Molecular basis of binding between MERS-CoV and CD26s from 7

bat species

Supporting Information includes

Tables S1

Figures S1-S3

References for SI reference citations

Residues in MD bCD26/hCD26	MD bCD26/MERS-RBD	hCD26/MERS-RBD
—/T188		E536 (1)
N227/N229	NAG: W535 (4), E536 (16),	NAG: W535 (3), E536 (13), D539 (1)
	NAG: W535 (22), D539 (2)	NAG: W535 (23), D539 (2)
	BMA: W535 (5)	BMA: W535 (6)
—/T265	_	Y540 (3)
—/V266		Y540 (1)
K265/K267	D537 (3), G538 (5), D539 (2)	E536 (3), D537 (5), G538 (12), D539 (7)
Y267/F269	D537 (6)	D537 (5)
E278/T283	V561 (1)	_
Q281/Q286	N501 (2), G538 (4), S557 (2), G558	N501 (4), D537 (1), G538 (11), S557
	(1), S559 (1)	(3), G558 (1), S559 (1)
V283/T288	N501 (1), K502 (3), S557 (6)	N501 (4), K502 (10), S557 (4)
A284/A289	K502 (4)	K502 (5)
P285/P290	K502 (4), E513 (3)	K502 (3), E513 (3)
A286/A291	K502 (3), S504 (2), L506 (1), E513	K502 (2), S504 (1), L506 (4), E513
	(10), V555 (6)	(11), V555 (4)
S287/S292	L506 (9), D510 (2), R511 (1)	L506 (7), D510 (1)
L289/L294	Y540 (11),Y541 (1),R542 (4),	K502 (2), Y540 (7), R542 (8), V555
	V555 (6)	(4)
T290/I295	L506 (1), R542 (15), W553 (27),	L506 (3), D510 (3), R542 (12), W553
	V555 (1)	(28), V555 (2)
G291/G296	Y540 (9), R542 (9)	R542 (7)
D292/D297	Y540 (3)	R542 (1)
H293/H298	Y540 (7)	Y540 (7)
R312/R317	L506 (1), D510 (10)	L506 (1), D510 (11)
Y317/Y322	D510 (10), R511 (4)	D510 (4), R511 (4)
T329/S334	S460 (1),	S454 (1), D455 (1)
K331/R336	A461 (3), P463 (1), Q466 (2)	M452 (1), D455 (8), P463 (9), Y499
		(10)
V336/V341	E513 (11), P515 (1)	E513 (9), P515 (2)
Q339/Q344	R511 (1), E513 (5)	E513 (5)
I341/I346	R511 (7)	R511 (11)
—/K392	_	R511 (2)
Total contacts	282	328

Table S1. Comparison of MERS-RBD binding to MD bCD26 and hCD26

The number in the parentheses represent the number of van der Walls contacts, which the indicated residues conferred. The number in red suggest the potential H-bond between the pair of residues. In this table, van der Walls contact was analyzed at the cutoff of 4.5 Å and the H-bonds at the cutoff of 3.3 Å.

