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(54) **Title**: COMBINATIONS OF LOW, IMMUNE ENHANCING. DOSES OF MTOR INHIBITORS AND CARS

(57) **Abstract**: The invention relates, in part, to a method of treating a subject comprising administering to the subject a low, immune enhancing of a mTOR inhibitor and an immune effector cell engineered to expres a CAR.

# COMBINATIONS OF LOW, IMMUNE ENHANCING, DOSES OF MTOR INHIBITORS AND CARs

## RELATED APPLICATIONS

[001] This application claims priority to U.S. Serial No. 62/027152 filed July 21, 2014, U.S. Serial No. 62/076197 filed Nov 6, 2014, and U.S. Serial No. 62/164357 filed May 20, 2015, the contents of which are incorporated herein by reference in their entireties.

## SEQUENCE LISTING

[002] The instant application contains a Sequence Listing which has been submitted electronically in ASCII format and is hereby incorporated by reference in its entirety. Said ASCII copy, created on July 21, 2015, is named N2067-7065WO_SL.txt and is 169,256 bytes in size.

## FIELD OF THE INVENTION

[003] The invention relates generally to the administration of a low, immune enhancing dose of an mTOR inhibitor in combination with immune effector cells (e.g., T cells or NK cells) engineered to express a Chimeric Antigen Receptor (CAR) to treat a disease, e.g., a disease associated with expression of a tumor marker.

## BACKGROUND

[004] Functional and effective T-cell responses play an important role in effective immune responses, for example, against infectious diseases and cancer. However, under certain conditions, such as chronic infection or cancer, effector T cells can be suppressed by various immunosuppressive mechanisms, including (PD-L1)/programmed death-1 (PD-1) interaction, leading to T-cell exhaustion (Pen et al. Gene Therapy 21, 262-271, 2014). It is thought that programmed death ligand-1 PD-L1 is normally expressed by most cell types, while its receptor PD-1 is only present on certain immune cells, such as activated T cells and regulatory T (Treg)

cells. It is also thought that PD-L1/PD-1 binding is important in the maintenance of peripheral T-cell tolerance, preventing autoimmune responses. On the other hand, high levels of PD-1 expression generally correlate with loss of T cell function, leading to increased viral load in cases of viral infection (Pen et al. Gene Therapy 21, 262-271, 2014).

## SUMMARY OF THE INVENTION

[005] Methods and compositions disclosed herein are directed to the administration of a low, immune enhancing dose of an mTOR inhibitor and immune effector cells (e.g., T cells or NK cells) engineered to express a Chimeric Antigen Receptor (CAR), to treat a disease, e.g., a disease associated with expression of a cancer associated antigen (or tumor marker).

[006] It has been discovered that partial mTOR inhibition, e.g., with low, immune enhancing, doses of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, such as RAD001, is effective in improving immune function in a subject, and can be combined with CAR therapy to treat the subject. While not wishing to be bound by theory, it is believed that treatment with a low, immune enhancing, dose (e.g., a dose that is insufficient to completely suppress the immune system but sufficient to improve immune function) of an mTOR inhibitor is accompanied by a decrease in PD-1 positive T cells or an increase in PD-1 negative cells. PD-1 positive T cells, but not PD-1 negative T cells, can be exhausted by engagement with cells which express a PD-1 ligand, e.g., PD-L1 or PD-L2. In addition or alternatively, again without wishing to be bound by theory, it is believed that treatment with a low, immune enhancing, dose of an mTOR inhibitor can increase naive T cell numbers, e.g., at least transiently, e.g., as compared to a non-treated subject. In addition or alternatively, again without wishing to be bound by theory, it is believed that treatment with a low, immune enhancing, dose of an mTOR inhibitor, after a sufficient amount of time or sufficient dosing, results in an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; and an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2; wherein any of the changes described above occurs, e.g., at least transiently, e.g., as compared to a non-treated subject. Thus,

embodiments of the invention are based, at least in part, on the recognition that partial mTOR inhibition, e.g., with low, immune enhancing, dose of an mTOR inhibitor, is associated with a reduction in the percentage of programmed death (PD)-1 positive CD4 and CD8 T lymphocytes.

[007] In an embodiment this approach can be used to optimize the performance of immune effector cells, e.g., T cells, in the subject. While not wishing to be bound by theory, it is believed that, in an embodiment, the performance of endogenous, non-modified immune effector cells, e.g., T cells, is improved. While not wishing to be bound by theory, it is believed that, in an embodiment, the performance of immune effector cells, e.g., T cells, that are harvested to be engineered to express a CAR, is improved. In other embodiments, immune effector cells, e.g., T cells, which have, or will be engineered to express a CAR, can be treated ex vivo by contact with an amount of an mTOR inhibitor that increases the number of PD1 negative immune effector cells, e.g., T cells or increases the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells.

[008] Accordingly, in one aspect, the present invention relates to a method of treating, e.g., promoting an immune response in, a subject, e.g., a human subject, comprising,

a) administering to the subject a low, immune enhancing, dose of an mTOR inhibitor, e.g., RAD001 or rapamycin, and

b) administering to the subject, an immune effector cell, e.g., a T cell, engineered to express a CAR,

thereby treating, e.g., enhancing, an immune response in the subject.

[009] In an embodiment, the CAR comprises an antigen binding domain (e.g., antibody or antibody fragment, TCR or TCR fragment) a transmembrane domain, and an intracellular signaling domain (e.g., an intracellular signaling domain comprising a costimulatory domain and/or a primary signaling domain). In an embodiment, the antigen binding domain binds a cancer associated antigen (or tumor marker). In an embodiment, the cancer associated antigen (or tumor marker) is a solid cancer associated antigen (or a solid tumor marker). In an embodiment, the cancer associated antigen (or tumor marker) is a hematological cancer marker.

[0010] In an embodiment, administration of the low, immune enhancing, dose of an mTOR inhibitor is initiated prior to administration of the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR.

[0011] In an embodiment, administration of the low, immune enhancing, dose of an mTOR inhibitor, is completed prior to administration of the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR.

[0012] In an embodiment, administration of the low, immune enhancing, dose of an mTOR inhibitor overlaps with the administration of the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR.

[0013] In an embodiment, administration of the low, immune enhancing, dose of an mTOR inhibitor continues after the administration of the immune effector cell, e.g., T cellor NK cell, engineered to express a CAR.

[0014] In an embodiment, the immune effector cell, e.g., T cell, engineered to express a CAR, is administered after a sufficient time, or after sufficient dosing of the low, immune enhancing, dose of an mTOR inhibitor, such that the level of PD1 negative immune effector cells, e.g., T cells, or the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, has been, at least transiently, increased.

[0015] In an embodiment, the immune effector cell, e.g., T cell, to be engineered to express a CAR, is harvested after a sufficient time, or after sufficient dosing of the low, immune enhancing, dose of an mTOR inhibitor, such that the level of PD1 negative immune effector cells, e.g., T cells, or the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, in the subject or harvested from the subject has been, at least transiently, increased.

[0016] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered for an amount of time sufficient to decrease the proportion of PD-1 positive T cells, increase the proportion of PD-1 negative T cells, or increase the ratio of PD-1 negative T cells/ PD-1 positive T cells, in the peripheral blood of the subject, or in a preparation of T cells isolated from the subject.

[0017] In an embodiment, the method of treating, e.g., promoting an immune response in, a subject, e.g., a human subject, comprises inhibiting a negative immune response mediated by the engagement of PD-1 with PD-L1 or PD-L2.

[0018] In an embodiment, the method of treating, e.g., promoting an immune response in, a subject, e.g., a human subject, comprises increasing the number of T cells capable of proliferation.

[0019] In an embodiment, the method of treating, e.g., promoting an immune response in, a subject, e.g., a human subject, comprises increasing the number of T cells capable of cytotoxic function, secreting cytokines, or activation.

[0020] In an embodiment, the administering of the low, immune enhancing, dose of an mTOR inhibitor results in the partial, but not total, inhibition of mTOR for at least 1, 5, 10, 20, 30, or 60 days.

[0021] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered prior to administration of immune effector cells, e.g., T cells to be engineered to express an CAR, (e.g., prior to or after harvest of the immune effector cells) for an amount of time sufficient for one or more of the following to occur:

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated subject. In an embodiment, the immune effector cell, e.g., T cell, to be engineered to

express a RCAR, is harvested at least 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, or 60 days after initiation, or completion, of dosing with the low, immune enhancing, dose of an mTOR inhibitor.

[0022] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered prior to harvest of immune effector cells, e.g., T cells to be engineered to express an CAR, for an amount of time sufficient for one or more of the following to occur e.g., to occur in the harvested cells or in the engineered cells (or in non-harvested cells, or in both):

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated subject. In an embodiment, the immune effector cell, e.g., T cell, to be engineered to express a RCAR, is harvested at least 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, or 60 days after initiation, or completion, of dosing with the low, immune enhancing, dose of an mTOR inhibitor.

[0023] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered after harvest of immune effector cells, e.g., T cells to be engineered to express an CAR, for an amount of time sufficient for one or more of the following to occur:

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated subject.

[0024] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered after administration of immune effector cells, e.g., T cells to be engineered to express an CAR, for an amount of time sufficient for one or more of the following to occur:

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated subject.

[0025] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is administered to immune effector cells, e.g., T cells, which have, or will be engineered to express a RCAR, ex vivo for an amount of time sufficient for one or more of the following to occur:

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated cell.

[0026] In an embodiment, the mTOR inhibitor is an allosteric mTOR inhibitor. In an embodiment, the mTOR inhibitor is a RAD001. In an embodiment, the mTOR inhibitor is rapamycin.

[0027] In an embodiment, the mTOR inhibitor is a catalytic inhibitor, e.g., a kinase inhibitor. In an embodiment, the kinase inhibitor is selective for mTOR. In an embodiment, the kinase inhibitor is selected from BEZ235 and CCG168.

[0028] In an embodiment, the low, immune enhancing, dose comprises a plurality of mTOR inhibitors. In an embodiment, the dose comprises an allosteric and a catalytic mTOR inhibitor.

[0029] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is associated with mTOR inhibition of at least 5 but no more than 90%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[0030] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is associated with mTOR inhibition of at least 10% but no more than 80%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[0031] In an embodiment, the low, immune enhancing, dose of an mTOR inhibitor is associated with mTOR inhibition of at least 10% but no more than 40%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[0032] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in an immediate release dosage form, 0.1 to 20, 0.5 to 10, 2.5 to 7.5, 3 to 6, or about 5, mgs of RAD001.

[0033] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, once per week, in an immediate release dosage form, about 5 mgs of RAD001.

[0034] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a one per week, immediate release dosage form of 0.1 to 20, 0.5 to 10, 2.5 to 7.5, 3 to 6, or about 5 mgs of RAD001.

[0035] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, once per week, in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, immediate release dosage form of about 5 mgs of RAD001.

[0036] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of RAD001.

[0037] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, once per week, in a sustained release dosage form, about 15 mgs of RAD001.

[0038] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, sustained release dosage form of 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of RAD001.

[0039] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, once per week, in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week sustained release dosage form of about 15 mgs of RAD001.

[0040] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in an immediate release dosage form, 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs of RAD001.

[0041] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering once per day, in an immediate release dosage form, about 0.5 mgs of RAD001.

[0042] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, immediate release dosage form of 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs of RAD001.

[0043] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, once per day, in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, immediate release dosage form of about 0.5 mgs of RAD001.

[0044] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in a sustained release dosage form, 0.015 to 4.5, 0.03 to 4.5, 0.3 to 4.5, 0.6 to 4.5, 0.9 to 4.5, 1.2 to 4.5, 1.5 to 4.5, 1.8 to 4.5, 2.1 to 4.5, 2.4 to 4.5, 3.0 to 4.5, 0.9 to 1.8, or about 1.5 mgs of RAD001.

[0045] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, sustained release dosage form of 0.015 to 4.5, 0.03 to 4.5, 0.3 to 4.5, 0.6 to 4.5, 0.9 to 4.5, 1.2 to 4.5, 1.5 to 4.5, 1.8 to 4.5, 2.1 to 4.5, 2.4 to 4.5, 3.0 to 4.5, 0.9 to 1.8, or about 1.5 mgs of RAD001.

[0046] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, 0.1 to 30, 0.2 to 30, 2 to 30, 4 to 30, 6 to 30, 8 to 30, 10 to 30, 1.2 to 30, 14 to 30, 16 to 30, 20 to 30, 6 to 12, or about 10 mgs of RAD001.

[0047] In an embodiment, administering to the subject a low, immune enhancing, dose of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, sustained release dosage form of 0.1 to 30, 0.2 to 30, 2 to 30, 4 to 30, 6 to 30, 8 to 30, 10 to 30, 1.2 to 30, 14 to 30, 16 to 30, 20 to 30, 6 to 12, or about 10 mgs of RAD001.

[0048] In an embodiment, the mTOR inhibitor is RAD001 and the dose provides for a trough level of RAD001 in a range of between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

[0049] In an embodiment, the mTOR inhibitor is other than RAD001 and the dose is bioequivalent to a dose of RAD001 that provides for a trough level of RAD001 in a range of

between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

[0050] In an embodiment, the subject has cancer and the method comprises promoting the subject's immune response to the cancer. In an embodiment, the subject was selected on the basis of having cancer. In an embodiment, a cell of the cancer expresses PD-L1 or PD-L2. In an embodiment, a cell in the cancer microenvironment expresses PD-L1 or PD-L2.

[0051] In an embodiment, the cancer comprises a solid tumor. In an embodiment, the cancer is a hematological cancer. In an embodiment, the cancer is a leukemia. In an embodiment, the cancer is a chronic lymphocytic leukemia (CLL). In an embodiment, the cancer is CLL and wherein the antigen binding domain of the CAR targets CD19. In an embodiment, the cancer is melanoma.

[0052] In an embodiment, the method further comprises administering an additional treatment, e.g., a chemotherapeutic, radiation, a cellular thereapy, bone marrow transplant to the subject. In an embodiment, the method further comprises administering an additional treatment that kills T cells, e.g., radiation or cytotoxic chemotherapy. In an embodiment, the method further comprises administering to the subject an mTOR pathway inhibitor, such as vitamin E, vitamin A, an antibacterial antibiotic, an antioxidant, L- carnitine, lipoic acid, metformin, resveratrol, leptine, a non-steroid anti- inflammatory drug, or a COX inhibitor. In an embodiment, the method further comprises administering metformin to the subject. In an embodiment, the low, immune enhancing, dose of mTOR inhibitor is administered prior to or after the initiation of the additional treatment. In an embodiment, the method further comprises administering an additional treatment for the cancer.

[0053] In an embodiment, the subject is immunocompromised. In an embodiment, the subject is HIV+ or has AIDs. In an embodiment, the subject has an infectious disease.

[0054] In an embodiment, the subject has an impaired immune response. In an embodiment, the subject is immunoscenescent. In an embodiment, the subject has an age related condition.

[0055] In an embodiment, the method of treating, e.g., promoting an immune response in, a subject, e.g., a human subject, further comprises, enhancing an immune response to an antigen in the subject. In an embodiment, the method further comprises administering the antigen or a

vaccine to the subject. In an embodiment, prior to the step of administering a low, immune enhancing, dose of an mTOR inhibitor, the method comprises a step of identifying a subject having an impaired immune response to an antigen.

[0056] In one embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, is a cell described herein, e.g., a human T cell or a human NK cell, e.g., a human T cell described herein or a human NK cell described herein. In one embodiment, the human T cell is a CD8+ T cell.

[0057] In another embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, can further express another agent, e.g., an agent which enhances the activity of a CAR-expressing cell. For example, in one embodiment, the agent can be an agent which inhibits an inhibitory molecule. Examples of inhibitory molecules include PD-1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta, e.g., as described herein. In one embodiment, the agent which inhibits an inhibitory molecule comprises a first polypeptide, e.g., an inhibitory molecule, associated with a second polypeptide that provides a positive signal to the cell, e.g., an intracellular signaling domain described herein. In one embodiment, the agent comprises a first polypeptide, e.g., of an inhibitory molecule such as PD-1, PD-L1, PD-L2, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, CTLA4, VISTA, CD160, BTLA, LAIR1, TIM3, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TIGIT, or a fragment of any of these, and a second polypeptide which is an intracellular signaling domain described herein (e.g., comprising a costimulatory domain (e.g., 4-1BB, CD27, ICOS, or CD28, e.g., as described herein) and/or a primary signaling domain (e.g., a CD3 zeta signaling domain described herein). In one embodiment, the agent comprises a first polypeptide of PD-1 or a fragment thereof, and a second polypeptide of an intracellular signaling domain described herein (e.g., a CD28, CD27, OX40, ICOS, or 4-IBB signaling domain described herein and/or a CD3 zeta signaling domain described herein).

[0058] In embodiments, the intracellular signaling domain of the isolated CAR molecule comprises a costimulatory domain. In embodiments, the intracellular signaling domain of the isolated CAR molecule comprises a primary signaling domain. In embodiments, the intracellular signaling domain of the isolated CAR molecule comprises a costimulatory domain and a primary signaling domain.

[0059] In one embodiment, the costimulatory domain comprises a functional signaling domain of a protein selected from the group consisting of MHC class I molecule, TNF receptor proteins, Immunoglobulin-like proteins, cytokine receptors, integrins, signaling lymphocytic activation molecules (SLAM proteins), activating NK cell receptors, BTLA, a Toll ligand receptor, OX40, CD2, CD7, CD27, CD28, CD30, CD40, CDS, ICAM-1, LFA-1 (CD11a/CD18), 4-1BB (CD137), B7-H3, CDS, ICAM-1, ICOS (CD278), GITR, BAFFR, LIGHT, HVEM (LIGHTR), KIRDS2, SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, CD19a, and a ligand that specifically binds with CD83. In embodiments, the costimulatory domain comprises 4-1BB, CD27, CD28, or ICOS. In one embodiment, the costimulatory domain comprises a sequence of SEQ ID NO:14. In one embodiment, the costimulatory domain comprises an amino acid sequence having at least one, two or three modifications (e.g., substitutions) but not more than 20, 10 or 5 modifications (e.g., substitutions) of an amino acid sequence of SEQ ID NO:14, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO:14.

[0060] In embodiments, the primary signaling domain comprises a functional signaling domain of CD3 zeta. In embodiments, the functional signaling domain of CD3 zeta comprises SEQ ID NO: 18 or SEQ ID NO: 20.

[0061] In another embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, can further express one or more CARs (e.g., a T cell contains two or more

CARs). In one embodiment, an immune effector cell (e.g., T cell, NK cell) of the present invention comprises a first CAR comprising an antigen binding domain that binds to a tumor marker as described herein, and a second CAR comprising a PD1 extracellular domain or a fragment thereof.

[0062] In an embodiment, the method further comprises administering the immune effector cell, e.g., T cell, engineered to express a CAR, in combination with another agent (in addition to the low, immune enhancing, dose of an mTOR inhibititor). In one embodiment, the agent can be a kinase inhibitor, e.g., a CDK4/6 inibitor, a BTK inhibitor, an mTOR inhibitor (administered, e.g., at a dose that is higher than the low, immune enhancing dose discussed elsewhere herein, e.g., a dose that provides an anti-cancer effect), a MNK inhibitor, or a dual mTOR/P13K kinase inhibitor, and combinations thereof).

[0063] In an embodiment, the method comprises providing an anti-tumor immunity in a mammal. In one embodiment, the cell is an autologous T cell or an autologous NK cell. In one embodiment, the cell is an allogeneic T cell or an allogeneic NK cell. In one embodiment, the mammal is a human.

[0064] In an embodiment the method comprises treating a mammal having a disease associated with expression of a cancer associated antigen or tumor marker.

[0065] In one embodiment, the method comprises administering an agent that increases the efficacy of the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, e.g., an agent described herein.

[0066] In one embodiment, the method comprises administering agent that ameliorates one or more side effect associated with administration of a cell expressing a CAR molecule the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, e.g., an agent described herein.

[0067] In one embodiment, the method comprises administering an agent that treats the disease associated with a cancer associated antigen as described herein, e.g., an agent described herein.

[0068] In one embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, expresses two or more CAR molecules and, e.g., is administered to a subject in need thereof to treat cancer.

[0069] In one embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, is administered at a dose and/or dosing schedule described herein.

[0070] In one embodiment, the CAR molecule is introduced into immune effector cells (e.g., T cells, NK cells), e.g., using in vitro transcription, and the subject (e.g., human) receives an initial administration of cells comprising a CAR molecule, and one or more subsequent administrations of cells comprising a CAR molecule, wherein the one or more subsequent administrations are administered less than 15 days, e.g., 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, or 2 days after the previous administration. In one embodiment, more than one administration of cells comprising a CAR molecule are administered to the subject (e.g., human) per week, e.g., 2, 3, or 4 administrations of cells comprising a CAR molecule are administered per week. In one embodiment, the subject (e.g., human subject) receives more than one administration of cells comprising a CAR molecule per week (e.g., 2, 3 or 4 administrations per week) (also referred to herein as a cycle), followed by a week of no administration of cells comprising a CAR molecule, and then one or more additional administration of cells comprising a CAR molecule (e.g., more than one administration of the cells comprising a CAR molecule per week) is administered to the subject. In another embodiment, the subject (e.g., human subject) receives more than one cycle of cells comprising a CAR molecule, and the time between each cycle is less than 10, 9, 8, 7, 6, 5, 4, or 3 days. In one embodiment, the cells comprising a CAR molecule are administered every other day for 3 administrations per week. In one embodiment, the cells comprising a CAR molecule are administered for at least two, three, four, five, six, seven, eight or more weeks.

[0071] In one embodiment, the immune effector cell, e.g., T cell or NK cell, engineered to express a CAR, e.g., a CAR molecule described herein, are administered as a first line treatment for the disease, e.g., the cancer, e.g., the cancer described herein. In another embodiment, the immune effector cell, e.g., T cell, engineered to express a CAR, e.g., a CAR molecule described herein, are administered as a second, third, fourth line treatment for the disease, e.g., the cancer, e.g., the cancer described herein.

[0072] In one embodiment, a population of cells described herein is administered.

[0073] In one embodiment, the low, immune enhancing, dose of an mTOR inhibitor (e.g., RAD001 or rapamycin) and the immune effector cell, e.g., a T cell, engineered to express a CAR, are present in a single composition, e.g., are administered as a single composition. In one embodiment, the low, immune enhancing, dose of an mTOR inhibitor (e.g., RAD001 or rapamycin) and the immune effector cell, e.g., a T cell, engineered to express a CAR, are present in separate compositions, e.g., are administered as separate compositions.

[0074] In another aspect, the invention pertains to the isolated nucleic acid molecule encoding a CAR of the invention, the isolated polypeptide molecule of a CAR of the invention, the vector comprising a CAR of the invention, a formulation of a low, immune enhancing dose, of an mTOR inhibitor, and the cell comprising a CAR of the invention for use as a medicament.

[0075] In another aspect, the invention pertains to the isolated nucleic acid molecule encoding a CAR of the invention, the isolated polypeptide molecule of a CAR of the invention, the vector comprising a CAR of the invention, a formulation of a low, immune enhancing, dose of an mTOR inhibitor, and the cell comprising a CAR of the invention for use in the treatment of a disease expressing a cancer associated antigen as described herein.

[0076] In certain aspects, the disclosure provides an mTOR inhibitor for use in the treatment of a subject, wherein said mTOR inhibitor enhances an immune response of said subject, and wherein said subject has received, is receiving or is about to receive an immune effector cell engineered to express a CAR. In some embodiments, the mTOR inhibitor is at a low, immune-enhancing dose. In some embodiments, the mTOR inhibitor is administered at a low, immune-enhancing dose.

[0077] In certain aspects, the disclosure provides an immune effector cell engineered to express a CAR for use in the treatment of a subject, wherein said subject has received, is receiving, or is about to receive, an mTOR inhibitor that enhances an immune response of said subject. In some embodiments, the mTOR inhibitor is at a low, immune-enhancing dose. In some embodiments, the mTOR inhibitor is administered at a low, immune-enhancing dose.

[0078] In one embodiment, the isolated nucleic acid molecule further comprises a sequence encoding a costimulatory domain, e.g., a costimulatory domain described herein. In embodiments, the intracellular signaling domain comprises a costimulatory domain. In embodiments, the intracellular signaling domain comprises a primary signaling domain. In

embodiments, the intracellular signaling domain comprises a costimulatory domain and a primary signaling domain.

[0079] In one embodiment, the encoded costimulatory domain is a functional signaling domain obtained from a protein, e.g., described herein, e.g., selected from the group consisting of MHC class I molecule, TNF receptor proteins, Immunoglobulin-like proteins, cytokine receptors, integrins, signaling lymphocytic activation molecules (SLAM proteins), activating NK cell receptors, BTLA, a Toll ligand receptor, OX40, CD2, CD7, CD27, CD28, CD30, CD40, CDS, ICAM-1, LFA-1 (CD11a/CD18), 4-1BB (CD137), B7-H3, CDS, ICAM-1, ICOS (CD278), GITR, BAFFR, LIGHT, HVEM (LIGHTR), KIRDS2, SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, CD19a, and a ligand that specifically binds with CD83. In embodiments, the encoded costimulatory domain comprises 4-1BB, CD27, CD28, or ICOS.

[0080] In one embodiment, the encoded costimulatory domain of 4-1BB comprises the sequence of SEQ ID NO:14. In one embodiment, the encoded costimulatory domain comprises an amino acid sequence having at least one, two or three modifications but not more than 20, 10 or 5 modifications of an amino acid sequence of SEQ ID NO:14, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO:14. In one embodiment, the nucleic acid sequence encoding the costimulatory domain comprises the nucleotide sequence of SEQ ID NO:15, or a sequence with 95-99% identity thereof. In another embodiment, the encoded costimulatory domain of CD28 comprises the amino acid sequence of SEQ ID NO:91. In one embodiment, the encoded costimulatory domain comprises an amino acid sequence having at least one, two or three modifications but not more than 20, 10 or 5 modifications of an amino acid sequence of SEQ ID NO:91, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO:91. In one embodiment, the nucleic acid sequence encoding the costimulatory domain of CD28 comprises the nucleotide sequence of SEQ ID NO:92, or a sequence with 95-

99% identity thereof. In another embodiment, the encoded costimulatory domain of CD27 comprises the amino acid sequence of SEQ ID NO:16. In one embodiment, the encoded costimulatory domain comprises an amino acid sequence having at least one, two or three modifications but not more than 20, 10 or 5 modifications of an amino acid sequence of SEQ ID NO:16, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO:16. In one embodiment, the nucleic acid sequence encoding the costimulatory domain of CD27 comprises the nucleotide sequence of SEQ ID NO:17, or a sequence with 95-99% identity thereof. In another embodiment, the encoded costimulatory domain of ICOS comprises the amino acid sequence of SEQ ID NO:93. In one embodiment, the encoded costimulatory domain of ICOS comprises an amino acid sequence having at least one, two or three modifications but not more than 20, 10 or 5 modifications of an amino acid sequence of SEQ ID NO:93, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO:93. In one embodiment, the nucleic acid sequence encoding the costimulatory domain of ICOS comprises the nucleotide sequence of SEQ ID NO:94, or a sequence with 95-99% identity thereof.

[0081] In embodiments, the encoded primary signaling domain comprises a functional signaling domain of CD3 zeta. In embodiments, the functional signaling domain of CD3 zeta comprises the sequence of SEQ ID NO: 18 (mutant CD3 zeta) or SEQ ID NO: 20 (wild type human CD3 zeta), or a sequence with 95-99% identity thereof.

[0082] In one embodiment, the intracellular signaling domain comprises a functional signaling domain of CD27 and/or a functional signaling domain of CD3 zeta. In one embodiment, the intracellular signaling domain comprises a functional signaling domain of CD28 and/or a functional signaling domain of CD3 zeta. In one embodiment, the intracellular signaling domain comprises a functional signaling domain of ICOS and/or a functional signaling domain of CD3 zeta. In one embodiment, the intracellular signaling domain comprises a functional signaling domain of 4-1BB and/or a functional signaling domain of CD3 zeta.

[0083] In one aspect, the invention includes a population of autologous cells that are transfected or transduced with a vector comprising a nucleic acid molecule encoding a CAR molecule, e.g., as described herein. In one embodiment, the vector is a retroviral vector. In one embodiment, the vector is a self-inactivating lentiviral vector as described elsewhere herein. In one embodiment, the vector is delivered (e.g., by transfecting or electroporating) to a cell, e.g., a

T cell or a NK cell, wherein the vector comprises a nucleic acid molecule encoding a CAR of the present invention as described herein, which is transcribed as an mRNA molecule, and the CARs of the present invention is translated from the RNA molecule and expressed on the surface of the cell.

[0084] In another aspect, the present invention provides a population of CAR-expressing cells, e.g., CAR-expressing T cells (CART cells) or CAR-expressing NK cells. In some embodiments, the population of CAR-expressing cells comprises a mixture of cells expressing different CARs. For example, in one embodiment, the population of CAR-expressing cells can include a first cell expressing a CAR having an antigen binding domain that binds to a first tumor marker as described herein, and a second cell expressing a CAR having a different antigen binding domain that binds to a second tumor marker as described herein. As another example, the population of CAR-expressing cells can include a first cell expressing a CAR that includes an antigen binding domain that binds to a tumor marker as described herein, and a second cell expressing a CAR that includes an antigen binding domain to a target other than a tumor marker as described herein. In one embodiment, the population of CAR-expressing cells includes, e.g., a first cell expressing a CAR that includes a primary intracellular signaling domain, and a second cell expressing a CAR that includes a secondary signaling domain.

[0085] In another aspect, the present invention provides a population of cells wherein at least one cell in the population expresses a CAR having an antigen binding domain that binds to a tumor marker as described herein, and a second cell expressing another agent, e.g., an agent which enhances the activity of a CAR-expressing cell. For example, in one embodiment, the agent can be an agent which inhibits an inhibitory molecule. Examples of inhibitory molecules include PD-1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta. In one embodiment, the agent which inhibits an inhibitory molecule, e.g., is a molecule described herein, e.g., an agent that comprises a first polypeptide, e.g., an inhibitory molecule, associated with a second polypeptide that provides a positive signal to the cell, e.g., an intracellular signaling domain described herein. In one embodiment, the agent comprises a first polypeptide, e.g., of an inhibitory molecule such as PD-1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or

CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta, or a fragment of any of these, and a second polypeptide which is an intracellular signaling domain described herein (e.g., comprising a costimulatory domain (e.g., 4-1BB, ICOS, CD27, or CD28, e.g., as described herein) and/or a primary signaling domain (e.g., a CD3 zeta signaling domain described herein). In one embodiment, the agent comprises a first polypeptide of PD-1 or a fragment thereof, and a second polypeptide of an intracellular signaling domain described herein (e.g., a CD28, CD27, ICOS, OX40 or 4-1BB signaling domain described herein and/or a CD3 zeta signaling domain described herein).

[0086] In one embodiment, the nucleic acid molecule encoding a CAR of the present invention, e.g., as described herein, is expressed as an mRNA molecule. In one embodiment, the genetically modified CAR of the present invention-expressing cells, e.g., immune effector cells (e.g., T cells, NK cells), can be generated by transfecting or electroporating an RNA molecule encoding the desired CARs (e.g., without a vector sequence) into the cell. In one embodiment, a CAR of the present invention molecule is translated from the RNA molecule once it is incorporated and expressed on the surface of the recombinant cell.

[0087] In an aspect, the present invention also provides a method of making an immune effector cell, e.g., a T cell, having disposed therein a nucleic acid encoding a CAR, comprising:

a) providing an immune effector cell, e.g., a T cell, made by:

i) administering to a subject a low, immune enhancing dose, of an mTOR inhibitor, e.g., RAD001, or rapamycin, for an amount of time sufficient

for one or more of the following to occur:

1a) an increase in the proportion of PD-1 negative immune effector cells;

1b) a decrease in the proportion of PD-1 positive immune effector cells;

1c) an increase in the ratio of PD-1 negative immune effector cells, e.g., T cells/ PD-1 positive immune effector cells, e.g., T cells;

1d) an increase in the number of naïve T cells;

1e) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

1f) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

1g) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein 1a), 1b), 1c), 1d), 1e), 1f) or 1g) occurs e.g., at least transiently, e.g., as compared to a non-treated subject, in the subject or in a preparation of immune effector cells, e.g., T cells, collected from the subject; and

(ii) collecting the immune effector cell, e.g., a T cell, from the subject; and

b) inserting nucleic acid that encodes the CAR into the collected immune effector cell, e.g., a T cell,

thereby making an immune effector cell, e.g., a T cell, having disposed therein a nucleic acid encoding a CAR.

[0088] In an embodiment, providing an immune effector cell, e.g., a T cell, comprises one or both of:

administering to a subject a low, immune enhancing dose, of an mTOR inhibitor, e.g., RAD001, or rapamycin, for an amount of time sufficient

for one or more of the following to occur:

a) an increase in the proportion of PD-1 negative immune effector cells;

b) a decrease in the proportion of PD-1 positive immune effector cells;

c) an increase in the ratio of PD-1 negative immune effector cells, e.g., T cells/ PD-1 positive immune effector cells, e.g., T cells;

d) an increase in the number of naïve T cells;

e) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

f) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

g) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein a), b), c), d), e), f) or g) occurs e.g., at least transiently, e.g., as compared to a non-treated subject, in the subject or in a preparation of immune effector cells, e.g., T cells, collected from the subject; and

collecting an immune effector cell, e.g., a T cell, from the subject.

[0089] In an aspect, the present invention also provides a method of making an immune effector cell, which is optionally at T cell, having disposed therein a nucleic acid encoding a CAR, comprising:

a) contacting an immune effector cell, which is optionally a T cell, with an mTOR inhibitor; and

b) inserting nucleic acid that encodes the CAR into the immune effector cell;

thereby making an immune effector cell, which is optionally a T cell, having disposed therein a nucleic acid encoding a CAR,

wherein said contacting of step a) occurs prior to, concurrently with, or after said inserting of step b);

and wherein the mTOR inhibitor causes one or more of the following to occur:

1a) an increase in the proportion of PD-1 negative immune effector cells;

1b) a decrease in the proportion of PD-1 positive immune effector cells;

1c) an increase in the ratio of PD-1 negative immune effector cells, which are optionally T cells/ PD-1 positive immune effector cells, which are optionally T cells;

1d) an increase in the number of naïve T cells;

1e) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, which are optionally on memory T cells, which are optionally memory T cell precursors;

1f) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

1g) an increase in the number of memory T cell precursors, which are optionally cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein 1a), 1b), 1c), 1d), 1e), 1f) or 1g) occurs, optionally, at least transiently, optionally, as compared to a non-contacted preparation of immune effector cells.

[0090] In an embodiment, the CAR comprises an antigen binding domain (e.g., antibody or antibody fragment, TCR or TCR fragment) a transmembrane domain, and an intracellular signaling domain (e.g., an intracellular signaling domain comprising a costimulatory domain and/or a primary signaling domain). In an embodiment, the antigen binding domain binds a tumor marker. In an embodiment, the tumor marker is a solid tumor marker.

[0091] In an embodiment, the method of making an immune effector cell, e.g., a T cell, having disposed therein a nucleic acid encoding a CAR, further comprises introducing the immune effector cell, e.g., a T cell or a NK cell, having disposed therein a nucleic acid encoding a CAR, into a subject, e.g., the subject from which the immune effector cells were derived from a different subject. In an embodiment, the subject is the subject from which the immune effector cells were derived. In an embodiment, the subject is a different subject. In an embodiment, the immune effector cells are T cells. In an embodiment, the immune effector cells are NK cells.

[0092] In an embodiment, the method further comprises evaluating the level of PD1 negative or PD1 positive immune effector cells, e.g., T cells, in the subject or in T cells taken from the subject.

[0093] In some embodiments, the method of making disclosed herein further comprises contacting the population of immune effector cells with a nucleic acid encoding a telomerase subunit, e.g., hTERT. The nucleic acid encoding the telomerase subunit can be DNA.

[0094] In some embodiments, the method of making disclosed herein further comprises culturing the population of immune effector cells in serum comprising 2% hAB serum.

[0095] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor is initiated at least 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 days prior to collection of T cells.

[0096] In an embodiment, the administering to a subject a low, immune enhancing dose, of an mTOR inhibitor results in the partial, but not total, inhibition of mTOR for at least at least 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 days prior to collection of immune effector cells, e.g., T cells, from the subject.

[0097] In an embodiment, the mTOR inhibitor is an allosteric mTOR inhibitor. In an embodiment, the mTOR inhibitor is a RAD001. In an embodiment, the mTOR inhibitor is rapamycin. In an embodiment, the mTOR inhibitor is a catalytic inhibitor, e.g., a kinase inhibitor. In an embodiment, the kinase inhibitor is selective for mTOR. In an embodiment, the kinase inhibitor is selected from BEZ235 and CCG168.

[0098] In an embodiment, the method of making an immune effector cell, e.g., a T cell, having disposed therein a nucleic acid encoding a CAR, comprises increasing the number of T cells capable of proliferation.

[0099] In an embodiment, the method of making an immune effector cell, e.g., a T cell, having disposed therein a nucleic acid encoding a CAR, comprises increasing the number of T cells capable of cytotoxic function, secreting cytokines, or activation.

[00100] In an embodiment, the administering of a low, immune enhancing, dose of an mTOR inhibitor results in the partial, but not total, inhibition of mTOR for at least 1, 5, 10, 20, 30, or 60 days.

[00101] In an embodiment, the dose of an mTOR inhibitor is associated with mTOR inhibition of at least 5% but no more than 90%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[00102] In an embodiment, the dose of an mTOR inhibitor is associated with mTOR inhibition of at least 10% but no more than 80%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[00103] In an embodiment, the dose of an mTOR inhibitor is associated with mTOR inhibition of at least 10 but no more than 40%, e.g., as measured by p70 S6K inhibition. In an embodiment, the mTOR inhibitor comprises RAD001.

[00104] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in an immediate release dosage form, 0.1 to 20, 0.5 to 10, 2.5 to 7.5, 3 to 6, or about 5 mgs of RAD001.

[00105] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, once per week, in an immediate release dosage form, about 5 mgs of RAD001.

[00106] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, immediate release dosage form of 0.1 to 20, 0.5 to 10, 2.5 to 7.5, 3 to 6, or about 5 mgs of RAD001.

[00107] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, once per week, in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, immediate release dosage form of about 5 mgs of RAD001.

[00108] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of RAD001.

[00109] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, once per week, in a sustained release dosage form, about 15 mgs of RAD001.

[00110] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, sustained release dosage form of 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of RAD001.

[00111] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, once per week, in a sustained release dosage form, an

amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week, sustained release dosage form of about 15 mgs of RAD001.

[00112] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in an immediate release dosage form, 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs of RAD001.

[00113] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering once per day, in an immediate release dosage form, about 0.5 mgs of RAD001.

[00114] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, immediate release dosage form of 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs of RAD001.

[00115] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, once per day, in an immediate release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, immediate release dosage form of about 0.5 mgs of RAD001.

[00116] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in a sustained release dosage form, 0.015 to 4.5, 0.03 to 4.5, 0.3 to 4.5, 0.6 to 4.5, 0.9 to 4.5, 1.2 to 4.5, 1.5 to 4.5, 1.8 to 4.5, 2.1 to 4.5, 2.4 to 4.5, 3.0 to 4.5, 0.9 to 1.8, or about 1.5 mgs of RAD001.

[00117] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per day, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per day, sustained release dosage form of 0.015 to 4.5, 0.03 to 4.5, 0.3 to 4.5, 0.6 to 4.5, 0.9 to 4.5, 1.2 to 4.5, 1.5 to 4.5, 1.8 to 4.5, 2.1 to 4.5, 2.4 to 4.5, 3.0 to 4.5, 0.9 to 1.8, or about 1.5 mgs of RAD001.

[00118] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, 0.1 to 30, 0.2 to 30, 2 to 30, 4 to 30, 6 to 30, 8 to 30, 10 to 30, 1.2 to 30, 14 to 30, 16 to 30, 20 to 30, 6 to 12, or about 10 mgs of RAD001.

[00119] In an embodiment, administering to a subject a low, immune enhancing dose, of an mTOR inhibitor comprises administering, e.g., once per week, e.g., in a sustained release dosage form, an amount of an mTOR inhibitor other than RAD001, that is bioequivalent to a once per week sustained release form of 0.1 to 30, 0.2 to 30, 2 to 30, 4 to 30, 6 to 30, 8 to 30, 10 to 30, 1.2 to 30, 14 to 30, 16 to 30, 20 to 30, 6 to 12, or about 10 mgs of RAD001.

[00120] In an embodiment, the mTOR inhibitor is RAD001 and the dose provides for a trough level of RAD001 in a range of between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

[00121] In an embodiment, the mTOR inhibitor is other than RAD001 and the dose is bioequivalent to a dose of RAD001 that provides for a trough level of RAD001 in a range of between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

[00122] In an embodiment, the subject has cancer. In an embodiment, a cell of the cancer expresses PD-L1 or PD-L2. In an embodiment, a cell in the cancer microenvironment expresses PD-L1 or PD-L2. In an embodiment, the cancer comprises a solid tumor. In an embodiment, the cancer is a hematological cancer. In an embodiment, the cancer is chronic lymphocytic leukemia (CLL). In an embodiment, the cancer is CLL and the antigen binding domain of the CAR targets CD19. In an embodiment, the cancer is selected from a cancer described herein. In an embodiment, the cancer is melanoma.

[00123] In an embodiment, the subject is immunocompromised.

[00124] In an embodiment, the subject is HIV+ or has AIDs.

[00125] In an embodiment, the subject has an infectious disease.

[00126] In an embodiment, the subject has an impaired immune response.

[00127] In an embodiment, the subject is immunosenescent.

[00128] In an embodiment, the subjest has an age related condition.

[00129] In an aspect, a preparation of human immune effector cells, e.g., T cells, is also described herein, wherein the preparation of human effector cells has disposed therein a nucleic acid encoding a CAR made by any of the methods described herein. In an embodiment, the subject has cancer or is immunocompromised.

[00130] Headings, sub-headings or numbered or lettered elements, e.g., (a), (b), (i) etc, are presented merely for ease of reading. The use of headings or numbered or lettered elements in this document does not require the steps or elements be performed in alphabetical order or that the steps or elements are necessarily discrete from one another.

[00131] All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety.

[00132] Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

[00133] FIG. 1A and 1B are graphs showing an increase in titers to influenza vaccine strains as compared to placebo. In FIG. 1A, the increase above baseline in influenza geometric mean titers to each of the 3 influenza vaccine strains (H1N1 A/California/ 07/2009, H3N2 A/Victoria/210/2009, B/Brisbane/60/ 2008) relative to the increase in the placebo cohort 4 weeks after vaccination is shown for each of the RAD001 dosing cohorts in the intention to treat population. The bold black line indicates the 1.2 fold increase in titers relative to placebo that is required to be met for 2 out of 3 influenza vaccine strains to meet the primary endpoint of the study. The star "*" indicates that the increase in GMT titer relative to placebo exceeds 1 with posterior probability of at least 80%. FIG 1B is a graph of the same data as in FIG. 1A for the subset of subjects with baseline influenza titers <= 1:40.

[00134] FIG. 2 shows a scatter plot of RAD001 concentration versus fold increase in geometric mean titer to each influenza vaccine strain 4 weeks after vaccination. RAD001 concentrations (1 hour post dose) were measured after subjects had been dosed for 4 weeks. All

subjects who had pharmacokinetic measurements were included in the analysis set. The fold increase in geometric mean titers at 4 weeks post vaccination relative to baseline is shown on the y axis.

[00135] FIG. 3 is a graphic representation showing increase in titers to heterologous influenza strains as compared to placebo. The increase above baseline in influenza geometric mean titers to 2 heterologous influenza strains (A/H1N1 strain A/New Jersey/8/76 and A/H3N2 strain A/Victoria/361/11) not contained in the influenza vaccine relative to the increase in the placebo cohort 4 weeks after vaccination is shown for each of the RAD001 dosing cohorts in the intention to treat population. * indicates increase in titer relative to placebo exceeds 1 with a posterior probability of at least 80%.

[00136] FIG. 4A and 4B are graphic representations of IgG and IgM levels before and after influenza vaccination. Levels of anti-A/H1N1/California/07/2009 influenza IgG and IgM were measured in serum obtained from subjects before and 4 weeks post influenza vaccination. No significant difference in the change from baseline to 4 weeks post vaccination in anti-H1N1 influenza IgG and IgM levels were detected between the RAD001 and placebo cohorts (all p values > 0.05 by Kruskal-Wallis rank sum test).

[00137] FIG. 5A, 5B, and 5C are graphic representations of the decrease in percent of PD-1-positive CD4 and CD8 and increase in PD-1-negative CD4 T cells after RAD001 treatment. The percent of PD-1-positive CD4, CD8 and PD-1-negative CD4 T cells was determined by FACS analysis of PBMC samples at baseline, after 6 weeks of study drug treatment (Week 6) and 6 weeks after study drug discontinuation and 4 weeks after influenza vaccination (Week 12). FIG. 5A shows there was a significant decrease (-37.1 – -28.5%) in PD-1-positive CD4 T cells at week 12 in cohorts receiving RAD001 at dose levels 0.5mg/Day (n=25), 5mg/Week (n=29) and 20 mg/Week (n=30) as compared to the placebo cohort (n=25) with p=0.002 (0.02), p=0.003 (q=0.03), and p= 0.01 (q=0.05) respectively. FIG. 5B shows there was a significant decrease (-43.3 – -38.5%) in PD-1-positive CD8 T cells at week 12 in cohorts receiving RAD001 (n=109) at dose levels 0.5mg/Day (n=25), 5mg/Week (n=29) and 20 mg/Week (n=30) as compared to the placebo cohort (n=25) with p=0.01 (0.05), p=0.007 (q=0.04), and p= 0.01 (q=0.05) respectively. FIG. 5C shows was a significant increase (3.0 – 4.9%) in PD-1-negative CD4 T cells at week 12 in cohorts receiving RAD001 (n=109) at dose levels 0.5mg/Day (n=25), 5mg/Week (n=29) and

20 mg/Week (n=30) as compared to the placebo cohort (n=25) with p=0.0007 (0.02), p=0.03 (q=0.07), and p= 0.03 (q=0.08) respectively.

[00138] FIG. 6A and 6B are graphic representations of the decrease in percent of PD-1-positive CD4 and CD8 and increase in PD-1-negative CD4 T cells after RAD001 treatment adjusted for differences in baseline PD-1 expression. The percent of PD-1-positive CD4, CD8 and PD-1-negative CD4 T cells was determined by FACS analysis of PBMC samples at baseline, after 6 weeks of study drug treatment (Week 6) and 6 weeks after study drug discontinuation and 4 weeks after influenza vaccination (Week 12). FIG. 6A shows a significant decrease of 30.2% in PD-1+ CD4 T cells at week 6 in the pooled RAD cohort (n=84) compared to placebo cohort (n=25) with p=0.03 (q=0.13). The decrease in PD-1-positive CD4 T cells at week 12 in the pooled RAD as compared to the placebo cohort is 32.7% with p=0.05 (q=0.19). FIG. 6B shows a significant decrease of 37.4% in PD-1-positive CD8 T cells at week 6 in the pooled RAD001 cohort (n=84) compared to placebo cohort (n=25) with p=0.008 (q=0.07). The decrease in PD-1-positive CD8 T cells at week 12 in the pooled RAD001 as compared to the placebo cohort is 41.4% with p=0.066 (q=0.21). FIG. 6A and 6B represent the data in FIG. 5A, 5B, and 5C but with the different RAD001 dosage groups of FIG. 5A, 5B, and 5C pooled into the single RAD001-treated group in FIG. 6A and 6B.

[00139] FIG. 7 depicts increases in exercise and energy in elderly subjects in response to RAD001.

[00140] FIG. 8A and 8B depict the predicted effect of RAD001 on P70 S6K activity in cells. FIG. 8A depicts P70 S6 kinase inhibition with higher doses of weekly and daily RAD001; FIG. 8B depicts P70 S6 kinase inhibition with lower doses of weekly RAD001.

[00141] FIG. 9 indicates that PD1 interaction with PDL-1 is sufficient in causing clustering of PD1 on the Jurkat cell surface and triggers the strong activation of the NFAT pathway.

[00142] Figure 10 shows that the proliferation of CAR-expressing, transduced T cells is enhanced by low doses of RAD001 in a cell culture system. CARTs were co-cultured with NALM6 (Nalm-6) cells in the presence of different concentrations of RAD001 (nM). The number of CAR-positive CD3-positive T cells (black) and total T cells (white) was assessed after 4 days of co-culture.

[00143] Figure 11 depicts tumor growth measurements of NALM6-luc cells with daily RAD001 dosing at 0.3, 1, 3, and 10 mg/kg (mpk) or vehicle dosing. Circles denote the vehicle; squares denote the 10 mg/kg dose of RAD001; triangles denote the 3 mg/kg dose of RAD001, inverted triangles denote the 1 mg/kg dose of RAD001; and diamonds denote the 0.3 mg/kg dose of RAD001.

[00144] Figures 12A and 12B show pharmacokinetic curves showing the amount of RAD001 in the blood of NSG mice with NALM6 tumors. FIG. 12A shows day 0 PK following the first dose of RAD001. FIG. 12B shows Day 14 PK following the final RAD001 dose. Diamonds denote the 10 mg/kg dose of RAD001; squares denote the 1 mg/kg dose of RAD001; triangles denote the 3 mg/kg dose of RAD001; and x's denote the 10 mg/kg dose of RAD001.

[00145] Figures 13A and 13B show *in vivo* proliferation of humanized CD19 CART cells with and without RAD001 dosing. Low doses of RAD001 (0.003 mg/kg) daily lead to an enhancement in CAR T cell proliferation, above the normal level of huCAR19 proliferation. Figures 13A shows $CD4^+$ CAR T cells; FIG. 13B shows $CD8^+$ CAR T cells. Circles denote PBS; squares denote huCTL019; triangles denote huCTL019 with 3 mg/kg RAD001; inverted triangles denote huCTL019 with 0.3 mg/kg RAD001; diamonds denote huCTL019 with 0.03 mg/kg RAD001; and circles denote huCTL019 with 0.003 mg/kg RAD001.

[00146]

## DETAILED DESCRIPTION

### Definitions

[00147] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains.

[00148] The term "a" and "an" refers to one or to more than one (i.e., to at least one) of the grammatical object of the article. By way of example, "an element" means one element or more than one element.

[00149] The term "about" when referring to a measurable value such as an amount, a temporal duration, and the like, is meant to encompass ±20% or in some instances ±10%, or in some instances ±5%, or in some instances ±1%, or in some instances ±0.1% from the specified value, as such variations are appropriate to perform the disclosed methods.

[00150] The phrase “about to receive”, when used herein in the context of a patient receiving a first therapeutic who is about to receive a second therapeutic, refers to a situation where the patient is receiving or has received the first therapeutic for a disorder (e.g., a cancer), wherein the patient receives or will receive the second therapeutic in the course of treatment for that disorder.

[00151] The term "adjuvant" refers to a compound that, when used in combination with a specific immunogen, e.g., a vaccine immunogen, in a formulation, augments or otherwise alters, modifies or enhances the resultant immune responses.

[00152] The term “allogeneic” refers to any material derived from a different animal of the same species as the individual to whom the material is introduced. Two or more individuals are said to be allogeneic to one another when the genes at one or more loci are not identical. In some aspects, allogeneic material from individuals of the same species may be sufficiently unlike genetically to interact antigenically.

[00153] The term “anti-cancer effect” refers to a biological effect which can be manifested by various means, including but not limited to, e.g., a decrease in tumor volume, a decrease in the number of cancer cells, a decrease in the number of metastases, an increase in life expectancy, decrease in cancer cell proliferation, decrease in cancer cell survival, or amelioration of various physiological symptoms associated with the cancerous condition. An “anti-cancer effect” can also be manifested by the ability of the compounds (e.g., mTOR inhibitors), peptides, polynucleotides, cells and antibodies of the invention in prevention of the occurrence of cancer in the first place. The term “anti-tumor effect” refers to a biological effect which can be manifested by various means, including but not limited to, e.g., a decrease in tumor volume, a decrease in the number of tumor cells, a decrease in tumor cell proliferation, or a decrease in tumor cell survival.

[00154] The term “antibody,” as used herein, refers to a protein, or polypeptide sequence derived from an immunoglobulin molecule which specifically binds with an antigen. Antibodies can be polyclonal or monoclonal, multiple or single chain, or intact immunoglobulins, and may be derived from natural sources or from recombinant sources. Antibodies can be tetramers of immunoglobulin molecules.

[00155] The term “antibody fragment” refers to at least one portion of an intact antibody, or recombinant variants thereof, and refers to the antigen binding domain, e.g., an antigenic determining variable region of an intact antibody, that is sufficient to confer recognition and

specific binding of the antibody fragment to a target, such as an antigen. Examples of antibody fragments include, but are not limited to, Fab, Fab', $F(ab')_2$, Fv fragments, scFv antibody fragments, disulfide-linked Fvs (sdFv), a Fd fragment consisting of the VH and CH1 domains, linear antibodies, single domain antibodies such as sdAb (either VL or VH), camelid VHH domains, multi-specific molecules formed from antibody fragments such as a bivalent fragment comprising two or more, e.g., two, Fab fragments linked by a disulfide brudge at the hinge region, or two or more, e.g., two isolated CDR or other epitope binding fragments of an antibody linked. An antibody fragment can also be incorporated into single domain antibodies, maxibodies, minibodies, nanobodies, intrabodies, diabodies, triabodies, tetrabodies, v-NAR and bis-scFv (see, e.g., Hollinger and Hudson, Nature Biotechnology 23:1126-1136, 2005). Antibody fragments can also be grafted into scaffolds based on polypeptides such as a fibronectin type III (Fn3)(see U.S. Patent No.: 6,703,199, which describes fibronectin polypeptide minibodies).

[00156] The term "scFv" refers to a fusion protein comprising at least one antibody fragment comprising a variable region of a light chain and at least one antibody fragment comprising a variable region of a heavy chain, wherein the light and heavy chain variable regions are contiguously linked via a short flexible polypeptide linker, and capable of being expressed as a single chain polypeptide, and wherein the scFv retains the specificity of the intact antibody from which it is derived. Unless specified, as used herein, an scFv may have the VL and VH variable regions in either order, e.g., with respect to the N-terminal and C-terminal ends of the polypeptide, the scFv may comprise VL-linker-VH or may comprise VH-linker-VL.

[00157] The terms "complementarity determining region" or "CDR," as used herein, refer to the sequences of amino acids within antibody variable regions which confer antigen specificity and binding affinity. For example, in general, there are three CDRs in each heavy chain variable region (e.g., HCDR1, HCDR2, and HCDR3) and three CDRs in each light chain variable region (LCDR1, LCDR2, and LCDR3). The precise amino acid sequence boundaries of a given CDR can be determined using any of a number of well-known schemes, including those described by Kabat et al. (1991), "Sequences of Proteins of Immunological Interest," 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD ("Kabat" numbering scheme), Al-Lazikani et al., (1997) JMB 273,927-948 ("Chothia" numbering scheme), or a combination thereof. Under the Kabat numbering scheme, in some embodiments, the CDR amino acid residues in the

heavy chain variable domain (VH) are numbered 31-35 (HCDR1), 50-65 (HCDR2), and 95-102 (HCDR3); and the CDR amino acid residues in the light chain variable domain (VL) are numbered 24-34 (LCDR1), 50-56 (LCDR2), and 89-97 (LCDR3). Under the Chothia numbering scheme, in some embodiments, the CDR amino acids in the VH are numbered 26-32 (HCDR1), 52-56 (HCDR2), and 95-102 (HCDR3); and the CDR amino acid residues in the VL are numbered 26-32 (LCDR1), 50-52 (LCDR2), and 91-96 (LCDR3). In a combined Kabat and Chothia numbering scheme, in some embodiments, the CDRs correspond to the amino acid residues that are part of a Kabat CDR, a Chothia CDR, or both. For instance, in some embodiments, the CDRs correspond to amino acid residues 26-35 (HCDR1), 50-65 (HCDR2), and 95-102 (HCDR3) in a VH, e.g., a mammalian VH, e.g., a human VH; and amino acid residues 24-34 (LCDR1), 50-56 (LCDR2), and 89-97 (LCDR3) in a VL, e.g., a mammalian VL, e.g., a human VL.

[00158] The portion of the CAR of the invention comprising an antibody or antibody fragment thereof may exist in a variety of forms, for example, where the antigen binding domain is expressed as part of a polypeptide chain including, for example, a single domain antibody fragment (sdAb), a single chain antibody (scFv), or e.g., a humanized antibody, or bispecific antibody (Harlow et al., 1999, In: Using Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, NY; Harlow et al., 1989, In: Antibodies: A Laboratory Manual, Cold Spring Harbor, New York; Houston et al., 1988, Proc. Natl. Acad. Sci. USA 85:5879-5883; Bird et al., 1988, Science 242:423-426). In one aspect, the antigen binding domain of a CAR composition of the invention comprises an antibody fragment. In a further aspect, the CAR comprises an antibody fragment that comprises a scFv. The precise amino acid sequence boundaries of a given CDR can be determined using any of a number of well-known schemes, including those described by Kabat et al. (1991), "Sequences of Proteins of Immunological Interest," 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD ("Kabat" numbering scheme), Al-Lazikani et al., (1997) JMB 273,927-948 ("Chothia" numbering scheme), or a combination thereof.

[00159] As used herein, the term "binding domain" or "antibody molecule" refers to a protein, e.g., an immunoglobulin chain or fragment thereof, comprising at least one immunoglobulin variable domain sequence. The term "binding domain" or "antibody molecule" encompasses antibodies and antibody fragments. In an embodiment, an antibody molecule is a multispecific

antibody molecule, e.g., it comprises a plurality of immunoglobulin variable domain sequences, wherein a first immunoglobulin variable domain sequence of the plurality has binding specificity for a first epitope and a second immunoglobulin variable domain sequence of the plurality has binding specificity for a second epitope. In an embodiment, a multispecific antibody molecule is a bispecific antibody molecule. A bispecific antibody has specificity for no more than two antigens. A bispecific antibody molecule is characterized by a first immunoglobulin variable domain sequence which has binding specificity for a first epitope and a second immunoglobulin variable domain sequence that has binding specificity for a second epitope.

[00160] The term "antibody heavy chain," refers to the larger of the two types of polypeptide chains present in antibody molecules in their naturally occurring conformations, and which normally determines the class to which the antibody belongs.

[00161] The term "antibody light chain," refers to the smaller of the two types of polypeptide chains present in antibody molecules in their naturally occurring conformations. Kappa (κ) and lambda (λ) light chains refer to the two major antibody light chain isotypes.

[00162] The term "antigen" or "Ag" refers to a molecule that provokes an immune response. This immune response may involve either antibody production, or the activation of specific immunologically-competent cells, or both. The skilled artisan will understand that any macromolecule, including virtually all proteins or peptides, can serve as an antigen. Furthermore, antigens can be derived from recombinant or genomic DNA. A skilled artisan will understand that any DNA, which comprises a nucleotide sequence or a partial nucleotide sequence encoding a protein that elicits an immune response therefore encodes an "antigen" as that term is used herein. Furthermore, one skilled in the art will understand that an antigen need not be encoded solely by a full length nucleotide sequence of a gene. It is readily apparent that the present invention includes, but is not limited to, the use of partial nucleotide sequences of more than one gene and that these nucleotide sequences are arranged in various combinations to encode polypeptides that elicit the desired immune response. Moreover, a skilled artisan will understand that an antigen need not be encoded by a "gene" at all. It is readily apparent that an antigen can be generated synthesized or can be derived from a biological sample, or might be macromolecule besides a polypeptide. Such a biological sample can include, but is not limited to a tissue sample, a tumor sample, a cell or a fluid with other biological components.

[00163] The term "antigen presenting cell" or "APC" refers to an immune system cell such as an accessory cell (e.g., a B-cell, a dendritic cell, and the like) that displays a foreign antigen complexed with major histocompatibility complexes (MHC's) on its surface. T-cells may recognize these complexes using their T-cell receptors (TCRs). APCs process antigens and present them to T-cells.

[00164] The term "autologous" refers to any material derived from the same individual to whom it is later to be re-introduced into the individual.

[00165] The term "bioequivalent" refers to an amount of an agent other than the reference compound (e.g., RAD001), required to produce an effect equivalent to the effect produced by the reference dose or reference amount of the reference compound (e.g., RAD001). In an embodiment, the effect is the level of mTOR inhibition, e.g., as measured by P70 S6 kinase inhibition, e.g., as evaluated in an in vivo or in vitro assay, e.g., as measured by an assay described herein, e.g., the Boulay assay, or measurement of phosphorylated S6 levels by western blot. In an embodiment, the effect is the alteration of the ratio of PD-1 positive/PD-1 negative T cells, as measured by cell sorting. In an embodiment, a bioequivalent amount or dose of an mTOR inhibitor is the amount or dose that achieves the same level of P70 S6 kinase inhibition as does the reference dose or reference amount of a reference compound. In an embodiment, a bioequivalent amount or dose of an mTOR inhibitor is the amount or dose that achieves the same level of alteration in the ratio of PD-1 positive/PD-1 negative T cells as does the reference dose or reference amount of a reference compound.

[00166] The term "Chimeric Antigen Receptor" or alternatively a "CAR" refers to a recombinant polypeptide construct comprising at least an extracellular antigen binding domain, a transmembrane domain and a cytoplasmic signaling domain (also referred to herein as "an intracellular signaling domain") comprising a functional signaling domain derived from a stimulatory molecule as defined below. In some embodiments, the domains in the CAR polypeptide construct are in the same polypeptide chain, e.g., comprise a chimeric fusion protein. In other embodiments, the domains in the CAR polypeptide construct are not contiguous with each other, e.g., are in different polypeptide chains, e.g., as provided in an RCAR as described herein.

[00167] In one aspect, the stimulatory molecule of the CAR is the zeta chain associated with the T cell receptor complex. In one aspect, the cytoplasmic signaling domain comprises a

primary signaling domain (e.g., a primary signaling domain of CD3-zeta). In one aspect, the cytoplasmic signaling domain further comprises one or more functional signaling domains derived from at least one costimulatory molecule as defined below. In one aspect, the costimulatory molecule is chosen from 4-1BB (i.e., CD137), CD27 and/or CD28. In one aspect, the CAR comprises a chimeric fusion protein comprising an extracellular antigen binding domain, a transmembrane domain and an intracellular signaling domain comprising a functional signaling domain derived from a stimulatory molecule. In one aspect, the CAR comprises a chimeric fusion protein comprising an extracellular antigen binding domain, a transmembrane domain and an intracellular signaling domain comprising a functional signaling domain derived from a co-stimulatory molecule and a functional signaling domain derived from a stimulatory molecule. In one aspect, the CAR comprises a chimeric fusion protein comprising an extracellular antigen binding domain, a transmembrane domain and an intracellular signaling domain comprising two functional signaling domains derived from one or more co-stimulatory molecule(s) and a functional signaling domain derived from a stimulatory molecule. In one aspect, the CAR comprises a chimeric fusion protein comprising an extracellular antigen binding domain, a transmembrane domain and an intracellular signaling domain comprising at least two functional signaling domains derived from one or more co-stimulatory molecule(s) and a functional signaling domain derived from a stimulatory molecule. In one aspect, the CAR comprises an optional leader sequence at the amino-terminus (N-ter) of the CAR fusion protein. In one aspect, the CAR further comprises a leader sequence at the N-terminus of the extracellular antigen binding domain, wherein the leader sequence is optionally cleaved from the antigen binding domain (e.g., a scFv) during cellular processing and localization of the CAR to the cellular membrane. In an embodiment a CAR comprises an antigen binding domain. In an embodiment, a CAR comprises an extracellular ligand domain specific for a counter ligand.

[00168] A CAR that comprises an antigen binding domain (e.g., a scFv, a single domain antibody, or TCR (e.g., a TCR alpha binding domain or TCR beta binding domain)) that targets a specific tumor marker X, such as those described herein, is referred to as XCAR. For example, a CAR that comprises an antigen binding domain that targets CD19 is referred to as CD19CAR. The CAR can be expressed in any cell, e.g., an immune effector cell as described herein (e.g., a T cell or an NK cell).

[00169] The term “cancer” refers to a disease characterized by the uncontrolled growth of aberrant cells. Cancer cells can spread locally or through the bloodstream and lymphatic system to other parts of the body. Examples of various cancers are described herein and include but are not limited to, breast cancer, prostate cancer, ovarian cancer, cervical cancer, skin cancer, pancreatic cancer, colorectal cancer, renal cancer, liver cancer, brain cancer, lymphoma, leukemia, lung cancer and the like. In an embodiment, a cancer is characterized by expression of a PD-1 ligand, e.g., PD-L1 or PD-L2, on a cancer cell or in a tumor microenvironment. The term "cancer" refers to all types of cancerous growths or oncogenic processes, metastatic tissues or malignantly transformed cells, tissues, or organs, irrespective of histopathologic type or stage of invasiveness. The terms “tumor” and “cancer” are used interchangeably herein, e.g., both terms encompass solid and liquid, e.g., diffuse or circulating, tumors. As used herein, the term “cancer” or “tumor” includes premalignant, as well as malignant cancers and tumors.

[00170] The terms “cancer associated antigen” or “tumor marker” interchangeably refers to a molecule (typically protein, carbohydrate or lipid) that is preferentially expressed on the surface of a cancer cell, either entirely or as a fragment (e.g., MHC/peptide), in comparison to a normal cell, and which is useful for the preferential targeting of a pharmacological agent to the cancer cell. In some embodiments, a cancer-associated antigen is a cell surface molecule that is overexpressed in a cancer cell in comparison to a normal cell, for instance, 1-fold over expression, 2-fold overexpression, 3-fold overexpression or more in comparison to a normal cell. In some enbodiments, a cancer-associated antigen is a cell surface molecule that is inappropriately synthesized in the cancer cell, for instance, a molecule that contains deletions, additions or mutations in comparison to the molecule expressed on a normal cell. In some enbodiments, a cancer-associated antigen will be expressed exclusively on the cell surface of a cancer cell, entirely or as a fragment (e.g., MHC/peptide), and not synthesized or expressed on the surface of a normal cell.

[00171] As used herein, the term “CD19” refers to the Cluster of Differentiation 19 protein, which is an antigenic determinant detectable on leukemia precursor cells. The human and murine amino acid and nucleic acid sequences can be found in a public database, such as GenBank, UniProt and Swiss-Prot. For example, the amino acid sequence of human CD19 can be found as UniProt/Swiss-Prot Accession No. P15391 and the nucleotide sequence encoding of the human CD19 can be found at Accession No. NM_001178098. As used herein, “CD19” includes

proteins comprising mutations, e.g., point mutations, fragments, insertions, deletions and splice variants of full length wild-type CD19. CD19 is expressed on most B lineage cancers, including, e.g., acute lymphoblastic leukaemia, chronic lymphocyte leukaemia and non-Hodgkin lymphoma. Other cells with express CD19 are provided below in the definition of "disease associated with expression of CD19." It is also an early marker of B cell progenitors. See, e.g., Nicholson et al. Mol. Immun. 34 (16-17): 1157-1165 (1997). In one aspect the antigen-binding portion of the CART recognizes and binds an antigen within the extracellular domain of the CD19 protein. In one aspect, the CD19 protein is expressed on a cancer cell.

[00172] As used herein, the term "CD20" refers to an antigenic determinant known to be detectable on B cells. Human CD20 is also called membrane-spanning 4-domains, subfamily A, member 1 (MS4A1). The human and murine amino acid and nucleic acid sequences can be found in a public database, such as GenBank, UniProt and Swiss-Prot. For example, the amino acid sequence of human CD20 can be found at Accession Nos. NP_690605.1 and NP_068769.2, and the nucleotide sequence encoding transcript variants 1 and 3 of the human CD20 can be found at Accession No. NM_152866.2 and NM_021950.3, respectively. In one aspect the antigen-binding portion of the CAR recognizes and binds an antigen within the extracellular domain of the CD20 protein. In one aspect, the CD20 protein is expressed on a cancer cell.

[00173] As used herein, the term "CD22," refers to an antigenic determinant known to be detectable on leukemia precursor cells. The human and murine amino acid and nucleic acid sequences can be found in a public database, such as GenBank, UniProt and Swiss-Prot. For example, the amino acid sequences of isoforms 1-5 human CD22 can be found at Accession Nos. NP 001762.2, NP 001172028.1, NP 001172029.1, NP 001172030.1, and NP 001265346.1, respectively, and the nucleotide sequence encoding variants 1-5 of the human CD22 can be found at Accession No. NM 001771.3, NM 001185099.1, NM 001185100.1, NM 001185101.1, and NM 001278417.1, respectively. In one aspect the antigen-binding portion of the CAR recognizes and binds an antigen within the extracellular domain of the CD22 protein. In one aspect, the CD22 protein is expressed on a cancer cell.

[00174] As used herein, the term "ROR1" refers to an antigenic determinant known to be detectable on leukemia precursor cells. The human and murine amino acid and nucleic acid sequences can be found in a public database, such as GenBank, UniProt and Swiss-Prot. For

example, the amino acid sequences of isoforms 1 and 2 precursors of human ROR1 can be found at Accession Nos. NP_005003.2 and NP_001077061.1, respectively, and the mRNA sequences encoding them can be found at Accession Nos. NM_005012.3 and NM_001083592.1, respectively. In one aspect the antigen-binding portion of the CAR recognizes and binds an antigen within the extracellular domain of the ROR1 protein. In one aspect, the ROR1 protein is expressed on a cancer cell.

[00175] The term "conservative sequence modifications" refers to amino acid modifications that do not significantly affect or alter the binding characteristics of the antibody or antibody fragment containing the amino acid sequence. Such conservative modifications include amino acid substitutions, additions and deletions. Modifications can be introduced into an antibody or antibody fragment of the invention by standard techniques known in the art, such as site-directed mutagenesis and PCR-mediated mutagenesis. Conservative substitutions are ones in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine, tryptophan), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine). Thus, one or more amino acid residues within a CAR of the invention can be replaced with other amino acid residues from the same side chain family and the altered CAR can be tested using the functional assays described herein.

[00176] The term "constitutive" promoter refers to a nucleotide sequence which, when operably linked with a polynucleotide which encodes or specifies a gene product, causes the gene product to be produced in a cell under most or all physiological conditions of the cell.

[00177] "Derived from" as that term is used herein, indicates a relationship between a first and a second molecule. It generally refers to structural similarity between the first molecule and a second molecule and does not connotate or include a process or source limitation on a first molecule that is derived from a second molecule. For example, in the case of an intracellular signaling domain that is derived from a CD3zeta molecule, the intracellular signaling domain

retains sufficient CD3zeta structure such that it has the required function, namely, the ability to generate a signal under the appropriate conditions. It does not connotate or include a limitation to a particular process of producing the intracellular signaling domain, e.g., it does not mean that, to provide the intracellular signaling domain, one must start with a CD3zeta sequence and delete unwanted sequence, or impose mutations, to arrive at the intracellular signaling domain.

[00178] The phrase "disease associated with expression of a tumor marker as described herein" includes, but is not limited to, a disease associated with a cell that expresses a tumor marker as described herein or condition associated with a cell which expresses, or at any time expressed, a tumor marker as described herein including, e.g., proliferative diseases such as a cancer or malignancy or a precancerous condition such as a myelodysplasia, a myelodysplastic syndrome or a preleukemia; or a noncancer related indication associated with a cell which expresses a tumor marker as described herein. In one aspect, a cancer associated with expression of a tumor marker as described herein is a hematological cancer. In one aspect, a cancer associated with expression of a tumor marker as described herein is a solid cancer. Further diseases associated with expression of a tumor marker as described herein include, but not limited to, e.g., atypical and/or non-classical cancers, malignancies, precancerous conditions or proliferative diseases associated with expression of a tumor marker as described herein. Non-cancer related indications associated with expression of a tumor marker as described herein include, but are not limited to, e.g., autoimmune disease, (e.g., lupus), inflammatory disorders (allergy and asthma) and transplantation.

[00179] The phrase "disease associated with expression of CD19" includes, but is not limited to, a disease associated with a cell that expresses CD19 or condition associated with a cell which expresses, or at any time expressed, CD19 including, e.g., proliferative diseases such as a cancer or malignancy or a precancerous condition such as a myelodysplasia, a myelodysplastic syndrome or a preleukemia; or a noncancer related indication associated with a cell which expresses CD19. For the avoidance of doubt, a disease associated with expression of CD19 may include a condition associated with a cell which does not presently express CD19, e.g., because CD19 expression has been downregulated, e.g., due to treatment with a molecule targeting CD19, e.g., a CD19 CAR, but which at one time expressed CD19. In one aspect, a cancer associated with expression of CD19 is a hematological cancer. In one aspect, the hematolical cancer is a leukemia or a lymphoma. In one aspect, a cancer associated with expression of CD19

includes cancers and malignancies including, but not limited to, e.g., one or more acute leukemias including but not limited to, e.g., B-cell acute Lymphoid Leukemia (BALL), T-cell acute Lymphoid Leukemia (TALL), acute lymphoid leukemia (ALL); one or more chronic leukemias including but not limited to, e.g., chronic myelogenous leukemia (CML), Chronic Lymphoid Leukemia (CLL). Additional cancers or hematologic conditions associated with expression of CD19 comprise, but are not limited to, e.g., B cell prolymphocytic leukemia, blastic plasmacytoid dendritic cell neoplasm, Burkitt's lymphoma, diffuse large B cell lymphoma, Follicular lymphoma, Hairy cell leukemia, small cell- or a large cell-follicular lymphoma, malignant lymphoproliferative conditions, MALT lymphoma, mantle cell lymphoma (MCL), Marginal zone lymphoma, multiple myeloma, myelodysplasia and myelodysplastic syndrome, non-Hodgkin lymphoma, Hodgkin lymphoma, plasmablastic lymphoma, plasmacytoid dendritic cell neoplasm, Waldenstrom macroglobulinemia, and "preleukemia" which are a diverse collection of hematological conditions united by ineffective production (or dysplasia) of myeloid blood cells, and the like. Further diseases associated with expression of CD19 expression include, but not limited to, e.g., atypical and/or non-classical cancers, malignancies, precancerous conditions or proliferative diseases associated with expression of CD19. Non-cancer related indications associated with expression of CD19 include, but are not limited to, e.g., autoimmune disease, (e.g., lupus), inflammatory disorders (allergy and asthma) and transplantation. In some embodiments, the tumor antigen-expressing cell expresses, or at any time expressed, mRNA encoding the tumor antigen. In an embodiment, the tumor antigen -expressing cell produces the tumor antigen protein (e.g., wild-type or mutant), and the tumor antigen protein may be present at normal levels or reduced levels. In an embodiment, the tumor antigen -expressing cell produced detectable levels of a tumor antigen protein at one point, and subsequently produced substantially no detectable tumor antigen protein.

[00180] The term "effective amount" or "therapeutically effective amount" are used interchangeably herein, and refer to an amount of a compound, formulation, material, or composition, as described herein effective to achieve a particular biological result.

[00181] The term "encoding" refers to the inherent property of specific sequences of nucleotides in a polynucleotide, such as a gene, a cDNA, or an mRNA, to serve as templates for synthesis of other polymers and macromolecules in biological processes having either a defined sequence of nucleotides (e.g., rRNA, tRNA and mRNA) or a defined sequence of amino acids

and the biological properties resulting therefrom. Thus, a gene, cDNA, or RNA, encodes a protein if transcription and translation of mRNA corresponding to that gene produces the protein in a cell or other biological system. Both the coding strand, the nucleotide sequence of which is identical to the mRNA sequence and is usually provided in sequence listings, and the non-coding strand, used as the template for transcription of a gene or cDNA, can be referred to as encoding the protein or other product of that gene or cDNA.

[00182] The term "endogenous" refers to any material from or produced inside an organism, cell, tissue or system.

[00183] The term "exogenous" refers to any material introduced from or produced outside an organism, cell, tissue or system.

[00184] The term "expression" refers to the transcription and/or translation of a particular nucleotide sequence driven by a promoter.

[00185] The term "expression vector" refers to a vector comprising a recombinant polynucleotide comprising expression control sequences operatively linked to a nucleotide sequence to be expressed. An expression vector comprises sufficient cis-acting elements for expression; other elements for expression can be supplied by the host cell or in an in vitro expression system. Expression vectors include all those known in the art, including cosmids, plasmids (e.g., naked or contained in liposomes) and viruses (e.g., lentiviruses, retroviruses, adenoviruses, and adeno-associated viruses) that incorporate the recombinant polynucleotide.

[00186] The term "flexible polypeptide linker" or "linker" as used in the context of a scFv refers to a peptide linker that consists of amino acids such as glycine and/or serine residues used alone or in combination, to link variable heavy and variable light chain regions together. In one embodiment, the flexible polypeptide linker is a Gly/Ser linker and comprises the amino acid sequence (Gly-Gly-Gly-Ser)n, where n is a positive integer equal to or greater than 1. For example, n=1, n=2, n=3, n=4, n=5 and n=6, n=7, n=8, n=9 and n=10 (SEQ ID NO:28). In one embodiment, the flexible polypeptide linkers include, but are not limited to, $(Gly_4Ser)_4$ (SEQ ID NO:29) or $(Gly_4Ser)_3$ (SEQ ID NO:30). In another embodiment, the linkers include multiple repeats of $(Gly_2Ser)$, (GlySer) or $(Gly_3Ser)$ (SEQ ID NO:31). Also included within the scope of the invention are linkers described in WO2012/138475 (incorporated herein by reference).

[00187] "Fully human" refers to an immunoglobulin, such as an antibody or antibody fragment, where the whole molecule is of human origin or consists of an amino acid sequence identical to a human form of the antibody or immunoglobulin.

[00188] The term "homologous" or "identity" refers to the subunit sequence identity between two polymeric molecules, e.g., between two nucleic acid molecules, such as, two DNA molecules or two RNA molecules, or between two polypeptide molecules. When a subunit position in both of the two molecules is occupied by the same monomeric subunit; e.g., if a position in each of two DNA molecules is occupied by adenine, then they are homologous or identical at that position. The homology between two sequences is a direct function of the number of matching or homologous positions; e.g., if half (e.g., five positions in a polymer ten subunits in length) of the positions in two sequences are homologous, the two sequences are 50% homologous; if 90% of the positions (e.g., 9 of 10), are matched or homologous, the two sequences are 90% homologous.

[00189] "Humanized" forms of non-human (e.g., murine) antibodies are chimeric immunoglobulins, immunoglobulin chains or fragments thereof (such as Fv, Fab, Fab', F(ab')2 or other antigen-binding subsequences of antibodies) which contain minimal sequence derived from non-human immunoglobulin. For the most part, humanized antibodies and antibody fragments thereof are human immunoglobulins (recipient antibody or antibody fragment) in which residues from a complementary-determining region (CDR) of the recipient are replaced by residues from a CDR of a non-human species (donor antibody) such as mouse, rat or rabbit having the desired specificity, affinity, and capacity. In some instances, Fv framework region (FR) residues of the human immunoglobulin are replaced by corresponding non-human residues. Furthermore, a humanized antibody/antibody fragment can comprise residues which are found neither in the recipient antibody nor in the imported CDR or framework sequences. These modifications can further refine and optimize antibody or antibody fragment performance. In general, the humanized antibody or antibody fragment thereof will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin and all or a significant portion of the FR regions are those of a human immunoglobulin sequence. The humanized antibody or antibody fragment can also comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. For further details, see Jones et al., Nature, 321: 522-

525, 1986; Reichmann et al., Nature, 332: 323-329, 1988; Presta, Curr. Op. Struct. Biol., 2: 593-596, 1992.

[00190] "Immune effector cell," as that term is used herein, refers to a cell that is involved in an immune response, e.g., in the promotion of an immune effector response. Examples of immune effector cells include T cells, e.g., alpha/beta T cells and gamma/delta T cells, B cells, natural killer (NK) cells, natural killer T (NKT) cells, mast cells, and myeloic-derived phagocytes.

[00191] "Immune effector function or immune effector response," as that term is used herein, refers to function or response, e.g., of an immune effector cell, that enhances or promotes an immune attack of a target cell. E.g., an immune effector function or response refers a property of a T or NK cell that promotes killing or the inhibition of growth or proliferation, of a target cell. In the case of a T cell, primary stimulation and co-stimulation are examples of immune effector function or response.

[00192] The term "effector function" refers to a specialized function of a cell. Effector function of a T cell, for example, may be cytolytic activity or helper activity including the secretion of cytokines.

[00193] The term "immunosenescence" refers to a decrease in immune function resulting in impaired immune response, e.g., to cancer, vaccination, infectious pathogens, among others. It involves both the host's capacity to respond to infections and the development of long-term immune memory, especially by vaccination. This immune deficiency is ubiquitous and found in both long- and short-lived species as a function of their age relative to life expectancy rather than chronological time. It is considered a major contributory factor to the increased frequency of morbidity and mortality among the elderly. Immunosenescence is not a random deteriorative phenomenon, rather it appears to inversely repeat an evolutionary pattern and most of the parameters affected by immunosenescence appear to be under genetic control. Immunosenescence can also be sometimes envisaged as the result of the continuous challenge of the unavoidable exposure to a variety of antigens such as viruses and bacteria. Immunosenescence is a multifactorial condition leading to many pathologically significant health problems, e.g., in the aged population. Age-dependent biological changes such as depletion of hematopoietic stem cells, decline in the total number of phagocytes and NK cells and a decline in

humoral immunity contribute to the onset of immunosenescence. In one aspect, immunosenescence can be measured in an individual by measuring telomere length in immune cells (See, e.g., US5741677). Immunosenescence can also be determined by documenting in an individual a lower than normal number of naïve CD4 and/or CD8 T cells, T cell repertoire, or response to vaccination in a subject greater than or equal to 65 years of age.

[00194] The term "impaired immune response" refers to a state in which a subject does not have an appropriate immune response, e.g., to cancer, vaccination, pathogen infection, among others. In some embodiments, a subject having an impaired immune response is predicted not to get protective antibody titer levels following prophylactic vaccination, or in which a subject does not have a decrease in disease burden after therapeutic vaccination. A subject can also have an impaired immune response if the subject is a member of a population known to have decreased immune function or that has a history of decreased immune function such as the elderly, subjects undergoing chemotherapy treatment, asplenic subjects, immunocompromised subjects, or subjects having HIV/AIDS. Methods described herein allow for the treatment of an impaired immune response by administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, such as RAD001.

[00195] The term "inducible" promoter refers to a nucleotide sequence which, when operably linked with a polynucleotide which encodes or specifies a gene product, causes the gene product to be produced in a cell substantially only when an inducer which corresponds to the promoter is present in the cell.

[00196] An "intracellular signaling domain," as the term is used herein, refers to an intracellular portion of a molecule. In embodiments, the intracellular signal domain transduces the effector function signal and directs the cell to perform a specialized function. While the entire intracellular signaling domain can be employed, in many cases it is not necessary to use the entire chain. To the extent that a truncated portion of the intracellular signaling domain is used, such truncated portion may be used in place of the intact chain as long as it transduces the effector function signal. The term intracellular signaling domain is thus meant to include any truncated portion of the intracellular signaling domain sufficient to transduce the effector function signal.

[00197] In an embodiment, the intracellular signaling domain can comprise a primary intracellular signaling domain. Exemplary primary intracellular signaling domains include those

derived from the molecules responsible for primary stimulation, or antigen dependent simulation. In an embodiment, the intracellular signaling domain can comprise a costimulatory intracellular domain. Exemplary costimulatory intracellular signaling domains include those derived from molecules responsible for costimulatory signals, or antigen independent stimulation. For example, in the case of a CART, a primary intracellular signaling domain can comprise a cytoplasmic sequence of a T cell receptor, and a costimulatory intracellular signaling domain can comprise cytoplasmic sequence from co-receptor or costimulatory molecule.

[00198] A primary intracellular signaling domain can comprise a signaling motif which is known as an immunoreceptor tyrosine-based activation motif or ITAM. Examples of ITAM containing primary cytoplasmic signaling sequences include, but are not limited to, those derived from CD3 zeta, FcR gamma, FcR beta, CD3 gamma, CD3 delta, CD3 epsilon, CD5, CD22, CD79a, CD79b, CD278 (also known as "ICOS"), FcεRI, and CD66d. Further examples of molecules containing a primary intracellular signaling domain that are of particular use in the invention include those of DAP10, DAP12, and CD32.

[00199] The term "zeta" or alternatively "zeta chain", "CD3-zeta" or "TCR-zeta" is defined as the protein provided as GenBan Acc. No. BAG36664.1, or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like, and a "zeta stimulatory domain" or alternatively a "CD3-zeta stimulatory domain" or a "TCR-zeta stimulatory domain" is defined as the amino acid residues from the cytoplasmic domain of the zeta chain that are sufficient to functionally transmit an initial signal necessary for T cell activation. In one aspect the cytoplasmic domain of zeta comprises residues 52 through 164 of GenBank Acc. No. BAG36664.1 or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like, that are functional orthologs thereof. In one aspect, the "zeta stimulatory domain" or a "CD3-zeta stimulatory domain" is the sequence provided as SEQ ID NO:18. In one aspect, the "zeta stimulatory domain" or a "CD3-zeta stimulatory domain" is the sequence provided as SEQ ID NO:20.

[00200] The term "costimulatory molecule" refers to the cognate binding partner on a T cell that specifically binds with a costimulatory ligand, thereby mediating a costimulatory response by the T cell, such as, but not limited to, proliferation. Costimulatory molecules are cell surface molecules other than antigen receptors or their ligands that are required for an efficient immune

response. Costimulatory molecules include, but are not limited to an MHC class I molecule, TNF receptor proteins, Immunoglobulin-like proteins, cytokine receptors, integrins, signaling lymphocytic activation molecules (SLAM proteins), activating NK cell receptors, BTLA, a Toll ligand receptor, OX40, CD2, CD7, CD27, CD28, CD30, CD40, CDS, ICAM-1, LFA-1 (CD11a/CD18), 4-1BB (CD137), B7-H3, CDS, ICAM-1, ICOS (CD278), GITR, BAFFR, LIGHT, HVEM (LIGHTR), KIRDS2, SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, CD19a, and a ligand that specifically binds with CD83.

[00201] A costimulatory intracellular signaling domain refers to the intracellular portion of a costimulatory molecule.

[00202] The intracellular signaling domain can comprise the entire intracellular portion, or the entire native intracellular signaling domain, of the molecule from which it is derived, or a functional fragment thereof.

[00203] The term "4-1BB" refers to a member of the TNFR superfamily with an amino acid sequence provided as GenBank Acc. No. AAA62478.2, or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like; and a "4-1BB costimulatory domain" is defined as amino acid residues 214-255 of GenBank accno. AAA62478.2, or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like. In one aspect, the "4-1BB costimulatory domain" is the sequence provided as SEQ ID NO:14 or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like.

[00204] As used herein, "in vitro transcribed RNA" refers to RNA, preferably mRNA, that has been synthesized in vitro. Generally, the in vitro transcribed RNA is generated from an in vitro transcription vector. The in vitro transcription vector comprises a template that is used to generate the in vitro transcribed RNA.

[00205] The term "isolated" means altered or removed from the natural state. For example, a nucleic acid or a peptide naturally present in a living animal is not "isolated," but the same nucleic acid or peptide partially or completely separated from the coexisting materials of its natural state is "isolated." An isolated nucleic acid or protein can exist in substantially purified form, or can exist in a non-native environment such as, for example, a host cell.

[00206] In the context of the present invention, the following abbreviations for the commonly occurring nucleic acid bases are used. "A" refers to adenosine, "C" refers to cytosine, "G" refers to guanosine, "T" refers to thymidine, and "U" refers to uridine.

[00207] The term "lentivirus" refers to a genus of the Retroviridae family. Lentiviruses are unique among the retroviruses in being able to infect non-dividing cells; they can deliver a significant amount of genetic information into the DNA of the host cell, so they are one of the most efficient methods of a gene delivery vector. HIV, SIV, and FIV are all examples of lentiviruses.

[00208] The term "lentiviral vector" refers to a vector derived from at least a portion of a lentivirus genome, including especially a self-inactivating lentiviral vector as provided in Milone et al., Mol. Ther. 17(8): 1453–1464 (2009). Other examples of lentivirus vectors that may be used in the clinic, include but are not limited to, e.g., the LENTIVECTOR® gene delivery technology from Oxford BioMedica, the LENTIMAX™ vector system from Lentigen and the like. Nonclinical types of lentiviral vectors are also available and would be known to one skilled in the art.

[00209] The term 'low, immune enhancing, dose" when used in conjuction with an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001 or rapamycin, or a catalytic mTOR inhibitor, refers to a dose of mTOR inhibitor that partially, but not fully, inhibits mTOR activity, e.g., as measured by the inhibition of P70 S6 kinase activity. Methods for evaluating mTOR activity, e.g., by inhibition of P70 S6 kinase, are discussed herein. The dose is insufficient to result in complete immune suppression but is sufficient to enhance the immune response. In an embodiment, the low, immune enhancing, dose of mTOR inhibitor results in a decrease in the number of PD-1 positive T cells and/or an increase in the number of PD-1 negative T cells, or an increase in the ratio of PD-1 negative T cells/PD-1 positive T cells. In an embodiment, the low, immune enhancing, dose of mTOR inhibitor results in an increase in the number of naive T cells.

In an embodiment, the low, immune enhancing, dose of mTOR inhibitor results in one or more of the following:

an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; and

an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

wherein any of the changes described above occurs, e.g., at least transiently, e.g., as compared to a non-treated subject.

[00210] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 90%, at least 10 but no more than 90%, at least 15, but no more than 90%, at least 20 but no more than 90%, at least 30 but no more than 90%, at least 40 but no more than 90%, at least 50 but no more than 90%, at least 60 but no more than 90%, or at least 70 but no more than 90%.

[00211] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 80%, at least 10 but no more than 80%, at least 15, but no more than 80%, at least 20 but no more than 80%, at least 30 but no more than 80%, at least 40 but no more than 80%, at least 50 but no more than 80%, or at least 60 but no more than 80%.In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 70%, at least 10 but no more than 70%, at least 15, but no more than 70%, at least 20 but no more than 70%, at least 30 but no more than 70%, at least 40 but no more than 70%, or at least 50 but no more than 70%.

[00212] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 60%, at least 10 but no more than 60%, at least 15, but no more than 60%, at least 20 but no more than 60%, at least 30 but no more than 60%, or at least 40 but no more than 60%.

[00213] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 50%, at least 10 but no more than 50%, at least

15, but no more than 50%, at least 20 but no more than 50%, at least 30 but no more than 50%, or at least 40 but no more than 50%.

[00214] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 40%, at least 10 but no more than 40%, at least 15, but no more than 40%, at least 20 but no more than 40%, at least 30 but no more than 40%, or at least 35 but no more than 40%.

[00215] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 5 but no more than 30%, at least 10 but no more than 30%, at least 15, but no more than 30%, at least 20 but no more than 30%, or at least 25 but no more than 30%.

[00216] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 1, 2, 3, 4 or 5 but no more than 20%, at least 1, 2, 3, 4 or 5 but no more than 30%, at least 1, 2, 3, 4 or 5, but no more than 35, at least 1, 2, 3, 4 or 5 but no more than 40%, or at least 1, 2, 3, 4 or 5 but no more than 45%.

[00217] In an embodiment, a dose of an mTOR inhibitor is associated with, or provides, mTOR inhibition of at least 1, 2, 3, 4 or 5 but no more than 90%.

[00218] As is discussed hrein, the extent of mTOR inhibition can be expressed as the extent of P70 S6K inhibition, e.g., the extent of mTOR inhibition can be determined by the level of decrease in P70 S6K activity, e.g., by the decrease in phosphorylation of a P70 S6K substrate. The level of mTOR inhibition can be evaluated by a method described herein, e.g. by the Boulay assay.

[00219] Unless otherwise specified, a "nucleotide sequence encoding an amino acid sequence" includes all nucleotide sequences that are degenerate versions of each other and that encode the same amino acid sequence. The phrase nucleotide sequence that encodes a protein or an RNA may also include introns to the extent that the nucleotide sequence encoding the protein may in some version contain an intron(s).

[00220] In the context of the present invention, the following abbreviations for the commonly occurring nucleic acid bases are used. "A" refers to adenosine, "C" refers to cytosine, "G" refers to guanosine, "T" refers to thymidine, and "U" refers to uridine.

[00221] The term "nucleic acid" or "polynucleotide" refers to deoxyribonucleic acids (DNA) or ribonucleic acids (RNA) and polymers thereof in either single- or double-stranded form. Unless specifically limited, the term encompasses nucleic acids containing known analogues of natural nucleotides that have similar binding properties as the reference nucleic acid and are metabolized in a manner similar to naturally occurring nucleotides. Unless otherwise indicated, a particular nucleic acid sequence also implicitly encompasses conservatively modified variants thereof (e.g., degenerate codon substitutions), alleles, orthologs, SNPs, and complementary sequences as well as the sequence explicitly indicated. Specifically, degenerate codon substitutions may be achieved by generating sequences in which the third position of one or more selected (or all) codons is substituted with mixed-base and/or deoxyinosine residues (Batzer et al., Nucleic Acid Res. 19:5081 (1991); Ohtsuka et al., J. Biol. Chem. 260:2605-2608 (1985); and Rossolini et al., Mol. Cell. Probes 8:91-98 (1994)).

[00222] The term "operably linked" or "transcriptional control" refers to functional linkage between a regulatory sequence and a heterologous nucleic acid sequence resulting in expression of the latter. For example, a first nucleic acid sequence is operably linked with a second nucleic acid sequence when the first nucleic acid sequence is placed in a functional relationship with the second nucleic acid sequence. For instance, a promoter is operably linked to a coding sequence if the promoter affects the transcription or expression of the coding sequence. Operably linked DNA sequences can be contiguous with each other and, e.g., where necessary to join two protein coding regions, are in the same reading frame.

[00223] The term "parenteral" administration of an immunogenic composition includes, e.g., subcutaneous (s.c.), intravenous (i.v.), intramuscular (i.m.), or intrasternal injection, intratumoral, or infusion techniques.

[00224] The terms "peptide," "polypeptide," and "protein" are used interchangeably, and refer to a compound comprised of amino acid residues covalently linked by peptide bonds. A protein or peptide must contain at least two amino acids, and no limitation is placed on the maximum number of amino acids that can comprise a protein's or peptide's sequence. Polypeptides include any peptide or protein comprising two or more amino acids joined to each other by peptide bonds. As used herein, the term refers to both short chains, which also commonly are referred to in the art as peptides, oligopeptides and oligomers, for example, and to longer chains, which

generally are referred to in the art as proteins, of which there are many types. "Polypeptides" include, for example, biologically active fragments, substantially homologous polypeptides, oligopeptides, homodimers, heterodimers, variants of polypeptides, modified polypeptides, derivatives, analogs, fusion proteins, among others. A polypeptide includes a natural peptide, a recombinant peptide, or a combination thereof.

[00225] As used herein, a "poly(A)" is a series of adenosines attached by polyadenylation to the mRNA. In the preferred embodiment of a construct for transient expression, the polyA is between 50 and 5000 (SEQ ID NO: 34), preferably greater than 64, more preferably greater than 100, most preferably greater than 300 or 400. poly(A) sequences can be modified chemically or enzymatically to modulate mRNA functionality such as localization, stability or efficiency of translation.

