of acetone (97% + 3% H_2O) and cooled with ice. This solution was added dropwise during stirring to an ice-cold solution of 120 mg of NBS in acetone. After complete addition, the mixture was cooled with ice for 10 min and after this period 1 mL of a saturated aqueous solution of Na_2SO_3 added. Extraction with 10 mL of hexane–CH_2Cl_2 (1:1) yielded an organic phase, which was washed with aqueous $NaHCO_3$ and dried (Na_2SO_4). After evaporation of the solvent and chromatography on silica (benzene) **23** was obtained: yield, 21 mg (63%); ^1H NMR δ 0.84 (s, 3 H, CH_3-18), 1,24 (s, 3 H, CH_3-19), 1.82 (d, 1 H), 2.08 (d, 1 H), 2.18 (dd, 1 H), 2.36 (dd, 1 H), 2.42 (m, 1 H), 2.80 (dd, 1 H), 3.08 (dd, 1 H), 3.39 (s, 3 H, OCH_3), 4.13 (d, 1 H), 4.90 (d, 1 H), 6.96 (d, 1 H), 7.59 (d, 1 H); IR 3600, 2960, 1725, 1597 cm^{-1}; mass spectrum, *m/z* (relative intensity) 341 (6), 324 (3), 227 (5), 84 (27), 71 (17), 69 (17), 57 (41), 55 (38), 43 (100). Anal. Calcd for $C_{21}H_{26}O_4$: C, 73.66; H, 7.65. Found: C, 73.40; H, 8.03.

24 was obtained by the same procedure as described for **23**. In the ^1H NMR spectrum an equilibrium of keto and enol forms could be observed: ^1H NMR (keto form) δ 1.01 (s, 3 H, CH_3-18), 1.30 (s, 3 H, CH_3-19), 2.22 (dd, 1 H), 2.63 (dd, 1 H), 2.80–3.14 (m, 1 H), 3.35 (s, 3 H, OCH_3), 4.62 (t, 1 H), 7.06 (d, 1 H), 7.69 (d, 1 H), (enol form) 0.92 (s, 3 H, CH_3-18), 1.27 (s, 3 H, CH_3-19), 2.89–3.35 (m, 3 H), 3.32 (s, 3 H, OCH_3), 4.16 (d, 1 H), 4.96 (d, 1 H), 6.96 (d, 1 H), 7.59 (d, 1 H); IR (3600, 2960, 1725, 1597 cm^{-1}; mass spectrum, *m/z* (relative intensity) 341 (6), 324 (3), 227 (5), 84 (27), 71 (17), 69 (15), 57 (41), 43 (100), 41 (54).

Registry No. **5**, 2115-43-7; **7**, 90164-49-1; **10**, 90164-55-9; **11**, 97644-60-5; **12**, 97644-61-6; **14**, 22465-61-8; **16**, 97644-62-7; **16** (enol), 97644-63-8; **17**, 97644-64-9; **18**, 97644-65-0; **19**, 97644-66-1; **20**, 97644-67-2; **21**, 97644-68-3; **22**, 97644-69-4; **23**, 97644-70-7; **24**, 97644-71-8; **24** (enol), 97644-72-9.

Directed Openings of 2,3-Epoxy Alcohols via Reactions with Isocyanates: Synthesis of (+)-*erythro*-Dihydrosphingosine

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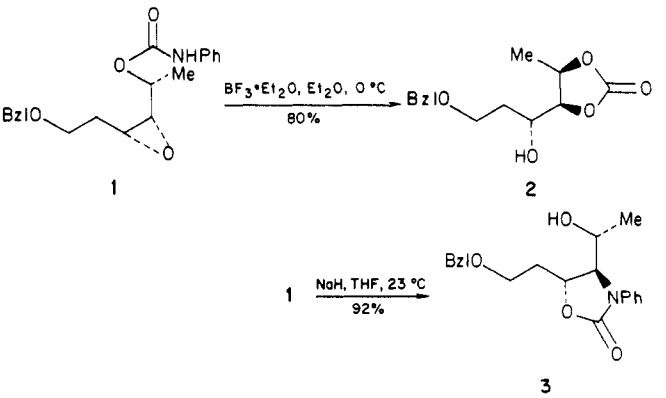
Received March 22, 1985

Two methods for the synthesis of 2-(*N*-alkylamino) 1,3-diols from 2,3-epoxy alcohols are described. In one procedure (method A) an epoxyurethane (**5**, **8**, **11**, **14**, **16**) prepared from the corresponding epoxy alcohol by standard procedures is cyclized to a 2-oxazolidinone derivative (**6**, **9**, **12**, **15**, **17**) in 81–90% yield by treatment with NaH in THF or NaOMe in MeOH. The second procedure (method B) involves treatment of the epoxy alcohol (**4**, **7**, **10**, **13**, **24**) with benzyl isocyanate, an NH_3 synthetic equivalent, and NaH in THF at reflux. Hydrolysis of the crude isoxazolidinones by exposure to LiOH in EtOH at reflux smoothly affords 2-(*N*-benzylamino) 1,3-diols (**22**, **23**, **30**, **31**) in 68–72% overall yield. These procedures are highly regioselective; products resulting from intramolecular addition of the urethane nitrogen atom to the epoxide β-position were not detected. This methodology was applied to a short, highly stereoselective synthesis of (+)-*erythro*-dihydrosphingosine (**26**) from palmitic aldehyde (47–54% overall yield).

Renewed interest in the use of 2,3-epoxy alcohols as intermediates in organic synthesis has greatly stimulated by the discovery of the Sharpless asymmetric epoxidation reaction.[2-4] Indeed, highly selective methods for converting the epoxy alcohol unit into a variety of useful functional groups via hydride reduction[5] or by nucleophilic substitution reactions (e.g., carbon,[6] oxygen,[7] and sulfur[7e,8] nucleophiles) have been developed in the past several years. During this period one of our interests has been the use of 2,3-epoxy alcohols in the synthesis of carbohydrates and related compounds.[9] We have observed, for example, that treatment of epoxyurethanes such as **1** with Lewis acids under aprotic conditions effected a



(1) Holder of the Roger and Georges Firmenich Career Development Chair in Natural Products Chemistry, 1981–1984; Fellow of the Alfred P. Sloan Foundation, 1982–1986.

(2) (a) Katsuki, T.; Sharpless, K. B. *J. Am. Chem. Soc.* **1980**, *102*, 5975. (b) Rossiter, B. E.; Katsuki, T.; Sharpless, K. B. *Ibid.* **1981**, *103*, 464. (c) Martin, V. S.; Woodward, S. S.; Katsuki, T.; Yamada, Y.; Ikeda, M.; Sharpless, K. B. *Ibid.* **1981**, *103*, 6237.

(3) For a summary of alternative diastereoselective epoxidation procedures, see: (a) Mihelich, E. D.; Daniels, K.; Eickhoff, D. J. *J. Am. Chem. Soc.* **1981**, *103*, 7690. (b) Mihelich, E. D. *Tetrahedron Lett.* **1979**, 4729. (c) Rossiter, B. E.; Verhoeven, T. R.; Sharpless, K. B. *Ibid.* **1979**, 4733. (d) Tomioka, H.; Suzuki, T.; Oshima, K.; Nozaki, H. *Ibid.* **1982**, *23*, 3387. (e) Narula, A. S. *Ibid.* **1982**, *23*, 5579.

(4) For recent reviews on the chemistry of epoxides, see: (a) Rao, A. S.; Paknikar, S. K.; Kirtane, J. G. *Tetrahedron* **1983**, *39*, 2323. (b) Sharpless, K. B.; Behrens, C. H.; Katsuki, T.; Lee, A. W. M.; Martin, V. S.; Takatani, M.; Viti, S. M.; Walker, F. J.; Woodward, S. S. *Pure Appl. Chem.* **1983**, *55*, 589. (c) Behrens, C. H.; Sharpless, K. B. *Aldrichimica Acta* **1983**, *16*, 67 and references cited therein.

