Synthesis of (±)-ω-Aza[x.y.1]bicycloalkanes by an Intramolecular Mannich Reaction

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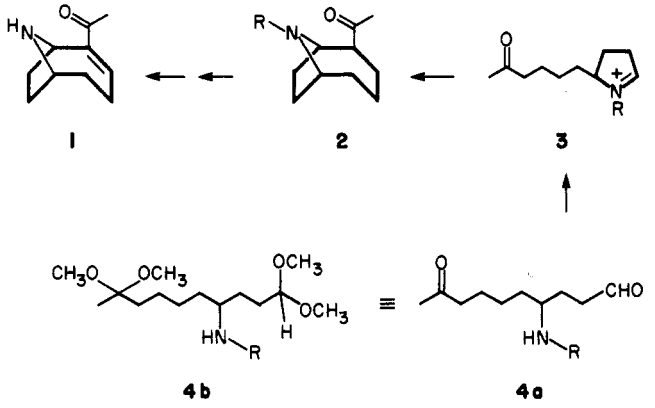
Nine acyclic acetal ketal benzylamines have been synthesized and their cyclization reactions in acidic methanol have been examined. In three cases, bicyclic amines—a tropane, a granatanine, and a homotropane—are formed. In five cases, cyclic iminium salts which do not undergo further bicyclization are formed, and these salts were reduced to afford three 2,5-disubstituted pyrrolidines and two substituted piperidines. In the one case requiring seven-membered ring formation, no iminium salt formation was observed.

The venerable Mannich reaction provides a classical and efficient process for the synthesis of a broad range of heterocyclic compounds. We have previously reported the application of this method to a general synthesis of 1-aza[x.y.0]bicycloalkanes based on the reaction of malonates with iminium salts,[1] the Mannich intermediates, and the limitations of this route for the synthesis of the homotropane, anatoxin *a* (**1**).[2a] Our successful completion of



the anatoxin synthesis was based on the reaction of a ketone with an iminium salt.[2a,2b] We now report a concise synthesis of homotropane **2**, an intermediate in the anatoxin synthesis,[2b] as well as extension of this methodology to the tropane and granatanine ring systems. These ring systems are of importance because of the diverse array of biological activities shown by their derivatives.[3]

Our earlier work made use of iminium salts **3** generated from α-amino acids; however, these salts may also be generated from amino aldehydes such as **4a** or their protected equivalents **4b**.[4] We have prepared nine compounds related to **4** in four steps by α,α′-alkylations of hydrazones, followed by hydrazone hydrolysis and reductive amination, and examined their cyclization reactions.

Results and Discussion

Acyclic Acetal Ketal Amines. The syntheses of amines **17a–i** are outlined in Scheme I. Our first efforts were directed toward **17g**, the homotropane precursor. Alkylation of acetone dimethylhydrazone[5] with bromo ketal **5**[6] gave hydrazone **7** in 93% yield. The crude product was predominantly (*Z*)-**7** which isomerized to give mostly (*E*)-**7** during distillation. A second alkylation with bromoacetaldehyde dimethyl acetal (**14a**) required the addition of HMPT. In the absence of HMPT, less than 10% of the desired α,α′-dialkylated hydrazone **15g** was formed. Attempts to reverse the order of alkylation were unsuccessful, but dimethoxypentanone **12**[7] was readily converted to hydrazone **13**,[5b] and alkylation of this hydrazone with bromo ketal **5** gave a 91% yield of **15g**. The crude **15g** reflected the stereochemistry of the starting hydrazone (**7** or **13**) but isomerization occurs on distillation. The hydrazones **15h** and **15i** were prepared by the alkylation of **7** with bromo acetals **14b**[8] and **14c**,[9] respectively. In a similar fashion, we prepared dialkylated hydrazones **15d–f** from iodo ketal **8**[10] and bromo acetals **14a–c**.

We had anticipated that hydrazone **11** would be difficult to prepare by an alkylation reaction and therefore investigated the preparation of monoketal **10** from 2,5-hexanedione instead. In analogy to the reported procedure for 2,6-heptanedione,[11] monoketal **10** was obtained in modest yield and purified via its bisulfite adduct. Hydrazone formation (94%) and subsequent alkylations occurred uneventfully to give **15a–c**.

Catalytic hydrogenation over Rh, Pt, or Pd catalysts failed to reduce hydrazone **15g** directly to the primary amine. As an alternative path to the amines via the ketones, we employed copper-assisted hydrolysis of the hydrazones **15**. This method gave the ketones **16** in 80–90% yield and $Cu(OAc)_2$ was superior to $CuCl_2$ for this purpose.[12] Traces of nitrogen containing compounds were removed from the ketones by washing with dilute phosphoric acid. At this stage we addressed the question of regioselectivity in the hydrazone alkylations.[13] Analysis of the ketones was preferable to examining the hydrazones directly because they were all mixtures of *Z* and *E* isomers.

The ketone which would be derived from the undesired methylene alkylation of hydrazone **11** with bromo acetal **14c** is the methyl ketone **18**. Ketone **18** should show a three proton singlet near 2.15 ppm in its ^1H NMR while the desired **16c** should show no ^1H absorptions from 2.05–2.35 ppm. Samples of ketone **16c** were doped with 1.7 and 3.4 mol % of methyl ketone **10** (as a model for **18**)

(1) Csendes, I. G.; Lee, Y. Y.; Padgett, H. C.; Rapoport, H. *J. Org. Chem.* **1979**, *44*, 4173.
(2) (a) Bates, H. A.; Rapoport, H. *J. Am. Chem. Soc.* **1979**, *101*, 1259. (b) Petersen, J. S.; Fels, G.; Rapoport, H. *J. Am. Chem. Soc.*, in press.
(3) Clarke, R. L. "The Alkaloids"; Manske, R. H. F., Ed.; Academic Press: New York, 1977; Vol. 16, p 83.
(4) Tramoutini, M. *Synthesis* **1973**, 703.
(5) (a) Whitesell, J. K.; Whitesell, M. A. *Synthesis* **1983**, 517. (b) Stork, G.; Benaim, J. *J. Am. Chem. Soc.* **1971**, *93*, 5938. Corey, E. J.; Enders, D. *Chem. Ber.* **1978**, *111*, 1337.
(6) Collonges, F.; Descotes, G. *Bull. Soc. Chim. Fr.* **1973**, 3491.
(7) Iwasaki, T.; Nishitani, T.; Horikawa, H.; Inoue, I. *J. Org. Chem.* **1982**, *47*, 3799.
(8) Battersby, A. R.; Buckley, D. G.; Staunton, J.; Williams, P. J. *J. Chem. Soc., Perkin Trans. 1* **1979**, 2550.
(9) Vedejs, E.; Arnost, M. J.; Hagen, J. P. *J. Org. Chem.* **1979**, *44*, 3230. The bromo aldehyde was converted to the bromo acetal with trimethyl orthoformate in methanol containing catalytic NH_4Cl.
(10) Trost, B. M.; Kunz, R. A. *J. Am. Chem. Soc.* **1975**, *97*, 7132.
(11) Micheli, R. A.; Hajos, Z. G.; Cohen, N.; Parrish, D. R.; Portland, C. A.; Sciamanna, W.; Scott, M. A.; Wehrli, P. A. *J. Org. Chem.* **1975**, *40*, 675.
(12) Corey, E. J.; Knapp, S. *Tetrahedron Lett.* **1976**, 3667.
(13) Ludwig, J. W.; Newcomb, M.; Bergbreiter, D. E. *J. Org. Chem.* **1980**, *45*, 4666 and references cited therein.