[00226] As used herein, "polyadenylation" refers to the covalent linkage of a polyadenylyl moiety, or its modified variant, to a messenger RNA molecule. In eukaryotic organisms, most messenger RNA (mRNA) molecules are polyadenylated at the 3' end. The 3' poly(A) tail is a long sequence of adenine nucleotides (often several hundred) added to the pre-mRNA through the action of an enzyme, polyadenylate polymerase. In higher eukaryotes, the poly(A) tail is added onto transcripts that contain a specific sequence, the polyadenylation signal. The poly(A) tail and the protein bound to it aid in protecting mRNA from degradation by exonucleases. Polyadenylation is also important for transcription termination, export of the mRNA from the nucleus, and translation. Polyadenylation occurs in the nucleus immediately after transcription of DNA into RNA, but additionally can also occur later in the cytoplasm. After transcription has been terminated, the mRNA chain is cleaved through the action of an endonuclease complex associated with RNA polymerase. The cleavage site is usually characterized by the presence of the base sequence AAUAAA (SEQ ID NO:40) near the cleavage site. After the mRNA has been cleaved, adenosine residues are added to the free 3' end at the cleavage site.

[00227] "Prodrug", or "pro-drug" refers to a compound that is processed, in the body of a subject, into a drug. In an embodiment, the processing comprises the breaking or formation of a bond, e.g., a covalent bond. Typically, breakage of a covalent bond releases the drug.

[00228] The term "promote" or "enhance" in the context of an immune response refers to an increase in immune response, such as an increase in the ability of immune cells to target and/or

kill cancer cells, to target and/or kill pathogens and pathogen infected cells, and protective immunity following vaccination, among others. In some embodiments, protective immunity refers to the presence of sufficient immune response (such as antibody titers) to protect against subsequent infection by a pathogen expressing the same antigen.

[00229] The term "promoter" refers to a DNA sequence recognized by the synthetic machinery of the cell, or introduced synthetic machinery, required to initiate the specific transcription of a polynucleotide sequence.

[00230] The term "promoter/regulatory sequence" refers to a nucleic acid sequence which is required for expression of a gene product operably linked to the promoter/regulatory sequence. In some instances, this sequence may be the core promoter sequence and in other instances, this sequence may also include an enhancer sequence and other regulatory elements which are required for expression of the gene product. The promoter/regulatory sequence may, for example, be one which expresses the gene product in a tissue specific manner.

[00231] The term "prophylaxis" means the prevention of or protective treatment for a disease or disease state. Prevention may be complete, e.g., the total absence of a disease or disease state. The prevention may also be partial, such that the likelihood of the occurrence of the disease or disease state in a subject is less likely to occur than had the subject not received the prophylactic treatment.

[00232] As used herein, the term "rapalog" refers to a small molecule analog of rapamycin.

[00233] The term "recombinant antibody" refers to an antibody which is generated using recombinant DNA technology, such as, for example, an antibody expressed by a bacteriophage or yeast expression system. The term should also be construed to mean an antibody which has been generated by the synthesis of a DNA molecule encoding the antibody and which DNA molecule expresses an antibody protein, or an amino acid sequence specifying the antibody, wherein the DNA or amino acid sequence has been obtained using recombinant DNA or amino acid sequence technology which is available and known in the art.

[00234] As used herein, a 5' cap (also termed an RNA cap, an RNA 7-methylguanosine cap or an RNA $m^7G$ cap) is a modified guanine nucleotide that has been added to the "front" or 5' end of a eukaryotic messenger RNA shortly after the start of transcription. The 5' cap consists of a terminal group which is linked to the first transcribed nucleotide. Its presence is critical for

recognition by the ribosome and protection from RNases. Cap addition is coupled to transcription, and occurs co-transcriptionally, such that each influences the other. Shortly after the start of transcription, the 5' end of the mRNA being synthesized is bound by a cap-synthesizing complex associated with RNA polymerase. This enzymatic complex catalyzes the chemical reactions that are required for mRNA capping. Synthesis proceeds as a multi-step biochemical reaction. The capping moiety can be modified to modulate functionality of mRNA such as its stability or efficiency of translation.

[00235] The term "signal transduction pathway" refers to the biochemical relationship between a variety of signal transduction molecules that play a role in the transmission of a signal from one portion of a cell to another portion of a cell. The phrase "cell surface receptor" includes molecules and complexes of molecules capable of receiving a signal and transmitting signal across the membrane of a cell.

[00236] The term "signaling domain" refers to the functional portion of a protein which acts by transmitting information within the cell to regulate cellular activity via defined signaling pathways by generating second messengers or functioning as effectors by responding to such messengers.

[00237] The term, a "substantially purified" cell refers to a cell that is essentially free of other cell types. A substantially purified cell also refers to a cell which has been separated from other cell types with which it is normally associated in its naturally occurring state. In some instances, a population of substantially purified cells refers to a homogenous population of cells. In other instances, this term refers simply to cell that have been separated from the cells with which they are naturally associated in their natural state. In some aspects, the cells are cultured in vitro. In other aspects, the cells are not cultured in vitro.

[00238] The term "specifically binds," refers to an antibody, or a ligand, which recognizes and binds with a cognate binding partner (e.g., a stimulatory and/or costimulatory molecule present on a T cell) protein present in a sample, but which antibody or ligand does not substantially recognize or bind other molecules in the sample.

[00239] The term "stimulation," refers to a primary response induced by binding of a stimulatory molecule (e.g., a TCR/CD3 complex or CAR) with its cognate ligand (or tumor antigen in the case of a CAR) thereby mediating a signal transduction event, such as, but not

limited to, signal transduction via the TCR/CD3 complex or signal transduction via the appropriate NK receptor or signaling domains of the CAR. Stimulation can mediate altered expression of certain molecules.

[00240] The term "stimulatory molecule," refers to a molecule expressed by a T cell that provides the primary cytoplasmic signaling sequence(s) that regulate primary activation of the TCR complex in a stimulatory way for at least some aspect of the T cell signaling pathway. In one aspect, the primary signal is initiated by, for instance, binding of a TCR/CD3 complex with an MHC molecule loaded with peptide, and which leads to mediation of a T cell response, including, but not limited to, proliferation, activation, differentiation, and the like. A primary cytoplasmic signaling sequence (also referred to as a "primary signaling domain") that acts in a stimulatory manner may contain a signaling motif which is known as immunoreceptor tyrosine-based activation motif or ITAM. Examples of an ITAM containing primary cytoplasmic signaling sequence that is of particular use in the invention includes, but is not limited to, those derived from CD3 zeta, common FcR gamma (FCER1G), FcR beta (Fc Epsilon R1b), CD3 gamma, CD3 delta, CD3 epsilon, CD5, CD22, CD79a, CD79b, DAP10, DAP12, CD278 (also known as "ICOS"), FcεRI, CD66d, DAP10, and DAP12. In a specific CAR of the invention, the intracellular signaling domain in any one or more CARs of the invention comprises an intracellular signaling sequence, e.g., a primary signaling sequence of CD3-zeta. In a specific CAR of the invention, the primary signaling sequence of CD3-zeta is the sequence provided as SEQ ID NO:18, or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like. In a specific CAR of the invention, the primary signaling sequence of CD3-zeta is the sequence as provided in SEQ ID NO:20, or the equivalent residues from a non-human species, e.g., mouse, rodent, monkey, ape and the like.

[00241] The term "subject", refers to any living organisms in which an immune response can be elicited (e.g., mammals, human). In an embodiment, the subject is a human. A subject may be of any age. In an embodiment, the subject is an elderly human subject, e.g., 65 years of age or older. In an embodiment, a subject is a human subject who is not an elderly, e.g., less than 65 years of age. In an embodiment, a subject is a human pediatric subject, e.g., 18 years of age or less. In an embodiment, a subject is an adult subject, e.g., older than 18 years of age.

[00242] The term "therapeutic" as used herein means a treatment. A therapeutic effect is obtained by reduction, suppression, remission, or eradication of a disease state.

[00243] The term “transfer vector” refers to a composition of matter which comprises an isolated nucleic acid and which can be used to deliver the isolated nucleic acid to the interior of a cell. Numerous vectors are known in the art including, but not limited to, linear polynucleotides, polynucleotides associated with ionic or amphiphilic compounds, plasmids, and viruses. Thus, the term “transfer vector” includes an autonomously replicating plasmid or a virus. The term should also be construed to further include non-plasmid and non-viral compounds which facilitate transfer of nucleic acid into cells, such as, for example, a polylysine compound, liposome, and the like. Examples of viral transfer vectors include, but are not limited to, adenoviral vectors, adeno-associated virus vectors, retroviral vectors, lentiviral vectors, and the like.

[00244] The term “tissue-specific” promoter refers to a nucleotide sequence which, when operably linked with a polynucleotide encodes or specified by a gene, causes the gene product to be produced in a cell substantially only if the cell is a cell of the tissue type corresponding to the promoter.

[00245] The term “transfected” or “transformed” or “transduced” refers to a process by which exogenous nucleic acid is transferred or introduced into the host cell. A “transfected” or “transformed” or “transduced” cell is one which has been transfected, transformed or transduced with exogenous nucleic acid. The cell includes the primary subject cell and its progeny.

[00246] As used herein, “transient” refers to expression of a non-integrated transgene for a period of hours, days or weeks, wherein the period of time of expression is less than the period of time for expression of the gene if integrated into the genome or contained within a stable plasmid replicon in the host cell.

[00247] In the context of the present invention, "tumor antigen" or "hyperproliferative disorder antigen" or "antigen associated with a hyperproliferative disorder" refers to antigens that are common to specific hyperproliferative disorders. In certain aspects, the hyperproliferative disorder antigens of the present invention are derived from, cancers including but not limited to primary or metastatic melanoma, thymoma, lymphoma, sarcoma, lung cancer, liver cancer, non-Hodgkin lymphoma, Hodgkins lymphoma, leukemias, uterine cancer, cervical cancer, bladder cancer, kidney cancer and adenocarcinomas such as breast cancer, prostate cancer, ovarian cancer, pancreatic cancer, and the like.

[00248] The term "vaccine" refers to a composition, such as a suspension or solution of antigen or antigenic moieties, usually containing an antigen (e.g., an inactivated infectious agent, or some part of the infectious agent, a tumor antigen, among others) that is injected or otherwise introduced into the body to produce active immunity. The antigen or antigenic moiety making up the vaccine can be a live or killed microorganism, or a natural product purified from a microorganism or other cell including, but not limited to tumor cells, a synthetic product, a genetically engineered protein, peptide, polysaccharide or similar product or an allergen. The antigen or antigenic moiety can also be a subunit of a protein, peptide, polysaccharide or similar product.

[00249] "Regulatable chimeric antigen receptor (RCAR),"as that term is used herein, refers to a set of polypeptides, typically two in the simplest embodiments, which when in a RCARX cell, provides the RCARX cell with specificity for a target cell, typically a cancer cell, and with regulatable intracellular signal generation or proliferation, which can optimize an immune effector property of the RCARX cell. An RCARX cell relies at least in part, on an antigen binding domain to provide specificity to a target cell that comprises the antigen bound by the antigen binding domain. In an embodiment, an RCAR includes a dimerization switch that, upon the presence of a dimerization molecule, can couple an intracellular signaling domain to the antigen binding domain.

[00250] "Membrane anchor" or "membrane tethering domain", as that term is used herein, refers to a polypeptide or moiety, e.g., a myristoyl group, sufficient to anchor an extracellular or intracellular domain to the plasma membrane.

[00251] "Switch domain," as that term is used herein, e.g., when referring to an RCAR, refers to an entity, typically a polypeptide-based entity, that, in the presence of a dimerization molecule, associates with another switch domain. The association results in a functional coupling of a first entity linked to, e.g., fused to, a first switch domain, and a second entity linked to, e.g., fused to, a second switch domain. A first and second switch domain are collectively referred to as a dimerization switch. In embodiments, the first and second switch domains are the same as one another, e.g., they are polypeptides having the same primary amino acid sequence, and are referred to collectively as a homodimerization switch. In embodiments, the first and second switch domains are different from one another, e.g., they are polypeptides having different primary amino acid sequences, and are referred to collectively as a

heterodimerization switch. In embodiments, the switch is intracellular. In embodiments, the switch is extracellular. In embodiments, the switch domain is a polypeptide-based entity, e.g., FKBP or FRB-based, and the dimerization molecule is small molecule, e.g., a rapalogue. In embodiments, the switch domain is a polypeptide-based entity, e.g., an scFv that binds a myc peptide, and the dimerization molecule is a polypeptide, a fragment thereof, or a multimer of a polypeptide, e.g., a myc ligand or multimers of a myc ligand that bind to one or more myc scFvs. In embodiments, the switch domain is a polypeptide-based entity, e.g., myc receptor, and the dimerization molecule is an antibody or fragments thereof, e.g., myc antibody.

[00252] "Dimerization molecule," as that term is used herein, e.g., when referring to an RCAR, refers to a molecule that promotes the association of a first switch domain with a second switch domain. In embodiments, the dimerization molecule does not naturally occur in the subject, or does not occur in concentrations that would result in significant dimerization. In embodiments, the dimerization molecule is a small molecule, e.g., rapamycin or a rapalogue, e.g, RAD001.

[00253] "Refractory" as used herein refers to a disease, e.g., cancer, that does not respond to a treatment. In embodiments, a refractory cancer can be resistant to a treatment before or at the beginning of the treatment. In other embodiments, the refractory cancer can become resistant during a treatment. A refractory cancer is also called a resistant cancer.

[00254] "Relapsed" or a "relapse" as used herein refers to the reappearance of a disease (e.g., cancer) or the signs and symptoms of a disease such as cancer after a period of improvement or responsiveness, e.g., after prior treatment of a therapy, e.g., cancer therapy. For example, the period of responsiveness may involve the level of cancer cells falling below a certain threshold, e.g., below 20%, 1%, 10%, 5%, 4%, 3%, 2%, or 1%. The reappearance may involve the level of cancer cells rising above a certain threshold, e.g., above 20%, 1%, 10%, 5%, 4%, 3%, 2%, or 1%.

[00255] Ranges: throughout this disclosure, various aspects of the invention can be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically

disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 2.7, 3, 4, 5, 5.3, and 6. As another example, a range such as 95-99% identity, includes something with 95%, 96%, 97%, 98% or 99% identity, and includes subranges such as 96-99%, 96-98%, 96-97%, 97-99%, 97-98% and 98-99% identity. This applies regardless of the breadth of the range.

[00256] The term "preparation of T cells," refers to a preparation that comprises at least one T cell. In an embodiment it is enriched for T cell as compared to peripheral blood.

[00257] The term "xenogeneic" refers to a graft derived from an animal of a different species.

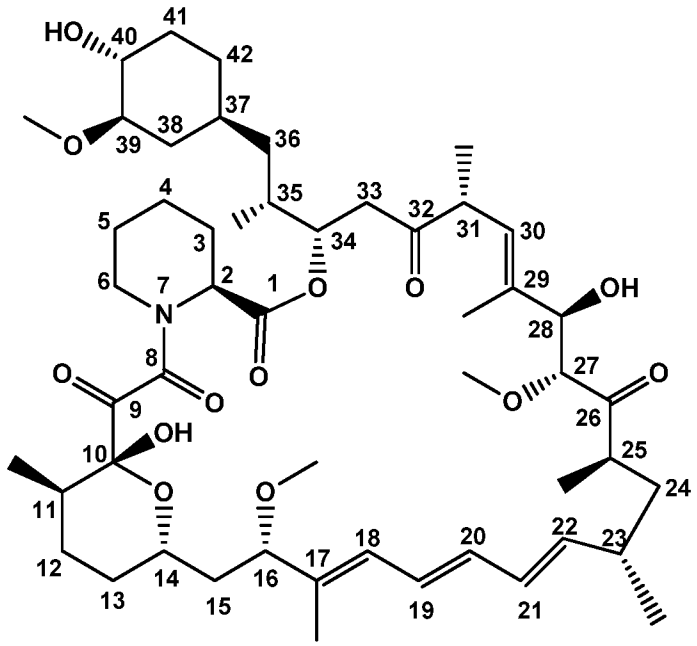
[00258] The term "apheresis" as used herein refers to the art-recognized extracorporeal process by which the blood of a donor or patient is removed from the donor or patient and passed through an apparatus that separates out selected particular constituent(s) and returns the remainder to the circulation of the donor or patient, e.g., by retransfusion. Thus, "an apheresis sample" refers to a sample obtained using apheresis.

**mTOR Inhibitors**

[00259] As used herein, the term "mTOR inhibitor" refers to a compound or ligand, or a pharmaceutically acceptable salt thereof, which inhibits the mTOR kinase in a cell. In an embodiment an mTOR inhibitor is an allosteric inhibitor. In an embodiment an mTOR inhibitor is a catalytic inhibitor.

[00260] Allosteric mTOR inhibitors include the neutral tricyclic compound rapamycin (sirolimus), rapamycin-related compounds, that is compounds having structural and functional similarity to rapamycin including, e.g., rapamycin derivatives, rapamycin analogs (also referred to as rapalogs) and other macrolide compounds that inhibit mTOR activity.

[00261] Rapamycin is a known macrolide antibiotic produced by *Streptomyces hygroscopicus* having the structure shown in Formula A.



[00262] (A)

[00263] See, e.g., McAlpine, J.B., et al., J. Antibiotics (1991) 44: 688; Schreiber, S.L., et al., J. Am. Chem. Soc. (1991) 113: 7433; U.S. Patent No. 3,929,992. There are various numbering schemes proposed for rapamycin. To avoid confusion, when specific rapamycin analogs are named herein, the names are given with reference to rapamycin using the numbering scheme of formula A.

[001] Rapamycin analogs useful in the invention are, for example, O-substituted analogs in which the hydroxy group on the cyclohexyl ring of rapamycin is replaced by $OR_1$ in which $R_1$ is hydroxyalkyl, hydroxyalkoxyalkyl, acylaminoalkyl, or aminoalkyl; e.g. RAD001, also known as, everolimus as described in US 5,665,772 and WO94/09010 the contents of which are incorporated by reference. Other suitable rapamycin analogs include those substituted at the 26- or 28-position. The rapamycin analog may be an epimer of an analog mentioned above, particularly an epimer of an analog substituted in position 40, 28 or 26, and may optionally be further hydrogenated, e.g. as described in US 6,015,815, WO95/14023 and WO99/15530 the contents of which are incorporated by reference, e.g. ABT578 also known as zotarolimus or a rapamycin analog described in US 7,091,213, WO98/02441 and WO01/14387 the contents of which are incorporated by reference, e.g. AP23573 also known as ridaforolimus.

[00264] Examples of rapamycin analogs suitable for use in the present invention from US 5,665,772 include, but are not limited to, 40-O-benzyl-rapamycin, 40-O-(4'-

hydroxymethyl)benzyl-rapamycin, 40-O-[4'-(1,2-dihydroxyethyl)]benzyl-rapamycin, 40-O-allyl-rapamycin, 40-O-[3'-(2,2-dimethyl-1,3-dioxolan-4(S)-yl)-prop-2'-en-1'-yl]-rapamycin, (2'E,4'S)-40-O-(4',5'-dihydroxypent-2'-en-1'-yl)-rapamycin, 40-O-(2-hydroxy)ethoxycarbonylmethyl-rapamycin, 40-O-(2-hydroxy)ethyl-rapamycin , 40-O-(3-hydroxy)propyl-rapamycin, 40-O-(6-hydroxy)hexyl-rapamycin, 40-O-[2-(2-hydroxy)ethoxy]ethyl-rapamycin, 40-O-[(3S)-2,2-dimethyldioxolan-3-yl]methyl-rapamycin, 40-O-[(2S)-2,3-dihydroxyprop-1-yl]-rapamycin, 40-O-(2-acetoxy)ethyl-rapamycin, 40-O-(2-nicotinoyloxy)ethyl-rapamycin, 40-O-[2-(N-morpholino)acetoxy]ethyl-rapamycin, 40-O-(2-N-imidazolylacetoxy)ethyl-rapamycin, 40-O-[2-(N-methyl-N'-piperazinyl)acetoxy]ethyl-rapamycin, 39-O-desmethyl-39,40-O,O-ethylene-rapamycin, (26R)-26-dihydro-40-O-(2-hydroxy)ethyl-rapamycin, 40-O-(2-aminoethyl)-rapamycin, 40-O-(2-acetaminoethyl)-rapamycin, 40-O-(2-nicotinamidoethyl)-rapamycin, 40-O-(2-(N-methyl-imidazo-2'-ylcarbethoxamido)ethyl)-rapamycin, 40-O-(2-ethoxycarbonylaminoethyl)-rapamycin, 40-O-(2-tolylsulfonamidoethyl)-rapamycin and 40-O-[2-(4',5'-dicarboethoxy-1',2',3'-triazol-1'-yl)-ethyl]-rapamycin.

[00265] Other rapamycin analogs useful in the present invention are analogs where the hydroxy group on the cyclohexyl ring of rapamycin and/or the hydroxy group at the 28 position is replaced with an hydroxyester group are known, for example, rapamycin analogs found in US RE44,768, e.g. temsirolimus.

[00266] Other rapamycin analogs useful in the preset invention include those wherein the methoxy group at the 16 position is replaced with another substituent, preferably (optionally hydroxy-substituted) alkynyloxy, benzyl, orthomethoxybenzyl or chlorobenzyl and/or wherein the mexthoxy group at the 39 position is deleted together with the 39 carbon so that the cyclohexyl ring of rapamycin becomes a cyclopentyl ring lacking the 39 position methyoxy group; e.g. as described in WO95/16691 and WO96/41807 the contents of which are incorporated by reference. The analogs can be further modified such that the hydroxy at the 40-position of rapamycin is alkylated and/or the 32-carbonyl is reduced.

[00267] Examples of rapamycin analogs suitable for use in the present invention from WO95/16691 include, but are not limited to, 16-demethoxy-16-(pent-2-ynyl)oxy-rapamycin, 16-demethoxy-16-(but-2-ynyl)oxy-rapamycin, 16-demethoxy-16-(propargyl)oxy-rapamycin, 16-demethoxy-16-(4-hydroxy-but-2-ynyl)oxy-rapamycin, 16-demethoxy-16-benzyloxy-40-O-(2-

hydroxyethyl)-rapamycin, 16-demethoxy-16-benzyloxy-rapamycin, 16-demethoxy-16-*ortho*-methoxybenzyl-rapamycin, 16-demethoxy-40-O-(2-methoxyethyl)-16-pent-2-ynyl)oxy-rapamycin, 39-demethoxy-40-desoxy-39-formyl-42-nor-rapamycin, 39-demethoxy-40-desoxy-39-hydroxymethyl-42-nor-rapamycin, 39-demethoxy-40-desoxy-39-carboxy-42-nor-rapamycin, 39-demethoxy-40-desoxy-39-(4-methyl-piperazin-1-yl)carbonyl-42-nor-rapamycin, 39-demethoxy-40-desoxy-39-(morpholin-4-yl)carbonyl-42-nor-rapamycin, 39-demethoxy-40-desoxy-39-[N-methyl, N-(2-pyridin-2-yl-ethyl)]carbamoyl-42-nor-rapamycin and 39-demethoxy-40-desoxy-39-(p-toluenesulfonylhydrazonomethyl)-42-nor-rapamycin.

[00268] Examples of rapamycin analogs suitable for use in the present invention from WO96/41807 include, but are not limited to, 32-deoxo-rapamycin, 16-O-pent-2-ynyl-32-deoxo-rapamycin, 16-O-pent-2-ynyl-32-deoxo-40-O-(2-hydroxy-ethyl)-rapamycin, 16-O-pent-2-ynyl-32-(S)-dihydro-40-O-(2-hydroxyethyl)-rapamycin, 32(S)-dihydro-40-O-(2-methoxy)ethyl-rapamycin and 32(S)-dihydro-40-O-(2-hydroxyethyl)-rapamycin.

[00269] Another suitable rapamycin analog is umirolimus as described in US2005/0101624 the contents of which are incorporated by reference.

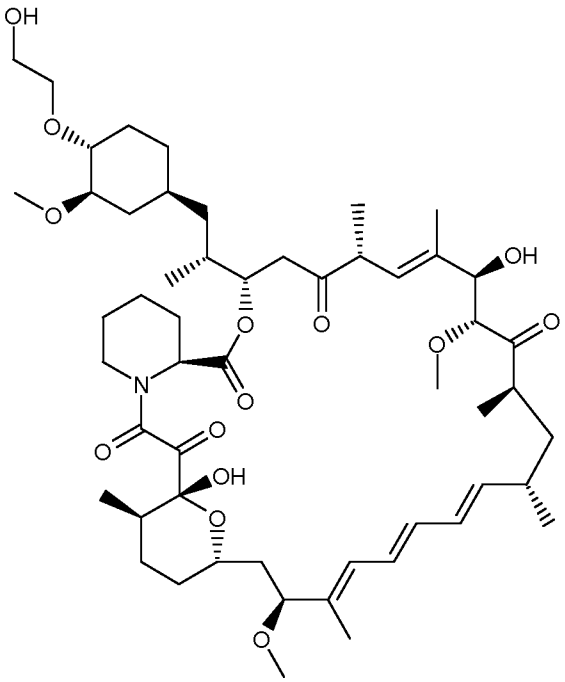
[00270] In mammalian cells, the target of rapamycin (mTOR) kinase exists as a multiprotein complex described as the mTORC1 complex or mTORC2 complex, which senses the availability of nutrients and energy and integrates inputs from growth factors and stress signaling. The mTORC1 complex is sensitive to allosteric mTOR inhibitors such as rapamycin, is composed of mTOR, GβL, and regulatory associated proteins of mTOR (raptor), and binds to the peptidyl-prolyl isomerase FKBP12 protein (a FK506-binding protein 1A, 12 kDa). In contrast, the mTORC2 complex is composed of mTOR, GβL, and rapamycin-insensitive companion proteins of mTOR (rictor), and does not bind to the FKBP12 protein in vitro.

[00271] The mTORC1 complex has been shown to be involved in protein translational control, operating as a growth factor and nutrient sensitive apparatus for growth and proliferation regulation. mTORC1 regulates protein translation via two key downstream substrates: P70 S6 kinase, which in turn phosphorylates ribosomal protein P70 S6, and eukaryotic translation initiation factor 4E binding protein 1 (4EBP1), which plays a key role in modulating eIF4E regulated cap-dependent translation. The mTORC1 complex regulates cell growth in response to the energy and nutrient homeostasis of the cell, and the deregulation of mTORC1 is common in a

wide variety of human cancers. The function of mTORC2 involves the regulation of cell survival via phosphorylation of Akt and the modulation of actin cytoskeleton dynamics.

[00272] The mTORC1 complex is sensitive to allosteric mTOR inhibitors such as rapamycin and derivatives in large part due to rapamycin`s mode of action, which involves the formation of an intracellular complex with the FKBP12 and binding to the FKBP12-rapamycin binding (FRB) domain of mTOR. This results in a conformational change in mTORC1 which is believed to alter and weaken the interaction with its scaffolding protein raptor, in turn impeding substrates such as P70 S6K1 from accessing mTOR and being phosphorylated. Rapamycin and rapalogues such as RAD001 have gained clinical relevance by inhibiting hyperactivation of mTOR associated with both benign and malignant proliferation disorders.

[00273] RAD001, otherwise known as everolimus (Afinitor®), has the chemical name (1R,9S,12S,15R,16E,18R,19R,21R,23S,24E,26E,28E,30S,32S,35R)-1,18-dihydroxy-12-{(1R)-2-[(1S,3R,4R)-4-(2-hydroxyethoxy)-3-methoxycyclohexyl]-1-methylethyl}-19,30-dimethoxy-15,17,21,23,29,35-hexamethyl-11,36-dioxa-4-aza-tricyclo[30.3.1.04,9]hexatriaconta-16,24,26,28-tetraene-2,3,10,14,20-pentaone and the following chemical structure

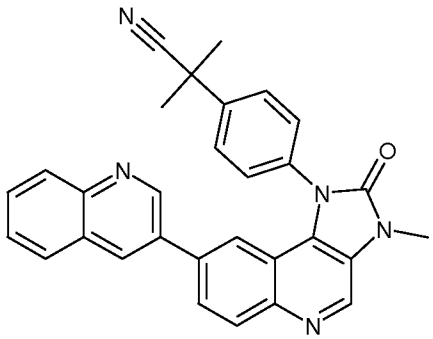



[00274] Everolimus is an FDA approved drug for the treatment of advanced kidney cancer and is being investigated in several other phase III clinical trials in oncology. Preclinical studies have shown that Everolimus is able to inhibit the proliferation of a wide variety of tumor cell

lines both in vitro and in vivo, presumably through the suppression of rapamycin sensitive mTORC1 function. Everolimus, as a derivative of rapamycin, is an allosteric mTOR inhibitor that is highly potent at inhibiting part of the mTORC1 function, namely P70 S6 kinase (P70 S6K) and the downstream P70 S6K substrate P70 S6. Allosteric mTOR inhibitors like everolimus (and other rapamycin analogs) have little or no effect at inhibiting the mTORC2 pathway, or its resulting activation of Akt signaling. Further examples of allosteric mTOR inhibitors include sirolimus (rapamycin, AY-22989), 40-[3-hydroxy-2-(hydroxymethyl)-2-methylpropanoate]-rapamycin (also called temsirolimus or CCI-779) and ridaforolimus (AP-23573/MK-8669). Other examples of allosteric mTor inhibtors include zotarolimus (ABT578) and umirolimus.

[00275] Alternatively or additionally, catalytic, ATP-competitive mTOR inhibitors have been found to target the mTOR kinase domain directly and target both mTORC1 and mTORC2. These are also more effective inhibitors of mTORC1 than such allosteric mTOR inhibitors as rapamycin, because they modulate rapamycin-resistant mTORC1 outputs such as 4EBP1-T37/46 phosphorylation and cap-dependent translation.

[00276] BEZ235 is a catalytic mTOR inhibitor, having the chemical name 2-methyl-2-[4-(3-methyl-2-oxo-8-quinolin-3-yl-2,3-dihydro-imidazo[4,5-c]quinolin-1-yl)-phenyl]-propionitrile and the following chemical structure

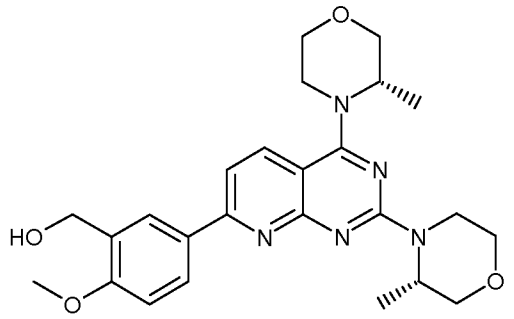


[00277] BEZ235 may also be used in its monotosylate salt form. The synthesis of BEZ235 is described in WO2006/122806.

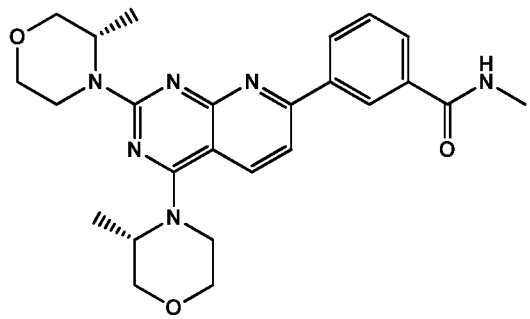
[00278] As a catalytic mTOR inhibitor BEZ235 is capable of shutting down the complete function of mTORC1 complex, including both the rapamycin sensitive (phosphorylation of P70 S6K, and subsequently phosphorylation of P70 S6) and rapamycin insensitive (phosphorylation of 4EBP1) functions. BEZ235 has a differential effect according to the drug concentration used,

whereby mTOR inhibition predominates at a low concentration (less than 100 nmol/L) but dual PI3K/ mTOR inhibition at relatively higher concentrations (approximately 500 nmol/L), Serra et al., 2008.

[00279] Another catalytic mTOR inhibitor described in the literature is CCG168 (otherwise known as AZD-8055, Chresta, C.M., et al., Cancer Res, 2010, 70(1), 288-298) which has the chemical name {5-[2,4-bis-((S)-3-methyl-morpholin-4-yl)-pyrido[2,3d]pyrimidin-7-yl]-2-methoxy-phenyl}-methanol and the following chemical structure

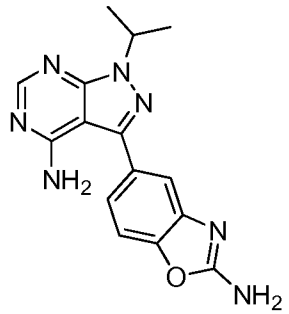


[00280] Another catalytic mTOR inhibitor described in the literature is 3-[2,4-bis[(3S)-3-methylmorpholin-4-yl]pyrido[2,3-d]pyrimidin-7-yl]-*N*-methylbenzamide (WO09104019) having the following chemical structure:



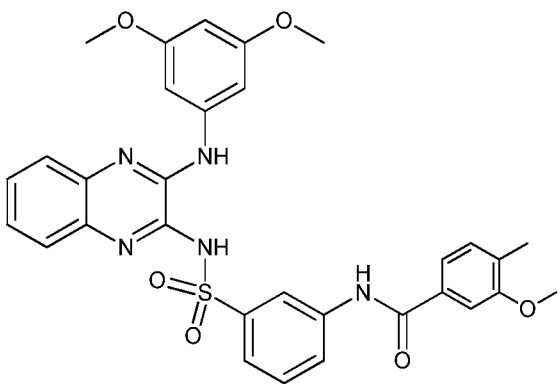
[00281]

[00282] Another catalytic mTOR inhibitor described in the literature is 3-(2-aminobenzo[d]oxazol-5-yl)-1-isopropyl-1H-pyrazolo[3,4-d]pyrimidin-4-amine (WO10051043 and WO2013023184) having following chemical structure:



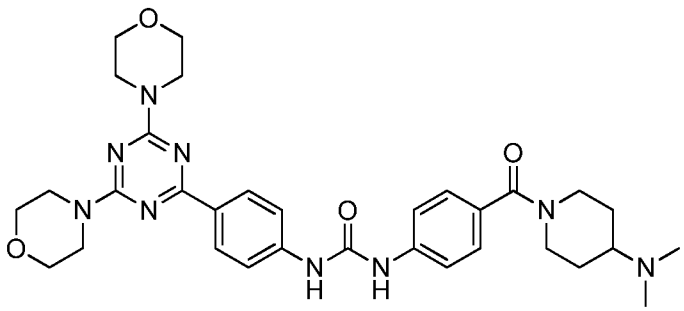
[00283] .

[00284] Another catalytic mTOR inhibitor described in the literature is N-(3-(N-(3-((3,5-dimethoxyphenyl)amino)quinoxaline-2-yl)sulfamoyl)phenyl)-3-methoxy-4-methylbenzamide (WO07044729 and WO12006552) having the following chemical structure:



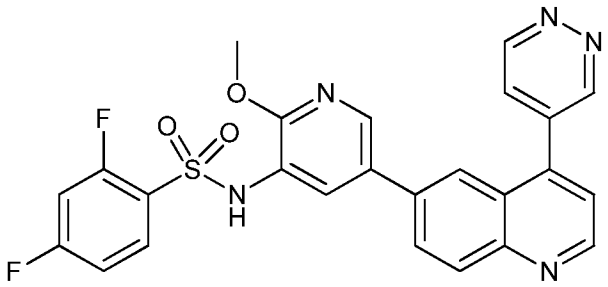
[00285] .

[00286] Another catalytic mTOR inhibitor described in the literature is PKI-587 (Venkatesan, A.M., J. Med.Chem., 2010, 53, 2636-2645) which has the chemical name 1-[4-[4-(dimethylamino)piperidine-1-carbonyl]phenyl]-3-[4-(4,6-dimorpholino-1,3,5-triazin-2-yl)phenyl]urea and having the following chemical structure



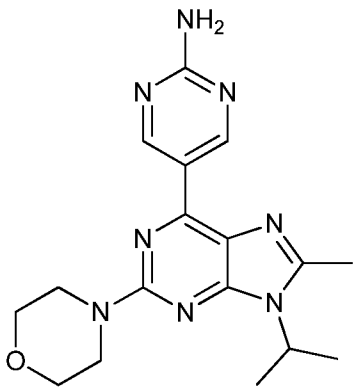
[00287] .

[00288] Another catalytic mTOR inhibitor described in the literature is GSK-2126458 (ACS Med. Chem. Lett., 2010, 1, 39-43) which has the chemical name 2,4-difluoro-N-{2-methoxy-5-[4-(4-pyridazinyl)-6-quinolinyl]-3-pyridinyl}benzenesulfonamide and having the following chemical structure:



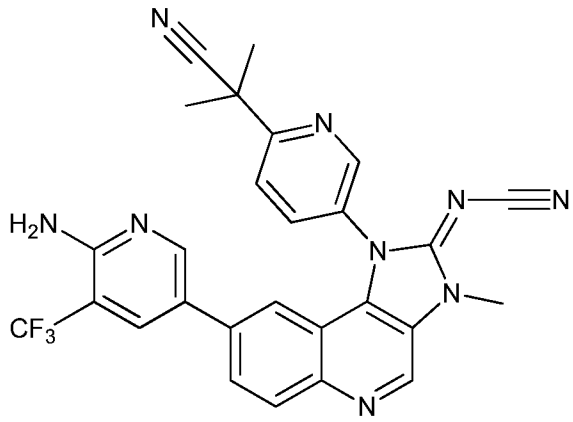
[00289] .

[00290] Another catalytic mTOR inhibitor described in the literature is 5-(9-isopropyl-8-methyl-2-morpholino-9H-purin-6-yl)pyrimidin-2-amine (WO10114484) having the following chemical structure:



[00291] .

[00292] Another catalytic mTOR inhibitor described in the literature is (E)-*N*-(8-(6-amino-5-(trifluoromethyl)pyridin-3-yl)-1-(6-(2-cyanopropan-2-yl)pyridin-3-yl)-3-methyl-1*H*-imidazo[4,5-c]quinolin-2(3H)-ylidene)cyanamide (WO12007926) having the following chemical structure:



[00293] .

[00294] Further examples of catalytic mTOR inhibitors include 8-(6-methoxy-pyridin-3-yl)-3-methyl-1-(4-piperazin-1-yl-3-trifluoromethyl-phenyl)-1,3-dihydro-imidazo[4,5-c]quinolin-2-one (WO2006/122806) and Ku-0063794 (Garcia-Martinez JM, et al.,Biochem J., 2009, 421(1), 29-42.. Ku-0063794 is a specific inhibitor of the mammalian target of rapamycin (mTOR).) WYE-354 is another example of a catalytic mTor inhibitor (Yu K, et al. (2009). Biochemical, Cellular, and In vivo Activity of Novel ATP-Competitive and Selective Inhibitors of the Mammalian Target of Rapamycin. Cancer Res. 69(15): 6232-6240).

[00295] mTOR inhibitors useful according to the present invention also include prodrugs, derivatives, pharmaceutically acceptable salts, or analogs thereof of any of the foregoing.

[00296] mTOR inhibitors, such as RAD001, may be formulated for delivery based on well-established methods in the art based on the particular dosages described herein. In particular, US Patent 6,004,973 (incorporated herein by reference) provides examples of formulations useable with the mTOR inhibitors described herein.

[00297] Exemplary mTOR inhibitors include, e.g., temsirolimus; ridaforolimus (formally known as deferolimus, (1*R*,2*R*,4*S*)-4-[(2*R*)-2 [(1*R*,9*S*,12*S*,15*R*,16*E*,18*R*,19*R*,21*R*, 23*S*,24*E*,26*E*,28*Z*,30*S*,32*S*,35*R*)-1,18-dihydroxy-19,30-dimethoxy-15,17,21,23, 29,35-hexamethyl-2,3,10,14,20-pentaoxo-11,36-dioxa-4-azatricyclo[30.3.1.$0^{4,9}$] hexatriaconta-16,24,26,28-tetraen-12-yl]propyl]-2-methoxycyclohexyl dimethylphosphinate, also known as AP23573 and MK8669, and described in PCT Publication No. WO 03/064383); everolimus (Afinitor® or RAD001); rapamycin (AY22989, Sirolimus®); simapimod (CAS 164301-51-3); emsirolimus, (5-{2,4-Bis[(3*S*)-3-methylmorpholin-4-yl]pyrido[2,3-*d*]pyrimidin-7-yl}-2-methoxyphenyl)methanol (AZD8055); 2-Amino-8-[*trans*-4-(2-hydroxyethoxy)cyclohexyl]-6-(6-

methoxy-3-pyridinyl)-4-methyl-pyrido[2,3-*d*]pyrimidin-7(8*H*)-one (PF04691502, CAS 1013101-36-4); and $N^2$-[1,4-dioxo-4-[[4-(4-oxo-8-phenyl-4*H*-1-benzopyran-2-yl)morpholinium-4-yl]methoxy]butyl]-L-arginylglycyl-L-α-aspartylL-serine- (SEQ ID NO: 90), inner salt (SF1126, CAS 936487-67-1), and XL765.

[00298] In another embodiment, administration of a low, immune enhancing, dose of an mTOR inhibitor results in increased or prolonged proliferation or persistence of CAR-expressing cells, e.g., in culture or in a subject, e.g., as compared to non-treated CAR-expressing cells or a non-treated subject. In embodiments, increased proliferation or persistence is associated with in an increase in the number of CAR-expressing cells. Methods for measuring increased or prolonged proliferation are described in Examples 6 and 7. In another embodiment, administration of a low, immune enhancing, dose of an mTOR inhibitor results in increased killing of cancer cells by CAR-expressing cells, e.g., in culture or in a subject, e.g., as compared to non-treated CAR-expressing cells or a non-treated subject. In embodiments, increased killing of cancer cells is associated with in a decrease in tumor volume. Methods for measuring increased killing of cancer cells are described, e.g., in International Application WO2014/153270, which is herein incorporated be reference in its entirety.

[00299] Certain methods for measuring mTOR inhibition, dosages, treatment regimens, and suitable pharmaceutical compositions are described in U.S. Patent Application No. 2015/01240036, hereby incorporated by reference.

**Downstream Inhibitors**

[00300] Many of the methods described herein rely on the use of a low, immune enhancing, dose of an mTOR inhibitors, e.g., to increase the level of PD1 negative immune effector cells, e.g., T cells, to decrease the level of PD1 positive immune effector cells, e.g., T cells, to increase the ratio of PD1 negative immune effector cells, e.g., T cells/PD1 positive immune effector cells, e.g., T cells, to increase the level of naive T cells, or to increase the number of memory T cell precursors or the expression level of memory T cell precursor markers. Any of these methods can also be practiced with, in place of the low, immune enhancing, dose of an mTOR inhibitors, the administration of an inhibitor of a downstream element in the pathway, e.g., P70 S6K or TORC1. Examples of inhibitors of P70 S6K include PF-4708671 (Pfizer) or

LY2584702 tosylate (Eli Lilly). Examples of inhibitors of mTORC1 include allosteric mTOR inhibitors that specifically inhibit mTORC1, but do not inhibit mTORC2. In an embodiment, a downstream inhibitor is adminered at a dose effective to increase the level of PD1 negative immune effector cells, e.g., T cells, to decrease the level of PD1 positive immune effector cells, e.g., T cells, to increase the ratio of PD1 negative immune effector cells, e.g., T cells/PD1 positive immune effector cells, e.g., T cells, to increase the level of naive T cells, or to increase the number of memory T cell precursors or the expression level of memory T cell precursor markers.

**Evaluation of mTOR Inhibition**

[00301] mTOR phosphorylates the kinase P70 S6, thereby activating P70 S6K and allowing it to phosphorylate its substrate. The extent of mTOR inhibition can be expressed as the extent of P70 S6K inhibition, e.g., the extent of mTOR inhibition can be determined by the level of decrease in P70 S6K activity, e.g., by the decrease in phosphorylation of a P70 S6K substrate. One can determine the level of mTOR inhibition, by measuring P70 S6K activity (the ability of P70 S6K to phsophorylate a substrate), in the absence of inhibitor, e.g., prior to administration of inhibitor, and in the presences of inhibitor, or after the administration of inhibitor. The level of inhibition of P70 S6K gives the level of mTOR inhibition. Thus, if P70 S6K is inhibited by 40%, mTOR activity, as measured by P70 S6K activity, is inhibited by 40%. The extent or level of inhibition referred to herein is the average level of inhibition over the dosage interval. By way of example, if the inhibitor is given once per week, the level of inhibition is given by the average level of inhibition over that interval, namely a week.

[00302] Boulay et al., *Cancer Res*, 2004, 64:252-61, hereby incorporated by reference, teaches an assay that can be used to assess the level of mTOR inhibition (referred to herein as the Boulay assay). In an embodiment, the assay relies on the measurement of P70 S6 kinase activity from biological samples before and after administration of an mTOR inhibitor, e.g., RAD001. Samples can be taken at preselected times after treatment with an mTOR ihibitor, e.g., 24, 48, and 72 hours after treatment. Biological samples, e.g., from skin or peripheral blood mononuclear cells (PBMCs) can be used. Total protein extracts are prepared from the samples. P70 S6 kinase is isolated from the protein extracts by immunoprecipitation using an antibody

that specifically recognizes the P70 S6 kinase. Activity of the isolated P70 S6 kinase can be measured in an *in vitro* kinase assay. The isolated kinase can be incubated with 40S ribosomal subunit substrates (which is an endogenous substrate of P70 S6K) and gamma-$^{32}$P under conditions that allow phosphorylation of the substrate. Then the reaction mixture can be resolved on an SDS-PAGE gel, and $^{32}$P signal analyzed using a PhosphorImager. A $^{32}$P signal corresponding to the size of the 40S ribosomal subunit indicates phosphorylated substrate and the activity of P70 S6K. Increases and decreases in kinase activity can be calculated by quantifying the area and intensity of the $^{32}$P signal of the phosphorylated substrate (e.g., using ImageQuant, Molecular Dynamics), assigning arbitrary unit values to the quantified signal, and comparing the values from after administration with values from before administration or with a reference value. For example, percent inhibition of kinase activity can be calculated with the following formula: 1-(value obtained after administration/value obtained before administration) x 100. As described above, the extent or level of inhibition referred to herein is the average level of inhibition over the dosage interval.

[00303] Methods for the evaluation of kinase activity, e.g., P70 S6 kinase activity, are also provided in US 7,727,950, hereby incorporated by reference.

[00304] The level of mTOR inhibition can also be evaluated by a change in the ratio of PD1 negative to PD1 positive T cells. T cells from peripheral blood can be identified as PD1 negative or positive by art-known methods.

## Low-Dose mTOR Inhibitors

[00305] Methods described herein use low, immune enhancing, dose mTOR inhibitors, doses of mTOR inhibitors, e.g., allosteric mTOR inhibitors, including rapalogs such as RAD001. In contrast, levels of inhibitor that fully or near fully inhibit the mTOR pathway are immunosuppressive and are used, e.g., to prevent organ transplant rejection. In addition, high doses of rapalogs that fully inhibit mTOR also inhibit tumor cell growth and are used to treat a variety of cancers (See, e.g., Antineoplastic effects of mammalian target of rapamycine inhibitors. Salvadori M. World J Transplant. 2012 Oct 24;2(5):74-83; Current and Future Treatment Strategies for Patients with Advanced Hepatocellular Carcinoma: Role of mTOR Inhibition. Finn RS. Liver Cancer. 2012 Nov;1(3-4):247-256; Emerging Signaling Pathways in

Hepatocellular Carcinoma. Moeini A, Cornellà H, Villanueva A. Liver Cancer. 2012 Sep;1(2):83-93; Targeted cancer therapy - Are the days of systemic chemotherapy numbered? Joo WD, Visintin I, Mor G. Maturitas. 2013 Sep 20.; Role of natural and adaptive immunity in renal cell carcinoma response to VEGFR-TKIs and mTOR inhibitor. Santoni M, Berardi R, Amantini C, Burattini L, Santini D, Santoni G, Cascinu S. Int J Cancer. 2013 Oct 2).

[00306] The present invention is based, at least in part, on the surprising finding that doses of mTOR inhibitors well below those used in current clinical settings had a superior effect in increasing an immune response in a subject and increasing the ratio of PD-1 negative T cells/PD-1 positive T cells. It was surprising that low doses of mTOR inhibitors, producing only partial inhibition of mTOR activity, were able to effectively improve immune responses in human subjects and increase the ratio of PD-1 negative T cells/PD-1 positive T cells.

[00307] Alternatively, or in addition, without wishing to be bound by any theory, it is believed that low, a low, immune enhancing, dose of an mTOR inhibitor can increase naive T cell numbers, e.g., at least transiently, e.g., as compared to a non-treated subject. Alternatively or additionally, again while not wishing to be bound by theory, it is believed that treatment with an mTOR inhibitor after a sufficient amount of time or sufficient dosing results in one or more of the following:

an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; and

an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein any of the changes described above occurs, e.g., at least transiently, e.g., as compared to a non-treated subject (Araki, K et al. (2009) *Nature* 460:108-112). Memory T cell precursors are memory T cells that are early in the differentiation program. For example, memory T cells have one or more of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and/or increased BCL2.

[00308] Accordingly, in one aspect, the present invention provides compositions, e.g., provides as a unit dosage form, comprising an mTOR inhibitor, e.g., an allosteric mTOR

inhibitor, e.g., RAD001, at a concentration of about 0.005-1.5 mg, about 0.005-1.5 mg, about 0.01-1 mg, about 0.01-0.7 mg, about 0.01-0.5 mg, or about 0.1-0.5 mg. In a further aspect the present invention provides compositions comprising an mTOR inhibitor, e.g., RAD001, at a concentration of 0.005-1.5 mg, 0.005-1.5 mg, 0.01-1 mg, 0.01-0.7 mg, 0.01-0.5 mg, or 0.1-0.5 mg. More particularly, in one aspect, the invention provides compositions comprising an mTOR inhibitor, e.g., RAD001, at a dose of about 0.005 mg, 0.006 mg, 0.007 mg, 0.008 mg, 0.009 mg, 0.01 mg, 0.02 mg, 0.03 mg, 0.04 mg, 0.05 mg, 0.06 mg, 0.07 mg, 0.08 mg, 0.09 mg, 0.1 mg, 0.2 mg, 0.3 mg, 0.4 mg, 0.5 mg, 0.6 mg, 0.7 mg, 0.8 mg, 0.9 mg, or 1.0 mg. In one aspect, the mTOR inhibitor, e.g., RAD001, is at a dose of 0.5 mg or less. In a still further aspect, the mTOR inhibitor, e.g., RAD001, is at a dose of about 0.5 mg. In a further aspect, the invention provides compositions comprising an mTOR inhibitor, e.g., RAD001, at a dose of 0.005 mg, 0.006 mg, 0.007 mg, 0.008 mg, 0.009 mg, 0.01 mg, 0.02 mg, 0.03 mg, 0.04 mg, 0.05 mg, 0.06 mg, 0.07 mg, 0.08 mg, 0.09 mg, 0.1 mg, 0.2 mg, 0.3 mg, 0.4 mg, 0.5 mg, 0.6 mg, 0.7 mg, 0.8 mg, 0.9 mg, or 1.0 mg. In one aspect, the mTOR inhibitor, e.g., RAD001, is at a dose of 0.5 mg or less. In a still further aspect, the mTOR inhibitor, e.g., RAD001, is at a dose of 0.5 mg.

[00309] In a further aspect, the invention relates to compositions comprising an mTOR inhibitor that is not RAD001, in an amount that is bioequivalent to the specific amounts or doses specified for RAD001.

[00310] In a further aspect, the invention relates to compositions comprising an mTOR inhibitor in an amount sufficient to inhibit P70 S6 kinase by no greater than 80%. In a further aspect the compositions described herein comprise an mTOR inhibitor in an amount sufficient to inhibit P70 S6 kinase by no greater than 38%.

[00311] In an embodiment, the invention relates to a composition, or dosage form, of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., a rapalog, rapamycin, or RAD001, or a catalytic mTOR inhibitor, which, when administered on a selected dosing regimen, e.g., once daily or once weekly, is associated with: a level of mTOR inhibition that is not associated with complete, or significant immune suppression, but is associated with enhancement of the immune response.

[00312] In a further aspect, the invention provides methods for enhancing immune response, e.g., treating immunosenescence, comprising a step of administering to a subject an mTOR inhibitor. In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g.,

RAD001, can be administered at a dose of about 0.005-1.5 mg daily, about 0.01-1 mg daily, about 0.01-0.7 mg daily, about 0.01-0.5 mg daily, or about 0.1-0.5 mg daily. In a further aspect, an mTOR inhibitor, e.g., RAD001, can be administered at a dose of about 0.1-20 mg weekly, about 0.5-15 mg weekly, about 1-10 mg weekly, or about 3-7 mg weekly. In some embodiments, an mTOR inhibitor, e.g., RAD001, can be administered at a dose of 0.005-1.5 mg daily, 0.01-1 mg daily, 0.01-0.7 mg daily, 0.01-0.5 mg daily, or 0.1-0.5 mg daily. In some embodiments, an mTOR inhibitor, e.g., RAD001, can be administered at a dose of about 0.1-20 mg weekly, 0.5-15 mg weekly, 1-10 mg weekly, 3-7 mg weekly, or 5mg weekly.

[00313] In a further aspect, the invention relates to methods for enhancing immune response, e.g., treating immunosenescence, comprising the step of administering an mTOR inhibitor that is not RAD001, in an amount that is bioequivalent to the specific amounts or doses described herein for RAD001.

[00314] In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, eg., e.g., RAD001, can be administered at a dose of about 0.005 mg daily, 0.006 mg daily, 0.007 mg daily, 0.008 mg daily, 0.009 mg daily, 0.01 mg daily, 0.02 mg daily, 0.03 mg daily, 0.04 mg daily, 0.05 mg daily, 0.06 mg daily, 0.07 mg daily, 0.08 mg daily, 0.09 mg daily, 0.1 mg daily, 0.2 mg daily, 0.3 mg daily, 0.4 mg daily, 0.5 mg daily, 0.6 mg daily, 0.7 mg daily, 0.8 mg daily, 0.9 mg daily, or 1.0 mg daily. In some embodiments, RAD001 can be administered at a dose of no greater than about 0.7 mg in a 24 hour period. In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, can be administered at a dose of no greater than about 0.5 mg in a 24 hour period. In some embodiments, RAD001 can be administered at a dose of 0.5 mg or less daily. In some embodiments, RAD001 can be administered at a dose of 0.5 mg daily.

[00315] In a further aspect, the invention can utilize an mTOR inhibitor other than RAD001 in an amount that is bioequivalent to the specific amounts or doses specified for RAD001.

[00316] In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, can be administered at a dose of 0.1 mg weekly, 0.2 mg weekly, 0.3 mg weekly, 0.4 mg weekly, 0.5 mg weekly, 0.6 mg weekly, 0.7 mg weekly, 0.8 mg weekly, 0.9 mg weekly, 1 mg weekly, 2 mg weekly, 3 mg weekly, 4 mg weekly, 5 mg weekly, 6 mg weekly, 7 mg weekly, 8 mg weekly, 9 mg weekly, 10 mg weekly, 11 mg weekly, 12 mg weekly, 13 mg weekly, 14 mg weekly, 15 mg weekly, 16 mg weekly, 17 mg weekly, 18 mg weekly, 19 mg weekly, or 20 mg

weekly. In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, is administered at a dose of 5 mg or less weekly. In some embodiments, an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, is administered at a dose of 5 mg weekly.

[00317] In some embodiments, the invention can utilize an mTOR inhibitor other than RAD001 in an amount that is bioequivalent to the specific amounts or doses specified for RAD001.

[00318] An mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., a rapalog, rapamycin, or RAD001, or a catalytic mTOR inhibitor, can be provided in a sustained relase formulation. Any of the compositions or unit dosage forms described herein can be provided in a sustained release formulation. In some embodiments, a sustained release formulation will have lower bioavailability than an immediate release formulation. E.g., in embodiments, to attain a similar therapeutic effect of an immediate release forlation a sustained release formulation will have from about 2 to about 5, about 2.5 to about 3.5, or about 3 times the amount of inhibitor provided in the immediate release formulation.

[00319] In an embodiment, immediate release forms, e.g., of RAD001, typically used for one administration per week, having 0.1 to 20, 0.5 to 10, 2.5 to 7.5, 3 to 6, or about 5, mgs per unit dosage form, are provided. For once per week administrations, these immediate release formulations correspond to sustained release forms, having, respectively, 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001. In embodiments both forms are administered on a once/week basis.

[00320] In an embodiment, immediate release forms, e.g., of RAD001, typically used for one administration per day, having having 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs per unit dosage form, are provided. For once per day administrations, these immediate release forms correspond to sustained release forms, having, respectively, 0.015 to 4.5, 0.03 to 4.5, 0.3 to 4.5, 0.6 to 4.5, 0.9 to 4.5, 1.2 to 4.5, 1.5 to 4.5, 1.8 to 4.5, 2.1 to 4.5, 2.4 to 4.5, 3.0 to 4.5, 0.9 to 1.8, or about 1.5 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001. For once per week administrations, these immediate release forms correspond to sustained release forms, having, respectively, 0.1 to 30, 0.2 to 30, 2 to 30, 4 to 30, 6 to 30, 8 to

30, 10 to 30, 1.2 to 30, 14 to 30, 16 to 30, 20 to 30, 6 to 12, or about 10 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001.

[00321] In an embodiment, immediate release forms, e.g., of RAD001, typically used for one administration per day, having having 0.01 to 1.0 mgs per unit dosage form, are provided. For once per day administrations, these immediate release forms correspond to sustained release forms, having, respectively, 0.03 to 3 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001.For once per week administrations, these immediate release forms correspond to sustained release forms, having, respectively, 0.2 to 20 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001.

[00322] In an embodiment, immediate release forms, e.g., of RAD001, typically used for one administration per week, having having 0.5 to 5.0 mgs per unit dosage form, are provided. For once per week administrations, these immediate release forms correspond to sustained release forms, having, respectively, 1.5 to 15 mgs of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., rapamycin or RAD001.

[00323] As described above, one target of the mTOR pathway is the P70 S6 kinase. Thus, doses of mTOR inhibitors which are useful in the methods and compositions described herein are those which are sufficient to achieve no greater than 80% inhibition of P70 S6 kinase activity relative to the activity of the P70 S6 kinase in the absence of an mTOR inhibitor, e.g., as measured by an assay described herein, e.g., the Boulay assay. In a further aspect, the invention provides an amount of an mTOR inhibitor sufficient to achieve no greater than 38% inhibition of P70 S6 kinase activity relative to P70 S6 kinase activity in the absence of an mTOR inhibitor, e.g., as measured by an assay described herein, e.g., the Boulay assay In one aspect the dose of mTOR inhibitor useful in the methods and compositions of the invention is sufficient to achieve, e.g., when administered to a human subject, 90%, 89%, 88%, 87%, 86%, 85%, 84%, 83%, 82%, 81%, 80%, 79%, 78%, 77%, 76%, 75%, 74%, 73%, 72%, 71%, 70%, 69%, 68%, 67%, 66%, 65%, 64%, 63%, 62%, 61%, 60%, 59%, 58%, 57%, 56%, 55%, 54%, 54%, 53%, 52%, 51%, 50%, 49%, 48%, 47%, 46%, 45%, 44%, 43%, 42%, 41%, 40%, 39%, 38%, 37%, 36%, 35%, 34%, 33%, 32%, 31%, 30%, 29%, 28%, 27%, 26%, 25%, 24%, 23%, 22%, 21%, 20%, 19%, 18%, 17%, 16%, 15%, 14%, 13%, 12%, 11%, or 10% or less inhibition of P70 S6 kinase activity, e.g., as measured by an assay described herein, e.g., the Boulay assay .

[00324] In one aspect the dose of mTOR inhibitor useful in the methods and compositions of the invention is sufficient to achieve, e.g., when administered to a human subject, 90 +/-5 % (i.e., 85-95%), 89+/-5 %, 88+/-5 %, 87+/-5 %, 86+/-5 %, 85+/-5 %, 84+/-5 %, 83+/-5 %, 82+/-5 %, 81+/-5 %, 80+/-5 %, 79+/-5 %, 78+/-5 %, 77+/-5 %, 76+/-5 %, 75+/-5 %, 74+/-5 %, 73+/-5 %, 72 +/-5%, 71 +/-5%, 70 +/-5%, 69 +/-5%, 68 +/-5%, 67 +/-5%, 66 +/-5%, 65 +/-5%, 64 +/-5%, 63 +/-5%, 62 +/-5%, 61 +/-5%, 60 +/-5%, 59 +/-5%, 58 +/-5%, 57 +/-5%, 56 +/-5%, 55 +/-5%, 54 +/-5%, 54 +/-5%, 53 +/-5%, 52 +/-5%, 51 +/-5%, 50 +/-5%, 49 +/-5%, 48 +/-5%, 47 +/-5%, 46 +/-5%, 45 +/-5%, 44 +/-5%, 43 +/-5%, 42 +/-5%, 41 +/-5%, 40 +/-5%, 39 +/-5%, 38 +/-5%, 37 +/-5%, 36 +/-5%, 35 +/-5%, 34 +/-5%, 33 +/-5%, 32 +/-5%, 31 +/-5%, 30 +/-5%, 29 +/-5%, 28 +/-5%, 27 +/-5%, 26 +/-5%, 25 +/-5%, 24 +/-5%, 23 +/-5%, 22 +/-5%, 21 +/-5%, 20 +/-5%, 19 +/-5%, 18 +/-5%, 17 +/-5%, 16 +/-5%, 15 +/-5%, 14 +/-5%, 13 +/-5%, 12 +/-5%, 11 +/-5%, or 10 +/-5%, inhibition of P70 S6 kinase activity , e.g., as measured by an assay described herein, e.g., the Boulay assay.

[00325] P70 S6 kinase activity in a subject may be measured using methods known in the art, such as, for example, according to the methods described in U.S. Pat. 7,727,950, by immunoblot analysis of phosphoP70 S6K levels and/or phosphoP70 S6 levels or by in vitro kinase activity assays.

[00326] In a further aspect, the invention relates to compositions comprising an mTOR inhibitor such as an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001. Doses of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, in such compositions can be in the range of about 30 pM to 4 nM. In one aspect, the dose of an mTOR inhibitor, e.g., an allosteric mTOR inhibitor, e.g., RAD001, is in the range of about 50 pM to 2nM, about 100 pM to 1.5 nM, about 200 pM to 1 nM, or about 300 pM to 500 pM. In one aspect, the dose of RAD001 is in the range of 50 pM to 2nM, 100 pM to 1.5 nM, 200 pM to 1 nM, or 300 pM to 500 pM. In a further aspect the dose of RAD001 is about 30 pM, 40 pM, 50 pM, 60 pM, 70 pM, 80 pM, 90 pM, 100 pM, 150 pM, 200 pM, 250 pM, 300 pM, 350 pM, 400 pM, 450 pM, 500 pM, 550 pM, 600 pM, 650 pM, 700 pM, 750 pM, 800 pM, 850 pM, 900 pM, 950 pM, 1 nM, 1.5 nM, 2 nM, 2.5 nM, 3 nM, 3.5 nM, or 4 nM.

[00327] In a further aspect, the invention can utilize an mTOR inhibitor other than RAD001 in an amount that is bioequivalent to the specific amounts or doses specified for RAD001.

[00328] The invention further relates to methods comprising the administration of an mTOR inhibitor to a subject. Such methods may employ doses of the mTOR inhibitor RAD001 in the range of about 30 pM to 4 nM. In a further aspect, the dose of RAD001 can be in the range of about 50 pM to 2nM, about 100 pM to 1.5 nM, about 200 pM to 1 nM, or about 300 pM to 500 pM. In one aspect, the dose of RAD001 is in the range of 50 pM to 2nM, 100 pM to 1.5 nM, 200 pM to 1 nM, or 300 pM to 500 pM. In a further aspect the dose of RAD001 is about 30 pM, 40 pM, 50 pM, 60 pM, 70 pM, 80 pM, 90 pM, 100 pM, 150 pM, 200 pM, 250 pM, 300 pM, 350 pM, 400 pM, 450 pM, 500 pM, 550 pM, 600 pM, 650 pM, 700 pM, 750 pM, 800 pM, 850 pM, 900 pM, 950 pM, 1 nM, 1.5 nM, 2 nM, 2.5 nM, 3 nM, 3.5 nM, or 4 nM.

[00329] In a further aspect, the methods of the invention can utilize an mTOR inhibitor other than RAD001 in an amount that is bioequivalent to the specific amounts or doses specified for RAD001.

[00330] As used herein, the term "about" in reference to a dose of mTOR inhibitor refers to up to a +/- 10% variability in the amount of mTOR inhibitor, but can include no variability around the stated dose.

[00331] In some embodiments, the invention provides methods comprising administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage within a target trough level. In some embodiments, the trough level is significantly lower than trough levels associated with dosing regimens used in organ transplant and cancer patients. In an embodiment mTOR inhibitor, e.g., RAD001, or rapamycin, is administerd to result in a trough level that is less than ½, 1/4, 1/10, or 1/20 of the trough level that results in immunosuppression or an anticancer effect. In an embodiment mTOR inhibitor, e.g., RAD001, or rapamycin, is administerd to result in a trough level that is less than ½, 1/4, 1/10, or 1/20 of the trough level provided on the FDA approved packaging insert for use in immunosuppression or an anticancer indications.

[00332] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 0.1 to 10 ng/ml, 0.1 to 5 ng/ml, 0.1 to 3ng/ml, 0.1 to 2 ng/ml, or 0.1 to 1 ng/ml.

[00333] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 0.2 to 10 ng/ml, 0.2 to 5 ng/ml, 0.2 to 3ng/ml, 0.2 to 2 ng/ml, or 0.2 to 1 ng/ml.

[00334] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g. an, allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 0.3 to 10 ng/ml, 0.3 to 5 ng/ml, 0.3 to 3ng/ml, 0.3 to 2 ng/ml, or 0.3 to 1 ng/ml.

[00335] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 0.4 to 10 ng/ml, 0.4 to 5 ng/ml, 0.4 to 3ng/ml, 0.4 to 2 ng/ml, or 0.4 to 1 ng/ml.

[00336] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 0.5 to 10 ng/ml, 0.5 to 5 ng/ml, 0.5 to 3ng/ml, 0.5 to 2 ng/ml, or 0.5 to 1 ng/ml.

[00337] In an embodiment a method disclosed herein comprises administering to a subject an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, at a dosage that provides a target trough level of 1 to 10 ng/ml, 1 to 5 ng/ml, 1 to 3ng/ml, or 1 to 2 ng/ml.

[00338] As used herein, the term "trough level" refers to the concentration of a drug in plasma just before the next dose, or the minimum drug concentration between two doses.

[00339] In some embodiments, a target trough level of RAD001 is in a range of between about 0.1 and 4.9 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between about 0.1 and 3 ng/ml. In an embodiment, the target trough level is below 3ng/ml, e.g., is between 0.3 or less and 3 ng/ml. In an embodiment, the target trough level is below 3ng/ml, e.g., is between 0.3 or less and 1 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between about 2.4 and 3 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between about 0.1 and 2.4 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between about 0.1 and 1.5 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between 0.1 and 3 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between 2.4 and 3 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between 0.1 and 2.4 ng/ml. In some embodiments, a target trough level of RAD001 is in a range of between 0.1 and 1.5 ng/ml. In some embodiments, a target trough level of RAD001 is 0.1 ng/ml. In some embodiments, a target trough level of RAD001 is 0.2 ng/ml. In some embodiments, a target trough level of RAD001 is 0.3 ng/ml. In some embodiments, a target trough level of RAD001 is 0.4 ng/ml. In some embodiments, a target trough level of RAD001 is 0.5 ng/ml. In some embodiments, a target trough level of RAD001 is 0.6 ng/ml. In some embodiments, a target

trough level of RAD001 is 0.7 ng/ml. In some embodiments, a target trough level of RAD001 is 0.8 ng/ml. In some embodiments, a target trough level of RAD001 is 0.9 ng/ml. In some embodiments, a target trough level of RAD001 is 1.0 ng/ml. In some embodiments, a target trough level of RAD001 is 1.1 ng/ml. In some embodiments, a target trough level of RAD001 is 1.2 ng/ml. In some embodiments, a target trough level of RAD001 is 1.3 ng/ml. In some embodiments, a target trough level of RAD001 is 1.4 ng/ml. In some embodiments, a target trough level of RAD001 is 1.5 ng/ml. In some embodiments, a target trough level of RAD001 is less than 5 ng/ml. In some embodiments, a target trough level of RAD001 is less than 2.5 ng/ml. In some embodiments, a target trough level of RAD001 is less than 3 ng/ml, 2 ng/ml, 1.9 ng/ml, 1.8 ng/ml, 1.7 ng/ml, 1.6 ng/ml, 1.5 ng/ml, 1.4 ng/ml, 1.3 ng/ml, 1.2 ng/ml, 1.1 ng/ml, 1.0 ng/ml, 0.9 ng/ml, 0.8 ng/ml, 0.7 ng/ml, 0.6 ng/ml, 0.5 ng/ml, 0.4 ng/ml, 0.3 ng/ml, 0.2 ng/ml, or 0.1 ng/ml.

[00340] In a further aspect, the invention can utilize an mTOR inhibitor other than RAD001 in an amount that is associated with a target trough level that is bioequivalent to the specified target trough level for RAD001. In an embodiment, the target trough level for an mTOR inhibitor other than RAD001, is a level that gives the same level of mTOR inhibition (e.g., as measured by a method described herein, e.g., the inhibition of P70 S6K) as does a trough level of RAD001 described herein.

## CARs and CAR-Expressing Cells for Use With Administration of a Low, Immune Enhancing, Dose of an mTOR Inhibitor

[00341] Described herein are methods for combining administration of a low, immune enhancing dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, in combination with an immune effector cell, e.g., a T cell or a NK cell, engineered to express a CAR. (The cell is engineered to express a CAR, and in embodiments, expresses the CAR by the time at which it is administered to the subject. In other embodiments, expression initiates after administration.) In some embodiments, the cell is a T cell engineered to express a CAR, wherein the CAR T cell ("CART") exhibits an anticancer property.

[00342] Provided herein are compositions of matter and methods of use for the treatment of a disease such as cancer using immune effector cells (e.g., T cells, NK cells) engineered with

CARs in combination with administration of a low, imune enhancing dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor.

[00343] Provided herein are a number of chimeric antigen receptors (CAR) comprising an antigen binding domain (e.g., antibody or antibody fragment, TCR or TCR fragment) engineered for enhanced binding to a tumor marker as described herein. Provided herein is an immune effector cell (e.g., T cell, NK cell) engineered to express a CAR, wherein the engineered immune effector cells exhibit an antitumor property. In one aspect a cell is transformed with the CAR and the CAR is expressed on the cell surface. In some embodiments, the cell (e.g., T cell, NK cell) is transduced with a viral vector encoding a CAR. In some embodiments, the viral vector is a retroviral vector. In some embodiments, the viral vector is a lentiviral vector. In some such embodiments, the cell may stably express the CAR. In another embodiment, the cell (e.g., T cell, NK cell) is transfected with a nucleic acid, e.g., mRNA, cDNA, DNA, encoding a CAR. In some such embodiments, the cell may transiently express the CAR.

[00344] In one aspect, the antigen binding domain of the CARs described herein is a scFv antibody fragment. In one aspect such antibody fragments are functional in that they retain the equivalent binding affinity, e.g., they bind the same antigen with comparable affinity, as the IgG antibody from which it is derived. In one aspect such antibody fragments are functional in that they provide a biological response that can include, but is not limited to, activation of an immune response, inhibition of signal-transduction origination from its target antigen, inhibition of kinase activity, and the like, as will be understood by a skilled artisan. In one aspect, the antigen binding domain of the CAR is a scFv antibody fragment that is humanized compared to the murine sequence of the scFv from which it is derived. In one aspect, the parental murine scFv sequence is the CAR19 construct provided in PCT publication WO2012/079000 (incorporated herein by reference) and provided herein as SEQ ID NO:43. In one embodiment, the anti-CD19 binding domain is a scFv described in WO2012/079000 and provided in SEQ ID NO:43.

[00345] In some aspects, the antibodies of the invention are incorporated into a chimeric antigen receptor (CAR). In one aspect, the CAR comprises the polypeptide sequence provided as SEQ ID NO: 12 in PCT publication WO2012/079000, and provided herein as SEQ ID NO: 42, wherein the scFv domain is substituted by one or more sequences selected from SEQ ID NOS: 44-55. In one aspect, the scFv domains of SEQ ID NOS:44-55 are humanized variants of the

scFv domain of SEQ ID NO:43, which is an scFv fragment of murine origin that specifically binds to human CD19. Humanization of this mouse scFv may be desired for the clinical setting, where the mouse-specific residues may induce a human-anti-mouse antigen (HAMA) response in patients who receive CART19 treatment, e.g., treatment with T cells transduced with the CAR19 construct.

[00346] The CD19 CAR provided as SEQ ID NO: 12 in PCT publication WO2012/079000 is:

[00347] MALPVTALLLPLALLLHAARPdiqmtqttsslsaslgdrvtiscrasqdiskylnwyqqkpdgtvklliy htsrlhsgvpsrfsgsgsgtdysltisnleqediatyfcqqgntlpytfgggtkleitggggsggggsggggsevklqesgpglvapsqsls vtctvsgvslpdygvswirqpprkglewlgviwgsettyynsalksrltiikdnsksqvflkmnslqtddtaiyycakhyyyggsyam dywgqgtsvtvsstttpaprpptpaptiasqplslrpeacrpaaggavhtrgldfacdiyiwaplagtcgvlllslvitlyckrgrkkllyifk qpfmrpvqttqeedgcscrfpeeeeggcelrvkfsrsadapaykqgqnqlynelnlgrreeydvldkrrgrdpemggkprrknpqeg lynelqkdkmaeayseigmkgerrrgkghdglyqglstatkdtydalhmqalppr (SEQ ID NO: 42)

[00348] In one aspect, the antigen binding domain of a CAR of the invention (e.g., a scFv) is encoded by a transgene whose sequence has been codon optimized for expression in a mammalian cell. In one aspect, entire CAR construct of the invention is encoded by a transgene whose entire sequence has been codon optimized for expression in a mammalian cell. Codon optimization refers to the discovery that the frequency of occurrence of synonymous codons (i.e., codons that code for the same amino acid) in coding DNA is biased in different species. Such codon degeneracy allows an identical polypeptide to be encoded by a variety of nucleotide sequences. A variety of codon optimization methods is known in the art, and include, e.g., methods disclosed in at least US Patent Numbers 5,786,464 and 6,114,148.

[00349] In one aspect, the CARs of the invention combine an antigen binding domain of a specific antibody with an intracellular signaling molecule. For example, in some aspects, the intracellular signaling molecule includes, but is not limited to, CD3-zeta chain, 4-1BB and CD28 signaling modules and combinations thereof. In one aspect, the antigen binding domain binds to a tumor marker as described herein.

[00350] Furthermore, the present invention provides CAR-expressing cell compositions and a low, immune enhancing, dose of mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and their use in medicaments or methods for treating, among other diseases,

cancer or any malignancy or autoimmune diseases involving cells or tissues which express a tumor marker as described herein.

[00351] In one aspect, the CAR of the invention can be used with administration of a low, immune enhancing, dose of an mTOR inhibitor, to eradicate normal cells that express a tumor marker as described herein, thereby applicable for use as a cellular conditioning therapy prior to cell transplantation. In one aspect, the normal cells that express a tumor marker as described herein is a normal stem cell and the cell transplantation is a stem cell transplantation.

[00352] In one aspect, the invention provides an immune effector cell (e.g., T cell, NK cell) engineered to express a chimeric antigen receptor (CAR), wherein the engineered immune effector cell exhibits an anticancer property. A preferred antigen is a cancer associated antigen (i.e., tumor marker) as described herein. In one aspect, the antigen binding domain of the CAR comprises a partially humanized antibody fragment. In one aspect, the antigen binding domain of the CAR comprises a partially humanized scFv. Accordingly, the invention provides CARs that comprises a humanized antigen binding domain and is engineered into an immune effector cell, e.g., a T cell or an NK cell, and methods of their use for adoptive therapy.

[00353] In one aspect, the CARs of the invention comprise at least one intracellular domain selected from the group of a CD137 (4-1BB) signaling domain, a CD28 signaling domain, a CD3zeta signal domain, and any combination thereof. In one aspect, the CARs of the invention comprise at least one intracellular signaling domain is from one or more co-stimulatory molecule(s) other than a CD137 (4-1BB) or CD28.

[00354] Sequences of some examples of various components of CARs of the instant invention is listed in Table 1, where aa stands for amino acids, and na stands for nucleic acids that encode the corresponding peptide.

Table 1. Sequences of various components of CAR (aa – amino acids, na – nucleic acids that encodes the corresponding protein)

| SEQ ID NO | description | Sequence | Corresp. To huCD19 |
|---|---|---|---|
| 1 | EF-1 promoter | CGTGAGGCTCCGGTGCCCGTCAGTGGGCAGAGCGC<br>ACATCGCCCACAGTCCCCGAGAAGTTGGGGGGAG<br>GGGTCGGCAATTGAACCGGTGCCTAGAGAAGGTG<br>GCGCGGGGTAAACTGGGAAAGTGATGTCGTGTACT<br>GGCTCCGCCTTTTTCCCGAGGGTGGGGGAGAACCG<br>TATATAAGTGCAGTAGTCGCCGTGAACGTTCTTTTT<br>CGCAACGGGTTTGCCGCCAGAACACAGGTAAGTGC<br>CGTGTGTGGTTCCCGCGGGCCTGGCCTCTTTACGG<br>GTTATGGCCCTTGCGTGCCTTGAATTACTTCCACCT<br>GGCTGCAGTACGTGATTCTTGATCCCGAGCTTCGG<br>GTTGGAAGTGGGTGGGAGAGTTCGAGGCCTTGCGC<br>TTAAGGAGCCCCTTCGCCTCGTGCTTGAGTTGAGG<br>CCTGGCCTGGGCGCTGGGGCCGCCGCGTGCGAATC<br>TGGTGGCACCTTCGCGCCTGTCTCGCTGCTTTCGAT<br>AAGTCTCTAGCCATTTAAAATTTTTGATGACCTGCT<br>GCGACGCTTTTTTTCTGGCAAGATAGTCTTGTAAAT<br>GCGGGCCAAGATCTGCACACTGGTATTTCGGTTTTT<br>GGGGCCGCGGGCGGCGACGGGGCCCGTGCGTCCC<br>AGCGCACATGTTCGGCGAGGCGGGGCCTGCGAGC<br>GCGGCCACCGAGAATCGGACGGGGGTAGTCTCAA<br>GCTGGCCGGCCTGCTCTGGTGCCTGGCCTCGCGCC<br>GCCGTGTATCGCCCCGCCCTGGGCGGCAAGGCTGG<br>CCCGGTCGGCACCAGTTGCGTGAGCGGAAAGATGG<br>CCGCTTCCCGGCCCTGCTGCAGGGAGCTCAAAATG<br>GAGGACGCGGCGCTCGGGAGAGCGGGCGGGTGAG<br>TCACCCACACAAAGGAAAAGGGCCTTTCCGTCCTC<br>AGCCGTCGCTTCATGTGACTCCACGGAGTACCGGG<br>CGCCGTCCAGGCACCTCGATTAGTTCTCGAGCTTTT<br>GGAGTACGTCGTCTTTAGGTTGGGGGGAGGGGTTT<br>TATGCGATGGAGTTTCCCCACACTGAGTGGGTGGA<br>GACTGAAGTTAGGCCAGCTTGGCACTTGATGTAAT<br>TCTCCTTGGAATTTGCCCTTTTTGAGTTTGGATCTT<br>GGTTCATTCTCAAGCCTCAGACAGTGGTTCAAAGT<br>TTTTTTCTTCCATTTCAGGTGTCGTGA | 100 |
| 2 | Leader (aa) | MALPVTALLLPLALLLHAARP | 13 |
| 3 | Leader (na) | ATGGCCCTGCCTGTGACAGCCCTGCTGCTGCCTCTG<br>GCTCTGCTGCTGCATGCCGCTAGACCC | 54 |

| | | | |
|---|---|---|---|
| 4 | CD 8 hinge (aa) | TTTPAPRPPTPAPTIASQPLSLRPEACRPAAGGAVHTR GLDFACD | 14 |
| 5 | CD8 hinge (na) | ACCACGACGCCAGCGCCGCGACCACCAACACCGG CGCCCACCATCGCGTCGCAGCCCCTGTCCCTGCGC CCAGAGGCGTGCCGGCCAGCGGCGGGGGGCGCAG TGCACACGAGGGGGCTGGACTTCGCCTGTGAT | 55 |
| 6 | Ig4 hinge (aa) | ESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTP EVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPR EEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKG LPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSL TCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSD GSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYT QKSLSLSLGKM | 102 |
| 7 | Ig4 hinge (na) | GAGAGCAAGTACGGCCCTCCCTGCCCCCCTTGCCC TGCCCCCGAGTTCCTGGGCGGACCCAGCGTGTTCC TGTTCCCCCCCAAGCCCAAGGACACCCTGATGATC AGCCGGACCCCCGAGGTGACCTGTGTGGTGGTGGA CGTGTCCCAGGAGGACCCCGAGGTCCAGTTCAACT GGTACGTGGACGGCGTGGAGGTGCACAACGCCAA GACCAAGCCCCGGGAGGAGCAGTTCAATAGCACCT ACCGGGTGGTGTCCGTGCTGACCGTGCTGCACCAG GACTGGCTGAACGGCAAGGAATACAAGTGTAAGG TGTCCAACAAGGGCCTGCCCAGCAGCATCGAGAAA ACCATCAGCAAGGCCAAGGGCCAGCCTCGGGAGC CCCAGGTGTACACCCTGCCCCCTAGCCAAGAGGAG ATGACCAAGAACCAGGTGTCCCTGACCTGCCTGGT GAAGGGCTTCTACCCCAGCGACATCGCCGTGGAGT GGGAGAGCAACGGCCAGCCCGAGAACAACTACAA GACCACCCCCCCTGTGCTGGACAGCGACGGCAGCT TCTTCCTGTACAGCCGGCTGACCGTGGACAAGAGC CGGTGGCAGGAGGGCAACGTCTTTAGCTGCTCCGT GATGCACGAGGCCCTGCACAACCACTACACCCAGA AGAGCCTGAGCCTGTCCCTGGGCAAGATG | 103 |
| 8 | IgD hinge (aa) | RWPESPKAQASSVPTAQPQAEGSLAKATTAPATTRN TGRGGEEKKKEKEKEEQEERETKTPECPSHTQPLGVY LLTPAVQDLWLRDKATFTCFVVGSDLKDAHLTWEV AGKVPTGGVEEGLLERHSNGSQSQHSRLTLPRSLWN AGTSVTCTLNHPSLPPQRLMALREPAAQAPVKLSLNL LASSDPPEAASWLLCEVSGFSPPNILLMWLEDQREVN | 47 |

| | | | |
|---|---|---|---|
| | | TSGFAPARPPPQPGSTTFWAWSVLRVPAPPSPQPATY TCVVSHEDSRTLLNASRSLEVSYVTDH | |
| 9 | IgD hinge (na) | AGGTGGCCCGAAAGTCCCAAGGCCCAGGCATCTAG TGTTCCTACTGCACAGCCCCAGGCAGAAGGCAGCC TAGCCAAAGCTACTACTGCACCTGCCACTACGCGC AATACTGGCCGTGGCGGGGAGGAGAAGAAAAAGG AGAAAGAGAAAGAAGAACAGGAAGAGAGGGAGA CCAAGACCCCTGAATGTCCATCCCATACCCAGCCG CTGGGCGTCTATCTCTTGACTCCCGCAGTACAGGA CTTGTGGCTTAGAGATAAGGCCACCTTTACATGTTT CGTCGTGGGCTCTGACCTGAAGGATGCCCATTTGA CTTGGGAGGTTGCCGGAAAGGTACCCACAGGGGG GGTTGAGGAAGGGTTGCTGGAGCGCCATTCCAATG GCTCTCAGAGCCAGCACTCAAGACTCACCCTTCCG AGATCCCTGTGGAACGCCGGGACCTCTGTCACATG TACTCTAAATCATCCTAGCCTGCCCCCACAGCGTCT GATGGCCCTTAGAGAGCCAGCCGCCCAGGCACCAG TTAAGCTTAGCCTGAATCTGCTCGCCAGTAGTGAT CCCCCAGAGGCCGCCAGCTGGCTCTTATGCGAAGT GTCCGGCTTTAGCCCGCCCAACATCTTGCTCATGTG GCTGGAGGACCAGCGAGAAGTGAACACCAGCGGC TTCGCTCCAGCCCGGCCCCCACCCCAGCCGGGTTC TACCACATTCTGGGCCTGGAGTGTCTTAAGGGTCC CAGCACCACCTAGCCCCCAGCCAGCCACATACACC TGTGTTGTGTCCCATGAAGATAGCAGGACCCTGCT AAATGCTTCTAGGAGTCTGGAGGTTTCCTACGTGA CTGACCATT | 48 |
| 10 | GS hinge/linker (aa) | GGGGSGGGGS | 49 |
| 11 | GS hinge/linker (na) | GGTGGCGGAGGTTCTGGAGGTGGAGGTTCC | 50 |
| 12 | CD8TM (aa) | IYIWAPLAGTCGVLLLSLVITLYC | 15 |
| 13 | CD8 TM (na) | ATCTACATCTGGGCGCCCTTGGCCGGGACTTGTGG GGTCCTTCTCCTGTCACTGGTTATCACCCTTTACTG C | 56 |

| | | | |
|---|---|---|---|
| 14 | 4-1BB intracellular domain (aa) | KRGRKKLLYIFKQPFMRPVQTTQEEDGCSCRFPEEEEGGCEL | 16 |
| 15 | 4-1BB intracellular domain (na) | AAACGGGGCAGAAAGAAACTCCTGTATATATTCAAACAACCATTTATGAGACCAGTACAAACTACTCAAGAGGAAGATGGCTGTAGCTGCCGATTTCCAGAAGAAGAAGAAGGAGGATGTGAACTG | 60 |
| 16 | CD27 (aa) | QRRKYRSNKGESPVEPAEPCRYSCPREEEGSTIPIQEDYRKPEPACSP | 51 |
| 17 | CD27 (na) | AGGAGTAAGAGGAGCAGGCTCCTGCACAGTGACTACATGAACATGACTCCCCGCCGCCCCGGGCCCACCCGCAAGCATTACCAGCCCTATGCCCCACCACGCGACTTCGCAGCCTATCGCTCC | 52 |
| 18 | CD3-zeta (aa) | RVKFSRSADAPAYKQGQNQLYNELNLGRREEYDVLDKRRGRDPEMGGKPRRKNPQEGLYNELQKDKMAEAYSEIGMKGERRRGKGHDGLYQGLSTATKDTYDALHMQALPPR | 17 |
| 19 | CD3-zeta (na) | AGAGTGAAGTTCAGCAGGAGCGCAGACGCCCCCGCGTACAAGCAGGGCCAGAACCAGCTCTATAACGAGCTCAATCTAGGACGAAGAGAGGAGTACGATGTTTTGGACAAGAGACGTGGCCGGGACCCTGAGATGGGGGGAAAGCCGAGAAGGAAGAACCCTCAGGAAGGCCTGTACAATGAACTGCAGAAAGATAAGATGGCGGAGGCCTACAGTGAGATTGGGATGAAAGGCGAGCGCCGGAGGGGCAAGGGGCACGATGGCCTTTACCAGGGTCTCAGTACAGCCACCAAGGACACCTACGACGCCCTTCACATGCAGGCCCTGCCCCCTCGC | 101 |
| 20 | CD3-zeta (aa) | RVKFSRSADAPAYQQGQNQLYNELNLGRREEYDVLDKRRGRDPEMGGKPRRKNPQEGLYNELQKDKMAEAYSEIGMKGERRRGKGHDGLYQGLSTATKDTYDALHMQALPPR | 43 |
| 21 | CD3-zeta | AGAGTGAAGTTCAGCAGGAGCGCAGACGCCCCCG | 44 |

| | | | |
|---|---|---|---|
| | (na) | CGTACCAGCAGGGCCAG<br><br>AACCAGCTCTATAACGAGCTCAATCTAGGACGAAG AGAGGAGTACGATGTTT<br><br>TGGACAAGAGACGTGGCCGGGACCCTGAGATGGG GGGAAAGCCGAGAAGGA<br><br>AGAACCCTCAGGAAGGCCTGTACAATGAACTGCAG AAAGATAAGATGGCGG<br><br>AGGCCTACAGTGAGATTGGGATGAAAGGCGAGCG CCGGAGGGGCAAGGGGC<br><br>ACGATGGCCTTTACCAGGGTCTCAGTACAGCCACC AAGGACACCTACGACGC<br><br>CCTTCACATGCAGGCCCTGCCCCCTCGC | |
| 22 | linker | GGGGS | 18 |
| 23 | linker | GGTGGCGGAGGTTCTGGAGGTGGAGGTTCC | 50 |
| 24 | PD-1 extracellular domain (aa) | pgwfldspdrpwnpptfspallvvtegdnatftcsfsntsesfvlnwyrmspsnq tdklaafpedrsqpgqdcrfrvtqlpngrdfhmsvvrarrndsgtylcgaislapk aqikeslraelrvterraevptahpspsprpagqfqtlv | |
| 25 | PD-1 extracellular domain (na) | cccggatggtttctggactctccggatcgcccgtggaatcccccaaccttctcaccg gcactcttggttgtgactgagggcgataatgcgaccttcacgtgctcgttctccaaca cctccgaatcattcgtgctgaactggtaccgcatgagcccgtcaaaccagaccgac aagctcgccgcgtttccggaagatcggtcgcaaccgggacaggattgtcggttccg cgtgactcaactgccgaatggcagagacttccacatgagcgtggtccgcgctaggc gaaacgactccgggacctacctgtgcggagccatctcgctggcgcctaaggccca aatcaaagagagcttgagggccgaactgagagtgaccgagcgcagagctgaggt gccaactgcacatccatccccatcgcctcggcctgcggggcagtttcagaccctgg tc | |
| 26 | PD-1 CAR (aa) with signal | Malpvtalllplalllhaarppgwfldspdrpwnpptfspallvvtegdnatftcsf sntsesfvlnwyrmspsnqtdklaafpedrsqpgqdcrfrvtqlpngrdfhmsv vrarrndsgtylcgaislapkaqikeslraelrvterraevptahpspsprpagqfqt lvtttpaprpptpaptiasqplslrpeacrpaaggavhtrgldfacdiyiwaplagtc gvlllslvitlyckrgrkkllyifkqpfmrpvqttqeedgcscrfpeeeeggcelrvk fsrsadapaykqgqnqlynelnlgrreeydvldkrrgrdpemggkprrknpqeg | |

| | | | |
|---|---|---|---|
| | | lynelqkdkmaeayseigmkgerrrgkghdglyqglstatkdtydalhmqalp pr | |
| 27 | PD-1 CAR (na) | Atggccctccctgtcactgccctgcttctccccctcgcactcctgctccacgccgcta gaccacccggatggtttctggactctccggatcgcccgtggaatcccccaaccttct caccggcactcttggttgtgactgagggcgataatgcgaccttcacgtgctcgttctc caacacctccgaatcattcgtgctgaactggtaccgcatgagcccgtcaaaccaga ccgacaagctcgccgcgtttccggaagatcggtcgcaaccgggacaggattgtcg gttccgcgtgactcaactgccgaatggcagagacttccacatgagcgtggtccgcg ctaggcgaaacgactccgggacctacctgtgcggagccatctcgctggcgcctaa ggcccaaatcaaagagagcttgagggccgaactgagagtgaccgagcgcagagc tgaggtgccaactgcacatccatccccatcgcctcggcctgcggggcagtttcaga ccctggtcacgaccactccggcgccgcgcccaccgactccggccccaactatcgc gagccagcccctgtcgctgaggccggaagcatgccgccctgccgccggaggtgc tgtgcatacccggggattggacttcgcatgcgacatctacatttgggctcctctcgcc ggaacttgtggcgtgctccttctgtccctggtcatcaccctgtactgcaagcggggtc ggaaaaagcttctgtacattttcaagcagcccttcatgaggcccgtgcaaaccaccc aggaggaggacggttgctcctgccggttccccgaagaggaagaaggaggttgcg agctgcgcgtgaagttctcccggagcgccgacgcccccgcctataagcagggcca gaaccagctgtacaacgaactgaacctgggacggcgggaagagtacgatgtgctg gacaagcggcgcggccgggaccccgaaatgggcgggaagcctagaagaaaga accctcaggaaggcctgtataacgagctgcagaaggacaagatggccgaggccta ctccgaaattgggatgaagggagagcggcggaggggaaaggggcacgacggc ctgtaccaaggactgtccaccgccaccaaggacacatacgatgccctgcacatgca ggcccttccccctcgc | |
| 28 | linker | $(Gly\text{-}Gly\text{-}Gly\text{-}Ser)_n$, where n = 1-10 | 105 |
| 29 | linker | (Gly4 Ser)4 | 106 |
| 30 | linker | (Gly4 Ser)3 | 107 |
| 31 | linker | (Gly3Ser) | 108 |
| 32 | polyA | $(A)_{2000}$ | 118 |
| 33 | polyA | $(A)_{150}$ | 104 |
| 34 | polyA | $(A)_{5000}$ | 109 |

| | | | |
|---|---|---|---|
| 35 | polyT | $(T)_{100}$ | 110 |
| 36 | polyT | $(T)_{5000}$ | 111 |
| 37 | polyA | $(A)_{5000}$ | 112 |
| 38 | polyA | $(A)_{400}$ | 113 |
| 39 | PD1 CAR (aa) | pgwfldspdrpwnpptfspallvvtegdnatftcsfsntsesfvlnwyrmspsnq tdklaafpedrsqpgqdcrfrvtqlpngrdfhmsvvrarrndsgtylcgaislapk aqikeslraelrvterraevptahpspsprpagqfqtlvtttpaprpptpaptiasqpl slrpeacrpaaggavhtrgldfacdiyiwaplagtcgvlllslvitlyckrgrkkllyi fkqpfmrpvqttqeedgcscrfpeeeeggcelrvkfsrsadapaykqgqnqlyn elnlgrreeydvldkrrgrdpemggkprrknpqeglynelqkdkmaeayseig mkgerrrgkghdglyqglstatkdtydalhmqalppr | |
| 91 | CD28 Intracellular domain (amino acid sequence) | RSKRSRLLHSDYMNMTPRRPGPTRKHYQPYAPPRDF AAYRS | |
| 92 | CD28 Intracellular domain (nucleotide sequence) | AGGAGTAAGAGGAGCAGGCTCCTGCACAGTGACT ACATGAACATGACTCCCCGCCGCCCCGGGCCCACC CGCAAGCATTACCAGCCCTATGCCCCACCACGCGA CTTCGCAGCCTATCGCTCC | |
| 93 | ICOS Intracellular domain (amino acid sequence) | T K K K Y S S S V H D P N G E Y M F M R A V N T A K K S R L T D V T L | |
| 94 | ICOS Intracellular domain (nucleotide sequence) | ACAAAAAAGAAGTATTCATCCAGTGTGCACGACCC TAACGGTGAATACATGTTCATGAGAGCAGTGAACA CAGCCAAAAAATCCAGACTCACAGATGTGACCCTA | |

[00355] In embodiments, CAR scFv fragments are cloned into lentiviral vectors to create a full length CAR construct in a single coding frame, and using a promoter, e.g., EF1 alpha promoter, for expression (SEQ ID NO: 1).

