Chemistry of 6*H*-Pyrido[4,3-*b*]carbazoles. Part 13.[1] Syntheses of Ring-A- and Ring-D-substituted Ellipticines

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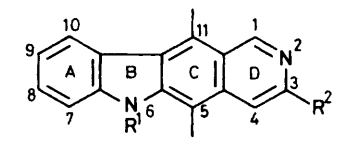
The synthesis of 3-hydroxymethyl-5,11-dimethyl-6*H*-pyrido[4,3-*b*]carbazole is described, and uses a modified Cranwell–Saxton approach to ellipticines. The rearrangement of 9-allyl-6-methoxy-1,4-dimethylcarbazole to the 8-allyl isomer has been employed as the first step in a related synthesis of 7-(3-diethylaminopropyl)-9-methoxy-5,11-dimethyl-6*H*-pyrido[4,3-*b*]carbazole. Routes to potential starting materials for the syntheses of 1-, 8-, and 10-substituted ellipticines have also been investigated.

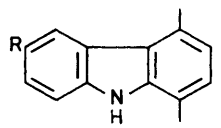
3-Substituted ellipticines are rare and only 3,5,11-methyl-6*H*-pyrido[4,3-*b*]carbazole (**1**) and its derivative (**2**) have been synthesized[2] as potential anti-cancer drugs. Our computer projections reveal, however, that substitution at this site does not restrict the intercalation of the tetracyclic unit between the base pairs of DNA,[3] thus C-3 may be a good anchorage point to attach side-chains bearing solubilising groups or functions which would permit coupling between two 'monomeric' ellipticines and hence the synthesis of potential bis-intercalating DNA agents. The modified Cranwell–Saxton approach to pyrido[4,3-*b*]carbazoles[4] seems ideally suited to the synthesis of 3-substituted ellipticines since rings A, B, and C of the tetracycle are already provided by readily available 1,4-dimethylcarbazoles (**3**) which undergo regioselective Vilsmeier formylation at C-3.[4] From the product aldehydes (**4**) the pyridine ring D may be formed by the implementation of a Pomeranz–Fritsch-type reaction sequence (**5**)—(**9**), in which cyclisation of the sulphonamides (**7**) to the dihydroellipticines (**8**) is accompanied by the elimination of toluene-4-sulphinic acid, thus affording the fully aromatic tetracycles (**9**) as the final products.

Our initial target was the 3-carboxylate ester (**9**; R^1 = OMe, R^2 = CO_2Me) and in order to prepare its precursor, the imine (**5**; R^1 = OMe, R^2 = CO_2Me), we treated the aldehyde (**4**; R = OMe) with methyl 2-amino-3,3,dimethoxypropionate. The product imine proved to be unstable and was reduced immediately to the corresponding amine (**6**; R^1 = OMe, R^2 = CO_2Me) by reaction with sodium borohydride. The overall yield for the two-step conversion was only 53%, and the amine was accompanied by 16% of the α,β-unsaturated amino ester (**10**). Significantly, the same by-product was formed when the reduction was performed using sodium cyanoborohydride in an acidic medium and we recognised that the elimination of methanol from the side-chain might prove to be a problem in the acid-catalysed cyclisation of the *N*-tosyl derivative (**7**; R^1 = OMe, R^2 = CO_2Me). Indeed this was the case and all attempts to effect the penultimate step of the synthesis failed.

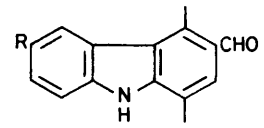
In some preliminary studies we treated the aldehyde (**4**; R = OMe) with *O*-benzylserine, hoping to obtain, after reduction of the intermediate imine (**11**), the amine (**13**; R^1 = H, R^2 = CO_2H). In practice, however, this product was not formed and the amine (**13**; R^1 = R^2 = H) was isolated instead. Since a repetition of the two-step reaction now with the methyl



(**1**) R^1 = H, R^2 = Me
(**2**) R^1 = R^2 = Me



(**3**)



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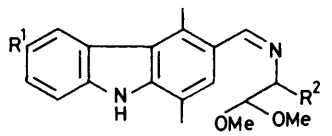
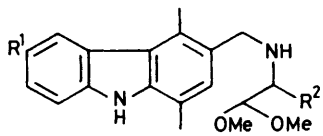
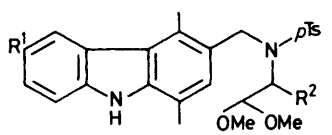


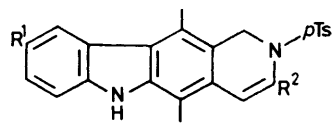
(**5**)



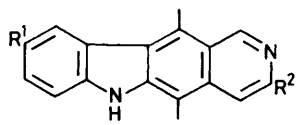
(**6**)



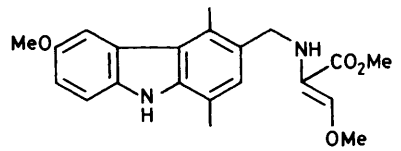
(**7**)



(**8**)

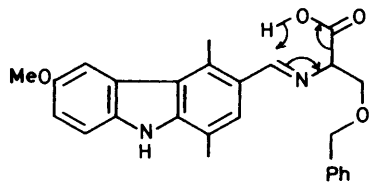


(**9**)



(**10**)

pTs = $S(O)_2$–C$_6$H$_4$–Me



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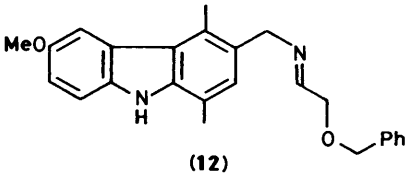

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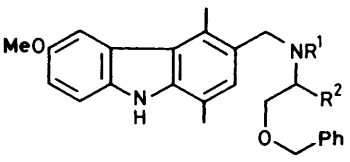

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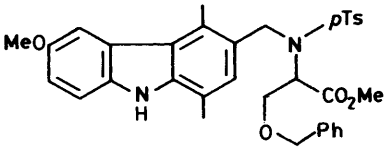

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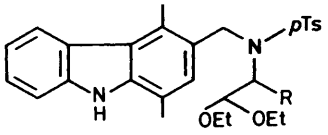

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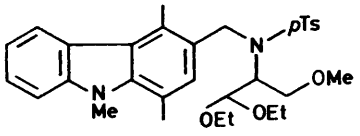

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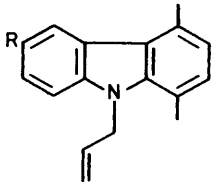

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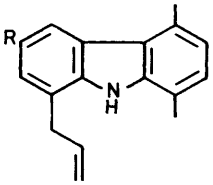

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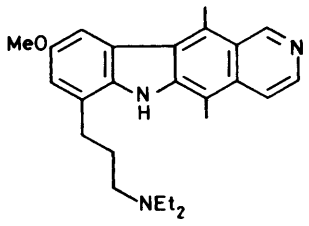

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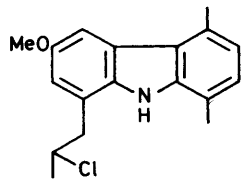

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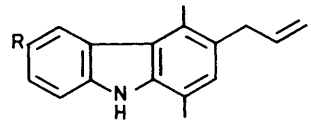

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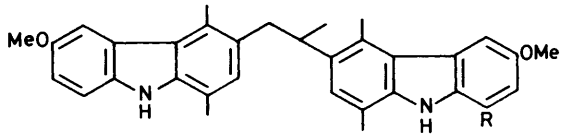
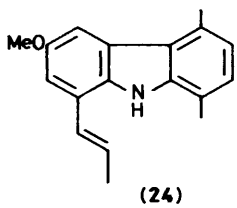


(22) R =

(23) R =



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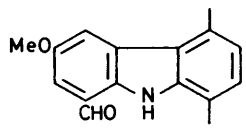

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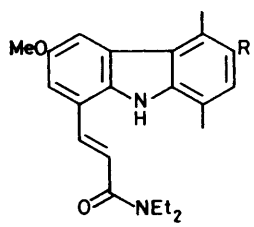

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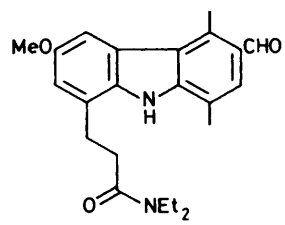

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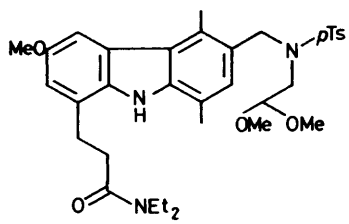

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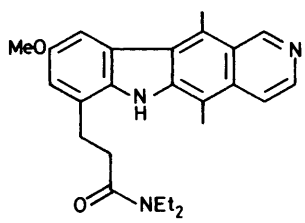


(29)

ester of *O*-benzylserine gave the appropriate amine (**13**; R^1 = H, R^2 = CO_2Me) without difficulty, we conclude that the initially formed imine undergoes isomerisation and decarboxylation probably through a six-membered transition state as shown (**11**)—(**12**). The product of decarboxylation, the imine (**12**), is then reduced to the amine (**13**; R^1 = R^2 = H) in a subsequent step. *N*-Tosylation of the amine (**13**; R^1 = H, R^2 = CO_2Me) gave the corresponding sulphonamide (**14**), but again all attempts to cyclise this compound and its *O*-debenzyl derivative by treatment with acidic reagents led to complex mixtures from which no tetracyclic product could be isolated.

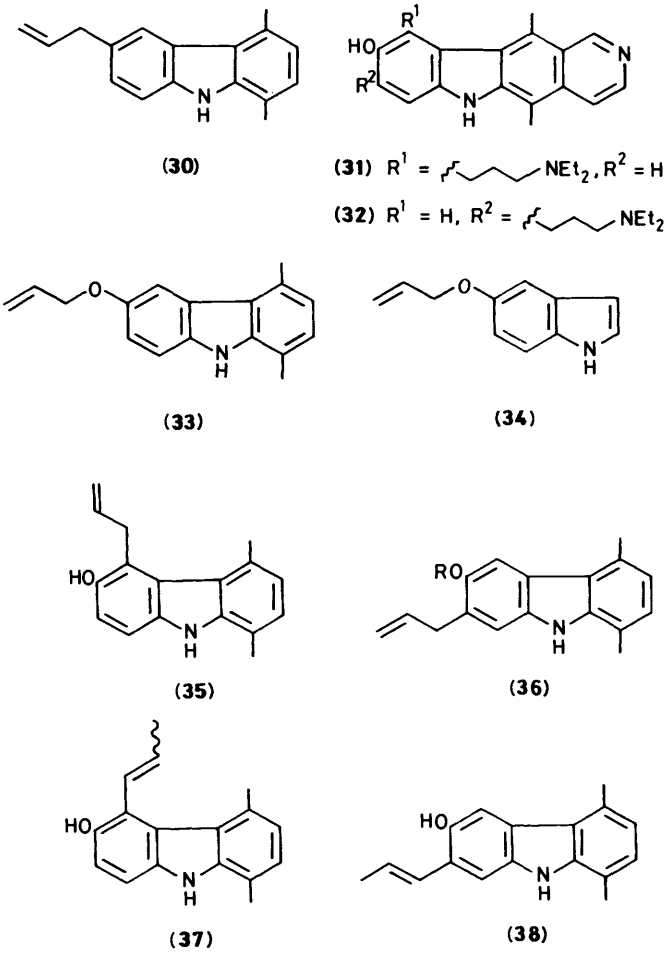
Clearly the presence of an electron-withdrawing α-substituent

to the nitrogen atom in the side-chain is undesirable and this promotes the loss of methanol rather than allowing the normal Pomaranz–Fritsch cyclisation to occur. To overcome this problem we elected to investigate the ring closure of the alcohol (**7**; R^1 = OMe, R^2 = CH_2OH). This compound is available from the reduction of the sulphonamide (**7**; R^1 = OMe, R^2 = CO_2Me) with lithium aluminium hydride, or more efficiently from the amine (**6**; R^1 = OMe, R^2 = CO_2Me) by reaction with the same reagent, followed by *N*-tosylation of the derived amino alcohol (**6**; R^1 = OMe, R^2 = CH_2OH). Reaction of the alcohol (**7**; R^1 = OMe, R^2 = CH_2OH) with 6M hydrochloric acid in boiling dioxane gave the required ellipticine (**9**; R^1 = OMe, R^2 = CH_2OH), but only in 12% yield, together with much resin. At this point our supply of methoxylated aldehyde was exhausted and further work was continued with the demethoxy compound (**4**; R = H). This through a parallel series of reactions using ethyl 2-amino-3,3-diethoxypropionate, rather than the trimethyl analogue, eventually afforded the sulphonamido alcohol (**15**; R = CH_2OH), which was converted into the *N*,*O*-dimethyl derivative (**16**) by treatment with iodomethane and sodium hydroxide. Neither it nor the alcohol (**15**; R = CH_2OH) cyclised to the corresponding ellipticines when they were treated with acid, and again we consider that degradation of the side-chains successfully competes with ring closure to the required tetracycles.

