



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 05:02 PM UTC

PDB ID : 9BON / pdb_00009bon
Title : Crystal structure of glucosyltransferase (GTD) domain of TpeL
Authors : Gill, S.; Sugiman-Marangos, S.N.; Beilhardt, G.L.; Mei, E.; Taipale, M.; Melnyk, R.A.
Deposited on : 2024-05-05
Resolution : 2.22 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
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

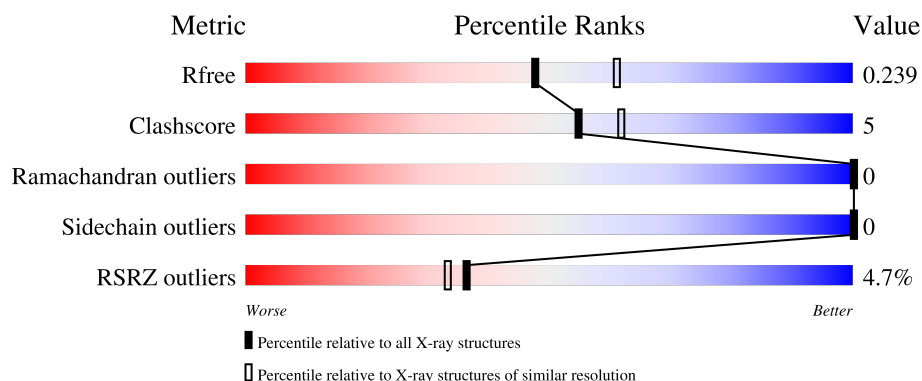
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.22 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	7682 (2.24-2.20)
Clashscore	190562	8402 (2.24-2.20)
Ramachandran outliers	187476	8303 (2.24-2.20)
Sidechain outliers	187428	8304 (2.24-2.20)
RSRZ outliers	180081	7683 (2.24-2.20)

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	551	3% 89% 11%
1	B	551	6% 82% 13%

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 9196 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 TpeL.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	548	Total	C	N	O	S	0	0	0
			4503	2895	728	868	12			
1	B	527	Total	C	N	O	S	0	0	0
			4330	2788	699	830	13			

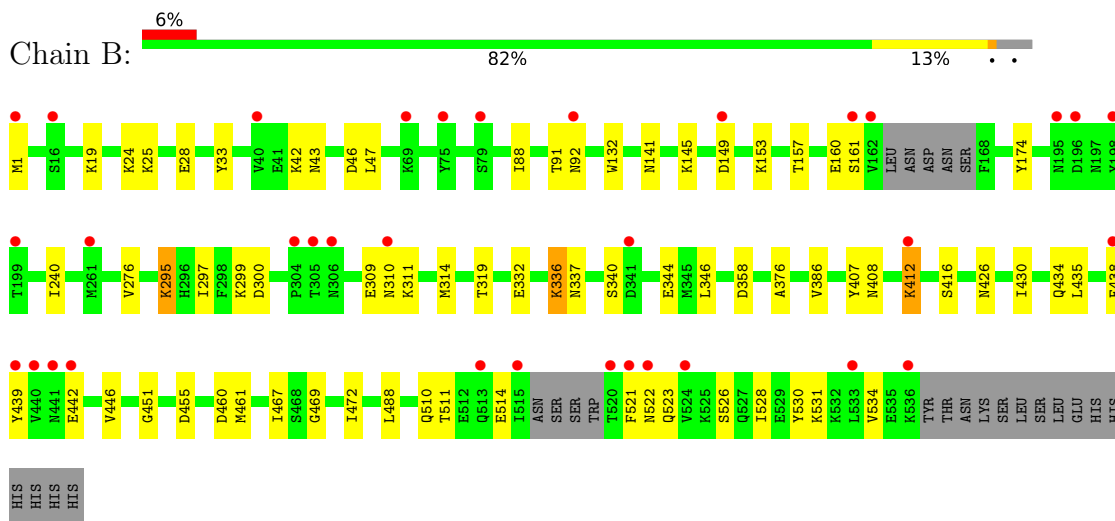
There are 16 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	544	LEU	-	expression tag	UNP A2PYQ6
A	545	GLU	-	expression tag	UNP A2PYQ6
A	546	HIS	-	expression tag	UNP A2PYQ6
A	547	HIS	-	expression tag	UNP A2PYQ6
A	548	HIS	-	expression tag	UNP A2PYQ6
A	549	HIS	-	expression tag	UNP A2PYQ6
A	550	HIS	-	expression tag	UNP A2PYQ6
A	551	HIS	-	expression tag	UNP A2PYQ6
B	544	LEU	-	expression tag	UNP A2PYQ6
B	545	GLU	-	expression tag	UNP A2PYQ6
B	546	HIS	-	expression tag	UNP A2PYQ6
B	547	HIS	-	expression tag	UNP A2PYQ6
B	548	HIS	-	expression tag	UNP A2PYQ6
B	549	HIS	-	expression tag	UNP A2PYQ6
B	550	HIS	-	expression tag	UNP A2PYQ6
B	551	HIS	-	expression tag	UNP A2PYQ6

