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Synthesis of 24-Epicathasterone and Related Brassinosteroids with Modified Side Chain

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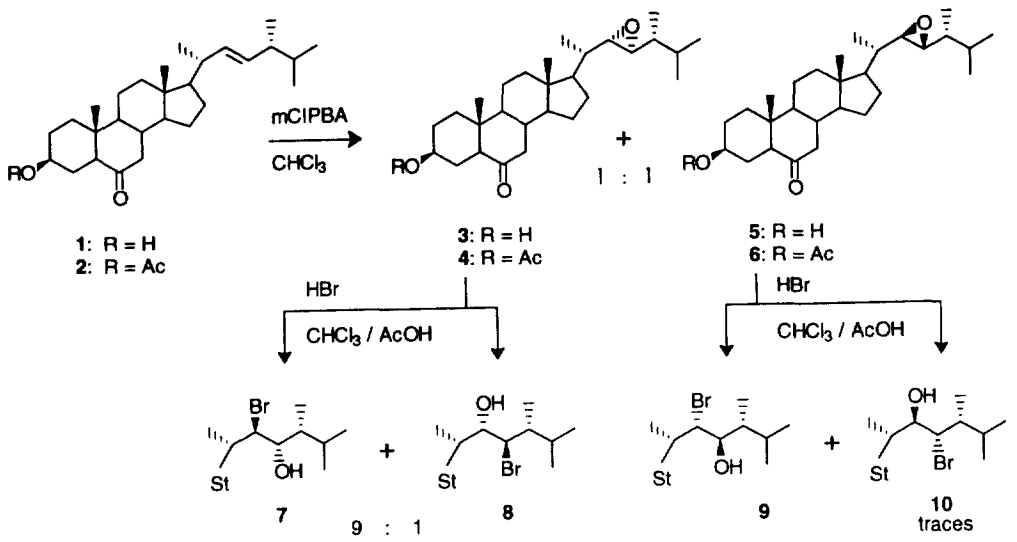
Dedicated to Prof. Dr. Peter Welzel on the occasion of his 60th birthday

Abstract: The synthesis of 24-epicathasterone (**20**), 22-deoxy-24-epiteasterone (**22**) and 24-hydroxy-6-oxo-24-epicampestanol (**24**) via 22,23-epoxy- and 22,23-bromohydrin intermediates starting with ergosterol is reported. The structures of the new brassinosteroids were determined especially by X-ray analysis of intermediate bromohydrins. © 1997 Elsevier Science Ltd.

The brassinosteroids represent a new class of steroidal phytohormones of ubiquitous occurrence in the plant kingdom with high growth promoting and antistress activity.[1] The detection of the new brassinosteroid cathasterone [(22S,24R)-3β,22-dihydroxy-5α-ergostan-6-one] as a biosynthetic precursor of brassinolide by feeding of campesterol in cultured cells of *Catharanthus roseus*[2] stimulated our efforts to develop effective methods for the synthesis of 24-epicathasterone [(22S,24S)-3β,22-dihydroxy-5α-ergostan-6-one, **20**] as corresponding precursor in the likewise naturally occurring and metabolized 24-epibrassinosteroid series.[3,4] Whereas in an earlier publication we described a pathway leading to 24-epiteasterone and 24-epityphasterol[5] we now report on the first synthesis of 24-epicathasterone as well as 22-deoxy-24-epiteasterone and 24-hydroxy-6-oxo-24-epicampestanol starting with ergosterol. For the structural elucidation of the new brassinosteroids, especially with regard to the side chain moiety, the X-ray analysis of intermediate bromohydrins played an important role.

RESULTS AND DISCUSSION

For the synthesis of the desired brassinosteroids the known (24R)-3β-hydroxy-24-methyl-5α-cholest-22-en-6-one (**1**), prepared in 5 steps from ergosterol,[5] was transformed to both epimeric epoxides **3** and **5** (Scheme 1). Thus, reaction of **1** and its 3-acetoxy derivative **2** with m-chloro-perbenzoic acid (mClPBA) gave the (22S,23S)- and (22R,23R)-epoxy compounds **3** and **5** as well as **4** and **6**, respectively, in a 1:1 ratio, whereas with methyl(trifluoro-methyl)dioxirane (TFD)[6] starting from **2** the (22R,23R)-epoxide **6** was the main product (**4** : **6** = 1 : 3). Reaction of both epimeric epoxides, separated by preparative HPLC, with dilute



Scheme 1

hydrobromic acid afforded the corresponding trans-bromohydrins. Thus, from (22S,23S)-epoxide **4** with HBr the stereoisomeric bromohydrins **7** and **8** were obtained in a 9 : 1 ratio, whereas epoxide **6** afforded only the bromohydrin **9**. The desired (22R,23S)-22-hydroxy-bromohydrin **10**, suitable for the synthesis of 24-epicathasterone, was formed only in traces with this method. Therefore, as an alternative pathway the olefin **2** was treated with N-bromosuccinimide (NBS) in dimethoxyethane (DME)/water (Scheme 2). Flash chromatography of the reaction product on silica gel afforded with n-hexane/ethyl acetate 98 : 2 (v/v) at first 20 % of a crystalline mixture of (22R,23R)- and (22S,23S)-dibromo derivatives **11** and **12**, detected by HPLC (R_t = 35.8 and 33.3, respectively). The fractions eluted with n-hexane-ethyl acetate 95 : 5 (v/v) gave 5 % of the 22-bromo-23,24-epoxy derivative **13**, the structure of which was established by X-ray analysis. Further elution with n-hexane/ethyl acetate 9 : 1 (v/v) afforded besides 30 % of bromohydrin **9** 15 % of the desired (22R,23S)-22-hydroxy-bromohydrin **10**. Further elution with n-hexane/ethyl acetate 85 : 15 (v/v) gave a 1 : 1 mixture of (22S,23R)-22-hydroxy-bromohydrin **8** and surprisingly the 24-hydroxy-bromohydrin **14** separated by preparative HPLC. The structures of the bromohydrins **7**, **8**, **9** and **14** were determined by X-ray analysis (Figures 1-2).

The 23-hydroxylated bromohydrins **7** and **9** were oxidized with Jones reagent to afford both 22-epimeric 22-bromo-23-ketones **15** and **16** (Scheme 3). The CD curves of **15** and **16** exhibit strong negative Cotton effects ($\Delta\varepsilon$ -4.35 and -4.30) at 303 and 293 nm, respectively (Figure 3). In comparison, the 6-keto-22,23-bromohydrins **7**, **8** and **9** have Cotton effects of $\Delta\varepsilon \sim -1.3$, as expected for the 6-keto-chromophore.[7]

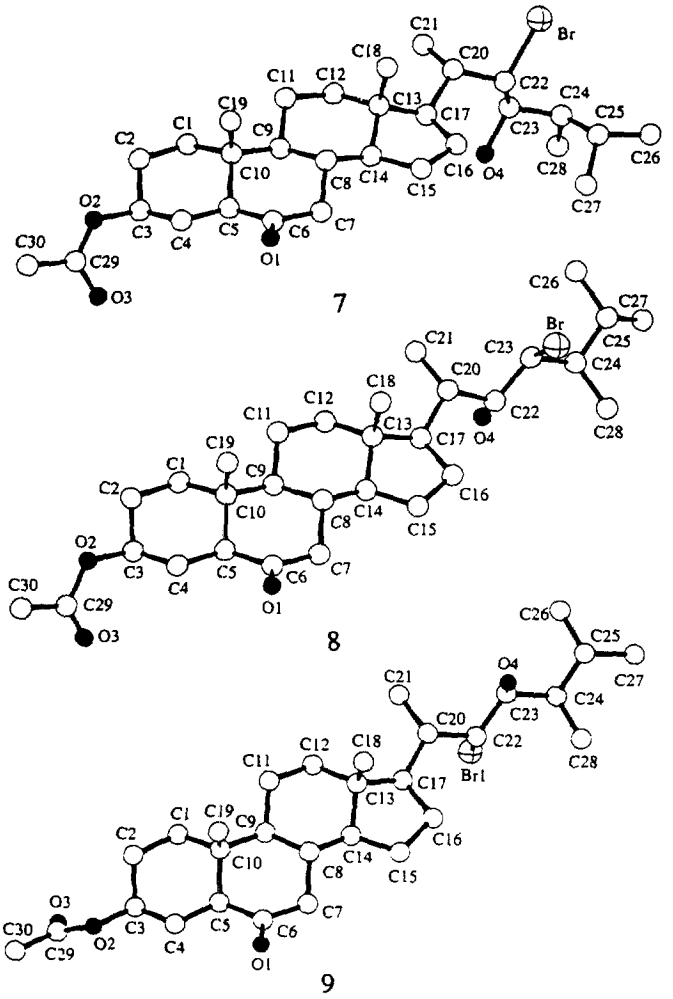


Fig.1. Molecular Structures of **7**, **8** and **9**.

