Claims:

1. A composition, comprising a first population of mesoporous silica particles and a viral vector.

2. The composition ~~according to~~of claim 1, wherein the viral vector is conjugated to the first population of mesoporous silica particles.

3. The composition ~~according to~~of claim 2, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.

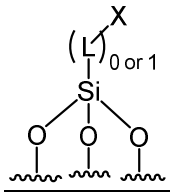
4. The composition ~~according to~~of claim 2, wherein the first population of mesoporous silica particles are surface modified.

5. The composition of claim 4, wherein the surface modification on the first population of mesoporous silica particles comprises a primary, secondary, tertiary, or quaternary amine.

6. The composition of claim 4 or 5, wherein the the surface modification on the first population of mesoporous silica particles comprises a polyethyleneimine.

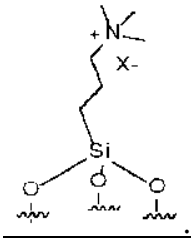
7. The composition of claim 5 or 6, wherein the polyethyleneimine or primary, secondary, tertiary, or quaternary amine is separated from the silica surface by a linker.

8. The composition of any one of claims 4-6, wherein the general structure of the surface modifications is as follows:



wherein L is a linker, and X is the primary, secondary, tertiary, or quaternary amine or polyethyleneimine.

9. The composition of any one of claims 4-8, wherein the surface modification on the first population of mesoporous silica particles comprises the following structure:



.

10. The composition of any one of claims 4-9, wherein the surface modification on the first population of mesoporous silica particles comprises:

(i) trimethylammonium;

(ii) N,N,N-trimethylpropan-1-ammonium; or

(iii) –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or (-O(CH2-CH_2-)$_{1-25}$ linker.

11. The composition of any one of claims 1-10, wherein the first population of mesoporous silica particles is covalently modified on their surface with a trialkoxysilyl compound or a trihydroxysilyl compound.

12. The composition of any one of claims 4-11, wherein the surface modification on the first population of mesoporous silica particles comprises a polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about 8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).

~~5. The composition according to claim 4, wherein the surface modification on the first population of mesoporous silica particles is –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or (-O(CH2-CH_2-)$_{1-25}$ linker.~~

~~6. The composition according to claim 5, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.~~

~~7. The composition according to claim 5, wherein the surface modification on the first population of mesoporous silica particles is a polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about 8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).~~

13. The composition of any one of the preceding claims, wherein:

(a) the mesoporous silica particles comprise pores of between 2-50 nm in diameter;

(b) the mesoporous silica particles have a surface area of at least about 100 m^2/g;

(c) the composition is suitable for injectable use.

~~8~~14. The composition ~~according to~~of any one of the preceding claims, wherein the viral vector is a retrovirus, adenovirus, adeno-associated virus, herpes virus, or lentivirus.

~~9~~15. The composition ~~according to~~of any one of the preceding claims, wherein the viral vector comprises ~~an expression vector comprising a recombinant polynucleotide comprising~~ an expression control sequence operatively linked to a nucleotide sequence ~~to be expressed~~.

~~10~~16. The composition ~~according to~~of claim ~~9~~15, wherein the nucleotide sequence encodes:

(i) a chimeric antigen receptor (CAR), an engineered TCR, one or more cytokines, one or more chemokines a polypeptide which targets a tumor antigen~~, an shRNA to block an inhibitory molecule, or wherein the nucleotide sequence comprises~~; or

(ii) an shRNA to block an inhibitory molecule or an mRNA to induce expression of a protein.

~~11. The composition according to claim 10, wherein the nucleotide sequence encodes a polypeptide engineered to target a tumor antigen.~~

