Synthesis of Cyclic Amines and Allylic Sulfides by Phenylthio Migration of β-Hydroxy Sulfides

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Rearrangement of β-hydroxy sulfides proceeds stereospecifically with capture of the episulfonium ion by the nitrogen atom of an amide. Almost quantitative yields of substituted pyrrolidines are obtained using a sulfonamide as the intramolecular nucleophile and with activation by trimethylsilyl trifluoromethanesulfonate (TMSOTf). With a free amine no cyclization takes place, but instead allylic sulfides are formed.

Treatment of a β-hydroxy sulfide with acid gives rise to the formation of an intermediate episulfonium ion and release of water. This so-formed three-membered episulfonium ion cannot be isolated and breaks down by loss of a proton and cleavage of the weaker carbon–sulfur bond to give an allylic sulfide.[1] For example, with acid catalysis the β-hydroxy sulfide *anti*-**1**, R = $SiPh_2Bu^t$ gives the episulfonium ion **2** which loses a proton to give the allylic sulfide *syn*-**3**, R = $SiPh_2Bu^t$.[2] This 1,2-migration of a phenylthio group proceeds stereospecifically with inversion of stereochemistry at the migration terminus. When the rearrangement is performed with *anti*-**1**, (R = H) the intermediate episulfonium ion **2** is captured intramolecularly by the hydroxy group. This gives the spirocyclic ether **4** in essentially quantitative yield.[2] It is possible to control the relative stereochemistry of both the allylic sulfide **3** and the cyclic ether **4** as in both cases the phenylthio group migrates with complete inversion of stereochemistry at the migration terminus.[3]

We were interested in extending this cyclization procedure to the stereocontrolled synthesis of cyclic amines.[4] We now describe the successful use of amides as intramolecular nitrogen nucleophiles to give the corresponding nitrogen heterocycles.[5]

Initially we focussed our attention on the rearrangement of the β-hydroxy sulfides *syn*- and *anti*-**9** and *syn*- and *anti*-**11**, which have an amino group as a potential intramolecular nucleophile to capture the episulfonium ion. The *syn* isomers were prepared using a stereoselective aldol reaction with *S*-phenyl propanethioate **5**[6] and the 2-phenylthio aldehyde **6**.[7] The resulting thioester **7** was converted into the primary amide **8** using aqueous ammonia. Reduction then gave the amine *syn*-**9** ready for attempted rearrangement–cyclisation.

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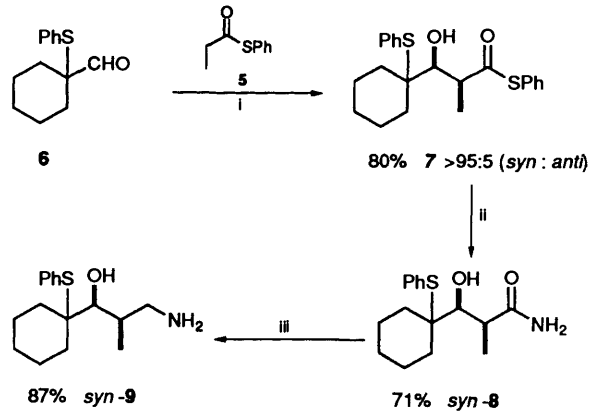
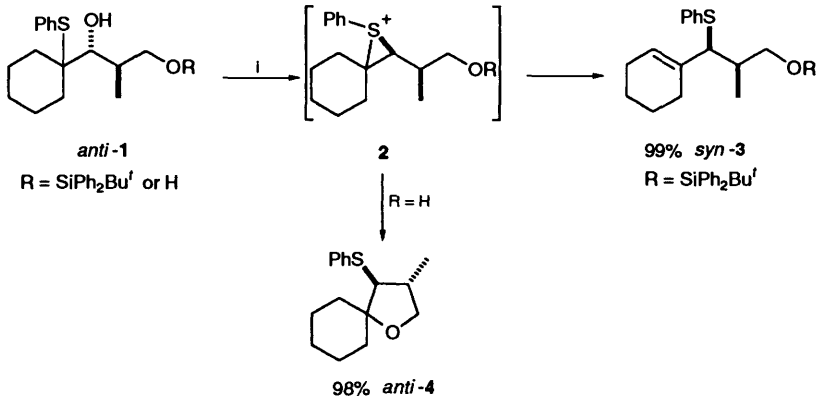


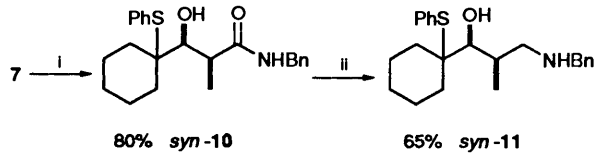
Scheme 2 *Reagents:* i, 9-BBN triflate, Pr^i_2NEt, Et_2O; ii, NH_4OH; iii, BH_3-THF

With benzylamine instead of ammonia, the *N*-substituted primary amide *syn*-**10** could be prepared, but yields were considerably improved by using the Weinreb procedure[8] in which the amine is first treated with trimethylaluminium before addition of the ester. Reduction of the amide *syn*-**10** gave the desired amine *syn*-**11**.

We have previously studied the aldol reaction on aldehyde **6** with the aim of obtaining high 2,3-stereoselectivity.[2b] As mentioned above, the boron enolate of *S*-phenyl propanethioate gives excellent *syn* selectivity (> 95 : < 5 *syn* : *anti*) and we have found that the use of the lithium enolate of 2,6-dimethylphenyl propionate gives excellent *anti* selectivity (< 5 : > 95 *syn* : *anti*). Unfortunately, this route to the amines *anti*-**9** and *anti*-**11** was thwarted by the lack of reactivity of the bulky aromatic ester to ammonia or benzylamine.

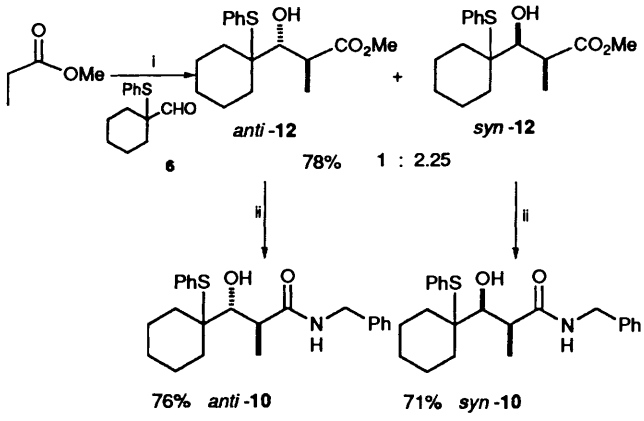


Scheme 1 *Reagents:* i, TsOH (cat.), benzene



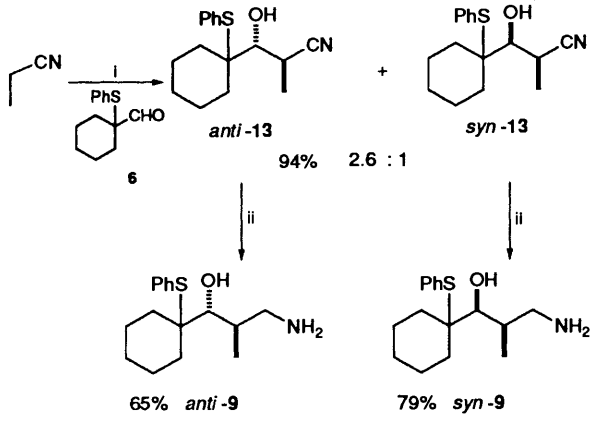
Scheme 3 *Reagents:* i, $PhCH_2NH_2$, Me_3Al; ii, BH_3·THF

The less bulky methyl esters *anti*-**12** and *syn*-**12**, formed from a less selective aldol reaction with methyl propionate, could however be converted into the *N*-substituted primary amides *anti*-**10** and *syn*-**10**. In these cases with the methyl esters it was imperative to use the Weinreb procedure as simple reflux with benzylamine caused epimerization at C-2. Attempts to reduce the amide *anti*-**10** with borane or $LiAlH_4$ failed.



Scheme 4 *Reagents:* i, LDA; then **6**; ii, $PhCH_2NH_2$, Me_3Al

A route to the *anti* series was achieved using the anion from propiononitrile with the aldehyde **6**. This turned out to be moderately selective in favour of the nitrile *anti*-**13** which was reduced to the amine *anti*-**9** using $LiAlH_4$. The nitrile *syn*-**13** could also be reduced to the amine *syn*-**9**, thereby confirming the stereochemical assignment.



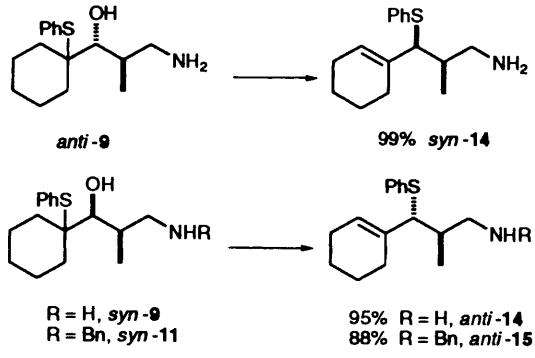
Scheme 5 *Reagents:* i, LDA; then **6**; ii, $LiAlH_4$, Et_2O

It is interesting to note that in both the ester **12** and the nitrile **13** the $J^{2,3}$-value is larger for the *syn* isomer than for the corresponding *anti* isomer (Table 1).* This reversal is thought to be due to the bulky 1-phenylthiocyclohexyl group at C-3. The ^{13}C NMR shift of the methyl group on C-2 has proved to be a more reliable guide to the stereochemistry (Table 1).[9]

With the amines *syn*-**9**, *anti*-**9** and *syn*-**11** in hand, we were ready to carry out the rearrangement reaction. Under the conditions used for the diols[2b] in which a catalytic amount of acid is used we observed no reaction whatsoever. However, when more than one equivalent of acid was added, the rearrangement proceeded smoothly. This gave not the expected cyclic amine but the allylic sulfides **14** and **15**. The allylic sulfides were formed in excellent yield and with complete stereochemical control, inversion of stereochemistry having taken place at the migration terminus. The lack of any cyclized product suggests that the amine remains protonated throughout the rearrangement, thereby preventing the nitrogen lone pair from intercepting the intermediate episulfonium ion.

Table 1 Comparison of coupling constants and ^{13}C NMR data

	$J^{2,3}$ (Hz)	δ_C (Me^2) (ppm)
syn-**7**	5.3	15.2
syn-**8**	3.1	14.2
syn-**10**	3.1	14.2
anti-**10**	m	19.3
anti-**12**	1.8	18.0
anti-**13**	0.9	18.4
syn-**12**	5.6	14.2
syn-**13**	6.5	15.6



Scheme 6 *Reagents and conditions:* 1.9 mol equiv. TsOH, benzene, reflux

Attempts were made to effect the rearrangement of the amines **9** and **11** under a variety of conditions (*e.g.*, $SOCl_2$, BuLi then $SOCl_2$, TMSOTf, $TiCl_4$, Ph_3P + diethyl azodicarboxylate, Ph_3P + CCl_4) in the hope that the nitrogen lone pair would remain available for intramolecular attack. In no case did we observe any cyclized product; with Lewis acids the only isolable compound was the allylic sulfide and with Mitsunobu conditions no reaction took place.

Cyclization to the pyrrolidine could be achieved by a two-step process in which the allylic sulfide was treated with mercury(II) acetate followed by reduction of the carbon–mercury bond by $NaBH_4$. This reaction may proceed *via* cyclization onto either the three-membered mercuronium ion or onto the episulfonium ion. The cyclic amine *syn*-**16** was obtained as a single stereoisomer.

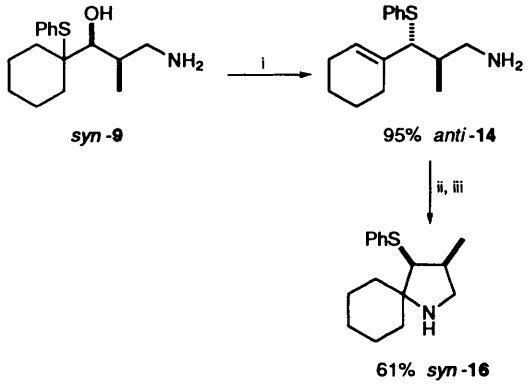
With the failure to promote the direct cyclization of the amino-β-hydroxy sulfides, we turned our attention to the cyclization of the corresponding amido-β-hydroxy sulfides. The cyclization of the nitrogen atom of an amide group onto an episulfonium ion[10] or an episelenonium ion[11] is known. These reported cyclizations are all accomplished from the activation of an alkene and so suffer from lack of complete stereochemical control. Only simple carboxylic amides or carbamates have been investigated although studies with other amide groups, in particular ureas and sulfonamides, have been carried out on cyclizations onto alkenes by activation with Pd^{II}[12] or I_2.[13] The work described in this paper confirms the trend that, in general,

* For further examples, see ref. 2*b*.

Table 2 Conversion of amines into amides

9 **17–24**

Stereochemistry	Conditions	Product	R	Yield (%)
syn-**9**	MeCOCl	*syn*-**17**	COMe	73
anti-**9**	MeCOCl	*anti*-**17**	COMe	84
syn-**9**	EtNCO	*syn*-**18**	CONHEt	97
syn-**9**	Et_2NCOCl	*syn*-**19**	$CONEt_2$	60
syn-**9**	PhNCO	*syn*-**20**	CONHPh	89
anti-**9**	PhNCO	*anti*-**20**	CONHPh	97
anti-**9**	*p*-$MeOC_6H_4NCO$	*syn*-**21**	$CONHC_6H_4OMe$-*p*	92
anti-**9**	*p*-$O_2NC_6H_4NCO$	*syn*-**22**	$CONHC_6H_4NO_2$-*p*	96
syn-**9**	EtOCOCl	*syn*-**23**	CO_2Et	99
anti-**9**	EtOCOCl	*anti*-**23**	CO_2Et	98
syn-**9**	$TolSO_2Cl$	*syn*-**24**	SO_2Tol	94
anti-**9**	$TolSO_2Cl$	*anti*-**24**	SO_2Tol	96



syn-**9** 95% *anti*-**14** 61% *syn*-**16**

Scheme 7 i, TsOH; ii, $Hg(OAc)_2$; iii, $NaBH_4$

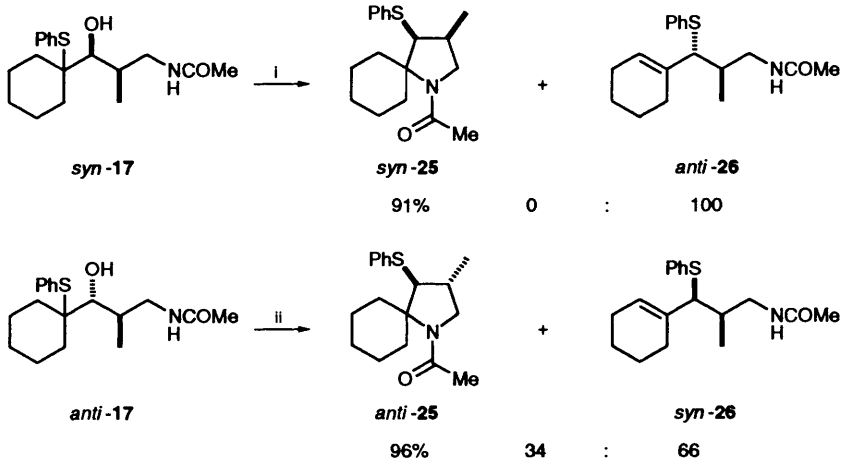
sulfonamides are the best group for nitrogen cyclization. Carbamates are slightly better than ureas which, in turn, are much better than simple carboxylic amides.

The *syn* and *anti* amides **17–24** were prepared as shown in Table 2. These amides were treated with TsOH or TMSOTf to allow the 1,2-phenylthio migration. In each case rearrangement took place with complete stereochemical control with inversion of stereochemistry at the migration terminus.

The simple carboxylic amides *syn*-**17** and *anti*-**17** rearranged to give the allylic sulfides *anti*-**26** and *syn*-**26**, respectively. With TsOH the allylic sulfide was the only product. However, with TMSOTf a small amount of the pyrrolidine *anti*-**25** was formed. The lack of reactivity of simple carboxylic amides is often attributed to the strain in the pyrrolidine products as judged from the rotational barrier around the amide bond.[13] As the nitrogen lone pair will be strongly delocalized into the carbonyl group we turned our attention to other, less basic amide groups.

Under our usual conditions for the 1,2-shift (0.8 mol equiv. of TsOH) the rearrangement of the urea *syn*-**18** was slow. However, under these conditions a greater ratio of the pyrrolidine *syn*-**27** to the allylic sulfide *anti*-**28** resulted as compared with the much faster reaction when using excess of TsOH. This suggests that the urea group is protonated in preference to the secondary hydroxy group. With less than 1 mol equiv. of acid there will therefore be only a low concentration of the hydroxy-protonated species which is required for episulfonium ion formation. When more than 1 mol equiv. of acid is used, the urea group can remain protonated during the rearrangement and so be unavailable for nucleophilic attack. This will result in a greater proportion of allylic sulfide with excess of acid. We found that the solvent plays only a minor role (Table 3); the use of higher-boiling solvents speeds up the reaction and the less polar solvents such as benzene favour the allylic sulfide.

The bulkier diethyl urea *syn*-**19** (Table 3) rearranges with excess of acid to give almost exclusively the allylic sulfide *anti*-**30**. With a catalytic amount of acid the ratio of pyrrolidine *syn*-



syn-**17** *syn*-**25** *anti*-**26**

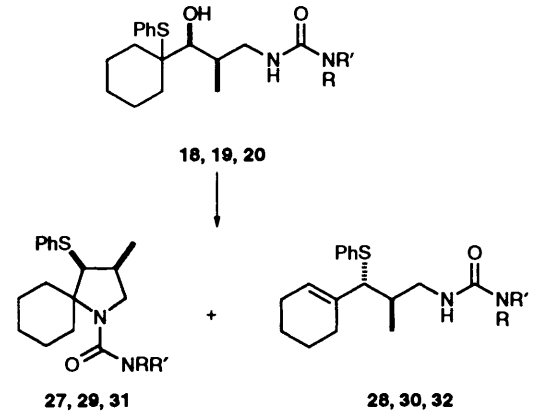
91% 0 : 100

anti-**17** *anti*-**25** *syn*-**26**

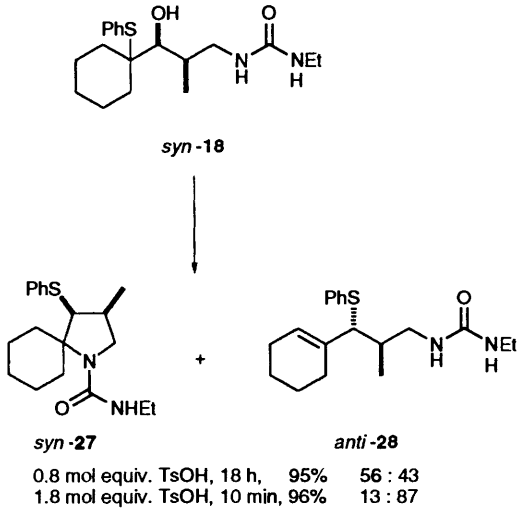
96% 34 : 66

Scheme 8 *Reagents and conditions:* i, TsOH; ii, TMSOTf, CH_2Cl_2, −78 °C to room temp.

Table 3 Rearrangement of ureas **18**, **19** and **20** with TsOH



Starting urea	R	R'	Conditions	Yield (%)	Ratio	Product
syn-**18**	H	Et	0.8 TsOH,			
			CH_2Cl_2, 18 h	95	1.3:1	*syn*-**27**:*anti*-**28**
			MeCN, 90 min	83	1.5:1	
			$CHCl_3$, 2 h	83	1:1.2	
			PhH, 45 min	92	1:1.8	
			1.9 TsOH,			
			CH_2Cl_2, 10 min	96	1:7.0	
			$SOCl_2$, CH_2Cl_2	83	1:4.2	
syn-**19**	Et	Et	0.8 TsOH,			
			CH_2Cl_2, 14 h	77	1:6	*syn*-**29**:*anti*-**30**
			$CHCl_3$, 80 min	78	1:2.4	
			1.9 TsOH,			
			CH_2Cl_2, 30 min	83	1:99	
syn-**20**	H	Ph	0.8 TsOH,			
			CH_2Cl_2, 3 h	87	3:1	*syn*-**31**:*anti*-**32**
			MeCN, 30 min	76	1:1.5	
			$CHCl_3$, 40 min	98	2.5:1	
			PhH, 15 min	91	1:3.3	
			1.8 TsOH			
			CH_2Cl_2, 10 min	87	2.6:1	



Scheme 9 *Reagents:* TsOH, CH_2Cl_2

29 to the allylic sulfide *anti*-**30** increases as expected; however, the yield of the cyclized product *syn*-**29** is lower than that for the monoethyl urea *syn*-**18**. This lower yield probably results from greater steric interaction of the diethyl urea group with the cyclohexyl ring.

The rearrangement of the phenyl urea *syn*-**20** (Table 3) with TsOH gave similar yields and ratios to the ethyl urea *syn*-**18**. The cyclized product *syn*-**31** was shown to have *syn* stereochemistry by nuclear Overhauser enhancement (NOE) difference spectroscopy, thereby confirming the stereospecificity of the reaction with inversion of stereochemistry at the migration terminus.

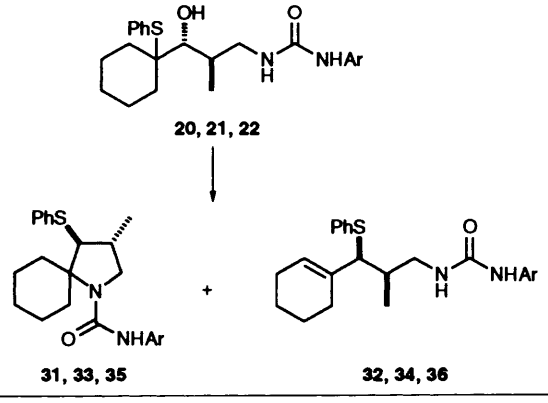
A comparison of different aromatic groups was undertaken as shown in Table 4. The *para*-methoxy-substituted aromatic urea *anti*-**21** (Table 4) gave a lower ratio of the pyrrolidine *anti*-**33** compared to the allylic sulfide *syn*-**34**. This might be expected if the urea *anti*-**21** is slightly more basic than the aryl-unsubstituted urea *anti*-**20**. Rearrangement of the slightly less basic urea *anti*-**22** did not, however, lead to any significant improvement in the ratio of the two products.

We next turned our attention to the rearrangement of the corresponding carbamates **23** and sulfonamides **24**. These were rearranged under the usual conditions of catalytic TsOH to give a mixture of the pyrrolidine and the allylic sulfide products.