Supplemental figures and figure legends

100/100 98.03/37.1 88.83/33.21 100/100 98.03/97.81 88.83/33.21 100/100 100/100 100/100 100/100 100/100 100/100	H. sapien R. aegyptiacus	H. sapien 100/100	Pleropodides R. eegyptiacus E. buettikojeri P. vampyrus P. alecto 88.73/83.94 88.60/82.48 88.20/81.75 88.85/82 100/100 96.46/94.16 94.89/20.70 94.88/92	Planopodidae Rhino E. buettikoleri P. vampyrus P. alecto R. Jerumeque 5.6.0/ 82.46 88.20/ 81.75 88.85/ 82.48 86.09/ 81.75 96.46/ 91.0 5.46/ 91.01 5.46/ 91.77 98.85/ 82.48 86.09/ 81.75	DOUTOE B B B B B B B C C C D C D D D D D D D D	P. alecto 88.85/82.48 94.88/91.24	R. ferrumequinum 8. ferrumequinum 93.40/ 81.75 93.40/ 84.67	Hilpp Midee R. sinicus 86.50/ 81.75 88.73/ 86.13	Hippoosidentides Iddee Embellio		00000000000000000000000000000000000000	0 0 0 0 0 0 0 0 0 0 0 0 0 0	Hipposidenidee Hipposidenidee Phylice Embellonundee Phylic 	deae Dellomunideae Phyliostomuldt S. bilineeta A. planirostis A. jamaicensis C. perspicilla 85.56/82.48 94.51/81.75 94.38/81.02 83.39/81.75 85.68/81.02 85.79/80.29 85.81/81.02 84.79/75.56	Phyllostomidee 5 A. Jonaicensis C. perspicillata D. rotun 84.38/81.02 83.39/81.75 84.78/8 85.38/81.02 84.78/79.56 85.56/7 85.39/81.02 84.78/79.56 85.56/7	rotun 1.78/8	Miniopletic	Miniopleridee	Miniopleridee	Miniopheridice Vesperillion rotundus Annatalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. natalensis E. Juscus P. pipistrellus M. lucilugus rotundus M. and rotundus B. substance B. substance P. pipistrellus M. lucilugus rotundus B. substance B. substance B. substance B. substance B. substance rotundus B. substance B. substance B. substance B. substance B. substance rotundus <t< th=""></t<>
s 100/100 96.46/94.16 94.63/92.70 94.86/91.48 74/04.67 88.73/86.13 87.91/94.56 100/100 95.67/91.19 95.67/91.18 85.94.67 88.86/83.21 88.66/83.21 87.94/85.5 100/100 95.67/91.18 85.94.67 87.12/82.35 100/100 95.67/91.18 85.94.67 87.12/82.35 100/100 95.67/91.18 85.94.67 87.12/82.35 100/100 95.67/91.18 85.94.67 87.12/82.35 100/100 95.67/91.18 85.94.67 87.12/82.34 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24 100/100 91.77/88.24	4. sapien	H. sapien 100/ 100	R. aegyptiacus 88.73/ 83.94	E. buettikoferi 88.60/ 82.48	P. vampyrus 88.20/ 81.75	5 P. alecto 88.85/ 82.48	R. ferrumequinum 86.09/ 81.75	R. sinicus 86.50/ 81.75	H. armiger 84.89/ 81.62	S. bilin 85.56/	eata 82.48	eata A. planirosti 82.48 84.51/ 81.75	eata A. planirostris A. jamaicen 82.48 84.51/81.75 84.38/81.02	eata A. planirostris A. jamaicensis C. perspicilla 82.48 84.51/81.75 84.38/81.02 83.99/81.75	s A. jamaicensis C. perspicillata 84.38/ 81.02 83.99/ 81.75	s A. jamaicensis C. perspicillata D. rotundus 84.38/ 81.02 83.99/ 81.75 84.78/ 83.21	S A. jamaicensis C. perspicillata D. rotundus M. natalensis 84.38/81.02 83.99/81.75 84.78/83.21 83.99/81.75	's A. jamaicensis C. perspicillata D. rotundus M. natalensis E. fuscus 84.38/81.02 83.99/81.75 84.78/83.21 83.99/81.75 84.74/83.70	's A. jamaicensis C. perspicillata D. rotundus M. natalensis E. fuscus P. pipistrellus 84.38/81.02 83.99/81.75 84.78/83.21 83.99/81.75 84.74/83.70 82.37/78.83	's A. Jamaicensis C. perspicillata D. rotundus M. natalensis E. fuscus P. pipistrellus M. lucifugus 84.38/81.02 83.99/81.75 84.78/83.21 83.99/81.75 84.74/83.70 82.37/78.83 83.60/80.29
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num 100/100 86.59/81.75 100/100 100/100 100/100 100/100	P. vampyrus			DOT JOIT	100/ 100	98.03/ 97.81	86.88/ 83.21	88.47/ 84.67	87.12/ 82.35	87.25/ 79.56	79.56	79.56 85.56/ 78.10	85.56/ 78.10		85.56/ 78.10 85.70/ 78.83 85.17/ 79.56	85.56/ 78.10 85.70/ 78.83	85.56/ 78.10 85.70/ 78.83 85.17/ 79.56 86.35/ 79.56	85.56/ 78.10 85.70/ 78.83 85.17/ 79.56 86.35/ 79.56 85.17/ 79.56	85.56/ 78.10 85.70/ 78.83 85.17/ 79.56 86.35/ 79.56 85.17/ 79.56 86.05/ 80.74	85.56/ 78.10 85.70/ 78.83 85.17/ 79.56 86.35/ 79.56 85.17/ 79.56 86.05/ 80.74 83.68/ 78.10
