



Full wwPDB X-ray Structure Validation Report ⓘ

Jan 26, 2026 – 01:03 PM JST

PDB ID : 9X0I / pdb_00009x0i
Title : Glyoxysomal Citrate Synthase 3 from Arabidopsis thaliana in complex with OAA and CoA
Authors : Nishio, K.; Takagi, K.; Mizushima, T.
Deposited on : 2025-09-30
Resolution : 1.70 Å(reported)

This is a Full wwPDB X-ray Structure Validation 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 : ?? (??), CSD ??CSD?? (???)
Xtriage (Phenix) : 2.0
EDS : 3.0
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)
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) : 2.47

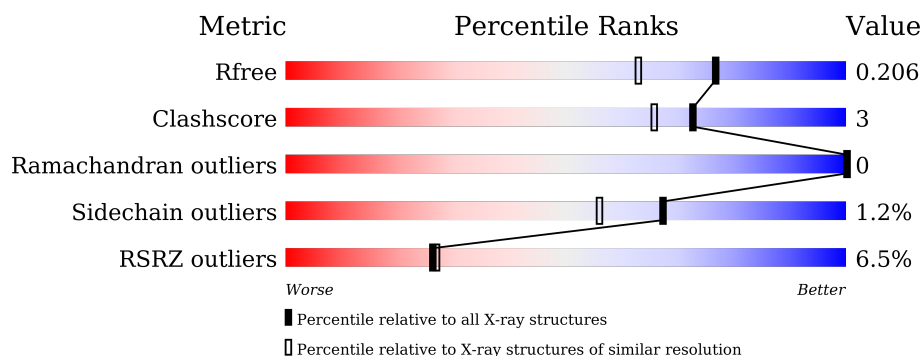
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

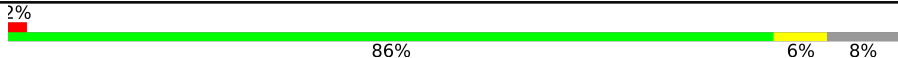
The reported resolution of this entry is 1.70 Å.

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}	164625	5161 (1.70-1.70)
Clashscore	180529	5671 (1.70-1.70)
Ramachandran outliers	177936	5594 (1.70-1.70)
Sidechain outliers	177891	5594 (1.70-1.70)
RSRZ outliers	164620	5159 (1.70-1.70)

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	479	
1	B	479	

2 Entry composition

There are 8 unique types of molecules in this entry. The entry contains 7902 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.

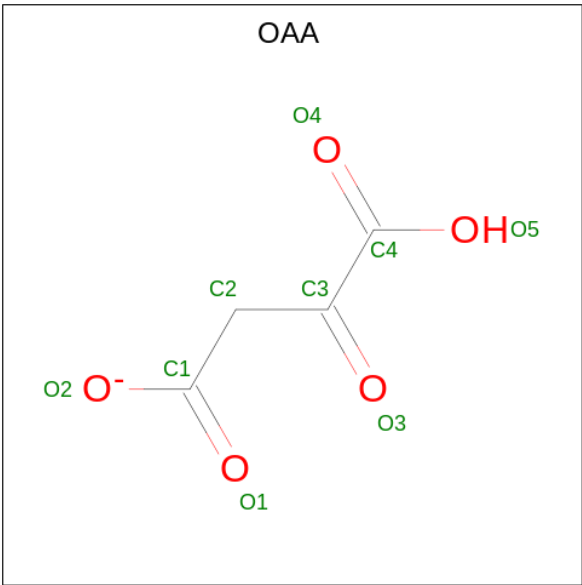
- Molecule 1 is a protein called Citrate synthase 3, peroxisomal.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	441	Total	C	N	O	S	0	5	0
			3475	2232	590	635	18			
1	B	440	Total	C	N	O	S	0	7	0
			3485	2237	595	637	16			

There are 10 discrepancies between the modelled and reference sequences:

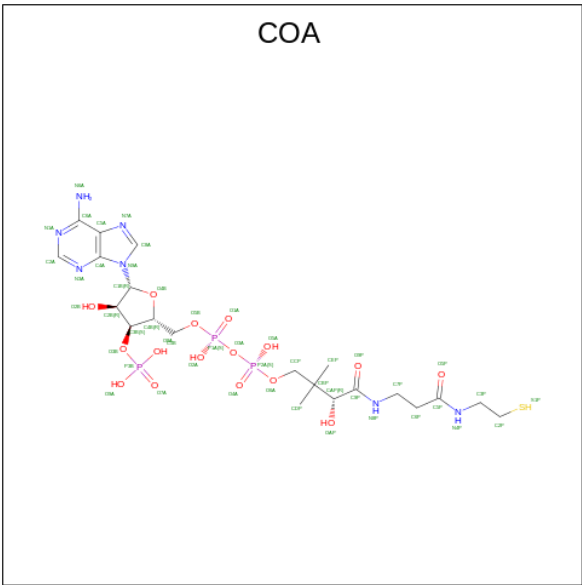
Chain	Residue	Modelled	Actual	Comment	Reference
A	31	GLY	-	expression tag	UNP Q9SJH7
A	32	PRO	-	expression tag	UNP Q9SJH7
A	33	LEU	-	expression tag	UNP Q9SJH7
A	34	GLY	-	expression tag	UNP Q9SJH7
A	35	SER	-	expression tag	UNP Q9SJH7
B	31	GLY	-	expression tag	UNP Q9SJH7
B	32	PRO	-	expression tag	UNP Q9SJH7
B	33	LEU	-	expression tag	UNP Q9SJH7
B	34	GLY	-	expression tag	UNP Q9SJH7
B	35	SER	-	expression tag	UNP Q9SJH7

- Molecule 2 is OXALOACETATE ION (CCD ID: OAA) (formula: $C_4H_3O_5$).



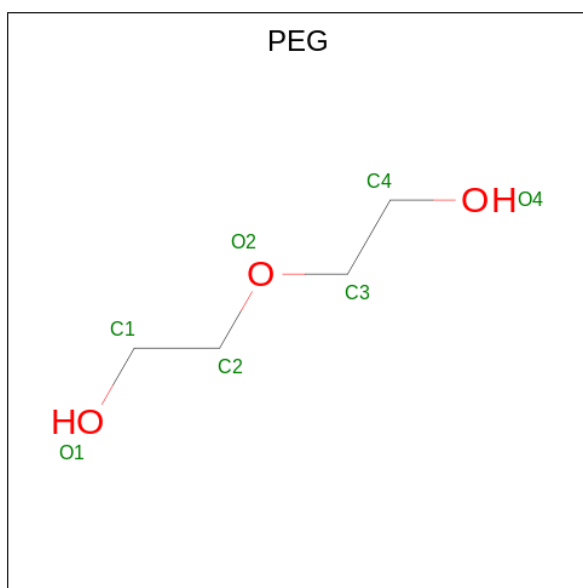
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			9	4	5		
2	B	1	Total	C	O	0	0
			9	4	5		

- Molecule 3 is COENZYME A (CCD ID: COA) (formula: $C_{21}H_{36}N_7O_{16}P_3S$).



Mol	Chain	Residues	Atoms						ZeroOcc	AltConf
3	A	1	Total	C	N	O	P	S	0	1
			48	21	7	16	3	1		
3	B	1	Total	C	N	O	P	S	0	0
			48	21	7	16	3	1		

- Molecule 4 is DI(HYDROXYETHYL)ETHER (CCD ID: PEG) (formula: $C_4H_{10}O_3$).

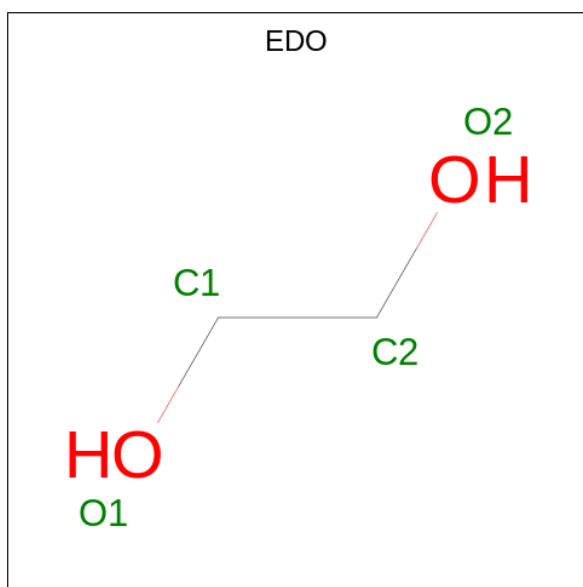


Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	0	0
			7	4	3		
4	A	1	Total	C	O	0	0
			7	4	3		