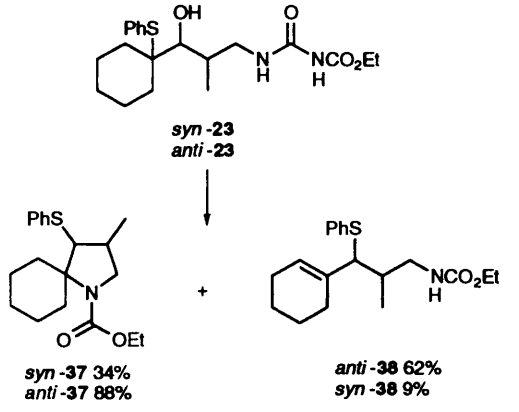
In both cases the yield of the cyclized pyrrolidine products **37** and **39** had improved, particularly from the sulfonamide **24**. The slightly lower yield of the pyrrolidine *syn*-**37** may be due to steric factors on bringing the phenylthio and methyl groups *syn* to one another.[3] This is not a thermodynamic equilibrium as no interconversion of the pyrrolidine and the allylic sulfide takes place under conditions identical with those for the rearrangement.

Lewis acids are known to promote the 1,2-phenylthio shift and indeed for the simple carboxylic amide *anti*-**17** the use of TMSOTf allowed the formation of a small but significant amount of the cyclized product *anti*-**25**. Avoidance of protic conditions should aid the cyclization by leaving the nitrogen atom available for nucleophilic attack. A comparison of the use

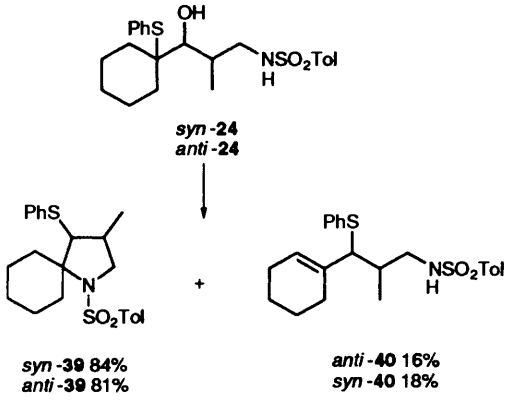
Table 4 Rearrangement of *N*-arylureas *anti*-**20**, -**21** and -**22** with TsOH



Starting urea	Ar	Conditions	Yield (%)	Ratio	Product
anti-**20**	Ph	0.8 TsOH, $CHCl_3$, 2 h	68	1:1.2	*anti*-**31**:*syn*-**32**
anti-**21**	C_6H_4OMe-*p*	0.8 TsOH, $CHCl_3$, 2 h	45	1:10	*anti*-**33**:*syn*-**34**
anti-**22**	$C_6H_4NO_2$-*p*	0.8 TsOH, $CHCl_3$, 2 h	56	1:1	*anti*-**35**:*syn*-**36**



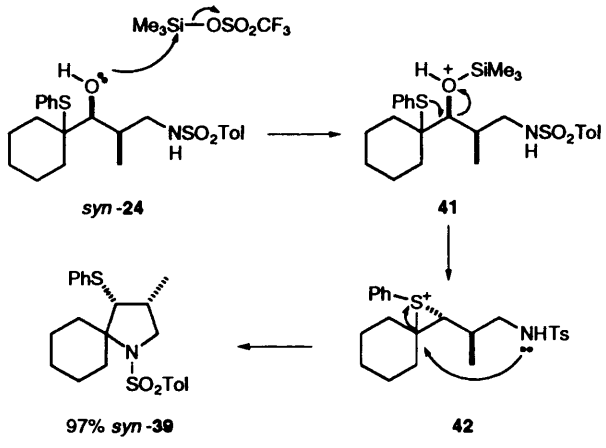
Scheme 10 *Reagents and conditions:* 0.8 mol equiv. TsOH, CH_2Cl_2, reflux, 30 mm



Scheme 11 *Reagents and conditions:* 0.8 mol equiv. TsOH, CH_2Cl_2, reflux, 30 min

of TMSOTf with the ureas **20**, the carbamates **23** and the sulfonamides **24** is shown in Table 5.

In each case the pyrrolidine was formed in good yield and with the sulfonamide as the intramolecular nucleophile an excellent yield of the cyclized product was obtained. The mechanism for this transformation is thought to involve initial attack by the hydroxy group onto the silicon atom and displacement of the triflate group to give species **41**. Formation of the episulfonium ion **42** from this intermediate will leave the nitrogen atom unprotonated and available for nucleophilic attack. In addition, the less basic counter-anion, $CF_3SO_2O^-$, will be less prone to remove the proton α- to the carbon–sulfur bond which would give the undesired allylic sulfide.



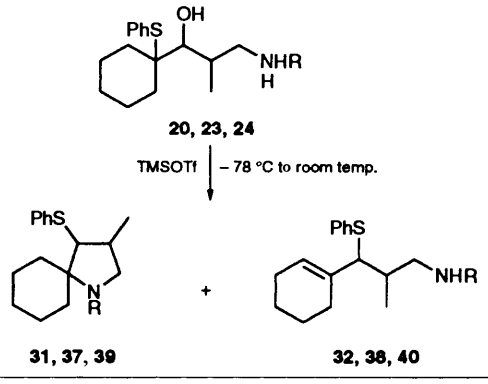
Scheme 12

We now have a stereospecific route to either the allylic sulfide, formed by rearrangement of the amine with excess of TsOH, or the pyrrolidine, formed by rearrangement of the corresponding sulfonamide with TMSOTf. Both of these reactions generally proceed in >90% yield to give a single stereoisomer of the product.

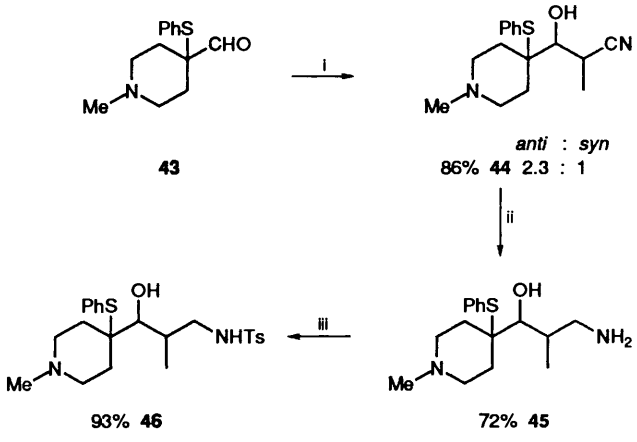
These reactions can be applied to other β-hydroxy sulfides. For example, the sulfonamides *syn*- and *anti*-**46** were prepared from the 2-phenylthio aldehyde **43**.[4] Addition of this aldehyde **43** to the anion of propiononitrile gave a mixture of the nitriles *syn*- and *anti*-**44**. The major isomer was assigned as having the *anti* configuration as predicted from the Felkin–Anh model. These stereoisomers were reduced to the amines *syn*- and *anti*-**45** and tosylated to give the sulfonamides *syn*- and *anti*-**46**. Separation was easiest at this stage and each isomer **46** was treated with TMSOTf to give the spirocyclic diamines *syn*- and *anti*-**47** respectively. In each case none of the allylic sulfide was detected (<5% allylic sulfide) and the pyrrolidines **47** were isolated in excellent yield.

As expected, the rearrangement of the free amine *anti*-**45**

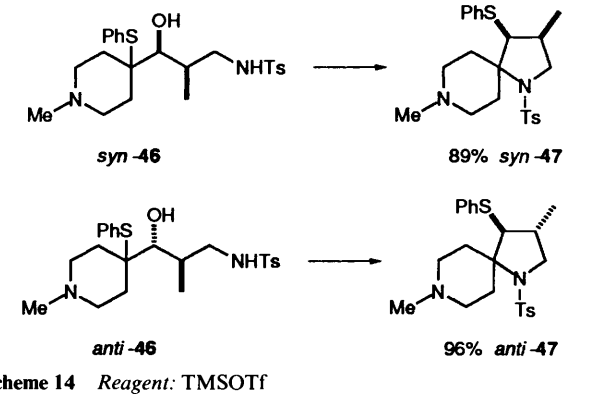
Table 5 Rearrangement of amides **20**, **23** and **24** with TMSOTf



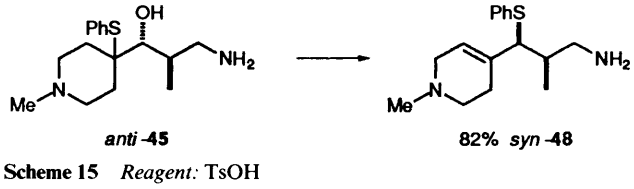
Starting material	R	Solvent	Yield (%)	Ratio	Product
syn-**20**	CONHPh	THF	84	3.7:1	*syn*-**31**:*anti*-**32**
anti-**20**	CONHPh	THF	78	3.6:1	*anti*-**31**:*syn*-**32**
syn-**23**	CO_2Et	CH_2Cl_2	94	3.7:1	*syn*-**37**:*anti*-**38**
anti-**23**	CO_2Et	CH_2Cl_2	98	1.8:1	*anti*-**37**:*syn*-**38**
syn-**24**	SO_2Tol	CH_2Cl_2	99	49:1	*syn*-**39**:*anti*-**40**
anti-**24**	SO_2Tol	CH_2Cl_2	99	10:1	*anti*-**39**:*syn*-**40**



Scheme 13 *Reagents:* i, EtCN, LDA; ii, $LiAlH_4$; iii, TsCl



Scheme 14 *Reagent:* TMSOTf



Scheme 15 *Reagent:* TsOH

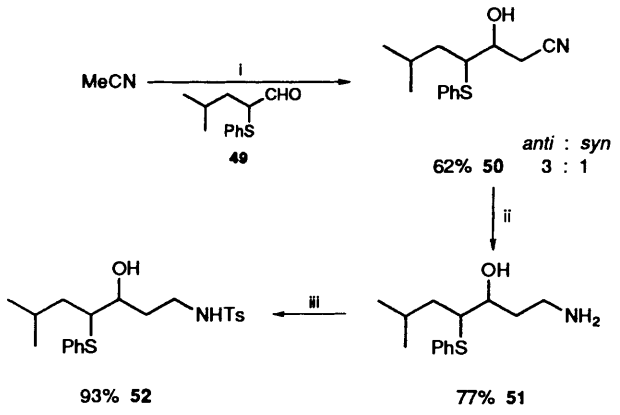
(prepared by separating the nitriles **44** and reduction) gave no cyclized product but allowed the preparation of the allylic sulfide *syn*-**48**.

So far we have successfully addressed the issue of five-membered cyclic amine formation with attack by the nitrogen atom on the more substituted end of the episulfonium ion. The phenylthio group migrates from the tertiary to the secondary centre. This we call a downhill migration of sulfur and in the above cases the cyclization would be referred to as a 5-*endo-tet* reaction. This is formally a disallowed process although these rules [14] cannot strictly be applied in this case as we are dealing with the second-row element sulfur and the transition state is presumably very loose with some cationic character at the tertiary carbon.

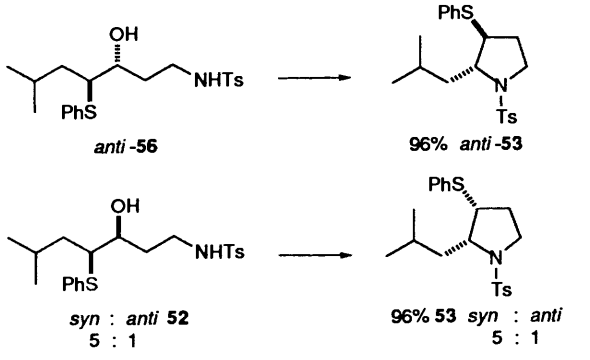
These model studies have been carried out with a cyclohexyl group at the migration origin. This group is one which is quite likely to favour allylic sulfide formation as an endocyclic double bond in a six-membered ring will be formed. A different substitution pattern at the migration origin may well therefore further enhance the yield of the cyclized product and should allow the use of a carbamate as the nitrogen nucleophile. Of more importance in probing the generality of the cyclization we envisaged three areas which needed investigation: the cyclization with secondary to secondary phenylthio migration, the 5-*exo-tet* mode of cyclization, and the possibility of the formation of other ring sizes. These are described below.

Secondary to Secondary Phenylthio Migration.—When both the phenylthio and the hydroxy groups are at secondary centres, allylic sulfide formation is known to be disfavoured.[1] However, the formation of cyclic ethers is possible by secondary to secondary phenylthio migration [3] and takes place with inversion of stereochemistry at both the migration terminus and the migration origin. In order to probe the possibility of cyclic amine synthesis with secondary to secondary phenylthio migration we prepared the sulfonamides **52** starting from the 2-phenylthio aldehyde **49**.[7] Using the Felkin–Anh model with the phenylthio group as the largest group we would expect the *anti* stereochemistry to predominate in the addition of the aldehyde **49** to the anion of acetonitrile. The 3:1 mixture of nitriles **50** was not separated but was reduced to the corresponding amines **51** and tosylated to give the sulfonamides **52**. Separation by HPLC gave the pure major isomer of the sulfonamide **52** and the minor isomer as a 5:1 mixture. Treatment of the major isomer *anti*-**52** with TMSOTf gave essentially a quantitative yield of the pyrrolidine *anti*-**53**. This was obtained as a single stereoisomer although an X-ray crystal structure or NOE studies could not be obtained. Rearrangement of the minor isomer (5:1 minor:

major) likewise occurred stereospecifically to give the pyrrolidine *syn*-**53** (5:1 *syn*:*anti*). This time NOE studies could be performed and verified that the minor isomer of the sulfonamide had cyclized to the pyrrolidine *syn*-**53**. If we assume that inversion of stereochemistry takes place at both the migration terminus and the migration origin, then the minor isomer of the sulfonamide **52** does indeed have *syn* stereochemistry as predicted.



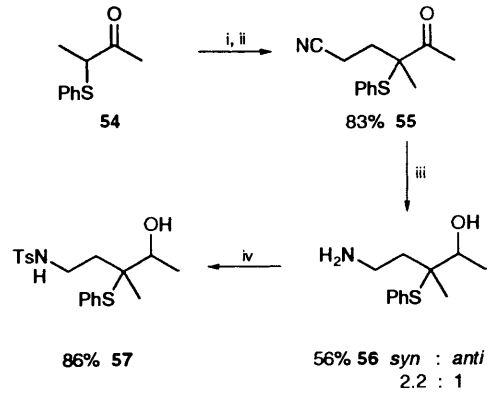
Scheme 16 *Reagents:* i, LDA; then **49**; ii, $LiAlH_4$; iii, TsCl



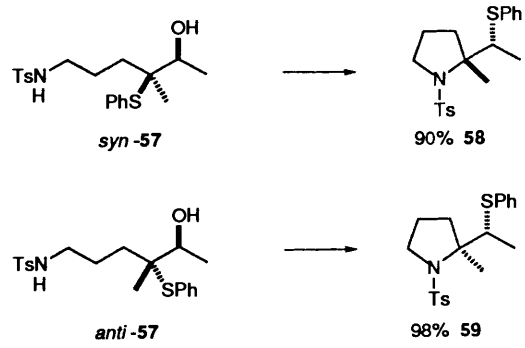
Scheme 17 *Reagent:* TMSOTf

The 5-exo *Mode of Cyclization.*—When the phenylthio group migrates to a position outside (*exo*) the newly forming ring the cyclization should be easier than the *endo* mode. This is because the nucleophile's filled orbital can become colinear with the breaking bond of the electrophile and so can overlap to maximum effect. To test whether 5-*exo* amido cyclization is possible, we prepared the sulfonamide **57** starting from the 2-phenylthio ketone **54**.[15] Addition of acrylonitrile to the anion of ketone **54** gave recovered starting material. By use of 3-bromopropiononitrile the alkylation was successful. Reduction of the nitrile group and the ketone group of compound **55** was performed simultaneously using $LiAlH_4$. This gave a 2.2:1 mixture of the amino alcohol **56**, which was tosylated and separated by HPLC. Each isomer of the sulfonamide **57** was treated with TMSOTf to effect the rearrangement to the pyrrolidines **58** and **59**. In each case cyclization took place in high yield to give a single and different isomer of the cyclic amine. This demonstrates the stereospecificity of the rearrangement. In this case it was not possible to identify which isomer was which, although it is likely that the major isomer of the sulfonamide **57** has *syn* stereochemistry based on a consideration of the Felkin–Anh model. The sulfonamide *syn*-**57** would give the pyrrolidine **58** if inversion took place at both the migration origin and the migration terminus.

Attempted Six-membered-ring Formation.—By analogy with the cyclization of a hydroxy group onto an episulfonium ion

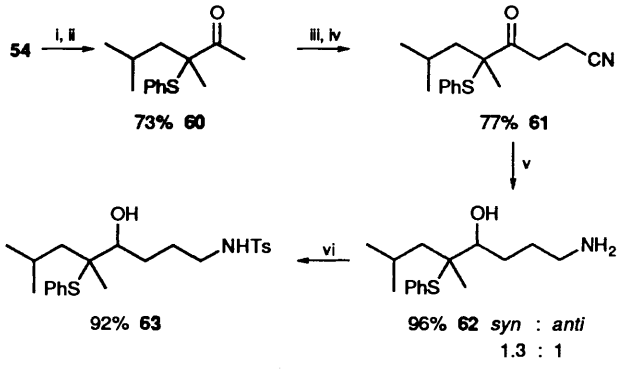


Scheme 18 *Reagents:* i, NaH; ii, $BrCH_2CH_2CN$, Bu_4NI; iii, $LiAlH_4$; iv, TsCl



Scheme 19 *Reagent:* TMSOTf

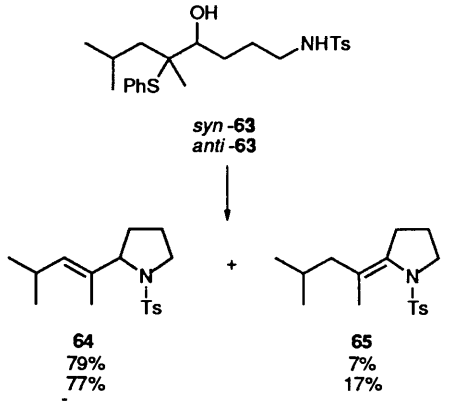
and formation of a tetrahydropyran[16] we expected that cyclization to the corresponding piperidines would be successful. This is likely to be the case for the *exo* mode of cyclization; however, we chose to investigate the rearrangement of the sulfonamide **63**. There are no reported preparations of piperidines by cyclization of a nitrogen atom onto an episulfonium ion. Attack onto an episelenonium ion generated from an alkene is known to allow the formation of substituted piperidines.[17]



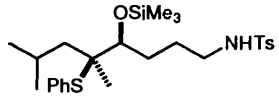
Scheme 20 *Reagents:* i, NaH; ii, Bu^iI; iii, LDA, HMPA; iv, $BrCH_2CN$; v, $LiAlH_4$, Et_2O; vi, TsCl

Addition of hexamethylphosphoric triamide (HMPA) was necessary to allow the alkylation of the ketone **60** to give nitrile **61**. Simultaneous reduction of both the ketone and the nitrile gave a 1.3:1 ratio of the amine **62**. Tosylation and separation gave the sulfonamides *syn*-**63** and *anti*-**63** of which the major isomer was assigned *syn* stereochemistry. On treatment with TMSOTf, each isomer cyclized to the five-membered ring by an *exo* cyclization. No six-membered ring was observed to occur by an *endo* cyclization. The electronic preference for *endo* attack at the more substituted end of the episulfonium ion has been

overcome by the preferential *exo* attack to give a five-membered ring. Steric factors may also play a role. To our surprise, using the same conditions as before, the phenylthio group was lost to give a mixture of the alkenes **64** and **65**. If the reaction was quenched at −78 °C it was possible to isolate the silyl ether **66**. This silyl ether is a likely intermediate in all the above TMSOTf-mediated reactions, which warming allows formation of the episulfonium ion and hence cyclization by the nitrogen atom.

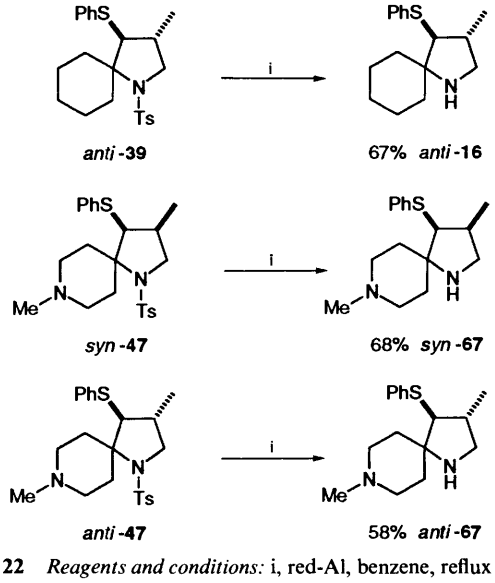


Scheme 21 *Reagent:* TMSOTf

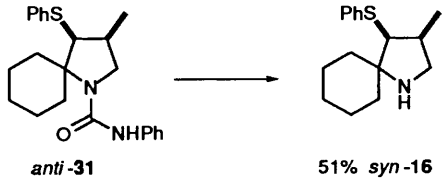


66

Removal of Sulfur from the Rearrangement Products.—The sulfonamide group in the spirocyclic pyrrolidines *anti*-**39**, *syn*-**47**, and *anti*-**47** was cleaved by heating under reflux with the reducing agent red-Al [Na^+ $(MeOCH_2CH_2O)_2$ − AlH_2].[18] No loss of stereochemical purity of the respective amines *anti*-**16**, *syn*-**67**, and *anti*-**67** was observed. The spirocyclic amine *anti*-**16** was isomeric with that formed by hydrolysis of the amine *syn*-**31** with KOH.

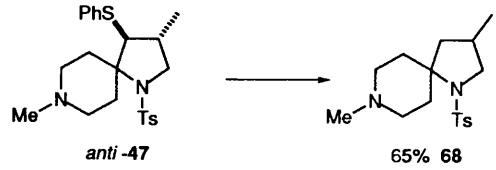


Scheme 22 *Reagents and conditions:* i, red-Al, benzene, reflux



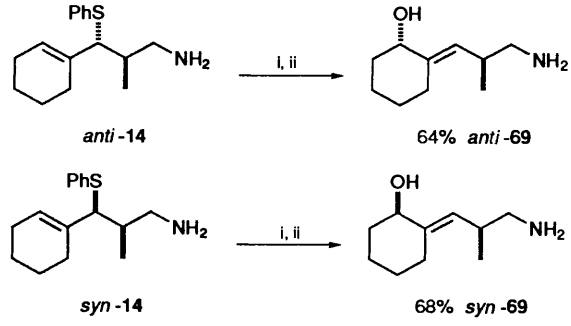
Scheme 23 *Reagents:* KOH, EtOH

In addition, the phenylthio group can be cleaved using Raney nickel. This allowed the preparation of the spirocyclic amine **68** from the amine *anti*-**47**.



