690. *Some Ring-A Derivatives in the Lanosterol Series.*

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Various derivatives of lanostane and of lanost-8-ene substituted in ring A have been prepared. In particular, convenient routes to the 1,3-diketones have been developed.

The rearrangement of 1α,2α-epoxylanost-8-en-3-one with boron trifluoride in benzene has been studied and the constitution of the product has been determined.

In miscellaneous experiments the action of chromyl chloride on 8- and 7,9(11)-unsaturated lanosterol derivatives has been investigated.

The impetus to the work described in the present paper was the description of two interesting triterpenoid 1,3-diketones isolated and studied by Heymann, Bhatnagar, and Fieser.[1] Both compounds were shown to contain the system $-CO\cdot CH_2\cdot CO-$ in fully enolised form. In conventional triterpenoids such a grouping can only be placed in ring A [see (I)]. Since such compounds have not been described in the triterpenoid literature, we decided first to synthesise examples in the lanosterol series for spectroscopic and rotational comparison.

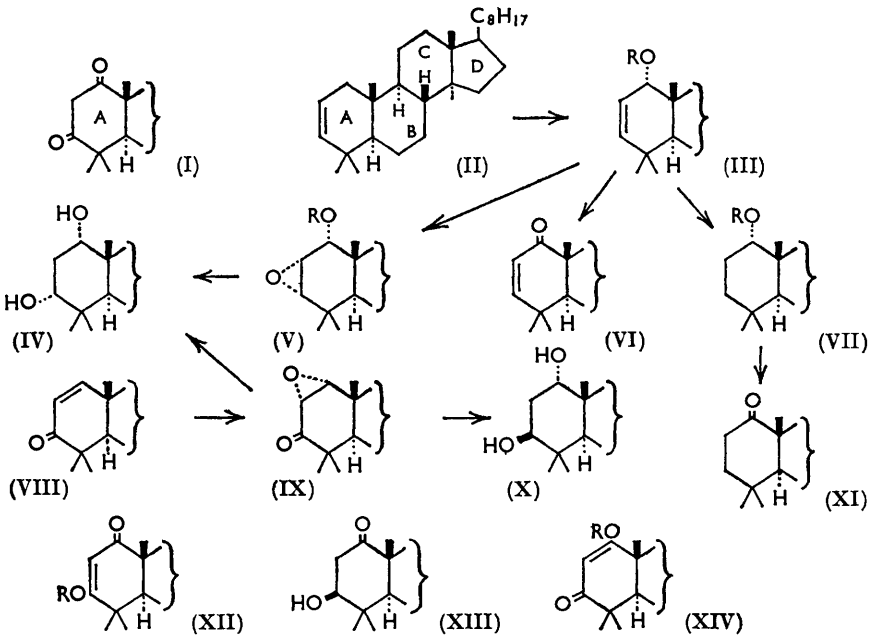
Oxidation of lanost-2-ene [2] (II) with selenium dioxide in acetic acid–acetic anhydride [3] gave 1α-acetoxylanost-2-ene (III; R = Ac). Catalytic hydrogenation of the latter afforded 1α-acetoxylanostane (VII; R = Ac) which, on reductive fission with lithium aluminium hydride, furnished lanostan-1α-ol (VII; R = H). Oxidation of the latter by chromic acid gave lanostan-1-one (XI). The formation of this ketone excludes formulation of the product (III; R = Ac) as the alternative 3α(or β)-acetoxylanost-1-ene.

Reductive fission of 1α-acetoxylanost-2-ene (III; R = Ac) furnished lanost-2-en-1α-ol (III; R = H) which was also obtained by oxidation of lanost-2-ene (II) with selenium dioxide in dioxan.[3] Chromic acid oxidised lanost-2-en-1α-ol gave lanost-2-en-1-one (VI).

The assignment of the 1α-configuration to the pertinent compounds mentioned above

[1] Heymann, Bhatnagar, and Fieser, *J. Amer. Chem. Soc.*, 1954, **76**, 3689.
[2] Barton, Lewis, and McGhie, *J.*, 1957, 2907.
[3] Cf. Jeger, Montavon, Nowak, and Ruzicka, *Helv. Chim. Acta*, 1947, **30**, 1869.

is based on molecular-rotation considerations [4] in relation to model compounds of defined configuration.[3,5,6]



Epoxidation of the allylic alcohol (III; R = H) gave the epoxy-alcohol (V; R = H), characterised as its nicely crystalline acetate (V; R = Ac). Analogy with the epoxidation of lanost-2-ene [2] as well as the directive effect of the 1α-hydroxy-group [7] would predict the α-configuration for this epoxide. By reduction with lithium aluminium hydride this epoxide gave lanostane-1α,3α-diol (IV). Cautious treatment with chromic acid then afforded the desired enolic lanostane-1,3-dione (XII; R = H).

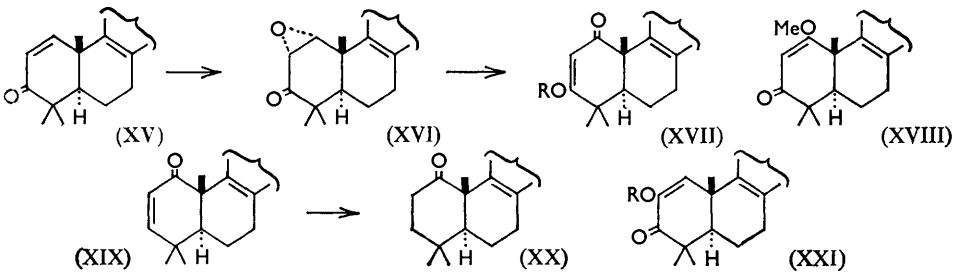
A more economical route to this diketone was the following. Lanost-1-en-3-one [2] (VIII) was oxidised with alkaline hydrogen peroxide to the epoxy-ketone (IX), reduction of which with lithium aluminium hydride gave [5] a mixture of lanostane-1α,3α- (IV) and -1α,3β-diol (X). Since there can be no doubt about the α-epoxide configuration in the precursor (IX), the formation of the same 1α,3α-diol in this and the earlier sequence of reactions confirms the assignment of the α-configuration to the hydroxyl group in the allylic alcohol (III; R = H) and its derivatives. Chromic acid oxidised the mixture of lanostane-1α,3α- and -1α,3β-diol to the desired 1,3-diketone (XII) in satisfactory yield. A by-product of the oxidation was 3β-hydroxylanostan-1-one (XIII). On mild alkaline treatment this gave the enone (VI) described above. The (equatorial) 3β-hydroxyl configuration is assigned in order to explain its (relative) resistance to chromic acid.

Lanostane-1,3-dione was characterised as its enol acetate (XII; R = Ac). The justification for the assignment of structures of type (XII) rather than (XIV) is presented below.

Lanosta-1,8-dien-3-one [2] (XV) with alkaline hydrogen peroxide gave the α-epoxide (XVI), whence lithium aluminium hydride furnished a mixture (see above) of 1,3-diols which, without separation, were oxidised by chromic acid to the enolic 1,3-diketone

[4] Klyne and Stokes, *J.*, 1954, 1979.
[5] Striebel and Tamm, *Helv. Chim. Acta*, 1954, **37**, 1094; Plattner, Fürst, and Els, *ibid.*, p. 1399; Sallmann and Tamm, *ibid.*, 1956, **39**, 1340.
[6] Henbest and Wilson, *J.*, 1956, 3289.
[7] Henbest and Wilson, *J.*, 1957, 1958.

(XVII; R = H), characterised as its acetate (XVII; R = Ac). Treatment of this 1,3-diketone with methanol containing toluene-*p*-sulphonic acid gave a mixture of two methyl ethers (XVII; R = Me) and (XVIII). The constitutions of these two compounds were determined by reduction with lithium aluminium hydride followed by hydrolysis with dilute sulphuric acid.[8] The enol ether (XVII; R = Me) gave the initial dienone (XV) whilst its isomer (XVIII) afforded the unsaturated ketone (XIX). Hydrogenation of the latter gave lanost-8-en-1-one (XX).



The enol ether (XVIII) had $[\alpha]_D$ −25° and its isomer (XVII; R = Me) $[\alpha]_D$ +220°. A high positive rotation ($[\alpha]_D$ +198°) was shown by the unsaturated ketone (XIX), but a relatively small positive rotation ($[\alpha]_D$ +38°) by the unsaturated ketone (XV). The 1,3-diketone (XVII; R = H) and its acetate (XVII; R = Ac) had rotations of +145° and +189°, respectively. It seems reasonable to associate these high positive rotations with 2-en-1-one structures as already written. Similar, though less striking, arguments apply to the assignment of constitutions to lanostane-1,3-dione (XII; R = H) and its acetate (XII; R = Ac) (see above).

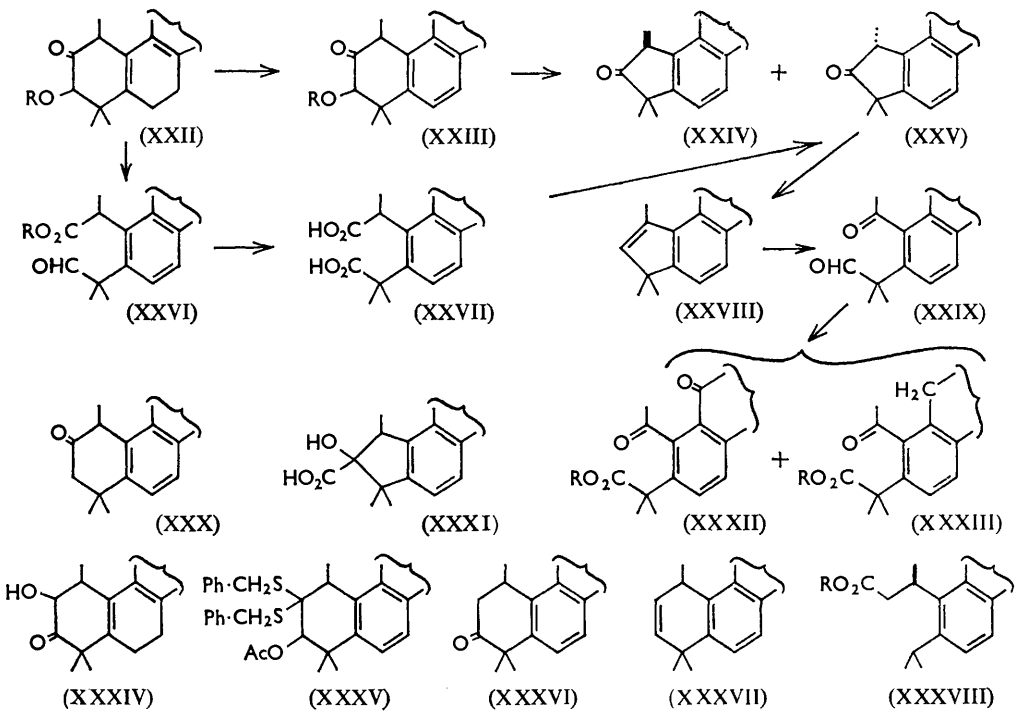
The 1,3-diketo-derivatives of lanosterol described above had ultraviolet spectra both in neutral and, where appropriate, in alkaline solution comparable with those of the compounds of Heymann, Bhatnagar, and Fieser.[1] However, from a comparison of molecular rotations, it is possible that these novel triterpenoids are not simply the 1,3-diketone analogues of any well-known triterpenoid system. They clearly deserve further investigation.

