3 H); IR (NaCl) 3440 (br), 3060, 2960, 2930, 2860, 1470, 1380, 1070, 970, 850 cm^{-1}.

General Procedure for the Workup of the Payne Rearrangement–Opening Reaction of a 2,3-Epoxy Alcohol with an Amine. The reaction mixture is brought to room temperature and concentrated. After all of the volatile amine and most of the water are removed, a semisolid mass remains in the flask. This material is dried under high vacuum and then peracetylated in the usual way. The product thus obtained is taken up in CH_2Cl_2 and a minimum amount of water. The aqueous phase is extracted with CH_2Cl_2, and the combined organic portions are washed with water (1×), dried (Na_2SO_4), concentrated, and dried under high vacuum to constant weight.

Payne Rearrangement–Opening Reaction of (2*R,3*R**)-2,3-Epoxy-1-decanol (4) with Me_2NH/KOH.** The epoxy alcohol **4** (0.0531 g, 0.309 mmol) in 8 mL of a solution prepared by dissolving KOH (0.6 g, 10.7 mmol) in 20 mL of 40% aqueous Me_2NH was stirred at room temperature for 37 h and worked up according to the general procedure to afford 0.0875 g (94%) of a 10:2.8:1.0 mixture of (2*R**,3*S**)-1-(dimethylamino)-2,3-decanediol diacetate (**41a**), (2*R**,3*R**)-3-(dimethylamino)-1,2-decanediol diacetate (**41b**), and (2*R**,3*S**)-2-(dimethylamino)-1,3-decanediol diacetate (**41c**) as an oil. Purification by flash chromatography (4:1 hexane–acetone) affords 0.0507 g (55%) of **41a** and 0.0193 g (21%) of a mixture of **41b** and **41c**.

41a: ^1H NMR ($CDCl_3$) δ 5.16 (m, 1 H), 5.06 (m, 1 H), 2.52 (dd, J = 7.5, 14.9 Hz, 1 H), 2.39 (dd, J = 3.8, 14.9 Hz, 1 H), 2.24 (s, 6 H), 2.07 (s, 3 H), 2.05 (s, 3 H), 1.55 (m, 2 H), 1.28 (br, 10 H), 0.88 (t, J = 5.6 Hz, 3 H); IR (NaCl) 2960, 2940, 2870, 2835, 1745, 1465, 1375, 1250, 1230, 1040, 950, 850 cm^{-1}; mass spectrum, m/e 301 (parent ion). Anal. Calcd for $C_{16}H_{31}NO_4$: C, 63.76; H, 10.37; N, 4.65. Found: C, 63.64; H, 10.38; N, 4.87.

41b and 41c: IR (NaCl) 2960, 2930, 2860, 2800, 1745, 1460, 1375, 1240 (br), 1050, 840 cm^{-1}. Anal. Calcd for $C_{16}H_{31}NO_4$: C, 63.76; H, 10.37; N, 4.65. Found: C, 63.88; H, 10.60; N, 4.35.

Payne Rearrangement–Opening Reaction of (2*S*,3*S*)-2,3-Epoxy-1-hexanol (34) with Me_2NH/Me_4NOH. The epoxy alcohol **34** (0.0866 g, 0.746 mmol) in 4 mL of 40% aqueous Me_2NH was treated with 2.2611 g (12.5 mmol) of $Me_4NOH{\cdot}5H_2O$, stirred at room temperature for 36 h, and then worked up according to the general procedure to afford 0.1140 g (94%) of a 11.1:2.9:1.0 mixture of **42a**, **42b**, and **42c** along with a trace of **38** as an oil.

42a: ^1H NMR ($CDCl_3$) δ 5.04–5.21 (m, 2 H), 2.52 (dd, J = 8.1, 13.1 Hz, 1 H), 2.38 (dd, J = 4.5, 13.1 Hz, 1 H), 2.24 (s, 6 H), 2.07 (s, 3 H), 2.05 (s, 3 H), 1.22–1.71 (m, 4 H), 0.92 (t, 3 H); IR (NaCl) 2970, 2940, 2880, 1740, 1650, 1240, 1030, 840 cm^{-1}.

Payne Rearrangement–Opening Reaction of (2*S*,3*S*)-2,3-Epoxy-1-hexanol (34) with Et_2NH/KOH in THF. The epoxy alcohol **34** (0.083 g, 0.71 mmol) in 16 mL of 1:1:2 Et_2NH–0.5 N KOH–THF was heated to reflux for 20 h and worked up according to the general procedure to afford 0.155 g (80%) of a 6:1 mixture of (2*R*,3*S*)-1-(*N*,*N*-diethylamino)-2,3-hexanediol diacetate (**43**) and the combined regioisomers along with 1,2,3-hexanetriol triacetate (**38**). Flash chromatography (2:1 hexane–EtOAc) afforded 0.110 g (57%) of **43** as an oil: ^1H NMR ($CDCl_3$) δ 5.06–5.20 (m, 2 H), 2.49–2.59 (m, 6 H), 2.06 (s, 3 H), 2.05 (s, 3 H), 1.23–1.66 (m, 4 H), 1.01 (t, J = 7.4 Hz, 6 H), 0.93 (t, J = 7.3 Hz, 3 H).

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Supplementary Material Available: The experimental procedures and spectroscopic data not described in the Experimental Section (18 pages). Ordering information is given on any current masthead page.

Selective Transformations of 2,3-Epoxy Alcohols and Related Derivatives. Strategies for Nucleophilic Attack at Carbon-3 or Carbon-2

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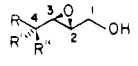
The ring-opening reactions of 2,3-epoxy alcohols 1 under nonisomerizing conditions were investigated. There is an inherent tendency for ring-opening at the C-3 position of 1 due to an electronic effect of the C-1 hydroxyl group. Since the hydroxyl group is a relatively weak inductively electron-withdrawing group, C-3 selective ring-opening reactions are observed only with certain simple 2,3-epoxy alcohols. Since an electronic effect of the C-1 hydroxyl group was found to promote ring-opening at the C-3 position of 1, the ring-opening reactions of 2,3-epoxy acetals and 2,3-epoxy amides were also explored, under the assumption that the acetal and amide groups might promote C-3 opening more strongly than the hydroxyl group. As expected, 2,3-epoxy acetals were opened with various nucleophiles exclusively at the C-3 position. However, the ring-opening reactions of 2,3-epoxy amides exhibited variable behavior, affording the C-3 ring-opened products with $Mg(N_3)_2$ and the C-2 ring-opened products with PhSK.

There are three reactive sites for nucleophilic substitution in 2,3-epoxy alcohol 1. Regioselective nucleophilic substitution at the C-1 position is best accomplished by Payne rearrangement–opening, direct displacement on the corresponding epoxy sulfonate, or through conversion to the 1,2-epoxy 3-ol via the "diol sulfonate" or "diol sulfide" methods.[1] Nucleophilic substitution of 1 at the C-2 or C-3 positions is not as straightforward because the ring-opening reactions are not always regioselective. One reliable means of regioselective ring-opening of a 2,3-epoxy alcohol utilizes the C-1 hydroxyl group as a point of attachment for in-

(1) See: Behrens, C. H.; Ko, S. Y.; Sharpless, K. B.; Walker, F. J. *J. Org. Chem.*, preceding paper in this issue and references cited therein.

0022-3263/85/1950-5696$01.50/0

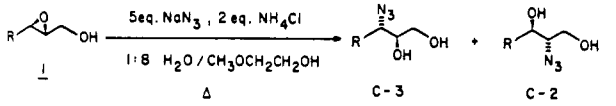
ternal nucleophiles. This strategy has been successfully explored by several research groups.[2,3] These intramolecular methods enable extremely selective nucleophilic substitution at the C-2 position. Similarly, intramolecular hydroxyl directing effects have been found to improve the regioselectivity in the ring-opening reactions of 2,3-epoxy alcohols with certain other types of nucleophiles.[4,5]



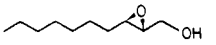
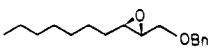
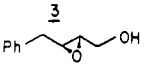
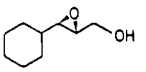
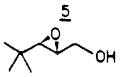
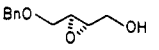
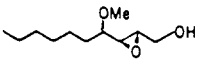
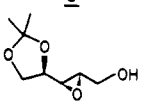
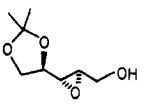
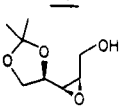
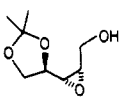
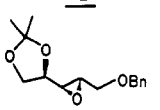
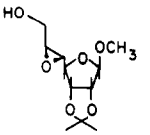
1

The bimolecular nucleophilic ring-opening reactions of 2,3-epoxy alcohols can also be very regioselective. Some of the best examples are found in the ring-opening reaction with cuprates. In most cases ring-opening occurs at the least hindered position, suggesting that steric factors are decisive in influencing the regioselectivity of the ring-opening.[6-8] However, there are cases of unusual regioselectivities in the ring-opening reactions of 2,3-epoxy alcohols with cuprates. In these examples a high regioselectivity is exhibited in the absence of a significant steric bias for ring-opening at either C-3 or C-2.[9] The reaction of organoaluminum reagents with 2,3-epoxy alcohols and epoxy benzyl ethers have been investigated.[9a,10-12] In contrast to the cuprate reagents, the organoaluminum reagents reliably opened the epoxide at C-3 in substrates in which there is very little difference in the steric hindrance at C-2 and C-3. Amines have been observed to open 2,3-epoxy ethers at the C-3 position,[13] but the regioselectivity in the ring-opening reaction of 2,3-epoxy alcohols with amine nucleophiles is rather low.[14] These examples illustrate that steric hindrance is not always the only factor to influence the regioselectivity of epoxy alcohol ring-opening reactions. In an attempt to provide a better understanding of the effects that influence these reactions, the regioselectivity in the ring-opening of a series of 2,3-epoxy alcohols and related compounds was determined. The results of this study indicate that, in addition to steric effects, electronic effects can play an important role in epoxide ring-opening reactions.

