

Song, Y., Mao, J., and Gunner, M. R. (2009)

MCCE2: Improving Protein pKa Calculations with Extensive Side Chain Rotamer Sampling J. Comp. Chem. 30, 2231-2247.

Supplementary Material S3. Calculated pK_as - FULL MCCE single X-ray structure; 33

proteins

Protein	Res	Calc pK1	Calc pK2	exp pK	Comments	DSSP
Apo E2	LYS 69	12.6		10.1		H
Apo E2	LYS 72	10.6		10		H
Apo E2	LYS 75	11.3		10		H
Apo E2	LYS 95	10.1		10.2		H
Apo E2	LYS 143	10.1		9.4		H
Apo E2	LYS 146	9.2		9.9		H
Apo E2	LYS 157	11.5		10.9		H
Apo E3	LYS 69	11.7		10.4		H
Apo E3	LYS 72	10.7		10		H
Apo E3	LYS 75	11.8		10.1		H
Apo E3	LYS 95	10.2		10.1		H
Apo E3	LYS 143	9.7		9.5		H
Apo E3	LYS 146	9.7		9.2		H
Apo E3	LYS 157	12.0		11.1		H
Apo E4	LYS 69	11.2		10.1		H
Apo E4	LYS 72	10.4		10		H
Apo E4	LYS 75	10.5		10.1		H
Apo E4	LYS 95	10.7		10.1		H
Apo E4	LYS 143	9.8		9.9		H
Apo E4	LYS 146	9.8		9.4		H
Apo E4	LYS 157	11.9		10.9		H
B1 Domain of protein G	TYR 3	15.6		11	Lower Limit	E
B1 Domain of protein G	LYS 4	11.8		11	Lower Limit	E
B1 Domain of protein G	LYS 10	11.9		11	expt val approximate	S
B1 Domain of protein G	LYS 13	11.8		11	Lower Limit	E
B1 Domain of protein G	GLU 15	5.0		4.4		E
B1 Domain of protein G	GLU 19	4.1		3.7		E
B1 Domain of protein G	ASP 22	2.3		2.9		S
B1 Domain of protein G	GLU 27	4.9		4.5		H
B1 Domain of protein G	LYS 28	10.9		10.9		H
B1 Domain of protein G	TYR 33	11.1		11	expt val approximate	H
B1 Domain of protein G	ASP 36	4.9		3.8		H
B1 Domain of protein G	ASP 40	4.4		4		L
B1 Domain of protein G	GLU 42	4.0		4.4		E
B1 Domain of protein G	TYR 45	15.8		12	Lower Limit	E
B1 Domain of protein G	ASP 46	3.8		3.6		E
B1 Domain of protein G	ASP 47	3.3		3.4		T
B1 Domain of protein G	GLU 56	3.7		4		L
B2 Domain of protein G	TYR 8	14.8		11	Lower Limit	E
B2 Domain of protein G	LYS 9	11.5		11	expt val approximate	E
B2 Domain of protein G	LYS 15	12.4		11	Lower Limit	S
B2 Domain of protein G	LYS 18	11.6		11	Lower Limit	E

