Claims:

1. An antigen-presenting synthetic surface for activating a T lymphocyte (T cell), comprising:

    a plurality of primary activating molecular ligands, wherein each primary activating molecular ligand comprises a major histocompatibility complex (MHC) Class I molecule configured to bind to a T cell receptor (TCR) of the T cell; and,

    a plurality of co-activating molecular ligands each comprising a TCR co-activating molecule or an adjunct TCR activating molecule,

    wherein each of the plurality of primary activating molecular ligands and the plurality of co-activating molecular ligands is specifically bound to the antigen presenting surface;

    wherein a ratio of the TCR co-activating molecules to the adjunct TCR activating molecules is 10:1 to 1:10~~20:1 to 1:20~~;

    wherein the TCR co-activating molecule comprises a CD28 binding protein or a fragment thereof which retains binding ability with CD28, and the adjunct TCR activating molecule comprises a CD2 binding protein or a fragment thereof which retains binding ability with CD2, a CD27 binding protein or a fragment thereof which retains binding ability with CD27, or a CD137 binding protein or a fragment thereof which retains binding ability with CD137.

2. The antigen-presenting synthetic surface of claim 1, wherein the plurality of primary activating molecular ligands is disposed upon at least a portion of the antigen-presenting synthetic surface at a density from $4x10^2$ to $3x\ 10^4$ molecules per square micron.

3. The antigen-presenting synthetic surface of claim 1 or claim 2, further comprising a plurality of surface-blocking molecular ligands.

4. The antigen-presenting synthetic surface of any one of claims 1-3, wherein the plurality of co-activating molecular ligands is disposed upon at least a portion of the antigen-presenting synthetic surface at a density from $5x\ 10^3$ to $2x\ 10^4$ molecules per square micron.

5. The antigen-presenting synthetic surface of any one of claims 1-4, wherein a ratio of the primary activating molecular ligands to the co-activating molecular ligands present on the antigen-presenting synthetic surface is 1:10 to 2:1.

6. The antigen-presenting synthetic surface of any one of claims 1-5, wherein:
(i) the antigen-presenting synthetic surface comprises glass, metal, ceramic, and/or a metal oxide; and/or
(ii) the antigen-presenting synthetic surface comprises a polymeric surface.

7. The antigen-presenting synthetic surface of any one of claims 1-6, wherein each of the plurality of primary activating molecular ligands is noncovalently bound to a binding moiety, and further wherein the binding moiety is (i) covalently bound to the antigen-presenting synthetic surface or (ii) noncovalently bound to a second binding moiety that is covalently bound to the surface.

8. The antigen-presenting synthetic surface of any one of claims 1-7, wherein the MHC Class I molecule comprises an MHC protein sequence and a beta microglobulin.

9. The antigen-presenting synthetic surface of any one of claims 1-8, wherein the MHC Class I molecule further comprises a tumor associated antigen associated thereto.

10. The antigen-presenting synthetic surface of claim 9, wherein the tumor associated antigen is SLC45A2, TCL1, VCX3A, MART1 or NYESO1.

11. The antigen-presenting synthetic surface of any one of claims 1-10, wherein:
~~(i) the TCR co-activating molecule comprises a CD-28 binding protein or a fragment thereof which retains binding ability with CD28; or~~
~~(ii)~~ the TCR co-activating molecule comprises an anti-CD28 antibody or a fragment thereof, wherein the fragment retains binding activity with CD28.

12. The antigen-presenting synthetic surface of any one of claims 1-11, wherein:
(i) the adjunct TCR activating molecule comprises a CD2 binding protein or a fragment thereof, wherein the fragment retains binding activity with CD2; or
(ii) the adjunct TCR activating molecule comprises an anti-CD2 antibody or a fragment thereof, wherein the fragment retains binding activity with CD2.

13. The antigen-presenting synthetic surface of claim ~~4~~3, wherein each of the plurality of surface-blocking molecular ligands comprises a polyethylene glycol (PEG) moiety, a carboxylic acid moiety, or a combination thereof.

14. The antigen-presenting synthetic surface of any one of claims 1-13, wherein the ratio of the TCR co-activating molecules to the adjunct TCR activating molecules of the plurality of co-activating molecular ligands is from 3:1 to 1:3.

