



# wwPDB NMR Structure Validation Summary Report ⓘ

Apr 26, 2016 – 07:10 PM BST

PDB ID : 1YHO  
Title : Solution structure of human dihydrofolate reductase complexed with trimethoprim and nadph, 25 structures  
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Deposited on : 2005-01-10

This is a wwPDB NMR Structure Validation Summary Report for a publicly released PDB entry.  
We welcome your comments at [validation@mail.wwpdb.org](mailto:validation@mail.wwpdb.org)  
A user guide is available at  
<http://wwpdb.org/validation/2016/NMRValidationReportHelp>  
with specific help available everywhere you see the ⓘ symbol.

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The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

Cyrange : Kirchner and Güntert (2011)  
NmrClust : Kelley et al. (1996)  
MolProbity : 4.02b-467  
Mogul : 1.7.1 (RC1), CSD as537be (2016)  
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)  
RCI : v\_1n\_11\_5\_13\_A (Berjanski et al., 2005)  
PANAV : Wang et al. (2010)  
ShiftChecker : rb-20027457  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : rb-20027457

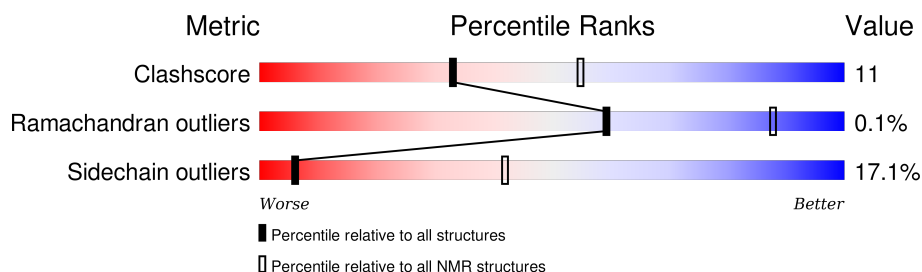
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 77%.

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)	NMR archive (#Entries)
Clashscore	114402	11133
Ramachandran outliers	111179	9975
Sidechain outliers	111093	9958

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and 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	186	 74% 26% .

## 2 Ensemble composition and analysis

This entry contains 25 models. Model 2 is the overall representative, medoid model (most similar to other models). The authors have identified model 1 as representative, based on the following criterion: *minimized average structure*.

The following residues are included in the computation of the global validation metrics.

Well-defined (core) protein residues			
Well-defined core	Residue range (total)	Backbone RMSD (Å)	Medoid model
1	A:2-A:186 (185)	0.36	2

Ill-defined regions of proteins are excluded from the global statistics.

Ligands and non-protein polymers are included in the analysis.

The models can be grouped into 4 clusters and 9 single-model clusters were found.

Cluster number	Models
1	4, 6, 7, 8, 10, 12, 14, 16
2	1, 2, 17, 21
3	18, 24
4	11, 13
Single-model clusters	3; 5; 9; 15; 19; 20; 22; 23; 25

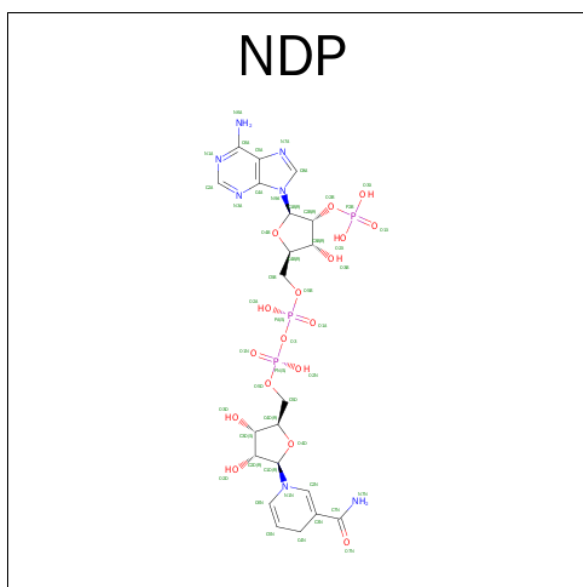
### 3 Entry composition [i](#)

There are 3 unique types of molecules in this entry. The entry contains 3130 atoms, of which 1559 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Dihydrofolate reductase.