~~12. The composition according to claim 11, wherein the polypeptide targets a tumor antigen selected from the group consisting of: TSHR, CD19, CD123, CD22, CD30, CD171, CS-1, CLL-1, CD33, EGFRvIII , GD2, GD3, BCMA, Tn Ag, PSMA, ROR1, FLT3, FAP, TAG72, CD38, CD44v6, CEA, EPCAM, B7H3, KIT, IL-13Ra2, Mesothelin, IL-11Ra, PSCA, PRSS21, VEGFR2, LewisY, CD24, PDGFR-beta, SSEA-4, CD20, Folate receptor alpha, ERBB2 (Her2/neu), MUC1, EGFR, NCAM, Prostase, PAP, ELF2M, Ephrin B2, IGF-I receptor, CAIX, LMP2, gp100, bcr-abl, tyrosinase, EphA2, Fucosyl GM1, sLe, GM3, TGS5, HMWMAA, o-acetyl-GD2, Folate receptor beta, TEM1/CD248, TEM7R, CLDN6, GPRC5D, CXORF61, CD97, CD179a, ALK, Polysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, MAGE-A1, legumain, HPV E6,E7, MAGE A1, ETV6-AML, sperm protein 17, XAGE1, Tie 2, MAD-CT-1, MAD-CT-2, Fos-related antigen 1, p53, p53 mutant, prostein, survivin and telomerase, PCTA-1/Galectin 8, MelanA/MART1, Ras mutant, hTERT, sarcoma translocation breakpoints, ML-IAP, ERG (TMPRSS2 ETS fusion gene), NA17, PAX3, Androgen receptor, Cyclin B1, MYCN, RhoC, TRP-2, CYP1B1, BORIS, SART3, PAX5, OY-TES1, LCK, AKAP-4, SSX2, RAGE-1, human telomerase reverse transcriptase, RU1, RU2, intestinal carboxyl esterase, mut hsp70-2, CD79a, CD79b, CD72, LAIR1, FCAR, LILRA2, CD300LF, CLEC12A, BST2, EMR2, LY75, GPC3, FCRL5, IGLL1, and any combination thereof.~~

~~13~~17. The composition ~~according~~ of ~~to any of~~ claim~~s~~ ~~10 to 12~~16, wherein the ~~protein is a~~ CAR ~~that~~ comprises an antigen binding domain, a transmembrane domain, a costimulatory signaling region, and a signaling domain.

~~14~~18. The composition ~~according to~~of claim ~~13~~17, wherein:

(i) the antigen binding domain binds a tumor antigen; and/or

(ii) the signaling domain is a CD3 zeta signaling domain.

19. The composition of any one of claims 16-18, wherein the tumor antigen is selected from TSHR, CD19, CD123, CD22, CD30, CD171, CS-1, CLL-1, CD33, EGFRvIII , GD2, GD3, BCMA, Tn Ag, PSMA, ROR1, FLT3, FAP, TAG72, CD38, CD44v6, CEA, EPCAM, B7H3, KIT, IL-13Ra2, Mesothelin, IL-11Ra, PSCA, PRSS21, VEGFR2, LewisY, CD24, PDGFR-beta, SSEA-4, CD20, Folate receptor alpha, ERBB2 (Her2/neu), MUC1, EGFR, NCAM, Prostase, PAP, ELF2M, Ephrin B2, IGF-I receptor, CAIX, LMP2, gp100, bcr-abl, tyrosinase, EphA2, Fucosyl GM1, sLe, GM3, TGS5, HMWMAA, o-acetyl-GD2, Folate receptor beta, TEM1/CD248, TEM7R, CLDN6, GPRC5D, CXORF61, CD97, CD179a, ALK, Polysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, MAGE-A1, legumain, HPV E6,E7, MAGE A1, ETV6-AML, sperm protein 17, XAGE1, Tie 2, MAD-CT-1, MAD-CT-2, Fos-related antigen 1, p53, p53 mutant, prostein, survivin and telomerase, PCTA-1/Galectin 8, MelanA/MART1, Ras mutant, hTERT, sarcoma translocation breakpoints, ML-IAP, ERG (TMPRSS2 ETS fusion gene), NA17, PAX3, Androgen receptor, Cyclin B1, MYCN, RhoC, TRP-2, CYP1B1, BORIS, SART3, PAX5, OY-TES1, LCK, AKAP-4, SSX2, RAGE-1, human telomerase reverse transcriptase, RU1, RU2, intestinal carboxyl esterase, mut hsp70-2, CD79a, CD79b, CD72, LAIR1, FCAR, LILRA2, CD300LF, CLEC12A, BST2, EMR2, LY75, GPC3, FCRL5, IGLL1, or a combination thereof.

~~15~~20. The composition of any one of the preceding claims, further comprising:

(i) a T cell stimulating compound or tumor antigen; and/or

(ii) a cytokine.

