1 filter paper treated with 5% olive oil in chloroform. The descending chromatograms were run for 2.5 days.[24] The derivatives were also run both ascending and descending in methanol–isoöctane (1:1) on untreated paper.[25] The two 2,4-dinitrophenylhydrazones had identical R_f values differing from those of formaldehyde, acetaldehyde and isobutyraldehyde.

Isopropyltriphenylphosphonium Bromide.—A pressure bottle was charged with 3.1 g. of isopropyl bromide and 6.6 g. of triphenylphosphine and was heated at 150° for one day. The crystalline precipitate weighed 6 g. It was recrystallized from a small amount of ethanol with ether, m.p. 238–239°.

Triphenylphosphine Isopropylidine Reagent.—The reagent was prepared from 3.08 g. (8 mmoles) of isopropyltriphenylphosphonium bromide, 12.9 ml. (8 mmoles) of an 0.62 *N* butyllithium solution and 25 ml. of anhydrous ether by shaking overnight at room temperature in a pressure bottle under nitrogen.

3β-Acetoxy-5-cholenaldehyde.—Ethyl 3β-acetoxy-thiol-5-cholenate was prepared according to the method of Levin, *et al.*[26] The acid chloride of 4 g. of 3β-acetoxy-5-cholenic acid was prepared and treated with ethyl mercaptan in pyridine, giving 3 g. of thiol ester, m.p. 98–101°. The thiol ester was reduced[27] with deactivated Raney nickel (30 g. of nickel alloy activated in the usual manner and partially deactivated with acetone) to give a crude product melting at 132–140°. After purification over the bisulfite addition product, 1.36 g. of aldehyde was obtained, m.p. 140–142°.

Synthesis of 24-Dehydrocholesterol Acetate.—To the alkylidene reagent in the pressure bottle was added under nitrogen 840 mg. of 3β-acetoxy-5-cholenaldehyde, m.p. 140–142°. The bottle was sealed and shaken at room temperature for one hour. It then was heated at 65° for 6 hours. The reaction product was filtered and the solid material washed several times with moist ether. The ether extracts were evaporated and the residue was acetylated and chromatographed on a silicic acid:Celite column (7.5 cm. × 14 cm.). By-products from the reaction were eluted with Skellysolve C–benzene (1:1). Benzene then eluted 205 mg. of crude 24-dehydrocholesterol acetate. The acetate was recrystallized several times from aq. ethanol, m.p. 99–100°, $[\alpha]^{22}D$ −38.8° (*c* 2.6 in $CHCl_3$), mixed m.p. 100° with the natural product.

The sterol was crystallized from aq. methanol, m.p. 117–118°, $[\alpha]^{22}D$ −37.9° (*c* 2.1 in $CHCl_3$), mixed m.p. 117° with the natural product.

The benzoate was crystallized from aq. acetone, m.p. 131°, $[\alpha]^{22}D$ −14.0° (*c* 2.7 in $CHCl_3$), mixed m.p. 130° with the natural product.

Zone 3 Sterol.—The azoyl ester was crystallized from benzene–ethanol and hydrolyzed to the sterol which was crystallized twice from aq. methanol, m.p. 148°, $[\alpha]^{22}D$ −40.2° (*c* 3.0 in $CHCl_3$), mixed m.p. 148° with cholesterol.

Anal. Calcd. for $C_{27}H_{46}O$: C, 83.87; H, 11.99. Found: C, 83.82; H, 11.92.

The acetate crystallized from aq. ethanol, m.p. 116°, $[\alpha]^{22}D$ −47.0° (*c* 3.2 in $CHCl_3$), mixed m.p. 116° with cholesteryl acetate. *Anal.* Calcd. for $C_{29}H_{48}O_2$: C, 81.25; H, 11.29. Found: C, 81.34; H, 11.23.

The benzoate was crystallized from acetone, m.p. 145°, $[\alpha]^{22}D$ −14.2° (*c* 3.1 in $CHCl_3$), mixed m.p. 145° with cholesteryl benzoate.

The infrared spectrum and the modified Liebermann–Burchard reaction were identical to those of authentic cholesterol.

Acknowledgment.—We are indebted to CIBA Pharmaceutical Products, Inc., Summit, N. J., for a sample of methyl 3β-hydroxy-5-cholenate, and to the Upjohn Co., Kalamazoo, Mich., for a sample of ethyl 3β-hydroxy-5-thiolcholenate. Mr. A. P. Ronald of our Instrumentation section recorded the infrared spectra and obtained many of the analytical data.

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[CONTRIBUTION FROM STERLING-WINTHROP RESEARCH INSTITUTE]

D-Homosteroids. I. Derivatives of D-Homoetiocholan-3α-ol-11,17a-dione

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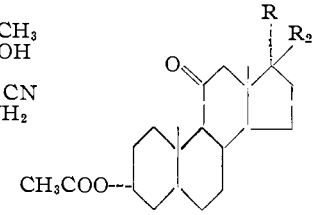
A number of 11-oxygenated-D-homosteroids have been synthesized from D-homoetiocholan-3α-ol-11,17a-dione. Several of these compounds possessed interesting endocrinological activity.

The detailed studies carried out by Ruzicka and Heusser[1] have shown a number of interesting correlations of endocrinological activity between homologous pairs of 11-desoxy-steroids and 11-desoxy-D-homosteroids. These and related observations stimulated our interest in the preparation of a series of 11-oxygenated-D-homosteroids, leading eventually to the synthesis of D-homopregn-4-ene-17aα,21-diol-3,11,20-trione 21-acetate (D-homocortisone acetate).[2] The present paper presents the synthesis of a series of derivatives of D-homoetiocholan-3α-ol-11,17a-dione.

D-Homoetiocholan-3α-ol-11,17a-dione 3-acetate has been prepared by Wendler, Taub and Slates[3] through application of the Tiffeneau ring-enlargement reaction[4] to the two epimeric 17-aminomethyletiocholane - 3α,17 - diol - 11 - ones. A similar procedure was followed in our work; however, we were able to isolate the two isomeric 17-cyanoetiocholane-3α,17-diol-11-one 3-acetates (Ia and Ib) and their corresponding 17-acetates IIa and IIb. We assigned the configuration at C_{17} in our compounds on the basis of the relative rates of acetylation of the 17-hydroxy group in the two

Ia, **R** = CN; R_2 = OH
IIa, R = CN; R_2 = $OCOCH_3$
IIIa, R = CH_2NH_2; R_2 = OH
Ib, R = OH; R_2 = CN
IIb, **R** = $OCOCH_3$; R_2 = CN
IIIb, R = OH, R_2 = CH_2NH_2



(1) *Cf. inter alia*, L. Ruzicka, N. Wahba, P. Herzig and H. Heusser, *Chem. Ber.*, **85**, 491 (1952).

(2) To be published.