**Cancer Associated Antigens**

[00356] The present invention provides immune effector cells (e.g., T cells, NK cells) that are engineered to contain one or more CARs that direct the immune effector cells to cancer for administration in combination with administration of a low, immune enhancing, dose of an mTOR inhibitor. This is achieved through a binding domain on CARs that are specific for cancer associated antigens. There are two classes of cancer associated antigens (tumor markers or antigens) can be targeted by the CARs of the instant invention: (1) cancer associated antigens that are expressed on the surface of cancer cells; and (2) cancer associated antigens that itself is intracellar, however, a fragment of such antigen (peptide) is presented on the surface of the cancer cells by MHC (major histocompatibility complex).

[00357] Accordingly, the present invention provides CARTs that target the following cancer associated antigens (tumor markers): 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, 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, TSHR, GPRC5D, CXORF61, CD97, CD179a, ALK, Plysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, legumain, HPV E6,E7, MAGE-A1, 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, and IGLL1.

[00358] In some embodiments, the tumor antigen is a tumor antigen described in International Application PCT/US2015/020606, which is herein incorporated by reference in its entirety. In some embodiments, the tumor antigen is chosen from one or more of: CD19; CD123; CD22; CD30; CD171; CS-1 (also referred to as CD2 subset 1, CRACC, SLAMF7, CD319, and 19A24); C-type lectin-like molecule-1 (CLL-1 or CLECL1); CD33; epidermal growth factor receptor variant III (EGFRvIII); ganglioside G2 (GD2); ganglioside GD3 (aNeu5Ac(2-8)aNeu5Ac(2-3)bDGalp(1-4)bDGlcp(1-1)Cer); TNF receptor family member B cell maturation (BCMA); Tn antigen ((Tn Ag) or (GalNAcα-Ser/Thr)); prostate-specific membrane antigen (PSMA); Receptor tyrosine kinase-like orphan receptor 1 (ROR1); Fms-Like Tyrosine Kinase 3 (FLT3); Tumor-associated glycoprotein 72 (TAG72); CD38; CD44v6; Carcinoembryonic antigen (CEA); Epithelial cell adhesion molecule (EPCAM); B7H3 (CD276); KIT (CD117); Interleukin-13 receptor subunit alpha-2 (IL-13Ra2 or CD213A2); Mesothelin; Interleukin 11 receptor alpha (IL-11Ra); prostate stem cell antigen (PSCA); Protease Serine 21 (Testisin or PRSS21); vascular endothelial growth factor receptor 2 (VEGFR2); Lewis(Y) antigen; CD24; Platelet-derived growth factor receptor beta (PDGFR-beta); Stage-specific embryonic antigen-4 (SSEA-4); CD20; Folate receptor alpha; Receptor tyrosine-protein kinase ERBB2 (Her2/neu); Mucin 1, cell surface associated (MUC1); epidermal growth factor receptor (EGFR); neural cell adhesion molecule (NCAM); Prostase; prostatic acid phosphatase (PAP); elongation factor 2 mutated (ELF2M); Ephrin B2; fibroblast activation protein alpha (FAP); insulin-like growth factor 1 receptor (IGF-I receptor), carbonic anhydrase IX (CAIX); Proteasome (Prosome, Macropain) Subunit, Beta Type, 9 (LMP2); glycoprotein 100 (gp100); oncogene fusion protein consisting of breakpoint cluster region (BCR) and Abelson murine leukemia viral oncogene homolog 1 (Abl) (bcr-abl); tyrosinase; ephrin type-A receptor 2 (EphA2); Fucosyl GM1; sialyl Lewis adhesion molecule (sLe); ganglioside GM3 (aNeu5Ac(2-3)bDGalp(1-4)bDGlcp(1-1)Cer); transglutaminase 5 (TGS5); high molecular weight-melanoma-associated antigen (HMWMAA); o-acetyl-GD2 ganglioside (OAcGD2); Folate receptor beta; tumor endothelial marker 1 (TEM1/CD248); tumor endothelial marker 7-related (TEM7R); claudin 6 (CLDN6); thyroid stimulating hormone receptor (TSHR); G protein-coupled receptor class C group 5, member D (GPRC5D); chromosome X open reading frame 61 (CXORF61); CD97; CD179a; anaplastic

lymphoma kinase (ALK); Polysialic acid; placenta-specific 1 (PLAC1); hexasaccharide portion of globoH glycoceramide (GloboH); mammary gland differentiation antigen (NY-BR-1); uroplakin 2 (UPK2); Hepatitis A virus cellular receptor 1 (HAVCR1); adrenoceptor beta 3 (ADRB3); pannexin 3 (PANX3); G protein-coupled receptor 20 (GPR20); lymphocyte antigen 6 complex, locus K 9 (LY6K); Olfactory receptor 51E2 (OR51E2); TCR Gamma Alternate Reading Frame Protein (TARP); Wilms tumor protein (WT1); Cancer/testis antigen 1 (NY-ESO-1); Cancer/testis antigen 2 (LAGE-1a); Melanoma-associated antigen 1 (MAGE-A1); ETS translocation-variant gene 6, located on chromosome 12p (ETV6-AML); sperm protein 17 (SPA17); X Antigen Family, Member 1A (XAGE1); angiopoietin-binding cell surface receptor 2 (Tie 2); melanoma cancer testis antigen-1 (MAD-CT-1); melanoma cancer testis antigen-2 (MAD-CT-2); Fos-related antigen 1; tumor protein p53 (p53); p53 mutant; prostein; surviving; telomerase; prostate carcinoma tumor antigen-1 (PCTA-1 or Galectin 8), melanoma antigen recognized by T cells 1 (MelanA or MART1); Rat sarcoma (Ras) mutant; human Telomerase reverse transcriptase (hTERT); sarcoma translocation breakpoints; melanoma inhibitor of apoptosis (ML-IAP); ERG (transmembrane protease, serine 2 (TMPRSS2) ETS fusion gene); N-Acetyl glucosaminyl-transferase V (NA17); paired box protein Pax-3 (PAX3); Androgen receptor; Cyclin B1; v-myc avian myelocytomatosis viral oncogene neuroblastoma derived homolog (MYCN); Ras Homolog Family Member C (RhoC); Tyrosinase-related protein 2 (TRP-2); Cytochrome P450 1B1 (CYP1B1); CCCTC-Binding Factor (Zinc Finger Protein)-Like (BORIS or Brother of the Regulator of Imprinted Sites), Squamous Cell Carcinoma Antigen Recognized By T Cells 3 (SART3); Paired box protein Pax-5 (PAX5); proacrosin binding protein sp32 (OY-TES1); lymphocyte-specific protein tyrosine kinase (LCK); A kinase anchor protein 4 (AKAP-4); synovial sarcoma, X breakpoint 2 (SSX2); Receptor for Advanced Glycation Endproducts (RAGE-1); renal ubiquitous 1 (RU1); renal ubiquitous 2 (RU2); legumain; human papilloma virus E6 (HPV E6); human papilloma virus E7 (HPV E7); intestinal carboxyl esterase; heat shock protein 70-2 mutated (mut hsp70-2); CD79a; CD79b; CD72; Leukocyte-associated immunoglobulin-like receptor 1 (LAIR1); Fc fragment of IgA receptor (FCAR or CD89); Leukocyte immunoglobulin-like receptor subfamily A member 2 (LILRA2); CD300 molecule-like family member f (CD300LF); C-type lectin domain family 12 member A (CLEC12A); bone marrow stromal cell antigen 2 (BST2); EGF-like module-containing mucin-

like hormone receptor-like 2 (EMR2); lymphocyte antigen 75 (LY75); Glypican-3 (GPC3); Fc receptor-like 5 (FCRL5); and immunoglobulin lambda-like polypeptide 1 (IGLL1).

[00359] In some embodiments, tumor antigen bound by the encoded CAR molecule is chosen from one or more of: TSHR, CD171, CS-1, CLL-1, GD3, Tn Ag, FLT3, CD38, CD44v6, B7H3, KIT, IL-13Ra2, IL-11Ra, PSCA, PRSS21, VEGFR2, LewisY, CD24, PDGFR-beta, SSEA-4, MUC1, EGFR, NCAM, CAIX, LMP2, 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, ETV6-AML, sperm protein 17, XAGE1, Tie 2, MAD-CT-1, MAD-CT-2, Fos-related antigen 1, p53 mutant, hTERT, sarcoma translocation breakpoints, ML-IAP, ERG (TMPRSS2 ETS fusion gene), NA17, PAX3, Androgen receptor, Cyclin B1, MYCN, RhoC, CYP1B1, BORIS, SART3, PAX5, OY-TES1, LCK, AKAP-4, SSX2, CD79a, CD79b, CD72, LAIR1, FCAR, LILRA2, CD300LF, CLEC12A, BST2, EMR2, LY75, GPC3, FCRL5, and IGLL1.

[00360] In certain embodiments, the tumor antigen bound by the encoded CAR molecule is chosen from one or more of: TSHR, CLDN6, GPRC5D, CXORF61, CD97, CD179a, ALK, Polysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, and OR51E2.

[00361] A CAR as described herein includes a CAR comprising an antigen binding domain (e.g., antibody or antibody fragment) that binds to a MHC presented-peptide. Normally, peptides derived from endogenous proteins fill the pockets of Major histocompatibility complex (MHC) class I molecules, and are recognized by T cell receptors (TCRs) on CD8 + T lymphocytes. The MHC class I complexes are constitutively expressed by all nucleated cells. In cancer, virus-specific and/or tumor-specific peptide/MHC complexes represent a unique class of cell surface targets for immunotherapy. TCR-like antibodies targeting peptides derived from viral or tumor antigens in the context of human leukocyte antigen (HLA)-A1 or HLA-A2 have been described (see, e.g., Sastry et al., J Virol. 2011 85(5):1935-1942; Sergeeva et al., Bood, 2011 117(16):4262-4272; Verma et al., J Immunol 2010 184(4):2156-2165; Willemsen et al., Gene Ther 2001 8(21) :1601-1608 ; Dao et al., Sci Transl Med 2013 5(176) :176ra33 ; Tassev et al., Cancer Gene Ther 2012 19(2):84-100). For example, TCR-like antibody can be identified from

screening a library, such as a human scFv phage displayed library. Accordingly, the present invention provides a CAR, e.g., a RCAR described herein, that comprises an antigen binding domain that binds to a MHC presented peptide of a molecule selected from any tumor antigen described above that is expressed intracellularly, e.g., p53, BCR-Abl, Ras, K-ras, and c-met.

**Chimeric Antigen Receptor (CAR)**

[00362] The present invention encompasses the use of a low, immune enhancing, dose of an mTOR inhibitor together with an immune effector cell, e.g., a T cell or NK cell, comprising a CAR. The immune effector cell can be engineered to express a CAR by insertion of a recombinant DNA construct comprising sequences encoding a CAR, wherein the CAR comprises an antigen binding domain (e.g., antibody or antibody fragment, TCR or TCR fragment) that binds specifically to a cancer associated antigen as described herein, wherein the sequence of the antibody fragment is contiguous with and in the same reading frame as a nucleic acid sequence encoding an intracellular signaling domain. The intracellular signaling domain can comprise a costimulatory signaling domain and/or a primary signaling domain, e.g., a zeta chain. The costimulatory signaling domain refers to a portion of the CAR comprising at least a portion of the intracellular domain of a costimulatory molecule. In one embodiment, the antigen binding domain is a murine antibody or antibody fragment described herein. In one embodiment, the antigen binding domain is a humanized antibody or antibody fragment.

[00363] In specific aspects, a CAR construct of the invention comprises a scFv domain, wherein the scFv may be preceded by an optional leader sequence such as provided in SEQ ID NO: 2, and followed by an optional hinge sequence such as provided in SEQ ID NO:4 or SEQ ID NO:6 or SEQ ID NO:8 or SEQ ID NO:10, a transmembrane region such as provided in SEQ ID NO:12, an intracellular signalling domain that includes SEQ ID NO:14 or SEQ ID NO:16 and a CD3 zeta sequence that includes SEQ ID NO:18 or SEQ ID NO:20, wherein the domains are contiguous with and in the same reading frame to form a single fusion protein. Also included in the invention is a nucleotide sequence that encodes the polypeptide of each of the scFv fratgments. In one aspect an exemplary CAR construct comprises an optional leader sequence, an extracellular antigen binding domain, a hinge, a transmembrane domain, and an intracellular stimulatory domain. In one aspect an exemplary CAR construct comprises an optional leader

sequence, an extracellular antigen binding domain, a hinge, a transmembrane domain, an intracellular costimulatory domain and an intracellular stimulatory domain.

[00364] An exemplary leader sequence is provided as SEQ ID NO: 2. An exemplary hinge/spacer sequence is provided as SEQ ID NO: 4 or SEQ ID NO:6 or SEQ ID NO:8 or SEQ ID NO:10. An exemplary transmembrane domain sequence is provided as SEQ ID NO:12. An exemplary sequence of the intracellular signaling domain of the 4-1BB protein is provided as SEQ ID NO: 14. An exemplary sequence of the intracellular signaling domain of CD27 is provided as SEQ ID NO:16. An exemplary CD3zeta domain sequence is provided as SEQ ID NO: 18 or SEQ ID NO:20.

[00365] In one aspect, the present invention encompasses a recombinant nucleic acid construct comprising a nucleic acid molecule encoding a CAR, wherein the nucleic acid molecule comprises the nucleic acid sequence encoding an antigen binding domain, e.g., described herein, that is contiguous with and in the same reading frame as a nucleic acid sequence encoding an intracellular signaling domain.

[00366] In one aspect, the present invention encompasses the use of a recombinant nucleic acid construct comprising a transgene encoding a CAR, wherein the nucleic acid molecule comprises a nucleic acid sequence encoding an antigen binding domain, wherein the sequence is contiguous with and in the same reading frame as the nucleic acid sequence encoding an intracellular signaling domain. An exemplary intracellular signaling domain that can be used in the CAR includes, but is not limited to, one or more intracellular signaling domains of, e.g., CD3-zeta, CD28, 4-1BB, and the like. In some instances, the CAR can comprise any combination of CD3-zeta, CD28, 4-1BB, and the like.

[00367] The nucleic acid sequences coding for the desired molecules can be obtained using recombinant methods known in the art, such as, for example by screening libraries from cells expressing the gene, by deriving the gene from a vector known to include the same, or by isolating directly from cells and tissues containing the same, using standard techniques. Alternatively, the nucleic acid of interest can be produced synthetically, rather than be cloned.

[00368] The present invention includes the use of retroviral and lentiviral vector constructs expressing a CAR that can be directly transduced into a cell.

[00369] The present invention also includes the use of an RNA construct that can be directly transfected into a cell. A method for generating mRNA for use in transfection involves in vitro transcription (IVT) of a template with specially designed primers, followed by polyA addition, to produce a construct containing 3' and 5' untranslated sequence ("UTR"), a 5' cap and/or Internal Ribosome Entry Site (IRES), the nucleic acid to be expressed, and a polyA tail, typically 50-2000 bases in length (SEQ ID NO:32). RNA so produced can efficiently transfect different kinds of cells. In one embodiment, the template includes sequences for the CAR. In an embodiment, an RNA CAR vector is transduced into a T cell by electroporation.

**Antigen binding domain**

[00370] In one aspect, the CAR used in the invention comprises a target-specific binding element otherwise referred to as an antigen binding domain. The choice of moiety depends upon the type and number of ligands that define the surface of a target cell. For example, the antigen binding domain may be chosen to recognize an antigen that acts as a cell surface marker on target cells associated with a particular disease state. Thus examples of cell surface markers that may act as ligands for the antigen binding domain in a CAR of the invention include those associated with viral, bacterial and parasitic infections, autoimmune disease and cancer cells.

[00371] In one aspect, the CAR-mediated T-cell response can be directed to an antigen of interest by way of engineering an antigen binding domain that specifically binds a desired antigen into the CAR.

[00372] In one aspect, the portion of the CAR comprising the antigen binding domain comprises an antigen binding domain that targets a tumor marker as described above.

[00373] In one embodiment, the portion of the CAR comprising the antigen binding domain comprises an antigen binding domain that targets CD19. In one aspect, the antigen binding domain targets human CD19. In one aspect, the antigen binding domain of the CAR has the same or a similar binding specificity as the FMC63 scFv fragment described in Nicholson et al. Mol. Immun. 34 (16-17): 1157-1165 (1997). In one embodiment, the antigen binding domain of the CAR includes the scFv fragment described in Nicholson et al. Mol. Immun. 34 (16-17): 1157-1165 (1997). A CD19 antibody molecule can be, e.g., an antibody molecule (e.g., a

humanized anti-CD19 antibody molecule) described in WO2014/153270, which is incorporated herein by reference in its entirety. WO2014/153270 also describes methods of assaying the binding and efficacy of various CART constructs.

[00374] The antigen binding domain can be any domain that binds to the antigen including but not limited to a monoclonal antibody, a polyclonal antibody, a recombinant antibody, a human antibody, a humanized antibody, and a functional fragment thereof, including but not limited to a single-domain antibody such as a heavy chain variable domain (VH), a light chain variable domain (VL) and a variable domain (VHH) of camelid derived nanobody, and to an alternative scaffold known in the art to function as antigen binding domain, such as a recombinant fibronectin domain, a T cell receptor (TCR), or a fragment there of, e.g., single chain TCR, and the like. In some instances, it is beneficial for the antigen binding domain to be derived from the same species in which the CAR will ultimately be used in. For example, for use in humans, it may be beneficial for the antigen binding domain of the CAR to comprise human or humanized residues for the antigen binding domain of an antibody or antibody fragment.

[00375] In one embodiment, the antigen binding domain against CD22 is derived from antibodies as described in, e.g., Haso et al., Blood, 121(7): 1165-1174 (2013); Wayne et al., Clin Cancer Res 16(6): 1894-1903 (2010); Kato et al., Leuk Res 37(1):83-88 (2013); Creative BioMart (creativebiomart.net): MOM-18047-S(P).

[00376] In one embodiment, the antigen binding domain against CS-1 is derived from Elotuzumab (BMS), see e.g., Tai et al., 2008, Blood 112(4):1329-37; Tai et al., 2007, Blood. 110(5):1656-63.

[00377] In one embodiment, the antigen binding domain against CLL-1 is derived from antibodies that are available from R&D, ebiosciences, Abcam, for example, PE-CLL1-hu Cat# 353604 (BioLegend); and PE-CLL1 (CLEC12A) Cat# 562566 (BD).

[00378] In one embodiment, the antigen binding domain against CD33 is derived from antibodies as described in, e.g., Bross et al., Clin Cancer Res 7(6):1490-1496 (2001) (Gemtuzumab Ozogamicin, hP67.6),Caron et al., Cancer Res 52(24):6761-6767 (1992) (Lintuzumab, HuM195), Lapusan et al., Invest New Drugs 30(3):1121-1131 (2012) (AVE9633), Aigner et al., Leukemia 27(5): 1107-1115 (2013) (AMG330, CD33 BiTE), Dutour et al., Adv hematol 2012:683065 (2012), and Pizzitola et al., Leukemia doi:10.1038/Lue.2014.62 (2014).

[00379] In one embodiment, the antigen binding domain against GD2 is derived from antibodies as described in, e.g., Mujoo et al., Cancer Res. 47(4):1098-1104 (1987); Cheung et al., Cancer Res 45(6):2642-2649 (1985), Cheung et al., J Clin Oncol 5(9):1430-1440 (1987), Cheung et al., J Clin Oncol 16(9):3053-3060 (1998), Handgretinger et al., Cancer Immunol Immunother 35(3):199-204 (1992). mAb 14.18, 14G2a, ch14.18, hu14.18, 3F8, hu3F8, 3G6, 8B6, 60C3, 10B8, ME36.1, 8H9, see e.g., WO2012033885, WO2013040371, WO2013192294, WO2013061273, WO2013123061, WO2013074916, and WO201385552.

[00380] In one embodiment, the antigen binding domain against BCMA is derived from antibodies as described in, e.g., WO2012163805, WO200112812, and WO2003062401.

[00381] In one embodiment, the antigen binding domain against Tn antigen is derived from antibodies as described in, e.g., US8,440,798, Brooks et al., PNAS 107(22):10056-10061 (2010), and Stone et al., OncoImmunology 1(6):863-873(2012).

[00382] In one embodiment, the antigen binding domain against PSMA is derived from antibodies as described in, e.g., Parker et al., Protein Expr Purif 89(2):136-145 (2013), US 20110268656 (J591 ScFv); Frigerio et al, European J Cancer 49(9):2223-2232 (2013) (scFvD2B); WO 2006125481 (mAbs 3/A12, 3/E7 and 3/F11) and single chain antibody fragments (scFv A5 and D7).

[00383] In one embodiment, the antigen binding domain against ROR1 is derived from antibodies as described in, e.g., Hudecek et al., Clin Cancer Res 19(12):3153-3164 (2013); WO 2011159847; and US20130101607.

[00384] In one embodiment, the antigen binding domain against FLT3 is derived from antibodies as described in, e.g., WO2011076922, US5777084, EP0754230, US20090297529, and several commercial catalog antibodies (R&D, ebiosciences, Abcam).

[00385] In one embodiment, the antigen binding domain against TAG72 is derived from antibodies as described in, e.g., Hombach et al., Gastroenterology 113(4):1163-1170 (1997); and Abcam ab691.

[00386] In one embodiment, the antigen binding domain agaist FAP is derived from antibodies described in, e.g., Ostermann et al., Clinical Cancer Research 14:4584-4592 (2008) (FAP5), US Pat. Publication No. 2009/0304718; sibrotuzumab (see e.g., Hofheinz et al.,

Oncology Research and Treatment 26(1), 2003); and Tran et al., J Exp Med 210(6):1125-1135 (2013).

[00387] In one embodiment, the antigen binding domain against CD38 is derived from daratumumab (see, e.g., Groen et al., Blood 116(21):1261-1262 (2010); MOR202 (see, e.g., US8,263,746); or antibodies described in US8,362,211.

[00388] In one embodiment, the antigen binding domain against CD44v6 is derived from antibodies as described in, e.g., Casucci et al., Blood 122(20):3461-3472 (2013).

[00389] In one embodiment, the antigen binding domain against CEA is derived from antibodies as described in, e.g., Chmielewski et al., Gastoenterology 143(4):1095-1107 (2012).

[00390] In one embodiment, the antigen binding domain against EPCAM is derived from MT110, EpCAM-CD3 bispecific Ab (see, e.g., clinicaltrials.gov/ct2/show/NCT00635596); Edrecolomab; 3622W94; ING-1; and adecatumumab (MT201).

[00391] In one embodiment, the antigen binding domain against B7H3 is derived from MGA271 (Macrogenics).

[00392] In one embodiment, the antigen binding domain against KIT is derived from antibodies as described in, e.g., US7915391, US20120288506 , and several commercial catalog antibodies.

[00393] In one embodiment, the antigen binding domain against IL-13Ra2 is derived from antibodies as described in, e.g., WO2008/146911, WO2004087758, several commercial catalog antibodies, and WO2004087758.

[00394] In one embodiment, the antigen binding domain against CD30 is derived from antibodies as described in, e.g., US7090843 B1, and EP0805871.

[00395] In one embodiment, the antigen binding domain against GD3 is derived from antibodies as described in, e.g., US7253263; US 8,207,308; US 20120276046; EP1013761; WO2005035577; and US6437098.

[00396] In one embodiment, the antigen binding domain against CD171 is derived from antibodies as described in, e.g., Hong et al., J Immunother 37(2):93-104 (2014).

[00397] In one embodiment, the antigen binding domain against IL-11Ra is derived from antibodies that are available from Abcam (cat# ab55262) and Novus Biologicals (cat# EPR5446). In another embodiment, the antigen binding domain again IL-11Ra is a peptide, see, e.g., Huang et al., Cancer Res 72(1):271-281 (2012).

[00398] In one embodiment, the antigen binding domain against PSCA is derived from antibodies as described in, e.g., Morgenroth et al., Prostate 67(10):1121-1131 (2007) (scFv 7F5); Nejatollahi et al., J of Oncology 2013(2013), article ID 839831 (scFv C5-II); and US Pat Publication No. 20090311181.

[00399] In one embodiment, the antigen binding domain against VEGFR2 is derived from antibodies as described in, e.g., Chinnasamy et al., J Clin Invest 120(11):3953-3968 (2010).

[00400] In one embodiment, the antigen binding domain against LewisY is derived from antibodies as described in, e.g., Kelly et al., Cancer Biother Radiopharm 23(4):411-423 (2008) (hu3S193 Ab (scFvs)); Dolezal et al., Protein Engineering 16(1):47-56 (2003) (NC10 scFv).

[00401] In one embodiment, the antigen binding domain against CD24 is derived from antibodies as described in, e.g., Maliar et al., Gastroenterology 143(5):1375-1384 (2012).

[00402] In one embodiment, the antigen binding domain against PDGFR-beta is derived from Abcam ab32570.

[00403] In one embodiment, the antigen binding domain against SSEA-4 is derived from MC813 (Cell Signaling), and other commercially available antibody reagent.

[00404] In one embodiment, the antigen binding domain against CD20 is derived from Rituximab, Ofatumumab, Ocrelizumab, Veltuzumab, or GA101.

[00405] In one embodiment, the antigen binding domain against Folate receptor alpha is derived from antibody component of IMGN853, US20120009181; US4851332, LK26: US5952484.

[00406] In one embodiment, the antigen binding domain against ERBB2 (Her2/neu) is derived from trastuzumab, or pertuzumab.

[00407] In one embodiment, the antigen binding domain against MUC1 is derived from the antibody component of SAR566658.

[00408] In one embodiment, the antigen binding domain against EGFR is derived from cetuximab, panitumumab, zalutumumab, nimotuzumab, or matuzumab.

[00409] In one embodiment, the antigen binding domain against NCAM is derived from clone 2-2B: MAB5324 (EMD milipore)

[00410] In one embodiment, the antigen binding domain against Ephrin B2 is derived from antibodies as described in, e.g., Abengozar et al., Blood 119(19):4565-4576 (2012).

[00411] In one embodiment, the antigen binding domain against IGF-I receptor is derived from antibodies as described in, e.g., US8344112 B2; EP2322550 A1; WO 2006/138315, and PCT/US2006/022995.

[00412] In one embodiment, the antigen binding domain against CAIX is derived from clone 303123 (R&D Systems).

[00413] In one embodiment, the antigen binding domain against LMP2 is derived from antibodies as described in, e.g., US7,410,640, and US20050129701.

[00414] In one embodiment, the antigen binding domain against gp100 is derived from HMB45, NKIbetaB, those described in WO2013165940, or US20130295007

[00415] In one embodiment, the antigen binding domain against tyrosinase is derived from antibodies as described in, e.g., US5843674; or US19950504048.

[00416] In one embodiment, the antigen binding domain against EphA2 is derived from antibodies as described in, e.g., Yu et al., Mol Ther 22(1):102-111 (2014).

[00417] In one embodiment, the antigen binding domain against GD3 is derived from antibodies as described in, e.g., US7253263; US 8,207,308; US 20120276046; EP1013761 A3; 20120276046; WO2005035577; or US6437098.

[00418] In one embodiment, the antigen binding domain against fucosyl GM1 is derived from antibodies as described in, e.g., US20100297138; or WO2007/067992.

[00419] In one embodiment, the antigen binding domain against sLe is derived from G193 (for lewis Y), see Scott AM et al, Cancer Res 60: 3254-61 (2000), also as described in Neeson et al, J Immunol May 2013 190 (Meeting Abstract Supplement) 177.10.

[00420] In one embodiment, the antigen binding domain against GM3 is derived from CA 2523449 (mAb 14F7).

[00421] In one embodiment, the antigen binding domain against HMWMAA is derived from antibodies as described in, e.g., Kmiecik et al., Oncoimmunology 3(1):e27185 (2014) (PMID: 24575382) (mAb9.2.27); US6528481; WO2010033866; or US 20140004124.

[00422] In one embodiment, the antigen binding domain against o-acetyl-GD2 is derived from 8B6.

[00423] In one embodiment, the antigen binding domain against TEM1/CD248 is derived from antibodies as described in, e.g., Marty et al., Cancer Lett 235(2):298-308 (2006); Zhao et al., J Immunol Methods 363(2):221-232 (2011).

[00424] In one embodiment, the antigen binding domain against CLDN6 is derived from IMAB027 (Ganymed Pharmaceuticals), see e.g., clinicaltrial.gov/show/NCT02054351.

[00425] In one embodiment, the antigen binding domain against TSHR is derived from antibodies as described in, e.g., US8,603,466; US8,501,415; or US8,309,693.

[00426] In one embodiment, the antigen binding domain against GPRC5D is derived from FAB6300A (R&D Systems); or LS-A4180 (Lifespan Biosciences).

[00427] In one embodiment, the antigen binding domain against CD97 is derived from antibodies as described in, e.g., US6,846,911;de Groot et al., J Immunol 183(6):4127-4134 (2009); antibody from R&D:MAB3734.

[00428] In one embodiment, the antigen binding domain against ALK is derived from antibodies as described in, e.g., Mino-Kenudson et al., Clin Cancer Res 16(5):1561-1571 (2010).

[00429] In one embodiment, the antigen binding domain against plysialic acid is derived from antibodies as described in, e.g., Nagae et al., J Biol Chem 288(47):33784-33796 (2013).

[00430] In one embodiment, the antigen binding domain against PLAC1 is derived from antibodies as described in, e.g., Ghods et al., Biotechnol Appl Biochem 2013 doi:10.1002/bab.1177.

[00431] In one embodiment, the antigen binding domain against GloboH is derived from VK9; or those described in, e.g., Kudryashov V et al, Glycoconj J.15(3):243-9 ( 1998), Lou et

al., Proc Natl Acad Sci USA 111(7):2482-2487 (2014) ; MBr1: Bremer E-G et al. J Biol Chem 259:14773–14777 (1984).

[00432] In one embodiment, the antigen binding domain against NY-BR-1 is derived from antibodies as described in, e.g., Jager et al., Appl Immunohitochem Mol Morphol 15(1):77-83 (2007).

[00433] In one embodiment, the antigen binding domain against WT-1 is derived from antibodies as described in, e.g., Dao et al., Sci Transl Med 5(176):176ra33 (2013); or WO2012/135854.

[00434] In one embodiment, the antigen binding domain against MAGE-A1 is derived from antibodies as described in, e.g., Willemsen et al., J Immunol 174(12):7853-7858 (2005) (TCR-like scFV).

[00435] In one embodiment, the antigen binding domain against sperm protein 17 is derived from antibodies as described in, e.g., Song et al., Target Oncol 2013 Aug 14 (PMID: 23943313); Song et al., Med Oncol 29(4):2923-2931 (2012).

[00436] In one embodiment, the antigen binding domain against Tie 2 is derived from AB33 (Cell Signaling Technology).

[00437] In one embodiment, the antigen binding domain against MAD-CT-2 is derived from antibodies as described in, e.g., PMID: 2450952; US7635753.

[00438] In one embodiment, the antigen binding domain against Fos-related antigen 1 is derived from12F9 (Novus Biologicals).

[00439] In one embodiment, the antigen binding domain against MelanA/MART1 is derived from antibodies as described in, EP2514766 A2; US 7,749,719.

[00440] In one embodiment, the antigen binding domain against sarcoma translocation breakpoints is derived from antibodies as described in, e.g., Luo et al, EMBO Mol. Med. 4(6):453-461 (2012).

[00441] In one embodiment, the antigen binding domain against TRP-2 is derived from antibodies as described in, e.g., Wang et al, J Exp Med. 184(6):2207-16 (1996).

[00442] In one embodiment, the antigen binding domain against CYP1B1 is derived from antibodies as described in, e.g., Maecker et al, Blood 102 (9): 3287-3294 (2003).

[00443] In one embodiment, the antigen binding domain against RAGE-1 is derived from MAB5328 (EMD Milipore).

[00444] In one embodiment, the antigen binding domain against human telomerase reverse transcriptase is derived from cat no: LS-B95-100 (Lifespan Biosciences)

[00445] In one embodiment, the antigen binding domain against intestinal carboxyl esterase is derived from 4F12: cat no: LS-B6190-50 (Lifespan Biosciences).

[00446] In one embodiment, the antigen binding domain against mut hsp70-2 is derived from Lifespan Biossciences: monoclonal: cat no: LS-C133261-100 (Lifespan Biosciences).

[00447] An antigen binding domain can comprise a sequence from Table 3.

[00448] Table 3: Exemplary Sequences for Antigen Binding Domains

| SEQ ID NO | Target Antigen | Name | Amino Acid Sequence |
|---|---|---|---|
| 44 | CD19 | huscFv1 | EIVMTQSPATLSLSPGERATLSCRASQDISKYLNWYQQKP GQAPRLLIYHTSRLHSGIPARFSGSGSGTDYTLTISSLQP EDFAVYFCQQGNTLPYTFGQGTKLEIKGGGGSGGGGSGGG GSQVQLQESGPGLVKPSETLSLTCTVSGVSLPDYGVSWIR QPPGKGLEWIGVIWGSETTYYSSSLKSRVTISKDNSKNQV SLKLSSVTAADTAVYYCAKHYYYGGSYAMDYWGQGTLVTV SS |
| 45 | CD19 | huscFv2 | Eivmtqspatlslspgeratlscrasqdiskylnwyqqkpgqaprlliy htsrlhsgiparfsgsgsgtdytltisslqpedfavyfcqqgntlpytf gqgtkleikggggsggggsggggsqvqlqesgpglvkpsetlsltctvs gvslpdygvswirqppgkglewigviwgsettyyqsslksrvtiskdns knqvslklssvtaadtavyycakhyyyggsyamdywgqgtlvtvss |
| 46 | CD19 | huscFv3 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig viwgsettyyssslksrvtiskdnsknqvslklssvtaadtavyycakh yyyggsyamdywgqgtlvtvssggggsggggsggggseivmtqspatls lspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhsgipar fsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkleik |
| 47 | CD19 | huscFv4 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig viwgsettyyqsslksrvtiskdnsknqvslklssvtaadtavyycakh yyyggsyamdywgqgtlvtvssggggsggggsggggseivmtqspatls lspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhsgipar fsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkleik |
| 48 | CD19 | huscFv5 | Eivmtqspatlslspgeratlscrasqdiskylnwyqqkpgqaprlliy htsrlhsgiparfsgsgsgtdytltisslqpedfavyfcqqgntlpytf gqgtkleikggggsggggsggggsggggsqvqlqesgpglvkpsetlsl tctvsgvslpdygvswirqppgkglewigviwgsettyyssslksrvti skdnsknqvslklssvtaadtavyycakhyyyggsyamdywgqgtlvtv |

| | | | |
|---|---|---|---|
| | | | ss |
| 49 | CD19 | huscFv6 | Eivmtqspatlslspgeratlscrasqdiskylnwyqqkpgqaprlliy<br>htsrlhsgiparfsgsgsgtdytltisslqpedfavyfcqqgntlpytf<br>gqgtkleikggggsggggsggggsggggsqvqlqesgpglvkpsetlsl<br>tctvsgvslpdygvswirqppgkglewigviwgsettyyqsslksrvti<br>skdnsknqvslklssvtaadtavyycakhyyyggsyamdywgqgtlvtv<br>ss |
| 50 | CD19 | huscFv7 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig<br>viwgsettyyssslksrvtiskdnsknqvslklssvtaadtavyycakh<br>yyyggsyamdywgqgtlvtvssggggsggggsggggsggggseivmtqs<br>patlslspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhs<br>giparfsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkle<br>ik |
| 51 | CD19 | huscFv8 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig<br>viwgsettyyqsslksrvtiskdnsknqvslklssvtaadtavyycakh<br>yyyggsyamdywgqgtlvtvssggggsggggsggggsggggseivmtqs<br>patlslspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhs<br>giparfsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkle<br>ik |
| 52 | CD19 | huscFv9 | Eivmtqspatlslspgeratlscrasqdiskylnwyqqkpgqaprlliy<br>htsrlhsgiparfsgsgsgtdytltisslqpedfavyfcqqgntlpytf<br>gqgtkleikggggsggggsggggsggggsqvqlqesgpglvkpsetlsl<br>tctvsgvslpdygvswirqppgkglewigviwgsettyynsslksrvti<br>skdnsknqvslklssvtaadtavyycakhyyyggsyamdywgqgtlvtv<br>ss |
| 53 | CD19 | Hu<br>scFv10 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig<br>viwgsettyynsslksrvtiskdnsknqvslklssvtaadtavyycakh<br>yyyggsyamdywgqgtlvtvssggggsggggsggggsggggseivmtqs<br>patlslspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhs<br>giparfsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkle<br>ik |
| 54 | CD19 | Hu<br>scFv11 | Eivmtqspatlslspgeratlscrasqdiskylnwyqqkpgqaprlliy<br>htsrlhsgiparfsgsgsgtdytltisslqpedfavyfcqqgntlpytf<br>gqgtkleikggggsggggsggggsqvqlqesgpglvkpsetlsltctvs<br>gvslpdygvswirqppgkglewigviwgsettyynsslksrvtiskdns<br>knqvslklssvtaadtavyycakhyyyggsyamdywgqgtlvtvss |
| 55 | CD19 | Hu<br>scFv12 | Qvqlqesgpglvkpsetlsltctvsgvslpdygvswirqppgkglewig<br>viwgsettyynsslksrvtiskdnsknqvslklssvtaadtavyycakh<br>yyyggsyamdywgqgtlvtvssggggsggggsggggseivmtqspatls<br>lspgeratlscrasqdiskylnwyqqkpgqaprlliyhtsrlhsgipar<br>fsgsgsgtdytltisslqpedfavyfcqqgntlpytfgqgtkleik |
| 43 | CD19 | muCTL<br>019 | Diqmtqttsslsaslgdrvtiscrasqdiskylnwyqqkpdgtvklliy<br>htsrlhsgvpsrfsgsgsgtdysltisnleqediatyfcqqgntlpytf<br>gggtkleitggggsggggsggggsevklqesgpglvapsqslsvtctvs<br>gvslpdygvswirqpprkglewlgviwgsettyynsalksrltiikdns<br>ksqvflkmnslqtddtaiyycakhyyyggsyamdywgqgtsvtvss |
| 56 | CD123 | Mu1172 | DIVLTQSPASLAVSLGQRATISCRASESVDNYGNTFMHWYQQKP<br>GQPPKLLIYRASNLESGIPARFSGSGSRTDFTLTINPVEADDVATY<br>YCQQSNEDPPTFGAGTKLELKGGGGSGGGGSSGGGSQIQLVQSG<br>PELKKPGETVKISCKASGYIFTNYGMNWVKQAPGKSFKWMGWI<br>NTYTGESTYSADFKGRFAFSLETSASTAYLHINDLKNEDTATYFC<br>ARSGGYDPMDYWGQGTSVTVSS |
| 57 | CD123 | Mu1176 | DVQITQSPSYLAASPGETITINCRASKSISKDLAWYQEKPGKTNKL<br>LIYSGSTLQSGIPSRFSGSGSGTDFTLTISSLEPEDFAMYYCQQHNK<br>YPYTFGGGTKLEIKGGGGSGGGGSSGGGSQVQLQQPGAELVRPG |

| | | | |
|---|---|---|---|
| | | | ASVKLSCKASGYTFTSYWMNWVKQRPDQGLEWIGRIDPYDSET HYNQKFKDKAILTVDKSSSTAYMQLSSLTSEDSAVYYCARGNW DDYWGQGTTLTVSS |
| 58 | CD123 | huscFv1 | Divltqspdslavslgeratincrasesvdnygntfmhwyqqkpgqppkllliyrasnlesgvpdrfs gsgsrtdftltisslqaedvavyycqqsnedpptfgqgtkleikggggsggggsggggsggggsqiq lvqsgselkkpgasvkvsckasgyiftnygmnwvrqapgqglewmgwintytgestysadfkgr fvfsldtsvstaylqinalkaedtavyycarsggydpmdywgqgttvtvss |
| 59 | CD123 | huscFv2 | Divltqspdslavslgeratincrasesvdnygntfmhwyqqkpgqppkllliyrasnlesgvpdrfs gsgsrtdftltisslqaedvavyycqqsnedpptfgqgtkleikggggsggggsggggsggggsqiq lvqsgaevkkpgasvkvsckasgyiftnygmnwvrqapgqrlewmgwintytgestysadfkg rvtitldtsastaymelsslrsedtavyycarsggydpmdywgqgttvtvss |
| 60 | CD123 | huscFv3 | Eivltqspatlslspgeratlscrasesvdnygntfmhwyqqkpgqaprlliyrasnlesgiparfsgs gsrtdftltisslepedvavyycqqsnedpptfgqgtkleikggggsggggsggggsggggsqiqlv qsgselkkpgasvkvsckasgyiftnygmnwvrqapgqglewmgwintytgestysadfkgrfv fsldtsvstaylqinalkaedtavyycarsggydpmdywgqgttvtvss |
| 61 | CD123 | huscFv4 | Eivltqspatlslspgeratlscrasesvdnygntfmhwyqqkpgqaprlliyrasnlesgiparfsgs gsrtdftltisslepedvavyycqqsnedpptfgqgtkleikggggsggggsggggsggggsqiqlv qsgaevkkpgasvkvsckasgyiftnygmnwvrqapgqrlewmgwintytgestysadfkgrv titldtsastaymelsslrsedtavyycarsggydpmdywgqgttvtvss |
| 62 | CD123 | huscFv5 | Qiqlvqsgselkkpgasvkvsckasgyiftnygmnwvrqapgqglewmgwintytgestysad fkgrfvfsldtsvstaylqinalkaedtavyycarsggydpmdywgqgttvtvssggggsggggsg gggsggggsdivltqspdslavslgeratincrasesvdnygntfmhwyqqkpgqppkllliyrasnl esgvpdrfsgsgsrtdftltisslqaedvavyycqqsnedpptfgqgtkleik |
| 63 | CD123 | huscFv6 | Qiqlvqsgselkkpgasvkvsckasgyiftnygmnwvrqapgqglewmgwintytgestysad fkgrfvfsldtsvstaylqinalkaedtavyycarsggydpmdywgqgttvtvssggggsggggsg gggsggggseivltqspatlslspgeratlscrasesvdnygntfmhwyqqkpgqaprlliyrasnle sgiparfsgsgsrtdftltisslepedvavyycqqsnedpptfgqgtkleik |
| 64 | CD123 | huscFv7 | Qiqlvqsgaevkkpgasvkvsckasgyiftnygmnwvrqapgqrlewmgwintytgestysad fkgrvtitldtsastaymelsslrsedtavyycarsggydpmdywgqgttvtvssggggsggggsg gggsggggsdivltqspdslavslgeratincrasesvdnygntfmhwyqqkpgqppkllliyrasnl esgvpdrfsgsgsrtdftltisslqaedvavyycqqsnedpptfgqgtkleik |
| 65 | CD123 | huscFv8 | Qiqlvqsgaevkkpgasvkvsckasgyiftnygmnwvrqapgqrlewmgwintytgestysad fkgrvtitldtsastaymelsslrsedtavyycarsggydpmdywgqgttvtvssggggsggggsg gggsggggseivltqspatlslspgeratlscrasesvdnygntfmhwyqqkpgqaprlliyrasnle sgiparfsgsgsrtdftltisslepedvavyycqqsnedpptfgqgtkleik |
| 66 | EGFR vIII | huscFv1 | Eiqlvqsgaevkkpgatvkisckgsgfniedyyihwvqqapgkglewmgridpendetkygpif qgrvtitadtstntvymelsslrsedtavyycafrggvywgqgttvtvssggggsggggsggggsgg ggsdvvmtqspdslavslgeratinckssqslldsdgktylnwlqqkpgqppkrlislvskldsgvp drfsgsgsgtdftltisslqaedvavyycwqgthfpgtfgggtkveik |
| 67 | EGFR vIII | huscFv2 | Dvvmtqspdslavslgeratinckssqslldsdgktylnwlqqkpgqppkrlislvskldsgvpdrf sgsgsgtdftltisslqaedvavyycwqgthfpgtfgggtkveikggggsggggsggggsggggse iqlvqsgaevkkpgatvkisckgsgfniedyyihwvqqapgkglewmgridpendetkygpifq grvtitadtstntvymelsslrsedtavyycafrggvywgqgttvtvss |
| 68 | EGFR vIII | huscFv3 | Eiqlvqsgaevkkpgeslrisckgsgfniedyyihwvrqmpgkglewmgridpendetkygpif qghvtisadtsintvylqwsslkasdtamyycafrggvywgqgttvtvssggggsggggsggggs ggggsdvvmtqsplslpvtlgqpasisckssqslldsdgktylnwlqqrpgqsprrlislvskldsgv pdrfsgsgsgtdftlkisrveaedvgvyycwqgthfpgtfgggtkveik |
| 69 | EGFR vIII | huscFv4 | Dvvmtqsplslpvtlgqpasisckssqslldsdgktylnwlqqrpgqsprrlislvskldsgvpdrfs gsgsgtdftlkisrveaedvgvyycwqgthfpgtfgggtkveikggggsggggsggggsggggse iqlvqsgaevkkpgeslrisckgsgfniedyyihwvrqmpgkglewmgridpendetkygpifq ghvtisadtsintvylqwsslkasdtamyycafrggvywgqgttvtvss |
| 70 | EGFR vIII | huscFv5 | Eiqlvqsgaevkkpgatvkisckgsgfniedyyihwvqqapgkglewmgridpendetkygpif qgrvtitadtstntvymelsslrsedtavyycafrggvywgqgttvtvssggggsggggsggggsgg ggsdvvmtqsplslpvtlgqpasisckssqslldsdgktylnwlqqrpgqsprrlislvskldsgvpd rfsgsgsgtdftlkisrveaedvgvyycwqgthfpgtfgggtkveik |

| | | | |
|---|---|---|---|
| 71 | EGFR vIII | huscFv6 | Eiqlvqsgaevkkpgeslrisckgsgfniedyyihwvrqmpgkglewmgridpendetkygpif qghvtisadtsintvylqwsslkasdtamyycafrggvywgqgttvtvssggggsggggsggggs ggggsdvvmtqspdslavslgeratinckssqslldsdgktylnwlqqkpgqppkrlislvskldsg vpdrfsgsgsgtdftltisslqaedvavyycwqgthfpgtfgggtkveik |
| 72 | EGFR vIII | huscFv7 | Dvvmtqspdslavslgeratinckssqslldsdgktylnwlqqkpgqppkrlislvskldsgvpdrf sgsgsgtdftltisslqaedvavyycwqgthfpgtfgggtkveikggggsggggsggggsggggse iqlvqsgaevkkpgeslrisckgsgfniedyyihwvrqmpgkglewmgridpendetkygpifq ghvtisadtsintvylqwsslkasdtamyycafrggvywgqgttvtvss |
| 73 | EGFR vIII | huscFv8 | Dvvmtqsplslpvtlgqpasisckssqslldsdgktylnwlqqrpgqsprrlislvskldsgvpdrfs gsgsgtdftlkisrveaedvgvyycwqgthfpgtfgggtkveikggggsggggsggggsggggse iqlvqsgaevkkpgatvkisckgsgfniedyyihwvqqapgkglewmgridpendetkygpifq grvtitadtstntvymelsslrsedtavyycafrggvywgqgttvtvss |
| 74 | EGFR vIII | Mu310C | eiqlqqsgaelvkpgasvklsctgsgfniedyyihwvkqrteqglewigridpendetkygpifqgr atitadtssntvylqlssltsedtavyycafrggvywgpgttltvssggggsggggsggggshmdvv mtqspltlsvaigqsasisckssqslldsdgktylnwllqrpgqspkrlislvskldsgvpdrftgsgsg tdftlrisrveaedlgiyycwqgthfpgtfgggtkleik |
| 75 | mesothelin | ss1 | Q V Q L Q Q S G P E L E K P G A S V K I S C K A S G Y S F T G Y T M N W V K Q S H G K S L E W I G L I T P Y N G A S S Y N Q K F R G K A T L T V D K S S S T A Y M D L L S L T S E D S A V Y F C A R G G Y D G R G F D Y W G Q G T T V T V S S G G G G S G G G G G S G G G G S D I E L T Q S P A I M S A S P G E K V T M T C S A S S S V S Y M H W Y Q Q K S G T S P K R W I Y D T S K L A S G V P G R F S G S G S G N S Y S L T I S S V E A E D D A T Y Y C Q Q W S G Y P L T F G A G T K L E I |

[00449] In an embodiment, the antigen binding domain comprises any antibody, or a fragment thereof, e.g., an scFv, known in the art that targets or specifically binds to any one of the following: BCMA (also known as TNFRSF17, Tumor Necrosis Factor Receptor Superfamily, Member 17, or B Cell Maturation Antigen), CD33, CLL-1 (also known as C-type Lectin-Like domain family 1, or CLECL1), claudin-6 (CLDN6) or WT-1 (Wilms tumor 1). The antibody, or fragment thereof, can be a murine, humanized, or fully human antibody or fragment thereof.

[00450] In an embodiment, the antigen binding domain comprises an anti-CD19 antibody, or fragment thereof, e.g., an scFv. For example, the antigen binding domain comprises a variable heavy chain and a variable light chain listed inTable 8. The linker sequence joining the variable heavy and variable light chains can be any of the linker sequences described herein, or alternatively, can be GSTSGSGKPGSGEGSTKG (SEQ ID NO: 76).

[00451] Table 8: Anti-CD 19 antibody binding domains

| Antibody | VH Sequence | VL Sequence |
|---|---|---|
| SJ25-C1 | QVQLLESGAELVRPGSSVKISCKASGYAFSSYWMNWVKQRPGQGLEWIGQIYPGDGDTNYNGKFKGQATLTADKSSSTAYMQLSGLTSEDSAVYSCARKTISSVVDFYFDYWGQGTTVT (SEQ ID NO: 77) | ELVLTQSPKFMSTSVGDRVSVTCKASQNVGTNVAWYQQKPGQSPKPLIYSATYRNSGVPDRFTGSGSGTDFTLTITNVQSKDLADYFYFCQYNRYPYTSGGGTKLEIKRRS (SEQ ID NO: 78) |

[00452] Any known CD19 CAR, e.g., the CD19 antigen binding domain of any known CD19 CAR, in the art can be used in accordance with the instant invention. For example, LG-740; CD19 CAR described in the US Pat. No. 8,399,645; US Pat. No. 7,446,190; Xu et al., Leuk Lymphoma. 2013 54(2):255-260(2012); Cruz et al., Blood 122(17):2965-2973 (2013); Brentjens et al., Blood, 118(18):4817-4828 (2011); Kochenderfer et al., Blood 116(20):4099-102 (2010); Kochenderfer et al., Blood 122 (25):4129-39(2013); and 16th Annu Meet Am Soc Gen Cell Ther (ASGCT) (May 15-18, Salt Lake City) 2013, Abst 10.

[00453] In one embodiment, the antigen binding domain comprises one, two three (e.g., all three) heavy chain CDRs, HC CDR1, HC CDR2 and HC CDR3, from an antibody listed above, and/or one, two, three (e.g., all three) light chain CDRs, LC CDR1, LC CDR2 and LC CDR3, from an antibody listed above. In one embodiment, the antigen binding domain comprises a heavy chain variable region and/or a variable light chain region of an antibody listed above.

[00454] In some embodiments, the antigen binding domain comprises a HC CDR1, a HC CDR2, and a HC CDR3 of any heavy chain binding domain amino acid sequences listed in Table 3. In embodiments, the antigen binding domain further comprises a LC CDR1, a LC CDR2, and a LC CDR3. In embodiments, the antigen binding domain comprises a LC CDR1, a LC CDR2, and a LC CDR3 of any light chain binding domain amino acid sequences listed in Table 3.

[00455] In some embodiments, the antigen binding domain comprises one, two or all of LC CDR1, LC CDR2, and LC CDR3 of any light chain binding domain amino acid sequences listed in Table 3, and one, two or all of HC CDR1, HC CDR2, and HC CDR3 of any heavy chain binding domain amino acid sequences listed in Table 3.

[00456] In some embodiments, the CDRs are defined according to the Kabat numbering scheme, the Chothia numbering scheme, or a combination thereof.

[00457] In embodiments, the order in which the VL and VH domains appear in the scFv is varied (i.e., VL-VH, or VH-VL orientation), and where either three or four copies of the "G4S" (SEQ ID NO:25) subunit, in which each subunit comprises the sequence GGGGS (SEQ ID NO:28) (e.g., (G4S)3 (SEQ ID NO:30) or (G4S)4(SEQ ID NO:29)), connect the variable domains to create the entirety of the scFv domain. Alternatively, the CAR construct can include, for example, a linker including the sequence GSTSGSGKPGSGEGSTKG (SEQ ID NO: 95)

[00458] Exemplary sequences of various scFv fragments and other CAR components are provided herein. It is noted that these CAR components (e.g., of SEQ ID Nos. 42, 26) without a leader sequence (e.g., without the amino acid sequence of SEQ ID NO: 2 or the nucleotide sequence of SEQ ID NO:3), are also provided herein.

[00459] In embodiments, the CAR sequences described herein contain a Q/K residue change in the signal domain of the co-stimulatory domain derived from CD3zeta chain.

[00460] In another aspect, the antigen binding domain comprises a humanized antibody or an antibody fragment. In some aspects, a non-human antibody is humanized, where specific sequences or regions of the antibody are modified to increase similarity to an antibody naturally produced in a human or fragment thereof. In one aspect, the antigen binding domain is humanized.

[00461] A humanized antibody can be produced using a variety of techniques known in the art, including but not limited to, CDR-grafting (see, e.g., European Patent No. EP 239,400; International Publication No. WO 91/09967; and U.S. Pat. Nos. 5,225,539, 5,530,101, and 5,585,089, each of which is incorporated herein in its entirety by reference), veneering or resurfacing (see, e.g., European Patent Nos. EP 592,106 and EP 519,596; Padlan, 1991, Molecular Immunology, 28(4/5):489-498; Studnicka et al., 1994, Protein Engineering, 7(6):805-814; and Roguska et al., 1994, PNAS, 91:969-973, each of which is incorporated herein by its entirety by reference), chain shuffling (see, e.g., U.S. Pat. No. 5,565,332, which is incorporated herein in its entirety by reference), and techniques disclosed in, e.g., U.S. Patent Application Publication No. US2005/0042664, U.S. Patent Application Publication No. US2005/0048617, U.S. Pat. No. 6,407,213, U.S. Pat. No. 5,766,886, International Publication No. WO 9317105,

Tan et al., J. Immunol., 169:1119-25 (2002), Caldas et al., Protein Eng., 13(5):353-60 (2000), Morea et al., Methods, 20(3):267-79 (2000), Baca et al., J. Biol. Chem., 272(16):10678-84 (1997), Roguska et al., Protein Eng., 9(10):895-904 (1996), Couto et al., Cancer Res., 55 (23 Supp):5973s-5977s (1995), Couto et al., Cancer Res., 55(8):1717-22 (1995), Sandhu J S, Gene, 150(2):409-10 (1994), and Pedersen et al., J. Mol. Biol., 235(3):959-73 (1994), each of which is incorporated herein in its entirety by reference. Often, framework residues in the framework regions will be substituted with the corresponding residue from the CDR donor antibody to alter, for example improve, antigen binding. These framework substitutions are identified by methods well-known in the art, e.g., by modeling of the interactions of the CDR and framework residues to identify framework residues important for antigen binding and sequence comparison to identify unusual framework residues at particular positions. (See, e.g., Queen et al., U.S. Pat. No. 5,585,089; and Riechmann et al., 1988, Nature, 332:323, which are incorporated herein by reference in their entireties.)

[00462] A humanized antibody or antibody fragment has one or more amino acid residues remaining in it from a source which is nonhuman. These nonhuman amino acid residues are often referred to as “import” residues, which are typically taken from an “import” variable domain. As provided herein, humanized antibodies or antibody fragments comprise one or more CDRs from nonhuman immunoglobulin molecules and framework regions wherein the amino acid residues comprising the framework are derived completely or mostly from human germline. Multiple techniques for humanization of antibodies or antibody fragments are well-known in the art and can essentially be performed following the method of Winter and co-workers (Jones et al., Nature, 321:522-525 (1986); Riechmann et al., Nature, 332:323-327 (1988); Verhoeyen et al., Science, 239:1534-1536 (1988)), by substituting rodent CDRs or CDR sequences for the corresponding sequences of a human antibody, i.e., CDR-grafting (EP 239,400; PCT Publication No. WO 91/09967; and U.S. Pat. Nos. 4,816,567; 6,331,415; 5,225,539; 5,530,101; 5,585,089; 6,548,640, the contents of which are incorporated herein by reference herein in their entirety). In such humanized antibodies and antibody fragments, substantially less than an intact human variable domain has been substituted by the corresponding sequence from a nonhuman species. Humanized antibodies are often human antibodies in which some CDR residues and possibly some framework (FR) residues are substituted by residues from analogous sites in rodent antibodies. Humanization of antibodies and antibody fragments can also be achieved by

veneering or resurfacing (EP 592,106; EP 519,596; Padlan, 1991, Molecular Immunology, 28(4/5):489-498; Studnicka et al., Protein Engineering, 7(6):805-814 (1994); and Roguska et al., PNAS, 91:969-973 (1994)) or chain shuffling (U.S. Pat. No. 5,565,332), the contents of which are incorporated herein by reference herein in their entirety.

[00463] The choice of human variable domains, both light and heavy, to be used in making the humanized antibodies is to reduce antigenicity. According to the so-called "best-fit" method, the sequence of the variable domain of a rodent antibody is screened against the entire library of known human variable-domain sequences. The human sequence which is closest to that of the rodent is then accepted as the human framework (FR) for the humanized antibody (Sims et al., J. Immunol., 151:2296 (1993); Chothia et al., J. Mol. Biol., 196:901 (1987), the contents of which are incorporated herein by reference herein in their entirety). Another method uses a particular framework derived from the consensus sequence of all human antibodies of a particular subgroup of light or heavy chains. The same framework may be used for several different humanized antibodies (see, e.g., Nicholson et al. Mol. Immun. 34 (16-17): 1157-1165 (1997); Carter et al., Proc. Natl. Acad. Sci. USA, 89:4285 (1992); Presta et al., J. Immunol., 151:2623 (1993), the contents of which are incorporated herein by reference herein in their entirety). In some embodiments, the framework region, e.g., all four framework regions, of the heavy chain variable region are derived from a VH4_4-59 germline sequence. In one embodiment, the framework region can comprise, one, two, three, four or five modifications, e.g., substitutions, e.g., from the amino acid at the corresponding murine sequence. In one embodiment, the framework region, e.g., all four framework regions of the light chain variable region are derived from a VK3_1.25 germline sequence. In one embodiment, the framework region can comprise, one, two, three, four or five modifications, e.g., substitutions, e.g., from the amino acid at the corresponding murine sequence.

[00464] In some aspects, the portion of a CAR composition of the invention that comprises an antibody fragment is humanized with retention of high affinity for the target antigen and other favorable biological properties. According to one aspect of the invention, humanized antibodies and antibody fragments are prepared by a process of analysis of the parental sequences and various conceptual humanized products using three-dimensional models of the parental and humanized sequences. Three-dimensional immunoglobulin models are commonly available and are familiar to those skilled in the art. Computer programs are available which illustrate and

display probable three-dimensional conformational structures of selected candidate immunoglobulin sequences. Inspection of these displays permits analysis of the likely role of the residues in the functioning of the candidate immunoglobulin sequence, e.g., the analysis of residues that influence the ability of the candidate immunoglobulin to bind the target antigen. In this way, FR residues can be selected and combined from the recipient and import sequences so that the desired antibody or antibody fragment characteristic, such as increased affinity for the target antigen, is achieved. In general, the CDR residues are directly and most substantially involved in influencing antigen binding.

[00465] A humanized antibody or antibody fragment may retain a similar antigenic specificity as the original antibody, e.g., in the present invention, the ability to bind human a cancer associated antigen as described herein. In some embodiments, a humanized antibody or antibody fragment may have improved affinity and/or specificity of binding to human a cancer associated antigen as described herein.

[00466] In one aspect, the antigen binding domain of the invention is characterized by particular functional features or properties of an antibody or antibody fragment. For example, in one aspect, the portion of a CAR composition of the invention that comprises an antigen binding domain specifically binds a tumor marker as described herein.

[00467] In one aspect, the anti- cancer associated antigen as described herein binding domain is a fragment, e.g., a single chain variable fragment (scFv). In one aspect, the anti- cancer associated antigen as described herein binding domain is a Fv, a Fab, a (Fab')2, or a bi-functional (e.g. bi-specific) hybrid antibody (e.g., Lanzavecchia et al., Eur. J. Immunol. 17, 105 (1987)). In one aspect, the antibodies and fragments thereof of the invention binds a cancer associated antigen as described herein protein with wild-type or enhanced affinity.

[00468] In some instances, scFvs can be prepared according to method known in the art (see, for example, Bird et al., (1988) Science 242:423-426 and Huston et al., (1988) Proc. Natl. Acad. Sci. USA 85:5879-5883). ScFv molecules can be produced by linking VH and VL regions together using flexible polypeptide linkers. The scFv molecules comprise a linker (e.g., a Ser-Gly linker) with an optimized length and/or amino acid composition. The linker length can greatly affect how the variable regions of a scFv fold and interact. In fact, if a short polypeptide linker is employed (e.g., between 5-10 amino acids) intrachain folding is prevented. Interchain

folding is also required to bring the two variable regions together to form a functional epitope binding site. For examples of linker orientation and size see, e.g., Hollinger et al. 1993 Proc Natl Acad. Sci. U.S.A. 90:6444-6448, U.S. Patent Application Publication Nos. 2005/0100543, 2005/0175606, 2007/0014794, and PCT publication Nos. WO2006/020258 and WO2007/024715, is incorporated herein by reference.

[00469] An scFv can comprise a linker of at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, 50, or more amino acid residues between its VL and VH regions. The linker sequence may comprise any naturally occurring amino acid. In some embodiments, the linker sequence comprises amino acids glycine and serine. In another embodiment, the linker sequence comprises sets of glycine and serine repeats such as $(Gly_4Ser)_n$, where n is a positive integer equal to or greater than 1 (SEQ ID NO:22). In one embodiment, the linker can be $(Gly_4Ser)_4$ (SEQ ID NO:29) or $(Gly_4Ser)_3$(SEQ ID NO:30). Variation in the linker length may retain or enhance activity, giving rise to superior efficacy in activity studies.

[00470] In another aspect, the antigen binding domain is a T cell receptor ("TCR"), or a fragment thereof, for example, a single chain TCR (scTCR). Methods to make such TCRs is known in the art. See, e.g., Willemsen RA et al, Gene Therapy 7: 1369–1377 (2000); Zhang T et al, Cancer Gene Ther 11: 487–496 (2004); Aggen et al, Gene Ther. 19(4):365-74 (2012) (references are incorporated herein by its entirety). For example, scTCR can be engineered that contains the Vα and Vβ genes from a T cell clone linked by a linker (e.g., a flexible peptide). This approach is very useful to cancer associated target that itself is intracellar, however, a fragment of such antigen (peptide) is presented on the surface of the cancer cells by MHC.

*Stability and Mutations*

[00471] The stability of an anti- cancer associated antigen as described herein binding domain, e.g., scFv molecules (e.g., soluble scFv) can be evaluated in reference to the biophysical properties (e.g., thermal stability) of a conventional control scFv molecule or a full length antibody. In one embodiment, the humanized scFv has a thermal stability that is greater than about 0.1, about 0.25, about 0.5, about 0.75, about 1, about 1.25, about 1.5, about 1.75, about 2, about 2.5, about 3, about 3.5, about 4, about 4.5, about 5, about 5.5, about 6, about 6.5, about 7, about 7.5, about 8, about 8.5, about 9, about 9.5, about 10 degrees, about 11 degrees, about 12

degrees, about 13 degrees, about 14 degrees, or about 15 degrees Celsius than a control binding molecule (e.g. a conventional scFv molecule) in the described assays.

[00472] The improved thermal stability of the anti- cancer associated antigen as described herein binding domain, e.g., scFv is subsequently conferred to the entire CART19 construct, leading to improved therapeutic properties of the CART19 construct. The thermal stability of the anti- cancer associated antigen as described herein binding domain, e.g., scFv can be improved by at least about 2°C or 3°C as compared to a conventional antibody. In one embodiment, the anti- cancer associated antigen as described herein binding domain, e.g., scFv has a 1°C improved thermal stability as compared to a conventional antibody. In another embodiment, the anti- cancer associated antigen as described herein binding domain, e.g., scFv has a 2°C improved thermal stability as compared to a conventional antibody. In another embodiment, the scFv has a 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15°C improved thermal stability as compared to a conventional antibody. Comparisons can be made, for example, between the scFv molecules disclosed herein and scFv molecules or Fab fragments of an antibody from which the scFv VH and VL were derived. Thermal stability can be measured using methods known in the art. For example, in one embodiment, Tm can be measured. Methods for measuring Tm and other methods of determining protein stability are described in more detail below.

[00473] Mutations in scFv (arising through humanization or direct mutagenesis of the soluble scFv) alter the stability of the scFv and improve the overall stability of the scFv and the CART19 construct. Stability of the humanized scFv is compared against the murine scFv using measurements such as Tm, temperature denaturation and temperature aggregation.

[00474] The binding capacity of the mutant scFvs can be determined using assays described in the Examples.

[00475] In one embodiment, the anti- cancer associated antigen as described herein binding domain, e.g., scFv comprises at least one mutation arising from the humanization process such that the mutated scFv confers improved stability to the CAR construct. In another embodiment, the anti- cancer associated antigen as described herein binding domain, e.g., scFv comprises at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 mutations arising from the humanization process such that the mutated scFv confers improved stability to the CAR construct.

*Methods of Evaluating Protein Stability*

[00476] The stability of an antigen binding domain may be assessed using, e.g., the methods described below. Such methods allow for the determination of multiple thermal unfolding transitions where the least stable domain either unfolds first or limits the overall stability threshold of a multidomain unit that unfolds cooperatively (e.g., a multidomain protein which exhibits a single unfolding transition). The least stable domain can be identified in a number of additional ways. Mutagenesis can be performed to probe which domain limits the overall stability. Additionally, protease resistance of a multidomain protein can be performed under conditions where the least stable domain is known to be intrinsically unfolded via DSC or other spectroscopic methods (Fontana, *et al.*, (1997) Fold. Des., 2: R17-26; Dimasi *et al.* (2009) J. Mol. Biol. 393: 672-692). Once the least stable domain is identified, the sequence encoding this domain (or a portion thereof) may be employed as a test sequence in the methods.

*a) Thermal Stability*

[00477] The thermal stability of the compositions may be analyzed using a number of non-limiting biophysical or biochemical techniques known in the art. In certain embodiments, thermal stability is evaluated by analytical spectroscopy.

[00478] An exemplary analytical spectroscopy method is Differential Scanning Calorimetry (DSC). DSC employs a calorimeter which is sensitive to the heat absorbances that accompany the unfolding of most proteins or protein domains (see, e.g. Sanchez-Ruiz, et al., Biochemistry, 27: 1648-52, 1988). To determine the thermal stability of a protein, a sample of the protein is inserted into the calorimeter and the temperature is raised until the Fab or scFv unfolds. The temperature at which the protein unfolds is indicative of overall protein stability.

[00479] Another exemplary analytical spectroscopy method is Circular Dichroism (CD) spectroscopy. CD spectrometry measures the optical activity of a composition as a function of increasing temperature. Circular dichroism (CD) spectroscopy measures differences in the absorption of left-handed polarized light versus right-handed polarized light which arise due to structural asymmetry. A disordered or unfolded structure results in a CD spectrum very different from that of an ordered or folded structure. The CD spectrum reflects the sensitivity of the proteins to the denaturing effects of increasing temperature and is therefore indicative of a protein's thermal stability (see van Mierlo and Steemsma, J. Biotechnol., 79(3):281-98, 2000).

[00480] Another exemplary analytical spectroscopy method for measuring thermal stability is Fluorescence Emission Spectroscopy (see van Mierlo and Steemsma, supra). Yet another exemplary analytical spectroscopy method for measuring thermal stability is Nuclear Magnetic Resonance (NMR) spectroscopy (see, e.g. van Mierlo and Steemsma, supra).

[00481] The thermal stability of a composition can be measured biochemically. An exemplary biochemical method for assessing thermal stability is a thermal challenge assay. In a "thermal challenge assay", a composition is subjected to a range of elevated temperatures for a set period of time. For example, in one embodiment, test scFv molecules or molecules comprising scFv molecules are subject to a range of increasing temperatures, e.g., for 1-1.5 hours. The activity of the protein is then assayed by a relevant biochemical assay. For example, if the protein is a binding protein (e.g. an scFv or scFv-containing polypeptide) the binding activity of the binding protein may be determined by a functional or quantitative ELISA.

[00482] Such an assay may be done in a high-throughput format, e.g., using *E. coli* and high throughput screening. A library of anti- cancer associated antigen as described herein binding domain, e.g., scFv variants may be created using methods known in the art. Anti- cancer associated antigen as described herein binding domain, e.g., scFv expression may be induced and the anti- cancer associated antigen as described herein binding domain, e.g., scFv may be subjected to thermal challenge. The challenged test samples may be assayed for binding and those anti- cancer associated antigen as described herein binding domain, e.g., scFvs which are stable may be scaled up and further characterized.

[00483] Thermal stability is evaluated by measuring the melting temperature (Tm) of a composition using any of the above techniques (e.g. analytical spectroscopy techniques). The melting temperature is the temperature at the midpoint of a thermal transition curve wherein 50% of molecules of a composition are in a folded state (See e.g., Dimasi *et al.* (2009) J. Mol Biol. 393: 672-692). In one embodiment, Tm values for an anti- cancer associated antigen as described herein binding domain, e.g., scFv are about 40°C, 41°C, 42°C, 43°C, 44°C, 45°C, 46°C, 47°C, 48°C, 49°C, 50°C, 51°C, 52°C, 53°C, 54°C, 55°C, 56°C, 57°C, 58°C, 59°C, 60°C, 61°C, 62°C, 63°C, 64°C, 65°C, 66°C, 67°C, 68°C, 69°C, 70°C, 71°C, 72°C, 73°C, 74°C, 75°C, 76°C, 77°C, 78°C, 79°C, 80°C, 81°C, 82°C, 83°C, 84°C, 85°C, 86°C, 87°C, 88°C, 89°C, 90°C, 91°C, 92°C, 93°C, 94°C, 95°C, 96°C, 97°C, 98°C, 99°C, 100°C. In one embodiment, Tm values for an IgG

is about 40°C, 41°C, 42°C, 43°C, 44°C, 45°C, 46°C, 47°C, 48°C, 49°C, 50°C, 51°C, 52°C, 53°C, 54°C, 55°C, 56°C, 57°C, 58°C, 59°C, 60°C, 61°C, 62°C, 63°C, 64°C, 65°C, 66°C, 67°C, 68°C, 69°C, 70°C, 71°C, 72°C, 73°C, 74°C, 75°C, 76°C, 77°C, 78°C, 79°C, 80°C, 81°C, 82°C, 83°C, 84°C, 85°C, 86°C, 87°C, 88°C, 89°C, 90°C, 91°C, 92°C, 93°C, 94°C, 95°C, 96°C, 97°C, 98°C, 99°C, 100°C. In one embodiment, Tm values for an multivalent antibody is about 40°C, 41°C, 42°C, 43°C, 44°C, 45°C, 46°C, 47°C, 48°C, 49°C, 50°C, 51°C, 52°C, 53°C, 54°C, 55°C, 56°C, 57°C, 58°C, 59°C, 60°C, 61°C, 62°C, 63°C, 64°C, 65°C, 66°C, 67°C, 68°C, 69°C, 70°C, 71°C, 72°C, 73°C, 74°C, 75°C, 76°C, 77°C, 78°C, 79°C, 80°C, 81°C, 82°C, 83°C, 84°C, 85°C, 86°C, 87°C, 88°C, 89°C, 90°C, 91°C, 92°C, 93°C, 94°C, 95°C, 96°C, 97°C, 98°C, 99°C, 100°C.

[00484] Thermal stability is also evaluated by measuring the specific heat or heat capacity (Cp) of a composition using an analytical calorimetric technique (e.g. DSC). The specific heat of a composition is the energy (e.g. in kcal/mol) is required to rise by 1°C, the temperature of 1 mol of water. As large Cp is a hallmark of a denatured or inactive protein composition. The change in heat capacity (ΔCp) of a composition is measured by determining the specific heat of a composition before and after its thermal transition. Thermal stability may also be evaluated by measuring or determining other parameters of thermodynamic stability including Gibbs free energy of unfolding (ΔG), enthalpy of unfolding (ΔH), or entropy of unfolding (ΔS). One or more of the above biochemical assays (e.g. a thermal challenge assay) are used to determine the temperature (i.e. the $T_C$ value) at which 50% of the composition retains its activity (e.g. binding activity).

[00485] In addition, mutations to the anti- cancer associated antigen as described herein binding domain, e.g., scFv alter the thermal stability of the anti- cancer associated antigen as described herein binding domain, e.g., scFv compared with the unmutated anti- cancer associated antigen as described herein binding domain, e.g., scFv. When the humanized anti- cancer associated antigen as described herein binding domain, e.g., scFv is incorporated into a CART19 construct, the anti- cancer associated antigen as described herein binding domain, e.g., humanized scFv confers thermal stability to the overall anti-CARs of the present invention. In one embodiment, the anti- cancer associated antigen as described herein binding domain, e.g., scFv comprises a single mutation that confers thermal stability to the anti- cancer associated antigen as described herein binding domain, e.g., scFv. In another embodiment, the anti- cancer

associated antigen as described herein binding domain, e.g., scFv comprises multiple mutations that confer thermal stability to the anti- cancer associated antigen as described herein binding domain, e.g., scFv. In one embodiment, the multiple mutations in the anti- cancer associated antigen as described herein binding domain, e.g., scFv have an additive effect on thermal stability of the anti- cancer associated antigen as described herein binding domain, e.g., scFv.

*b) % Aggregation*

[00486] The stability of a composition can be determined by measuring its propensity to aggregate. Aggregation can be measured by a number of non-limiting biochemical or biophysical techniques. For example, the aggregation of a composition may be evaluated using chromatography, e.g. Size-Exclusion Chromatography (SEC). SEC separates molecules on the basis of size. A column is filled with semi-solid beads of a polymeric gel that will admit ions and small molecules into their interior but not large ones. When a protein composition is applied to the top of the column, the compact folded proteins (i.e. non-aggregated proteins) are distributed through a larger volume of solvent than is available to the large protein aggregates. Consequently, the large aggregates move more rapidly through the column, and in this way the mixture can be separated or fractionated into its components. Each fraction can be separately quantified (e.g. by light scattering) as it elutes from the gel. Accordingly, the % aggregation of a composition can be determined by comparing the concentration of a fraction with the total concentration of protein applied to the gel. Stable compositions elute from the column as essentially a single fraction and appear as essentially a single peak in the elution profile or chromatogram.

*c) Binding Affinity*

[00487] The stability of a composition can be assessed by determining its target binding affinity. A wide variety of methods for determining binding affinity are known in the art. An exemplary method for determining binding affinity employs surface plasmon resonance. Surface plasmon resonance is an optical phenomenon that allows for the analysis of real-time biospecific interactions by detection of alterations in protein concentrations within a biosensor matrix, for example using the BIAcore system (Pharmacia Biosensor AB, Uppsala, Sweden and Piscataway, N.J.). For further descriptions, see Jonsson, U., et al. (1993) Ann. Biol. Clin. 51:19-26; Jonsson,

U., i (1991) Biotechniques 11:620-627; Johnsson, B., *et al.* (1995) J. Mol. Recognit. 8:125-131; and Johnnson, B., *et al.* (1991) Anal. Biochem. 198:268-277.

[00488] In one aspect, the antigen binding domain of the CAR comprises an amino acid sequence that is homologous to an antigen binding domain amino acid sequence described herein, and the antigen binding domain retains the desired functional properties of the anti-cancer associated antigen as described herein antibody fragments described herein. In one specific aspect, the CAR composition of the invention comprises an antibody fragment. In a further aspect, that antibody fragment comprises a scFv.

[00489] In various aspects, the antigen binding domain of the CAR is engineered by modifying one or more amino acids within one or both variable regions (e.g., VH and/or VL), for example within one or more CDR regions and/or within one or more framework regions. In one specific aspect, the CAR composition of the invention comprises an antibody fragment. In a further aspect, that antibody fragment comprises a scFv.

[00490] It will be understood by one of ordinary skill in the art that the antibody or antibody fragment of the invention may further be modified such that they vary in amino acid sequence (e.g., from wild-type), but not in desired activity. For example, additional nucleotide substitutions leading to amino acid substitutions at "non-essential" amino acid residues may be made to the protein For example, a nonessential amino acid residue in a molecule may be replaced with another amino acid residue from the same side chain family. In another embodiment, a string of amino acids can be replaced with a structurally similar string that differs in order and/or composition of side chain family members, e.g., a conservative substitution, in which an amino acid residue is replaced with an amino acid residue having a similar side chain, may be made.

[00491] Families of amino acid residues having similar side chains have been defined in the art, including basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine).

[00492] Percent identity in the context of two or more nucleic acids or polypeptide sequences, refers to two or more sequences that are the same. Two sequences are "substantially identical" if two sequences have a specified percentage of amino acid residues or nucleotides that are the same (e.g., 60% identity, optionally 70%, 71%. 72%. 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% identity over a specified region, or, when not specified, over the entire sequence), when compared and aligned for maximum correspondence over a comparison window, or designated region as measured using one of the following sequence comparison algorithms or by manual alignment and visual inspection. Optionally, the identity exists over a region that is at least about 50 nucleotides (or 10 amino acids) in length, or more preferably over a region that is 100 to 500 or 1000 or more nucleotides (or 20, 50, 200 or more amino acids) in length.

[00493] For sequence comparison, typically one sequence acts as a reference sequence, to which test sequences are compared. When using a sequence comparison algorithm, test and reference sequences are entered into a computer, subsequence coordinates are designated, if necessary, and sequence algorithm program parameters are designated. Default program parameters can be used, or alternative parameters can be designated. The sequence comparison algorithm then calculates the percent sequence identities for the test sequences relative to the reference sequence, based on the program parameters. Methods of alignment of sequences for comparison are well known in the art. Optimal alignment of sequences for comparison can be conducted, e.g., by the local homology algorithm of Smith and Waterman, (1970) Adv. Appl. Math. 2:482c, by the homology alignment algorithm of Needleman and Wunsch, (1970) J. Mol. Biol. 48:443, by the search for similarity method of Pearson and Lipman, (1988) Proc. Nat'l. Acad. Sci. USA 85:2444, by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Dr., Madison, WI), or by manual alignment and visual inspection (see, e.g., Brent et al., (2003) Current Protocols in Molecular Biology).

[00494] Two examples of algorithms that are suitable for determining percent sequence identity and sequence similarity are the BLAST and BLAST 2.0 algorithms, which are described in Altschul et al., (1977) Nuc. Acids Res. 25:3389-3402; and Altschul et al., (1990) J. Mol. Biol.

215:403-410, respectively. Software for performing BLAST analyses is publicly available through the National Center for Biotechnology Information.

[00495] The percent identity between two amino acid sequences can also be determined using the algorithm of E. Meyers and W. Miller, (1988) Comput. Appl. Biosci. 4:11-17) which has been incorporated into the ALIGN program (version 2.0), using a PAM120 weight residue table, a gap length penalty of 12 and a gap penalty of 4. In addition, the percent identity between two amino acid sequences can be determined using the Needleman and Wunsch (1970) J. Mol. Biol. 48:444-453) algorithm which has been incorporated into the GAP program in the GCG software package (available at www.gcg.com), using either a Blossom 62 matrix or a PAM250 matrix, and a gap weight of 16, 14, 12, 10, 8, 6, or 4 and a length weight of 1, 2, 3, 4, 5, or 6.

[00496] In one aspect, the present invention contemplates modifications of the starting antibody or fragment (e.g., scFv) amino acid sequence that generate functionally equivalent molecules. For example, the VH or VL of an anti- cancer associated antigen as described herein binding domain, e.g., scFv, comprised in the CAR can be modified to retain at least about 70%, 71%. 72%. 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%,81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% identity of the starting VH or VL framework region of the anti- cancer associated antigen as described herein binding domain, e.g., scFv. The present invention contemplates modifications of the entire CAR construct, e.g., modifications in one or more amino acid sequences of the various domains of the CAR construct in order to generate functionally equivalent molecules. The CAR construct can be modified to retain at least about 70%, 71%. 72%. 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% identity of the starting CAR construct.

[00497] *Bispecific CARs*

[00498] In an embodiment a multispecific antibody molecule is a bispecific antibody molecule. A bispecific antibody has specificity for no more than two antigens. A bispecific antibody molecule is characterized by a first immunoglobulin variable domain sequence which has binding specificity for a first epitope and a second immunoglobulin variable domain sequence that has binding specificity for a second epitope. In an embodiment the first and second epitopes are on the same antigen, e.g., the same protein (or subunit of a multimeric

protein). In an embodiment the first and second epitopes overlap. In an embodiment the first and second epitopes do not overlap. In an embodiment the first and second epitopes are on different antigens, e.g., different proteins (or different subunits of a multimeric protein). In an embodiment a bispecific antibody molecule comprises a heavy chain variable domain sequence and a light chain variable domain sequence which have binding specificity for a first epitope and a heavy chain variable domain sequence and a light chain variable domain sequence which have binding specificity for a second epitope. In an embodiment a bispecific antibody molecule comprises a half antibody having binding specificity for a first epitope and a half antibody having binding specificity for a second epitope. In an embodiment a bispecific antibody molecule comprises a half antibody, or fragment thereof, having binding specificity for a first epitope and a half antibody, or fragment thereof, having binding specificity for a second epitope. In an embodiment a bispecific antibody molecule comprises a scFv, or fragment thereof, have binding specificity for a first epitope and a scFv, or fragment thereof, have binding specificity for a second epitope.

[00499] In certain embodiments, the antibody molecule is a multi-specific (e.g., a bispecific or a trispecific) antibody molecule. Protocols for generating bispecific or heterodimeric antibody molecules are known in the art; including but not limited to, for example, the "knob in a hole" approach described in, e.g., US 5731168; the electrostatic steering Fc pairing as described in, e.g., WO 09/089004, WO 06/106905 and WO 2010/129304; Strand Exchange Engineered Domains (SEED) heterodimer formation as described in, e.g., WO 07/110205; Fab arm exchange as described in, e.g., WO 08/119353, WO 2011/131746, and WO 2013/060867; double antibody conjugate, e.g., by antibody cross-linking to generate a bi-specific structure using a heterobifunctional reagent having an amine-reactive group and a sulfhydryl reactive group as described in, e.g., US 4433059; bispecific antibody determinants generated by recombining half antibodies (heavy-light chain pairs or Fabs) from different antibodies through cycle of reduction and oxidation of disulfide bonds between the two heavy chains, as described in, e.g., US 4444878; trifunctional antibodies, e.g., three Fab' fragments cross-linked through sulfhdryl reactive groups, as described in, e.g., US5273743; biosynthetic binding proteins, e.g., pair of scFvs cross-linked through C-terminal tails preferably through disulfide or amine-reactive chemical cross-linking, as described in, e.g., US5534254; bifunctional antibodies, e.g., Fab fragments with different binding specificities dimerized through leucine zippers (e.g., c-fos and

c-jun) that have replaced the constant domain, as described in, e.g., US5582996; bispecific and oligospecific mono-and oligovalent receptors, e.g., VH-CH1 regions of two antibodies (two Fab fragments) linked through a polypeptide spacer between the CH1 region of one antibody and the VH region of the other antibody typically with associated light chains, as described in, e.g., US5591828; bispecific DNA-antibody conjugates, e.g., crosslinking of antibodies or Fab fragments through a double stranded piece of DNA, as described in, e.g., US5635602; bispecific fusion proteins, e.g., an expression construct containing two scFvs with a hydrophilic helical peptide linker between them and a full constant region, as described in, e.g., US5637481; multivalent and multispecific binding proteins, e.g., dimer of polypeptides having first domain with binding region of Ig heavy chain variable region, and second domain with binding region of Ig light chain variable region, generally termed diabodies (higher order structures are also encompassed creating for bispecifc, trispecific, or tetraspecific molecules, as described in, e.g., US5837242; minibody constructs with linked VL and VH chains further connected with peptide spacers to an antibody hinge region and CH3 region, which can be dimerized to form bispecific/multivalent molecules, as described in, e.g., US5837821; VH and VL domains linked with a short peptide linker (e.g., 5 or 10 amino acids) or no linker at all in either orientation, which can form dimers to form bispecific diabodies; trimers and tetramers, as described in, e.g., US5844094; String of VH domains (or VL domains in family members) connected by peptide linkages with crosslinkable groups at the C-terminus futher associated with VL domains to form a series of FVs (or scFvs), as described in, e.g., US5864019; and single chain binding polypeptides with both a VH and a VL domain linked through a peptide linker are combined into multivalent structures through non-covalent or chemical crosslinking to form, e.g., homobivalent, heterobivalent, trivalent, and tetravalent structures using both scFV or diabody type format, as described in, e.g., US5869620. Additional exemplary multispecific and bispecific molecules and methods of making the same are found, for example, in US5910573, US5932448, US5959083, US5989830, US6005079, US6239259, US6294353, US6333396, US6476198, US6511663, US6670453, US6743896, US6809185, US6833441, US7129330, US7183076, US7521056, US7527787, US7534866, US7612181, US2002004587A1, US2002076406A1, US2002103345A1, US2003207346A1, US2003211078A1, US2004219643A1, US2004220388A1, US2004242847A1, US2005003403A1, US2005004352A1, US2005069552A1, US2005079170A1, US2005100543A1,

US2005136049A1, US2005136051A1, US2005163782A1, US2005266425A1, US2006083747A1, US2006120960A1, US2006204493A1, US2006263367A1, US2007004909A1, US2007087381A1, US2007128150A1, US2007141049A1, US2007154901A1, US2007274985A1, US2008050370A1, US2008069820A1, US2008152645A1, US2008171855A1, US2008241884A1, US2008254512A1, US2008260738A1, US2009130106A1, US2009148905A1, US2009155275A1, US2009162359A1, US2009162360A1, US2009175851A1, US2009175867A1, US2009232811A1, US2009234105A1, US2009263392A1, US2009274649A1, EP346087A2, WO0006605A2, WO02072635A2, WO04081051A1, WO06020258A2, WO2007044887A2, WO2007095338A2, WO2007137760A2, WO2008119353A1, WO2009021754A2, WO2009068630A1, WO9103493A1, WO9323537A1, WO9409131A1, WO9412625A2, WO9509917A1, WO9637621A2, WO9964460A1. The contents of the above-referenced applications are incorporated herein by reference in their entireties.

[00500] Within each antibody or antibody fragment (e.g., scFv) of a bispecific antibody molecule, the VH can be upstream or downstream of the VL. In some embodiments, the upstream antibody or antibody fragment (e.g., scFv) is arranged with its VH (VH1) upstream of its VL (VL1) and the downstream antibody or antibody fragment (e.g., scFv) is arranged with its VL (VL2) upstream of its VH (VH2), such that the overall bispecific antibody molecule has the arrangement VH1-VL1-VL2-VH2. In other embodiments, the upstream antibody or antibody fragment (e.g., scFv) is arranged with its VL (VL1) upstream of its VH (VH1) and the downstream antibody or antibody fragment (e.g., scFv) is arranged with its VH (VH2) upstream of its VL (VL2), such that the overall bispecific antibody molecule has the arrangement VL1-VH1-VH2-VL2. Optionally, a linker is disposed between the two antibodies or antibody fragments (e.g., scFvs), e.g., between VL1 and VL2 if the construct is arranged as VH1-VL1-VL2-VH2, or between VH1 and VH2 if the construct is arranged as VL1-VH1-VH2-VL2. The linker may be a linker as described herein, e.g., a $(Gly_4\text{-}Ser)_n$ linker, wherein n is 1, 2, 3, 4, 5, or 6, preferably 4 (SEQ ID NO: 29). In general, the linker between the two scFvs should be long enough to avoid mispairing between the domains of the two scFvs. Optionally, a linker is disposed between the VL and VH of the first scFv. Optionally, a linker is disposed between the VL and VH of the second scFv. In constructs that have multiple linkers, any two or more of the

linkers can be the same or different. Accordingly, in some embodiments, a bispecific CAR comprises VLs, VHs, and optionally one or more linkers in an arrangement as described herein.

[00501] In one aspect, the bispecific antibody molecule is characterized by a first immunoglobulin variable domain sequence, e.g., a scFv, which has binding specificity for a first cancer-associated antigen, e.g., comprises a scFv as described herein, e.g., as described in Table 3, or comprises the light chain CDRs and/or heavy chain CDRs from a scFv described herein, and a second immunoglobulin variable domain sequence that has binding specificity for a second epitope on a different antigen. In some aspects the second immunoglobulin variable domain sequence has binding specificity for an antigen expressed on AML cells. For example, the second immunoglobulin variable domain sequence has binding specificity for CD123. As another example, the second immunoglobulin variable domain sequence has binding specificity for CD33. As another example, the second immunoglobulin variable domain sequence has binding specificity for CLL-1. As another example, the second immunoglobulin variable domain sequence has binding specificity for CD34. As another example, the second immunoglobulin variable domain sequence has binding specificity for FLT3. For example, the second immunoglobulin variable domain sequence has binding specificity for folate receptor beta. In some aspects, the second immunoglobulin variable domain sequence has binding specificity for an antigen expressed on B-cells, for example, CD19, CD20, CD22 or ROR1.

*Chimeric TCR*

[00502] In one aspect, the antibodies and antibody fragments disclosed herein (for example, those disclosed in Table 3) can be grafted to one or more constant domain of a T cell receptor ("TCR") chain, for example, a TCR alpha or TCR beta chain, to create an chimeric TCR that binds specifically to a cancer associated antigen. Without being bound by theory, it is believed that chimeric TCRs will signal through the TCR complex upon antigen binding. For example, an scFv as disclosed herein, can be grafted to the constant domain, e.g., at least a portion of the extracellular constant domain, the transmembrane domain and the cytoplasmic domain, of a TCR chain, for example, the TCR alpha chain and/or the TCR beta chain. As another example, an antibody fragment, for example a VL domain as described herein, can be grafted to the constant domain of a TCR alpha chain, and an antibody fragment, for example a VH domain as described herein, can be grafted to the constant domain of a TCR beta chain (or alternatively, a VL domain

may be grafted to the constant domain of the TCR beta chain and a VH domain may be grafted to a TCR alpha chain). As another example, the CDRs of an antibody or antibody fragment, e.g., the CDRs of an antibody or antibody fragment as described in Table 3 may be grafted into a TCR alpha and/or beta chain to create a chimeric TCR that binds specifically to a cancer associated antigen. For example, the LC CDRs disclosed herein may be grafted into the variable domain of a TCR alpha chain and the HC CDRs disclosed herein may be grafted to the variable domain of a TCR beta chain, or vice versa. Such chimeric TCRs may be produced by any appropriate method (For example, Willemsen RA et al, Gene Therapy 2000; 7: 1369–1377; Zhang T et al, Cancer Gene Ther 2004; 11: 487–496; Aggen et al, Gene Ther. 2012 Apr;19(4):365-74).

**Transmembrane domain**

[00503] With respect to the transmembrane domain, in various embodiments, a CAR can be designed to comprise a transmembrane domain that is attached to the extracellular domain of the CAR. A transmembrane domain can include one or more additional amino acids adjacent to the transmembrane region, e.g., one or more amino acid associated with the extracellular region of the protein from which the transmembrane was derived (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 up to 15 amino acids of the extracellular region) and/or one or more additional amino acids associated with the intracellular region of the protein from which the transmembrane protein is derived (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 up to 15 amino acids of the intracellular region). In one aspect, the transmembrane domain is one that is associated with one of the other domains of the CAR e.g., in one embodiment, the transmembrane domain may be from the same protein that the signaling domain, costimulatory domain or the hinge domain is derived from. In another aspect, the transmembrane domain is not derived from the same protein that any other domain of the CAR is derived from. In some instances, the transmembrane domain can be selected or modified by amino acid substitution to avoid binding of such domains to the transmembrane domains of the same or different surface membrane proteins, e.g., to minimize interactions with other members of the receptor complex. In one aspect, the transmembrane domain is capable of homodimerization with another CAR on the cell surface of a CAR-expressing cell. In a different aspect the amino acid sequence of the transmembrane domain may be modified or substituted so

as to minimize interactions with the binding domains of the native binding partner present in the same CAR-expressing cell.

[00504] The transmembrane domain may be derived either from a natural or from a recombinant source. Where the source is natural, the domain may be derived from any membrane-bound or transmembrane protein. In one aspect the transmembrane domain is capable of signaling to the intracellular domain(s) whenever the CAR has bound to a target. A transmembrane domain of particular use in this invention may include at least the transmembrane region(s) of e.g., the alpha, beta or zeta chain of the T-cell receptor, CD28, CD27, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD134, CD137, CD154. In some embodiments, a transmembrane domain may include at least the transmembrane region(s) of, e.g., KIRDS2, OX40, CD2, CD27, LFA-1 (CD11a, CD18), ICOS (CD278), 4-1BB (CD137), GITR, CD40, BAFFR, HVEM (LIGHTR), SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD160, CD19, IL2R beta, IL2R gamma, IL7R α, ITGA1, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, TNFR2, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, PAG/Cbp, NKG2D, and NKG2C.

[00505] In some instances, the transmembrane domain can be attached to the extracellular region of the CAR, e.g., the antigen binding domain of the CAR, via a hinge, e.g., a hinge from a human protein. For example, in one embodiment, the hinge can be a human Ig (immunoglobulin) hinge (e.g., an IgG4 hinge an IgD hinge), a GS linker (e.g., a GS linker described herein), a KIR2DS2 hinge or a CD8a hinge. In one embodiment, the hinge or spacer comprises (e.g., consists of) the amino acid sequence of SEQ ID NO:4. In one aspect, the transmembrane domain comprises (e.g., consists of) a transmembrane domain of SEQ ID NO: 12.