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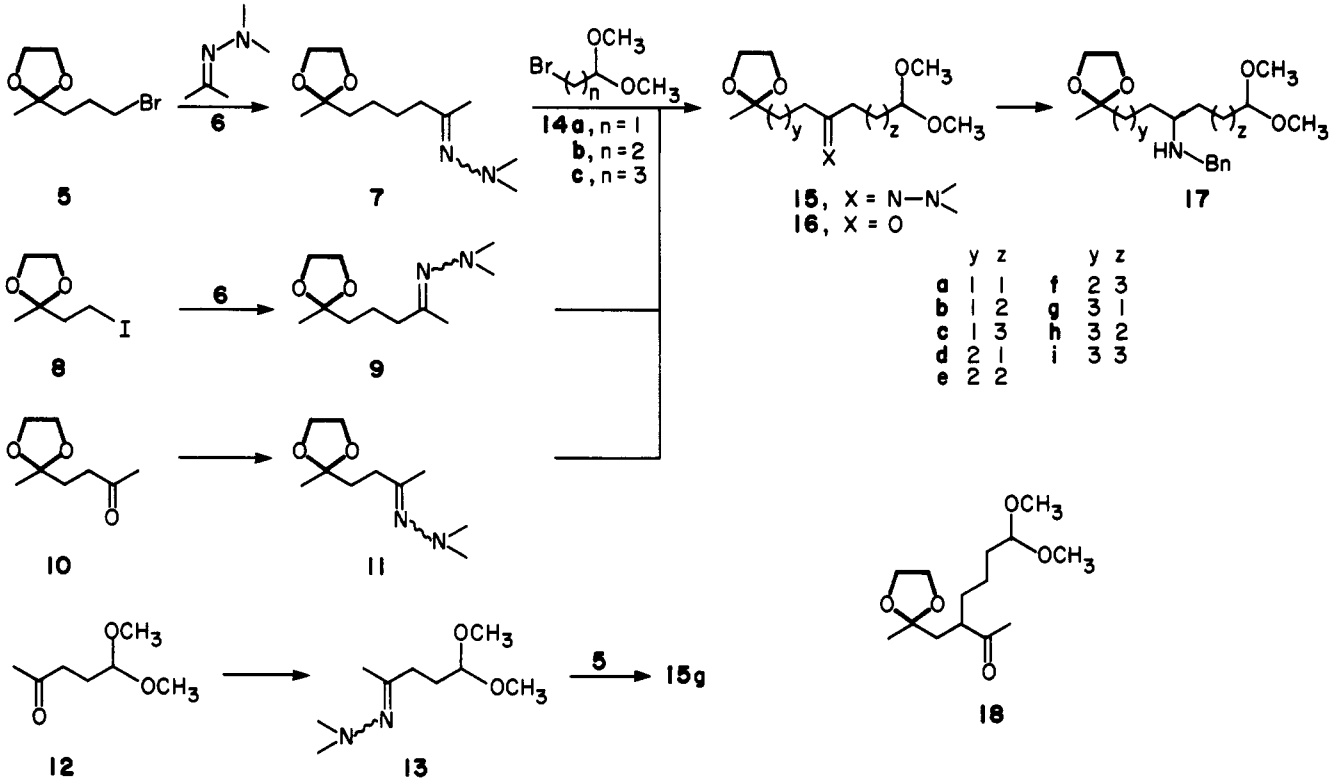
Scheme I. Synthesis of Acetal Ketal Benzylamines



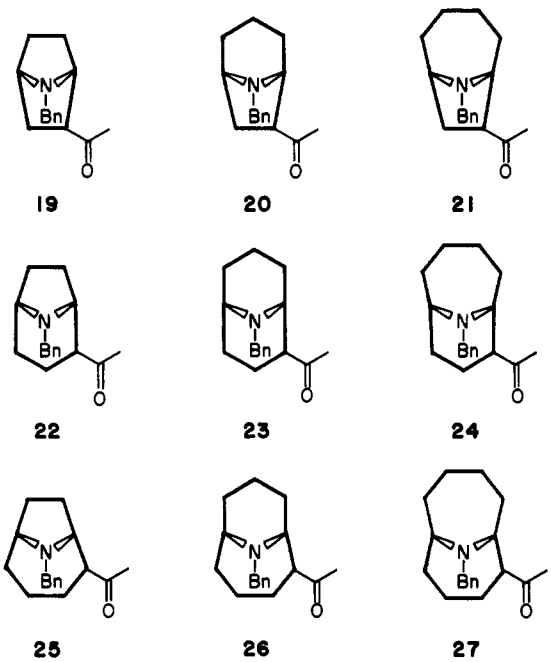
and examined by ^{1}H NMR. Analysis showed that **16c** did contain a methyl ketone impurity at the 1–2% level. The impurity may be ketone **10** from incomplete alkylation of **11**, as supported by the coincidence of chemical shifts in doped samples, but also could be methyl ketone **18**, the product from methylene alkylation of hydrazone **11**, or perhaps a product from adventitious ketal cleavage. All the ketones **16** were greater than 98% pure by this ^{1}H NMR analysis, indicating that the regioselectivity of hydrazone alkylation is at least 50/1 and that no significant ketal cleavage occurs during hydrazone hydrolysis.

Treatment of the ketones with benzylamine and catalytic benzoic acid gave the imines which were then reduced with sodium borohydride to afford amines **17a–i** in 80–85% yield after chromatography.[14]

Cyclizations of Benzylamines 17. The bicyclic β-amino ketones which potentially would be obtained from initial iminium salt formation with the aldehyde and subsequent Mannich reaction with the ketone are shown in Scheme II. The products **20** and **22** represent the same tropane ring system but the appended ketone is transposed from the five- to the six-membered ring. Homotropanes **21** and **25** and homogranatanines **24** and **26** are related in the same manner. Along the diagonal, bicycles **19**, **23**, and **27** uniquely present the [2.2.1]-, [3.3.1]-, and [4.4.1]azabicycloalkanes. We first investigated the cyclization of **17g** which should give homotropane **25**.

The iminium salt forms readily at room temperature in MeOD/D_2O/DCl as established by ^{1}H NMR, but no cyclization occurs at room temperature. Catalytic reduction of this solution over Pt on carbon gives pyrrolidine **39**. At 38 °C cyclization is very slow and gives about 10% bicycle after 16 h. At 50 °C the equilibrium product mixture was reached after 48 h, while at 60 °C a similar mixture was obtained after 20–24 h. Higher temperatures gave less favorable product mixtures. That the mixture of products we obtained does in fact represent an equilibrium was established by subjecting bicycle **25** to the reaction conditions. Under the best conditions a 47% yield of the homotropane as a mixture of diastereomers was obtained along with 34% of pyrrolidine **39** after a reductive isolation.

