Synthetic Studies of the 18-Membered Antitumor Macrolide, Tedanolide. 3. Stereocontrolled Synthesis of the C1-C12 Part *via* a Synthesis of the C1-C7 Fragment by a Mismatched but Efficient Sharpless Dihydroxylation and Its Coupling with the C8-C11 Fragment[1)]

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The C1-C12 part (4) of tedanolide (1) was synthesized starting from methyl (*R*)-3-hydroxy-2-methylpropionate (11a) *via* a coupling between the C1-C7 aldehyde (6) and the C8-C11 iodoalkene (7a). For a synthesis of 6, a mismatched but highly efficient Sharpless dihydroxylation of the α,β-unsaturated ester (15) with AD-mix-α was successfully applied. Compound 7a was synthesized using hydrozirconation to the alkyne (32).

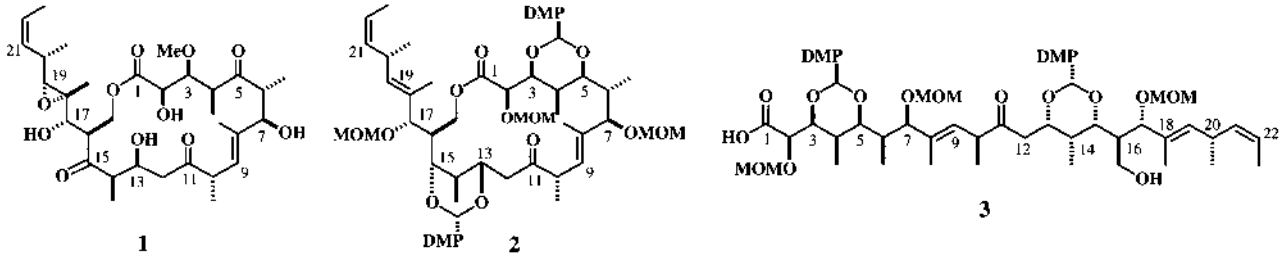
Key words macrolide; Sharpless epoxidation; sonication; hydrozirconation; Sharpless dihydroxylation; AD-mix

Because of their unusual structural features as well as strong biological activity, a number of marine natural products have stimulated intensive synthetic interest. A tumor inhibitory macrolide, tedanolide (**1**), isolated from a Caribbean sponge *Tedania ignis*, has had its structure elucidated by means of X-ray analysis by Schmitz *et al*. in 1984,[2)] when it was found to have a unique structure compared with many typical macrolides[3)]; **1** has four labile aldol units, a side-chain containing an α-epoxy alcohol and an 18-membered lactone with a C16-primary hydroxy and a C1-carbonyl group. The aldols seemed to be quite difficult to prepare. The aldol structures in **1** are all arranged in non-antiperiplanar form so as to avoid undesirable decomposition and dehydration and to maintain the stability of the 18-membered lactone ring. In the course of the synthesis of **1**, however, such a stabilized conformation cannot be expected in flexible acyclic intermediates before macrocyclization and, hence, we decided to carry out the synthesis of **1** replacing the aldols by protected diol groups, which can be oxidized selectively to the aldols after formation of the 18-membered lactone ring.

In macrolide synthesis, it is extremely important to design a seco-acid derivative suitable for macrolactonization,[4,5)] which is usually the most crucial step; thus, the seco-acid should be designed so that its conformation is as close as possible to that of the corresponding macrolactone. However, it is quite difficult to accurately predict the dominant conformations of large flexible molecules such as macrolides and their acyclic seco-acids, which can exist as a number of conformers. The solution can only be provided by computational chemistry.[4,6)] This methodology was applied to planning the synthesis of **1**; after conformational analyses with the aid of molecular mechanics (MM2-CONFLEX 3)[7)] calculations in order to search for a key intermediate to **1**, we designed the seco-acid (**3**), the conformation of which is very close to that of the corresponding lactone (**2**). In fact, synthetic **3** cyclized efficiently to **2**[8)] by the modified Yamaguchi method.[4,9)]

A retrosynthetic analysis of **2** is shown in Chart 1. The most important step was the macrolactonization of **3** to **2**, and **3** was planned to be synthesized by coupling between C1-C12 (**4**) and C13-C23 (**5**) moieties, precursors of which were C1-C7 (**6**), C8-C11 (**7a**), C13-C17 (**8**) and C18-C21 (**7b**) fragments, derived from methyl (*R* and *S*)-3-hydroxy-2-methylpropionates (**11a**, **b**). A notable feature of this plan is the use of common synthetic units in order to achieve a convergent synthesis of **2**; **9** is a common intermediate to **6** and **8**; **11a** and **11b** are enantiomeric. In this paper we describe a stereoselective synthesis of the C1-C12 moiety (**4**), almost half the molecule **3**.

Synthesis of C1-C7 Fragment (6) As a common starting material to both **6** and **7a**, we chose **11a**, which was first converted to the aldehyde (**10**)[10)] in quantitative yield *via* three conventional reactions; *tert*-butyldiphenylsilyl (TBDPS) protection of the hydroxy group, reduction of the ester group with lithium borohydride ($LiBH_4$) and Swern oxidation. Wit-



DMP: 3,4-$(MeO)_2C_6H_3$- MOM: $MeOCH_2$-

Fig. 1

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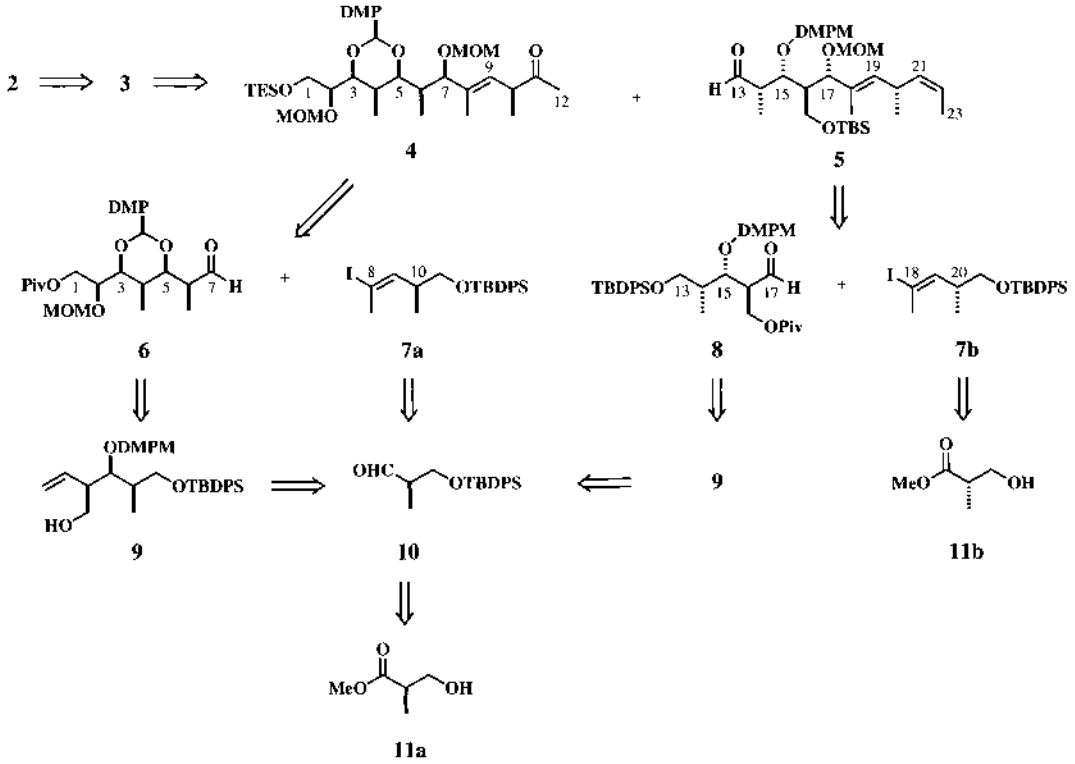
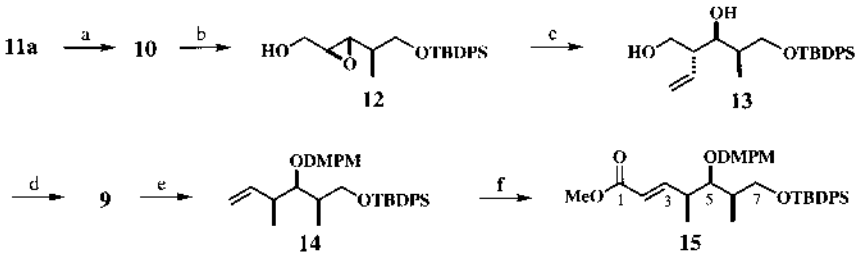


TES: Et_3Si- DMPM: 3,4-$(MeO)_2C_6H_3CH_2$- TBS: *t*-$BuMe_2Si$- Piv: Me_3CCO- TBDPS: *t*-$BuPh_2Si$-

Chart 1



(a) 1) TBDPSCl, imidazole, CH_2Cl_2, r.t.; 2) $LiBH_4$, Et_2O, r.t.; 3) DMSO, $(COCl)_2$, CH_2Cl_2, Et_3N (3 steps 100%). (b) 1) $Ph_3P{=}CHCO_2Me$, C_6H_6, r.t. (98%); 2) DIBAH, CH_2Cl_2-*n*-hexane, −60°C (91%); 3) (+)-DET, $(i\text{-}PrO)_4Ti$, TBHP, MS4A, CH_2Cl_2, −25°C (98%). (c) $CH_2{=}CHMgBr$, CuCN, Et_2O-THF, sonication, r.t. (78%). (d) 1) $DMPCH(OMe)_2$, CSA, CH_2Cl_2, r.t. (90%); 2) DIBAH, CH_2Cl_2-*n*-hexane, -30°C (98%). (e) 1) TsCl, Et_3N, DMAP, CH_2Cl_2, r.t.; 2) $LiAlH_4$, THF, r.t. (2 steps 90%). (f) 1) OsO_4, NMO, Me_2CO-H_2O, r.t. (98%); 2) $NaIO_4$, MeOH-H_2O, r.t.; 3) $Ph_3P{=}CHCO_2Me$, C_6H_6, r.t. (2 steps 98%).

Chart 2

tig reaction of **10** with a stable ylide and subsequent reduction with diisobutylaluminum hydride (DIBAH) readily gave an allyl alcohol,[11] which was transformed to an epoxy alcohol (**12**) by Sharpless asymmetric epoxidation[12] in the presence of diethyl L-(+)-tartrate [L-(+)-DET]. In order to introduce correctly two asymmetric centers at C4 and C5,[13] regioselective opening of the epoxide ring with a vinylcopper reagent[14] in ether and tetrahydrofuran (THF) was examined under several conditions. Since the copper reagent was poorly soluble, the yield of the expected vinylated compound (**13**) was hardly reproducible. This problem was overcome by sonication; thus, when the reaction mixture was occasionally sonicated at room temperature, **13** was always obtained in about 80% yield. The structure of **13** was confirmed by X-ray analysis (Fig. 2). The diol of **13** was protected as a 3,4-dimethoxybenzylidene (DMP) acetal, which was then reduced regioselectively with DIBAH to give **9**. After the primary alcohol of **9** was reduced by tosylation and subsequent reduction with lithium aluminum hydride ($LiAlH_4$) to give **14**, further conversion of **14** to the α,β-unsaturated ester (**15**) was carried out smoothly in the usual way: osmylation of the

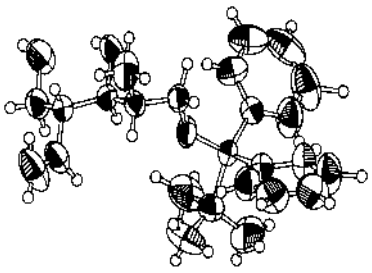
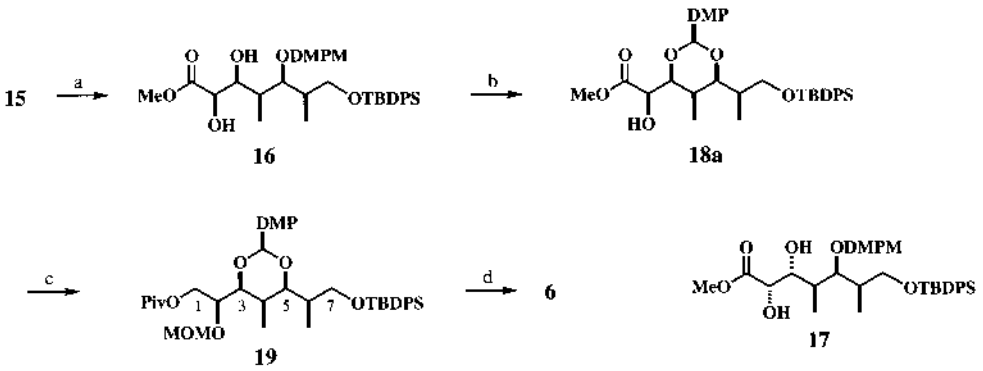
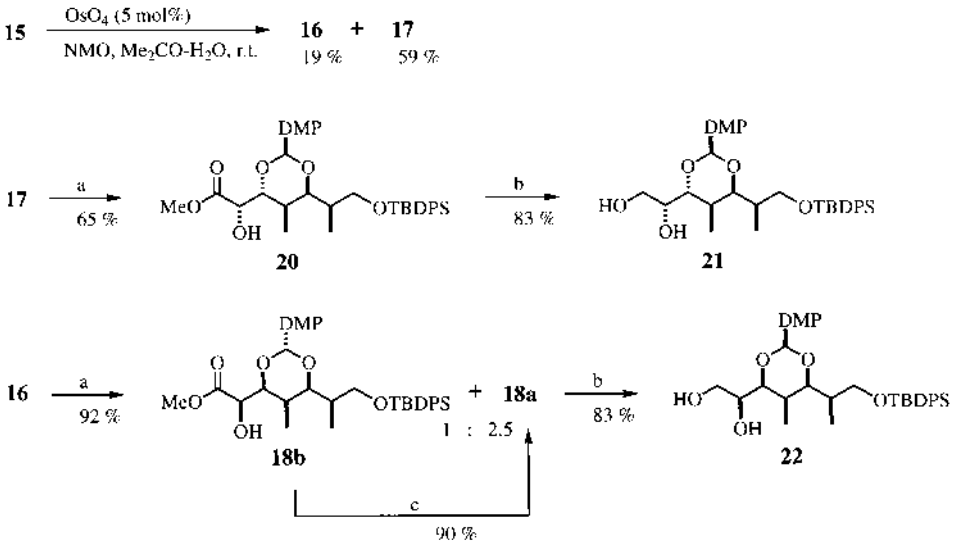


Fig. 2. X-Ray Crystal Structure of **13**



(a) AD-mix-α, $MeSO_2NH_2$, *tert*-BuOH-H_2O, r.t. (95%, >99% de). (b) 1) DDQ, MS3A, CH_2Cl_2, r.t.; 2) CSA, MS3A, C_6H_6, r.t. (2 steps 83%). (c) 1) MOMCl, *i*-Pr_2EtN, CH_2Cl_2, r.t. (83%); 2) $LiAlH_4$, Et_2O, r.t. (89%); 3) PivCl, Et_3N, DMAP, CH_2Cl_2, r.t. (99%). (d) 1) *n*-Bu_4NF, THF, 0°C (97%); 2) Dess-Martin reagent, pyridine, CH_2Cl_2, r.t. (100%).

Chart 3



(a) DDQ, MS3A, CH_2Cl_2, r.t. (b) $LiBH_4$, THF, r.t. (c) CSA, MS3A, C_6H_6, r.t.

Chart 4

double bond, oxidative cleavage of diol with sodium periodate, and Wittig reaction with the stable ylide.

Osmylation of **15** was next carefully examined. When **15** was treated with 5 mol% osmium tetroxide (OsO_4) in the presence of an excess of *N*-methylmorpholine *N*-oxide (NMO)[15] at room temperature, a 1 : 3 mixture of the expected diol (**16**) and its diastereoisomer (**17**) was obtained. The main product was disappointingly the unwanted **17**; thus, this reaction had the opposite diastereoselectivity (*vide infra*). Therefore, we decided to examine asymmetric osmylation with AD-mix.[16] When **15** was treated with AD-mix-α (2.0 mol% based on OsO_4) at room temperature, surprisingly, **16** was obtained in excellent yield (95%) with complete selectivity [>99% diastereomeric excess (de)], although this is a mismatched case.[17] Detailed discussion of this will take place in the next section.

Treatment of **16** with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) in the presence of molecular sieves under anhydrous conditions,[18] and then with *dl*-camphorsulfonic acid (CSA), gave DMP-acetal (**18a**). The remaining C2-hydroxy group was protected with a methoxymethyl (MOM) group and the ester group reduced with $LiAlH_4$ to give a primary hydroxy compound, protection of which with a pivaloyl (Piv) group readily gave **19**. Conversion of **19** to the C1-C7 fragment (**6**) was easily achieved by treatment with tetra-*n*-butylammonium fluoride (TBAF) and then with Dess–Martin reagent.[19] The overall yield for the 22 steps starting from **11a** to **6** was 26.7%.

Mechanistic Studies of Dihydroxylation of 15 OsO_4 is usually used for dihydroxylation of double bonds. In the case of olefinic compounds with chiral centers such as **15**, diastereoselective face selectivity of OsO_4 oxidation is mainly governed by the conformation of the olefins. Two favorable conformations of **15**, A and B, are predictable (Fig. 3). A is the conformation controlled by the 1,3-allylic strain,[20] whereas in the B-conformation a large R group is situated in the antiperiplanar position to the double bond. Since A is generally more favorable than B,[20] attack of OsO_4 to the *re-si* face of A was expected to mainly occur. However, as already mentioned, the osmylation of **15** with a catalytic amount of OsO_4[15] gave a 1 : 3 mixture of **16** and **17**. The main product was disappointingly unwanted **17**, which was

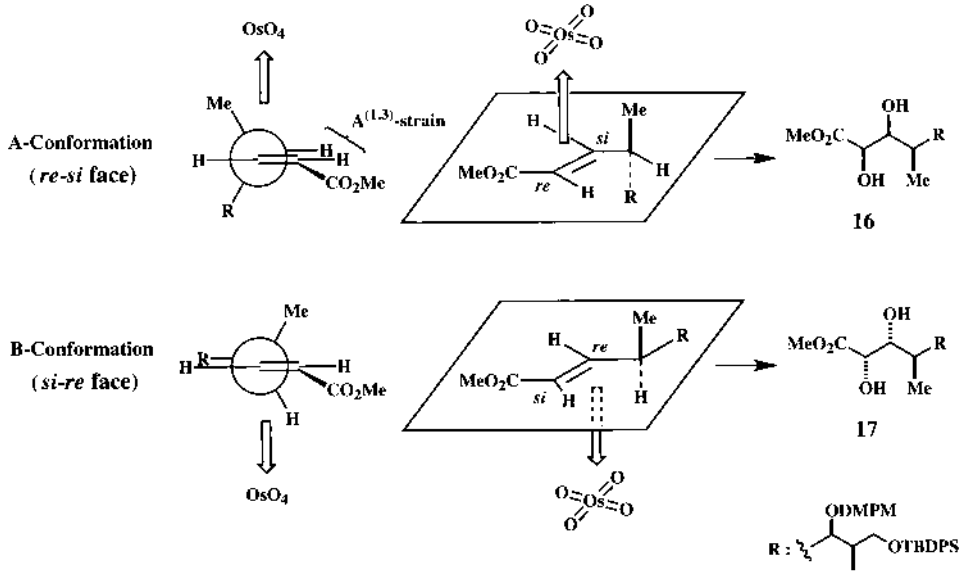


Fig. 3

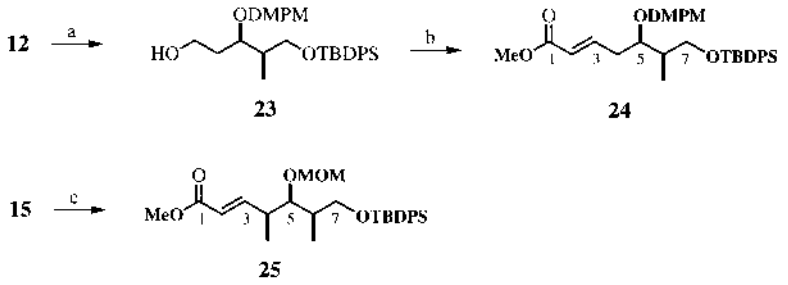
formed by osmylation on the *si-re* face of the B-conformation. Structures of **16** and **17** were confirmed as follows. The main product (**17**) was first converted by treatment with DDQ under anhydrous conditions[18] to DMP-acetal (**20**), and then reduced with $LiBH_4$ to give diol (**21**), which proved to be an unwanted product by comparing its ^{1}H-NMR spectrum with that of the expected product (**22**) prepared by an alternative route.[21] Compound **16** was next treated with DDQ under the same conditions to give a mixture of two isomeric DMP-acetals, **18a** and **18b**. Since **18a** is thermodynamically more stable than **18b**, treatment of the mixture with CSA gave only **18a**. This indicates that the acetalization with DDQ proceeds kinetically rather than thermodynamically.[22] Reduction of **18a** gave **22**, which was identical to the sample prepared by the alternative route with respect to spectral data.[21]

Since a convenient osmylation with a catalytic amount of OsO_4 gave only a poor result, asymmetric osmylation with AD-mix was next examined. Face selectivity of α,β-unsaturated esters by AD-mix has been well studied, and the reaction on the *re-si* face can be achieved with AD-mix-α, but not -β.[16] Unfortunately, this is a mismatched case.[17] However, as already mentioned, treatment of **15** with AD-mix-α in the presence of methanesulfonic amide, gave **16** in excellent yield with $>$99% de. This excellent result clearly shows that the conformation of **15** changed from B to A during this reaction with AD-mix-α. However the matched case, osmylation with AD-mix-β, gave a very poor result, and the yield of **17** was only 22%, although under somewhat different reaction conditions.

For this type of cinchona-catalyzed dihydroxylation (Sharpless asymmetric dihydroxylation), two mechanisms *via* [3+2][23] and [2+2][16b,24] cycloadditions of OsO_4 have been proposed. In Corey's mechanism [Criegee-Corey-Noe (CCN) model],[23] osmylation should proceed *via* a concerted [3+2] cycloaddition of OsO_4 to an olefin in a U-shaped binding pocket of catalyst composed of the two parallel methoxyquinoline units. If the 3,4-dimethoxybenzene part of **15** comes between the methoxyquinoline units, the olefin part in the A-conformation, not in the B-conformation, can fit into the binding pocket and can be situated very close to OsO_4, coordinated in advance to an amine ligand. This enzyme-like binding of conformationally changing **15** with AD-mix-α may account for the face-selectivity change from *si-re* to *re-si*. According to inspection of the Corey-Pauling-Koltun (CPK) molecular models, **15** in the A-conformation can fit smoothly into the pocket of AD-mix-α, but not that of AD-mix-β because of the steric hindrance caused by the bulky C6-C7 portion of **15**. Actually, very poor reactivity was observed in the reaction of **15** with AD-mix-β, as mentioned above.

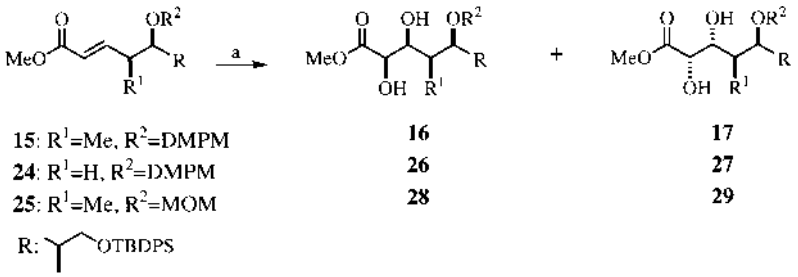
The C4 demethyl compound (**24**) can fit into AD-mix-β as well as -α and should be smoothly oxidized by both reagents, although some steric effect may arise from the bulky C6-C7 portion. This compound (**24**) was readily synthesized from **12** *via* a five-step conventional reaction: diborane reduction, DMP-acetalization, DIBAH reduction, Dess–Martin oxidation, and Wittig reaction. The C5-OMOM compound (**25**) was also synthesized from **15** *via* deprotection of the 3,4-dimethoxybenzyl (DMPM) group by DDQ oxidation[25] in order to examine whether **25** differs from **15** in terms of binding to AD-mix-α (Chart 5). Three compounds, **15**, **24** and **25**, were treated with both AD-mix-α and -β under the same reaction conditions and the results are shown in Table 1. AD-mix-β as well as -α was highly reactive to **24**, and rather more reactive than AD-mix-α, although poorly reactive to **25**. The reactivity of **24** is consistent with our prediction and probably supports the CCN model[23] for Sharpless asymmetric dihydroxylation.[16] The MOM derivative (**25**) acts in the same way to the reagents as **15**. This differed slightly from our expectations, although many olefins without, as well as with, aromatic rings are known to smoothly react with AD-mix-α and -β.[16b] The structure of **28** was confirmed after conversion to the lactone (**30**), which was also derived from **16** as shown in Chart 7. Similarly, **26** was converted to **31**, the ^{1}H-NMR spectrum of which is quite similar to that of **30**.[26]

Synthesis of C8-C11 Fragment (7a) After unsuccessful trials involving hydroalumination[27] and hydroboration,[28] the



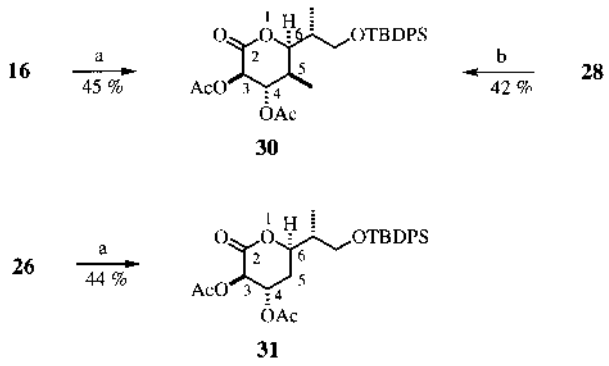
(a) 1) B_2H_6, THF-HMPA, r.t. (86%); 2) $DMPCH(OMe)_2$, CSA, CH_2Cl_2, r.t. (88%); 3) DIBAH, CH_2Cl_2-*n*-hexane, −20° (92%). (b) 1) Dess-Martin reagent, pyridine-CH_2Cl_2, r.t.; 2) $Ph_3P{=}CHCO_2Me$, C_6H_6, r.t. (2 steps 93%). (c) 1) DDQ, CH_2Cl_2-H_2O, r.t.; 2) MOMCl, *i*-Pr_2EtN, CH_2Cl_2, r.t. (2 steps 93%).

Chart 5



(a) 1) AD-mix (1.0 mol%), $MeSO_2NH_2$ (2.0 eq), *t*-BuOH-H_2O (1 : 1), r.t., 6h.

Chart 6



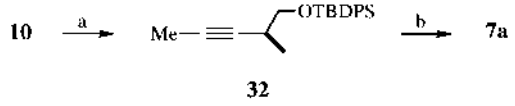
(a) 1) Ac_2O, DMAP, pyridine; 2) DDQ, CH_2Cl_2-H_2O; 3) CSA, C_6H_6.
(b) 1) Ac_2O, DMAP, pyridine; 2) Me_3SiI, CH_2Cl_2.

Chart 7

Table 1. Asymmetric Dihydroxylation of **15**, **24** and **25**[a]

Entry	Substrate	AD-mix	Product	Yield (%)[b]	De (%)[c]	SM (%)[d]
1	**15**	α	**16**	78	>99	13
2	**15**	β	**17**	39	78	49
3	**24**	α	**26**	83	72	13
4	**24**	β	**27**	93	84	0
5	**25**	α	**28**	89	92	10
6	**25**	β	**29**	37	75	57

a) Conditions: **15**, **24**, **25** (50 μmol), AD-mix (0.01 eq), $MeSO_2NH_2$ (2 eq), *tert*-BuOH–H_2O (1 : 1, 1.0 ml), r.t., 6 h. *b*) Yield of a mixture with the corresponding stereoisomer. *c*) Diastereomeric excess. *d*) Recovered starting material.

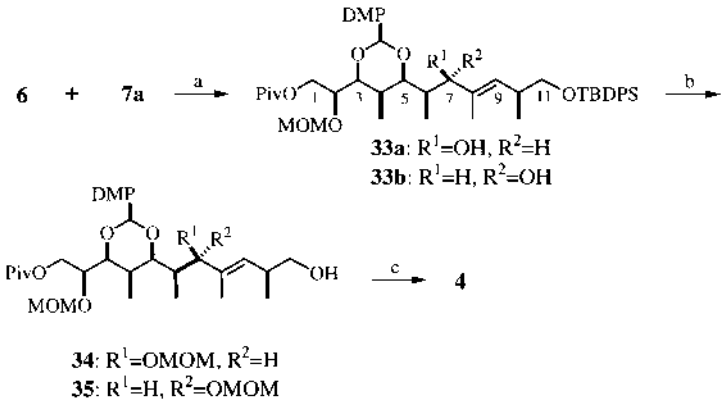


(a) 1) CBr_4, Ph_3P, CH_2Cl_2, −60°C (94%); 2) *n*-BuLi, MeI, THF, r.t. (98%).
(b) Cp_2ZrHCl, C_6H_6, 45°C, then I_2 (54%).

Chart 8

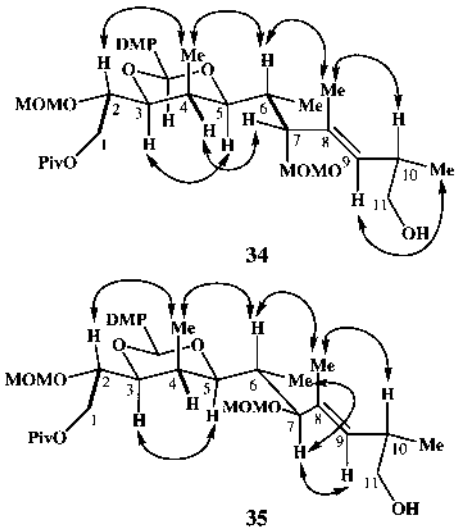
synthesis of the C8-C11 iodoalkene (**7a**)[29] was achieved by hydrozirconation of alkyne (**32**),[30] which was readily prepared from **10** *via* a dibromoalkene in the usual way.[31] Hydrozirconation of **32** was carefully examined under various conditions, because regioselectivity of this reaction and yield of products varied according to the reaction conditions, and finally reproducible conditions with complete selectivity were established, although the product yield was still very poor. When **32** was treated with 3 eq of Schwartz reagent[30] at 45 °C and then with iodine, the expected iodoalkene (**7a**) was obtained as a single product in at least 50% yield.

Synthesis of C1-C12 Part (4) *via* Coupling Between 6 and 7a Excess **7a** was first lithiated with *tert*-BuLi[32] and allowed to react with C1-C7 aldehyde (**6**). The coupling reaction proceeded slowly to give a 3.6 : 1 mixture of the expected Cram adduct (**33a**) and its C7-isomer (**33b**). Since it was quite difficult to separate **33a** from **33b**, the mixture was treated with MOM chloride and, subsequently, with fluoride anion to give a mixture of **34** and **35** which was easily separated by column chromatography. The configurations at C7 of **34** and **35** were confirmed by coupling constants in ^{1}H-NMR and correlations in nuclear Overhauser and exchange spectroscopy (NOESY); thus, **34** has a favorable conformation, in which the *syn*-pentane interaction[33] between two methyl groups at C4 and C6 as well as the 1,3-allylic strain[20] to C8-methyl group and C9-hydrogen are minimized, and, hence, C4- and C7-hydrogens come so close that a NOESY signal was clearly observed. In **35**, a NOESY correlation ap-



(a) *tert*-BuLi, Et_2O, −25°C (85%). (b) 1) MOMCl, *i*-Pr_2EtN, CH_2Cl_2, r.t. (100%); 2) *n*-Bu_4NF, AcOH, THF, r.t. (**34** 77%, **35** 22%). (c) 1) Dess-Martin reagent, pyridine, CH_2Cl_2, r.t. (82%); 2) MeLi, Et_2O, 0°C (100%); 3) TESCl, *tert*-BuOK, THF, −78°C (66%); 4) Dess-Martin reagent, pyridine, CH_2Cl_2, r.t. (94%).

Chart 9



J H-H	Hz
2-3	9.0
3-4	1.5
4-5	1.5
5-6	9.0
6-7	1.5
9-10	9.5

J H-H	Hz
2-3	8.5
3-4	1.0
4-5	1.5
5-6	5.5
6-7	9.0
9-10	9.5

Fig. 4. NOESY Correlations and Coupling Constants of **34** and **35**

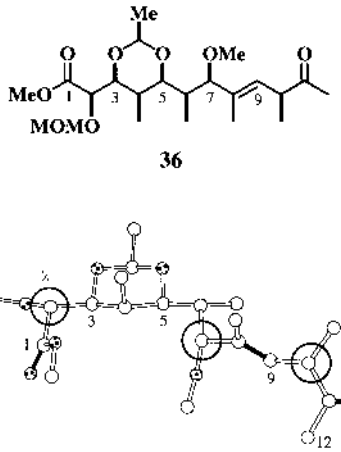


Fig. 5. The Most Stable Conformer of **36** Calculated by MM2-CONFLEX-3

peared between the C7-hydrogen and C6-methyl group for the same reason (Fig. 4). Conversion of **34** to the C1-C12 part (**4**) was carried out in the usual way without difficulty: Dess–Martin oxidation to an aldehyde, which was treated with methyllithium to introduce the C12-methyl group, then the deprotected C1-primary hydroxy group was protected with a triethylsilyl (TES) group and, finally, the C11-secondary alcohol was oxidized again with Dess–Martin reagent to give the title compound (**4**). The most stable conformer of **36**,[34] calculated by MM2-CONFLEX-3,[7] is shown Fig. 5,[8] in which the conformation of the C2-C10 portion is quite similar to that predicted from the NMR data of **34** and **4**.