~~16~~21. The composition ~~according to~~of claim ~~15~~20, wherein the T cell stimulating compound or the tumor antigen ~~is conjugated to or adsorbed on the first population of mesoporous silica particles or a second population of mesoporous silica particles, and wherein the T-cell stimulating compound~~ is IL-2, IL-15, anti-CD2 mAb, anti-CD3 mAb, anti-CD28 mAb, neo-antigen peptides peptides from shared antigens such as TRP2, gp100, tumor cell lysate, CD19, CD20, CD22, ROR1, mesothelin, CD33/IL3Ra, c-Met, PSMA, Glycolipid F77, EGFRvIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or combinations thereof.

~~17. The composition according to claim 16, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed on the first population of mesoporous silica particles.~~

~~18~~22. The composition ~~according to~~ of any one of claims 1-~~16~~21, which further ~~comprising~~ comprises ~~the~~ a second population of mesoporous silica particles.~~, and~~

23. The composition of claim 22, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed:

(i) on the first population of mesoporous silica particles or the second population of mesoporous silica particles; or

(ii) to a lipid envelope on the surface of the second population of mesoporous silica particles.

~~19. The composition of any of claims 15 to 18, further comprising a cytokine.~~

~~20~~24. The composition of any one of claims ~~19~~20-23, wherein the cytokine ~~is~~:

(i) is conjugated to or adsorbed on the first or second population of mesoporous silica particles; and/or

(ii)~~.~~ is

~~21. The composition of any of claims 19 or 20, wherein the cytokine is~~ IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

~~22. The composition of any of the preceding claims, wherein the mesoporous silica particles comprise pores of between 2-50 nm in diameter.~~

~~23. The composition of any of the preceding claims, wherein the mesoporous silica particles have a surface area of at least about 100 m^2/g.~~

~~24. The composition of any of the preceding claims, wherein the composition is suitable for injectable use.~~

25. A method comprising ~~:~~

~~———~~contacting T lymphocytes with ~~a~~ the composition of any one of claims 1-24~~comprising a first population of mesoporous silica particles and a viral vector;~~

~~———wherein the viral vector comprises an expression vector comprising a recombinant polynucleotide comprising an expression control sequence operatively linked to a nucleotide sequence to be expressed~~.

26. The method of claim 25, wherein the method further comprises contacting the T lymphocytes with a T cell stimulating compound or tumor antigen.

~~26~~27. The method ~~according~~ of ~~to~~ claim 25 or 26, wherein the contacting occurs *in vitro* or *in vivo*.

~~27. The method according to claim 25, wherein the T lymphocytes are activated before or after contacting with the first population of mesoporous silica particles.~~

~~28. The method according to any of claims 25-27, wherein the viral vector is conjugated to the first population of mesoporous silica particles.~~

~~29. The method according to claim 28, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.~~

~~30. The method according to any of claims 25 to 29, wherein the first population of mesoporous silica particles are surface modified.~~

~~31. The method according to claim 30, wherein the surface modification on the first population of mesoporous silica particles is –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide,~~

azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or $(-O(CH_2-CH_2-)_{1-25}$ linker.

32. The method according to claim 31, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.

33. The method according to claim 31, wherein the first population of mesoporous silica particles are surface modified with polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about

~~8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).~~

~~34. The method according to any of claims 25 to 33, wherein the viral vector is a lentivirus, retrovirus, or adenovirus.~~

~~35. The method according to any of claims 25 to 34, wherein the nucleotide sequence encodes a chimeric antigen receptor (CAR).~~

~~36. The method according to claim 35, wherein the CAR is engineered to target a tumor antigen.~~ ~~37~~28. The method ~~according to~~of any one of claims 25~~ to 36~~-27, wherein the method further comprises activating the T lymphocytes~~ are activated~~ by contacting the T lymphocytes with a T cell stimulating compound or tumor antigen.