B2 Domain of protein G	GLU 20	4.8	4.3		E
B2 Domain of protein G	LYS 24	11.1	10.7		E
B2 Domain of protein G	ASP 27	3.0	2.9		S
B2 Domain of protein G	GLU 29	4.3	4.2		H
B2 Domain of protein G	GLU 32	4.9	4.6		H
B2 Domain of protein G	LYS 33	10.8	11	expt val approximate	H
B2 Domain of protein G	TYR 38	11.9	11	expt val approximate	H
B2 Domain of protein G	ASP 41	5.1	3.9		H
B2 Domain of protein G	ASP 45	4.4	4		L
B2 Domain of protein G	TYR 50	16.3	12	Lower Limit	E
B2 Domain of protein G	ASP 51	3.6	3.6		E
B2 Domain of protein G	ASP 52	3.2	3.4		T
B2 Domain of protein G	GLU 61	4.7	4.2		L
<i>Bacterial phosphono- acetaldehyde hydrolase</i>	<i>LYS 53</i>	<i>7.8</i>	<i>9.3</i>	<i>pH dependence of inactivation</i>	<i>H</i>
<i>Bacterial proteinase inhibitor Ssi</i>	<i>HIS 43</i>	<i>1.7</i>	<i>3.15</i>	<i>A - see below</i>	<i>L</i>
Bacterial proteinase inhibitor Ssi	HIS 106	4.9	6		T
Barnase	ASP 8	3.6	3.3		H
Barnase	ASP 12	4.0	3.8		H
Barnase	HIS 18	7.6	7.73		S
Barnase	ASP 22	3.9	3.3		T
Barnase	GLU 29	5.3	3.75		H
Barnase	ASP 44	4.2	3.35		H
Barnase	ASP 54	3.8	2.2		E
Barnase	GLU 60	3.9	3		T
Barnase	GLU 73	2.1	4.4 2.2		E
Barnase	ASP 75	2.4	3.1	change boundary	E
Barnase	ASP 86	5.8	4.2		L
Barnase	ASP 93	1.2	2	Upper Limit	T
Barnase	ASP 101	2.0	1.1 2		S
Barnase	HIS 102	6.2	6.3		T
Barnase	CTR	3.6	3.3		ND
BPTI	NTR	6.9	7.9		ND
BPTI	ASP 3	3.5	3.55		G
BPTI	GLU 7	3.9	3.85		S
BPTI	TYR 10	10.2	9.46		L
BPTI	LYS 15	10.7	10.4		L
BPTI	TYR 21	10.5	9.94		E
BPTI	TYR 23	12.2	11		E
BPTI	LYS 26	10.7	10.4		T
BPTI	TYR 35	10.4	10.6		E
BPTI	LYS 41	11.3	10.8		L
BPTI	LYS 46	10.5	10.4		S
BPTI	GLU 49	4.0	3.91		H
BPTI	ASP 50	2.7	3.2		H
BPTI	CTR	3.7	3.1		ND
Calbindin D9k	LYS 1	11.3	10.6		L

Calbindin D9k	GLU 4	4.1	3.8		H
Calbindin D9k	GLU 5	2.8	3.4		H
Calbindin D9k	LYS 7	11.6	11.4		H
Calbindin D9k	GLU 11	4.9	4.7		H
Calbindin D9k	LYS 12	11.2	11.1		H
Calbindin D9k	LYS 16	11.9	10.1		T
Calbindin D9k	GLU 17	3.5	3.62		S
Calbindin D9k	LYS 25	11.7	11.7		H
Calbindin D9k	GLU 26	3.7	4.1		H
Calbindin D9k	LYS 29	11.0	11.4		H
Calbindin D9k	LYS 41	10.7	10.9		L
Calbindin D9k	ASP 47	3.9	3		H
Calbindin D9k	GLU 48	4.4	4.6		H
Calbindin D9k	LYS 55	12.2	12.1		T
Calbindin D9k	GLU 64	3.7	3.8		H
Calbindin D9k	LYS 71	9.8	10.7		H
Calbindin D9k	LYS 72	10.6	11.3		H
Calbindin D9k	CTR	3.9	3.2		ND
Cardiotoxin A5	HIS 4	6.2	5.6		E
Cardiotoxin A5	GLU 17	3.8	4		T
Cardiotoxin A5	ASP 42	3.2	3.2		S
Cardiotoxin A5	ASP 59	1.8	2.3	Upper Limit	T
CD2d1	ASP 2	2.3	3.5		L
CD2d1	ASP 25	3.5	3.53		T
CD2d1	ASP 26	4.0	3.58		T
CD2d1	ASP 28	4.0	3.57		E
CD2d1	GLU 29	5.1	4.51		E
CD2d1	GLU 33	4.0	4.2		E
CD2d1	GLU 41	6.7	6.53		E
CD2d1	GLU 56	4.4	3.95		E
CD2d1	ASP 62	6.2	4.18		L
CD2d1	ASP 71	3.8	3.2		G
CD2d1	ASP 72	5.2	4.14		G
CD2d1	ASP 94	3.1	3.83		E
CD2d1	GLU 99	4.3	4.1		L
CD2d1	CTR	4.0	3.11		ND
Chymotrypsin Inhibitor 2	GLU 23	4.3	3.2		B
Chymotrypsin Inhibitor 2	GLU 26	2.4	3.3		G
Chymotrypsin Inhibitor 2	GLU 33	3.2	4.2		H
Chymotrypsin Inhibitor 2	GLU 34	3.8	3.8		H
Chymotrypsin Inhibitor 2	GLU 45	3.2	3.85		T
Chymotrypsin Inhibitor 2	GLU 60	3.1	3.5		L
Chymotrypsin Inhibitor 2	ASP 64	4.8	3.8		T
Chymotrypsin Inhibitor 2	ASP 71	2.1	2.8		L
Chymotrypsin Inhibitor 2	ASP 74	4.4	4.95		S
chymotrypsinogen	His 40	3.7	4.6		E
chymotrypsinogen	His 57	8.8	7.3		G
Cyclophilin	HIS 54	1.4	4.2	Upper Limit	L
Cyclophilin	HIS 70	6.3	5.8		S

