Remote Allylic Silyloxy Groups as Stereocontrol Elements in Intramolecular Oxymercurations of γ-Hydroxyalkenes

Katharina Bratt,[†,‡] Agatha Garavelas,[†] Patrick Perlmutter,*[,†] and Gunnar Westman[†]

Department of Chemistry, Monash University, Clayton, Victoria, 3168, Australia, and Department of Organic Chemistry, University of Uppsala, 751 21 Uppsala, Sweden

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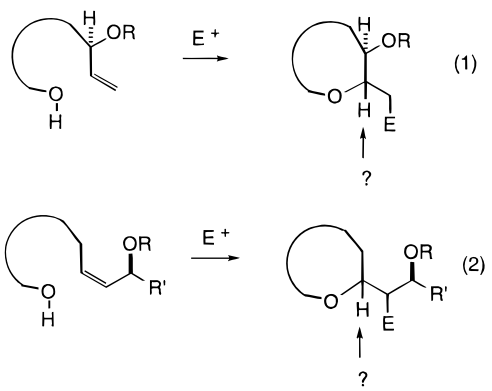
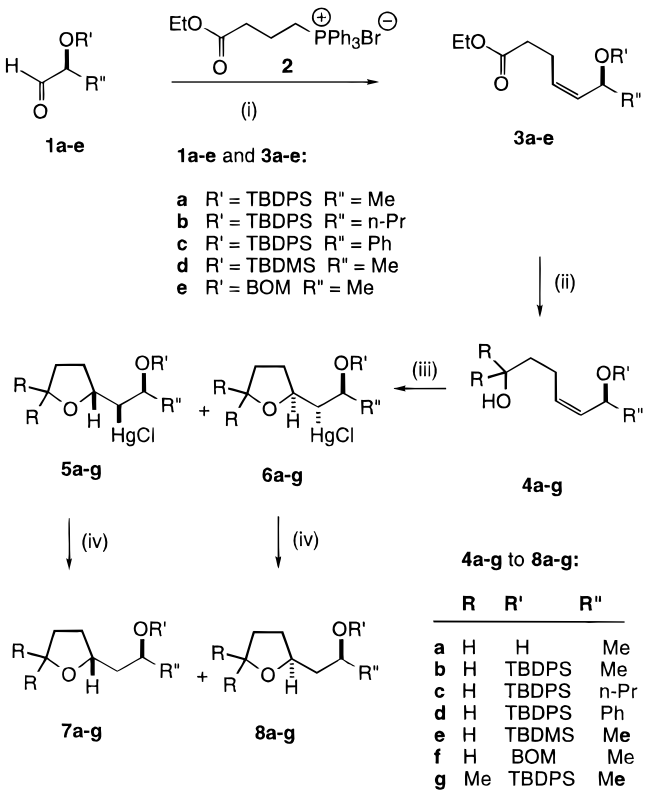
The diastereoselectivity in intramolecular oxymercurations of γ-hydroxyalkenes bearing a remote allylic oxy substituent has been investigated. It was found that the best selectivity was obtained by employing a combination of (*Z*)-alkene geometry and a *tert*-butyldiphenylsilyl protecting group attached to the remote allylic oxygen as in **4a**−**g**. Cyclization, using mercuric acetate in dichloromethane, of all the (*Z*)-alkenols gave the *syn* diastereomer, **5a**−**g**, as the major product. For example, cyclization of **4b** gave *syn* diastereomer **5b** and *anti* diastereomer **6b** in a ratio of 7:1. It was found that this ratio could be improved by replacing dichloromethane with acetonitrile. Under these conditions the ratio of **5b** to **6b** increased to 19:1. Cyclization of (*E*)-alkene **9** gave very poor diastereoselection. These *syn*-selective intramolecular oxymercurations were exploited in enantioselective syntheses of two diastereomers of methyl nonactate.

Introduction

Stereoselective electrophilic ring closures have been the subject of numerous articles and reviews over the past decade.[1] Several groups have identified the importance of a "proximal" allylic oxygen-based substituent (i.e., a substituent attached to the allylic carbon adjacent to the alkene carbon undergoing ring closure) in the substrate for controlling the stereochemistry of the closure (eq 1). A few examples also exist of the use of a "remote" allylic substituent as a stereocontrol element (eq 2).[2] Recently we reported our first results from a more systematic study of the influence of the nature of the remote allylic substituent on the diastereoselectivity of ring closures.[3] In particular we examined intramolecular oxymercurations of γ-hydroxyalkenes bearing a remote allylic oxygen-based substituent. We have now extended the range of substrates and have found that such closures often proceed with high levels of diastereoselectivity.



Scheme 1



4a-g to **8a-g:**

	R	R'	R"
a	H	H	Me
b	H	TBDPS	Me
c	H	TBDPS	n-Pr
d	H	TBDPS	Ph
e	H	TBDMS	Me
f	H	BOM	Me
g	Me	TBDPS	Me

(i) $NaN(TMS)_2$, THF, 0°C; (ii) $LiAlH_4$, THF; (iii) (a) $Hg(OAc)_2$, solvent (see Table 1), (b) Aq. NaCl; (iv) Bu_3SnH, AIBN, toluene.

Results and Discussion

The alkenols used in this study were prepared by *Z*-selective olefination of the appropriate aldehyde (**1a**−**e**)[4] with the ylide derived from (3-(ethoxycarbonyl)-propyl)triphenylphosphonium bromide[5] (**2**) (Scheme 1). Reduction of alkenoates **3a**−**e** with $LiAlH_4$ gave the primary alcohols **4b**−**f**. Diol **4a** was prepared by de-

† Monash University.
‡ University of Uppsala.
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(1) (a) Harmange, J.-C.; Figadere, B. *Tetrahedron: Asymmetry* **1993**, *4*, 1711. (b) Cardillo, G.; Orena, M. *Tetrahedron* **1990**, *46*, 3321. (c) Boivin, T. L. B. *Tetrahedron* **1987**, *43*, 3309.

(2) (a) Hanessian, S.; Cooke, N. G.; DeHoff, B.; Sakito, Y. *J. Am. Chem. Soc.* **1990**, *112*, 5276. (b) Evans, D. A.; Dow, R. L.; Shih, T. L.; Takacs, J. M.; Zahler, R. *J. Am. Chem. Soc.* **1990**, *112*, 5290.

(3) Garavelas, A.; Mavropoulos, I.; Perlmutter, P.; Westman, G. *Tetrahedron Lett.* **1995**, 36, 463−466.

(4) The stereochemistry for the "**c**" series is enantiomeric to that shown in Scheme 1 but has been left as shown for simplicity.

(5) Hellwinkel, D.; Kosack, T. *Leibigs Ann. Chim.* **1985**, *226*, 2.

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Table 1. Results from Intramolecular Oxymercurations[a] of Alkenols 4a–g

entry	alkenol	R	R′	R″	solvent	yield[b] (%)	ratio **5**:**6**
1	**4a**	H	H	Me	CH_2Cl_2	85	2.5:1
2	**4b**	H	TBDPS	Me	CH_2Cl_2	93	7:1
3					$CHCl_3$	92	10:1
4					CH_3CN	90	19:1
5	**4c**	H	TBDPS	*n*-Pr	CH_2Cl_2	76	7:1
6					$CHCl_3$	92	10:1
7	**4d**	H	TBDPS	Ph	CH_2Cl_2	84	6:1
8					CH_3CN	86	10:1
9	**4e**	H	TBDMS	Me	CH_2Cl_2	89	6:1
10					CH_3CN	92	8:1
11	**4f**	H	BOM	Me	CH_2Cl_2	99	4.5:1
12					$CHCl_3$	80	7.5:1
13	**4g**	Me	TBDPS	Me	CH_2Cl_2	90	3:1
14					CH_3CN	89	10:1

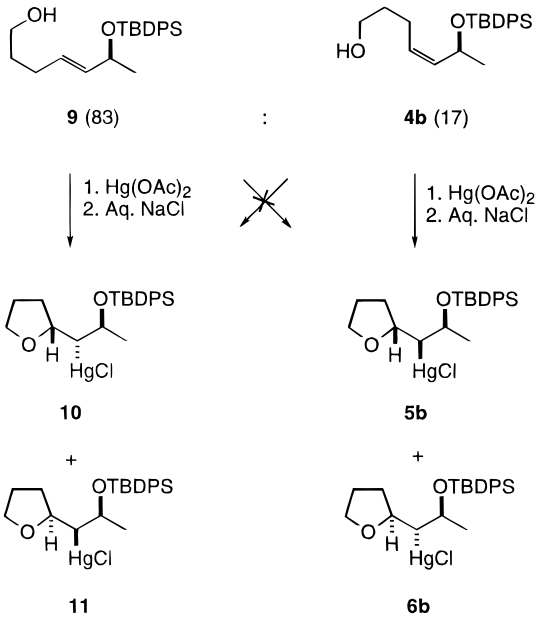
[a] $Hg(OAc)_2$, solvent, rt; aqueous NaCl. [b] Total isolated yield.

silylation of **4b**. Alkenol **4g** was prepared by addition of excess methylmagnesium bromide to **3a**.

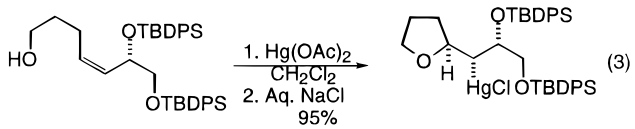
From Table 1 it can be seen that good to excellent diastereoselectivity may be obtained in these intramolecular oxymercurations. The ether protecting group which conferred the greatest selectivity was the *tert*-butyldiphenylsilyl (TBDPS) group (entries 2–8 and 14). The use of benzyloxymethyl (BOM, entries 11 and 12), *tert*-butyldimethylsilyl (TBDMS, entries 9 and 10), or no protecting group at all (entry 1) gave poorer, although in some cases still useful, results. We also found that in some cases increasing the polarity of the solvent significantly improved diastereoselectivity. This was found to be especially so when acetonitrile was used as solvent (entries 4, 8, 10, and 14). This effect was also observed where a tertiary alcohol was the internal nucleophile (compare entries 13 and 14).

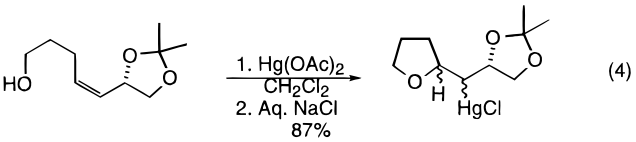
We briefly examined the influence of alkene geometry on the ring closure. Photoisomerization of (*Z*)-alkene **4b** gave (*E*)-alkene **9** in an *E*:*Z* isomer ratio of 83:17. The mixture of geometrical isomers could not be separated and was used as such in the ring closure. Intramolecular oxymercuration of this mixture gave a similar ratio (compared to that of the starting materials) of two pairs of products. The minor pair of isomers was identical to that obtained from the ring closure of pure *Z*-**4b**. The major products, i.e., those obtained from ring closure of **9**, were formed with little selectivity. This result is not surprising as (*E*)-olefins suffer from little allylic strain and probably react through several significantly populated conformers.[6] It is worth noting here that the isolation of the two pairs of oxymercuration products in similar ratios to the starting *E*/*Z* alkenes suggests that a stereochemically clean inversion process occurs during ring closure. This in turn points to the involvement of a mercuronium intermediate or a very tightly-bound π-complex. If this were not the case, i.e., there were a competing S_N1-like process occurring, then it is unlikely that these ratios would have been maintained.