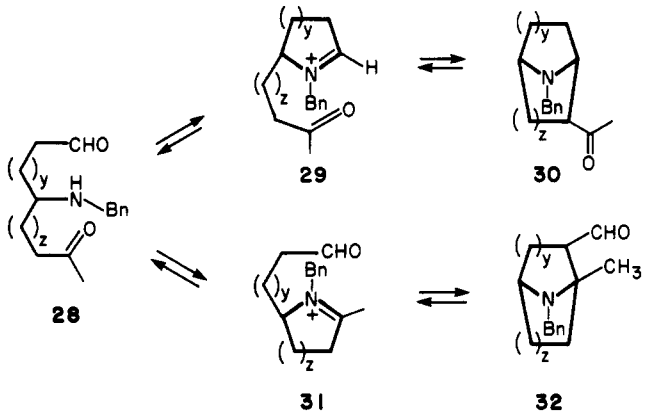
Scheme II. Potential Bicyclic β-Amino Ketones from Cyclization of Benzylamines 17



The cyclizations of the remaining amines **17** were all conducted in MeOH/H_2O/HCl solutions at 55–60 °C. We expected to find products derived from the various equilibria depicted in Scheme III. Surprisingly, each of the remaining eight amines shows a strong tendency to exist as a single compound of the five possibilities shown in Scheme III. The amines **17d** and **17e** cyclize to give, respectively, the tropane **22** (92%) and the granatanine **23** (78%), which are easily purified by distillation. In both

(14) Rai, M.; Singh, A. *Indian J. Chem., Sect. B* **1976**, *14B*, 377.

Scheme III. Equilibria Involved in Aldehydo Keto Amine Cyclizations



cases the crude products are mostly the α-ketones which partially isomerize to the β-ketones on distillation. These assignments are based on ^{1}H NMR, which shows the benzylic methylene as a quartet and upfield shifts for the methyl ketones in β-**22** and β-**23**. In the α-ketones, the distance between these groups is too large to allow interaction, thus the benzylic methylene appears as a singlet and the methyl ketones show more usual chemical shifts. Synthesis of the [4.2.1]- and [3.3.1]bicycles by the intramolecular Mannich reaction is regiospecific in contrast to synthesis from cyclooctadiene or its derivatives which give mixtures of isomers.[15]

The amines **17a–c** do not cyclize to form bicycles **19**, **20**, and **21**, respectively, but react through the methyl ketone to give very stable pyrrolinium salts **31**. Catalytic reduction and acidic hydrolysis give the amino aldehydes **33a–c** which were characterized as amino acetals **34a–c**. Both **33** and **34** appear to be 93/7, cis/trans, mixtures of diastereomers by ^{1}H NMR. In similar fashion, **17f** gave the 2,6-disubstituted piperidine **35b** (81% yield) as a 1/1 mixture of diastereomers. While **17h** cyclizes through the aldehyde none of the bicycle **26** is formed. Trapping the iminium salt by catalytic reduction gives amino ketone **36a** while sodium cyanoborohydride reduction gives amino alcohol **36b**. Finally, amine **17i** did not form an iminium salt and reduction with cyanoborohydride gives amino diol **37**. Catalytic hydrogenation gave a complex mixture of products but none of the azepine **38** was obtained. These results are depicted in Scheme IV.

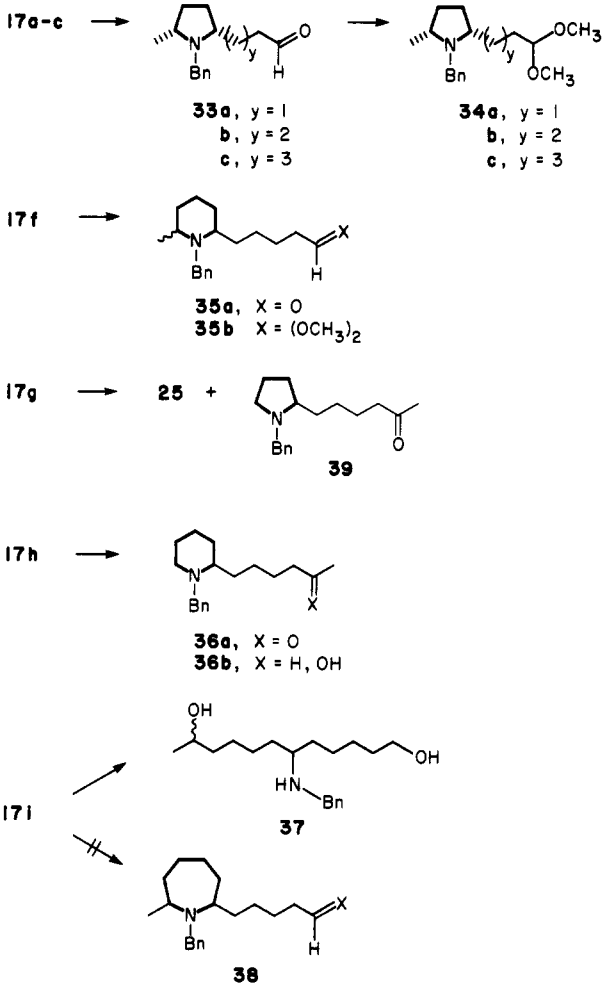
Of these failures to observe bicycle formation, we were particularly struck by the failure to obtain tropane **20** which should be energetically very similar to tropane **22**. However, attempted cyclization at lower and higher temperatures failed to give **20**. This indicates that the methyl-substituted pyrrolinium salts **31** are much more stable than their unsubstituted counterparts **29**. Thus while cyclization of ketal acetal amines does provide short (5 steps), convenient syntheses of tropane **22**, granatanine **23**, and homotropane **25**, this method is apparently limited to these bicycles.

Experimental Section

General Methods. Tetrahydrofuran (THF) was distilled from sodium/benzophenone. Toluene was distilled from sodium/benzophenone and stored over 3-nm molecular sieves. Hexamethylphosphoramide (HMPT) was distilled from CaH_2 under reduced pressure and stored over 3-nm molecular sieves. Methanol was distilled from $Mg(OCH_3)_2$ and stored over 3-nm molecular

(15) Campbell, H. F.; Edwards, O. E.; Elder, J. W.; Kolt, R. J. *Pol. J. Chem.* **1979**, *53*, 27.

Scheme IV. Various Products from Acid Treatment of Acetal Ketal Amines followed by Reduction



sieves. Chloroform was analytical reagent grade containing 0.75% ethanol.

Boiling points are uncorrected. IR spectra were determined with a Perkin-Elmer 137 spectrophotometer using polystyrene film for calibration (1601 cm^{-1} absorption). NMR spectra were determined on the following spectrometers: Berkeley UCB-200 (^{1}H, 201.9 MHz, ^{13}C, 50.77), Berkeley UCB-250 (^{1}H, 250.8 MHz, ^{13}C, 63.07 MHz), or Berkeley BVX-300 (^{1}H, 300.2 MHz, ^{13}C 75.48 MHz); they were recorded in $CDCl_3$, and chemical shifts are reported in ppm (δ) downfield from Me_4Si (^{1}H) or relative to $CDCl_3$ at 77.0 ppm (^{13}C). Mass spectra (electron impact, 70 eV) were obtained with AEI MS-12 (low resolution) and Kratos MS-50 (high resolution) instruments. Elemental analyses were performed by the Analytical Laboratory, College of Chemistry, University of California, Berkeley.

Gas chromatography (GC) was done with a Wilkins Aerograph 600-D chromatograph by using a 6% SE-30 on a 100/120 Chromosorb W glass column (2 m). Preparative medium-pressure liquid chromatography (MPLC) was done with a Perkin-Elmer Series 1 pump, Ace Michel-Miller glass columns, 40–63 μm silica gel 60 (E. M. Reagents) and an Altex 153 UV detector. Analytical thin-layer chromatography (TLC) was done with silica gel 60 F-254 aluminum backed plates.

Unless otherwise noted reactions were carried out under a nitrogen atmosphere with magnetic stirring at room temperature. Other temperatures refer to bath temperatures. Organic solutions were dried over Na_2SO_4 unless otherwise noted then evaporated with a Berkeley rotary evaporator (water aspirator) followed by static evaporation with an oil pump. Distillations were bulb to bulb unless otherwise noted. Hydrogenations were done on a Parr apparatus with shaking at room temperature.

