CLAIMS

1. A vector comprising a nucleotide sequence S1 encoding a CD8α polypeptide, a nucleotide sequence S2 encoding a CD8β polypeptide, a nucleotide sequence S3 encoding a T cell receptor (TCR)α polypeptide, and a nucleotide sequence S4 encoding a TCRβ polypeptide, wherein the nucleotide sequences are arranged in a 5' to 3' orientation of S2-S1-S4-S3.

2. The vector of claim 1, wherein the CD8α polypeptide comprises an amino acid sequence that is 100% identical to the CD8α polypeptide as comprised in SEQ ID NO: 11, and the CD8β polypeptide comprises an amino acid sequence that is 100% identical to the CD8β polypeptide as comprised in SEQ ID NO: 12, and wherein optionally the CD8α polypeptide and the CD8β polypeptide each comprise up to 10 conservative amino acid substitutions.

3. The vector of claim 1 or 2, further comprising a nucleotide sequence S5 encoding a 2A peptide and a nucleotide sequence S6 encoding a linker peptide, wherein S5 and S6 are positioned between S1 and S2, S1 and S4, and/or S3 and S4.

4. The vector of claim 3, wherein the 2A peptide is selected from P2A (SEQ ID NO: 3), T2A (SEQ ID NO: 4), E2A (SEQ ID NO: 5), and F2A (SEQ ID NO: 6).

5. The vector of claim 3 or 4, wherein the linker peptide is GSG or SGSG (SEQ ID NO: 8).

6. The vector of claim 1 or 2, further comprising a nucleotide sequence S7 encoding a furin peptide (SEQ ID NO: 2), wherein S7 is positioned between S1 and S2, S1 and S4, and/or S3 and S4.

7. The vector of claim 1 or 2, further comprising a seventh nucleotide sequence S7 encoding a furin peptide (SEQ ID NO: 2), wherein S7 is positioned between S1 and S2, S1 and S4, and/or S3 and S4.

8. The vector of claim 1 or 2, further comprising a post-transcriptional regulatory element (PRE) sequence selected from a Woodchuck PRE (WPRE) and a hepatitis B virus (HBV) PRE (HPRE).

9. The vector of claim 1 or 2, further comprising a promoter sequence that controls the transcription of the S1-S7, wherein the promoter sequence is selected from cytomegalovirus (CMV) promoter, phosphoglycerate kinase (PGK) promoter, myelin basic protein (MBP) promoter, glial fibrillary acidic protein (GFAP) promoter, modified MoMuLV LTR containing myeloproliferative sarcoma virus enhancer (MNDU3), Ubiquitin C promoter, EF-1 alpha promoter, or Murine Stem Cell Virus (MSCV) promoter.

10. The vector of claim 1 or 2, wherein said vector is a viral vector selected from adenoviruses, poxviruses, alphaviruses, arenaviruses, flaviviruses, rhabdoviruses, retroviruses, lentiviruses, herpesviruses, paramyxoviruses, and picornaviruses.

11. The vector of claim 10, wherein the vector is pseudotyped with an envelope protein of a virus selected from the native feline endogenous virus (RD114), a chimeric version of RD114 (RD114TR), gibbon ape leukemia virus (GaLV), a chimeric version of GaLV (GaLV-TR), amphotropic murine leukemia virus (MLV 4070A), baculovirus (GP64), vesicular stomatitis virus (VSV-G), fowl plague virus (FPV), Ebola virus (EboV), and lymphocytic choriomeningitis virus (LCMV), or baboon retroviral envelope glycoprotein (BaEV).

12. A method of preparing T cells for immunotherapy, wherein the method comprises

activating isolated T cells,

transducing the activated T cells with the vector of claim 1 or 2, and

expanding the transduced T cells.

13. The method of claim 12, wherein the T cells are isolated from a leukapheresis human sample.

14. The method of claim 12, wherein the activating is performed in the presence of an aminobisphosphonate selected from pamidronic acid, alendronic acid, zoledronic acid, risedronic acid, ibandronic acid, incadronic acid, a salt of any of the foregoing and/or a hydrate thereof.

15. The method of claim 12, wherein the activating is performed in the presence of interleukin-2 (IL-2) and/or interleukin-15 (IL-15).

