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LYCOPODIUM ALKALOIDS—II[1]

THE OBSCURINES*

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Abstract—Structures VIIa and VIIIa are developed for α- and β-obscurine, respectively. The transformation of α-obscurine (VIIa) into dihydrolycopodine (XII) is described. Since the structure and stereochemistry of the latter is known, the structure and stereochemistry of the obscurines is thereby established and is as shown in XIV.

THE isolation of obscurine was first reported by Manske and Marion in 1942.[2] The name obscurine was chosen since the alkaloid was first obtained from *Lycopodium obscurum* L. It has subsequently been shown that obscurine is a minor alkaloid occurring in several Lycopodium species.[3] In 1953, Moore and Marion[4] showed that obscurine, which had been assigned the molecular formula $C_{18}H_{28}ON_2$,[2] was actually a mixture of two compounds of molecular formula $C_{17}H_{26}ON_2$ (designated α-obscurine) and $C_{17}H_{24}ON_2$ (β-obscurine), which could not be separated by repeated recrystallization but which were easily separable by chromatography over alumina.

Our analytical results confirmed the molecular formulas and showed the presence of a C-methyl and an N-methyl group in each of the alkaloids. The presence of these functional groups has also been established by nuclear magnetic resonance spectroscopy (see below). The initial structural studies of Moore and Marion[4] indicated that β-obscurine contains a 2-pyridone ring as shown by its infrared and ultraviolet spectra. The infra-red spectrum shows NH absorption[4] and as it has been shown that the basic nitrogen is tertiary,[5] the pyridone nitrogen must be unsubstituted. The NMR spectrum[6] of β-obscurine shows signals at low field (2·21τ and 3·63τ, centres of doublets) forming a typical AB quartet ($J_{AB} \approx 10$ cps) characteristic of two *ortho* protons.[7]

From this evidence it can be seen that β-obscurine must be a 3,4-, 3,6-, or 5,6-disubstituted 2-pyridone.†

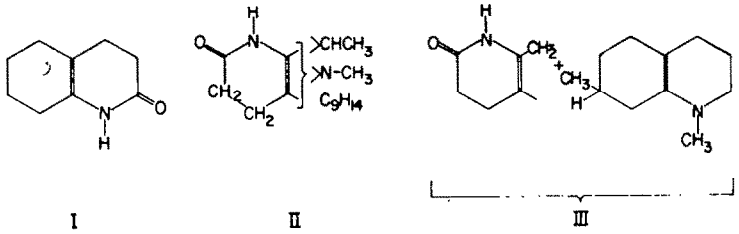
* Part of this work has been treated in a preliminary communication: W. A. Ayer and G. G. Iverach, *Tetrahedron Letters* No. 10, 19 (1960).

† Recently, chemical shift data for the 2-pyridone system has been published[8] and is in agreement with the assignment of the 3·63τ peak to a proton on the 3-position of the 2-pyridine ring.

[1] Part I: W. A. Ayer and G. G. Iverach, *Canad. J. Chem.* **38**, 1823 (1960).
[2] R. H. F. Manske and L. Marion, *Canad. J. Res.* **B20**, 87 (1942).
[3] R. H. F. Manske, *The Alkaloids* Vol. V, p. 295. Academic Press, New York (1955).
[4] B. P. Moore and L. Marion, *Canad. J. Chem.* **31**, 952 (1953).
[5] F. A. L. Anet and C. R. Eves, *Canad. J. Chem.* **36**, 902 (1958).
[6] Determined at 56·4 Mc in $CDCl_3$.
[7] L. M. Jackman, *Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry* Pergamon Press, New York (1959).
[8] J. A. Elvidge and L. M. Jackman, *J. Chem. Soc.* 859 (1961).

