



Full wwPDB X-ray Structure Validation Report ⓘ

Apr 25, 2026 – 05:25 PM EDT

PDB ID : 6THA / pdb_00006tha
Title : Crystal structure of human sugar transporter GLUT1 (SLC2A1) in the inward conformation
Authors : Pedersen, B.P.; Paulsen, P.A.; Custodio, T.F.
Deposited on : 2019-11-19
Resolution : 2.40 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	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
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

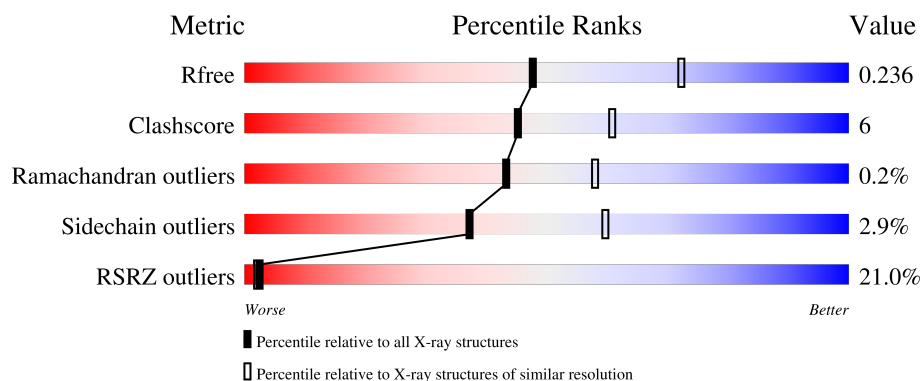
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.40 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	4912 (2.40-2.40)
Clashscore	190562	5391 (2.40-2.40)
Ramachandran outliers	187476	5320 (2.40-2.40)
Sidechain outliers	187428	5321 (2.40-2.40)
RSRZ outliers	180081	4916 (2.40-2.40)

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	496	

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 3556 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.

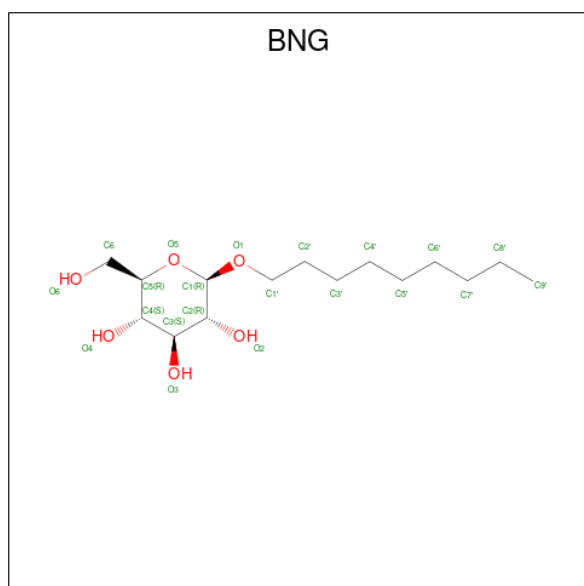
- Molecule 1 is a protein called Solute carrier family 2, facilitated glucose transporter member 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	448	Total	C	N	O	S	0	0	0
			3478	2299	563	594	22			

There are 4 discrepancies between the modelled and reference sequences:

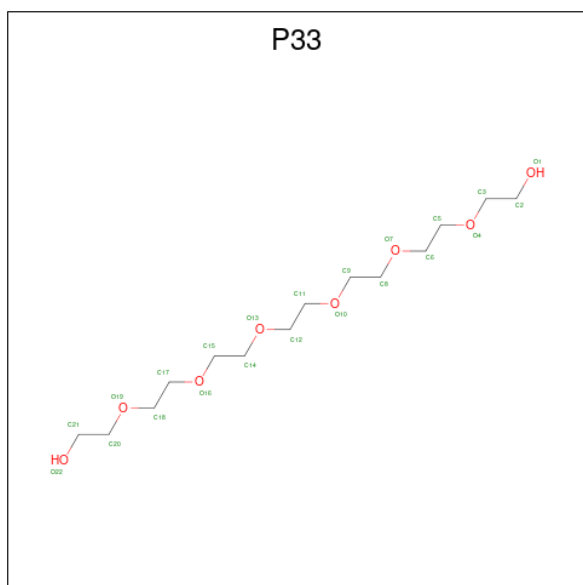
Chain	Residue	Modelled	Actual	Comment	Reference
A	493	LEU	-	expression tag	UNP P11166
A	494	VAL	-	expression tag	UNP P11166
A	495	PRO	-	expression tag	UNP P11166
A	496	ARG	-	expression tag	UNP P11166