Scheme 24 *Reagents and conditions:* Ra–Ni, EtOH, reflux

We have previously shown [2] that allylic sulfides formed by the 1,2-phenylthio shift can be oxidized and rearranged to give the corresponding allylic alcohols. In the same way, the allylic sulfides *anti*-**14** and *syn*-**14** were subjected to a [2,3]-sigmatropic shift. Oxidation of the sulfides to the sulfoxides was achieved using sodium perborate [19] as this avoided any N-oxidation. The sulfoxides were heated with a thiophile to give the allylic alcohols *anti*-**69** and *syn*-**69** respectively. This rearrangement is stereospecific and so can be used to control the stereochemistry of 1,4-chirally related centres.



Scheme 25 *Reagents:* i, $NaBO_3$; ii, $(MeO)_3P$

In conclusion, we have demonstrated that amines do not participate in the rearrangement of β-hydroxy sulfides, so allowing the stereospecific formation of allylic sulfides (and hence allylic alcohols by [2,3]-sigmatropic shift). However, amides, in particular sulfonamides, may be successfully used for intramolecular nucleophilic opening of an episulfonium ion. This gives rise to cyclic and spirocyclic amines with complete stereochemical control.

Experimental

General Methods.—(2RS,3RS)-3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propanamide* syn-**8**. Aq. ammonia (0.13 cm^3, 2.6 mmol) was added to a solution of the thioester *syn*-**7**[2b] (102 mg, 0.26 mmol) in MeOH (1 cm^3) under argon at room temperature. After 4 h at 40 °C the mixture was poured into HCl (20 cm^3; 0.1 mol dm^{-3}) and was extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (11 g) with CH_2Cl_2–MeOH (20:1) as eluent to give the *amide* syn-**8** (55 mg, 71%) as needles, m.p. 146–147 °C; R_f [CH_2Cl_2–MeOH (20:1)] 0.26; $\nu_{max}(CHCl_3)/cm^{-1}$ 3500 and 3400 (NH_2), 3180 (OH) and 1670 (C=O); $\delta_H(CDCl_3)$ 7.53–7.48 (2 H, m, Ph), 7.40–7.27 (3 H, m, Ph), 5.95 (1 H, s, NH), 5.28 (1 H, s, NH), 3.68 (1 H, d, *J* 3.1, C*H*OH), 3.30 (1 H, s, OH), 2.87 (1 H, qd, *J* 7.1 and 3.1, C*H*Me), 1.95–1.37 (10 H, m, C_6H_{10}) and 1.30 (3 H, d, *J* 7.1, CH*Me*); $\delta_C(CDCl_3)$ 179.52, 136.98, 130.23, 129.09, 128.92, 74.12, 61.49, 41.54, 31.13, 30.99, 25.85, 21.84 and 14.16 (Found: M^+ − $C_4H_7NO_2$, 192.0972. $C_{12}H_{16}S$ requires M − $C_4H_7NO_2$, 192.0972); *m/z* 192 (36%. M^+ − $C_4H_7NO_2$), 191 (43, M − $C_4H_8NO_2$), 83 (75, C_6H_{11}) and 81 (100, C_6H_9)

(Found: C, 65.4; H, 7.9; N, 4.9; S, 11.3. $C_{16}H_{23}NO_2S$ requires C, 65.49; H, 7.90; N, 4.77; s, 10.93%).

(1RS,2RS)-3-*Amino*-2-*methyl*-1-[1-(*phenylthio*)*cyclohexyl*]-*propan*-1-*ol* syn-**9**.—A solution of the amide *syn*-**8** (29 mg, 0.1 mmol) in tetrahydrofuran (THF) was added to borane–THF complex (0.3 cm^3, 0.3 mmol) under argon at 0 °C. The mixture was heated under reflux for 1 h and was quenched with water (5 cm^3). The mixture was basified (NaOH) and extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (4 g) with CH_2Cl_2–EtOH–aq. NH_3 (87:12:1) as eluent to give the *amine* syn-**9** (24 mg, 87%) as needles, m.p. 78–79 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.19; ν_{max}($CHCl_3$)/cm^{-1} 3420 and 3380 (NH_2) and 1580 (Ph); δ_H($CDCl_3$) 7.52–7.49 (2 H, m, Ph), 7.34–7.25 (3 H, m, Ph), 3.46 (1 H, d, *J* 1.8, C*H*OH), 2.78 (1 H, dd, *J* 12.4 and 4.4, CH_AH_BN), 2.67 (1 H, dd, *J* 12.4 and 5.0, CH_AH_BN), 2.26 (3 H, s, OH and NH_2), 2.18–2.08 (1 H, m, C*H*Me), 1.93–1.13 (10 H, m, C_6H_{10}) and 1.05 (3 H, d, *J* 6.9, CH*Me*); δ_C($CDCl_3$) 137.08, 130.96, 128.74, 128.68, 76.56, 61.33, 49.13, 34.49, 31.07, 30.75, 25.98, 22.05, 21.93 and 12.46 (Found: M^+ − OH, 262.1647. $C_{16}H_{24}NS$ requires M − OH, 262.1629); *m*/*z* 262 (0.5%, M^+ − OH), 191 (32, M − $C_4H_{10}NO$), 110 (54, PhSH) and 88 (100, $C_4H_{10}NO$) (Found: C, 68.55; H, 9.2; N, 5.0; S, 11.5. $C_{16}H_{25}NOS$ requires C, 68.77; H, 9.02; N, 5.01; S, 11.47%).

(1RS,2RS)-3-*Amino*-2-*methyl*-1-[1-*phenylthio*)*cyclohexyl*]-*propan*-1-*ol* anti-**9**.—Lithium aluminium hydride (1.73 g, 45.5 mmol) was added to the nitrile *anti*-**13** (5.0 g, 18.2 mmol) in diethyl ether (80 cm^3) under argon at 0 °C. After 5 h the mixture was poured into NaOH (300 cm^3, 0.1 mol dm^{-3}) and aq. sodium potassium tartrate (300 cm^3; 0.1 mol dm^{-3}) was added. The ether layer was removed and the aqueous layer was extracted with CH_2Cl_2 (3 × 100 cm^3). The combined organic phases were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (200 g) with CH_2Cl_2–EtOH–aq. NH_3 (100:8:1) as eluent to give the *amine* anti-**9** (3.27 g, 65%) as needles, m.p. 106–108 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.30; ν_{max}($CHCl_3$)/cm^{-1} 1565 (NH); δ_H($CDCl_3$) 7.56–7.52 (2 H, m, Ph), 7.32–7.26 (3 H, m, Ph), 3.43 (1 H, d, *J* 3.6, C*H*OH), 3.12 (1 H, dd, *J* 12.4 and 3.8, CH_AH_BN), 2.92 (1 H, dd, *J* 12.4 and 5.7, CH_AH_BN), 2.68 (3 H, s, OH and NH_2), 2.27–2.17 (1 H, m, C*H*Me), 1.89–1.21 (10 H, m, C_6H_{10}) and 1.07 (3 H, d, *J* 7.0, CH*Me*); δ_C($CDCl_3$) 137.06, 131.43, 128.48, 128.39, 80.60, 61.20, 45.63, 32.96, 31.16, 31.04, 25.85, 22.01, 21.93 and 19.39 (Found: M^+ + H, 280.1759. $C_{16}H_{26}NOS$ requires M + H, 280.1735); *m*/*z* 280 (0.2%, M^+ + H), 192 (54, M − $C_4H_{10}NO$), 110 (56, PhSH) and 88 (100, $C_4H_{10}NO$).

(2RS,3SR)-N-*Benzyl*-3-*hydroxy*-2-*methyl*-3-[1-(*phenylthio*)-*cyclohexyl*]*propanamide* anti-**10**.—Trimethylaluminium (0.45 cm^3, 0.90 mmol) was added to a solution of benzylamine (0.1 cm^3, 0.9 mmol) in CH_2Cl_2 (2 cm^3) under argon at room temperature. After 25 min a solution of the ester *anti*-**12** (212 mg, 0.69 mmol) in CH_2Cl_2 (2 cm^3) was added and the mixture was stirred at 40 °C for 10 h. HCl (40 cm^3; 3 mol dm^{-3}) was added and the mixture was extracted with CH_2Cl_2 (3 × 50 cm^3). The combined extracts were dried (Na_2SO_4) and evaporated and the residue was recrystallized from CH_2Cl_2–hexane to give the *amide* anti-**10** (201 mg, 76%) as needles, m.p. 142–144 °C; R_f [light petroleum (60–80 °C)–ethyl acetate (2:1)] 0.36; ν_{max}($CHCl_3$)/cm^{-1} 3430 (NH), 3350 (OH), and 1640 (C=O); δ_H($CDCl_3$) 7.43–7.40 (2 H, m, Ph), 7.36–7.25 (8 H, m, Ph), 6.40 (1 H, s, NH), 5.27 (1 H, d, *J* 8.6, OH), 4.38 (2 H, d, *J* 5.7, CH_2N), 3.20 (2 H, m, C*H*Me and C*H*OH), 1.94–1.11 (10 H, m, C_6H_{10}) and 1.38 (3 H, d, *J* 6.9, CH*Me*); δ_C($CDCl_3$) 177.25, 137.88, 136.84, 131.07, 128.83, 128.79, 128.71, 128.00, 127.58, 79.83, 70.73, 43.46, 38.79, 30.66, 29.21, 25.76, 21.91, 21.81 and 19.33 (Found: M^+ − C_6H_6S, 273.1713. $C_{17}H_{23}NO_2$ requires M − C_6H_6S, 273.1729); *m*/*z* 273 (1%, M^+ − PhSH), 192 (57, M − $C_6H_{10}SPh$), 135 (27, $PhCH_2NHCOH$) and 91 (100, $PhCH_2$) (Found: C, 72.2; H, 7.7; N, 3.6; S, 8.4. $C_{23}H_{29}NO_2S$ requires C, 72.02; H, 7.62; N, 3.65; S, 8.36%).

(2RS,3RS)-N-*Benzyl*-3-*hydroxy*-2-*methyl*-3-[1-(*phenylthio*)-*cyclohexyl*]*propanamide* *syn*-**10**.—In the same way as the amide *anti*-**10**, trimethylaluminium (0.71 cm^3, 1.42 mmol), benzylamine (0.15 cm^3, 1.4 mmol) and the ester *syn*-**12** (363 mg, 1.18 mmol) gave the *amide* syn-**10** (322 mg, 71%) as cubes, m.p. 131–133 °C; R_f [light petroleum (60–80 °C)–ethyl acetate (2:1)] 0.28; ν_{max}($CHCl_3$)/cm^{-1} 3360 (NH) and 1655 (C=O); δ_H($CDCl_3$) 7.47–7.43 (2 H, m, Ph), 7.39–7.21 (8 H, m, Ph), 6.26 (1 H, t, *J* 5.5, NH), 4.38 (2 H, d, *J* 5.5, CH_2N), 3.68 (1 H, d, *J* 3.1, C*H*OH), 3.25 (1 H, s, OH), 2.88 (1 H, dq, *J* 7.1 and 3.1, C*H*Me), 1.92–1.17 (10 H, m, C_6H_{10}) and 1.30 (3 H, d, *J* 7.1, CH*Me*); δ_C($CDCl_3$) 176.60, 138.43, 136.88, 130.70, 128.90, 128.81, 128.64, 127.63, 127.37, 74.75, 61.38, 43.36, 42.11, 31.41, 31.25, 25.84, 21.96, 21.91 and 14.19 (Found: M^+ − C_6H_5S, 274.1802. $C_{17}H_{24}NO_2$ requires M − C_6H_5S, 274.1807); *m*/*z* 274 (3%, M^+ − PhS), 192 (29, M − $C_6H_{10}SPh$), 135 (32, $PhCH_2NHCOH$) and 91 (100, $PhCH_2$) (Found: C, 72.0; H, 7.5; N, 3.6%).

(2RS,3SR)-3-*Benzylamino*-2-*methyl*-1-[1-(*phenylthio*)*cyclohexyl*]*propan*-1-*ol* syn-**11**.—In the same way as the amine *syn*-**9** the amide *syn*-**10** (394 mg, 1.03 mmol) and borane–THF complex (2.1 cm^3, 2.1 mmol) gave the amine *syn*-**11** (248 mg, 65%) as an oil, R_f [light petroleum (60–80 °C)–ethyl acetate–triethylamine (66:33:1)] 0.35; ν_{max}($CHCl_3$)/cm^{-1} 3250 (NH_2), 1600 and 1580 (Ph); δ_H($CDCl_3$) 7.53–7.48 (2 H, m, Ph), 7.37–7.20 (8 H, m, Ph), 3.72 (2 H, s, CH_2Ph), 3.56 (1 H, d, *J* 1.3, C*H*OH), 2.78 (1 H, dd, *J* 11.7 and 5.1, CH_AH_BN), 2.60 (1 H, dd, *J* 11.7 and 4.6, CH_AH_BN), 2.34 (1 H, m, C*H*Me), 1.93–1.18 (10 H, m, C_6H_{10}) and 1.08 (3 H, d, *J* 7.0, CH*Me*); δ_C($CDCl_3$) 140.07, 137.07, 131.43, 128.57, 128.36, 128.04, 126.97, 77.16, 60.94, 56.84, 54.24, 33.19, 31.41, 30.92, 26.00, 22.12, 22.01 and 13.05 (Found: M^+ − PhS, 260.2016. $C_{17}H_{26}NO$ requires M − C_6H_5S, 260.2014); *m*/*z* 260 (8%, M^+ − PhS), 178 (25, M − $C_6H_{10}SPh$), 120 (88, $PhCH_2NHCH_2$), 110 (39, PhSH) and 91 (100, $PhCH_2$).

(2RS,3RS)- *and* (2RS,3SR)-3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propiononitrile* anti- *and* syn-**13**.—A solution of propiononitrile (2.3 cm^3, 31.8 mmol) in dry THF (40 cm^3) was added dropwise to a solution of lithium diisopropylamide (LDA) (34.6 mmol) in THF (80 cm^3) under argon at −78 °C. After 40 min a solution of the aldehyde **6** (6.35 g, 29 mmol) in THF (25 cm^3) and the mixture was stirred for 25 min. The solution was poured into saturated aq. ammonium chloride (200 cm^3) and was extracted with diethyl ether (3 × 150 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (500 g) with hexane–diethyl ether (3:1) as eluent to give the (2RS,3SR)-*nitrile* syn-**13** (1.71 g, 22%) as plates, m.p. 96–97 °C; R_f [hexane–diethyl ether (3:1)] 0.34; ν_{max}($CHCl_3$)/cm^{-1} 2225 (CN) and 1580 (Ph); δ_H($CDCl_3$) 7.54–7.49 (2 H, m, Ph), 7.44–7.31 (3 H, m, Ph), 3.52 (1 H, d, *J* 6.5, C*H*OH), 3.21 (1 H, s, OH), 2.96 (1 H, qn, *J* 7.1, C*H*Me), 2.02–1.24 (10 H, m, C_6H_{10}) and 1.43 (3 H, d, *J* 7.1, CH*Me*); δ_C($CDCl_3$) 136.96, 129.46, 129.11, 122.68, 74.98, 61.57, 31.65, 30.47, 26.28, 25.75, 21.79, 21.76 and 15.60 (Found: M^+, 275.1346. $C_{16}H_{21}NOS$ requires M, 275.1344); *m*/*z* 275 (6%, M^+), 191 (32, $C_6H_{10}SPh$) and 110 (100, PhSH) (Found: C, 69.6; H, 7.65; N, 5.0; S, 11.7. $C_{16}H_{21}NOS$ requires C, 69.78; H, 7.69; N, 5.09; S, 11.64%), and the (2RS,3RS)-*nitrile* anti-**13** (5.61 g, 71%) as prisms, m.p. 117–118 °C; R_f [hexane–diethyl ether (3:1)] 0.14; ν_{max}($CHCl_3$)/cm^{-1} 2230 (CN) and 1580 (Ph);

$\delta_H(CDCl_3)$ 7.49–7.45 (2 H, m, Ph), 7.41–7.29 (3 H, m, Ph), 3.27 (1 H, q, *J* 7.2, C*H*Me), 3.11 [1 H, d, *J* 3.3, C*H*OH (D_2O shake reveals d, *J* 0.9)], 2.98 (1 H, d, *J* 4.1, OH), 2.01–1.19 (10 H, m, C_6H_{10}) and 1.44 (3 H, d, *J* 7.2, CH*Me*); $\delta_C(CDCl_3)$ 136.98, 129.46, 129.32, 128.99, 121.05, 76.62, 60.07, 29.85, 29.77, 26.90, 25.83, 21.54 and 18.40 (Found: M^+, 275.1354. $C_{16}H_{21}NOS$ requires M, 275.1344); *m/z* 275 (14%, M^+), 191 (42, $C_6H_{10}SPh$) and 110 (100, PhSH).

(2RS,3RS)-3-(*Cyclohex*-1-*enyl*)-2-*methyl*-3-(*phenylthio*)*propylamine* anti-**14**.—A solution of the amine *syn*-**9** (279 mg, 1.0 mmol) and TsOH (363 mg, 1.9 mmol) in benzene (5 cm^3) was heated under reflux in a foil-wrapped flask under argon for 10 min. Water (50 cm^3) was added, the mixture was basified with NaOH and was extracted with CH_2Cl_2 (3 × 80 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (20 g) with (100:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the allylic sulfide *anti*-**14** (245 mg, 94%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.36; $\nu_{max}(CHCl_3)/cm^{-1}$ 3370 (NH), 1650 (C=C), 1600 and 1580 (Ph); $\delta_H(CDCl_3)$ 7.36–7.29 (2 H, m, Ph), 7.27–7.16 (3 H, m, Ph), 5.18–5.16 (1 H, m, HC=C), 3.37 (1 H, d, *J* 10.4, C*H*SPh), 3.08 (1 H, dd, *J* 13.0 and 3.5, CH_AH_BN), 2.84, dd, *J* 13.0 and 6.5, CH_AH_BN), 2.29–2.06 (3 H, m, HCC=C and NH_2), 1.93–1.40 (8 H, m, C*H*Me and C_4H_7) and 0.94 (3 H, d, *J* 6.8, CH*Me*); $\delta_C(CDCl_3)$ 135.66, 134.80, 133.36, 128.31, 126.88, 126.24, 61.88, 45.86, 37.30, 25.14, 23.82, 22.44 and 16.35 (Found: $M^+ - C_3H_8N$, 203.0885. $C_{13}H_{15}S$ requires $M - C_3H_8N$, 203.0895); *m/z* 203 (2%, $M - C_3H_8N$), 152 (100, M – PhS) and 109 (41, PhS).

(2RS,3SR)-3-(*Cyclohex*-1-*enyl*)-2-*methyl*-3-(*phenylthio*)*propylamine* syn-**14**.—In the same way as the allylic sulfide *anti*-**14**, the amine *anti*-**9** (300 mg, 1.07 mmol) and TsOH (385 mg, 2.02 mmol) gave, after purification by column chromatography on silica gel (25 g) with (100:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent, the allylic sulfide *syn*-**14** (280 mg, 99%) as an oil R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.48; ν_{max}(film)/cm^{-1} 3360 (NH) and 1580 (Ph); $\delta_H(CDCl_3)$ 7.34–7.15 (5 H, m, Ph), 5.29–5.24 (1 H, m, HC=C), 3.41 (1 H, d, *J* 9.8, C*H*SPh), 2.75 (1 H, dd, *J* 13.0 and 4.1, CH_AH_BN), 2.51 (1 H, dd, *J* 13.0 and 6.8, CH_AH_BN), 2.30–2.23 (1 H, m, HCC=C), 1.93–1.39 (8 H, m, C*H*Me and C_4H_7) and 1.17 (3 H, d, *J* 6.7, CH*Me*); $\delta_C(CDCl_3)$ 135.90, 135.20, 133.03, 128.34, 126.72, 125.974, 62.49, 46.36, 37.62, 25.17, 24.26, 22.66 and 16.04 (Found: $M^+ - C_3H_8N$, 203.0908. $C_{13}H_{15}S$ requires $M - C_3H_8N$, 203.0895); *m/z* 203 (2%, $M - C_3H_8N$), 152 (100, M – PhS) and 110 (27, PhSH).

(2RS,3RS)-N-*Benzyl*-3-(*cyclohex*-1-*enyl*)-2-*methyl*-3-(*phenylthio*)*propylamine* anti-**15**.—In the same way as the amine *anti*-**14**, the amine *syn*-**11** (0.116 g, 0.31 mmol) and TsOH (0.12 g, 0.63 mmol) in benzene (2 cm^3) gave the allylic sulfide *anti*-**15** (97 mg, 88%) as an oil, R_f [light petroleum (60–80 °C)–ethyl acetate–triethylamine (66:33:1)] 0.56; $\nu_{max}(CHCl_3)/cm^{-1}$ 1600 and 1580 (Ph); $\delta_H(CDCl)_3$ 7.36–7.16 (10 H, m, Ph), 5.20 (1 H, br s, CH=C), 3.81 (2 H, ABq, *J* 13.3, CH_2Ph), 3.44 (1 H, d, *J* 10.0, C*H*SPh), 2.99 (1 H, dd, *J* 11.9 and 4.0, $CHCH_AH_BN$), 2.68 (1 H, dd, *J* 11.9 and 6.9, $CHCH_AH_BN$), 2.24 (1 H, br, NH), 1.94 (1 H, m, C*H*Me), 1.90–1.41 (8 H, m, C_4H_8) and 0.96 (3 H, d, *J* 6.8, CH*Me*); $\delta_C(CDCl_3)$ 140.68, 135.98, 135.04, 133.13, 128.32, 128.30, 128.08, 126.79, 126.75, 126.12, 62.37, 54.27, 53.59, 35.52, 25.18, 24.06, 22.69, 22.47 and 17.15 (Found: M^+ – PhS, 242.1931. $C_{17}H_{24}N$ requires $M - C_6H_5S$, 242.1908); *m/z* 242 (26%, M – PhS), 120 (100, $PhCH_2NHCH_2$), 110 (27, PhSH) and 91 (52, $PhCH_2$).

(3RS,4RS)-3-*Methyl*-4-(*phenylthio*)-*1-azaspiro*[4.5]*decane* syn-**16**.—*Method A* (*aminomercuriation*). A solution of the amine *anti*-**14** (28 mg, 0.107 mmol) in THF (0.1 cm^3) was added to a mixture of mercury(II) acetate (36 mg, 0.11 mmol) in THF–water (1:1) (1.0 cm^3) under argon at 30 °C. After 4 h, a solution of sodium borohydride (4 mg, 0.11 mmol) in NaOH (0.2 cm^3; 10% was added. Water (20 cm^3) was added and the aqueous layer was extracted with CH_2Cl_2 (3 × 25 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (7 g) with (120:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *amine* syn-**16** (17 g, 61%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (120:8:1)] 0.37; $\nu_{max}(CHCl_3)/cm^{-1}$ 3300 (NH) and 1580 (Ph); δ_H-($CDCl_3$) 7.38–7.13 (5 H, m, Ph), 3.40 (1 H, d, *J* 8.0, C*H*SPh), 3.31 (1 H, dd, *J* 11.0 and 7.4, CH_AH_BN), 2.78 (1 H, dd, *J* 11.0 and 7.0, CH_AH_BN), 2.72–2.61 (1 H, m, C*H*Me), 1.81–1.51 (11 H, m, NH and C_6H_{10}) and 1.11 (3 H, d, *J* 6.9, CH*Me*); $\delta_C(CDCl_3)$ 137.64, 129.32, 128.83, 125.70, 65.33, 61.82, 51.52, 37.64, 36.56, 32.39, 25.43, 23.37, 22.40 and 16.86 (Found: M^+, 261.1530. $C_{16}H_{23}NS$ requires M, 261.1551); *m/z* 261 (24%, M), 152 (30, M – PhS), 111 (100) and 110 (50, PhSH).

Method B (*hydrolysis of urea*). A 5% solution of KOH (100 mg) in water (2 cm^3) was added to the urea *syn*-**31** (20 mg, 0.05 mmol). Ethanol (2 cm^3) was added and the mixture was refluxed for 24 h. HCl (0.1 cm^3; 3 mol dm^{-3}) was added, and the mixture was adjusted to pH 9–10 (Universal indicator paper) with Na_2CO_3 (10 cm^3) and extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (5 g) with (150:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the amine *syn*-**16** (7 mg, 51%) as an oil, characterization as in Method A.

(3RS,4SR)-3-*Methyl*-4-(*phenylthio*)-1-*azaspiro*[4.5]*decane* anti-**16**.—Red-Al (42 cm^3, 0.3 mmol) was added to a mixture of sulfonamide *anti*-**39** (31 mg, 0.075 mmol) in benzene (1 cm^3) under argon at room temperature and the mixture was heated under reflux under argon. After 5 h, dil. NaOH (10 cm^3; 0.2 mol dm^{-3}) and aq. sodium potassium tartrate (5 cm^3; 0.2 mol dm^{-3}) were added and the solution was extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (9 g) with (100:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *amine* anti-**16** (13 mg, 67%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.28; $\nu_{max}(CHCl_3)/cm^{-1}$ 1580 (Ph); $\delta_H(CDCl_3)$ 7.49–7.42 (2 H, m, Ph), 7.36–7.17 (3 H, m, Ph), 4.20 (1 H, dd, *J* 11.3 and 8.6, CH_AH_BN), 2.80 (1 H, d, *J* 10.7, C*H*SPh), 2.69 (1 H, dd, *J* 11.3 and 8.6, CH_AH_BN), 2.32–2.16 (1 H, m, C*H*Me), 1.78–1.53 (10 H, m, C_6H_{10}) and 1.13 (3 H, d, *J* 6.6, CH*Me*) (Found: M^+, 261.1553. $C_{16}H_{23}NS$ requires M, 261.1551); *m/z* 261 (34%, M), 111 (100) and 110 (30, PhSH).

(2RS,3SR)-N{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*acetamide* syn-**17**.—Acetyl chloride (0.06 cm^3, 0.86 mmol) was added to a solution of the amine *syn*-**9** (200 mg, 0.72 mmol) and pyridine (0.03 cm^3, 0.36 mmol) in CH_2Cl_2 (5 cm^3) under argon at 0 °C. After 5 h, water (40 cm^3) and CH_2Cl_2 (50 cm^3) were added, the mixture was basified with aq. NaOH (2 cm^3; 10%), the organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 40 cm^3). The combined organic phases were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (28 g) with (110:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the amide *syn*-**17** (168 mg, 73%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.38; $\nu_{max}(CHCl_3)/cm^{-1}$ 3610 (OH), 3440 and 3400 (NH), 1600 (C=O) and 1520; $\delta_H(CDCl_3)$ 7.51–7.47 (2 H, m, Ph), 7.37–7.28 (3 H, m, Ph), 5.88 (1 H, br s, NH), 3.42–3.34 (1 H, m, CH_AH_BN), 3.31 (1 H, br s, OH), 3.30 (1 H, d, *J* 1.4, C*H*OH), 2.96 (1 H, dt, *J* 9.6 and 4.8, CH_AH_BN), 2.14–2.12 (1 H, sym. m, C*H*Me), 1.88 (3 H, s. COMe), 1.87–1.69 (4 H, m, C_6H_4), 1.60–

1.49 (4 H, m, C_6H_4), 1.33–1.23 (2 H, m, C_6H_2) and 1.00 (3 H, d, *J* 6.8, CH*Me*); δ_C($CDCl_3$) 170.62, 136.99, 130.53, 128.95, 128.79, 74.53, 62.14, 46.22, 32.64, 31.02, 30.75, 26.05, 23.18, 22.04, 21.83 and 12.70 (Found: M^+ – PhS, 212.1660. $C_{12}H_{22}NO_2$ requires M – C_6H_5S, 212.1651); *m/z* 212 (14%, M – C_6H_5S), 191 (58, $C_6H_{10}SPh$), 130 (100, M – $C_6H_{10}SPh$), (62, PhSH) and 81 (76, C_6H_9).

(2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*acetamide* anti-**17**.—In the same way as the amide *syn*-**17**, the amine *anti*-**9** (140 mg, 0.5 mmol) and acetyl chloride (0.04 cm^3, 0.55 mmol) gave, after purification by column chromatography on silica gel (25 g) with (300:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent, the amide *anti*-**17** (136 mg, 84%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.51; ν_{max}(film)/cm^{-1} 3300 (OH and NH) and 1630 (C=O); δ_H($CDCl_3$) 7.50–7.46 (2 H, m, Ph), 7.39–7.29 (3 H, m, Ph), 6.35 (1 H, br t, *J* 2.9, NH), 3.66–3.21 (1 H, br s, OH), 3.37 (2 H, t, *J* 5.7, CH_2N), 3.12 (1 H, d, *J* 4.3, C*H*OH), 2.05–1.94 (2 H, m, C_6H_2), 1.96 (3 H, s, COMe), 1.83–1.18 (9 H, m, C*H*Me and C_6H_8) and 0.88 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+ – $C_5H_{10}NO$, 221.0993. $C_{13}H_{17}OS$ requires M – $C_5H_{10}NO$, 221.1000); *m/z* 221 (0.1%, M – $C_5H_{10}NO$), 212 (27, M – PhS), 192 (42, $C_6H_{11}SPh$) and 130 (100, M – $C_6H_{10}SPh$).

Rearrangement of (2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*acetamide* anti-**17**.—TMSOTf (19.5 cm^3, 0.1 mmol) was added to a solution of the amide *anti*-**17** (32 mg, 0.1 mmol) in dry CH_2Cl_2 (1.0 cm^3) under argon at −78 °C. The solution was allowed to warm slowly to room temperature and was stirred at room temperature for 15 h. Water (20 cm^3) was added and the mixture was extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (27 g) with (200:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *pyrrolidine* anti-**25** (10 mg, 33%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (200:8:1)] 0.32; ν_{max}($CHCl_3$)/cm^{-1} 1625 (C=O) and 1580 (Ph); δ_H($CDCl_3$) 7.50–7.18 (5 H, m, Ph), 3.83 (1 H, dd, *J* 10.2 and 6.9, CH_AH_BN), 3.42 (1 H, d, *J* 4.4, C*H*SPh), 3.12, (1 H, dd, *J* 10.2 and 4.3, CH$_A$*H*$_B$N), 2.91–2.70 (2 H, m, C_6H_2), 2.34–2.25 (1 H, sym. m, C*H*Me), 2.03 (3 H, s, COMe), 1.91–1.21 (8 H, m, C_6H_8) and 1.13 (3 H, d, *J* 7.1, CH*Me*) (Found: M^+, 303.1682. $C_{18}H_{25}NOS$ requires M, 303.1657); *m/z* 303 (15%, M), 194 (100, M – PhS) and 110 (59, PhSH), and the *allylic sulfide* syn-**26** (19 mg, 63%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (200:8:1)] 0.27; ν_{max}($CHCl_3$)/cm^{-1} 3280 (NH), 1635 (C=O) and 1545 (NH); δ_H($CDCl_3$) 7.35–7.17 (5 H, m, Ph), 5.56 (1 H, br s, NH), 5.28 (1 H, br s, HC=C), 3.38–3.29 (1 H, m, CH_AH_BN), 3.32 (1 H, d, *J* 9.0, C*H*SPh), 3.09–2.98 (1 H, m, CH$_A$*H*$_B$N), 2.29–2.20 (1 H, m, HCC=C), 2.06–1.40 (8 H, m, C*H*Me and C_4H_7), 1.95 (3 H, s, COMe) and 1.12 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+, 303.1679. $C_{18}H_{25}NOS$ requires M, 303.1657); *m/z* 303 (1%, M), 194 (100, M – PhS) and 135 (84, $C_{10}H_{15}$).

(2RS,3SR)-N-*Ethyl*-N′-{3-*hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*urea* syn-**18**.—Ethyl isocyanate (0.046 cm^3, 0.58 mmol) was added to a solution of the amine *syn*-**9** (148 mg, 0.53 mmol) in dry THF (2 cm^3) at room temperature. After 18 h, the solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (15 g) with (300:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the urea *syn*-**18** (181 mg, 97%) as a foam, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.38; ν_{max}($CHBr_3$)/cm^{-1} 3400 (OH and NH), 1660 (C=O) and 1530 (NH); δ_H($CDCl_3$) 7.54–7.48 (2 H, m, Ph), 7.40–7.30 (3 H, m, Ph), 4.73 (1 H, br t, *J* 6.0, NH), 4.37 (1 H, br t, *J* 6.0, NH), 3.42 (2 H, br s, OH and C*H*OH), 3.27 (1 H, dt, *J* 13.5 and 7.5, MeCHCH_AH_BN), 3.19–3.08 (2 H, m, NCH_2Me), 2.94 (1 H, dt, *J* 13.5 and 5.0, MeCH$_A$*H*$_B$N), 2.17–2.07 (1 H, m, C*H*Me), 2.00–1.19 (10 H, m, C_6H_{10}), 1.11 (3 H, t, *J* 7.0, NCH_2*Me*) and 1.01 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+ – PhS, 241.1903. $C_{13}H_{25}N_2O_2$ requires M – C_6H_5S, 241.1916); *m/z* 241 (8%, M – PhS), 191 (40, $C_6H_{10}SPh$), 159 (100, M – C_6H_{10}·SPh) and 81 (78, C_6H_9).

Rearrangement of (2RS,3SR)-N-*Ethyl*-N′-{3-*hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*urea* syn-**18**.—In the same way as the allylic sulfide *anti*-**26**, the urea *syn*-**18** (35 mg, 0.1 mmol) and TsOH (35 mg, 0.19 mmol) in CH_2Cl_2 (1 cm^3) gave the *pyrrolidine* syn-**27** (4 mg, 12%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.48; ν_{max}($CHBr_3$)/cm^{-1} 3455 (NH) and 1635 (C=O); δ_H($CDCl_3$) 7.44–7.39 (2 H, m, Ph), 7.30–7.23 (2 H, m, Ph), 7.20–7.13 (1 H, m, Ph), 4.00 (1 H, br s, NH), 3.87 (1 H, d, *J* 4.8, C*H*SPh), 3.34–3.07 (4 H, m, 2 × NCH_2), 2.92 (1 H, td, *J* 13.2 and 3.6, C_6H), 2.82–2.72 (1 H, m, C*H*Me), 2.54 (1 H, td, *J* 13.2 and 4.2, C_6H), 2.04–1.98 (1 H, m, C_6H), 1.80–1.24 (7 H, m, C_6H_7), 1.12 (3 H, t, *J* 7.2, NCH_2*Me*) and 1.01 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+, 332.1969. $C_{19}H_{28}N_2OS$ requires M, 332.1934); *m/z* 332 (13%, M), 223 (100, M – PhS), 152 (77, M – EtNCO) and 111 (64), and the *allylic sulfide* anti-**28** (28 mg, 84%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.40; ν_{max}($CHBr_3$)/cm^{-1} 3445 (NH), 3360 (NH), 1660 (C=O) and 1530 (NH); δ_H($CDCl_3$) 7.34–7.20 (5 H, m, Ph), 5.17 (1 H, br s, HC=C), 4.73 (2 H, br s, 2 × NH), 3.52–3.41 (1 H, m, CH_AH_BN), 3.32–3.08 (3 H, m, CH$_A$*H*$_B$N and NCH_2Me), 3.30 (1 H, d, *J* 10.4, C*H*SPh), 2.28–2.21 (1 H, m, HCC=C), 1.93–1.43 (8 H, m, C*H*Me and C_4H_7), 1.11 (3 H, t, *J* 7.2, NCH_2*Me*) and 0.91 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+, 332.1937); *m/z* 332 (0.3%, M), 223 (100, M – PhS) and 101 (44, $CH_2NHCONHEt$).

(2RS,3SR)-N,N-*Diethyl*-N′-{3-*hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*urea* syn-**19**.—*N*,*N*-Diethylcarbamoyl chloride (0.029 cm^3, 0.23 mmol) was added to a solution of the amine *syn*-**9** (58 mg, 0.21 mmol) in CH_2Cl_2 (1.5 cm^3) under nitrogen at room temperature. After 23 h, the solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (10 g) with (150:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the urea *syn*-**19** (47 mg, 60%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.37; ν_{max}($CHBr_3$)/cm^{-1} 3470 and 3430 (OH and NH) and 1630 (C=O); δ_H($CDCl_3$) 7.53–7.48 (2 H, m, Ph), 7.36–7.25 (3 H, m, Ph), 4.83 (1 H, br t, *J* 5.0, NH), 3.56 (1 H, d, *J* 3.0, C*H*OH), 3.40–3.21 (1 H, m, MeCHCH_AH_BN), 3.18 [4 H, q, *J* 7.0, $N(CH_2)_2$], 3.02 (1 H, dt, *J* 13.5 and 4.5, MeCHCH$_A$*H*$_B$N), 2.25–2.10 (1 H, m, C*H*Me), 2.03–1.49 (8 H, m, C_6H_7 and OH), 1.35–1.18 (3 H, m, C_6H_3), 1.08 [6 H, t, *J* 7.0, $N(CH_2Me)_2$] and 1.03 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+ – Et_2NH, 305.1445. $C_{17}H_{23}NO_2S$ requires M – $C_4H_{11}N$, 305.1449); *m/z* 305 (0.1%, M – Et_2NH), 269 (13, M – SPh), 187 (42, M – $C_6H_{10}SPh$) and 100 (100, Et_2NCO).

Rearrangement of (2RS,3SR)-N,N-*Diethyl* N′-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*urea* syn-**19**.—In the same way as the allylic sylfide *anti*-**26**, the urea *syn*-**19** (23 mg, 0.06 mmol) and TsOH (9.3 mg, 0.05 mmol) in $CHCl_3$ (0.7 cm^3) gave the *pyrrolidine* syn-**29** (5 mg, 23%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.39; ν_{max}($CHBr_3$)/cm^{-1} 1615 (C=O); δ_H($CDCl_3$) 7.47–7.40 (2 H, m, Ph), 7.33–7.24 (2 H, m, Ph), 7.22–7.14 (1 H, m, Ph), 3.87 (1 H, d, *J* 4.5, C*H*SPh), 3.37–3.18 (3 H, m, CH_AH_BN and NCH_2^AMe), 3.10–2.95 (3 H, m, CH$_A$*H*$_B$N and NCH_2^BMe), 2.86–2.72 (1 H, m, C*H*Me), 2.44 (1 H, td, *J* 13.1 and 3.9, C_6H), 2.00–1.90 (1 H, m, C_6H), 1.82–1.20 (8 H, m, C_6H_8), 1.12 [6 H, t, *J* 7.2, $N(CH_2Me)_2$] and 1.03 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+, 360.2211. $C_{21}H_{32}N_2OS$ requires M, 360.2235); *m/z* 360 (10%, M), 251 (52, M – PhS) and 100

(100, Et_2NCO), and the *allylic sulfide* anti-**30** (12 mg, 55%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (200:8:1)] 0.38; ν_{max}($CHBr_3$)/cm^{-1} 3475 (NH) and 1630 (C=O); δ_H($CDCl_3$) 7.38–7.32 (2 H, m, Ph), 7.30–7.21 (3 H, m, Ph), 5.17 (1 H, br s, HC=C), 4.76 (1 H, br t, *J* 6.0, NH), 3.55 (1 H, dt, *J* 14.0 and 5.5, CHMeC$H_A$$CH_B$N), 3.41 (1 H, dt, *J* 14.0 and 6.0, CHMeCH_A-CH_BN), 3.26 [5 H, m, C*H*SPh and N(CH_2Me)$_2$], 2.33–2.20 (1 H, m, HCC=C), 2.00–1.41 (8 H, m, C*H*Me and C_4H_7), 1.13 [6 H, t, *J* 7.2, N(CH_2*Me*)$_2$] and 0.93 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+, 360.2243); *m*/*z* 360 (0.2%, M), 251 (51, M – PhS) and 100 (100, Et_2NCO).

(2RS,3SR)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-*phenylurea* syn-**20**.—Phenyl isocyanate (0.03 cm^3, 0.28 mmol) was added to a solution of the amine *syn*-**9** (72 mg, 0.26 mmol) in dry THF (1 cm^3) under nitrogen at room temperature. After 24 h, the solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (11 g) with (200:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *urea* syn-**20** (92 mg, 89%) as needles, m.p. 186–187 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.38; ν_{max}($CHBr_3$)/cm^{-1} 3360 and 3330 (OH and NH), 1680 (C=O), 1600 (Ph), 1560 (C=O) and 1500 (Ph); δ_H[$(CD_3)_2SO$] 8.49 (1 H, s, Ph), 7.58–7.55 (2 H, m, Ph), 7.42–7.39 (2 H, m, Ph), 7.32–7.19 (4 H, m, Ph), 6.88 (1 H, t, *J* 7.3, NHC_6H_4-*p*-*H*), 6.24 (1 H, t, *J* 5.7, NH), 4.70 (1 H, d, *J* 6.2, OH), 3.26 (1 H, d, *J* 6.0, C*H*OH), 3.08 (1 H, dt, *J* 13.1 and 6.5, CH_AN_BN), 2.92 (1 H, dt, *J* 13.1 and 6.6, CH_AH_BN), 2.62–2.54 (1 H, m, C*H*Me), 1.86–1.08 (10 H, m, C_6H_{10}) and 0.90 (3 H, d, *J* 6.6, CH*Me*) (Found: M^+ – $PhNH_2$, 305.1464. $C_{17}H_{23}NO_2S$ requires M – C_6H_7N, 305.1450); *m*/*z* 305 (1%, M – $PhNH_2$), 289 (16, M – SPh), 207 (64, M – C_6H_{10}·SPh), 191 (46, C_6H_{10}SPh), 119 (50, PhNCO), 93 (100, $PhNH_2$) and 81 (72, C_6H_9) (Found: C, 68.7; H, 7.5; N, 6.8. $C_{23}H_{30}N_2O_2S$ requires C, 69.31; H, 7.59; N, 7.03%).

Rearrangement of (2RS,3SR)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-*phenylurea* syn-**20**.—In the same way as the allylic sulfide *anti*-**26**, the urea *syn*-**20** (30 mg, 0.075 mmol) and TsOH (11.5 mg, 0.06 mmol) in $CHCl_3$ (1 cm^3) gave the *pyrrolidine* syn-**31** (20 mg, 70%) as needles, m.p. 187–189 °C, R_f [hexane–diethyl ether (1:1)] 0.53; ν_{max}(Nujol)/cm^{-1} 3845 (NH), 1645 (C=O), 600 (Ph) and 1530 (NH); δ_H($CDCl_3$) 7.48–7.42 (2 H, m, Ph), 7.38–7.16 (7 H, m, Ph), 7.05–6.98 (1 H, m, Ph), 6.03 (1 H, br s, NH), 3.93 (1 H, d, *J* 5.0, C*H*SPh), 3.52 (1 H, t, *J* 8.0, CH_AH_BN), 3.32 (1 H, dd, *J* 11.0 and 8.0, CH_AH_B), 3.01–2.78 (2 H, m, C*H*Me and C$_6$H), 2.73–2.59 (1 H, td, *J* 13.0 and 4.0, C$_6$H), 2.12–2.02 (1 H, m, C$_6$H), 1.86–1.28 (7 H, m, C_6H_7) and 1.08 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+, 380.1913. $C_{23}H_{28}N_2OS$ requires M, 380.1922); *m*/*z* 380 (7%, M), 271 (27, M – PhS), 152 (44, M – PhS – PhHCO), 119 (55, PhNCO) and 111 (100), and the *allylic sulfide* anti-**32** (8 mg, 28%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.40; ν_{max}($CHBr_3$)/cm^{-1} 3420 (NH), 1670 (C=O), 1600 (Ph) and 1525 (NH); δ_H($CDCl_3$) 7.33–7.21 (9 H, m, Ph), 7.15–7.06 (1 H, m, Ph), 6.51 (1 H, br s, NH), 5.13 (1 H, br s, C=CH), 4.99 (1 H, t, *J* 6.5, NH), 3.61 (1 H, ddd, *J* 14.0, 6.5, and 4.5, CH_ACH_BN), 3.42 (1 H, dt, *J* 14.0 and 6.0, CH_AH_BN), 3.28 (1 H, d, *J* 10.5, C*H*SPh), 2.33–2.19 (1 H, m, HCC=C), 2.01–1.38 (8 H, m, C*H*Me and C_4H_7) and 0.96 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+, 380.1899); *m*/*z* 380 (1%, M), 271 (100, M – PhS) and 110 (25, PhSH).

(2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-*phenylurea* anti-**20**.—In the same way as for the urea *syn*-**20**, the amine *anti*-**9** (431 mg, 1.54 mmol) and phenyl isocyanate (0.18 cm^3, 1.67 mmol) gave the *urea* anti-**20** (599 mg, 97%) as needles, m.p. 180–181 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.43; ν_{max}($CHBr_3$)/cm^{-1} 3415 (NH) and 1665 (C=O); δ_H($CDCl_3$) 7.47–7.26 (10 H, m, Ph), 7.13–7.07 (1 H, m, NH), 6.43 (1 H, br s, NH), 3.44 (1 H, dd, *J* 13.6 and 4.0, CH_AH_BN), 3.35 (1 H, dd, *J* 13.6 and 6.2, CH_AH_BN), 3.11 (1 H, d, *J* 4.8, C*H*OH), 2.08–1.21 (12 H, m, C*H*Me, C_6H_{10}, and OH) and 0.90 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+ – PhSH, 288.1324. $C_{17}H_{24}N_2O_2$ requires M – C_6H_6S, 288.1337); *m*/*z* 288 (0.6%, M – PhSH), 207 (79, M – C_6H_{10}SPh), 119 (72, PhNCO), 110 (52, PhSH), 93 (100, $PhNH_2$) and 88 (87, $C_4H_{10}NO$) (Found: C, 69.3; H, 7.6; N, 7.1. $C_{23}H_{30}N_2O_2S$ requires C, 69.31; H, 7.59; N, 7.03%).

