De Novo Approach to Dideoxyribosides. 5-*Endo-trig*-like Cyclizations of δ-Hydroxy Enol Ethers

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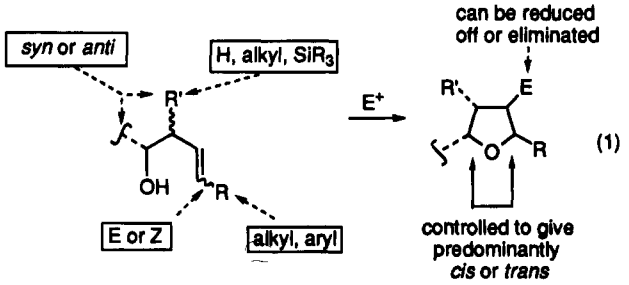
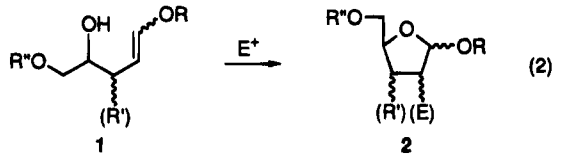
Electrophile-initiated cyclizations of homoallylic alcohols which proceed *via* 5-*endo-trig*-like closures have been shown to afford substituted tetrahydrofurans, key subunits of polyether natural products, with considerable stereocontrol. Substrates bearing either (*E*)- or (*Z*)-alkyl or (hetero)aryl-substituted olefins, with occasional substitution at the allylic (3) position, readily react in the presence of reagents (E^+) such as I_2 (with or without Ag(I) salts), PhSeCl, protons, and Hg(II) salts (eq 1).[1] Replacement of the alkyl/aryl group in the educt with an ether unit (OR) presents opportunities for cyclizations involving enol ethers **1**, the result of which might lead to controlled access to (di)deoxyriboses **2** (eq 2).[2] We now report on the preparation of precursors **1**, conditions that allow for their stereoselective cyclizations to **2**, and a comparison of commonly employed electrophilic reagents, E^+, in terms of the extent of stereoselectivity realized with each.



(1)



1 2 (2)

From glycidol benzyl or thexyldimethylsilyl ether (**3a**, **3b**, respectively),[3] epoxide opening to **4** was readily achieved with an alanate reagent[4,5] derived from Me_3Al and the lithiated form of an acetylenic ether.[6] Reduction with LAH in THF afforded the (*E*)-isomers **5**, while hydrogenation over Lindlar catalyst led to (*Z*)-enol ethers **6** (Scheme 1).

Cyclizations of various substrates were examined, induced by PhSeCl or I_2/Ag^+ in CH_3CN at 0 °C[1b] or with KH/I_2 in Et_2O at −78 °C (Table 1). The selectivity in all cases using PhSeCl or I_2 was on the order of 2:1 or *less*, while KH/I_2 gave ratios that were significantly improved, along with good isolated yields.[7] Other, nonethereal solvents (*e.g.*, CH_2Cl_2, $PhCH_3$, DMF) at low temperatures (between 0 and −78 °C) gave inferior results. In general, cyclizations of enol ethers proceeded in a short period of time (<10 min) even when an electron-withdrawing group was present in the enol ether (entry 3).[8] Diastereoselectivity was somewhat higher with (*E*)- rather than (*Z*)-enol ethers (compare entries 1 and 4), and protecting groups at the side-chain position were of no consequence (entries 4, R = Bn *vs* entry 6, R = thexyldimethylsilyl). Placement of a bulky substituent such as the $Me_2Si(O$-*t*-Bu) group in the allylic position (**13**) bearing an *anti* disposition relative to the adjacent hydroxyl group raised the diastereoselectivity of **14a/14b** to >95:5 (Scheme 2),[9] while placement of this residue in the *syn* arrangement (**16**) led to no net enhancement (85:15, 83% yield).[10] Reductive removal of the iodide from the products of cyclization readily occurred *via* Bu_3SnH treatment. Silicon substituents such as that in **14a/14b** could be further reduced to dideoxyriboside **15a/15b** using fluoride ion in hot DMF (Scheme 2).[11]

Given the ease with which acetylenic ethers (*e.g.*, **17**) can be constructed,[5,6] application of the methodology to disaccharide formation using glucose derivative **19** was next considered. Interestingly, this more complex educt cyclized under standard conditions (*i.e.*, KH, I_2, Et_2O, −78 °C) to afford a ≥95:5 mix of product 2,5-*trans* **21a**:2,5-*cis* **21b** (R = H) isomers (Scheme 3).[12] The effect of an additional substituent at carbon bearing the free hy-

(1) For cyclizations using PhSeX, see: (a) Mihelich, E. D.; Hite, G. A. *J. Am. Chem. Soc.* **1992**, *114*, 7318. (b) Lipshutz, B. H.; Barton, J. C. *Ibid.* **1992**, *114*, 1084. (c) Kang, S. H.; Hwang, T. S.; Kim, W. J.; Lim, J. K. *Tetrahedron Lett.* **1991**, *32*, 4015. (d) Kang, S. H. *Ibid.* **1990**, *31*, 5917. (e) Mihelich, E. D.; Hite, G. A. *J. Am. Chem. Soc.* **1990**, *112*, 8995. (f) Murata, S.; Suzuki, T. *Tetrahedron Lett.* **1990**, *31*, 6535. Using iodine: (g) Kang, S. H.; Lee, S. B. *Tetrahedron Lett.* **1993**, *34*, 7579. (h) Kang, S. H.; Lee, S. B. *Ibid.* **1993**, *34*, 1955. (i) Bedford, S. B.; Bell, K. E.; Fenton, G.; Hayes, C. J.; Knight, D. W.; Shaw, D. *Ibid.* **1992**, *33*, 6511. (j) Bennett, F.; Bedford, S. B.; Bell, K. E.; Fenton, G.; Knight, D. W.; Shaw, D. *Ibid.* **1992**, *33*, 6507. (k) Marek, I.; Lefrancois, J.-M.; Normant, J.-F. *Ibid.* **1992**, *33*, 1747. (l) Evans, R. D.; Magee, J. W.; Herman Shauble, J. *Synthesis* **1988**, 862. For cyclizations using other sources of electrophiles, see, for example: (m) Kocovsky, P.; Pour, M. *J. Org. Chem.* **1990**, *55*, 5580. (n) Craig, D.; Smith, A. M. *Tetrahedron Lett.* **1992**, *33*, 695. (o) Polt, R.; Wijayaratne, T. *Ibid.* **1991**, *32*, 4831.

(2) For the synthesis of carbohydrates, in particular from noncarbohydrate precursors, see: (a) Mash, E. A.; Arterburn, J. B.; Fryling, J. A.; Mitchell, S. H. *J. Org. Chem.* **1991**, *56*, 1088. (b) Mash, E. A. *Synlett* **1991**, 529. (c) Ager, D. J.; East, M. B. *Tetrahedron* **1993**, *49*, 5683.

(3) For the synthesis of **3a** see: (a) Anisuzzaman, A. K. M.; Owen, L. N. *J. Chem. Soc. C* **1967**, 1021. (b) Takano, S.; Goto, E.; Hirama, M.; Ogasawara, K. *Heterocycles* **1981**, *16*, 381. Compound **3b** was synthesized by treatment of glycidol (Aldrich Corp.) with thexyldimethylsilyl chloride/imidazole in CH_2Cl_2 (87% yield; see Experimental Section).

(4) Skrydstrup, T.; Benechie, M.; Khoung-Hung, F. *Tetrahedron Lett.* **1990**, *31*, 7145.

(5) Fried, J.; Sih, J. C.; Dalven, P.; Lin, C. *J. Am. Chem. Soc.* **1972**, *94*, 4343.

(6) Moyano, A.; Charbonnier, F.; Greene, A. E. *J. Org. Chem.* **1987**, *52*, 2919.