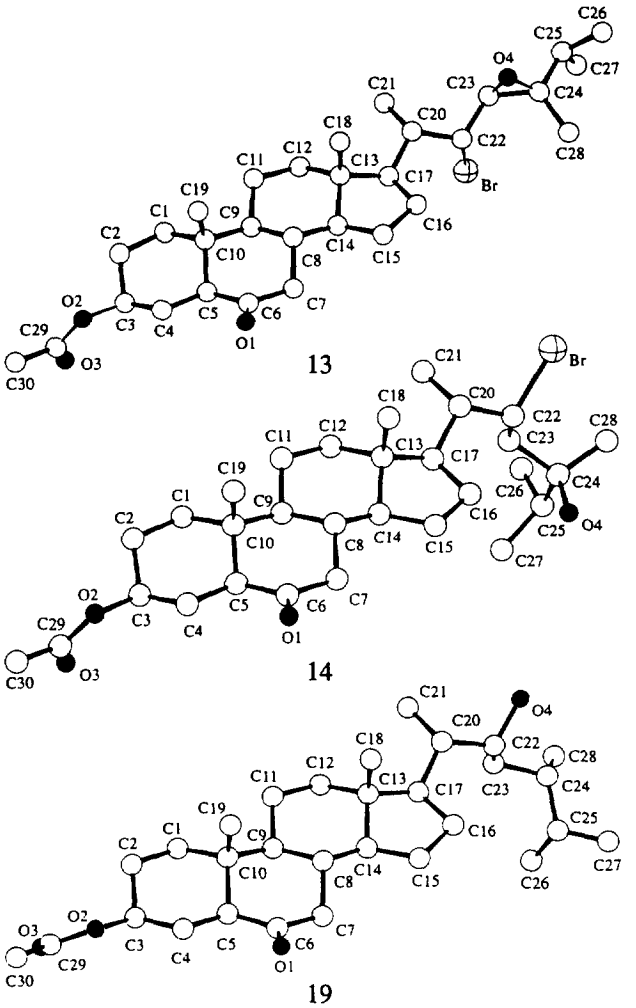
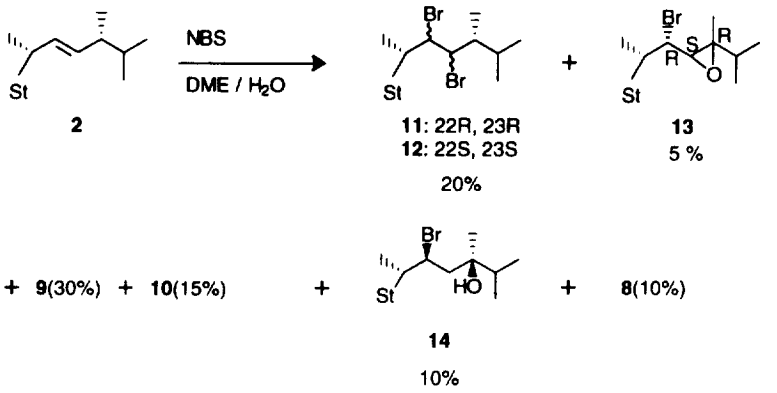
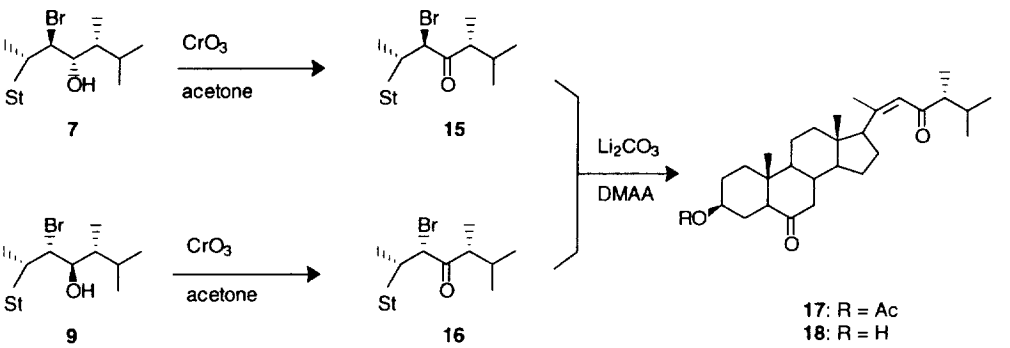


Fig. 2. Molecular Structures of **13**, **14** and **19**.



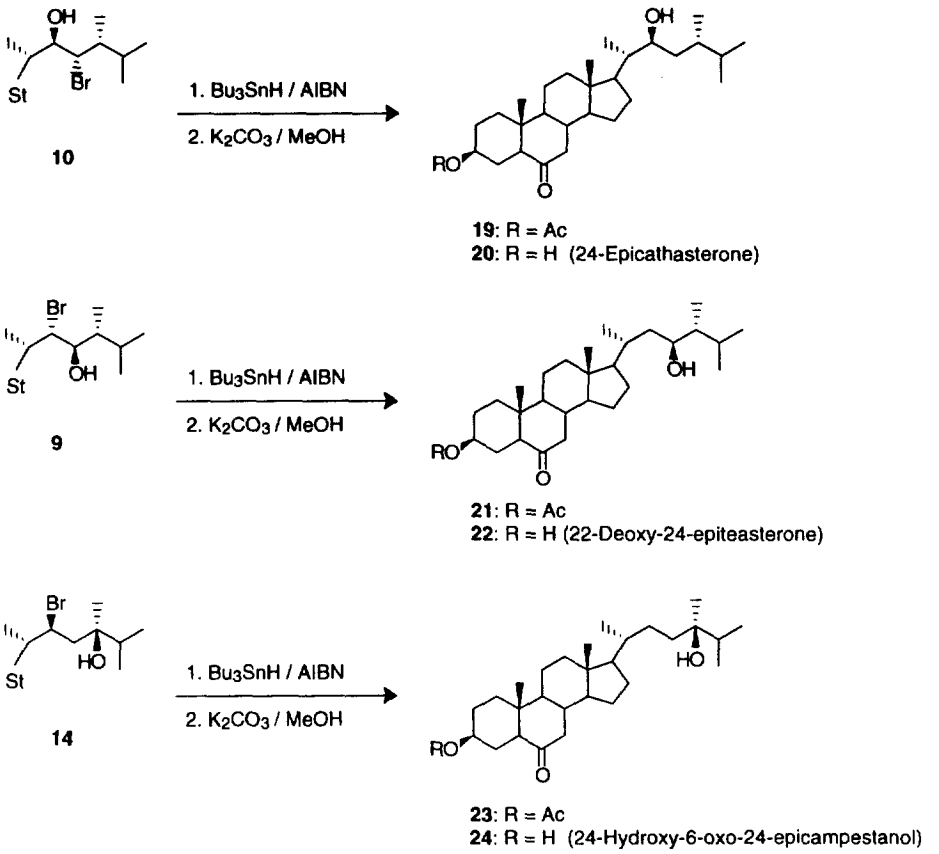
Scheme 2



Scheme 3

Our results for **15** and **16** are contrary to published[8] data for 22-bromo-23-ketones of the stigmastan serie showing opposite Cotton effects for both 22-epimers. This effect must be due to the different configuration of the alkyl substituent at C-24 resulting in a change of the side chain conformation as shown also in the case of the phytohormones brassinolide and 24-epibrassinolide by combined NMR- and molecular modelling experiments.[9] A similar synthesis of $\Delta^{20(22)}$-23-ketones via 22-bromo-23-ketones in the 3-acetoxy-Δ^5 serie was described by Khripach et al.[10]

Hydrogen bromide elimination of both bromoketones **15** and **16** with lithium carbonate in dimethyl acetamide (DMAA) afforded the $\Delta^{20(22)}$-23-enone **17**, and upon hydrolysis the corresponding compound **18** as potential precursor for 20,22,23-trihydroxylated brassinosteroid analogs.



