ANTIBODIES FOR THE TREATMENT AND PREVENTION OF COVID-19 AND EMERGING VARIANTS

[0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 63/181,138, filed on April 28, 2021, the content of which is hereby incorporated by reference in its entirety.

[0002] All patents, patent applications and publications cited herein are hereby incorporated by reference in their entirety. The disclosures of these publications in their entireties are hereby incorporated by reference into this application.

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BACKGROUND OF THE INVENTION

[0004] Coronavirus disease 2019 (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease affects multiple organs in the body including the lungs. There is an urgent need for the development of therapeutics to treat and prevent COVID-19.

SUMMARY OF THE INVENTION

[0005] In certain aspects, the subject matter described herein provides an engineered antibody or a functional fragment thereof, wherein the antibody or fragment thereof selectively binds at least a portion of a SARS-CoV-2 spike protein.

[0006] In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 4 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 6 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 8 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 9. In some embodiments, the antibody or

fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 12 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 16 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 18 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 20 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 21. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 22 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 23. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 24 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 26 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 32 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 33.

[0007] In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 2 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%,

80%, 85%, 90%, or 95% identity with SEQ ID NO: 14 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 10 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 28 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 30 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 34 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 35.

[0008] In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 4 and a second amino acid sequence comprising SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 6 and a second amino acid sequence comprising SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 8 and a second amino acid sequence comprising SEQ ID NO: 9. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 12 and a second amino acid sequence comprising SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 16 and a second amino acid sequence comprising SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 18 and a second amino acid sequence comprising SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 20 and a second amino acid sequence comprising SEQ ID NO: 21. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 22 and a second amino acid sequence comprising SEQ ID

NO: 23. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 24 and a second amino acid sequence comprising SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 26 and a second amino acid sequence comprising SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 32 and a second amino acid sequence comprising SEQ ID NO: 33.

[0009] In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 2 and a second amino acid sequence comprising SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 14 and a second amino acid sequence comprising SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 10 and a second amino acid sequence comprising SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 28 and a second amino acid sequence comprising SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 30 and a second amino acid sequence comprising SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 34 and a second amino acid sequence comprising SEQ ID NO: 35.

[0010] In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 4 and the complementarity-determining regions (CDRs) of SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 6 and the complementarity-determining regions (CDRs) of SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 8 and the complementarity-determining regions (CDRs) of SEQ ID NO: 9. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 12 and the complementarity-determining regions (CDRs) of SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 16 and the complementarity-determining regions (CDRs) of SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 18 and the complementarity-

determining regions (CDRs) of SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 20 and the complementarity-determining regions (CDRs) of SEQ ID NO: 21. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 22 and the complementarity-determining regions (CDRs) of SEQ ID NO: 23. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 24 and the complementarity-determining regions (CDRs) of SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 26 and the complementarity-determining regions (CDRs) of SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 32 and the complementarity-determining regions (CDRs) of SEQ ID NO: 33.

[0011] In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 2 and the complementarity-determining regions (CDRs) of SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 14 and the complementarity-determining regions (CDRs) of SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 10 and the complementarity-determining regions (CDRs) of SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 28 and the complementarity-determining regions (CDRs) of SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 30 and the complementarity-determining regions (CDRs) of SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 34 and the complementarity-determining regions (CDRs) of SEQ ID NO: 35.

[0012] In some embodiments, the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.

[0013] In some embodiments, the antibody neutralizes a SARS-CoV-2 virus. In some embodiments, the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus. In some embodiments, the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.

[0014] In certain aspects, the subject matter described herein provides a method for treating a subject having a viral infection or preventing a subject from developing a viral infection, the method comprising administering to the subject a therapeutically effective amount of a composition comprising any engineered monoclonal antibody described herein, wherein the antibody or fragment selectively binds at least a portion of a SARS-CoV-2 spike protein.

[0015] In some embodiments, the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the antibody neutralizes a SARS-CoV-2 virus. In some embodiments, the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus. In some embodiments, the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.

[0016] In certain aspects, the subject matter described herein provides a purified protein, wherein the protein comprises at least a portion of a SARS-CoV-2 surface protein.

[0017] In some embodiments, the at least a portion of a SARS-CoV-2 surface protein is a B.1.351.2-7 variant surface protein. In some embodiments, the B.1.351.2-7 variant surface protein is a spike protein (S). In some embodiments, the spike protein comprises an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the spike protein comprises SEQ ID NO: 1.

[0018] In certain aspects, the subject matter described herein provides a synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein.

[0019] In some embodiments, the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%,

60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.

[0020] In certain aspects, the subject matter described herein provides a pharmaceutical composition comprising a purified spike protein encoded by an amino acid sequence defined by SEQ ID NO: 1 or a portion thereof and a carrier, wherein the composition induces an immune response in a subject in need thereof.

[0021] In certain aspects, the subject matter described herein provides a pharmaceutical composition comprising: (i) a synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein or a portion thereof; and (ii) a carrier.

[0022] In some embodiments, the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the composition further comprises an adjuvant.

[0023] In certain aspects, the subject matter described herein provides a method of inducing an immune response in a subject in need thereof, the method comprising administering to the subject the any composition described herein. In some embodiments, the subject is at risk of contracting a SARS-CoV-2 virus. In some embodiments, the SARS-CoV-2 virus is a WA1 strain. In some embodiments, the SARS-CoV-2 virus is a B.1.351 strain. In some embodiments the SARS-CoV-2 virus is a B.1.351.2-7 strain. In some embodiments, the method comprises a prime-boost regimen of administering the composition. In some embodiments, the prime and the boost comprise the same composition. In some embodiments, the prime and the boost comprise a different composition.

BRIEF DESCRIPTION OF FIGURES

[0024] The patent or application file contains at least one drawing originally in color. To conform to the requirements for PCT patent applications, many of the figures presented herein are black and white representations of images originally created in color.

[0025] **FIGS. 1A-T** show neutralization of mAb 2-7-resistant SARS-CoV-2 B.1.351 virus strain (B.1.351.2-7) with monoclonal antibodies (mAb) to the receptor binding domain (RBD) of the B.1.351.2-7 spike protein (S). FIG. 1A shows neutralization for mAb 2-7. FIG. 1B shows neutralization for mAb REGN10987. FIG. 1C shows neutralization for mAb 2-38. FIG. 1D shows neutralization for mAb C135. FIG. 1E shows neutralization for mAb CoV2-2130. FIG. 1F shows neutralization for mAb 2-36. FIG. 1G shows neutralization for mAb COVA 1-16. FIG. 1H shows neutralization for mAb 1-20. FIG. 1I shows neutralization for mAb 2-15. FIG. 1J shows neutralization for mAb 2-43. FIG. 1K shows neutralization for mAb C121. FIG. 1L shows neutralization for mAb LY CoV 555. FIG. 1M shows neutralization for mAb 2-30. FIG. 1N shows neutralization for mAb REGN10985. FIG. 1O shows neutralization for mAb CB6. FIG. 1P shows neutralization for mAb 1-57. FIG. 1Q shows neutralization for mAb REGN10985. FIG. 1R shows neutralization for mAb S309. FIG. 1S shows neutralization for mAb CoV2-2196. FIG. 1T shows neutralization for mAb CR3022.

[0026] **FIGS. 2A-J** show neutralization of mAb 2-7-resistant SARS-CoV-2 B.1.351 virus strain (B.1.351.2-7) with monoclonal antibodies to the N-terminal domain (NTD) of the B.1.351.2-7 spike protein. FIG. 2A shows neutralization for mAb 4A8. FIG. 2B shows neutralization for mAb 4-8. FIG. 2C shows neutralization for mAb 5-24. FIG. 2D shows neutralization for mAb 1-68. FIG. 2E shows neutralization for mAb 1-87. FIG. 2F shows neutralization for mAb 2-51. FIG. 2G shows neutralization for mAb 2-17. FIG. 2H shows neutralization for mAb 4-18. FIG. 2I shows neutralization for mAb 4-19. FIG. 2J shows neutralization for mAb 5-7.

[0027] **FIG. 3** shows a range of neutralization potency (IC_{50} μg/ml) of spike protein RBD-specific mAbs to the SARS-CoV-2 WA1 (wild-type), B.1.351 (beta variant), and B.1.351.2-7 virus strains.

[0028] **FIG. 4** shows neutralization potency (IC_{50} μg/ml) of spike protein NTD-specific mAbs to the WA1, B.1.351, and the B.1.351.2-7 virus strains.

[0029] **FIG. 5** shows a schematic representation of B.1.351.2-7 variant strain mutations.

[0030] **FIG. 6** shows the sequence of the B.1.351.2-7 spike protein. Yellow highlight indicates the NTD. Green font indicates the RBD. Dark blue font indicates the S1/S2 domains. Light blue font is the FP domain. Orange font indicates the HR1 domain. Brown font indicates the HR2 domain. Purple font is the TM domain. Pink font is the CT domain.

DETAILED DESCRIPTION OF THE INVENTION

[0031] In certain aspects, the subject matter described herein provides an engineered antibody or a functional fragment thereof, wherein the antibody or fragment thereof selectively binds at least a portion of a SARS-CoV-2 spike protein.

[0032] In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 4 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 6 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 8 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 9. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 12 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 16 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 18 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 20 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 21. In some embodiments, the antibody

or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 22 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 23. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 24 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 26 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 32 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 33.

[0033] In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 2 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 14 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 10 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 28 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 30 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%,

80%, 85%, 90%, or 95% identity with SEQ ID NO: 34 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 35.

[0034] In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 4 and a second amino acid sequence comprising SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 6 and a second amino acid sequence comprising SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 8 and a second amino acid sequence comprising SEQ ID NO: 9. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 12 and a second amino acid sequence comprising SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 16 and a second amino acid sequence comprising SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 18 and a second amino acid sequence comprising SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 20 and a second amino acid sequence comprising SEQ ID NO: 21. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 22 and a second amino acid sequence comprising SEQ ID NO: 23. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 24 and a second amino acid sequence comprising SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 26 and a second amino acid sequence comprising SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 32 and a second amino acid sequence comprising SEQ ID NO: 33.

