*Steroids. Part XIV.** 7 : 8-*Epoxides of* 9α- *and* 9β-*Ergostan*-11-*one Derivatives.*

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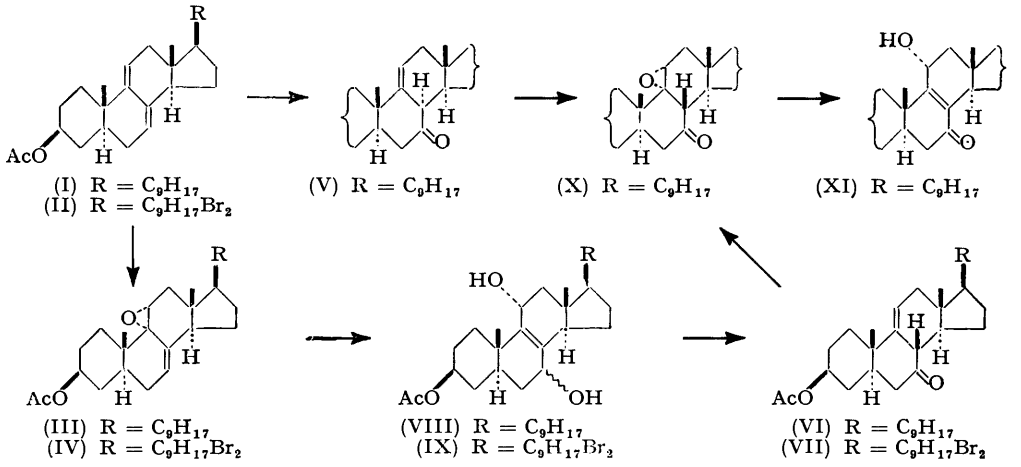
22 : 23-Dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate is isomerised by brief contact with alumina to the 9α-isomer. Oxidation of the latter with perbenzoic acid gives 22 : 23-dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate while similar treatment of the 9β-isomer gives 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate. Both oxo-epoxides are isomerised by hydrogen bromide to 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate. The action of alkali and acid upon the two oxo-epoxides has been studied and the products have been isolated and characterised.

A NUMBER of oxidation products derived from steroid 7 : 9(11)-dienes have been described during the last three years. In particular it is known that oxidation of ergosteryl-D acetate (I) with aromatic peracids gives the 9α : 11α-epoxide (III) (Chamberlin, Ruyle, Erickson, Chemerda, Aliminosa, Erickson, Sita, and Tishler, *J. Amer. Chem. Soc.*, 1951, **73**, 2396; 1953, **75**, 3477; Heusser, Eichenberger, Kurath, Dallenbach, and Jeger, *Helv. Chim. Acta*, 1951, **34**, 2106) whereas with performic acid the βγ-unsaturated ketone 7-oxo-8α-ergosta-9(11) : 22-dien-3β-yl acetate (V) is produced (Budziarek, Newbold, Stevenson, and Spring, *J.*, 1952, 2892; Budziarek, Stevenson, and Spring, *J.*, 1952, 4874; Maclean and Spring, *J.*, 1954, 328). The normal $C_{(8)}$-epimer of (V), 7-oxoergosta-9(11) : 22-dien-3β-yl acetate (VI), is obtained, first, by controlled mineral-acid treatment of 9α : 11α epoxyergosta-7 : 22-dien-3β-ol (Schoenewaldt, Turnbull, Chamberlin, Reinhold, Erickson, Ruyle, Chemerda, and Tishler, *J. Amer. Chem. Soc.*, 1952, **74**, 2696) followed by acetylation; secondly, from 7ξ : 11α-dihydroxyergosta-8 : 22-dien-3β-yl acetate (VIII), itself obtained from (III) by treatment with mineral acid (Chamberlin *et al.*, *loc. cit.*; Heusser *et al.*, *loc. cit.*) and by reaction with hydrogen peroxide in acetic acid (Heusser, Anliker, Eichenberger, and Jeger, *Helv. Chim. Acta*, 1952, **35**, 936); and, thirdly, from 22 : 23-dibromo-7ξ : 11α-dihydroxyergost-8-en-3β-yl acetate (IX), obtained from the 7 : 9(11)-diene (II) *via* the oxide (IV), which with the boron trifluoride–ether complex gives the βγ-unsaturated dibromo-ketone (VII), debromination of which gives (VI) (Maclean and Spring, *loc. cit.*). Each of the $C_{(8)}$-epimeric βγ-unsaturated ketones (V) and (VI) has been converted into

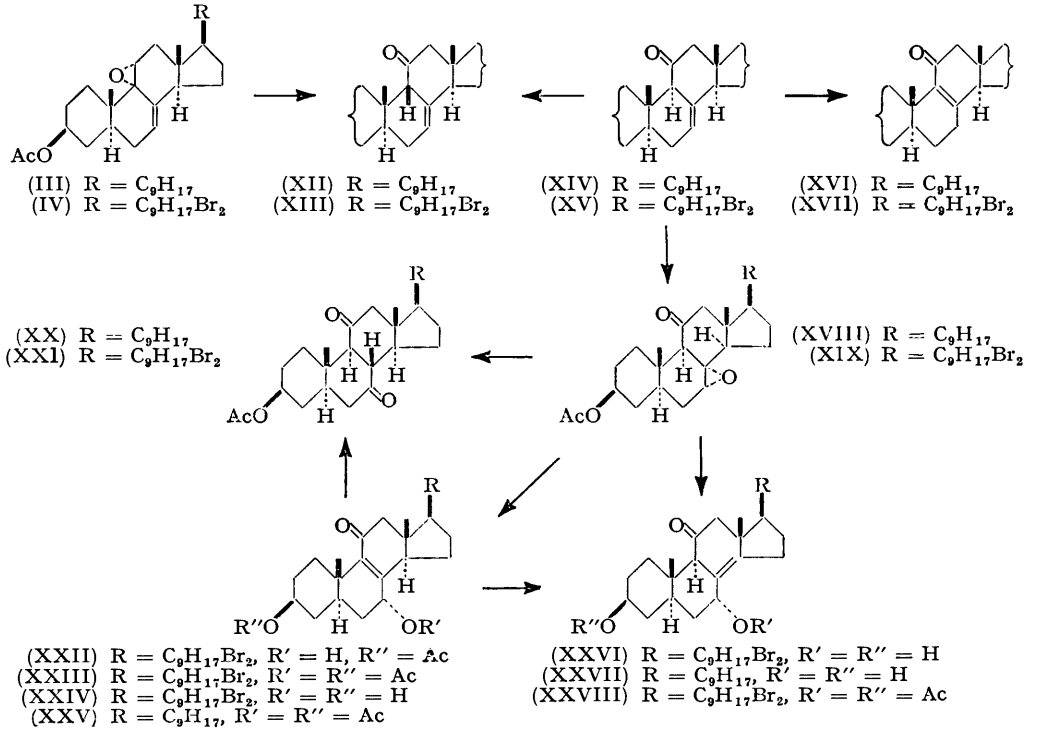
* Part XIII, *J.*, 1954, 1302.

9α : 11α-epoxy-7-oxoergost-22-en-3β-yl acetate (X) (inversion at $C_{(8)}$ occurring in the former case) which although stable to mineral acid is readily converted into 3β : 11α-dihydroxyergosta-8 : 22-dien-7-one (XI) by treatment with alkali (Budziarek, Newbold



et al., loc. cit.). The present paper describes the nature and behaviour of the oxidation products derived from two related βγ-unsaturated ketones obtained from steroid 7 : 9(11)-dienes.

In Part X (Maclean and Spring, *loc. cit.*) it was shown that treatment of 22 : 23-dibromo-