Cyclophilin	HIS 92	-2.8	4.2	Upper Limit	L
Cyclophilin	HIS 126	5.2	6.3		S
Fungal beta cryptogein	NTR	9.0	7.43		ND
Fungal beta cryptogein	TYR 12	10.4	11.5	expt val approximate	H
Fungal beta cryptogein	ASP 21	2.1	2.49		S
Fungal beta cryptogein	ASP 30	5.0	2.51		H
Fungal beta cryptogein	TYR 33	18.1	12	Lower Limit	L
Fungal beta cryptogein	TYR 47	14.0	12	Lower Limit	H
Fungal beta cryptogein	LYS 61	10.4	10.1	Ambiguous assignment	H
Fungal beta cryptogein	ASP 72	4.0	2.61		B
Fungal beta cryptogein	TYR 85	10.0	10.4		H
Fungal beta cryptogein	TYR 87	17.5	12	Lower Limit	H
Fungal beta cryptogein	LYS 94	10.7	9.4	Ambiguous assignment	H
Fungal beta cryptogein	CTR	4.2	3.51		ND
Hen egg white lysozyme	LYS 1	10.9	10.8		L
Hen egg white lysozyme	GLU 7	3.0	2.85		H
Hen egg white lysozyme	LYS 13	11.1	10.5		H
Hen egg white lysozyme	HIS 15	6.0	5.36		T
Hen egg white lysozyme	ASP 18	2.3	2.66		T
Hen egg white lysozyme	TYR 20	11.6	10.3		B
Hen egg white lysozyme	TYR 23	10.7	9.8		B
Hen egg white lysozyme	LYS 33	9.4	10.4		H
Hen egg white lysozyme	GLU 35	6.1	6.2		H
Hen egg white lysozyme	ASP 48	3.5	1.6		T
Hen egg white lysozyme	ASP 52	4.2	3.68		E
Hen egg white lysozyme	ASP 66	1.0	0.9		L
Hen egg white lysozyme	ASP 87	2.1	2.1		S
Hen egg white lysozyme	ASP 87	2.1	2.07		S
Hen egg white lysozyme	LYS 96	11.3	10.8		H
Hen egg white lysozyme	LYS 97	11.0	10.3		H
Hen egg white lysozyme	ASP 101	5.2	4.08		T
Hen egg white lysozyme	LYS 116	10.2	10.2		T
Hen egg white lysozyme	ASP 119	3.9	3.2		L
Hen egg white lysozyme	CTR	3.3	2.75		ND
Human DNA polymerase					
lambda lyase domain	LYS 312	9.6	8.1	9.5	H
Human thioredoxin (ox)	GLU 6	3.8		4.9	L
Human thioredoxin (ox)	GLU 13	4.2		4.4	H
Human thioredoxin (ox)	ASP 16	3.9		4.2	H
Human thioredoxin (ox)	ASP 20	3.2		3.8	T
Human thioredoxin (ox)	ASP 26	10.7	13.0	8.1	E
Human thioredoxin (ox)	GLU 47	4.5		4.3	H
Human thioredoxin (ox)	GLU 56	2.4		3.2	E
Human thioredoxin (ox)	Asp 58/60/61 2.7, 3.9, 5.2 (coupled expt values)				L
Human thioredoxin (ox)	ASP 58	2.5	7.3		E
Human thioredoxin (ox)	ASP 60	3.8			T
Human thioredoxin (ox)	ASP 61	5.0	3.4		T
Human thioredoxin (ox)	ASP 64	3.8		3.2	H
Human thioredoxin (ox)	GLU 68	4.3		5.1	H