[0035] In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 2 and a second amino acid sequence comprising SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 14 and a second amino acid sequence comprising SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 10 and a second amino acid sequence comprising SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises a first amino acid

sequence comprising SEQ ID NO: 28 and a second amino acid sequence comprising SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 30 and a second amino acid sequence comprising SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 34 and a second amino acid sequence comprising SEQ ID NO: 35.

[0036] In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 4 and the complementarity-determining regions (CDRs) of SEQ ID NO: 5. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 6 and the complementarity-determining regions (CDRs) of SEQ ID NO: 7. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 8 and the complementarity-determining regions (CDRs) of SEQ ID NO: 9. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 12 and the complementarity-determining regions (CDRs) of SEQ ID NO: 13. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 16 and the complementarity-determining regions (CDRs) of SEQ ID NO: 17. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 18 and the complementarity-determining regions (CDRs) of SEQ ID NO: 19. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 20 and the complementarity-determining regions (CDRs) of SEQ ID NO: 21. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 22 and the complementarity-determining regions (CDRs) of SEQ ID NO: 23. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 24 and the complementarity-determining regions (CDRs) of SEQ ID NO: 25. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 26 and the complementarity-determining regions (CDRs) of SEQ ID NO: 27. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 32 and the complementarity-determining regions (CDRs) of SEQ ID NO: 33.

[0037] In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 2 and the complementarity-determining regions

(CDRs) of SEQ ID NO: 3. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 14 and the complementarity-determining regions (CDRs) of SEQ ID NO: 15. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 10 and the complementarity-determining regions (CDRs) of SEQ ID NO: 11. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 28 and the complementarity-determining regions (CDRs) of SEQ ID NO: 29. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 30 and the complementarity-determining regions (CDRs) of SEQ ID NO: 31. In some embodiments, the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 34 and the complementarity-determining regions (CDRs) of SEQ ID NO: 35.

[0038] In some embodiments, the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.

[0039] In some embodiments, the antibody neutralizes a SARS-CoV-2 virus. In some embodiments, the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus. In some embodiments, the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.

[0040] In certain aspects, the subject matter described herein provides a method for treating a subject having a viral infection or preventing a subject from developing a viral infection, the method comprising administering to the subject a therapeutically effective amount of a composition comprising any engineered monoclonal antibody described herein, wherein the antibody or fragment selectively binds at least a portion of a SARS-CoV-2 spike protein.

[0041] In some embodiments, the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein. In some embodiments, the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the antibody neutralizes a SARS-CoV-2 virus. In some embodiments,

the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus. In some embodiments, the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.

[0042] In certain aspects, the subject matter described herein provides a purified protein, wherein the protein comprises at least a portion of a SARS-CoV-2 surface protein.

[0043] In some embodiments, the at least a portion of a SARS-CoV-2 surface protein is a B.1.351.2-7 variant surface protein. In some embodiments, the B.1.351.2-7 variant surface protein is a spike protein (S). In some embodiments, the spike protein comprises an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the spike protein comprises SEQ ID NO: 1.

[0044] In certain aspects, the subject matter described herein provides a synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein.

[0045] In some embodiments, the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.

[0046] In certain aspects, the subject matter described herein provides a pharmaceutical composition comprising a purified spike protein encoded by an amino acid sequence defined by SEQ ID NO: 1 or a portion thereof and a carrier, wherein the composition induces an immune response in a subject in need thereof.

[0047] In certain aspects, the subject matter described herein provides a pharmaceutical composition comprising: (i) a synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein or a portion thereof; and (ii) a carrier.

[0048] In some embodiments, the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant

spike protein comprising SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1. In some embodiments, the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1. In some embodiments, the composition further comprises an adjuvant.

[0049] In certain aspects, the subject matter described herein provides a method of inducing an immune response in a subject in need thereof, the method comprising administering to the subject the any composition described herein. In some embodiments, the subject is at risk of contracting a SARS-CoV-2 virus. In some embodiments, the SARS-CoV-2 virus is a WA1 strain. In some embodiments, the SARS-CoV-2 virus is a B.1.351 strain. In some embodiments the SARS-CoV-2 virus is a B.1.351.2-7 strain. In some embodiments, the method comprises a prime-boost regimen of administering the composition. In some embodiments, the prime and the boost comprise the same composition. In some embodiments, the prime and the boost comprise a different composition.

[0050] In some embodiments, the subject matter described herein related to monoclonal antibodies (mAb) specific for wild-type SAR-CoV-2 (WA1) and variant strains including, but not limited to SARS-CoV-2 B.1.351 or B.1.351.2-7. In some embodiments, the B.1.351.2-7 virus strain is resistant to the neutralizing effects of the mAb 2-7. During the study of emerging COVID-19 variants, it was observed that the neutralization activities of many monoclonal antibodies, mAb therapeutics for FDA emergency use authorization (EUA), and many clinical development candidates, are significantly impacted by the SARS-CoV-2 pan-resistant virus strain designated as B.1.351.2-7. This resistant virus strain was identified using the monoclonal antibody 2-7 *in vitro* selection. Antibody 2-7 is a receptor binding domain (RBD), neutralizing monoclonal antibody that shows potent neutralization activities against multiple SARS-CoV-2 variants, including the B.1.351 strain.

[0051] In some embodiments, the subject matter described herein relates to the isolation and sequencing of the resistant B.1.351.2-7 variant virus. The key mutations in its spike protein sequence include H66R, V445G, and a 677-681 deletion as shown in FIG. 5. A pseudovirus neutralization assay will be performed to dissect which point mutations, or a combination of the mutations, contribute to the resistant phenotype. In some embodiments, the subject matter described herein relates to B.1.351.2-7 variant virus neutralization assays using a panel of monoclonal antibodies. In some embodiments, the mAbs are specific for the

RBD of the spike protein of the B.1.351.2-7 variant virus. In some embodiments, the mAbs are specific for the NTD of the spike protein of the B.1.351.2-7 variant virus. Convalescent sera and vaccinee sera will be utilized to assess the potential impact of this resistant virus on currently available therapeutics and vaccines.

[0052] As the B.1.351.2-7 virus is pan-resistant to most of the neutralizing antibodies and current EUA therapeutic antibodies, the effectiveness of current COVID-19 therapies and vaccines can be severely impacted by emerging variants sharing similar sequences as the pan-resistant viral strain disclosed herein. In one embodiment, the subject matter disclosed herein relates to development of vaccine candidates to inoculate subjects against the B.1.351.2-7 strain. In one embodiment, the subject matter disclosed herein relates to isolating antibody therapeutics that effective against the B.1.351.2-7 resistant strain. In one embodiment, the subject matter disclosed herein relates to the prevention and treatment of future COVID-19 outbreaks caused by resistant SARS-CoV-2 variants. In one embodiment, the subject matter disclosed herein relates to designing vaccines against emerging SARS-CoV-2 variants. In some embodiments, the subject matter disclosed herein relates to designing a bait protein for isolating neutralizing antibodies that show potent and/or cross-reactivity against the B.1.351.2-7 resistant strain and
future pan-resistant variant of SARS-CoV-2. In some embodiments, the bait protein is designed from at least a portion of a protein from the B.1.351.2-7 viral particle. In some embodiments, the subject matter disclosed herein relates to detection of viral variants.

[0053] Earlier passages will be sequenced and viral sequences that are pan-resistant to current neutralizing antibodies will be isolated. Key mutations contributing to the resistant phenotype will be identified by pseudovirus neutralization. Neutralization against additional panel of antibodies (both RBD and NTD), convalescent sera and vaccinee sera will be performed to assess the potential impact of this resistant virus on therapeutics and vaccines. Spike trimer will be generated based on the resistant viral sequence for structural characterization and for immunization in a humanized mouse system or other animal models known in the art to generate the next generation of neutralizing antibodies as therapeutics.

[0054] SEQ ID NO: 1 is the amino acid sequence of variant B.1.351.2-7 full length spike protein:

MFVFLVLLPLVSSQCVNLTTRTQLPPAYTNSFTRGVYYPDKVFRSSVLHSTQDLFLPF
FSNVTWFRAIHVSGTNGTKRFANPVLPFNDGVYFASTEKSNIIRGWIFGTTLDSKTQS
LLIVNNATNVVIKVCEFQFCNDPFLGVYYHKNNKSWMESEFRVYSSANNCTFEYVS

QPFLMDLEGKQGNFKNLREFVFKNIDGYFKIYSKHTPINLVRGLPQGFSALEPLVDLP
IGINITRFQTLHRSYLTPGDSSSGWTAGAAAYYVGYLQPRTFLLKYNENGTITDAVDC
ALDPLSETKCTLKSFTVEKGIYQTSNFRVQPTESIVRFPNITNLCPFGEVFNATRFASV
YAWNRKRISNCVADYSVLYNSASFSTFKCYGVSPTKLNDLCFTNVYADSFVIRGDEV
RQIAPGQTGNIADYNYKLPDDFTGCVIAWNSNNLDSKGGGNYNYLYRLFRKSNLKP
FERDISTEIYQAGSTPCNGVKGFNCYFPLQSYGFQPTYGVGYQPYRVVVLSFELLHAP
ATVCGPKKSTNLVKNKCVNFNFNGLTGTGVLTESNKKFLPFQQFGRDIADTTDAVR
DPQTLEILDITPCSFGGVSVITPGTNTSNQVAVLYQGVNCTEVPVAIHADQLTPTWRV
YSTGSNVFQTRAGCLIGAEHVNNSYECDIPIGAGICASYQTRRARSVASQSIIAYTMSL
GVENSVAYSNNSIAIPTNFTISVTTEILPVSMTKTSVDCTMYICGDSTECSNLLLQYGS
FCTQLNRALTGIAVEQDKNTQEVFAQVKQIYKTPPIKDFGGFNFSQILPDPSKPSKRSF
IEDLLFNKVTLADAGFIKQYGDCLGDIAARDLICAQKFNGLTVLPPLLTDEMIAQYTS
ALLAGTITSGWTFGAGAALQIPFAMQMAYRFNGIGVTQNVLYENQKLIANQFNSAIG
KIQDSLSSTASALGKLQDVVNQNAQALNTLVKQLSSNFGAISSVLNDILSRLDKVEAE
VQIDRLITGRLQSLQTYVTQQLIRAAEIRASANLAATKMSECVLGQSKRVDFCGKGY
HLMSFPQSAPHGVVFLHVTYVPAQEKNFTTAPAICHDGKAHFPREGVFVSNGTHWF
VTQRNFYEPQIITTDNTFVSGNCDVVIGIVNNTVYDPLQPELDSFKEELDKYFKNHTS
PDVDLGDISGINASVVNIQKEIDRLNEVAKNLNESLIDLQELGKYEQYIKWPWYIWLG
FIAGLIAIVMVTIMLCCMTSCCSCLKGCCSCGSCCKFDEDDSEPVLKGVKLHYT*