Having available a good supply of the epoxy-ketone (XVI) some of its reactions were investigated further. Treatment with ethanolic potassium hydroxide under reflux gave a mixture of 2-hydroxylanosta-1,8-dien-3-one (XXI; R = H) and its 2-ethyl ether (XXI; R = Et). The diosphenol (XXI; R = H), which was further characterised as its acetate (XXI; R = Ac), was also obtained by acid-catalysed rearrangement of the epoxy-ketone (XVI) and by acidic hydrolysis of the ethyl ether (XXI; R = Et). Ethylation of the diosphenol (XXI; R = H) with diethyl sulphate gave back the ethyl ether (XXI; R = Et). The diosphenol (XXI; R = H) is, of course, more easily obtained by base-catalysed autoxidation of lanost-8-en-3-one.[9]

Treatment of the epoxy-ketone (XVI) with the boron trifluoride–ether complex [10] in benzene solution gave an interesting rearrangement product which we have shown to have the constitution (XXII; R = H) on the basis of the following evidence. The compound contained a secondary α-ketol system as shown by formation of an acetate (XXII; R = Ac) and a 2,4-dinitrophenylhydrazone, its infrared spectrum, and its reducing properties.

[8] Cf. Woodward, Sondheimer, Taub, Heusler, and McLamore, *J. Amer. Chem. Soc.*, 1952, **74**, 4223.
[9] Barton, Pradhan, Sternhell, and Templeton, *J.*, 1961, 255; Bailey, Barton, Elks, and Templeton, *J.*, 1962, 1578; Hanna and Ourisson, *Bull. Soc. chim. France*, 1961, 1945.
[10] Cf., *inter al.*, Camerino and Vercellone, *Gazzetta*, 1956, **86**, 260; Camerino, Patelli, and Vercellone, *J. Amer. Chem. Soc.*, 1956, **78**, 3540; Collins, *J.*, 1959, 3919; Shapiro, Steinberg, Gould, Gentles, Herzog, Gilmore, Charney, Hershberg, and Mandell, *J. Amer. Chem. Soc.*, 1959, **81**, 6483; Dauben, *Bull. Soc. chim. France*, 1960, 1338.

The presence of a fully substituted homoannular diene system was indicated by the ultraviolet spectrum [$\lambda_{max.}$ 267 mμ (ε 8100)] and by the absence of a vinylic-hydrogen signal in the nuclear magnetic resonance spectrum. With peracid or bromine the acetoxyketone (XXII; R = Ac) was smoothly oxidised to the aromatic derivative (XXIII;



R = Ac). This showed two doublets (τ 3·09, 2·98, 2·85, and 2·72) corresponding to two *ortho*-aromatic protons in its nuclear magnetic resonance spectrum. There was a sharp singlet at τ 4·31 indicative of a proton in the system $-C-CH<^{O-}_{CO-}$. In comparable experiments the α-ketol (XXII; R = H) was converted into its methanesulphonate (XXII; R = $Me\cdot SO_2$) which with bromine was also smoothly oxidised to the aromatic derivative (XXIII; R = $Me\cdot SO_2$). These experiments show that the dienic system must be in the B ring of the molecule.

The facility of aromatisation was further demonstrated by periodate oxidation of the α-ketol (XXII; R = H) which gave the aromatic aldehydic acid (XXVI; R = H). Although this acid was not obtained completely pure it gave a well-characterised methyl ester (XXVI; R = Me) and was oxidised further by potassium permanganate to the crystalline dicarboxylic acid (XXVII). Pyrolysis of the latter gave a mixture of two cyclopentanones (XXIV) and (XXV) which was separated with some difficulty. The same two ketones were also obtained by treatment of the α-ketol acetate (XXIII; R = Ac) with aqueous-ethanolic potassium hydroxide to give, by autoxidation and benzilic acid-type rearrangement, the hydroxy-acid (XXXI). Cleavage of the crude hydroxy-acid with lead tetra-acetate then furnished the mixed cyclopentanones (XXIV) and (XXV). The formation of two cyclopentanones proves that the α-ketol is contained in a six-membered ring and suggests that a centre of asymmetry is α to the ketone. One isomer gave a positive Cotton effect and the other a negative one. Since this is the sort of molecule

where the octant rule [11] should be reliably applicable, we believe that the positive Cotton effect isomer has the β-configuration (XXIV) and the other the α-configuration (XXV).*

Reduction of the mixed ketones (XXIV) and (XXV) with potassium borohydride followed by dehydration with phosphorus oxychloride in pyridine gave the olefin (XXVIII). The same olefin was obtained by starting with either of the pure ketones. The ultraviolet absorption spectrum of this olefin ($\lambda_{max.}$ 266 mμ; ε 9800) showed close agreement with that of 3-methylindene ($\lambda_{max.}$ 250 mμ; ε 10,000).[12] Hydroxylation with osmium tetroxide followed by cleavage with lead tetra-acetate gave the keto-aldehyde (XXIX). Although a good analysis was not obtained for this compound it showed bands at τ 0·647 (aldehyde proton) and 7·700 (methyl ketone) in the correct ratio (1 : 3) in its nuclear magnetic resonance spectrum. Oxidation with potassium permanganate gave the crystalline keto-acid (XXXIII; R = H), characterised as its methyl ester (XXXIII; R = Me). Both compounds had ultraviolet absorption indicative of the acetophenone chromophore. In one repetition of this oxidation a compound with an extra ketone group was obtained. This is formulated as (XXXII; R = H); it readily furnished a methyl ester (XXXII; R = Me); in its nuclear magnetic resonance spectrum it had bands in the correct intensity ratios for methyl ketone (τ 7·83), methyl ester (τ 6·39), and the two *ortho*-aromatic protons.

These results show that the rearrangement product (XXII; R = H) has a methyl group in ring A and that, in view of its mode of genesis and other demonstrated features, it must be formulated as written or as the isomer (XXXIV). The first experiment to settle this question decisively was as follows. The ketol acetate (XXIII; R = Ac) was reduced by calcium in liquid ammonia [13] to the ketone (XXX). By equilibration under alkaline conditions it was shown that this ketone can exist in two stereoisomeric configurations. Clearly the ketone must be α to the grouping >CHMe.

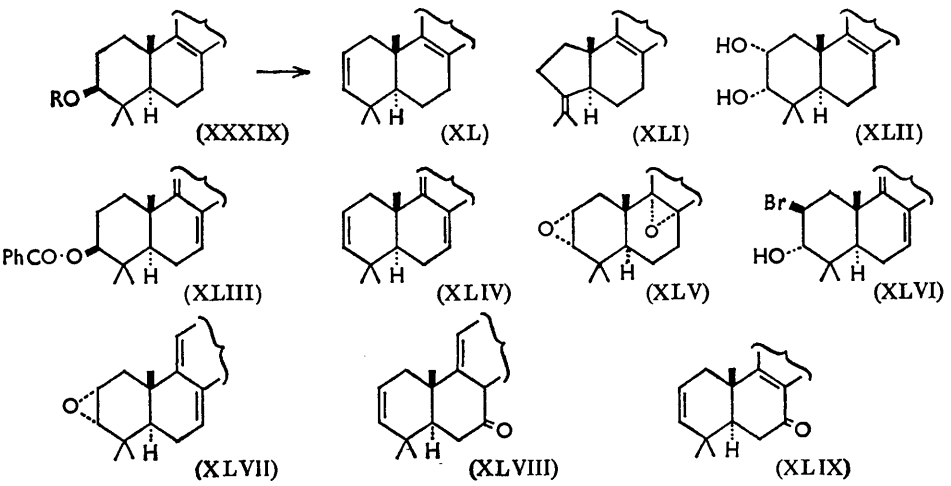
A second proof of the position of the ketone grouping in the α-ketol system was secured as follows. The acetate (XXII; R = Ac) was treated with toluene-ω-thiol in the usual manner to furnish the derivative (XXXV). This was not purified but was at once treated with Raney nickel and then with lithium aluminium hydride. The resultant alcohol was oxidised with chromic acid to the ketone (XXXVI). In agreement with this formulation the ketone did not equilibrate under alkaline conditions. The major product of the reaction sequence was, however, not the ketone (XXXVI) but the olefin (XXXVII). A relevant analogy for this type of eliminated product in a desulphurisation reaction has recently been given by Narasimha, Rao, and Gollberg.[14] As shown by these workers elimination to olefin can be avoided if the acetate grouping is hydrolysed first to alcohol before desulphurisation. Accordingly the α-ketol acetate (XXII; R = Ac) was converted into the dibenzyl thioketal and then oxidised with bromine to the aromatic compound (XXXV) used previously. The latter was reduced with lithium aluminium hydride to the alcohol and treated with Raney nickel, and the product was oxidised as before to the ketone (XXXVI). In this case none of the olefin (XXXVII) was formed.

The constitution of the ketone (XXXVI) was further confirmed by the following experiment. Photolysis of (XXXVI) in aqueous acetic acid [15] gave the acid (XXXVIII; R = H). With diazomethane this gave the methyl ester (XXXVIII; R = Me). In its nuclear magnetic resonance spectrum this ester showed a doublet at τ 7·36 corresponding to the system $MeO_2C{\cdot}CH_2{\cdot}CH<$ as well as the appropriate bands for methyl ester and for two *ortho*-aromatic protons.

* We cordially thank Professor W. Klyne of Westfield College for the determination and interpretation of the optical rotatory dispersion curves.

[11] Moffitt, Woodward, Moscowitz, Klyne, and Djerassi, *J. Amer. Chem. Soc.*, 1961, **83**, 4013.
[12] Gillam and Stern, "An Introduction to Electron Absorption Spectroscopy in Organic Chemistry," Edward Arnold, London, 1954, p. 116.
[13] Chapman, Elks, Phillipps, and Wyman, *J.*, 1956, 4344.
[14] Narasimha, Rao, and Gollberg, *Chem. and Ind.*, 1961, 1317.
[15] Cf. Arigoni, Barton, Bernasconi, Djerassi, Mills, and Wolff, *J.*, 1960, 1900.

In experiments related to those so far reported several observations were made which deserve brief mention. Having need of lanosta-2,8-diene (XL) we prepared it by pyrolysis of lanost-8-en-3β-yl benzoate (XXXIX; R = Bz). The product had m. p. 83—84°, $[\alpha]_D$ +124°, different from the constants previously reported[16] for this hydrocarbon under the name " α-lanostadiene." Hydrogenation of authentic lanosta-2,8-diene gave lanost-8-ene in quantitative yield. " α-Lanostadiene " was prepared by dehydration of lanost-8-enol with phosphorus oxychloride in pyridine. The literature method gave a



product with the constants reported[16] but by fractional crystallisation this was separated into lanosta-2,8-diene, with constants as above, and isolanostadiene (XLI), the latter being the product of dehydration of lanost-8-enol with phosphorus pentachloride.[16,17] On treatment with bromine " α-lanostadiene " was said[16] to furnish hydrocarbon " X " whilst with hydrogen chloride " β-lanostadiene " was formed. We have shown that both these hydrocarbons are lanosta-2,8-diene in essentially pure form. Lanosta-2,8-diene (XL) was further characterised by reaction with osmium tetroxide to give the crystalline diol (XLII).

Pyrolysis of lanosta-7,9(11)-dien-3β-yl benzoate (XLIII) gave the triene (XLIV) with constants in agreement with those in the literature.[16]

Epoxidation of lanosta-2,8-diene gave the diepoxide (XLV) which with hydrogen bromide afforded the bromohydrin (XLVI) converted by base into the oxide (XLVII).

