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Radical Cyclisation Reactions Leading to Polycyclics Related to the *Amaryllidaceae* and *Erythrina* Alkaloids

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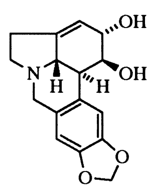
Abstract—Novel radical cyclisation reactions, mediated by tributyltin hydride, samarium(II) iodide or manganese(III) acetate, have been explored to form tri- and tetra-cyclic ring systems related to the *Amaryllidaceae* or *Erythrina* family of alkaloids. Haloethanamide precursors possessing a cyclohexenone ring have been shown to form octahydroindolones, and erythrinane-type systems can be formed from precursors bearing unsaturated side-chains in tandem cyclisations. An octahydroindolone has been converted to the ring skeleton of γ-lycorane using samarium(II) iodide while reaction with manganese(III) acetate has been shown to yield a novel tetracyclic ring system bearing a 7-membered ring. Finally, a new tandem cyclisation of a cyclohexenone aryl halide has been shown to provide a quick approach to a 5,5,6,6-tetracycle related to erythrinane natural products. © 2000 Elsevier Science Ltd. All rights reserved.

Introduction

The synthesis of *Amaryllidaceae* and *Erythrina* alkaloids has attracted considerable synthetic attention in recent years.[1] This can be attributed to the wide range of biological properties that these compounds exhibit (including emetic behaviour, inhibition of protein and DNA synthesis in certain cells; antineoplastic, antiviral, short-term hypotensive and insect antifeedant activity) and the synthetic challenge of constructing the polycyclic ring systems associated with these compounds. These ring systems generally consist of four (two carbocyclic and two heterocyclic) contiguous rings as illustrated by the Amaryllidaceae alkaloids lycorine **1**, γ-lycorane **2** (a degradation product of lycorine-type alkaloids) and sternbergine **3**, and the *Erythrina* alkaloids cocculine **4** and erysotrine **5**.



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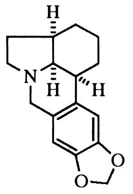

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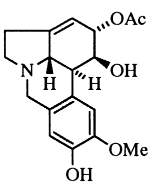

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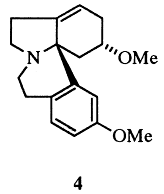

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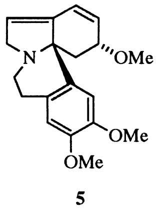

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A number of very recent synthetic approaches to these types of alkaloid have centred on the formation of the tetracyclic skeleton using a radical cyclisation reaction in the key step.[2–8] In 1996, Schultz and co-workers[2] reported the first asymmetric synthesis of (+)-lycorine **1** using a key 6-*endo-trig* cyclisation of an aryl radical and a similar approach was reported (in the same year) by Rigby and Mateo to form α-lycorane.[3] The first total synthesis of (−)-γ-lycorane **2**, which employed both a 5-*endo-trig* and a 6-*exo-trig* radical cyclisation (mediated by tributyltin hydride), was reported in 1998 by Ikeda and co-workers.[4] Since then, Zard and co-workers[5,6] have developed two radical approaches to racemic γ-lycorane **2**; the first approach centred on a 5-*endo-trig* cyclisation (mediated by Ni/AcOH), followed by a 6-*endo-trig* cyclisation (mediated by tributyltin hydride), while the second approach exploited a tandem cyclisation of an amidyl radical to construct the tetracyclic ring system. Finally, Cossy and co-workers[7] have recently employed an aminyl radical cyclisation (mediated by CuCl/$CuCl_2$) as a key step in a racemic synthesis of **2**. In this paper, we report the development of some novel radical cyclisation reactions, mediated by tributyltin hydride, samarium(II) iodide or manganese(III) acetate, which provide a short approach to polycyclic ring systems related to the *Amaryllidaceae* or *Erythrina* family of alkaloids.

Results and Discussion

Our initial studies investigated the formation of a 5,6-bicyclic ring system by radical cyclisation of dichloroethanamides **6a–d** (Scheme 1, Table 1). These were prepared on acylation of the imine/enamine derived from 1,2-cyclohexanedione and the appropriate benzylamine, in a one-pot reaction. Reaction with 2.2 equiv. of tributyltin hydride

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Keywords: radicals and radical reactions; cyclisation; alkaloids; enamides.

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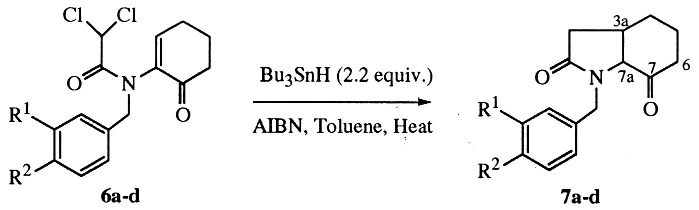


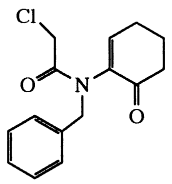
Scheme 1.

in boiling toluene or benzene resulted in 5-*endo-trig* cyclisation leading to the formation of octahydroindolones **7a–d** in 63–85% (isolated) yield. It was found that the best cyclisation yields were obtained when 1.1 equiv. of tributyltin hydride were added to the dichloride over 5 h (rather than 1 h); the second equivalent (of tributyltin hydride) can then be added in one portion to reduce the remaining carbon–chlorine bond. In all cases separable mixtures of *cis*- and *trans*-ring junction isomers, in the ratio 3.3–5.1:1, were formed as indicated by the ^{1}H and ^{13}C NMR spectra. For example, for the doublet signals due to H_{7a} in the ^{1}H NMR spectra, coupling constants of ca. 8 and 11 Hz were assigned to the (major) *cis*- and (minor) *trans*-isomers, respectively. This assignment was substantiated by base-induced equilibration experiments. Thus, heating the *trans*-isomer of **7a** with (catalytic) DBU in toluene for 5 h resulted in epimerisation to give only the thermodynamically more stable *cis*-isomer. These results contrast with radical cyclisation of a related *N*-(*S*)-1-phenylethyl-iodoethanamide precursor by Ikeda and co-workers, for which only the *cis*-ring junction isomer was reported.[4]

Interestingly, when the related monochloroethanamide **8** was reacted with 1.1 equiv. of tributyltin hydride, added over 1 h, in addition to the formation of **7a** in 29% yield (as a 3.7:1 mixture of *cis*-/*trans*-isomers), the hydroxy derivative **9** was also obtained (as a single diastereoisomer) in 22% yield. The unexpected formation of **9** could arise from reaction of molecular oxygen with the intermediate (captodative) α-amino ketone radical **10**.[9] However, it is unclear why related alcohols were not isolated from reaction of dichloroethanamides **6a–d** with tributyltin hydride under similar conditions. It should also be noted that the position of the ketone group influences the efficiency of the 5-*endo* cyclisation. Thus, when chloroethanamide **11**, bearing a ketone group at C-3 (rather than C-6), was reacted with tributyltin hydride (added over 5 h) only 16% yield of the octahydroindolone was isolated (together with the ethanamide derived from simple reduction in 52% yield). This presumably reflects the relative stability of the intermediate radicals produced on 5-*endo* cyclisation—the ketone can only (mesomerically) stabilise the radical derived from 5-*endo* cyclisation when positioned at C-6.

Table 1. Tributyltin hydride-mediated cyclisation of dichloroethanamides **6a–d**

6	R^{1}	R^{2}	Bu_3SnH addition time/h	Yield of 7 (%)	*cis*:*trans*
a	H	H	1	63	4.2:1
b	H	MeO	1	65	4.8:1
b	H	MeO	5	85	3.3:1
c	OCH_2O		5	74	5.1:1
d	F	H	5	71	4.6:1



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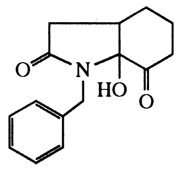

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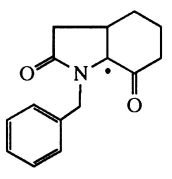

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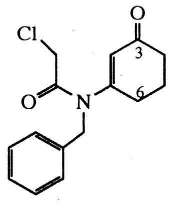

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Given the possible trapping of the α-amino keto radical **10** with molecular oxygen, it was envisaged that radicals similar to **10** could also be trapped by a (second) carbon–carbon double bond in an intramolecular tandem cyclisation reaction. This could allow the formation of erythrinane-type ring systems. Indeed, reaction of the *N*-but-3-enyl and *N*-4-ethoxycarbonylbut-3-enyl dichloroethanamides **12a–b** with tributyltin hydride resulted in tandem cyclisation to form tricycles **13** and **14** in 58 and 64% yield, respectively (Scheme 2). The exclusive formation of 5,6,6-tricycle **13** (as a single diastereomer) can be explained by a 5-*endo*/6-*endo* cyclisation mechanism and the formation of the 6-membered ring is presumably due to the stability[†] of the intermediate captodative radical (of type **10**); this promotes a reversible cyclisation leading to the thermodynamic (6-ring) product.[11] In contrast, a 5-*endo*/5-*exo* tandem cyclisation was observed for **12b** because the ester substituent is able to stabilise the radical produced on 5-*exo* cyclisation; the second cyclisation is no longer reversible and so the kinetic (5-ring) product **14** is formed (as a 1:1 mixture of diastereomers). Steric effects may also be important as indicated by the reaction of the *N*-2-(cyclohex-1-enyl)ethyl precursor **15** (Scheme 3). Following reaction with tributyltin hydride, the desired erythrinane-type 5,6,6,6-tetracycle **16** was isolated in only 19% yield (as a single diastereomer) together with octahydroindolone **17** in 38% yield (as a 4.7:1 mixture of *cis*-:*trans*-isomers). The lower yield for **16** compared to **13** may be attributed to steric effects. Indeed, cyclisation of a related monochloroethanamide, without the ketone group, has been shown to lead to a similar tetracycle in 44% yield.[10] In order to reduce the rate of hydrogen-atom

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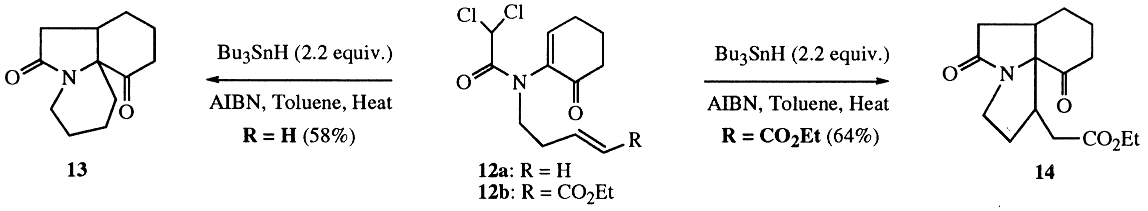
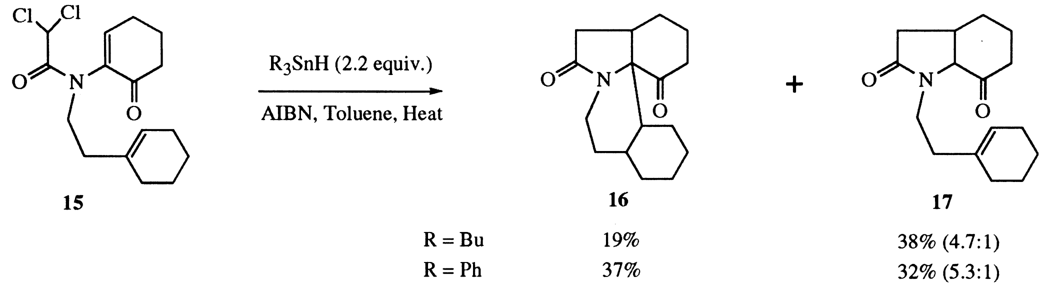
[†] Stabilisation of the radical by the ketone group is important as cyclisation of the corresponding chloroethanamide, without the ketone group, produced a mixture of 5,5,6- and 5,6,6-tricycles in a 1.2:1 ratio (Ref. 10).



Scheme 2.

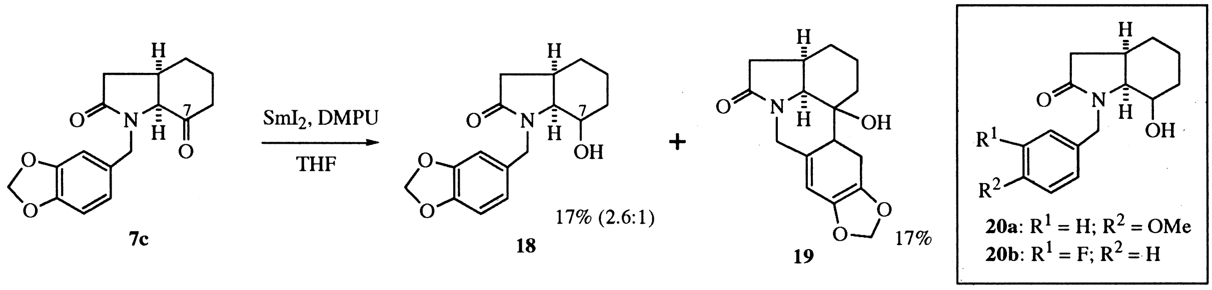


Scheme 3.

trapping of the (sterically hindered) α-amino keto radical leading to **17**, the bulkier triphenyltin hydride was reacted with **15** (in place of tributyltin hydride). Gratifyingly, this resulted in an improved yield of 37% for **16** while the yield of **17** was reduced slightly (to 32%).

