



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 9, 2026 – 10:35 AM UTC

PDB ID : 2NZD / pdb_00002nzd
Title : Nucleosome core particle containing 145 bp of DNA
Authors : Ong, M.S.; Richmond, T.J.; Davey, C.A.
Deposited on : 2006-11-23
Resolution : 2.65 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

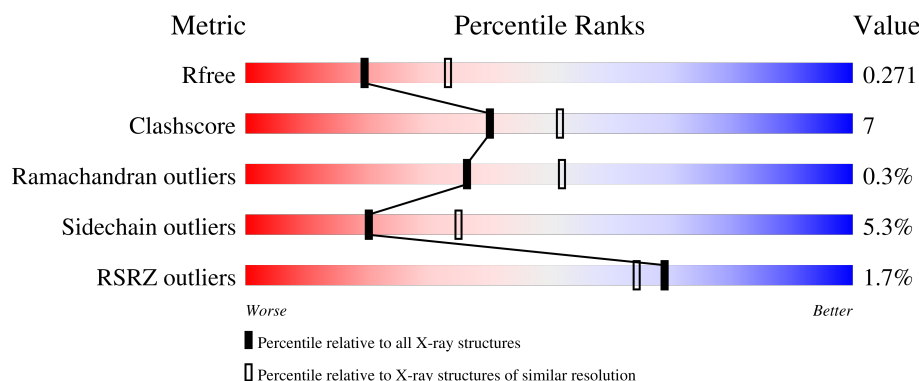
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.65 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.



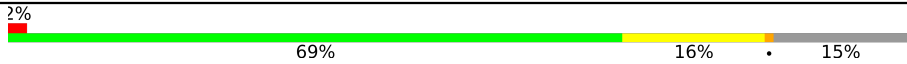
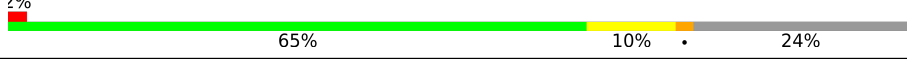
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	1110 (2.66-2.66)
Clashscore	190562	1141 (2.66-2.66)
Ramachandran outliers	187476	1126 (2.66-2.66)
Sidechain outliers	187428	1126 (2.66-2.66)
RSRZ outliers	180081	1110 (2.66-2.66)

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	I	145	 3% 76% 21% •
2	J	145	 % 64% 33% •
3	A	135	 % 61% 10% •• 28%
3	E	135	 % 57% 13% • 28%
4	B	102	 2% 67% 13% • 20%

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Mol	Chain	Length	Quality of chain
4	F	102	 2% 69% 16% • 15%
5	C	119	 2% 72% 14% •• 11%
5	G	119	 80% 8% • 11%
6	D	125	 2% 65% 10% • 24%
6	H	125	 62% 13% • 24%

2 Entry composition

There are 8 unique types of molecules in this entry. The entry contains 12158 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 DNA chain called DNA (145-MER).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	I	145	Total	C	N	O	P	0	0	0
			2970	1421	538	867	144			

- Molecule 2 is a DNA chain called DNA (145-MER).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	J	145	Total	C	N	O	P	0	0	0
			2969	1421	535	869	144			

- Molecule 3 is a protein called Histone H3.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	A	97	Total	C	N	O	S	4	0	0
			802	506	155	138	3			
3	E	97	Total	C	N	O	S	4	0	0
			802	506	155	138	3			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	102	ALA	GLY	variant	GB 288992
A	111	ALA	GLY	variant	GB 288992
E	102	ALA	GLY	variant	GB 288992
E	111	ALA	GLY	variant	GB 288992

- Molecule 4 is a protein called Histone H4.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	B	82	Total	C	N	O	S	0	0	0
			653	412	127	113	1			
4	F	87	Total	C	N	O	S	0	0	0
			703	442	142	118	1			

- Molecule 5 is a protein called histone H2A.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
5	C	106	Total	C	N	O	0	0	0
			818	516	160	142			
5	G	106	Total	C	N	O	0	0	0
			818	516	160	142			

- Molecule 6 is a protein called Histone H2B.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
6	D	95	Total	C	N	O	S	0	0	0
			745	469	134	140	2			
6	H	95	Total	C	N	O	S	0	0	0
			745	469	134	140	2			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	29	THR	SER	variant	UNP P02281
H	29	THR	SER	variant	UNP P02281

- Molecule 7 is MANGANESE (II) ION (CCD ID: MN) (formula: Mn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	I	5	Total	Mn	0	0
			5	5		
7	J	5	Total	Mn	0	0
			5	5		
7	E	1	Total	Mn	0	0
			1	1		

- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	I	15	Total	O	0	0
			15	15		
8	J	18	Total	O	0	0
			18	18		
8	A	10	Total	O	0	0
			10	10		
8	B	10	Total	O	0	0
			10	10		

