

Dissection of USP catalytic domains reveals five common insertion points

Supplementary Information

Yu Ye^{1§}, Hartmut Scheel^{2§}, Kay Hofmann² and David Komander^{1*}

1 MRC Laboratory of Molecular Biology, Hills Road, Cambridge CB2 0QH, UK

2 Miltenyi Biotec, Friedrich-Ebert-Strasse 68, 51429 Bergisch-Gladbach,
Germany.

§ These authors contributed equally to the work.

* Correspondence should be addressed to:

David Komander, MRC Laboratory of Molecular Biology, Protein and Nucleic
Acid Chemistry Division, Hills Road, Cambridge, CB2 0QH, UK.

Email: dk@mrc-lmb.cam.ac.uk, Tel: +441223402300, Fax: +441223412178

Running title: USP domain insertions

Supplementary Figure 1: Box annotation for USP domain structures.

A) Structure of USP2 (pdb-id 2hd5, ¹), with boxes coloured in blue (box 1), light blue (box 2), light green (box 3), dark green (box 4), orange (box 5) and dark red (box 6). Regions in grey are not part of any box, and represent the points where insertions can occur. The catalytic as well as Zn-binding residues are shown in a stick model with yellow carbon atoms, blue nitrogen atoms, red oxygen atoms and green sulphur atoms. B) Structure of USP8 (pdb-id 2gfo, ²) coloured as in A. USP8 contains a small helical insertion between boxes 4/5. C) Structure of USP14 (pdb-id 2ayo, ³), coloured as in A. USP14 contains a small mainly disordered insert between boxes 4/5. D) Structure of CYLD (pdb-id 2vhf, ⁴), coloured as in A. CYLD displays a truncated Fingers subdomain, and contains a B-box insertion (yellow) between box 4 and box 5 (see main text).

Supplementary Figure 1: Box annotation for USP domain structures.

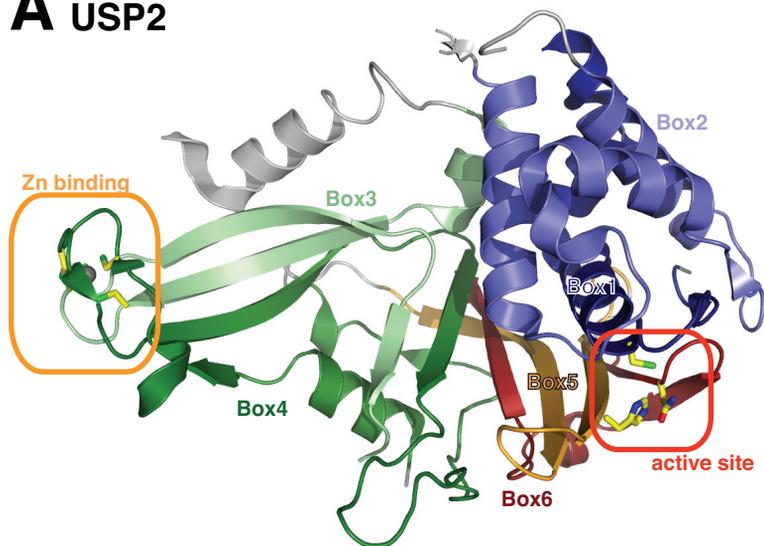
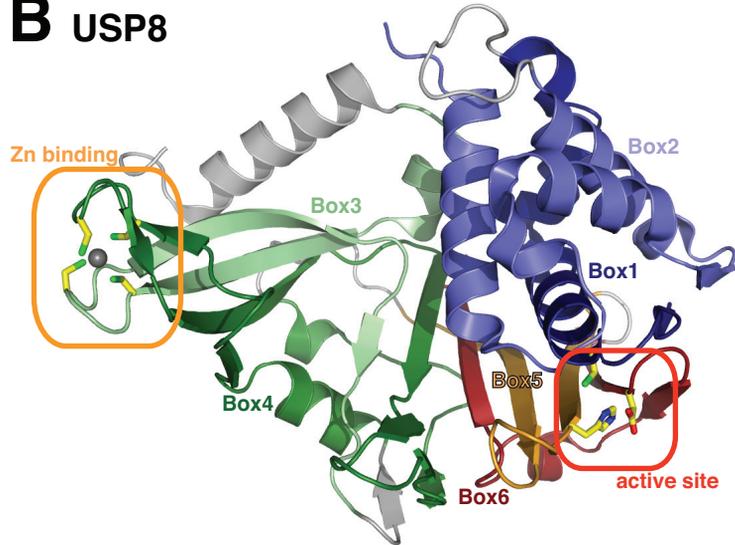
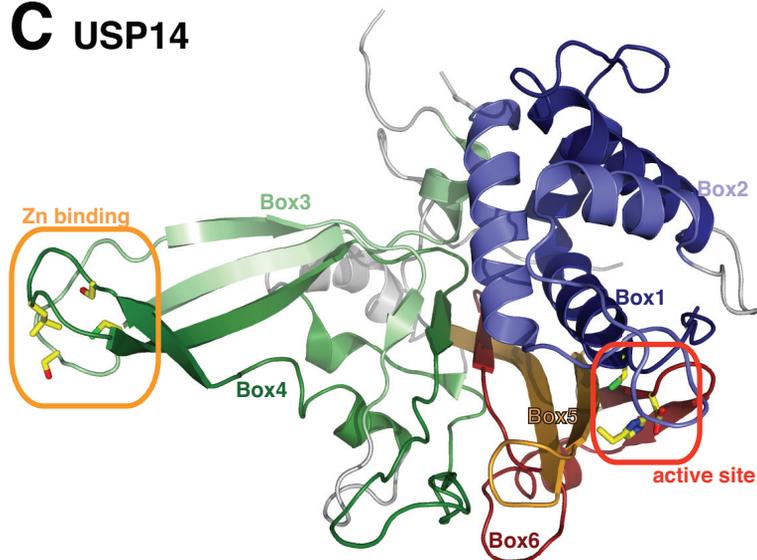
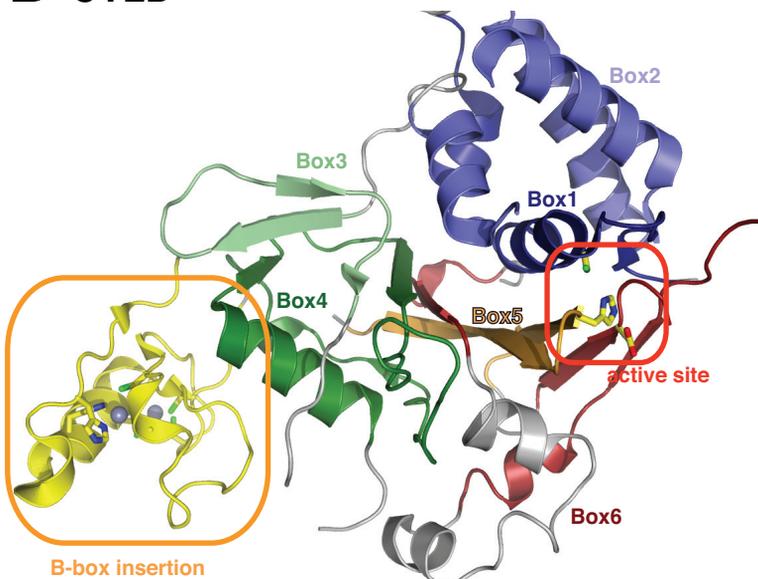
Alignment as in Fig.2 of main text, in larger format.