Table I. Ring-Opening Reaction of 2,3-Epoxy Alcohols with NH_4N_3



1

entry	epoxy alcohol	C-3:C-2	reactn time, h	combined yield, %
1	 2	3.5:1	ca. 5	88
2	 3	4:1	10	97
3	 4	1.4:1	72	71
4	 5	1.7:1	10	93
5	 6	C-2 only	ca. 12	47
6	 7	1:1	4	93
7	 8	1:2	4	84
8	 9	1:10	5	90
9	 10	1:8	4	92
10	 11	1:10	4	96
11	 12	1:9	10	90
12	 13	1:8	11	92
13	 14	1:4.5	20	78

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Results and Discussion

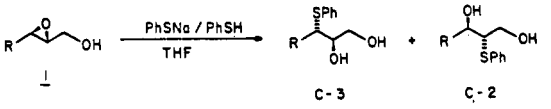
Ring-Opening of 2,3-Epoxy Alcohols. Azide was the first nucleophile studied for the ring-opening of 2,3-epoxy alcohols as it is known to open epoxides readily. A method generally used for the ring-opening of epoxy sugars (NaN_3, NH_4Cl, H_2O–$CH_3O(CH_2)_2OH$, reflux) was tested with 2,3-epoxy alcohols and found to be very satisfactory.[15,16] The results of the ring-opening reaction of a series of 2,3-epoxy alcohols with NaN_3/NH_4Cl (or NH_4N_3) are presented in Table I.[17]

As expected, with increasing steric hindrance at the C-3 position (cf. entries 1–5) more of the product of ring-opening at C-2 (i.e., 1,3-diol) is found in the product mixture. However, it is interesting to note that while in compounds **2**, **3**, and **4** the C-3 and C-2 positions are very nearly comparably hindered and in compound **5** the C-3 position is clearly more hindered than the C-2 position, the product of ring-opening at C-3 is still the major product.[18] However, the reaction of NH_4N_3 with **6** leads exclusively to the product of ring-opening at C-2, but this is not surprising because neopentyl substitution (i.e., ring-opening of **6** at C-3) is difficult to achieve in any circumstance.[19]

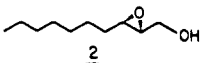
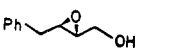
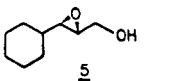
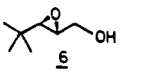
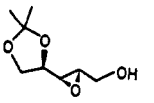
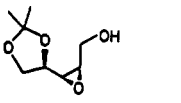
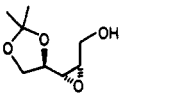
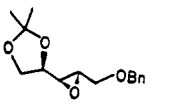
These results (entries 1–4) provide evidence that the C-1 hydroxyl group of a 2,3-epoxy alcohol does provide a measurable, albeit modest, deterent to ring-opening at the C-2 position. Such results cannot be explained on the basis of steric effects, because if anything C-2 is less hindered than C-3 in simple epoxy alcohols such as **2**. These regioselectivities are also probably not due to an intramolecular hydroxyl directing effect: there is very little difference in regioselectivity between the ring-opening of **2** and **3**. In another control experiment, the epoxy alcohol **7** reacted, as predicted, nonregioselectively (i.e., C-3:C-2 of 1:1) with NH_4N_3. In this substrate (**7**) the steric and electronic environments at C-2 and C-3 are essentially identical. Therefore, it appears likely that the C-1 hydroxyl group exerts its influence on the regioselectivity in the epoxide-opening reaction via an electron-withdrawing inductive effect.

Clearly the preference for ring-opening at the C-3 position of "simple" 2,3-epoxy alcohols should vanish in the case of "oxygenated" 2,3-epoxy alcohols (i.e., **1**; R = alkoxy, R′ = alkyl, R″ = H), because in such cases the C-3 carbon bears a substituent that is not only sterically demanding but is also capable of exerting an electron-withdrawing inductive effect. As shown in Table I (entries 7–13), a variety of "oxygenated" 2,3-epoxy alcohols are opened by

Table II. Ring-Opening Reaction of 2,3-Epoxy Alcohols with PhSNa



1

entry	epoxy alcohol	C-3:C-2	yield, %
1	 2	2.5:1	ca. 80
2	 4	1:1.4	72
3	 5	1:1	69
4	 6	C-2 only	76
5	 9	1:>10	76
6	 11	ca. 1:10	67
7	 12	ca. 1:10	64
8	 13	1:9[a]	ca. 80

[a] Reaction conducted with KH in DMF.

NH_4N_3 regioselectively at the C-2 position. The selectivity in the ring-opening reaction of **8** (which was actually prepared as a mixture of the erythro and threo isomers) was poor (C-2:C-3 of 2:1), but it was generally good (C-2:C-3 of >4.5:1) for compounds **9**–**14**.

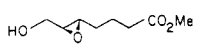
For the purposes of comparison with the ring-opening reaction of 2,3-epoxy alcohols with NH_4N_3, the regioselectivities in the ring-opening reaction of many of these 2,3-epoxy alcohols with PhSNa were determined. Like the NH_4N_3 reactions, the PhSNa ring-opening reactions were buffered with a weak acid. In this case, PhSH is the most convenient buffer. The reactions were performed by first generating the PhSNa/PhSH buffer system by treatment of NaH in THF with an excess of PhSH and then adding the epoxy alcohol to this solution. The results are presented in Table II.[20] As expected, the trend in the regioselectivities for these thiolate openings of **2**, **4**, **5**, and **6** parallels that observed in the ring-opening reactions of these compounds with NH_4N_3. Thus, with increasing steric hindrance at the C-3 position, more of the product of

(15) Guthrie, R. D.; Murphy, D. *J. Chem. Soc.* **1963**, 5288.

(16) An alternative procedure for the ring-opening of epoxides with azide (1 equiv of $MgSO_4$, 2 equiv of NaN_3, MeOH, reflux) is effective with 2,3-epoxy amides (vide infra) but much less effective with 2,3-epoxy alcohols.

(17) The regioselectivities in the epoxide-opening reactions were assigned on the basis of the diagnostic chemical shifts (δ) and multiplicity (d, dd, etc.) of signals with ^1H NMR spectrum of the unpurified diol product mixture and in the unpurified product mixture after peracetylation with pyridine and acetic anhydride. The signals of the hydroxyl protons (δ 1.7–2.9) of the diol products and the signals corresponding to RR′C*H*OAc (δ 5–6), RR′C*H*N_3 (δ 3.3–3.9), and RR′CHO*Ac* (δ 1.9–2.2) of the peracetylated products were found to be particularly useful.

(18) In a related example, the 2,3-epoxy alcohol i affords a 7:1 mixture of isomers upon treatment with NaN_3 and NH_4Cl in ethanol. Zamboni, R.; Rokach, J. *Tetrahedron Lett.* **1983**, *24*, 331.



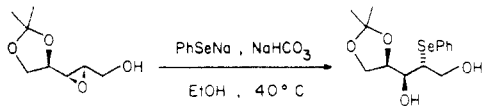
i

(19) For an example in which the trans-diaxial opening rule is violated to avoid neopentyl substitution, see: Sirat, H. M.; Thomas, E. J.; Wallis, J. D. *J. Chem. Soc., Perkin Trans. 1* **1982**, 2885.

(20) The regioselectivity in the ring-opening reaction was usually assigned on the basis of the diagnostic chemical shifts (δ) and multiplicity of signals in the ^1H NMR spectrum of the unpurified diol product mixture and in the unpurified product mixture after peracetylation with pyridine and acetic anhydride. The signals of the hydroxyl proton (δ 1.7–2.9) of the diol products and the signals corresponding to RR′C*H*OAc (δ 5–6), RR′C*H*SPh (δ 2–3), and RR′CHO*Ac* (δ 1.7–2.2) of the peracetylated products were found to be particularly useful.

ring-opening at C-2 (i.e., 1,3-diol) is found in the product mixture. The difference is that with PhSNa as the nucleophile the overall preference for ring-opening at C-3 (presumably due to the influence of the C-1 hydroxyl group) is not as pronounced as with NH_4N_3 as the nucleophile (cf. Table I (entries 1, 3, 4, and 5) and Table II (entries 1–4)). The compounds **9**, **11–13** each react with PhSNa/PhSH to afford the C-2 ring-opened products (entries 5–8) with a regioselectivity of approximately 10 to 1. These C-2 selectivities are comparable with those observed in the ring-opening reactions of the same compounds with NH_4N_3.

The use of PhSeNa as the nucleophile for the opening of epoxy alcohol **9** was briefly investigated. The PhSeNa reagent is normally generated in a protic solvent such as EtOH by the treatment of diphenyl diselenide with $NaBH_4$. In the ring-opening reaction of **9** with PhSeNa the addition of a buffer (e.g., $NaHCO_3$) was found to improve the yield. In the best case (eq 1) **9** reacted with PhSeNa



(1)

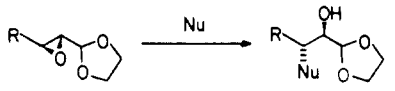
9 15 90% yield

in the presence of $NaHCO_3$ (EtOH, 40 °C, 4 h) to afford the C-2 product **15** (C-2:C-3 of ca. 10:1) in close analogy to the ring-opening reaction of **9** with PhSNa/PhSH.