7ξ : 11α-dihydroxyergost-8-en-3β-yl acetate (IX) with boron trifluoride gives a mixture from which 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (XIII) was isolated, debromination of which yields the corresponding 11-oxo-9β-ergosta-7 : 22-dien-3β-yl

acetate (XII). The βγ-unsaturated ketone (XII) has been obtained by controlled treatment of 9α : 11α-epoxyergosta-7 : 22-dien-3β-yl acetate (III) with the boron trifluoride–ether complex (Heusler and Wettstein, *Helv. Chim. Acta*, 1953, **36**, 398; Bladon, Henbest, Jones, Lovell, Wood, Woods, Elks, Evans, Hathway, Oughton, and Thomas, *J.*, 1953, 2921), and the βγ-unsaturated ketone (XIII) has been obtained by a similar isomerisation of 22 : 23-dibromo-9α : 11α-epoxyergost-7-en-3β-yl acetate (IV) (Elks, Evans, Robinson, Thomas, and Wyman, *J.*, 1953, 2933). During an attempt to obtain an enol acetate of 22 : 23-dibromo-11-oxoergost-8-en-3β-yl acetate by treating the dibromo-epoxide (IV) with boron trifluoride in the presence of acetic anhydride, we found that the reaction gave instead the βγ-unsaturated ketone (XIII). Filtration of a benzene solution of 11-oxo-9β-ergosta-7 : 22-dien-3β-yl acetate (XII) through alumina causes inversion at $C_{(9)}$, to give 11-oxoergosta-7 : 22-dien-3β-yl acetate (XIV) (Bladon *et al.*, *loc. cit.*). Similar treatment of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (XIII) gives 22 : 23-dibromo-11-oxoergost-7-en-3β-yl acetate (XV) in good yield. The structure of (XV) was established by its conversion into 11-oxoergosta-7 : 22-dien-3β-yl acetate (XIV) by treatment with zinc dust. If the alumina treatment of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (XIII) is prolonged it is isomerised to 22 : 23-dibromo-11-oxoergost-8-en-3β-yl acetate (XVII) (Maclean and Spring, *loc. cit.*), showing that (XV) is an intermediate in the alumina rearrangement of (XIII) into (XVII). In the same way, prolonged contact with alumina converts 11-oxoergosta-7 : 22-dien-3β-yl acetate (XIV) into 11-oxoergosta-8 : 22-dien-3β-yl acetate (XVI) albeit in poor yield. The molecular rotation change associated with the conversion of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate into the 9α-epimer ($\Delta = +930°$) is similar to that associated with the conversion of 11-oxo-9β-ergost-7 : 22-dien-3β-yl acetate into the 9α-epimer ($\Delta = +1070°$).

Treatment of 22 : 23-dibromo-11-oxoergost-7-en-3β-yl acetate (XV) with perbenzoic acid gives, in high yield, 22 : 23-dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (XIX). The structure ascribed to this oxo-epoxide follows from its method of preparation and from reactions which are described below. The oxidation of the isolated 7 : 8-double bond in a normal 5α-steroid to an epoxide has not been previously observed. According to Fieser and Fieser (" Natural Products Related to Phenanthrene," Reinhold Publ. Corp., New York, 1944, p. 245; Fieser and Ourisson, J. *Amer. Chem. Soc.*, 1953, **75**, 4404) oxidation of a Δ^7-5α-stenol with perbenzoic acid proceeds by initial hydroxylation at $C_{(14)}$ and not by 7 : 8-oxide formation. Two steroid 7 : 8-epoxides have been described in the literature; one of these, 7β : 8β-epoxy-11-oxo-9β-ergost-22-en-3β-yl acetate (unnatural configuration at $C_{(9)}$) is obtained by oxidation of 11-oxo-9β-ergosta-7 : 22-dien-3β-yl acetate with monoperphthalic acid and is discussed in some detail later in this paper. The second, methyl 3α-acetoxy-7ξ : 8ξ-epoxychol-9(11)-enate, is obtained by oxidation of methyl 3α-acetoxychola-7 : 9(11)-dienate with monoperphthalic acid (Heusser, Anliker, Eichenberger and Jeger, *loc. cit.*).

22 : 23-Dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (XIX) does not show intense selective absorption in the ultra-violet above 2000 Å and the absence of a hydroxyl group was confirmed by its infra-red absorption spectrum. When treated with zinc dust in a neutral solvent, (XIX) is smoothly debrominated to 7α : 8α-epoxy-11-oxoergost-22-en-3β-yl acetate (XVIII).

22 : 23-Dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (XIX) is readily rearranged by mineral acids; with hydrogen bromide in chloroform–acetic acid it gives 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (XXI), the structure of which follows from its ready conversion into the known 7 : 11-dioxoergost-22-en-3β-yl acetate (XX) by treatment with zinc in a neutral solvent. The natural configuration at $C_{(8)}$ and $C_{(9)}$ in (XXI) follows both from this reaction and from its recovery unchanged after alkaline hydrolysis followed by re-acetylation. Treatment of the oxo-epoxide (XIX) with sulphuric acid in dioxan gives 22 : 23-dibromo-7α-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXII) which shows the characteristic ultra-violet absorption spectrum of an αβ-unsaturated ketone. The presence of a hydroxyl group in (XXII) was established by acetylation which yielded a diacetate (XXIII). 22 : 23-Dibromo-7α-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXII) is an intermediate in the conversion of the oxo-epoxide (XIX) into the saturated diketone (XXI)

since it is converted into the last compound by treatment with hydrogen bromide in chloroform–acetic acid.

The behaviour of the oxo-epoxide with alkali was next examined. In 1% methanolic potassium hydroxide at *room temperature*, the oxo-epoxide (XIX) gives 22 : 23-dibromo-3β : 7α-dihydroxyergost-8-en-11-one (XXIV), acetylation of which yields the diacetate (XXIII) mentioned above. Treatment of the diol (XXIV) with zinc dust followed by acetylation of the product gives 3β : 7α-diacetoxyergosta-8 : 22-dien-11-one (XXV), also obtained by debromination of (XXIII) with zinc. The diacetate (XXV) has been obtained by Henbest and Wagland (*J.*, 1954, 728) * by the action of acetic acid on 9α : 11α-epoxyergosta-7 : 22-dien-3β-yl acetate (III), followed by oxidation of the intermediate 3β : 7α-diacetoxyergosta-8 : 22-dien-11α-ol with chromic acid.

When treated with *refluxing* methanolic potassium hydroxide the oxo-epoxide (XIX) gives 22 : 23-dibromo-3β : 7α-dihydroxyergost-8(14)-en-11-one (XXVI) which shows the light absorption characteristic of the isolated 8 : 14-double bond (Bladon, Henbest, and Wood, *J.*, 1952, 2737) and is readily acetylated to the diacetate (XXVIII). Debromination of the diol (XXVI) yields 3β : 7α-dihydroxyergosta-8(14) : 22-dien-11-one (XXVII). 22 : 23-Dibromo-3β : 7α-diacetoxyergost-8-en-11-one (XXIV), obtained from the oxo-epoxide (XIX) by treatment with cold alkali, is an intermediate in the conversion of (XIX) into 22 : 23-dibromo-3β : 7α-dihydroxyergost-8(14)-en-11-one (XXVI) since it is converted into the last compound by refluxing methanolic potassium hydroxide.

The 7α : 8α-configuration is ascribed to the epoxide ring in (XIX) in analogy with the established attack from the rear (α) face of Δ^7-stenols by osmium tetroxide–acid. Oxidation of cholest-7-enyl acetate with osmium tetroxide followed by hydrolysis yields cholestane-3β : 7α : 8α-triol (Fieser and Ourisson, *loc. cit.*; Fieser, *Experientia*, 1950, **6**, 312; Wintersteiner and Moore, *J. Amer. Chem. Soc.*, 1943, **65**, 1507); it follows that the hydroxyl groups in each of the unsaturated alcohols (XXII) and XXVI) derived from it are 7α-orientated.

The oxidation of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (XIII) with perbenzoic acid was next examined; by using a freshly prepared reagent and mineral acid-free chloroform an almost quantitative yield of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (XXX) was obtained. The oxo-epoxide is also obtained from (XIII) by oxidation with monoperphthalic acid in ether. Debromination of (XXX) by zinc in a neutral solvent gives 7β : 8β-epoxy-11-oxo-9β-ergost-22-en-3β-yl acetate (XXIX), previously obtained by Heussler and Wettstein (*loc. cit.*) and Henbest and Wagland (*loc. cit.*) by direct oxidation of (XII) with monoperphthalic acid.

Treatment of the oxo-epoxide (XXX) in chloroform with a trace of hydrobromic acid gives 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII) which shows the characteristic ultra-violet absorption spectrum of an αβ-unsaturated ketone; its infra-red spectrum shows peaks characteristic of an αβ-unsaturated ketone, hydroxyl, and acetoxy-groups. The presence of a hydroxyl group was confirmed by acetylation of (XXXIII) to the diacetate (XXXIV). Apart from the orientation of the 7-hydroxyl group, the correctness of the formulation (XXXIII) for the acid-rearrangement product from the oxo-epoxide (XXX) was established by oxidation with chromic acid followed by treatment with zinc dust and acetic acid which yielded 7 : 11-dioxoergost-22-en-3β-yl acetate (XX). It follows that the compound obtained by the action of hydrobromic acid on the oxo-epoxide (XXX) can differ from 22 : 23-dibromo-7α-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXII), the preparation of which is described above, only in the orientation of the hydroxyl group. As a corollary, the epoxide ring in (XXX) has the β-configuration.

It is of interest to comment upon the difference in behaviour of the $C_{(9)}$-epimeric βγ-unsaturated 11-ketones (XIII) and (XV) with perbenzoic acid. The 9α-epimer (XV) is attacked on the rear (α) face, thus following the general rule for similar reactions for steroids with natural configuration. The 9β-epimer (XIII) is attacked on the front (β) face; β-attack on this bond has been established for the addition of hydrogen (Bladon *et al.*, *loc. cit.*). The reason for the difference is disclosed by inspection of models, which show that

* We are grateful to Professor E. R. H. Jones, F.R.S., for sending us a copy of this paper before its general publication.

the 7 : 8-double bond in (XIII) is considerably more accessible from the β-face than is the case with the $C_{(9)}$-α-epimer (XV).