[00506] In one aspect, the hinge or spacer comprises an IgG4 hinge. For example, in one embodiment, the hinge or spacer comprises a hinge of the amino acid sequence ESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWY

VDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTIS KAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPP VLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGKM (SEQ ID NO:6). In some embodiments, the hinge or spacer comprises a hinge encoded by a nucleotide sequence of

GAGAGCAAGTACGGCCCTCCCTGCCCCCCTTGCCCTGCCCCCGAGTTCCTGGGCGGA CCCAGCGTGTTCCTGTTCCCCCCCAAGCCCAAGGACACCCTGATGATCAGCCGGACC CCCGAGGTGACCTGTGTGGTGGTGGACGTGTCCCAGGAGGACCCCGAGGTCCAGTT CAACTGGTACGTGGACGGCGTGGAGGTGCACAACGCCAAGACCAAGCCCCGGGAG GAGCAGTTCAATAGCACCTACCGGGTGGTGTCCGTGCTGACCGTGCTGCACCAGGA CTGGCTGAACGGCAAGGAATACAAGTGTAAGGTGTCCAACAAGGGCCTGCCCAGCA GCATCGAGAAAACCATCAGCAAGGCCAAGGGCCAGCCTCGGGAGCCCCAGGTGTAC ACCCTGCCCCCTAGCCAAGAGGAGATGACCAAGAACCAGGTGTCCCTGACCTGCCT GGTGAAGGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAACGGCCAGC CCGAGAACAACTACAAGACCACCCCCCCTGTGCTGGACAGCGACGGCAGCTTCTTC CTGTACAGCCGGCTGACCGTGGACAAGAGCCGGTGGCAGGAGGGCAACGTCTTTAG CTGCTCCGTGATGCACGAGGCCCTGCACAACCACTACACCCAGAAGAGCCTGAGCC TGTCCCTGGGCAAGATG (SEQ ID NO:7).

[00507] In one aspect, the hinge or spacer comprises an IgD hinge. For example, in one embodiment, the hinge or spacer comprises a hinge of the amino acid sequence RWPESPKAQASSVPTAQPQAEGSLAKATTAPATTRNTGRGGEEKKKEKEKEEQEERETK TPECPSHTQPLGVYLLTPAVQDLWLRDKATFTCFVVGSDLKDAHLTWEVAGKVPTGGV EEGLLERHSNGSQSQHSRLTLPRSLWNAGTSVTCTLNHPSLPPQRLMALREPAAQAPVK LSLNLLASSDPPEAASWLLCEVSGFSPPNILLMWLEDQREVNTSGFAPARPPPQPGSTTF WAWSVLRVPAPPSPQPATYTCVVSHEDSRTLLNASRSLEVSYVTDH (SEQ ID NO:8). In some embodiments, the hinge or spacer comprises a hinge encoded by a nucleotide sequence of AGGTGGCCCGAAAGTCCCAAGGCCCAGGCATCTAGTGTTCCTACTGCACAGCCCCA GGCAGAAGGCAGCCTAGCCAAAGCTACTACTGCACCTGCCACTACGCGCAATACTG GCCGTGGCGGGGAGGAGAAGAAAAAGGAGAAAGAGAAAGAAGAACAGGAAGAGA GGGAGACCAAGACCCCTGAATGTCCATCCCATACCCAGCCGCTGGGCGTCTATCTCT TGACTCCCGCAGTACAGGACTTGTGGCTTAGAGATAAGGCCACCTTTACATGTTTCG

TCGTGGGCTCTGACCTGAAGGATGCCCATTTGACTTGGGAGGTTGCCGGAAAGGTAC
CCACAGGGGGGGTTGAGGAAGGGTTGCTGGAGCGCCATTCCAATGGCTCTCAGAGC
CAGCACTCAAGACTCACCCTTCCGAGATCCCTGTGGAACGCCGGGACCTCTGTCACA
TGTACTCTAAATCATCCTAGCCTGCCCCCACAGCGTCTGATGGCCCTTAGAGAGCCA
GCCGCCCAGGCACCAGTTAAGCTTAGCCTGAATCTGCTCGCCAGTAGTGATCCCCCA
GAGGCCGCCAGCTGGCTCTTATGCGAAGTGTCCGGCTTTAGCCCGCCCAACATCTTG
CTCATGTGGCTGGAGGACCAGCGAGAAGTGAACACCAGCGGCTTCGCTCCAGCCCG
GCCCCCACCCCAGCCGGGTTCTACCACATTCTGGGCCTGGAGTGTCTTAAGGGTCCC
AGCACCACCTAGCCCCCAGCCAGCCACATACACCTGTGTTGTGTCCCATGAAGATAG
CAGGACCCTGCTAAATGCTTCTAGGAGTCTGGAGGTTTCCTACGTGACTGACCATT
(SEQ ID NO:9).

[00508] In one aspect, the transmembrane domain may be recombinant, in which case it will comprise predominantly hydrophobic residues such as leucine and valine. In one aspect a triplet of phenylalanine, tryptophan and valine can be found at each end of a recombinant transmembrane domain.

[00509] Optionally, a short oligo- or polypeptide linker, between 2 and 10 amino acids in length may form the linkage between the transmembrane domain and the cytoplasmic region of the CAR. A glycine-serine doublet provides a particularly suitable linker. For example, in one aspect, the linker comprises the amino acid sequence of GGGGSGGGGS (SEQ ID NO:10). In some embodiments, the linker is encoded by a nucleotide sequence of GGTGGCGGAGGTTCTGGAGGTGGAGGTTCC (SEQ ID NO:11).

[00510] In one aspect, the hinge or spacer comprises a KIR2DS2 hinge.

### Cytoplasmic domain

[00511] The cytoplasmic domain or region of a CAR of the present invention includes an intracellular signaling domain. An intracellular signaling domain is generally responsible for activation of at least one of the normal effector functions of the immune cell in which the CAR has been introduced. Examples of intracellular signaling domains for use in the CAR of the invention include the cytoplasmic sequences of the T cell receptor (TCR) and co-receptors that

act in concert to initiate signal transduction following antigen receptor engagement, as well as any derivative or variant of these sequences and any recombinant sequence that has the same functional capability.

[00512] It is known that signals generated through the TCR alone are insufficient for full activation of the T cell and that a secondary and/or costimulatory signal is also required. Thus, T cell activation can be said to be mediated by two distinct classes of cytoplasmic signaling sequences: those that initiate antigen-dependent primary activation through the TCR (primary intracellular signaling domains) and those that act in an antigen-independent manner to provide a secondary or costimulatory signal (secondary cytoplasmic domain, e.g., a costimulatory domain).

[00513] A primary signaling domain regulates primary activation of the TCR complex either in a stimulatory way, or in an inhibitory way. Primary intracellular signaling domains that act in a stimulatory manner may contain signaling motifs which are known as immunoreceptor tyrosine-based activation motifs or ITAMs.

[00514] Examples of ITAM containing primary intracellular signaling domains that are of particular use in the invention include those of CD3 zeta, common FcR gamma (FCER1G), Fc gamma RIIa, FcR beta (Fc Epsilon R1b), CD3 gamma, CD3 delta, CD3 epsilon, CD5, CD22, CD79a, CD79b, CD278 (also known as "ICOS"), FcεRI, DAP10, DAP12, and CD66d. In one embodiment, a CAR of the invention comprises an intracellular signaling domain, e.g., a primary signaling domain of CD3-zeta.

[00515] Further examples of molecules containing a primary intracellular signaling domain that are of particular use in the invention include those of DAP10, DAP12, and CD32.

[00516] In one embodiment, a primary signaling domain comprises a modified ITAM domain, e.g., a mutated ITAM domain which has altered (e.g., increased or decreased) activity as compared to the native ITAM domain. In one embodiment, a primary signaling domain comprises a modified ITAM-containing primary intracellular signaling domain, e.g., an optimized and/or truncated ITAM-containing primary intracellular signaling domain. In an embodiment, a primary signaling domain comprises one, two, three, four or more ITAM motifs.

[00517] The intracellular signalling domain of the CAR can comprise the CD3-zeta signaling domain by itself or it can be combined with any other desired intracellular signaling domain(s)

useful in the context of a CAR of the invention. For example, the intracellular signaling domain of the CAR can comprise a CD3 zeta chain portion and a costimulatory signaling domain. The costimulatory signaling domain refers to a portion of the CAR comprising the intracellular domain of a costimulatory molecule. A costimulatory molecule is a cell surface molecule other than an antigen receptor or its ligands that is required for an efficient response of lymphocytes to an antigen. Examples of such molecules include CD27, CD28, 4-1BB (CD137), OX40, CD30, CD40, PD-1, ICOS, lymphocyte function-associated antigen-1 (LFA-1), CD2, CD7, LIGHT, NKG2C, B7-H3, and a ligand that specifically binds with CD83, and the like. For example, CD27 costimulation has been demonstrated to enhance expansion, effector function, and survival of human CART cells in vitro and augments human T cell persistence and antitumor activity in vivo (Song et al. Blood. 2012; 119(3):696-706). Further examples of such costimulatory molecules include MHC class I molecule, TNF receptor proteins, Immunoglobulin-like proteins, cytokine receptors, integrins, signaling lymphocytic activation molecules (SLAM proteins), activating NK cell receptors, BTLA, a Toll ligand receptor, OX40, CD2, CD7, CD27, CD28, CD30, CD40, CDS, ICAM-1, LFA-1 (CD11a/CD18), 4-1BB (CD137), B7-H3, CDS, ICAM-1, ICOS (CD278), GITR, BAFFR, LIGHT, HVEM (LIGHTR), KIRDS2, SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, CD19a, and a ligand that specifically binds with CD83.

[00518] The intracellular signaling sequences within the cytoplasmic portion of the CAR of the invention may be linked to each other in a random or specified order. Optionally, a short oligo- or polypeptide linker, for example, between 2 and 10 amino acids (e.g., 2, 3, 4, 5, 6, 7, 8, 9, or 10 amino acids) in length may form the linkage between intracellular signaling sequence. In one embodiment, a glycine-serine doublet can be used as a suitable linker. In one embodiment, a single amino acid, e.g., an alanine, a glycine, can be used as a suitable linker.

[00519] In one aspect, the intracellular signaling domain is designed to comprise two or more, e.g., 2, 3, 4, 5, or more, costimulatory signaling domains. In an embodiment, the two or more, e.g., 2, 3, 4, 5, or more, costimulatory signaling domains, are separated by a linker molecule, e.g., a linker molecule described herein. In one embodiment, the intracellular signaling domain comprises two costimulatory signaling domains. In some embodiments, the linker molecule is a glycine residue. In some embodiments, the linker is an alanine residue.

[00520] In one aspect, the intracellular signaling domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of CD28. In one aspect, the intracellular signaling domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of 4-1BB. In one aspect, the signaling domain of 4-1BB is a signaling domain of SEQ ID NO: 14. In one aspect, the signaling domain of CD3-zeta is a signaling domain of SEQ ID NO: 18 (mutant CD3 zeta) or SEQ ID NO: 20 (wild type human CD3 zeta).

[00521] In one aspect, the intracellular signaling domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of CD27. In one aspect, the signaling domain of CD27 comprises an amino acid sequence of QRRKYRSNKGESPVEPAEPCRYSCPREEEGSTIPIQEDYRKPEPACSP (SEQ ID NO:16). In one aspect, the signalling domain of CD27 is encoded by a nucleic acid sequence of AGGAGTAAGAGGAGCAGGCTCCTGCACAGTGACTACATGAACATGACTCCCCGCCG CCCCGGGCCCACCCGCAAGCATTACCAGCCCTATGCCCCACCACGCGACTTCGCAGC CTATCGCTCC (SEQ ID NO:17).

[00522] In one aspect, the CAR-expressing cell described herein can further comprise a second CAR, e.g., a second CAR that includes a different antigen binding domain, e.g., to the same target (a cancer associated antigen as described herein) or a different target (e.g., CD19, CD123, CD22, CD30, CD34, 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, 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, TSHR, GPRC5D, CXORF61, CD97, CD179a, ALK, Plysialic acid, PLAC1, GloboH, NY-BR-1,

UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, legumain, HPV E6,E7, MAGE-A1, 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, or IGLL1). In one embodiment, when the CAR-expressing cell comprises two or more different CARs, the antigen binding domains of the different CARs can be such that the antigen binding domains do not interact with one another. For example, a cell expressing a first and second CAR can have an antigen binding domain of the first CAR, e.g., as a fragment, e.g., an scFv, that does not form an association with the antigen binding domain of the second CAR, e.g., the antigen binding domain of the second CAR is a VHH.

[00523] In some embodiments, the antigen binding domain comprises a single domain antigen binding (SDAB) molecules include molecules whose complementary determining regions are part of a single domain polypeptide. Examples include, but are not limited to, heavy chain variable domains, binding molecules naturally devoid of light chains, single domains derived from conventional 4-chain antibodies, engineered domains and single domain scaffolds other than those derived from antibodies. SDAB molecules may be any of the art, or any future single domain molecules. SDAB molecules may be derived from any species including, but not limited to mouse, human, camel, llama, lamprey, fish, shark, goat, rabbit, and bovine. This term also includes naturally occurring single domain antibody molecules from species other than Camelidae and sharks.

[00524] In one aspect, an SDAB molecule can be derived from a variable region of the immunoglobulin found in fish, such as, for example, that which is derived from the immunoglobulin isotype known as Novel Antigen Receptor (NAR) found in the serum of shark. Methods of producing single domain molecules derived from a variable region of NAR ("IgNARs") are described in WO 03/014161 and Streltsov (2005) Protein Sci. 14:2901-2909.

[00525] According to another aspect, an SDAB molecule is a naturally occurring single domain antigen binding molecule known as heavy chain devoid of light chains. Such single domain molecules are disclosed in WO 9404678 and Hamers-Casterman, C. et al. (1993) Nature 363:446-448, for example. For clarity reasons, this variable domain derived from a heavy chain molecule naturally devoid of light chain is known herein as a VHH or nanobody to distinguish it from the conventional VH of four chain immunoglobulins. Such a VHH molecule can be derived from Camelidae species, for example in camel, llama, dromedary, alpaca and guanaco. Other species besides Camelidae may produce heavy chain molecules naturally devoid of light chain; such VHHs are within the scope of the invention.

[00526] The SDAB molecules can be recombinant, CDR-grafted, humanized, camelized, de-immunized and/or in vitro generated (e.g., selected by phage display).

[00527] It has also been discovered, that cells having a plurality of chimeric membrane embedded receptors comprising an antigen binding domain that interactions between the antigen binding domain of the receptors can be undesirable, e.g., because it inhibits the ability of one or more of the antigen binding domains to bind its cognate antigen. Accordingly, disclosed herein are cells having a first and a second non-naturally occurring chimeric membrane embedded receptor comprising antigen binding domains that minimize such interactions. Also disclosed herein are nucleic acids encoding a first and a second non-naturally occurring chimeric membrane embedded receptor comprising a antigen binding domains that minimize such interactions, as well as methods of making and using such cells and nucleic acids. In an embodiment the antigen binding domain of one of said first said second non-naturally occurring chimeric membrane embedded receptor, comprises an scFv, and the other comprises a single VH domain, e.g., a camelid, shark, or lamprey single VH domain, or a single VH domain derived from a human or mouse sequence.

[00528] In some embodiments, the claimed invention comprises a first and second CAR, wherein the antigen binding domain of one of said first CAR said second CAR does not comprise a variable light domain and a variable heavy domain. In some embodiments, the antigen binding domain of one of said first CAR said second CAR is an scFv, and the other is not an scFv. In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises a single VH domain, e.g., a camelid, shark, or lamprey single VH domain, or a

single VH domain derived from a human or mouse sequence. In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises a nanobody. In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises a camelid VHH domain.

[00529] In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises an scFv, and the other comprises a single VH domain, e.g., a camelid, shark, or lamprey single VH domain, or a single VH domain derived from a human or mouse sequence. In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises an scFv, and the other comprises a nanobody. In some embodiments, the antigen binding domain of one of said first CAR said second CAR comprises comprises an scFv, and the other comprises a camelid VHH domain.

[00530] In some embodiments, when present on the surface of a cell, binding of the antigen binding domain of said first CAR to its cognate antigen is not substantially reduced by the presence of said second CAR. In some embodiments, binding of the antigen binding domain of said first CAR to its cognate antigen in the presence of said second CAR is 85%, 90%, 95%, 96%, 97%, 98% or 99% of binding of the antigen binding domain of said first CAR to its cognate antigen in the absence of said second CAR.

[00531] In some embodiments, when present on the surface of a cell, the antigen binding domains of said first CAR said second CAR, associate with one another less than if both were scFv antigen binding domains. In some embodiments, the antigen binding domains of said first CAR said second CAR, associate with one another 85%, 90%, 95%, 96%, 97%, 98% or 99% less than if both were scFv antigen binding domains.

[00532] In another aspect, the CAR-expressing cell described herein can further express another agent, e.g., an agent which enhances the activity of a CAR-expressing cell. For example, in one embodiment, the agent can be an agent which inhibits an inhibitory molecule. Inhibitory molecules, e.g., PD1, can, in some embodiments, decrease the ability of a CAR-expressing cell to mount an immune effector response. Examples of inhibitory molecules include PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and

TGFR beta. In one embodiment, the agent which inhibits an inhibitory molecule, e.g., is a molecule described herein, e.g., an agent that comprises a first polypeptide, e.g., an inhibitory molecule, associated with a second polypeptide that provides a positive signal to the cell, e.g., an intracellular signaling domain described herein. In one embodiment, the agent comprises a first polypeptide, e.g., of an inhibitory molecule such as PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta, or a fragment of any of these (e.g., at least a portion of an extracellular domain of any of these), and a second polypeptide which is an intracellular signaling domain described herein (e.g., comprising a costimulatory domain (e.g., 4-1BB, ICOS, CD27 or CD28, e.g., as described herein) and/or a primary signaling domain (e.g., a CD3 zeta signaling domain described herein). In one embodiment, the agent comprises a first polypeptide of PD1 or a fragment thereof (e.g., at least a portion of an extracellular domain of PD1), and a second polypeptide of an intracellular signaling domain described herein (e.g., a CD28 signaling domain described herein and/or a CD3 zeta signaling domain described herein). In embodiments, the CAR-expressing cell described herein comprises a switch costimulatory receptor, e.g., as described in WO 2013/019615, which is incorporated herein by reference in its entirety. PD1 is an inhibitory member of the CD28 family of receptors that also includes CD28, CTLA-4, ICOS, and BTLA. PD-1 is expressed on activated B cells, T cells and myeloid cells (Agata et al. 1996 Int. Immunol 8:765-75). Two ligands for PD1, PD-L1 and PD-L2 have been shown to downregulate T cell activation upon binding to PD1 (Freeman et a. 2000 J Exp Med 192:1027-34; Latchman et al. 2001 Nat Immunol 2:261-8; Carter et al. 2002 Eur J Immunol 32:634-43). PD-L1 is abundant in human cancers (Dong et al. 2003 J Mol Med 81:281-7; Blank et al. 2005 Cancer Immunol. Immunother 54:307-314; Konishi et al. 2004 Clin Cancer Res 10:5094). Immune suppression can be reversed by inhibiting the local interaction of PD1 with PD-L1.

[00533] In an embodiment, the extracellular binding domain is an extracellular domain specific for a counter ligand, e.g, the extracellular domain is from PD1 and the counter ligand is PD1-L1 or PD1-L2).

[00534] In one embodiment, the agent comprises the extracellular domain (ECD) of an inhibitory molecule, e.g., Programmed Death 1 (PD1), can be fused to a transmembrane domain

and intracellular signaling domains such as 4-1BB and CD3 zeta (also referred to herein as a PD1 CAR). In one embodiment, the PD1 CAR, when used incombinations with a XCAR described herein, improves the persistence of the T cell. In one embodiment, the CAR is a PD1 CAR comprising the extracellular domain of PD1 indicated as underlined in SEQ ID NO: 26. In one embodiment, the PD1 CAR comprises the amino acid sequence of SEQ ID NO:26.

[00535] Malpvtalllplalllhaarppgwfldspdrpwnpptfspallvvtegdnatftcsfsntsesfvlnwyrmspsnqtdkl aafpedrsqpgqdcrfrvtqlpngrdfhmsvvrarrndsgtylcgaislapkaqikeslraelrvterraevptahpspsprpagqfqtlvt ttpaprpptpaptiasqplslrpeacrpaaggavhtrgldfacdiyiwaplagtcgvlllslvitlyckrgrkkllyifkqpfmrpvqttqeed gcscrfpeeeeggcelrvkfsrsadapaykqgqnqlynelnlgrreeydvldkrrgrdpemggkprrknpqeglynelqkdkmaea yseigmkgerrrgkghdglyqglstatkdtydalhmqalppr (SEQ ID NO:26).

[00536] In one embodiment, the PD1 CAR comprises the amino acid sequence provided below (SEQ ID NO:39).

[00537] pgwfldspdrpwnpptfspallvvtegdnatftcsfsntsesfvlnwyrmspsnqtdklaafpedrsqpgqdcrfrvtq lpngrdfhmsvvrarrndsgtylcgaislapkaqikeslraelrvterraevptahpspsprpagqfqtlvtttpaprpptpaptiasqplslr peacrpaaggavhtrgldfacdiyiwaplagtcgvlllslvitlyckrgrkkllyifkqpfmrpvqttqeedgcscrfpeeeeggcelrvkf srsadapaykqgqnqlynelnlgrreeydvldkrrgrdpemggkprrknpqeglynelqkdkmaeayseigmkgerrrgkghdgl yqglstatkdtydalhmqalppr (SEQ ID NO:39).

[00538] In one embodiment, the agent comprises a nucleic acid sequence encoding the PD1 CAR, e.g., the PD1 CAR described herein. In one embodiment, the nucleic acid sequence for the PD1 CAR is shown below, with the PD1 ECD underlined below in SEQ ID NO: 27

[00539] atggccctccctgtcactgccctgcttctccccctcgcactcctgctccacgccgctagaccacccggatggtttctggactc tccggatcgcccgtggaatcccccaaccttctcaccggcactcttggttgtgactgagggcgataatgcgaccttcacgtgctcgttctccaa cacctccgaatcattcgtgctgaactggtaccgcatgagcccgtcaaaccagaccgacaagctcgccgcgtttccggaagatcggtcgcaa ccgggacaggattgtcggttccgcgtgactcaactgccgaatggcagagacttccacatgagcgtggtccgcgctaggcgaaacgactcc gggacctacctgtgcggagccatctcgctggcgcctaaggcccaaatcaaagagagcttgagggccgaactgagagtgaccgagcgca gagctgaggtgccaactgcacatccatccccatcgcctcggcctgcggggcagtttcagaccctggtcacgaccactccggcgccgcgc ccaccgactccggccccaactatcgcgagccagcccctgtcgctgaggccggaagcatgccgccctgccgccggaggtgctgtgcatac ccggggattggacttcgcatgcgacatctacatttgggctcctctcgccggaacttgtggcgtgctccttctgtccctggtcatcaccctgtact gcaagcggggtcggaaaaagcttctgtacattttcaagcagcccttcatgaggcccgtgcaaaccacccaggaggaggacggttgctcct gccggttccccgaagaggaagaaggaggttgcgagctgcgcgtgaagttctcccggagcgccgacgcccccgcctataagcagggcca

gaaccagctgtacaacgaactgaacctgggacggcgggaagagtacgatgtgctggacaagcggcgcggccgggaccccgaaatggg cgggaagcctagaagaaagaaccctcaggaaggcctgtataacgagctgcagaaggacaagatggccgaggcctactccgaaattggg atgaagggagagcggcggaggggaaaggggcacgacggcctgtaccaaggactgtccaccgccaccaaggacacatacgatgccct gcacatgcaggcccttcccccctcgc (SEQ ID NO: 27).

[00540] In another aspect, the present invention provides a population of CAR-expressing cells, e.g., CAR-expressing cells for use with administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor. In some embodiments, the population of CAR-expressing cells comprises a mixture of cells expressing different CARs. For example, in one embodiment, the population of CART cells can include a first cell expressing a CAR having an anti- cancer associated antigen as described herein binding domain described herein, and a second cell expressing a CAR having a different anti- cancer associated antigen as described herein binding domain, e.g., an anti- cancer associated antigen as described herein binding domain described herein that differs from the anti-cancer associated antigen as described herein binding domain in the CAR expressed by the first cell. As another example, the population of CAR-expressing cells can include a first cell expressing a CAR that includes an anti- cancer associated antigen as described herein binding domain, e.g., as described herein, and a second cell expressing a CAR that includes an antigen binding domain to a target other than a cancer associated antigen as described herein (e.g., CD123). In one embodiment, the population of CAR-expressing cells includes, e.g., a first cell expressing a CAR that includes a primary intracellular signaling domain, and a second cell expressing a CAR that includes a secondary signaling domain.

[00541] In another aspect, the present invention provides a population of cells wherein at least one cell in the population expresses a CAR having an anti- cancer associated antigen binding domain as described herein domain, and a second cell expressing another agent, e.g., an agent which enhances the activity of a CAR-expressing cell. For example, in one embodiment, the agent can be an agent which inhibits an inhibitory molecule. Inhibitory molecules, e.g., PD-1, can, in some embodiments, decrease the ability of a CAR-expressing cell to mount an immune effector response. Examples of inhibitory molecules include PD-1, PD-L1, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4 and TGFR beta. In one embodiment, the agent which inhibits an inhibitory molecule, e.g., is a molecule described herein, e.g., an agent that comprises a first

polypeptide, e.g., an inhibitory molecule, associated with a second polypeptide that provides a positive signal to the cell, e.g., an intracellular signaling domain described herein. In one embodiment, the agent comprises a first polypeptide, e.g., of an inhibitory molecule such as PD1, PD-L1, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4 or TGFR beta, or a fragment of any of these, and a second polypeptide which is an intracellular signaling domain described herein (e.g., comprising a costimulatory domain (e.g., 4-1BB, CD27, OX40, ICOS, or CD28, e.g., as described herein) and/or a primary signaling domain (e.g., a CD3 zeta signaling domain described herein). In one embodiment, the agent comprises a first polypeptide of PD-1 or a fragment thereof (e.g., at least a portion of the extracellular domain of PD1), and a second polypeptide of an intracellular signaling domain described herein (e.g., a CD28 signaling domain described herein and/or a CD3 zeta signaling domain described herein).

[00542] In one aspect, the present invention provides methods comprising administering a population of CAR-expressing cells, e.g., CART cells, e.g., a mixture of cells expressing different CARs, in combination with another agent, e.g., a kinase inhibitor, such as a kinase inhibitor described herein. In another aspect, the present invention provides methods comprising administering a population of cells wherein at least one cell in the population expresses a CAR having an anti- cancer associated antigen binding domain as described herein, and a second cell expressing another agent, e.g., an agent which enhances the activity of a CAR-expressing cell, in combination with another agent, e.g., a kinase inhibitor, such as a kinase inhibitor described herein.

## Natural Killer Cell Receptor (NKR) CARs

[00543] In an embodiment, the CAR molecule described herein comprises one or more components of a natural killer cell receptor (NKR), thereby forming an NKR-CAR. The NKR component can be a transmembrane domain, a hinge domain, or a cytoplasmic domain from any of the following natural killer cell receptors: killer cell immunoglobulin-like receptor (KIR), e.g., KIR2DL1, KIR2DL2/L3, KIR2DL4, KIR2DL5A, KIR2DL5B, KIR2DS1, KIR2DS2, KIR2DS3, KIR2DS4, DIR2DS5, KIR3DL1/S1, KIR3DL2, KIR3DL3, KIR2DP1, and KIR3DP1; natural cytoxicity receptor (NCR), e.g., NKp30, NKp44, NKp46; signaling lymphocyte activation molecule (SLAM) family of immune cell receptors, e.g., CD48, CD229, 2B4, CD84, NTB-A,

CRACC, BLAME, and CD2F-10; Fc receptor (FcR), e.g., CD16, and CD64; and Ly49 receptors, e.g., LY49A, LY49C. The NKR-CAR molecules described herein may interact with an adaptor molecule or intracellular signaling domain, e.g., DAP12. Exemplary configurations and sequences of CAR molecules comprising NKR components are described in International Publication No. WO2014/145252, the contents of which are hereby incorporated by reference.

**Strategies for Regulating Chimeric Antigen Receptors**

[00544] There are many ways CAR activities can be regulated. In some embodiments, a regulatable CAR (RCAR) where the CAR activity can be controlled is desirable to optimize the safety and efficacy of a CAR therapy. For example, inducing apoptosis using, e.g., a caspase fused to a dimerization domain (see, e.g., Di et al., N Engl. J. Med. 2011 Nov. 3; 365(18):1673-1683), can be used as a safety switch in the CAR therapy of the instant invention. In another example, CAR-expressing cells can also express an inducible Caspase-9 (iCaspase-9) molecule that, upon administration of a dimerizer drug (e.g., rimiducid (also called AP1903 (Bellicum Pharmaceuticals) or AP20187 (Ariad)) leads to activation of the Caspase-9 and apoptosis of the cells. The iCaspase-9 molecule contains a chemical inducer of dimerization (CID) binding domain that mediates dimerization in the presence of a CID. This results in inducible and selective depletion of CAR-expressing cells. In some cases, the iCaspase-9 molecule is encoded by a nucleic acid molecule separate from the CAR-encoding vector(s). In some cases, the iCaspase-9 molecule is encoded by the same nucleic acid molecule as the CAR-encoding vector. The iCaspase-9 can provide a safety switch to avoid any toxicity of CAR-expressing cells. See, e.g., Song et al. Cancer Gene Ther. 2008; 15(10):667-75; Clinical Trial Id. No. NCT02107963; and Di Stasi et al. N. Engl. J. Med. 2011; 365:1673-83.

[00545] Alternative strategies for regulating the CAR therapy of the instant invention include utilizing small molecules or antibodies that deactivate or turn off CAR activity, e.g., by deleting CAR-expressing cells, e.g., by inducing antibody dependent cell-mediated cytotoxicity (ADCC). For example, CAR-expressing cells described herein may also express an antigen that is recognized by molecules capable of inducing cell death, e.g., ADCC or compliment-induced cell death. For example, CAR expressing cells described herein may also express a receptor capable of being targeted by an antibody or antibody fragment. Examples of such receptors include

EpCAM, VEGFR, integrins (e.g., integrins αvβ3, α4, αI3/4β3, α4β7, α5β1, αvβ3, αv), members of the TNF receptor superfamily (e.g., TRAIL-R1 , TRAIL-R2), PDGF Receptor, interferon receptor, folate receptor, GPNMB, ICAM-1 , HLA-DR, CEA, CA-125, MUC1 , TAG-72, IL-6 receptor, 5T4, GD2, GD3, CD2, CD3, CD4, CD5, CD1 1 , CD1 1 a/LFA-1 , CD15, CD18/ITGB2, CD19, CD20, CD22, CD23/lgE Receptor, CD25, CD28, CD30, CD33, CD38, CD40, CD41 , CD44, CD51 , CD52, CD62L, CD74, CD80, CD125, CD147/basigin, CD152/CTLA-4, CD154/CD40L, CD195/CCR5, CD319/SLAMF7, and EGFR, and truncated versions thereof (e.g., versions preserving one or more extracellular epitopes but lacking one or more regions within the cytoplasmic domain). For example, CAR-expressing cells described herein may also express a truncated epidermal growth factor receptor (EGFR) which lacks signaling capacity but retains the epitope that is recognized by molecules capable of inducing ADCC, e.g., cetuximab (ERBITUX®), such that administration of cetuximab induces ADCC and subsequent depletion of the CAR-expressing cells (see, e.g., WO2011/056894, and Jonnalagadda et al., Gene Ther. 2013; 20(8)853-860). Another strategy includes expressing a highly compact marker/suicide gene that combines target epitopes from both CD32 and CD20 antigens in the CAR-expressing cells described herein, which binds rituximab, resulting in selective depletion of the CAR-expressing cells, e.g., by ADCC (see, e.g., Philip et al., Blood. 2014; 124(8)1277-1287). Other methods for depleting CAR-expressing cells described herein include administration of CAMPATH®, a monoclonal anti-CD52 antibody that selectively binds and targets mature lymphocytes, e.g., CAR-expressing cells, for destruction, e.g., by inducing ADCC. In other embodiments, the CAR-expressing cell can be selectively targeted using a CAR ligand, e.g., an anti-idiotypic antibody. In some embodiments, the anti-idiotypic antibody can cause effector cell activity, e.g, ADCC or ADC activities, thereby reducing the number of CAR-expressing cells. In other embodiments, the CAR ligand, e.g., the anti-idiotypic antibody can be coupled to an agent that induces cell killing, e.g., a toxin, thereby reducing the number of CAR-expressing cells. In other embodiments, CAR-expressing cells can be selectively targeted using a CAR ligand, e.g., an anti-idiotypic antibody. In some embodiments, the anti-idiotypic antibody can cause effector cell activity, e.g, ADCC or ADC activities, thereby reducing the number of CAR-expressing cells. In other embodiments, the CAR ligand, e.g., the anti-idiotypic antibody, can be coupled to an agent that induces cell killing, e.g., a toxin, thereby reducing the number of

CAR-expressing cells. Alternatively, the CAR molecules themselves can be configured such that the activity can be regulated, e.g., turned on and off, as described below.

[00546] In an aspect, a RCAR comprises a set of polypeptides, typically two in the simplest embodiments, in which the components of a standard CAR described herein, e.g., an antigen binding domain and an intracellular signaling domain, are partitioned on separate polypeptides or members. In some embodiments, the set of polypeptides include a dimerization switch that, upon the presence of a dimerization molecule, can couple the polypeptides to one another, e.g., can couple an antigen binding domain to an intracellular signaling domain. In one embodiment, the CARs of the present invention utilizes a dimerization switch as those described in, e.g., WO2014127261, which is incorporated by reference herein. Additional description and exemplary configurations of such regulatable CARs are provided herein and in International Publiciation No. WO 2015/090229, hereby incorporated by reference in its entirety.

[00547] In an aspect, an RCAR comprises two polypeptides or members: 1) an intracellular signaling member comprising an intracellular signaling domain, e.g., a primary intracellular signaling domain described herein, and a first switch domain; 2) an antigen binding member comprising an antigen binding domain, e.g., that targets CD19, as described herein and a second switch domain. Optionally, the RCAR comprises a transmembrane domain described herein. In an embodiment, a transmembrane domain can be disposed on the intracellular signaling member, on the antigen binding member, or on both. (Unless otherwise indicated, when members or elements of an RCAR are described herein, the order can be as provided, but other orders are included as well. In other words, in an embodiment, the order is as set out in the text, but in other embodiments, the order can be different. E.g., the order of elements on one side of a transmembrane region can be different from the example, e.g., the placement of a switch domain relative to a intracellular signaling domain can be different, e.g., reversed).

[00548] In an embodiment, the first and second switch domains can form an intracellular or an extracellular dimerization switch. In an embodiment, the dimerization switch can be a homodimerization switch, e.g., where the first and second switch domain are the same, or a heterodimerization switch, e.g., where the first and second switch domain are different from one another.

[00549] In embodiments, an RCAR can comprise a "multi switch." A multi switch can comprise heterodimerization switch domains or homodimerization switch domains. A multi switch comprises a plurality of, e.g., 2, 3, 4, 5, 6, 7, 8, 9, or 10, switch domains, independently, on a first member, e.g., an antigen binding member, and a second member, e.g., an intracellular signaling member. In an embodiment, the first member can comprise a plurality of first switch domains, e.g., FKBP-based switch domains, and the second member can comprise a plurality of second switch domains, e.g., FRB-based switch domains. In an embodiment, the first member can comprise a first and a second switch domain, e.g., a FKBP-based switch domain and a FRB-based switch domain, and the second member can comprise a first and a second switch domain, e.g., a FKBP-based switch domain and a FRB-based switch domain.

[00550] In an embodiment, the intracellular signaling member comprises one or more intracellular signaling domains, e.g., a primary intracellular signaling domain and one or more costimulatory signaling domains.

[00551] In an embodiment, the antigen binding member may comprise one or more intracellular signaling domains, e.g., one or more costimulatory signaling domains. In an embodiment, the antigen binding member comprises a plurality, e.g., 2 or 3 costimulatory signaling domains described herein, e.g., selected from 4-1BB, CD28, CD27, ICOS, and OX40, and in embodiments, no primary intracellular signaling domain. In an embodiment, the antigen binding member comprises the following costimulatory signaling domains, from the extracellular to intracellular direction: 4-1BB - CD27; 4-1BB - CD27; CD27 - 4-1BB; 4-1BB - CD28; CD28 - 4-1BB; OX40 - CD28; CD28 - OX40; CD28 - 4-1BB; or 4-1BB - CD28. In such embodiments, the intracellular binding member comprises a CD3zeta domain. In one such embodiment the RCAR comprises (1) an antigen binding member comprising, an antigen binding domain, a transmembrane domain, and two costimulatory domains and a first switch domain; and (2) an intracellular signaling domain comprising a transmembrane domain or membrane tethering domain and at least one primary intracellular signaling domain, and a second switch domain.

[00552] An embodiment provides RCARs wherein the antigen binding member is not tethered to the surface of the CAR cell. This allows a cell having an intracellular signaling member to be conveniently paired with one or more antigen binding domains, without transforming the cell with a sequence that encodes the antigen binding member. In such embodiments, the RCAR

comprises: 1) an intracellular signaling member comprising: a first switch domain, a transmembrane domain, an intracellular signaling domain, e.g., a primary intracellular signaling domain, and a first switch domain; and 2) an antigen binding member comprising: an antigen binding domain, and a second switch domain, wherein the antigen binding member does not comprise a transmembrane domain or membrane tethering domain, and, optionally, does not comprise an intracellular signaling domain. In some embodiments, the RCAR may further comprise 3) a second antigen binding member comprising: a second antigen binding domain, e.g., a second antigen binding domain that binds a different antigen than is bound by the antigen binding domain; and a second switch domain.

[00553] Also provided herein are RCARs wherein the antigen binding member comprises bispecific activation and targeting capacity. In this embodiment, the antigen binding member can comprise a plurality, e.g., 2, 3, 4, or 5 antigen binding domains, e.g., scFvs, wherein each antigen binding domain binds to a target antigen, e.g. different antigens or the same antigen, e.g., the same or different epitopes on the same antigen. In an embodiment, the plurality of antigen binding domains are in tandem, and optionally, a linker or hinge region is disposed between each of the antigen binding domains. Suitable linkers and hinge regions are described herein.

[00554] An embodiment provides RCARs having a configuration that allows switching of proliferation. In this embodiment, the RCAR comprises: 1) an intracellular signaling member comprising: optionally, a transmembrane domain or membrane tethering domain; one or more co-stimulatory signaling domain, e.g., selected from 4-1BB, CD28, CD27, ICOS, and OX40, and a switch domain; and 2) an antigen binding member comprising: an antigen binding domain, a transmembrane domain, and a primary intracellular signaling domain, e.g., a CD3zeta domain, wherein the antigen binding member does not comprise a switch domain, or does not comprise a switch domain that dimerizes with a switch domain on the intracellular signaling member. In an embodiment, the antigen binding member does not comprise a co-stimulatory signaling domain. In an embodiment, the intracellular signaling member comprises a switch domain from a homodimerization switch. In an embodiment, the intracellular signaling member comprises a first switch domain of a heterodimerization switch and the RCAR comprises a second intracellular signaling member which comprises a second switch domain of the heterodimerization switch. In such embodiments, the second intracellular signaling member comprises the same intracellular signaling domains as the intracellular signaling member. In an

embodiment, the dimerization switch is intracellular. In an embodiment, the dimerization switch is extracellular.

[00555] In any of the RCAR configurations described here, the first and second switch domains comprise a FKBP-FRB based switch as described herein.

[00556] Also provided herein are cells comprising an RCAR described herein. Any cell that is engineered to express a RCAR can be used as a RCARX cell. In an embodiment the RCARX cell is a T cell, and is referred to as a RCART cell. In an embodiment the RCARX cell is an NK cell, and is referred to as a RCARN cell.

[00557] Also provided herein are nucleic acids and vectors comprising RCAR encoding sequences. Sequence encoding various elements of an RCAR can be disposed on the same nucleic acid molecule, e.g., the same plasmid or vector, e.g., viral vector, e.g., lentiviral vector. In an embodiment, (i) sequence encoding an antigen binding member and (ii) sequence encoding an intracellular signaling member, can be present on the same nucleic acid, e.g., vector. Production of the corresponding proteins can be achieved, e.g., by the use of separate promoters, or by the use of a bicistronic transcription product (which can result in the production of two proteins by cleavage of a single translation product or by the translation of two separate protein products). In an embodiment, a sequence encoding a cleavable peptide, e.g., a P2A or F2A sequence, is disposed between (i) and (ii). In an embodiment, a sequence encoding an IRES, e.g., an EMCV or EV71 IRES, is disposed between (i) and (ii). In these embodiments, (i) and (ii) are transcribed as a single RNA. In an embodiment, a first promoter is operably linked to (i) and a second promoter is operably linked to (ii), such that (i) and (ii) are transcribed as separate mRNAs.

[00558] Alternatively, the sequence encoding various elements of an RCAR can be disposed on the different nucleic acid molecules, e.g., different plasmids or vectors, e.g., viral vector, e.g., lentiviral vector. E.g., the (i) sequence encoding an antigen binding member can be present on a first nucleic acid, e.g., a first vector, and the (ii) sequence encoding an intracellular signaling member can be present on the second nucleic acid, e.g., the second vector.

*Dimerization switches*

[00559] Dimerization switches can be non-covalent or covalent. In a non-covalent dimerization switch, the dimerization molecule promotes a non-covalent interaction between the switch domains. In a covalent dimerization switch, the dimerization molecule promotes a covalent interaction between the switch domains.

[00560] In an embodiment, the RCAR comprises a FKBP/FRAP, or FKBP/FRB,-based dimerization switch. FKBP12 (FKBP, or FK506 binding protein) is an abundant cytoplasmic protein that serves as the initial intracellular target for the natural product immunosuppressive drug, rapamycin. Rapamycin binds to FKBP and to the large PI3K homolog FRAP (RAFT, mTOR). FRB is a 93 amino acid portion of FRAP, that is sufficient for binding the FKBP-rapamycin complex (Chen, J., Zheng, X. F., Brown, E. J. & Schreiber, S. L. (1995) *Identification of an 11-kDa FKBP12-rapamycin-binding domain within the 289-kDa FKBP12-rapamycin-associated protein and characterization of a critical serine residue*. Proc Natl Acad Sci U S A 92: 4947-51.)

[00561] In embodiments, an FKBP/FRAP, e.g., an FKBP/FRB, based switch can use a dimerization molecule, e.g., rapamycin or a rapamycin analog.

[00562] The amino acid sequence of FKBP is as follows:

D V P D Y A S L G G P S S P K K K R K V S R G V Q V E T I S P G D G R T F P K R G Q T C V V H Y T G M L E D G K K F D S S R D R N K P F K F M L G K Q E V I R G W E E G V A Q M S V G Q R A K L T I S P D Y A Y G A T G H P G I I P P H A T L V F D V E L L K L E T S Y (SEQ ID NO: 79)

[00563] In embodiments, an FKBP switch domain can comprise a fragment of FKBP having the ability to bind with FRB, or a fragment or analog thereof, in the presence of rapamycin or a rapalog, e.g., the underlined portion of SEQ ID NO: 79, which is:

V Q V E T I S P G D G R T F P K R G Q T C V V H Y T G M L E D G K K F D S S R D R N K P F K F M L G K Q E V I R G W E E G V A Q M S V G Q R A K L T I S P D Y A Y G A T G H P G I I P P H A T L V F D V E L L K L E T S (SEQ ID NO: 80)

[00564] The amino acid sequence of FRB is as follows:

ILWHEMWHEG LEEASRLYFG ERNVKGMFEV LEPLHAMMER GPQTLKETSF NQAYGRDLME AQEWCRKYMK SGNVKDLTQA WDLYYHVFRR ISK (SEQ ID NO: 81)

[00565] "FKBP/FRAP, e.g., an FKBP/FRB, based switch" as that term is used herein, refers to a dimerization switch comprising: a first switch domain, which comprises an FKBP fragment or analog thereof having the ability to bind with FRB, or a fragment or analog thereof, in the presence of rapamycin or a rapalog, e.g., RAD001, and has at least 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99% identity with, or differs by no more than 30, 25, 20, 15, 10, 5, 4, 3, 2, or 1 amino acid residues from, the FKBP sequence of SEQ ID NO: 79 or 80; and a second switch domain, which comprises an FRB fragment or analog thereof having the ability to bind with FRB, or a fragment or analog thereof, in the presence of rapamycin or a rapalog, and has at least 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99% identity with, or differs by no more than 30, 25, 20, 15, 10, 5, 4, 3, 2, or 1 amino acid residues from, the FRB sequence of SEQ ID NO: 81. In an embodiment, a RCAR described herein comprises one switch domain comprises amino acid residues disclosed in SEQ ID NO: 79 (or SEQ ID NO: 80), and one switch domain comprises amino acid residues disclosed in SEQ ID NO: 81.

[00566] In embodiments, the FKBP/FRB dimerization switch comprises a modified FRB switch domain that exhibits altered, e.g., enhanced, complex formation between an FRB-based switch domain, e.g., the modified FRB switch domain, a FKBP-based switch domain, and the dimerization molecule, e.g., rapamycin or a rapalogue, e.g., RAD001. In an embodiment, the modified FRB switch domain comprises one or more mutations, e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10 or more, selected from mutations at amino acid position(s) L2031, E2032, S2035, R2036, F2039, G2040, T2098, W2101, D2102, Y2105, and F2108, where the wild-type amino acid is mutated to any other naturally-occurring amino acid. In an embodiment, a mutant FRB comprises a mutation at E2032, where E2032 is mutated to phenylalanine (E2032F), methionine (E2032M), arginine (E2032R), valine (E2032V), tyrosine (E2032Y), isoleucine (E2032I), e.g., SEQ ID NO: 82, or leucine (E2032L), e.g., SEQ ID NO: 83. In an embodiment, a mutant FRB comprises a mutation at T2098, where T2098 is mutated to phenylalanine (T2098F) or leucine (T2098L), e.g., SEQ ID NO: 84. In an embodiment, a mutant FRB comprises a mutation at E2032 and at T2098, where E2032 is mutated to any amino acid, and where T2098 is mutated to any amino acid, e.g., SEQ ID NO: 85. In an embodiment, a mutant FRB comprises an E2032I and a

T2098L mutation, e.g., SEQ ID NO: 86. In an embodiment, a mutant FRB comprises an E2032L and a T2098L mutation, e.g., SEQ ID NO: 87.

[00567] Table 10. Exemplary mutant FRB having increased affinity for a dimerization molecule.

| FRB mutant | Amino Acid Sequence | SEQ ID NO: |
|---|---|---|
| E2032I mutant | ILWHEMWHEGLIEASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDLTQAWDLYYHVFRRISKTS | 82 |
| E2032L mutant | ILWHEMWHEGLLEASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDLTQAWDLYYHVFRRISKTS | 83 |
| T2098L mutant | ILWHEMWHEGLEEASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDLLQAWDLYYHVFRRISKTS | 84 |
| E2032, T2098 mutant | ILWHEMWHEGL**X**EASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDL**X**QAWDLYYHVFRRISKTS | 85 |
| E2032I, T2098L mutant | ILWHEMWHEGLIEASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDLLQAWDLYYHVFRRISKTS | 86 |
| E2032L, T2098L mutant | ILWHEMWHEGLLEASRLYFGERNVKGMFEVLEPLHAMMERGPQTLKETSFNQAYGR DLMEAQEWCRKYMKSGNVKDLLQAWDLYYHVFRRISKTS | 87 |

[00568] Other suitable dimerization switches include a GyrB-GyrB based dimerization switch, a Gibberellin-based dimerization switch, a tag/binder dimerization switch, and a halo-tag/snap-tag dimerization switch. Following the guidance provided herein, such switches and relevant dimerization molecules will be apparent to one of ordinary skill.

*Dimerization molecule*

[00569] Association between the switch domains is promoted by the dimerization molecule. In the presence of dimerization molecule interaction or association between switch domains allows for signal transduction between a polypeptide associated with, e.g., fused to, a first switch domain, and a polypeptide associated with, e.g., fused to, a second switch domain. In the presence of non-limiting levels of dimerization molecule signal transduction is increased by 1.1,

1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 5, 10, 50, 100 fold, e.g., as measured in a system described herein.

[00570] Rapamycin and rapamycin analogs (sometimes referred to as rapalogues), e.g., RAD001, can be used as dimerization molecules in a FKBP/FRB-based dimerization switch described herein. In an embodiment the dimerization molecule can be selected from rapamycin (sirolimus), RAD001 (everolimus), zotarolimus, temsirolimus, AP-23573 (ridaforolimus), biolimus and AP21967. Additional rapamycin analogs suitable for use with FKBP/FRB-based dimerization switches are further described in the section entitled "Combination Therapies", or in the subsection entitled "mTOR inhibitors".

## Split CAR

In some embodiments, the CAR-expressing cell uses a split CAR. The split CAR approach is described in more detail in publications WO2014/055442 and WO2014/055657. Briefly, a split CAR system comprises a cell expressing a first CAR having a first antigen binding domain and a costimulatory domain (e.g., 4-1BB), and the cell also expresses a second CAR having a second antigen binding domain and an intracellular signaling domain (e.g., CD3 zeta). When the cell encounters the first antigen, the costimulatory domain is activated, and the cell proliferates. When the cell encounters the second antigen, the intracellular signaling domain is activated and cell-killing activity begins. Thus, the CAR-expressing cell is only fully activated in the presence of both antigens. In embodiments, the first antigen binding domain recognizes a cancer associated antigen described herein (e.g., CD19, CD123, CD22, CD30, CD34, 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, 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, TSHR, GPRC5D, CXORF61, CD97, CD179a, ALK, Plysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, legumain, HPV E6,E7, MAGE-A1, 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, or IGLL1).

**RNA Transfection**

[00571] Disclosed herein are methods for producing an in vitro transcribed RNA CAR. The present invention also includes a CAR encoding RNA construct that can be directly transfected into a cell for use with administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor. A method for generating mRNA for use in transfection can involve in vitro transcription (IVT) of a template with specially designed primers, followed by polyA addition, to produce a construct containing 3' and 5' untranslated sequence ("UTR"), a 5' cap and/or Internal Ribosome Entry Site (IRES), the nucleic acid to be expressed, and a polyA tail, typically 50-2000 bases in length (SEQ ID NO:32). RNA so produced can efficiently transfect different kinds of cells. In one aspect, the template includes sequences for the CAR.

[00572] In one aspect the anti-CARs of the present invention is encoded by a messenger RNA (mRNA). In one aspect the mRNA encoding the anti-CARs of the present invention is introduced into an immune effector cell, e.g., a T cell or NK cell, for production of a CAR-expressing cell, e.g., a CART cell or a CAR NK.

[00573] In one embodiment, the in vitro transcribed RNA CAR can be introduced to a cell as a form of transient transfection. The RNA is produced by in vitro transcription using a polymerase chain reaction (PCR)-generated template. DNA of interest from any source can be directly converted by PCR into a template for in vitro mRNA synthesis using appropriate primers and RNA polymerase. The source of the DNA can be, for example, genomic DNA, plasmid DNA, phage DNA, cDNA, synthetic DNA sequence or any other appropriate source of DNA. The desired temple for in vitro transcription is a CAR of the present invention. For example, the template for the RNA CAR comprises an extracellular region comprising a single chain variable

domain of an anti-tumor antibody; a hinge region, a transmembrane domain (e.g., a transmembrane domain of CD8a); and a cytoplasmic region that includes an intracellular signaling domain, e.g., comprising the signaling domain of CD3-zeta and the signaling domain of 4-1BB.

[00574] In one embodiment, the DNA to be used for PCR contains an open reading frame. The DNA can be from a naturally occurring DNA sequence from the genome of an organism. In one embodiment, the nucleic acid can include some or all of the 5' and/or 3' untranslated regions (UTRs). The nucleic acid can include exons and introns. In one embodiment, the DNA to be used for PCR is a human nucleic acid sequence. In another embodiment, the DNA to be used for PCR is a human nucleic acid sequence including the 5' and 3' UTRs. The DNA can alternatively be an artificial DNA sequence that is not normally expressed in a naturally occurring organism. An exemplary artificial DNA sequence is one that contains portions of genes that are ligated together to form an open reading frame that encodes a fusion protein. The portions of DNA that are ligated together can be from a single organism or from more than one organism.

[00575] PCR is used to generate a template for in vitro transcription of mRNA which is used for transfection. Methods for performing PCR are well known in the art. Primers for use in PCR are designed to have regions that are substantially complementary to regions of the DNA to be used as a template for the PCR. "Substantially complementary," as used herein, refers to sequences of nucleotides where a majority or all of the bases in the primer sequence are complementary, or one or more bases are non-complementary, or mismatched. Substantially complementary sequences are able to anneal or hybridize with the intended DNA target under annealing conditions used for PCR. The primers can be designed to be substantially complementary to any portion of the DNA template. For example, the primers can be designed to amplify the portion of a nucleic acid that is normally transcribed in cells (the open reading frame), including 5' and 3' UTRs. The primers can also be designed to amplify a portion of a nucleic acid that encodes a particular domain of interest. In one embodiment, the primers are designed to amplify the coding region of a human cDNA, including all or portions of the 5' and 3' UTRs. Primers useful for PCR can be generated by synthetic methods that are well known in the art. "Forward primers" are primers that contain a region of nucleotides that are substantially complementary to nucleotides on the DNA template that are upstream of the DNA sequence that is to be amplified. "Upstream" is used herein to refer to a location 5, to the DNA sequence to be

amplified relative to the coding strand. “Reverse primers” are primers that contain a region of nucleotides that are substantially complementary to a double-stranded DNA template that are downstream of the DNA sequence that is to be amplified. “Downstream” is used herein to refer to a location 3' to the DNA sequence to be amplified relative to the coding strand.

[00576] Any DNA polymerase useful for PCR can be used in the methods disclosed herein. The reagents and polymerase are commercially available from a number of sources.

[00577] Chemical structures with the ability to promote stability and/or translation efficiency may also be used. The RNA preferably has 5' and 3' UTRs. In one embodiment, the 5' UTR is between one and 3000 nucleotides in length. The length of 5' and 3' UTR sequences to be added to the coding region can be altered by different methods, including, but not limited to, designing primers for PCR that anneal to different regions of the UTRs. Using this approach, one of ordinary skill in the art can modify the 5' and 3' UTR lengths required to achieve optimal translation efficiency following transfection of the transcribed RNA.

[00578] The 5' and 3' UTRs can be the naturally occurring, endogenous 5' and 3' UTRs for the nucleic acid of interest. Alternatively, UTR sequences that are not endogenous to the nucleic acid of interest can be added by incorporating the UTR sequences into the forward and reverse primers or by any other modifications of the template. The use of UTR sequences that are not endogenous to the nucleic acid of interest can be useful for modifying the stability and/or translation efficiency of the RNA. For example, it is known that AU-rich elements in 3' UTR sequences can decrease the stability of mRNA. Therefore, 3' UTRs can be selected or designed to increase the stability of the transcribed RNA based on properties of UTRs that are well known in the art.

[00579] In one embodiment, the 5' UTR can contain the Kozak sequence of the endogenous nucleic acid. Alternatively, when a 5' UTR that is not endogenous to the nucleic acid of interest is being added by PCR as described above, a consensus Kozak sequence can be redesigned by adding the 5' UTR sequence. Kozak sequences can increase the efficiency of translation of some RNA transcripts, but does not appear to be required for all RNAs to enable efficient translation. The requirement for Kozak sequences for many mRNAs is known in the art. In other embodiments the 5' UTR can be 5’UTR of an RNA virus whose RNA genome is stable in cells.

In other embodiments various nucleotide analogues can be used in the 3' or 5' UTR to impede exonuclease degradation of the mRNA.

[00580] To enable synthesis of RNA from a DNA template without the need for gene cloning, a promoter of transcription should be attached to the DNA template upstream of the sequence to be transcribed. When a sequence that functions as a promoter for an RNA polymerase is added to the 5' end of the forward primer, the RNA polymerase promoter becomes incorporated into the PCR product upstream of the open reading frame that is to be transcribed. In one preferred embodiment, the promoter is a T7 polymerase promoter, as described elsewhere herein. Other useful promoters include, but are not limited to, T3 and SP6 RNA polymerase promoters. Consensus nucleotide sequences for T7, T3 and SP6 promoters are known in the art.

[00581] In a preferred embodiment, the mRNA has both a cap on the 5' end and a 3' poly(A) tail which determine ribosome binding, initiation of translation and stability mRNA in the cell. On a circular DNA template, for instance, plasmid DNA, RNA polymerase produces a long concatameric product which is not suitable for expression in eukaryotic cells. The transcription of plasmid DNA linearized at the end of the 3' UTR results in normal sized mRNA which is not effective in eukaryotic transfection even if it is polyadenylated after transcription.

[00582] On a linear DNA template, phage T7 RNA polymerase can extend the 3' end of the transcript beyond the last base of the template (Schenborn and Mierendorf, Nuc Acids Res., 13:6223-36 (1985); Nacheva and Berzal-Herranz, Eur. J. Biochem., 270:1485-65 (2003).

[00583] The conventional method of integration of polyA/T stretches into a DNA template is molecular cloning. However polyA/T sequence integrated into plasmid DNA can cause plasmid instability, which is why plasmid DNA templates obtained from bacterial cells are often highly contaminated with deletions and other aberrations. This makes cloning procedures not only laborious and time consuming but often not reliable. That is why a method which allows construction of DNA templates with polyA/T 3' stretch without cloning highly desirable.

[00584] The polyA/T segment of the transcriptional DNA template can be produced during PCR by using a reverse primer containing a polyT tail, such as 100T tail (SEQ ID NO: 35) (size can be 50-5000 T (SEQ ID NO: 36)), or after PCR by any other method, including, but not limited to, DNA ligation or in vitro recombination. Poly(A) tails also provide stability to RNAs and reduce their degradation. Generally, the length of a poly(A) tail positively correlates with the

stability of the transcribed RNA. In one embodiment, the poly(A) tail is between 100 and 5000 adenosines (SEQ ID NO: 37).

[00585] Poly(A) tails of RNAs can be further extended following in vitro transcription with the use of a poly(A) polymerase, such as E. coli polyA polymerase (E-PAP). In one embodiment, increasing the length of a poly(A) tail from 100 nucleotides to between 300 and 400 nucleotides (SEQ ID NO: 38) results in about a two-fold increase in the translation efficiency of the RNA. Additionally, the attachment of different chemical groups to the 3' end can increase mRNA stability. Such attachment can contain modified/artificial nucleotides, aptamers and other compounds. For example, ATP analogs can be incorporated into the poly(A) tail using poly(A) polymerase. ATP analogs can further increase the stability of the RNA.

[00586] 5' caps on also provide stability to RNA molecules. In a preferred embodiment, RNAs produced by the methods disclosed herein include a 5' cap. The 5' cap is provided using techniques known in the art and described herein (Cougot, et al., Trends in Biochem. Sci., 29:436-444 (2001); Stepinski, et al., RNA, 7:1468-95 (2001); Elango, et al., Biochim. Biophys. Res. Commun., 330:958-966 (2005)).

[00587] The RNAs produced by the methods disclosed herein can also contain an internal ribosome entry site (IRES) sequence. The IRES sequence may be any viral, chromosomal or artificially designed sequence which initiates cap-independent ribosome binding to mRNA and facilitates the initiation of translation. Any solutes suitable for cell electroporation, which can contain factors facilitating cellular permeability and viability such as sugars, peptides, lipids, proteins, antioxidants, and surfactants can be included.

[00588] RNA can be introduced into target cells using any of a number of different methods, for instance, commercially available methods which include, but are not limited to, electroporation (Amaxa Nucleofector-II (Amaxa Biosystems, Cologne, Germany)), (ECM 830 (BTX) (Harvard Instruments, Boston, Mass.) or the Gene Pulser II (BioRad, Denver, Colo.), Multiporator (Eppendort, Hamburg Germany), cationic liposome mediated transfection using lipofection, polymer encapsulation, peptide mediated transfection, or biolistic particle delivery systems such as “gene guns” (see, for example, Nishikawa, et al. Hum Gene Ther., 12(8):861-70 (2001).

**Non-viral delivery methods**

[00589] In some aspects, non-viral methods can be used to deliver a nucleic acid encoding a CAR described herein into a cell or tissue or a subject.

[00590] In some embodiments, the non-viral method includes the use of a transposon (also called a transposable element). In some embodiments, a transposon is a piece of DNA that can insert itself at a location in a genome, for example, a piece of DNA that is capable of self-replicating and inserting its copy into a genome, or a piece of DNA that can be spliced out of a longer nucleic acid and inserted into another place in a genome. For example, a transposon comprises a DNA sequence made up of inverted repeats flanking genes for transposition.

[00591] Exemplary methods of nucleic acid delivery using a transposon include a Sleeping Beauty transposon system (SBTS) and a piggyBac (PB) transposon system. See, e.g., Aronovich et al. Hum. Mol. Genet. 20.R1(2011):R14-20; Singh et al. Cancer Res. 15(2008):2961–2971; Huang et al. Mol. Ther. 16(2008):580–589; Grabundzija et al. Mol. Ther. 18(2010):1200–1209; Kebriaei et al. Blood. 122.21(2013):166; Williams. Molecular Therapy 16.9(2008):1515–16; Bell et al. Nat. Protoc. 2.12(2007):3153-65; and Ding et al. Cell. 122.3(2005):473-83, all of which are incorporated herein by reference.

[00592] The SBTS includes two components: 1) a transposon containing a transgene and 2) a source of transposase enzyme. The transposase can transpose the transposon from a carrier plasmid (or other donor DNA) to a target DNA, such as a host cell chromosome/genome. For example, the transposase binds to the carrier plasmid/donor DNA, cuts the transposon (including transgene(s)) out of the plasmid, and inserts it into the genome of the host cell. See, e.g., Aronovich et al. *supra.*

[00593] Exemplary transposons include a pT2-based transposon. See, e.g., Grabundzija et al. Nucleic Acids Res. 41.3(2013):1829-47; and Singh et al. Cancer Res. 68.8(2008): 2961–2971, all of which are incorporated herein by reference. Exemplary transposases include a Tc1/mariner-type transposase, e.g., the SB10 transposase or the SB11 transposase (a hyperactive transposase which can be expressed, e.g., from a cytomegalovirus promoter). See, e.g., Aronovich et al.; Kebriaei et al.; and Grabundzija et al., all of which are incorporated herein by reference.

[00594] Use of the SBTS permits efficient integration and expression of a transgene, e.g., a nucleic acid encoding a CAR described herein. Provided herein are methods of generating a cell,

e.g., T cell or NK cell, that stably expresses a CAR described herein, e.g., using a transposon system such as SBTS.

[00595] In accordance with methods described herein, in some embodiments, one or more nucleic acids, e.g., plasmids, containing the SBTS components are delivered to a cell (e.g., T or NK cell). For example, the nucleic acid(s) are delivered by standard methods of nucleic acid (e.g., plasmid DNA) delivery, e.g., methods described herein, e.g., electroporation, transfection, or lipofection. In some embodiments, the nucleic acid contains a transposon comprising a transgene, e.g., a nucleic acid encoding a CAR described herein. In some embodiments, the nucleic acid contains a transposon comprising a transgene (e.g., a nucleic acid encoding a CAR described herein) as well as a nucleic acid sequence encoding a transposase enzyme. In other embodiments, a system with two nucleic acids is provided, e.g., a dual-plasmid system, e.g., where a first plasmid contains a transposon comprising a transgene, and a second plasmid contains a nucleic acid sequence encoding a transposase enzyme. For example, the first and the second nucleic acids are co-delivered into a host cell.

[00596] In some embodiments, cells, e.g., T or NK cells, are generated that express a CAR described herein by using a combination of gene insertion using the SBTS and genetic editing using a nuclease (e.g., Zinc finger nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), the CRISPR/Cas system, or engineered meganuclease re-engineered homing endonucleases).

[00597] In some embodiments, use of a non-viral method of delivery permits reprogramming of cells, e.g., T or NK cells, and direct infusion of the cells into a subject. Advantages of non-viral vectors include but are not limited to the ease and relatively low cost of producing sufficient amounts required to meet a patient population, stability during storage, and lack of immunogenicity.

## Nucleic Acid Constructs Encoding a CAR

[00598] The present invention also provides nucleic acid molecules encoding one or more CAR constructs described herein. In one aspect, the nucleic acid molecule is provided as a

messenger RNA transcript. In one aspect, the nucleic acid molecule is provided as a DNA construct.

[00599] Accordingly, in one aspect, the invention pertains to an isolated nucleic acid molecule encoding a chimeric antigen receptor (CAR), wherein the CAR comprises an antigen binding domain that binds to a tumor marker as described herein, a transmembrane domain, and an intracellular signaling domain comprising a stimulatory domain, e.g., a costimulatory signaling domain and/or a primary signaling domain, e.g., zeta chain. In one embodiment, the transmembrane domain is transmembrane domain of a protein selected from the group consisting of the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD134, CD137 and CD154. In one embodiment, the transmembrane domain comprises a sequence of SEQ ID NO: 12, or a sequence with 95-99% identity thereof. In one embodiment, the antigen binding domain is connected to the transmembrane domain by a hinge region, e.g., a hinge described herein. In one embodiment, the hinge region comprises SEQ ID NO:4 or SEQ ID NO:6 or SEQ ID NO:8 or SEQ ID NO:10, or a sequence with 95-99% identity thereof. In one embodiment, the isolated nucleic acid molecule further comprises a sequence encoding a costimulatory domain. In one embodiment, the costimulatory domain is a functional signaling domain of a protein selected from the group consisting of OX40, CD27, CD28, CDS, ICAM-1, LFA-1 (CD11a/CD18), ICOS (CD278), 4-1BB (CD137), CDS, ICAM-1, GITR, BAFFR, HVEM (LIGHTR), SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD160, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, CD19a, and a ligand that specifically binds with CD83. In embodiments, the costimulatory domain comprises 4-1BB, CD27, CD28, or ICOS. In one embodiment, the costimulatory domain comprises a sequence of SEQ ID NO:16, or a sequence with 95-99% identity thereof. In one embodiment, the intracellular signaling domain comprises a functional signaling domain of 4-1BB and a functional signaling domain of

CD3 zeta. In one embodiment, the intracellular signaling domain comprises the sequence of SEQ ID NO: 14 or SEQ ID NO:16, or a sequence with 95-99% identity thereof, and the sequence of SEQ ID NO: 18 or SEQ ID NO:20, or a sequence with 95-99% identity thereof, wherein the sequences comprising the intracellular signaling domain are expressed in the same frame and as a single polypeptide chain.

[00600] In another aspect, the invention pertains to an isolated nucleic acid molecule encoding a CAR construct comprising a leader sequence of SEQ ID NO: 2, a scFv domain as described herein, a hinge region of SEQ ID NO:4 or SEQ ID NO:6 or SEQ ID NO:8 or SEQ ID NO:10 (or a sequence with 95-99% identity thereof), a transmembrane domain having a sequence of SEQ ID NO: 12 (or a sequence with 95-99% identity thereof), a 4-1BB costimulatory domain having a sequence of SEQ ID NO:14 or a CD27 costimulatory domain having a sequence of SEQ ID NO:16 (or a sequence with 95-99% identity thereof), and a CD3 zeta stimulatory domain having a sequence of SEQ ID NO:18 or SEQ ID NO:20 (or a sequence with 95-99% identity thereof).

[00601] In another aspect, the invention pertains to a nucleic acid molecule encoding a chimeric antigen receptor (CAR) molecule that comprises an antigen binding domain, a transmembrane domain, and an intracellular signaling domain comprising a stimulatory domain, and wherein said antigen binding domain binds to a tumor marker selected from a group consisting of: CD19, CD123, CD22, CD30, CD171, CS-1, CLL-1 (CLECL1), CD33, EGFRvIII , GD2, GD3, BCMA, Tn Ag, PSMA, ROR1, FLT3, FAP, TAG72, CD38, CD44v6, CEA, EPCAM, B7H3, KIT, IL-13Ra2, Mesothelin, IL-11Ra, PSCA, 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, TSHR, GPRC5D, CXORF61, CD97, CD179a, ALK, Plysialic 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, and IGLL1.

[00602] In one embodiment, the encoded CAR molecule further comprises a sequence encoding a costimulatory domain. In one embodiment, the costimulatory domain is a functional signaling domain of a protein selected from the group consisting of OX40, CD27, CD28, CDS, ICAM-1, LFA-1 (CD11a/CD18) and 4-1BB (CD137). Further examples of such costimulatory molecules include CDS, ICAM-1, GITR, BAFFR, HVEM (LIGHTR), SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD160, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, LAT, GADS, SLP-76, and PAG/Cbp. In one embodiment, the costimulatory domain comprises a sequence of SEQ ID NO:14. In one embodiment, the transmembrane domain is a transmembrane domain of a protein selected from the group consisting of the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD134, CD137 and CD154. In some embodiments, a transmembrane domain may include at least the transmembrane region(s) of, e.g., KIRDS2, OX40, CD2, CD27, LFA-1 (CD11a, CD18), ICOS (CD278), 4-1BB (CD137), GITR, CD40, BAFFR, HVEM (LIGHTR), SLAMF7, NKp80 (KLRF1), NKp44, NKp30, NKp46, CD160, CD19, IL2R beta, IL2R gamma, IL7R α, ITGA1, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, NKG2D, NKG2C, TNFR2, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3), BLAME (SLAMF8), SELPLG (CD162), LTBR, PAG/Cbp.

[00603] In one embodiment, the transmembrane domain comprises a sequence of SEQ ID NO:12. In one embodiment, the intracellular signaling domain comprises a functional signaling domain of 4-1BB and a functional signaling domain of zeta. In one embodiment, the intracellular signaling domain comprises the sequence of SEQ ID NO: 14 and the sequence of SEQ ID NO: 18, wherein the sequences comprising the intracellular signaling domain are expressed in the same frame and as a single polypeptide chain. In one embodiment, the anti- cancer associated antigen as described herein binding domain is connected to the transmembrane domain by a hinge region. In one embodiment, the hinge region comprises SEQ ID NO:4. In one embodiment, the hinge region comprises SEQ ID NO:6 or SEQ ID NO:8 or SEQ ID NO:10.

[00604] The nucleic acid sequences coding for the desired molecules can be obtained using recombinant methods known in the art, such as, for example by screening libraries from cells expressing the gene, by deriving the gene from a vector known to include the same, or by isolating directly from cells and tissues containing the same, using standard techniques. Alternatively, the gene of interest can be produced synthetically, rather than cloned.

[00605] The present invention also provides vectors in which a DNA of the present invention is inserted. Vectors derived from retroviruses such as the lentivirus are suitable tools to achieve long-term gene transfer since they allow long-term, stable integration of a transgene and its propagation in daughter cells. Lentiviral vectors have the added advantage over vectors derived from onco-retroviruses such as murine leukemia viruses in that they can transduce non-proliferating cells, such as hepatocytes. They also have the added advantage of low immunogenicity. A retroviral vector may also be, e.g., a gammaretroviral vector. A gammaretroviral vector may include, e.g., a promoter, a packaging signal (ψ), a primer binding site (PBS), one or more (e.g., two) long terminal repeats (LTR), and a transgene of interest, e.g., a gene encoding a CAR. A gammaretroviral vector may lack viral structural gens such as gag, pol, and env. Exemplary gammaretroviral vectors include Murine Leukemia Virus (MLV), Spleen-Focus Forming Virus (SFFV), and Myeloproliferative Sarcoma Virus (MPSV), and vectors derived therefrom. Other gammaretroviral vectors are described, e.g., in Tobias Maetzig et al., "Gammaretroviral Vectors: Biology, Technology and Application" Viruses. 2011 Jun; 3(6): 677–713.

[00606] In another embodiment, the vector comprising the nucleic acid encoding the desired CAR of the invention is an adenoviral vector (A5/35). In another embodiment, the expression of nucleic acids encoding CARs can be accomplished using of transposons such as sleeping beauty, crisper, CAS9, and zinc finger nucleases. See below June et al. 2009*Nature Reviews Immunology* 9.10: 704-716, is incorporated herein by reference.

[00607] In brief summary, the expression of natural or synthetic nucleic acids encoding CARs is typically achieved by operably linking a nucleic acid encoding the CAR polypeptide or portions thereof to a promoter, and incorporating the construct into an expression vector. The vectors can be suitable for replication and integration eukaryotes. Typical cloning vectors contain transcription and translation terminators, initiation sequences, and promoters useful for regulation of the expression of the desired nucleic acid sequence.

[00608] The expression constructs of the present invention may also be used for nucleic acid immunization and gene therapy, using standard gene delivery protocols. Methods for gene delivery are known in the art. See, e.g., U.S. Pat. Nos. 5,399,346, 5,580,859, 5,589,466, incorporated by reference herein in their entireties. In another embodiment, the invention provides a gene therapy vector.

[00609] The nucleic acid can be cloned into a number of types of vectors. For example, the nucleic acid can be cloned into a vector including, but not limited to a plasmid, a phagemid, a phage derivative, an animal virus, and a cosmid. Vectors of particular interest include expression vectors, replication vectors, probe generation vectors, and sequencing vectors.

[00610] Further, the expression vector may be provided to a cell in the form of a viral vector. Viral vector technology is well known in the art and is described, for example, in Sambrook et al., 2012, MOLECULAR CLONING: A LABORATORY MANUAL, volumes 1 -4, Cold Spring Harbor Press, NY), and in other virology and molecular biology manuals. Viruses, which are useful as vectors include, but are not limited to, retroviruses, adenoviruses, adeno- associated viruses, herpes viruses, and lentiviruses. In general, a suitable vector contains an origin of replication functional in at least one organism, a promoter sequence, convenient restriction endonuclease sites, and one or more selectable markers, (e.g., WO 01/96584; WO 01/29058; and U.S. Pat. No. 6,326,193).

[00611] A number of viral based systems have been developed for gene transfer into mammalian cells. For example, retroviruses provide a convenient platform for gene delivery systems. A selected gene can be inserted into a vector and packaged in retroviral particles using techniques known in the art. The recombinant virus can then be isolated and delivered to cells of the subject either in vivo or ex vivo. A number of retroviral systems are known in the art. In some embodiments, adenovirus vectors are used. A number of adenovirus vectors are known in the art. In one embodiment, lentivirus vectors are used. Exemplary promoters include the CMV IE gene, EF-1α, ubiquitin C, or phosphoglycerokinase (PGK) promoters. In an embodiment, the promoter is a PGK promoter, e.g., a truncated PGK promoter as described herein.

[00612] Additional promoter elements, e.g., enhancers, regulate the frequency of transcriptional initiation. Typically, these are located in the region 30-110 bp upstream of the start site, although a number of promoters have been shown to contain functional elements downstream of the start site as well. The spacing between promoter elements frequently is flexible, so that promoter function is preserved when elements are inverted or moved relative to one another. In the thymidine kinase (tk) promoter, the spacing between promoter elements can be increased to 50 bp apart before activity begins to decline. Depending on the promoter, it appears that individual elements can function either cooperatively or independently to activate transcription.

[00613] An example of a promoter that is capable of expressing a CAR transgene in a mammalian T cell is the EF1a promoter. The native EF1a promoter drives expression of the alpha subunit of the elongation factor-1 complex, which is responsible for the enzymatic delivery of aminoacyl tRNAs to the ribosome. The EF1a promoter has been extensively used in mammalian expression plasmids and has been shown to be effective in driving CAR expression from transgenes cloned into a lentiviral vector. See, e.g., Milone et al., Mol. Ther. 17(8): 1453–1464 (2009). In one aspect, the EF1a promoter comprises the sequence provided as SEQ ID NO:1.

[00614] Another example of a promoter is the immediate early cytomegalovirus (CMV) promoter sequence. This promoter sequence is a strong constitutive promoter sequence capable of driving high levels of expression of any polynucleotide sequence operatively linked thereto. However, other constitutive promoter sequences may also be used, including, but not limited to

the simian virus 40 (SV40) early promoter, mouse mammary tumor virus (MMTV), human immunodeficiency virus (HIV) long terminal repeat (LTR) promoter, MoMuLV promoter, an avian leukemia virus promoter, an Epstein-Barr virus immediate early promoter, a Rous sarcoma virus promoter, as well as human gene promoters such as, but not limited to, the actin promoter, the myosin promoter, the elongation factor-1α promoter, the hemoglobin promoter, and the creatine kinase promoter. Further, the invention should not be limited to the use of constitutive promoters. Inducible promoters are also contemplated as part of the invention. The use of an inducible promoter provides a molecular switch capable of turning on expression of the polynucleotide sequence which it is operatively linked when such expression is desired, or turning off the expression when expression is not desired. Examples of inducible promoters include, but are not limited to a metallothionine promoter, a glucocorticoid promoter, a progesterone promoter, and a tetracycline promoter.

[00615] Another example of a promoter is the phosphoglycerate kinase (PGK) promoter. In embodiments, a truncated PGK promoter (e.g., a PGK promoter with one or more, e.g., 1, 2, 5, 10, 100, 200, 300, or 400, nucleotide deletions when compared to the wild-type PGK promoter sequence) may be desired. The nucleotide sequences of exemplary PGK promoters are provided below.

*WT PGK Promoter*

[00616] ACCCCTCTCTCCAGCCACTAAGCCAGTTGCTCCCTCGGCTGACGGCTGCAC GCGAGGCCTCCGAACGTCTTACGCCTTGTGGCGCGCCCGTCCTTGTCCCGGGTGTGA TGGCGGGGTGTGGGGCGGAGGGCGTGGCGGGGAAGGGCCGGCGACGAGAGCCGCG CGGGACGACTCGTCGGCGATAACCGGTGTCGGGTAGCGCCAGCCGCGCGACGGTAA CGAGGGACCGCGACAGGCAGACGCTCCCATGATCACTCTGCACGCCGAAGGCAAAT AGTGCAGGCCGTGCGGCGCTTGGCGTTCCTTGGAAGGGCTGAATCCCCGCCTCGTCC TTCGCAGCGGCCCCCCGGGTGTTCCCATCGCCGCTTCTAGGCCCACTGCGACGCTTG CCTGCACTTCTTACACGCTCTGGGTCCCAGCCGCGGCGACGCAAAGGGCCTTGGTGC GGGTCTCGTCGGCGCAGGGACGCGTTTGGGTCCCGACGGAACCTTTTCCGCGTTGGG GTTGGGGCACCATAAGCT (SEQ ID NO: 96)

*Exemplary truncated PGK Promoters:*

[00617] PGK100:

[00618] ACCCCTCTCTCCAGCCACTAAGCCAGTTGCTCCCTCGGCTGACGGCTGCAC GCGAGGCCTCCGAACGTCTTACGCCTTGTGGCGCGCCCGTCCTTGTCCCGGGTGTGA TGGCGGGGTG (SEQ ID NO: 97)

[00619] PGK200:

[00620] ACCCCTCTCTCCAGCCACTAAGCCAGTTGCTCCCTCGGCTGACGGCTGCAC GCGAGGCCTCCGAACGTCTTACGCCTTGTGGCGCGCCCGTCCTTGTCCCGGGTGTGA TGGCGGGGTGTGGGGCGGAGGGCGTGGCGGGGAAGGGCCGGCGACGAGAGCCGCG CGGGACGACTCGTCGGCGATAACCGGTGTCGGGTAGCGCCAGCCGCGCGACGGTAA CG (SEQ ID NO: 98)

[00621] PGK300:

[00622] ACCCCTCTCTCCAGCCACTAAGCCAGTTGCTCCCTCGGCTGACGGCTGCAC GCGAGGCCTCCGAACGTCTTACGCCTTGTGGCGCGCCCGTCCTTGTCCCGGGTGTGA TGGCGGGGTGTGGGGCGGAGGGCGTGGCGGGGAAGGGCCGGCGACGAGAGCCGCG CGGGACGACTCGTCGGCGATAACCGGTGTCGGGTAGCGCCAGCCGCGCGACGGTAA CGAGGGACCGCGACAGGCAGACGCTCCCATGATCACTCTGCACGCCGAAGGCAAAT AGTGCAGGCCGTGCGGCGCTTGGCGTTCCTTGGAAGGGCTGAATCCCCG (SEQ ID NO: 99)

[00623] PGK400:

[00624] ACCCCTCTCTCCAGCCACTAAGCCAGTTGCTCCCTCGGCTGACGGCTGCAC GCGAGGCCTCCGAACGTCTTACGCCTTGTGGCGCGCCCGTCCTTGTCCCGGGTGTGA TGGCGGGGTGTGGGGCGGAGGGCGTGGCGGGGAAGGGCCGGCGACGAGAGCCGCG CGGGACGACTCGTCGGCGATAACCGGTGTCGGGTAGCGCCAGCCGCGCGACGGTAA CGAGGGACCGCGACAGGCAGACGCTCCCATGATCACTCTGCACGCCGAAGGCAAAT AGTGCAGGCCGTGCGGCGCTTGGCGTTCCTTGGAAGGGCTGAATCCCCGCCTCGTCC TTCGCAGCGGCCCCCCGGGTGTTCCCATCGCCGCTTCTAGGCCCACTGCGACGCTTG CCTGCACTTCTTACACGCTCTGGGTCCCAGCCG (SEQ ID NO: 100)

[00625] A vector may also include, e.g., a signal sequence to facilitate secretion, a polyadenylation signal and transcription terminator (e.g., from Bovine Growth Hormone (BGH) gene), an element allowing episomal replication and replication in prokaryotes (e.g. SV40 origin

and ColE1 or others known in the art) and/or elements to allow selection (e.g., ampicillin resistance gene and/or zeocin marker).

[00626] In order to assess the expression of a CAR polypeptide or portions thereof, the expression vector to be introduced into a cell can also contain either a selectable marker gene or a reporter gene or both to facilitate identification and selection of expressing cells from the population of cells sought to be transfected or infected through viral vectors. In other aspects, the selectable marker may be carried on a separate piece of DNA and used in a co- transfection procedure. Both selectable markers and reporter genes may be flanked with appropriate regulatory sequences to enable expression in the host cells. Useful selectable markers include, for example, antibiotic-resistance genes, such as neo and the like.

[00627] Reporter genes are used for identifying potentially transfected cells and for evaluating the functionality of regulatory sequences. In general, a reporter gene is a gene that is not present in or expressed by the recipient organism or tissue and that encodes a polypeptide whose expression is manifested by some easily detectable property, e.g., enzymatic activity. Expression of the reporter gene is assayed at a suitable time after the DNA has been introduced into the recipient cells. Suitable reporter genes may include genes encoding luciferase, beta-galactosidase, chloramphenicol acetyl transferase, secreted alkaline phosphatase, or the green fluorescent protein gene (e.g., Ui-Tei et al., 2000 FEBS Letters 479: 79-82). Suitable expression systems are well known and may be prepared using known techniques or obtained commercially. In general, the construct with the minimal 5' flanking region showing the highest level of expression of reporter gene is identified as the promoter. Such promoter regions may be linked to a reporter gene and used to evaluate agents for the ability to modulate promoter- driven transcription.

[00628] In embodiments, the vector may comprise two or more nucleic acid sequences encoding a CAR, e.g., a first CAR described herein and a second CAR, e.g., an inhibitory CAR or a CAR that specifically binds to a second antigen, e.g., another cancer associated antigen described herein (e.g., CD19, CD123, CD22, CD30, CD34, 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, 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, TSHR, GPRC5D, CXORF61, CD97, CD179a, ALK, Plysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, legumain, HPV E6,E7, MAGE-A1, 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, or IGLL1). In such embodiments, the two or more nucleic acid sequences encoding the CAR are encoded by a single nucleic molecule in the same frame and as a single polypeptide chain. In this aspect, the two or more CARs, can, e.g., be separated by one or more peptide cleavage sites. (e.g., an auto-cleavage site or a substrate for an intracellular protease). Examples of peptide cleavage sites include the following, wherein the GSG residues are optional:

[00629] T2A: (GSG)EGRGSLLTCGDVEENPGP (SEQ ID NO: 101)

[00630] P2A: (GSG)ATNFSLLKQAGDVEENPGP (SEQ ID NO: 102)

[00631] E2A: (GSG)QCTNYALLKLAGDVESNPGP (SEQ ID NO: 103)

[00632] F2A: (GSG)VKQTLNFDLLKLAGDVESNPGP (SEQ ID NO: 104)

[00633] Methods of introducing and expressing genes into a cell are known in the art. In the context of an expression vector, the vector can be readily introduced into a host cell, e.g., mammalian, bacterial, yeast, or insect cell by any method in the art. For example, the expression vector can be transferred into a host cell by physical, chemical, or biological means.

[00634] Physical methods for introducing a polynucleotide into a host cell include calcium phosphate precipitation, lipofection, particle bombardment, microinjection, electroporation, and the like. Methods for producing cells comprising vectors and/or exogenous nucleic acids are well-known in the art. See, for example, Sambrook et al., 2012, MOLECULAR CLONING: A

LABORATORY MANUAL, volumes 1 -4, Cold Spring Harbor Press, NY). A preferred method for the introduction of a polynucleotide into a host cell is calcium phosphate transfection

[00635] Biological methods for introducing a polynucleotide of interest into a host cell include the use of DNA and RNA vectors. Viral vectors, and especially retroviral vectors, have become the most widely used method for inserting genes into mammalian, e.g., human cells. Other viral vectors can be derived from lentivirus, poxviruses, herpes simplex virus I, adenoviruses and adeno-associated viruses, and the like. See, for example, U.S. Pat. Nos. 5,350,674 and 5,585,362.

[00636] Chemical means for introducing a polynucleotide into a host cell include colloidal dispersion systems, such as macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. An exemplary colloidal system for use as a delivery vehicle in vitro and in vivo is a liposome (e.g., an artificial membrane vesicle). Other methods of state-of-the-art targeted delivery of nucleic acids are available, such as delivery of polynucleotides with targeted nanoparticles or other suitable sub-micron sized delivery system.

[00637] In the case where a non-viral delivery system is utilized, an exemplary delivery vehicle is a liposome. The use of lipid formulations is contemplated for the introduction of the nucleic acids into a host cell (in vitro, ex vivo or in vivo). In another aspect, the nucleic acid may be associated with a lipid. The nucleic acid associated with a lipid may be encapsulated in the aqueous interior of a liposome, interspersed within the lipid bilayer of a liposome, attached to a liposome via a linking molecule that is associated with both the liposome and the oligonucleotide, entrapped in a liposome, complexed with a liposome, dispersed in a solution containing a lipid, mixed with a lipid, combined with a lipid, contained as a suspension in a lipid, contained or complexed with a micelle, or otherwise associated with a lipid. Lipid, lipid/DNA or lipid/expression vector associated compositions are not limited to any particular structure in solution. For example, they may be present in a bilayer structure, as micelles, or with a "collapsed" structure. They may also simply be interspersed in a solution, possibly forming aggregates that are not uniform in size or shape. Lipids are fatty substances which may be naturally occurring or synthetic lipids. For example, lipids include the fatty droplets that naturally occur in the cytoplasm as well as the class of compounds which contain long-chain

aliphatic hydrocarbons and their derivatives, such as fatty acids, alcohols, amines, amino alcohols, and aldehydes.

[00638] Lipids suitable for use can be obtained from commercial sources. For example, dimyristyl phosphatidylcholine ("DMPC") can be obtained from Sigma, St. Louis, MO; dicetyl phosphate ("DCP") can be obtained from K & K Laboratories (Plainview, NY); cholesterol ("Choi") can be obtained from Calbiochem-Behring; dimyristyl phosphatidylglycerol ("DMPG") and other lipids may be obtained from Avanti Polar Lipids, Inc. (Birmingham, AL.). Stock solutions of lipids in chloroform or chloroform/methanol can be stored at about -20°C. Chloroform is used as the only solvent since it is more readily evaporated than methanol. "Liposome" is a generic term encompassing a variety of single and multilamellar lipid vehicles formed by the generation of enclosed lipid bilayers or aggregates. Liposomes can be characterized as having vesicular structures with a phospholipid bilayer membrane and an inner aqueous medium. Multilamellar liposomes have multiple lipid layers separated by aqueous medium. They form spontaneously when phospholipids are suspended in an excess of aqueous solution. The lipid components undergo self-rearrangement before the formation of closed structures and entrap water and dissolved solutes between the lipid bilayers (Ghosh et al., 1991 Glycobiology 5: 505-10). However, compositions that have different structures in solution than the normal vesicular structure are also encompassed. For example, the lipids may assume a micellar structure or merely exist as nonuniform aggregates of lipid molecules. Also contemplated are lipofectamine-nucleic acid complexes.

[00639] Regardless of the method used to introduce exogenous nucleic acids into a host cell or otherwise expose a cell to the inhibitor of the present invention, in order to confirm the presence of the recombinant DNA sequence in the host cell, a variety of assays may be performed. Such assays include, for example, "molecular biological" assays well known to those of skill in the art, such as Southern and Northern blotting, RT-PCR and PCR; "biochemical" assays, such as detecting the presence or absence of a particular peptide, e.g., by immunological means (ELISAs and Western blots) or by assays described herein to identify agents falling within the scope of the invention.

[00640] The present invention further provides a vector comprising a CAR encoding nucleic acid molecule. In one aspect, a CAR vector can be directly transduced into a cell, *e.g.,* a T cell

or a NK cell. In one aspect, the vector is a cloning or expression vector, *e.g.,* a vector including, but not limited to, one or more plasmids (*e.g.*, expression plasmids, cloning vectors, minicircles, minivectors, double minute chromosomes), retroviral and lentiviral vector constructs. In one aspect, the vector is capable of expressing the CAR construct in mammalian immune effector cells (e.g., T cells, NK cells). In one aspect, the mammalian T cell is a human T cell. In one aspect, the mammalian NK cell is a human NK cell.

**Sources of Cells**

[00641] Prior to expansion and genetic modification or other modification, a source of cells, e.g., T cells or natural killer (NK) cells can be obtained from a subject. The term "subject" is intended to include living organisms in which an immune response can be elicited (e.g., mammals). Examples of subjects include humans, monkeys, chimpanzees, dogs, cats, mice, rats, and transgenic species thereof. T cells can be obtained from a number of sources, including peripheral blood mononuclear cells, bone marrow, lymph node tissue, cord blood, thymus tissue, tissue from a site of infection, ascites, pleural effusion, spleen tissue, and tumors.

[00642] In certain aspects of the present disclosure, immune effector cells, e.g., T cells, can be obtained from a unit of blood collected from a subject using any number of techniques known to the skilled artisan, such as Ficoll™ separation. In one preferred aspect, cells from the circulating blood of an individual are obtained by apheresis. The apheresis product typically contains lymphocytes, including T cells, monocytes, granulocytes, B cells, other nucleated white blood cells, red blood cells, and platelets. In one aspect, the cells collected by apheresis may be washed to remove the plasma fraction and, optionally, to place the cells in an appropriate buffer or media for subsequent processing steps. In one embodiment, the cells are washed with phosphate buffered saline (PBS). In an alternative embodiment, the wash solution lacks calcium and may lack magnesium or may lack many if not all divalent cations.

[00643] Initial activation steps in the absence of calcium can lead to magnified activation. As those of ordinary skill in the art would readily appreciate a washing step may be accomplished by methods known to those in the art, such as by using a semi-automated "flow-through" centrifuge (for example, the Cobe 2991 cell processor, the Baxter CytoMate, or the Haemonetics Cell Saver 5) according to the manufacturer's instructions. After washing, the cells may be resuspended in a variety of biocompatible buffers, such as, for example, Ca-free, Mg-free PBS,

PlasmaLyte A, or other saline solution with or without buffer. Alternatively, the undesirable components of the apheresis sample may be removed and the cells directly resuspended in culture media.

[00644] It is recognized that the methods of the application can utilize culture media conditions comprising 5% or less, for example 2%, human AB serum, and employ known culture media conditions and compositions, for example those described in Smith et al., "Ex vivo expansion of human T cells for adoptive immunotherapy using the novel Xeno-free CTS Immune Cell Serum Replacement" Clinical & Translational Immunology (2015) 4, e31; doi:10.1038/cti.2014.31.

[00645] In one aspect, T cells are isolated from peripheral blood lymphocytes by lysing the red blood cells and depleting the monocytes, for example, by centrifugation through a PERCOLLTM gradient or by counterflow centrifugal elutriation.

[00646] The methods described herein can include, e.g., selection of a specific subpopulation of immune effector cells, e.g., T cells, that are a T regulatory cell-depleted population, CD25+ depleted cells, using, e.g., a negative selection technique, e.g., described herein. Preferably, the population of T regulatory depleted cells contains less than 30%, 25%, 20%, 15%, 10%, 5%, 4%, 3%, 2%, 1% of CD25+ cells.

[00647] In one embodiment, T regulatory cells, e.g., CD25+ T cells, are removed from the population using an anti-CD25 antibody, or fragment thereof, or a CD25-binding ligand, IL-2. In one embodiment, the anti-CD25 antibody, or fragment thereof, or CD25-binding ligand is conjugated to a substrate, e.g., a bead, or is otherwise coated on a substrate, e.g., a bead. In one embodiment, the anti-CD25 antibody, or fragment thereof, is conjugated to a substrate as described herein.

[00648] In one embodiment, the T regulatory cells, e.g., CD25+ T cells, are removed from the population using CD25 depletion reagent from Miltenyi$^{TM}$. In one embodiment, the ratio of cells to CD25 depletion reagent is 1e7 cells to 20 uL, or 1e7 cells to15 uL, or 1e7 cells to 10 uL, or 1e7 cells to 5 uL, or 1e7 cells to 2.5 uL, or 1e7 cells to 1.25 uL. In one embodiment, e.g., for T regulatory cells, e.g., CD25+ depletion, greater than 500 million cells/ml is used. In a further aspect, a concentration of cells of 600, 700, 800, or 900 million cells/ml is used.

[00649] In one embodiment, the population of immune effector cells to be depleted includes about 6 x $10^9$ CD25+ T cells. In other aspects, the population of immune effector cells to be depleted include about 1 x $10^9$ to 1x $10^{10}$ CD25+ T cell, and any integer value in between. In one embodiment, the resulting population T regulatory depleted cells has 2 x $10^9$ T regulatory cells, e.g., CD25+ cells, or less (e.g., 1 x $10^9$, 5 x $10^8$ , 1 x $10^8$, 5 x $10^7$, 1 x $10^7$, or less CD25+ cells).

[00650] In one embodiment, the T regulatory cells, e.g., CD25+ cells, are removed from the population using the CliniMAC system with a depletion tubing set, such as, e.g., tubing 162-01. In one embodiment, the CliniMAC system is run on a depletion setting such as, e.g., DEPLETION2.1.

[00651] Without wishing to be bound by a particular theory, decreasing the level of negative regulators of immune cells (e.g., decreasing the number of unwanted immune cells, e.g., $T_{REG}$ cells), in a subject prior to apheresis or during manufacturing of a CAR-expressing cell product can reduce the risk of subject relapse. For example, methods of depleting $T_{REG}$ cells are known in the art. Methods of decreasing $T_{REG}$ cells include, but are not limited to, cyclophosphamide, anti-GITR antibody (an anti-GITR antibody described herein), CD25-depletion, and combinations thereof.

[00652] In some embodiments, the manufacturing methods comprise reducing the number of (e.g., depleting) $T_{REG}$ cells prior to manufacturing of the CAR-expressing cell. For example, manufacturing methods comprise contacting the sample, e.g., the apheresis sample, with an anti-GITR antibody and/or an anti-CD25 antibody (or fragment thereof, or a CD25-binding ligand), e.g., to deplete $T_{REG}$ cells prior to manufacturing of the CAR-expressing cell (e.g., T cell, NK cell) product.