The synthesis of the C13-C23 part (**5**) and its coupling with **4**, followed by macrocyclization to the lactone (**2**) will be reported soon.[35]

Experimental

(2*R*)-3-(*tert*-Butyldiphenylsilyloxy)-2-methylpropanal (10) Imidazole (8.14 g, 136 mmol) and *tert*-butyldiphenylsilyl chloride (TBDPSCl) (26.5 ml, 102 mmol) were added to a stirred solution of **11a** (10.0 g, 85 mmol) in CH_2Cl_2 (100 ml) at 0 °C under argon. The solution was stirred for 1 h at room temperature and then recooled to 0 °C. After the reaction was quenched with MeOH, saturated aqueous NH_4Cl was added, and then the mixture was extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (5 : 1), to give a silyl ether as a colorless oil (30.2 g, 100%). $[\alpha]_D^{21}$ −17° (c=0.88, $CHCl_3$). IR (neat) cm^{-1}: 1730, 1580, 1460, 1380, 1350, 1190, 1100, 810, 730. ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 1.03 (s, 9H), 1.16 (d, 3H, J=6.9 Hz), 2.65—2.79 (m, 1H), 3.69 (s, 3H), 3.72 (dd, 1H, J=6.0, 9.8 Hz), 3.83 (dd, 1H, J=7.0, 9.8 Hz), 7.33—7.47 (m, 6H), 7.60—7.71 (m, 4H). EI-MS m/z (%): 299 [M^+−57(*t*-Bu), 98], 213 (100), 183 (42), 153 (23), 105 (22), 57 (13). HR-MS Calcd for $C_{17}H_{19}O_3Si$ [M^+−57(*t*-Bu)]: 299.1103. Found: 299.1078.

A solution of the silyl ether (30.2 g, 85 mmol) in Et_2O (200 ml) was added to a stirred suspension of $LiBH_4$ (1.84 g, 84 mmol) in Et_2O (150 ml) at 0 °C, under argon. Stirring was continued for 70 h at room temperature. After being cooled at 0 °C, the reaction was quenched with saturated aqueous NH_4Cl, and the mixture was extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (5 : 1), to give (2*S*)-3-(*tert*-butyldiphenylsilyloxy)-2-methylpropan-1-ol as a colorless oil (27.8 g, 100%). $[\alpha]_D^{21}$ −7.3° (c=1.06, $CHCl_3$). IR (neat) cm^{-1}: 3600—3100, 1580, 1460, 1380, 1110, 1030, 820, 730. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.83 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.92—2.06 (m, 1H), 2.49—2.56 (m, 1H), 3.55—3.76 (m, 4H), 7.33—7.49 (m, 6H), 7.60—7.73 (m, 4H). EI-MS m/z (%): 271 [M^+−57(*t*-Bu), 98], 229 (35), 199 (100), 193 (89), 135 (23), 105 (17), 91 (23), 77 (35), 57 (6.3). HR-MS Calcd for $C_{16}H_{19}O_2Si$ [M^+−57(*t*-Bu)]: 271.1154. Found: 271.1165.

A solution of dimethylsulfoxide (DMSO) (13.2 ml, 186 mmol) in CH_2Cl_2 (20 ml) was added dropwise to a stirred solution of $(COCl)_2$ (8.1 ml, 92 mmol) in CH_2Cl_2 (150 ml) at −78 °C under argon. After 15 min, a solution of the above alcohol (10.17 g, 31 mmol) in CH_2Cl_2 (150 ml) was added dropwise, and stirring was continued for 30 min. After dropwise addition of Et_3N (33 ml, 237 mmol), the solution was allowed to warm to −55 °C over 2 h, and then the reaction was quenched with saturated aqueous NH_4Cl. The mixture was extracted with Et_2O. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo* to leave **10** as a crude oil (11.8 g), which was immediately used for the next step. ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 1.04 (s, 9H), 1.10 (d, 3H, J=7.0 Hz), 2.50—2.63 (m, 1H), 3.84 (dd, 1H, J=6.0, 10.5 Hz), 3.90 (dd, 1H, J=5.5, 10.5 Hz), 7.33—7.48 (m, 6H), 7.60—7.70 (m, 4H), 9.76 (s, 1H).

(2*S*,3*S*,4*R*)-5-(*tert*-Butyldiphenylsilyloxy)-2,3-epoxy-4-methylpentan-1-ol (12) Methoxycarbonylmethylenetriphenylphosphorane (18.5 g, 55.4 mmol) was added to a stirred solution of crude **10** (16.89 g) in benzene (150 ml) at room temperature under argon. After 17 h, the solution was diluted with *n*-hexane–Et_2O (1 : 1), and the insoluble materials were removed by filtration. The filtrate was concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (10 : 1), to give methyl (2*E*,4*S*)-5-(*tert*-butyldiphenylsilyloxy)-4-methyl-2-pentenoate as a pale yellow oil (15.87 g, 98%). $[\alpha]_D^{26}$ −14.4° (c=1.50, $CHCl_3$). ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 1.05 (s, 9H), 1.06 (d, 3H, J=7.0 Hz), 2.49—2.61 (m, 1H), 3.55 (dd, 1H, J=6.0, 10.0 Hz), 3.60 (dd, 1H, J=7.0, 10.0 Hz), 3.73 (s, 3H), 5.84 (dd, 1H, J=1.5, 16.0 Hz), 6.95 (dd, 1H, J=7.5, 16.0 Hz), 7.30—7.50 (m, 6H), 7.55—7.70 (m, 4H).

A 1.0 M solution of diisobutylaluminum hydride (DIBAH) in *n*-hexane (106 ml, 106 mmol) was diluted with CH_2Cl_2 (100 ml) under argon, and then cooled to −78 °C. To this solution was added dropwise a solution of the above ester (15.87 g, 41.5 mmol) in CH_2Cl_2 (150 ml), and the reaction mixture was allowed to warm to −60 °C over 1.5 h. After the reaction was quenched with MeOH, the mixture was diluted with Et_2O, and then saturated potassium sodium tartrate was added. The whole mixture was vigorously stirred for 1 h at room temperature. The separated organic layer was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 1), to give (4*S*)-5-(*tert*-butyldiphenylsilyloxy)-4-methyl-2-penten-1-ol as a colorless oil (13.38 g, 91%). $[\alpha]_D^{25}$ −4.3° (c=1.50, $CHCl_3$). IR (neat) cm^{-1}: 3500—3200, 2950, 1590, 1480, 1420, 1110, 1000, 970, 820, 740, 700. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 1.03 (d, 3H, J=6.5 Hz), 1.05 (s, 9H), 1.12—1.17 (m, 1H), 2.35—2.45 (m, 1H), 3.50 (dd, 1H, J=6.5, 10.0 Hz), 3.56 (dd, 1H, J=6.0, 10.0 Hz), 4.00—4.10 (m, 2H), 5.50—5.70 (m, 2H), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 17.41, 20.30, 27.86, 39.91, 64.81, 69.50, 128.56, 129.76, 130.54, 134.91, 136.45, 136.60. El-MS *m*/*z* (%): 297 [M^+−57(*t*-Bu), 5.7], 279 (4.7), 229 (34), 199 (100). HR-MS Calcd for $C_{18}H_{21}O_2Si$ [M^+−57(*t*-Bu)]: 297.1311. Found: 297.1303.

Titanium tetraisopropoxide (4.6 ml, 16 mmol) was added dropwise to a stirred suspension of diethyl L-(+)-tartrate [(+)-DET] (3.98 g, 19 mmol) and 4 Å molecular sieves (6.6 g) in CH_2Cl_2 (30 ml) at −25 °C under argon. After 15 min, a solution of the alcohol (13.7 g, 39 mmol) in CH_2Cl_2 (100 ml) was added dropwise, and the mixture was stirred for 30 min. A 3 M solution of *tert*-butylhydroperoxide (TBHP) in 2,2,4-trimethylpentane (26 ml, 78 mmol) was added, and stirring was continued for 23 h. The reaction mixture was allowed to warm to 0 °C, and then H_2O (100 ml) was added. After 1 h, a 30% solution of NaOH in brine (30 ml) was added, and stirring was continued for 1 h. Insoluble materials were removed by filtration through a Celite pad. After separation of the organic layer, the aqueous layer was extracted with Et_2O. The combined organic layers were dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 1), to give **12** as a colorless oil (14.11 g, 98%). $[\alpha]_D^{21}$ −18.7° (c=1.06, $CHCl_3$). IR (neat) cm^{-1}: 3500—3200, 2950, 1450, 1425, 1110, 820, 740, 700. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 0.98 (d, 3H, J=6.5 Hz), 1.05 (s, 9H), 1.50—1.80 (m, 2H), 2.90 (dd, 1H, J=2.5, 7.5 Hz), 3.06 (ddd, 1H, J=2.5, 2.5, 4.0 Hz), 3.52—3.70 (m, 3H), 3.92 (dd, 1H, J=2.5, 12.5 Hz), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 14.32, 20.19, 27.81, 39.42, 59.29, 59.70, 62.70, 67.29, 128.70, 130.71, 134.44, 134.48, 136.52. EI-MS *m*/*z* (%): 313 [M^+−57(*t*-Bu), 0.5], 295 (1.2), 283 (20), 199 (100), 139 (50). HR-MS Calcd for $C_{18}H_{21}O_3Si$ [M^+−57(*t*-Bu)]: 313.1260. Found: 313.1233.

(3*R*,4*S*,5*R*)-6-(*tert*-Butyldiphenylsilyloxy)-4-hydroxy-3-hydroxymethyl-5-methyl-1-hexene (13) A 1.0 M solution of vinylmagnesium bromide in THF (30 ml, 30 mmol) was added dropwise to a stirred suspension of cuprous cyanide (266 mg, 3.0 mmol) in Et_2O (5 ml) at −30 °C under argon. After 30 min, a solution of **12** (1.1 g, 3.0 mmol) in Et_2O (10 ml) was added dropwise, then the reaction mixture was allowed to warm to room temperature over 2 h, and stirring was continued for 12 h, applying sonication at 30 min intervals. The reaction mixture was diluted with Et_2O (30 ml), then quenched with 28% aqueous ammonia-saturated aqueous NH_4Cl (1 : 9), and filtered with the aid of Celite. The filtered organic layer was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 1), to give **13** as a colorless oil (922 mg, 78%). $[\alpha]_D^{22}$ −2.7° (c=1.78, $CHCl_3$). IR (neat) cm^{-1}: 3600—3200, 2950, 1640, 1590, 1470, 1430, 1110, 1000, 920, 740, 700. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 0.98 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.63—1.80 (m, 1H), 2.48 (dddd, 1H, J=4.5, 7.5, 9.0, 9.5 Hz), 3.11 (dd, 1H, J=4.0, 8.0 Hz), 3.53 (d, 1H, J=2.0 Hz), 3.59—3.69 (m, 1H), 3.66 (dd, 1H, J=4.5, 10.0 Hz), 3.83 (dd, 1H, J=3.5, 10.0 Hz), 3.87 (ddd, 1H, J=4.0, 7.5, 10.5 Hz), 4.02 (ddd, 1H, J=1.5, 2.0, 9.5 Hz), 5.10 (dd, 1H, J=2.0, 10.0 Hz), 5.14 (dd, 1H, J=2.0, 17.0 Hz), 5.48 (ddd, 1H, J=9.0, 10.0, 17.5 Hz), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 10.00, 20.12, 27.85, 37.49, 50.25, 67.47, 70.64, 78.59, 118.85, 128.79, 130.86, 130.91, 133.62, 133.86, 136.52, 136.66, 136.77. EI-MS *m*/*z* (%): 341 [M^+−57(*t*-Bu), 1.2], 323 (3.2), 263 (22), 199 (100), 107 (31), 95 (27). HR-MS Calcd for $C_{20}H_{25}O_3Si$ [M^+−57(*t*-Bu)]: 341.1573. Found: 341.1582.

(3*R*,4*S*,5*R*)-6-(*tert*-Butyldiphenylsilyloxy)-3-hydroxymethyl-4-(3,4-dimethoxybenzyloxy)-5-methyl-1-hexene (9) A solution of **13** (640 mg, 1.6 mmol), 3,4-dimethoxybenzaldehyde dimethylacetal (511 mg, 2.4 mmol) and *dl*-camphorsulfonic acid (CSA) (37 mg, 159 μmol) in CH_2Cl_2 (8 ml) was stirred at room temperature for 15 min. The reaction mixture was quenched with saturated aqueous $NaHCO_3$, and extracted with EtOAc. The extract was washed with saturated aqueous $NaHCO_3$ and brine, dried over K_2CO_3, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 1), to give an acetal as a colorless oil (874 mg, 100%). $[\alpha]_D^{22}$ −26.5° (c=1.49, $CHCl_3$). IR (neat) cm^{-1}: 2950, 1520, 1460, 1420, 1260, 1230, 1160, 1110, 1080, 1025, 700. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 0.88 (d, 3H, J=7.0 Hz), 1.05 (s, 9H), 2.00—2.12 (m, 1H), 2.64—2.75 (m, 1H), 3.53 (dd, 1H, J=6.0, 10.0 Hz), 3.69 (d, 1H, J=11.0 Hz), 3.75 (t, 1H, J=9.5 Hz), 3.85 (s, 3H), 3.89 (s, 3H), 4.06 (dd, 1H, J=2.0, 10.0 Hz), 4.12 (dd, 1H, J=5.0, 11.0 Hz), 5.16—5.27 (m, 2H), 5.42 (s, 1H), 5.50 (ddd, 1H, J=9.0, 10.0, 17.5 Hz), 6.80—6.90 (m, 1H), 6.95—7.05 (m, 2H), 7.15—7.45 (m, 6H), 7.50—7.70 (m, 4H). ^{13}C-NMR (125 MHz, C_6D_6) δ: 9.82, 19.55, 27.16, 37.58, 41.78, 55.59, 55.63, 65.87, 71.33, 79.14, 101.51, 111.05, 111.87, 118.47, 119.26, 128.19, 128.29, 129.93, 129.95, 132.58, 134.20, 134.22, 134.57, 135.95, 149.95, 150.47. EI-MS *m*/*z* (%): 546 (M^+, 1.5), 489 [M^+−57(*t*-Bu), 31], 323 (47), 293 (26), 199 (59), 183 (40), 166 (62), 151 (100). HR-MS Calcd for $C_{33}H_{42}O_5Si$ (M^+): 546.2801. Found: 546.2800.

A solution of the acetal (1.228 g, 2.24 mmol) in CH_2Cl_2 (10 ml) was added dropwise to a stirred 1.0 M solution of DIBAH in *n*-hexane (8.0 ml, 8.0 mmol) diluted with CH_2Cl_2 (15 ml) at −30 °C under argon. After 24 h, the solution was cooled to −50 °C, and the reaction was quenched with MeOH. Et_2O and saturated aqueous potassium sodium tartrate were added, and the mixture was vigorously stirred for 1 h. The organic layer was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with (*n*-hexan–EtOAc (3 : 2), to give **9** as a colorless oil (1.203 g, 98%). $[\alpha]_D^{23}$ +6.0° (c=1.03, $CHCl_3$). IR (neat) cm^{-1}: 3600—3630, 2950, 1590, 1515, 1460, 1420, 1260, 1230, 1160, 1110, 1030, 820, 800, 740, 700. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 0.82 (d, 3H, J=7.0 Hz), 1.08 (s, 9H), 1.88—2.02 (m, 1H), 2.36 (t, 1H, J=6.0 Hz), 2.47—2.60 (m, 1H), 3.58 (dd, 1H, J=6.0, 10.0 Hz), 3.66 (dd, 1H, J=9.0, 10.0 Hz), 3.54—3.68 (m, 1H), 3.76—3.93 (m, 2H), 3.83 (s, 3H), 3.87 (s, 3H), 4.51 (d, 1H, J=11.0 Hz), 4.59 (d, 1H, J=11.0 Hz), 5.12—5.22 (m, 2H), 5.63 (ddd, 1H, J=9.5, 10.0, 17.5 Hz), 6.75—6.85 (m, 3H), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 11.04, 20.26, 27.93, 39.59, 50.57, 56.81, 56.91, 65.67, 67.30, 75.94, 81.48, 112.03, 112.21, 118.89, 121.32, 128.65, 128.67, 130.67, 132.08, 134.61, 134.68, 136.56, 138.00, 149.68, 149.97. EI-MS *m*/*z* (%): 548 (M^+, 0.4), 491 [M^+−57(*t*-Bu), 0.3], 307 (1.2), 239 (1.3), 199 (8.1), 151 (100). HR-MS Calcd for $C_{33}H_{44}O_5Si$ (M^+): 548.2958. Found: 548.2969.