- Molecule 2 is nonyl beta-D-glucopyranoside (CCD ID: BNG) (formula: $C_{15}H_{30}O_6$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			21	15	6		
2	A	1	Total	C	O	0	0
			21	15	6		

- Molecule 3 is 3,6,9,12,15,18-HEXA OXAICOSANE-1,20-DIOL (CCD ID: P33) (formula: $C_{14}H_{30}O_8$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			22	14	8		

- Molecule 4 is CHLORIDE ION (CCD ID: CL) (formula: Cl) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	1	Total	Cl	0	0
			1	1		

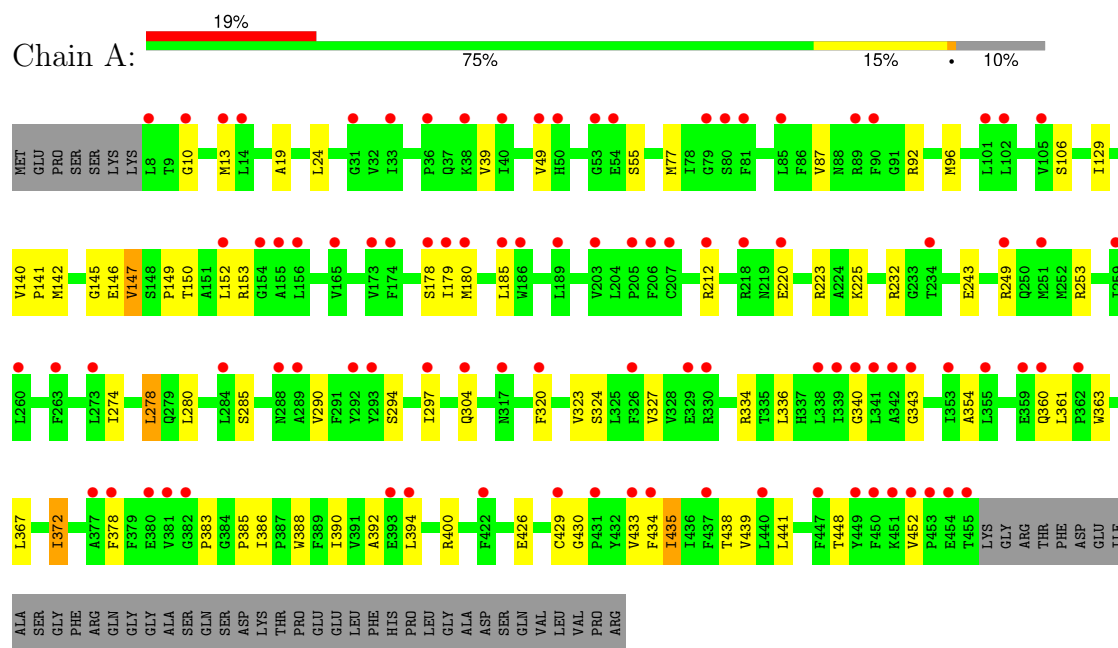
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	13	Total	O	0	0
			13	13		

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: Solute carrier family 2, facilitated glucose transporter member 1



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	120.00Å 102.18Å 69.00Å 90.00° 98.89° 90.00°	Depositor
Resolution (Å)	41.66 – 2.40 41.66 – 2.40	Depositor EDS
% Data completeness (in resolution range)	99.8 (41.66-2.40) 99.9 (41.66-2.40)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.03 (at 2.39Å)	Xtriage
Refinement program	PHENIX dev-2614	Depositor
R, R_{free}	0.204 , 0.229 0.210 , 0.236	Depositor DCC
R_{free} test set	1583 reflections (4.92%)	wwPDB-VP
Wilson B-factor (Å ²)	78.6	Xtriage
Anisotropy	0.412	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.27 , 63.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	3556	wwPDB-VP
Average B, all atoms (Å ²)	105.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.78% 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: BNG, CL, P33

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	0.19	0/3561	0.38	0/4836

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

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	3478	0	3601	43	0
2	A	42	0	60	1	0
3	A	22	0	30	1	0
4	A	1	0	0	0	0
5	A	13	0	0	0	0
All	All	3556	0	3691	43	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 6.