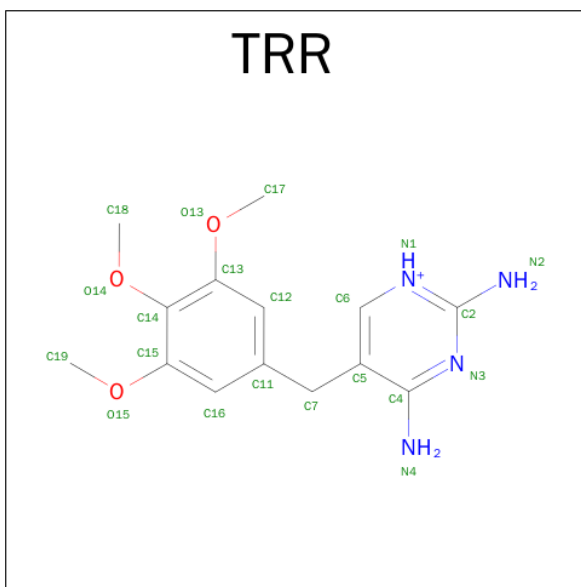
Mol	Chain	Residues	Atoms						Trace
1	A	186	Total	C	H	N	O	S	0
			3016	963	1514	253	279	7	

- Molecule 2 is NADPH DIHYDRO-NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (three-letter code: NDP) (formula:  $C_{21}H_{30}N_7O_{17}P_3$ ).



Mol	Chain	Residues	Atoms					
2	A	1	Total	C	H	N	O	P
			74	21	26	7	17	3

- Molecule 3 is 2,4-DIAMINO-5-(3,4,5-TRIMETHOXY-BENZYL)-PYRIMIDIN-1-IUM (three-letter code: TRR) (formula:  $C_{14}H_{19}N_4O_3$ ).



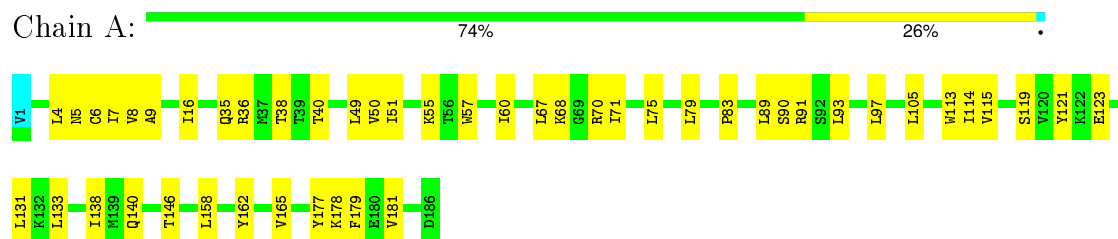
Mol	Chain	Residues	Atoms				
			Total	C	H	N	O
3	A	1	40	14	19	4	3

## 4 Residue-property plots

### 4.1 Average score per residue in the NMR ensemble

These plots are provided for all protein, RNA and DNA chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-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 outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

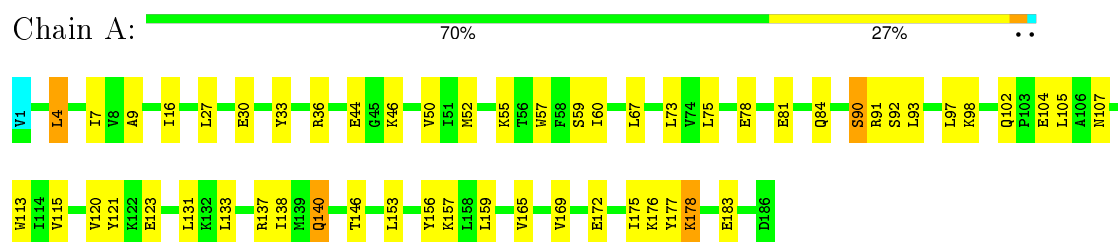
- Molecule 1: Dihydrofolate reductase



### 4.2 Residue scores for the representative (medoid) model from the NMR ensemble

The representative model is number 2. Colouring as in section 4.1 above.

- Molecule 1: Dihydrofolate reductase



## 5 Refinement protocol and experimental data overview

The models were refined using the following method: *simulated annealing, molecular dynamics*.

