



# Full wwPDB NMR Structure Validation Report ⓘ

Apr 27, 2016 – 12:14 AM BST

PDB ID : 2L8M  
Title : Reduced and CO-bound cytochrome P450cam (CYP101A1)  
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Deposited on : 2011-01-19

This is a Full wwPDB NMR Structure Validation Report for a publicly released PDB entry.  
We welcome your comments at [validation@mail.wwpdb.org](mailto:validation@mail.wwpdb.org)  
A user guide is available at  
<http://wwpdb.org/validation/2016/NMRValidationReportHelp>  
with specific help available everywhere you see the ⓘ symbol.

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The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

Cyrange : Kirchner and Güntert (2011)  
NmrClust : Kelley et al. (1996)  
MolProbity : 4.02b-467  
Mogul : 1.7.1 (RC1), CSD as537be (2016)  
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)  
RCI : v\_1n\_11\_5\_13\_A (Berjanski et al., 2005)  
PANAV : Wang et al. (2010)  
ShiftChecker : rb-20027457  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : rb-20027457

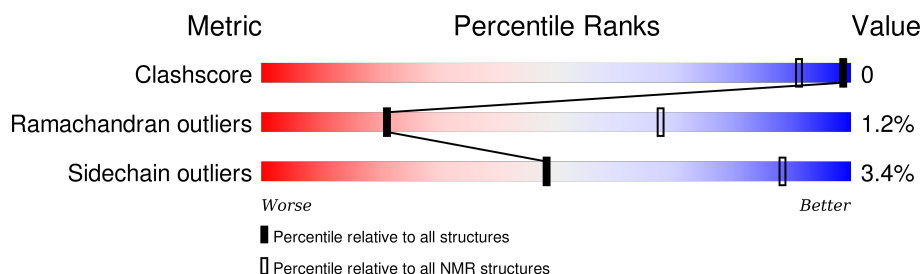
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 23%.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	NMR archive (#Entries)
Clashscore	114402	11133
Ramachandran outliers	111179	9975
Sidechain outliers	111093	9958

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and a grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions  $\leq 5\%$ .

Mol	Chain	Length	Quality of chain
1	A	415	 75% 21% . .

## 2 Ensemble composition and analysis ⓘ

This entry contains 1 models. Identification of well-defined residues and clustering analysis are not possible.

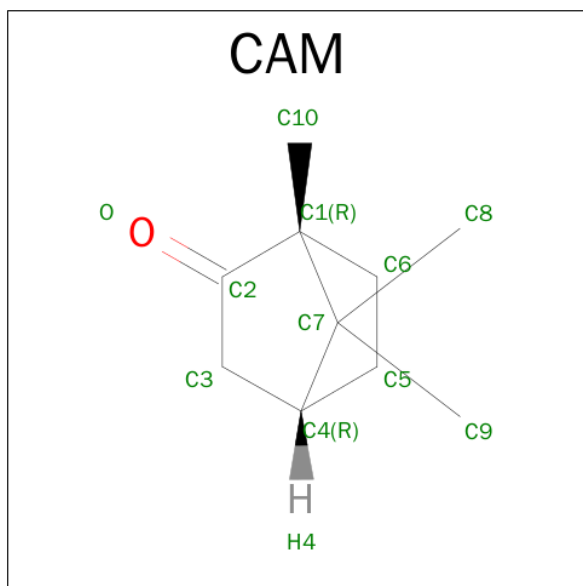
### 3 Entry composition [i](#)

There are 7 unique types of molecules in this entry. The entry contains 16111 atoms, of which 9627 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Camphor 5-monooxygenase.

