; S, 5·9. $C_{33}H_{55}NO_5S$ requires C, 68·6; H, 9·5; N, 2·4; S, 5·55%).

3β-*Acetoxylanost*-7-*en*-32-*onitrile* (IV; X = CN).—A solution of 3β-acetoxy-32-nitrilolanostan-7α-yl methanesulphonate (3·38 g) in dry collidine (72 ml) was refluxed in an atmosphere of dry, oxygen-free nitrogen for 21 h (disappearance of i.r. absorptions at 1340 and 1170 cm^{-1}). The mixture was poured into water and extracted with ether. The combined extracts were thoroughly washed with 2N-hydrochloric acid, then water, and dried. Evaporation left a clear oil (3·12 g) which crystallised from chloroform–methanol as plates (2·23 g, 79%). 3β-*Acetoxylanost*-7-*en*-32-*onitrile* had m.p. 139—141°, $[\alpha]_D$ +30° (*c* 0·7), $\nu_{max.}$ 2230, 1740, and 1240 cm^{-1}, τ 4·2, 4·35 (1H, vinyl proton at C-7), and 5·45 (1H, 3α-proton) (Found: C, 79·6; H, 10·8; N, 2·8. $C_{32}H_{51}NO_2$ requires C, 79·8; H, 10·7; N, 2·9%).

3β-*Acetoxylanosta*-7,9(11)-*dien*-32-*onitrile* (V; X = CN).—3β-Acetoxylanost-7-en-32-onitrile (861 mg), selenium dioxide (432 mg), and water (216 mg) were heated in refluxing glacial acetic acid (27 ml) for 4 h. The mixture was filtered hot. Hot water was added to the filtrate until it became turbid. On cooling, fine plates of 3β-*acetoxylanosta*-7,9(11)-*dien*-32-*onitrile* were deposited (372 mg), m.p. 176—180°. Purified by chromatography on type O alumina and crystallisation from ethyl acetate–methanol, the compound had m.p. 183—186°, $[\alpha]_D$ +99° (*c* 0·6), $\nu_{max.}$ 2240, 1730, and 1240 cm^{-1}, $\lambda_{max.}$ 234, 242, and 251 nm (ε 13,000, 14,000, and 9800) (Found: C, 80·0; H, 10·3. $C_{32}H_{49}NO_2$ requires C, 80·1; H, 10·3%).

Reduction of 3β-*Acetoxylanosta*-7,9(11)-*dien*-32-*onitrile with Lithium in Liquid Ammonia*.—3β-Acetoxylanosta-7,9(11)-dien-32-onitrile (439 mg) in ether (100 ml) was added during 15 min to a stirred solution of redistilled liquid ammonia (150 ml) containing lithium (0·2 g). Further lithium (0·8 g) was added during 2 h. After a further 4 h ethanol (20 ml) was added. The mixture was set aside overnight. Water was added and the mixture was extracted with ether to give an oil (425 mg). Crystallisation from methanol gave a solid, m.p. 117—126°, $[\alpha]_D$ +21° (*c* 0·94); benzoate, m.p. 105—117°. In a separate experiment the crude product in glacial acetic acid (25 ml) was shaken with Adams platinum oxide (100 mg) in an atmosphere of hydrogen overnight. The product thus obtained was crystallised four times from ethyl acetate to give 4,4-dimethylcholest-8(14)-en-3β-ol (105 mg), m.p. 141—143°, $[\alpha]_D$ +15·4° (*c* 0·78) (lit.,[24] m.p. 142—143°, $[\alpha]_D$ +15·0°); acetate, m.p. 108—112°, $[\alpha]_D$ +32° (*c* 1·00) (lit.,[24] m.p. 115—117°, $[\alpha]_D$ +30°).

Methyl 3β-*Acetoxy*-7α-*hydroxy*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = H, R^2 = CO_2Me, X = Me).—Methyl 3β-acetoxy-7,11-dioxo-25,26,27-trinorlanostan-24-oate (18·1 g) in ethyl acetate (450 ml) and glacial acetic acid (450 ml) was hydrogenated in the presence of perchloric acid (72%; 6 drops) and Adams platinum oxide (500 mg) as described for 3β-acetoxylanostan-7-one. Crystallisation of the product from benzene–light petroleum gave *methyl* 3β-*acetoxy*-7α-*hydroxy*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (10·5 g, 58%), m.p. 250—251°, $[\alpha]_D$ +42° (*c* 0·51), $\nu_{max.}$ 3450, 1745, 1735, 1680, and 1250 cm^{-1} (Found: C, 71·5; H, 9·8. $C_{30}H_{48}O_6$ requires C, 71·4; H, 9·6%). The mother liquors from the crystallisation were chromatographed on type H alumina (750 g). Elution with benzene–light petroleum (1 : 1 v/v) gave *methyl* 3β-*acetoxy*-25,26,27-*trinorlanosta*-7,9(11)-*dien*-24-*oate* (3·2 g), m.p. (from methanol) 193—

[24] F. Gautschi and K. Bloch, *J. Biol. Chem.*, 1958, **233**, 1343.

194°, $[\alpha]_D$ +76·4° (*c* 0·52), $\lambda_{max.}$ 235, 242, and 251 nm (log ε 4·06, 4·10, and 3·95) (Found: C, 76·4; H, 10·0. $C_{30}H_{46}O_4$ requires C, 76·55; H, 9·85%). Further elution, with benzene–ether (9 : 1 v/v) gave a mixture of methyl 3β-acetoxy-7β-hydroxy-11-oxo-25,26,27-trinorlanostan-24-oate and the required 7α-epimer (3·8 g).

