



wwPDB X-ray Structure Validation Summary Report ⓘ

Oct 11, 2021 – 07:26 AM EDT

PDB ID : 2RDA
Title : Human Thymidylate Synthase Stabilized in Active Conformation by R163K
Mutation: Asymmetry and Reactivity of Cys195
Authors : Gibson, L.M.; Lovelace, L.L.; Lebioda, L.
Deposited on : 2007-09-21
Resolution : 2.67 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 following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

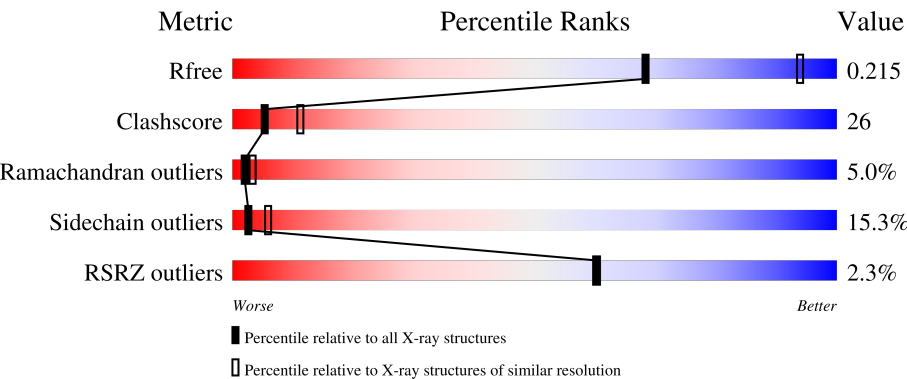
MolProbity : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix) : 1.13
EDS : 2.23.2
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac : 5.8.0158
CCP4 : 7.0.044 (Gargrove)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.23.2

1 Overall quality at a glance i

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.67 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}	130704	3863 (2.70-2.66)
Clashscore	141614	4210 (2.70-2.66)
Ramachandran outliers	138981	4141 (2.70-2.66)
Sidechain outliers	138945	4141 (2.70-2.66)
RSRZ outliers	127900	3780 (2.70-2.66)

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	313	<div><div>%</div><div><div></div><div>38%</div><div>35%</div><div>14%</div><div>•</div><div>10%</div></div></div>
1	B	313	<div><div></div><div>42%</div><div>39%</div><div>7%</div><div>•</div><div>10%</div></div>
1	C	313	<div><div></div><div>42%</div><div>34%</div><div>10%</div><div>•</div><div>10%</div></div>
1	D	313	<div><div>%</div><div></div><div>40%</div><div>35%</div><div>14%</div><div>•</div><div>10%</div></div>
1	E	313	<div><div>4%</div><div></div><div>29%</div><div>41%</div><div>19%</div><div>•</div><div>10%</div></div>

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Mol	Chain	Length	Quality of chain
1	F	313	

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
2	PO4	C	616	-	X	-	-
2	PO4	E	618	-	-	X	-
2	PO4	E	619	-	-	X	-

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 13834 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.

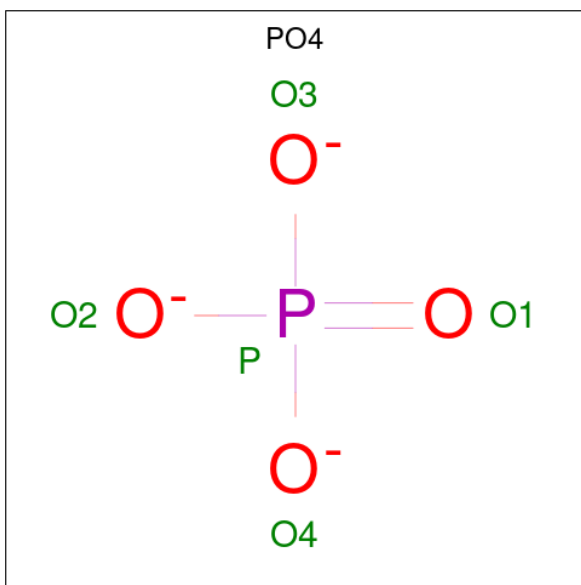
- Molecule 1 is a protein called Thymidylate synthase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	282	Total	C	N	O	S	0	0	0
			2279	1457	399	412	11			
1	B	281	Total	C	N	O	S	0	0	0
			2268	1451	395	411	11			
1	C	281	Total	C	N	O	S	0	0	0
			2268	1451	395	411	11			
1	D	281	Total	C	N	O	S	0	0	0
			2268	1451	395	411	11			
1	E	281	Total	C	N	O	S	0	0	0
			2268	1451	395	411	11			
1	F	281	Total	C	N	O	S	0	0	0
			2268	1451	395	411	11			