Rearrangement of (2RS,3RS)-N-3-{*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-*phenylurea* anti-**20**.—In the same way as the rearrangement of the amide *syn*-**24** (see below), the urea *anti*-**20** (60 mg, 0.15 mmol) and TMSOTf (31 mm^3, 0.15 mmol) gave the *pyrrolidine* anti-**31** (35 mg, 61%) as an oil, R_f [hexane–diethyl ether (2:1)] 0.35; ν_{max}($CHCl_3$)/cm^{-1} 3430 (NH), 1650 (C=O) and 1590 (Ph); δ_H($CDCl_3$) 7.42–7.19 (9 H, m, Ph and C_6H_4), 7.04–6.97 (1 H, m, NHC_6H_4-*p*-*H*), 6.11 (1 H, br s, NH), 3.87 (1 H, t, *J* 8.2, CH_AH_BN), 3.48 (1 H, d, *J* 4.5, C*H*SPh), 3.26 (1 H, dd, *J* 8.2 and 4.3, CH_AH_BN), 2.94–2.69 (2 H, m, C_6H_2), 2.46–2.36 (1 H, m, C*H*Me), 1.92–1.24 (8 H, m, C_6H_8) and 1.20 (3 H, d, *J* 7.1, CH*Me*) (Found: M^+, 380.1945. $C_{23}H_{28}N_2OS$ requires M, 380.1922); *m*/*z* 380 (1%, M), 119 (100, PhNCO) and 111 (57); and the allylic sulfide *syn*-**32** (10 mg, 17%) as an oil, R_f [hexane–diethyl ether (2:1)] 0.14; ν_{max}($CHCl_3$)/cm^{-1} 3320 (NH), 1650 (C=O) and 1590 (Ph); δ_H($CDCl_3$) 7.39–7.14 (9 H, m, Ph), 7.07–7.00 (1 H, m, NHC_6H_4-*p*-*H*), 6.95 (1 H, br s, NH), 5.26–5.22 (2 H, m, NH and HC=C), 3.43–3.31 (1 H, m, CH_ACH_BN), 3.32 (1 H, d, *J* 9.2, C*H*SPh), 3.01–2.91 (1 H, dt, *J* 13.4 and 6.7, CH_AH_NN), 2.28–2.19 (1 H, m, HCC=C), 2.05–1.36 (8 H, m, C*H*Me and C_4H_7) and 1.11 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+ – $PhNH_2$, 287.1347. $C_{17}H_{21}NOS$ requires M – C_6H_7N, 287.1344); *m*/*z* 287 (0.4%, M – $PhNH_2$), 271 (100, M – PhS) and 93 (65, $PhNH_2$).

(2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*-N′-(p-*methoxyphenyl*)*urea* anti-**21**.—In the same way as the urea *syn*-**20**, the amine *anti*-**9** (248 mg, 0.89 mmol) and *p*-methoxyphenyl isocyanate (0.126 cm^3, 0.98 mmol) gave the urea *anti*-**21** (350 mg, 92%) as a foam, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.37; ν_{max}($CHCl_3$)/cm^{-1} 3420 (NH) and 1650 (C=O); δ_H($CDCl_3$) 7.45–7.30 (5 H, m, Ph), 7.17 (2 H, dd, *J* 6.7 and 2.2, NHC_6H_2OMe), 6.86 (2 H, dd, *J* 6.7 and 2.2, NHC_6H_2OMe), 6.30 (1 H, br s, NH), 3.80 (3 H, s, OMe), 3.39 (1 H, dd, *J* 13.0 and 4.0, CH_AH_BN), 3.30 (1 H, dd, *J* 13.0 and 6.6, CH_AH_BN), 3.08 (1 H, d, *J* 4.8, C*H*OH), 2.05–1.16 (11 H, m, C*H*Me and C_6H_{10}) and 0.87 (3 H, d, *J* 6.9, CH*Me*); δ_C($CDCl_3$) 157.02, 156.71, 137.04, 131.31, 129.68, 129.15, 128.89, 124.53, 114.44, 78.17, 63.14, 55.49, 43.62, 33.30, 30.24, 29.08, 26.07, 21.85, 21.63 and 19.59 (Found: M^+ – H_2O, 410.2013. $C_{24}H_{30}N_2O_2S$ requires M – H_2O, 410.2028); *m*/*z* 410 (0.1%, M – H_2O), 237 (40, M – C_6H_{10}·SPh), 149 (60, $MeOC_6H_4NCO$) and 88 (100, $C_4H_{10}NO$).

Rearrangement of (2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-(p-*methoxyphenyl*)*urea* anti-**21**. In the same way as the allylic sulfide *anti*-**26**, the urea *anti*-**21** (38 mg, 0.09 mmol) and TsOH (13.5 mg, 0.07 mmol) in $CHCl_3$ (1 cm^3) gave the *pyrrolidine* anti-**33** (1.5 mg, 4%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.52; ν_{max}(Nujol)/cm^{-1} 1645 (C=O); δ_H($CDCl_3$) 7.42–7.19 (7 H, m, Ph and NHC_6H_2OMe), 6.82 (2 H, dd, *J* 6.7 and 2.2, NHC_6H_2OMe), 5.95 (1 H, br s, NH), 3.85 (1 H, t, *J* 7.7, CH_AH_BN), 3.77 (3 H, s, OMe), 3.48 (1 H, d, *J* 4.5, C*H*SPh), 3.14 (1 H, dd, *J* 8.4 and 4.3, CH_AH_BN), 2.91–2.68 (2 H, m, C_6H_2), 2.44–2.38 (1 H, m, C*H*Me), 1.91–1.24 (8 H, m, C_6H_8) and 1.19 (3 H, d, *J* 7.1,

CH*Me*) (Found: M^+, 410.2041. $C_{24}H_{30}N_2O_2S$ requires M, 410.2028); *m/z* 410 (0.8%, M), 149 (93, $MeOC_6H_4NCO$) and 110 (100, PhSH); and the *allylic sulfide* syn-**34** (15 mg, 41%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.28; ν_{max}($CHCl_3$)/cm^{-1} 3410 (NH) and 1655 (C=O); δ_H($CDCl_3$) 7.28–7.10 (7 H, m, Ph and NHC_6H_2OMe), 6.81 (2 H, dd, *J* 6.7 and 2.1, NHC_6H_2OMe), 6.45 (1 H, br s, NH), 5.18 (1 H, br s, C=CH), 4.85 (1 H, br s, NH), 3.76 (3 H, s, OMe), 3.36 (1 H, dd, *J* 13.6 and 4.9, CH_ACH_BN), 3.30 (1 H, d, *J* 9.0, C*H*SPh), 2.96 (1 H, dd, *J* 13.6 and 7.3, CH_AH_BN), 2.28–2.12 (1 H, m, HCC=C), 2.04–1.39 (8 H, m, C*H*Me and C_4H_7) and 1.09 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+, 410.2044. $C_{24}H_{30}N_2O_2S$ requires M, 410.2027); *m/z* 410 (2%, M), 301 (97, M – PhS), 152 (64, M – PhS – $MeOC_6H_4NCO$) 149 (100, $MeOC_6H_4HCO$) and 110 (75, PhSH).

(2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-(p-*nitrophenyl*)*urea* anti-**22**.—In the same way as the urea *syn*-**20**, the amine *anti*-**9** (140 mg, 0.5 mmol) and *p*-nitrophenyl isocyanate (0.92 mg, 0.55 mmol) gave the urea *anti*-**22** (212 mg, 96%) as a foam, R_f [CH_2Cl_2–EtOH–aq. NH_3 (150:8:1)] 0.34; ν_{max}($CHCl_3$)/cm^{-1} 3390 (NH), 1690 (C=O), 1600 (Ph) and 1330 (NO_2); δ_H($CDCl_3$) 8.15 (2 H, d, *J* 9.2, $NHC_6H_2NO_2$), 7.53 (2 H, d, *J* 9.2, $NHC_6H_2NO_2$), 7.48–7.31 (5 H, m, Ph), 3.53–3.22 (1 H, br s, OH), 3.44–3.42 (2 H, m, CH_2N), 3.16 (1 H, d, *J* 4.8, C*H*OH) 2.08–1.14 (11 H, m, C*H*Me and C_6H_{10}) and 0.93 (3 H, d, *J* 7.0, CH*Me*); δ_C($CDCl_3$) 155.17, 146.07, 141.85, 136.97, 129.35, 129.02, 125.27, 117.67, 113.57, 78.26, 63.09, 43.73, 33.19, 30.38, 29.20, 26.06, 21.85, 21.62 and 1950 (Found: M^+ – PhS – H_2O, 316.1651. $C_{17}H_{22}N_3O_3$ requires M – C_6H_7OS, 316.1661); *m/z* 316 (0.4%, M – PhS – H_2O), 191 (40, $C_6H_{10}SPh$), 152 (43, M – PhS – H_2O – $O_2NC_6H_4HCO$), 138 (43, $O_2NC_6H_4NH_2$), 111 (75), 110 (62, PhSH) and 88 (100, $C_4H_{10}NO$).

Rearrangement of (2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}-N′-(p-*nitrophenyl*)*urea* anti-**22**.—In the same way as the allylic sulfide *anti*-**26**, the urea *anti*-**22** (44 mg, 0.1 mmol) and TsOH (15 mg, 0.08 mmol) in $CHCl_3$ (1 cm^3) gave the *pyrrolidine* anti-**35** (12 mg, 28%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (200:8:1)] 0.76; ν_{max}(Nujol)/cm^{-1} 1660 (C=O), 1595 (Ph) and 1325 (NO_2); δ_H($CDCl_3$) 8.18–8.12 (2 H, m, $NHC_6H_2NO_2$), 7.56–7.51 (2 H, m, $NHC_6H_2NO_2$), 7.42–7.20 (5 H, m, Ph), 6.49 (1 H, br s, NH), 3.92 (1 H, t, *J* 7.7, CH_AH_BN), 3.50 (1 H, d, *J* 4.4, C*H*SPh), 3.19 (1 H, dd, *J* 8.3 and 4.1, CH_AH_BN), 2.86–2.63 (2 H, m, C_6H_2), 2.49–2.39 (1 H, m, C*H*Me), 1.93–1.24 (8 H, m, C_6H_8) and 1.20 (3 H, d, *J* 7.2, CH*Me*) (Found: M^+, 425.1750. $C_{23}H_{27}N_3O_3S$ requires M, 425.1773); *m/z* 425 (0.1%, M), 261 (21, M – $O_2NC_2H_4NCO$), 164 (38, $O_2NC_6H_4NCO$), 152 (37, M – PhS – $O_2NC_6H_4$-NCO), 111 (100), and (41, PhSH); and the allylic sulfide *syn*-**36** (12 mg, 28%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (200:8:1)] 0.40; ν_{max}($CHCl_3$)/cm^{-1} 3360 (NH), 1660 (C=O), 1595 (Ph) and 1325 (NO_2); δ_H($CDCl_3$) 8.11 (2 H, d, *J* 9.2, $NHC_6H_2NO_2$), 7.52–7.47 (2 H, m, $NHC_6H_2NO_2$), 7.31–7.17 (5 H, m, Ph), 5.37 (1 H, br s, NH), 5.31 (1 H, br s, C=CH), 3.50–3.40 (1 H, m, CH_ACH_BN), 3.38 (1 H, d, *J* 8.9, C*H*SPh), 3.02 (1 H, dd, *J* 13.2 and 7.4, CH_AH_BN), 2.27–2.21 (1 H, m, HCC=C), 2.07–1.98 (1 H, m, C*H*Me), 1.91–1.44 (7 H, m, C_4H_7) and 1.14 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+ – PhS, 316.1652. $C_{17}H_{22}N_3O_3$ requires M – C_6H_5S, 316.1661); *m/z* 316 (5%, M – PhS) 152 (90, M – PhS – $O_2NC_6H_4NCO$), 135 (74, $C_{10}H_{15}$), 110 (51, PhSH) and 95 (100).

(2RS,3SR)-*Ethyl* N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)-*cyclohexyl*]*propyl*}*carbamate* syn-**23**.—In the same way as the amide *syn*-**17**, the amine *syn*-**9** (140 mg, 0.5 mmol) and ethyl chloroformate (0.057 cm^3, 0.6 mmol) gave the *carbamate* syn-**23** (174 mg, 99%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.37; ν_{max}($CHBr_3$)/cm^{-1} 3450 (NH), 1705 (C=O) and 1510 (NH); δ_H($CDCl_3$) 7.53–7.48 (2 H, m, Ph), 7.38–7.32 (3 H, m, Ph), 4.98 (1 H, br s, NH), 4.07 (2 H, q, *J* 7.0, OCH_2), 3.33 (1 H, br s, OH), 3.28–3.15 (1 H, m, CH_AH_BN), 3.14 (1 H, d, *J* 3.0, C*H*OH), 2.99 (1 H, dt, *J* 13.5 and 5.5, CH_AH_BN), 2.18–1.24 (11 H, m, C*H*Me and C_6H_{10}), 1.21 (3 H, t, *J* 7.0, OCH_2Me) and 1.02 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+, 351.1861. $C_{19}H_{29}NO_3S$ requires M, 351.1868); *m/z* 351 (0.2%, M), 305 (4, M – EtOH) and 242 (53, M – PhS).

(2RS,3RS)-*Ethyl* N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*carbamate* anti-**23**.—Ethyl chloroformate (0.07 cm^3, 0.73 mmol) was added to a solution of the amine *anti*-**9** (185 mg, 0.66 mmol) and 4-(dimethylamino)pyridine (4-DMAP) (88 mg, 0.73 mmol) in CH_2Cl_2 (5 cm^3) under argon at 0 °C. After 2 h the solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (13 g) with (300:8:1) CH_2Cl_2–EtOH–aq. NH_2 as eluent to give the *carbamate* anti-**23** (228 mg, 98%) as needles, m.p. 116–117 °C; R_f [hexane–diethyl ether (1:1)] 0.32; ν_{max}($CHCl_3$)/cm^{-1} 3430 (NH) and 1700 (C=O); δ_H($CDCl_3$) 7.49–7.46 (2 H, m, Ph), 7.41–7.28 (3 H, m, Ph), 5.36 (1 H, br s, NH), 4.09 (2 H, qd, *J* 7.1 and 1.9, OCH_2), 3.38–3.22 (2 H, m, CH_2N), 3.11 (1 H, d, *J* 4.3, C*H*OH), 2.10–1.17 (12 H, m, OH, C*H*Me and C_6H_{10}), 1.23 (3 H, t, *J* 7.1, OCH_2Me) and 0.88 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+, 351.1887. $C_{19}H_{29}NO_3S$ requires M, 351.1868); *m/z* 351 (0.2%, M), 242 (50, M – PhS), 224 (57, M – PhSH – OH), 160 (66, M – $C_6H_{10}SPh$) and 102 (100, CH_2NHCO_2Et).

Rearrangement of (2RS,3SR)-*Ethyl* N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*carbamate* syn-**23**.—In the same way as the rearrangement of the amide *anti*-**17**, the carbamate *syn*-**23** (27 mg, 0.077 mmol) and TMSOTf (15.6 cm^3, 0.08 mmol) gave, after purification by column chromatography on silica gel (12 g) and elution with (4:1) hexane–diethyl ether, the *pyrrolidine* syn-**37** (19 mg, 74%) as needles, m.p. 111–112 °C; R_f [hexane–diethyl ether (3:1)] 0.43; ν_{max}($CHBr_3$)/cm^{-1} 1680 (C=O) and 1580 (Ph); δ_H($CDCl_3$) 7.44–7.14 (5 H, m, Ph), 4.10 (2 H, q, *J* 7.0, OCH_2), 3.84 (1 H, d, *J* 4.8, C*H*SPh), 3.58 (1 H, br t, *J* 7.4, CH_AH_BN), 3.14 (1 H, t, *J* 11.0, CH_AH_BN), 2.78–2.56 (2 H, m, C*H*Me and C_6H), 2.40–2.21 (1 H, m, C_6H), 2.04 (1 H, br d, *J* 13.5, C_6H), 1.79–1.16 (7 H, m, C_6H_7), 1.25 (3 H, t, *J* 7.0, OCH_2Me) and 1.01 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+, 333.1774. $C_{19}H_{27}NO_2S$ requires M, 333.1763); *m/z* 333 (24%, M), 224 (100, M – PhS) and 110 (18, PhSH) (Found: C, 68.4; H, 8.1; N, 3.8. $C_{19}H_{27}NO_2S$ requires C, 68.43; H, 8.16; N, 4.20%); and the allylic sulfide *anti*-**38** (5 mg, 20%) as an oil, R_f [hexane–diethyl ether (3:1)] 0.28; ν_{max}($CHBr_3$)/cm^{-1} 3440 (NH) and 1710 (C=O); δ_H($CDCl_3$) 7.37–7.32 (2 H, m, Ph), 7.30–7.22 (3 H, m, Ph), 5.17 (1 H, br s, HC=C), 4.84 (1 H, br s, NH), 4.13 (2 H, q, *J* 7.0, OCH_2), 3.58 (1 H, ddd, *J* 13.9, 6.6 and 4.2, CH_AH_BN), 3.32–3.21 (1 H, m, CH_AH_BN), 3.27 (1 H, d, *J* 10.3, C*H*SPh), 2.29–2.21 (1 H, m, HCC=C), 1.96–1.41 (8 H, m, C*H*Me and C_4H_7), 1.24 (3 H, 5, *J* 7.0, OCH_2Me) and 0.92 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+ – EtOH, 287.1327. $C_{17}H_{21}NOS$ requires M – C_2H_6O, 287.1344); *m/z* 287 (2%, M – EtOH), 224 (67, M – PhS) and 102 (100, CH_2NHCO_2Et).

Rearrangement of (2RS,3RS)-*Ethyl* N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*carbamate* anti-**23**.—A solution of the carbamate *anti*-**23** (35 mg, 0.1 mmol) and TsOH (15 mg, 0.08 mmol) in CH_2Cl_2 (1.5 cm^3) was heated under reflux under argon for 30 min. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (10 g) and elution with (4:1) light petroleum (40–60 °C)–diethyl ether, to give the *pyrrolidine* anti-

37 (29.5 mg, 88%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (2:1)] 0.54; $\nu_{max}(CHCl_3)/cm^{-1}$ 1670 (C=O) and 1575 (Ph); $\delta_H(CDCl_3)$ 7.40–7.17 (5 H, m, Ph), 4.09 (2 H, q, *J* 7.1, OCH_2), 3.75 (1 H, dd, *J* 11.0 and 7.1, CH_AH_BN), 3.35 (1 H, d, *J* 5.1, *CH*SPh), 3.17 (1 H, dd, *J* 11.0 and 4.9, CH_AH_BN), 2.56–2.41 (2 H, m, C_6H_2), 2.28–2.19 (1 H, sym. m, *CH*Me), 1.93–1.30 (8 H, m, C_6H_8), 1.25 (3 H, t, *J* 7.1, OCH_2*Me*) and 1.11 (3 H, d, *J* 7.0, CH*Me*) (Found: M^+, 333.1763. $C_{19}H_{27}NO_2S$ requires M, 333.1763); *m/z* 333 (19%, M), 224 (100, M – PhS) and 110 (26, PhSH); and the *allylic sulfide* syn-**38** (3 mg, 9%) as an oil, R_f [hexane–diethyl ether (3:1)] 0.30; $\nu_{max}(CHCl_3)/cm^{-1}$ 3440 (NH) and 1700 (C=O); $\delta_H(CDCl_3)$ 7.45–7.15 (5 H, m, Ph), 5.26 (1 H, br s, HC=C), 4.68 (1 H, br s, NH), 4.09 (2 H, q, *J* 7.1, OCH_2), 3.35–3.25 (1 H, m, CH_AH_BN), 3.32 (1 H, d, *J* 9.4, *CH*SPh), 2.97–2.86 (1 H, m, CH_AH_BN), 2.30–2.21 (1 H, m, HCC=C), 2.04–1.27 (8 H, m, *CH*Me and C_4H_7), 1.22 (3 H, t, *J* 7.1, OCH_2*Me*) and 1.14 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+, 333.1760); *m/z* 333 (15%, M), 224 (54, M – PhS) and 102 (100, CH_2NHCO_2Et).

(2RS,3SR)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*tosylamide* syn-**24**.—A solution of the amine *syn*-**9** (140 mg, 0.5 mmol), toluene-*p*-sulfonyl chloride (101 mg, 0.53 mmol) and 4-DMAP (64 mg, 0.53 mmol) in CH_2Cl_2 (4 cm^3) was stirred at room temperature under argon for 3 h. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (12 g) with (1:1) hexane–diethyl ether as eluent to give the *sulfonamide* syn-**24** (205 g, 94%) as needles, m.p. 145–147 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.43; $\nu_{max}(CHCl_3)/cm^{-1}$ 1575 (Ph), 1330 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.68 (2 H, d, *J* 8.2, C_6H_2Me), 7.47–7.28 (7 H, m, Ph and C_6H_2Me), 4.89 (1 H, br s, NH), 3.31 (1 H, d, *J* 1.0, *CH*OH), 2.96 (1 H, dd, *J* 12.2 and 6.1, CH_AH_BN), 2.80 (1 H, dd, *J* 12.2 and 5.0, CH_AH_BN), 2.42 (3 H, s, Ar*Me*), 2.01–1.90 (2 H, m, *CH*Me and OH), 1.80–1.17 (10 H, m, C_6H_{10}) and 0.96 (3 H, d, *J* 6.9, CH*Me*) (Found: M^+, 433.1757. $C_{23}H_{31}NO_3S_2$ requires M, 433.1745); *m/z* 433 (0.2%, M), 324 (23, M – PhS), 184 (84, CH_2NHSO_2Tol), 155 (73, SO_2Tol), 110 (100, PhSH) and 91 (79, C_6H_4Me) (Found: C, 63.8; H, 7.2; N, 3.2; S, 14.5. $C_{23}H_{31}NO_3S_2$ requires C, 63.70; H, 7.21; N, 3.23; S, 14.79%).

Rearrangement of (2RS,3SR)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*tosylamide* syn-**24**.—TMSOTf (10.5 mm^3, 0.05 mmol) was added to a solution of the sulfonamide *syn*-**24** (21 mg, 0.048 mmol) in dry CH_2Cl_2 (1.0 cm^3) under argon at −78 °C. The solution was allowed to warm slowly to room temperature and was stirred for 3 h. Purification by column chromatography on silica gel (7 g) and elution with (2:1) hexane–diethyl ether gave the *sulfonamide* syn-**39** (19.5 mg, 97%) as an oil, R_f [hexane–diethyl ether (1:1)] 0.57; $\nu_{max}(CHCl_3)/cm^{-1}$ 1580 (Ph), 1320 and 1140 (SO_2); $\delta_H(CDCl_3)$ 7.74 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.37–7.13 (7 H, m, Ph and $SO_2C_6H_2$), 3.83 (1 H, d, *J* 4.6, *CH*SPh), 3.73 (1 H, t, *J* 8.7, CH_AH_BN), 3.08 (1 H, dd, *J* 11.4 and 9.1, CH_AH_BN), 2.86–2.74 (1 H, sym. m, *CH*Me), 2.42 (3 H, s, Ar*Me*), 2.38–2.21 (2 H, m, C_6H_2), 2.04–1.19 (8 H, m, C_6H_8) and 1.00 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+, 415.1632. $C_{23}H_{29}NO_2S_2$ requires M, 415.1640); *m/z* 415 (5%, M), 260 (23, M – SO_2Tol), 110 (100, PhSH) and 91 (41, C_6H_4Me); and the *allylic sulfide* anti-**40** (0.5 mg, 2%) as an oil, R_f [hexane–diethyl ether (1:1)] 0.41; ν_{max}(film)/cm^{-1} 3340 (NH), 1580 (Ph), 1330 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.78–7.73 (2 H, m, $SO_2C_6H_2$), 7.37–7.18 (7 H, m, Ph and $SO_2C_6H_2$), 5.13 (1 H, br s, C=CH), 4.65 (1 H, t, *J* 7.0, NH), 3.33–3.17 (1 H, m, CH_AH_BN), 3.24 (1 H, d, *J* 10.5, *CH*SPh), 3.06 (1 H, dt, *J* 12.8 and 6.2, CH_AH_BN), 2.42 (3 H, s, Ar*Me*), 2.26–2.13 (1 H, m, HCC=C), 1.95–1.37 (8 H, m, *CH*Me and C_4H_7) and 0.92 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+, 415.1638. $C_{23}H_{29}NO_2S_2$ requires M, 415.1640); *m/z* 415 (0.6%, M), 306 (40 – PhS), 184 (100, CH_2NHSO_2Tol), 155 (70, SO_2Tol) and 91 (57, C_6H_4Me).

(2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*tosylamide* anti-**24**.—In the same way as the sulfonamide *syn*-**24**, the amine *anti*-**9** (140 mg, 0.5 mmol) gave the sulfonamide *anti*-**24** (209 mg, 96%) as a foam, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.61; $\nu_{max}(CHCl_3)/cm^{-1}$ 3320 (NH), 1575 (Ph), 1330 and 1155 (SO_2); $\delta_H(CDCl_3)$ 7.73 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.44–7.28 (7 H, m, Ph and $SO_2C_6H_2$), 5.43 (1 H, br s, NH), 3.39 (1 H, br s, OH), 3.05 (1 H, d, *J* 5.1, *CH*OH), 3.04–2.91 (2 H, m, NCH_2), 2.42 (3 H, s, Ar*Me*), 2.03–1.01 (11 H, m, *CH*Me and C_6H_{10}) and 0.84 (3 H, d, *J* 6.9, CH*Me*) (Found: M^+ – PhS, 324.1649. $C_{17}H_{26}NO_3S$ requires M – C_6H_5S, 324.1634); *m/z* 324 (4%, M – PhS), 191 (70, $ChH_6H_{10}SPh$), 184 (100, CH_2NHSO_2Tol), 155 (86, SO_2Tol), 110 (62, PhSH), 91 (85, C_6H_4Me) and 81 (62, C_6H_9).

Rearrangement of (2RS,3RS)-N-{3-*Hydroxy*-2-*methyl*-3-[1-(*phenylthio*)*cyclohexyl*]*propyl*}*tosylamide* anti-**24**.—In the same way as the sulfonamide *syn*-**24**, the sulfonamide *anti*-**24** (43 mg, 0.10 mmol) gave the *sulfonamide* anti-**39** (37 g, 90%) as an oil, R_f [hexane–diethyl ether (1:1)] 0.65; ν_{max}(film)/cm^{-1} 1600 and 1580 (Ph), 1325 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.74 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.35–7.15 (7 H, m, Ph and $SO_2C_6H_2$), 3.71 (1 H, dd, *J* 9.8 and 7.3, CH_AH_BN), 3.34 (1 H, d, *J* 4.2, *CH*SPh), 3.17 (1 H, dd, *J* 9.8 and 4.8, CH_AH_BN), 2.42 (C H, s, Ar*Me*), 2.39–2.15 (3 H, m, *CH*Me and C_6H_2), 2.01–1.24 (8 H, m, C_6H_8) and 1.05 (3 H, d, *J* 7.2, CH*Me*) (Found: M^+, 415.1619. $C_{23}H_{29}NO_2S_2$ requires M, 415.1640); *m/z* 415 (10%, M), 260 (29, M – SO_2Tol), 110 (100, PhSH) and 91 (42, C_6H_4Me); and the *allylic sulfide* syn-**40** (3.5 mg, 9%) as an oil, R_f [hexane–diethyl ether (1:1)] 0.42; ν_{max}(film)/cm^{-1} 3340 (NH), 1580 (Ph), 1325 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.69 (2 H, d, *J* 8.2, $SO_2C_6H_2$), 7.31–7.18 (7 H, m, Ph and $SO_2C_6H_2$), 5.23 (1 H, br s, C=CH), 4.42 (1 H, t, *J* 6.2, NH), 3.29 (1 H, d, *J* 9.2, *CH*SPh), 3.02–2.94 (1 H, m, CH_AH_BN), 2.78–2.70 (1 H, m, CH_AH_BN), 2.41 (3 H, s, Ar*Me*), 2.14–2.11 (1 H, m, C_4H), 1.96–1.39 (8 H, m, *CH*Me and C_4H_7) and 1.10 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+, 415.1646); *m/z* 415 (0.2%, M), 306 (33, M – PhS), 184 (100, CH_2NHSO_2Tol), 155 (84, SO_2Tol) and 91 (76, C_6H_4Me).

(2RS,3RS)-N-[3-(1-*Cyclohex*-1-*enyl*)-2-*methyl*-3-(*phenylthio*)*propyl*]*acetamide* anti-**26**.—A solution of the amide *syn*-**17** (28 mg, 0.087 mmol) and TsOH (13 mg, 0.07 mmol) in benzene (1.0 cm^3) was heated under reflux in a foil-wrapped flask under argon for 7 min. Water (20 cm^3) was added and the organic layer was extracted with CH_2Cl_2 (4 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated and purified by column chromatography on silica gel (6 g) with (160:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *allylic sulfide* anti-**26** (24 mg, 91%) as needles, m.p. 98–101 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (120:8:1)] 0.46; $\nu_{max}(CHCl_3)$ 3430 (NH), 1655 (C=O) and 1580 (Ph); $\delta_H(CDCl_3)$ 7.36–7.31 (2 H, m, Ph), 7.30–7.21 (3 H, m, Ph), 5.68 (1 H, br s, NH), 5.19–5.16 (1 H, m, HC=C), 3.58 (1 H, ddd, *J* 13.8, 5.8 and 4.9, CH_AH_BN), 3.36 (1 H, dt, *J* 13.8 and 6.4, CH_AH_BN), 3.25 (1 H, d, *J* 10.2, *CH*SPh), 2.28–2.20 (1 H, m, CHC=C), 1.98 (3 H, s, COMe), 1.95–1.43 (8 H, m, *CH*Me and C_4H_7) and 0.92 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+, 303.1628. $C_{18}H_{25}NOS$ requires M, 303.1657); *m/z* 303 (0.7%, M), 194 (100, M – PhS) and 135 (88, M – PhS – C_2H_5NO).

(2RS,3RS)- *and* (2RS,3SR)-3-*Hydroxy*-2-*methyl*-3-{4′-[1-*methyl*-4-(*phenylthio*)*piperidyl*]*propiononitrile* **44**.—In the same was for the nitrile **50** (see later), the aldehyde **43** (6.27 g, 27 mmol) and propiononitrile (2.1 cm^3, 29 mmol) gave, after purification by column chromatography on silica gel (200 g) and elution with (100:8:1) CH_2Cl_2–EtOH–aq. NH_3, a 2:3:1

mixture of the nitrile **44** (6.64 g, 86%), a portion of which was further purified by column chromatography on silica gel (180 g) and elution with (100:8:1) CH_2Cl_2–EtOH–aq. NH_3 to give the (2RS,3RS)-*nitrile* syn-**44** (820 mg) as needles after recrystallization from CH_2Cl_2–hexane, m.p. 144–145 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.40; $\nu_{max}(CHCl_3)/cm^{-1}$ 2230 (CN); $\delta_H(CDCl_3)$ 7.52–7.48 (2 H, m, Ph), 7.43–7.31 (3 H, m, Ph), 3.62 (1 H, d, *J* 6.7, C*H*OH), 3.39 (1 H, br s, OH), 3.12 (1 H, qn, *J* 7.0, C*H*Me), 2.72–2.57 [4 H, m, $N(CH_2)_2$], 2.33 (3 H, s, NMe), 2.09–1.95 (2 H, m, NCH_2CH_2), 1.81–1.51 (2 H, m, NCH_2CH_2) and 1.42 (3 H, d, *J* 7.1, CH*Me*); $\delta_C(CDCl_3)$ 137.31, 137.23, 129.42, 129.10, 123.40, 74.92, 57.41, 51.10, 51.04, 46.13, 30.44, 30.24, 26.72 and 14.50 (Found: M^+, 290.1437. $C_{16}H_{22}N_2OS$ requires M, 290.1453); *m/z* 290 (1%, M), 181 (100, M – PhS) and 126 (36, M – PhS – C_3H_5N); and the (2RS,3SR)-*nitrile* anti-**44** (1.29 g) as needles after recrystallization from CH_2Cl_2, m.p. 191–193 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.34; $\nu_{max}(CHCl_3)/cm^{-1}$ 2230 (CN); $\delta_H(CDCl_3)$ 7.47–7.30 (5 H, m, Ph), 3.85–3.52 (1 H, br s, OH), 3.45 (1 H, q, *J* 7.3, C*H*Me), 3.21 (1 H, s, C*H*OH), 2.84–2.65 [4 H, m, $N(CH_2)_2$], 2.40 (3 H, s, NMe), 2.37–2.25 (1 H, m, NCH_2CH), 2.17–1.93 (2 H, m, NCH_2CH_2), 1.62–1.51 (1 H, m, NCH_2CH) and 1.47 (3 H, d, *J* 7.3, CH*Me*); $\delta_C(CDCl_3)$ 137.24, 129.57, 129.18, 129.10, 120.99, 76.54, 57.02, 51.04, 50.88, 46.14, 29.56, 29.06, 27.19 and 18.39 (Found: M^+, 290.1434); *m/z* 290 (4%, M), 181 (100, M – PhS) and 126 (53, M – PhS – C_3H_5N) (Found: C, 66.45; H, 7.7; N, 9.7%).

(1RS,2SR)-3-*Amino*-2-*methyl*-1-{4′-[1-*methyl*-4-(*phenylthio*)*piperidyl*]}*propan*-1-*ol* syn-**45**.—In the same way as for the amine **62** (see later), the nitrile *syn*-**44** (400 mg, 1.38 mmol) and $LiAlH_4$ (160 mg, 4.15 mmol) gave the (2*RS*,3*SR*)-amine *syn*-**45** (311 mg, 77%) as needles, m.p. 94–96 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (25:8:1)] 0.13; $\nu_{max}(CHCl_3)/cm^{-1}$ 1570 (NH); $\delta_H(CDCl_3)$ 7.55–7.48 (2 H, m, Ph), 7.37–7.28 (3 H, m, Ph), 3.58 (1 H, d, *J* 1.1, C*H*OH), 2.82 (1 H, dd, *J* 12.5 and 4.9, MeNC*H*), 2.75–2.60 (5 H, m, MeNC*H*, $MeNCH_2$, and CH_2NH_2), 2.49–1.97 [6 H, m, $N(CH_2CH^{ax})_2$, C*H*Me, NH_2 and OH], 2.37 (3 H, s, NMe), 1.62 (1 H, ddd, *J* 14.6, 5.1 and 2.5, NCH_2CH^{eq}), 1.46 (1 H, ddd, *J* 14.6, 5.5 and 2.8, NCH_2CH^{eq}) and 1.08 (3 H, d, *J* 7.0, CH*Me*); $\delta_C(CDCl_3)$ 137.24, 130.55, 128.86, 128.77, 76.54, 58.31, 51.60, 51.35, 49.36, 46.28, 34.88, 30.51, 30.22 and 12.34 (Found: M^+ – C_3H_8N, 236.1130. $C_{13}H_{18}NOS$ requires M – C_3H_8N, 236.1109); *m/z* 236 (1%, M – C_3H_8N), 206 (50, $C_6H_{11}NSPh$), 185 (100, M – PhS), 156 (56, M – PhS – CH_2NH) and 110 (75, PhSH).

(1RS,2RS)-3-*Amino*-2-*methyl*-1-{4-[1-*methyl*-4-(*phenylthio*)*piperidyl*]}*propan*-1-*ol* anti-**45**.—In the same way as for the amine **62**, the nitrile *anti*-**44** (500 mg, 1.72 mmol) and $LiAlH_4$ (197 mg, 5.17 mmol) gave the (2*RS*,3*RS*)-amine *anti*-**45** (426 mg, 84%) as needles, m.p. 131–133 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (50:8:1)] 0.12; $\nu_{max}(CHCl_3)/cm^{-1}$ 1565 (NH); $\delta_H(CDCl_3)$ 7.60–7.50 (2 H, m, Ph), 7.34–7.26 (3 H, m, Ph), 3.49 (1 H, d, *J* 3.8, C*H*OH), 3.15 (1 H, dd, *J* 12.5 and 3.7, $CH_AH_BNH_2$), 3.10–2.68 (3 H, br s, OH and NH_2), 2.92 (1 H, dd, *J* 12.5 and 5.9, $CH_AH_BNH_2$), 2.66–2.51 [4 H, m, $N(CH_2)_2$], 2.32 (3 H, s, NMe), 2.30–1.96 (3 H, m, C*H*Me and NCH_2CH_2), 1.66–1.54 (2 H, m, NCH_2CH_2) and 1.07 (3 H, d, *J* 7.1, CH*Me*) (Found: M^+ – C_3H_8N, 236.1099. $C_{13}H_{18}NOS$ requires M – C_3H_8N, 236.1109); *m/z* 236 (2%, M – C_3H_8N), 185 (100, M – PhS) and 156 (52, M – PhS – CH_2NH).

(2RS,3RS)- *and* (2RS,3SR)-N-(3-*Hydroxy*-2-*methyl*-3-{4′-[1′-*methyl*-4′-(*phenylthio*)*piperidyl*]}*propyl*)*tosylamide* **46**.—A mixture of the (2*RS*,3*RS*)- and (2*RS*,3*SR*)-amine **45** (1.28 g, 4.35 mmol), DMAP (5 mg, 0. 04 mmol) and TsCl (871 mg, 4.57 mmol) in dry CH_2Cl_2 (40 cm^3) was stirred at room temperature under argon for 20 h. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (100 g) with (75:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the (2*RS*,3*SR*)-sulfonamide *syn*-**46** (360 mg, 19%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.16; $\nu_{max}(CHCl_3)/cm^{-1}$ 1325 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.69 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.50–7.28 (7 H, m, Ph and $SO_2C_6H_2$), 5.09 (1 H, br s, NH), 3.50 (1 H, s, C*H*OH), 3.21 (1 H, br s, OH), 2.96 (1 H, dd,* *J* 13.0 and 6.5, CH_AH_BN), 2.79 (1 H, dd, *J* 13.0 and 5.4, CH_AH_BN), 2.76–2.61 [4 H, m, $N(CH_2)_2$], 2.41 (3 H, s, Ar*Me*), 2.39 (3 H, s, NMe), 2.30–2.07 (2 H, m, C*H*Me and NCH_2CH^{ax}), 1.93–1.81 (1 H, m, NCH_2CH^{ax}), 1.63 (1 H, dd, *J* 14.5 and 2.6, NCH_2CH^{eq}), 1.31 (1 H, dd, *J* 14.5 and 2.5, NCH_2CH^{eq}) and 0.96 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+ – PhSH, 339.1742. $C_{17}H_{27}N_2O_3S$ requires M – C_6H_5S, 339.1742); *m/z* 339 (1%, M – PhS), 110 (100, PhSH), 96 (55, $C_6H_{10}N$) and 91 (36, C_6H_4Me); and a 2:7:1 (*syn*:*anti*) mixture of the sulfonamide **46** (430 mg, 22%) and the (2*RS*,3*RS*)-sulfonamide *anti*-**46** (1.015 g, 52%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.28; $\nu_{max}(CHCl_3)/cm^{-1}$ 3300 (NH) and 1325 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.72 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.44–7.27 (7 H, m, Ph and $SO_2C_6H_2$), 5.48 (1 H, br s, NH), 3.55 (1 H, br s, OH), 3.18 (1 H, d, *J* 5.0, C*H*OH), 3.07–2.90 (2 H, m, CH_2NH), 2.79–2.44 [4 H, m, $N(CH_2)_2$], 2.41 (3 H, s, Ar*Me*), 2.38 (3 H, s, NMe), 2.10–1.91 (2 H, m, C*H*Me and NCH_2CH^{ax}), 1.81–1.69 (1 H, m, NCH_2CH^{ax}), 1.55 (1 H, dd, *J* 14.5 and 2.4, NCH_2CH^{eq}), 1.26 (1 H, dd, *J* 14.5 and 2.4, NCH_2CH^{eq}) and 0.90 (3 H, d, *J* 6.9, CH*Me*) (Found: M^+ – PhSH, 339.1747. $C_{17}H_{27}N_2O_3S$ requires M – C_6H_5S, 339.1742); *m/z* 339 (25%, M – PhS), 110 (100, PhSH), 96 (53, $C_6H_{10}N$) and 91 (37, C_6H_4Me).

Rearrangement of (2RS,3SR)-N-(3-*Hydroxy*-2-*methyl*-3-{4-[1-*methyl*-4-(*phenylthio*)*piperidyl*]}*propyl*)*tosylamide* syn-**46**.—In the same way as for the pyrrolidine **53** (see later), the sulfonamide *syn*-**46** (100 mg, 0.22 mmol) and TMSOTf (47 mm^3, 0.25 mmol) gave, after purification by column chromatography on silica gel (12 g) and elution with (150:8:1) CH_2Cl_2–EtOH–aq. NH_3 the *pyrrolidine* syn-**47** (85 mg, 89%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.44; ν_{max}(film)/cm^{-1} 1580 (Ph) and 1325 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.74 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.37–7.15 (7 H, m, Ph and $SO_2C_6H_2$), 3.82 (1 H, d, *J* 4.8, C*H*SPh), 3.76 (1 H, dd, *J* 9.1 and 7.5, CH_AH_BN), 3.12 (1 H, dd, *J* 11.0 and 9.1, CH_AH_BN), 2.96–2.59 [5 H, m, $N(CH_2)_2$ and piperidine NCH_2CH], 2.42 (3 H, s, Ar*Me*), 2.27 (3 H, s, NMe), 2.22–1.75 (4 H, m, C*H*Me, NCH_2CH_2 and NCH_2CH) and 1.02 (3 H, d, *J* 6.5, CH*Me*) (Found: M^+, 430.1735. $C_{23}H_{30}N_2O_2S_2$ requires M, 430.1749); *m/z* 420 (4%, M), 275 (38, M – SO_2Tol), 165 (22, M – SO_2Tol – PhSH) and 70 (100, C_4H_8N).

Rearrangement of 2(RS,3RS)-N-(3-*Hydroxy*-2-*methyl*-3-{4-[1-*methyl*-4-(*phenylthio*)*piperidyl*]}*propyl*)*tosylamide* anti-**46**.—In the same way as for the pyrrolidine **53**, the sulfonamide *anti*-**46** (200 mg, 0.45 mmol) and TMSOTf (95 mm^3, 0.49 mmol) gave the *pyrrolidine* anti-**47** (184 mg, 96%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.44; ν_{max}(film)/cm^{-1} 1600 and 1580 (Ph) and 1330 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.73 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.37–7.19 (7 H, m, Ph and $SO_2C_6H_2$), 3.70 (1 H, dd, *J* 10.4 and 7.7, CH_AH_BN), 3.22 (1 H, dd, *J* 10.4 and 5.2, CH_AH_BN), 3.17–3.15 (1 H, m, C*H*SPh), 3.02–2.95 (1 H, m, NCH), 2.83–2.74 (1 H, m, NCH), 2.69–2.16 (4 H, m, C*H*Me and NCH_2CH), 2.42 (3 H, s, Ar*Me*), 2.33 (3 H, s, NMe), 2.07–1.85 (3 H, m, NCH_2CH and NCH_2CH_2) and 1.07 (3 H, d,

* Revealed by D_2O shake.

J 7.0, CH*Me*) (Found: M^+, 430.1744); *m/z* 430 (4%, M), 321 (12, M − PhS), 275 (28, M − SO_2Tol) and 70 (100, C_4H_8N).

(2RS,3SR)-2-*Methyl*-3-[4-(1-*methyl*-1,2,3,6-*tetrahydropiperidyl*)]-3-*phenylthiopropylamine* **48**.—A solution of the amine *anti*-**45** (35 mg, 0.12 mmol) and TsOH (138 mg, 0.72 mmol) in CH_2Cl_2 (1 cm^3) was heated under reflux in a foil-wrapped flask under argon for 6 h. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (3 g) with (50:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the *amine* **48** (27 mg, 82%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (25:8:1)] 0.37; ν_{max}(film)/cm^{-1} 3340 and 3260 (NH) and 1580 (Ph); δ_H($CDCl_3$) 7.57–7.16 (5 H, m, Ph), 5.24 (1 H, br s, HC=C), 3.51 (1 H, d, *J* 9.0, C*H*SPh), 2.94 (1 H, br d, *J* 14.7, NCH_AH_BC=C), 2.79 (1 H, dd, *J* 12.8 and 4.4, NCH_AH_BC=C), 2.73–2.31 (5 H, m, C$H_2$$NH_2$ and MeNCH_2C*H*), 2.28 (3 H, m, NMe), 2.23–2.05 (1 H, m, ring NCH_2C*H*), 2.04–1.70 (3 H, m, NH_2 and C*H*Me) and 1.15 (3 H, d, *J* 6.7, CH*Me*) (Found: M^+, 276.1640. $C_{16}H_{24}N_2S$ requires M, 276.1660); *m/z* 276 (0.2%, M), 167 (100, M − PhS) and 110 (61, PhSH).

(3RS,4RS)- *and* (3RS,4SR)-3-*Hydroxy*-6-*methyl*-4-(*phenylthio*)*heptanonitrile* **50**.—Butyllithium (3.5 cm^3, 5.3 mmol) was added to a solution of diisopropylamine (0.74 cm^3, 5.3 mmol) in dry THF (20 cm^3) under argon at −5 °C. After 30 min the solution was cooled to −78 °C and a solution of acetonitrile (0.26 cm^3, 5.05 mmol) in dry THF (10 cm^3) was added. After 40 min a solution of the aldehyde **49**[7] (1.0 g, 4.8 mmol) in dry THF (5 cm^3) was added. After a further 20 min the mixture was poured into saturated aq. NH_4Cl (50 cm^3) and was extracted with diethyl ether (3 × 40 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (50 g) with (4:1) hexane–diethyl ether as eluent to give a 3:1 mixture of the *nitrile* **50** (750 mg, 62%) as an oil, R_f [hexane–diethyl ether (1:1)] 0.38; ν_{max}(film)/cm^{-1} 3440 (OH), 2445 (CN), and 1580 (Ph); δ_H($CDCl_3$) 7.47–7.41 (2 H, m, Ph), 7.37–7.28 (3 H, m, Ph), 3.99–3.92 and 3.88–3.80 (1 H, m, and m, C*H*OH), 3.28 and 3.22 (1 H, dt and dt, *J* 10.4 and 4.0, and 9.8 and 5.5, C*H*SPh), 2.76–2.50 (3 H, m, OH and CH_2CN), 2.09–1.95 (1 H, m, C*H*Me_2), 1.54–1.32 (2 H, m, CH_2CS) and 0.99–0.92 (6 H, m, CH*Me*$_2$); δ_C($CDCl_3$) 133.28, 132.80, 132.66, 132.41, 129.35, 129.29, 127.97, 127.86, 117.38, 69.27, 69.00, 53.34, 53.13, 39.36, 37.49, 25.43, 25.36, 23.40, 23.13, 22.96, 22.49, 21.42 and 21.21 (Found: M^+, 249.1172. $C_{14}H_{19}NOS$ requires M, 249.1188); *m/z* 249 (10%, M), 179 (34, M − C_3H_4NO), 123 (100, M − PhS − OH) and 110 (27, PhSH).

(3RS,4RS)-*and*(3RS,4SR)-1-*Amino*-6-*methyl*-4-(*phenylthio*)-*heptan*-3-*ol* **51**.—Lithium aluminium hydride (300 mg, 7.9 mmol) was added to a solution of the nitrile **50** (670 mg, 2.7 mmol) in dry diethyl ether (12 cm^3) under argon at 0 °C. After 5 h the mixture was poured into aq. NaOH (50 cm^3; 0.2 mol dm^{-3}) and aq. sodium potassium tartrate (50 cm^3; 0.1 mol dm^{-3}) and was extracted with CH_2Cl_2 (4 × 40 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (21 g) with elution with (75:8:1) CH_2Cl_2–EtOH–aq. NH_3 to give a 2:1 mixture of the *amine* **51** (526 mg, 77%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_2 (75:8:1)] 0.11; ν_{max}(film)/cm^{-1} 3360 and 3280 (NH), 3170 (OH) and 1580 (Ph); δ_H($CDCl_3$) 7.46–7.39 (2 H, m, Ph), 7.30–7.16 (3 H, m, Ph), 3.93–3.83 (1 H, m, C*H*OH), 3.21 and 3.12 (1 H, m, C*H*SPh), 3.10–3.03 (1 H, m, NCH_AH_B), 2.89–2.77 (1 H, m, NCH_AH_B), 2.71–2.49 (2 H, br s, NH_2), 2.01–1.90 (1 H, m, C*H*Me_2), 1.74–1.39 (4 H, m, CH_2CS and CH_2CO), 0.92 and 0.92 (3 H, d and d, *J* 6.6 and 6.7, Me) and 0.88 and 0.87 (3 H, d and d, *J* 6.5 and 6.5, Me); δ_C($CDCl_3$) 135.93, 135.88, 131.61, 131.09, 128.84, 126.63, 126.39, 74.55, 74.07, 54.50, 53.32, 40.88, 40.56, 39.44, 39.17, 34.77, 33.83, 25.47, 23.38, 23.30, 21.68 and 21.58 (Found: M^+ + H, 254.1573. $C_{14}H_{24}$-NOS requires M +H, 254.1579); *m/z* 254 (0.3%, M + H), 253 (0.1, M), 180 (12, M − C_3H_8NO), 123 (26, $C_8H_{13}N$) and 74 (100, C_3H_8NO).

(3RS,4RS)- *and* (3RS,3SR)-N-[3-*Hydroxy*-6-*methyl*-4-(*phenylthio*)*heptyl*]*tosylamide* **52**.—Toluene-*p*-sulfonyl chloride (230 mg, 1.21 mmol) was added to a mixture of the amine **51** (292 mg, 1.15 mmol) and DMAP (146 mg, 1.21 mmol) in dry CH_2Cl_2 (7 cm^3) under argon at room temperature. After 3 h the solution was poured into brine (50 cm^3)–HCl (5 cm^3; 0.01 mol dm^{-3}) and was extracted with CH_2Cl_2 (3 + 40 cm^3). The combined extracts were dried (Na_2SO_4) and evaporated to give an oil, which was triturated in diethyl ether to give a solid (437 mg, 93%) of which one-half (235 mg) was purified by HPLC with (10:12:1) CH_2Cl_2–hexane–diethyl ether as eluent to give the (3RS,4SR)-*sulfonamide* anti-**52** (141 mg, 56%) as needles, m.p. 104–105 °C; R_f [diethyl ether:hexane (2:1)] 0.35; ν_{max}-($CHCl_3$)/cm^{-1} 3300 (NH) and 1580 (Ph); δ_H($CDCl_3$) 7.71 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.40–7.24 (7 H, m, Ph and $SO_2C_6H_2$), 5.21–4.95 (1 H, br s, NH), 3.63 (1 H, dt, *J* 10.3 and 2.8, C*H*OH), 3.19–3.08 (2 H, m, C*H*SPh and NCH_AH_B), 3.03–2.94 (1 H, m, NCH_AH_B), 2.41 (3 H, s, Ar*Me*), 2.11–1.68 (1 H, br s, OH), 1.93–1.82 (1 H, sym. m, C*H*Me_2), 1.63–1.22 (4 H, m, 2 × CH_2), 0.92 (3 H, d, *J* 6.6, Me) and 0.85 (3 H, d, *J* 6.5, Me); δ_C($CDCl_3$) 143.21, 136.98, 134.32, 132.03, 129.64, 129.16, 127.37, 127.05, 71.34, 54.90, 41.48, 37.85, 31.99, 25.49, 23.36, 21.48 and 21.35 (Found: M^+, 407.1549. $C_{21}H_{29}NO_3S_2$ requires M, 407.1589); *m/z* 407 (4%, M), 228 (61, M − C_5H_{10}SPh), 184 (100, CH_2NHSO_2Tol), 180 (90, C_5H_{11}SPh), 155 (59, SO_2Tol), 123 (77, $C_8H_{13}N$), 110 (52, PhSH) and 91 (73, C_6H_4Me); and the (3RS,4RS)-*sulfonamide* syn-**52** as a 5:1 (3*RS*,4*RS*):(3*RS*,4*SR*) mixture (84 mg, 33%) as an oil, R_f [diethyl ether–hexane (2:1)] 0.35; ν_{max}($CHCl_3$)/cm^{-1} 3300 (NH) and 1580 (Ph); δ_H-($CDCl_3$) 7.74–7.70 (2 H, m, $SO_2C_6H_2$), 7.41–7.26 (7 H, m, Ph and $SO_2C_6H_2$), 5.25–5.02 (1 H, br s, NH), 3.48 (1 H, td, *J* 6.8 and 2.8, C*H*OH), 3.16–3.11 (1 H, m, C*H*SPh), 3.04–3.01 (1 H, m, NCH_AH_B), 2.93–2.85 (1 H, m, NCH_AH_B), 2.41 (3 H, s, Ar*Me*), 2.10–1.93 (1 H, m, C*H*Me_2), 1.79–1.48 (4 H, m, OH, CH_2CH and CH_AH_BCH), 1.30–1.21 (1 H, m, CH_AH_BCH), 0.89 (3 H, d, *J* 6.7, Me) and 0.82 (3 H, d, *J* 6.5, Me); δ_C($CDCl_3$) 143.23, 136.90, 133.41, 132.73, 129.64, 129.05, 127.55, 127.05, 72.03, 55.35, 41.08, 39.66, 32.64, 25.32, 23.34, 21.48 and 21.35 (Found: M^+, 407.154 39. $C_{21}H_{29}NO_3S_2$ requires M, 407.1589); *m/z* 407 (4%, M), 228 (61, M − C_5H_{10}SPh), 184 (100, CH_2NHSO_2Tol), 180 (90, C_5H_{11}SPh), 155 (59, SO_2Tol), 123 (77, $C_8H_{13}N$), 110 (52, PhSH) and 91 (73, C_6H_4Me).

Rearrangement of (3RS,4SR)-N-[3-*Hydroxy*-6-*methyl*-4-(*phenylthio*)*heptyl*]*tosylamide* anti-**52**.—TMSOTf(23 mm^3, 0.12 mmol) was added to a solution of the sulfonamide *anti*-**52** (44 mg, 0.11 mmol) in CH_2Cl_2 (2 cm^3) under argon at −78 °C. The solution was allowed to warm slowly to room temperature over a period of 4 h. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (6 g) and eluted with (1:1) hexane–diethyl ether to give the *pyrrolidine* anti-**53** (40.5 mg, 96%) as an oil, R_f [diethyl ether–hexane (1:1)] 0.58; ν_{max}(film)/cm^{-1} 1600 and 1580 (Ar) and 1340 (SO_2); δ_H($CDCl_3$) 7.74 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.35 (2 H, m, $SO_2C_6H_2$), 7.24–7.20 (3 H, m, Ph), 7.11–7.06 (2 H, m, Ph), 3.58–3.34 (4 H, m, CH_2N, CHN and C*H*SPh), 2.47 (3 H, s, Ar*Me*), 2.25–2.20 (1 H, m, C*H*Me_2), 1.78–1.67 (2 H, m, CH_2), 1.44–1.38 (2 H, m, CH_2), 0.88 (3 H, d, *J* 6.4, Me) and 0.73 (3 H, d, *J* 6.4, Me); δ_C($CDCl_3$) 143.24, 133.95, 133.70, 132.02, 129.40, 128.83, 127.82, 127.35, 64.13, 51.00, 47.01, 46.05, 29.49, 25.47, 23.42, 21.48 and 21.17 (Found: M^+,

389.1471. $C_{21}H_{27}NO_2S_2$ requires M, 389.1483); *m/z* 389 (3%, M), 332 (86, M − C_4H_9), 161 (51, C_4H_4SPh), 155 (48, SO_2Tol) and 91 (100, C_6H_4Me).

Rearrangement of (3RS,4RS)-N-[3-*Hydroxy*-6-*methyl*-4-(*phenylthio*)*heptyl*]*tosylamide* syn-**52**.—In the same way as for the pyrrolidine *anti*-**53**, the 5:1 (*syn*:*anti*) mixture of the sulfonamide **52** (44 mg, 0.11 mmol) and TMSOTf (23 mm^3, 0.12 mmol) gave a 5:1 (*syn*:*anti*) mixture of the *pyrrolidine* **53** (40.5 mg, 96%) as an oil, R_f [diethyl ether–hexane (1:1)] 0.55; ν_{max}(film)/cm^{-1} 1580 (Ar) and 1340 (SO_2); δ_H($CDCl_3$) 7.75–7.67 (2 H, m, $SO_2C_6H_2$), 7.37–7.10 (7 H, m, Ph and $SO_2C_6H_2$), 3.92–3.84 (1 H, m, SCCHN), 3.55–3.38 (2 H, m, NCH_2), 2.91 (1 H, dt, *J* 10.9 and 6.7, C*H*SPh), 2.43 (3 H, s, Ar*Me*), 1.99–1.77 (3 H, m, C*H*Me_2 and CH_2), 1.42–1.33 (2 H, m, CH_2), 0.94 (3 H, d, *J* 6.7, Me) and 0.86 (3 H, d, *J* 6.4, Me); δ_C($CDCl_3$) 143.60, 135.10, 134.86, 130.38, 129.79, 128.97, 127.33, 126.87, 60.74, 48.38, 46.18, 38.52, 29.98, 24.17, 23.48, 21.66 and 21.53 (Found: M^+, 389.1493. $C_{21}H_{27}NO_2S_2$ requires M, 389.1483); *m/z* 389 (16%, M), 332 (100, M − C_4H_9), 161 (45, C_4H_4SPh), 98 (63) and 91 (82, C_6H_4Me).

4-*Methyl*-5-*oxo*-4-(*phenylthio*)*hexanonitrile* **55**.—A solution of the ketone **54**[15] (240 mg, 1.33 mmol) in dry THF (2 cm^3) was added to light petroleum-washed NaH (59 mg, 1.47 mmol) suspended in dry THF (6 cm^3) under argon at room temperature. After 30 min the mixture was heated to reflux and a mixture of 3-bromopropiononitrile (0.132 cm^3, 1.6 mmol) and tetrabutylammonium iodide (147 mg, 0.4 mmol) in THF (1 cm^3) was added. After 30 min saturated aq. NH_4Cl (50 cm^3) was added and the mixture was extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (25 g) with (2:1) light petroleum (40–60 °C)–diethyl ether as eluent to give the *ketone* **55** (257 mg, 83%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (2:1)] 0.16; ν_{max}(film)/cm^{-1} 2250 (CN), 1690 (C=O) and 1580 (Ph); δ_H($CDCl_3$) 7.42–7.29 (5 H, m, Ph), 2.53–2.32 (2 H, m, CH_2CN), 2.41 (3 H, s, COMe), 2.13–1.90 (2 H, m, CH_2CS) and 1.46 (3 H, s, PhSC*Me*); δ_C($CDCl_3$) 136.06, 129.93, 129.24, 129.19, 119.43, 58.82, 31.35, 24.78, 20.68 and 12.85 (Found: M^+, 233.0880. $C_{13}H_{15}NOS$ requires M, 233.0875); *m/z* 233 (0.8%, M) and 190 (100, M − COMe).

(2RS,3RS)- *and* (2RS,3SR)-6-*Amino*-3-*methyl*-3-(*phenylthio*)*hexan*-2-*ol* **56**.—In the same way as for the amine **51**, the ketone **55** (206 mg, 0.88 mmol) and $LiAlH_4$ (133 mg, 3.5 mmol) gave the amine **56** (118 mg, 56%, 2.2:1 *syn*:*anti*) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (50:8:)] 0.18; ν_{max}(film)/cm^{-1} 3355 and 3285 (NH and OH) and 1580 (Ph); δ_H($CDCl_3$) 7.52–7.48 (2 H, m, Ph), 7.37–7.28 (3 H, m, Ph), 3.62 and 3.54 (1 H, q and q, *J* 6.4, and 6.3, C*H*OH), 2.69 (2 H, br t, *J* 6.4, NCH_2), 2.00 (3 H, br s, OH and NH_2), 1.95–1.84 (1 H, m, CH), 1.68–1.41 (3 H, m, CH_2CH), 1.16 and 1.15 (3 H, d and d, *J* 6.3 and 6.4, CH*Me*) and 1.13 and 1.10 (3 H, s, and s, PhSC*Me*); δ_C($CDCl_3$) 137.48, 137.08, 130.36, 130.26, 129.07, 129.00, 128.79, 128.67, 70.52, 70.11, 60.16, 58.82, 58.18, 42.55, 42.43, 33.45, 31.80, 28.28, 28.06, 22.87, 18.41 and 16.33 (Found: M^+ − C_2H_4O, 195.1074. $C_{11}H_{17}NS$ requires M − C_2H_4O, 195.1082); *m/z* 195 (31%, M − C_2H_4O), 110 (97, PhSH), 86 (100, M − C_2H_4O − PhS) and 84 (61, M − C_2H_5O − PhSH).

(4RS,5RS)- *and* (4RS,5SR)-N-[5-*Hydroxy*-4-*methyl*-4-(*phenylthio*)*hexyl*]*tosylamide* **57**.—In the same way as for the sulfonamide **52**, the amine **56** (82 mg, 0.34 mmol) and TsCl (69 mg, 0.36 mmol) gave, after purification by HPLC and elution with (10:1) CH_2Cl_2–diethyl ether, the (4*RS*,5*RS*)-sulfonamide *syn*-**57** (86 mg, 64%) as an oil, R_f [CH_2Cl_2–diethyl ether (10:1)] 0.29; ν_{max}(film)/cm^{-1} 3460 (OH), 3250 (NH), 1595 (Ar) and 1150 (SO_2); δ_H($CDCl_3$) 7.71 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.45–7.27 (7 H, m, Ph and $SO_2C_6H_2$), 4.35 (1 H, br t, *J* 5.9, NH), 3.44 (1 H, q, *J* 6.4, C*H*Me), 2.92 (2 H, q,* *J* 6.7, NCH_2), 2.41 (3 H, s, Ar*Me*), 1.98–1.88 (1 H, m, CH), 1.70–1.58 (3 H, m, CH_2 and OH), 1.39–1.11 (1 H, m, C*H*CMe), 1.08 (3 H, d, *J* 6.4, CH*Me*) and 1.05 (3 H, s, PhSC*Me*) (Found: M^+ − C_2H_4O, 349.1187. $C_{18}H_{23}NO_2S_2$ requires M − C_2H_4O, 349.1171); *m/z* 349 (2%, M − C_2H_4O), 155 (58, SO_2Tol), 110 (60, PhSH) and 91 (100, C_6H_4Me); and the (4*RS*,5*SR*)-sulfonamide *anti*-**57** (29 mg, 22%) as an oil, R_f [CH_2Cl_2–diethyl ether (10:1)] 0.25; ν_{max}(film)/cm^{-1} 3470 (NH), 3260 (OH), 1600 (Ar) and 1155 (SO_2); δ_H($CDCl_3$) 7.75 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.47–7.28 (7 H, m, Ph and $SO_2C_6H_2$), 4.36 (1 H, br s, NH), 3.52 (1 H, q, *J* 6.3, C*H*Me), 3.00–2.92 (2 H, m, NCH_2), 2.24 (3 H, s, Ar*Me*), 1.85–1.49 (5 H, m, OH and CH_2CH_2), 1.09 (3 H, d, *J* 6.3, CH*Me*) and 1.01 (3 H, s, PhSC*Me*) (Found: M^+ − C_2H_4O, 349.1169. $C_{18}H_{23}NO_2S_2$ requires M − C_2H_4O, 349.1171); *m/z* 349 (18%, M − C_2H_4O), 155 (66, SO_2Tol), 110 (62, PhSH) and 91 (100, C_6H_4Me).

Rearrangement of (4RS,5RS)-N-[5-*Hydroxy*-4-*methyl*-4-(*phenylthio*)*hexyl*]*tosylamide* syn-**57**.—In the same way as for the pyrrolidine **53**, the sulfonamide *syn*-**57** (38 mg, 0.097 mmol) and TMSOTf (0.02 cm^3, 0.104 mmol) gave the *pyrrolidine* **58** (32.5 mg, 90%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (2:1)] 0.44; ν_{max}(film)/cm^{-1} 1600 and 1580 (Ar) and 1325 and 1150 (SO_2); δ_H($CDCl_3$) 7.72 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.46–7.42 (2 H, m, Ph), 7.38–7.17 (5 H, m, Ph and $SO_2C_6H_2$), 4.12 (1 H, q, *J* 6.9, C*H*SPh), 3.39–3.27 (2 H, m, CH_2N), 2.40 (3 H, s, Ar*Me*), 2.28–2.14 (1 H, m, CH), 1.87–1.51 (3 H, m, $CHCH_2$), 1.59 (3 H, s, NCMe) and 1.46 (3 H, d, *J* 6.9, CH*Me*); δ_C($CDCl_3$) 142.89, 137.93, 136.12, 131.03, 129.40, 128.94, 127.27, 126.53, 71.58, 53.05, 49.96, 35.68, 25.95, 23.27, 21.44 and 17.81 (Found: M^+, 375.1318. $C_{20}H_{25}NO_2S_2$ requires M, 375.1327); *m/z* 375 (2%, M), 266 (19, M − PhSH), 238 (100, M − C_2H_4SPh) and 91 (51, C_6H_4Me).

Rearrangement of (4RS,5SR)-N-[5-*Hydroxy*-4-*methyl*-4-(*phenylthio*)*hexyl*]*tosylamide* anti-**57**.—In the same way as for the pyrrolidine **53**, the sulfonamide *anti*-**57** (24 mg, 0.06 mmol) and TMSOTf (12.5 mm^3, 0.064 mmol) gave the *pyrrolidine* **59** (22.5 mg, 98%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (2:1)] 0.36; ν_{max}(film)/cm^{-1} 1600 (SO_2); δ_H($CDCl_3$) 7.91 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.58–7.48 (2 H, m, Ph), 7.37–7.21 (5 H, m, Ph and $SO_2C_6H_2$), 4.28 (1 H, q, *J* 6.8, C*H*SPh), 3.46 (1 H, br dd, *J* 12.8 and 3.6, CH_AH_BN), 2.92 (1 H, td, *J* 12.8 and 3.0, CH_AH_BN), 2.41 (3 H, s, Ar*Me*), 2.19–2.10 (1 H, m, CH), 1.66–1.44 (3 H, m, $CHCH_2$) 1.12 (3 H, d, *J* 6.9, CH*Me*) and 1.04 (3 H, s, NCMe) (Found: M^+, 375.1325); *m/z* 375 (10%, M), 266 (100, M − PhSH), 238 (41, M − C_2H_4SPh), 110 (58, PhSH) and 91 (97, C_6H_4Me).

3,5-*Dimethyl*-3-(*phenylthio*)*hexan*-2-*one* **60**.—A solution of the ketone **54** (910 mg, 5.06 mmol) in dry THF (4 cm^3) was added to light-petroleum-washed NaH (212 mg, 5.3 mmol) suspended in dry THF (25 cm^3) under argon at room temperature. After 30 min the mixture was heated to reflux and isobutyl iodide (0.58 cm^3, 5.06 mmol) was added. After 46 h, saturated aq. NH_4Cl (50 cm^3) was added and the mixture was extracted with CH_2Cl_2 (3 × 30 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (100 g) with (20:1) light petroleum (40–60 °C)–diethyl ether as eluent to give the *ketone* **60** (872 mg, 73%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (10:1)] 0.38; ν_{max}(film)/cm^{-1} 1695 (C=O) and 1580 (Ph);

* Reduces to triplet after D_2O shake.

$\delta_H(CDCl_3)$ 7.37–7.27 (5 H, m, Ph), 2.39 (3 H, s, COMe), 1.91–1.66 (3 H, m, CH_2 and $CHMe_2$), 1.33 (3 H, s, MeCS), 0.97 (3 H, d, *J* 6.2, $CHMe_AMe_B$) and 0.83 (3 H, d, *J* 6.4, $CHMe_AMe_B$) (Found: M^+, 236.1229. $C_{14}H_{20}OS$ requires M, 236.1235); *m/z* 236 (3.5%, M), 193 (68, M – COMe), 137 (100, PhSCHMe) and 110 (32, PhSH).

5,7-*Dimethyl*-4-*oxo*-5-(*phenylthio*)*octanonitrile* **61**.—Butyllithium (2.3 cm^3, 3.45 mmol) was added to a solution of diisopropylamine (0.53 cm^3, 3.76 mmol) in dry THF (25 cm^3) under argon at 0 °C. After 15 min the solution was cooled to −78 °C and a mixture of the ketone **60** (740 mg, 3.14 mmol) and HMPA (1.2 cm^3, 6.9 mmol) in dry THF (12 cm^3) was added dropwise. After 40 min bromoacetonitrile (0.26 cm^3, 3.76 mmol) was added and the mixture was stirred for 15 min before being poured into saturated aq. NH_4Cl (50 cm^3) and was extracted with CH_2Cl_2 (3 × 50 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (30 g) with (10:1) light petroleum (40–60 °C)–diethyl ether as eluent to give the *ketone* **61** (664 mg, 77%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (10:1)] 0.07; ν_{max}(film)/cm^{-1} 2230 (CN), 1700 (C=O) and 1580 (Ph); $\delta_H(CDCl_3)$ 7.39–7.29 (5 H, m, Ph), 3.34 (1 H, dt, *J* 18.0 and 7.3, CH_AH_BCO), 3.02 (1 H, dt, *J* 18.0 and 7.3, CHN),2.58 (2 H, t, *J* 7.3, CH_2N), 1.87–1.68 (3 H, m, $CHMe_2$), 1.39 (3 H, s, Me), 0.97 (3 H, d, *J* 6.2, $CHMe_AMe_B$) and 0.79 (3 H, d, *J* 6.4, $CHMe_AMe_B$); $\delta_C(CDCl_3)$ 203.17, 136.37, 130.00, 129.60, 128.89, 119.17, 59.58, 45.14, 32.16, 25.55, 24.52, 23.21, 20.64 and 12.04 (Found: M^+, 275.1340. $C_{16}H_{21}NOS$ requires M, 275.1344); *m/z* 275 (8%, M), 193 (100, M – $OCCH_2CH_2CN$) and 137 (76, PhSCHMe).

