



# Full wwPDB/EMDatabank EM Map/Model Validation Report ⓘ

Jul 1, 2019 – 02:18 PM EDT

PDB ID : 6NZU  
EMDB ID: : EMD-0560  
Title : Structure of the human frataxin-bound iron-sulfur cluster assembly complex  
Authors : Fox, N.G.; Yu, X.; Xidong, F.; Alain, M.; Joseph, N.; Claire, S.D.; Christine, B.; Han, S.; Yue, W.W.  
Deposited on : 2019-02-14  
Resolution : 3.20 Å(reported)  
Based on PDB ID : 5KZ5, 5WKP

This is a Full wwPDB/EMDatabank EM Map/Model Validation Report  
for a publicly released PDB/EMDB entry.

We welcome your comments at [validation@mail.wwpdb.org](mailto:validation@mail.wwpdb.org)

A user guide is available at

<https://www.wwpdb.org/validation/2017/EMValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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MolProbity : 4.02b-467  
Mogul : 1.8.0 (224370), CSD as540be (2019)  
Percentile statistics : 20171227.v01 (using entries in the PDB archive December 27th 2017)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et. al. (1996)  
Validation Pipeline (wwPDB-VP) : 2.3.2

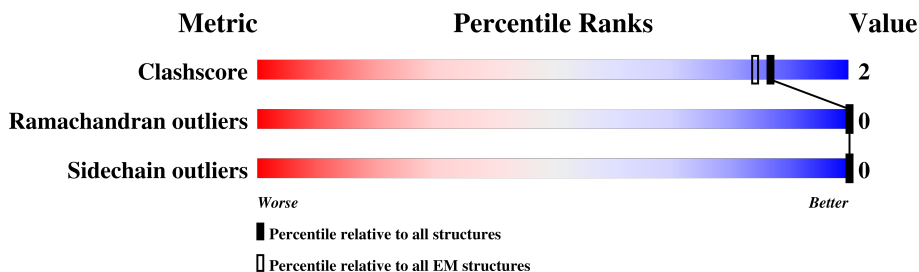
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*ELECTRON MICROSCOPY*

The reported resolution of this entry is 3.20 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)	EM structures (#Entries)
Clashscore	136327	1886
Ramachandran outliers	132723	1663
Sidechain outliers	132532	1531

The table below summarises the geometric issues observed across the polymeric chains. The red, orange, yellow and green segments on the bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. 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  $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	403	95% 5%
1	E	403	95% 5%
2	B	92	83% 5% 12%
2	F	92	83% 5% 12%
3	C	74	86% 8% 5%
3	G	74	84% 11% 5%
4	D	124	91% 8% .
4	H	124	90% 10% .
5	I	132	83% 7% 11%

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Mol	Chain	Length	Quality of chain
5	J	132	 84% 5% 11%

## 2 Entry composition [i](#)

There are 8 unique types of molecules in this entry. The entry contains 12570 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, 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 Cysteine desulfurase, mitochondrial.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
1	A	402	Total	C	N	O	S	1	0
			3139	1968	558	593	20		
1	E	402	Total	C	N	O	S	1	0
			3139	1968	558	593	20		

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	55	MET	-	initiating methionine	UNP Q9Y697
E	55	MET	-	initiating methionine	UNP Q9Y697

- Molecule 2 is a protein called LYR motif-containing protein 4.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
2	B	81	Total	C	N	O	S	1	0
			685	430	136	118	1		
2	F	81	Total	C	N	O	S	1	0
			685	430	136	118	1		

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	0	SER	-	expression tag	UNP Q9HD34
B	11	ALA	SER	conflict	UNP Q9HD34
F	0	SER	-	expression tag	UNP Q9HD34
F	11	ALA	SER	conflict	UNP Q9HD34

- Molecule 3 is a protein called Acyl carrier protein.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
3	C	70	Total	C	N	O	S	0	0
			547	339	83	124	1		

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Mol	Chain	Residues	Atoms					AltConf	Trace
3	G	70	Total	C	N	O	S	0	0
			547	339	83	124	1		

- Molecule 4 is a protein called Iron-sulfur cluster assembly enzyme ISCU, mitochondrial.

Mol	Chain	Residues	Atoms					AltConf	Trace
4	D	123	Total	C	N	O	S	0	0
			927	585	159	177	6		
4	H	123	Total	C	N	O	S	0	0
			927	585	159	177	6		

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	34	MET	-	initiating methionine	UNP Q9H1K1
H	34	MET	-	initiating methionine	UNP Q9H1K1

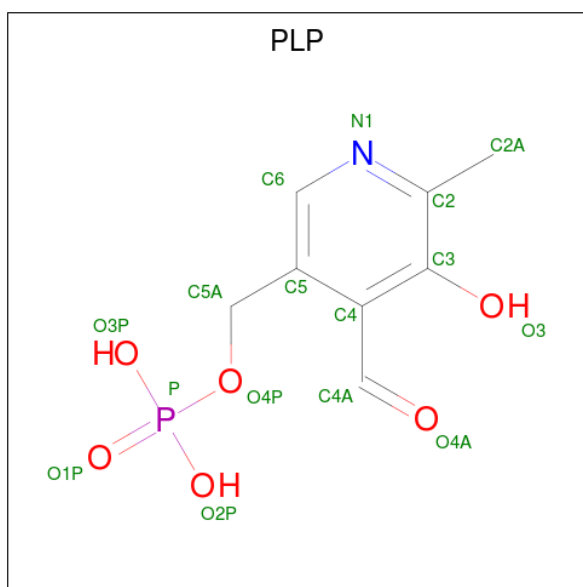
- Molecule 5 is a protein called Frataxin, mitochondrial.

Mol	Chain	Residues	Atoms				AltConf	Trace
5	I	118	Total	C	N	O	1	0
			937	601	146	190		
5	J	118	Total	C	N	O	1	0
			937	601	146	190		

There are 4 discrepancies between the modelled and reference sequences:

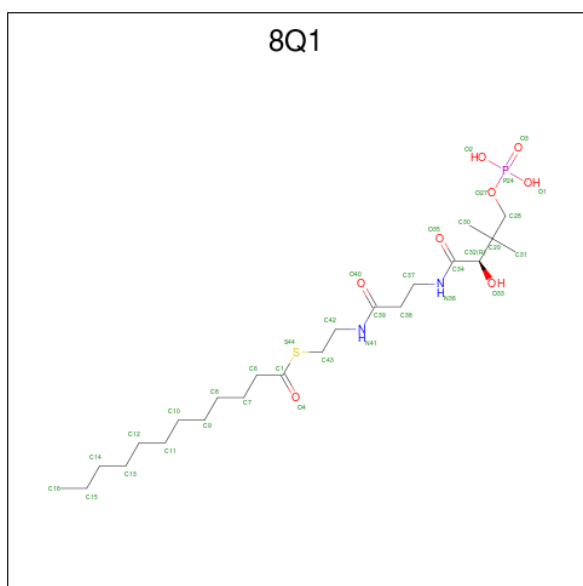
Chain	Residue	Modelled	Actual	Comment	Reference
I	79	SER	-	expression tag	UNP Q16595
I	80	MET	-	expression tag	UNP Q16595
J	79	SER	-	expression tag	UNP Q16595
J	80	MET	-	expression tag	UNP Q16595

- Molecule 6 is PYRIDOXAL-5'-PHOSPHATE (three-letter code: PLP) (formula: C<sub>8</sub>H<sub>10</sub>NO<sub>6</sub>P).



Mol	Chain	Residues	Atoms					AltConf
			Total	C	N	O	P	
6	A	1	15	8	1	5	1	0
6	E	1	15	8	1	5	1	0

- Molecule 7 is S-[2-({N-[(2R)-2-hydroxy-3,3-dimethyl-4-(phosphonoxy)butanoyl]-beta-alanyl]amino)ethyl] dodecanethioate (three-letter code: 8Q1) (formula: C<sub>23</sub>H<sub>45</sub>N<sub>2</sub>O<sub>8</sub>PS).



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Mol	Chain	Residues	Atoms						AltConf
			Total	C	N	O	P	S	
7	G	1	34	23	2	7	1	1	0

- Molecule 8 is ZINC ION (three-letter code: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		AltConf
8	H	1	Total	Zn	0
			1	1	
8	D	1	Total	Zn	0
			1	1	

### 3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA and DNA 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. 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. 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: Cysteine desulfurase, mitochondrial

Chain A:  95% 5%




- Molecule 1: Cysteine desulfurase, mitochondrial

Chain E:  95% 5%




- Molecule 2: LYR motif-containing protein 4

Chain B:  83% 5% 12%




- Molecule 2: LYR motif-containing protein 4

Chain F:  83% 5% 12%




- Molecule 3: Acyl carrier protein

Chain C:  86% 8% 5%



- Molecule 3: Acyl carrier protein

Chain G:  84% 11% 5%

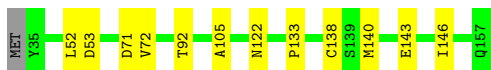




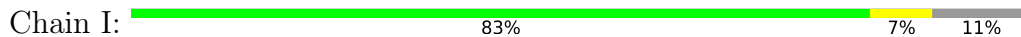
- Molecule 4: Iron-sulfur cluster assembly enzyme ISCU, mitochondrial



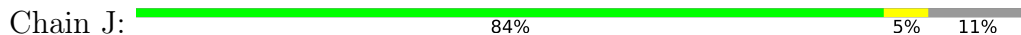
- Molecule 4: Iron-sulfur cluster assembly enzyme ISCU, mitochondrial



- Molecule 5: Frataxin, mitochondrial



- Molecule 5: Frataxin, mitochondrial



## 4 Experimental information

Property	Value	Source
Reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, C2	Depositor
Number of particles used	267153	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	FEI TITAN KRIOS	Depositor
Voltage (kV)	300	Depositor
Electron dose ( $e^-/\text{\AA}^2$ )	42	Depositor
Minimum defocus (nm)	Not provided	Depositor
Maximum defocus (nm)	Not provided	Depositor
Magnification	Not provided	Depositor
Image detector	GATAN K2 SUMMIT (4k x 4k)	Depositor

## 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: 8Q1, ZN, PLP

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  >2	RMSZ	# Z  >2
1	A	0.64	0/3200	0.61	0/4325
1	E	0.64	0/3200	0.61	0/4325
2	B	0.57	0/697	0.62	0/934
2	F	0.58	0/697	0.65	0/934
3	C	0.31	0/550	0.50	0/744
3	G	0.31	0/550	0.50	0/744
4	D	0.42	0/940	0.53	0/1266
4	H	0.42	0/940	0.53	0/1266
5	I	0.46	0/962	0.56	0/1306
5	J	0.46	0/962	0.57	0/1306
All	All	0.55	0/12698	0.59	0/17150

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	3139	0	3162	12	0
1	E	3139	0	3162	13	0
2	B	685	0	716	4	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	F	685	0	716	4	0
3	C	547	0	524	3	0
3	G	547	0	524	4	0
4	D	927	0	959	6	0
4	H	927	0	959	8	0
5	I	937	0	909	6	0
5	J	937	0	909	4	0
6	A	15	0	6	0	0
6	E	15	0	6	1	0
7	C	34	0	0	1	0
7	G	34	0	0	1	0
8	D	1	0	0	0	0
8	H	1	0	0	0	0
All	All	12570	0	12552	55	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 2.

All (55) 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)
2:B:6:ARG:NH2	7:C:101:8Q1:O3	2.20	0.75
4:H:52:LEU:O	4:H:53:ASP:OD1	2.06	0.74
4:D:52:LEU:O	4:D:53:ASP:OD1	2.06	0.73
2:F:6:ARG:NH2	7:G:101:8Q1:O3	2.22	0.72
4:H:122:ASN:N	4:H:143:GLU:OE1	2.28	0.66
1:A:122:ILE:HD13	1:A:270:ILE:HD12	1.78	0.66
1:E:122:ILE:HD13	1:E:270:ILE:HD12	1.78	0.66
4:D:122:ASN:N	4:D:143:GLU:OE1	2.28	0.66
4:D:122:ASN:ND2	4:D:140:MET:SD	2.71	0.64
4:H:122:ASN:ND2	4:H:140:MET:SD	2.71	0.63
1:A:456:GLN:OE1	5:I:151:ASN:ND2	2.32	0.62
1:A:363:GLY:O	1:A:366:LEU:N	2.32	0.61
1:A:64:GLN:NE2	1:A:352:GLY:O	2.34	0.61
1:E:363:GLY:O	1:E:366:LEU:N	2.34	0.61
1:E:258:LYS:NZ	6:E:501:PLP:O3	2.33	0.60
1:E:64:GLN:NE2	1:E:352:GLY:O	2.37	0.57
4:D:105:ALA:HB1	4:D:146:ILE:HD11	1.87	0.57
1:A:109:GLN:NE2	1:A:309:GLU:OE1	2.38	0.57
4:H:105:ALA:HB1	4:H:146:ILE:HD11	1.87	0.56
1:E:109:GLN:NE2	1:E:309:GLU:OE1	2.38	0.56