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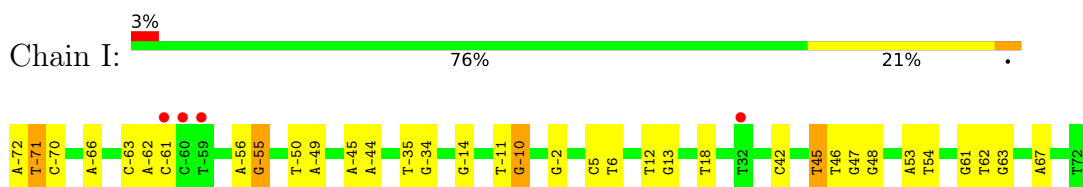
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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	C	14	Total 14	O 14	0	0
8	D	4	Total 4	O 4	0	0
8	E	16	Total 16	O 16	0	0
8	F	16	Total 16	O 16	0	0
8	G	11	Total 11	O 11	0	0
8	H	8	Total 8	O 8	0	0

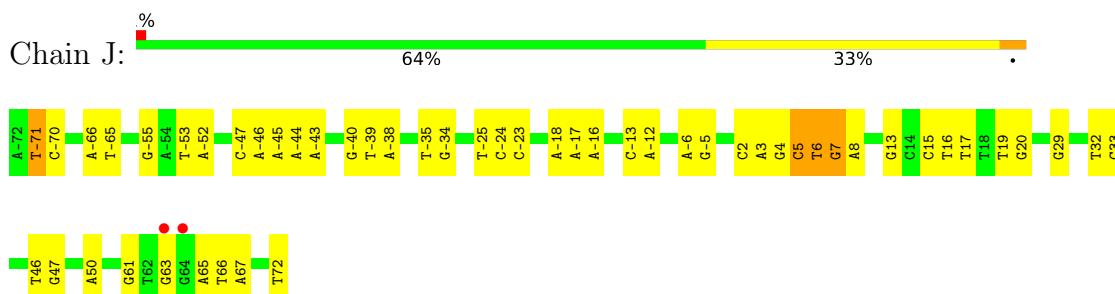
3 Residue-property plots [i](#)

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.

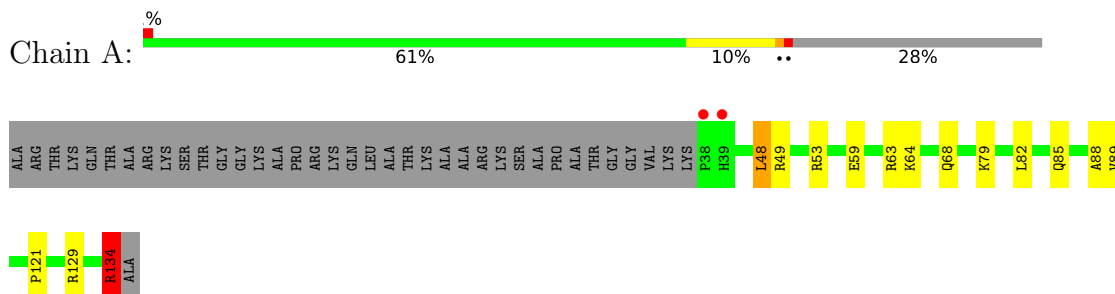
- Molecule 1: DNA (145-MER)



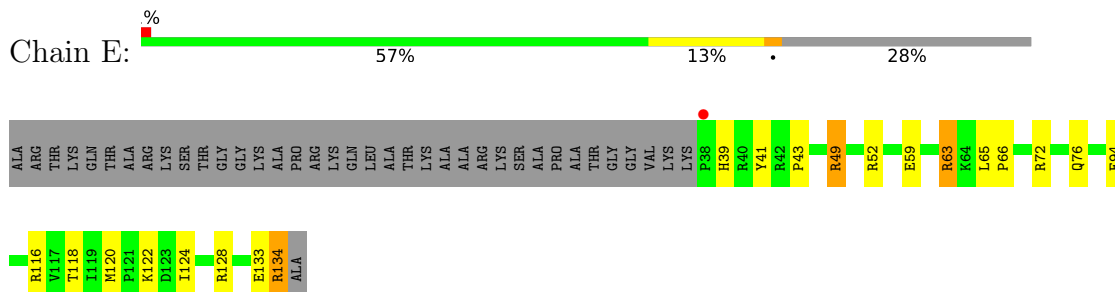
- Molecule 2: DNA (145-MER)