There are 6 discrepancies between the modelled and reference sequences:

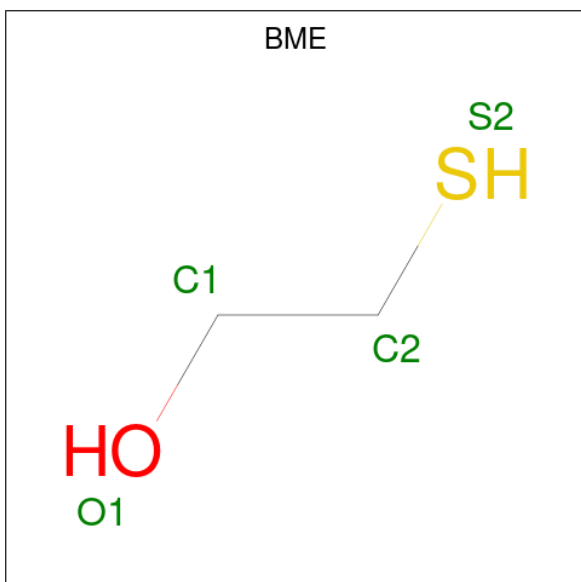
Chain	Residue	Modelled	Actual	Comment	Reference
A	163	LYS	ARG	engineered mutation	UNP P04818
B	163	LYS	ARG	engineered mutation	UNP P04818
C	163	LYS	ARG	engineered mutation	UNP P04818
D	163	LYS	ARG	engineered mutation	UNP P04818
E	163	LYS	ARG	engineered mutation	UNP P04818
F	163	LYS	ARG	engineered mutation	UNP P04818

- Molecule 2 is PHOSPHATE ION (three-letter code: PO4) (formula: O₄P).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	O	P	0	0
			5	4	1		
2	C	1	Total	O	P	0	0
			5	4	1		
2	D	1	Total	O	P	0	0
			5	4	1		
2	E	1	Total	O	P	0	0
			5	4	1		
2	E	1	Total	O	P	0	0
			5	4	1		

- Molecule 3 is BETA-MERCAPTOETHANOL (three-letter code: BME) (formula: C_2H_6OS).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
3	C	1	Total	C	O	S	0	0
			4	2	1	1		
3	E	1	Total	C	O	S	0	0
			4	2	1	1		

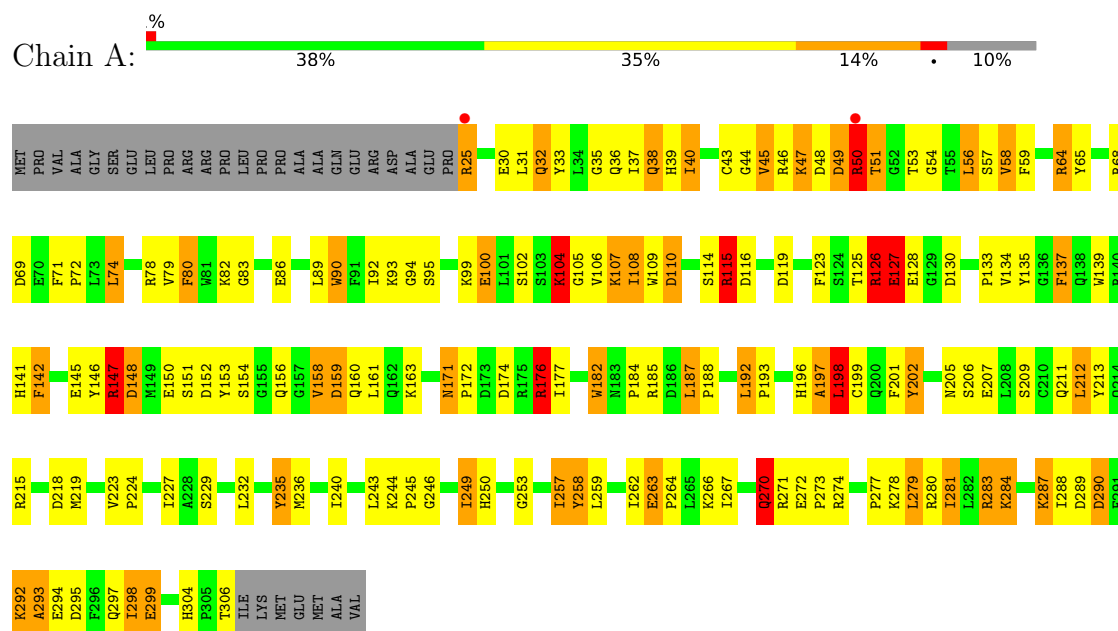
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	62	Total	O	0	0
			62	62		
4	B	52	Total	O	0	0
			52	52		
4	C	30	Total	O	0	0
			30	30		
4	D	23	Total	O	0	0
			23	23		
4	E	9	Total	O	0	0
			9	9		
4	F	6	Total	O	0	0
			6	6		