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:387:GLU:OE2	5:I:149:THR:OG1	2.24	0.55
5:J:182:LEU:HD23	5:J:186:LEU:HD12	1.89	0.55
1:E:208:GLU:OE1	1:E:389:SER:OG	2.25	0.54
5:I:182:LEU:HD23	5:I:186:LEU:HD12	1.90	0.53
4:D:133:PRO:O	5:I:157:SER:OG	2.20	0.53
1:A:208:GLU:OE1	1:A:389:SER:OG	2.26	0.51
5:I:91:ASP:OD1	5:I:92:GLU:N	2.45	0.50
1:E:314:GLU:OE1	2:F:31:TYR:OH	2.31	0.49
5:J:91:ASP:OD1	5:J:92:GLU:N	2.46	0.48
1:E:436:MET:O	4:H:92:THR:N	2.44	0.48
3:C:22:GLU:OE2	3:C:24:THR:OG1	2.32	0.48
3:G:22:GLU:OE2	3:G:24:THR:OG1	2.32	0.48
5:I:95:TYR:OH	5:I:153:GLN:O	2.26	0.47
1:A:383:SER:O	1:A:383:SER:OG	2.33	0.46
3:G:16:LEU:HD21	3:G:33:LEU:HB3	1.97	0.46
3:C:16:LEU:HD21	3:C:33:LEU:HB3	1.97	0.46
3:C:25:ASN:OD1	3:C:26:ASN:N	2.49	0.46
5:J:95:TYR:OH	5:J:153:GLN:O	2.29	0.46
1:E:314:GLU:OE2	2:F:35:ARG:NE	2.40	0.45
2:F:27:ASN:OD1	2:F:28:TYR:N	2.49	0.45
2:B:27:ASN:OD1	2:B:28:TYR:N	2.49	0.45
1:E:251:LEU:HD11	1:E:276:VAL:HG11	1.98	0.45
3:G:25:ASN:OD1	3:G:26:ASN:N	2.49	0.44
4:H:71:ASP:OD2	4:H:138:CYS:SG	2.76	0.44
4:D:71:ASP:OD2	4:D:138:CYS:SG	2.76	0.44
1:A:251:LEU:HD11	1:A:276:VAL:HG11	2.00	0.43
1:E:131:ASN:O	1:E:135:ILE:HD12	2.19	0.43
4:H:133:PRO:O	5:J:157:SER:OG	2.20	0.43
1:E:233:ALA:O	1:E:237:VAL:HG23	2.19	0.42
4:H:72:VAL:O	4:H:92:THR:OG1	2.20	0.42
1:A:233:ALA:O	1:A:237:VAL:HG23	2.19	0.42
1:A:314:GLU:OE1	2:B:31:TYR:OH	2.37	0.42
1:A:317:TYR:OH	2:B:38:ASP:OD2	2.32	0.42
3:G:39:ASP:O	3:G:43:LEU:N	2.51	0.42

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 PDB entries followed by that with respect to all EM entries.

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	401/403 (100%)	371 (92%)	30 (8%)	0	100	100
1	E	401/403 (100%)	373 (93%)	28 (7%)	0	100	100
2	B	80/92 (87%)	76 (95%)	4 (5%)	0	100	100
2	F	80/92 (87%)	76 (95%)	4 (5%)	0	100	100
3	C	68/74 (92%)	64 (94%)	4 (6%)	0	100	100
3	G	68/74 (92%)	64 (94%)	4 (6%)	0	100	100
4	D	121/124 (98%)	114 (94%)	7 (6%)	0	100	100
4	H	121/124 (98%)	114 (94%)	7 (6%)	0	100	100
5	I	117/132 (89%)	105 (90%)	12 (10%)	0	100	100
5	J	117/132 (89%)	103 (88%)	14 (12%)	0	100	100
All	All	1574/1650 (95%)	1460 (93%)	114 (7%)	0	100	100

There are no Ramachandran outliers to report.

### 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 PDB entries followed by that with respect to all EM entries.

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	344/344 (100%)	344 (100%)	0	100	100
1	E	344/344 (100%)	344 (100%)	0	100	100
2	B	73/81 (90%)	73 (100%)	0	100	100
2	F	73/81 (90%)	73 (100%)	0	100	100

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
3	C	61/65 (94%)	61 (100%)	0	100	100
3	G	61/65 (94%)	61 (100%)	0	100	100
4	D	101/102 (99%)	101 (100%)	0	100	100
4	H	101/102 (99%)	101 (100%)	0	100	100
5	I	103/112 (92%)	103 (100%)	0	100	100
5	J	103/112 (92%)	103 (100%)	0	100	100
All	All	1364/1408 (97%)	1364 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	456	GLN
4	D	48	ASN
4	H	48	ASN
5	I	151	ASN
5	J	151	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 carbohydrates in this entry.

## 5.6 Ligand geometry [i](#)

Of 6 ligands modelled in this entry, 2 are monoatomic - leaving 4 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
6	PLP	A	501	1	15,15,16	0.85	1 (6%)	20,22,23	0.87	0
7	8Q1	C	101	3	27,33,34	0.26	0	33,40,43	0.52	0
6	PLP	E	501	1	15,15,16	0.90	1 (6%)	20,22,23	0.92	1 (5%)
7	8Q1	G	101	3	27,33,34	0.26	0	33,40,43	0.53	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
6	PLP	A	501	1	-	1/6/6/8	0/1/1/1
7	8Q1	C	101	3	-	3/38/40/41	-
6	PLP	E	501	1	-	0/6/6/8	0/1/1/1
7	8Q1	G	101	3	-	3/38/40/41	-

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
6	E	501	PLP	C4A-C4	-2.44	1.46	1.51
6	A	501	PLP	C4A-C4	-2.38	1.46	1.51

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
6	E	501	PLP	C4A-C4-C5	2.33	123.19	120.91

There are no chirality outliers.

All (7) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
7	G	101	8Q1	O4-C1-S44-C43
7	C	101	8Q1	O4-C1-S44-C43
7	G	101	8Q1	C6-C1-S44-C43
7	C	101	8Q1	C6-C1-S44-C43

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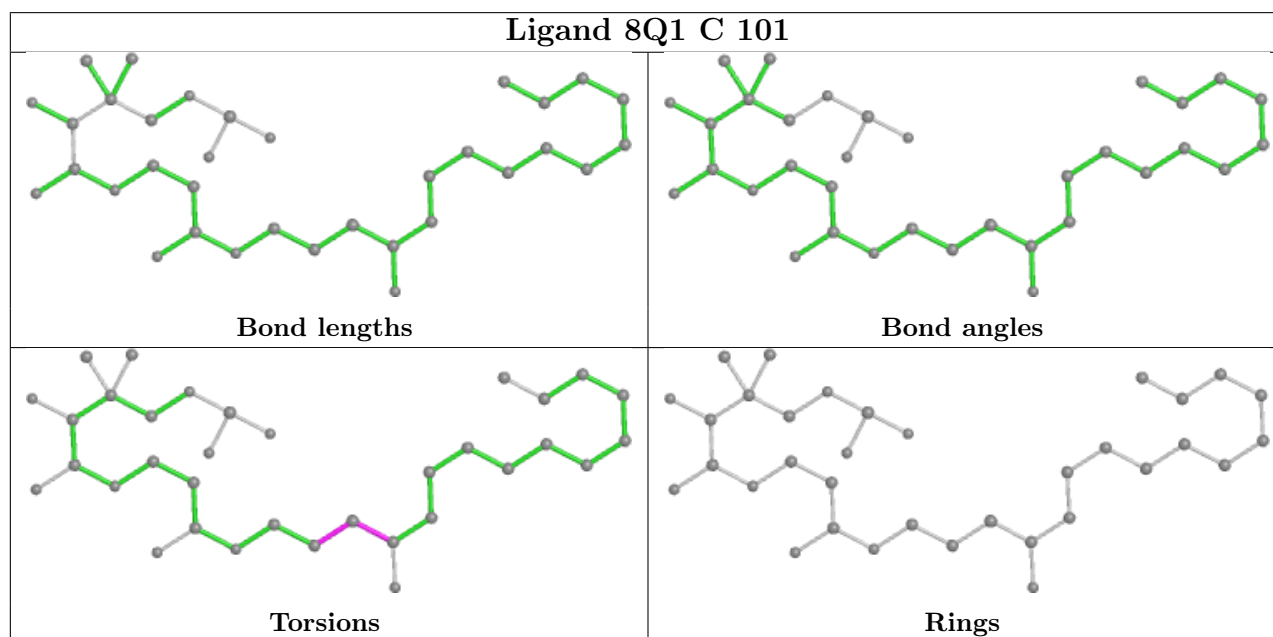
Mol	Chain	Res	Type	Atoms
6	A	501	PLP	C4-C5-C5A-O4P
7	G	101	8Q1	C42-C43-S44-C1
7	C	101	8Q1	C42-C43-S44-C1