Supplementary Table I: catalytic domain and insertion boundaries for all human USPs

Catalytic domain boundaries, according to ProSite annotation, and position of insertions identified in this study. All numbers are based on the human sequences.

References

1. M. Renatus, S. G. Parrado, A. D'Arcy, U. Eidhoff, B. Gerhartz, U. Hassiepen, B. Pierrat, R. Riedl, D. Vinzenz, S. Worpenberg and M. Kroemer, *Structure*, 2006, **14**, 1293-1302.
2. G. V. Avvakumov, J. R. Walker, S. Xue, P. J. Finerty, Jr., F. Mackenzie, E. M. Newman and S. Dhe-Paganon, *J Biol Chem*, 2006, **281**, 38061-38070.
3. M. Hu, P. Li, L. Song, P. D. Jeffrey, T. A. Chenova, K. D. Wilkinson, R. E. Cohen and Y. Shi, *Embo J*, 2005, **24**, 3747-3756.
4. D. Komander, C. J. Lord, H. Scheel, S. Swift, K. Hofmann, A. Ashworth and D. Barford, *Mol Cell*, 2008, **29**, 451-464.

A USP2**B** USP8**C** USP14**D** CYLD**Supplementary Figure 1**

	<-a	box1		box2		box3	>-b																																																									
USP1	VGLNHL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	LASYLE	ICSQSDISVEQL	12	DELATCR	RRLNT	RELNPM	EGYLOD	DAEFL	LOQ	ENL	TCQLL	195	INKGEEQIGF	VEK	FGQ	LV	LRTR	LE	ESL	ERR	DQD	SE	VEQD	17																																			
USP2	AGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	NAHTA	VEEF	AKH	QHT	WTSS	PND	VISE	SE	FKTQ	QRY	YAPR	VGYN	OODA	BEFL	RRL	LDG	HNE	NRV	22	MWRKYL	ERED	SR	GD	FGQ	LK	ST	TD	Q	YCS	TVF	FD	LD	EP	PAKR	2																								
USP3	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	DNMVS	VEEF	FKT	CA	WQG	SQT	AFS	ES	FV	WKIM	FN	RGY	OODA	BEFL	RRL	LDG	HNE	NRV	17	SNKNCING	AST	VV	TA	FG	Q	NE	NG	L	IO	Q	YS	RKF	FD	LD	EP	PLK	12																						
USP4	CGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GMKGE	AEAY	AD	LK	QWSG	RD	AV	RM	FKTQ	GRFA	FO	SGY	OODA	BEFL	RRL	LDG	HNE	NRV	18	AWENHRL	RNS	SV	VD	TH	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	289	3																					
USP5	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	DPTQ	DS	FQ	AK	LHG	LSG	20	VQD	Q	AB	RM	FKTQ	GRFA	FO	SGY	OODA	BEFL	RRL	LDG	HNE	NRV	5	AWNHHRL	RNS	SV	VD	TH	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	30																			
USP6	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GMKGH	AKCY	GD	LK	QWSG	TQ	KS	VA	BL	KTRT	AKY	APK	DG	FO	OD	CS	BE	FL	RRL	LDG	HNE	NRV	7	AWNHHRL	RNS	SV	VD	TH	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	314																		
USP7	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	DSKS	PLA	OR	FY	B	QHS	DKP	VT	CK	TK	SPG	WET	LD	S	NO	BE	FL	RRL	LDG	HNE	NRV	7	AWNHHRL	RNS	SV	VD	TH	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	314																			
USP8	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GKGE	AE	EF	TK	AL	WTG	QYR	Y	SE	KDF	KT	GKIND	AGY	OODA	BEFL	RRL	LDG	HNE	NRV	22	AWQ	HKH	Q	LN	SE	IV	AE	GG	QF	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	314																			
USP9X	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	EYNI	G	LRH	Q	V	FGH	AA	S	RL	QY	VE	RG	FW	KQ	RL	WE	EP	VG	NR	22	AWQ	HKH	Q	LN	SE	IV	AE	GG	QF	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	314																			
USP9Y	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	EYNI	G	LRH	Q	V	FGH	AA	S	RL	QY	VE	RG	FW	KQ	RL	WE	EP	VG	NR	22	AWQ	HKH	Q	LN	SE	IV	AE	GG	QF	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	314																			
USP10	RGLINK	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	CTST	PN	IDS	FV	R	NE	FT	NM	19	PG	AA	FE	TY	YRL	TV	NK	SS	LS	EK	GR	OD	DA	BE	FL	RRL	LDG	HNE	NRV	47	SVTR	QAD	FV	Q	PT	CG	FG	CH	R	SV	Y	Q	SS	K	ES	TA	LO	FF	TD	Q	DS	285								
USP11	CGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GMKGE	AEAY	AD	LK	QWSG	HR	SV	IV	FK	KN	GH	FA	SO	LG	Y	OODA	BEFL	RRL	LDG	HNE	NRV	22	AWN	Q	H	R	R	N	S	V	D	T	H	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	285													
USP12	FGLVNF	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	YKPP	KSE	TE	Q	M	KE	HK	P	Q	Q	N	S	R	M	FK	TA	Y	SK	SH	PE	SS	N	OODA	BEFL	RRL	LDG	HNE	NRV	16	AWN	Q	H	R	R	N	S	V	D	T	H	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	285						
USP13	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	YKPP	KSE	TE	Q	M	KE	HK	P	Q	Q	N	S	R	M	FK	TA	Y	SK	SH	PE	SS	N	OODA	BEFL	RRL	LDG	HNE	NRV	16	AWN	Q	H	R	R	N	S	V	D	T	H	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	285						
USP14	CGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	ASAQ	Y	T	A	A	R	D	F	S	D	K	T	SS	P	E	I	L	Q	F	H	M	A	F	P	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12												
USP15	CGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GMRGE	AKSY	A	L	K	Q	WSG	KFS	Y	V	T	R	A	F	K	T	Q	GR	F	A	P	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12															
USP16	KGLSNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	EPGP	T	L	A	S	Q	N	E	M	Q	E	T	K	G	V	S	O	Q	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12	AWN	Q	H	R	R	N	S	V	D	T	H	GL	FK	ST	V	PC	AK	VS	VT	FD	LD	EP	PLK	312
USP17	AGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	RHGG	CL	T	Q	A	H	T	R	A	L	H	N	Q	A	L	A	A	G	F	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12																	
USP17L1	AGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	RPKC	CL	T	Q	A	H	T	R	A	L	H	N	Q	A	L	A	A	G	F	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12																	
USP17L2	AGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	RPKC	CL	T	Q	A	H	T	R	A	L	H	N	Q	A	L	A	A	G	F	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12																	
USP18	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	BQRS	R	P	O	L	L	E	K	Q	D	S	R	Q	K	A	R	L	E	A	Y	C	Q	K	N	V	P	L	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12										
USP19	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GTGG	R	A	I	G	F	A	V	L	R	A	L	W	K	G	T	H	H	A	F	O	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12																
USP20	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	DKPA	C	K	S	Y	Q	R	L	S	M	H	K	R	P	S	Y	V	T	S	H	G	L	N	P	M	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12												
USP21	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GRAQ	E	T	E	A	F	A	D	I	G	A	L	H	W	P	D	S	C	E	A	N	T	R	F	R	A	V	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12										
USP22	RGLINK	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	SPSS	C	V	C	S	S	F	Q	E	F	Y	S	G	W	H	R	S	P	H	E	R	A	F	L	M	T	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12											
USP24	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	NPDS	F	Y	Q	E	F	Y	S	G	W	H	R	S	P	H	E	R	A	F	L	M	T	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12															
USP25	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	HNL	F	P	M	R	E	R	Y	F	L	V	G	T	K	R	K	Y	D	S	R	A	V	E	I	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12													
USP26	HGLVNF	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	IFNL	N	M	C	A	R	L	F	F	K	D	T	Y	N	I	E	K	E	L	L	L	L	K	K	A	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12												
USP27X	RGLINK	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	SPEL	N	V	C	S	S	F	Q	E	F	Y	S	G	W	H	R	S	P	H	E	R	A	F	L	M	T	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12											
USP28	VGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	KRN	I	M	F	M	O	E	S	S	F	Q	E	F	Y	S	G	W	H	R	S	P	H	E	R	A	F	L	M	T	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12								
USP29	QGFNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	IP	E	A	I	M	T	L	L	L	K	D	F	C	S	E	V	T	K	I	R	E	L	L	K	V	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12												
USP30	FGLVNF	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	SPHQ	Y	S	L	T	L	H	L	S	C	Q	E	V	T	D	D	E	V	D	A	S	O	L	D	V	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12												
USP31	AGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	QGG	E	T	Q	A	H	L	R	A	W	L	N	E	Y	T	P	O	H	S	R	F	K	T	Q	6	Q	Y	L	O	D	A	B	E	F	L	R	L	D	G	H	N	E	R	N	R	12													
USP32	TGLRNL	GNTCYMNSLQVLYFC	SFSC	SKHLFNIS	22	GMKGH	AKCY	GD	LK	QWSG	TQ	KS	VA	BL	KTRT	AKY	APK	DG	FO	OD	CS	BE	FL	RRL	LDG	HNE	NRV	22	AWN	Q	H	R	R	N	S	V	D	T	H	GL	FK	ST	V																					