(3) N. L. Wendler, D. Taub and H. L. Slates, THIS JOURNAL, **77**, 3559 (1955). The present work was completed prior to the appearance of this paper.

(4) *Cf.* M. W. Goldberg and E. Wydler, *Helv. Chim. Acta*, **26**, 1142 (1943).

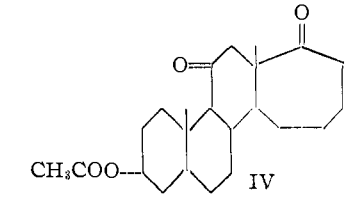
epimers[5]; these assignments are in agreement with those made by Wendler, Taub and Slates.[3] The rearrangement of either pure 17-aminomethyl epimer IIIa and IIIb by means of nitrous acid gave substantially the same mixture of 17- and 17a-keto-D-homo compounds, as previously noted.[3]

D-Homoetiocholan-3α-ol-11,17a-dione was converted into D-homoetiochol-4-ene-3,11,17a-trione by the sequence of oxidation, bromination and dehydrobromination, and thence by hydrogenation over palladium catalyst to D-homoandrostane-3,11-17a-trione. The latter two compounds were potent inhibitors of pituitary activity when tested in mice or rats.[6] D-Homoetiochol-4-en-17aβ-ol-3,11-dione was prepared by a procedure similar to that used in the original synthesis of testosterone[7] and also by the partial reduction (at C_{17a}) of D-homoetiochol-4-ene-3,11,17a-trione by means of sodium borohydride. The compound, as the 17a-propionate, had only minimal androgenic or anabolic activities but was a potent pituitary inhibitor. In this case, the low androgenic activity can be contrasted with the high activity of the 11-desoxy compound.[1]

Models showed that the 17a-keto group in the D-homosteroid series is slightly more sterically hindered toward rearward approach of a given reagent than is the 17-keto group in the normal steroid series. This observation was confirmed by the isolation of small amounts (4–6%) of the 17aα-ol when the 17a-keto group was reduced by means of sodium borohydride and by the formation of a slightly greater quantity of the 17aα-epimer (14–15%) when the reduction was carried out by catalytic hydrogenation. A Walden inversion carried out on the 17aβ-tosylate gave very low yields of the 17aα-acetate; a similar reaction applied in the normal steroid series was reported[8] to give a 5% yield of the 17α-ol.

D-Homoetiocholan-3α-ol-11,17a-dione 17a-ethyleneketal (or 17a-ethylenehemithioketal) was readily converted to the 11β-hydroxyl derivative by means of sodium borohydride or lithium aluminum hydride reduction and to the 11α-epimer when reduced by means of sodium in 1-propanol.[9] The configuration of the 11-hydroxy group in the latter compound was confirmed by its conversion to a 3α,11α-diacetate under mild conditions,[9] whereas the 3α,11β-diol formed only a 3α-monoacetate under the same conditions.[10] The 11α-acetoxy group was very resistant toward saponification, as previously noted.[11] Dehydration of the 11β-ol derivatives to the $\Delta^{9,11}$-enes took place smoothly in an acetic acid–boron trifluoride mixture.[12]

D-Homoetiocholan-3α-ol-11,17a-dione 3-acetate could be further converted by means of the Tiffeneau ring enlargement method to what is believed to be the next higher homolog, D-bishomoetiocholan-3α-ol-11,17b-dione 3-acetate (IV). The structure assigned was based upon analogy and upon the relatively high yield obtained in the ring enlargement reaction.



IV

Experimental[13]

Etiocholan-3α-ol-11,17-dione.—The preparation of this compound by a variety of methods was thoroughly investigated.[14] The results may be of interest for application to related types. The procedure of Wilson,[15] involving nitrite cleavage of the 17-acetyl group, gave 48–52% yields of pure product on a 0.2-mole scale. The chromic acid oxidation[16] of pregnane-3α,17α-diol-11,20-dione 3-acetate gave 48–50% yields of etiocholan-3α-ol-11,17-dione 3-acetate by direct crystallization (0.3-mole scale). Modification of the latter procedure by the use of a two-phase system (benzene–water–acetic acid) increased the yield to 60–65%. The reduction of pregnane-3α,17α-diol-11,20-dione 3-acetate to the 3α,17α,20β-triol by means of sodium borohydride[17] in 90% ethanol (90 minutes at 10°) followed by cleavage of the crude product with lead tetraacetate in acetic acid solution (16 hr. at 25°) gave 75–80% yields of the pure title compound on a 0.3-mole scale. Herzog, *et al.*,[18] have reported an analogous procedure involving the *catalytic* reduction of pregnane-3α,17α-diol-11,20-dione, with somewhat better over-all yields. Either method leads to the formation, as a minor by-product, of pregnane-3α,17α,20β-triol-11-one 3,20-diacetate, m.p. 248.2–250.5°, $[\alpha]_D$ +73.4°.[17,19] Rate reaction studies on the cleavage of the pure 3α,17α,20β-triol by means of lead tetraacetate in acetic acid solution showed that the reaction was 93% complete in 4 hr. at 25°.

17-Epimeric 17-Cyanoetiocholane-3α,17-diol-11-one 3-acetates (I). A.—To a solution of 69.3 g. (0.200 mole) of etiocholane-3α-ol-11,17-dione 3-acetate in 1500 ml. of ethanol was added 390 g. (6.0 moles) of C.P. potassium cyanide, and the mixture was cooled to −5°. While stirring, there was added 288 g. (4.8 moles) of glacial acetic acid dropwise during 45 minutes; the temperature was maintained at −5° during this addition and for 1 hr. thereafter. After standing for 18 hr. at room temperature, the mixture was diluted to 10 liters with water, filtered, and the insoluble material was washed thoroughly with water. A solution of the wet cake in ethyl acetate was decolorized (Darco G-60) and evaporated *in vacuo* to yield 70–72 g. (94–96%) of crude epimeric cyanohydrins, melting within the range of 219–227°. This material was suitable for reduction to the 17-aminomethyl compounds (see below).

(5) The 17β-hydroxy group (pseudo-equatorial) is the less sterically hindered.

(6) All endocrinological data were determined by Dr. A. L. Beyler and Dr. G. O. Potts of these laboratories.

(7) L. Ruzicka, A. Wettstein and H. Kagi, *Helv. Chim. Acta*, **18**, 1478 (1935).

(8) J. Elks and C. W. Shoppee, *J. Chem. Soc.*, 241 (1953); O. S. Modaeva and F. A. Lur'i, *Doklady Akad. Nauk S.S.S.R.*, **84**, 713 (1952) (*C. A.*, **47**, 3326 (1953)); F. Sondheimer, O. Mancera, M. Urquiza and G. Rosenkranz, THIS JOURNAL, **77**, 4145 (1955).

(9) H. Heuser, R. Anliker and O. Jeger, *Helv. Chim. Acta*, **35**, 1537 (1952); H. L. Herzog, M. A. Jevnik and E. B. Hershberg, THIS JOURNAL, **75**, 269 (1953).