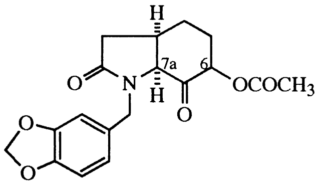
The elaboration of *N*-benzyl-octahydroindolones **7b**–**d** was then investigated with a view to forming the fourth ring of the lycorane or the erythrinane-type ring system. This requires the formation of a new carbon–carbon bond between the benzene ring and position 7 or 7a of the octahydroindolone ring. Initially, it was envisaged that the lycorane ring system could be accessed from reaction of **7b**–**d** with samarium(II) iodide. Reaction with the ketone group was expected to lead to the formation of a ketyl radical which could then cyclise on to the substituted benzene ring.[12] Hence, reaction of *cis*-**7c** with 3.3 equiv. of samarium(II) iodide and 8 equiv. of DMPU in tetrahydrofuran, resulted in the isolation of alcohol **18** in 17% yield (as a 2.6:1 mixture of isomers) and tetracycle **19** in 17% yield (together with 4% unreacted starting material) (Scheme 4). The unexpected formation of the cyclohexadiene **19** (as a single diastereomer) could result from radical cyclisation on to the benzene ring to give a cyclohexadienyl radical, which is subsequently reduced by samarium(II) iodide to give an anion which is protonated on workup. Alternatively, **19** could be formed by an intramolecular Friedel–Crafts reaction in which the samarium(II) iodide acts as a Lewis acid to promote nucleophilic attack at the ketone. All the spectroscopic data for **19** were consistent with the structure shown, although the diene (*m*/*z* 290, $M+H^+$) was sensitive to aerial oxidation to give the corresponding benzene ring as indicated by the mass spectrum (*m*/*z* 288, $M+H^+$). The successful formation of the desired lycorane-type ring system then led us to explore the cyclisation of octahydroindolones **7b** and **7d** bearing different substituents [namely 4-methoxy (electron-donating) and 3-fluoro (electron-withdrawing) groups] on the acceptor benzene ring. Unfortunately, reaction of these substrates with samarium(II) iodide/DMPU lead to the formation of many products (as evidenced by TLC), the major products of which were the alcohols **20a**–**b** (isolated in 24% and 33% yield, respectively), and the formation of the desired tetracycles was only tentatively assigned, in <9% yield, from the NMR and mass spectra.

The cyclisation of *cis*-**7c**, to form a 5,5,6,6-tetracyclic analogue of the erythrinane ring system, was then investigated using manganese(III) acetate. It was envisaged that reaction of the ketone group with manganese(III) acetate would lead to generation of an α-amino ketone radical (of type **10**) which could then cyclise on to the benzene ring to form a new 5-membered ring.[13] Hence, *cis*-**7c** was reacted with 4 equiv. of manganese(III) acetate in boiling benzene.



Scheme 4.

This yielded the 6-acetoxy ketone **21**[14] in 18% yield (as a 2.7:1 mixture of isomers) together with two inseparable regioisomeric tetracycles, **22** and **23**, in the ratio 2.8:1, in 34% yield. The formation of **21** and tetracycles **22**–**23**, which possess a novel ring system, presumably results from radical generation at C-6 (rather than C-7a). Cyclisation of this radical on to the two possible positions of the benzene ring produces the observed 7-membered rings and the predominance of **22** over **23** can be attributed to steric effects. Activation of the benzene ring is required for reasonable yields of cyclisation because when the corresponding *N*-benzyl-octahydroindolone **7a** was reacted with manganese(III) acetate, ≪10% yield of the cyclised product was isolated. The major product was the 6-acetoxy ketone (as a 2.1:1 mixture of isomers) in 52% yield. Interestingly, reaction of manganese(III) acetate with *trans*-**7c** only produced the 7a-acetoxy adduct in poor yield (7%) together with recovered starting material (43%). The ring strain associated with the *trans*-ring junction presumably prevents radical cyclisation to form a 7-membered ring.



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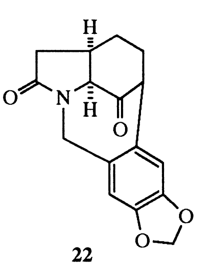

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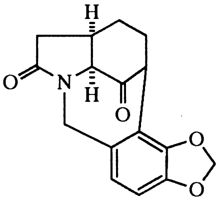

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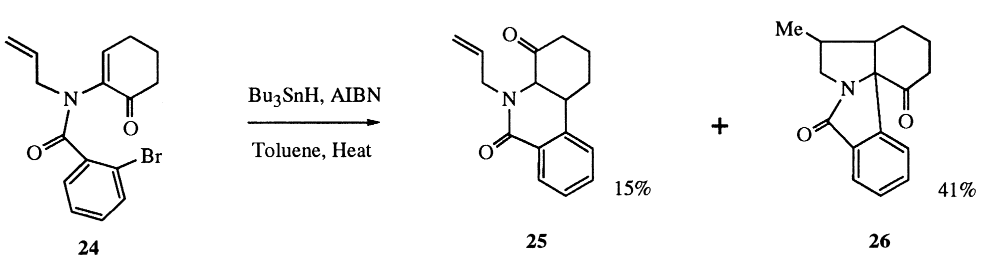
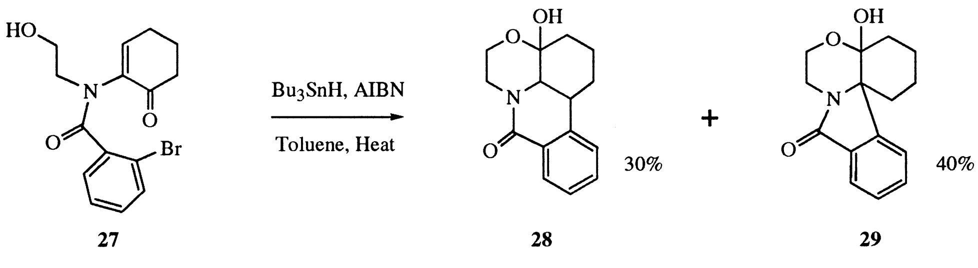
The 5,5,6,6-tetracyclic (erythrinane-type) ring system could, however, be prepared using an alternative radical cyclisation strategy (Scheme 5). Hence, reaction of aryl bromide **24** (prepared from allylamine, 2-bromobenzoyl chloride and 1,2-cyclohexanedione in a one-pot reaction) with tributyltin hydride (added over 1 h) resulted in the formation of tricycle **25** in 15% yield (as a 1.6:1 mixture of *trans*-/*cis*-isomers) and the desired tetracycle **26** in 41% yield. Tetracycle **26** was isolated as a mixture of 4 isomers in the ratio 17.8:5.0:2.3:1 (from the ^{1}H NMR spectra) and **25** and **26** were isolated in similar yields and diastereomer ratios when tributyltin hydride or triphenyltin hydride were added to **24** over 5 h. The initial aryl radical can cyclise in a 6-*endo* fashion to form **25**, while the formation of **26** can be explained by a competitive 5-*exo*/5-*exo* tandem cyclisation. Of particular note is the construction of the hindered quaternary centre in **26** by the (initial) 5-*exo* cyclisation. The predominance of 5-*exo* over 6-*endo* cyclisation was also observed using substrates for which a second radical cyclisation is impossible. For example, cyclisation of the related *N*-2-hydroxyethyl precursor **27** produced tetracycles **28** and **29** in 30% and 40% yield (as single diastereomers), respectively (Scheme 6). The major product, **29**, is derived from 5-*exo* cyclisation of the aryl radical while **28** is formed from a competitive 6-*endo* cyclisation. Both cyclisation pathways lead to tricycles, which then react to form the observed hemiacetals **28** and **29**, presumably on (silica) column chromatography.

This work has demonstrated a number of novel radical cyclisation reactions leading to tri- and tetra-cyclic ring systems related to the lycorane and erythrinane-type skeletons. Haloethanamide precursors possessing a cyclohexenone ring have been shown to form octahydroindolones, and erythrinane-type systems can be formed from precursors bearing unsaturated side-chains in tandem cyclisations. An octahydroindolone has been converted to the ring skeleton of lycorane using samarium(II) iodide while reaction with manganese(III) acetate has been shown to yield a novel tetracyclic ring system bearing a 7-membered ring. Finally, a novel tandem (5-*exo*/5-*exo*)



Scheme 5.



Scheme 6.

cyclisation of an unsaturated aryl halide has been shown to provide a quick 2-step approach to a 5,5,6,6-ring system related to the erythrinane natural products.

Experimental

IR spectra were recorded on an ATI Mattson Genesis FTIR spectrometer. ^{1}H and ^{13}C NMR spectra were recorded on a Jeol EX 270 spectrometer. The carbon spectra were assigned using DEPT experiments. Coupling constants (*J*) were recorded in Hertz to the nearest 0.5 Hz. Mass spectra were recorded on a Fisons Instruments VG Analytical Autospec Spectrometer system. Thin layer chromatography was performed on Merck aluminium-backed silica gel plates. Melting points were recorded on a Gallenkamp melting point apparatus. The Chemical Analytical Services Unit, University of Newcastle performed microanalyses using a Carlo Erba 1106 Elemental Analyser. Compounds were visualised under a UV lamp, using alkaline potassium permanganate solution and/or acidic cerium(IV) sulfate-molybdic acid solution. Column chromatography was performed using silica gel (Matrex Silica 60, 70–200 micron Fisons or ICN flash silica 60, 32–63 μm). Petroleum ether refers to the fraction with bp 40–60°C.

General procedure for the preparation of 6a–d, 8, 12a, 15 and 24

To a stirred solution of 1,2-cyclohexanedione (0.35–2.5 g, 3.12–22.30 mmol) in benzene or toluene (50–100 cm^3) at room temperature was added the amine (0.28–3.36 g, 1.1 equiv., 3.43–24.53 mmol). The solution was heated at reflux in a Dean–Stark water separator until TLC indicated that no starting material remained (approx. 3 h). After cooling to 0°C, the acid halide (0.81–3.62 g, 1.1 equiv., 3.43–24.53 mmol) was added dropwise. Pyridine or triethylamine (0.27–2.48 g, 1.1 equiv., 3.43–24.53 mmol) was then added and the solution allowed to warm to room temperature. After stirring overnight, the solution was washed with water, brine, dried (magnesium sulfate) and the solvent evaporated under reduced pressure to afford the crude alkene, which was purified by column chromatography (silica) (0.77–4.39 g, 48–65%).

***N*-Benzyl-*N*-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 6a.** 49%; White solid; mp 120–122°C; R_f 0.4 (ethyl acetate-petroleum ether, 2:3); ν_{max} (CHCl$_3$)/cm^{-1} 3064 (w), 3031(w), 3007 (m), 2952 (w), 2936 (w), 1689 (s), 1655 (s), 1613 (s), 1495 (w), 1451 (w), 1394 (s), 1342 (m), 1233 (w) and 1188 (w); δ_H (270 MHz, CDCl$_3$) 7.35–7.16 (5H, m, aromatics), 6.68 (1H, t, *J*=4 Hz, C*H*=C), 5.90 (1H, s, C*H*Cl$_2$), 5.32 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ph), 4.05 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ph), 2.57–2.31 (4H, m, C*H*$_2$CO and C*H*$_2$CH) and 2.08–1.92 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.4 (CH$_2$*C*O), 163.9 (N*C*O), 151.7 (*C*H=C), 136.8, 135.9 (*C*=CH and *C*=CH), 129.1, 128.6, 128.0 (3×*C*H=C), 64.8 (*C*HCl$_2$), 52.0 (N*C*H$_2$Ph), 38.2 (*C*H$_2$CO), 26.0 (*C*H$_2$CH) and 22.1 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 331 (^{37,35}M+NH$_4^+$, 15%), 329 (^{35}M+NH$_4^+$, 25), 314 (^{37,35}M+H$^+$, 15), 312 (^{35}M+H$^+$, 20), 295 (10), 278 (25), 259 (20), 244 (80), 242 (100), 200 (10), 185 (15) and 108 (20); Found: M+H$^+$, 312.0552. C$_{15}$H$_{15}$^{35}Cl$_2$NO$_2$ requires for M+H$^+$, 312.0558.

***N*-(4-Methoxybenzyl)-*N*-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 6b.** 58%; Solid; mp 121–124°C (Found: C, 56.44; H, 5.05; N, 4.04. C$_{16}$H$_{17}$Cl$_2$NO$_3$ requires C, 56.16; H, 5.01; N, 4.09%); R_f 0.35 (ethyl acetate-petroleum ether, 1:1); ν_{max} (CHCl$_3$)/cm^{-1} 3031 (w), 3009 (w), 2958 (w), 2937 (w), 1696 (br, s), 1612 (w), 1513(m), 1400 (w), 1250 (m), 1209 (w), 1177 (w), 1112 (w) and 1035 (w); δ_H (270 MHz, CDCl$_3$) 7.09 (2H, d, *J*=8.5 Hz, 2×C*H*CHCOMe), 6.80 (2H, d, *J*=8.5 Hz, 2×C*H*COMe), 6.64 (1H, t, *J*=4 Hz, C*H*=C), 5.87 (1H, s, C*H*Cl$_2$), 5.20 (1H, d, *J*=14 Hz, NC*H*$_A$H$_B$Ar), 3.98 (1H, d, *J*=14 Hz, NCH$_A$*H*$_B$Ar), 3.76 (3H, s, OC*H*$_3$), 2.51–2.34 (4H, m, C*H*$_2$CO and C*H*$_2$CH) and 2.06–1.92 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.4 (CH$_2$*C*O), 163.6 (N*C*O), 159.2 (*C*OMe), 151.8 (*C*H=C), 136.4 (*C*=CH), 130.4 (*C*HCHCOMe), 127.7 (*C*=CH), 113.8 (*C*HCOMe), 64.8 (*C*HCl$_2$), 55.1 (O*C*H$_3$), 51.3 (N*C*H$_2$Ar), 38.0 (*C*H$_2$CO), 25.9 (*C*H$_2$CH) and 22.0 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 361 (^{37,35}M+NH$_4^+$, 20%), 359 (^{35}M+NH$_4^+$, 30), 325 (35), 308 (15), 291 (10), 274 (25), 138 (35) and 121 (100); Found: M+NH$_4^+$, 359.0930. C$_{16}$H$_{17}$^{35}Cl$_2$NO$_3$ requires for M+NH$_4^+$, 359.0929.