α-Obscurine, the major component of the mixed obscurines, does not exhibit the spectral properties of a 2-pyridone but shows instead a maximum in the ultra-violet at 255 mμ (log ε 3·73) and bands in the infra-red (CCl_4 solution) at 1700 cm^{-1} (medium intensity) and 1675 cm^{-1} (strong). Since α-obscurine gives 6-methyl-2-pyridone on dehydrogenation[4] and differs from β-obscurine only by two hydrogen atoms it appeared likely that it is simply a derivative of β-obscurine in which the pyridone ring has been reduced to a dihydropyridone ring. Furthermore, since the spectral properties do not agree well with those of 5,6-dihydro-2-pyridones[9] and since 3,6-dihydro-2-pyridones would not be expected to absorb strongly above 220 mμ in the ultra-violet, a 3,4-dihydro-2-pyridone was indicated. In fact, the ultra-violet spectrum of 3,4,5,6,7,8-hexahydrocarbostyril (I), prepared by the method of Campbell and Stevens[10] was almost superimposable upon that of α-obscurine.* The carbonyl region of the infra-red spectrum of the model compound was similar to that of α-obscurine, showing a weak side band at 1695 cm^{-1} and a strong band at 1675 cm^{-1} with a shoulder at 1660 cm^{-1}. Chemical proof of the close relationship was obtained by interconversion of the two alkaloids. α-Obscurine, when treated with N-bromosuccinimide in carbon tetrachloride was smoothly transformed into β-obscurine. As we have reported in connection with another problem,[1] reduction of β-obscurine with lithium in ammonia gives α-obscurine.

The NMR spectrum[6] of α-obscurine shows only one peak in the low field region, a broad peak centred at 1·99τ which we assign to the NH of the dihydropyridone ring. The lack of olefinic hydrogen indicates that the 3,4-dihydro-2-pyridone ring is substituted in positions 5 and 6. Since β-obscurine shows two *ortho* protons on the pyridone ring, it follows that the pyridone positions 3 and 4 are unsubstituted in both alkaloids. The NMR spectrum also shows peaks at 7·55τ ($N—CH_3$)[7] and at 9·14τ (doublet, J = 5 cps. $>CHCH_3$)[7]. The corresponding peaks in β-obscurine are at 7·46τ and 9·17τ (broadened singlet). These results may be summarized in terms of partial structure II for α-obscurine (β-obscurine is the corresponding 2–pyridone).



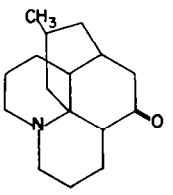
I II III

The key reaction for the further development of the structures was the previously mentioned dehydrogenation of α-obscurine which yielded, besides 6-methyl-2-pyridone, 7-methylquinoline.[4] If we make the assumption that no rearrangement

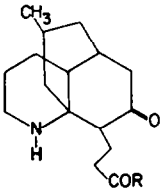
* The possibility that the hexahydrocarbostyril obtained was actually the $\Delta^{6,9}$-isomer was ruled out by the NMR spectrum which showed the absence of olefinic hydrogen. The $\Delta^{8,9}$-isomer would be expected to show a maximum at about 234 mμ in the ultra-violet.[11]

[9] O. E. Edwards and T. Singh, *Canad. J. Chem.* **32**, 683 (1954).
[10] D. A. Campbell and I. D. R. Stevens, *J. Chem. Soc.* 959 (1956).
[11] M. Uskokovic and M. Gut, *Helv. Chem. Acta* **42**, 2258 (1959).

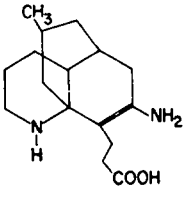
of the carbon skeleton has occurred during the dehydrogenation and that the tertiary N-methyl must be eliminated to allow aromatization of the quinoline ring, these fragments account for all the carbon, nitrogen and oxygen of β-obscurine. Furthermore, if the methyl group of the 6-methyl-2-pyridone, which cannot be the original methyl group of α-obscurine (NMR data above), is considered to arise from a methylene group attached to the 6 position, the partial structure II may be expanded to III. Since α-obscurine appears to contain no unsaturation other than that of the dihydropyridone ring it must be tetracyclic and the problem reduces to one of uniting the two fragments of partial structure III in the appropriate fashion.