(10) A. Lardon and T. Reichstein, *Helv. Chim. Acta*, **26**, 586 (1943).

(11) A. Katz, *ibid.*, **30**, 883 (1947); O. Mancera, *et al.*, *J. Org. Chem.*, **17**, 1066 (1952).

(12) H. Heymann and L. F. Fieser, THIS JOURNAL, **73**, 5252 (1951).

(13) All melting points are corrected. Unless otherwise noted, the rotations were determined in chloroform solution at 25°, *c* ~1%. The analyses were carried out by Mr. K. D. Fleischer and staff, and the spectral determinations were made by Dr. F. C. Nachod and Miss Catherine Martini.

(14) *Cf.* the recent application of the Beckmann rearrangement in a similar series by J. Schmidt-Thomé, *Ann.*, **609**, 43 (1957).

(15) A. G. Wilson, U. S. Patent 2,515,482.

(16) T. H. Kritchevsky, D. L. Garmaise and T. F. Gallagher, THIS JOURNAL, **74**, 483 (1952); *cf.* ref. 3.

(17) E. P. Oliveto and E. B. Hershberg, *ibid.*, **75**, 488 (1953), report a 55% yield of the pure 3α,17α,20β-triol by a similar method.

(18) H. L. Herzog, *et al.*, *ibid.*, **75**, 266 (1953).

(19) L. H. Sarett, *ibid.*, **71**, 1169 (1949); M. Finkelsten, J. v. Euw and T. Reichstein, *Helv. Chim. Acta*, **36**, 1270 (1953).

A portion of the crude product was recrystallized five times from ethyl acetate to yield pure **17α-cyanoetiocholane-3α,17β-diol-11-one 3-acetate (Ia)**, m.p. 238.3–241.3°, $[\alpha]_D$ +85.9° (acetone).

Anal. Calcd. for $C_{22}H_{31}NO_4$: C, 70.75; H, 8.37; N, 3.75. Found: C, 70.48; H, 8.40; N, 3.76.

A 13.5 g. portion of the crude epimeric product above was dissolved in a mixture of 40 ml. of dry pyridine and 20 ml. of acetic anhydride, and the solution was allowed to stand at room temperature for 6 hr. The solution was poured into an excess of cold dilute sulfuric acid, the precipitated gum was extracted into ether, and the ether solution was washed with 3% sodium chloride solution. After thorough drying the ether was evaporated to a residual volume of 75 ml. On standing at room temperature there was deposited 3.1 g. of crude **17β-cyanoetiocholane-3α,17α-diol 11-one 3-acetate** (Ib). After two recrystallizations from ethyl acetate the latter compound formed rosettes of needles, m.p. 224–225° dec. (immersed at 210°), $[\alpha]_D$ +92.6°. The mixed m.p. of Ia and Ib was 221–235° dec.

Anal. Found: C, 70.57; H, 8.26; N, 3.74.

The above ethereal solution, from which Ib had been removed, was evaporated to dryness *in vacuo* and the residual solid was recrystallized from an ethyl acetate–*n*-hexane mixture and then from methanol to give pure **17α-cyanoetiocholane-3α,17β-diol-11-one 3,17-diacetate (IIa)** as dense prisms of m.p. 185.7–187.7°, $[\alpha]_D$ +21°.[20]

Anal. Calcd. for $C_{24}H_{33}NO_5$: C, 69.21; H, 8.01; N, 3.37. Found: C, 69.48; H, 8.43; N, 3.54.

A solution of 2.7 g. of Ib in 20 ml. of dry pyridine and 40 ml. of acetic anhydride was allowed to stand at room temperature for 48 hr. After working up by the usual procedure, the crude product was recrystallized from ethyl acetate–*n*-hexane; **17β-cyanoetiocholane-3α,17α-diol-11-one 3,17-diacetate (IIb)** formed slender needles with m.p. 182.8–184.8°, $[\alpha]_D$ +68.5°.

Anal. Found: C, 69.08; H, 8.20; N, 3.43.

The mixed m.p. of IIa and IIb was 145–155°; additionally, the infrared spectra of IIa and IIb differed in the fingerprint region.

B.—A solution of 20.0 g. of etiocholan-3α-ol-11,17-dione 3-acetate in 50 ml. of freshly prepared acetone cyanohydrin[21] was allowed to stand at room temperature for 18 hr.[22] The resulting semi-solid mixture was diluted with 800 ml. of water and filtered. The precipitate, after thorough washing with water, was dried at 70° and then weighed 21.1 g. (100%). The material had m.p. 221–225° and was suitable for reduction to the 17-aminomethyl epimers.

D-Homoetiocholan-3α-ol-11,17a-dione 3-Acetate.[23]—To a solution of 70.5 g. of the crude epimeric mixture of 17-cyanoetiocholane-3α,17-diol-11-one 3-acetates (see above) in 1500 ml. of glacial acetic acid was added 5 g. of platinum oxide catalyst (J. T. Baker), and the mixture was hydrogenated at 100 lb. pressure and a temperature of 25–30°. The reduction was complete in 105 minutes; the catalyst was removed by filtration and the filtrate was concentrated *in vacuo* to a residual volume of 150 ml. To the clear solution was added 1500 ml. of water and the resulting turbid mixture[24] was clarified by filtration through a Filtercel pad. The aqueous filtrate[25] was cooled to 5°, 800 g. of ice was added and to this mixture was added in one portion a solution of 25 g. of sodium nitrite in 75 ml. of water. After thorough stirring the mixture was allowed to stand for 18 hr., first in the cold (3 hr.) and then at room temperature (foaming, evolution of oxides of nitrogen). The precipitated solid was filtered, washed thoroughly with water and dried at 70°. After five recrystallizations from methanol there was obtained 32–35 g. (47–52%) of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate, m.p. 171.2–171.5°, $[\alpha]_D$ +22.3° (acetone) (reported[3]) m.p. 167–168° (cor.), $[\alpha]_D$ +28.7° ($CHCl_3$). Chromatography of the mother liquors on acid-washed alumina yielded an additional 12–18% of pure compound, as well as substantial amounts of the isomeric 17-keto compound.[3]

The 17a-oxime derivative crystallized from ether in tiny white prisms, m.p. 147.4–150.4°.

Anal. Calcd. for $C_{22}H_{33}NO_4$: C, 70.37; H, 8.86; N, 3.73. Found: C, 70.00; H, 8.68; N, 3.65.

D-Homoetiocholan-3α-ol-11,17a-dione.—Saponification of the above acetate by means of potassium carbonate in aqueous methanol (1.5 hr. reflux) gave a quantitative yield of the title compound as thick needles from benzene, m.p. 205.5–207.7°, $[\alpha]_D$ −7.6°.

Anal. Calcd. for $C_{20}H_{30}O_3$: C, 75.43; H, 9.50. Found: C, 75.36; H, 9.25.