Of the 40 calculated structures, 25 were deposited, based on the following criterion: *structures with the lowest energy*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
CNS	refinement	Brunger
Aria	refinement	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	BMRB entry 5981
Number of chemical shift lists	3
Total number of shifts	2056
Number of shifts mapped to atoms	2020
Number of unparsed shifts	0
Number of shifts with mapping errors	36
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	77%

No validations of the models with respect to experimental NMR restraints is performed at this time.

## 6 Model quality

### 6.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: NDP, TRR

There are no covalent bond-length or bond-angle outliers.

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no planarity outliers.

### 6.2 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 each 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 averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	1495	1503	1500	29±4
2	A	48	26	26	10±2
3	A	21	19	19	4±2
All	All	39100	38700	38625	856

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 11.

5 of 241 unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:60:ILE:HG23	3:A:200:TRR:C18	0.82	2.04	16	14
1:A:5:ASN:O	1:A:114:ILE:HD12	0.79	1.78	21	8
1:A:16:ILE:HD11	1:A:146:THR:CG2	0.78	2.09	1	10
1:A:4:LEU:HD11	1:A:97:LEU:HD21	0.77	1.56	22	2
1:A:6:CYS:SG	1:A:114:ILE:HD13	0.76	2.21	5	9



## 6.3 Torsion angles [i](#)

### 6.3.1 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 NMR 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	184/186 (99%)	177±1 (96±1%)	7±1 (4±1%)	0±0 (0±0%)	59	88
All	All	4600/4650 (99%)	4422 (96%)	173 (4%)	5 (0%)	59	88

All 3 unique Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	25	PRO	3
1	A	43	VAL	1
1	A	67	LEU	1

### 6.3.2 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 NMR 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	167/168 (99%)	138±4 (83±3%)	29±4 (17±3%)	6	42
All	All	4175/4200 (99%)	3459 (83%)	716 (17%)	6	42

5 of 109 unique residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	179	PHE	17
1	A	158	LEU	16
1	A	36	ARG	15
1	A	93	LEU	14
1	A	68	LYS	14

### 6.3.3 RNA ⓘ

There are no RNA molecules in this entry.

## 6.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

## 6.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 6.6 Ligand geometry ⓘ

2 ligands are modelled in this entry.

In the following table, the Counts columns list the number of bonds for which Mogul statistics could be retrieved, the number of bonds that are observed in the model and the number of bonds 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 is the number of standard deviations the observed value is removed from the expected value. A bond length with  $|Z| > 2$  is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond lengths.

Mol	Type	Chain	Res	Link	Bond lengths		
					Counts	RMSZ	#Z>2
2	NDP	A	190	-	44,52,52	1.46±0.00	1±0 (2±0%)
3	TRR	A	200	-	22,22,22	1.67±0.01	0±0 (0±0%)

In the following table, the Counts columns list the number of angles for which Mogul statistics could be retrieved, the number of angles that are observed in the model and the number of 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 angle is the number of standard deviations the observed value is removed from the expected value. A bond angle with  $|Z| > 2$  is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond angles.

Mol	Type	Chain	Res	Link	Bond angles		
					Counts	RMSZ	#Z>2
2	NDP	A	190	-	55,80,80	1.80±0.00	3±0 (5±0%)
3	TRR	A	200	-	30,30,30	1.53±0.00	0±0 (0±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	NDP	A	190	-	-	0±0,30,77,77	0±0,5,5,5
3	TRR	A	200	-	-	0±0,10,10,10	0±0,2,2,2

All unique bond outliers are listed below.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)	Models	
								Worst	Total
2	A	190	NDP	C6N-N1N	6.55	1.54	1.37	12	25

All unique angle outliers are listed below. They are sorted according to the Z-score of the worst occurrence in the ensemble.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)	Models	
								Worst	Total
2	A	190	NDP	O3X-P2B-O2X	6.86	132.64	107.44	6	25
2	A	190	NDP	C1D-N1N-C2N	5.30	130.06	120.85	6	25
2	A	190	NDP	C4N-C3N-C7N	5.22	132.35	118.19	14	25

There are no chirality outliers.

All unique torsion outliers are listed below.

Mol	Chain	Res	Type	Atoms	Models (Total)
2	A	190	NDP	P2B-O2B-C2B-C1B	1

There are no ring outliers.

## 6.7 Other polymers [i](#)

There are no such molecules in this entry.

## 6.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

## 7 Chemical shift validation

The completeness of assignment taking into account all chemical shift lists is 77% for the well-defined parts and 77% for the entire structure.

### 7.1 Chemical shift list 1

File name: BMRB entry 5981

Chemical shift list name: *assigned\_chem\_shift\_list\_1*

#### 7.1.1 Bookkeeping

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	2020
Number of shifts mapped to atoms	2020
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	17

#### 7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	183	$-0.19 \pm 0.08$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}_\beta$	168	$-0.05 \pm 0.19$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}'$	170	$0.17 \pm 0.15$	None needed ( $< 0.5$ ppm)
$^{15}\text{N}$	173	$-0.32 \pm 0.40$	None needed ( $< 0.5$ ppm)

#### 7.1.3 Completeness of resonance assignments

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 77%, i.e. 1813 atoms were assigned a chemical shift out of a possible 2369. 1 out of 32 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	871/901 (97%)	347/358 (97%)	351/370 (95%)	173/173 (100%)
Sidechain	832/1279 (65%)	508/756 (67%)	302/465 (65%)	22/58 (38%)

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	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Aromatic	110/189 (58%)	60/99 (61%)	41/81 (51%)	9/9 (100%)
Overall	1813/2369 (77%)	915/1213 (75%)	694/916 (76%)	204/240 (85%)

#### 7.1.4 Statistically unusual chemical shifts ⓘ

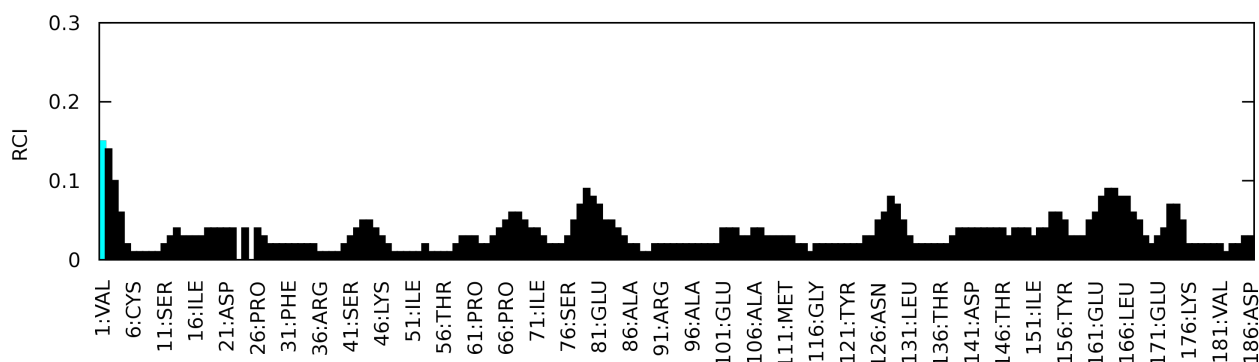
The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	65	ARG	HD2	0.90	4.27 – 1.97	-9.7
1	A	23	PRO	HD3	0.43	5.52 – 1.72	-8.4
1	A	72	ASN	H	12.92	11.45 – 5.25	7.4
1	A	170	GLN	HB3	0.03	3.37 – 0.67	-7.4
1	A	57	TRP	HD1	4.69	8.95 – 5.35	-6.8
1	A	11	SER	HB2	5.41	5.18 – 2.58	5.9
1	A	38	THR	HG23	-0.16	2.29 – -0.01	-5.6
1	A	38	THR	HG22	-0.16	2.29 – -0.01	-5.6
1	A	38	THR	HG21	-0.16	2.29 – -0.01	-5.6
1	A	138	ILE	HD11	-0.95	2.13 – -0.77	-5.6
1	A	138	ILE	HD12	-0.95	2.13 – -0.77	-5.6
1	A	138	ILE	HD13	-0.95	2.13 – -0.77	-5.6
1	A	75	LEU	HB3	-0.43	3.34 – -0.26	-5.5
1	A	149	PRO	HD3	1.60	5.52 – 1.72	-5.3
1	A	46	LYS	HD2	2.82	2.76 – 0.46	5.2
1	A	38	THR	HA	1.96	6.86 – 2.06	-5.2
1	A	55	LYS	CE	37.63	46.00 – 37.80	-5.2

#### 7.1.5 Random Coil Index (RCI) plots ⓘ

The image below reports *random coil index* values for the protein chains in the structure. The height of each bar gives a probability of a given residue to be disordered, as predicted from the available chemical shifts and the amino acid sequence. A value above 0.2 is an indication of significant predicted disorder. The colour of the bar shows whether the residue is in the well-defined core (black) or in the ill-defined residue ranges (cyan), as described in section 2 on ensemble composition.

