WHAT IS CLAIMED IS:

1. An engineered protein comprising a metapneumovirus (MPV) F protein ectodomain having at least 90% identity to (i) amino acids 19-489 of any of SEQ ID NOs: 1, 2, and 4-7, or (ii) amino acids 19-484 of SEQ ID NO: 3, said engineered protein comprising at least one mutation relative to the sequence of any one of SEQ ID NOs: 1-7, said at least one mutation comprising a substitution at a position corresponding to: K166, N342, A/D185, K188, T49, V262, H435, E26, G439, N46, L158, A161, L50, V162, E51, R163, V104, N457, L110, N322, A113, D336, A116, A338, A140, A147, S291, S443, S293, S444, S355, V442, T365, V463, S22, G53, V169, E305, L302, V47, A159, T127, N153, G121, I/F258, G106, A107, T160, I128, A190, V118, Q426, L165, V191, S149, I137, V/I122, S192, T317, L105, L134, A117, S347, G261, I268, S470, L473, S265, L460, F48, Q455, V231, A374, I217, S376, G366, S194, L219 A344, A86, T114, V148, D461, L66, L73, N145, Q195, E453, and/or H368.

2. The engineered protein of claim 1, comprising a proline substitution corresponding to A/D185P.

3. The engineered protein of claim 1, comprising a substitution corresponding to RQSR (residues 99-102 of any one of SEQ ID NOs: 1-7) to RRRR (SEQ ID NO: 10).

4. The engineered protein of claim 1, comprising a proline substitution corresponding to A/D185P and a substitution corresponding to RQSR (residues 99-102 of any one of SEQ ID NOs: 1-7) to RRRR (SEQ ID NO: 10).

5. The engineered protein of claim 1, comprising a substitution of residues 87-104 of any one of SEQ ID NOs: 1-7 to GGGGSGGGGSR (SEQ ID NO: 8).

6. The engineered protein of any one of claims 1-5, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to: E26C and G439C; N46C and L158C; T49C and A161C; L50C and V162C; E51C and R163C; E51C and K166C; V104C and N457C; L110C and N322C; A113C and D336C; A116C and A338C; A140C and A147C; S291C and S443C; S293C and S443C; S293C and S444C; S355C and V442C; T365C and V463C; S22C and H435C; G53C and K166C; G53C and V169C; E305C and N457C; S291C and L302C; V47C and A159C; T127C and N153C; G121C and I/F258C; F48C and T160C; and/or T365C and Q455C.

7. The engineered protein of claim 6, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to: A116C and A338C; T365C and V463C; T127C and N153C; T365C and Q455C; V104C and N457C; L110C and N322C; or A140C and A147C.

8. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to A140C and A147C.

9. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to V104C and N457C.

10. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to L110C and N322C.

11. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to T365C and V463C.

12. The engineered protein of claim 11, further comprising a substitution at a position corresponding to L219 and/or V231.

13. The engineered protein of claim 11, further comprising a substitution corresponding to L219K and/or V231I.

14. The engineered protein of any one of claims 11-13, further comprising paired cysteine substitutions corresponding to T127C and N153C.

15. The engineered protein of any one of claims 11-13, further comprising paired cysteine substitutions corresponding to L110C and N322C.

16. The engineered protein of any one of claims 11-15, further comprising paired cysteine substitutions corresponding to A140C and A147C.

17. The engineered protein of any one of claims 11-16, further a substitution corresponding to G366S.

18. The engineered protein of claim 11, further comprising a substitution at a position corresponding to Q426, T49, L187, L473 and/or S347.

19. The engineered protein of claim 11, further comprising a substitution at a position corresponding to Q426, T49, L187, L473 and/or S347.

20. The engineered protein of claim 11, further comprising a substitution corresponding to Q426W, T49E, L187F, L473F and/or S347Q.

21. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to A116C and A338C.

22. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to T365C and V463C.

23. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to T127C and N153C.

