



# Full wwPDB NMR Structure Validation Report ⓘ

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PDB ID : 1LMS  
Title : Structural model for an alkaline form of ferricytochrome c  
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This is a Full wwPDB NMR Structure Validation 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

<https://www.wwpdb.org/validation/2017/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	:	1.7.3 (157068), CSD as539be (2018)
Percentile statistics	:	20171227.v01 (using entries in the PDB archive December 27th 2017)
RCI	:	v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV	:	Wang et al. (2010)
ShiftChecker	:	trunk30686
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	trunk30686

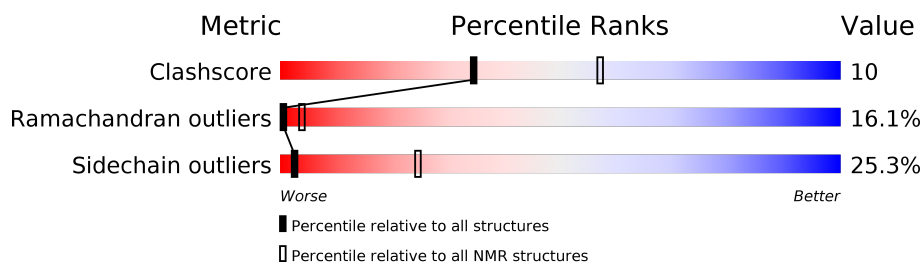
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 35%.

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	136279	12091
Ramachandran outliers	132675	10835
Sidechain outliers	132484	10811

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	108	<div> <div></div> <div>45%</div> <div>27%</div> <div>12%</div> <div>•</div> <div>12%</div> </div>

## 2 Ensemble composition and analysis ⓘ

This entry contains 1 models. Identification of well-defined residues and clustering analysis are not possible.

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

There are 2 unique types of molecules in this entry. The entry contains 1553 atoms, of which 760 are hydrogens and 0 are deuteriums.

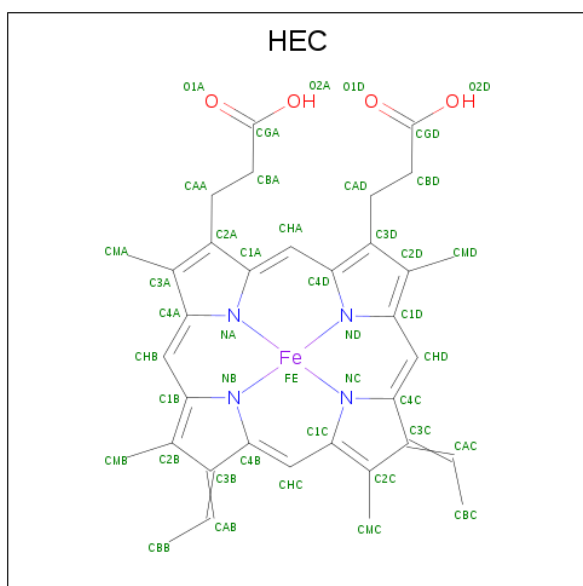
- Molecule 1 is a protein called Cytochrome c, iso-1.

Mol	Chain	Residues	Atoms						Trace
1	A	95	Total	C	H	N	O	S	0
			1478	473	728	133	140	4	

There are 3 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	72	ALA	LYS	ENGINEERED	UNP P00044
A	79	ALA	LYS	ENGINEERED	UNP P00044
A	102	THR	CYS	ENGINEERED	UNP P00044

- Molecule 2 is HEME C (three-letter code: HEC) (formula:  $C_{34}H_{34}FeN_4O_4$ ).



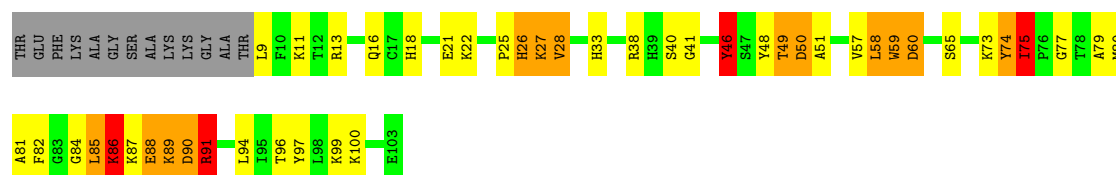
Mol	Chain	Residues	Atoms					
2	A	1	Total	C	Fe	H	N	O
			75	34	1	32	4	4

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

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: Cytochrome c, iso-1

Chain A: 



## 5 Refinement protocol and experimental data overview

The models were refined using the following method: *simulated annealing in torsion angle space*.

