



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 5, 2026 – 07:39 PM UTC

PDB ID : 4EZ1 / pdb_00004ez1
Title : Crystal structure of acetylcholine binding protein (AChBP) from Aplysia Californica in complex with alpha-conotoxin BuIA
Authors : Talley, T.T.; Reger, A.S.; Kim, C.; Sankaran, B.; Ho, K.; Taylor, P.; McIntosh, J.M.
Deposited on : 2012-05-02
Resolution : 2.49 Å(reported)

This is a wwPDB X-ray Structure Validation Summary Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

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

MolProbity	:	4-5-2 with Phenix2.0
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

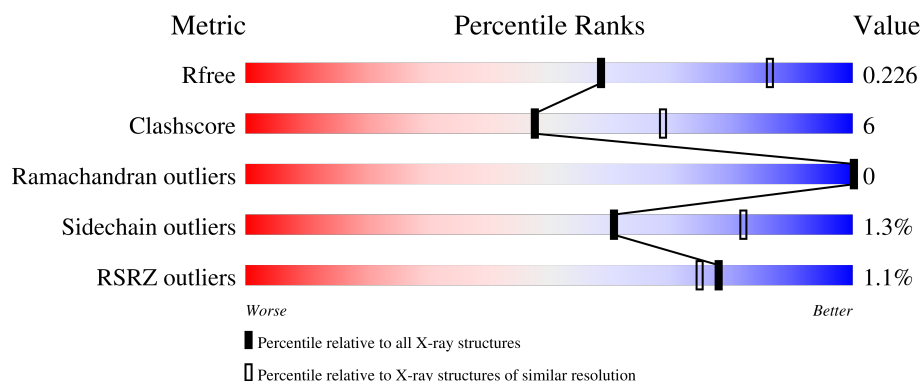
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.49 Å.

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)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	5829 (2.50-2.50)
Clashscore	190562	6492 (2.50-2.50)
Ramachandran outliers	187476	6378 (2.50-2.50)
Sidechain outliers	187428	6380 (2.50-2.50)
RSRZ outliers	180081	5833 (2.50-2.50)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. 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 $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	230	2% 76% 12% 12%
1	B	230	80% 8% 12%
1	C	230	2% 79% 11% 10%
1	D	230	79% 10% 10%
1	E	230	2% 78% 9% 12%

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Mol	Chain	Length	Quality of chain
2	K	14	 64% 29% 7%
2	L	14	 86% 14%
2	M	14	 79% 21%
2	N	14	 86% 14%
2	O	14	 64% 36%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 8714 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called Soluble acetylcholine receptor.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	203	Total	C	N	O	S	0	0	0
			1585	1002	258	316	9			
1	B	203	Total	C	N	O	S	0	0	0
			1600	1014	260	318	8			
1	C	207	Total	C	N	O	S	0	0	0
			1635	1032	265	330	8			
1	D	208	Total	C	N	O	S	0	0	0
			1653	1044	269	332	8			
1	E	202	Total	C	N	O	S	0	0	0
			1599	1013	258	319	9			

There are 55 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-8	ASP	-	expression tag	UNP Q8WSF8
A	-7	TYR	-	expression tag	UNP Q8WSF8
A	-6	LYS	-	expression tag	UNP Q8WSF8
A	-5	ASP	-	expression tag	UNP Q8WSF8
A	-4	ASP	-	expression tag	UNP Q8WSF8
A	-3	ASP	-	expression tag	UNP Q8WSF8
A	-2	ASP	-	expression tag	UNP Q8WSF8
A	-1	LYS	-	expression tag	UNP Q8WSF8
A	0	LEU	-	expression tag	UNP Q8WSF8
A	220	SER	-	expression tag	UNP Q8WSF8
A	221	ARG	-	expression tag	UNP Q8WSF8
B	-8	ASP	-	expression tag	UNP Q8WSF8
B	-7	TYR	-	expression tag	UNP Q8WSF8
B	-6	LYS	-	expression tag	UNP Q8WSF8
B	-5	ASP	-	expression tag	UNP Q8WSF8
B	-4	ASP	-	expression tag	UNP Q8WSF8
B	-3	ASP	-	expression tag	UNP Q8WSF8
B	-2	ASP	-	expression tag	UNP Q8WSF8
B	-1	LYS	-	expression tag	UNP Q8WSF8