24. The engineered protein of claim 7, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to T365C and Q455C.

25. The engineered protein of claim 7, further comprising at least one additional engineered disulfide bond.

26. The engineered protein of any one of claims 1-5, comprising a cavity filling substitution at a position corresponding to: G106, A107, T160, L158, I128, A190, V118, Q426, L165, V191, T160, S149, I137, S149, V169, N46, T49, V/I122, S192, T317, V162, L105, L134, A117, S347, V47, G261, I268, S470, V231, A374, I217, and/or S355.

27. The engineered protein of claim 26, comprising a cavity filling substitution at a position corresponding to: L105, V118, I137, S149, L158, L165 or Q426.

28. The engineered protein of claim 27, comprising a substitution corresponding to L105I or L105W.

29. The engineered protein of claim 27, comprising a substitution corresponding to L158W.

30. The engineered protein of claim 27, comprising a substitution corresponding to V118F or V118M.

31. The engineered protein of claim 27, comprising a substitution corresponding to Q426W.

32. The engineered protein of claim 27, comprising a substitution corresponding to L165F.

33. The engineered protein of claim 27, comprising a substitution corresponding to S149V or S149I.

34. The engineered protein of claim 33, further comprising a substitution at a position corresponding to I137.

35. The engineered protein of claim 34, comprising a substitution corresponding to I137L.

36. The engineered protein of claim 26, comprising a cavity filling substitution selected from the group consisting of: G106W, A107F, T160M, L158W, I128F, A190M, V118F, V118M, Q426W, L165F, V191I, T160V, S149V, I137L, S149I, V169I, N46V, T49I, V/I122L, S192L, T317L, V162F, V162W, L105I, L105F, L105W, L134I, A117M, S347M, S347K, S347Q, V47M, G261M, I268M, S470Y, V231I, A374V, I217V, and/or S355F.

37. The engineered protein of any one of claims 1-5, comprising a proline substitution selected from the group consisting of: A86P, A107P, A113P, T114P, V148P, S443P, D461P, L130P, L141P, K142P, E146P, L151P, N153P, V162P, A/D185P, D186P, L187P, K188P, N342P, and A344P.

38. The engineered protein of any one of claims 1-5, comprising a substitution at a position corresponding to S376, G366, and/or S194.

39. The engineered protein of claim 38, comprising a substitution corresponding to S376T, G366S, and/or S194Q.

40. The engineered protein of any one of claims 1-5, comprising a substitution at a position corresponding to K166.

41. The engineered protein of claim 40, comprising a substitution corresponding to K166E.

42. The engineered protein of any one of claims 1-5, comprising a substitution modulating pH sensitivity at a position corresponding to H435.

43. The engineered protein of claim 42, comprising a substitution corresponding to H435E, H435D or H435N.

44. The engineered protein of any one of claims 1-5, comprising an electrostatic interaction substitution at a position corresponding to L66, L73, N145, Q195, E453, L66, K188, H368, D461, T49 and/or V262.

45. The engineered protein of claim 44, comprising a substitution corresponding to L66N, L73E, N145E, Q195K, E453Q, L66D, K188R, H368R, D461E, T49E, and/or V262D.

46. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, L219K, V231I, N322C, T365C, E453Q, and/or V463C.

47. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to T127C, N153C, A185P, T365C, V463C, L219K, and V231I.

48. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to T127C, N153C, A185P, T365C, V463C, L219K, V231I, and RQSR (residues 99-102 of any one of SEQ ID NOs: 1-7) to RRRR (SEQ ID NO: 10).

49. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to T127C, N153C, T365C, V463C, L219K, and V231I.

50. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, A185P, L219K, V231I, N322C, T365C, N368H, E453Q, and V463C.

51. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, A185P, L219K, V231I, N322C, T365C, N368H, E453Q, V463C, and RQSR (residues 99-102 of any one of SEQ ID NOs: 1-7) to RRRR (SEQ ID NO: 10).

52. The engineered protein of any one of claims 1-5, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, L219K, V231I, N322C, T365C, N368H, E453Q, and V463C.

53. The engineered protein of any one of claims 6-52, comprising a substitution corresponding to residues 87-104 of any one of SEQ ID NOs: 1-7 to GGGGSGGGGSR (SEQ ID NO: 8).