***N*-(3,4-Methylenedioxybenzyl)-*N*-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 6c.** 63%; Solid; mp 110–116°C; R_f 0.25 (ethyl acetate-petroleum ether, 2:3); ν_{max} (CHCl$_3$)/cm^{-1} 2935 (w), 2893 (w), 1693 (s), 1490 (m), 1444 (w), 1403 (w), 1244 (m), 1192 (w), 1124 (w) and 1040 (m); δ_H (270 MHz, CDCl$_3$) 6.74 (1H, t, *J*=4 Hz, C*H*=C), 6.73 (1H, d, *J*=1.5 Hz, CC*H*CO), 6.71 (1H, d, *J*=8 Hz, CHC*H*CO), 6.61 (1H, dd, *J*=8, 1.5 Hz, C*H*CHCO), 5.95 (2H, s, OC*H*$_2$O), 5.90 (1H, s, C*H*Cl$_2$), 5.21 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 3.93 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 2.59–2.42 (4H, m, C*H*$_2$CO and C*H*$_2$CH) and 2.10–1.98 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.3 (CH$_2$*C*O), 163.7 (N*C*O), 151.8 (*C*H=C), 147.8, 147.2 (CHCH*C*O and CCH*C*O), 136.5 (*C*=CH), 129.5 (NCH$_2$*C*), 122.6 (*C*HCHCO), 109.2, 108.0 (CH*C*HCO and C*C*HCO), 101.1 (O*C*H$_2$O), 64.7 (*C*HCl$_2$), 51.7 (N*C*H$_2$Ar), 38.1 (*C*H$_2$CO), 25.9 (*C*H$_2$CH) and 22.1 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 375 (^{37,35}M+NH$_4^+$, 55%), 373 (^{35}M+NH$_4^+$, 85), 358 (^{37,35}M+H$^+$, 25), 357 (25), 356 (^{35}M+H$^+$, 30), 355 (25), 339 (45), 322 (15), 286 (30), 152 (20) and 135 (100); Found: M+NH$_4^+$, 373.0719. C$_{16}$H$_{15}$^{35}Cl$_2$NO$_4$ requires for M+NH$_4^+$, 373.0722.

***N*-(3-Fluorobenzyl)-*N*-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 6d.** 63%; Solid; mp 79–83°C; R_f 0.2 (diethyl ether–petroleum ether, 3:2); ν_{max} (CHCl$_3$)/cm^{-1} 3038 (w), 3030 (w), 3023 (w), 3007 (w), 2957 (w), 2936 (w), 1697 (br, s), 1632 (w), 1616 (w), 1592 (w), 1488 (w), 1452 (w), 1399 (w), 1358 (w), 1343 (w), 1301 (w), 1256 (w), 1232 (w) and 1216 (w); δ_H (270 MHz, CDCl$_3$) 7.29 (1H, dt, *J*=6, 8 Hz, C*H*CHCF), 7.01–6.93 (3H, m, CC*H*CF, CHC*H*CF and C*H*CCHCF), 6.80 (1H, t, *J*=4 Hz, C*H*=C), 5.93 (1H, s, C*H*Cl$_2$), 5.27 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 4.05 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 2.63–2.38 (4H, m, C*H*$_2$CO and C*H*$_2$CH) and 2.11–1.99 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.4 (CH$_2$*C*O), 164.1 (N*C*O), 162.8 (d, $^1J_{CF}$=248 Hz, *C*F), 151.8 (*C*H=C), 138.4 (d, $^3J_{CF}$=

8 Hz, *C*CHCF), 136.8 (*C*=CH), 130.2 (d, $^3J_{CF}$=8 Hz, *C*HCHCF), 124.5 (d, $^4J_{CF}$=3 Hz, *C*HCCHCF), 115.7 (d, $^2J_{CF}$=22 Hz, *C*HCF), 114.9 (d, $^2J_{CF}$=22 Hz, *C*HCF), 64.7 (*C*HCl$_2$), 51.6 (N*C*H$_2$Ar), 38.1 (*C*H$_2$CO), 26.0 (*C*H$_2$CH) and 22.1 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 349 (^{37,35}M+NH$_4^+$, 65%), 347 (^{35}M+NH$_4^+$, 100), 332 (^{37,35}M+H$^+$, 10), 330 (^{35}M+H$^+$, 15), 313 (15), 277 (15), 260 (20) and 218 (15); Found: M+NH$_4^+$, 347.0727. C$_{15}$H$_{14}$^{35}Cl$_2$FNO$_2$ requires for M+NH$_4^+$, 347.0729.

_N_-Benzyl-_N_-(6-oxocyclohex-1-enyl)-2-chloroethanamide 8. 65%; Oil; R_f 0.3 (ethyl acetate-petroleum ether, 1:1); ν_{max} (CHCl$_3$)/cm^{-1} 3032 (w), 3009 (m), 2955 (w), 2934 (w), 2889 (w), 2873 (w), 1691 (br s), 1632 (w), 1496 (w), 1455 (w), 1428 (w), 1408 (w), 1361 (w), 1344 (w), 1253(w), 1233 (w), 1219 (w), 1191 (w), 1152 (w), 1123 (w) and 1080 (w); δ_H (270 MHz, CDCl$_3$) 7.36–7.20 (5H, m, aromatics), 6.69 (1H, t, *J*=4.5 Hz, C*H*=C), 5.32 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ph), 4.05 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ph), 3.92 (2H, s, C*H*$_2$Cl), 2.57–2.37 (4H, m, C*H*$_2$COC and C*H*$_2$CH) and 2.07–1.98 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.5 (CH$_2$*C*OC), 166.0 (N*C*O), 150.7 (*C*H=C), 137.0, 136.0 (2×*C*=CH), 128.5, 128.1, 127.3 (3×*C*H=C), 50.9 (N*C*H$_2$Ph), 41.4 (*C*H$_2$Cl), 37.8 (*C*H$_2$COC), 25.5 (*C*H$_2$CH) and 21.8 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 280 (^{37}M+H$^+$, 35%), 278 (^{35}M+H$^+$, 100), 244 (75), 200 (50) and 91 (20); Found: M+H$^+$, 278.0945. C$_{15}$H$_{16}$^{35}ClNO$_2$ requires for M+H$^+$, 278.0948.

_N_-(But-3-enyl)-_N_-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 12a. 56%; Oil: R_f 0.1 (diethyl ether–petroleum ether, 1:1); ν_{max} (CHCl$_3$)/cm^{-1} 3035 (w), 3011(w), 2955 (w), 2938 (w), 1698 (br, s), 1633 (w), 1403 (w), 1346 (m), 1231 (w), 1216 (w), 1198 (w) and 1117 (w); δ_H (270 MHz, CDCl$_3$) 7.21 (1H, t, *J*=4 Hz, C*H*=C), 5.95 (1H, s, C*H*Cl$_2$), 5.74 (1H, ddt, *J*=17, 10.5, 7 Hz, C*H*=CH$_2$), 5.10–5.02 (2H, m, CH=C*H*$_A$H$_B$ and CH=CH$_A$*H*$_B$), 3.88 (1H, dt, *J*=13.5, 7.5 Hz, NC*H*$_A$H$_B$), 3.20 (1H, dt, *J*=13.5, 7.5 Hz, NCH$_A$*H*$_B$), 2.69–2.59 (4H, m, C*H*$_2$CO and C*H*$_2$CH=C), 2.32–2.22 (2H, appt quintet, *J*=7 Hz, NCH$_2$C*H*$_2$) and 2.15 (2H, appt quintet, *J*=6.5 Hz, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.4 (CH$_2$*C*O), 163.3 (N*C*O), 151.1 (*C*H=C), 137.1 (*C*=CH), 134.2 (*C*H=CH$_2$), 116.6 (CH=*C*H$_2$), 64.4 (*C*HCl$_2$), 47.8 (N*C*H$_2$), 37.7 (*C*H$_2$CO), 31.3 (NCH$_2$*C*H$_2$), 25.6 (*C*H$_2$CH=C) and 21.7 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 280 (^{37}M+H$^+$, 10%), 278 (^{37,35}M+H$^+$, 65), 276 (^{35}M+H$^+$, 100), 242 (30), 234 (20), 206 (90), 166 (20), 164 (35) and 124 (45); Found: M+H$^+$, 276.0557. C$_{12}$H$_{15}$^{35}Cl$_2$NO$_2$ requires for M+H$^+$, 276.0558.

_N_-[2-(Cyclohex-1-enyl)ethyl]-_N_-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide 15. 48%; Oil; R_f 0.2 (diethyl ether–petroleum ether, 3:2); ν_{max} (CHCl$_3$)/cm^{-1} 3023 (m), 3011 (m), 2934 (s), 2891 (m), 2860 (m), 2837 (m), 1692 (br, s), 1632 (m), 1449 (m), 1438 (m), 1405 (m), 1346 (m), 1307 (w), 1235 (w), 1216 (w), 1186 (w), 1154 (w) and 1123 (m); δ_H (270 MHz, CDCl$_3$) 7.14 (1H, t, *J*=4 Hz, COC=C*H*), 5.87 (1H, s, C*H*Cl$_2$), 5.41 (1H, br s, C*H*=CCH$_2$), 3.95 (1H, dt, *J*=13.5, 7.5 Hz, NC*H*$_A$H$_B$), 3.14 (1H, dt, *J*=13.5, 7.5 Hz, NCH$_A$*H*$_B$), 2.65–2.58 (4H, m, C*H*$_2$CO and C*H*$_2$CH=CCO), 2.18–2.09 (4H, m, NCH$_2$C*H*$_2$ and C*H*$_2$CH$_2$CO), 1.96–1.83 (4H, m, C*H*$_2$C=CH and C*H*$_2$CH=CCH$_2$) and 1.64–1.47 (4H, m, C*H*$_2$CH$_2$C=CH and C*H*$_2$CH$_2$CH=CCH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.4 (CH$_2$*C*O), 163.4 (N*C*O), 150.6 (COC=*C*H), 137.7 (CO*C*=CH), 134.0 (CH$_2$*C*=CH), 123.3 (CH$_2$C=*C*H), 64.6 (*C*HCl$_2$), 47.2 (N*C*H$_2$), 38.1 (*C*H$_2$CO), 35.5 (NCH$_2$*C*H$_2$), 28.0, 25.9, 25.1 (*C*H$_2$CH=CCO, *C*H$_2$C=CH and *C*H$_2$CH=CCH$_2$), 22.6 and 22.1 (*C*H$_2$CH$_2$CO, *C*H$_2$CH$_2$CH=CCH$_2$ and *C*H$_2$CH$_2$C=CH); *m/z* (CI, NH$_3$) 332 (^{37,35}M+H$^+$, 65%), 330 (^{35}M+H$^+$, 100), 296 (15) and 260 (25); Found: M+H$^+$, 330.1022. C$_{16}$H$_{21}$^{35}Cl$_2$NO$_2$ requires for M+H$^+$, 330.1028.

_N_-Allyl-_N_-(6-oxocyclohex-1-enyl)-2-bromobenzamide 24. 51%; Oil; R_f 0.2 (petroleum ether–diethyl ether–dichloromethane, 5:4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3016 (m), 2955 (w), 2930 (w), 1689 (s), 1656 (s), 1629 (m), 1592 (w), 1471 (w), 1430 (w), 1399 (m), 1358 (w), 1297 (w), 1237 (w), 1121 (w) and 1027 (w); δ_H (270 MHz, CDCl$_3$) 7.48 (1H, dd, *J*=7.5, 1.5 Hz, C*H*CBr), 7.24–7.10 (3H, m, aromatics), 7.05 (1H, br t, *J*=4.5 Hz, C*H*=C), 5.88 (1H, ddt, *J*=17, 10, 6.5 Hz, C*H*=CH$_2$), 5.26–5.15 (2H, m, CH=C*H*$_2$), 4.77–4.73 (1H, br m, NC*H*$_A$H$_B$), 3.85–3.72 (1H, br m, NCH$_A$*H*$_B$), 2.45–2.05 (4H, br m, C*H*$_2$CO and CH$_2$C*H*$_2$CH), 1.93–1.74 (1H, br m, CH$_2$C*H*$_A$H$_B$CH$_2$) and 1.63–1.45 (1H, br m, CH$_2$CH$_A$*H*$_B$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 194.9 (CH$_2$*C*O), 168.1 (N*C*O), 149.0 (*C*H=C), 138.3, 138.1 (*C*=CBr and *C*=CH), 132.7, 132.1, 129.9, 127.6, 126.8 (4×*C*H=C and *C*H=CH$_2$), 119.3 (*C*Br), 118.2 (CH=*C*H$_2$), 49.5 (N*C*H$_2$), 37.9 (*C*H$_2$CO), 25.6 (*C*H$_2$CH$_2$CH) and 21.8 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 336 (^{81}M+H$^+$, 100%), 334 (^{79}M+H$^+$, 95), 300 (15), 256 (40), 228 (15), 185 (15), 183 (15) and 150 (40); Found: M+H$^+$, 334.0437. C$_{16}$H$_{16}$^{79}BrNO$_2$ requires for M+H$^+$, 334.0443.