All (43) 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:278:LEU:HD12	1:A:390:ILE:HG12	1.68	0.75
1:A:426:GLU:HA	1:A:433:VAL:HG21	1.80	0.64
1:A:145:GLY:O	1:A:153:ARG:NH2	2.30	0.63
1:A:10:GLY:HA2	1:A:13:MET:HE3	1.85	0.59
1:A:334:ARG:NH1	1:A:448:THR:O	2.37	0.57
1:A:146:GLU:HG2	1:A:212:ARG:HD3	1.87	0.57
1:A:340:GLY:HA3	1:A:383:PRO:HD3	1.88	0.55
1:A:19:ALA:HA	1:A:96:MET:HE1	1.90	0.53
1:A:324:SER:HA	1:A:327:VAL:HG12	1.88	0.53
1:A:290:VAL:HG22	1:A:372:ILE:HD13	1.91	0.53
1:A:274:ILE:HG23	1:A:452:VAL:HG22	1.91	0.53
1:A:434:PHE:O	1:A:438:THR:HG23	2.08	0.53
1:A:220:GLU:OE1	1:A:223:ARG:HD3	2.10	0.52
1:A:354:ALA:HB2	1:A:367:LEU:HD23	1.90	0.52
1:A:147:VAL:O	1:A:232:ARG:NH2	2.40	0.52
1:A:430:GLY:O	1:A:433:VAL:HG23	2.10	0.50
1:A:150:THR:OG1	1:A:243:GLU:OE1	2.29	0.50
1:A:149:PRO:HG2	1:A:152:LEU:HD12	1.94	0.49
1:A:49:VAL:HG12	1:A:55:SER:HA	1.96	0.48
1:A:140:VAL:HB	1:A:141:PRO:HD3	1.97	0.47
1:A:361:LEU:HD22	1:A:363:TRP:CZ2	2.49	0.47
1:A:87:VAL:CG2	1:A:92:ARG:HG3	2.44	0.47
1:A:385:PRO:HA	2:A:501:BNG:H4'1	1.98	0.46
1:A:334:ARG:NH1	1:A:452:VAL:O	2.49	0.46
1:A:274:ILE:HG22	1:A:390:ILE:HD13	1.98	0.45
1:A:343:GLY:HA3	1:A:378:PHE:CD1	2.51	0.45
1:A:106:SER:OG	1:A:129:ILE:HB	2.17	0.45
1:A:388:TRP:CZ2	3:A:503:P33:H142	2.51	0.45
1:A:320:PHE:HA	1:A:323:VAL:HB	2.00	0.44
1:A:142:MET:HE2	1:A:142:MET:HB3	1.74	0.44
1:A:77:MET:HE2	1:A:77:MET:HB3	1.81	0.44
1:A:336:LEU:HB2	1:A:386:ILE:HD11	2.00	0.43
1:A:285:SER:HB2	1:A:441:LEU:HD21	1.99	0.43
1:A:180:MET:HA	1:A:185:LEU:HB2	2.00	0.42
1:A:278:LEU:HD12	1:A:390:ILE:CG1	2.46	0.42
1:A:392:ALA:HA	1:A:400:ARG:HD3	2.02	0.42
1:A:429:CYS:HB2	1:A:433:VAL:HG22	2.01	0.42
1:A:426:GLU:HA	1:A:433:VAL:CG2	2.48	0.41
1:A:360:GLN:OE1	1:A:360:GLN:N	2.50	0.41
1:A:294:SER:O	1:A:297:ILE:HG13	2.20	0.41
1:A:290:VAL:O	1:A:294:SER:HB3	2.20	0.41
1:A:435:ILE:O	1:A:439:VAL:HG23	2.20	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:249:ARG:O	1:A:253:ARG:HG3	2.21	0.40

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	446/496 (90%)	433 (97%)	12 (3%)	1 (0%)	43 58

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	304	GLN

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	376/416 (90%)	365 (97%)	11 (3%)	37 60

All (11) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	24	LEU
1	A	39	VAL

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Mol	Chain	Res	Type
1	A	147	VAL
1	A	178	SER
1	A	179	ILE
1	A	225	LYS
1	A	278	LEU
1	A	280	LEU
1	A	372	ILE
1	A	394	LEU
1	A	435	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	317	ASN

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 4 ligands modelled in this entry, 1 is monoatomic - leaving 3 for Mogul analysis.