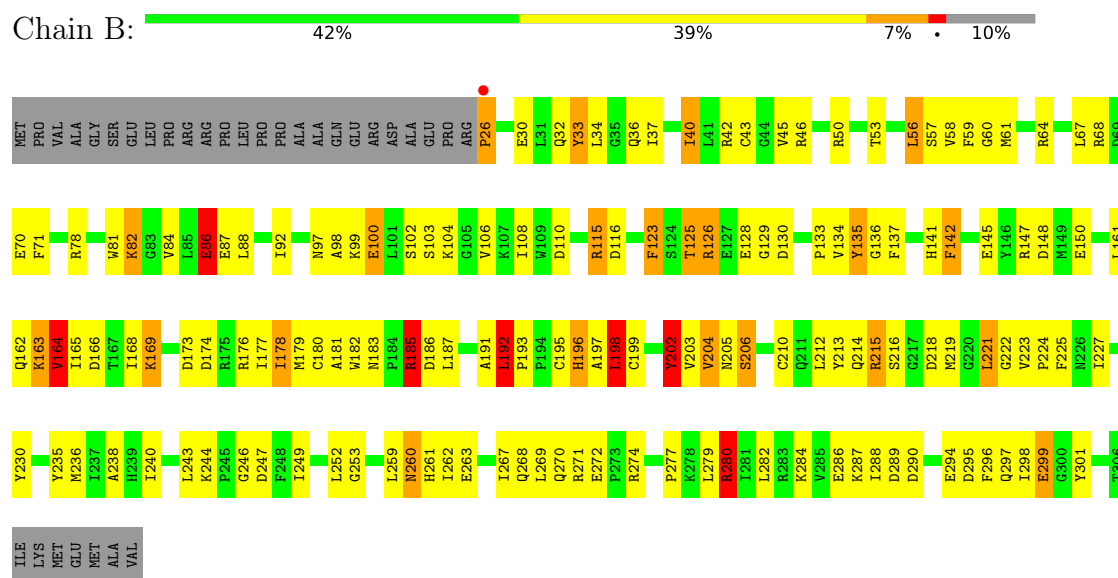
3 Residue-property plots

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.

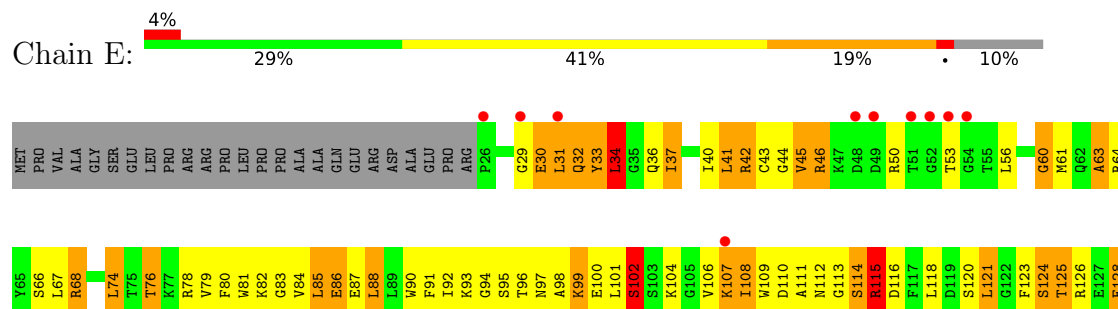
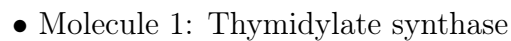
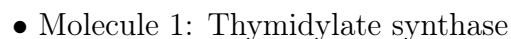
• Molecule 1: Thymidylate synthase