(5) (a) Viti, S. M. *Tetrahedron Lett.* **1982**, *23*, 4541. (b) Finan, J. M.; Kishi, Y. *Ibid.* **1982**, *23*, 2719. (c) Ma, P.; Martin, V. S.; Masamune, S.; Sharpless, K. B.; Viti, S. M. *J. Org. Chem.* **1982**, *47*, 1378. (d) Nicolaou, K. C.; Uenishi, J. *J. Chem. Soc., Chem. Commun.* **1982**, 1292.

(6) (a) Eis, M. J.; Wrobel, J. E.; Ganem, B. *J. Am. Chem. Soc.* **1984**, *106*, 3693. (b) Wrobel, J. E.; Ganem, B. *J. Org. Chem.* **1983**, *48*, 3761. (c) Roush, W. R.; Adam, M. A.; Peseckis, S. M. *Tetrahedron Lett.* **1983**, *24*, 1377. (d) Suzuki, T.; Saimoto, H.; Tomioka, H.; Oshima, K.; Nozaki, H. *Ibid.* **1982**, *23*, 3597. (e) Johnson, M. R.; Nakata, T.; Kishi, Y. *Tetrahedron Lett.* **1979**, 4343. (f) Tius, M. A.; Fauq, A. H. *J. Org. Chem.* **1983**, *48*, 4131.

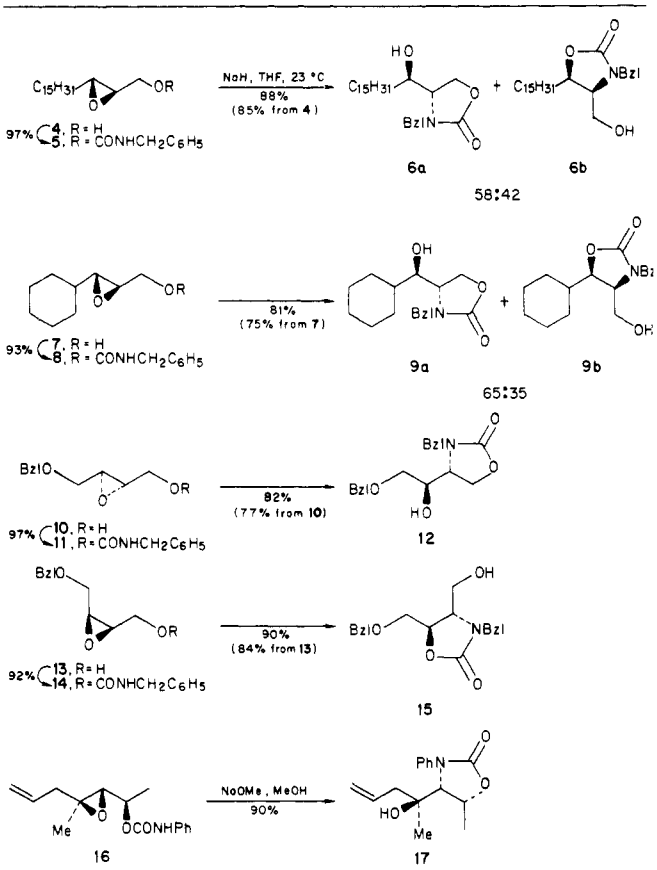
(7) (a) Roush, W. R.; Brown, R. J.; DiMare, M. *J. Org. Chem.* **1983**, *48*, 5083. (b) Roush, W. R.; Brown, R. J. *Ibid.* **1982**, *47*, 1371. (c) Minami, N.; Ko, S. S.; Kishi, Y. *J. Am. Chem. Soc.* **1982**, *104*, 1109. (d) Colvin, E. W.; Robertson, A. D.; Wakharkar, S. *J. Chem. Soc., Chem. Commun.* **1983**, 312. (e) Caron, M.; Sharpless, K. B. *J. Org. Chem.* **1985**, *50*, 1557.

(8) Katsuki, T.; Lee, A. W. M.; Ma, P.; Martin, V. S.; Masamune, S.; Sharpless, K. B.; Tuddenham, D.; Walker, R. J. *J. Org. Chem.* **1982**, *47*, 1373.

(9) (a) Roush, W. R.; Brown, R. J. *J. Org. Chem.* **1983**, *48*, 5093. (b) Roush, W. R.; Hagadorn, S. M. *Carbohydr. Res.* **1985**, *136*, 187.

0022-3263/85/1950-3752$01.50/0

Table I

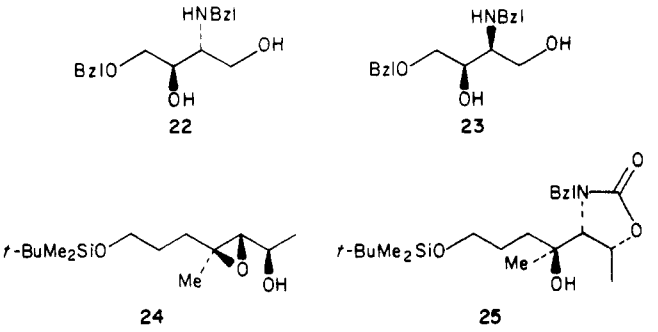


highly regioselective α-epoxide opening leading to differentiated triol derivatives **2** in excellent yield.[7a,b] Under basic conditions, however, complementary chemoselectivity occurred with internal delivery of a nitrogen nucleophile to the epoxide α-position (**1** → **3**).[10]

We recognized that the intramolecular opening of epoxides by urethane anions, if general, would nicely complement existing methodology.[11,12] Although it has been known for some time that amines add preferentially to C(3) of 2,3-epoxy alcohols,[7e,13] a satisfactory method for selective addition of nitrogen nucleophiles to C(2) of such systems was unavailable.[14] We now describe extensions of our initial study including the finding that the reaction of 2,3-epoxy alcohols with an isocyanate and NaH constitutes a convenient one-pot procedure for regioselective delivery of nitrogen nucleophiles to C(2) of epoxy alcohol systems.

Table I summarizes the results of cyclization experiments with epoxyurethanes **5**, **8**, **11**, **14**, and **16**. With one exception, best results were realized by exposure of these compounds to NaH in THF at 23 C (method A); NaOMe in MeOH was preferred in the case of **16**.[15] In contrast to the results reported by Kishi,[7c] acyl transfer was a serious problem in the cyclizations of **5**, **8**, and especially **14**, for which complete isomerization to **15** was observed. Attempts to suppress acyl transfer in the cyclization of **5** by modifying the counter ion (K^+, Na^+, Li^+), solvent, and reaction temperature were unsuccessful.

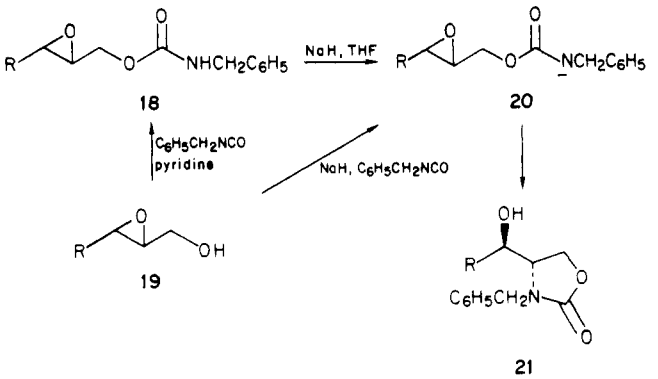
Table II



substrate	method[a]	products	yield
4	B	**6a** + **6b** (1:1)	76%
7	B	**9a** + **9b** (1:1)	81%
10	B,C	**22**	68%
13	B,C	**23**	72%
24	B	**25**	55%

[a] Method B: NaH, $C_6H_5CH_2NCO$, THF, reflux; Method C: LiOH, aqueous EtOH, reflux.

A second and more direct procedure for accomplishing these epoxide substitution reactions was developed as follows. We reasoned that the urethane anion **20**, the key intermediate in the cyclization of generalized epoxyurethane **18** to carbamate **21**, could also be generated by treatment of the parent epoxy alcohol **19** with a strong base (e.g., NaH) and an isocyanate in an aprotic medium[16] (method B). This indeed proved to be the case (see Table II).