We found that, compared to a cyclic acetonide, the use of a TBDPS ether also had a remarkable effect on the stereoselectivity of ring closure (eqs 3 and 4). Closure of acetonide **14** proceeded with little diastereoselectivity. In contrast, ring closure of **12** gave only one diastereomer

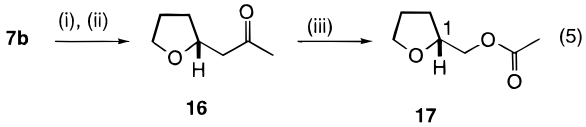


(within the usual limits of detection by high-field ^1H NMR spectroscopy). This observation is currently being exploited in a new synthesis of mono- and bicyclic alkaloids.[7]





Proof of the stereochemistry of these cyclizations was first obtained by chemical means. Hence the major product from the ring closure of **4b**, i.e., **5b**, was transformed into the known acetate **17**[8] following reductive demercuration to **7b**. This involved a sequence of desilylation, Swern oxidation, and Baeyer–Villiger oxidation. Comparison of our synthetic sample with an authentic sample prepared by Kenyon's method[8] provided unambiguous proof that the stereochemistry at C1 was *R*. Subsequently we confirmed these results by obtaining an X-ray crystal structure of **5b**.



(i) $Bu_4N^+F^-$, THF; (ii) (a) DMSO, $(COCl)_2$, CH_2Cl_2, -78°C, (b) Et_3N, 85%; (iii) CF_3CO_3H, CH_2Cl_2, reflux, 2h, 71%

We were also interested in examining intramolecular oxymercurations with stereochemically-defined secondary alcohols as internal nucleophiles. This also provided

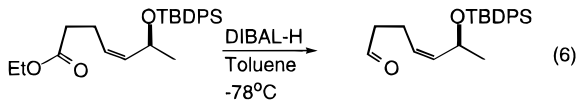
(6) (a) Hoveyda, A. H.; Evans, D. A.; Fu, G. C. *Chem. Rev.* **1993**, *93*, 1307. (b) Hoffmann, R. W. *Chem. Rev.* **1989**, *89*, 1841. (c) Chamberlin, A. R.; Mulholland, R. L., Jr.; Kahn, S. D.; Hehre, W. J. *J. Am. Chem. Soc.* **1987**, *109*, 672.

(7) Bratt, K.; Enierga, G.; Perlmutter, P.; Pruis, J. Unpublished results.

(8) Kenyon, J.; Balfe, M. P.; Irwin, M. *J. Chem. Soc.* **1941**, 312.

us with an opportunity to prepare two diastereomers of nonactic acid which had previously been identified, but not isolated pure, as byproducts in Bartlett's total synthesis of nonactin.[9]

Thus ester **3a** was reduced to aldehyde **18**. The aldehyde proved to be surprisingly robust. It was quite stable to chromatography on silica gel and could be stored for several weeks under nitrogen without decomposition. *Syn* aldol reaction of **18** with the *N*-propionylsultam

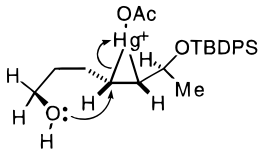


(6)

3a **18**

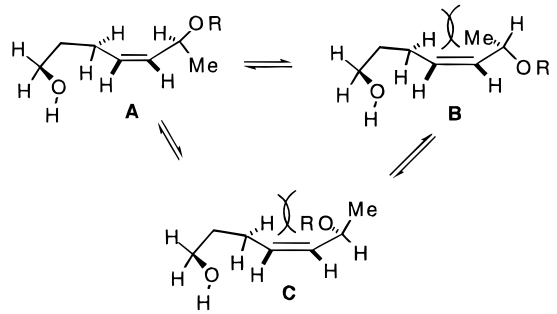
boron enolate **19**[10] gave adduct **20** as a single diastereomer (Scheme 2) whose structure was confirmed by single-crystal X-ray diffraction[17] (see Figure 1). Intramolecular oxymercuration of **20** gave a 93:7 mixture of diastereomers in favor of **21a** in excellent yield. Consistent with all our previous observations the major isomer was the product of a *syn*-selective ring closure. Reductive demercuration,[11] followed sequentially by amide hydrolysis, esterification, and desilylation, gave the methyl nonactate isomer **25**. Similarly, **32** was synthesized in six steps using *N*-propionylsultam boron enolate **26**. Interestingly, the ring closure of **27** was slightly less diastereoselective (84:16) than that for **20**, although still in favor of the *syn* diastereomer **28a**.[12]

The *syn* stereochemistry observed in all the cyclizations described in this work arises from intramolecular attack (by the hydroxyl group) of the *Re* face of each alkene. In turn, this is a consequence of preferential formation of the mercuronium intermediate from the (opposite) *Si* face of the alkene. What factors control this? First, assuming



that the hydrogen-eclipsed conformation (**A**, lower in energy than **B** or **C**) most resembles the reacting conformer in these reactions, then the role of the allylic substituents is of critical importance. (Conformers which involve the allylic C−O bond aligning itself orthogonal to the plane of the double bond can be excluded on stereoelectronic grounds).

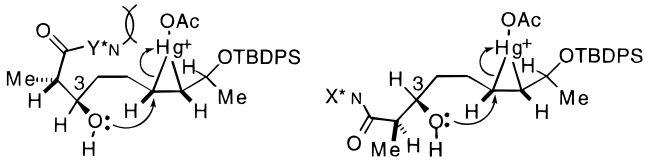
In fact, the crystal structure of one of the alkenols, **20**, clearly shows that the allylic methyl group, C9, is essentially perpendicular to the plane of the double bond (Figure 1). Thus if one considers the possibility that, in solution, the eclipsing allylic hydrogen (cf. H8 in Figure 1) is not quite in plane[6b] but rotated by an amount similar to that found in the crystal structure, then the methyl group blocks approach to the *Si* face of the alkene. (Naturally, the phenyl group, as depicted in Figure 1, would need to swing away from its position "above" the



alkene or mercuronium intermediate in order to enable ring closure to occur.)

Alternatively, the silyl ether is behaving, effectively, as a sterically "smaller" group than methyl (a consequence of the long carbon−silicon bond) or some favorable interaction occurs between the silyl ether and the mercuronium. Such interactions might be coordination to the silyl ether oxygen or mercury−phenyl complexation. Coordination to silyl ethers by metal cations is generally regarded as unlikely; however little work has so far been carried out on mercuronium coordination.[13]

The greater selectivity associated with the cyclization of **20** (93:7) compared to that of **27** (84:16) may be the result of the difference in stereochemistry at C3 for each compound. For **27** an unfavorable pseudodiaxial interaction leads to a slightly higher energy transition state (**D**) than that for **20** where no such interaction operates (**E**).



D **E**

With pure samples of **25** and **32** in hand, it was now possible to compare the chemical shifts of these nonactate isomers with those used earlier in Bartlett's study to assign the relative stereochemistry of *ent*-**25** and *ent*-**32**. The relevant data are collected in Table 2. All four compounds in Table 2 possess the unnatural relative configuration between C2 and C3 and between C6 and C8. Bartlett[9a] noted that the C10 hydrogens resonate at $\delta < 1.14$ for the natural C2/C3 nonactate configuration but at $\delta > 1.22$ for the unnatural configuration. They also observed that the C9 hydrogens resonate at $\delta > 1.20$ for the natural nonactate C6/C8 configuration but at $\delta < 1.18$ for the unnatural configuration. Also the coupling constants for the C9 and C10 hydrogens were consistently 6.2 and 7.0 Hz, respectively. All these trends are apparent in Table 2 and fully support the assignment of relative stereochemistry in this and earlier work.

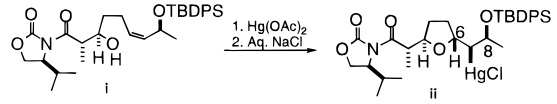
The intramolecular oxymercurations carried out in this study are noteworthy for several reasons. First, the

(9) (a) Bartlett, P. A.; Meadows, J. D.; Ottow, E. *J. Am. Chem. Soc.* **1984**, *106*, 5304. (b) For a comprehensive list of nonactic acid and nonactin syntheses, see: Fleming, I.; Ghosh, S. K. *J. Chem. Soc., Chem. Commun.* **1994**, 2285.

(10) Oppolzer, W.; Blagg, J.; Rodriguez, I.; Walther, E. *J. Am. Chem. Soc.* **1990**, *112*, 2767.

(11) Evans, D. A.; Bender, S. L.; Morris, J. *J. Am. Chem. Soc.* **1988**, *110*, 2506.

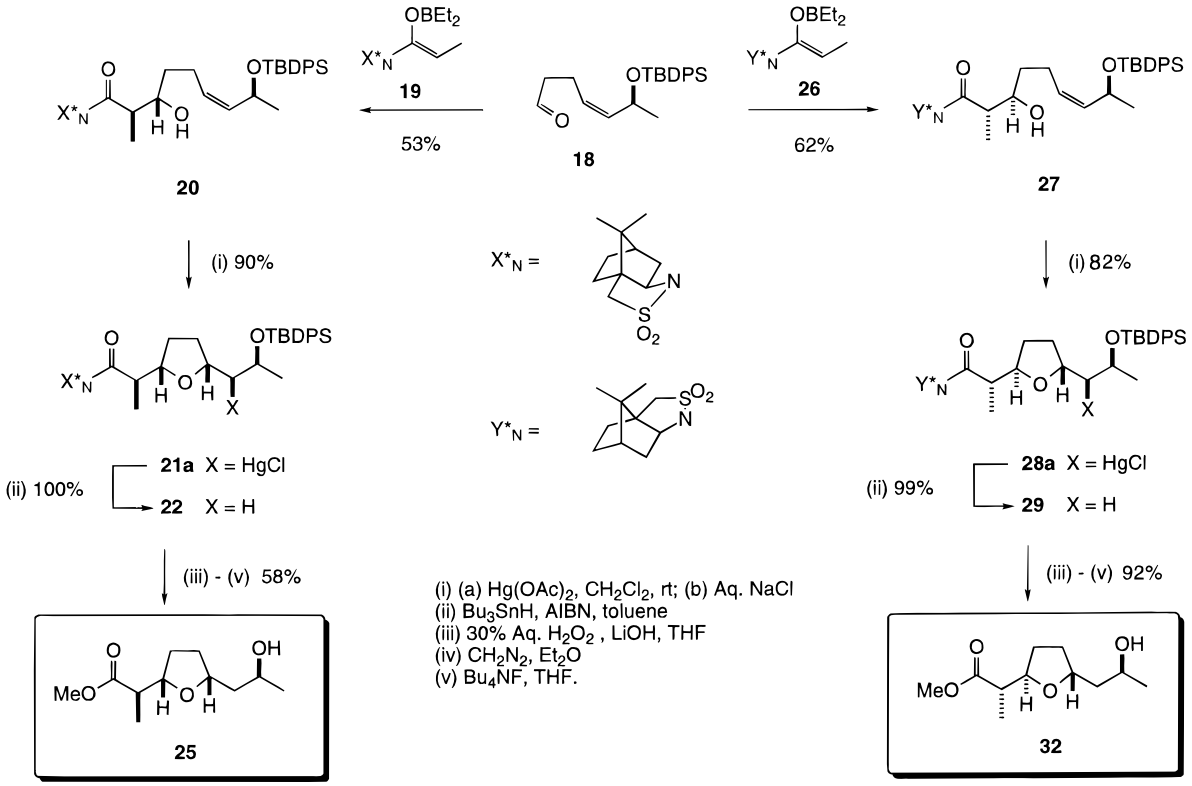
(12) We have also briefly examined the use of Evans' valine-derived auxiliary in this chemistry. We were rewarded with a crystalline material for the major diastereomer **ii** of the ring closure (see below). This clearly confirmed the *syn* relative stereochemistry between C6 and C8 (Garavelas, A. Ph.D. Thesis, Monash University, 1995).



i ii

(13) Kitching, W.; Drew, G. M.; Alberts, V. *Organometallics* **1982**, *1*, 331.