Human thioredoxin (ox)	GLU 70	4.2	4.8		T
Human thioredoxin (ox)	GLU 88	2.8	3.6		E
Human thioredoxin (ox)	GLU 95	3.7	4.1		H
Human thioredoxin (ox)	GLU 98	3.4	3.9		H
Human thioredoxin (ox)	GLU 103	4.1	4.5		H
Human thioredoxin (red)	GLU 6	4.3	4.8		L
Human thioredoxin (red)	GLU 13	4.0	4.4		H
Human thioredoxin (red)	ASP 16	3.7	4		H
Human thioredoxin (red)	ASP 20	3.4	3.8		T
Human thioredoxin (red)	ASP 26	10.7	9.9		E
Human thioredoxin (red)	HIS 43	7.4	5.5		H
Human thioredoxin (red)	GLU 47	3.6	4.1		H
Human thioredoxin (red)	GLU 56	2.9	3.1		E
Human thioredoxin (red)	ASP 58/60/61 2.8, 4.2, 5.3 (coupled expt values)				L
Human thioredoxin (red)	ASP 58	2.7	7.5		E
Human thioredoxin (red)	ASP 60	5.2			T
Human thioredoxin (red)	ASP 61	4.8			T
Human thioredoxin (red)	ASP 64	3.7	3.2		H
Human thioredoxin (red)	GLU 68	3.9	4.9		H
Human thioredoxin (red)	GLU 70	3.7	4.6		T
Human thioredoxin (red)	GLU 88	2.9	3.7		E
Human thioredoxin (red)	GLU 95	4.2	4.1		H
Human thioredoxin (red)	GLU 98	4.2	3.9		H
Human thioredoxin (red)	GLU 103	4.4	4.4		H
Myoglobin - horse	HIS 36	6.1	7.8		L
Myoglobin - horse	HIS 48	5.9	5.62		T
Myoglobin - horse	HIS 81	7.0	6.94		L
Myoglobin - horse	HIS 113	6.0	5.87		H
Myoglobin - horse	HIS 116	6.6	6.79		H
Myoglobin - horse	HIS 119	5.6	6.56		S
Myoglobin - sperm whale	HIS 12	7.4	6.5		H
Myoglobin - sperm whale	HIS 24	-0.5	5	Upper Limit	H
Myoglobin - sperm whale	HIS 36	7.0	8		L
Myoglobin - sperm whale	HIS 48	6.5	5.6		T
Myoglobin - sperm whale	HIS 64	1.8	5	Upper Limit	H
Myoglobin - sperm whale	HIS 81	6.9	6.9		L
Myoglobin - sperm whale	HIS 82	3.8	5	Upper Limit	L
Myoglobin - sperm whale	HIS 97	5.8	5.6		S
Myoglobin - sperm whale	HIS 113	6.5	5.4		H
Myoglobin - sperm whale	HIS 116	6.8	6.7		H
Myoglobin - sperm whale	HIS 119	5.6	6.2		L
Phage T4 lysozyme	HIS 31	7.9	9.1		E
RNase A	GLU 2	3.0	2.6		L
RNase A	GLU 9	4.6	4		H
RNase A	HIS 12	4.1	6		H
RNase A	ASP 14	1.8	1.8		L
RNase A	ASP 38	3.2	3.5		S
RNase A	HIS 48	7.8	6.1		L
RNase A	GLU 49	4.4	4.7		S