Scheme 4

The bromohydrin **10** was used for the synthesis of 24-epicathasterone. Thus, a solution of bromohydrin **10** in dry toluene with tri-n-butyltin hydride (Bu_3SnH) and 2,2'-azobis(isobutyronitrile) (AIBN) was heated at 100° C under argon for 1 h to give **19**, which was hydrolyzed to the desired brassinosteroid 24-epicathasterone (**20**). The structure of compound **20** was confirmed by X-ray analysis of its 3-acetoxy derivative **19** (Figure 2). In the same manner the bromohydrins **9** and **14** were reacted with Bu_3SnH / AIBN to give the corresponding hydroxy compounds **21** and **23** and upon hydrolysis 22-deoxy-24-epiteasterone (**22**) and 24-hydroxy-6-oxo-24-epicampestanol (**24**), respectively.

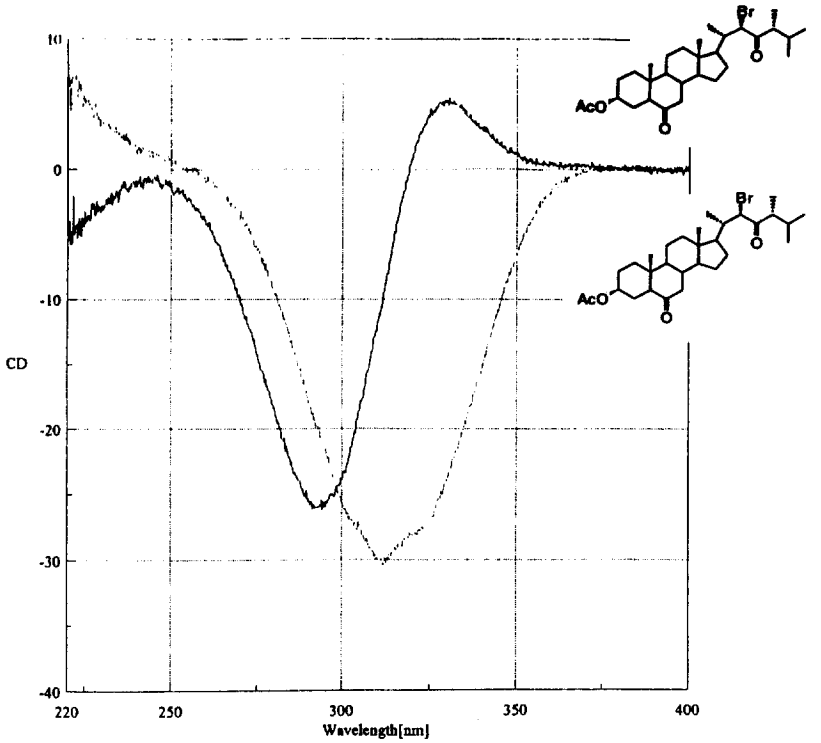


Fig. 3. Circular Dichroism Spectra of Bromoketones **15** and **16**

The spectral data of our new compounds are in agreement with the given structures (see Experimental Section). The constitution of the steroid side chains were determined by combined use of one- and two-dimensional NMR experiments including ^{1}H, ^{13}C shift correlated spectra (HSQC, HMBC). As a result the ^{1}H and ^{13}C NMR signals could be assigned unequivocally. Relevant ^{1}H and ^{13}C NMR data are shown in Tables 1 and 2.

The phytohormone activity of the synthesized brassinosteroid analogs was studied using the highly sensitive and specific rice lamina inclination bioassay according to the method of Arima et al.[11] The obtained results showed that the Δ^{22}-olefin **1** at a concentration of 0.1 ppm was inactive, whereas the (22S,23S)- and (22R,23R)-epoxides **3** and **5** showed 33 and 35 %, 24-epicathasterone (**20**) 20 %, 22-deoxy-24-epiteasterone (**22**) 58 % related to 24-epicastasterone as standard (100 %). These results are in agreement with data of Fujioka et al.[2], found for corresponding brassinosteroid analogs of the campestanol serie. Studies on biosynthetic transformations as well as normalizing effects of 24-epicastasterone on brassinosteroid deficient mutants of *Arabidopsis thaliana* are on the way.[12]

Table 1: ^{1}H NMR data (δ, multiplicity, coupling constants in Hz) for relevant protons of compounds **4, 6, 7, 8, 9, 10, 13, 14, 16, 20, 22** and **24**

Pos.	4	6	7	8	9	10	13	14	16	20[a]	22	24
3	4.67, m	4.67, m	4.67, m	4.67, m	4.67, m	4.67, m	4.67, m	4.67, m	4.67, m	3.53, m	3.57, m	3.58, m
17	*1.32*	*1.34*	*1.81*	*1.47*	*1.54*	*1.67*	*1.47*	*1.23*	*1.26*	*1.15*	*1.14*	*1.17*
18	0.66, s	0.66, s	0.68, s	0.72, s	0.72, s	0.71, s	0.71, s	0.69, s	0.75, s	0.69, s	0.70, s	0.67, s
19	0.77, s	0.77, s	0.77, s	0.78, s	0.77, s	0.77, s	0.77, s	0.77, s	0.78, s	0.75, s	0.76, s	0.76, s
20	*1.17*	*1.32*	2.21, qdd, 6.8/10.7/1.7	2.21, qdd, 6.8/10.4/1.4	*1.95*	*1.99*	*1.73*	*2.04*	*1.91*	*1.67*	*1.65*	*1.39*
21	1.09, d, 6.5	1.00, d, 6.4	1.19, d, 6.8	0.90, d, 6.8	1.03, d, 6.4	1.09, d, 7.0	1.11, d, 6.4	1.12, d, 6.7	0.95, d, 6.4	0.92, d, 6.7	0.97, d, 6.5	0.93, d, 6.5
22	2.39, dd, 8.1/2.2	2.59, dd, 6.8/2.3	4.32, dd, 10.1/1.7	3.85, br d, 10.1	4.07, dd, 9.6/1.8	3.94, br m	3.80, dd, 9.9/1.1	4.54, ddd, 8.6/2.6/2.6	4.66, d, 1.7	3.73, br d, 10.2	*1.53* / 1.02, ddd, 14.0/10.7/1.9	*1.45* / *1.08*
23	2.67, dd, 8.3/2.2	2.46, dd, 7.9/2.3	3.82, ddd, 10.1/4.9/3.0	4.20, dd, 10.1/1.7	3.98, dd, 9.6/1.8	4.27, dd, 8.3/3.5	3.10, d, 9.9	*1.91* / *1.91*	-	*1.36* / *1.07*	3.70, ddd, 10.5/4.8/1.9	*1.54* / *1.31*
24	*1.08*	*1.04*	*2.02*	*1.56*	*1.87*	*1.95*	-	-	2.70, dq, 7.2/6.9	*1.58*	*1.16*	-
25	*1.77*	*1.64*	*2.00*	*1.57*	*1.59*	*2.04*	*1.44*	*1.74*	*1.91*	*1.72*	*1.69*	*1.70*
26[b]	0.96, d, 6.9	0.95, d, 6.9	0.94, d, 6.8	0.98, d, 6.5	0.97, d, 6.7	0.97, d, 6.8	1.01, d, 7.0	0.96, d, 6.8	0.92, d, 6.7	0.91, d, 6.8	0.94, d, 6.8	0.92, d, 7.0
27[b]	0.92, d, 6.7	0.93, d, 6.8	0.89, d, 6.8	0.95, d, 6.7	0.95, d, 6.7	0.92, d, 6.7	0.96, d, 7.0	0.89, d, 6.9	0.90, d, 6.7	0.77, d, 6.8	0.84, d, 6.8	0.88, d, 6.8
28	0.91, d, 6.9	0.98, d, 6.7	0.92, d, 7.2	0.96, d, 6.7	0.84, d, 7.0	1.03, d, 6.9	1.21 s	1.21, s	1.03, d, 6.9	0.84, d, 6.9	0.86, d, 6.9	1.07 s

in $CDCl_3$; [a] in $CDCl_3$ / CD_3OD = 35 : 1; [b] *proR* and *proS* not assigned;

values in *italic* face are chemical shifts of HSQC cross peaks

Table 2: ^{13}C chemical shifts for selected carbons of compounds **4**, **6**, **7**, **8**, **9**, **10**, **13**, **14**, **16**, **20**, **22** and **24**