In experiments designed to furnish ring-A chlorohydrins we examined the action of chromyl chloride[18] on lanosta-2,8-diene. Unexpectedly[18] the product was lanosta-2,9(11)-dien-7-one (XLVIII) readily isomerised by base to the conjugated isomer (XLIX). Similar oxidation of lanost-8-ene itself gave lanost-9(11)-en-7-one and thence lanost-8-en-7-one. Also, oxidation of lanost-8-enyl acetate (XXXIX; R = Ac) by chromyl chloride afforded, after treatment with base and reacetylation, the well-known 3β-acetoxylanost-8-en-7-one. The same sequence applied to 3β-acetoxylanosta-7,9(11)-diene furnished the same conjugated ketone in improved yield. Clearly, the oxidation of triterpenoid and steroid olefins with chromyl chloride is worthy of further study.

Experimental

Rotations were taken for $CHCl_3$ solution at 15—25°. Unless specified to the contrary, ultraviolet absorption spectra were taken for EtOH solutions, and infrared spectra for Nujol

[16] Dorée, McGhie, and Kurzer, *J.*, 1947, 1467.
[17] Ruzicka, Montavon, and Jeger, *Helv. Chim. Acta*, 1948, **31**, 818; Dorée, McGhie, and Kurzer, *J.*, 1949, S167.
[18] Cf. Cristol and Eilar, *J. Amer. Chem. Soc.*, 1950, **72**, 4353.

mulls. Nuclear magnetic resonance spectra were determined for $CDCl_3$ solutions in a Varian Associates spectrometer model V 4311 at 56·445 Mc./sec.; line positions were measured by the conventional side-band technique with a Muirhead Decade oscillator, tetramethylsilane being used as an internal standard; we thank Dr. J. W. Lown and Mr. R. G. Foster for the determination and interpretation of these spectra.

The phrase " in the usual way " refers to dilution with water and ether-extraction, followed by washing with water (or dilute acid or alkali where appropriate) and evaporation of the ethereal solution *in vacuo*. Where necessary, the ethereal solutions were dried (Na_2SO_4 or $MgSO_4$) before evaporation.

Light petroleum refers to the fraction of b. p. 40—60° unless stated otherwise. Kiliani's chromic acid mixture was prepared from sodium dichromate (60 g.) in water (270 ml.) to which concentrated sulphuric acid (80 g.) was added. Chromic acid oxidations in acetone were carried out according to directions of Bowers, Halsall, Jones, and Lemin.[19]

Lanost-2-en-1α-yl Acetate (III; R = Ac) (with Dr. S. A. Knight).—Lanost-2-ene (4 g.) in acetic acid (150 ml.) and acetic anhydride (20 ml.) was treated with selenium dioxide (4 g.), and the mixture was heated under reflux for 2 hr. The precipitated selenium was removed by filtration, and the filtrate diluted with water. Working up in the usual way gave a yellow oil. Chromatography of this oil over alumina (120 g.; grade III) and elution with light petroleum (2 : 1) gave the *acetate* (III; R = Ac) (1·007 g.) which, crystallising as blades from methylene chloride–methanol, had m. p. 127—128°, $[\alpha]_D$ +188° (*c* 0·90) (Found: C, 81·65; H, 11·55. $C_{32}H_{54}O_2$ requires C, 81·6; H, 11·6%).

Lanostan-1α-yl Acetate (VII; R = Ac).—Lanost-2-en-1α-yl acetate (240 mg.) in glacial acetic acid (20 ml.) was hydrogenated in the presence of Adams platinum catalyst at room temperature. Working up in the usual way afforded the saturated *acetate* (VII; R = Ac) (208 mg.). Crystallisation from methylene chloride–methanol gave blades, m. p. 133—134°, $[\alpha]_D$ +63° (*c* 0·51) (Found: C, 81·3; H, 11·9. $C_{32}H_{56}O_2$ requires C, 81·3; H, 11·9%).

Lanostan-1α-ol (VII; R = H).—Lanostan-1α-yl acetate (310 mg.) was recovered unchanged on attempted hydrolysis with potassium hydroxide (320 mg.) in ethanol–benzene (2 : 1; 25 ml.) at room temperature overnight.

Lanostan-1α-yl acetate (50 mg.), dissolved in dry ether (10 ml.), was treated with lithium aluminium hydride (100 mg.). The mixture was heated under reflux for 2 hr. and the excess of lithium aluminium hydride decomposed by cautious addition of ethyl acetate. Processing in the usual way gave *lanostan-1α-ol* (VII; R = H), which after recrystallisation from methylene chloride–methanol had m. p. 123·5—124·5°, $[\alpha]_D$ +48° (*c* 1·13) (Found: C, 83·85; H, 12·55. $C_{30}H_{54}O$ requires C, 83·65; H, 12·65%).

Lanostan-1-one (XI).—Lanostan-1α-yl acetate (182 mg.), dissolved in dry ether, was treated with lithium aluminium hydride (200 mg.), and the mixture heated under reflux for 1 hr.; the excess of lithium aluminium hydride was decomposed with ethyl acetate, and the product isolated in the usual way. This material, without further purification, was dissolved in " AnalaR " glacial acetic acid–benzene (1 : 1; 15 ml.), and Kiliani's chromic acid solution (1·5 ml.) was added dropwise with stirring at room temperature during 15 min. The excess of chromic acid was destroyed with sodium hydrogen sulphite, and the product, isolated as usual, crystallised from acetone, affording *lanostan-1-one* (XI) (104 mg.), m. p. 144—146°, raised by further crystallisation from the same solvent to 148—150°, $[\alpha]_D$ +81° (*c* 0·33) (Found: C, 84·2; H, 12·2. $C_{30}H_{52}O$ requires C, 84·05; H, 12·25%).

Lanost-2-en-1α-ol (III; R = H) (with Dr. S. A. Knight).—Lanost-2-ene (200 mg.) and selenium dioxide (200 mg.) in dioxan (15 ml.) were introduced into a Carius tube (*ca.* 45 ml. capacity) and the tube was sealed and heated at 180° for 2·5 hr.; the reaction mixture was then filtered and evaporated. The product was chromatographed on alumina; elution with benzene afforded *lanost-2-en-1α-ol* (III; R = H) (70 mg.). Recrystallisation from methylene chloride–methanol gave needles possessing a double m. p. 52° and 120—122°, $[\alpha]_D$ +100° (*c* 0·13) (Found: C, 83·6; H, 11·9. $C_{30}H_{52}O$ requires C, 84·05; H, 12·25%).

Lanost-2-en-1-one (VI).—Lanost-2-en-1α-ol (30 mg.) in glacial acetic acid–benzene (1 : 1; 3 ml.) was oxidised by Kiliani's chromic acid (0·3 ml.) dropwise with stirring during 15 min. The excess of chromic acid was decomposed by sodium hydrogen sulphite, and the product isolated as usual. Crystallisation from methylene chloride–methanol yielded *lanost-2-en-1-one*

[19] Bowers, Halsall, Jones, and Lemin, *J.*, 1953, 2548.

(VI), m. p. 156—158°, $[\alpha]_D$ +85° (*c* 0·196), $\lambda_{max.}$ 225 mμ (ε 9000) (Found: C, 84·3; H, 11·65. $C_{30}H_{58}O$ requires C, 84·4; H, 11·8%).

2α,3α-*Epoxylanostan*-1α-*ol* (V; R = H).—Lanost-2-en-1α-yl acetate (250 mg.) was reductively hydrolysed as previously described, and the resulting crystals were treated with a solution of perbenzoic acid in chloroform (100% excess) at room temperature for 56 hr. Working up in the usual manner, followed by crystallisation from acetone, gave 2α,3α-*epoxylanostan*-1α-*ol* (V; R = H), m. p. 165—167°, $[\alpha]_D$ +56° (*c* 0·54) (Found: C, 81·3; H, 11·6. $C_{30}H_{52}O_2$ requires C, 81·0; H, 11·8%). With acetic anhydride and pyridine at room temperature this afforded an *acetate* (V; R = Ac), m. p. 135—136°, $[\alpha]_D$ +94° (*c* 0·24) (Found: C, 79·05; H, 11·2. $C_{32}H_{54}O_3$ requires C, 79·0; H, 11·2%).

Lanostane-1α,3α-*diol* (IV).—2α,3α-Epoxylanostan-1α-ol (100 mg.) in anhydrous tetrahydrofuran (10 ml.) was reduced with lithium aluminium hydride (100 mg.) under reflux for 8 hr. The excess of hydride was decomposed with ethyl acetate, and the product worked up in the usual way, to yield a gum. On crystallisation from aqueous acetone this afforded *lanostane*-1α,3α-*diol* (IV) (80 mg.), m. p. 219—220°, $[\alpha]_D$ +40° (*c* 0·37) (Found: C, 80·7; H, 12·2. $C_{30}H_{54}O_2$ requires C, 80·65; H, 12·2%).

Lanost-1-*en*-3-*one* (VIII).—2α-Bromolanostan-3-one (10 g.) was treated with anhydrous lithium chloride (2·55 g.) in anhydrous dimethyl formamide (150 ml.) under reflux for 4 hr. The mixture was cooled, then diluted with water, and the product isolated as usual. Crystallisation of the product from ethanol furnished needles of lanost-1-en-3-one (VIII) (7·2 g.), m. p. 118—120°, $[\alpha]_D$ +47° (*c* 0·53), $\lambda_{max.}$ 229 mμ (ε 9000) {Barton, Lewis, and McGhie [2] give m. p. 118—119°, $[\alpha]_D$ +48°, $\lambda_{max.}$ 230 mμ (ε 6500)}.

1α,2α-*Epoxylanostan*-3-*one* (IX).—Lanost-1-en-3-one (0·93 g.) in acetone (400 ml.) was treated with solutions of sodium hydroxide (10%; 35 ml.) and hydrogen peroxide (100-vol.; 15 ml.) added simultaneously, with stirring, during 15 min. The mixture was stirred for a further 2·5 hr., then set aside overnight; after concentration to half volume *in vacuo*, the residue was diluted with water and the product isolated in the usual way. Recrystallisation from ethanol afforded 1α,2α-*epoxylanostan*-3-*one* (IX) (0·85 g.), m. p. 142—144°. Further crystallisation, from methylene chloride–methanol, gave needles, m. p. 145—147°, $[\alpha]_D$ +118° (*c* 1·17), $\lambda_{max.}$ 297 mμ (ε 54), $\nu_{max.}$ 1702 (C=O) and 879 (epoxide) cm.$^{-1}$ (Found: C, 81·25; H, 11·3. $C_{30}H_{50}O_2$ requires C, 81·4; H, 11·4%).

Reduction of 1α,2α-*Epoxylanostan*-3-*one* (IX) *with Lithium Aluminium Hydride*.—1α,2α-Epoxylanostan-3-one (250 mg.) in anhydrous tetrahydrofuran (10 ml.) was slowly added to a boiling suspension of lithium aluminium hydride (500 mg.) in the same solvent (10 ml.). The mixture was refluxed for a further 20 min., then the excess of hydride was decomposed with ethyl acetate. Isolation of the product in the usual manner yielded a solid which was chromatographed on alumina (5 g.; Peter Spence's grade H). Elution with benzene–ether (9 : 1) afforded lanostane-1α,3α-diol (IV), identified by m. p., mixed m. p., and rotation {$[\alpha]_D$ +40° (*c* 0·16)}. Further elution with benzene–ether (7 : 3) gave an impure solid, which on rechromatography followed by recrystallisation afforded lanostane-1α,3β-diol (X), separating as needles, m. p. 207—208°, $[\alpha]_D$ +38° (*c* 0·23), from aqueous methanol. The mixed m. p. of the two diols was 185—205°.