aum 100/ 100 100/ 100 100/ 100	P. alecto					100/100	86.99/ 81.75	88.58/ 83.21	87.65/ 81.62	87.50	0/ 79.56		86.20/78.83	86.20/78.83 86.33/79.56	86.20/78.83 86.33/79.56 85.28/78.83	86.20/78.83 86.33/79.56 85.28/78.83 86.73/78.83	86.20/ 78.83 86.33/ 79.56 85.28/ 78.83 86.73/ 78.83 85.55/ 78.83	86.20/ 78.83 86.33/ 79.56 85.28/ 78.83 86.73/ 78.83 85.55/ 78.83 86.56/ 80.00	86.20/ 78.83 86.33/ 79.56 85.28/ 78.83 86.73/ 78.83 85.55/ 78.83 86.56/ 80.00 84.19/ 77.37	86.20/ 78.83 86.33/ 79.56 85.28/ 78.83 86.73/ 78.83 85.55/ 78.83 86.56/ 80.00 84.19/ 77.37 85.41/ 75.91
	R. ferrumequinum						100/100	95.01/ 90.51	90.00/ 88.24	86.9	7/ 83.21		85.41/81.02		85.41/81.02 85.28/80.29 85.41/82.48	85.41/81.02 85.28/80.29 85.41/82.48	85.41/ 81.02 85.28/ 80.29 85.41/ 82.48 85.55/ 82.48 86.73/ 83.94	85.41/81.02 85.28/80.29 85.41/82.48 85.55/82.48 86.73/83.94 85.51/86.67	85.41/81.02 85.28/80.29 85.41/82.48 85.55/82.48 86.73/83.94 85.51/86.67 83.40/81.02 :	85.41/81.02 85.28/80.29 85.41/82.48 85.55/82.48 86.73/83.94 85.51/86.67 83.40/81.02 84.89/82.48
	R. sinicus							100/100	91.72/ 88.24	87.2	5/ 80.29	5/ 80.29 85.70/ 80.29	85.70/ 80.29		85.70/80.29 85.56/79.56 85.83/81.02	85.70/80.29 85.56/79.56	85.70/80.29 85.56/79.56 85.83/81.02 86.22/81.02	85.70/80.29 85.56/79.56 85.83/81.02 86.22/81.02 87.01/81.02	85.70/ 80.29 85.56/ 79.56 85.83/ 81.02 86.22/ 81.02 87.01/ 81.02 86.05/ 82.96	85.70/80.29 85.56/79.56 85.83/81.02 86.22/81.02 87.01/81.02 86.05/82.96 84.61/82.48
A. planisetia A. planisetii A. Janaiensis C. perspicillata D. rotundus M. antiensis E. fuscus E. fuscus B. pipsitellus M. hucilgus M. ducilgus	H. armiger								100/100	85.	38/ 80.88	.88	84.47/ 80.88	84.47/80.88 84.34/80.15	84.47/80.88 84.34/80.15 84.87/83.09	84.47/80.88 84.34/80.15 84.87/83.09 85.13/83.09	84.47/80.88 84.34/80.15 84.87/83.09 85.13/83.09 85.79/80.88	84.47/80.88 84.34/80.15 84.87/83.09 85.13/83.09 85.79/80.88 84.85/82.22	84.47/80.88 84.34/80.15 84.87/83.09 85.13/83.09 85.79/80.88 84.85/82.22 82.98/80.88	84.47/80.88 84.34/80.15 84.87/83.09 85.13/83.09 85.79/80.88 84.85/82.22 82.98/80.88 85.00/82.35
A, Janinostris A, Janinostris C. perspicillata G. perspicillata M. natalesis E. fusos P. pipistrellus M. lucifugus M. ducidii	S. bilineata									100	100/100	/ 100 85.28/ 79.56	85.28/79.56		85.28/79.56 85.15/78.83 84.76/81.75	85.28/79.56 85.15/78.83 84.76/81.75	85.28/79.56 85.15/78.83 84.76/81.75 85.68/81.75 85.13/79.56	85.28/ 79.56 85.15/ 78.83 84.76/ 81.75 85.68/ 81.75 85.13/ 79.56 85.22/ 81.48	85.28/79.56 85.15/78.83 84.76/81.75 85.68/81.75 85.13/79.56 85.22/81.48 83.25/78.10	85.28/79.56 85.15/78.83 84.76/81.75 85.68/81.75 85.13/79.56 85.22/81.48 83.25/78.10
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D. rotundus M. natalensis E. fuscus P. pipistrellus M. lucifigus M. davidii	C. perspicillata														100/ 100	100/ 100 94.12/ 94.16	100/100 94.12/94.16 84.91/ 83.21	100/100 94.12/94.16 84.91/ 83.21	100/ 100 94.12/ 94.16 84.91/ 83.21 84.61/ 82.22 83.95/ 82.48	100/ 100 94.12/ 94.16 84.91/ 83.21 84.61/ 82.22 83.95/ 82.48 84.78/ 83.21
M. natalensis E. fuscus P. pipistrellus M. lucifiqus M. davidii	D. rotundus														100/100	100/100 86.22/ 82.48		86.22/ 82.48	86.22/ 82.48 85.79/ 83.70	86.22/82.48 85.79/83.70 84.34/81.02
E foscus E pipistellus M. locifigus M. dovidii	M. natalensis															100/100	100/100 88.68/ 85.93		88.68/ 85.93	88.68/85.93 85.66/80.29
A, pipistrellus M. lucifugus M. davidli	E. fuscus																100/100	100/100 93.80/88.89		93.80/ 88.89
M. lucifugus M. dovidii	P. pipistrellus																	100/100	100/100 90.79/ 86.86	
M. davidii	M. lucifugus																		100/ 100	100/100 96.58/93.43
	M. davidii																			100/ 100