54. The engineered protein of any one of claims 1-53, comprising a combination of at least one engineered disulfide bond, at least one cavity filling substitution and at least one proline substitution.

55. The engineered protein of claim 1-54, wherein the engineered protein comprises a polypeptide sequence at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, or 100% identical to SEQ ID NO: 14 or 16.

56. The engineered protein of claim 1-54, wherein the engineered protein comprises a polypeptide sequence at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, or 100% identical to SEQ ID NO: 15 or 17.

57. The engineered protein of any one of claims 1-56, having at least 95% identity to the amino acid sequences of SEQ ID NOs: 1-3.

58. The engineered protein of any one of claims 1-56, comprising an engineered hMPV F protein ectodomain having 95% identity to SEQ ID NO: 3.

59. The engineered protein of any one of claims 1-58, wherein the protein is fused or conjugated to a trimerization domain.

60. The engineered protein of claim 59, wherein the protein is fused to a trimerization domain.

61. The engineered protein of claim 60, wherein the trimerization domain comprises a T4 fibritin trimerization domain.

62. The engineered protein of any one of claims 1-58, wherein the protein is fused or conjugated to a transmembrane domain.

63. The engineered protein of claim 62, wherein the protein is fused to a transmembrane domain.

64. The engineered protein of claim 62, wherein the transmembrane domain comprises a metapneumovirus (MPV) F protein transmembrane domain.

65. The engineered protein of any one of claims 1-62, comprising an N-terminal signal sequence.

66. The engineered protein of claim 65, wherein the N-terminal signal sequence is MSWKVMIIISLLITPQHG (SEQ ID NO: 11).

67. An engineered metapneumovirus (MPV) F protein trimer comprising at least one subunit according to any one of claims 1-66.

68. The engineered trimer of claim 67, wherein the trimer is stabilized in a prefusion conformation relative to a trimer of wildtype metapneumovirus (MPV) F subunits.

69. The engineered trimer of claim 67, wherein the trimer comprises at least one engineered disulfide bond between subunits.

70. The engineered trimer of claim 69, wherein the at least one engineered disulfide bond between subunits is selected from: S316C and D421C.

71. A pharmaceutical composition comprising a pharmaceutically acceptable carrier; and (i) the engineered protein of any one of claims 1-66, or (ii) the engineered trimer of any one of claims 67-70.

72. The composition of claim 71, further comprising an adjuvant.

73. A nucleic acid molecule comprising a nucleotide sequence that encodes an amino acid sequence of the engineered protein of any one of claims 1-66.

74. The nucleic acid of claim 73, wherein the nucleic acid comprises a DNA expression vector.

75. The nucleic acid of claim 73, wherein the nucleic acid comprises a mRNA.

76. A method of preventing metapneumovirus (MPV) infection or a disease associate with metapneumovirus infection in a subject, comprising administering to the subject an effective amount of the pharmaceutical composition of any one of claims 71-72 or a nucleic acid molecule of any one of claims 73-75.

77. The pharmaceutical composition of any one of claims 71-72 or the nucleic acid molecule of any one of claims 73-75 for use in the treatment or prevention of a metapneumovirus (MPV) infection or a disease associate with metapneumovirus infection in a subject.

78. Use of the pharmaceutical composition of any one of claims 71-72 or the nucleic acid molecule of any one of claims 73-75 in the manufacture of a medicament for the treatment or prevention of a metapneumovirus (MPV) infection or a disease associate with metapneumovirus infection.

79. A composition comprising the engineered protein of any of claims 1-66 or the engineered trimer of any one of claims 67-70 bound to an antibody.

WHAT IS CLAIMED IS:

1. An engineered protein comprising a metapneumovirus (MPV) F protein ectodomain having at least 90% identity to amino acids 19-489 of any one of SEQ ID NOs: 4-7, said engineered protein comprising at least one mutation relative to the sequence of any one of SEQ ID NOs: 4-7, said at least one mutation comprising a substitution at a position corresponding to: V262, H435, N46, L158, L50, N457, N322, S291, S444, S355, S22, G53, E305, L302, V47, T127, G121, I128, A190, L165, S149, V/I122, S192, T317, L134, S347, I268, S265, F48, V231, I217, S194, L219, V148, L73, Q195, and/or E453.