~~38. The method according to claim 37, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed on the first population of mesoporous silica particles or a second population of mesoporous silica particles.~~

~~39. The method according to claim 38, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed on the first population of mesoporous silica particles.~~

~~40. The method according to claim 39, wherein the T cell stimulating compound or tumor antigen is conjugated directly to the second population of mesoporous silica particles or to a lipid envelope on the surface of the second population of mesoporous silica particles.~~

~~41. The method of any of claims 25 to 40, further comprising contacting the T lymphocytes with a cytokine.~~

~~42. The method of claim 41, wherein the cytokine is in the medium or conjugated to or adsorbed on the first or second population of mesoporous silica particles.~~

~~43. The method of any of claims 40 to 42, wherein the cytokine is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.~~

44. A method of genetically transducing T lymphocytes with a recombinant polynucleotide *in vivo*, comprising:

administering to a subject, having one or more T lymphocytes, a composition comprising a first population of mesoporous silica particles and a viral vector;

wherein the viral vector comprises an expression vector comprising a recombinant polynucleotide comprising an expression control sequence operatively linked to a nucleotide sequence to be expressed, and

wherein when the composition contacts one or more T lymphocytes, the T lymphocytes are genetically transduced with the recombinant polynucleotide.

45. The method according to claim 44, wherein the viral vector is conjugated to the first population of mesoporous silica particles.

46. The method according to claim 45, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.

47. The method according to any of claims 44 to 46, wherein the first population of mesoporous silica particles are surface modified.

48. The method according to claim 47, wherein the surface modification on the first population of mesoporous silica particles is –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or $(-O(CH_2-CH_2-)_{1-25}$ linker.

49. The method according to claim 48, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.

50. The method according to any of claims 44 to 48, wherein the first population of mesoporous silica particles are surface modified with polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about

~~8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).~~

51. The method according to any of claims 44 to 50, wherein the viral vector is a lentivirus, retrovirus, or adenovirus.

52. The method according to any of claims 44 to 51, wherein the nucleotide sequence encodes a chimeric antigen receptor (CAR).

53. The method according to claim 51, wherein the CAR is engineered to target a tumor antigen.

54. The method according to any of claims 44 to 53, wherein the composition further comprises a T cell stimulating compound or tumor antigen conjugated to or adsorbed on the first population of mesoporous silica particles or a second population of mesoporous silica particles.

55. The method according to claim 54, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed on the first population of mesoporous silica particles.

56. The method according to claim 54, wherein the composition comprises the second population of mesoporous silica particles, and wherein the T cell stimulating compound or tumor antigen is conjugated directly to the second population of mesoporous silica particles or to a lipid envelope on the surface of the second population of mesoporous silica particles.

57. The method according to any of claims 44 to 56, wherein the first or second population of mesoporous silica particles further comprises a cytokine conjugated to or adsorbed on the first or second population of mesoporous silica particles.

58. The method according to claim 57, wherein the cytokine is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

59. The method according to any of claims 44 to 58, wherein the subject's T lymphocytes expand *in vivo*.

~~60~~29. A method of expanding a T lymphocyte population ~~*in vitro*~~, comprising

(a) contacting the T lymphocyte population with ~~a~~ the composition ~~comprising a first population of mesoporous silica particles and a viral vector to provide a transduced T lymphocyte population~~ of any one of claims 1-24; and

_____(b) contacting the ~~transduced~~ T lymphocyte population with a T cell stimulating compound or tumor antigen ~~and optionally, a cytokine;~~

~~wherein the viral vector comprises an expression vector comprising a recombinant polynucleotide comprising an expression control sequence operatively linked to a nucleotide sequence to be expressed~~.

~~61. The method according to claim 60, wherein the viral vector is conjugated to the first population of mesoporous silica particles.~~

~~62. The method according to claim 61, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.~~

~~63. The method according to any of claims 60 to 62, wherein the first population of mesoporous silica particles are surface modified.~~

~~64. The method according to claim 63, wherein the surface modification on the first population of mesoporous silica particles is –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or $(-O(CH_2-CH_2-)_{1-25}$ linker.~~

~~65. The method according to claim 64, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.~~

~~66. The method according to any of claims 60 to 65, wherein the first population of mesoporous silica particles are surface modified with polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about 8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).~~

~~67. The method according to any of claims 60 to 66, wherein the viral vector is a lentivirus, retrovirus, or adenovirus.~~

~~68. The method according to any of claims 60 to 67, wherein the nucleotide sequence encodes a chimeric antigen receptor (CAR).~~

~~69. The method according to claim 68, wherein the CAR is engineered to target a tumor antigen.~~

~~70~~30. The method ~~according to any~~ of claim~~s~~ 28 or 29~~60 to 69~~, wherein the T cell stimulating compound or tumor antigen ~~is conjugated to or adsorbed on the first population of mesoporous silica particles or a second population of mesoporous silica particles, and wherein the T-cell stimulating compound or tumor antigen~~ is IL-2, IL-15, anti-CD2 mAb, anti-CD3 mAb, anti-CD28 mAb, neo-antigen peptides, CD19, CD20, CD22, ROR1, mesothelin, CD33/IL3Ra, c-Met, PSMA, Glycolipid F77, EGFRvIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or combinations thereof.

