



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 14, 2026 – 08:27 PM UTC

PDB ID : 4LN1 / pdb_00004ln1
Title : CRYSTAL STRUCTURE OF L-lactate dehydrogenase from *Bacillus cereus* ATCC 14579 complexed with calcium, NYSGRC Target 029452
Authors : Malashkevich, V.N.; Bonanno, J.B.; Bhosle, R.; Toro, R.; Hillerich, B.; Gizzi, A.; Garforth, S.; Kar, A.; Chan, M.K.; Lafluer, J.; Patel, H.; Matikainen, B.; Chamala, S.; Lim, S.; Celikgil, A.; Villegas, G.; Evans, B.; Love, J.; Fiser, A.; Khafizov, K.; Seidel, R.; Almo, S.C.; New York Structural Genomics Research Consortium (NYSGRC)
Deposited on : 2013-07-11
Resolution : 1.90 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
Mogul	:	2022.3.0, CSD as543be (2022)
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)

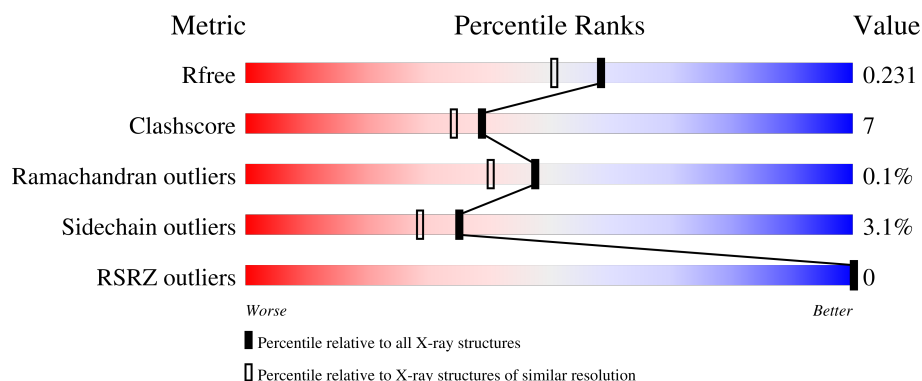
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.90 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	7789 (1.90-1.90)
Clashscore	190562	8410 (1.90-1.90)
Ramachandran outliers	187476	8333 (1.90-1.90)
Sidechain outliers	187428	8333 (1.90-1.90)
RSRZ outliers	180081	7790 (1.90-1.90)

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	336	 77% 17% 6%
1	B	336	 77% 17% ..
1	C	336	 71% 21% .. 6%

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Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

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Mol	Chain	Length	Quality of chain
1	D	336	74% 19% • 6%

2 Entry composition [i](#)

There are 3 unique types of molecules in this entry. The entry contains 10343 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 L-lactate dehydrogenase 1.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	317	Total	C	N	O	S	Se	0	1	0
			2494	1590	415	479	3	7			
1	B	321	Total	C	N	O	S	Se	0	4	0
			2535	1617	421	486	3	8			
1	C	316	Total	C	N	O	S	Se	0	0	0
			2474	1579	409	476	3	7			
1	D	315	Total	C	N	O	S	Se	0	2	0
			2483	1584	413	476	3	7			

There are 88 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-21	MSE	-	expression tag	UNP Q81EP4
A	-20	HIS	-	expression tag	UNP Q81EP4
A	-19	HIS	-	expression tag	UNP Q81EP4
A	-18	HIS	-	expression tag	UNP Q81EP4
A	-17	HIS	-	expression tag	UNP Q81EP4
A	-16	HIS	-	expression tag	UNP Q81EP4
A	-15	HIS	-	expression tag	UNP Q81EP4
A	-14	SER	-	expression tag	UNP Q81EP4
A	-13	SER	-	expression tag	UNP Q81EP4
A	-12	GLY	-	expression tag	UNP Q81EP4
A	-11	VAL	-	expression tag	UNP Q81EP4
A	-10	ASP	-	expression tag	UNP Q81EP4
A	-9	LEU	-	expression tag	UNP Q81EP4
A	-8	GLY	-	expression tag	UNP Q81EP4
A	-7	THR	-	expression tag	UNP Q81EP4
A	-6	GLU	-	expression tag	UNP Q81EP4
A	-5	ASN	-	expression tag	UNP Q81EP4
A	-4	LEU	-	expression tag	UNP Q81EP4
A	-3	TYR	-	expression tag	UNP Q81EP4
A	-2	PHE	-	expression tag	UNP Q81EP4
A	-1	GLN	-	expression tag	UNP Q81EP4