Pos.	4	6	7	8	9	10	13	14	16	20[a]	22	24
3	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.7	70.1	70.6	70.7
17	53.5	55.9	54.9	52.7	54.2	52.5	53.7	53.3	53.8	52.9	56.7	55.8
18	12.0	12.1	11.9	12.0	12.6	12.0	12.5	12.0	12.5	11.8	12.0	12.0
19	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	12.9	13.1	13.1
20	39.4	38.6	43.3	31.9	36.2	41.4	38.2	46.3	37.5	42.5	32.6	36.0
21	16.9	14.0	15.3	11.2	14.2	16.4	14.2	14.2	15.3	12.1	18.6	18.7
22	62.9	64.1	61.8	73.3	64.9	77.5	58.3	57.1	64.8	71.4	42.1	29.0
23	63.7	60.3	77.7	61.8	72.6	64.1	62.7	40.6	207.3	34.4	70.6	36.2
24	42.4	42.2	40.2	37.9	40.8	42.8	66.3	74.3	50.0	35.2	45.4	74.7
25	31.0	31.5	25.7	29.7	30.8	30.0	36.2	37.8	31.1	29.5	29.5	36.2
26[b]	20.2	19.4	22.8	21.0	20.7	22.8	17.4	16.8	21.2	20.9	21.4	16.8
27[b]	18.5	16.0	17.9	20.5	20.3	19.2	18.3	17.8	19.0	15.9	18.4	17.5
28	12.5	13.6	11.4	12.7	9.3	13.9	12.0	22.9	14.2	15.4	9.8	23.3

in $CDCl_3$; [a] in $CDCl_3$: CD_3OD = 35 : 1; [b] *proR* and *proS* not assigned

EXPERIMENTAL SECTION

***General*:** Melting points (m.p.) were determined on a Boetius hot stage microscope and are uncorrected. IR spectra were recorded on a Bruker IFS 28 instrument. Optical rotations were measured on a DIP 1000-polarimeter, UV spectra on an Uvikon 941 Kontron instrument. CD spectra were recorded with a Jasco J 710 spectrometer. Mass spectra (EI-MS, 70 eV) were obtained with a AMD 402 spectrometer. The GC-MS data of trimethylsilyl derivatives were obtained with a MD-800 Fisons instrument. The relative retention times (RRt) values were calculated with respect to 5α-cholestane. ^{1}H and 2D NMR spectra were recorded on a Varian UNITY 500 spectrometer at 499.8 MHz, whereas ^{13}C and APT spectra were recorded on a Varian GEMINI 2000 spectrometer at 75.5 MHz. $CDCl_3$ was used as solvent unless other noted. TMS (δ 0) and $CDCl_3$ (δ 77.0) were used as internal reference for ^{1}H and ^{13}C spectra, respectively. For TLC plates precoated with silica gel 60 PF_{254} 0.2 mm (Merck) and for column chromatography silica gel 60, 0.04 - 0.063 mm (Merck), were used. The preparative HPLC was carried out on a Knauer instrument, with a YMC-column, on ODS, 5 µm, 20 x 150 mm, MeCN-H_2O as eluent and UV detection at 210 nm. The elemental analyses were carried out on a LECO CHNS-932 instrument (LECO Instrumente GmbH, Kirchheim / München.

For the x-ray crystal structure the data were collected on a STOE-IPDS diffractometer using Mo-Kα radiation (λ = 0.71073 Å) at room temperature. The structure was solved by direct methods (SHELXS-86)[13] and all non H-atoms were refined anisotropically by full-matrix least-squares on F^2; H-atoms were included in calculated positions and refined as riding atoms (SHELXL-93).[14] For the graphical representations the program DIAMOND was used.[15]

(22S,23S,24R)-3β-Hydroxy-24-methyl-22,23-epoxy-5α-cholestan-6-one (**3**) and its *(22R,23R)-epimer* **5**. A solution of ketol **1** (207 mg, 0.5 mmol) in dichloromethane (7 ml) and mClPBA (76 mg, 0.55 mmol) was allowed to stand with stirring at rt for 48 h. After evaporation of the solvent the crude residue was chromatographed on silica gel. Elution with hexane / ethyl acetate 1 : 1 v/v gave 210 mg (100 %) of **3** and **5**, which were separated by preparative HPLC: **3** (MeCN-H_2O 97 : 3, v/v, Rt 9.21): m.p. 107 - 108° C; $[\alpha]_D^{23}$ -16.8° (c 1.12, MeOH); IR (nujol): ν_{max} 3392 (OH), 1705 (CO), 912 cm^{-1} (epoxy); UV (c 1.12, MeOH): λ_{max} (ε) 282 nm (64); CD (MeOH): $\Delta\varepsilon_{294}$ - 1.17; ^{1}H NMR: δ 0.66 (3H, s, 18-H_3), 0.76 (3H, s, 19-H_3), 0.91 (3H, d, J 7.2, 28-H_3), 0.92 (3H, d, J 6.6, 27*-H_3), 0.96 (3H, d, J 6.9, 26*-H_3), 1.11 (3H, d, J 6.0, 21-H_3), 2.38 (1H, dd, J 8.0/2.5, 22-H), 2.67 (1H, dd, J 8.2/2.2, 23-H), 3.58 (1H, m, 3α-H). EI-MS: *m/z* (relative intensities) 430 (M^+, 12), 412 (M^+-H_2O, 5), 387 (M^+-43,4), 359 (M^+-71, 100); GC-MS: RR_t 2.114; EI-MS of the TMS-ether: *m/z* 502 (M^+, 12), 487 (M^+-15, 35), 473 (M^+-29, 52). 431 (M^+-71, 42), 73 (100). HR-MS: 430.3402 (calcd. for $C_{28}H_{46}O_3$ 430.3357), 359.2608 (calcd. for $C_{23}H_{35}O_3$ 359.2630), 315.2345 (calcd. for $C_{21}H_{31}O_2$ 315.2366). Anal. calcd. for $C_{28}H_{46}O_3$: C, 78.09; H, 10.77. Found: C, 78.10; H, 10.99 %.

Compound **5** (MeCN - H_2O 97:3, v/v, Rt 10.17): m.p. 177-178° C; $[\alpha]_D^{24}$ -51.3° (c 1.14, MeOH); IR (nujol): ν_{max} 3390 (OH), 1709 (CO), 902 cm^{-1} (epoxy); UV (c 1.14, MeOH): λ_{max} (ε) 292 nm (57); CD (MeOH): $\Delta\varepsilon_{294}$ -1.29; ^{1}H NMR: δ 0.66 (3H, s, 18-H_3), 0.76 (3H, s, 19-H_3), 0.93 (3H, d, J 6.6, 27*-H_3), 0.95 (3H, d, J 6.6, 26*-H_3), 0.98 (3H, d, J 8.0, 28-H_3), 1.00 (3H, d, J 8.0, 21-H_3), 2.45 (1H, dd, J 7.7/2.2, 23-H), 2.58 (1H, dd, J 6.9/2.2, 22-H), 3.58 (1H, m, 3α-H). EI-MS: *m/z* 430 (M^+, 10), 412 (M^+-

H_2O, 4), 387 (M^+-43, 3), 359 (M^+-71, 100); GC-MS: RR_t 2.102; EI-MS of the TMS-ether: *m/z* 502 (M^+, 12), 487 (M^+-15, 32), 473 (M^+-29, 58), 431 (M^+-71, 43), 73 (100). HR-MS: 430.3451 (calcd. for $C_{28}H_{46}O_3$ 430.3455), 359.2564 (calcd. for $C_{23}H_{35}O_3$ 359.2586). Anal. calcd. for $C_{28}H_{46}O_3$: C, 78.09; H, 10.77. Found: C, 78.16; H, 10.90 %.