[0055] In some embodiments, the subject matter described herein relates to a purified variant B.1.351.2-7 spike protein. In some embodiment, a vector encoding a variant B.1.351.2-7 spike protein is introduced into a population of bacteria. In some embodiments, the protein is produced in a bacteria culture comprising the population of bacteria transform with the vector encoding a variant B.1.351.2-7 spike protein. In some embodiments, the protein is purified from the bacterial culture. In some embodiments, the vector comprises a vector backbone and a nucleic acid sequence encoding for an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO:1. In some embodiments, the vector comprises a vector backbone and a nucleic acid sequence encoding for SEQ ID NO:1. In some embodiments, the vector backbone is any backbone used in the art for expression vectors. In some embodiments, the protein is purified using affinity chromatography. In some embodiments, the protein is purified using any suitable method known in the art. In some embodiments, the purified variant B.1.351.2-7 spike protein is a recombinant protein.

[0056] Sequences of mAbs to SARS-CoV-2 B.1.351.2-7 variant spike protein

[0057] Underlined and italicized amino acids in the following SEQ ID NOS represent the respective complementarity-determining regions (CDRs).

[0058] Sequence of mAb 2-7

[0059] SEQ ID NO: 2 is the variable region of the heavy chain of antibody number 2-7, which specifically recognizes the RBD.

SQITLKESGPTLVKPTQTLTLTCTFSG*FSLSTSGVGVG*WIRQPPGKALEWLA*LIYWDDD KRYSPSL*KSRLTITKDTSKNQVVLTMTNMDPVDTATYYCAH*HKIERIFDY*WGQGTLV TVSSAS

[0060] SEQ ID NO: 3 is the variable region of the light chain of antibody number 2-7, which specifically recognizes the RBD.

QSALAQPASVSGSPGQSITISC*TGTSSDVGAYNYVS*WYQQHPGKAPKLMIY*DVSKRPS*G VSNRFSGSKSGNTASLTISGLQAEDEADYYC*SSYTTSSTV*FGGGTKLTVL

[0061] Sequence of mAb 2-38

[0062] SEQ ID NO: 4 is the variable region of the heavy chain of antibody number 2-38.

EVQLVESGGGLVKPGGSLRLSCAASG*FTFSSYSMN*WVRQAPGKGLEWVS*SISSSSSYIY YADSVKG*RFTISRDNAKNSLYLQMNSLRAEDTAVYYCTR*AGWELRLDAFDI*WGQGT MVTVSS

[0063] SEQ ID NO: 5 is the variable region of the light chain of antibody number 2-38.

SSELTQDPAVSVALGQTVRITC*QGDSLRSSYAS*WYQQKPGQAPILVIY*DKNNRPS*GIPD RFSGSSSGNTASLTITGAQAEDEADYYC*NSRDSSGIL*FGGGTKLTVL

[0064] Sequence of mAb 2-36

[0065] SEQ ID NO: 6 is the variable region of the heavy chain of antibody number 2-36, which specifically recognizes the RBD.

QVQLQESGPGLVKPSETLSLTCTVSG*GSVSSSNYYWS*WIRQPPGKGLEWIG*YMYYSGST KYNPSL*KSRVTISVDTSKNQFSLKLSSVTAADTAVYYCAR*EVYYYDRSGYYASDGFDI*W GQGTMVTVSS

[0066] SEQ ID NO: 7 is the variable region of the light chain of antibody number 2-36, which specifically recognizes the RBD.

EIVLTQSPGTLSLSPGERATLSC*RASQSVSSSYLA*WYQQKPGQAPRLLIY*GASSRAT*GIPD RFSGSGSGTDFTLTISRLEPEDFAVYYC*QQYGSSPQT*FGQGTKVEIK

[0067] Sequence of mAb 1-20

[0068] SEQ ID NO: 8 is the variable region of the heavy chain of antibody number 1-20, which specifically recognizes the RBD.

EVQLVESGGGLIQPGGSLRLSCAASG*LTVSSNYMS*WVRQAPGKGLEWVS*VIYSGGSTF YADSV*KGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCAR*DLFYYGMDV*WGQGTTVT VSS

[0069] SEQ ID NO: 9 is the variable region of the light chain of antibody number 1-20, which specifically recognizes the RBD.

DIQLTQSPSFLSASVGDRVTITC*RASQGISSYLA*WYQQKPGKAPKLLIY*AASTLQS*GVPS RFSGSGSGTEFTLTISSLQPEDFATYYC*QQLNSYPC*FGPGTKVDIK

[0070] Sequence of mAb 2-15

[0071] SEQ ID NO: 10 is the variable region of the heavy chain of antibody number 2-15.

QVQLVQSGAEVKKPGASVRVSCKASG*YTFTGYYMH*WVRQAPGQGLEWMG*WINPISD GTNYAQ*KFQGWVTMTRDTSISTVYMELSRLRSDDTAVYYCAR*GGSRCSGGNCYGWA YDAFDI*WGQGTMITVSS

[0072] SEQ ID NO: 11 is the variable region of the light chain of antibody number 2-15.

QSALTQPASVSGSPGQSITISC*TGTSSDVGGYNFVS*WYQQHPGKAPKLMIY*DVSKRPS*G VSNRFSGSKSGNTASLTISGLQAEDEADCYC*SSYTSSSTFV*FGTGTKVTVL

[0073] Sequence of mAb 2-43

[0074] SEQ ID NO: 12 is the variable region of the heavy chain of antibody number 2-43, which recognizes an epitope other than the RBD or the NTD.

QVQLVQSGAEVKKPGASVKVSCKASG*YTFTGYYMH*WVRQAPGQGLEWMG*WINPNS GGTNYAQ*KFQGRVTMTRDTSITTAYMELRRLRSDDTAVYYCAR*GLGVGCSGGNCYL DYYY*MDVWGKGTTVTVSS

[0075] SEQ ID NO: 13 is the variable region of the light chain of antibody number 2-43, which recognizes an epitope other than the RBD or the NTD.

QSALTQPASVSGSPGQSITISC*TGTSSDVGGYNYVS*WYQQHPGKAPKLMIY*DVSKRPS*G VSNRFSGSKSGNTASLTISGLQAEDEGDYYC*SSYTSSSTWV*FGGGTKLTVL

[0076] Sequence of mAb 1-57

[0077] SEQ ID NO: 14 is the variable region of the heavy chain of antibody number 1-57, which specifically recognizes the RBD.

EVHLVESGGGLVQPGGSLRLSCAASG*FTFSDHYMD*WVRQAPGKGLEWVG*RTRNKAN SYTTEYAASV*KGRFTISRDDAKNSLYLQMNSLKTEDTAVYYCAR*VHRWAYCINGVCFG AYSDY*WGQGTLVTVSS

[0078] SEQ ID NO: 15 is the variable region of the light chain of antibody number 1-57, which specifically recognizes the RBD.

EIVLTQSPGTLSLSPGERATLSC*RASQSVSSSYLA*WYQQKPGQAPRLLIY*GASSRAT*GIPD RFSGSGSGTDFTLTISRLEPEDFAVYYC*QQYGSSPST*FGQGTKLEIK

[0079] Sequence of mAb 2-30

[0080] SEQ ID NO: 16 is the variable region of the heavy chain of antibody number 2-30, which specifically recognizes the RBD.

QVQLVESGGGVVQPGRSLRLSCAASG*FTFSSYTMH*WVRQAPGKGLEWVA*AISYDGN NKYYADSV*KGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCAR*SILYGGGMDV*WGQGT TVTVSS

[0081] SEQ ID NO: 17 is the variable region of the light chain of antibody number 2-30, which specifically recognizes the RBD.

DIQLTQSPSSLSASVGDRVTITC*RASQGISSYLA*WYQQKPGQAPKLLIY*AASTLQS*GVPS RFSGSGSGTDFTLTISSLQPEDFATYYC*QQLNSYPLT*FGGGTKVEIK

[0082] Sequence of mAb 4-8

[0083] SEQ ID NO: 18 is the variable region of the heavy chain of antibody number 4-8.

QVQLVQSGAEVKKAGSSVKVSCKASG*GTFSSHTIT*WVRQAPGQGLEWMG*RIIPILGIA NYAQKFQG*RVTITADKSTSTAYMELSSLRSEDTAVYYCAS*LQTVDTAIEKYYGMDV*W GQGTTVTVSS

[0084] SEQ ID NO: 19 is the variable region of the light chain of antibody number 4-8

SYELTQPPSVSVSPGQTASITC*SGDKLGDKYAC*WYQQKPGQSPVLVIY*QDNKRPS*GIPE RFSGSNSGNTATLTISGTQAMDEADYYC*QAWDSSTAV*FGGGTKLTVL

[0085] Sequence of mAb 5-24

[0086] SEQ ID NO: 20 is the variable region of the heavy chain of antibody number 5-24, which specifically recognizes the NTD.

QVQLVESGGGVVQPGRSLRLSCAASG*LTFSSYVMH*WVRQAPGKGLDWVG*VIWYDGS KKYYADSV*KGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCAR*DPRDYYDFWSGYDY YYGLDV*WGQGTTVTVSS

[0087] SEQ ID NO: 21 is the variable region of the light chain of antibody number 5-24, which specifically recognizes the NTD.