Random coil index (RCI) for chain A:



## 7.2 Chemical shift list 2

File name: BMRB entry 5981

Chemical shift list name: *assigned\_chem\_shift\_list\_2*

### 7.2.1 Bookkeeping ⓘ

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	17
Number of shifts mapped to atoms	0
Number of unparsed shifts	0
Number of shifts with mapping errors	17
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	0

The following assigned chemical shifts were not mapped to the molecules present in the coordinate file.

- Chain not found in structure. First 5 (of 17) occurrences are reported below.

Chain	Res	Type	Atom	Shift Data		
				Value	Uncertainty	Ambiguity
UNMAPPED	1	NAP	1H14	3.546	0.012	1
UNMAPPED	1	NAP	1H9	2.542	0.012	2
UNMAPPED	1	NAP	3H20	3.558	0.007	1
UNMAPPED	1	NAP	1HN7	9.203	0.0	2
UNMAPPED	1	NAP	H21	5.767	0.0	1

### 7.2.2 Chemical shift referencing ⓘ

No chemical shift referencing corrections were calculated (not enough data).

### 7.2.3 Completeness of resonance assignments [i](#)

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 0%, i.e. 0 atoms were assigned a chemical shift out of a possible 2369. 0 out of 32 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Backbone	0/901 (0%)	0/358 (0%)	0/370 (0%)	0/173 (0%)
Sidechain	0/1279 (0%)	0/756 (0%)	0/465 (0%)	0/58 (0%)
Aromatic	0/189 (0%)	0/99 (0%)	0/81 (0%)	0/9 (0%)
Overall	0/2369 (0%)	0/1213 (0%)	0/916 (0%)	0/240 (0%)

### 7.2.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

### 7.2.5 Random Coil Index (RCI) plots [i](#)

No *random coil index* (RCI) plot could be generated from the current chemical shift list (assigned\_chem\_shift\_list\_2). RCI is only applicable to proteins.

## 7.3 Chemical shift list 3

File name: BMRB entry 5981

Chemical shift list name: *assigned\_chem\_shift\_list\_3*

### 7.3.1 Bookkeeping [i](#)

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	19
Number of shifts mapped to atoms	0
Number of unparsed shifts	0
Number of shifts with mapping errors	19
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	0

The following assigned chemical shifts were not mapped to the molecules present in the coordinate file.

- Chain not found in structure. First 5 (of 19) occurrences are reported below.

Chain	Res	Type	Atom	Shift Data		
				Value	Uncertainty	Ambiguity
UNMAPPED	1	TOP	AH4*	4.577	0.007	1
UNMAPPED	1	TOP	AH3*	4.143	0.003	1
UNMAPPED	1	TOP	AH52	4.65	0.004	1
UNMAPPED	1	TOP	NH4*	4.082	0.008	1
UNMAPPED	1	TOP	AH51	4.405	0.009	1

### 7.3.2 Chemical shift referencing [i](#)

No chemical shift referencing corrections were calculated (not enough data).

### 7.3.3 Completeness of resonance assignments [i](#)

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 0%, i.e. 0 atoms were assigned a chemical shift out of a possible 2369. 0 out of 32 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Backbone	0/901 (0%)	0/358 (0%)	0/370 (0%)	0/173 (0%)
Sidechain	0/1279 (0%)	0/756 (0%)	0/465 (0%)	0/58 (0%)
Aromatic	0/189 (0%)	0/99 (0%)	0/81 (0%)	0/9 (0%)
Overall	0/2369 (0%)	0/1213 (0%)	0/916 (0%)	0/240 (0%)

### 7.3.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

### 7.3.5 Random Coil Index (RCI) plots [i](#)

No *random coil index* (RCI) plot could be generated from the current chemical shift list (assigned\_chem\_shift\_list\_3). RCI is only applicable to proteins.