CLAIMS

We claim:

1. A recombinant poxvirus which is stable through successive passaging of the recombinant poxvirus, the recombinant poxvirus comprising a first nucleic acid encoding a MUC1 peptide having at least two Variable N-Terminal Repeat (VNTR) domains, wherein a) the order of the nucleic acids encoding the at least two VNTR domains are rearranged, and b) the at least two VNTR domains are codon optimized, wherein the recombinant poxvirus is stable through successive passaging of the recombinant poxvirus.

2. The recombinant poxvirus of claim 1, wherein the first nucleic acid comprises at least three VNTR domains.

3. The recombinant poxvirus of any one of claims 1-2, wherein the order of the at least two VNTR domains are rearranged.

4. The recombinant poxvirus of any one of claims 1-3, wherein the presence of a) and b) improves stability through successive passaging as compared to a recombinant poxvirus comprising a nucleic acid encoding a MUC1 peptide and having the sequence set forth in SEQ ID NO: 2.

5. The recombinant poxvirus of any one of claims 1-4 wherein the first nucleic acid sequence comprises a nucleic acid sequence having at least 95%, 96%, 97%, or 98% identity to SEQ ID NO:2.

6. The recombinant poxvirus of any one of claims 1-5, wherein the first nucleic acid sequence comprises SEQ ID NO:2.

7. The recombinant poxvirus of any one of claims 1-6, further comprising a second nucleic acid encoding a carcinoembryonic antigen (CEA).

8. The recombinant poxvirus of claim 7, wherein the second nucleic acid comprises SEQ ID NO:13.

9. The recombinant poxvirus of claim 7, wherein the second nucleic acid comprises at least one nucleotide substitution in at least one repetitive nucleotide region of the second nucleic acid, wherein the at least one repetitive nucleotide region is defined as a)

three more consecutively repeated G or C nucleotides and/or b) three or more consecutively repeated T nucleotides.

10. The recombinant poxvirus of claim 9, wherein the at least one repetitive nucleotide region is further defined as a) three or more consecutively repeated G nucleotides and/or b) three or more consecutively repeated C nucleotides.

11. The recombinant poxvirus of any one of claims 9 – 10, wherein the second nucleic acid comprises at least one substitution to at least 2, 3, 4, 5, or 10 of the repetitive nucleotide regions of the second nucleic acid.

12. The recombinant poxvirus of any one of claims 9 – 11, wherein the second nucleic acid comprises SEQ ID NO: 14.

13. The recombinant poxvirus of any one of the preceding claims, wherein the recombinant poxvirus is selected from an orthopoxvirus and an avipoxvirus.

14. The recombinant poxvirus of claim 13, wherein the orthopoxvirus is a vaccinia virus.

15. The recombinant poxvirus of claim 14, wherein the vaccinia virus is a modified vaccinia virus Ankara (MVA).

16. The recombinant poxvirus of claim 15, wherein the MVA is MVA-BN as deposited at the ECACC under number V00083008.

17. The recombinant poxvirus of any one of the preceding claims, wherein the recombinant poxvirus is stable through at least Passage 3 and/or Passage 4.

18. The recombinant poxvirus of claim 17, wherein the poxvirus is a fowlpox virus.

19. The recombinant poxvirus of any one of the preceding claims, wherein the first nucleic acid further comprises a nucleotide sequence encoding a peptide fragment selected from the group consisting of: YLAPPAHGV (SEQ ID NO:25), YLDTRPAPV (SEQ ID NO:26), YLAIVYLIAL (SEQ ID NO:27), YLIALAVCQV (SEQ ID NO:28), YLSYTNPAV (SEQ ID NO:29), SLFRSPYEK (SEQ ID NO:30), and combinations thereof.

20. The recombinant poxvirus of any one of the preceding claims, wherein the poxvirus further comprises a nucleic acid encoding one or more co-stimulatory molecules.

21. The recombinant poxvirus of claim 20, wherein the one or more co-stimulatory molecules are selected from B7-1, ICAM-1, LFA-3, and combinations thereof.

22. The recombinant poxvirus of claim 21, wherein the B7-1 nucleic acid is at least 80%, 85%, 90%, or 95% homologous to SEQ ID NOs: 15, 16, or 17.

23. The recombinant poxvirus of any one of claims 21-22, wherein the B7-1 nucleic acid comprises SEQ ID NO: 15, 16, or 17.

24. The recombinant poxvirus of claim 21, wherein the ICAM-1 nucleic acid is at least 80%, 85%, 90%, or 95% homologous to SEQ ID NOs: 18, 19, or 20.

25. The recombinant poxvirus of any one of claims 21 and 24, wherein the ICAM-1 nucleic acid comprises SEQ ID NO: 18, 19, or 20.

26. The recombinant poxvirus of claim 21, wherein the LFA-3 nucleic acid is at least 80%, 85%, 90%, or 95% homologous to SEQ ID NOs: 21, 22, or 23.

27. The recombinant poxvirus of claim 26, wherein the LFA-3 nucleic acid comprises SEQ ID NO: 21, 22, or 23.

28. An immunogenic composition comprising the recombinant poxvirus of any one of claims 1-27.

29. A recombinant poxvirus according to any one of claims 1 – 27 for use in treating cancer, wherein said recombinant poxvirus is to be administered as part of a heterologous prime-boost dose regimen of a vaccine.

30. The recombinant poxvirus for use of claim 29, wherein the heterologous prime-boost dosing regimen comprises:

a) one or more priming doses of a vaccinia virus; and

b) one or more boosting doses of a fowlpox virus.

31. The recombinant poxvirus of claim 22, further comprising an ICAM-1 nucleic acid that is at least 80%, 85%, 90%, or 95% homologous to SEQ ID NOs: 18, 19, or 20 and

an LFA-3 nucleic acid is at least 80%, 85%, 90%, or 95% homologous to SEQ ID NOs: 21, 22, or 23.