Similarly, hydrogenation of 3β-acetoxylanostane-7,11-dione gave as the major product 3β-*acetoxy*-7α-*hydroxylanostan*-11-*one*, m.p. 270—271°, $[\alpha]_D$ +39° (Found: C, 76·3; H, 10·8. $C_{32}H_{54}O_4$ requires C, 76·4; H, 10·8%).

Methyl 3β-*Acetoxy*-7α-*hydroxy*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* 7α-*Nitrite* (VIII; R^1 = NO, R^2 = CO_2Me, X = Me).—Prepared from the 7α-alcohol (8 g) the *nitrite* (7·9 g, 93%) had m.p. (from methanol–pyridine) 185—186°, $[\alpha]_D$ −38° (*c* 0·51 in pyridine), $\nu_{max.}$ 1740, 1735, 1685, 1615, 1245, and 800 cm^{-1} (Found: C, 67·4; H, 9·0; N, 2·7. $C_{30}H_{47}NO_7$ requires C, 67·5; H, 8·9; N, 2·6%).

Prepared similarly, 3β-*acetoxy*-11-*oxolanostan*-7α-*yl nitrite* (VIII; R^1 = NO, R^2 = Bu^i, X = Me) had m.p. 193—194°, $[\alpha]_D$ −35° (Found: C, 72·1; H, 10·0; N, 2·6. $C_{32}H_{53}NO_5$ requires C, 72·3; H, 10·05; N, 2·6%).

Methyl 3β-*Acetoxy*-7α-*hydroxy*-32-*hydroxyimino*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH).—The nitrite (VIII; R^1 = NO, R^2 = CO_2Me, X = Me) (4 g) in dry benzene (400 ml) was photolysed as described for 3β-acetoxylanostan-7α-yl nitrite. Crystallisation of the product from benzene–light petroleum gave the *oxime* (2·2 g, 55%), m.p. 249—251°, $[\alpha]_D$ +12° (*c* 0·48), $\nu_{max.}$ 3440, 3350, 1740, 1730, 1710, 1635, and 1250 cm^{-1} (Found: C, 67·4; H, 8·9; N, 2·8. $C_{30}H_{47}NO_7$ requires C, 67·5; H, 8·9; N, 2·6%).

Similarly prepared, 3β-*acetoxy*-7α-*hydroxy*-32-*hydroxyiminolanostan*-11-*one* (VIII; R^1 = H, R^2 = Bu^i, X = CH:N·OH) had m.p. 190—192°, $[\alpha]_D$ +16° (Found: C, 72·1; H, 10·2; N, 2·8. $C_{32}H_{53}NO_5$ requires C, 72·3; H, 10·05; N, 2·6%).

Treatment of Methyl 3β-*Acetoxy*-7α-*hydroxy*-32-*hydroxyimino*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH) *under Various Acetylating Conditions*.—The oxime (1·0 g) in acetic anhydride (3 ml) and pyridine (50 ml) was left at room temperature for 1 h. Normal work-up gave *methyl* 3β-*acetoxy*-32-*acetoxyimino*-7α-*hydroxy*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OAc) (705 mg, 66%), m.p. (from methanol) 156—157 and 241—242° [the latter being the m.p. of (VIII; R^1 = H, R^2 = CO_2Me, X = CN)], $[\alpha]_D$ −32·7° (*c* 0·51), $\nu_{max.}$ 3540, 1760, 1735, 1725, 1615, 1250, and 1210 cm^{-1} (Found: C, 66·8; H, 8·5; N, 2·3. $C_{32}H_{49}NO_8$ requires C, 66·75; H, 8·6; N, 2·4%). The oxime (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH) (200 mg) in acetic anhydride (2 ml) and pyridine (5 ml) was left at room temperature for 24 h. Normal work-up gave *methyl* 3β,7α-*diacetoxy*-32-*acetoxyimino*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = Ac, R^2 = CO_2Me, X = CH:N·OAc) (150 mg, 65%), m.p. (from methanol) 160—161 and 248—249° [the latter being the m.p. of (VIII; R^1 = Ac, R^2 = CO_2Me, X = CN)], $[\alpha]_D$ +28·8° (*c* 1·2), $\nu_{max.}$ 1770, 1740, 1730, 1706, 1620, 1240, and 1210 cm^{-1} (Found: C, 66·3; H, 8·3; N, 2·3. $C_{34}H_{51}NO_9$ requires C, 66·1; H, 8·3; N, 2·3%).

The oxime (VIII; R^1 = H, R^2 = CO_2Me, X = CH:N·OH) (100 mg) and fused sodium acetate (200 mg) in acetic anhydride (1 ml) and pyridine (5 ml) was heated on a steam-bath for 1·5 h. Normal work-up gave *methyl* 3β,7α-*diacetoxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII; R^1 = Ac, R^2 = CO_2Me, X = CN) (60 mg, 58%), m.p. (from methanol) 249—250°, $[\alpha]_D$ +28·2° (*c* 0·86), $\nu_{max.}$ 2230, 1745, 1730, 1710, and 1240 cm^{-1} (Found: C, 68·7; H, 8·4; N, 2·7. $C_{32}H_{47}NO_7$ requires C, 68·9; H, 8·5; N, 2·5%).