Oxidation of Lanostane-1,3-*diols*.—A mixture of lanostane-1,3-diols (1 g.), obtained from the hydride reduction of 1α,2α-epoxylanostan-3-one, was treated in acetone (500 ml.) with a solution of chromium trioxide (0·314 g.) in water (10 ml.) containing sulphuric acid (0·25 ml.). The mixture was shaken for 30 min. and the product isolated in the usual way. Chromatography on alumina (50 g.; grade V) and elution with benzene afforded 3β-*hydroxylanostan*-1-*one* (XIII), which crystallised as needles (from ethanol), m. p. 197·5—199°, $[\alpha]_D$ +95° (*c* 1·00), $\lambda_{max.}$ 295 mμ (ε 44) (Found: C, 81·0; H, 11·85. $C_{30}H_{52}O_2$ requires C, 81·0; H, 11·8%). Further elution, with ether, afforded *lanostane*-1,3-*dione* (XII; R = H), needles (from ethanol), m. p. 190—192°, $[\alpha]_D$ +85° (*c* 0·44), $\lambda_{max.}$ 256 mμ (ε 14,100) and in 0·01N-sodium hydroxide in 70% aqueous ethanol 286 mμ (ε 25,100), returning to $\lambda_{max.}$ 256 mμ on acidification; this had infrared bands at 1724, 1701, 1463, 1383, and 1138 cm.$^{-1}$ (in $CHCl_3$) (Found: C, 81·35; H, 11·5. $C_{30}H_{50}O_2$ requires C, 81·4; H, 11·4%).

3-*Acetoxylanost*-2-*en*-1-*one* (XII; R = Ac).—Lanostane-1,3-dione (103 mg.) was treated with pyridine (1 ml.), acetic anhydride (1 ml.), and acetic acid (2 ml.) at 90° for 3 hr. On cooling, the product crystallised. It was filtered off and recrystallised from ethyl acetate–methanol, affording the *acetate* (XII; R = Ac) (60 mg.), m. p. 189—190·5, $[\alpha]_D$ +87° (*c* 0·46), $\lambda_{max.}$ 235·5

mμ (ε 10,300), and in 0·01N-sodium hydroxide in 70% aqueous ethanol 286 mμ (ε 20,000) changing to $\lambda_{max.}$ 256 mμ on acidification, $\nu_{max.}$ 1764, 1672, 1461, 1367, 1331, 1172, 1135, 1093, 1062, and 1008 cm.$^{-1}$ (in $CHCl_3$) (Found: C, 79·45; H, 10·9. $C_{32}H_{52}O_3$ requires C, 79·3; H, 10·8%).

Lanosta-1,8-dien-3-one (XV).—2-Bromolanost-8-en-3-one [2] (8·06 g.; mixed isomers) in redistilled dimethylformamide (80 ml.) was stirred and refluxed with lithium carbonate (8·0 g.) for 5 hr. under nitrogen. After cooling, the mixture was filtered, diluted with ether, washed with water, dried, and evaporated. The residue was dissolved in light petroleum–benzene (1 : 1) and filtered through an alumina column (40 g.). Elution of the column with light petroleum–benzene and evaporation of the eluates gave a colourless solid (6·024 g.). Two crystallisations from methanol afforded lanosta-1,8-dien-3-one (XV) (5·11 g.) as blades, m. p. 108—110°, $[\alpha]_D$ +38° (*c* 1·01), $\lambda_{max.}$ 226 mμ (ε 12,520) (Found: C, 84·6; H, 11·3. Calc. for $C_{30}H_{48}O$: C, 84·8; H, 11·4%) {lit.,[2] m. p. 109—110°, $[\alpha]_D$ +46°, $\lambda_{max.}$ 225 mμ (ε 8130)}.

1α,2α-*Epoxylanost-8-en-3-one* (XVI).—Aqueous 4N-sodium hydroxide (2·0 ml.) and hydrogen peroxide (30% w/v; 2·0 ml.) were added separately and simultaneously during a few minutes to a stirred solution of lanosta-1,8-dien-3-one (XV) (500 mg.) in acetone (30 ml.) and ethanol (20 ml.) at 0°. Stirring was continued for 2 hr. at room temperature, and the mixture left overnight. Isolation of the product in the usual way by ether-extraction gave a gum which crystallised spontaneously. Several crystallisations from ethanol afforded the pure *epoxyketone* (XVI) as needles, m. p. 121—123°, $[\alpha]_D$ +152° (*c* 1·00), $\nu_{max.}$ 1691 cm.$^{-1}$ (saturated ketone) (Found: C, 82·0; H, 11·0. $C_{30}H_{48}O_2$ requires C, 81·8; H, 11·0%).

For larger-scale preparations it was more convenient to remove the bulk of the solvent *in vacuo* below 40° at the end of the reaction and to precipitate the product with a large volume of water. One crystallisation of the dried precipitate normally sufficed to give material of satisfactory purity in yields of up to 92%.

Reaction of 1α,2α-*Epoxylanost-8-en-3-one* (XVI) with Potassium Hydroxide.—The epoxyketone (XVI) (5·0 g.) in 5% ethanolic potassium hydroxide (200 ml.) was refluxed for 3·5 hr., the bulk of the solvent removed *in vacuo*, and the residue diluted with water and acidified with acetic acid. The product was extracted with ether, the extract washed to neutrality with water, dried, and evaporated, and the residue chromatographed on alumina (100 g.; grade III). Elution with light petroleum gave a yellow solid which crystallised from ethanol to afford unchanged starting material (1·2 g.), m. p. and mixed m. p. 120—124°.

Further elution with light petroleum–benzene and with benzene gave a solid (2·21 g.), which crystallised from methanol to yield 2-*ethoxylanosta-1,8-dien-3-one* (XXI; R = Et) as needles, m. p. 124—125°, $[\alpha]_D$ +47° (*c* 0·66), $\lambda_{max.}$ 265 mμ (ε 8800), $\nu_{max.}$ 1674 (conjugated ketone), 1618 (conjugated C=C), and 1084 (enol ether) cm.$^{-1}$ (Found: C, 82·4; H, 11·2. $C_{32}H_{52}O_2$ requires C, 82·0; H, 11·2%).

Elution of the column with ether gave a solid (321 mg.) which, after crystallisation from acetone and then ethanol, afforded 2-*hydroxylanosta-1,8-dien-3-one* (XXI; R = H) as plates, m. p 158—160°, $[\alpha]_D$ +50° (*c* 0·94), $\lambda_{max.}$ 269 mμ (ε 9000), $\lambda_{max.}$ (in 0·1N-NaOH) 313 mμ (ε 12,750), $\nu_{max.}$ 3400 (OH) and 1653 (conjugated ketone) cm.$^{-1}$. The compound gave a purple colour with ferric chloride solution (Found: C, 82·1; H, 11·2. $C_{30}H_{48}O_2$ requires C, 81·8; H, 11·0%).

Acetylation with pyridine–acetic anhydride for 1·5 hr. on the steam-bath gave, after the usual working up, 2-*acetoxylanosta-1,8-dien-3-one* (XXII; R = Ac) as needles (from ethanol), m. p. 139—140°, $[\alpha]_D$ +35° (*c* 1·00), $\lambda_{max.}$ 234 mμ (ε 10,230) (Found: C, 79·6; H, 10·7. $C_{32}H_{50}O_3$ requires C, 79·6; H, 10·4%).

Hydrolysis of 2-*Ethoxylanosta-1,8-dien-3-one* (XXI; R = Et).—The enol ether (200 mg.) was heated under reflux in 95% ethanol (5 ml.) containing concentrated hydrochloric acid (0·2 ml.) for 20 hr., then the solution was left at room temperature for a further 24 hr. Addition of water precipitated a solid which was collected, washed with water, dried, and crystallised from acetone and then ethanol. In this way there was obtained 2-hydroxylanosta-1,8-dien-3-one (XXI; R = H) (m. p., mixed m. p., and infrared spectrum).

Etherification of 2-*Hydroxylanosta-1,8-dien-3-one* (XXI; R = H).—The diosphenol (55 mg.) in 10% ethanolic potassium hydroxide (2·5 ml.) was treated with diethyl sulphate (0·5 ml.) at room temperature for 30 min. Water was then added and the solid collected, washed with water, and dried *in vacuo*. Chromatography on alumina (grade III) gave, on elution with light petroleum–benzene, a gum which solidified spontaneously. Two crystallisations from methanol then afforded 2-ethoxylanosta-1,8-dien-3-one (XXI; R = Et) (m. p., mixed m. p., and infrared spectrum).

Reaction of 1α,2α-*Epoxylanost*-8-*en*-3-*one* (XVI) *with Sulphuric Acid.*—The epoxy-ketone (XVI) (1·0 g.) in ethanol (100 ml.) containing 20N-sulphuric acid (10 ml.) was heated under reflux for 48 hr. The product isolated in the usual way was chromatographed on alumina (grade III; 30 g.). Elution with light petroleum and light petroleum–benzene gave gums (532 mg.) which were not further investigated. Benzene and benzene–ether eluted a solid (407 mg.), m. p. 130—152°. Crystallisation from ethanol afforded 2-hydroxylanosta-1,8-dien-3-one (XXI; R = H) (285 mg.), m. p. and mixed m. p. 157—160°.

Lanost-8-*ene*-1,3-*dione* (XVII; R = H).—1α,2α-Epoxylanost-8-en-3-one (XVI) (1·5 g. in anhydrous ether (25 ml.) was stirred with lithium aluminium hydride (750 mg.) in ether (50 ml.) for 15 min. at room temperature, then refluxed for 1 hr. before being worked up in the usual way. A portion (500 mg.) of the resulting 1,3-diol mixture was dissolved in acetone (50 ml.) at 10—15°, and chromic acid solution (1·0 ml.) added dropwise with vigorous stirring in 1 min. Stirring was continued for a further 3 min. before addition of methanol to destroy the excess of oxidant. Isolation of the product in the usual manner afforded the impure 1,3-dione (464 mg.), m. p. 137—160°. This was further purified by shaking it in ether with dilute sodium hydroxide solution; the sodium salt was collected, washed with ether, and reconverted into the free diketone by acidification. There was thus obtained a solid (317 mg.), m. p. 135—145°. Crystallisation from methanol afforded *lanost*-8-*ene*-1,3-*dione* (XVII; R = H), m. p. 147—150°, $[\alpha]_D$ +145° (*c* 0·90), $\lambda_{max.}$ 256 mμ (ε 10,585), $\lambda_{max.}$ (in 0·01N-NaOH) 287 mμ (ε 24,480), $\nu_{max.}$ 1720 and 1695 (β-diketone) cm.$^{-1}$ (Found: C, 81·9; H, 11·0. $C_{30}H_{48}O_2$ requires C, 81·8; H, 11·0%).

Acetylation of the dione (118 mg.) with acetic anhydride–pyridine overnight at room temperature, and isolation of the product in the normal manner, afforded 3-*acetoxylanosta*-2,8-*dien*-1-*one* (XVII; R = Ac) (109 mg.), blades (from methanol), m. p. 145—147°, $[\alpha]_D$ +189° (*c* 0·905), $\lambda_{max.}$ 235 mμ (ε 11,800), $\nu_{max.}$ 1770 (enol OAc), 1665 (conjugated ketone), and 1645 (conjugated C=C) cm.$^{-1}$ (Found: C, 79·65; H, 10·4. $C_{32}H_{50}O_3$ requires C, 79·6; H, 10·4%).