<----- box4 ----->
USP1 EMKIRWALISQ...SASVERIV...GEDR...EENH...HYTE...ESLS...LFDK...MPEV...IT...HLK...RAAS 7 GGGLSKNTPL...L...K...S...E...E...STK...
USP2 PEVITMOCVRL...ETKE...VLD...D...GDEKPT...CRGR...G...GKRCIK...K...F...W...R...K...L...V...H...K...R...E...S...E...S...R...I...R...I...T...S...K...D...T...T...F...N...P...R...D...L...D...R...E...A...S...N...
USP3 PVSICIRICLRS...STDL...E...ETE...M...H...K...K...K...K...Q...K...S...T...K...F...W...Q...R...F...L...L...C...H...L...K...R...R...H...H...T...A...Y...L...R...K...N...K...D...T...T...V...E...F...F...R...G...L...D...K...C...L...L...E...P...E...N...S...
USP4 TVTARICL...EL...ET...M...E...H...D...P...F...P...N...K...K...K...K...Q...Q...T...K...F...W...L...S...L...K...L...V...H...K...R...R...H...H...T...A...Y...L...R...K...N...K...D...T...T...V...E...F...F...R...G...L...D...K...C...L...L...E...P...E...N...S...
USP5 AQPFPSSC...EA...G...A...F...O...D...D...D...W...S...T...A...L...Q...A...K...S...V...V...T...R...F...A...S...P...D...Y...V...I...Q...K...K...F...T...G...L...D...W...P...K...D...V...S...E...M...E...E...L...S...Q...L...R...G...T...G...L...P...
USP6 EPIN...D...S...C...R...A...R...A...T...S...E...E...B...G...G...E...E...M...Y...S...K...K...K...T...H...C...L...T...K...K...D...M...L...P...P...L...I...H...L...K...R...R...Q...V...V...N...D...Q...W...I...S...Q...K...I...K...R...F...E...R...E...S...D...P...S...A...F...L...V...R...P...D...
USP7 GKKN...F...S...F...V...D...V...A...V...D...D...D...G...N...K...D...A...G...E...H...G...L...Q...E...B...K...G...K...F...L...T...L...P...V...D...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP8 SKCIR...M...C...I...R...L...S...K...E...B...R...L...T...D...N...N...R...Y...S...H...R...R...A...R...D...S...K...E...B...T...W...L...P...V...D...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP9X NHQNL...L...S...T...E...Q...V...K...G...D...L...E...G...A...N...A...H...E...K...E...K...N...K...K...V...D...T...V...K...N...L...K...L...R...P...L...A...L...K...R...E...D...W...E...R...E...C...A...I...R...E...N...D...Y...E...F...E...P...E...R...E...L...D...M...E...P...T...V...A...G...V...A...K...
USP9Y NHQNL...L...S...T...E...Q...I...K...G...L...L...E...G...A...N...A...H...E...K...E...K...D...K...K...V...D...T...V...K...N...L...K...L...R...P...L...A...L...K...R...E...D...W...E...R...E...C...A...I...R...E...N...D...Y...E...F...E...P...E...R...E...L...D...M...E...P...T...V...A...G...V...A...K...
USP10 KIR...T...V...O...A...L...E...S...L...V...A...R...E...S...V...O...Q...G...Y...T...T...K...T...K...Q...E...V...E...I...S...R...V...T...E...L...P...V...D...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP11 APV...R...C...O...C...E...L...T...T...V...E...T...E...K...E...N...P...I...Y...P...S...K...K...Q...H...L...T...K...K...D...M...L...P...E...L...I...H...L...K...R...R...S...T...K...F...S...R...E...K...D...T...L...V...E...F...F...R...D...L...F...E...S...E...V...I...O...P...Q...N...E...
USP12 QNT...S...T...H...C...I...R...G...S...N...T...E...P...I...C...S...E...Y...K...Y...E...B...E...R...R...S...K...Q...E...K...K...R...K...L...P...M...L...A...H...L...K...R...K...M...D...Q...L...H...R...Y...T...K...S...Y...R...V...E...P...L...E...R...E...N...T...S...G...D...A...V...
USP13 AKIP...F...S...A...C...L...Q...A...S...E...P...E...N...D...D...W...S...S...A...L...Q...A...K...S...A...V...K...T...S...R...F...A...S...P...D...Y...V...I...Q...K...K...F...T...G...L...D...W...P...K...D...V...S...E...M...E...E...L...S...Q...L...R...G...T...G...L...P...
USP14 EVKY...F...T...G...L...L...R...L...Q...E...B...T...K...Q...S...P...T...L...Q...R...N...A...I...Y...S...S...R...S...E...L...P...A...Y...T...V...R...R...F...K...E...K...E...S...V...N...A...R...K...L...D...K...K...P...P...L...M...D...Y...E...L...C...T...P...E...L...Q...E...
USP15 PVVK...K...C...I...R...L...E...T...T...K...E...R...G...A...E...D...P...Y...F...P...N...K...G...E...H...Q...E...Q...T...K...K...D...L...S...L...P...V...D...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP16 DECS...I...Q...H...C...I...R...L...S...T...R...N...E...R...K...L...D...A...N...K...L...E...V...C...T...17...V...Y...T...N...A...K...O...L...D...S...L...A...P...L...V...H...L...K...R...R...Q...A...S...G...F...N...L...R...K...N...K...H...K...F...E...P...E...R...I...L...D...A...P...C...T...L...C...K...C...N...
USP17 AAQS...V...Q...O...A...L...E...Q...L...V...K...F...E...P...I...N...G...E...N...A...H...E...G...L...L...Q...R...A...P...S...N...T...T...H...T...S...A...K...L...I...V...L...K...R...R...S...D...V...T...G...N...K...I...A...K...N...Q...V...E...C...L...D...M...E...P...M...S...Q...N...
USP17L1 AAQS...V...Q...O...A...L...E...Q...L...V...K...F...E...P...I...N...G...E...N...A...H...E...G...L...L...Q...R...A...P...S...N...T...T...H...T...S...A...K...L...I...V...L...K...R...R...S...D...V...T...G...N...K...I...A...K...N...Q...V...E...C...L...D...M...E...P...M...S...Q...N...
USP17L2 AAQS...V...Q...O...A...L...E...Q...L...V...K...F...E...P...I...N...G...E...N...A...H...E...G...L...L...Q...R...A...P...S...N...T...T...H...T...S...A...K...L...I...V...L...K...R...R...S...D...V...T...G...N...K...I...A...K...N...Q...V...E...C...L...D...M...E...P...M...S...Q...N...
USP18 PLK...T...E...A...L...H...C...S...K...S...K...C...F...E...N...G...K...K...T...R...K...O...V...K...T...H...L...P...O...T...L...H...L...K...R...R...S...I...R...N...S...Q...T...R...K...I...C...H...S...Y...P...P...O...L...D...F...S...Q...L...P...M...K...R...E...S...