- Molecule 5 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

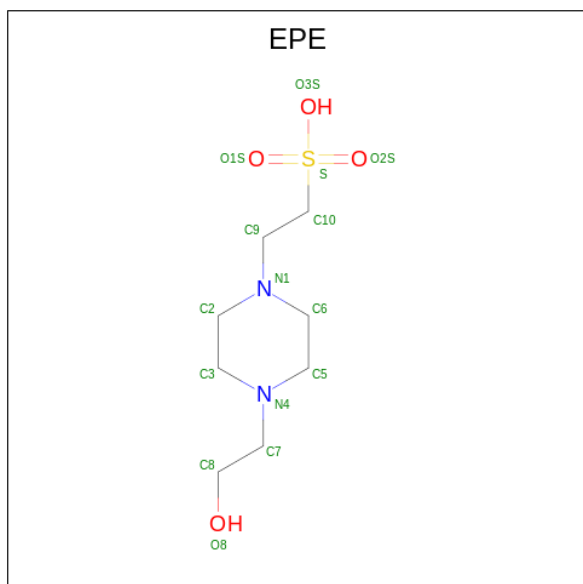
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	3	Total	Mg	0	0
			3	3		
5	B	2	Total	Mg	0	0
			2	2		

- Molecule 6 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: $C_2H_6O_2$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	B	1	Total	C	O	0	0
			4	2	2		

- Molecule 7 is 4-(2-HYDROXYETHYL)-1-PIPERAZINE ETHANESULFONIC ACID (CCD ID: EPE) (formula: $C_8H_{18}N_2O_4S$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
7	B	1	Total	C	N	O	S	0	0
			15	8	2	4	1		

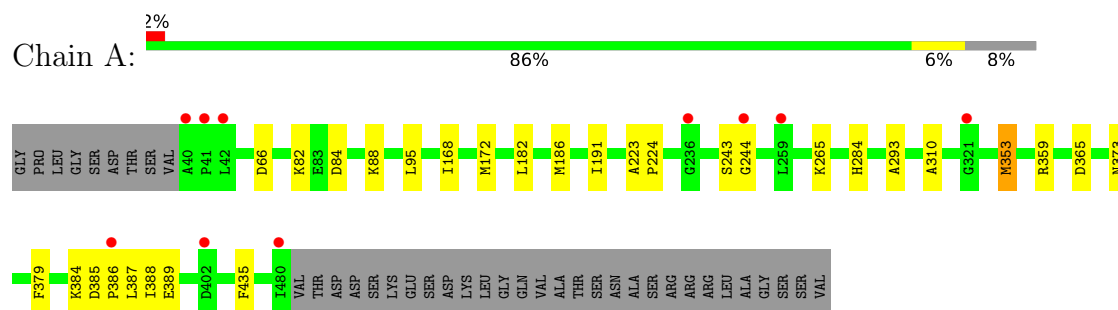
- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	A	443	Total 446	O 446	0	3
8	B	344	Total 344	O 344	0	0