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
2	BNG	A	502	-	21,21,21	0.11	0	26,26,26	0.32	0
2	BNG	A	501	-	21,21,21	0.19	0	26,26,26	0.21	0
3	P33	A	503	-	21,21,21	0.19	0	20,20,20	0.15	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
2	BNG	A	502	-	-	2/12/32/32	0/1/1/1
2	BNG	A	501	-	-	1/12/32/32	0/1/1/1
3	P33	A	503	-	-	9/19/19/19	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (12) torsion outliers are listed below:

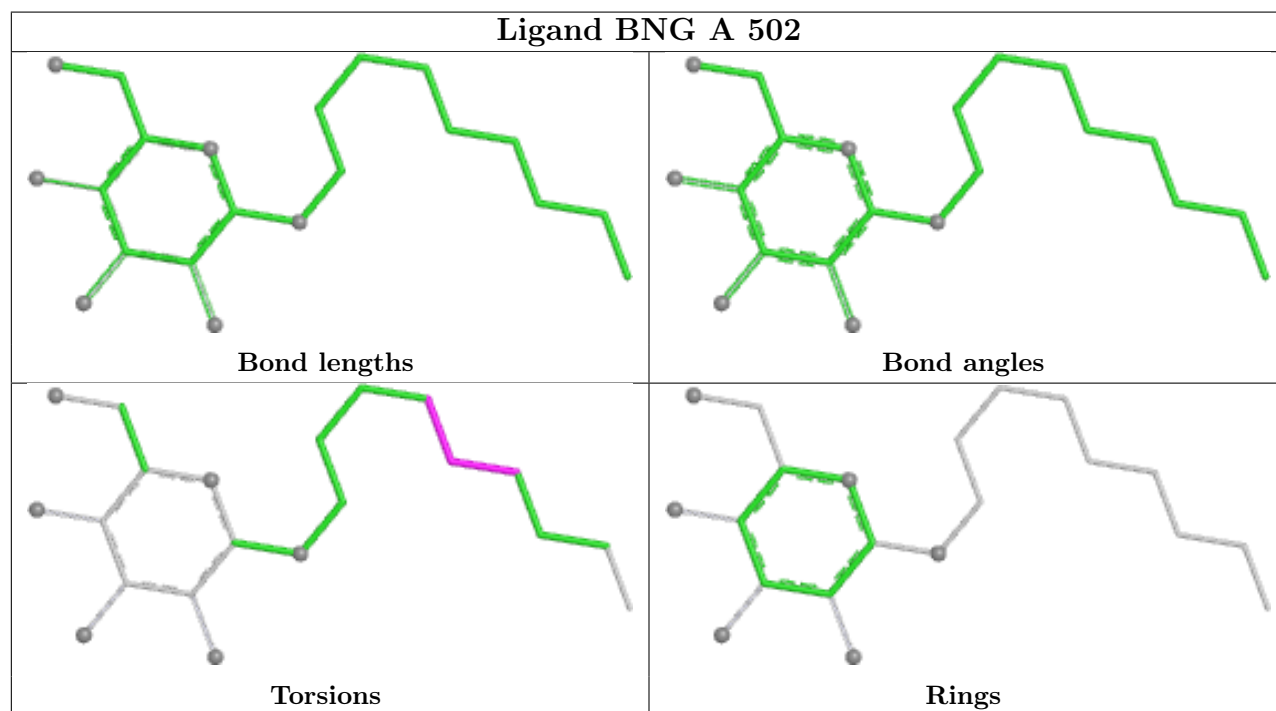
Mol	Chain	Res	Type	Atoms
3	A	503	P33	C11-C12-O13-C14
2	A	502	BNG	C4'-C5'-C6'-C7'
3	A	503	P33	C5-C6-O7-C8
3	A	503	P33	O13-C14-C15-O16
3	A	503	P33	C18-C17-O16-C15
3	A	503	P33	C21-C20-O19-C18
3	A	503	P33	C17-C18-O19-C20
2	A	501	BNG	C2'-C1'-O1-C1
3	A	503	P33	O10-C11-C12-O13
3	A	503	P33	O16-C17-C18-O19
3	A	503	P33	O4-C5-C6-O7
2	A	502	BNG	C3'-C4'-C5'-C6'

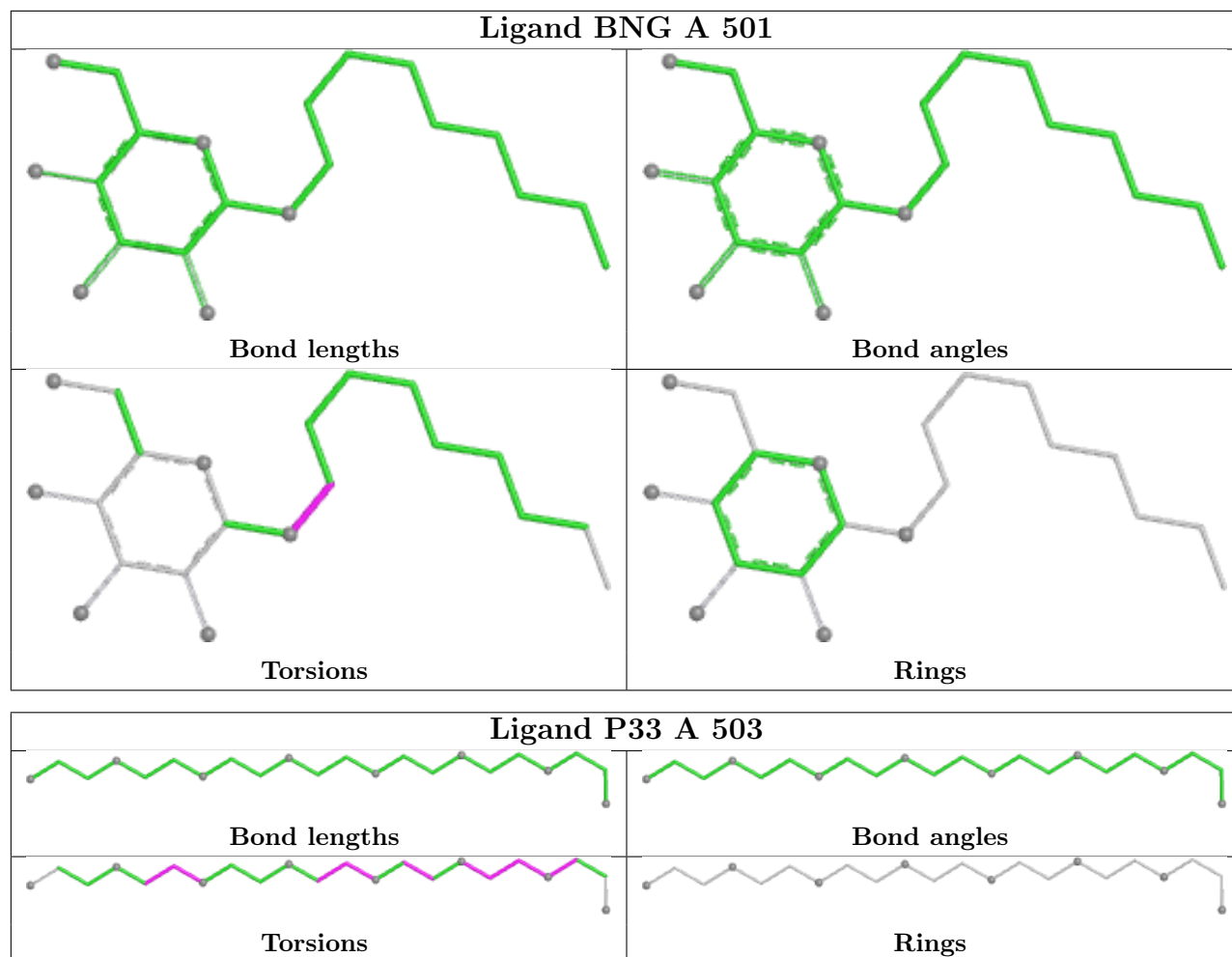
There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	501	BNG	1	0
3	A	503	P33	1	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.





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	448/496 (90%)	1.15	94 (20%) 2 2	66, 101, 152, 188	0

All (94) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	53	GLY	10.0
1	A	454	GLU	8.9
1	A	89	ARG	7.8
1	A	8	LEU	7.7
1	A	13	MET	6.7
1	A	455	THR	6.1
1	A	14	LEU	5.8
1	A	54	GLU	5.7
1	A	206	PHE	5.2
1	A	292	TYR	5.0
1	A	260	LEU	4.9
1	A	360	GLN	4.9
1	A	451	LYS	4.8
1	A	393	GLU	4.8
1	A	381	VAL	4.7
1	A	49	VAL	4.6
1	A	377	ALA	4.4
1	A	450	PHE	4.4
1	A	339	ILE	4.4
1	A	378	PHE	4.1
1	A	452	VAL	4.0
1	A	90	PHE	4.0
1	A	38	LYS	3.9
1	A	33	ILE	3.8
1	A	326	PHE	3.7
1	A	382	GLY	3.7
1	A	50	HIS	3.7