Analogous acetylations of 3β-acetoxy-7α-hydroxy-32-hydroxyiminolanostan-11-one gave 3β-*acetoxy*-32-*acetoxyimino*-7α-*hydroxylanostan*-11-*one* (VIII; R^1 = H, R^2 = Bu^i, X = CH:N·OAc), m.p. 183—184 and 247—248° [the latter being the m.p. of (VIII; R^1 = H, R^2 = Bu^i, X = CN)], $[\alpha]_D$ −30° (*c* 0·5), $\nu_{max.}$ 3540, 1775, 1720, 1695, 1620, 1255, and 1205 cm^{-1} (Found: C, 71·45; H, 9·6; N, 2·30. $C_{34}H_{55}NO_6$ requires C, 71·3; H, 9·7; N, 2·4%), 3β,7α-*diacetoxy*-32-*acetoxyiminolanostan*-11-*one* (VIII; R^1 = Ac, R^2 = Bu^i, X = CH:N·OAc), m.p. (from methanol) 164—165 and 204—205° [the latter being the m.p. of (VIII; R^1 = Ac, R^2 = Bu^i, X = CN)], $[\alpha]_D$ +32·2° (*c* 0·35), $\nu_{max.}$ 1770, 1735, 1730, 1700, 1620, 1245, and 1210 cm^{-1} (Found: C, 70·1; H, 9·4; N, 2·4. $C_{36}H_{57}NO_7$ requires C, 70·2; H, 9·3; N, 2·3%), and 3β,7α-*diacetoxy*-11-*oxolanostan*-32-*onitrile* (VIII; R^1 = Ac, R^2 = Bu^i, X = CN), m.p. (from methanol) 204—205°, $[\alpha]_D$ +33·8° (*c* 0·51), $\nu_{max.}$ 2235, 1745, 1735, 1710, and 1240 cm^{-1} (Found: C, 73·6; H, 9·7; N, 2·7. $C_{34}H_{53}NO_5$ requires C, 73·5; H, 9·6; N, 2·5%).

Alternative Preparation of 3β,7α-*Diacetoxy*-11-*oxolanostan*-32-*onitrile* (VIII; R^1 = Ac, R^2 = Bu^i, X = CN).—3β,7α-Diacetoxy-32-acetoxyiminolanostan-11-one (150 mg) in pyridine (10 ml) was heated on a steam-bath for 1·5 h. Normal work-up gave the nitrile, m.p. 204—205°, $[\alpha]_D$ +32·9°. Methyl 3β,7α-diacetoxy-32-nitrilo-11-oxo-25,26,27-trinorlanostan-24-oate (VIII; R^1 = Ac, R^2 = CO_2Me, X = CN) was also prepared by this method.

3β-*Acetoxy*-7α-*hydroxy*-11-*oxolanostan*-32-*onitrile* (VIII; R^1 = H, R^2 = Bu^i, X = CN).—3β-Acetoxy-32-acetoxyimino-7α-hydroxylanostan-11-one (700 mg) in dry pyridine (50 ml) was heated on a steam-bath for 1·5 h. Normal work-up gave the *nitrile* (510 mg, 81%), m.p. (from methanol) 247—248°, $[\alpha]_D$ +38° (*c* 0·50), $\nu_{max.}$ 3400, 2240, 1730, 1690, and 1240 cm^{-1} (Found: C, 74·65; H, 10·0; N, 2·8. $C_{32}H_{51}NO_4$ requires C, 74·8; H, 10·0; N, 2·7%). Hydrolysis with 5% sodium hydroxide in ethanol gave 3β,7α-*dihydroxy*-11-*oxolanostan*-32-*onitrile*, m.p. (from methanol) 239—240°, $[\alpha]_D$ +41·6 (*c* 0·55), $\nu_{max.}$ 3340, 3200, 2240, and 1700 cm^{-1} (Found: C, 76·2; H, 10·6; N, 2·9. $C_{30}H_{49}NO_3$ requires C, 76·4; H, 10·5; N, 3·0%).

Similarly methyl 3β-acetoxy-32-acetoxyimino-7α-hydroxy-11-oxo-25,26,27-trinorlanostan-24-oate gave *methyl* 3β-*acetoxy*-7α-*hydroxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate*, m.p. (from methanol) 242—243°, $[\alpha]_D$ +32·4° (*c* 0·51), $\nu_{max.}$ 3450, 2225, 1735, 1725, 1695, and 1245 cm^{-1} (Found: C, 69·9; H, 8·6; N, 2·2. $C_{30}H_{45}NO_6$ requires C, 69·9; H, 8·8; N, 2·7%).

3β-*Acetoxy*-32-*nitrilo*-11-*oxolanostan*-7α-*yl Methanesulphonate* (VIII; R^1 = SO_2Me, R^2 = Bu^i, X = CN).—A solution of 3β-acetoxy-7α-hydroxy-11-oxolanostan-32-onitrile (4·4 g) in dry pyridine (75 ml) at 0° was treated with methanesulphonyl chloride (7 ml). The solution was maintained at this temperature overnight and then poured on ice. The precipitate was filtered off, washed with water, and dried. Recrystallisation from chloroform–methanol gave the *methanesulphonate* (3·5 g, 69%), m.p. 227—228°, $[\alpha]_D$ +23·6° (*c* 0·48), $\nu_{max.}$ 2225, 1730, 1710, 1340, 1260, 1175, and 900 cm^{-1} (Found: C, 66·8; H, 8·8; N, 2·3; S, 5·4. $C_{33}H_{53}NO_6S$ requires C, 67·0; H, 9·0; N, 2·4; S, 5·4%).