It is known that the substituents on an epoxide affect the regioselectivity of its ring-opening reactions through a combination of steric and electronic effects. Electronically, a substituent may exert its effect through resonance or induction or both. Resonance donating substituents (e.g., phenyl, vinyl) promote ring-opening at the proximal carbon atom.[21] However, strong inductive electron-withdrawing substituents (e.g., trifluoromethyl) deter ring-opening at the proximal carbon atom.[22] This electronic effect has also been well-documented in relative rate studies.[23,24] The evidence presented in Tables I and II indicates that the C-1 hydroxyl group does influence the regioselectivity in the nucleophilic ring-opening reactions of a 2,3-epoxy alcohol. More specifically, the net effect of the C-1 hydroxyl group is to deter ring-opening (probably via an electron-withdrawing inductive effect) at the C-2 position of **1**. The effect is a modest one, however, because the C-1 hydroxyl group is a relatively weak electron-withdrawing group.

Ring-Opening of 2,3-Epoxy Acetals. Regioselective ring-opening reactions of 2,3-epoxy alcohols at the C-3 position are not always easily achieved.[25] It has been shown that (bimolecular) regioselective ring-opening reactions at the C-3 position are only expected in the case of "simple" epoxy alcohols (**1**; R = alkyl, R′ = R″ = H) and that in the case of "oxygenated" epoxy alcohols (**1**; R = alkoxy, R′ = alkyl, R″ = H) regioselective ring-opening reactions at the C-2 position are expected. Since intramolecular ring-opening reactions (in which the C-1 hydroxyl group is the point of attachment of the nucleophile)

Table III. Ring-Opening Reactions of 2,3-Epoxy Acetals



16 R = n-C_7H_{15} **18 – 22**

17 R = $PhCH_2O$

entry	epoxy acetal	reactn condns	product[e]	yield, %
1	**16**	*a*	**18**, R = *n*-C_7H_{15}; Nu = H	83
2	**16**	*b*	**19**, R = *n*-C_7H_{15}; Nu = N_3	73
3	**16**	*c*	**20**, R = *n*-C_7H_{15}; Nu = PhS	76
4	**16**	*d*	**21**, R = *n*-C_7H_{15}, Nu = CH_3	81
5	**17**	*d*	**22**, R = $PhCH_2O$, Nu = CH_3	71

[a] $LiAlH_4$, Et_2O, 0 °C, 0.5 h. [b] NaN_3, NH_4Cl, 1:1:1 THF–H_2O–$CH_3OCH_2CH_2CH_2OH$, reflux, 12 h. [c] PhSNa, PhSH, THF, reflux, 3.5 h. [d] Me_2CuLi, Et_2O, −40 °C, 70 min. [e] In no case is the isolated yield quantitative. However, there is no evidence in the ^1H NMR spectrum of the unpurified product to indicate that the ring-opened product is a mixture of regioisomers.

are also selective for C-2, ring-opening of oxygenated 2,3-epoxy alcohols at the C-3 position is normally not possible. An approach to countering this problem is to modify the C-1 hydroxyl group of **1** in such a way that bimolecular ring-opening at the C-3 position becomes more favorable than at C-2. One possibility is to cap the C-1 hydroxyl group with a bulky and/or electron-withdrawing group. For example, the regioselectivity in the methanolysis of a 2,3-epoxy mesylate (C-3:C-2 of ca. 9:1) is higher than the regioselectivity in the methanolysis of a 2,3-epoxy ether (C-3:C-2 of 3.6:1.0). It is interesting to note that the regioselectivity in the methanolysis of **3** is the same under acidic conditions ($HClO_4$, CH_3OH, 1 h, room temperature) as it is under basic conditions (CH_3ONa, CH_3OH, 24 h, reflux).[26]

An alternate, and probably more generally applicable approach is to bring the C-1 hydroxyl group of **1** to a higher oxidation level (i.e., aldehyde or carboxylic acid) under the assumption that the greater group electronegativity (and, in some cases, steric bulk) that attends the higher oxidation levels is likely to promote ring-opening at the C-3 position of these compounds.

2,3-Epoxy aldehydes are readily prepared by the oxidation of the parent 2,3-epoxy alcohol. They can be difficult to purify, so it is common to use them immediately, with little or no purification, in the subsequent synthetic step. We did not examine the nucleophilic ring-opening reactions of 2,3-epoxy aldehydes, partly because they are difficult to work with and partly because the acetal derivative was expected to be a more effective C-3 directing group than the aldehyde. There is an extensive body of literature concerning the nucleophilic ring-opening reactions of carbohydrate 2,3-epoxy acetals, especially 2,3-anhydropyranosides.[27] Unfortunately, the steric and electronic effects of the acetal group in these compounds

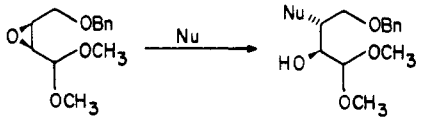
(21) VanderWerf, C. A.; Heisler, R. Y.; McEwen, W. E. *J. Am. Chem. Soc.* **1954**, *76*, 1231.
(22) McBee, E. T.; Hathaway, C. E.; Roberts, C. W. *J. Am. Chem. Soc.* **1956**, *78*, 4053.
(23) Bordwell, F. G.; Brannen, Jr., W. T. *J. Am. Chem. Soc.* **1964**, *86*, 4645.
(24) Hine, J.; Brader, Jr., W. H. *J. Am. Chem. Soc.* **1953**, *75*, 3964.
(25) Recently it has been observed that ring-opening reactions of 2,3-epoxy alcohols conducted in the presence of a titanium reagent (e.g., Ti-(O-i-Pr)$_4$) offer very high regioselectivities for ring-opening at the C-3 position with a variety of nucleophiles (e.g., R_2NH, ROH, and RCOOH). Caron, M.; Sharpless, K. B. *J. Org. Chem.* **1985**, *50*, 1557.
(26) It has also been observed that the ring-opening reaction of **6** with a sulfur nucleophile gives very similar regioselectivity (C-3:C-2 of 2:1) under both acidic (camphorsulfonic acid, PhSH, 15 h, room temperature) and basic (PhSNa, PhSH, 8 h, 100 °C) conditions. (Chong, J. M.; Sharpless, K. B., unpublished results.) In our opinion, these results tend to support, in a qualitative way, the contention that the evidence for a "borderline S_N2 mechanism" in epoxide ring-opening reactions is not strong. See: Wohl, R. A. *Chimia* **1974**, *26*, 1.
(27) Williams, N. R. In "Advances in Carbohydrate Chemistry and Biochemistry"; Tipson, R. S., Horton, D., Eds.; Academic Press: New York, 1970; Vol. 25, p 109.

are obscured by the very strong trans-diaxial conformational effect. However, the potential utility of the acetal functional group is suggested by the 40-year-old report of the regioselective ring-opening reaction of a 2,3-epoxy acetal with dimethylamine.[28]

Our initial investigations were conducted with the racemic epoxy acetals **16** and **17** (see Table III). Both compounds were obtained from the corresponding allylic alcohol via a three-step procedure involving oxidation (PCC, CH_2Cl_2) to the aldehyde, acetalization ($HOCH_2CH_2OH$, TsOH, benzene), and epoxidation (MCPBA, CH_2Cl_2) to the 2,3-epoxy acetal. These 2,3-epoxy acetals were treated with a variety of nucleophiles, and the regioselectivity of the opening reactions was determined. As can be seen from the results in Table III (entries 1–4), 2,3-epoxy acetal **16** was regioselectively opened at the C-3 position with $LiAlH_4$, NH_4N_3, PhSNa, and Me_2CuLi. The epoxy acetal **17** also reacts with Me_2CuLi highly selectively at C-3 (entry 5). This stands in contrast to the C-2 selective ring-opening reaction of **7** with Me_2CuLi under similar conditions.[9a,b] The higher regioselectivities (C-3:C-2 of >20:1, estimated from ^1H NMR analysis) in the ring-opening reactions of **16** and **17** as compared with **2** and **7** is clearly a reflection of the greater steric hindrance and electronegativity of the acetal group compared to the hydroxymethylene group.

Although the selective ring-opening reaction of 2,3-epoxy acetals at C-3 is a potentially useful transformation in the racemic series, it would be a much more useful reaction if the epoxy acetals could be derived from optically pure 2,3-epoxy alcohols. Encouraged by the high selectivities in the racemic series, we began to investigate the feasibility of synthesizing 2,3-epoxy acetals from homochiral epoxy alcohols (**1**). The oxidation of a 2,3-epoxy alcohol to the corresponding aldehyde is readily accomplished.[29] For example, the 2,3-epoxy aldehyde **23** is obtained in 71% yield by the oxidation (PCC, CH_2Cl_2, 3-Å molecular sieve powder) of the corresponding epoxy alcohol. However, the selective acetalization of **23** proved to be a difficult step. Several methods were tried without success. The problem is that any acid that might be employed to catalyze acetal formation is likely to be an effective epoxide-opening catalyst as well. For example, application of the standard acetalization method (ROH, PhH, catalytic TsOH, azeotropic distillation) or the Noyori method[30] (ROTMS, catalytic Me_3SiOTf) to **23** leads to an unidentified mixture of products. A modification of the acetalization procedure of Chan ($HOCH_2CH_2OH$, Me_3SiCl, CH_3OH, 2,6-di-*tert*-butylpyridine) was also ineffective, as the major product isolated was the chlorohydrin of the desired epoxy acetal.[31]

Table IV. Ring-Opening Reactions of (2*S*,3*S*)-4-(Benzyloxy)-1,1-dimethoxy-2,3-epoxybutane (24)

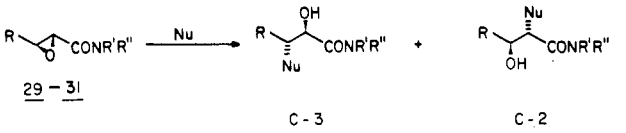


24 **26 - 27**

epoxy acetal	reactn conditns	product[c]	yield, %
24	*a*	**26**, Nu = N_3	67
24	*b*	**27**, Nu = PhS	87

[a] NaN_3, NH_4Cl, 1:1 water–diglyme, reflux, 168 h. [b] PhSNa, PhSH, THF, reflux, 2 h. [c] In neither case is the isolated yield quantitative. However, there is no evidence in the ^1H NMR spectrum of the unpurified product to indicate that the ring-opened product is a mixture of regioisomers.