[00653] In an embodiment, a subject is pre-treated with one or more therapies that reduce $T_{REG}$ cells prior to collection of cells for CAR-expressing cell product manufacturing, thereby reducing the risk of subject relapse to CAR-expressing cell treatment. In an embodiment, methods of decreasing $T_{REG}$ cells include, but are not limited to, administration to the subject of one or more of cyclophosphamide, anti-GITR antibody, CD25-depletion, or a combination thereof. Administration of one or more of cyclophosphamide, anti-GITR antibody, CD25-depletion, or a combination thereof, can occur before, during or after an infusion of the CAR-expressing cell product.

[00654] In an embodiment, a subject is pre-treated with cyclophosphamide prior to collection of cells for CAR-expressing cell product manufacturing, thereby reducing the risk of subject relapse to CAR-expressing cell treatment. In an embodiment, a subject is pre-treated with an anti-GITR antibody prior to collection of cells for CAR-expressing cell product manufacturing, thereby reducing the risk of subject relapse to CAR-expressing cell treatment.

[00655] In one embodiment, the population of cells to be removed are neither the regulatory T cells or tumor cells, but cells that otherwise negatively affect the expansion and/or function of CART cells, e.g. cells expressing CD14, CD11b, CD33, CD15, or other markers expressed by potentially immune suppressive cells. In one embodiment, such cells are envisioned to be removed concurrently with regulatory T cells and/or tumor cells, or following said depletion, or in another order.

[00656] The methods described herein can include more than one selection step, e.g., more than one depletion step. Enrichment of a T cell population by negative selection can be accomplished, e.g., with a combination of antibodies directed to surface markers unique to the negatively selected cells. One method is cell sorting and/or selection via negative magnetic immunoadherence or flow cytometry that uses a cocktail of monoclonal antibodies directed to cell surface markers present on the cells negatively selected. For example, to enrich for CD4+ cells by negative selection, a monoclonal antibody cocktail can include antibodies to CD14, CD20, CD11b, CD16, HLA-DR, and CD8.

[00657] The methods described herein can further include removing cells from the population which express a tumor antigen, e.g., a tumor antigen that does not comprise CD25, e.g., CD19, CD30, CD38, CD123, CD20, CD14 or CD11b, to thereby provide a population of T regulatory depleted, e.g., CD25+ depleted, and tumor antigen depleted cells that are suitable for expression of a CAR, e.g., a CAR described herein. In one embodiment, tumor antigen expressing cells are removed simultaneously with the T regulatory, e.g., CD25+ cells. For example, an anti-CD25 antibody, or fragment thereof, and an anti-tumor antigen antibody, or fragment thereof, can be attached to the same substrate, e.g., bead, which can be used to remove the cells or an anti-CD25 antibody, or fragment thereof, or the anti-tumor antigen antibody, or fragment thereof, can be attached to separate beads, a mixture of which can be used to remove the cells. In other

embodiments, the removal of T regulatory cells, e.g., CD25+ cells, and the removal of the tumor antigen expressing cells is sequential, and can occur, e.g., in either order.

[00658] Also provided are methods that include removing cells from the population which express a check point inhibitor, e.g., a check point inhibitor described herein, e.g., one or more of PD1+ cells, LAG3+ cells, and TIM3+ cells, to thereby provide a population of T regulatory depleted, e.g., CD25+ depleted cells, and check point inhibitor depleted cells, e.g., PD1+, LAG3+ and/or TIM3+ depleted cells. Exemplary check point inhibitors include PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta. In one embodiment, check point inhibitor expressing cells are removed simultaneously with the T regulatory, e.g., CD25+ cells. For example, an anti-CD25 antibody, or fragment thereof, and an anti-check point inhibitor antibody, or fragment thereof, can be attached to the same bead which can be used to remove the cells, or an anti-CD25 antibody, or fragment thereof, and the anti-check point inhibitor antibody, or fragment there, can be attached to separate beads, a mixture of which can be used to remove the cells. In other embodiments, the removal of T regulatory cells, e.g., CD25+ cells, and the removal of the check point inhibitor expressing cells is sequential, and can occur, e.g., in either order.

[00659] Methods described herein can include a positive selection step. For example, T cells can be isolated by incubation with anti-CD3/anti-CD28 (e.g., 3x28)-conjugated beads, such as DYNABEADS® M-450 CD3/CD28 T, for a time period sufficient for positive selection of the desired T cells. In one embodiment, the time period is about 30 minutes. In a further embodiment, the time period ranges from 30 minutes to 36 hours or longer and all integer values there between. In a further embodiment, the time period is at least 1, 2, 3, 4, 5, or 6 hours. In yet another embodiment, the time period is 10 to 24 hours, e.g., 24 hours. Longer incubation times may be used to isolate T cells in any situation where there are few T cells as compared to other cell types, such in isolating tumor infiltrating lymphocytes (TIL) from tumor tissue or from immunocompromised individuals. Further, use of longer incubation times can increase the efficiency of capture of CD8+ T cells. Thus, by simply shortening or lengthening the time T cells are allowed to bind to the CD3/CD28 beads and/or by increasing or decreasing the ratio of beads to T cells (as described further herein), subpopulations of T cells can be preferentially selected

for or against at culture initiation or at other time points during the process. Additionally, by increasing or decreasing the ratio of anti-CD3 and/or anti-CD28 antibodies on the beads or other surface, subpopulations of T cells can be preferentially selected for or against at culture initiation or at other desired time points.

[00660] In one embodiment, a T cell population can be selected that expresses one or more of IFN-γ, TNFα, IL-17A, IL-2, IL-3, IL-4, GM-CSF, IL-10, IL-13, granzyme B, and perforin, or other appropriate molecules, e.g., other cytokines. Methods for screening for cell expression can be determined, e.g., by the methods described in PCT Publication No.: WO 2013/126712.

[00661] For isolation of a desired population of cells by positive or negative selection, the concentration of cells and surface (e.g., particles such as beads) can be varied. In certain aspects, it may be desirable to significantly decrease the volume in which beads and cells are mixed together (e.g., increase the concentration of cells), to ensure maximum contact of cells and beads. For example, in one aspect, a concentration of 10 billion cells/ml, 9 billion/ml, 8 billion/ml, 7 billion/ml, 6 billion/ml, or 5 billion/ml is used. In one aspect, a concentration of 1 billion cells/ml is used. In a further aspect, greater than 100 million cells/ml is used. In a further aspect, a concentration of cells of 10, 15, 20, 25, 30, 35, 40, 45, or 50 million cells/ml is used. In yet one aspect, a concentration of cells from 75, 80, 85, 90, 95, or 100 million cells/ml is used. In further aspects, concentrations of 125 or 150 million cells/ml can be used.

[00662] Using high concentrations can result in increased cell yield, cell activation, and cell expansion. Further, use of high cell concentrations allows more efficient capture of cells that may weakly express target antigens of interest, such as CD28-negative T cells, or from samples where there are many tumor cells present (e.g., leukemic blood, tumor tissue, etc.). Such populations of cells may have therapeutic value and would be desirable to obtain. For example, using high concentration of cells allows more efficient selection of CD8+ T cells that normally have weaker CD28 expression.

[00663] In a related aspect, it may be desirable to use lower concentrations of cells. By significantly diluting the mixture of T cells and surface (e.g., particles such as beads), interactions between the particles and cells is minimized. This selects for cells that express high amounts of desired antigens to be bound to the particles. For example, CD4+ T cells express higher levels of CD28 and are more efficiently captured than CD8+ T cells in dilute

concentrations. In one aspect, the concentration of cells used is 5 x $10^6$/ml. In other aspects, the concentration used can be from about 1 x $10^5$/ml to 1 x $10^6$/ml, and any integer value in between.

[00664] In other aspects, the cells may be incubated on a rotator for varying lengths of time at varying speeds at either 2-10°C or at room temperature.

[00665] T cells for stimulation can also be frozen after a washing step. Wishing not to be bound by theory, the freeze and subsequent thaw step provides a more uniform product by removing granulocytes and to some extent monocytes in the cell population. After the washing step that removes plasma and platelets, the cells may be suspended in a freezing solution. While many freezing solutions and parameters are known in the art and will be useful in this context, one method involves using PBS containing 20% DMSO and 8% human serum albumin, or culture media containing 10% Dextran 40 and 5% Dextrose, 20% Human Serum Albumin and 7.5% DMSO, or 31.25% Plasmalyte-A, 31.25% Dextrose 5%, 0.45% NaCl, 10% Dextran 40 and 5% Dextrose, 20% Human Serum Albumin, and 7.5% DMSO or other suitable cell freezing media containing for example, Hespan and PlasmaLyte A, the cells then are frozen to -80°C at a rate of 1° per minute and stored in the vapor phase of a liquid nitrogen storage tank. Other methods of controlled freezing may be used as well as uncontrolled freezing immediately at -20° C or in liquid nitrogen.

[00666] In certain aspects, cryopreserved cells are thawed and washed as described herein and allowed to rest for one hour at room temperature prior to activation using the methods of the present invention.

[00667] Also contemplated in the context of the invention is the collection of blood samples or apheresis product from a subject at a time period prior to when the expanded cells as described herein might be needed. As such, the source of the cells to be expanded can be collected at any time point necessary, and desired cells, such as T cells, isolated and frozen for later use in immune effector cell therapy for any number of diseases or conditions that would benefit from immune effector cell therapy, such as those described herein. In one aspect a blood sample or an apheresis is taken from a generally healthy subject. In certain aspects, a blood sample or an apheresis is taken from a generally healthy subject who is at risk of developing a disease, but who has not yet developed a disease, and the cells of interest are isolated and frozen for later use. In certain aspects, the T cells may be expanded, frozen, and used at a later time. In

certain aspects, samples are collected from a patient shortly after diagnosis of a particular disease as described herein but prior to any treatments. In a further aspect, the cells are isolated from a blood sample or an apheresis from a subject prior to any number of relevant treatment modalities, including but not limited to treatment with agents such as natalizumab, efalizumab, antiviral agents, chemotherapy, radiation, immunosuppressive agents, such as cyclosporin, azathioprine, methotrexate, mycophenolate, and FK506, antibodies, or other immunoablative agents such as CAMPATH, anti-CD3 antibodies, cytoxan, fludarabine, cyclosporin, FK506, rapamycin, mycophenolic acid, steroids, FR901228, and irradiation.

[00668] In a further aspect of the present invention, T cells are obtained from a patient directly following treatment that leaves the subject with functional T cells. In this regard, it has been observed that following certain cancer treatments, in particular treatments with drugs that damage the immune system, shortly after treatment during the period when patients would normally be recovering from the treatment, the quality of T cells obtained may be optimal or improved for their ability to expand ex vivo. Likewise, following ex vivo manipulation using the methods described herein, these cells may be in a preferred state for enhanced engraftment and in vivo expansion. Thus, it is contemplated within the context of the present invention to collect blood cells, including T cells, dendritic cells, or other cells of the hematopoietic lineage, during this recovery phase. Further, in certain aspects, mobilization (for example, mobilization with GM-CSF) and conditioning regimens can be used to create a condition in a subject wherein repopulation, recirculation, regeneration, and/or expansion of particular cell types is favored, especially during a defined window of time following therapy. Illustrative cell types include T cells, B cells, dendritic cells, and other cells of the immune system.

[00669] In one embodiment, the immune effector cells expressing a CAR molecule, e.g., a CAR molecule described herein, are obtained from a subject that has received a low, immune enhancing dose of an mTOR inhibitor. In an embodiment, the population of immune effector cells, e.g., T cells, to be engineered to express a CAR, are harvested after a sufficient time, or after sufficient dosing of the low, immune enhancing, dose of an mTOR inhibitor, such that the level of PD1 negative immune effector cells, e.g., T cells, or the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, in the subject or harvested from the subject has been, at least transiently, increased.

[00670] In other embodiments, a population of immune effector cells, e.g., T cells, which have, or will be engineered to express a CAR, can be treated ex vivo by contact with an amount of an mTOR inhibitor that increases the number of PD1 negative immune effector cells, e.g., T cells or increases the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells.

[00671] In one embodiment, a T cell population is diaglycerol kinase (DGK)-deficient. DGK-deficient cells include cells that do not express DGK RNA or protein, or have reduced or inhibited DGK activity. DGK-deficient cells can be generated by genetic approaches, e.g., administering RNA-interfering agents, e.g., siRNA, shRNA, miRNA, to reduce or prevent DGK expression. Alternatively, DGK-deficient cells can be generated by treatment with DGK inhibitors described herein.

[00672] In one embodiment, a T cell population is Ikaros-deficient. Ikaros-deficient cells include cells that do not express Ikaros RNA or protein, or have reduced or inhibited Ikaros activity, Ikaros-deficient cells can be generated by genetic approaches, e.g., administering RNA-interfering agents, e.g., siRNA, shRNA, miRNA, to reduce or prevent Ikaros expression. Alternatively, Ikaros-deficient cells can be generated by treatment with Ikaros inhibitors, e.g., lenalidomide.

[00673] In embodiments, a T cell population is DGK-deficient and Ikaros-deficient, e.g., does not express DGK and Ikaros, or has reduced or inhibited DGK and Ikaros activity. Such DGK and Ikaros-deficient cells can be generated by any of the methods described herein.

[00674] In an embodiment, the NK cells are obtained from the subject. In another embodiment, the NK cells are an NK cell line, e.g., NK-92 cell line (Conkwest).

[00675] In an embodiment, immune effector cells, e.g., T cells, are obtained or harvested from a subject after administration to the subject of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor.

[00676] In an embodiment, the immune effector cells, e.g., T cells, are collected after an increase in the number of PD1 negative immune effector, e.g., T cells, or after an increase in the ratio of PD1 negative immune effector, e.g., T cells/ PD1 positive immune effector, e.g., T cells, has occurred.

[00677] In an embodiment, the immune effector cells, e.g., T cells, are collected after an increase in the number of naive T cells has occurred.

[00678] In an embodiment, the immune effector cells, e.g., T cells, are collected after one or more of the following:

an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2.

The increase or decrease can be transient. The increase or decrease can be as compared with a standard, e.g., an untreated subject.

[00679] In embodiment, immune effector cells, e.g., T cells, are contacted, ex vivo (after removal from the subject or a donor and before introduction into the subject), with an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor.

[00680] In an embodiment, the contact is at a level which results in an increase in the number of PD1 negative immune effector, e.g., T cells, or an increase in the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector, e.g., T cells.

[00681] In an embodiment, immune effector cells, e.g., T cells, are contacted, ex vivo (after removal from the subject or a donor and before introduction into the subject), with an mTOR inhibitor, at a level which results in an increase in the number of naive T cells.

[00682] In an embodiment, immune effector cells, e.g., T cells, are contacted, ex vivo (after removal from the subject or a donor and before introduction into the subject), with an mTOR inhibitor, at a level which results in one or more of the following:

an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2.

The increase or decrease can be transient. The increase or decrease can be as compared with a standard, e.g., an untreated subject.

[00683] In an embodiment a preparation of T cells is evaluated for the level of increase in the number of PD1 negative immune effector, e.g., T cells, or an increase in the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector, e.g., T cells.

[00684] In an embodiment, a preparation of T cells is evaluated for the level of increase in the number of naive T cells. In an embodiment, a preparation of T cells is evaluated for one or more of the following:

an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2.

The increase or decrease can be transient. The increase or decrease can be as compared with a standard, e.g., an untreated subject.

**Allogeneic CAR**

[00685] In embodiments described herein, the immune effector cell can be an allogeneic immune effector cell, e.g., T cell or NK cell. For example, the cell can be an allogeneic T cell, e.g., an allogeneic T cell lacking expression of a functional T cell receptor (TCR) and/or human leukocyte antigen (HLA), e.g., HLA class I and/or HLA class II.

[00686] A T cell lacking a functional TCR can be, e.g., engineered such that it does not express any functional TCR on its surface, engineered such that it does not express one or more subunits that comprise a functional TCR (e.g., engineered such that it does not express (or exhibits reduced expression) of TCR alpha, TCR beta, TCR gamma, TCR delta, TCR epsilon, and/or TCR zeta) or engineered such that it produces very little functional TCR on its surface. Alternatively, the T cell can express a substantially impaired TCR, e.g., by expression of mutated or truncated forms of one or more of the subunits of the TCR. The term "substantially impaired TCR" means that this TCR will not elicit an adverse immune reaction in a host.

[00687] A T cell described herein can be, e.g., engineered such that it does not express a functional HLA on its surface. For example, a T cell described herein, can be engineered such that cell surface expression HLA, e.g., HLA class 1 and/or HLA class II, is downregulated. In some embodiments, downregulation of HLA may be accomplished by reducing or eliminating expression of beta-2 microglobulin (B2M).

[00688] In some embodiments, the T cell can lack a functional TCR and a functional HLA, e.g., HLA class I and/or HLA class II.

[00689] Modified T cells that lack expression of a functional TCR and/or HLA can be obtained by any suitable means, including a knock out or knock down of one or more subunit of TCR or HLA. For example, the T cell can include a knock down of TCR and/or HLA using siRNA, shRNA, clustered regularly interspaced short palindromic repeats (CRISPR) transcription-activator like effector nuclease (TALEN), or zinc finger endonuclease (ZFN).

[00690] In some embodiments, the allogeneic cell can be a cell which does not express or expresses at low levels an inhibitory molecule, e.g. a cell engineered by any method described herein. For example, the cell can be a cell that does not express or expresses at low levels an inhibitory molecule, e.g., that can decrease the ability of a CAR-expressing cell to mount an immune effector response. Examples of inhibitory molecules include PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine,and TGFR beta. Inhibition of an inhibitory molecule, e.g., by inhibition at the DNA, RNA or protein level, can optimize a CAR-expressing cell performance. In embodiments, an inhibitory

nucleic acid, e.g., an inhibitory nucleic acid, e.g., a dsRNA, e.g., an siRNA or shRNA, a clustered regularly interspaced short palindromic repeats (CRISPR), a transcription-activator like effector nuclease (TALEN), or a zinc finger endonuclease (ZFN), e.g., as described herein, can be used.

***siRNA and shRNA to inhibit TCR or HLA***

[00691] In some embodiments, TCR expression and/or HLA expression can be inhibited using siRNA or shRNA that targets a nucleic acid encoding a TCR and/or HLA, and/or an inhibitory molecule described herein (e.g., PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta), in a T cell.

[00692] Expression of siRNA and shRNAs in T cells can be achieved using any conventional expression system, e.g., such as a lentiviral expression system.

[00693] Exemplary shRNAs that downregulate expression of components of the TCR are described, e.g., in US Publication No.: 2012/0321667. Exemplary siRNA and shRNA that downregulate expression of HLA class I and/or HLA class II genes are described, e.g., in U.S. publication No.: US 2007/0036773.

***CRISPR to inhibit TCR or HLA***

[00694] "CRISPR" or "CRISPR to TCR and/or HLA" or "CRISPR to inhibit TCR and/or HLA" as used herein refers to a set of clustered regularly interspaced short palindromic repeats, or a system comprising such a set of repeats. "Cas", as used herein, refers to a CRISPR-associated protein. A "CRISPR/Cas" system refers to a system derived from CRISPR and Cas which can be used to silence or mutate a TCR and/or HLA gene, and/or an inhibitory molecule described herein (e.g., PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta).

[00695] Naturally-occurring CRISPR/Cas systems are found in approximately 40% of sequenced eubacteria genomes and 90% of sequenced archaea. Grissa *et al.* (2007) *BMC*

*Bioinformatics* 8: 172. This system is a type of prokaryotic immune system that confers resistance to foreign genetic elements such as plasmids and phages and provides a form of acquired immunity. Barrangou *et al.* (2007) *Science* 315: 1709-1712; Marragini *et al.* ( 2008) *Science* 322: 1843-1845.

[00696] The CRISPR/Cas system has been modified for use in gene editing (silencing, enhancing or changing specific genes) in eukaryotes such as mice or primates. Wiedenheft *et al.* (2012) *Nature* 482: 331-8. This is accomplished by introducing into the eukaryotic cell a plasmid containing a specifically designed CRISPR and one or more appropriate Cas.

[00697] The CRISPR sequence, sometimes called a CRISPR locus, comprises alternating repeats and spacers. In a naturally-occurring CRISPR, the spacers usually comprise sequences foreign to the bacterium such as a plasmid or phage sequence; in the TCR and/or HLA CRISPR/Cas system, the spacers are derived from the TCR or HLA gene sequence.

[00698] RNA from the CRISPR locus is constitutively expressed and processed by Cas proteins into small RNAs. These comprise a spacer flanked by a repeat sequence. The RNAs guide other Cas proteins to silence exogenous genetic elements at the RNA or DNA level. Horvath *et al.* (2010) *Science* 327: 167-170; Makarova *et al.* (2006) *Biology Direct* 1: 7. The spacers thus serve as templates for RNA molecules, analogously to siRNAs. Pennisi (2013) *Science* 341: 833-836.

[00699] As these naturally occur in many different types of bacteria, the exact arrangements of the CRISPR and structure, function and number of Cas genes and their product differ somewhat from species to species. Haft *et al.* (2005) *PLoS Comput. Biol.* 1: e60; Kunin *et al.* (2007) *Genome Biol.* 8: R61; Mojica *et al.* (2005) *J. Mol. Evol.* 60: 174-182; Bolotin *et al.* (2005) *Microbiol.* 151: 2551-2561; Pourcel et al. (2005) *Microbiol.* 151: 653-663; and Stern *et al.* (2010) *Trends. Genet*. 28: 335-340. For example, the Cse (Cas subtype, E. coli) proteins (e.g., CasA) form a functional complex, Cascade, that processes CRISPR RNA transcripts into spacer-repeat units that Cascade retains. Brouns et al. (2008) *Science* 321: 960-964. In other prokaryotes, Cas6 processes the CRISPR transcript. The CRISPR-based phage inactivation in E. coli requires Cascade and Cas3, but not Cas1 or Cas2. The Cmr (Cas RAMP module) proteins in Pyrococcus furiosus and other prokaryotes form a functional complex with small CRISPR RNAs that recognizes and cleaves complementary target RNAs. A simpler CRISPR system relies on

the protein Cas9, which is a nuclease with two active cutting sites, one for each strand of the double helix. Combining Cas9 and modified CRISPR locus RNA can be used in a system for gene editing. Pennisi (2013) *Science* 341: 833-836.

[00700] The CRISPR/Cas system can thus be used to edit a TCR and/or HLA gene (adding or deleting a basepair), or introducing a premature stop which thus decreases expression of a TCR and/or HLA. The CRISPR/Cas system can alternatively be used like RNA interference, turning off TCR and/or HLA gene in a reversible fashion. In a mammalian cell, for example, the RNA can guide the Cas protein to a TCR and/or HLA promoter, sterically blocking RNA polymerases.

[00701] Artificial CRISPR/Cas systems can be generated which inhibit TCR and/or HLA, using technology known in the art, e.g., that described in U.S. Publication No.20140068797, and Cong (2013) Science 339: 819-823. Other artificial CRISPR/Cas systems that are known in the art may also be generated which inhibit TCR and/or HLA, e.g., that described in Tsai (2014) Nature Biotechnol., 32:6 569-576, U.S. Patent No.: 8,871,445; 8,865,406; 8,795,965; 8,771,945; and 8,697,359.

***TALEN to inhibit TCR and/or HLA***

[00702] "TALEN" or "TALEN to HLA and/or TCR" or "TALEN to inhibit HLA and/or TCR" refers to a transcription activator-like effector nuclease, an artificial nuclease which can be used to edit the HLA and/or TCR gene, and/or an inhibitory molecule described herein (e.g., PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta).

[00703] TALENs are produced artificially by fusing a TAL effector DNA binding domain to a DNA cleavage domain. Transcription activator-like effects (TALEs) can be engineered to bind any desired DNA sequence, including a portion of the HLA or TCR gene. By combining an engineered TALE with a DNA cleavage domain, a restriction enzyme can be produced which is specific to any desired DNA sequence, including a HLA or TCR sequence. These can then be introduced into a cell, wherein they can be used for genome editing. Boch (2011) *Nature*

*Biotech*. 29: 135-6; and Boch et al. (2009) *Science* 326: 1509-12; Moscou et al. (2009) *Science* 326: 3501.

[00704] TALEs are proteins secreted by Xanthomonas bacteria. The DNA binding domain contains a repeated, highly conserved 33-34 amino acid sequence, with the exception of the 12th and 13th amino acids. These two positions are highly variable, showing a strong correlation with specific nucleotide recognition. They can thus be engineered to bind to a desired DNA sequence.

[00705] To produce a TALEN, a TALE protein is fused to a nuclease (N), which is a wild-type or mutated FokI endonuclease. Several mutations to FokI have been made for its use in TALENs; these, for example, improve cleavage specificity or activity. Cermak et al. (2011) *Nucl. Acids Res.* 39: e82; Miller et al. (2011) *Nature Biotech*. 29: 143-8; Hockemeyer et al. (2011) *Nature Biotech*. 29: 731-734; Wood et al. (2011) *Science* 333: 307; Doyon et al. (2010) *Nature Methods* 8: 74-79; Szczepek et al. (2007) *Nature Biotech.* 25: 786-793; and Guo et al. (2010) *J. Mol. Biol.* 200: 96.

[00706] The FokI domain functions as a dimer, requiring two constructs with unique DNA binding domains for sites in the target genome with proper orientation and spacing. Both the number of amino acid residues between the TALE DNA binding domain and the FokI cleavage domain and the number of bases between the two individual TALEN binding sites appear to be important parameters for achieving high levels of activity. Miller et al. (2011) *Nature Biotech.* 29: 143-8.

[00707] A HLA or TCR TALEN can be used inside a cell to produce a double-stranded break (DSB). A mutation can be introduced at the break site if the repair mechanisms improperly repair the break via non-homologous end joining. For example, improper repair may introduce a frame shift mutation. Alternatively, foreign DNA can be introduced into the cell along with the TALEN; depending on the sequences of the foreign DNA and chromosomal sequence, this process can be used to correct a defect in the HLA or TCR gene or introduce such a defect into a wt HLA or TCR gene, thus decreasing expression of HLA or TCR.

[00708] TALENs specific to sequences in HLA or TCR can be constructed using any method known in the art, including various schemes using modular components. Zhang et al. (2011) *Nature Biotech.* 29: 149-53; Geibler et al. (2011) *PLoS ONE* 6: e19509.

***Zinc finger nuclease to inhibit HLA and/or TCR***

[00709] "ZFN" or "Zinc Finger Nuclease" or "ZFN to HLA and/or TCR" or "ZFN to inhibit HLA and/or TCR" refer to a zinc finger nuclease, an artificial nuclease which can be used to edit the HLA and/or TCR gene, and/or an inhibitory molecule described herein (e.g., PD1, PD-L1, PD-L2, CTLA4, TIM3, CEACAM (e.g., CEACAM-1, CEACAM-3 and/or CEACAM-5), LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta).

[00710] Like a TALEN, a ZFN comprises a FokI nuclease domain (or derivative thereof) fused to a DNA-binding domain. In the case of a ZFN, the DNA-binding domain comprises one or more zinc fingers. Carroll et al. (2011) *Genetics Society of America* 188: 773-782; and Kim et al. (1996) *Proc. Natl. Acad. Sci. USA* 93: 1156-1160.

[00711] A zinc finger is a small protein structural motif stabilized by one or more zinc ions. A zinc finger can comprise, for example, Cys2His2, and can recognize an approximately 3-bp sequence. Various zinc fingers of known specificity can be combined to produce multi-finger polypeptides which recognize about 6, 9, 12, 15 or 18-bp sequences. Various selection and modular assembly techniques are available to generate zinc fingers (and combinations thereof) recognizing specific sequences, including phage display, yeast one-hybrid systems, bacterial one-hybrid and two-hybrid systems, and mammalian cells.

[00712] Like a TALEN, a ZFN must dimerize to cleave DNA. Thus, a pair of ZFNs are required to target non-palindromic DNA sites. The two individual ZFNs must bind opposite strands of the DNA with their nucleases properly spaced apart. Bitinaite et al. (1998) *Proc. Natl. Acad. Sci. USA* 95: 10570-5.

[00713] Also like a TALEN, a ZFN can create a double-stranded break in the DNA, which can create a frame-shift mutation if improperly repaired, leading to a decrease in the expression and amount of HLA and/or TCR in a cell. ZFNs can also be used with homologous recombination to mutate in the HLA or TCR gene.

[00714] ZFNs specific to sequences in HLA AND/OR TCR can be constructed using any method known in the art. See, e.g., Provasi (2011) Nature Med. 18: 807-815; Torikai (2013)

Blood 122: 1341-1349; Cathomen et al. (2008) *Mol. Ther.* 16: 1200-7; and Guo et al. (2010) *J. Mol. Biol.* 400: 96; U.S. Patent Publication 2011/0158957; and U.S. Patent Publication 2012/0060230.

**Telomerase expression**

[00715] While not wishing to be bound by any particular theory, in some embodiments, a therapeutic T cell has short term persistence in a patient, due to shortened telomeres in the T cell; accordingly, transfection with a telomerase gene can lengthen the telomeres of the T cell and improve persistence of the T cell in the patient. See Carl June, "Adoptive T cell therapy for cancer in the clinic", Journal of Clinical Investigation, 117:1466-1476 (2007). Thus, in an embodiment, an immune effector cell, e.g., a T cell, ectopically expresses a telomerase subunit, e.g., the catalytic subunit of telomerase, e.g., TERT, e.g., hTERT. In some aspects, this disclosure provides a method of producing a CAR-expressing cell, comprising contacting a cell with a nucleic acid encoding a telomerase subunit, e.g., the catalytic subunit of telomerase, e.g., TERT, e.g., hTERT. The cell may be contacted with the nucleic acid before, simultaneous with, or after being contacted with a construct encoding a CAR.

[00716] In one aspect, the disclosure features a method of making a population of immune effector cells (e.g., T cells or NK cells). In an embodiment, the method comprises: providing a population of immune effector cells (e.g., T cells or NK cells), contacting the population of immune effector cells with a nucleic acid encoding a CAR; and contacting the population of immune effector cells with a nucleic acid encoding a telomerase subunit, e.g., hTERT, under conditions that allow for CAR and telomerase expression.

[00717] In an embodiment, the nucleic acid encoding the telomerase subunit is DNA. In an embodiment, the nucleic acid encoding the telomerase subunit comprises a promoter capable of driving expression of the telomerase subunit.

[00718] In an embodiment, hTERT has the amino acid sequence of GenBank Protein ID AAC51724.1 (Meyerson et al., "hEST2, the Putative Human Telomerase Catalytic Subunit Gene, Is Up-Regulated in Tumor Cells and during Immortalization" Cell Volume 90, Issue 4, 22 August 1997, Pages 785–795) as follows:

MPRAPRCRAVRSLLRSHYREVLPLATFVRRLGPQGWRLVQRGDPAAFRALVAQCLVCVPWDAR
PPPAAPSFRQVSCLKELVARVLQRLCERGAKNVLAFGFALLDGARGGPPEAFTTSVRSYLPNTVT

DALRGSGAWGLLLRRVGDDVLVHLLARCALFVLVAPSCAYQVCGPPLYQLGAATQARPPPHAS
GPRRRLGCERAWNHSVREAGVPLGLPAPGARRRGGSASRSLPLPKRPRRGAAPEPERTPVGQGS
WAHPGRTRGPSDRGFCVVSPARPAEEATSLEGALSGTRHSHPSVGRQHHAGPPSTSRPPRPWDTP
CPPVYAETKHFLYSSGDKEQLRPSFLLSSLRPSLTGARRLVETIFLGSRPWMPGTPRRLPRLPQRY
WQMRPLFLELLGNHAQCPYGVLLKTHCPLRAAVTPAAGVCAREKPQGSVAAPEEEDTDPRRLV
QLLRQHSSPWQVYGFVRACLRRLVPPGLWGSRHNERRFLRNTKKFISLGKHAKLSLQELTWKM
SVRGCAWLRRSPGVGCVPAAEHRLREEILAKFLHWLMSVYVVELLRSFFYVTETTFQKNRLFFY
RKSVWSKLQSIGIRQHLKRVQLRELSEAEVRQHREARPALLTSRLRFIPKPDGLRPIVNMDYVVG
ARTFRREKRAERLTSRVKALFSVLNYERARRPGLLGASVLGLDDIHRAWRTFVLRVRAQDPPPE
LYFVKVDVTGAYDTIPQDRLTEVIASIIKPQNTYCVRRYAVVQKAAHGHVRKAFKSHVSTLTDL
QPYMRQFVAHLQETSPLRDAVVIEQSSSLNEASSGLFDVFLRFMCHHAVRIRGKSYVQCQGIPQG
SILSTLLCSLCYGDMENKLFAGIRRDGLLLRLVDDFLLVTPHLTHAKTFLRTLVRGVPEYGCVVN
LRKTVVNFPVEDEALGGTAFVQMPAHGLFPWCGLLLDTRTLEVQSDYSSYARTSIRASLTFNRG
FKAGRNMRRKLFGVLRLKCHSLFLDLQVNSLQTVCTNIYKILLLQAYRFHACVLQLPFHQQVWK
NPTFFLRVISDTASLCYSILKAKNAGMSLGAKGAAGPLPSEAVQWLCHQAFLLKLTRHRVTYVP
LLGSLRTAQTQLSRKLPGTTLTALEAAANPALPSDFKTILD (SEQ ID NO: 88)

[00719] In an embodiment, the hTERT has a sequence at least 80%, 85%, 90%, 95%, 96^, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 88. In an embodiment, the hTERT has a sequence of SEQ ID NO: 88. In an embodiment, the hTERT comprises a deletion (e.g., of no more than 5, 10, 15, 20, or 30 amino acids) at the N-terminus, the C-terminus, or both. In an embodiment, the hTERT comprises a transgenic amino acid sequence (e.g., of no more than 5, 10, 15, 20, or 30 amino acids) at the N-terminus, the C-terminus, or both.

[00720] In an embodiment, the hTERT is encoded by the nucleic acid sequence of GenBank Accession No. AF018167 (Meyerson et al., "hEST2, the Putative Human Telomerase Catalytic Subunit Gene, Is Up-Regulated in Tumor Cells and during Immortalization" Cell Volume 90, Issue 4, 22 August 1997, Pages 785–795):

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   1 caggcagcgt ggtcctgctg cgcacgtggg aagccctggc cccggccacc cccgcgatgc
  61 cgcgcgctcc ccgctgccga gccgtgcgct ccctgctgcg cagccactac cgcgaggtgc
 121 tgccgctggc cacgttcgtg cggcgcctgg ggccccaggg ctggcggctg gtgcagcgcg
 181 gggacccggc ggctttccgc gcgctggtgg cccagtgcct ggtgtgcgtg ccctgggacg
 241 cacggccgcc ccccgccgcc ccctccttcc gccaggtgtc ctgcctgaag gagctggtgg
 301 cccgagtgct gcagaggctg tgcgagcgcg gcgcgaagaa cgtgctggcc ttcggcttcg
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361 cgctgctgga cggggcccgc gggggccccc ccgaggcctt caccaccagc gtgcgcagct
421 acctgcccaa cacggtgacc gacgcactgc gggggagcgg ggcgtggggg ctgctgttgc
481 gccgcgtggg cgacgacgtg ctggttcacc tgctggcacg ctgcgcgctc tttgtgctgg
541 tggctcccag ctgcgcctac caggtgtgcg ggccgccgct gtaccagctc ggcgctgcca
601 ctcaggcccg gcccccgcca cacgctagtg gaccccgaag gcgtctggga tgcgaacggg
661 cctggaacca tagcgtcagg gaggccgggg tccccctggg cctgccagcc ccgggtgcga
721 ggaggcgcgg gggcagtgcc agccgaagtc tgccgttgcc caagaggccc aggcgtggcg
781 ctgcccctga gccggagcgg acgcccgttg ggcaggggtc ctgggcccac ccgggcagga
841 cgcgtggacc gagtgaccgt ggtttctgtg tggtgtcacc tgccagaccc gccgaagaag
901 ccacctcttt ggagggtgcg ctctctggca cgcgccactc ccacccatcc gtgggccgcc
961 agcaccacgc gggcccccca tccacatcgc ggccaccacg tccctgggac acgccttgtc
1021 ccccggtgta cgccgagacc aagcacttcc tctactcctc aggcgacaag gagcagctgc
1081 ggccctcctt cctactcagc tctctgaggc ccagcctgac tggcgctcgg aggctcgtgg
1141 agaccatctt tctgggttcc aggccctgga tgccagggac tccccgcagg ttgccccgcc
1201 tgccccagcg ctactggcaa atgcggcccc tgtttctgga gctgcttggg aaccacgcgc
1261 agtgccccta cggggtgctc ctcaagacgc actgcccgct gcgagctgcg gtcaccccag
1321 cagccggtgt ctgtgcccgg gagaagcccc agggctctgt ggcggccccc gaggaggagg
1381 acacagaccc ccgtcgcctg gtgcagctgc tccgccagca cagcagcccc tggcaggtgt
1441 acggcttcgt gcgggcctgc ctgcgccggc tggtgccccc aggcctctgg ggctccaggc
1501 acaacgaacg ccgcttcctc aggaacacca agaagttcat ctccctgggg aagcatgcca
1561 agctctcgct gcaggagctg acgtggaaga tgagcgtgcg gggctgcgct tggctgcgca
1621 ggagcccagg ggttggctgt gttccggccg cagagcaccg tctgcgtgag gagatcctgg
1681 ccaagttcct gcactggctg atgagtgtgt acgtcgtcga gctgctcagg tctttctttt
1741 atgtcacgga gaccacgttt caaaagaaca ggctcttttt ctaccggaag agtgtctgga
1801 gcaagttgca aagcattgga atcagacagc acttgaagag ggtgcagctg cgggagctgt
1861 cggaagcaga ggtcaggcag catcgggaag ccaggcccgc cctgctgacg tccagactcc
1921 gcttcatccc caagcctgac gggctgcggc cgattgtgaa catggactac gtcgtgggag
1981 ccagaacgtt ccgcagagaa aagagggccg agcgtctcac ctcgagggtg aaggcactgt
2041 tcagcgtgct caactacgag cgggcgcggc gccccggcct cctgggcgcc tctgtgctgg
2101 gcctggacga tatccacagg gcctggcgca ccttcgtgct gcgtgtgcgg gcccaggacc
2161 cgccgcctga gctgtacttt gtcaaggtgg atgtgacggg cgcgtacgac accatccccc
2221 aggacaggct cacggaggtc atcgccagca tcatcaaacc ccagaacacg tactgcgtgc
2281 gtcggtatgc cgtggtccag aaggccgccc atgggcacgt ccgcaaggcc ttcaagagcc
2341 acgtctctac cttgacagac ctccagccgt acatgcgaca gttcgtggct cacctgcagg
2401 agaccagccc gctgagggat gccgtcgtca tcgagcagag ctcctccctg aatgaggcca
2461 gcagtggcct cttcgacgtc ttcctacgct tcatgtgcca ccacgccgtg cgcatcaggg
2521 gcaagtccta cgtccagtgc caggggatcc cgcagggctc catcctctcc acgctgctct
2581 gcagcctgtg ctacggcgac atggagaaca agctgtttgc ggggattcgg cgggacgggc

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2641 tgctcctgcg tttggtggat gatttcttgt tggtgacacc tcacctcacc cacgcgaaaa
2701 ccttcctcag gaccctggtc cgaggtgtcc ctgagtatgg ctgcgtggtg aacttgcgga
2761 agacagtggt gaacttccct gtagaagacg aggccctggg tggcacggct tttgttcaga
2821 tgccggccca cggcctattc ccctggtgcg gcctgctgct ggatacccgg accctggagg
2881 tgcagagcga ctactccagc tatgcccgga cctccatcag agccagtctc accttcaacc
2941 gcggcttcaa ggctgggagg aacatgcgtc gcaaactctt tggggtcttg cggctgaagt
3001 gtcacagcct gtttctggat ttgcaggtga acagcctcca gacggtgtgc accaacatct
3061 acaagatcct cctgctgcag gcgtacaggt ttcacgcatg tgtgctgcag ctcccatttc
3121 atcagcaagt ttggaagaac cccacatttt tcctgcgcgt catctctgac acggcctccc
3181 tctgctactc catcctgaaa gccaagaacg cagggatgtc gctgggggcc aagggcgccg
3241 ccggccctct gccctccgag gccgtgcagt ggctgtgcca ccaagcattc ctgctcaagc
3301 tgactcgaca ccgtgtcacc tacgtgccac tcctggggtc actcaggaca gcccagacgc
3361 agctgagtcg gaagctcccg gggacgacgc tgactgccct ggaggccgca gccaacccgg
3421 cactgccctc agacttcaag accatcctgg actgatggcc acccgcccac agccaggccg
3481 agagcagaca ccagcagccc tgtcacgccg ggctctacgt cccagggagg gaggggcggc
3541 ccacacccag gcccgcaccg ctgggagtct gaggcctgag tgagtgtttg gccgaggcct
3601 gcatgtccgg ctgaaggctg agtgtccggc tgaggcctga gcgagtgtcc agccaagggc
3661 tgagtgtcca gcacacctgc cgtcttcact tccccacagg ctggcgctcg gctccacccc
3721 agggccagct tttcctcacc aggagcccgg cttccactcc ccacatagga atagtccatc
3781 cccagattcg ccattgttca cccctcgccc tgccctcctt tgccttccac ccccaccatc
3841 caggtggaga ccctgagaag gaccctggga gctctgggaa tttggagtga ccaaaggtgt
3901 gccctgtaca caggcgagga ccctgcacct ggatgggggt ccctgtgggt caaattgggg
3961 ggaggtgctg tgggagtaaa atactgaata tatgagtttt tcagttttga aaaaaaaaaa
4021 aaaaaaa (SEQ ID NO: 89)
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[00721] In an embodiment, the hTERT is encoded by a nucleic acid having a sequence at least 80%, 85%, 90%, 95%, 96, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 89. In an embodiment, the hTERT is encoded by a nucleic acid of SEQ ID NO: 89.

## Activation and Expansion of Immune Effector Cells (e.g., T Cells)

[00722] Immune effector cells such as T cells may be activated and expanded generally using methods as described, for example, in U.S. Patents 6,352,694; 6,534,055; 6,905,680; 6,692,964; 5,858,358; 6,887,466; 6,905,681; 7,144,575; 7,067,318; 7,172,869; 7,232,566; 7,175,843; 5,883,223; 6,905,874; 6,797,514; 6,867,041; and U.S. Patent Application Publication No. 20060121005.

[00723] The procedure for *ex vivo* expansion of hematopoietic stem and progenitor cells is described in U.S. Pat. No. 5,199,942, incorporated herein by reference, can be applied to the cells of the present invention. Other suitable methods are known in the art, therefore the present invention is not limited to any particular method of *ex vivo* expansion of the cells. Briefly, *ex vivo* culture and expansion of T cells can comprise: (1) collecting CD34+ hematopoietic stem and progenitor cells from a mammal from peripheral blood harvest or bone marrow explants; and (2) expanding such cells *ex vivo*. In addition to the cellular growth factors described in U.S. Pat. No. 5,199,942, other factors such as flt3-L, IL-1, IL-3 and c-kit ligand, can be used for culturing and expansion of the cells.

[00724] Generally, invention population of immune effector cells, e.g., T regulatory cell depleted cells, may be expanded by contact with a surface having attached thereto an agent that stimulates a CD3/TCR complex associated signal and a ligand that stimulates a costimulatory molecule on the surface of the T cells. In particular, T cell populations may be stimulated as described herein, such as by contact with an anti-CD3 antibody, or antigen-binding fragment thereof, or an anti-CD2 antibody immobilized on a surface, or by contact with a protein kinase C activator (e.g., bryostatin) in conjunction with a calcium ionophore. For co-stimulation of an accessory molecule on the surface of the T cells, a ligand that binds the accessory molecule is used. For example, a population of T cells can be contacted with an anti-CD3 antibody and an anti-CD28 antibody, under conditions appropriate for stimulating proliferation of the T cells. To stimulate proliferation of either CD4+ T cells or CD8+ T cells, an anti-CD3 antibody and an anti-CD28 antibody can be used. Examples of an anti-CD28 antibody include 9.3, B-T3, XR-CD28 (Diaclone, Besançon, France) can be used as can other methods commonly known in the art (Berg et al., Transplant Proc. 30(8):3975-3977, 1998; Haanen et al., J. Exp. Med. 190(9):13191328, 1999; Garland et al., J. Immunol Meth. 227(1-2):53-63, 1999).

[00725] In certain aspects, the primary stimulatory signal and the costimulatory signal for the T cell may be provided by different protocols. For example, the agents providing each signal may be in solution or coupled to a surface. When coupled to a surface, the agents may be coupled to the same surface (i.e., in "cis" formation) or to separate surfaces (i.e., in "trans" formation). Alternatively, one agent may be coupled to a surface and the other agent in solution. In one aspect, the agent providing the costimulatory signal is bound to a cell surface and the agent providing the primary activation signal is in solution or coupled to a surface. In certain

aspects, both agents can be in solution. In one aspect, the agents may be in soluble form, and then cross-linked to a surface, such as a cell expressing Fc receptors or an antibody or other binding agent which will bind to the agents. In this regard, see for example, U.S. Patent Application Publication Nos. 20040101519 and 20060034810 for artificial antigen presenting cells (aAPCs) that are contemplated for use in activating and expanding T cells in the present invention.

[00726] In one aspect, the two agents are immobilized on beads, either on the same bead, i.e., "cis," or to separate beads, i.e., "trans." By way of example, the agent providing the primary activation signal is an anti-CD3 antibody or an antigen-binding fragment thereof and the agent providing the costimulatory signal is an anti-CD28 antibody or antigen-binding fragment thereof; and both agents are co-immobilized to the same bead in equivalent molecular amounts. In one aspect, a 1:1 ratio of each antibody bound to the beads for CD4+ T cell expansion and T cell growth is used. In certain aspects of the present invention, a ratio of anti CD3:CD28 antibodies bound to the beads is used such that an increase in T cell expansion is observed as compared to the expansion observed using a ratio of 1:1. In one particular aspect an increase of from about 1 to about 3 fold is observed as compared to the expansion observed using a ratio of 1:1. In one aspect, the ratio of CD3:CD28 antibody bound to the beads ranges from 100:1 to 1:100 and all integer values there between. In one aspect, more anti-CD28 antibody is bound to the particles than anti-CD3 antibody, i.e., the ratio of CD3:CD28 is less than one. In certain aspects, the ratio of anti CD28 antibody to anti CD3 antibody bound to the beads is greater than 2:1. In one particular aspect, a 1:100 CD3:CD28 ratio of antibody bound to beads is used. In one aspect, a 1:75 CD3:CD28 ratio of antibody bound to beads is used. In a further aspect, a 1:50 CD3:CD28 ratio of antibody bound to beads is used. In one aspect, a 1:30 CD3:CD28 ratio of antibody bound to beads is used. In one preferred aspect, a 1:10 CD3:CD28 ratio of antibody bound to beads is used. In one aspect, a 1:3 CD3:CD28 ratio of antibody bound to the beads is used. In yet one aspect, a 3:1 CD3:CD28 ratio of antibody bound to the beads is used.

[00727] Ratios of particles to cells from 1:500 to 500:1 and any integer values in between may be used to stimulate T cells or other target cells. As those of ordinary skill in the art can readily appreciate, the ratio of particles to cells may depend on particle size relative to the target cell. For example, small sized beads could only bind a few cells, while larger beads could bind many. In certain aspects the ratio of cells to particles ranges from 1:100 to 100:1 and any integer values

in-between and in further aspects the ratio comprises 1:9 to 9:1 and any integer values in between, can also be used to stimulate T cells. The ratio of anti-CD3- and anti-CD28-coupled particles to T cells that result in T cell stimulation can vary as noted above, however certain preferred values include 1:100, 1:50, 1:40, 1:30, 1:20, 1:10, 1:9, 1:8, 1:7, 1:6, 1:5, 1:4, 1:3, 1:2, 1:1, 2:1, 3:1, 4:1, 5:1, 6:1, 7:1, 8:1, 9:1, 10:1, and 15:1 with one preferred ratio being at least 1:1 particles per T cell. In one aspect, a ratio of particles to cells of 1:1 or less is used. In one particular aspect, a preferred particle: cell ratio is 1:5. In further aspects, the ratio of particles to cells can be varied depending on the day of stimulation. For example, in one aspect, the ratio of particles to cells is from 1:1 to 10:1 on the first day and additional particles are added to the cells every day or every other day thereafter for up to 10 days, at final ratios of from 1:1 to 1:10 (based on cell counts on the day of addition). In one particular aspect, the ratio of particles to cells is 1:1 on the first day of stimulation and adjusted to 1:5 on the third and fifth days of stimulation. In one aspect, particles are added on a daily or every other day basis to a final ratio of 1:1 on the first day, and 1:5 on the third and fifth days of stimulation. In one aspect, the ratio of particles to cells is 2:1 on the first day of stimulation and adjusted to 1:10 on the third and fifth days of stimulation. In one aspect, particles are added on a daily or every other day basis to a final ratio of 1:1 on the first day, and 1:10 on the third and fifth days of stimulation. One of skill in the art will appreciate that a variety of other ratios may be suitable for use in the present invention. In particular, ratios will vary depending on particle size and on cell size and type. In one aspect, the most typical ratios for use are in the neighborhood of 1:1, 2:1 and 3:1 on the first day.

[00728] In further aspects, the cells, such as T cells, are combined with agent-coated beads, the beads and the cells are subsequently separated, and then the cells are cultured. In an alternative aspect, prior to culture, the agent-coated beads and cells are not separated but are cultured together. In a further aspect, the beads and cells are first concentrated by application of a force, such as a magnetic force, resulting in increased ligation of cell surface markers, thereby inducing cell stimulation.

[00729] By way of example, cell surface proteins may be ligated by allowing paramagnetic beads to which anti-CD3 and anti-CD28 are attached (3x28 beads) to contact the T cells. In one aspect the cells (for example, $10^4$ to $10^9$ T cells) and beads (for example, DYNABEADS® M-450 CD3/CD28 T paramagnetic beads at a ratio of 1:1) are combined in a buffer, for example

PBS (without divalent cations such as, calcium and magnesium). Again, those of ordinary skill in the art can readily appreciate any cell concentration may be used. For example, the target cell may be very rare in the sample and comprise only 0.01% of the sample or the entire sample (i.e., 100%) may comprise the target cell of interest. Accordingly, any cell number is within the context of the present invention. In certain aspects, it may be desirable to significantly decrease the volume in which particles and cells are mixed together (i.e., increase the concentration of cells), to ensure maximum contact of cells and particles. For example, in one aspect, a concentration of about 10 billion cells/ml, 9 billion/ml, 8 billion/ml, 7 billion/ml, 6 billion/ml, 5 billion/ml, or 2 billion cells/ml is used. In one aspect, greater than 100 million cells/ml is used. In a further aspect, a concentration of cells of 10, 15, 20, 25, 30, 35, 40, 45, or 50 million cells/ml is used. In yet one aspect, a concentration of cells from 75, 80, 85, 90, 95, or 100 million cells/ml is used. In further aspects, concentrations of 125 or 150 million cells/ml can be used. Using high concentrations can result in increased cell yield, cell activation, and cell expansion. Further, use of high cell concentrations allows more efficient capture of cells that may weakly express target antigens of interest, such as CD28-negative T cells. Such populations of cells may have therapeutic value and would be desirable to obtain in certain aspects. For example, using high concentration of cells allows more efficient selection of CD8+ T cells that normally have weaker CD28 expression.

[00730] In one embodiment, cells transduced with a nucleic acid encoding a CAR, e.g., a CAR described herein, are expanded, e.g., by a method described herein. In one embodiment, the cells are expanded in culture for a period of several hours (e.g., about 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 18, 21 hours) to about 14 days (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14 days). In one embodiment, the cells are expanded for a period of 4 to 9 days. In one embodiment, the cells are expanded for a period of 8 days or less, e.g., 7, 6 or 5 days. In one embodiment, the cells, e.g., a CD19 CAR cell described herein, are expanded in culture for 5 days, and the resulting cells are more potent than the same cells expanded in culture for 9 days under the same culture conditions. Potency can be defined, e.g., by various T cell functions, e.g. proliferation, target cell killing, cytokine production, activation, migration, or combinations thereof. In one embodiment, the cells, e.g., a CD19 CAR cell described herein, expanded for 5 days show at least a one, two, three or four fold increase in cells doublings upon antigen stimulation as compared to the same cells expanded in culture for 9 days under the same culture conditions. In one embodiment, the

cells, e.g., the cells expressing a CD19 CAR described herein, are expanded in culture for 5 days, and the resulting cells exhibit higher proinflammatory cytokine production, e.g., IFN-γ and/or GM-CSF levels, as compared to the same cells expanded in culture for 9 days under the same culture conditions. In one embodiment, the cells, e.g., a CD19 CAR cell described herein, expanded for 5 days show at least a one, two, three, four, five, ten fold or more increase in pg/ml of proinflammatory cytokine production, e.g., IFN-γ and/or GM-CSF levels, as compared to the same cells expanded in culture for 9 days under the same culture conditions.

[00731] Several cycles of stimulation may also be desired such that culture time of T cells can be 60 days or more. Conditions appropriate for T cell culture include an appropriate media (e.g., Minimal Essential Media or RPMI Media 1640 or, X-vivo 15, (Lonza)) that may contain factors necessary for proliferation and viability, including serum (e.g., fetal bovine or human serum), interleukin-2 (IL-2), insulin, IFN-γ, IL-4, IL-7, GM-CSF, IL-10, IL-12, IL-15, TGFβ, and TNF-α or any other additives for the growth of cells known to the skilled artisan. Other additives for the growth of cells include, but are not limited to, surfactant, plasmanate, and reducing agents such as N-acetyl-cysteine and 2-mercaptoethanol. Media can include RPMI 1640, AIM-V, DMEM, MEM, α-MEM, F-12, X-Vivo 15, and X-Vivo 20, Optimizer, with added amino acids, sodium pyruvate, and vitamins, either serum-free or supplemented with an appropriate amount of serum (or plasma) or a defined set of hormones, and/or an amount of cytokine(s) sufficient for the growth and expansion of T cells. Antibiotics, e.g., penicillin and streptomycin, are included only in experimental cultures, not in cultures of cells that are to be infused into a subject. The target cells are maintained under conditions necessary to support growth, for example, an appropriate temperature (e.g., 37° C) and atmosphere (e.g., air plus 5% $CO_2$).

[00732] In one embodiment, the cells are expanded in an appropriate media (e.g., media described herein) that includes one or more interleukin that result in at least a 200-fold (e.g., 200-fold, 250-fold, 300-fold, 350-fold) increase in cells over a 14 day expansion period, e.g., as measured by a method described herein such as flow cytometry. In one embodiment, the cells are expanded in the presence of IL-15 and/or IL-7 (e.g., IL-15 and IL-7).

[00733] In embodiments, methods described herein, e.g., CAR-expressing cell manufacturing methods, comprise removing T regulatory cells, e.g., CD25+ T cells, from a cell population, e.g., using an anti-CD25 antibody, or fragment thereof, or a CD25-binding ligand, IL-2. Methods of

removing T regulatory cells, e.g., CD25+ T cells, from a cell population are described herein. In embodiments, the methods, e.g., manufacturing methods, further comprise contacting a cell population (e.g., a cell population in which T regulatory cells, such as CD25+ T cells, have been depleted; or a cell population that has previously contacted an anti-CD25 antibody, fragment thereof, or CD25-binding ligand) with IL-15 and/or IL-7. For example, the cell population (e.g., that has previously contacted an anti-CD25 antibody, fragment thereof, or CD25-binding ligand) is expanded in the presence of IL-15 and/or IL-7.

[00734] In some embodiments a CAR-expressing cell described herein is contacted with a composition comprising a interleukin-15 (IL-15) polypeptide, a interleukin-15 receptor alpha (IL-15Ra) polypeptide, or a combination of both a IL-15 polypeptide and a IL-15Ra polypeptide e.g., hetIL-15, during the manufacturing of the CAR-expressing cell, e.g., ex vivo. In embodiments, a CAR-expressing cell described herein is contacted with a composition comprising a IL-15 polypeptide during the manufacturing of the CAR-expressing cell, e.g., ex vivo. In embodiments, a CAR-expressing cell described herein is contacted with a composition comprising a combination of both a IL-15 polypeptide and a IL-15 Ra polypeptide during the manufacturing of the CAR-expressing cell, e.g., ex vivo. In embodiments, a CAR-expressing cell described herein is contacted with a composition comprising hetIL-15 during the manufacturing of the CAR-expressing cell, e.g., ex vivo.

[00735] In one embodiment the CAR-expressing cell described herein is contacted with a composition comprising hetIL-15 during ex vivo expansion. In an embodiment, the CAR-expressing cell described herein is contacted with a composition comprising an IL-15 polypeptide during ex vivo expansion. In an embodiment, the CAR-expressing cell described herein is contacted with a composition comprising both an IL-15 polypeptide and an IL-15Ra polypeptide during ex vivo expansion. In one embodiment the contacting results in the survival and proliferation of a lymphocyte subpopulation, e.g., CD8+ T cells.

[00736] T cells that have been exposed to varied stimulation times may exhibit different characteristics. For example, typical blood or apheresed peripheral blood mononuclear cell products have a helper T cell population (TH, CD4+) that is greater than the cytotoxic or suppressor T cell population (TC, CD8+). Ex vivo expansion of T cells by stimulating CD3 and CD28 receptors produces a population of T cells that prior to about days 8-9 consists

predominantly of TH cells, while after about days 8-9, the population of T cells comprises an increasingly greater population of TC cells. Accordingly, depending on the purpose of treatment, infusing a subject with a T cell population comprising predominately of TH cells may be advantageous. Similarly, if an antigen-specific subset of TC cells has been isolated it may be beneficial to expand this subset to a greater degree.

[00737] Further, in addition to CD4 and CD8 markers, other phenotypic markers vary significantly, but in large part, reproducibly during the course of the cell expansion process. Thus, such reproducibility enables the ability to tailor an activated T cell product for specific purposes.

[00738] In other embodiments, the method of making discosed herein further comprises contacting the population of immune effector cells with a nucleic acid encoding a telomerase subunit, e.g., hTERT. The the nucleic acid encoding the telomerase subunit can be DNA.

[00739] Once a CAR of the present invention is constructed, various assays can be used to evaluate the activity of the molecule, such as but not limited to, the ability to expand T cells following antigen stimulation, sustain T cell expansion in the absence of re-stimulation, and anti-cancer activities in appropriate in vitro and animal models. Assays to evaluate the effects of a cars of the present invention are described in further detail below

[00740] Western blot analysis of CAR expression in primary T cells can be used to detect the presence of monomers and dimers. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Very briefly, T cells (1:1 mixture of $CD4^+$ and $CD8^+$ T cells) expressing the CARs are expanded *in vitro* for more than 10 days followed by lysis and SDS-PAGE under reducing conditions. CARs containing the full length TCR-ζ cytoplasmic domain and the endogenous TCR-ζ chain are detected by western blotting using an antibody to the TCR-ζ chain. The same T cell subsets are used for SDS-PAGE analysis under non-reducing conditions to permit evaluation of covalent dimer formation.

[00741] *In vitro* expansion of $CAR^+$ T cells following antigen stimulation can be measured by flow cytometry. For example, a mixture of $CD4^+$ and $CD8^+$ T cells are stimulated with αCD3/αCD28 beads followed by transduction with lentiviral vectors expressing GFP under the control of the promoters to be analyzed. Exemplary promoters include the CMV IE gene, EF-1α, ubiquitin C, or phosphoglycerokinase (PGK) promoters. GFP fluorescence is evaluated on day 6

of culture in the $CD4^+$ and/or $CD8^+$ T cell subsets by flow cytometry. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Alternatively, a mixture of $CD4^+$ and $CD8^+$ T cells are stimulated with αCD3/αCD28 coated magnetic beads on day 0, and transduced with CAR on day 1 using a bicistronic lentiviral vector expressing CAR along with eGFP using a 2A ribosomal skipping sequence. Cultures are re-stimulated with either a cancer associated antigen as described herein$^+$ K562 cells (K562-a cancer associated antigen as described herein), wild-type K562 cells (K562 wild type) or K562 cells expressing hCD32 and 4-1BBL in the presence of antiCD3 and anti-CD28 antibody (K562-BBL-3/28) following washing. Exogenous IL-2 is added to the cultures every other day at 100 IU/ml. $GFP^+$ T cells are enumerated by flow cytometry using bead-based counting. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009).

[00742] Sustained $CAR^+$ T cell expansion in the absence of re-stimulation can also be measured. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Briefly, mean T cell volume (fl) is measured on day 8 of culture using a Coulter Multisizer particle counter, a Nexcelom Cellometer Vision or Millipore Scepter, following stimulation with αCD3/αCD28 coated magnetic beads on day 0, and transduction with the indicated CAR on day 1.

[00743] Animal models can also be used to measure a CART activity. For example, xenograft model using human a cancer associated antigen as described herein-specific $CAR^+$ T cells to treat a primary human pre-B ALL in immunodeficient mice can be used. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Very briefly, after establishment of ALL, mice are randomized as to treatment groups. Different numbers of a cancer associated antigen as described herein specific CAR engineered T cells are coinjected at a 1:1 ratio into NOD-SCID-$\gamma^{-/-}$ mice bearing B-ALL. The number of copies of α cancer associated antigen as described herein-ζ and α cancer associated antigen as described herein-BB-ζ vector in spleen DNA from mice is evaluated at various times following T cell injection. Animals are assessed for leukemia at weekly intervals. Peripheral blood a cancer associated antigen as described herein$^+$ B-ALL blast cell counts are measured in mice that are injected with a cancer associated antigen-specific $CAR^+$ T cells or mock-transduced T cells. Survival curves for the groups are compared using the log-rank test. In addition, absolute peripheral blood $CD4^+$ and $CD8^+$ T cell counts 4 weeks following T cell injection in NOD-SCID-$\gamma^{-/-}$ mice can also be analyzed. Mice are injected with leukemic cells and 3 weeks later are injected with T cells engineered to express CAR by a

bicistronic lentiviral vector that encodes the CAR linked to eGFP. T cells are normalized to 45–50% input $GFP^+$ T cells by mixing with mock-transduced cells prior to injection, and confirmed by flow cytometry. Animals are assessed for leukemia at 1-week intervals. Survival curves for the $CAR^+$ T cell groups are compared using the log-rank test.

[00744] Dose dependent CAR treatment response can be evaluated. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). For example, peripheral blood is obtained 35–70 days after establishing leukemia in mice injected on day 21 with CAR T cells, an equivalent number of mock-transduced T cells, or no T cells. Mice from each group are randomly bled for determination of peripheral blood a cancer associated antigen as described $herein^+$ ALL blast counts and then killed on days 35 and 49. The remaining animals are evaluated on days 57 and 70.

[00745] Assessment of cell proliferation and cytokine production has been previously described, *e.g.*, at Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Briefly, assessment of CAR-mediated proliferation is performed in microtiter plates by mixing washed T cells with K562 cells expressing a cancer associated antigen as described herein (K19) or CD32 and CD137 (KT32-BBL) for a final T-cell:K562 ratio of 2:1. K562 cells are irradiated with gamma-radiation prior to use. Anti-CD3 (clone OKT3) and anti- CD28 (clone 9.3) monoclonal antibodies are added to cultures with KT32-BBL cells to serve as a positive control for stimulating T-cell proliferation since these signals support long-term $CD8^+$ T cell expansion *ex vivo*. T cells are enumerated in cultures using CountBright™ fluorescent beads (Invitrogen, Carlsbad, CA) and flow cytometry as described by the manufacturer. $CAR^+$ T cells are identified by GFP expression using T cells that are engineered with eGFP-2A linked CAR-expressing lentiviral vectors. For CAR+ T cells not expressing GFP, the CAR+ T cells are detected with biotinylated recombinant a cancer associated antigen as described herein protein and a secondary avidin-PE conjugate. CD4+ and $CD8^+$ expression on T cells are also simultaneously detected with specific monoclonal antibodies (BD Biosciences). Cytokine measurements are performed on supernatants collected 24 hours following re-stimulation using the human TH1/TH2 cytokine cytometric bead array kit (BD Biosciences, San Diego, CA) according the manufacturer's instructions. Fluorescence is assessed using a FACScalibur flow cytometer, and data is analyzed according to the manufacturer's instructions.

[00746] Cytotoxicity can be assessed by a standard 51Cr-release assay. See, *e.g.*, Milone *et al.*, Molecular Therapy 17(8): 1453-1464 (2009). Briefly, target cells (K562 lines and primary pro-B-ALL cells) are loaded with 51Cr (as NaCrO4, New England Nuclear, Boston, MA) at 37°C for 2 hours with frequent agitation, washed twice in complete RPMI and plated into microtiter plates. Effector T cells are mixed with target cells in the wells in complete RPMI at varying ratios of effector cell:target cell (E:T). Additional wells containing media only (spontaneous release, SR) or a 1% solution of triton-X 100 detergent (total release, TR) are also prepared. After 4 hours of incubation at 37°C, supernatant from each well is harvested. Released 51Cr is then measured using a gamma particle counter (Packard Instrument Co., Waltham, MA). Each condition is performed in at least triplicate, and the percentage of lysis is calculated using the formula: % Lysis = (ER– SR) / (TR – SR), where ER represents the average 51Cr released for each experimental condition.

[00747] Imaging technologies can be used to evaluate specific trafficking and proliferation of CARs in tumor-bearing animal models. Such assays have been described, for example, in Barrett *et al.*, Human Gene Therapy 22:1575-1586 (2011). Briefly, NOD/SCID/$\gamma c^{-/-}$ (NSG) mice are injected IV with Nalm-6 cells followed 7 days later with T cells 4 hour after electroporation with the CAR constructs. The T cells are stably transfected with a lentiviral construct to express firefly luciferase, and mice are imaged for bioluminescence. Alternatively, therapeutic efficacy and specificity of a single injection of $CAR^+$ T cells in Nalm-6 xenograft model can be measured as the following: NSG mice are injected with Nalm-6 transduced to stably express firefly luciferase, followed by a single tail-vein injection of T cells electroporated with cars of the present invention 7 days later. Animals are imaged at various time points post injection. For example, photon-density heat maps of firefly luciferasepositive leukemia in representative mice at day 5 (2 days before treatment) and day 8 (24 hr post $CAR^+$ PBLs) can be generated.

[00748] Other assays, including those described in the Example section herein as well as those that are known in the art can also be used to evaluate the CAR constructs of the invention.

[00749] Alternatively, or in combination to the methods disclosed herein, methods and compositions for one or more of detection and/or quantification of CAR-expressing cells (*e.g.*, *in vitro* or *in vivo* (e.g., clinical monitoring)), immune cell expansion and/or activation, and/or

CAR-specific selection, that involve the use of a CAR ligand, are disclosed. In one exemplary embodiment, the CAR ligand is an antibody that binds to the CAR molecule, e.g., binds to the extracellular antigen binding domain of CAR (e.g., an antibody that binds to the antigen binding domain, e.g., an anti-idiotypic antibody; or an antibody that binds to a constant region of the extracellular binding domain). In other embodiments, the CAR ligand is a CAR antigen molecule (e.g., a CAR antigen molecule as described herein).

[00750] In one aspect, a method for detecting and/or quantifying CAR-expressing cells is disclosed. For example, the CAR ligand can be used to detect and/or quantify CAR-expressing cells *in vitro* or *in vivo* (e.g., clinical monitoring of CAR-expressing cells in a patient, or dosing a patient). The method includes:

[00751] providing the CAR ligand (optionally, a labelled CAR ligand, e.g., a CAR ligand that includes a tag, a bead, a radioactive or fluorescent label);

[00752] acquiring the CAR-expressing cell (e.g., acquiring a sample containing CAR-expressing cells, such as a manufacturing sample or a clinical sample);

[00753] contacting the CAR-expressing cell with the CAR ligand under conditions where binding occurs, thereby detecting the level (e.g., amount) of the CAR-expressing cells present. Binding of the CAR-expressing cell with the CAR ligand can be detected using standard techniques such as FACS, ELISA and the like.

[00754] In another aspect, a method of expanding and/or activating cells (e.g., immune effector cells) is disclosed. The method includes:

[00755] providing a CAR-expressing cell (e.g., a first CAR-expressing cell or a transiently expressing CAR cell);

[00756] contacting said CAR-expressing cell with a CAR ligand, e.g., a CAR ligand as described herein), under conditions where immune cell expansion and/or proliferation occurs, thereby producing the activated and/or expanded cell population.

[00757] In certain embodiments, the CAR ligand is present on (e.g., is immobilized or attached to a substrate, e.g., a non-naturally occurring substrate). In some embodiments, the substrate is a non-cellular substrate. The non-cellular substrate can be a solid support chosen from, e.g., a plate (e.g., a microtiter plate), a membrane (e.g., a nitrocellulose membrane), a

matrix, a chip or a bead. In embodiments, the CAR ligand is present in the substrate (e.g., on the substrate surface). The CAR ligand can be immobilized, attached, or associated covalently or non-covalently (e.g., cross-linked) to the substrate. In one embodiment, the CAR ligand is attached (e.g., covalently attached) to a bead. In the aforesaid embodiments, the immune cell population can be expanded *in vitro* or *ex vivo*. The method can further include culturing the population of immune cells in the presence of the the ligand of the CAR molecule, e.g., using any of the methods described herein.

[00758] In other embodiments, the method of expanding and/or activating the cells further comprises addition of a second stimulatory molecule, e.g., CD28. For example, the CAR ligand and the second stimulatory molecule can be immobilized to a substrate, e.g., one or more beads, thereby providing increased cell expansion and/or activation.

[00759] In other embodiments, a method for selecting or enriching for a CAR expressing cell is provided. The method includes contacting the CAR expressing cell with a CAR ligand as described herein; and selecting the cell on the basis of binding of the CAR ligand.

[00760] In yet other embodiments, a method for depleting (e.g., reducing and/or killing) a CAR expressing cell is provided. The method includes contacting the CAR expressing cell with a CAR ligand as described herein; and targeting the cell on the basis of binding of the CAR ligand thereby reducing the number, and/or killing, the CAR-expressing cell. In one embodiment, the CAR ligand is coupled to a toxic agent (e.g., a toxin or a cell ablative drug). In another embodiment, the anti-idiotypic antibody can cause effector cell activity, e.g., ADCC or ADC activities.

[00761] Exemplary anti-CAR antibodies that can be used in the methods disclosed herein are described, e.g., in WO 2014/190273 and by Jena et al., "Chimeric Antigen Receptor (CAR)-Specific Monoclonal Antibody to Detect CD19-Specific T cells in Clinical Trials", PLOS March 2013 8:3 e57838, the contents of which are incorporated by reference. In one embodiment, the anti-idiotypic antibody molecule recognizes an anti-CD19 antibody molecule, e.g., an anti-CD19 scFv. For instance, the anti-idiotypic antibody molecule can compete for binding with the CD19-specific CAR mAb clone no. 136.20.1 described in Jena et al., PLOS March 2013 8:3 e57838; may have the same CDRs (e.g., one or more of, e.g., all of, VH CDR1, VH CDR2, CH CDR3, VL CDR1, VL CDR2, and VL CDR3, using the Kabat definition, the Chothia definition,

or a combination of tthe Kabat and Chothia definitions) as the CD19-specific CAR mAb clone no. 136.20.1; may have one or more (e.g., 2) variable regions as the CD19-specific CAR mAb clone no. 136.20.1, or may comprise the CD19-specific CAR mAb clone no. 136.20.1. In some embodiments, the anti-idiotypic antibody was made according to a method described in Jena et al. In another embodiment, the anti-idiotypic antibody molecule is an anti-idiotypic antibody molecule described in WO 2014/190273. In some embodiments, the anti-idiotypic antibody molecule has the same CDRs (e.g., one or more of, e.g., all of, VH CDR1, VH CDR2, CH CDR3, VL CDR1, VL CDR2, and VL CDR3) as an antibody molecule of WO 2014/190273 such as 136.20.1; may have one or more (e.g., 2) variable regions of an antibody molecule of WO 2014/190273, or may comprise an antibody molecule of WO 2014/190273 such as 136.20.1. In other embodiments, the anti-CAR antibody binds to a constant region of the extracellular binding domain of the CAR molecule, e.g., as described in WO 2014/190273. In some embodiments, the anti-CAR antibody binds to a constant region of the extracellular binding domain of the CAR molecule, e.g., a heavy chain constant region (e.g., a CH2-CH3 hinge region) or light chain constant region. For instance, in some embodiments the anti-CAR antibody competes for binding with the 2D3 monoclonal antibody described in WO 2014/190273, has the same CDRs (e.g., one or more of, e.g., all of, VH CDR1, VH CDR2, CH CDR3, VL CDR1, VL CDR2, and VL CDR3) as 2D3, or has one or more (e.g., 2) variable regions of 2D3, or comprises 2D3 as described in WO 2014/190273.

[00762] In some aspects and embodiments, the compositions and methods herein are optimized for a specific subset of T cells, e.g., as described in US Serial No. 62/031,699 filed July 31, 2014, the contents of which are incorporated herein by reference in their entirety. In some embodiments, the optimized subsets of T cells display an enhanced persistence compared to a control T cell, e.g., a T cell of a different type (e.g., CD8+ or CD4+) expressing the same construct.

[00763] In some embodiments, a CD4+ T cell comprises a CAR described herein, which CAR comprises an intracellular signaling domain suitable for (e.g., optimized for, e.g., leading to enhanced persistence in) a CD4+ T cell, e.g., an ICOS domain. In some embodiments, a CD8+ T cell comprises a CAR described herein, which CAR comprises an intracellular signaling domain suitable for (e.g., optimized for, e.g., leading to enhanced persistence of) a CD8+ T cell, e.g., a 4-1BB domain, a CD28 domain, or another costimulatory domain other than an ICOS

domain. In some embodiments, the CAR described herein comprises an antigen binding domain described herein

## Therapeutic Applications

[00764] In one aspect, the invention provides methods for treating a disease associated with expression of a cancer associated antigen as described herein. The method comprises the administration of a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and administraton of a cell, e.g., a T cell, that expresses, or can express a CAR.

[00765] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an XCAR, wherein X represents a tumor marker (or cancer associated antigen) as described herein, and wherein said cancer cells express said X tumor marker (or cancer associated antigen).

[00766] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD19CAR, wherein the cancer cells express CD19. In one embodiment, the cancer to be treated is ALL (acute lymphoblastic leukemia), CLL (chronic lymphocytic leukemia), DLBCL (diffuse large B-cell lymphoma), MCL (Mantle cell lymphoma, or MM (multiple myeloma).

[00767] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an EGFRvIIICAR, wherein the cancer cells express EGFRvIII. In one embodiment, the cancer to be treated is glioblastoma.

[00768] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an

allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a mesothelinCAR, wherein the cancer cells express mesothelin. In one embodiment, the cancer to be treated is mesothelioma, pancreatic cancer, or ovarian cancer.

[00769] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD123CAR, wherein the cancer cells express CD123. In one embodiment, the cancer to be treated is AML.

[00770] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD22CAR, wherein the cancer cells express CD22. In one embodiment, the cancer to be treated is B cell malignancies.

[00771] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CS-1CAR, wherein the cancer cells express CS-1. In one embodiment, the cancer to be treated is multiple myeloma.

[00772] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CLL-1CAR, wherein the cancer cells express CLL-1. In one embodiment, the cancer to be treated is AML.

[00773] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD33CAR, wherein the cancer cells express CD33. In one embodiment, the cancer to be treated is AML.

[00774] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GD2CAR, wherein the cancer cells express GD2. In one embodiment, the cancer to be treated is neuroblastoma.

[00775] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a BCMACAR, wherein the cancer cells express BCMA. In one embodiment, the cancer to be treated is multiple myeloma.

[00776] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TnCAR, wherein the cancer cells express Tn antigen. In one embodiment, the cancer to be treated is ovarian cancer.

[00777] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PSMACAR, wherein the cancer cells express PSMA. In one embodiment, the cancer to be treated is prostate cancer.

[00778] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a ROR1CAR, wherein the cancer cells express ROR1. In one embodiment, the cancer to be treated is B cell malignancies.

[00779] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a FLT3 CAR, wherein the cancer cells express FLT3. In one embodiment, the cancer to be treated is AML.

[00780] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereo a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and f immune effector cells (e.g., T cells, NK cells) that are engineered to express a TAG72CAR, wherein the cancer cells express TAG72. In one embodiment, the cancer to be treated is gastrointestinal cancer.

[00781] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD38CAR, wherein the cancer cells express CD38. In one embodiment, the cancer to be treated is multiple myeloma.

[00782] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD44v6CAR, wherein the cancer cells express CD44v6. In one embodiment, the cancer to be treated is cervical cancer, AML, or MM.

[00783] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CEACAR, wherein the cancer cells express CEA. In one embodiment, the cancer to be treated is pastrointestinal cancer, or pancreatic cancer.

[00784] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a EPCAMCAR, wherein the cancer cells express EPCAM. In one embodiment, the cancer to be treated is gastrointestinal cancer.

[00785] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T

cells, NK cells) that are engineered to express a B7H3CAR, wherein the cancer cells express B7H3.

[00786] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a KITCAR, wherein the cancer cells express KIT. In one embodiment, the cancer to be treated is gastrointestinal cancer.

[00787] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a IL-13Ra2CAR, wherein the cancer cells express IL-13Ra2. In one embodiment, the cancer to be treated is glioblastoma.

[00788] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD30CAR, wherein the cancer cells express CD30. In one embodiment, the cancer to be treated is lymphomas, or leukemias.

[00789] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GD3CAR, wherein the cancer cells express GD3. In one embodiment, the cancer to be treated is melanoma.

[00790] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD171CAR, wherein the cancer cells express CD171. In one embodiment, the cancer to be treated is neuroblastoma, ovarian cancer, melanoma, breast cancer, pancreatic cancer, colon cancers, or NSCLC (non-small cell lung cancer).

[00791] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a IL-11RaCAR, wherein the cancer cells express IL-11Ra. In one embodiment, the cancer to be treated is osteosarcoma.

[00792] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PSCACAR, wherein the cancer cells express PSCA. In one embodiment, the cancer to be treated is prostate cancer.

[00793] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a VEGFR2CAR, wherein the cancer cells express VEGFR2. In one embodiment, the cancer to be treated is a solid tumor.

[00794] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a LewisYCAR, wherein the cancer cells express LewisY. In one embodiment, the cancer to be treated is ovarian cancer, or AML.

[00795] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD24CAR, wherein the cancer cells express CD24. In one embodiment, the cancer to be treated is pancreatic cancer.

[00796] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PDGFR-betaCAR, wherein the cancer cells express PDGFR-beta. In one embodiment, the cancer to be treated is breast cancer, prostate

cancer, GIST (gastrointestinal stromal tumor), CML, DFSP (dermatofibrosarcoma protuberans), or glioma.

[00797] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a SSEA-4CAR, wherein the cancer cells express SSEA-4. In one embodiment, the cancer to be treated is glioblastoma, breast cancer, lung cancer, or stem cell cancer.

[00798] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD20CAR, wherein the cancer cells express CD20. In one embodiment, the cancer to be treated is B cell malignancies.

[00799] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Folate receptor alphaCAR, wherein the cancer cells express folate receptor alpha. In one embodiment, the cancer to be treated is ovarian cancer, NSCLC, endometrial cancer, renal cancer, or other solid tumors.

[00800] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an ERBB2CAR, wherein the cancer cells express ERBB2 (Her2/neu). In one embodiment, the cancer to be treated is breast cancer, gastric cancer, colorectal cancer, lung cancer, or other solid tumors.

[00801] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MUC1CAR, wherein the cancer cells express

MUC1. In one embodiment, the cancer to be treated is breast cancer, lung cancer, or other solid tumors.

[00802] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a EGFRCAR, wherein the cancer cells express EGFR. In one embodiment, the cancer to be treated is glioblastoma, SCLC (small cell lung cancer), SCCHN (squamous cell carcinoma of the head and neck), NSCLC, or other solid tumors.

[00803] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a NCAMCAR, wherein the cancer cells express NCAM. In one embodiment, the cancer to be treated is neuroblastoma, or other solid tumors.

[00804] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CAIXCAR, wherein the cancer cells express CAIX. In one embodiment, the cancer to be treated is renal cancer, CRC, cervical cancer, or other solid tumors.

[00805] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an EphA2CAR, wherein the cancer cells express EphA2. In one embodiment, the cancer to be treated is GBM.

[00806] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GD3CAR, wherein the cancer cells express GD3. In one embodiment, the cancer to be treated is melanoma.

[00807] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Fucosyl GM1CAR, wherein the cancer cells express Fucosyl GM

[00808] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a sLeCAR, wherein the cancer cells express sLe. In one embodiment, the cancer to be treated is NSCLC, or AML.

[00809] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GM3CAR, wherein the cancer cells express GM3.

[00810] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TGS5CAR, wherein the cancer cells express TGS5.

[00811] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a HMWMAACAR, wherein the cancer cells express HMWMAA. In one embodiment, the cancer to be treated is melanoma, glioblastoma, or breast cancer.

[00812] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an o-acetyl-GD2CAR, wherein the cancer cells

express o-acetyl-GD2. In one embodiment, the cancer to be treated is neuroblastoma, or melanoma.

[00813] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a FolatereceptorbetaCAR, wherein the cancer cells express CD19. In one embodiment, the cancer to be treated is AML, or myeloma.

[00814] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TEM1/CD248CAR, wherein the cancer cells express TEM1/CD248. In one embodiment, the cancer to be treated is a solid tumor.

[00815] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TEM7RCAR, wherein the cancer cells express TEM7R. In one embodiment, the cancer to be treated is solid tumor.

[00816] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CLDN6CAR, wherein the cancer cells express CLDN6. In one embodiment, the cancer to be treated is ovarian cancer, lung cancer, or breast cancer.

[00817] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TSHRCAR, wherein the cancer cells express TSHR. In one embodiment, the cancer to be treated is thyroid cancer, or multiple myeloma.

[00818] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GPRC5DCAR, wherein the cancer cells express GPRC5D. In one embodiment, the cancer to be treated is multiple myeloma.

[00819] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CXORF61CAR, wherein the cancer cells express CXORF61.

[00820] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD97CAR, wherein the cancer cells express CD97. In one embodiment, the cancer to be treated is B cell malignancies, gastric cancer, pancreatic cancer, esophageal cancer, glioblastoma, breast cancer, or colorectal cancer.

[00821] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD179aCAR, wherein the cancer cells express CD179a. In one embodiment, the cancer to be treated is B cell malignancies.

[00822] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an ALK CAR, wherein the cancer cells express ALK. In one embodiment, the cancer to be treated is NSCLC, ALCL (anaplastic large cell lymphoma), IMT (inflammatory myofibroblastic tumor), or neuroblastoma.

[00823] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T

cells, NK cells) that are engineered to express a Plysialic acid CAR, wherein the cancer cells express Plysialic acid. In one embodiment, the cancer to be treated is small cell lung cancer.

[00824] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PLAC1CAR, wherein the cancer cells express PLAC1. In one embodiment, the cancer to be treated is HCC (hepatocellular carcinoma).

[00825] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GloboHCAR, wherein the cancer cells express GloboH. In one embodiment, the cancer to be treated is ovarian cancer, gastric cancer, prostate cancer, lung cancer, breast cancer, or pancreatic cancer.

[00826] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a NY-BR-1CAR, wherein the cancer cells express NY-BR-1. In one embodiment, the cancer to be treated is breast cancer.

[00827] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a UPK2CAR, wherein the cancer cells express UPK2. In one embodiment, the cancer to be treated is bladder cancer.

[00828] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a HAVCR1CAR, wherein the cancer cells express HAVCR1. In one embodiment, the cancer to be treated is renal cancer.

[00829] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a ADRB3CAR, wherein the cancer cells express ADRB3. In one embodiment, the cancer to be treated is Ewing sarcoma.

[00830] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PANX3CAR, wherein the cancer cells express PANX3. In one embodiment, the cancer to be treated is osteosarcoma.

[00831] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a GPR20CAR, wherein the cancer cells express GPR20. In one embodiment, the cancer to be treated is GIST.

[00832] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a LY6KCAR, wherein the cancer cells express LY6K. In one embodiment, the cancer to be treated is breast cancer, lung cancer, ovary caner, or cervix cancer.

[00833] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a OR51E2CAR, wherein the cancer cells express OR51E2. In one embodiment, the cancer to be treated is prostate cancer.

[00834] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T

cells, NK cells) that are engineered to express a TARPCAR, wherein the cancer cells express TARP. In one embodiment, the cancer to be treated is prostate cancer.

[00835] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a WT1CAR, wherein the cancer cells express WT1.

[00836] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a NY-ESO-1CAR, wherein the cancer cells express NY-ESO-1.

[00837] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a LAGE-1a CAR, wherein the cancer cells express LAGE-1a.

[00838] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MAGE-A1CAR, wherein the cancer cells express MAGE-A1. In one embodiment, the cancer to be treated is melanoma.

[00839] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MAGE A1CAR, wherein the cancer cells express MAGE A1.

[00840] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an

allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a ETV6-AML CAR, wherein the cancer cells express ETV6-AML.

[00841] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a sperm protein 17 CAR, wherein the cancer cells express sperm protein 17. In one embodiment, the cancer to be treated is ovarian cancer, HCC, or NSCLC.

[00842] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a XAGE1CAR, wherein the cancer cells express XAGE1. In one embodiment, the cancer to be treated is Ewings, or rhabdo cancer.

[00843] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Tie 2 CAR, wherein the cancer cells express Tie 2. In one embodiment, the cancer to be treated is a solid tumor.

[00844] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MAD-CT-1CAR, wherein the cancer cells express MAD-CT-1. In one embodiment, the cancer to be treated is prostate cancer, or melanoma.

[00845] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MAD-CT-2CAR, wherein the cancer cells express MAD-CT-2. In one embodiment, the cancer to be treated is prostate cancer, melanoma.

[00846] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Fos-related antigen 1 CAR, wherein the cancer cells express Fos-related antigen 1. In one embodiment, the cancer to be treated is glioma, squamous cell cancer, or pancreatic cancer.

[00847] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a p53CAR, wherein the cancer cells express p53.

[00848] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a prostein CAR, wherein the cancer cells express prostein.

[00849] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a survivin and telomerase CAR, wherein the cancer cells express survivin and telomerase.

[00850] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PCTA-1/Galectin 8 CAR, wherein the cancer cells express PCTA-1/Galectin 8.

[00851] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MelanA/MART1CAR, wherein the cancer cells express MelanA/MART1.

[00852] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Ras mutant CAR, wherein the cancer cells express Ras mutant.

[00853] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a p53 mutant CAR, wherein the cancer cells express p53 mutant.

[00854] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a hTERT CAR, wherein the cancer cells express hTERT.

[00855] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a sarcoma translocation breakpoints CAR, wherein the cancer cells express sarcoma translocation breakpoints. In one embodiment, the cancer to be treated is sarcoma.

[00856] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a ML-IAP CAR, wherein the cancer cells express ML-IAP. In one embodiment, the cancer to be treated is melanoma.

[00857] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T

cells, NK cells) that are engineered to express a ERGCAR, wherein the cancer cells express ERG (TMPRSS2 ETS fusion gene).

[00858] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a NA17CAR, wherein the cancer cells express NA17. In one embodiment, the cancer to be treated is melanoma.

[00859] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PAX3CAR, wherein the cancer cells express PAX3. In one embodiment, the cancer to be treated is alveolar rhabdomyosarcoma.

[00860] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an androgen receptor CAR, wherein the cancer cells express androgen receptor. In one embodiment, the cancer to be treated is metastatic prostate cancer.

[00861] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Cyclin B1CAR, wherein the cancer cells express Cyclin B1.

[00862] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a MYCNCAR, wherein the cancer cells express MYCN.

[00863] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a RhoC CAR, wherein the cancer cells express RhoC.

[00864] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a TRP-2CAR, wherein the cancer cells express TRP-2. In one embodiment, the cancer to be treated is melanoma.

[00865] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a CYP1B1CAR, wherein the cancer cells express CYP1B1. In one embodiment, the cancer to be treated is breast cancer, colon cancer, lung cancer, esophagus cancer, skin cancer, lymph node cancer, brain cancer, or testis cancer.

[00866] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a BORIS CAR, wherein the cancer cells express BORIS. In one embodiment, the cancer to be treated is lung cancer.

[00867] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a SART3CAR, wherein the cancer cells express SART3

[00868] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T

cells, NK cells) that are engineered to express a PAX5CAR, wherein the cancer cells express PAX5.

[00869] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a OY-TES1CAR, wherein the cancer cells express OY-TES1.

[00870] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a LCK CAR, wherein the cancer cells express LCK.

[00871] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a AKAP-4CAR, wherein the cancer cells express AKAP-4.

[00872] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a SSX2CAR, wherein the cancer cells express SSX2.

[00873] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a RAGE-1CAR, wherein the cancer cells express RAGE-1. In one embodiment, the cancer to be treated is RCC (renal cell cancer), or other solid tumors

[00874] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a human telomerase reverse transcriptaseCAR, wherein the cancer cells express human telomerase reverse transcriptase. In one embodiment, the cancer to be treated is solid tumors.

[00875] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a RU1CAR, wherein the cancer cells express RU1.

[00876] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a RU2CAR, wherein the cancer cells express RU2.

[00877] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an intestinal carboxyl esteraseCAR, wherein the cancer cells express intestinal carboxyl esterase. In one embodiment, the cancer to be treated is thyroid cancer, RCC, CRC (colorectal cancer), breast cancer, or other solid tumors.

[00878] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a Prostase CAR, wherein the cancer cells express Prostase.

[00879] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a PAPCAR, wherein the cancer cells express PAP.

[00880] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express an IGF-I receptor CAR, wherein the cancer cells express IGF-I receptor.

[00881] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a gp100 CAR, wherein the cancer cells express gp100.

[00882] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a bcr-abl CAR, wherein the cancer cells express bcr-abl.

[00883] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a tyrosinase CAR, wherein the cancer cells express tyrosinase.

[00884] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a Fucosyl GM1CAR, wherein the cancer cells express Fucosyl GM1.

[00885] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and immune effector cells (e.g., T cells, NK cells) that are engineered to express a mut hsp70-2CAR, wherein the cancer cells express mut hsp70-2. In one embodiment, the cancer to be treated is melanoma.

[00886] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD79a CAR, wherein the cancer cells express CD79a.

[00887] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD79b CAR, wherein the cancer cells express CD79b.

[00888] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD72 CAR, wherein the cancer cells express CD72.

[00889] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a LAIR1 CAR, wherein the cancer cells express LAIR1.

[00890] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a FCAR CAR, wherein the cancer cells express FCAR.

[00891] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a LILRA2 CAR, wherein the cancer cells express LILRA2.

[00892] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a CD300LF CAR, wherein the cancer cells express CD300LF.

[00893] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a CLEC12A CAR, wherein the cancer cells express CLEC12A.

[00894] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a BST2 CAR, wherein the cancer cells express BST2.

[00895] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express an EMR2 CAR, wherein the cancer cells express EMR2.

[00896] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a LY75 CAR, wherein the cancer cells express LY75.

[00897] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a GPC3 CAR, wherein the cancer cells express GPC3.

[00898] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express a FCRL5 CAR, wherein the cancer cells express FCRL5.

[00899] In one aspect, the present invention provides methods of treating cancer by providing to the subject in need thereof immune effector cells (e.g., T cells, NK cells) that are engineered to express an IGLL1 CAR, wherein the cancer cells express IGLL1.

[00900] In one aspect, the present invention relates to treatment of a subject in vivo using a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and an PD1 CAR such that growth of cancerous tumors is inhibited. A PD1 CAR may be used alone to inhibit the growth of cancerous tumors. Alternatively, PD1 CAR may be used in conjunction with other CARs, immunogenic agents, standard cancer treatments, or other antibodies. In one embodiment, the subject is treated with a PD1 CAR and an XCAR described herein. In an embodiment, a PD1 CAR is used in conjunction with another CAR, e.g., a CAR described herein, and a kinase inhibitor, e.g., a kinase inhibitor described herein.

[00901] In another aspect, a method of treating a subject, e.g., reducing or ameliorating, a hyperproliferative condition or disorder (e.g., a cancer), e.g., a solid tumor, a soft tissue tumor, a hematological cancer, or a metastatic lesion, in a subject, is provided. In embodiments the method comprises administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and a CAR.

[00902] Examples of cancers that can be treated with methods disclosed herein include bone cancer, pancreatic cancer, skin cancer, cancer of the head or neck, cutaneous or intraocular malignant melanoma, uterine cancer, ovarian cancer, rectal cancer, cancer of the anal region, stomach cancer, testicular cancer, uterine cancer, carcinoma of the fallopian tubes, carcinoma of the endometrium, carcinoma of the cervix, carcinoma of the vagina, carcinoma of the vulva, Hodgkin's Disease, non-Hodgkin's lymphoma, cancer of the esophagus, cancer of the small intestine, cancer of the endocrine system, cancer of the thyroid gland, cancer of the parathyroid gland, cancer of the adrenal gland, sarcoma of soft tissue, cancer of the urethra, cancer of the penis, chronic or acute leukemias including acute myeloid leukemia, chronic myeloid leukemia, acute lymphoblastic leukemia, chronic lymphocytic leukemia, solid tumors of childhood, lymphocytic lymphoma, cancer of the bladder, cancer of the kidney or ureter, carcinoma of the renal pelvis, neoplasm of the central nervous system (CNS), primary CNS lymphoma, tumor angiogenesis, spinal axis tumor, brain stem glioma, pituitary adenoma, Kaposi's sarcoma, epidermoid cancer, squamous cell cancer, T-cell lymphoma, environmentally induced cancers including those induced by asbestos, and combinations of said cancers. Treatment of metastatic cancers, e.g., metastatic cancers that express PD-L1 (Iwai et al. (2005) Int. Immunol. 17:133-144) can be effected using the antibody molecules described herein.

[00903] Examples of solid tumors that can be treated with methods disclosed herein include malignancies, e.g., sarcomas, adenocarcinomas, and carcinomas, of the various organ systems, such as those affecting liver, lung, breast, lymphoid, gastrointestinal (e.g., colon), genitourinary tract (e.g., renal, urothelial cells), prostate and pharynx. Adenocarcinomas include malignancies such as most colon cancers, rectal cancer, renal-cell carcinoma, liver cancer, non-small cell carcinoma of the lung, cancer of the small intestine and cancer of the esophagus. In one embodiment, the cancer is a melanoma, e.g., an advanced stage melanoma. Metastatic lesions of the aforementioned cancers can also be treated or prevented using the methods and compositions of the invention.