RNase A	ASP 53	4.2	3.7		H
RNase A	ASP 83	5.3	3.3		E
RNase A	GLU 86	4.3	4		E
RNase A	HIS 105	6.8	6.5		L
RNase A	GLU 111	4.2	3.5		E
RNase A	HIS 119	5.5	6.5		E
RNase A	ASP 121	2.6	3		E
RNase A	CTR	2.8	2.3		?
RNase H1	GLU 6	4.0	4.5		E
RNase H1	ASP 10	8.2	6.1		E
RNase H1	GLU 32	4.2	3.6		E
RNase H1	GLU 48	1.8	4.4		H
RNase H1	GLU 57	3.7	3.2		H
RNase H1	GLU 61	3.3	3.9		S
RNase H1	HIS 62	6.7	7		L
RNase H1	GLU 64	4.5	4.4		E
RNase H1	ASP 70	3.6	2.6		L
RNase H1	HIS 83	5.9	5.5		H
RNase H1	ASP 94	4.2	3.2		T
RNase H1	ASP 102	0.9	2	Upper Limit	H
RNase H1	ASP 108	3.8	3.2		H
RNase H1	HIS 114	-0.1	5	Upper Limit	S
RNase H1	GLU 119	5.2	4.1		E
RNase H1	HIS 124	7.9	7.1		S
RNase H1	HIS 127	7.3	7.9		L
RNase H1	GLU 129	3.3	3.6		H
RNase H1	GLU 131	4.6	4.3		H
RNase H1	ASP 134	2.7	4.3		H
RNase H1	GLU 135	4.7	4.3		H
RNase H1	GLU 147	4.5	4.2		L
RNase H1	ASP 148	-1.6	2	Upper Limit	L
RNase H1	GLU 154	4.5	4.4		L
RNase H1	CTR	3.4	3.4		ND
RNase SA	NTR	8.6	9.14		ND
RNase SA	ASP 1	3.2	3.44		L
RNase SA	GLU 14	5.3	5.05		H
RNase SA	ASP 17	4.7	3.72		H
RNase SA	ASP 25	5.1	4.87		T
RNase SA	TYR 30	10.5	11.3		S
RNase SA	ASP 33	0.6	2.39		T
RNase SA	GLU 41	3.5	4.14		T
RNase SA	TYR 49	10.1	10.6		T
RNase SA	TYR 51	15.8	11.5	Lower Limit	S
RNase SA	TYR 52	19.4	11.5	Lower Limit	L
RNase SA	HIS 53	8.9	8.27		E
RNase SA	GLU 54	4.2	3.42		E
RNase SA	TYR 55	13.8	11.5	Lower Limit	E
RNase SA	GLU 74	5.0	3.47		S
RNase SA	GLU 78	4.9	3.13		L

