in the neutral hydrocarbon, are observed at τ 12.50–13.96, a shift upfield of about 12 ppm. The signals for the other protons of the interior alkyl groups appear at intermediate field with the protons at the β carbon exhibiting a signal in the range of τ −2.59 to −0.70, and the protons of the γ methyl at τ 4.49. The integrated areas for each of the signals are in accord with these assignments.[8]

Table I

R	Chemical shifts, τ: Protons of the interior alkyl groups α	β	γ	Exterior protons
	Neutral Hydrocarbons (I)[a]			
$\overset{\alpha}{C}H_3$	14.25			1.33–2.05
$\overset{\alpha}{C}H_2\overset{\beta}{C}H_3$	13.96	11.86		1.33–2.05
$\overset{\alpha}{C}H_2\overset{\beta}{C}H_2\overset{\gamma}{C}H_3$	13.95	11.87	10.65	1.33–2.05
	Dianions (III)[b]			
$\overset{\alpha}{C}H_3$	−11.00			13.19–13.96
$\overset{\alpha}{C}H_2\overset{\beta}{C}H_3$	−11.15	−0.70		12.50–13.14
$\overset{\alpha}{C}H_2\overset{\beta}{C}H_2\overset{\gamma}{C}H_3$	−11.24	−2.59	+4.49	12.56–13.14

[a] The synthesis of 15,16-dimethyldihydropyrene has been reported by V. Boekelheide and J. B. Phillips (*J. Amer. Chem. Soc.*, **89**, 1965 (1967)), and that of 15,16-diethyldihydropyrene by V. Boekelheide and T. Miyasaka (*ibid.*, **89**, 1709 (1967)). The preparation of 15,16-di-*n*-propyldihydropyrene was accomplished by Thomas Hylton and will be reported shortly. [b] The dianions were produced using the potassium mirror technique with perdeuteriotetrahydrofuran as solvent. Spectra were recorded at −65° with a Varian HA-100 using HR mode, sweeping through the center band with minimized side bands. For calibration a 400.0-Hz side band was applied and values for the tetrahydrofuran signals relative to tetramethylsilane were assumed. The separation between the tetrahydrofuran signals is in agreement with accepted values. The chemical shift values for the dianions are the average of several spectra whose divergence for any signal was never more than 0.1 ppm.

To our knowledge the signal at τ −11 for the interior α-methylene protons of these dianions is the lowest downfield value yet recorded for hydrogen bonded to carbon. From the theories proposed,[2-4] it is clear that the magnitude of the paramagnetic ring current effect is dependent on rather different considerations than diamagnetic ring current effects. The paramagnetic ring current effect should be particularly sensitive to the energy difference between the lowest singlet and triplet states for the compound.[2] Presumably, this energy difference is smaller in the case of the rigid dihydropyrene dianion than for the floppy isoelectronic [16]annulene, and so it is reasonable that the paramagnetic ring current effect is much larger for the dihydropyrene dianion. Aside from rigidity, other factors such as peripheral substitution should play a role in the magnitude of the paramagnetic ring current effect, and experiments designed to test whether or not there are such correlations are under way.

(8) The downfield signals in Figure 1 are broad and not sufficiently resolved to allow an interpretation of the coupling pattern. The condensation necessary to present these spectra in a reasonable space is a contributing factor. However, the lack of resolution is apparently more fundamental. One probable explanation is the presence of low concentrations of the radical anion in equilibrium with the dianion, thus leading to broadening of the signals by electron exchange.

(9) We thank the National Science Foundation for their support of this investigation.

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Mechanisms of Indole Alkaloid Biosynthesis. The *Corynanthe–Strychnos* Relationship

Sir:

As a result of our previous study[1] of the sequential appearance of various alkaloidal types in germinating *Vinca rosea*, strong circumstantial evidence was adduced for the order *Corynanthe* → *Aspidosperma* → *Iboga* and experimental proof was provided by the incorporation of multiply labeled stemmadenine (VI) and of [Ar-^{3}H]corynantheine aldehyde (IIa) into the appropriate *Aspidosperma* and *Iboga* representatives. Further definition of the important role of the *Corynanthe* system as a progenitor of both *Strychnos* and *Iboga* types is now provided by two methods.