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Chain	Residue	Modelled	Actual	Comment	Reference
A	0	SER	-	expression tag	UNP Q81EP4
B	-21	MSE	-	expression tag	UNP Q81EP4
B	-20	HIS	-	expression tag	UNP Q81EP4
B	-19	HIS	-	expression tag	UNP Q81EP4
B	-18	HIS	-	expression tag	UNP Q81EP4
B	-17	HIS	-	expression tag	UNP Q81EP4
B	-16	HIS	-	expression tag	UNP Q81EP4
B	-15	HIS	-	expression tag	UNP Q81EP4
B	-14	SER	-	expression tag	UNP Q81EP4
B	-13	SER	-	expression tag	UNP Q81EP4
B	-12	GLY	-	expression tag	UNP Q81EP4
B	-11	VAL	-	expression tag	UNP Q81EP4
B	-10	ASP	-	expression tag	UNP Q81EP4
B	-9	LEU	-	expression tag	UNP Q81EP4
B	-8	GLY	-	expression tag	UNP Q81EP4
B	-7	THR	-	expression tag	UNP Q81EP4
B	-6	GLU	-	expression tag	UNP Q81EP4
B	-5	ASN	-	expression tag	UNP Q81EP4
B	-4	LEU	-	expression tag	UNP Q81EP4
B	-3	TYR	-	expression tag	UNP Q81EP4
B	-2	PHE	-	expression tag	UNP Q81EP4
B	-1	GLN	-	expression tag	UNP Q81EP4
B	0	SER	-	expression tag	UNP Q81EP4
C	-21	MSE	-	expression tag	UNP Q81EP4
C	-20	HIS	-	expression tag	UNP Q81EP4
C	-19	HIS	-	expression tag	UNP Q81EP4
C	-18	HIS	-	expression tag	UNP Q81EP4
C	-17	HIS	-	expression tag	UNP Q81EP4
C	-16	HIS	-	expression tag	UNP Q81EP4
C	-15	HIS	-	expression tag	UNP Q81EP4
C	-14	SER	-	expression tag	UNP Q81EP4
C	-13	SER	-	expression tag	UNP Q81EP4
C	-12	GLY	-	expression tag	UNP Q81EP4
C	-11	VAL	-	expression tag	UNP Q81EP4
C	-10	ASP	-	expression tag	UNP Q81EP4
C	-9	LEU	-	expression tag	UNP Q81EP4
C	-8	GLY	-	expression tag	UNP Q81EP4
C	-7	THR	-	expression tag	UNP Q81EP4
C	-6	GLU	-	expression tag	UNP Q81EP4
C	-5	ASN	-	expression tag	UNP Q81EP4
C	-4	LEU	-	expression tag	UNP Q81EP4
C	-3	TYR	-	expression tag	UNP Q81EP4

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Chain	Residue	Modelled	Actual	Comment	Reference
C	-2	PHE	-	expression tag	UNP Q81EP4
C	-1	GLN	-	expression tag	UNP Q81EP4
C	0	SER	-	expression tag	UNP Q81EP4
D	-21	MSE	-	expression tag	UNP Q81EP4
D	-20	HIS	-	expression tag	UNP Q81EP4
D	-19	HIS	-	expression tag	UNP Q81EP4
D	-18	HIS	-	expression tag	UNP Q81EP4
D	-17	HIS	-	expression tag	UNP Q81EP4
D	-16	HIS	-	expression tag	UNP Q81EP4
D	-15	HIS	-	expression tag	UNP Q81EP4
D	-14	SER	-	expression tag	UNP Q81EP4
D	-13	SER	-	expression tag	UNP Q81EP4
D	-12	GLY	-	expression tag	UNP Q81EP4
D	-11	VAL	-	expression tag	UNP Q81EP4
D	-10	ASP	-	expression tag	UNP Q81EP4
D	-9	LEU	-	expression tag	UNP Q81EP4
D	-8	GLY	-	expression tag	UNP Q81EP4
D	-7	THR	-	expression tag	UNP Q81EP4
D	-6	GLU	-	expression tag	UNP Q81EP4
D	-5	ASN	-	expression tag	UNP Q81EP4
D	-4	LEU	-	expression tag	UNP Q81EP4
D	-3	TYR	-	expression tag	UNP Q81EP4
D	-2	PHE	-	expression tag	UNP Q81EP4
D	-1	GLN	-	expression tag	UNP Q81EP4
D	0	SER	-	expression tag	UNP Q81EP4