1-*Methoxylanosta*-1,8-*dien*-3-*one* (XVIII) *and* 3-*Methoxylanosta*-2,8-*dien*-1-*one* (XVII; R = Me).—Lanost-8-ene-1,3-dione (XVII; R = H) (200 mg.) in anhydrous benzene (80 ml.) containing methanol (40 ml.) and toluene-*p*-sulphonic acid (20 mg.) was refluxed for 9 hr. in an apparatus which allowed the condensed vapours to percolate through a Soxhlet thimble containing " Drierite." The product was isolated by ether-extraction, the extracts being washed with dilute sodium hydrogen carbonate solution and water, dried, and evaporated, and the residue chromatographed on alumina (grade II; 6 g.). Elution with light petroleum–benzene (1 : 9 to 1 : 1) gave solids, which, after re-chromatography followed by crystallisation from methanol, afforded 3-*methoxylanosta*-2,8-*dien*-1-*one* (XVII; R = Me) (116 mg.), m. p. 167—170°, $[\alpha]_D$ +220° (*c* 1·24), $\lambda_{max.}$ 250 mμ (ε 13,950), $\nu_{max.}$ 1657 (conjugated ketone) and 1608 (conjugated C=C) cm.$^{-1}$ (Found: C, 82·2; H, 11·2. $C_{31}H_{50}O_2$ requires C, 81·9; H, 11·1%).

Further elution of the first chromatogram with benzene and benzene–ether gave a solid (40 mg.), m. p. 125—137°, which, after several crystallisations from methanol, afforded 1-*methoxylanosta*-1,8-*dien*-3-*one* (XVIII), m. p. 138—141°, $[\alpha]_D$ −25° (*c* 0·84), $\lambda_{max.}$ 254 mμ (ε 16,500), $\nu_{max.}$ 1655 (conjugated ketone) and 1599 (conjugated C=C) cm.$^{-1}$ (Found: C, 81·7; H, 10·9%).

Reduction of 3-*Methoxylanosta*-2,8-*dien*-1-*one* (XVII; R = Me).—The enol ether (120 mg.) in anhydrous ether (5 ml.) was added to lithium aluminium hydride (100 mg.) in ether (10 ml.). After being stirred for 30 min. at room temperature, the mixture was decomposed by water, followed by dilute sulphuric acid, and the product isolated in the usual way. The solid (110 mg.), m. p. 102—111°, thus obtained, crystallised from methanol to yield lanosta-1,8-dien-3-one (XV), m. p. 108—111°, $[\alpha]_D$ +40° (*c* 0·905). The identity was confirmed by mixed m. p. and infrared spectrum.

Lanosta-2,8-*dien*-1-*one* (XIX).—1-Methoxylanosta-1,8-dien-3-one (XVIII) (348 mg.) in anhydrous ether (10 ml.) was reduced with lithium aluminium hydride (300 mg.) in ether (5 ml.) for 10 min. at room temperature. After working up as in the previous experiment, a gum was obtained. This was dissolved in the minimum volume of light petroleum, and the solution run on to a column of alumina (grade II; 10 g.), and left overnight. Elution of the column with light petroleum gave a solid (157 mg.) which crystallised from methanol to afford *lanosta*-2,8-*dien*-1-*one* (XIX) as needles, m. p. 122—124°, $[\alpha]_D$ +198° (*c* 0·66), $\lambda_{max.}$ 206 and 219 mμ (ε 10,860 and 9960, respectively), $\nu_{max.}$ 1682 (conjugated ketone) cm.$^{-1}$ (Found: C, 84·9; H, 11·4. $C_{30}H_{48}O$ requires C, 84·8; H, 11·4%).

Lanost-8-en-1-one (XX).—Hydrogenation of lanosta-2,8-dien-1-one (XIX) (112 mg.) in ethanol (50 ml.) over palladised charcoal (50 mg.) at room temperature for 15 min. gave, after filtration and evaporation, a solid (112 mg.), m. p. 104—113°. Crystallisation from methanol furnished needles of *lanost-8-en-1-one* (XX), m. p. 113—115°, $[\alpha]_D$ +67° (*c* 0·93), $\nu_{max.}$ 1705 cm.$^{-1}$ (saturated ketone) (Found: C, 84·25; H, 11·9. $C_{30}H_{50}O$ requires C, 84·4; H, 11·8%).

Rearrangement of 1α,2α-*Epoxylanost-8-en-3-one* (XVI) *with Boron Trifluoride–Ether.*—Freshly distilled boron trifluoride–ether (22·5 ml.) was added to 1α,2α-epoxylanost-8-en-3-one (4·5 g.) in anhydrous benzene (45 ml.), and the solution, which rapidly developed a blood-red colour, left for 1 hr. at room temperature before being poured into water containing ice. Ether was added, and the mixture shaken vigorously until the red colour of the organic phase had faded to pale yellow. The ether solution was washed free from acid with water, dried, and evaporated to a yellow gum which crystallised spontaneously. Recrystallisation from ethanol afforded 3-*hydroxy*-1-*methyl*-19-*norlanosta*-5(10),8-*dien*-2-*one* (XXII; R = H) (2·93 g.) as needles, m. p. 121—123°, $[\alpha]_D$ +76° (*c* 0·95), $\lambda_{max.}$ 267 mμ (ε 8100), $\nu_{max.}$ 3474 (OH), 1710 (saturated ketone), and 1640 (conjugated diene) cm.$^{-1}$ (Found: C, 82·0; H, 11·1; O, 7·3. $C_{30}H_{48}O_2$ requires C, 81·8; H, 11·0; O, 7·3%). The compound gave a negative Zimmermann test but a strong reddish-brown colour with tetranitromethane. No adduct was obtained when equimolar quantities of the compound and tetracyanoethylene were mixed in benzene, or when the reactants were refluxed in toluene for 3 hr.

Treatment of the ketol with acetic anhydride–pyridine overnight at room temperature, and crystallisation of the product from ethanol, gave the *acetate* (XXII; R = Ac) as plates, m. p. 137—140°, $[\alpha]_D$ +27° (*c* 1·05), $\lambda_{max.}$ 268 mμ (ε 7810), $\nu_{max.}$ (in CCl_4) at 1750 (OAc), 1740 (C=O adjacent to OAc), and 1636 (conjugated diene) cm.$^{-1}$ (Found: C, 70·4; H, 10·4. $C_{32}H_{50}O_3$ requires C, 79·6; H, 10·4%). The 2,4-*dinitrophenylhydrazone* of the ketol (XXII; R = H) was obtained as orange plates (from ethanol), m. p. 238—240°, $\lambda_{max.}$ 233, 260, and 375 mμ (ε 18,600, 16,800, and 26,800, respectively) (Found: C, 69·6; H, 8·8; N, 8·9. $C_{36}H_{52}N_4O_5$ requires C, 69·6; H, 8·4; N, 9·0%).

3-*Acetoxy*-1-*methyl*-19-*norlanosta*-5,7,9-*trien*-2-*one* (XXIII; R = Ac).—(*a*) 3-Acetoxy-1-methyl-19-norlanosta-5(10),8-dien-2-one (XXII; R = Ac) (500 mg.) in chloroform (15 ml.) was treated with freshly prepared chloroformic 0·28M-perbenzoic acid solution (10 ml.) at room temperature. Titration of an aliquot part after 1 hr. showed that one equivalent of oxygen had been taken up. The mixture was poured into ether, and the solution washed with ice-cold dilute sodium hydroxide and water, dried, and evaporated. Crystallisation of the residue from ethanol gave the aromatic *acetate* (XXIII; R = Ac) (446 mg.) as plates, m. p. 170—172°, $[\alpha]_D$ +18° (*c* 0·9), $\lambda_{max.}$ 260s, 269, and 278 mμ (ε 328, 434, and 352, respectively), $\nu_{max.}$ (in CCl_4) at 1748 (OAc) and 1738 (C=O adjacent to OAc) cm.$^{-1}$ (Found: C, 80·2; H, 10·4; O, 9·8. $C_{32}H_{48}O_3$ requires C, 79·95; H, 10·1; O, 10·0%).

(*b*) Bromine in anhydrous carbon tetrachloride (1·07% v/v; 1·0 ml.) was added during 1 min. to a stirred solution of 3-acetoxy-1-methyl-19-norlanosta-5(10),8-dien-2-one (XXII; R = Ac) (100 mg.) in carbon tetrachloride (10 ml.). The bromine was rapidly absorbed and hydrogen bromide evolved. When addition was complete, the solution was evaporated to dryness *in vacuo*, and the residue crystallised from ethanol to afford the aromatic acetate (XXIII; R = Ac) (98 mg.) (m. p., mixed m. p., and infrared spectrum).

Cleavage of 3-*Hydroxy*-1-*methyl*-19-*norlanosta*-5(10),8-*dien*-2-*one* (XXII; R = H) *with Periodic Acid.*—The diene (1·0 g.) in purified dioxan (50 ml.) was treated with aqueous 0·705M-periodic acid (3·58 ml.) for 5 hr. at room temperature before pouring of the mixture into water and extraction with ether. The ethereal extract was washed with water, dilute sodium thiosulphate solution, and water again, dried, and evaporated to give a pale yellow gum. Trituration with a little ethanol gave a solid product, which, after treatment with aqueous ethanol, yielded crystals (962 mg.), m. p. 100—155°, of the aromatic aldehydic acid (XXVII; R = H). A pure sample of this compound could not be obtained by crystallisation or chromatography. However, the physical properties [$\lambda_{max.}$ 269 mμ (ε 485), $\nu_{max.}$ 3590—2700 (CO_2H), 1720 (CHO), and 1705 (CO_2H) cm.$^{-1}$; p*K* 7·15; equiv., 526 calc., 455)] were in agreement with the postulated structure.

Treatment of the crude acid (500 mg.) in ether (10 ml.) with ethereal diazomethane (10% excess) at 0° overnight gave, after evaporation, a gum which crystallised on trituration with methanol. Several crystallisations from methanol gave the pure *ester-aldehyde* (XXVI; R = Me), m. p. 129—131°, $[\alpha]_D$ +103° (*c* 1·05), $\lambda_{max.}$ 270 and 277 mμ (ε 500 and 435, respectively),

$\nu_{max.}$ 2684 (CHO), 1720 (ester and aldehyde), 1214 (ester), and 818 (aromatic ring) cm.$^{-1}$ (Found: C, 79·2; H, 10·1. $C_{31}H_{48}O_3$ requires C, 79·4; H, 10·3%).

Seco-1-methyl-19-norlanosta-5,7,9-triene-2,3-dioic Acid (XXVII).—The crude acid-aldehyde (XXVI; R = H) (see above) (10 g.) in acetone (100 ml.) was shaken for 3 hr. at room temperature with finely powdered potassium permanganate (500 mg.). The mixture was poured into acidified ferrous sulphate solution, and the product was extracted with ether. After being washed with water, the ethereal solution was extracted twice with dilute sodium hydroxide solution, and the combined alkaline extracts were washed with ether and freed from dissolved solvent by being subjected to a slow stream of air bubbles. Acidification with dilute sulphuric acid precipitated the dicarboxylic acid (761 mg.), m. p. 135—150°. Several crystallisations from slightly aqueous ethanol gave the pure *seco-diacid* (XXVII), m. p. 203—206° (decomp.), $[\alpha]_D$ +61° (*c* 0·87), $\lambda_{max.}$ 270 and 279 mμ (ε 550 and 475, respectively), $\nu_{max.}$ 3625—2652 (CO_2H), 1715 and 1680 (CO_2H), and 815 (aromatic ring) cm.$^{-1}$ (Found: C, 76·0; H, 9·9. $C_{30}H_{46}O_4$ requires C, 76·55; H, 9·85%).