~~71~~31. The method ~~according to~~ of any one of claims 28-30~~70~~, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed:

(i) on the first population of mesoporous silica particles or a second population of mesoporous silica particles; and/or

(ii) ~~.~~

~~72. The method according to claim 70, comprising the second population of mesoporous silica particles, and wherein the T cell stimulating compound or tumor antigen is conjugated to the second population of mesoporous silica particles or~~ to a lipid envelope on the surface of ~~the~~ a second population of mesoporous silica particles.

~~73~~32. The method of any one of claims ~~60 to 72~~25-31, further comprising~~:~~

~~(c)~~ contacting the T lymphocytes with a cytokine; optionally,

wherein the cytokine is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

33. A pharmaceutical composition comprising the composition of any one of claims 1-24, and a pharmaceutically acceptable excipient.

34. Use of the composition of any one of claims 1-24 or the pharmaceutical composition of claim 33, in the manufacture of a medicament for treating a subject having a disease, disorder, or condition associated with a tumor antigen.

35. The use of claim 34, wherein the disease, disorder, or condition associated with a tumor antigen is a cancer.

~~74. A method of treating a subject having a disease, disorder, or condition associated with an elevated expression of a tumor antigen, the method comprising:~~

administering to the subject a composition comprising a first population of mesoporous silica particles and a viral vector,

wherein the viral vector comprises a recombinant polynucleotide comprising an expression control sequence operatively linked to a nucleotide sequence that encodes a chimeric antigen receptor (CAR) that is engineered to target the tumor antigen,

thereby treating the subject.

75. The method according to claim 74, wherein the viral vector is conjugated to the first population of mesoporous silica particles.

76. The method according to claim 75, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.

77. The method according to any of claims 74 to 76, wherein the first population of mesoporous silica particles are surface modified.

78. The method according to claim 77, wherein the surface modification on the first population of mesoporous silica particles is –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or $(-O(CH_2-CH_2-)_{1-25}$ linker.

79. The method according to claim 78, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.

80. The method according to any of claims 74 to 78, wherein the first population of mesoporous silica particles are surface modified with polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about 8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).

~~81. The method according to any of claims 74 to 80, wherein the viral vector is a lentivirus, retrovirus, or adenovirus.~~

82. The method according to any of claims 74 to 81, wherein the composition further comprises a T cell stimulating compound or tumor antigen conjugated to or adsorbed on the first population of mesoporous silica particles or a second population of mesoporous silica particles.

83. The method according to claim 82, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed on the first population of mesoporous silica particles.

84. The method according to claim 83, wherein the composition comprises the second population of mesoporous silica particles, and wherein the T cell stimulating compound or tumor antigen is conjugated directly to the second population of mesoporous silica particles or to a lipid envelope on the surface of the second population of mesoporous silica particles, and wherein the T-cell stimulating compound or tumor antigen is IL-2, IL-15, anti-CD2 mAb, anti-CD3 mAb, anti-CD28 mAb, neo-antigen peptides, CD19, CD20, CD22, ROR1, mesothelin, CD33/IL3Ra, c-Met, PSMA, Glycolipid F77, EGFRvIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or combinations thereof.

85. The method according to any of claims 74 to 84, wherein the first or second population of mesoporous silica particles further comprises a cytokine conjugated to or adsorbed on the first or second population of mesoporous silica particles.

86. The method according to claim 85, wherein the cytokine is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

87. A method of delivering a viral vector to a desired site of action in a subject, comprising administering to the subject a composition comprising a first population of mesoporous silica particles and the viral vector.

88. The method according to claim 87, wherein the viral vector is conjugated to the first population of mesoporous silica particles.

~~89. The method according to claim 88, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.~~

90. The method according to any of claims 87 to 89, wherein the first population of mesoporous silica particles are surface modified.