IV



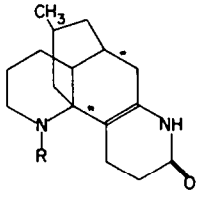
V a, R = OH
b, R = NH_2



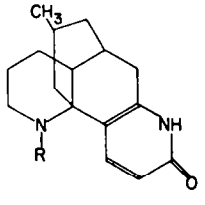
VI

A consideration of the possible biogenetic relationship between α-obscurine and lycopodine (IV),[12] which occurs along with the obscurines in many *Lycopodium* species[3] and which also yields 7-methylquinoline on dehydrogenation,[13] suggested a possible solution to this problem. If both alkaloids arise from a similar biogenetic precursor, such as Va, lactam formation and reduction of the lactam carbonyl would lead to lycopodine (IV), whereas condensation of the ketonic carbonyl with ammonia, or its biological equivalent, to give VI, followed by ring closure to the dihydropyridone* and N-methylation, leads to a structure (VIIa) for α-obscurine which incorporates all of the features of partial structure III (the starred bonds in VII indicate the bonds formed in linking the two fragments of III).

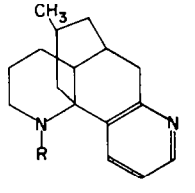
In order to rigorously establish structure VIIa for α-obscurine (and hence VIIIa for β-obscurine) we decided to attempt a reversal of the suggested biogenetic scheme, i.e., the transformation of α-obscurine to the amino acid V, then lactam formation



VII a, R = CH_3
b, R = H
c, R = CN
d, R = NO



VIII a, R = CH_3
b, R = H



IX a, R = H
b, R = CH_3

* Condensation with ammonia to give the keto-amide Vb and subsequent ring closure is equally feasible.

[12] D. B. MacLean and W. A. Harrison, *Chem. & Ind.* 261 (1960).
[13] L. Marion and R. H. F. Manske, *Canad. J. Res.* **B20**, 153 (1942).

and reduction to give dihydrolycopodine (IV, ketone reduced to hydroxyl), the structure of which has been firmly established.[12] This interconversion has now been realized and is described below.

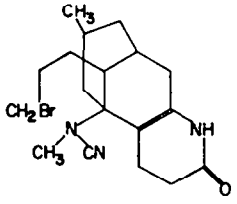
While this transformation was being carried out, the conversion of lycopodine to lycodine (IXa)[1] was announced.[14] Since lycodine (IXa) had already[1] been obtained from β-obscurine, this result[14] also confirms the structure of the obscurines.

Our first objective was the preparation of de-N-methyl-α-obscurine (VIIIb) and toward this end we first investigated the reaction of α-obscurine with cyanogen bromide. Treatment of VIIa with cyanogen bromide in refluxing chloroform gave, in about 45 per cent yield, a neutral fraction which could not be induced to crystallize even after repeated chromatography. The ultra-violet spectrum showed the retention of the dihydropyridone chromophore and the infra-red spectrum showed cyanamide absorption at 2200 cm^{-1}. These properties are consistent with the demethylated cyanamide VIIc or with the ring opened cyanobromo compound X and analysis (which showed about 3% bromine) suggested that the non-crystalline neutral product was a mixture of VIIc (ca. 85 per cent) and X (ca. 15 per cent). This reaction was not further investigated when it was found that α-obscurine could be conveniently demethylated with nitrous acid in aqueous acetic acid.[15] The product was formulated as de-N-methyl-N-nitroso-α-obscurine (VIId) on the basis of its neutrality, its analysis ($C_{16}H_{23}O_2N_3$) and its spectral properties. Hydrolysis of VIId with 2N HCl gave the desired de-N-methyl-α-obscurine (VIIb). Methylation of VIIb with formaldehyde and formic acid gave back α-obscurine (VIIa). De-N-methyl-β-obscurine (VIIIb) was prepared by the same reaction sequence.