Table V. Ring-Opening Reaction of 2,3-Epoxy Amides with NaN_3



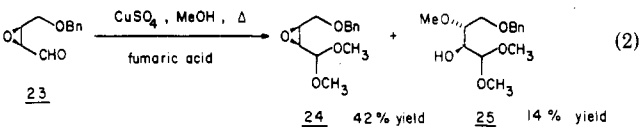
29 - 31 C-3 C-2

29, R = n-C_7H_{15}; R′ = $PhCH_2$; R″ = H
30, R = n-C_7H_{15}; R′ = $PhCH_2$; R″ = $PhCH_2$
31, R = cyclohexyl; R′ = $PhCH_2$; R″ = H

entry	epoxy amide	reactn conditns	regioselectivity C-3:C-2	yield, %
1	**29**	*a*	ca. 1.5:1	94
2	**29**	*b*	10:1	ca. 95
3	**30**	*b*	10:1	ca. 76
4	**31**	*b*	10:1	82
5	**29**	*c*	1:5	54
6	**30**	*c*	C-2 only	81
7	**31**	*c*	C-2 only	88

[a] NaN_3, NH_4Cl, 8:1 $CH_3OCH_2CH_2OH$–H_2O, reflux, 16.5 h. [b] NaN_3, $MgSO_4$, CH_3OH, reflux, ca. 12 h. [c] PhSNa, PhSH, DMF, 36 h.

At present the most successful method for the preparation of an epoxy acetal is to treat a solution of the aldehyde in anhydrous CH_3OH with $CuSO_4$ (as a dessicant) and a mild acid catalyst such as fumaric acid or acetic acid (eq 2).[32] The best isolated yield of **24** was 42%, along with

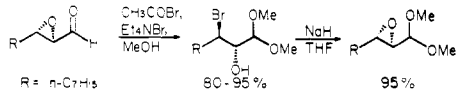


23 **24** 42% yield **25** 14% yield (2)

14% of the methanolysis product **25**. The results of the reactions of **24** with NH_4N_3 and PhSNa/PhSH are presented in Table IV. As expected, the regioselectivities in these ring-opening reactions were very good, with no C-2 ring-opened products detected.

The difficulties associated with selective acetalization of 2,3-epoxy aldehydes prompted us to consider the imidazolidine protecting group as an alternative to the acetal protecting group. The reaction of **23** with *N*,*N*′-diphenylethylenediamine (Wanzlick's reagent) in CH_3OH in the presence of acetic acid afforded the corresponding 2,3-epoxyimidazolidine **28** in 63% yield following chromatography. However, the imidazolidine protecting group did not appear promising because preliminary ring-opening

(28) Fourneau, J. P.; Chantalou, S. *Bull. Soc. Chim. Fr.* **1945**, *12*, 845.
(29) (a) Corey, E. J.; Marfat, A.; Goto, G. *J. Am. Chem. Soc.* **1980**, *102*, 6607. (b) Corey, E. J.; Marfat, A.; Monroe, J.; Kim, K. S.; Kaplin, P. B.; Brion, F. *Tetrahedron Lett.* **1981**, *22*, 1077. (c) Rossiter, B. E.; Katsuki, T.; Sharpless, K. B. *J. Am. Chem. Soc.* **1981**, *103*, 464. (d) Mills, L. S.; North, P. C. *Tetrahedron Lett.* **1983**, *24*, 409.
(30) Tsunoda, T.; Suzuki, M.; Noyori, R. *Tetrahedron Lett.* **1980**, *21*, 1357.
(31) (a) Chan, T. H.; Brook, M. A.; Chaley, T. *Synthesis* **1983**, 203. (b) We have recently developed a new procedure to make homochiral epoxy acetals via simultaneous acetylization/epoxide-opening of epoxy aldehydes followed by reclosure to the epoxide. Thus, treatment of a homochiral epoxy aldehyde with CH_3COBr (10 equiv) and Et_4NBr (10 equiv) in MeOH (0.1 M solution) yielded the bromohydrindimethyl acetal, which then, was converted to the desired epoxy acetal by treatment with a base. This is clearly the best route to homochiral epoxy acetals provided the rest of the molecule can tolerate the strong acidity of the first step. Gao, Y.; Sharpless, K. B., unpublished results.



R = n-C_7H_{15} 80-95% 95%

(32) Foster, A. B. In "The Carbohydrates"; Pigman, W., Horton, D., Eds.; Academic Press: New York, 1972; Vol. 1A, p 391.

reactions of **28** with $LiAlH_4$ and Me_2CuLi were much less selective (C-3:C-2 of ca. 5:1) than the corresponding reactions with **17** and **24**.

Ring-Opening of 2,3-Epoxy Amides. There have been a number of interesting literature reports concerning the ring-opening reactions of 2,3-epoxy acids, esters, and amides. For example, 2,3-epoxycrotonic acid is reported to react with aqueous benzylamine or aqueous ammonia to afford only the C-2 product (i.e., the 3-hydroxy acid) in high yield,[33] while 2,3-epoxy esters and amides react under similar conditions to afford the C-3 product (i.e., the 2-hydroxy amide) exclusively.[34-36] In the reaction of a 2,3-epoxy ester with an amine, ester aminolysis normally precedes epoxide cleavage. There is only one known example of the ring-opening of a 2,3-epoxy amide with an amine to afford the C-2 product.[37]

These reports of C-3 selectivity in the ring-opening of 2,3-epoxy amides prompted a brief investigation of the reaction of these compounds with NaN_3 and with PhSNa. The epoxy amides in Table V were obtained from the corresponding epoxy alcohol by oxidation to the carboxylic acid (RuO_4, $NaIO_4$, CH_3CN–CCl_4–H_2O),[38] followed by coupling with either benzylamine or dibenzylamine (DCC, 1-hydroxybenzotriazole, THF).[35b] As shown in Table V, the reaction of **29** with NH_4N_3 proceeds with almost no selectivity (entry 1). However, the same substrate reacts with $Mg(N_3)_2$ (i.e., NaN_3, $MgSO_4$) to afford the C-3 product selectively. The ring-opening reaction with $Mg(N_3)_2$ also works well for **30** and **31** as shown in entries 3 and 4.

In contrast to 2,3-epoxy amides, 2,3-epoxy esters reveal little selectivity in reactions with $Mg(N_3)_2$.[6] This finding, together with the data presented in Table V, suggests that there is an interaction of the magnesium cation and the epoxy amide that is weaker (or absent) in the case of the epoxy ester. This seems reasonable since amides are more basic than esters.[39] While it is not yet clear just how the magnesium ion affects the ring-opening reaction of epoxy amides, we suspect that intramolecular chelation with the epoxide oxygen is involved. In fact, chelation effects have recently been found to exert dramatic changes in the regioselectivity of the openings of epoxy alcohols,[25] epoxy acids,[43,44] and epoxy amides[43] with a wide variety of nucleophiles.

For the purposes of comparison with the results obtained for the reaction of the 2,3-epoxy amides **29–31** with $Mg(N_3)_2$, the regioselectivities for the reactions of these compounds with PhSNa/PhSH were determined. In sharp contrast to the C-3 selective ring-opening reactions of epoxy amides with $Mg(N_3)_2$ and with amines, the epoxy amides **29–31** were opened regioselectively at the C-2 position with PhSNa/PhSH. The C-2:C-3 product ratio for the ring opening reaction of **29** is 5:1 (entry 5), and only the C-2 product is observed in the reaction of **30** and **31** with PhSNa (entries 6 and 7).[40] It is well-known that the rate of an S_N2 substitution reaction with compounds in which the leaving group is adjacent to a carbonyl-containing functional group (e.g., CH_3COCH_2Cl, $PhCOCH_2Cl$) can be as much as 10^4 times greater than the corresponding S_N2 substitution reaction with a model compound such as *n*-butyl chloride.[23] From this point of view, it is the $Mg(N_3)_2$ and RR'NH ring-opening reactions of 2,3-epoxy amides that appear to be anomalous. Clearly, more exploratory work is needed on the ring-opening reactions of 2,3-epoxy amides. Such studies will hopefully lead to a better understanding of the factors that affect the regioselectivity of epoxide-opening reactions.

Experimental Section

Melting points were determined with a Thomas-Hoover capillary melting point apparatus. All melting points are uncorrected. Infrared (IR) spectra were measured with a Perkin-Elmer Model 597 grating infrared spectrophotometer. The 1601-cm^{-1} absorption band of polystyrene film was used to calibrate the chart paper. ^1H NMR spectra were measured with Brucker 250-MHz or 270-MHz spectrometers. The solvent used was $CDCl_3$ unless otherwise noted. Tetramethylsilane (Me_4Si) was used as an internal standard. The chemical shifts are given in δ (ppm) downfield from Me_4Si, and the coupling constants are in hertz. Low-resolution mass spectra (MS) were obtained with a Finnegan MAT 8200 mass spectrometer. Optical rotations were measured with a Perkin-Elmer Model 241 polarimeter with a 1-cm^3 capacity (10-cm path length) quartz cell. Elemental analyses were performed by Robertson Laboratory Inc., Florham Park, NJ.