(22S,23S)-3β-Acetoxy-24-methyl-22,23-epoxy-5α-cholestan-6-one (**4**) and its *(22R,23R)-epimer* **6**. A solution of **2** (456 mg, 1 mmol) in dichloromethane (15 ml) and mClPBA (160 mg, 1.1 mmol) and mClPBA (155 mg, 1 mmol) was treated in the same manner as described for **3** and **5**. After 48 h the reaction was complete. Working up gave a crude mixture of **4** and **6**, which were separated bei flash chromatography and preparative HPLC: **4** (MeCN-H_2O 97 : 3, v/v, Rt 11.87): m. p. 142 - 143° C; $[\alpha]_D^{27}$ -29.6° (c 1.21, MeOH); IR (nujol): 1728 (OAc), 1705 (CO), 907 cm^{-1} (epoxy); UV (c 1.22, MeOH): λ_{max} (ε) 286 nm (67); CD (MeOH): $\Delta\varepsilon_{291}$ - 1.23; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 472 (M^+, 12), 429 (M^+-43, 4 %), 412 (M^+-60, 9 %), 401 (M^+-71, 100); Anal. calcd. for $C_{30}H_{48}O_4$: C, 76.23; H, 10.24. Found: C, 76.08; H, 9.96 %.

Compound **6** (MeCN - H_2O 97:3, v/v, Rt 13.15): m.p. 102 104° C; $[\alpha]_D^{30}$ -53.4° (c 1.11, MeOH); IR (nujol): ν_{max} 1739 (OAc), 1714 (CO), 904 cm^{-1} (epoxy); UV (c 1.11, MeOH): λ_{max} (ε) 290 nm (66); CD (MeOH): $\Delta\varepsilon_{293}$ -1.31; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 472 (M^+, 13), 454 (M^+-H_2O, 7), 429 (M^+-43, 4), 412 (M^+-AcOH, 9), 401 (M^+-71, 100). Anal. calcd. for $C_{30}H_{46}O_4$: C, 76.23; H, 10.24. Found: C, 76.44; H, 9.99 %.

The olefin **2** (1.37 g, 3 mmol) in dichloromethane (50 ml) was treated with a solution of 2.4 equivalents of TFD in dichloromethane under nitrogen at rt over 3 days. Evaporation of the solvent and preparative HPLC separation of the reaction mixture gave both epoxides **4** and **6** in the 1 : 3 ratio, all physical data were identical with them of the mClPBA-procedure obtained products.

(22R,23R,24R)-3β-Acetoxy-22-bromo-23-hydroxy-24-methyl-5α-cholestan-6-one (**7**) and *(22S,23R,24R)-3β-acetoxy-22-hydroxy-23-bromo-24-methyl-5α-cholestan-6-one* (**8**). A solution of epoxide **4** (100 mg, 0.2 mmol) in chloroform (10 ml) and acetic acid (1 ml) were reacted with HBr (1ml, 48 %) at rt with stirring. After 48 h the educt was complete reacted to two more polar products. The crude mixture was separated bei SiO_2 chromatography to give by elution with n-hexane/ethyl acetate 85 : 15 v/v the bromohydrin **7** (90 mg, 77 %), m. p. 185 - 186° C (acetone - n-hexane); $[\alpha]_D^{27}$ -14.2° (c 1.07, MeOH); IR (nujol): ν_{max} 3543 (OH), 1733 (OAc), 1699 cm^{-1} (CO); UV (c 1.07, MeOH): λ_{max} (ε) 283 nm (70); CD ($CHCl_3$): $\Delta\varepsilon_{298}$ - 1.44; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 554/552 (M^+, 1), 494/492 (M^+-AcOH, 2), 472 (M^+-HBr, 8), 454 (472-H_2O, 9), 411 (454-43, 14), 401 (472-71, 12), 43 (100). Anal. calcd. for $C_{30}H_{49}BrO_4$: C, 65.09; H, 8.92; Br, 14.43. Found: C, 65.25; H, 8.99; Br, 14.26 %.

X-ray crystal structure determination of **7**: $C_{30}H_{49}BrO_4$; orthorhombic; space group: $P2_12_12_1$; unit cell dimensions: a = 7.6258 (14) Å, b = 11.058 (2) Å, c = 35.571 (8) Å, $\alpha = \beta = \gamma = 90°$, V = 2999.6 (10) $Å^3$, Z= 4, density (calcd.) = 1.226 Mg/m^3; absorption coefficient 1.401 mm^{-1}; F (000) = 1184. Θ range: 1.93 to 22.50°; index ranges: -8<=h<=8, -11<=k<=12, -40<=l<=40; reflections collected: 10288; independent reflections: 3903; data / restraints / parameters: 3903 / 0 / 316. S: 0.995; final R indices [I>2σ (I)]: R_1 = 0.0638, wR_2 = 0.1476; R indices (all data): R_1 = 0.1135, wR_2 = 0.1740; absolute structure parameter: 0.02 (2); largest diff. peak and hole: 0.263 and - 0.552 e./$Å^3$.[16]

Further elution with n-hexane/ethyl acetate 8 : 2 v/v gave compound **8** (10 mg, 8.5 %), m. p. 226 - 228°C (acetone/n-hexane); $[\alpha]_D^{30}$ -26.4° (c 1.13, MeOH); IR (nujol): ν_{max} 3445 (OH), 1738 (OAc), 1716 cm^{-1}

(CO); UV (c 1.13, MeOH): λ_{max} (ε) 291 nm (65); CD ($CHCl_3$): $\Delta\varepsilon_{300}$ - 0.99; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 554/552 (M^+, 1), 494/492 (M^+-AcOH, 2), 472 (M^+-HBr, 7), 429 (472-43, 6), 389 (15), 329 (389-AcOH, 92), 43 (100). Anal. calcd. for $C_{30}H_{49}BrO_4$: C, 65.09; H, 8.92; Br, 14.43. Found: C, 65.09; H, 9.76; Br, 14.25 %.

X-ray crystal structure determination of **8**: $C_{30}H_{49}BrO_4$; monoclinic; space group: $P2_1$; unit cell dimensions: a = 12.390 (3) Å, b = 7.552 (6) Å, c = 17.020 (5) Å, α = 90°, β = 110.49 (2)° γ = 90°, V = 1491.8 (14) $Å^3$, Z = 2, density (calcd.) = 1.232 Mg/m^3; absorption coefficient 1.408 mm^{-1}; F (000) = 592. Θ range: 1.75 to 22.50°; index ranges: -13‹=h‹=14, -8‹=k‹=8, -18‹=l‹=19; reflections collected: 7291; independent reflections: 3771; data / restraints / parameters: 3771 / 1 / 316; S: 1.037; final R indices [I›2σ (I)]: R_1 = 0.0777, wR_2 = 0.1954; R indices (all data): R_1 = 0.1089, wR_2 = 0.2177; absolute structure parameter: -0.02 (2); largest diff. peak and hole: 0.522 and - 0.557 e./$Å^3$.[16]

(22S,23R,24R)-3β-Acetoxy-22-bromo-23-hydroxy-24-methyl-5α-cholestan-6-one (9). A solution of epoxide **6** (100 mg, 0.2 mmol) in chloroform (10 ml) and acetic acid (1 ml) were reacted with HBr (1ml, 48 %) at rt for 48 h with stirring. SiO_2-chromatography of the reaction product and elution with n-hexane/ethyl acetate 85 : 15 v/v gave **9** (108 mg, 92 %), m. p. 212 - 214° C (from MeOH); $[\alpha]_D^{28}$ -33.8° (c 1.12, MeOH); IR (nujol): ν_{max} 3502 (OH), 1733 (OAc), 1716 cm^{-1} (CO); UV (c 1.12, MeOH): λ_{max} (ε) 291 nm (65); CD (MeOH): $\Delta\varepsilon_{292}$ - 1.31; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 554/552 (M^+, 1), 494/492 (M^+-AcOH, 7), 472 (M^+-HBr, 13), 394/392 (494/492-100, 98), 313 (394/392-HBr, 65), 43 (100). Anal. calcd. for $C_{30}H_{49}BrO_4$: C, 65.09; H, 8.92; Br, 14.43. Found: C, 65.41; H, 8.69; Br, 14.25 %.