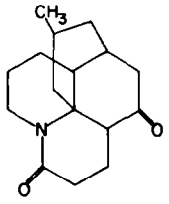
Additional de-N-methyl-α-obscurine was obtained from natural sources. During an examination of the minor alkaloids of *Lycodopium clavatum* L.[16] a chromatographic fraction exhibiting an ultra-violet maximum in the 255 mμ region was obtained. The compound responsible for this chromophore proved to be identical with the de-N-methyl-α-obscurine prepared from α-obscurine. About 200 milligrams were obtained from approximately 30 kilograms of dried plant. This same plant material also yielded about 10 milligrams of α-obscurine. The isolation of the de-N-demethyl-α-obscurine is perhaps not unexpected since lycodine (IXa), the pyridine analog of VIIb, also occurs in *L. clavatum* L.[16] In this connection it is interesting to note that N-methyllycodine (IXb), the pyridine analog of the obscurines, has recently been isolated from *L. complanatum* L.[17]

Vigorous hydrolysis of the dihydropyridone VIIb with concentrated hydrochloric acid followed by removal of solvents gave a hydroscopic foam formulated as a mixture of the hydrochloride of the amino acid V and ammonium chloride on the basis of the following observations. The infra-red spectrum of the crude amphoteric water soluble product showed broad bands in the 2300–3500 cm^{-1} and 1580–1700 cm^{-1} regions, typical of amino acid hydrochlorides.[18] Crystallization from methanol–acetone yielded ammonium chloride. Attempts to isolate Va either as its hydrochloride or as its methyl ester were unsuccessful; however, treatment of the

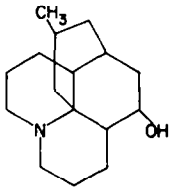
[14] F. A. L. Anet and M. V. Rao, *Tetrahedron Letters* No. 20, 9 (1960).
[15] R. C. Cookson and M. E. Trevett, *J. Chem. Soc.* 2589 (1956).
[16] D. A. Law and J. A. Berezowsky, this laboratory, unpublished results.
[17] R. Hayatsu, this laboratory, unpublished results.
[18] L. J. Bellamy, *The Infrared Spectra of Complex Molecules* p. 232. Methuen, London (1958).



X

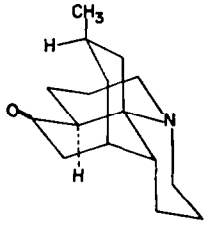


XI

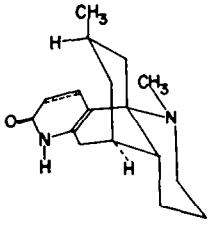


XII

crude hydrolysis mixture with dicyclohexylcarbodiimide, a reagent which has found extensive use in the preparation of amides[19] and lactones,[20] in refluxing pyridine, gave a neutral compound $C_{16}H_{23}O_2N$ which showed absorption in the infra-red at 1700 cm^{-1} (ketone) and 1626 (δ-lactam). The melting point and the infra-red spectrum were virtually identical to those of the lactam XI, which had previously been prepared from lycopodine.[21] Reduction of the lactam XI, prepared from α-obscurine, with lithium aluminium hydride gave dihydrolycopodine (XII), identical in all respects, including optical rotation, with an authentic sample prepared by lithium aluminium hydride reduction of lycopodine.



XIII



XIV

Since both the relative and absolute stereochemistry of lycopodine is known[22] and is as depicted in XIII, the stereochemistry of the obscurines is as shown in XIV, where the only uncertainty is in the conformation of the N-methyl group, which is assigned the presumably more favourable equatorial conformation.[23]

EXPERIMENTAL

Ultra-violet spectra were measured in 95% ethanol and, unless otherwise specified, infra-red spectra in chloroform. M.p. were determined on a hot stage and are approximately corrected for stem exposure. Analyses were performed by Pascher Mikroanalytisches Laboratorium, Bonn, Germany.