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Mol	Chain	Res	Type	RSRZ
1	A	31	GLY	3.5
1	A	394	LEU	3.5
1	A	340	GLY	3.5
1	A	453	PRO	3.5
1	A	218	ARG	3.4
1	A	156	LEU	3.4
1	A	273	LEU	3.4
1	A	284	LEU	3.4
1	A	433	VAL	3.3
1	A	304	GLN	3.3
1	A	36	PRO	3.3
1	A	101	LEU	3.2
1	A	440	LEU	3.2
1	A	180	MET	3.1
1	A	342	ALA	3.1
1	A	102	LEU	3.0
1	A	220	GLU	3.0
1	A	380	GLU	2.9
1	A	85	LEU	2.9
1	A	80	SER	2.9
1	A	178	SER	2.8
1	A	174	PHE	2.8
1	A	359	GLU	2.8
1	A	154	GLY	2.8
1	A	207	CYS	2.8
1	A	205	PRO	2.7
1	A	263	PHE	2.7
1	A	355	LEU	2.7
1	A	251	MET	2.7
1	A	437	PHE	2.7
1	A	249	ARG	2.7
1	A	81	PHE	2.6
1	A	429	CYS	2.6
1	A	431	PRO	2.6
1	A	293	TYR	2.5
1	A	40	ILE	2.5
1	A	152	LEU	2.5
1	A	155	ALA	2.5
1	A	329	GLU	2.5
1	A	320	PHE	2.5
1	A	173	VAL	2.4
1	A	289	ALA	2.4

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Mol	Chain	Res	Type	RSRZ
1	A	185	LEU	2.4
1	A	259	ILE	2.4
1	A	449	TYR	2.4
1	A	105	VAL	2.4
1	A	317	ASN	2.4
1	A	362	PRO	2.3
1	A	422	PHE	2.3
1	A	338	LEU	2.3
1	A	297	ILE	2.2
1	A	186	TRP	2.2
1	A	330	ARG	2.2
1	A	79	GLY	2.2
1	A	447	PHE	2.2
1	A	341	LEU	2.2
1	A	353	ILE	2.1
1	A	212	ARG	2.1
1	A	434	PHE	2.1
1	A	203	VAL	2.1
1	A	288	ASN	2.1
1	A	10	GLY	2.1
1	A	189	LEU	2.1
1	A	165	VAL	2.1
1	A	343	GLY	2.1
1	A	234	THR	2.1
1	A	179	ILE	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 ⓘ

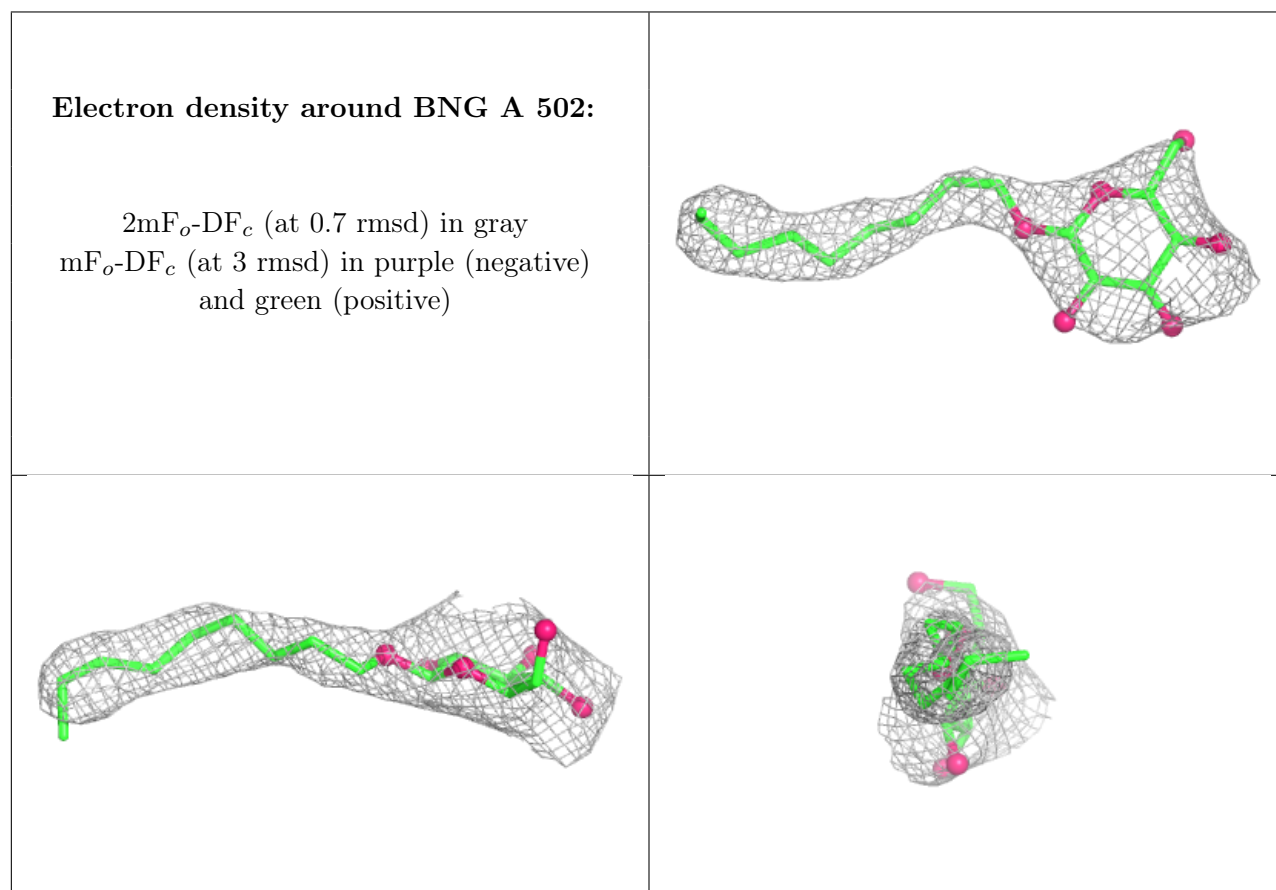
There are no oligosaccharides in this entry.