When 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (XXX) is treated with dioxan containing dilute sulphuric acid 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV) is formed; this shows the ultra-violet absorption spectrum of a $\Delta^{8(14)}$-stenol. The presence of a hydroxyl group in (XXXV) was confirmed by the infra-red absorption spectrum and by acetylation to the diacetate (XXXVI). With zinc in a neutral solvent 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV) yields 7β-hydroxy-11-oxo-9β-ergosta-8(14) : 22-dien-3β-yl acetate (XXXVII). The 9β-configuration is assigned to (XXXV), (XXXVI), and (XXXVII) because alkaline hydrolysis of the first compound at room temperature gives a diol, the ultra-violet absorption spectrum of which established the presence therein of the 8(14)-double bond. Acetylation of the diol gives a diacetate which differs from (XXXVI) and is consequently considered to be 22 : 23-dibromo-3β : 7β-diacetoxyergost-8(14)-en-11-one (XXXIX), differing from (XXXVI) solely in configuration at $C_{(9)}$. Debromination of the 9α-diacetate (XXXIX) by zinc in a neutral solvent gives 3β : 7β-diacetoxyergosta-8(14) : 22-dien-11-one (XL) which is also obtained from 22 : 23-dibromo-3β : 7β-dihydroxyergost-8(14)-en-11-one (XXXVIII) by debromination to (XLI) followed by acetylation.* Thus the formation of the oxo-epoxide from (XIII) is not accompanied by inversion at $C_{(9)}$. For different reasons the same conclusion was reached by Henbest and Wagland (*loc. cit.*) concerning the structure of the related bromine-free oxo-epoxide (XXIX).

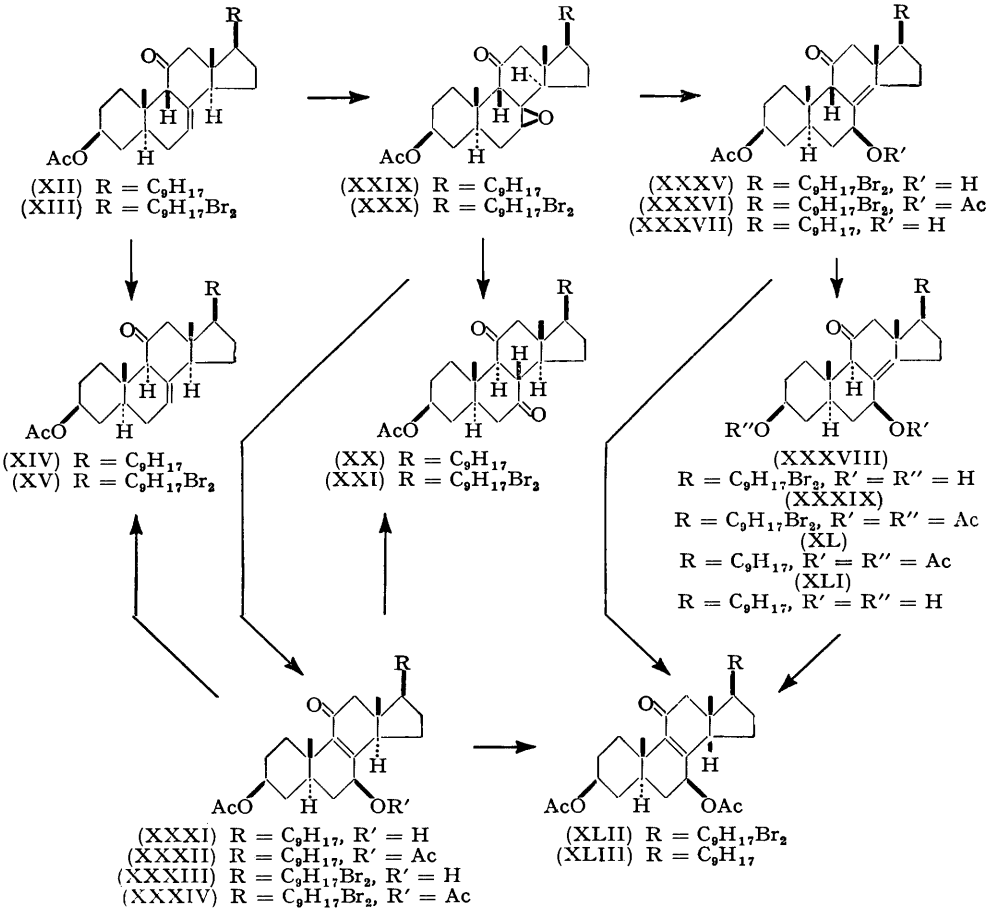
In spite of many attempts, it was not possible to convert the 9β-oxo-epoxide (XXX) into the 9α-isomer. In our view, it is unlikely that the conversion of the oxo-epoxide (XXX) into 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII) proceeds *via* the 9α-oxo-epoxide; when the reaction was followed polarimetrically and spectroscopically the values support the view that (XXXIII) is formed directly from (XXX). Again, oxidation of the βγ-unsaturated ketone (XIII) by perbenzoic acid which had been stored for several days and contained a trace of free hydrogen chloride gave a mixture of the oxo-epoxide (XXX) and 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII).

The acetate (XXXIII) is recovered unchanged after treatment with sulphuric acid in dioxan under conditions which convert the oxo-epoxide (XXX) into 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV); it follows that (XXXIII) is not an intermediate in the conversion of (XXX) into (XXXV) by mineral acid; this conclusion is in agreement with the established 9β-configuration in (XXXV). When treated with a trace of hydrobromic acid in chloroform under conditions which convert the oxo-epoxide (XXX) into 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII), 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV) is not converted into (XXXIII) but is dehydrated to give an oxo-diene the structure of which will be discussed in a later paper. In our view this behaviour proves that 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV) is not an intermediate in the conversion of the oxo-epoxide (XXX) into 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII). When treated with hydrobromic acid in acetic acid–chloroform 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII) is converted into 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (XXI). The diketone (XXI) is also obtained by treatment of the oxo-epoxide (XXX) with hydrobromic acid in acetic acid–chloroform.

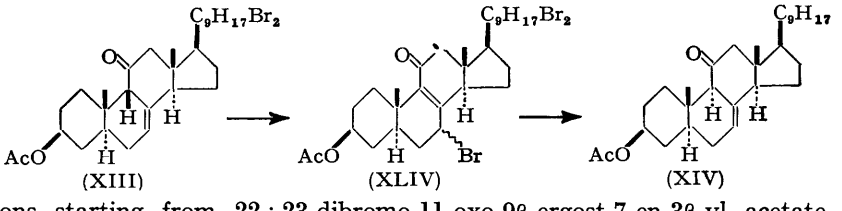
22 : 23-Dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII) was debrominated by means of zinc in a neutral solvent to the related 7β-hydroxy-11-oxoergosta-8 : 22-

* A compound designated 7ξ-hydroxy-11-oxoergosta-8(14) : 22-dien-3β-yl acetate has been obtained by Heusler and Wettstein (*loc. cit.*) by treatment of the oxo-epoxide (XXIX) with boron trifluoride in hot dioxan. Although the m. p. of this compound is similar to that of 7β-hydroxy-11-oxo-9β-ergosta-8(14) : 22-dien-3β-yl acetate (XXXVII), the rotations of the two preparations (+76°, +216° respectively) are markedly different. We have not prepared 7β-hydroxy-11-oxoergosta-8(14) : 22-dien-3β-yl acetate; the related diacetate (XL), m. p. 111—113°, $[\alpha]_D$ +34°, again differs appreciably from the diacetate (m. p. 153—155°) obtained by Heusler and Wettstein. These authors appreciated that their preparation was not pure. Repetition of their experiment did not give a homogeneous product.

dien-3β-yl acetate (XXXI), which gave the 3β : 7β-diacetate (XXXII) (*cf.* Henbest and Wagland, *loc. cit.*). An attempt to debrominate the diacetate (XXXIV) by zinc in a neutral solvent, however, gave 11-oxoergosta-7 : 22-dien-3β-yl acetate (XIV), identical with the product obtained by Bladon *et al.* (*loc. cit.*) by rearrangement of the 9β-isomer



(XII) on alumina. Bladon *et al.* found that hydrogenation of (XIV) in an acidic medium gave ergost-8(14)-en-3β-yl acetate (α-ergostenyl acetate), presumably by conjugation of the double bond, hydrogenolysis of the 11-oxygen function, and migration of the double bond. We have confirmed this behaviour and we also find that hydrogenation of (XIV) in ethyl acetate gives 11-oxoergost-7-en-3β-yl acetate previously obtained in a crude form by Bladon *et al.*, using dioxan as solvent. The 9α-ketone (XIV) was also obtained by a related series



of reactions starting from 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (XIII). Treatment of (XIII) with bromine gives 7ξ : 22 : 23-tribromo-11-oxoergost-8-en-3β-yl acetate (XLIV) which shows the characteristic ultra-violet absorption spectrum of an

αβ-unsaturated ketone. Treatment of the tribromo-ketone with zinc in a neutral solvent gives 11-oxoergosta-7 : 22-dien-3β-yl acetate (XIV). Thus the behaviour of the epimeric 7-acetoxy-derivatives from 22 : 23-dibromo-11-oxoergost-8-en-3β-yl acetate on treatment with zinc appears to be controlled by the orientation at $C_{(7)}$, the 7α-epimer (XXIII) giving (XXV) by normal side-chain dehalogenation, whereas the 7β-epimer (XXXIV) gives the βγ-unsaturated ketone (XIV). As a consequence we suggest that the bromine attached to $C_{(7)}$ in (XLIV) is β-oriented.