Similarly prepared, *methyl* 3β-*acetoxy*-7α-*methylsulphonyloxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanostan*-24-*oate* (VIII;

$R^1 = SO_2Me$, $R^2 = CO_2Me$, X = CN) had m.p. (from methanol) 209—210°, $[\alpha]_D$ +2·2° (*c* 1·0), $\nu_{max.}$ 2260 1750, 1740, 1710, 1330, 1240, 1170, and 900 cm^{-1} (Found: C, 62·5; H, 7·85; N, 2·3; S, 5·2. $C_{31}H_{47}NO_8S$ requires C, 62·7; H, 8·0; N, 2·4; S, 5·4%).

Reaction of 3β-*Acetoxy*-32-*nitrilo*-11-*oxolanostan*-7α-*yl Methanesulphonate in Refluxing Collidine*.—A solution of the methanesulphonate (400 mg) in dry collidine (60 ml) was heated under reflux for 90 h. Work-up in the usual manner gave an oil which was chromatographed on type H alumina (10 g). Elution with benzene–light petroleum (1 : 1 v/v) gave an oil (363 mg), shown by t.l.c. to be a mixture of two compounds, $\nu_{max.}$ 2225, 1740, 1710 (ketone), 1670 and 1600 (αβ-unsaturated ketone), and 1245 cm^{-1}, $\lambda_{max.}$ 247 nm (log ε 3·5). Attempts to isomerise this mixture entirely to the conjugated isomer (X; R = Bu^i) with boron trifluoride–ether in refluxing benzene or methanesulphonic acid in refluxing glacial acetic acid failed.

3β-*Acetoxy*-11-*oxolanost*-8-*en*-32-*onitrile* (X; R = Bu^i) *and* 3β-*Acetoxy*-7,11-*dioxolanost*-8-*en*-32-*onitrile* (XI; R = Bu^i).—3β-Acetoxy-32-nitrilo-11-oxolanostan-7α-yl methanesulphonate (4 g) in dry t-butyl alcohol (150 ml) was heated under reflux in an atmosphere of nitrogen. Potassium (1·2 g) in dry t-butyl alcohol (100 ml) was added. The solution was refluxed for a further 3 h, then poured into water, and extracted with ether. The product thus obtained was dissolved in pyridine (9 ml) and acetic anhydride (12 ml) and left overnight at room temperature. Normal work-up gave a yellow solid which was chromatographed on type H alumina (100 g). Elution with benzene–light petroleum (2 : 1 v/v) gave 3β-*acetoxy*-11-*oxolanost*-8-*en*-32-*onitrile* (1·8 g), m.p. (from methanol) 175—176°, $[\alpha]_D$ +79·7° (*c* 0·49), $\nu_{max.}$ 2225, 1740, 1670, 1600, and 1245 cm^{-1}, $\lambda_{max.}$ 247 nm (log ε 3·96) (Found: C, 77·35; H, 9·8; N, 2·9. $C_{32}H_{49}NO_3$ requires C, 77·5; H, 10·0; N, 2·8%). Further elution gave some mixed fractions (0·65 g) and then pure 3β-*acetoxy*-7,11-*dioxolanost*-8-*en*-32-*onitrile* (1·4 g), m.p. (from methanol) 200—201°, $[\alpha]_D$ +22·3° (*c* 0·46), $\nu_{max.}$ 2230, 1730, 1695, 1685, and 1260 cm^{-1}, $\lambda_{max.}$ 257 nm (log ε 3·91) (Found: C, 75·3; H, 9·5; N, 2·9. $C_{32}H_{47}NO_4$ requires C, 75·4; H, 9·3; N, 2·75%).

3β-*Acetoxy*-7,11-*dioxolanostan*-32-*onitrile* (VII; R = Bu^i, X = CN).— 3β-Acetoxy-7,11-dioxolanost-8-en-32-onitrile (200 mg) in refluxing glacial acetic acid (30 ml) was treated with zinc dust (200 mg) over a period of 30 min. The solution was refluxed for a further 2 h and then decanted on crushed ice. The residual zinc was extracted with boiling glacial acetic acid (2 × 5 ml), and these extracts were added to the ice. The precipitate was filtered off, washed with water, and dried. Recrystallisation from methanol gave 3β-acetoxy-7,11-dioxolanostan-32-onitrile (153 mg, 76%), m.p. and mixed m.p. 243—244° (see following paper).

3β-*Acetoxy*-7β-*hydroxy*-11-*oxolanost*-8-*en*-32-*onitrile*.—Sodium borohydride (200 mg) suspended in ethanol (20 ml) was added during 30 min to a stirred solution of 3β-acetoxy-7,11-dioxolanost-8-en-32-onitrile (400 mg) in ethanol (100 ml) at room temperature. The mixture was stirred for a further 2 h and then poured into water. Extraction with ether gave the *monoketone* (253 mg, 63%), m.p. (from methanol) 221—222°, $[\alpha]_D$ +89·6° (*c* 0·50), $\nu_{max.}$ 3400, 2230, 1740, 1650, 1595, and 1240 cm^{-1}, $\lambda_{max.}$ 243 nm (log ε 3·88) (Found: C, 75·3; H, 9·8; N, 2·45. $C_{32}H_{49}NO_4$ requires C, 75·1; H, 9·65; N, 2·7%).

3β-*Acetoxy*-11-*oxolanost*-8-*en*-32-*onitrile*.—3β-Acetoxy-7β-hydroxy-11-oxolanost-8-en-32-onitrile (200 mg) in refluxing glacial acetic acid (30 ml) was reduced with zinc dust (200 mg) as described for the 7,11-dione to give 3β-acetoxy-11-oxolanost-8-en-32-onitrile (146 mg, 73%), m.p. (from methanol) 175—176°, $[\alpha]_D$ +80·7° (*c* 0·52), identical with an authentic sample.

Methyl 3β-*Hydroxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanost*-8-*en*-24-*oate and Methyl* 3β-*Hydroxy*-32-*nitrilo*-7,11-*dioxo*-25,26,27-*trinorlanost*-8-*en*-24-*oate*.—Methyl 3β-acetoxy-7α-methylsulphonyloxy-32-nitrilo-11-oxo-25,26,27-trinorlanostan-24-oate (500 mg) was treated with potassium t-butoxide in t-butyl alcohol as described for 3β-acetoxy-32-nitrilo-11-oxolanostan-7α-yl methanesulphonate. The product was re-esterified by treatment with boron trifluoride–ether (0·2 ml) in refluxing methanol (30 ml). The yellow oil thus obtained was chromatographed on type H alumina (10 g). Elution with light petroleum–ethyl acetate (7 : 3 v/v) gave the 11-*monoketone* (113 mg), m.p. (from ethyl acetate–light petroleum) 168—169°, $[\alpha]_D$ +80° (*c* 1·0), $\nu_{max.}$ 3290, 2230, 1730, 1665, and 1595 cm^{-1}, $\lambda_{max.}$ 247 nm (log ε 3·9) (Found: C, 74·1; H, 9·1; N, 3·2. $C_{28}N_{41}NO_4$ requires C, 73·8; H, 9·1; N, 3·1%); *acetate*, m.p. (from methanol) 178—179°, $[\alpha]_D$ +77·3° (*c* 0·40), $\nu_{max.}$ 2220, 1735, 1725, 1660, 1590, and 1250 cm^{-1}, $\lambda_{max.}$ 247 nm (log ε 3·9) (Found: C, 72·6; H, 8·55; N, 2·8. $C_{30}H_{43}NO_5$ requires C, 72·4; H, 8·7; N, 2·8%); followed by the 7,11-*dione* (93 mg), m.p. (from methanol) 202—203°, $[\alpha]_D$ +19·7° (*c* 0·39), $\nu_{max.}$ 3390, 2230, 1730, 1690, and 1680 cm^{-1}, $\lambda_{max.}$ 257 nm (log ε 3·89) (Found: C, 69·4; H, 8·4; N, 2·5. $C_{28}H_{39}NO_5$,MeOH requires C, 69·4; H, 8·6; N, 2·8%); *acetate*, m.p. (from acetone–methanol) 213—215°, $[\alpha]_D$ +27·5 (*c* 0·52), $\nu_{max.}$ 2230, 1740, 1730, 1690, 1680, and 1250 cm^{-1}, $\lambda_{max.}$ 257 nm (log ε 3·87) (Found: C, 70·6; H, 8·05; N, 2·7. $C_{30}H_{41}NO_6$ requires C, 70·4; H, 8·1; N, 2·7%).

Methyl 3β-*Acetoxy*-7β-*hydroxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanost*-8-*en*-24-*oate*.—Methyl 3β-acetoxy-32-nitrilo-11-dioxo-25,26,27-trinorlanost-8-en-24-oate (360 mg) was reduced with sodium borohydride as described for 3β-acetoxy-7,11-dioxolanost-8-en-32-onitrile. The 7β-*alcohol* thus obtained (250 mg, 70%) had m.p. (from methanol) 231—232°, $[\alpha]_D$ +72·7° (*c* 0·26), $\nu_{max.}$ 3420, 2230, 1740, 1730, 1670, 1595, and 1270 cm^{-1}, $\lambda_{max.}$ 244 nm (log ε 3·8) (Found: C, 70·0; H, 8·4; N, 2·7. $C_{30}H_{43}NO_6$ requires C, 70·15; H, 8·4; N, 2·7%).

Methyl 3β-*Acetoxy*-32-*nitrilo*-11-*oxo*-25,26,27-*trinorlanost*-8-*en*-24-*oate* (X; R = CO_2Me).—Methyl 3β-acetoxy-7β-hydroxy-32-nitrilo-11-oxo-25,26,27-trinorlanost-8-en-24-oate (250 mg) was reduced with zinc dust (350 mg) as described for 3β-acetoxy-7β-hydroxy-11-oxolanost-8-en-32-onitrile. The product (175 mg, 73%) had m.p. (from ethyl acetate–light petroleum) 178—179°, $[\alpha]_D$ +78·1° (*c* 0·49) and was identical (mixed m.p., i.r., and t.l.c.) with an authentic sample.

Attempted Hydrolysis of 3β-*Acetoxylanost*-7-*en*-32-*onitrile*.—The nitrile (IV; X = CN) was treated with the following reagents: (*a*) concentrated hydrochloric acid (2 ml) in ethanol (12 ml), reflux overnight; (*b*) aqueous potassium hydroxide (40%; 2 ml) in ethanol (12 ml), reflux overnight; and (*c*) aqueous sodium hydroxide (40%; 2 ml) in methanol (15 ml) at 65° with the addition of hydrogen peroxide (90%; 15 ml) over a period of 36 h. In each case reacetylation of the product gave only starting material (IV; X = CN) (mixed m.p., i.r., and t.l.c.).

