Bis-*p*-toluenesulfonate of 1,6-Dihydroxyspiro[4.4]nonane.—A mixture of 1.05 g. of 1,6-dihydroxyspiro[4.4]nonane, obtained by the catalytic reduction of the diketone,[2] 2.50 g. of *p*-toluenesulfonyl chloride and 5 ml. of pyridine was allowed to stand for 12 hours at room temperature. The mixture was then cooled in an ice-bath and acidified with ice-cold 10% hydrochloric acid. The crystalline solid was quickly filtered, washed with dilute sodium bicarbonate solution and dried in a vacuum desiccator; 2.0 g. (63%). The substance was recrystallized from methanol; m.p. 115° dec. Unlike the monotosylate, this substance was found to be stable at room temperature over a period of months.

Anal. Calcd. for $C_{23}H_{28}S_2O_6$: C, 59.47; H, 6.03. Found: C, 59.33; H, 6.08.

1,6-Diacetoxyspiro[4.4]nonane.—A mixture of 2.10 g. of the diol,[2] obtained by the catalytic reduction of the diketone,[1] 4.0 g. of acetic anhydride and 0.05 g. of acetyl chloride was heated on a steam-bath for 12 hours and the excess acetic anhydride was removed under reduced pressure, b.p. 152–153° (20 mm.). On standing, colorless crystals separated. The solid was separated by decanting the supernatant liquid and drying; wt. 0.70 g. Vacuum sublimation at 100° (0.50 mm.) gave an oil-free crystalline substance, m.p. 80°.

Anal. Calcd. for $C_{13}H_{20}O_4$: C, 65.00; H, 8.33. Found: C, 64.79; H, 8.14.

The liquid fraction, 1.30 g., did not yield any more crystalline material on standing and was redistilled for analysis, b.p. 152–153° (20 mm.), $n^{25}D$ 1.4788.

Anal. Calcd. for $C_{13}H_{20}O_4$: C, 65.00; H, 8.33. Found: C, 64.88; H, 8.29.

LOS ANGELES, CALIFORNIA

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF WAYNE UNIVERSITY]

Terpenoids. XVI.[1] The Constitution of the Cactus Triterpene Cochalic Acid. Partial Reductions of Methyl Diketoechinocystate[2]

BY CARL DJERASSI, G. H. THOMAS[3] AND H. MONSIMER

RECEIVED FEBRUARY 1, 1955

From the cactus *Myrtillocactus cochal*, there has been isolated a new triterpene acid, $C_{30}H_{48}O_4$, named cochalic acid (Ia). Oxidation of methyl cochalate furnished methyl diketoechinocystate (IIIa), while lithium aluminum hydride reduction led to the cactus triterpene longispinogenin (Vb). These transformations establish the constitution and stereochemistry of cochalic acid as 16β-hydroxyoleanolic acid (16-epiechinocystic acid). Rosenmund reduction of the acid chloride of diacetyl cochalic acid yielded the cactus triterpene gummosogenin (Va), thus establishing a further chemical connection in this class of closely related triterpenes. Reduction of methyl diketoechinocystate with sodium borohydride gives methyl 16-keto-oleanolate (IVc), while treatment with lithium in liquid ammonia results in elimination of the angular carbomethoxy group and formation of norechinocystenolorne (VIa).

In continuation of our investigations[4] of natural products present in giant cacti, we have undertaken a study of the genus *Myrtillocactus*[5] which is indigenous to Mexico and Guatemala. Through the kind coöperation of Mr. Howard E. Gates of Corona, California, we have been able to secure specimens of *Myrtillocactus cochal*, a species growing chiefly in the Mexican State of Baja California.[6] The cactus did not contain alkaloids, but acid hydrolysis of the glycosides yielded a mixture of triterpenes from which a new acid could be isolated. We have named this substance cochalic acid and the present paper is concerned with the elucidation of its structure.[7]

Cochalic acid (Ia) is a dihydroxy acid ($C_{30}H_{48}O_4$) as demonstrated by the formation of a diacetate Ib, methyl ester Ic and methyl ester diacetate Id. Oxidation of the methyl ester diacetate Id with selenium dioxide in acetic acid furnished methyl diacetyl dehydrocochalate (II) which showed the levorotation and triple ultraviolet absorption maxima at 243, 251 and 260 mμ typical[8] of $\Delta^{11,13(18)}$-dienes of the β-amyrin series. Oxidation of methyl cochalate (Ic) with the chromium trioxide–pyridine reagent[9] led to a diketone, which could be identified as the known[10] methyl diketoechinocystate (IIIa) by direct comparison with an authentic sample.[11] Cochalic acid is, therefore, an isomer of echinocystic acid (IV) and can differ from it only in the configuration of the hydroxyl groups at C-3 and/or C-16.