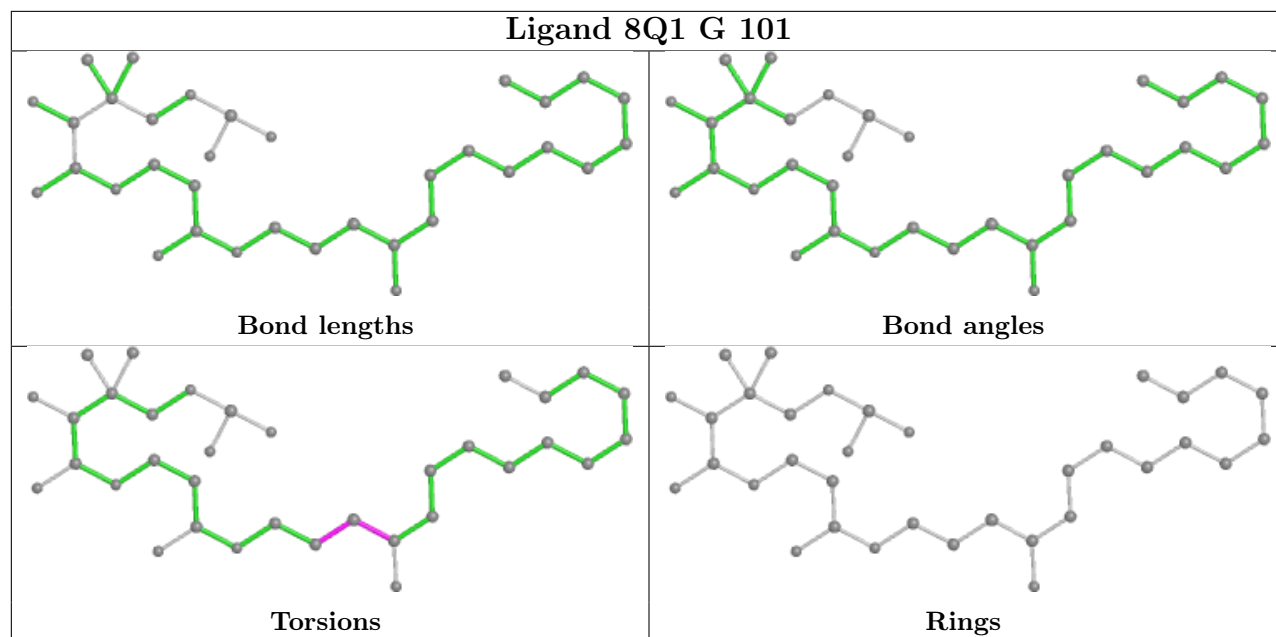
There are no ring outliers.

3 monomers are involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
7	C	101	8Q1	1	0
6	E	501	PLP	1	0
7	G	101	8Q1	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.