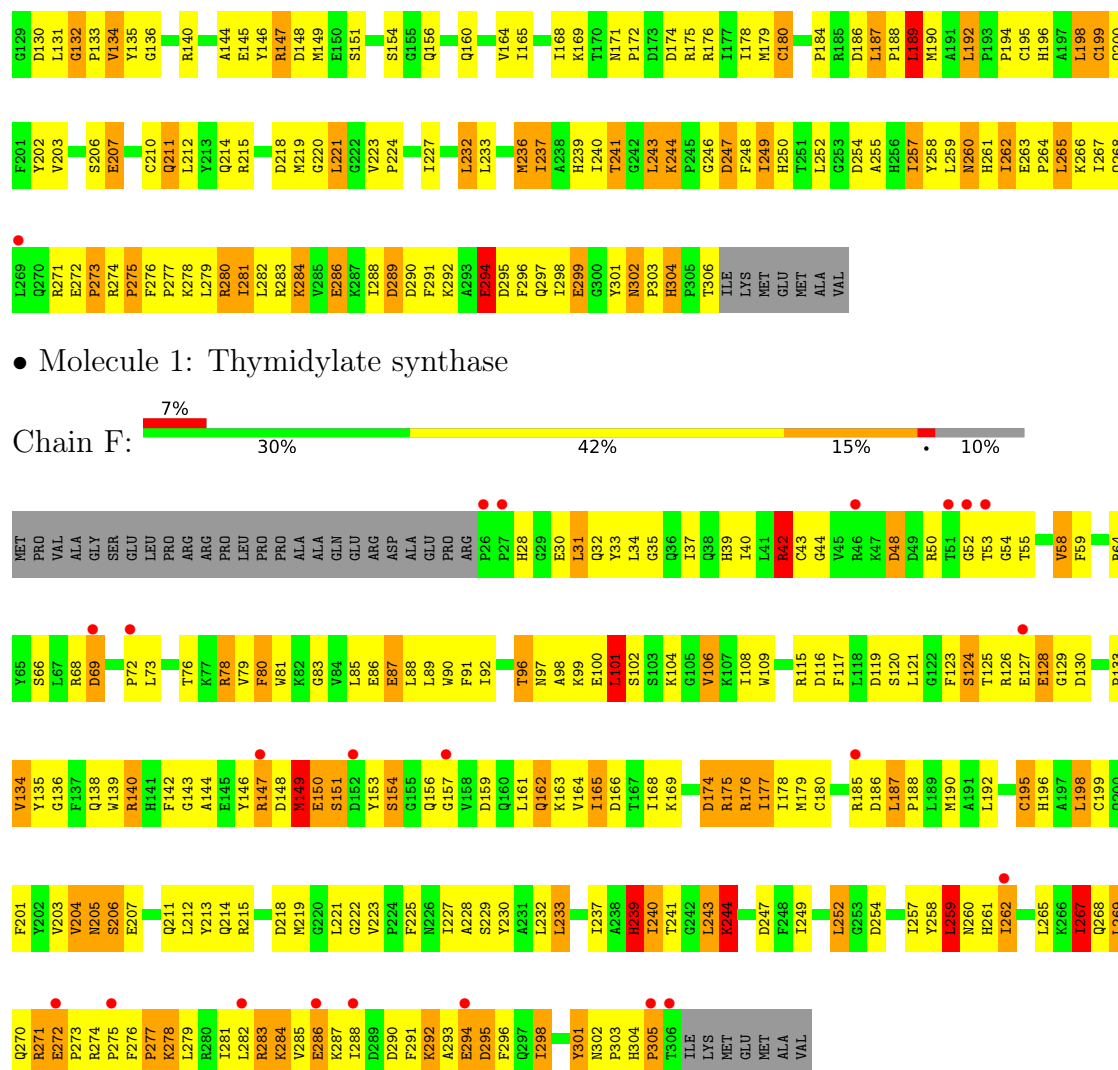


• Molecule 1: Thymidylate synthase



Chain C: 42% 34% 10% 10% 10%





• Molecule 1: Thymidylate synthase

4 Data and refinement statistics

Property	Value	Source
Space group	P 32 2 1	Depositor
Cell constants a, b, c, α , β , γ	123.79Å 123.79Å 284.77Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	107.21 – 2.67 46.68 – 2.64	Depositor EDS
% Data completeness (in resolution range)	97.2 (107.21-2.67) 94.2 (46.68-2.64)	Depositor EDS
R_{merge}	0.21	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.33 (at 2.65Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.209 , 0.279 0.210 , 0.215	Depositor DCC
R_{free} test set	7351 reflections (10.12%)	wwPDB-VP
Wilson B-factor (Å ²)	35.8	Xtriage
Anisotropy	0.438	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 48.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.30$	Xtriage
Estimated twinning fraction	0.028 for -h,-k,l	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	13834	wwPDB-VP
Average B, all atoms (Å ²)	44.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 12.50% 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: BME, PO4

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	2.05	62/2339 (2.7%)	1.69	45/3165 (1.4%)
1	B	2.13	74/2328 (3.2%)	1.73	47/3150 (1.5%)
1	C	1.89	41/2328 (1.8%)	1.64	37/3150 (1.2%)
1	D	1.72	31/2328 (1.3%)	1.52	38/3150 (1.2%)
1	E	1.44	12/2328 (0.5%)	1.36	16/3150 (0.5%)
1	F	1.26	5/2328 (0.2%)	1.21	12/3150 (0.4%)
All	All	1.78	225/13979 (1.6%)	1.54	195/18915 (1.0%)

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	A	0	1
1	D	0	2
All	All	0	3

The worst 5 of 225 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	150	GLU	CG-CD	13.31	1.72	1.51
1	C	199	CYS	CB-SG	-11.57	1.62	1.82
1	B	150	GLU	CB-CG	10.62	1.72	1.52
1	B	294	GLU	CD-OE1	10.57	1.37	1.25
1	B	195	CYS	CB-SG	-10.48	1.64	1.82

The worst 5 of 195 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	215	ARG	NE-CZ-NH2	-11.27	114.67	120.30
1	E	34	LEU	CA-CB-CG	10.96	140.51	115.30
1	B	126	ARG	NE-CZ-NH2	-10.94	114.83	120.30
1	B	274	ARG	NE-CZ-NH1	10.45	125.53	120.30
1	C	140	ARG	NE-CZ-NH2	-10.43	115.09	120.30

There are no chirality outliers.

All (3) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	47	LYS	Peptide
1	D	217	GLY	Peptide
1	D	44	GLY	Peptide

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	2279	0	2247	115	0
1	B	2268	0	2235	70	0
1	C	2268	0	2235	96	0
1	D	2268	0	2235	93	0
1	E	2268	0	2235	190	0
1	F	2268	0	2235	162	0
2	A	5	0	0	0	0
2	C	5	0	0	0	0
2	D	5	0	0	0	0
2	E	10	0	0	5	0
3	C	4	0	6	3	0
3	E	4	0	6	2	0
4	A	62	0	0	11	0
4	B	52	0	0	1	0
4	C	30	0	0	1	0
4	D	23	0	0	3	0
4	E	9	0	0	5	0
4	F	6	0	0	1	0
All	All	13834	0	13434	715	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 26.

The worst 5 of 715 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:C:42:ARG:CD	1:C:42:ARG:CG	1.77	1.59
1:B:168:ILE:CD1	1:B:168:ILE:CG1	1.81	1.58
1:A:104:LYS:CE	1:A:104:LYS:NZ	1.67	1.54
1:B:26:PRO:CB	1:B:26:PRO:CG	1.79	1.52
1:E:31:LEU:O	1:E:32:GLN:HG2	1.34	1.25

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	280/313 (90%)	251 (90%)	21 (8%)	8 (3%)	4	9
1	B	279/313 (89%)	254 (91%)	20 (7%)	5 (2%)	8	19
1	C	279/313 (89%)	239 (86%)	32 (12%)	8 (3%)	4	9
1	D	279/313 (89%)	235 (84%)	32 (12%)	12 (4%)	2	4
1	E	279/313 (89%)	210 (75%)	41 (15%)	28 (10%)	0	0
1	F	279/313 (89%)	208 (75%)	49 (18%)	22 (8%)	1	1
All	All	1675/1878 (89%)	1397 (83%)	195 (12%)	83 (5%)	2	3