It has been shown earlier[12] that gummosogenin (Va), a triterpene isolated from the cactus *Machaereocereus gummosus*, can be converted to maniladiol (Vc) thus demonstrating that both hydroxyl groups at C-3 and C-16 are β-oriented. Since longispinogenin (Vb), a triterpene triol obtained[13] from the cactus *Lemaireocereus longispinus*, has been related to gummosogenin (Va) by lithium aluminum hydride reduction[12] of the latter, two triterpenes (Va, Vb) of known structure and stereochemistry (at C-3 and C-16) were available for comparison. Lithium aluminum hydride reduction of methyl cochalate (Ic) produced longispinogenin (Vb); this established the stereochemistry of

(1) Paper XV, C. Djerassi, W. Rittel, A. L. Nussbaum, F. W. Donovan and J. Herran, THIS JOURNAL, **76**, 6410 (1954).

(2) We are indebted to the Division of Research Grants of the U. S. Public Health Service for generous financial assistance (grant No. G-3863).

(3) Postdoctorate research fellow, 1954–1955.

(4) For leading references see paper XI, C. Djerassi, L. H. Liu, E. Farkas, A. E. Lippman, A. J. Lemin, L. E. Geller, R. N. McDonald and B. J. Taylor, THIS JOURNAL, **77**, 1200 (1955).

(5) N. L. Britton and J. N. Rose, "The Cactaceae," Carnegie Institution of Washington, Washington, D. C., 1920, Vol. II, pp. 178–181.

(6) H. Bravo, "Las Cactaceas de Mexico," Mexico, D. F., 1937, p. 312.

(7) Some of our results already have been reported in a preliminary communication (C. Djerassi and G. H. Thomas, *Chemistry & Industry*, 1354 (1954)).

(8) *Cf.* L. Ruzicka, G. Müller and H. Schellenberg, *Helv. Chim. Acta*, **22**, 767 (1939); D. H. R. Barton and C. J. W. Brooks, *J. Chem. Soc.*, 257 (1951).

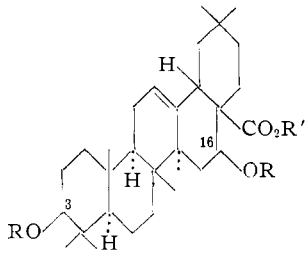
(9) G. I. Poos, G. E. Arth, R. E. Beyler and L. H. Sarett, THIS JOURNAL, **75**, 422 (1953).

(10) W. R. White and C. R. Noller, *ibid.*, **61**, 983 (1939).

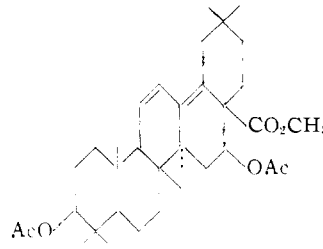
(11) We are greatly indebted to Prof. C. R. Noller (Stanford University) for supplying this substance.

(12) C. Djerassi, L. E. Geller and A. J. Lemin, THIS JOURNAL, **76**, 4089 (1954).

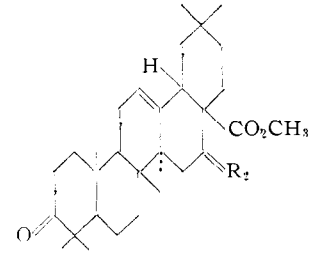
(13) C. Djerassi, R. N. McDonald and A. J. Lemin, *ibid.*, **75**, 5940 (1953).



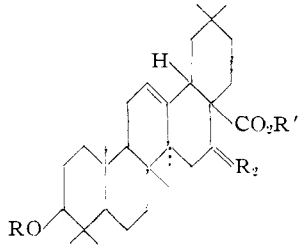
Ia, R = R′ = H
b, R = Ac; R′ = H
c, R = H; R′ = CH_3
d, R = Ac; R′ = CH_3



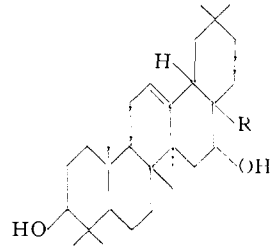
II



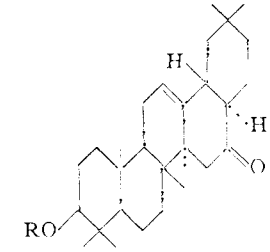
IIIa, R_2 = O
b, R_2 = H_2



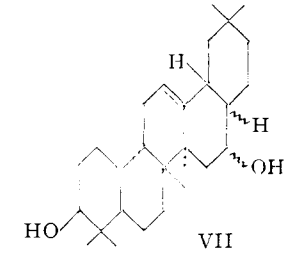
IVa, R = R′ = H; R_2 = 
b, R = H; R′ = CH_3; R_2 = 
c, R = H; R′ = CH_3; R_2 = O
d, R = Ac; R′ = CH_3; R_2 = O
e, R = H; R′ = CH_3; R_2 = H_2



Va, R = CHO
b, R = CH_2OH
c, R = CH_3



VIa, R = H
b, R = Ac



VII

the hydroxyl groups at C-3 and C-16 as β and independent confirmation could be adduced by the Rosenmund reduction of the acid chloride of diacetyl cochalic acid (Ib) which yielded[14] (after saponification) gummosogenin (Va). Cochalic acid (Ia) now can be defined unambiguously as 16β-hydroxyoleanolic acid (16-epiechinocystic acid).

The biogenetic relationship which is emerging from the structure elucidation of the various new cactus triterpenes isolated in our laboratory is illustrated in a striking manner in the series cochalic acid (Ia), gummosogenin (Va) and longispinogenin (Vb). These three triterpenes, isolated[12,13] from three different genera of the cactus family, represent different oxidation states at C-28 of the same fundamental skeleton.

Prior to the isolation of cochalic acid (Ia), we had attempted to synthesize this substance from its 16-epimer, echinocystic acid (IVa), in order to have the acid available as a reference compound. The synthesis failed but the results are of sufficient intrinsic interest so that they are recorded below.

The starting material was the readily available methyl diketoechinocystate (IIIa)[10] and it was planned to reduce the two carbonyl functions to the corresponding alcohols with the desired (β) configuration. Treatment with sodium borohydride under mild conditions effected only reduction of the C-3 keto group with the formation of methyl 16-ketoöleanolate (IVc), further characterized as the known[10] 3-acetate IVd. More vigorous conditions resulted in the reduction of both carbonyl groups but the product proved to be methyl echinocystate (IVb), the C-16 carbonyl function having been converted to the axial 16α-alcohol.[15] Since reduction with metals, such as the lithium–ammonia system,[16] invariably leads to equatorial alcohols irrespective of the degree of hindrance[15] of the carbonyl group as has been demonstrated first with 11-ketosteroids,[17] emphasis was placed on developing conditions which would be suitable for our purpose.

That the C-16 carbonyl group can be transformed to the equatorial 16β-alcohol already has been demonstrated[12] in the partial synthesis of longispinogenin (Vb) from methyl diketoechinocystate (IIIa). In that instance, lithium–ammonia in the presence of a large amount of methanol[18] was employed since it was felt that such a combination would most closely resemble Bouveault–Blanc conditions and effect simultaneous reduction of the carbonyl and ester functions. Since in the present

(14) The yield of aldehyde was markedly lower and the reduction proceeded at a much slower rate than has been observed (O. Jeger, C. Nisoli and L. Ruzicka, *Helv. Chim. Acta*, **29**, 1183 (1946)) with the 16α-epimer (diacetylechinocystic acid).

(15) The generalization has been made (D. H. R. Barton, *J. Chem. Soc.*, 1027 (1953)) that sodium borohydride (and lithium aluminum hydride) reduction of cyclohexanones yields the equatorial alcohol unless the carbonyl group is hindered. According to the index of carbonyl hindrance introduced by Barton, the 16-keto group in IIIa should be assigned a value of 3 which is nearly of the same order of magnitude as the 11-keto function in the steroid series.

(16) A. L. Wilds and N. A. Nelson, THIS JOURNAL, **75**, 5360 (1953).

(17) *Cf.* F. Sondheimer, O. Mancera, G. Rosenkranz and C. Djerassi, *ibid.*, **75**, 1282 (1953).

(18) W. S. Johnson, B. Bannister, B. M. Bloom, A. D. Kemp, R. Pappo, E. R. Rogier and J. Szmuszkovicz, *ibid.*, **75**, 2275, footnote 5 (1953).

instance attack of the latter was to be avoided, some model reductions were carried out with methyl oleanonate (IIIb), and with a limited amount of methanol it was indeed possible to convert the keto ester IIIb to methyl oleanolate (IVe) in *ca.* 40% yield. This appears to be a reflection of the extremely hindered nature of the angular carbomethoxy group[19] since similar reduction conditions in the case of a steroidal etio acid[20] resulted in the formation of the corresponding primary alcohol. However, when this procedure was applied to methyl diketoechinocystate (IIIa), a substance differing from the model IIIb only in the presence of an additional keto group at C-16, entirely different results were observed. The predominant product was a hydroxy-ketone ($C_{29}H_{46}O_2$), further characterized as the acetate, which also could be obtained by standard ketonic cleavage of methyl 16-keto-oleanolate (IVc) with methanolic potassium hydroxide solution.[21] The product, therefore, is norechinocystenolone (Δ^{12}-28-nor-17α,18β-oleanen-3β-ol-16-one) (VIa)[10,22] and the net result in the lithium–ammonia reaction was reduction of the 3-keto group and loss of the angular carbomethoxy function, the 16-ketone remaining unchanged. A small amount of a diol, $C_{29}H_{48}O_2$, presumably the derived alcohol VII, also was isolated. It is now clear that our earlier success in converting methyl diketoechinocystate (IIIa) into longispinogenin (Vb) by drastic lithium–ammonia–methanol reduction was not due chiefly to the fact that these conditions facilitated the transformation of the ester to the primary alcohol (at C-28), but rather that they were sufficiently drastic to effect rapid reduction of the 16-keto group, thus preventing loss of the angular substituent as observed above in the formation of norechinocystenolone (VIa).

Two mechanistic possibilities present themselves for explaining the loss of the angular substituent in the presence of a 16-keto group: (a) the alkaline reduction medium causes ketonic hydrolysis of the β-keto ester (IVc→VIa) or (b) the ester is reduced to the corresponding primary alcohol[23] which undergoes a retro-aldol reaction (with loss of formaldehyde) in the manner observed with such hydroxy-ketones in the icterogenin[24] or iresin[1] series.

Experimental[25]

Isolation of Cochalic Acid. (Ia).—Stems (11 kg.) of *Myrtillocactus cochal* from the gardens of Mr. Howard E. Gates (Corona, California) were cut into small pieces and dried to constant weight at 80°. The powdered material (816 g.) was continuously extracted in a soxhlet extractor with 95% ethanol for 3 days and the dry alcoholic extract (250 g.) was refluxed for 4 hours with 700 cc. of 95% ethanol and 300 cc. of concentrated hydrochloric acid. Dilution with water yielded a sticky solid which was collected and extracted continuously with 2 l. of ether for 3 days. Separation into acidic and neutral components in the usual manner[12] and crystallization of the acid fraction from acetone furnished 2.0 g. of **cochalic acid (Ia)**, m.p. 299–301°; additional quantities were isolated *via* the methyl ester (*vide infra*). The analytical sample crystallized from methanol as plates, m.p. 303–306°, $[\alpha]_D$ +58° (dioxane).

Anal. Calcd. for $C_{30}H_{48}O_4$: C, 76.22; H, 10.24. Found: C, 75.93; H, 10.15.

Methylation with diazomethane followed by crystallization from ether–hexane yielded **methyl cochalate (Ic)**, m.p. 192–194°, $[\alpha]_D$ +55°. Crude methyl cochalate (m.p. 175–185°) could be secured quite readily by methylating the mother liquors from the above-mentioned direct crystallization of cochalic acid and passing through 500 g. of alumina. Elution with ether followed by one crystallization yielded *ca.* 2.6 g. of methyl cochalate, which raises the total yield of cochalic acid[26] based on dry cactus to 0.56%.

Anal. Calcd. for $C_{31}H_{50}O_4$: C, 76.50; H, 10.36. Found: C, 76.97; H, 10.52.

Methyl diacetyl cochalate (Id) was prepared from the methyl ester by acetylation with pyridine–acetic anhydride for 2 hours at 100°; rods (from methanol), m.p. 194–196°, $[\alpha]_D$ +58°, $\lambda_{max}^{CHCl_3}$ 5.80 μ.

Anal. Calcd. for $C_{35}H_{54}O_6$: C, 73.64; H, 9.54. Found: C, 73.85; H, 9.55.

Diacetyl cochalic acid (Ib) could be obtained by the standard pyridine–acetic anhydride procedure but the following method was preferable. The acid (0.15 g.) was refluxed for 2 hours with 0.1 g. of anhydrous sodium acetate, 5 cc. of glacial acetic acid and 2.5 cc. of acetic anhydride, the solution concentrated until a precipitate appeared and 10 cc. of methanol was added. After refluxing for an additional 2 hours, water was added and the diacetate isolated in the usual manner; yield 0.175 g., m.p. 304–310°. The analytical sample was obtained from methanol–chloroform, m.p. 308–310°, $[\alpha]_D$ +58°. The molecular rotation difference (+406) between diacetyl cochalic acid and diacetyl echinocystic acid is in good agreement with that reported[27] for other pairs of epimeric 3,16-diacetates.

Anal. Calcd. for $C_{34}H_{52}O_6$: C, 73.34; H, 9.41. Found: C, 72.90; H, 9.32.

Selenium Dioxide Oxidation of Methyl Diacetyl Cochalate (Id).—A solution of 0.15 g. of the diacetyl methyl ester Id and 150 mg. of sublimed selenium dioxide in 10 cc. of glacial acetic acid was refluxed for 2 hours. Isolation with benzene, filtration through alumina and crystallization from methanol gave the $\Delta^{11,13(18)}$-diene II (**methyl diacetyl dehydrocochalate**) as plates (80 mg.), m.p. 227–229°, $[\alpha]_D$ −140°, λ_{max}^{EtOH} 243, 251 and 260 mμ (log ϵ 4.39, 4.44 and 4.26), strong brown color with tetranitromethane.

Anal. Calcd. for $C_{35}H_{52}O_6$: C, 73.91; H, 9.22. Found: C, 74.17; H, 9.27.

Oxidation of Methyl Cochalate (Ic) to Methyl Diketoechinocystate (IIIa).—Methyl cochalate (Ib) (0.3 g.) in 20 cc. of pyridine was treated at 0° with 0.3 g. of chromium trioxide and the mixture left at room temperature for 18 hours. The crude product (m.p. 151–154°) obtained by chloroform extraction was dissolved in benzene and chromatographed on 15 g. of alumina. Elution with benzene–ether (3:1) and crystallization from methanol produced 0.145 g. of needles, m.p. 170–172°, $[\alpha]_D$ +5°, which proved to be identical by mixture melting point determination and coincidence of infrared spectra with an authentic sample[11] of methyl diketoechinocystate (IIIa).

(19) *Cf.* L. Ruzicka, S. L. Cohen, M. Furter and F. C. van der Sluys-Veer, *Helv. Chim. Acta*, **21**, 1735 (1938).

(20) A. Sandoval, G. H. Thomas, C. Djerassi, G. Rosenkranz and F. Sondheimer, THIS JOURNAL, **77**, 148 (1955).

(21) The difficulty in saponifying methyl echinocystate (IVb) is of the same order of magnitude (*cf.* ref. 10 and I. Bergsteinsson and C. R. Noller, THIS JOURNAL, **56**, 1403 (1934)) as that observed with methyl oleanolate (IVe) (*cf.* ref. 19), but in the 16-keto series (IIIa, IVc) alcoholic potassium hydroxide suffices (ref. 10).

(22) *Cf.* F. A. Alves and C. R. Noller, THIS JOURNAL, **75**, 4043 (1952).

(23) A precedent is furnished by the reaction reported in the steroid series (ref. 20).

(24) D. H. R. Barton and P. de Mayo, *J. Chem. Soc.*, 887 (1953).

(25) All melting points were taken on the Kofler block. Rotations and infrared spectra (Baird double beam recording spectrophotometer, using 0.1-mm. cells) were measured in chloroform solution unless indicated otherwise. The microanalyses were carried out by Geller Laboratories, Hackensack, N. J.

(26) Saponification of methyl cochalate (Ic) requires fairly drastic conditions. In a typical experiment, 0.25 g. of methyl ester was refluxed for 16 hours with 6 g. of potassium hydroxide and 25 cc. of ethylene glycol. Dilution with water and ether extraction gave only 8 mg. of neutral material, while acidification followed by extraction and crystallization from methanol yielded 0.23 g. of cochalic acid, m.p. 299–302°.

(27) C. Djerassi, L. E. Geller and A. J. Lemin, *Chemistry & Industry*, 161 (1954).

Lithium Aluminum Hydride Reduction of Methyl Cochalate (Ic) to Longispinogenin (Vb).—Methyl cochalate (0.2 g.) was stirred for 3 hours at room temperature with an excess of lithium aluminum hydride in 20 cc. of tetrahydrofuran. Crystallization of the crude product from acetone gave 0.14 g. of longispinogenin (Vb), m.p. 247–249°; triacetate, m.p. 224–226°,[28] $[\alpha]$ +71°. The identity of the alcohol and its triacetate was confirmed by mixture melting point and infrared comparison with authentic specimens.[12,13]

Conversion of Diacetyl Cochalic Acid (Ib) to Gummosogenin (Va).—Diacetyl cochalic acid (0.2 g.) was refluxed with 1 cc. of thionyl chloride and 10 cc. of benzene for 1.5 hours and then evaporated to dryness *in vacuo*. Crystallization from ether–hexane yielded the analytical sample of the **acid chloride**, m.p. 217–220°.

Anal. Calcd. for $C_{34}H_{51}ClO_5$: C, 70.99; H, 8.94; Cl, 6.16. Found: C, 70.60; H, 8.86; Cl, 6.52.

The recrystallized acid chloride, prepared from 0.475 g. of diacetyl cochalic acid was dissolved in 20 cc. of dry xylene, 0.5 g. of 5% palladium-on-barium sulfate catalyst was added and hydrogen was passed through the solution with vigorous stirring, the temperature being maintained at 80–90°.[29] No more hydrogen chloride was evolved after 10 hours, whereupon the catalyst was filtered, ether was added and the solution extracted with 10% potassium hydroxide solution and water. After drying, the solvent was removed, the residue was refluxed for 1.5 hours with 5% methanolic potassium hydroxide and the product was purified by chromatography on 10 g. of alumina (activity II–III). The ether eluates crystallized readily and after recrystallization from acetone–hexane yielded 0.05 g. of **gummosogenin (Va)**, m.p. 250–252°, undepressed after admixture with authentic material,[12] $[\alpha]_D$ +27°; identity was confirmed by infrared comparison.

Sodium Borohydride Reduction of Methyl Diketoechinocystate (IIIa). (a) At Room Temperature.—A solution of 205 mg. of methyl diketoechinocystate (IIIa)[30] and 500 mg. of sodium borohydride in 35 cc. of methanol was left at room temperature for 3.5 hours. Addition of 1 cc. of hydrochloric acid and 20 cc. of water followed by concentration to *ca.* one-half the original volume yielded crystals which appeared to be a borate complex since they did not melt below 360°. The solid was, therefore, warmed on the steam-bath for 30 minutes with 20 cc. of methanol containing 2 cc. of concd. hydrochloric acid and then diluted with water. Filtration gave 210 mg. of solid, m.p. 200–205°, which was purified by chromatography on 40 g. of alumina deactivated with 0.5 cc. of 10% acetic acid. Crystallization of the benzene–ether (4:1) eluates from methanol furnished 130 mg. of **methyl 16-ketoöleanolate (IVc)**, m.p. 215–218°, $[\alpha]_D$ −4°.

Anal. Calcd. for $C_{31}H_{48}O_4$: C, 76.81; H, 9.98. Found: C, 76.53; H, 9.97.

Acetylation of a sample with acetic anhydride–pyridine at room temperature and recrystallization from chloroform–methanol produced 50 mg. of **methyl 3-acetyl 16-keto-oleanolate (IVd)**, m.p. 202–204°, $[\alpha]_D$ −6° (dioxane); reported[10] m.p. 203–205° and 229–232° (two polymorphic forms), $[\alpha]_D$ −9.8° (dioxane).

From the later eluates (benzene–ether 1:1) there was isolated 30 mg. of methyl echinocystate (IVb).

(28) This melting point is somewhat higher than that reported (m.p. 219–221° uncor.) for the original sample (ref. 13).

(29) The Rosenmund conditions employed were essentially those recorded for diacetyl echinocystyl chloride (ref. 14). In our hands, the reaction was complete in 4.5 hours and yielded 64% of the reported (ref. 14) diacetyl aldehyde.