In the first of these, a more detailed examination of the alkaloidal fractions of *V. rosea* seedlings has uncovered several alkaloids hitherto undescribed in this species. The latest sequence is shown in Table I. Of particular interest are the new isolates geissoschizine (III), which has previously been described as a degradation product of geissospermine,[2] and preakuammicine[3] (IV). The circumstantial evidence for the parallel of sequence and intermediacy depicted in Chart I is compelling, the precursor activity of I, IIa, VI, and VII for the "later" alkaloids having already been demonstrated.[1,4]

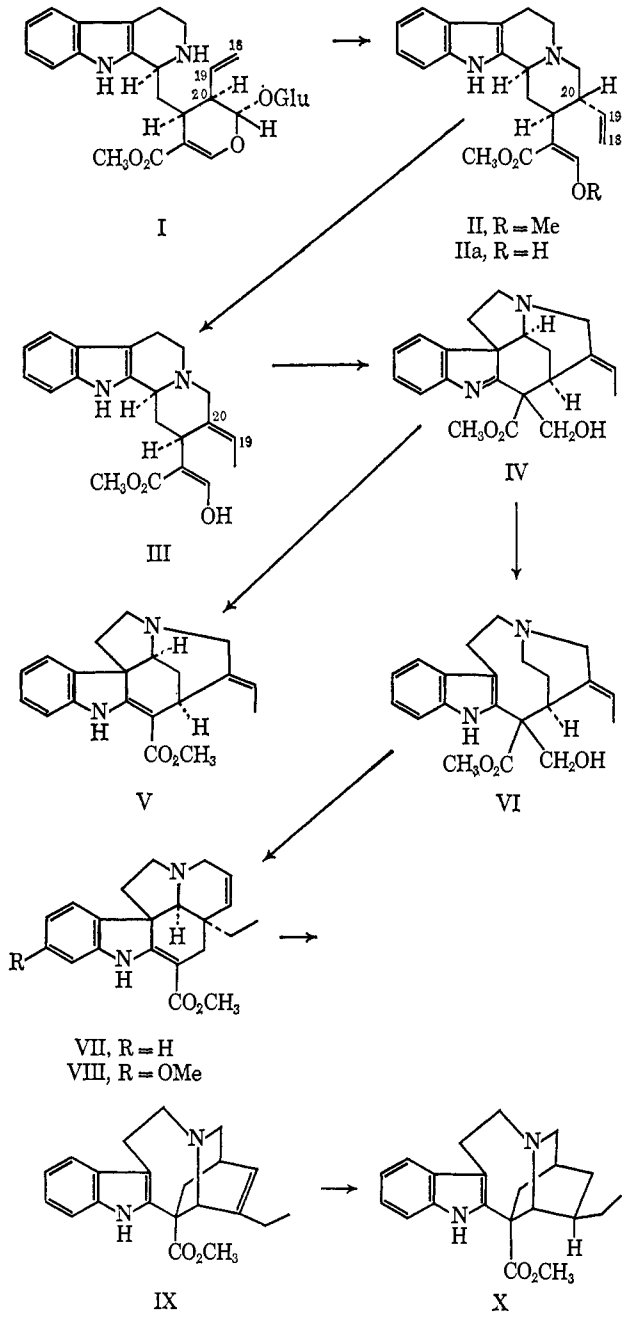
Table I. Isolation of Alkaloids from *V. rosea* Seedlings

Germination time, hr	Alkaloid isolated[a]	Type
0	None	
26	Vincoside (I)	"Corynanthe"
	Corynantheine (II)	Corynanthe
28–40	Corynantheine aldehyde (IIa)	
	Geissoschizine (III)	
	"Preakuammicine" (IV)[a,b]	"*Corynanthe–Strychnos*"
42–48	Akuammicine (V)	*Strychnos*
50	Stemmadenine (VI)	"*Corynanthe–Strychnos*"
72	Tabersonine (VII)	*Aspidosperma*
	11-Methoxytabersonine (VIII)	
100–160	Catharanthine (IX)	*Iboga*
	Coronaridine (X)	

[a] Identified by comparison with authentic samples. We thank Professors J. Le Men, R. Goutarel, and A. R. Battersby and Drs. G. F. Smith and D. Stauffacher for gifts of alkaloids. [b] A. I. Scott and A. A. Qureshi, submitted for publication.

(1) A. A. Qureshi and A. I. Scott, *Chem. Commun.*, 945, 947, 948 (1968).
(2) M. M. Janot, *Tetrahedron*, 14, 113 (1961), and references cited therein.
(3) See Table I, footnote *b*.
(4) A. R. Battersby, A. R. Burnett, and P. G. Parsons, *Chem. Commun.*, 1282 (1968).