All oxygen- or water-sensitive reactions were conducted in oven-dried (140 °C) or flame-dried glassware under an atmosphere of dry nitrogen. All commercial chemicals and reagents were used as received. Benzene and methylene chloride (CH_2Cl_2) were distilled from CaH_2; methanol was distilled from magnesium metal; tetrahydrofuran was distilled from sodium benzophenone ketyl. Pyridine and dimethylformamide (DMF) were stored over activated 3-Å molecular sieves. Analytical thin-layer chromatography (TLC) was performed with aluminum plates coated with 0.20-mm thickness of Merck silica gel 60 F-254. Flash chromatography was performed with Merck silica gel 60 (230–400 mesh) as described by Still.[41]

Reductions with either $LiAlH_4$ or AlH_3 were quenched by the "Fieser workup" according to the following procedure.[42] The reaction mixture from a reaction with *n* grams of $LiAlH_4$ is treated by successive dropwise addition of *n* mL of ice-cold water, *n* mL of an aqueous 15% NaOH solution, and 3*n* mL of ice-cold water. After being stirred for at least 0.5 h, the mixture is filtered through a sintered glass frit. The precipitated aluminum salts are then washed as specified in each particular case.

In general, compounds (e.g., alcohols, diols, amines, etc.) were peracetylated for ^1H NMR analysis according to the following procedure. A 5–10-mL round-bottomed flask is charged with the compound to be peracetylated (0.5–5 mg) and 1.5–3.0 mL of 2:1 pyridine–acetic anhydride. After standing for a period of at least 2 h (but usually overnight) at room temperature, the excess pyridine, acetic anhydride, and acetic acid are removed in vacuo to afford the peracetate.

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Representative Experimental Procedures. Reaction of (2*R*,3*R*,4*S*)-1,2-*O*-Isopropylidene-3,4-epoxy-1,2,5-pentanetriol (9) with NaN_3/NH_4Cl. The epoxy alcohol **9** (0.0398 g, 0.228 mmol) in 2 mL of an 8:1 $CH_3OCH_2CH_2OH-H_2O$ solution was refluxed with NaN_3 (0.0757 g, 1.17 mmol) and NH_4Cl (0.0250 g, 0.467 mmol) for 5 h. The reaction mixture was then cooled to room temperature, concentrated, and passed through a very short silica gel column with EtOAc to afford 0.0448 g (90%) of (2*R*,3*R*,4*R*)-4-azido-1,2-*O*-isopropylidene-1,2,3,5-pentanetetrol (**32**) as an oil: $[\alpha]^{25}_D$ −48.9° (*c* 1.57, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 4.34 (dt, *J* = 2.5, 6.4 Hz, 1 H), 4.12 (dd, *J* = 6.2, 8.1 Hz, 1 H), 3.97–4.07 (m, 1 H), 3.93 (m, 1 H superimposed on a dd, *J* = 7.0, 8.1 Hz, 1 H), 3.52 (m, 2 H), 2.45 (br d, *J* = 7.0 Hz, 1 H), 2.16 (br t, *J* = 6.2 Hz, 1 H), 1.46 (s, 3 H), 1.40 (s, 3 H); IR (NaCl) 3440 (br), 2980, 2930, 2890, 2100, 1450, 1375, 1260, 1215, 1160, 1060, 840, 760 cm^{-1}. Anal. Calcd for $C_8H_{15}N_3O_4$: C, 44.23; H, 6.96; N, 19.34. Found: C, 44.46; H, 7.08; N, 19.64.

A small sample of **32** was peracetylated in the usual way to afford (2*R*,3*R*,4*R*)-4-azido-1,2-*O*-isopropylidene-1,2,3,5-pentanetetrol diacetate as an oil: ^1H NMR ($CDCl_3$) δ 4.97 (dd, *J* = 2.7, 8.6 Hz, 1 H, H_3), 4.43 (ddd, *J* = 2.7, 5.7, 6.7 Hz, 1 H, H_2), 4.34 (dd, *J* = 2.9, 11.7 Hz, 1 H, H_5), 4.22 (dd, *J* = 6.6, 11.7 Hz, 1 H, H_5'), 4.05 (dd, *J* = 6.7, 8.8 Hz, 1 H, H_1), 3.96 (ddd, *J* = 2.9, 6.6, 8.6 Hz, 1 H, H_4), 3.72 (dd, *J* = 5.7, 8.8 Hz, 1 H, H_1'), 2.14 (s, 3 H), 2.11 (s, 3 H), 1.45 (s, 3 H), 1.37 (s, 3 H); IR (NaCl) 2990, 2940, 2890, 2100, 1745, 1455, 1380, 1230, 1160, 1125, 1050, 840 cm^{-1}.

Reaction of (2*S*,3*S*)-2,3-Epoxy-1-decanol (2) with PhSNa/PhSH. A 60% dispersion of NaH in oil (0.0164 g, 0.4 mmol) was suspended in 1 mL of THF and treated with benzenethiol (0.080 mL, 0.085 g, 0.78 mmol) at 0 °C. This procedure affords a sodium benzenethiolate solution which is buffered with thiophenol. The epoxy alcohol **2** (0.0467 g, 0.272 mmol) ($[\alpha]^{25}_D$ −24.3° (*c* 1.3, EtOH), 95% ee) was added. After being stirred at room temperature for 3.5 h, the reaction mixture was quenched with a saturated aqueous NH_4Cl solution. The solvents were removed in vacuo, and the residue thus obtained was taken up in EtOAc and passed through a very short silica gel column to remove inorganic salts. The resulting organic solution was concentrated and dried under high vacuum to afford a 2.5:1.0 mixture of (2*S*,3*R*)-3-(phenylthio)-1,2-decanediol (**33a**) and (2*R*,3*S*)-2-(phenylthio)-1,3-decanediol (**33b**). This mixture was partially separated by flash chromatography (7:3 hexane–EtOAc) to afford 0.0139 g (18%) of **33b** as an oil, 0.0147 g (19%) of a mixture of **33b** and **33a** as an oil, and 0.290 g (38%) of **33a** as an oil for a 75% overall yield.

33a: $[\alpha]^{25}_D$ +5.0° (*c* 2.90, EtOH); ^1H NMR ($CDCl_3$) δ 7.40–7.45 (m, 2 H), 7.23–7.33 (m, 3 H), 3.60–3.82 (m, 3 H), 3.19 (m, 1 H), 2.75 (d, *J* = 5.5 Hz), 2.17 (dd, *J* = 5.2, 6.4 Hz, 1 H), 1.18–1.82 (m, 12 H), 0.88 (t, 3 H); IR (NaCl) 3400 (br), 3080, 3060, 2960, 2930, 2860, 1580, 1485, 1470, 1440, 1070, 750, 695 cm^{-1}. Anal. Calcd for $C_{16}H_{26}O_2S$: C, 68.04; H, 9.28; S, 11.35. Found: C, 62.75; H, 9.42; S, 11.06.

A small sample of **33a** was peracetylated in the usual way to afford (2*S*,3*R*)-3-(phenylthio)-1,2-decanediol diacetate as an oil: ^1H NMR ($CDCl_3$) δ 7.39–7.50 (m, 2 H), 7.19–7.35 (m, 3 H), 5.15 (m, 1 H), 4.25–4.46 (m, 2 H), 3.29 (m, 1 H), 1.96 (s, 3 H), 1.88 (s, 3 H), 1.21–1.81 (m, 12 H), 0.89 (t, 3 H); ^1H NMR ($CDCl_3$, decoupled at 5.15 δ) δ 7.39–7.50 (m), 7.19–7.35 (m), 4.31, 4.39 (AB, J_{AB} = 11 Hz), 3.29 (br), 1.96 (s), 1.88 (s), 1.21–1.81 (m), 0.89 (t); ^1H NMR ($CDCl_3$, decoupled at 3.29 δ) δ 7.39–7.50 (m), 7.19–7.35 (m), 5.15 (dd, *J* = 3.8, 5.6 Hz), 4.25–4.46 (m), 1.96 (s), 1.88 (s), 1.21–1.81 (m), 0.89 (t).

33b: $[\alpha]^{25}_D$ −5.0° (*c* 1.17, EtOH); ^1H NMR ($CDCl_3$) δ 7.38–7.49 (m, 2 H), 7.20–7.35 (m, 3 H), 3.75–4.01 (m, 3 H), 3.23 (m, 1 H), 2.56 (t, *J* = 6.3 Hz, 1 H), 2.45 (d, *J* = 5.5 Hz, 1 H), 1.19–1.81 (m, 12 H), 0.88 (t, 3 H); IR (NaCl) 3380 (br), 3080, 3060, 2960, 2930, 2860, 1580, 1485, 1470, 1440, 1070, 750, 695 cm^{-1}. Anal. Calcd for $C_{16}H_{26}O_2S$: C, 68.04; H, 9.28; S, 11.35. Found: C, 67.80; H, 9.50; S, 11.67.

A small sample of **33b** was peracetylated in the usual way to afford (2*R*,3*S*)-2-(phenylthio)-1,3-decanediol diacetate as an oil: ^1H NMR ($CDCl_3$) δ 7.40–7.49 (m, 2 H), 7.22–7.34 (m, 3 H), 5.14 (dt, *J* = 5.3, 7.5 Hz, 1 H), 4.27 (m, 2 H), 3.52 (m, 1 H), 2.04 (s, 3 H), 2.00 (s, 3 H), 1.70 (m, 2 H), 1.26 (m, 10 H), 0.88 (t, 3 H); ^1H NMR ($CDCl_3$, decoupled at δ 5.1) δ 7.40–7.49 (m), 7.22–7.34 (m), 4.27 (m), 3.52 (t, *J* = 6.8 Hz), 2.04 (s), 2.00 (s), 1.70 (m), 1.26 (m), 0.88 (t); ^1H NMR ($CDCl_3$, decoupled at δ 3.52) δ 7.40–7.49 (m), 7.22–7.34 (m), 4.27 (t, *J* = 5.3 Hz), 4.25, 4.29 (AB, J_{AB} = 11.2 Hz), 2.04 (s), 2.00 (s), 1.70 (m), 1.26 (m), 0.88 (t).