15. The antigen-presenting synthetic surface of any one of claims 1-14, wherein the antigen presenting surface is the surface of a bead.

16. A method of activating T lymphocytes (T cells) comprising:

contacting a plurality of T cells with an antigen-presenting synthetic surface comprising:

a plurality of primary activating molecular ligands, each comprising a major histocompatibility (MHC) Class I molecule configured to bind to a T cell receptor of the T cells; and

a plurality of co-activating molecular ligands presented on the antigen-presenting synthetic surface, each comprising a T cell receptor (TCR) co-activating molecule or an adjunct TCR activating molecule;

a plurality of surface-blocking molecular ligands; and

culturing the plurality of T cells in contact with the antigen-presenting synthetic surface, thereby converting at least a portion of the plurality of T cells to activated T cells;

wherein a ratio of the TCR co-activating molecules to the adjunct TCR activating molecules is 10:1 to 1:10~~20:1 to 1:20~~;

wherein the TCR co-activating molecule comprises a CD28 binding protein or a fragment thereof which retains binding ability with CD28, and the adjunct TCR activating molecule comprises a CD2 binding protein or a fragment thereof which retains binding ability with CD2, a CD27 binding protein or a fragment thereof which retains binding ability with CD27, or a CD137 binding protein or a fragment thereof which retains binding ability with CD137.

17. A method of activating T lymphocytes (T cells) comprising:

contacting a plurality of T cells with the antigen-presenting synthetic surface of any one of claims 1-15; and

culturing the plurality of T cells in contact with the antigen-presenting synthetic surface, thereby converting at least a portion of the plurality of T cells to activated T cells.

18. The method of claim 16 or claim 17, wherein the T cells comprise CD8+ T cells.

19. The method of any one of claims 16-18, further comprising contacting the plurality of T cells with a plurality of growth stimulatory molecular ligands.

20. The method of claim 19, wherein each of the growth stimulatory molecular ligands comprises a growth factor receptor ligand.

21. The method of claim 20, wherein the growth factor receptor ligand comprises IL-21 or a IL-21 receptor ligand fragment thereof.

22. The method of any one of claims 16-21, wherein the culturing in contact with the antigen-presenting synthetic surface is performed for a period from four days to seven days.

23. The method of any one of claims 16-22, further comprising:

completing a first period of activation in contact with the antigen-presenting synthetic surface, wherein the antigen-presenting synthetic surface is a first antigen-presenting synthetic surface;

contacting the plurality of activated T cells with a second antigen-presenting synthetic surface comprising a plurality of primary activating molecular ligands, each comprising a MHC molecule, and a plurality of co-activating molecular ligands each comprising a T cell receptor (TCR) co-activating molecule or an adjunct TCR activating molecule; and,

culturing the plurality of activated T cells in contact with the second antigen-presenting synthetic surface for a second period of culturing, thereby providing an expanded plurality of activated T cells.

24. The method of claim 23, wherein the second antigen-presenting synthetic surface is the surfaces of a plurality of antigen-presenting beads, wherein said plurality of antigen-presenting beads is added in a 1:1 ratio to the plurality of activated T cells.

25. The method of any one of claims 16-24, wherein the activated T cells are CD45RO+.

26. The method of any one of claims 16-25, wherein the activated T cells are CD28 positive.

27. The method of claim 17, wherein the antigen presenting synthetic surface is the surface of a bead, and.

28. The method of claim 27, wherein the plurality of T cells is contacted with antigen-presenting beads in a ratio of antigen-presenting beads to cells of about 1:1.

29. A method of performing an antigen-specific cytotoxicity assay within a microfluidic device comprising:

a flow region containing a first liquid medium; and

a sequestration pen comprising an isolation region and a connection region, wherein the connection region has a proximal opening to the flow region and a distal opening to the isolation region and the isolation region opens to the connection region, wherein said isolation region of said first sequestration pen is an unswept region of said flow region, the method comprising:

loading one or more target cells into a sequestration pen of the microfluidic device;

loading one or more T cells in the sequestration pen, such that the one or more T cells can contact the one or more target cells; wherein the one or more T cells are produced by the method of any one of claims 16-28;

contacting the target cells with a detectable marker that labels apoptotic cells; and

detecting whether the target cells become apoptotic.