This result was disappointing although we expected the ring-closure reactions to be somewhat less easy in this series, which lacks the activational influence of the methoxy group in ring A. We now turned to the syntheses of ellipticines functionalised at C-7 or at C-8, sites where our analyses[3] also predict that substitution does not inhibit DNA docking and intercalation. Compounds bearing suitable groups at C-7 were targetted first, thus 6-methoxy-1,4-dimethylcarbazole (**3**; R = OMe) was treated with sodium hydride and allyl bromide to give the *N*-allyl derivative (**17**; R = OMe). We hoped that an aza-Cope rearrangement of this compound would afford the 8-allylcarbazole (**18**; R = OMe) which could be transformed into 7-(3-diethylaminopropyl)-9-methoxyellipticine (**19**) where the substituent is both a pharmacophore and a solubilising group.

Treatment of the *N*-allylcarbazole in dichloromethane at −35 °C, with aluminium trichloride, followed by a period of some hours when the reaction mixture was stirred at room temperature, gave a three-component mixture of the desired carbazole (**18**; R = OMe), its hydrogen chloride adduct (**20**), and the isomeric 3-allylcarbazole (**21**; R = OMe). If the addition and the subsequent reaction are carried out entirely at 18—20 °C two additional products, the dimeric compounds (**22**) and (**23**), are obtained, and in some cases these were the only products isolated. It is noteworthy that the products of the last type were not isolated when the 'low-temperature' reaction was repeated with the demethoxyallylcarbazole (**17**; R = H), and in this case the only products isolated were the isomeric *C*-allyl carbazoles (**18**; R = H) and (**21**; R = H).

The chloro compound (**20**) was readily dehydrochlorinated to the allylcarbazole (**18**; R = OMe) by treatment with sodium hydride, and this product was then isomerised to the conjugated isomer (**24**) by the action of bis(acetonitrile)palladium(II) chloride. The alkenylcarbazole (**24**) so obtained was treated with ozone to afford the aldehyde (**25**), and this was combined with diethylphosphono-*N*,*N*-diethylacetamide to yield the unsaturated amide (**26**; R = H). This product was formylated at C-3, using trifluoroacetic anhydride (TFAA) and imidazole, and the aldehyde (**26**; R = CHO) so obtained was hydrogenated in the presence of palladium–carbon catalyst to yield the saturated amide (**27**), and converted by several further steps into the sulphonamide (**28**). This compound was then treated with hydrochloric acid to afford the pyrido[4,3-*b*]carbazole (**29**),

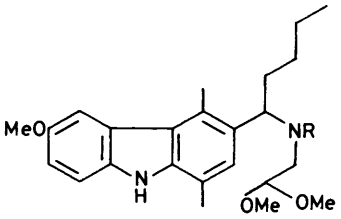


which was reduced to the corresponding amino derivative (**19**) by reaction with diborane–dimethyl sulphide.

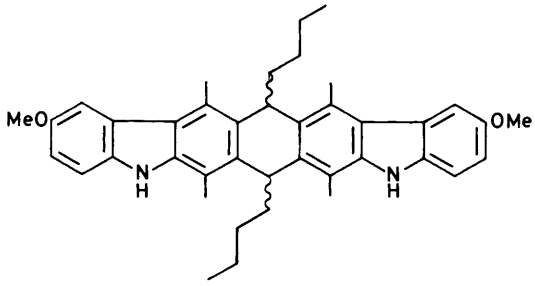
Interestingly, when *N*-allyl-1,4-dimethylcarbazole (**17**; R = H) is heated with aluminium chloride the products are the isomeric 3- and 6-allyl carbazoles (**21**; R = H) and (**30**) respectively, but if a mixture of 6-methoxy-1,4-dimethylcarbazole (**3**; R = OMe) and *N*-allyl-1,4-dimethylcarbazole (**17**; R = H) is treated in the presence of 2 mol equiv. of aluminium trichloride no crossover of the allyl group is observed, and only the isomeric demethoxy *C*-allyl carbazoles (**21**; R = H) and (**30**) are detected and isolated. This result suggests that the rearrangement processes involved in the formation of these products proceeds by two consecutive intramolecular 3,3-sigmatropic shifts and not by intermolecular Friedel–Crafts-type reactions.

Thus far we have not completed the syntheses of the analogous 8- and 10-substituted ellipticines (**31**) and (**32**), although we observe that a Claisen rearrangement of the allyl ether (**33**), synthesized from 5-allyloxyindole (**34**), gives the appropriate starting materials: the allylcarbazoles (**35**) and (**36**) (R = H) respectively. These compounds are easily separated, and individually can be converted into the corresponding conjugated isomers (**37**) and (**38**) (as *E*- and *Z*-forms) by treatment with bis(acetonitrile)palladium(II) chloride.

Finally we supposed that access to 1-substituted ellipticines would be possible through treatment of the iminocarbazoles (**5**) with lithium alkyls and alkenyls, followed by implementation of the usual ring-D-forming sequence. Certainly the addition of lithium alkyls to the imine (**5**; R = OMe) works well and, for example, we were able to obtain the butyl compound (**39**) in



(39) R = H
(40) R = *p*Ts



(41)

good yield by treating the imine with butyl-lithium. *N*-Sulphonylation of this product gave the sulphonamide (**40**), but an attempted cyclisation of the sulphonamide with hydrochloric acid in dioxane gave only the dicarbazole derivative (**41**), as a mixture of diastereoisomers.

It seems likely that steric hindrance to ring closure by interaction with the C-4 methyl on the carbazole nucleus is responsible for this anomalous result, for cyclisations of this type are known to occur satisfactorily in the olivacine series where this group is absent.[5] It is noteworthy, however, that other workers have synthesized 1-substituted ellipticines,[6,7] but by modification of the intact tetracyclic system.

Research into alternative ways to prepare 1-substituted ellipticines was set aside when the results of our computer analyses showed that such compounds would not easily be accommodated within the base-pair cavities of DNA.[3]

Experimental

U.v. spectra were recorded for solutions in 95% ethanol. ^{1}H N.m.r. spectra were obtained at 270 MHz and ^{13}C n.m.r. spectra at 67.8 MHz, both with tetramethylsilane as internal standard. N.m.r. locants refer to the ring protons. Solvents were removed under reduced pressure using a rotary evaporator and a water-pump. Light petroleum refers to that fraction boiling over the range 60—80 °C. Tetrahydrofuran (THF) was dried by distillation from sodium, and dimethyl sulphoxide (DMSO) was dried by treatment with 4 Å molecular sieves. The usual drying agent for organic solvent extracts was anhydrous sodium sulphate. Silica gel of various grades was normally employed for column chromatography and Kieselgel 60 F_{254} plates were used for t.l.c. analyses.

Methyl 3,3-*Dimethoxy*-2-[(6-*methoxy*-1,4-*dimethylcarbazol*-3-*yl*)*methylamino*]*propionate* (**6**; R^1 = OMe; R^2 = CO_2Me) *and Methyl* 3-*Methoxy*-2-[(6-*methoxy*-1,4-*dimethylcarbazol*-3-*yl*)*methylamino*]*acrylate* (**10**).—A stirred suspension of 6-methoxy-1,4-dimethylcarbazole-3-carbaldehyde (**4**; R = OMe) (3.1 g, 12 mmol) and methyl 2-amino-3,3-dimethoxypropionate (2 g, 12 mmol) in toluene (40 cm^3) was heated at reflux overnight in a Dean–Stark apparatus. The resulting orange solution was cooled to room temperature whereupon the corresponding imine (**5**; R^1 = OMe, R^2 = CO_2Me) crystallised as an off-white solid (3.55 g, 73%); $\nu_{max.}$(Nujol) 3 320, 1 740, and 1 630 cm^{-1}; δ_H($CDCl_3$) 8.79 (1 H, s, CH=N), 8.3 (1 H, br s, NH), 7.9 (1 H, s, 2-H), 7.67 (1 H, d, *J* 2 Hz, 5-H), 7.39 (1 H, d, *J* 9 Hz, 8-H), 7.09 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.98 [1 H, d, *J* 7 Hz, $(MeO)_2CH$], 4.24 (1 H, d, *J* 7 Hz, $HCCO_2Me$), 3.95 and 3.83 (6 H, CO_2Me and 6-OMe), and 3.5 (6 H, s, 2 × OMe).

Sodium borohydride (0.3 g, 8.1 mmol) was added to a stirred suspension of the imine (3.5 g, 8.8 mmol) in methanol (40 cm^3), and the mixture was then stirred at room temperature for 30 min. The resulting orange solution was evaporated to dryness, treated with 2M hydrochloric acid (20 cm^3), neutralised with sodium hydrogen carbonate, and extracted with ethyl acetate (3 × 20 cm^3). The dried extracts were evaporated, and separated by flash chromatography (ethyl acetate–hexane–triethylamine, 25:25:1) to give two products, both of which were obtained as off-white foams. Early fractions contained the *enamine* (**10**) (0.57 g, 16.3%); δ_H($CDCl_3$) 7.86 (1 H, br s, NH), 7.74 (1 H, d, *J* 2 Hz, 5-H), 7.34 (1 H, d, *J* 9 Hz, 8-H), 7.16 (1 H, s, 2-H), 7.05 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 6.80 (1 H, s, C=C*H*OMe), 4.32 (2 H, s, ArCH_2NH), 3.94, 3.81, and 3.72 (3 × 3 H, 3 s, ArO*Me* and *Me*OCH=CCO_2Me), 2.88 (3 H, s, 1-Me), and 2.46 (3 H, s, 4-Me) (Found: M^+, 368.1740. $C_{21}H_{24}N_2O_4$ requires *M*, 368.1736). Later fractions from the column afforded the *acetal* (**6**; R^1 = OMe, R^2 = CO_2Me) as an oil (2.6 g, 73%); δ_H($CDCl_3$) 8.1 (1 H, br s, NH), 7.73 (1 H, d, *J* 2 Hz, 5-H), 7.35 (1 H, d, *J* 9 Hz, 8-H), 7.16 (1 H, s, 2-H), 7.05 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.52 [1 H, d, *J* 7 Hz, $(MeO)_2CH$], 3.95 and 3.83 [14 H, 2 s, ArO*Me*, $(MeO)_2CH$, CO_2Me, and ArCH_2NH], 3.58 (1 H, d, *J* 7 Hz, $CHCO_2Me$), and 2.79 and 2.46 (2 × 3 H, s, 2 × Ar*Me*) (Found: M^+, 400.1992. $C_{22}H_{28}N_2O_5$ requires *M*, 400.1998).