(7) Attempts using other bases (*e.g.*, NaH, KO-*t*-Bu) failed to increase the selectivity of the reaction in Et_2O. Only NaH in THF was equally effective, judging from the one case examined (*i.e.*, Table 1, entry 4; ratio: 6:1). Selectivity also was not improved using nonbasic conditions and/or different electrophiles (*e.g.*, I_2 or $PhSeCl/ZnBr_2$, $(collidine)_2I^+ClO_4^-$, NIS).

(8) The reaction of a homoallylic alcohol as described in ref 1b for 8 h under our standard conditions (KH, Et_2O, I_2, −78 °C) led to 20% recovered educt (ratio of stereoisomers: 10:1).

(9) Only one isomer was detected and subsequently isolated.

(10) Reactions of *anti*-**13** and *syn*-**16** with I_2 or PhSeCl in CH_3CN produced only a complex mixture of products. Compounds **13** and **16** were synthesized by treatment of (*E*)- or (*Z*)-1-(benzyloxy)-3-(*tert*-butoxydimethylsilyl)-2,3-epoxypropane (**27** and **31**, respectively; see supplementary material) with an alanate reagent followed by reduction of the acetylenic ether with Lindlar catalyst as described in the Experimental Section.

(11) Hale, M. R.; Hoveyda, A. H. *J. Org. Chem.* **1992**, *57*, 1643 and references therein.

(12) Compounds **17** and **18** were synthesized by treatment of (*R*)-(+)-glycidol or (*R*)-2-methylglycidol (Aldrich) with benzyl bromide/NaH in THF (60% yield) followed by the reaction with an alanate reagent in toluene (65–70% yield; *cf.* Experimental Section for this epoxide transformation).

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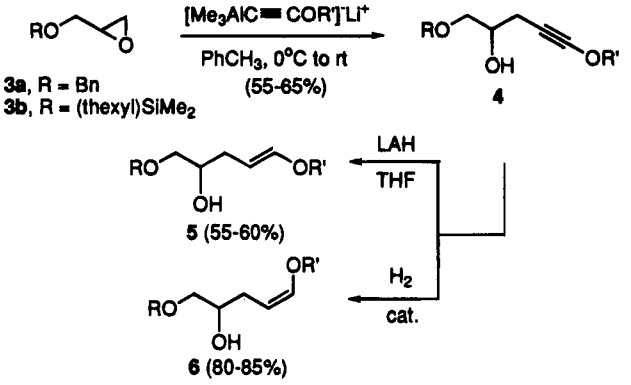
droxyl (*i.e.*, educt **20**) was also studied with this system. The high diastereoselectivity realized with **19** was essentially lost in the conversion of **20** to **21a/21b** (R = Me), as expected due to the similarity in steric demand of each of the two substituents.

Stereochemical assignments for these cyclizations were made on the basis of (1) data acquired *via* chemical correlation, (2) relative chemical shift data, and (3) NOE experiments. Our previous reliance solely on this latter technique for assigning stereochemistry in tetrahydrofurans demonstrated just how sensitive these measurements can be to the conditions of an NOE experiment.[1b] Indeed, we were misled by the results from these earlier studies resulting in several incorrect assignments and conclusions regarding *iodo*cyclizations of homoallylic alcohols, which have since been corrected.[1a,13] Stereochemical assignments herein could be made by taking advantage of the known additions of nucleophiles to furanose glycals (*e.g.*, **22**) under the influence of I^+, which occur selectively in a *trans* fashion with the electrophile approaching predominantly from the α-face to give iodohydrin derivatives **7a/7b**.[14] Thus, in the presence of cyclohexanol as nucleophile, products of *anti* addition were obtained in a 1:14 ratio (Scheme 4). Recalling that cyclization of enol ether **5a** led to the same two products **7a/7b**, it was clear by NMR that major product **7b** from **22** was identical to the minor product obtained from **5a**.[15] Furthermore, removal of iodide with Bu_3SnH from each of the products **10a** and **7a**, as with silyl-substituted **14a/14b**, led to dideoxyriboses **15a** and **15b**, respectively. Hence, (*E*)-enol ethers afford 2,5-*trans* dideoxyribosides, while (*Z*)-isomers lead to the corresponding 2,5-*cis* analogs.

In sum, it has been demonstrated for the first time that δ-hydroxy (*E*)- and (*Z*)-enol ethers can be cyclized to afford mainly 2,5-*trans* or 2,5-*cis* dideoxyriboses, respectively, *via* treatment with KH/I_2.[18] The more commonly used conditions[1a-l] of PhSeCl and I_2/Ag^+ are not effective for closures in this system. Incorporation of a sugar in the enol ether can be employed as an inroad to disaccharide formation. Further applications of these electrophilically-driven cyclizations to nitrogen-containing substrates is in progress and will be reported in due course.

Scheme 1



Experimental Section

General Procedure. All reactions were performed in oven-dried glassware equipped with a magnetic stirring bar under a positive pressure of dry argon using standard syringe techniques. All reagents were purchased from the Aldrich Chemical Co. and were purified and dried prior to use. Tetrahydrofuran (THF) and diethyl ether were distilled from sodium/benzophenone inmmediately prior to use. Toluene and DMF were distilled from CaH_2. Mass spectra were run on either a VG-Autospec at the UCLA campus or an analytical VG 70-250 HF instrument. Proton magnetic resonance spectra (500 MHz) were recorded with a General Electric GN-500 spectrometer as solutions in deuteriochloroform and recorded in ppm from tetramethylsilane with the solvent resonance as an internal standard (7.24 ppm). Carbon-13 magnetic resonance spectra (125 MHz) were recorded with a General Electric GN-500 spectrometer with proton decoupling as solutions in deuteriochloroform and recorded in ppm from tetramethylsilane with the solvent resonance as an internal standard (77.0 ppm). Column chromatography was performed with silica gel 60 (32–63 mesh, ICN Biomedical), and TLC was run on silica gel 60 F-254 plates (Merck).

Epoxide 3b. To a round-bottom flask containing glycidol (2.5 mL, 37 mmol), imidazole (2.5 g, 37 mmol), and CH_2Cl_2 (300 mL) was added (thexyl)dimethylsilyl chloride (5.0 mL, 25 mmol) dropwise. After 2 h the reaction was filtered, washed with brine (2×), and then dried over anhydrous Na_2SO_4. Filtration and solvent removal *in vacuo* was followed by purification by column chromatography (mixture of hexanes/Et_2O) to obtain 4.7 g (87%) of **3b**: ^1H NMR ($CDCl_3$) δ 3.79 (dd, J = 11.9, 3.1 Hz, 1 H), 3.61 (dd, J = 11.9, 4.7 Hz, 1 H), 3.04 (m, 1 H), 2.73 (dd, J = 5.1, 4.1 Hz, 1 H), 2.60 (dd, J = 5.1, 2.7 Hz, 1 H), 1.60 (m, 1 H), 0.86/0.85 (s, 6 H), 0.09/0.08 (s, 6 H); ^{13}C NMR ($CDCl_3$) δ 63.4, 52.4, 44.5, 34.1, 25.5, 20.2, 18.5, −3.5; HRMS (EI) $^+$ calcd for $C_5H_{11}O_2Si$ [M − C_6H_{13}]$^+$ 131.0525, found 131.0543.

General Procedure for the Opening of an Epoxide with an Alanate Reagent. To a round-bottom flask containing the acetylenic ether (12.3 mmol) and toluene (80 mL) at 0 °C was added *n*-BuLi (6.5 mL, 13 mmoL, 2.0 M) dropwise. After 30 min, Me_3Al (6.2 mL, 12.3 mmol, 2.0 M in toluene) was added to the solution. Following a 4 h period, the epoxide (6.2 mmol), diluted in 4 mL of toluene, was introduced and the reaction was stirred overnight at rt. The reaction was quenched dropwise with an aqueous saturated solution of $NaHCO_3$ and then diluted with Et_2O. The aqueous phase was extracted with Et_2O (2×), and the combined organic layers were washed with brine and then dried over anhydrous Na_2SO_4. Filtration and solvent removal *in vacuo* was followed by purification by column chromatography (mixture of hexanes/Et_2O with 2% Et_3N as eluent) to obtain the desired product.

Acetylenic ether 4a; R = benzyl, R′ = cyclohexyl: ^1H NMR δ 7.30–7.24 (m, 5 H), 4.57 (s, 2 H), 3.95 (m, 1 H), 3.87 (m, 1 H), 3.60 (dd, J = 9.5, 4.1 Hz, 1 H), 3.48 (dd, J = 9.5, 6.6 Hz,

(13) A re-evaluation of the iodocyclizations previously reported by us[1b] and later confirmed[1a] revealed poor selectivities (60:40 to 80:20) and exclusively *trans* addition of I^+ and the hydroxyl group to the olefin. A paper claiming high selectivities using our original conditions (*i.e.*, I_2 in CH_3CN), however, has just appeared; *cf.* Barks, J. M.; Knight, D. W.; Seaman, C. J.; Weingarten, G. G. *Tetrahedron Lett.* **1994**, *35*, 7259.

(14) (a) Kim, C. U.; Misco, P. F. *Tetrahedron Lett.* **1992**, *33*, 5733. (b) Wang, J.; Wurster, J. A.; Wilson, L. J.; Liotta, D. *Ibid.* **1993**, *34*, 4881.

(15) According to the method of Williams,[16] stereochemical assignments could be made based on the Δδ values for the nonequivalent protons at C-4 in product iodotetrahydrofurans. For those products bearing a *cis* relationship between iodine at C-3 and the C-5 residue (in **7a–12a**), Δδ was found in all cases to be ≥0.40 ppm, while for those of *trans* configuration (for **7b–12b**), Δδ ≤ 0.20 ppm, fully supporting the assignments from chemical correlations (*vide supra*).[14] The C-2, C-3 relationships follow as well from the deshielding effect of the C-3 halogen *cis* to the proton at the anomeric center (δ ≥ 5.3 ppm) relative to the alternative *trans* orientation (δ ≤ 5.0 ppm).[17] Lastly, careful NOE experiments on **7a** and **10a** (see supplementary material) were in line as well with the above analyses.

(16) Williams, D. R.; Harigaya, Y.; Moore, J. L.; D'sa, A. *J. Am. Chem. Soc.* **1984**, *106*, 2641; see also ref 1a.

(17) Lambert, J. B. *Organic Structural Analysis*; MacMillan: New York, 1976; pp 33–34.

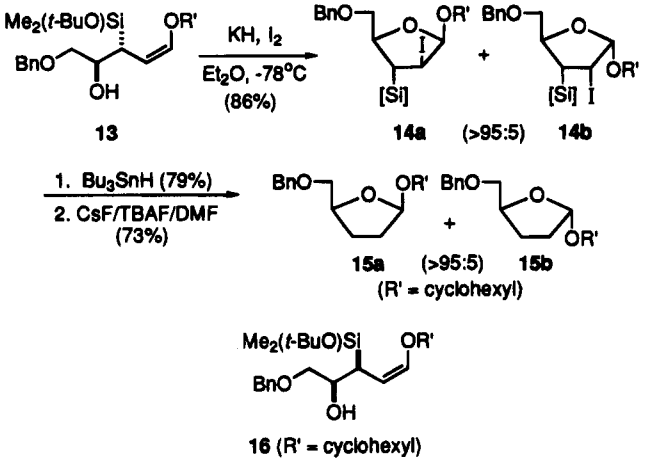
(18) For related work on the syntheses of isotopically labeled ribose derivatives and their incorporation into ribonucleosides see: (a) Jung, M. E.; Gardiner, J. M. *Tetrahedron Lett.* **1994**, *35*, 6755. (b) Goering, B. K.; Lee, K.; An, B.; Cha, J. K. *J. Org. Chem.* **1993**, *58*, 1100. (c) Hodge, R. P.; Brush, C. K.; Harris, C. M.; Harris, T. M. *ibid.* **1991**, *56*, 1553 and references therein. For related work on the synthesis of substituted γ-lactones which proceeds *via* cyclization/oxidation of γ-hydroxy enol carbamates, see: (a) Rehders, F.; Hoppe, D. *Synthesis*, **1992**, 859. (b) Hoppe, D.; Bronneke, A. *Tetrahedron Lett.* **1983**, *24*, 1687.

Table 1. Comparison of KH/I_2 with Iodo- and Selenocyclizations of δ-Hydroxy (*E*)- and (*Z*)-Enol Ethers 5 and 6

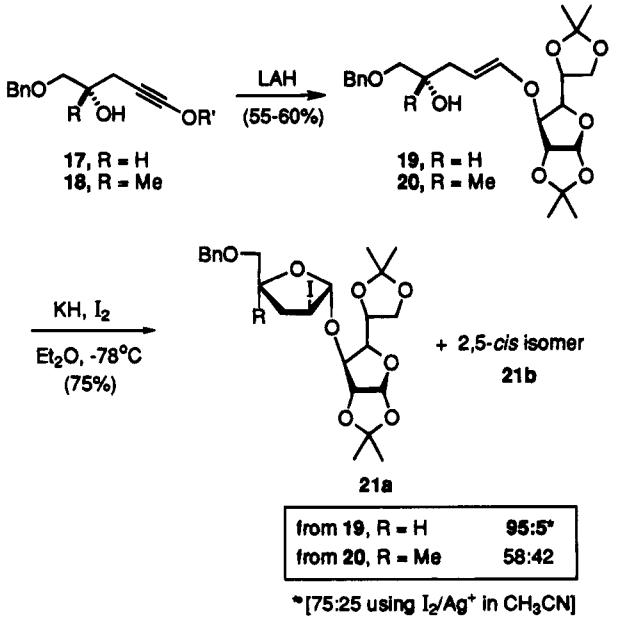
Entry	Educt[c]	R'	Ratio[a] (yield%)[b] KH / I_2[d]	I_2 / Ag^+[e]	PhSeCl[e]	Products
1	5a	cyclohexyl	91:9 (83)[f]	66:34(82)	60:40(-)[g]	7a/7b
2	5b	-$(CH_2)_3$Ph	89:11 (75)	66:33 (-)[g]		8a/8b
3	5c	β-naphthyl	88:12 (80)			9a/9b
						(a : b)
4	6a	cyclohexyl	85:15 (85)	64:36 (-)[g]	66:33(-)[g]	10a/10b
5	6b	-$(CH_2)_3$Ph	84:16 (79)			11a/11b
6	6c[h]	cyclohexyl	85:15 (82)	60:40(-)[g]	60:40(-)[g]	12a/12b
						(a : b)

[a] Refers to series of products (a:b); determined by ^1H NMR of the crude mixture. [b] Isolated yield of both isomers after chromatography. [c] R = benzyl, unless otherwise indicated. [d] Reaction was carried out in Et_2O at −78 °C. [e] Reaction was carried out according to ref 1b. [f] Use of THF instead of Et_2O resulted in a decrease in diastereoselectivity (85:15). [g] Yield not determined. [h] R = thexyldimethylsilyl.

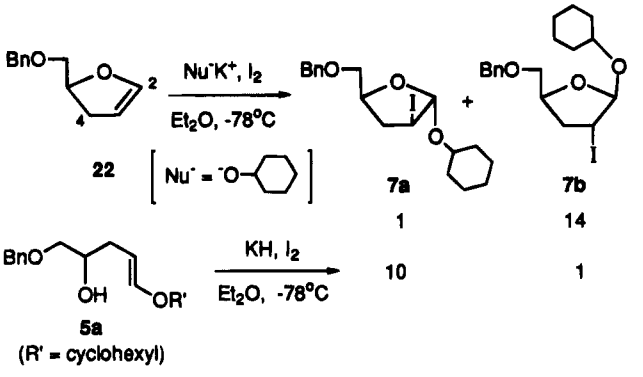
Scheme 2



Scheme 3



Scheme 4



1 H), 2.41 (m, 2 H), 2.0−1.0 (m, 10 H); ^{13}C NMR δ 128.4, 127.7, 89.9, 85.7, 73.4, 73.1, 69.5, 30.9, 25.1, 23.2, 22.6; HRMS (CI/NH_3) calcd for $C_{18}H_{25}O_3$ [M + H]$^+$ 289.1804, found 289.1803.

Acetylenic ether 4b; R = benzyl, R' = $(CH_2)_3$Ph: ^1H NMR δ 7.5−7.0 (m, 10 H), 4.55 (s, 2 H), 3.97 (t, *J* = 6.3 Hz, 2 H), 3.88 (m, 1 H), 3.59 (dd, *J* = 9.5, 4.0 Hz, 1 H), 3.48 (dd, *J* = 9.5, 6.7 Hz, 1 H), 2.70 (t, *J* = 7.6 Hz, 2 H), 2.40 (m, 3 H), 2.01 (m, 2 H); ^{13}C NMR δ 137.9, 128.4, 127.6, 126.1, 91.2, 77.3, 73.4, 73.0, 69.4, 32.8, 31.4, 30.3, 22.4; HRMS (CI/NH_3) calcd for $C_{21}H_{25}O_3$ [M + H]$^+$ 325.1804, found 325.1806.

Acetylenic ether 4c; R = benzyl, R' = β-naphthyl: ^1H NMR δ 7.80 (m, 3 H), 7.69 (d, *J* = 2.4 Hz, 1 H), 7.5−7.4 (m, 2 H), 7.36−7.27 (m, 6 H), 4.61 (s, 2 H), 4.04 (m, 1 H), 3.69 (dd, *J* = 9.5, 3.9 Hz, 1 H), 3.59 (dd, *J* = 9.5, 6.6 Hz, 1 H), 2.65−2.47 (m, 3 H), 1.03 (t, *J* = 7.2 Hz, 1 H); ^{13}C NMR δ 153.9, 137.8, 133.8, 130.6, 129.8, 128.4, 127.8, 127.7, 127.2, 126.9, 125.1, 116.0, 110.1, 84.9, 73.5, 73.1, 69.4, 40.9, 22.5; HRMS (CI/NH_3) calcd for $C_{22}H_{21}O_3$ [M + H]$^+$ 333.1491, found 333.1489.

Acetylenic ether 4d; R = thexyldimethylsilyl, R' = cyclohexyl: ^1H NMR δ 3.93 (m, 1 H), 3.66 (m, 2 H), 3.56 (m, 1 H), 2.33 (m, 3 H), 2.0−1.0 (m, 9 H), 0.85 (m, 12 H), 0.10 (m, 6 H); ^{13}C NMR δ 89.9, 85.6, 70.8, 65.4, 34.2, 33.7, 30.9, 25.1, 23.2, 22.1, 20.3, 20.1, 18.5, −3.5; HRMS (EI) calcd for $C_{13}H_{27}O_3Si$ [M − C_6H_9]$^+$ 259.1722, found 259.1742.

Acetylenic ether 17; R = H, R' = diacetone-D-glucose: ^1H NMR δ 7.3−7.2 (m, 5 H), 5.89 (d, *J* = 3.7 Hz, 1 H), 4.85 (d, *J* = 3.8 Hz, 1 H), 4.57 (s, 2 H), 4.47 (d, *J* = 2.6 Hz, 1 H), 4.31 (m, 1 H), 4.12−4.07 (m, 2 H), 4.02 (dd, *J* = 8.8, 4.6 Hz, 1 H), 3.90 (m, 1 H), 3.57 (dd, *J* = 9.5, 4.2 Hz, 1 H), 3.48 (dd, *J* = 9.5, 6.5 Hz, 1 H), 2.40 (d, *J* = 6.2 Hz, 2 H), 1.50 (s, 3 H), 1.44 (s, 3 H), 1.36 (s, 3 H), 1.33 (s, 3 H); HRMS (CI/NH_3) calcd for $C_{24}H_{36}O_8N$ [M + NH_4]$^+$ 466.2440, found 466.2441.

Acetylenic ether 18; R = Me, R' = diacetone-D-glucose: ^1H NMR δ 7.3−7.2 (m, 5 H), 5.89 (d, *J* = 3.7 Hz, 1 H), 4.84 (d, *J* = 3.7 Hz, 1 H), 4.58 (s, 2 H), 4.45 (d, *J* = 2.6 Hz, 1 H), 4.31 (m, 1 H), 4.12−4.07 (m, 2 H), 4.03 (dd, *J* = 8.8, 4.5 Hz, 1 H), 3.42 (d, *J* = 8.9 Hz, 1 H), 3.36 (d, *J* = 8.9 Hz, 1 H), 2.43 (d, *J* = 16.2 Hz, 1 H), 2.37 (d, *J* = 16.2 Hz, 1 H), 1.50 (s, 3 H), 1.43 (s, 3 H), 1.35

(s, 3 H), 1.32 (s, 3 H), 1.25 (s, 3 H); ^{13}C NMR δ 138.1, 128.4, 127.6, 127.5, 112.3, 109.5, 104.8, 89.3, 88.3, 81.9, 79.9, 75.9, 73.4, 71.7, 71.6, 67.0, 35.2, 28.2, 26.9, 26.6, 26.2, 25.1, 23.8; HRMS (CI/NH_3) calcd for $C_{25}H_{35}O_8$ $[M + H]^+$ 463.2287, found 463.2289.

General Procedure for the Reduction of a δ-Hydroxy Acetylenic Ether to an (*E*)-δ-Hydroxy Enol Ether. To a round-bottom flask containing a δ-hydroxy acetylenic ether (1.2 mmol) and 12 mL of THF at 0 °C was added $LiAlH_4$ (0.84 mL, 0.84 mmol, 1.0 M in THF) dropwise. The reaction was allowed to reach rt and followed by TLC. When complete, it was quenched dropwise with a saturated aqueous solution of $NaHCO_3$, and the aqueous phase was extracted with Et_2O (2×). The organic layers were combined and washed with brine and then dried over anhydrous Na_2SO_4. After filtration and solvent removal *in vacuo* the residue was purified by chromatography (mixture of hexanes/Et_2O with 2% Et_3N as eluent) to afford the expected product.

(*E*)-δ-Hydroxy enol ether 5a; R = benzyl, R′ = cyclohexyl: ^{1}H NMR δ 7.30−7.24 (m, 5 H), 6.16 (d, J = 12.4 Hz, 1 H), 4.83 (m, 1 H), 4.57 (m, 2 H), 3.77 (m, 1 H), 3.64 (m, 1 H), 3.51 (dd, J = 9.5, 3.5 Hz, 1 H), 3.38 (dd, J = 9.5, 7.2 Hz, 1 H), 2.13 (m, 2 H), 1.9−1.2 (m, 10 H); ^{13}C NMR δ 147.1, 128.4, 127.7, 100.5, 78.2, 73.6, 73.3, 70.4, 32.0, 31.9, 25.5, 23.7; HRMS (EI) calcd for $C_{12}H_{15}O_2$ $[M - OC_6H_{11}]^+$ 191.1068, found 191.1072.

(*E*)-δ-Hydroxy enol ether 5b; R = benzyl, R′ = $(CH_2)_3$-Ph: ^{1}H NMR δ 7.5−7.0 (m, 10 H), 6.29 (d, J = 12.6 Hz, 1 H), 4.71 (m, 1 H), 4.55 (s, 2 H), 3.76 (m, 1 H), 3.65 (t, J = 6.3 Hz, 2 H), 3.51 (dd, J = 9.5, 3.5 Hz, 1 H,), 3.38 (dd, J = 9.5, 7.1 Hz, 1 H), 2.70 (t, J = 7.7 Hz, 2 H), 2.13 (m, 2 H), 1.96 (m, 2 H); ^{13}C NMR δ 148.3, 141.5, 137.9, 128.4, 127.7, 125.8, 98.7, 73.7, 73.3, 70.5, 68.2, 32.1, 31.9, 30.8; HRMS (CI/NH_3) calcd for $C_{21}H_{30}O_3N$ $[M + NH_4]^+$ 344.2226, found 344.2235.

(*E*)-δ-Hydroxy enol ether 5c; R = benzyl, R′ = β-naphthyl: ^{1}H NMR δ 8.0−7.0 (m, 12 H), 6.63 (d, J = 12.1 Hz, 1 H), 5.43 (dt, J = 12.1, 7.9 Hz, 1 H), 4.58 (s, 2 H), 3.90 (m, 1 H), 3.59 (dd, J = 9.5, 3.4 Hz, 1 H), 3.45 (dd, J = 9.5, 7.0 Hz, 1 H), 2.30 (t, J = 7.2 Hz, 2 H); ^{13}C NMR δ 154.9, 143.5, 137.9, 134.2, 129.8, 129.7, 128.4, 127.7, 126.9, 126.5, 124.3, 118.5, 110.6, 108.7, 73.7, 73.4, 70.1, 31.4; HRMS (CI/NH_3) calcd for $C_{22}H_{22}O_3$ $[M + H]^+$ 334.1564, found 334.1569.

(*E*)-δ-Hydroxy enol ether 19: ^{1}H NMR δ 7.3−7.2 (m, 5 H), 6.20 (d, J = 12.5 Hz, 1 H), 5.84 (d, J = 3.7 Hz, 1 H), 4.91 (dt, J = 12.5, 7.7 Hz, 1 H), 4.58 (m, 3 H), 4.45 (m, 2 H), 4.13 (m, 1 H), 4.05 (dd, J = 13.6, 6.2 Hz, 1 H), 4.00 (dd, J = 8.6, 5.2 Hz, 1 H), 3.78 (m, 1 H), 3.47 (dd, J = 9.5, 3.7 Hz, 1 H), 3.36 (dd, J = 9.4, 7.0 Hz, 1 H), 2.20 (m, 2 H), 1.49 (s, 3 H), 1.41 (s, 3 H), 1.32 (s, 3 H), 1.29 (s, 3 H); ^{13}C NMR δ 146.2, 137.8, 128.2, 127.5, 111.7, 108.9, 104.8, 101.9, 82.1, 81.1, 80.3, 73.4, 73.1, 71.9, 69.9, 66.8, 31.6, 26.6, 26.5, 26.0, 25.1; HRMS (CI/NH_3) calcd for $C_{24}H_{38}O_8N$ $[M + NH_4]^+$ 468.2597, found 468.2592.

(*E*)-δ-Hydroxy enol ether 20: ^{1}H NMR δ 7.3−7.2 (m, 5 H), 6.17 (d, J = 12.5 Hz, 1 H), 5.87 (d, J = 3.7 Hz, 1 H), 4.94 (m, 1 H), 4.55 (m, 3 H), 4.26 (m, 2 H), 4.14 (dd, J = 8.0, 2.8 Hz, 1 H), 4.07 (dd, J = 8.7, 6.1 Hz, 1 H), 4.02 (dd, J = 8.7, 5.1 Hz, 1 H), 3.34 (dd, J = 8.9, 2.8 Hz, 1 H), 3.28 (d, J = 8.9 Hz, 1 H), 2.18 (dd, J = 13.9, 7.7 Hz, 1 H), 2.11 (dd, J = 13.9, 8.2 Hz, 1 H), 1.51 (s, 3 H), 1.42 (s, 3 H), 1.33 (s, 3 H), 1.31 (s, 3 H), 1.15 (s, 3 H); ^{13}C NMR δ 146.9, 138.1, 128.4, 127.7, 127.6, 111.9, 109.2, 105.1, 101.7, 82.5, 81.4, 80.6, 73.5, 72.1, 71.9, 67.1, 37.3, 26.9, 26.8, 26.2, 25.2, 23.8; HRMS (CI/NH_3) calcd for $C_{25}H_{37}O_8$ $[M + H]^+$ 465.2443, found 465.2463.

General Procedure for the Reduction of a δ-Hydroxy Acetylenic Ether to a (*Z*)-δ-Hydroxy Enol Ether. A mixture of freshly distilled quinoline (0.2 mL), 100 mg of Lindlar catalyst, and the δ-hydroxy acetylenic ether (1.5 mmol) in 30 mL of dry hexane was exposed to H_2 gas using a filled rubber ballon. After *ca.* 30 min (TLC), the reaction mixture was filtered and purified by column chromatography (mixture of hexanes/Et_2O with 2% Et_3N as eluent).

(*Z*)-δ-Hydroxy enol ether 6a; R = benzyl, R′ = cyclohexyl: ^{1}H NMR δ 7.30−7.24 (m, 5 H), 6.08 (d, J = 5.9 Hz, 1 H), 4.54 (s, 2 H), 4.38 (m, 1 H), 3.84 (m, 1 H), 3.58 (m, 1 H), 3.49 (dd, J = 9.6, 3.8 Hz, 1 H), 3.38 (dd, J = 9.6, 7.4 Hz, 1 H), 2.28 (m, 2 H), 1.8−1.2 (m, 10 H); ^{13}C NMR δ 145.6, 138.2, 128.4, 127.6, 127.5, 101.2, 79.3, 74.2, 73.3, 70.6, 32.2, 28.4, 25.5, 23.5; HRMS (CI/NH_3) calcd for $C_{18}H_{27}O_3$ $[M + H]^+$ 291.1960, found 291.1964.

(*Z*)-δ-Hydroxy enol ether 6b; R = benzyl, R′ = $(CH_2)_3$Ph: ^{1}H NMR δ 7.4−7.2 (m, 10 H), 6.04 (d, J = 6.0 Hz, 1 H), 4.56 (s, 2 H), 4.42 (m, 1 H), 3.87 (m, 1 H), 3.72 (t, J = 6.4 Hz, 2 H), 3.53 (dd, J = 9.5, 3.6 Hz, 1 H), 3.40 (dd, J = 9.5, 7.5 Hz, 1 H), 2.69 (t, J = 7.6 Hz, 2 H), 2.31 (t, J = 7.0 Hz, 2 H), 1.92 (m, 2 H); HRMS (CI/NH_3) calcd for $C_{21}H_{30}O_3N$ $[M + NH_4]^+$ 344.2226, found 344.2220.

(*Z*)-δ-Hydroxy enol ether 6c; R= thexyldimethylsilyl, R′ = cyclohexyl: ^{1}H NMR δ 6.08 (d, J = 6.3 Hz, 1 H), 4.39 (m, 1 H), 3.7−3.5 (m, 3 H), 3.42 (dd, J = 9.9, 6.8 Hz, 1 H), 2.24 (m, 2 H), 1.8−1.2 (m, 11 H), 0.85 (m, 12 H), 0.10 (m, 6 H); ^{13}C NMR δ 145.3, 101.6, 79.2, 71.9, 66.5, 34.2, 32.2, 27.9, 25.5, 23.5, 20.3, 18.5, −3.5; HRMS (CI/NH_3) calcd for $C_{19}H_{42}O_3SiN$ $[M + NH_4]^+$ 360.2934, found 360.2923.

(*Z*)-δ-Hydroxy enol ether 13: ^{1}H NMR δ 7.4−7.25 (m, 5 H), 6.09 (d, J = 6.3 Hz, 1 H), 4.60 (d, J = 12.1 Hz, 1 H), 4.51 (d, J = 12.1 Hz, 1 H), 4.48 (dd, J = 10.9, 6.3 Hz, 1 H), 4.18 (m, 1 H), 3.6−3.5 (m, 2 H), 3.44 (dd, J = 9.6, 4.4 Hz, 1 H), 2.14 (dd, J = 10.9, 2.7 Hz, 1 H), 1.9−1.3 (m, 10 H), 1.25 (s, 9 H), 0.23/0.19 (s, 6 H); ^{13}C NMR δ 143.5, 138.7, 128.2, 127.7, 127.3, 100.9, 79.0, 74.6, 73.3, 70.3, 32.4, 32.3, 31.8, 30.3, 25.5, 23.7, 0.81, 0.28; HRMS (FAB) calcd for $C_{24}H_{40}O_4Si$ $[M]^+$ 420.2638, found 420.2695.

(*Z*)-δ-Hydroxy enol ether 16: ^{1}H NMR δ 7.4−7.3 (m, 5 H), 6.03 (d, J = 6.3 Hz, 1 H), 4.65 (d, J = 12.2 Hz, 1 H), 4.59 (d, J = 12.2 Hz, 1 H), 4.10−4.02 (m, 2 H), 3.65 (dd, J = 10.0, 2.1 Hz, 1 H), 3.59 (m, 1 H), 3.43 (dd, J = 10.0, 7.3 Hz, 1 H), 2.42 (dd, J = 10.5, 10.4 Hz, 1 H), 1.9−1.4 (m, 10 H), 1.32 (s, 9 H), 0.25/0.23 (s, 6 H); ^{13}C NMR δ 143.6, 138.8, 128.2, 127.7, 127.2, 101.9, 79.1, 74.9, 73.3, 72.2, 32.4, 32.3, 31.8, 30.6, 25.5, 23.6, 23.6, 0.68, −1.0; HRMS (FAB) calcd for $C_{20}H_{31}O_3Si$ $[M + 1 - t\text{-BuOH}]^+$ 347.2026, found 347.2042.

General Procedure for the Cyclization of a δ-Hydroxy Enol Ether. To a round bottom flask cooled to −78 °C and containing KH (48 mg, 0.42 mmol, 35% in oil) and 2.4 mL of Et_2O was added dropwise the δ-hydroxy enol ether (0.20 mmol) diluted in 2.4 mL of Et_2O. Then, a solution of I_2 (262 mg, 1.03 mmol) in 2.4 mL of Et_2O was added and the reaction was followed by TLC. After completion (<10 min) the cold bath was removed and the reaction was diluted with Et_2O/Et_3N and quenched with an aqueous saturated solution of $Na_2S_2O_3$ (for better results in the case of **9a/9b** and **21a/21b,** a saturated solution of $Na_2S_2O_3$ was added *dropwise* to remove excess iodine, *i.e.*, until the red color disappeared). The aqueous phase was extracted with Et_2O (2×) and the combined organic layers were washed with brine and dried over anhydrous Na_2SO_4. The solvent was then evaporated *in vacuo*. The resulting crude material was analyzed by ^{1}H NMR and then purified by column chromatography to obtain the expected products (mixture of hexanes/Et_2O with 2% Et_3N as eluent).

Iodotetrahydrofuran 7a; R = benzyl, R′ = cyclohexyl: R_f 0.20, 10% ethyl ether/hexanes; ^{1}H NMR δ 7.3−7.2 (m, 5 H), 5.44 (s, 1 H), 4.64 (d, J = 12.2 Hz, 1 H), 4.58 (d, J = 12.2 Hz, 1 H), 4.41 (m, 1 H), 4.08 (m, 1 H), 3.72 (dd, J = 10.1, 6.3 Hz, 1 H), 3.60 (m, 2 H), 2.83 (m, 1 H), 2.16 (m, 1 H), 1.9−1.5 (m, 10 H); ^{13}C NMR δ 138.4, 128.4, 127.8, 127.7, 109.4, 75.3, 73.4, 72.1, 38.9, 33.6, 31.8, 25.6, 24.2, 24.0, 22.8; HRMS (CI/NH_3) calcd for $C_{18}H_{29}O_3IN$ $[M + NH_4]^+$ 434.1192, found 434.1188.

Iodotetrahydrofuran 7b; R = benzyl, R′ = cyclohexyl: R_f 0.26, 10% ethyl ether/hexane; ^{1}H NMR δ 7.3−7.2 (m, 5 H), 5.47 (s, 1 H), 4.59 (m, 3 H), 4.16 (d, J = 5.5 Hz, 1 H), 3.63−3.50 (m, 3 H), 2.34 (m, 1 H), 2.26 (m, 1 H), 1.9−1.5 (m, 10 H); ^{13}C NMR δ 138.1, 128.3, 127.7, 127.6, 108.7, 78.4, 75.1, 73.3, 73.2, 38.3, 33.5, 31.8, 26.3, 25.6, 24.2, 23.9; MS (CI/NH_3) for $C_{18}H_{29}O_3$-IN $[M + NH_4]$ 434.1.

Iodotetrahydrofuran 8a; R = benzyl, R′ = $(CH_2)_3$Ph: R_f 0.15, 10% ethyl ether/hexanes; ^{1}H NMR δ 7.5−7.0 (m, 10 H), 5.36 (s, 1 H), 4.62 (d, J = 12.3 Hz, 1 H), 4.56 (d, J = 12.0 Hz, 1 H), 4.38 (m, 1 H), 4.09 (m, 1 H), 3.70 (m, 1 H), 3.59 (dd, J = 10.2, 4.6 Hz, 1 H), 3.42 (dt, J = 9.7, 6.5 Hz, 1 H), 2.80 (m, 1 H), 2.65 (m, 2 H), 2.14 (m, 1 H), 1.86 (m, 2 H); ^{13}C NMR δ 141.7, 138.0, 128.4, 128.3, 127.8, 127.7, 125.8, 111.5, 77.5, 73.4, 71.9, 67.1, 39.0, 32.3, 31.2, 21.7; HRMS (EI) calcd for $C_{21}H_{25}O_3I$ $[M^+]$ 452.0848, found 452.0860.

Iodotetrahydrofuran 8b; R = benzyl, R′ = $(CH_2)_3$Ph: R_f 0.21, 10% ethyl ether/hexanes; ^{1}H NMR δ 7.5−7.0 (m, 10 H), 5.30 (s, 1 H), 4.59−4.54 (m, 3 H), 4.17 (d, J = 5.6 Hz, 1 H), 3.66 (dt, J = 9.6, 6.4 Hz, 1 H), 3.56 (dd, J = 10.0, 6.3 Hz, 1 H), 3.51 (dd, J = 10.0, 4.7 Hz, 1 H), 3.36 (dt, J = 9.6, 6.5 Hz, 1 H), 2.58

(m, 2 H), 2.30 (ddd, J = 14.3, 8.9, 5.8 Hz, 1 H), 2.24 (ddd, J = 14.3, 6.2, 0.9 Hz, 1 H), 1.80 (m, 2 H); ^{13}C NMR δ 141.7, 128.4, 127.7, 125.8, 110.7, 78.7, 73.3, 73.0, 66.7, 38.2, 32.3, 31.2, 25.3; MS (CI/NH_3) for $C_{21}H_{29}O_3IN$ $[M + NH_4]^+$ 470.1.

Iodotetrahydrofuran 9a; R = benzyl, R′ = β-naphthyl: R_f 0.15, 10% ethyl ether/hexanes; ^{1}H NMR δ 7.75 (m, 3 H), 7.45–7.15 (m, 9 H), 6.16 (s, 1 H), 4.62 (s, 2 H), 4.59 (m, 1 H), 4.41 (m, 1 H), 3.79 (dd, J = 10.3, 5.7 Hz, 1 H), 3.71 (dd, J = 10.3, 4.9 Hz, 1 H), 2.98 (m, 1 H), 2.35 (ddd, J = 14.3, 6.4, 4.7 Hz, 1 H); ^{13}C NMR δ 153.9, 134.3, 129.6, 129.5, 128.4, 127.8, 127.7, 127.6, 127.2, 126.4, 124.2, 119.0, 110.8, 109.9, 78.8, 73.5, 71.5, 38.7, 21.1; HRMS (CI/NH_3) for $C_{22}H_{25}O_3IN$ $[M + NH_4]^+$ calcd 478.0879, found 478.0880.

Iodotetrahydrofuran 9b; R = benzyl, R′ = β-naphthyl: R_f 0.21, 10% ethyl ether/hexanes; ^{1}H NMR δ 7.75 (m, 3 H), 7.45–7.15 (mult, 9 H), 6.14 (s, 1 H), 4.78 (m, 1 H), 4.45–4.51 (m, 3 H), 3.63 (dd, J = 10.4, 5.9 Hz, 1 H), 3.59 (dd, J = 10.4, 4.7 Hz, 1 H), 2.58 (ddd, J = 14.6, 9.0, 5.8 Hz, 1 H), 2.39 (dd, J = 14.6, 6.0 Hz, 1 H); ^{13}C NMR δ 153.8, 138.0, 134.3, 129.5, 128.2, 127.5, 127.1, 126.4, 124.2, 118.9, 110.4, 108.9, 80.1, 73.4, 72.4, 37.8, 24.8; MS (CI/NH_3) calcd for $C_{22}H_{21}O_3I$ $[M]^+$ 460.1, found 460.1.

Iodotetrahydrofuran 10a; R = benzyl, R′ = cyclohexyl: R_f 0.48, 40% ethyl ether/hexanes; ^{1}H NMR δ 7.3–7.2 (m, 5 H), 5.02 (d, J = 4.1 Hz, 1 H), 4.56 (m, 2 H), 4.24 (m, 1 H), 3.96 (ddd, J = 12.1, 7.1, 4.1 Hz, 1 H), 3.61 (m, 1 H), 3.58 (dd, J = 9.7, 7.3 Hz, 1 H), 3.45 (dd, J = 9.7, 4.9 Hz, 1 H), 2.51 (ddd, J = 12.2, 7.1, 7.1 Hz, 1 H), 2.11 (ddd, J = 12.2, 12.2, 9.0 Hz, 1 H), 1.9–1.2 (m, 10 H); ^{13}C NMR δ138.0, 128.3, 127.8, 127.7, 100.9, 78.3, 75.2, 74.4, 73.4, 37.8, 33.3, 31.0, 25.7, 23.8, 23.6, 20.0; HRMS (CI/NH_3) calcd for $C_{18}H_{29}O_3IN$ $[M + NH_4]^+$ 434.1192, found 434.1209.

Iodotetrahydrofuran 10b; R = benzyl, R′ = cyclohexyl: R_f 0.58, 40% ethyl ether/hexanes; ^{1}H NMR δ 7.3–7.2 (m, 5 H), 5.08 (d, J = 3.9 Hz, 1 H), 4.55 (m, 2 H), 4.29 (m, 1 H), 4.01 (ddd, J = 10.6, 8.6, 3.9 Hz, 1 H), 3.63 (m, 1 H), 3.50 (dd, J = 10.3, 3.9 Hz, 1 H), 3.45 (dd, J = 10.3, 4.7 Hz, 1 H), 2.46 (m, 1 H), 2.32 (ddd, J = 12.4, 8.6, 3.6 Hz, 1 H), 1.8–1.2 (m, 10 H); ^{13}C NMR δ 138.0, 128.4, 127.7, 127.6, 101.4, 76.3, 75.4, 73.5, 71.9, 37.1, 33.3, 31.3, 25.7, 23.8, 23.7, 20.6; MS (CI/NH_3) for $C_{18}H_{29}O_3IN$ $[M + NH_4]^+$ 434.1.

Iodotetrahydrofuran 11a; R = benzyl, R′ = $(CH_2)_3$Ph: R_f 0.28, 20% ethyl ether/hexanes; ^{1}H NMR δ 7.4–7.2 (m, 10 H), 4.86 (d, J = 4.0 Hz, 1 H), 4.53 (s, 2 H), 4.26 (m, 1 H), 3.95 (ddd, J = 12.1, 7.9, 4.0 Hz, 1 H), 3.67 (dt, J = 9.7, 6.0 Hz, 1 H), 3.51 (dd, J = 9.8, 7.1 Hz, 1 H), 3.43 (dd, J = 10.0, 4.8 Hz, 1 H), 3.39 (m, 1 H), 2.71 (t, J = 7.7 Hz, 2 H), 2.51 (m, 1 H), 2.11 (ddd, J = 12.2, 12.2, 9.0 Hz, 1 H), 1.85 (m, 2 H); ^{13}C NMR δ 141.9, 138.0, 128.5, 128.4, 128.3, 127.7, 125.7, 102.5, 78.5, 74.1, 73.3, 66.8, 37.7, 32.2, 30.9, 19.2; HRMS (CI/NH_3) calcd for $C_{21}H_{29}O_3IN$ $[M + NH_4]^+$ 470.1192, found 470.1185.

Iodotetrahydrofuran 11b; R = benzyl, R′ = $(CH_2)_3$Ph: R_f 0.42, 20% ethyl ether/hexanes; ^{1}H NMR δ 7.4–7.2 (m, 10 H), 4.91 (d, J = 3.9 Hz, 1 H), 4.53 (m, 2 H), 4.27 (m, 1 H), 4.02 (ddd, J = 10.5, 8.6, 3.9 Hz, 1 H), 3.72 (dt, J = 9.7, 6.2 Hz, 1 H), 3.5–3.4 (m, 3 H), 2.74 (t, J = 9.1 Hz, 2 H), 2.45 (m, 1 H), 2.32 (ddd, J = 12.4, 8.7, 3.6 Hz, 1 H), 1.90 (m, 2 H); ^{13}C NMR δ 141.9, 128.6, 128.4, 127.7, 127.6, 125.7, 102.9, 76.4, 73.5, 71.9, 67.1, 37.2, 32.2, 31.1, 19.9; MS (CI/NH_3) calcd for $C_{21}H_{26}O_3I$ $[M + H]^+$ 470.1.

Iodotetrahydrofuran 12a; R = thexyldimethylsilyl, R′ = cyclohexyl: R_f 0.38, 10% ethyl ether/hexanes; ^{1}H NMR δ 4.98 (d, J = 4.1 Hz, 1 H), 4.06 (m, 1 H), 3.94 (ddd, J = 11.7, 7.8, 4.0 Hz, 1 H), 3.71 (dd, J = 9.9, 6.2 Hz, 1 H), 3.59 (m, 1 H), 3.49 (dd, J = 9.9, 6.6 Hz, 1 H), 2.49 (ddd, J = 12.3, 7.2, 7.2 Hz, 1 H), 2.09 (m, 1 H), 1.9–1.2 (m, 11 H), 0.85 (d, J = 7.0 Hz, 6 H), 0.81 (s, 6 H), 0.73/0.68 (d, 6 H); ^{13}C NMR δ 100.7, 79.9, 75.1, 67.3, 38.3, 34.2, 33.4, 31.0, 25.8, 23.8, 23.6, 20.4, 20.3, 18.5, -3.4; HRMS (CI/NH_3) calcd for $C_{19}H_{41}O_3INSi$ $[M + NH_4]^+$ 486.1901, found 486.1909.

Iodotetrahydrofuran 12b; R = thexyldimethylsilyl, R′ = cyclohexyl: R_f 0.48, 10% ethyl ether/hexane; ^{1}H NMR δ 5.00 (d, J = 3.9 Hz, 1 H), 4.13 (m, 1 H), 3.98 (ddd, J = 10.5, 8.6, 3.9 Hz, 1 H), 3.56 (m, 3 H), 2.45–2.30 (m, 3 H), 1.9–1.2 (m, 11 H), 0.85 (d, J = 7.0 Hz, 6 H), 0.81 (s, 6 H), 0.73/0.68 (d, 6 H). ^{13}C NMR δ 101.5, 77.8, 75.5, 64.7, 36.8, 34.2, 33.4, 31.4, 25.8, 23.9, 23.7, 21.0, 20.3, 18.5, −3.4, −3.6; MS (CI/NH_3) for $C_{19}H_{41}O_3INSi$ $[M + NH_4]^+$ 486.1.

Iodotetrahydrofuran 14a: ^{1}H NMR δ 7.4–7.25 (m, 5 H), 4.98 (d, J = 3.9 Hz, 1 H), 4.59 (d, J = 12.2 Hz, 1 H), 4.55 (d, J = 12.2 Hz, 1 H), 4.27 (m, 1 H), 3.87 (dd, J = 12.4, 3.9 Hz, 1 H), 3.64 (m, 1 H), 3.54–3.46 (m, 2 H), 1.8–1.3 (m, 11 H), 1.21 (s, 9 H), 0.28/.026 (s, 6 H); ^{13}C NMR δ 138.4, 128.3, 127.8, 127.5, 101.4, 81.6, 75.4, 74.9, 73.3, 35.8, 33.3, 31.9, 31.0, 25.8, 23.8, 23.6, 2.2, 0.41; HRFAB calcd for $C_{24}H_{38}O_4ISi$ $[M + 1 - H_2]$ 545.1631, found: 545.1584.

Iodotetrahydrofuran 21a (R = H): R_f 0.42, 50% ethyl ether/hexanes; ^{1}H NMR δ 7.3–7.2 (m, 5 H), 5.83 (d, J = 5.6 Hz, 1 H), 5.63 (s, 1 H), 4.64 (d, J = 12.2 Hz, 1 H), 4.59 (d, J = 12.2 Hz, 1 H), 4.56 (d, J = 3.5 Hz, 1 H), 4.41 (m, 1 H), 4.23 (d, J = 3.0 Hz, 1 H), 4.19 (m, 1 H), 4.12 (m, 2 H), 4.06 (dd, J = 8.4, 2.8 Hz, 1 H), 3.94 (dd, J = 8.4, 5.8 Hz, 1 H), 3.74 (dd, J = 10.2, 6.0 Hz, 1 H), 3.64 (dd, J = 10.2, 4.8 Hz, 1 H), 2.80 (m, 1 H), 2.18 (m, 1 H), 1.49 (s, 3 H), 1.42 (s, 3 H), 1.37 (s, 3 H), 1.30 (s, 3 H); ^{13}C NMR δ 137.9, 128.4, 127.7, 127.6, 111.9, 109.2, 105.3, 84.0, 81.3, 80.0, 78.0, 73.5, 72.2, 71.7, 67.7, 38.9, 26.9, 26.7, 26.2, 25.5, 20.4; HRMS (CI/NH_3) calcd for $C_{24}H_{37}O_8IN$ $[M + NH_4]^+$ 594.1563, found 594.1541.

Iodotetrahydrofuran 21b (R = H): R_f 0.48, 50% ethyl ether/hexanes; ^{1}H NMR δ 7.3–7.2 (m, 5 H), 5.84 (d, J = 3.7 Hz, 1 H), 5.51 (s, 1 H), 4.7–4.5 (m, 4 H), 4.37 (d, J = 3.1 Hz, 1 H), 4.21–4.10 (m, 3 H), 4.03 (dd, J = 8.5, 6.4 Hz, 1 H), 3.95 (dd, J = 8.5, 5.8 Hz, 1 H), 3.77 (dd, J = 10.2, 6.6 Hz, 1 H), 3.63 (dd, J = 10.2, 4.5 Hz, 1 H), 2.26 (m, 2 H), 1.50 (s, 3 H), 1.37 (s, 3 H), 1.31 (s, 3 H), 1.30 (s, 3 H); ^{13}C NMR δ 138.1, 128.4, 127.7, 127.6, 11.9, 107.7, 105.1, 81.5, 80.8, 79.9, 76.4, 73.2, 72.5, 72.1, 67.2, 37.9, 26.8, 26.2, 25.5, 24.8; MS (CI/NH_3) for $C_{24}H_{37}O_8IN$ $[M + NH_4]^+$ 594.1.

General Procedure for the Reduction of an Iodotetrahydrofuran to a (Di)deoxyribose. A mixture of iodotetrahydrofuran (0.1 mmol) and Bu_3SnH (0.5 mL) was stirred for 6–12 h. The reaction mixture was filtered through silica (100% hexanes containing 2% Et_3N, then with hexanes/Et_2O, 50:50 containing 2% Et_3N). The filtered material was purified by chromatography (mixture of hexanes/Et_2O with 2% Et_3N as eluent).

(Di)deoxyribose 15a: ^{1}H NMR δ 7.4–7.25 (m, 5 H), 5.27 (s, 1 H), 4.60 (d, J = 12.2 Hz, 1 H), 4.56 (d, J = 12.2 Hz, 1 H), 4.25 (m, 1 H), 3.60–3.52 (m, 2 H), 3.47 (dd, J = 9.7, 4.8 Hz, 1 H), 2.0–1.0 (m, 14 H); ^{13}C NMR δ 128.3, 127.7, 127.5, 101.6, 78.7, 74.8, 74.2, 73.3, 33.8, 32.9, 31.8, 26.6, 25.7, 24.5, 24.2; HRMS (CI/NH_3) calcd for $C_{18}H_{30}O_3N$ $[M + NH_4]^+$ 308.2226, found 308.2222.

(Di)deoxyribose 15b: ^{1}H NMR δ 7.4–7.25 (m, 5 H), 5.33 (d, J = 4.6 Hz, 1 H), 4.60 (d, J = 12.2 Hz, 1 H), 4.56 (d, J = 12.2 Hz, 1 H), 4.31 (m, 1 H), 3.57 (m, 1 H), 3.48 (m, 2 H), 2.2–1.1 (m, 14 H); ^{13}C NMR δ 128.3, 127.7, 127.5, 102.1, 76.7, 74.4, 73.3, 72.5, 33.9, 32.2, 31.9, 26.0, 25.7, 24.5, 24.3; MS (CI/NH_3) for $C_{18}H_{30}O_3N$ $[M + NH_4]^+$ 308.1.

(Proto)desilylation of 14a/14b. After reduction of iodines **14a/14b**, the isolated product (0.05 mmol) was diluted with 2 mL of DMF to which was added Bu_4NF (0.06 mmol, 1.0 M in THF) and CsF (0.31 mmol, 80% tech.). The reaction was heated to 100 °C for 12 h (followed by TLC), after which it was diluted with Et_2O and water and the aqueous phase extracted with Et_2O (2×). The organic phases were combined and washed with brine, then dried over anhydrous $NaSO_4$ and the solvent evaporated *in vacuo*. The crude material was purified by column chromatography (mixture of hexanes/Et_2O containing 2% of Et_3N) to obtain **15a/15b**, which were chromatographically and spectrally identical to the materials isolated from the deiodinations of **7a/7b**.

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Supplementary Material Available: NOE data for compounds **7a** and **10a**, procedures for the preparation of precursors to compounds **13** and **16**, and ^{1}H NMR spectra for all tetrahydrofurans (23 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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