Of the ? calculated structures, 1 were deposited, based on the following criterion: ?.

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

Software name	Classification	Version
DYANA	structure solution	1.5
AMBER	refinement	6.0

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 5466
Number of chemical shift lists	1
Total number of shifts	486
Number of shifts mapped to atoms	486
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	35%

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: HEC

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 (average) 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	0.65	0/767 (0.0%)	1.31	5/1030 (0.5%)
All	All	0.65	0/767 (0.0%)	1.31	5/1030 (0.5%)

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	Planarity
1	A	0	20
All	All	0	20

There are no bond-length outliers.

All angle outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	74	TYR	CB-CG-CD2	-7.02	116.79	121.00
1	A	75	ILE	CA-CB-CG2	6.33	123.57	110.90
1	A	91	ARG	NE-CZ-NH2	5.82	123.21	120.30
1	A	59	TRP	NE1-CE2-CZ2	5.74	136.72	130.40
1	A	74	TYR	CB-CG-CD1	5.03	124.02	121.00

There are no chirality outliers.

All planar outliers are listed below.

Mol	Chain	Res	Type	Group
1	A	77	GLY	Peptide
1	A	85	LEU	Peptide
1	A	91	ARG	Sidechain

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Mol	Chain	Res	Type	Group
1	A	18	HIS	Peptide
1	A	86	LYS	Peptide
1	A	26	HIS	Peptide
1	A	21	GLU	Peptide
1	A	82	PHE	Sidechain,Peptide
1	A	84	GLY	Peptide
1	A	25	PRO	Peptide
1	A	87	LYS	Peptide
1	A	38	ARG	Sidechain
1	A	27	LYS	Peptide
1	A	88	GLU	Peptide
1	A	46	TYR	Sidechain,Peptide
1	A	60	ASP	Peptide
1	A	79	ALA	Peptide
1	A	81	ALA	Peptide

## 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	750	728	738	13
2	A	43	32	30	2
All	All	793	760	768	15

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 10.

All clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)
1:A:57:VAL:HG22	1:A:75:ILE:HG22	0.68	1.65
2:A:118:HEC:HMB1	2:A:118:HEC:CBB	0.66	2.21
1:A:46:TYR:O	1:A:49:THR:HG23	0.57	1.99
1:A:57:VAL:CG2	1:A:75:ILE:HG22	0.56	2.30
1:A:57:VAL:HG22	1:A:75:ILE:CG2	0.55	2.32
2:A:118:HEC:HBB2	2:A:118:HEC:HMB1	0.53	1.80
1:A:58:LEU:HD22	1:A:59:TRP:N	0.51	2.20
1:A:85:LEU:HD12	1:A:86:LYS:H	0.50	1.66

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Atom-1	Atom-2	Clash(Å)	Distance(Å)
1:A:9:LEU:CD2	1:A:90:ASP:HA	0.48	2.38
1:A:91:ARG:C	1:A:91:ARG:HD2	0.47	2.30
1:A:85:LEU:HD21	1:A:90:ASP:OD2	0.47	2.09
1:A:85:LEU:HD12	1:A:86:LYS:N	0.46	2.26
1:A:85:LEU:CD1	1:A:86:LYS:H	0.43	2.25
1:A:46:TYR:CE2	1:A:49:THR:HG21	0.43	2.48
1:A:91:ARG:CD	1:A:91:ARG:C	0.41	2.89

## 6.3 Torsion angles

### 6.3.1 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 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	93/108 (86%)	54 (58%)	24 (26%)	15 (16%)	0	4
All	All	93/108 (86%)	54 (58%)	24 (26%)	15 (16%)	0	4

All 15 Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type
1	A	48	TYR
1	A	51	ALA
1	A	27	LYS
1	A	49	THR
1	A	11	LYS
1	A	33	HIS
1	A	40	SER
1	A	88	GLU
1	A	22	LYS
1	A	41	GLY
1	A	60	ASP
1	A	89	LYS
1	A	80	MET
1	A	50	ASP
1	A	28	VAL

### 6.3.2 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 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	79/87 (91%)	59 (75%)	20 (25%)	2	24
All	All	79/87 (91%)	59 (75%)	20 (25%)	2	24

All 20 residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type
1	A	75	ILE
1	A	97	TYR
1	A	74	TYR
1	A	28	VAL
1	A	13	ARG
1	A	99	LYS
1	A	90	ASP
1	A	94	LEU
1	A	100	LYS
1	A	96	THR
1	A	91	ARG
1	A	46	TYR
1	A	26	HIS
1	A	89	LYS
1	A	73	LYS
1	A	58	LEU
1	A	16	GLN
1	A	86	LYS
1	A	65	SER
1	A	50	ASP

### 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

1 ligand is 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	HEC	A	118	1	26,50,50	0.90	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	HEC	A	118	1	18,82,82	1.25	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	HEC	A	118	1	-	0,6,54,54	0,0,8,8

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no torsion outliers.

