

-continued

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 Ser Tyr Ile Asp Leu Lys Glu Leu Gly Asn Tyr Thr Tyr Tyr Asn
 1280 1285 1290
 Lys Trp Pro Trp Tyr Ile Trp Leu Gly Phe Ile Ala Gly Leu Val
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 Ala Leu Ala Leu Cys Val Phe Phe Ile Leu Cys Cys Thr Gly Cys
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 <220> FEATURE:
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 Asn Thr Trp Pro Met Pro Ile Asp Thr Ser Lys Ala Glu Gly Val Ile
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 Tyr Pro Asn Gly Lys Ser Tyr Ser Asn Ile Ser Leu Thr Tyr Thr Gly
 65 70 75 80
 Leu Tyr Pro Lys Ala Lys Asp Leu Gly Lys Gln Tyr Leu Phe Ser Asp
 85 90 95
 Gly His Ser Ala Pro Asn Gln Leu Asn Asp Leu Phe Val Ser Asn Tyr
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 Ser Ala Gln Val Glu Ser Phe Asp Asp Gly Phe Val Val Arg Ile Gly
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 Ala Ala Ser Asn Lys Thr Gly Thr Thr Val Ile Ser Gln Thr Thr Phe
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 Gly Asn Tyr Thr Pro Thr Asn Ile Thr Gly Arg Tyr Leu Asn His Thr
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 Leu Val Ile Leu Pro Asp Gly Cys Gly Thr Leu Val His Ala Phe Tyr
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Phe Asp Leu Ile Asn Cys Thr Phe Arg Tyr Asn Tyr Thr Ile Thr Glu
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 Asp Glu Asn Ala Glu Trp Phe Gly Ile Thr Gln Asp Thr Gln Gly Val
 260 265 270
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 His Phe Ala Thr Leu Pro Val Tyr Gln Lys Ile Leu Tyr Tyr Thr Val
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 Ile Pro Arg Ser Ile Arg Ser Pro Phe Asn Asp Arg Lys Ala Trp Ala
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 Ala Phe Tyr Ile Tyr Lys Leu His Pro Leu Thr Tyr Leu Leu Asn Phe
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 Phe Ala Gln Leu Gln Cys Ser Tyr Glu Asn Phe Asp Val Glu Thr Gly
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 Thr Pro Pro Pro Ile Tyr Asp Phe Lys Arg Leu Val Phe Thr Asn Cys
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Leu	Thr	Leu	Ala	Pro	Ile	Asn	Ser	Thr	Gly	Phe	Val	Val	Ala	Val	Pro
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	785				790					795					800
Gln	Lys	Ile	Thr	Val	Asp	Cys	Lys	Gln	Tyr	Val	Cys	Asn	Gly	Phe	Lys
				805					810					815	
Lys	Cys	Glu	Asp	Leu	Leu	Lys	Glu	Tyr	Gly	Gln	Phe	Cys	Ser	Lys	Ile
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Thr	Thr	Gly	Glu	Arg	Lys	Tyr	Arg	Ser	Thr	Ile	Glu	Asp	Leu	Leu	Phe
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	930				935						940				
Glu	Ala	Ala	Tyr	Thr	Ser	Ser	Leu	Leu	Gly	Ser	Ile	Ala	Gly	Ala	Ser
	945				950					955					960
Trp	Thr	Ala	Gly	Leu	Ser	Ser	Phe	Ala	Ala	Ile	Pro	Phe	Ala	Gln	Ser
				965					970					975	
Ile	Phe	Tyr	Arg	Leu	Asn	Gly	Val	Gly	Ile	Thr	Gln	Gln	Val	Leu	Ser
		980					985					990			
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Asp	Ile	Leu	Ala	Arg	Leu	Asp	Thr	Val	Glu	Gln	Glu	Ala	Gln	Ile	
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Arg	Asn	Gly	Phe	Cys	Gly	Thr	Gly	Thr	His	Ile	Val	Ser	Phe	Ala
1115						1120					1125			
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1130						1135					1140			
Pro	Thr	Ser	His	Val	Asn	Ala	Thr	Ala	Ala	Tyr	Gly	Leu	Cys	Asn
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Thr	Glu	Asn	Pro	Pro	Lys	Cys	Ile	Ala	Pro	Ile	Asp	Gly	Tyr	Phe
1160						1165					1170			
Val	Leu	Asn	Gln	Thr	Thr	Ser	Thr	Ala	Arg	Ser	Ser	Gly	Asp	Gln
1175						1180					1185			
His	Trp	Tyr	Tyr	Thr	Gly	Ser	Ser	Phe	Phe	His	Pro	Glu	Pro	Ile
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Thr	Leu	Leu	Asn	Leu	Asn	Thr	Glu	Leu	Met	Val	Leu	Ser	Glu	Val
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Val	Lys	Gln	Leu	Asn	Glu	Ser	Tyr	Ile	Asp	Leu	Lys	Glu	Leu	Gly
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Phe	Ile	Ala	Gly	Leu	Val	Ala	Leu	Ala	Leu	Cys	Val	Phe	Phe	Ile
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Leu	Cys	Cys	Thr	Gly	Cys	Gly	Thr	Ser	Cys	Leu	Gly	Lys	Leu	Lys
1325						1330					1335			
Cys	Asn	Arg	Cys	Cys	Asp	Ser	Tyr	Asp	Glu	Tyr	Glu	Val	Glu	Lys
1340						1345					1350			
Ile	His	Val	His											
1355														

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What is claimed is:

1. A chimeric coronavirus spike protein comprising, in orientation from amino to carboxy terminus:

- a) a first region comprising a portion of a coronavirus spike protein ectodomain that precedes a coronavirus spike protein receptor binding domain (RBD) as located in a nonchimeric coronavirus spike protein, of a first coronavirus;
- b) a second region comprising a coronavirus spike protein receptor binding domain (RBD) of a second coronavirus that is different from said first coronavirus;
- c) a third region comprising a portion of a coronavirus spike protein S1 domain as located in a nonchimeric coronavirus spike protein immediately downstream of the RBD, contiguous with a portion of a coronavirus spike protein S2 domain as located immediately upstream of a fusion protein domain in a nonchimeric

coronavirus spike protein, wherein said third region is of said first coronavirus; and

- d) a fourth region comprising a portion of a coronavirus spike protein from the start of the fusion protein domain through the carboxy terminal end as located in a nonchimeric coronavirus spike protein of a third coronavirus that is different from said first coronavirus and said second coronavirus.

2. The chimeric coronavirus spike protein of claim 1, wherein the chimeric coronavirus spike protein is derived from subgroup 1a coronaviruses, subgroup 1b coronaviruses, subgroup 2a coronaviruses, subgroup 2b coronaviruses, subgroup 2c coronaviruses, subgroup 2d coronaviruses or subgroup 3 coronaviruses.

3. The chimeric coronavirus of claim 2, derived from subgroup 2b coronaviruses wherein said first, second and third subgroup 2b coronaviruses are different from one

another and wherein the subgroup 2b coronaviruses are selected from the group consisting of Bat SARS CoV (GenBank Accession No. FJ211859), SARS CoV (GenBank Accession No. FJ211860), BtSARS.HKU3.1 (GenBank Accession No. DQ022305), BtSARS.HKU3.2 (GenBank Accession No. DQ084199), BtSARS.HKU3.3 (GenBank Accession No. DQ084200), BtSARS.Rm1 (GenBank Accession No. DQ412043), BtCoV.279.2005 (GenBank Accession No. DQ648857), BtSARS.Rf1 (GenBank Accession No. DQ412042), BtCoV.273.2005 (GenBank Accession No. DQ648856), BtSARS.Rp3 (GenBank Accession No. DQ071615), SARS CoV.A022 (GenBank Accession No. AY686863), SARSCoV.CUHK-W1 (GenBank Accession No. AY278554), SARSCoV.GD01 (GenBank Accession No. AY278489), SARSCoV.HC.SZ.61.03 (GenBank Accession No. AY515512), SARSCoV.SZ16 (GenBank Accession No. AY304488), SARSCoV.Urbani (GenBank Accession No. AY278741), SARSCoV.civet010 (GenBank Accession No. AY572035), and SARSCoV.MA.15 (GenBank Accession No. DQ497008).

4. The chimeric subgroup 2b coronavirus spike protein of claim 3, wherein said first subgroup 2b coronavirus is Bat SARS CoV-HKU3 (GenBank Accession No. FJ211859), said second subgroup 2b coronavirus is SARSCoV.Urbani (GenBank Accession No. AY278741.1), and said third subgroup 2b coronavirus is BtCoV 279.2005 (DQ648857).

5. The chimeric coronavirus spike protein of claim 1, comprising the amino acid sequence:

third subgroup 2c coronaviruses are different from one another and wherein the subgroup 2c coronaviruses are selected from the group consisting of Middle East respiratory syndrome coronavirus isolate Riyadh_2_2012 (GenBank Accession No. KF600652.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_18_2013 (GenBank Accession No. KF600651.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_17_2013 (GenBank Accession No. KF600647.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_15_2013 (GenBank Accession No. KF600645.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_16_2013 (GenBank Accession No. KF600644.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_21_2013 (GenBank Accession No. KF600634), Middle East respiratory syndrome coronavirus isolate Al-Hasa_19_2013 (GenBank Accession No. KF600632), Middle East respiratory syndrome coronavirus isolate Buraidah_1_2013 (GenBank Accession No. KF600630.1), Middle East respiratory syndrome coronavirus isolate Hafr-Al-Batin_1_2013 (GenBank Accession No. KF600628.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_12_2013 (GenBank Accession No. KF600627.1), Middle East respiratory syndrome coronavirus isolate Bisha_1_2012 (GenBank Accession No. KF600620.1), Middle East respiratory syndrome coronavirus isolate Riyadh_3_2013 (GenBank Accession No. KF600613.1), Middle East respiratory syndrome coronavirus isolate Riyadh_1_2012 (GenBank Accession No.

(SEQ ID NO: 1)

1 MKILIFAPLA NLAKAQEGCG IISRKPQPKM AQVSSRRGV YNDDIFRSD VLHLTQDYFL
 61 PFDSNLTQYF SLNVDSDRYT YFDNPILDFG DGVYFAATEK SNVIRGWIFG SFDNTTQSA
 121 VIVNNSHII IRVCNFNLCK EPMYTVSRGT QQNAWVYQSA FNCTYDRVEK SFQLDTPKT
 181 GNPKDLREYV FKNRDGLFSV YQTYTAVNLP RGLPTGFSVL KPILKLPFGI NITSYRVVMA
 241 MFSQTTSNFL PESAAIYVGN LKYSTFMLRF NENGTITDAV DCSQNPLAEL KCTIKNFNVD
 301 KGIYQTSNFR VSPQTQEVIRF PNITNLCPPG EVFNATKPPS VYAWERKKIS NCVADYSVLY
 361 NSTFFSTFKC YGVSATKLNLD LCFSNVYADS FVVKGDDVRQ IAPGQTGVIA DYNKLPDDE
 421 MGCVLAWNTR NIDATSTGNY NYKYRYLRHG KLRPFERDIS NVPFSPDGKP CTPPALNCYW
 481 PLNDYGFYTT TGIGYQPYRV VVLSFELLNA PATVCGPKLS TDLVKNQCVN FNFNGLRGTG
 541 VLTSSSKRFQ SFQQFGRDTS DFTDSVRDPQ TLEILDISPC SFGGVSVITP GTNASSEVAV
 601 LYQDVNCTDV PTAIRADQLT PAWRVYSTGV NVFQTQAGCL IGAEHVNASY ECDIPIGAGI
 661 CASYHTASVL RSTGQKSIVA YTMSLGAENS IAYANNSIAI PTNFSISVTT EVMFVMAKT
 721 AVDCTMYICG DSLECSNLLL QYGSECTQLN RALTGIAIEQ DKNTQEVFAQ VKQMYKTPAI
 781 KDFGGFNFSQ ILPDPSPKPK RSPFIEDLLFN KVTLADAGFM KQYGDCLGDV SARDLICAQK
 841 FNGLTVLPLP LTDEMVAAYT AALVSGTATA GWTFGAGSAL QIPFAMQMay RFNGIGVTQN
 901 VLYENQKQIA NQFNKAISQI QESLTTTSTA LGKLDVVND NAQALNTLVK QLSSNFGAIS
 961 SVLNDILSRL DKVEAEVQID RLITGRLQSL QTYVTQQLIR AAEIRASANL AATKMSECVL
 1021 GQSKRVDFCG KGYHLMSPFQ AAPHGVVFLH VTYVPSQERN FTTAPAICHE GKAYFPREGV
 1081 FVSNGTSWPI TQRNFYSPQI ITTDNTFVAG NCDVVIGIIN NTVYDPLQPE LDSPKKELDK
 1141 YPKNHTSPDV DLGDISGINA SVVNIQREID RLNEVAKNLN ESLIDLQELG KYEQYIKWPW
 1201 YVWLGFIAGL IAIVMVTILL CCMTSCCCL KGACSCGCC KFDDEDSEPV LKGVKLHYT.

65

6. The chimeric coronavirus of claim 2, derived from subgroup 2c coronaviruses wherein said first, second and

KF600612.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_3_2013 (GenBank Accession No.

