



Full wwPDB X-ray Structure Validation Report ⓘ

Sep 9, 2026 – 04:07 PM EDT

PDB ID : 9YIR / pdb_00009yir
Title : HPV_2-1 TCR in complex with HLA-A*01:01 presenting HPV16 E2 9mer peptide (151-QVDYYGLYY-159)
Authors : Miller, H.A.; Palowitch, G.M.; Dulberger, C.L.
Deposited on : 2025-10-02
Resolution : 2.28 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 : 9.0.015 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.50

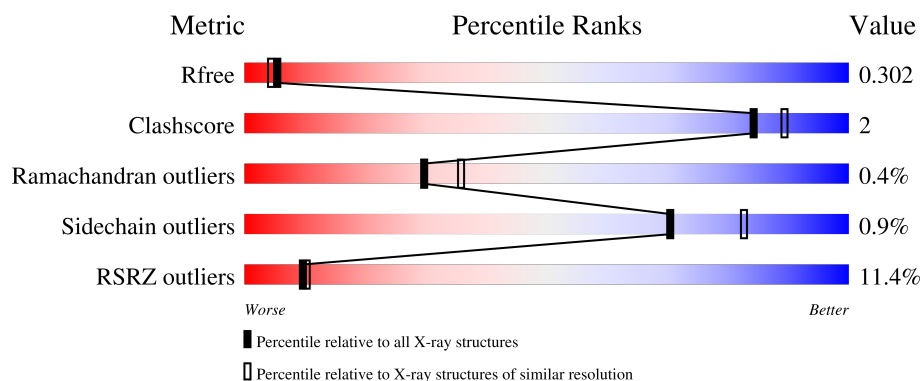
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.28 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	9078 (2.30-2.26)
Clashscore	190562	9802 (2.30-2.26)
Ramachandran outliers	187476	9690 (2.30-2.26)
Sidechain outliers	187428	9691 (2.30-2.26)
RSRZ outliers	180081	9085 (2.30-2.26)

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	C	275	
2	D	100	
3	P	9	
4	A	213	
5	B	252	

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 6365 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 HLA class I histocompatibility antigen A alpha chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	C	274	Total	C	N	O	S	0	0	0
			2135	1334	386	405	10			

- Molecule 2 is a protein called Beta-2-microglobulin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	D	98	Total	C	N	O	S	0	0	0
			780	498	131	148	3			

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	0	MET	-	initiating methionine	UNP P61769

- Molecule 3 is a protein called Regulatory protein E2.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
3	P	9	Total	C	N	O	0	0	0
			85	58	10	17			

- Molecule 4 is a protein called TCR alpha chain (TRAV21).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	A	200	Total	C	N	O	S	0	0	0
			1493	938	242	306	7			

- Molecule 5 is a protein called TCR beta chain (TRBV27).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
5	B	240	Total	C	N	O	S	0	0	0
			1847	1172	318	349	8			

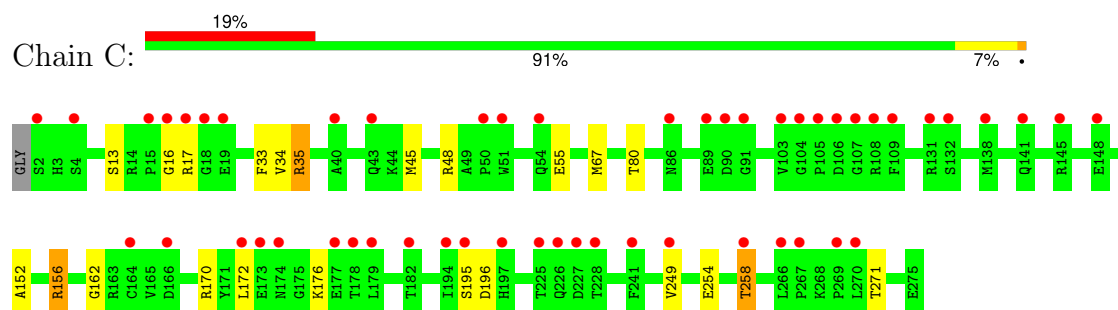
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	C	7	Total 7	O 7	0	0
6	D	3	Total 3	O 3	0	0
6	A	11	Total 11	O 11	0	0
6	B	4	Total 4	O 4	0	0