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Chain	Residue	Modelled	Actual	Comment	Reference
B	0	LEU	-	expression tag	UNP Q8WSF8
B	220	SER	-	expression tag	UNP Q8WSF8
B	221	ARG	-	expression tag	UNP Q8WSF8
C	-8	ASP	-	expression tag	UNP Q8WSF8
C	-7	TYR	-	expression tag	UNP Q8WSF8
C	-6	LYS	-	expression tag	UNP Q8WSF8
C	-5	ASP	-	expression tag	UNP Q8WSF8
C	-4	ASP	-	expression tag	UNP Q8WSF8
C	-3	ASP	-	expression tag	UNP Q8WSF8
C	-2	ASP	-	expression tag	UNP Q8WSF8
C	-1	LYS	-	expression tag	UNP Q8WSF8
C	0	LEU	-	expression tag	UNP Q8WSF8
C	220	SER	-	expression tag	UNP Q8WSF8
C	221	ARG	-	expression tag	UNP Q8WSF8
D	-8	ASP	-	expression tag	UNP Q8WSF8
D	-7	TYR	-	expression tag	UNP Q8WSF8
D	-6	LYS	-	expression tag	UNP Q8WSF8
D	-5	ASP	-	expression tag	UNP Q8WSF8
D	-4	ASP	-	expression tag	UNP Q8WSF8
D	-3	ASP	-	expression tag	UNP Q8WSF8
D	-2	ASP	-	expression tag	UNP Q8WSF8
D	-1	LYS	-	expression tag	UNP Q8WSF8
D	0	LEU	-	expression tag	UNP Q8WSF8
D	220	SER	-	expression tag	UNP Q8WSF8
D	221	ARG	-	expression tag	UNP Q8WSF8
E	-8	ASP	-	expression tag	UNP Q8WSF8
E	-7	TYR	-	expression tag	UNP Q8WSF8
E	-6	LYS	-	expression tag	UNP Q8WSF8
E	-5	ASP	-	expression tag	UNP Q8WSF8
E	-4	ASP	-	expression tag	UNP Q8WSF8
E	-3	ASP	-	expression tag	UNP Q8WSF8
E	-2	ASP	-	expression tag	UNP Q8WSF8
E	-1	LYS	-	expression tag	UNP Q8WSF8
E	0	LEU	-	expression tag	UNP Q8WSF8
E	220	SER	-	expression tag	UNP Q8WSF8
E	221	ARG	-	expression tag	UNP Q8WSF8

- Molecule 2 is a protein called Alpha-conotoxin BuIA.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	K	14	Total	C	N	O	S	0	0	1
			88	54	14	16	4			

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Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	L	14	Total	C	N	O	S	0	0	1
			88	54	14	16	4			
2	M	14	Total	C	N	O	S	0	0	1
			88	54	14	16	4			
2	N	14	Total	C	N	O	S	0	0	1
			88	54	14	16	4			
2	O	14	Total	C	N	O	S	0	0	1
			88	54	14	16	4			

There are 5 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
K	14	NH2	-	expression tag	UNP P69657
L	14	NH2	-	expression tag	UNP P69657
M	14	NH2	-	expression tag	UNP P69657
N	14	NH2	-	expression tag	UNP P69657
O	14	NH2	-	expression tag	UNP P69657

- Molecule 3 is MANGANESE (II) ION (CCD ID: MN) (formula: Mn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	C	1	Total	Mn	0	0
			1	1		