EIVLTQSPGILSLSPGERATLSC*RASQSVSSSYLA*WYQQKPGQAPRLLIY*GASSRAT*GIPD RFSGSGSGTDFTLTISRLEPEDFAVYYC*QQYGSSGALT*FGGGTKVEIK

[0088] Sequence of mAb 1-68

[0089] SEQ ID NO: 22 is the variable region of the heavy chain of antibody number 1-68, which specifically recognize the NTD.

QVQLVQSGAEVKKPGASVKVSCKVSG*YTLIELSMH*WVRQAPGKG*LEWMGGFDPEDA ETIYAQ*KFQGRVTMTEDTSTDTAYMELSSLRSEDTAVYYCAT*GWAVAGSSDVWYYYY GMDV*WGQGTTVTVSS

[0090] SEQ ID NO: 23 is the variable region of the light chain of antibody number 1-68, which specifically recognizes the NTD.

QSALTQPPSVSGSPGQSVTISC*TGTSSDVGSYNRVS*WYQQPPGTAPKLMIY*EVSNRPS*G VPDRFSGSKSGNTASLTISGLQAEDEADYYC*SSYTSSSTYV*FGTGTKVTVL

[0091] Sequence of mAb 1-87

[0092] SEQ ID NO: 24 is the variable region of the heavy chain of antibody number 1-87, which specifically recognizes the NTD.

QVQLVQSGAEVKKPGASVKVSCKVSG*YTLIELSMH*WVRQAPGKGLEWMG*GFDPED AETIYAQ*KFQGRVTMTEDTSTDTAYMELSSLRSEDTAVYYCAT*GIAVIGPPPSTYYYYG MDV*WGQGTTVTVSS

[0093] SEQ ID NO: 25 is the variable region of the light chain of antibody number 1-87, which specifically recognizes the NTD.

QSALTQPASVSGSPGQSITISCTGTS*SDVGGYNYVS*WYQQHPGKAPKLMIY*DVSKRPS*G VSNRFSGSKSGNTASLTISGLQAEDEADYYC*SSYTSSSTYV*FGTGTKVTVL

[0094] Sequence of mAb 2-51

[0095] SEQ ID NO: 26 is the variable region of the heavy chain of antibody number 2-51.

QVQLVQSGAEVKKPGASVKVSCKVSG*YTLIELSMH*WVRQAPGKGLEWMG*GFDPED VETIYAQQFQG*RVTMTEDTSTDTAYMELSSLRSEDTAVYYCAT*GWAYKSTWYFGY*WG QGTLVTVSS

[0096] SEQ ID NO: 27 is the variable region of the light chain of antibody number 2-51.

QSALTQPPSASGSPGQSVTISC*TGTSSDVGGYNYVS*WYQQHPGKAPKLMIY*EVSKRPS*G VPDRFSGSKSGNTASLTVSGLQAEDEADYYC*SSYAGSRMG*FGGGTKLTVL

[0097] Sequence of mAb 2-17

[0098] SEQ ID NO: 28 is the variable region of the heavy chain of antibody number 2-17, which recognizes an epitope other than the RBD or the NTD.

QVQLVQSGAEVKKPGSSVKVSCKASG*GTFSSYAIS*WVRQAPGQGLEWMG*GNIPIFGT ANYAQ*KFQGRVTITADESTSTAYMELSSLRSEDTAVYYCAR*GVGYRGVIPLNWFDP*W GQGTVVTVSS

[0099] SEQ ID NO: 29 is the variable region of the light chain of antibody number 2-17, which recognizes an epitope other than the RBD or the NTD.

EIVMTQSPATLSVSPGERATLSC*RASQSVSSDLA*WYQHKPGQAPRLLIY*GASTRAT*GIPV RFSGSGSGTEFTLTISSLQSEDFAVYYC*QQYNNWPPFT*FGGGTKVEIK

[0100] Sequence of mAb 4-18

[0101] SEQ ID NO: 30 is the variable region of the heavy chain of antibody number 4-18, which specifically recognizes the NTD.

QVQLVESGGGVVQPGRSLRLSCAASG*FTFSSYGMH*WVRQAPGKGLEWVA*VISYDGS NKHYADSV*KGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCAK*DSGYNYGYSWFDP*W GQGTLVTVSS

[0102] SEQ ID NO: 31 is the variable region of the light chain of antibody number 4-18, which specifically recognizes the NTD.

SYELTQPPSVSVSPGQTARITC*SADALAKQYAY*WYQQKPGQAPVLVIY*KDSERPS*GIPE RFSGSSSGTTVTLTISGVQAEDEADYYC*QSTDNSGTYPNWV*FGGGTKLTVL

[0103] Sequence of mAb 4-19

[0104] SEQ ID NO: 32 is the variable region of the heavy chain of antibody number 4-19, which recognizes an epitope other than the RBD or the NTD.

QVQLQESGPGLVKPSETLSLTCTVSG*GSISNYYWS*WIRQSPGKGLEWIG*YIYYSGSTNYN PSL*KSRVTISVDTSKNQFSLKLSSVTAADTAVYYCAR*SAKHWLAPPGDYYYYMDV*WG KGTTVTVSS

[0105] SEQ ID NO: 33 is the variable region of the light chain of antibody number 4-19, which recognizes an epitope other than the RBD or the NTD.

DIQLTQSPSFLSASVGDRVTITC*RASQGISSYLA*WYQQKPGKAPKLLIY*AASTLQS*GVPS RFSGSGSGTEFTLTISSLQPEDFATYYC*QQLNSYLT*FGGGTKVEIK

[0106] Sequence of mAb 5-7

[0107] SEQ ID NO: 34 is the variable region of the heavy chain of antibody number 5-7, which specifically recognizes the NTD.

QVQLVQSGAEVKKPGASVKVSCKASG*YTFTSYYMH*WVRQAPGQGLEWMG*VINPSGG STSYAE*KFRGRVTMTRDTSTSTVYMELSSLRSEDTAVYYCAR*DREPHSDSSGYWDSLK YYYYYALDV*WGQGTTVTVSS

[0108] SEQ ID NO: 35 is the variable region of the light chain of antibody number 5-7, which specifically recognizes the NTD.

AIQLTQSPSSLSASVGDRVTITC*RASQGISSYLA*WYQQKPGKAPELLIY*AASTLQS*GVPS RFSGSGSGTDFTLTISSLQPEDFATYYC*QQLNTYPFT*FGPGTKVDIK

[0109] In some embodiments, the subject matter described herein reports the isolation, characterization and sequences of potent monoclonal antibodies (mAbs) against SARS-CoV-2 and variants including the B.1.351.2-7 variant. The mAbs can be isolated from blood samples from patients with COVID-19, and once the antibody sequences are obtained from these samples, the mAbs can be synthesized *in vitro*.

[0110] The SARS-CoV-2 neutralizing mAbs described herein can be used for treatment of subjects infected with SARS-CoV-2. In some embodiments, the mAbs described herein reduce SARS-CoV-2 viral load in a subject in need thereof. In some embodiment, the mAbs

described herein decrease disease severity in a subject in need thereof. In some embodiments, the mAbs described herein improve clinical outcome of COVID-19 in subjects in need thereof. In some embodiments, the mAbs described herein can be used as prophylaxis to prevent high risk subjects and individuals from becoming infected with SARS-CoV-2.

Flow Through of Identification Process for the Potent COVID-19 mAbs Disclosed Herein

[0111] 1. Plasma samples from COVID-19 patients were isolated and evaluated for the ability of potential antibodies contained within these plasma samples to neutralize SARS-CoV-2 and variants *in vitro*.

[0112] 2. Peripheral blood mononuclear cells (PMBCs) were isolated from patients to isolate single B cells containing mAb-sequences that could be responsible for strong plasma antiviral activity. The antibody sequences were recovered from these single B cells by high throughput sequencing.

[0113] 3. Genes from single B cells encoding for these mAb sequences were synthesized and cloned into expression vectors. mAbs were expressed *in vitro* and purified for subsequent analyses and characterization.

[0114] 4. *In vitro*-produced and purified mAbs were then tested for their ability to neutralize an infection cause by SARS-CoV-2 or a variant virus.

[0115] In some embodiments, the mAb described herein can be used for treatment and/or prevention of COVID-19. In some embodiment, the mAbs can be used for diagnosis of COVID-19 subject exposure. In some embodiment, the mAbs described herein can be utilized in laboratory research and development activities.

[0116] Immunoglobulins or antibodies are Y-shaped proteins consisting of two identical light chains (LCs) and two identical heavy chains (HCs) of amino acid sequences. The light and heavy chains associates with each other to form the intact immunoglobulin heterodimer. In some embodiments, the HC and LC of the heterodimer are linked through disulfide bonds. In some embodiments, the two HCs of the heterotetramer are linked by disulfide bridges. Human LCs can be one of two functionally similar classes, κ or λ. Both LC classes have two domains, a constant domain (CL) and a variable domain (VL). Human antibody HCs can be one of five isotypes, IgA, IgD, IgE, IgG, and IgM. IgAs, IgDs, and IgGs have three constant (C) and one variable (V) domains. IgEs and IgMs have one variable and four constant domains. The IgA and IgM isotopes have an additional J-chain, which allows the formation of dimers and pentamers, respectively.

[0117] An antibody molecule has three functional components, two Fragment antigen binding domains (Fabs) and the fragment crystallizable (Fc), with the two Fabs linked to the Fc by a hinge region that allows the Fabs a large degree of flexibility relative to the Fc. In monoclonal antibodies, each of the Fabs have identical antigen-binding sites for binding to a specific target antigen. The Fv region of the Fab is composed of a pair of variable domains (variable heavy (VH) and variable light (VL)) contributed by the heavy chain (HC) and the light chain (LC). In some embodiments, the domains of heavy and light chains are approximately 110 amino acid residues in length. The Fv domains of the immunoglobulin structure, which interact with the target antigen, are at the N-termini of the HCs and LCs. The Fab regions of an immunoglobulin molecule are formed by the pairing of VL and constant light (CL) of the LCs with VH and the first constant heavy region (CH1) of the HCs. The pairing of VL and VH, form the antigen-binding site.