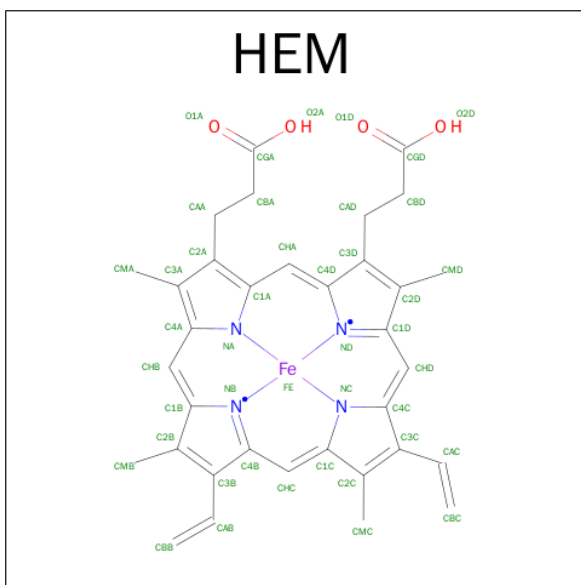
Mol	Chain	Residues	Atoms						Trace
1	A	405	Total	C	H	N	O	S	0
			6365	2033	3157	560	597	18	

- Molecule 2 is CAMPHOR (three-letter code: CAM) (formula:  $C_{10}H_{16}O$ ).



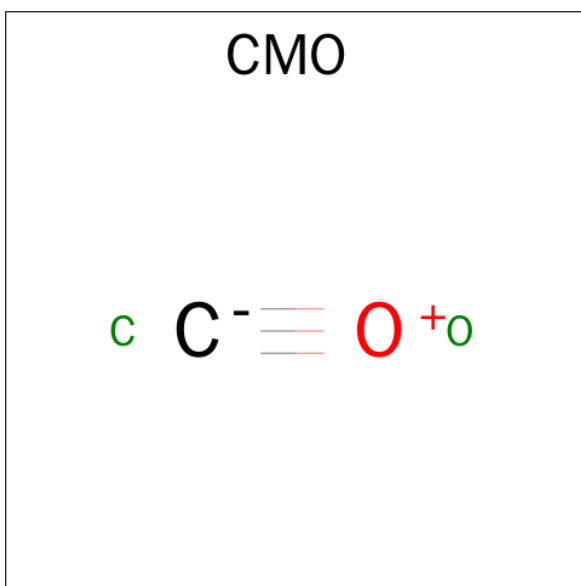
Mol	Chain	Residues	Atoms			
2	A	1	Total	C	H	O
			27	10	16	1

- Molecule 3 is PROTOPORPHYRIN IX CONTAINING FE (three-letter code: HEM) (formula:  $C_{34}H_{32}FeN_4O_4$ ).



Mol	Chain	Residues	Atoms					
3	A	1	Total	C	Fe	H	N	O
			73	34	1	30	4	4

- Molecule 4 is CARBON MONOXIDE (three-letter code: CMO) (formula: CO).



Mol	Chain	Residues	Atoms		
4	A	1	Total	C	O
			2	1	1

- Molecule 5 is POTASSIUM ION (three-letter code: K) (formula: K).

Mol	Chain	Residues	Atoms	
5	A	4	Total	K
			4	4

- Molecule 6 is CHLORIDE ION (three-letter code: CL) (formula: Cl).

Mol	Chain	Residues	Atoms	
6	A	3	Total	Cl
			3	3

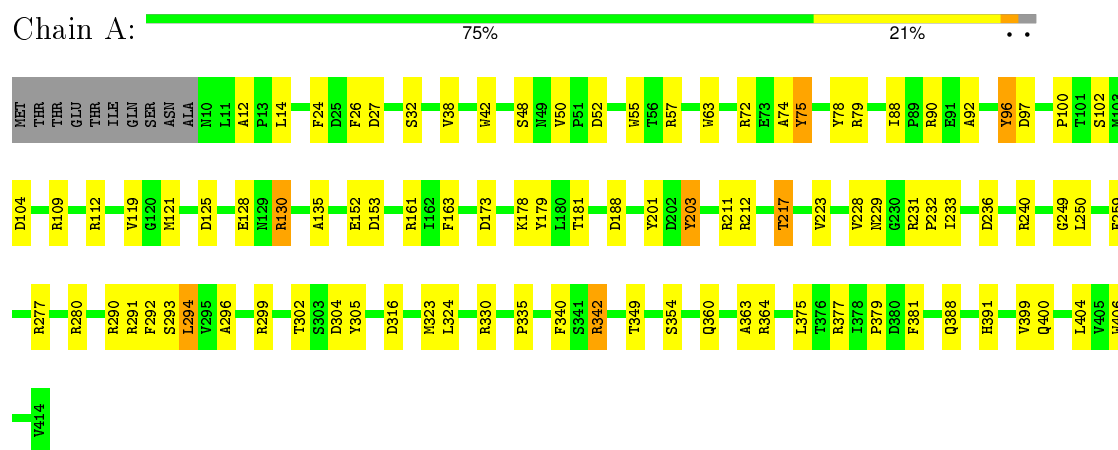
- Molecule 7 is water.