(3*S*,4*R*,5*R*)-6-(*tert*-Butyldiphenylsilyloxy)-4-(3,4-dimethoxybenzyloxy)-3,5-dimethyl-1-hexene (14) Et_3N (790 μl, 5.67 mmol), 4-dimethylaminopyridine (DMAP) (100 mg, 0.82 mmol), and *p*-toluenesulfonyl chloride (TsCl) (540 mg, 2.83 mmol) were successively added to a stirred solution of **9** (1.2 g, 2.18 mmol) in CH_2Cl_2 (10 ml) at 0 °C under argon. After 3 h at room temperature, the reaction was quenched with MeOH, and the reaction mixture was diluted with Et_2O, washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, and concentrated *in vacuo* to give a crude to-

sylate, which was dissolved in THF (15 ml). This solution was added to dropwise a stirred suspension of $LiAlH_4$ (80 mg, 2.1 mmol) in THF (10 ml) at 0 °C, and the stirring was continued overnight at room temperature. After addition of MeOH to quench the reaction, the reaction mixture was diluted with Et_2O, washed with 1 N HCl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (5 : 1), to give **14** as a colorless oil (1.04 g, 90%). $[\alpha]_D^{28}$ −9.0° (c=1.73, $CHCl_3$). IR (neat) cm^{-1}: 2950, 2875, 1520, 1465, 1265, 1240, 1175, 705. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.84 (d, 3H, J=7.0 Hz), 1.09 (s. 9H), 1.11 (d, 3H, J=6.5 Hz), 1.92—2.01 (m, 1H), 2.43—2.52 (m, 1H), 3.50—3.60 (m, 2H), 3.64 (dd, 1H, J=8.5, 10.0 Hz), 3.84 (s, 3H), 3.87 (s, 3H), 4.52 (d, 1H, J=11.0 Hz), 4.55 (d, 1H, J=11.0 Hz), 4.99 (dd, 1H, J=1.0, 10.0 Hz), 5.05 (ddd, 1H, J=1.0, 1.5, 17.0 Hz), 5.76 (ddd, 1H, J=8.0, 10.0, 17.0 Hz), 6.70—6.90 (m, 3H), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 10.77, 17.26, 19.46, 27.09, 38.47, 41.26, 55.91, 56.10, 66.73, 74.99, 82.73, 111.09, 111.24, 114.16, 120.21, 127.80, 127.88, 129.77, 132.03, 133.95, 134.01, 135.76, 142.10, 148.55, 149.01. EI-MS *m/z* (%): 532 (M^+, 0.4), 475 [M^+−57(*t*-Bu), 0.4], 349 (0.4), 309 (0.8), 239 (1.2), 199 (5.6), 183 (3.3), 152 (13), 151 (100), 135 (3.0). HR-MS Calcd for $C_{33}H_{44}O_4Si$ (M^+): 532.3009. Found: 532.2971.

Methyl (2E,4S,5R,6R)-7-(tert-Butyldiphenylsilyloxy)-5-(3,4-dimethoxybenzyloxy)-4,6-dimethyl-2-heptenoate (15) A 4 w/v% solution of OsO_4 in 2-methyl-2-propanol (4.60 ml, 0.73 mmol) was added dropwise to a stirred solution of **14** (7.778 g, 14.6 mmol), H_2O (16 ml) and *N*-methylmorpholine *N*-oxide (NMO) (3.43 g, 29.2 mmol) in acetone (64 ml) at room temperature. After 21 h, a solution of $Na_2S_2O_4$ (6.10 g, 35.1 mmol) in H_2O (60 ml) and Celite were added, and the mixture was stirred for 2 h. Insoluble materials were removed by filtration, and the filtrate was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (2 : 3), to give a 3 : 1 mixture of diols as a colorless oil (8.11 g, 98%). IR (neat) cm^{-1}: 3600—3200, 2950, 2850, 1590, 1515, 1460, 1425, 1265, 1240, 1105, 1070, 1025, 805, 740, 705. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.84 (d, 2.25H, J=7.0 Hz), 0.93 (d, 0.75H, J=7.0 Hz), 1.02 (d, 0.75H, J=7.0 Hz), 1.03 (d, 2.25H, J=6.5 Hz), 1.05 (s, 6.75H), 1.07 (s, 2.25H), 1.75—1.80 (m, 0.25H), 1.83 (dd, 0.25H, J=4.0, 7.5 Hz), 1.99 (t, 0.75H, J=6.0 Hz), 1.94—2.14 (m, 2.25H), 2.61 (d, 0.25H, J=3.0 Hz), 3.44—3.83 (m, 6.75H), 3.84 (s, 2.25H), 3.85 (s, 0.75H), 3.86 (s, 2.25H), 3.87 (s, 0.75H), 4.42 (d, 0.25H, J=10.5 Hz), 4.44 (d, 0.75H, J=11.0 Hz), 4.55 (d, 0.25H, J=10.5 Hz), 4.57 (d, 0.75H, J=11.0 Hz), 6.75—6.90 (m, 3H), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). EI-MS *m/z* (%): 566 (M^+, 0.3), 509 [M^+−57(*t*-Bu), 0.2], 402 (0.2), 391 (0.4), 341 (0.2), 269 (1.2), 239 (1.5), 199 (6.9), 152 (13), 151 (100). HR-MS Calcd for $C_{33}H_{46}O_6Si$ (M^+): 566.3064. Found: 566.3096.

A solution of $NaIO_4$ (4.60 g, 21.5 mmol) in H_2O (20 ml) was added to a stirred solution of the diol (8.11 g, 14.3 mmol) in MeOH (60 ml) at 0 °C and stirring was continued for 6 h at room temperature. Insoluble materials were removed by filtration through a Celite pad and washed with Et_2O. The filtered organic layer was washed with brine, dried over Na_2SO_4, and concentrated *in vacuo* to leave a crude aldehyde (7.67 g). IR (neat) cm^{-1}: 2950, 2850, 1735, 1510, 1460, 1265, 1240, 1110, 740, 705. 1H-NMR (500 MHz, C_6D_6) δ: 1.01 (d, 3H, J=7.0 Hz), 1.09 (d, 3H, J=7.0 Hz), 1.22 (s, 9H), 1.90—2.00 (m, 1H), 2.35—2.45 (m, 1H), 3.45 (s, 3H), 3.51 (s, 3H), 3.57 (dd, 1H, J=5.5, 10.0 Hz), 3.70 (dd, 1H, J=6.5, 10.0 Hz), 4.04 (t, 1H, J=5.0 Hz), 4.43 (d, 1H, J=11.0 Hz), 4.47 (d, 1H, J=11.0 Hz), 6.64 (d, 1H, J=8.5 Hz), 6.85—6.90 (m, 2H), 7.20—7.30 (m, 6H), 7.75—7.85 (m, 4H), 9.66 (s, 1H).

A solution of triphenylcarbomethoxymethylenephosphorane (7.17 g, 21.5 mmol) and the above aldehyde (7.67 g) in benzene (80 ml) was stirred for 12 h at room temperature under argon, and then diluted with *n*-hexane–Et_2O (1 : 1). After removal of insoluble materials by filtration, the filtrate was concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (5 : 1), to give **15** as a pale yellow oil (8.2 g, 98%). $[\alpha]_D^{28}$ −15.9° (c=1.22, $CHCl_3$). IR (neat) cm^{-1}: 2950, 2875, 1725, 1515, 1460, 1270, 1240, 1115, 1030, 745, 710. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 0.82 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.13 (d, 3H, J=7.0 Hz), 1.80—1.90 (m, 1H), 2.60—2.70 (m, 1H), 3.51 (dd, 1H, J=5.5, 10.0 Hz), 3.60 (dd, 1H, J=8.5, 10.0 Hz), 3.64 (dd, 1H, J=3.0, 7.5 Hz), 3.71 (s, 3H), 3.81 (s, 3H), 3.83 (s, 3H), 4.53 (s, 2H), 5.84 (d, 1H, J=15.5 Hz), 6.75—6.85 (m, 3H), 6.97 (dd, 1H, J=8.5, 15.5 Hz), 7.30—7.50 (m, 6H), 7.60—7.70 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 11.07, 16.24, 19.43, 27.10, 38.78, 40.15, 51.64, 55.92, 56.09, 66.51, 74.90, 82.02, 111.09, 111.26, 120.32, 120.49, 127.85, 129.83, 129.86, 131.58, 133.73, 133.83, 135.75, 148.68, 149.05, 152.09, 167.22. EI-MS *m/z* (%): 590 (M^+, 0.4), 533 (1.6), 391 (0.2), 367 (0.6), 351 (0.3), 269 (7.4), 239 (2.5), 183 (3.8), 151 (100), 91 (1.6). HR-MS Calcd for $C_{35}H_{46}O_6Si$ (M^+): 590.3064. Found: 590.3108.

Methyl (2*R*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-(3,4-dimethoxybenzyloxy)-4,6-dimethylheptanoate (16) and Methyl (2*S*,3*R*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-(3,4-dimethoxybenzyloxy)-4,6-dimethylheptanoate (17) a) NMO (40 mg, 341 μmol) and OsO_4 (2.2 mg, 8.6 μmol) were added to a stirred solution of **15** (102 mg, 173 μmol) in acetone–H_2O (4 : 1, 3.5 ml) at room temperature. After 22 h, saturated aqueous Na_2SO_3 was added, and the reaction mixture was stirred vigorously for 20 min and then filtered with the aid of Celite. The filtrate was washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1) to give a 1 : 3 mixture of **16** and **17** as a colorless oil (108 mg, 100%), which was subjected to HPLC (Shimadzu LC-8A, Chemcosorb 7Si) (*n*-hexane–EtOAc 1 : 1) to give colorless oils of **16** (21 mg, 19%) and **17** (64 mg, 59%). **16**: IR (neat) cm^{-1}: 3499, 1742, 1266, 1239, 1027. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.97 (d, 3H, J=7.0 Hz), 1.06 (d, 3H, J=7.0 Hz), 1.07 (s, 9H), 1.96—2.08 (m, 2H), 2.33 (d, 1H, J=7.4 Hz), 2.99 (d, 1H, J=5.5 Hz), 3.56 (dd, 1H, J=5.9, 9.9 Hz), 3.64 (dd, 1H, J=6.8, 9.9 Hz), 3.69 (t, 1H, J=4.4 Hz), 3.78 (s, 3H), 3.84 (s, 3H), 3.86 (s, 3H), 3.87 (m, 1H), 4.27 (dd, 1H, J=2.9, 5.5 Hz), 4.46 (d, 1H, J=11.0 Hz), 4.50 (d, 1H, J=11.0 Hz), 6.78—6.84 (m, 3H), 7.34—7.44 (m, 6H), 7.63—7.67 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 10.4, 12.4, 19.2, 26.9, 38.5, 38.9, 52.7, 55.7, 55.9, 66.7, 72.3, 73.9, 74.1, 81.1, 110.9, 111.1, 120.2, 127.6, 129.6, 131.2, 133.6, 135.6, 148.5, 148.9, 174.1. FAB-MS *m/z* (%): 647 (M^++Na, 1.1), 625 (M^++1, 0.2), 624 (M^+, 0.4), 301 (1.4), 213 (1.0), 199 (5.8), 165 (3.1), 151 (100), 135 (11), 121 (3.0), 107 (2.2), 91 (2.6). HR-MS (FAB) *m/z* Calcd for $C_{35}H_{49}O_8Si$ (M^++H): 625.3197. Found: 625.3208. **17**: IR (neat) cm^{-1}: 3487, 1743, 1265, 1237, 1030. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.90 (d, 3H, J=7.0 Hz), 1.04 (d, 3H, J=7.0 Hz), 1.05 (s, 9H), 1.94—2.03 (m, 1H), 2.28 (ddd, 1H, J=2.9, 3.3, 7.0 Hz), 2.97 (d, 1H, J=7.3 Hz), 3.51 (d, 2H, J=6.23 Hz), 3.81 (s, 3H), 3.84 (s, 3H), 3.86 (s, 3H), 3.88—3.90 (m, 2H), 4.19 (d, 1H, J=7.3 Hz), 4.46 (d, 1H, J=11.4 Hz), 4.59 (d, 1H, J=11.4 Hz), 6.69—6.84 (m, 3H), 7.34—7.44 (m, 6H), 7.62—7.66 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 12.1, 13.1, 19.2, 26.9, 36.3, 37.1, 52.7, 55.7, 55.9, 66.8, 71.5, 73.5, 75.0, 81.2, 110.8, 111.1, 120.3, 127.7, 129.7, 130.9, 133.6, 135.5, 148.6, 148.9, 174.1. FAB-MS *m/z* (%): 625 (M^++1, 1.1), 624 (M^+, 1.2), 623 (M^+−1, 0.3), 307 (1.1), 301 (3.9), 269 (1.1), 239 (2.3), 213 (1.7), 199 (9.2), 167 (5.6), 151 (100), 135 (18), 121 (4.8), 107 (5.1), 91 (5.0). HR-MS (FAB) *m/z* Calcd for $C_{35}H_{49}O_8Si$ (M^++H): 625.3197. Found: 625.3117.

b) $CH_3SO_2NH_2$ (1.4 mg, 15 μmol) was added to a stirred solution of AD-mix-α (210 mg) in *tert*-BuOH and H_2O (1 : 1, 0.8 ml) at room temperature. After 5 min, a solution of **15** (8.8 mg, 15 μmol) in *tert*-BuOH (0.1 ml) was added at 0 °C, and stirring was continued for 25 h at room temperature. The reaction mixture was quenched with Na_2SO_3 (225 mg) and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1) to give **16** as a colorless oil (8.9 mg, 95%, 99% de).

c) $CH_3SO_2HN_2$ (4.8 mg, 47 μmol) was added to a stirred solution of AD-mix-β (105 mg) in *tert*-BuOH and H_2O (1 : 1, 0.5 ml) at room temperature. After 5 min, a solution of **15** (28 mg, 51 μmol) in *tert*-BuOH (40 μl) was added, and the reaction mixture was stirred for 42 h, then quenched with Na_2SO_3 (77 mg), and extracted with EtOAc. The extract was washed with saturated aqueous $Na_2S_2O_4$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1) to give colorless oils of **17** (7 mg, 22%) and recovered **15** (17 mg, 60%).

Methyl (2*R*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2-hydroxy-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-4,6-dimethylheptanoate (18a) and Methyl (2*R*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2-hydroxy-3,5-[(*R*)-3,4-dimethoxybenzylidenedioxy]-4,6-dimethylheptanoate (18b) Molecular sieves 3 Å (500 mg) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) (534 mg, 2.4 mmol) were added to a stirred solution of **16** (1.47 g, 2.4 mmol) in CH_2Cl_2 (12 ml) at 0 °C under argon. After 10 min at room temperature, saturated aqueous $NaHCO_3$ was added, and the mixture was diluted with Et_2O (50 ml), stirred vigorously for 20 min, and then extracted with Et_2O. The extract was washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give a 5 : 2 mixture of **18a** and **18b** as a colorless oil (1.33 g, 91%).

Isomerization of 18b to 18a Molecular sieves 3 Å (300 mg) and a solution of CSA (32 mg, 138 μmol) in THF (1 ml) were added to a stirred solution of a mixture of **18a** and **18b** (284 mg, 456 μmol) in THF (3.5 ml) at room temperature under argon. After 30 min, the reaction mixture was

quenched with ice-cold saturated aqueous $NaHCO_3$, and extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 2 : 1) to give **18a** as a colorless oil (258 mg, 91%). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 1.06 (d, 3H, J=6.8 Hz), 1.07 (s, 9H), 1.13 (d, 3H, J=6.6 Hz), 1.72—1.82 (m, 1H), 1.88—2.02 (m, 1H), 2.89 (d, 1H, J=5.5 Hz), 3.59 (dd, 2H, J=1.8, 4.3 Hz), 3.71 (dd, 1H, J=1.8, 9.8 Hz), 3.75 (s, 3H), 3.88 (s, 3H), 3.90 (s, 3H), 4.02 (t, 1H, J=5.9 Hz), 5.54 (s, 1H), 6.86 (d, 1H, J=8.2 Hz), 7.01—7.06 (m, 2H), 7.36—7.45 (m, 6H), 7.63—7.66 (m, 4H). FAB-MS *m/z* (%): 623 (M^++1, 14), 622 (M^+, 3.4), 621 (M^+−1, 1.7), 519 (8.2), 319 (9.1), 307 (19), 289 (13), 269 (14), 239 (15), 213 (11), 199 (44), 183 (26), 165 (31), 154 (100), 137 (78), 107 (25), 91 (24). HR-MS (FAB) *m/z* Calcd for $C_{35}H_{47}O_8Si$ (M^++H): 623.3041. Found: 623.2992.

(2*S*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2-methoxymethoxy-4,6-methyl-1-heptyl 2,2-Dimethylpropanoate (19) Diisopropylethylamine (415 μl, 2.38 mmol) and methoxymethyl chloride (MOMCl) (181 μl, 2.38 mmol) were added to a stirred solution of **18a** (99 mg, 159 μmol) in CH_2Cl_2 (1.6 ml) at 0 °C under argon. After 6 d at room temperature, the reaction mixture was quenched with saturated aqueous NH_4Cl, and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give methyl (2*R*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-butyldiphenylsilyloxy)-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2-methoxymethoxy-4,6-dimethylheptanoate as a colorless oil (88 mg, 83%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.05 (d, 3H, J=7.1 Hz), 1.06 (s, 9H), 1.12 (d, 3H, J=6.6 Hz), 1.66—1.75 (m, 1H), 1.87—2.00 (m, 1H), 3.35 (s, 3H), 3.53 (dd, 1H, J=3.9, 10.3 Hz), 3.60 (dd, 1H, J=4.5, 10.3 Hz), 3.67 (s, 3H), 3.74 (dd, 1H, J=1.4, 9.6 Hz), 3.87 (s, 3H), 3.88 (s, 3H), 4.12 (dd, 1H, J=1.8, 9.0 Hz), 4.29 (d, 1H, J=9.0 Hz), 4.70 (d, 1H, J=6.9 Hz), 4.74 (d, 1H, J=6.9 Hz), 5.56 (s, 1H), 6.85 (d, 1H, J=8.2 Hz), 7.04—7.08 (m, 2H), 7.37—7.44 (m, 6H), 7.62—7.65 (m, 4H). FAB-MS *m/z* (%): 667 (M^++1, 2.2), 666 (M^+, 2.2), 665 (M^+−1, 2.3), 635 (M^+−MeO, 1.5), 609 (1.1), 427 (2.2), 379 (3.6), 309 (3.9), 269 (16), 239 (20), 213 (19), 197 (45), 165 (45), 151 (61), 135 (100), 121 (15), 105 (12), 91 (15). HR-MS (FAB) *m/z* Calcd for $C_{37}H_{51}O_9Si$ (M^++H): 667.3303. Found: 667.3283.

$LiAlH_4$ (6 mg, 159 μmol) was added to a stirred solution of the above ester (106 mg, 159 μmol) in Et_2O (0.75 ml) at 0 °C under argon. After 5 min at room temperature, the reaction mixture was cooled to 0 °C, quenched with saturated aqueous NH_4Cl, diluted with Et_2O (2 ml), then stirred vigorously for 10 min, and extracted with EtOAc, The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1) to give a primary alcohol as a colorless oil (89 mg, 89%). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 0.90 (d, 3H, J=6.7 Hz), 1.06 (s, 9H), 1.16 (d, 3H, J=6.6 Hz), 1.60—1.71 (m, 1H), 1.87—2.00 (m, 1H), 2.54 (t, 1H, J=6.2 Hz), 3.41 (s, 3H), 3.44—3.55 (m, 1H), 3.56 (d, 2H, J=4.3 Hz), 3.65—3.79 (m, 3H), 3.88 (s, 3H), 3.89 (s, 3H), 3.92 (dd, 1H, J=2.1, 8.8 Hz), 4.78 (d, 1H, J=6.6 Hz), 4.82 (d, 1H, J=6.6 Hz), 5.52 (s, 1H), 6.85 (d, 1H, J=8.2 Hz), 7.03—7.07 (m, 2H), 7.37—7.45 (m, 6H), 7.63—7.68 (m, 4H).

Et_3N (814 μl, 5.8 mmol), DMAP (14 mg, 0.1 mmol) and pivaloyl chloride (284 μl, 2.3 mmol) were added successively to a stirred solution of the above alcohol (741 mg, 1.17 mmol) in CH_2Cl_2 (12 ml) at 0 °C under argon. After 10 h at room temperature, the reaction mixture was cooled to 0 °C, quenched with saturated aqueous NH_4Cl, and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give **19** as a colorless oil (839 mg, 100%). $[\alpha]_D^{25}$ −23.4° (c=0.80, $CHCl_3$). IR (neat) cm^{-1}: 2950, 1730, 1520, 1460, 1265, 1160, 1115, 1030, 760, 740, 705. ^{1}H-NMR (500 MHz, C_6D_6) δ: 1.05 (d, 3H, J=6.5 Hz), 1.22 (s, 9H), 1.23 (s, 9H), 1.32 (d, 3H, J=6.5 Hz), 1.75—1.85 (m, 1H), 1.96—2.10 (m, 1H), 3.33 (s, 3H), 3.42 (s, 3H), 3.52 (s, 3H), 3.60 (d, 2H, J=4.5 Hz), 3.73 (d, 1H, J=9.5 Hz), 4.05 (dd, 1H, J=4.0, 12.0 Hz), 4.08—4.18 (m, 2H), 4.57 (dd, 1H, J=2.0, 12.0 Hz), 4.83 (d, 1H, J=6.5 Hz), 4.93 (d, 1H, J=6.5 Hz), 5.61 (s, 1H), 6.67 (d, 1H, J=8.0 Hz), 7.10—7.40 (m, 8H), 7.70—7.90 (m, 4H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 7.41, 14.57, 19.53, 27.12, 27.40, 31.73, 36.89, 39.02, 55.94, 55.98, 56.13, 63.28, 65.21, 75.22, 82.17, 83.53, 97.01, 101.87, 109.45, 110.92, 118.75, 127.95, 127.98, 129.98, 131.91, 133.57, 133.71, 135.73, 135.82, 148.85, 149.39, 178.45. FAB-MS *m/z* (%): 723 (M^++1, 5.0), 722 (M^+, 4.2), 721 (M^+−1, 3.0), 335 (5.6), 309 (5.2), 283 (20), 269 (20), 239 (21), 197 (45), 165 (44), 151 (52), 135 (100), 107 (18), 91 (14). HR-MS (FAB) *m/z* Calcd for $C_{41}H_{59}O_9Si$ (M^++H): 723.3929. Found: 723.3911.

(2*S*,3*S*,4*R*,5*S*,6*S*)-6-Formyl-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2-methoxymethoxy-4-methyl-1-heptyl 2,2-Dimethylpropanoate (6) A 1.0 M solution of tetra-*n*-butylammonium fluoride (TBAF) in THF (5.62 ml, 5.62 mmol) was added to a stirred solution of **19** (2.707 g, 3.74 mmol) in THF (40 ml) at 0 °C, and stirring was continued for 8 h. After addition of H_2O, the reaction mixture was extracted with Et_2O. The extraxct was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (2 : 3), to give an alcohol as a pale yellow oil (1.754 g, 97%). $[\alpha]_D^{25}$ −17.0° (c=2.19, $CHCl_3$). IR (neat) cm^{-1}: 3600—3200, 2975, 2850, 1730, 1520, 1460, 1270, 1160, 1030. ^{1}H-NMR (500 MHz, $CDCl_3$) δ: 1.04 (d, 3H, J=6.5 Hz), 1.10 (d, 3H, J=6.5 Hz), 1.22 (s, 9H), 1.56—1.68 (br, 1H), 1.68—1.75 (m, 1H), 1.85—1.95 (m, 1H), 3.35 (s, 3H), 3.54 (dd, 1H, J=5.0, 10.5 Hz), 3.59 (dd, 1H, J=3.5, 10.5 Hz), 3.63 (d, 1H, J=9.5 Hz), 3.85 (s, 3H), 3.86 (s, 3H), 3.94—4.02 (br, 2H), 4.08 (dd, 1H, J=3.0, 12.5 Hz), 4.34 (d, 1H, J=12.5 Hz), 4.74 (d, 1H, J=6.5 Hz), 4.79 (d, 1H, J=6.5 Hz), 5.52 (s, 1H), 6.83 (d, 1H, J=8.0 Hz), 7.00—7.10 (m, 2H). ^{13}C-NMR (125 MHz, $CDCl_3$) δ: 7.41, 14.25, 27.36, 27.40, 31.31, 36.47, 39.10, 55.94, 56.01, 56.15, 63.50, 64.00, 75.20, 82.07, 83.21, 96.96, 101.93, 109.38, 110.89, 118.72, 131.79, 148.83, 149.38, 178.72. EI-MS *m/z* (%): 484 (M^+, 42), 295 (16), 182 (14), 166 (96), 151 (21), 139 (26), 95 (30), 57 (58), 45 (100). HR-MS Calcd for $C_{25}H_{40}O_9$ (M^+): 484.2673. Found: 484.2655.

A solution of the alcohol (1.181 g, 2.44 mmol) in CH_2Cl_2 (15 ml) was added dropwise to a stirred solution of the Dess–Martin reagent (1.73 g, 4.08 mmol) and pyridine (0.99 ml, 12.2 mmol) in CH_2Cl_2 (20 ml) at room temperature. After 2 h, saturated aqueous $NaHCO_3$ and saturated aqueous $Na_2S_2O_3$ were added to quench the reaction. The reaction mixture was extracted with Et_2O. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (1 : 1), to give **6** as a colorless oil (1.176 g, 100%). IR (neat) cm^{-1}: 2975, 2850, 1730, 1520, 1460, 1270, 1160, 1035. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.99 (d, 3H, J=7.0 Hz), 1.00 (d, 3H, J=7.0 Hz), 1.30 (s, 9H), 1.75—1.85 (m, 1H), 2.42—2.52 (m, 1H), 3.28 (s, 3H), 3.42 (s, 3H), 3.52 (s, 3H), 3.78 (dd, 1H, J=1.5, 9.5 Hz), 4.01 (dd, 1H, J=3.5, 12.0 Hz), 4.05—4.11 (m, 2H), 4.47 (dd, 1H, J=2.0, 12.0 Hz), 4.76 (d, 1H, J=6.5 Hz), 4.86 (d, 1H, J=6.5 Hz), 5.50 (s, 1H), 6.67 (d, 1H, J=8.0 Hz), 7.20—7.40 (m, 2H), 9.32 (d, 1H, J=1.0 Hz).

Methyl (2*S*,3*R*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2-hydroxy-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-4,6-dimethylheptanoate (20) Molecular sieves 3 Å (25 mg) and DDQ (10.4 mg, 45.8 μmol) were added to a stirred solution of **17** (28.6 mg, 45.8 μmol) in CH_2Cl_2 (0.9 ml) at room temperature under argon. After 5 min, saturated aqueous $NaHCO_3$ was added, and the reaction mixture was extracted with Et_2O. The extract was washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give **20** as a colorless oil (18.6 mg, 65%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.07 (s, 9H), 1.12 (d, 3H, J=6.6 Hz), 1.13 (d, 3H, J=7.0 Hz), 1.93—2.08 (m, 2H), 3.07 (d, 1H, J=5.0 Hz), 3.56 (dd, 1H, J=5.1, 10.3 Hz), 3.61 (dd, 1H, J=4.3, 10.3 Hz), 3.72 (s, 3H), 3.87 (s, 3H), 3.88 (s, 3H), 3.92 (dd, 1H, J=2.2, 4.9 Hz), 4.25 (dd, 1H, J=2.8, 9.6 Hz), 4.51 (t, 1H, J=4.8 Hz), 5.98 (s, 1H), 6.84 (d, 1H, J=8.3 Hz), 6.99—7.02 (m, 2H), 7.37—7.44 (m, 6H), 7.66—7.70 (m, 4H).

(2*R*,3*R*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-4,6-dimethylheptane-1,2-diol (21) A solution of **20** (6.1 mg, 9.8 μmol) in THF (0.7 ml) was added to a stirred solution of $LiBH_4$ (0.3 mg, 13.8 μmol) in THF (0.3 ml) at 0 °C under argon. After 5 min at room temperature, the reaction mixture was cooled to 0 °C, quenched with saturated aqueous NH_4Cl, and extracted with Et_2O. The extract was washed with brine, dried over K_2CO_3, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1) to give **21** as a colorless oil (4.8 mg, 83%). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 1.06 (d, 3H, J=6.8 Hz), 1.07 (s, 9H), 1.13 (d, 3H, J=6.6 Hz), 1.77 (m, 1H), 1.95 (m, 1H), 2.89 (d, 1H, J=5.5 Hz), 3.59 (dd, 2H, J=1.8, 4.3 Hz), 3.71 (dd, 1H, J=1.8, 9.8 Hz), 3.75 (s, 3H), 3.88 (s, 3H), 3.90 (s, 3H), 4.02 (t, 1H, J=5.9 Hz), 5.54 (s, 1H), 6.86 (d, 1H, J=8.2 Hz), 7.01—7.06 (m, 2H), 7.36—7.45 (m, 6H), 7.63—7.66 (m, 4H).

(2*S*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-4,6-methylheptane-1,2-diol (22) A solution of **18a** (4.7 mg, 7.5 μmol) in THF (0.6 ml) was added to a stirred solution of $LiBH_4$ (0.2 mg, 9.0 μmol) in THF (0.2 ml) at 0 °C under argon. After 5 min at room temperature, the reaction mixture was cooled to 0 °C, quenched with saturated aqueous NH_4Cl, and extracted with Et_2O. The extract was washed with brine, dried over K_2CO_3, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc

1 : 1) to give **22** as a colorless oil (2.4 mg, 53%). $[\alpha]_D^{26}$ −17° (c=0.55, $CHCl_3$). IR (neat) cm^{-1}: 3700—3200, 2950, 1535, 1480, 1280, 1125, 1045, 770, 715. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.97 (d, 3H, J=7.0 Hz), 1.23 (s, 9H), 1.33 (d, 3H, J=6.5 Hz), 1.73—1.82 (m, 1H), 1.95—2.05 (m, 1H), 2.18—2.20 (br, 1H), 2.75—2.85 (br, 1H), 3.43 (s, 3H), 3.50 (s, 3H), 3.46—3.60 (m, 3H), 3.65—3.71 (m, 1H), 3.76 (dd. 1H, J=1.0, 10.0 Hz), 3.75—3.83 (m, 1H), 3.92 (dd, 1H, J=2.0, 8.0 Hz), 5.53 (s, 1H), 6.69 (d, 1H, J=8.0 Hz), 7.20—7.40 (m, 8H), 7.70—7.90 (m, 4H). ^{13}C-NMR (100 MHz, C_6D_6) δ: 7.21, 14.69, 19.48, 27.11, 31.33, 36.85, 55.65, 55.71, 62.11, 65.16, 72.28, 82.22, 83.58, 102.91, 111.18, 111.87, 119.46, 127.89, 128.15, 130.10, 130.20, 132.30, 133.78, 136.03, 149.96, 150.66. EI-MS (m/z, %): 594 (M^+, 0.5), 537 (11), 371 (15), 351 (28), 339 (36), 269 (35), 239 (21), 199 (64), 167 (56), 151 (100), 123 (52). HR-MS Calcd for $C_{34}H_{46}O_7Si$ (M^+): 594.3013. Found: 594.2998.

(3*R*,4*R*)-5-(*tert*-Butyldiphenylsilyloxy)-3-(3,4-dimethoxybenzyloxy)-4-methylpentan-1-ol (23) A 1.0 M solution of diborane in THF (2.5 ml, 2.5 mmol) was added dropwise to a stirred solution of **12** (149 mg, 402 μmol) in THF–HMPA (1 : 1, 5.0 ml) at −20 °C. After 5 h at room temperature, the reaction mixture was diluted with Et_2O (30 ml), washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give a diol as a colorless oil (129 mg, 86%). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 0.92 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.49—1.60 (m, 1H), 1.77—1.89 (m, 2H), 2.81 (br, 1H), 3.42 (br, 1H), 3.67 (dd, 1H, J=6.3, 10.2 Hz), 3.76 (dd, 1H, J=4.4, 10.2 Hz), 3.82—3.92 (m, 2H), 4.08 (dt, 1H, J=2.6, 10.4 Hz), 7.36—7.49 (m, 6H), 7.62—7.70 (m, 4H).

A solution of 3,4-dimethoxybenzaldehyde dimethyl acetal (282 mg, 1.3 mmol) in CH_2Cl_2 (2.0 ml) and CSA (19 mg, 81 μmol) were added to a stirred solution of the diol (198 mg, 531 μmol) in CH_2Cl_2 (3.0 ml) at room temperature under argon. After 1 h, the reaction mixture was quenched with saturated aqueous $NaHCO_3$, and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over K_2CO_3, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give an acetal as a colorless oil (254 mg, 92%). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 1.03 (d, 3H, J=6.9 Hz), 1.06 (s, 9H), 1.41 (dq, 1H, J=1.4, 13.2 Hz), 1.78—2.00 (m, 2H), 3.61 (dd, 1H, J=5.4, 10.0 Hz), 3.75 (dd, 1H, J=6.7, 10.0 Hz), 3.86 (s, 3H), 3.88 (s, 3H), 3.92—4.06 (m, 2H), 4.26 (dd, 1H, J=3.9, 11.3 Hz), 5.46 (s, 1H), 6.84 (d, 1H, J=8.9 Hz), 6.99—7.25 (m, 2H), 7.27—7.42 (m, 6H), 7.62—7.68 (m, 4H).