[0118] The polypeptide region connecting the Fab and the Fc regions called the hinge region. The hinge region functionally allows the Fabs a large degree of conformational flexibility relative to the Fc. The antibody hinge can be divided into three regions, the upper hinge, core hinge, and lower hinge, each with a different functional role. The upper hinge allows the movement and rotation of the Fabs. The central core hinge contains a variable number of cysteine residues depending on the IgG subtype that forms disulfide bonds, stabilizing the association of the two heavy chains. The lower hinge that allows movement of the Fc relative to the Fabs.

EXAMPLE 1 – Neutralizing antibodies against SARS-CoV-2 and its variants

[0119] **FIGS. 1A-T** show a neutralization of 2-7 resistant B.1.351 (B.1.351.2-7) virus strain with monoclonal antibodies to the receptor binding domain (RBD) of the B.1.351.2-7 spike protein. FIG. 1A shows neutralization for mAb 2-7. FIG. 1B shows neutralization for mAb REGN10987. FIG. 1C shows neutralization for mAb 2-38. FIG. 1D shows neutralization for mAb C135. FIG. 1E shows neutralization for mAb CoV2-2130. FIG. 1F shows neutralization for mAb 2-36. FIG. 1G shows neutralization for mAb COVA 1-16. FIG. 1H shows neutralization for mAb 1-20. FIG. 1I shows neutralization for mAb 2-15. FIG. 1J shows neutralization for mAb 2-43. FIG. 1K shows neutralization for mAb C121. FIG. 1L shows neutralization for mAb LY CoV 555. FIG. 1M shows neutralization for mAb 2-30. FIG. 1N shows neutralization for mAb REGN10985. FIG. 1O shows neutralization for mAb CB6. FIG. 1P shows neutralization for mAb 1-57. FIG. 1Q shows neutralization for mAb REGN10985. FIG. 1R shows neutralization for mAb S309. FIG. 1S shows neutralization for

mAb CoV2-2196. FIG. 1T shows neutralization for mAb CR3022. Also shown are the neutralization curves for the SARS-CoV-2 wild-type virus and the B.1.351 virus variant.

[0120] **FIGS. 2A-J** shows neutralization of 2-7 resistant B.1.351 (B.1.351.2-7) virus strain with monoclonal antibodies (mAb) to the N-terminal domain (NTD) of the B.1.351.2-7 spike protein. FIG. 1A shows neutralization for mAb 4A8. FIG. 1B shows neutralization for mAb 4-8. FIG. 1C shows neutralization for mAb 5-24. FIG. 1D shows neutralization for mAb 1-68. FIG. 1E shows neutralization for mAb 1-87. FIG. 1F shows neutralization for mAb 2-51. FIG. 1G shows neutralization for mAb 2-17. FIG. 1H shows neutralization for mAb 4-18. FIG. 1I shows neutralization for mAb 4-19. FIG. 1J shows neutralization for mAb 5-7. Also shown are the neutralization curves for the SARS-CoV-2 wild-type virus and the B.1.351 virus variant.

[0121] **FIG. 3** shows a range of potency (IC_{50} μg/ml) of RBD mAbs to the WA1, B.1.351, and the B.1.351.2-7 virus strains.

[0122] **FIG. 4** shows neutralization (IC_{50} μg/ml) of NTD mAbs to the WA1, B.1.351, and the B.1.351.2-7 virus strains.

[0123] **FIG. 5** shows a schematic representation of the SARS-CoV-2 B.1.351.2-7 variant mutations. FIG. 5 also shows the key differences in spike protein sequence from strain WA1 to strain B1.351 and to strain B.1.351.2-7. In the NTD of the spike protein sequence for the B.1.351.2-7 stain, amino acids L241, L242, and A243 are deleted while R66 has replaced H66. In the RBD of the spike protein sequence for the B.1.351.2-7 strain, amino acid G445 has replaced V445 as compared to the B.1.351 strain. In the S1/S2 domains of the spike protein sequence for the B.1.351.2-7 stain, amino acids 677-681 are deleted while G614 has replaced D614 as compared to the WA1 strain.

[0124] **FIG. 6** shows the sequence of the B.1.351.2-7 spike protein. Yellow highlight indicates the NTD. Green font indicates the RBD. Dark blue font indicates the S1/S2 domains. Light blue font is the FP domain. Orange font indicates the HR1 domain. Brown font indicates the HR2 domain. Purple font is the TM domain. Pink font is the CT domain. A label for each domain can be found next to its corresponding amino acid sequence. The sequence for the FP domain is in the center of the corresponding line.

EXAMPLE 2 – DNA-based Vaccine against B.1.351.2-7

[0125] In some embodiments, the subject matter disclosed herein relates to a vaccine that induces an immune response against severe acute respiratory syndrome coronavirus (SARS-CoV-2). In some embodiments, the vaccine is administered as prophylaxis against a SARS-

CoV-2 virus, which can invade susceptible host organisms and cause disease therein. In some embodiments, the vaccine is administered to treat diseases caused by the infection. In some embodiments, the vaccine contains a nucleic acid sequence encoding at least a portion of a SARS-CoV-2 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a B.1.351.2-7 variant spike protein. In some embodiments, the vaccine contains a nucleic acid sequence encoding at least a portion of the amino acid sequence defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a nucleic acid sequence encoding an amino acid sequence which is 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identical to an amino acid sequence defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a nucleic acid sequence encoding the amino acid sequence defined by SEQ ID NO: 1.

[0126] In some embodiments, the host animals in which the vaccine disclosed herein may induce the immune response against SARS-CoV-2 include, but are not limited to, mammals or birds, for example, humans, dogs, cats, pigs, horses, chickens, ducks, turkeys, ferrets, and the like.

[0127] The vaccine described herein may additionally contain, but is not limited to, at least one component selected from the group consisting of solvent, adjuvant and/or excipient. The solvent may include physiological saline or distilled water. The adjuvant may include Freund's incomplete or complete adjuvants, aluminum hydroxide gels, and vegetable and mineral oils. Excipients may include aluminum phosphate, aluminum hydroxide, or aluminum potassium sulfate. In some embodiments, the vaccine disclosed herein contain at least one substance used in vaccine preparation, which is well known to those skilled in the art.

[0128] In some embodiments, the composition of the vaccine described herein is adjusted for administrations depending on the subject's body weight, age, severity of symptoms, or other physical characteristics. In some embodiments, the vaccine described herein may be prepared in oral or parenteral formulations. In some embodiments, the vaccine may be administered via intradermal, intramuscular, intraperitoneal, intranasally or epidural route. In some embodiments, the vaccine is administered by any suitable route known in the art.

[0129] In some embodiments, the subject matter described herein relates to a method of preventing or treating SARS-CoV-2 or variant SARS-CoV-2 infections by administering the vaccine described herein to one or more subjects. Such infections can lead to COVID-19 symptoms or disease in subjects. The term "subject" as used herein refers to any animal including a human that has already been infected or may be infected with a SARS-CoV-2

virus or a variant virus. In some embodiments, the SARS-CoV-2 variants contain at least one amino acid mutation in the sequence encoding the spike protein is SARS-CoV-2 compared to wild-type SARS-CoV-1. In some embodiments, the vaccine described herein may be administered alone or in combination with any COVID-19 treatment agent. In some embodiments, the vaccine can be administered with any agents used in the art to treat infections.

[0130] As used herein, the term "prevention" refers to any action that inhibits infection with SARS-CoV-2 or a variant strain or delays development or decreases severity of disease caused by the infection via administration of the vaccine described herein.

[0131] As used herein, the term "treatment" refers to any action in which symptoms caused by SARS-CoV-2 or variant strain infection are reduced or beneficially altered via administration of the vaccine described herein.

[0132] In some embodiments, the vaccine described herein is administered as an individual therapeutic agent or administered in combination with other therapeutic agents. In some embodiments, the vaccine may be administered sequentially or simultaneously with a conventional therapeutic agent. In some embodiments, the vaccine may be administered in a single or multiple manner.

[0133] In one embodiment, the subject matter disclosed herein relates to the generation and validation of a vaccine against the B.1.351.2-7 variant of the SARS-CoV-2 virus or other emerging SARS-CoV-2 variants. In one embodiment, the vaccine is based on the DNA nucleotide sequence encoding at least a portion of the B.1.351.2-7 spike protein (SEQ ID NO: 1).

[0134] In one embodiment, the DNA-based vaccine against B.1.351.2-7 introduces a genetically engineered plasmid containing the DNA sequence encoding at least a portion of the B.1.351.2-7 spike protein (SEQ ID NO: 1) into a subject in need thereof. In some embodiments, the vaccine contains a DNA nucleic acid sequence encoding at least a portion of a SARS-CoV-2 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a B.1.351.2-7 variant spike protein. In some embodiments, the vaccine contains a nucleic acid sequence encoding at least a portion of the amino acid sequence defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a nucleic acid sequence encoding an amino acid sequence which is 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identical to an amino acid sequence defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a nucleic acid sequence encoding the amino acid sequence defined by SEQ ID NO: 1. In

some embodiments, the introduction is via injection. In some embodiments, the introduction is via a nasal spray. In some embodiments, the introduction is via any suitable method know in the art. In some embodiments, the vaccination is to prevent the spread of the B.1.351.2-7 variant. In some embodiments, the vaccination is to treat a subject that has tested positive for B.1.351.2-7. In some embodiments, the subject has been exposed to B.1.351.2-7. In some embodiments, the subject exhibits COVID-19 symptoms. In some embodiments, the subject has been diagnosed with COVID-19.

[0135] Following the inoculation of the subject with the DNA-based vaccine described herein, the subject's cells directly produce the B.1.351.2-7 spike protein or at least the portion encoded by the DNA. This causes a protective immunological response to be generated in the subject's systems. When the vaccinated subject is infected with the B.1.351.2-7 virus, severe disease can be avoided. In some embodiments, the vaccinated subject infected with B.1.351.2-7 shows no symptoms of disease or very mild symptoms. In some embodiments, the vaccinated subject does not transmit the virus to other subjects. In some embodiments, the DNA vaccine can induce a wide range of immune response types.

