

Supplementary Figure S1

A	Original	ATGTTTGTGTTTTCTGTTTATTGCCACTAGTCTCTAGTCAGTGTTAATCTTACAACC	60
	Optimized	ATGTTCTGTGTTTCTGGTGTCTGCTCTGGTGAGCTCCCACTGCGTAACCTGACCACA	60

Original	AGAACTCAATTACCCCTGCATACATACTCTTTACACAGTGGTGGTTATTACCGTGAC	120	
Optimized	AGGACCCAGCTGCCCGCTGCCTATACCAATTCTCTACACGGGCGTGCTACTATCCCGAC	120	
		** ** *	

Original	AAAGTTTTTCAGATCCTCAGTTTTACATTCAACTCAGGACTGTTCCTTACCTTTCTTTCC	180	
Optimized	AAGGTGTTTAGATCTAGCGTCTGCACCTCCACACAGGATCTGTTCTGCGCTTTCTTTCT	180	
		** ** *	

Original	AATGTACTTGGTTCATGCTATACATGCTCTCTGGGACCAATGGTACTAAGAGGTTTGAT	240	
Optimized	AACGTGACCTGTTTCCACGCCATCCAGCTGAGCGGCACCAATGGCACAAAGCGGTTCTGAC	240	
		** ** *	

Original	AACCCCTGTCTACCATTTAATGATGGTGTATTTTTGCTTCCACTGAGAAGCTCTAACATA	300	
Optimized	AATCCAGTGTGCCCTTTAACGATGGCGGTACTTCGCCTCCACGAGAAGCTCTAACATC	300	
		** ** *	

Original	ATAAGAGGCTGGATTTTGGTACTACTTTAGATTGGAAGACCAGTCCCTACTTATTGTT	360	
Optimized	ATCAGAGGCTGGATCTTTGGCACCACTGGACAGCAAGACAGATCCCTGCTGATCGTG	360	
		** ** *	

Original	AATAACGCTACTAATGTTGTTATTAAGTCTGTGAATTTCAATTTTGTAAATGATCCATT	420	
Optimized	AACAATGCCACCAACGTGTCTACAGGTGTGGAGTTCCAGTTTGTAAATGATCACTTC	420	
		** ** *	

Original	TTGGGTGTTTATTACCACAAAACACAAAAGTTGGATGGAAAGTGAGTTCAGAGTTTAT	480	
Optimized	CTGGCGGTGCTACTATCACAAGAACATAAGTCTTGATGGAGAGCGAGTTTCGCGTGAT	480	

Original	TCTAGTGGCAATTAATGCACCTTTGAATATGCTCTCAGCCTTTTCTTATGGACCTTGA	540	
Optimized	TCCTCTGCCAACAAATTGCACATTTGAGTAGCTGCCAGCCCTTCTGTAGGACCTGGAG	540	
		** ** *	

Original	GGAAAACAGGTAATTTCAAAAATCTTAGGGAATTTGTGTTTAAGAATATTGATGGTTAT	600	
Optimized	GGCAAGCAGGCGCAATTTCAAGAACTGAGGGAGTTCTGTGTTTAAGAATATCATGGCTAC	600	
		** ** *	

Original	TTTAAATATATTCTAAGCACACGCCATTAAATTTAGTGGTGATCCCTCAGGGTTTT	660	
Optimized	TTCAAGATCTACTCCAAGCACACCCCAATCAACCTGGTGGCGACCTGCCACAGGGCTTC	660	
		** ** *	

Original	TCGGCTTTAGAACCATTGGTAGATTTGCCAATAGGTATTAACTACTAGGTTTCAAAC	720	
Optimized	CTGCGCTGGAGCACTGGTGGATCTGCCATCGGCATCAACATCACC CGGTTTCAGACA	720	
		** ** *	

Original	TTACTTGCTTTACATAGAAGTTATTTGACTCCTGGTGATTCCTTTCAGGTTGGACAGCT	780	
Optimized	CTGCTGGCCCTGCACAGAAGCTACTGCACACAGGCGAGCTCCTCTGGATGGACGCA	780	
		** ** *	

Original	GGTGCTGCAGCTTATTATGTGGGTTATCTTCAACCTAGGACTTTTCTATTAAAATATAAT	840	
Optimized	GGAGCAGCAGCCTACTATGTGGGCTATCTGCAGGCCAGGACCTTCTGCTGAAGTACAAC	840	
		** ** *	

Original	GAAAATGGAAACCATTACAGATGCTGTAGACTGTGCACCTGACCCTCTCTCAGAAACAAG	900	
Optimized	GAGAATGGCACCATCACAGACGAGTGGATTGCGCACTGGACCCCTGTCTGAGACCAAG	900	
		** ** *	

Original	TGTACGTTGAAATCCTTCACTGTAGAAAAGGAATCTATCAAACTTCTAACTTTAGAGTC	960	
Optimized	TGTACACTGAAGAGCTTTACGTTGAGAGGGCACTATCAGACAGCAATTTCAAGGTG	960	

Original	CAACCAACAGAACTCTATTGTTAGATTTCCTAATATTACAACTTGTGCCCTTTTGGTGAA	1020	
Optimized	CAGCCTACCGAGTCCATGTGGCGTTTCCCAATATCACAACTGTGCCCTTTTGGCGAG	1020	
		** ** *	

Original	GTTTTTAACGCCACCAGATTGCACTGTGTTATGCTTGAACAGGAAGAAATCAGCAAC	1080	
Optimized	GTGTTCAACGCACACAGGTTGCCAAGCGTATCGCATGGAATAGGAAGCGCATCTCCAAC	1080	
		** ** *	

Original	TGTGTGCTGATTATTCTGTCTATATAATTCCGCATCAITTTTCACTTTTAAGTGTTAT	1140	
Optimized	TGCGTGGCGCACTATTCTGTGCTGTACAACAGCGCTCTCTCTCACTTTTAAGTGCTAT	1140	
		** ** *	

Original	GGAGTGCTCTCTACTAAATTAATGATCTCTGCTTTACTAATGCTATGCAGATTCAATTT	1200	
Optimized	GGCGTGAGCCCCACAAGCTGAATGACCTGTGCTTTACCAACGTGTACGCCGATTCTCTC	1200	
		** ** *	

Original	GTAATTAGAGTGATGAAGTCAGACAAATCGCTCCAGGGCAAACTGGAAAGATTGCTGAT	1260	
Optimized	GTGATCAGGGGGCAGGAGTGGCCAGATGTCACCCAGGACAGACAGGCAAGATCGCAGAC	1260	
		** ** *	

Original	TATAATTATAAATTACAGATGATTTTACAGCGTGCCTTATAGCTTGAATTTCTAACAA	1320	
Optimized	TACAATTATAAGCTGCCTGACGATTTTACCGGCTGCGTATCGCTGGAACCTCAACAA	1320	
		** ** *	

Original	CTTGATTCTAAGTTGGTGGTAATTATAATTACCTGTATAGATTGTTTAGGAAGTCTAAT	1380	
Optimized	CTGGATAGCAAGTGGCGGCACTACAATTATCTGTACCGGCTGTTAGAAAGTCTAAT	1380	
		** ** *	

Original	CTCAAACTTTTGAGAGAGATTTTCAACTGAAATCTATCAGGCGGTAGCACACCTTGT	1440	
Optimized	CTGAAGCCATTGAGAGGGACATCTCCACAGAGATCTACAGCGCGGCTCTACCCCTGC	1440	
		** ** *	

Original	AATGGTGTGAAGGTTTTAATTGTACTTTCCCTTTACAATCATATGGTTTCAACCCACT	1500	
Optimized	AATGGCGTGAGGGCTTTAACTGTTATTTCCCTCTGCAGAGACTACGGCTTCCAGCAACA	1500	

Original	AATGGTGTGGTTACCAACCATACAGAGTAGTAGTCTTTCTTTGAACTTCTACATGCA	1560	
Optimized	AACGGCGTGGGCTATCAGCCCTACCAGGTGGTGGTGTCTGTTTGGAGTGTGTCAGCGCA	1560	
		** ** *	

Original	CCAGCAACTGTTTGTGGACCTAAAAAGTCTACTAATTTGGTTAAAAACAAATGTGCAAT	1620	
Optimized	CTGCAACAGTGTGCGGACCAAGAAGAGCACCAATCTGGTGAAGAACAAAGTGCCTGAAC	1620	
		** ** *	

Original	TTCAACTTCAATGGTTTAAACAGGACAGGTTCTTACTGAGTCTAACAAAAGTTTCTG	1680	
Optimized	TTCAACTTCAAGGACTGACCGGCACAGGCGTGTGACCGAGTCCAACGAAGATTCTCTG	1680	

