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Total syntheses of *cis*-cyclopropane fatty acids: dihydromalvalic acid, dihydrosterculic acid, lactobacillic acid, and 9,10-methylenehexadecanoic acid†

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cis-Cyclopropane fatty acids (*cis*-CFAs) are widespread constituents of the seed oils of subtropical plants, membrane components of bacteria and protozoa, and the fats and phospholipids of animals. We describe a systematic approach to the synthesis of enantiomeric pairs of four *cis*-CFAs: *cis*-9,10-methylenehexadecanoic acid, lactobacillic acid, dihydromalvalic acid, and dihydrosterculic acid. The approach commences with $Rh_2(OAc)_4$-catalyzed cyclopropenation of 1-octyne and 1-decyne, and hinges on the preparative scale chromatographic resolution of racemic 2-alkylcycloprop-2-ene-1-carboxylic acids using a homochiral Evan's auxiliary. Saturation of the individual diastereomeric *N*-cycloprop-2-ene-1-carbonylacyloxazolidines, followed by elaboration to alkylcyclopropylmethylsulfones, allowed Julia–Kocienski olefination with various ω-aldehyde-esters. Finally, saponification and diimide reduction afforded the individual *cis*-CFA enantiomers.

Introduction

cis-Cyclopropane fatty acids (*cis*-CFAs) are widely distributed in microorganisms,[1] the seed oils of sub-tropical plants,[2] protozoa,[3] and less commonly, within fats and phospholipids produced by animals.[4] They are biosynthesized by methylenation of *cis*-unsaturated fatty acids (typically when esterified to phospholipid) with *S*-adenosylmethionine, catalyzed by CFA synthases.[5] *cis*-CFAs are common components of bacterial membrane constituents, including phospholipids and glycolipids.[1] In bacteria, *cis*-CFA synthesis peaks in late exponential/early stationary phase, and it has been speculated that this modification results in alteration of membrane fluidity that assists in adaptation to stationary phase.[1] Additionally, CFAs are chemically more stable against oxidative conditions than the unsaturated precursors, and may provide protective properties when incorporated into membrane components.[1] *cis*-CFA-containing natural products with notable biological activities include PHYLPA[6] from the slime mold *Physarium polycephalum*, GL1[7] from *Lactobacillus plantarum*, the maradolipids[8] from *Caenorhabditis elegans*, ornithine lipids from *Rhizobacterium tropici*,[9] and a lysophosphatidylcholine from the marine sponge *Spirastrella abata*.[10] Efforts to determine the structures and study the biological activity of these and other *cis*-CFA containing molecules would benefit from effective approaches to synthesize these molecules in enantiopure form.

Prominent *cis*-CFAs include those derived from: *cis*-palmitoleic acid (*cis*-Δ^9 C16:1), namely *cis*-9,10-methylenehexadecanoic acid;[11] 8*Z*-heptadecenoic acid (*cis*-Δ^8 C17:1), namely dihydromalvalic acid;[12] oleic acid (*cis*-Δ^9 C18:1), namely dihydrosterculic acid;[13] and *cis*-vaccenic acid (*cis*-Δ^{11} C18:1), namely lactobacillic acid[14] (Fig. 1). In nature, *cis*-9,10-methylenehexadecanoic acid occurs as the 9*R*,10*S* enantiomer in *Escherichia coli*[15] and the 9*S*,10*R* isomer in the slime mold *P. polycephalum*.[16] Lactobacillic acid exists as the 11*R*,12*S* isomer in *L. plantarum*,[17] *E. coli*,[15] and *Brucella melitensis*.[18] Dihydrosterculic acid has been obtained as the 9*R*,10*S* isomer from the plant *Litchi chinensis*,[19] and the 9*S*,10*R* isomer from *L. plantarum*.[17] Interestingly, 9*S*,10*R*-dihydrosterculic acid co-occurs with 11*R*,12*S*-lactobacillic acid in *L. plantarum*, and there is evidence that the same cyclopropane synthase is involved in the biosynthesis of the two pseudoenantiomers.[20] To the best of our knowledge, the stereochemistry of naturally-occurring dihydromalvalic acid has not been determined.

Several approaches to these enantioenriched and enantiopure *cis*-CFAs have been reported. Minnikin and co-workers reported the synthesis of both enantiopodes of enantiopure lactobacillic acid **4** by bidirectional elaboration of a homo-

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†Electronic supplementary information (ESI) available: Crystallographic information file for **14b**. Copies of ^{1}H and ^{13}C NMR spectra of all new compounds. CCDC 1009686. For ESI and crystallographic data in CIF or other electronic format see DOI: 10.1039/c4ob01863j

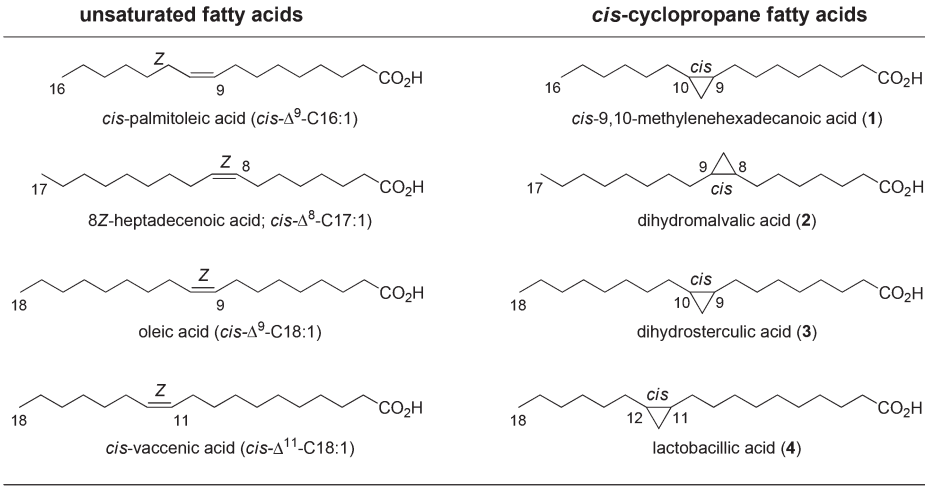


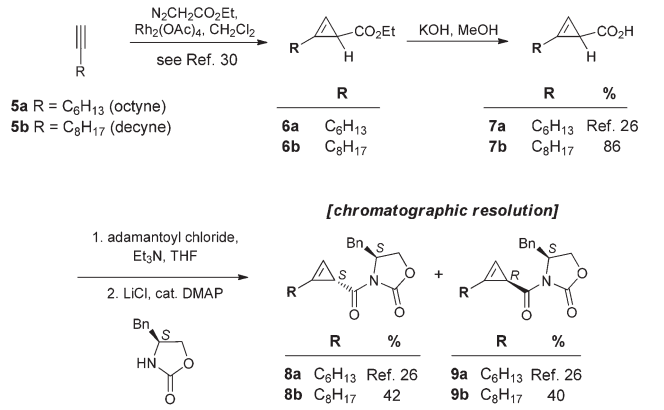
Fig. 1 Structures of *cis*-cyclopropane fatty acids **1–4** and their biogenic precursor unsaturated fatty acids.

chiral cyclopropane linchpin, which was derived from lipase-mediated desymmetrization of *cis*-cyclopropane-1,2-dimethanol or by diastereoselective Simmons–Smith cyclopropanation of a D-mannitol-derived alkene.[21,22] Kobayashi and co-workers reported a related approach to both enantiomers of *cis*-9,10-methylenehexadecanoic acid **1** involving bidirectional Wittig extension of an enzymatically-derived homochiral cyclopropa-γ-lactone.[16] Manthorpe and co-workers have reported the synthesis of enantiopure 9*R*,10*S*-dihydrosterculic acid **3** with the key step involving the Corey–Chaykovsky cyclopropanation of a homochiral alkylidene bis(sulfoxide).[23] Corey and co-workers reported the synthesis of enantioenriched 9*R*,10*S*-dihydrosterculic acid **3** in 87% ee using an enantioselective cyclopropenation with a chiral Rh^{II}-catalyst.[24] Katsuki and co-workers reported the enantioselective synthesis of the methyl ester of *cis*-9*R*,10*S*-methylenehexadecanoic acid **1** in 98% ee using a chiral Ir^{III}-salen mediated cyclopropanation.[25] Herein we report a general approach to synthesize *cis*-CFAs in enantiopure forms using a diastereomeric resolution of cyclopropenecarboxamides, originally developed by the Fox group,[26] as a key enabling step, allowing the preparation of both enantiomers of the four CFAs **1–4**.

Results and discussion

Our approach hinged on the identification of a practical entry point with one arm of the target fatty acid already installed in order to minimize the number of carbon–carbon bond forming reactions and thus total number of synthetic steps. Despite advances in enantioselective cyclopropenation[27] and cyclopropanation[28] reactions, the imperfect stereoselectivities of even the state-of-the-art methods and the complexity of catalyst synthesis dissuaded us from these approaches. Congruous with our goal to obtain enantiomeric pairs of *cis*-CFAs, our attention was drawn to the elegant work of Fox and co-workers, who reported the medium-scale chromatographic resolution of cycloprop-2-ene carboxylic acids derived from $Rh_2(OAc)_4$-catalyzed cyclopropenation of terminal alkenes.[26] Computational approaches were used to identify chiral oxazolidinones as chromatographic resolving auxiliaries based on the pronounced differences in conformation between the diastereoisomers derived from racemic cyclopropene carboxamides.

Cyclopropenation of 1-octyne **5a** or 1-decyne **5b** with ethyl diazoacetate in toluene, catalyzed by $Rh_2(OAc)_4$,[29] afforded multigram quantities of the racemic cyclopropene esters **6a**[30] and **6b**,[30] respectively (Scheme 1). Saponification (KOH–MeOH) of these esters afforded the corresponding acids **7a**[26] and **7b**, respectively, which were converted to the *N*-acyloxazolidinones, by treatment with adamantoyl chloride and Et_3N (to generate the mixed anhydride), and then with (*S*)-4-benzyl-2-oxazolidinone and LiCl.[26] As espoused by Fox, the use of adamantoyl chloride limits formation of unwanted *N*-acyloxazolidinone derived from reaction with the activating agent when pivalyl chloride is used;[26] our work is in concordance and also established the superiority of adamatoyl chloride over isobutylchloroformate. The diastereomers **8a** and **9a** (derived

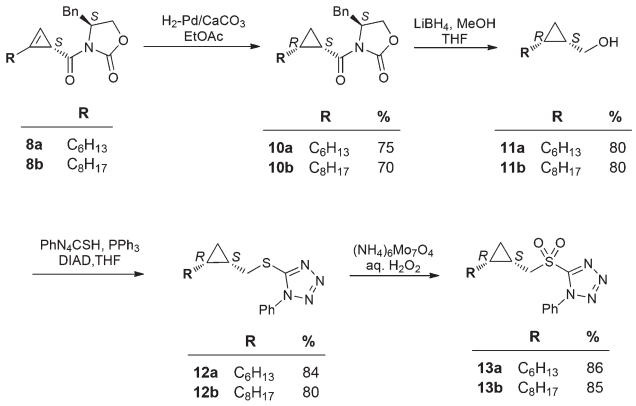


Scheme 1 Synthesis and resolution of cyclopropenecarboxamides.

from 1-octyne) were readily resolved by flash chromatography, and the stereochemistry of the individual isomers was readily assigned by direct comparison with the data reported.[26] In the case of **8b** and **9b** (derived from 1-decyne), these isomers were also readily resolved by flash chromatography; however, the assignment of stereochemistry to each isomer had to await the identification of a crystalline derivative suitable for X-ray crystallographic analysis (*vide infra*).

It has been reported that reduction of cyclopropenes can be achieved with high stereoselectivity using either diimide[31] or catalytic hydrogenation.[24,32] In the latter case, H_2/Pd-C/$CaCO_3$ [24] is preferred to avoid unwanted cyclopropane ring cleavage that occurs when using H_2/Pd-C.[33] Surprisingly, we found that in all cases investigated, reductions of **8a** or **8b** using diimide ($NH_2NH_2/CuSO_4$, $TsNHNH_2$, $KO_2CN{=}NCO_2K$) or catalytic hydrogenation (H_2/Pd-C, H_2/Pd-C/$CaCO_3$) afforded significant quantities of *trans* cyclopropanes in amounts up to 10%. The *trans*-stereochemistry of the minor components obtained from reduction of **8a** or **8b** was identified on the basis of characteristic ^1H–^1H-coupling constants (*cis*-isomer: J_{cis} = 7.8, 8.6 Hz; J_{trans} = 5.6 Hz. *trans*-isomer: J_{cis} = 8.0 Hz; J_{trans} = 4.0, 4.6 Hz). Several sources of these compounds were considered, including possible isomerisation of the cyclopropene prior to reduction, loss of stereoselectivity arising from the presence of a chiral auxiliary, or imperfect stereoselectivity of reduction. To address the first point, if isomerisation of the cycloprop-2-ene **8a** to a cycloprop-1-ene preceded reduction, the analogous reduction of the diastereoisomer **9a** should yield the enantiomer; in fact, ^1H NMR analysis revealed that the two respective *trans* isomers were diastereoisomers. To address the second point, elaboration of **8a** to 5-({[(1*S*)-2-hexylcycloprop-2-en-1-yl]methyl}sulfonyl)-1-phenyl-1*H*-tetrazole and subsequent reduction also yielded similar amounts of the corresponding *trans*-isomer. We therefore conclude that the *trans*-isomer arises from intrinsic poor stereoselectivity in the reduction. We were unable to find a literature precedent for the formation of minor amounts of *trans*-cyclopropanes by reduction of similar systems, although we note that similar transformations by others are rarely quantitative.[24,31] In practice, catalytic hydrogenation using H_2/Pd-C/$CaCO_3$ provided reproducible and satisfactory results, allowing acquisition of **10a**, **10b**, **14a** and **14b** in 70–75% yields (Schemes 2 and 3). In the case of **14b**, single crystals were obtained that were suitable for X-ray analysis (Fig. 2), allowing the stereochemistry to be defined relative to the known (*S*) configuration of the 4-benzyloxazolidinone auxiliary, and allowing stereochemical assignment of the two diastereomers **8b** and **9b** (Scheme 1).

Reduction of the octyne-derived *N*-acyloxazolidinones **10a** and **14a** with $LiBH_4$ in MeOH–THF[34] afforded the volatile alcohols **11a** and **15a**, respectively, which were converted to the phenyltetrazole sulfides **12a** and **16a** (Schemes 2 and 3). Oxidation to the sulfones **13a** and **17a**, respectively, occurred smoothly upon treatment with ammonium molybdate/H_2O_2.[35] A similar sequence of reactions on the decyne-derived *N*-acyloxazolidinones **10b** (→**11b** → **12b**) and **14b** (→**15b** → **16b**), followed by oxidation, afforded **13b** and **17b**, respectively.

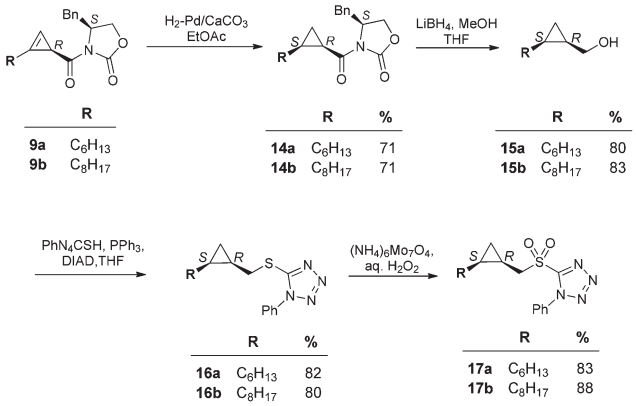


	R		R	%		R	%
8a	C_6H_{13}	**10a**	C_6H_{13}	75	**11a**	C_6H_{13}	80
8b	C_8H_{17}	**10b**	C_8H_{17}	70	**11b**	C_8H_{17}	80

	R	%
12a	C_6H_{13}	84
12b	C_8H_{17}	80

	R	%
13a	C_6H_{13}	86
13b	C_8H_{17}	85

Scheme 2 Preparation of (2*S*,3*R*)-cyclopropane sulfones **13a** and **13b**.



	R		R	%		R	%
9a	C_6H_{13}	**14a**	C_6H_{13}	71	**15a**	C_6H_{13}	80
9b	C_8H_{17}	**14b**	C_8H_{17}	71	**15b**	C_8H_{17}	83

	R	%
16a	C_6H_{13}	82
16b	C_8H_{17}	80

	R	%
17a	C_6H_{13}	83
17b	C_8H_{17}	88

Scheme 3 Preparation of (2*R*,3*S*)-cyclopropane sulfones **17a** and **17b**.

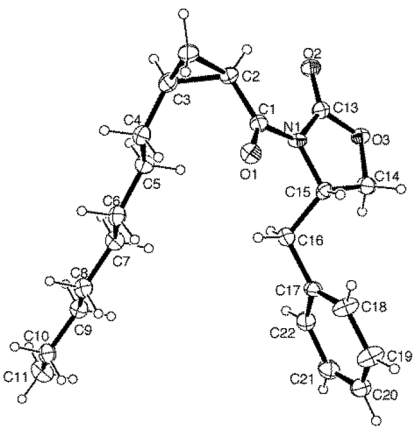
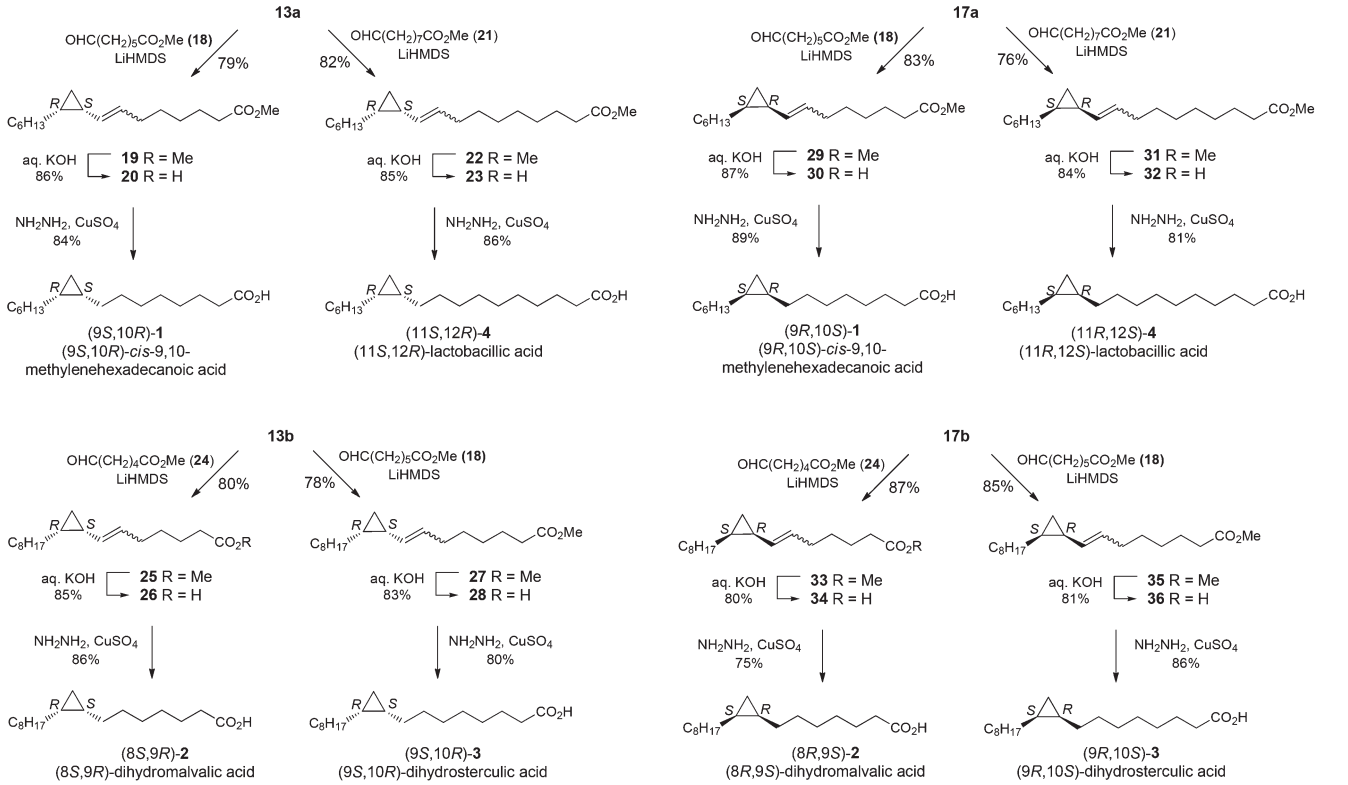


Fig. 2 ORTEP representation of the molecular structure of (2*R*,3*S*)-cyclopropanecarboxamide **14b**, determined by single-crystal X-ray crystallography. Ellipsoids are at the 30% probability level.

The stage was now set for elongation of the fragments **13a**, **13b**, **17a** and **17b** to the full length fatty acids. We illustrate the general approach by the synthesis of (9*S*,10*R*)-**1** (Scheme 4). Julia-Kocienski olefination of **18** [36] with octyne-derived sulfone **13a** in the presence of LiHMDS[37] yielded alkene **19** in 79% yield (*E*/*Z* ratio not determined). Saponification (aq. KOH) gave **20**,



Scheme 4 Synthesis of (9*S*,10*R*)-**1** and (9*R*,10*S*)-**1**; (8*S*,9*R*)-**2** and (8*R*,9*S*)-**2**; (9*S*,10*R*)-**3** and (9*R*,10*S*)-**3**; and (11*S*,12*R*)-**4** and (11*R*,12*S*)-**4**.

followed by diimide reduction afforded (9*S*,10*R*)-**1**.[38] In this reduction, we observed some formation of ring cleaved products when using $TsNHNH_2$ or $KO_2CN{=}NCO_2K$, which we attribute to high concentrations of highly reactive diimide formed by thermal decomposition of these reagents.[31] By similar logic, **13a** and **21**[39] afforded (11*S*,12*R*)-**4**. Equivalent approaches using the combinations of **13b**, **17a** and **17b** with the appropriate ω-aldehyde esters **18**,[36] **21**[39] or **24**[40] afforded the remaining enantiopure *cis*-CFAs.

Conclusions

cis-CFAs are widespread constituents of many complex molecules however access to these compounds in enantiopure form has remained challenging. We report a general route to both enantiomers of four common *cis*-CFAs employing the practicable resolution method of Fox and co-workers and utilizing cyclopropenecarboxylates as synthetic intermediates. In several cases ((8*S*,9*R*)-**2**, (8*R*,9*S*)-**2** and (9*S*,10*R*)-**3**) this work represents the first total synthesis of these *cis*-CFAs. The methods outlined in this report provide a practical means to not only access these *cis*-CFAs, but should be readily modified to allow the preparation of other straight chain *cis*-CFAs. This method thus stands as an efficient approach to acquire enantiomeric pairs of straight-chain *cis*-CFAs, which will be of particular utility in establishing the stereochemistry of natural materials by HPLC analysis.[41]

Experimental

General

Proton nuclear magnetic resonance spectra (^{1}H NMR, 400 MHz) and proton decoupled carbon nuclear magnetic resonance spectra (^{13}C NMR, 100 MHz) were obtained in deuterochloroform, with residual protonated solvent as internal standard. Chemical shifts are followed by multiplicity, coupling constant(s) (*J*, Hz), integration and assignments where possible. Flash chromatography was carried out according to the procedure of Still *et al.*[42] Analytical thin layer chromatography (t.l.c.) was conducted on aluminium-backed 2 mm thick silica gel 60 GF_{254} and chromatograms were visualized with 20% w/w ceric ammonium molybdate in ethanol. High resolution mass spectra (HRMS) were obtained by ionizing samples using electron spray ionization (ESI) and a time of flight mass analyzer. Dry THF and CH_2Cl_2 was obtained by the method of Pangborn *et al.*[43] Pet. spirits refers to petroleum ether, boiling range 40–60 °C. All other commercially available reagents were used as received. IR spectra were obtained as a thin film on a diamond-coated ZnSe attenuated total reflectance FT-IR spectrometer. The preparation of **6a**,[30] **6b**,[30] **7a**,[26] **8a**[26] and **9a**[26] have been reported previously.

2-Octylcycloprop-2-ene-1-carboxylic acid (7b). Aqueous KOH (8.5% w/v, 15 ml) was added to a solution of **6b** (1.80 g, 8.03 mmol) in methanol (15 ml) at 0 °C. The resulting mixture was stirred overnight at room temperature, concentrated to remove the methanol, acidified with conc. HCl to pH 1–3,

extracted with CH_2Cl_2, dried ($MgSO_4$), filtered and concentrated. Flash chromatography of the residue (EtOAc–pet. spirits–AcOH 20 : 79 : 1) afforded **7b** as a colorless oil (1.35 g, 86%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.32 (1 H, m), 2.48–2.51 (2 H, m), 2.12 (1 H, d, J = 1.5 Hz), 1.56–1.60 (2 H, m), 1.24–1.36 (10 H, m), 0.88 (3 H, t, J = 6.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 181.7, 115.5, 93.6, 32.0, 29.4, 29.32, 29.30, 26.7, 25.1, 22.8, 19.4, 14.2; IR (neat) ν 2926, 2855, 1687, 1420, 1368, 1279, 1236 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{12}H_{20}NaO_2$ $(M + Na)^+$ 219.1355. Found 219.1356.

(4*S*)-4-Benzyl-3-[(1*S*)-2-octylcycloprop-2-ene-1-carbonyl]oxazolidinone (8b) and (4*S*)-4-benzyl-3-[(1*R*)-2-octylcycloprop-2-ene-1-carbonyl]oxazolidinone (9b). A stirred solution of **7b** (0.352 g, 1.78 mmol) in dry THF (80 ml) at −30 °C was sequentially treated with triethylamine (0.871 ml, 6.24 mmol) then adamantoyl chloride (0.375 g, 1.87 mmol). The mixture was stirred at −30 °C for 1 h, then lithium chloride (0.381 g, 8.91 mmol), (*S*)-(−)-4-benzyl-2-oxazolidinone (0.351 g, 1.96 mmol) and DMAP (0.021 g, 0.17 mmol) were added. The reaction mixture was gradually allowed to warm to room temperature and stirring was continued overnight. The solvent was evaporated and the residue was partitioned between Et_2O and water. The aqueous layer was extracted 3 times with Et_2O. The combined organic extracts were dried ($MgSO_4$), filtered and concentrated, and the residue purified by flash chromatography (8–15% EtOAc–hexanes). First to elute: **8b** as a colorless oil (0.272 g, 42%), R_f 0.55 in 10% EtOAc–pet. spirits, run twice, $[\alpha]_D^{21}$ +103 (c 0.120, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.20–7.34 (5 H, m), 6.29 (1H, m), 4.63–4.68 (1 H, m), 4.15–4.23 (2 H, m), 3.46 (1 H, d, J = 1.6 Hz), 3.31 (1 H, dd, J = 10, 3.2 Hz,), 2.75 (1 H, dd, J = 9.6, 3.6 Hz), 2.48–2.54 (2 H, m), 1.58–1.62 (2 H, m), 1.27–1.38 (10 H, m), 0.88 (3 H, t, J = 6.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.2, 154.1, 135.7, 129.6, 129.0, 127.4, 114.3, 92.3, 66.4, 55.8, 38.2, 32.0, 29.4, 29.32, 29.30, 26.9, 25.1, 22.8, 20.1, 14.2; IR (CH_2Cl_2) ν 2927, 2856, 1778, 1686, 1455, 1368, 1275, 1260, 1078 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{22}H_{29}NNaO_3$ $(M + Na)^+$ 378.2038. Found 378.2040.

Second to elute: **9b** as a semisolid (0.251 g, 40%), R_f 0.45 in 10% EtOAc–pet. spirits, run twice. $[\alpha]_D^{26}$ +43.1 (c 0.20, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.20–7.34 (5 H, m), 6.28 (1 H, m), 4.63–4.69 (1 H, m), 4.15–4.24 (2 H, m), 3.45 (1 H, d, J = 1.6 Hz), 3.29 (1 H, dd, J = 10, 3.2 Hz), 2.78 (1 H, dd, J = 9.6, 3.6 Hz), 2.52–2.56 (2 H, m), 1.55–1.64 (2 H, m), 1.26–1.40 (10 H, m), 0.87 (3 H, t, J = 6.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.1, 154.2, 135.7, 129.6, 129.0, 127.4, 114.1, 92.6, 66.5, 55.9, 38.2, 32.0, 29.4, 29.32, 29.30, 27.0, 25.1, 22.8, 20.2, 14.2; IR (CH_2Cl_2) ν 2927, 2855, 1779, 1687, 1454, 1369, 1275, 1260 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{22}H_{29}NNaO_3$ $(M + Na)^+$ 378.2038. Found 378.2040.

General procedure for reduction of cyclopropenes

A solution of the cyclopropene in EtOAc (10 ml) was purged with hydrogen, and then 5% Pd/$CaCO_3$ (unreduced) (0.10 g per g of cyclopropene) was added. The suspension was stirred vigorously under H_2 for 2 h (until the catalyst changed color from brown to black). The reaction mixture was filtered through Celite and concentrated under reduced pressure to afford a residue.

General procedure for reductive cleavage of [cyclopropane-1-carbonyl]oxazolidinones

Methanol (1 eq.) was added to a stirred solution of [cyclopropane-1-carbonyl]oxazolidinone in dry THF (10 ml mmol^{-1}) at ice cold temperature followed by addition of $LiBH_4$ (4 eq.). The mixture was gradually warmed to room temperature and stirring was continued for further 4 h. The mixture was quenched with saturated aqueous NH_4Cl solution, extracted with Et_2O, dried ($MgSO_4$), filtered and concentrated at room temperature (at 600–800 mmHg pressure; caution, the cyclopropanecarbinols are volatile).

General procedure for Mitsunobu reactions

1-Phenyl-1*H*-tetrazole-5-thiol (1.2 eq.) was added to a stirred solution of cyclopropylmethanol in dry THF (10 ml) at 0 °C, followed by addition of PPh_3 (1.2 eq.) and powdered 4 Å molecular sieves (0.5 g). Stirring was continued for 10 min after which DIAD (1.2 eq.) was added. The reaction mixture was warmed to room temperature and stirring was continued overnight. The reaction mixture was filtered through Celite and concentrated under reduced pressure.

General procedure for molybdate oxidation of 1-phenyl-1*H*-tetrazolylsulfides

Ammonium molybdate tetrahydrate (0.05 eq.) was dissolved in stages in 30% aq. H_2O_2 (24 eq.) and added slowly to a solution of 1-phenyl-1*H*-tetrazolylsulfide dissolved in a mixture of ethanol and THF (2 : 3, 30 ml per g of sulfide). After stirring at room temperature for 2 h, additional ammonium molybdate tetrahydrate (0.05 eq.) in 30% aq. H_2O_2 (24 eq.) was added and the mixture was stirred overnight. After partial concentration, the mixture was quenched with water and extracted with dichloromethane. The combined organic layers were dried ($MgSO_4$) and evaporated to dryness.

(4*S*)-4-Benzyl-3-[(1*S*,2*R*)-2-hexylcyclopropanecarbonyl]oxazolidin-2-one (10a). The general procedure for reduction of cyclopropenes conducted with **8a** (0.702 g, 2.14 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **10a** as a colorless oil (0.540 g, 75%). $[\alpha]_D^{26}$ +87.6 (c 0.120, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.21–7.35 (5 H, m), 4.67–4.73 (1 H, m), 4.14–4.17 (2 H, m), 3.12–3.35 (1 H, dd, J = 10, 3.2 Hz), 3.08–3.14 (1H, m), 2.77 (1 H, dd, J = 10, 3.6 Hz), 1.25–1.55 (11 H, m), 1.21 (1 H, m), 1.14 (1 H, m), 0.86 (3 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.1, 154.0, 135.6, 129.6, 129.1, 127.4, 66.0, 55.6, 38.2, 32.0, 29.7, 29.1, 27.0, 24.7, 22.8, 19.1, 14.5, 14.2; IR (CH_2Cl_2) ν 2956, 2925, 2857, 1774, 1687, 1384, 1349, 1219 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{20}H_{28}NO_3$ $(M + H)^+$ 330.2064. Found 330.2085.

(4*S*)-4-Benzyl-3-[(1*S*,2*R*)-2-octylcyclopropane-1-carbonyl]oxazolidin-2-one (10b). The general procedure for reduction of cyclopropenes conducted with **8b** (1.00 g, 2.81 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **10b** as

colorless oil (0.705 g, 70%). $[\alpha]_D^{20}$ +86 (*c* 0.155, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.21–7.35 (5 H, m), 4.68–4.74 (1 H, m), 4.14–4.17 (2 H, m), 3.31 (1 H, dd, J = 10, 3.2 Hz), 3.13 (1H, ddd, J = 5.6, 7.8, 8.6 Hz), 2.77 (1 H, dd, J = 9.6, 3.6 Hz), 1.21–1.57 (15 H, m), 1.21 (1 H, ddd, J = 4.2, 5.6, 6.6 Hz), 1.14 (1 H, ddd, J = 4.2, 5.6, 6.6 Hz), 0.87 (3 H, t, J = 6.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.1, 154.0, 135.6, 129.6, 129.1, 127.4, 66.0, 55.6, 38.2, 32.0, 29.7, 29.4, 29.4, 27.0, 24.7, 22.8, 19.1, 14.5, 14.3; IR (CH_2Cl_2) ν 2923, 2854, 1775, 1687, 1455, 1384, 1349, 1241, 1208 cm^{-1}; HRMS (ESI^+) calcd for $C_{22}H_{31}NNaO_3$ $(M + Na)^+$ 380.2196. Found 380.2207.

[(1*S*,2*R*)-2-Hexylcyclopropyl]methanol (11a). The general procedure for reductive cleavage of [cyclopropane-1-carbonyl]-oxazolidinones conducted with **10a** (0.550 g, 1.67 mmol), after flash chromatography (Et_2O–*n*-pentane 15 : 85) afforded **11a** as a colorless oil (0.212 g, 80%). $[\alpha]_D^{26}$ −23.9 (*c* 0.105, $CHCl_3$) (lit.[22] = −26.1). ^1H NMR ($CDCl_3$, 400 MHz) δ 3.55–3.67 (2 H, m), 1.19–1.45 (10 H, m), 1.06–1.12 (1 H, m), 0.83–0.90 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.67–0.72 (1 H, m), −0.04 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 63.5, 32.0, 30.3, 29.8, 29.3, 28.7, 22.8, 18.3, 16.3, 14.2, 9.6; IR (CH_2Cl_2) ν 3304, 3991, 2995, 2924, 2855, 1443, 1425, 1379 cm^{-1}; HRMS (ESI^+) calcd for $C_{10}H_{20}NaO$ $(M + Na)^+$ 179.1406. Found 179.1407.

[(1*S*,2*R*)-2-Octylcyclopropyl]methanol (11b). The general procedure for reductive cleavage of [cyclopropane-1-carbonyl]-oxazolidinones conducted with **10b** (0.501 g, 1.39 mmol), after flash chromatography (Et_2O–*n*-pentane 15 : 85) afforded **11b** as a colorless oil (0.220 g, 80%). ^1H NMR ($CDCl_3$, 400 MHz) δ 3.55–3.67 (2 H, m), 1.05–1.52 (15 H, m), 0.83–0.86 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.67–0.73 (1 H, m), −0.03 (1 H, q, J = 4.8 Hz). HRMS (ESI^+) calcd for $C_{12}H_{24}NaO$ $(M + Na)^+$ 207.1719. Found 207.1719.

5-({[(1*S*,2*R*)-2-Hexylcyclopropyl]methyl}thio)-1-phenyl-1*H*-tetrazole (12a). The general procedure for Mitsunobu reactions conducted with **11a** (0.131 g, 0.832 mmol), after flash chromatography (EtOAc–hexane 1 : 9) afforded **12a** as a colorless oil (0.221 g, 84%). $[\alpha]_D^{22}$ −6.4 (*c* 0.135, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.53–7.62 (5 H, m), 3.47 (2 H, d, J = 8.0 Hz), 1.22–1.56 (11 H, m), 0.86–0.96 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.79–0.85 (1 H, m), 0.07 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 154.8, 134.0, 130.2, 129.9, 124.0, 35.2, 32.0, 30.1, 29.3, 28.6, 22.8, 18.1, 14.8, 14.2, 12.6; IR (CH_2Cl_2) ν 2954, 2924, 2854, 1499, 1409, 1384, 1219, 684 cm^{-1}; HRMS (ESI^+) calcd for $C_{17}H_{25}N_4S$ $(M + H)^+$ 317.1794. Found 317.1795.

5-({[(1*S*,2*R*)-2-Octylcyclopropyl]methyl}thio)-1-phenyl-1*H*-tetrazole (12b). The general procedure for Mitsunobu reactions conducted with **11b** (0.160 g, 0.818 mmol), after flash chromatography (EtOAc–hexane 1 : 9) afforded **12b** as colorless oil (0.242 g, 80%). $[\alpha]_D^{24}$ −4.9 (*c* 0.47, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.52–7.62 (5 H, m), 3.48 (2 H, d, J = 7.6 Hz), 1.19–1.53 (15 H, m), 0.89–0.96 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.79–0.85 (1 H, m), 0.07 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 154.1, 134.1, 129.2, 128.9, 122.9, 34.2, 31.0, 29.2, 28.7, 28.6, 28.4, 27.6, 21.8, 17.1, 13.7, 13.2, 11.6; IR (CH_2Cl_2) ν 3016, 2970, 2925, 1743, 1366, 1216, 900 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{28}N_4NaS$ $(M + Na)^+$ 367.1927. Found 367.1927.

5-({[(1*S*,2*R*)-2-Hexylcyclopropyl]methyl}sulfonyl)-1-phenyl-1*H*-tetrazole (13a). The general procedure for molybdate oxidation of 1-phenyl-1*H*-tetrazolylsulfides applied to **12a** (0.172 g, 0.537 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **13a** as a colorless liquid (0.164 g, 86%). $[\alpha]_D^{24}$ +36.3 (*c* 0.73, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.52–7.70 (5 H, m), 3.96 (1 H, dd, J = 5.6, 14.8 Hz), 3.55 (1 H, dd, J = 9.6, 14.8 Hz), 1.22–1.56 (11 H, m), 1.14–1.17 (1 H, m), 0.96–1.02 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.24 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 153.9, 133.2, 131.6, 129.8, 125.3, 57.3, 31.9, 29.7, 29.2, 22.8, 16.0, 14.2, 11.5, 8.1; IR (CH_2Cl_2) ν 2956, 2926, 2856, 1661, 1628, 1497, 1338, 1219, 1150, 686 cm^{-1}; HRMS (ESI^+) calcd for $C_{17}H_{24}N_4NaO_2S$ $(M + Na)^+$ 371.1512. Found 371.1510.

5-({[(1*S*,2*R*)-2-Octylcyclopropyl]methyl}sulfonyl)-1-phenyl-1*H*-tetrazole (13b). The general procedure for molybdate oxidation of 1-phenyl-1*H*-tetrazolylsulfides applied to **12b** (0.131 g, 0.377 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **13b** as colorless liquid (0.125 g, 85%). $[\alpha]_D^{24}$ +36.4 (*c* 0.73, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.60–7.70 (5 H, m), 3.96 (1 H, dd, J = 5.6, 14.8 Hz), 3.56 (1 H, dd, J = 9.2, 14.4 Hz), 1.22–1.47 (15 H, m), 1.26–1.19 (1 H, m), 0.98–1.02 (1 H, m), 0.87 (3 H, t, J = 6.8 Hz), 0.24 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 153.9, 132.2, 131.6, 129.8, 125.2, 57.3, 32.0, 29.8, 29.7, 29.6, 29.4, 29.2, 22.8, 16.0, 14.3, 11.5, 8.2; IR (CH_2Cl_2) ν 3016, 2970, 1738, 1743, 1366, 1217, 1228, 1150, 771 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{28}N_4NaSO_2$ $(M + Na)^+$ 399.1825. Found 399.1825.

(4*S*)-4-Benzyl-3-[(1*R*,2*S*)-2-hexylcyclopropane-1-carbonyl]oxazolidin-2-one (14a). The general procedure for reduction of cyclopropenes conducted with **9a** (0.502 g, 0.152 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **14a** as a colorless oil (0.352 g, 71%). $[\alpha]_D^{20}$ +51 (*c* 0.155, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.22–7.35 (5 H, m), 4.63–4.69 (1 H, m), 4.13–4.20 (2 H, m), 3.26 (1 H, dd, J = 10, 3.2 Hz), 3.02–3.08 (1H, m), 2.63–2.69 (1 H, dd, J = 10, 3.2 Hz), 1.17–1.56 (11 H, m), 1.10–1.21 (1 H, m), 1.12–1.21 (1 H, m), 0.85 (3 H, t, J = 6.4 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.0, 154.0, 135.7, 129.5, 129.1, 127.4, 66.1, 56.0, 38.3, 32.0, 29.9, 29.2, 27.0, 24.8, 22.8, 19.1, 14.2; IR (CH_2Cl_2) ν 2955, 2923, 2856, 1775, 1686, 1404, 1349, 1219, 1192 cm^{-1}; HRMS (ESI^+) calcd for $C_{20}H_{28}NO_3$ $(M + H)^+$ 330.2064. Found 330.2063.

(4*S*)-4-Benzyl-3-[(1*R*,2*S*)-2-octylcyclopropane-1-carbonyl]oxazolidin-2-one (14b). The general procedure for reduction of cyclopropenes conducted with **9b** (0.251 g, 0.703 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **14b** (0.18 g, 71%) as white solid, mp 62 °C; $[\alpha]_D^{25}$ +42.8 (*c* 0.47, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.21–7.35 (5 H, m), 4.63–4.69 (1 H, m), 4.13–4.20 (2 H, m), 3.32 (1 H, dd, J = 3.2, 13.2 Hz), 3.05 (1H, ddd, J = 5.6, 7.8, 8.6 Hz), 2.66 (1 H, dd, J = 10, 13.2 Hz), 1.17–1.56 (15H, m), 1.14 (1 H, ddd, J = 4.2, 7.8, 8.0 Hz), 1.10 (1 H, ddd, J = 4.2, 5.6, 6.6 Hz), 0.84 (3 H, t, J = 6.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.0, 154.0, 135.7, 129.56, 129.01, 127.4, 66.1, 56.0, 38.3, 32.0, 29.9, 29.8, 29.5,

29.4, 27.0, 24.8, 22.8, 19.1, 14.2, 14.2; IR (CH_2Cl_2) ν 2953, 2918, 2850, 1781, 1683, 1384, 1350, 1239, 1199 cm^{-1}; HRMS (ESI^+) calcd for $C_{22}H_{31}NNaO_3$ $(M + Na)^+$ 380.2196. Found 380.2196.

[(1*R*,2*S*)-2-Hexylcyclopropyl]methanol (15a). The general procedure for reductive cleavage of [cyclopropane-1-carbonyl]-oxazolidinones conducted with **14a** (0.705 g, 2.12 mmol), after flash chromatography (Et_2O–*n*-pentane 15 : 85) afforded **15a** as a colorless oil (0.310 g, 80%). $[\alpha]_D^{25}$ +22.9 (*c* 0.251, $CHCl_3$) (lit.[22] +23.1). ^1H NMR ($CDCl_3$, 400 MHz) δ 3.55–3.67 (2 H, m), 1.05–1.52 (15 H, m), 0.83–0.86 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.67–0.73 (1 H, m), −0.04 (1 H, q, J = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 63.5, 32.0, 30.3, 29.4, 28.7, 22.8, 18.3, 16.3, 14.3, 9.6; IR (CH_2Cl_2) ν 3307, 3291, 2924, 2855, 1442, 1424, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{10}H_{20}NaO$ $(M + Na)^+$ 179.1406. Found 179.1407.

[(1*R*,2*S*)-2-Octylcyclopropyl]methanol (15b). The general procedure for reductive cleavage of [cyclopropane-1-carbonyl]-oxazolidinones conducted with **14b** (0.472 g, 0.89 mmol), after flash chromatography (Et_2O–*n*-pentane 2 : 8) afforded **15b** as a colorless oil (0.205 g, 83%). ^1H NMR ($CDCl_3$, 400 MHz) δ 3.57–3.65 (2 H, m), 1.04–1.49 (15 H, m), 0.82–0.95 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.67–0.73 (1 H, m), −0.03 (1 H, q, J = 5.6 Hz). HRMS (ESI^+) calcd for $C_{12}H_{24}NaO$ $(M + Na)^+$ 207.1719. Found 207.1719.

5-({[(1*R*,2*S*)-2-Hexylcyclopropyl]methyl}thio)-1-phenyl-1*H*-tetrazole (16a). The general procedure for Mitsunobu reactions conducted with **15a** (0.332 g, 2.11 mmol), after flash chromatography (EtOAc–hexane 1 : 9) afforded **16a** as a colorless oil (0.554 g, 82%). $[\alpha]_D^{20}$ +6 (*c* 0.155, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.53–7.61 (5 H, m), 3.47 (2 H, d, J = 8.0 Hz), 1.27–1.58 (11 H, m), 0.86–0.96 (1 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.79–0.83 (1 H, m), 0.07 (1 H, q, J = 5.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 154.8, 133.9, 130.2, 129.9, 124.0, 35.2, 32.0, 30.1, 29.3, 28.6, 22.8, 18.1, 14.8, 14.2, 12.6; IR (CH_2Cl_2) ν 2955, 2924, 2854, 1499, 1384, 1219, 684 cm^{-1}; HRMS (ESI^+) calcd for $C_{17}H_{24}N_4NaS$ $(M + H)^+$ 317.1794. Found 317.1795.

5-({[(1*R*,2*S*)-2-Octylcyclopropyl]methyl}thio)-1-phenyl-1*H*-tetrazole (16b). The general procedure for Mitsunobu reactions conducted with **15b** (0.201 g, 0.851 mmol), after flash chromatography (EtOAc–hexane 1 : 9) afforded **16b** as colorless oil (0.272 g, 80%). $[\alpha]_D^{25}$ +4.2 (*c* 0.57, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.51–7.61 (5 H, m), 3.47 (2 H, d, J = 7.6 Hz), 1.19–1.57 (15 H, m), 0.91–0.96 (1 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.79–0.83 (1 H, m), 0.06 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 154.8, 134.0, 130.2, 129.9, 124.0, 35.2, 32.0, 30.2, 29.8, 29.7, 29.5, 28.6, 22.8, 18.1, 14.8, 14.3, 12.6; IR (CH_2Cl_2) ν 3066, 2923, 2853, 1597, 1499, 1385, 1244, 1014, 758 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{29}N_4S$ $(M + H)^+$ 345.2107. Found 345.2113.

5-({[(1*R*,2*S*)-2-Hexylcyclopropyl]methyl}sulfonyl)-1-phenyl-1*H*-tetrazole (17a). The general procedure for molybdate oxidation of 1-phenyl-1*H*-tetrazolylsulfides applied to **16a** (0.331 g, 1.04 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **17a** as a colorless liquid (0.305 g, 83%). $[\alpha]_D^{21}$ −36.2 (*c* 0.095, $CHCl_3$), (lit.[25] −36.9). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.58–7.70 (5 H, m), 3.96 (1 H, dd, J = 5.6, 14.4 Hz), 3.56 (1 H, dd, J = 9.2, 14.4 Hz), 1.14–1.45 (11 H, m), 0.97–1.02 (1 H, m), 0.89 (3 H, t, J = 6.4 Hz), 0.24 (1 H, q, J = 5.6 Hz), 0.07 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 153.9, 133.2, 131.6, 129.8, 125.3, 57.3, 31.9, 29.7, 29.2, 22.8, 16.0, 14.2, 11.5, 8.1; IR (CH_2Cl_2) ν 3609, 2956, 2925, 2856, 1497, 1461, 1338, 1219, 1149, 770, 687 cm^{-1}; HRMS (ESI^+) calcd for $C_{17}H_{24}N_4NaO_2S$ $(M + Na)^+$ 371.1512. Found 371.1512.

5-({[(1*R*,2*S*)-2-Octylcyclopropyl]methyl}sulfonyl)-1-phenyl-1*H*-tetrazole (17b). The general procedure for molybdate oxidation of 1-phenyl-1*H*-tetrazolylsulfides applied to **16b** (0.232 g, 0.661 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **17b** as colorless liquid (0.222 g, 88%). $[\alpha]_D^{26}$ −38.2 (*c* 0.13, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 7.60–7.70 (5 H, m), 3.96 (1 H, dd, J = 5.6, 14.8 Hz), 3.56 (1 H, dd, J = 9.2, 14.4 Hz), 1.22–1.47 (15 H, m), 1.26–1.19 (1 H, m), 0.98–1.02 (1 H, m), 0.87 (3 H, t, J = 6.8 Hz), 0.24 (1 H, q, J = 5.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 154.0, 133.3, 131.7, 129.9, 125.4, 57.3, 32.1, 29.9, 29.8, 29.7, 29.5, 29.3, 22.9, 16.1, 14.3, 11.6, 8.2; IR (CH_2Cl_2) ν 2924, 2854, 2361, 2359, 2320, 1738, 1743, 1366, 1217, 1228 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{29}N_4SO_2$ $(M + H)^+$ 377.2006. Found 377.2018.

General procedure for Julia–Kocienski olefination

LiHDMS in THF (1 M, 1.2 eq.) was added to a solution of sulfone in dry THF (15 ml per g of sulfone) cooled to −78 °C. After stirring for 10 min, a solution of aldehyde (1.2 eq.) in dry THF (10 ml per g of aldehyde) was added at −78 °C. The reaction was gradually warmed to room temperature and stirring was continued overnight. The reaction mixture was quenched with sat. aq. ammonium chloride, extracted in 1 : 1 Et_2O–pet. spirits, washed with water, dried ($MgSO_4$) and concentrated.

General procedure for saponification

A solution of KOH (3 eq.) in H_2O (20 ml per g of ester) was added to a solution of ester in THF (2 ml per g of ester) and methanol (2 ml per g of ester) at 0 °C. The resulting mixture was gradually warmed to room temperature and stirring was continued overnight. The solvent was evaporated under reduced pressure, and the residue obtained was acidified with 0.5 M citric acid, extracted with Et_2O, dried ($MgSO_4$), filtered and concentrated.

General procedure for diimide reduction

Hydrazine monohydrate (1.60 ml) was added to a solution of alkene in ethanol (5 ml). Aliquots of a saturated aqueous solution of $CuSO_4$ (total amount 0.16 ml) were added daily for 5 d until ^1H-NMR analysis of an aliquot of the reaction mixture showed complete consumption of the starting material. The reaction mixture was quenched with 2 N HCl, extracted several times in Et_2O, dried ($MgSO_4$) and concentrated.