[0136] In some embodiments, the vaccination regimen includes one or more events of introducing the B.1.351.2-7 DNA into the subject. In some embodiments, the introduction events are spread over time. In some embodiments, the initial vaccination is followed by at least one booster shot within a month of the initial vaccination. In some embodiments, the initial vaccine and the booster shots are based on the same B.1.351.2-7 DNA spike protein sequence encoding at least a portion of the B.1.351.2-7 spike protein. In some embodiments, the initial vaccine and the booster shots are based on different B.1.351.2-7 DNA spike protein sequences, each encoding at least a portion of the B.1.351.2-7 spike protein.

EXAMPLE 3 – RNA Vaccine against B.1.351.2-7

[0137] In some embodiments, the vaccine described herein is based on the mRNA nucleotide sequence encoding at least a portion of the B.1.351.2-7 spike protein (SEQ ID NO: 1). In some embodiments, the vaccine contains a mRNA nucleic acid encoding at least a portion of a SARS-CoV-2 spike protein. In some embodiments, the SARS-CoV-2 spike protein is a B.1.351.2-7 variant spike protein. In some embodiments, the vaccine contains a mRNA nucleic acid encoding at least a portion of the amino acid defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a mRNA nucleic acid encoding an amino acid sequence which is 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identical to an

amino acid sequence defined by SEQ ID NO: 1. In some embodiments, the vaccine contains a nucleic acid sequence encoding the amino acid sequence defined by SEQ ID NO: 1.

[0138] The mRNA strand introduced into the subject enters the body's cells and the cells use the genetic information encoded by the mRNA to produce the B.1.351.2-7 spike protein or the encoded portion thereof. The subject's immune system then learns to recognize the protein. RNA vaccines can be delivered by a variety of methods including but not limited to needle-syringe injections or needle-free into the skin; via injection into the blood, muscle, lymph node or directly into organs; or via a nasal spray.

[0139] In some embodiments, the vaccination regimen includes one or more events of delivering the B.1.351.2-7 RNA, the events being spread over time. In some embodiments, the initial vaccination is followed by at least one booster shot within a month of the initial vaccination. In some embodiments, the initial vaccine and the booster shots are based on the same B.1.351.2-7 RNA sequence encoding at least a portion of the B.1.351.2-7 spike protein. In some embodiments, the initial vaccine and the booster shots are based on different B.1.351.2-7 RNA sequences, each encoding at least a portion of the B.1.351.2-7 spike protein.

SEQUENCE LISTING

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    450                 455                 460

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Lys Gly Phe Asn Cys Tyr Phe Pro Leu Gln Ser Tyr Gly Phe Gln Pro
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    530                 535                 540

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945                 950                 955                 960


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            980                 985                 990


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Phe Leu  His Val Thr Tyr Val  Pro Ala Gln Glu Lys  Asn Phe Thr
    1055                1060                1065


Thr Ala  Pro Ala Ile Cys His  Asp Gly Lys Ala His  Phe Pro Arg
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Leu Ile  Asp Leu Gln Glu Leu  Gly Lys Tyr Glu Gln  Tyr Ile Lys
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Trp Pro  Trp Tyr Ile Trp Leu  Gly Phe Ile Ala Gly  Leu Ile Ala
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Ile Val  Met Val Thr Ile Met  Leu Cys Cys Met Thr  Ser Cys Cys
    1220                1225                1230

Ser Cys  Leu Lys Gly Cys Cys  Ser Cys Gly Ser Cys  Cys Lys Phe
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35 40 45

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Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu
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35 40 45

Ser Ser Ile Ser Ser Ser Ser Ser Tyr Ile Tyr Tyr Ala Asp Ser Val
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Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ala Lys Asn Ser Leu Tyr
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Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
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20 25 30

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35 40 45

Asp Lys Asn Asn Arg Pro Ser Gly Ile Pro Asp Arg Phe Ser Gly Ser
50 55 60

Ser Ser Gly Asn Thr Ala Ser Leu Thr Ile Thr Gly Ala Gln Ala Glu
65 70 75 80

Asp Glu Ala Asp Tyr Tyr Cys Asn Ser Arg Asp Ser Ser Gly Ile Leu
85 90 95

Phe Gly Gly Gly Thr Lys Leu Thr Val Leu
100 105

<210> 6
<211> 128
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 6
Gln Val Gln Leu Gln Glu Ser Gly Pro Gly Leu Val Lys Pro Ser Glu
1 5 10 15

Thr Leu Ser Leu Thr Cys Thr Val Ser Gly Gly Ser Val Ser Ser Ser
20 25 30

Asn Tyr Tyr Trp Ser Trp Ile Arg Gln Pro Pro Gly Lys Gly Leu Glu
35 40 45

Trp Ile Gly Tyr Met Tyr Tyr Ser Gly Ser Thr Lys Tyr Asn Pro Ser
50 55 60

Leu Lys Ser Arg Val Thr Ile Ser Val Asp Thr Ser Lys Asn Gln Phe
65 70 75 80

Ser Leu Lys Leu Ser Ser Val Thr Ala Ala Asp Thr Ala Val Tyr Tyr
85 90 95

Cys Ala Arg Glu Val Tyr Tyr Tyr Asp Arg Ser Gly Tyr Tyr Ala Ser
100 105 110

Asp Gly Phe Asp Ile Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser
115 120 125

<210> 7
<211> 108
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 7
Glu Ile Val Leu Thr Gln Ser Pro Gly Thr Leu Ser Leu Ser Pro Gly
1 5 10 15

Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Ser
20 25 30

Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu
35 40 45

Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro Asp Arg Phe Ser
50 55 60

Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
65 70 75 80

Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Ser Ser Pro
85 90 95

Gln Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
100 105

<210> 8
<211> 117
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 8
Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Ile Gln Pro Gly Gly
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Leu Thr Val Ser Ser Asn
20 25 30

Tyr Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Ser Val Ile Tyr Ser Gly Gly Ser Thr Phe Tyr Ala Asp Ser Val Lys
50 55 60

Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr Leu
65 70 75 80

Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala
85 90 95

Arg Asp Leu Phe Tyr Tyr Gly Met Asp Val Trp Gly Gln Gly Thr Thr
100 105 110

Val Thr Val Ser Ser
115

<210> 9
<211> 106
<212> PRT
<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 9

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Asp Ile Gln Leu Thr Gln Ser Pro Ser Phe Leu Ser Ala Ser Val Gly
1               5                  10                  15


Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Tyr
            20                  25                  30


Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile
        35                  40                  45


Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
    50                  55                  60


Ser Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65                  70                  75                  80


Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Leu Asn Ser Tyr Pro Cys
                85                  90                  95


Phe Gly Pro Gly Thr Lys Val Asp Ile Lys
            100                 105
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<210> 10
<211> 129
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 10

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Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala
1               5                  10                  15