Scheme 2



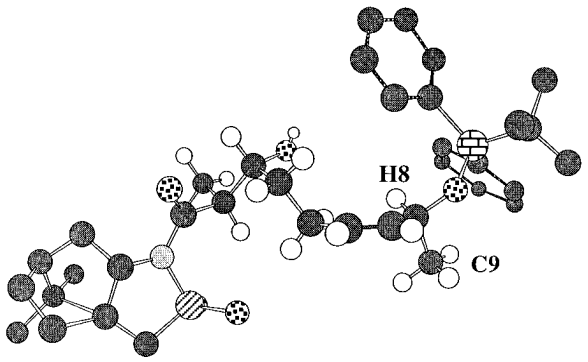


Figure 1. X-ray crystal structure of aldol adduct (20).

cyclizations of these and other systems bearing a remote allylic TBDPS ether show good to excellent *syn* selectivity. Second, the reaction conditions are very mild. Third, the method described in this study provides access to both *cis*- and *trans*-2,5-disubstituted tetrahydrofurans selectively.

In summary, the use of remote allylic ethers, especially TBDPS ethers of (*Z*)-alkenes, in intramolecular oxymercurations of alkenols leads to a highly 1,3-*syn*-diastereoselective process. This *syn* diastereoselectivity is often enhanced when polar solvents, such as chloroform or acetonitrile, are employed. This process, coupled to an aldol reaction, has provided a stereoselective route to nonactate isomers **32** and **25**. Variation of this sequence, for example *anti* aldol/*anti* cyclization, should lead to a flexible approach to the synthesis of the other nonactate isomers as well as the structurally-related pamamycins.[14] The development of these alternative sequences is underway in our laboratories.

(14) A related approach employing intramolecular oxymercurations of allenes has been reported. See: (a) Walkup, R. D.; Kim, S. W. *J. Org. Chem.* **1994**, *59*, 3433. (b) Walkup, R. D.; Park, G. *J. Am. Chem. Soc.* **1990**, *112*, 1597.

Table 2.[a] Selected ^{1}H NMR Chemical Shifts and Coupling Constants for Methyl Nonactate Diastereomers 25, 32, *ent*-25, and *ent*-32

compd	CH_3O δ	$C(9)H_3$ δ	$C(9)H_3$ J (Hz)	$C(10)H_3$ δ	$C(10)H_3$ J (Hz)
32	3.679	1.176	6.2	1.228	7.0
ent-**32**	3.678	1.178	6.2	1.226	7.0
25	3.682	1.178	6.2	1.221	7.0
ent-**25**	3.681	1.177	6.2	1.221	7.0

[a] Chemical shifts are given for solutions in $CDCl_3$ and were recorded at 200 MHz. Spectra for compounds *ent*-**25** and *ent*-**32** were recorded at 250 MHz.[8a]

Experimental Section

General. Melting points were recorded on a hotstage melting point apparatus and are uncorrected. ^{1}H and ^{13}C NMR spectra were run in $CDCl_3$ at 200 or 300 and 50 MHz, respectively. Chemical shifts are downfield from tetramethylsilane as the internal reference for ^{1}H NMR spectra while the central peak of $CDCl_3$ was used as the internal reference for ^{13}C NMR spectra. All solvents were dried and distilled according to standard procedures. Ether refers to diethyl ether. Microanalyses were conducted by the Commonwealth and Microanalytical Service or National Analytical Laboratories, Melbourne, Australia.

Ethyl (4*Z*,6*S*)-6-[(*tert*-Butyldiphenylsilyl)oxy]-4-heptenoate (3a). To a stirred suspension of the phosphonium salt **2** (13.16 g, 0.029 mol) in THF (150 mL) at 0 °C was added $NaN(SiMe_3)_2$ (1 M in THF, 31.7 mL, 0.032 mol) dropwise. The resulting egg yolk colored mixture was stirred for 20 min at 0 °C, and a solution of the aldehyde **1a**[15] (3.00 g, 0.010 mol) in THF (20 mL plus 10 mL rinse) was added dropwise. The pale yellow mixture was stirred for 30 min and then poured into ether (200 mL). The organic layer was washed with brine (2 × 100 mL), dried ($MgSO_4$), and filtered and the solvent removed under reduced pressure. The viscous oil was subjected to flash column chromatography (silica, 5% ether/light petroleum ether) to give **3a** as a colorless oil (3.43 g, 87%).

(15) Massad. S. K.; Hawkins, L. D.; Baker, D. C. *J. Org. Chem.* **1983**, *48*, 5180.

GLC analysis of the crude product indicated the *Z*:*E* ratio to be 94:6 respectively: $[\alpha]^{19}_D$ +9.9° (*c* 1.01, $CHCl_3$); IR (film) 3407 m, 1736 s, 1730 sh cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.04 (s, 9H), 1.17 (d, J = 7.4 Hz, 3H), 1.22 (t, J = 7.1 Hz, 3H), 1.80−2.01 (m, 2H), 2.04−2.26 (m, 2H), 4.07 (q, J = 7.1 Hz, 1H), 4.58 (dqd, J = 8.5, 7.4, 1.1 Hz, 1H), 5.53 (ddt, J = 10.9, 8.5, 1.6 Hz, 1H), 7.30−7.72 (m, 10H); MS (EI) m/z 410 (M^+, 0.1%), 199 (100). Anal. Calcd for $C_{25}H_{34}O_2Si$: C, 73.1; H, 8.4. Found: C, 72.7; H, 8.4.

(4*Z*,6*S*)-6-[(*tert*-Butyldiphenyl)silyloxy]-4-hepten-1-ol (4b). A solution of **3a** (6.00 g, 14.6 mmol) in ether (20 mL) was added dropwise to a stirred suspension of lithium aluminum hydride (1.11 g, 29.3 mmol) in ether (30 mL) at room temperature. The mixture was heated under reflux for 1 h and then left to cool to room temperature. Ice was added carefully and the mixture stirred until white granules formed. The solid was removed by filtration and the organic layer dried ($MgSO_4$) and filtered. The solvent was removed under reduced pressure and the remaining oil subjected to flash column chromatography (10% ether/light petroleum ether) to give **4b** (>95% *Z*) as a colorless liquid (5.01 g, 93%): $[\alpha]^{19}_D$ +13.3° (*c* 2.29, $CHCl_3$); IR (film) 3342 bs cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.04 (s, 9H), 1.17 (d, J = 6.4 Hz, 3H), 1.30−1.45 (m, 3H, one exch), 1.63−1.76 (m, 2H), 3.41 (t, J = 6.4 Hz, 2H), 4.57 (dqd, J = 8.4, 6.4, 1.0 Hz, 1H), 5.17 (dtd, J = 11.0, 8.4, 1.5 Hz, 1H), 5.53 (ddt, J = 11.0, 8.4, 1.5 Hz, 1H), 7.30−7.74 (m, 10H); MS (EI) m/z no M^+ at 368 observed, 311 ($M^+ - C(CH_3)_3$, 8%), 199 (100); TLC R_f 0.11 (10% ether/light petroleum ether). Anal. Calcd for $C_{23}H_{32}O_2Si$: C, 74.95; H, 8.75. Found: C, 74.77; H, 9.01.

(4*Z*,6*S*)-4-Heptene-1,6-diol (4a). A mixture of **4b** (150 mg, 0.41 mmol) and TBAF (1 M in THF, 1.3 mL, 1.3 mmol) was stirred at room temperature for 18 h. The reaction mixture was diluted with ether (20 mL), dried ($MgSO_4$), and filtered and the mixture concentrated. Purification of the oil by preparative TLC (silica, 50% ether/light petroleum ether) gave the diol **4a** (48 mg, 91%) as a colorless viscous oil: $[\alpha]^{21}_D$ +3.7° (*c* 1.82, $CHCl_3$); IR (film) 3332 bs cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.25 (d, J = 6.3 Hz, 3H), 1.46−1.82 (m, 2H), 2.02−2.17 (m, 1H), 2.33−2.52 (m, 1H), 2.82 (bs, 2H), 3.63 (dd, J = 6.9, 5.1 Hz, 1H), 4.26 (dq J = 6.3, 6.3 Hz, 1H), 4.66 (dq, J = 7.4, 6.9 Hz, 1H), 5.35−5.73 (m, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.4, 23.5, 31.4, 60.9, 63.2, 130.8, 134.6; MS (CI) 261 ($2M^+$ + 1, 13%), 95 (100).

(4*E*,6*S*)-[(*tert*-Butyldiphenylsilyl)oxy]-4-hepten-1-ol (9). A solution of **4b** (600 mg, 1.63 mmol) and diphenyl disulfide (107 mg, 30 mol%) in benzene (7 mL) was placed in a quartz vessel and exposed to sunlight for 6 h. Benzene was removed under reduced pressure and analysis of the crude product indicated the ratio of esters **4b** and **9** to be 27:73, respectively. A further portion of diphenyl disulfide (107 mg) was added to the crude material in benzene (7 mL), and the mixture was exposed to sunlight for 4 h. After the solvent was evaporated, analysis of the crude material indicated no change in the isomer ratio. The crude product was purified using flash column chromatography (silica, 20% ether/light petroleum ether) giving the isomeric mixture of products as a colorless liquid (591 mg). This material was cycled twice more through the above procedure, yielding an 83:17 mixture of **9** and **4b**, respectively. This mixture of products was used for the subsequent cyclization reactions: $[\alpha]^{22}_D$ −36.0° (*c* 1.81, EtOH); IR (film) 3424 bs cm^{-1}; ^1H NMR (200 MHz) δ 1.06 (s, 9H), 1.15 (d, J = 6.3 Hz, 3H), 1.46−1.60 (m, 2H), 1.64 (bs, 1H), 1.94−2.04 (m, 2H), 3.40 (t, J = 6.5 Hz, 2H, **4b**), 3.54 (t, J = 6.5 Hz, 2H, **9**), 4.26 (dq, J = 6.3 Hz, 1H, **4b**), 5.17 (dtd, J = 11.0, 7.3, 0.9 Hz, 1H, **4b**), 5.28−5.58 (m, 2H), 7.28−7.75 (m, 10H); MS (EI) m/z 368 (M^+, 0.1%), 95 (100). Anal. Calcd for $C_{23}H_{32}O_2Si$: C, 74.95; H, 8.75. Found: C, 74.97; H, 8.85.