Methyl 8-[(1*S*,2*R*)-2-hexylcyclopropyl]oct-7-enoate (19). The general procedure for Julia–Kocienski olefination applied to **13a** (0.305 g, 0.862 mmol) and methyl 7-oxaheptanoate (**18**)[36] (0.163 g, 1.03 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **19** (0.191 g, 79%). $[\alpha]_D^{24}$ −34.9 (*c* 0.505, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.49 (0.7 H, m),

5.31–5.38 (0.3 H, m), 5.10–5.16 (0.7 H, m), 4.97–5.02 (0.3 H, m), 3.62 (3 H, s), 2.24–2.29 (2 H, m), 2.08–2.14 (0.6 H, m), 1.96 (1.4 H, q, J = 6.8 Hz), 1.55–1.64 (2 H, m), 1.20–1.39 (18 H, m), 0.72–0.88 (1.3 H, m), 0.84 (3 H, t, J = 6.8 Hz), 0.03–0.09 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.2, 130.0, 129.9, 129.9, 51.6, 34.3, 34.2, 32.7, 32.0, 29.9, 29.8, 29.6, 29.5, 29.4, 29.3, 29.0, 28.8, 27.5, 25.0, 22.8, 18.6, 18.5, 14.3, 14.3, 14.1, 12.5; IR (CH_2Cl_2) ν 2924, 2854, 1741, 1436, 1219 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{18}H_{33}O_2$ $(M + H)^+$ 281.2475. Found 281.2494.

(9*S*,10*R*)-*cis*-Methylenehexadecanoic acid ((9*S*,10*R*)-1)

*8-((1S,2R)-2-Hexylcyclopropyl)oct-7-enoic acid (**20**).* The general procedure for saponification applied to **19** (0.102 g, 0.361 mmol) afforded crude **20** (0.081, 86%). $[\alpha]_D^{24}$ −36.8 (c 0.405, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.14–5.20 (0.7 H, m), 5.01–5.06 (0.3 H, m), 2.33–2.37 (2 H, m), 2.14–2.16 (0.6 H, m), 2.01 (1.4 H, q, J = 6.8 Hz), 1.59–1.69 (2 H, m), 1.59–1.69 (0.3 H, m), 1.20–1.43 (16.7 H, m), 0.76–0.94 (1.3 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 179.2, 130.1, 130.0, 129.8, 34.0, 34.0, 32.6, 32.0, 29.9, 29.8, 29.6, 29.5, 29.4, 29.3, 28.9, 28.7, 27.4, 24.8, 24.7, 22.8, 18.7, 18.6, 18.5, 14.3, 14.3, 14.1, 12.5; IR (CH_2Cl_2) ν 2924, 2854, 1707, 1412, 1219 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{17}H_{31}O_2$ $(M + H)^+$ 267.2319. Found 267.2338.

(9S,10R)-cis-Methylenehexadecanoic acid ((9S,10R)-1). The general procedure for diimide reduction applied to **20** (0.079 g, 0.296 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **(9*S*,10*R*)-1** (0.073 g, 84%). $[\alpha]_D^{25}$ −1.63 (c 0.23, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.35 (2 H, t, J = 6.7 Hz), 1.60–1.65 (2 H, m), 1.10–1.36 (20 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.61–0.67 (2 H, m), 0.53–0.58 (1 H, m), −0.33 (1 H, q, J = 5.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 179.7, 34.0, 31.9, 30.1, 30.1, 29.4, 29.3, 29.2, 29.0, 28.7, 28.6, 24.6, 22.7, 15.7, 15.7, 14.1, 10.1; IR (CH_2Cl_2) ν 2922, 2853, 1708, 1457, 1284, 1412 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{17}H_{33}O_2$ $(M + H)^+$ 269.2475. Found 269.2475.

Methyl 10-((1*S*,2*R*)-2-hexylcyclopropyl)dec-9-enoate (22). The general procedure for Julia–Kocienski olefination applied to **13a** (0.081 g, 0.23 mmol) and methyl 7-oxanonanoate (**21**)[39] (0.051 g, 0.28 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **22** (0.061 g, 82%). $[\alpha]_D^{25}$ −32.3 (c 0.79, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.46–5.53 (0.7 H, m), 5.35–5.42 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.00–5.05 (0.3 H, m), 3.66 (3 H, s), 2.27–2.32 (2 H, m), 2.10–2.18 (0.6 H, m), 1.98 (1.4 H, q, J = 6.4 Hz), 1.59–1.63 (2 H, m), 1.26–1.41 (20 H, m), 0.75–1.07 (1.3 H, m), 0.87 (3 H, t, J = 6.8 Hz), 0.07–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.1, 130.0, 129.9, 129.8, 51.5, 34.2, 32.6, 32.0, 29.9, 29.8, 29.72, 29.71, 29.52, 29.51, 29.4, 29.3, 28.7, 27.4, 24.9, 22.8, 18.6, 18.4, 14.2, 14.0, 12.5; IR (CH_2Cl_2) ν 2924, 2854, 1741, 1436, 1365, 1219 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{20}H_{37}O_2$ $(M + H)^+$ 309.2788. Found 309.2809.

(11*S*,12*R*)-Lactobacillic acid ((11*S*,12*R*)-4)

*10-((1S,2R)-2-Hexylcyclopropyl)dec-9-enoic acid (**23**).* The general procedure for saponification applied to **22** (0.052 g, 0.36 mmol) afforded crude **23** (0.042 g, 85%). $[\alpha]_D^{25}$ −36.5 (c 0.40, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.46–5.53 (0.7 H, m), 5.36–5.42 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.00–5.05 (0.3 H, m), 2.32–2.37 (2 H, m), 2.10–2.16 (0.6 H, m), 1.99 (1.4 H, q, J = 6.4 Hz), 1.53–1.65 (2 H, m), 1.27–1.43 (21 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.3, 130.4, 130.2, 129.8, 129.8, 33.9, 32.8, 32.0, 29.9, 29.8, 29.6, 29.4, 29.3, 29.21, 29.20, 29.1, 27.6, 24.9, 22.8, 18.6, 18.4, 14.3, 14.1, 12.5; IR (CH_2Cl_2) ν 2923, 2854, 1707, 1412, 1278, 1219, 959 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{35}O_2$ $(M + H)^+$ 295.2632. Found 295.2656.

(11S,12R)-Lactobacillic acid ((11S,12R)-4). The general procedure for diimide reduction applied to **23** (0.042 g, 0.30 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **(11*S*,12*R*)-4** (0.032 g, 86%). $[\alpha]_D^{26}$ −0.61 (c 0.25, $CHCl_3$), (lit.[22] −0.31). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.43 (2 H, t, J = 7.6 Hz), 1.62–1.68 (2 H, m), 1.25–1.37 (22 H, m), 1.10–1.17 (2 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.64–0.68 (2 H, m), 0.53–0.59 (1 H, m), −0.33 (1 H, q, J = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 179.3, 34.0, 32.1, 30.4, 30.3, 29.9, 29.8, 29.6, 29.5, 29.4, 29.2, 28.94, 28.91, 24.8, 22.9, 15.92, 15.90, 14.3, 11.1; IR (CH_2Cl_2) ν 2923, 2854, 1740, 1365, 1217 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{37}O_2$ $(M + H)^+$ 296.2788. Found 297.2786. The ^{1}H and ^{13}C NMR data reported here differs from those previously reported.[22]

Methyl 7-[(1*S*,2*R*)-2-octylcyclopropyl]hept-6-enoate (25). The general procedure for Julia–Kocienski olefination applied to **13b** (0.0821 g, 0.319 mmol) and methyl 6-oxohexanoate (**24**)[40] (0.055 g, 0.383 mmol) after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **25** (0.062 g, 80%). $[\alpha]_D^{24}$ −35.2 (c 0.21, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.15–5.21 (0.7 H, m), 5.02–5.07 (0.3 H, m), 3.66 (3 H, s), 2.28–2.34 (2 H, m), 2.16 (0.6 H, q, J = 7.2 Hz), 2.02 (1.4 H, q, J = 6.8 Hz), 1.59–1.71 (2 H, m), 1.16–1.44 (18 H, m), 0.76–0.94 (1.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.3, 130.3, 130.2, 129.7, 129.5, 51.6, 34.12, 34.10, 32.5, 32.1, 29.9, 29.8, 29.7, 29.6, 29.5, 29.4, 29.3, 24.7, 24.6, 22.8, 18.6, 18.5, 18.4, 14.3, 12.5; IR (CH_2Cl_2) ν 2992, 2924, 2854, 1742, 1457, 1436, 1200, 1168 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{34}NaO_2$ $(M + Na)^+$ 317.2451. Found 317.2451.

8*S*,9*R*-Dihydromalvalic acid ((8*S*,9*R*)-2)

*7-[(1S,2R)-2-Octylcyclopropyl]hept-6-enoic acid (**26**).* The general procedure for saponification applied to **25** (0.055 g, 0.17 mmol) afforded crude **26** (0.041 g, 85%). $[\alpha]_D^{24}$ −31.7 (c 0.14, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.15–5.21 (0.7 H, m), 5.03–5.08 (0.3 H, m), 2.33–2.39 (2 H, m), 2.18 (0.6 H, q, J = 7.2 Hz), 2.03 (1.4 H, q, J = 7.2 Hz), 1.63–1.69 (2 H, m), 1.26–1.63 (18 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.09–0.13 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.7, 130.4, 130.3, 129.6, 129.4, 33.7, 33.6, 32.4, 32.1, 29.9, 29.8, 29.7, 29.6, 29.5, 29.3, 29.3, 27.2, 24.5, 24.3, 22.9, 18.7, 18.6, 18.5, 14.4, 14.3, 14.1, 12.6; IR (CH_2Cl_2) ν 2923, 2854, 1740, 1365, 1217 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{18}H_{32}NaO_2$ $(M + Na)^+$ 303.2294. Found 303.2295.

8S,9R-Dihydromalvalic acid (8S,9R-2). The general procedure for diimide reduction applied to **26** (0.035 g, 0.13 mmol), after

flash chromatography (EtOAc–hexane 20 : 80) yielded **(8*S*,9*R*)-2** (0.026 g, 86%). $[\alpha]_D^{25}$ −0.77 (*c* 0.32, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.35 (2 H, t, J = 7.6 Hz), 1.62–1.66 (2 H, m), 1.27–1.38 (20 H, m), 1.12–1.14 (2 H, m), 0.88 (3 H, t, J = 7.2 Hz), 0.60–0.69 (2 H, m), 0.53–0.58 (1 H, m), −0.33 (1 H, q, J = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 179.7, 34.1, 32.1, 30.4, 30.1, 29.8, 29.5, 29.4, 29.3, 289, 28.8, 24.9, 22.9, 15.9, 15.9, 14.3, 11.1; IR (CH_2Cl_2) ν 2970, 2924, 2854, 1738, 1456, 1366, 1228, 1217 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{18}H_{34}NaO_2$ $(M + Na)^+$ 305.2451. Found 305.2451.

Methyl 8-[(1*S*,2*R*)-2-octylcyclopropyl]oct-7-enoate (27). The general procedure for Julia–Kocienski olefination applied to **13b** (0.102 g, 0.265 mmol) and methyl 7-oxoheptanoate (**18**)[36] (0.0512 g, 0.319 mmol) after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **27** (0.074 g, 78%). $[\alpha]_D^{26}$ −36.0 (*c* 0.45, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.53 (0.7 H, m), 5.36–5.42 (0.3 H, m), 5.14–5.20 (0.7 H, m), 5.01–5.06 (0.3 H, m), 3.66 (3 H, s), 2.28–2.33 (2 H, m), 2.12–2.17 (0.6 H, m), 1.98–3.04 (1.4 H, q, J = 6.4 Hz), 1.58–1.65 (2 H, m), 1.26–1.43 (19 H, m), 0.76–0.91 (2.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.2, 130.02, 130.01, 129.9, 51.6, 34.2, 32.7, 32.1, 29.9, 29.84, 29.83, 29.7, 29.6, 29.52, 29.50, 29.3, 28.8, 25.0, 22.9, 18.6, 18.5, 14.32, 14.31, 12.5; IR (CH_2Cl_2) ν 2970, 2923, 2854, 1740, 1436, 1365, 1217, 1228, 1204 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{20}H_{36}NaO_2$ $(M + Na)^+$ 331.2607. Found 331.2608.

(9*S*,10*R*)-Dihydrosterculic acid ((9*S*,10*R*)-3)

*8-[(1S,2R)-2-Octylcyclopropyl]oct-7-enoic acid (**28**).* The general procedure for saponification applied to **27** (0.071 g, 0.24 mmol) afforded crude **28** (0.052 g, 83%). $[\alpha]_D^{26}$ −37.6 (*c* 0.21, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.53 (0.7 H, m), 5.36–5.42 (0.3 H, m), 5.14–5.20 (0.7 H, m), 5.01–5.06 (0.3 H, m), 3.66 (3 H, s), 2.28–2.33 (2 H, m), 2.12–2.17 (0.6 H, m), 1.98–3.04 (1.4 H, q, J = 6.4 Hz), 1.58–1.65 (2 H, m), 1.26–1.43 (17 H, m), 0.76–0.91 (2.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.7, 130.2, 130.1, 129.9, 33.8, 32.7, 32.2, 30.0, 29.92, 29.91, 29.8, 29.7, 29.6, 29.4, 28.9, 28.8, 27.5, 24.8, 24.8, 22.9, 18.71, 18.70, 18.5, 14.4, 14.4, 14.2, 12.6; IR (CH_2Cl_2) ν 2970, 2924, 2854, 1713, 1455, 1365, 1228, 1217 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{34}NaO_2$ $(M + Na)^+$ 317.2451. Found 317.2451.

*(9S,10R)-Dihydrosterculic acid ((9S,10R)-**3**).* The general procedure for diimide reduction applied to **28** (0.050 g, 0.17 mmol), after flash chromatography (EtOAc–hexane–AcOH 20 : 80 : 1) gave **(9*S*,10*R*)-3** as a white solid (0.042 g, 80%). $[\alpha]_D^{24}$ −0.81 (*c* 0.295, $CHCl_3$). ^{1}H NMR ($CDCl_3$ + 1% TFA, 400 MHz) δ 2.43 (2 H, t, J = 7.6 Hz), 1.62–1.68 (2 H, m), 1.25–1.37 (22 H, m), 1.10–1.17 (2 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.64–0.68 (2 H, m), 0.53–0.59 (1 H, m), −0.33 (1 H, q, J = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.7, 34.1, 32.1, 30.4, 30.3, 29.8, 29.6, 29.5, 29.4, 29.2, 28.9, 28.8, 24.9, 22.9, 15.9, 15.9, 14.3, 11.1; IR (CH_2Cl_2) ν 3016, 2970, 2925, 2854, 1738, 1436, 1366, 1229, 1217 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{36}NaO_2$ $(M + Na)^+$ 319.2608. Found 319.2608.

Methyl 8-[(1*R*,2*S*)-2-hexylcyclopropyl]oct-7-enoate (29). The general procedure for Julia–Kocienski olefination applied to **17a** (0.101 g, 0.520 mmol) and methyl 7-oxaheptanoate (**18**)[36] (0.091 g, 0.62 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **29** (0.122 g, 83%). $[\alpha]_D^{22}$ +35.6 (*c* 0.190, $CHCl_3$) (lit.[25] +31.6). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.01–5.06 (0.3 H, m), 3.66 (3 H, s), 2.28–2.33 (2 H, m), 2.12–2.17 (0.6 H, m), 2.01 (1.4 H, q, J = 6.8 Hz), 1.58–1.65 (2 H, m), 1.23–1.42 (18 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.06–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.1, 130.0, 129.9, 129.8, 51.5, 34.2, 32.6, 32.0, 29.8, 29.7, 29.6, 29.5, 29.4, 29.3, 28.9, 28.7, 27.4, 25.0, 24.9, 22.8, 18.5, 18.4, 14.3, 14.2, 14.1, 12.5; IR (CH_2Cl_2) ν 2989, 2924, 2855, 1741, 1543, 1437, 1219, 1168 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{18}H_{32}NaO_2$ $(M + Na)^+$ 303.2294. Found 303.2294.

(9*R*,10*S*)-*cis*-Methylenehexadecanoic acid ((9*R*,10*S*)-1)

*8-[(1R,2S)-2-Hexylcyclopropyl]oct-7-enoic acid (**30**).* The general procedure for saponification applied to **29** (0.125 g, 0.446 mmol) afforded crude **30** (0.103 g, 87%). $[\alpha]_D^{23}$ +32.5 (*c* 0.34, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.14–5.20 (0.7 H, m), 5.01–5.06 (0.3 H, m), 2.32–2.37 (2 H, m), 2.13–2.17 (0.6 H, m), 2.00 (1.4 H, q, J = 6.8 Hz), 1.66–1.67 (1 H, m), 1.52–1.56 (1 H, m), 1.20–1.43 (16 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, J = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.8, 130.1, 130.0, 129.8, 33.9, 33.9, 32.6, 32.0, 29.8, 29.7, 29.5, 29.4, 29.3, 29.3, 28.8, 28.6, 27.4, 24.7, 22.8, 18.6, 18.5, 18.4, 14.3, 14.2, 14.0, 12.5; IR (CH_2Cl_2) ν 2923, 2854, 1708, 1456, 1412, 1219, 959 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{17}H_{31}O_2$ $(M + H)^+$ 267.2319. Found 267.2340.

*(9R,10S)-cis-Methylenehexadecanoic acid ((9R,10S)-**1**).* The general procedure for diimide reduction applied to **30** (0.08 g, 0.30 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **(9*R*,10*S*)-1** (0.092 g, 89%). $[\alpha]_D^{20}$ +0.86 (*c* 0.155, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.35 (2 H, t, J = 7.6 Hz), 1.60–1.65 (2 H, m), 1.12–1.36 (20 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.64–0.67 (2 H, m), 0.53–0.58 (1 H, m), −0.33 (1 H, q, J = 5.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.6, 34.0 32.1, 30.3, 30.2, 29.8, 29.6, 29.5, 29.4, 29.2, 28.9, 28.8, 25.0, 22.8, 15.9, 15.8, 14.2, 11.1; IR (CH_2Cl_2) ν 2922, 2853, 1708, 1458, 1412, 1284, 937 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{17}H_{33}O_2$ $(M + H)^+$ 269.2475. Found 269.2475.

Methyl 10-[(1*R*,2*S*)-2-hexylcyclopropyl]dec-9-enoate (31). The general procedure for Julia–Kocienski olefination applied to **17a** (0.152 g, 0.431 mmol) and methyl 9-oxanonanoate (**21**)[39] (0.091 g, 0.52 mmol), after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **31** (0.115 g, 76%). $[\alpha]_D^{24}$ +31.3 (*c* 0.35, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 5.46–5.53 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.00–5.05 (0.3 H, m), 3.66 (3 H, s), 2.27–2.31 (2 H, m), 2.10–2.15 (0.6 H, m), 1.98 (1.4 H, q, J = 6.8 Hz), 1.57–1.63 (2 H, m), 1.26–1.42 (20 H, m), 0.75–0.9 (1.3 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.5, 130.5, 130.2, 129.8, 129.7, 51.5, 34.2, 32.8, 32.0, 29.8, 29.8, 29.7, 29.5, 29.33, 29.30, 29.24, 29.21, 29.0, 27.6, 2.1, 22.8, 18.6, 18.5, 18.4, 14.32, 14.31, 14.1, 12.5; IR (CH_2Cl_2) ν 2989, 2924, 2854, 1741, 1542, 1437,

1377, 1219, 1170, 673 cm^{-1}; HRMS (ESI^+) calcd for $C_{20}H_{36}NaO_2$ $(M + Na)^+$ 331.2608. Found 331.2608.

(11*R*,12*S*)-Lactobacillic acid ((11*R*,12*S*)-4)

*10-[(1R,2S)-2-Hexylcyclopropyl]dec-9-enoic acid (**32**).* The general procedure for saponification applied to **31** (0.102 g, 0.324 mmol) afforded crude **32** (0.082 g, 84%). $[\alpha]_D^{23}$ +36.8 (*c* 0.3, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.46–5.53 (0.7 H, m), 5.36–5.42 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.00–5.05 (0.3 H, m), 2.32–2.36 (2 H, m), 2.10–2.16 (0.6 H, m), 1.99 (1.4 H, q, *J* = 6.8 Hz), 1.52–1.66 (2 H, m), 1.20–1.43 (20 H, m), 0.76–0.92 (1.3 H, m), 0.87 (3 H, t, *J* = 6.8 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.9, 130.4, 130.1, 129.8, 129.7, 33.9, 32.8, 32.0, 29.9, 29.82, 29.80, 29.6, 29.4, 29.32, 29.30, 29.2, 29.1, 29.0, 27.6, 24.8, 22.8, 18.61, 18.60, 18.4, 14.3, 14.2, 14.0, 12.5; IR (CH_2Cl_2) ν 2923, 2854, 1708, 1457, 1412, 1285, 959 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{35}O_2$ $(M + H)^+$ 295.2632. Found 295.2654.