Ser Val Arg Val Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Gly Tyr
            20                  25                  30
```

Tyr Met His Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met
35 40 45

Gly Trp Ile Asn Pro Ile Ser Asp Gly Thr Asn Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Trp Val Thr Met Thr Arg Asp Thr Ser Ile Ser Thr Val Tyr
65 70 75 80

Met Glu Leu Ser Arg Leu Arg Ser Asp Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Gly Gly Ser Arg Cys Ser Gly Gly Asn Cys Tyr Gly Trp Ala
100 105 110

Tyr Asp Ala Phe Asp Ile Trp Gly Gln Gly Thr Met Ile Thr Val Ser
115 120 125

Ser

<210> 11
<211> 110
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 11
Gln Ser Ala Leu Thr Gln Pro Ala Ser Val Ser Gly Ser Pro Gly Gln
1 5 10 15

Ser Ile Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr
20 25 30

Asn Phe Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu
35 40 45

Met Ile Tyr Asp Val Ser Lys Arg Pro Ser Gly Val Ser Asn Arg Phe
50 55 60

Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu
65 70 75 80

Gln Ala Glu Asp Glu Ala Asp Cys Tyr Cys Ser Ser Tyr Thr Ser Ser
85 90 95

Ser Thr Phe Val Phe Gly Thr Gly Thr Lys Val Thr Val Leu
100 105 110

<210> 12
<211> 129
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 12
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala
1 5 10 15

Ser Val Lys Val Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Gly Tyr
20 25 30

Tyr Met His Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met
35 40 45

Gly Trp Ile Asn Pro Asn Ser Gly Gly Thr Asn Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Arg Val Thr Met Thr Arg Asp Thr Ser Ile Thr Thr Ala Tyr
65 70 75 80

Met Glu Leu Arg Arg Leu Arg Ser Asp Asp Thr Ala Val Tyr Tyr Cys

85 90 95

Ala Arg Gly Leu Gly Val Gly Cys Ser Gly Gly Asn Cys Tyr Leu Asp
100 105 110

Tyr Tyr Tyr Met Asp Val Trp Gly Lys Gly Thr Thr Val Thr Val Ser
115 120 125

Ser

<210> 13
<211> 110
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 13
Gln Ser Ala Leu Thr Gln Pro Ala Ser Val Ser Gly Ser Pro Gly Gln
1 5 10 15

Ser Ile Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr
20 25 30

Asn Tyr Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu
35 40 45

Met Ile Tyr Asp Val Ser Lys Arg Pro Ser Gly Val Ser Asn Arg Phe
50 55 60

Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu
65 70 75 80

Gln Ala Glu Asp Glu Gly Asp Tyr Tyr Cys Ser Ser Tyr Thr Ser Ser
85 90 95

Ser Thr Trp Val Phe Gly Gly Gly Thr Lys Leu Thr Val Leu
100 105 110

<210> 14
<211> 130
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 14
Glu Val His Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Asp His
20 25 30

Tyr Met Asp Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Gly Arg Thr Arg Asn Lys Ala Asn Ser Tyr Thr Thr Glu Tyr Ala Ala
50 55 60

Ser Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asp Ala Lys Asn Ser
65 70 75 80

Leu Tyr Leu Gln Met Asn Ser Leu Lys Thr Glu Asp Thr Ala Val Tyr
85 90 95

Tyr Cys Ala Arg Val His Arg Trp Ala Tyr Cys Ile Asn Gly Val Cys
100 105 110

Phe Gly Ala Tyr Ser Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val
115 120 125

Ser Ser
130

<210> 15
<211> 108
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 15
Glu Ile Val Leu Thr Gln Ser Pro Gly Thr Leu Ser Leu Ser Pro Gly
1 5 10 15

Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Ser
20 25 30

Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu
35 40 45

Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro Asp Arg Phe Ser
50 55 60

Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
65 70 75 80

Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Ser Ser Pro
85 90 95

Ser Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys
100 105

<210> 16
<211> 119
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 16

20
Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
20 25 30

Thr Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Ala Ala Ile Ser Tyr Asp Gly Asn Asn Lys Tyr Tyr Ala Asp Ser Val
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Ser Ile Leu Tyr Gly Gly Gly Met Asp Val Trp Gly Gln Gly
100 105 110

Thr Thr Val Thr Val Ser Ser
115

<210> 17
<211> 107
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 17
Asp Ile Gln Leu Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly
1 5 10 15

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Tyr
20 25 30

Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Lys Leu Leu Ile
35 40 45

Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50 55 60

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65 70 75 80

Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Leu Asn Ser Tyr Pro Leu
85 90 95

Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys
100 105

<210> 18
<211> 125
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 18
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Ala Gly Ser
1 5 10 15

Ser Val Lys Val Ser Cys Lys Ala Ser Gly Gly Thr Phe Ser Ser His
20 25 30

Thr Ile Thr Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met
35 40 45

Gly Arg Ile Ile Pro Ile Leu Gly Ile Ala Asn Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Arg Val Thr Ile Thr Ala Asp Lys Ser Thr Ser Thr Ala Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Ser Leu Gln Thr Val Asp Thr Ala Ile Glu Lys Tyr Tyr Gly Met
100 105 110

Asp Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser
115 120 125

<210> 19
<211> 106
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 19
Ser Tyr Glu Leu Thr Gln Pro Pro Ser Val Ser Val Ser Pro Gly Gln
1 5 10 15

Thr Ala Ser Ile Thr Cys Ser Gly Asp Lys Leu Gly Asp Lys Tyr Ala
20 25 30

Cys Trp Tyr Gln Gln Lys Pro Gly Gln Ser Pro Val Leu Val Ile Tyr
35 40 45

Gln Asp Asn Lys Arg Pro Ser Gly Ile Pro Glu Arg Phe Ser Gly Ser
50 55 60

Asn Ser Gly Asn Thr Ala Thr Leu Thr Ile Ser Gly Thr Gln Ala Met
65 70 75 80

Asp Glu Ala Asp Tyr Tyr Cys Gln Ala Trp Asp Ser Ser Thr Ala Val
85 90 95

Phe Gly Gly Gly Thr Lys Leu Thr Val Leu

100 105

<210> 20
<211> 129
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 20
Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Leu Thr Phe Ser Ser Tyr
20 25 30

Val Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Asp Trp Val
35 40 45

Gly Val Ile Trp Tyr Asp Gly Ser Lys Lys Tyr Tyr Ala Asp Ser Val
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Asp Pro Arg Asp Tyr Tyr Asp Phe Trp Ser Gly Tyr Asp Tyr
100 105 110

Tyr Tyr Gly Leu Asp Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser
115 120 125

Ser

<210> 21
<211> 109
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 21
Glu Ile Val Leu Thr Gln Ser Pro Gly Ile Leu Ser Leu Ser Pro Gly
1 5 10 15

Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Ser
20 25 30

Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu
35 40 45

Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro Asp Arg Phe Ser
50 55 60

Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
65 70 75 80

Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Ser Ser Gly
85 90 95

Ala Leu Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys
100 105

<210> 22
<211> 128
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 22
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala

25
1 5 10 15

Ser Val Lys Val Ser Cys Lys Val Ser Gly Tyr Thr Leu Ile Glu Leu
20 25 30

Ser Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Met
35 40 45

Gly Gly Phe Asp Pro Glu Asp Ala Glu Thr Ile Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Arg Val Thr Met Thr Glu Asp Thr Ser Thr Asp Thr Ala Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Thr Gly Trp Ala Val Ala Gly Ser Ser Asp Val Trp Tyr Tyr Tyr
100 105 110

Tyr Gly Met Asp Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser
115 120 125

<210> 23
<211> 110
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 23
Gln Ser Ala Leu Thr Gln Pro Pro Ser Val Ser Gly Ser Pro Gly Gln
1 5 10 15

Ser Val Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Ser Tyr
20 25 30

Asn Arg Val Ser Trp Tyr Gln Gln Pro Pro Gly Thr Ala Pro Lys Leu
35 40 45

Met Ile Tyr Glu Val Ser Asn Arg Pro Ser Gly Val Pro Asp Arg Phe
50 55 60

Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu
65 70 75 80

Gln Ala Glu Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr Thr Ser Ser
85 90 95

Ser Thr Tyr Val Phe Gly Thr Gly Thr Lys Val Thr Val Leu
100 105 110

<210> 24
<211> 128
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 24
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala
1 5 10 15

Ser Val Lys Val Ser Cys Lys Val Ser Gly Tyr Thr Leu Ile Glu Leu
20 25 30

Ser Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Met
35 40 45

Gly Gly Phe Asp Pro Glu Asp Ala Glu Thr Ile Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Arg Val Thr Met Thr Glu Asp Thr Ser Thr Asp Thr Ala Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Thr Gly Ile Ala Val Ile Gly Pro Pro Pro Ser Thr Tyr Tyr Tyr
100 105 110

Tyr Gly Met Asp Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser
115 120 125

<210> 25
<211> 110
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 25
Gln Ser Ala Leu Thr Gln Pro Ala Ser Val Ser Gly Ser Pro Gly Gln
1 5 10 15

Ser Ile Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr
20 25 30

Asn Tyr Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu
35 40 45

Met Ile Tyr Asp Val Ser Lys Arg Pro Ser Gly Val Ser Asn Arg Phe
50 55 60

Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu
65 70 75 80

Gln Ala Glu Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr Thr Ser Ser
85 90 95

Ser Thr Tyr Val Phe Gly Thr Gly Thr Lys Val Thr Val Leu
100 105 110

<210> 26
<211> 121
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 26
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala
1 5 10 15

Ser Val Lys Val Ser Cys Lys Val Ser Gly Tyr Thr Leu Ile Glu Leu
20 25 30

Ser Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Met
35 40 45

Gly Gly Phe Asp Pro Glu Asp Val Glu Thr Ile Tyr Ala Gln Gln Phe
50 55 60

Gln Gly Arg Val Thr Met Thr Glu Asp Thr Ser Thr Asp Thr Ala Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Thr Gly Trp Ala Tyr Lys Ser Thr Trp Tyr Phe Gly Tyr Trp Gly
100 105 110

Gln Gly Thr Leu Val Thr Val Ser Ser
115 120

<210> 27
<211> 109
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 27
Gln Ser Ala Leu Thr Gln Pro Pro Ser Ala Ser Gly Ser Pro Gly Gln
1 5 10 15

Ser Val Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr
20 25 30

Asn Tyr Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu
35 40 45

Met Ile Tyr Glu Val Ser Lys Arg Pro Ser Gly Val Pro Asp Arg Phe
50 55 60

Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Val Ser Gly Leu
65 70 75 80

Gln Ala Glu Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr Ala Gly Ser
85 90 95

Arg Met Gly Phe Gly Gly Gly Thr Lys Leu Thr Val Leu
100 105

<210> 28
<211> 124
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 28
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ser
1 5 10 15

Ser Val Lys Val Ser Cys Lys Ala Ser Gly Gly Thr Phe Ser Ser Tyr
20 25 30

Ala Ile Ser Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met
35 40 45

Gly Gly Asn Ile Pro Ile Phe Gly Thr Ala Asn Tyr Ala Gln Lys Phe
50 55 60

Gln Gly Arg Val Thr Ile Thr Ala Asp Glu Ser Thr Ser Thr Ala Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Gly Val Gly Tyr Arg Gly Val Ile Pro Leu Asn Trp Phe Asp
100 105 110

Pro Trp Gly Gln Gly Thr Val Val Thr Val Ser Ser
115 120

<210> 29
<211> 108
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 29
Glu Ile Val Met Thr Gln Ser Pro Ala Thr Leu Ser Val Ser Pro Gly
1 5 10 15

Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Asp
20 25 30

Leu Ala Trp Tyr Gln His Lys Pro Gly Gln Ala Pro Arg Leu Leu Ile
35 40 45

Tyr Gly Ala Ser Thr Arg Ala Thr Gly Ile Pro Val Arg Phe Ser Gly

50 55 60

Ser Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Ser
65 70 75 80

Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Asn Asn Trp Pro Pro
85 90 95

Phe Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys
100 105

<210> 30
<211> 122
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 30
Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
20 25 30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Ala Val Ile Ser Tyr Asp Gly Ser Asn Lys His Tyr Ala Asp Ser Val
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Lys Asp Ser Gly Tyr Asn Tyr Gly Tyr Ser Trp Phe Asp Pro Trp
100 105 110

Gly Gln Gly Thr Leu Val Thr Val Ser Ser
115 120

<210> 31
<211> 110
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 31
Ser Tyr Glu Leu Thr Gln Pro Pro Ser Val Ser Val Ser Pro Gly Gln
1 5 10 15

Thr Ala Arg Ile Thr Cys Ser Ala Asp Ala Leu Ala Lys Gln Tyr Ala
20 25 30

Tyr Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Val Leu Val Ile Tyr
35 40 45

Lys Asp Ser Glu Arg Pro Ser Gly Ile Pro Glu Arg Phe Ser Gly Ser
50 55 60

Ser Ser Gly Thr Thr Val Thr Leu Thr Ile Ser Gly Val Gln Ala Glu
65 70 75 80

Asp Glu Ala Asp Tyr Tyr Cys Gln Ser Thr Asp Asn Ser Gly Thr Tyr