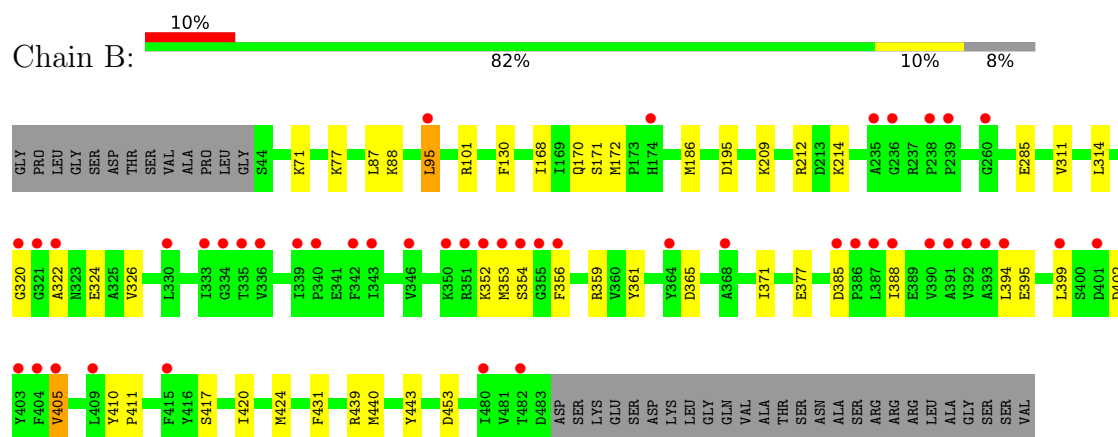
3 Residue-property plots [i](#)

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: Citrate synthase 3, peroxisomal



- Molecule 1: Citrate synthase 3, peroxisomal



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 2	Depositor
Cell constants a, b, c, α , β , γ	193.86Å 60.60Å 76.86Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	38.32 – 1.70 38.32 – 1.70	Depositor EDS
% Data completeness (in resolution range)	98.6 (38.32-1.70) 98.6 (38.32-1.70)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.98 (at 1.70Å)	Xtriage
Refinement program	REFMAC 5.8.0419	Depositor
R, R_{free}	0.166 , 0.197 0.172 , 0.206	Depositor DCC
R_{free} test set	1977 reflections (1.97%)	wwPDB-VP
Wilson B-factor (Å ²)	22.7	Xtriage
Anisotropy	0.063	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 38.9	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	0.97	EDS
Total number of atoms	7902	wwPDB-VP
Average B, all atoms (Å ²)	29.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.63% 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: OAA, EPE, MG, EDO, COA, PEG

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	0.77	1/3571 (0.0%)	1.14	7/4844 (0.1%)
1	B	0.74	0/3589	1.12	7/4867 (0.1%)
All	All	0.75	1/7160 (0.0%)	1.13	14/9711 (0.1%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	243	SER	CA-CB	-5.72	1.45	1.53

All (14) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	88	LYS	N-CA-CB	-7.05	99.56	110.85
1	A	88	LYS	N-CA-CB	-7.00	99.65	110.85
1	B	361	TYR	N-CA-CB	6.92	120.36	109.71
1	B	365	ASP	CA-CB-CG	6.80	119.40	112.60
1	A	435	PHE	CA-CB-CG	6.32	120.12	113.80
1	A	365	ASP	CA-CB-CG	6.10	118.70	112.60
1	B	195	ASP	CA-CB-CG	6.00	118.60	112.60
1	A	84	ASP	CA-CB-CG	5.52	118.12	112.60
1	A	265	LYS	CB-CA-C	-5.51	102.74	110.13
1	A	373	ASN	CA-CB-CG	-5.35	107.25	112.60
1	A	66	ASP	CA-CB-CG	5.14	117.74	112.60
1	B	324	GLU	N-CA-CB	5.08	117.44	110.07
1	B	130	PHE	CA-CB-CG	-5.07	108.73	113.80
1	B	431	PHE	CA-CB-CG	5.04	118.84	113.80

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	3475	0	3503	14	0
1	B	3485	0	3523	29	0
2	A	9	0	2	0	0
2	B	9	0	2	0	0
3	A	48	0	32	0	0
3	B	48	0	32	1	0
4	A	14	0	20	1	0
5	A	3	0	0	0	0
5	B	2	0	0	0	0
6	B	4	0	6	2	0
7	B	15	0	18	1	0
8	A	446	0	0	4	3
8	B	344	0	0	10	2
All	All	7902	0	7138	44	3

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 3.