Reaction of (2*R*,3*R*,4*S*)-1,2-*O*-Isopropylidene-3,4-epoxy-1,2,5-pentanetriol (9) with PhSNa/PhSH. The epoxy alcohol **9** (0.0463 g, 0.266 mmol) was treated with an excess of sodium benzenethiolate and benzenethiol in THF in a procedure similar to the one described above to afford, after flash chromatography (17:3 hexane–EtOAc), 0.0573 g (76%) of (2*R*,3*S*,4*R*)-1,2-*O*-isopropylidene-4-(phenylthio)-1,2,3,5-pentanetetrol (**34**) as an oil: $[\alpha]^{20}_D$ −11.4° (*c* 1.38, EtOH); ^1H NMR ($CDCl_3$) δ 7.43 (m, 2 H), 7.27 (m, 3 H), 4.51 (dt, *J* = 2.8, 7.1 Hz, 1 H), 4.07 (dd, *J* = 7.1, 7.8 Hz, 1 H), 3.82–3.96 (m, 3 H), 3.67 (dt, *J* = 2.8, 7.8 Hz, 1 H), 3.28 (ddd, *J* = 5.0, 5.7, 7.8 Hz, 1 H), 2.84 (dd, *J* = 6.0, 6.5 Hz, 1 H), 2.63 (d, *J* = 8.0 Hz, 1 H), 1.43 (s, 3 H), 1.31 (s, 3 H); IR (NaCl) 3450 (br), 3060, 2990, 2940, 1585, 1480, 1440, 1385, 1375, 1260, 1220, 1120, 1060, 1039, 980, 880, 845, 745, 695 cm^{-1}. Anal. Calcd for $C_{14}H_{20}O_4S$: C, 59.13; H, 7.09; S, 11.28. Found: C, 58.89; H, 6.94; S, 11.13.

A small sample of **34** was peracetylated in the usual way to afford (2*R*,3*S*,4*R*)-1,2-*O*-isopropylidene-4-(phenylthio)-1,2,3,5-pentanetetrol diacetate as an oil: ^1H NMR ($CDCl_3$) δ 7.50 (m, 2 H), 7.28 (m, 3 H), 5.16 (dd, *J* = 3.0, 9.0 Hz, 1 H), 4.68 (dt, *J* = 3.0, 6.7 Hz, 1 H), 4.26–4.48 (m, 2 H), 4.04 (dd, *J* = 6.3, 8.7 Hz, 1 H), 3.58–3.71 (m, 2 H including a dd at 3.67, *J* = 6.0, 8.7 Hz), 2.11 (s, 3 H), 2.04 (s, 3 H), 1.42 (s, 3 H), 1.28 (s, 3 H).

Reaction of (2*R*,3*R*,4*S*)-1,2-*O*-Isopropylidene-3,4-epoxy-1,2,5-pentanetriol (9) with PhSeNa. A solution of 0.069 g (0.221 mmol) of diphenyl diselenide in 1.5 mL of EtOH was treated with $NaBH_4$ in small increments until the characteristic yellow color of the diphenyl diselenide had completely dissipated. To this solution was added the epoxy alcohol **9** (0.0712 g, 0.409 mmol) in one portion, and the reaction mixture was allowed to stir until the epoxy alcohol had been completely consumed, which required 5 h. The reaction mixture was quenched with an excess of a 0.5 M aqueous $NaHCO_3$ solution. The organic product was extracted from the aqueous layer with Et_2O, and the combined organic portions were dried ($MgSO_4$), concentrated, and dried under high vacuum to afford 0.0931 g (69%) of (2*R*,3*S*,4*R*)-1,2-*O*-isopropylidene-4-(phenylseleno)-1,2,3,5-pentanetetrol (**15**) as an oil: $[\alpha]^{25}_D$ −5.3° (*c* 1.22, EtOH); ^1H NMR ($CDCl_3$) δ 7.52–7.63 (m, 2 H, Ar), 7.18–7.38 (m, 3 H, Ar), 4.55 (dt, *J* = 2.8, 6.5 Hz, 1 H, H_2), 4.08 (dd, *J* = 6.5, 7.9 Hz, 1 H), 3.92–4.03 (m, 2 H), 3.88 (dd, *J* = 7.0, 7.9 Hz, 1 H), 3.80 (m, 1 H), 3.35 (dt, *J* = 5.5, 7.0 Hz, 1 H, H_4), 2.84 (t, *J* = 6.5 Hz, 1 H), 2.68 (d, *J* = 8.0 Hz, 1 H), 1.45 (s, 3 H), 1.33 (s, 3 H); IR (NaCl) 3450 (br), 3080, 3060, 2990, 2940, 2890, 1580, 1480, 1440, 1385, 1375, 1260, 1220, 1065 (br), 850, 750, 695 cm^{-1}. Anal. Calcd for $C_{14}H_{20}O_4Se$: C, 50.76; H, 6.09. Found: C, 50.48; H, 6.12.

A small sample of **15** was peracetylated in the usual way to afford (2*R*,3*S*,4*R*)-1,2-*O*-isopropylidene-4-(phenylseleno)-1,2,3,5-pentanetetrol diacetate as an oil: ^1H NMR ($CDCl_3$) δ 7.57–7.66 (m, 2 H, Ar), 7.22–7.35 (m, 3 H, Ar), 5.23 (dd, *J* = 4.5, 8.2 Hz, 1 H, H_3), 4.67 (dt, *J* = 4.5, 6.4 Hz, 1 H, H_2), 4.48 (dd, *J* = 4.9, 11.5 Hz, 1 H, H_5), 4.37 (dd, *J* = 5.1, 11.5 Hz, 1 H, H_5'), 4.01 (dd, *J* = 7.9, 8.6 Hz, 1 H, H_1), 3.65 (dd, *J* = 5.8, 8.6 Hz, 1 H, H_1'), 3.61 (m, 1 H, H_4), 2.10 (s, 3 H), 2.0 (s, 3 H), 1.40 (s, 3 H), 1.25 (s, 3 H).

Reaction of (2*R*,3*R*,4*S*)-1,2-*O*-Isopropylidene-3,4-epoxy-1,2,5-pentanetriol (9) with $PhSeNa/NaHCO_3$. A solution of 0.1690 g (0.0541 mmol) of diphenyl diselenide and 0.094 g (1.12 mmol) of $NaHCO_3$ in 5 mL of EtOH was treated with $NaBH_4$ in small increments until the characteristic color of the diselenide had completely dissipated. To this solution was added the epoxy alcohol **9** (0.1809 g, 1.07 mmol) in one portion, and the reaction mixture was heated to 40 °C and stirred for 4 h. The reaction mixture was cooled to room temperature and extracted with Et_2O. The combined organic phases were dried (K_2CO_3), concentrated, and dried under high vacuum to afford 0.3205 g (90%) of (2*R*,3*S*,4*R*)-1,2-*O*-isopropylidene-4-(phenylseleno)-1,2,3,5-pentanetetrol (**15**).

Reaction of 2-[(1′*R,2′*S**)-1′,2′-Epoxy-1′-nonyl]-1,3-dioxolane (16) with $LiAlH_4$.** A 1 M solution of $LiAlH_4$ in Et_2O (Aldrich) (1 mL, 1 mmol) was cooled to 0 °C, and the epoxy acetal **16** was added via syringe in one portion. After stirring for 0.5 h, the Fieser workup was employed. The filtrate was triturated

with Et_2O and then with CH_2Cl_2. The combined organic portions were dried over K_2CO_3, concentrated, and dried under high vacuum to afford 0.0370 g (83%) of 2-[(1′*R**)-1′-hydroxy-1′-nonyl]-1,3-dioxolane (**18**) as a low melting solid: mp 30–31.5 °C; ^1H NMR ($CDCl_3$) δ 4.78 (d, J = 3.5 Hz, 1 H), 3.97–4.08 (m, 2 H), 3.86–3.97 (m, 2 H), 3.60 (m, 1 H), 2.00 (d, J = 4.4 Hz, 1 H), 1.17–1.63 (m, 14 H), 0.89 (t, 3 H); IR (NaCl) 3450 (br), 2920, 2860, 1465, 1380, 1155, 1120, 1030, 975, 945, 835 cm^{-1}. Anal. Calcd for $C_{12}H_{24}O_3$: C, 65.09; H, 10.14. Found: C, 65.12; H, 10.27.

A small sample of **18** was peracetylated in the usual way: ^1H NMR ($CDCl_3$) δ 4.88–5.00 (m, 2 H), 3.94–4.01 (m, 2 H), 3.84–3.94 (m, 2 H), 2.10 (s, 3 H), 1.60 (m, 2 H), 1.26 (m, 12 H), 0.88 (t, 3 H).

Reaction of 2-[(1′*R,2′*S**)-1′,2′-Epoxy-1′-nonyl]-1,3-dioxolane (16) with NaN_3/NH_4Cl.** A solution of the epoxy acetal **16** (0.0402 g, 0.188 mmol) in 3 mL of a 1:1:1 THF–$CH_3OCH_2CH_2OH$–H_2O solution was refluxed overnight with NaN_3 (0.0673 g, 1.04 mmol) and NH_4Cl (0.0270 g, 0.505 mmol). The reaction mixture was cooled to room temperature and concentrated. The organic material was dissolved in Et_2O, and the inorganic salts were extracted into water. The aqueous wash was back-extracted 3 times with Et_2O, and the combined organic phases were dried (K_2CO_3) and concentrated to afford an oil. Purification of this material by flash chromatography (4:1 hexane–EtOAc) provided 0.0349 g (72%, 79% based on recovered **16**) of 2-[(1′*R**,2′*R**)-2′-azido-1′-hydroxy-1′-nonyl]-1,3-dioxolane (**19**) as an oil: ^1H NMR ($CDCl_3$) δ 5.01 (d, J = 4.1 Hz, 1 H), 3.89–4.11 (m, 4 H), 3.62 (m, 1 H), 3.44 (m, 1 H), 2.31 (d, J = 4.9 Hz, 1 H), 1.21–1.86 (m, 12 H), 0.90 (t, 3 H); IR (NaCl) 3450 (br), 2950, 2930, 2860, 2100, 1470, 1380, 1340, 1260, 1160, 1035, 945, 850 cm^{-1}.