[00904] Methods described herein can be used to treat any of the following cancers:

Digestive/gastrointestinal cancers such as anal cancer; bile duct cancer; extrahepatic bile duct cancer; appendix cancer; carcinoid tumor, gastrointestinal cancer; colon cancer; colorectal cancer including childhood colorectal cancer; esophageal cancer including childhood esophageal cancer; gallbladder cancer; gastric (stomach) cancer including childhood gastric

(stomach) cancer; hepatocellular (liver) cancer including adult (primary) hepatocellular (liver) cancer and childhood (primary) hepatocellular (liver) cancer; pancreatic cancer including childhood pancreatic cancer; sarcoma, rhabdomyosarcoma; islet cell pancreatic cancer; rectal cancer; and small intestine cancer;

[00905] Endocrine cancers such as islet cell carcinoma (endocrine pancreas); adrenocortical carcinoma including childhood adrenocortical carcinoma; gastrointestinal carcinoid tumor; parathyroid cancer; pheochromocytoma; pituitary tumor; thyroid cancer including childhood thyroid cancer; childhood multiple endocrine neoplasia syndrome; and childhood carcinoid tumor;

[00906] Eye cancers such as intraocular melanoma; and retinoblastoma;

[00907] Musculoskeletal cancers such as Ewing's family of tumors; osteosarcoma/malignant fibrous histiocytoma of the bone; childhood rhabdomyosarcoma; soft tissue sarcoma including adult and childhood soft tissue sarcoma; clear cell sarcoma of tendon sheaths; and uterine sarcoma;

[00908] Breast cancer such as breast cancer including childhood and male breast cancer and pregnancy;

[00909] Neurologic cancers such as childhood brain stem glioma; brain tumor; childhood cerebellar astrocytoma; childhood cerebral astrocytoma/malignant glioma; childhood ependymoma; childhood medulloblastoma; childhood pineal and supratentorial primitive neuroectodermal tumors; childhood visual pathway and hypothalamic glioma; other childhood brain cancers; adrenocortical carcinoma; central nervous system lymphoma, primary; childhood cerebellar astrocytoma; neuroblastoma; craniopharyngioma; spinal cord tumors; central nervous system atypical teratoid/rhabdoid tumor; central nervous system embryonal tumors; and childhood supratentorial primitive neuroectodermal tumors and pituitary tumor;

[00910] Genitourinary cancers such as bladder cancer including childhood bladder cancer; renal cell (kidney) cancer; ovarian cancer including childhood ovarian cancer; ovarian epithelial cancer; ovarian low malignant potential tumor; penile cancer; prostate cancer; renal cell cancer including childhood renal cell cancer; renal pelvis and ureter, transitional cell cancer; testicular cancer; urethral cancer; vaginal cancer; vulvar cancer; cervical cancer; Wilms tumor and other childhood kidney tumors; endometrial cancer; and gestational trophoblastic tumor;

[00911] Germ cell cancers such as childhood extracranial germ cell tumor; extragonadal germ cell tumor; ovarian germ cell tumor; and testicular cancer;

[00912] Head and neck cancers such as lip and oral cavity cancer; oral cancer including childhood oral cancer; hypopharyngeal cancer; laryngeal cancer including childhood laryngeal cancer; metastatic squamous neck cancer with occult primary; mouth cancer; nasal cavity and paranasal sinus cancer; nasopharyngeal cancer including childhood nasopharyngeal cancer; oropharyngeal cancer; parathyroid cancer; pharyngeal cancer; salivary gland cancer including childhood salivary gland cancer; throat cancer; and thyroid cancer;

[00913] Lung cancer such as non-small cell lung cancer; and small cell lung cancer;

[00914] Respiratory cancers such as malignant mesothelioma, adult; malignant mesothelioma, childhood; malignant thymoma; childhood thymoma; thymic carcinoma; bronchial adenomas/carcinoids including childhood bronchial adenomas/carcinoids; pleuropulmonary blastoma; non-small cell lung cancer; and small cell lung cancer;

[00915] Skin cancers such as Kaposi's sarcoma; Merkel cell carcinoma; melanoma; and childhood skin cancer;

[00916] AIDS-related malignancies;

[00917] Other childhood cancers, unusual cancers of childhood and cancers of unknown primary site;

[00918] and metastases of the aforementioned cancers can also be treated or prevented in accordance with the methods described herein. Exemplary cancers whose growth can be inhibited include cancers typically responsive to immunotherapy. Non-limiting examples of cancers for treatment include melanoma (e.g., metastatic malignant melanoma), renal cancer (e.g. clear cell carcinoma), prostate cancer (e.g. hormone refractory prostate adenocarcinoma), breast cancer, colon cancer and lung cancer (e.g. non-small cell lung cancer). Additionally, refractory or recurrent malignancies can be treated using the molecules described herein.

[00919] Methods described herein can be used to treat a hematological cancer or malignancy or precancerous condition, e.g., a leukemia or a lymphoma. The cancer can be one associated with expression of a cancer associated antigen as described herein. Hematological cancers and malignancies include, one or more acute leukemias including, e.g., B-cell acute Lymphoid Leukemia ("BALL"), T-cell acute Lymphoid Leukemia ("TALL"), acute lymphoid leukemia (or acute lymphoblastic leukemia) (ALL), including adult and childhood acute lymphoid leukemia;

acute myeloid leukemia, including adult and childhood acute myeloid leukemia; one or more chronic leukemias, e.g., chronic myelogenous leukemia (CML), Chronic Lymphoid Leukemia (or chronic lymphocytic leukemia) (CLL). Additional cancers or hematologic conditions that can be treated with methods disclosed herein include, e.g., AIDS-related lymphoma, B cell prolymphocytic leukemia, blastic plasmacytoid dendritic cell neoplasm, Burkitt's lymphoma, chronic myeloproliferative disorders; cutaneous T-cell lymphoma, diffuse large B cell lymphoma, Follicular lymphoma, Hairy cell leukemia, Hodgkin's lymphoma (including adult and childhood Hogkin's lymphoma and Hodgkin's lymphoma during pregnancy), small cell- or a large cell-follicular lymphoma, malignant lymphoproliferative conditions, MALT lymphoma, mantle cell lymphoma, Marginal zone lymphoma, multiple myeloma, multiple myeloma/plasma cell neoplasm, myelodysplasia and myelodysplastic syndrome, myelodysplastic/myeloproliferative disorders, mycosis fungoides, non-Hodgkin's lymphoma (including adult and childhood non-Hodgkin's lymphoma and non-Hodkin's lymphoma during pregnancy), plasmablastic lymphoma, plasmacytoid dendritic cell neoplasm, Sezary syndrome, Waldenstrom macroglobulinemia, primary central system lymphoma, and "preleukemia" which are a diverse collection of hematological conditions united by ineffective production (or dysplasia) of myeloid blood cells, and the like. Further a disease associated with a cancer associated antigen as described herein expression include, but not limited to, e.g., atypical and/or non-classical cancers, malignancies, precancerous conditions or proliferative diseases associated with expression of a cancer associated antigen as described herein.

[00920] In certain embodiments, the cancer that can be treated with a CAR cell, e.g., a CART, of the present invention is chronic lymphoid leukemia (CLL). In an embodiment, the cancer that can be treated is CLL, and the CAR comprises an antigen binding domain that binds specifically to CD19.

[00921] In some embodiments, a cancer that can be treated with a CAR cell, e.g., a CART, of the present invention is multiple myeloma. Multiple myeloma is a cancer of the blood, characterized by accumulation of a plasma cell clone in the bone marrow. Current therapies for multiple myeloma include, but are not limited to, treatment with lenalidomide, which is an analog of thalidomide. Lenalidomide has activities which include anti-tumor activity, angiogenesis inhibition, and immunomodulation. Generally, myeloma cells are thought to be negative for a cancer associated antigen as described herein expression by flow cytometry. The

present invention encompasses the recognition that a small percent of myeloma tumor cells express a cancer associated antigen as described herein. Thus, in some embodiments, a CD19 CAR, e.g., as described herein, may be used to target myeloma cells. In some embodiments, a CAR of the present invention can be used in combination with one or more additional therapies, e.g., lenalidomide treatment.

[00922] In one embodiment, lymphocyte infusion, for example allogeneic lymphocyte infusion, is used in the treatment of the cancer, wherein the lymphocyte infusion comprises at least one CAR of the present invention-expressing cell. In one embodiment, autologous lymphocyte infusion is used in the treatment of the cancer, wherein the autologous lymphocyte infusion comprises at least one a cancer associated antigen as described herein-expressing cell.

[00923] In one embodiment, subject has received a previous stem cell transplantation, e.g., autologous stem cell transplantation.

[00924] In one embodiment, the subject has received a previous dose of melphalan.

[00925] In some embodiments, the cancer is associated with elevated percentages of PD1+ T cells in the subject. In certain embodiments, the cancer is a cancer that generally responds to PD-1 targeted drugs, such as melanoma. In certain embodiments, the cancer is a cancer that generally responds to T-cell directed immunotherapies, such as renal cell carcinoma. In an embodiment the cancer is one in which can be treated by increasing the ration of PD-1 negative to PD-1 positive T cells.

[00926] The present invention provides methods for inhibiting the proliferation or reducing a cancer associated antigen as described herein-expressing cell population, the methods comprising contacting a population of cells comprising a cancer associated antigen as described herein with a CAR-expressing cells (e.g., T cell) of the invention that binds to the cancer associated antigen as described herein. In a specific aspect, the present invention provides methods for inhibiting the proliferation or reducing the population of cancer cells expressing a cancer associated antigen as described herein, the methods comprising contacting a cancer cell population expressing a cancer associated antigen as described herein with a CAR-expressing cell of the present invention that binds to the cell expressing the cancer associated antigen. In an embodiment, the immune effector cell (e.g., T cell) can be from a subject treated with a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a

catalytic inhibitor. In an embodiment, the immune effector cells (e.g., T cells) have been contacted with an amount of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor sufficient to decrease the number of PD1 positive immune effector cells, increase the number of PD1 negative immune effector cells, e.g., T cells, increase the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, increase the number of naïve T cells, increase the number of memory T cell precursors, or increase the expression level of memory T cell precursor markers, as described herein. In certain aspects, a CAR of the present invention reduces the quantity, number, amount or percentage of cells and/or cancer cells by at least 25%, at least 30%, at least 40%, at least 50%, at least 65%, at least 75%, at least 85%, at least 95%, or at least 99% in a subject with or animal model for a cancer associated with a cancer associated antigen as described herein (e.g., a hematological cancer) relative to a negative control. In one aspect, the subject is a human.

[00927] The present invention also provides methods for preventing, treating and/or managing a disease associated with a cancer associated antigen as described herein-expressing cells (e.g., a cancer associated with a cancer associated antigen as described herein, e.g., a hematological cancer), the methods comprising administering to a subject in need a CAR-expressing cell (e.g., T cell) of the invention that binds to a cell expressing a cancer associated antigen as described herein. In an embodiment, the immune effector cell, e.g., T cell, can be from a subject treated a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor. In an embodiment, the immune effector cells, e.g., T cells, have been contacted with an amount of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor sufficient to decrease the number of PD1 positive immune effector cells, increase the number of PD1 negative immune effector cells, e.g., T cells, increase the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, increase the number of naïve T cells, increase the number of memory T cell precursors, or increase the expression level of memory T cell precursor markers, as described herein. In one aspect, the subject is a human.

[00928] The present invention provides methods for preventing relapse of cancer associated with a cancer associated antigen as described herein, the methods comprising administering to a subject in need thereof a CAR-expressing cell, e.g., a T cell, of the invention that binds to a cancer associated antigen as described herein. In an embodiment, the immune effector cell, e.g.,

T cell, can be from a subject treated a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor. In an embodiment, the immune effector cells, e.g., T cells, have been contacted with an amount of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor sufficient to decrease the number of PD1 positive immune effector cells, increase the number of PD1 negative immune effector cells, e.g., T cells, increase the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, increase the number of naïve T cells, increase the number of memory T cell precursors, or increase the expression level of memory T cell precursor markers, as described herein.

[00929] In one aspect, the methods comprise administering to the subject in need thereof an effective amount of an CAR-expressing cell of the present invention or aT cell described herein that binds to a cell expressing a cancer associated antigen as described herein, in combination with an effective amount of another therapy.

[00930] In one aspect, the invention pertains to a vector comprising a CAR operably linked to promoter for expression in mammalian immune effector cells (e.g., T cells, NK cells). In one aspect, the invention provides a recombinant T cell expressing a CAR of the present invention for use in treating cancer expressing a cancer associated antigen as described herein. In one aspect, a CART of the invention is capable of contacting a tumor cell with at least one cancer associated antigen expressed on its surface such that the CART targets the tumor cell and growth of the tumor is inhibited.

[00931] The invention includes a type of cellular therapy where immune effector cells (e.g., T cells, NK cells) are genetically modified to express a chimeric antigen receptor (CAR) and the CAR T cell is infused, and a low, immune enhancing dose of an mTOR inhibitor administered, to a recipient in need thereof. The infused cell is able to kill tumor cells in the recipient. Unlike antibody therapies, CAR-modified immune effector cells (e.g., T cells, NK cells) are able to replicate in vivo resulting in long-term persistence that can lead to sustained tumor control. In various aspects, the immune effector cells (e.g., T cells, NK cells) administered to the patient, or their progeny, persist in the patient for at least four months, five months, six months, seven months, eight months, nine months, ten months, eleven months, twelve months, thirteen months, fourteen month, fifteen months, sixteen months, seventeen months, eighteen months, nineteen

months, twenty months, twenty-one months, twenty-two months, twenty-three months, two years, three years, four years, or five years after administration of the T cell to the patient.

[00932] The invention also includes a type of cellular therapy where immune effector cells (e.g., T cells, NK cells) are modified, e.g., by in vitro transcribed RNA, to transiently express a chimeric antigen receptor (CAR) and the CAR-expressing cell cell is infused, and a low, immune enhancing dose of an mTOR inhibitor administered, to a recipient in need thereof. The infused cell is able to kill tumor cells in the recipient. Thus, in various aspects, the immune effector cells (e.g., T cells, NK cells) administered to the patient, is present for less than one month, e.g., three weeks, two weeks, one week, after administration of the T cell to the patient.

[00933] Without wishing to be bound by any particular theory, the anti-tumor immunity response elicited by the CAR-modified immune effector cells (e.g., T cells, NK cells) may be an active or a passive immune response, or alternatively may be due to a direct vs indirect immune response. In one aspect, the CAR transduced immune effector cells (e.g., T cells, NK cells) exhibit specific proinflammatory cytokine secretion and potent cytolytic activity in response to human cancer cells expressing a cancer associated antigen as described herein, resist soluble a cancer associated antigen as described herein inhibition, mediate bystander killing and mediate regression of an established human tumor. For example, antigen-less tumor cells within a heterogeneous field of a cancer associated antigen as described herein-expressing tumor may be susceptible to indirect destruction by a cancer associated antigen as described herein-redirected immune effector cells (e.g., T cells, NK cells) that have previously reacted against adjacent antigen-positive cancer cells.

[00934] In one aspect, the fully-human CAR-modified immune effector cells (e.g., T cells, NK cells) of the invention may be a type of vaccine for ex vivo immunization and/or in vivo therapy in a mammal. In one aspect, the mammal is a human.

[00935] With respect to ex vivo immunization, at least one of the following occurs in vitro prior to administering the cell into a mammal: i) expansion of the cells, ii) introducing a nucleic acid encoding a CAR to the cells or iii) cryopreservation of the cells and optionally, iv) contact with the cells with an amount of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor sufficient to decrease the number of PD1 positive immune effector cells, increase the number of PD1 negative immune effector cells, e.g., T cells, increase the ratio of

PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, increase the number of naïve T cells, increase the number of memory T cell precursors, or increase the expression level of memory T cell precursor markers, as described herein.

[00936] Ex vivo procedures are well known in the art and are discussed more fully below. Briefly, cells are isolated from a mammal (e.g., a human) and genetically modified (i.e., transduced or transfected in vitro) with a vector expressing a CAR disclosed herein. The CAR-modified cell can be administered to a mammalian recipient to provide a therapeutic benefit. The mammalian recipient may be a human and the CAR-modified cell can be autologous with respect to the recipient. Alternatively, the cells can be allogeneic, syngeneic or xenogeneic with respect to the recipient.

[00937] The procedure for ex vivo expansion of hematopoietic stem and progenitor cells is described in U.S. Pat. No. 5,199,942, incorporated herein by reference, and can be applied to the cells of the present invention. Other suitable methods are known in the art; therefore, the present invention is not limited to any particular method of ex vivo expansion of the cells. Briefly, ex vivo culture and expansion of immune effector cells (e.g., T cells, NK cells) comprises: (1) collecting CD34+ hematopoietic stem and progenitor cells from a mammal from peripheral blood harvest or bone marrow explants; and (2) expanding such cells ex vivo. In addition to the cellular growth factors described in U.S. Pat. No. 5,199,942, other factors such as flt3-L, IL-1, IL-3 and c-kit ligand, can be used for culturing and expansion of the cells.

[00938] In addition to using a cell-based vaccine in terms of ex vivo immunization, the present invention also provides compositions and methods for in vivo immunization to elicit an immune response directed against an antigen in a patient.

[00939] Generally, administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and the cells activated and expanded as described herein may be utilized in the treatment and prevention of diseases that arise in individuals who are immunocompromised. In particular, the CAR-modified immune effector cells (e.g., T cells, NK cells) of the invention are used in the treatment of diseases, disorders and conditions associated with expression of a cancer associated antigen as described herein. In certain aspects, the cells of the invention are used in the treatment of patients at risk for developing diseases, disorders and conditions associated with expression of a cancer associated

antigen as described herein. Thus, the present invention provides methods for the treatment or prevention of diseases, disorders and conditions associated with expression of a cancer associated antigen as described herein comprising administering to a subject in need thereof, a therapeutically effective amount of the CAR-modified immune effector cells (e.g., T cells, NK cells) of the invention.

[00940] Non-cancer related indications associated with expression of a cancer associated antigen as described herein include, but are not limited to, e.g., autoimmune disease, (e.g., lupus), inflammatory disorders (allergy and asthma) and transplantation.

[00941] The CAR-modified immune effector cells (e.g., T cells, NK cells) of the present invention may be administered either alone, or as a pharmaceutical composition in combination with diluents and/or with other components such as IL-2 or other cytokines or cell populations.

[00942] In one embodiment, the subject can be administered an agent which reduces or ameliorates a side effect associated with the administration of a CAR-expressing cell. Side effects associated with the administration of a CAR-expressing cell include, but are not limited to CRS, and hemophagocytic lymphohistiocytosis (HLH), also termed Macrophage Activation Syndrome (MAS). Symptoms of CRS include high fevers, nausea, transient hypotension, hypoxia, and the like. CRS may include clinical constitutional signs and symptoms such as fever, fatigue, anorexia, myalgias, arthalgias, nausea, vomiting, and headache. CRS may include clinical skin signs and symptoms such as rash. CRS may include clinical gastrointestinal signs and symptoms such as nausea, vomiting and diarrhea. CRS may include clinical respiratory signs and symptoms such as tachypnea and hypoxemia. CRS may include clinical cardiovascular signs and symptoms such as tachycardia, widened pulse pressure, hypotension, increased cardiac output (early) and potentially diminished cardiac output (late). CRS may include clinical coagulation signs and symptoms such as elevated d-dimer, hypofibrinogenemia with or without bleeding. CRS may include clinical renal signs and symptoms such as azotemia. CRS may include clinical hepatic signs and symptoms such as transaminitis and hyperbilirubinemia. CRS may include clinical neurologic signs and symptoms such as headache, mental status changes, confusion, delirium, word finding difficulty or frank aphasia, hallucinations, tremor, dymetria, altered gait, and seizures. Accordingly, the methods described herein can comprise administering a CAR-expressing cell described herein to a subject and

further administering one or more agents to manage elevated levels of a soluble factor resulting from treatment with a CAR-expressing cell. In one embodiment, the soluble factor elevated in the subject is one or more of IFN-γ, TNFα, IL-2 and IL-6. In an embodiment, the factor elevated in the subject is one or more of IL-1, GM-CSF, IL-10, IL-8, IL-5 and fraktalkine. Therefore, an agent administered to treat this side effect can be an agent that neutralizes one or more of these soluble factors. In one embodiment, the agent that neutralizes one or more of these soluble forms is an antibody or antigen binding fragment thereof. Examples of such agents include, but are not limited to a steroid (e.g., corticosteroid), an inhibitor of TNFα, and an inhibitor of IL-6. An example of a TNFα inhibitor is an anti-TNFα antibody molecule such as infliximab, adalimumab, certolizumab pegol, and golimumab. Another example of a TNFα inhibitor is a fusion protein such as entanercept. Small molecule inhibitor of TNFα include, but are not limited to, xanthine derivatives (e.g. pentoxifylline) and bupropion. An example of an IL-6 inhibitor is an anti-IL-6 antibody molecule such as tocilizumab (toc), sarilumab, elsilimomab, CNTO 328, ALD518/BMS-945429, CNTO 136, CPSI-2364, CDP6038, VX30, ARGX-109, FE301, and FM101. In one embodiment, the anti-IL-6 antibody molecule is tocilizumab. An example of an IL-1R based inhibitor is anakinra.

[00943] In embodiments, a lymphodepleting chemotherapy is administered to the subject prior to, concurrently with, or after administration (e.g., infusion) of CAR cells, e.g., CAR-expressing cells described herein. In an example, the lymphodepleting chemotherapy is administered to the subject prior to administration of CAR cells. For example, the lymphodepleting chemotherapy ends 1-4 days (e.g., 1, 2, 3, or 4 days) prior to CAR cell infusion. In embodiments, multiple doses of CAR cells are administered, e.g., as described herein. For example, a single dose comprises about 5 x $10^8$ CAR cells. In embodiments, a lymphodepleting chemotherapy is administered to the subject prior to, concurrently with, or after administration (e.g., infusion) of a CAR-expressing cell described herein.

[00944] In some embodiments, a low, immune enhancing dose of an mTOR inhibitor, in combination with a CAR-expressing cell described herein, is administered to a subject in combination with a CD19 CAR-expressing cell, e.g., CTL019, e.g., as described in WO2012/079000, incorporated herein by reference, for treatment of a disease associated with the expression of cancer antigen, e.g., a cancer described herein. Without being bound by theory, it

is believed that administering a CD19 CAR-expressing cell in combination with another CAR-expressing cell improves the efficacy of a CAR-expressing cell described herein by targeting early lineage cancer cells, e.g., cancer stem cells, modulating the immune response, depleting regulatory B cells, and/or improving the tumor microenvironment. For example, a CD19 CAR-expressing cell targets cancer cells that express early lineage markers, e.g., cancer stem cells and CD19-expressing cells, while the other CAR-expressing cell described herein targets cancer cells that express later lineage markers, e.g., CD33. This preconditioning approach can improve the efficacy of the CAR-expressing cell described herein. In such embodiments, the CD19 CAR-expressing cell is administered prior to, concurrently with, or after administration (e.g., infusion) of the second CAR-expressing cell.

[00945] In embodiments, a CAR-expressing cell which expresses a CAR targeting a cancer antigen other than CD19 also expresses a CAR targeting CD19, e.g., a CD19 CAR. In an embodiment, the cell expressing a non-CD19 CAR and a CD19 CAR is administered to a subject for treatment of a cancer described herein, e.g., AML. In an embodiment, the configurations of one or both of the CAR molecules comprise a primary intracellular signaling domain and a costimulatory signaling domain. In another embodiment, the configurations of one or both of the CAR molecules comprise a primary intracellular signaling domain and two or more, e.g., 2, 3, 4, or 5 or more, costimulatory signaling domains. In such embodiments, the non-CD19 CAR molecule and the CD19 CAR may have the same or a different primary intracellular signaling domain, the same or different costimulatory signaling domains, or the same number or a different number of costimulatory signaling domains. Alternatively, the non-CD19 CAR and the CD19 CAR are configured as a split CAR, in which one of the CAR molecules comprises an antigen binding domain and a costimulatory domain (e.g., 4-1BB), while the other CAR molecule comprises an antigen binding domain and a primary intracellular signaling domain (e.g., CD3 zeta).

[00946]

*Hematologic Cancer*

[00947] Hematological cancer conditions are the types of cancer such as leukemia, lymphoma and malignant lymphoproliferative conditions that affect blood, bone marrow and the lymphatic system.

[00948] Leukemia can be classified as acute leukemia and chronic leukemia. Acute leukemia can be further classified as acute myelogenous leukemia (AML) and acute lymphoid leukemia (ALL). Chronic leukemia includes chronic myelogenous leukemia (CML) and chronic lymphoid leukemia (CLL). Other related conditions include myelodysplastic syndromes (MDS, formerly known as "preleukemia") which are a diverse collection of hematological conditions united by ineffective production (or dysplasia) of myeloid blood cells and risk of transformation to AML.

[00949] Lymphoma is a group of blood cell tumors that develop from lymphocytes. Exemplary lymphomas include non-Hodgkin lymphoma and Hodgkin lymphoma.

## Combination Therapies

[00950] Methods described herein that comprise administering a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR-expressing cell described herein may be used in combination with other known agents and therapies.

[00951] Administered "in combination", as used herein, means that two (or more) different treatments are delivered to the subject during the course of the subject's affliction with the disorder, e.g., the two or more treatments are delivered after the subject has been diagnosed with the disorder and before the disorder has been cured or eliminated or treatment has ceased for other reasons. In some embodiments, the delivery of one treatment is still occurring when the delivery of the second begins, so that there is overlap in terms of administration. This is sometimes referred to herein as "simultaneous" or "concurrent delivery". In other embodiments, the delivery of one treatment ends before the delivery of the other treatment begins. In some embodiments of either case, the treatment is more effective because of combined administration. For example, the second treatment is more effective, e.g., an equivalent effect is seen with less of the second treatment, or the second treatment reduces symptoms to a greater extent, than would be seen if the second treatment were administered in the absence of the first treatment, or the analogous situation is seen with the first treatment. In some embodiments, delivery is such that the reduction in a symptom, or other parameter related to the disorder is greater than what would be observed with one treatment delivered in the absence of the other. The effect of the two treatments can be partially additive, wholly additive, or greater than additive. The delivery can

be such that an effect of the first treatment delivered is still detectable when the second is delivered.

[00952] A CAR-expressing cell described herein, a low, immune enhancing, dose of an mTOR inhibitor, and the at least one additional therapeutic agent can be administered simultaneously, in the same or in separate compositions, or sequentially. The three agents can be administeted in any order. For example, in sequential administration, the low, immune enhancing, dose of an mTOR inhibitor and the CAR-expressing cell described herein can be administered first, and the additional agent can be administered second, or the order of administration can be reversed.

[00953] The CAR therapy and/or other therapeutic agents, procedures or modalities can be administered during periods of active disorder, or during a period of remission or less active disease. The CAR therapy can be administered before another treatment, concurrently with the treatment, post-treatment, or during remission of the disorder.

[00954] When administered in combination, the CAR therapy and the additional agent (e.g., second or third agent), or all, can be administered in an amount or dose that is higher, lower or the same than the amount or dosage of each agent used individually, e.g., as a monotherapy. In certain embodiments, the administered amount or dosage of the CAR therapy, the additional agent (e.g., second or third agent), or all, is lower (e.g., at least 20%, at least 30%, at least 40%, or at least 50%) than the amount or dosage of each agent used individually, e.g., as a monotherapy. In other embodiments, the amount or dosage of the CAR therapy, the additional agent (e.g., second or third agent), or all, that results in a desired effect (e.g., treatment of cancer) is lower (e.g., at least 20%, at least 30%, at least 40%, or at least 50% lower) than the amount or dosage of each agent used individually, e.g., as a monotherapy, required to achieve the same therapeutic effect.

[00955] In further aspects, administration of a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR-expressing cell described herein may be used in a treatment regimen in combination with surgery, chemotherapy, radiation, an mTOR pathway inhibitor, immunosuppressive agents, such as cyclosporin, azathioprine, methotrexate, mycophenolate, and FK506, antibodies, or other immunoablative agents such as CAMPATH, anti-CD3 antibodies or other antibody therapies,

cytoxin, fludarabine, cyclosporin, FK506, rapamycin, mycophenolic acid, steroids, FR901228, cytokines, and irradiation. peptide vaccine, such as that described in Izumoto et al. 2008 J Neurosurg 108:963-971.

[00956] In one embodiment, administration of a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR-expressing cell described herein can be used in combination with an mTOR pathway inhibitor, e.g., an agent that reduces mTOR pathway activation by acting on a target, other than mTOR, which target is in a biological pathway with mTOR. Without wishing to be bound by theory, in some embodiments, by combining an mTOR inhibitor with an mTOR pathway inhibitor, more pronounced mTOR inhibition can be achieved. In some embodiments, the mTOR pathway inhibitor is an activator of adenosine monophosphate activated protein kinase (AMPK), such as metformin or an analog, pharmaceutically acceptable form, or prodrug thereof. According to the non-limiting theory herein, stimulation of AMPK (e.g., by metformin) can lead to inhibition of the mTOR ribosomal S6 kinase pathway. In some embodiments, the mTOR pathway inhibitor is selected from the group consisting of: vitamin E, vitamin A, an antibacterial antibiotic, an antioxidant, L- carnitine, lipoic acid, metformin, resveratrol, leptine, a non-steroid anti-inflammatory drug, or a COX inhibitor, or an analog, pharmaceutically acceptable form, or prodrug thereof. In some embodiments, the mTOR pathway inhibitor is an agent described in International Application WO2010/056754 or WO2008/110491, or Liu et al, Anticancer Res., 32: 1627-1638 (2012), each of which is incorporated herein by reference in its entirety.

[00957] In one embodiment, administration of a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR-expressing cell described herein can be used in combination with a chemotherapeutic agent. Exemplary chemotherapeutic agents include an anthracycline (e.g., doxorubicin (e.g., liposomal doxorubicin)). a vinca alkaloid (e.g., vinblastine, vincristine, vindesine, vinorelbine), an alkylating agent (e.g., cyclophosphamide, decarbazine, melphalan, ifosfamide, temozolomide), an immune cell antibody (e.g., alemtuzamab, gemtuzumab, rituximab, ofatumumab, tositumomab, brentuximab), an antimetabolite (including, e.g., folic acid antagonists, pyrimidine analogs, purine analogs and adenosine deaminase inhibitors (e.g., fludarabine)), an mTOR inhibitor, a TNFR glucocorticoid induced TNFR related protein (GITR) agonist, a proteasome

inhibitor (e.g., aclacinomycin A, gliotoxin or bortezomib), an immunomodulator such as thalidomide or a thalidomide derivative (e.g., lenalidomide).

[00958] General Chemotherapeutic agents for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include anastrozole (Arimidex®), bicalutamide (Casodex®), bleomycin sulfate (Blenoxane®), busulfan (Myleran®), busulfan injection (Busulfex®), capecitabine (Xeloda®), N4-pentoxycarbonyl-5-deoxy-5-fluorocytidine, carboplatin (Paraplatin®), carmustine (BiCNU®), chlorambucil (Leukeran®), cisplatin (Platinol®), cladribine (Leustatin®), cyclophosphamide (Cytoxan® or Neosar®), cytarabine, cytosine arabinoside (Cytosar-U®), cytarabine liposome injection (DepoCyt®), dacarbazine (DTIC-Dome®), dactinomycin (Actinomycin D, Cosmegan), daunorubicin hydrochloride (Cerubidine®), daunorubicin citrate liposome injection (DaunoXome®), dexamethasone, docetaxel (Taxotere®), doxorubicin hydrochloride (Adriamycin®, Rubex®), etoposide (Vepesid®), fludarabine phosphate (Fludara®), 5-fluorouracil (Adrucil®, Efudex®), flutamide (Eulexin®), tezacitibine, Gemcitabine (difluorodeoxycitidine), hydroxyurea (Hydrea®), Idarubicin (Idamycin®), ifosfamide (IFEX®), irinotecan (Camptosar®), L-asparaginase (ELSPAR®), leucovorin calcium, melphalan (Alkeran®), 6-mercaptopurine (Purinethol®), methotrexate (Folex®), mitoxantrone (Novantrone®), mylotarg, paclitaxel (Taxol®), phoenix (Yttrium90/MX-DTPA), pentostatin, polifeprosan 20 with carmustine implant (Gliadel®), tamoxifen citrate (Nolvadex®), teniposide (Vumon®), 6-thioguanine, thiotepa, tirapazamine (Tirazone®), topotecan hydrochloride for injection (Hycamptin®), vinblastine (Velban®), vincristine (Oncovin®), and vinorelbine (Navelbine®).

[00959] Anti-cancer agents of particular interest for combinations with the compounds of the present invention include: anthracyclines; alkylating agents; antimetabolites; drugs that inhibit either the calcium dependent phosphatase calcineurin or the p70S6 kinase FK506) or inhibit the p70S6 kinase; mTOR inhibitors (e.g., at a dose suitable for treating cancer); immunomodulators; anthracyclines; vinca alkaloids; proteosome inhibitors; GITR agonists; protein tyrosine phosphatase inhibitors; a CDK4 kinase inhibitor; a BTK inhibitor; a MKN kinase inhibitor; a DGK kinase inhibitor; or an oncolytic virus.

[00960] Exemplary antimetabolites include, without limitation, pyrimidine analogs, purine analogs and adenosine deaminase inhibitors): methotrexate (Rheumatrex®, Trexall®), 5-

fluorouracil (Adrucil®, Efudex®, Fluoroplex®), floxuridine (FUDF®), cytarabine (Cytosar-U®, Tarabine PFS), 6-mercaptopurine (Puri-Nethol®)), 6-thioguanine (Thioguanine Tabloid®), fludarabine phosphate (Fludara®), pentostatin (Nipent®), pemetrexed (Alimta®), raltitrexed (Tomudex®), cladribine (Leustatin®), clofarabine (Clofarex®, Clolar®), azacitidine (Vidaza®), decitabine and gemcitabine (Gemzar®). Preferred antimetabolites include, cytarabine, clofarabine and fludarabine.

[00961] Exemplary alkylating agents for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include, without limitation, nitrogen mustards, ethylenimine derivatives, alkyl sulfonates, nitrosoureas and triazenes): uracil mustard (Aminouracil Mustard®, Chlorethaminacil®, Demethyldopan®, Desmethyldopan®, Haemanthamine®, Nordopan®, Uracil nitrogen mustard®, Uracillost®, Uracilmostaza®, Uramustin®, Uramustine®), chlormethine (Mustargen®), cyclophosphamide (Cytoxan®, Neosar®, Clafen®, Endoxan®, Procytox®, Revimmune™), ifosfamide (Mitoxana®), melphalan (Alkeran®), Chlorambucil (Leukeran®), pipobroman (Amedel®, Vercyte®), triethylenemelamine (Hemel®, Hexalen®, Hexastat®), triethylenethiophosphoramine, Temozolomide (Temodar®), thiotepa (Thioplex®), busulfan (Busilvex®, Myleran®), carmustine (BiCNU®), lomustine (CeeNU®), streptozocin (Zanosar®), and Dacarbazine (DTIC-Dome®). Additional exemplary alkylating agents include, without limitation, Oxaliplatin (Eloxatin®); Temozolomide (Temodar® and Temodal®); Dactinomycin (also known as actinomycin-D, Cosmegen®); Melphalan (also known as L-PAM, L-sarcolysin, and phenylalanine mustard, Alkeran®); Altretamine (also known as hexamethylmelamine (HMM), Hexalen®); Carmustine (BiCNU®); Bendamustine (Treanda®); Busulfan (Busulfex® and Myleran®); Carboplatin (Paraplatin®); Lomustine (also known as CCNU, CeeNU®); Cisplatin (also known as CDDP, Platinol® and Platinol®-AQ); Chlorambucil (Leukeran®); Cyclophosphamide (Cytoxan® and Neosar®); Dacarbazine (also known as DTIC, DIC and imidazole carboxamide, DTIC-Dome®); Altretamine (also known as hexamethylmelamine (HMM), Hexalen®); Ifosfamide (Ifex®); Prednumustine; Procarbazine (Matulane®); Mechlorethamine (also known as nitrogen mustard, mustine and mechloroethamine hydrochloride, Mustargen®); Streptozocin (Zanosar®); Thiotepa (also known as thiophosphoamide, TESPA and TSPA, Thioplex®); Cyclophosphamide (Endoxan®, Cytoxan®, Neosar®, Procytox®, Revimmune®); and Bendamustine HCl (Treanda®).

[00962] Exemplary immunomodulators for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include, e.g., afutuzumab (available from Roche®); pegfilgrastim (Neulasta®); lenalidomide (CC-5013, Revlimid®); thalidomide (Thalomid®), pomalidomide, actimid (CC4047); and IRX-2 (mixture of human cytokines including interleukin 1, interleukin 2, and interferon γ, CAS 951209-71-5, available from IRX Therapeutics).

[00963] Exemplary anthracyclines for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include, e.g., doxorubicin (Adriamycin® and Rubex®); bleomycin (lenoxane®); daunorubicin (dauorubicin hydrochloride, daunomycin, and rubidomycin hydrochloride, Cerubidine®); daunorubicin liposomal (daunorubicin citrate liposome, DaunoXome®); mitoxantrone (DHAD, Novantrone®); epirubicin (Ellence™); idarubicin (Idamycin®, Idamycin PFS®); mitomycin C (Mutamycin®); geldanamycin; herbimycin; ravidomycin; and desacetylravidomycin.

[00964] Exemplary vinca alkaloids for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include, e.g., vinorelbine tartrate (Navelbine®), Vincristine (Oncovin®), and Vindesine (Eldisine®)); vinblastine (also known as vinblastine sulfate, vincaleukoblastine and VLB, Alkaban-AQ® and Velban®); and vinorelbine (Navelbine®).

[00965] Exemplary proteosome inhibitors for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include bortezomib (Velcade®); carfilzomib (PX-171-007, (S)-4-Methyl-N-((S)-1-(((S)-4-methyl-1-((R)-2-methyloxiran-2-yl)-1-oxopentan-2-yl)amino)-1-oxo-3-phenylpropan-2-yl)-2-((S)-2-(2-morpholinoacetamido)-4-phenylbutanamido)-pentanamide); marizomib (NPI-0052); ixazomib citrate (MLN-9708); delanzomib (CEP-18770); and O-Methyl-N-[(2-methyl-5-thiazolyl)carbonyl]-L-seryl-O-methyl-N-[(1S)-2-[(2R)-2-methyl-2-oxiranyl]-2-oxo-1-(phenylmethyl)ethyl]- L-serinamide (ONX-0912).

[00966] Exemplary GITR agonists for use in combination with the low, immune enhancing, dose of mTOR and a CAR cell therapy include, e.g., GITR fusion proteins and anti-GITR antibodies (e.g., bivalent anti-GITR antibodies) such as, e.g., a GITR fusion protein described in U.S. Patent No.: 6,111,090, European Patent No.: 090505B1, U.S Patent No.: 8,586,023, PCT

Publication Nos.: WO 2010/003118 and 2011/090754, or an anti-GITR antibody described, e.g., in U.S. Patent No.: 7,025,962, European Patent No.: 1947183B1, U.S. Patent No.: 7,812,135, U.S. Patent No.: 8,388,967, U.S. Patent No.: 8,591,886, European Patent No.: EP 1866339, PCT Publication No.: WO 2011/028683, PCT Publication No.:WO 2013/039954, PCT Publication No.: WO2005/007190, PCT Publication No.: WO 2007/133822, PCT Publication No.: WO2005/055808, PCT Publication No.: WO 99/40196, PCT Publication No.: WO 2001/03720, PCT Publication No.: WO99/20758, PCT Publication No.: WO2006/083289, PCT Publication No.: WO 2005/115451, U.S. Patent No.: 7,618,632, and PCT Publication No.: WO 2011/051726.

[00967] In an embodiment, a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, and cells expressing a CAR described herein, are administered to a subject in combination with a molecule that decreases the Treg cell population. Methods that decrease the number of (e.g., deplete) Treg cells are known in the art and include, e.g., CD25 depletion, cyclophosphamide administration, and modulating GITR function. Without wishing to be bound by theory, it is believed that reducing the number of Treg cells in a subject prior to apheresis or prior to administration of a CAR-expressing cell described herein reduces the number of unwanted immune cells (e.g., Tregs) in the tumor microenvironment and reduces the subject's risk of relapse. In one embodiment, a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR expressing cell described herein are administered to a subject in combination with a molecule targeting GITR and/or modulating GITR functions, such as a GITR agonist and/or a GITR antibody that depletes regulatory T cells (Tregs). In one embodiment, a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR expressing cell described herein are administered to a subject in combination with cyclophosphamide. In one embodiment, the GITR binding molecule and/or molecule modulating GITR function (e.g., GITR agonist and/or Treg depleting GITR antibodies) is administered prior to the CAR-expressing cell. For example, in one embodiment, the GITR agonist can be administered prior to apheresis of the cells. In embodiments, cyclophosphamide is administered to the subject prior to administration (e.g., infusion or re-infusion) of the CAR-expressing cell or prior to aphersis of the cells. In embodiments, cyclophosphamide and an anti-GITR antibody are administered to the subject prior to administration (e.g., infusion or re-infusion) of the CAR-expressing cell or prior to apheresis of the cells. In one embodiment, the

subject has cancer (e.g., a solid cancer or a hematological cancer such as ALL or CLL). In one embodiment, the subject has CLL. In embodiments, the subject has a solid cancer, e.g., a solid cancer described herein.

[00968] Exemplary GITR agonists include, e.g., GITR fusion proteins and anti-GITR antibodies (e.g., bivalent anti-GITR antibodies) such as, e.g., a GITR fusion protein described in U.S. Patent No.: 6,111,090, European Patent No.: 090505B1, U.S Patent No.: 8,586,023, PCT Publication Nos.: WO 2010/003118 and 2011/090754, or an anti-GITR antibody described, e.g., in U.S. Patent No.: 7,025,962, European Patent No.: 1947183B1, U.S. Patent No.: 7,812,135, U.S. Patent No.: 8,388,967, U.S. Patent No.: 8,591,886, European Patent No.: EP 1866339, PCT Publication No.: WO 2011/028683, PCT Publication No.:WO 2013/039954, PCT Publication No.: WO2005/007190, PCT Publication No.: WO 2007/133822, PCT Publication No.: WO2005/055808, PCT Publication No.: WO 99/40196, PCT Publication No.: WO 2001/03720, PCT Publication No.: WO99/20758, PCT Publication No.: WO2006/083289, PCT Publication No.: WO 2005/115451, U.S. Patent No.: 7,618,632, and PCT Publication No.: WO 2011/051726.

[00969] In one embodiment, a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor and a CAR-expressing cell described herein can be used in combination with a kinase inhibitor.

[00970] In one embodiment, the kinase inhibitor is an MNK inhibitor, e.g., a MNK inhibitor selected from CGP052088; 4-amino-3-(p-fluorophenylamino)-pyrazolo [3,4-d] pyrimidine (CGP57380); cercosporamide; ETC-1780445-2; and 4-amino-5-(4-fluoroanilino)-pyrazolo [3,4-d] pyrimidine. The MNK inhibitor can be, e.g., a MNK1a, MNK1b, MNK2a and/or MNK2b inhibitor. In one embodiment, the kinase inhibitor is 4-amino-5-(4-fluoroanilino)-pyrazolo [3,4-d] pyrimidine.

[00971] In one embodiment, the kinase inhibitor is a CDK4 inhibitor selected from 7-cyclopentyl-*N,N*-dimethyl-2-((5-(piperazin-1-yl)pyridine-2-yl)amino)-7*H*-pyrrolo[2,3-d]pyrimidine-6-carboxamide (also referred to as LEE011); aloisine A; flavopiridol or HMR-1275, 2-(2-chlorophenyl)-5,7-dihydroxy-8-[(3S,4R)-3-hydroxy-1-methyl-4-piperidinyl]-4-chromenone; crizotinib (PF-02341066; 2-(2-Chlorophenyl)-5,7-dihydroxy-8-[(2R,3S)-2-(hydroxymethyl)-1-methyl-3-pyrrolidinyl]- 4H-1-benzopyran-4-one, hydrochloride (P276-00); 1-methyl-5-[[2-[5-(trifluoromethyl)-1H-imidazol-2-yl]-4-pyridinyl]oxy]-N-[4-

(trifluoromethyl)phenyl]-1H-benzimidazol-2-amine (RAF265); indisulam (E7070); roscovitine (CYC202); palbociclib (PD0332991); dinaciclib (SCH727965); N-[5-[[(5-tert-butyloxazol-2-yl)methyl]thio]thiazol-2-yl]piperidine-4-carboxamide (BMS 387032); 4-[[9-chloro-7-(2,6-difluorophenyl)-5H-pyrimido[5,4-d][2]benzazepin-2-yl]amino]-benzoic acid (MLN8054); 5-[3-(4,6-difluoro-1H-benzimidazol-2-yl)-1H-indazol-5-yl]-N-ethyl-4-methyl-3-pyridinemethanamine (AG-024322); 4-(2,6-dichlorobenzoylamino)-1H-pyrazole-3-carboxylic acid N-(piperidin-4-yl)amide (AT7519); 4-[2-methyl-1-(1-methylethyl)-1H-imidazol-5-yl]-N-[4-(methylsulfonyl)phenyl]- 2-pyrimidinamine (AZD5438); and XL281 (BMS908662).

[00972] In one embodiment, the kinase inhibitor is a CDK4 inhibitor, e.g., a CDK4 inhibitor described herein, e.g., a CDK4/6 inhibitor, such as, e.g., 7-cyclopentyl-*N,N*-dimethyl-2-((5-(piperazin-1-yl)pyridine-2-yl)amino)-7*H*-pyrrolo[2,3-d]pyrimidine-6-carboxamide (also referred to as LEE011) or 6-Acetyl-8-cyclopentyl-5-methyl-2-(5-piperazin-1-yl-pyridin-2-ylamino)-8H-pyrido[2,3-d]pyrimidin-7-one, hydrochloride (also referred to as palbociclib or PD0332991).

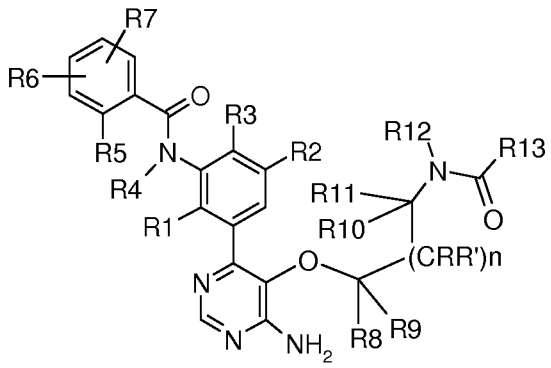
[00973] In one embodiment, the kinase inhibitor is a CDK4 inhibitor, e.g., palbociclib (PD0332991), and the palbociclib is administered at a dose of about 50 mg, 60 mg, 70 mg, 75 mg, 80 mg, 90 mg, 100 mg, 105 mg, 110 mg, 115 mg, 120 mg, 125 mg, 130 mg, 135 mg (e.g., 75 mg, 100 mg or 125 mg) daily for a period of time, e.g., daily for 14-21 days of a 28 day cycle, or daily for 7-12 days of a 21 day cycle. In one embodiment, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more cycles of palbociclib are administered.

[00974] In one embodiment, the kinase inhibitor is a BTK inhibitor, e.g., selected from ibrutinib (PCI-32765); GDC-0834; RN-486; CGI-560; CGI-1764; HM-71224; CC-292; ONO-4059; CNX-774; and LFM-A13. In a preferred embodiment, the BTK inhibitor does not reduce or inhibit the kinase activity of interleukin-2-inducible kinase (ITK), and is selected from GDC-0834; RN-486; CGI-560; CGI-1764; HM-71224; CC-292; ONO-4059; CNX-774; and LFM-A13.

[00975] In one embodiment, the kinase inhibitor is a BTK inhibitor, e.g., ibrutinib (PCI-32765), and the ibrutinib is administered at a dose of about 250 mg, 300 mg, 350 mg, 400 mg, 420 mg, 440 mg, 460 mg, 480 mg, 500 mg, 520 mg, 540 mg, 560 mg, 580 mg, 600 mg (e.g., 250 mg, 420 mg or 560 mg) daily for a period of time, e.g., daily for 21 day cycle cycle, or daily for

28 day cycle. In one embodiment, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more cycles of ibrutinib are administered.

[00976] In some embodiments of the methods, uses, and compositions herein, the BTK inhibitor is a BTK inhibitor described in International Application WO/2015/079417, which is herein incorporated by reference in its entirety. For instance, in some embodiments, the BTK inhibitor is a compound of formula (I) or a pharmaceutically acceptable salt thereof;




(I)

[00977] wherein,

[00978] R1 is hydrogen, C1-C6 alkyl optionally substituted by hydroxy;

[00979] R2 is hydrogen or halogen;

[00980] R3 is hydrogen or halogen;

[00981] R4 is hydrogen;

[00982] R5 is hydrogen or halogen;

[00983] or R4 and R5 are attached to each other and stand for a bond, -CH2-, -CH2-CH2- , -CH=CH-, -CH=CH-CH2-; -CH2-CH=CH-; or -CH2-CH2-CH2-;

[00984] R6 and R7 stand independently from each other for H, C1-C6 alkyl optionally substituted by hydroxyl, C3-C6 cycloalkyl optionally substituted by halogen or hydroxy, or halogen;

[00985] R8, R9, R, R', R10 and R11 independently from each other stand for H, or C1-C6 alkyl optionally substituted by C1-C6 alkoxy; or any two of R8, R9, R, R', R10 and R11 together with the carbon atom to which they are bound may form a 3 – 6 membered saturated carbocyclic ring;

[00986] R12 is hydrogen or C1-C6 alkyl optionally substituted by halogen or C1-C6 alkoxy;

[00987] or R12 and any one of R8, R9, R, R', R10 or R11 together with the atoms to which they are bound may form a 4, 5, 6 or 7 membered azacyclic ring, which ring may optionally be substituted by halogen, cyano, hydroxyl, C1-C6 alkyl or C1-C6 alkoxy;

[00988] n is 0 or 1; and

[00989] R13 is C2-C6 alkenyl optionally substituted by C1-C6 alkyl, C1-C6 alkoxy or N,N-di-C1-C6 alkyl amino; C2-C6 alkynyl optionally substituted by C1-C6 alkyl or C1-C6 alkoxy; or C2-C6 alkylenyl oxide optionally substituted by C1-C6 alkyl.

[00990] In some embodiments, the BTK inhibitor of Formula I is chosen from: N-(3-(5-((1-Acryloylazetidin-3-yl)oxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (E)-N-(3-(6-Amino-5-((1-(but-2-enoyl)azetidin-3-yl)oxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-((1-propioloylazetidin-3-yl)oxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-((1-(but-2-ynoyl)azetidin-3-yl)oxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(5-((1-Acryloylpiperidin-4-yl)oxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(2-(N-methylacrylamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (E)-N-(3-(6-Amino-5-(2-(N-methylbut-2-enamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(2-(N-methylpropiolamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (E)-N-(3-(6-Amino-5-(2-(4-methoxy-N-methylbut-2-enamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(2-(N-methylbut-2-ynamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(2-((4-Amino-6-(3-(4-cyclopropyl-2-fluorobenzamido)-5-fluoro-2-methylphenyl)pyrimidin-5-yl)oxy)ethyl)-N-methyloxirane-2-carboxamide; N-(2-((4-Amino-6-(3-(6-cyclopropyl-8-fluoro-1-oxoisoquinolin-2(1H)-yl)phenyl)pyrimidin-5-yl)oxy)ethyl)-N-methylacrylamide; N-(3-(5-(2-Acrylamidoethoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(2-(N-ethylacrylamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(2-(N-(2-

fluoroethyl)acrylamido)ethoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(5-((1-Acrylamidocyclopropyl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(5-(2-Acrylamidopropoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(6-Amino-5-(2-(but-2-ynamido)propoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(6-Amino-5-(2-(N-methylacrylamido)propoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(6-Amino-5-(2-(N-methylbut-2-ynamido)propoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(3-(N-methylacrylamido)propoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(5-((1-Acryloylpyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(6-Amino-5-((1-(but-2-ynoyl)pyrrolidin-2-yl)methoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-2-(3-(5-((1-Acryloylpyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-(hydroxymethyl)phenyl)-6-cyclopropyl-3,4-dihydroisoquinolin-1(2H)-one; N-(2-((4-Amino-6-(3-(6-cyclopropyl-1-oxo-3,4-dihydroisoquinolin-2(1H)-yl)-5-fluoro-2-(hydroxymethyl)phenyl)pyrimidin-5-yl)oxy)ethyl)-N-methylacrylamide; N-(3-(5-(((2S,4R)-1-Acryloyl-4-methoxypyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(((2S,4R)-1-(but-2-ynoyl)-4-methoxypyrrolidin-2-yl)methoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; 2-(3-(5-(((2S,4R)-1-Acryloyl-4-methoxypyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-(hydroxymethyl)phenyl)-6-cyclopropyl-3,4-dihydroisoquinolin-1(2H)-one; N-(3-(5-(((2S,4S)-1-Acryloyl-4-methoxypyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(((2S,4S)-1-(but-2-ynoyl)-4-methoxypyrrolidin-2-yl)methoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(5-(((2S,4R)-1-Acryloyl-4-fluoropyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(6-Amino-5-(((2S,4R)-1-(but-2-ynoyl)-4-fluoropyrrolidin-2-yl)methoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(5-((1-Acryloylazetidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-N-(3-(6-Amino-5-((1-

propioloylazetidin-2-yl)methoxy)pyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (S)-2-(3-(5-((1-Acryloylazetidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-(hydroxymethyl)phenyl)-6-cyclopropyl-3,4-dihydroisoquinolin-1(2H)-one; (R)-N-(3-(5-((1-Acryloylazetidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; (R)-N-(3-(5-((1-Acryloylpiperidin-3-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(5-(((2R,3S)-1-Acryloyl-3-methoxypyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; N-(3-(5-(((2S,4R)-1-Acryloyl-4-cyanopyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide; or N-(3-(5-(((2S,4S)-1-Acryloyl-4-cyanopyrrolidin-2-yl)methoxy)-6-aminopyrimidin-4-yl)-5-fluoro-2-methylphenyl)-4-cyclopropyl-2-fluorobenzamide.

[00991] Unless otherwise provided, the chemical terms used above in describing the BTK inhibitor of Formula I are used according to their meanings as set out in International Application WO/2015/079417, which is herein incorporated by reference in its entirety.

[00992] In one embodiment, the kinase inhibitor is an mTOR inhibitor. MTOR inhibitors can be selected from the section elsewhere herein entitled mTOR Inhibitors. The dose referred to here is not the low, immune enhancing, dose of an mTOR inhibitor, but rather a dose sufficient to give an anti-cancer effect, and is higher than the low, immune enhancing, dose, described herein, e.g., a dose. Thus, in an embodiment, two different administrations of an mTOR inhibitor are given, a low, immune enhancing dose, e.g., to optimize immune effector cell function, and a higher dose given for an anticancer effect.

[00993] In one embodiment, the kinase inhibitor is an mTOR inhibitor, e.g., rapamycin, and the rapamycin is administered at a dose sufficient to give an anti-cancer effect, and higher than the low, immune enhancing, dose, sescribed herein, e.g., a dose of about 3 mg, 4 mg, 5 mg, 6 mg, 7 mg, 8 mg, 9 mg, 10 mg (e.g., 6 mg) daily for a period of time, e.g., daily for 21 day cycle cycle, or daily for 28 day cycle. In one embodiment, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more cycles of rapamycin are administered.

[00994] In one embodiment, the kinase inhibitor is an mTOR inhibitor, e.g., everolimus and the everolimus is administered at a dose sufficient to give an anti-cancer effect, and higher than

the low, immune enhancing, dose, sescribed herein, e.g., a dose of about 2 mg, 2.5 mg, 3 mg, 4 mg, 5 mg, 6 mg, 7 mg, 8 mg, 9 mg, 10 mg, 11 mg, 12 mg, 13 mg, 14 mg, 15 mg (e.g., 10 mg) daily for a period of time, e.g., daily for 28 day cycle. In one embodiment, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more cycles of everolimus are administered.

[00995] In one embodiment, the kinase inhibitor is a dual phosphatidylinositol 3-kinase (PI3K) and mTOR inhibitor selected from 2-Amino-8-[*trans*-4-(2-hydroxyethoxy)cyclohexyl]-6-(6-methoxy-3-pyridinyl)-4-methyl-pyrido[2,3-*d*]pyrimidin-7(8*H*)-one (PF-04691502); *N*-[4-[[4-(Dimethylamino)-1-piperidinyl]carbonyl]phenyl]-*N*'-[4-(4,6-di-4-morpholinyl-1,3,5-triazin-2-yl)phenyl]urea (PF-05212384, PKI-587); 2-Methyl-2-{4-[3-methyl-2-oxo-8-(quinolin-3-yl)-2,3-dihydro-1*H*-imidazo[4,5-c]quinolin-1-yl]phenyl}propanenitrile (BEZ-235); apitolisib (GDC-0980, RG7422); 2,4-Difluoro-N-{2-(methyloxy)-5-[4-(4-pyridazinyl)-6-quinolinyl]-3-pyridinyl}benzenesulfonamide (GSK2126458); 8-(6-methoxypyridin-3-yl)-3-methyl-1-(4-(piperazin-1-yl)-3-(trifluoromethyl)phenyl)-1H-imidazo[4,5-c]quinolin-2(3H)-one Maleic acid (NVP-BGT226); 3-[4-(4-Morpholinylpyrido[3',2':4,5]furo[3,2-d]pyrimidin-2-yl]phenol (PI-103); 5-(9-isopropyl-8-methyl-2-morpholino-9H-purin-6-yl)pyrimidin-2-amine (VS-5584, SB2343); and N-[2-[(3,5-Dimethoxyphenyl)amino]quinoxalin-3-yl]-4-[(4-methyl-3-methoxyphenyl)carbonyl]aminophenylsulfonamide (XL765).

[00996] Drugs that inhibit either the calcium dependent phosphatase calcineurin (cyclosporine and FK506) or inhibit the p70S6 kinase that is important for growth factor induced signaling (rapamycin). (Liu et al., Cell 66:807-815, 1991; Henderson et al., Immun. 73:316-321, 1991; Bierer et al., Curr. Opin. Immun. 5:763-773, 1993) can also be used.

[00997] In some embodiments, a CAR-expressing cell described herein is administered to a subject in combination with a CD20 inhibitor, e.g., an anti-CD20 antibody (e.g., an anti-CD20 mono- or bispecific antibody) or a fragment thereof. Exemplary anti-CD20 antibodies include but are not limited to rituximab, ofatumumab, ocrelizumab, veltuzumab, obinutuzumab, TRU-015 (Trubion Pharmaceuticals), ocaratuzumab, and Pro131921 (Genentech). See, e.g., Lim et al. Haematologica. 95.1(2010):135-43.

[00998] In some embodiments, a CAR-expressing cell described herein is administered in combination with an oncolytic virus. In embodiments, oncolytic viruses are capable of selectively replicating in and triggering the death of or slowing the growth of a cancer cell. In

some cases, oncolytic viruses have no effect or a minimal effect on non-cancer cells. An oncolytic virus includes but is not limited to an oncolytic adenovirus, oncolytic Herpes Simplex Viruses, oncolytic retrovirus, oncolytic parvovirus, oncolytic vaccinia virus, oncolytic Sinbis virus, oncolytic influenza virus, or oncolytic RNA virus (e.g., oncolytic reovirus, oncolytic Newcastle Disease Virus (NDV), oncolytic measles virus, or oncolytic vesicular stomatitis virus (VSV)).

[00999] In some embodiments, the oncolytic virus is a virus, e.g., recombinant oncolytic virus, described in US2010/0178684 A1, which is incorporated herein by reference in its entirety. In some embodiments, a recombinant oncolytic virus comprises a nucleic acid sequence (e.g., heterologous nucleic acid sequence) encoding an inhibitor of an immune or inflammatory response, e.g., as described in US2010/0178684 A1, incorporated herein by reference in its entirety. In embodiments, the recombinant oncolytic virus, e.g., oncolytic NDV, comprises a pro-apoptotic protein (e.g., apoptin), a cytokine (e.g., GM-CSF, interferon-gamma, interleukin-2 (IL-2), tumor necrosis factor-alpha), an immunoglobulin (e.g., an antibody against ED-B firbonectin), tumor associated antigen, a bispecific adapter protein (e.g., bispecific antibody or antibody fragment directed against NDV HN protein and a T cell co-stimulatory receptor, such as CD3 or CD28; or fusion protein between human IL-2 and single chain antibody directed against NDV HN protein). See, e.g., Zamarin et al. Future Microbiol. 7.3(2012):347-67, incorporated herein by reference in its entirety. In some embodiments, the oncolytic virus is a chimeric oncolytic NDV described in US 8591881 B2, US 2012/0122185 A1, or US 2014/0271677 A1, each of which is incorporated herein by reference in their entireties.

[001000] In some embodiments, the oncolytic virus comprises a conditionally replicative adenovirus (CRAd), which is designed to replicate exclusively in cancer cells. See, e.g., Alemany et al. Nature Biotechnol. 18(2000):723-27. In some embodiments, an oncolytic adenovirus comprises one described in Table 1 on page 725 of Alemany et al., incorporated herein by reference in its entirety.

[001001] Exemplary oncolytic viruses include but are not limited to the following:

[001002] Group B Oncolytic Adenovirus (ColoAd1) (PsiOxus Therapeutics Ltd.) (see, e.g., Clinical Trial Identifier: NCT02053220);

[001003] ONCOS-102 (previously called CGTG-102), which is an adenovirus comprising granulocyte-macrophage colony stimulating factor (GM-CSF) (Oncos Therapeutics) (see, e.g., Clinical Trial Identifier: NCT01598129);

[001004] VCN-01, which is a genetically modified oncolytic human adenovirus encoding human PH20 hyaluronidase (VCN Biosciences, S.L.) (see, e.g., Clinical Trial Identifiers: NCT02045602 and NCT02045589);

[001005] Conditionally Replicative Adenovirus ICOVIR-5, which is a virus derived from wild-type human adenovirus serotype 5 (Had5) that has been modified to selectively replicate in cancer cells with a deregulated retinoblastoma/E2F pathway (Institut Català d'Oncologia) (see, e.g., Clinical Trial Identifier: NCT01864759);

[001006] Celyvir, which comprises bone marrow-derived autologous mesenchymal stem cells (MSCs) infected with ICOVIR5, an oncolytic adenovirus (Hospital Infantil Universitario Niño Jesús, Madrid, Spain/ Ramon Alemany) (see, e.g., Clinical Trial Identifier: NCT01844661);

[001007] CG0070, which is a conditionally replicating oncolytic serotype 5 adenovirus (Ad5) in which human E2F-1 promoter drives expression of the essential E1a viral genes, thereby restricting viral replication and cytotoxicity to Rb pathway-defective tumor cells (Cold Genesys, Inc.) (see, e.g., Clinical Trial Identifier: NCT02143804); or

[001008] DNX-2401 (formerly named Delta-24-RGD), which is an adenovirus that has been engineered to replicate selectively in retinoblastoma (Rb)-pathway deficient cells and to infect cells that express certain RGD-binding integrins more efficiently (Clinica Universidad de Navarra, Universidad de Navarra/ DNAtrix, Inc.) (see, e.g., Clinical Trial Identifier: NCT01956734).

[001009] In some embodiments, an oncolytic virus described herein is administering by injection, e.g., subcutaneous, intra-arterial, intravenous, intramuscular, intrathecal, or intraperitoneal injection. In embodiments, an oncolytic virus described herein is administered intratumorally, transdermally, transmucosally, orally, intranasally, or via pulmonary administration.

[001010] In a further aspect, the cell compositions of the present invention may be administered to a patient in conjunction with (e.g., before, simultaneously or following) bone

marrow transplantation, T cell ablative therapy using chemotherapy agents such as, fludarabine, external-beam radiation therapy (XRT), cyclophosphamide, and/or antibodies such as OKT3 or CAMPATH. In one aspect, the cell compositions of the present invention are administered following B-cell ablative therapy such as agents that react with CD20, e.g., Rituxan. For example, in one embodiment, subjects may undergo standard treatment with high dose chemotherapy followed by peripheral blood stem cell transplantation. In certain embodiments, following the transplant, subjects receive an infusion of the expanded immune cells of the present invention. In an additional embodiment, expanded cells are administered before or following surgery.

[001011] In one embodiment, the subject can be administered an agent which reduces or ameliorates a side effect associated with the administration of a CAR-expressing cell. Side effects associated with the administration of a CAR-expressing cell include, but are not limited to CRS, and hemophagocytic lymphohistiocytosis (HLH), also termed Macrophage Activation Syndrome (MAS). Symptoms of CRS include high fevers, nausea, transient hypotension, hypoxia, and the like. CRS may include clinical constitutional signs and symptoms such as fever, fatigue, anorexia, myalgias, arthalgias, nausea, vomiting, and headache. CRS may include clinical skin signs and symptoms such as rash. CRS may include clinical gastrointestinal signs and symsptoms such as nausea, vomiting and diarrhea. CRS may include clinical respiratory signs and symptoms such as tachypnea and hypoxemia. CRS may include clinical cardiovascular signs and symptoms such as tachycardia, widened pulse pressure, hypotension, increased cardac output (early) and potentially diminished cardiac output (late). CRS may include clinical coagulation signs and symptoms such as elevated d-dimer, hypofibrinogenemia with or without bleeding. CRS may include clinical renal signs and symptoms such as azotemia. CRS may include clinical hepatic signs and symptoms such as transaminitis and hyperbilirubinemia. CRS may include clinical neurologic signs and symptoms such as headache, mental status changes, confusion, delirium, word finding difficulty or frank aphasia, hallucinations, tremor, dymetria, altered gait, and seizures. Accordingly, the methods described herein can comprise administering a CAR-expressing cell described herein to a subject and further administering one or more agents to manage elevated levels of a soluble factor resulting from treatment with a CAR-expressing cell. In one embodiment, the soluble factor elevated in the subject is one or more of IFN-γ, TNFα, IL-2 and IL-6. In an embodiment, the factor elevated

in the subject is one or more of IL-1, GM-CSF, IL-10, IL-8, IL-5 and fraktalkine. Therefore, an agent administered to treat this side effect can be an agent that neutralizes one or more of these soluble factors. In one embodiment, the agent that neutralizes one or more of these soluble forms is an antibody or antibody fragment thereof. Examples of such agents include, but are not limited to a steroid (e.g., corticosteroid), an inhibitor of TNFα, and an inhibitor of IL-6. An example of a TNFα inhibitor is an anti-TNFα antibody molecule such as, infliximab, adalimumab, certolizumab pegol, and golimumab. Another example of a TNFα inhibitor is a fusion protein such as entanercept. Small molecule inhibitor of TNFα include, but are not limited to, xanthine derivatives (e.g. pentoxifylline) and bupropion. An example of an IL-6 inhibitor is an anti-IL-6 antibody molecule or an anti-IL-6 receptor antibody molecule such as tocilizumab (toc), sarilumab, elsilimomab, CNTO 328, ALD518/BMS-945429, CNTO 136, CPSI-2364, CDP6038, VX30, ARGX-109, FE301, and FM101. In one embodiment, the anti-IL-6 receptor antibody molecule is tocilizumab. An example of an IL-1R based inhibitor is anakinra.

[001012] In one embodiment, the subject can be administered an agent which enhances the activity of a CAR-expressing cell. For example, in one embodiment, the agent can be an agent which inhibits an inhibitory molecule, e.g., the agent is a checkpoint inhibitor. Inhibitory molecules, e.g., Programmed Death 1 (PD-1), can, in some embodiments, decrease the ability of a CAR-expressing cell to mount an immune effector response. Examples of inhibitory molecules include PD-1, PD-L1, PD-L2, CTLA4, TIM3, LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4, CD80, CD86, B7-H3 (CD276), B7-H4 (VTCN1), HVEM (TNFRSF14 or CD270), KIR, A2aR, MHC class I, MHC class II, GAL9, adenosine, and TGFR beta. Inhibition of an inhibitory molecule, e.g., by inhibition at the DNA, RNA or protein level, can optimize a CAR-expressing cell performance. In embodiments, an inhibitory nucleic acid, e.g., an inhibitory nucleic acid, e.g., a dsRNA, e.g., an siRNA or shRNA, a clustered regularly interspaced short palindromic repeats (CRISPR), a transcription-activator like effector nuclease (TALEN), or a zinc finger endonuclease (ZFN), e.g., as described herein, can be used to inhibit expression of an inhibitory molecule in the CAR-expressing cell. In an embodiment the inhibitor is an shRNA. In an embodiment, the inhibitory molecule is inhibited within a CAR-expressing cell. In these embodiments, a dsRNA molecule that inhibits expression of the inhibitory molecule is linked to the nucleic acid that encodes a component, e.g., all of the components, of the CAR.

[001013] In an embodiment, a nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is operably linked to a promoter, e.g., a H1- or a U6-derived promoter such that the dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is expressed, e.g., is expressed within a CAR-expressing cell. See e.g., Tiscornia G., "Development of Lentiviral Vectors Expressing siRNA," Chapter 3, in *Gene Transfer: Delivery and Expression of DNA and RNA* (eds. Friedmann and Rossi). Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, USA, 2007; Brummelkamp TR, *et al.* (2002) *Science* 296: 550–553; Miyagishi M, *et al.* (2002) *Nat. Biotechnol.* 19: 497–500. In an embodiment the nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is present on the same vector, e.g., a lentiviral vector, that comprises a nucleic acid molecule that encodes a component, e.g., all of the components, of the CAR. In such an embodiment, the nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is located on the vector, e.g., the lentiviral vector, 5'- or 3'- to the nucleic acid that encodes a component, e.g., all of the components, of the CAR. The nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function can be transcribed in the same or different direction as the nucleic acid that encodes a component, e.g., all of the components, of the CAR. In an embodiment the nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is present on a vector other than the vector that comprises a nucleic acid molecule that encodes a component, e.g., all of the components, of the CAR. In an embodiment, the nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function it transiently expressed within a CAR-expressing cell. In an embodiment, the nucleic acid molecule that encodes a dsRNA molecule that inhibits expression of the molecule that modulates or regulates, e.g., inhibits, T-cell function is stably integrated into the genome of a CAR-expressing cell. In an embodiment, the the molecule that modulates or regulates, e.g., inhibits, T-cell function is PD-1.

[001014] In one embodiment, the inhibitor of an inhibitory signal can be, e.g., an antibody or antibody fragment that binds to an inhibitory molecule. For example, the agent can be an

antibody or antibody fragment that binds to PD-1, PD-L1, PD-L2 or CTLA4 (e.g., ipilimumab (also referred to as MDX-010 and MDX-101, and marketed as Yervoy®; Bristol-Myers Squibb; Tremelimumab (IgG2 monoclonal antibody available from Pfizer, formerly known as ticilimumab, CP-675,206).). In an embodiment, the agent is an antibody or antibody fragment that binds to TIM3. In an embodiment, the agent is an antibody or antibody fragment that binds to LAG3. In embodiments, the agent that enhances the activity of a CAR-expressing cell, e.g., inhibitor of an inhibitory molecule, is administered in combination with an allogeneic CAR, e.g., an allogeneic CAR described herein (e.g., described in the Allogeneic CAR section herein). In an embodiment PD1 inhibitors are administered after the administration of a low, immune enhancing, dose, of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, or after such administration results in an increase in PD1 negative immune effector cells, e.g., T cells, or after an increase in the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells.

[001015] PD-1 is an inhibitory member of the CD28 family of receptors that also includes CD28, CTLA-4, ICOS, and BTLA. PD-1 is expressed on activated B cells, T cells and myeloid cells (Agata et al. 1996 Int. Immunol 8:765-75). Two ligands for PD-1, PD-L1 and PD-L2 have been shown to downregulate T cell activation upon binding to PD-1 (Freeman et a. 2000 J Exp Med 192:1027-34; Latchman et al. 2001 Nat Immunol 2:261-8; Carter et al. 2002 Eur J Immunol 32:634-43). PD-L1 is abundant in human cancers (Dong et al. 2003 J Mol Med 81:281-7; Blank et al. 2005 Cancer Immunol. Immunother 54:307-314; Konishi et al. 2004 Clin Cancer Res 10:5094). Immune suppression can be reversed by inhibiting the local interaction of PD-1 with PD-L1. Antibodies, antibody fragments, and other inhibitors of PD-1, PD-L1 and PD-L2 are knwon and may be used combination with a CAR of the present invention described herein. For example, nivolumab (also referred to as BMS-936558 or MDX1106; Bristol-Myers Squibb) is a fully human IgG4 monoclonal antibody which specifically blocks PD-1. Nivolumab (clone 5C4) and other human monoclonal antibodies that specifically bind to PD-1 are disclosed in US 8,008,449 and WO2006/121168. Pidilizumab (CT-011; Cure Tech) is a humanized IgG1k monoclonal antibody that binds to PD-1. Pidilizumab and other humanized anti-PD-1 monoclonal antibodies are disclosed in WO2009/101611. Pembrolizumab (formerly known as lambrolizumab, and also referred to as Keytruda, MK03475; Merck) is a humanized IgG4 monoclonal antibody that binds to PD-1. Pembrolizumab and other humanized anti-PD-1

antibodies are disclosed in US 8,354,509 and WO2009/114335. MEDI4736 (Medimmune) is a human monoclonal antibody that binds to PDL1, and inhibits interaction of the ligand with PD1. MDPL3280A (Genentech / Roche) is a human Fc optimized IgG1 monoclonal antibody that binds to PD-L1. MDPL3280A and other human monoclonal antibodies to PD-L1 are disclosed in U.S. Patent No.: 7,943,743 and U.S Publication No.: 20120039906. Other anti-PD-L1 binding agents include YW243.55.S70 (heavy and light chain variable regions are shown in SEQ ID NOs 20 and 21 in WO2010/077634) and MDX-1 105 (also referred to as BMS-936559, and, e.g., anti-PD-L1 binding agents disclosed in WO2007/005874). AMP-224 (B7-DCIg; Amplimmune; e.g., disclosed in WO2010/027827 and WO2011/066342), is a PD-L2 Fc fusion soluble receptor that blocks the interaction between PD-1 and B7-H1. Other anti-PD-1 antibodies include AMP 514 (Amplimmune), among others, e.g., anti-PD-1 antibodies disclosed in US 8,609,089, US 2010028330, and/or US 20120114649.

[001016] TIM3 (T cell immunoglobulin-3) also negatively regulates T cell function, particularly in IFN-g-secreting CD4+ T helper 1 and CD8+ T cytotoxic 1 cells, and plays a critical role in T cell exhaustion. Inhibition of the interaction between TIM3 and its ligands, e.g., galectin-9 (Gal9), phosphotidylserine (PS), and HMGB1, can increase immune response. Antibodies, antibody fragments, and other inhibitors of TIM3 and its ligands are available in the art and may be used combination with a CD19 CAR described herein. For example, antibodies, antibody fragments, small molecules, or peptide inhibitors that target TIM3 binds to the IgV domain of TIM3 to inhibit interaction with its ligands. Antibodies and peptides that inhibit TIM3 are disclosed in WO2013/006490 and US20100247521. Other anti-TIM3 antibodies include humanized versions of RMT3-23 (disclosed in Ngiow et al., 2011, Cancer Res, 71:3540-3551), and clone 8B.2C12 (disclosed in Monney et al., 2002, Nature, 415:536-541). Bi-specific antibodies that inhibit TIM3 and PD-1 are disclosed in US20130156774.

[001017] In other embodiments, the agent which enhances the activity of a CAR-expressing cell is a CEACAM inhibitor (*e.g.*, CEACAM-1, CEACAM-3, and/or CEACAM-5 inhibitor). In one embodiment, the inhibitor of CEACAM is an anti-CEACAM antibody molecule. Exemplary anti-CEACAM-1 antibodies are described in WO 2010/125571, WO 2013/082366 WO 2014/059251 and WO 2014/022332, *e.g.,* a monoclonal antibody 34B1, 26H7, and 5F4; or a recombinant form thereof, as described in, *e.g.*, US 2004/0047858, US 7,132,255 and WO 99/052552. In other embodiments, the anti-CEACAM antibody binds to CEACAM-5 as

described in, *e.g.*, Zheng et al. *PLoS One*. 2010 Sep 2;5(9). pii: e12529 (DOI:10:1371/journal.pone.0021146), or crossreacts with CEACAM-1 and CEACAM-5 as described in, *e.g.*, WO 2013/054331 and US 2014/0271618.

[001018] Without wishing to be bound by theory, carcinoembryonic antigen cell adhesion molecules (CEACAM), such as CEACAM-1 and CEACAM-5, are believed to mediate, at least in part, inhibition of an anti-tumor immune response (*see e.g.*, Markel *et al. J Immunol*. 2002 Mar 15;168(6):2803-10; Markel et al. *J Immunol*. 2006 Nov 1;177(9):6062-71; Markel et al. *Immunology*. 2009 Feb;126(2):186-200; Markel et al. *Cancer Immunol Immunother*. 2010 Feb;59(2):215-30; Ortenberg et al. *Mol Cancer Ther*. 2012 Jun;11(6):1300-10; Stern et al. *J Immunol*. 2005 Jun 1;174(11):6692-701; Zheng et al. *PLoS One*. 2010 Sep 2;5(9). pii: e12529). For example, CEACAM-1 has been described as a heterophilic ligand for TIM-3 and as playing a role in TIM-3-mediated T cell tolerance and exhaustion (*see e.g.*, WO 2014/022332; Huang, *et al.* (2014) *Nature* doi:10.1038/nature13848). In embodiments, co-blockade of CEACAM-1 and TIM-3 has been shown to enhance an anti-tumor immune response in xenograft colorectal cancer models (*see e.g.*, WO 2014/022332; Huang, *et al.* (2014), *supra*). In other embodiments, co-blockade of CEACAM-1 and PD-1 reduce T cell tolerance as described, *e.g.*, in WO 2014/059251. Thus, CEACAM inhibitors can be used with the other immunomodulators described herein (*e.g.*, anti-PD-1 and/or anti-TIM-3 inhibitors) to enhance an immune response against a cancer, *e.g.*, a melanoma, a lung cancer (e.g., NSCLC), a bladder cancer, a colon cancer an ovarian cancer, and other cancers as described herein.

[001019] LAG3 (lymphocyte activation gene-3 or CD223) is a cell surface molecule expressed on activated T cells and B cells that has been shown to play a role in CD8+ T cell exhaustion. Antibodies, antibody fragments, and other inhibitors of LAG3 and its ligands are available in the art and may be used combination with a CD19 CAR described herein. For example, BMS-986016 (Bristol-Myers Squib) is a monoclonal antibody that targets LAG3. IMP701 (Immutep) is an antagonist LAG3 antibody and IMP731 (Immutep and GlaxoSmithKline) is a depleting LAG3 antibody. Other LAG3 inhibitors include IMP321 (Immutep), which is a recombinant fusion protein of a soluble portion of LAG3 and Ig that binds to MHC class II molecules and activates antigen presenting cells (APC). Other antibodies are disclosed, e.g., in WO2010/019570.

[001020] In some embodiments, the agent which enhances the activity of a CAR-expressing cell can be, e.g., a fusion protein comprising a first domain and a second domain, wherein the first domain is an inhibitory molecule, or fragment thereof, and the second domain is a polypeptide that is associated with a positive signal, e.g., a polypeptide comrpsing an antracellular signaling domain as described herein. In some embodiments, the polypeptide that is associated with a positive signal can include a costimulatory domain of CD28, CD27, ICOS, e.g., an intracellular signaling domain of CD28, CD27 and/or ICOS, and/or a primary signaling domain, e.g., of CD3 zeta, e.g., described herein. In one embodiment, the fusion protein is expressed by the same cell that expressed the CAR. In another embodiment, the fusion protein is expressed by a cell, e.g., a T cell that does not express an anti-CAR of the present invention.

[001021] In one embodiment, the agent which enhances activity of a CAR-expressing cell described herein is miR-17-92.

[001022] In one embodiment, the agent which enhances activity of a CAR-described herein is a cytokine. Cytokines have important functions related to T cell expansion, differentiation, survival, and homeostatis. Cytokines that can be administered to the subject receiving a CAR-expressing cell described herein include: IL-2, IL-4, IL-7, IL-9, IL-15, IL-18, and IL-21, or a combination thereof. In preferred embodiments, the cytokine administered is IL-7, IL-15, or IL-21, or a combination thereof. The cytokine can be administered once a day or more than once a day, e.g., twice a day, three times a day, or four times a day. The cytokine can be administered for more than one day, e.g. the cytokine is administered for 2 days, 3 days, 4 days, 5 days, 6 days, 1 week, 2 weeks, 3 weeks, or 4 weeks. For example, the cytokine is administered once a day for 7 days.

[001023] In embodiments, the cytokine is administered in combination with CAR-expressing cells. The cytokine can be administered simultaneously or concurrently with the CAR-expressing cells, e.g., administered on the same day. The cytokine may be prepared in the same pharmaceutical composition as the CAR-expressing cells, or may be prepared in a separate pharmaceutical composition. Alternatively, the cytokine can be administered shortly after administration of the CAR-expressing cells, e.g., 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, or 7 days after administration of the CAR-expressing cells. In embodiments where the cytokine is administered in a dosing regimen that occurs over more than one day, the first day of the

cytokine dosing regimen can be on the same day as administration with the CAR-expressing cells, or the first day of the cytokine dosing regimen can be 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, or 7 days after administration of the CAR-expressing cells. In one embodiment, on the first day, the CAR-expressing cells are administered to the subject, and on the second day, a cytokine is administered once a day for the next 7 days. In a preferred embodiment, the cytokine to be administered in combination with the CAR-expressing cells is IL-7, IL-15, or IL-21, or a combination thereof.

[001024] In other embodiments, the cytokine is administered a sufficient period of time after administration of the CAR-expressing cells, e.g., at least 2 weeks, 3 weeks, 4 weeks, 6 weeks, 8 weeks, 10 weeks, 12 weeks, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 11 months, or 1 year or more after administration of CAR-expressing cells. In one embodiment, the cytokine is administered after assessment of the subject's response to the CAR-expressing cells. For example, the subject is administered CAR-expressing cells according to the dosage and regimens described herein. The response of the subject to CART therapy is assessed at 2 weeks, 3 weeks, 4 weeks, 6 weeks, 8 weeks, 10 weeks, 12 weeks, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 11 months, or 1 year or more after administration of CAR-expressing cells, using any of the methods described herein, including inhibition of tumor growth, reduction of circulating tumor cells, or tumor regression. Subjects that do not exhibit a sufficient response to CART therapy can be administered a cytokine. Administration of the cytokine to the subject that has sub-optimal response to the CART therapy improves CART efficacy or anti-tumor activity. In a preferred embodiment, the cytokine administered after administration of CAR-expressing cells is IL-7.

[001025] In some embodiments, an mTOR inhibitor, e.g., an mTOR inhibitor described herein, is administered at low, immune enhancing, dose together with an immune effector cell, e.g., a T cell or a NK cell, having a CAR, to a subject who has cancer, e.g., a cancer described herein. The subject may receive treatment with an additional therapeutic agent, such as an approved drug for that type of cancer, in combination with the mTOR inhibitor. For example, Table 2 below provides a list of various cancers and their approved treatments.