16. The method of claim 12, wherein the expanding is performed in the presence of IL-2 and/or IL-15.

17. The method of claim 12, wherein the T cells comprise αβ T cells, γδ T cells, and/or natural killer T cells.

18. The method of claim 12, wherein the CD8α polypeptide, the CD8β polypeptide, the TCRα polypeptide, and the TCRβ polypeptide are co-expressed on the surface of the expanded T cells.

19. T cells prepared by the method of claim 12.

20. A composition comprising the T cells of claim 19 for use in the treatment of a patient who has cancer,

wherein the T cells kill cancer cells that present a peptide in a complex with an MHC molecule on the surface,

wherein the cancer is selected from the group consisting of non-small cell lung cancer, small cell lung cancer, melanoma, liver cancer, breast cancer, uterine cancer, Merkel cell carcinoma, pancreatic cancer, gallbladder cancer, bile duct cancer, colorectal cancer, urinary bladder cancer, kidney cancer, leukemia, ovarian cancer, esophageal cancer, brain cancer, gastric cancer, and prostate cancer.

21. The composition of claim 20, wherein the composition further comprises an adjuvant.

22. The composition of claim 21, wherein the adjuvant is selected from anti-CD40 antibody, imiquimod, resiquimod, GM-CSF, cyclophosphamide, sunitinib, bevacizumab, atezolizumab, interferon-alpha, interferon-beta, CpG oligonucleotides and derivatives, poly-(I:C) and derivatives, RNA, sildenafil, particulate formulations with poly(lactide co-glycolide) (PLG), virosomes, interleukin (IL)-1, IL-2, IL-4, IL-7, IL-12, IL-13, IL-15, IL-21, and IL-23.

23. A composition comprising the T cells of claim 19 for use in eliciting an immune response in a patient who has cancer,

wherein the T cells kill cancer cells that present a peptide in a complex with an MHC molecule on the surface,

wherein the cancer is selected from the group consisting of non-small cell lung cancer, small cell lung cancer, melanoma, liver cancer, breast cancer, uterine cancer, Merkel cell carcinoma, pancreatic cancer, gallbladder cancer, bile duct cancer, colorectal cancer, urinary bladder cancer, kidney cancer, leukemia, ovarian cancer, esophageal cancer, brain cancer, gastric cancer, and prostate cancer.

24. The composition of claim 23, wherein the composition further comprises an adjuvant.

25. The composition of claim 24, wherein the adjuvant is selected from anti-CD40 antibody, imiquimod, resiquimod, GM-CSF, cyclophosphamide, sunitinib, bevacizumab, atezolizumab, interferon-alpha, interferon-beta, CpG oligonucleotides and derivatives, poly-(I:C) and derivatives, RNA, sildenafil, particulate formulations with poly(lactide co-glycolide) (PLG), virosomes, interleukin (IL)-1, IL-2, IL-4, IL-7, IL-12, IL-13, IL-15, IL-21, and IL-23.

26. The composition of claim 23, wherein the immune response comprises a cytotoxic T cell response.

27. The method of claim 12, wherein the activating the T cells is performed in the presence of a statin; and the vector is pseudotyped with an envelope protein of VSV-G.

28. The method of claim 27, wherein the T cells comprise αβ T cells, γδ T cells, and/or natural killer T cells.

29. The method of claim 27, wherein the statin is selected from atorvastatin, cerivastatin, dalvastatin, fluindostatin, fluvastatin, mevastatin, pravastatin, simvastatin, velostatin, and rosuvastatin.

30. The method of claim 12, wherein the T cells comprise αβ T cells.

31. The method of claim 30, wherein the activating is performed in the presence of an anti-CD3 antibody and an anti-CD28 antibody.

32. The method of claim 30, wherein the expanding is performed in the presence of IL-7 and/or IL-15.

33. T cells prepared by the method of claim 30.

34. A composition comprising the T cells of claim 33 for use in the treatment of cancer,

wherein the T cells kill cancer cells that present a peptide in a complex with an MHC molecule on the surface,

wherein the cancer is selected from the group consisting of non-small cell lung cancer, small cell lung cancer, melanoma, liver cancer, breast cancer, uterine cancer, Merkel cell carcinoma, pancreatic cancer, gallbladder cancer, bile duct cancer, colorectal cancer, urinary bladder cancer, kidney cancer, leukemia, ovarian cancer, esophageal cancer, brain cancer, gastric cancer, and prostate cancer.