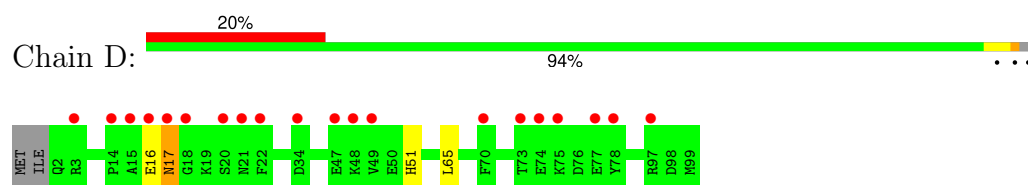
3 Residue-property plots

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.

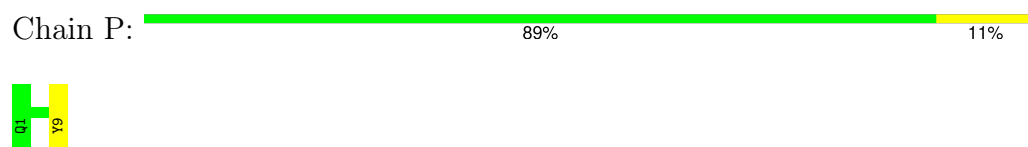
- Molecule 1: HLA class I histocompatibility antigen A alpha chain



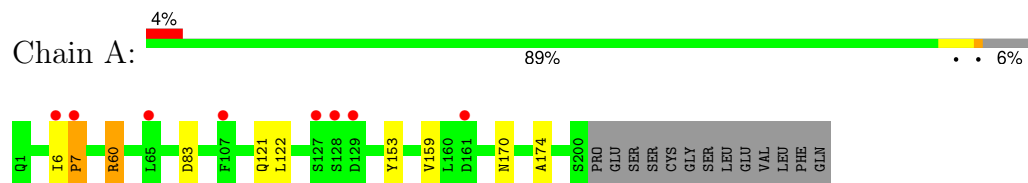
- Molecule 2: Beta-2-microglobulin



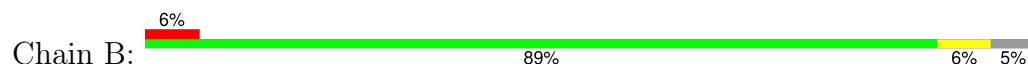
- Molecule 3: Regulatory protein E2

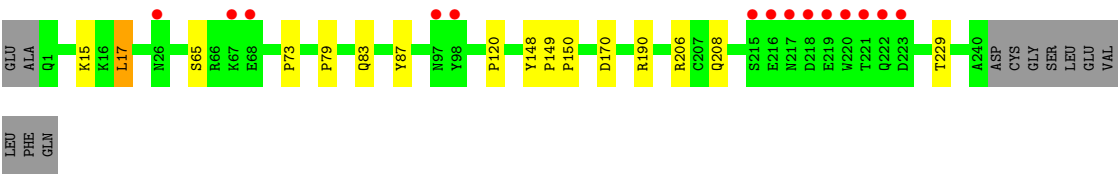


- Molecule 4: TCR alpha chain (TRAV21)



- Molecule 5: TCR beta chain (TRBV27)





4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	100.22Å 54.98Å 106.71Å 90.00° 115.63° 90.00°	Depositor
Resolution (Å)	90.36 – 2.28 90.36 – 2.28	Depositor EDS
% Data completeness (in resolution range)	98.6 (90.36-2.28) 98.7 (90.36-2.28)	Depositor EDS
R_{merge}	0.24	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.18 (at 2.27Å)	Xtriage
Refinement program	REFMAC 5.8.0430	Depositor
R, R_{free}	0.253 , 0.299 0.258 , 0.302	Depositor DCC
R_{free} test set	2326 reflections (4.85%)	wwPDB-VP
Wilson B-factor (Å ²)	36.5	Xtriage
Anisotropy	0.034	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 31.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	0.016 for h,-k,-h-l	Xtriage
F_o, F_c correlation	0.91	EDS
Total number of atoms	6365	wwPDB-VP
Average B, all atoms (Å ²)	37.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.31% 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

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	C	0.49	0/2194	0.91	1/2989 (0.0%)
2	D	0.49	0/803	0.86	0/1094
3	P	0.41	0/88	0.81	0/118
4	A	0.49	0/1523	0.87	0/2077
5	B	0.49	0/1899	0.91	2/2600 (0.1%)
All	All	0.49	0/6507	0.89	3/8878 (0.0%)

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
4	A	0	2
5	B	0	1
All	All	0	3

There are no bond length outliers.

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	B	170	ASP	CA-CB-CG	5.54	118.14	112.60
1	C	258	THR	CA-CB-OG1	-5.27	101.69	109.60
5	B	229	THR	CA-CB-OG1	-5.26	101.70	109.60

There are no chirality outliers.

All (3) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
4	A	6	ILE	Peptide
4	A	60	ARG	Sidechain
5	B	120	PRO	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	C	2135	0	1937	12	0
2	D	780	0	705	2	0
3	P	85	0	73	1	0
4	A	1493	0	1378	4	0
5	B	1847	0	1709	7	0
6	A	11	0	0	0	0
6	B	4	0	0	0	0
6	C	7	0	0	0	0
6	D	3	0	0	0	0
All	All	6365	0	5802	25	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 (25) 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)
5:B:206:ARG:NH1	5:B:208:GLN:OE1	2.24	0.69
1:C:195:SER:OG	1:C:196:ASP:N	2.41	0.53
5:B:17:LEU:C	5:B:17:LEU:HD23	2.35	0.52
1:C:45:MET:HE1	1:C:67:MET:HE2	1.92	0.51
1:C:33:PHE:O	1:C:48:ARG:N	2.40	0.51
4:A:60:ARG:NH2	4:A:83:ASP:OD2	2.42	0.50
1:C:55:GLU:CD	1:C:170:ARG:HH21	2.20	0.49
5:B:149:PRO:HB2	5:B:150:PRO:HD2	1.95	0.49
1:C:35:ARG:HG2	1:C:35:ARG:HH11	1.78	0.48
1:C:80:THR:HG21	3:P:9:TYR:O	2.14	0.48
4:A:121:GLN:C	4:A:122:LEU:HD12	2.39	0.48
2:D:16:GLU:O	2:D:17:ASN:C	2.58	0.47
1:C:33:PHE:CD2	1:C:34:VAL:HG13	2.50	0.46
5:B:83:GLN:O	5:B:87:TYR:OH	2.29	0.46
5:B:15:LYS:O	5:B:79:PRO:HG2	2.15	0.46
1:C:172:LEU:O	1:C:176:LYS:HB3	2.17	0.45
1:C:152:ALA:O	1:C:156:ARG:HD2	2.18	0.44
1:C:258:THR:OG1	1:C:271:THR:HG23	2.18	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
4:A:159:VAL:HG22	4:A:170:ASN:OD1	2.18	0.43
5:B:65:SER:O	5:B:73:PRO:HD2	2.19	0.42
2:D:51:HIS:HA	2:D:65:LEU:O	2.20	0.42
5:B:148:TYR:CD1	5:B:148:TYR:C	2.97	0.42
1:C:16:GLY:O	1:C:17:ARG:C	2.63	0.42
4:A:153:TYR:O	4:A:174:ALA:HA	2.21	0.40
1:C:249:VAL:HG11	1:C:254:GLU:HA	2.02	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	C	272/275 (99%)	261 (96%)	10 (4%)	1 (0%)	30	36
2	D	96/100 (96%)	91 (95%)	4 (4%)	1 (1%)	12	13
3	P	7/9 (78%)	6 (86%)	1 (14%)	0	100	100
4	A	198/213 (93%)	193 (98%)	4 (2%)	1 (0%)	24	29
5	B	238/252 (94%)	232 (98%)	6 (2%)	0	100	100
All	All	811/849 (96%)	783 (96%)	25 (3%)	3 (0%)	30	36

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
4	A	7	PRO
2	D	17	ASN
1	C	162	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	
1	C	209/232 (90%)	206 (99%)	3 (1%)	59	74
2	D	83/95 (87%)	83 (100%)	0	100	100
3	P	8/8 (100%)	8 (100%)	0	100	100
4	A	161/187 (86%)	160 (99%)	1 (1%)	78	87
5	B	192/223 (86%)	190 (99%)	2 (1%)	68	81
All	All	653/745 (88%)	647 (99%)	6 (1%)	70	82

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	13	SER
1	C	35	ARG
1	C	156	ARG
4	A	7	PRO
5	B	17	LEU
5	B	190	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
2	D	42	ASN
5	B	151	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 [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	C	274/275 (99%)	1.25	52 (18%) 3 3	28, 42, 66, 80	0
2	D	98/100 (98%)	1.12	20 (20%) 3 3	27, 41, 62, 73	0
3	P	9/9 (100%)	0.47	0 100 100	32, 35, 38, 38	0
4	A	200/213 (93%)	0.46	8 (4%) 42 44	18, 32, 47, 65	0
5	B	240/252 (95%)	0.45	14 (5%) 29 30	20, 30, 51, 65	0
All	All	821/849 (96%)	0.80	94 (11%) 10 10	18, 36, 60, 80	0

All (94) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
5	B	217	ASN	5.5
1	C	106	ASP	4.8
1	C	105	PRO	4.7
2	D	74	GLU	4.5
1	C	225	THR	4.4
1	C	227	ASP	4.4
1	C	197	HIS	4.4
1	C	226	GLN	4.3
1	C	267	PRO	4.2
1	C	178	THR	4.0
1	C	17	ARG	4.0
1	C	107	GLY	3.9
5	B	223	ASP	3.9
5	B	219	GLU	3.8
2	D	22	PHE	3.8
1	C	19	GLU	3.7
1	C	91	GLY	3.4
1	C	131	ARG	3.4
1	C	18	GLY	3.3
2	D	75	LYS	3.3

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Mol	Chain	Res	Type	RSRZ
4	A	129	ASP	3.3
4	A	7	PRO	3.3
4	A	127	SER	3.3
2	D	78	TYR	3.1
2	D	48	LYS	3.1
1	C	86	ASN	3.1
1	C	50	PRO	3.0
1	C	132	SER	3.0
2	D	20	SER	3.0
2	D	17	ASN	3.0
5	B	222	GLN	2.9
1	C	90	ASP	2.9
1	C	166	ASP	2.9
1	C	43	GLN	2.9
2	D	73	THR	2.8
2	D	49	VAL	2.7
1	C	54	GLN	2.7
4	A	6	ILE	2.7
1	C	172	LEU	2.7
1	C	249	VAL	2.6
5	B	221	THR	2.6
1	C	108	ARG	2.6
1	C	266	LEU	2.6
1	C	179	LEU	2.6
1	C	148	GLU	2.5
2	D	15	ALA	2.5
1	C	16	GLY	2.5
1	C	270	LEU	2.5
1	C	174	ASN	2.5
5	B	98	TYR	2.5
5	B	67	LYS	2.5
1	C	15	PRO	2.5
2	D	18	GLY	2.5
1	C	2	SER	2.4
1	C	241	PHE	2.4
1	C	173	GLU	2.4
4	A	107	PHE	2.4
2	D	21	ASN	2.4
2	D	47	GLU	2.4
5	B	68	GLU	2.4
1	C	228	THR	2.4
1	C	104	GLY	2.3

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Mol	Chain	Res	Type	RSRZ
1	C	195	SER	2.3
5	B	216	GLU	2.3
1	C	51	TRP	2.3
1	C	40	ALA	2.3
2	D	77	GLU	2.3
1	C	89	GLU	2.3
1	C	269	PRO	2.3
2	D	3	ARG	2.3
1	C	141	GLN	2.3
1	C	177	GLU	2.3
2	D	70	PHE	2.2
2	D	97	ARG	2.2
4	A	161	ASP	2.2
1	C	109	PHE	2.2
1	C	164	CYS	2.2
1	C	258	THR	2.2
4	A	65	LEU	2.1
2	D	34	ASP	2.1
1	C	138	MET	2.1
1	C	194	ILE	2.1
5	B	218	ASP	2.1
2	D	14	PRO	2.1
2	D	16	GLU	2.1
1	C	103	VAL	2.1
5	B	220	TRP	2.1
1	C	4	SER	2.0
5	B	26	ASN	2.0
1	C	145	ARG	2.0
1	C	182	THR	2.0
4	A	128	SER	2.0
5	B	215	SER	2.0
5	B	97	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.