(4RS,5RS)- *and* (4RS,5SR)-1-*Amino*-5,7-*dimethyl*-5-(*phenylthio*)*octan*-4-*ol* **62**.—Lithium aluminium hydride (340 mg, 8.9 mmol) was added to a solution of the ketone **61** (615 mg, 2.23 mmol) in dry diethyl ether (20 cm^3) under argon at 0 °C. After 90 min the mixture was poured into aq. NaOH (50 cm^3; 0.2 mol dm^{-3}) and aq. sodium potassium tartrate (50 cm^3; 0.2 mol dm^{-3}) and was extracted with CH_2Cl_2 (4 × 40 cm^3). The combined extracts were dried (Na_2SO_4) and evaporated to give a 1:3:1 mixture of the amine **62** (603 mg, 96%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (50:8:1)] 0.28; ν_{max}(film)/cm^{-1} 3340, and 3270 (NH), 3150 (OH) and 1580 (Ph); $\delta_H(CDCl_3)$ 7.60–7.49 (2 H, m, Ph), 7.41–7.27 (3 H, m, Ph), 3.26 (1 H, t, *J* 7.8, CHOH), 2.89–2.73 (1 H, m, NCH_AH_B), 2.70–2.59 (1 H, m, NCH_AH_B), 2.56–2.23 (3 H, br s, OH and NH_2), 2.18–1.86 (2 H, m, CH_2), 1.73–1.20 (5 H, m, CHMe and 2 × CH_2), 1.22 and 1.15 (3 H, s and s, Me), 0.99 (3 H, d, *J* 6.6, $CHMe_AMe_B$) and 0.98 and 0.94 (3 H, d and d, *J* 6.6 and 6.8, $CHMe_AMe_B$); $\delta_C(CDCl_3)$ 137.49, 137.30, 131.10, 130.62, 128.84, 128.71, 128.55, 128.53, 75.65, 59.66, 59.56, 44.09, 43.20, 42.08, 31.28, 31.09, 29.41, 28.59, 25.47, 25.31, 25.11, 25.04, 24.44, 23.09 and 21.12 (Found: M^+ – $CH_2CH_2CH_2NH_2$, 233.1161. $C_{13}H_{19}OS$ requires M – C_3H_8N, 233.1157); *m/z* 233 (0.3%, M – $CH_2CH_2CH_2NH_2$), 193 (10, $C_6H_{11}SPh$), 137 (18, C_2H_4SPh) and 88 (100, $C_4H_{10}NO$).

(4RS,5RS)- *and* (4RS,5SR)-N-[4-*Hydroxy*-5,7-*dimethyl*-5-(*phenylthio*)*octyl*]*tosylamide* **63**.—In the same was as for the sulfonamide **52**, the amine **62** (201 mg, 0.715 mmol) and TsCl (143 mg, 0.75 mmol) gave an oil (285 mg, 92%), which was purified by HPLC and elution with (10:1) CH_2Cl_2–diethyl ether to give the (4*RS*,5*RS*)-sulfonamide *syn*-**63** (121 mg, 39%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.27; ν_{max}(film)/cm^{-1} 3480 (NH), 3260 (OH) and 1600 (Ph); $\delta_H(CDCl_3)$ 7.71 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.49–7.26 (7 H, m, Ph and $SO_2C_6H_2$), 5.10–4.72 (1 H, br s, NH), 3.12 (1 H, dd, *J* 10.0 and 2.0, CHOH), 2.97–2.88 (2 H, sym. m, CH_2N), 2.41 (3 H, s, Ar*Me*), 2.03–1.97 (1 H, sym. m, $CHMe_2$), 1.65–1.25 (7 H, m, OH, CH_2CHMe_2, and $CH_2CH_2CH_2N$), 1.09 (3 H, s, MeCS), 1.00 (3 H, d, *J* 6.7, $CHMe_AMe_B$) and 0.99 (3 H, d, *J* 6.6, $CHMe_AMe_B$); $\delta_C(CDCl_3)$ 143.13, 137.46, 137.01, 129.74, 129.59, 129.20, 128.80, 127.07, 75.31, 59.93, 43.20, 42.26, 27.36, 27.15, 25.54, 25.06, 24.46, 23.43 and 21.48 (Found: M^+ – PhS, 326.1789. $C_{17}H_{28}NO_3S$ requires M – C_6H_5S, 326.1790); *m/z* 326 (5%, M – PhS), 242 (76, M – $C_6H_{12}SPh$), 155 (48, SO_2Tol) and 91 (100, C_6H_4Me); and the (4*RS*,5*SR*)-sulfonamide *anti*-**63** (112 mg, 36%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (300:8:1)] 0.25; ν_{max}(film)/cm^{-1} 3475 (NH), 3260 (OH) and 1600 (Ph); $\delta_H(CDCl_3)$, 7.72 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.48–7.27 (7 H, m, Ph and $SO_2C_6H_2$), 5.03–4.74 (1 H, br s, NH), 3.16 (1 H, d, *J* 10.3, CHOH), 3.00–2.92 (2 H, sym. m, CH_2N), 2.41 (3 H, s, Ar*Me*), 2.19–2.15 (1 H, m, $CHMe_2$), 1.70–1.50 (5 H, m, OH and $CH_2CH_2CH_2N$), 1.30–1.08 (2 H, m, CH_2CHMe_2), 1.13 (3 H, s, MeCS), 0.98 (3 H, d, *J* 6.5, $CHMe_AMe_B$) and 0.90 (3 H, d, *J* 6.8, $CHMe_AMe_B$); $\delta_C(CDCl_3)$ 143.12, 136.99, 130.21, 129.58, 129.03, 128.78, 127.05, 74.64, 61.14, 44.25, 43.19, 27.83, 27.21, 25.26, 24.86, 24.52, 21.45 and 19.53 (Found: M^+ – PhS, 306.1778. $C_{17}H_{28}NO_3S$ requires M – C_6H_5S, 326.1790); *m/z* 306 (12%, M – PhS), 242 (100, M – $C_6H_{12}SPh$), 193 (58, $C_6H_{11}SPh$), 155 (57, SO_2Tol), 110 (63, PhSH) and 91 (99, C_6H_4Me).

Rearrangement of (4RS,5SR)-N-[4-*Hydroxy*-5,7-*dimethyl*-5-(*phenylthio*)*octyl*]*tosylamide* anti-**63**.—In the same way as for the pyrrolidine **53**, the sulfonamide *anti*-**63** (50 mg, 0.115 mmol) and TMSOTf (24.4 mm^3, 0.126 mmol) gave the *pyrrolidine* **64** (27 mg, 77%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (4:1)] 0.29; ν_{max}(film)/cm^{-1} 1600 (Ar) and 1345 and 1160 (SO_2); $\delta_H(CDCl_3)$ 7.69 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.28 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 5.16 (1 H, d, *J* 9.1, HC=C), 3.93 (1 H, t, *J* 6.2, C=CCHN), 3.48–3.32 (2 H, m, CH_2N), 2.53–2.32 (1 H, m, $CHMe_2$), 2.41 (3 H, s, Ar*Me*), 1.89–1.56 (4 H, m, CH_2Cl_2), 1.52 (3 H, d, *J* 1.2, C=CMe), 0.94 (3 H, d, *J* 6.6, $CHMe_AMe_B$) and 0.90 (3 H, d, *J* 6.7, $CHMe_AMe_B$); $\delta_C(CDCl_3)$ 142.96, 135.53, 134.19, 131.96, 129.38, 127.50, 66.52, 49.39, 31.56, 26.90, 23.97, 22.77, 21.48 and 12.43 (Found: M^+, 307.1610. $C_{17}H_{25}NO_2S$ requires M, 307.1606); *m/z* 307 (7%, M), 224 (100, M – C_6H_{11}), 155 (65, SO_2Tol), 152 (57, M – SO_2Tol) and 91 (77, C_6H_4Me); and the *pyrrolidine* **65** (6 mg, 17%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether (4:1)] 0.41; ν_{max}(film)/cm^{-1} 1600 (Ar) and 1320 and 1150 (SO_2); $\delta_H(CDCl_3)$ 7.70 (2 H, d, *J* 8.2, $SO_2C_6H_2$), 7.24 (2 H, d, *J* 8.2, $SO_2C_6H_2$), 3.83 (1 H, dt, *J* 13.8 and 3.7, CH_AH_BN), 3.19 (1 H, td, *J* 13.8 and 2.5, CH_AH_BN), 2.40 (3 H, s, Ar*Me*), 1.80 (1 H, dd, *J* 13.6 and 5.2, ring HCC=C), 1.74–1.40 (6 H, m, CH_2CHMe_2 and NCH_2CH_2CH), 1.42 (3 H, s, MeC=C) and 0.92 (6 H, t, *J* 6.1, Me_2C) (Found: M^+, 307.1602); *m/z* 307 (0.04%, M), 252 (100, M – C_4H_7), 155 (30, SO_2Tol) and 91 (47, C_6H_4Me).

Rearrangement of (4RS,5RS)-N-[4-*Hydroxy*-5,7-*dimethyl*-5-(*phenylthio*)*octyl*]*tosylamide* syn-**63**.—In the same way as for the pyrrolidine **53**, the sulfonamide *syn*-**63** (41.5 mg, 0.095 mmol) and TMSOTf (20 mm^3, 0.105 mmol) gave the pyrrolidine **63** (23 mg, 79%) as an oil, characterization as before, and the pyrrolidine **65** (2 mg, 7%) as an oil, characterization as before.

(4RS,5RS)-N-[5,7-*Dimethyl*-5-*phenylthio*-4-(*trimethylsiloxy*)-*octyl*]*tosylamide* **66**.—TMSOTf (11.6 mm^3, 0.06 mmol) was added to a solution of the sulfonamide *syn*-**63** (25 mg, 0.057 mmol) in dry THF (1 cm^3) under argon at −78 °C. After 20 min the solution was poured into brine (10 cm^3) and was extracted with CH_2Cl_2 (2 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (7 g) with (2:1) light petroleum (40–60 °C)–diethyl ether as eluent to to give the sulfonamide **66** (15 mg, 51%) as an oil, R_f [light petroleum (40–60 °C)–diethyl ether

(2:1)] 0.34; ν_{max}(film)/cm^{-1} 3270 (NH), 1600 (OH), and 1325 and 1160 (SO_2); δ_H($CDCl_3$) 7.75 (2 H, d, *J* 8.3, $SO_2C_6H_2$), 7.49–7.45 (2 H, m, Ph), 7.32–7.23 (5 H, m, Ph and $SO_2C_6H_2$), 4.44 (1 H, br t, *J* 6.1, NH), 3.42 (1 H, dd, *J* 9.0 and 1.8, CHO), 2.96 (2 H, q, *J* 6.6, CH_2N), 2.42 (3 H, s, Ar*Me*), 2.05–1.91 (1 H, sym. m, C*H*Me_2), 1.82–1.24 (6 H, m, CH_2CS and $CH_2CH_2CH_2N$), 1.06 (3 H, s, MeCS), 0.94 (3 H, d, *J* 6.7, $CHMe_AMe_B$), 0.93 (3 H, d, *J* 6.6, $CHMe_AMe_B$) and −0.02 (9 H, s, $SiMe_3$); δ_C($CDCl_3$) 143.16, 137.48, 137.24, 129.61, 129.23, 128.32, 128.24, 127.10, 80.11, 58.16, 46.38, 43.52, 29.82, 27.64, 26.95, 25.46, 25.18, 24.48, 21.50 and 0.86 (Found: M^+ − PhS, 398.2186. $C_{20}H_{36}NO_3SSi$ requires M − C_6H_5S, 398.2185); *m*/*z* 398 (6%, M − PhS), 224 (100, $C_4H_6NHSO_2Tol$), 155 (70, SO_2Tol), 110 (62, PhSH), 91 (70, C_6H_4Me) and 73 (72, $SiMe_3$).

(3RS,4SR)-3,8-*Dimethyl*-4-*phenylthio*-1,8-*diazaspiro*[4.5]*decane* anti-**67**.—*Method A* (*red-Al*). Sodium bis(2-methoxyethoxy)aluminium hydride (red-Al) (26 mm^3, 0.19 mmol) was added to a mixture of sulfonamide *anti*-**47** (20 mg, 0.046 mmol) in benzene (1 cm^3) under argon at room temperature. The solution was heated under reflux for 6 h, poured into aq. NaOH (10 cm^3; 0.2 mol dm^{-3}) and aq. sodium potassium tartrate (5 cm^3; 0.2 mol dm^{-3}), and extracted with CH_2Cl_2 (3 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (4 g) with elution with (50:8:1) CH_2Cl_2–EtOH–aq. NH_3 to give the *amine* anti-**67** (7.5 mg, 58%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (50:8:1)] 0.40; ν_{max}($CHCl_3$)/cm^{-1} 1580 (Ph); δ_H($CDCl_3$) 7.47–7.42 (2 H, m, Ph), 7.30–7.15 (3 H, m, Ph), 3.15 (1 H, dd, *J* 11.3 and 8.4, CH_AH_BN), 2.78–2.65 (2 H, m, NCH_2), 2.72 (1 H, d, *J* 10.1, C*H*SPh), 2.53 (1 H, dd, *J* 11.3 and 8.1, CH_AH_BN), 2.43–2.08 (4 H, m, NCH_2, NH and C*H*Me), 2.28 (3 H, s, NMe), 2.06 (1 H, td, *J* 13.0 and 4.1, NCH_2CH^{ax}), 1.93 (1 H, td, *J* 13.0 and 4.5, NCH_2CH^{ax}), 1.45 (1 H, ddd, *J* 13.3, 5.5 and 2.8, NCH_2CH^{eq}), 1.29 (1 H, ddd, *J* 13.3, 5.5 and 2.7, NCH_2CH^{eq}) and 1.14 (3 H, d, *J* 6.6, CH*Me*) (Found: M^+, 276.1657. $C_{16}H_{24}N_2S$ requires M, 276.1660); *m*/*z* 276 (9%, M), 275 (11, M − H), 167 (100, M − PhS) and 110 (38, PhSH).

Method B (*sodium naphthalenide*). Sodium metal (200 mg) was added to naphthalene (280 mg, recrystallized from MeOH) in freshly distilled 1,2-dimethoxyethane (6 cm^3) under argon at room temperature. The resulting green solution was stirred at 0 °C for 2 h, and a fraction of this (1.5 cm^3) was added to a solution of the sulfonamide *anti*-**47** (61 mg, 0.14 mmol) in dry 1,2-dimethoxyethane (1 cm^3) under argon at −65 °C. After 15 min the mixture was quenched with aq. NH_4Cl (5 cm^3), poured into saturated aq. $NaHCO_3$ (40 cm^3), and extracted with CH_2Cl_2 (4 × 20 cm^3). The combined extracts were dried (Na_2SO_4), evaporated, and purified by column chromatography on silica gel (4 g) with (75:8:1) CH_2Cl_2–EtOH–aq. NH_3 as eluent to give the amine *anti*-**67** (17 mg, 43%) as an oil, characterization as before.

(3RS,4RS)-3,8-*Dimethyl*-4-*phenylthio*-1,8-*diazaspiro*[4.5]-*decane* syn-**67**.—In the same way as for the amine *anti*-**67**, the sulfonamide *syn*-**47** (55 mg, 0.13 mmol) and red-Al (72 mm^3, 0.51 mmol) gave the *amine* syn-**67** (24 mg, 68%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (75:8:1)] 0.31; ν_{max}(film)/cm^{-1} 3280 (NH) and 1580 (Ph); δ_H($CDCl_3$) 7.44–7.33 (2 H, m, Ph), 7.30–7.11 (3 H, m, Ph), 3.34 (1 H, d, *J* 7.5, C*H*SPh), 3.20 (1 H, ddd, *J* 13.3, 6.4 and 3.9, CH_AH_BNH), 2.71–2.58 (4 H, m, NCH_2, NCH and CH_AH_BNH), 2.38–2.21 (2 H, m, NCH and NH), 2.28 (3 H, s, NMe), 2.13–1.84 (3 H, m, C*H*Me and NCH_2CH_2), 1.62 (1 H, ddd, *J* 13.4, 5.8 and 2.7, NCH_2CH^{eq}), 1.43 (1 H, ddd, *J* 13.4, 5.8 and 2.9, NCH_2CH^{eq}) and 1.10 (3 H, d, *J* 6.8, CH*Me*) (Found: M^+, 276.1667. $C_{16}H_{24}N_2S$ requires M, 276.1660); *m*/*z* 276 (12%, M), 275 (15, M − H), 167 (100, M − PhS) and 58 (76, C_3H_8N).

3,8-*Dimethyl*-1-*tosyl*-1,8-*diazaspiro*[4.5]*decane* **68**.—Raney nickel (1 g; 50% slurry in water) was added to a solution of the sulfonamide *anti*-**47** (49 mg, 0.114 mmol) in ethanol (1.5 cm^3) under argon at room temperature. The mixture was heated under reflux for 30 min, and was then filtered through Celite and washed with ethanol (100 cm^3). The solvent was evaporated off under reduced pressure to give the *sulfonamide* **68** (24 mg, 65%) as needles, m.p. 117–118 °C; R_f [CH_2Cl_2–EtOH–aq. NH_3 (100:8:1)] 0.55; ν_{max}($CHCl_3$)/cm^{-1} 1330 (Ph); δ_H($CDCl_3$) 7.71 (2 H, d, *J* 8.2, $SO_2C_6H_2$), 7.23 (2 H, d, *J* 8.2, $SO_2C_6H_2$), 3.64 (1 H, t, *J* 8.3, CH_AH_BNS), 2.86–2.72 [4 H, m, $N(CH_2)_2$], 2.64–2.42 (1 H, m, CH_AH_BNS), 2.38 (3 H, s, Ar*Me*), 2.35–2.10 (1 H, m, C*H*Me), 2.22 (3 H, s, NMe), 2.04–1.81 (2 H, m, $NCH_2CH_2^{ax}$), 1.47 (1 H, dd, *J* 13.0 and 2.5, NCH_2CH^{eq}), 1.32–1.00 [3 H, m, $CH_2CH(Me)CH_2N$ and NCH_2CH^{eq}] and 0.99 (3 H, d, *J* 6.3, CH*Me*) (Found: M^+, 322.1716. $C_{17}H_{26}N_2O_2S$ requires M, 322.1715); *m*/*z* 322 (6%, M), 167 (58, M − SO_2Tol) and 70 (100, C_4H_8N) (Found: C, 63.1; H, 8.1; N, 8.7; S, 10.0. $C_{17}H_{26}N_2O_2S$ requires C, 63.32; H, 8.13; N, 8.69; S, 9.94%).

[1RS,2'RS(E)]-2-(3'-*Amino*-2'-*methylpropylidene*)*cyclohexanol* anti-**69**.—Sodium perborate (62 mg, 0.4 mmol) was added to a solution of the allylic sulfide *anti*-**14** (101 mg, 0.39 mmol) in glacial acetic acid (1.5 cm^3) under nitrogen at room temperature. After 4 h, water (20 cm^3) and aq. NaOH (8 cm^3; 10%) were added and the mixture was extracted with CH_2Cl_2 (4 × 30 cm^3). The combined extracts were dried (Na_2SO_4) and evaporated to give the sulfoxide, to which, in MeOH (4 cm^3), was added trimethyl phosphite (0.09 cm^3, 0.77 mmol) and the solution was refluxed for 10 min. The solvent was evaporated off under reduced pressure and the residue was purified by column chromatography on silica gel (6 g) and eluted with (50:8:1) CH_2Cl_2–EtOH–aq. NH_3 to give the *allylic alcohol* anti-**69** (42 mg, 64%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (80:8:1)] 0.06; ν_{max}($CHCl_3$) 3600 (OH), 3360 (NH_2), 1650 (C=C) and 1600 (NH bend); δ_H($CDCl_3$) 5.09 (1 H, d, *J* 8.4, HC=C), 4.07 (1 H, dd, *J* 6.7 and 2.3, C*H*OH), 2.73–2.59 (1 H, m, CH_AH_BN), 2.55–2.42 (2 H, m, CH_AH_BN and OH), 2.07–1.38 (11 H, m, C_4H_8, C*H*Me and NH_2) and 0.94 (3 H, d, *J* 6.2, CH*Me*); δ_C($CDCl_3$) 142.97, 124.58, 73.21, 48.03, 36.07, 34.07, 27.57, 26.38, 22.73 and 19.17 (Found: M^+ − H, 168.1383. $C_{10}H_{18}NO$ requires M − H, 168.1388); *m*/*z* 168 (3%, M − H), 122 (100, M − OH − CH_2NH_2), 107 (54, C_8H_{11}), 93 (33, C_7H_9) and 79 (46).

[1RS,2'SR(E)]-2-(3'-*Amino*-2'-*methylpropylidene*)*cyclohexanol* syn-**69**.—In the same way as for the alcohol *anti*-**69**, the allylic sulfide *syn*-**14** (104 mg, 0.4 mmol) gave the allylic alcohol *syn*-**69** (46 mg, 68%) as an oil, R_f [CH_2Cl_2–EtOH–aq. NH_3 (75:8:1)] 0.05; ν_{max}($CHCl_3$)/cm^{-1} 3330 and 3260 (NH_2) and 1585 (NH bend); δ_H($CDCl_3$) 5.11 (1 H, d, *J* 8.1, HC=C), 4.06 (1 H, br t, *J* 4.1, C*H*OH), 2.66–2.37 (3 H, m, C*H*Me and CH_2N), 1.96 (3 H, br s, NH_2 and OH), 1.90–1.68 (4 H, m, C_4H_4), 1.63–1.34 (4 H, m, C_4H_4) and 0.94 (3 H, d, *J* 6.2, CH*Me*); δ_C($CDCl_3$) 142.99, 123.76, 73.13, 48.45, 36.55, 34.66, 27.71, 27.05, 23.41 and 18.98 (Found: M^+ − H_2O, 151.1367. $C_{10}H_{17}N$ requires M − H_2O, 151.1361); *m*/*z* 151 (7%, M − H_2O), 122 (100, M − H_2O − CH_2NH) and 109 (43).

Acknowledgements

We thank the SERC for a grant (to I. C.) and Glaxo Group Research (Ware) for a CASE award (to I. C.).

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Paper 3/01126G
Received 25*th February* 1993
Accepted 8*th April* 1993