Reduction of 3β-*Acetoxylanost*-7-*en*-32-*onitrile with Lithium Aluminium Hydride*.—The nitrile (226 mg) in dry tetra-

hydrofuran (13 ml) was cooled in an ice-bath and lithium aluminium hydride (226 mg) was added at such a rate that the temperature of the mixture did not rise above 25°. The mixture was then shaken at room temperature for 72 h. The excess of lithium aluminium hydride was destroyed with ethyl acetate. 2N-Hydrochloric acid (13 ml) was added and the mixture was refluxed for 3 h. Extraction with ether gave a solid (208 mg) which was crystallised from methanol to give needles of 3β-*hydroxylanost-7-en-32-al* (146 mg), m.p. 128—130°, $\nu_{max.}$ 3270, 2715, and 1710 cm^{-1}; *acetate* (98 mg, 43%), m.p. (from ethyl acetate–methanol) 144—145° (sealed tube), $[\alpha]_D$ +24° (*c* 0·26), $\nu_{max.}$ 2725, 1725, 1705, and 1240 cm^{-1}, τ 0·4 (1H, CHO), 4·37 and 4·55 (1H, vinyl H at C-7), and 5·5 (1H, 3α-H) (Found: C, 79·35; H, 10·7. $C_{32}H_{52}O_3$ requires C, 79·3; H, 10·8%). The mother liquors from the methanol crystallisation of the total product were acetylated (pyridine–acetic anhydride; room temperature overnight) and chromatographed on type H alumina to give 3β-acetoxy-4,4-dimethylcholest-8(14)-ene, m.p. 114—115°, $[\alpha]_D$ +30° (lit.,[24] m.p. 115—117°, $[\alpha]_D$ +30°), a mixture of 3β-acetoxylanost-7-en-32-onitrile and 3β-acetoxylanost-7-en-32-al, and 3β-*acetoxy-32-acetylaminolanost-7-ene*, m.p. 178—178·5°, $[\alpha]_D$ 0·0° (*c* 1·0), $\nu_{max.}$ 3310, 3095, 1735, 1650, 1555, and 1240 cm^{-1} (Found: C, 77·3; H, 10·95; N, 2·8. $C_{34}H_{57}NO_3$ requires C, 77·4; H, 10·9; N, 2·65%).

3β,32-*Diacetoxylanost-7-ene* (IV; X = CH_2·OAc).—Lithium aluminium hydride (100 mg) was added to a solution of 3β-acetoxylanost-7-en-32-al (100 mg) in dry tetrahydrofuran (25 ml). The mixture was heated under reflux for 5 h (i.r. control). The excess of lithium aluminium hydride was destroyed with ethyl acetate. Addition of water and extraction with ether gave a white solid (90 mg) which was crystallised from methanol to give needles of *lanost-7-ene*-3β,32-*diol* (81 mg, 88%), m.p. 201—203°, $[\alpha]_D$ +12° (*c* 0·27); *diacetate*, m.p. (from methanol) 122—123°, $[\alpha]_D$ +33° (*c* 0·27), $\nu_{max.}$ 1735 and 1240 cm^{-1} (Found: C, 77·5; H, 10·5. $C_{34}H_{56}O_4$ requires C, 77·2; H, 10·7%).

2,3-*Dihydro-2-t-butylbenzothiazole* (XIII).—2-Aminobenzenethiol hydrochloride (1·0 g) in methanol (10 ml) was treated with pivalaldehyde (1·4 ml) under nitrogen. The exothermic reaction was completed by refluxing for 30 min. The solution was adjusted to pH 9 with N-sodium carbonate solution and extracted with ether to give a yellow oil (1·1 g). A low temperature crystallisation from aqueous methanol gave 2,3-dihydro-2-t-butylbenzothiazole as pale yellow plates, m.p. 46—48°, $\nu_{max.}$ 3300 and 1570 cm^{-1}, $\lambda_{max.}$ 227, 263, and 317 nm.

2-*t-Butylbenzothiazole* (XIV).—2,3-Dihydro-2-t-butylbenzothiazole (500 mg) in ethanol (10 ml) was treated with iron(III) chloride hexahydrate (1·75 g) in water (3 ml). The mixture was warmed on a steam-bath for 10 min and then poured into N-sodium carbonate solution. Extraction with ether gave 2-t-butylbenzothiazole as a yellow oil (310 mg, 63%), b.p. 255—260° at 761 mmHg, $\nu_{max.}$ 1510 cm^{-1}, $\lambda_{max.}$ 200, 217, 252, 283, and 293 nm (ε 23,000, 23,700, 7500, 1760, and 1400); picrate, m.p. (from methanol) 115—117° (lit.,[14] 118°).

Attempted Hydrolysis of 2-t-Butylbenzothiazole with Alkaline Hydrogen Peroxide.—A solution of 2-t-butylbenzothiazole (172 mg) in ethanol (10 ml) containing 2N-sodium hydroxide (2 ml) was warmed to 60° and hydrogen peroxide (90%; 10 ml) was added over a period of 2 days. The mixture was worked up to give a neutral fraction containing 2-t-butylbenzothiazole (27 mg), and an acid fraction equivalent to 2·8 ml of standardised 0·1N-sodium hydroxide solution. Allowing for recovered starting material this represented a 31% yield of pivalic acid.

Attempted Hydrolysis of 2-t-Butylbenzothiazole via Preliminary Methylation.—2-t-Butylbenzothiazole (100 mg) in dry ether (10 ml) was treated with redistilled dimethyl sulphate (100 mg). The solution was left overnight, during which time pale brown needles of bis-(*N*-methyl-2-t-butylbenzothiazolium) sulphate separated (60 mg), m.p. 168—171°, $\nu_{max.}$ 1870 and 1180 cm^{-1}. This salt (75 mg) was added to a solution of potassium hydroxide (174 mg) in ethanol (3·6 ml) and water (2 ml). The mixture was heated on a steam-bath overnight, then poured into water and extracted with ether. The oil thus obtained (52 mg) was identical with 2-t-butylbenzothiazole (i.r. and t.l.c.).