X-ray crystal structure determination of **9**: $C_{60}H_{98}Br_2O_8$; monoclinic; space group: $P2_1$; unit cell dimensions: a = 10.982 (4) Å, b = 21.021 (7) Å, c = 13.850 (5) Å, α = 90°, β = 103.64 (3)° γ = 90°, V = 3107 (2) $Å^3$, Z = 2, density (calcd.) = 1.184 Mg/m^3; absorption coefficient 1.353 mm^{-1}; F (000) = 1184. Θ range: 2.35 to 22.50°; index ranges: -14‹=h‹=14, -27‹=k‹=27, -18‹=l‹=18; reflections collected: 22800; independent reflections: 8026; data / restraints / parameters: 8026 / 1 / 631. S: 1.035; final R indices [I›2σ (I)]: R_1 = 0.0480, wR_2 = 0.1332; R indices (all data): R_1 = 0.0570, wR_2 = 0.1409; absolute structure parameter: 0.007 (9); largest diff. peak and hole: 0.906 and - 0.198 e./$Å^3$.[16]

Reaction of **2** with NBS: A solution of olefin **2** (460 mg, 1 mmol) in dimethoxyethane (60 ml) and water (10 ml) was reacted with NBS (360 mg, 2 mmol, white crystals) under argon in the dark at rt with stirring for 24 h. After evaporation of the solvent and extraction with ethyl acetate resulted a crystalline mixture, which was separated by flash chromatography: Elution with n-hexane/ethyl acetate gave a crystalline mixture of dibromo derivatives **11** and **12** (120 mg, 20 %), Rt 33.32 and Rt 35.84, m. p. 218-219° C $[\alpha]_D^{25}$ -39.7° (c 0.83, MeOH); IR (nujol): ν_{max} 1735 (OAc), 1712 cm^{-1} (CO); UV (c 0.83, MeOH): λ_{max}(ε) 293 nm (226); CD (CHCl3): $\Delta\varepsilon_{298}$ - 1.21; EI-MS: *m/z* 616 (M^+, 10), 556 (M^+-AcOH, 73), 541 (556-Me, 28). Anal. calcd. for $C_{30}H_{48}Br_2O_3$: C, 58.45; H, 7.85; Br, 25.92. Found: C, 58.59; H, 7.78; Br, 25.85 %.

Further elution with n-hexane/ethyl acetate 9 : 1 v/v afforded **13** (28 mg, 5 %), m. p. 128-130° C (acetone/n-hexane), $[\alpha]_D^{26}$ -26.0° (c 1.10, MeOH); IR (nujol): ν_{max} 1736 (OAc), 1716 cm^{-1} (CO); UV (c 1.10, MeOH): λ_{max} (ε) 286 nm (175); CD (MeOH): $\Delta\varepsilon_{299}$ - 1.33; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 452 (81), 437 (18), 409 (20), 329 (19), 121 (100). Anal. calcd. for $C_{30}H_{47}BrO_4$: C, 65.32; H, 8.59; Br, 14.49. Found: C, 65.21; H, 8.43; Br, 14.28%.

X-ray crystal structure determination of **13**: $C_{30}H_{47}BrO_4$; monoclinic; space group: $P2_1$; unit cell dimensions: a = 14.068 (3) Å, b = 8.0810 (10) Å, c = 14.155 (3) Å, α = 90°, β = 114.79 (2)° γ = 90°, V = 1460.9 (5) $Å^3$,

Z = 2, density (calcd.) = 1.254 Mg/m^3; absorption coefficient 1.438 mm^{-1}; F (000) = 588, crystal size: 0.2 x 0.1 x 0.1 mm; Θ range for data collection: 2.68 to 28.24°; index ranges: -18<=h<=18, -10<=k<=10, -18<=l<=18; reflections collected: 12978; independent reflections: 7086[R(int)= 0.1249]; data / restraints / parameters: 7086 / 1 / 316. S: 0.979; final R indices [I>2σ (I)]: R_1 = 0.0620, wR_2 = 0.1445; R indices (all data): R_1 = 0.1343, wR_2 = 0.1823; absolute structure parameter: -0.03 (2); largest diff. peak and hole: 0.252 and - 0.382 e./Å^3.[16]

Further elution with n-hexane/ethyl acetate 85 : 15 v/v afforded the bromohydrin **9** (166 mg, 30 %) and **10** (83 mg, 15 %), m. p. 182 - 185° C (acetone/n-hexane), $[\alpha]_D^{23}$ -43.2° (c 1.12, MeOH); IR (nujol): ν_{max} 3457 (OH), 1725 (OAc), 1713 cm^{-1} (CO); UV (c 1.12, MeOH): λ_{max} (ε) 287 nm (50); CD ($CHCl_3$): $\Delta\varepsilon_{300}$ - 1.30; ^{1}H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 554/552 (M^+, 2), 494/492 (M^+-AcOH, 15), 472 (M^+-HBr, 14), 329 (78), 300 (60), 271 (80), 113 (100). Anal. calcd. for $C_{30}H_{49}BrO_4$: C, 65.09; H, 8.92; Br, 14.43. Found: C, 65.09; H, 8.76; Br, 14.22 %.

Further elution with n-hexane/ethyl acetate 8 : 2 v/v led to a mixture of bromohydrins **8** and **14**, which were separated by preparative HPLC (MeCN-H_2O 95 : 5 v/v) to give **8** (55 mg, 10 %), R_t 14.084, and **14** (55 mg, 10 %), R_t 11.995, m. p. 183-186° C (acetone/n-hexane), $[\alpha]_D^{21}$ +3.8° (c 1.00, MeOH); IR (nujol): ν_{max} 3513 (OH), 1730 (OAc) and 1713 cm^{-1} (CO); UV (c 1.00, MeOH): λ_{max} (ε) 287 nm (70); CD ($CHCl_3$): $\Delta\varepsilon_{300}$ - 1.36; ^{1}H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 454 (M^+-HBr-H_2O, 98), 329 (454-C_9H_{17}, 80), 123 (C_9H_{15}, 100), HR-MS: 454.3442 (calcd. for $C_{30}H_{46}O_3$ 454.3437), 329.2115 (calcd. for $C_{21}H_{29}O_3$ 329.2113), 123.1177 (calcd. for C_9H_{15} 123.1180). Anal. calcd. for $C_{30}H_{49}BrO_4$: C, 65.09; H, 8.92; Br, 14.43. Found: C, 64.91; H, 8.72; Br, 14.23 %.

X-ray crystal structure determination of **14**: $C_{30}H_{49}BrO_4$; orthorhombic; space group: $P2_12_12_1$; unit cell dimensions: a = 8.016 (2) Å, b = 11.783 (3) Å, c = 31.668 (8) Å, α = β = γ = 90°, V = 2991.3 (13) Å^3, Z = 4, density (calcd.) = 1.229 Mg/m^3; absorption coefficient 1.405 mm^{-1}; F (000) = 1184. Θ range: 1.84 to 24.20°; index ranges: -9<=h<=9, -12<=k<=12, -36<=l<=36; reflections collected: 25304; independent reflections: 4605 [R(int)= 0.0699]; data / restraints / parameters: 4605 / 0 / 316. S: 0.971; final R indices [I>2σ (I)]: R_1 = 0.0484, wR_2 = 0.1017; R indices (all data): R_1 = 0.0896, wR_2 = 0.1164; absolute structure parameter: -0.002 (12); largest diff. peak and hole: 0.248 and - 0.274 e./Å^3.[16]

(22R,24R)-3β-Acetoxy-22-bromo-24-methyl-5α-cholestane-6,23-dione (**15**). A solution of bromohydrin **7** (26 mg, 0.05 mmol) in acetone (3 ml) was oxidized with a slight excess of Jones reagent at rt for 30 min. The reaction mixtures was diluted with water and extracted with ethyl acetate to give **15** (20 mg, 80 %), m. p. 133 - 134° C; $[\alpha]_D^{26}$ -100.5° (c 0.90, $CHCl_3$); IR (nujol): ν_{max} 1743 (OAc), 1715 (CO), 1703 cm^{-1} (CO); UV (c 0.90, $CHCl_3$): λ_{max} (ε) 299 nm (116); CD ($CHCl_3$): $\Delta\varepsilon_{303}$ - 4.35; ^{1}H NMR: δ 0.68 (3H, s, 18-H_3), 0.77 (3H, s, 19-H_3), 0.84 (3H, d, J 6.9), 0.95 (3H, d, J 6.6), 1.05 (3H, d, J 6.9), 1.27 (3H, d, J 6.9, 21-H_3), 2.88 (1H), 4.60 (1H, d, J 3.0), 4.67 (1H, m, 3α-H). EI-MS: *m/z* 552/550 (M^+, 1), 471 (M^+-80, 7), 427 (471-CO_2, 5), 411 (471-AcOH, 8), 358 (M^+-193, 18), 99 (74), 71 (100). Anal. calcd. for $C_{30}H_{47}BrO_4$: C, 65.32; H, 8.59; Br, 14.49. Found: C, 65.20; H, 8.39; Br, 14.20 %.