6-(2-Methyl-1,3-dioxolan-2-yl)-2-hexanone Dimethylhydrazone (7). A solution of acetone dimethylhydrazone (6, 10.0 g, 99.8 mmol, 197 mol %, distilled from CaH_2) in THF (160 mL)

Table I. Preparation of 15, 16, and 17

			15			16		
	y	z	method	bp, °C (0.1 torr)	yield, %	bp, °C (0.1 torr)	yield, %	17 yield, %
a	1	1	B	95	36	95	92	81
b	1	2	A	100	84	100	88	95
c	1	3	A	110	89	100	90	84
d	2	1	B	120	30	90	73	89
e	2	2	A	120	74	110	86	86
f	2	3	A	130	63	110	86	71
g	3	1	A	135	91	110	92	81
			B		60			
h	3	2	A	140	85	120	92	78
i	3	3	A	140	63	120	82	65

was cooled to −78 °C, a solution of *n*-BuLi in hexanes (48.6 mL, 76.8 mmol, 151 mol %) was added at 2.2 mL/min, and the solution was maintained at −78 °C for 0.5 h during which time a white precipitate formed. Bromo ketal **5**[6] (7.8 mL, 50.7 mmol) was added at 0.84 mL/min and the mixture was maintained at −78 °C for 1 h. Then the solution was warmed to 0 °C over a period of 1 h, maintained at 0 °C for 3 h and room temperature for 1.5 h. Methanol (10 mL) was added, and the solvent was evaporated. The residue was dissolved in water (120 mL) and extracted with Et_2O (2 × 200 mL), the Et_2O phases were washed with water (120 mL) and saturated aqueous NaCl (120 mL), the organic phases were combined, dried (K_2CO_3), filtered, and evaporated, and the residue was distilled to give hydrazone **7** as a clear oil (10.7 g, 46.9 mmol, 93% yield): bp 80 °C (0.1 torr); TLC ($MeOH/CHCl_3$, 10/90) R_f 0.50; IR 2950, 1635 cm^{-1}; ^1H NMR δ 1.30, 1.31 (3 H, two s), 1.35–1.80 (6 H, m), 1.91, 1.94 (3 H, two s), 2.21 (2 H, t, J = 7.6 Hz), 2.40, 2.43 (3 H, two s), 3.90–4.00 (4 H, m). Anal. Calcd for $C_{12}H_{24}N_2O_2$: C, 63.1; H, 10.6; N, 12.4. Found: C, 62.8; H, 10.6; N, 12.1.

5-(2-Methyl-1,3-dioxolan-2-yl)-2-pentanone Dimethylhydrazone (9). Following the same procedure as described for hydrazone **7**, the iodo ketal **8**[10] (15.0 g, 62.0 mmol) was converted to hydrazone **9** (8.67 g, 40.5 mmol, 65% yield): bp 50 °C (0.1 torr); IR 1635 cm^{-1}; ^1H NMR δ 1.31, 1.32 (3 H, two s), 1.60–1.65 (4 H, m), 1.92, 1.95 (3 H, two s), 2.15–2.25 (2 H, m), 2.40, 2.43 (6 H, two s), 3.90–4.00 (4 H, m). Anal. Calcd for $C_{11}H_{22}N_2O_2$: C, 61.7; H, 10.4; N, 13.1. Found: C, 62.0; H, 10.6; N, 13.1.

4-(2-Methyl-1,3-dioxolan-2-yl)-2-butanone (10). In analogy to the reaction of 2,6-heptanedione,[11] 2,5-hexanedione (86.7 g, 760 mmol) was converted to monoketal **10** (40.8 g, 257 mmol, 34% yield): bp 40–45 °C (0.05 torr); GC (125 °C) t_R 2.2 min; ^1H NMR δ 1.31 (3 H, s), 1.98 (2 H, t, J = 7.5 Hz), 2.15 (3 H, s), 2.51 (2 H, t, J = 7.5 Hz), 3.85–4.00 (4 H, m). Anal. Calcd for $C_8H_{14}O_3$: C, 60.7; H, 8.9. Found: C, 61.0; H, 9.0.

4-(2-Methyl-1,3-dioxolan-2-yl)-2-butanone Dimethylhydrazone (11). Monoketal **10** (4.09 g, 25.0 mmol) and 1,1-dimethylhydrazine (2.28 g, 37.9 mmol, 146 mol %) were heated at 50 °C[6b] for 17 h after which the solution was cooled, diluted with H_2O (25 mL), and extracted with CH_2Cl_2 (2 × 25 mL). The organic phases were washed with saturated aqueous NaCl (30 mL), combined, dried, filtered, evaporated, and distilled to give hydrazone **11** as a clear oil (4.89 g, 24.4 mmol, 94% yield) with a diastereomeric ratio of 85/15, E/Z: bp 55 °C (0.20 torr); GC (125 °C) t_R 4.7 min; IR 1640 cm^{-1}; ^1H NMR (E isomer) δ 1.34 (3 H, s), 1.80–1.93 (2 H, m), 1.95 (3 H, s), 2.25–2.35 (2 H, m), 2.43 (6 H, s), 3.90–4.00 (4 H, m) (Z isomer) δ 1.35 (s), 1.92 (s), 2.41 (s), 2.50–2.60 (m). Anal. Calcd for $C_{10}H_{20}N_2O_2$: C, 60.0; H, 10.1; N, 14.0. Found: C, 59.9; H, 10.2; N, 14.0.

5,5-Dimethoxy-2-pentanone Dimethylhydrazone (13). Ketone **12**[7] (6.86 g, 47.0 mmol) was treated as above to give hydrazone **13** which was purified by short-path distillation (8.24 g, 43.8 mmol, 93% yield); bp 60–63 °C (0.2 torr); GC (75 °C) t_R 9.6 min; IR 1645 cm^{-1}; ^1H NMR (E isomer) δ 1.75–1.90 (2 H, m), 1.95 (3 H, s), 2.20–2.30 (2 H, m), 2.43 (6 H, s), 3.33 (6 H, s), 4.38 (1 H, t, J = 5.6 Hz) (Z isomer) δ 1.93 (s), 2.40 (s), 3.35 (s), 4.37 (t). Anal. Calcd for $C_9H_{20}N_2O_2$: C, 57.4; H, 10.7; N, 14.9. Found: C, 57.1; H, 10.6; N, 15.0.

Alkylation of Hydrazones. 1,1-Dimethoxy-8-(2-methyl-1,3-dioxolan-2-yl)-4-octanone Dimethylhydrazone (15g). Method A. To a solution of dimethoxyhydrazone **13** (7.95 g, 42.2 mmol) in THF (85 mL) cooled to −78 °C under argon was added a solution of *n*-BuLi in hexanes (27.5 mL, 43.2 mmol, 102 mol %) at 1 mL/min. The homogeneous solution was stirred at −78 °C for 30 min, then bromo ketal **5** (6.50 mL, 42.3 mmol, 100 mol %) was added in one portion, and the solution was allowed to warm to room temperature over 2 h, stirred at room temperature 19 h, and then quenched with MeOH (2 mL). Most of the solvent was evaporated, the residue was dissolved in CH_2Cl_2 (80 mL) and washed with H_2O (80 mL) and saturated aqueous NaCl (100 mL), the aqueous phases were extracted with CH_2Cl_2 (80 mL), and the organic phases were dried, filtered, and evaporated. The residue was heated to 80 °C (0.1 torr) for 30 min to remove low-boiling impurities and distilled to give **15g** as a pale yellow oil (12.2 g, 38.6 mmol, 91% yield).

Method B. To a solution of ketal hydrazone **7** (10.7 g, 46.9 mmol) in THF (100 mL) cooled to −78 °C was added a solution of *n*-BuLi in hexanes (29.7 mL, 46.9 mmol, 100 mol %) at 1.5 mL/min. After 30 min, HMPT (40 mL) was added followed by bromo acetal **14a** (6.50 mL, 56.4 mmol, 120 mol %) and the solution was allowed to warm to room temperature. After 15 h, MeOH (5 mL) was added, most of the THF was evaporated, and the residue was dissolved in Et_2O (300 mL) and washed with water (3 × 200 mL) and saturated aqueous NaCl (200 mL). The aqueous phases were extracted with Et_2O (300 mL) and the organic phases were dried (K_2CO_3), filtered, and evaporated to give crude product. Distillation gave pure dialkylated hydrazone **15g** (9.0 g, 28 mmol, 60% yield): bp 135 °C (0.1 torr); IR 2900, 1635 cm^{-1}; ^1H NMR δ 1.30, 1.31 (3 H, two s), 1.35–1.95 (10 H, m), 2.15–2.30 (2 H, m), 2.38, 2.39 (3 H, two s), 2.35–2.50 (2 H, m), 3.33, 3.34 (6 H, two s), 3.87–3.97 (4 H, m), 4.36, 4.38 (1 H, two t, J = 5.6 Hz). Anal. Calcd for $C_{16}H_{32}N_2O_4$: C, 60.7; H, 10.2; N, 8.9. Found: C, 60.7; H, 10.0; N, 8.8.

Yields and boiling points of **15a–i** prepared by one or the other of these procedures are shown in Table I. All had satisfactory elemental analyses for C, H, and N. The IR absorption for C=N appeared at 1635–1650 cm^{-1} (not measured for **15d,e,h**). ^1H NMR spectra were similar to that of **15g** except that in **15a–c** the signals for the CH_2 groups adjacent to C=N were not separated from the other CH_2 signals.

Hydrolysis of Hydrazones. 1,1-Dimethoxy-8-(2-methyl-1,3-dioxolan-2-yl)-4-octanone (16g). A solution of hydrazone **15g** (12.2 g, 38.6 mmol) in THF (350 mL) was added to a solution of $Cu(OAc)_2 \cdot H_2O$ (16.2 g, 81.0 mmol, 210 mol %) in H_2O (350 mL). After 45 min, most of the THF was evaporated, and the solution was diluted with 1.5 M aqueous NH_4Cl (500 mL) and adjusted to pH 8 with 27% aqueous NH_4OH (several drops). This solution was extracted with CH_2Cl_2 (2 × 250 mL), the organic phases were washed with 0.1 M aqueous H_3PO_4 (2 × 200 mL) and saturated aqueous $NaHCO_3$ (1 × 200 mL), and the organic phases were combined, dried, filtered, and evaporated. The residue was heated to 80 °C (0.1 torr) for 30 min to remove low-boiling impurities and distilled to give ketone **16g** as a clear oil (9.70 g, 35.4 mmol, 92%): bp 110 °C (0.1 torr); IR 1710 cm^{-1}; ^1H NMR δ 1.30 (3 H, s), 1.30–1.70 (6 H, m), 1.83–1.93 (2 H, m), 2.43 (2 H, t, J = 7.6 Hz), 2.47 (2 H, t, J = 7.5 Hz), 3.31 (6 H, s), 3.90–4.00 (4 H, m), 4.36 (1 H, t, J = 5.5 Hz).

Yields and boiling points of **16a–i** prepared by this procedure are shown in Table I. All had satisfactory elemental analyses for C and H. The C=O IR peak appeared at 1710–1720 cm^{-1} (not measured for **16d,e,h**). The ^1H NMR spectra were all similar

except that the chain CH_2 protons were not separated in **15a**.

Conversion of Ketones to Benzylamine Derivatives. 4-(*N*-Benzylamino)-1,1-dimethoxy-8-(2-methyl-1,3-dioxolan-2-yl)octane (17g). A solution of ketone **16g** (9.68 g, 35.2 mmol), benzylamine (7.60 g, 70.9 mmol, 201 mol %), and benzoic acid (0.43 g, 3.52 mmol, 10 mol %) in toluene (150 mL) was heated at reflux in a flask equipped with a Dean–Stark apparatus. After 2 h, most of the toluene was distilled to leave approximately 30 mL of solution. This solution was cooled to 0 °C, methanol (150 mL) and sodium borohydride (2.67 g, 70.6 mmol, 200 mol %) were added, and the solution was stirred at 0 °C (30 min) and room temperature (1 h). Most of the solvent was evaporated, the residue was dissolved in H_2O (50 mL) and saturated $NaHCO_3$ (100 mL) and extracted with CH_2Cl_2 (2 × 100 mL), and the organic phases were washed with 75% saturated $NaHCO_3$ (150 mL), combined, dried, filtered, and evaporated to a yellow oil. MPLC ($MeOH/CHCl_3$, 3/97) gave amine **17g** as a clear oil (10.5 g, 28.7 mmol, 81%). An analytical sample was prepared by distillation: IR 1450, 1370 cm^{-1}; ^1H NMR δ 1.31 (3 H, s), 1.28–1.76 (12 H, m), 2.50–2.57 (1 H, m), 3.31 (6 H, s), 3.75 (2 H, s), 3.88–3.97 (4 H, m), 4.35 (1 H, t, J = 5.7 Hz), 7.20–7.40 (5 H, m).

Yields of **17a–i** so prepared are given in Table I. All had satisfactory elemental analyses for C, H, and N; two IR peaks appeared in the ranges 1350–1380 and 1450–1460 cm^{-1}. All ^1H NMR spectra were similar to that of **17g**.

1-Benzyl-2-(5-oxohexyl)pyrrolidine (39). Amine **17g** (173 mg, 0.47 mmol) was dissolved in methanol (11 mL), 12 M aqueous HCl (1 mL) was added, and the solution was degassed with argon and maintained at room temperature for 5 h. The solution was degassed again (N_2), 5% platinum on carbon (16 mg, 9 wt%) was added, the mixture was hydrogenated at 14 psig for 15 min and then filtered, and most of the methanol was evaporated. Water (20 mL) was added, the solution was cooled to 0 °C, and K_2CO_3 (s) was added to pH 10. This aqueous solution was extracted with CH_2Cl_2 (3 × 20 mL) and the organic phases dried, filtered, and evaporated to give racemic pyrrolidine **39** (114 mg, 0.44 mmol, 93% yield), identical, except for fotation, with optically active **39** prepared previously.[2b]

1-Acetyl-9-benzyl-9-azabicyclo[4.2.1]nonane (25). To amine **17g** (2.08 g, 5.69 mmol), dissolved in methanol (120 mL), was added 12 M aqueous HCl (10 mL) and the solution was degassed with argon and heated to 58 °C for 22 h. The solution was then cooled to room temperature, 5% Pt on carbon (190 mg, 9 wt%) was added, the mixture was hydrogenated (10 psig) for 15 min and filtered, and most of the methanol was evaporated. Water (80 mL) was added, the solution was washed with Et_2O (80 mL), the Et_2O was extracted with 0.5 M HCl (20 mL), the combined aqueous phases were cooled to 0 °C, and K_2CO_3 (s) was added to pH 7. Then 1 M aqueous K_2CO_3 (30 mL) was added, the solution was extracted with CH_2Cl_2 (3 × 50 mL), the CH_2Cl_2 phases were dried, filtered, and evaporated, and MPLC ($CHCl_3$) of the residue gave **25** (691 mg, 2.69 mmol, 47% yield) as a mixture of diastereomers (α/β, 30/70). Further elution (TEA/$CHCl_3$, 1/99) gave the racemic monocycle **39** (500 mg, 1.93 mmol, 34% yield), identical with the optically active compounds prepared previously[2b] except for rotation. α-**25** (minor diastereomer): TLC ($MeOH/CHCl_3$, 10/90) R_f 0.71; ^1H NMR δ 1.20–2.40 (10 H, m), 2.00 (3 H, s), 2.82–2.95 (1 H, m), 3.27–3.40 (1 H, m), 3.66 (1 H, ddd, J = 2.0, 4.1, 8.7 Hz), 3.84 (2 H, s), 7.15–7.45 (5 H, m); ^{13}C NMR δ 23.0, 25.3, 29.1, 31.8, 35.4, 57.8, 58.5, 61.3, 63.6, 126.8, 128.1, 210.8. β-**25** (major diastereomer): TLC ($MeOH/CHCl_3$, 10/90) R_f 0.48; IR 1705 cm^{-1}; ^1H NMR δ 1.30–1.85 (8 H, m), 1.90–2.20 (1 H, m), 1.98 (3 H, s), 2.22–2.50 (2 H, m), 3.22–3.32 (1 H, m), 3.55 (1 H, ddd, J = 0.9, 4.7, 9.5 Hz); ^{13}C NMR δ 22.7, 27.0, 27.1, 27.6, 33.0, 36.5, 61.2, 61.5, 63.4, 64.0, 126.6, 127.9, 128.5, 140.9, 211.4; mass spectrum, m/z (relative intensity) 258 (1), 257 (44), 214 (16), 186 (13), 91 (100); exact mass calcd for $C_{17}H_{23}NO$, mz 257.1779, found 257.1777.

1-Acetyl-8-benzyl-8-azabicyclo[3.2.1]octane (22). To amine **17d** (139 mg, 0.39 mmol) dissolved in methanol (11 mL) was added 12 M aqueous HCl (1 mL), the solution was degassed with argon and heated to 58 °C for 21 h and then cooled to room temperature, and the methanol was evaporated. The residue was dissolved in water (20 mL), cooled to 0 °C, K_2CO_3 (s) was added to pH 7, then 1 M aqueous K_2CO_3 (5 mL) was added, and the solution was extracted with CH_2Cl_2 (3 × 20 mL). The organic phases were dried, filtered, and evaporated to give a 3/1 mixture of α-**22** and β-**22**. Distillation gave analytically pure tropane **22** (89 mg, 0.37 mmol, 92% yield, α/β, 60/40). α-**22**: bp 110 °C (0.1 torr); TLC ($MeOH/CHCl_3$, 3/97) R_f 0.26; IR 1705 cm^{-1}; ^1H NMR δ 1.20–2.30 (8 H, m), 2.04 (3 H, s), 2.80–2.95 (1 H, m), 3.10–3.20 (1 H, m), 3.40–3.50 (1 H, m), 3.85 (2 H, s), 7.20–7.45 (5 H, m); ^{13}C NMR δ 18.6, 23.8, 26.2, 28.4, 29.9, 53.3, 56.5, 58.8, 60.5, 126.9, 128.2, 128.5, 139.7, 210.0. Anal. Calcd for $C_{16}H_{21}NO$: C, 79.0; H, 8.7; N, 5.8. Found: C, 78.9; H, 8.7; N, 5.7. β-**22**: ^1H NMR δ 1.85 (s), 3.31 (d, J = 12.9 Hz), 3.41 (d, J = 12.9 Hz); ^{13}C NMR δ 16.7, 25.7, 26.4, 27.4, 30.4, 54.7, 58.4, 61.2, 61.3, 126.9, 128.0, 129.0, 139.5, 208.8.

1-Acetyl-9-benzyl-9-azabicyclo[3.3.1]nonane (23). In analogy to the preparation of **22**, amine **17e** (166 mg, 0.45 mmol) was converted to a 60/40 mixture of α-**23** to β-**23**. Distillation gave analytically pure granatanine **23** (α/β, 55/45, 91 mg, 0.35 mmol, 78% yield). MPLC ($MeOH/CHCl_3$, 3/97) allowed the isolation of pure α-**23** and β-**23** containing 10% of the α isomer. α-**23**: bp 120 °C (0.1 torr); TLC ($MeOH/CHCl_3$, 3/97) R_f 0.57; IR 1700 cm^{-1}; ^1H NMR δ 1.30–2.15 (9 H, m), 2.04 (3 H, s), 2.20–2.45 (1 H, m), 2.75–2.85 (1 H, m), 3.05–3.20 (2 H, m), 3.90 (2 H, s), 7.20–7.45 (5 H, m); ^{13}C NMR δ 20.1, 21.7, 24.6, 25.0, 28.0, 28.4, 49.4, 50.0, 52.5, 56.8, 126.8, 128.2, 128.3, 139.8, 210.7. Anal. Calcd for $C_{17}H_{23}NO$: C, 79.3; H, 9.0; N, 5.4. Found: C, 79.2; H, 9.0; N, 5.5. β-**23**: TLC ($MeOH/CHCl_3$, 3/97) R_f 0.37; ^1H NMR δ 1.20–1.55 (3 H, m), 1.60–1.80 (1 H, m), 1.85–2.30 (6 H, m), 1.92 (3 H, s), 2.40–2.50 (1 H, m), 2.77–2.87 (1 H, m), 3.22–3.30 (1 H, m), 3.77 (1 H, d, J = 13.6 Hz), 3.84 (1 H, d, J = 13.6 Hz); ^{13}C NMR δ 19.1, 20.6, 23.2, 23.3, 27.4, 27.5, 50.4, 51.6, 53.6, 56.9, 126.8, 128.0, 128.5, 139.9, 210.3.

***cis*-1-Benzyl-2-(3,3-dimethoxypropyl)-5-methylpyrrolidine (34a).** A solution of acyclic amine **17a** (160 mg, 0.47 mmol) in methanol (11 mL) and 12 M aqueous HCl (1 mL) was degassed with argon, heated to 55–60 °C for 14 h, then allowed to cool to room temperature, and degassed with nitrogen, and 5% platinum on carbon (37 mg, 23 wt%) was added. The mixture was hydrogenated at 20 psig for 20 min and filtered, most of the methanol was evaporated, and the residue was dissolved in water (20 mL), cooled to 0 °C, and adjusted to pH 7 with K_2CO_3 (s). Then 1 M aqueous K_2CO_3 (5 mL) was added and the resulting solution (pH 10–11) was extracted with CH_2Cl_2 (3 × 20 mL). The organic phases were dried, filtered, and evaporated to give crude aldehyde **33a** [^1H NMR δ 1.03 (3 H, d, J = 6.0 Hz), 3.65 (1 H, d, J = 14.2 Hz), 3.75 (1 H, d, J = 14.2 Hz), 9.59 (1 H, t, J = 2.0 Hz)], which was dissolved in methanol (5 mL), and trimethyl orthoformate (1 mL) and *p*-toluenesulfonic acid monohydrate (153 mg, 0.8 mmol) were added. After 3 h the solution was diluted with CH_2Cl_2 (30 mL) and washed with 1 M aqueous K_2CO_3 (20 mL), the aqueous phase was extracted with CH_2Cl_2 (20 mL), and the organic phases were dried, filtered, and evaporated. The residue was distilled to give analytically pure cis acetal **34a** (112 mg, 0.40 mmol, 85% yield): bp 105 °C (0.1 torr); TLC ($MeOH/CHCl_3$, 10/90) R_f 0.55; IR 1450, 1380 cm^{-1}; ^1H NMR δ .90, 1.01 (total 3 H, two d, J = 6.5, 6.0, respectively, ratio 7/93), 1.10–1.85 (8 H, m), 2.50–2.70 (2 H, m), 3.26 (6 H, s), 3.73 (2 H, s), 4.23 (1 H, t, J = 5.5 Hz), 7.15–7.40 (5 H, m); ^{13}C NMR δ 20.7, 28.7, 29.0, 30.0, 31.8, 52.5, 52.6, 56.1, 60.0, 64.2, 104.7, 126.5, 127.8, 129.0, 139.8, a small peak at 15.2 was also visible. Anal. Calcd for $C_{17}H_{27}NO_2$: C, 73.6; H, 9.8; N, 5.1. Found: C, 73.6; H, 9.7; N, 5.1.

***cis*-1-Benzyl-2-(4,4-dimethoxybutyl)-5-methylpyrrolidine (34b).** Amine **17b** was cyclized and reduced to give aldehyde **33b** which was converted to acetal **34b** in 76% overall yield. Cis aldehyde **33b**: ^1H NMR δ 1.03 (3 H, d, J = 6.0 Hz), 3.66 (1 H, d, J = 14.4 Hz), 3.76 (1 H, d, J = 14.4 Hz), 9.66 (1 H, t, J = 1.7 Hz). Cis acetal **34b**: bp 120 °C (0.1 torr); TLC ($MeOH/CHCl_3$, 10/90) R_f 0.62; IR 1450, 1370 cm^{-1}; ^1H NMR δ .91, 1.02 (total 3 H, two d, J = 6.4, 6.0 Hz, respectively, ratio 6/94), 1.10–1.90 (10 H, m), 2.45–2.70 (2 H, m), 3.28 (6 H, s), 3.72 (2 H, s), 4.30 (1 H, t, J = 5.6 Hz), 7.15–7.40 (5 H, m); ^{13}C NMR δ 20.7, 21.3, 28.9, 31.7, 32.8, 35.3, 52.59, 52.63, 56.2, 60.0, 64.8, 104.5, 126.5, 127.8, 129.0, 139.9, a small peak at 15.3 was also present. Anal. Calcd for $C_{18}H_{29}NO_2$: C, 74.2; H, 10.0; N, 4.8. Found: C, 74.2; H, 9.8; N, 4.7.

***cis*-1-Benzyl-2-(5,5-dimethoxypentyl)-5-methylpyrrolidine (34c).** Amine **17c** was cyclized and reduced to give aldehyde **33c** which was converted to acetal **34c** in 61% overall yield. Cis aldehyde **33c**: ^1H NMR δ 1.03 (3 H, d, J = 6.1 Hz), 2.33 (2 H,

d of t, J = 1.8, 7.3 Hz), 3.68 (1 H, d, J = 14.4 Hz), 3.76 (1 H, d, J = 14.4 Hz), 9.70 (1 H, t, J = 1.8 Hz). Cis acetate **34c**: bp 130 °C (0.1 torr); TLC (MeOH/$CHCl_3$, 10/90) R_f 0.66; IR 1450, 1370 cm^{-1}; ^1H NMR δ .91, 1.02 (total 3 H, two d, J = 6.3, 6.0 Hz, respectively, ratio 6/94), 1.10–1.90 (12 H, m), 2.45–2.65 (2 H, m), 3.29 (6 H, s), 3.73 (2 H, s), 4.32 (1 H, t, J = 5.7 Hz), 7.15–7.35 (5 H, m); ^{13}C NMR δ 20.8, 24.9, 26.1, 29.0, 31.8, 32.6, 35.4, 52.57, 52.62, 56.3, 60.2, 64.9, 104.6, 126.5, 127.8, 129.0, 140.1, a small peak at 15.3 was also present. Anal. Calcd for $C_{19}H_{31}NO_2$: C, 74.4; H, 10.2; N, 4.6. Found: C, 74.8; H, 10.1; N, 4.9.

1-Benzyl-2-(5,5-dimethoxypentyl)-6-methylpiperidine (35b). Amine **17f** was cyclized and reduced to give aldehyde **35a** which was converted to acetal **35b** in 81% overall yield. Aldehyde **35a**: ^1H NMR δ 1.027, 1.034 (total 3 H, two d, J = 6.35, 6.7 Hz, respectively, ratio 55/45), 2.24, 2.35 (2 H, two d of t, J = 1.9, 7.2 and 1.9, 7.3 Hz, respectively, ratio 55/45), 3.59 (d, J = 14.2 Hz), 3.70 (s), 3.76 (d, J = 14.3 Hz) (total 2 H), 9.62, 9.69 (total 1 H, two t, J = 1.9, 1.9 Hz, respectively, ratio 55/45). Acetal **35b**: bp 130 °C (0.1 torr); TLC (MeOH/$CHCl_3$, 10/90) R_f 0.66; IR 1450, 1360 cm^{-1}; ^1H NMR δ 1.01, 1.02 (total 3 H, two d, J = 6.4, 6.6 Hz, respectively, ratio 55/45), 1.10–1.90 (14 H, m), 2.4–3.0 (2 H, m), 3.26, 3.29 (total 6 H, two s, ratio 60/40), 3.58 (d, J = 14.3 Hz), 3.71 (s), 3.77 (d, J = 14.3 Hz) (total 2 H), 4.26, 4.31 (total 1 H, two t, J = 5.7, 5.8 Hz, respectively, ratio 55/45), 7.15–7.40 (5 H, m); ^{13}C NMR δ 18.1, 19.9, 22.0, 24.0, 24.8, 26.2, 26.9, 29.2, 29.6, 30.2, 32.4, 32.5, 32.7, 34.9, 49.6, 51.6, 52.5, 52.6, 52.8, 54.5, 58.1, 62.8, 104.47, 104.55, 125.8, 126.2, 127.6, 127.8, 127.9, 128.1, 141.8, 143.0. Anal. Calcd for $C_{20}H_{33}NO_2$: C, 75.2; H, 10.4; N, 4.4. Found: C, 75.3; H, 10.3; N, 4.3.

1-Benzyl-2-(5-oxohexyl)piperidine (36a). A solution of acyclic amine **17h** (148 mg, 0.39 mmol) in methanol (11 mL) and 12 M aqueous HCl (1 mL) was degassed with argon, heated to 56 °C for 12 h, allowed to cool to room temperature, and degassed with nitrogen, and 5% platinum on carbon (36 mg, 24 wt%) was added. The mixture was hydrogenated at 20 psig for 20 min and filtered, the methanol was evaporated, and the residue was dissolved in water (20 mL), cooled to 0 °C, and adjusted to pH 7 with K_2CO_3 (s). Then 1 M aqueous K_2CO_3 (5 mL) was added and the resulting solution (pH 10–11) extracted with CH_2Cl_2 (3 × 20 mL). The organic phases were dried, filtered, and evaporated, and the residue was distilled to give analytically pure ketone **36a** (93 mg, 0.34 mmol, 87% yield): bp 130 °C (0.1 torr); TLC R_f 0.62; IR 1710, 1450, 1360 cm^{-1}; ^1H NMR δ 1.20–1.75 (12 H, m), 1.95–2.10 (1 H, m), 2.11 (3 H, s), 2.20–2.35 (1 H, m), 2.42 (2 H, t, J = 7.3 Hz), 2.67–2.80 (1 H, m), 3.20 (1 H, d, J = 13.5 Hz), 3.94 (1 H, d, J = 13.5 Hz), 7.20–7.40 (5 H, m); ^{13}C NMR δ 23.6, 24.3, 25.0, 25.1, 29.8, 30.2, 31.5, 43.8, 51.7, 57.6, 60.5, 126.5, 128.0, 128.8, 139.9, 208.9. Anal. Calcd for $C_{18}H_{27}NO$: C, 79.1; H, 10.0; N, 5.1. Found: C, 78.8; H, 10.0; N, 5.2.

1-Benzyl-2-(5-hydroxyhexyl)piperidine (36b). A solution of the amine **17h** (172 mg, 0.45 mmol) in methanol (10 mL) and 12 M aqueous HCl (0.8 mL) was degassed with argon, heated to 57 °C for 24 h, and allowed to cool to room temperature, water (10 mL) was added, and the solution was cooled to 0 °C. Sodium cyanoborohydride (650 mg, 10.5 mmol, 2300 mol %) was added in three portions at 20 min intervals. The solution was maintained at room temperature for 1 h, 1 M aqueous K_2CO_3 (20 mL) was added, and the solution was extracted with CH_2Cl_2 (2 × 20 mL). The organic phases were dried, filtered, and evaporated to a clear oil which on MPLC (TEA/MeOH/$CHCl_3$, 0.3/3/97) gave amino alcohol **36b** (76 mg, 2.76 mmol, 61% yield): bp 135 °C (0.1 torr); TLC R_f 0.39; IR 3400, 1450, 1360 cm^{-1}; ^1H NMR δ 1.17 (3 H, d, J = 6.2 Hz), 1.20–1.75 (14 H, m), 1.95–2.10 (1 H, m), 2.20–2.35 (1 H, m), 2.65–2.80 (1 H, m), 3.21, 3.22 (total 1 H, two d, J = 13.5, 13.5 Hz), 3.70–3.85 (1 H, m), 3.95 (1 H, d, J = 13.5 Hz), 7.20–7.40 (5 H, m); ^{13}C NMR δ 23.4, 23.6, 25.0, 25.4, 26.2, 30.1, 31.6, 39.2, 51.6, 57.5, 60.5, 67.8, 126.5, 128.0, 128.9, 139.6; mass spectrum, m/z (relative intensity) 275 (3), 274 (2), 260 (10), 175 (56), 174 (96), 91 (100). Anal. Calcd for $C_{18}H_{29}NO$: C, 78.5; H, 10.6; N, 5.1. Found: C, 78.4; H, 10.6; N, 5.1.

6-(*N*-Benzylamino)-11-hydroxydodecanol (37). Benzylamine **17i** (174 mg, 0.44 mmol) was treated with methanolic HCl and reduced with cyanoborohydride as above to give amino diol **37** (131 mg, 0.43 mmol, 96% yield) as a clear oil: IR 3450, 1450, 1370 cm^{-1}; ^1H NMR δ 1.17 (3 H, d, J = 6.2 Hz), 1.20–1.65 (16 H, m), 2.00–2.20 (2 H, s), 2.50–2.60 (1 H, m), 3.58 (2 H, t, J = 6.6 Hz), 3.74 (2 H, s), 3.68–3.83 (1 H, m), 7.20–7.40 (5 H, m); ^{13}C NMR δ 23.4, 25.3, 25.5, 25.6, 25.9, 32.6, 33.6, 51.0, 56.39, 56.44, 62.5, 67.8, 126.8, 128.1, 128.3, 140.5; mass spectrum, m/z (relative intensity) 307 (1), 306 (2), 292 (2), 235 (1), 234 (6), 221 (19), 220 (100), 207 (10), 206 (70), 91 (96); exact mass calcd for $C_{19}H_{33}NO_2$, m/z 307.2511, found 307.2506.

Registry No. **5**, 24400-75-7; **6**, 13483-31-3; (*E*)-**7**, 90718-46-0; (*Z*)-**7**, 90719-01-0; **8**, 53750-51-9; (*E*)-**9**, 90718-47-1; (*Z*)-**9**, 90719-11-2; **10**, 33528-35-7; **10** (dione), 110-13-4; (*E*)-**11**, 90718-48-2; (*Z*)-**11**, 90718-49-3; **12**, 3209-78-7; (*E*)-**13**, 90718-50-6; (*Z*)-**13**, 90719-00-9; **14a**, 7252-83-7; **14b**, 36255-44-4; **14c**, 24157-02-6; (*E*)-**15a**, 90718-51-7; (*Z*)-**15a**, 90719-03-2; (*E*)-**15b**, 90740-84-4; (*Z*)-**15b**, 90719-04-3; (*E*)-**15c**, 90740-85-5; (*Z*)-**15c**, 90719-05-4; (*E*)-**15d**, 90718-52-8; (*Z*)-**15d**, 90719-06-5; (*E*)-**15e**, 90718-53-9; (*Z*)-**15e**, 90719-07-6; (*E*)-**15f**, 90718-54-0; (*Z*)-**15f**, 90719-08-7; (*E*)-**15g**, 90718-55-1; (*Z*)-**15g**, 90719-02-1; (*E*)-**15h**, 90718-56-2; (*Z*)-**15h**, 90719-09-8; (*E*)-**15i**, 90718-57-3; (*Z*)-**15i**, 90719-10-1; **16a**, 90718-58-4; **16b**, 90718-59-5; **16c**, 90718-60-8; **16d**, 90718-61-9; **16e**, 90718-62-0; **16f**, 90740-86-6; **16g**, 90718-63-1; **16h**, 90718-64-2; **16i**, 90718-65-3; **17a**, 90718-66-4; **17b**, 90718-67-5; **17c**, 90718-68-6; **17d**, 90718-69-7; **17e**, 90718-70-0; **17f**, 90718-71-1; **17g**, 90718-72-2; **17h**, 90718-73-3; **17i**, 90718-74-4; α-**22**, 90718-78-8; β-**22**, 90718-79-9; α-**23**, 90718-80-2; β-**23**, 90837-88-0; α-**25**, 90718-76-6; β-**25**, 90718-77-7; **33a**, 90718-81-3; *trans*-**33a**, 90718-82-4; **33b**, 90718-85-7; *trans*-**33b**, 90718-86-8; **33c**, 90718-89-1; *trans*-**33c**, 90718-90-4; **34a**, 90718-83-5; *trans*-**34a**, 90718-84-6; **34b**, 90718-87-9; *trans*-**34b**, 9078-88-0; **34c**, 90718-91-5; *trans*-**34c**, 90718-92-6; *cis*-**35a**, 90718-93-7; *trans*-**35a**, 90718-94-8; *cis*-**35b**, 90718-95-9; *trans*-**35b**, 90718-96-0; **36a**, 90718-97-1; **36b**, 90718-98-2; **37**, 90718-99-3; (±)-**39**, 90718-75-5; $(CH_3)_2NNH_2$, 57-14-7; $BnNH_2$, 100-46-9.

Supplementary Material Available: ^1H NMR peaks for **15**, **16**, and **17** (7 pages). Ordering information is given on any current masthead page.