A small sample of **19** was peracetylated in the usual way to afford 2-[(1′*R**,2′*R**)-1′-acetoxy-2′-azido-1′-nonyl]-1,3-dioxolane as an oil: ^1H NMR ($CDCl_3$) δ 5.14 (d, J = 4.0 Hz, 1 H), 5.04 (t, J = 5.0 Hz, 1 H), 3.89–4.04 (m, 4 H), 3.57 (m, 1 H), 2.16 (s, 3 H), 1.24–1.67 (m, 12 H), 0.90 (t, 3 H).

Reaction of 2-[(1′*R,2′*S**)-1′,2′-Epoxy-1′-nonyl]-1,3-dioxolane (16) with PhSNa/PHSH.** The epoxy acetal **16** (0.0281 g, 0.131 mmol) was treated with an excess of sodium benzenethiolate and benzenethiol in THF in a procedure similar to the one described above for the ring-opening reaction of 2,3-epoxy alcohols. The reaction mixture was refluxed for 3.5 h, cooled to room temperature, and quenched with 0.5 mL of a saturated aqueous NH_4Cl solution. The reaction mixture was poured into a saturated aqueous NH_4Cl solution and then extracted 5 times with Et_2O. The combined organic portions were washed twice with a saturated aqueous NaCl solution, dried (K_2CO_3), concentrated, and then dried under high vacuum. This material was purified by flash chromatography (4:1 hexane–EtOAc) to afford 0.0323 g (76%) of 2-[(1′*R**,2′*R**)-1′-hydroxy-2′-(phenylthio)-1′-nonyl]-1,3-dioxolane (**20**) as an oil: ^1H NMR ($CDCl_3$) δ 7.36–7.51 (m, 2 H, Ar), 7.17–7.33 (m, 3 H, Ar), 5.11 (d, J = 3.8 Hz, 1 H), 3.78–4.13 (m, 4 H), 3.66 (m, 1 H), 3.22 (m, 1 H), 2.46 (d, J = 4.5 Hz, 1 H), 1.87 (m, 1 H), 1.41–1.75 (m, 3 H), 1.26 (m, 8 H), 0.87 (t, 3 H); IR (NaCl) 3480 (br), 3070, 3060, 2950, 2920, 2850, 1585, 1575, 1480, 1465, 1440, 1380, 1150, 1050, 980, 945, 840, 740, 690 cm^{-1}. Anal. Calcd for $C_{12}H_{28}O_3S$: C, 66.63; H, 8.70; S, 9.88. Found: C, 66.76; H, 8.73; S, 9.87.

Reaction of 2-[(1′*R,2′*S**)-1′,2′-Epoxy-1′-nonyl]-1,3-dioxolane (16) with Me_2CuLi.** A 10-mL round-bottomed flask was charged with 0.1582 g (0.83 mmol) of CuI, sealed with a septum, and flushed with nitrogen. Anhydrous Et_2O (3 mL) was introduced via syringe, and the flask was immersed in a slush of Et_2O, CCl_4, and dry ice. This slush was maintained between −40 and −35 °C throughout the course of the reaction. A solution of MeLi (1.7 M in hexane, 1.2 mL, 2 mmol) was added with stirring to the CuI to afford an ethereal solution of Me_2CuLi. After allowing the Me_2CuLi to stir for 40 min, the epoxy acetal **16** (0.0338 g, 0.158 mmol) was added to the reaction mixture, and stirring was continued for an additional 70 min. The reaction mixture was quenched with ca. 6 mL of a saturated aqueous NH_4Cl solution, which caused a green solid to precipitate from solution. After the reaction mixture was stirred for 2 h in the presence of air, the green precipitate dissolved completely to give a deep blue aqueous layer and a colorless organic layer. The phases were separated, and the aqueous layer was extracted 3 times with Et_2O. The combined organic phases were washed once with a saturated aqueous $NaHCO_3$ solution and once with a saturated aqueous NaCl solution, dried (K_2CO_3), concentrated, and dried under high vacuum to afford 0.0296 g (81%) of 2-[(1′*R**,2′*R**)-1′-hydroxy-2′-methyl-1′-nonyl]-1,3-dioxolane (**21**) as an oil: ^1H NMR ($CDCl_3$) δ 4.93 (d, J = 3.4 Hz, 1 H), 3.85–4.07 (m, 4 H), 3.42 (m, 1 H), 2.15 (d, J = 4.5 Hz, 1 H), 1.10–1.82 (m, 13 H) 0.96 (d, J = 6.7 Hz, 3 H), 0.88 (t, J = 5.6 Hz, 3 H); IR (NaCl) 3500 (br), 2960, 2930, 2860, 1470, 1380, 1165, 1130, 1040, 950 cm^{-1}. Anal. Calcd for $C_{13}H_{26}O_3$: C, 67.79; H, 11.38. Found: C, 67.41; H, 11.07.

A small sample of **21** was peracetylated in the usual way to afford 2-[(1′*R**,2′*R**)-1′-acetoxy-2′-methyl-1′-nonyl]-1,3-dioxolane as an oil: ^1H NMR ($CDCl_3$) δ 5.07 (d, J = 4.4 Hz, 1 H), 4.83 (dd, J = 4.4, 6.2 Hz, 1 H), 3.81–4.04 (m, 4 H), 2.10 (s, 3 H), 1.87 (m, 1 H), 1.09–1.63 (m, 12 H), 0.96 (d, J = 6.9 Hz, 3 H), 0.88 (t, J = 6.9 Hz, 3 H).

Preparation of (2*S*,3*S*)-4-(Benzyloxy)-1,1-dimethoxy-2,3-epoxybutane (24). A solution of the epoxy aldehyde **23** (0.0221 g, 0.115 mmol) was stirred with anhydrous $CuSO_4$ (0.0470 g, 0.297 mmol) and fumaric acid (0.080 g, 0.70 mmol) in 6 mL of anhydrous methanol at room temperature for 35 min. The reaction mixture was then heated to reflux, and an additional amount of fumaric acid (0.080 g) was introduced to the reaction mixture. After 10 min at reflux there was complete consumption of **23** by TLC, and the reaction mixture was cooled to room temperature. The acid was neutralized with an excess of saturated aqueous $NaHCO_3$ solution, and the reaction mixture was filtered. The phases were separated, and the aqueous layer extracted with CH_2Cl_2. The combined organic phases were dried (K_2CO_3), concentrated, and dried under high vacuum to afford 0.0184 g of an oil. This material was purified by flash chromatography (19:1 hexane–EtOAc) to afford 0.0114 g (42%) of **24** as an oil: $[\alpha]^{20}_D$ +5.2° (c 1.99, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.22–7.41 (d, J = 6.0 Hz, 1 H, H_1), 4.56, 4.64 (AB, J_{AB} = 11.8 Hz, 2 H, benzylic), 4.24 (d, J = 6.0 Hz, 1 H, H_1), 3.83 (dd, J = 3.2, 11.5 Hz, 1 H, H_4), 3.57 (dd, J = 6.8, 11.5 Hz, 1 H, H_4'), 3.43 (s, 3 H), 3.37 (s, 3 H), 3.28 (m, 1 H, H_3), 3.14 (dd, J = 4.5, 6.0 Hz, H_2); IR (NaCl) 3080, 3060, 3030, 2990, 2930, 2910, 2830, 1595, 1450, 1380, 1365, 1350, 1300, 1250, 1200, 1150, 1100, 965, 910, 855, 785, 735, 690 cm^{-1}.

In addition to **24**, there was also obtained 0.0043 g (14%) of an oil that was assumed to be (2*S*,3*R*)-4-(benzyloxy)-1,1,3-trimethoxy-2-butanol (**25**) on the basis of the ^1H NMR spectrum: ^1H NMR ($CDCl_3$) δ 7.24–7.35 (m, 5 H), 4.57 (s, 2 H), 4.42 (d, J = 6.9 Hz, 1 H), 3.63–3.73 (m, 3 H), 3.58 (m, 1 H), 3.49 (s, 3 H), 3.45 (s, 3 H), 3.44 (s, 3 H), 2.49 (d, J = 4.1 Hz, 1 H).

Reaction of (2*S*,3*S*)-4-(Benzyloxy)-1,1-dimethoxy-2,3-epoxybutane (24) with PhSNa/PhSH. The epoxy acetal **24** (0.0305 g, 0.128 mmol) was treated with an excess of sodium benzenethiolate and benzenethiol in THF in a procedure similar to the one described above for the ring-opening reaction of 2,3-epoxy alcohols. The reaction mixture was refluxed for 2 h, cooled to room temperature, and quenched with a saturated aqueous NH_4Cl solution. The reaction mixture was concentrated to remove the THF and then partitioned between aqueous NH_4Cl and CH_2Cl_2. The aqueous phase was extracted with CH_2Cl_2, and the combined organic phases were dried (K_2CO_3), concentrated, and dried under high vacuum. The product was purified via flash chromatography to afford 0.0387 g (87%) of (2*R*,3*R*)-4-(benzyloxy)-1,1-dimethoxy-3-(phenylthio)-2-butanol (**27**) as an oil: $[\alpha]^{25}_D$ −21.9° (c 2.49, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.37–7.47 (m, 2 H, Ar), 7.18–7.34 (m, 8 H, Ar), 4.66 (d, J = 7.8 Hz, 1 H), 4.53 (s, 2 H, benzylic), 4.12 (m, 1 H), 3.84 (m, 1 H), 3.69 (dd, J = 4.7, 10.1 Hz, 1 H), 3.57 (m, 1 H), 3.48 (s, 3 H), 3.32 (s, 3 H), 2.57 (d, J = 3.0 Hz, 1 H); IR (NaCl) 3450 (br), 3060, 3040, 2990, 1585, 1485, 1465, 1440, 1360, 1200, 1100 (br), 980, 910, 740, 700 cm^{-1}. Anal. Calcd for $C_{19}H_{24}O_4S$: C, 65.49; H, 6.94; S, 9.20. Found: C, 65.57; H, 6.88; S, 9.48.