USP19 GHFI...D...O...C...I...R...L...S...T...R...F...E...P...I...A...L...P...E...E...A...I...Y...P...O...K...K...S...E...S...T...K...T...M...L...P...V...D...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP20 PVV...I...E...C...I...A...A...S...F...A...A...P...D...K...G...D...N...M...S...E...R...K...K...L...R...N...V...Y...C...K...L...L...E...L...L...E...L...L...H...L...K...R...R...E...H...E...V...M...Y...S...F...K...N...S...H...S...P...P...E...G...L...D...R...P...L...A...K...E...C...T...
USP21 GKVS...R...C...F...N...L...S...T...R...E...P...I...L...E...S...E...N...A...P...V...D...R...R...R...Q...K...T...R...S...T...K...T...V...O...R...E...P...R...L...V...H...L...K...R...R...S...A...S...R...G...S...I...K...S...V...G...V...D...F...P...L...Q...R...L...S...G...D...F...A...S...D...K...
USP22 GTT...I...E...C...I...R...L...S...T...R...F...E...P...I...L...E...S...S...A...K...I...S...G...H...L...S...Y...Q...E...S...T...K...T...M...K...L...B...I...A...C...H...L...K...R...R...E...H...S...A...K...L...R...K...I...T...T...Y...S...F...P...L...E...L...D...M...E...P...M...A...S...S...K...E...S...
USP24 SCQS...E...I...S...D...L...S...T...R...F...E...P...I...L...E...S...G...N...A...Y...P...S...K...K...E...K...R...I...Y...K...I...T...C...K...L...S...L...V...H...L...K...R...R...E...H...E...D...W...E...S...G...R...S...I...Y...D...E...Q...Y...F...F...M...N...E...P...I...V...S...G...M...A...R...
USP25 GPKD...H...C...I...R...A...A...M...I...E...G...E...L...L...S...L...H...S...E...N...S...G...S...G...E...H...H...F...E...L...P...I...T...E...S...R...E...P...I...N...Q...A...L...G...R...P...E...K...H...N...K...E...P...E...Q...V...L...Y...D...R...M...H...R...R...E...I...
USP26 HPS...E...Q...S...T...F...D...L...S...T...R...F...E...P...I...L...E...S...K...A...K...E...H...K...T...S...V...G...H...S...F...S...L...E...R...L...I...H...L...K...R...R...S...L...N...E...F...C...A...L...K...N...D...Q...E...I...S...K...Y...L...K...S...S...H...C...N...E...G...T...R...P...
USP27X GITH...I...E...C...I...R...L...S...T...R...F...E...P...I...L...E...S...S...A...K...I...S...G...S...Q...S...Y...Q...E...S...T...K...T...M...K...L...B...I...A...C...H...L...K...R...R...E...H...S...A...S...R...G...S...I...K...S...V...G...V...D...F...P...L...Q...R...L...S...G...D...F...A...S...D...K...
USP28 GYRN...D...E...C...I...R...L...S...T...R...F...E...P...I...L...E...S...A...M...V...E...G...D...E...L...L...P...S...D...H...S...V...Y...G...Q...E...R...W...F...T...L...P...I...T...E...S...R...E...P...I...N...Q...S...L...G...Q...E...P...K...H...N...K...E...P...E...Q...I...Y...D...R...M...Y...R...S...K...E...L...
USP29 LPL...S...O...N...S...D...L...S...T...R...F...E...P...I...L...E...S...F...K...E...B...L...E...N...O...M...C...K...Q...K...S...C...V...A...R...H...T...F...S...L...R...L...I...H...L...K...R...R...S...N...S...A...S...R...G...S...I...K...S...V...G...V...D...F...P...L...Q...R...L...S...G...D...F...A...S...D...K...
USP30 HPL...I...D...H...C...I...R...L...S...T...R...E...P...I...L...E...S...I...S...S...E...S...V...R...D...V...U...D...N...O...T...15...Q...R...T...T...V...P...O...K...L...P...O...C...H...I...Q...L...S...S...H...G...T...P...L...R...H...E...H...O...N...E...F...M...D...I...K...Y...H...L...L...G...
USP31 QTC...I...S...Q...C...F...O...L...S...T...R...E...P...I...L...E...S...T...K...E...B...R...L...A...P...D...A...R...P...H...K...K...Q...L...O...Q...S...I...T...S...W...L...P...D...I...L...H...L...K...R...R...Q...E...D...G...D...R...M...K...N...Q...M...K...F...L...T...G...L...M...P...H...V...K...R...S...Q...S...
USP32 EPIN...D...S...C...R...A...R...A...T...S...E...E...B...G...G...E...E...M...Y...S...K...K...K...T...H...C...L...T...K...K...D...M...L...P...P...L...I...H...L...K...R...R...Q...V...V...N...D...Q...W...I...S...Q...K...I...K...R...F...E...R...E...S...D...P...S...A...F...L...V...R...P...D...
USP33 PVV...I...E...C...I...A...A...S...F...A...A...P...D...K...G...D...N...M...S...E...R...K...K...L...R...N...V...Y...C...K...L...L...E...L...L...E...L...L...H...L...K...R...R...E...H...E...V...M...Y...S...F...K...N...S...H...S...P...P...E...G...L...D...R...P...L...A...K...E...C...T...
USP34 DMKN...Y...S...L...D...E...V...T...I...K...T...L...E...G...D...N...M...S...E...R...K...K...K...V...R...E...K...N...A...C...F...K...L...B...R...L...S...N...M...R...T...N...M...V...T...M...K...E...W...N...H...S...F...P...L...R...L...D...M...P...T...E...D...F...L...M...G...
USP35 GSR...S...V...L...L...U...N...Y...L...S...P...E...R...L...T...A...E...N...R...Y...E...S...G...A...S...L...Q...D...E...K...V...E...L...S...O...G...C...Y...I...T...L...R...S...D...L...R...T...M...R...R...K...L...D...D...S...I...P...L...L...R...P...L...A...G...
USP36 QAAN...V...R...A...L...E...L...S...V...K...V...L...S...G...E...N...A...M...A...K...K...K...V...P...S...K...F...T...H...T...S...N...L...T...S...L...K...R...E...A...N...F...S...G...K...T...K...D...G...Y...E...P...L...N...R...P...M...S...Q...N...
USP37 PPR...S...O...S...L...D...L...S...T...R...F...R...A...B...L...E...L...S...E...K...O...G...K...C...L...V...H...K...F...N...L...P...R...L...I...H...L...K...R...R...S...N...V...A...L...S...L...N...K...I...G...O...O...I...T...R...Y...L...L...S...S...H...C...T...E...N...T...P...K...