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 [i](#)

The completeness of assignment taking into account all chemical shift lists is 35% for the well-defined parts and 35% for the entire structure.

### 7.1 Chemical shift list 1

File name: BMRB entry 5466

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

#### 7.1.1 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	486
Number of shifts mapped to atoms	486
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	31

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

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	0	—	None (insufficient data)
$^{13}\text{C}_\beta$	0	—	None (insufficient data)
$^{13}\text{C}'$	0	—	None (insufficient data)
$^{15}\text{N}$	68	$1.08 \pm 0.74$	None needed (imprecise)

#### 7.1.3 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 35%, i.e. 407 atoms were assigned a chemical shift out of a possible 1170. 0 out of 11 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	212/467 (45%)	144/186 (77%)	0/190 (0%)	68/91 (75%)
Sidechain	169/596 (28%)	166/352 (47%)	0/215 (0%)	3/29 (10%)

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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	26/107 (24%)	25/57 (44%)	0/45 (0%)	1/5 (20%)
Overall	407/1170 (35%)	335/595 (56%)	0/450 (0%)	72/125 (58%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 35%, i.e. 407 atoms were assigned a chemical shift out of a possible 1170. 0 out of 11 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Backbone	212/467 (45%)	144/186 (77%)	0/190 (0%)	68/91 (75%)
Sidechain	169/596 (28%)	166/352 (47%)	0/215 (0%)	3/29 (10%)
Aromatic	26/107 (24%)	25/57 (44%)	0/45 (0%)	1/5 (20%)
Overall	407/1170 (35%)	335/595 (56%)	0/450 (0%)	72/125 (58%)

#### 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	73	LYS	HD2	24.50	2.76 – 0.46	99.5
1	A	73	LYS	HB2	10.94	3.03 – 0.53	36.6
1	A	18	HIS	HE1	-10.00	10.53 – 5.43	-35.3
1	A	18	HIS	HB2	15.37	4.91 – 1.31	34.1
1	A	18	HIS	HD2	21.00	9.28 – 4.78	31.0
1	A	73	LYS	HB3	9.43	3.10 – 0.40	28.4
1	A	73	LYS	HG2	6.70	2.67 – 0.07	20.5
1	A	18	HIS	HB3	9.74	5.00 – 1.10	17.2
1	A	30	PRO	HD3	-1.76	5.52 – 1.72	-14.2
1	A	18	HIS	HA	10.80	6.81 – 2.41	14.1
1	A	29	GLY	HA2	-1.25	5.87 – 2.07	-13.7
1	A	29	GLY	HA3	0.79	5.80 – 2.00	-8.2
1	A	41	GLY	HA2	1.22	5.87 – 2.07	-7.2
1	A	71	PRO	HD2	1.09	5.45 – 1.85	-7.1
1	A	86	LYS	HD3	-0.03	2.75 – 0.45	-7.1
1	A	30	PRO	HG3	-0.05	3.56 – 0.26	-5.9
1	A	86	LYS	HD2	0.27	2.76 – 0.46	-5.8
1	A	64	MET	HE3	-0.89	4.28 – -0.52	-5.8
1	A	64	MET	HE1	-0.89	4.28 – -0.52	-5.8
1	A	64	MET	HE2	-0.89	4.28 – -0.52	-5.8
1	A	75	ILE	HD12	-0.99	2.13 – -0.77	-5.8
1	A	75	ILE	HD11	-0.99	2.13 – -0.77	-5.8

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Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	75	ILE	HD13	-0.99	2.13 – -0.77	-5.8
1	A	71	PRO	HB2	0.08	3.82 – 0.32	-5.7
1	A	75	ILE	HG22	-0.73	2.13 – -0.57	-5.6
1	A	75	ILE	HG21	-0.73	2.13 – -0.57	-5.6
1	A	75	ILE	HG23	-0.73	2.13 – -0.57	-5.6
1	A	19	THR	HG22	2.39	2.29 – -0.01	5.4
1	A	19	THR	HG21	2.39	2.29 – -0.01	5.4
1	A	19	THR	HG23	2.39	2.29 – -0.01	5.4
1	A	38	ARG	HD2	1.92	4.27 – 1.97	-5.2

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

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:

