

**(1*R*,5*S*,8*R*)-1,8-Dihydroxy-6-oxa-3-azabicyclo-
[3.2.1]octan-2-one**Francesco Punzo,^{a*‡} David J. Watkin,^b Michela Iezzi Simone^c and George W. J. Fleet^c^aDipartimento di Scienze Chimiche, Facoltà di Farmacia, Università di Catania, Viale A. Doria 6, 95125 Catania, Italy, ^bDepartment of Chemical Crystallography, Chemical Research Laboratory, Mansfield Road, Oxford OX1 3TA, England, and ^cDepartment of Organic Chemistry, Chemical Research Laboratory, Mansfield Road, Oxford OX1 3TA, England

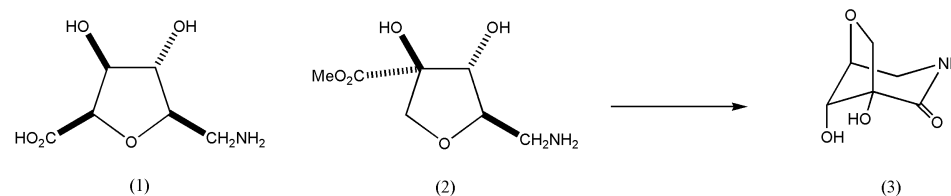
‡ Current address: Visiting Scientist at the Department of Chemical, Crystallography, Chemical Research Laboratory, Mansfield Road, Oxford OX1 3TA, England

Correspondence e-mail:
francesco.punzo@chemistry.oxford.ac.uk**Key indicators**Single-crystal X-ray study
T = 190 K
Mean $\sigma(\text{C}-\text{C}) = 0.002 \text{ \AA}$
R factor = 0.028
wR factor = 0.069
Data-to-parameter ratio = 9.7For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.The crystal structure of the title bicyclic lactam, C₆H₉NO₄, has firmly established the stereochemistry of the branched δ -sugar amino acid scaffold.

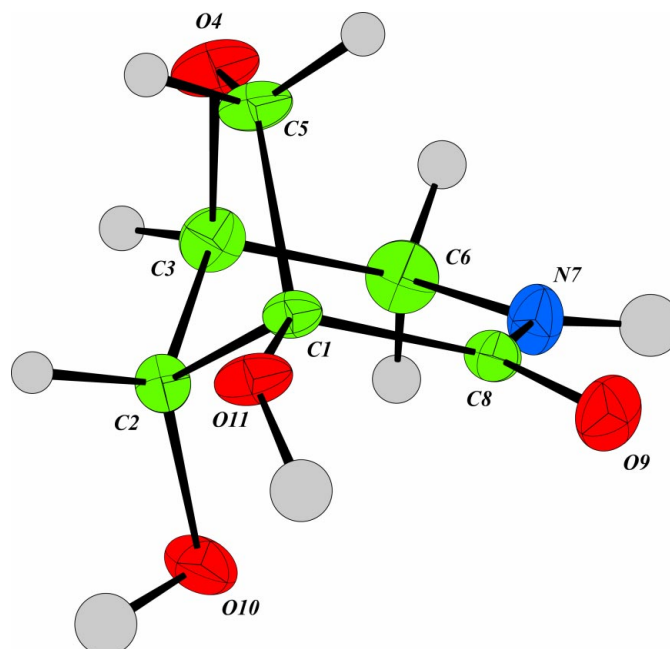
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CommentSugar amino acids (SAA) have been extensively investigated as peptidomimetics (Chakraborty *et al.*, 2004). δ -Tetrahydrofuran (THF) SAA have been shown to be dipeptide isosteres (Grotenberg *et al.*, 2004; van Well *et al.*, 2003); in particular, those THF SAA which have the carboxylic acid and amino methyl components *cis* to each other, as in (1) (see scheme), almost invariably induce β -turn-like structures in their homooligomers (Smith *et al.*, 1998, 2003).

Most such THF SAA have been derived from carbohydrates and all examples previously have contained a linear

**Figure 1**
The molecular structure of (3), with displacement ellipsoids drawn at the 50% probability level. H-atom radii are arbitrary.

carbon chain. The branched THF SAA scaffold (2), prepared from a branched sugar lactone (Hotchkiss *et al.*, 2004), spontaneously underwent an intramolecular cyclization to form the crystalline bicyclic lactam (3) (Figs. 1 and 2, and Table 1). A number of stereochemical and structural uncertainties in the synthesis of (2) are removed by the X-ray crystallographic analysis of (3).

Experimental

The bicyclic compound was dissolved in methanol in a flask and then crystallized as the solvent slowly evaporated to give colourless plate-like crystals. A suitable piece was cut from a larger crystal.

Crystal data

$C_6H_9NO_4$	Mo $K\alpha$ radiation
$M_r = 159.14$	Cell parameters from 1160 reflections
Orthorhombic, $P2_12_12_1$	$\theta = 5-30^\circ$
$a = 5.9624 (1) \text{ \AA}$	$\mu = 0.13 \text{ mm}^{-1}$
$b = 10.5889 (2) \text{ \AA}$	$T = 190 \text{ K}$
$c = 10.7089 (2) \text{ \AA}$	Block cut from plate, colourless
$V = 676.11 (2) \text{ \AA}^3$	$0.50 \times 0.30 \times 0.20 \text{ mm}$
$Z = 4$	
$D_x = 1.563 \text{ Mg m}^{-3}$	

Data collection

Nonius KappaCCD diffractometer	1158 independent reflections
ω scans	1158 reflections with no $I/\sigma(I)$ cutoff
Absorption correction: multi-scan	$R_{\text{int}} = 0.007$
DENZO/SCALEPACK	$\theta_{\text{max}} = 30.0^\circ$
(Otwinowski & Minor, 1997)	$h = -8 \rightarrow 8$
$T_{\text{min}} = 0.96, T_{\text{max}} = 0.97$	$k = -14 \rightarrow 14$
1981 measured reflections	$l = -14 \rightarrow 15$

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F^*) + 0.035p^2 + 0.136p]$
$R[F^2 > 2\sigma(F^2)] = 0.028$	where $p = [\max(F_o^2, 0) + 2F_c^2]/3$
$wR(F^2) = 0.069$	$(\Delta/\sigma)_{\text{max}} < 0.001$
$S = 1.03$	$\Delta\rho_{\text{max}} = 0.27 \text{ e \AA}^{-3}$
1158 reflections	$\Delta\rho_{\text{min}} = -0.15 \text{ e \AA}^{-3}$
119 parameters	Extinction correction: Larson (1970)
H atoms treated by a mixture of independent and constrained refinement	Extinction coefficient: 160 (40)

Table 1

Selected geometric parameters ($\text{\AA}, ^\circ$).

C1—C2	1.5387 (17)	C3—O4	1.4383 (17)
C1—C5	1.5292 (17)	C3—C6	1.5125 (19)
C1—C8	1.5330 (16)	O4—C5	1.4374 (16)
C1—O11	1.4028 (14)	C6—N7	1.4651 (17)
C2—C3	1.5263 (18)	N7—C8	1.3363 (16)
C2—O10	1.4080 (15)	C8—O9	1.2348 (15)
C2—C1—C5	100.65 (10)	C2—C3—C6	110.98 (10)
C2—C1—C8	107.94 (9)	O4—C3—C6	109.68 (11)
C5—C1—C8	110.19 (10)	C3—O4—C5	109.17 (10)
C2—C1—O11	115.93 (10)	C1—C5—O4	105.12 (10)
C5—C1—O11	109.32 (9)	C3—C6—N7	110.52 (10)
C8—C1—O11	112.17 (10)	C6—N7—C8	125.51 (10)
C1—C2—C3	98.03 (9)	C1—C8—N7	116.23 (10)
C1—C2—O10	114.20 (10)	C1—C8—O9	121.38 (11)
C3—C2—O10	111.84 (10)	N7—C8—O9	122.35 (11)
C2—C3—O4	103.70 (10)		

As the data were collected with molybdenum radiation, there were no measurable anomalous differences, as a consequence of which it

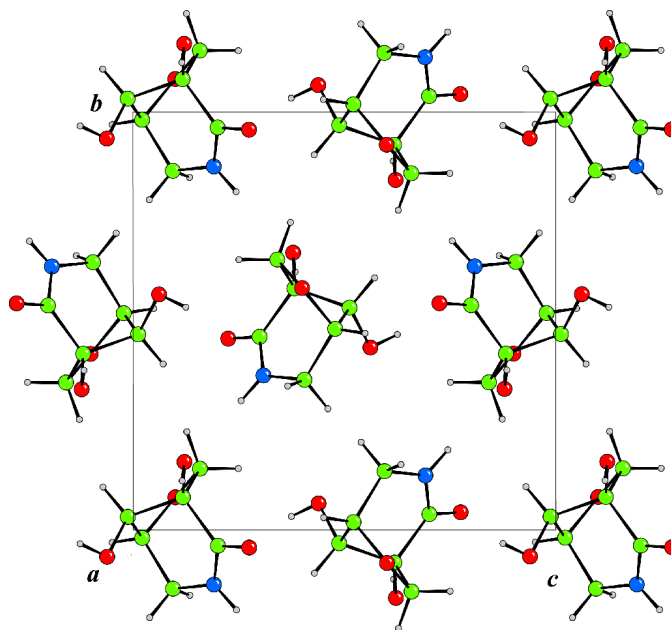


Figure 2
Packing diagram of (3), viewed down the a axis.

was admissible to merge Friedel pairs of reflections. The H atoms were all seen in a difference map but those attached to carbon were placed geometrically. Their positions and U_{iso} were regularized using slack restraints. The refinement was completed using riding constraints for the H atoms bonded to carbon, and retaining the slack restraints for the other H atoms.

Data collection: COLLECT (Nonius, 1997); cell refinement: DENZO/SCALEPACK (Otwinowski & Minor, 1997); data reduction: DENZO/SCALEPACK; program(s) used to solve structure: SIR92 (Altomare *et al.*, 1994); program(s) used to refine structure: CRYSTALS (Betteridge *et al.*, 2003); molecular graphics: CAMERON (Watkin *et al.*, 1996); software used to prepare material for publication: CRYSTALS.

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supporting information

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(1R,5S,8R)-1,8-Dihydroxy-6-oxa-3-azabicyclo[3.2.1]octan-2-one

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(1R,5S,8R)-1,8-Dihydroxy-6-oxa-3-azabicyclo[3.2.1]octan-2-one*Crystal data*

$C_6H_9NO_4$	$F(000) = 336$
$M_r = 159.14$	$D_x = 1.563 \text{ Mg m}^{-3}$
Orthorhombic, $P2_12_12_1$	Mo $K\alpha$ radiation, $\lambda = 0.71073 \text{ \AA}$
Hall symbol: P 2ac 2ab	Cell parameters from 1160 reflections
$a = 5.9624 (1) \text{ \AA}$	$\theta = 5\text{--}30^\circ$
$b = 10.5889 (2) \text{ \AA}$	$\mu = 0.13 \text{ mm}^{-1}$
$c = 10.7089 (2) \text{ \AA}$	$T = 190 \text{ K}$
$V = 676.11 (2) \text{ \AA}^3$	Plate, colourless
$Z = 4$	$0.50 \times 0.30 \times 0.20 \text{ mm}$

Data collection

Nonius KappaCCD diffractometer	1981 measured reflections
Graphite monochromator	1158 independent reflections
ω scans	1158 reflections with no $I/\sigma(I)$ cutoff
Absorption correction: multi-scan	$R_{\text{int}} = 0.007$
DENZO/SCALEPACK (Otwinowski & Minor, 1996)	$\theta_{\text{max}} = 30.0^\circ$, $\theta_{\text{min}} = 5.2^\circ$
$T_{\text{min}} = 0.96$, $T_{\text{max}} = 0.97$	$h = -8 \rightarrow 8$
	$k = -14 \rightarrow 14$
	$l = -14 \rightarrow 15$

Refinement

Refinement on F^2	H atoms treated by a mixture of independent and constrained refinement
Least-squares matrix: full	Method: SHELXL97 (Sheldrick, 1997); $w = 1/[\sigma^2(F^*) + 0.035p^2 + 0.136p]$
$R[F^2 > 2\sigma(F^2)] = 0.028$	where $p = 0.333\max(F_o^2, 0) + (1-0.333)/F_c^2$
$wR(F^2) = 0.069$	$(\Delta/\sigma)_{\text{max}} < 0.001$
$S = 1.03$	$\Delta\rho_{\text{max}} = 0.27 \text{ e \AA}^{-3}$
1158 reflections	$\Delta\rho_{\text{min}} = -0.15 \text{ e \AA}^{-3}$
119 parameters	Extinction correction: Larson (1970).
22 restraints	Crystallographic Computing eq 22
Primary atom site location: structure-invariant direct methods	Extinction coefficient: 160 (40)
Hydrogen site location: inferred from neighbouring sites	

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (\AA^2)

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
C1	0.46908 (19)	0.57839 (11)	0.38206 (11)	0.0155
C2	0.3993 (2)	0.53163 (12)	0.51244 (11)	0.0189
C3	0.1674 (2)	0.48138 (12)	0.47830 (12)	0.0222