The 17-benzal derivative was prepared from benzaldehyde and the D-homoketone in methanolic sodium hydroxide solution (3 days at 25° in the dark); colorless prisms from methanol, m.p. 198.7–203.2°.

Anal. Calcd. for $C_{27}H_{34}O_3$: C, 79.76; H, 8.43. Found: C, 79.81; H, 8.45.

D-Homoetiocholane-3,11,17a-trione.—To a solution of 113.7 g. of D-homoetiocholan-3α-ol-11,17a-dione in 2400 ml. of acetone was added 400 ml. of water, and the resulting solution was cooled to 10°; 74 g. (1.5-mole proportion) of N-bromoacetamide was added and stirred into solution; the resulting clear solution was allowed to stand at 5–10° for 5 hr. During this period the color of the solution changed to deep orange-red (usually within 1 hr.) and back again to colorless. To the stirred, cold solution was added 40 g. of zinc dust followed by 60 ml. of glacial acetic acid, and the slurry was stirred at room temperature for 30 minutes. A further 40-g. portion of zinc dust was added, and stirring was continued for an additional 30 minutes. The zinc dust was filtered and washed with acetone; the combined filtrates were concentrated *in vacuo* to about 1000 ml., 500 ml. of water was added and the remainder of the acetone was removed *in vacuo*. The residual suspension was diluted with 2 liters of water, filtered and the solid product was washed thoroughly with water. After drying at 70°, there was obtained 112.4 g. (99%) of material melting at 162–164°. One recrystallization from ethyl acetate–Skellysolve C or from dilute methanol gave pure material with but little loss, crystallizing in tiny needles or plates, m.p. 163.3–164.3°, $[\alpha]_D$ −0.2°.

Anal. Calcd. for $C_{20}H_{28}O_3$: C, 75.91; H, 8.92. Found: C, 76.02; H, 9.09.

4-Bromo-D-homoetiocholane-3,11,17a-trione.—To a solution of 12.23 g. (0.0387 mole) of D-homoetiocholane-3,11,17a-trione in 150 ml. of glacial acetic was added 0.2 ml. of a 30% solution of hydrogen bromide in acetic acid. To the resulting pale yellow colored solution, with stirring, there was added dropwise a solution of 13.15 g. (0.0387 mole) of 94.4% pyridinium bromide perbromide and 5.16 g. (0.0380 mole) of C.P. sodium acetate trihydrate in 100 ml. of glacial acetic acid. The addition required 30 minutes; the solution was then diluted slowly with water to a volume of 2 liters. The precipitated solid was filtered, washed well with water and dried at 40°. One recrystallization from acetone–ether gave 8.52 g. of pure product, m.p. 192.5–194.1° dec. (immersed at 180°), $[\alpha]_D$ +38.5°; λ_{max}^{KBr} 5.80 (Br–C–CO), 5.87 μ.

Anal. Calcd. for $C_{20}H_{27}BrO_3$: C, 60.76; H, 6.88; Br, 20.22. Found: C, 60.27; H, 7.44; Br, 20.60.

The combined mother liquors, on reduction with zinc dust and acetic acid at room temperature, gave a 90% recovery of unconverted D-homoetiocholane-3,11,17a-trione.

D-Homoetiochol-4-ene-3,11,17a-trione.—Application of the semicarbazide dehydrobromination procedure of Gallagher[16] to the above 4-bromoketone afforded, after chromatography on alumina, 25–30% yields of the title compound; large feathery crystals from ethyl acetate, m.p. 206.1–

(20) Reported[3] m.p. 183–185°, $[\alpha]_D$ +23°.

(21) E. C. Wagner and M. Baizer, *Org. Syntheses*, **20**, 43 (1940).

(22) *Cf.* A. Ercoli and P. de Ruggieri, THIS JOURNAL, **75**, 650 (1953).

(23) *Cf.* ref. 3, footnote 14.

(24) The trace of insoluble material present at this point was identified as etiocholane-3α,17β-diol-11-one 3-acetate.

(25) The addition of an excess of solid potassium carbonate to this solution precipitated a gum. Crystallization of this crude mixture of IIIa and IIIb from acetone gave the oxazolidine derivative of 17α-aminomethyletiocholane-3α,17β-diol-11-one 3-acetate, m.p. 173.8–175.8°, $[\alpha]_D$ +34.8°. *Anal.* Calcd. for $C_{25}H_{39}NO_4$: C, 71.89; H, 9.41; N, 3.36. Found: C, 71.63; H, 9.70; N, 3.36. Starting with pure IIIb (from pure Ib), we were unable to prepare the corresponding oxazolidine derivative (*cf.* ref. 3, footnote 15). Models indicate the existence of greater steric hindrance toward the formation of the oxazolidine ring in this epimer.

209.6°, $[\alpha]_D$ +144.4°, λ_{max}^{EtOH} 239 mμ (ε 15,400); λ_{max}^{KBr} 5.88, 6.04 and 6.21 μ.

Anal. Calcd. for $C_{20}H_{26}O_3$: C, 76.39; H, 8.34. Found: C, 76.53; H, 8.42.

When the semicarbazide dehydrobromination was carried out in aqueous tertiary butanol, there was formed as a by-product in small yield an *unknown semicarbazone* of m.p. above 300°, λ_{max}^{EtOH} 254 mμ (ε 4100), and stable to further treatment with pyruvic acid.[26]

Anal. Calcd. for $C_{21}H_{29}N_3O_3$: C, 67.90; H, 7.87; N, 11.13. Found: C, 67.71; H, 7.24; N, 11.18.

The application of the lithium chloride–dimethylformamide procedure of Holysz[27] to the 4-bromoketone gave 40–50% yields of the title compound by direct crystallization.

D-Homoandrostane-3,11,17a-trione.—To a solution of 6.0 g. of D-homoetiochol-4-ene-3,11,17a-trione in 200 ml. of ethanol was added 500 mg. of 22% palladium hydroxide–strontium carbonate catalyst, and the mixture was hydrogenated at 29° and 30 lb. pressure until reduction was complete (25 minutes). After removal of the catalyst, the alcoholic filtrate was concentrated to dryness *in vacuo* and the residual gum was reoxidized by means of N-bromoacetamide in acetone solution. The usual work-up (see above) afforded 6.0 g. of a crystalline mixture of D-homoetiocholane-3,11,17a-trione and D-homoandrostane-3,11,17a-trione. Fractional recrystallization from acetone gave 1.5 g. of pure D-homoandrostane-3,11,17a-trione, m.p. 226.0–228.0° (partial sublimation), $[\alpha]_D$ 0°; λ_{max}^{KBr} 5.87, 5.94 μ. Further amounts were obtained by chromatography of the mother liquors on alumina.

Anal. Calcd. for $C_{20}H_{28}O_3$: C, 75.91; H, 8.92. Found: C, 75.92; H, 8.90.

D-Homoetiocholane-3α,17aβ-diol-11-one 3-Acetate.—To a solution of 25.0 g. (0.0693 mole) of D-homoetiocholane-3α-ol-11,17a-dione 3-acetate in 250 ml. of pure dioxane was added a solution of 2.62 g. (0.0693 mole) of sodium borohydride in a mixture of 25 ml. of water and 50 ml. of pure dioxane. The temperature was held at 25–30° (initially by means of external cooling) for 40 minutes and then at 50° for 30 minutes. The mixture was diluted to 2.5 liters with water, extracted with ether, and the ethereal extracts were washed twice with 2% sodium chloride solution. After drying, the ethereal solution was evaporated to dryness *in vacuo* and the residual crystalline solid was recrystallized twice from an ethyl acetate–*n*-hexane mixture. The product (20.8 g.) crystallized as prismatic needles, m.p. 185.0–187.1°, $[\alpha]_D$ +73.0°.

Anal. Calcd. for $C_{22}H_{34}O_4$: C, 72.87; H, 9.45. Found: C, 73.09; H, 9.52.

Saponification of the 3-acetate by means of aqueous methanolic potassium carbonate solution gave **D-homoetiocholane-3α,17aβ-diol-11-one** as slender needles from ethyl acetate, m.p. 271.6–280.3°, $[\alpha]_D$ +58.3° (methanol).

Anal. Calcd. for $C_{20}H_{32}O_3$: C, 74.95; H, 10.07. Found: C, 74.83; H, 10.09.

Acetylation of the 3-acetate by means of pyridine–acetic anhydride gave **D-homoetiocholane-3α,17aβ-diol-11-one 3,17a-diacetate** as thick needles from Skellysolve C, m.p. 184.9–186.0°, $[\alpha]_D$ +39.4°.

Anal. Calcd. for $C_{24}H_{36}O_5$: C, 71.25; H, 8.97. Found: C, 71.01; H, 8.83.

Treatment of the 3-acetate with *p*-toluenesulfonyl chloride in pyridine solution (17 hr. at 25°) afforded **D-homoetiocholane-3α,17aβ-diol-11-one 3-acetate-17a-*p*-toluenesulfonate,** needles from methanol, m.p. 135.2–136.4°.

Anal. Calcd. for $C_{29}H_{40}O_6S$: C, 67.41; H, 7.80; S, 6.21. Found: C, 67.20; H, 7.99; S, 6.39.

D-Homoetiocholane-3α,17aα-diol-11-one 3-Acetate.—The combined mother liquor material recovered from the preparation and recrystallization of D-homoetiocholane-3α,17aβ-diol 3-acetate above was chromatographed on acid-washed alumina. A mixture of 10–15% benzene–*n*-hexane eluted a series of fractions melting within the range 119–128°. Further elution with 20–40% benzene–*n*-hexane gave material identified as D-homoetiocholane-3α,17aβ-diol-11-one 3-acetate, and elution with benzene gave a third series of fractions melting in the range 209–219° (see below). The first fractions, of m.p. range 119–128°, were combined and recrystallized from Skellysolve C and from 80% methanol to yield D-homoetiocholane-3α,17aα-diol-11-one 3-acetate, small thick needles, m.p. 134.1–135°, resolidifying and remelting at 146–147.9°, $[\alpha]_D$ +57.4°. The yield of the pure 17aα-epimer was 5% in this experiment.

Anal. Calcd. for $C_{22}H_{34}O_4$: C, 72.87; H, 9.45. Found: C, 72.82; H, 9.39.

Saponification of the 3-acetate gave **D-homoetiocholane-3α,17aα-diol-11-one,** small prisms from dilute methanol, m.p. 181.9–183.9°, $[\alpha]_D$ +34.6°.

Anal. Calcd. for $C_{20}H_{32}O_3$: C, 74.95; H, 10.07. Found: C, 74.60; H, 9.75.

An attempt also was made to prepare the 17aα-epimer by means of a Walden inversion carried out on the 17aβ-tosylate (see above). Refluxing the 17aβ-tosylate with anhydrous potassium acetate in dry acetic acid for 3 hr. followed by saponification yielded an oil containing in addition to very small amounts of the 17aα-ol a number of unsaturated products.[8] On the other hand, the catalytic reduction of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate (platinum oxide catalyst, glacial acetic acid solution) gave increased amounts of the 17aα-epimer (2.15 g. from 14.4 g. of the 17a-ketone) in analogy with the normal steroid series.[28]

D-Homoetiocholane-3α,11β,17aβ-triol 3-Acetate.—The chromatographic fractions of m.p. range 209–219° (see above) were combined and recrystallized twice from benzene to yield the title compound as rosettes of tiny needles, m.p. 217.1–218.7°, $[\alpha]_D$ +56.5°.

Anal. Calcd. for $C_{22}H_{36}O_4$: C, 72.48; H, 9.96. Found: C, 72.70; H, 9.98.

Saponification gave **D-homoetiocholane-3α,11β,17aβ-triol** as rosettes of slender needles from ethyl acetate, m.p. 204.5–208.0°, $[\alpha]_D$ +38.6°.

Anal. Calcd. for $C_{20}H_{34}O_3$: C, 74.49; H, 10.63. Found: C, 74.49; H, 10.94.

This latter compound also was prepared by the direct reduction of D-homoetiocholane-3α-ol-11,17a-dione 3-acetate or D-homoetiocholane-3α,17aβ-diol-11-one 3,17a-diacetate by means of lithium aluminum hydride in ether–benzene solution or by refluxing with an excess of sodium borohydride in methanolic sodium hydroxide solution for 18 hr. Acetylation of the 3α,11β,17aβ-triol with pyridine–acetic anhydride gave the **3,17a-diacetate,** long feathery crystals from methanol, m.p. 252.1–254.8°, $[\alpha]_D$ +42.7°.

Anal. Calcd. for $C_{24}H_{38}O_5$: C, 70.90; H, 9.42. Found: C, 70.60; H, 9.26.

D-Homoetiocholane-3α,11α,17aβ-triol.—D-Homoetiocholane-3α,17aβ-diol-11-one was reduced by sodium in propanol.[9] The crude triol melted at 236–240°. Recrystallization from ethyl acetate and from 50% alcohol gave pure material: brilliant short needles, m.p. 241.3–243.2°, $[\alpha]_D$ −0.5° (dioxane).

Anal. Calcd. for $C_{20}H_{34}O_3$: C, 74.49; H, 10.63. Found: C, 74.80; H, 10.32.

Acetylation with pyridine–acetic anhydride at room temperature gave **D-homoetiocholane-3α,11α,17aβ-triol 3,11,17a-triacetate,** clusters of hair-like needles from *n*-hexane, m.p. 179.4–181.0°, $[\alpha]_D$ −10.5°.

Anal. Calcd. for $C_{26}H_{40}O_6$: C, 69.61; H, 8.99. Found: C, 69.92; H, 8.95.