(22S,24R)-3β-Acetoxy-22-bromo-24-methyl-5α-cholestane-6,23-dione (**16**). A solution of bromohydrin **9** (120 mg, 0.22 mmol) in acetone (15 ml) was oxidized with a slight excess of Jones reagent at rt for 30 min. Working up gave **16** (102 mg, 85 %), m. p. 225 - 226° C (ethyl acetate/n-hexane); $[\alpha]_D^{23}$ -54.5° (c 1.04, $CHCl_3$); IR (nujol): ν_{max} 1743 (OAc), 1703 cm^{-1} (CO); UV (c 1.04, $CHCl_3$): λ_{max} (ε) 293 nm (110); CD ($CHCl_3$): $\Delta\varepsilon_{293}$ - 4.30; ^{1}H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 552/550 (M^+, 4), 492/490

(M^+-60, 3), 471 (M^+-HBr, 19), 411 (471-60, 8), 358 (550-192, 30), 299 (44), 99 (100) 71 (88). Anal. calcd. for $C_{30}H_{47}BrO_4$: C, 65.32; H, 8.59; Br, 14.49. Found: C, 65.19; H, 8.46; Br, 14.35 %.

(24R)-3β-Acetoxy-24-methyl-5α-cholest-20(22)-en-6,23-dione (**17**). To a solution of bromoketone **16** (385 mg, 0.7 mmol) in dimethyl acetamide (20 ml) lithium carbonate (1.07 g) was added and the mixture refluxed under argon for 3 h. Extraction with ethyl acetate and evaporation of the solvent gave **17** (279 mg, 85 %), m. p. 151 - 152° C (ethyl acetate/n-hexane); $[\alpha]_D^{23}$ -65.4° (c 1.56, $CHCl_3$); IR (nujol): ν_{max} 1736 (OAc), 1708 cm^{-1} (CO); UV (c 1.56, $CHCl_3$): λ_{max} (ε) 280 nm (1180), 330 nm (95); CD ($CHCl_3$): $\Delta\varepsilon_{292}$ - 1.78; ^1H NMR: δ 0.58 (3H, s, 18-H_3), 0.78 (3H, s, 19-H_3), 0.86 (3H, d, J 6.6), 0.90 (3H, d, J 6.6), 1.02 (3H, d, J 6.9), 2.14 (3H, s, 21-H_3), 4.66 (1H, m, 3α-H), 6.11 (1H, s, 22-H). EI-MS: *m/z* 470 (M^+, 23), 455 (M^+-15, 8), 427 (M^+-43, 7) 410 (M^+-60, 7), 399 (M^+-71, 100). Anal. calcd. for $C_{30}H_{46}O_4$: C, 76.55; H, 9.85. Found: C, 76.77; H, 9.61 %.

Bromoketone **15** (5.5 mg, 0.01 mmol) was reacted in the same manner as described for **16** to give **17** with m. p. 147 - 149° C, all further data are identical with that of **17**, synthesized from **16**.

(24R)-3β-Hydroxy-24-methyl-5α-cholest-20(22)-en-6,23-dione (**18**). A solution of enone **16** (290 mg, 0.62 mmol) in MeOH (50 ml) was hydrolysed with K_2CO_3 (300 mg) at rt overnight to give 260 mg crude **18**, which was purified by SiO_2 chromatography. Elution with n-hexane - ethyl acetate 6 : 4 v/v afforded pure **18** (229 mg, 87 %), m. p. 143 - 144° C, $[\alpha]_D^{26}$ -54.6° (c 1.32, $CHCl_3$); IR (nujol): ν_{max} 3333 (OH), 1709 (CO), 1678 (C=C); UV (c 1.32, $CHCl_3$): λ_{max} (ε) 280 nm (1100), 330 nm (90); CD ($CHCl_3$): $\Delta\varepsilon_{291}$ - 1.98; ^1H NMR: δ 0.58 (3H, s, 18-H_3), 0.76 (3H, s, 19-H_3), 0.86 (3H, d, J 6.9), 0.90 (3H, d, J 6.6), 1.02 (3H, d, J 6.9), 2.14 (3H, s, 21-H_3), 3.58 (1H, m, 3α-H), 6.11 (1H, s, 22-H). EI-MS: *m/z* 428 (M^+, 24) 413 (M^+-15, 4), 395 (413-18, 3), 357 (M^+-71, 100). Anal. calcd. for $C_{28}H_{44}O_3$: C, 78.46; H,10.35. Found: C, 78.39; H, 10.24 %.

(22S,24S)-3β-Acetoxy-22-hydroxy-24-methyl-5α-cholestan-6-one (**19**). Treatment of bromohydrin **10** (73 mg, 0.13 mmol) in dry toluene (10 ml) with Bu_3SnH (0.4 ml) in the presence of AIBN (15 mg) under argon with stirring for 1 h at 100° C afforded after extraction with ethyl acetate a crude residue, which was purified by flash chromatography on silica gel. Elution with n-hexane/ethyl acetate 9 : 1 v/v gave **19** (60 mg, 97 %), m. p. 203 - 204° C (acetone/n-hexane); $[\alpha]_D^{23}$ -11.1° (c 1.06, MeOH); IR (nujol): ν_{max} 3479 (OH), 1732 (OAc), 1703 cm^{-1} (CO); UV (c 1.06, MeOH); λ_{max} (ε) 286 nm (75); CD (MeOH): $\Delta\varepsilon_{299}$ - 1.01; ^1H NMR: δ 0.69 (3H, s, 18-H_3), 0.77 (3H, s, 19-H_3), 0.77 (3H, d, J 6.9, 27*-H_3), 0.85 (3H, d, J 6.9, 28-H_3), 0.91 (3H, d, J 7.2, 26*-H_3), 0.93 (3H, d, J 6.9, 21-H_3), 3.74 (1H, d, J 10.7, 22-H), 4.67 (1H, m, 3α-H). EI-MS: *m/z* 456 (M^+-18, 1) 414 (M^+-60, 2), 375 (M^+-99, 6), 360 (375-15, 10), 300 (360-60, 100). Anal. calcd. for $C_{30}H_{50}O_4$: C, 75.90; H, 10.62. Found: C, 75.84; H, 10.39%.