1β- *and* 1α-*Methyl-*A*-nor-19-norlanosta-5,7,9-trien-2-one.*—(*a*) Partially purified seco-diacid (XXVII) (see above) (6·98 g.) was heated for 20 min. at 260°/0·1 mm. The product in light petroleum was filtered through a column of alumina (grade III; 150 g.), and the column washed with further quantities (6 × 200 ml.) of the same solvent. Evaporation of the combined eluates gave a pale yellow solid which crystallised from ethanol–methanol (1 : 1) to give the A-norketone mixture (3·71 g.), m. p. 94—118°. Fractional crystallisation from methanol, aided by hand-picking, afforded 1β-*methyl-*A-*nor-19-norlanosta-5,7,9-trien-2-one* (XXIV) as blades, m. p. 102—104°, $[\alpha]_D$ +100° (*c* 1·05), $\lambda_{max.}$ 271 and 280 mμ (ε 835 and 876, respectively), $\nu_{max.}$ 1750 (5-membered ketone) and 825 (aromatic ring) cm.$^{-1}$ (Found: C, 85·25; H, 11·0. $C_{29}H_{44}O$ requires C, 85·2; H, 10·85%), and its 1α-*methyl analogue* (XXV) as needles, m. p. 133—135°, $[\alpha]_D$ −11° (*c* 0·92), $\lambda_{max.}$ 272 and 280 mμ (ε 941 and 955, respectively), $\nu_{max.}$ 1750 (5-membered ketone) and 824 (aromatic ring) cm.$^{-1}$ (Found: C, 85·0; H, 11·0%).

(*b*) 3-Acetoxy-1-methyl-19-norlanosta-5,7,9-trien-2-one (XXIII; R = Ac) (2·0 g.) was refluxed for 48 hr. with potassium hydroxide (20 g.) in 80% ethanol (200 ml.), the bulk of the solvent removed *in vacuo*, and the residue treated with water and solid carbon dioxide. The precipitated white solid was collected, washed with water, and dried *in vacuo* to afford crude 2-*hydroxy-1-methyl-19-nor-*A-*norcholesta-5(10),6,8-triene-2-carboxylic acid* (XXXI) (2·0 g.). A portion (1·5 g.) of this acid in anhydrous benzene (100 ml.) was shaken with lead tetra-acetate (1·5 g.) for 1 hr., water-saturated ether was added, and the precipitated lead salts were removed by filtration. Evaporation of the solvent, filtration of a light petroleum solution of the residue through alumina (30 g.), and evaporation gave a solid (360 mg.). Fractional crystallisation from methanol, as described above, afforded 1α- (XXVI)- and 1β-methyl-A-nor-19-norlanosta-5,7,9-trien-2-one (XXIV), whose identities were confirmed by m. p., mixed m. p., and infrared spectra.

1-*Methyl-*A-*nor-19-norlanosta-1,5,7,9-tetraene* (XXVIII).—1-Methyl-A-nor-19-norlanosta-5,7,9-trien-2-one (825 mg.; mixed isomers) in methanol (20 ml.) and ether (10 ml.) was stirred at room temperature for 2 hr. with potassium borohydride (800 mg.). The total product, isolated in the usual manner, was heated for 1·5 hr. on the steam-bath with pyridine (8 ml.) and phosphorus oxychloride (2 ml.). Working up in the usual way gave a brown oil which was filtered in light petroleum through alumina (30 g.). Elution with the same solvent and evaporation of the eluate gave a pale yellow oil (673 mg.). The pure *tetraene* (XXVIII), obtained by distillation in a high vacuum, was a viscous oil, $[\alpha]_D$ +44° (*c* 1·26), $\lambda_{max.}$ 266 mμ (ε 9820), $\nu_{max.}$ 1615, 1591 (conjugated aromatic ring), and 808 (aromatic ring) cm.$^{-1}$ (Found: C, 88·4; H, 11·3. $C_{29}H_{44}$ requires C, 88·7; H, 11·3%). The same olefin was also obtained from both pure A-norketones when these were subjected to the above reaction sequence.

Degradation of the Olefin (XXVIII).—The olefin (XXVIII) (440 mg.) in anhydrous ether (10 ml.) containing pyridine (0·5 ml.) was treated with osmium tetroxide (400 mg.) at room temperature for 4 days. Addition of ether and methylene chloride gave a solution which was washed with aqueous sodium hydrogen sulphite and water, dried, and evaporated. The brown residue in ether (100 ml.) containing lithium aluminium hydride (500 mg.) was refluxed for 2 hr. Working up in the usual manner gave a white solid (427 mg.). This glycol mixture (125 mg.) in anhydrous benzene (5 ml.) was shaken for 2 min. with lead tetra-acetate (130 mg.). Addition of ether precipitated the lead salts, and evaporation of the solvent after filtration afforded the keto-aldehyde (XXIX) as a pale yellow oil. This compound did not crystallise,

but its physical properties [$\lambda_{max.}$ 205 and 217 mμ (ε 25,090 and 10,410, respectively), $\nu_{max.}$ at 1736 (CHO) and 1701 (Me·CO) cm.$^{-1}$], were in agreement with the postulated structure.

Oxidation of the Keto-aldehyde (XXIX) *with Potassium Permanganate.*—The crude keto-aldehyde (XXIX), obtained as above from the A-norglycol (636 mg.), in acetone (150 ml.) was stirred vigorously with powdered potassium permanganate (636 mg.) for 2·5 hr. The mixture was poured into ether, the solution washed with acidified ferrous sulphate solution, then water, and the product extracted with dilute sodium hydroxide solution. After being washed with ether, the alkaline extract was acidified with dilute sulphuric acid, and the product isolated in the usual way. Evaporation of the solvent gave a solid (410 mg.) which, after several crystallisations from methanol, afforded the *keto-acid* (XXXIII; R = H) as blades, m. p. 155—160° (loss of solvent above 100°), $[\alpha]_D$ +38° (*c* 0·885), $\lambda_{max.}$ 202, 215s, 255, and 300 mμ (ε 26,400, 15,200, 2470, and 656, respectively), $\nu_{max.}$ 3300—2500 (broad) (CO_2H) and 1696 CO_2H and Me·CO) cm.$^{-1}$. A sample for analysis was dried at 110°/0·1 mm. (Found: C, 78·7; H, 9·7. $C_{29}H_{44}O_3$ requires C, 79·0; H, 10·1%). Addition of ethereal diazomethane (5% excess) to the keto-acid (185 mg.) in ether (5 ml.), followed by evaporation to dryness, gave the *methyl ester* (XXXIII; R = Me). This crystallised from methanol as blades, m. p. 112—115°, $[\alpha]_D$ +41° (*c* 0·725), $\lambda_{max.}$ 202, 215s, 253, and 301 mμ (26,100, 15,600, 2380, and 614, respectively). A sample for analysis was dried at 80°/0·1 mm. (Found: C, 79·1; H, 10·2. $C_{30}H_{46}O_3$ requires C, 79·2; H, 10·2%).

In a later attempted preparation of the keto-acid by the procedure given above, the *diketo-acid* (XXXII; R = H) was obtained. This crystallised from methanol as needles, m. p. 195—196°, $[\alpha]_D$ −36° (*c* 1·05), $\lambda_{max.}$ 260 and 306 mμ (ε 7110 and 2225, respectively), $\nu_{max.}$ 1701 (CO_2H and Me·CO), 1674 (conjugated ketone), 1581 and 1560 (conjugated aromatic ring) cm.$^{-1}$ (Found: C, 76·8; H, 9·1. $C_{29}H_{42}O_4$ requires C, 76·6; H, 9·3%). Esterification of this acid with ethereal diazomethane gave the *methyl ester* (XXXII; R = Me) as needles (from methanol), m. p. 151—153°, $[\alpha]_D$ −40° (*c* 0·815), $\lambda_{max.}$ 258 and 306 mμ (ε 6940 and 2180, respectively), $\nu_{max.}$ 1720 (ester), 1687 (Me·CO), 1664 (conjugated ketone), 1584 and 1577 (conjugated aromatic ring) cm.$^{-1}$ (Found: C, 77·2; H, 9·25. $C_{30}H_{44}O_4$ requires C, 76·9; H, 9·5%).

1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-2-*one* (XXX) (*Isomer A*).—To a stirred solution of calcium (100 mg.) in liquid ammonia (25 ml.) was added during a few minutes the aromatic acetate (XXIII; R = Ac) (500 mg.) in anhydrous ether (20 ml.). The blue colour of the mixture faded during the addition, so that a further portion (100 mg.) of calcium was added before recommencing the addition of the triterpene. Stirring was continued for a further 5 min. before the mixture was decomposed with solid ammonium chloride. The liquid ammonia was allowed to evaporate, and the residue diluted with water and ether. The ether layer was washed with water, dried, and evaporated to give a froth which solidified after trituration with methanol. The solid (377 mg.), m. p. 120—135°, thus obtained was crystallised several times from methanol, to furnish the *ketone* (XXX) (*isomer A*), m. p. 147—150°, $[\alpha]_D$ −74° (*c* 0·87), $\lambda_{max.}$ 269 and 277 mμ (ε 400 and 360, respectively), $\nu_{max.}$ 1705 (saturated ketone) cm.$^{-1}$. The ketone gave a weak Zimmermann test (Found: C, 85·5; H, 10·9. $C_{30}H_{46}O$ requires C, 85·2; H, 11·0%).

1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-2-*one* (XXX) (*Isomer B*).—1-Methyl-19-norlanosta-5,7,9-trien-2-one (isomer A) (500 mg.) in ethanol (50 ml.) containing dissolved sodium (1·0 g.) was refluxed in an atmosphere of argon for 1 hr. Working up in the usual manner gave a gum which was chromatographed on alumina (grade II; 15 g.). Elution with light petroleum and light petroleum–benzene gave a series of crystalline fractions of m. p. *ca.* 97—115°. The combined fractions (372 mg.) crystallised from methanol to give a first crop of crystals, m. p. 100—113°; the second crop had m. p. 107—145°. Several further crystallisations of the first crop afforded 1-*methyl*-19-*norlanosta*-5,7,9-*trien*-2-*one* (*isomer B*) as needles, m. p. 114—117°, $[\alpha]_D$ +158° (*c* 0·575), $\lambda_{max.}$ 269 mμ (ε 510), $\nu_{max.}$ 1704 (C=O) and 817 (aromatic ring) cm.$^{-1}$ (Found: C, 85·4; H, 10·9. $C_{30}H_{46}O$ requires C, 85·2; H, 11·0%). The second crop of crystals gave, after several further crystallisations from methanol, the starting ketone (isomer A), m. p. and mixed m. p. 145—147°.

Equilibration of Isomers A and B of 1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-2-*one.*—The isomer A ketone (162 mg.) was refluxed in 2% w/v ethanolic sodium ethoxide solution (16 ml.) for 1 hr. under argon. The cooled solution was diluted to 25 ml. with ethanol, and the rotation measured ($[\alpha]_D$ +68°). Recovery of the dissolved solids was carried out in the usual manner. This material had a rotation of +52° in chloroform.