1-*Hydroperoxy-2,2-dimethylpropane-1-azobenzene* (XVI).—A mixture of pivalaldehyde (2·0 g) and redistilled phenylhydrazine (1·0 g) was heated on a steam-bath for 30 min. The excess of pivalaldehyde was distilled off to leave a red oil (1·54 g), $\nu_{max.}$ 3400 and 1600 cm^{-1}, $\lambda_{max.}$ 207, 247, 274, and 298 nm. This oil (100 mg) in light petroleum (b.p. 60—80°; 10 ml) was shaken in oxygen at room temperature. After a few minutes a yellow precipitate began to form. After 4 h the uptake of oxygen (12·2 ml) appeared to be complete (1 mol. equiv. = 13·8 ml). The yellow crystals of the *hydroperoxide* were filtered off (64 mg); m.p. 82° (decomp.), $\nu_{max.}$ 3230 and 1600 cm^{-1}, $\lambda_{max.}$ 213, 242infl, 275, and 405 nm. The compound decomposed when attempts were made to dry it for analysis.

Alkaline Hydrolysis of 1-*Hydroperoxy-2,2-dimethylpropane-1-azobenzene* (XVI).—The hydroperoxide (100 mg) in ethanol (10 ml) was treated with aqueous potassium hydroxide (30%; 2 ml). After the solution had become colourless (about 3 h) it was acidified with 2N-hydrochloric acid and extracted with ether. The extracts were washed thoroughly with water, dried, and evaporated. The resulting oil (ethanol plus pivalic acid) was titrated against standard 0·1N-potassium hydroxide. This indicated a yield of pivalic acid of 65%. The acid was further characterised as its anilide, m.p. 129—131° (lit., 130—132°).

Oxidation of 1-*Hydroperoxy-2,2-dimethylpropane-1-azobenzene* (XVI).—The hydroperoxide (100 mg) in acetone (5 ml) was shaken with Kiliani's chromic acid (1 ml) for 45 min at room temperature. The solution was poured into aqueous sodium disulphite and extracted with ether. Further processing as in the previous experiment indicated an 85% yield of pivalic acid.

Other less successful oxidations of (XVI) were performed as follows (see also Table 1): (*a*) manganese dioxide in benzene, room temperature overnight; (*b*) neutral silver oxide in tetrahydrofuran, room temperature overnight; (*c*) potassium permanganate in aqueous acetone, room temperature overnight; and (*d*) acetone–oxygen–platinum catalyst, room temperature for 3 days.

3β-*Acetoxy-32-hydroperoxy-32-phenylazolanost-7-ene* [IV; X = CH(O·OH)N:NPh].—Redistilled phenylhydrazine (350 mg) in glacial acetic acid (350 mg) was added to a refluxing solution of 3β-acetoxylanost-7-en-32-al (250 mg) in methanol (10 m After 16 h no starting material remained (t.l.c.). The bulk of the methanol was evaporated off and the solution then poured into water to give a solid (274 mg). This was crude 3β-acetoxylanost-7-en-32-al phenylhydrazone (IV; X = CH:N·NHPh), m.p. 88—97°, $\nu_{max.}$ 3370, 1750, 1725, 1610, 1500, and 1250 cm^{-1}, $\lambda_{max.}$ 208 and 273 nm. This phenylhydrazone (100 mg) in light petroleum (b.p. 60—80°;

10 ml) was shaken in an atmosphere of oxygen. After 30 min a yellow precipitate began to form and after 4 h the uptake of oxygen appeared to be complete (3·01 ml; theory requires 3·95 ml). The solid was filtered off and recrystallised from cold benzene–light petroleum (b.p. 60—80°) to give yellow needles of the *azo-peroxide* (56 mg), m.p. 108—109°, $\nu_{max.}$ 3170, 1740, 1600, and 1240 cm^{-1}, $\lambda_{max.}$ 220, 283, and 405 nm. The compound decomposed during a determination of its n.m.r. spectrum and when being dried for analysis. When subjected to hydrolysis or oxidation as described for (XVI), the hydroperoxide [IV; X = CH(O·OH)N:NPh] gave rise to mixtures of products which did not appear to contain any of the required acid.

Formation and Cleavage of Benzohydroxamic Acid.—Redistilled benzaldehyde (250 mg) was dissolved in ethanol (10 ml) and solutions of potassium hydroxide (1·26 g) in ethanol (12·6 ml) and benzenesulphonohydroxamic acid (1·64 g) in ethanol (2 ml) were added over a period of 30 min. The mixture was adjusted to pH 11 with ethanolic potassium hydroxide and then stirred for 1 h. The solution was acidified with 2N-sulphuric acid and periodic acid (5 g) in water (5 ml) was added. After 1 h the mixture was extracted with ether to give benzoic acid (240 mg, 84%), m.p. (from water) 119—120·5°. Similarly, pivalaldehyde gave pivalic acid (42%).