Chart I. Sequential Scheme for Indole Alkaloid Biogenesis



Evidence that geissoschizine (III) is indeed implicated both in *Strychnos* and *Aspidosperma–Iboga* biosynthesis was obtained by feeding Ar-^{2}H-labeled geissoschizine containing 20% d_4 (10 mg) to *V. rosea* seedlings (100 g). The incorporations into derived alkaloids measured from the enrichment of the appropriate (M + 4) mass spectral intensities of akuammicine (V; 1.53%) and coronaridine (X; 0.35%) leave no doubt that, as predicted[1] on the basis of several models and analogies, the intact[5] *Corynanthe* alkaloids serve as intermediates for the *Strychnos* as well as the *Aspidosperma* and *Iboga* series, since tabersonine (VII) has already been shown to be the intermediate for the isomeric catharanthine (IX).

The implications of the isolation of preakuammicine (IV), the prototype of the *Strychnos* family, will be discussed in a subsequent communication.[3] We note at this time that a prerequisite of the *Corynanthe* → *Strychnos* → *Iboga* change *in vitro* is the presence of the $\Delta^{19,20}$ double bond in geissoschizine. This may be achieved at the vincoside[4,6] (I) or corynantheine aldehyde (IIa) level. Available evidence[1] indicates that at least in young seedlings of *V. rosea* the required isomerization can take place on the intact *Corynanthe* template, IIa → III. Detailed studies of the mechanisms connecting geissoschizine (III) with akuammicine (V), strychnine, and stemmadenine (VI) are in progress. The intermediacy of geissoschizine in *Strychnos*, *Aspidosperma*, and *Iboga* biosynthesis has been independently demonstrated by Battersby and Hall.[6]

Acknowledgment. This work was generously supported by National Institutes of Health Grant CA-11095.

(5) An alternative hypothesis[4] involving formation of IV from I without passing through *Corynanthe* intermediates is rendered less likely by these experiments.

(6) A. R. Battersby and E. S. Hall, *Chem. Commun.*, in press. We thank Professor Battersby for exchange of manuscripts prior to publication.

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Synthesis of *dl*-Sirenin

Sir:

The structure of sirenin, the chemotactic hormone produced by female *Allomyces* gametes, has been recently established.[1] We now describe the synthesis of *dl*-sirenin.

Triphenylphosphine and 5-bromovaleric acid, heated 12 hr at 80°, gave the phosphonium salt **1**, mp 205–206°. The salt **1** and 6-methyl-5-hepten-2-one (**2**),[2] dissolved in dimethyl sulfoxide–tetrahydrofuran (1:1), were added to excess sodium hydride in tetrahydrofuran at 0°. After 24 hr the C_{13}-diene acid **3**,[3] bp 147–153° (0.2 mm), containing 13 of the 15 carbon atoms of sirenin, was isolated (75% yield) as a mixture of *cis* and *trans* isomers (*ca.* 1:1, by glpc of the methyl esters prepared using dimethyl sulfate).[4] The corresponding phosphonium salt of the valeric ester cannot be used in the Wittig reaction due to cyclization of the intermediate ylide;[5] however, protection of the carboxyl function as the carboxylate ion allows formation of olefin in the normal manner with retention of carboxyl functionality in the product.

The sodium salt of the mixture of isomers of 6,10-dimethyl-5,9-undecadienoic acid (**3**) was converted to acid chloride (oxalyl chloride in benzene) to which excess ethereal diazomethane was added. Heating the diazo ketone thus formed in refluxing cyclohexane in the presence of cupric sulfate led to cyclization[6] and

(1) W. H. Nutting, H. Rapoport, and L. Machlis, *J. Am. Chem. Soc.*, **90**, 6434 (1968).
(2) Commercially available.
(3) Satisfactory elemental analyses and confirmatory mass spectral data were obtained for all new compounds. Structures assigned are consistent with ir and nmr spectra, the latter being obtained in carbon tetrachloride or deuteriochloroform with internal TMS. Temperatures reported as boiling points are bath temperatures.
(4) F. H. Stodola, *J. Org. Chem.*, **29**, 2490 (1964).
(5) L. D. Bergelson and M. M. Shemyakin, *Angew. Chem.*, **76**, 113 (1964).
(6) Analogous cyclizations of diazo ketones have been reported by, among others, G. Stork and J. Ficini, *J. Am. Chem. Soc.*, **83**, 4678 (1961), and M. M. Fawzi and C. D. Gutsche, *J. Org. Chem.*, **31**, 1390 (1966).