Preparation of (2*R*,3*S*)-*N*-Benzyl-2,3-epoxy-1-decanamide (29). A 25-mL round-bottomed flask equipped with an efficient magnetic stirring bar was charged with 2 mL of acetonitrile, 2 mL of carbon tetrachloride, 3 mL of water, 0.1741 g (1.01 mmol) of (2*S*,3*S*)-2,3-epoxy-1-decanol (**2**), and 0.0054 g (0.021 mmol, 2.0 mol %) of ruthenium trichloride hydrate. This reaction mixture was treated with 0.878 g (4.1 mmol) of sodium metaperiodate and allowed to stir at room temperature. After 3 h, the reaction mixture was diluted with 10 mL of methylene chloride. After stirring for ca. 15 min, the phases were separated. The aqueous

phase was extracted 3 times with methylene chloride, and the combined organic phases were filtered and concentrated. The residue was taken up in 20 mL of ether, dried over $MgSO_4$, filtered through a pad of Celite, concentrated, and dried under high vacuum to afford 0.1458 g (0.0798 mmol, 79% yield) of the crude (2*R*,3*S*)-2,3-epoxy-1-decanoic acid.

The epoxy acid was immediately dissolved in 10 mL of THF. This solution was treated sequentially with freshly distilled benzylamine (0.087 mL, 0.085 g, 0.798 mmol), 1-hydroxybenzotriazole (0.215 g, 1.59 mmol), and dicyclohexylcarbodiimide (0.197 g, 0.96 mmol) and stirred at room temperature for 48 h. The crude reaction mixture was filtered and concentrated. The residue was taken up in Et_2O, and the insoluble portion was removed by filtration. The solvent was evaporated to give a crude product. This material was purified by flash chromatography (10:1 CH_2Cl_2–EtOAc) to afford 0.1678 g (76% from the acid, 60% overall) of **29**: mp 51–52.5 °C; $[\alpha]^{25}_D$ −2.1° (*c* 0.14, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.21–7.46 (m, 5 H), 6.46 (br m, 1 H), 4.42 (d, *J* = 5.6 Hz, 2 H), 3.28 (s, 1 H), 2.96 (m, 1 H), 1.22–1.77 (m, 12 H), 0.88 (t, 3 H); IR (NaCl) 3300, 3090, 3050, 2950, 2880, 1670, 1550, 1465, 1370, 1300, 1265, 1240, 1080, 1040, 910, 750, 710 cm^{-1}. Anal. Calcd for $C_{17}H_{25}NO_2$: C, 74.14; H, 9.15; N, 5.09. Found: C, 74.10; H, 9.39; N, 4.98.

Reaction of (2*R*,3*S*)-*N*-Benzyl-2,3-epoxy-1-decanamide (29) with NaN_3/NH_4Cl. The epoxy amide **29** (0.0287 g, 0.104 mmol) in 2 mL of an 8:1 2-methoxyethanol–H_2O solution was refluxed for a period of 16.5 h with 0.0358 g (0.55 mmol) of NaN_3 and 0.0219 g (0.409 mmol) of NH_4Cl. The reaction mixture was cooled to room temperature and then concentrated. The residue was taken up and passed through a very short silica gel column with EtOAc. After evaporation of the solvent and drying of the product in vacuo, there was obtained 0.0313 g (94%) of an oil that was found to be a mixture of (2*R*,3*R*)-*N*-benzyl-3-azido-2-hydroxy-1-decanamide (**35a**) and (2*S*,3*S*)-*N*-benzyl-2-azido-3-hydroxy-1-decanamide (**35b**). A small sample of this mixture was peracetylated in the usual way. A comparison of the ^1H NMR spectra of this reaction mixture with that of authentic **35a** (vide infra) demonstrated that **35a** is indeed the major product formed in this reaction. However, the selectivity was only 1.5 to 1.0 as determined by the ^1H NMR integration.

Reaction of (2*R*,3*S*)-*N*-Benzyl-2,3-epoxy-1-decanamide (29) with $NaN_3/MgSO_4$. A solution of the epoxy amide **29** (0.0189 g, 0.069 mmol) in 2 mL of methanol was refluxed overnight with 0.0098 g (0.151 mmol) of NaN_3 and 0.086 g (0.071 mmol) of $MgSO_4$. During the course of the reaction, nearly all of the methanol evaporated. The reaction mixture was cooled and then concentrated to dryness. The residue was taken up in ether and washed with a small amount of an aqueous $NaHCO_3$ solution. The organic phase was concentrated and then dried under high vacuum to afford 0.0219 g (quantitative yield) of (2*R*,3*R*)-*N*-benzyl-3-azido-2-hydroxy-1-decanamide (**35a**) as an oil. A portion of this material was purified by flash chromatography (2:3 EtOAc-hexane): $[\alpha]^{25}_D$ +19.4° (*c* 1.64, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.22–7.39 (m, 5 H, Ar), 6.97 (br m, 1 H, amide), 4.47 (m, 2 H, benzylic), 4.29 (t, *J* = 4.2 Hz, 1 H, H_2), 3.73 (m, 1 H, H_3), 3.19 (d, *J* = 4.8 Hz, 1 H, –OH), 1.19–1.72 (m, 12 H, alkyl), 0.88 (t, 3 H); IR (NaCl) 3300–3400 (br), 3100, 3070, 2960, 2930, 2860, 2110, 1655, 1535, 1455, 1260, 735, 700 cm^{-1}. Anal. Calcd for $C_{17}H_{26}N_4O_2$: C, 64.13; H, 8.23; N, 17.60. Found: C, 64.28; H, 8.50; N, 17.43.

A portion of the unpurified sample of **35a** was peracetylated in the usual way: ^1H NMR ($CDCl_3$) δ 7.20–7.41 (m, 5 H, Ar), 6.38 (br m, 1 H, amide), 5.38 (d, *J* = 3.5 Hz, 1 H, H_2), 4.50 (m, 2 H, benzylic), 3.80 (m, 1 H, H_3), 2.18 (s, 3 H, acetate), 1.15–1.65 (m, 12 H, alkyl), 0.89 (t, 3 H).

Reaction of (2*R*,3*S*)-*N*-Benzyl-2,3-epoxy-1-decanamide (29) with PhSK/PhSH. A tared round-bottomed flask was charged with a small portion of a 22% KH in oil dispersion (Alfa). The KH was washed 3 times with benzene and then dried in vacuo to afford 0.069 g (1.72 mmol) of dry KH as a free-flowing powder. The KH was dissolved in 7 mL of DMF, and this solution was cooled to 0–5 °C in an ice bath and treated with 0.39 mL (3.8 mmol) of benzenethiol. This procedure results in a stock solution of potassium benzenthiolate (0.23 M) buffered with an excess of benzenethiol (0.28 M) that is suitable for use in the ring-opening reactions of 2,3-epoxy amides.

A solution of the epoxy amide **29** (0.0264 g, 0.096 mmol) in 1 mL of DMF was treated with 0.85 mL (ca. 0.196 mmol PhSK) of the buffered benzenethiolate stock solution and stirred at room temperature. After 8 h, an additional 0.85 mL of the benzenethiolate stock solution was added to the reaction mixture. The reaction was judged to be complete after stirring for 36 h. The DMF was removed in vacuo to afford a white residue. This material was purified by flash chromatography (19:1 $HCCl_3$–EtOAc) to afford 0.0199 g (54%) of (2*S*,3*S*)-*N*-benzyl-3-hydroxy-2-(phenylthio)-1-decanamide (**36**) as a solid: mp 82.5–84 °C; $[\alpha]^{25}_D$ −55.1° (*c* 1.82, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.10–7.50 (m, 10 H, Ar), 6.85 (br t, 1 H, amide), 4.43 (m, 2 H, benzylic), 4.04 (m, 1 H, H_3), 3.68 (d, *J* = 5.4 Hz, 1 H, H_2), 3.22 (d, *J* = 5.9 Hz, 1 H, OH), 1.13–1.79 (m, 12 H), 0.88 (t, 3 H); IR (KBr) 3200–3450 (br), 3080, 3030, 2960, 2930, 2860, 1650, 1550, 740, 705, 695 cm^{-1}. Anal. Calcd for $C_{23}H_{31}NO_2S$: C, 71.65; H, 8.10; N, 3.53. Found: C, 71.63; H, 8.29; N, 3.44.

A sample of **36** was peracetylated in the usual way to afford (2*S*,3*S*)-*N*-benzyl-3-acetoxy-2-(phenylthio)-1-decanamide as a solid: mp 94–96 °C; $[\alpha]^{25}_D$ −60.4° (*c* 0.23, $HCCl_3$); ^1H NMR ($CDCl_3$) δ 7.10–7.37 (m, 10 H, Ar), 6.93 (br t, 1 H, amide), 5.35 (m, 1 H, H_3), 4.44 (m, 2 H, benzylic), 4.05 (d, *J* = 4.8 Hz, 1 H, H_2), 2.00 (s, 3 H, acetate), 1.73 (m, 2 H), 1.27 (m, 10 H), 0.88 (t, 3 H); IR (NaCl) 3300 (br), 3070, 3040, 2960, 2930, 2860, 1735, 1660, 1540, 1250, 1030, 750, 695 cm^{-1}. Anal. Calcd for $C_{25}H_{33}NO_3S$: C, 70.22; H, 7.78; N, 3.28. Found: C, 70.41; H, 8.06; N, 3.15.

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Supplementary Material Available: All the experimental procedures except the ones described in the Experimental Section, spectroscopic data of all the products (27 pages). Ordering information is given on any current masthead page.