Mol	Chain	Residues	Atoms		
7	A	3213	Total	H	O
			9637	6424	3213

## 4 Residue-property plots

These plots are provided for all protein, RNA and DNA chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. Stretches of 2 or more consecutive residues without any outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

- Molecule 1: Camphor 5-monooxygenase



## 5 Refinement protocol and experimental data overview

The models were refined using the following method: *molecular dynamics*.

Of the 18 calculated structures, 1 were deposited, based on the following criterion: *structures with the least restraint violations*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
AMBER	refinement	10

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	2l8m_cs.str
Number of chemical shift lists	1
Total number of shifts	1189
Number of shifts mapped to atoms	1189
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	23%

No validations of the models with respect to experimental NMR restraints is performed at this time.

## 6 Model quality

### 6.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: CMO, HEM, K, CAM, CL

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with  $|Z| > 5$  is considered an outlier worth inspection. RMSZ is the (average) root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	#Z>5	RMSZ	#Z>5
1	A	1.51	14/3287 (0.4%)	1.92	80/4465 (1.8%)
All	All	1.51	14/3287 (0.4%)	1.92	80/4465 (1.8%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	Chirality	Planarity
1	A	0	11
All	All	0	11

All bond outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	152	GLU	CG-CD	6.46	1.61	1.51
1	A	100	PRO	N-CD	-6.15	1.39	1.47
1	A	32	SER	CA-CB	-5.95	1.44	1.52
1	A	354	SER	CA-CB	5.90	1.61	1.52
1	A	128	GLU	CD-OE2	-5.85	1.19	1.25
1	A	179	TYR	CE1-CZ	5.79	1.46	1.38
1	A	48	SER	CA-CB	5.75	1.61	1.52
1	A	335	PRO	N-CD	-5.74	1.39	1.47
1	A	377	ARG	CZ-NH1	-5.52	1.25	1.33
1	A	203	TYR	CG-CD1	5.35	1.46	1.39
1	A	399	VAL	N-CA	5.32	1.56	1.46
1	A	302	THR	CB-OG1	-5.21	1.32	1.43
1	A	102	SER	CB-OG	5.16	1.49	1.42
1	A	211	ARG	CZ-NH1	-5.07	1.26	1.33