O4	0.07521 (16)	0.57859 (10)	0.39976 (11)	0.0281
C5	0.2554 (2)	0.64695 (12)	0.34158 (13)	0.0214
C6	0.1851 (2)	0.35936 (13)	0.40555 (13)	0.0251
N7	0.35777 (19)	0.36957 (10)	0.30873 (10)	0.0225
C8	0.5087 (2)	0.46236 (11)	0.29935 (11)	0.0177
O9	0.66711 (17)	0.45784 (10)	0.22519 (9)	0.0280
O10	0.53826 (18)	0.43619 (9)	0.56141 (9)	0.0264
O11	0.65015 (14)	0.66291 (8)	0.37860 (9)	0.0214
H21	0.389 (2)	0.6029 (13)	0.5712 (13)	0.0227*
H31	0.068 (2)	0.4703 (14)	0.5491 (13)	0.0261*
H51	0.258 (3)	0.7354 (13)	0.3728 (13)	0.0251*
H52	0.237 (3)	0.6469 (13)	0.2507 (12)	0.0251*
H61	0.221 (3)	0.2901 (13)	0.4609 (14)	0.0304*
H62	0.039 (2)	0.3439 (15)	0.3661 (14)	0.0304*
H9	0.7732	0.6178	0.3838	0.0500*
H11	0.5929	0.4673	0.6253	0.0500*
H1	0.3644	0.3088	0.2554	0.0500*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0115 (4)	0.0152 (4)	0.0197 (5)	-0.0004 (4)	-0.0014 (4)	0.0014 (4)
C2	0.0194 (5)	0.0198 (5)	0.0177 (5)	0.0005 (5)	-0.0002 (4)	-0.0013 (4)
C3	0.0167 (5)	0.0264 (6)	0.0234 (5)	-0.0017 (5)	0.0041 (5)	0.0011 (5)
O4	0.0121 (4)	0.0292 (5)	0.0430 (6)	0.0011 (4)	0.0002 (4)	0.0057 (4)
C5	0.0134 (5)	0.0204 (5)	0.0305 (6)	0.0018 (5)	-0.0026 (5)	0.0033 (5)
C6	0.0210 (6)	0.0235 (6)	0.0308 (7)	-0.0081 (5)	0.0017 (5)	0.0002 (5)
N7	0.0228 (5)	0.0201 (5)	0.0245 (5)	-0.0026 (4)	0.0013 (5)	-0.0066 (4)
C8	0.0166 (5)	0.0205 (5)	0.0160 (5)	0.0019 (5)	-0.0015 (4)	0.0005 (4)
O9	0.0227 (4)	0.0349 (5)	0.0263 (4)	0.0006 (4)	0.0083 (4)	-0.0029 (4)
O10	0.0319 (5)	0.0240 (4)	0.0233 (4)	0.0012 (4)	-0.0098 (4)	0.0033 (4)
O11	0.0124 (4)	0.0167 (4)	0.0352 (5)	-0.0020 (3)	-0.0031 (4)	0.0042 (4)

Geometric parameters (Å, °)

C1—C2	1.5387 (17)	C5—H51	0.994 (13)
C1—C5	1.5292 (17)	C5—H52	0.979 (13)
C1—C8	1.5330 (16)	C6—N7	1.4651 (17)
C1—O11	1.4028 (14)	C6—H61	0.967 (13)
C2—C3	1.5263 (18)	C6—H62	0.979 (14)
C2—O10	1.4080 (15)	N7—C8	1.3363 (16)
C2—H21	0.985 (13)	N7—H1	0.861
C3—O4	1.4383 (17)	C8—O9	1.2348 (15)
C3—C6	1.5125 (19)	O10—H11	0.826
C3—H31	0.969 (13)	O11—H9	0.877
O4—C5	1.4374 (16)		
C2—C1—C5	100.65 (10)	C1—C5—H51	109.7 (9)

C2—C1—C8	107.94 (9)	O4—C5—H51	109.9 (9)
C5—C1—C8	110.19 (10)	C1—C5—H52	111.9 (9)
C2—C1—O11	115.93 (10)	O4—C5—H52	110.4 (9)
C5—C1—O11	109.32 (9)	H51—C5—H52	109.7 (11)
C8—C1—O11	112.17 (10)	C3—C6—N7	110.52 (10)
C1—C2—C3	98.03 (9)	C3—C6—H61	110.3 (9)
C1—C2—O10	114.20 (10)	N7—C6—H61	109.6 (9)
C3—C2—O10	111.84 (10)	C3—C6—H62	107.6 (9)
C1—C2—H21	110.5 (8)	N7—C6—H62	109.3 (9)
C3—C2—H21	111.3 (9)	H61—C6—H62	109.5 (12)
O10—C2—H21	110.4 (8)	C6—N7—C8	125.51 (10)
C2—C3—O4	103.70 (10)	C6—N7—H1	116.531
C2—C3—C6	110.98 (10)	C8—N7—H1	117.916
O4—C3—C6	109.68 (11)	C1—C8—N7	116.23 (10)
C2—C3—H31	114.0 (9)	C1—C8—O9	121.38 (11)
O4—C3—H31	108.2 (9)	N7—C8—O9	122.35 (11)
C6—C3—H31	110.0 (9)	C2—O10—H11	104.724
C3—O4—C5	109.17 (10)	C1—O11—H9	107.130
C1—C5—O4	105.12 (10)		