KF186565.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_1_2013 (GenBank Accession No. KF186567.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_2_2013 (GenBank Accession No. KF186566.1), Middle East respiratory syndrome coronavirus isolate Al-Hasa_4_2013 (GenBank Accession No. KF186564.1), Middle East respiratory syndrome coronavirus (GenBank Accession No. KF192507.1), Betacoronavirus England I-N1 (GenBank Accession No. NC_019843), MERS-CoV_SA-N1 (GenBank Accession No. KC667074), an isolate of Middle East Respiratory Syndrome Coronavirus having GenBank Accession No: KF600656.1, GenBank Accession No: KF600655.1, GenBank Accession No: KF600654.1, GenBank Accession No: KF600649.1, GenBank Accession No: KF600648.1, GenBank Accession No: KF600646.1, GenBank Accession No: KF600643.1, GenBank Accession No: KF600642.1, GenBank Accession No: KF600640.1, GenBank Accession No: KF600639.1, GenBank Accession No: KF600638.1, GenBank Accession No: KF600637.1, GenBank Accession No: KF600636.1, GenBank Accession No: KF600635.1, GenBank Accession No: KF600631.1, GenBank Accession No: KF600626.1, GenBank Accession No: KF600625.1, GenBank Accession No: KF600624.1, GenBank Accession No: KF600623.1, GenBank Accession No: KF600622.1, GenBank Accession No: KF600621.1, GenBank Accession No: KF600619.1, GenBank Accession No: KF600618.1, GenBank Accession No: KF600616.1, GenBank Accession No: KF600615.1, GenBank Accession No: KF600614.1, GenBank Accession No: KF600641.1, GenBank Accession No: KF600633.1, GenBank Accession No: KF600629.1, or GenBank Accession No: KF600617.1, Coronavirus Neoromicia/PML-PHE1/RSA/2011 GenBank Accession: KC869678.2, Bat Coronavirus Taper/CILKSA_287/Bisha/Saudi Arabia/GenBank Accession No: KF493885.1, Bat coronavirus Rhhar/CII_KSA_003/Bisha/Saudi Arabia/2013 GenBank Accession No: KF493888.1, Bat coronavirus Pikuih/CII_KSA_001/Riyadh/Saudi Arabia/2013 GenBank Accession No: KF493887.1, Bat coronavirus Rhhar/CII_KSA_002/Bisha/Saudi Arabia/2013 GenBank Accession No: KF493886.1, Bat Coronavirus Rhhar/CII_KSA_004/Bisha/Saudi Arabia/2013 GenBank Accession No: KF493884.1, BtCoV.HKU4.2 (GenBank Accession No. EF065506), BtCoV.HKU4.1 (GenBank Accession No. NC_009019), BtCoV.HKU4.3 (GenBank Accession No. EF065507), BtCoV.HKU4.4 (GenBank Accession No. EF065508), BtCoV133.2005 (GenBank Accession No. NC_008315), BtCoV.HKU5.5 (GenBank Accession No. EF065512); BtCoV.HKU5.1 (GenBank Accession No. NC_009020), BtCoV.HKU5.2 (GenBank Accession No. EF065510), BtCoV.HKU5.3 (GenBank Accession No. EF065511), human betacoronavirus 2c Jordan-N3/2012 (GenBank Accession No. KC776174.1); human betacoronavirus 2c EMC/2012 (GenBank Accession No. JX869059.2), and a Pipistrellus bat coronavirus HKU5 isolate having GenBank Accession No:KC522089.1, GenBank Accession No:KC522088.1, GenBank Accession No:KC522087.1, GenBank Accession No:KC522086.1, GenBank Accession No: KC522085.1, GenBank Accession No:KC522084.1, GenBank Accession No:KC522083.1, GenBank Accession No:KC522082.1, GenBank Accession No:KC522081.1, GenBank Accession No:KC522080.1, GenBank Accession No:KC522079.1, GenBank Accession No: KC522078.1, GenBank Accession No:KC522077.1, GenBank Accession No:KC522076.1, GenBank Accession No:KC522075.1, GenBank Accession No:KC522104.1, GenBank Accession No:KC522104.1, GenBank Accession

No:KC522103.1, GenBank Accession No: KC522102.1, GenBank Accession No:KC522101.1, GenBank Accession No:KC522100.1, GenBank Accession No:KC522099.1, GenBank Accession No:KC522098.1, GenBank Accession No:KC522097.1, GenBank Accession No:KC522096.1, GenBank Accession No: KC522095.1, GenBank Accession No:KC522094.1, GenBank Accession No:KC522093.1, GenBank Accession No:KC522092.1, GenBank Accession No:KC522091.1, GenBank Accession No:KC522090.1, GenBank Accession No:KC522119.1 GenBank Accession No: KC522118.1 GenBank Accession No:KC522117.1 GenBank Accession No:KC522116.1 GenBank Accession No:KC522115.1 GenBank Accession No:KC522114.1 GenBank Accession No:KC522113.1 GenBank Accession No:KC522112.1 GenBank Accession No: KC522111.1 GenBank Accession No:KC522110.1 GenBank Accession No:KC522109.1 GenBank Accession No:KC522108.1, GenBank Accession No:KC522107.1, GenBank Accession No:KC522106.1, GenBank Accession No:KC522105.1) Pipistrellus bat coronavirus HKU4 isolates (GenBank Accession No:KC522048.1, GenBank Accession No:KC522047.1, GenBank Accession No:KC522046.1, GenBank Accession No:KC522045.1, GenBank Accession No:KC522044.1, GenBank Accession No:KC522043.1, GenBank Accession No: KC522042.1, GenBank Accession No:KC522041.1, GenBank Accession No:KC522040.1 GenBank Accession No:KC522039.1, GenBank Accession No:KC522038.1, GenBank Accession No:KC522037.1, GenBank Accession No:KC522036.1, GenBank Accession No:KC522048.1 GenBank Accession No:KC522047.1, GenBank Accession No:KC522046.1 GenBank Accession No:KC522045.1 GenBank Accession No:KC522044.1 GenBank Accession No:KC522043.1 GenBank Accession No:KC522042.1 GenBank Accession No:KC522041.1 GenBank Accession No:KC522040.1, GenBank Accession No:KC522039.1 GenBank Accession No:KC522038.1 GenBank Accession No:KC522037.1 GenBank Accession No:KC522036.1, GenBank Accession No:KC522061.1 GenBank Accession No:KC522060.1 GenBank Accession No:KC522059.1 GenBank Accession No:KC522058.1 GenBank Accession No:KC522057.1 GenBank Accession No:KC522056.1 GenBank Accession No:KC522055.1 GenBank Accession No:KC522054.1 GenBank Accession No:KC522053.1 GenBank Accession No:KC522052.1 GenBank Accession No:KC522051.1 GenBank Accession No:KC522050.1 GenBank Accession No:KC522049.1 GenBank Accession No:KC522074.1, GenBank Accession No:KC522073.1 GenBank Accession No:KC522072.1 GenBank Accession No:KC522071.1 GenBank Accession No:KC522070.1 GenBank Accession No:KC522069.1 GenBank Accession No:KC522068.1 GenBank Accession No:KC522067.1, GenBank Accession No:KC522066.1 GenBank Accession No:KC522065.1 GenBank Accession No:KC522064.1, GenBank Accession No:KC522063.1, or GenBank Accession No:KC522062.1.

7. The chimeric subgroup 2c coronavirus spike protein of claim 6, wherein said first subgroup 2c coronavirus is BtCoV HKU4.2 (GenBank Accession No. EF065506.1); said second subgroup 2c coronavirus is MERS-CoV (GenBank Accession No. JX869059.2), and said third subgroup 2c coronavirus is BtCoV HKU5.5 (EF065512.1).

8. The chimeric coronavirus spike protein of claim 1, comprising the amino acid sequence:

(SEQ ID NO: 5)