X-ray crystal structure determination of **19**: $C_{30}H_{50}O_4$; orthorhombic; space group: $P2_12_12_1$; unit cell dimensions: a = 6.1987 (8) Å, b = 10.998 (2) Å, c = 41.534 (7) Å, α = β = γ = 90°, V = 2831.4 (7) $Å^3$, Z = 4, density (calcd.) = 1.114 Mg/m^3; absorption coefficient 0.072 mm^{-1}; F (000) = 1048; crystal size: 0.2 x 0.1 x 0.1 mm. Θ range: 1.92 to 23.99°; reflections collected: 6634; independent reflections: 2870 [R (int.) = 0.0346]; data / restraints / parameters: 2869 / 0 / 308; S: 1.029; final R indices [I›2σ (I)]: R_1 = 0.0464, wR_2 = 0.1170; R indices (all data): R_1 = 0.0640, wR_2 = 0.1334; absolute structure parameter: 1 (2); largest diff. peak and hole: 0.205 and - 0.151 e.$Å^3$.[16]

(22S,24S)-3β,22-Dihydroxy-24-methyl-5α-cholestan-6-one (**20**, 24-epicathasterone). A solution of **19** (82 mg, 0.17 mmol) in MeOH (10 ml) was hydrolyzed with K_2CO_3 (70 mg) with stirring at rt for 3 h. Working

up gave **20** (65 mg, 87 %), m. p. 224 - 225° C ($CHCl_3$), $[\alpha]_D^{23}$ -4.17° (c 1.15, MeOH); IR (nujol): ν_{max} 3437 (OH), 1685 cm^{-1} (CO); UV (c 1.15, MeOH): λ_{max} (ε) 284 nm (47); CD (MeOH): $\Delta\varepsilon_{293}$ - 1.48; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 432 (M^+, 1) 414 (M^+-18, 2), 399 (414-15, 2), 361 (M^+-71, 2), 318 (M^+-114, 100); GC-MS: RR_t 1.988; EI-MS of TMS-ether: *m/z* 575 (M^+-1, 2), 561 (M^+-15, 5), 462 (561-99, 33), 187 (72), 97 (100). HR-MS: 318.2541 (calcd. for $C_{21}H_{34}O_2$ 318.2523), 300.2453 (calcd. for $C_{21}H_{32}O$ 300.2453), 285.2211 (calcd. for $C_{20}H_{29}O$ 285.2203), 139.0758 (calcd. for $C_8H_{11}O_2$ 139.0758). Anal. calcd. for $C_{28}H_{48}O_3$: C, 77.73; H, 11.18. Found: C, 77.83; H, 10.93 %.

(23S,24S)-3β-Acetoxy-23-hydroxy-24-methyl-5α-cholestan-6-one (**21**). Treatment of **9** (113 mg, 0.20 mmol) with Bu_3SnH / AIBN as described for the synthesis of **19** gave a residue, which was purified by flash chromatography on silica gel. Elution with n-hexane/ethyl acetate 9 : 1 v/v afforded **21** (81 mg, 83 %), m. p. 165 - 167° C (acetone/n-hexane); $[\alpha]_D^{23}$ -8.1° (c 1.07, MeOH); IR (nujol): ν_{max} 3567 (OH), 1725 (OAc), 1720 cm^{-1} (CO); UV (c 1.07, MeOH): λ_{max} (ε) 299 nm (160); CD ($CHCl_3$): $\Delta\varepsilon_{293}$ - 1.52; ^1H NMR: δ 0.70 (3H, s, 18-H_3), 0.77 (3H, s, 19-H_3), 0.84 (3H, d, J 6.6, 27*-H_3), 0.86 (3H, d, J 6.6, 28-H_3), 0.94 (3H, d, J 6.9, 26*-H_3), 0.96 (3H, d, J 7.1, 21-H_3), 3.68 (1H, ddd, J 10.5/5.0/1.9, 23-H), 3.72 (1H, dd, J 3.0/1.9, 22-H), 4.67 (1H, m, 3α-H). EI-MS: *m/z* 474 (M^+, 3) 456 (M^+-18, 12), 441 (456-15, 2), 414 (M^+-60, 6), 403 (M^+-71, 16), 358 (456-98, 40), 343 (403 -60, 100). Anal. calcd. for $C_{30}H_{50}O_4$: C, 75.90; H, 10.62. Found: C, 76.14; H, 10.55 %.

(23S,24S)-3,23-Dihydroxy-24-methyl-5α-cholestan-6-one (**22**, 22-deoxy-24-epiteasterone). A solution of **21** (68 mg, 0.14 mmol) were hydrolyzed with K_2CO_3 and worked up as described for **20** to give **22** (51 mg, 83 %), m. p. 172 - 174° C (MeOH-H_2O), $[\alpha]_D^{27}$ -10.94° (c 1.02, MeOH); IR (nujol): ν_{max} 3445, 3400 (OH), 1711 cm^{-1} (CO); UV (c 1.02, MeOH): λ_{max} (ε) 284 nm (40); CD (MeOH): $\Delta\varepsilon_{293}$ - 1.53; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS: *m/z* 432 (M^+, 5) 414 (M^+-18, 30), 399 (414-15, 6), 381 (399-18, 3), 361 (M^+-71, 100); GC-MS: RR_t 2.177; EI-MS of TMS-ether: *m/z* 575 (M^+-1, 1), 561 (M^+-15, 6), 505 (M^+-71, 18), 415 (505-90, 19), 325 (415-90, 42), 173 (41), 73 (100). HR-MS: 432.3613 (calcd. for $C_{28}H_{48}O_3$ 432.3622), 414.3498 (calcd. for $C_{28}H_{46}O_2$ 414.3498), 361.2741 (calcd. for $C_{23}H_{37}O_3$ 361.2739). Anal. calcd. for $C_{28}H_{48}O_3$: C, 77.73; H, 11.18. Found: C, 77.59; H, 11.22 %.

(24S)-3β-Acetoxy-24-hydroxy-24-methyl-5α-cholestan-6-one (**23**). Treatment of bromohydrin **14** (90 mg, 0.16 mmol) with Bu_3SnH / AIBN as described for the synthesis of **19** gave a residue, which was purified by flash chromatography on silica gel. Elution with n-hexane/ethyl acetate 9 : 1 v/v afforded **23** (65 mg, 84 %), m. p. 162 - 164° C, $[\alpha]_D^{25}$ -37.9° (c 1.06, MeOH); IR (nujol): ν_{max} 3513 (OH), 1714 cm^{-1} (CO); UV (c 1.08, MeOH): λ_{max} (ε) 291 nm (55); CD (MeOH): $\Delta\varepsilon_{293}$ - 1.18; ^1H NMR: δ 0.67 (3H, s, 18-H_3), 0.77 (3H, s, 19-H_3), 0.88 (3H, d, J 6.9, 27*-H_3), 0.91 (3H, d, J 7.4, 26*-H_3), 0.94 (3H, d, J 7.2, 21-H_3), 1.07 (3H, s, 28-H_3), 4.67 (1H, m, 3α-H). EI-MS: *m/z* 474 (M^+, 1) 456 (M^+-18, 30), 441 (456-15, 9), 431 (M^+-43, 23), 413 (456-43, 22), 371 (431-60, 100). Anal. calcd. for $C_{30}H_{50}O_4$: C, 75.90; H, 10.62. Found: C, 75.70; H, 10.65 %.

(24S)-3.24-Dihydroxy-24-methyl-5α-cholestan-6-one (**24**). A solution of **23** (30 mg, 0.06 mmol) were hydrolyzed with K_2CO_3 in MeOH and worked up as described for **20** to give **24** (22 mg, 82 %), m. p. 156 - 158° C, $[\alpha]_D^{22}$ -12.4° (c 1.00, MeOH); IR (nujol): ν_{max} 3264 (OH), 1711 cm^{-1} (CO); UV (c 1.00, MeOH): λ_{max} (ε) 285 nm (90); CD (MeOH): $\Delta\varepsilon_{292}$ - 1.05; EI-MS: *m/z* 414 (M^+-18, 32) 399 (414-15, 14), 389 (M^+-43, 100), 371 (389-18, 96); GC-MS: RR_t 2.338; ^1H and ^{13}C NMR data see tables 1 and 2. EI-MS of TMS-ether: *m/z* 561 (M^+-15, 8), 533 (M^+-43, 52), 443 (533-90, 22), 159 (100). HR-MS: 414.3482 (calcd. for

$C_{28}H_{46}O_2$ 414.3466), 389.3073 (calcd. for $C_{25}H_{41}O_3$ 389.3090), 371.2962 (calcd. for $C_{25}H_{39}O_2$ 371.2973), 330.2569 (calcd. for $C_{22}H_{34}O_2$ 330.2579), 315.2340 (calcd. for $C_{21}H_{31}O_2$ 315.2356), 287.2009 (calcd. for $C_{19}H_{27}O_2$ 287.2007), 271.2076 (calcd. for $C_{19}H_{27}O$ 271.2090). Anal. calcd. for $C_{28}H_{48}O_3$: C, 77.73; H, 11.18. Found: C, 77.53; H, 11.10 %.

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