General Method for Intramolecular Oxymercuration Reactions. Mercuric acetate (0.12 g, 0.38 mmol) was added in one portion to a solution of the appropriate alkenol (0.32 mmol) in a solvent (5 mL, see Table 1). After stirring (usually for 20 h) at room temperature, brine (2 mL) was added and the mixture stirred for a further 15 min. The mixture was partitioned between hexanes (10 mL) and brine (10 mL), and the layers were separated. The organic layer was washed with additional brine (5 mL) and dried ($MgSO_4$). Removal of the solvent under reduced pressure gave the crude product as a foam. Purification of the diastereomeric organomercury chlorides was usually carried out by preparative TLC (silica).

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-hydroxy-1-propyl]-tetrahydrofuran (5a) and (2*S*)-2-[(1*S*,2*S*)-1-(Chloromercurio)-2-hydroxy-1-propyl]tetrahydrofuran (6a). Using the general procedure described above diol **4a** was cyclized to yield **5a** and **6a** as an inseparable 2.5:1 mixture in 85% yield: $[\alpha]^{23}_D$ −25.6° (*c* 3.11, EtOH); IR ($CHCl_3$) 3331 bs cm^{-1}; ^1H NMR (200 MHz) δ 1.26 (d, J = 6.1 Hz, 3H **5a**), 1.37 (d, J = 6.2 Hz, 3H, **6a**), 1.36−1.59 (m, 2H), 1.84−2.25 (m, 2H), 3.07 (t obscured, 1H, **6a**), 3.10 (t, J = 1.9 Hz, 1H, **5a**), 3.65 (bs, 1H), 3.71−3.83 (m, 1H), 3.91−4.07 (m, 1H), 4.27 (dddd, J = 383.0 ($J^3_{H,Hg}$), 8.5, 6.1, 2.3 Hz, 1H, **5a**), 4.40 (dqd, J = 380.0 ($J^3_{H,Hg}$), 6.1, 1.9 Hz, 1H, **5a**); ^{13}C NMR (50 MHz) δ 25.0, 25.1, 25.6, 25.7, 34.1, 34.2, 67.9, 68.2, 69.9, 70.4, 71.6, 72.7, 78.7, 83.3; MS (CI) m/z 367 (M+ , 0.3%), (100). Anal. Calcd for $C_7H_{13}ClHgO_2$: C, 23.02; H, 3.59. Found: C, 23.05; H, 3.60.

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]tetrahydrofuran (5b) and (2*S*)-2-[(1*S*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]tetrahydrofuran (6b). Using the general intramolecular oxymercuration procedure, alkenol **4b** gave **5b** and **6b** in a 19:1 ratio, respectively and an overall yield of 90%. **5b**: mp 69−71 °C; $[\alpha]^{20}_D$ −31.2° (*c* 2.80, $CHCl_3$); ^1H NMR (200 MHz) δ 1.07 (s, 9H), 1.15 (d, J = 6.0 Hz, 3H), 1.57−1.96 (m, 4H), 2.68 (ddd, J = 221.0, 7.6, 3.0 Hz, 1H), 3.56−3.67 (m, 1H), 3.78−3.89 (m, 1H), 3.94−4.04 (m, 1H), 4.20 (qd, J = 6.0, 3.0 Hz, 1H), 7.28−7.75 (m, 10H); ^{13}C NMR (50 MHz) δ 19.1, 25.9, 26.5, 27.1, 32.9, 67.3, 70.7, 73.0, 79.5, 12.5, 127.8, 129.7, 129.9, 133.3, 134.0, 136.0; MS (CI) m/z no M^+ at 603 observed, 367 (100%). Anal. Calcd for $C_{23}H_{31}ClHgO_2Si$: C, 45.77; H, 5.18. Found: C, 45.56; H, 4.94. **6b**: $[\alpha]^{22}_D$ −26.2° (*c* 1.08, $CHCl_3$); ^1H NMR (200 MHz) δ 1.07 (s, 9H), 1.25 (d, J = 5.8 Hz, 3H), 1.68−1.87 (m, 4H), 2.87 (t, J = 4.9 Hz, 1H), 3.41−3.63 (m, 1H), 3.70−3.68 (m, 2H), 4.19 (qd, J = 5.8, 4.9 Hz, 1H), 7.32−7.75 (m, 10H); ^{13}C NMR (50 MHz) δ 19.0, 25.6, 26.5, 27.0, 33.1, 67.3, 71.0, 72.7, 78.4, 127.7, 127.8, 129.7, 129.8, 129.9, 133.7, 133.8, 134.8, 135.8, 136.0; MS (CI) m/z no M^+ at 603 observed, 233 (100%). Anal. Calcd for $C_{23}H_{31}ClHgO_2Si$: C, 45.77; H, 5.18. Found: C, 45.63; H, 4.96.

(2*R*)-2-[(1*R*,2*R*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-pentyl]tetrahydrofuran (5c) and (2*S*)-2-[(1*S*,2*R*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-pentyl]tetrahydrofuran (6c). Using the general intramolecular oxymercuration procedure, alkenol **4c** was cyclized to yield **5c** and **6c** as an inseparable 10:1 mixture in 92% yield: $[\alpha]^{20}_D$ 13.8° (*c* 0.22, $CHCl_3$); ^1H NMR (200 MHz) δ 0.67 (t, J = 7.3 Hz, 3H), 1.07 (s, 9H), 1.15−1.56 (m, 6H), 1.70−1.85 (m, 2H), 2.72 (dd, J = 1.7, 8.5, 1H), 3.56−3.65 (m, 1H), 3.76−3.97 (m, 3H), 7.35−7.45 (m, 4H), 7.62−7.72 (m, 6H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 18.8, 27.1, 32.7, 42.1, 67.3, 69.9, 74.4, 77.6, 79.8, 127.5, 127.7, 129.7, 129.9, 133.4, 136.0, 136.1.

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-2-phenyl-1-ethyl]tetrahydrofuran (5d) and (2*S*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-2-phenyl-1-ethyl]tetrahydrofuran (6d). Using the general intramolecular oxymercuration procedure, alkenol **4d** was cyclized to yield **5d** and **6d**. *Syn*:*anti* ratio: 6:1 (CH_2Cl_2), 84%, 10:1 (CH_3CN), 86%. **5d**: $[\alpha]^{19}_D$ 2.81° (*c* 0.92, $CHCl_3$); ^1H NMR (200 MHz, $CDCl_3$) δ 1.06 (s, 9H), 1.20 (d, J = 6.1 Hz, 3H), 1.39−1.52 (m, 2H), 1.62−1.1.82 (m, 2H), 2.78 (dd, J = 3.9,7.5 Hz, 1H), 3.49 (ddd, J = 8.0, 8.0, 7.9 Hz, 1H), 3.59−3.80 (m, 2H), 5.06 (d, J = 3.9 Hz, 6H), 7.16−7.46 (m, 11H), 7.69−7.74 (m, 4H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.9, 26.6, 27.9, 33.5, 67.9, 76.1, 77.4, 79.8, 126.2, 128.0, 128.3, 128.5, 129.2, 130.3, 130.6, 136.5, 136.7; MS (EI) m/z no M^+ at 665 observed, 295 (66%), 71 (100).

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldimethylsilyl)oxy)-1-propyl]tetrahydrofuran (5e) and (2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldimethylsilyl)oxy)-1-propyl]tetrahydrofuran (6e). Using the general intramolecular oxymercuration procedure, alkenol **4e** was cyclized to yield **5e** and **6e**; $[\alpha]^{20}_D$ −22.83° (*c* 0.60, $CHCl_3$, 6:1 mixture of **5e** and **6e**); ^1H NMR (200 MHz, $CDCl_3$) δ 0.08 (s,

3H), 0.09 (s, 3H), 0.88 (s, 9H, **6e**), 0.90 (s, 9H), 1.22 (d, $J = 6.0$ Hz, 3H), 1.27 (d, $J = 6.0$ Hz, 3H, **6e**), 1.30−1.48 (m, 1H), 1.85−2.14 (m, 3H), 2.76 (dd, $J = 4.0$, 6.7 Hz, 1H), 3.05 (t, $J = 4.6$ Hz, 1H, **6e**), 3.67 (ddd, $J = 1.0$, 7.4, 14.3 Hz, 1H), 3.84−3.97 (m, 1H), 4.06 (dd, $J = 6.9$, 13.7 Hz, 1H), 4.18 (m, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ −4.7, −3.9, 17.7, 25.9, 26.4, 33.1, 67.4, 69.5, 72.9, 73.6, 79.7; MS (EI) m/z M^+ 479 (0.2%), 75 (100).

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-(benzyloxymethoxy)-1-propyl]tetrahydrofuran (5f) and (2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-(benzyloxymethoxy)-1-propyl]tetrahydrofuran (6f). Using the general intramolecular oxymercuration procedure, alkenol **4f** was cyclized to yield an inseparable mixture of **5f** and **6f**: $[\alpha]^{18}_D$ −13.58° (*c* 1.06, $CHCl_3$, 7.5:1 mixture of **5f** and **6f**); ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.27 (d, $J = 6.0$ Hz, 3 H, **5f**), 1.33 (d, $J = 6.1$ Hz, 3 H, **6f**), 1.27−1.48 (m, 1H), 1.85−2.08 (m, 3 H), 2.75 (dd, $J = 4.0$, 7.0 Hz, 1H, **5f**), 3.06 (t, $J = 4.0$ Hz, 1H, **6f**), 3.68 (dd, $J = 6.8$, 16 Hz, 1 H), 3.90 (dd, $J = 5.6$, 6.0 Hz, 1 H), 4.09−4.21 (m, 2H), 4.59 (d, $J = 12.0$ Hz, 1 H, **5f**), 4.69 (d, $J = 12.0$ Hz, 1 H, **5f**), 4.75 (d, $J = 7.2$ Hz, 1 H, **5f**), 4.77 (d, $J = 7.2$ Hz, 1 H, **6f**), 4.84 (d, $J = 7.2$ Hz, 1 H, **6f**), 4.86 (d, $J = 7.2$ Hz, 1 H, **5f**), 7.28−7.38 (m, 5 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 12.9, 22.5, 25.7, 25.9, 33.4, 33.7, 67.6, 69.8, 69.9, 70.0, 74.2, 74.7, 79.8, 92.6, 127.8, 127.8, 127.9, 128.5, 128.5; MS m/z M^+ 485 (4%), 97 (100). Anal. Calcd for $C_{15}H_{21}ClHgO_3$: C, 37.12; H, 4.36. Found: C, 37.14, H, 4.29.

(2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]-5,5-dimethyltetrahydrofuran (5g) and (2*R*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]-5,5-dimethyltetrahydrofuran (6g). Using the general intramolecular oxymercuration procedure, alkenol **4g** was cyclized to yield **5g** and **6g**: $[\alpha]^{18}_D$ +2.69° (*c* 0.26, $CHCl_3$, 10:1 mixture of **5g** and **6g**). **5g**: ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.07 (s, 9 H), 1.12 (d, $J = 6.0$ Hz, 3 H), 1.16 (s, 3H), 1.20 (s, 3H), 1.24−1.29 (m, 1H), 1.56−1.72 (m, 3 H), 2.69 (dd, $J = 2.6$, 7.0 Hz, 1 H), 4.07−4.22 (m, 2 H), 7.35−7.46 (m, 6 H), 7.64−7.75 (m, 4 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.1, 26.5, 27.08, 33.7, 38.9, 70.9, 74.5, 78.8, 80.9, 127.5, 127.7, 129.7, 129.8, 134.2, 136.0, 136.1; MS (EI) m/z no M^+ observed at 631, 199 (100%). Anal. Calcd for $C_{25}H_{35}ClHgO_2Si$: C, 47.54; H, 5.59. Found: C, 47.31; H, 5.32.

(2*S*)-2-[(1*R*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]tetrahydrofuran (10) and (2*R*)-2-[(1*S*,2*S*)-1-(Chloromercurio)-2-((*tert*-butyldiphenylsilyl)oxy)-1-propyl]tetrahydrofuran (11). Using the general procedure described above, alkenol **9** (200 mg, 0.51 mmol, containing 20% **4b**) was cyclized to yield two pairs of diastereomers in 76% overall yield and a ratio of 3.3:1. The minor pair of isomers was shown, by comparison of their ^{1}H NMR spectra with authentic samples, to consist of **5b** and **6b** in a 7:1 ratio. The major pair of isomers, **10** and **11**, was obtained in a ratio of 1.6:1, respectively. Purification by preparative TLC (silica, ether/light petroleum ether) gave an inseparable mixture of **10** and **11** (190 mg) as a colorless gum. **10** and **11** (2:1 ratio): $[\alpha]^{21}_D$ −21.6° (*c* 1.35, $CHCl_3$); ^{1}H NMR (200 MHz) δ 1.07 (s, 9H, **10**), 1.09 (s, 9H, **11**), 1.25 (d, $J = 5.9$ Hz, 3H), 1.29−1.42 (m, 1H), 1.73−1.95 (m, 2H), 1.97−2.14 (m, 1H), 2.89 (dd, $J = 8.7$, 3.3 1H, **10**), 3.03 (dd, $J = 9.3$, 5.0 Hz, 1H, **11**), 3.60−3.71 (m, 1H), 3.77−3.88 (m, 1H), 3.98−4.15 (m, 1H), 4.43−4.54 (m, 1H), 7.34−7.74 (m, 10H); ^{13}C NMR (50 MHz) δ 19.1, **11**; 19.2, **10**; 25.7, **11**; 25.8, **10**; 25.9, **11**; 26.8, **10**; 27.2, **10**; 34.7, 34.8, **10**; 67.9, 70.2, **11**; 70.5, **10**; 72.0 **11**; 73.0, **10**; 78.8, **11**; 79.6, **10**; 127.7, 127.8, 127.9, 127.9, 129.8, 129.9, 130.0, 133.5, 133.8, 134.2, 135.9, 136.0 136.0, CH; MS (CI) m/z no M^+ at 603 observed, 79 (100). Anal. Calcd for $C_{23}H_{31}ClHgO_2Si$: C, 45.77; H, 5.18. Found: C, 45.81; H, 5.17.

2-(1′-(Chloromercurio)-2′,3′-bis[(*tert*-butyldiphenylsilyl)oxy]-2-propyl)tetrahydrofuran (13). Using the general intramolecular oxymercuration procedure, alkenol **12** was cyclized to yield **13** as a single diastereomer in 95% yield: $[\alpha]^{18}_D$ 1.81° (*c* 0.55, $CHCl_3$); ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.00 (s, 18H), 1.36−1.57 (m, 2H), 1.61−1.90 (m, 2H), 2.83 (dd, $J = 1.8$, 7.8 Hz, 1H), 3.39 (d, $J = 7.8$ Hz, 1H), 3.56−3.68 (m, 2H), 3.73−4.01 (m, 3H), 7.22−7.66 (m, 10H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.7, 19.8, 26.4, 27.7, 33.5, 66.5, 68.0, 68.4, 75.1, 79.9, 128.2, 128.4, 128.5, 130.4, 130.5, 130.6, 133.6, 134.2, 136.2, 136.3, 136.5, 136.7; MS (EI) m/z no M^+ observed at 858.03, 199 (100%). Anal. Calcd for $C_{39}H_{49}ClHgO_3Si_2$: C, 54.59; H, 5.76. Found: C, 54.47; H, 5.93.

4-[(4*S*)-[(1*R*)-1-(Chloromercurio)((2*S*)-tetrahydrofuran-2-yl)methyl]-2,2-dimethyl-1,3-dioxolane and 4-[(4*S*)-[(1*S*)-1-(Chloromercurio)((2*R*)-tetrahydrofuran-2-yl)methyl]-2,2-dimethyl-1,3-dioxolane (15). Mercuric acetate (1.438 g, 4.51 mmol) was added in one portion to a stirred solution of the alcohol (0.420 g, 2.28 mmol) in CH_2Cl_2 (30 mL) at room temperature. The mixture was stirred for 18 h and then brine (12 mL) was added and the reaction left to stir for a further 15 min. The aqueous phase was extracted with CH_2Cl_2, and the combined organic extracts were washed with brine and dried ($MgSO_4$) to give a solid (0.835 g, 87%). Separation by flash column chromatography (50% ether/light petroleum ether) gave the diastereomers as colorless crystals. Diastereomer 1: $[\alpha]_D$ +11.9° (*c* 0.68, $CHCl_3$); ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.35 (s, 3H), 1.43 (s, 3H), 1.93 (m, 2H), 2.13 (m, 2H), 3.12 (m, 1H), 3.71 (m, 2H), 3.93 (m, 2H), 4.15 (m, 1H), 4.50 (q, $J = 6.1$Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 25.6, 25.7, 27.4, 34.0, 65.1, 67.7, 71.1, 77.4, 78.7, 109.3; MS (EI) m/z 421 (M^+, 0.8%), 111 (100). Anal. Calcd for $C_{10}H_{17}ClHgO_3$: C, 28.51; H, 4.07. Found: C, 28.29; H, 4.07. Diastereomer 2: $[\alpha]_D$ +0.6° (*c* 0.64, $CHCl_3$); ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.33 (s, 3H), 1.41 (s, 3H), 2.02 (m, 4H), 2.86 (t, $J = 5.2$ Hz, 1H), 3.53 (m, 2H), 3.74 (m, 2H), 3.93 (m, 1H), 4.48 (q, $J = 6.1$ Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 25.3, 25.8, 27.4, 33.5, 65.1, 67.9, 70.5 , 76.8, 79.8, 109.6; MS (EI) m/z 421 (M^+, 0.2%), 71 (100). Anal. Calcd for $C_{10}H_{17}ClHgO_3$: C, 28.51; H, 4.07. Found: C, 28.25; H, 4.10.

(2*R*)-2-[(2*S*)-2-((*tert*-Butyldiphenylsilyl)oxy)-1-propyl]-tetrahydrofuran (7b). Tributylstannane (0.17 mL, 0.63 mmol) was added in one portion to a stirred solution of the chloromercurial **5b** (0.154 g, 0.26 mmol) and azobis(isobutyronitrile) (AIBN) (3.4 mg, 0.021 mmol) in toluene (2.5 mL) under an atmosphere of argon at room temperature. Mercury began to precipitate almost immediately, and the reaction mixture was stirred at room temperature for 1 h and then at 50 °C for a further 1 h. The oil bath was removed, and carbon tetrachloride (0.5 mL) was added to consume the excess tributylstannane. After 1 h, the solution was decanted from mercury, diluted with 25% dichloromethane/light petroleum ether and washed with a 5% aqueous potassium fluoride solution (3 × 5 mL). The organic layer was dried ($MgSO_4$) and filtered and the solvent removed under reduced pressure. Purification of the crude product using preparative TLC (silica) gave **7b** as a colorless oil (94 mg, 100%): $[\alpha]^{19}_D$ −10.9° (*c* 0.52, $CHCl_3$); ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.05 (s, 9H), 1.12 (d, $J = 2.9$ Hz, 3H), 1.21−1.40 (m, 1H), 1.43−1.56 (m, 1H), 1.68−1.93 (m, 4H), 3.56−3.76 (m, 2H), 3.85−4.07 (m, 2H), 7.31−7.74 (m, 10H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.2, 23.4, 25.5, 27.0, 45.2, 67.3, 67.6, 76.2, 127.4, 127.5, 129.4, 128.5, 134.4, 134.7, 135.9; MS (EI) m/z no M^+ at 368 observed, 367 ($M^+ - 1$, 15%), 311 (100), 291 (100); TLC R_f 0.24 (silica, 20% ether/light petroleum ether). Anal. Calcd for $C_{23}H_{32}O_2Si$: C, 74.95; H, 8.75. Found: C, 74.68; H, 8.54.

(2*S*)-2-[(2*S*)-2-((*tert*-Butyldiphenylsilyl)oxy)-1-propyl]-tetrahydrofuran (8b). Using the procedure described above for **5b**, demercuration of the chloromercurial **6b** (210 mg, 0.35 mmol) gave **8b** as a colorless oil (120 mg, 94%); $[\alpha]^{22}_D$ −7.6° (*c* 1.54, $CHCl_3$); ^{1}H NMR (200 MHz) δ 1.05 (s, 9H), 1.12 (d, $J = 6.1$ Hz, 3H), 1.28−1.56 (m, 2H), 1.68−1.93 (m, 2H), 3.56−3.76 (m, 2H), 3.85−4.07 (m, 2H), 7.32−7.71 (m, 10H); ^{13}C NMR (50 MHz) δ 19.3, 23.5, 25.6, 27.1, 31.7, 127.5, 127.6, 129.5, 129.6, 134.5, 134.9, 135.99, 136.01; MS (CI) m/z 367 ($M^+ - 1$, 8%), 311 (100). Anal. Calcd for $C_{23}H_{32}O_2Si$: C, 74.95; H, 8.75. Found: C, 75.05; H, 8.90.

1-((2*R*)-2-Tetrahydrofuranyl)-(2*S*)-2-propanol (7a). Tetrabutylammonium fluoride (1 M, 17 mL, 17 mmol) was added dropwise to a stirred solution of **7b** (2.081 g, 5.65 mmol) in THF (30 mL). The reaction mixture was stirred at room temperature for 42 h, then diluted with ether (150 mL), dried ($MgSO_4$), and filtered and the solvent removed under reduced pressure. The oily residue was purified using flash column chromatography (silica, 50% ether/light petroleum ether) to give the alcohol as a colorless oil (723 mg, 99%): $[\alpha]^{22}_D$ +14.5°

(*c* 0.42, EtOH), $[\alpha]^{20}_D$ +3.7° (*c* 1.36 $CHCl_3$); IR (film) 3418 bs cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.18 (d, J = 6.2 Hz, 3H), 1.40−1.71 (m, 2H), 1.79−2.10 (m, 2H), 3.71−3.88 (m, 3H), 3.91−4.10 (m, 2H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.5, 25.3, 32.3, 44.1, 68.0, 68.1, 79.9; MS (CI) *m*/*z* 131 (M^+ + 1, 2%), 71 (100). Satisfactory elemental analysis proved to be unobtainable with this compound. Therefore it was fully characterized as its 3,5-dinitrobenzoate. 3,5-Dinitrobenzoyl chloride (21 mg, 0.91 mmol) was added to a stirred solution of **7a** (11 mg, 0.085 mmol) in dry pyridine (1 mL) at room temperature. After stirring for 18 h, dichloromethane (5 mL) was added, the mixture washed successively with 5% aqueous sulfuric acid (2 × 5 mL) and saturated aqueous sodium bicarbonate solution (2 × 5 mL) and dried ($MgSO_4$), and the solvent was removed *in vacuo*. The residue was purified by preparative TLC (silica, 20% ether/light petroleum ether) giving colorless needles: mp 75−77 °C; $[\alpha]^{24}_D$ +29.7° (*c* 0.94, $CHCl_3$); IR (Nujol) 1718 s cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.43−1.61 (m, 1H), 1.48 (d, J = 6.3 Hz, 3H), 1.78−2.18 (m, 3H), 3.64−4.00 (m, 3H), 5.42 (ddq, J = 6.1, 1.9, 1.9 Hz, 1H), 9.17−9.21 (m, 2H), 9.22−9.23 (m, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 20.3, 25.5, 32.0, 41.8, 67.9, 72.9, 76.3; mass spectrum (CI) *m*/*z* 325 (M^+, 1%), 71 (100). Anal. Calcd for $C_{14}H_{16}N_2O_7$: C, 51.85; H, 4.97; N, 8.64. Found: C, 51.74; H, 4.95; N, 8.51.

Desilylation of 5b. A 1 M solution of tetrabutylammonium fluoride (0.19 mL, 0.19 mmol) was added dropwise to a solution of the chloromercurial **5b** (37 mg, 0.06 mmol) in THF (1 mL) at room temperature. After stirring for 24 h, the reaction mixture was worked up as described above. Purification by preparative TLC (silica, ether/light petroleum ether) gave **5a** as a colorless gum (21 mg, 94%); $[\alpha]^{23}_D$ −25.6° (*c* 3.11, EtOH); IR ($CHCl_3$) 3406 bs, cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.26 (d, J = 6.1 Hz, 3H), 1.29−1.50 (m, 1H), 1.86−2.01 (m, 2H), 2.10−2.25 (m, 1H), 3.10 (dt, J = 115.8, 2.2 Hz, 1H), 3.65 (bs, 1H), 3.71−3.83 (m, 1H), 3.96−4.07 (m, 1H), 4.28 (ddd, J = 8.6, 6.1, 2.2 Hz, 1H), 4.40 (bqd, J = 6.1, 1.6 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 25.1, 34.4, 68.3, 71.6, 83.3; MS (CI) *m*/*z* 351 ($M^+ + CH_4$, 4%), 85 (100). Anal. Calcd for $C_7H_{13}ClHgO_2$: C, 23.02; H, 3.59. Found: C, 23.15; H, 3.58.

1-((2*R*)-2-Tetrahydrofuranyl)-2-propanone (16). Dimethyl sulfoxide (0.360 g, 4.61 mmol) in dichloromethane (2.5 mL) was added dropwise to a stirred solution of oxalyl chloride (0.268 g, 2.11 mmol) in dichloromethane (5 mL) at −78 °C. Stirring was continued at this temperature for 10 min followed by dropwise addition of a solution of **5b** (0.250 g, 1.92 mmol) in dichloromethane (2 mL). The reaction mixture was stirred for a further 15 min and then NEt_3 (0.973 g, 9.62 mmol) was added over a period of 5 min. The cooling bath was removed, water (6 mL) was added at room temperature, and stirring was continued for 10 min. The organic phase was separated and the aqueous layer extracted with dichloromethane (3 × 10 mL). The organic layers were combined and dried ($MgSO_4$), and the solvent was removed *in vacuo*. Purification of the yellow oil by flash column chromatography (silica, 40% ether/light petroleum ether) gave **16** as a colorless oil (0.210 g, 85%): $[\alpha]^{20}_D$ +1.9° (*c* 0.85, $CHCl_3$); IR (film) 1714 s cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.38−1.56 (m, 1H), 1.83−1.97 (m, 2H), 2.03−2.18 (m, 1H), 2.20 (s, 3H), 2.56 (dd, J = 15.9, 5.6 Hz, 1H), 2.76 (dd, J = 15.9, 7.2 Hz, 1H), 3.68−3.92 (m, 2H), 4.23 (dq, J = 7.4, 6.0 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 25.6, 30.8, 31.6, 49.7, 67.9, 75.1, 207.4; MS (EI) *m*/*z* 128 (M^+, 4%), 71 (100); TLC R_f 0.25 (40% ether/light petroleum ether); HRMS (EI) 128.083 ± 0.001 (M^+ calcd for $C_7H_{12}O_2$ 128.084).

((2*R*)-2-Tetrahydrofuranyl)methyl Acetate (17). Trifluoroacetic anhydride (0.51 mL) was added dropwise to an unstirred solution of hydrogen peroxide (82%, 0.12 mL) in dichloromethane (0.5 mL) at 0 °C. Stirring was begun, and the reaction mixture was stirred for 10 min at 0 °C, warmed to room temperature, and then stirred for a further 30 min. Trifluoroperacetic acid solution prepared as just described (1.4 mL) was added dropwise to a stirred suspension of the ketone **16** (50 mg, 0.40 mmol) and dipotassium hydrogen phosphate (400 mg, 2.3 mmol) in dichloromethane (2.5 mL) at 0 °C. The cooling bath was removed, and the mixture was heated at reflux for 2 h when all starting material had been consumed as indicated by analytical TLC. Saturated $NaHCO_3$ solution (10 mL) was added to the cooled (room temperature) solution, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 5 mL), the organic layers were combined and dried ($MgSO_4$), and the solvent was removed *in vacuo*. Purification of the residue by preparative TLC (silica, 50% ether/light petroleum ether) gave the ester **17** as a colorless oil (40 mg, 71%): $[\alpha]^{20}_D$ −25.2° (*c* 0.82, $CHCl_3$), lit.[16] $[\alpha]^{20}_D$ −17.9° (neat, l = 0.5): ^1H NMR (200 MHz, $CDCl_3$) δ 1.52−1.70 (m, 1H), 1.84−2.08 (m, 3H), 2.10 (s, 3H), 3.75−4.21 (m, 5H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 20.9, 25.6, 27.9, 66.6, 68.4, 76.5, 171.1; TLC R_f 0.35 (50% ether/light petroleum ether).

(4*Z*,6*S*)-[(*tert*-Butyldiphenylsilyl)oxy]-4-heptenal (18). DIBAL-H (1 M in toluene, 1.28 mL, 1.28 mmol) was added dropwise to a stirred solution of the ester (*S*)-(+)-**3a** (95% *Z*, 0.500 g, 1.22 mmol) in toluene (5 mL) at −78 °C. The reaction mixture was stirred for 1 h, the reaction was quenched with water (1 mL), and then the mixture was allowed to warm to room temperature. The insoluble material was removed by filtration and rinsed with ether (3 × 10 mL). The filtrate was separated and the aqueous phase extracted with ether (3 × 10 mL). The combined organic phases were dried ($MgSO_4$) and filtered, and the solvent was removed *in vacuo*. Purification of the residue by preparative TLC (silica, 20% ether/light petroleum ether) gave aldehyde (*S*)-(+)-**18** (>95% *Z*) as a colorless oil (0.360 g, 81%): $[\alpha]^{19}_D$ +12.1° (*c* 4.43, $CHCl_3$); IR (film) 1726 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.04 (s, 9H), 1.18 (d, J = 6.3 Hz, 3H), 1.83−2.06 (m, 2H), 2.12−2.23 (m, 2H), 4.57 (dqd, J = 8.5, 6.3, 1.0 Hz, 1H), 5.11 (dtd, J = 10.9, 7.2, 1.0 Hz, 1H), 5.54 (ddt, J = 10.9, 8.5, 1.6 Hz, 1H), 7.30−7.47 (m, 6H), 7.64−7.73 (m, 4H), 9.56 (t, J = 1.5 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.1, 19.2, 20.0, 24.5, 26.9, 43.3, 65.7, 125.6, 127.3, 127.5, 129.46, 129.53, 134.1, 134.3, 135.6, 135.8, 135.9, 136.0, 201.6; MS (CI) *m*/*z* 369 (M^+ + 1, 10%), 291 (100). Anal. Calcd for $C_{23}H_{30}O_2Si$: C, 75.36; H, 8.25. Found: C, 75.01, H, 8.49.

Aldol Adduct (−)-(2*R*,3*S*,6*Z*,8*S*)-20. Trifluoromethanesulfonic acid (89 μL, 152 mg, 1.01 mmol) was added dropwise to a stirred solution of triethylborane (1 M in hexanes, 1.01 mL, 1.01 mmol) at room temperature. Bubbles of gas were observed to evolve. The mixture was heated at 40 °C until it became homogeneous (ca. 40 min) and then cooled to −5 °C. *N*-Propionylsultam (137 mg, 0.51 mmol) dissolved in dichloromethane (2 mL) was added dropwise to the cooled solution followed by $^iPr_2EtN$ (137 mg, 1.06 mmol) in dichloromethane (1 mL). The reaction mixture was stirred for 30 min at this temperature and then cooled to −78 °C. A solution of aldehyde **18** (200 mg, 0.55 mmol) in dichloromethane (1.0 mL) was then added dropwise, and the reaction mixture was stirred for a further 75 min. Phosphate buffer (pH 7, 1 mL) was added and the reaction mixture left to warm to room temperature. The layers were separated, and the aqueous phase was extracted with ether (3 × 10 mL). The combined organic layers were washed with saturated aqueous NH_4Cl (20 mL), dried ($MgSO_4$), and filtered and the solvent removed *in vacuo*. Purification of the residue using flash column chromatography (silica, 30% ether/light petroleum ether) followed by preparative TLC (silica, 30% ether/light petroleum ether, R_f 0.23) to remove traces of **18** gave **20** as a colorless gum (170 mg, 53%): $[\alpha]^{21}_D$ −93.3° (*c* 0.12, $CHCl_3$); IR ($CHCl_3$) 3531, 1677, 1336 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.97 (s, 3H), 1.04 (s, 9H), 1.14 (s, 3H), 1.16 (d, J = 7.0 Hz, 3H), 1.19 (d, J = 7.2 Hz, 3H), 1.39−1.45 (m, 2H), 1.72−1.92 (m, 7 H), 2.03 (bd, J = 6.2 Hz, 2H), 2.84 (bs, 1H), 2.93 (qd, J = 7.2, 3.0 Hz, 1H), 3.43 (d, J = 13.8 Hz, 1H), 3.50 (d, J = 13.8 Hz, 1H), 3.69−3.80 (m, 1H), 3.86 (bt, J = 6.2 Hz, 1H), 4.62 (dqd, J = 8.4, 7.1, 0.9 Hz, 1H), 5.16 (dtd, J = 11.0, 8.6, 0.9 Hz, 1H), 5.50 (ddt, J = 11.0, 8.4, 1.2 Hz, 1H), 7.31−7.72 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 11.7, 19.2, 19.9, 20.9, 23.8, 24.8, 26.5, 27.0, 32.9, 33.6, 38.4, 44.4, 44.6, 47.8, 48.4, 53.1, 65.0, 66.0, 69.8, 127.47, 127.54,

(16) Gagnaire, D.; Butt, A. *Bull. Soc. Chem. Fr.* **1961**, 312.

(17) The author has deposited atomic coordinates for this structure with the Cambridge Crystallographic Data Centre. The coordinates can be obtained, on request, from the Director, Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge, CB2 1EZ, UK.

129.5, 134.4, 134.8, 135.3, 135.9, 136.0, 177.1; MS (EI) *m/z* 637 (M^+, 0.2%), 199 (100). Anal. Calcd for $C_{36}H_{51}NO_5SSi$: C, 67.78; H, 8.06; N, 2.20. Found: C, 68.07; H, 8.37, N, 2.06.

Aldol Adduct (+)-(2*S*,3*R*,6*Z*,8*S*)-27. The aldol adduct (+)-**27** was prepared from aldehyde **18** according to the procedure described above using *N*-propionylsultam **11** in place of **16**. The title compound (+)-**27** (220 mg, 62%) was obtained as a colorless gum which crystallized on standing following purification by flash chromatography and preparative TLC (silica, 20% ether/light petroleum ether, R_f 0.10). A sample for X-ray crystallographic analysis was obtained by recrystallization from ether/light petroleum ether to give colorless rhomboid crystals (mp 95−97°) $[\alpha]^{22}_D$ +54.7° (*c* 1.75, $CHCl_3$); IR ($CHCl_3$) 3530, 1677 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 0.98 (s, 3H), 1.03 (s, 9H), 1.15 (s, 3H), 1.17 (d, *J* = 6.8 Hz, 3H), 1.18 (d, *J* = 7.0 Hz, 3H), 1.26−1.46 (m, 4H), 1.59−1.70 (m, 1H), 1.80−1.95 (m, 4H), 2.04 (bd, *J* = 6.3 Hz, 2H), 2.90 (bd, *J* = 2.7 Hz, 1H), 2.92 (qd, *J* = 7.0, 2.7 Hz, 1H), 3.40 (d, *J* = 13.8 Hz, 1H), 3.46 (d, *J* = 13.8 Hz, 1H), 3.73 (bdq, *J* = 9.2, 2.7 Hz, 1H), 3.88 (bt, *J* = 6.3 Hz, 1H), 4.59 (dqd, *J* = 8.6, 6.8,1.1 Hz, 1H), 5.14 (dtd, *J* = 10.2, 8.1, 1.1 Hz, 1H), 5.49 (ddt, *J* = 10.2, 8.6, 1.8 Hz, 1H), 7.31−7.71 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 11.7, 19.2, 19.9, 20.9, 24.0, 24.7, 26.5, 27.0, 32.9, 33.7, 38.4, 44.3, 44.6, 47.8, 48.4, 53.2, 65.0, 66.1, 70.1, 127.47, 127.56, 127.61, 129.5, 134.4, 134.7, 135.2, 135.9, 136.0, 177.1; MS (EI) *m/z* 637 (M^+, 0.1%), 199 (100). Anal. Calcd for $C_{36}H_{51}NO_5SSi$: C, 67.78; H, 8.06. Found: C, 67.64; H, 8.07.

Intramolecular Oxymercuration of 20. Mercuric acetate (234 mg, 0.734 mmol) was added in one portion to a stirred solution of **20** (237 mg, 0.372 mmol) in dichloromethane (5 mL) at room temperature. After stirring for 20 h, brine was added (2 mL) and the reaction left to stir for a further 15 min. The mixture was diluted with light petroleum ether (25 mL), and the layers were separated. The organic phase was washed with a further portion of brine (10 mL), dried ($MgSO_4$), and filtered. The solvent was removed under reduced pressure to give the crude product as a highly viscous oil. The ^1H NMR spectrum (200 MHz) of the crude mixture indicated that the chloromercurials **21a** and **21b** were in a 93:7 ratio. The products were purified and separated using preparative TLC (silica, 20%, ether/light petroleum ether) to give each of the diastereomers as colorless gums. **21a**: R_f 0.12 (294 mg, 90%); $[\alpha]^{21}_D$ −44.5° (*c* 1.09, $CHCl_3$); IR ($CHCl_3$) 1689, 1332 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.97 (s, 3H), 1.07 (s, 9H), 1.14 (s, 3H), 1.27 (d, *J* = 6.3 Hz, 3H), 1.30 (d, *J* = 7.0 Hz, 3H), 1.33−1.64 (m, 2H), 1.72−1.91 (m, 7 H), 2.03 (bd, *J* = 6.1 Hz, 2H), 2.64 (dd, *J* = 8.5, 2.4 Hz, 1H), 3.12 (dq, *J* = 8.5, 7.0 Hz, 1H), 3.42−3.53 (m, 2H), 3.84−4.04 (m, 3H), 4.15 (qd, *J* = 6.3, 2.4 Hz, 1H), 7.33−7.72 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 16.6, 19.1, 19.8, 20.8, 26.4, 26.5, 27.1, 29.7, 32.6, 38.3, 44.6, 45.8, 47.7, 48.3, 53.2, 64.8, 70.4, 73.0, 79.6, 79.8, 127.5, 127.7, 127.8, 129.7, 133.3, 134.0, 134.8, 135.8, 136.0, 174.4; MS (EI) *m/z* no M^+ ($^{202}Hg^{35}Cl$) at 873 observed, 199 (100%). Anal. Calcd for $C_{36}H_{50}ClHgNO_5SSi$: C, 49.53; H, 5.77; N, 1.60. Found: C, 49.67; H, 5.52; N, 1.33. **17b**: R_f 0.06 (22 mg, 7%); $[\alpha]^{19}_D$ −67.7° (*c* 0.07, $CHCl_3$); IR ($CHCl_3$) 1686, 1334 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.98 (s, 3H), 1.07 (s, 9H), 1.17 (s, 3H), 1.23 (d, *J* = 7.1 Hz, 3H), 1.25 (d, *J* = 6.8 Hz, 3H), 1.28−1.63 (m, 2H), 1.88−2.01 (m, 7 H), 2.05 (bd, *J* = 6.4 Hz, 2H), 2.81 (dd, *J* = 9.2, 2.8 Hz, 1H), 3.02 (dq, *J* = 8.9, 7.1 Hz, 1H), 3.40−3.57 (m, 2H), 3.87 (bt, *J* = 6.4 Hz, 1H), 4.05−4.12 (m, 1H), 4.13−4.30 (m, 1H), 4.48−4.53 (m, 1H), 7.35−7.74 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 17.1, 19.2, 19.9, 20.8, 26.4, 27.1, 29.7, 31.1, 32.8, 38.3, 44.6, 46.4, 47.8, 48.3, 53.2, 64.8, 70.2, 73.3, 77.9, 80.0, 127.5, 127.9, 129.7, 130.0, 135.9, 175.5; MS (CI) *m/z* no M^+ ($^{202}Hg^{35}Cl$) at 873 observed, 199 (100%); HRMS (EI) *m/z* 579.246 ± 0.006 ($(M - C(CH_3)_3HgCl)^+$ calcd for $C_{32}H_{41}NO_5SSi$ 579.247). Anal. Calcd for $C_{36}H_{50}ClHgNO_5SSi$: C, 49.5; H, 5.8; N, 1.6. Found: C, 49.8; H, 5.6; N, 1.4.

Intramolecular Oxymercuration of 27. Oxymercuration of aldol adduct **27** (288 mg, 0.452 mmol) according to the procedure described above afforded the chloromercurials **28a** (329 mg, 82%) and **28b** (55 mg, 14%) as colorless gums after purification by preparative TLC (silica, 20% ether/light petroleum ether). The ^1H NMR spectrum (200 MHz) of the crude product indicated the two diastereomers to be in a ratio of 84:16. **28a**: R_f 0.17 $[\alpha]^{22}_D$ +10.9° (*c* 1.94, $CHCl_3$); IR ($CHCl_3$) 1687 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.98 (s, 3H), 1.08 (s, 9H), 1.14 (d, *J* = 6.5 Hz, 3H), 1.15 (s, 3H), 1.26−1.59 (m, 7H), 1.31 (d, *J* = 6.9 Hz, 3H), 1.88−2.05 (m, 4H), 2.65 (dd, *J* = 8.1, 2.6 Hz, 1H), 3.04 (dq, *J* = 9.2, 6.9 Hz, 1H), 3.46 (d *J* = 13.6 Hz, 1H), 3.54 (d *J* = 13.6 Hz, 1H), 3.87 (bt, *J* = 6.3 Hz, 1H), 4.08−4.19 (m, 3H), 7.35−7.73 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 17.1, 19.1, 20.0, 20.8, 26.6, 26.7, 27.2, 31.3, 32.9, 33.4, 38.4, 44.6, 46.1, 47.9, 48.4, 53.3, 64.9, 70.5, 74.2, 79.0, 79.4, 127.6, 128.0, 129.8, 130.1, 134.3, 136.1, 136.06, 136.14, 174.6; MS (EI) *m/z* no M^+ ($^{202}Hg^{35}Cl$) at 873 observed, 199 (100%). Anal. Calcd for $C_{36}H_{50}ClHgNO_5SSi$: C, 49.53; H, 5.77; N, 1.60. Found: C, 49.79; H, 6.01; N, 1.43. **28b**: R_f 0.23; $[\alpha]^{22}_D$ +18.1° (*c* 1.40, $CHCl_3$); IR ($CHCl_3$) 1688, 1333 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.97 (s, 3H), 1.07 (s, 9H), 1.15 (s, 3H), 1.16−1.76 (m, 5H), 1.23 (d, *J* = 5.8 Hz, 3H), 1.26 (d, *J* = 7.2 Hz, 3H), 1.79−2.03 (m, 6H), 2.87 (bt, *J* = 5.1 Hz, 1H), 3.19, (dq *J* = 7.2, 7.2 Hz, 1H), 3.51 (m, 2H), 3.70−3.79 (m, 1H), 3.86−3.93 (m, 1H), 4.02 (bt, *J* = 6.3 Hz, 1H), 4.17 (qd, *J* = 5.8, 5.1 Hz, 1H), 7.34−7.69 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 16.2, 19.0, 19.9, 20.9, 26.4, 26.7, 27.0, 28.7, 32.6, 38.3, 44.7, 45.0, 47.7, 48.2, 53.2, 64.8, 71.0, 72.3, 78.8, 79.8, 127.6, 127.8, 129.8, 129.9, 133.7, 133.8, 135.8, 135.8, 174.4; MS (EI) *m/z* no M^+ ($^{202}Hg^{35}Cl$) at 873 observed, 199 (100%). Anal. Calcd for $C_{36}H_{50}ClHgNO_5SSi$: C, 49.53; H, 5.77; N, 1.60. Found: C, 49.52; H, 5.64; N, 1.41.