1 MTLMLCLLMS LLIFVRGCD S QFVDMSPASN TSECLESQVD AAFAFKLMWP YPIDPSKVDG
61 IYYPLGRITYS NITLAYTGLF PLQGDLSQY LYSVSHAVGH DGDPTKAYIS NYSLLVNDFD
121 NGFVVRIGAA ANSTGTIVIS PSVNTRIKKA YPAFILGSSL TNSAGQPLY ANYSLTIIPD
181 GCGTVLHAFY CILKPRTVNR CPSGTGYVSY FIYETVHND C QSTINRNASL NSFKSFDFLV
241 NCTFFNSWDI TADETKKWF G ITQDTQGVHL YSSRKGDL Y GNMFRFATLP VYEGIKYYTV
301 IPRSFRRKAN KREAAAFYV YKLHQLTYLL DFSVDGYIRR AIDCGHDDL S QLHCSYTSFE
361 VDTGVYSVSS YEAKPSGSV V EQAEGVECDF SPLLSGTPP Q VYNFKRLVFT NCNYNLTKLL
421 SLFSVNDFTC SQISPAAIAS NCYSSLILDY FSYPLSMKSD LSVSSAGPIS QFNKQSFNS
481 PTCLILATVP HNLTTITKPL KYSYINKCSR LLSDDRTEVP QLVNANQYSP CVSIVPSTVW
541 EDGDYYRKQL SPLEGGGWLV ASGSTVAMTE QLQMGFGITV QYGTDTNSVC PKLDLGDLSLT
601 ITNRLGKCDV YSLYGVTRG VFQNTAVGV KQRFVYDSF DNLVGYISDD GNYICVRPCV
661 SVFVSVIYDK STNLHATLFG SVACEHVTTM MSQFSRLTQS NLRRRDSNIP LQTAVGCVIG
721 LSNNSLVVSD CKLPLGQSLC AVPPVSTFRS YSASQQLAV LNYTSPIVVT PINSSGFTAA
781 IPTNFSFSVT QEYIETSIQK VTDCKQYVC NGFTRCEKLL VEYQQFCSKI NQALHGANLR
841 QDESVYLSYS NIKTTSTQTL EYGLNGDFNL TLLQVPQIGG SSSSYRSAIE DLLFDKVTIA
901 DPGYMQGYDD CMKQGPQ SAR DLICAQYVSG YKVLPLLYDF NMEAAYTSSL LGSIAGAGWT
961 AGLSSFAAIP FAQSMFYRLN GVGITQQVLS ENQKIANKF NQALGAMQTG FTTTNLAFNK
1021 VQDAVNANAM ALSKLAAELS NTFGAISSI SDILARLDTV EQEAQIDRLI NGRLTSLNAF
1081 VAQQLVRTEA AARSAQLAQD KVNCEVKSQS KRNGFCGTGT HIVSFAINAP NGLYFFHVG Y
1141 QPTSHVNATA AYGLCNTENP PKCIAPIDGY FVLNQTSTA RSSGDQHWY TGSSFFHPEP
1201 ITEANSKYVS MDVKFENLTN KLPPPLLSNS TDLDFRDELE EFFKNVSSQG PNFQEISKIN
1261 TLLNLNTEL MVLSEVVKQL NESYIDLKEL GNYTFYQKWP WYIWLGFIA G LVALALCVFF
1321 ILCCTGCCTS CLGKLCNRC CDSYDEYEVE KIHVH.

- 9. An isolated nucleic acid molecule encoding the chimeric coronavirus spike protein of claim 1.
- 10. A vector comprising the isolated nucleic acid molecule encoding the chimeric coronavirus spike protein of claim 1.
- 11. A Venezuelan equine encephalitis replicon particle (VRP) comprising the isolated nucleic acid molecule encoding the chimeric coronavirus spike protein of claim 1.
- 12. A virus like particle (VLP) comprising the chimeric coronavirus spike protein of claim 1 and a matrix protein of any virus that can form a VLP.
- 13. A coronavirus particle comprising the chimeric coronavirus spike protein of claim 1.
- 14. A population of VLPs of claim 12.
- 15. A composition comprising the chimeric spike protein of claim 1 in a pharmaceutically acceptable carrier.
- 16. A composition comprising the nucleic acid molecule of claim 9 in a pharmaceutically acceptable carrier.
- 17. A composition comprising the vector of claim 10 in a pharmaceutically acceptable carrier.
- 18. A composition comprising the VRP of claim 11 in a pharmaceutically acceptable carrier.
- 19. A composition comprising the population of claim 14 in a pharmaceutically acceptable carrier.

- 20. A method of producing an immune response to a coronavirus in a subject, comprising administering to the subject an effective amount of the chimeric coronavirus spike protein of claim 1, thereby producing an immune response to a coronavirus in the subject.
- 21. A method of treating a coronavirus infection in a subject in need thereof, comprising administering to the subject an effective amount of the chimeric coronavirus spike protein of claim 1, thereby treating a coronavirus infection in the subject.
- 22. A method of preventing a disease or disorder caused by a coronavirus infection in a subject, comprising administering to the subject an effective amount of the chimeric coronavirus spike protein of claim 1, thereby preventing a disease or disorder caused by a coronavirus infection in the subject.
- 23. A method of protecting a subject from the effects of coronavirus infection, comprising administering to the subject an effective amount of the chimeric coronavirus spike protein of claim 1, thereby protection the subject from the effects of coronavirus infection.

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