RNase SA	ASP 79	7.4	7.37		E
RNase SA	TYR 80	18.1	11.5	Lower Limit	E
RNase SA	TYR 81	13.2	11.5	Lower Limit	E
RNase SA	ASP 84	2.7	3.01		S
RNase SA	HIS 85	5.9	6.35		T
RNase SA	TYR 86	14.0	11.5	Lower Limit	T
RNase SA	ASP 93	3.8	3.09		E
RNase SA	CTR	2.1	2.43		ND
RNase T1	ASP 15	4.2	3.52		H
RNase T1	HIS 27	8.4	7		H
RNase T1	GLU 28	6.1	5.61		H
RNase T1	ASP 29	5.5	4.26		H
RNase T1	GLU 31	4.6	5.36		L
RNase T1	HIS 40	8.5	7.9		E
RNase T1	GLU 46	4.0	3.62		T
RNase T1	ASP 49	5.0	4.22		L
RNase T1	GLU 58	2.5	3.96		E
RNase T1	ASP 66	4.6	3.9		S
RNase T1	ASP 76	4.1	0.5	B - see below	E
RNase T1	GLU 82	2.8	3.27		T
RNase T1	HIS 92	6.1	7.3		S
RNase T1	GLU 102	5.3	5.3		E
Snake erabutoxin b	HIS 6	0.1	2.8	Upper Limit	L
Snake erabutoxin b	TYR 25	13.5	12	Lower Limit	E
Snake erabutoxin b	HIS 26	5.6	5.8		E
Staph Nuclease	HIS 8	7.6	6.52		L
Staph Nuclease	HIS 46	6.4	5.86		L
Staph Nuclease	HIS 121	6.6	5.3		T
Staph Nuclease	HIS 124	4.6	5.73		H
Turkey ovomucoid inhibitor	NTR	6.0	8		ND
Turkey ovomucoid inhibitor	ASP 7	2.1	2.6	Upper Limit	L
Turkey ovomucoid inhibitor	GLU 10	2.5	4.2		T
Turkey ovomucoid inhibitor	TYR 11	9.2	11.5	10.2	L
Turkey ovomucoid inhibitor	LYS 13	11.2	14.1	9.9	L
Turkey ovomucoid inhibitor	GLU 19	3.7	3.2		L
Turkey ovomucoid inhibitor	TYR 20	10.3	11.1		L
Turkey ovomucoid inhibitor	ASP 27	3.3	2.3	Upper Limit	T
Turkey ovomucoid inhibitor	LYS 29	11.4	11.1		L
Turkey ovomucoid inhibitor	TYR 31	14.9	12.5	Lower Limit	E
Turkey ovomucoid inhibitor	LYS 34	10.6	10.1		H
Turkey ovomucoid inhibitor	GLU 43	3.9	4.8		H
Turkey ovomucoid inhibitor	HIS 52	7.3	7.5		E
Turkey ovomucoid inhibitor	LYS 55	11.1	11.1		L
Tyrosin phosphatase	HIS 66	6.8	8.3		T
Tyrosin phosphatase	HIS 72	7.3	9.2		L
Xylanase BA	ASP 5	4.6	3.84		S
Xylanase BA	HIS 11	7.4	0.7	6.5 change boundary	E
Xylanase BA	ASP 12	5.2	3.94		T
Xylanase BA	ASP 15	3.2	3.35		E

Xylanase BA	GLU 17	3.5		4.31		E
Xylanase BA	ASP 21	2.8		3.46		L
Xylanase BA	HIS 32	5.4		6.7		S
Xylanase BA	HIS 60	4.0	6.2	4		H
Xylanase BA	ASP 90	4.0		3.88		T
Xylanase BA	GLU 94	4.6	8.1	3.94		E
Xylanase BA	ASP 99	2.2		2.7	Upper Limit	E
Xylanase BA	ASP 118	2.5		2.7	Upper Limit	T
Xylanase BA	ASP 123	0.4		2.7	Upper Limit	E
Xylanase BA	GLU 126	4.7		4.51		E
Xylanase BA	HIS 162	-2.5		2.7	Upper Limit	H
Xylanase BA	GLU 167	2.3		3.58		H
Xylanase BA	GLU 178	4.5	7.1	4.1	change boundary	E
Xylanase BA	GLU 184	5.3		6.5		E
Xylanase BA	CTR	4.2		6.52		ND
Xylanase BC	ASP 11	2.2		2.5		L
Xylanase BC	GLU 78	4.3	7.2	4.6		E
Xylanase BC	ASP 101	1.1		2	Upper Limit	T
Xylanase BC	ASP 106	4.6		2.7		E
Xylanase BC	ASP 119	3.3		3.2		T
Xylanase BC	ASP 121	4.7		3.6		S
Xylanase BC	HIS 149	-1.3		2.3	Upper Limit	H
Xylanase BC	HIS 156	6.7		6.5		T
Xylanase BC	GLU 172	6.7	4.1	6.7		E

References to experimental values in Table S2

pK2 provided when bimodal equation provides significantly better fit to calculated titration

Comments

Upper or lower limit indicates the residue pK could not be seen in experimental titration

Change boundary: Rerun with MCCE selected exposed conformer substituted for experimental input positions used to calculate the corrected boundary

Other notes refer to ambiguity of assignments.