The action of alkali on the oxo-epoxide (XXX) and its two primary acid-rearrangment products (XXXIII) and (XXXV) has been examined. Short treatment of the oxo-epoxide (XXX) with alcoholic alkali and subsequent acetylation yield 22 : 23-dibromo-3β : 7β-diacetoxyergost-8-en-11-one (XXXIV). Prolonged treatment of the oxo-epoxide (XXX) with alkali followed by acetylation gives a mixture from which three homogeneous reaction products have been isolated. One of these is (XXXIV), a second is 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (XXI), and the third is a diacetate $C_{32}H_{48}O_5Br_2$, m. p. 187°. Similar protracted treatment of 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (XXXIII) with alkali followed by acetylation gives a mixture of the diketone (XXI) and the diacetate, m. p. 187°. The diacetate, m. p. 187°, shows the light-absorption properties of an αβ-unsaturated ketone both in the ultra-violet and in the infra-red. It is also obtained from 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (XXXV) by refluxing with alkali followed by acetylation. These relationships, we believe, show that the acetate, m. p. 187°, is 22 : 23-dibromo-3β : 7β-diacetoxy-14β-ergost-8-en-11-one (XLII), differing from (XXXIV) solely in configuration at $C_{(14)}$. In contrast to the behaviour of the 14α-isomer (XXXIV), debromination of (XLII) with zinc in a neutral solvent proceeds normally to give 3β : 7β-diacetoxy-14β-ergosta-8 : 22-dien-11-one (XLIII). It is pertinent to note a remarkable difference in behaviour of 7α- and 7β-hydroxy-substituted 22 : 23-dibromo-11-oxoergost-8-en-3β-yl acetates in refluxing alkali. The 7α-hydroxy-derivative (XXIV) is converted into the non-conjugated 22 : 23-dibromo-3β : 7α-dihydroxyergost-8(14)-en-11-one (XXVI), the double bond moving out of conjugation to give an alkali-stable βγ-unsaturated ketone. In the case of the 7β-hydroxy-derivative (XXXIII), however, similar alkali treatment (followed by acetylation) leads to the 14β-epimer (XLII). This behaviour of the 7β-hydroxy-Δ^8-11-ketone (XXXIII) is the same as that of a related Δ^8-11-ketone of the sapogenin series which epimerises at $C_{(14)}$ on treatment with alkali (Djerassi, Frick, Rosenkranz, and Sondheimer, *J. Amer. Chem. Soc.*, 1953, **75**, 3496).

Experimental

Specific rotations were determined in chloroform solution (unless otherwise stated) in a 1-dm. tube at approx. 15°. Ultra-violet absorption spectra were measured in ethanol solution with a Unicam SP.500 spectrophotometer. Infra-red absorption measurements were determined in Nujol suspension.

22 : 23-*Dibromo*-11-*oxo*-9β-*ergost*-7-*en*-3β-*yl Acetate*.—A suspension of 22 : 23-dibromo-9α : 11α-epoxyergost-7-en-3β-yl acetate (500 mg.) (Budziarek, Johnson, and Spring, *J.*, 1952, 3410) in dry ether (20 c.c.) and acetic anhydride (15 c.c.) was shaken at room temperature with the boron trifluoride–ether complex (10 drops). Dissolution was complete in 10 min., whereafter solid began to separate. After 1 hr. the solid (220 mg.), m. p. 198°, was collected and crystallised from acetone from which 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate separated as prismatic needles or prisms, m. p. 200° undepressed when mixed with a specimen prepared as described by Maclean and Spring (*loc. cit.*), $[\alpha]_D$ −122° (*c*, 1·1) (Found : C, 58·3; H, 7·5. Calc. for $C_{30}H_{46}O_3Br_2$: C, 58·6; H, 7·55%).

22 : 23-*Dibromo*-11-*oxoergost*-7-*en*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (700 mg.) in light petroleum (b. p. 60—80°)–benzene (1 : 1; 70 c.c.) was adsorbed rapidly under pressure on an alumina column * (10 × 1·5 cm.). The column was immediately eluted with benzene (100 c.c.) containing pyridine (1 c.c.) again under pressure; these operations took 5 min. Evaporation of the filtrate under reduced pressure and crystallis-

* The alumina was prepared as follows: Spence "Type H" alumina (1 kg.) was stirred for 3 hr. with 10% acetic acid (1·5 l.), filtered off, washed with distilled water (2 l.), methanol (2 l.), and distilled water (2 l.) and then reactivated at 400° for 5 hr.

ation of the residue from chloroform–methanol gave 22 : 23-*dibromo*-11-*oxoergost*-7-*en*-3β-*yl acetate* * (620 mg.) as felted needles, m. p. 189—190°, $[\alpha]_D$ +29° (*c*, 0·4) (Found : C, 58·7; H, 7·55. $C_{30}H_{46}O_3Br_2$ requires C, 58·6; H, 7·55%). Light absorption : ε_{2060} = 1550.

11-*Oxoergosta*-7 : 22-*dien*-3β-*yl Acetate*.—22 : 23-Dibromo-11-oxoergost-7-en-3β-yl acetate (306 mg.) in benzene–methanol (1 : 1; 200 c.c.) was refluxed with zinc dust (2 g.) for 2½ hr. Isolation in the usual way followed by crystallisation from methanol gave 11-oxoergosta-7 : 22-dien-3β-yl acetate (150 mg.) as plates, m. p. 176—177°, $[\alpha]_D$ +32° (*c*, 1·0) (Found : C, 79·4; H, 10·6. Calc. for $C_{30}H_{46}O_3$: C, 79·2; H, 10·2%). Light absorption : ε_{2040} = 2000. Bladon *et al.* (*loc. cit.*) give m. p. 175—180°, $[\alpha]_D$ +25°, for a specimen obtained by filtration of a solution of the 9β-epimer through alumina.

11-*Oxoergosta*-8 : 22-*dien*-3β-*yl Acetate*.—A solution of 11-oxoergosta-7 : 22-dien-3β-yl acetate (150 mg.) in benzene–chloroform (10 c.c.; 99 : 1) was adsorbed on a column of Grade II alumina (10 × 2 cm.) and left for 5 days. Elution with benzene (50 c.c.) and crystallisation from methanol gave 11-oxoergosta-8 : 22-dien-3β-yl acetate (30 mg.) as blades, m. p. and mixed m. p. 125—127°, $[\alpha]_D$ +102° (*c*, 0·5). Light absorption : Max. at 2530 Å (ε 8000).

22 : 23-*Dibromo*-7α : 8α-*epoxy*-11-*oxoergostan*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-11-oxoergost-7-en-3β-yl acetate (380 mg.) in chloroform (10 c.c.) at 0° was treated with a freshly prepared solution of perbenzoic acid in mineral acid-free chloroform (2·5 mol.; 2·5 c.c.). The solution was kept at 0° for 8 days, then diluted with chloroform (100 c.c.) and washed successively with saturated sodium hydrogen carbonate solution and water, and dried (Na_2SO_4). The chloroform solution was concentrated under reduced pressure below 35° and diluted with methanol to give 22 : 23-*dibromo*-7α : 8α-*epoxy*-11-*oxoergostan*-3β-*yl acetate* (300 mg.) separating from chloroform–methanol as needles, m. p. 210—212°, $[\alpha]_D$ −17·5° (*c*, 1·7) (Found : C, 57·3; H, 7·6. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·4%). The oxo-epoxide does not show high intensity light absorption above 2000 Å, and it does not give a colour with tetranitromethane in chloroform; it was recovered unchanged after treatment at room temperature with acetic anhydride and pyridine. Infra-red spectrum : peaks at 1747 and 1250 (acetate) and 1717 cm.$^{-1}$ (ketone); no hydroxyl peak.

7α : 8α-*Epoxy*-11-*oxoergost*-22-*en*-3β-*yl Acetate*.—22 : 23-Dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (320 mg.) in benzene–methanol was debrominated in the usual way with zinc. 7α : 8α-*Epoxy*-11-*oxoergost*-22-*en*-3β-*yl acetate* (190 mg.) separates from chloroform–methanol as elongated plates, m. p. 190—191°, $[\alpha]_D$ −15·5° (*c*, 1·3) (Found : C, 76·4; H, 9·8. $C_{30}H_{46}O_4$ requires C, 76·55; H, 9·85%). Light absorption : ε_{2040} = 2100. It gives a pale yellow colour with tetranitromethane in chloroform.

22 : 23-*Dibromo*-3β : 7α-*dihydroxyergost*-8-*en*-11-*one*.—22 : 23-Dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (275 mg.) in benzene (6 c.c.) was treated with methanolic potassium hydroxide (50 c.c.; 1%) and the solution kept for 3½ hr. at room temperature. Isolation of the product in ether, followed by crystallisation from chloroform–methanol, gave the 3β : 7α-*diol* (240 mg.) as felted needles, m. p. 211°, $[\alpha]_D$ +113°, +112° (*c*, 0·6, 0·7) (Found : C, 56·0; H, 7·5. $C_{28}H_{44}O_3Br_2,CH_3{\cdot}OH$ requires C, 56·1; H, 7·8%). Light absorption : Max. at 2500 Å (ε 9600). Acetylation with acetic anhydride and pyridine at room temperature gives the *diacetate* which separates from methanol as prismatic plates, m. p. 212—213°, $[\alpha]_D$ +104° (*c*, 1·5) (Found : C, 57·2; H, 7·3. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%). Light absorption : Max. at 2460 Å (ε 9400).

3β : 7α-*Diacetoxyergosta*-8 : 22-*dien*-11-*one*.—(*a*) Debromination of 22 : 23-dibromo-3β : 7α-diacetoxyergost-8-en-11-one (500 mg.) by zinc in ether–methanol gives 3β : 7α-diacetoxyergosta-8 : 22-dien-11-one (200 mg.), separating from methanol as fine needles, m. p. 102—103°, $[\alpha]_D$ +109° (*c*, 1·0) (Found : C, 74·9; H, 9·6. Calc. for $C_{32}H_{48}O_5$: C, 75·0; H, 9·4%). Light absorption : Max. at 2490 Å (ε 8800); ε_{2040} = 3800. Henbest and Wagland (*loc. cit.*) give m. p. 102—105°, $[\alpha]_D$ +109°.

(*b*) Treatment of 22 : 23-dibromo-3β : 7α-dihydroxyergost-8-en-11-one (150 mg.) in benzene–methanol with zinc, followed by acetylation of the product with acetic anhydride in pyridine at

* Dr. R. M. Evans (personal communication, March 30th, 1954) writes : "Professor Spring has kindly drawn our attention to the difference in physical properties between the 22 : 33-dibromo-11-oxoergost-7-en-3β-yl acetate as prepared at Glasgow and the compound to which we attributed the same structure (Elks, Evans, Robinson, Thomas, and Wyman, *J.*, 1953, 2933). We have now re-examined our compound and find that it forms a 2 : 4-dinitrophenylhydrazone in greater than 70% yield; we wish, therefore, to withdraw the above structure. Since treatment of our compound with perchloric acid in acetic acid produces material with $\lambda_{max.}$ 2525 Å ($E^{1\%}_{1\,cm.}$ 121) it seems probable that it has a keto-group at $C_{(7)}$, but its physical properties do not agree with those reported for 22 : 23-dibromo-7-oxoergost-9-en-3β-yl acetate (Elks, Evans, Long, and Thomas, *J.*, 1954, 451; Maclean and Spring, *J.*, 1954, 328). Shortage of material has precluded a more thorough examination."

room temperature, gave 3β : 7α-diacetoxyergosta-8 : 22-dien-11-one (50 mg.), separating from methanol as needles, m. p. and mixed m. p. 102—103°, $[\alpha]_D$ +113° (*c*, 0·5).

22 : 23-*Dibromo*-3β : 7α-*dihydroxyergost*-8(14)-*en*-11-*one*.—(*a*) A solution of 22 : 23-dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (320 mg.) in benzene (10 c.c.) and methanolic potassium hydroxide (60 c.c.; 2%) was refluxed for 1½ hr. Concentration under reduced pressure, isolation of the product with ether, and crystallisation from chloroform–methanol gave 22 : 23-*dibromo*-3β : 7α-*dihydroxyergost*-8(14)-*en*-11-*one* (200 mg.) as needles, m. p. 202—203°, $[\alpha]_D$ +33° (*c*, 0·3 in pyridine) (Found: C, 57·2; H, 7·7. $C_{28}H_{44}O_3Br_2$ requires C, 57·15; H, 7·5%). Light absorption: ε_{2060} = 8700. Overnight acetylation of the diol with acetic anhydride in pyridine at room temperature gave the *diacetate* which separates from methanol as needles, m. p. 194—195°, $[\alpha]_D$ +32° (*c*, 1·4) (Found: C, 57·4; H, 7·3. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%). Light absorption: ε_{2070} = 8600.

(*b*) Hydrolysis of 22 : 23-dibromo-3β : 7α-diacetoxyergost-8-en-11-one (140 mg.) with aqueous methanolic potassium hydroxide as in (*a*) gave the 3β : 7α-diol (90 mg.), m. p. and mixed m. p. 202—203°, $[\alpha]_D$ +31° (*c*, 0·2 in pyridine). Light absorption: ε_{2060} = 10,200.

3β : 7α-*Dihydroxyergosta*-8(14) : 22-*dien*-11-*one*.—A solution of 22 : 23-dibromo-3β : 7α-dihydroxyergost-8(14)-en-11-one (110 mg.) in benzene–methanol (1 : 1; 50 c.c.) was refluxed with zinc (2 g.) for 2½ hr. Crystallisation of the product from aqueous methanol gave 3β : 7α-*dihydroxyergosta*-8(14) : 22-*dien*-11-*one* (66 mg.) as needles, m. p. 179—181°, $[\alpha]_D$ +8° (*c*, 0·7) (Found: C, 78·4; H, 10·4. $C_{28}H_{44}O_3$ requires C, 78·45; H, 10·35%). Light absorption: ε_{2080} = 7000.

22 : 23-*Dibromo*-7α-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (400 mg.) in benzene (10 c.c.) was refluxed with 2N-sulphuric acid (5 c.c.) in methanol (50 c.c.) for 1 hr. Isolation in ether, followed by crystallisation from chloroform–methanol, gave 22 : 23-*dibromo*-7α-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl acetate* (130 mg.) as needles, m. p. 216—217°, $[\alpha]_D$ +97° (*c*, 1·8) (Found: C, 56·9; H, 7·1. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·35%). Light absorption: Max. at 2490 Å (ε = 9000). Acetylation (acetic anhydride and pyridine on the steam-bath) gave the diacetate which separates from methanol as prismatic plates, m. p. and mixed m. p. 212—213°, $[\alpha]_D$ +100° (*c*, 0·8).

22 : 23-*Dibromo*-7β : 8β-*epoxy*-11-*oxo*-9β-*ergostan*-3β-*yl Acetate*.—(*a*) A solution of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (5·9 g.) in chloroform (70 c.c.) was treated during 1 hr. at 0° with a freshly prepared solution of perbenzoic acid in chloroform (23 c.c.; 62·5 mg./c.c.). After overnight storage at 0° isolation was carried out in the usual way; crystallisation from chloroform–methanol gave 22 : 23-*dibromo*-7β : 8β-*epoxy*-11-*oxo*-9β-*ergostan*-3β-*yl acetate* (5·0 g.) as needles, m. p. 218—221°, $[\alpha]_D$ −29° (*c*, 0·7) (Found: C, 52·7, 52·8; H, 6·9, 7·1; Cl + Br, 30·75. $C_{30}H_{46}O_4Br_2,\frac{1}{2}CHCl_3$ requires C, 53·1; H, 6·8; Cl, 7·7; Br, 23·15%). The solvent of crystallisation was not expelled at 100° *in vacuo*; heating at 135° *in vacuo* was accompanied by decomposition as shown by a change toward dextrorotation and the appearance of high-intensity ultra-violet absorption at 2540 Å. Infra-red spectrum: Peaks at 1730 and 1241 (acetate), 1717 (ketone) and 750 cm.$^{-1}$ (asymmetrical stretching frequency of C–Cl bond). The compound gave no colour with tetranitromethane in chloroform.

(*b*) A suspension of 22 : 23-dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (1·7 g.) in dry ether (200 c.c.) was refluxed with freshly prepared monoperphthalic acid in ether (8·4 c.c.; 91 mg./c.c.) for 5½ hr. The suspended solid (1·2 g.), m. p. 198—199·5°, $[\alpha]_D$ −122° (*c*, 0·5), was unchanged starting material. The ethereal mother-liquor on storage deposited needles (240 mg.), m. p. 206—215°, $[\alpha]_D$ −36° (*c*, 0·5), which on crystallisation from benzene–light petroleum (b. p. 60—80°) gave 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (200 mg.) as rosettes of fine needles, m. p. 225—226°, $[\alpha]_D$ −29° (*c*, 0·7) (Found: C, 57·4; H, 7·5. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·35%). Infra-red spectrum: Peaks at 1731 and 1245 (acetate) and 1715 cm.$^{-1}$ (ketone). It was undepressed in m. p. when mixed with the solvated specimen described above and on crystallisation from chloroform–methanol it gave needles, m. p. 226—227°, containing chloroform of crystallisation.

7β : 8β-*Epoxy*-11-*oxo*-9β-*ergost*-22-*en*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (1·5 g.) in benzene (50 c.c.), moist ether (50 c.c.), and methanol (50 c.c.) was heated under reflux for 5 hr. with zinc dust (5 g.) previously activated by treatment with ammonium chloride. The product, isolated by means of ether, was crystallised from methanol, to give 7β : 8β-epoxy-11-oxo-9β-ergost-22-en-3β-yl acetate (1·0 g.) as needles, m. p. 185°, $[\alpha]_D$ −64°, −67° (*c*, 0·5, 1·2) (Found: C, 76·3; H, 10·0. Calc. for $C_{30}H_{46}O_4$: C, 76·55; H, 9·85%). It gives a pale yellow colour in chloroform with tetranitromethane and does not exhibit high-intensity ultra-violet light absorption. Heusler and Wettstein (*loc. cit.*) give

m. p. 170·5—171·5°, $[\alpha]_D$ −74°, for this compound; Henbest and Wagland (*loc. cit.*) record m. p. 175—177°, $[\alpha]_D$ −63°.

7 : 11-*Dioxoergost*-22-*en*-3β-*yl Acetate from* 7β : 8β-*Epoxy*-11-*oxo*-9β-*ergost*-22-*en*-3β-*yl Acetate*.—7β : 8β-Epoxy-11-oxo-9β-ergost-22-en-3β-yl acetate (800 mg.) in chloroform (30 c.c.) and acetic acid (60 c.c.) containing aqueous hydrogen bromide (12 drops; 46%) was kept overnight at room temperature. The crude product was crystallised once from methanol, and a solution of the crystalline solid (500 mg.) in benzene–light petroleum (b. p. 60—80°) (100 c.c.; 2 : 1) was filtered through grade II—III alumina (15 × 2 cm.); the column was washed with benzene (200 c.c.). Thereafter benzene (100 c.c.) and benzene–ether (200 c.c.; 19 : 1) eluted a solid (130 mg.), m. p. 198°, crystallisation of which from aqueous methanol gave 7 : 11-dioxoergost-22-en-3β-yl acetate as felted needles, m. p. 198—200° (alone or mixed with a reference specimen), $[\alpha]_D$ −30° (*c*, 1·7) (Found: C, 76·6; H, 9·5. Calc. for $C_{30}H_{46}O_4$: C, 76·55; H, 9·85%).

22 : 23-*Dibromo*-7β-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl Acetate*.—(*a*) 22 : 23-Dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (500 mg.) in chloroform (10 c.c.) was treated with a solution of aqueous hydrogen bromide (0·05 c.c.; 46%) in chloroform (100 c.c.). The mixture was kept at room temperature for 3 days. The crystalline solid (185 mg.) which had separated was collected and crystallised from chloroform–methanol, to yield 22 : 23-*dibromo*-7β-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl acetate*, m. p. 232—234°, $[\alpha]_D$ +85° (*c*, 0·4) (Found: C, 57·05; H, 7·55. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·35%). Light absorption: Max. at 2540 Å (ε 9000).

(*b*) 22 : 23-Dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (1·2 g.) in chloroform (40 c.c.) was treated with perbenzoic acid in chloroform (4·8 c.c.; 59 mg./c.c.) which had been kept at 0° for 3 weeks before use. The solution was concentrated under reduced pressure to approximately half bulk, then diluted with methanol, and the solid (0·8 g.) was collected and crystallised from chloroform, to give 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (250 mg.) as plates, m. p. 232° alone or mixed with the specimen prepared by method (*a*), $[\alpha]_D$ +78° (*c*, 0·35) (Found: C, 57·15; H, 7·5%). It does not give a colour with tetranitromethane in chloroform. Light absorption: Max. at 2550 Å (ε 10,000). Infra-red spectrum: Peaks at 3461 (hydroxyl), 1737 and 1245 (acetate), and 1661 cm.$^{-1}$ (αβ-unsaturated ketone). From the chloroform mother-liquor 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (200 mg.) was isolated; after crystallisation from chloroform–methanol it separated as needles, m. p. 218—220° undepressed by the specimen previously described, $[\alpha]_D$ −28° (*c*, 0·5) (Found: C, 52·8; H, 6·9%).

7 : 11-*Dioxoergost*-22-*en*-3β-*yl Acetate from* 22 : 23-*Dibromo*-7β-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl Acetate*.—22 : 23-Dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (85 mg.) suspended in glacial acetic acid (10 c.c.) was treated, with stirring at room temperature, with a solution of chromium trioxide in acetic acid (0·45 c.c.; N) diluted with acetic acid (5 c.c.), added in five equal portions during 1 hr. After a further hour the mixture was heated at 50—60° for 1 hr. and stored overnight at room temperature. The reaction solution was worked up by using ether, and the product dissolved in glacial acetic acid (10 c.c.) and stirred with zinc dust on the steam-bath for 4 hr. Isolation in ether followed by percolation through a short column of Grade II alumina and crystallisation from aqueous methanol gave 7 : 11-dioxoergost-22-en-3β-yl acetate as felted needles, m. p. and mixed m. p. 195—197°, $[\alpha]_D$ −31° (*c*, 0·5) (Found: C, 76·6; H, 10·0. Calc. for $C_{30}H_{46}O_4$: C, 76·55; H, 9·85%).

7β-*Hydroxy*-11-*oxoergosta*-8 : 22-*dien*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (250 mg.) in a mixture of benzene (15 c.c.), methanol (15 c.c.), and ether (15 c.c.) was heated under reflux with activated zinc (1·25 g.) for 5 hr. The product was crystallised from chloroform–methanol from which 7β-*hydroxy*-11-*oxoergosta*-8 : 22-*dien*-3β-*yl acetate* (150 mg.) separated as plates, m. p. 245—246°, $[\alpha]_D$ +104° (*c*, 1·7) (Found: C, 76·5; H, 9·9. $C_{30}H_{46}O_4$ requires C, 76·55; H, 9·85%). Light absorption: Max. at 2540 Å (ε = 10,500). 11-Oxoergosta-8 : 22-diene-3β : 7β-diol diacetate was prepared by treatment of the monoacetate with acetic anhydride and pyridine at room temperature; it separates from aqueous methanol as needles, m. p. 152—153°, $[\alpha]_D$ +82° (*c*, 0·7) (Found: C, 74·8; H, 9·4. Calc. for $C_{32}H_{48}O_5$: C, 75·0; H, 9·4%). Light absorption: Max. at 2490 Å (ε 8800). Henbest and Wagland (*loc. cit.*) record m. p. 149—152°, $[\alpha]_D$ +83°.

22 : 23-*Dibromo*-3β : 7β-*diacetoxyergost*-8-*en*-11-*one*.—(*a*) 22 : 23-Dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (90 mg.) in pyridine (3 c.c.) and acetic anhydride (3 c.c.) was heated on the steam-bath for 1½ hr. Crystallisation of the product from methanol gave the *diacetate* as felted needles, m. p. 169—170°, $[\alpha]_D$ +70° (*c*, 1·2) (Found: C, 57·3; H, 7·3. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%), which did not give a colour with tetranitromethane. Light absorption: Max. at 2500 Å (ε 9200).

(*b*) A solution of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (200 mg.) in

benzene (10 c.c.) and methanolic potassium hydroxide (20 c.c.; 5%) was heated under reflux for 10 min. The precipitated solid was separated, washed with methanol, dried, and heated on the steam-bath for 1 hr. with pyridine (10 c.c.) and acetic anhydride (5 c.c.). Isolation in ether gave 22 : 23-dibromo-3β : 7β-diacetoxyergost-8-en-11-one (100 mg.) which separates from aqueous methanol as felted needles, m. p. and mixed m. p. 170—171°, $[\alpha]_D$ +69° (*c*, 0·6) (Found : C, 56·7; H, 7·15%).

7ξ : 22 : 23-*Tribromo*-11-*oxoergost*-8-*en*-3β-*yl Acetate*.—22 : 23-Dibromo-11-oxo-9β-ergost-7-en-3β-yl acetate (1·0 g.) in dry ether (200 c.c.) was treated with a solution of bromine in glacial acetic acid (7·8 c.c.; 0·0316 g./c.c.), added dropwise with stirring at 15°. After being kept for 10 min., the colourless solution was washed with 1% sodium hydroxide solution, then with water, and dried (Na_2SO_4). Crystallisation of the product from chloroform–methanol gave 7ξ : 22 : 23-*tribromo*-11-*oxoergost*-8-*en*-3β-*yl acetate* (800 mg.) as plates, m. p. 198—199° (decomp.), $[\alpha]_D$ +78° (*c*, 1·0) (Found : C, 51·8; H, 6·7. $C_{30}H_{45}O_3Br_3$ requires C, 52·0; H, 6·5%). Light absorption : Max. at 2620 Å (ε 9500).

11-*Oxoergosta*-7 : 22-*dien*-3β-*yl Acetate from* 7ξ : 22 : 23-*Tribromo*-11-*oxoergost*-8-*en*-3β-*yl Acetate*.—A solution of the tribromo-compound (490 mg.) in methanol–ether (70 c.c.; 1 : 1) was refluxed with activated zinc (2 g.), added in portions during 3 hr. Isolation by means of ether gave 11-oxoergosta-7 : 22-dien-3β-yl acetate (280 mg.) which separated from methanol as plates, m. p. and mixed m. p. 175—177°, $[\alpha]_D$ +30° (*c*, 1·1) (Found : C, 79·15; H, 10·4. Calc. for $C_{30}H_{46}O_3$: C, 79·2; H, 10·2%). It gives a pale yellow colour with tetranitromethane in chloroform. Light absorption : ε_{2040} = 3400.

11-*Oxoergosta*-7 : 22-*dien*-3β-*yl Acetate from* 22 : 23-*Dibromo*-3β : 7β-*diacetoxyergost*-8-*en*-11-*one*.—Treatment of the diacetate named (226 mg.) in refluxing benzene–methanol–ether (1 : 1 : 1; 75 c.c.) with activated zinc (2 g.) for 5½ hr. gave 11-oxoergosta-7 : 22-dien-3β-yl acetate (120 mg.) separating from methanol as plates, m. p. 174—176°, $[\alpha]_D$ +29° (*c*, 1·1) (Found : C, 79·1; H, 10·1%). Hydrogenation of this βγ-unsaturated ketone over platinum in acetic acid gave ergost-8(14)-en-3β-yl acetate (α-ergostenyl acetate) as plates from methanol, m. p. 107—109°, $[\alpha]_D$ +3° (*c*, 1·4) (Found : C, 81·6; H, 11·4. Calc. for $C_{30}H_{50}O_2$: C, 81·4; H, 11·4%). The m. p. of a mixture with an authentic specimen, m. p. 109—110°, $[\alpha]_D$ +4° (*c*, 2·0), was undepressed.

11-*Oxoergost*-7-*en*-3β-*yl Acetate*.—A solution of 11-oxoergosta-7 : 22-dien-3β-yl acetate (250 mg.) in ethyl acetate (200 c.c.) was shaken in hydrogen for 24 hr. with platinum (from 60 mg. of PtO_2). Crystallisation of the product from methanol gave 11-*oxoergost*-7-*en*-3β-*yl acetate* (160 mg.) as needles, m. p. 162—164°, $[\alpha]_D$ +48°, +47° (*c*, 1·1, 1·5) (Found : C, 79·15; H, 10·8. $C_{30}H_{48}O_3$ requires C, 78·9; H, 10·6%). For a crude (not analysed) specimen of this compound, Bladon *et al.* (*loc. cit.*) give m. p. 145—156°, $[\alpha]_D$ +32°. Light absorption : ε_{2050} = 3500.

22 : 23-*Dibromo*-7β-*hydroxy*-11-*oxo*-9β-*ergost*-8(14)-*en*-3β-*yl Acetate*.—A solution of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (1·19 g.) in dioxan (230 c.c.) was treated with sulphuric acid (8 c.c.; 2N) and stored at room temperature for 4 hr. The solution was diluted with water, and the product isolated by means of ether and crystallised from methanol. The first crop (40 mg.), which showed high-intensity absorption at 2540 Å, was rejected. Concentration of the mother-liquor and crystallisation of the solid obtained from aqueous methanol gave 22 : 23-*dibromo*-7β-*hydroxy*-11-*oxo*-9β-*ergost*-8(14)-*en*-3β-*yl acetate* (940 mg.) as plates, m. p. 201—202°, $[\alpha]_D$ +196° (*c*, 1·5) (Found : C, 57·0; H, 7·6. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·35%). It gives a yellow colour with tetranitromethane in chloroform. Light absorption : ε_{2110} = 9000. Infra-red spectrum : Peaks at 3470 (hydroxyl), 1740 and 1250 (acetate) and 1710 cm.$^{-1}$ (ketone). Acetylation with acetic anhydride–pyridine at room temperature gave 22 : 23-*dibromo*-3β : 7β-*diacetoxy*-9β-*ergost*-8(14)-*en*-11-*one* which separated from methanol as plates, m. p. 170—171°, $[\alpha]_D$ +142° (*c*, 1·0) (Found : C, 57·1; H, 7·5. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%). Light absorption : ε_{2100} = 8400.

7β-*Hydroxy*-11-*oxo*-9β-*ergosta*-8(14) : 22-*dien*-3β-*yl Acetate*.—22 : 23-Dibromo-7β-hydroxy-11-oxoergost-8(14)-en-3β-yl acetate (250 mg.) was debrominated with activated zinc dust in benzene–ether–methanol, and the product crystallised from aqueous acetone to give 7β-*hydroxy*-11-*oxo*-9β-*ergosta*-8(14) : 22-*dien*-3β-*yl acetate* (130 mg.) as plates, m. p. 192—195°, $[\alpha]_D$ +216° (*c*, 1·45) (Found : C, 75·35; H, 9·9. $C_{30}H_{46}O_4,C_3H_6O$ requires C, 75·0; H, 9·9%). It gives a yellow colour in chloroform with tetranitromethane. Light absorption : ε_{2090} = 8000.

Dehydration of 22 : 23-*Dibromo*-7β-*hydroxy*-11-*oxo*-9β-*ergost*-8(14)-*en*-3β-*yl Acetate*.—A solution of the acetate (420 mg.) in chloroform (10 c.c.) was treated with aqueous hydrogen bromide (0·05 c.c.; 46%) in chloroform (10 c.c.) and kept at 15° for 4 days. The mixture was diluted with chloroform, and the product isolated in the usual manner. Crystallisation from chloroform–methanol gave the *dienone* (80 mg.) as plates, m. p. 215—217°, $[\alpha]_D$ +24° (*c*, 1·25) (Found :

C, 58·8; H, 7·6. $C_{30}H_{44}O_3Br_2$ requires C, 58·8; H, 7·2%). Light absorption: Max. at 2640 Å (ε 9000). It gives a red-brown colour with tetranitromethane in chloroform.

22 : 23-*Dibromo*-3β : 7β-*dihydroxyergost*-8(14)-*en*-11-*one*.—A solution of 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (1·8 g.) in methanol (150 c.c.) was treated with potassium hydroxide (2·0 g.) in water (5 c.c.) and kept at room temperature for 16 hr. The crystalline solid was separated at −50°, washed with water, and crystallised from chloroform–methanol from which the 3β : 7β-*diol* (1·25 g.) separated as elongated plates, m. p. 207—209°, $[\alpha]_D$ +85° (*c*, 0·5) (Found: C, 55·6; H, 7·9. $C_{28}H_{44}O_3Br_2,2CH_3{\cdot}OH$ requires C, 55·2; H, 8·0%). Light absorption: ε_{2090} = 10,500.

Treatment of the diol with acetic anhydride–pyridine on the steam-bath for 3 hr., isolation by means of ether, and crystallisation from methanol gave the *diacetate* as prismatic needles, m. p. 183—185°, $[\alpha]_D$ +55° (*c*, 1·0 on specimen dried at room temperature; drying at 100° causes decomposition accompanied by a change in rotation) (Found: C, 56·8; H, 7·3. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%). Light absorption of air-dried specimen: ε_{2080} = 11,000.

3β : 7β-*Dihydroxyergosta*-8(14) : 22-*dien*-11-*one*.—Debromination of the preceding diol (500 mg.) in ether–methanol with zinc gave, after crystallisation of the product from aqueous acetone, 3β : 7β-*dihydroxyergosta*-8(14) : 22-*dien*-11-*one* (320 mg.) as plates, m. p. 166—168°, $[\alpha]_D$ +76° (*c*, 1·4) (Found: C, 78·3; H, 10·1. $C_{28}H_{44}O_3$ requires C, 78·45; H, 10·35%). Light absorption: ε_{2080} = 11,500.

3β : 7β-*Diacetoxyergosta*-8(14) : 22-*dien*-11-*one*.—(*a*) The diol with acetic anhydride and pyridine at room temperature overnight gave the *diacetate*, plates (from aqueous methanol), m. p. 111—113°, $[\alpha]_D$ +34° (*c*, 2·0) (Found: C, 74·6; H, 9·4. $C_{32}H_{48}O_5$ requires C, 75·0; H, 9·4%). Light absorption: ε_{2120} = 9000.

(*b*) Treatment of 22 : 23-dibromo-3β : 7β-diacetoxyergost-8(14)-en-11-one (700 mg.) in ether–methanol with zinc gave 3β : 7β-diacetoxyergosta-8(14) : 22-dien-11-one (480 mg.) which separates from aqueous methanol as plates, m. p. and mixed m. p. 111—113°, $[\alpha]_D$ +35° (*c*, 2·0). Light absorption: ε_{2120} = 9200.

22 : 23-*Dibromo*-7 : 11-*dioxoergostan*-3β-*yl Acetate*.—(*a*) A solution of 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (250 mg.) in chloroform (15 c.c.) containing aqueous hydrogen bromide (8 drops; 46%) was kept overnight. The product was isolated in the usual manner and crystallised from chloroform–methanol, to give 22 : 23-*dibromo*-7 : 11-*dioxoergostan*-3β-*yl acetate* (170 mg.) as fine needles, m. p. 263° (decomp.), $[\alpha]_D$ −5° (*c*, 1·3) (Found: C, 57·4; H, 7·4. $C_{30}H_{46}O_4Br_2$ requires C, 57·1; H, 7·35%). The diketone does not give a colour with tetranitromethane in chloroform and does not show high-intensity ultra-violet absorption.

(*b*) A solution of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (400 mg.) in chloroform (25 c.c.) was treated with glacial acetic acid (50 c.c.) containing aqueous hydrobromic acid (10 drops; 46%) and kept overnight at room temperature. After dilution of the mixture with water the product was isolated by means of chloroform, and the solid crystallised from chloroform–methanol, to give 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (90 mg.) as fine needles, m. p. and mixed m. p. 263° (decomp.), $[\alpha]_D$ −2° (*c*, 1·3) (Found: C, 56·75; H, 7·5%).

(*c*) Similar treatment of 22 : 23-dibromo-7α : 8α-epoxy-11-oxoergostan-3β-yl acetate (300 mg.) under the conditions described in (*b*) gave 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (160 mg.) which separated from methanol as fine needles, m. p. and mixed m. p. 262° (decomp.), $[\alpha]_D$ −3° (*c*, 1·1) (Found: C, 57·2; H, 7·4%).

(*d*) A solution of 22 : 23-dibromo-7α-hydroxy-11-oxoergost-8-en-3β-yl acetate (200 mg.) in chloroform (10 c.c.), acetic acid (20 c.c.) and aqueous hydrogen bromide (5 drops; 46%) was kept at room temperature overnight. Isolation in the usual way followed by crystallisation from chloroform–methanol gave 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (80 mg.) as needles, m. p. and mixed m. p. 261—262°, $[\alpha]_D$ −2° (*c*, 1·0) (Found: C, 57·3; H, 7·5%).

7 : 11-*Dioxoergost*-22-*en*-3β-*yl Acetate*.—22 : 23-Dibromo-7 : 11-dioxoergostan-3β-yl acetate (200 mg.) was treated with activated zinc dust in benzene–ether–methanol. The product, isolated by means of ether, separated from methanol giving 7 : 11-dioxoergost-22-en-3β-yl acetate as felted needles, m. p. and mixed m. p. 197—199°, $[\alpha]_D$ −30° (*c*, 0·8) (Found: C, 76·45; H, 9·9. Calc. for $C_{30}H_{46}O_4$: C, 76·55; H, 9·85%).

Treatment of 22 : 23-*Dibromo*-7β : 8β-*epoxy*-11-*oxo*-9β-*ergostan*-3β-*yl Acetate with Alkali*.—A solution of 22 : 23-dibromo-7β : 8β-epoxy-11-oxo-9β-ergostan-3β-yl acetate (1·0 g.) in benzene (25 c.c.) and methanolic potassium hydroxide (55 c.c.; 10%) was refluxed for 4 hr. The solution was concentrated under reduced pressure, diluted with water, and extracted with ether to give an extract and an ether-insoluble solid (147 mg.), m. p. 235°, which were separated.

Acetylation of the solid with acetic anhydride and pyridine gave 22 : 23-dibromo-3β : 7β-diacetoxyergost-8-en-11-one which separated from aqueous methanol as felted needles, m. p. 170—171°, $[\alpha]_D$ +70° (*c*, 0·5) (Found : C, 57·0; H, 7·4%). Infra-red spectrum : Peaks at 1734 and 1235 (acetate) and 1682 cm.$^{-1}$ (αβ-unsaturated ketone).

The ether solution was evaporated and the residue acetylated with acetic anhydride–pyridine on the steam-bath for 1 hr. The solid product, isolated by means of ether, was digested with methanol, and the insoluble fraction (80 mg.; m. p. 240°) collected and crystallised from chloroform–methanol to give 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate as fine needles, m. p. and mixed m. p. 263° (decomp.), $[\alpha]_D$ −3° (*c*, 1·5) (Found : C, 57·4; H, 7·6%).

3β : 7β-*Diacetoxy*-22 : 23-*dibromo*-14β-*ergost*-8-*en*-11-*one*.—(*a*) On standing, the methanol digest described above deposited prismatic needles (350 mg.), m. p. 175°, crystallisation of which from aqueous acetone gave 3β : 7β-*diacetoxy*-22 : 23-*dibromo*-14β-*ergost*-8-*en*-11-*one* (250 mg.) as needles, m. p. 187°, $[\alpha]_D$ +61°, +62° (*c*, 1·0, 0·9) (Found : C, 57·5; H, 7·3. $C_{32}H_{48}O_5Br_2$ requires C, 57·1; H, 7·2%). Light absorption : Max. at 2440 Å (ε = 9200). Infra-red spectrum : Peaks at 1737 and 1241 (acetate) and 1689 cm.$^{-1}$ (αβ-unsaturated ketone).

(*b*) A solution of 22 : 23-dibromo-7β-hydroxy-11-oxo-9β-ergost-8(14)-en-3β-yl acetate (150 mg.) in methanolic potassium hydroxide (50 c.c.; 2%) was heated under reflux for 2 hr. Isolation by means of ether followed by treatment of the product with acetic anhydride and pyridine at room temperature gave a solid, crystallisation of which from aqueous acetone yielded 3β : 7β-diacetoxy-22 : 23-dibromo-14β-ergost-8-en-11-one (100 mg.) as needles, m. p. 184—186°, $[\alpha]_D$ +63° (*c*, 1·3) (Found : C, 57·4; H, 7·35%). Light absorption : Max. at 2430 Å (ε = 8500).

(*c*) Alkali treatment of 22 : 23-dibromo-3β : 7β-dihydroxyergost-8(14)-en-11-one exactly as in (*b*), followed by acetylation, gave 3β : 7β-diacetoxy-22 : 23-dibromo-14β-ergost-8-en-11-one which separated from aqueous acetone as needles, m. p. and mixed m. p. 185—186°, $[\alpha]_D$ +62° (*c*, 0·9). Light absorption : Max. at 2440 Å (ε = 8900).

3β : 7β-*Diacetoxy*-14β-*ergosta*-8 : 22-*dien*-11-*one*.—Debromination of 3β : 7β-diacetoxy-22 : 23-dibromo-14β-ergost-8-en-11-one (100 mg.) by activated zinc in benzene–ether–methanol gave 3β : 7β-*diacetoxy*-14β-*ergosta*-8 : 22-*dien*-11-*one* (40 mg.), separating from methanol as needles, m. p. 82—84° (softening at 65°), $[\alpha]_D$ +103° (*c*, 0·9) (Found : C, 72·9; H, 9·3. $C_{32}H_{48}O_5$,MeOH requires C, 72·75; H, 9·6%). Light absorption : Max. at 2460 Å (ε = 8400).

Rearrangement of 22 : 23-*Dibromo*-7β-*hydroxy*-11-*oxoergost*-8-*en*-3β-*yl Acetate with Alkali*.—A solution of 22 : 23-dibromo-7β-hydroxy-11-oxoergost-8-en-3β-yl acetate (250 mg.) in benzene (20 c.c.) and methanolic potassium hydroxide (40 c.c.; 5%) was heated under reflux for 4 hr. The product was isolated by using ether and heated with acetic anhydride (4 c.c.) and pyridine (4 c.c.) on the steam-bath for 1 hr. Isolation by using ether gave a gum which crystallised from chloroform–methanol to give 22 : 23-dibromo-7 : 11-dioxoergostan-3β-yl acetate (40 mg.) as needles, m. p. and mixed m. p. 263° (decomp.), $[\alpha]_D$ −5° (*c*, 1·8) (Found : C, 57·4; H, 7·6%). Concentration of the first chloroform–methanol mother liquor gave a solid which after recrystallisation from aqueous acetone yielded 3β : 7β-diacetoxy-22 : 23-dibromo-14β-ergost-8-en-11-one as needles, m. p. 187—188°, $[\alpha]_D$ +64° (*c*, 1·2) (Found : C, 56·9; H, 7·5%). Light absorption : Max. at 2430 Å (ε = 9000).

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