2. The engineered protein of claim 1, further comprising a proline substitution corresponding to A/D185P.

3. The engineered protein of claim 1, further comprising a substitution of residues corresponding to positions 87-104 of any one of SEQ ID NOs: 4-7 to GGGGSGGGGSR (SEQ ID NO: 8).

4. The engineered protein of claim 1, further comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to A140C and A147C.

5. The engineered protein of claim 1, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to L110C and N322C.

6. The engineered protein of claim 1, comprising an engineered disulfide bond comprising paired cysteine substitutions corresponding to T127C and N153C.

7. The engineered protein of claim 6, further comprising substitutions at positions corresponding to L219 and V231.

8. The engineered protein of claim 6, further comprising substitutions corresponding to L219K and V231I.

9. The engineered protein of claim 6, further comprising paired cysteine substitutions corresponding to T365C and V463C.

10. The engineered protein of claim 6, further comprising paired cysteine substitutions corresponding to L110C and N322C.

11. The engineered protein of claim 6, further comprising paired cysteine substitutions corresponding to A140C and A147C.

12. The engineered protein of claim 6, further comprising a substitution corresponding to G366S.

13. The engineered protein of claim 1, comprising an electrostatic interaction substitution at a position corresponding to L66, L73, N145, Q195, E453, K188, H368, D461, T49 and/or V262.

14. The engineered protein of claim 13, comprising a substitution corresponding to L66N, L73E, N145E, Q195K, E453Q, L66D, K188R, H368R, D461E, T49E, and/or V262D.

15. The engineered protein of claim 1, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, L219K, V231I, N322C, T365C, E453Q, and/or V463C.

16. The engineered protein of claim 1, comprising substitutions corresponding to T127C, N153C, A185P, T365C, V463C, L219K, and V231I.

17. The engineered protein of claim 1, comprising substitutions corresponding to T127C, N153C, A185P, T365C, V463C, L219K, V231I, and RQSR (residues corresponding to positions 99-102 of any one of SEQ ID NOs: 4-7) to RRRR (SEQ ID NO: 10).

18. The engineered protein of claim 1, comprising substitutions corresponding to T127C, N153C, T365C, V463C, L219K, and V231I.

19. The engineered protein of claim 1, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, A185P, L219K, V231I, N322C, T365C, E453Q, and V463C.

20. The engineered protein of claim 1, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, A185P, L219K, V231I, N322C, T365C, E453Q, V463C, and RQSR (residues corresponding to positions 99-102 of any one of SEQ ID NOs: 4-7) to RRRR (SEQ ID NO: 10).

21. The engineered protein of claim 1, comprising substitutions corresponding to L110C, T127C, A140C, A147C, N153C, L219K, V231I, N322C, T365C, E453Q, and V463C.

22. The engineered protein of claim 1, wherein the engineered protein comprises a polypeptide sequence at least 95% identical to SEQ ID NO: 14.

23. The engineered protein of claim 1, wherein the engineered protein comprises a polypeptide sequence at least 95% identical to SEQ ID NO: 15.

24. The engineered protein of claim 1, having at least 95% identity to the amino acid sequence of SEQ ID NO: 2.

25. The engineered protein of claim 1, comprising an engineered hMPV F protein ectodomain having 95% identity to amino acids 19-489 of SEQ ID NO: 4.

26. The engineered protein of claim 1, wherein the protein is fused to a trimerization domain.

27. The engineered protein of claim 26, wherein the trimerization domain comprises a T4 fibritin trimerization domain.

28. A nucleic acid molecule comprising a nucleotide sequence that encodes an amino acid sequence of the engineered protein of any one of claims 1-27.

29. Use of the nucleic acid molecule of claim 28 in the manufacture of a medicament for preventing metapneumovirus (MPV) infection or a disease associated with metapneumovirus infection.

30. Use of the engineered protein of claim 1 in the manufacture of a medicament for preventing metapneumovirus (MPV) infection or a disease associated with metapneumovirus infection.