All (44) 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:182:LEU:HD11	1:A:186[B]:MET:HE3	1.74	0.69
1:A:387:LEU:HD13	8:A:795:HOH:O	1.94	0.67
1:B:209:LYS:HZ1	6:B:603:EDO:H11	1.61	0.66
1:B:95:LEU:HD22	1:B:359:ARG:NH1	2.13	0.64
1:B:353:MET:HE3	1:B:394:LEU:HD21	1.87	0.55
1:A:386:PRO:O	1:A:389:GLU:OE1	2.24	0.55
1:B:186[B]:MET:HE1	8:B:927:HOH:O	2.08	0.53
1:B:212[B]:ARG:HG3	8:B:739:HOH:O	2.11	0.51
1:B:171:SER:O	8:B:701:HOH:O	2.20	0.50
1:B:322:ALA:O	1:B:326:VAL:HG23	2.10	0.50
1:A:244:GLY:N	8:A:706:HOH:O	2.36	0.48
1:B:71:LYS:NZ	8:B:711:HOH:O	2.46	0.48
1:A:385:ASP:C	1:A:385:ASP:OD1	2.57	0.47
1:B:424:MET:O	7:B:606:EPE:H52	2.14	0.47

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:371:ILE:HD13	1:B:417:SER:HB3	1.96	0.47
1:B:371:ILE:HG23	1:B:420:ILE:HD12	1.97	0.47
1:B:168:ILE:HG22	1:B:172[B]:MET:HE3	1.97	0.47
1:A:353:MET:HE2	1:A:353:MET:HB2	1.63	0.46
1:A:168:ILE:HG22	1:A:172[B]:MET:HE3	1.98	0.45
1:B:402:ASP:HA	1:B:405:VAL:HG22	1.98	0.45
1:B:356:PHE:HA	1:B:410:TYR:O	2.17	0.44
1:B:399:LEU:HD21	1:B:411:PRO:HD3	1.98	0.44
1:B:186[B]:MET:HE3	8:B:773:HOH:O	2.18	0.43
1:B:352:LYS:HE3	8:B:962:HOH:O	2.19	0.43
1:B:77:LYS:NZ	8:B:717:HOH:O	2.50	0.43
1:B:209:LYS:NZ	6:B:603:EDO:H11	2.30	0.43
1:B:377:GLU:OE2	8:B:702:HOH:O	2.21	0.43
1:B:101[A]:ARG:NH2	1:B:453:ASP:OD1	2.48	0.42
1:A:191:ILE:HD13	1:B:172[B]:MET:SD	2.59	0.42
1:B:314:LEU:O	1:B:320:GLY:HA3	2.19	0.42
1:B:395:GLU:O	1:B:399:LEU:HG	2.19	0.42
1:B:439:ARG:HG3	1:B:443:TYR:CZ	2.55	0.42
1:A:293:ALA:HB2	1:A:310:ALA:HB2	2.00	0.42
1:A:385:ASP:O	1:A:388:ILE:HG22	2.19	0.42
1:B:311:VAL:CG1	1:B:440:MET:HE1	2.49	0.42
1:B:95:LEU:HD22	1:B:359:ARG:CZ	2.49	0.42
3:B:602:COA:S1P	8:B:892:HOH:O	2.26	0.41
1:B:87[A]:LEU:HD23	8:B:908:HOH:O	2.20	0.41
1:A:387:LEU:CD1	8:A:795:HOH:O	2.60	0.41
1:A:379:PHE:HB3	1:A:384:LYS:HA	2.02	0.41
1:A:223:ALA:HB3	1:A:224:PRO:HD3	2.02	0.41
1:A:95:LEU:HD23	1:A:359:ARG:NH1	2.36	0.40
4:A:604:PEG:H12	8:A:1012:HOH:O	2.21	0.40
1:B:385:ASP:O	1:B:388:ILE:HG22	2.20	0.40

All (3) 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)
8:A:926:HOH:O	8:B:909:HOH:O[3_359]	2.13	0.07
8:A:880:HOH:O	8:B:891:HOH:O[3_349]	2.15	0.05
8:A:943:HOH:O	8:A:943:HOH:O[2_355]	2.16	0.04

5.3 Torsion angles

5.3.1 Protein backbone

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	444/479 (93%)	440 (99%)	4 (1%)	0	100	100
1	B	445/479 (93%)	437 (98%)	8 (2%)	0	100	100
All	All	889/958 (93%)	877 (99%)	12 (1%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 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 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	373/399 (94%)	370 (99%)	3 (1%)	79	71
1	B	376/399 (94%)	370 (98%)	6 (2%)	58	44
All	All	749/798 (94%)	740 (99%)	9 (1%)	67	56