D-Homoetiocholane-3α,17aβ-diol-11-one 3-Acetate-17a-benzoate.—A stirred solution of 23.87 g. of D-homoetiocholane-3α,17aβ-diol-11-one 3-acetate in 210 ml. of dry pyridine was cooled to 0° and treated dropwise with 46.5 g. of redistilled benzoyl chloride. When the addition of the benzoyl chloride was complete the mixture was maintained at 0° for a further 2 hr. and then allowed to stand at room temperature for 17 hr. There was then added dropwise, with stirring and cooling, 25 ml. of water, and the resulting mixture was allowed to stand for 4 hr. After quenching in 3 liters of water, the precipitate was filtered off, washed with water and stirred with 1 liter of 3% aqueous sodium bicarbonate solution for 45 minutes. The insoluble product was filtered, washed, dried at 50° and recrystallized from Skelly-

(26) The 3-semicarbazones of Δ^4-3-ones have λ_{max}^{EtOH} 265–272 mμ (ε 25,000–38,000); *cf.* L. Dorfman, *Chem. Revs.*, **53**, 47 (1953).

(27) R. P. Holysz, THIS JOURNAL, **75**, 4432 (1953).

(28) BIOS Final Report, No. 449, pp. 195, 256 (PBM 77766 (1945)).

solve C to yield 29.0 g. of material melting at 177–180° and suitable for hydrolysis. Two further recrystallizations from methanol gave the pure compound, crystallizing in long slender needles, m.p. 180.0–181.9°, $[\alpha]_D$ +106°.

Anal. Calcd. for $C_{29}H_{38}O_5$: C, 74.64; H, 8.21. Found: C, 74.57; H, 8.00.

D-Homoetiocholane-3α,17aβ-diol-11-one 17a-Benzoate.—To a solution of 29.0 g. of D-homoetiocholane-3α,17aβ-diol-11-one 3-acetate-17a-benzoate (m.p. 177–180°) in 1350 ml. of hot methanol was added a solution of 7.8 g. of potassium bicarbonate in 270 ml. of water. The mixture was refluxed for 3.5 hr., and the methanol was then distilled *in vacuo*. The residual slurry was diluted with water, filtered, and the precipitate was washed with water and dried at 50°. The dried solid was refluxed for 15 minutes with 300 ml. of benzene, and the heterogeneous mixture was allowed to stand overnight at room temperature. The insoluble material (D-homoetiocholane-3α,17aβ-diol-11-one) was filtered and washed with a little benzene. The combined filtrates were concentrated to dryness, and the residual solid was recrystallized from ethyl acetate. There was obtained a total of 16.7 g. of material melting above 200° and suitable for the next step. The pure compound formed silky needles from methanol or ethyl acetate, m.p. 202.4–204.4°, $[\alpha]_D$ +81.0°.

Anal. Calcd. for $C_{27}H_{36}O_4$: C, 76.38; H, 8.55. Found: C, 76.31; H, 8.36.

D-Homoetiocholan-17aβ-ol-3,11-dione 17a-Benzoate.—The above 3α-ol was oxidized by means of N-bromoacetamide as outlined above, using, however, a trace of hydrobromic acid to start the reaction. The product was obtained in 98.6% yield, m.p. 198–201°. The pure compound crystallized from methanol in tiny prisms, m.p. 198.5–202.0°, $[\alpha]_D$ +95.2°. The mixed m.p. with the 3α-ol was 186–191°.

Anal. Calcd. for $C_{27}H_{34}O_4$: C, 76.74; H, 8.11. Found: C, 76.96; H, 8.20.

The yield was considerably lower with other oxidation methods, *e.g.*, two phase chromic acid oxidation or the chromic acid–pyridine method of Sarett.[29]

D-Homoetiocholan-17aβ-ol-3,11-dione.—Saponification of the 17a-benzoate by refluxing for 2 hr. with aqueous methanolic potassium carbonate solution gave the title compound in high yield of clusters of thick needles from benzene, m.p. 238.7–246.0°, $[\alpha]_D$ +57.1°.

Anal. Calcd. for $C_{20}H_{30}O_3$: C, 75.43; H, 9.50. Found: C, 75.76; H, 9.84.

4-Bromo-D-homoetiocholan-17aβ-ol-3,11-dione 17a-Benzoate.—The above 3,11-dione was brominated by means of the pyridinium bromide perbromide procedure outlined above. Recrystallization from acetone and from ethyl acetate gave pure material of m.p. 198–199° dec. (immersed at 185°), $[\alpha]_D$ +119.3°.

Anal. Calcd. for $C_{27}H_{33}BrO_4$: C, 64.67; H, 6.63; Br, 15.94. Found: C, 64.04; H, 6.73; Br, 16.20.

D-Homoetiochol-4-en-17aβ-ol-3,11-dione 17a-Benzoate.—Dehydrobromination of the 4-bromo compound by the lithium chloride–dimethylformamide procedure[27] gave 40–50% yields of product; heavy prisms from ethyl acetate, m.p. 187.2–190.2°, $[\alpha]_D$+227.9°; λ_{max}^{EtOH} 232 mμ (ε 27,700), 280 (ε 1040) mμ.[30]

Anal. Calcd. for $C_{27}H_{32}O_4$: C, 77.11; H, 7.67. Found: C, 77.30; H, 7.28.

D-Homoetiochol-4-en-17aβ-ol-3,11-dione.—Saponification of the benzoate with aqueous methanolic potassium carbonate solution (3 hr. reflux) gave an 85% yield of crude product melting at 185–190°. Two recrystallizations from dilute methanol gave the pure compound as brilliant leaflets, m.p. 197–198°, $[\alpha]_D$ +212.0°, λ_{max}^{EtOH} 238 mμ (ε 16,100).

Anal. Calcd. for $C_{20}H_{28}O_3$: C, 75.91; H, 8.92. Found: C, 75.77; H, 8.64.

D-Homoetiochol-4-en-17aβ-ol-3,11-dione 17a-Propionate.—To a solution of 6.0 g. of D-homoetiochol-4-ene-3,11,17a-trione in 100 ml. of methanol and 5 ml. of pyridine was added 500 mg. of sodium hydroxide in 15 ml. of methanol, and the solution was cooled to 5°. To the cold solution was added 0.39 g. of sodium borohydride, and after standing for 1 hr. at 0–5°, the mixture was treated with an excess of acetic acid and evaporated to dryness. The residue was taken up in a benzene–water mixture and the benzene layer was washed with water and with dilute sodium bicarbonate solution. After drying, the benzene extract was evaporated to dryness, the residue was dissolved in 14 ml. of pyridine and 7 ml. of propionic anhydride, and the solution was allowed to stand at room temperature for 48 hr. After the usual work-up the product was chromatographed on silica gel. The fractions eluted with 7.5% ether–benzene weighed 3.42 g.; recrystallization from benzene–ether and from methanol gave 1.45 g. of **D-homoetiochol-4-ene-3,17aβ-diol-11-one 3,17a-dipropionate**, small brilliant prisms, m.p. 165.8–169.0°, $[\alpha]_D$ +14.4°; only end absorption in the ultraviolet, λ_{max}^{KBr} 5.77, 8.88 (propionate), 5.84 (C=O), 5.98 (C=C) μ.