Isolation of α- and β-obscurine. The crude alkaloids of *L. annotinum L.* were isolated as described by Manske and Marion[24] and most of the annotinine removed by crystallization from ethanol. The remaining material was dissolved in benzene and chromatographed over alumina (activity III, 25 g

[19] J. C. Sheehan and G. P. Hess, *J. Amer. Chem. Soc.* **77**, 1067 (1955).
[20] R. B. Woodward, F. E. Bader, H. Bickel, A. J. Frey and R. W. Kierstead, *Tetrahedron* **2**, 1 (1958).
[21] D. B. MacLean, private communication. We wish to thank Dr. MacLean for a copy of the infra-red spectrum of XI.
[22] [a] F. A. L. Anet, *Tetrahedron Letters* No. 20, 13 (1960);
[b] K. Wiesner, J. E. Francis, J. A. Findlay and Z. Valenta, *Ibid.* No. 5, 187 (1961).
[23] D. H. R. Barton and R. C. Cookson, *Quart. Res.* **10**, 72 (1956).
[24] R. H. F. Manske and L. Marion, *Canad. J. Res.* **B21**, 92 (1943).

Al_2O_3 per gram of alkaloid mixture). After thorough elution with benzene, and then ether, elution with ethyl acetate afforded several functions exhibiting UV maxima at 255 mμ. Crystallization of these fractions from acetone yielded relatively pure α-obscurine. Several recrystallizations from methanol–acetone yielded the analytical sample of m.p. 282–283°.

(Found: C, 74·43, 74·61; H, 9·51, 9·40; N, 10·27; N—Me, 5·49; C—CH_3, 3·03. Calc. for $C_{17}H_{26}ON_2$: C, 74·41; H, 9·55; N, 10·21; 1N—Me, 5·48; 1C—CH_3, 5·48%).

After further elution of the column with $CHCl_3$, elution with $CHCl_3$:MeOH (19:1 and 9:1) gave fractions showing ultra-violet maxima at 230 and 315 mμ. Trituration with acetone left relatively pure β-obscurine. The analytical sample, m.p. 317–318°, was prepared by recrystallization from methanol–acetone.

(Found: C, 74·88; H, 8·74, 8·82; N, 10·13; N—Me, 5·21, 5·42. Calc. for $C_{17}H_{24}ON_2$: C, 74·96; H, 8·88; N, 10·29; N—Me, 5·48%).

100 g of crude annotinine-free alkaloid when processed in this way gave 1·3 g α-obscurine and 0·76 g β-obscurine. The acetone mother liquors from the crystallization of α-obscurine yielded alkaloid L.8 and annotoxine on further concentration.

β-Obscurine from α-obscurine. α-Obscurine (180 mg), N-bromosuccinimde (235 mg), and benzoyl peroxide (1 mg) were refluxed in CCl_4 (30 ml) under illumination by an ordinary 100 watt incandescent lamp for 1 hr. The reaction mixture was diluted with $CHCl_3$, washed with 2N NaOH, dried and evaporated to yield a light brown foam (100 mg). Chromatography over alumina (5 g) gave, on elution with CH_2Cl_2:$CHCl_3$ (1:1), unreacted α-obscurine (72 mg). Elution with $CHCl_3$MeOH (39:1) and crystallization from acetone–methanol yielded β-obscurine (20 mg) identical with an authentic sample in m.p., mixed m.p., and infra-red spectrum.

3,4,5,6,7,8-*Hexahydrocarbostyril* (I) was prepared as described by Campbell and Stevens.[10] Ultra-violet spectrum: λ_{max} 253 mμ (log ε 3·67). Infrared spectrum: $\nu_{max}^{CCl_4}$ 3420, 3220, 3170, 3100 (NH), 1695, 1675, 1660 sh (dihydropyridone).

Reaction of α-obscurine with cyanogen bromide. Preliminary experiments showed that α-obscurine does not react readily with cyanogen bromide at room temp. The highest yield of cyanamide was obtained in the following manner: α-obscurine (104 mg) and cyanogen bromide (1·2 g) were dissolved in $CHCl_3$ (5 ml). Sodium carbonate (0·07 g) was added and the mixture was refluxed for 21 hr. The solvent and the excess cyanogen bromide were removed under red press and the residue distributed between chloroform and dil HCl. The aqueous layer was separated, made basic with dil NH_4OH, and extracted with $CHCl_3$ to yield unreacted α-obscurine (50 mg).