Equilibration of the isomer B ketone by the same procedure gave an ethanolic solution, $[\alpha]_D$ +67°, from which the crude solid isolated as above had $[\alpha]_D$ +48° in chloroform. The infrared spectra of the two crude solids were virtually identical.

The equilibration mixture from ketone B was dissolved in light petroleum–benzene (9 : 1), the solution was filtered through a column of alumina (grade II; 6 g.), and the column was eluted with further quantities of the same solvent mixture. Evaporation of the solvent gave crystals (95 mg.) which, after repeated crystallisation from methanol, furnished isomer A, m. p. and mixed m. p. 144—147°, and isomer B, m. p. and mixed m. p. 114—116°. The infrared spectra of these ketones were identical with those of the corresponding authentic samples.

1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-3-*one* (XXXVI) *and* 1-*Methyl*-19-*norlanosta*-2,5,7,9-*tetraene* (XXXVII).—The aromatic α-ketol acetate (XXIII; R = Ac) (500 mg.) was dissolved in toluene-ω-thiol (2·5 ml.) by gentle warming, and, after cooling to room temperature, boron trifluoride–ether (10 drops) was added. After 30 min., the solution was diluted with ether and washed with dilute sodium hydroxide solution and water, dried, and evaporated to yield a yellow gum, $\nu_{max.}$ 1750 (OAc) and 695 (CH_2Ph) cm.$^{-1}$. This crude thioketal in ethanol (100 ml.) was refluxed for 5 hr. with freshly prepared Raney nickel W7 (5 g.), the mixture filtered hot, and the residue washed with chloroform. Evaporation of the filtrate gave an oil (386 mg.), $\nu_{max.}$ 1740 (OAc) cm.$^{-1}$. This crude ester was treated with lithium aluminium hydride (150 mg.) in ether (10 ml.) for about 3 min., and the product, isolated in the usual manner, was oxidised with chromic acid solution (0·4 ml.) in acetone (40 ml.) at room temperature for 5 min. Recovery of the product in the normal way gave a gum which was chromatographed on alumina (grade II; 9 g.). Elution with light petroleum afforded crystals (256 mg.) which, after several crystallisations from acetone, gave 1-*methyl*-19-*norlanosta*-2,5,7,9-*tetraene* (XXXVII) as blades, m. p. 108—111°, $[\alpha]_D$ −29° (*c* 1·12), $\lambda_{max.}$ 268 mμ (ε 380), $\nu_{max.}$ 823 (aromatic ring) and 752 (C=C) cm.$^{-1}$ (Found: C, 88·8; H, 11·7. $C_{30}H_{46}$ requires C, 88·6; H, 11·4%). Further elution of the chromatogram column with light petroleum–benzene gave a solid (67 mg.) which, after several crystallisations from methanol–ethanol (2 : 1), afforded 1-*methyl*-19-*norlanosta*-5,7,9-*trien*-3-*one* (XXXVI) as needles, m. p. 155—157°, $[\alpha]_D$ +107° (*c* 0·965), $\lambda_{max.}$ 267 mμ (ε 402), $\nu_{max.}$ 1720 (C=O) and 823 (aromatic ring) cm.$^{-1}$ (Found: C, 85·0; H, 11·05. $C_{30}H_{46}O$ requires C, 85·2; H, 11·0%). This ketone gave a strong positive Zimmermann test.

1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-3-*one* (XXXVI) *from the Acetate* (XXII; R = Ac).—The α-ketol acetate (XXII; R = Ac) (2 g.) in toluene-ω-thiol (5 ml.) was treated with boron trifluoride–ether (10 drops) and the red solution left at room temperature for 3 hr. before being poured into ether. The ethereal solution was washed with dilute sodium hydroxide solution, then water, dried, and evaporated, to give a gum (2·742 g.). This was dissolved in carbon tetrachloride (150 ml.) at 0°, and a solution of bromine in the same solvent (2·026% v/v; 10 ml.) added dropwise with stirring in 2—3 min. The solution was washed with dilute sodium hydrogen carbonate solution and water, dried, and evaporated and the residue was dissolved in ether (150 ml.). Lithium aluminium hydride (1·5 g.) was added, and the suspension stirred at room temperature for 3 min. before decomposition in the usual manner. The product, isolated in the usual way, was desulphurised by refluxing it for 5 hr. in ethanol (100 ml.) with freshly prepared Raney nickel W7 (10 g.). The mixture was cooled and filtered and the residue washed with chloroform. Evaporation of the filtrate and washings gave an oil which was chromatographed on alumina (grade III; 60 g.). Oils were eluted, which were discarded, by light petroleum–benzene. Elution with benzene gave an oil (176 mg.) which was oxidised with chromic acid solution (0·2 ml.) in acetone (20 ml.) for 3 min. Isolation of the product in the usual way and crystallisation from ethanol–methanol (1 : 1) afforded needles (100 mg.), m. p. 137—148°. Several further crystallisations from methanol gave the pure ketone (XXXVI) (m. p., mixed m. p., and infrared spectrum).

Photolysis of 1-*Methyl*-19-*norlanosta*-5,7,9-*trien*-3-*one* (XXXVI).—The ketone (350 mg.) in aqueous acetic acid (1 : 9; 75 ml.) at 90° was exposed to the radiation of a bare 125-w mercury-arc lamp for 5 days, in an atmosphere of oxygen-free nitrogen. The cooled solution was poured into water, the product was extracted with light petroleum, and the extracts were washed with dilute sodium hydroxide solution. Acidification of the basic extract gave, after extraction with ether and evaporation, an oil (138 mg.). This did not solidify, and was treated with an excess of diazomethane in ether. Evaporation of the solvent gave an oily residue; this was

dissolved in light petroleum and filtered through a small column of alumina (grade III), and the column was washed with light petroleum. Evaporation of the combined eluates gave a clear yellow oil. Distillation of this product at 0·3 mm. afforded the pure *ester* (XXXVIII; R = Me), $[\alpha]_D$ +19° (*c* 1·355), $\lambda_{max.}$ 270 mμ (ε 485), $\nu_{max.}$ (in $CHCl_3$) 1729 (CO_2Me) $cm.^{-1}$ (Found: C, 81·9; H, 11·1. $C_{31}H_{50}O_2$ requires C, 81·9; H, 11·1%).

3-Methanesulphonyloxy-1-methyl-19-norlanosta-5(10),8-dien-2-one (XXII; R = Me·SO_2).—A solution of the α-ketol (XXII; R = H) (100 mg.) in anhydrous pyridine (1·0 ml.) was treated with methanesulphonyl chloride (0·5 ml.) overnight at room temperature. Working up in the usual way, and crystallisation of the product from ethanol, gave plates (80 mg.), m. p. 153—155°. Two further crystallisations afforded the pure *methanesulphonate* (XXII; R = Me·SO_2), m. p. 154—157°, $[\alpha]_D$ +34° (*c* 1·086), $\lambda_{max.}$ 268 mμ (ε 8143), $\nu_{max.}$ 1736 (exalted C=O), 1359, 1180, and 1171 (Me·SO_2·O) $cm.^{-1}$ (Found: C, 71·6; H, 10·0; S, 6·0. $C_{31}H_{50}O_4S$ requires C, 71·8; H, 9·7; S, 6·2%).

3-Methanesulphonyl-1-methyl-19-norlanosta-5,7,9-trien-2-one (XXIII; R = Me·SO_2).—The diene methanesulphonate (XXII; R = Me·SO_2) (100 mg.) in carbon tetrachloride (10 ml.) at −20° was stirred with bromine in the same solvent (0·099% v/v; 10 ml.). The resulting pale yellow solution was evaporated at reduced pressure, and the residue triturated with ethanol to give a solid, m. p. 90—110°. Two crystallisations from methanol afforded the pure aromatic *methanesulphonate* (XXIII; R = Me·SO_2) as needles, m. p. 108—110°, $[\alpha]_D$ +31° (*c* 1·01), $\lambda_{max.}$ 269 mμ (ε 458), $\nu_{max.}$ 1740 (exalted C=O), 1367 and 1177 (Me·SO_2·O), and 837 (aromatic ring) $cm.^{-1}$ (Found: C, 72·0; H, 9·7; S, 6·25. $C_{31}H_{48}O_4S$ requires C, 72·0; H, 9·4; S, 6·2%).

Lanosta-2,8-diene (XL).—Lanost-8-en-3β-yl benzoate (2·0 g.) was heated under nitrogen for 3 hr. at 330° (bath-temp.) under an air condenser. After cooling, the residual brown oil was dissolved in light petroleum (60 ml.) and the solution filtered through a short column of alumina. Elution of the column with light petroleum, and evaporation of the combined eluates, gave a colourless oil which solidified at 0°. Crystallisation from acetone gave a solid (0·91 g.), m. p. 70—77°, which after two crystallisations from chloroform–acetone–methanol (1 : 1 : 1), and then two from acetone, afforded pure *lanosta-2,8-diene* (XL), m. p. 83—84°, $[\alpha]_D$ +124° (*c* 0·555) (Found: C, 87·7; H, 12·5. $C_{30}H_{50}$ requires C, 87·7; H, 12·3%).

This pyrolytic procedure for preparing the hydrocarbon gave variable results, and several techniques were investigated in an endeavour to find a reliable method. For the best results, it was preferable to reflux the benzoate in a flask heated by means of an electric mantle. Periodically, the flask and its contents were cooled, and the sublimed benzoic acid removed both from the condenser and from the inside walls of the flask. Heating was then resumed, and the process repeated at intervals until evolution of benzoic acid ceased. The residue was then processed as described above.

Dehydration of Lanost-8-en-3β-ol (XXXIX; R = H) *with Phosphorus Oxychloride–Pyridine.*—Phosphorus oxychloride (7·5 ml.) was added dropwise with efficient stirring and cooling to lanost-8-en-3β-ol (5·0 g.) in pyridine (50 ml.). The mixture was heated for 1·5 hr. on a steam-bath, cooled, and poured into a large volume of water. Isolation of the product in the usual way gave a solid which was dissolved in light petroleum and filtered through a short alumina column. Elution with light petroleum gave colourless crystals (4·5 g.) which recrystallised from ethanol–ether (1 : 2). Fractionation of the more soluble portion from acetone gave lanosta-2,8-diene (m. p., mixed m. p., rotation, and infrared spectrum). Recrystallisation of the less soluble portion from acetone gave isolanostadiene (XLI), m. p. 142—143°, $[\alpha]_D$ +76° (*c* 0·93), whose identity was confirmed by its infrared spectrum.

In a second experiment, the total crude product obtained from the dehydration of lanost-8-en-3β-ol (1·6 g.) was dissolved in anhydrous ether (15 ml.), and a solution of bromine (0·22 ml.) in acetic acid (50 ml.) was added. After 4 hr. at room temperature, the mixture was worked up in the usual manner, to give a dark brown gum. This was dissolved in light petroleum, the solution filtered through an alumina column, and the eluate evaporated to furnish a pale yellow solid. Two crystallisations from acetone gave slightly impure lanosta-2,8-diene, m. p. 79—81°, $[\alpha]_D$ +116° (*c* 1·19).

Hydrogenation of Lanosta-2,8-diene (XL).—The diene (100 mg.) in acetic acid (10 ml.) was hydrogenated at 60° over pre-reduced Adams catalyst. The catalyst was filtered off, and the filtrate cooled. Lanost-8-ene (82 mg.) separated (m. p. and mixed m. p.).