- Molecule 2 is CALCIUM ION (CCD ID: CA) (formula: Ca).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	2	Total Ca 2 2	0	0
2	B	2	Total Ca 2 2	0	0
2	C	1	Total Ca 1 1	0	0
2	D	1	Total Ca 1 1	0	0

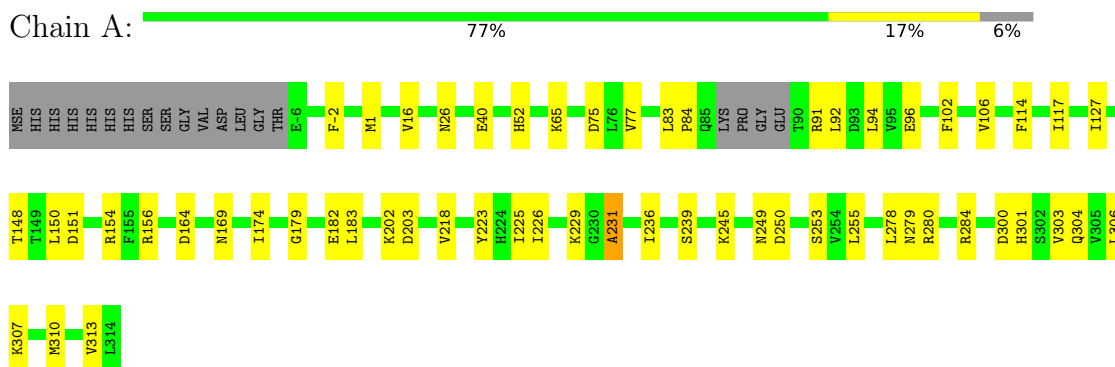
- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	93	Total 93	O 93	0	0
3	B	85	Total 85	O 85	0	0
3	C	89	Total 89	O 89	0	0
3	D	84	Total 84	O 84	0	0

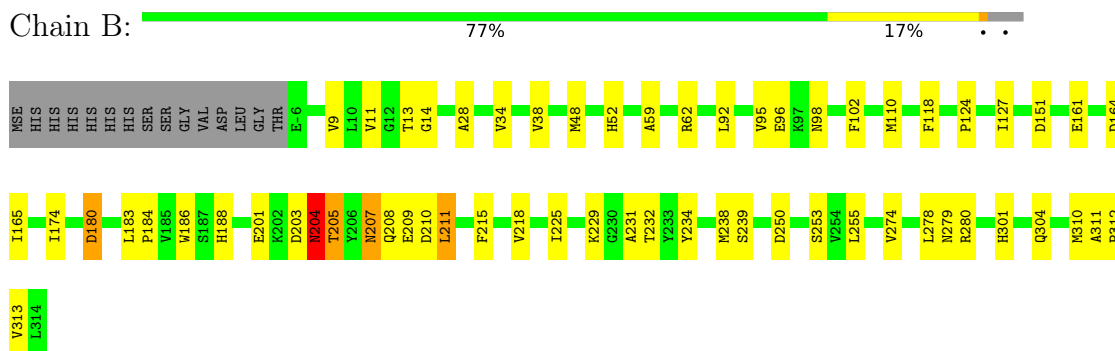
3 Residue-property plots

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.