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.

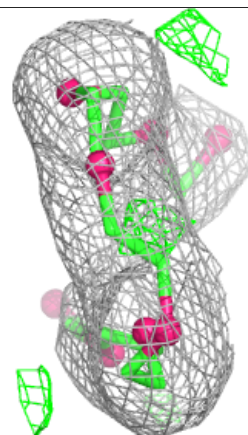
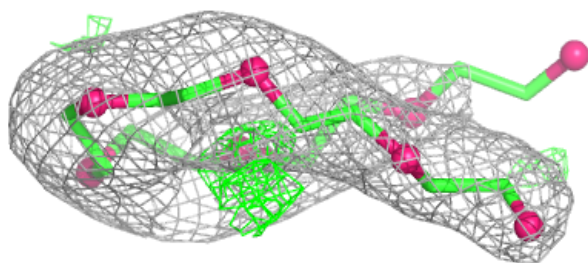
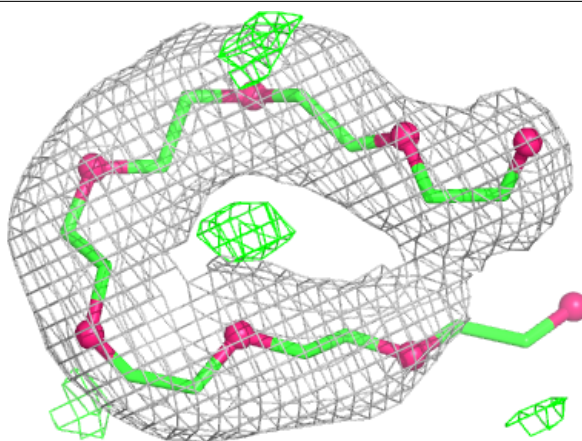
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
2	BNG	A	502	21/21	0.90	0.16	94,133,140,145	0
3	P33	A	503	22/22	0.92	0.18	73,111,142,144	0
4	CL	A	504	1/1	0.92	0.13	106,106,106,106	0
2	BNG	A	501	21/21	0.94	0.18	85,98,123,128	0

The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.



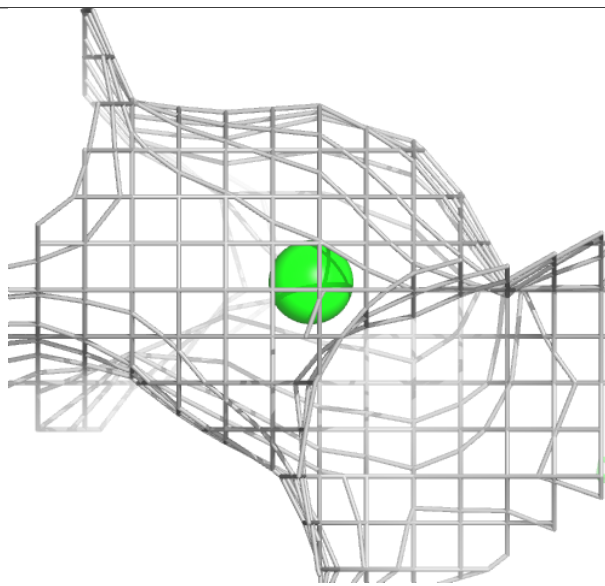
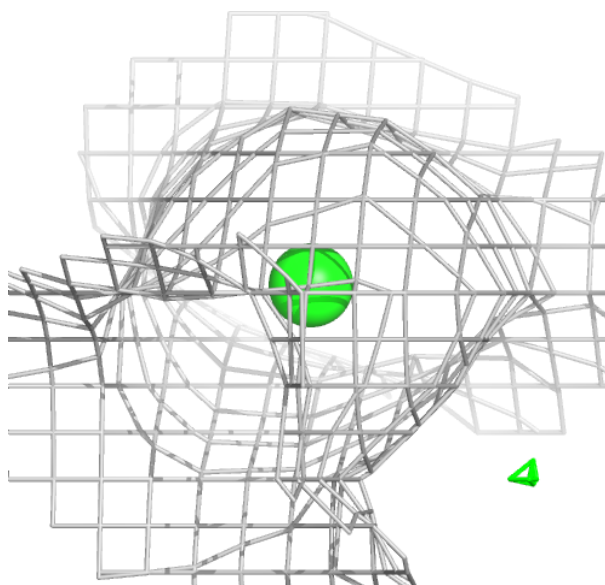
Electron density around P33 A 503:

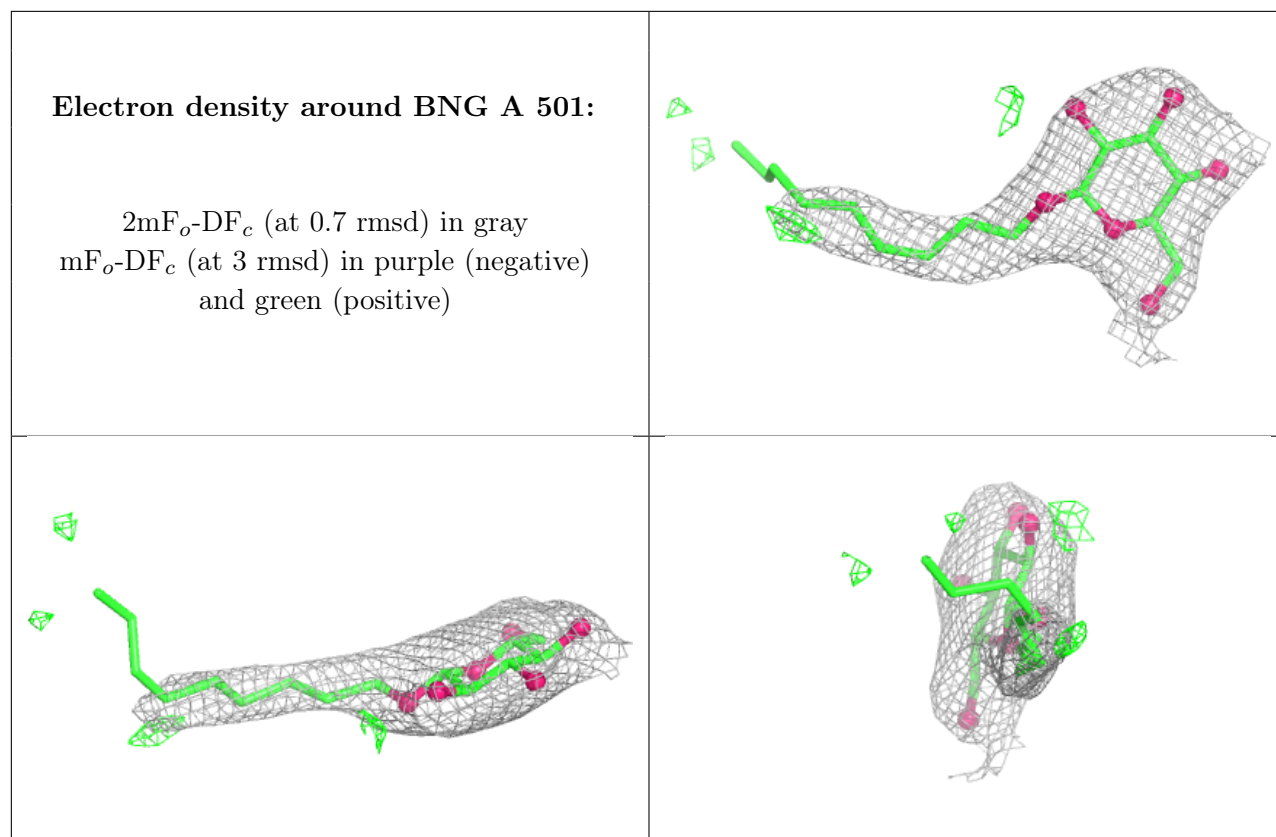
$2mF_o-DF_c$ (at 0.7 rmsd) in gray
 mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)



Electron density around CL A 504:

$2mF_o-DF_c$ (at 0.7 rmsd) in gray
 mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)





6.5 Other polymers [i](#)

There are no such residues in this entry.