Original	CCTTTCCAACAATTTGGCAGAGACATTGCTGACACTACTGATGCTGCCGTGATCCACAG	1740	
Optimized	CCTTTTCAGAGTTTGGCAGGACATCGCAGATACCAAGACGCGCTGCGGACCTCAG	1740	

Original	ACACTTGAGATTCTTGACATTACACCATGTTCTTTTGGTGGTGCAGTGTATAACACCA	1800	
Optimized	ACCTCGGAGATCCTGGATTATCACACCATGCTCCTTGGCGGGCTGTCTGTATCACACCA	1800	
		** ** *	

Original	GGAACAAATACCTTCAACAGGTTGCTGTTCTTTATCAGGATGTTAACTGCACAGAAGTC	1860	
Optimized	GGCACCAATACAAGCAACCAAGTGGCGGTGCTGATCAGGACGTGAATTGTACCGAGGTG	1860	
		** ** *	

Original	CCTGTGCTATTTCATGCAGATCACTTACTCCTACTTGGCGTGTTTATTTCTACAGGTTCT	1920	
Optimized	CCGCTGGCAATCCACGCAGATCAGCTGACCCCTACATGGCGGTGTACTCTACCGGCAGC	1920	
		** ** *	

Original	AATGTTTTTCAACACGTCAGGCTGTTTAATAGGGGCTGAACATGTCACAACTCATAT	1980	
Optimized	AACGTGTTTCCAGACAGAGCAGGATGCCCTGATCGGAGCAGCAGCTGACAAATAGCTAT	1980	
		** ** *	

Original	GAGTGTGACATACCCATTGGTGCAGGTATATGCGCTAGTTATCAGACTCAGACTAATCT	2040	
Optimized	GAGTGCACATCCTATCGCGCGGCATCTGTGCTCTTACCAGACCAGACAACTCC	2040	

Original	CCTCGGCGGGCAGTAGTGTAGCTAGTCAATCCATCATTGCCTACACTATGTCACCTGGT	2100
Optimized	CCAAGGAGAGCAGGTCTGTGGCAGGCAGTCCATCATCGCTATACCATGAGCGTGGGC * * * * *	2100
Original	GCAGAAAATTCAGTTGCTTACTCTAATAACTCTATTGCCATACCCACAAATTTTACTATT	2160
Optimized	GCCGAGAATTCCTGGGCTACTCCAACAATTCTATGCCATCCCTACCAACTTCACATC * * * * *	2160
Original	AGTGTTCACACAGAATTCTACAGTGTCTATGACCAAGACATCAGTAGTTGTACAATG	2220
Optimized	TCGTTGACCACAGAGATCCTGCGAGTGAGCATGACCAAGACATCCGTGACTGCACAATG * * * * *	2220
Original	TACATTGTGGTGATTCAACTGAATGCAGCAATCTTTGTGCAATATGGCAGTTTTGT	2280
Optimized	TATATCTGTGGGATTCCACCGAGTGCTTAACCTGCTGCTGAGTACGGCTCTTTTGT * * * * *	2280
Original	ACACAATTAAACCGTGCTTTAACTGGAATAGCTGTTGAACAAGACAAAAACCCCAAGAA	2340
Optimized	ACCCAGCTGAATAGAGCCTGACAGGCATCGCCGTGGAGCAGGACAGAACACACAGAGAG * * * * *	2340
Original	GTTTTGACAGAATCAAAACAATTACAAAACACCAATTAAGATTTTGGTGGTTT	2400
Optimized	GTGTTGCCCGAGGTGAAGCAGATCTACAGACCCGCCATCAAGAGCTTTGGCGGCTTC * * * * *	2400
Original	AATTTTTCACAAATATTACAGATCCATCAAAACCAAGCAAGAGTCATTATTGAAGAT	2460
Optimized	AACCTCAGCCAGATCTGCCCGATCTAGCAAGCCATCAAGCGCTCTTTATCGAGGAC * * * * *	2460
Original	CTACTTTTCAACAAAGTGACACTTGAGATGCTGGCTTCATCAACAATATGGTGATTGC	2520
Optimized	CTGCTGTTCAACAAGTGACCTGGCGGATGCCGGCTTCATCAAGCAGTATGGCGATTGC * * * * *	2520
Original	CTGGTGATATTGCTGTAGAGACTCATTTGTGCACAAAGTTTAAAGGCTTACTGTT	2580
Optimized	CTGGGCGACATCGCCGCGAGAGCTGATCTGTGCCAGAAGTTAATGGCTGACCGTG * * * * *	2580
Original	TTGCCACCTTTGCTCAGAGTGAATGATTGCTCAATACACTCTGCAGCTGTAGCGGGT	2640
Optimized	CTGCCCTCACTGCTGACAGATGAGATGATCGCCAGTACACATCTGCCCTGTGGCAGGC * * * * *	2640
Original	ACAATCACTTCTGGTTGGACCTTTGGTGAGGTGCTGATTACAATACCATTGCTATG	2700
Optimized	ACCATCACAGCGGATGGACCTTGGGCGAGGAGCGCCCTGCAGATCCCTTTGCCATG * * * * *	2700
Original	CAAAATGGCTTATAGTTTAAATGGTATTGGAGTTACACAGAATGTTCTCTAGAGAACCA	2760
Optimized	CAGATGGCCTATCGGTTCAACGGCATCGGCGTGACCCAGAATGTGCTGTACGAGAACCAG * * * * *	2760
Original	AAATTGATTGCCAACCAATTAAATAGTGCTATTGGCAAAATCAAGACTCACTTTCTTCC	2820
Optimized	AAGCTGATCGCAATCAGTTTAACTCGCCATCGGCAAGATCCAGGACTCTCTGAGCTCC * * * * *	2820
Original	ACAGCAAGTGCACTTGAAAACTTCAAGATGTGGTCAACCAAAATGCACAAGCTTTAAAC	2880
Optimized	ACAGCAAGCGCCTGGGCAAGTGCAGGATGTGGTGAATCAGAAAGCCAGGCGCTGAAT * * * * *	2880
Original	ACGCTTGTTAACAACCTTAGCTCCAAATTTGGTGCAATTTCAAGTGTTTAAATGATATC	2940
Optimized	ACCGTGTGAAGCAGCTGTCTAGCAACTTCGGCGCATCTCCTCTGTGCTGAATGATATC * * * * *	2940
Original	CTTTCACGCTTTGACAAAGTTGAGGTGAAGTCAAAATGATAGTTGATCAGAGCAGA	3000
Optimized	CTGAGCAGGCTGGACAAAGTTGAGGACAGAGTGCAGATCGCCGCTGATCAGAGCAGA * * * * *	3000
Original	CTTCAAAATTTGCAGACATATGTGACTCAACAATTAAATAGAGTGCAGAAATCAGAGCT	3060
Optimized	CTGCAGTCCCTGCAGACTACGTGACAGCAGCTGATCAGGCGCAGCAGATCAGGGCA * * * * *	3060
Original	TCTGCTAATCTTGCTGCTACTAAAATGTGAGAGTGTACTTGGACAAATCAAAAAGAGTT	3120
Optimized	TCTGCCAATCTGGCGGCCACCAAGATGAGCGAGTGCCTGTGGCGCAGTCCAAGAGAGTG * * * * *	3120
Original	GATTTTGTGGAAGGGCTATCATCTTATGTCCTTCCCTCAGTCAGCACCTCATGGTGTA	3180
Optimized	GACTTTTGTGGCAAGGGCTATCACTGATGAGCTTCCACAGTCCGCCCTCACGGAGTG * * * * *	3180
Original	GCTTTCTGCATGTGACTTATGCTCCCTGCACAAGAAAGAACTTCACACTGCTCCTGCC	3240
Optimized	GTGTTCTGCAGTGTGACTACGTGCCAGCCAGGAGAGAACTTCACACAGCACCAAGCA * * * * *	3240
Original	ATTTGTCAATGATGAAAAGCACACTTCTCTGTAAGGTGTCTTTGTTCAAAATGGCACA	3300
Optimized	ATCTGCCACAGATGGCAAGGCACACTTCTTAGGAGGGCGTGTTCGTGAGCAACGGCAC * * * * *	3300
Original	CACCTGGTTTGAACACAAGGAATTTTATGAACCAAAATCATTTACTACAGACAACACA	3360
Optimized	CACCTGGTTTGTACACAGCGCAATTTCTACGAGCCAGATCATCACCACAGACAATACA * * * * *	3360
Original	TTTGTGCTGGTAAGTGTGATGTTGTAATAGGAATTGTCAACAACAGCTTTATGATCCT	3420
Optimized	TTGCTGTCGGCACTGTGACGTGGTCATCGGCATCGTGAACAATACCGTGATGATCCT * * * * *	3420
Original	TTGCAACCTGAATTAGACTCATTCAGAGGAGGATTAGATAAATATTTAAGAATCATACA	3480
Optimized	CTGCAGCCAGAGCTGGACTCTTTAAGGAGGAGCTGGATAAGTACTTCAAGAATCACACC * * * * *	3480
Original	TCACCAGATGTTGATTTAGTGACATCTCTGGCATTAAATGCTTCAGTTGTAACATTCAA	3540
Optimized	AGCCCCGACGTGGATCTGGGCGACATCTCTGGCATCAATGCCAGCGTGGTGAACATCCAG * * * * *	3540
Original	AAAGAAATTCACCGCTCAATGAGGTGCGCAAGAAATTAATGAATCTCTCATCGATCTC	3600
Optimized	AAGGAGATCGACAGGTGAACGAGGTGGCAAGAAATCGAACGAGTCCCTGATCGATCTG * * * * *	3600
Original	CAAGAACTTGAAAGTATGAGCAGTATATAAAATGGCCATGGTACATTTGGCTAGGTTTT	3660
Optimized	CAGGAGCTGGGCAAGTATGAGCAGTACATCAAGTGGCCCTGGTATATCTGGCTGGGCTTC * * * * *	3660
Original	ATAGCTGGCTTGATTGCCATAGTAATGGTGACAAATATGCTTTGCTGTATGACCAAGTTC	3720
Optimized	ATCGCGCGCTGATCGCATCTGTGATGTTGACCATGCTGTGCTGTATGACAAGCTGC * * * * *	3720
Original	TGTAGTTGTCTCAAGGGCTGTTGTTCTGTGGATCTGCTGCAAAATTTGATGAAGACGAC	3780
Optimized	TGTTCTCGCTGAAGGGCTGCTGTTCTGTGGCAGCTGCTGAAGTTGATGAGGACGAT * * * * *	3780
Original	TCTGAGCCAGTGTCAAAGGAGTCAAATTACATTACACATAA	3822
Optimized	AGCGAGCTGTGCTGAAGGGCGTGAAGCTGCACACCTAA *****	3822