- Molecule 2 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	217	Total	O	0	0
			217	217		
2	B	146	Total	O	0	0
			146	146		

- Molecule 1: TpeL



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	75.09Å 64.73Å 121.18Å 90.00° 102.03° 90.00°	Depositor
Resolution (Å)	73.44 – 2.22 73.44 – 2.22	Depositor EDS
% Data completeness (in resolution range)	99.4 (73.44-2.22) 99.4 (73.44-2.22)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.33 (at 2.22Å)	Xtriage
Refinement program	PHENIX 1.16_3549: ???	Depositor
R, R_{free}	0.193 , 0.237 0.195 , 0.239	Depositor DCC
R_{free} test set	2775 reflections (4.92%)	wwPDB-VP
Wilson B-factor (Å ²)	37.3	Xtriage
Anisotropy	0.516	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 42.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	9196	wwPDB-VP
Average B, all atoms (Å ²)	48.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.01% 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](#)

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	0.26	0/4580	0.52	9/6172 (0.1%)
1	B	0.33	0/4400	0.61	10/5919 (0.2%)
All	All	0.30	0/8980	0.56	19/12091 (0.2%)

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	B	0	1

There are no bond length outliers.

All (19) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	412	LYS	CB-CG-CD	8.13	130.00	111.30
1	A	14	LYS	CB-CG-CD	-8.06	92.77	111.30
1	B	412	LYS	CG-CD-CE	6.89	127.16	111.30
1	A	14	LYS	CA-CB-CG	-6.62	100.85	114.10
1	A	186	LYS	CG-CD-CE	6.56	126.39	111.30
1	A	14	LYS	CG-CD-CE	6.36	125.93	111.30
1	B	19	LYS	CD-CE-NZ	-6.32	91.68	111.90
1	B	309	GLU	CA-C-N	-6.26	110.18	121.14
1	B	309	GLU	C-N-CA	-6.26	110.18	121.14
1	B	19	LYS	CG-CD-CE	5.78	124.59	111.30
1	B	337	ASN	N-CA-CB	5.47	118.50	110.57
1	B	336	LYS	CA-C-N	-5.46	111.45	122.55
1	B	336	LYS	C-N-CA	-5.46	111.45	122.55
1	A	186	LYS	CB-CG-CD	5.29	123.47	111.30
1	A	14	LYS	CD-CE-NZ	5.22	128.60	111.90
1	A	461	MET	CA-C-N	-5.13	114.88	123.04

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	461	MET	C-N-CA	-5.13	114.88	123.04
1	A	7	GLU	CB-CG-CD	5.08	121.24	112.60
1	B	295	LYS	CD-CE-NZ	-5.08	95.65	111.90

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	B	521	PHE	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	4503	0	4528	39	0
1	B	4330	0	4372	46	0
2	A	217	0	0	12	0
2	B	146	0	0	6	0
All	All	9196	0	8900	85	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 5.

All (85) 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:B:310:ASN:HB3	1:B:510:GLN:HG3	1.42	1.01
1:B:240:ILE:O	2:B:601:HOH:O	1.84	0.95
1:A:325:GLN:OE1	2:A:601:HOH:O	1.89	0.91
1:A:349:LYS:NZ	2:A:602:HOH:O	2.03	0.83
1:A:422:SER:OG	1:A:426:ASN:ND2	2.15	0.80
1:A:462:ARG:N	2:A:604:HOH:O	2.08	0.76
1:B:161:SER:N	2:B:603:HOH:O	2.16	0.76
1:A:419:GLU:OE1	2:A:603:HOH:O	2.04	0.76
1:A:486:ARG:NE	2:A:605:HOH:O	2.17	0.73

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:434:GLN:HE21	1:B:438:PHE:HE2	1.37	0.73
1:B:455:ASP:O	2:B:602:HOH:O	2.11	0.69
1:A:296:HIS:HD2	2:A:778:HOH:O	1.78	0.66
1:A:465:LEU:HD12	1:A:470:PRO:HD2	1.80	0.64
1:B:311:LYS:HA	1:B:314:MET:HG3	1.79	0.64
1:A:332:GLU:HG3	1:A:336:LYS:HE2	1.81	0.62
1:A:412:LYS:HG3	2:A:777:HOH:O	1.99	0.62
1:B:434:GLN:NE2	1:B:438:PHE:HE2	1.97	0.61
1:A:306:ASN:HB3	2:A:619:HOH:O	2.00	0.61
1:A:10:ILE:HG23	1:A:14:LYS:HE2	1.81	0.61
1:B:530:TYR:O	1:B:534:VAL:HG23	2.00	0.61
1:A:423:ASN:HA	2:A:618:HOH:O	2.00	0.60
1:B:434:GLN:HG2	1:B:438:PHE:CE2	2.36	0.60
1:A:225:ILE:O	1:A:229:LYS:HG3	2.01	0.59
1:B:416:SER:HB3	1:B:434:GLN:OE1	2.03	0.59
1:B:310:ASN:HB3	1:B:510:GLN:CG	2.26	0.58
1:B:145:LYS:O	1:B:149:ASP:HB2	2.03	0.58
1:A:310:ASN:ND2	2:A:614:HOH:O	2.36	0.58
1:B:408:ASN:O	1:B:412:LYS:HG2	2.04	0.57
1:B:42:LYS:HB3	1:B:47:LEU:HD11	1.86	0.57
1:A:14:LYS:HD2	2:A:628:HOH:O	2.04	0.57
1:B:141:ASN:HB3	2:B:658:HOH:O	2.05	0.56
1:B:174:TYR:CE2	1:B:526:SER:HB2	2.42	0.55
1:B:376:ALA:HB2	1:B:386:VAL:HB	1.90	0.54
1:B:460:ASP:OD2	1:B:523:GLN:HB2	2.09	0.53
1:A:229:LYS:O	1:A:233:LYS:HG3	2.09	0.52
1:A:207:LYS:NZ	1:A:218:ASP:OD1	2.36	0.52
1:A:377:PHE:HE1	1:A:494:GLN:HE22	1.56	0.52
1:A:407:TYR:CE2	1:A:467:ILE:HG22	2.45	0.52
1:B:132:TRP:NE1	1:B:276:VAL:HG11	2.26	0.50
1:B:160:GLU:N	2:B:603:HOH:O	2.45	0.49
1:B:141:ASN:O	1:B:145:LYS:HG3	2.13	0.49
1:A:371:LEU:HD22	1:A:480:LEU:HD11	1.94	0.48
1:B:522:ASN:O	1:B:526:SER:N	2.41	0.47
1:B:426:ASN:O	1:B:430:ILE:HG13	2.16	0.46
1:B:407:TYR:CE2	1:B:467:ILE:HG22	2.50	0.46
1:B:469:GLY:O	1:B:472:ILE:HG12	2.16	0.46
1:A:376:ALA:HB2	1:A:386:VAL:HB	1.97	0.46
1:B:340:SER:O	1:B:344:GLU:HG3	2.16	0.45
1:B:319:THR:HG21	1:B:346:LEU:HB3	1.98	0.45
1:A:378:MET:HG3	1:A:509:GLN:NE2	2.31	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:33:TYR:OH	1:A:88:ILE:HD11	2.17	0.45
1:A:155:VAL:HG21	1:A:177:ARG:HA	1.99	0.45
1:B:33:TYR:OH	1:B:88:ILE:HD11	2.16	0.45
1:B:295:LYS:O	1:B:299:LYS:HB3	2.17	0.45
1:A:304:PRO:HG2	1:A:307:ILE:HD12	1.98	0.45
1:A:338:LEU:O	1:A:343:GLN:NE2	2.46	0.44
1:B:24:LYS:O	1:B:28:GLU:HG2	2.18	0.44
1:B:1:MET:O	2:B:605:HOH:O	2.20	0.44
1:B:511:THR:O	1:B:514:GLU:HB3	2.17	0.43
1:B:153:LYS:O	1:B:157:THR:HG23	2.18	0.43
1:A:51:LEU:HD22	1:A:81:LEU:HD22	2.01	0.43
1:A:139:LEU:HD11	1:A:225:ILE:HD11	2.01	0.42
1:A:403:ILE:HG13	1:A:472:ILE:HD12	2.01	0.42
1:B:435:LEU:HB3	1:B:446:VAL:HG22	2.01	0.42
1:B:43:ASN:HB3	1:B:46:ASP:HB2	2.02	0.42
1:A:74:LEU:HD23	1:A:74:LEU:HA	1.86	0.42
1:A:126:ASP:OD1	1:A:126:ASP:N	2.47	0.42
1:B:442:GLU:HG2	1:B:488:LEU:HD12	2.02	0.42
1:A:210:LEU:HB3	1:A:216:LYS:HG3	2.02	0.42
1:B:439:TYR:CD2	1:B:439:TYR:N	2.88	0.41
1:B:522:ASN:O	1:B:526:SER:HB3	2.20	0.41
1:A:156:LEU:HA	1:A:156:LEU:HD23	1.83	0.41
1:B:25:LYS:HE2	1:B:25:LYS:HA	2.02	0.41
1:B:336:LYS:NZ	1:B:336:LYS:HB2	2.35	0.41
1:A:481:LEU:HD23	1:A:481:LEU:HA	1.90	0.41
1:B:451:GLY:HA3	1:B:461:MET:HG2	2.01	0.41
1:A:442:GLU:O	1:A:446:VAL:HG23	2.20	0.41
1:B:332:GLU:HB3	1:B:336:LYS:HG3	2.01	0.41
1:A:95:PRO:O	1:A:390:LYS:HE2	2.21	0.41
1:A:306:ASN:ND2	2:A:619:HOH:O	2.44	0.41
1:A:328:LYS:HE3	1:A:328:LYS:HB2	1.79	0.41
1:B:528:ILE:O	1:B:531:LYS:HB3	2.20	0.41
1:B:299:LYS:HG3	1:B:300:ASP:OD1	2.20	0.41
1:B:91:THR:O	1:B:92:ASN:HB2	2.15	0.40
1:B:297:ILE:HD11	1:B:358:ASP:O	2.21	0.40

There are no symmetry-related clashes.

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	546/551 (99%)	534 (98%)	12 (2%)	0	100	100
1	B	521/551 (95%)	510 (98%)	11 (2%)	0	100	100
All	All	1067/1102 (97%)	1044 (98%)	23 (2%)	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	507/518 (98%)	507 (100%)	0	100	100
1	B	485/518 (94%)	485 (100%)	0	100	100
All	All	992/1036 (96%)	992 (100%)	0	100	100

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

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (14) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	43	ASN
1	A	171	ASN
1	A	235	ASN
1	A	494	GLN
1	A	523	GLN
1	A	539	ASN

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Mol	Chain	Res	Type
1	B	193	ASN
1	B	197	ASN
1	B	257	GLN
1	B	411	ASN
1	B	504	GLN
1	B	513	GLN
1	B	522	ASN
1	B	527	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](#)

There are no ligands in this entry.

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	548/551 (99%)	0.20	17 (3%)	51 49	25, 43, 67, 91	0
1	B	527/551 (95%)	0.39	34 (6%)	25 22	29, 46, 85, 105	0
All	All	1075/1102 (97%)	0.29	51 (4%)	36 33	25, 45, 80, 105	0

All (51) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	519	TRP	5.2
1	B	438	PHE	4.4
1	B	524	VAL	3.7
1	A	1	MET	3.6
1	B	199	THR	3.6
1	B	441	ASN	3.5
1	B	196	ASP	3.5
1	A	548	HIS	3.4
1	B	515	ILE	3.4
1	B	162	VAL	3.1
1	A	186	LYS	3.0
1	A	462	ARG	3.0
1	A	219	GLU	2.9
1	B	520	THR	2.9
1	B	75	TYR	2.9
1	A	166	ASN	2.9
1	B	439	TYR	2.9
1	B	92	ASN	2.8
1	A	261	MET	2.7
1	B	195	ASN	2.7
1	B	310	ASN	2.7
1	A	7	GLU	2.7
1	A	539	ASN	2.6
1	B	1	MET	2.5

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Mol	Chain	Res	Type	RSRZ
1	B	533	LEU	2.5
1	A	75	TYR	2.5
1	A	494	GLN	2.5
1	A	14	LYS	2.5
1	B	149	ASP	2.5
1	B	40	VAL	2.4
1	B	198	TYR	2.4
1	B	304	PRO	2.4
1	B	521	PHE	2.4
1	B	440	VAL	2.4
1	A	352	GLU	2.4
1	B	442	GLU	2.4
1	B	341	ASP	2.3
1	B	305	THR	2.3
1	B	412	LYS	2.3
1	A	440	VAL	2.3
1	B	513	GLN	2.2
1	B	522	ASN	2.2
1	B	261	MET	2.2
1	B	69	LYS	2.2
1	B	161	SER	2.2
1	B	536	LYS	2.1
1	A	38	ASN	2.1
1	B	16	SER	2.1
1	B	79	SER	2.1
1	A	161	SER	2.0
1	B	306	ASN	2.0

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](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.