5 of 83 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	49	ASP
1	A	50	ARG
1	A	53	THR

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Mol	Chain	Res	Type
1	C	103	SER
1	D	69	ASP

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	246/271 (91%)	217 (88%)	29 (12%)	5	11
1	B	245/271 (90%)	221 (90%)	24 (10%)	8	17
1	C	245/271 (90%)	216 (88%)	29 (12%)	5	11
1	D	245/271 (90%)	208 (85%)	37 (15%)	3	6
1	E	245/271 (90%)	193 (79%)	52 (21%)	1	2
1	F	245/271 (90%)	191 (78%)	54 (22%)	1	2
All	All	1471/1626 (90%)	1246 (85%)	225 (15%)	2	6

5 of 225 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	280	ARG
1	F	287	LYS
1	E	147	ARG
1	F	284	LYS
1	F	185	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 36 such sidechains are listed below:

Mol	Chain	Res	Type
1	F	97	ASN
1	F	302	ASN
1	F	112	ASN
1	F	214	GLN
1	C	250	HIS

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 monosaccharides in this entry.

5.6 Ligand geometry ⓘ

7 ligands are modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or 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 length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\# Z > 2$	Counts	RMSZ	$\# Z > 2$
3	BME	C	626	-	3,3,3	0.64	0	1,2,2	1.37	0
2	PO4	C	616	-	4,4,4	1.38	1 (25%)	6,6,6	2.69	4 (66%)
2	PO4	E	619	-	4,4,4	0.78	0	6,6,6	1.18	0
2	PO4	E	618	-	4,4,4	0.61	0	6,6,6	1.26	1 (16%)
2	PO4	A	615	-	4,4,4	0.79	0	6,6,6	1.62	2 (33%)
2	PO4	D	617	-	4,4,4	1.26	0	6,6,6	0.98	0
3	BME	E	628	-	3,3,3	0.19	0	1,2,2	1.40	0

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
3	BME	E	628	-	-	0/1/1/1	-
3	BME	C	626	-	-	0/1/1/1	-

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	C	616	PO4	P-O4	-2.15	1.48	1.54

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

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	C	616	PO4	O4-P-O3	4.34	121.90	107.97
2	C	616	PO4	O3-P-O1	-3.81	96.97	110.89
2	A	615	PO4	O2-P-O1	-3.30	98.82	110.89
2	C	616	PO4	O4-P-O1	-2.32	102.42	110.89
2	E	618	PO4	O2-P-O1	-2.25	102.65	110.89

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

4 monomers are involved in 8 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	C	626	BME	3	0
2	E	619	PO4	3	0
2	E	618	PO4	2	0
3	E	628	BME	2	0

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 [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	282/313 (90%)	-0.57	2 (0%) 87 88	5, 26, 51, 82	0
1	B	281/313 (89%)	-0.69	1 (0%) 92 93	3, 21, 48, 58	0
1	C	281/313 (89%)	-0.56	0 100 100	9, 33, 56, 65	0
1	D	281/313 (89%)	-0.39	2 (0%) 87 88	13, 40, 70, 93	0
1	E	281/313 (89%)	0.20	11 (3%) 39 37	29, 60, 99, 108	0
1	F	281/313 (89%)	0.44	22 (7%) 13 11	30, 76, 102, 114	0
All	All	1687/1878 (89%)	-0.26	38 (2%) 60 60	3, 39, 91, 114	0

The worst 5 of 38 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	E	31	LEU	5.0
1	F	147	ARG	4.0
1	E	51	THR	3.9
1	E	53	THR	3.9
1	E	26	PRO	3.6

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 monosaccharides 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
3	BME	E	628	4/4	0.76	0.23	71,78,82,89	0
3	BME	C	626	4/4	0.84	0.22	45,47,50,58	0
2	PO4	E	618	5/5	0.95	0.11	98,99,100,102	0
2	PO4	D	617	5/5	0.97	0.14	70,72,74,76	0
2	PO4	E	619	5/5	0.98	0.10	75,77,79,80	0
2	PO4	C	616	5/5	0.99	0.13	31,33,40,43	0
2	PO4	A	615	5/5	0.99	0.10	36,38,40,42	0

6.5 Other polymers [i](#)

There are no such residues in this entry.