The chloroform layer was washed with water, dried ($MgSO_4$), and evaporated to give a pale yellow glass (48 mg) which showed strong absorption at 2200 cm^{-1} in the infra-red. The combined neutral fractions (360 mg) from several reactions were chromatographed over alumina (60 g). Elution with CH_2Cl_2:MeOH (99:1) gave 240 mg of colourless viscous oil which could not be induced to crystallize. Further chromatography failed to effect a separation (as judged by inspection of the infra-red spectra of the various fractions). The material purified in this manner showed bands in the infra-red at 3420 cm^{-1} (NH), 2200 cm^{-1} (—C≡N) and 1675 cm^{-1} (dihydropyridone) and exhibited a maximum in the ultra-violet at 255 mμ. A portion was distilled for analysis.

(Found: C, 69·15; H, 8·16; N, 13·09; Br. 2·96. $C_{17}H_{23}ON_3$ requires: C, 71·55; H, 8·12; N, 14·72. $C_{17}H_{26}ON_3Br$ requires: C, 56·84; H, 6·89; N, 11·05; Br, 21·01%). The found values agree reasonably well with a 17:3 mixture of the above compounds).

De-N-*methyl*-N-*nitroso*-α-*obscurine* (VIId). A solution of α-obscurine (204 mg) in 25% aq acetic acid (8 ml) was combined with 60% aq sodium nitrite (2 ml) and the resulting solution kept at room temp for 19 hr. Dil hydrochloric acid was then added and the resulting solution extracted with $CHCl_3$. The $CHCl_3$ extract was washed with dil sodium carbonate and then water, dried, and evaporated to yield 81 mg crude, crystalline, *de*-N-*methyl*-N-*nitroso*-α-*obscurine*, m.p. 260–265°, suitable for the following step. The analytical sample was prepared by recrystallization from ethyl acetate–acetone, m.p. 271–273°. Infra-red spectrum (nujol): ν_{max} 3220, 3120 (NH), 1708 sh, 1683 s, 1645 m cm^{-1}. Ultra-violet spectrum, λ_{max} 240 mμ (log ε 3·92). (Found: C, 66,61; H, 8·18; O, 11·04; N, 14·42. $C_{16}H_{23}O_2N_3$ requires C, 66·40; H, 8·01; O, 11·07; N, 14·52%).

The aqueous acid layer (above) yielded unchanged α-obscurine when worked up in the usual manner.

De-N-*methyl*-α-*obscurine* (VIIb). A solution of de-N-methyl-N-nitroso-α-obscurine (78 mg) in 2N HCl (35 ml) was refluxed for 2½ hr. The solution was diluted with water, washed with $CHCl_3$ to

remove unreacted neutral material, made alkaline with ammonium hydroxide solution, and extracted several times with $CHCl_3$. Removal of the $CHCl_3$ under red press gave 58 mg of crystalline material.

The combined crystalline material (540 mg) from several such runs was dissolved in benzene and chromatographed over alumina (15 g).

The fractions eluted with ether–dichloromethane (3:2) and dichloromethane and which displayed UV absorption at 255 mμ were combined and recrystallized from acetone to give colourless needles of de-N-methyl-α-obscurine, m.p. 266–268°. Infra-red spectrum: ν_{max} 3270, 3200 (NH), 1698 m. 1680 s, 1642 sh (dihydropyridone). Ultra-violet spectrum: λ_{max} 255 mμ ($\log \varepsilon = 3{\cdot}8$). (Found: C, 73·77, 73·35; H, 9·89, 9·67; N, 10·81. $C_{16}H_{24}ON_2$ requires: C, 73·79; H, 9·29; N, 10·76%).

The isolation of de-N-methyl-α-obscurine from *L. clavatum* L. will be reported in detail in our full paper on the minor alkaloids of this species.