A Exp pK = 3.2. Protonation of His occurs with denaturation of the protein. Therefore, pKa for the wildtype protein should be <3.2. High desolvation energy is consistent with the low solvent accessibility found in the NMR measurements. (Fujii et al., 1980, J Biochem (Tokyo))

B Small ppm shift is found in Spitzner et al. at pH 4 and 8, ambiguous data in Koumanov et al. Pfeiffer et al. suggest it is protonated at pH 5.5

DSSP assignment: H helix; E b-sheet; L loops; ND termini not defined; S,T etc other

Protein	exp pK _a	PDB	Method	# of Models	Substrates used	Substrates deleted
Ribonuclease alpha-sarcin precursor	Perez-Canadillas et al., 1998 (1; Garcia-Mayoral et al., 2003 (2)	1DE3	NMR	20		
B1 Domain of protein G	Khare et al., 1997 (3)	1GB1	NMR	60		
		1PGA	X-ray	1		
		1PGB	X-ray	1		
B2 Domain of protein G	Khare et al., 1997 (3)	2IGH	NMR	24		
		1IGD	X-ray	1		
		2IGD	X-ray	1		
Barnase	Oliveberg et al., 1995 (4; Loewenthal et al., 1992 (5; Loewenthal et al., 1993 (6; Mossakowska et al., 1989 (7; Sali et al., 1988 (8)	1A2P	X-ray	3		Zn on the surface
		1B2X	X-ray	3		Zn on the surface
		1BNR	NMR	20		
		1FW7	NMR	20		
Pancreatic trypsin inhibitor precursor (BPTI)	March et al., 1982 (9; Richarz & Wuthrich, 1978 (10)	1BPI	X-ray	1		PO ₄ , on the surface
		1JV8	NMR	23		
		4PTI	X-ray	1		
Calbindin D9k	Kesvatera et al., 1996 (11)	1KQV	NMR	30		LA(III) not affecting benchmarked residues
		1KSM	NMR	1		LA(III)
		1IG5	X-ray	1		Mg
		4ICB	X-ray	1		Ca
Cardiotoxin A5	Chiang et al., 1996 (12)	1KXI	X-ray	2		

CD2d1	Chen et al., 2000 (13)	1HNG	X-ray	2		
Chymotrypsin Inhibitor 2	Tan et al., 1995 (14)	2CI2	X-ray	1		
		2SNI	X-ray	1		Ca, only chain I is used
		3CI2	NMR	20		
fungal beta cryptogein	Gooley et al., 1998 (15)	1BEG	NMR	18		
		1BEO	X-ray	1		
		1BXM	X-ray	1		ERG
hen egg white lysozyme	Bartik et al., 1994 (16; Kuramitsu & Hamaguchi, 1980 (17; Takahashi et al., 1992 (18)	1E8L	NMR	50		
		1LSE	X-ray	1		
		4LZT	X-ray	1		NO3
human DNA polymerase lambda lyase domain	Gao et al., 2006 (19)	1NZP	NMR	8		
		1XSN	X-ray	1		
Epidermal growth factor	Kohda et al., 1991 (20)	1EGF	NMR	16		
		1EPG	NMR	1		
		1EPH	NMR	10		
		1EPI	NMR	1		
		1EPJ	NMR	5		
Myoglobin - horse	Kao et al., 2000 (21; Papa et al., 1992 (22)	1DWR	X-ray	1	HEM	CMO,SO4
		1WLA	X-ray	1	HEM	SO4
		1YMB	X-ray		HEM	SO4
Myoglobin - sperm whale	Kao et al., 2000 (21; Bashford et al., 1993 (23)	1MYF	NMR	12	HEM	
		1A6K	X-ray	1	HEM	SO4
		1A6M	X-ray	1	HEM	Oxy,SO4
RNase A	Rico et al., 1991 (24; Baker & Kintanar, 1996 (25)	2AAS	NMR	32		
		7RSA	X-ray	1		TBU

RNase H1	Oda et al., 1994 (26; Oda et al., 1994 (27)	9RAT	X-ray	1	
		3RN3	X-ray	1	SO4, pruned by mcce
		1RCH	NMR	8	
		1GOA	X-ray	1	
RNase SA	Douglas V. Laurents, 2003 (28)	2RN2	X-ray	1	
		1C54	NMR	20	
		1LNI	X-ray	2	GOL,SO4
		1RGG	X-ray	2	SO4
RNase T1	Koumanov et al., 2001 (29; Spitzner et al., 2001 (30; Inagaki et al., 1981 (31; Giletto & Pace, 1999 (32)	1IYY	NMR	24	
		1IOV	X-ray	1	ADP,MG,POB: removed, protein only in nmr pka measurements
		1BVI	X-ray	4	2GP,Ca
		1RGA	X-ray	1	3GP, Ca, G
Sso7d	Consonni et al., 2003 (33)	1JIC	NMR	1	
		1SSO	NMR	1	
		1BBX	NMR	2	
			NMR		
		1C8C	X-ray	1	Methylation (residue 1) removed, CTR disordered
Tyrosin phosphatase	exp: Zhou et al., (34; Tishmack et al., 1997 (35) calc: Dillet et al., 2000 (36)	1BVH	NMR	15	
		1DG9	X-ray	1	EPE
		1Z12	X-ray	1	VO4

Xylanase BA	Betz et al., 2004 (37)	1Z13	X-ray	1	MOO
		1PNT	X-ray	1	PO4
		1H4G	X-ray	2	FXP,SO4
		1H4H	X-ray	4	XYP,XYS, residue 1 changed from Glu to Gln
		1QH6	X-ray	2	FXP
Xylanase BC	Joshi et al., 1997 (38)	1QH7	X-ray	2	XYP
		1BVV	X-ray	1	DFX,XYP
		1C5H	X-ray	1	
bacterial MutT	Harris et al., 2000 (39)	1XNB	X-ray	1	SO4
		1PPX	NMR	20	8OG, MO2
		1MUT	NMR	15	
bacterial phosphonoacetaldehyde hydrolase	Zhang et al., 2002 (40)	1FEZ	X-ray	4	Mg, WO4
		1RQL	X-ray	2	Mg, VSO
bacterial proteinase inhibitor Ssi	Fujii et al., 1980 (41)	2SIC	X-ray	1	Ca
		3SIC	X-ray	1	Ca
		5SIC	X-ray	1	Ca
		3SSI	X-ray	1	
Apo E2	Lund-Katz et al., 2001 (42)	1LE2	X-ray	1	
Apo E3	Lund-Katz et al., 2000 (43)	1NFN	X-ray	1	
Apo E4	Lund-Katz et al., 2001 (42)	1GS9	X-ray	1	
human thioredoxin (reduced)	Forman-Kay et al., 1992 (44)	1ERT	X-ray	1	
		3TRX	NMR	1	
		4TRX	NMR	33	
human thioredoxin (oxidized)	Forman-Kay et al., 1992 (44)	1ERU	X-ray	1	
		1AUC	X-ray	1	
phage T4 lysozyme	Anderson et al., 1990 (45)	2LZM	X-ray	1	
phage T4 lysozyme mutant	Dao-pin et al., 1991 (46)	1L54	X-ray	1	

Sea anemone neurotoxin III	Norton et al., 1993 (47)	1ANS	NMR	28	
snake erabutoxin b	Inagaki et al., 1978 (48)	1ERA	NMR	1	
		1FRA	NMR	14	
		3EBX	X-ray	1	SO4
Turkey ovomucoid inhibitor	Schaller & Robertson, 1995 (49); Swint-Kruse & Robertson, 1995 (50)	1OMT	NMR	50	
		1OMU	NMR	50	
		1PPF	X-ray	1	BMA,FUC,GAL,GLC, MAN,NAG -- complex structure
		1TUR	NMR	12	
		1TUS	NMR	12	
Chymotrypsin	Markley & Ibanez, 1978 (51)	2TGA	X-ray		Ca
Cyclophilin	Yu & Fesik, 1994 (52)	2CPL	X-ray		
		1OCA	NMR	20	
FKBP	Yu & Fesik, 1994 (52)	1FKS	NMR		
Staphylococcal Nuclease	Lee et al., 2002 (53)	1STY	X-ray		

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