Synthesis of Bridgehead-Functionalized Bicyclo[3.2.1]octanes *via* Intramolecular Titanium- and Tributylstannane-Induced Pinacol Coupling

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The synthesis of the enantiomerically pure, bridgehead-functionalized bicyclo[3.2.1]octanes **11** and **16**, containing a conformationally fixed trihydroxypropyl (aminodihydroxypropyl) unit, as well as the X-ray structure of **11** are described. These compounds are of interest as sugar surrogates in the preparation of DNA analogs. Compounds **11** and **16** became available in 10 and 12 steps, respectively, and in an overall yield of 11 and 4% from D-arabinose *via* a highly stereoselective pinacol coupling as the key step.

Introduction. – In extension of our program on the synthesis and properties of conformationally restricted oligonucleotide analogs, we became interested in the DNA analog 'bicyclo[3.2.1]-DNA', built from nucleosides containing the bicyclo[3.2.1] skeleton **A** (*Fig. 1*). As an essential structural feature, **A** contains a trihydroxypropyl (aminodihydroxypropyl) unit that is conformationally fixed in a $-g/-g$ arrangement, as observed for the corresponding substructure in the backbone of DNA duplexes of the B-type. Here we wish to report on a convenient synthesis of the core compounds **A** displaying either a hydroxy or an amino group at the bridgehead position. The synthesis starts from D-arabinose and uses a highly stereoselective intramolecular pinacol coupling [1] as the key step for the elaboration of the bridgehead-functionalized skeleton (*Scheme 1*).

Synthesis. – The synthetic pathway to the common intermediate **9**, necessary for subsequent pinacol coupling, is outlined in *Scheme 2*.

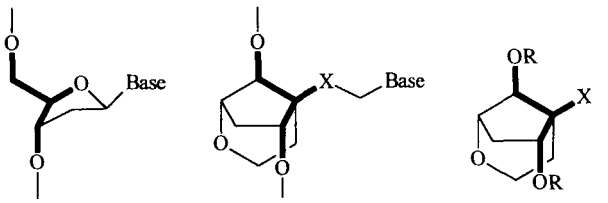
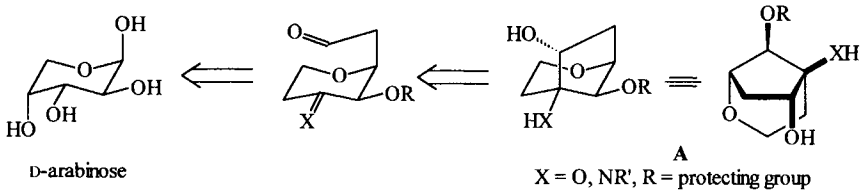


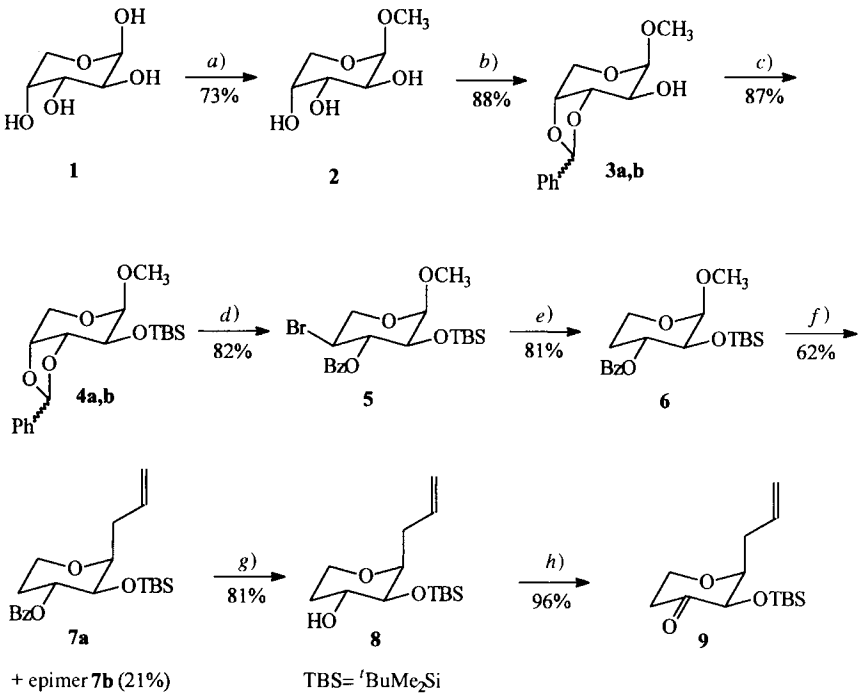
Fig. 1. *Structures of DNA, bicyclo[3.2.1]-DNA, as well as the core structure* **A** *of the bicyclo[3.2.1]-nucleosides*

Scheme 1. *Retrosynthetic Approach to* **A** *from* D-*Arabinose*



The mixture of benzylidene glycosides **3a,b** that was available in an overall yield of 49% from D-arabinose **1** (in two steps *via* **2**, in analogy to published procedures [2][3]) was silylated with (*tert*-butyl)dimethylsilyl triflate (^{t}BuMe$_2$SiOTf) to give **4a,b** in 87% yield. Although separation of the two isomers is possible at this stage, it was not necessary for the subsequent transformations. Removal of the oxy function at C(4) of **4** was achieved in a two-step procedure by benzylidene-ring opening of **4** *via* photooxidation ($CBrCl_3$, $h\nu > 254$ nm) [4] (→ 4-bromo-4-deoxy-3-*O*-benzoyl derivative **5**) followed by reductive removal of the Br-atom by Bu_3SnH/2,2′-azobis[isobutyronitrile](AIBN) to give the benzoate **6** (68% from **4**). The UV-induced oxidation was favored over the well-established *Hanessian-Hullar* protocol using *N*-bromosuccinimide/AIBN [5], mainly for

Scheme 2



a) MeOH/sat. HCl, r.t., 2d. *b*) $PhCH(OMe)_2$ (1.1 equiv.), cat. TsOH, DMF, 60°, 1 h. *c*) ^{t}BuMe$_2$SiOTf (1.1 equiv.), pyridine, 60°, 3 h. *d*) *hv*, CCl_3Br (3.1 equiv.), CCl_4, r.t., 5 h. *e*) Bu_3SnH (1.3 equiv.), AIBN (0.5 equiv.), toluene, 60°, 3 h. *f*) Allyl $SiMe_3$ (4 equiv.), Me_3SiOTf (0.02 equiv.), MeCN, r.t., 3 d. *g*) $LiAlH_4$ (1 equiv.), THF, 4° → r.t. *h*) *Dess-Martin* periodinane (1.3 equiv.), CH_2Cl_2, r.t., 1 h.

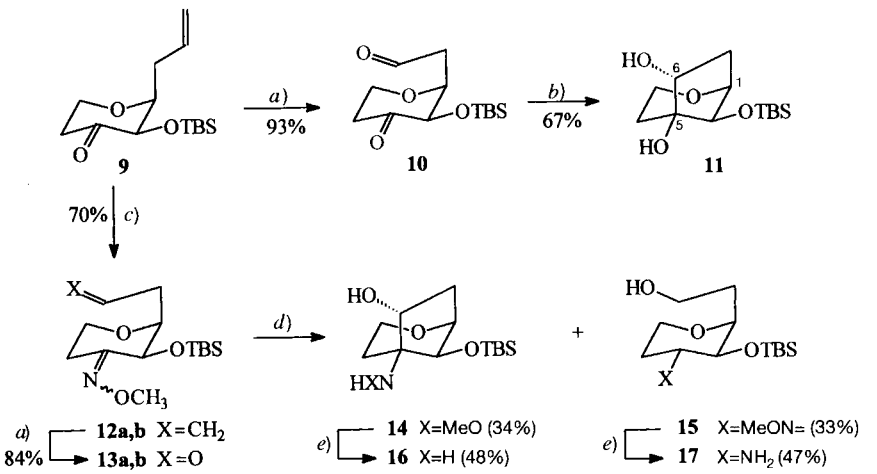
its milder reaction conditions (low temperature) from which a higher regioselectivity was expected. Indeed, the reaction to **5** proceeded regio- and stereospecifically (NMR evidence), thus highlighting the extraordinary preference of the Br^- ion to displace the oxy group at C(4). Under optimized conditions, the reaction was almost quantitative, even on a 40-gram scale. Methyl glycoside **6** was further transformed into the allyl *C*-glycosides **7** using allyltrimethylsilane and the *Lewis* acid CF_3SO_3Me as a promotor [6]. Catalytic amounts of CF_3SO_3Me were sufficient to drive the reaction to completion and proved to be advantageous over stoichiometric amounts in that scrambling of silyl groups at O(2) was suppressed. The ratio α-D/β-D of 3:7 (NMR evidence) of **7** was not optimized and the relative configuration at C(1) was assigned by ^{1}H-NMR (α-D, $J(1,2) = 8.8$ Hz; β-D, $J(1,2) = 3.7$ Hz; numbering as for **6**). Debenzoylation to **8** was best achieved (80–85%) by reduction with $LiAlH_4$ in THF. Hydrolytic removal of the benzoyl group (NaOH in MeOH) was only partially successful and led in up to 40% to the isomeric 3-*O*-silylated product (numbering as for **6**), most likely arising from an intramolecular 1,2-*trans*-silyl shift in **8**. Oxidation of **8** worked smoothly using pyridinium chlorochromate (PCC) or *Dess-Martin* reagent [7] in CH_2Cl_2 and gave the relatively volatile propenyl-substituted ketone **9** in yields around 90%.

The required precursor **10** for ring closure to **11** was obtained directly from **9** by ozonolysis, while transformation of the keto function in **9** to the oxime **12** had to precede ozonolysis in order to obtain the precursor for **14** (*Scheme 3*). Transformation of **9** to **12** with *O*-methylhydroxylamine proceeded smothly in 70% yield. Ozonolysis of the propenyl-substituted ketone **9** and oxime **12** was conducted at −78° in MeOH, followed by reductive workup. The somewhat labile β-alkoxy aldehydes **10** and **13** could be isolated in yields around 80%. Ring closure of **10** to the partially protected bicyclic triol derivative **11** was successful by the use of $TiCl_3$, either in combination with $LiAlH_4$ in THF [8] or as the easy-to-handle $TiCl_3 \cdot (CH_2OMe)_2$ (2:3) complex with a Cu–Zn couple in $(CH_2OMe)_2$ [9]. The latter reagent was preferred due to the high reproducibility and cleanness of the reaction. Compound **11** was isolated in respectable yields (65–85%), and no significant amounts of by-products arising from incomplete cyclization or partial reduction were observed. The cyclization proceeded with high diastereoselectivity. The C(6)-epimer could not be isolated. The observed high stereoselectivity is most likely the result of the sterically steering effect of the ^{t}BuMe$_2$SiO group at C(3) of the pyran ring. The reaction went to completion within 10 min at 80°. High-dilution conditions to prevent intermolecular coupling were not necessary. The relative configuration at C(6) in **11** was determined by ^{1}H-NOE experiments[1]) and confirmed by X-ray analysis. In contrast to this, cyclization of **13** to the methoxyamine **14** using $TiCl_3 \cdot (CH_2OMe)$ (2:3)/Cu–Zn in $(CH_2OMe)_2$ failed in our hands. Also, the use of Zn/Me_3SiCl [10] in THF proved to be unsuccessful. Changing to Bu_3SnH/AIBN in toluene [11] finally led to the production of the methoxyamino alcohol **14**, however, in only moderate yields (30–40%). As a significant, by FC not easily removable by-product, the reduced methoxyimino alcohol **15** was produced in equal amounts. The relative configuration at C(6)

[1]) Irradiation at the resonance of H–C(6) in **11** and **14** resulted in no NOE at the signal of H_{eq}–C(4) or H_{ax}–C(3). Irradiation at the resonance of H–C(7) (*trans*-oriented to H–C(6)), however, resulted in mutual NOEs at the signal of H_{ax}–C(3). An independent proof for the correct structural assignment was obtained for **11** by X-ray analysis.

of **14** was again determined by ^{1}H-NMR NOE experiments[1]). Finally, reduction of the mixture **14**/**15** by H_2/*Raney*-Ni in MeOH cleanly produced the readily separable amines **16** and **17** in yields of 48 and 47%, respectively.

Scheme 3



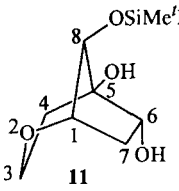
a) 1. O_3, MeOH, −78°, 10 min, 2. Me_2S (10–20 equiv.), −78° → r.t., 2–3 h. *b*) 1. $TiCl_3 \cdot (CH_2OMe)_2$ (2:3) (8 equiv.), Cu–Zn (12 equiv.), $(CH_2OMe)_2$, 80°, 2 h; 2. **10**, $(CH_2OMe)_2$, 80°, 10 min. *c*) $MeONH_2$ (1.2 equiv.), pyridine, r.t., 1 h. *d*) Bu_3SnH (4.4 equiv.), AIBN (1.3 equiv.), toluene, 95°, 4 h. *e*) *Raney*-Ni, H_2, MeOH, r.t., 20 bar, 12 h.

X-Ray Structure of 11. – To ensure the constitution and the relative configuration at the asymmetric centers in **11**, and furthermore, to gain knowledge about the structural details (especially torsion angles) of the bicyclic system, we subjected crystals of **11** to X-ray analysis (*Fig. 2*)[2]). The asymmetric unit consists of two independent molecules, **11A** and **11B**, that are not symmetry-related and that can not be superimposed by translation (*Fig. 2, b*). These molecules differ mainly in conformation of the ^{t}BuMe$_2$Si group but, as expected, only marginally in the bicyclic skeleton. The crystal structure clearly confirms the constitution of **11** and the relative configuration at all asymmetric centers. As expected, the six-membered ring adopts a chair and the five-membered ring an envelope conformation. The three oxy substituents at C(5), C(6), and C(8) are all in the (−)-*gauche* orientation with torsion angles as indicated in *Fig. 2, a*. Thus, the angles analogous to the DNA backbone torsion angles δ(O(6)–(C(6)–C(5)–C(8)) of 154.4 (**11A**) and 157.2° (**11B**) as well as γ(C(6)–C(5)–C(8)–O(8)) of 67.1 (**11A**) and 61.8° (**11B**) are well in accord with reported values for B-DNA [12]. No anomalous bond lenght or bond angles were detected.

In conclusion, we have described a convenient synthetic entry into highly substituted bridgehead-functionalized bicyclo[3.2.1]octanes in general, and two representatives of

[2]) Crystal data and coordinates were deposited with the *Cambridge Crystallographic Data Centre* as deposition No. CCDC-101234. Copies of the data can be obtained, free of charge, on application to the *CCDC*, 12 Union Road, Cambridge CB2 1EZ, UK (fax: + 44 (1223) 336033; e-mail: deposit(*a*) ccdc.can.ac.uk).

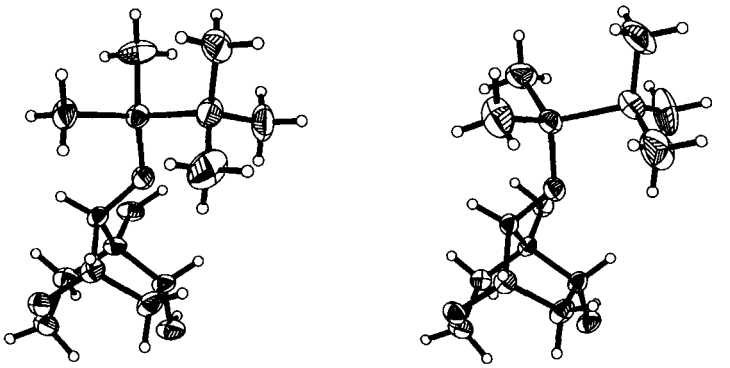
a)



11

Selected Torsion angles	11A	11B
O(6)-C(6)-C(5)-O(5)	-81.0°	-80.9°
O(6)-C(6)-C(5)-C(8)	154.4°	157.2°
O(5)-C(5)-C(8)-O(8)	-54.0°	-55.9°
C(6)-C(5)-C(8)-O(8)	67.1°	61.8°

b)



11A **11B**

c)

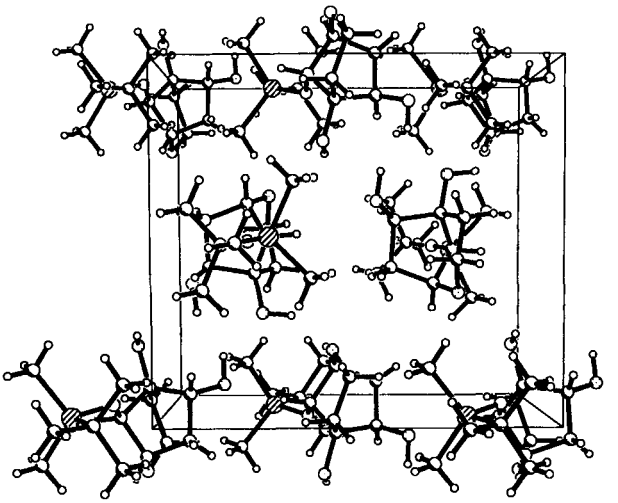


Fig. 2. *X-Ray structure of* **11**: a) *representation, numbering scheme, and selected torsion angles for molecules* **11A** *and* **11B**; b) *ORTEP plots* (20% probability thermal ellipsoids) *of molecule* **11A** *and* **11B**; c) *projection of the crystal structure along the crystallographic* c-*axis*

this class (**11** and **16**) displaying a conformationally restricted trihydroxypropyl (aminodihydroxypropyl) substructure with $-g/-g$ orientation of the oxy (amino) functions in particular. Having found this efficient access, our next task was the preparation

of nucleoside analogs in which the nucleobases are attached to the central tertiary hydroxy or amino function in **11** and **16**, respectively, *via* suitable linker elements. The results of theses investigations will be subject of further communications.

We thank *Carl Epple* for his contributions to the scale-up of the reaction sequence **9** → **10** → **11**. Financial support from the *Swiss National Science Foundation* (grant No. 2000-49'191.96) is gratefully acknowledged.

Experimental Part

General. Unless indicated otherwise, reactions were performed under Ar. Workup includes dilution of the crude product (solvent mentioned), extraction (brine, sat. $NaHCO_3$ soln.), drying of the org. phase (Na_2SO_4), and evaporation. Solvents for extraction and flash column chromatography: technical grade, distilled. Solvents for reactions: reagent-grade, distilled over CaH_2 (MeCN, pyridine, toluene), Na ($CH_2OMe)_2$, Et_2O, THF), or P_2O_5 (CH_2Cl_2, CCl_4). Reagents: if not otherwise stated, from *Fluka*, highest quality available. TLC: silica gel *G-25 UV*$_{254}$ pre-coated glass plates, *Macherey-Nagel*; visualization by UV (254 nm), or by dipping in a soln. of cerium(IV) sulfate (10.5 g), phosphomolybdic acid (21 g), sulfuric acid (60 ml), and H_2O (900 ml), or in a soln. of ninhydrin (0.3 g), BuOH (100 ml), and AcOH (3 ml), followed by heating with a heat gun. Flash column chromatography (FC): silica gel 30–60 μm from *J. T. Baker*. M.p.: not corrected. Optical rotation: $d = 10$ cm, c in g/100 ml. IR: $\tilde{\nu}$ in cm^{-1}. NMR: δ in ppm rel. to $CHCl_3$ (δ(H) 7.24, δ(C) 77.00), (D_6) 77.00), (D_6)DMSO (δ(H) 2.49, δ(C) 39.70) or C_6D_5H (δ(H) 7.20, δ(C) 128.00), J in Hz; ^{13}C multiplicities from DEPT spectra. MS: m/z (int. in %); EI, ionization energy 70 eV.

*Methyl β-*D*-arabinopyranoside* (**2**) *and methyl 3,4-O-benzylidene-β-*D*-arabinopyranoside* (**3a,b**) were prepared as described in [2] and [3], resp.

*Methyl 3,4-*O*-Benzylidene-2-*O*-[(*tert*-butyl)dimethylsilyl]-β-*D*-arabinopyranoside* (**4a,b**). At r.t., a soln. of **3a,b** (22 g, 87 mmol) in dry pyridine (20 ml) was treated dropwise with $^tBuMe_2SiOTf$ (20 ml, 87 mmol) at 0°, then heated to 60°, kept for 3 h, and evaporated. Dissolution of the residue in AcOEt followed by extraction (sat. $NaHCO_3$) and FC (AcOEt/hexane 6:94) gave **4a,b** (28 g, 87%; isomers partially separable by column chromatography). Anal. data from pure samples.

Data of **4a**: White solid. TLC (AcOEt/hexane 6: 94): R_f 0.24. $[\alpha]_D^{25} = -124.4$ ($c = 0.53$, $CHCl_3$). IR (film): 3067*w*, 3036*w*, 2953*s*, 2928*s*, 2896*s*, 2857*s*, 1762*w*, 1496*w*, 1472*m*, 1462*m*, 1404*m*, 1360*m*, 1338*m*, 1310*w*, 1251*m*, 1218*w*, 1196*m*, 1131*s*, 1102*s*, 1087*s*, 1069*s*, 1050*s*, 1028*s*, 1017*m*, 1003*m*, 968*m*, 950*m*, 901*m*, 838*s*, 792*m*, 778*s*, 758*s*, 732*w*, 700*m*, 668*w*, 629*w*, 600*w*, 574*w*, 530*w*. ^1H-NMR (300 MHz, $CDCl_3$): −0.11, −0.04 (2*s*, MeSi); 0.84 (*s*, Me_3C); 3.41 (*s*, MeO); 3.74–3.77 (*m*, 1 H); 3.96–4.09 (*m*, 2 H–C(5)); 4.23–4.27 (*m*, 2 H); 4.57 (*d*, $J = 3.3$, H–C(1)); 5.90 (*s*, PhC*H*); 7.33–7.53 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): −5.10 (*q*); −4.76 (*q*); 18.03 (*s*); 25.70 (*q*); 55.81 (*q*); 58.85 (*t*); 72.26 (*d*); 75.87 (*d*); 76.37 (*d*); 100.11 (*d*); 103.58 (*d*); 126.54 (*d*); 128.24 (*d*); 129.12 (*d*); 137.60 (*s*). EI-MS (80°): 337 (4), 311 (33), 310 (15), 278 (17), 204 (17), 172 (21), 156 (20), 145 (31), 144 (100), 134 (20), 120 (26), 106 (31), 102 (45). Anal. calc. for $C_{19}H_{30}O_5Si$ (366.53): C 62.26, H 8.20; found: C 62.24, H 8.26.

Data of **4b**: Colorless oil. TLC (AcOEt/hexane 6:94): R_f 0.29. $[\alpha]_D^{25} = -112.5$ ($c = 0.63$, $CHCl_3$). IR (film): 3034*s*, 2953*s*, 2928*s*, 2896*s*, 2857*s*, 1718*w*, 1495*w*, 1472*m*, 1463*m*, 1389*w*, 1361*m*, 1334*w*, 1256*m*, 1196*m*, 1128*s*, 1104*s*, 1084*m*, 1072*m*, 1051*m*, 1028*m*, 1012*w*, 1002*w*, 979*m*, 948*w*, 901*m*, 853*m*, 838*s*, 778*m*, 698*m*, 671*w*, 629*w*, 608*w*. ^1H-NMR (300 MHz, $CDCl_3$): 0.12, 0.14 (2*s*, MeSi); 0.91 (*s*, Me_3C); 3.42 (*s*, MeO); 3.86–4.00 (*m*, 3 H, H–C(2), 2 H–C(5)); 4.18 (*dd*, $J = 5.3, 2.0$, H–C(4)); 4.42 (*dd*, $J = 7.7, 5.5$, H–C(3)); 4.64 (*d*, $J = 3.7$, H–C(1)); 6.14 (*s*, PhC*H*); 7.34–7.44 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): −4.95 (*q*); −4.50 (*q*); 18.21 (*s*); 25.80 (*q*); 55.92 (*q*); 58.74 (*t*); 69.12 (*d*); 73.56 (*d*); 77.82 (*d*); 100.25 (*d*); 102.46 (*d*); 126.03 (*d*); 128.40 (*d*); 129.01 (*d*); 139.20 (*s*). EI-MS (140°): 338 (12), 312 (100), 205 (17), 181 (16), 173 (20), 156 (25), 146 (59), 145 (55), 144 (99), 134 (32), 132 (25), 130 (21), 120 (47), 118 (20), 117 (26), 106 (63), 104 (19), 103 (12), 102 (56). Anal. calc. for $C_{19}H_{30}O_9Si$ (366.53): C 62.26, H 8.20; found: C 61.99, H 8.10.

*Methyl 3-*O*-Benzoyl-4-bromo-2-*O*-[(*tert*-butyl)dimethylsilyl]-4-deoxy-α-*L*-xylopyranoside* (**5**). A soln. of **4a,b** (18 g, 49 mmol) and CCl_3Br (15 ml, 152 mmol) in dry CCl_4 (300 ml) was irradiated (Hg high-pressure lamp, 150 W) in a *Pyrex* tube for 5 h at r.t. and evaporated. FC (AcOEt/hexane 3:97) gave **5** (18 g, 82%). White foam. TLC (AcOEt/hexane 1:9): R_f 0.48. $[\alpha]_D^{25} = -46.0$ ($c = 1.13$, $CHCl_3$). IR (film): 2952*m*, 2930*m*, 2887*m*, 2857*m*, 1733*s*, 1603*w*, 1472*w*, 1463*w*, 1451*w*, 1388*w*, 1362*w*, 1314*w*, 1267*s*, 1191*w*, 1176*w*, 1149*s*, 1099*s*, 1086*s*, 1070*w*, 1051*m*, 1025*m*, 938*m*, 905*m*, 861*m*, 838*m*, 778*m*, 749*w*, 709*m*, 674*w*, 664*w*. ^1H-NMR (300 MHz, C_6D_6): −0.11, −0.03 (2*s*, MeSi); 0.85 (*s*, Me_3C); 3.08 (*s*, MeO); 3.59–3.64 (*m*, H–C(4)); 3.76 (*dd*, $J = 9.4, 3.5$, H–C(2));

3.82–3.94 (*m*, 2 H–C(5)); 4.66 (*d*, *J* = 3.7, H–C(1)); 6.14 (*t*, *J* = 9.6, H–C(3)); 7.08–8.27 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, C_6D_6): −4.84 (*q*); −4.63 (*q*); 17.99 (*s*); 25.58 (*q*); 45.87 (*d*); 55.22 (*q*); 62.45 (*t*); 73.58 (*d*); 74.96 (*d*); 100.84 (*d*); 128.51 (*d*); 130.09 (*d*); 130.85 (*s*); 132.94 (*d*); 164.06 (*s*). EI-MS (80°): 389 (25), 387 (25), 305 (11), 267 (94), 266 (18), 265 (93), 181 (13), 180 (40), 179 (100), 135 (14), 106 (18), 105 (80). Anal. calc. for $C_{19}H_{29}O_5BrSi$ (445.43): C 51.23, H 6.56; found: C 51.32, H 6.56.

*Methyl 3-O-Benzoyl-2-O-[(*tert*-butyl)dimethylsilyl]-4-deoxy-β*-D-*threo-pentopyranoside* (**6**). A soln. of **5** (18 g, 40 mmol) in toluene (40 ml) was treated with Bu_3SnH (13.3 ml, 50 mmol) and AIBN (3 g, 18 mmol), kept at 60° for 3 h, and evaporated. FC (hexane → AcOEt/hexane 1:9) afforded **6** (12 g, 81%). Colorless rods. TLC (AcOEt/hexane 1:9): R_f 0.38. M.p. 70–72°. $[\alpha]_D^{25} = -114.1$ (*c* = 0.98, $CHCl_3$). IR (film): 2930*w*, 2063*w*, 1732*s*, 1262*m*, 1118*m*, 1066*m*, 840*m*, 788*m*, 711*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): −0.05, 0.06 (2*s*, MeSi); 0.80 (*s*, Me_3C); 1.70–1.82, 2.09–2.18 (2*m*, 2 H–C(4)); 3.49 (*s*, MeO); 3.61 (*ddd*, *J* = 11.6, 5.3, 2.2, 1 H–C(5)); 3.80–3.88 (*m*, H–C(2), 1 H–C(5)); 4.68 (*d*, *J* = 3.3, H–C(1)); 5.36 (*ddd*, *J* = 10.7, 9.2, 5.2, H–C(3)); 7.38–7.56 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): −4.68 (*q*); −4.66 (*q*); 18.00 (*s*); 25.60 (*q*); 30.77 (*t*); 55.41 (*q*); 57.54 (*t*); 71.48 (*d*); 72.47 (*d*); 101.10 (*d*); 128.23 (*d*); 129.6 (*d*); 130.43 (*s*); 132.83 (*d*); 165.69 (*s*). EI-MS (120°): 309 (6), 188 (15), 187 (93), 180 (19), 179 (100), 105 (75). Anal. calc. for $C_{19}H_{30}O_5Si$ (366.53): C 62.26, H 8.25; found: C 62.21, H 8.24.

*4-(Benzoyloxy)-3-{[(*tert*-butyl)dimethylsilyl]oxy}tetrahydro-2-(prop-2-enyl)-2*H*-pyran* (**7a,b**). To a soln. of **6** (18 g, 49 mmol) in MeCN (30 ml) were added $CH_2{=}CHCl_2SiMe_3$ (31.6 ml, 199 mmol) and Me_3SiOTf (0.2 ml, 1 mmol). The mixture was stirred at r.t. for 3 d and evaporated. Redissolution and extraction (AcOEt/sat. $NaHCO_3$ soln.) followed by FC (CH_2Cl_2/hexane 3:7) afforded **7a** (11.5 g, 62%) and **7b** (4 g, 21%).

Data of (2S,3R,4R)-Isomer **7a**: White solid. TLC (AcOEt/hexane 4:96): R_f 0.37. M.p. 51–52°. $[\alpha]_D^{25} = -64.5$ (*c* = 1.13, $CHCl_3$). IR (film): 3073*w*, 2957*m*, 2929*m*, 2857*m*, 1721*s*, 1643*w*, 1602*w*, 1472*w*, 1452*w*, 1362*w*, 1315*w*, 1268*s*, 1177*w*, 1112*s*, 1071*s*, 1026*w*, 1004*w*, 973*w*, 909*w*, 838*m*, 775*m*, 710*m*, 675*w*, 524*w*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.11, 0.16 (2*s*, MeSi); 0.94 (*s*, Me_3C); 1.64 (*dd*, *J* = 14.3, 2.6, 1 H–C(5)); 2.09–2.19 (*m*, 1 H, $CH_2{=}CHCH_2$); 2.25–2.47 (*m*, 2 H, 1 H–C(5), $CH_2{=}CHCH_2$); 3.61 (*d*, *J* = 3.7, H–C(3)); 3.67 (*ddd*, *J* = 8.8, 4.8, 1.5, H–C(2)); 3.78–3.92 (*m*, 2 H–C(6)); 5.02–5.16 (*m*, H–C(4), $CH_2{=}CHCH_2$); 5.77–5.91 (*m*, $CH_2{=}CHCH_2$); 7.41–8.13 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): −4.84 (*q*); −4.55 (*q*); 18.06 (*s*); 25.82 (*q*); 25.92 (*t*); 35.78 (*t*); 62.67 (*t*); 68.17 (*d*); 70.41 (*d*); 75.80 (*d*); 116.73 (*t*); 128.47 (*d*); 129.60 (*d*); 130.13 (*s*); 133.18 (*d*); 135.20 (*d*); 165.40 (*s*). EI-MS (140°): 319 (14), 197 (29), 180 (19), 179 (100), 123 (12), 105 (85). Anal. calc. for $C_{21}H_{32}O_4Si$ (376.57): C 66.98, H 8.57; found: C 66.84, H 8.52.

Data of (2R,3R,4R)-Isomer **7b**: White solid. TLC (AcOEt/hexane 4:96): R_f 0.39. ^{1}H-NMR (300 MHz, $CDCl_3$): −012, 0.08 (2*s*, MeSi); 0.76 (*s*, Me_3C); 1.65–1.79 (*m*, 1 H); 2.10–2.26 (*m*, 2 H); 2.61–2.70 (*m*, 1 H); 3.26 (*dt*, *J* = 8.6, 2.8, H–C(2)); 3.49 (*dt*, *J* = 12.3, 1.8, 1 H–C(6)); 3.58 (*t*, *J* = 8.8, H–C(3)); 3.94 (*ddd*, *J* = 11.7, 5.1, 1.7, H–C(6)); 5.01–5.15 (*m*, H–C(4), $CH_2{=}CHCH_2$); 5.84–5.90 (*m*, H–C(3)); 7.24–8.05 (*m*, 5 arom. H).

*(2S,3S)-3-{[(*tert*-Butyl)dimethylsilyl]oxy}tetrahydro-2-(prop-2-enyl)-2*H*-pyran-4-ol* (**8**). A soln. of **7a** (12 g, 32 mmol) in THF (15 ml) was added dropwise to a suspension of $LiAlH_4$ (1.2 g, 32 mmol) in THF (15 ml) at 4°. Stirring was continued at r.t. for 1 h, followed by cautious addition of formic acid (*ca.* 2 ml) and filtration over *Celite*. Evaporation of the filtrate followed by FC (AcOEt/hexane 1:9) gave **8** (8 g, 81%). Colorless needles. TLC (AcOEt/hexane 1:9): R_f 0.33. $[\alpha]_D^{25} = -32.9$ (*c* = 0.52, $CHCl_3$). IR (film): 3504*w* (br.), 2953*m*, 2929*m*, 2857*m*, 1721*s*, 1603*w*, 1585*w*, 1472*w*, 1452*w*, 1360*w*, 1316*w*, 1275*s*, 1194*w*, 1177*w*, 1128*m*, 1085*m*, 1043*m*, 1043*m*, 1026*m*, 997*m*, 959*w*, 931*w*, 837*m*, 780*m*, 750*w*, 711*s*, 687*w*, 600*w*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.07 (*s*, MeSi); 0.90 (*s*, Me_3C); 1.49–1.56 (*m*, 1 H); 1.65 (*d*, *J* = 2.9, OH–C(4)); 2.07–2.22 (*m*, 2 H); 2.33–2.44 (*m*, 1 H); 3.44 (*dd*, *J* = 4.8, 2.6, H–C(3)); 3.68–3.78 (*m*, H–C(2), 2 H–C(6)); 3.84–3.89 (*m*, H–C(4)); 5.02–5.13 (*m*, $CH_2{=}CHCH_2$); 5.76–5.89 (*m*, $CH_2{=}CHCH_2$). ^{13}C-NMR (75 MHz, $CDCl_3$): −4.64 (*q*); −4.62 (*q*); 18.07 (*s*); 25.81 (*q*); 29.38 (*t*); 34.25 (*t*); 61.13 (*t*); 68.14 (*d*); 71.97 (*d*); 75.14 (*d*); 116.57 (*t*); 136.38 (*d*). EI-MS (110°): 232 (32), 217 (22), 216 (57), 76 (100). Anal. calc. for $C_{14}H_{28}O_3Si$ (272.46): C 61.72, H 10.36; found: C 61.68, H 10.31.

*(2S,3R)-3-{[(*tert*-Butyl)dimethylsilyl]oxy}tetrahydro-2-(prop-2-enyl)-4*H*-pyran-4-one* (**9**). To a soln. of **8** (7.0 g, 26 mmol) in CH_2Cl_2 (26 ml), 1,1,1-tris(acetyloxy)-1,1-dihydro-1,2-benziodoxol-3(1*H*)-one (*Dess-Martin* reagent; 13.1 g, 31 mmol) was added and the resulting suspension stirred at r.t. for 1 h. Dilution ('BuOMe) and filtration followed by FC (AcOEt/hexane 1:3) gave **9** (6.7 g, 96%). Colorless oil. TLC (AcOEt/hexane 1:9): R_f 0.48. $[\alpha]_D^{25} = -65.2$ (*c* = 0.33, $CHCl_3$). IR (film): 2930*m*, 2858*m*, 1732*m*, 1472*w*, 1362*w*, 1257*m*, 1106*m*, 1047*w*, 919*w*, 838*s*, 780*m*, 667*w*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.03, 0.04 (2*s*, MeSi); 0.88 (*s*, Me_3C); 2.24–2.48 (*m*, 1 H–C(5), $CH_2{=}CHCH_2$); 2.95 (*ddd*, *J* = 14.7, 8.5, 6.3, 1 H–C(5)); 3.61–3.71 (*m*, H–C(2), 1 H–C(6)); 3.92 (*dd*, *J* = 2.6, 1.1, H–C(3)); 4.15 (*ddd*, *J* = 11.6, 6.3, 4.1, 1 H–C(6)); 5.06–5.15 (*m*, $CH_2{=}CHCH_2$); 5.78

(*m*, CH_2=C*H*CH_2). ^{13}C-NMR (75 MHz, $CDCl_3$): −5.27 (*q*); −4.87 (*q*); 18.20 (*s*); 25.67 (*q*); 33.82 (*t*); 39.81 (*t*); 65.88 (*t*); 77.32 (*d*); 81.64 (*d*); 117.54 (*t*); 133.84 (*d*); 207.15 (*s*). EI-MS (20°): 213 (23), 143 (76), 101 (27), 43 (100).

*(2S,3R)-3-{[(*tert*-Butyl)dimethylsilyl]oxy}tetrahydro-4-oxo-2*H*-pyran-2-acetaldehyde* (**10**). At −78°, a soln. of **9** (2.65 g, 9.8 mmol) in MeOH (250 ml) was treated with O_3 (saturation) and stirred for additional 5 min. Addition of Me_2S (14.4 ml, 196 mmol), warming up to r.t., evaporation, and FC (AcOEt/hexane 1:3 → 1:2) gave **10** (2.49 g, 93%). Colorless oil. TLC (AcOEt/hexane 2:8): R_f 0.35. $[\alpha]_D^{25} = -16.8$ (*c* = 1.19, $CHCl_3$). IR (film): 2962*m*, 2857*m*, 2363*w*, 1734*m*, 1469*m*, 1412*m*, 1261*s*, 1107*s*, 798*s*, 685*m*. ^{1}H-NMR (300 MHz, $CDCl_3$)): 0.02, 0.03 (2*s*, MeSi); 0.88 (*s*, Me_3C); 2.33 (*ddd*, *J* = 14.0, 4.0, 1.5, 1 H−C(5)); 2.60 (*ddd*, *J* = 16.9, 5.2, 1.5, 1 H, CH_2CHO); 2.77 (*ddd*, *J* = 16.9, 7.7, 2.2, 1 H, CH_2CHO); 2.91 (*ddd*, *J* = 14.5, 8.5, 4.9, 1 H−C(5)); 3.74 (*ddd*, *J* = 11.7, 9.6, 3.9, 1 H−C(6)); 3.89 (*dd*, *J* = 2.94, 1.10, H−C(3)); 4.12 (*ddd*, *J* = 10.8, 6.2, 4.5, 1 H−C(6)); 4.23 (*ddd*, *J* = 7.7, 5.2, 2.8, H−C(2)); 9.77 (*t*, *J* = 1.8, CH_2C*H*O). ^{13}C-NMR (75 MHz, $CDCl_3$): −5.34 (*q*); −4.91 (*q*); 18.17 (*s*); 25.64 (*q*); 39.67 (*t*); 43.75 (*t*); 65.94 (*t*); 76.96 (*d*); 199.41 (*s*); 205.80 (*d*). EI-MS (130°): 272 (3, M^+), 233 (16), 232 (88), 215 (24), 214 (97), 213 (14), 204 (16), 203 (28), 202 (100), 201 (16), 198 (19), 197 (19), 186 (60), 172 (36), 156 (34).

*(1S,5S,6R,8R)-8-{[(*tert*-Butyl)dimethylsilyl]oxy}-2-oxabicyclo[3.2.1]octane-5,6-diol* (**11**). A soln. of **10** (2.0 g, 7.34 mmol) in dry and deoxygenated $(CH_2OMe)_2$ (5 ml) was added dropwise to a suspn. of $TiCl_3$ · DME (2:3) (10.62 g, 36.7 mmol) and Cu−Zn (11.35 g) in $(CH_2OMe)_2$ (200 ml), preheated for *ca.* 2 h at 80°, and kept at 80° for 20 min. The mixture was then poured on 20% K_2CO_3 soln. (300 ml) and filtered and the residue washed with *t*BuOMe. Extraction of the org. phase (20% K_2CO_3 soln., brine) followed by FC (AcOEt/hexane 1:2) gave **11** (1.35 g, 67%). Colorless solid. Recrystallization from AcOEt/hexane produced colorless plates suitable for X-ray analysis. TLC (AcOEt/hexane 6:4): R_f 0.27. M.p. 116.5–117°. $[\alpha]_D^{25} = -42.7$ (*c* = 0.33, $CHCl_3$). IR ($CHCl_3$): 3684*w*, 3618*w*, 3852*w*, 3851*w* (br.), 3026*s*, 2976*w*, 2930*w*, 2859*w*, 1602*w*, 1521*w*, 1472*w*, 1433*w*, 1362*w*, 1334*w*. ^{1}H-NMR (500 MHz, $CDCl_3$): 0.07, 0.09 (2*s*, MeSi); 0.87 (*s*, Me_3C); 1.71 (*ddd*, *J* = 15.8, 4.1, 1.8, 1 H−C(7)); 1.77 ('*dt*', *J* = 12.5, 7.2, 1.1, 1 H−C(4)); 2.10 (*dd*, *J* = 12.7, 3.4, 1 H−C(4)); 2.26 (br. *s*, OH−C(5), OH−C(6)); 2.49 (*ddd*, *J* = 15.9, 10.3, 5.6, 1 H−C(7)); 3.61 (*t*, *J* = 1.5, H−C(8)); 3.73 (*dd*, *J* = 11.9, 7.2, 1 H−C(3)); 3.96 (*d*, *J* = 4.8, H−C(1)); 3.99 (*dt*, *J* = 12.1, 4.2, 1 H−C(3)); 4.25 (*dd*, *J* = 10.7, 3.7, H−C(6)). Difference NOE: 1.71 (H−C(7)) → 2.49 (H−C(7)), 3.96 (H−C(1)), 3.99 (H−C(3)). ^{13}C-NMR (75 MHz, $CDCl_3$): −4.98 (*q*); −4.61 (*q*); 17.94 (*s*); 25.67 (*q*); 32.43 (*t*); 34.06 (*t*); 59.90 (*t*); 76.05 (*d*); 77.42 (*d*); 80.72 (*s*); 81.49 (*d*). EI-MS (130°): 257 (2), 199 (18), 174 (12), 173 (100), 155 (34), 125 (17). Anal. calc. for $C_{13}H_{26}O_4Si$ (274.44): C 56.90, H 9.55; found: C 56.89, H 9.49.

X-Ray Structure of **11**. Transparent colorless plate (0.49 × 0.49 × 0.30 mm); $C_{13}H_{26}O_4Si$; monoclinic space group $P2_1$, *Z* = 4; *a* = 11.0670 (10), *b* = 12.3080 (10), *c* = 11.8810 (10) Å. Intensities were measured with a *Enraf-Nonius-CAD4* diffractometer (CuK_α, λ = 1.54178 Å). Of the 3446 independent reflections (3.73° < θ < 74.23°), 3133 with $F > 2\sigma(F)$ were used in the refinement. The structure was solved using direct methods with SHELXS-86 and refined by full-matrix least-square procedures SHELXL-93. Non-H-atoms were refined anisotropically. From the 52 H-atoms, 34 could be localized by a difference-*Fourier* synthesis. As it is difficult to localize H-atoms accurately using X-ray data, the positions of all H-atoms were calculated and adjusted after every least-squares cycle. The refinement converged at *R* 0.0603, R_w 0.1847.

*(2S,3R,E/Z)-3-{[(*tert*-Butyl)dimethylsilyl]oxy}tetrahydro-2-(prop-2-enyl)-4*H*-pyran-4-one (O-Methyloxime)* (**12a,b**). A soln. of **9** (6.5 g, 24 mmol) and *O*-methylhydroxylamine (2.4 g, 29 mmol) in dry pyridine (20 ml) was stirred at r.t. for 1 h and evaporated. Dissolution of the residue (AcOEt), workup ($NaHCO_3$), and FC (AcOEt/hexane 2:8) gave **12a,b** (5 g, 70%; isomers partially separable by column chromatography). Anal. data from pure samples.

Data of (Z)-Isomer **12a**: TLC (AcOEt/hexane 1:9): R_f 0.43. $[\alpha]_D^{25} = -86.0$ (*c* = 1.05, $CHCl_3$). IR (film): 3083*w*, 2968*w*, 2863*w*, 1635*w*, 1478*w*, 1358*w*, 1257*w*, 1094*m*, 1056*m*, 955*w*, 864*w*, 836*w*, 783*w*. ^{1}H-NMR (300 MHz, C_6D_6): 0.18 (*s*, MeSi); 1.03 (*s*, Me_3C); 2.00 ('*td*', *J* = 13.2, 1.1, 1 H−C(5)); 2.30–2.40 (*m*, 1 H, CH_2=CHCH_2); 2.60–2.71 (*m*, 1 H, CH_2=CHCH_2); 2.76 (*dt*, *J* = 12.9, 5.9, 1 H−C(5)); 3.15 (*ddd*, *J* = 6.2, 5.9, 1.3, H−C(2)); 3.22 (*ddd*, *J* = 11.5, 10.7, 2.2, 1 H−C(6)); 3.77 (*s*, MeO); 3.85 (*ddd*, *J* = 11.0, 5.9, 1.1, 1 H−C(6)); 5.04–5.17 (*m*, H−C(3), CH_2=CHCH_2); 5.81–5.94 (*m*, CH_2=C*H*CH_2). ^{13}C-NMR (75 MHz, C_6D_6): −4.56 (*q*); −4.55 (*q*); 18.92 (*s*); 26.44 (*q*); 29.67 (*t*); 36.75 (*t*); 61.66 (*d* or *q*); 63.57 (*d* or *q*); 68.84 (*t*); 81.83 (*d*); 117.54 (*t*); 135.52 (*d*); 157.61 (*s*). EI-MS: 299 (15, M^+), 268 (32), 242 (10), 210 (19), 170 (22), 73 (100).

Data of (E)-Isomer **12b**: TLC (AcOEt/hexane 1:9): R_f 0.54. $[\alpha]_D^{25} = -131.9$ (*c* = 1.59, $CHCl_3$). IR (film): 3079*w*, 2957*s*, 2876*s*, 1644*m*, 1472*m*, 1426*m*, 1361*m*, 1347*m*, 1255*s*, 1192*w*, 1097*s*, 1048*s*, 986*m*, 913*m*, 840*s*, 776*s*, 676*m*. ^{1}H-NMR (300 MHz, C_6D_6): 0.17, 0.19 (2*s*, MeSi); 1.02 (*s*, Me_3C); 2.31–2.46 (*m*, 1 H−C(5), CH_2=CHCH_2); 2.61–2.71 (*m*, 1 H, CH_2=CH−CH_2)); 2.94 ('*td*', *J* = 13.9, 1.1, 1 H−C(5)); 3.14 (*ddd*, *J* = 13.9, 11.2, 2.7, 1 H−C(6)); 3.25 (*ddd*, *J* = 7.5, 6.1, 1.5, H−C(2)); 3.75–3.83 (*ddd*, *J* = 11.0, 6.6, 1.1, 1 H−C(6)); 3.79 (*s*, MeO); 4.13 (*s*, H−C(3)); 5.05–5.18 (*m*, CH_2=CHCH$_2$); 5.80–5.94 (*m*, CH_2=C*H*CH_2). ^{13}C-NMR (75 MHz,

C_6D_6): −4.53 (*q*); −3.73 (*q*); 18.88 (*s*); 24.01 (*t*); 26.51 (*q*); 36.67 (*t*); 61.79 (*q*); 66.83 (*t*); 71.22 (*d*); 82.49 (*d*); 117.53 (*t*); 135.51 (*d*); 176.00 (*s*). EI-MS: 299 (7, M^+), 268 (25), 242 (78), 170 (21), 141 (10), 73 (100).

*(2S,3S,E/Z)-3-{[(*tert*-Butyl)dimethylsilyl]oxy}tetrahydro-4-(methoxyimino)-2H-pyran-2-acetaldehyde* (**13a,b**). At −78°, a soln. of **12a,b** (5.0 g, 17 μmol) in MeOH (85 ml) was treated with O_3 (saturation) and stirred for additional 5 min. Addition of Me_2S (25 ml, 340 mmol), slow warming up to r.t. (*ca.* 2 h), evaporation, and FC (AcOEt/hexane 2:8) gave **13a,b** (4.2 g, 84%; isomers partially separable by column chromatography). Anal. data from pure samples.

Data of (Z)-Isomer **13a**: Colorless solid. TLC (AcOEt/hexane 2:6): R_f 0.41. $[\alpha]_D^{25} = -83.4$ ($c = 0.63$, $CHCl_3$). IR (film): 2931*s*, 2989*s*, 2857*s*, 2726*m*, 1731*s*, 1728*s*, 1472*s*, 1463*s*, 1408*m*, 1423*m*, 1390*m*, 1362*m*, 1254*s*, 1093*s*, 1006*s*, 839*s*. ^{1}H-NMR (300 MHz, C_6D_6): 0.09, 0.13 (2*s*, MeSi); 0.98 (*s*, Me_3C); 1.95 ('*td*', $J = 14.7$, 1.1, H−C(5)); 2.13 (*ddd*, $J = 16.9$, 5.0, 1.4, 1 H, CH_2CHO); 2.60 (*ddd*, $J = 16.9$, 7.7, 2.2, 1 H, CH_2CHO); 2.66 (*dt*, $J = 13.2$, 5.9, 1 H−C(5)); 3.15 (*ddd*, $J = 11.8$, 11.0, 2.6, 1 H−C(6)); 3.46 (*ddd*, $J = 7.7$, 4.8, 1.5, H−C(2)); 3.73 (*ddd*, $J = 10.7$, 5.5, 1.1, H−C(6)); 3.76 (*s*, MeO); 4.93 (*s*, H−C(3)); 9.47 (*dd*, $J = 1.5$, 2.2, CH_2CHO). ^{13}C-NMR (75 MHz, C_6D_6): −5.18 (*q*); −5.16 (*q*); 18.33 (*s*); 25.77 (*q*); 25.89 (*q*); 25.94 (*q*); 28.82 (*t*); 45.60 (*t*); 61.21 (*d* or *q*); 63.27 (*d* or *q*); 68.27 (*t*); 76.01 (*d*); 156.12 (*s*); 198.90 (*d*). EI-MS: 301 (6, M^+), 270 (10), 179 (100), 125 (11), 105 (63).

Data of (E)-Isomer **13b**: Colorless oil. TLC (AcOEt/hexane 2:8): R_f 0.49. $[\alpha]_D^{25} = -123.7$ ($c = 1.32$, $CHCl_3$). IR (film): 2931*s*, 2897*s*, 2857*s*, 2726*m*, 1737*s*, 1732*s*, 1472*s*, 1463*s*, 1424*m*, 1391*m*, 1362*m*, 1348*m*, 1254*s*, 1094*s*, 1006*s*, 839*s*. ^{1}H-NMR (300 MHz, C_6D_6): 0.10, 0.14 (2*s*, MeSi); 0.97 (*s*, Me_3C); 2.20 (*ddd*, $J = 17.3$, 5.1, 1.2, 1 H, CH_2CHO); 2.27 (*ddd*, $J = 14.3$, 12.5, 6.5, 1 H−C(5)); 2.45 (*ddd*, $J = 17.3$, 7.4, 2.2, 1, CH_2CHO); 2.88 (*td*, $J = 14.3$, 1.2, 1 H−C(5)); 3.07 (*ddd*, $J = 12.5$, 11.2, 2.6, 1 H−C(6)); 3.59 (*ddd*, $J = 7.4$, 5.5, 1.7, H−C(2)); 3.67 (*ddd*, $J = 11.2$, 6.4, 1.3, 1 H−C(6)); 3.78 (*s*, MeO); 4.06 (*s*, H−C(3)); 9.48 (*dd*, $J = 2.0$, 1.3, CH_2CHO). ^{13}C-NMR (75 MHz, C_6D_6): −5.10 (*q*); −4.38 (*q*); 18.30 (*d*); 23.15 (*t*); 25.94 (*q*); 45.59 (*t*); 61.35 (*q*); 66.23 (*t*); 70.92 (*d*); 77.12 (*d*); 155.75 (*s*); 198.96 (*d*). EI-MS: 301 (9, M^+) 270 (25), 244 (46), 73 (100).

*(1S,5S,6R,8S)-8-{[(*tert*-Butyl)dimethysilyl]oxy}-5-(methoxyamino)-2-oxabicyclo[3.2.1]octan-6-ol* (**14**). A soln. of Bu_3SnH (3.6 ml, 13.2 mmol) and AIBN (0.25 g, 1.5 mmol) in toluene (3.6 ml) was slowly added by a syringe pump within 2 h to a soln. of **13a,b** (1.0 g, 3 mmol) and AIBN (0.5 g, 3 mmol) in toluene (16 ml) at 95°, kept at 95° for 2 h, and evaporated. FC (AcOEt/hexane 8:2) gave **14**/**15** (0.7 g, 70%); ratio **14**/**15** *ca.* 1:1 (by ^{1}H-NMR). The mixture was only partially separable by FC at this stage. Anal. data from a pure sample.

Data of **14**: TLC (AcOEt/hexane 4:6): R_f 0.30. $[\alpha]_D^{25} = -53.3$ ($c = 1.4$, $CHCl_3$). IR (film): 3446*w*, 2954*m*, 2895*m*, 1472*w*, 1436*w*, 1361*w*, 1259*m*, 1140*w*, 1103*s*, 1056*w*, 1005*w*, 912*w*, 837*s*, 778*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.04, 0.07 (2*s*, MeSi); 0.85 (*s*, Me_3C); 1.74 (*ddd*, $J = 15.1$, 4.0, 1.8, 1 H−C(7)); 1.87 (*dt*, $J = 12.1$, 6.7, 1 H−C(4)); 2.05 (*dd*, $J = 12.9$, 4.2, 1 H−C(4)); 2.13 (*s*, OH−C(6)); 2.49 (*ddd*, $J = 15.8$, 10.3, 5.4, 1 H−C(7)); 3.50 (*s*, MeO); 3.72 (*dd*, $J = 11.7$, 7.5, 1 H−C(3)); 3.77 (*t*, $J = 1.7$, H−C(8)); 3.94 (*dd*, $J = 5.5$, 1.8, H−C(1)); 4.02 (*dt*, $J = 11.8$, 4.2, 1 H−C(3)); 4.23–4.27 (br. *d*, $J = 9.9$, H−C(6)); 6.0 (*s*, NH−C(5)). Difference NOE: 1.74 (H−C(7)) → 2.49 (H−C(7)), 3.94 (H−C(1)), 4.03 (H−C(3)). ^{13}C-NMR (75 MHz, (D_6)DMSO): −5.05 (*q*); −4.66 (*q*); 17.95 (*s*); 25.84 (*q*); 29.12 (*t*); 35.61 (*t*); 59.28 (*t*); 62.46 (*q*); 69.78 (*s*); 71.27 (*d*); 77.59 (*d*); 77.84 (*d*). EI-MS (40°): 303 (29, M^+), 272 (19), 247 (15), 246 (52), 229 (16), 228 (30), 214 (34), 197 (27), 170 (51), 140 (94), 73 (100).

*(1S,5S,6R,8S)-5-Amino-8-{[(*tert*-butyl)dimethysilyl]oxy}-2-oxabicyclo[3.2.1]octan-6-ol* (**16**). A soln. of **14**/**15** (0.7 g, 2.3 mmol) and *Raney*-Ni (200 mg) in MeOH (10 ml) was stirred under H_2 (20 bar) at r.t. for 1 d. Filtration over *Celite*, evaporation, and FC (Et_2O/MeOH 9.5:0.5 to 8:2) gave **16** (0.31 g, 48%) and **17** (0.30 g, 47%).

Data of **16**: TLC (Et_2O/MeOH 8:2): R_f 0.47. $[\alpha]_D^{25} = -39.2$ ($c = 0.78$, $CHCl_3$). IR (film): 3348*w*, 3286*w*, 3180*m*, 2952*s*, 2904*m*, 2856*m*, 1601*w*, 1462*w*, 1436*w*, 1363*w*, 1324*w*, 1178*w*, 1104*m*, 1061*w*, 1006*w*, 973*m*, 940*m*, 912*w*, 854*s*, 821*w*, 776*s*, 678*w*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.06, 0.07 (2*s*, MeSi); 0.87 (*s*, Me_3C); 1.54 (*dt*, $J = 12.5$, 7.0, 1 H−C(4)); 1.72 (*ddd*, $J = 15.4$, 4.0, 1.8, 1 H−C(7)); 1.90 (*dd*, $J = 12.7$, 3.9, 1 H−C(4)); 2.45 (*ddd*, $J = 15.5$, 10.7, 5.2, 1 H−C(7)); 3.47 (*t*, $J = 1.5$, H−C(8)); 3.69 (*dd*, $J = 11.8$, 6.6, 1 H−C(3)); 3.95 (*dd*, $J = 5.5$, 1.5, H−C(1)); 3.99 (*dt*, $J = 11.8$, 4.0, 1 H−C(3)); 4.07 (*dd*, $J = 10.3$, 3.7, H−C(6)). ^{13}C-NMR (75 MHz, $CDCl_3$): −5.01 (*q*); −4.62 (*q*); 17.87 (*s*); 25.62 (*q*); 33.49 (*t*); 34.73 (*t*); 59.81 (*t*); 62.55 (*s*); 74.42 (*d*); 77.83 (*d*); 82.94 (*d*). EI-MS: 273 (3, M^+), 218 (37), 171 (45), 145 (77), 131 (42), 75 (100). Anal. calc. for $C_{13}H_{27}NO_3Si$ (273.45): C 57.10, H 9.95, N 5.12; found: C 56.89, H 9.97, N 5.05.

*Data of (2S,3S,4R or 4S)-4-Amino-3-{[*tert*-butyl)dimethylsilyl]oxy}tetrahydro-2H-pyran-2-ethanol* (**17**): TLC (Et_2O/MeOH 8:2): R_f 0.15. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.07, 0.09 (2*s*, MeSi); 0.92 (*s*, Me_3C); 1.36–1.47 (*m*, 2 H); 1.64–1.78 (*m*, 1 H); 1.85–1.98 (*m*, 1 H); 2.72 (*ddd*, $J = 11.8$, 4.0, 2.6, 1 H); 3.36–3.45 (*m*, 2 H); 3.50 (*s*, 1 H); 3.72 (*t*, $J = 5.7$, CH_2CH_2OH); 3.92 (*ddd*, $J = 11.4$, 4.8, 1.8, 1 H). ^{13}C-NMR (75 MHz, $CDCl_3$): −3.7 (*q*); −3.6 (*q*); 18.4 (*s*); 26.1 (*q*); 30.5 (*t*); 35.1 (*t*); 52.3 (*d*); 60.7 (*t*); 66.8 (*t*); 73.3 (*d*); 79.2 (*d*).

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Received January 12, 1998