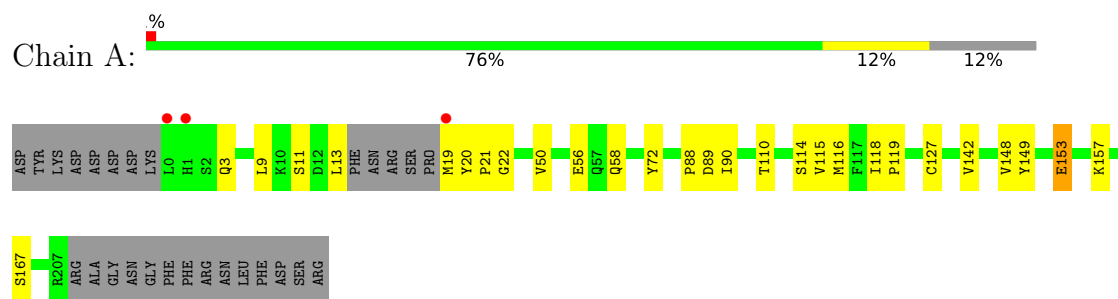
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	39	Total	O	0	0
			39	39		
4	B	36	Total	O	0	0
			36	36		
4	C	39	Total	O	0	0
			39	39		
4	D	44	Total	O	0	0
			44	44		
4	E	42	Total	O	0	0
			42	42		
4	K	1	Total	O	0	0
			1	1		

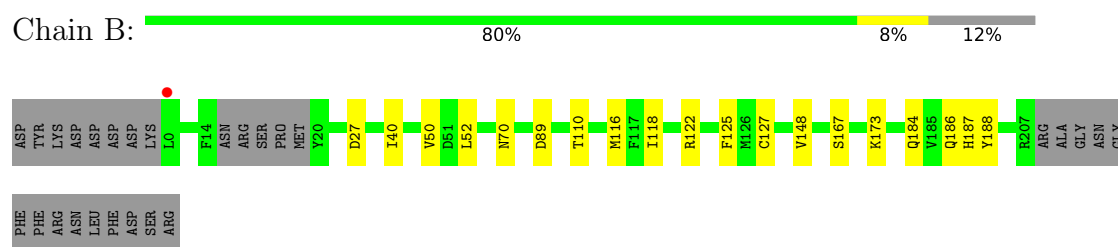
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-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. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

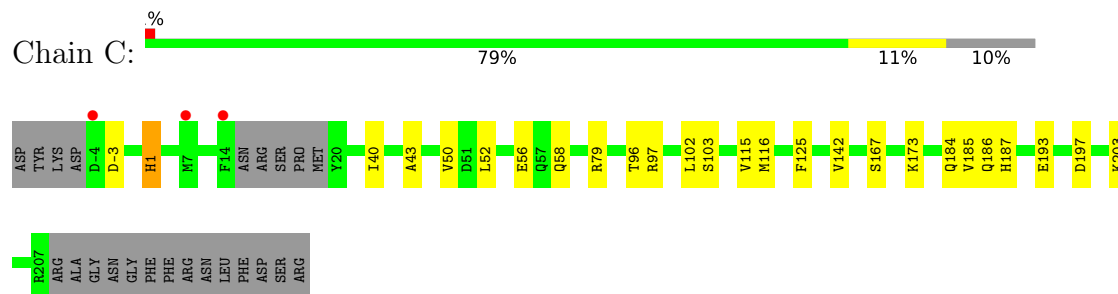
- Molecule 1: Soluble acetylcholine receptor



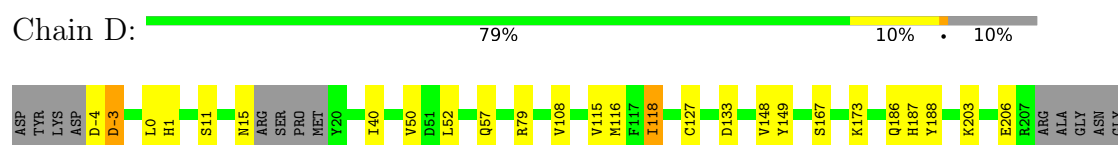
- Molecule 1: Soluble acetylcholine receptor



- Molecule 1: Soluble acetylcholine receptor



- Molecule 1: Soluble acetylcholine receptor



PHE
PHE
ARG
ASN
LEU
PHE
ASP
SER
ARG

- Molecule 1: Soluble acetylcholine receptor

Chain E:  2% 78% 9% 12%

ASP TYR LYS ASP ASP ASP LYS LEU LEU HIS S2 M7 D12 L13 F14 ASN ARG ARG SER PRO M19 Y20 P21 G22 T36 Y55 Y59 M63 M66 Y72 Q105 I106 M116 F117 P129 V132 E136 Y149 E153 I154 D155 T160 D161 S167

R183 R207 ARG ALA GLY ASN GLY PHE PHE ARG ASN LEU PHE ASP SER ARG

- Molecule 2: Alpha-conotoxin BuIA

Chain K:  64% 29% 7%

G1 C2 C3 S4 T5 P6 Y12 C13 NH214

- Molecule 2: Alpha-conotoxin BuIA

Chain L:  86% 14%

G1 S4 NH214

- Molecule 2: Alpha-conotoxin BuIA

Chain M:  79% 21%

G1 C2 C3 S4 A9 NH214

- Molecule 2: Alpha-conotoxin BuIA

Chain N:  86% 14%

G1 S4 NH214

- Molecule 2: Alpha-conotoxin BuIA

Chain O:  64% 36%

G1 C2 C3 S4 T5 P6 P7 NH214

4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	68.44Å 78.64Å 117.64Å 90.00° 93.20° 90.00°	Depositor
Resolution (Å)	45.00 – 2.49 45.00 – 2.49	Depositor EDS
% Data completeness (in resolution range)	98.5 (45.00-2.49) 98.5 (45.00-2.49)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.00 (at 2.48Å)	Xtriage
Refinement program	REFMAC 5.6.0117	Depositor
R, R_{free}	0.171 , 0.227 0.171 , 0.226	Depositor DCC
R_{free} test set	2186 reflections (4.98%)	wwPDB-VP
Wilson B-factor (Å ²)	31.5	Xtriage
Anisotropy	0.645	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 35.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	8714	wwPDB-VP
Average B, all atoms (Å ²)	32.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.94% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: NH2, MN

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 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	1.03	0/1622	0.93	0/2216
1	B	1.07	2/1638 (0.1%)	0.94	0/2235
1	C	1.11	4/1674 (0.2%)	0.95	0/2285
1	D	1.07	1/1692 (0.1%)	0.98	1/2307 (0.0%)
1	E	1.04	0/1637	0.96	0/2233
2	K	0.96	0/89	1.19	3/122 (2.5%)
2	L	1.06	0/89	1.05	0/122
2	M	1.07	0/89	0.94	0/122
2	N	1.07	0/89	1.16	0/122
2	O	0.93	0/89	1.00	0/122
All	All	1.06	7/8708 (0.1%)	0.96	4/11886 (0.0%)

The worst 5 of 7 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	187	HIS	CG-CD2	5.86	1.42	1.35
1	C	187	HIS	CE1-NE2	5.34	1.37	1.32
1	B	187	HIS	CE1-NE2	5.32	1.37	1.32
1	C	97	ARG	C-O	5.28	1.29	1.24
1	C	103	SER	C-O	-5.18	1.19	1.24

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	D	-3	ASP	N-CA-C	-8.37	102.16	111.28
2	K	1	GLY	N-CA-C	-5.51	97.33	113.30
2	K	6	PRO	CA-C-N	-5.15	114.51	119.87
2	K	6	PRO	C-N-CA	-5.15	114.51	119.87

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the 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 within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	1585	0	1498	17	0
1	B	1600	0	1524	18	0
1	C	1635	0	1538	17	2
1	D	1653	0	1573	18	2
1	E	1599	0	1521	21	0
2	K	88	0	81	7	0
2	L	88	0	81	3	0
2	M	88	0	81	3	0
2	N	88	0	81	3	0
2	O	88	0	81	6	0
3	C	1	0	0	0	0
4	A	39	0	0	0	0
4	B	36	0	0	0	0
4	C	39	0	0	0	0
4	D	44	0	0	0	0
4	E	42	0	0	0	0
4	K	1	0	0	0	0
All	All	8714	0	8059	92	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 6.

The worst 5 of 92 close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:E:63:ASN:HA	1:E:66:MET:HE3	1.52	0.92
1:B:184:GLN:HG2	1:B:186:GLN:NE2	1.92	0.85
1:B:167:SER:HB3	2:K:4:SER:HB2	1.62	0.81
1:E:167:SER:HB2	2:M:4:SER:HB2	1.64	0.79
2:K:1:GLY:H2	2:K:4:SER:H	1.30	0.78

All (2) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:-3:ASP:OD1	1:D:-3:ASP:OD1[2_646]	1.98	0.22
1:C:1:HIS:CE1	1:D:-3:ASP:OD2[2_646]	2.02	0.18

5.3 Torsion angles [i](#)

5.3.1 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 X-ray entries followed by that with respect to entries of similar resolution.

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	199/230 (86%)	193 (97%)	6 (3%)	0	100	100
1	B	199/230 (86%)	194 (98%)	5 (2%)	0	100	100
1	C	203/230 (88%)	199 (98%)	4 (2%)	0	100	100
1	D	204/230 (89%)	199 (98%)	5 (2%)	0	100	100
1	E	198/230 (86%)	192 (97%)	6 (3%)	0	100	100
2	K	12/14 (86%)	11 (92%)	1 (8%)	0	100	100
2	L	12/14 (86%)	11 (92%)	1 (8%)	0	100	100
2	M	12/14 (86%)	12 (100%)	0	0	100	100
2	N	12/14 (86%)	12 (100%)	0	0	100	100
2	O	12/14 (86%)	12 (100%)	0	0	100	100
All	All	1063/1220 (87%)	1035 (97%)	28 (3%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

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	177/208 (85%)	173 (98%)	4 (2%)	44	72
1	B	180/208 (86%)	178 (99%)	2 (1%)	65	84
1	C	184/208 (88%)	182 (99%)	2 (1%)	65	84
1	D	188/208 (90%)	185 (98%)	3 (2%)	55	79
1	E	181/208 (87%)	179 (99%)	2 (1%)	65	84
2	K	11/11 (100%)	11 (100%)	0	100	100
2	L	11/11 (100%)	11 (100%)	0	100	100
2	M	11/11 (100%)	11 (100%)	0	100	100
2	N	11/11 (100%)	11 (100%)	0	100	100
2	O	11/11 (100%)	11 (100%)	0	100	100
All	All	965/1095 (88%)	952 (99%)	13 (1%)	61	82

5 of 13 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	142	VAL
1	D	0	LEU
1	E	153	GLU
1	D	203	LYS
1	E	136	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 14 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	121	GLN
1	D	15	ASN
1	E	121	GLN
1	E	58	GLN
1	E	105	GLN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 1 ligands modelled in this entry, 1 is monoatomic - leaving 0 for Mogul analysis.

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.

No monomer is involved in short contacts.

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data ⓘ

6.1 Protein, DNA and RNA chains ⓘ

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	203/230 (88%)	-0.36	3 (1%) 72 68	16, 31, 56, 76	0
1	B	203/230 (88%)	-0.41	1 (0%) 87 85	18, 30, 56, 69	0
1	C	207/230 (90%)	-0.50	3 (1%) 73 70	16, 28, 47, 69	0
1	D	208/230 (90%)	-0.53	0 100 100	15, 26, 51, 70	0
1	E	202/230 (87%)	-0.35	5 (2%) 58 54	15, 29, 62, 71	0
2	K	13/14 (92%)	-0.53	0 100 100	18, 25, 39, 44	0
2	L	13/14 (92%)	-0.06	0 100 100	26, 35, 64, 65	0
2	M	13/14 (92%)	-0.13	0 100 100	27, 36, 56, 58	0
2	N	13/14 (92%)	-0.19	0 100 100	23, 31, 46, 47	0
2	O	13/14 (92%)	-0.15	0 100 100	21, 32, 56, 56	0
All	All	1088/1220 (89%)	-0.42	12 (1%) 78 75	15, 29, 56, 76	0

The worst 5 of 12 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	-4	ASP	4.1
1	A	0	LEU	3.4
1	B	0	LEU	3.3
1	A	1	HIS	3.3
1	A	19	MET	3.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	MN	C	301	1/1	0.99	0.03	31,31,31,31	1

6.5 Other polymers [i](#)

There are no such residues in this entry.