Methyl 3,3-*Dimethoxy*-2-{[N-(6-*methoxy*-1,4-*dimethylcarbazol*-3-*yl*)*methyl*]-N-(4-*tosyl*)*amino*}*propionate* (**7**; R^1 = OMe; R^2 = CO_2Me) (**14**).—Toluene-4-sulphonyl chloride (1.9 g, 0.01 mol) was added to a solution of the amino acetal from the above experiment (2.57 g, 6.4 mmol) and sodium carbonate (1.0 g) in THF (40 cm^3) and water (80 cm^3). The solution was stirred at room temperature, and more toluene-4-sulphonyl chloride (1.9 g) and sodium carbonate (1.0 g) were added after 15 h, and again after 23 h. The mixture was stirred for a further 17 h. 0.2M Aqueous sodium hydroxide (180 cm^3) was added, and the mixture was left for 20 min, then extracted with ethyl acetate (3 × 100 cm^3). The combined extracts were washed successively with 8% aqueous sodium hydrogen carbonate (2 × 100 cm^3) and brine (2 × 50 cm^3), dried, and evaporated to afford a yellow oil. Flash chromatography (ethyl acetate–hexane, 2:3) gave the *required product* as a viscous yellow oil (1.08 g, 30%) (82% based on recovered starting material), and starting material (1.6 g). The product had δ_H($CDCl_3$) * 7.88 (1 H, br s, NH), 7.7 (3 H, m, 5-, 2′-, and 6′-H), 7.37 (1 H, d, *J* 9 Hz, 8-H), 7.23 (2 H, d, *J* 8 Hz, 3′- and 5′-H), 7.19 (1 H, s, 2-H), 7.06 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.77 (2 H, s, CH_2N), 4.62 and 4.46 (2 H, m, CHCH), 3.93, 3.65, 3.30, and 3.16 [4 × 3 H, 4 s, Ar*OMe*, CO_2Me, and $CH(OMe)_2$], 2.76 (3 H, s, $SO_2C_6H_4Me$), and 2.43 and 2.34 (2 × 3 H, 2 s, 2 × Ar*Me*) (Found: C, 62.6; H, 5.9; N, 4.8. $C_{29}H_{34}N_2O_7S$ requires C, 62.8; H, 6.2; N, 5.05%).

3-[N-(2-*Benzyloxyethyl*)-N-(4-*tosyl*)*aminomethyl*]-6-*methoxy*-1,4-*dimethylcarbazole* (**13**; R^1 = *p*-Ts, R^2 = H).—A mixture of 6-methoxy-1,4-dimethylcarbazole-3-carbaldehyde (**4**; R = OMe) (0.12 g), *O*-benzylserine (0.10 g), and toluene (1.5 cm^3) was heated under reflux for 24 h. Evaporation of the solvent under reduced pressure afforded an orange oil, which was dissolved in methanol (4 cm^3) and treated with sodium

* Primed locants refer to the tosyl substituent.

borohydride (0.02 g) at room temperature for 30 min. The solvent was evaporated off under reduced pressure, and the residue was dissolved in ethyl acetate (15 cm^3), washed successively with 2M hydrochloric acid (5 cm^3) and brine (10 cm^3), dried, and evaporated to afford a brown foam (0.13 g). This was dissolved in a mixture of THF and water (2 × 4 cm^3) containing sodium carbonate (0.15 g). Toluene-4-sulphonyl-chloride (0.10 g) was added, and the mixture was stirred at room temperature for 3 h, then diluted with water (25 cm^3), and extracted with ethyl acetate (3 × 15 cm^3). The combined, dried extracts were evaporated, and the residue was purified by flash column chromatography (ethyl acetate–hexane, 3:7) to afford first a mixture of the title compound and starting material 0.06 g), and then the pure *product* (as a solid) (0.04 g, 17%); $\delta_H(CDCl_3)$ 7.88 (1 H, br s, NH), 7.78 (2 H, d, *J* 8 Hz, AA′BB′, ½ × $SO_2C_6H_4Me$), 7.72 (1 H, d, *J* 2 Hz, 5-H), 7.41 (1 H, d, *J* 9 Hz, 8-H), 7.30 (2 H, d, *J* 8 Hz, ½ × $SO_2C_6H_4Me$), 7.2—7.0 (7 H, m, other aromatic protons), 4.35 (2 H, s, OCH_2Ph), 4.16 (2 H, s, $ArCH_2N$), 3.91 (3 H, s, OMe), 3.23 (4 H, s, NCH_2CH_2O), 2.79 (3 H, s, Ar*Me*), and 2.44 and 2.41 (6 H, 2 s, 2 × Ar*Me*) (Found: C, 71.0; H, 6.1; N, 5.0. $C_{32}H_{34}N_2O_4S$ requires C, 70.8; H, 6.3; N, 5.2%).

Methyl 3-Benzyloxy-2-[(6-methoxy-1,4-dimethylcarbazol-3-yl)methylamino]propionate (**13**; R^1 = H, R^2 = CO_2Me).—A stirred solution of 6-methoxy-1,4-dimethylcarbazole-3-carbaldehyde (**4**; R = OMe) (0.17 g) and the methyl ester of *O*-benzylserine (0.14 g) in toluene (10 cm^3) was heated under reflux overnight. The solvent was evaporated off under reduced pressure to afford a partially solid yellow oil, which was dissolved in ethyl acetate (15 cm^3); the solution was filtered to remove the precipitated solid, and the filtrate was evaporated under reduced pressure to afford a viscous yellow oil (0.24 g), which was used in the next stage without further purification or characterisation.

This product was dissolved in methanol (10 cm^3) and the solution was treated with sodium borohydride (0.05 g), stirred at room temperature for 10 min, then evaporated under reduced pressure. The residue was treated with 2M hydrochloric acid (10 cm^3), then made basic with 2M aqueous sodium carbonate, and extracted with ethyl acetate (3 × 10 cm^3). The combined, dried extracts were evaporated to give a yellow oil. Flash chromatography (ethyl acetate–hexane, 1:1) gave the *title compound* as a viscous yellow oil (0.1 g, 35%); $\nu_{max.}(CHCl_3)$ 3 360, 2 830, and 1 745 cm^{-1}; $\delta_H(CDCl_3)$ 7.88 (1 H, br s, NH), 7.69 (1 H, d, *J* 2 Hz, 5-H), 7.36—7.16 (6 H, m, Ph and 8-H), 7.1 (1 H, s, 2-H), 7.02 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.47 (2 H, s, OCH_2Ph), 4.06—3.54 (11 H, m, ArO*Me*, CO_2Me, $ArCH_2NH$, and $CHCH_2$), 2.81 (3 H, s, 1-Me), and 2.42 (3 H, s, 4-Me) (Found: M^+, 446.2198. $C_{27}H_{30}N_2O_4$ requires *M*, 446.2205).

3-{N-[2,2-*Dimethoxy*-1-(*hydroxymethyl*)*ethyl*]-N-(4-*tosyl*)-*aminomethyl*}-6-*methoxy*-1,4-*dimethylcarbazole* (**7**; R^1 = OMe, R^2 = CH_2OH).—(*a*) A suspension of the sulphonamide (**7**; R^1 = OMe, R^2 = CO_2Me) (0.3 g) in dry ether (25 cm^3) was added to a stirred suspension of lithium aluminium hydride (0.08 g) in dry diethyl ether (10 cm^3) at 0 °C under dry nitrogen. The mixture was stirred at 0 °C for 1 h, then allowed to warm to room temperature during 90 min. 30% Aqueous ammonium sodium tartrate (50 cm^3) was added cautiously, and the mixture was thoroughly stirred for 30 min. The phases were washed with brine (2 × 15 cm^3), and the organic layer was dried, and evaporated to afford a viscous oil (0.22 g). Column chromatography (ethyl acetate–light petroleum, 2:3) gave first unchanged starting material (0.07 g, 27% recovery), and then the *required product* as a white foam (0.15 g, 60%); $\delta_H(CDCl_3)$ 8.2 (1 H, br s, NH), 7.8–7.6 (3 H, m, 5-, 2′-, and 6′-H), 7.36 (1 H, d, *J* 9 Hz, 8-H), 7.25—7.2 (3 H, m, 2-, 3′-, and 5′-H), 7.1 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.65 (2 H, br s, $ArCH_2N$), 4.1—3.6 (7 H s and m, ArO*Me* and $CHCHCH_2$), 3.2 [6 H 2 s, $(OMe)_2$], 2.65 (3 H, s, $SO_2C_6H_4Me$), and 2.35 (6 H, br s, 2 × Ar*Me*) (Found: C, 64.1; H, 6.4; N, 5.2. $C_{28}H_{34}N_2O_6S$ requires C, 63.9; H, 6.5; N, 5.3%).

(*b*) The same product was also formed by a two-step sequence. A solution of the amino ester (**6**; R^1 = OMe, R^2 = CO_2Me) (0.4 g) in dry ether (15 cm^3) was added dropwise to a stirred suspension of lithium aluminium hydride (0.2 g) in dry diethyl ether (15 cm^3) under nitrogen. The mixture was stirred at room temperature for 5 min, then 30% aqueous ammonium sodium tartrate (50 cm^3) was added cautiously. The phases were separated, and the aqueous phase was extracted with ethyl acetate (2 × 30 cm^3). The combined, dried extracts were evaporated to afford the amino alcohol (**6**; R^1 = OMe, R^2 = CH_2OH) as a viscous oil (0.34 g, 91%) which was not characterised, and which was used directly for the next stage without purification. Toluene-4-sulphonyl chloride (0.60 g) was added to a stirred solution of the amino alcohol (0.34 g) in a mixture of THF (15 cm^3) and water (25 cm^3) containing sodium carbonate (0.34 g). The mixture was stirred at room temperature overnight, then diluted with water (80 cm^3), and extracted with ethyl acetate (3 × 40 cm^3). The combined extracts were washed with brine (2 × 40 cm^3), dried, and evaporated to afford a white foam (0.41 g, 84%), which was identical with the material prepared by the reduction of the sulphonamide (**7**; R^1 = OMe, R^2 = CH_2OH) as described in procedure (*a*) above.

(9-*Methoxy*-5,11-*dimethyl*-6H-*pyrido*[4,3-b]*carbazol*-3-*yl*)-*methanol* (**9**; R^1 = OMe, R^2 = CH_2OH).—A solution of the sulphonamide (**7**; R^1 = OMe, R^2 = CH_2OH) (0.12 g) in a mixture of 1,4-dioxane (10 cm^3) and 6M hydrochloride acid (0.3 cm^3) was heated under reflux under nitrogen for 90 min. The resulting orange solution was diluted with water (10 cm^3) and neutralised with 2M aqueous sodium carbonate. Extraction with ethyl acetate (3 × 15 cm^3), followed by pressure column chromatography eluting with dichloromethane–methanol–triethylamine (94:5:1), gave a red solid (9 mg, 12%), which was crystallised as prisms from methanol, m.p. 213 °C (decomp.); $\lambda_{max.}$ 244, 274, 296, 340, and 353 nm; $\delta_H[(CD_3)_2SO]$ 11.16 (1 H, br s, NH), 9.51 (1 H, s, 1-H), 7.91 (1 H, s, 4-H), 7.85 (1 H, d, *J* 2 Hz, 10-H), 7.48 (1 H, d, *J* 9 Hz, 7-H), 7.18 (1 H, dd, J_1 9, J_2 2 Hz, 8-H), 4.77 (2 H, d, *J* 5 Hz, CH_2OH), 3.89 (3 H, s, OMe), 3.24 and 2.75 (2 × 3 H, 2 s, 2 × Ar*Me*), and 1.14 (1 H, br s, OH); *m/z* 306 (100%, M^+) (Found: C, 74.4; H, 5.8; N, 9.0. $C_{19}H_{18}N_2O_2$ requires C, 74.5; H, 5.9; N, 9.15%).