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Pfizer	ATGTTCTGTTCTCTGGTGCTGCTGCCTCTGGTGTCAGCCAGTGTGTGAACCTGACCACC	60
Moderna	ATGTTCTGTTCTCTGGTGCTGCTGCCCCCTGGTGAGCAGCCAGTGCCTGAACCTGACCACC	60
Optimized	ATGTTCTGTTCTCTGGTGCTGCTGCCTCTGGTGAGCTCCAGTGCCTGAACCTGACCACA *****	60
Pfizer	AGAACACAGCTGCCTCCAGCCTACACCAACAGCTTTACCAGAGCGTGTACTACCCCGAC	120
Moderna	CGGACCCAGCTGCCACCAGCCTACACCAACAGCTTCACCCGGGGCGTGTACTACCCCGAC	120
Optimized	AGGACCCAGCTGCCCCCTGCCTATACCAATTCCTTCACACGGGGCGTGTACTATCCCGAC * * * *	120
Pfizer	AAGGTGTTTCAGATCCAGCGTGCTGCACTCTACCCAGGACCTGTTCTGCCTTTCTTCAGC	180
Moderna	AAGGTGTTCCGGAGCAGCGTCTGCACAGCACCAGGACCTGTTCTGCCCTTCTTCAGC	180
Optimized	AAGGTGTTTAGATCTAGCGTGCTGCACTCCACACAGGATCTGTTCTGCCTTTCTTTTCT *****	180
Pfizer	AACGTGACCTGGTTCCACGCCATCCACGTGTCCGGCACCAATGGCACCAAGAGATTGAC	240
Moderna	AACGTGACCTGGTTCCACGCCATCCACGTGAGCGGCACCAACGGCACCAAGCGGTTGAC	240
Optimized	AACGTGACCTGGTTCCACGCCATCCACGTGAGCGGCACCAATGGCACAAAGCGGTTGAC *****	240
Pfizer	AACCCCGTGCTGCCCTTCAACGACGGGGTGACTTTGCCAGCACCGAGAAGTCCAACATC	300
Moderna	AACCCCGTGCTGCCCTTCAACGACGGCGTGACTTCGCCAGCACCGAGAAGAGCAACATC	300
Optimized	AATCCAGTGCTGCCCTTAAACGATGGCGTGACTTCGCCTCCACCGAGAAGTCTAACATC ** * *	300
Pfizer	ATCAGAGGCTGGATCTTCGGCACCACACTGGACAGCAAGACCCAGAGCCTGCTGATCGTG	360
Moderna	ATCCGGGGCTGGATCTTCGGCACCACCTGGACAGCAAGACCCAGAGCCTGCTGATCGTG	360
Optimized	ATCAGAGGCTGGATCTTCGGCACCACACTGGACAGCAAGACACAGTCCCTGCTGATCGTG *** * *	360
Pfizer	AACAACGCCACCAACGTGGTCATCAAAGTGTGCGAGTTCAGTTCTGCAACGACCCCTTC	420
Moderna	AATAACGCCACCAACGTGGTGATCAAGGTGTGCGAGTTCAGTTCTGCAACGACCCCTTC	420
Optimized	AACAATGCCACCAACGTGGTCATCAAAGTGTGCGAGTTCAGTTTTGTAATGATCCATTC * * * *	420
Pfizer	CTGGGCGTCTACTACCACAAGAACAACAAGAGCTGGATGGAAAGCGAGTTCGGGTGTAC	480
Moderna	CTGGGCGTGTACTACCACAAGAACAACAAGAGCTGGATGGAGAGCGAGTTCGGGTGTAC	480
Optimized	CTGGGCGTGTACTATCACAGAACAATAAGTCTTGGATGGAGAGCGAGTTTCGCGTGTAT *****	480
Pfizer	AGCAGCGCCAACAACCTGCACCTTCGAGTACGTGTCCAGCCTTTCCTGATGGACCTGGAA	540
Moderna	AGCAGCGCCAACAACCTGCACCTTCGAGTACGTGAGCCAGCCCTTCCTGATGGACCTGGAG	540
Optimized	TCCTCTGCCAACAATTGCACATTGAGTACGTGTCCAGCCTTTCCTGATGGACCTGGAG * * *	540
Pfizer	GGCAAGCAGGGCAACTTCAAGAACCTGCGCGAGTTCGTGTTTAAAGAACATCGACGGCTAC	600
Moderna	GGCAAGCAGGGCAACTTCAAGAACCTGCGGGAGTTCGTGTTCAAGAACATCGACGGCTAC	600
Optimized	GGCAAGCAGGGCAATTTCAGAAGCTGAGGGAGTTCGTGTTTAAAGATATCGATGGCTAC *****	600
Pfizer	TTCAAGATCTACAGCAAGCACACCCCTATCAACCTCGTGCGGGATCTGCCTCAGGGCTTC	660
Moderna	TTCAAGATCTACAGCAAGCACACCCCAATCAACCTGGTGCGGGATCTGCCCCAGGGCTTC	660
Optimized	TTCAAGATCTACTCCAAGCACACCCCAATCAACCTGGTGCGGACCTGCCACAGGGCTTC *****	660
Pfizer	TCTGCTCTGGAACCCCTGGTGGATCTGCCCATCGGCATCAACATCACCCGGTTTCAGACA	720
Moderna	TCAGCCCTGGAGCCCCTGGTGGACCTGCCCATCGGCATCAACATCACCCGGTTTCAGACC	720
Optimized	TCTGCCCTGGAGCCACTGGTGGATCTGCCCATCGGCATCAACATCACCCGGTTTCAGACA * * *	720
Pfizer	CTGCTGGCCCTGCACAGAAGCTACCTGACACCTGGCGATAGCAGCAGCGGATGGACAGCT	780
Moderna	CTGCTGGCCCTGCACCGAGCTACCTGACCCAGGGCAGCAGCAGCGGGTGGACAGCA	780
Optimized	CTGCTGGCCCTGCACAGAAGCTACCTGACACCGAGCAGCTCCTCTGGATGGACCGCA *****	780