_N_-(2-Hydroxyethyl)-_N_-(6-oxocyclohex-1-enyl)-2-bromobenzamide 27. Following the general procedure 1,2-cyclohexanedione (0.35 g, 3.12 mmol) in toluene (70 cm^3) was reacted with 2-(*tert*-butyldimethylsilyloxy)ethylamine (0.60 g, 3.43 mmol), 2-bromobenzoyl chloride (0.45 cm^3, 3.43 mmol) and triethylamine (0.48 cm^3, 3.43 mmol). Column chromatography (silica; diethyl ether–petroleum ether, 3:2) afforded the silyl protected alcohol (0.86 g, 61%) as a white crystalline solid: mp 92–95 °C; R_f 0.3 (diethyl ether–petroleum ether, 3:2); ν_{max} (CHCl$_3$)/cm^{-1} 3009 (w), 2954 (w), 2931 (w), 2888 (w), 2857 (w), 1688 (s), 1654 (s), 1632 (m), 1591 (w), 1472 (w), 1429 (w), 1401 (w), 1349 (w), 1311 (w), 1257 (w), 1228 (w), 1102 (w) and 1085 (w); δ_H (270 MHz, d$_8$-toluene, 80 °C) 7.38–6.84 (5H, m, aromatics and C*H*=C), 4.15–3.80 (4H, br m, NC*H*$_2$ and C*H*$_2$OSi), 2.20–2.00 (2H, br m, C*H*$_2$CO or C*H*$_2$CH), 2.00–1.80 (2H, br m, C*H*$_2$CO or C*H*$_2$CH), 1.30–1.55 (2H, br m, CH$_2$C*H*$_2$CH$_2$), 1.12 [9H, s, SiC(C*H*$_3$)$_3$] and 0.25 [6H, s, Si(C*H*$_3$)$_2$]; δ_C (67.5 MHz, CDCl$_3$) 195.0 (CH$_2$*C*O), 168.6 (N*C*O), 148.6 (*C*H=C), 139.7, 138.6 (*C*=CBr and *C*=CH), 132.2, 129.9, 127.9, 126.8 (4×*C*=C), 119.5 (*C*Br), 61.0 (*C*H$_2$OSi), 50.0 (N*C*H$_2$), 38.1 (*C*H$_2$CO), 25.8 [SiC(*C*H$_3$)$_3$], 25.7 (*C*H$_2$CH), 22.0 (CH$_2$*C*H$_2$CH$_2$), 18.1 [Si*C*(CH$_3$)$_2$] and −5.4 [Si(*C*H$_3$)$_2$]; *m/z* (CI, NH$_3$) 454 (^{81}M+H$^+$, 100%), 452 (^{79}M+H$^+$, 95), 396 (35), 394 (30), 374 (70), 372 (55), 322 (20), 320 (20), 240 (15), 185 (15) and 183 (15); Found: M+H$^+$, 452.1258. C$_{21}$H$_{30}$^{79}BrNO$_3$Si requires for M+H$^+$, 452.1257.

p-Toluenesulfonic acid (0.13 g, 0.71 mmol) was added to a solution of the protected alcohol (3.19 g, 7.06 mmol) in THF–water (20:1; 21 cm^3) at room temperature. The solution was stirred overnight, ethyl acetate was added and the solution was washed with water, brine, dried (magnesium sulfate) and the solvent evaporated under reduced pressure. Column chromatography (silica; ethyl acetate) afforded alcohol **27** (1.38 g, 58%) as a colourless oil: R_f 0.2 (ethyl acetate); ν_{max} (CHCl$_3$)/cm^{-1} 3470 (br w, OH), 3025 (w), 3009 (w), 2951 (w), 2826 (w), 1685 (s), 1655 (s), 1629 (s), 1592 (w), 1473 (w), 1428 (m), 1404 (m), 1365 (w), 1347 (w), 1307 (w), 1229 (w), 1208 (w), 1123 (w), 1070 (w) and 1044 (w); δ_H (270 MHz, d$_8$-toluene, 80°C) 7.55–6.94 (5H, br m, aromatics and C*H*=C), 4.10–3.00 (5H, br m, NC*H*$_2$, C*H*$_2$OH and CH$_2$O*H*), 2.09 (2H, br s, C*H*$_2$CO or C*H*$_2$CH), 1.95 (2H, br s, C*H*$_2$CO or C*H*$_2$CH) and 1.45 (2H, br s, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, d$_8$-toluene, 80°C) 196.3 (CH$_2$*C*OC), 170.1 (N*C*O), 149.2 (*C*H=C), 141.1, 140.7 (*C*=CBr and *C*=CH), 133.5, 131.0, 129.9, 128.0 (4×*C*H=C), 121.1 (*C*Br), 61.8 (*C*H$_2$OH), 52.6 (N*C*H$_2$), 39.3 (*C*H$_2$COC), 26.8 (*C*H$_2$CH) and 23.3 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 340 (^{81}M+H$^+$, 50%), 338 (^{79}M+H$^+$, 50), 322 (95), 320 (100), 260 (35), 258 (35), 242 (100), 240 (55), 214 (40), 186 (30), 138 (35) and 136 (35); Found: M+H$^+$, 338.0391. C$_{15}$H$_{16}$^{79}BrNO$_3$ requires for M+H$^+$, 338.0392.

Ethyl (*E*)-5-[*N*-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamido]pent-2-enoate 12b. A mixture of diene **12a** (0.30 g, 1.09 mmol) and osmium tetroxide (one crystal) in dioxane–water (2:1, 10 cm^3) was stirred while sodium periodate (0.51 g, 2.39 mmol) was added portionwise over 0.3 h. After stirring for 1 h at room temperature the solution was extracted with ethyl acetate (×3) and the combined organic extracts were washed with water, dried (magnesium sulfate) and evaporated to afford the crude aldehyde, *N-(2-formylethyl)-N-(6-oxocyclohex-1-enyl)-2,2-dichloroethanamide:* δ_H (270 MHz, CDCl$_3$) 9.72 (1H, t, *J*=1 Hz, C*H*O), 7.15 (1H, t, *J*=4 Hz, C*H*=C), 5.79 (1H, s, C*H*Cl$_2$), 3.79 (2H, t, *J*=6.5 Hz, NC*H*$_2$), 2.85 (2H, dt, *J*=1, 6.5 Hz, NCH$_2$C*H*$_2$), 2.65–2.58 (4H, m, C*H*$_2$COC and C*H*$_2$CH=C) and 2.20–2.09 (2H, m, CH$_2$C*H*$_2$CH$_2$). This was dissolved in dichloromethane (8 cm^3) and (carbethoxymethylene)triphenylphosphorane (0.57 g, 1.63 mmol) was added portionwise. The mixture was stirred for 4 h and further dichloromethane (20 cm^3) added. After washing with water, the solvent was evaporated and purification of the crude product by column chromatography (silica; diethyl ether) afforded **12b** (0.26 g, 68%) as a colourless oil: R_f 0.3 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3026 (w), 3011 (w), 2958 (w), 2939 (w), 1700 (br, s), 1602 (w), 1321 (w), 1310 (w), 1279 (w), 1233 (w), 1196 (w), 1124 (w), 1097 (w) and 1042 (w); δ_H (270 MHz, CDCl$_3$) 7.16 (1H, t, *J*=4 Hz, C*H*=C), 6.84 (1H, dt, *J*=16, 7 Hz, C*H*=CHCO$_2$Et), 5.88 (1H, s, C*H*Cl$_2$), 5.85 (1H, dt, *J*=16, 1.5 Hz, CH=C*H*CO$_2$Et), 4.18 (2H, q, *J*=7 Hz, CO$_2$C*H*$_2$CH$_3$), 3.86 (1H, dt, *J*=13.5, 7.5 Hz, NC*H*$_A$H$_B$), 3.36 (1H, dt, *J*=13.5, 7 Hz, NCH$_A$*H*$_B$), 2.66–2.59 (4H, m, C*H*$_2$CO and C*H*$_2$CH=C), 2.53–2.42 (2H, m, NCH$_2$C*H*$_2$), 2.15 (2H, appt quintet, *J*=6.5 Hz, CH$_2$C*H*$_2$CH$_2$) and 1.28 (3H, t, *J*=7 Hz, CO$_2$CH$_2$C*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) 194.5 (CH$_2$*C*OC), 165.9 (O*C*O), 163.7 (N*C*O), 151.0 (*C*H=C), 144.4 (*C*H=CHCO$_2$Et), 137.8 (*C*=CH), 123.4 (CH=*C*HCO$_2$Et), 64.5 (*C*HCl$_2$), 60.2 (CO$_2$*C*H$_2$CH$_3$), 48.0 (N*C*H$_2$), 38.0 (*C*H$_2$COC), 30.1 (NCH$_2$*C*H$_2$), 25.9 (*C*H$_2$CH=C), 22.0 (CH$_2$*C*H$_2$CH$_2$) and 14.1 (CO$_2$CH$_2$*C*H$_3$); *m/z* (CI, NH$_3$) 367 (^{37,35}M+NH$_4^+$, 65%), 365 (^{35}M+NH$_4^+$, 100), 350 (^{37,35}M+H$^+$, 45), 348 (^{35}M+H$^+$, 30), 321 (35), 319 (55), 314 (30), 304 (40), 302 (60), 278 (70), 264 (15), 236 (45), 234 (30), 190 (15), 137 (15), 124 (95) and 81 (70); Found: M+NH$_4^+$, 365.1018. C$_{15}$H$_{19}$^{35}Cl$_2$NO$_4$ requires for M+NH$_4^+$, 365.1035.

General procedure for radical cyclisation of precursors 6a–d, 8, 12a–b, 15, 24, 27

A 0.014 (or 0.028) mol dm^{-3} solution containing tributyl- or triphenyl-tin hydride (0.09–2.66 g, 1.1–1.3 equiv., 0.32–7.59 mmol) and azobisisobutyronitrile (10–270 mg, 0.2–0.3 equiv.) in degassed toluene or benzene (23–230 cm^3) was added dropwise over 1 or 5 h via a syringe pump to a 0.024 (or 0.048) mol dm^{-3} solution of the alkene (0.1–2.0 g, 0.29–5.84 mmol) in boiling degassed toluene or benzene (12–122 cm^3) whilst the latter was stirred under nitrogen. The solution was heated at reflux for a further 3 h and, when using dichloroamides, more tributyl- or triphenyl-tin hydride (0.09–2.25 g, 1.1 equiv.) and azobisisobutyronitrile (10–190 mg, 0.2 equiv.) were added immediately and the solution heated at reflux for a further 2 h. Diethyl ether (10–15 cm^3) and aqueous potassium fluoride solution (10%, 10–15 cm^3) were added to the residue and the mixture was stirred for 2 h. The organic layer was separated, washed with water, brine, dried (magnesium sulfate), evaporated and purified by column chromatography (silica) to afford cyclic products (0.11–1.11 g, 57–85%).

1-Benzyloctahydroindole-2,7-dione 7a. 63% (d.r. 4.2–3.7:1); (3a*R**,7a*S**) — *Major diastereomer*: oil; R_f 0.3 (ethyl acetate–petroleum ether, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3006 (m), 2938 (m), 2873 (w), 1708 (s), 1691 (s), 1449 (m), 1417 (s), 1357 (w), 1305 (w), 1247 (m), 1143 (w) and 1124 (w); δ_H (270 MHz, CDCl$_3$) 7.32–7.19 (5H, m, aromatics), 5.18 (1H, d, *J*=15 Hz, NC*H*$_A$H$_B$Ph), 4.18 (1H, d, *J*=15 Hz, NCH$_A$*H*$_B$Ph), 3.78 (1H, d, *J*=8.5 Hz, COC*H*N), 2.96–2.82 (1H, m, NCHC*H*), 2.44 (1H, dd, *J*=16.5, 8 Hz, C*H*$_A$H$_B$CON), 2.23 (2H, t, *J*=6.5 Hz, C*H*$_2$COC), 2.12 (1H, dd, *J*=16.5, 10.5 Hz, CH$_A$*H*$_B$CON) and 1.97–1.62 (4H, m, CH$_2$C*H*$_2$CH and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 209.5 (CH$_2$*C*OC), 173.7 (N*C*O), 136.2 (*C*=CH), 128.5, 128.1, 127.4 (3×*C*H=C), 64.5 (CO*C*HN), 45.8 (N*C*H$_2$Ph), 39.5 (*C*H$_2$COC), 36.8 (NCH*C*H), 35.1 (*C*H$_2$CON), 26.5 and 22.1 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 244 (M+H$^+$, 100%); Found: M+H$^+$, 244.1335. C$_{15}$H$_{17}$NO$_2$ requires for M+H$^+$, 244.1338. (3a*R**,7a*R**) — *Minor diastereomer*: oil; R_f 0.35 (ethyl acetate-petroleum ether, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3008 (w), 2948 (w), 1695 (br s), 1448 (w), 1394 (w), 1328 (w) and 1136 (w); δ_H (270 MHz, CDCl$_3$) 7.25–7.11 (5H, m, aromatics), 5.12 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ph), 4.37 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ph), 3.50 (1H, d, *J*=11 Hz, COC*H*N), 2.53–2.42 (1H, m, C*H*$_A$H$_B$CON), 2.27–1.94 (6H, m, CH$_A$*H*$_B$CON, NCHC*H*, C*H*$_2$COC and CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$) and 1.81–1.43 (2H, m, CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 205.4 (CH$_2$*C*OC), 174.5 (N*C*O), 136.3 (*C*=CH), 128.7, 128.7, 127.6 (3×*C*H=C), 67.9 (CO*C*HN), 44.9 (N*C*H$_2$Ph), 43.8 (NCH*C*H), 39.7, 37.5 (*C*H$_2$COC and *C*H$_2$CON), 27.9 and

27.4 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 261 (M+NH$_4^+$, 45%) and 244 (M+H$^+$, 100); Found: M+H$^+$, 244.1334. C$_{15}$H$_{17}$NO$_2$ requires for M+H$^+$, 244.1338.

1-(4-Methoxybenzyl)octahydroindole-2,7-dione 7b. 65–85%(d.r. 3.3–4.8:1); (3aR^*,7aS^*) — *Major diastereomer*: solid; mp 101–104°C; R_f 0.35 (ethyl acetate–petroleum ether, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3007 (w), 2935 (w), 1720 (m), 1686 (s), 1612 (w), 1513 (m), 1448 (w), 1415 (w), 1303 (w), 1246 (w), 1177 (w) and 1035(m); δ_H (270 MHz, CDCl$_3$) 7.14 (2H, d, *J*=8.5 Hz, 2×C*H*CHCOMe), 6.84 (2H, d, *J*=8.5 Hz, 2×C*H*COMe), 5.08 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 4.12 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 3.79–3.75 (4H, m, OC*H*$_3$ and COC*H*N), 2.92–2.80 (1H, m, NCHC*H*), 2.42 (1H, dd, *J*=16.5, 8 Hz, C*H*$_A$H$_B$CON), 2.35–2.13 (3H, m, C*H*$_2$COC and CH$_A$*H*$_B$CON) and 2.04–1.60 (4H, m, CH$_2$C*H*$_2$CH and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 209.6 (CH$_2$*C*OC), 173.7 (N*C*O), 158.9 (*C*OMe), 129.6 (*C*HCHCOMe), 128.2 (NCH$_2$*C*), 113.9 (*C*HCOMe), 64.4 (CO*C*HN), 55.1 (O*C*H$_3$), 45.3 (N*C*H$_2$Ar), 39.5 (*C*H$_2$COC or *C*H$_2$CON), 36.7 (NCH*C*H), 35.4 (*C*H$_2$COC or *C*H$_2$CON), 26.6 and 22.2 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 274 (M+H$^+$, 100%) and 121 (15); Found: M+H$^+$, 274.1441. C$_{16}$H$_{19}$NO$_3$ requires for M+H$^+$, 274.1443. (3aR^*,7aR^*) — *Minor diastereomer*: solid; mp 98–101 °C; R_f 0.4 (ethyl acetate–petroleum ether, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3007 (w), 2952 (w), 1726 (m), 1691 (s), 1611 (w), 1513 (m), 1391 (w), 1247 (m), 1178 (w), 1137 (w) and 1035 (w); δ_H (270 MHz, CDCl$_3$) 7.12 (2H, d, *J*=8.5 Hz, 2×C*H*CHCOMe), 6.81 (2H, d, *J*=8.5 Hz, 2×C*H*COMe), 5.12 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 4.37 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 3.78 (3H, s, OC*H*$_3$), 3.55 (1H, d, *J*=11.5 Hz, COC*H*N), 2.60–2.46 (1H, m, C*H*$_A$H$_B$CON), 2.34–1.98 (6H, m, NCHC*H*, CH$_A$*H*$_B$CON, C*H*$_2$COC, CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$) and 1.88–1.50 (2H, m, CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 206.0 (CH$_2$*C*OC), 175.0 (N*C*O), 159.5 (*C*OMe), 130.5 (*C*HCHCOMe), 128.9 (NCH$_2$*C*), 114.4 (*C*HCOMe), 68.3 (CO*C*HN), 55.6 (O*C*H$_3$), 44.7 (N*C*H$_2$Ar), 44.1 (NCH*C*H), 40.2, 38.0 (*C*H$_2$COC and *C*H$_2$CON), 28.4 and 28.3 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 274 (M+H$^+$, 100%) and 121 (25); Found: M+H$^+$, 274.1438. C$_{16}$H$_{19}$NO$_3$ requires for M+H$^+$, 274.1443.

1-(3,4-Methylenedioxybenzyl)octahydroindole-2,7-dione 7c. 74% (d.r. 5.1:1); (3aR^*,7aS^*) — *Major diastereomer*: solid; mp 103–105 °C; (Found: C, 66.95; H, 5.94; N, 4.83%. C$_{16}$H$_{17}$NO$_4$ requires C, 66.89; H, 5.96; N, 4.88%); R_f 0.2 (ethyl acetate-petroleum ether, 7:3); ν_{max} (CHCl$_3$)/cm^{-1} 3006 (m), 2940(m), 1720 (s), 1690 (s), 1491 (m), 1444 (m), 1418 (m), 1369 (w), 1246 (s), 1195 (w) and 1042 (m); δ_H (270 MHz, CDCl$_3$) 6.74 (1H, d, *J*=8 Hz, CHC*H*CO), 6.71 (1H, d, *J*=1.5 Hz, CC*H*CO), 6.66 (1H, dd, *J*=8, 1.5 Hz, C*H*CHCO), 5.94 (2H, s, OC*H*$_2$O), 5.06 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 4.08 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 3.80 (1H, d, *J*=8.5 Hz, COC*H*N), 2.97–2.82 (1H, m, NCHC*H*), 2.42 (1H, dd, *J*=16.5, 8 Hz, C*H*$_A$H$_B$CON), 2.33 (2H, appt t, *J*=6 Hz, C*H*$_2$COC), 2.18 (1H, dd, *J*=16.5, 11 Hz, CH$_A$*H*$_B$CON) and 2.03–1.62 (4H, m, CH$_2$C*H*$_2$CH and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 209.6 (CH$_2$*C*OC), 173.6 (N*C*O), 147.8, 146.9 (CHCH*C*O and CCH*C*O), 130.0 (NCH$_2$*C*), 121.6 (*C*HCHCO), 108.5, 108.1 (CH*C*HCO and C*C*HCO), 100.9 (O*C*H$_2$O), 64.3 (CO*C*HN), 45.6 (N*C*H$_2$Ar), 39.5 (*C*H$_2$COC or *C*H$_2$CON), 36.7 (NCH*C*H), 35.2 (*C*H$_2$COC or *C*H$_2$CON), 26.6 and 22.1 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 288 (M+H$^+$, 100%) and 135 (20); Found: M+H$^+$, 288.1236. C$_{16}$H$_{17}$NO$_4$ requires for M+H$^+$, 288.1236. (3aR^*,7aR^*) — *Minor diastereomer*: solid; mp 119–121°C (Found: C, 66.67; H, 6.03; N, 4.46%. C$_{16}$H$_{17}$NO$_4$ requires C, 66.89; H, 5.96; N, 4.88%); R_f 0.2 (ethyl acetate–petroleum ether, 7:3); ν_{max} (CHCl$_3$)/cm^{-1} 3007 (w), 2950 (w), 1727 (m), 1691 (s), 1490 (m), 1446 (m), 1394 (w), 1245 (m), 1136 (w) and 1042 (m); δ_H (270 MHz, CDCl$_3$) 6.71 (1H, d, *J*=8 Hz, CHC*H*CO), 6.69 (1H, d, *J*=1.5 Hz, CC*H*CO), 6.64 (1H, dd, *J*=8, 1.5 Hz, C*H*CHCO), 5.93 (2H, s, OC*H*$_2$O), 5.08 (1H, d, *J*=14 Hz, NC*H*$_A$H$_B$Ar), 4.34 (1H, d, *J*=14 Hz, NCH$_A$*H*$_B$Ar), 3.59 (1H, d, *J*=11.5 Hz, COC*H*N), 2.60–2.48 (1H, m, C*H*$_A$H$_B$CON), 2.36–2.02 (6H, m, CH$_A$*H*$_B$CON, NCHC*H*, C*H*$_2$COC and CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$) and 1.88–1.52 (2H, m, CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 205.9 (CH$_2$*C*OC), 175.0 (N*C*O), 148.3, 147.5 (CHCH*C*O and CCH*C*O), 130.6 (NCH$_2$*C*), 122.6 (*C*HCHCO), 109.5, 108.7 (CH*C*HCO and C*C*HCO), 101.5 (O*C*H$_2$O), 68.2 (CO*C*HN), 45.1 (N*C*H$_2$Ar), 44.1 (NCH*C*H), 40.2, 38.0 (*C*H$_2$COC and *C*H$_2$CON), 28.4 and 27.9 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 288 (M+H$^+$, 100%), 154 (10) and 135 (20); Found: M+H$^+$, 288.1234. C$_{16}$H$_{17}$NO$_4$ requires for M+H$^+$, 288.1236.

1-(3-Fluorobenzyl)octahydroindole-2,7-dione 7d. 71% (d.r. 4.6:1); (3aR^*,7aS^*) — *Major diastereomer*: oil; R_f 0.2 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3037 (w), 3022 (w), 3007 (w), 2939 (w), 2874 (w), 1701 (s), 1689 (s), 1616 (w), 1592 (w), 1488 (w), 1451 (w), 1416 (m), 1352 (w), 1306 (w), 1256 (m), 1228 (w), 1206 (w) and 1139 (w); δ_H (270 MHz, CDCl$_3$) 7.28 (1H, dt, *J*=6, 8 Hz, C*H*CHCF), 7.02–6.89 (3H, m, CC*H*CF, CHC*H*CF and C*H*CCHCF), 5.16 (1H, d, *J*=15 Hz, NC*H*$_A$H$_B$Ar), 4.18 (1H, d, *J*=15 Hz, NCH$_A$*H*$_B$Ar), 3.84 (1H, d, *J*=8.5 Hz, COC*H*N), 3.03–2.83 (1H, m, NCHC*H*), 2.45 (1H, dd, *J*=16.5, 8 Hz, C*H*$_A$H$_B$CON), 2.38–2.32 (2H, m, C*H*$_2$COC), 2.19 (1H, dd, *J*=16.5, 11 Hz, CH$_A$*H*$_B$CON) and 2.05–1.64 (4H, m, CH$_2$C*H*$_2$CH and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 209.4 (CH$_2$*C*OC), 173.8 (N*C*O), 162.7 (d, $^1J_{CF}$=246 Hz, *C*F), 138.9 (d, $^3J_{CF}$=7 Hz, *C*CHCF), 130.0 (d, $^3J_{CF}$=8 Hz, *C*HCHCF), 123.5 (d, $^4J_{CF}$=3 Hz, *C*HCCHCF), 114.6 (d, $^2J_{CF}$=22 Hz, *C*HCF), 114.2 (d, $^2J_{CF}$=21 Hz, *C*HCF), 64.4 (CO*C*HN), 45.3 (N*C*H$_2$Ar), 39.4 (*C*H$_2$COC or *C*H$_2$CON), 36.7 (NCH*C*H), 34.7 (*C*H$_2$COC or *C*H$_2$CON), 26.3 and 22.0 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 262 (M+H$^+$, 100%); Found: M+H$^+$, 262.1237. C$_{15}$H$_{16}$FNO$_2$ requires for M+H$^+$, 262.1243. (3aR^*,7aR^*) — *Minor diastereomer*: solid; mp 89–92 °C; R_f 0.2 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3054 (w), 3040 (w), 3021 (w), 3006 (w), 2950 (w), 2871 (w), 1706 (br, s), 1616 (w), 1592 (w), 1488 (w), 1451 (w), 1432 (w), 1399 (m), 1340 (w), 1257 (w), 1228 (w), 1206 (w), 1167 (w), 1138 (w) and 1079 (w); δ_H (270 MHz, CDCl$_3$) 7.30–7.22 (1H, dt, *J*=6, 8 Hz, C*H*CHCF), 6.99–6.88 (3H, m, CC*H*CF, CHC*H*CF and C*H*CCHCF), 5.11 (1H, d, *J*=14.5 Hz, NC*H*$_A$H$_B$Ar), 4.47 (1H, d, *J*=14.5 Hz, NCH$_A$*H*$_B$Ar), 3.62 (1H, d, *J*=12 Hz, COC*H*N), 2.62–2.49 (1H, m, C*H*$_A$H$_B$CON) and 2.37–2.02 (6H, m, CH$_A$*H*$_B$CON, NCHC*H*, C*H*$_2$COC and CH$_2$C*H*$_2$CH or CH$_2$C*H*$_2$CH$_2$), 1.93–1.53 (2H, m, CH$_2$C*H*$_2$CH or

CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 205.3 (CH$_2$*C*OC), 174.6 (N*C*O), 162.9 (d, $^1J_{CF}$=246 Hz, *C*F), 138.9 (d, $^3J_{CF}$=7 Hz, *C*CHCF), 130.2 (d, $^3J_{CF}$=8 Hz, *C*HCHCF), 124.2 (d, $^4J_{CF}$=3 Hz, *C*HCCHCF), 115.4 (d, $^2J_{CF}$=22 Hz, *C*HCF), 114.6 (d, $^2J_{CF}$=22 Hz, *C*HCF), 67.9 (CO*C*HN), 44.5 (N*C*H$_2$Ar), 43.8 (NCH*C*H), 39.7, 37.4 (*C*H$_2$COC and *C*H$_2$CON), 27.9 and 27.4 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 262 (M+H$^+$, 100%); Found: M+H$^+$, 262.1235. C$_{15}$H$_{16}$FNO$_2$ requires for M+H$^+$, 262.1243.

1-Benzyl-7a-hydroxyoctahydroindole-2,7-dione 9. 22%; Oil; R_f 0.4 (ethyl acetate–petroleum ether, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3474 (br w, OH), 3009 (w), 2953 (m), 2870 (w), 1702 (br s), 1449 (w), 1398 (m), 1334 (w), 1236 (w), 1136 (w), 1105 (m) and 1066 (w); δ_H (270 MHz, CDCl$_3$) 7.28–7.18 (5H, m, aromatics), 4.96 (1H, s, CO*H* exchangeable), 4.75 (1H, d, *J*=15 Hz, NC*H*$_A$H$_B$Ph), 3.77 (1H, d, *J*=15 Hz, NCH$_A$*H*$_B$Ph), 2.94 (1H, dd, *J*=17, 7 Hz, C*H*$_A$H$_B$CON), 2.51–2.43 (1H, m, NCC*H*) and 2.23–1.25 (7H, m, CH$_A$*H*$_B$CON, C*H*$_2$COC, CH$_2$C*H*$_2$CH and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 208.2 (CH$_2$*C*OC), 176.2 (N*C*O), 136.9 (*C*═CH), 129.1, 128.6, 127.6 (3×*C*H═C), 90.2 (*C*OH), 43.8 (NCH*C*H), 42.7 (N*C*H$_2$Ph), 37.3, 36.4 (*C*H$_2$COC and *C*H$_2$CON), 30.1 and 23.4 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 260 (M+H$^+$, 100%), 244 (65), 242 (35), 189 (15), 106 (25) and 91 (35); Found: M+H$^+$, 260.1284. C$_{15}$H$_{17}$NO$_3$ requires for M+H$^+$, 260.1287.

(7a*R**,11a*S**)-Decahydro-6H-pyrido[2,1-i]indole-6,11-dione 13. 58%; Solid; mp 104–106°C (Found: C, 69.67; H, 8.52; N, 6.73. C$_{12}$H$_{17}$NO$_2$ requires C, 69.54; H, 8.27; N, 6.76%); R_f 0.2 (ethyl acetate); ν_{max} (CHCl$_3$)/cm^{-1} 3035 (w), 3025 (m), 3006 (s), 2947 (s), 2863 (m), 1717 (s), 1688 (s), 1461 (m), 1449 (m), 1431 (m), 1414 (s), 1365 (w), 1292 (m), 1252 (m), 1243 (w), 1207 (w), 1163 (w), 1147 (w), 1123 (w) and 1052 (w); δ_H (270 MHz, CDCl$_3$) 4.06 (1H, dd, *J*=13, 4.5 Hz, NC*H*$_A$H$_B$), 3.29 (1H, ddt, *J*=3.5, 1.5, 13 Hz, NCH$_A$C*H*$_B$), 2.63–1.68 (12H, m, C*H*$_2$CO, C*H*$_2$CON, NCC*H*, CH$_2$C*H*$_2$CH, C*H*$_2$CH$_2$CO, NCC*H*$_2$ and NCH$_2$C*H*$_A$H$_B$) and 1.52–1.26 (3H, m, NCH$_2$CH$_A$*H*$_B$ and NCH$_2$CH$_2$C*H*$_2$); δ_C (67.5 MHz, CDCl$_3$) 212.0 (CH$_2$*C*OC), 172.0 (N*C*O), 69.9 (CO*C*N), 45.5 (NC*C*H), 38.5, 38.0 (N*C*H$_2$ and *C*H$_2$COC), 33.4, 32.8 (*C*H$_2$CON and NC*C*H$_2$), 24.1, 23.4, 22.0 and 19.5 (NCH$_2$*C*H$_2$, CH$_2$*C*H$_2$CH, *C*H$_2$CH$_2$CO and NCH$_2$CH$_2$*C*H$_2$); *m*/*z* (CI, NH$_3$) 208 (M+H$^+$, 100%), 179 (15), 150 (25) and 137 (10); Found: M+H$^+$, 208.1337. C$_{12}$H$_{17}$NO$_2$ requires for M+H$^+$, 208.1338.

(1R*S*,6a*R**,10a*R**)-1-[(Ethoxycarbonyl)methyl]octahydro-1H,5H-pyrollo[2,1-i]indole-5,10-dione 14. 64% (d.r. 1:1); Solid; mp 105–109°C; R_f 0.2 (ethyl acetate-dichloromethane, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3036 (w), 3025 (w), 3005 (w), 2951 (w), 1725 (s), 1685 (s), 1476 (w), 1417 (m), 1381 (w), 1314 (w), 1241 (w), 1233 (w), 1220 (w), 1207 (w), 1194 (w), 1177 (w), 1166 (w) and 1027 (w); δ_H (270 MHz, CDCl$_3$) (mixture of diastereomers) 4.24–4.14 (2H, m, CO$_2$C*H*$_2$CH$_3$), 3.64–3.28 (2H, m, NC*H*$_2$), 2.93–1.66 (14H, m, C*H*$_2$CO, C*H*$_2$CON, NCC*H*, C*H*CH$_2$CO$_2$Et, C*H*$_2$CO$_2$Et, C*H*$_2$CH$_2$CH$_2$CO, C*H*$_2$CH$_2$CO, NCH$_2$C*H*$_2$) and 1.32–1.26 (3H, m, CO$_2$CH$_2$C*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) (mixture of diastereomers) 211.5, 210.9 (CH$_2$*C*OC), 172.0, 171.6, 171.4, 171.1 (O*C*O and N*C*O), 79.7, 78.1 (CO*C*N), 61.1 (CO$_2$*C*H$_2$CH$_3$), 45.5, 44.0 (NC*C*H), 42.2, 41.1 (N*C*H$_2$ or *C*H$_2$COC), 39.9 (*C*HCH$_2$CO$_2$Et), 39.7, 38.9, 38.8 (*C*H$_2$CO$_2$Et and N*C*H$_2$ or *C*H$_2$COC), 37.0 (*C*HCH$_2$CO$_2$Et), 35.5, 35.3, 32.1, 32.0 (*C*H$_2$CON and NCH$_2$*C*H$_2$), 25.7, 25.3 (*C*H$_2$CH$_2$CH$_2$CO), 21.7, 20.1 (CH$_2$*C*H$_2$CH$_2$) and 14.2 (CO$_2$CH$_2$*C*H$_3$); *m*/*z* (CI, NH$_3$) 280 (M+H$^+$, 100%); Found: M+H$^+$, 280.1544. C$_{15}$H$_{21}$NO$_4$ requires for M+H$^+$, 280.1549.

(4a*R**,9a*S**,13a*S**,13b*R**)-Tetradecahydro-6H-indolo-[7a,1-*a*]isoquinoline-1,6-dione 16. 19–37%; Solid; mp 124–127°C; R_f 0.2 (diethyl ether-dichloromethane, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3006 (m), 2932 (s), 2857 (m), 1703 (s), 1673 (s), 1449 (m), 1434 (m), 1419 (m), 1366 (w), 1301 (w), 1268 (w), 1250 (w), 1237 (w), 1216 (w), 1199 (w), 1175 (w), 1125 (w) and 1105 (w); δ_H (270 MHz, CDCl$_3$) 4.10 (1H, ddd, *J*=13, 5.5, 1.5 Hz, NC*H*$_A$H$_B$), 3.41 (1H, ddt, *J*=3.5, 1.5, 13 Hz, NCH$_A$*H*$_B$), 2.69–2.22 (5H, m, C*H*$_2$CO, C*H*$_2$CON and C*H*CH$_2$CON) and 2.08–0.83 (16H, m, NCH$_2$CH$_2$C*H*, NCH$_2$CH$_2$CHC*H*, 4×CH$_2$C*H*$_2$CH and 3×CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 212.2 (CH$_2$*C*OC), 172.3 (N*C*O), 70.9 (CO*C*N), 53.5 (NCH$_2$CH$_2$CH*C*H), 42.5 (N*C*H$_2$ or *C*H$_2$COC or *C*H$_2$CON), 42.1 (*C*HCH$_2$CON), 39.1, 35.4 (two from N*C*H$_2$, *C*H$_2$COC or *C*H$_2$CON), 35.0 (NCH$_2$CH$_2$*C*H), 34.3, 32.4, 29.4, 27.6, 27.1, 25.8 and 19.4 (4×CH$_2$*C*H$_2$CH and 3×CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 262 (M+H$^+$, 100%); Found: M+H$^+$, 262.1805. C$_{16}$H$_{23}$NO$_2$ requires for M+H$^+$, 262.1807.

1-[2-(Cyclohex-1-enyl)ethyl]octahydroindole-2,7-dione 17. 32–38% (d.r. 4.7–5.3:1); Oil; (3a*R**,7a*S**) — *Major diastereomer*: R_f 0.2 (diethyl ether-dichloromethane, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3020 (w), 3010 (w), 2937 (m), 2872 (w), 2861 (w), 1698 (br s), 1449 (w), 1408 (m), 1366 (w), 1349 (w), 1236 (w), 1217 (w) and 1176 (w); δ_H (270 MHz, CDCl$_3$) 5.44–5.40 (1H, br m, C*H*═C), 4.03 (1H, d, *J*=8.5 Hz, COC*H*N), 3.95 (1H, dt, *J*=14, 7.5 Hz, NC*H*$_A$H$_B$), 3.06 (1H, dt, *J*=14, 7 Hz, NCH$_A$*H*$_B$), 2.97–2.83 (1H, m, NCHC*H*), 2.41 (2H, appt t, *J*=6.5 Hz, C*H*$_2$COC), 2.36 (1H, dd, *J*=16.5, 8 Hz, C*H*$_A$H$_B$CON) and 2.20–1.41 (15H, m, CH$_A$*H*$_B$CON, NCH$_2$C*H*$_2$, CH$_2$CH$_2$C*H*$_2$C═CH, C*H*$_2$CH═C, C*H*$_2$CH$_2$CO, C*H*$_2$CH$_2$CH$_2$CO, C*H*$_2$CH$_2$CH═C, CH$_2$C*H*$_2$CH$_2$C═CH); δ_C (67.5 MHz, CDCl$_3$) 209.4 (CH$_2$*C*OC), 173.8 (N*C*O), 134.8 (*C*═CH), 123.0 (*C*H═C), 65.6 (CO*C*HN), 40.5, 39.5 (N*C*H$_2$ and *C*H$_2$COC), 36.8 (NCH*C*H), 35.5, 35.5 (*C*H$_2$CON and NCH$_2$*C*H$_2$), 27.8, 26.8, 25.2 (*C*H$_2$CH═C, CH$_2$CH$_2$*C*H$_2$C═CH and *C*H$_2$CH$_2$CH$_2$CO), 22.8, 22.4 and 22.2 (3×CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 262 (M+H$^+$, 100%) and 154 (15); Found: M+H$^+$, 262.1801. C$_{16}$H$_{23}$NO$_2$ requires for M+H$^+$, 262.1807. (3a*R**,7a*R**) — *Minor diastereomer*: oil; R_f 0.3 (diethyl ether-dichloromethane, 4:1); ν_{max} (CHCl$_3$)/cm^{-1} 3024 (w), 3009 (w), 2940 (m), 2867 (w), 1702 (br s), 1449 (w), 1405 (m), 1372 (w), 1351 (w), 1234 (w), 1220 (w) and 1175 (w); δ_H (270 MHz, CDCl$_3$) 5.41 (1H, br s, C*H*═C), 3.98 (1H, d, *J*=11 Hz, COC*H*N), 3.81 (1H, dt, *J*=13.5, 7.5 Hz, NC*H*$_A$H$_B$), 3.52 (1H, dt, *J*=13.5, 7 Hz, NCH$_A$*H*$_B$), 2.51–2.34 (3H, m, C*H*$_2$COC and C*H*$_A$H$_B$CON or NCHC*H*) and 2.23–1.45 (16H, m, C*H*$_A$H$_B$CON or NCHC*H*, CH$_A$*H*$_B$CON, NCH$_2$C*H*$_2$, CH$_2$CH$_2$C*H*$_2$C═CH, C*H*$_2$CH═C, C*H*$_2$CH$_2$CO,

$CH_2CH_2CH_2CO$, $CH_2CH_2CH{=}C$, $CH_2CH_2CH_2C{=}CH$); δ_C (67.5 MHz, $CDCl_3$) 205.5 (CH_2COC), 174.3 (NCO), 135.4 ($C{=}CH$), 123.1 ($CH{=}C$), 69.3 (COCHN), 44.3 (NCHCH), 39.9, 39.6, 37.5, 35.8 (NCH_2, CH_2COC, CH_2CON and NCH_2CH_2), 28.3, 27.9, 27.6, 25.4, 22.9 and 22.4 ($CH_2CH{=}C$, $CH_2CH_2CH_2C{=}CH$, $CH_2CH_2CH_2CO$ and $3\times CH_2CH_2CH_2$); *m*/*z* (CI, NH_3) 262 ($M+H^+$, 100%) and 154 (10); Found: $M+H^+$, 262.1804. $C_{16}H_{23}NO_2$ requires for $M+H^+$, 262.1807.

Treatment of (3a*R**,7a*S**)-1-(3,4-methylenedioxybenzyl)octahydroindole-2,7-dione 7c with samarium(II) iodide in the presence of DMPU

To a solution of octahydroindolone **7c** (0.15 g, 0.52 mmol) in anhydrous THF (15 cm^3) was added DMPU (0.51 cm^3, 4.18 mmol) and the solution was stirred for 0.25 h. SmI_2 solution (0.1 mol dm^{-3} in THF; 11.50 cm^3, 1.15 mmol) was added dropwise over 1 h via a syringe pump and the solution was stirred for a further 3 h, after which TLC indicated that starting material remained. Further SmI_2 solution (5.75 cm^3, 0.57 mmol) was added and the solution stirred for a further 1 h. The solution was filtered through Celite and the solvent removed under reduced pressure. Column chromatography (silica; ethyl acetate) afforded *(3aR*,11cS*)-11b-hydroxy-9,10-methylene-dioxy-1,2,3,3a,4,5,11,11a,11b,11c-decahydro-7H-pyrollo[3,2,1-de]phenanthridin-5-one* **19** (25 mg, 17%) as a single diastereomer and *(3aR*,7R*S*,7aS*)-7-hydroxy-1-(3,4-methylenedioxybenzyl)octahydroindol-2-one* **18** (26 mg, 17%) as an inseparable 2.6:1 mixture of diastereomers.

18 (*Major diastereomer*): solid; mp 131–134°C; R_f 0.25 (ethyl acetate); ν_{max} ($CHCl_3$)/cm^{-1} 3615 (w, OH), 3019 (w), 2938 (w), 2901 (w), 1673 (s), 1504 (w), 1490 (m), 1444 (m), 1421 (m), 1371 (w), 1246 (m), 1224 (m), 1098 (w) and 1042 (w); δ_H (270 MHz, $CDCl_3$) 6.78–6.74 (3H, m, aromatics), 5.93 (2H, s, OCH_2O), 4.93 (1H, d, *J*=14.5 Hz, NCH_AH_BAr), 4.31 (1H, d, *J*=14.5 Hz, NCH_AH_BAr), 3.68 (1H, ddd, *J*=10.5, 7.5, 4 Hz, CHOH), 3.18 (1H, t, *J*=7.5 Hz, CHOHCHN), 2.63–2.25 (4H, m, NCHCH, CH_2CON and CHOH) and 1.88–1.17 (6H, m, CH_2CHOH, CH_2CH_2CH and $CH_2CH_2CH_2$); δ_C (67.5 MHz, $CDCl_3$) 174.7 (NCO), 147.8, 146.8 (CHCHCO and CCHCO), 131.1 (NCH_2C), 121.5 (CHCHCO), 108.6, 108.2 (CHCHCO and CCHCO), 100.9 (OCH_2O), 73.3 (CHOH), 63.1 (CHOHCHN), 45.7 (NCH_2Ar), 35.3 (CH_2CHOH or CH_2CON), 34.0 (NCHCH), 32.5 (CH_2CHOH or CH_2CON), 25.8 (CH_2CH_2CH) and 18.8 ($CH_2CH_2CH_2$); *m*/*z* (CI, NH_3) 290 ($M+H^+$, 100%), 156 (10) and 135 (30); Found: $M+H^+$, 290.1391. $C_{16}H_{19}NO_4$ requires for $M+H^+$, 290.1392. *Minor diastereomer*: the presence of this was indicated by: δ_H (270 MHz, $CDCl_3$) 5.95 (2H, s, OCH_2O), 4.76 (1H, d, *J*=15 Hz, NCH_AH_BAr), 4.08 (1H, d, *J*=15 Hz, NCH_AH_BAr), 4.03–3.98 (1H, br m, CHOH), 3.27 (1H, dd, *J*=7, 4 Hz, CHOHCHN); δ_C (67.5 MHz, $CDCl_3$) 176.9 (NCO), 148.0, 147.0 (CHCO), 130.9 (NCH_2C), 121.3 (CHCHCO), 108.4, 108.3 (CHCHCO and CCHCO), 101.1 (OCH_2O), 65.6 (CHOH), 60.0 (CHOHCHN), 44.7 (NCH_2Ar), 36.4 (CH_2CHOH or CH_2CON), 32.3 (NCHCH), 29.4 (CH_2CHOH or CH_2CON), 25.7 (CH_2CH_2CH) and 14.5 ($CH_2CH_2CH_2$).

19: Oil; R_f 0.2 (ethyl acetate); ν_{max} ($CHCl_3$)/cm^{-1} 3571 (br w, OH), 3021 (w), 3007 (w), 2939 (w), 2867 (w), 1683 (s), 1445 (w), 1418 (w), 1384 (w), 1373 (w), 1321 (w), 1301 (w), 1268 (w), 1241 (w), 1227 (w), 1187 (w), 1160 (w), 1037 (w) and 1016 (w); δ_H (270 MHz, $CDCl_3$) 5.77–5.74 (1H, m, $CH{=}C$), 5.70–5.68 (2H, m, OCH_2O), 4.43 (1H, d, *J*=14.5 Hz, NCH_AH_B), 3.40–3.34 (2H, m, NCH_AH_B and COHCHN), 3.27 (1H, br t, *J*=8 Hz, $COHCHCH_2$), 3.01–2.92 (2H, m, $COHCHCH_2$), 2.60–2.48 (1H, m, NCHCH), 2.45 (1H, dd, *J*=16, 6 Hz, CH_AH_BCON), 2.01 (1H, d, *J*=16 Hz, CH_AH_BCON) and 1.73–1.03 (6H, m, CH_2COH, CH_2CH_2CH and $CH_2CH_2CH_2$); δ_C (67.5 MHz, $CDCl_3$) 175.9 (NCO), 134.3, 131.2, 129.6 ($C{=}CH$ and $2\times C{=}C$), 121.5 ($CH{=}C$), 99.5 (OCH_2O), 72.3 (COH), 63.1 (COHCHN), 47.8 ($COHCHC{=}CH$), 46.5 (NCH_2Ar), 40.3 (CH_2CON), 31.2 (NCHCH), 29.2, 29.0 ($CH_2C{=}C$ and CH_2COH), 24.8 (CH_2CH_2CH) and 19.3 ($CH_2CH_2CH_2$); *m*/*z* (CI, NH_3) 290 ($M+H^+$, 100%), 154 (15), 136 (25) and 134 (20); Found: $M+H^+$, 290.1390. $C_{16}H_{19}NO_4$ requires for $M+H^+$, 290.1392.

Treatment of (3a*R**,7a*S**)-1-(3,4-methylenedioxybenzyl)octahydroindole-2,7-dione 7c with manganese(III) acetate dihydrate

To a solution of octahydroindolone **7c** (0.11 g, 0.38 mmol) in degassed benzene (15 cm^3) was added manganese(III) acetate dihydrate (0.41 g, 1.53 mmol). The solution was heated overnight at reflux under nitrogen, cooled, filtered through Celite, washed with water, brine, dried (magnesium sulfate) and the solvent evaporated under reduced pressure. Column chromatography (silica; ethyl acetate) afforded *11,12-methylene-dioxy-2,3,3a,4,5,6,7,7a-octahydro-6,1-([1,2]benzenomethano)indole-2,7-dione* **22** and *12,13-methylenedioxy-2,3,3a,4,5,6,7,7a-octahydro-6,1-([1,2]benzenomethano)indole-2,7-dione* **23** (37 mg, 34%) as an inseparable 2.8:1 mixture and *(3aR*,6R*S*,7aS*)-6-acetoxy-1-(3,4-methylenedioxybenzyl)octahydroindole-2,7-dione* **21** (24 mg, 18%) as an inseparable 2.7:1 mixture of diastereomers.

21: Oil; *Major diastereomer*: R_f 0.4 (ethyl acetate); ν_{max} ($CHCl_3$)/cm^{-1} 3007 (w), 2928 (m), 1741 (s), 1691 (s), 1491 (m), 1445 (m), 1418 (w), 1372 (w), 1243 (s) and 1042 (m); δ_H (270 MHz, $CDCl_3$) 6.75–6.63 (3H, m, aromatics), 5.94 (2H, s, OCH_2O), 5.16 (1H, d, *J*=15 Hz, NCH_AH_BAr), 5.12–5.03 (1H, m, COOCH), 4.04–3.94 (2H, m, NCH_AH_BAr and COCHN), 3.02–2.82 (1H, m, NCHCH), 2.35 (1H, dd, *J*=17, 8 Hz, CH_AH_BCON) and 2.24–1.89 (8H, m, CH_AH_BCON, CH_3COO, CH_2CHCO and CH_2CH_2CH); δ_C (67.5 MHz, $CDCl_3$) 203.1 (CHCOCH), 172.9 (NCO), 169.7 (CH_3COO), 147.9, 147.0 (CHCHCO and CCHCO), 129.7 (NCH_2C), 121.5 (CHCHCO), 108.9, 108.3 (CHCHCO and CCHCO), 100.9 (OCH_2O), 74.6 (COOCH), 64.2 (COCHN), 45.7 (NCH_2Ar), 37.5 (NCHCH), 33.7 (CH_2CON), 27.5 (CH_2CHCO), 22.5 (CH_2CH_2CH) and 20.3 (CH_3COO); *m*/*z* (CI, NH_3) 346 ($M+H^+$, 100%), 286 ($M-CH_3COO$, 40) and 135 (25); Found: $M+H^+$, 346.1290. $C_{18}H_{19}NO_6$ requires for $M+H^+$, 346.1291. *Minor diastereomer*: the presence of this was indicated by: δ_H (270 MHz, $CDCl_3$) 5.93 (2H, s, OCH_2O), 4.96 (1H, d, *J*=14.5 Hz, NCH_AH_BAr), 3.89 (1H, d, *J*=14.5 Hz, NCH_AH_BAr), 2.77–2.66 (1H, m, NCHCH) and 2.47 (1H, dd, *J*=16.5, 7.5 Hz, CH_AH_BCON); δ_C

(67.5 MHz, CDCl$_3$) 202.9 (CH*C*OCH), 174.4 (N*C*O), 169.8 (CH$_3$*C*OO), 74.9 (COO*C*H), 65.6 (CO*C*HN), 45.2 (N*C*H$_2$Ar), 36.0 (NCH*C*H) and 20.4 (*C*H$_3$COO).

22: Oil; R_f 0.3 (ethyl acetate); ν_{max} (CHCl$_3$)/cm^{-1} 3024 (w), 3007 (w), 2955 (w), 2923 (w), 1692 (s), 1487 (m), 1452 (w), 1410 (w), 1320 (w), 1237 (m) and 1043 (w); δ_H (270 MHz, CDCl$_3$) 6.69 (1H, s, aromatic), 6.54 (1H, s, aromatic), 5.93 (2H, s, OC*H*$_2$O), 4.97 (1H, d, *J*=16.5 Hz, NC*H*$_A$H$_B$Ar), 4.18 (1H, d, *J*=8 Hz, COC*H*N), 3.92 (1H, d, *J*=16.5 Hz, NCH$_A$*H*$_B$Ar), 3.61 (1H, t, *J*=8.5 Hz, COC*H*Ar), 3.04–2.97 (1H, m, NCHC*H*), 2.88 (1H, dd, *J*=16.5, 3 Hz, C*H*$_A$H$_B$CON), 2.39–2.22 (1H, m, C*H*$_A$H$_B$CHCO or CH$_2$C*H*$_A$H$_B$CH), 2.16 (1H, d, *J*=16.5 Hz, CH$_A$*H*$_B$CON), 2.00–1.85, 1.82–1.66 and 1.54–1.47 (3×1H, m, CH$_A$*H*$_B$CHCO and CH$_2$C*H*$_2$CH or CH$_2$CH$_A$*H*$_B$CH and C*H*$_2$CHCO); δ_C (67.5 MHz, CDCl$_3$) 209.3 (CH*C*OCH), 174.9 (N*C*O), 147.0, 146.6 (CCH*C*O), 131.1, 127.2 (NCH$_2$*C* and NCH$_2$C*C*), 110.1, 108.9 (C*C*HCO), 101.3 (O*C*H$_2$O), 67.9 (CO*C*HN), 55.5 (CO*C*HAr), 45.1 (N*C*H$_2$Ar), 37.9 (*C*H$_2$CON), 34.5 (NCH*C*H), 30.6 (*C*H$_2$CHCO) and 26.6 (CH$_2$*C*H$_2$CH); *m/z* (CI, NH$_3$) 286 (M+H$^+$, 100%) and 256 (10); Found: M+H$^+$, 286.1076. $C_{16}H_{15}NO_4$ requires for M+H$^+$, 286.1079.

23: The presence of this was indicated by: δ_H (270 MHz, CDCl$_3$) 6.72 (1H, d, *J*=8 Hz, aromatic), 6.65 (1H, d, *J*=8 Hz, aromatic), 5.98 (1H, d, *J*=1.5 Hz, OC*H*$_A$H$_B$O), 5.91 (1H, d, *J*=1.5 Hz, OCH$_A$*H*$_B$O), 5.00 (1H, d, *J*=16.5 Hz, NC*H*$_A$H$_B$Ar), 4.21 (1H, d, *J*=8 Hz, COC*H*N), 3.98 (1H, t, *J*=8 Hz, COC*H*Ar), 3.90 (1H, d, *J*=16.5 Hz, NCH$_A$*H*$_B$Ar) and 2.85 (1H, dd, *J*=16.5, 3 Hz, C*H*$_A$H$_B$CON); δ_C (67.5 MHz, CDCl$_3$) 209.1 (CH*C*OCH), 174.8 (N*C*O), 146.1, 146.0 (CHCH*C*O and CC*C*O), 128.3 (NCH$_2$*C* or NCH$_2$C*C*), 121.7 (*C*HCHCO), 119.6 (NCH$_2$*C* or NCH$_2$C*C*), 107.0 (CH*C*HCO), 101.0 (O*C*H$_2$O), 68.2 (CO*C*HN), 48.3 (CO*C*HAr), 45.0 (N*C*H$_2$Ar), 37.9 (*C*H$_2$CON), 34.9 (NCH*C*H), 28.5 (*C*H$_2$CHCO) and 26.3 (CH$_2$*C*H$_2$CH).

Treatment of *N*-allyl-*N*-(6-oxocyclohex-1-enyl)-2-bromobenzamide 24 with Bu$_3$SnH

Tributyltin hydride (0.21 g, 0.73 mmol) and azobisisobutyronitrile (28 mg) in degassed toluene (52 cm^3) were added to diene **24** (0.18 g, 0.56 mmol) in degassed toluene (23 cm^3) over 1 h following the general cyclisation procedure. Column chromatography (silica; diethyl ether) afforded **5-allyl-1,2,3,4,4a,5,6,10b-octahydrophenanthridine-4,6-dione 25** (20 mg, 15%) as a separable 1.6:1 mixture of two diastereomers and **5-methyl-2,3,4,4a,5,6-hexahydro-1H, 8H-isoindolo[3,2-*i*]indole-1,8-dione 26** (56 mg, 41%) as a 17.8:5.0:2.3:1 mixture of four diastereomers (obtained as two fractions of two inseparable diastereomers) as oils.

25 (4a*R**,10b*R**) — *Major diastereomer*: R_f 0.4 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3031 (w), 3008 (w), 2958 (w), 2931 (w), 2873 (w), 1724 (m), 1658 (s), 1603 (w), 1518(w), 1486 (w), 1463 (w), 1417 (w), 1379 (w), 1351 (w), 1286 (w) and 1237 (w); δ_H (270 MHz, CDCl$_3$) 8.18 (1H, dd, *J*=8, 1.5 Hz, C*H*=C), 7.52–7.38 (2H, m, 2×CHC*H*CH), 7.33 (1H, br d, *J*=8 Hz, C*H*=C), 5.73 (1H, dddd, *J*=17, 10, 9, 4.5 Hz, C*H*=CH$_2$), 5.18–5.07 (2H, m, CH=C*H*$_2$), 5.03 (1H, ddt, *J*=15, 4.5, 1.5 Hz, NC*H*$_A$H$_B$), 4.42 (1H, dd, *J*=13, 1 Hz, COC*H*N), 4.19 (1H, ddt, *J*=15, 9, 1 Hz, NCH$_A$*H*$_B$), 3.30–3.20 (1H, br m, NCHC*H*), 2.75–2.32 (4H, m, C*H*$_2$CO and C*H*$_2$CHAr) and 2.02–1.80 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 206.7 (CH$_2$*C*O), 164.9 (N*C*O), 137.9 (*C*=CH), 132.9, 132.3, 128.5, 128.2, 126.9, 123.3 (4×*C*H, *C*=CH and *C*H=CH$_2$), 118.9 (CH=*C*H$_2$), 66.8 (CO*C*HN), 45.9 (N*C*H$_2$), 44.1 (NCH*C*HAr), 41.2 (*C*H$_2$CO), 27.6 and 27.5 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 256 (M+H$^+$, 100%); Found: M+H$^+$, 256.1329. $C_{16}H_{17}NO_2$ requires for M+H$^+$, 256.1338. (4a*R**,10b*S**) — *Minor diastereomer*: R_f 0.2 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3008 (m), 2957 (m), 2929 (m), 2874 (w), 1724 (s), 1650 (s), 1603 (w), 1466 (m), 1445 (w), 1427 (w), 1417 (w), 1379 (w), 1359 (w), 1315 (w), 1289 (w), 1252 (w) and 1237 (w); δ_H (270 MHz, CDCl$_3$) 8.15 (1H, dd, *J*=7.5, 1.5 Hz, C*H*=C), 7.47 (1H, dt, *J*=7.5, 1.5 Hz, CHC*H*CH), 7.35 (1H, dt, *J*=7.5, 1 Hz, CHC*H*CH), 7.21 (1H, br d, *J*=7.5 Hz, C*H*=C), 5.86 (1H, dddd, *J*=17, 10, 7.5, 5 Hz, C*H*=CH$_2$), 5.27–5.19 (2H, m, CH=C*H*$_2$), 4.95 (1H, ddt, *J*=15.5, 5, 2 Hz, NC*H*$_A$H$_B$), 4.21 (1H, d, *J*=6.5 Hz, COC*H*N), 3.93–3.90 (1H, br m, NCHC*H*Ar), 3.49 (1H, ddt, *J*=15.5, 7.5, 1 Hz, NCH$_A$*H*$_B$), 2.75–2.65 (1H, m, C*H*$_A$H$_B$CO or C*H*$_A$H$_B$CHAr), 2.47–2.17 (3H, m, CH$_A$*H*$_B$CHAr and C*H*$_2$CO or CH$_A$*H*$_B$CO and C*H*$_2$CHAr), 2.09–1.76 (2H, m, CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 206.3 (CH$_2$*C*O), 164.2 (N*C*O), 135.8 (*C*=CH), 133.7, 132.1, 130.1, 129.2, 127.5, 123.8 (4×*C*H=C, *C*=CH and *C*H=CH$_2$), 117.8 (CH=*C*H$_2$), 65.9 (CO*C*HN), 49.0 (N*C*H$_2$), 41.0 (NCH*C*HAr), 40.5 (*C*H$_2$CO), 25.8 (*C*H$_2$CHAr) and 22.3 (CH$_2$*C*H$_2$CH$_2$); *m/z* (CI, NH$_3$) 256 (M+H$^+$, 100%) and 150 (10); Found: M+H$^+$, 256.1337. $C_{16}H_{17}NO_2$ requires for M+H$^+$, 256.1338.

26 *Diastereomer 1:* R_f 0.2 (diethyl ether); ν_{max} (CHCl$_3$)/cm^{-1} 3007 (m), 2963(m), 2880 (w), 1720 (s), 1692 (s), 1611 (w), 1466 (m), 1374 (m), 1348 (w), 1311 (w) and 1238 (w); δ_H (270 MHz, CDCl$_3$) 7.82–7.78 (1H, m, C*H*=C), 7.61–7.52 (2H, m, C*H*=C and CHC*H*CH), 7.47 (1H, dt, *J*=1.5, 7.5 Hz, CHC*H*CH), 4.17 (1H, dd, *J*=12, 7.5 Hz, NC*H*$_A$H$_B$), 3.00–2.85 (1H, m, NCC*H*), 2.83 (1H, dd, *J*=12, 8 Hz, NCH$_A$*H*$_B$), 2.71–2.51 (3H, m, C*H*$_2$CO and CH$_2$C*H*$_A$H$_B$CH or CH$_2$C*H*$_2$CH and C*H*$_A$H$_B$CO), 2.30–2.00 (3H, m, CH$_2$C*H*$_2$CH$_2$ and CH$_2$CH$_A$*H*$_B$CH or CH$_A$*H*$_B$CO), 1.75–1.62 (1H, m, C*H*CH$_3$) and 1.06 (3H, d, *J*=7 Hz, CHC*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) 205.8 (CH$_2$*C*O), 170.8 (N*C*O), 144.8 (*C*=CH), 132.7 (*C*=CH), 132.0, 129.0, 124.7, 121.4 (4×*C*H), 80.9 (CO*C*N), 48.7 (N*C*H$_2$), 48.2, 39.9 (NC*C*H and *C*HCH$_3$), 37.2 (*C*H$_2$CO), 23.0, 22.8 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$) and 14.9 (CH*C*H$_3$); *m/z* (CI, NH$_3$) 256 (M+H$^+$, 100%); Found: M+H$^+$, 256.1329. $C_{16}H_{17}NO_2$ requires for M+H$^+$, 256.1338. *Diastereomer 2:* The presence of this was indicated by: δ_H (270 MHz, CDCl$_3$) 3.63 (1H, dd, *J*=11.5, 8.5 Hz, NC*H*$_A$H$_B$), 3.29 (1H, dd, *J*=11.5, 8.5 Hz, NCH$_A$*H*$_B$), 1.87–1.81 (1H, m, C*H*CH$_3$) and 1.09 (3H, d, *J*=7 Hz, CHC*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) 204.4 (CH$_2$*C*O), 170.3 (N*C*O), 143.0 (*C*=CH), 133.2 (*C*=CH), 131.5, 129.3, 124.8, 121.5 (4×*C*H), 81.6 (CO*C*N), 52.9 (NC*C*H), 47.8 (N*C*H$_2$), 40.4 (*C*H$_2$CO), 37.6 (*C*HCH$_3$), 22.2, 22.2 (CH$_2$*C*H$_2$CH and CH$_2$*C*H$_2$CH$_2$) and 16.7 (CH*C*H$_3$). *Diastereomer 3:* The presence of this was indicated by: R_f 0.3 (diethyl ether);

ν_{max} (CHCl$_3$)/cm^{-1} 3009 (w), 2963 (w), 2930 (w), 2875 (w), 1758 (w), 1698 (s), 1605 (w), 1467 (w), 1381 (w), 1360 (w), 1342 (w), 1329 (w), 1235 (w), 1157 (w), 1138 (w), 1102 (w) and 1030 (w); δ_H (270 MHz, CDCl$_3$) 7.82–7.78 (1H, m, C*H*═C), 7.53 (1H, dt, *J*=1.5, 7.5 Hz, CHC*H*CH), 7.46 (1H, dt, *J*=1, 7.5 Hz, CHC*H*CH), 7.24 (1H, br d, *J*=7.5 Hz, C*H*═C), 4.09 (1H, dd, *J*=12, 6.5 Hz, NC*H*$_A$H$_B$), 2.98–1.20 (9H, m, NCH$_A$*H*$_B$, NCC*H*, C*H*$_2$CO, CH$_2$C*H*$_2$CH, CH$_2$C*H*$_2$CH$_2$ and C*H*CH$_3$) and 1.04 (3H, d, *J*=7 Hz, CHC*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) 213.1 (CH$_2$*C*O), 174.2 (N*C*O), 147.2, 132.8 (2×*C*═CH), 132.7, 129.0, 124.6, 121.1 (4×*C*H), 80.2 (CO*C*N), 49.8 (N*C*H$_2$), 44.7, 39.1 (NC*C*H and *C*HCH$_3$) and 11.1 (CH*C*H$_3$); *m*/*z* (CI, NH$_3$) 256 (M+H$^+$, 100%) and 185 (10); Found: M+H$^+$, 256.1334. C$_{16}$H$_{17}$NO$_2$ requires for M+H$^+$, 256.1338. *Diastereomer 4:* The presence of this was indicated by: δ_H (270 MHz, CDCl$_3$) 4.24 (1H, dd, *J*=12, 7.5 Hz, NC*H*$_A$H$_B$) and 1.13 (3H, d, *J*=7 Hz, CHC*H*$_3$); δ_C (67.5 MHz, CDCl$_3$) 212.0 (CH$_2$*C*O), 173.4 (N*C*O), 146.9 (*C*═CH), 79.4 (CO*C*N), 51.0 (N*C*H$_2$), 45.6, 39.6 (NC*C*H and *C*HCH$_3$) and 14.3 (CH*C*H$_3$).

Treatment of *N*-(2-hydroxyethyl)-*N*-(6-oxocyclohex-1-enyl)-2-bromobenzamide 27 with Bu$_3$SnH

To a solution of alkene **27** (0.30 g, 0.89 mmol) in degassed toluene (37 cm^3) was added tributyltin hydride (0.34 g, 1.15 mmol) and azobisisobutyronitrile (44 mg) in toluene (82 cm^3) over 5 h according to the general procedure. Column chromatography (silica; ethyl acetate) afforded **3a-hydroxy-1,2,3,3a,5,6,12b,12c-octahydro-8H-[1,4]oxazino-[2,3,4-de]phenanthridin-8-one 28** (70 mg, 30%) and **4a-hydroxy-2,3,4,4a,6,7-hexahydro-1H,9H-isoindolo[2,3-d][1,4]-benzoxazin-9-one 29** (92 mg, 40%) as single diastereomers.

28: solid; mp 188–191°C; R_f 0.3 (ethyl acetate); ν_{max} (CHCl$_3$)/cm^{-1} 3586 (w, OH), 3017 (w), 3006 (m), 2948 (m), 2888 (w), 2868 (w), 1688 (w), 1644 (s), 1603 (w), 1461 (w), 1447 (w), 1424 (w), 1349 (w), 1285 (w), 1253 (w), 1231 (w), 1220 (w), 1208 (w), 1126 (w), 1106 (w), 1075 (w) and 1056 (w); δ_H (270 MHz, CDCl$_3$) 8.13 (1H, dd, *J*=7.5, 1 Hz, C*H*═C), 7.47 (1H, dt, *J*=7.5, 1.5 Hz, CHC*H*CH), 7.40–7.25 (2H, m, C*H*═C and CHC*H*CH), 4.30–4.08 (2H, m, NC*H*$_A$H$_B$ and NCH$_2$C*H*$_A$H$_B$OC), 3.80–3.48 (1H, m, NCH$_A$*H*$_B$ or NCH$_2$CH$_A$*H*$_B$OC), 3.28–3.03 (2H, m, NCH$_A$*H*$_B$ or NCH$_2$CH$_A$*H*$_B$OC and COHCHN), 2.52–2.48 (1H, br m, C*H*$_A$H$_B$COH or C*H*$_A$H$_B$CHAr) and 2.10–1.20 (6H, m, C*H*$_A$H$_B$COH or C*H*$_A$H$_B$CHAr and CH$_A$*H*$_B$COH, CH$_A$*H*$_B$CHAr, CH$_2$C*H*$_2$COH, C*H*$_2$CHAr and CH$_2$C*H*$_2$CH$_2$); δ_C (67.5 MHz, CDCl$_3$) 166.1 (N*C*O), 139.9 (*C*═CH), 132.4, 128.4 (2×*C*H═C), 127.4 (*C*═CH), 126.6, 123.5 (2×*C*H═C), 94.1 (*C*OH), 63.4 (N*C*HCH), 58.6 (N*C*H$_2$), 41.0, 36.1 (NCH$_2$*C*H$_2$OC and CH$_2$*C*OH), 35.2 (NCH*C*H), 27.2 (*C*H$_2$CH) and 21.4 (CH$_2$*C*H$_2$CH$_2$); *m*/*z* (CI, NH$_3$) 260 (M+H$^+$, 45%), 242 (100), 240 (50), 230 (15) and 213 (15); Found: M+H$^+$, 260.1287. C$_{15}$H$_{17}$NO$_3$ requires for M+H$^+$, 260.1287.

29: solid; mp 192–196°C; R_f 0.2 (ethyl acetate); ν_{max} (CHCl$_3$)/cm^{-1} 3582 (w, OH), 3005 (w), 2929 (m), 2873 (w), 2857 (w), 1682 (s), 1488 (w), 1470 (w), 1452 (w), 1414 (w), 1365 (w), 1353 (w), 1285 (w), 1207 (w), 1144 (w) and 1064 (w); δ_H (270 MHz, CDCl$_3$) 7.73 (2H, appt t, *J*=7.5 Hz, aromatics), 7.51 (1H, dt, *J*=7.5, 1 Hz, aromatic), 7.39 (1H, t, *J*=7.5 Hz, aromatic), 4.26–4.09 (2H, m, NC*H*$_A$H$_B$ and NCH$_2$C*H*$_A$H$_B$OC), 3.73 (1H, dd, *J*=11, 5 Hz, NCH$_A$*H*$_B$ or NCH$_2$CH$_A$*H*$_B$OC), 3.35 (1H, dt, *J*=5, 12.5 Hz, NCH$_A$*H*$_B$ or NCH$_2$CH$_A$*H*$_B$OC), 3.08 (1H, br s, CO*H*), 2.47 (1H, dt, *J*=13, 5 Hz, C*H*$_A$H$_B$COH or C*H*$_A$H$_B$CN) and 2.17–1.56 (7H, m, C*H*$_A$H$_B$CN or C*H*$_A$H$_B$COH, CH$_A$*H*$_B$COH, CH$_A$*H*$_B$CN, C*H*$_2$CH$_2$CN and C*H*$_2$CH$_2$COH); δ_C (67.5 MHz, CDCl$_3$) 166.8 (N*C*O), 147.3 (*C*═CH), 132.9 (*C*═CH), 130.9, 128.3, 124.1, 122.9 (4×*C*H), 96.1 (*C*OH), 66.3 (N*C*Ar), 58.6 (N*C*H$_2$), 37.0, 35.6, 31.4 (NCH$_2$*C*H$_2$OC, CH$_2$*C*OH and *C*H$_2$CAr), 22.0 and 21.8 (*C*H$_2$CH$_2$CAr and *C*H$_2$CH$_2$COH); *m*/*z* (CI, NH$_3$) 260 (M+H$^+$, 100%), 245 (10), 242 (15) and 200 (10); Found: M+H$^+$, 260.1285. C$_{15}$H$_{17}$NO$_3$ requires for M+H$^+$, 260.1287.

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