USP38 TTF...S...V...L...L...U...N...Y...L...A...P...E...I...T...G...D...N...Q...Y...E...N...A...S...L...Q...N...E...T...O...T...E...P...E...Y...I...T...L...R...S...D...Q...K...Y...H...V...R...K...I...L...D...N...S...I...P...L...L...E...P...V...K...R...I...T...S...F...S...
USP39 KDEKE...Q...L...I...P...Q...V...P...L...E...N...I...A...K...F...N...G...I...T...E...K...E...Y...K...T...Y...K...E...N...L...K...K...F...O...T...L...P...P...Y...I...F...C...K...R...K...T...K...N...F...F...V...E...R...N...P...T...I...N...F...P...I...N...D...I...R...E...L...S...E...E...V...O...A...
USP40 NVSG...E...A...L...W...M...V...E...E...V...F...D...C...D...N...I...H...G...T...D...R...L...V...K...A...S...A...K...R...L...P...P...L...T...S...L...R...R...N...D...E...V...K...C...E...R...Y...E...T...S...C...Y...T...P...L...R...N...K...P...C...E...Q...S...E...L...D...
USP41 PLK...I...E...A...L...H...C...S...K...S...K...C...F...E...N...G...K...K...T...R...K...O...V...K...T...H...L...P...O...T...L...H...L...K...R...R...S...I...R...N...S...Q...T...R...K...I...C...H...S...Y...P...P...O...L...D...F...S...Q...L...P...M...K...R...E...S...
USP42 AAQS...V...N...K...A...L...E...Q...L...V...K...F...E...P...O...L...D...G...E...N...S...Y...K...S...K...K...K...M...V...P...S...K...F...T...H...T...S...N...L...T...S...L...K...R...E...A...N...F...S...G...K...T...K...D...G...Y...E...P...L...N...R...P...M...S...Q...N...
USP43 HSC...I...D...E...C...F...O...F...L...S...T...E...B...O...L...A...Q...D...D...A...K...P...H...Q...V...L...Q...O...M...Y...S...W...L...P...D...I...L...H...L...K...R...E...Q...S...G...E...R...R...N...K...I...G...O...O...I...T...R...Y...L...L...S...S...H...C...T...E...N...T...P...K...
USP44 QPCL...T...E...M...A...K...S...T...E...T...E...A...L...E...G...K...I...V...D...O...Q...N...11...V...L...T...E...O...K...O...M...I...C...H...L...P...L...R...H...L...K...R...R...S...G...S...R...N...R...K...E...G...V...H...G...E...I...N...E...P...C...R...E...T...L...K...
USP45 KEC...S...Q...S...C...F...O...L...S...T...S...M...E...B...L...M...G...N...N...K...L...L...E...N...T...19...V...Y...T...N...R...K...O...L...I...S...A...P...A...V...L...I...H...L...K...R...H...O...A...S...L...S...L...K...V...N...R...H...D...F...P...L...L...A...P...C...S...A...T...C...K...N...
USP46 QNT...S...T...H...C...I...R...D...S...N...T...E...P...I...C...S...E...Q...K...Y...E...T...C...S...K...Q...E...K...K...R...K...L...P...M...L...A...H...L...K...R...K...M...E...Q...L...H...R...Y...T...K...S...Y...R...V...E...P...L...E...R...E...N...T...S...D...A...V...
USP47 AFAS...E...A...L...H...A...S...I...Q...P...E...L...D...G...P...N...O...F...E...R...K...K...K...C...D...R...G...R...F...L...P...E...L...L...T...L...K...R...E...D...D...Y...T...M...H...R...I...K...N...D...R...T...E...B...E...L...D...M...S...T...I...D...V...E...D...E...K...
USP48 GHK...O...T...I...C...E...S...E...L...K...E...K...L...E...G...D...N...R...Y...E...N...Q...S...K...Q...N...E...T...R...K...R...L...S...L...D...E...C...T...I...N...H...C...M...R...E...M...D...D...Q...T...Q...N...I...K...N...D...R...E...F...E...Q...E...D...E...L...Q...K...T...D...P...
USP49 TEC...I...T...E...M...A...K...S...T...E...T...E...A...L...E...G...R...I...A...D...O...Q...N...11...V...L...S...E...R...K...O...M...Y...E...L...O...L...R...H...L...K...R...R...S...G...S...R...N...R...K...E...G...V...H...G...E...I...N...E...P...C...R...E...T...L...K...
USP50 YEC...S...I...R...O...C...I...R...L...S...T...R...F...O...Q...A...L...T...W...N...E...I...H...S...F...G...E...T...R...Q...E...T...A...V...A...S...S...A...K...I...S...G...H...L...I...H...L...K...R...E...D...I...Q...G...T...K...R...K...I...D...H...I...P...L...N...L...D...P...I...C...S...I...F...
USP51 GIFS...I...R...O...C...I...R...L...S...T...R...F...R...E...L...G...S...S...A...K...I...S...G...H...L...S...Y...Q...E...S...T...K...T...M...K...L...B...I...A...C...H...L...K...R...R...E...H...S...A...K...L...R...K...I...T...T...Y...S...F...P...L...E...L...D...M...E...P...M...A...S...S...K...E...S...
USP52 KTG...K...N...Y...F...A...Q...V...L...K...R...S...I...D...E...Q...N...T...Q...A...D...T...E...K...Y...O...P...T...O...T...R...N...H...I...P...D...I...L...I...N...C...E...V...N...S...K...E...B...A...D...F...W...Q...A...E...A...R...A...K...K...H...G...G...E...I...S...K...N...K...E...
USP53 LCN...E...R...M...E...R...H...E...R...F...K...F...E...M...A...5...A...N...T...D...D...Y...R...K...P...S...N...C...Q...K...I...K...I...R...V...M...N...C...E...L...V...T...G...V...M...D...S...E...H...S...D...L...T...E...A...V...R...N...A...T...H...Y...P...G...L...F...R...V...T...D...E...N...
USP54 QAIC...L...R...R...E...K...P...S...M...F...E...L...Q...1...A...S...T...M...G...D...L...R...N...P...S...N...C...G...E...R...I...K...I...R...V...M...A...Q...I...T...G...V...M...D...S...H...S...D...L...A...E...D...I...H...S...G...T...O...L...K...G...D...L...F...R...V...T...D...D...R...
USP11 HMK...S...V...T...F...N...T...I...P...E...W...H...L...N...A...H...F...E...N...N...S...K...S...Q...I...R...K...V...L...P...S...P...I...F...M...H...V...E...G...L...P......Q...M...H...O...H...A...V...H...
CYLD LEL...N...I...T...I...L...E...D...T...P...P...Q...R...C...1...G...L...A...M...P...E...R...E...Y...D...D...P...D...S...A...K...I...Q...F...C...T...C...N...T...O...H...H...K...R...L...N...H...K......Y...N...P...S...I...K...D...E...P...D...W...I...R...H...C...

<----- box5 ----->
 PTNDS...G...L...P...A...V...M...S...E...I...T...I...S...S...G...Y...T...A...S...K...R...142
 TNAHV...M...A...V...S...N...H...S...E...G...T...M...G...G...Y...T...A...C...E...S...
 1 PESC...L...D...L...A...A...V...V...H...S...G...V...G...G...Y...T...A...A...
 ARPV...V...D...L...A...V...S...N...H...S...E...G...A...M...G...V...Y...T...A...A...N...
186 DQPG...K...V...Q...L...P...A...S...I...S...M...E...T...S...T...M...C...G...Y...V...C...H...K...
191 HIKP...I...N...L...M...A...S...C...H...S...E...I...L...G...G...Y...T...A...K...
 KDP...A...N...I...L...P...A...V...M...S...E...I...D...N...H...G...Y...V...V...Y...N...P...
 NNL...K...M...L...P...A...V...S...N...H...S...E...G...L...D...G...Y...T...A...C...N...
 23 AGST...K...R...L...V...G...V...H...S...E...G...A...S...G...G...Y...S...Y...I...Q...
 23 AGGT...K...R...L...V...G...V...H...S...E...G...A...S...G...G...Y...S...Y...I...Q...
 4 KCHR...T...H...L...P...A...V...M...H...H...E...N...S...A...T...G...G...Y...T...D...I...F...
 2 PELV...Y...D...L...A...V...S...N...H...S...E...G...M...R...D...G...Y...T...A...C...N...
 NPD...R...M...D...L...P...A...V...M...S...E...G...S...G...P...N...R...G...Y...T...A...K...
179 DGS...T...M...E...L...P...A...S...I...S...M...E...T...S...T...M...S...G...Y...I...C...H...K...
 47 NNC...G...Y...M...L...C...A...V...T...H...O...E...R...S...S...S...G...Y...S...V...M...V...K...
 AGP...C...R...N...L...P...A...V...S...N...H...S...E...G...M...G...G...Y...T...A...A...K...N...
 4 NTR...V...L...S...L...G...V...H...S...E...G...T...M...R...S...G...Y...T...A...K...E...
 23 TGPL...V...V...L...A...V...I...V...H...A...G...W...S...C...H...D...G...Y...S...Y...V...K...
 TGPL...V...V...L...A...V...I...V...H...A...G...W...S...C...H...D...G...Y...S...Y...V...K...
 5 QSG...G...E...L...P...A...V...I...A...R...V...E...M...A...D...S...G...Y...C...V...Y...N...
 QSG...G...E...L...P...A...V...I...A...R...V...E...M...A...D...S...G...Y...C...V...Y...N...
 8 RSD...V...M...L...C...A...V...I...A...R...V...E...M...A...D...S...G...Y...T...A...C...A...E...
 SQT...I...T...D...L...S...T...C...H...E...T...A...G...S...G...Y...T...A...C...O...N...
 AGS...P...V...M...L...C...A...V...I...A...R...V...E...M...A...D...S...G...Y...T...A...C...E...
 13 NND...N...D...M...L...C...A...V...I...A...R...V...E...M...A...D...S...G...Y...S...F...I...R...
 26 ALTE...N...E...L...V...I...V...H...S...E...G...A...H...A...G...Y...T...A...C...N...
174 MIQ...V...P...R...L...A...V...I...V...H...S...E...G...Q...A...N...A...G...Y...W...A...Y...F...D...
261 KGD...H...T...R...L...S...V...S...L...E...K...T...L...K...S...G...Y...I...C...D...A...Y...D...
 13 NEN...K...S...L...P...A...V...I...V...H...S...E...G...T...L...E...S...G...Y...S...F...I...R...
174 LRQ...V...M...L...C...A...V...I...A...R...V...E...M...A...D...S...G...Y...T...A...C...N...
270 DPL...Q...M...R...L...A...V...I...V...H...S...E...G...S...P...N...S...G...Y...S...D...Y...D...
 69 SST...Y...L...R...M...A...V...I...V...H...S...E...G...D...M...H...S...G...Y...T...A...C...N...
 20 PED...Y...I...D...L...A...V...C...N...H...S...E...G...T...M...O...G...Y...T...A...C...N...
187 RIKP...I...N...L...M...A...S...C...H...S...E...I...L...G...G...Y...T...A...K...
 AQI...V...T...D...L...S...T...C...H...E...T...A...S...S...G...Y...T...A...C...N...
 17 SES...Y...E...D...L...E...V...T...V...H...T...E...T...A...D...G...G...Y...S...F...I...R...
 GRG...Q...A...M...L...C...A...V...I...V...H...S...E...G...S...S...E...S...G...Y...C...V...Y...N...
 GDP...V...M...G...L...A...V...I...V...H...S...E...G...S...C...H...A...G...Y...C...Y...K...
283 NLPH...S...L...P...A...V...I...V...H...S...E...G...T...S...S...G...Y...S...D...Y...D...
 32 TKLV...P...L...I...S...S...V...H...S...E...G...I...S...E...S...G...Y...S...V...A...R...
 1 HKNT...T...D...L...A...V...I...V...H...S...E...G...K...P...E...S...G...Y...R...I...H...L...H...
 DLEY...I...D...L...P...A...V...I...V...H...S...E...G...C...Y...G...Y...V...Y...V...R...
 5 QSG...G...E...L...P...A...V...I...A...R...V...E...M...A...D...S...G...Y...C...V...Y...N...
 GEP...I...V...V...L...A...V...I...V...H...S...E...G...N...C...H...A...G...Y...C...Y...K...
 21 PLDF...L...D...L...A...V...C...N...H...S...E...G...F...G...S...G...Y...T...A...C...N...
 3 PECF...I...N...D...L...A...V...I...V...H...S...E...G...F...G...S...G...Y...T...A...C...N...
 3 GDKV...I...G...L...E...V...I...V...H...S...E...G...S...M...R...E...G...Y...T...A...K...
 NLD...R...M...D...L...P...A...V...I...V...H...S...E...G...S...G...P...N...R...G...Y...T...A...K...
 54 KNS...L...I...E...L...P...A...V...I...V...H...S...E...G...S...A...G...G...Y...T...A...C...N...
 GGS...Y...S...E...L...P...A...V...I...V...H...S...E...G...S...A...Y...S...G...Y...T...A...C...N...
 3 KET...F...A...M...D...L...A...V...I...V...H...S...E...G...F...G...S...G...Y...T...A...C...N...
 RKY...P...K...N...L...C...A...V...I...V...H...S...E...G...L...D...G...G...Y...T...A...C...N...
 12 PNE...K...S...L...P...A...V...I...V...H...S...E...G...T...L...E...S...G...Y...S...F...I...R...
64 HGV...V...D...L...P...A...V...I...V...H...S...E...G...D...S...R...T...G...S...L...V...A...H...I...K...
 AKNS...E...L...V...E...L...C...Y...T......S...O...Y...C...A...F...H...
 AKO...S...E...L...V...E...L...C...Y...T......G...N...S...T...E...F...F...O...
 FEG...C...L...O...I...T...Y...Q...R...E......K...H...S...T...I...L...
66 I...P...C...O...N...M...E...L...P...A...V...I...V...H...S...E...G...T...S...Y...V...A...V...Y...

<----- box6 ----->
 EYEG...M...L...F...D...D...S...E...V...K...V...T...E...E...D...F...7...T...S...P...T...F...L...F...Y...K...L...
 PGT...G...B...M...H...T...F...N...D...S...S...V...P...L...S...S...Q...S...V...K...T...S...D...A...Y...L...F...Y...E...L...A...
 T...H...E...G...R...W...I...H...F...N...D...S...T...V...I...L...D...E...B...E...T...V...V...K...A...Y...L...F...Y...E...H...
 K...L...N...G...W...I...V...D...S...N...V...L...A...S...E...D...Q...V...T...K...A...Y...L...F...Y...E...Q...R...
 .K...E...G...R...W...I...N...D...K...V...C...A...S...E...K...P...K...D...L...Y...M...P...Y...O...R...
 N...P...N...C...K...W...I...C...M...D...S...S...C...E...H...P...D...E...D...T...D...S...A...Y...L...F...Y...E...Q...Q...
 K...G...D...G...K...W...C...K...F...D...D...V...E...R...C...T...E...A...13...V...R...H...C...T...N...A...Y...M...L...F...Y...E...
 A...A...R...Q...R...M...K...F...D...D...H...E...V...D...I...S...V...S...S...V...K...S...A...A...Y...L...F...Y...E...T...S...L...
 5 GERN...N...M...K...F...D...D...G...V...E...C...K...M...D...D...D...28...Q...K...R...W