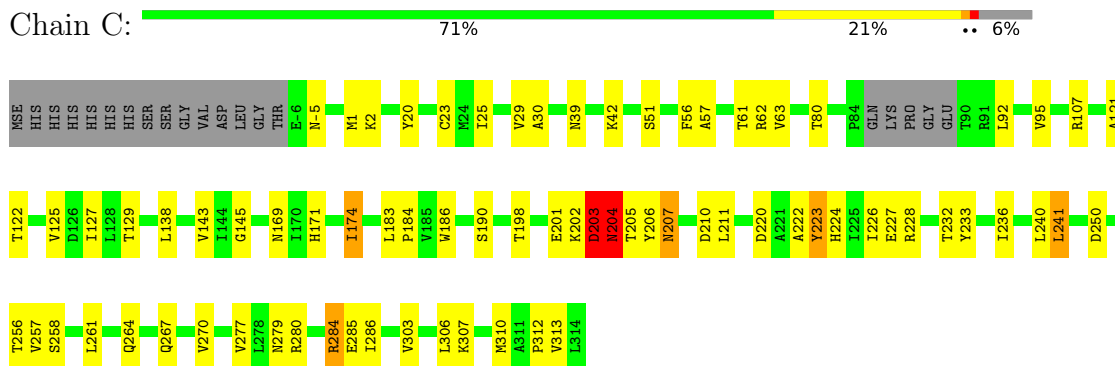
- Molecule 1: L-lactate dehydrogenase 1



- Molecule 1: L-lactate dehydrogenase 1



- Molecule 1: L-lactate dehydrogenase 1



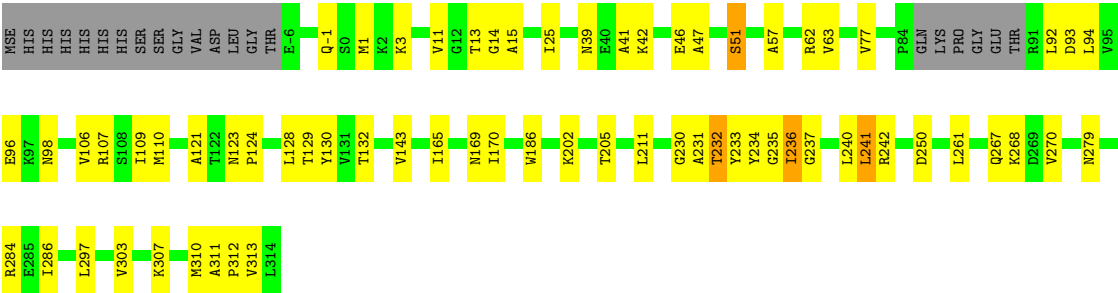
● Molecule 1: L-lactate dehydrogenase 1

Chain D:

74%

19%

6%



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	83.72Å 75.45Å 100.14Å 90.00° 89.99° 90.00°	Depositor
Resolution (Å)	42.98 – 1.90 42.98 – 1.90	Depositor EDS
% Data completeness (in resolution range)	99.6 (42.98-1.90) 99.6 (42.98-1.90)	Depositor EDS
R_{merge}	0.06	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.10 (at 1.79Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.209 , 0.241 0.207 , 0.231	Depositor DCC
R_{free} test set	5791 reflections (4.99%)	wwPDB-VP
Wilson B-factor (Å ²)	29.6	Xtriage
Anisotropy	0.460	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 35.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.468 for h,-k,-l	Xtriage
Reported twinning fraction	0.514 for H, K, L 0.486 for h,-k,-l	Depositor
Outliers	3 of 115401 reflections (0.003%)	Xtriage
F_o, F_c correlation	0.98	EDS
Total number of atoms	10343	wwPDB-VP
Average B, all atoms (Å ²)	41.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 89.69 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 3.1000e-08. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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 [i](#)

5.1 Standard geometry [i](#)

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

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	0.70	1/2533 (0.0%)	0.94	0/3420
1	B	0.81	7/2588 (0.3%)	0.98	6/3496 (0.2%)
1	C	0.90	11/2513 (0.4%)	0.98	7/3394 (0.2%)
1	D	0.73	8/2525 (0.3%)	0.92	4/3410 (0.1%)
All	All	0.79	27/10159 (0.3%)	0.96	17/13720 (0.1%)

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 outliers	#Planarity outliers
1	C	0	1

The worst 5 of 27 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	29	VAL	C-O	-8.74	1.14	1.24
1	D	11	VAL	C-O	-7.85	1.14	1.24
1	C	223	TYR	C-O	-7.80	1.15	1.24
1	C	257	VAL	C-O	-7.70	1.15	1.24
1	C	232	THR	C-O	-7.32	1.15	1.24

The worst 5 of 17 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	204	ASN	N-CA-C	12.46	127.07	108.14
1	B	201	GLU	N-CA-C	7.63	119.68	111.36
1	C	204	ASN	N-CA-C	7.40	122.47	111.81
1	D	13	THR	N-CA-C	6.75	120.95	111.30

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	D	57	ALA	CA-C-N	6.59	126.53	119.28

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	C	203	ASP	Peptide

5.2 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 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	2494	0	2485	41	0
1	B	2535	0	2537	37	0
1	C	2474	0	2465	46	0
1	D	2483	0	2476	33	0
2	A	2	0	0	0	0
2	B	2	0	0	0	0
2	C	1	0	0	0	0
2	D	1	0	0	0	0
3	A	93	0	0	4	0
3	B	85	0	0	0	0
3	C	89	0	0	4	0
3	D	84	0	0	1	0
All	All	10343	0	9963	136	0

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 7.

The worst 5 of 136 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:A:306:LEU:O	1:A:310:MSE:HG3	1.68	0.92
1:C:284:ARG:NH2	1:C:285:GLU:OE2	2.06	0.87
1:C:220:ASP:O	1:C:223:TYR:HB2	1.85	0.76

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:202:LYS:O	1:C:203:ASP:HB2	1.86	0.76
1:B:301:HIS:HA	1:B:304:GLN:HG2	1.68	0.74

There are no symmetry-related clashes.

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	314/336 (94%)	303 (96%)	11 (4%)	0	100	100
1	B	323/336 (96%)	313 (97%)	10 (3%)	0	100	100
1	C	312/336 (93%)	300 (96%)	11 (4%)	1 (0%)	36	29
1	D	313/336 (93%)	299 (96%)	14 (4%)	0	100	100
All	All	1262/1344 (94%)	1215 (96%)	46 (4%)	1 (0%)	48	40

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	203	ASP

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	270/277 (98%)	267 (99%)	3 (1%)	65	67

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	B	276/277 (100%)	267 (97%)	9 (3%)	33	26
1	C	268/277 (97%)	258 (96%)	10 (4%)	30	22
1	D	269/277 (97%)	258 (96%)	11 (4%)	27	19
All	All	1083/1108 (98%)	1050 (97%)	33 (3%)	35	30

5 of 33 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	232	THR
1	D	236	ILE
1	D	297	LEU
1	C	-5	ASN
1	B	274	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 9 such sidechains are listed below:

Mol	Chain	Res	Type
1	D	249	ASN
1	D	301	HIS
1	B	104	GLN
1	C	104	GLN
1	C	207	ASN

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 ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry

Of 6 ligands modelled in this entry, 6 are 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

There are no such residues in this entry.

5.8 Polymer linkage issues

There are no chain breaks in this entry.

6 Fit of model and data [i](#)

6.1 Protein, DNA and RNA chains [i](#)

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	310/336 (92%)	-1.08	0 100 100	15, 37, 61, 92	1 (0%)
1	B	314/336 (93%)	-1.06	0 100 100	20, 39, 68, 92	3 (0%)
1	C	309/336 (91%)	-1.02	0 100 100	23, 40, 70, 92	0
1	D	308/336 (91%)	-1.04	0 100 100	15, 39, 70, 98	2 (0%)
All	All	1241/1344 (92%)	-1.05	0 100 100	15, 39, 68, 98	6 (0%)

There are no RSRZ outliers to report.

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

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(Å ²)	Q<0.9
2	CA	B	501	1/1	0.99	0.02	40,40,40,40	0
2	CA	A	501	1/1	1.00	0.04	37,37,37,37	0
2	CA	B	500	1/1	1.00	0.02	34,34,34,34	0
2	CA	A	500	1/1	1.00	0.01	34,34,34,34	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
2	CA	C	501	1/1	1.00	0.02	37,37,37,37	0
2	CA	D	501	1/1	1.00	0.02	43,43,43,43	0

6.5 Other polymers [i](#)

There are no such residues in this entry.