Best results were obtained when all reactants (epoxy alcohol, THF, and benzyl isocyanate) were purified immediately before use and when care was taken to exclude moisture and oxygen from the reaction mixtures. These conversions were complete usually within a 1–2-h period in THF at reflux. Longer reaction times (18–24 h) were required for experiments performed at ambient temperature. Mixtures of acyl transfer products were obtained in

(10) Similar observations have been reported by Kishi.[7c]

(11) Intramolecular openings of epoxides by amide anions are well documented. See, for example: (a) Schultz, R. J.; Staas, W. H.; Spurlock, L. A. *J. Org. Chem.* **1973**, *38*, 3091. (b) Corey, E. J.; Sachdev, H. S.; Gougoutas, Z.; Saenger, W. *J. Am. Chem. Soc.* **1970**, *92*, 2488.

(12) The base-catalyzed cyclizations of glycidyl-derived urethanes had been described before our work was initiated: (a) Farrissey, W. J., Jr.; Nashu, A. M. *J. Heterocyl. Chem.* **1970**, *7*, 331. (b) Braun, D.; Weinert, J. *Liebigs, Ann. Chem.* **1979**, 200. (c) Sorokin, M. F.; et al. *Zh. Org. Khim.* **1980**, *16*, 1241; *Izv. Vyssh. Uchebn. Zavd., Khim. Khim. Tekhnol.* **1981**, *24*, 561. (d) See also: Schubert, J.; Schwesinger, R.; Prinzbach, H. *Angew. Chem., Int. Ed. Engl.* **1984**, *23*, 167.

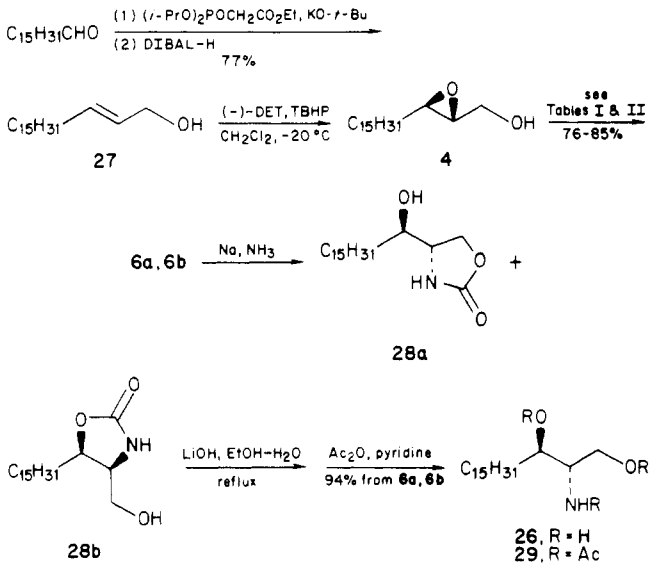
(13) (a) McCaslund, G. E.; Matchett, T. J.; Hollander, M. *J. Am. Chem. Soc.* **1952**, *74*, 3429. (b) Jenny, E. F.; Grob, C. A. *Hev. Chim. Acta* **1953**, *36*, 1454. (c) Jenny, E. F.; Grob, C. A. *Ibid.* **1953**, *36*, 1936. (d) Bannard, R. A. B.; Casselman, A. A.; Langstaff, E. J.; Moir, R. Y. *Can. J. Chem.* **1968**, *46*, 35. (e) Shtacher, G.; Rubenstein, R.; Somani, P. *J. Med. Chem.* **1978**, *21*, 678. (f) Mori, K.; Umemura, T.; *Tetrahedron Lett.* **1981**, *22*, 4433. (g) Mori, K.; Umemura, T. *Ibid.* **1982**, *23*, 3391.

(14) Sharpless has recently reported that amine nucleophiles add with modest selectivity to C(2) of 2,3-epoxy acids; see ref 4b and: Chong, J. M.; Sharpless, K. B. *J. Org. Chem.* **1985**, *50*, 1560.

(15) Treatment of **16** with NaH in THF effected elimination to an *E,Z* mixture of *threo*-4-methyl-2-[(*N*-phenylcarbamoyl)oxy]hept-4,6-dien-3-ol. We thank Susannah M. Hagadorn for performing the experiments with **16** and **24**.

(16) Epoxide migration does not occur under these conditions: Payne, G. B. *J. Org. Chem.* **1962**, *27*, 3819.

Scheme I

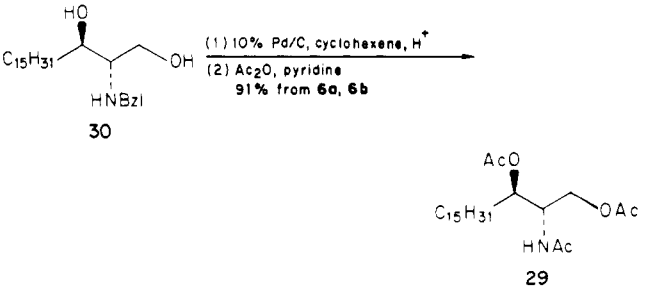


the transformations of **4** and **7**, and here again, attempts to suppress this problem by use of modified reaction conditions were unsuccessful.

Comparison of the data in Table II with Table I indicates that the efficiency of the one-pot conversion (method B) is comparable to the two-step procedure (method A) for simple epoxides **4**, **7**, **10**, and **13**. Note that for **10** and **13** (Table II) a hydrolysis step was performed prior to chromatographic purification of benzylamino diols **22** and **23**. Only for hindered epoxides such as **16** and **24** does there appear to be a distinct advantage to the two-step procedure.

Each of the transformations summarized in Tables I and II is highly regioselective. Isomeric products resulting from intramolecular addition of the urethane nitrogen atom to the epoxide β-position were not detected. Structural assignments in all cases are based on the spectroscopic data summarized in the Experimental Section and the chemical conversions described below. In this connection it is interesting to note that the complete acyl transfer isomerization which occurs in the conversion of **14** to **15** (compare **11** → **12**) is fully consistent with the expected *threo* stereochemistry of **15**.

As an illustration of this methodology we describe a synthesis of (+)-*erythro*-dihydrosphingosine (**26**; see Scheme I).[17] Although several syntheses of this compound have already been recorded,[13c,f,18] each suffers either from low-yielding step or from low stereo- or regioselectivity. This is especially apparent in approaches based on the ammonolysis of epoxy alcohol intermediates.[13c,f,g] In the present work the known allylic alcohol **27**[13b,c] was prepared from palmitic aldehyde by a modified Horner–Emmons reaction[19] followed by DIBAL-H reduction of the intermediate α,β-unsaturated ester. Asymmetric epoxidation of **27** then afforded epoxy alcohol **4** in 88% yield and >95% optical purity as determined by Mosher ester analysis.[20] Conversion of **4** to a mixture of urethanes **6a** and **6b** was accomplished in 76–85% yield as outlined previously. Treatment of this mixture with sodium in liquid ammonia effected smooth debenzylation to give the corresponding mixture of carbamates **28a** and **28b**, which could be separated if desired. On a routine basis, however, this mixture was directly hydrolyzed (LiOH in aqueous EtOH) to afford dihydrosphingosine **26**, which was fully characterized as the triacetyl derivative **29** (94% yield from **6a**/**6b**). An alternative deprotection sequence[21] involved hydrolysis of **6a**/**6b** to give *N*-benzylamine **30**, which was smoothly debenzylated by transfer hydrogenolysis (10% Pd/C, cyclohexene).[22] This procedure provided **29** in 91% overall yield following acylation of crude **26**. The physical constants for (+)-D-dihydrosphingosine triacetate obtained by either sequence were in excellent agreement with the literature values.



This synthesis of **29** is much simpler and more efficient than the routes previously reported.[13c,f,18] It also nicely illustrates a useful strategy for the synthesis of 2-amino 1,3-diol units, which occur in a variety of natural products including amino sugars.[23,24] Although the present study has concentrated on the use of benzyl isocyanate as a synthetic equivalent of NH_3, this methodology should also be applicable to other isocyanates when the objective is the synthesis of 2-(*N*-alkylamino) 1,3-diols.[12d]

Experimental Section

^{1}H NMR spectra were measured at 250 and 270 MHz on Bruker 250 and 270 instruments. Chemical shifts are reported in δ units relative to internal $CHCl_3$ (7.24 ppm). Infrared spectra were measured on a Perkin-Elmer Model 283B Infrared Spectrometer and were calibrated with the 1601 cm^{-1} absorption of polystyrene. Mass spectra were measured at 70 eV on a Varian MAT 44 instrument. High-resolution mass spectra were provided by the facility supported by NIH Grant RR00317 (Principal Investigator, Professor K. Biemann) from the Biotechnology Resources Branch, Division of Research Resources, and were obtained on a CEC 21-1110B high-resolution mass spectrometer equipped with a PDP-1145 based computer system to process data recorded on photographic plates. Melting points were recorded on Fisher-Johns hot stage melting point apparatus and are uncorrected. Optical rotations were measured on a Perkin-Elmer 144 polarimeter or a Rudolph Autopal III polarimeter using a 1-cm^3 capacity quartz cell (10-cm path length). Elemental analyses were performed by Robertson Laboratories, Inc., Florham Park, NJ.

All reactions were conducted in oven-dried (120 °C) glassware under atmospheres of dry argon or nitrogen. All solvents were

(17) For reviews of the chemistry and biochemistry of the glycososphingolipids, see: (a) Li, Y.-T.; Li, S.-C.; *Adv. Carbohydr. Chem. Biochem.* **1982**, *40*, 235. (b) Shapiro, D. "Chemistry of Sphingolipids"; Hermann: Paris, 1969. (c) Stoffel, W. *Chem. Phys. Lipids* **1973**, *11*, 318. (d) Coffey, S., Ed. "Rodd's Chemistry of Carbon Compounds", 2nd ed.; Elsevier: Amsterdam, 1976; Vol. 1, Part E, p 394.

(18) (a) Carter, H. E.; Shapiro, D. *J. Am. Chem. Soc.* **1953**, *75*, 5131. (b) Grob, C. A.; Jenny, E. F.; Utzinger, H. *Helv. Chim. Acta* **1951**, *34*, 2249. (c) Reist, E. J.; Christie, P. H. *J. Org. Chem.* **1970**, *35*, 3521, 4127.

(19) Nagaoka, H.; Kishi, Y. *Tetrahedron* **1981**, *37*, 3873.

(20) Dale, J. A.; Dull, D. L.; Mosher, H. S. *J. Org. Chem.* **1969**, *34*, 2543.

(21) For a review, see: Green, T. W. "Protective Groups in Organic Synthesis"; Wiley-Interscience: New York, 1981.

(22) (a) Jackson, A. E.; Johnstone, R. A. W. *Synthesis* **1976**, 685. (b) This deprotection sequence was also successfully applied to **9a**/**9b** to give **31** in 78% yield (see Experimental Section).

(23) Horton, D.; Wander, J. D. In "The Carbohydrates", 2nd ed.; Pigman, W., Horton, D., Eds.; Academic Press: New York, 1980; Vol. Ib, p 643.

(24) While our work was in progress, a conceptually similar synthesis of D-*erythro*-sphingosine was reported: Bernet, B.; Vasella, A. *Tetrahedron Lett.* **1983**, *24*, 5491.

freshly distilled before use: THF was distilled first from sodium benzophenone ketyl and then from lithium aluminum hydride; CH_2Cl_2 was distilled from P_2O_5; benzene was distilled from sodium benzophenone ketyl.

Analytical thin-layer chromatography (TLC) was performed by using 2.5 cm × 10 cm plates coated with a 0.25-mm layer of silica gel containing PF254 indicator (Analtech). Preparative thin-layer chromatography was performed on 20 × 20 cm plates coated with 0.5 mm thicknesses of silica gel containing PF 254 indicator (Analtech). Compounds were eluted from the adsorbents with ethyl acetate. Flash chromatography was performed as described by Still.[25] All chromatography solvents were distilled prior to use.

(*E*)-Octadec-2-en-1-ol (27). To a 0 °C solution of ethyl α-(diisopropoxyphosphinyl)acetate (5.81 g, 23.1 mmol) in 40 mL of THF was added KO-*t*-Bu (2.53 g, 22.5 mmol). This mixture was stirred at room temperature for 1 h and then was cooled to −78 °C. Palmitic aldehyde (3.56 g, 14.8 mmol) as a solution in 10 mL of THF was added, and the resulting solution was stirred for 1.5 h at this temperature. The reaction mixture was then poured into 120 mL of saturated aqueous NH_4Cl and extracted with CH_2Cl_2 (4 × 70 mL). The combined organic layers were washed with 100 mL of saturated aqueous NaCl, dried over $MgSO_4$, filtered, and concentrated in vacuo. The resulting crude product was purified by flash chromatography (50 × 160 mm column, 1% ether–hexane as eluant), giving 4.30 g (94%) of pure (*E*)-octadecenoic acid ethyl ester:[26] R_f 0.37 (2% ether–hexane); ^{1}H NMR (270 MHz) δ 6.92 (dt, J = 16, 7 Hz, 1 H, H_3), 5.78 (d, J = 16 Hz, 1 H, H_2), 4.15 (q, J = 6 Hz, 2 H, CH_2), 2.18 (br q, J = 7 Hz, 2 H, H_4), 1.15–1.50 (7, 29 H), 0.85 (t, J = 6 Hz, 3 H, CH_3).

To a 0 °C solution of 3.62 g (11.7 mmol) of the above unsaturated ester in 100 mL of Et_2O was added dropwise 35 mL (35.0 mmol) of DIBAL-H (1 M in hexane). The resulting mixture was allowed to warm to room temperature over 0.5 h, then recooled to 0 °C, and treated with 75 mL of 1 N HCl. The resulting gel was dissolved by dropwise addition of 6 N HCl. The ethereal phase was separated, and the aqueous phase was extracted with CH_2Cl_2 (3 × 100 mL). The combined organic extracts were washed with 75 mL of saturated aqueous $NaHCO_3$, then dried over $MgSO_4$, filtered, and concentrtaed in vacuo. The crude allylic alcohol was chromatographed on a 40 × 160 mm flash silica gel column using 5:1 hexane–Et_2O as eluant to give 2.84 g (91%) of pure **27**: R_f 0.49 (1:1 hexane–Et_2O); mp 46–48 °C [lit. mp 47–48 °C[13b,c]]; ^{1}H NMR (250 MHz) δ 5.64 (m, 2 H, $H_{2,3}$), 4.07 (t, J = 5.3 Hz, 2 H, H_1), 2.03 (br q, J = 6 Hz, 2 H, H_4), 1.17–1.36 (m, 27 H), 0.86 (t, J = 6.5 Hz, 3 H, CH_3); IR (melt) 3350, 3000, 2950, 2860, 1480, 1200, 1050, 950 cm^{-1}; mass spectrum, m/e 268 (parent ion).

(*E*)-2,3-Epoxyoctadecan-1-ol (4). Freshly distilled Ti(O-*i*-Pr)$_4$ (3.8 mL, 12.7 mmol) was added to CH_2Cl_2 (115 mL), and the resulting solution was cooled to a temperature between −30 and −20 °C (dry ice/CCl_4). Freshly distilled (−)-diethyl tartarate (2.89 mL, 16.9 mmol) was then added. The resulting mixture was stirred for 15 min, and then a solution of the allylic alcohol **27** (2.83 g, 10.6 mmol) in CH_2Cl_2 (20 mL) was added. Ten minutes later *tert*-butyl hydroperoxide solution (8.7 mL of 3.64 M solution in toluene; 31.7 mmol)[27] was added, and the reaction mixture was then stored in a −20 °C freezer for 24 h. The reaction was then quenched by addition of dimethyl sulfide (3 mL, 41 mmol). The resulting mixture was stirred at −20 °C for 30 min, and then saturated aqueous Na_2SO_4 (13 mL) was added. This suspension was allowed to warm to room temperature, then was filtered through a pad of Celite, and washed with Et_2O. Concentration of the filtrate provided an oil, which was chromatographed on a 50 × 160 mm flash silica gel column with solvent increasing in polarity from hexane to 5:1 hexane–Et_2O. The appropriate fractions were combined and concentrated in vacuo to give 2.65 g (88%) of crystalline **4** (R_f 0.30, 1:1 Et_2O–hexane), which proved to be >95% optically pure by Mosher ester analysis: mp 77–78 °C (petroleum ether) [lit. mp[13f] 78–79 °C]; $[\alpha]^{23}_D$ +22.5° (*c* 0.79, $CHCl_3$) [lit.[13f] $[\alpha]^{23}_D$ +21.6° (*c* 0.49, $CHCl_3$)]; ^{1}H NMR (250 MHz) δ 3.90 (ddd, J = 12.6, 5.5, 2.5 Hz, 1 H, H_{1a}), 3.61 (ddd, J = 12.6, 4.2, 3.1 Hz, 1 H, H_{1b}), 2.91 (m, 2 H, $H_{2,3}$), 1.65 (dd, J = 7.3, 5.6 Hz, 2 H), 1.23–1.57 (m, 27 H), 0.86 (t, J = 6.6 Hz, 3 H, CH_3); IR (CH_2Cl_2) 3780, 3210, 2915, 2860, 1420, 1250, 1110 cm^{-1}; mass spectrum, m/e 284 (parent ion).

1-[(*N*-Benzylcarbamoyl)oxy]-*trans*-2,3-epoxyoctadecane (5). To a solution of **4** (547 mg, 1.93 mmol) in CH_2Cl_2 (20 mL) were added sequentially triethylamine (0.35 mL, 3.8 mmol) and freshly distilled benzyl isocyanate (0.31 mL, 2.5 mmol). After being stirred overnight at room temperature, the reaction mixture was diluted with saturated aqueous NH_4Cl (10 mL) and extracted with CH_2Cl_2 (4 × 10 mL). The combined extracts were dried (Na_2SO_4), filtered, and concentrated in vacuo. The resulting crude product was chromatographed on a 40 × 160 mm silica gel column with 5:1 hexane–EtOAc as eluent, affording 781 mg (97%) of pure crystalline urethane **5**: mp 80–81 °C; R_f 0.64 (2:1 hexane–EtOAc); ^{1}H NMR (250 MHz) δ 7.31 (m, 5 H, Ar), 5.16 (br s, 1 H, NH), 4.45 (dd, J = 12.1, 3.1 Hz, 1 H, H_{1a}), 4.39 (d, J = 6.3 Hz, 2 H, benzylic, partially superimposed on H_{1a}), 3.93 (dd, J = 12.1, 6.3 Hz, 1 H, H_{1b}), 2.98 (m, 1 H, H_2), 2.85 (br s, 1 H, H_3), 1.55 (t, J = 6.2 Hz, 2 H), 1.26–1.46 (m, 27 H), 0.86 (t, J = 6.6 Hz, 3 H, CH_3); IR (melt) 3285, 2910, 2850, 1687, 1270, 678 cm^{-1}; mass spectrum, m/e 417 (parent ion). Anal. Calcd for $C_{26}H_{43}NO_3$: C, 74.78; H, 10.38. Found: C, 74.52; H, 10.21.

1-[(*N*-Benzylcarbamoyl)oxy]-3-cyclohexyl-*trans*-2,3-epoxypropane (8) was prepared from racemic epoxy alcohol **7**[5a] in 93% yield with the procedure described for **5**: mp 94–94.5 °C (hexane–EtOAc); R_f 0.82 (1:1 hexane–EtOAc); ^{1}H NMR (250 MHz) δ 7.24–7.35 (m, 5 H, Ar), 5.05 (br, s, 1 H, NH), 4.38 (dd, J = 12.0, 3.1 Hz, 1 H, H_{1a}), 4.36 (d, J = 5.4 Hz, 2 H, benzylic, partially superimposed on H_{1a}), 3.92 (dd, J = 12.0, 6.2 Hz, 1 H, H_{1b}), 3.00 (m, 1 H, H_2), 2.63 (d, J = 5.0 Hz, 1 H, H_3), 1.03–1.84 (m, 11 H); IR (neat) 3380, 2920, 2850, 1710, 1533, 1490, 1455, 1260, 1235, 1140, 1040 cm^{-1}; mass spectrum, m/e 289 (parent ion). Anal. Calcd for $C_{17}H_{23}NO_3$: C, 70.56; H, 8.01. Found: C, 70.71; H, 8.30.

[(*N*-Benzylcarbamoyl)oxy]-4-(benzyloxy)-*trans*-2,3-epoxybutane (11) was prepared from racemic **10**[8] in 94% yield: mp 45–46 °C (hexane–EtOAc); R_f 0.61 (1:1 hexane–EtOAc); ^{1}H NMR (250 MHz) δ 7.23–7.39 (m, 10 H, Ar), 5.15 (br s, 1 H, NH), 4.58, 4.54 (AB, J = 12 Hz, 2 H, *O*-benzyl), 4.42 (dd, J = 12.1, 3.3 Hz, 1 H, H_{1a}), 4.35 (d, J = 7.5 Hz, 2 H, *N*-benzyl), 3.95 (dd, J = 12.1, 5.6 Hz, 1 H, H_{1b}), 3.75 (dd, J = 11.2, 2.7 Hz, 1 H, H_{4a}), 3.48 (dd, J = 11.2, 2.7 Hz, 1 H, H_{4b}), 3.12 (m, 2 H, H_2 and H_3); IR (melt) 3330, 3060, 3030, 2940, 2860, 1720, 1520, 1450, 1360, 1240, 1110, 1040, 980, 860 cm^{-1}; mass spectrum, m/e 327 (parent ion). Anal. Calcd for $C_{19}H_{21}NO_4$: C, 69.71; H, 6.47. Found: C, 69.77; H, 6.63.

1-[(*N*-Benzylcarbamoyl)oxy]-4-(benzyloxy)-*cis*-2,3-epoxybutane (14) was prepared from racemic **13**[8] in 92% yield: R_f 0.38 (2:1 hexane–EtOAc); ^{1}H NMR (250 MHz) δ 7.24–7.32 (m, 10 H, Ar), 5.09 (br s, 1 H, NH), 4.60, 4.51 (AB, J = 11.9 Hz, 2 H, *O*-benzyl), 4.35 (d, J = 5.9 Hz, 2 H, *N*-benzyl, superimposed on m, 1 H, H_{1a}), 4.03 (dd, J = 12.1, 6.8 Hz, 1 H, H_{1b}), 3.72 (dd, J = 11.1, 3.5 Hz, 1 H, H_{4a}), 3.56 (dd, J = 11.1, 6.0 Hz, 1 H, H_{4b}), 3.27 (m, 2 H, H_2 and H_3); IR (neat) 3325, 3025, 2920, 1740, 1520, 1450, 1250, 1095, 730, 690 cm^{-1}; mass spectrum, m/e 327 (parent ion). Anal. Calcd for $C_{19}H_{21}NO_4$: C, 69.21; H, 6.46; N, 4.28. Found: C, 69.50; H, 6.53; N, 4.30.

General Procedure for Epoxyurethane Cyclizations (Table I). A solution of urethane **5** (780 mg, 1.87 mmol) in THF (25 mL) at room temperature was treated with NaH (180 mg, 7.50 mmol). After 5 h the reaction was quenched by careful addition of saturated aqueous NH_4Cl (20 mL) and then was extracted with CH_2Cl_2 (4 × 20 mL). The combined extracts were dried (Na_2SO_4) and concentrated to give a crystalline crude product, which was chromatographed on a 40 × 160 mm column with 5:1 hexane–EtOAc as eluent. This afforded 685 mg (88%) of a crystalline mixture (58:42) of **6a** and **6b** (NMR analysis). Separation of **6a** and **6b** could be accomplished by careful chromatography of small samples (0.5-mm silica gel preparative plate, six developments with 4:1 hexane–EtOAc).