3-{N-[2,2-*Diethoxy*-1-(*hydroxymethyl*)*ethyl*]-N-(4-*tosyl*)-*aminomethyl*}-1,4-*dimethylcarbazole* (**15**; R = CH_2OH).—*Step* (a). A mixture of 1,4-dimethylcarbazole-3-carbaldehyde (**4**; R = H) (2.2 g, 0.01 mol), ethyl 2-amino-3,3-diethoxypropionate (2.1 g, 0.01 mol), and toluene (40 cm^3) was heated under reflux for 3 h. The solvent was evaporated off under reduced pressure, and the residue was recrystallised from toluene to give the corresponding imine as a solid (2.43 g, 59%), m.p. 134—136 °C; $\nu_{max.}$(Nujol) 3 310, 1 740, and 1 630 cm^{-1}; $\delta_H(CDCl_3)$ 8.52 (2 H, br s, NH, HC=N), 7.92 (1 H, dd, J_1 7, J_2 2 Hz, 5-H), 7.61 (1 H, s, 2-H), 7.4—7.0 (3 H, m, 6-, 7-, and 8-H), 4.95 [1 H, d, *J* 7 Hz, $CH(OEt)_2$], 4.4—4.2 (3 H, m, $CHCO_2CH_2Me$), 3.7—3.4 [4 H, m, $(OCH_2Me)_2$], 1.3—1.0 [9 H, m, $(OCH_2Me)_2$ and CO_2CH_2Me].

Step (b). A suspension of the imine (3.45 g) in dry diethyl ether (150 cm^3) was added to a stirred suspension of lithium aluminium hydride (1.0 g) in dry diethyl ether (200 cm^3) under dry nitrogen. The resulting mixture was stirred at 0 °C for 10 min, then allowed to warm to room temperature overnight. 30% Aqueous ammonium sodium tartrate (200 cm^3) was cautiously added, and the mixture was thoroughly stirred for 10 min. The

phases were separated, and the aqueous phase was extracted with ethyl acetate (2 × 50 cm^3). The combined, dried extracts were evaporated under reduced pressure to afford the corresponding amino alcohol as a yellow gum, which was not characterised, and which was used in the next stage without purification.

Step (c). Toluene-4-sulphonyl chloride (0.4 g) was added to a stirred suspension of the amino alcohol (0.37 g) in a mixture of THF (4 cm^3) and water (8 cm^3) containing sodium carbonate (0.24 g). The mixture was stirred overnight at room temperature, and then 0.5M aqueous sodium hydroxide (10 cm^3) was added to the resulting clear solution which was then kept at room temperature for a further 2 h. The solution was extracted with ethyl acetate (2 × 20 cm^3), and the combined, dried extracts were evaporated to afford a gum. Column chromatography (SiO_2; ethyl acetate) afforded the *title compound* as a viscous oil (0.25 g, 48%), which was rechromatographed and eventually crystallised as low melting prisms; $\delta_H(CDCl_3)$ 8.75 (1 H, br s, NH), 8.0 (1 H, dd, J_1 7, J_2 2 Hz, 5-H), 7.71 (2 H, d, J 8 Hz, 2′- and 6′-H), 7.45—7.0 (6 H, m, other aromatic protons), 5.75 [3 H, m, $ArCH_2N$ and $CH(OEt)_2$], 4.0—3.2 (7 H, m, $(OCH_2Me)_2$, $CHCH_2OH$), 2.72 (3 H, s, $SO_2C_6H_4Me$), 2.24 (6 H, br s, 2 × $ArMe$), and 1.2—0.95 [6 H, m, $(OCH_2Me)_2$] (Found: C, 66.3; H, 7.1; N, 5.1. $C_{29}H_{36}N_2O_5S$ requires C, 66.4; H, 6.9; N, 5.3%).

3-{N-[2,2-*Diethoxy*-1-(*methoxymethyl*)*ethyl*]-N-(4-*tosyl*)-*aminomethyl*}-1,4,9-*trimethylcarbazole* (**16**).—Iodomethane (0.86 g) was added to a stirred suspension of potassium hydroxide (0.67 g) and the alcohol (**15**; R = CH_2OH) (0.78 g) in DMSO (3.5 cm^3). The mixture was stirred overnight at room temperature, then diluted with water (40 cm^3), and extracted with dichloromethane (3 × 15 cm^3). The combined extracts were washed with water (5 × 10 cm^3), dried, and evaporated to a viscous oil (0.6 g). Pressure column chromatography (ethyl acetate–light petroleum 1:4) gave a white amorphous powder (0.54 g, 66%), m.p. 120—123 °C; $\delta_H(CDCl_3)$ 8.05 (1 H, dd, J_1 7, J_2 2 Hz, 2-H), 7.6—6.9 (8 H, m, other aromatic protons), 4.75—4.6 [3 H, s and d, $ArCH_2N$ and $HC(OEt)_2$], 4.2 (1 H, m, $CHCHCH_2$), 4.0 (3 H, s, NMe), 3.8—3.4 [6 H, m, $(OCH_2Me)_2$ and CH_2OMe], 3.1 (3 H, s, OMe), 2.8 and 2.72 (6 H, 2 s, 2 × $ArMe$), 2.25 (3 H, s, $ArMe$), and 1.3—0.95 [6 H, m, $(OCH_2Me)_2$] (Found: C, 67.3; H, 7.2; N, 5.1. $C_{31}H_{40}N_2O_5S$ requires C, 67.4; H, 7.3; N, 5.1%).

9-*Allyl*-1,4-*dimethylcarbazole* (**17**; R = H).—A solution of 1,4-dimethylcarbazole (9.75 g) in dry *N*,*N*-dimethylformamide (DMF) (90 cm^3) was cautiously added to a 60% suspension of sodium hydride in oil (2.4 g) also in DMF (90 cm^3) and protected under nitrogen. After the addition the mixture was stirred for 10 min before freshly distilled allyl bromide (7.25 g) in dry DMF was introduced dropwise. The reaction mixture was stirred for 10 min at room temperature and then at ~50 °C for 6 h. After this time the flask contents were cooled, poured into water (300 cm^3), and extracted with ethyl acetate (3 × 150 cm^3). The combined extracts were washed successively with water (3 × 50 cm^3) and brine (50 cm^3), dried, and evaporated to afford a solid, which was purified by column chromatography. Elution with dichloromethane–light petroleum (1:1) gave the *title carbazole* as plates (10 g, 90%), m.p. 106 °C; $\nu_{max.}$(Nujol) 1 640, 1 600, and 900 cm^{-1}; $\delta_H(CDCl_3)$ 8.16 (1 H, m, 5-H), 7.39 (1 H, m, 7-H), 7.29 (1 H, d, J 7.4 Hz, 8-H), 7.21 (1 H, m, 6-H), 7.05 (1 H, d, J 7.3 Hz, 2-H), 6.86 (1 H, d, J 7.3 Hz, 3-H), 6.07 (1 H, m, $CH{=}CH_2$), 5.12 (2 H, m, $CH{=}CH_2$), 4.83 (2 H, m, NCH_2), 2.84 (3 H, s, 4-Me), and 2.74 (3 H, s, 1-Me); *m*/*z* 235 (93%, M^+), and 194 (100) (Found: M^+, 235.1368. $C_{17}H_{17}N$ requires *M*, 235.1361).

9-*Allyl*-6-*methoxy*-1,4-*dimethylcarbazole* (**17**; R = OMe).—The same procedure as used for the previous experiment was employed. Thus, 6-methoxy-1,4-dimethylcarbazole (11.25 g) afforded the *title compound* (12.2 g, 92%) as prisms, m.p. 139 °C; $\lambda_{max.}$ 232, 245sh, 268, and 295 nm; $\nu_{max.}$(Nujol) 1 610, 1 200, 1 140, and 910 cm^{-1}; $\delta_H(CDCl_3)$ 7.71 (1 H, d, J 2.6 Hz, 5-H), 7.24 (1 H, d, J 8.8 Hz, 8-H), 7.08 (1 H, dd, J_1 8.8, J_2 2.6 Hz, 7-H), 7.05 (1 H, d, J 7.4 Hz, 2-H), 6.86 (1 H, d, J 7.4 Hz, 3-H), 6.05 (1 H, m, $CH{=}CH_2$), 5.12 (2 H, m, $CH{=}CH_2$), 4.82 (2 H, m, NCH_2), 3.93 (3 H, s, OMe), 2.84 (3 H, s, 4-Me), and 2.73 (3 H, s, 1-Me); *m*/*z* 265 (10%, M^+) and 224 (33) (Found: C, 81.4; H, 7.2; N, 5.4. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%).

1-*Allyl*-3-*methoxy*-5,8-*dimethylcarbazole* (**18**; R = OMe).—The carbazole (**17**; R = OMe) (5.3 g) in dry dichloromethane (180 cm^3) was treated with a suspension of freshly ground aluminium chloride (2.93 g) in dry dichloromethane (50 cm^3) in portions while the reaction temperature was held at ~ −30 °C. The mixture was then allowed to warm to room temperature and was stirred for 7 h, before being added to water–ice (~250 cm^3). The organic phase was collected and the aqueous layer was extracted with dichloromethane (2 × 100 cm^3). The combined organic phase and extracts were then washed successively with water (2 × 100 cm^3) and saturated brine (100 cm^3), dried, and evaporated. Chromatography on silica with light petroleum and an increasing proportion of dichloromethane (gradient elution) gave three solid products, in order of elution: (a) 1-*allyl*-3-*methoxy*-5,8-*dimethylcarbazole* (**18**; R = OMe) (3.28 g, 62%), m.p. 119—120 °C; $\delta_H(CDCl_3)$ 7.82 (1 H, br s, NH), 7.57 (1 H, d, J 2.4 Hz, 4-H), 7.09 (1 H, d, J 7.4 Hz, 2-H), 6.91 (1 H, d, J 2.4 Hz, 7-H), 6.89 (1 H, d, J 7.4 Hz, 6-H), 6.12 (1 H, m, $CH{=}CH_2$), 5.30—5.20 (2 H, m, $CH{=}CH_2$), 3.93 (3 H, s, OMe), 3.70 (2 H, d, J 6.2 Hz, $CH_2CH{=}CH_2$), 2.83 (3 H, s, 5-Me), and 2.50 (3 H, s, 8-Me); *m*/*z* 265 (10%, M^+), 250 (60), and 224 (10) (Found: C, 81.7; H, 7.25; N, 5.2. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%).

(b) 1-(2-*Chloropropyl*)-3-*methoxy*-5,8-*dimethylcarbazole* (**20**) (0.42 g, 7%), m.p. 120—121 °C; $\lambda_{max.}$ 234, 246, 255sh, and 295nm; $\nu_{max.}$(Nujol) 3 460, 1 610, and 1 300 cm^{-1}; $\delta_H(CDCl_3)$ 7.86 (1 H, br s, NH), 7.60 (1 H, d, J 2.4 Hz, 4-H), 7.11 (1 H, d, J 7.3 Hz, 7-H), 6.90 (1 H, d, J 7.3 Hz, 6-H), 6.89 (1 H, d, J 2.4 Hz, 2-H), 4.45 [1 H, sextet, J 6.6 Hz, $CH_2CH(Cl)Me$], 3.92 (3 H, s, OMe), 3.42 [1 H, dd, J_1 14.5, J_2 6.6 Hz, $CH(H)CH(Cl)Me$], 3.25 [1 H, dd, J_1 14.5, J_2 6.6 Hz, $CH(H)CH(Cl)Me$], 2.82 (3 H, s, 5-Me), 2.54 (3 H, s, 8-Me), and 1.59 (3 H, d, J 6.6 Hz, $CH(Cl)Me$]; *m*/*z* 303 and 301 (M^+), and 265 (100%) (Found: C, 71.5; H, 6.6; N, 4.7. $C_{18}H_{20}ClNO$ requires C, 71.6; H, 6.7; N, 4.6%). A solution of this compound (1.5 g) in DMF (25 cm^3) at 0 °C was stirred with sodium hydride (0.44 g of a 60% dispersion in oil) and was then poured onto ice, followed by extraction and column chromatography (SiO_2; CH_2Cl_2–light petroleum) to give the propenylcarbazole (**18**; R = OMe) (1.1 g, 86%) identical with that previously obtained in (a) above.

(c) 3-*Allyl*-6-*methoxy*-1,4-*dimethylcarbazole* (**21**; R = OMe) (1.3 g, 24%), m.p. 125—126 °C; $\delta_H(CDCl_3)$ 7.78 (1 H, br s, NH), 7.75 (1 H, d, J 2.6 Hz, 5-H), 7.36 (1 H, d, J 8.8 Hz, 8-H), 7.05 (1 H, dd, J_1 8.8, J_2 2.6 Hz, 7-H), 7.02 (1 H, s, 2-H), 6.03 (1 H, m, $CH{=}CH_2$), 5.10—4.90 (2 H, m, $CH{=}CH_2$), 3.93 (3 H, s, OMe), 3.55 (2 H, m, $CH_2CH{=}CH_2$), 2.77 (3 H, s, 4-Me), and 2.49 (3 H, s, 1-Me); *m*/*z* 265 (100%, M^+), 250 (25), 225 (27), and 149 (37) (Found: C, 81.5; H, 7.3; N, 5.3. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%). A similar reaction was carried out, but now the addition was conducted with the reaction temperature at ~18—20 °C, to give two further compounds A and B in 25 and 10% yield respectively after column chromatography.

Compound A, 8-*allyl*-6-*methoxy*-3-[2-(6′-*methoxy*-1′,4′-*dimethylcarbazol*-3′-*yl*)-1-*methylethyl*]-1,4-*dimethylcarbazole* (**22**), was eluted from the column with dichloromethane–light petroleum (1:10) as a solid, m.p. ~240 °C (decomp.); $\lambda_{max.}$ 247,

258sh, 268sh, and 299 nm; $\nu_{max.}$(Nujol) 3 460, 1 600, and 1 300 cm^{-1}; $\delta_H(CDCl_3)$ 7.76 (2 H, br s, 2 × NH), 7.75 (1 H, d, *J* 2.4 Hz, 5′-H), 7.62 (1 H, d, *J* 2.4 Hz, 5-H), 7.35 (1 H, d, *J* 8.8 Hz, 8′-H), 7.27 (1 H, s, 2-H), 7.05 (1 H, dd, J_1 8.8, J_2 2.4 Hz, 7′-H), 6.99 (1 H, s, 2′-H), 6.89 (1 H, *J* 2.4 Hz, 7-H), 6.11 (1 H, m, C*H*=CH_2), 5.28—5.19 (2 H, m, CH=CH_2), 3.93 and 3.90 (2 × 3 H, 2 s, 2 × OMe), 3.69 (2 H, m, CH_2CH=CH_2), 3.54 (1 H, m, C*H*Me), 3.14 [1 H, dd, J_1 12.8, J_2 5.3 Hz, C*H*(H)CHMe], 3.02 [1 H, dd, J_1 12.8, J_2 9.2 Hz, CH(*H*)CHMe], 2.82 and 2.74 (2 × 3 H, 2 s, 4- and 4′-Me), 2.55 and 2.45 (2 × 3 H, 2 s, 1- and 1′-Me), and 1.29 (3 H, d, *J* 6.9 Hz, CH*Me*); *m/z* 530 (M^+), 380, 307, 292 (100%), and 238 (Found: C, 81.3; H, 7.4: N, 5.0. $C_{36}H_{38}N_2O_2$ requires C, 81.5; H, 7.2; N, 5.3%).

Compound B, 8-(2-*chloropropyl*)-6-*methoxy*-3-[2-(6′-*methoxy*-1′,4′-*dimethylcarbazol*-3′-*yl*)-1-*methylethyl*]-1,4-*dimethylcarbazole* (**23**), is slightly more polar and was eluted off the column with dichloromethane–light petroleum (1:5). Removal of the solvent gave *compound* (**23**) as prisms, m.p. >195 °C (decomp.); $\lambda_{max.}$ 247, 258sh, 268sh, and 298 nm; $\nu_{max.}$(Nujol) 3 460, 1 600, and 1 300 cm^{-1}; $\delta_H(CDCl_3)$ 7.79 (2 H, br s, 2 × NH), 7.74 (1 H, d, *J* 8.6 Hz, 5′-H), 7.64 (1 H, d, *J* 2.2 Hz, 5-H), 7.33 (1 H, d, *J* 8.6 Hz, 8′-H), 7.29 (1 H, s, 2-H), 7.04 (1 H, dd, J_1 8.6, J_2 2.4 Hz, 7′-H), 7.00 (1 H, s, 2′-H), 6.87 (1 H, d, *J* 2.2 Hz, 7-H), 4.45 [1 H, m, C*H*(Cl)Me], 3.93 and 3.90 (2 × 3 H, 3 s, 2 × OMe), 3.56 (1 H, m, CH_2C*H*Me), 3.44 [1 H, dd, J_1 15.4, J_2 6.4 Hz, C*H*(H)CHCl], 3.26 [1 H, dd, J_1 15.4 Hz, J_2 6.4 Hz, CH(*H*)CHCl], 3.17 [1 H, dd, J_1 13.6, J_2 9.1 Hz, C*H*(H)CHMe], 3.04 [1 H, dd, J_1 13.6, J_2 5.4 Hz, CH(*H*)CHCH_3], 2.82 and 2.74 (2 × 3 H, 2 s, 4- and 4′-Me), 2.59 and 2.44 (2 × 3 H, 2 s, 1- and 1′-Me), 1.57 [3 H, d, *J* 6.4 Hz, CH(Cl)*Me*], and 1.27 (3 H, d, *J* 6.9 Hz,CH_2CH*Me*); *m/z* 568 and 566 (M^+) (Found: C, 76.1; H, 6.7; N, 4.8. $C_{36}H_{39}ClN_2O_2$ requires C, 76.2; H, 6.9; N, 4.9%).

3-*Methoxy*-5,8-*dimethyl*-1-(*prop*-1-*enyl*)*carbazole* (**24**).—A solution of the carbazole (**18**; R = OMe) (4.9 g, 17 mmol) in dry benzene (80 cm^3) containing bis(acetonitrile)palladium(II) chloride (0.5 g, 2 mmol) was stirred under nitrogen at 50 °C for 24 h. After removal of the solvent, the residue was chromatographed on silica with dichloromethane–light petroleum (2:1) as eluant to give the *title compound* as a solid (4.0 g, 89%), m.p. 138 °C; $\lambda_{max.}$ 210sh, 235, and 283 nm; $\nu_{max.}$(Nujol) 3 360, 1 610, 1 590, and 1 310 cm^{-1}; $\delta_H(CDCl_3)$ 7.85 (1 H, br s, NH), 7.56 (1 H, d, *J* 2.4 Hz, 4-H), 7.10 (1 H, d, *J* 7.1 Hz, 7-H), 7.06 (1 H, d, *J* 2.4 Hz, 2-H), 6.88 (1 H, d, *J* 7.1 Hz, 6-H), 6.73 (1 H, dd, J_1 15.6, J_2 1.8 Hz, C*H*=CHMe), 6.37 (1 H, dq, J_1 15.6, J_2 6.6 Hz, CH=C*H*Me), 3.93 (3 H, s, OMe), 2.81 (3 H, s, 5-Me), 2.53 (3 H, s, 8-Me), and 2.02 (3 H, dd, J_1 6.6, J_2 1.8 Hz, CH=CH*Me*); *m/z* 265 (10%, M^+) (Found: C, 81.5; H, 7.3; N, 5.2. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%).

6-*Methoxy*-1,4-*dimethyl*-3-(*prop*-1-*enyl*)*carbazole*.—An identical experiment was performed on the carbazole (**21**; R = OMe), leading to the *title compound*, in 82% yield, as prisms, m.p. 195 °C; $\lambda_{max.}$ 235 and 281 nm; $\nu_{max.}$(Nujol) 3 420, 1 610, 1 220, and 950 cm^{-1}; $\delta_H(CDCl_3)$ 7.80 (1 H, br s, NH), 7.74 (1 H, d, *J* 2.4 Hz, 5-H), 7.34 (1 H, d, *J* 8.8 Hz, 8-H), 7.30 (1 H, s, 2-H), 7.04 (1 H, dd, J_1 8.8, J_2 2.4 Hz, 7-H), 6.84 (1 H, dq, J_1 15.5, J_2 1.7 Hz, C*H*=CHMe), 6.04 (1 H, dq, J_1 15.5, J_2 6.6 Hz, CH=C*H*Me), 3.93 (3 H, s, OMe), 2.82 (3 H, s, 4-Me), 2.48 (3 H, s, 1-Me), and 1.94 (3 H, dd, J_1 6.6, J_2 1.7 Hz, CH=CH*Me*); *m/z* 265 (100%) (Found: C, 81.4; H, 7.4; N, 5.1. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%).

3-*Methoxy*-5,8-*dimethylcarbazole*-1-*carbaldehyde* (**25**).—A solution of the propenylcarbazole (**24**) (5.3 g) in a mixture of methanol (100 cm^3) and dichloromethane (100 cm^3) was cooled to −20 °C and ozone was admitted in a steady stream until all the starting material has disappeared. Excess of ozone was then displaced by nitrogen and dimethyl sulphide (2 cm^3) was added. The reaction mixture was allowed to warm to room temperature during 2 h, and the solvents were removed. Column chromatography of the residue (SiO_2; ethyl acetate–light petroleum, 1:10) gave the required *aldehyde* (**25**) as yellow prisms (4.0 g, 79%), m.p. 161 °C; $\lambda_{max.}$ 230, 264, and 298 nm; $\nu_{max.}$(Nujol) 3 350, 1 670, 1 613, and 1 300 cm^{-1}; $\delta_H(CDCl_3)$ 10.11 (1 H, s, CHO), 9.88 (1 H, br s, NH), 7.93 (1 H, d, *J* 2.6 Hz, 4-H), 7.36 (1 H, d, *J* 2.6 Hz, 2-H), 7.17 (1 H, d, *J* 7.3 Hz, 7-H), 6.95 (1 H, d, *J* 7.3 Hz, 6-H), 3.97 (1 H, s, OMe), 2.80 (3 H, s, 5-Me), and 2.56 (3 H, s, 8-Me); $\delta_C(CDCl_3)$ 193.1, 153.0, 140.0, 133.6, 130.9, 127.2, 126.7, 121.6, 121.5, 118.5, 118.1, 115.6, 115.4, 56.5, 20.4, and 16.6; *m/z* 253 (100%, M^+) and 238 (Found: C, 75.9; H, 6.0; N, 5.4. $C_{16}H_{15}NO_2$ requires C, 75.9; H, 6.0; N, 5.5%).

(E)-N,N-*Diethyl*-3-(3-*methoxy*-5,8-*dimethylcarbazol*-1-*yl*)-*acrylamide* (**26**; R = H).—A solution of diethyl *N*,*N*-diethylphosphonoacetamide (5.75 g, 21 mmol) was added very slowly to a suspension of sodium hydride (60% dispersion in oil; 1.7 g, 42 mmol) in DMF (160 cm^3). After being stirred for 10 min at ~15 °C, the reaction mixture was cooled to 0 °C and a solution of the aldehyde (**25**) (4.4 g, 17.2 mmol) in DMF (120 cm^3) was introduced. The resulting red solution was stirred at room temperature for 24 h until all the aldehyde had reacted, when it was poured into cold water (500 cm^3). The combined organic layers were washed successively with water (4 × 150 cm^3) and saturated brine (150 cm^3), dried, and the solvent was removed to give a solid residue. Column chromatography of this material, with ethyl acetate–light petroleum mixtures, afforded the *title compound* as a yellow solid (5.9 g, 98%), m.p. 207 °C; $\lambda_{max.}$ 238, 255sh, 315, and 410 nm; $\nu_{max.}$(Nujol) 3 250, 1 630, 1 590, 1 200, and 980 cm^{-1}; $\delta_H(CDCl_3)$ 8.60 (1 H, br s, NH), 8.21 (1 H, d, *J* 15.2 Hz, CH=C*H*CONEt$_2$), 7.68 (1 H, d, *J* 2.4 Hz, 4-H), 7.24 (1 H, d, *J* 2.4 Hz, 2-H), 7.11 (1 H, d, *J* 7.2 Hz, 7-H), 6.94 (1 H, d, *J* 15.2 Hz, C*H*=CHCONEt$_2$), 6.89 (1 H, d, *J* 7.2 Hz, 6-H), 3.95 (3 H, s, OMe), 3.53 [4 H, m, N(CH_2Me)$_2$], 2.81 (3 H, s, 5-Me), 2.52 (3 H, s, 8-Me), 1.30 (3 H, t, *J* 7.1 Hz, NCH_2*Me*), and 1.21 (3 H, t, *J* 7.1 Hz, NCH_2*Me*); *m/z* 350 (65%, M^+), 277 (100), and 262 (31) (Found: C, 75.3; H, 7.6; N, 7.9. $C_{22}H_{26}N_2O_2$ requires C, 75.4; H, 7.5; N, 8.0%).

(E)-N,N-*Diethyl*-3-(6-*formyl*-3-*methoxy*-5,8-*dimethylcarbazol*-1-*yl*)*acrylamide* (**26**; R = CHO).—Freshly distilled TFAA (21.4 g, 1.2 mmol) was added dropwise to a solution of imidazole (1.5 g, 22 mmol) in dry acetonitrile (120 cm^3). After the addition, the reaction mixture was heated to reflux and a solution of the amidocarbazole (**26**; R = H) (5.9 g, 17 mmol) in dry acetonitrile (50 cm^3) was introduced. After being heated under reflux for a further 3.5 h under nitrogen, the resultant brown solution was cooled to room temperature. The solvent was removed and the residue was dissolved in a mixture of sodium hydroxide–ethanol–water (15 g:300 cm^3:150 cm^3). The mixture was then heated and stirred at 80 °C for 15 min. Most of the solvent was then removed and the residue was treated with water (150 cm^3) and extracted with ethyl acetate (4 × 100 cm^3). The combined extracts were washed successively with water (4 × 80 cm^3) and saturated brine (80 cm^3), dried, and evaporated. Column chromatography of the residue with ethyl acetate–light petroleum mixtures as eluant afforded the pure *title compound* as yellow plates (5.3 g, 83%), m.p. 230 °C; $\lambda_{max.}$ 223, 253, 316, and 380 nm; $\nu_{max.}$(Nujol) 3 220, 1 670, 1 640, and 970 cm^{-1}; $\delta_H(CDCl_3)$ 10.28 (1 H, s, CHO), 9.58 (1 H, s, NH), 8.25 (1 H, d, *J* 15.4 Hz, CH=C*H*CONEt$_2$), 7.66 (1 H, s, 7-H), 7.65 (1 H, d, *J* 2.2 Hz, 4-H), 7.19 (1 H, d, *J* 2.2 Hz, 2-H), 6.90 (1 H, d, *J* 15.4 Hz, C*H*=CHCONEt$_2$), 3.94 (3 H, s, OMe), 3.51 [4 H, q, *J* 7.1 Hz, N(CH_2Me)$_2$], 3.07 (3 H, s, 5-Me), 2.50 (3 H, s, 8-Me), 1.30 (3 H, t, *J* 7.1 Hz, NCH_2*Me*), and 1.18 (3 H, t, *J* 7.1 Hz,

NCH_2Me); *m/z* 378 (M^+), 347, 305, and 289 (Found: C, 73.1; H, 7.1; N, 7.4. $C_{23}H_{26}N_2O_3$ requires C, 73.0; H, 6.9; N, 7.4%).

N,N-*Diethyl*-3-(6-*formyl*-3-*methoxy*-5,8-*dimethylcarbazol*-1-*yl*)*propionamide* (**27**).—A solution of the acrylamide (**26**; R = CHO) (5.14 g) in ethyl acetate (300 cm^3) was hydrogenated at atmospheric pressure with 10% palladium–carbon (0.5 g) as catalyst. Removal of catalyst and solvent and chromatography of the residue (ethyl acetate–light petroleum 1:1) gave the *required compound* (**27**) as pale yellow prisms (4.3 g, 82%), m.p. 162—163 °C; $\lambda_{max.}$ 229, 251, 278, 297, and 336 nm; $\nu_{max.}$(Nujol) 3 230, 2 920, 2 850, 1 730, 1 660, 1 610, and 1 030 cm^{-1}; $\delta_H(CDCl_3)$ 10.68 (1 H, br s, NH), 10.42 (1 H, s, CHO), 7.71 (1 H, s, 7-H), 7.63 (1 H, d, *J* 2.6 Hz, 4-H), 6.91 (1 H, d, *J* 2.6 Hz, 2-H), 3.94 (3 H, s, OMe), 3.37 (4 H, m, NCH_2Me and $CH_2CH_2CONEt_2$), 3.22 (2 H, q, *J* 7.3 Hz, NCH_2Me), 3.17 (3 H, s, 5-Me), 2.77 (2 H, m, $CH_2CH_2CONEt_2$), 2.62 (3 H, s, 8-Me), and 1.02 (6 H, t, *J* 7.3 Hz, $N(CH_2Me)_2$; *m/z* 380 (10%, M^+), and 307 (100) (Found: C, 72.8; H, 7.55; N, 7.3. $C_{23}H_{28}N_2O_3$ requires C, 72.6; H, 7.4; N, 7.4%).

3-{6-[N-(2,2-*Dimethoxyethyl*)-N-(4-*tosyl*)*aminoethyl*]-3-*methoxy*-5,8-*dimethylcarbazol*-1-*yl*}-N,N-*diethylpropionamide* (**28**).—A mixture of the formylcarbazole (**27**) (1.9 g, 5 mmol) and excess of dry aminoacetaldehyde dimethyl acetal (5.0 g) in the presence of activated molecular sieves (4 Å) was heated at 80 °C until all the formyl compound had reacted, as indicated by t.l.c. (on neutral alumina). Most of the remaining acetal reagent was removed by distillation under reduced pressure and the residue was redissolved in absolute ethanol (120 cm^3) and was then hydrogenated, in the presence of platinum(IV) oxide (0.2 g), at atmospheric pressure for 4 h. The hydrogenation mixture was filtered through a pad of Celite to remove the catalyst, and the filtrate was evaporated to afford the *N*-detosyl title compound as a solid (2.1 g, 90%).

This compound (2.1 g) was converted directly into its *N*-tosyl derivative (**28**) by reaction with toluene-4-sulphonyl chloride (1 g) in pyridine solution (50 cm^3) at room temperature during 24 h. The reaction mixture was poured into water (200 cm^3) and extracted with ethyl acetate (3 × 80 cm^3). The combined extracts were washed successively with 0.5M hydrochloric acid (3 × 30 cm^3), 2M aqueous sodium hydrogen carbonate (120 cm^3), and water (2 × 20 cm^3), dried, and evaporated. Chromatography of the residue, with ethyl acetate as eluant, gave the required *sulphonamide* (**28**) as prisms (2.4 g, 85%), m.p. 174 °C; $\lambda_{max.}$ 238, 264sh, 268, and 297nm; $\nu_{max.}$(Nujol) 3 300, 1 615, and 1 160 cm^{-1}; $\delta_H(CDCl_3)$ 9.91 (1 H, br s, NH), 7.75 (2 H, d, *J* 8.3 Hz, tosyl protons), 7.30 (2 H, d, *J* 8.3 Hz, tosyl protons), 7.69 (1 H, d, *J* 2.5 Hz, 4-H), 6.88 (1 H, s, 7-H), 6.87 (1 H, d, *J* 2.5 Hz, 2-H), 4.58 (2 H, s, 6-CH_2N), 4.13 [1 H, t, *J* 5.5 Hz, $CH(OMe)_2$], 3.91 (3 H, s, 3-Me), 3.35 (2 H, q, *J* 7.1 Hz, $CONCH_2Me$), 3.34 (2 H, m, $CH_2CH_2CONEt_2$), 3.20 (2 H, q, *J* 7.1 Hz, $CONCH_2Me$), 3.16 [2 H, d, *J* 5.5 Hz, $CH_2CH(OMe)_2$], 3.12 [6 H, s, $CH(OMe)_2$], 2.81 (3 H, s, 5-Me), 2.75 (2 H, m, $CH_2CH_2CONEt_2$), 2.48 (3 H, s, 8-Me), 2.42 (3 H, s, $SO_2C_6H_4Me$), and 1.00 [6 H, t, *J* 7.1 Hz, $N(CH_2Me)_2$]; *m/z* 623 (M^+), 366 (100%), 293, 278, and 250 (Found: C, 65.3; H, 7.4; N, 6.7. $C_{34}H_{45}N_3O_6S$ requires C, 65.5; H, 7.3; N, 6.7%).

N,N-*Diethyl*-3-(9-*methoxy*-5,11-*dimethyl*-6H-*pyrido*[4,3-b]-*carbazol*-7-*yl*)*propionamide* (**29**).—Conc. hydrochloric acid (1 cm^3) was added to a solution of the sulphonamide (**28**) (320 g, 0.5 mmol) in dioxane (20 cm^3) protected under nitrogen. The mixture was heated and stirred at ~100 °C for 3 h, before being cooled and diluted with water (40 cm^3). Ammonium hydroxide was added until the solution became basic and the mixture was then extracted with ethyl acetate (3 × 40 cm^3). The combined extracts were washed successively with water (20 cm^3) and brine (20 cm^3), dried, and evaporated to give the ellipticine (**29**) as a yellow solid. This was crystallised from a minimum of ethyl acetate as *prisms* (116 mg, 56%), m.p. 163—164 °C; $\lambda_{max.}$ 210 (30 200), 243 (26 800), 296 (62 800), 337 (6 260), and 410 nm (4 100); $\nu_{max.}$(Nujol) 3 280 and 1 600 cm^{-1}; $\delta_H(CDCl_3)$ 10.32 (1 H, br s, NH), 9.68 (1 H, s, 1-H), 8.45 (1 H, d, *J* 6.2 Hz, 3-H), 7.85 (1 H, dd, J_1 6.2, J_2 0.6 Hz, 4-H), 7.75 (1 H, d, *J* 2.4 Hz, 10-H), 6.97 (1 H, d, *J* 2.4 Hz, 8-H), 3.96 (3 H, s, OMe), 3.38 (2 H, m, $CH_2CH_2CONEt_2$), 3.37 (2 H, q, *J* 7.14 Hz, NCH_2Me), 3.26 (3 H, s, 11-Me), 3.21 (2 H, q, *J* 7.14 Hz, NCH_2Me), 2.84 (3 H, d, *J* 0.6 Hz, 5-Me), 2.79 (2 H, m, $CH_2CH_2CONEt_2$), and 1.00 [6 H, t, *J* 7.14 Hz, $N(CH_2Me)_2$]; *m/z* 403 (100%, M^+), 386, 368, 353, 348, and 330 (Found: C, 74.6; H, 7.35; N, 10.4 $C_{25}H_{29}N_3O_2$ requires C, 74.4; H, 7.2; N, 10.4%).

7-(3-*Diethylaminopropyl*)-9-*methoxy*-5,11-*dimethyl*-6H-*pyrido*[4,3-b]*carbazole* (**19**).—A solution of 2M borane–dimethyl sulphide complex in THF (0.6 cm^3) was added to a solution of the amidoellipticine (**29**) (114 mg) in THF (6 cm^3) protected under nitrogen. After the addition, the reaction mixture was heated at reflux for 75 min, then partially cooled and treated with 6M hydrochloric acid (1 cm^3). After a further 15 min, the solution was evaporated to afford a solid residue, which was mixed with water (20 cm^3) and extracted with dichloromethane (3 × 10 cm^3). The combined extracts were washed successively with water (20 cm^3) and brine (20 cm^3), dried, and evaporated to afford the crude ellipticine derivative (**19**) as a brown oil. Purification by column chromatography, with triethylamine–ethyl acetate–light petroleum (0.5:75:25) as eluant, gave an orange gum (56 mg, 51%); $\lambda_{max.}$ 210 (29 900), 243 (32 000), 296 (61 800), and 405 nm (4 000); $\nu_{max.}$(Nujol) 3 250 and 1 610 cm^{-1}; $\delta_H(CDCl_3)$ 10.25 (1 H, br s, NH), 9.59 (1 H, s, 1-H), 8.37 (1 H, d, *J* 6.1 Hz, 3-H), 7.72 (1 H, d, *J* 6.1 Hz, 4-H), 7.64 (1 H, d, *J* 2.4 Hz, 10-H), 6.89 (1 H, d, *J* 2.4 Hz, 8-H), 3.88 (3 H, s, OMe), 3.15 (3 H, s, 11-Me), 2.94 (2 H, br t, *J* 6.7 Hz, $CH_2[CH_2]_2NEt_2$), 2.68 (3 H, s, 5-Me), 2.58 [4 H, q, *J* 7 Hz, $N(CH_2Me)_2$], 2.32 (2 H, br t, *J* 7 Hz, CH_2NEt_2), 1.93 (2 H, m, $CH_2CH_2NEt_2$), and 0.94 [6 H, t, *J* 7 Hz, $N(CH_2Me)_2$] (Found: M^+, 389.2475 (100%); C, 77.0; H, 8.15; N, 10.7. $C_{25}H_{31}N_3O$ requires *M*, 389.2467; C, 77.1; H, 8.0; N, 10.8%).

6-*Allyl*-1,4-*dimethylcarbazole* (**30**) *and* 3-*Allyl*-1,4-*dimethylcarbazole* (**21**; R = H).—A solution of the carbazole (**18**; R = H) (235 mg, 1 mmol) in dry dichloromethane (25 cm^3) was cooled to −30 °C and treated in portions with a suspension of freshly ground aluminium chloride (160 mg, 1.2 mmol) in dichloromethane (2 cm^3). After the addition, the mixture was stirred at room temperature for 9 h before being poured into water (50 cm^3). The aqueous phase was separated and extracted with dichloromethane (2 × 30 cm^3) and the extracts were then combined with the organic mother liquor. This solution was then washed successively with water (2 × 30 cm^3) and brine (40 cm^3), and dried. Evaporation of the solvent and chromatography of the residue with dichloromethane–light petroleum (3:10) as eluant gave first the *carbazole* (**21**; R = H) (108 mg, 46%) as a solid, m.p. 76—77 °C; $\lambda_{max.}$ 223sh, 242, 250sh, 259, and 288 nm; $\nu_{max.}(CHCl_3)$ 3 400, 1 500, and 1 310 cm^{-1}; $\delta_H(CDCl_3)$ 8.07 (1 H, d, *J* 7.3 Hz, 5-H), 8.00 (1 H, br s, NH), 7.24—7.18 (2 H, m, 7- and 8-H), 7.12 (1 H, d, *J* 7.1 Hz, 2-H), 6.92 (1 H, d, *J* 7.1 Hz, 6-H), 6.14 (1 H, m, $CH{=}CH_2$), 5.30—5.20 (2 H, m, $CH{=}CH_2$), 3.75 (2 H, m, $CH_2CH{=}CH_2$), 2.84 (3 H, s, 4-Me), and 2.52 (3 H, s, 1-Me); *m/z* 235 (100%, M^+) and 220 (40) (Found: C, 86.7; H, 7.3; N, 5.9. $C_{17}H_{17}N$ requires C, 86.8; H, 7.3; N, 5.95%).

The second product from the column was the isomeric *carbazole* (**30**). It was isolated as a solid (96 mg, 41%), m.p. 80—81 °C; $\lambda_{max.}$ 241, 250sh, 262, and 291 nm; $\nu_{max.}(CHCl_3)$ 8.22 (1 H, d, *J* 7.3 Hz, 5-H), 7.88 (1 H, br s, NH), 7.47—7.36 (2 H, m, 7- and 8-H), 7.22 (1 H, m, 3-H), 7.03 (1 H, s, 2-H), 6.04 (1 H, m,

C*H*=CH_2), 5.08—4.92 (2 H, m, CH=CH_2), 3.38—3.33 (2 H, m, CH_2CH=CH_2), 2.78 (3 H, m, 4-Me), and 2.48 (3 H, s, 1-Me); *m/z* 235 (100%, M^+) and 220 (25) (Found: C, 86.7; H, 7.3; N, 5.9%).

1-*Allyl*-3-*methyl*-4-*nitrobenzene*.—A mixture of 3-methyl-4-nitrophenol (61.2 g), anhydrous potassium carbonate (66.2), freshly distilled allyl bromide (58.0 g), and acetone (800 cm^3) was heated at reflux for 6 h. Then the mixture was cooled and filtered, and the filtrate was evaporated to leave an oil, which was dissolved in ethyl acetate (300 cm^3), and the solution was washed successively with water (2 × 150 cm^3) and saturated brine (150 cm^3). After drying, the solvent was removed and the residue was dissolved in the minimum volume of hot light petroleum. On cooling, the title compound separated as prisms (71.0 g, 93%), m.p. 34 °C; $\nu_{max.}$(Nujol) 1 600, 1 580, 1 320, and 1 250 cm^{-1}; δ_H($CDCl_3$) 8.09 (1 H, m, 5-H), 6.81 (2 H, m, 2- and 6-H), 6.04 (1 H, m, C*H*=CH_2), 5.40 (2 H, m, CH=CH_2), 4.61 (2 H, m, OCH_2), and 2.62 (3 H, s, Me): *m/z* 193 (5%, M^+), 176 (25), and 41 (100). This compound was not purified further, but was used directly in the next experiment.

5-*Allyloxyindole* (**34**).—The allyloxybenzene (5.0 g, 26 mmol) from the previous experiment and tripiperidinomethane (10.3 g, 39 mmol) were heated at 110 °C for 9 h under reduced pressure (15 mmHg). In this way piperidine liberated in the reaction was continuously removed. The viscous red oil remaining was cooled and dissolved in a minimum volume of acetone, and the solution was shaken vigorously during 10 min with a buffered solution of titanium(II) chloride (100 cm^3, 20% w/v in dilute hydrochloric acid) and 4M aqueous ammonium acetate (300 cm^3). The solution was then extracted with diethyl ether (8 × 50 cm^3) and the combined extracts were washed successively with saturated aqueous sodium hydrogen carbonate (2 × 25 cm^3) and brine (1 × 25 cm^3) before being dried and evaporated to yield an oil. This material was chromatographed, and eluted with ethyl acetate–light petroleum (1:5), to afford the *title compound* as an amber oil (2.7 g, 61%); $\nu_{max.}$(film) 3 400, 3 090, 1 610, and 1 210 cm^{-1}; δ_H($CDCl_3$) 7.95 (1 H, br s, NH), 7.15 (1 H, d, *J* 8.8 Hz, 7-H), 7.11 (1 H, d, *J* 2.4 Hz, 4-H), 7.03 (1 H, m, 2-H), 6.87 (1 H, dd, *J* 8.8, J_2 2.4 Hz, 6-H), 6.43 (1 H, m, 3-H), 6.08 (1 H, m, C*H*=CH_2), 5.41 [1 H, m, CH=C*H*(*H*)], 5.25 [1 H, m, CH=CH(*H*)], and 4.54 (2 H, m, OCH_2); *m/z* 173 (45%, M^+) and 132 (100) (Found: M^+, 173.0831. $C_{11}H_{11}NO$ requires *M*, 173.0840).

6-*Allyloxy*-1,4-*dimethylcarbazole* (**33**).—5-Allyloxyindole (17.3 g) and hexane-2,5-dione (11.4 g) in absolute ethanol (200 cm^3) were slowly added to a solution of toluene-4-sulphonic acid (9.5 g) in hot absolute ethanol (50 cm^3) and the mixture was then heated at reflux for 5 h. After removal of the solvent, the residue was chromatographed with dichloromethane–light petroleum (1:1) as eluant. This gave the *carbazole* (**33**) as prisms (20.3 g, 81%), m.p. 140—141 °C; $\lambda_{max.}$ 230, 244, 255sh, 265, and 295 nm; $\nu_{max.}$(Nujol) 3 440, 1 630, 1 600, 1 240, 1 215, and 820 cm^{-1}; δ_H($CDCl_3$) 7.80 (1 H, br s, NH), 7.70 (1 H, d, *J* 2.4 Hz, 5-H), 7.32 (1 H, d, *J* 8.6 Hz, 8-H), 7.09 (1 H, d, *J* 7.1 Hz, 2-H), 7.06 (1 H, dd, J_1 8.6, J_2 2.4 Hz, 7-H), 6.88 (1 H, d, *J* 7.1 Hz, 3-H), 6.14 (1 H, m, C*H*=CH_2), 5.47 [1 H, m, CH=C*H*(H)], 5.30 [1 H, m, CH=CH(*H*)], 4.64 (2 H, m, OCH_2), 2.81 (3 H, s, 4-Me), and 2.47 (3 H, s, 1-Me); *m/z* 251 (38%, M^+) and 210 (100) (Found: C, 81.0; H, 6.9; N, 5.8. $C_{17}H_{17}NO$ requires C, 81.2; H, 6.8; N, 5.6%).

4-*Allyl*-5,8-*dimethylcarbazol*-3-*ol* (**35**) *and* 2-*Allyl*-5,8-*dimethylcarbazol*-3-*ol* (**36**; R = H).—A solution of the allyloxycarbazole (**33**) (0.5 g) in xylene (20 cm^3) was heated at reflux for 60 h and the solvent was then removed under reduced pressure. The residue was chromatographed on neutral alumina with dichloromethane–light petroleum (1:1) to afford the *title compound* (**35**) as a solid (0.4 g, 80%) as the sole product, $\lambda_{max.}$ 243, 250, 260sh, and 298 nm; $\nu_{max.}$(Nujol) 3 420, 3 380, 1 610, 1 210, and 1 170 cm^{-1}; δ_H[$(CD_3)_2CO$] 10.12 (1 H, br s, OH), 7.72 (1 H, br s, NH), 7.29 (1 H, d, *J* 8.4 Hz, 1-H), 7.05 (1 H, d, *J* 8.4 Hz, 2-H), 7.02 (1 H, d, *J* 7.3 Hz, 7-H), 6.81 (1 H, d, *J* 7.3 Hz, 6-H), 6.20 (1 H, m, C*H*=CH_2), 5.05—4.25 (2 H, m, CH=CH_2), 4.12 (2 H, m, CH_2CH=CH_2), 2.93 (3 H, s, 5-Me), and 2.49 (3 H, s, 8-Me) (Found: C, 81.1; H, 6.75; N, 5.8. $C_{17}H_{17}NO$ requires C, 81.2; H, 6.8; N, 5.6%).

The reaction was repeated by treating the allyloxycarbazole (1.29 g) in dry dichloromethane (80 cm^3) at −25 °C with boron trichloride for 35 min. After the reaction mixture had been quenched with ice–water, extraction (CH_2Cl_2) and column chromatography (SiO_2; CH_2Cl_2–light petroleum, 1:1) gave two compounds A and B (in order of elution). Compound A was shown to be the carbazolol (**35**) (1.1 g, 83%), identical with that obtained from the previous reaction, and compound B was characterised as 2-allyl-5,8-dimethylcarbazol-3-ol (**36**; R = H) (0.15 g, 12%); $\nu_{max.}$($CHCl_3$) 3 440, 3 300, 1 610, and 1 300 cm^{-1}; δ_H($CDCl_3$) 7.78 (1 H, s, NH), 7.61 (1 H, s, 4-H), 7.20 (1 H, s, 1-H), 7.08 (1 H, d, *J* 7.3 Hz, 7-H), 6.87 (1 H, d, *J* 7.3 Hz, 6-H), 6.09 (1 H, m, C*H*=CH_2), 5.18 (2 H, m, CH=CH_2), 4.87 (1 H, s, OH and water of crystallisation), 3.57 (2 H, m, CH_2CH=CH_2), 2.78 (3 H, s, 5-Me), and 2.49 (3 H, s, 8-Me). Satisfactory analytical data could not be obtained for this product so it was converted into its methyl ether 7-allyl-6-methoxy-1,4-dimethylcarbazole (**36**; R = Me) as follows. The parent phenol (250 mg), triethyl(phenyl)ammonium bromide (687 mg), iodomethane (200 mg), and sodium hydroxide (100 mg) were stirred vigorously in a mixture of dichloromethane (30 cm^3) and water (15 cm^3) under nitrogen for 10 days. The aqueous phase was separated and extracted with dichloromethane (2 × 50 cm^3) and the extracts were then combined with the organic phase. After being washed successively with water (2 × 20 cm^3) and brine (20 cm^3), the solution was dried and evaporated. The solid residue was then chromatographed with dichloromethane–light petroleum (1:1) as eluant to give the required *methyl ether* (**36**; R = Me) (236 mg, 89%) as prisms, m.p. 110—111 °C; $\lambda_{max.}$ 236, 243sh, 254sh, and 265 nm; $\nu_{max.}$(Nujol) 3 370, 1 610, and 1 200 cm^{-1}; δ_H($CDCl_3$) 7.72 (1 H, br s, NH), 7.59 (1 H, s, 5-H), 7.20 (1 H, s, 8-H), 7.06 (1 H, d, *J* 7.2 Hz, 2-H), 6.87 (1 H, d, *J* 7.2 Hz, 3-H), 6.09 (1 H, m, C*H*=CH_2), 5.13—5.04 (2 H, m, CH=CH_2), 3.93 (3 H, s, OMe), 3.54 (2 H, d, *J* 6.6 Hz, CH_2CH=CH_2), 2.82 (3 H, s, 4-Me), and 2.46 (3 H, s, 1-Me); *m/z* 265 (100%, M^+), 250 (20), and 235 (40) (Found: C, 81.5; H, 7.3; N, 5.2. $C_{18}H_{19}NO$ requires C, 81.5; H, 7.2; N, 5.3%).

(E,Z)-5,8-*Dimethyl*-4-(*prop*-1-*enyl*)*carbazol*-3-*ol* (**37**).—A solution of the hydroxycarbazole (**35**) (100 mg) in dry benzene (100 cm^3) was heated at reflux with bis(acetonitrile)palladium(II) chloride (10 mg) under nitrogen for 7 h. After removal of the solvent, column chromatography of the residue on flash silica and elution with ethyl acetate–light petroleum (1:4) gave two products. The more polar was (E)-5,8-*dimethyl*-4-(*prop*-1-*enyl*)-*carbazol*-3-*ol* (66 mg, 66%), δ_H[$(CD_3)_2CO$] 10.03 (1 H, br s, NH), 7.28 (1 H, d, *J* 8.4 Hz, 1-H), 7.02 (1 H, d, *J* 7.3 Hz, 7-H), 7.00 (1 H, s, OH), 6.99 (1 H, d, *J* 8.4 Hz, 2-H), 6.95 (1 H, dq, J_1 16.1, J_2 1.8 Hz, C*H*=CHMe), 6.78 (1 H, d, *J* 7.3 Hz, 6-H), 5.97 (1 H, dq, J_1 16.1, J_2 6.6 Hz, CH=C*H*Me), 2.79 (3 H, s, 5-Me), 2.49 (3 H, s, 8-Me), and 1.99 (3 H, dd, J_1 6.6, J_2 1.8 Hz, CH=CH*Me*) (Found: M^+, 251.1313. $C_{17}H_{17}NO$ requires *M*, 251.1310).

The less polar isomer, (Z)-5,8-*dimethyl*-4-(*prop*-1-*enyl*)-*carbazol*-3-*ol*, was also obtained as an oil (17 mg, 17%); δ_H[$(CD_3)_2CO$] 10.13 (1 H, br s, NH), 7.36 (1 H, d, *J* 8.4 Hz, 1-H), 7.03 (1 H, d, *J* 8.4 Hz, 2-H), 7.02 (1 H, d, *J* 7.7 Hz, 7-H), 6.94 (1 H, dq, J_1 11.0, J_2 1.8 Hz, C*H*=CHMe), 6.76 (1 H, d, *J* 7.7 Hz, 6-H), 6.75 (1 H, s, OH), 6.09 (1 H, dq, J_1 11.0, J_2 6.6 Hz,

CH=C*H*Me), 2.79 (3 H, s, 5-Me), 2.50 (3 H, s, 8-Me), and 1.51 (3 H, dd, J_1 6.6, J_2 1.8 Hz, CH=CH*Me*) (Found: M^+, 251.1308).

3-[1-(2,2-*Dimethoxyethylamino*)*pentyl*]-6-*methoxy*-1,4-*dimethylcarbazole* (**39**).—1.55M Butyl-lithium in hexane (4.26 cm^3, 6.6 mmol) was added dropwise to a solution of 3-[(2,2-dimethoxyethyl)iminomethyl]-6-methoxy-1,4-dimethylcarbazole (**5**; R^1 = OMe, R^2 = H) (1.02 g, 3 mmol) in dry THF (20 cm^3) at −78 °C under dry nitrogen. The mixture was kept at −78 °C for 40 min, then allowed to warm to 0 °C. Saturated aqueous ammonium chloride (60 cm^3) was added, and the mixture was thoroughly stirred for 10 min. The phases were separated, and the aqueous phase was extracted with ethyl acetate (3 × 30 cm^3). The combined, dried organic layers were evaporated under reduced pressure and the resulting orange oil was purified by flash column chromatography (ethyl acetate) to afford the *title compound* (**39**) as a pale yellow hygroscopic foam (0.63 g, 53%); $\lambda_{max.}$ 236 (41 300), 246 (36 800), 268 (16 300), 299 (19 000), 340 (4 650), and 353 nm (4 600); $\nu_{max.}(CHBr_3)$ 3 460 and 2 830 cm^{-1}; $\delta_H(CDCl_3)$ 7.92 (1 H, br s, ring NH), 7.76 (1 H, d, *J* 2 Hz, 5-H), 7.38 (1 H, d, *J* 9 Hz, 8-H), 7.28 (1 H, s, 2-H), 7.06 (1 H, dd, J_1 9, J_2 2 Hz, 7-H), 4.45 [1 H, t, *J* 6 Hz, C*H*(OMe)$_2$], 4.18 (1 H, t, *J* 7 Hz, CH_2CHNH), 3.92 (3 H, s, ArO*Me*), 3.34 and 3.26 [2 × 3 H, 2 s, (OMe)$_2$], 2.82 (3 H, s, 4-Me), 27—2.5 [2 H, m, CH_2CH(OMe)$_2$], 2.5 (3 H, s, 1-Me), 1.9—1.7 (3 H, s, NH and CH_2CH_2CHNH), 1.4—1.2 (4 H, m, MeCH_2CH_2), 0.82 (3 H, t, *J* 8 Hz, *Me*CH_2) (Found: C, 72.0; H, 8.5; N, 6.8. $C_{24}H_{34}N_2O_3$ requires C, 72.3; H, 8.6; N, 7.0%).

3-{1-[N-(2,2-*Dimethoxyethyl*)-N-(4-*tosyl*)*amino*]*pentyl*}-6-*methoxy*-1,4-*dimethylcarbazole* (**40**).—A mixture of toluene-4-sulphonyl chloride (0.21 g, 1.0 mmol), the secondary amine (**39**) (0.30 g, 0.08 mmol), sodium carbonate (0.12 g, 1.0 mmol), water (9 cm^3), and THF (45 cm^3) was stirred overnight at room temperature. Additional portions of toluene-4-sulphonyl chloride (0.21 g, and 0.31 g) and sodium carbonate (0.12 g and 18 g) were added after 16 and 24 h, and the mixture was stirred for 48 h after the final addition. 2M Aqueous sodium hydroxide (2 cm^3) was added and the mixture was stirred for 15 min. Water (45 cm^3) was added, and the mixture was extracted with ethyl acetate (3 × 15 cm^3). The combined, dried extracts were evaporated under reduced pressure to afford an orange oil, which was purified by flash column chromatography (ethyl acetate–hexane, 3:7) to afford the *title compound* as a white foam (0.4 g, 78%); $\nu_{max.}(CHBr_3)$ 3 460 (NH) and 2 830 cm^{-1} (OMe); δ_H[(CD)$_3$SO] 9.37 (1 H, br s, NH), 7.67 (1 H, d, *J* 2 Hz, 5-H), 7.52 (2 H, $\frac{1}{2}$AA′BB′, *J* 9 Hz, $\frac{1}{2}SO_2C_6H_4$), 7.4 (1 H, d, *J* 9 Hz, 8-H), 7.13—7.0 (4 H, m and $\frac{1}{2}$AA′BB′, 2- and 7-H and $\frac{1}{2}SO_2C_6H_4$), 5.4 [1 H, m, (MeO)$_2$C*H*CH$_2$], 3.91 (4 H, m s, ArO*Me* and NC*H*CH$_2$), 3.95 (6 H, br s, 2 × OMe), 3.41—3.26 [2 H, m, (MeO)$_2$CHCH_2], 3.05 (3 H, s, 4-Me), 2.24 (3 H, s, $SO_2C_6H_4$*Me*), 2.05 (3 H, s, 1-Me), 2.07—1.97 (2 H, m, NCHCH_2), 1.36—1.05 (4 H, m, Me$CH_2CH_2CH_2$), and 0.82 (3 H, t, *J* 8 Hz, *Me*CH_2) (Found: C, 67.2; H, 7.1; N, 5.2. $C_{31}H_{40}N_2O_5S$ requires C, 67.4; H, 7.3; N, 5.1%).

7,15-*Dibutyl*-2,12-*dimethoxy*-6,8,14,16-*tetramethyl*-5,7,9,15-*tetrahydrobenzo*[1,2-b; 5,4-b′]*dicarbazole* (**41**).—A solution of the sulphonamide (**40**) (86 mg) in a mixture of 1,4-dioxane (4 cm^3) and 5M hydrochloric acid (2 cm^3) was stirred at room temperature overnight. The resulting green solution was diluted with water (10 cm^3), made basic by addition of 2M aqueous sodium carbonate, and extracted with ethyl acetate (3 × 15 cm^3). The combined, dried extracts were evaporated under reduced pressure, and the residue was purified by flash chromatography with ethyl acetate as eluant to afford the title compound as a solid (35 mg), m.p. 279—281 °C; $\lambda_{max.}$ 233, 245, 269, 298, 339, and 352 nm; δ_H [(CD)$_3$SO] 7.9—7.7 (4 H, m, 2 × NH, and 1- and 13-H), 7.39—7.27 (2 H, m, 4- and 10-H), 7.11—7.00 (2 H, m, 3- and 11-H), 3.97 (6 H, s, 2 × OMe), 3.00—2.82 (2 H, m, 7- and 15-H), 2.30—2.03 (12 H, m, 4 × Ar*Me*), 1.88—1.04 (12 H, 2 m, 2 × $CH_2CH_2CH_2$), and 0.97—0.76 (6 H, br t, 2 × *Me*CH_2); *m/z* 586 (8%), 529 (8), and 125 (100) (Found: M^+, 586.3553. $C_{40}H_{46}N_2O_2$ requires *M*, 586.3559).

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