3β-*Acetoxy*-32-*hydroxyiminolanost*-7-*ene* (IV; X = CH:N·OH).—A solution of 3β-acetoxylanost-7-en-32-al (100 mg) and hydroxylamine hydrochloride (100 mg) in ethanol (10 ml) and pyridine (1 ml) was refluxed overnight. The solution was poured into water and extracted with ether. Crystallisation from aqueous methanol gave needles of 3β-*acetoxy*-32-*hydroxyiminolanost*-7-*ene* (93 mg, 90%), m.p. 159—163°, $[\alpha]_D$ 0·0° (*c* 0·84), $\nu_{max.}$ 3450, 1742, 1705, and 1250 cm^{-1} (Found: C, 76·8; H, 10·8; N, 2·7. $C_{32}H_{53}NO_3$ requires C, 76·9; H, 10·7; N, 2·8%).

3β-*Acetoxylanost*-7-*en*-32-*onitrile* N-*Oxide* (IV; X = C≡N$^+$–O$^-$).—A solution of 3β-acetoxy-32-hydroxyiminolanost-7-ene (94 mg) in dry methylene dichloride (10 ml) was treated with recrystallised lead tetra-acetate (94 mg). A white precipitate formed immediately. After 10 min at room temperature the solution was poured into water. The organic layer was separated and the aqueous layer extracted twice more with methylene dichloride. The combined extracts were washed with water and evaporated. The pale yellow residue (94 mg) was crystallised from methanol to give needles of the *nitrile oxide* (58 mg, 62%), m.p. 135—136°, $[\alpha]_D$ +67° (*c* 1·00), $\nu_{max.}$ 2275, 1730, and 1260 cm^{-1} (Found: C, 77·1; H, 10·2; N, 3·0. $C_{32}H_{51}NO_3$ requires C, 77·2; H, 10·3; N, 2·8%).

O-*Acetyl*-3β-*acetoxylanost*-7-*en*-32-*ohydroxamic Acid* (IV; X = CO·NH·OAc).—A solution of the foregoing nitrile oxide (47 mg) in glacial acetic acid (10 ml) was maintained at 55° for 7 h (t.l.c. control). The solution was poured into water and extracted with ether to give a pale yellow solid (43 mg). Crystallisation from light petroleum–benzene gave needles of the O-*acetylhydroxamic acid* (29 mg, 54%), m.p. 151—152°, $[\alpha]_D$ +77° (*c* 1·00), $\nu_{max.}$ 3280, 1790, 1705, 1695, and 1260 cm^{-1} (Found: C, 72·95; H, 10·2; N, 2·5. $C_{34}H_{55}NO_5$ requires C, 73·2; H, 9·9; N, 2·5%).

Formation and Periodic Acid Cleavage of 3β-*Hydroxylanost*-7-*en*-32-*ohydroxamic Acid* (IV; X = CO·NH·OH).—A solution of *O*-acetyl-3β-acetoxylanost-7-en-32-ohydroxamic acid (56 mg) in ethanol (8·1 ml) containing potassium hydroxide (81 mg) was left overnight at room temperature. The solution was poured into water and extracted with ether to give an oil (42 mg). This oil (10 mg) in ethanol (5 ml) was treated with aqueous periodic acid (10%; 2 drops). After 1 h at room temperature the solution was poured into water and extracted with ether to give an oil (6 mg.) which by t.l.c. (silica gel GF_{254}, eluted with 15% ethyl acetate in light petroleum) contained *ca.* 70% of a compound slightly more polar than 3β-hydroxy-4,4-dimethylcholest-8(14)-ene.

Reaction of Pivalohydroxamic Acid with Neutral Silver Oxide.—Pivalohydroxamic acid (100 mg) in tetrahydrofuran (5 ml) was treated with freshly prepared neutral silver oxide (500 mg). The mixture was shaken vigorously for 15 min [negative iron(III) chloride test] and then filtered. The solid was washed thoroughly with tetrahydrofuran. The combined filtrates were evaporated to give a solid (72 mg) which was crystallised from aqueous methanol to give needles of O-*pivaloylpivalohydroxamic acid*, m.p. 147—148°, $\nu_{max.}$ 3150, 1770, and 1650 cm^{-1} (Found: C, 59·4; H, 9·8; N, 7·1. $C_{10}H_{19}NO_3$ requires C, 59·7; H, 9·5; N, 7·0%). Similar yields of the same product were obtained by the reaction of pivalohydroxamic acid with manganese dioxide in chloroform or aqueous potassium ferricyanide adjusted to pH 9 by the addition of sodium carbonate.

Reaction of Pivalohydroxamic Acid with Potassium t-Butoxide in t-Butyl Alcohol and Oxygen.—A solution of pivalohydroxamic acid (100 mg) and potassium t-butoxide (448 mg) in dry t-butyl alcohol (10 ml) was shaken in an atmosphere of oxygen at room temperature. After 2·5 h the uptake of oxygen (18·9 ml; theory requires 19·1 ml) appeared to be complete. The mixture was poured into water and extracted with ether to give pivalic acid (76%), characterised as the *p*-bromophenacyl ester, m.p. 75—76°.

Reaction of Benzonitrile Oxide with Hydrogen Peroxide at pH 11.—Benzohydroximic chloride (774 mg) was dissolved in ethanol (50 ml) and 0·2N-potassium dihydrogen phosphate (25 ml) was added. The solution was adjusted to pH 11 (pH meter) with 0·2N-sodium hydroxide. Hydrogen peroxide (100 vols; 2 ml) was added, and the mixture was stirred at room temperature for 2 h. It was then neutralised with 2N-hydrochloric acid, and extracted with ether. The combined extracts were washed with 2N-sodium hydrogen carbonate solution (3 × 20 ml). These washings were combined, acidified with 2N-hydrochloric acid, and extracted with ether to give benzoic acid (298 mg, 49%), m.p. (from water) 118—119°.

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