85 90 95

Pro Asn Trp Val Phe Gly Gly Gly Thr Lys Leu Thr Val Leu
100 105 110

<210> 32
<211> 126
<212> PRT

<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 32
Gln Val Gln Leu Gln Glu Ser Gly Pro Gly Leu Val Lys Pro Ser Glu
1 5 10 15

Thr Leu Ser Leu Thr Cys Thr Val Ser Gly Gly Ser Ile Ser Asn Tyr
20 25 30

Tyr Trp Ser Trp Ile Arg Gln Ser Pro Gly Lys Gly Leu Glu Trp Ile
35 40 45

Gly Tyr Ile Tyr Tyr Ser Gly Ser Thr Asn Tyr Asn Pro Ser Leu Lys
50 55 60

Ser Arg Val Thr Ile Ser Val Asp Thr Ser Lys Asn Gln Phe Ser Leu
65 70 75 80

Lys Leu Ser Ser Val Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala
85 90 95

Arg Ser Ala Lys His Trp Leu Ala Pro Pro Gly Asp Tyr Tyr Tyr Tyr
100 105 110

Met Asp Val Trp Gly Lys Gly Thr Thr Val Thr Val Ser Ser
115 120 125

<210> 33
<211> 106
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic
polypeptide

<400> 33

Asp Ile Gln Leu Thr Gln Ser Pro Ser Phe Leu Ser Ala Ser Val Gly
1 5 10 15

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Tyr
20 25 30

Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile
35 40 45

Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50 55 60

Ser Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65 70 75 80

Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Leu Asn Ser Tyr Leu Thr
85 90 95

Phe Gly Gly Gly Thr Lys Val Glu Ile Lys
100 105

<210> 34
<211> 134
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 34
Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala
1 5 10 15

Ser Val Lys Val Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Ser Tyr
20 25 30

Tyr Met His Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met
35 40 45

Gly Val Ile Asn Pro Ser Gly Gly Ser Thr Ser Tyr Ala Glu Lys Phe
50 55 60

Arg Gly Arg Val Thr Met Thr Arg Asp Thr Ser Thr Ser Thr Val Tyr
65 70 75 80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Asp Arg Glu Pro His Ser Asp Ser Ser Gly Tyr Trp Asp Ser
100 105 110

Leu Lys Tyr Tyr Tyr Tyr Tyr Ala Leu Asp Val Trp Gly Gln Gly Thr
115 120 125

Thr Val Thr Val Ser Ser
130

<210> 35
<211> 107
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic polypeptide

<400> 35
Ala Ile Gln Leu Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly
1 5 10 15

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Tyr
20 25 30

Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Glu Leu Leu Ile
35 40 45

Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50 55 60

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65 70 75 80

Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Leu Asn Thr Tyr Pro Phe
85 90 95

Thr Phe Gly Pro Gly Thr Lys Val Asp Ile Lys
100 105

<210> 36
<211> 21
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic peptide

<220>
<221> MOD_RES
<222> (8)..(12)
<223> Any amino acid

<400> 36
Ile Cys Ala Ser Tyr Gln Thr Xaa Xaa Xaa Xaa Xaa Arg Arg Ala Arg
1 5 10 15

Ser Val Ala Ser Gln
20

<210> 37
<211> 21
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic peptide

<400> 37
Ile Cys Ala Ser Tyr Gln Thr Gln Thr Asn Ser Pro Arg Arg Ala Arg

1 5 10 15

Ser Val Ala Ser Gln
20

<210> 38
<211> 16
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic peptide

<400> 38
Ile Cys Ala Ser Tyr Gln Thr Arg Arg Ala Arg Ser Val Ala Ser Gln
1 5 10 15

<210> 39
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: Synthetic peptide

<400> 39
Gln Thr Asn Ser Pro Arg Arg Ala Arg
1 5

What is claimed is:

1. An engineered antibody or a functional fragment thereof, wherein the antibody or fragment thereof selectively binds at least a portion of a SARS-CoV-2 spike protein.
2. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 4 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 5.
3. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 6 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 7.
4. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 8 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 9.
5. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 12 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 13.
6. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 16 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 17.
7. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 18 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 19.
8. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 20 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 21.
9. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%,

or 95% identity with SEQ ID NO: 22 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 23.

10. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 24 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 25.
11. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 26 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 27.
12. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 32 and a second amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 33.
13. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 4 and a second amino acid sequence comprising SEQ ID NO: 5.
14. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 6 and a second amino acid sequence comprising SEQ ID NO: 7.
15. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 8 and a second amino acid sequence comprising SEQ ID NO: 9.
16. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 12 and a second amino acid sequence comprising SEQ ID NO: 13.
17. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 16 and a second amino acid sequence comprising SEQ ID NO: 17.
18. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 18 and a second amino acid sequence comprising SEQ ID NO: 19.

19. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 20 and a second amino acid sequence comprising SEQ ID NO: 21.
20. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 22 and a second amino acid sequence comprising SEQ ID NO: 23.
21. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 24 and a second amino acid sequence comprising SEQ ID NO: 25.
22. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 26 and a second amino acid sequence comprising SEQ ID NO: 27.
23. The antibody or fragment of claim 1, wherein the antibody or fragment comprises a first amino acid sequence comprising SEQ ID NO: 32 and a second amino acid sequence comprising SEQ ID NO: 33.
24. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 4 and the complementarity-determining regions (CDRs) of SEQ ID NO: 5.
25. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 6 and the complementarity-determining regions (CDRs) of SEQ ID NO: 7.
26. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 8 and the complementarity-determining regions (CDRs) of SEQ ID NO: 9.
27. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 12 and the complementarity-determining regions (CDRs) of SEQ ID NO: 13.
28. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 16 and the complementarity-determining regions (CDRs) of SEQ ID NO: 17.
29. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 18 and the complementarity-determining regions (CDRs) of SEQ ID NO: 19.

30. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 20 and the complementarity-determining regions (CDRs) of SEQ ID NO: 21.
31. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 22 and the complementarity-determining regions (CDRs) of SEQ ID NO: 23.
32. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 24 and the complementarity-determining regions (CDRs) of SEQ ID NO: 25.
33. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 26 and the complementarity-determining regions (CDRs) of SEQ ID NO: 27.
34. The antibody or fragment of claim 1, wherein the antibody or fragment comprises the complementarity-determining regions (CDRs) of SEQ ID NO: 32 and the complementarity-determining regions (CDRs) of SEQ ID NO: 33.
35. The antibody or fragment of any one of claims 1-34, wherein the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein.
36. The antibody or fragment of any one of claims 1-34, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein.
37. The antibody or fragment of any one of claims 1-34, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein.
38. The antibody or fragment of any one of claims 1-34, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
39. The antibody or fragment of any one of claims 1-34, wherein the antibody neutralizes a SARS-CoV-2 virus.
40. The antibody or fragment of any one of claims 1-34, wherein the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus.
41. The antibody or fragment of any one of claims 1-34, wherein the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.
42. A method for treating a subject having a viral infection or preventing a subject from developing a viral infection, the method comprising administering to the subject a therapeutically effective amount of a composition comprising the engineered

monoclonal antibody or fragment of any one of claims 1-34, wherein the antibody or fragment selectively binds at least a portion of a SARS-CoV-2 spike protein.

43. The method of claim 42, wherein the SARS-CoV-2 spike protein is a wild-type SARS-CoV-2 WA1 spike protein.
44. The method of claim 42, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351 variant spike protein.
45. The method of claim 42, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein.
46. The method of claim 42, wherein the SARS-CoV-2 spike protein is a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
47. The method of claim 42, wherein the antibody neutralizes a SARS-CoV-2 virus.
48. The method of claim 42, wherein the antibody neutralizes a SARS-CoV-2 B.1.351 variant virus.
49. The method of claim 42, wherein the antibody a SARS-CoV-2 B.1.351.2-7 variant virus.
50. A purified protein, wherein the protein comprises at least a portion of a SARS-CoV-2 surface protein.
51. The protein of claim 50, wherein the at least a portion of a SARS-CoV-2 surface protein is a B.1.351.2-7 variant surface protein.
52. The protein of claim 51, wherein the B.1.351.2-7 variant surface protein is a spike protein (S).
53. The protein of claim 52, wherein the spike protein comprises an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1.
54. The protein of claim 52, wherein the spike protein comprises SEQ ID NO: 1.
55. A synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein.
56. The nucleic acid of claim 55, wherein the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
57. The nucleic acid of claim 55, wherein the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for a SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.

58. The nucleic acid of claim 55, wherein the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1.
59. The nucleic acid of claim 55, wherein the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
60. A pharmaceutical composition comprising a purified spike protein encoded by an amino acid sequence defined by SEQ ID NO: 1 or a portion thereof and a carrier, wherein the composition induces an immune response in a subject in need thereof.
61. A pharmaceutical composition comprising:

(i) a synthetic nucleic acid sequence comprising a nucleotide sequence encoding a SARS-CoV-2 B.1.351.2-7 variant spike protein or a portion thereof; and

(ii) a carrier.

62. The composition of claim 61, wherein the nucleic acid sequence is a complementary deoxyribonucleic acid (cDNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
63. The composition of claim 61, wherein the nucleic acid sequence is a messenger ribonucleic acid (mRNA) encoding for the SARS-CoV-2 B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
64. The composition of claim 61, wherein the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising an amino acid sequence having 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% identity with SEQ ID NO: 1.
65. The composition of claim 61, wherein the nucleic acid sequence encodes a B.1.351.2-7 variant spike protein comprising SEQ ID NO: 1.
66. The composition of any one of claims 61-65 further comprising an adjuvant.
67. A method of inducing an immune response in a subject in need thereof, the method comprising administering to the subject the composition of any one of claims 61-62.
68. The method of claim 67, wherein the subject is at risk of contracting a SARS-CoV-2 virus.
69. The method of claim 68, wherein the SARS-CoV-2 virus is a WA1 strain.
70. The method of claim 68, wherein the SARS-CoV-2 virus is a B.1.351 strain.
71. The method of claim 68, wherein the SARS-CoV-2 virus is a B.1.351.2-7 strain.
72. The method of claim 67, wherein the method comprises a prime-boost regimen of administering the composition.

73. The method of claim 69, wherein the prime and the boost comprise the same composition.
74. The method of claim 69, wherein the prime and the boost comprise a different composition.