*(11R,12S)-Lactobacillic acid ((11R,12S)-**4**).* The general procedure for diimide reduction applied to **32** (0.080 g, 0.27 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **(11*R*,12*S*)-4** (0.062 g, 81%). $[\alpha]_D^{20}$ +0.94 (*c* 0.155, $CHCl_3$) (lit.[22] +0.16; lit.[44] +0.25). ^1H NMR ($CDCl_3$, 400 MHz) δ 2.35 (2 H, t, *J* = 7.6 Hz), 1.61–1.65 (2 H, m), 1.25–1.37 (22 H, m), 1.10–1.17 (2 H, m), 0.88 (3 H, t, *J* = 6.8 Hz), 0.64–0.68 (2 H, m), 0.53–0.59 (1 H, m), −0.33 (1 H, q, *J* = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 180.1, 34.2, 32.1, 30.4, 30.3, 29.9, 29.8, 29.6, 29.5, 29.4, 29.2, 28.9, 24.8, 22.9, 15.9, 15.9, 14.3, 11.1; IR (CH_2Cl_2) ν 2923, 2854, 1708, 1412, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{36}O_2$ $(M + H)^+$ 297.2788. Found 297.2788. The ^1H and ^{13}C NMR data reported here differs from those previously reported.[22]

Methyl 7-[(1*R*,2*S*)-2-octylcyclopropyl]hept-6-enoate (33). The general procedure for Julia–Kocienski olefination applied to **17b** (0.062 g, 0.15 mmol) and methyl 6-oxohexanoate (**24**)[40] (0.0412 g, 0.191 mmol) after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **33** (0.042 g, 87%). $[\alpha]_D^{24}$ +33.3 (*c* 0.25, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.15–5.21 (0.7 H, m), 5.00–5.07 (0.3 H, m), 3.66 (3 H, s), 2.28–2.34 (2 H, m), 2.13–2.17 (0.6 H, q, *J* = 7.2 Hz), 2.02 (1.4 H, q, *J* = 6.4 Hz), 1.59–1.71 (2 H, m), 1.21–1.46 (18 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, *J* = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.3, 130.2, 129.8, 129.5, 51.6, 34.1, 32.5, 32.1, 29.9, 29.8, 29.7, 29.6, 29.5, 29.4, 29.3, 27.3, 24.6, 22.9, 18.6, 18.5, 14.3, 14.1, 12.6; IR (CH_2Cl_2) ν 2923, 2854, 1742, 1436, 1365, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{35}O_2$ $(M + H)^+$ 295.2632. Found 295.2650.

(8*R*,9*S*)-Dihydromalvalic acid ((8*R*,9*S*)-2)

*7-[(1R,2S)-2-Octylcyclopropyl]hept-6-enoic acid (**34**).* The general procedure for saponification applied to **33** (0.042 g, 0.14 mmol) afforded crude **34** (0.029, 80%). $[\alpha]_D^{25}$ +32.9 (*c* 0.24, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.54–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.15–5.21 (0.7 H, m), 5.03–5.08 (0.3 H, m), 2.33–2.39 (2 H, m), 2.18 (0.6 H, q, *J* = 7.2 Hz), 2.03 (1.4 H, q, *J* = 7.2 Hz), 1.63–1.69 (2 H, m), 1.26–1.63 (16 H, m), 0.76–0.92 (1.3 H, m), 0.88 (3 H, t, *J* = 6.4 Hz), 0.09–0.13 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.7, 130.4, 130.3, 129.6, 129.4, 33.7, 33.6, 32.4, 32.1, 29.9, 29.84, 29.82, 29.7, 29.6, 29.5, 29.3, 27.2, 24.5, 24.3, 22.9, 18.7, 18.6, 18.5, 14.4, 14.3, 14.1, 12.6; IR (CH_2Cl_2) ν 2924, 2855, 1710, 1542, 1457, 1365, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{18}H_{33}O_2$ $(M + H)^+$ 281.2475. Found 281.2494.

*(8R,9S)-Dihydromalvalic acid ((8R,9S)-**2**).* The general procedure for diimide reduction applied to **34** (0.021 g, 0.075 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **(8*R*,9*S*)-2** as a colorless oil (0.015 g, 75%). $[\alpha]_D^{24}$ +0.61 (*c* 0.350, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 2.36 (2 H, t, *J* = 7.2 Hz), 1.63–1.66 (2 H, m), 1.25–1.37 (20 H, m), 1.10–1.14 (2 H, m), 0.88 (3 H, t, *J* = 7.2 Hz), 0.64–0.67 (2 H, m), 0.53–0.58 (1 H, m), −0.33 (1 H, q, *J* = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.4, 33.9, 32.1, 30.4, 30.1, 29.8, 29.5, 29.4, 29.3, 28.9, 28.8, 24.9, 22.9, 15.92, 15.90, 14.3, 11.1; IR (CH_2Cl_2) ν 2922, 2854, 1708, 1458, 1366, 1284, 1217 cm^{-1}; HRMS (ESI^+) calcd for $C_{18}H_{34}NaO_2$ $(M + Na)^+$ 305.2451. Found 305.2451.

Methyl 8-[(1*R*,2*S*)-2-octylcyclopropyl]oct-7-enoate (35). The general procedure for Julia–Kocienski olefination applied to **17b** (0.130 g, 0.345 mmol) and methyl 7-oxoheptanoate (**18**)[36] (0.0651 g, 0.414 mmol) after flash chromatography (EtOAc–pet. spirits 1 : 9) afforded **35** (0.094 g, 85%) as a colorless oil. $[\alpha]_D^{24}$ +34.1 (*c* 0.36, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.52 (0.7 H, m), 5.35–5.41 (0.3 H, m), 5.13–5.19 (0.7 H, m), 5.01–5.06 (0.3 H, m), 3.66 (3 H, s), 2.28–2.33 (2 H, m), 2.12–2.15 (0.6 H, m), 2.00 (1.4 H, q, *J* = 6.8 Hz), 1.58–1.65 (2 H, m), 1.21–1.42 (18 H, m), 0.76–0.92 (2.3 H, m), 0.88 (3 H, t, *J* = 6.4 Hz), 0.08–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 174.4, 130.2, 130.0, 129.9, 129.9, 51.6, 34.2, 32.7, 29.9, 29.84, 29.82, 29.7, 29.6, 29.51, 29.50, 29.3, 28.8, 25.0, 22.9, 18.6, 18.5, 14.3, 14.1, 12.5; IR (CH_2Cl_2) ν 2990, 2923, 2853, 1742, 1365, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{20}H_{37}O_2$ $(M + H)^+$ 309.2788. Found 309.2876.

8-[(1*R*,2*S*)-2-Octylcyclopropyl]octanoic acid (9*R*,10*S*-dihydrosterculic acid; 3)

*8-[(1R,2S)-2-Octylcyclopropyl]oct-7-enoic acid (**36**).* The general procedure for saponification applied to **35** (0.051 g, 0.17 mmol) afforded crude **36** (0.042 g, 81%) as a colorless oil. $[\alpha]_D^{26}$ +37.6 (*c* 0.24, $CHCl_3$) (lit.[24] +40). ^1H NMR ($CDCl_3$, 400 MHz) δ 5.45–5.53 (0.7 H, m), 5.36–5.41 (0.3 H, m), 5.14–5.20 (0.7 H, m), 5.01–5.06 (0.3 H, m), 2.33–2.38 (2 H, m), 2.15–2.17 (0.6 H, m), 2.01 (1.4 H, q, *J* = 6.4 Hz), 1.62–1.67 (2 H, m), 1.22–1.43 (19 H, m), 0.76–0.91 (2.3 H, m), 0.88 (3 H, t, *J* = 6.4 Hz), 0.07–0.12 (0.7 H, m); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 177.7, 130.2, 130.1, 129.9, 33.8, 32.7, 32.2, 30.0, 29.9, 29.9, 29.8, 29.7, 29.6, 29.4, 28.9, 28.8, 27.5, 24.84, 24.82, 22.9, 18.7, 18.7, 18.5, 14.42, 14.41, 14.2, 12.6; IR (CH_2Cl_2) ν 2922, 2853, 2329, 1708, 1456, 1219 cm^{-1}; HRMS (ESI^+) calcd for $C_{19}H_{35}O_2$ $(M + H)^+$ 295.2632. Found 295.2522.

*8-[(1R,2S)-2-Octylcyclopropyl]octanoic acid (9R,10S-dihydrosterculic acid; **3**).* The general procedure for diimide reduction applied to **36** (0.035 g, 0.17 mmol), after flash chromatography (EtOAc–hexane 20 : 80) yielded **9*R*,10*S*-3** as a semisolid (0.031 g, 86%). $[\alpha]_D^{24}$ +0.95 (*c* 0.55, $CHCl_3$), (lit.[24] +0.92). ^1H NMR ($CDCl_3$, 400 MHz) δ 2.35 (2 H, t, *J* = 7.6 Hz), 1.62–1.65

(2 H, m), 1.25–1.36 (22 H, m), 1.12–1.16 (2 H, m), 0.88 (3 H, t, J = 6.8 Hz), 0.64–0.68 (2 H, m), 0.53–0.58 (1 H, m), −0.33 (1 H, q, J = 4.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 178.8, 33.9, 32.1, 30.4, 30.3, 29.8, 29.5, 29.4, 29.2, 28.9, 28.8, 24.9, 22.9, 15.92, 15.90, 14.3, 11.1; IR (CH_2Cl_2) ν 2924, 2854, 1711, 1456, 1219 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{19}H_{37}O_2$ $(M + H)^+$ 297.2788. Found 297.2788.

X-ray crystallography

Intensity data were collected on an Oxford SuperNova CCD diffractometer using Cu-Kα radiation (graphite crystal monochromator λ = 1.54184), the temperature during data collection was maintained at 130.0(1).

Crystal data for **14b**. $C_{22}H_{31}NO_3$, M = 357.48, T = 130.0(2) K, λ = 1.5418 Å, Monoclinic, space group $C2$ a = 32.485(3), b = 5.3094(4), c = 11.6620(7) Å, β = 91.786(7)°, V = 2010.5(3) Å^3, Z = 4, D_c = 1.181 Mg M^{-3} μ(Cu-Kα) 0.613 mm^{-1}, F(000) = 776, crystal size 0.55 × 0.08 × 0.03 mm, 5781 reflections measured, 3169 independent reflections (R_{int} = 0.067) the final R was 0.0556 [$I > 2\sigma(I)$] and w$R(F^2)$ was 0.1387 (all data), absolute structure parameter = 0.1(4), GOOF = 0.991. CCDC deposition: 1009686.

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