Pfizer	GGTGGCCGCGCTTACTATGTGGGCTACCTGCAGCCTAGAACCCTCTGCTGAAGTACAAC	840
Moderna	GGCGCGGCTGCTTACTACGTGGGCTACCTGCAGCCCCGACCTTCCTGCTGAAGTACAAC	840
Optimized	GGAGCAGCAGCTTACTATGTGGGCTATCTGCAGCCCAGGACCTTCCTGCTGAAGTACAAC ** ** * * * ***** **** * *****	840
Pfizer	GAGAACGGCACCATCACCGACGCCGTGGATTGTGCTCTGGATCCTCTGAGCGAGACAAAG	900
Moderna	GAGAACGGCACCATCACCGACGCCGTGGACTGCGCCTTGACCCCTCTGAGCGAGACCAAG	900
Optimized	GAGAATGGCACCATCACAGACGCA GTGGATTGCGCACTGGACCCCTGTCTGAGACCAAG ***** ***** * * * * * * * * * * * *	900
Pfizer	TGCACCTGAAGTCCTTCACCGTGGAAAAGGCATCTACCAGACCAGCAACTTCCGGGTG	960
Moderna	TGCACCTGAAGAGCTTCACCGTGGAGAAGGCATCTACCAGACCAGCAACTTCCGGGTG	960
Optimized	TGTACACTGAAGAGCTTTACCGTGGAGAAGGCATCTATCAGACAAGCAATTCAGGGTG ** ** * * * * * * * * * * * * * * * * * *	960
Pfizer	CAGCCCACCGAATCCATCGTGCGGTTCCCCAATATACCAATCTGTGCCCTTCGGCGAG	1020
Moderna	CAGCCCACCGAGAGCATCGTGCGGTTCCCCAACATACCAACCTGTGCCCTTCGGCGAG	1020
Optimized	CAGCCTACCGAGTCCATCGTGCGCTTTCCAATATCACAAACCTGTGCCCTTTTGCGGAG ***** * * * * * * * * * * * * * * * * *	1020
Pfizer	GTGTTCAATGCCACCAGATTCGCTCTGTGTACGCCTGGAACCGGAAGCGGATCAGCAAT	1080
Moderna	GTGTTCAACGCCACCCGGTTGCCAGCGTGTACGCCTGGAACCGGAAGCGGATCAGCAAC	1080
Optimized	GTGTTCAACGCAACCAGTTTGC AAGCGTGTACG CATGGAATAGGAAGCGCATCTCCAAC ***** ** * * * * * * * * * * * * * * * *	1080
Pfizer	TGCGTGCGCGACTACTCCGTGCTGTACAAC TCGCCAGCTTCAGCACCTTCAAGTGCTAC	1140
Moderna	TGCGTGCGCGACTACAGCGTGTGTACAACAGCGCCAGCTTCAGCACCTTCAAGTGCTAC	1140
Optimized	TGCGTGCGCGACTATTCTGTGCTGTACAACAGCGCTCCTTCTACCTTTAAGTGCTAT ***** * * * * * * * * * * * * * * * *	1140
Pfizer	GGCGTGTCCCTACCAAGCTGAACGACCTGTGCTTCACAAACGTGTACGCCGACAGCTTC	1200
Moderna	GGCGTGAGCCCCACCAAGCTGAACGACCTGTGCTTCACCAACGTGTACGCCGACAGCTTC	1200
Optimized	GGCGTGAGCCCCACAAAGCTGAATGACCTGTGCTTTACCAACGTGTACGCCGATTCTTTC ***** ** * * * * * * * * * * * * * * *	1200
Pfizer	GTGATCCGGGGAGATGAAGTGCGGCAGATTGCCCTGGACAGACAGGCAAGATCGCCGAC	1260
Moderna	GTGATCCGTGGCGACGAGGTGCGGCAGATCGACCCGGCCAGACAGGCAAGATCGCCGAC	1260
Optimized	GTGATCAGGGGCGACGAGGTGCGCCAGATCGACACGAGACAGACAGGCAAGATCGCAGAC ***** * * * * * * * * * * * * * * * *	1260
Pfizer	TACAAC TACAAGCTGCCCGACGACTTACC GGCTGTGTGATTGCCTGGAACAGCAACAAC	1320
Moderna	TACAAC TACAAGCTGCCCGACGACTTACC GGCTGCGTGATCGCCTGGAACAGCAACAAC	1320
Optimized	TACAATTATAAGCTGCCTGACGATTTACC GGCTGCGTGATCGCCTGGAAC TCTAACAA ***** ** * * * * * * * * * * * * * * *	1320
Pfizer	CTGGACTCCAAAGTCGCGGCAACTACAATTACCTGTACCGCTGTGTCCGGAAGTCCAAT	1380
Moderna	CTCGACAGCAAAGGTGGGCGGCAACTACAATACCTGTACCGCTGTGTCCGGAAGAGCAAC	1380
Optimized	CTGGATAGCAAAGTGGGCGGCAACTACAATTATCTGTACCGCTGTTTAGAAAGTCTAAT ** ** * * * * * * * * * * * * * * *	1380
Pfizer	CTGAAGCCCTTCGAGCGGGACATCTCCACCGAGATCTATCAGGCCGGCAGACCCCTTGT	1440
Moderna	CTGAAGCCCTTCGAGCGGGACATCAGACCGAGATCTACCAAGCCGGCTCCACCCCTTGC	1440
Optimized	CTGAAGCCATTGAGAGGGACATCTCCACAGAGATCTACCAGCCGGCTCTACCCCTGC ***** * * * * * * * * * * * * * * * *	1440
Pfizer	AACGGCGTGGAAGGCTTCAACTGCTACTTCCCACTGCAGTCTACGGCTTTCAGCCACA	1500
Moderna	AACGGCGTGGAAGGCTTCAACTGCTACTTCCCTCTGCAGAGCTACGGCTTTCAGCCACC	1500
Optimized	AATGGCGTGGAAGGCTTTAACTGTATTTCCTCTGCAGAGCTACGGCTTTCAGCCAACA ** * * * * * * * * * * * * * * * *	1500
Pfizer	AATGGCGTGGGCTATCAGCCCTACAGAGTGGTGGTGTGAGCTTCGAACTGCTGCATGCC	1560
Moderna	AACGGCGTGGGCTACCAGCCCTACCGGGTGGTGGTGTGAGCTTCGAGCTGCTGCACGCC	1560
Optimized	AACGGCGTGGGCTATCAGCCCTACCGCGTGGTGGTGTGCTTTTTGAGCTGCTGCACGCA ** * * * * * * * * * * * * * * * *	1560
Pfizer	CCTGCCACAGTGTGCGGCCCTAAGAAAAGCACCAATCTCGTGAAGAACAAGTGCGTGAAC	1620
Moderna	CCAGCCACCGTGTGTGGCCCCAAGAAGAGCACCAACCTGGTGAAGAACAAGTGCGTGAAC	1620
Optimized	CTTGCAACAGTGTGCGGACCAAGAAGAGCACCAATCTGGTGAAGAACAAGTGCGTGAAC ** * * * * * * * * * * * * * * * *	1620

Pfizer	TTCAACTTCAACGGCCTTACCGGCACCGGCGTGCTGACAGAGAGCAACAAGAAGTTCCTG	1680
Moderna	TTCAACTTCAACGGCCTTACCGGCACCGGCGTGCTGACCGAGAGCAACAAGAAATTCCCTG	1680
Optimized	TTCAACTTCAACGGACTGACCGGCACAGGCGTGCTGACCGAGTCCAACAAGAAGTTCCTG ***** ** ***** ***** ** ***** *****	1680
Pfizer	CCATTCCAGCAGTTTGGCCGGGATATCGCCGATACCACAGACGCCGTTAGAGATCCCCAG	1740
Moderna	CCCTTTCAGCAGTTTCGGCCGGGACATCGCCGACACCACGACGCTGTGCGGGATCCCCAG	1740
Optimized	CCTTTTCAGCAGTTTCGGCAGGACATCGCAGATACCACAGACGCCGTGCGGACCCCTCAG ** ** ***** ** * ** * ** *	1740
Pfizer	ACACTGGAATCCTGGACATCACCCCTTGACGCTTCGGCGGAGTGCTGTGATCACCCCT	1800
Moderna	ACCCTGGAGATCCTGGACATCACCCCTTGACGCTTCGGCGGCGTGAGCGTGATCACCCCA	1800
Optimized	ACCCTGGAGATCCTGGATATCACACCATGCTCCTTCGGCGGCGTGCTGTGATCACACCA ** ***** ***** ** * ** ***** ** ***** *	1800
Pfizer	GGCACCAACACCAGCAATCAGGTGGCAGTGCTGTACCAGGACGTGAAGTGTACCGAAGTG	1860
Moderna	GGCACCAACACCAGCAACCAGGTGGCCGTGCTGTACCAGGACGTGAAGTGTACCGAGGTG	1860
Optimized	GGCACCAATACAAGCAACCAGGTGGCCGTGCTGTATCAGGACGTGAATTGTACCGAGGTG ***** ** ***** ***** ***** ***** ** ***** **	1860
Pfizer	CCCGTGGCCATTACGCCGATCAGTGACACCTACATGGCGGGTGACTCCACCGGCAGC	1920
Moderna	CCCGTGGCCATCCACGCCGACAGCTGACACCCACCTGGCGGGTCTACAGCACCGGCAGC	1920
Optimized	CCCGTGGCAATCCACGCAGATCAGTGACCCCTACATGGCGGGTGACTCTACCGGCAGC ***** ** ***** ** * ** ***** ** ***** *****	1920
Pfizer	AATGTGTTTCAGACCAGAGCCGGCTGTCTGATCGGAGCCGAGCACGTGAACAATAGCTAC	1980
Moderna	AACGTGTTTCAGACCCGGGCGGTTGCCTGATCGGCGCCGAGCACGTGAACAACAGCTAC	1980
Optimized	AACGTGTTTCAGACAAGAGCAGGATGCCTGATCGGAGCAGAGCACGTGAACAATAGCTAT ** ***** ** * ** * ** ***** ** ***** ***** *	1980
Pfizer	GAGTGCGACATCCCCATCGGCGCTGGAATCTGCGCCAGCTACCAGACACAGACAAACAGC	2040
Moderna	GAGTGCGACATCCCCATCGGCGCCGGCATCTGTGCCAGCTACCAGACCCAGACCAATTCA	2040
Optimized	GAGTGCGACATCCCTATCGGCGCCGGCATCTGTGCCTCCTACCAGACCCAGACAAACTCC ***** ***** ** ***** ** ***** ***** ***** **	2040
Pfizer	CCTCGGAGAGCCAGAAGCGTGGCCAGCCAGAGCATCATTGCCTACACAATGTCTCTGGGC	2100
Moderna	CCCCGAGGGCAAGGAGCGTGGCCAGCCAGAGCATCATCGCTACACCATGAGCCTGGGC	2100
Optimized	CCAAGGAGAGCACGGTCTGTGGCAAGCCAGTCCATCATCGCCTATACCATGAGCCTGGGC ** *** ** * ***** ***** ***** ***** ** * *****	2100
Pfizer	GCCGAGAACAGCGTGGCCTACTCCAACAACTCTATCGCTATCCCCACCAACTTCACCATC	2160
Moderna	GCCGAGAACAGCGTGGCCTACAGCAACAACAGCATCGCCATCCCCACCAACTTCACCATC	2160
Optimized	GCCGAGAAATCCGTGGCCTACTCCAACAATTCTATCGCCATCCCTACCAACTTCACAATC ***** ***** ***** ***** ***** ***** ***** **	2160
Pfizer	AGCGTGACCACAGAGATCCTGCCTGTGTCCATGACCAAGACCAGCGTGGACTGCACCATG	2220
Moderna	AGCGTGACCACCGAGATTCTGCCGTGAGCATGACCAAGACCAGCGTGGACTGCACCATG	2220
Optimized	TCCGTGACCACAGAGATCCTGCCAGTGAGCATGACCAAGACATCCGTGGACTGCACAATG ***** ***** ***** ** ***** ***** ***** ***** **	2220
Pfizer	TACATCTGCGGCGATTCCACCGAGTGCTCAACCTGCTGCTGCAGTACGGCAGCTTCTGC	2280
Moderna	TACATCTGCGGCGACAGCACCGAGTGACAGCAACCTGCTGCTGCAGTACGGCAGCTTCTGC	2280
Optimized	TATATCTGTGGCGATTCCACCGAGTGCTCAACCTGCTGCTGCAGTACGGCTCTTTTGT ** ***** ***** ***** ***** ***** ***** ** *	2280
Pfizer	ACCCAGCTGAATAGAGCCCTGACAGGGATCGCCGTGGAACAGGACAAGAACACCCAAGAG	2340
Moderna	ACCCAGCTGAACCGGGCCCTGACCGGCATCGCCGTGGAGCAGGACAAGAACACCCAAGAG	2340
Optimized	ACCCAGCTGAATAGAGCCCTGACAGGCATCGCCGTGGAGCAGGACAAGAACACACAGGAG ***** * ***** ** ***** ***** ***** ***** ** *	2340
Pfizer	GTGTTCGCCCCAAGTGAAGCAGATCTACAAGACCCCTCCTATCAAGGACTTCGGCGGCTTC	2400
Moderna	GTGTTCGCCAGTGGAAGCAGATCTACAAGACCCCTCCATCAAGGACTTCGGCGGCTTC	2400
Optimized	GTGTTCGCCAGTGGAAGCAGATCTACAAGACCCACCATCAAGGACTTTGGCGGCTTC ***** ***** ***** ** ***** ***** ***** *****	2400
Pfizer	AATTTAGCCAGATTCTGCCGATCCTAGCAAGCCAGCAAGCGGAGTTCATCGAGGAC	2460
Moderna	AACTTAGCCAGATCCTGCCGACCCAGCAAGCCAGCAAGCGGAGTTCATCGAGGAC	2460
Optimized	AACTTAGCCAGATCCTGCCGATCCTAGCAAGCCATCCAAGCGGTCTTTTATCGAGGAC	2460

** ***** ** ***** ***** ** *****

Pfizer	CTGCTGTTCAACAAAGTGACACTGGCCGACGCCGGCTTCATCAAGCAGTATGGCGATTGT	2520
Moderna	CTGCTGTTCAACAAGGTGACCTAGCCGACGCCGGCTTCATCAAGCAGTACGGCGACTGC	2520
Optimized	CTGCTGTTCAACAAGGTGACCTGGCCGATGCCGGCTTCATCAAGCAGTATGGCGATTGC	2520
	***** ** *****	

Pfizer	CTGGGCGACATTGCCGCCAGGGATCTGATTTGCGCCAGAAGTTTAACGGACTGACAGTG	2580
Moderna	CTCGGCGACATAGCCGCCGGGACCTGATCTGCGCCAGAAGTTCAACGGCCTGACCGTG	2580
Optimized	CTGGGCGACATCGCCGCCAGAGACCTGATCTGTGCCAGAAGTTAATGGCCTGACCGTG	2580
	** ***** * ** ***** ** ***** ** ** ***** **	

Pfizer	CTGCCTCCTCTGCTGACCGATGAGATGATCGCCAGTACACATCTGCCCTGCTGGCCGGC	2640
Moderna	CTGCCTCCCCTGCTGACCGACGAGATGATCGCCAGTACACCAGCGCCCTGTTAGCCGGA	2640
Optimized	CTGCCTCCACTGCTGACAGATGAGATGATCGCCAGTACACATCTGCCCTGCTGGCAGGC	2640
	***** ***** ** ***** ***** * ** *	

Pfizer	ACAATCACAAGCGGCTGGACATTTGAGCAGGCGCCGCTCTGCAGATCCCCTTTGCTATG	2700
Moderna	ACCATCACCAGCGGCTGGACTTTTCGGCGCTGGAGCCGCTCTGCAGATCCCCTTCGCCATG	2700
Optimized	ACCATCACAAGCGGATGGACCTTCGGCGCAGGAGCGCCCTGCAGATCCCCTTTGCCATG	2700
	** ***** ** ** ** ***** ***** ** **	

Pfizer	CAGATGGCCTACCGGTTCAACGGCATCGGAGTGACCCAGAATGTGCTGTACGAGAACCAG	2760
Moderna	CAGATGGCCTACCGGTTCAACGGCATCGGCGTGACCCAGAACGTGCTGTACGAGAACCAG	2760
Optimized	CAGATGGCCTATCGGTTCAACGGCATCGGCGTGACCCAGAATGTGCTGTACGAGAACCAG	2760
	***** ***** ***** ***** *****	

Pfizer	AAGCTGATCGCCAACCAAGTTCAACAGCGCCATCGGCAAGATCCAGGACAGCCTGAGCAGC	2820
Moderna	AAGCTGATCGCCAACCAAGTTCAACAGCGCCATCGGCAAGATCCAGGACAGCCTGAGCAGC	2820
Optimized	AAGCTGATCGCCAATCAGTTAACTCCGCCATCGGCAAGATCCAGGACTCTCTGAGCTCC	2820
	***** ***** ** ***** ***** *	

Pfizer	ACAGCAAGCGCCCTGGGAAAGCTGCAGGACGTGGTCAACCAGAATGCCCAGGCACTGAAC	2880
Moderna	ACCGCTAGCGCCCTGGGCAAGCTGCAGGACGTGGTGAACCAGAAGCCCGAGCCCTGAAC	2880
Optimized	ACAGCAAGCGCCCTGGGCAAGCTGCAGGATGTGGTGAATCAGAACGCCAGGCCCTGAAT	2880
	** ** ***** ***** ** ***** ***** *****	

Pfizer	ACCCTGGTCAAGCAGCTGTCTCCAACCTTCGGCGCCATCAGCTCTGTGCTGAACGATATC	2940
Moderna	ACCTTGGTGAAGCAGCTGAGCAGCAACTTCGGCGCCATCAGCAGCGTGTGAACGACATC	2940
Optimized	ACCCTGGTGAAGCAGCTGTCTAGCAACTTCGGCGCCATCTCTCTGTGCTGAATGATATC	2940
	***** ***** ***** * ***** ** **	

Pfizer	CTGAGCAGACTGGACCTCCTGAGGCCGAGGTGCAGATCGACAGACTGATCACAGGCAGA	3000
Moderna	CTGAGCCGGCTGGACCTCCCGAGGCCGAGGTGCAGATCGACCGGCTGATCACTGGCCGG	3000
Optimized	CTGAGCAGGCTGGACAAGGTGGAGGCAGAGGTGCAGATCGACCGGCTGATCACAGGCAGA	3000
	***** * ***** ***** * ***** ** *	

Pfizer	CTGCAGAGCCTCCAGACATACGTGACCCAGCAGCTGATCAGAGCCGCCGAGATTAGAGCC	3060
Moderna	CTGCAGAGCCTGCAGACCTACGTGACCCAGCAGCTGATCCGGGCCGCCGAGATTCGGGCC	3060
Optimized	CTGCAGTCCCTGCAGACCTACGTGACACAGCAGCTGATCAGGGCAGCAGATCAGGGCA	3060
	***** ** ***** ***** ***** * ** ** ***** **	

Pfizer	TCTGCCAATCTGGCCGCCACCAAGATGTCTGAGTGTGTGCTGGGCCAGAGCAAGAGAGTG	3120
Moderna	AGCGCCAACCTGGCCGCCACCAAGATGAGCGAGTGCGTGCTGGGCCAGAGCAAGCGGGTG	3120
Optimized	TCTGCCAATCTGGCCGCCACCAAGATGAGCGAGTGCGTGCTGGGCCAGTCCAAGAGAGTG	3120
	***** ***** ***** ***** ***** ** * **	

Pfizer	GACTTTTGCGGCAAGGGCTACCACCTGATGAGCTTCCCTCAGTCTGCCCTCACGGCGTG	3180
Moderna	GACTTCTGCGGCAAGGGCTACCACCTGATGAGCTTTCAGAGCGCACCCACGAGTG	3180
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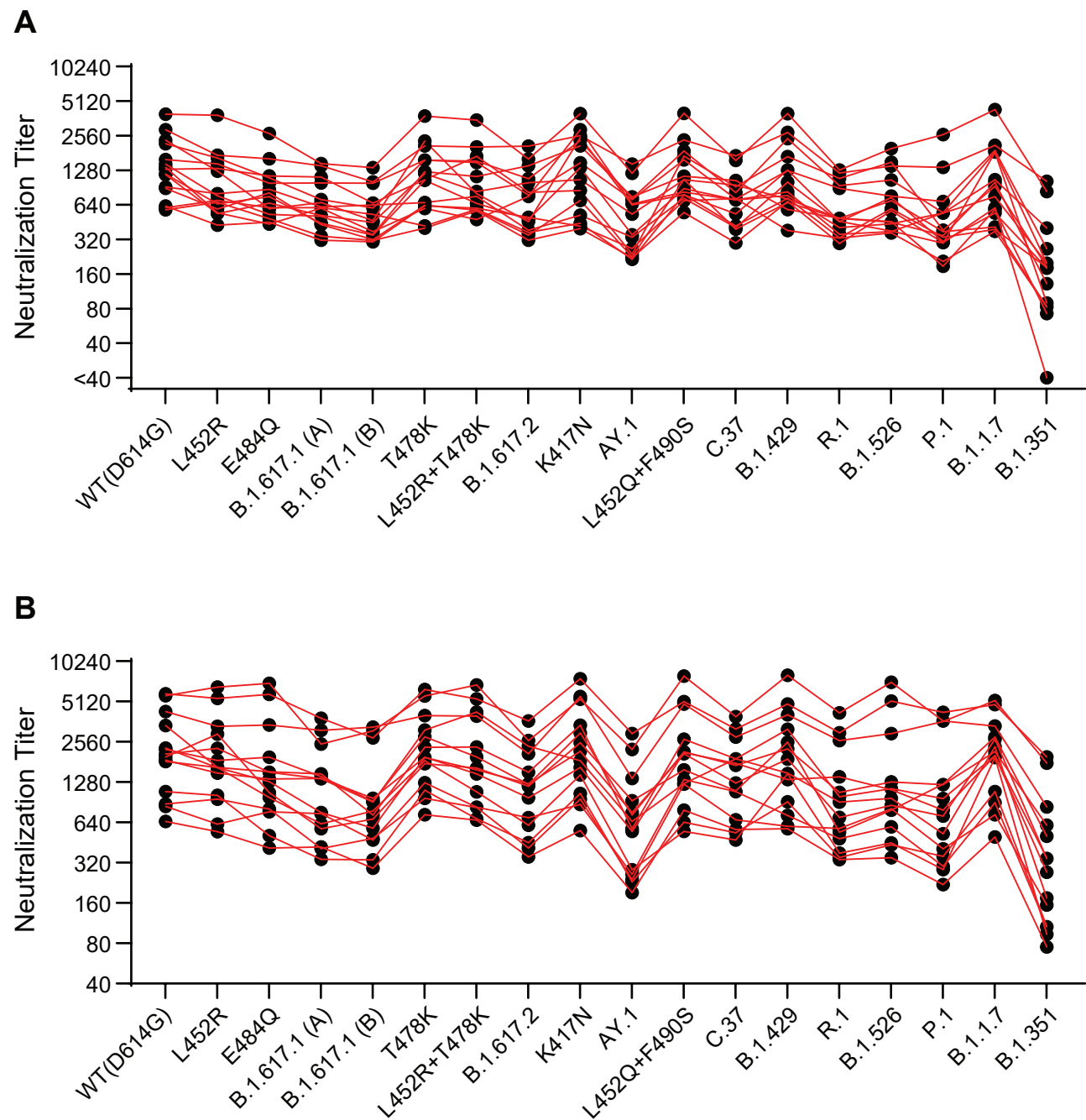
Pfizer	GTGTTTCTGCACGTGACATATGTGCCCGCTCAAGAGAAGAATTCACCACCGCTCCAGCC	3240
Moderna	GTGTTCTCTGCACGTGACCTACGTGCCCGCCAGGAGAAGAATTCACCACCGCCAGCC	3240
Optimized	GTGTTTCTGCACGTGACCTACGTGCCAGCCAGGAGAAGAATTCACCACAGCACCAGCA	3240
	***** ***** ** ***** ** ***** ***** ** *****	

Pfizer	ATCTGCCACGACGGCAAAGCCCACTTTCTAGAGAAGGCGTGTTCGTGTCCAACGGCACC	3300
Moderna	ATCTGCCACGACGGCAAAGGCCCACTTTCCCGGAGGGCGTGTTCGTGAGCAACGGCACC	3300

Optimized	ATCTGCCACGATGGCAAGGCACACTTTCCTAGGGAGGGCGTGTTCGTGAGCAACGGCACC ***** ** ***** * ** ***** *****	3300
Pfizer	CATTGGTTCGTGACACAGCGGAACCTTCTACGAGCCCCAGATCATCACCACCGACAACACC	3360
Moderna	CACTGGTTCGTGACCCAGCGGAACCTTCTACGAGCCCCAGATCATCACCACCGACAACACC	3360
Optimized	CACTGGTTTGTGACACAGCGCAATTTCTACGAGCCACAGATCATCACCACAGACAATACA ** ***** ** ***** ***** ***** ***** ***** **	3360
Pfizer	TTCGTGTCTGGCAACTGCGACGTCGTGATCGGCATTGTGAACAATACCGGTGTACGACCCT	3420
Moderna	TTCGTGAGCGGCAACTGCGACGTCGTGATCGGCATCGTGAACAACACCGGTGTACGATCCC	3420
Optimized	TTCGTGTCCGGCAACTGTGACGTGGTCATCGGCATCGTGAACAATACCGTGTATGATCCT ***** ***** ** ***** ***** ***** ***** **	3420
Pfizer	CTGCAGCCCGAGCTGGACAGCTTCAAAGAGGAACTGGACAAGTACTTTAAGAACCACACA	3480
Moderna	CTGCAGCCCGAGCTGGACAGCTTCAAAGAGGAGCTGGACAAGTACTTCAAGAATCACACC	3480
Optimized	CTGCAGCCAGAGCTGGACTCTTTAAGGAGGAGCTGGATAAGTACTTCAAGAATCACACC ***** ***** ** ***** ***** ***** ***** *****	3480
Pfizer	AGCCCCGACGTGGACCTGGGCGATATCAGCGGAATCAATGCCAGCGTCGTGAACATCCAG	3540
Moderna	AGCCCCGACGTGGACCTGGGCGACATCAGCGGCATCAACGCCAGCGTGGTGAACATCCAG	3540
Optimized	AGCCCCGACGTGGATCTGGGCGACATCTCTGGCATCAATGCCAGCGTGGTGAACATCCAG ***** ***** ** ***** ***** ***** ***** *****	3540
Pfizer	AAAGAGATCGACCGGCTGAACGAGGTGGCCAAGAATCTGAACGAGAGCCTGATCGACCTG	3600
Moderna	AAGGAGATCGATCGGCTGAACGAGGTGGCCAAGAACCTGAACGAGAGCCTGATCGACCTG	3600
Optimized	AAGGAGATCGACAGGCTGAACGAGGTGGCCAAGAATCTGAACGAGTCCCTGATCGATCTG ** ***** ***** ***** ***** ***** ***** *****	3600
Pfizer	CAAGAAGTGGGAAGTACGAGCAGTACATCAAGTGGCCCTGGTACATCTGGCTGGGCTTT	3660
Moderna	CAGGAGCTGGGCAAGTACGAGCAGTACATCAAGTGGCCCTGGTACATCTGGCTGGGCTTC	3660
Optimized	CAGGAGCTGGGCAAGTATGAGCAGTACATCAAGTGGCCCTGGTATATCTGGCTGGGCTTC ** ** ***** ***** ***** ***** ***** ***** *****	3660
Pfizer	ATCGCCGGACTGATTGCCATCGTGATGGTCACAATCATGCTGTGTGTCATGACCAGCTGC	3720
Moderna	ATCGCCGGCCTGATCGCCATCGTGATGGTGACCATCATGCTGTGCTGATGACCAGCTGC	3720
Optimized	ATCGCCGGCCTGATCGCCATCGTGATGGTGACCATCATGCTGTGCTGTATGACAAGCTGC ***** ***** ***** ***** ***** ***** ***** *****	3720
Pfizer	TGTAGTGCCTGAAGGGCTGTTGTAGCTGTGGCAGCTGCTGCAAGTTCGACGAGGACGAT	3780
Moderna	TGCAGTGCCTGAAGGGCTGTTGTCAGCTGCGGCAGCTGCTGCAAGTTCGACGAGGACGAC	3780
Optimized	TGTTCTGCTGCTGAAGGGCTGCTGTTCTGTGGCAGCTGCTGTAAGTTTGATGAGGACGAT ** ***** ** ***** ***** ***** ***** *****	3780
Pfizer	TCTGAGCCCGTGTGAAGGGCGTGAACTGCACTACACATGA	3822
Moderna	AGCGAGCCCGTGTGAAGGGCGTGAACTGCACTACACCTGA	3822
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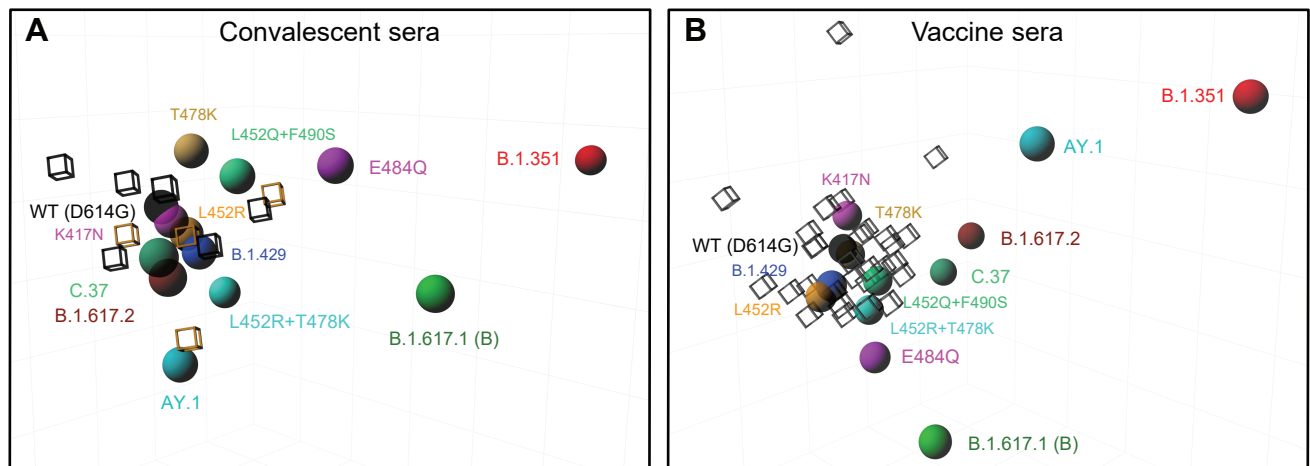
Supplementary Figure S1. SARS-CoV-2 Wuhan-Hu-1 spike gene open reading frame comparison. **A.** Nucleotide identity between original isolate SARS-CoV-2 Wuhan-Hu-1 spike gene sequence (Original) and codon optimized spike gene sequence of SARS-CoV-2 Wuhan-Hu-1 used in this study (Optimized). **B.** Nucleotide identity between spike gene sequence used in Pfizer/BioNtech BNT162b2 (Pfizer) [1], Moderna mRNA-1273 (Moderna) [2] and codon optimized spike gene sequence of SARS-CoV-2 Wuhan-Hu-1 used in this study (Optimized). There is 90.5% nucleotide identity between Pfizer and Moderna sequences, 86.7% identity between Pfizer sequence and optimized sequence used in this study, 87.6% identity between Moderna sequence and optimized sequence used in this study.

Supplementary Figure S2



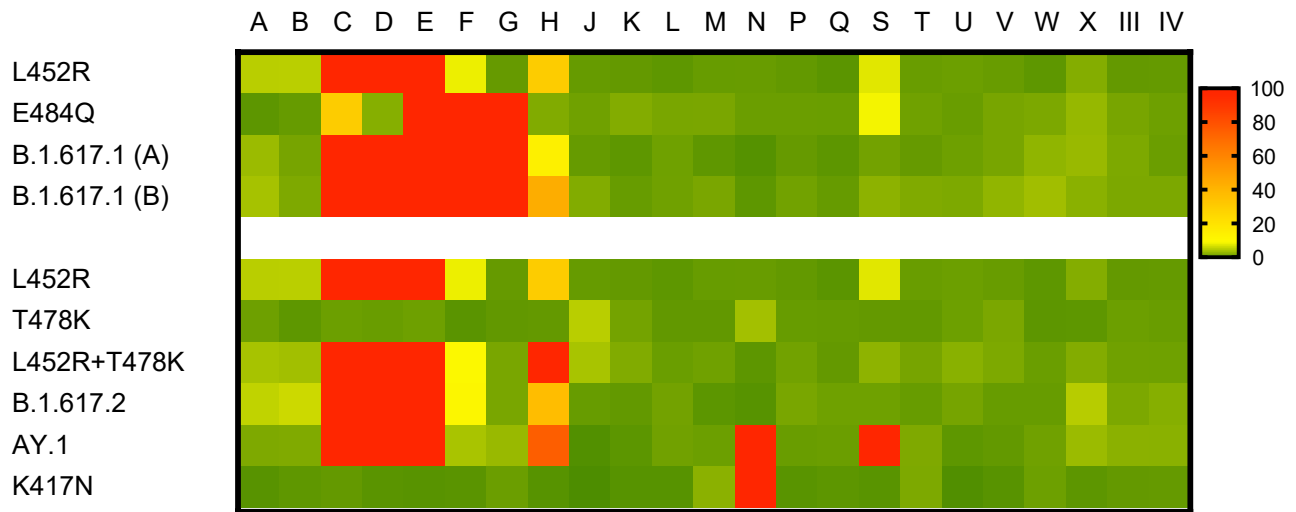
Supplementary Figure S2. Neutralization of variant SARS-CoV-2 pseudoviruses by vaccination sera. (A) Individual neutralization titers of Pfizer/BioNtech BNT162b2 vaccination sera are presented. (B) Individual neutralization titers of Moderna mRNA-1273 vaccination sera are presented. Lines connect responses from a given subject against the indicated variants.