(30) This sample was prepared for echinocystic acid according to the literature directions (ref. 10). We are grateful to Prof. C. R. Noller of Stanford University for putting at our disposal a generous amount of juice from the roots of *Echinocystis fabacea* ("man root") and from which the echinocystic acid was isolated.

(b) In **Refluxing Methanol.**—A solution of 250 mg. each of methyl diketoechinocystate and sodium borohydride in 10 cc. of methanol and 2 cc. of water was refluxed for 16 hours, diluted with water and extracted with ether. The ether residue was chromatographed on 24 g. of alumina (activity II–III) and yielded 36 mg. of **methyl 16-keto-oleanolate (IVc)** and 124 mg. of **methyl echinocystate (IVb)**, m.p. 213–214°, undepressed upon admixture with authentic material (lit.[21] m.p. 213–215°) and further identified by its infrared spectrum.

Lithium–Ammonia Reduction of Methyl Oleanonate (IIIb).—To a solution of 100 mg. of lithium in 25 cc. of liquid ammonia, distilled from sodium and cooled in a Dry Ice–acetone-bath, was added 250 mg. of methyl oleanonate (IIIb) dissolved in 20 cc. of absolute ether. After stirring for 5 minutes, 2 cc. of absolute methanol was added and stirring continued for 30 minutes, the blue color disappearing after approximately 15 minutes. The ammonia was evaporated, more ether was added and the solution was washed with dilute acid, water, dried and evaporated. Chromatography of the crude product (m.p. 130–145°) led to 104 mg. of methyl oleanolate (IVe), m.p. 196–198°, the identity of which was confirmed by mixture melting point and infrared comparison.

Norechinocystenolone (Δ^{12}-28-nor-17α,18β-oleanen-3β-ol-16-one) (VIa). (a) By Lithium–Ammonia Reduction of Methyl Diketoechinocystate (IIIa).—A solution of 1.0 g. of methyl diketoechinocystate (IIIa) in 100 cc. of ether was added to 0.7 g. of lithium in 150 cc. of liquid ammonia. Gradual addition of 14 cc. of methanol resulted in the disappearance of the blue color and 0.2 g. of lithium was added to restore the color which remained for nearly 15 minutes. After processing exactly as described above, chromatography on alumina (activity II–III) and elution with benzene yielded 0.4 g. of **norechinocystenolone (VIa)**. The analytical sample was obtained from methanol–chloroform, m.p. 223–225°, $[\alpha]_D$ −94° (dioxane), $\lambda_{max}^{CHCl_3}$ 5.85 μ; lit.[10] m.p. 230–233° and 268–271° (two polymorphic forms), $[\alpha]_D$ −86.7° (dioxane).

Anal. Calcd. for $C_{29}H_{46}O_2$: C, 81.63; H, 10.87. Found[31]: C, 82.20; H, 10.71.

Norechinocystenolone acetate (VIb) was prepared in the usual manner (acetic anhydride–pyridine, 20 hours, 25°) and recrystallized from methanol–chloroform; m.p. 210–213°, $[\alpha]_D$ −87°, −89° (dioxane), $\lambda_{max}^{CHCl_3}$ 5.80, 5.86 and 8.0μ.

Anal. Calcd. for $C_{31}H_{48}O_3$: C, 79.43; H, 10.32. Found: C, 79.45; H, 10.23.

The later eluates (benzene–ether 3:2) from the lithium–ammonia reduction gave 60 mg. of crystals (m.p. 160°) which were combined with similar material from another run. Several recrystallizations from methanol raised the m.p. to 190–191°, $[\alpha]_D$ +34°, no infrared carbonyl band. The substance is most likely **Δ^{12}-28-nor-17ξ,18-β-oleanene-3β,16ξ-diol (VII)**.

Anal. Calcd. for $C_{29}H_{48}O_2$: C, 81.25; H, 11.29. Found: C, 80.91; H, 11.30.

(b) From Methyl 16-Keto-oleanolate (IVc).—The crude 16-ketone IVc, prepared from 0.5 g. of 3,16-diketone IIIa as described above, was refluxed for 3 hours with 4 g. of potassium hydroxide and 50 cc. of methanol. Dilution with water, extraction with ether, washing with water, evaporation and chromatography led to 0.15 g. of norechinocystenolone (VIa), m.p. 222–224°, $[\alpha]_D$ −95° (dioxane); identity with a specimen prepared according to (a) was established in the usual manner.

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(31) The absence of a methoxyl group was confirmed further by a Zeisel determination.