Reductive Demercuration of 21a. Tributylstannane (0.148 g, 0.509 mmol) was added in one portion to a solution of the chloromercurial **21a** (177 mg, 0.203 mmol) and AIBN (2.7 mg, 0.016 mmol) in toluene (4 mL). Mercury began to precipitate almost immediately, and the mixture was left to stir at room temperature for 1 h and then at 55 °C for 1 h. The heating bath was removed, carbon tetrachloride (0.5 mL) was added, and the mixture was stirred for a further 1 h. The reaction mixture was decanted from mercury, diluted with 25% dichloromethane/light petroleum ether (20 mL), and washed with aqueous potassium fluoride (5% 4 × 10 mL). The organic layer was dried ($MgSO_4$) and filtered and the solvent removed *in vacuo*. Purification of the crude product by preparative TLC (silica, 20% ether/light petroleum ether, R_f 0.20) gave the reduced product **22** as a viscous oil (130 mg, 100%); $[\alpha]^{22}_D$ −62.0° (*c* 2.83, $CHCl_3$); IR ($CHCl_3$) 1687, 1334 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.97 (s, 3H) 1.04 (s, 9H), 1.09 (d, *J* = 6.1 Hz, 3H), 1.16 (s, 3H), 1.28 (d, *J* = 6.9 Hz, 3H), 1.33−1.61 (m, 6H), 1.67−1.99 (m, 5H), 2.03 (bd, *J* = 6.2 Hz, 2H), 3.01 (dq, *J* = 9.2, 6.9 Hz, 1H), 3.43 (d, *J* = 13.8 Hz, 1H), 3.50 (d, *J* = 13.8 Hz, 1H), 3.83−4.12 (m, 4H), 7.26−7.73 (m, 10 H); MS (electrospray) 638 (M^+ + 1, 100%); HRMS (FAB) *m/z* 638.335 ± 0.006 (M^+ calcd for $C_{36}H_{52}NO_5SSi$ 638.334).

Reductive Demercuration of 28a. Using the procedure described above, reductive demercuration of the chloromercurial **28a** (176 mg, 0.202 mmol) and purification by preparative TLC (silica, 20% ether/light petroleum ether, R_f 0.20) gave the reduced product **29** as a viscous oil (128 mg, 99%); $[\alpha]^{22}_D$ +36.9° (*c* 1.80, $CHCl_3$); IR ($CHCl_3$) 1689, 1334s cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 0.97 (s, 3H), 1.04 (s, 9H), 1.10 (d, *J* = 6.2 Hz, 3H), 1.15 (s, 3H), 1.29 (d, *J* = 6.9 Hz, 3H), 1.31−1.61 (m, 6H), 1.82−1.92 (m, 5H), 2.03 (bd, *J* = 6.0 Hz, 2H), 3.02 (dq, *J* = 9.2, 6.9 Hz, 1H), 3.44 (d, *J* = 13.8 Hz, 1H), 3.50 (d, *J* = 13.8 Hz, 1H), 3.87−4.01 (m, 4H), 7.32−7.70 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 17.0, 19.3, 19.9, 20.8, 23.5, 26.5, 27.1, 30.7, 31.9, 32.9, 38.4, 44.6, 45.3, 46.2, 47.8, 48.3, 53.3, 64.9, 67.6, 75.8, 79.1, 127.4, 129.5, 129.6, 134.4, 135.0, 136.0, 174.9; MS (EI) *m/z* no M^+ at 637 observed, 199 (100%). Anal. Calcd for $C_{36}H_{51}NO_5SSi$: C, 67.78; H, 8.06; N, 2.20. Found: C, 67.88; H, 7.99; N, 2.06.

Methyl (2*R*,3*S*,6*R*,8*S*)-*O*-(*tert*-Butyldiphenylsilyl)nonactate (24). Hydrogen peroxide (30%, w/v, 0.030 mL, 0.265 mmol) was added dropwise to a stirred solution of tetrahydrofuran **22** (47 mg, 0.074 mmol) and $LiOH·H_2O$ (6.0 mg, 0.143 mmol) in 80% THF/H_2O (1.5 mL) at 0 °C. The solution was stirred at this temperature for 30 min and then allowed to warm to room temperature. No starting material remained after 7 h as indicated by analytical TLC. A saturated aqueous sodium sulfite solution (1 mL) was added, and the mixture

was acidified with hydrochloric acid (1 M) and then saturated with sodium chloride. The mixture was separated, and the aqueous phase was extracted with ether (3 × 10 mL). The organic phases were combined, dried ($MgSO_4$), and filtered and the solvent removed under reduced pressure. Crude carboxylic acid **23** was dissolved in ether (10 mL) and treated with excess diazomethane at 0 °C using the method described by Lombardi.[12] After allowing the excess diazomethane to dissipate, the solution was dried ($MgSO_4$) and filtered and the solvent removed *in vacuo*. Purification of the residue by preparative TLC (silica, 20% ether/light petroleum ether, R_f 0.50) gave **24** as a colorless gum (22 mg, 66%): $[\alpha]^{21}_D$ −20.7° (*c* 0.83, $CHCl_3$); IR ($CHCl_3$) 1729 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.04 (s, 9H), 1.09 (d, J = 6.2 Hz, 3H), 1.18 (d, J = 7.1 Hz, 3H), 1.19−1.62 (m, 3H), 1.83−1.93 (m, 3H), 2.44 (dq, J = 7.1 Hz, 1H), 3.65 (s, 3H), 3.86−4.04 (m, 3H), 7.32−7.71 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 14.1, 19.3, 23.4, 27.0, 29.2, 31.2, 45.3, 45.7, 51.5, 67.5, 76.5, 79.4, 127.4, 127.5, 129.6, 129.6, 134.4, 134.8, 135.9, 136.0, 175.2; MS (EI) m/z no M^+ at 454 observed, 199 (100%); HRMS (EI) m/z 397.186 ± 0.004 ($M^+ - (CH_3)_3C$ calcd for $C_{23}H_{29}O_4Si$ 397.184).

Methyl (2*S*,3*R*,6*R*,8*S*)-*O*-(*tert*-Butyldiphenylsilyl)nonactate (31). Using a procedure similar to that described above, tetrahydrofuran **29** (47 mg, 0.074 mmol) gave **30** as a colorless gum after reaction with hydrogen peroxide (30% w/v, 0.020 mL, 0.176 mmol) and $LiOH·H_2O$ (4.0 mg, 0.095 mmol) for 10 h. The residue was treated with excess diazomethane and then purified by preparative TLC (silica, 20% ether/light petroleum ether, R_f 0.51) as above to give **31** (33 mg, 100%); $[\alpha]^{21}_D$ −2.0° (*c* 0.46, $CHCl_3$); IR ($CHCl_3$) 1729 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.04 (s, 9H), 1.11 (d, J = 6.1 Hz, 3H), 1.17 (d, J = 7.0 Hz, 3H), 1.22−1.65 (m, 2H), 1.74−1.95 (m, 4H), 2.45 (dq, J = 7.0 Hz, 1H), 3.65 (s, 3H), 3.84−4.04 (m, 3H), 7.32−7.70 (m, 10 H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 14.4, 19.3, 23.5, 27.1, 29.9, 32.1, 45.0, 45.2, 51.6, 67.6, 76.1, 79.4, 127.5, 127.6, 129.5, 129.6, 134.5, 134.8, 135.9, 136.0, 177.3; MS m/z no M^+ at 454 observed, 199 (100%); HRMS (EI) m/z 397.185 ± 0.004 ($M^+ - C(CH_3)_3$ calcd for $C_{23}H_{29}O_4Si$ 397.184).

Methyl (2*R*,3*S*,6*R*,8*S*)-Nonactate (25). Tetrabutylammonium fluoride (TBAF) (1 M in THF, 130 μL, 0.130 mmol) was added to a solution of silyl ether **24** (15.5 mg, 0.034 mmol) in THF (0.5 mL) at room temperature. After the reaction mixture was stirred for 24 h, analytical TLC indicated that starting material was still present. A further portion of TBAF (100 μL) was added and the solution stirred until analytical TLC indicated that no starting material remained (24 h). The solution was diluted with ether (20 mL), dried ($MgSO_4$), and filtered and the solvent removed under reduced pressure. The residue was purified by preparative TLC (silica, 50% ether/light petroleum ether, R_f 0.37) to give nonactate **25** as a colorless viscous oil (6.5 mg, 88%): $[\alpha]^{20}_D$ −16.9° (*c* 0.33, $CHCl_3$); IR ($CHCl_3$) 1730 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.178 (d, J = 6.2 Hz, 3H), 1.221 (d, J = 7.0 Hz, 3H), 1.36−1.79 (m, 4H), 1.88−2.07 (m, 2H), 2.579, (dq, J = 7.0 Hz, 1H), 3.65 (bs, 1H), 3.682 (s, 3H), 3.94−4.11 (m, 3H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 13.9, 23.4, 28.5, 31.9, 44.4, 44.8, 51.7, 68.0, 80.2, 80.9, 174.9; MS (CI) m/z 217 (M^+ + 1, 44), 157 (100%); HRMS (CI) m/z 217.145 ± 0.002 (M^+ + H calcd for $C_{11}H_{21}O_4$ 217.144).

Methyl (2*S*,3*R*,6*R*,8*S*)-Nonactate (32). Treatment of silyl ether **31** (18.0 mg, 0.396 mmol) with TBAF (120 μL, 0.120 mmol) in THF (0.5 mL) according to the procedure described above gave nonactate **32** as a colorless viscous oil: R_f 0.35 (7.9 mg, 92%); $[\alpha]^{19}_D$ +13.3° (*c* 0.34, $CHCl_3$); IR ($CHCl_3$) 1731 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 1.176 (d, J = 6.2 Hz, 3H), 1.228 (d, J = 7.0 Hz, 3H), 1.43−1.77 (m, 4H), 1.98−2.14 (m, 2H), 2.506 (dq, J = 7.0 Hz, 1H), 3.679 (s, 3H), 3.69 (bs, 1H), 3.92−4.03 (m, 1H), 4.04−4.21 (m, 2H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 14.0, 23.3, 29.4, 32.7, 44.0, 44.7, 51.7, 68.1, 79.96, 79.99, 174.9; MS m/z no M^+ at 216 observed, 71 (100%); HRMS (CI) m/z 217.145 ± 0.002 (M^+ + H calcd for $C_{11}H_{21}O_4$ 217.144).

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Supporting Information Available: Full experimental details for the preparation of compounds **4c**−**g**, **12**, and **14** (9 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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