All (9) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	82	LYS
1	A	284	HIS
1	A	353	MET
1	B	95	LEU
1	B	170	GLN
1	B	214	LYS
1	B	285	GLU
1	B	354	SER

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Mol	Chain	Res	Type
1	B	405	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	174	HIS
1	A	210	GLN
1	B	170	GLN

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

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

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 13 ligands modelled in this entry, 5 are monoatomic - leaving 8 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 ⓘ

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	441/479 (92%)	-0.18	10 (2%) 61 64	11, 22, 43, 80	5 (1%)
1	B	440/479 (91%)	0.32	47 (10%) 12 12	11, 26, 78, 115	7 (1%)
All	All	881/958 (91%)	0.07	57 (6%) 26 27	11, 23, 63, 115	12 (1%)

All (57) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	339	ILE	5.3
1	A	40	ALA	4.9
1	A	480	ILE	4.7
1	B	321	GLY	4.6
1	B	404	PHE	4.3
1	A	42	LEU	4.3
1	B	336	VAL	4.3
1	B	392	VAL	4.3
1	B	342	PHE	4.2
1	B	343	ILE	4.1
1	B	330	LEU	4.0
1	B	391	ALA	3.4
1	B	386	PRO	3.4
1	B	409	LEU	3.3
1	B	335	THR	3.2
1	B	385	ASP	3.2
1	B	405	VAL	3.2
1	B	393	ALA	3.1
1	B	351	ARG	3.1
1	B	174	HIS	3.0
1	A	41	PRO	3.0
1	B	399	LEU	3.0
1	B	346	VAL	2.9
1	B	387	LEU	2.9

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Mol	Chain	Res	Type	RSRZ
1	B	390	VAL	2.8
1	B	388	ILE	2.8
1	B	322	ALA	2.8
1	B	480	ILE	2.7
1	B	353	MET	2.7
1	B	239	PRO	2.7
1	B	340	PRO	2.7
1	B	354	SER	2.7
1	A	386	PRO	2.6
1	A	244	GLY	2.6
1	A	321	GLY	2.6
1	B	403	TYR	2.6
1	B	320	GLY	2.5
1	B	394	LEU	2.5
1	A	236	GLY	2.5
1	B	260	GLY	2.5
1	B	368	ALA	2.5
1	B	482	THR	2.4
1	B	350	LYS	2.4
1	B	355	GLY	2.4
1	B	236	GLY	2.4
1	B	235	ALA	2.4
1	B	401	ASP	2.4
1	B	238	PRO	2.3
1	B	333	ILE	2.3
1	B	334	GLY	2.3
1	A	259	LEU	2.3
1	B	364	TYR	2.2
1	B	95	LEU	2.2
1	B	352	LYS	2.1
1	A	402	ASP	2.0
1	B	356	PHE	2.0
1	B	415	PHE	2.0

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 ⓘ

There are no oligosaccharides in this entry.

6.4 Ligands

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
7	EPE	B	606	15/15	0.69	0.19	47,64,75,78	0
3	COA	B	602	48/48	0.76	0.14	41,84,113,121	0
5	MG	A	605	1/1	0.77	0.21	56,56,56,56	0
4	PEG	A	603	7/7	0.88	0.11	40,45,47,51	0
3	COA	A	602[A]	48/48	0.89	0.11	22,35,52,64	48
6	EDO	B	603	4/4	0.90	0.13	44,46,50,50	0
4	PEG	A	604	7/7	0.90	0.11	38,41,49,57	0
2	OAA	B	601	9/9	0.92	0.08	25,27,32,33	0
5	MG	B	604	1/1	0.95	0.17	46,46,46,46	0
5	MG	A	607	1/1	0.96	0.25	30,30,30,30	0
2	OAA	A	601	9/9	0.96	0.05	18,19,21,26	0
5	MG	A	606	1/1	0.97	0.23	41,41,41,41	0
5	MG	B	605	1/1	0.97	0.10	29,29,29,29	0

6.5 Other polymers

There are no such residues in this entry.