A 0.95 M solution of DIBAH in *n*-hexane (2.5 ml, 2.4 mmol) was added dropwise to a stirred solution of the acetal (245 mg, 470 μmol) in CH_2Cl_2 (4.7 ml) at −50 °C under argon. The reaction mixture was allowed to warm to −20 °C over 2 h and stirring was continued for 1 h. After addition of saturated aqueous NH_4Cl and Et_2O (10 ml), the mixture was stirred vigorously at room temperature for 30 min, then filtered with the aid of Celite, and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give **23** as a colorless oil (217 mg, 88%). IR (neat) cm^{-1}: 3435, 1264, 1239, 1027. ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 0.97 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.69—1.80 (m, 2H), 1.99 (ddd, 1H, J=4.3, 4.5, 6.7 Hz), 2.16 (br, 1H), 3.58 (dd, 1H, J=6.7, 10.0 Hz), 3.64—3.79 (m, 3H), 3.75 (dd, 1H, J=5.9, 10.0 Hz), 3.82 (s, 3H), 3.86 (s, 3H), 4.40 (d, 1H, J=11.1 Hz), 4.47 (d, 1H, J=11.1 Hz), 6.76—6.88 (m, 3H), 7.35—7.42 (m, 6H), 7.64—7.67 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 12.6, 15.3, 19.3, 26.9, 38.8, 55.9, 61.1, 65.5, 65.8, 72.1, 79.2, 110.9, 111.2, 120.4, 127.6, 129.6, 131.0, 133.7, 135.6, 148.6, 148.9.

Methyl (2*E*,5*R*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-5-(3,4-dimethoxybenzyloxy)-6-methyl-2-heptenoate (24) Pyridine (7.7 μl, 96 μmol) and a solution of **23** (10 mg, 19 μmol) in CH_2Cl_2 (0.2 ml) were added to a stirred solution of Dess–Martin reagent (16 mg, 38 μmol) in CH_2Cl_2 (0.2 ml) at room temperature. After 30 min, the reaction mixture was diluted with Et_2O (0.8 ml), quenched with saturated aqueous $NaHCO_3$ (0.8 ml) and saturated aqueous $Na_2S_2O_3$ (0.8 ml), and extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 2 : 1) to give a crude aldehyde (11 mg). ^{1}H-NMR (300 MHz, $CDCl_3$) δ: 0.92 (d, 3H, J=7.0 Hz), 1.06 (s, 9H), 1.86—2.00 (m, 1H), 2.55 (ddd, 1H, J=1.8, 4.4, 16.5 Hz), 2.71 (ddd, 1H, J=2.4, 7.9, 16.5 Hz), 3.59 (dd, 1H, J=5.9, 10.2 Hz), 3.71 (dd, 1H, J=6.7, 10.2 Hz), 3.82 (s, 3H), 3.86 (s, 3H), 4.18 (ddd, 1H, J=4.0, 4.4, 7.9 Hz), 4.45 (s, 2H), 6.79 (s, 3H), 7.36—7.43 (m, 6H), 7.64—7.66 (m, 4H), 9.76 (dd, 1H, J=1.8, 2.4 Hz).

Methoxycarbonylmethylenetriphenylphosphorane (9 mg, 27 μmol) was added to a stirred solution of the aldehyde (11 mg) in benzene (0.4 ml) at room temperature under argon. After 12 h, the reaction mixture was diluted with *n*-hexane (2 ml), and chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give **24** as a colorless oil (11 mg, 93%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.85 (d, 3H, J=7.0 Hz), 0.98 (s, 9H), 1.72—1.82 (m, 1H), 2.29—2.44 (m, 2H), 3.48 (dd, 1H, J=5.9, 10.3 Hz), 3.60 (dd, 1H, J=7.0, 10.3 Hz), 3.65 (s, 3H), 3.64—3.71 (m, 1H), 3.75 (s, 3H), 3.79 (s, 3H), 4.34 (d, 1H, J=11.2 Hz), 4.40 (d, 1H, J=11.2 Hz), 5.79 (d, 1H, J=15.8 Hz), 6.75—6.86 (m, 2H), 6.90 (ddd, 2H, J=7.3, 7.9, 15.8 Hz), 7.28—7.37 (m, 6H), 7.55—7.58 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 11.5, 19.2, 26.8, 34.8, 39.3, 51.4, 55.6, 55.8, 65.6, 72.2, 78.0, 110.8, 111.0, 120.1, 122.7, 127.6, 129.6, 129.6, 131.1, 133.6, 133.6, 135.5, 146.3, 166.7. FAB-MS m/z (%): 577 (M^++1, 1.4), 576 (M^+, 1.5), 307 (9.2), 289 (5.0), 257 (2.5), 239 (2.0), 199 (4.0), 154 (37), 152 (12), 151 (100), 136 (25), 107 (7.5), 91 (4.9). HR-MS (FAB) m/z Calcd for $C_{34}H_{45}O_6Si$ (M^++1): 577.2986. Found: 577.2967.

Methyl (2*E*,4*S*,5*R*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-5-methoxymethoxy-4,6-dimethyl-2-heptenoate (25) Phosphate buffer (pH 6.85, 20 μl) and DDQ (5.8 mg, 25 μmol) were added to a stirred solution of **15** (12.5 mg, 21 μmol) in CH_2Cl_2 (0.4 ml) at 0 °C. After 10 min at room temperature, the reaction mixture was diluted with Et_2O (3 ml), quenched with saturated aqueous $NaHCO_3$, and extracted with Et_2O. The extract was washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give an alcohol as a colorless oil (10.3 mg, 100%). IR (neat) cm^{-1}: 1724, 1657, 1274, 987. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.94 (d, 3H, J=7.0 Hz), 1.07 (s, 9H), 1.16 (d, 3H, J=6.6 Hz), 1.64—1.72 (m, 1H), 2.44—2.55 (m, 1H), 3.00 (d, 1H, J=2.3 Hz), 3.63 (dd, 1H, J=4.8, 10.3 Hz), 3.72 (s, 3H), 3.72—3.76 (m, 1H), 3.77 (dd, 1H, J=3.7, 10.3 Hz), 5.85 (dd, 1H, J=0.7, 15.8 Hz), 6.79 (dd, 1H, J=9.2, 15.8 Hz), 7.37—7.47 (m, 6H), 7.64—7.67 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 9.4, 16.6, 19.1, 26.9, 37.0, 40.8, 51.5, 69.3, 77.1, 120.8, 127.8, 129.8, 132.7, 135.5, 151.0, 167.0.

Diisopropylethylamine (166 μl, 953 μmol) and MOMCl (43.6 μl, 574 μmol) were added to a stirred solution of the alcohol (42.2 mg, 95.8 μmol) in CH_2Cl_2 (1.8 ml) at 0 °C under argon. After 3 d at room temperature, the reaction mixture was quenched with saturated aqueous NH_4Cl, and extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give **25** as a colorless oil (43.3 mg, 93%). IR (neat) cm^{-1}: 1724, 1656, 1272, 1033. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.80 (d, 3H, J=6.8 Hz), 1.05 (s, 9H), 1.10 (d, 3H, J=6.7 Hz), 1.76—1.86 (m, 1H), 2.58—2.68 (m, 1H), 3.32 (s, 3H), 3.45 (dd, 1H, J=5.8, 10.1 Hz), 3.54 (dd, 1H, J=8.1, 10.1 Hz), 3.69 (dd, 1H, J=2.9, 7.0 Hz), 3.75 (s, 3H), 4.61 (d, 1H, J=6.6 Hz), 4.67 (d, 1H, J=6.6 Hz), 5.83 (dd, 1H, J=1.0, 15.8 Hz), 6.98 (dd, 1H, J=8.1, 15.8 Hz), 7.35—7.45 (m, 6H), 7.62—7.67 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 10.9, 15.9, 19.2, 26.9, 38.1, 40.0, 51.5, 56.0, 66.2, 81.6, 98.2, 120.3, 127.6, 129.6, 133.7, 135.6, 151.8, 167.0. FAB-MS m/z (%): 485 (M^++1, 2.4), 453 (M^+−MeO, 7.3), 427 (7.7), 365 (8.7), 345 (8.0), 305 (47), 269 (26), 239 (27), 213 (55), 199 (62), 183 (30), 154 (26), 135 (100), 107 (48), 91 (36). HR-MS (FAB) m/z Calcd for $C_{28}H_{41}O_5Si$ (M^++1): 485.2724. Found: 485.2719.

Asymmetric Dihydroxylation of 15, 24 and 25 by AD-mix-α and -β $CH_3SO_2NH_2$ (9.5 mg, 0.1 mmol) was added to a stirred solution of AD-mix-α or -β (350 mg) in *tert*-BuOH and H_2O (1 : 1, 1.0 ml) at room temperature. After 5 min, a solution of **15**, **24** or **25** (50 μmol) in *tert*-BuOH (0.1 ml) was added at 0 °C, and the reaction mixture was stirred at room temperature for 6 h. Na_2SO_3 (375 mg) was added to quench the reaction, and the reaction mixture was diluted with *tert*-BuOH and H_2O (1 : 1, 2.0 ml), stirred vigorously for 1 h and then extracted with EtOAc. The extract was washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 1 : 1 for **15**, 3 : 2 for **24** and **25**). The results are shown in Table 1.

Methyl (2*R*,3*S*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-(3,4-dimethoxybenzyloxy)-6-methylheptanoate (**26**): IR (neat) cm^{-1}: 3485, 1742, 1265, 1237, 1030. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.97 (d, 3H, J=7.0 Hz), 1.07 (s, 9H), 1.68 (ddd, 1H, J=3.3, 3.3, 14.7 Hz), 1.89 (ddd, 1H, J=9.9, 9.9, 14.7 Hz), 2.02—2.14 (m, 1H), 2.98 (d, 1H, J=7.7 Hz), 3.41 (d, 1H, J=2.9 Hz), 3.61 (dd, 1H, J=7.0, 10.3 Hz), 3.78 (dd, 1H, J=5.9, 10.3 Hz), 3.80 (s, 3H), 3.80 (s, 6H), 3.80—3.85 (m, 1H), 3.86 (s, 3H), 3.99 (dd, 1H, J=0.7, 7.3 Hz), 4.06 (dd, 1H, J=2.0, 9.7 Hz), 4.33 (d, 1H, J=11.0 Hz), 4.48 (d, 1H, J=11.0 Hz), 6.74—6.77 (m, 3H), 7.36—7.45 (m, 6H), 7.65—7.68 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 12.7, 19.2, 27.0, 34.0, 38.4, 52.6, 55.7, 55.9, 65.0, 71.5, 72.3, 73.8, 80.1, 110.9, 111.1, 120.5, 127.7, 129.7, 130.4, 133.7, 135.6, 148.3, 148.7, 173.4. FAB-MS m/z (%): 611 (M^++1,

1.5), 610 (M^+, 0.9), 307 (3.9), 289 (2.4), 257 (1.4), 239 (1.4), 199 (3.6), 167 (3.0), 151 (100), 137 (13), 107 (4.0), 91 (2.9). HR-MS (FAB) *m/z* Calcd for $C_{34}H_{47}O_8Si$ (M^++1): 611.3041. Found: 611.3053.

Methyl (2*S*,3*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-(3,4-dimethoxybenzyloxy)-6-methylheptanoate (**27**): ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.99 (d, 3H, *J*=7.0 Hz), 1.06 (s, 9H), 1.66 (ddd, 1H, *J*=2.9, 8.8, 14.7 Hz), 1.84 (ddd, 1H, *J*=3.3, 9.9, 14.7 Hz), 1.94—2.03 (m, 1H), 2.06 (br, 1H), 3.00 (br, 1H), 3.58 (dd, 1H, *J*=6.2, 10.3 Hz), 3.73 (dd, 1H, *J*=5.9, 10.3 Hz), 3.79 (s, 3H), 3.84 (s, 3H), 3.81—3.90 (m, 1H), 3.87 (s, 3H), 3.97 (d, 1H, *J*=1.8 Hz), 4.08 (d, 1H, *J*=9.9 Hz), 4.46 (d, 1H, *J*=11.0 Hz), 4.51 (d, 1H, *J*=11.0 Hz), 6.76—6.85 (m, 3H), 7.34—7.44 (m, 6H), 7.64—7.67 (m, 4H). FAB-MS *m/z* (%): 611 (M^++1, 1.6), 610 (M^+, 0.9), 307 (7.9), 289 (4.4), 257 (2.3), 227 (1.7), 199 (3.8), 167 (3.8), 151 (100), 136 (23), 107 (6.9), 91 (4.5). HR-MS (FAB) *m/z* Calcd for $C_{34}H_{47}O_8Si$ (M^++1): 611.3041. Found: 611.3053.

Methyl (2*R*,3*S*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-methoxymethoxy-4,6-dimethylheptanoate (**28**): IR (neat) cm^{-1}: 3482, 1734, 1261, 1236, 1217, 1033. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.93 (d, 3H, *J*=7.0 Hz), 1.03 (d, 3H, *J*=7.0 Hz), 1.05 (s, 9H), 1.87—2.01 (m, 2H), 2.38 (d, 1H, *J*=7.7 Hz), 3.08 (d, 1H, *J*=5.1 Hz), 3.35 (s, 3H), 3.50 (dd, 1H, *J*=5.5, 10.1 Hz), 3.57 (dd, 1H, *J*=6.6, 10.1 Hz), 3.70 (dd, 1H, *J*=2.9, 5.5 Hz), 3.81 (s, 3H), 3.86—3.92 (m, 1H), 4.44 (dd, 1H, *J*=2.9, 5.1 Hz), 4.63 (d, 1H, *J*=6.6 Hz), 4.65 (d, 1H, *J*=6.6 Hz), 7.38—7.43 (m, 6H), 7.64—7.68 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 10.3, 12.9, 19.2, 26.9, 38.9, 39.0, 52.7, 55.9, 66.3, 72.0, 74.4, 81.7, 98.3, 127.6, 129.6, 133.6, 135.6, 174.2. FAB-MS *m/z* (%): 541 (M^++Na, 1.4), 519 (M^++1, 0.9), 487 (M^+−MeO, 22), 349 (7.1), 301 (7.2), 269 (14), 239 (19), 213 (37), 199 (57), 183 (48), 165 (27), 153 (30), 135 (100), 121 (19), 107 (11), 91 (25). HR-MS (FAB) *m/z* Calcd for $C_{28}H_{43}O_7Si$ (M^++1): 519.2778. Found: 519.2729.

Methyl (2*S*,3*R*,4*R*,5*S*,6*R*)-7-(*tert*-Butyldiphenylsilyloxy)-2,3-dihydroxy-5-methoxymethoxy-4,6-dimethylheptanoate (**29**): IR (neat) cm^{-1}: 3475, 1743, 1274, 1235, 1216, 1028. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.85 (d, 3H, *J*=6.6 Hz), 1.05 (d, 3H, *J*=6.6 Hz), 1.05 (s, 9H), 1.88—1.98 (m, 1H), 2.14 (ddd, 1H, *J*=2.6, 7.0, 9.5 Hz), 2.34 (t, 1H, *J*=7.3 Hz), 2.90 (d, 1H, *J*=8.4 Hz), 3.39 (s, 3H), 3.49 (dd, 1H, *J*=5.9, 10.3 Hz), 3.53 (dd, 1H, *J*=5.5, 10.3 Hz), 3.82 (s, 3H), 3.87 (t, 1H, *J*=1.9 Hz), 3.90 (dd, 1H, *J*=2.6, 7.3 Hz), 4.25 (d, 1H, *J*=8.1 Hz), 4.66 (d, 1H, *J*=6.6 Hz), 4.69 (d, 1H, *J*=6.6 Hz), 7.38—7.43 (m, 6H), 7.64—7.67 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 10.8, 14.1, 19.2, 26.8, 37.0, 38.1, 52.5, 56.1, 66.0, 71.7, 74.0, 81.4, 98.6, 127.6, 129.6, 133.5, 135.6, 174.4. FAB-MS *m/z* (%); 541 (M^++Na, 2.5), 519 (M^++1, 2.4), 487 (M^+−MeO, 19), 307 (19), 289 (13), 239 (8.5), 213 (15), 199 (27), 183 (17), 165 (18), 154 (100), 136 (75), 107 (25), 91 (23). HR-MS (FAB) *m/z* Calcd for $C_{28}H_{43}O_7Si$ (M^++1): 519.2778. Found: 519.2758.

(3*R*,4*S*,5*R*,6*S*)-3,4-Diacetoxy-6-[(1*R*)-2-(*tert*-butyldiphenylsilyloxy)-1-methylethyl]-5-methyl-2*H*-3,4,5,6-tetrahydropyran-2-one (30) a) Ac_2O (180 μl) was added to a stirred solution of **16** (22 mg, 36 μmol) in pyridine (180 μl) at room temperature. After 5 h, the reaction mixture was diluted with EtOAc (30 ml), washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give a diacetate as a colorless oil (25 mg, 98%). IR (neat) cm^{-1}: 1750, 1265, 1219, 1031. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.93 (d, 3H, *J*=7.0 Hz), 1.00 (d, 3H, *J*=7.0 Hz), 1.05 (s, 9H), 2.02 (s, 3H), 2.03 (s, 3H), 2.04—2.20 (m, 2H), 3.44 (d, 1H, *J*=9.2 Hz), 3.45 (dd, 1H, *J*=7.0, 9.9 Hz), 3.57 (dd, 1H, *J*=7.3, 9.9 Hz), 3.68 (s, 3H), 3.863 (s, 3H), 3.865 (s, 3H), 4.45 (d, 1H, *J*=11.0 Hz), 4.54 (d, 1H, *J*=11.0 Hz), 5.17 (d, 1H, *J*=3.8 Hz), 5.45 (dd, 1H, *J*=3.8, 7.3 Hz), 6.80 (d, 2H, *J*=0.7 Hz), 6.86 (s, 1H), 7.33—7.43 (m, 6H), 7.62—7.64 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 11.2, 12.2, 19.2, 20.4, 20.6, 26.9, 36.6, 38.2, 52.5, 55.7, 55.9, 66.3, 72.2, 72.4, 74.1, 79.4, 110.8, 110.9, 120.1, 127.7, 129.8, 131.0, 133.5, 135.5, 148.6, 149.0, 169.9, 170.1. FAB-MS *m/z* (%): 709 (M^++1, 1.0), 708 (M^+, 1.3), 307 (5.3), 289 (3.0), 241 (2.1), 227 (1.5), 199 (3.1), 167 (3.1), 151 (100), 137 (16), 107 (4.9), 91 (3.3). HR-MS (FAB) *m/z* Calcd for $C_{39}H_{53}O_{10}Si$ (M^++1): 708.3330. Found: 708.3337.