- Molecule 3: Histone H3



- Molecule 3: Histone H3



Amino Acid	Count
SER	1
GLY	1
ARG	1
GLY	1
LYS	1
GLY	1
GLY	1
LYS	1
LYS	1
LYS	1
LEU	1
GLY	1
LYS	1
GLY	1
GLY	1
GLY	1
ALA	1
LYS	1
ARG	1
HIS	1
LYS	1
ARG	1
ARG	1
V21	1
L22	1
R23	1
D24	1
R35	1
R39	1
S47	1
E52	1
R55	1
E74	1
T80	1
M84	1
Y88	1
G102	1

SER	GLY	ARG	GLY	LYS	GLY	GLY	LYS	GLY	LEU	GLY	LYS	GLY	GLY	ALA
R16	R17	H18	R19	T30	K31	P32	R35	R39	R45	I46	S47	I50	Y51	R55
D68	V87	Q93	G94	R95	G101	G102								

SER
GLY
ARG
GLY
LYS
GLN
GLY
GLY
LYS
THR
ARG
ALA
LYS
A14
R17
P26
R29
V30
H31
R32
R35
K36
E41
R42
P48
V54
L55
T59
R71
T76
I79
P80
R81
H82
Q104
K118
L119

SER	GLY	ARG	GLY	GLY	GLN	GLY	GLY	LYS	THR	ARG	ALA	LYS	A14	R17	P26	H31	R35	K75	T76	I79	H82	R88	E91	P117	K118	K119
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[illegible]

PRO	GLU	PRO	PRO	ALA	ALA	LYS	SER	ALA	PRO	ALA	ALA	PRO	PRO	LYS	LYS	GLY	SER	LYS	LYS	ALA	ALA	VAL	THR	THR	THR	GLN	LYS	LYS	ASP	GLY	LYS	LYS	ARG	ARG	K28	K28	T29	R30	K31				Y37		V41		V45	H46		T49		S53		S57		G72		S75		K82	H83	S84		G101	E102	L103
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K122

4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	105.62Å 109.86Å 181.22Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	40.00 – 2.65 40.00 – 2.65	Depositor EDS
% Data completeness (in resolution range)	90.6 (40.00-2.65) 90.6 (40.00-2.65)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	0.07	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.45 (at 2.65Å)	Xtriage
Refinement program	REFMAC 5.2.0019	Depositor
R, R_{free}	0.233 , 0.283 0.224 , 0.271	Depositor DCC
R_{free} test set	1136 reflections (1.83%)	wwPDB-VP
Wilson B-factor (Å ²)	59.5	Xtriage
Anisotropy	0.264	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.30 , 41.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	0.024 for k,h,-l	Xtriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	12158	wwPDB-VP
Average B, all atoms (Å ²)	64.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.69% 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 [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: 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	I	0.31	0/3332	1.00	5/5141 (0.1%)
2	J	0.32	0/3330	1.01	8/5138 (0.2%)
3	A	0.80	1/814 (0.1%)	0.92	2/1092 (0.2%)
3	E	1.00	1/814 (0.1%)	0.99	2/1092 (0.2%)
4	B	0.67	0/660	0.88	0/883
4	F	0.75	0/711	0.97	1/948 (0.1%)
5	C	0.67	0/828	0.96	1/1117 (0.1%)
5	G	0.64	0/828	0.86	0/1117
6	D	0.67	0/756	0.95	1/1015 (0.1%)
6	H	0.65	0/756	0.83	0/1015
All	All	0.56	2/12829 (0.0%)	0.97	20/18558 (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
3	A	0	1
3	E	0	1
All	All	0	2

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	E	134	ARG	CD-NE	-19.35	1.19	1.46
3	A	134	ARG	CD-NE	14.28	1.66	1.46

The worst 5 of 20 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	134	ARG	CG-CD-NE	9.61	133.14	112.00
3	E	134	ARG	CD-NE-CZ	8.05	135.67	124.40
3	E	134	ARG	CG-CD-NE	7.35	128.18	112.00
2	J	7	DG	C5'-C4'-C3'	-7.24	104.03	114.90
5	C	118	LYS	CB-CA-C	-6.76	108.76	116.54

There are no chirality outliers.

All (2) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
3	A	134	ARG	Sidechain
3	E	134	ARG	Sidechain

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	I	2970	0	1640	32	0
2	J	2969	0	1641	43	0
3	A	802	0	841	12	0
3	E	802	0	841	18	0
4	B	653	0	696	8	0
4	F	703	0	755	15	0
5	C	818	0	877	18	0
5	G	818	0	877	7	0
6	D	745	0	773	11	0
6	H	745	0	773	11	0
7	E	1	0	0	0	0
7	I	5	0	0	0	0
7	J	5	0	0	0	0
8	A	10	0	0	2	0
8	B	10	0	0	0	0
8	C	14	0	0	1	0
8	D	4	0	0	2	0
8	E	16	0	0	2	0
8	F	16	0	0	0	0
8	G	11	0	0	1	0
8	H	8	0	0	1	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
8	I	15	0	0	3	0
8	J	18	0	0	0	0
All	All	12158	0	9714	144	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 144 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)
3:E:49:ARG:HG3	3:E:49:ARG:HH11	1.21	1.02
5:C:17:ARG:HH22	5:C:31:HIS:CD2	1.79	1.00
5:C:17:ARG:HH22	5:C:31:HIS:HD2	1.03	0.99
4:F:87:VAL:HG11	4:F:102:GLY:HA3	1.52	0.91
4:B:23:ARG:HH11	4:B:23:ARG:HG2	1.40	0.85