3-Benzyl-4-(1′-hydroxyhexadecyl)-2-oxazolidinone (6a): R_f 0.36 (2:1 hexane–EtOAc); mp 51–52 °C; $[\alpha]^{23}_D$ −2.8° (*c* 1.2, CH_2Cl_2); ^{1}H NMR (250 MHz) δ 7.27–7.41 (m, 5 H, Ar), 4.61 (d, A of AB, J = 15.4 Hz, 1 H, benzylic), 4.32 (d, B of AB, J = 15.4 Hz, 1 H, superimposed on m, 2 H, H_5), 3.72 (br m, 1 H , H_4), 3.54

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(m, 1 H, $H_{1'}$), 1.14–1.58 (m, 28 H), 0.86 (t, J = 6.4 Hz, 3 H, CH_3); IR (melt) 3440, 3070, 3050, 3030, 2920, 2850, 1760, 1460, 1425, 1225, 1075, 710 cm^{-1}; mass spectrum, m/e 417 (parent ion).

3-Benzyl-*cis*-4-(hydroxymethyl)-5-pentadecyl-2-oxazolidinone (6b): R_f 0.32 (2:1 hexane–EtOAc); mp 100–101 °C; $[\alpha]^{23}_D$ +15.6° (c 0.64, CH_2Cl_2); ^1H NMR (250 MHz) δ 7.27–7.41 (m, 5 H, Ar), 4.75 (d, A of AB, J = 15.3 Hz, 1 H, benzylic), 4.46 (m, 1 H, H_5), 4.29 (d, B of AB, J = 15.3 Hz, 1 H), 3.73 (m, 2 H), 3.59 (m, 1 H, H_4), 1.13–1.56 (m, 29 H), 0.85 (t, J = 6.4 Hz, 3 H, CH_3); IR (melt) 3400, 3100, 3010, 2960, 2890, 1700, 1440, 1425, 1410, 1250, 1075, 810 cm^{-1}; mass spectrum, m/e 417 (parent ion).

3-Benzyl-4-(1′-cyclohexylhydroxymethyl)-2-oxazolidinone (9a) and 3-Benzyl-4-(hydroxymethyl)-5-cyclohexyl-2-oxazolidinone (9b). Urethane **8** was cyclized according to the general procedure described above to give a 65:35 mixture of **9a** and **9b** in 81% yield. Analytical samples of each isomer were obtained by preparative TLC (2:1 hexane–EtOAc, two developments).

9a: mp 128–129 °C (hexane–EtOAc); R_f 0.50 (1:1 hexane–EtOAc); ^1H NMR (270 MHz) δ 7.24–7.37 (m, 5 H, Ar), 4.70 (d, A of AB, J = 15.3 Hz, 1 H, benzylic), 4.36 (t, J = 7.0 Hz, 1 H, H_{5a}), 4.17 (m, 2 H, B of AB, J = 15.3 Hz, superimposed on H_{5b}), 3.72 (br t, J = 7.0 Hz, 1 H, H_4), 3.54 (m, 1 H, $H_{1'}$), 2.42 (m, 1 H, OH), 1.89 (br d, J = 13.1 Hz, 1 H), 0.77–1.41 (m, 9 H); IR (CH_2Cl_2) 3562, 2925, 2850, 1745, 1448, 1062 cm^{-1}; mass spectrum, m/e 289 (parent ion), 290 (M^+ + 1). Anal. Calcd for $C_{17}H_{23}NO_2$: C, 70.56; H, 8.01; N, 4.84. Found: C, 70.75; H, 8.00; N, 4.90.

9b: mp 172–173 °C; R_f 0.46 (1:1 hexane–EtOAc); ^1H NMR (270 MHz) δ 7.32–7.37 (m, 5 H, Ar), 4.85 (d, A of AB, J = 15.3 Hz, 1 H, benzylic), 4.21 (d, B of AB, J = 15.3 Hz, 1 H), 4.06 (dd, J = 10.1, 7.0 Hz, 1 H, H_5), 3.78 (br m, 2 H, CH_2OH), 3.47 (m, 1 H, H_4), 2.09 (m, 2 H), 0.86–1.85 (m, 10 H); IR (CH_2Cl_2) 2925, 2850, 1740, 1048 cm^{-1}; mass spectrum, m/e 289 (parent ion). Anal. Calcd for $C_{17}H_{23}NO_3$: C, 70.56; H, 8.01; N, 4.84. Found: C, 70.64; H, 7.75; N, 4.89.

3-Benzyl-4-[2′-(benzyloxy)-1′-hydroxyethyl]-2-oxazolidinone (12) was prepared in 82% yield by cyclization of **11**: R_f 0.36 (1:1 hexane–EtOAc); ^1H NMR (250 MHz) δ 7.21–7.36 (m, 10 H, Ar), 4.71 (d, A of AB, J = 15.4 Hz, 1 H, N-benzyl), 4.46 (s, 2 H, O-benzyl), 4.35 (dd, J = 8.8, 6.6 Hz, 1 H, H_{5a}), 4.18 (d, B of AB, J = 15.4 Hz, superimposed on m, 1 H, H_{5b}), 3.99 (br s, 1 H, H_4), 3.73 (dt, J = 6.5, 2.1 Hz, 1 H, $H_{1'}$), 3.41 (m, 2 H, $H_{2'}$), 2.61 (s, 1 H, OH); IR (neat) 3395, 3060, 3030, 2890, 1730, 1435, 1360, 1250, 1070 cm^{-1}; mass spectrum, m/e 372 (parent ion), 328 (M^+ + 1). Anal. Calcd for $C_{19}H_{21}NO_4$: C, 69.71; H, 6.46; N, 4.28. Found: C, 69.49; H, 6.44; N, 4.34.

3-Benzyl-*trans*-4-(hydroxymethyl)-5-[(benzyloxy)methyl]-2-oxazolidinone (15). Treatment of urethane **13** with NaH according to the general procedure afforded **15** in 91% yield: mp 95–95.5 °C (hexane–EtOAc); R_f 0.21 (1:1 hexane–EtOAc); ^1H NMR (250 MHz) δ 7.24–7.37 (m, 10 H, Ar), 4.72 (d, A of AB, J = 15.4 Hz, 1 H, N-benzyl), 4.55 (d, J = 7.2 Hz, 2 H, O-benzyl, superimposed on m, 1 H, H_5), 4.28 (d, B of AB, J = 15.4 Hz, 1 H), 3.62 (br m, 5 H, H_4, CH_2OH and CH_2OBzl), 2.39 (br s, 1 H, OH); IR (melt) 3400, 3080, 2920, 1745, 1430, 1260, 1070 cm^{-1} mass spectrum, m/e 327 (parent ion), 328 (M^+ + 1). Anal. Calcd for $C_{19}H_{21}NO_4$: C, 69.71; H, 6.47. Found: C, 70.11; H, 6.30.

***ribo*-4-(1′-Hydroxy-1′-methyl-3′-butenyl)-5-methyl-3-phenyl-2-oxazolidinone (17).** A solution of **16**[9b] (61 mg, 0.23 mmol) in 3 mL of NaOMe/MeOH (3 mL) was stirred at 45 °C for 4 h. The reaction mixture was then filtered through Dowex 50W-X8(H^+) resin using MeOH as eluant. Concentration of the filtrate gave an oil, which was purified by preparative TLC (1:1 hexane–Et_2O, two developments) to afford 55 mg (90%) of pure carbamate **17**: mp 144.5–145.5 °C; R_f 0.56 (Et_2O); ^1H NMR ($CDCl_3$–D_2O, 250 MHz) δ 7.21–7.47 (m, 5 H, Ar), 5.65 (m, 1 H, $H_{3'}$), 5.17 (br d, J = 10.1 Hz, 1 H, $H_{4'a}$), 4.98 (br d, J = 16.4 Hz, 1 H, $H_{4'b}$, partially superimposed on H_5), 4.94 (m, 1 H, H_5), 4.22 (d, J = 6.9 Hz, 1 H, H_4), 1.94 (d, J = 7.5 Hz, 2 H, $H_{2'}$), 1.72 (d, J = 7.0 Hz, 3 H, 5-CH_3), 1.33 (s, 3 H, CH_3); IR (CH_2Cl_2) 3540, 3020, 2920, 1775, 1595, 1500, 1390, 1210, 1130, 1090, 970 cm^{-1}; mass spectrum, m/e 261 (parent ion), 262 (M^+ + 1); high-resolution mass spectrum, calcd for $C_{15}H_{19}NO_3$ m/e 261.1365, found m/e 261.1369.

General Procedure for the Reaction of Epoxy Alcohols with Isocyanates and NaH (Table II): Synthesis of 6a and 6b. A solution of epoxy alcohol **4** (560 mg, 1.97 mmol) in THF (25 mL) was treated with NaH (100 mg, 4.2 mmol) and stirred for 10 min at room temperature. Freshly distilled benzyl isocyanate (0.316 mL, 2.56 mmol) was added and the reaction mixture heated to reflux for 1.5 h. The mixture was then cooled to 0 °C, quenched with saturated aqueous NH_4Cl (10 mL), and extracted with CH_2Cl_2 (4 × 10 mL). The organic extracts were dried over Na_2SO_4, filtered, and concentrated to yield the crude product. This material was purified by flash chromatography on a 40 × 160 mm column with 5:1 hexane–EtOAc as eluent to afford 624 mg (76%) of a crystalline 1:1 mixture of **6a** and **6b** (NMR analysis).

Epoxy alcohol **7** was converted to a 1:1 mixture **9a** and **9b** in 81% yield by using this procedure.

***threo*-4-(Benzyloxy)-2-(*N*-benzylamino)-1,3-butanediol (23).** To a solution of **13** (105 mg, 0.54 mmol) in THF (8 mL) was added NaH (26 mg, 1.1 mmol). Five minutes later freshly distilled benzyl isocyanate (80 μL, 0.65 mmol) was added. The reaction mixture was heated to reflux for 2.5 h, then was quenched by careful addition of saturated aqueous NH_4Cl (10 mL), and extracted with CH_2Cl_2 (4 × 10 mL). The combined extracts were filtered through a cotton plug and concentrated to afford 235 mg of crude product, which consisted of a 5:1 mixture of **15** and **23** (NMR analysis). This mixture was dissolved in 30% aqueous EtOH (10 mL) and treated with LiOH (390 mg, 16.2 mmol) at reflux for 9 h. The resulting solution was cooled to room temperature, diluted with 50% saturated NaCl solution (10 mL), and extracted with CH_2Cl_2 (4 × 10 mL). The organic extracts were filtered through a cotton plug and concentrated to give crude **23**, which was purified by chromatography on a 1.5-mm preparative TLC plate (9:1 CH_2Cl_2–MeOH). Subsequent extraction of the adsorbent with 6:4 CH_2Cl_2–MeOH afforded 121 mg (72%) of pure **23**: R_f 0.54 (9:1 CH_2Cl_2–MeOH); ^1H NMR (250 MHz) δ 7.22–7.34 (m, 10 H, Ar), 4.52 (s, 2 H, O-benzyl), 3.89 (d, A of AB, J = 13.0 Hz, 1 H, N-benzyl), 3.82 (m, 1 H, H_3), 3.75 (d, B of AB, J = 13.0 Hz, 1 H, N-benzyl, partially superimposed on H_3), 3.57 (m, 4 H, H_1 and H_4), 2.72 (m, 1 H, H_2), 2.28 (br s, 3 H, NH, and 2 × OH); IR (neat) 3380, 3040, 2900, 1600, 1490, 1450, 1360, 1260, 1205, 1090, 760, 690 cm^{-1}; mass spectrum, m/e 270 (M^+ − 31). Anal. Calcd for $C_{18}H_{23}NO_3$: C, 71.73; H, 7.69. Found: C, 71.41; H, 7.51.

***erythro*-4-(Benzyloxy)-2-(*N*-benzylamino)-1,3-butanediol (22)** was prepared from **10** in 68% yield with the procedure described for synthesis of **23**: mp 85–85.5 °C, (EtOAc–hexane); R_f 0.55 (9:1 CH_2Cl_2–MeOH); ^1H NMR (250 MHz) δ 7.24–7.36 (m, 10 H, Ar), 4.51 (s, 2 H, O-benzyl), 3.93 (br q, J = 5 Hz, 1 H, H_3), 3.80 (d, J = 4.1 Hz, 2 H, N-benzyl), 3.66 (br d, J = 4 Hz, 2 H, H_4), 3.47–3.58 (m, 2 H, H_1), 2.75 (m, 4 H, H_2, NH, and 2 × OH); IR (CH_2Cl_2) 3550, 3040, 2860, 1500, 1250, 1090, 680 cm^{-1}; mass spectrum, m/e 270 (M^+ − 31). Anal. Calcd for $C_{18}H_{23}NO_3$: C, 71.73; H, 7.69. Found: C, 71.51; H, 7.88.

***ribo*-3-Benzyl-4-[1′-hydroxy-1′-methyl-4′-((*tert*-butyldimethylsilyl)oxy)butyl]-5-methyl-2-oxazolidinone (25)** was prepared from epoxy alcohol **24** in 63% yield by using the procedure (method B) described for preparation of **6a** and **6b**: mp 100–101 °C (hexane); R_f 0.29 (12:1 CH_2Cl_2–Et_2O); ^1H NMR (250 MHz) δ 7.25–7.32 (m, 5 H, Ar), 4.91 (d, J = 14.6 Hz, 1 H, A of AB), 4.29 (d, J = 14.6 Hz, B of AB), 4.09 (m, 1 H, H_5), 3.53–3.62 (m, 2 H, $H_{4'}$), 3.20 (d, J = 2.3 Hz, 1 H, H_4), 2.15 (br s, 1 H, OH), 1.57–1.81 (br m, 4 H, $H_{2',3'}$), 1.26 (d, J = 6.3 Hz, 3 H, 5-CH_3), 1.14 (s, 3 H, CH_3), 0.86 (s, 9 H, $(CH_3)_3C$), 0.01 (s, 6 H, $(CH_3)_2Si$); IR (CH_2Cl_2) 3490, 3020, 2920, 2850, 1745, 1490, 1470, 1460, 1380, 1230, 1090, 1000, 940, 830 cm^{-1}; mass spectrum, m/e 391 (M^+ − 15). Anal. Calcd for $C_{22}H_{37}NO_4Si$: C, 64.83; H, 9.15; N, 3.44. Found: C, 65.04; H, 8.89; N, 3.70.

Synthesis of Dihydrosphingosine Triacetate from 6a/6b. Method A. Anhydrous NH_3 (40 mL) was condensed into a three-necked reaction flask containing a solution of **6a** and **6b** (610 mg, 1.46 mmol) in THF (15 mL) maintained at −78 °C. Sodium metal was then added until a dark blue color persisted. The reaction was stirred for 1 h and then was quenched by addition of solid NH_4Cl. After the NH_3 was removed by slow evaporation, the residue was dissolved in saturated aqueous NH_4Cl (15 mL) and extracted with CH_2Cl_2 (4 × 20 mL). The combined organic extracts were dried (Na_2SO_4), filtered, and concentrated to yield 482 mg of a mixture of **28a** and **28b**. On a routine basis this mixture was used directly in the next reaction. Analytical samples, however, were obtained by chromatographic separation

of the mixture (silica gel, 1:1 hexane–EtOAc).

28a: mp 75–76 °C (hexane); R_f 0.44 (3:1 EtOAc–hexane); $[\alpha]^{18}_D$ +12.5° (*c* 1.4, CH_2Cl_2); ^1H NMR (270 MHz) δ 6.54 (s, 1 H, NH), 4.39 (m, 2 H, H_1), 3.82 (m, 1 H, H_2), 3.66 (br s, 1 H, H_3), 3.29 (br s, 1 H, OH), 1.10–1.48 (m, 28 H), 0.85 (t, *J* = 6.7 Hz, CH_3); IR (melt) 3440, 2910, 2840, 1780, 1460, 1240, 1080, 1030, 720 cm^{-1}; mass spectrum, *m/e* 327 (parent ion). Anal. Calcd for $C_{19}H_{37}NO_3$: 69.68; H, 11.39; N, 4.28. Found: C, 69.57; H, 11.50; N, 4.47.