Supplementary Figure S3



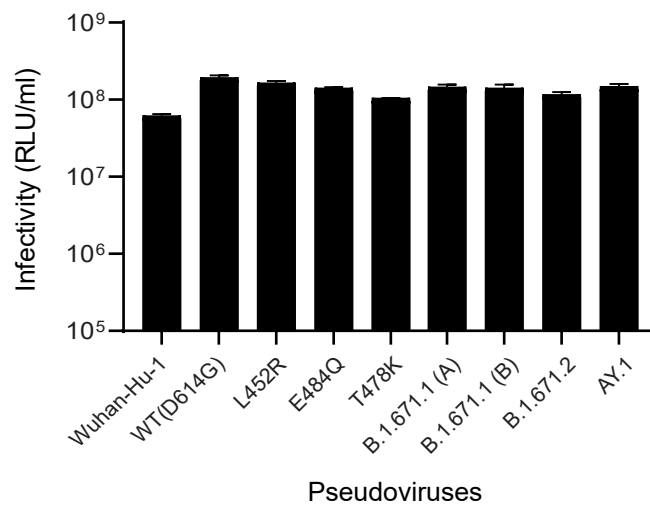
Supplementary Figure S3. 3D antigenic maps of SARS-CoV-2 variants made using antigenic cartography. Antigenic maps were made using neutralizing antibody titers from convalescent sera (A) and vaccine sera (B). Convalescent sera map (A) includes sera from the group of WT(D614G)-infected individuals and the group of individuals infected with strains containing L452R mutation. Vaccine sera map (B) includes sera from individuals vaccinated with Pfizer/BioNtech BNT162b2 and individuals vaccinated with Moderna mRNA-1273 vaccine. Sera are shown as open squares, pseudoviruses are shown as colored circles, labeled by strain name. Each grid-square corresponds to a two-fold dilution in the pseudovirus neutralization assay. Antigenic distance is interpretable in any direction.

Supplementary Figure S4



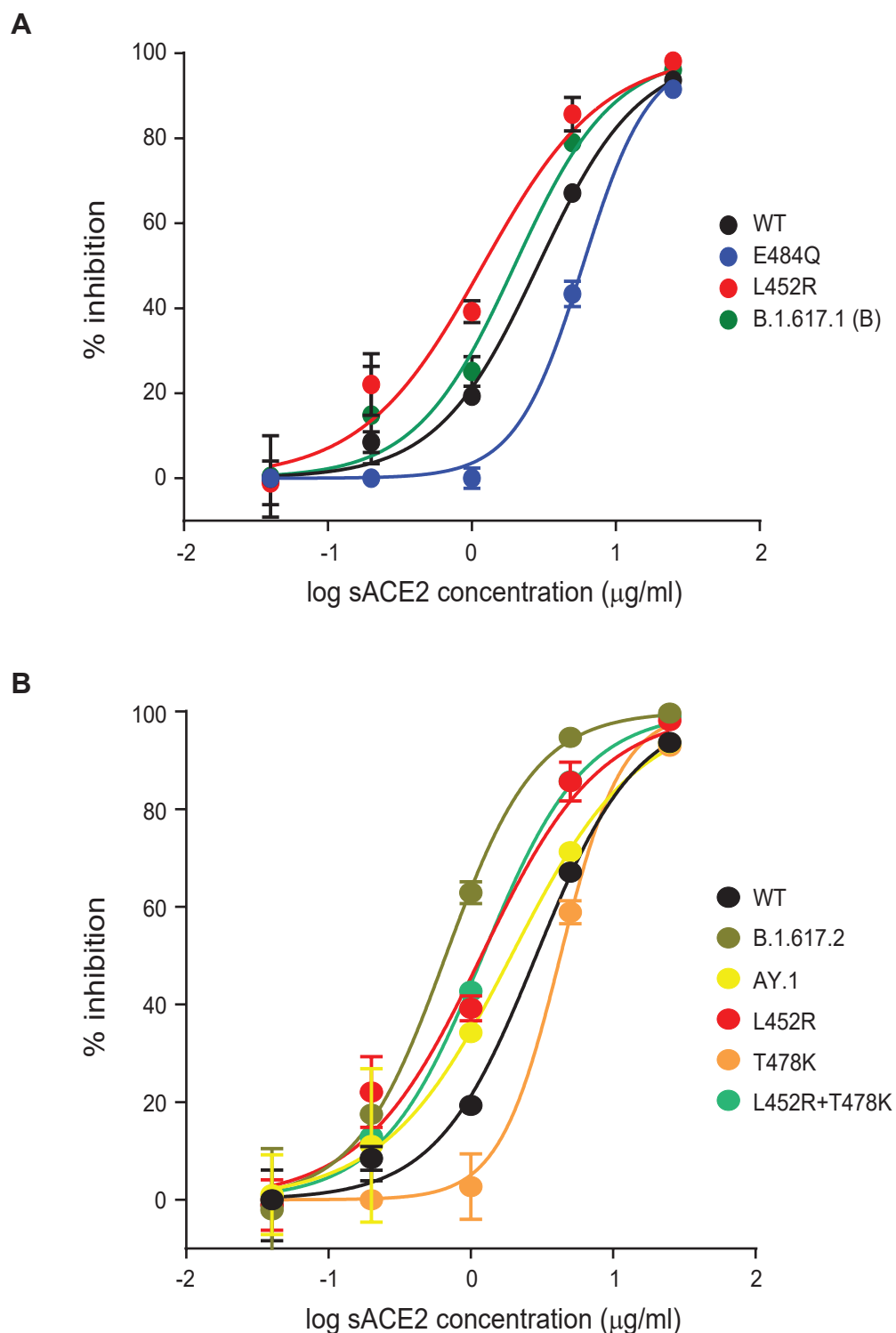
Supplementary Figure S4. Neutralization of variant SARS-CoV-2 pseudoviruses by therapeutic antibodies. The antibody panel, consisting of 15 single nAbs, 6 cnAbs, and 2 pAbs were tested against pseudoviruses bearing variant spikes and spikes with indicated RBD substitutions in the D614G background. Antibodies are blinded-coded according to an agreement with the manufacturers. Heat map representing the ratio of IC₅₀ values of the variant or RBD mutant spike relative to WT(D614G). Red indicates loss of potency (IC₅₀ ratios > 50). Yellow indicates moderate loss of potency (IC₅₀ ratios between 10-50), and green indicates retention of potency (IC₅₀ ratios <10).

Supplementary Figure S5



Supplementary Figure S5. Infectivity of pseudoviruses with variants spikes. Spike-bearing pseudoviruses infectivity in 293T-ACE2.TMPRSS2 cells. Cells were infected with pseudoviruses bearing spikes from SARS-CoV-2 variants. Bars: Mean \pm SD.

Supplementary Figure S6



Supplementary Figure S6. Neutralization of B.1.617 variant pseudoviruses by soluble ACE2. Pseudoviruses bearing B.1.617.1 (A) and B.1.617.2 (B) variant spike proteins were incubated with a serially diluted soluble ACE2 (sACE2) and then applied to 293T-ACE2.TMPRSS2 cells for infection. Each curve indicates percent inhibition of pseudoviruses by sACE2. The image represents results of one of three independent experiments.

Supplementary Table S1. Dimensionality testing of Antigenic Cartography maps

Dimension	Convalescent sera map				Vaccine sera map			
	Measured titers		Thresholded titers		Measured titers		Thresholded titers	
	Mean RMSE	variance RMSE	Mean RMSE	variance RMSE	Mean RMSE	variance RMSE	Mean RMSE	variance RMSE
1D	0.94	0.02	1.26	0.37	0.54	0.003	2.38	0.06
2D	0.95	0.15	1.41	1.18	0.51	0.003	2.18	0.07
3D	0.89	0.12	1.36	1.11	0.49	0.003	2.26	0.03
4D	0.88	0.14	1.34	1.14	0.49	0.002	2.23	0.02
5D	0.91	0.24	1.41	1.73	0.49	0.002	2.23	0.02

Dimensionality testing to identify best number of dimensions for fitting the antigenic maps. Each dataset was tested with cross-validation in 1-5 dimensions (100 maps, each made with 75% of the data to predict the exclude 25%), with low mean and variance in root-mean squared error (RMSE) for measured titers (within limit of detection) and thresholded titers (below the limit of detection) indicating the optimal number of dimensions. Convalescent sera from individuals infected either WT(D614G) or strains with L452R mutation. Vaccine sera from individuals vaccinated with either Pfizer/BioNtech BNT162b2 or Moderna mRNA-1273 vaccine.

References:

1. World Health Organization. Messenger RNA Encoding the Full-Length SARS-CoV-2 Spike Glycoprotein. 2020. Available online: <https://web.archive.org/web/20210105162941/https://mednet-communities.net/inn/db/media/docs/11889.doc> (accessed on 30 November 2021).
2. Jeong, D. E.; McCoy, M.; Artiles, K.; Ilbay, O.; Fire, A.; Nadeau, K.; Park, H.; Betts, B.; Boyd, S.; Hoh, R.; et al. Assemblies-of-Putative-SARS-CoV2-Spike-Encoding-mRNA-Sequences-for-Vaccines-BNT-162b2-and-mRNA-1273. Available online: <https://virological.org/t/assemblies-of-putative-sars-cov2-spike-encoding-mrna-sequences-for-vaccines-bnt-162b2-and-mrna-1273/663> (accessed on 30 November 2021).