Supplementary Table I. Catalytic domain boundaries, according to ProSite annotation, and position of insertions identified in this study. All numbers are based on the human sequences. USP names in bold letters contain insertions, and USP names not underlined are catalytically inactive.

	Enzyme	Total length	Insertion point	Catalytic core			Insert 1			Insert 2		
				Start	End	Length	Start	End	Length	Start	End	Length
1	<u>USP1</u>	785	2 - 3 and 5 - 6	81	785	705	219	413	195	600	741	142
2	<u>USP2</u>	605		267	600	334						
3	<u>USP3</u>	520		159	512	354						
4	<u>USP4</u>	963	3 - 4	302	914	613	485	773	289			
5	<u>USP5/IsoT</u>	858	3 - 4	326	857	532	610	795	186			
6	<u>USP6</u>	1406	3 - 4 and 4 - 5	532	1370	839	715	1028	314	1116	1306	191
7	<u>USP7/HAUSP</u>	1102		214	522	309						
8	<u>USP8</u>	1118		777	1110	334						
9	<u>USP9X</u>	2547	1 - 2	1550	1950	401	1586	1630	45			
10	<u>USP9Y</u>	2555	1 - 2	1559	1959	401	1596	1639	44			
11	<u>USP10</u>	798		415	796	382						
12	<u>USP11</u>	920	3 - 4	266	888	623	449	733	285			
13	<u>USP12</u>	370		39	370	332						
14	<u>USP13</u>	863	3 - 4	336	862	527	622	800	179			
15	<u>USP14</u>	494		105	484	380						
16	<u>USP15</u>	981	3 - 4	289	934	646	472	783	312			
17	<u>USP16</u>	823	3 - 4	196	823	628	393	628	236			
18	<u>USP17L2</u>	530		80	376	297						
19	<u>USP18</u>	372		55	371	317						
20	<u>USP19</u>	1318	3 - 4	497	1215	719	680	1055	376			
21	<u>USP20</u>	914	2 - 3	145	686	542	251	432	182			
22	<u>USP21</u>	565		212	559	348						
23	<u>USP22</u>	525		176	521	346						
24	<u>USP24</u>	2620		1689	2043	355						
25	<u>USP25</u>	1087	4 - 5	169	658	490	412	585	174			
26	<u>USP26</u>	913	4 - 5	295	887	593	558	818	261			

27	<u>USP27</u>	559		78	422	345						
28	<u>USP28</u>	1077	4 - 5	162	651	490	405	578	174			
29	<u>USP29</u>	922	4 - 5	285	886	602	548	817	270			
30	<u>USP30</u>	517	4 - 5	68	503	436	363	431	69			
31	<u>USP31</u>	1352	3 - 4	128	766	639	316	593	278			
32	<u>USP32</u>	1604	3 - 4 and 4 - 5	734	1568	835	917	1230	314	1318	1504	187
33	<u>USP33</u>	942	2 - 3	185	716	532	291	462	172			
34	<u>USP34</u>	3546		1894	2240	347						
35	<u>USP35</u>	1017	3 - 4	440	926	487	603	755	153			
36	<u>USP36</u>	1121		122	424	303						
37	<u>USP37</u>	979	4 - 5	341	952	612	601	883	283			
38	<u>USP38</u>	1042	3 - 4	445	950	506	624	713	90			
39	<u>USP39/SNUT2</u>	565		225	556	332						
40	<u>USP40</u>	1235	5 - 6	41	483	443	312	442	131			
41	<u>USP41</u>	358		55	358	304						
42	<u>USP42</u>	1325		111	413	303						
43	<u>USP43</u>	1124	3 - 4	101	712	612	277	538	262			
44	<u>USP44</u>	712	1 - 2	273	679	407	310	375	66			
45	<u>USP45</u>	814	3 - 4	190	814	625	388	615	228			
46	<u>USP46</u>	366		35	366	332						
47	<u>USP47</u>	1375		188	565	378						
48	<u>USP48</u>	1035		89	422	334						
49	<u>USP49</u>	688	1 - 2	253	658	406	290	351	62			
50	<u>USP50</u>	339		44	339	296						
51	<u>USP51</u>	711		363	707	345						
52	<u>USP52/PAN</u>	1202	4 - 5	517	925	409	781	844	64			
53	<u>USP53</u>	1073		39	352	314						
54	<u>USP54</u>	1684		33	353	321						
55	CYLD	956	4 - 5	592	951	360	784	857	74			
56	<u>USPL1</u>	1092		227	501	275						