DDQ (2.9 mg, 13 μmol) was added to a stirred solution of the diacetate (8.4 mg, 12 μmol) in CH_2Cl_2 and H_2O (22 : 1, 0.23 ml) at 0 °C. After 10 min at room temperature, the reaction mixture was dried over $MgSO_4$ and chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give an alcohol as a colorless oil (5.5 mg, 83%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.96 (d, 3H, *J*=6.9 Hz), 1.02 (d, 3H, *J*=6.8 Hz), 1.05 (s, 9H), 1.92—1.99 (m, 2H), 2.04 (s, 3H), 2.06 (s, 3H), 2.52 (br, 1H), 3.56—3.62 (m, 1H), 3.60 (d, 2H, *J*=4.9 Hz), 3.72 (s, 3H), 5.24 (d, 1H, *J*=4.5 Hz), 5.40 (dd, 1H, *J*=4.5, 5.3 Hz), 7.37—7.48 (m, 6H), 7.62—7.66 (m, 4H).

CSA (0.2 mg) was added to a stirred solution of the alcohol (5.5 mg, 9.8 μmol) in benzene (0.26 ml) at room temperature under argon. After 10 min, the reaction mixture was quenched with saturated aqueous $NaHCO_3$, and extracted with EtOAc. The extract was washed with brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give **30** as a colorless oil (3.0 mg, 58%). IR (neat) cm^{-1}: 1772, 1752, 1221, 1033. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.04 (d, 3H, *J*=7.0 Hz), 1.05 (s, 9H), 1.15 (d, 3H, *J*=7.0 Hz), 2.02 (s, 3H), 2.22 (s, 3H), 2.36—2.44 (m, 1H), 3.50 (dd, 1H, *J*=4.0, 10.6 Hz), 3.62 (dd, 1H, *J*=3.7, 10.6 Hz), 4.58 (dd, 1H, *J*=1.8, 9.5 Hz), 4.78 (d, 1H, *J*=7.0 Hz), 5.60 (d, 1H, *J*=7.0 Hz), 7.38—7.45 (m, 6H), 7.58—7.63 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 11.7, 14.6, 19.3, 20.6, 20.9, 26.8, 36.3, 38.0, 51.5, 65.0, 70.2, 80.6, 127.9, 129.9, 132.7, 135.5, 166.9, 169.9, 170.0. FAB-MS *m/z* (%): 527 (M^++1, 2.4), 526 (M^+, 0.9), 525 (M^+−1, 1.7), 469 (11), 409 (22), 307 (18), 289 (20), 269 (19), 241 (25), 199 (43), 154 (100), 137 (86), 107 (25), 89 (19). HR-MS (FAB) *m/z* Calcd for $C_{29}H_{39}O_7Si$ (M^++1): 527.2465. Found: 527.2460.

b) Ac_2O (77 μl) was added to a stirred solution of **28** (4.0 mg, 7.7 μmol) in pyridine (77 μl) at room temperature. After 1.5 h, the reaction mixture was diluted with EtOAc (15 ml), washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 2 : 1) to give a diacetate (4.2 mg, 90%). IR (neat) cm^{-1}: 1750, 1218, 1030. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.91 (d, 3H, *J*=7.0 Hz), 0.93 (d, 3H, *J*=6.8 Hz), 1.04 (s, 9H), 1.99 (s, 3H), 1.94—2.04 (m, 1H), 2.04 (s, 3H), 2.05—2.18 (m, 1H), 3.35 (dd, 1H, *J*=7.0, 9.9 Hz), 3.36 (d, 1H, *J*=3.7 Hz), 3.38 (s, 3H), 3.51 (dd, 1H, *J*=6.6, 9.9 Hz), 3.70 (s, 3H), 4.59 (d, 1H, *J*=7.0 Hz), 4.61 (d, 1H, *J*=7.0 Hz), 5.46—5.51 (m, 2H), 7.36—7.45 (m, 6H), 7.62—7.66 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 11.0, 12.9, 19.2, 20.3, 20.6, 26.8, 36.2, 38.5, 52.4, 56.1, 66.3, 71.8, 72.9, 79.7, 97.7, 127.7, 129.7, 133.5, 135.6, 168.4, 170.0. FAB-MS *m/z* (%): 603 (M^++1, 2.5), 571 (M^+−MeO, 14), 541 (26), 381 (10), 309 (31), 275 (38), 241 (65), 199 (54), 183 (44), 165 (59), 135 (100), 123 (27), 107 (19), 91 (25). HR-MS (FAB) *m/z* Calcd for $C_{32}H_{47}O_9Si$ (M^++1): 603.2990. Found: 603.2991.

Trimethyliodosilane (1.7 μl, 12.3 μmol) was added to a stirred solution of the diacetate (7.4 mg, 12.3 μmol) in CH_2Cl_2 (123 μl) at −30 °C. After 10 min, the reaction mixture was quenched with saturated aqueous $Na_2S_2O_3$, and extracted with EtOAc (15 ml). The extract was washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 4 : 1) to give **30** as a colorless oil (3.6 mg, 55 %).

(3*R*,4*S*,6*R*)-3,4-Diacetoxy-6-[(1*R*)-2-(*tert*-butyldiphenylsilyloxy)-1-methylethyl]-2*H*-3,4,5,6-tetrahydropyran-2-one (31) Ac_2O (65 μl) was added to a stirred solution of **26** (4.0 mg, 6.5 μmol) in pyridine (65 μl) at room temperature. After 1.5 h, the reaction mixture was diluted with EtOAc (15 ml), washed with saturated aqueous $NaHCO_3$ and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 3 : 2) to give a diacetate as a colorless oil (3.8 mg, 83%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.89 (d, 3H, *J*=7.0 Hz), 1.05 (s, 9H), 1.92—2.06 (m, 2H), 1.96 (s, 3H), 2.15 (s, 3H), 3.55—3.75 (m, 4H), 3.70 (s, 3H), 3.85 (s, 3H), 3.87 (s, 3H), 4.36 (d, 1H, *J*=11.4 Hz), 4.46 (d, 1H, *J*=11.4 Hz), 4.96 (d, 1H, *J*=2.9 Hz), 5.42 (td, 1H, *J*=2.9, 7.1 Hz), 6.79 (d, 2H, *J*=1.1 Hz), 6.88 (s, 1H), 7.32—7.43 (m, 6H), 7.62—7.66 (m, 4H). FAB-MS *m/z* (%): 695 (M^++1, 1.2), 694 (M^+, 1.4), 307 (4.1), 289 (2.4), 241 (2.3), 227 (1.4), 199 (3.6), 167 (3.4), 151 (100), 137 (15), 107 (4.4), 89 (3.1). HR-MS (FAB) *m/z* Calcd for $C_{38}H_{51}O_{10}Si$ (M^++H): 695.3252. Found: 695.3226.

DDQ (2.0 mg, 8.8 μmol) was added to a stirred solution of the diacetate (3.8 mg, 5.5 μmol) in CH_2Cl_2 (0.11 ml) at 0 °C. After 10 min at room temperature, the reaction mixture was quenched with saturated aqueous $NaHCO_3$, diluted with EtOAc (10 ml), washed with saturated aqueous NH_4Cl and brine, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was chromatographed on a silica gel column (*n*-hexane–EtOAc 2 : 3) to give a hydroxyester as a colorless oil (1.6 mg, 53%).

A solution of the hydroxyester (1.6 mg, 0.2 μmol) and CSA (0.2 mg) in benzene (0.1 ml) was stirred for 14 h at room temperature under argon. The reaction mixture was purified on TLC (*n*-hexane–EtOAc 3 : 1) to give **31** as a colorless oil (0.5 mg, 50%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.02 (d, 3H, *J*=7.0 Hz), 1.05 (s, 9H), 1.86 (m, 1H), 2.08 (s, 3H), 2.26 (s, 3H), 2.33—2.36 (m, 2H), 3.63 (dd, 1H, *J*=5.5, 10.4 Hz), 3.70 (dd, 1H, *J*=7.0, 10.4 Hz), 4.80 (ddd, 1H, *J*=2.2, 5.1, 11.9 Hz), 5.21 (ddd, 1H, *J*=1.8, 7.0, 7.3 Hz), 5.53 (d, 1H, *J*=7.0 Hz), 7.39—7.43 (m, 6H), 7.63—7.65 (m, 4H). FAB-MS *m/z* (%): 513 (M^++1, 0.8), 395 (4.8), 375 (8.1), 345 (4.2), 307 (26), 289 (13), 241 (4.8), 219 (4.1), 199 (6.5), 188 (7.9), 154 (100), 136 (72), 120 (12), 107

(18), 89 (14). HR-MS (FAB) *m/z* Calcd for $C_{28}H_{37}O_7Si$ (M^++1): 513.2309. Found: 513.2291.

(4*S*)-5-(*tert*-Butyldiphenylsilyloxy)-4-methyl-2-pentyne (32) CBr_4 (15.4 g, 46 mmol) was added to a stirred solution of Ph_3P (24.4 g, 93 mmol) in CH_2Cl_2 (250 ml) under argon. The solution was cooled to −78 °C, and a solution of **10** (11.8 g) in CH_2Cl_2 (120 ml) was added dropwise. The reaction mixture was allowed to warm to −60 °C over 2 h, then the reaction was quenched with saturated aqueous $NaHCO_3$, and the mixture was extracted with Et_2O. The extract was washed with saturated aqueous $NaHCO_3$ and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (20 : 1), to give (3*S*)-1,1-dibromo-4-(*tert*-butyldiphenylsilyloxy)-3-methyl-1-butene as a colorless oil (14.1 g, 94%). $[\alpha]_D^{21}$ +14° (*c*=0.82, $CHCl_3$). IR (neat) cm^{-1}: 1610, 1580, 1460, 1380, 1220, 1100, 1020, 780. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.04 (d, 3H, *J*=6.5 Hz), 1.06 (s, 9H), 2.64—2.75 (m, 1H), 3.52 (dd, 1H, *J*=6.0, 10.0 Hz), 3.57 (dd, 1H, *J*=6.0, 10.0 Hz), 6.27 (d, 1H, *J*=9.5 Hz), 7.35—7.47 (m, 6H), 7.64—7.70 (m, 4H). EI-MS *m/z* (%): 428 [M^+−57(*t*-Bu), 4.9], 425 (38), 315 (8.3), 263 (93), 199 (24), 181 (34), 135 (29), 105 (24), 83 (100), 57 (11). HR-MS Calcd for $C_{17}H_{17}OSiBr_2$ [M^+−57(*t*-Bu)]: 424.9395. Found: 424.9400.

A 1.63 M hexane solution of *n*-BuLi (45 ml, 73 mmol) was added dropwise to a stirred solution of the dibromoalkene (14.0 g, 29 mmol) in THF (150 ml) at −78 °C under argon. After 1 h, methyl iodide (9.0 ml, 145 mmol) was added, then the reaction mixture was allowed to warm to room temperature, and stirring was continued for 3 h. The reaction was quenched with saturated aqueous NH_4Cl, and the mixture was extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (20 : 1), to give **32** as a colorless oil (9.64 g, 98%). $[\alpha]_D^{21}$ +15° (*c*=0.84, $CHCl_3$). IR (neat) cm^{-1}: 1580, 1360, 1380, 1100, 1000, 820, 730. ^{1}H-NMR (400 MHz, $CDCl_3$) δ: 1.06 (s, 9H), 1.19 (d, 3H, *J*=7.0 Hz), 1.75 (d, 3H, *J*=2.5 Hz), 2.40—2.80 (m, 1H), 3.48 (dd, 1H, *J*=8.0, 9.5 Hz), 3.71 (dd, 1H, *J*=6.0, 9.5 Hz), 7.28—7.46 (m, 6H), 7.61—7.73 (m, 4H). EI-MS *m/z* (%): 279 [M^+−57(*t*-Bu), 100], 249 (38), 221 (69), 201 (42), 181 (25), 143 (69), 135 (27), 105 (25), 77 (15), 57 (6.3). HR-MS Calcd for $C_{18}H_{19}OSi$ [M^+−57(*t*-Bu)]: 279.1205. Found: 279.1217.

(2*E*,4*S*)-5-(*tert*-Butyldiphenylsilyloxy)-2-iodo-4-methyl-2-pentene (7a) A solution of chlorobis(cyclopentadienyl)hydridozirconium (6.1 g, 23 mmol) in benzene (20 ml) was added dropwise to a stirred solution of **32** (2.6 g, 7.7 mmol) in benzene (10 ml) at room temperature under argon. The solution was warmed to 45 °C, stirred for 4 h, and then cooled to room temperature. After dropwise addition of a solution of iodine (3.1 g, 12 mmol) in benzene (30 ml), the reaction mixture was poured into saturated aqueous $Na_2S_2O_3$, and the whole mixture was vigorously stirred for 1 h. Insoluble materials were filtered through a Celite pad and washed with Et_2O. The organic layers were washed with saturated aqueous $Na_2S_2O_3$ and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (20 : 1), to give **7a** as a pale yellow oil (1.8 g, 50%). $[\alpha]_D^{25}$ +16.3° (*c*=1.00, $CHCl_3$). IR (neat) cm^{-1}: 1630, 1580, 1460, 1380, 1240, 1100, 820, 730. ^{1}H-NMR (270 MHz, $CDCl_3$) δ: 0.97 (d, 3H, *J*=6.5 Hz), 1.05 (s, 9H), 2.33 (d, 3H, *J*=1.5 Hz), 2.55—2.65 (m, 1H), 3.43 (dd, 1H , *J*=6.5, 10.0 Hz), 3.49 (dd, 1H, *J*=6.0, 10.0 Hz), 5.96 (dq, 1H, *J*=9.5, 1.5 Hz), 7.35—7.46 (m, 6H), 7.64—7.71 (m, 4H). EI-MS *m/z* (%): 407 [M^+−57(*t*-Bu), 100], 309 (92), 249 (27), 199 (42), 181 (25), 149 (27), 135 (33), 81 (75), 69 (54), 57 (29). HR-MS Calcd for $C_{18}H_{20}OSiI$ [M^+−57(*t*-Bu)]: 407.0328. Found: 407.0306.

(2*S*,3*S*,4*R*,5*S*,6*S*,7*R*,8*E*,10*S*)-11-(*tert*-Butyldiphenylsilyloxy)-7-hydroxy-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2-methoxymethoxy-4,6,8,10-tetramethyl-8-undecen-1-yl 2,2-Dimethylpropanoate (33a) and Its C7 Isomer (33b) A 1.7 M solution of *tert*-BuLi in *n*-pentane (8.2 ml, 13.9 mmol) was added dropwise to a stirred solution of **7a** (3.06 g, 6.6 mmol) in Et_2O (66 ml) at −78 °C under argon. The solution was stirred for 1 h at −78 °C, then for 1 h at room temperature, and recooled to −78 °C. A solution of **6** (1.25 g, 2.59 mmol) in Et_2O (15 ml) was added dropwise, and then allowed to warm to −25 °C over 14 h. After addition of saturated aqueous NH_4Cl to quench the reaction, the reaction mixture was extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (2 : 1), to give a 3.6 : 1 mixture of **33a** and **33b** as a colorless oil (1.276 g, 85%). IR (neat) cm^{-1}: 3600—3300, 2975, 1730, 1520, 1460, 1265, 1165, 1115, 1030, 740, 705. FAB-MS *m/z* (%): 821 (M^++1, 12), 820 (M^+, 7.2), 763 (7.3), 337 (11), 289 (13), 239 (17), 199 (69), 165 (72), 151 (100), 137 (41), 57 (57). HR-MS Calcd for $C_{47}H_{69}O_{10}Si$ (M^++1): 821.4663. Found: 821.4646.

(2*S*,3*S*,4*R*,5*S*,6*S*,7*R*,8*E*,10*S*)-11-Hydroxy-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2,7-bis(methoxymethoxy)-4,6,8,10-tetramethyl-8-undecen-1-yl 2,2-Dimethylpropanoate (34) and (2*S*,3*S*,4*R*,5*S*,6*S*,7*S*,8*E*,10*S*)-11-Hydroxy-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2,7-bis(methoxymethoxy)-4,6,8,10-tetramethyl-8-undecen-1-yl 2,2-Dimethylpropanoate (35) Diisopropylethylamine (7.63 ml, 43.8 mmol) and MOMCl (1.73 ml, 21.9 mmol) were added to a stirred solution of **33** and its isomer (1.825 g, 2.22 mmol) in CH_2Cl_2 (10 ml) at 0 °C under argon. The solution was stirred for 5 d at room temperature, and then MeOH was added to quench the reaction. The reaction mixture was diluted with Et_2O, washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (2 : 1), to give MOM ether as a 3.6 : 1 diastereoisomeric mixture (1.904 g, 100%). IR (neat) cm^{-1}: 2950, 1730, 1515, 1460, 1265, 1160, 1110, 1030, 740, 705. FAB-MS *m/z* (%): 865 (M^++1, 21), 864 (M^+, 9.9), 807 (10), 411 (7.9), 337 (18), 289 (22), 269 (16), 239 (23), 211 (47), 165 (74), 135 (100). HR-MS Calcd for $C_{49}H_{73}O_{11}Si$ (M^++1): 865.4922. Found: 865.4955.

AcOH (750 μl, 13.1 mmol) and a 1.0 M solution of TBAF in THF (6.57 ml, 6.57 mmol) were added to a stirred solution of the above MOM ether (1.904 g, 2.19 mmol) in THF (20 ml) at 0 °C. The solution was stirred for 4 d at room temperature, then H_2O was added to quench the reaction, and the reaction mixture was extracted with Et_2O. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 2), to give **34** (1.059 g, 77%) and **35** (303 mg, 22%) as colorless oils. **34**: $[\alpha]_D^{23}$ −1.8° (*c*=0.56, $CHCl_3$). IR (neat) cm^{-1}: 3500, 2950, 2875, 1730, 1520, 1460, 1265, 1160, 1030. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.90 (d, 3H, *J*=6.5 Hz), 1.24 (d, 3H, *J*=6.5 Hz), 1.27 (s, 9H), 1.34 (d, 3H , *J*=6.5 Hz), 1.45 (s, 3H), 2.00—2.20 (m, 2H), 2.48—2.60 (m, 1H), 3.20—3.30 (m, 1H), 3.25 (s, 3H), 3.30—3.36 (m, 1H), 3.35 (s, 3H), 3.44 (s, 3H), 3.55 (s, 3H), 3.98 (dd, 1H, *J*=1.5, 9.0 Hz), 4.06 (d, 1H, *J*=1.5 Hz), 4.14 (dd, 1H, *J*=1.5, 9.0 Hz), 4.20 (dd, 1H, *J*=5.5, 12.0 Hz), 4.26—4.33 (m, 1H), 4.39 (d, 1H, *J*=6.5 Hz), 4.58 (d, 1H, *J*=6.5 Hz), 4.68 (dd, 1H, *J*=3.0, 12.0 Hz), 4.87 (d, 1H, *J*=6.5 Hz), 4.99 (d, 1H, *J*=6.5 Hz), 5.33 (d, 1H, *J*=9.5 Hz), 5.66 (s, 1H), 6.69 (d, 1H, *J*=8.0 Hz), 7.25—7.35 (m, 2H). ^{13}C-NMR (125 MHz, C_6D_6) δ: 7.38, 10.26, 14.29, 17.03, 27.32, 31.09, 35.47, 36.97, 38.92, 55.62, 55.67, 55.97, 63.85, 67.80, 75.32, 79.57, 83.04, 95.25, 97.31, 102.55, 111.01, 111.94, 119.17, 127.81, 128.29, 129.98, 132.56, 133.50, 149.98, 150.54, 177.93. FAB-MS *m/z* (%): 627 (M^++1, 98), 626 (M^+, 65), 367 (18), 325 (17), 307 (32), 289 (19), 211 (46), 166 (86), 151 (100), 136 (65). HR-MS Calcd for $C_{33}H_{55}O_{11}$ (M^++1): 627.3745. Found: 627.3733. **35**: ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.84 (d, 3H, *J*=6.5 Hz), 1.06 (d, 3H, *J*=7.0 Hz), 1.26 (d, 3H, *J*=6.5 Hz), 1.27 (s, 9H), 1.61 (s, 3H), 1.90—2.00 (m, 1H), 2.00—2.20 (m, 2H), 2.55—2.65 (m, 1H), 3.25 (s, 3H), 3.29 (d, 1H, *J*=8.5, 10.0 Hz), 3.33 (s, 3H), 3.44 (s, 3H), 3.40—3.50 (m, 1H), 3.54 (s, 3H), 3.76 (d, 1H, *J*=9.0 Hz), 4.02 (dd, 1H, *J*=1.5, 5.5 Hz), 4.10—4.20 (m, 2H), 4.23 (dd, 1H, *J*=1.0, 8.5 Hz), 4.46 (d, 1H, *J*=7.0 Hz), 4.54 (m, 1H), 4.63 (d, 1H, *J*=7.0 Hz), 4.83 (d, 1H, *J*=6.5 Hz), 4.93 (d, 1H, *J*=6.5 Hz), 5.09 (d, 1H, *J*=9.5 Hz), 5.71 (s, 1H), 6.69 (d, 1H, *J*=8.0 Hz), 7.25—7.35 (m, 2H). ^{13}C-NMR (125 MHz, C_6D_6) δ: 8.56, 12.16, 13.47, 17.18, 27.83, 35.19, 36.08, 37.94, 39.46, 56.03, 56.12, 56.42, 63.99, 68.46, 75.86, 83.40, 83.49, 88.41, 95.53, 97.56, 103.11, 111.55, 112.45, 119.70, 128.79, 133.12, 134.78, 135.45, 150.48, 151.05, 178.29.

(3*S*,4*E*,6*R*,7*S*,8*S*,9*R*,10*S*,11*S*)-12-Triethylsilyloxy-8,10-[(*S*)-3,4-dimethoxybenzylidenedioxy]-6,11-bis(methoxymethoxy)-3,5,7,9-tetramethyl-4-dodecen-2-one (4) A solution of **34** (712 mg, 1.14 mmol) in CH_2Cl_2 (10 ml) was added dropwise to a stirred solution of the Dess–Martin reagent (964 mg, 2.27 mmol) and pyridine (460 μl, 5.68 mmol) in CH_2Cl_2 (10 ml) at room temperature. The solution was stirred for 1.5 h, then saturated aqueous $NaHCO_3$ and saturated aqueous $Na_2S_2O_3$ were added to quench the reaction, and the reaction mixture was extracted with Et_2O. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (1 : 1), to give an aldehyde as a pale yellow oil (578 mg, 82%). IR (neat) cm^{-1}: 2975, 2900, 1730, 1520, 1460, 1265, 1160, 1035. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.96 (d, 3H, *J*=7.0 Hz), 1.23—1.29 (m, 15H), 1.30 (s, 3H), 1.98—2.07 (m, 1H), 2.14—2.23 (m, 1H), 2.85—2.94 (m, 1H), 3.22 (s, 3H), 3.36 (s, 3H), 3.43 (s, 3H), 3.54 (s, 3H), 3.97 (d, 1H, *J*=9.0 Hz), 4.06 (s, 1H), 4.12 (d, 1H, *J*=9.0 Hz), 4.20 (dd, 1H, *J*=5.5, 12.0 Hz), 4.28—4.36 (m, 2H), 4.50 (d, 1H, *J*=6.5 Hz), 4.70 (dd, 1H, *J*=3.0, 12.0 Hz), 4.88 (d, 1H, *J*=6.5 Hz), 4.99 (d, 1H, *J*=6.5 Hz), 5.32 (d, 1H, *J*=9.0 Hz), 5.65 (s, 1H), 6.69 (d, 1H, *J*=8.0 Hz), 7.25—7.35 (m, 2H), 9.28 (s, 1H).

A 1.5 M solution of MeLi in Et_2O (3.7 ml, 5.55 mmol) was added dropwise to a stirred solution of the aldehyde (578 mg, 0.93 mmol) in Et_2O (10 ml) at

−78 °C under argon. The solution was allowed to warm to 0 °C over 4 h. After addition of saturated aqueous NH_4Cl to quench the reaction, the reaction mixture was extracted with Et_2O. The extract was washed with saturated aqeous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with CH_2Cl_2–MeOH (15 : 1), to give a colorless oil of (2*S*,3*S*,4*R*,5*S*,6*S*,7*R*,8*E*,10*S*,11*RS*)-3,5-[(*S*)-3,4-dimethoxybenzylidenedioxy]-2,7-bis(methoxymethoxy)-4,6,8,10-tetramethyl-8-dodecene-1,11-diol (515 mg, 100%) as a 3.5 : 1 diastereoisomeric mixture. IR (neat) cm^{-1}: 3500, 2950, 1520, 1460, 1270, 1160, 1035. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.92 (d, 0.67H, J=7.0 Hz), 1.01 (d, 2.33H, J=6.5 Hz), 1.03 (d, 2.33H, J=6.0 Hz), 1.09 (d, 0.67H, J=6.0 Hz), 1.16 (d, 3H, J=6.5 Hz), 1.33 (d, 3H, J=6.0 Hz), 1.42 (s, 2.33H), 1.44 (s, 0.67H), 2.04—2.23 (m, 2H), 2.28—2.60 (m, 2H), 3.20 (s, 2.33H), 3.23 (s, 0.67H), 3.31 (s, 0.67H), 3.36 (s, 2.33H), 3.42 (s, 2.33H), 3.48 (s, 0.67H), 3.53 (s, 2.33H), 3.56 (s, 0.67H), 3.65—3.75 (m, 1H), 3.86 (d, 1H, J=11.0 Hz), 3.97—4.06 (m, 2H), 4.08 (s, 0.22H), 4.10 (s, 0.78H), 4.23 (dd, 0.78H, J=1.0, 9.0 Hz), 4.30—4.50 (m, 3.22H), 4.60 (d, 1H, J=6.5 Hz), 4.72 (d, 1H, d, J=6.0 Hz), 4.93 (d, 1H, J=6.5 Hz), 5.38 (d, 0.78H, J=10.0 Hz), 5.49 (d, 0.22H, J=10.0 Hz), 5.68 (s, 0.78H), 5.69 (s, 0.22H), 6.69 (d, 1H, J=8.0 Hz), 7.30—7.40 (m, 2H). FAB-MS *m*/*z* (%): 557 (M^++1, 21), 556 (M^+, 17), 411 (12), 338 (38), 282 (32), 259 (27), 211 (45), 151 (90), 115 (93), 69 (93), 57 (79), 45 (100). HR-MS Calcd for $C_{29}H_{49}O_{10}$ (M^++1): 557.3338. Found: 557.3310.

A 1.0 M solution of *tert*-BuOK in THF (1.11 ml, 1.11 mmol) was added dropwise to a stirred solution of the above diol (515 mg, 0.93 mmol) in THF (15 ml) at −78 °C under argon. After 15 min, triethylsilyl (TES) chloride (186 μl, 1.11 mmol) was added dropwise, and the solution was stirred for 30 min. The reaction was quenched with saturated aqueous NH_4Cl, and the reaction mixture was extracted with Et_2O. The extract was washed with saturated aqueous NH_4Cl and brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (3 : 1), to give the recovered starting material (39 mg, 7.6%) and a colorless oil of a mono alcohol (408 mg, 66%). IR (neat) cm^{-1}: 3500, 2950, 2800, 1520, 1460, 1265, 1165, 1110, 1085, 1035. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.73 (q, 6H, J=8.0 Hz), 0.91 (d, 0.86H, J=7.0 Hz), 1.00 (d, 2.14H, J=7.0 Hz), 1.01 (d, 0.86H, J=6.5 Hz), 1.02 (d, 2.14H, J=6.5 Hz), 1.10 (t, 9H, J=8.0 Hz), 1.30 (d, 3H, J=6.5 Hz), 1.34 (d, 3H, J=6.5 Hz), 1.44 (s, 3H), 2.06—2.40 (m, 3H), 3.32 (s, 0.86H), 3.34 (s, 2.14H), 3.41 (s, 3H), 3.43 (s, 3H), 3.45—3.55 (m, 1H), 3.54 (s, 3H), 3.89—4.00 (m, 2H), 4.07 (dd, 1H, J=1.5, 9.0 Hz), 4.15—4.21 (m, 1H), 4.26 (dd, 1H, J=1.5, 8.5 Hz), 4.43 (d, 0.71H, J=6.5 Hz), 4.45 (d, 0.29H, J=6.5 Hz), 4.63 (d, 0.71H, J=6.5 Hz), 4.65 (d, 0.29H, J=6.5 Hz), 4.94 (d, 0.29H, J=6.5 Hz), 4.95 (d, 0.71H, J=6.5 Hz), 5.09 (d, 0.29H, J=6.5 Hz), 5.10 (d, 0.71H, J=6.5 Hz), 5.39 (d, 0.71H, J=10.0 Hz), 5.50 (d, 0.29H, J=10.0 Hz), 5.73 (s, 1H), 6.70 (d, 1H, J=8.0 Hz), 7.30—7.40 (m, 2H). FAB-MS *m*/*z* (%): 671 (M^++1, 25), 670 (M^+, 12), 307 (35), 289 (17), 211 (22), 187 (20), 166 (29), 154 (100), 136 (67), 45 (52). HR-MS Calcd for $C_{35}H_{63}O_{10}Si$ (M^++1): 671.4190. Found: 671.4144.

A solution of the alcohol (395 mg, 0.59 mmol) in CH_2Cl_2 (5 ml) was added dropwise to a stirred solution of the Dess–Martin reagent (500 mg, 1.18 mmol) and pyridine (477 μl, 5.89 mmol) in CH_2Cl_2 (5 ml) at room temperature. The solution was stirred for 13 h, then saturated aqueous $NaHCO_3$ and saturated aqueous $Na_2S_2O_3$ were added to quench the reaction, and the reaction mixture was extracted with Et_2O. The extract was washed with brine, dried over Na_2SO_4, concentrated *in vacuo*, and chromatographed on a silica gel column, eluting with *n*-hexane–EtOAc (5 : 2), to give **4** as a colorless oil (370 mg, 94%). $[\alpha]_D^{23}$ +83° (c=0.87, $CHCl_3$). IR (neat) cm^{-1}: 2950, 2875, 1710, 1520, 1460, 1265, 1160, 1030, 760, 745. ^{1}H-NMR (500 MHz, C_6D_6) δ: 0.72 (q, 6H, J=8.0 Hz), 1.07 (d, 3H, J=7.0 Hz), 1.10 (t, 9H, J=8.0 Hz), 1.28 (d, 3H, J=6.5 Hz), 1.29 (d, 3H, J=6.5 Hz), 1.35 (s, 3H), 1.76 (s, 3H), 2.02—2.12 (m, 1H), 2.24—2.32 (m, 1H), 3.07—3.15 (m, 1H), 3.30 (s, 3H), 3.40 (s, 3H), 3.43 (s, 3H), 3.54 (s, 3H), 3.91 (dd, 1H, J=4.5, 11.0 Hz), 3.97 (dd, 1H, J=3.5, 11.0 Hz), 4.02 (dd, 1H, J=0.5, 9.5 Hz), 4.11 (br, 1H), 4.16—4.22 (m, 1H), 4.24 (dd, 1H, J=1.0, 8.5 Hz), 4.33 (d, 1H, J=7.0 Hz), 4.53 (d, 1H, J=7.0 Hz), 4.94 (d, 1H, J=6.5 Hz), 5.10 (d, 1H, J=6.5 Hz), 5.46 (d, 1H, J=10.0 Hz), 5.70 (s, 1H), 6.69 (d, 1H, J=8.0 Hz), 7.30—7.40 (m, 2H). ^{13}C-NMR (125 MHz, C_6D_6) δ: 5.28, 7.54, 8.14, 10.39, 14.86, 16.97, 27.95, 31.30, 37.30, 47.10, 56.06, 56.61, 63.63, 77.75, 78.89, 83.58, 83.69, 95.56, 97.78, 103.13, 111.43, 112.33, 119.66, 126.54, 128.79, 133.18, 135.63, 150.42, 150.95, 207.54. FAB-MS *m*/*z* (%): 669 (M^++1, 14), 668 (M^+, 21), 637 (5.4), 281 (10), 227 (20), 211 (38), 185 (27), 165 (69), 151 (100), 117 (43). HR-MS Calcd for $C_{35}H_{60}O_{10}Si$ (M^+): 668.3956. Found: 668.3976.

References and Notes

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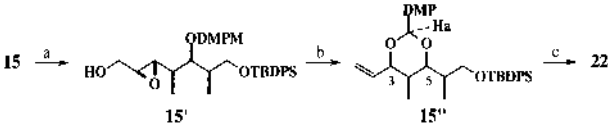

(a) 1) DIBAH; 2) (+)-DET, (*i*-PrO)$_4$Ti, TBHP. (b) 1) TsCl, TEA, DMAP; 2) NaI, $NaHCO_3$; 3) Zn, NH_4Cl; 4) DDQ. (c) OsO_4, NMO.
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4—5, 7.0; 5—6, 2.2) and **31** (J_{H-H}, Hz: 3—4, 7.0; 4—5, 2.2, 7.0; 5—6, 1.8, 9.5) probably show that both compounds have the same configuration.
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