All angle outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	291	ARG	NE-CZ-NH1	16.95	128.77	120.30
1	A	280	ARG	NE-CZ-NH1	15.19	127.89	120.30
1	A	291	ARG	NE-CZ-NH2	-14.43	113.08	120.30
1	A	90	ARG	NE-CZ-NH1	12.18	126.39	120.30
1	A	231	ARG	NE-CZ-NH2	-11.85	114.38	120.30
1	A	96	TYR	CB-CG-CD2	-11.45	114.13	121.00
1	A	231	ARG	NE-CZ-NH1	11.19	125.89	120.30
1	A	299	ARG	NE-CZ-NH2	-11.09	114.75	120.30
1	A	305	TYR	CB-CG-CD1	-9.90	115.06	121.00
1	A	330	ARG	NE-CZ-NH1	9.68	125.14	120.30
1	A	78	TYR	CB-CG-CD1	-9.34	115.40	121.00
1	A	130	ARG	NE-CZ-NH2	9.18	124.89	120.30
1	A	130	ARG	NE-CZ-NH1	9.15	124.88	120.30
1	A	96	TYR	CB-CG-CD1	9.02	126.41	121.00
1	A	299	ARG	NE-CZ-NH1	8.77	124.69	120.30
1	A	280	ARG	NE-CZ-NH2	-8.48	116.06	120.30
1	A	26	PHE	CB-CG-CD2	8.37	126.66	120.80
1	A	130	ARG	NH1-CZ-NH2	-8.36	110.20	119.40
1	A	112	ARG	NE-CZ-NH1	8.14	124.37	120.30
1	A	377	ARG	NE-CZ-NH1	8.00	124.30	120.30
1	A	316	ASP	CB-CG-OD1	7.96	125.47	118.30
1	A	381	PHE	CB-CG-CD2	-7.96	115.23	120.80
1	A	125	ASP	CB-CG-OD2	7.81	125.33	118.30
1	A	90	ARG	NH1-CZ-NH2	-7.65	110.99	119.40
1	A	163	PHE	CB-CG-CD2	-7.60	115.48	120.80
1	A	290	ARG	NE-CZ-NH1	-7.50	116.55	120.30
1	A	340	PHE	CB-CG-CD1	6.93	125.65	120.80
1	A	78	TYR	CB-CG-CD2	6.72	125.03	121.00
1	A	72	ARG	NE-CZ-NH1	6.70	123.65	120.30
1	A	27	ASP	CB-CG-OD2	6.41	124.07	118.30
1	A	296	ALA	CB-CA-C	6.27	119.51	110.10
1	A	57	ARG	NE-CZ-NH2	-6.27	117.17	120.30
1	A	340	PHE	CB-CG-CD2	-6.21	116.45	120.80
1	A	305	TYR	CG-CD1-CE1	-6.19	116.35	121.30
1	A	153	ASP	N-CA-CB	-6.15	99.53	110.60
1	A	212	ARG	NE-CZ-NH1	6.14	123.37	120.30
1	A	161	ARG	CD-NE-CZ	6.14	132.20	123.60
1	A	277	ARG	NE-CZ-NH2	6.08	123.34	120.30
1	A	228	VAL	CA-CB-CG2	5.97	119.85	110.90
1	A	364	ARG	NE-CZ-NH1	5.92	123.26	120.30
1	A	259	PHE	CG-CD1-CE1	-5.87	114.34	120.80
1	A	342	ARG	NE-CZ-NH1	5.86	123.23	120.30
1	A	92	ALA	N-CA-CB	5.84	118.28	110.10