Table 2. Cancers and Approved Treatment(s)

| **Cancer** | **Treatment(s)** |
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| Acute Lymphoblastic Leukemia | Abitrexate (Methotrexate); Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Arranon (Nelarabine); Asparaginase Erwinia chrysanthemi; Cerubidine (Daunorubicin Hydrochloride); Clafen (Cyclophosphamide); Clofarabine; Clofarex (Clofarabine); Clolar (Clofarabine); Cyclophosphamide; Cytarabine; Cytosar-U (Cytarabine); Cytoxan (Cyclophosphamide); Dasatinib; Daunorubicin Hydrochloride; Doxorubicin Hydrochloride; Erwinaze (Asparaginase Erwinia Chrysanthemi); Folex (Methotrexate); Folex PFS (Methotrexate); Gleevec (Imatinib Mesylate); Iclusig (Ponatinib Hydrochloride); Imatinib Mesylate; Marqibo (Vincristine Sulfate Liposome); Mercaptopurine;<br>Methotrexate; Methotrexate LPF (Methorexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Nelarabine; Neosar (Cyclophosphamide); Oncaspar (Pegaspargase); Pegaspargase; Purinethol (Mercaptopurine); Purixan (Mercaptopurine); Rubidomycin (Daunorubicin Hydrochloride); Sprycel (Dasatinib); Tarabine PFS (Cytarabine); Vincasar PFS (Vincristine Sulfate); Vincristine Sulfate; or Vincristine Sulfate Liposome.<br><br>DRUG COMBINATIONS<br>hyper-CVAD: Cyclophosphamide; Vincristine Sulfate; Doxorubicin Hydrochloride (Adriamycin); Dexamethasone. |
| Acute Myeloid Leukemia | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Arsenic Trioxide; Cerubidine (Daunorubicin Hydrochloride); Clafen (Cyclophosphamide); Cyclophosphamide; Cytarabine; Cytosar-U (Cytarabine); Cytoxan (Cyclophosphamide); Daunorubicin Hydrochloride; Doxorubicin Hydrochloride; Neosar (Cyclophosphamide); Rubidomycin (Daunorubicin Hydrochloride); Tarabine PFS (Cytarabine); Trisenox (Arsenic Trioxide); Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate.<br><br>DRUG COMBINATIONS<br>ADE: Cytarabine; Daunorubicin Hydrochloride; and Etoposide. |
| AIDS-Related Kaposi Sarcoma | Dox-SL (Doxorubicin Hydrochloride Liposome); Doxil (Doxorubicin Hydrochloride Liposome); Doxorubicin Hydrochloride Liposome; Evacet (Doxorubicin Hydrochloride Liposome); Intron A (Recombinant Interferon Alfa-2b); LipoDox (Doxorubicin Hydrochloride Liposome); Paclitaxel; Recombinant Interferon Alfa-2b; Taxol (Paclitaxel); Velban (Vinblastine Sulfate); Velsar (Vinblastine Sulfate); or Vinblastine Sulfate. |
| Basal Cell Carcinoma | Adrucil (Fluorouracil); Aldara (Imiquimod); Efudex (Fluorouracil); Erivedge (Vismodegib); Fluoroplex (Fluorouracil); Fluorouracil; Imiquimod; or Vismodegib. |
| Bladder Cancer | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF |

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| | (Doxorubicin Hydrochloride); Cisplatin; Doxorubicin Hydrochloride; Platinol (Cisplatin); or Platinol-AQ (Cisplatin). |
| Bone Cancer | Abitrexate (Methotrexate); Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Doxorubicin Hydrochloride; Folex (Methotrexate); Folex PFS (Methotrexate); Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); or Mexate-AQ (Methotrexate). |
| Brain Tumor | Afinitor (Everolimus); Afinitor Disperz (Everolimus); Avastin (Bevacizumab); Bevacizumab; CeeNu (Lomustine); Everolimus; Lomustine; Methazolastone (Temozolomide); Temodar (Temozolomide); or Temozolomide. |
| Breast Cancer | Abitrexate (Methotrexate); Abraxane (Paclitaxel Albumin-stabilized Nanoparticle Formulation); Ado-Trastuzumab Emtansine; Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Adrucil (Fluorouracil); Afinitor (Everolimus); Anastrozole; Aredia (Pamidronate Disodium); Arimidex (Anastrozole); Aromasin (Exemestane); Capecitabine; Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Docetaxel; Doxorubicin Hydrochloride; Efudex (Fluorouracil); Ellence (Epirubicin Hydrochloride); Epirubicin Hydrochloride; Everolimus; Exemestane; Fareston (Toremifene); Faslodex (Fulvestrant); Femara (Letrozole); Fluoroplex (Fluorouracil); Fluorouracil; Folex (Methotrexate); Folex PFS (Methotrexate); Fulvestrant; Gemcitabine Hydrochloride; Gemzar (Gemcitabine Hydrochloride); Goserelin Acetate; Herceptin (Trastuzumab); Ixabepilone; Ixempra (Ixabepilone); Kadcyla (Ado-Trastuzumab Emtansine); Lapatinib Ditosylate; Letrozole; Megace (Megestrol Acetate); Megestrol Acetate; Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Neosar (Cyclophosphamide); Nolvadex (Tamoxifen Citrate); Novaldex (Tamoxifen Citrate); Paclitaxel; Paclitaxel Albumin-stabilized Nanoparticle Formulation; Pamidronate Disodium; Perjeta (Pertuzumab); Pertuzumab; Tamoxifen Citrate; Taxol (Paclitaxel); Taxotere (Docetaxel); Trastuzumab; Toremifene; Tykerb (Lapatinib Ditosylate); Xeloda (Capecitabine); or Zoladex (Goserelin Acetate).<br><br>DRUG COMBINATIONS<br>AC: Doxorubicin Hydrochloride (Adriamycin) and Cyclophosphamide.<br>AC-T: Doxorubicin Hydrochloride (Adriamycin); Cyclophosphamide; and Paclitaxel (Taxol).<br>CAF: Cyclophosphamide; Doxorubicin Hydrochloride (Adriamycin); and Fluorouracil.<br>CMF: Cyclophosphamide; Methotrexate; and Fluorouracil.<br>FEC: Fluorouracil; Epirubicin Hydrochloride; and |

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|---|---|
| | Cyclophosphamide.<br>TAC: Docetaxel (Taxotere); Doxorubicin Hydrochloride (Adriamycin); and Cyclophosphamide. |
| Cervical Cancer | Blenoxane (Bleomycin); Bleomycin; Cisplatin; Hycamtin (Topotecan Hydrochloride); Platinol (Cisplatin); Platinol-AQ (Cisplatin); or Topotecan Hydrochloride.<br><br>DRUG COMBINATIONS<br>Gemcitabine-Cisplatin: Gemcitabine Hydrochloride and Cisplatin. |
| Chronic Lymphocytic Leukemia | Alemtuzumab; Ambochlorin (Chlorambucil); Amboclorin (Chlorambucil); Arzerra (Ofatumumab); Bendamustine Hydrochloride; Campath (Alemtuzumab); Chlorambucil; Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Fludara (Fludarabine Phosphate); Fludarabine Phosphate; Gazyva (Obinutuzumab); Ibrutinib; Imbruvica (Ibrutinib); Leukeran (Chlorambucil); Linfolizin (Chlorambucil); Neosar (Cyclophosphamide); Obinutuzumab; Ofatumumab; or Treanda (Bendamustine Hydrochloride).<br><br>DRUG COMBINATIONS<br>CHLORAMBUCIL-PREDNISONE: Chlorambucil and Prednisone.<br>CVP: Cyclophosphamide; Vincristine Sulfate; and Prednisone. |
| Chronic Myelogenous Leukemia | Bosulif (Bosutinib); Bosutinib; Busulfan; Busulfex (Busulfan); Clafen; Cyclophosphamide); Cyclophosphamide; Cytarabine; Cytosar-U (Cytarabine); Cytoxan (Cyclophosphamide); Dasatinib; Gleevec (Imatinib Mesylate); Iclusig (Ponatinib Hydrochloride); Imatinib Mesylate; Myleran (Busulfan); Neosar (Cyclophosphamide); Nilotinib; Omacetaxine Mepesuccinate; Ponatinib Hydrochloride; Sprycel (Dasatinib); Synribo (Omacetaxine Mepesuccinate); Tarabine PFS (Cytarabine); or Tasigna (Nilotinib). |
| Colon Cancer | Adrucil (Fluorouracil); Avastin (Bevacizumab); Bevacizumab; Camptosar (Irinotecan Hydrochloride); Capecitabine; Cetuximab; Efudex (Fluorouracil); Eloxatin (Oxaliplatin); Erbitux (Cetuximab); Fluoroplex (Fluorouracil); Fluorouracil; Irinotecan Hydrochloride; Leucovorin Calcium; Oxaliplatin; Panitumumab; Regorafenib; Stivarga (Regorafenib); Vectibix (Panitumumab); Wellcovorin (Leucovorin Calcium); Xeloda (Capecitabine); Zaltrap (Ziv-Aflibercept); or Ziv-Aflibercept.<br><br>DRUG COMBINATIONS<br>CAPOX: Capecitabine and Oxaliplatin.<br>FOLFIRI: Leucovorin Calcium (Folinic Acid); Fluorouracil; and Irinotecan Hydrochloride.<br>FOLFIRI-BEVACIZUMAB: Leucovorin Calcium (Folinic Acid); Fluorouracil; Irinotecan Hydrochloride; and Bevacizumab.<br>FOLFIRI-CETUXIMAB: Leucovorin Calcium (Folinic Acid); |

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| | Fluorouracil; Irinotecan Hydrochloride; and Cetuximab.<br>FOLFOX: Leucovorin Calcium (Folinic Acid); Fluorouracil; and Oxaliplatin.<br>XELOX: Capecitabine (Xeloda) and Oxaliplatin. |
| Endometrial Cancer | Megace (Megestrol Acetate) or Megestrol Acetate. |
| Gastric (Stomach) Cancer | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Adrucil (Fluorouracil); Cyramza (Ramucirumab); Docetaxel; Doxorubicin Hydrochloride; Efudex (Fluorouracil); Fluoroplex (Fluorouracil); Fluorouracil; Herceptin (Trastuzumab); Mitomycin C; Mitozytrex (Mitomycin C); Mutamycin (Mitomycin C); Ramucirumab; Taxotere (Docetaxel); or Trastuzumab. |
| Gastrointestinal stromal tumors | Gleevec (Imatinib Mesylate); Imatinib Mesylate; Regorafenib; Stivarga (Regorafenib); Sunitinib Malate; Sutent (Sunitinib Malate) |
| Head and neck cancer | Abitrexate (Methotrexate); Adrucil (Fluorouracil); Blenoxane (Bleomycin); Bleomycin; Cetuximab; Cisplatin; Docetaxel; Efudex (Fluorouracil); Erbitux (Cetuximab); Fluoroplex (Fluorouracil); Fluorouracil; Folex (Methotrexate); Folex PFS (Methotrexate); Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Platinol (Cisplatin); Platinol-AQ (Cisplatin); or Taxotere (Docetaxel). |
| Hodkin Lymphoma | Adcetris (Brentuximab Vedotin); Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Ambochlorin (Chlorambucil); Amboclorin (Chlorambucil); Blenoxane (Bleomycin); Bleomycin; Brentuximab Vedotin; Chlorambucil; Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Dacarbazine; Doxorubicin Hydrochloride; DTIC-Dome (Dacarbazine); Leukeran (Chlorambucil); Linfolizin (Chlorambucil); Lomustine; Matulane (Procarbazine Hydrochloride); Neosar (Cyclophosphamide); Procarbazine Hydrochloride; Velban (Vinblastine Sulfate); Velsar (Vinblastine Sulfate); Vinblastine Sulfate; Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate.<br><br>DRUG COMBINATIONS:<br>ABVD: Doxorubicin Hydrochloride (Adriamycin); Bleomycin; Vinblastine Sulfate; and Dacarbazine.<br>ABVE: Doxorubicin Hydrochloride (Adriamycin); Bleomycin; Vinblastine Sulfate; and Etoposide.<br>ABVE-PC: Doxorubicin Hydrochloride (Adriamycin); Bleomycin; Vinblastine Sulfate; Etoposide; Prednisone; and Cyclophosphamide.<br>BEACOPP: Bleomycin; Etoposide; Doxorubicin Hydrochloride (Adriamycin); Cyclophosphamide; Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; and Prednisone.<br>COPP: Cyclophosphamide; Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; and Prednisone. |

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| | COPP-ABV: Cyclophosphamide; Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; Prednisone; Doxorubicin Hydrochloride (Adriamycin); Bleomycin; and Vinblastine Sulfate.<br>ICE: Ifosfamide; Carboplatin; and Etoposide.<br>MOPP: Mechlorethamine Hydrochloride; Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; and Prednisone.<br>OEPA: Vincristine Sulfate (Oncovin); Etoposide; Prednisone; and Doxorubicin Hydrochloride (Adriamycin).<br>OPPA: Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; Prednisone; and Doxorubicin Hydrochloride (Adriamycin).<br>STANFORD V: Mechlorethamine Hydrochloride; Doxorubicin Hydrochloride; Vinblastine Sulfate; Vincristine Sulfate; Bleomycin; Etoposide; and Prednisone.<br>VAMP: Vincristine Sulfate; Doxorubicin Hydrochloride (Adriamycin); and Methotrexate; and Prednisone. |
| Kidney (Renal Cell) Cancer | Afinitor (Everolimus); Aldesleukin; Avastin (Bevacizumab); Axitinib; Bevacizumab; Everolimus; Inlyta (Axitinib); Nexavar (Sorafenib Tosylate); Pazopanib Hydrochloride; Proleukin (Aldesleukin); Sorafenib Tosylate; Sunitinib Malate; Sutent (Sunitinib Malate); Temsirolimus; Torisel (Temsirolimus); or Votrient (Pazopanib Hydrochloride). |
| Liver Cancer | Nexavar (Sorafenib Tosylate) or Sorafenib Tosylate. |
| Melanoma | Aldesleukin; Dabrafenib; Dacarbazine; DTIC-Dome (Dacarbazine); Intron A (Recombinant Interferon Alfa-2b); Ipilimumab; Mekinist (Trametinib); Peginterferon Alfa-2b; PEG-Intron (Peginterferon Alfa-2b); Proleukin (Aldesleukin); Recombinant Interferon Alfa-2b; Sylatron (Peginterferon Alfa-2b); Tafinlar (Dabrafenib); Trametinib; Vemurafenib; Yervoy (Ipilimumab); or Zelboraf (Vemurafenib). |
| Malignant Mesothelioma | Alimta (Pemetrexed Disodium); Cisplatin; Pemetrexed Disodium; Platinol (Cisplatin); or Platinol-AQ (Cisplatin). |
| Multiple myeloma | Aredia (Pamidronate Disodium); Bortezomib; Carfilzomib; Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Doxil (Doxorubicin Hydrochloride Liposome); Doxorubicin Hydrochloride Liposome; Dox-SL (Doxorubicin Hydrochloride Liposome); Evacet (Doxorubicin Hydrochloride Liposome); Kyprolis (Carfilzomib); Lenalidomide; LipoDox (Doxorubicin Hydrochloride Liposome); Mozobil (Plerixafor); Neosar (Cyclophosphamide); Pamidronate Disodium; Plerixafor; Pomalidomide (Pomalyst); Pomalyst; Revlimid (Lenalidomide); Synovir (Thalidomide); Thalidomide; Thalomid (Thalidomide); Velcade (Bortezomib); Zoledronic Acid; Zometa (Zoledronic Acid) |
| Myeloproliferative Disorders | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Arsenic Trioxide; Azacitidine; Cerubidine (Daunorubicin Hydrochloride); Clafen (Cyclophosphamide); Cyclophosphamide; Cytarabine; Cytosar-U (Cytarabine); Cytarabine; Cytoxan (Cyclophosphamide); Dacogen |

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| | (Decitabine); Dasatinib; Daunorubicin Hydrochloride; Decitabine; Doxorubicin Hydrochloride; Gleevec (Imatinib Mesylate); Imatinib Mesylate; Jakafi (Ruxolitinib Phosphate); Lenalidomide; Mylosar (Azacitidine); Neosar (Cyclophosphamide); Nilotinib; Revlimid (Lenalidomide); Rubidomycin (Daunorubicin Hydrochloride); Ruxolitinib Phosphate; Sprycel (Dasatinib); Tarabine PFS (Cytarabine); Tasigna (Nilotinib); Trisenox (Arsenic Trioxide); Vidaza (Azacitidine); Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate.<br><br>DRUG COMBINATIONS<br>ADE: Cytarabine; Daunorubicin Hydrochloride; and Etoposide. |
| Neuroblastoma | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Doxorubicin Hydrochloride; Neosar (Cyclophosphamide); Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate. |
| Non-Hodkin Lymphoma | Abitrexate (Methotrexate); Adcetris (Brentuximab Vedotin); Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Ambochlorin (Chlorambucil); Amboclorin (Chlorambucil); Arranon (Nelarabine); Bendamustine Hydrochloride; Bexxar (Tositumomab and Iodine I 131 Tositumomab); Blenoxane (Bleomycin); Bleomycin; Bortezomib; Brentuximab Vedotin; Chlorambucil; Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); Denileukin Diftitox; DepoCyt (Liposomal Cytarabine); Doxorubicin Hydrochloride; DTIC-Dome (Dacarbazine); Folex (Methotrexate); Folex PFS (Methotrexate); Folotyn (Pralatrexate); Ibritumomab Tiuxetan; Ibrutinib; Imbruvica (Ibrutinib); Intron A (Recombinant Interferon Alfa-2b); Istodax (Romidepsin); Lenalidomide; Leukeran (Chlorambucil); Linfolizin (Chlorambucil); Liposomal Cytarabine; Matulane (Procarbazine Hydrochloride); Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Mozobil (Plerixafor); Nelarabine; Neosar (Cyclophosphamide); Ontak (Denileukin Diftitox); Plerixafor; Pralatrexate; Recombinant Interferon Alfa-2b; Revlimid (Lenalidomide); Rituxan (Rituximab); Rituximab; Romidepsin; Tositumomab and Iodine I 131 Tositumomab; Treanda (Bendamustine Hydrochloride); Velban (Vinblastine Sulfate); Velcade (Bortezomib); Velsar (Vinblastine Sulfate); Vinblastine Sulfate; Vincasar PFS (Vincristine Sulfate); Vincristine Sulfate; Vorinostat; Zevalin (Ibritumomab Tiuxetan); or Zolinza (Vorinostat).<br><br>DRUG COMBINATIONS<br>CHOP: Cyclophosphamide; Doxorubicin Hydrochloride |

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| | (Hydroxydaunomycin); Vincristine Sulfate (Oncovin); and Prednisone.<br>COPP: Cyclophosphamide; Vincristine Sulfate (Oncovin); Procarbazine Hydrochloride; and Prednisone.<br>CVP: Cyclophosphamide; Vincristine Sulfate; and Prednisone.<br>EPOCH: Etoposide; Prednisone; Vincristine Sulfate (Oncovin); Cyclophosphamide; and Doxorubicin Hydrochloride (Hydroxydaunomycin).<br>Hyper-CVAD: Cyclophosphamide; Vincristine Sulfate; Doxorubicin Hydrochloride (Adriamycin); and Dexamethasone.<br>ICE: Ifosfamide; Carboplatin; and Etoposide.<br>R-CHOP: Rituximab; Cyclophosphamide; Doxorubicin Hydrochloride (Hydroxydaunomycin) ; Vincristine Sulfate (Oncovin); and Prednisone. |
| Non-Small Cell Lung Cancer | Abitrexate (Methotrexate); Abraxane (Paclitaxel Albumin-stabilized Nanoparticle Formulation); Afatinib Dimaleate; Alimta (Pemetrexed Disodium); Avastin (Bevacizumab); Bevacizumab; Carboplatin; Ceritinib; Cisplatin; Crizotinib; Docetaxel; Erlotinib Hydrochloride; Folex (Methotrexate); Folex PFS (Methotrexate); Gefitinib; Gilotrif (Afatinib Dimaleate); Gemcitabine Hydrochloride; Gemzar (Gemcitabine Hydrochloride); Iressa (Gefitinib); Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Paclitaxel; Paclitaxel Albumin-stabilized Nanoparticle Formulation; Paraplat (Carboplatin); Paraplatin (Carboplatin); Pemetrexed Disodium; Platinol (Cisplatin); Platinol-AQ (Cisplatin); Tarceva (Erlotinib Hydrochloride); Taxol (Paclitaxel); Taxotere (Docetaxel); Xalkori (Crizotinib); or Zykadia (Ceritinib).<br><br>DRUG COMBINATIONS<br>CARBOPLATIN-TAXOL; Carboplatin and Paclitaxel (Taxol).<br>Gemcitabine-Cisplatin: Gemcitabine Hydrochloride and Cisplatin. |
| Ovarian Cancer | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Carboplatin; Clafen (Cyclophosphamide);<br>Cisplatin; Cyclophosphamide; Cytoxan (Cyclophosphamide); Doxorubicin Hydrochloride; Dox-SL (Doxorubicin Hydrochloride Liposome); DOXIL (Doxorubicin Hydrochloride Liposome); Doxorubicin Hydrochloride Liposome; Evacet (Doxorubicin Hydrochloride Liposome); Gemcitabine Hydrochloride; Gemzar (Gemcitabine Hydrochloride); Hycamtin (Topotecan Hydrochloride); LipoDox (Doxorubicin Hydrochloride Liposome); Neosar (Cyclophosphamide); Paclitaxel; Paraplat (Carboplatin); Paraplatin (Carboplatin); Platinol (Cisplatin); Platinol-AQ (Cisplatin); Taxol (Paclitaxel); or Topotecan Hydrochloride. |

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| | DRUG COMBINATIONS<br>BEP: Bleomycin; Etoposide; and Cisplatin (Platinol).<br>CARBOPLATIN-TAXOL: Carboplatin and Paclitaxel (Taxol).<br>Gemcitabine-Cisplatin: Gemcitabine Hydrochloride and Cisplatin. |
| Pancreatic cancer | Adrucil (Fluorouracil); Afinitor (Everolimus); Efudex (Fluorouracil); Erlotinib Hydrochloride; Everolimus; Fluoroplex (Fluorouracil); Fluorouracil; Gemcitabine Hydrochloride; Gemzar (Gemcitabine Hydrochloride); Mitomycin C; Mitozytrex (Mitomycin C); Mutamycin (Mitomycin C); Sunitinib Malate; Sutent (Sunitinib Malate); or Tarceva (Erlotinib Hydrochloride).<br><br>DRUG COMBINATIONS<br>GEMCITABINE-OXALIPLATIN: Gemcitabine Hydrochloride and Oxaliplatin. |
| Penile cancer | Blenoxane (Bleomycin); Bleomycin |
| Rectal Cancer | Adrucil (Fluorouracil); Avastin (Bevacizumab); Bevacizumab; Camptosar (Irinotecan Hydrochloride); Cetuximab; Efudex (Fluorouracil); Erbitux (Cetuximab); Fluoroplex (Fluorouracil); Fluorouracil; Irinotecan Hydrochloride; Panitumumab; Regorafenib; Stivarga (Regorafenib); Vectibix (Panitumumab); Zaltrap (Ziv-Aflibercept); or Ziv-Aflibercept.<br><br>DRUG COMBINATIONS<br>CAPOX: Capecitabine and Oxaliplatin.<br>FOLFIRI: Leucovorin Calcium (Folinic Acid); FluorouracilL; Irinotecan Hydrochloride.<br>FOLFIRI-BEVACIZUMAB: Leucovorin Calcium (Folinic Acid); Fluorouracil; Irinotecan Hydrochloride; and Bevacizumab.<br>FOLFIRI-CETUXIMAB: Leucovorin Calcium (Folinic Acid); Fluorouracil; Irinotecan Hydrochloride; and Cetuximab.<br>FOLFOX: Leucovorin Calcium (Folinic Acid); Fluorouracil; and Oxaliplatin.<br>XELOX: Capecitabine (Xeloda) and Oxaliplatin. |
| Renal Cell Carcinoma | Afinitor (Everolimus); Aldesleukin; Avastin (Bevacizumab); Axitinib; Bevacizumab; Everolimus; Inlyta (Axitinib); Nexavar (Sorafenib Tosylate); Pazopanib hydrochloride; Proleukin (Aldesleukin); Sorafenib Tosylate; Temsirolimus; Torisel (Temsirolimus); Votrient (Pazopanib Hydrochloride) |
| Retinoblastoma | Clafen (Cyclophosphamide); Cyclophosphamide; Cytoxan (Cyclophosphamide); or Neosar (Cyclophosphamide). |
| Rhabdomyosarcoma | Cosmegen (Dactinomycin); Dactinomycin; Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate. |
| Skin cancer (basal cell carcinoma) | Adrucil (Fluorouracil); Aldara (Imiquimod); Efudex (Fluorouracil); Erivedge (Vismodegib); Fluoroplex (Fluorouracil); Fluorouracil; Imiquimod; or Vismodegib. |
| Skin cancer (melanoma) | Aldesleukin; Dacarbazine; DTIC-Dome (Dacarbazine); Ipilimumab; |

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| | Proleukin (Aldesleukin); Vemurafenib; Yervoy (Ipilimumab); or Zelboraf (Vemurafenib). |
| Small cell lung cancer | Abitrexate (Methotrexate); Etopophos (Etoposide Phosphate); Etoposide; Etoposide Phosphate; Folex (Methotrexate); Folex PFS (Methotrexate); Hycamtin (Topotecan Hydrochloride); Methotrexate; Methotrexate LPF (Methotrexate); Mexate (Methotrexate); Mexate-AQ (Methotrexate); Toposar (Etoposide); Topotecan Hydrochloride; or VePesid (Etoposide). |
| Soft tissue sarcoma | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Cosmegen (Dactinomycin); Dactinomycin; orDoxorubicin Hydrochloride. |
| Testicular cancer | Blenoxane (Bleomycin); Bleomycin; Cisplatin; Cosmegen (Dactinomycin); Cyfos (Ifosfamide); Dactinomycin; Etopophos (Etoposide Phosphate); Etoposide; Etoposide Phosphate; Ifex (Ifosfamide); Ifosfamide; Ifosfamidum (Ifosfamide); Platinol (Cisplatin); Platinol-AQ (Cisplatin); Toposar (Etoposide; ; Velban (Vinblastine Sulfate); Velsar (Vinblastine Sulfate); or VePesid (Etoposide); Vinblastine Sulfate. |
| Thyroid cancer | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Cabozantinib-S-Malate; Caprelsa (Vandetanib); Cometriq (Cabozantinib-S-Malate); Doxorubicin Hydrochloride; Nexavar (Sorafenib Tosylate); or Sorafenib Tosylate; Vandetanib. |
| Vaginal cancer | Gardasil (Recombinant HPV Quadrivalent Vaccine); or Recombinant Human Papillomavirus (HPV) Quadrivalent Vaccine. |
| Vulvar cancer | Blenoxane (Bleomycin); Bleomycin ; Gardasil (Recombinant HPV Quadrivalent Vaccine); or Recombinant Human Papillomavirus (HPV) Quadrivalent Vaccine. |
| Wilms Tumor or other childhood kidney cancers | Adriamycin PFS (Doxorubicin Hydrochloride); Adriamycin RDF (Doxorubicin Hydrochloride); Cosmegen (Dactinomycin); Dactinomycin; Doxorubicin Hydrochloride; Vincasar PFS (Vincristine Sulfate); or Vincristine Sulfate. |

[001026] In one embodiment, an mTOR inhibitor described herein is administered at a low, immune enhancing, dose to a subject in combination with a protein tyrosine phosphatase inhibitor, e.g., a protein tyrosine phosphatase inhibitor described herein. In one embodiment, the protein tyrosine phosphatase inhibitor is an SHP-1 inhibitor, e.g., an SHP-1 inhibitor described herein, such as, e.g., sodium stibogluconate. In one embodiment, the protein tyrosine phosphatase inhibitor is an SHP-2 inhibitor, e.g., an SHP-2 inhibitor described herein.

## Pharmaceutical Compositions: mTOR Inhibitors

[001027] In one aspect, the present invention relates to pharmaceutical compositions comprising an mTOR inhibitor, e.g., an mTOR inhibitor as described herein, formulated for use in combination with CAR cells described herien.

[001028] In some embodiments, the mTOR inhibitor is formulated for administration in combination with another agent, in addition to a CAR cell, e.g., as described herein.

[001029] In general, compounds of the invention will be administered in therapeutically effective amounts as described above via any of the usual and acceptable modes known in the art, either singly or in combination with one or more therapeutic agents.

[001030] The pharmaceutical formulations may be prepared using conventional dissolution and mixing procedures. For example, the bulk drug substance (e.g., an mTOR inhibitor or stabilized form of the compound (e.g., complex with a cyclodextrin derivative or other known complexation agent) is dissolved in a suitable solvent in the presence of one or more of the excipients described herein. The mTOR inhibitor is typically formulated into pharmaceutical dosage forms to provide an easily controllable dosage of the drug and to give the patient an elegant and easily handleable product.

[001031] Compounds of the invention can be administered as pharmaceutical compositions by any conventional route, in particular enterally, e.g., orally, e.g., in the form of tablets or capsules, or parenterally, e.g., in the form of injectable solutions or suspensions, topically, e.g., in the form of lotions, gels, ointments or creams, or in a nasal or suppository form. Where an mTOR inhibitor is administered in combination with (either simultaneously with or separately from) another agent as described herein, in one aspect, both components can be administered by the same route (e.g., parenterally). Alternatively, another agent may be administered by a different route relative to the mTOR inhibitor. For example, an mTOR inhibitor may be administered orally and the other agent may be administered parenterally. Pharmaceutical compositions comprising an mTOR inhibitor in free form or in a pharmaceutically acceptable salt form in association with at least one pharmaceutically acceptable carrier or diluent can be manufactured in a conventional manner by mixing, granulating or coating methods. For example, oral compositions can be tablets or gelatin capsules comprising the active ingredient together with a) diluents, e.g., lactose, dextrose, sucrose, mannitol, sorbitol, cellulose and/or glycine; b) lubricants, e.g., silica, talcum, stearic acid, its magnesium or calcium salt and/or polyethyleneglycol; for tablets also c) binders, e.g., magnesium aluminum silicate, starch paste,

gelatin, tragacanth, methylcellulose, sodium carboxymethylcellulose and or polyvinylpyrrolidone; if desired d) disintegrants, e.g., starches, agar, alginic acid or its sodium salt, or effervescent mixtures; and/or e) absorbents, colorants, flavors and sweeteners. Oral formulations can also comprise the active ingredient along with 20-60% Eudragit EPO, Hydroxypropyl cellulose EF, Hydroxypropyl methylcellulose, or Kollidon VA64, and up to 5% of pluronic F68, Cremophor EL, or Gelucire 44/14. Injectable compositions can be aqueous isotonic solutions or suspensions, and suppositories can be prepared from fatty emulsions or suspensions. The compositions may be sterilized and/or contain adjuvants, such as preserving, stabilizing, wetting or emulsifying agents, solution promoters, salts for regulating the osmotic pressure and/or buffers. In addition, they may also contain other therapeutically valuable substances. Suitable formulations for transdermal applications include an effective amount of a compound of the present invention with a carrier. A carrier can include absorbable pharmacologically acceptable solvents to assist passage through the skin of the host. For example, transdermal devices are in the form of a bandage comprising a backing member, a reservoir containing the compound optionally with carriers, optionally a rate controlling barrier to deliver the compound to the skin of the host at a controlled and predetermined rate over a prolonged period of time, and means to secure the device to the skin. Matrix transdermal formulations may also be used. In a further aspect, the mTOR inhibitors described herein may be administered via a microneedle patch. Microneedle based drug delivery is well known in the art (See, e.g., U.S. Pat. 8,162,901) and these technologies and methods may be adapted by one of skill in the art for administration of an mTOR inhibitor as described herein. Suitable formulations for topical application, e.g., to the skin and eyes, are preferably aqueous solutions, ointments, creams or gels well-known in the art. Such formulations may contain solubilizers, stabilizers, tonicity enhancing agents, buffers and preservatives.

[001032] The pharmaceutical composition (or formulation) for application may be packaged in a variety of ways depending upon the method used for administering the drug. Generally, an article for distribution includes a container having deposited therein the pharmaceutical formulation in an appropriate form. Suitable containers are well-known to those skilled in the art and include materials such as bottles (plastic and glass), sachets, ampoules, plastic bags, metal cylinders, and the like. The container may also include a tamper-proof assemblage to prevent indiscreet access to the contents of the package. In addition, the container has deposited thereon

a label that describes the contents of the container. The label may also include appropriate warnings. The invention also provides for a pharmaceutical combinations, e.g. a kit, comprising a) a first agent which is an mTOR inhibitor as disclosed herein, in free form or in pharmaceutically acceptable salt form, and b) at least one additional agent. The kit can comprise instructions for its administration.

[001033] The term "pharmaceutical combination" as used herein means a product that results from the mixing or combining of more than one active ingredient and includes both fixed and non-fixed combinations of the active ingredients. The term "fixed combination" means that the active ingredients, e.g. an mTOR inhibitor and other agent, are both administered to a patient simultaneously in the form of a single entity or dosage. The term "non-fixed combination" means that the active ingredients, e.g. an mTOR inhibitor and other agent, are both administered to a patient as separate entities either simultaneously, concurrently or sequentially with no specific time limits, wherein such administration provides therapeutically effective levels of the 2 compounds in the body of the patient. The latter also applies to cocktail therapy, e.g. the administration of 3 or more active ingredients.

**SUSTAINED RELEASE**

[001034] mTOR inhibitors, e.g., allosteric mTOR inhibitors or catalytic mTOR inhibitors, disclosed herein can be provided as pharmaceutical formulations in form of oral solid dosage forms comprising an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, which satisfy product stability requirements and/or have favorable pharmacokinetic properties over the immediate release (IR) tablets, such as reduced average plasma peak concentrations, reduced inter- and intra-patient variability in the extent of drug absorption and in the plasma peak concentration, reduced $C_{max}$ / $C_{min}$ ratio and/or reduced food effects. Provided pharmaceutical formulations may allow for more precise dose adjustment and/or reduce frequency of adverse events thus providing safer treatments for patients with an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001.

[001035] In some embodiments, the present disclosure provides stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, which are multi-particulate systems and may have functional layers and coatings.

[001036] The term “extended release, multi-particulate formulation” as used herein refers to a formulation which enables release of an mTOR inhibitor disclosed herein, e.g., rapamycin or

RAD001, over an extended period of time e.g. over at least 1, 2, 3, 4, 5 or 6 hours. The extended release formulation may contain matrices and coatings made of special excipients, e.g., as described herein, which are formulated in a manner as to make the active ingredient available over an extended period of time following ingestion.

[001037] The term "extended release" can be interchangeably used with the terms "sustained release" (SR) or "prolonged release". The term "extended release" relates to a pharmaceutical formulation that does not release active drug substance immediately after oral dosing but over an extended in accordance with the definition in the pharmacopoeias Ph. Eur. ($7^{th}$ edition) mongraph for tablets and capsules and USP general chapter <1151> for pharmaceutical dosage forms. The term "Immediate Release" (IR) as used herein refers to a pharmaceutical formulation which releases 85% of the active drug substance within less than 60 minutes in accordance with the definition of "Guidance for Industry: "Dissolution Testing of Immediate Release Solid Oral Dosage Forms" (FDA CDER, 1997). In some embodiments, the term "immediate release" means release of everolismus from tablets within the time of 30 minutes, e.g., as measured in the dissolution assay described herein.

[001038] Stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, can be characterized by an in-vitro release profile using assays known in the art, such as a dissolution assay as described herein: a dissolution vessel filled with 900 mL phosphate buffer pH 6.8 containing sodium dodecyl sulfate 0.2% at 37°C and the dissolution is performed using a paddle method at 75 rpm according to USP by according to USP testing monograph 711, and Ph.Eur. testing monograph 2.9.3. respectively.

[001039] In some embodiments, stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, release the mTOR inhibitor in the in-vitro release assay according to following release specifications:

0.5h: <45%, or <40, e.g., <30%

1h: 20-80%, e.g., 30-60%

2h: >50%, or >70%, e.g., >75%

3h: >60%, or >65%, e.g., >85%, e.g., >90%.

[001040] In some embodiments, stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, release 50% of the mTOR inhibitor not earlier than 45, 60, 75, 90, 105 min or 120 min in the in-vitro dissolution assay.

[001041] In one embodiment, stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, comprise an mTOR inhibitor in a fast dissolving or disintegrating carrier matrix in combination with coatings wherein at least one of the coatings is an extended release coating. In another embodiment, stable extended release formulations of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, comprise an mTOR inhibitor in a non-disintegrating carrier matrix with extended release properties, which can be combined optionally with additional coatings.

[001042] In some embodiments, a carrier matrix comprises matrix formers, typically matrix forming polymers, and may contain additional excipients, such as fillers, e.g., lactose, mannitol, maltodextrine, pregelatinized starch, calcium phosphate, or microcrystallline cellulose, and disintegrants, e.g., corn starch, croscamellose, sodium starch glycolate, or crospovidone, antioxidants, e.g., butylhydroxy anisol, butylhydroxy toluol, ascorbyl palmitate, tocopherol, vitamin E polyethylene glycol succinate, and process enhancing agents, such as lubricants and glidants, e.g., colloidal silicon dioxide, talc, glyceryl monostearate, magnesium stearate, calcium stearate, or sodium stearyl fumarate. The term "matrix former" typically relates to a pharmaceutically inert material which provides physical stability, such as e.g., mechanical or binding stability.

[001043] Suitable matrix forming polymers used for fast dissolving or disintegrating carrier matrices are known in the art include for instance cellulose or starch, for instance micro-crystalline cellulose ("MCC"), for example Avicel PH 101 (FMC BioPolymer), acacia, sodium alginate, gelatine, starch, pregeliatinised starch, methylcellulose, hydroxypropyl methylcellulose ("HPMC"), hydroxypropylcellulose, hydroxyethylcellulose, polyethylene glycol or polyvinylpyrrolidone ("PVP"), carrageenan, such as Gelcarin GP 812 or combinations thereof.

[001044] Suitable matrix forming excipients for non-disintegrating carrier matrices with extended release properties are known in the art include for instance acacia, sodium alginate, gelatine, carboxmethylcellulose sodium, (or "CMC sodium"), methylcellulose, ethylcellulose and cellulose acetate or polyacrylates, e.g., ammonio methacrylate copolymers (Eudragit RS/RL), hydroxypropyl methylcellulose ("HPMC"), hydroxypropylcellulose,

hydroxyethylcellulose, polyvinylacetate, polyethylene glycol or polyvinylpyrrolidone ("PVP"), e.g., carrageenan, such as Gelcarin GP 812, glyceryl monostearate, stearylalcohol, stearic acid, glyceryl behenate, Vitamin E polyethylen glycol succinate, or combinations thereof.

[001045] In one embodiment, the extended release coating is a layer formed with water insoluble, non-disintegrating polymers, controlling the release by permeation of the drug through this layer.

[001046] The extended release coating may also contain one or more of pore formers, plasticizers, and processing enhancing agents, such as lubricants and anti tacking agents. Suitable extended release coating forming polymers which enable diffusion controlled release are known in the art include for instance ethylcellulose and cellulose acetate or polyacrylates, e.g., ammonio methacrylate copolymers (Eudragit RS/RL), polyvinylacetate or combinations thereof. In a particular embodiment, the extended release coating forming polymer is ethylcellulose or cellulose acetate or polyacrylates, e.g., ammoniomethacrylate copolymer Type A (Eudragit RS) or ammonio-methacrylate copolymer Type B (Eudragit RL) or combinations thereof. Moreover, the extended release coating may include plasticizer, such as triacetine, triethyl citrate, dibutylsebacate, diethylsebacate, polyethylene glycol 3000, 4000 or 6000, acetyltriethylcitrate, acetyltributylcitrate, or diethylphthalate, and/or anti-tacking agents such Syloid 244 FP, talc, glyceryl monostearate, or titanium dioxide. In some embodiments, the amount of plasticizer may be between 5 to 40%, preferably 10 to 25%, relative to the amount of sustained release polymer.

[001047] In an embodiment, an extended release coating is a pore forming system which comprises a water insoluble coating forming polymer and a pore former. The term "pore former" relates to a readily soluble excipient which allows pores to be introduced or permeability of the coating to be increased, and a diffusion controlled release of the active ingredient. Suitable pore formers are known in the art include for instance hydroxypropylcellulose (HPC (e.g., Klucel™ EF, EXF,LF), or hydroxypropyl methylcellulose (HPMC, e.g., Methocel™ E3/E5, Pharmacoat 603™), polyethylen glycol (e.g., Macrogol 1500, 3500, 4000, 6000), poloxamer 188 (Pluronic F68™) or povidone (PVP, e.g., Kollidon K25/K30), a saccharide, e.g., a monosaccharide, such as dextrose, mannose, fructose, a disaccharide, such as sucrose or glucodifructose or combinations thereof. Preferably the pore former is hydroxypropylcellulose (HPC (Klucel™ EF, EXF,LF), or hydroxypropyl methylcellulose (HPMC, Methocel™ E3/E5, Pharmacoat 603™),

polyethylen glycol (Macrogol 1500, 3500, 4000, 6000), poloxamer 188 (Pluronic F68™) or povidone (PVP, Kollidon K25/K30) or combinations thereof. In some embodiments, suitable amounts of pore formers included in coating are equal to ratios of coating polymer to pore former of e.g. 100:20 to 100:50, or 100:20 to 100:100, preferably ratios of 100:35 to 100:45, particularly ratios of 100:35 to 100:50 relative to the amount of coating forming polymer. In some embodiments, suitable amounts of coating forming polymers included are equal to percentages of polymer weight increase of e.g., 4% to 15%, 5% to 15%, preferably 5% to 12%, more preferably 6% to 12% weight of total weight of pharmceutical formulation.

[001048] In another embodiment, a non-disintegrating extended release carrier matrix comprises matrix forming polymers which enable diffusion controlled release of the active ingredient by hydration of the polymer. The extended carrier matrix may contain further excipients, such as binders and or fillers and process enhancing agents, such as lubricants and glidants, etc.

[001049] The following exemplary matrix forming polymers may be used for diffusion controlled release: sodium alginate, polyacrylic acids (or "carbomers"), carboxmethylcellulose sodium, (or "CMC sodium"), methylcellulose, ethylcellulose and cellulose acetate or polyacrylates, e.g., ammonio methacrylate copolymers (Eudragit RS/RL), hydroxypropyl methylcellulose ("HPMC") of different viscosity grades (i.e., average polymer chain lengths) and combinations thereof, e.g., Methocel™ CR grades, hydroxypropyl cellulose, e.g. Klucel™ HF/MF, polyoxyethylene, e.g., Polyox™ or polyvinylpyrrolidone ("PVP"), e.g., PVP K60, K90, carrageenan, such as Viscarin™ GP-209/GP-379, or combinations thereof. Combining of matrix forming polymers allows adjusting the dissolution rate of the active ingredient according to the need.

[001050] In some embodiments, a non-disintegrating extended release matrix is formed with excipients, which enable release of the active ingredient by a controlled erosion. The erosion controlled matrices may contain lipophilic matrix formers, and also further excipients, such as fillers, disintegrants and process enhancing agents, such as lubricants and glidants. Exemplary lipophilic matrix forming excipients related to this matrix type include lipophilic excipients, such as glyceryl monostearate, e.g., Cutina GMS, glyceryl behenate, e.g., Compritol 888 ATO, stearyl alcohol, stearic acid, hart fat, e.g., Gelucire™, or Vitamin E polyethylen glycol succinate, e.g., Speziol TPGS or combinations thereof.

[001051] Exemplary suitable binders, fillers or further excipients include, but are not limited to, mannitol, pregelatinized starch, microcrystalline cellulose, lactose, calcium phosphate, talc, titanum dioxide, triethylcitrate, Aerosil, antioxidants such as e.g., BHT, desiccants and disintegrant such as e.g., crospovidone or sodium starch glycolate, starch, or croscarmellose.

[001052] In an embodiment, a stable extended release formulation comprises an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, in a fast dissolving/disintegrating matrix, e.g., in form of a solid dispersion as described herein, in combination with functional layers or coatings wherein at least one of the functional layer(s) or coating(s) has release controlling behavior enabling extended release of the active ingredient. In another embodiment, a stable extended release formulation comprises an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, in the extended release matrix which, optionally, can further contain functional layers or coatings, such as protective or sustained release layers or coatings. In some embodiments, the coating, e.g., the extended release coating may have a thickness in the range of 10 to 100 μm, e.g., 10 to 50 μm (assessed by confocal RAMAN spectroscopy).

[001053] In some embodiments, the formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is in form of a multi-particulate delivery system. In some embodiments, a multi-particulate drug delivery system is an oral dosage form consisting of multiple, small discrete dose units. In such systems, the dosage form of the drug substances such as capsule, tablets, sachet or stickpack, may contain a plurality of subunits, typically consisting of tens to hundreds or even up to thousands of spherical particles with diameter of 0.05-2.00mm. Formulations of the size 1.5 - 3 mm, e.g., minitablets, present another alternative. The dosage form may be designed to disintegrate rapidly in the stomach releasing the multi-particulates. Without wishing to be bound by a particular theory, it is thought that the multi-particulates are spread in the gastro-intestinal lumen and will be emptied gradually from the stomach releasing the drug substance in a controlled manner.

[001054] In one embodiment, the formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, e.g., in form of multi-particulate delivery system, comprises an mTOR inhibitor as active ingredient, e.g., dissolved or dispersed in the core of the particle, (e.g., a bead, pellet, granule or minitablet), or in a layer surrounding an inert core of the particle. The active ingredient can be for instance be embedded in an extended release matrix, preferably comprising a hydrophilic or lipophilic matrix forming excipients, or embedded in a fast disintegrating and/or

dissolving matrix in combination with functional layer(s) and top coating(s) wherein at least one of the functional layer(s) or top coating(s) comprises a coating forming polymer enabling diffusion controlled extended release of the active ingredient. Optionally, a protection layer for improving stability of the active ingredient separates the matrix containing the active substance from functional layers or top coatings, to ensure stability of the drug product.

[001055] In a another embodiment, the formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, e.g., in form of a multi-particulate delivery system, comprises an mTOR inhibitor as active ingredient and an outer coating layer comprising an insoluble polymer and a soluble component as pore former, and optionally further functional layers. For the purpose of the present invention the terms "outer layer" is a layer located towards to the outside of a particle and may be coated with a further layer(s) or may be a top coating. The terms "outer layer", "coating layer" or "top coat" may be used interchangeably depending on the context in which the terms are used.

[001056] In one embodiment, the particles comprise one or several top coats enabling extended release of the active ingredient. Top coats typically are final layers with release controlling behavior, which are enclosing each particle of the multi-particulates separately.

[001057] In an embodiment, the formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, comprises an outer layer or a top coating that controls the release by the diffusion of the drug through the coating layer which is permeable, optionally by the formation of pores in the insoluble polymer layer, or alternatively solely by the hydration of the insoluble polymer, or that controls the release by a combination of a pore former and hydration of the insoluble polymer. The polymer is insoluble independently from pH, and optionally contains water soluble pore former. The release rate is affected by the extent of pore formation after the pore former is dissolved. The insoluble coating polymer can be cellulose ethers such as ethylcellulose and cellulose acetate or polyacrylates, e.g., ammonio methacrylate copolymers (Eudragit RS/RL). Suitable pore formers include water soluble cellulose ethers, for instance hydroxypropylcellulose (HPC (Klucel™ EF, EXF, LF) or hydroxypropyl methylcellulose (HPMC, Methocel™ E3/E5, Pharmacoat 603™), polyethylen glycol (Macrogol 1500, 3500, 4000, 6000), poloxamer 188 (Pluronic F68™) or povidone (PVP, Kollidon K12, K25, K30). For instance, water soluble pore former can be mixed with insoluble polymer in a ratio of 2:1 to 1:10, e.g. 1:1 to 1:5, 1:3 or 1:5. In an embodiment, the pore former to insoluble polymer ratio is HPC,

e.g Klucel™ EF, EXF, LF or HMPC 3cP, e.g., Methocel™ E3, in a ratio of 1:1 to 1:4, e.g., about 1:1, 1:1.2, 1:1.5 or 1:2. Exemplary insoluble polymers include, but are not limited to ethylcellulose (EC, Aqualon EC N10™) in combination with a pore former. In some embodiments, without the use of a pore former, the combination of the insoluble polymers ammoniomethacrylate copolymer Type A (Eudragit RS) and ammonio-methacrylate copolymer Type B (Eudragit RL) may be at ratios of 1:2 to 9:1, preferably 1:1 to 4:1.

[001058] A sustained release top coat(s) may achieve release of majority of the active substance into the small intestine and allows protection of the active substance from stomach fluids and minimizes the exposure of the active substance to the mouth, esophagus and stomach.

[001059] In one embodiment, the formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, comprise a drug substance containing matrix, e.g., fast disintegrating and/or dissolving matrix layer or in an extended release matrix layer, e.g., on a starter core such as beads, pellets or granules, which can consist of one or more components, and in which the active ingredient is dispersed or dissolved. For instance, amorphous or crystalline mTOR inhibitor, e.g., rapamycin or RAD001,can be dispersed or dissolved in the matrix in a ratio from 1:100 to 100:1 in the matrix, e.g., 1:50 to 5:1; or 1:50 to 1:1 by weight, or 1:5 to 2:3, or 1:10 to 1:5 by weight (as to the matrix former).

[001060] In an embodiment, the drug substance containing matrix is layered onto the surface of starter cores. The layer may be built by spraying a dispersion or solution of the matrix components and the drug substance on to particles of uniform, regular size and shape in a fluid bed process. Alternatively, powder mixtures of the matrix components can be layered using a rotating disk processor. Starter cores have an average particle size 0.1 to 2.5 mm. They can be single crystals, e.g., sucrose, or granular agglomerates manufactured by fluid bed granulation, a rotorgranulation, extrusion and spheronization, or a compaction process. In some embodiments, minitablets can be used as starter cores. In particular embodiments, the starter cores have a spherical shape and consist of inert material such as sucrose and starch (Sugar Spheres, Suglets™, Non-pareils), mannitol (e.g. MCells™), lactose (e.g., spray dried lactose) or microcrystalline cellulose (e.g., Cellets™).

[001061] In another embodiment, the drug substance containing matrix is incorporated in the cores of the particles. The matrix forming excipients, fillers, and other ingredients for enhancing the process are mixed together with the drug substance. The powder mixtures obtained can be

formulated as particles by using wet extrusion or melt extrusion and subsequent spheronization, or by compacting the mixtures to minitablets. The matrices formed could be either fast disintegrating/dissolving matrices, or non-disintegrating matrices with extended release properties built with hydrophilic or lipophilic matrix forming excipients.

[001062] In an embodiment, multi-particulates consisting of a hydrophilic, non-disintegrating matrix which contains the drug substance or a solid dispersion thereof, are prepared by mixing the active ingredient, a filler, e.g., lactose, together with hydrophilic, hydrogel forming polymers with different viscosities, a glidant, and a lubricant. In some embodiments, the hydrophilic, hydrogel forming polymer may be, for example hydroxypropyl methylcellulose, with low viscosity grade of less than 20 mPas for a 2% by weight aqueous solution, e.g., Methocel E5, combined with hydroxypropyl methylcellulose grade with high viscosity of more than 100 mPas for a 2% by weight aqueous solution, e.g., Methocel K100. The powder mixture is then compressed on the tabletting machine to obtain minitablets. Alternatively, the powder mixture can be wetted with organic solvent, e.g., ethanol, and then extruded and spheronized for obtaining multi-particulates.

[001063] In another embodiment, multi-particulates consisting of a lipophilic, non-disintegrating matrix which contains the drug substance or a solid dispersion thereof are prepared by mixing the active ingredient, lipophilic, meltable, matrix forming excipients, and fillers. The mixture is processed by melting and mixing in an extruder. The obtained extudate strands are cut into particles and are optionally spheronized. The lipophilic excipients used are for example Vitamin E polyethylen glycol succinate (Vit E TPGS, e.g., Kolliphor TPGS Pharma from BASF) solely, or in combination with glycerol monostearate (GMS, e.g., Kolliwax GMS fromBASF) at ratios of 9:1 to 1:9.

[001064] In some embodiments, an extended release formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, reduces the peak concentration ($C_{max}$) to concentration at 24 hours post-dose ($C_{24h}$) ratio after a single dose administration in 24 healthy subjects, as compared to an immediate release tablet, e.g., a rapamycin or RAD001 immediate release tablet available to patients (Final Market Image or "FMI" tablets). In some embodiments, the $C_{max}/C_{24h}$ ratio is decreased, e.g., as measured by pharmacokinetic model simulations. An advantage of a reduced $C_{max}/C_{min}$ ratio is that, with the appropriate dose based on the bioavailability of the mTOR inhibitor relative to an FMI formulation, the concentration of

mTOR inhibitor may be maintained above the lower therapeutic range of drug (for sufficient efficacy) and at the same time distance away from the upper therapeutic range of drug (concentration region of toxicity). Thus, in some embodiments, an extended release formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is able to improve the safety profile of the mTOR inhibitor without affecting its efficacy. In an embodiment, a $C_{max}/C_{24h}$ (thus $C_{max}/C_{min}$) ratio in patients having been administered an extended release formulation of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is < 5 or <4, e.g. 3.5±1 or 3±0.5.

[001065] In an embodiment, an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is contained in a layer separate from the functional layer or top coat controlling the extended release properties of the formulation. Such layer may be made of any substance which is suitable for dispersing or dissolving the mTOR inhibitor. In an embodiment, the layer comprising the mTOR inhibitor is made of a hydrophilic carrier matrix. The carrier matrix may be embedding the active ingredient and protecting it against degradation. Suitable matrix formers include, but are not limited to, hydrophilic polymers, e.g. HPMC type 2910 or type 2280, HPC, HEC, MEC, MHEC, povidone, which can be dissolved or rapidly dispersed in water. In one embodiment, the matrix layer is in form of a solid dispersion, for instance as described in WO97/03654 or WO03/028705, the entire contents of each of which are incorporated herein by reference.

[001066] In an embodiment, the fast dissolving/disintegrating carrier matrix for an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is in form of a solid dispersion. In some embodiments, the solid dispersion comprises a carrier, e.g., a water-soluble polymer, for example one or a mixture of the following polymers may be used:

- hydroxypropylmethylcellulose (HPMC), e.g., Hypromellose type 2910, which is available as Methocel™ E from Dow Chemicals or Pharmacoat ™ from Shin Etsu. Good results may be obtained using HPMC with a low apparent viscosity, e.g., below 100 cps as measured at 20°C for a 2% by weight aqueous solution, e.g. below 50 cps, preferably below 20 cps, for example HPMC 3 cps;

- polyvinylpyrrolidone (povidone, PVP), e.g., PVP K25, K30 or PVP K12. PVP is available commercially, for example, as Kollidon® from the BASF company or as Plasdone® from ISP company. A PVP having an average molecular weight between about 8,000 and about 50,000 Daltons is preferred, e.g., PVP K30;

- hydroxypropylcellulose (HPC), e.g., Klucel EF/LF/JFor a derivative thereof. Examples of HPC derivatives include those having low dynamic viscosity in aqueous media, e.g., water, e.g. below about 400 cps as measured in a 5 % aqueous solution at 25°C. Preferred HPC derivatives an average molecular weight below about 200,000 Daltons, e.g., between 80,000 and 140,000 Daltons. Examples of HPC available commercially include Klucel® LF, Klucel® EF and Klucel® JF from the Hercules Aqualon company; and Nisso® HPC-L available from Nippon Soda Ltd;

- a polyethylene glycol (PEG). Examples include PEGs having an average molecular weight between 1000 and 9000 Daltons, e.g. between about 1800 and 7000, for example PEG 2000, PEG 4000, or PEG 6000 (Handbook of Pharmaceutical Excipients, p. 355-361);

- a saturated polyglycolised glyceride, available for example, as Gelucire®, e.g., Gelucire® 44/14, 53/10, 50/13, 42/12, or 35/10 from the Gattefossé company; or

- a cyclodextrin, for example a β-cyclodextrin or an α-cyclodextrin. Examples of suitable β-cyclodextrins include, but are not limited to, methyl-β-cyclodextrin; dimethyl-β-cyclodextrin; hydroxyproypl-β-cyclodextrin; glycosyl-β-cyclodextrin; maltosyl-β-cyclodextrin; sulfo-β-cyclodextrin; a sulfo-alkylethers of β-cyclodextrin, e.g. sulfo-$C_{1-4}$-alkyl ethers. Examples of α-cyclodextrins include, but are not limited to, glucosyl-α-cyclodextrin and maltosyl-α-cyclodextrin.

[001067] In one embodiment, an mTOR inhibitor-containing layer contains antioxidant in a ratio of 1:1000 to 1:1 related to the amount of drug substance. The antioxidant may also be present in other functional layers, e.g., at concentration of 0.1 to 10%, preferably 0.1 to 1%. Suitable antioxdants include, but are not limited to, butyl hydroxyl toluol, butyl hydroxy anisol, ascorbyl palmitate, tocopherol, vitamin E polyethylene glycol succinate. In a particular embodiment, the antioxidant is butyl hydroxyl toluol.

[001068] In one embodiment, a protection layer separates the layer containing the active substance from other functional layers, such as e.g., the top coating, to enhance stability of the of the drug product. The drug substance is stabilized by excluding any direct contact with the top coating. The protection layer also acts as diffusion barrier preventing any components in the top coating, e.g., polymer by-products or plasticizers, which can migrate through the layers, from

getting in direct contact with the active. Beside the polymers, which are used also as matrix formers (e.g., the matrix formers described above), high content, of inorganic pigments or anti-tacking agents such as talc and/or titanium dioxide, e.g., 10 to 100%, e.g., 20 to 50%, relative to the applied amount of polymer, contribute to the barrier function. The protection layer thickness can be adjusted to gain optimized drug product stability.

[001069] In another embodiment, the mTOR inhibitor, e.g., rapamycin or RAD001, is directly embedded in the extended release carrier matrix.

[001070] In some embodiments, a formulation comprising an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, contains strongly hygroscopic excipients, which are able to bind water moisture enclosed in the formulation working as an internal desiccant. Adsorbents such as e.g., crospovidone, croscarmellose sodium, sodium starch glycolate, or starch can be used. For example, in some embodiments, crospovidone is used as tablet disintegrant, e.g., at 2% to 25% crospovidone. The adsorbent, e.g., crospovidone, may be part of the powder mixtures used for wet and melt extrusion, part of the powder blend for compressing the minitablets, part of powder blend for tabletting the multi-particulates, and/or directly added to the multi-particulates in a sachet or capsule filling process.

[001071] In one aspect, an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is present in a particle (e.g., 0.1 to 0.5 mm), bead, pellet (e.g., 0.2 to 2 mm) or mini-tablet (e.g., 1.5 to 3 mm), with a low water moisture content of less than 5% in total, e.g., less than 3% or less than 2.5% in total.

[001072] In some embodiments, a pharmaceutical compositions, e.g., a multi-particulate delivery system of an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, can be formulated into a drug product such as e.g., capsules (e.g., HPMC or Hart Gelatine capsules), or filled into sachets or stick-packs, or formulated as tablets which release the particles upon disintegration.

[001073] In some embodiments, the primary packaging, such as sachets, stickpacks, blisters or bottles may include an water sorbing ingredient, e.g., silica gel, which reduces or stabilizes the water moisture content of the drug product during shelf life storage and/or in during in-use time.

[001074] Provided formulations may comprise and/or release multiple pellets, granules or minitablets.

[001075] In some embodiments, provided formulations, e.g., multi-particulates formulations, can be prepared by extruding and spheronizing a mixture of the matrix forming excipients together with the drug substance with the aid of heat or wetting liquids, or by compacting minitablets with drug containing mixtures, or by layering the drug containing matrix layer onto cores in a fluid bed or rotogranulation process.

[001076] In some embodiments, the layer containing the active substance can be prepared by spraying a spray dispersion with organic solvents in which the hydrophilic components and the active substance are dispersed or dissolved onto the core material, while concurrently the solvents are continuously removed by the aid of heated, dry air. By this process a matrix layer surrounding the cores is formed, e.g., the layer formed is a solid dispersion of the active in polymers such as e.g., HPMC, HPC, HEC.

[001077] In one aspect, a provided pharmaceutical formulation may be prepared as follows: An organic feed mixture for spraying in which the hydrophilic polymer is dispersed in colloidal manner and an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, is dispersed or dissolved, which precipitate together as a uniform, smooth layer of solid dispersion upon removal of the solvent in such a way that they can be coated with modified release coats. In some embodiments, the obtained drug containing multi-particulates can be coated with additional functional layers and top coatings. A spray dispersion containing coating polymers, lubricants, anti tack agents, pore formers and plastisizers, which are dissolved, dispersed and suspended in organic solvents and mixtures thereof, is sprayed onto the drug containing multi-particulates. During processing the multi-particulates are kept continuously in a controlled motion or fluidization, while dry, heated process gas is applied to the product bed for evaporating the solvents from the surface of the multi-particulates, where the film layer is formed at a defined temperature. The film layer thickness can be controlled by the amount of coating dispersion sprayed. Final drying is applied for minimizing the residual solvent content in the layered and coated multi-particulates.

[001078] In another aspect, an mTOR inhibitor disclosed herein, e.g., rapamycin or RAD001, may be formulated as part of a high drug load part of an extended release formulation. In some embodiments, the formulation further comprises a surfactant. The term "surfactant" can be used interchangeably with a "wetting agent" or "detergent" and refers to a non-ionic, ionic, anionic, cationic or amphoteric surfactant, e.g., a non-ionic, ionic, anionic, or amphoteric surfactant.

Examples of suitable surfactants/wetting agents include, but are not limited to, polyoxyethylene-polyoxypropylene co-polymers and block co-polymers known, for example, under the trademarks Pluronic or Poloxamer (e.g. poloxamer 188 (Pluronic F68), polyoxyethylene, sorbitan fatty acid esters including mono and tri lauryl, palmityl, stearyl and oleyl esters of the type known under the trade name Tween, polyoxyethylene fatty acid esters including polyoxyethylene stearic acid esters of the type known under the trade name Myrj, poly-oxyethylene alkyl ethers known under the trade mark Brij, sodium alkyl sulfates like Soldium lauryl sulphate (SDS) and sulfonates, and sodium alkyl aryl sulfonates, water soluble tocopheryl polyethylene glycol succinic acid esters (TPGS), polyglycerol fatty acid esters, alkylene polyol ethers or esters, polyethylene glycol glyceryl fatty acid esters, sterols and derivatives thereof, transesterified, polyoxyethylated caprylic-capric acid glycerides, sugar fatty acid esters, PEG sterol ethers, phospholipids, salts of fatty acids, fatty acid sulfates and sulfonates, salts of fatty acids, fatty acid sulfates and sulfonates, medium or long-chain alkyl, e.g., $C_6$-$C_{18}$, ammonium salts, bile acid or salt thereof; for example cholic acid, glycolic acid or a salt, e.g., sodium cholate and polyoxyethylene mono esters of a saturated $C_{10}$ to $C_{22}$ fatty acid. In a particular embodiment the surfactant is polyoxyethylene-polyoxypropylene co-polymer or block co-polymer, or a water soluble tocopheryl polyethylene glycol succinic acid ester, e.g., a water soluble tocopheryl polyethylene glycol succinic acid ester, e.g., Vitamin E polyethylene glycol 1000 succinate (TPGS). In another embodiment the surfactant in the present pharmaceutical formulation is polyoxyethylene-polyoxypropylene co-polymer, e.g., poloxamer 188. In yet another embodiment, the pharmaceutical formulation comprises the surfactant sodium alkyl sulfate, e.g., sodium lauryl sulfate.

[001079] The surfactant or wetting agent may be present in a formulation in a ratio to mTOR inhibitor, e.g., rapamycin or RAD001, from 10:1 to 1:200 by weight, e.g., 1:1 to 1:100 by weight, 1:2 to 1:8 by weight, 1:4 to 1:6 by weight.

[001080] In some embodiments, the mTOR inhibitor, e.g., rapamycin or RAD001, is in a high drug load containing first layer, and a surfactant in a second layer, wherein the second layer is beneath the first layer, optionally with additional extended release coating. In some such embodiments, the surfactant is not poloxamer 188 and TPGS. In some embodiments, the surfactant or wetting agent in a second layer can form a protection layer which separates the

active ingredient containing layer from the coating covering the formulation. The coating covering the formulation may be an extended release coating.

**Methods and Biomarkers for Evaluating CAR-Effectiveness or Sample Suitability**

[001081] In another aspect, the invention features a method of evaluating or monitoring the effectiveness of a CAR-expressing cell therapy, in a subject (e.g., a subject having a cancer), or the suitability of a sample (e.g., an apheresis sample) for a CAR therapy, e.g., therapy including administration of a low, immune-enhancing dose of an mTOR inhibitor. The method includes acquiring a value of effectiveness to the CAR therapy, or sample suitability, wherein said value is indicative of the effectiveness or suitability of the CAR-expressing cell therapy.

[001082] In embodiments, the value of effectiveness to the CAR therapy, or sample suitability, comprises a measure of one, two, three, four, five, six or more (all) of the following:

(i) the level or activity of one, two, three, or more (e.g., all) of resting $T_{EFF}$ cells, resting $T_{REG}$ cells, younger T cells (e.g., younger CD4 or CD8 cells, or gamma/delta T cells), or early memory T cells, or a combination thereof, in a sample (e.g., an apheresis sample or a manufactured CAR-expressing cell product sample);

(ii) the level or activity of one, two, three, or more (e.g., all) of activated $T_{EFF}$ cells, activated $T_{REG}$ cells, older T cells (e.g., older CD4 or CD8 cells), or late memory T cells, or a combination thereof, in a sample (e.g., an apheresis sample or a manufactured CAR-expressing cell product sample);

(iii) the level or activity of an immune cell exhaustion marker, e.g., one, two or more immune checkpoint inhibitors (e.g., PD-1, PD-L1, TIM-3 and/or LAG-3) in a sample (e.g., an apheresis sample or a manufactured CAR-expressing cell product sample). In one embodiment, an immune cell has an exhausted phenotype, e.g., co-expresses at least two exhaustion markers, e.g., co-expresses PD-1 and TIM-3. In other embodiments, an immune cell has an exhausted phenotype, e.g., co-expresses at least two exhaustion markers, e.g., co-expresses PD-1 and LAG-3;

(iv) the level or activity of CD27 and/or CD45RO- (e.g., CD27+ CD45RO-) immune effector cells, e.g., in a CD4+ or a CD8+ T cell population, in a sample (e.g., an apheresis sample or a manufactured CAR-expressing cell product sample);

(v) the level or activity of one, two, three, four, five, ten, twenty or more of the biomarkers chosen from CCL20, IL-17a and/or IL-6, PD-1, PD-L1, LAG-3, TIM-3, CD57, CD27, CD122, CD62L, KLRG1;

(vi) a cytokine level or activity (e.g., quality of cytokine reportoire) in a CAR-expressing cell product sample; or

(vii) a transduction efficiency of a CAR-expressing cell in a manufactured CAR-expressing cell product sample.

[001083] In some embodiments of any of the methods disclosed herein, the CAR-expressing cell therapy comprises a plurality (e.g., a population) of CAR-expressing immune effector cells, e.g., a plurality (e.g., a population) of T cells or NK cells, or a combination thereof. In one embodiment, the CAR-expressing cell therapy includes administration of a low, immune-enhancing dose of an mTOR inhibitor.

[001084] In some embodiments of any of the methods disclosed herein, the measure of one or more of (i)-(vii) is obtained from an apheresis sample acquired from the subject. The apheresis sample can be evaluated prior to infusion or re-infusion.

[001085] In some embodiments of any of the methods disclosed herein, the measure of one or more of (i)-(vii) is obtained from a manufactured CAR-expressing cell product sample. The manufactured CAR-expressing cell product can be evaluated prior to infusion or re-infusion.

[001086] In some embodiments of any of the methods disclosed herein, the subject is evaluated prior to receiving, during, or after receiving, the CAR-expressing cell therapy.

[001087] In some embodiments of any of the methods disclosed herein, the measure of one or more of (i)-(vii) evaluates a profile for one or more of gene expression, flow cytometry or protein expression.

[001088] In some embodiments of any of the methods disclosed herein, the method further comprises identifying the subject as a responder, a non-responder, a relapser or a non-relapser, based on a measure of one or more of (i)-(vii).

[001089] In some embodiments of any of the methods disclosed herein, a responder (e.g., a complete responder) has, or is identified as having, a greater level or activity of one, two, or more (all) of GZMK, PPF1BP2, or naïve T cells as compared to a non-responder.

[001090] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, a greater level or activity of one, two, three, four, five, six, seven, or more (e.g., all) of IL22, IL-2RA, IL-21, IRF8, IL8, CCL17, CCL22, effector T cells, or regulatory T cells, as compared to a responder.

[001091] In an embodiment, a relapser is a patient having, or who is identified as having, an increased level of expression of one or more of (e.g., 2, 3, 4, or all of) the following genes, compared to non relapsers: MIR199A1, MIR1203, uc021ovp, ITM2C, and HLA-DQB1 and/or a decreased levels of expression of one or more of (e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or all of) the following genes, compared to non relapsers: PPIAL4D, TTTY10, TXLNG2P, MIR4650-1, KDM5D, USP9Y, PRKY, RPS4Y2, RPS4Y1, NCRNA00185, SULT1E1, and EIF1AY.

[001092] In some embodiments of any of the methods disclosed herein, a complete responder has, or is identified as having, a greater, e.g., a statistically significant greater, percentage of CD8+ T cells compared to a reference value, e.g., a non-responder percentage of CD8+ T cells.

[001093] In some embodiments of any of the methods disclosed herein, a complete responder has, or is identified as having, a greater percentage of CD27+ CD45RO- immune effector cells, e.g., in the CD8+ population, compared to a reference value, e.g., a non-responder number of CD27+ CD45RO- immune effector cells.

[001094] In some embodiments of any of the methods disclosed herein, a complete responder or a partial responder has, or is identified as having, a greater, e.g., a statistically significant greater, percentage of CD4+ T cells compared to a reference value, e.g., a non-responder percentage of CD4+ T cells.

[001095] In some embodiments of any of the methods disclosed herein, a complete responder has, or is identified as having, a greater percentage of one, two, three, or more (e.g., all) of resting $T_{EFF}$ cells, resting $T_{REG}$ cells, younger T cells (e.g., younger CD4 or CD8 cells, or gamma/delta T cells), or early memory T cells, or a combination thereof, compared to a reference value, e.g., a non-responder number of resting $T_{EFF}$ cells, resting $T_{REG}$ cells, younger T cells (e.g., younger CD4 or CD8 cells), or early memory T cells.

[001096] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, a greater percentage of one, two, three, or more (e.g., all) of activated $T_{EFF}$ cells, activated $T_{REG}$ cells, older T cells (e.g., older CD4 or CD8 cells), or late memory T cells, or a combination thereof, compared to a reference value, e.g., a responder number of

activated $T_{EFF}$ cells, activated $T_{REG}$ cells, older T cells (e.g., older CD4 or CD8 cells), or late memory T cells.

[001097] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, a greater percentage of an immune cell exhaustion marker, e.g., one, two or more immune checkpoint inhibitors (e.g., PD-1, PD-L1, TIM-3 and/or LAG-3). In one embodiment, a non-responder has, or is identified as having, a greater percentage of PD-1, PD-L1, or LAG-3 expressing immune effector cells (e.g., CD4+ T cells and/or CD8+ T cells) (e.g., CAR-expressing CD4+ cells and/or CD8+ T cells) compared to the percentage of PD-1 or LAG-3 expressing immune effector cells from a responder.

[001098] In one embodiment, a non-responder has, or is identified as having, a greater percentage of immune cells having an exhausted phenotype, e.g., immune cells that co-express at least two exhaustion markers, e.g., co-expresses PD-1, PD-L1 and/or TIM-3. In other embodiments, a non-responder has, or is identified as having, a greater percentage of immune cells having an exhausted phenotype, e.g., immune cells that co-express at least two exhaustion markers, e.g., co-expresses PD-1 and LAG-3.

[001099] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, a greater percentage of PD-1/ PD-L1+/LAG-3+ cells in the CAR-expressing cell population compared to a responder (e.g., a complete responder) to the CAR-expressing cell therapy.

[001100] In some embodiments of any of the methods disclosed herein, a partial responder has, or is identified as having, a higher percentages of PD-1/ PD-L1+/LAG-3+ cells, than a responder, in the CAR-expressing cell population.

[001101] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, an exhausted phenotype of PD1/ PD-L1+ CAR+ and co-expression of LAG3 in the CAR-expressing cell population.

[001102] In some embodiments of any of the methods disclosed herein, a non-responder has, or is identified as having, a greater percentage of PD-1/ PD-L1+/TIM-3+ cells in the CAR-expressing cell population compared to the responder (e.g., a complete responder).

[001103] In some embodiments of any of the methods disclosed herein, a partial responders has, or is identified as having, a higher percentage of PD-1/ PD-L1+/TIM-3+ cells, than responders, in the CAR-expressing cell population.

[001104] In some embodiments of any of the methods disclosed herein, the presence of CD8+ CD27+ CD45RO- T cells in an apheresis sample is a positive predictor of the subject response to a CAR-expressing cell therapy.

[001105] In some embodiments of any of the methods disclosed herein, a high percentage of PD1+ CAR+ and LAG3+ or TIM3+ T cells in an apheresis sample is a poor prognostic predictor of the subject response to a CAR-expressing cell therapy.

[001106] In some embodiments of any of the methods disclosed herein, the responder (e.g., the complete or partial responder) has one, two, three or more (or all) of the following profile:

(i) has a greater number of CD27+ immune effector cells compared to a reference value, e.g., a non-responder number of CD27+ immune effector cells;

(ii) (i) has a greater number of CD8+ T cells compared to a reference value, e.g., a non-responder number of CD8+ T cells;

(iii) has a lower number of immune cells expressing one or more checkpoint inhibitors, e.g., a checkpoint inhibitor chosen from PD-1, PD-L1, LAG-3, TIM-3, or KLRG-1, or a combination, compared to a reference value, e.g., a non-responder number of cells expressing one or more checkpoint inhibitors; or

(iv) has a greater number of one, two, three, four or more (all) of resting $T_{EFF}$ cells, resting $T_{REG}$ cells, naïve CD4 cells, unstimulated memory cells or early memory T cells, or a combination thereof, compared to a reference value, e.g., a non-responder number of resting TEFF cells, resting TREG cells, naïve CD4 cells, unstimulated memory cells or early memory T cells.

[001107] In some embodiments of any of the methods disclosed herein, the cytokine level or activity of (vi) is chosen from one, two, three, four, five, six, seven, eight, or more (or all) of cytokine CCL20/MIP3a, IL17A, IL6, GM-CSF, IFNγ, IL10, IL13, IL2, IL21, IL4, IL5, IL9 or TNFα, or a combination thereof. The cytokine can be chosen from one, two, three, four or more (all) of IL-17a, CCL20, IL2, IL6, or TNFa. In one embodiment, an increased level or activity of a cytokine is chosen from one or both of IL-17a and CCL20, is indicative of increased responsiveness or decreased relapse.

[001108] In some embodiments of any of the methods disclosed herein, a transduction efficiency of 15% or higher in (vii) is indicative of increased responsiveness or decreased relapse.

[001109] In some embodiments of any of the methods disclosed herein, a transduction efficiency of less than 15% in (vii) is indicative of decreased responsiveness or increased relapse.

[001110] In embodiments, the responder, a non-responder, a relapser or a non-relapser identified by the methods herein can be further evaluated according to clinical criteria. For example, a complete responder has, or is identified as, a subject having a disease, e.g., a cancer, who exhibits a complete response, e.g., a complete remission, to a treatment. A complete response may be identified, e.g., using the NCCN Guidelines® (which are incorporated by reference herein in their entireties), as described herein. A partial responder has, or is identified as, a subject having a disease, e.g., a cancer, who exhibits a partial response, e.g., a partial remission, to a treatment. A partial response may be identified, e.g., using the NCCN Guidelines®, as described herein. A non-responder has, or is identified as, a subject having a disease, e.g., a cancer, who does not exhibit a response to a treatment, e.g., the patient has stable disease or progressive disease. A non-responder may be identified, e.g., using the NCCN Guidelines®, as described herein.

[001111] Alternatively, or in combination with the methods disclosed herein, responsive to said value, performing one, two, three, four or more of:

administering e.g., to a responder or a non-relapser, a CAR-expressing cell therapy;

administered an altered dosing of a CAR-expressing cell therapy;

altering the schedule or time course of a CAR-expressing cell therapy;

administering, e.g., to a non-responder or a partial responder, an additional agent in combination with a CAR-expressing cell therapy, e.g., a checkpoint inhibitor, e.g., a checkpoint inhibitor described herein;

administering to a non-responder or partial responder a therapy that increases the number of younger T cells in the subject prior to treatment with a CAR-expressing cell therapy;

modifying a manufacturing process of a CAR-expressing cell therapy, e.g., enriching for younger T cells prior to introducing a nucleic acid encoding a CAR, or increasing the transduction efficiency, e.g., for a subject identified as a non-responder or a partial responder;

administering an alternative therapy, e.g., for a non-responder or partial responder or relapser; or

if the subject is, or is identified as, a non-responder or a relapser, decreasing the $T_{REG}$ cell population and/or $T_{REG}$ gene signature, e.g., by one or more of CD25 depletion, administration of cyclophosphamide, anti-GITR antibody, or a combination thereof.

[001112] In certain embodiments, the subject is pre-treated with an anti-GITR antibody. In certain embodiment, the subject is treated with an anti-GITR antibody prior to infusion or re-infusion.

**Biopolymer delivery methods**

[001113] In some embodiments, one or more CAR-expressing cells as disclosed herein, optionally in combination with a low, immune-enhancing dose of an mTOR inhibitor (e.g., an mTOR inhibitor described herein) can be administered or delivered to the subject via a biopolymer scaffold, e.g., a biopolymer implant. Biopolymer scaffolds can support or enhance the delivery, expansion, and/or dispersion of the CAR-expressing cells described herein. A biopolymer scaffold comprises a biocompatible (e.g., does not substantially induce an inflammatory or immune response) and/or a biodegradable polymer that can be naturally occurring or synthetic.

[001114] Examples of suitable biopolymers include, but are not limited to, agar, agarose, alginate, alginate/calcium phosphate cement (CPC), beta-galactosidase (β-GAL), (1 ,2,3,4,6-pentaacetyl a-D-galactose), cellulose, chitin, chitosan, collagen, elastin, gelatin, hyaluronic acid collagen, hydroxyapatite, poly(3-hydroxybutyrate-co-3-hydroxy-hexanoate) (PHBHHx), poly(lactide), poly(caprolactone) (PCL), poly(lactide-co-glycolide) (PLG), polyethylene oxide (PEO), poly(lactic-co-glycolic acid) (PLGA), polypropylene oxide (PPO), polyvinyl alcohol) (PVA), silk, soy protein, and soy protein isolate, alone or in combination with any other polymer composition, in any concentration and in any ratio. The biopolymer can be augmented or modified with adhesion- or migration-promoting molecules, e.g., collagen-mimetic peptides that bind to the collagen receptor of lymphocytes, and/or stimulatory molecules to enhance the delivery, expansion, or function, e.g., anti-cancer activity, of the cells to be delivered. The biopolymer scaffold can be an injectable, e.g., a gel or a semi-solid, or a solid composition.

[001115] In some embodiments, CAR-expressing cells described herein are seeded onto the biopolymer scaffold prior to delivery to the subject. In embodiments, the biopolymer scaffold

further comprises one or more additional therapeutic agents described herein (e.g., another CAR-expressing cell, an antibody, or a small molecule) or agents that enhance the activity of a CAR-expressing cell, e.g., incorporated or conjugated to the biopolymers of the scaffold. In embodiments, the biopolymer scaffold is injected, e.g., intratumorally, or surgically implanted at the tumor or within a proximity of the tumor sufficient to mediate an anti-tumor effect. Additional examples of biopolymer compositions and methods for their delivery are described in Stephan et al., *Nature Biotechnology*, 2015, 33:97-101; and WO2014/110591.

## Pharmaceutical Compositions and Treatments: CARs and Combinations

[001116] In one aspect, the present invention relates to pharmaceutical compositions comprising an an immue effector cell, e.g., a T cell, engineered to express a CAR, for use in combination with a low, immune enhancing, dose of an mTOR inhibitor, e.g., an mTOR inhibitor as described herein.

[001117] In an embodiment, administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, is initiated prior to administration of immune effector cells, e.g., T cells, engineered to express a CAR. In an embodiment, the CAR cells are administered after a sufficient time, or sufficient dosing, of an mTOR inhibitor, such that the level of PD1 negative immune effector cells, e.g., T cells, or the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells, e.g., T cells, has been, at least transiently, increased.

[001118] In an embodiment, administration of a low, immune enhancing, dose of an mTOR inhibitor, e.g., an allosteric inhibitor, e.g., RAD001, or a catalytic inhibitor, is initiated prior to harvest of immue effector cells, e.g., T cells, which will be engineered for the expression of a CAR. In an embodiment, of immue effector cells, e.g., T cells are harvested after a sufficient time, or sufficient dosing, of an mTOR inhibitor, such that the level of PD1 negative immune effector cells, e.g., T cells, or the ratio of PD1 negative immune effector cells, e.g., T cells/ PD1 positive immune effector cells in the harvested cells has been, at least transiently, increased.

[001119] Pharmaceutical compositions of the present invention may comprise a CAR-expressing cell, e.g., a plurality of CAR-expressing cells, as described herein, in combination with one or more pharmaceutically or physiologically acceptable carriers, diluents or excipients.

Such compositions may comprise buffers such as neutral buffered saline, phosphate buffered saline and the like; carbohydrates such as glucose, mannose, sucrose or dextrans, mannitol; proteins; polypeptides or amino acids such as glycine; antioxidants; chelating agents such as EDTA or glutathione; adjuvants (e.g., aluminum hydroxide); and preservatives. Compositions of the present invention are in one aspect formulated for intravenous administration.

[001120] Pharmaceutical compositions of the present invention may be administered in a manner appropriate to the disease to be treated (or prevented). The quantity and frequency of administration will be determined by such factors as the condition of the patient, and the type and severity of the patient's disease, although appropriate dosages may be determined by clinical trials.

[001121] In one embodiment, the pharmaceutical composition is substantially free of, e.g., there are no detectable levels of a contaminant, e.g., selected from the group consisting of endotoxin, mycoplasma, replication competent lentivirus (RCL), p24, VSV-G nucleic acid, HIV gag, residual anti-CD3/anti-CD28 coated beads, mouse antibodies, pooled human serum, bovine serum albumin, bovine serum, culture media components, vector packaging cell or plasmid components, a bacterium and a fungus. In one embodiment, the bacterium is at least one selected from the group consisting of Alcaligenes faecalis, Candida albicans, Escherichia coli, Haemophilus influenza, Neisseria meningitides, Pseudomonas aeruginosa, Staphylococcus aureus, Streptococcus pneumonia, and Streptococcus pyogenes group A.

[001122] When "an immunologically effective amount," "an anti-tumor effective amount," "a tumor-inhibiting effective amount," or "therapeutic amount" is indicated, the precise amount of the compositions of the present invention to be administered can be determined by a physician with consideration of individual differences in age, weight, tumor size, extent of infection or metastasis, and condition of the patient (subject). It can generally be stated that a pharmaceutical composition comprising the immune effector cells (e.g., T cells, NK cells) described herein may be administered at a dosage of $10^4$ to $10^9$ cells/kg body weight, in some instances $10^5$ to $10^6$ cells/kg body weight, including all integer values within those ranges. T cell compositions may also be administered multiple times at these dosages. The cells can be administered by using infusion techniques that are commonly known in immunotherapy (see, e.g., Rosenberg et al., New Eng. J. of Med. 319:1676, 1988).

[001123] In certain aspects, it may be desired to administer activated immune effector cells (e.g., T cells, NK cells) to a subject and then subsequently redraw blood (or have an apheresis performed), activate immune effector cells (e.g., T cells, NK cells) therefrom according to the present invention, and reinfuse the patient with these activated and expanded immune effector cells (e.g., T cells, NK cells). This process can be carried out multiple times every few weeks. In certain aspects, immune effector cells (e.g., T cells, NK cells) can be activated from blood draws of from 10cc to 400cc. In certain aspects, immune effector cells (e.g., T cells, NK cells) are activated from blood draws of 20cc, 30cc, 40cc, 50cc, 60cc, 70cc, 80cc, 90cc, or 100cc.

[001124] The administration of the subject compositions may be carried out in any convenient manner, including by aerosol inhalation, injection, ingestion, transfusion, implantation or transplantation. The compositions described herein may be administered to a patient trans arterially, subcutaneously, intradermally, intratumorally, intranodally, intramedullary, intramuscularly, by intravenous (i.v.) injection, or intraperitoneally. In one aspect, the T cell compositions of the present invention are administered to a patient by intradermal or subcutaneous injection. In one aspect, the T cell compositions of the present invention are administered by i.v. injection. The compositions of immune effector cells (e.g., T cells, NK cells) may be injected directly into a tumor, lymph node, or site of infection.

[001125] In a particular exemplary aspect, subjects may undergo leukapheresis, wherein leukocytes are collected, enriched, or depleted ex vivo to select and/or isolate the cells of interest, e.g., T cells. These T cell isolates may be expanded by methods known in the art and treated such that one or more CAR constructs of the invention may be introduced, thereby creating a CAR T cell of the invention. Subjects in need thereof may subsequently undergo standard treatment with high dose chemotherapy followed by peripheral blood stem cell transplantation. In certain aspects, following or concurrent with the transplant, subjects receive an infusion of the expanded CAR T cells of the present invention. In an additional aspect, expanded cells are administered before or following surgery.

[001126] In embodiments, lymphodepletion is performed on a subject, e.g., prior to administering one or more cells that express a CAR described herein, e.g., a CD20-binding CAR described herein. In embodiments, the lymphodepletion comprises administering one or more of melphalan, cytoxan, cyclophosphamide, and fludarabine.

[001127] The dosage of the above treatments to be administered to a patient will vary with the precise nature of the condition being treated and the recipient of the treatment. The scaling of dosages for human administration can be performed according to art-accepted practices. The dose for CAMPATH, for example, will generally be in the range 1 to about 100 mg for an adult patient, usually administered daily for a period between 1 and 30 days. The preferred daily dose is 1 to 10 mg per day although in some instances larger doses of up to 40 mg per day may be used (described in U.S. Patent No. 6,120,766).

[001128] In one embodiment, the CAR is introduced into immune effector cells (e.g., T cells, NK cells), e.g., using in vitro transcription, and the subject (e.g., human) receives an initial administration of CAR immune effector cells (e.g., T cells, NK cells) of the invention, and one or more subsequent administrations of the CAR immune effector cells (e.g., T cells, NK cells) of the invention, wherein the one or more subsequent administrations are administered less than 15 days, e.g., 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, or 2 days after the previous administration. In one embodiment, more than one administration of the CAR immune effector cells (e.g., T cells, NK cells) of the invention are administered to the subject (e.g., human) per week, e.g., 2, 3, or 4 administrations of the CAR immune effector cells (e.g., T cells, NK cells) of the invention are administered per week. In one embodiment, the subject (e.g., human subject) receives more than one administration of the CAR immune effector cells (e.g., T cells, NK cells) per week (e.g., 2, 3 or 4 administrations per week) (also referred to herein as a cycle), followed by a week of no CAR immune effector cells (e.g., T cells, NK cells) administrations, and then one or more additional administration of the CAR immune effector cells (e.g., T cells, NK cells) (e.g., more than one administration of the CAR immune effector cells (e.g., T cells, NK cells) per week) is administered to the subject. In another embodiment, the subject (e.g., human subject) receives more than one cycle of CAR immune effector cells (e.g., T cells, NK cells), and the time between each cycle is less than 10, 9, 8, 7, 6, 5, 4, or 3 days. In one embodiment, the CAR immune effector cells (e.g., T cells, NK cells) are administered every other day for 3 administrations per week. In one embodiment, the CAR immune effector cells (e.g., T cells, NK cells) of the invention are administered for at least two, three, four, five, six, seven, eight or more weeks.

[001129] In one aspect, CAR-expressing cells of the present invention are generated using lentiviral viral vectors, such as lentivirus. Cells, e.g., CARTs generated that way will have stable CAR expression.

[001130] In one aspect, CAR-expressing cells, e.g., CARTs, are generated using a viral vector such as a gammaretroviral vector, e.g., a gammaretroviral vector described herein. CARTs generated using these vectors can have stable CAR expression.

[001131] In one aspect, CAR-expressing cells transiently express CAR vectors for 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 days after transduction. Transient expression of CARs can be effected by RNA CAR vector delivery. In one aspect, the CAR RNA is transduced into the T cell or the NK cell by electroporation.

[001132] A potential issue that can arise in patients being treated using transiently expressing CAR immune effector cells (e.g., T cells, NK cells) (particularly with murine scFv bearing CARTs) is anaphylaxis after multiple treatments.

[001133] Without being bound by this theory, it is believed that such an anaphylactic response might be caused by a patient developing humoral anti-CAR response, i.e., anti-CAR antibodies having an anti-IgE isotype. It is thought that a patient's antibody producing cells undergo a class switch from IgG isotype (that does not cause anaphylaxis) to IgE isotype when there is a ten to fourteen day break in exposure to antigen.

[001134] If a patient is at high risk of generating an anti-CAR antibody response during the course of transient CAR therapy (such as those generated by RNA transductions), CAR-expressing cell infusion breaks should not last more than ten to fourteen days.

## EXAMPLES

[001135] The invention is further described in detail by reference to the following experimental examples. These examples are provided for purposes of illustration only, and are not intended to be limiting unless otherwise specified. Thus, the invention should in no way be construed as being limited to the following examples, but rather, should be construed to encompass any and all variations which become evident as a result of the teaching provided herein.

[001136] Without further description, it is believed that one of ordinary skill in the art can, using the preceding description and the following illustrative examples, make and utilize the

compounds of the present invention and practice the claimed methods. The following working examples specifically point out various aspects of the present invention, and are not to be construed as limiting in any way the remainder of the disclosure.

**Example 1: Effects of mTOR Inhibition on Immunosenescence in the Elderly**

[001137] One of the pathways most clearly linked to aging is the mTOR pathway. The mTOR inhibitor rapamycin has been shown to extend lifespan in mice and improve a variety of aging-related conditions in old mice (Harrison, DE et al. (2009) *Nature* 460:392-395; Wilkinson JE et al. (2012) *Aging Cell* 11:675-682; and Flynn, JM et al. (2013) *Aging Cell* 12:851-862). Thus, these findings indicate that mTOR inhibitors may have beneficial effects on aging and aging-related conditions in humans.

[001138] An age-related phenotype that can be studied in a short clinical trial timeframe is immunosenescence. Immunosenescence is the decline in immune function that occurs in the elderly, leading to an increased susceptibility to infection and a decreased response to vaccination, including influenza vaccination. The decline in immune function with age is due to an accumulation of immune defects, including a decrease in the ability of hematopoietic stem cells (HSCs) to generate naïve lymphocytes, and an increase in the numbers of exhausted PD-1 positive lymphocytes that have defective responses to antigenic stimulation (Boraschi, D et al. (2013) *Sci. Transl. Med.*5:185ps8; Lages, CS et al. (2010) *Aging Cell* 9:785-798; and Shimatani, K et al., (2009) *Proc. Natl. Acad. Sci. USA* 106:15807-15812). Studies in elderly mice showed that 6 weeks of treatment with the mTOR inhibitor rapamycin rejuvenated HSC function leading to increased production of naïve lymphocytes, improved response to influenza vaccination, and extended lifespan (Chen, C et al. (2009) *Sci. Signal.* 2:ra75).

[001139] To assess the effects of mTOR inhibition on human aging-related phenotypes and whether the mTOR inhibitor RAD001 ameliorates immunosenescence, the response to influenza vaccine in elderly volunteers receiving RAD001 or placebo was evaluated. The findings presented herein suggest that RAD001 enhanced the response to influenza vaccine in elderly volunteers at doses that were well tolerated. RAD001 also reduced the percentage of programmed death (PD)-1 positive CD4 and CD8 T lymphocytes that accumulate with age.

These results show that mTOR inhibition has beneficial effects on immunosenescence in elderly volunteers.

[001140] As described herein, a 6 week treatment with the mTOR inhibitor RAD001, an analog of rapamycin, improved the response to influenza vaccination in elderly human volunteers.

## Methods

*Study population*

[001141] Elderly volunteers >= 65 years of age without unstable underlying medical diseases were enrolled at 9 sites in New Zealand and Australia. Exclusion criteria at screening included hemoglobin < 9.0 g/dL, white blood cell count <3,500/$mm^3$, neutrophil count <2,000/$mm^3$, or platelet count <125,000/$mm^3$, uncontrolled diabetes, unstable ischemic heart disease, clinically significant underlying pulmonary disease, history of an immunodeficiency or receiving immunosuppressive therapy, history of coagulopathy or medical condition requiring long-term anticoagulation, estimated glomerular filtration rate < 30 ml/min, presence of severe uncontrolled hypercholesterolemia (>350 mg/dL, 9.1 mmol/L) or hypertriglyceridemia (>500 mg/dL, 5.6 mmol/L).

[001142] Baseline demographics between the treatment arms were similar (Table 4). Of the 218 subjects enrolled, 211 completed the study. Seven subjects withdrew from the study. Five subjects withdrew due to adverse events (AEs), one subject withdrew consent, and one subject left the study as a result of a protocol violation.

Table 4: Demographic and Baseline characteristics of the Study Patients

| **Population** | | **RAD001 0.5 mg daily N=53** | **RAD001 5 mg weekly N=53** | **RAD001 20 mg weekly N=53** | **Placebo pooled N=59** | **Total N=218** |
|---|---|---|---|---|---|---|
| **Age (Years)** | **Mean (SD)** | 70.8 (5.0) | 72.0 (5.3) | 71.4 (5.2) | 71.1 (5.1) | 71.3 (5.2) |
| **Gender** | **Male– n (%)** | 34 (64%) | 27 (51%) | 32 (60%) | 31 (53%) | 124 (57%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **BMI* (kg/m2)** | **Mean (SD)** | 27.4 (4.2) | 28.8 (5.0) | 28.0 (4.1) | 28.0 (4.2) | 28.0 (4.4) |
| **Race - n (%)** | **Caucasian** | 48 (91%) | 50 (94%) | 46 (87%) | 54 (92%) | 198 (91%) |
| | **Other** | 5(9%) | 3 (6%) | 7 (13%) | 5 (8%) | 20 (9%) |

*The body-mass index is weight in kilograms divided by the square of the height in meters

*Study Design and Conduct*

[001143] From December 2011 to April 2012, 218 elderly volunteers were enrolled in a randomized, observer-blind, placebo-controlled trial. The subjects were randomized to treatment arms using a validated automated randomization system with a ratio of RAD001 to placebo of 5:2 in each treatment arm. The treatment arms were:

RAD001 0.5 mg daily or placebo

RAD001 5 mg weekly or placebo

RAD001 20 mg weekly or placebo

[001144] The trial was observer-blind because the placebo in the RAD001 0.5 mg daily and 20 mg weekly cohorts differed slightly from the RAD001 tablets in those cohorts. The study personnel evaluating the subjects did not see the study medication and therefore were fully blinded. The treatment duration for all cohorts was 6 weeks during which time subjects underwent safety evaluations in the clinic every 2 weeks. After subjects had been dosed for 4 weeks, RAD001 steady state levels were measured pre-dose and at one hour post dose. After completing the 6 week course of study drug, subjects were given a 2 week drug free break to reverse any possible RAD001-induced immunosuppression, and then were given a 2012 seasonal influenza vaccination (Agrippal®, Novartis Vaccines and Diagnostics, Siena, Italy) containing the strains H1N1 A/California/ 07/2009, H3N2 A/Victoria/210/2009, B/Brisbane/60/ 2008. Four weeks after influenza vaccination, subjects had serum collected for influenza titer measurements. Antibody titers to the 3 influenza vaccine strains as well as to 2 heterologous strains (A/H1N1 strain A/New Jersy/8/76 and A/H3N2 strain A/Victoria/361/11) were measured by standard hemagglutination inhibition assay (Kendal, AP et al. (1982) *Concepts and procedures for laboratory-based influenza surveillance. Atlanta: Centers for Disease Control and Prevention* B17-B35). Levels of IgG and IgM specific for the A/H1N1/California/07/2009 were measured in

serum samples taken before and 4 weeks after influenza vaccination as described previously (Spensieri, F. et al. (2013) *Proc. Natl. Acad. Sci. USA* 110:14330-14335). Results were expressed as fluorescence intensity.

[001145] All subjects provided written informed consent. The study was conducted in accordance with the principals of Good Clinical Practice and was approved by the appropriate ethics committees and regulatory agencies.

*Safety*

[001146] Adverse event assessment and blood collection for hematologic and biochemical safety assessments were performed during study visits. Adverse event information was also collected in diaries that subjects filled out at home during the 6 weeks they were on study drug. Data on all adverse events were collected from the time of informed consent until 30 days after the last study visit. Events were classified by the investigators as mild, moderate or severe.

*Statistical Analysis*

[001147] The primary analysis of geometric mean titer ratios was done using a normal Bayesian regression model with non-informative priors. This model was fitted to each antibody titer on the log scale. The primary outcome in each model was the Day 84 measurement. The Day 63 measurement was included in the outcome vector. The model fitted using SAS 9.2 proc mixed with the prior statement. The covariance structure of the matrix was considered as unstructured (option type=UN). A flat prior was used. For the secondary analysis of seroconversion rates, logistic regression was used.

[001148] The intention to treat population was defined as all subjects who received at least one full dose of study drug and who had no major protocol deviations impacting efficacy data. 199 out of the total of 218 subjects enrolled in the study were in the intention to treat population.

*Immunophenotyping*

[001149] Peripheral blood mononuclear cells were isolated from whole blood collected at 3 time points: baseline; after 6 weeks of study drug treatment; and at the end of study when subjects had been off study drug for 6 weeks and 4 weeks after influenza vaccination. Seventy-six PBMC subsets were analyzed by flow cytometry using 8-color immunophenotyping panels at the Human Immune Monitoring Center at Stanford University, CA, USA as described previously (Maecker, HT et al. (2012) *Nat Rev Immunol.* 12:191-200). Seventy-six PBMC subsets were

analyzed by flow cytometry using 8-color lyophilized immunophenotyping panels (BD Lyoplate, BD Biosciences, San Diego, CA). PBMC samples with viability >80% and yield of $2x10^6$ cells or greater were included in the analysis.

[001150] Relative changes of the immunophenotypes from baseline to Week 6 of study drug treatment and from baseline to the end of study (Week 12) were calculated for each of the RAD001 dosing cohorts. Student T test was conducted to examine if the relative change of the immunophenotypes from baseline to the two blood sampling time points was significantly different from zero, respectively, within each dosing group after adjusting for placebo effect. Missing data imputation in treatment effect analysis was not conducted. Therefore if a patient has a missing phenotype data at baseline, this patient was not be included in the analysis for this phenotype. If a patient had a missing phenotype data at 6 or 12 weeks, then this patient did not contribute to the analysis of this phenotype for the affected timepoint.

[001151] 608 tests in 76 phenotypes under 3 dosing groups were conducted to compare the treatment effect against the placebo effect. Stratified false discovery rate (FDR) control methodology was implemented to control the occurrence of false positives associated with multiple testing yet provide considerably better power. The cell type group was taken as the stratification factor and conducted FDR (q-value) calculation within each stratum respectively. All null-hypotheses were rejected at 0.05 significance level with corresponding q-value $\leq 0.1$. The multiple testing adjustment strategy with rejecting at 0.05 significance level and corresponding $q<0.1$ ensured that less than 10% of the findings are false.

[001152] In a second analysis, the immunophenotype changes between pooled treatment and placebo groups, where all three RAD001 dosing groups were combined. To determine which immunophenotype changes differed between the treated and placebo groups, within-patient cell count ratios for each measured phenotype were calculated between baseline and Week 6 of study drug treatment and between baseline and the end of study (Week 12). The ratios were log transformed, and analyzed by analysis of covariance at each time point in order to detect a difference between the pooled treatment and placebo groups. 152 tests in 76 phenotypes were performed to compare the pooled treatment effect against the placebo effect. Stratified false discovery rate (FDR) control methodology was implemented to control the occurrence of false positives associated with multiple testing yet provide considerably better power (Benjamini, Y.

et al. (1995) *J. Roy. Statist.* 57:289-300; and Sun, L. et al. (2006) *Genet. Epidemiol.* 30:519-530). The cell type group was taken as the stratification factor and FDR (q-value) calculation was conducted within each stratum respectively. All null-hypotheses at 0.05 significance level and q-value less than 20% were rejected. This can be interpreted as rejecting only those hypotheses with P values less than 0.05 and less than 20% probability that the each observed significant result is due to multiple testing.

**Results**

[001153] In general, RAD001 was well tolerated, particularly the 0.5 mg daily and 5 mg weekly dosing regimens. No deaths occurred during the study. Three subjects experienced four serious adverse events (SAEs) that were assessed as unrelated to RAD001. The 4 SAEs were retinal hemorrhage of the left eye with subsequent blindness in a subject with normal platelet counts who had completed a 6 week course of 5 mg weekly RAD001 6 weeks previously; severe back pain in a subject treated with placebo and severe gastroenteritis in a subject treated with placebo. A list of treatment-related adverse events (AEs) with an incidence >2% in any treatment group is provided in Table 5. The most common RAD001-related AE was mouth ulcer that, in the majority of cases, was of mild severity. Overall, subjects who received RAD001 had a similar incidence of severe AEs as those treated with placebo. Only one severe AE was assessed as related to RAD001 mouth ulcers in a subject treated with 20 mg weekly RAD001.

Table 5: Incidence of treatment-related AEs >2% in any treatment group by preferred term

| | **RAD001 0.5 mg daily N=53 n (%)** | **RAD001 5 mg weekly N=53 n (%)** | **RAD001 20 mg weekly N=53 n (%)** | **Placebo, pooled N=59 n (%)** | **Total N=218 n (%)** |
|---|---|---|---|---|---|
| Total AE(s) | 35 | 46 | 109 | 21 | 211 |
| Patients with AE(s) | 22 (41.5%) | 20 (37.7%) | 27 (50.9%) | 12 (20.3%) | 81 (37.2%) |
| Mouth ulceration | 6 (11.3%) | 2 (3.8%) | 9 (17.0%) | 3 (5.1%) | 20 (9.2%) |
| Headache | 0 | 2 (3.8%) | 9 (17.0%) | 1 (1.7%) | 12 (5.5%) |
| Blood cholesterol increased | 2 (3.8%) | 2 (3.8%) | 2 (3.8%) | 0 | 6 (2.8%) |
| Diarrhea | 1 (1.9%) | 4 (7.5%) | 1 (1.9%) | 0 | 6 (2.8%) |
| Dyspepsia | 0 | 3 (5.7%) | 2 (3.8%) | 1 (1.7%) | 6 (2.8%) |
| Fatigue | 0 | 2 (3.8%) | 4 (7.5%) | 0 | 6 (2.8%) |
| Low density lipoprotein increased | 2 (3.8%) | 1 (1.9%) | 2 (3.8%) | 0 | 5 (2.3%) |
| Tongue ulceration | 3 (5.7%) | 1 (1.9%) | 0 | 1 (1.7%) | 5 (2.3%) |
| Insomnia | 1 (1.9%) | 2 (3.8%) | 1 (1.9%) | 0 | 4 (1.8%) |
| Dry mouth | 0 | 0 | 2 (3.8%) | 1 (1.7%) | 3 (1.4%) |
| Neutropenia | 0 | 0 | 3 (5.7%) | 0 | 3 (1.4%) |
| Oral pain | 0 | 2 (3.8%) | 1 (1.9%) | 0 | 3 (1.4%) |
| Pruritus | 0 | 2 (3.8%) | 1 (1.9%) | 0 | 3 (1.4%) |
| Conjunctivitis | 0 | 2 (3.8%) | 0 | 0 | 2 (0.9%) |
| Erythema | 0 | 2 (3.8%) | 0 | 0 | 2 (0.9%) |
| Limb discomfort | 0 | 2 (3.8%) | 0 | 0 | 2 (0.9%) |
| Mucosal inflammation | 0 | 0 | 2 (3.8%) | 0 | 2 (0.9%) |

| | RAD001 0.5 mg daily N=53 n (%) | RAD001 5 mg weekly N=53 n (%) | RAD001 20 mg weekly N=53 n (%) | Placebo, pooled N=59 n (%) | Total N=218 n (%) |
|---|---|---|---|---|---|
| Paresthesia oral | 2 (3.8%) | 0 | 0 | 0 | 2 (0.9%) |
| Stomatitis | 0 | 0 | 2 (3.8%) | 0 | 2 (0.9%) |
| Thrombocytopenia | 0 | 0 | 2 (3.8%) | 0 | 2 (0.9%) |
| Urinary tract infection | 0 | 0 | 2 (3.8%) | 0 | 2 (0.9%) |

[001156] The ability of RAD001 to improve immune function in elderly volunteers was evaluated by measuring the serologic response to the 2012 seasonal influenza vaccine. The hemagglutination inhibition (HI) geometric mean titers (GMT) to each of the 3 influenza vaccine strains at baseline and 4 weeks after influenza vaccination are provided in Table 6. The primary analysis variable was the HI GMT ratio (4 weeks post vaccination/baseline). The study was powered to be able to demonstrate that in at least 2 out of 3 influenza vaccine strains there was 1) a $\geq$ 1.2-fold GMT increase relative to placebo; and 2) a posterior probability no lower than 80% that the placebo-corrected GMT ratio exceeded 1. This endpoint was chosen because a 1.2-fold increase in the influenza GMT ratio induced by the MF-59 vaccine adjuvant was associated with a decrease in influenza illness (Iob, A et al. (2005) *Epidemiol Infect* 133:687-693).

Table 6. HI GMTs for each influenza vaccine strain at baseline and at 4 weeks after influenza vaccination

| Influenza Vaccine Strain | | Time | RAD001 0.5mg daily N=50 | RAD001 5mg weekly N=49 | RAD001 20mg weekly N=49 | Placebo N=55 |
|---|---|---|---|---|---|---|
| **A/H1N1** | **GMT (CV%)** | **Baseline** | 102.8 (186.9) | 84.2 (236.4) | 90.1 (188.4) | 103.2 (219.7) |
| | | **Week 4** | 190.2 | 198.73(195.6) | 129.7 | 169.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (236.9) | | (175.9) | (259.8) |
| | **GMT ratio (CV%)** | | 2.6 (302.5) | 2.5 (214.3) | 1.8 (201.5) | 2.0 (132.7) |
| **A/H3N2** | **GMT (CV%)** | **Baseline** | 106.8 (168.2) | 126.04 (162.6) | 137.1 (211.5) | 131.7 (162.3) |
| | | **Week 4** | 194.4 (129.1) | 223.0 (118.8) | 223.0 (163.6) | 184.3 (153.2) |
| | **GMT ratio (CV%)** | | 2.1 (152.6) | 2.0 (189.2) | 2.1 (277.3) | 1.6 (153.6) |
| **B** | **GMT (CV%)** | **Baseline** | 44.2 (96.6) | 64.8 (87.3) | 58.0 (156.0) | 57.0 (112.6) |
| | | **Week 4** | 98.4 (94.8) | 117.3 (99.9) | 99.2 (124.1) | 114.6 (136.7) |
| | **GMT ratio (CV%)** | | 2.5 (111.2) | 2.2 (112.8) | 2.1 (126.5) | 2.2 (109.2) |

Baseline indicates 2 weeks prior to influenza vaccination
Week 4 indicates 4 weeks after influenza vaccination
N is number of subjects per cohort
GMT is geometric mean titer
GMT ratio is the GMT at week 4 post vaccination/GMT at baseline
CV% indicates coefficient of variation

[001157] In the intent-to-treat (ITT) population, the low, immune enhancing, dose RAD001 (0.5 mg daily or 5 mg weekly) cohorts but not higher dose (20 mg weekly) cohort met the primary endpoint of the study (Figure 1A). This demonstrates that there is a distinct immunomodulatory mechanism of RAD001 at the lower doses, and that at the higher dose the known immunosuppressive effects of mTOR inhibition may come into play. Furthermore, the results suggest a trend toward improved immune function in the elderly after low, immune enhancing, dose RAD001 treatment.