Figure S1. Diversity of bCD26s and homologies to hCD26. The percent identity matrix among bCD26s and hCD26 is displayed. In each pair of comparisons, the former number indicates the percent identity of the full-length CD26, and the latter number represents the percent identity of the region spanning blades IV and V. The family name of each species of bat is marked above the matrix and in the same color as the name of the species.

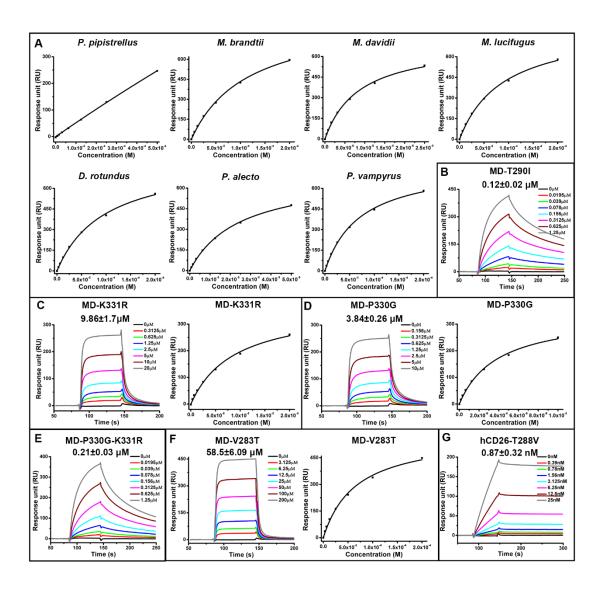


Figure S2. The interactions between MERS-RBD and the indicated CD26s. (A) The saturation profiles for the indicated binding pairs characterized in the SPR assay, which are related to Figure 1. (B-F) The interaction between MERS-RBD and MD CD26 and hCD26-T288V mutations. The upper panel indicates the binding profile, and the lower panel represents the saturation curves. (B) MD-T290I binding to MERS-RBD. (C) MD-K331R binding to MERS-RBD. (D) MD-P330G binding to MERS-RBD. (E) MD-P330G-K331R binding to MERS-RBD. (F) MD-V283T binding to MERS-RBD.

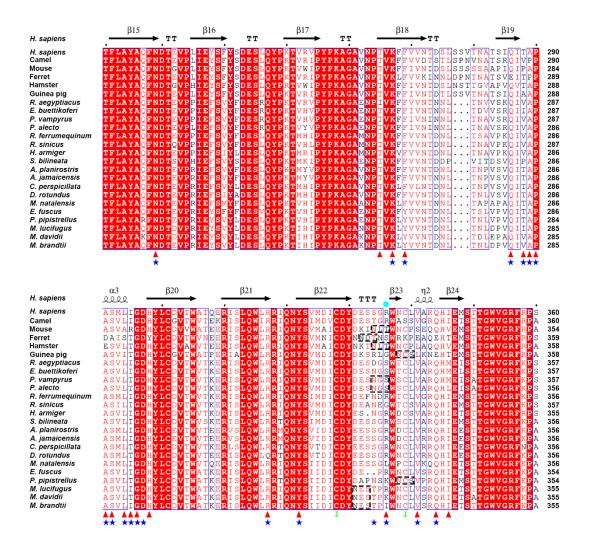


Figure S3. Structure-based sequence alignment. The secondary structure elements are defined based on an ESPript (1) algorithm and are labeled as in a previous report on the MERS-RBD structure (2). Spiral lines indicate α or 3₁₀ helices, while arrows represent β strands. The Arabic numeral 1 indicates cysteine residues that pair to form disulfide bonds. The residues located within the distance of 4.0 Å in the interaction interface were analyzed and marked. The ones in hCD26 that bind MERS-RBD are highlighted with red triangles, and the MD bCD26 residues that bind MERS-RBD are indicated with blue stars. The cyan circle above the sequences indicates R336 in hCD26. Glycosylation motif around hCD26 R336 equivalents among species and bats are highlighted with dashed boxes.

References for SI reference citations

- 1. Gouet P, Courcelle E, Stuart DI, Metoz F. 1999. ESPript: analysis of multiple sequence alignments in PostScript. Bioinformatics 15:305-308.
- Lu G, Hu Y, Wang Q, Qi J, Gao F, Li Y, Zhang Y, Zhang W, Yuan Y, Bao J, Zhang B, Shi Y, Yan J, Gao GF. 2013. Molecular basis of binding between novel human coronavirus MERS-CoV and its receptor CD26. Nature 500:227-31.