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	
3	A	95/135 (70%)	94 (99%)	1 (1%)	0	100	100
3	E	95/135 (70%)	95 (100%)	0	0	100	100
4	B	80/102 (78%)	76 (95%)	4 (5%)	0	100	100
4	F	85/102 (83%)	81 (95%)	4 (5%)	0	100	100
5	C	104/119 (87%)	100 (96%)	4 (4%)	0	100	100
5	G	104/119 (87%)	101 (97%)	3 (3%)	0	100	100
6	D	93/125 (74%)	91 (98%)	1 (1%)	1 (1%)	11	19
6	H	93/125 (74%)	90 (97%)	2 (2%)	1 (1%)	11	19

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles
All	All	749/962 (78%)	728 (97%)	19 (2%)	2 (0%)	36 52

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
6	D	101	GLY
6	H	101	GLY

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
3	A	85/110 (77%)	82 (96%)	3 (4%)	32 52
3	E	85/110 (77%)	82 (96%)	3 (4%)	32 52
4	B	67/78 (86%)	61 (91%)	6 (9%)	9 14
4	F	72/78 (92%)	69 (96%)	3 (4%)	26 45
5	C	84/92 (91%)	77 (92%)	7 (8%)	10 18
5	G	84/92 (91%)	80 (95%)	4 (5%)	23 39
6	D	81/105 (77%)	78 (96%)	3 (4%)	30 50
6	H	81/105 (77%)	76 (94%)	5 (6%)	16 29
All	All	639/770 (83%)	605 (95%)	34 (5%)	20 35

5 of 34 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
5	G	91	GLU
6	H	29	THR
6	H	57	SER
5	C	76	THR
5	C	59	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 6 such sidechains are listed below:

Mol	Chain	Res	Type
3	E	68	GLN
5	G	31	HIS
6	H	79	HIS
5	C	31	HIS
3	A	39	HIS

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 11 ligands modelled in this entry, 11 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 [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	I	145/145 (100%)	0.46	4 (2%) 55 48	39, 88, 124, 137	0
2	J	145/145 (100%)	0.39	2 (1%) 73 69	42, 86, 121, 129	0
3	A	97/135 (71%)	-0.14	2 (2%) 63 57	28, 44, 57, 75	1 (1%)
3	E	97/135 (71%)	-0.41	1 (1%) 79 76	22, 32, 46, 60	1 (1%)
4	B	82/102 (80%)	-0.20	2 (2%) 59 53	30, 38, 55, 78	0
4	F	87/102 (85%)	-0.34	2 (2%) 61 54	22, 31, 58, 90	0
5	C	106/119 (89%)	-0.13	2 (1%) 66 61	24, 39, 55, 73	0
5	G	106/119 (89%)	-0.19	0 100 100	29, 44, 66, 78	0
6	D	95/125 (76%)	-0.09	3 (3%) 50 42	29, 40, 65, 72	0
6	H	95/125 (76%)	-0.10	0 100 100	31, 44, 66, 85	0
All	All	1055/1252 (84%)	-0.03	18 (1%) 69 64	22, 44, 111, 137	2 (0%)

The worst 5 of 18 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
3	A	38	PRO	4.3
6	D	28	LYS	4.2
4	B	21	VAL	3.8
4	F	102	GLY	3.6
1	I	-59	DT	2.7

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($\text{\AA}^2$)	Q<0.9
7	MN	I	1011	1/1	0.75	0.10	129,129,129,129	0
7	MN	J	1006	1/1	0.76	0.20	116,116,116,116	0
7	MN	I	1008	1/1	0.82	0.16	100,100,100,100	0
7	MN	I	1003	1/1	0.84	0.14	97,97,97,97	0
7	MN	I	1002	1/1	0.84	0.22	104,104,104,104	0
7	MN	J	1010	1/1	0.84	0.08	112,112,112,112	0
7	MN	J	1004	1/1	0.91	0.19	75,75,75,75	0
7	MN	I	1009	1/1	0.92	0.15	81,81,81,81	0
7	MN	J	1005	1/1	0.92	0.18	76,76,76,76	0
7	MN	J	1007	1/1	0.95	0.10	84,84,84,84	0
7	MN	E	1001	1/1	1.00	0.03	33,33,33,33	0

6.5 Other polymers [i](#)

There are no such residues in this entry.