Anal. Calcd. for $C_{26}H_{38}O_5$: C, 72.52; H, 8.90. Found: C, 72.30; H, 8.92.

The fractions eluted with 17.5% ether–benzene weighed 1.74 g.; recrystallization from hexane–ether and from ethanol gave 1.29 g. of D-homoetiochol-4-en-17aβ-ol-3,11-dione 17a-propionate, m.p. 212.6–218.0°, $[\alpha]_D$ +145.1°, λ_{max}^{EtOH} 239 mμ (ε 15,400); λ_{max}^{KBr} 5.77, 8.47 (propionate), 5.87 (C=O), 6.02, 6.18 (C=C-C=O) μ.

Anal. Calcd. for $C_{23}H_{32}O_4$: C, 74.16; H, 8.66. Found: C, 74.40; H, 8.76.

D-Homoetiocholan-3α-ol-11,17a-dione 3-Acetate-17a-ethyleneketal.—A mixture of 21.65 g. of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate, 18.6 g. of redistilled ethylene glycol, 1.5 g. of *p*-toluenesulfonic acid monohydrate and 300 ml. of dry benzene was stirred and refluxed under a water trap for 4 hr. To the cooled mixture was added 2 ml. of pyridine and 300 ml. of water. The benzene layer was separated, washed with water, dried over sodium sulfate and evaporated to dryness *in vacuo*. The resinous residue was crystallized from Skellysolve C and from methanol (containing traces of pyridine) to give 10.70 g. (44%) of the ketal, m.p. 201–206°. The pure compound crystallized from methanol (containing traces of pyridine) as large lustrous plates, m.p. 209.1–213.6°, $[\alpha]_D$ +43.5°.

Anal. Calcd. for $C_{24}H_{36}O_5$: C, 71.25; H, 8.97. Found: C, 71.07; H, 9.47.

The mother liquors on hydrolysis with dilute alcoholic hydrochloric acid gave 9.7 g. of D-homoetiocholan-3α-ol-11,17a-dione (91% recovery of unreacted material as the 3α-ol).

Saponification of the 3-acetate-17a-ethyleneketal by means of aqueous methanolic potassium carbonate gave a quantitative yield of **D-homoetiocholan-3α-ol-11,17a-dione 17a-ethyleneketal**, large hexagonal crystals from ethyl acetate, m.p. 190.4–192.2°, $[\alpha]_D$ +15.4°.

Anal. Calcd. for $C_{22}H_{34}O_4$: C, 72.89; H, 9.46. Found: C, 73.19; H, 9.35.

Oxidation of the latter 3α-ol-17a-ethyleneketal by means of the chromic acid–pyridine reagent[29] gave a high yield of **D-homoetiocholane-3,11,17a-trione 17a-ethyleneketal**, large diamond-shaped crystals from ethyl acetate, m.p. 184.9–186.8°, $[\alpha]_D$ +23.3°. The mixed m.p. with the 3α-ol showed little or no depression, but the infrared spectrum indicated the absence of a hydroxy group.

Anal. Calcd. for $C_{22}H_{32}O_4$: C, 73.30; H, 8.95. Found: C, 73.10; H, 8.95.

D-Homoetiocholan-3α-ol-11,17a-dione 3-Acetate-17a-ethylenehemithioketal.—A solution of 7.2 g. of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate in 25 ml. of pure dioxane was cooled to 15° and treated with 7.8 g. of redistilled β-mercaptoethanol, 10 g. of anhydrous sodium sulfate and 10 g. of freshly fused zinc chloride. The resulting mixture was processed and worked up as previously described.[31] The oily product, containing excess β-mercaptoethanol, was triturated with 300 ml. of *n*-hexane. The insoluble solid was filtered, washed with *n*-hexane and dissolved in 50 ml. of hot ethyl acetate. After cooling thoroughly in an ice-bath,

(29) G. I. Poos, G. E. Arth, R. E. Beyler and L. H. Sarett, THIS JOURNAL, **75**, 422 (1953).

(30) The λ_{max}^{EtOH} data serve as structure confirmation, since the benzoate group contributes λ_{max}^{EtOH} 229 (ε 14,000), 280 (ε 1000) mμ; see ref. 26.

(31) J. Romo, G. Rosenkranz and C. Djerassi, THIS JOURNAL, **73**, 4961 (1951).

the mixture was filtered to remove a gelatinous precipitate and evaporated to dryness. Recrystallization of the residual solid from methanol containing a few drops of pyridine gave large hexagonal plates (3.0 g.), m.p. 229.2–236.2°, $[\alpha]_D$ +51.5°.[32]

Anal. Calcd. for $C_{24}H_{36}O_4S$: C, 68.53; H, 8.63; S, 7.62. Found: C, 68.10; H, 8.34; S, 7.62.

D-Homoetiocholane-3α,11β-diol-17a-one 17a-Ethyleneketal.—To a solution of 25.60 g. of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate-17a-ethyleneketal in 500 ml. of methanol was added a solution of 5.0 g. of potassium hydroxide and 13.0 g. of sodium borohydride in 100 ml. of water. The mixture was refluxed for 20 hr., filtered through a Filtercel pad and diluted with 400 ml. of water. After cooling in an ice-bath, the crystalline precipitate was filtered, washed with 50% methanol containing a few drops of pyridine and dried at 70°. There was thus obtained 20.87 g. (92%) of product melting at 193–194°. The mother liquors yielded an additional 2.03 g. (7%) of material melting at 187–192°. Recrystallization from methanol containing a trace of pyridine gave the pure compound (with about 8–10% loss) melting at 195.2–197.0°, $[\alpha]_D$ +20.9°.

Anal. Calcd. for $C_{22}H_{36}O_4$: C, 72.49; H, 9.96. Found: C, 72.69; H, 9.74.

D-Homoetiocholane-3α,11β-diol-17a-one 17a-Ethylenehemithioketal.—Four and two-tenths grams of D-homoetiocholane-3α-ol-11,17a-dione 3-acetate-17a-ethylenehemithioketal was reduced in ethereal solution by means of 1.52 g. of lithium aluminum hydride in the usual manner. The product, after crystallization from ethyl acetate, formed rosettes of needles, m.p. 207.0–207.8°, $[\alpha]_D$ +32.4°. The yield was 3.4 g.

Anal. Calcd. for $C_{22}H_{36}O_3S$: C, 69.42; H, 9.53; S, 8.43. Found: C, 69.80; H, 10.00; S, 8.17.

D-Homoetiocholane-3α,11β-diol-17a-one.—A solution of 20.87 g. of D-homoetiocholane-3α,11β-diol-17a-one 17a-ethyleneketal in 50 ml. of acetic acid and 20 ml. of water was heated on the steam-bath for 1 hr. The solvents were removed *in vacuo* and the residual resin was dried and acetylated by means of acetic anhydride–pyridine (1 hr. at 90°). The crude crystalline product (20.40 g., m.p. 134–144°) was repeatedly recrystallized from 85% methanol to yield 13.30 g. (64%) of pure **D-homoetiocholane-3α,11β-diol-17a-one 3-acetate**, m.p. 163.8–165.6°, $[\alpha]_D$ +14.5°.

Anal. Calcd. for $C_{22}H_{34}O_4$: C, 72.89; H, 9.45. Found: C, 73.08; H, 9.65.

Saponification gave the title compound, glistening prisms from ethyl acetate, m.p. 168.6–171.0°, $[\alpha]_D$ −14.1°.

Anal. Calcd. for $C_{20}H_{32}O_3$: C, 74.96; H, 10.06. Found: C, 74.92; H, 10.01.

Reductive cleavage[31] of the above hemithioketal gave only about a 50% yield of the title compound.

D-Homoetiocholane-3α,11α-diol-17a-one 3,11-Diacetate.—Seventeen and four-tenths grams of D-homoetiocholan-3α-ol-11,17a-dione 17a-ethyleneketal was reduced by sodium in propanol. The crude product was a semi-crystalline mass which formed stable gels when attempts were made to recrystallize from the usual solvents. The material was therefore acetylated by pyridine–acetic anhydride and the crystalline product from this reaction was recrystallized twice from absolute ethanol containing a trace of pyridine to yield 14.0 g. of **D-homoetiocholane-3α,11α-diol-17a-one 3,11-diacetate-17a-ethyleneketal**, long slender needles of m.p. 211.7–214.1°, $[\alpha]_D$ −18.0°.

Anal. Calcd. for $C_{26}H_{40}O_6$: C, 69.61; H, 8.99. Found: C, 69.72; H, 9.19.

Saponification with aqueous methanolic potassium carbonate solution (1 hr. reflux) gave **D-homoetiocholane-3α,11α-diol-17a-one 11-acetate-17a-ethyleneketal**, wide leaflets from dilute ethanol, m.p. 169.1–171.5° (dried at 120°), $[\alpha]_D$ −41.1°.

Anal. Calcd. for $C_{24}H_{38}O_5$: C, 70.90; H, 9.42. Found: C, 70.96; H, 9.43.

Cleavage of the 17a-ethyleneketal group from D-homoetiocholane-3α,11α-diol-17a-one 3,11-diacetate-17a-ethyleneketal by means of aqueous acetic acid gave the title compound, clusters of tiny needles from absolute ethanol, m.p. 172.9–175.9°, $[\alpha]_D$ −29.3°.

Anal. Calcd. for $C_{24}H_{36}O_5$: C, 71.25; H, 8.97. Found: C, 71.04; H, 8.74.

Mild saponification gave **D-homoetiocholane-3α,11α-diol-17a-one 11-acetate**, needles from ethyl acetate, m.p. 167.0–168.6°, $[\alpha]_D$ −70.9°.

Anal. Calcd. for $C_{22}H_{34}O_4$: C, 72.87; H, 9.45. Found: C, 72.94; H, 9.31.

D-Homoetiochol-9(11)-ene-3α,17aβ-diol 3,17a-Diacetate.—To a solution of 4.5 g. of D-homoetiocholane-3α,11β,17aβ-triol in 100 ml. of glacial acetic acid was added 5 ml. of 47% boron trifluoride etherate. After standing 19 hr. at room temperature the dark-colored solution was diluted with ethyl acetate and the mixture was washed with water and with sodium bicarbonate solution. After drying, the extract was concentrated to dryness *in vacuo* and the crystalline residue was recrystallized from Skellysolve C; needles, m.p. 162.5–163.5°, $[\alpha]_D$ +21.6°.

Anal. Calcd. for $C_{24}H_{36}O_4$: C, 74.19; H, 9.34. Found: C, 73.90; H, 9.19.

Saponification gave **D-homoetiochol-9(11)-ene-3α,17aβ-diol**, cottony needles from ethyl acetate, m.p. 214.8–217.4°, $[\alpha]_D$ +10.9° (dioxane).

Anal. Calcd. for $C_{20}H_{32}O_2$: C, 78.89; H, 10.59. Found: C, 79.02; H, 10.60.

D-Homoetiochol-9(11)-en-3α-ol-17a-one 3-Acetate.—D-Homoetiocholane-3α,11β-diol-17a-one 3-acetate was treated with boron trifluoride as described above. The crude product (98% yield, m.p. 175–177°) was recrystallized three times from ethyl acetate; colorless prisms, m.p. 176.0–177.6°, $[\alpha]_D$ +12.8°.

Anal. Calcd. for $C_{22}H_{32}O_3$: C, 76.70; H, 9.36. Found: C, 76.58; H, 9.36.

D-Bishomoetiocholan-3α-ol-11,17b-dione 3-Acetate (IV).—A solution of 3.60 g. of D-homoetiocholan-3α-ol-11,17a-dione 3-acetate in 10 ml. of freshly prepared acetone cyanohydrin was allowed to stand overnight at room temperature. The resulting dark brown colored solution was diluted with 200 ml. of water, filtered and the crystalline precipitate was washed well with water. There was thus obtained 3.88 g. of an epimeric mixture of the two 17a-cyano-D-homoetiocholane-3α,17a-diol-11-one 3-acetates, melting at 121–125° dec.[33] The crude mixture was hydrogenated with platinum oxide catalyst in glacial acetic acid solution, and the crude amine acetate solution was treated with sodium nitrite solution as outlined above for the lower homolog. Two recrystallizations of the product from methanol gave 2.02 g. of material melting at 169–170.5°; one further recrystallization from the same solvent gave the pure D-bishomo compound of m.p. 174.8–175.4°, $[\alpha]_D$ +18.2°. The mixed m.p. with the D-homo precursor was 151–156°.

Anal. Calcd. for $C_{23}H_{34}O_4$: C, 73.76; H, 9.15. Found: C, 74.10; H, 9.27.

RENSSELAER, NEW YORK

(32) It is of interest to note that there is a dextrorotatory change in converting the 17a-one to the 17a-ethylenehemithioketal, in contrast to the large levorotatory change observed in the normal steroid series; *cf.* ref. 31, footnote 10.

(33) Recrystallization from methanol and from benzene–hexane gave one pure epimer (probably the 17aα-cyano epimer) crystallizing in shiny prisms of m.p. 183–187°. *Anal.* Calcd. for $C_{23}H_{35}NO_3$: C, 71.29; H, 8.58; N, 3.62. Found: C, 71.31; H, 8.84; N, 3.31.