91. The method according to claim 90, wherein the surface modification on the first population of mesoporous silica particles is C_{1-20} alkyl amine, C_{1-20} carboxylic acid, C_{1-20} azide, and substituted or unsubstituted C_{1-20} alkyl.

92. The method according to claim 91, wherein the surface modification on the first population of mesoporous silica particles is a primary, secondary, tertiary, or quarternary amine.

93. The method according to any of claims 87 to 92, wherein the viral vector is a retrovirus, adenovirus, adeno-associated virus, herpes virus, or lentivirus.

94. The method according to any of claims 87 to 93, wherein the first population of mesoporous silica particles comprise pores of between 2-50 nm in diameter.

95. The method of any of claims 87 to 94, wherein the first population of mesoporous silica particles have a surface area of at least about 100 m^2/g.

96. A method of expanding a chimeric antigen receptor (CAR) T (CAR-T) cell population, comprising contacting the CAR-T cell population with mesoporous silica particles conjugated to a targeting moiety, wherein the targeting moiety is complementary to the CAR.

97. The method according to claim 96, wherein the CAR is a protein engineered to target a tumor antigen.

98. The method according to any of claims 96 or 97, wherein the tumor antigen is selected from the group consisting of selected from the group consisting of: TSHR, CD19, CD123, CD22, CD30, CD171, CS-1, CLL-1, CD33, EGFRvIII , GD2, GD3, BCMA, Tn Ag, PSMA, ROR1, FLT3, FAP, TAG72, CD38, CD44v6, CEA, EPCAM, B7H3, KIT, IL-13Ra2, Mesothelin, IL-11Ra, PSCA, PRSS21, VEGFR2, LewisY, CD24, PDGFR-beta, SSEA-4, CD20, Folate receptor

~~alpha, ERBB2 (Her2/neu), MUC1, EGFR, NCAM, Prostase, PAP, ELF2M, Ephrin B2, IGF-I receptor, CAIX, LMP2, gp100, bcr-abl, tyrosinase, EphA2, Fucosyl GM1, sLe, GM3, TGS5, HMWMAA, o-acetyl-GD2, Folate receptor beta, TEM1/CD248, TEM7R, CLDN6, GPRC5D, CXORF61, CD97, CD179a, ALK, Polysialic acid, PLAC1, GloboH, NY-BR-1,~~

~~UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, MAGE-A1, legumain, HPV E6,E7, MAGE-A1, ETV6-AML, sperm protein 17, XAGE1, Tie-2, MAD-CT-1, MAD-CT-2, Fos-related antigen 1, p53, p53 mutant, prostein, survivin and telomerase, PCTA-1/Galectin-8, MelanA/MART1, Ras mutant, hTERT, sarcoma translocation breakpoints, ML-IAP, ERG (TMPRSS2 ETS fusion gene), NA17, PAX3, Androgen receptor, Cyclin B1, MYCN, RhoC, TRP-2, CYP1B1, BORIS, SART3, PAX5, OY-TES1, LCK, AKAP-4, SSX2, RAGE-1, human telomerase reverse transcriptase, RU1, RU2, intestinal carboxyl esterase, mut hsp70-2, CD79a, CD79b, CD72, LAIR1, FCAR, LILRA2, CD300LF, CLEC12A, BST2, EMR2, LY75, GPC3, FCRL5, IGLL1, and any combination thereof.~~

~~99. The composition according to any of claims 1-24, or the methods according to any of claims 25-98, wherein the mesoporous silica particles are in the form of mesoporous silica rods.~~

~~100. A composition comprising mesoporous silica particles conjugated to poyethylenimine.~~

~~101. The composition of claim 100, wherein the mesoporous silica particles are in the form of mesoporous silica rods.~~

~~102. The composition of claim 100 or 101, further comprising an active agent.~~

~~103. The composition of claim 102, wherein the active agent is conjugated to or adsorbed on the mesoporous silica particles.~~

~~104. A method of delivering an active agent to a desired site of action in a subject, comprising administering to the subject the composition of claim 102 or 103.~~
~~105. The method according to claim 104, wherein the composition provides sustained delivery of the active agent to the subject.~~

~~106. A method of treating a subject having a disease, disorder, or condition, the method comprising: administering to the subject the composition of claim 102 or 103.~~

~~107. The method of claim 106, wherein the disease, disorder, or condition is associated with a tumor antigen.~~