28b: mp 103–104 °C (hexane–benzene); R_f 0.35 (3:1 EtOAc–hexane); $[\alpha]^{18}_D$ +0.9° (*c* 0.44, EtOH); ^1H NMR (270 MHz) δ 5.60 (s, 1 H, NH), 4.62 (m, 1 H, H_3), 3.82 (m, 1 H, H_2), 3.67 (m, 2 H, H_1), 2.18 (m, 1 H, OH), 1.08–1.74 (m, 28 H), 0.86 (t, *J* = 6.4 Hz, 3 H, CH_3); IR (melt) 3400, 2915, 2845, 1695, 1468, 1073 cm^{-1}; mass spectrum, *m/e* 327 (parent ion), 328 (M^+ + 1); high-resolution mass spectrum, calcd for $C_{19}H_{37}NO_3$ *m/e* 327.2773, found *m/e* 327.2777.

The mixture of crude oxazolidinones **28a** and **28b** (478 mg, 1.46 mmol) was dissolved in 30% aqueous EtOH (20 mL) and treated with LiOH (1.05 g, 43.8 mmol) at reflux overnight. The cooled solutio was diluted with brine (20 mL) and extracted with EtOAc (4 × 20 mL). The organic extracts were dried over Na_2SO_4, filtered, and concentrated to afford crude dihydrosphingosine **26** (R_f 0.11, 3:1 EtOAc–hexane).

To a solution of this material in CH_2Cl_2 (20 mL) was added pyridine (1.5 mL, 15.4 mmol), (dimethylamino)pyridine (one crystal), and acetyl chloride (1.1 mL, 15 mmol). After being stirred for 1.5 h, the reaction was quenched with MeOH (3 mL), poured into saturated aqueous $NaHCO_3$ (20 mL), and extracted with CH_2Cl_2 (4 × 20 mL). The combined extracts were washed with 1 N HCl (80 mL) and saturated aqueous $NaHCO_3$ (80 mL), filtered through a cotton plug, and concentrated. The crude triacetate was purified by column chromatography (40 × 160 mm silica gel packed column, 1:1 hexane–EtOAc as eluent, R_f 0.56, 3:1 EtOAc–hexane) to afford 564 mg (94%) of pure D-(+)-dihydroxyphingosine triacetate (**29**): mp 93–94 °C (hexane) [lit. mp[13f] 94–96 °C and mp[18a] 97–98 °C]; $[\alpha]^{23}_D$ +17.5° (*c* 1.0, $CHCl_3$) [lit. $[\alpha]^{23}_D$ +17.0° (*c* 1.1, $CHCl_3$)[13f] and $[\alpha]^{19}_D$ +17.4° (*c* 1.4, $CHCl_3$)[18a]]; ^1H NMR (250 MHz) δ 5.83 (d, *J* = 9.0 Hz, 1 H, NH), 4.88 (q, *J* = 5.5 Hz, 1 H, H_3), 4.37 (m, 1 H, H_2), 4.23 (dd, *J* = 11.4, 6.0 Hz, 1 H, H_{1a}), 4.03 (dd, *J* = 11.4, 3.9 Hz, 1 H, H_{1b}), 2.05 (s, 6 H, 2 Ac), 1.98 (s, 3 H, Ac), 1.02–1.37 (m, 28 H), 0.85 (t, *J* = 6.6 Hz, 3 H, CH_3); IR (melt) 3280, 2910, 2845, 1718, 1640, 1540, 1368, 1235, 1040 cm^{-1}; mass spectrum, *m/e* 427 (parent ion), 428 (M^+ + 1). Anal. Calcd for $C_{24}H_{45}NO_5$: C, 67.41; H, 10.61; N, 3.28. Found: C, 67.64; H, 10.34; N, 3.23.

Method B. A mixture of **6a** and **6b** (429 mg, 1.03 mmol) was dissolved in 30% aqueous EtOH (20 mL). LiOH (800 mg, 33.3 mmol) was added and the mixture heated at reflux overnight. The cooled mixture was then diluted with H_2O (25 mL) and extracted with CH_2Cl_2 (4 × 25 mL). The combined organic extracts were filtered through a cotton plug and concentrated to afford 413 mg of crude *N*-benzylamine **30** (R_f 0.19, 2:1 hexane–EtOAc). This material was used immediately in the next reaction without purification.

A solution of crude **30** in MeOH (15 mL) was treated with 10% Pd–C (410 mg), 1 N HCl (1.03 mL, 1.03 mmol), and cyclohexene (0.31 mL, 3.08 mmol).[26] The resulting slurry was heated at reflux for 2 h, then cooled to room temperature, filtered through a pad of Celite, and concentrated to give 315 mg of crude **26**.

A solution of this material in CH_2Cl_2 (10 mL) was treated with pyridine (1.5 mL, 15.4 mmol), acetyl chloride (0.8 mL, 11.1 mmol), and a crystal of 4-DMAP. The resulting solution was stirred for 2 h at room temperature, then quenched with MeOH (5 mL), and diluted with saturated aqueous $NaHCO_3$ (15 mL) and H_2O (10 mL). The organic layer was separated and the aqueous extracted with CH_2Cl_2 (5 × 25 mL). The combined organic extracts were washed with 1 N HCl (100 mL) and saturated aqueous $NaHCO_3$ (100 mL), filtered through a cotton plug, and concentrated to afford crude **29**. This material was purified by chromatography on a 40 × 160 mm silica gel column using 1:1 hexane–EtOAc as eluent to yield 399 mg (91%) of pure dihydrosphingosine triacetate.

***erythro*-2-Benzamido-3-cyclohexyl-1,3-bis(benzoyloxy)propane (31)** was prepared in 78% yield from the mixture of oxazolidinones **9a**/**9b** by using a slightly modified version of the deprotection sequences described for the synthesis of **29** (substitution of benzoyl chloride for acetyl chloride in the final step of methods A and B): mp 63–64 °C; R_f 0.50 (3:1 hexane–EtOAc); ^1H NMR (250 MHz) δ 7.31–8.16 (m, 15 H, Ar), 7.06 (d, *J* = 8.6 Hz, 1 H, NH), 5.22 (dd, *J* = 6.8, 4.1 Hz, 1 H, H_3), 5.04 (ddd, *J* = 10.3, 6.1, 4.2 Hz, 1 H, H_2), 4.58 (m, 2 H, H_1), 1.64–1.94 (m, 6 H), 1.06–1.30 (m, 5 H); IR (melt) 3330, 3060, 2930, 2880, 1790, 1720, 1640, 1600, 1580, 1530, 1490, 1450, 1270, 1070, 1025, 710 cm^{-1}; mass spectrum, *m/e* 485 (parent ion). Anal. Calcd for $C_{30}H_{31}NO_5$: C, 74.20; H, 6.43; N, 2.88. Found: C, 73.93; H, 6.57; N, 2.75.

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Alkaloids from a Marine Zoanthid

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The colonial zoanthid, *Zoanthus* sp., contains alkaloids of a new structural group. The structure of zoanthamine (**1**) was determined by X-ray crystallographic analysis and has been communicated previously. The structures of zoanthenamine (**2**) and zoanthamide (**3**) were elucidated by comparison of their spectral data with those of zoanthamine (**1**).

The chemical constituents of an unidentified colonial zoanthid, *Zoanthus* sp.,[1] were investigated as part of a program to study toxic marine organisms from the Visakhapatnam coast of India. The colonial zoanthids, which occur as dense mats on intertidal rocks, can eject jets of water when they are disturbed. If the spray comes in contact with a victim's eyes, it causes tears followed by prolonged redness and pain.[2] An initial investigation of extracts of the whole organism revealed the presence of a series of alkaloids, three of which were isolated and pu-

(1) The animals may be a new species of *Zoanthus*. They were first identified as *Z. sociatus*, but this species is regarded as being restricted to the Caribbean. Specimens are available from either Andhra University or Scripps Institution of Oceanography.

(2) The effects can last up to a week. Several collectors have experienced these irritant effects, and they recommend caution when handling zoanthids from any location.

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