Lanosta-7,9(11)-dien-3β-yl Benzoate.—Benzoyl chloride (10 ml.) was added with stirring to

lanosta-7,9(11)-dien-3β-ol (5·0 g.) in pyridine (35 ml.), and the solution heated on the steam-bath for 1·5 hr. After cooling, the semi-solid mass was added portionwise to ice-cold methanol (200 ml.), and the crystals were collected, washed with methanol, and dried. The crude ester (5·97 g.), m. p. 201—204°, crystallised from ethyl acetate to afford *lanosta*-7,9(11)-*dien*-3β-*yl benzoate* (XLIII) as needles, m. p. 203—204°, $[\alpha]_D$ +65° (*c* 1·11), $\lambda_{max.}$ (in cyclohexane) 237, 245, and 253 mμ (ε 21,220, 16,800, and 10,500, respectively) (Found: C, 83·3; H, 10·5. $C_{37}H_{54}O_2$ requires C, 83·7; H, 10·25%).

Pyrolysis of Lanosta-7,9(11)-*diene*-3β-*yl Benzoate*.—The benzoate (2·0 g.) was refluxed for 5 hr. under an air condenser. After cooling, the residue was dissolved in light petroleum and filtered through a short column of alumina, and the eluate was evaporated to dryness. Crystallisation of the residue from chloroform–methanol, and then acetone, gave lanosta-2,7,9(11)-triene (XLIV) as plates, m. p. 97—99°, $[\alpha]_D$ +126° (*c* 1·03), $\lambda_{max.}$ 237, 244, and 254 mμ (ε 12,670, 15,450, and 9280, respectively) (Dorée, McGhie, and Kurzer [16] give m. p. 94—98°, $[\alpha]_D$ +133°).

Lanost-8-*ene*-2α,3α-*diol* (XLII).—Lanosta-2,8-diene (500 mg.) in anhydrous benzene (25 ml.) was treated with osmium tetroxide (375 mg.) in anhydrous pyridine (25 ml.). After one week, the solvents were removed *in vacuo*, and the residue was refluxed for 4 hr. in ethanol–benzene (2 : 1; 45 ml.) containing water (7·5 ml.), mannitol (3 g.), and potassium hydroxide (3 g.). Isolation of the product in the usual way gave a yellow solid which was chromatographed on alumina (grade II; 10 g.). Elution of the column with ether–methanol (19 : 1), evaporation of the eluates, and crystallisation from methanol gave *lanost*-8-*ene*-2α,3α-*diol* (XLII) as needles, m. p. 177—179°, $[\alpha]_D$ +68° (*c* 1·03) (Found: C, 80·7; H, 11·8. $C_{30}H_{52}O_2$ requires C, 81·0; H, 11·8%).

2α,3α:8α,9α-*Diepoxylanostane* (XLV).—0·477M-Perbenzoic acid in chloroform (10 ml.) was added to a solution of lanosta-2,8-diene (500 mg.) in chloroform (10 ml.) at 0°. Titration of aliquot parts at intervals showed that one atom-equiv. of oxygen was absorbed in *ca.* 0·5 hr., and that after 20 hr. the uptake was 2·1 atom-equiv. The mixture was poured into ether, the solution washed with ice-cold 2N-sodium hydroxide, then with water, and dried, and the solvent removed. Crystallisation of the residue from ethanol and then methylene chloride–methanol afforded 2α,3α:8α,9α-*diepoxylanostane* (XLV) as needles, m. p. 124—126°, $[\alpha]_D$ +9° (*c* 0·99) (Found: C, 81·1; H, 11·3. $C_{30}H_{50}O_2$ requires C, 81·4; H, 11·4%).

2β-*Bromolanosta*-7,9(11)-*dien*-3α-*ol* (XLVI).—2α,3α:8α,9α-*Diepoxylanostane* (XLV) (350 mg.) in chloroform (15 ml.) was shaken vigorously for 20 min. with 48% aqueous hydrogen bromide (5 ml.). The mixture was diluted with water, and the product isolated by extraction with light petroleum, washed with water, dried, and recovered. The residue, after several crystallisations from methylene chloride–methanol, gave the *bromohydrin* (XLVI) as plates, m. p. 125—126°, $[\alpha]_D$ +125° (*c* 1·01), $\lambda_{max.}$ 238, 245, and 253 mμ (ε 10,540, 12,200, and 8370, respectively) (Found: C, 71·8; H, 9·7; Br, 15·7. $C_{30}H_{49}BrO$ requires C, 71·3; H, 8·9; Br, 15·8%).

The rate at which the compound eliminated hydrogen bromide with alkali was determined by the method of Barton, Lewis, and McGhie.[2] Titration after 5 min. showed 61% of elimination.

2α,3α-*Epoxylanosta*-7,9(11)-*diene* (XLVII).—Ethanolic 5% potassium hydroxide (50 ml.) was added to 2β-bromolanosta-7,9(11)-dien-3α-ol (XLVI) (1·0 g.) in benzene (5 ml.), and the mixture refluxed for 1 hr., cooled, treated with solid carbon dioxide, and evaporated to small bulk. Isolation of the product in the usual manner gave a gum which crystallised when treated with hot methanol. Several crystallisations from methylene chloride–methanol then gave 2α,3α-*epoxylanosta*-7,9(11)-*diene* (XLVII) as plates, m. p. 94—95°, $[\alpha]_D$ +108° (*c* 1·00), $\lambda_{max.}$ 253, 244, and 252 mμ (ε 13,940, 17,250, and 10,760, respectively) (Found: C, 84·7; H, 11·1. $C_{30}H_{48}O$ requires C, 84·8; H, 11·4%).

A solution of this epoxide (300 mg.) in chloroform (10 ml.) was shaken for 20 min. with aqueous 48% hydrogen bromide (3 ml.). Isolation of the product as before gave, after crystallisation from methylene chloride–methanol, 2β-bromolanosta-7,9(11)-dien-3α-ol (XLVI) (m. p., mixed m. p., rotation, and infrared spectrum).

Lanosta-2,9(11)-*diene*-7-*one* (XLVIII).—Chromyl chloride (0·81 ml.; redistilled) in anhydrous methylene chloride (40 ml.) was added in 1 hr. to a stirred solution of lanosta-2,8-diene (2·0 g.) in the same solvent (40 ml.) at −20°. Stirring was continued for a further 2 hr. at this temperature before addition of sodium hydrogen sulphite solution. The product was extracted with ether, and the extract washed to neutrality with water, dried, and evaporated to give a

gum which crystallised. Recrystallisation from methylene chloride–methanol gave a solid (1·09 g.), m. p. 108—110°. Several further crystallisations from ethanol and ether–methanol afforded *lanosta*-2,9(11)-*dien*-7-*one* (XLVIII) m. p. 115—117°, $[\alpha]_D$ +77° (*c* 1·10), $\lambda_{max.}$ 250 mμ (ε 107), $\nu_{max.}$ (in CCl_4) (1705 (saturated ketone) cm.$^{-1}$ (Found: C, 84·9; H, 11·5. $C_{30}H_{48}O$ requires C, 84·8; H, 11·4%).

Lanosta-2,8-*dien*-7-*one* (XLIX).—(*a*) Lanosta-2,9(11)-diene-7-one (XLVIII) (500 mg.) was refluxed for 10 min. in ethanol (30 ml.) containing dissolved sodium (50 mg.), and the solution was cooled, acidified with acetic acid, and evaporated to small bulk *in vacuo*. Isolation of the product in the usual way gave, after one crystallisation from ethanol, plates (380 mg.), m. p. 108—110°. Several recrystallisations from ethanol and finally acetone afforded *lanosta*-2,8-*dien*-7-*one* (XLIX), m. p. 112—114°, $[\alpha]_D$ +101° (*c* 1·23), $\lambda_{max.}$ 253 mμ (ε 9700) (Found: C, 85·05; H, 11·55. $C_{30}H_{48}O$ requires C, 84·8; H, 11·4%).

(*b*) Lanosta-2,9(11)-dien-7-one (XLVIII) (100 mg.) in anhydrous benzene (5 ml.) was treated with boron trifluoride–ether (6 drops) and next morning the solution was refluxed for 15 min. Isolation of the product in the usual way and crystallisation from ethanol gave lanosta-2,8-dien-7-one (XLIX) (m. p., mixed m. p., and infrared spectrum).

Lanost-9(11)-*en*-7-*one*.—To a stirred solution of lanost-8-ene (1·0 g.) in anhydrous methylene chloride (20 ml.) at −20°, was added, in 1 hr., a solution of chromyl chloride (0·41 ml.) in the same solvent (20 ml.). After being stirred for a further 2 hr. at −20°, the mixture was decomposed by sodium hydrogen sulphite solution, and the product isolated as described in the first example. Crystallisation from methylene chloride–methanol gave needles (340 mg.), m. p. 110—112°. These were recrystallised several times from ethanol to afford *lanost*-9(11)-*en*-7-*one* as blades, m. p. 112—114°, $[\alpha]_D$ +51° (*c* 1·16), $\lambda_{max.}$ 253 and 255 mμ (ε 745 and 725, respectively), $\nu_{max.}$ 1696 (saturated ketone) cm.$^{-1}$ (Found: C, 84·8; H, 11·9. $C_{30}H_{50}O$ requires C, 84·4; H, 11·8%).

The ultraviolet spectrum of this compound showed it to be contaminated with some conjugated ketone, presumably lanost-8-en-7-one. However, further crystallisation increased the amount of contaminant, indicating ready isomerisation.

Rearrangement of lanost-9(11)-en-7-one with sodium ethoxide or boron trifluoride–ether under the conditions previously described gave lanost-8-en-7-one (m. p., mixed m. p., and infrared spectra).

3β-*Acetoxylanost*-8-*en*-7-*one*.—(*a*) Treatment of lanost-8-en-3β-yl acetate (2·3 g.) in methylene chloride (40 ml.) at −20° with chromyl chloride (0·81 ml.) in the same solvent (40 ml.) according to the conditions previously described gave a solid (1·35 g.), m. p. 127—131° (from ethanol). The spectral data [$\lambda_{max.}$ 246 and 253 mμ (ε 3390 and 3640, respectively); $\nu_{max.}$ 1726 (OAc), 1696 (saturated ketone), and 1634 (conjugated ketone) cm.$^{-1}$] indicated that this product was an ~1 : 2 mixture of conjugated and non-conjugated ketones. Attempted purification by repeated crystallisation served only to increase the amount of conjugated impurity. The crude material (200 mg.; m. p. 129—134°) was therefore refluxed for 10 min. in ethanol (12 ml.) containing dissolved sodium (20 mg.). Isolation of the product in the usual way gave crystals which were reacetylated with acetic anhydride–pyridine. Crystallisation from acetone–methanol then afforded 3β-acetoxy-lanost-8-en-7-one (m. p., mixed m. p., and infrared spectrum).

(*b*) Lanosta-7,9(11)-dien-3β-yl acetate (2·3 g.) in methylene chloride (40 ml.) at −20° was treated with chromyl chloride (0·41 ml.) in the same solvent (20 ml.) under similar conditions to those already described. Isolation of the product in the usual manner, and crystallisation from ethanol, gave needles (1·226 g.), m. p. 145—148°, $\lambda_{max.}$ 254 mμ (ε 9200). Recrystallisation from ether–methanol yielded 3β-acetoxylanost-8-en-7-one (m. p., mixed m. p., and infrared spectrum).

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