De-N-methyl-β-obscurine (VIIIb). β-Obscurine (260 mg) was treated with nitrous acid in the same manner as described for α-obscurine. The crystalline neutral product (78 mg, infra-red bands at 3120, 1679, 1612, 1555 cm ^{1}, ultra-violet maxima at 230 and 315 mμ) was not further purified but was hydrolysed to give *de-N-methyl-β-obscurine* (52 mg) as colourless needles, m.p. 315°, from methanol–acetone. Infra-red spectrum (nujol): λ_{max} 3330 (NH), 1670, 1627, 1558 cm^{-1} (pyridone). Ultra-violet maxima at 230 and 315 mμ. (Found: C, 74·21, 74·30; H, 8·91, 8·54; N, 11·06%. $C_{16}H_{22}ON_2$ requires: C, 74·37; H, 8·58; N, 10·84%).

α-Obscurine from de-N-methyl-α-obscurine. De-N-methyl-α-obscurine (30 mg) was refluxed for 4 hr with 98% formic acid (0·25 ml) and 40% formaldehyde (0·25 ml). Dilution with water, basification (ammonium hydroxide) and extraction with $CHCl_3$ yielded α-obscurine (29 mg), identical in m.p. mixed m.p., and infra-red spectrum, with an authentic sample.

Keto-lactam XI. De-N-methyl-α-obscurine (149 mg) was refluxed in conc HCl (150 ml) until the 255 mμ chromophore had disappeared (108 hr). The cooled reaction solution was washed thoroughly with $CHCl_3$ and evaporated under red press to yield a light brown foam whose infra-red spectrum exhibited broad bands in the 2300–3500 cm^{-1} and 1580–1700 cm^{-1} regions.

This material was dissolved in pyridine (100 ml), N,N′-dicyclohexylcarbodiimide (150 mg) added, and the resulting solution refluxed under nitrogen for 4 hr, then allowed to stand at room temp for 18 hr. Removal of the solvent under red press yielded an oily residue which was distributed between $CHCl_3$ and dil HCl. The chloroform layer was evaporated to yield a semi-solid residue which was triturated with CH_2Cl_2. The insoluble portion consisted of N,N′-dicyclohexylurea. The soluble portion was chromatographed over alumina (10 g). Elution with benzene, ether, and CH_2Cl_2 gave further dicyclohexylurea, but elution with $CHCl_3$ yielded an oily fraction (63 mg) which crystalized after distillation (160°–165°/0·5 mm). The solid material was rechromatographed over neutral alumina (3 g, activity I). Elution with CH_2Cl_2 and CH_2Cl_2–$CHCl_3$ (1:1) gave 40 mg of crystalline material which was recrystallized from ether–Skellysolve B to give the *keto-lactum* XI, m.p. 177–180°. The infra-red spectrum (nujol), which showed carbonyl absorption at 1700 and 1626 cm^{-1}, was virtually identical with the infra-red spectrum of the keto-lactam XI prepared from lycopodine. (Found: C, 74·00; H, 8·64; O, 12·01. $C_{16}H_{23}O_2N$ requires: C, 73·52, H, 8·87; O, 12·24%).

Dihydrolycopodine. Keto-lactam XI (28 mg) was dissolved in diglyme (25 ml) containing a large excess of $LiAlH_4$ (200 mg). The reaction mixture was maintained at 85–92° for 4 hr, then the excess $LiAlH_4$ was destroyed by careful addition of wet ethyl acetate. Water and dil HCl were added and the solution was washed with ether, then made basic with ammonium hydroxide and throughly extracted with $CHCl_3$. The dried extract was evaporated under red press to yield a crystalline residue (15 mg) which on recrystallization from ether afforded stout needles m.p. 166–169°, $[\alpha]_D^{25}$ −33° (*c*, 0·56 in ethanol) identical in all respects (infra-red spectrum, mixed m.p., optical rotation) to an authentic sample of dihydrolycopodine.

Formation of the perchlorate in methanol and recrystallization from methanol–ether provided colourless needles, m.p. 219–222°. The infra-red spectrum of the perchlorate in nujol was superimposable upon that of an authentic sample of dihydrolycopodine perchlorate and the mixed m.p. was undepressed.

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