[001158] In a subgroup analysis, the subset of subjects with low baseline influenza titers (≤ 1:40) experienced a greater RAD001-associated increase in titers than did the ITT population (Figure 1B). These data show that RAD001 is particularly effective at enhancing the influenza vaccine response of subjects who did not have protective (>1:40) titers at baseline, and therefore were at highest risk of influenza illness.

[001159] Scatter plots of RAD001 concentration versus increase in titer to each influenza vaccine strain show an inverse exposure/response relationship (Figure 2). Modeling and simulation based on mTOR mediated phosphorylation of S6 kinase (S6K) predicts that the 20 mg weekly dosing regimen inhibits mTOR-mediated S6K activity almost completely, the 5 mg weekly dosing regimen inhibits S6K activity by over 50%, and the 0.5 mg daily dosing regiment inhibits S6K phosphorylation by approximately 38% during the dosing interval (Tanaka, C et al. (2008) *J. Clin. Oncol* 26:1596-1602). Thus, partial mTOR inhibition, e.g., mTOR-mediated S6K phosphorylation, with low, immune enhancing, dose RAD001 may be as, if not more effective, than near complete mTOR inhibition with high dose RAD001 at enhancing the immune response of the elderly.

[001160] Rates of seroconversion 4 weeks after influenza vaccination were also evaluated. Seroconversion was defined as the change from a negative pre-vaccination titer (i.e., HI titer <1:10) to post-vaccination HI titer ≥ 1:40 or at least 4-fold increase from a non-negative (≥ 1:10) pre-vaccination HI titer. In the intention-to-treat population, seroconversion rates for the H3N2 and B strains were increased in the RAD001 as compared to the placebo cohorts although the increases did not meet statistical significance (Table 7). In the subpopulation of subjects with baseline influenza titers <= 1:40, RAD001 treatment also increased the rates of seroconversion to the H3N2 and B strains, and these results reached statistical significance for the B strain in the 0.5 mg daily dosing cohort. These data further show that RAD001 enhanced the serologic response to influenza vaccination in the elderly.

Table 7: Percent of subjects with seroconversion to influenza 4 weeks after vaccination

| | **Placebo N=54** | **0.5 mg N=48** | **5 mg N=49** | **20 mg N=48** |
|---|---|---|---|---|
| Intention to Treat Population | | | | |
| H1N1 | 24 | 27 | 27 | 17 |
| H3N2 | 17 | 27 | 24 | 25 |

| | | | | |
|---|---|---|---|---|
| B | 17 | 27 | 22 | 19 |
| Subjects with Baseline Titers <=40 | | | | |
| H1N1 | 40 | 42 | 45 | 36 |
| H3N2 | 42 | 64 | 53 | 71 |
| B | 16 | 40* | 33 | 28 |

* Odds ratio for seroconversion between RAD001 and Placebo significantly different than 1 (two-sided p-value < 0.05 obtained by logistic regression with treatment as fixed effect)

[001162] Current seasonal influenza vaccines often provide inadequate protection against continuously emerging strains of influenza that present as variants of previously circulating viruses. However, mice vaccinated against influenza in the presence of the mTOR inhibitor rapamycin, as compared to placebo, developed a broader serologic response to influenza. The broader serologic response included antibodies to conserved epitopes expressed by multiple subtypes of influenza that provided protection against infection with heterologous strains of influenza not contained in the vaccine (Keating, R et al. (2013) *Nat Immunology* 14:2166-2178). To determine if RAD001 broadened the serologic response to influenza in the elderly volunteers, HI titers to 2 heterologous strains of influenza not contained in the influenza vaccine (A/H1N1 strain A/New Jersey/8/76 and A/H3N2 strain A/Victoria/361/11) were measured. The increase in the HI GMT ratios for the heterologous strains was higher in the RAD001 as compared to placebo cohorts (Figure 3). In addition, seroconversion rates for the heterologous strains were higher in the RAD001 as compared to placebo cohorts. The increase in seroconversion rates in the 5 and 20 mg weekly RAD001 dosing cohorts was statistically significant for the H3N2 heterologous strain (Table 8). The H3N2 seroconversion rate for the pooled RAD001 cohorts was 39% versus 20% for the placebo cohort (p=0.007). The results presented herein suggest that mTOR inhibition broadens the serologic response of elderly volunteers to influenza vaccination, and increases antibody titers to heterologous strains of influenza not contained in the seasonal influenza vaccine.

[001163] Broadened serologic response to heterologous strains of influenza in mice treated with rapamycin has been associated with an inhibition of class switching in B cells and an increase in anti-influenza IgM levels (Keating, R. et al. (2013) *Nat Immunol* 14:2166-2178). However, inhibition of class switching may not be involved in the broadened serologic response in humans treated with RAD001 because the post-vaccination anti-influenza IgM and IgG levels did not differ between RAD001 and placebo treated cohorts (Figure 4).

Table 8: Percentage of subjects who seroconvert to heterologous strains of influenza 4 weeks after seasonal influenza vaccination

| | **Placebo, pooled** | **RAD001 0.5mg daily** | **RAD001 5 mg weekly** | **RAD001 20 mg weekly** |
|---|---|---|---|---|
| A/H1N1 strain: A/NewJersey/8/76 | 7% | 17% | 16% | 8% |
| A/H3N2 strain: A/Victoria/361/11 | 20% | 38% | 39%* | 40% * |

* Odds ratio for seroconversion between RAD001 and Placebo significantly different than 1 (two-sided p-value < 0.05 obtained by logistic regression with treatment as fixed effect)

[001165] To address the mechanism by which RAD001 enhanced immune function in elderly volunteers, immunophenotyping was performed on PBMC samples obtained from subjects at baseline, after 6 weeks of study drug treatment and 4 weeks after influenza vaccination (6 weeks after study drug discontinuation). Although the percentage of most PBMC subsets did not differ between the RAD001 and placebo cohorts, the percentage of PD-1 positive CD4 and CD8 cells was lower in the RAD001 as compared to placebo cohorts (Figure 5). PD-1 positive CD4 and CD8 cells accumulate with age and have defective responses to antigen stimulation because PD-1 inhibits T cell receptor-induced T cell proliferation, cytokine production and cytolytic function (Lages, CS et al. (2010) *Aging Cell* 9:785-798). There was an increase in percentage of PD-1 positive T cells over time in the placebo cohort. At week 12 (4 weeks post-vaccination) this increase may have been due to influenza vaccination since influenza virus has been shown to increase PD-1 positive T cells (Erikson, JJ et al. (2012) *JCI* 122:2967-2982). However the percentage of CD4 PD-1 positive T cells decreased from baseline at week 6 and 12 in all RAD001 cohorts (Figure 5A). The percentage of CD8 PD-1 positive cells also decreased from baseline at both week 6 and 12 in the two lower dose RAD001 cohorts (Figure 5B). The percentage of PD-1 negative CD4 T cells was evaluated and increased in the RAD001 cohorts as compared to the placebo cohorts (Figure 5C).

[001166] Under more stringent statistical analysis, where the results from the RAD001 cohorts were pooled and adjusted for differences in baseline PD-1 expression, there was a statistically significant decrease of 30.2% in PD-1 positive CD4 T cells at week 6 in the pooled RAD cohort

(n=84) compared to placebo cohort (n=25) with p=0.03 (q=0.13) (Figure 6A). The decrease in PD-1 positive CD4 T cells at week 12 in the pooled RAD as compared to the placebo cohort is 32.7% with p=0.05 (q=0.19). Figure 6B shows a statistically significant decrease of 37.4% in PD-1 positive CD8 T cells at week 6 in the pooled RAD001 cohort (n=84) compared to placebo cohort (n=25) with p=0.008 (q=0.07). The decrease in PD-1 positive CD8 T cells at week 12 in the pooled RAD001 as compared to the placebo cohort is 41.4% with p=0.066 (q=0.21). Thus, the results from Figures 5 and 6 together suggest that the RAD001-associated decrease in the percentage of PD-1 positive CD4 and CD8 T cells may contribute to enhanced immune function.

**Conclusion**

[001167] In conclusion, the data presented herein show that the mTOR inhibitor RAD001 ameliorates the age-related decline in immunological function of the human elderly as assessed by response to influenza vaccination, and that this amelioration is obtained with an acceptable risk/benefit balance. In a study of elderly mice, 6 weeks treatment with the mTOR inhibitor rapamycin not only enhanced the response to influenza vaccination but also extended lifespan, suggesting that amelioration of immunosenescence may be a marker of a more broad effect on aging-related phenotypes.

[001168] Since RAD001 dosing was discontinued 2 weeks prior to vaccination, the immune enhancing effects of RAD001 may be mediated by changes in a relevant cell population that persists after discontinuation of drug treatment. The results presented herein show that RAD001 decreased the percentage of exhausted PD-1 positive CD4 and CD8 T cells as compared to placebo. PD-1 expression is induced by TCR signaling and remains high in the setting of persistent antigen stimulation including chronic viral infection. While not wishing to be bound by theory, is possible that RAD001 reduced chronic immune activation in elderly volunteers and thereby led to a decrease in PD-1 expression. RAD001 may also directly inhibit PD-1 expression as has been reported for the immunophilin cyclosporine A (Oestreich, KJ et al. (2008) *J Immunol.* 181:4832-4839). A RAD001-induced reduction in the percentage of PD-1 positive T cells is likely to improve the quality of T cell responses. This is consistent with previous studies showing that mTOR inhibition improved the quality of memory CD8 T cell response to vaccination in mice and primates (Araki, K et al. (2009) *Nature* 460:108-112). In aged mice, mTOR inhibition has also been shown to increase the number of hematopoietic stem cells, leading to increased production of naïve lymphocytes (Chen, C et al. (2009) *Sci Signal* 2:ra75).

Although significant differences in the percentages of naïve lymphocytes in the RAD001 versus placebo cohorts were not detected in this example, this possible mechanism may be further investigated.

[001169] The mechanism by which RAD001 broadened the serologic response to heterologous strains of influenza may be further investigated. Rapamycin has also been shown to inhibit class switching in B cells after influenza vaccination. As a result, a unique repertoire of anti-influenza antibodies was generated that promoted cross-strain protection against lethal infection with influenza virus subtypes not contained in the influenza vaccine (Keating, R et al. (2013) *Nat Immunol.* 14:2166-2178). The results described herein did not show that RAD001 altered B cell class switching in the elderly subjects who had discontinued RAD001 2 weeks prior to influenza vaccination.Although the underlying mechanism requires further elucidation, the increased serologic response to heterologous influenza strains described herein may confer enhanced protection to influenza illness in years when there is a poor match between the seasonal vaccine and circulating strains of influenza in the community.

[001170] The effect of RAD001 on influenza antibody titers was comparable to the effect of the MF59 vaccine adjuvant that is approved to enhance the response of the elderly to influenza vaccination (Podda, A (2001) *Vaccine* 19:2673-2680). Therefore, RAD001-driven enhancement of the antibody response to influenza vaccination may translate into clinical benefit as demonstrated with MF59-adjuvanted influenza vaccine in the elderly (Iob, A et al. (2005) *Epidemiol Infect.* 133:687-693). However, RAD001 is also used to suppress the immune response of organ transplant patients. These seemingly paradoxical findings raise the possibility that the immunomodulatory effects of mTOR inhibitors may be dose and/or antigen-dependent (Ferrer, IR et al. (2010) *J Immunol.* 185:2004-2008). A trend toward an inverse RAD001 exposure/vaccination response relationship was seen herein. It is possible that complete mTOR inhibition suppresses immune function through the normal cyclophilin-rapamycin mechanism, whereas partial mTOR inhibition, at least in the elderly, enhances immune function due to a distinct aging-related phenotype inhibition. Of interest, mTOR activity is increased in a variety of tissues including hematopoietic stem cells in aging animal models (Chen C. et al. (2009) *Sci Signal* 2:ra75 and Barns, M. et al. (2014) *Int J Biochem Cell Biol.* 53:174-185). Thus, turning down mTOR activity to levels seen in young tissue, as opposed to more complete suppression of mTOR activity, may be of clinical benefit in aging indications.

[001171] The safety profile of mTOR inhibitors such as RAD001 in the treatment of aging-related indications has been of concern. The toxicity of RAD001 at doses used in oncology or organ transplant indications includes rates of stomatitis, diarrhea, nausea, cytopenias, hyperlipidemia, and hyperglycemia that would be unacceptable for many aging-related indications. However, these AEs are related to the trough levels of RAD001 in blood. Therefore the RAD001 dosing regimens used in this study were chosen to minimize trough levels. The average RAD001 trough levels of the 0.5 mg daily, 5 mg weekly and 20 mg weekly dosing cohorts were 0.9 ng/ml, below 0.3 ng/ml (the lower limit of quantification), and 0.7 ng/ml, respectively. These trough levels are significantly lower than the trough levels associated with dosing regimens used in organ transplant and cancer patients. In addition, the limited 6 week course of treatment decreased the risk of adverse events. These findings suggest that the dosing regimens used in this study may have an acceptable risk/benefit for some conditions of the elderly. Nonetheless, significant numbers of subjects in the experiments described hereindeveloped mouth ulcers even when dosed as low as 0.5 mg daily. Therefore the safety profile of low, immune enhancing, dose RAD001 warrants further study. Development of mTOR inhibitors with cleaner safety profiles than currently available rapalogs may provide better therapeutic options in the future for aging-associated conditions.

**Example 2: Enhancement of Immune Response to Vaccine in Elderly Subjects**

[001172] Immune function declines in the elderly, leading to an increase incidence of infection and a decreased response to vaccination. As a first step in determining if mTOR inhibition has anti-aging effects in humans, a randomized placebo-controlled trial was conducted to determine if the mTOR inhibitor RAD001 reverses the aging-related decline in immune function as assessed by response to vaccination in elderly volunteers. In all cases, appropriate patent consents were obtained and the study was approved by national health authorities.

[001173] The following 3 dosing regimens of RAD001 were used in the study:

20 mg weekly (trough level: 0.7 ng/ml)

5 mg weekly (trough level was below detection limits)

0.5 mg daily (trough level: 0.9 ng/ml)

[001174] These dosing regimens were chosen because they have lower trough levels than the doses of RAD001 approved for transplant and oncology indications. Trough level is the lowest level of a drug in the body. The trough level of RAD001 associated with the 10 mg daily oncology dosing regimen is approximately 20 ng/ml. The trough level associated with the 0.75-1.5 mg bid transplant dosing regimen is approximately 3 ng/ml. In contrast, the trough level associated with the dosing regimens used in our immunization study were 3-20 fold lower.

[001175] Since RAD001-related AEs are associated with trough levels, the 3 dosing regimens were predicted to have adequate safety for normal volunteers. In addition, the 3 doses were predicted to give a range of mTOR inhibition. P70 S6 Kinase (P70 S6K) is a downstream target that is phosphorylated by mTOR. Levels of P70 S6K phosphorylation serve as a measure of mTOR activity. Based on modeling and simulation of P70 S6K phosphorylation data obtained in preclinical and clinical studies of RAD001, 20 mg weekly was predicted to almost fully inhibit mTOR activity for a full week, whereas 5 mg weekly and 0.5 mg daily were predicted to partially inhibit mTOR activity.

[001176] Elderly volunteers >= 65 years of age were randomized to one of the 3 RAD001 treatment groups (50 subjects per arm) or placebo (20 subjects per arm). Subjects were treated with study drug for 6 weeks, given a 2 week break, and then received influenza (Aggrippal, Novartis) and pneumoccal (Pneumovax 23, Merck), vaccinations. Response to influenza vaccination was assessed by measuring the geometric mean titers (GMTs) by hemagglutination inhibition assay to the 3 influenza strains (H1N1, H3N2 and B influenza subtypes) in the influenza vaccine 4 weeks after vaccination. The primary endpoints of the study were (1) safety and tolerability and (2) a 1.2 fold increase in influenza titers as compared to placebo in 2/3 of the influenza vaccine strains 4 weeks after vaccination. This endpoint was chosen because a 1.2 fold increase in influenza titers is associated with a decrease in influenza illness post vaccination, and therefore is clinically relevant. The 5 mg weekly and 0.5 mg daily doses were well tolerated and unlike the 20 mg weekly dose, met the GMT primary endpoint (Figure 1A). Not only did RAD001 improve the response to influenza vaccination, it also improved the response to pneumococcal vaccination as compared to placebo in elderly volunteers. The pneumococcal vaccine contains antigens from 23 pneumococcal serotypes. Antibody titers to 7 of the serotypes were measured in our subjects. Antibody titers to 6/7 serotypes were increased in all 3 RAD cohorts compared to placebo.

[001177] The combined influenza and pneumococcal titer data suggest that partial (less than 80-100%) mTOR inhibition is more effective at reversing the aging-related decline in immune function than more complete mTOR inhibition.

**Example 3: Low dose mTOR inhibition increases energy and exercise**

[001178] In preclinical models, mTOR inhibition with the rapalog rapamycin increases spontaneous physical activity in old mice (Wilkinson et al. Rapamycin slows aging in mice. (2012) Aging Cell; 11:675-82). Of interest, subjects in the 0.5 mg daily dosing cohort described in Example 2 also reported increased energy and exercise ability as compared to placebo in questionnaires administered one year after dosing (Figure 7). These data suggest that partial mTOR inhibition with rapalogs may have beneficial effects on aging-related morbidity beyond just immune function.

**Example 4: P70 S6 kinase inhibition with RAD001**

[001179] Modeling and simulation were performed to predict daily and weekly dose ranges of RAD001 that are predicted to partially inhibit mTOR activity. As noted above, P70 S6K is phosphorylated by mTOR and is the downstream target of mTOR that is most closely linked to aging because knockout of P70 S6K increases lifespan. Therefore modeling was done of doses of RAD001 that partially inhibit P70 S6K activity. Weekly dosing in the range of >= 0.1 mg and < 20 mg are predicted to achieve partial inhibition of P70 S6K activity (Figure 8).

[001180] For daily dosing, concentrations of RAD001 from 30 pM to 4 nM partially inhibited P70 S6K activity in cell lines (Table 9). These serum concentrations are predicted to be achieved with doses of RAD001 >= 0.005 mg to < 1.5 mg daily.

Table 9: Percent inhibition of P70 S6K activity in HeLa cells *in vitro*

| RAD001 concentration | 0 | 6 pM | 32 pM | 160 pM | 800 pM | 4 nM | 20 nM |
|---|---|---|---|---|---|---|---|
| % P70 S6K inhibition | 0 | 0 | 18 | 16 | 62 | 90 | 95 |

*Conclusion*

[001181] Methods of treating aging-related morbidity, or generally enhancing an immune response, with doses of mTOR inhibitors that only partially inhibit P70 S6K. The efficacy of partial mTOR inhibition with low doses of RAD001 in aging indications is an unexpected finding. RAD001 dose ranges between >= 0.1 mg to < 20 mg weekly and >= 0.005 mg to < 1.5 mg daily will achieve partial mTOR inhibition and therefore are expected to have efficacy in aging-related morbidity or in the enhancement of the immune response.

**Example 5: PD-1 CAR**

[001182] The PD-1CAR in this example comprises the extracellular domain (ECD) of inhibitory molecules, Programmed Death 1 (PD-1), fused to a transmembrane domain and intracellular signaling domains such as 4-1BB and CD3 zeta. In one embodiment, the PD-1 CAR can be used alone. In one embodiment, the PD-1 CAR can be used in combination with another CAR, e.g., CD19CAR. In one embodiment, the PD-1 CAR improves the persistence of the T cell. In one embodiment, the CAR is a PD-1 CAR comprising the extracellular domain of PD-1 indicated as underlined in SEQ ID NO: 26 (PD-1 domain is underlined)

[001183] Malpvtalllplalllhaarppgwfldspdrpwnpptfspallvvtegdnatftcsfsntsesfvlnwyrmspsnqtdkl aafpedrsqpgqdcrfrvtqlpngrdfhmsvvrarrndsgtylcgaislapkaqikeslraelrvterraevptahpspsprpagqfqtlvt ttpaprpptpaptiasqplslrpeacrpaaggavhtrgldfacdiyiwaplagtcgvlllslvitlyckrgrkkllyifkqpfmrpvqttqeed gcscrfpeeeeggcelrvkfsrsadapaykqgqnqlynelnlgrreeydvldkrrgrdpemggkprrknpqeglynelqkdkmaea yseigmkgerrrgkghdglyqglstatkdtydalhmqalppr SEQ ID NO: 26

[001184] The corresponding nucleotide sequence for the PD-1 CAR is shown below, with the PD-1 ECD underlined below in SEQ ID NO: 27 (PD-1 domian is underlined)

[001185] Atggccctccctgtcactgccctgcttctcccctcgcactcctgctccacgccgctagaccacccggatggtttctggact ctccggatcgcccgtggaatcccccaaccttctcaccggcactcttggttgtgactgagggcgataatgcgaccttcacgtgctcgttctcca acacctccgaatcattcgtgctgaactggtaccgcatgagcccgtcaaaccagaccgacaagctcgccgcgtttccggaagatcggtcgca accgggacaggattgtcggttccgcgtgactcaactgccgaatggcagagacttccacatgagcgtggtccgcgctaggcgaaacgactc cgggacctacctgtgcggagccatctcgctggcgcctaaggcccaaatcaaagagagcttgagggccgaactgagagtgaccgagcgc agagctgaggtgccaactgcacatccatccccatcgcctcggcctgcggggcagtttcagaccctggtcacgaccactccggcgccgcg cccaccgactccggccccaactatcgcgagccagcccctgtcgctgaggccggaagcatgccgccctgccgccggaggtgctgtgcata

cccggggattggacttcgcatgcgacatctacatttgggctcctctcgccggaacttgtggcgtgctccttctgtccctggtcatcaccctgta
ctgcaagcggggtcggaaaaagcttctgtacattttcaagcagcccttcatgaggcccgtgcaaaccacccaggaggaggacggttgctc
ctgccggttccccgaagaggaagaaggaggttgcgagctgcgcgtgaagttctcccggagcgccgacgcccccgcctataagcagggc
cagaaccagctgtacaacgaactgaacctgggacggcgggaagagtacgatgtgctggacaagcggcgcggccgggaccccgaaatg
ggcgggaagcctagaagaaagaaccctcaggaaggcctgtataacgagctgcagaaggacaagatggccgaggcctactccgaaattg
gatgaagggagagcggcggaggggaaaggggcacgacggcctgtaccaaggactgtccaccgccaccaaggacacatacgatgcc
ctgcacatgcaggcccttcccccctcgc SEQ ID NO: 27

[001186] Other examples of inhibitory molecules in include PD1, CTLA4, TIM3, LAG3, VISTA, BTLA, TIGIT, LAIR1, CD160, 2B4 and TGFR beta. PD1 is an inhibitory member of the CD28 family of receptors that also includes CD28, CTLA-4, ICOS, and BTLA. PD-1 is expressed on activated B cells, T cells and myeloid cells (Agata et al. 1996 Int. Immunol 8:765-75). Two ligands for PD1, PD-L1 and PD-L2 have been shown to downregulate T cell activation upon binding to PD1 (Freeman et a. 2000 J Exp Med 192:1027-34; Latchman et al. 2001 Nat Immunol 2:261-8; Carter et al. 2002 Eur J Immunol 32:634-43). PD-L1 is abundant in human cancers (Dong et al. 2003 J Mol Med 81:281-7; Blank et al. 2005 Cancer Immunol. Immunother 54:307-314; Konishi et al. 2004 Clin Cancer Res 10:5094). Immune suppression can be reversed by inhibiting the local interaction of PD1 with PD-L1.

[001187] Jurkat cells with NFAT-LUC reporter (JNL) were grown to the density of 0.5 x $10^6$/ml in Jurket cell growth media with puromycin at 0.5 μg/ml. For each transfection 3 x $10^6$ cells were spin down at 100g for 10 minutes. Four μg DNA per construct were used per transfection. Amaxa Nucleofector solution V and supplement I was mixed and 100 μl was added into the tube with DNA construct. The mixture was then added to the cells and transferred to the electroporation cuvette. Electroporation was done under setting X-001 using Amaxa Nucleofector II Device. 0.5 ml of growth media was added immediately after eletroporation and the mixture were transferred into 2 ml growth media in one well of the 6-well plate. After two hours, the rapalogue compound at various concentrations was added to cells. The cells were applied to tissue culture plate wells that were coated by the target. Tissue culture plate was coated with 5 μg/ml of PDL1-Fc or IgG1-Fc or any target for 2 hrs at 37°C, then blocked with the blocking buffer (DPBS with 5% serum) for 30 minutes. The transfected cells were added to the target plate with 100 μl per well and incubated further for 16 hrs. Luciferase One Glo reagent

100 µl was added per well. The samples were incubated for 5 min at 37°C and then luminescence is measured using Envision plate reader.

[001188] The PD1 CAR construct comprises PD1-ECD –TM – 4-1BB - CD3zeta. This construct may improve the persistence of cells transfected with the construct, e.g., CART cells transfected with PD1 CAR.

[001189] As shown in FIG. 9: PD1 CAR showed significant PD1 induced activation of NFAT inducible promoter driven luciferase activity, as compared to the control treatment by IgG1-Fc. This suggest that PD1 interaction with PDL-1 is sufficient in causing clustering of PD1 on Jurket cell surface and triggers the strong activation of the NFAT pathway.

**Example 6: Low dose RAD001 stimulates CART proliferation in a cell culture model**

[001190] The effect of low doses of RAD001 on CAR T cell proliferation in vitro was evaluated by co-culturing CART-expressing cells with target cells in the presence of different concentrations of RAD001.

[001191] **Materials and Methods**

*[001192] Generation of CAR-transduced T cells*

[001193] A humanized, anti-human CD19 CAR (huCART19) lentiviral transfer vector was used to produce the genomic material packaged into VSVg pseudotyped lentiviral particles. The amino acid and nucleotide sequence of the humanized anti-human CD19 CAR (huCART19) is CAR 1, ID 104875, described in PCT publication, WO2014/153270, filed March 15, 2014, and is designated SEQ ID NOs. 85 and 31 therein.

[001194] Lentiviral transfer vector DNA is mixed with the three packaging components VSVg env, gag/pol and rev in combination with lipofectamine reagent to transfect Lenti-X 293T cells. Medium is changed after 24h and 30h thereafter, the virus-containing media is collected, filtered and stored at -80°C. CARTs are generated by transduction of fresh or frozen naïve T cells obtained by negative magnetic selection of healthy donor blood or leukopak. T cells are activated by incubation with anti-CD3/anti-CD28 beads for 24h, after which viral supernatant or concentrated virus (MOI=2 or 10, respectively) is added to the cultures. The modified T cells are allowed to expand for about 10 days. The percentage of cells transduced (expressing the CARs

on the cell surface) and the level of CAR expression (relative fluorescence intensity, Geo Mean) are determined by flow cytometric analysis between days 7 and 9. The combination of slowing growth rate and T cell size approaching ~350 fL determines the state for T cells to be cryopreserved for later analysis.

*[001195] Evaluating proliferation of CARTs*

[001196] To evaluate the functionality of CARTs, the T cells are thawed and counted, and viability is assessed by Cellometer. The number of CAR-positive cells in each culture is normalized using non-transduced T cells (UTD). The impact of RAD001 on CARTs was tested in titrations with RAD001, starting at 50nM. The target cell line used in all co-culture experiments is NALM6 (Nalm-6), a human pre-B cell acute lymphoblastic leukemia (ALL) cell line expressing CD19 and transduced to express luciferase.

[001197] For measuring the proliferation of CARTs, T cells are cultured with target cells at a ratio of 1:1. The assay is run for 4 days, when cells are stained for CD3, CD4, CD8 and CAR expression. The number of T cells is assessed by flow cytometry using counting beads as reference.

*[001198]* ***Results***

[001199] The proliferative capacity of CART cells was tested in a 4 day co-culture assay. The number of CAR-positive CD3-positive T cells (dark bars) and total CD3-positive T cells (light bars) was assessed after culturing the CAR-transduced and non-transduced T cells with NALM6 (Nalm-6) (Fig. 10). huCART19 cells expanded when cultured in the presence of less than 0.016 nM of RAD001, and to a lesser extent at higher concentrations of the compound. Importantly, both at 0.0032 and 0.016 nM RAD001 the proliferation was higher than observed without the addition of RAD001. The non-transduced T cells (UTD) did not show detectable expansion.

## Example 7: Low dose RAD001 stimulates CART expansion in vivo

[001200] This example evaluates the ability of huCAR19 cells to proliferate in vivo with different concentrations of RAD001.

[001201] **Materials and Methods:**

[001202] NALM6-luc cells: The NALM6 human acute lymphoblastic leukemia (ALL) cell line was developed from the peripheral blood of a patient with relapsed ALL. The cells were then tagged with firefly luciferase. These suspension cells grow in RPMI supplemented with 10% heat inactivated fetal bovine serum.

[001203] Mice: 6 week old NSG (NOD.Cg-PrkdcscidIl2rgtm1Wjl/SzJ) mice were received from the Jackson Laboratory (stock number 005557).

[001204] Tumor implantation: NALM6-luc cells were grown and expanded in vitro in RPMI supplemented with 10% heat inactivated fetal bovine serum. The cells were then transferred to a 15 ml conical tube and washed twice with cold sterile PBS. NALM6-luc cells were then counted and resuspended at a concentration of 10x106 cells per milliliter of PBS. The cells were placed on ice and immediately (within one hour) implanted in the mice. NALM6-luc cells were injected intravenously via the tail vein in a 100 µl volume, for a total of $1x10^6$ cells per mouse.

[001205] CAR T cell dosing: Mice were administered $5x10^6$ CAR T cells 7 days after tumor implantation. Cells were partially thawed in a 37 degree Celsius water bath and then completely thawed by the addition of 1 ml of cold sterile PBS to the tube containing the cells. The thawed cells were transferred to a 15 ml falcon tube and adjusted to a final volume of 10 mls with PBS. The cells were washed twice at 1000rpm for 10 minutes each time and then counted on a hemocytometer. T cells were then resuspended at a concentration of $50x10^6$ CAR T cells per ml of cold PBS and kept on ice until the mice were dosed. The mice were injected intravenously via the tail vein with 100 µl of the CAR T cells for a dose of $5x10^6$ CAR T cells per mouse. Eight mice per group were treated either with 100 µl of PBS alone (PBS), or humanized CD19 CAR T cells.

[001206] RAD001 dosing: A concentrated micro-emulsion of 50mg equal to 1mg RAD001 was formulated and then resuspended in D5W (dextrose 5% in water) at the time of dosing. Mice were orally dosed daily (via oral gavage) with 200 µl of the desired doses of RAD001.

[001207] PK analysis: Mice were dosed daily with RAD001 starting 7 days post tumor implantation. Dosing groups were as follows: 0.3 mg/kg, 1 mg/kg, 3 mg/kg, and 10 mg/kg. Mice were bled on days 0 and 14 following the first and last dose of RAD001, at the following time points for PK analysis: 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours.

[001208] Results:

[001209] The expansion and pharmacokinetics of RAD001 was tested in NSG mice with NALM6-luc tumors. Daily oral dosing of RAD001 alone did not have an impact on the growth of NALM6-luc tumors (Figure 11). The pharmacokinetic analysis of RAD001 shows that it is fairly stable in the blood of tumor bearing mice (Figures 12A and 12B). Both the day 0 and day 14 PK analyses show that the RAD001 concentrations in the blood is above 10nm even 24 hours after dosing at the lowest dose tested (0.3 mg/kg).

[001210] Based on these doses, huCAR19 CAR T cells were dosed with and without RAD001 to determine the proliferative ability of these cells. The highest dose used was 3 mg/kg based on the levels of RAD001 in the blood 24 hours after dosing. As the concentration of RAD001 was above 10nM 24 hours after the final dose of RAD001, several lower doses of RAD001 were used in the in vivo study with CAR T cells. The CAR T cells were dosed IV one day prior to the start of the daily oral RAD001 dosing. Mice were monitored via FACS for T cell expansion.

[001211] The lowest doses of RAD001 show an enhanced proliferation of the CAR T cells (Figures 13A and 13B). This enhanced proliferation is more evident and prolonged with the CD4+ CAR T cells than the CD8+ CAR T cells. However, with the CD8+ CAR T cells, enhanced proliferation can be seen at early time points following the CAR T cell dose.

## EQUIVALENTS

[001212] The disclosures of each and every patent, patent application, and publication cited herein are hereby incorporated herein by reference in their entirety. While this invention has been disclosed with reference to specific aspects, it is apparent that other aspects and variations of this invention may be devised by others skilled in the art without departing from the true spirit and scope of the invention. The appended claims are intended to be construed to include all such aspects and equivalent variations.

[001213] Other embodiments are within the following claims.

What is claimed is:

1. An mTOR inhibitor for use in the treatment of a subject, wherein said mTOR inhibitor enhances an immune response of said subject, and wherein said subject has received, is receiving or is about to receive an immune effector cell engineered to express a CAR.

2. The composition for use of claim 1, wherein the mTOR inhibitor is at a low, immune-enhancing dose.

3. A method of making an immune effector cell, which is optionally at T cell, having disposed therein a nucleic acid encoding a CAR, comprising:

c) contacting an immune effector cell, which is optionally a T cell, with an mTOR inhibitor; and

d) inserting nucleic acid that encodes the CAR into the immune effector cell;

thereby making an immune effector cell, which is optionally a T cell, having disposed therein a nucleic acid encoding a CAR,

wherein said contacting of step a) occurs prior to, concurrently with, or after said inserting of step b);

and wherein the mTOR inhibitor causes one or more of the following to occur:

1a) an increase in the proportion of PD-1 negative immune effector cells;

1b) a decrease in the proportion of PD-1 positive immune effector cells;

1c) an increase in the ratio of PD-1 negative immune effector cells, which are optionally T cells/ PD-1 positive immune effector cells, which are optionally T cells;

1d) an increase in the number of naïve T cells;

1e) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, which are optionally on memory T cells, which are optionally memory T cell precursors;

1f) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

1g) an increase in the number of memory T cell precursors, which are optionally cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein 1a), 1b), 1c), 1d), 1e), 1f) or 1g) occurs, optionally, at least transiently, optionally, as compared to a non-contacted preparation of immune effector cells.

4. The method of claim 3, wherein said contacting is *ex vivo*.

5. A method of making an immune effector cell, which is optionally a T cell, having disposed therein a nucleic acid encoding a CAR, comprising:

a) providing an immune effector cell, which is optionally a T cell, made by:

i) administering to a subject an mTOR inhibitor, which is optionally RAD001 or rapamycin, for an amount of time sufficient for one or more of the following to occur:

1a) an increase in the proportion of PD-1 negative immune effector cells;

1b) a decrease in the proportion of PD-1 positive immune effector cells;

1c) an increase in the ratio of PD-1 negative immune effector cells, which are optionally T cells/ PD-1 positive immune effector cells, which are optionally T cells;

1d) an increase in the number of naïve T cells;

1e) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, which are optionally on memory T cells, which are optionally memory T cell precursors;

1f) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

1g) an increase in the number of memory T cell precursors, which are optionally cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein 1a), 1b), 1c), 1d), 1e), 1f) or 1g) occurs, optionally, at least transiently, optionally, as compared to a non-treated subject, in the subject or in a preparation of immune effector cells, which are optionally T cells, collected from the subject; and

(ii) collecting the immune effector cell, which is optionally a T cell, from the subject; and

b) inserting nucleic acid that encodes the CAR into the collected immune effector cell, which is optionally a T cell,

thereby making an immune effector cell, which is optionally a T cell, having disposed therein a nucleic acid encoding a CAR.

6. The composition for use or the method of any of the preceding claims, wherein the CAR comprises an antigen binding domain (which is optionally an antibody or antibody fragment, TCR or TCR fragment) a transmembrane domain, and an intracellular signaling domain (which is optionally an intracellular signaling domain comprising a costimulatory domain and/or a primary signaling domain).

7. The composition for use or the method of claim 6, wherein the antigen binding domain binds a tumor marker.

8. The composition for use or the method of claim 7, wherein the tumor marker is a solid tumor marker or a hematological cancer marker.

9. The composition for use of any of claims 1, 2, or 6-8, wherein administration of the mTOR inhibitor is initiated prior to administration of the immune effector cell engineered to express a CAR.

10. The composition for use of any of claims 1, 2, or 6-9, wherein administration of the mTOR inhibitor, is completed prior to administration of the immune effector cell engineered to express a CAR.

11. The composition for use of any of claims 1, 2, or 6-9, wherein administration of the mTOR inhibitor overlaps with the administration of the immune effector cell engineered to express a CAR.

12. The composition for use of claim 1 or 2, wherein the immune effector cell engineered to express a CAR is administered after a sufficient time, or after sufficient dosing of the mTOR inhibitor, such that the level of PD1 negative immune effector cells, which are optionally T cells, or the ratio of PD1 negative immune effector cells, which are optionally T cells/ PD1 positive immune effector cells, which are optionally T cells, has been, at least transiently, increased.

13. The composition for use or the method of any of the preceding claims, wherein the immune effector cell to be engineered to express a CAR, is harvested after a sufficient time, or after sufficient dosing of the mTOR inhibitor, such that the level of PD1 negative immune effector cells which are optionally T cells, or the ratio of PD1 negative immune effector cells, which are optionally T cells/ PD1 positive immune effector cells, which are optionally T cells, in the subject or harvested from the subject has been, at least transiently, increased.

14. The composition for use of any of claims 1, 2, 6-9, or 11-13, wherein administration of the mTOR inhibitor continues after the subject has received the immune effector cell engineered to express a CAR.

15. The composition for use or the method of any of the preceding claims, wherein the mTOR inhibitor is an allosteric mTOR inhibitor.

16. The composition for use or the method of any of the preceding claims, wherein the mTOR inhibitor is a RAD001.

17. The composition for use or the method of any of claims 1-15, wherein the mTOR inhibitor is rapamycin.

18. The composition for use or the method of any of claims 1-14, wherein the mTOR inhibitor is a catalytic inhibitor, and is optionally a kinase inhibitor.

19. The composition for use or the method of claim 18, wherein the kinase inhibitor is selective for mTOR.

20. The composition for use or the method of claim 18, wherein the kinase inhibitor is selected from BEZ235 and CCG168.

21. The composition for use or the method of any of the preceding claims, wherein the treatment or the contacting comprises treatment or contacting with a plurality of mTOR inhibitors.

22. The composition for use or the method of any of the preceding claims, wherein the mTOR inhibitor is administered or contacted for an amount of time sufficient to decrease the proportion of PD-1 positive T cells, increase the proportion of PD-1 negative T cells, or increase the ratio of PD-1 negative T cells/ PD-1 positive T cells, in the peripheral blood of the subject, or in a preparation of T cells isolated from the subject.

23. The composition for use or the method of any of the preceding claims, wherein the treatment or the contacting comprises inhibiting a negative immune response mediated by the engagement of PD-1 with PD-L1 or PD-L2.

24. The composition for use or the method of any of the preceding claims, wherein the treatment or the contacting comprises increasing the number of T cells capable of proliferation.

25. The composition for use or the method of any of the preceding claims, wherein the treatment or the contacting comprises increasing the number of T cells capable of cytotoxic function, secreting cytokines, or activation.

26. The composition for use of any of claims 1, 2, and 6-25, wherein the mTOR inhibitor is administered prior to administration of immune effector cells, e.g., T cells to be engineered to express an CAR, (e.g., prior to or after harvest of the immune effector cells) for an amount of time sufficient for one or more of the following to occur:

i) a decrease in the number of PD-1 positive immune effector cells;

ii) an increase in the number of PD-1 negative immune effector cells;

iii) an increase in the ratio of PD-1 negative immune effector cells / PD-1 positive immune effector cells;

iv) an increase in the number of naive T cells;

v) an increase in the expression of one or more of the following markers: $CD62L^{high}$, $CD127^{high}$, $CD27^{+}$, and BCL2, e.g., on memory T cells, e.g., memory T cell precursors;

vi) a decrease in the expression of KLRG1, e.g., on memory T cells, e.g., memory T cell precursors; or

vii) an increase in the number of memory T cell precursors, e.g., cells with any one or combination of the following characteristics: increased $CD62L^{high}$, increased $CD127^{high}$, increased $CD27^{+}$, decreased KLRG1, and increased BCL2;

and wherein i), ii), iii), iv), v), vi), or vii) occurs e.g., at least transiently, e.g., as compared to a non-treated subject.

27. The composition for use or method of any of the preceding claims, wherein an mTOR inhibitor is at a dose that is associated with mTOR inhibition of at least 5 but no more than 90%, e.g., as measured by p70 S6K inhibition.

28. The composition for use or the method of any of the preceding claims, wherein the an mTOR inhibitor is at a dose that is associated with mTOR inhibition of at least 10% but no more than 80%, e.g., as measured by p70 S6K inhibition.

29. The composition for use or the method of any of the preceding claims, wherein the mTOR inhibitor is at a dose that is associated with mTOR inhibition of at least 10% but no more than 40%, e.g., as measured by p70 S6K inhibition.

30. The composition for use or the method of any of the preceding claims, wherein the mTOR inhibitor is at a dose of 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs, optionally once per week, optionally in a sustained release dosage form and wherein the mTOR inhibitor is RAD001.

31. The composition for use or the method of any of claims 1-30, wherein the mTOR inhibitor is an mTOR inhibitor other than RAD001, and the mTOR inhibitor is at a dose that is bioequivalent to a once per week, sustained release dosage form of 0.3 to 60, 1.5 to 30, 7.5 to 22.5, 9 to 18, or about 15 mgs of RAD001, optionally once per week, optionally in a sustained release dosage form.

32. The composition for use or the method of any of claims 1-30, wherein the mTOR inhibitor is at a dose of 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs, optionally once per day, optionally in an immediate release dosage form, and wherein the mTOR inhibitor is RAD001.

33. The composition for use or the method of any of claims 1-30, wherein the mTOR inhibitor is an mTOR inhibitor other than RAD001, and the mTOR inhibitor is at a dose that is bioequivalent to a once per day, immediate release dosage form of 0.005 to 1.5, 0.01 to 1.5, 0.1 to 1.5, 0.2 to 1.5, 0.3 to 1.5, 0.4 to 1.5, 0.5 to 1.5, 0.6 to 1.5, 0.7 to 1.5, 0.8 to 1.5, 1.0 to 1.5, 0.3 to 0.6, or about 0.5 mgs of RAD001, optionally once per day, optionally in an immediate release dosage form.

34. The composition for use or the method of any of claims 1-30, wherein the mTOR inhibitor is RAD001 and is at a dose that provides for a trough level of RAD001 in a range of between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

35. The composition for use or the method of any of claims 1-30, wherein the mTOR inhibitor is other than RAD001 and is at a dose that is bioequivalent to a dose of RAD001 that provides for a trough level of RAD001 in a range of between about 0.1 and 3 ng/ml, between 0.3 or less and 3 ng/ml, or between 0.3 or less and 1 ng/ml.

36. The composition for use of any of claims 1, 2, or 6-35, wherein the subject has cancer and the method comprises promoting the subject's immune response to the cancer.

37. The composition for use of claim 36, wherein a cell of the cancer expresses PD-L1 or PD-L2.

38. The composition for use of claim 36, wherein a cell in the cancer microenvironment expresses PD-L1 or PD-L2.

39. The composition for use of claim 36, wherein cancer comprises a solid tumor.

40. The composition for use of claim 36, wherein the cancer is a hematological cancer.

41. The composition for use of claim 36, wherein the cancer is CLL and wherein optionally the antigen binding domain of the CAR targets CD19.

42. The composition for use of claim 36-38, wherein the cancer is melanoma.

43. The composition for use of any of claims 36-42, wherein the subject is a human.

44. The composition for use or the method of any of the preceding claims, wherein the immune effector cell is a T cell.

45. The method of any of claims 3-5, further comprising introducing the immune effector cell, which is optionally a T cell, having disposed therein a nucleic acid encoding a

CAR, into a subject, which is optionally the subject from which the immune effector cells were derived or from a different subject.

46. The method of any of claims 3-5, further comprising evaluating the level of PD1 negative or PD1 positive immune effector cells, which are optionally T cells, in the subject or in T cells taken from the subject.

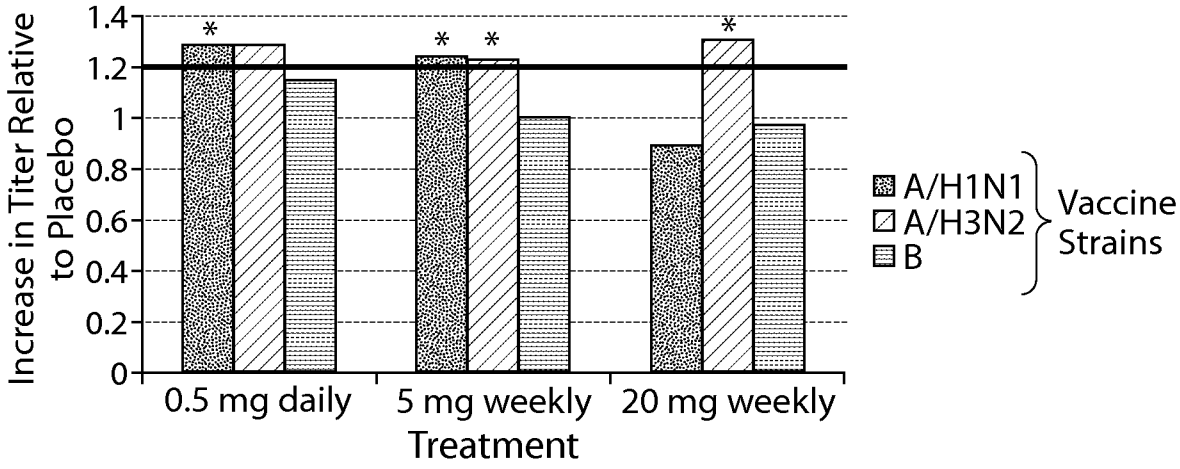
Increase in Titer Relative to Placebo
1.4
1.2
1
0.8
0.6
0.4
0.2
0
*
* *
*
0.5 mg daily
5 mg weekly
20 mg weekly
Treatment
A/H1N1
A/H3N2
B
Vaccine Strains

FIG. 1A

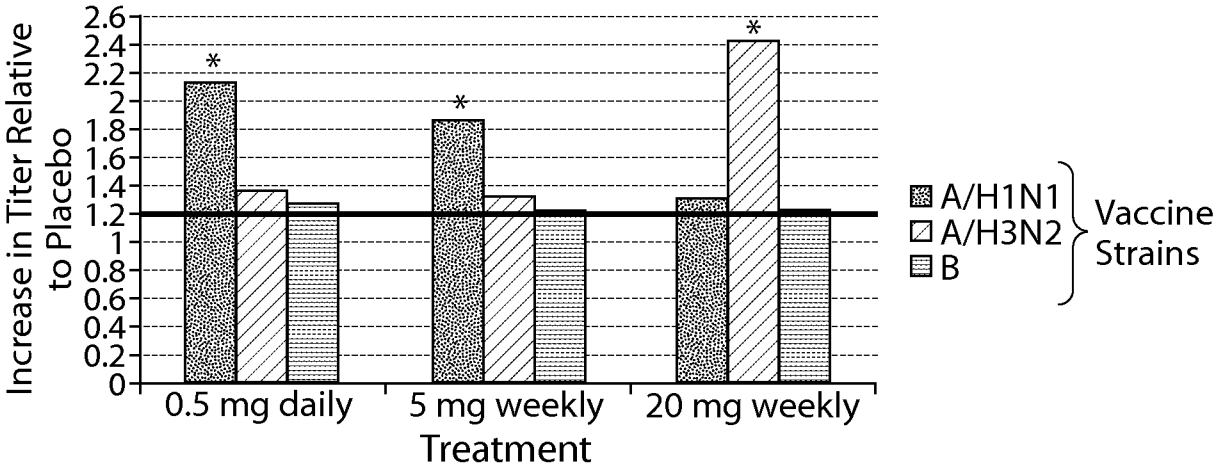
Increase in Titer Relative to Placebo
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
*
*
*
0.5 mg daily
5 mg weekly
20 mg weekly
Treatment
A/H1N1
A/H3N2
B
Vaccine Strains

FIG. 1B

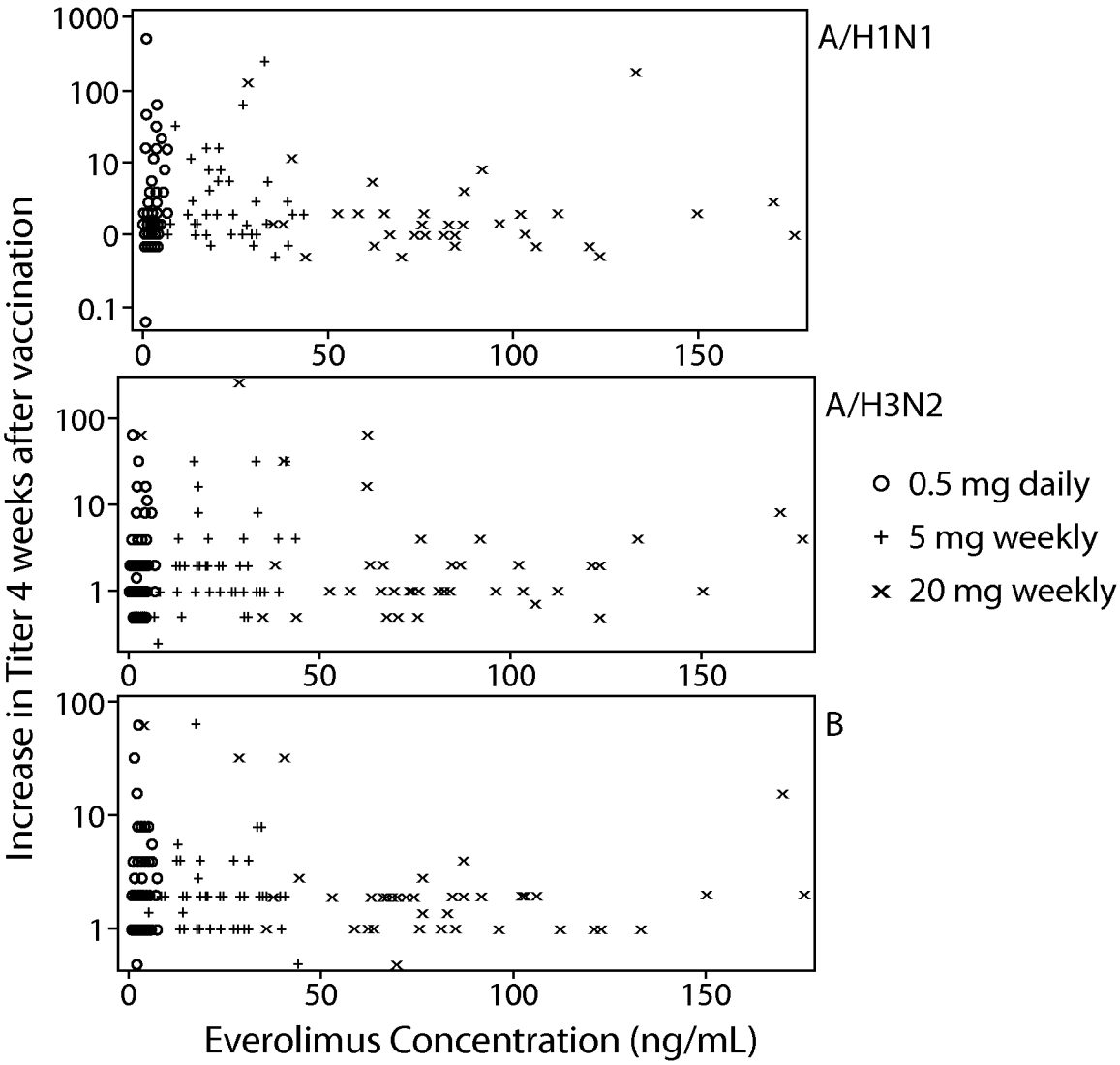
A/H1N1
A/H3N2
B
0.5 mg daily
5 mg weekly
20 mg weekly
Increase in Titer 4 weeks after vaccination
Everolimus Concentration (ng/mL)
1000
100
10
0
0.1
1
0
50
100
150

FIG. 2

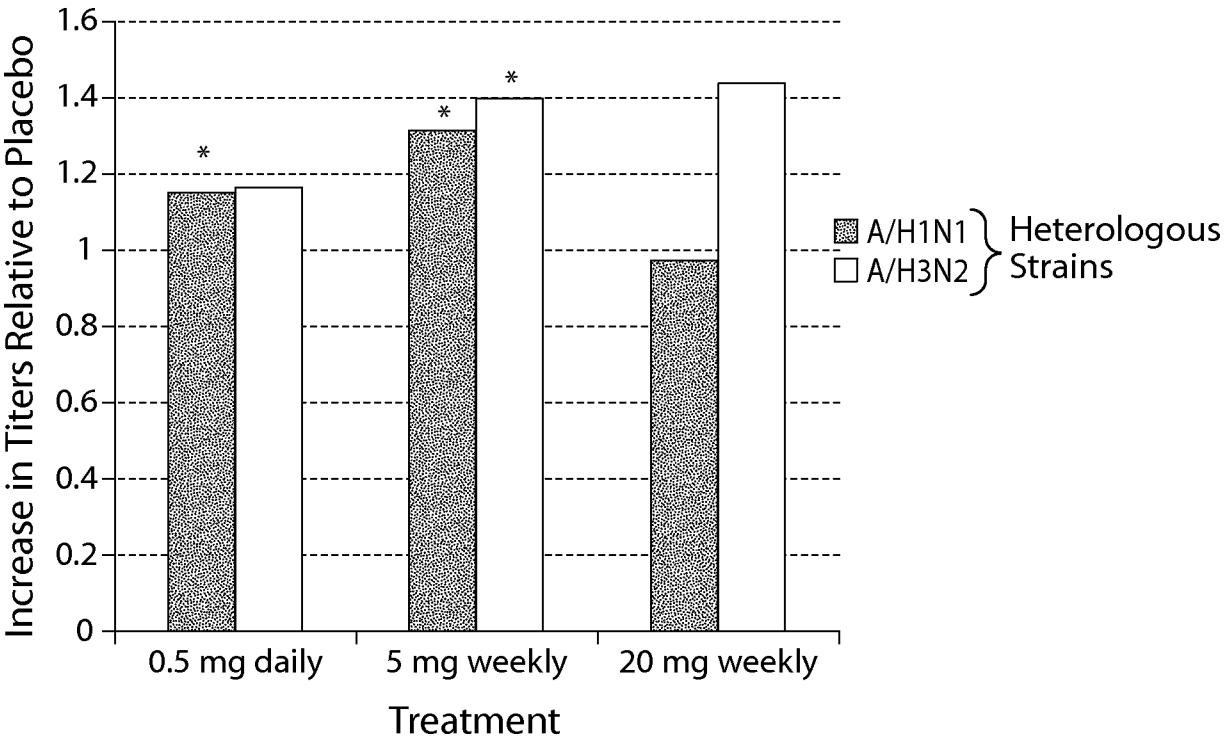
Increase in Titers Relative to Placebo
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
*
*
*
0.5 mg daily
5 mg weekly
20 mg weekly
Treatment
A/H1N1
A/H3N2
Heterologous Strains

FIG. 3

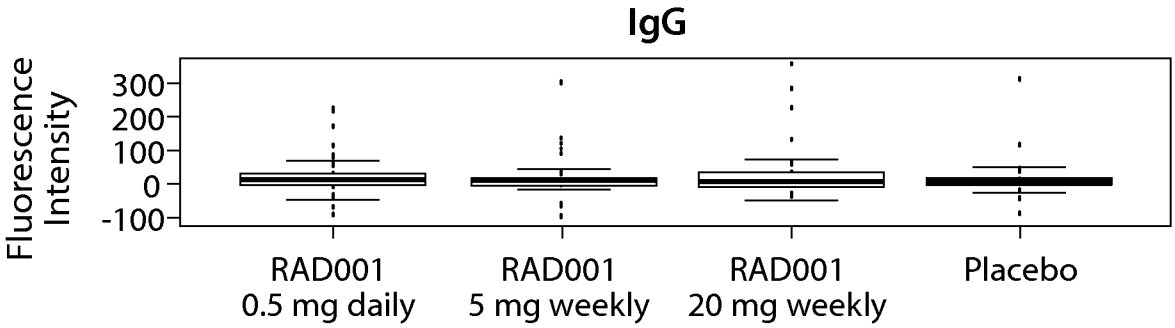
IgG
Fluorescence Intensity
300
200
100
0
-100
RAD001 0.5 mg daily
RAD001 5 mg weekly
RAD001 20 mg weekly
Placebo

FIG. 4A

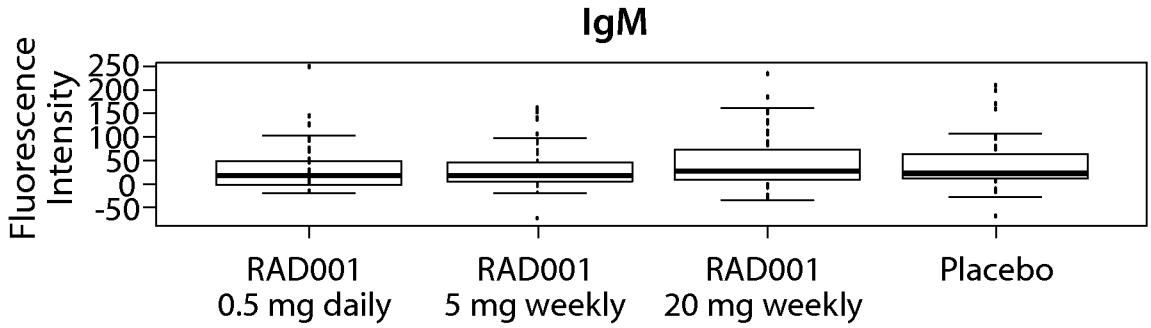
IgM
Fluorescence Intensity
250
200
150
100
50
0
-50
RAD001 0.5 mg daily
RAD001 5 mg weekly
RAD001 20 mg weekly
Placebo

FIG. 4B

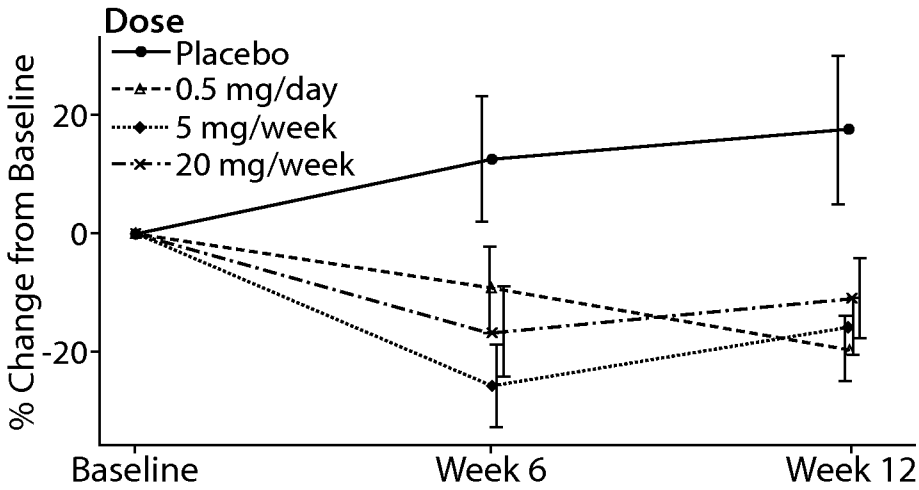


FIG. 5A

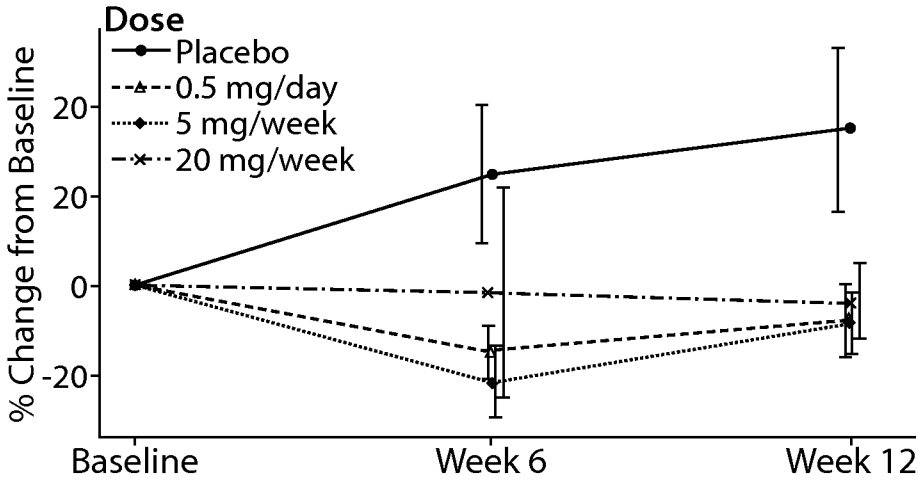


FIG. 5B

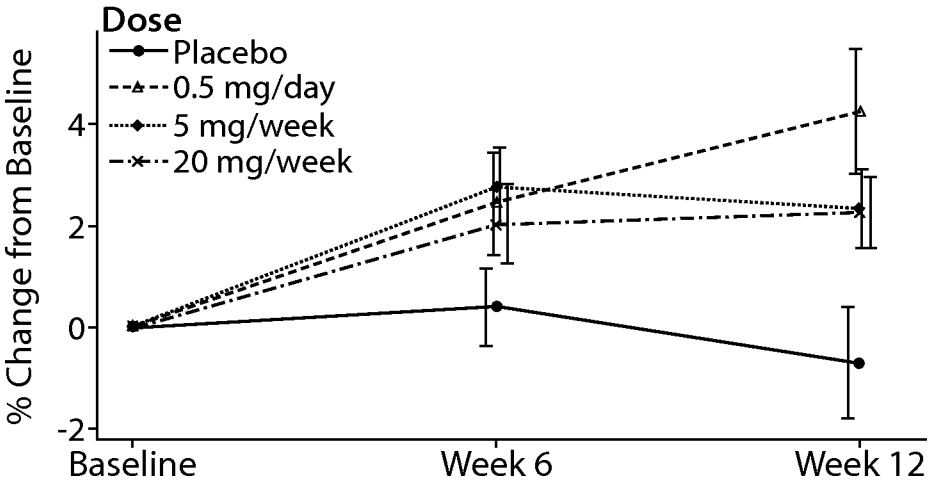


FIG. 5C

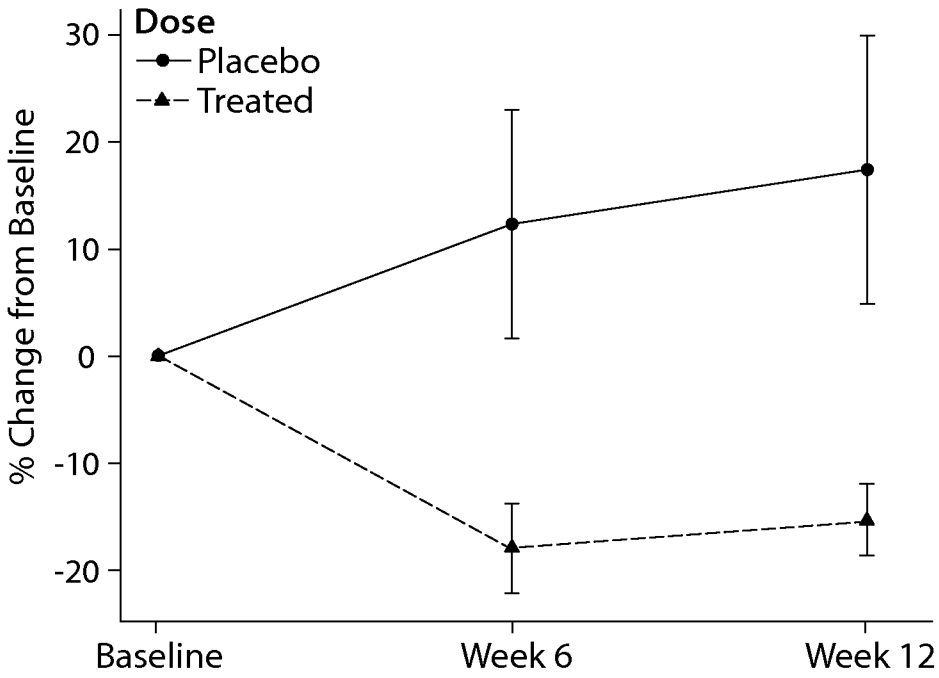
Dose
Placebo
Treated
% Change from Baseline
30
20
10
0
-10
-20
Baseline
Week 6
Week 12

FIG. 6A

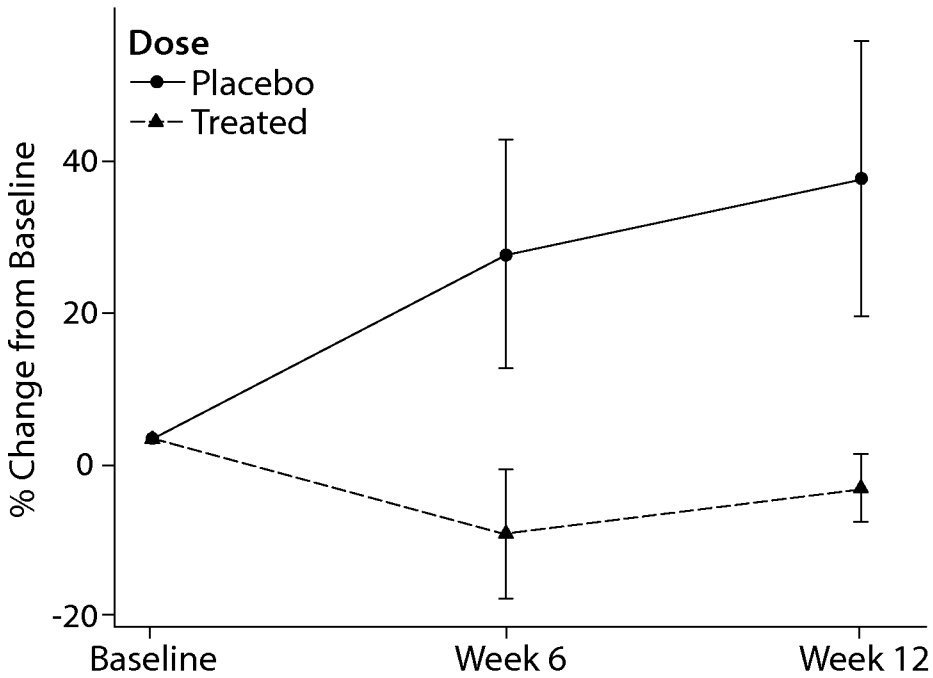
Dose
Placebo
Treated
% Change from Baseline
40
20
0
-20
Baseline
Week 6
Week 12

FIG. 6B

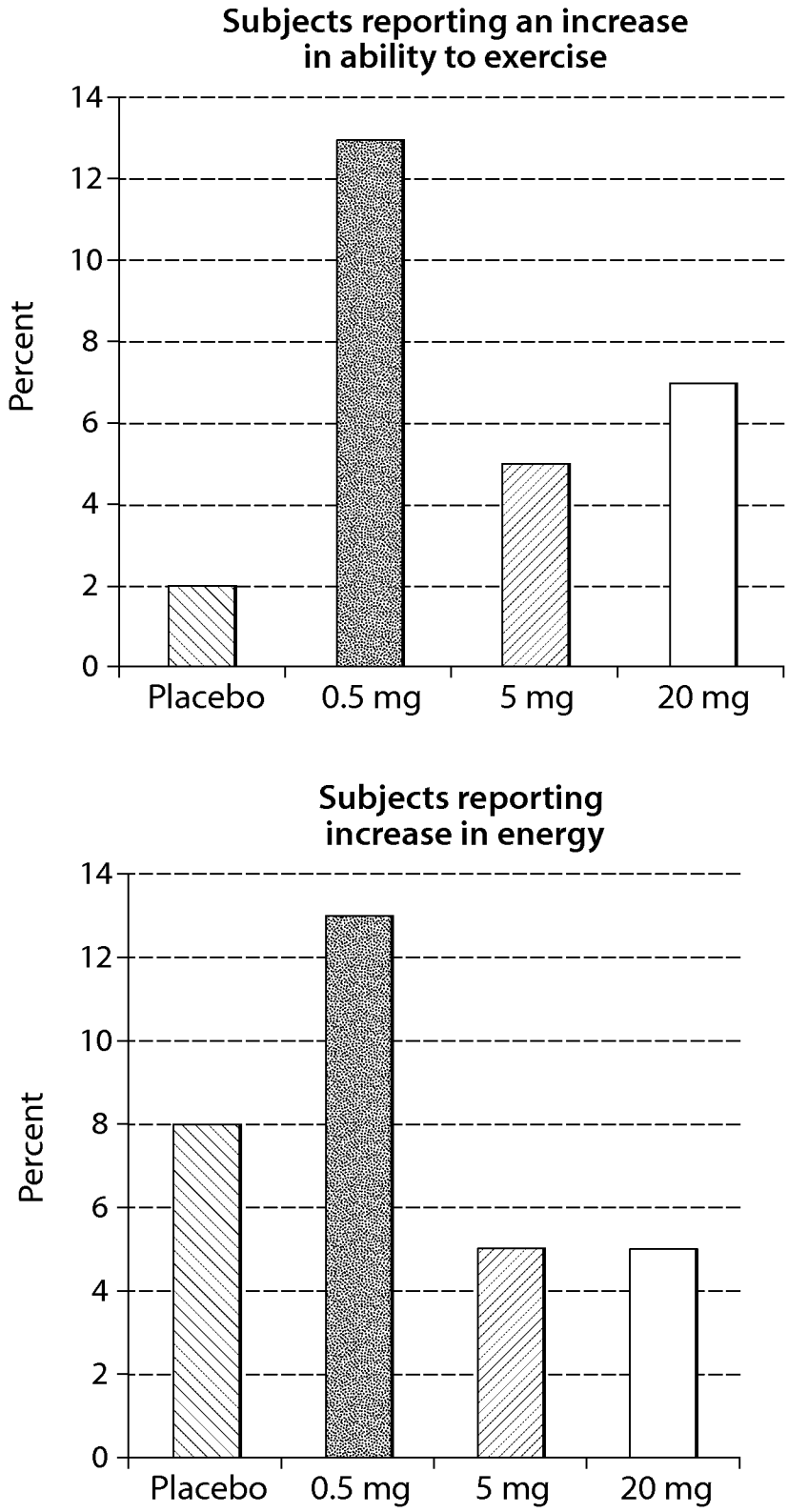
Subjects reporting an increase in ability to exercise
Percent
14
12
10
8
6
4
2
0
Placebo
0.5 mg
5 mg
20 mg
Subjects reporting increase in energy
Percent
14
12
10
8
6
4
2
0
Placebo
0.5 mg
5 mg
20 mg

FIG. 7

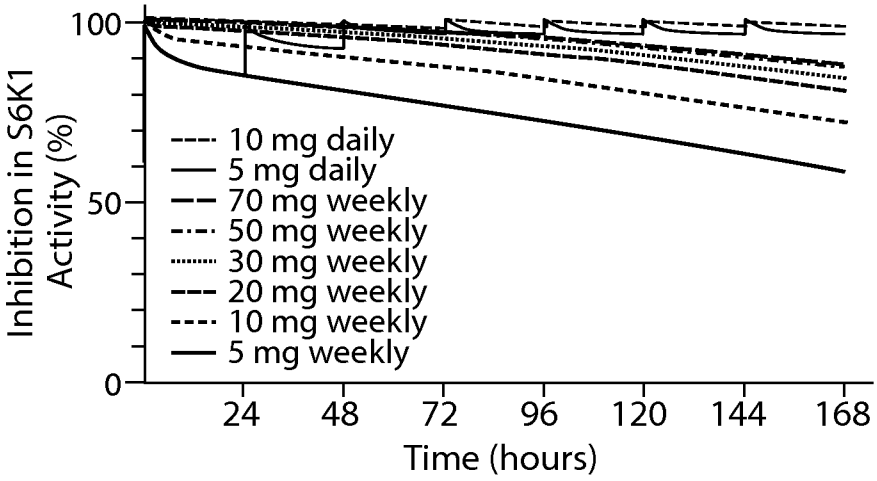
100
50
0
Inhibition in S6K1 Activity (%)
10 mg daily
5 mg daily
70 mg weekly
50 mg weekly
30 mg weekly
20 mg weekly
10 mg weekly
5 mg weekly
24
48
72
96
120
144
168
Time (hours)

FIG. 8A

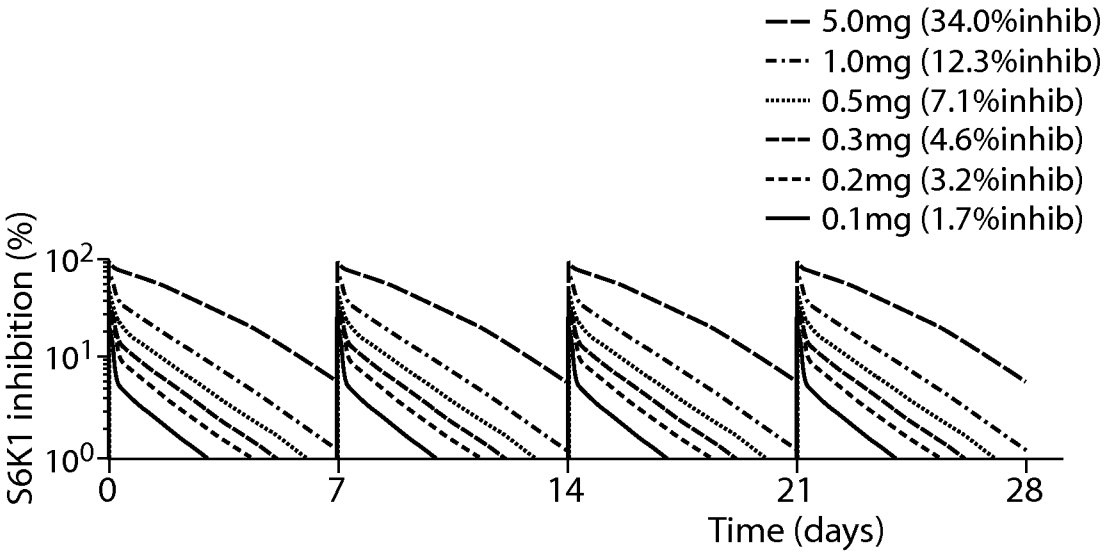
5.0mg (34.0%inhib)
1.0mg (12.3%inhib)
0.5mg (7.1%inhib)
0.3mg (4.6%inhib)
0.2mg (3.2%inhib)
0.1mg (1.7%inhib)
S6K1 inhibition (%)
$10^2$
$10^1$
$10^0$
0
7
14
21
28
Time (days)

FIG. 8B

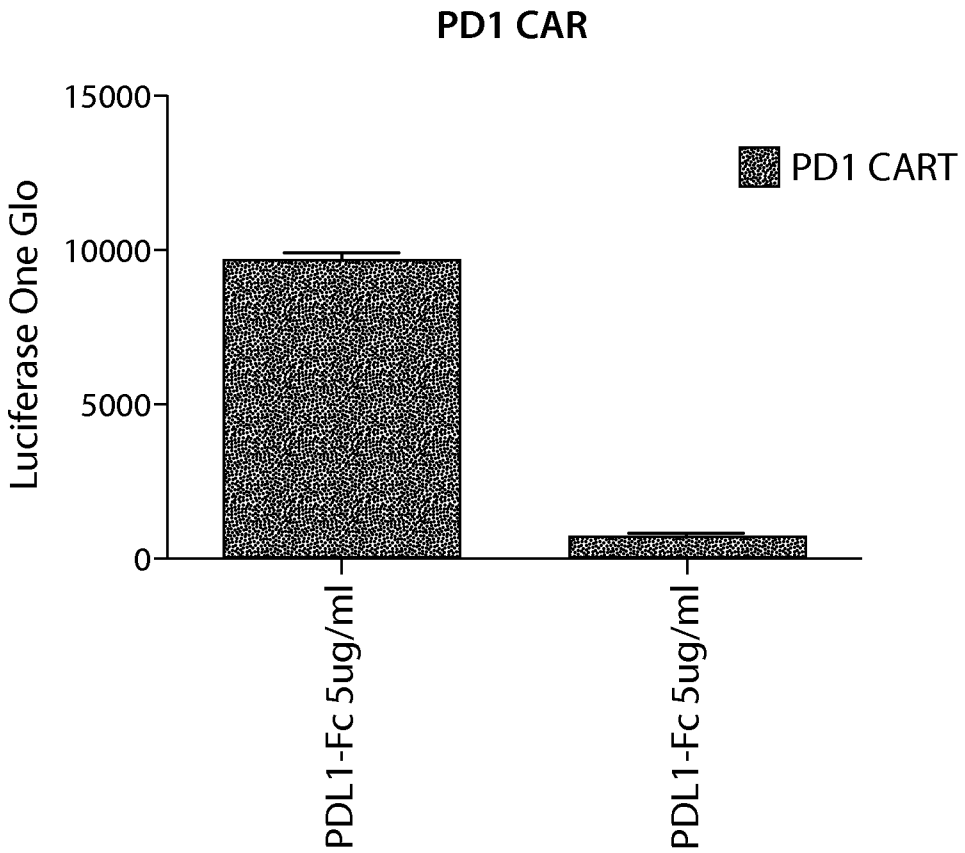
PD1 CAR
15000
10000
5000
0
Luciferase One Glo
PD1 CART
PDL1-Fc 5ug/ml
PDL1-Fc 5ug/ml

FIG. 9

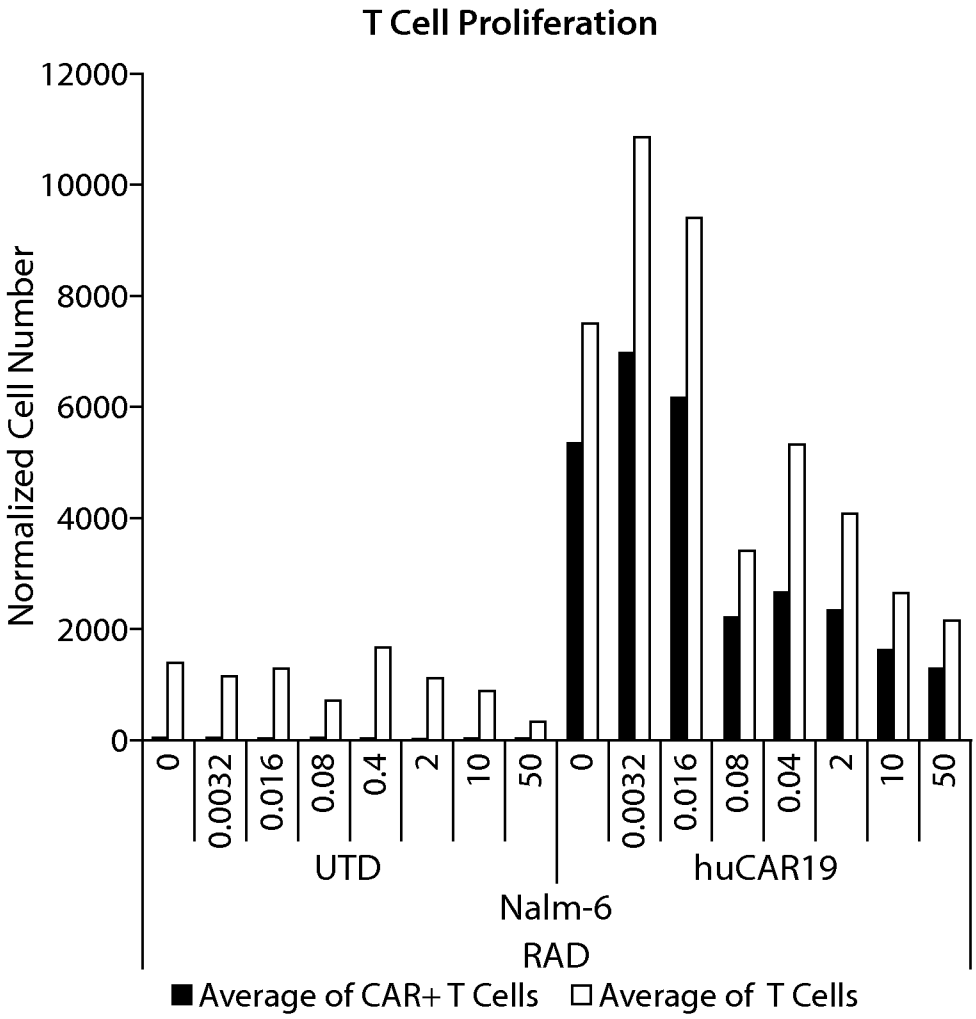
T Cell Proliferation
Normalized Cell Number
12000
10000
8000
6000
4000
2000
0
0
0.0032
0.016
0.08
0.4
2
10
50
0
0.0032
0.016
0.08
0.04
2
10
50
UTD
huCAR19
Nalm-6
RAD
Average of CAR+ T Cells
Average of T Cells

FIG. 10

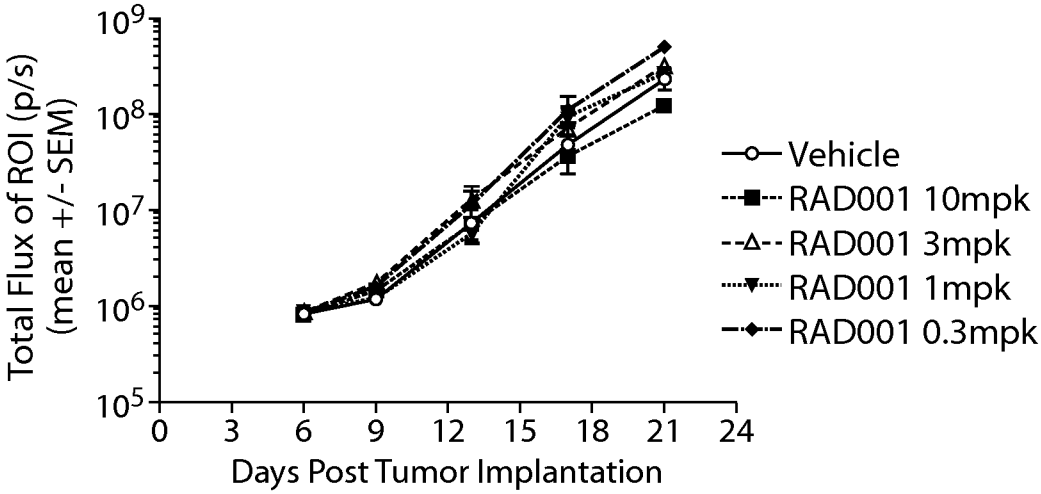
Total Flux of ROI (p/s)
(mean +/- SEM)
10^9
10^8
10^7
10^6
10^5
0
3
6
9
12
15
18
21
24
Days Post Tumor Implantation
Vehicle
RAD001 10mpk
RAD001 3mpk
RAD001 1mpk
RAD001 0.3mpk

FIG. 11

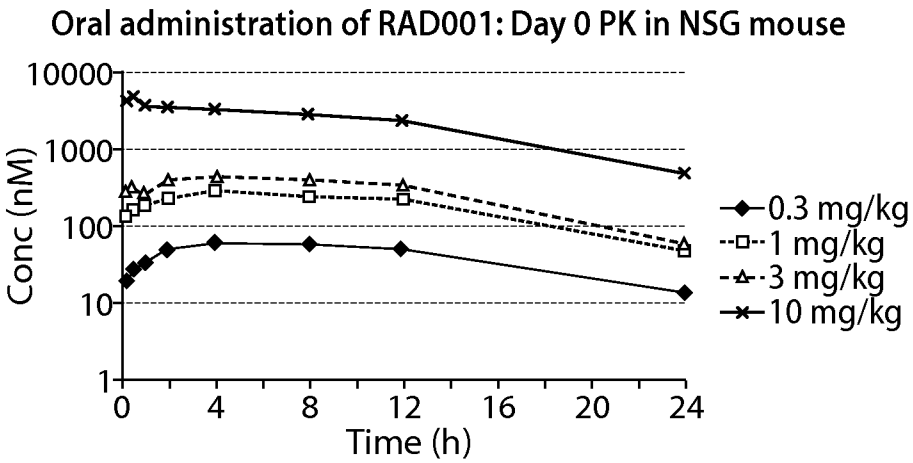


FIG. 12A

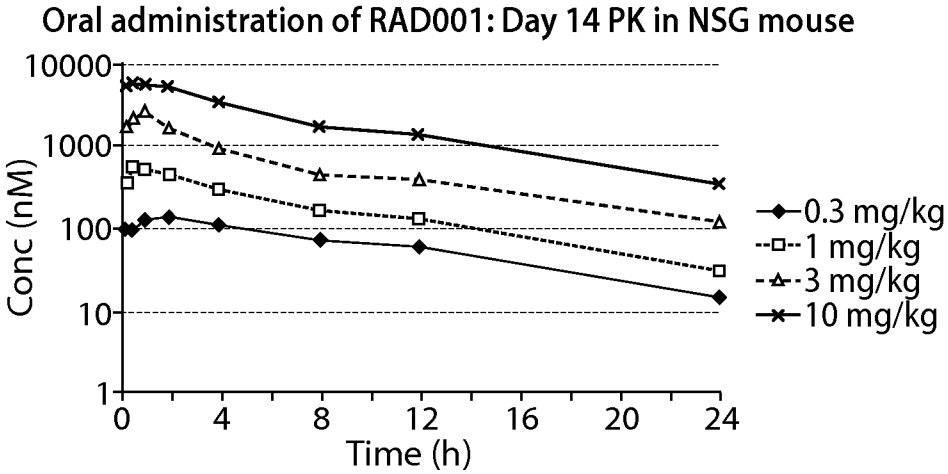


FIG. 12B

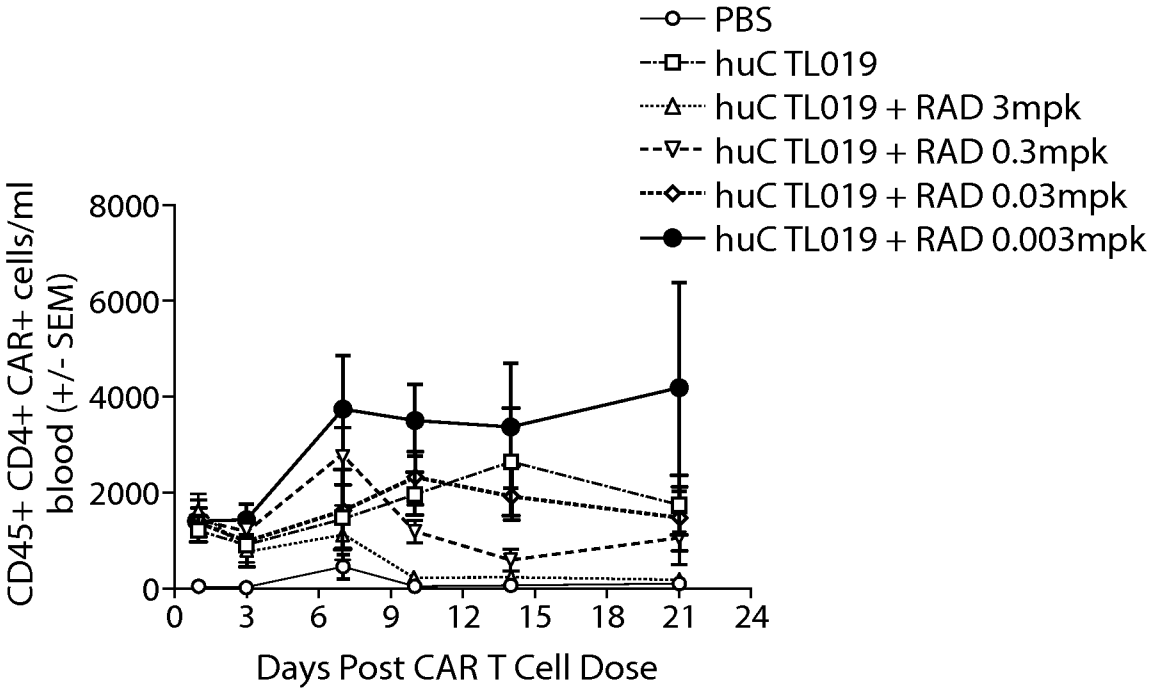


FIG. 13A

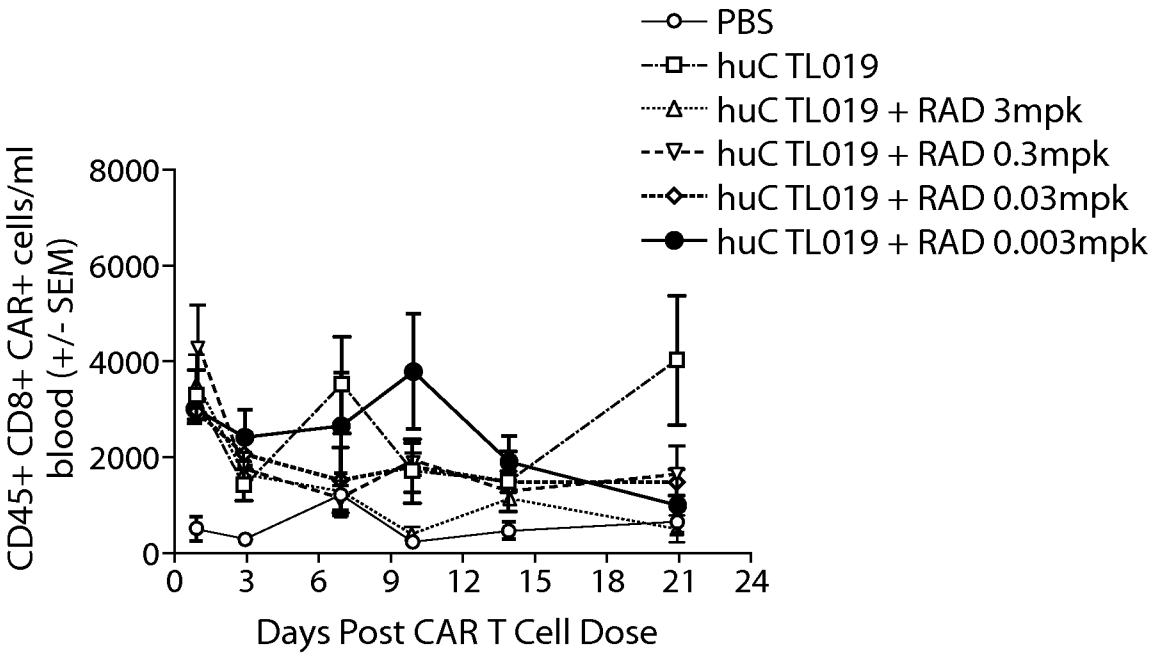


FIG. 13B

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/041330

**Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)**

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing:

   a. [X] forming part of the international application as filed:

      [X] in the form of an Annex C/ST.25 text file.

      [ ] on paper or in the form of an image file.

   b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. [ ] furnished subsequent to the international filing date for the purposes of international search only:

      [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

2. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments:

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/041330

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/041330

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61K39/00 A61K31/4745
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, BIOSIS, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | HAMMILL JOANNE A ET AL: "Rapamycin Treatment Endows Car-engineered CD8+Effector T Cells With Memory-like Properties Resulting in Enhanced in vivo Engraftment", JOURNAL OF IMMUNOTHERAPY, vol. 35, no. 9, November 2012 (2012-11), page 764, XP9186856, & 27TH ANNUAL SCIENTIFIC MEETING OF THE SOCIETY-FOR-IMMUNOTHERAPY-OF-CANCER (SITC); NORTH BETHESDA, MD, USA; OCTOBER 24 -28, 2012 the whole document<br>-----<br>-/-- | 1,3-8, 11, 15-21, 23-25, 36,43,44 |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 5 November 2015 | 12/11/2015 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Chavanne, Franz |

4

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | LESLIE E HUYE ET AL: "Combining mTor Inhibitors With Rapamycin-resistant T Cells: A Two-pronged Approach to Tumor Elimination", MOLECULAR THERAPY, vol. 19, no. 12, 30 August 2011 (2011-08-30), pages 2239-2248, XP055191016, GB ISSN: 1525-0016, DOI: 10.1038/mt.2011.179 abstract<br>----- | 1,3-8, 11, 15-21, 23-25, 36,43,44 |
| Y | WO 2010/017317 A2 (UNIV EMORY [US]; AHMED RAFI [US]; LARSEN CHRISTIAN P [US]; ARAKI KOICH) 11 February 2010 (2010-02-11) abstract<br>page 20, lines 23-31<br>page 21, lines 18-25<br>page 30, line 13 - page 35, line 2<br>examples 1-8<br>----- | 1-46 |
| Y | WO 2012/129514 A1 (HUTCHINSON FRED CANCER RES [US]; RIDDELL STANLEY R [US]; HUDECEK MICHA) 27 September 2012 (2012-09-27) abstract<br>page 2, line 18 - page 3, line 12<br>page 11, line 18 - page 12, line 8<br>page 23, line 12 - page 25, line 4<br>examples 1-6<br>----- | 1-46 |
| E | WO 2015/142675 A2 (NOVARTIS AG [CH]; UNIV PENNSYLVANIA [US]; LOEW ANDREAS [US]; MILONE MI) 24 September 2015 (2015-09-24) abstract<br>paragraphs [0058] - [0116], [0122], [0123], [0128] - [0148], [0243], [0265], [0275], [0323]<br>paragraphs [0339] - [0352], [0525], [0526], [0642] - [0671], [0881]<br>table 1<br>----- | 1-46 |

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/041330

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| WO 2010017317 A2 | 11-02-2010 | AU 2009279661 A1 | 11-02-2010 |
| | | CA 2733203 A1 | 11-02-2010 |
| | | EP 2318002 A2 | 11-05-2011 |
| | | US 2011129496 A1 | 02-06-2011 |
| | | US 2014370059 A1 | 18-12-2014 |
| | | WO 2010017317 A2 | 11-02-2010 |
| WO 2012129514 A1 | 27-09-2012 | AU 2012230780 A1 | 02-05-2013 |
| | | CA 2830953 A1 | 27-09-2012 |
| | | CN 103502438 A | 08-01-2014 |
| | | EP 2689010 A1 | 29-01-2014 |
| | | JP 2014510108 A | 24-04-2014 |
| | | KR 20140023931 A | 27-02-2014 |
| | | RU 2013147157 A | 27-04-2015 |
| | | SG 193591 A1 | 30-10-2013 |
| | | US 2014314795 A1 | 23-10-2014 |
| | | WO 2012129514 A1 | 27-09-2012 |
| WO 2015142675 A2 | 24-09-2015 | NONE | |

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/** 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-46

An mTOR inhibitor for use in the treatment of a subject, wherein said subject receives an immune effector cell engineered to express a CAR.

1.1. claims: 3-5, 45, 46(completely); 6-11, 13-44(partially)

Method of making an immune effector cell comprising a nucleic acid encoding a CAR comprising contacting the immune effector cell with a mTOR inhibitor.

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