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	78	TYR	CZ-CE2-CD2	5.81	125.03	119.80
1	A	181	THR	O-C-N	5.78	131.95	122.70
1	A	104	ASP	CB-CG-OD2	-5.68	113.19	118.30
1	A	75	TYR	CG-CD2-CE2	-5.67	116.77	121.30
1	A	173	ASP	CB-CG-OD1	-5.62	113.24	118.30
1	A	363	ALA	N-CA-CB	-5.61	102.25	110.10
1	A	236	ASP	CB-CA-C	5.60	121.60	110.40
1	A	79	ARG	NE-CZ-NH2	-5.59	117.50	120.30
1	A	249	GLY	CA-C-O	-5.55	110.60	120.60
1	A	294	LEU	O-C-N	-5.53	113.85	122.70
1	A	26	PHE	CG-CD1-CE1	5.50	126.85	120.80
1	A	232	PRO	O-C-N	-5.50	113.90	122.70
1	A	63	TRP	NE1-CE2-CZ2	5.46	136.41	130.40
1	A	42	TRP	CB-CG-CD2	5.44	133.67	126.60
1	A	135	ALA	CB-CA-C	5.40	118.21	110.10
1	A	14	LEU	N-CA-CB	-5.35	99.70	110.40
1	A	388	GLN	O-C-N	-5.34	114.15	122.70
1	A	78	TYR	CG-CD2-CE2	-5.33	117.03	121.30
1	A	400	GLN	O-C-N	-5.33	114.17	122.70
1	A	163	PHE	CB-CG-CD1	5.33	124.53	120.80
1	A	381	PHE	O-C-N	-5.28	114.25	122.70
1	A	109	ARG	NE-CZ-NH1	5.26	122.93	120.30
1	A	375	LEU	CB-CG-CD1	-5.24	102.09	111.00
1	A	50	VAL	CG1-CB-CG2	-5.23	102.53	110.90
1	A	299	ARG	CD-NE-CZ	5.21	130.90	123.60
1	A	404	LEU	CB-CG-CD1	5.19	119.82	111.00
1	A	79	ARG	CB-CA-C	5.18	120.77	110.40
1	A	26	PHE	CB-CG-CD1	-5.14	117.20	120.80
1	A	406	TRP	CZ3-CH2-CZ2	-5.12	115.45	121.60
1	A	55	TRP	NE1-CE2-CD2	-5.12	102.18	107.30
1	A	74	ALA	CB-CA-C	5.08	117.72	110.10
1	A	130	ARG	CA-CB-CG	5.08	124.58	113.40
1	A	217	THR	CA-CB-CG2	-5.04	105.34	112.40
1	A	290	ARG	CD-NE-CZ	5.04	130.66	123.60
1	A	342	ARG	NE-CZ-NH2	5.04	122.82	120.30
1	A	364	ARG	CD-NE-CZ	5.02	130.62	123.60
1	A	342	ARG	NH1-CZ-NH2	-5.00	113.89	119.40

There are no chirality outliers.

All planar outliers are listed below.

Mol	Chain	Res	Type	Group
1	A	203	TYR	Sidechain
1	A	130	ARG	Sidechain
1	A	240	ARG	Sidechain
1	A	342	ARG	Peptide
1	A	12	ALA	Peptide
1	A	292	PHE	Sidechain
1	A	96	TYR	Sidechain
1	A	75	TYR	Sidechain
1	A	324	LEU	Peptide
1	A	201	TYR	Sidechain
1	A	88	ILE	Mainchain

## 6.2 Too-close contacts [i](#)

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in each chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	3208	3157	3156	2
All	All	6484	9627	3202	2

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 0.

All clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)
1:A:38:VAL:HB	1:A:391:HIS:HB3	0.42	1.92
1:A:223:VAL:O	1:A:233:ILE:HG21	0.42	2.15

## 6.3 Torsion angles [i](#)

### 6.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all PDB entries followed by that with respect to all NMR entries. The Analysed column shows the number of residues for which the backbone conformation was analysed and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	403/415 (97%)	362 (90%)	36 (9%)	5 (1%)	21	68
All	All	403/415 (97%)	362 (90%)	36 (9%)	5 (1%)	21	68

All 5 Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type
1	A	293	SER
1	A	97	ASP
1	A	294	LEU
1	A	217	THR
1	A	379	PRO

### 6.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all PDB entries followed by that with respect to all NMR entries. The Analysed column shows the number of residues for which the sidechain conformation was analysed and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	350/359 (97%)	338 (97%)	12 (3%)	48	88
All	All	350/359 (97%)	338 (97%)	12 (3%)	48	88

All 12 residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type
1	A	250	LEU
1	A	188	ASP
1	A	119	VAL
1	A	229	ASN
1	A	52	ASP
1	A	323	MET
1	A	24	PHE
1	A	121	MET
1	A	349	THR
1	A	304	ASP
1	A	178	LYS
1	A	360	GLN

### 6.3.3 RNA ⓘ

There are no RNA molecules in this entry.

## 6.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

## 6.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 6.6 Ligand geometry ⓘ

Of 10 ligands modelled in this entry, 7 are monoatomic - leaving 3 for Mogul analysis.

In the following table, the Counts columns list the number of bonds for which Mogul statistics could be retrieved, the number of bonds that are observed in the model and the number of bonds that are defined in the chemical component dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length is the number of standard deviations the observed value is removed from the expected value. A bond length with  $|Z| > 2$  is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond lengths.

Mol	Type	Chain	Res	Link	Bond lengths		
					Counts	RMSZ	#Z>2
2	CAM	A	415	-	12,12,12	1.18	0 (0%)
3	HEM	A	416	1,4	24,50,50	1.52	0 (0%)
4	CMO	A	417	3	0,1,1	0.00	-

In the following table, the Counts columns list the number of angles for which Mogul statistics could be retrieved, the number of angles that are observed in the model and the number of angles that are defined in the chemical component dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond angle is the number of standard deviations the observed value is removed from the expected value. A bond angle with  $|Z| > 2$  is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond angles.

Mol	Type	Chain	Res	Link	Bond angles		
					Counts	RMSZ	#Z>2
2	CAM	A	415	-	21,21,21	1.10	0 (0%)
3	HEM	A	416	1,4	16,82,82	2.05	0 (0%)
4	CMO	A	417	3	0,0,0	0.00	-

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the chemical component dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
2	CAM	A	415	-	-	0,0,31,31	0,0,2,2
3	HEM	A	416	1,4	-	0,6,54,54	0,0,8,8
4	CMO	A	417	3	-	0,0,0,0	0,0,0,0

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

## 6.7 Other polymers [i](#)

There are no such molecules in this entry.

## 6.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

## 7 Chemical shift validation

The completeness of assignment taking into account all chemical shift lists is 23% for the well-defined parts and 23% for the entire structure.

### 7.1 Chemical shift list 1

File name: 2l8m\_cs.str

Chemical shift list name: *upload-req-shifts*

#### 7.1.1 Bookkeeping

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	1189
Number of shifts mapped to atoms	1189
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	3

#### 7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	330	$0.97 \pm 0.11$	Should be applied
$^{13}\text{C}_\beta$	266	$1.99 \pm 0.08$	Should be applied
$^{13}\text{C}'$	0	—	—
$^{15}\text{N}$	292	$0.33 \pm 0.20$	None needed ( $< 0.5$ ppm)

#### 7.1.3 Completeness of resonance assignments

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 23%, i.e. 1157 atoms were assigned a chemical shift out of a possible 5043. 0 out of 66 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	893/1965 (45%)	287/780 (37%)	322/810 (40%)	284/375 (76%)
Sidechain	258/2693 (10%)	0/1587 (0%)	258/982 (26%)	0/124 (0%)

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	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Aromatic	6/385 (2%)	3/208 (1%)	0/159 (0%)	3/18 (17%)
Overall	1157/5043 (23%)	290/2575 (11%)	580/1951 (30%)	287/517 (56%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 23%, i.e. 1157 atoms were assigned a chemical shift out of a possible 5043. 0 out of 66 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Backbone	893/1965 (45%)	287/780 (37%)	322/810 (40%)	284/375 (76%)
Sidechain	258/2693 (10%)	0/1587 (0%)	258/982 (26%)	0/124 (0%)
Aromatic	6/385 (2%)	3/208 (1%)	0/159 (0%)	3/18 (17%)
Overall	1157/5043 (23%)	290/2575 (11%)	580/1951 (30%)	287/517 (56%)

#### 7.1.4 Statistically unusual chemical shifts ⓘ

The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	358	LEU	H	2.74	11.47 – 4.97	-8.4
1	A	357	CYS	H	4.04	11.75 – 5.05	-6.5
1	A	349	THR	H	11.82	11.34 – 5.14	5.8

#### 7.1.5 Random Coil Index (RCI) plots ⓘ

The image below reports *random coil index* values for the protein chains in the structure. The height of each bar gives a probability of a given residue to be disordered, as predicted from the available chemical shifts and the amino acid sequence. A value above 0.2 is an indication of significant predicted disorder. The colour of the bar shows whether the residue is in the well-defined core (black) or in the ill-defined residue ranges (cyan), as described in section 2 on ensemble composition.

Random coil index (RCI) for chain A:

