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(54) **COMPOSITIONS AND METHODS FOR TREATING CANCER WITH ANTI-BCMA IMMUNOTHERAPY**

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(52) **U.S. Cl.**

CPC *C07K 14/7051* (2013.01); *A61K 40/11* (2025.01); *A61K 40/31* (2025.01); *A61K 40/4202* (2025.01); *A61K 40/4215* (2025.01); *A61P 35/00* (2018.01); *C07K 14/70517* (2013.01); *C07K 14/70521* (2013.01); *C07K 14/70578* (2013.01); *C07K 16/2878* (2013.01); *C12N 5/0636* (2013.01); *A61K 2239/31* (2023.05); *A61K 2239/48* (2023.05); *C12N 15/63* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

Chimeric antigen receptors containing BCMA antigen binding domains are disclosed. Nucleic acids, recombinant expression vectors, host cells, antigen binding fragments, and pharmaceutical compositions, relating to the chimeric antigen receptors are also disclosed. Methods of treating or preventing cancer in a subject, and methods of making chimeric antigen receptor T cells are also disclosed.

23 Claims, 10 Drawing Sheets

Specification includes a Sequence Listing.

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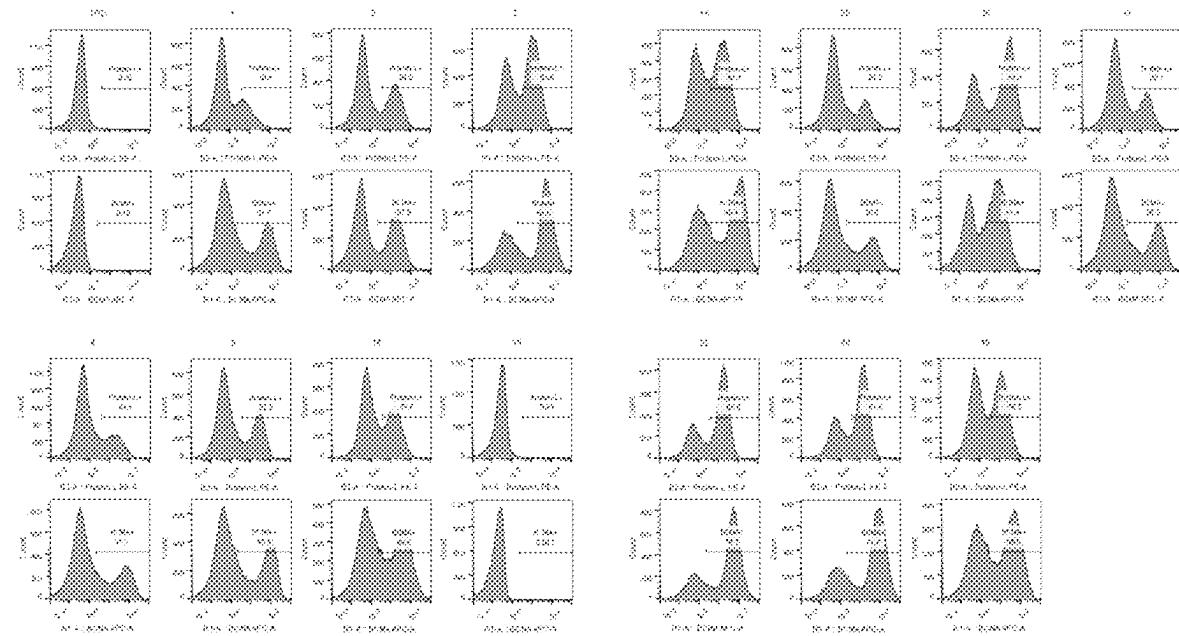
Hu anti-BCMA scFv

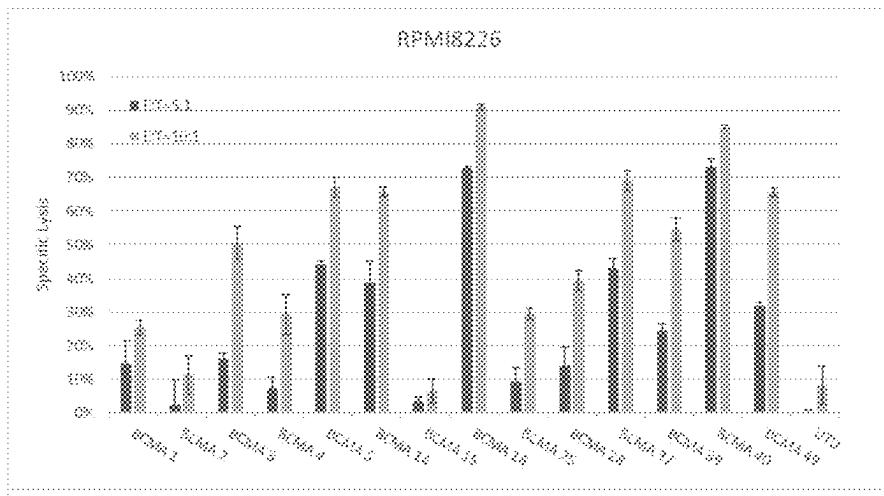
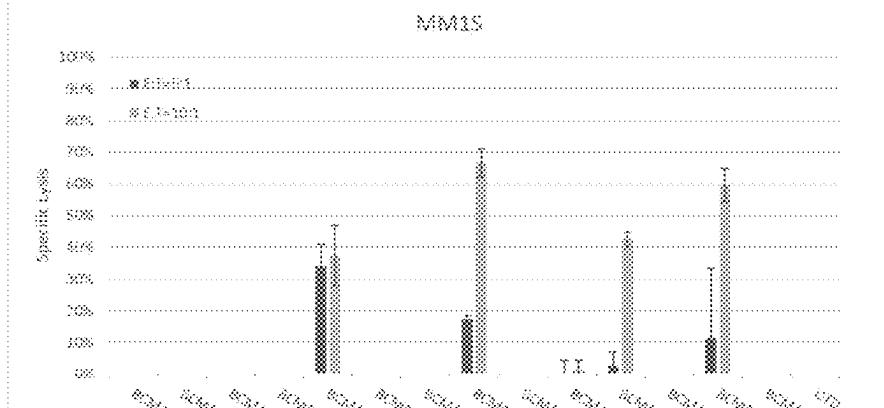
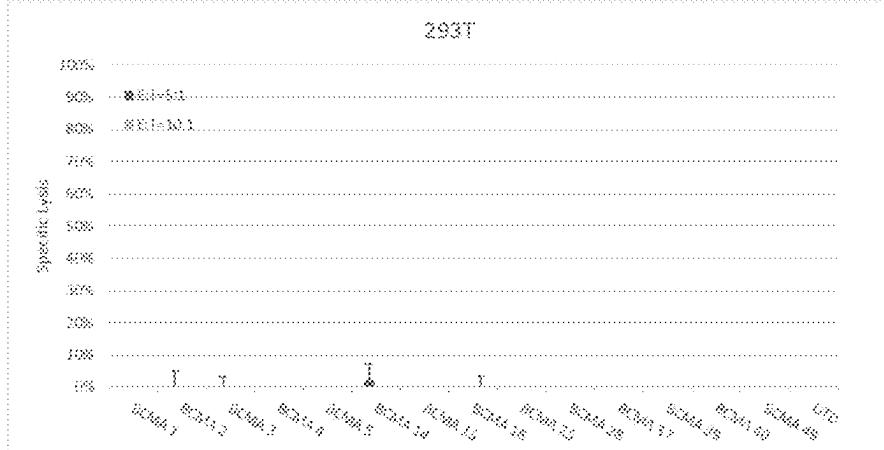
CD8 hinge and TM

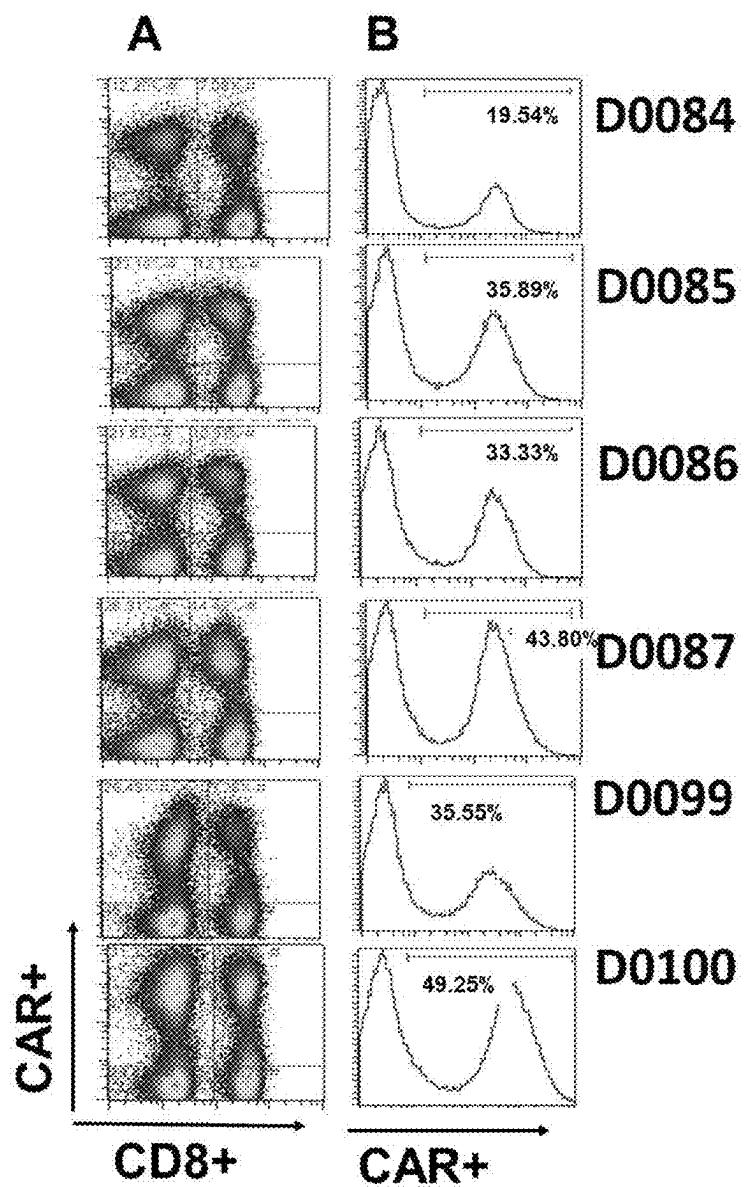
4-1BB

CD3 ζ

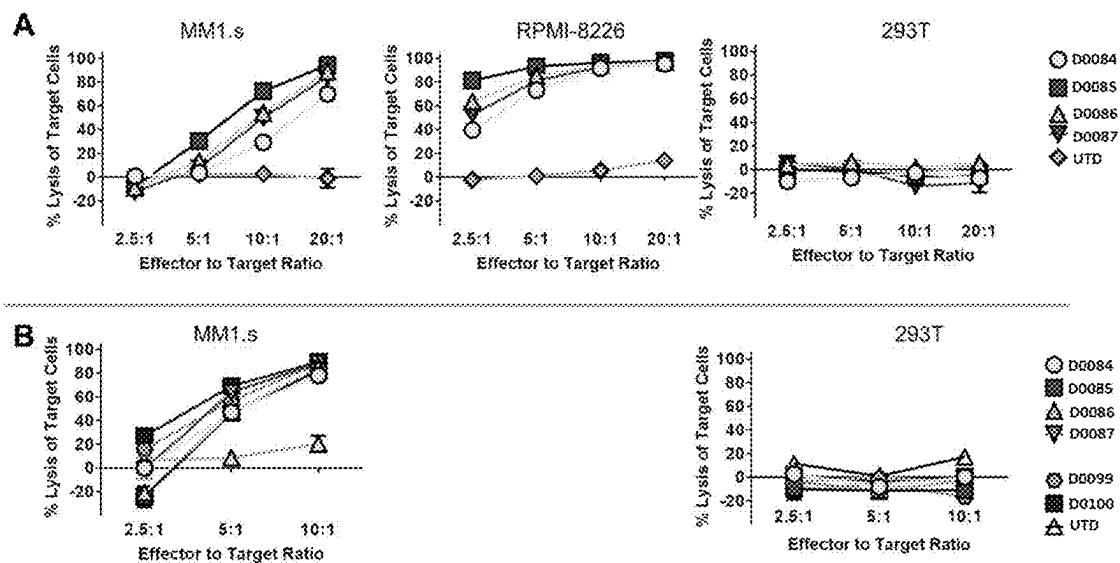
FIG. 1

**FIG. 2**

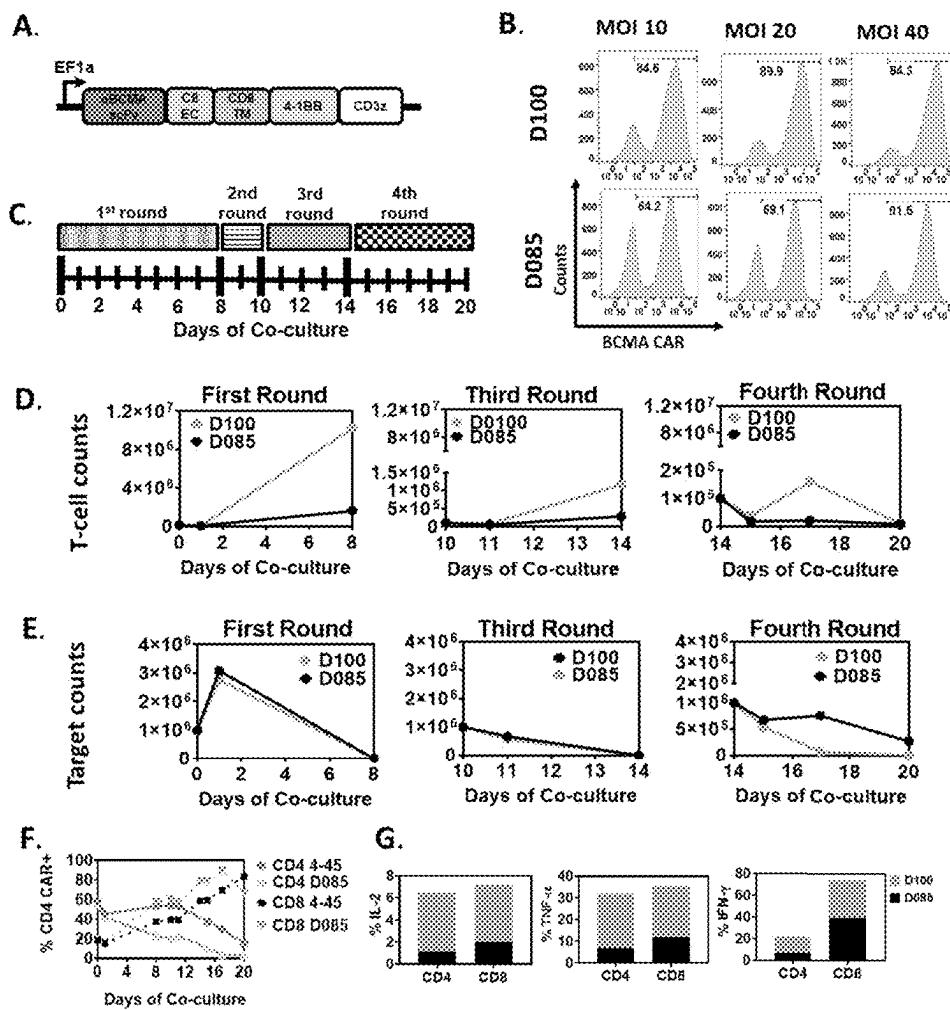
A**B****C****FIGS. 3A-C**



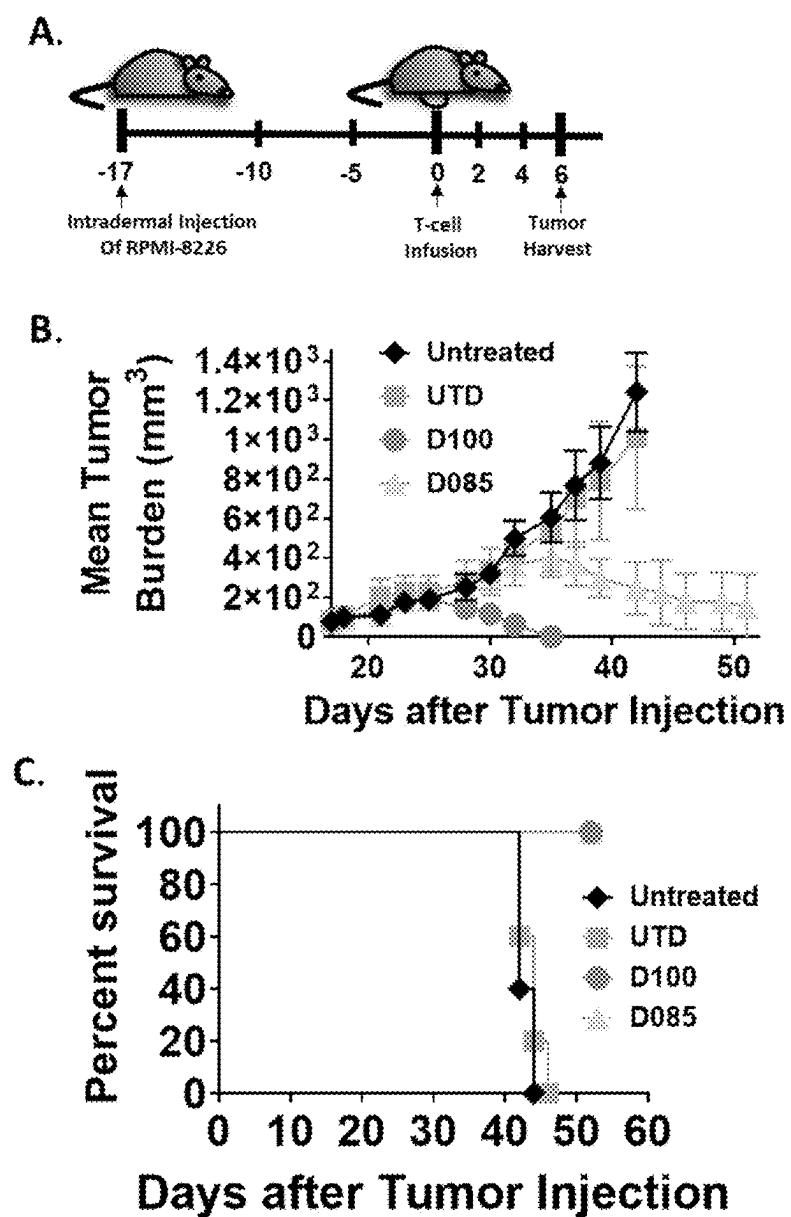
FIGS. 4A-B



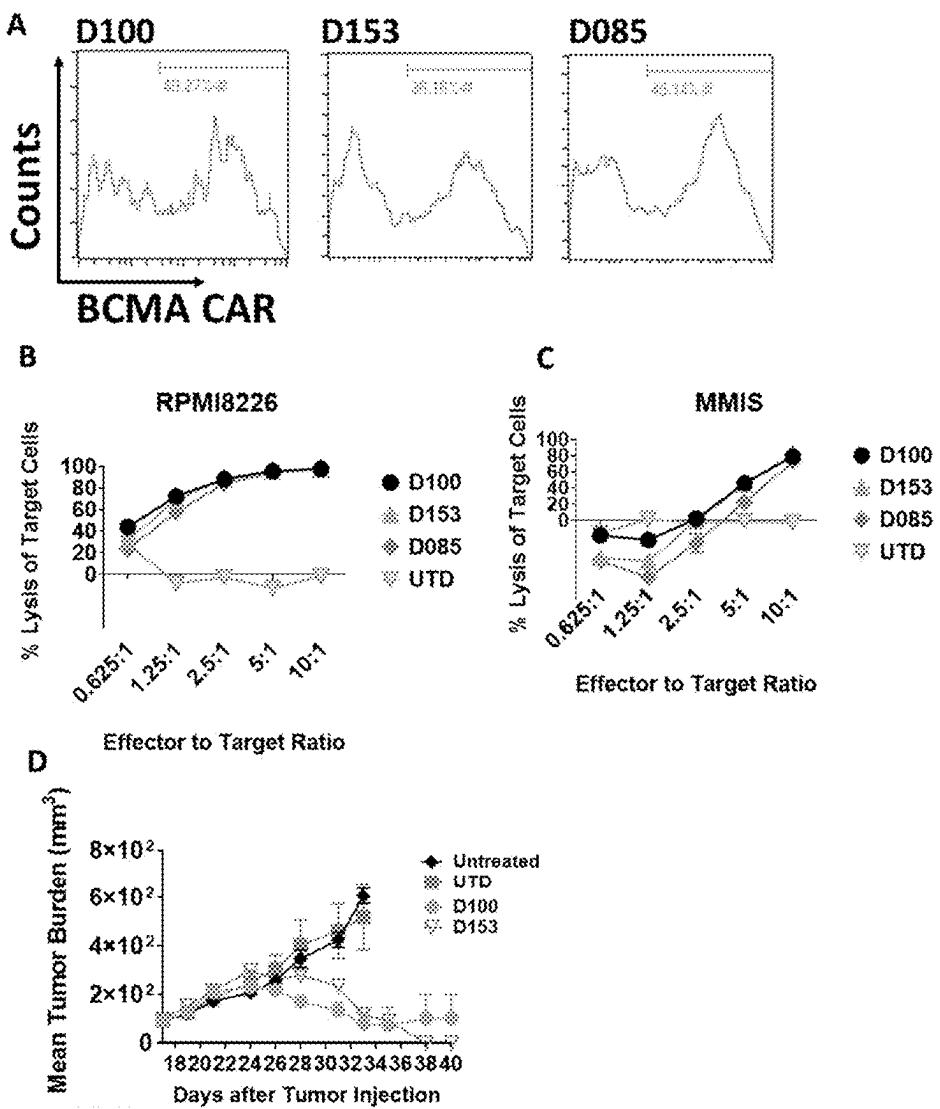
FIGS. 5A-B

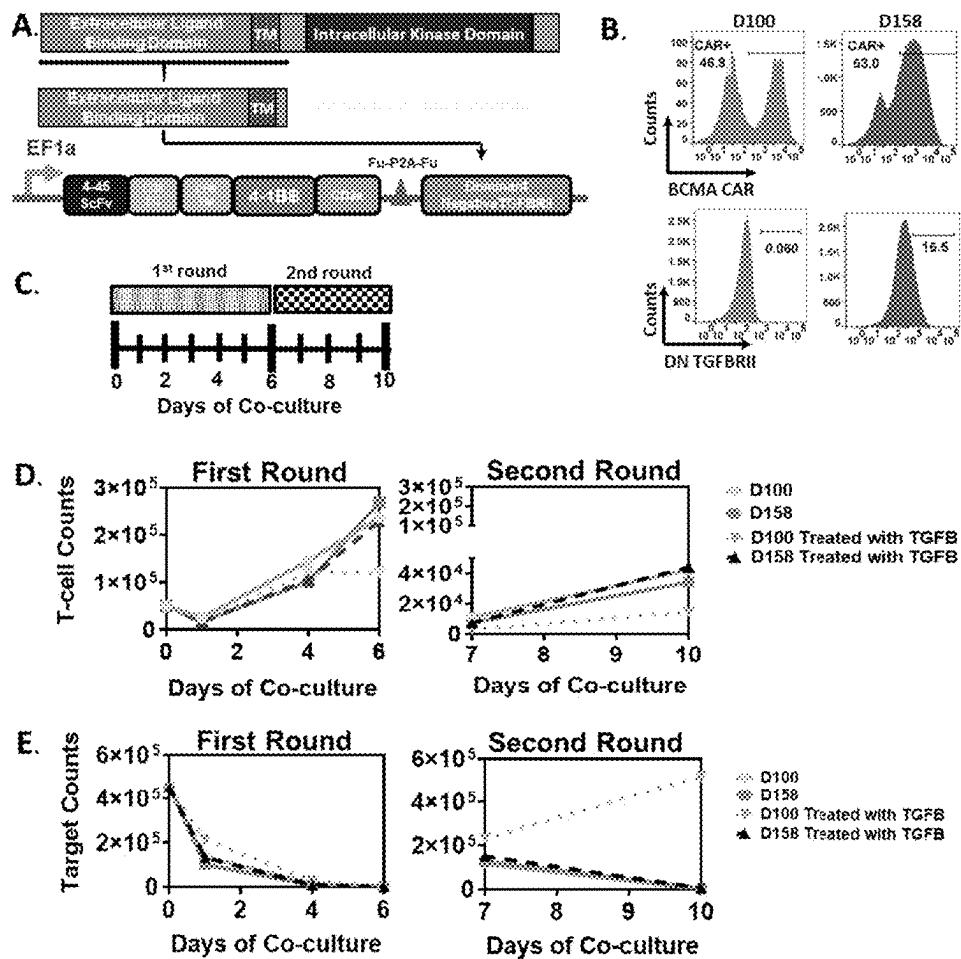


FIGS. 6A-G

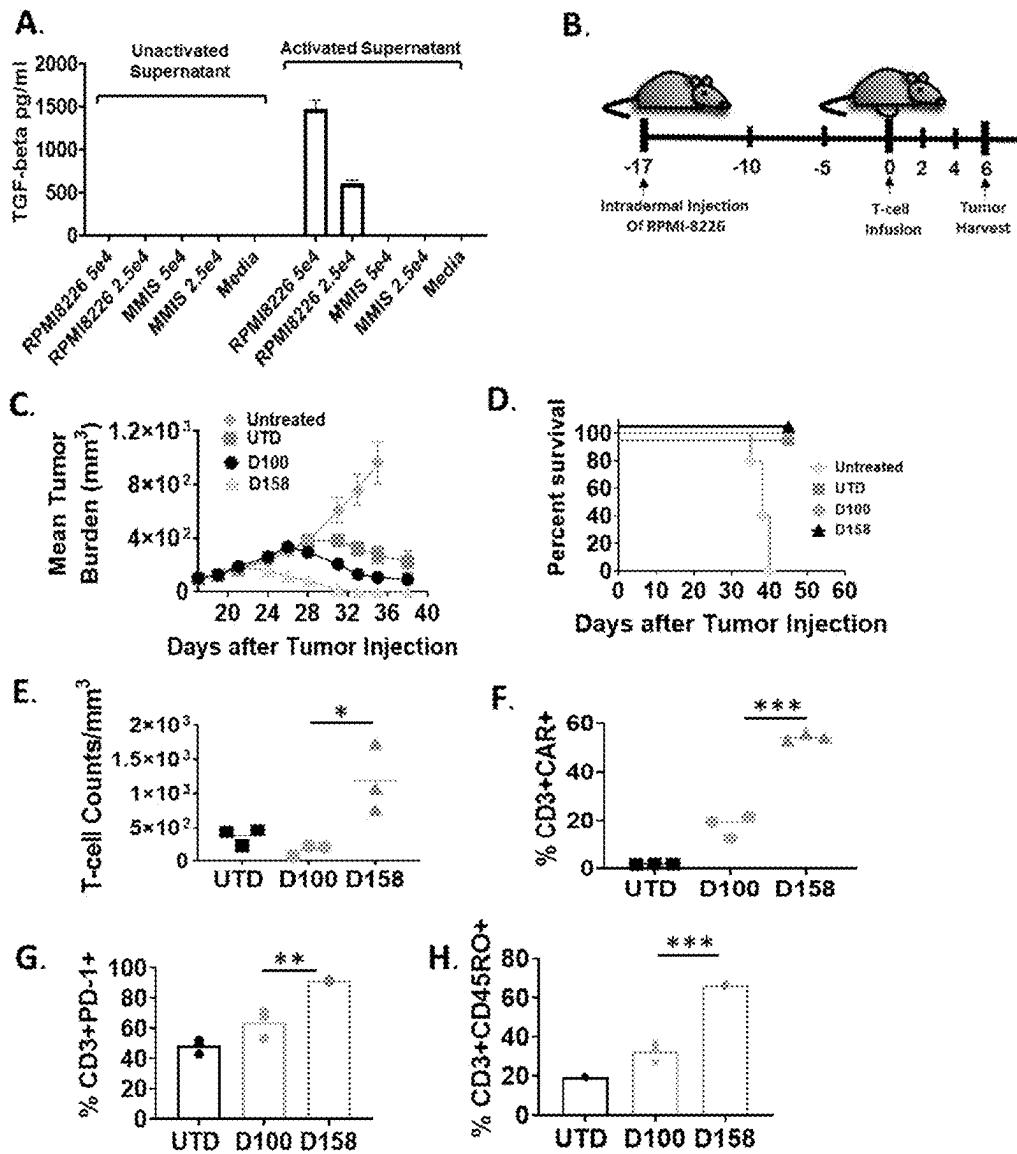


FIGS. 7A-C

**FIGS. 8A-D**



FIGS. 9A-E

**FIGS. 10A-H**

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**COMPOSITIONS AND METHODS FOR
TREATING CANCER WITH ANTI-BCMA
IMMUNOTHERAPY**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is a continuation of U.S. patent application Ser. No. 16/888,020, filed May 29, 2020, which claims priority to U.S. Provisional Patent Application Ser. No. 62/854,574, filed on May 30, 2019, the entire contents of which are hereby incorporated by reference.

SEQUENCE LISTING

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 May 28, 2020, is named Sequence_Listing.txt and is 146 kilobytes in size.

FIELD OF THE DISCLOSURE

This application relates to the field of cancer, particularly to B-cell maturation antigen (BCMA) antigen binding domains and chimeric antigen receptors (CARs) containing such BCMA antigen binding domains and methods of use thereof.

BACKGROUND

Cancer is one of the most deadly threats to human health. In the U.S. alone, cancer affects nearly 1.3 million new patients each year, and is the second leading cause of death after cardiovascular disease, accounting for approximately 1 in 4 deaths. Solid tumors are responsible for most of those deaths. Although there have been significant advances in the medical treatment of certain cancers, the overall 5-year survival rate for all cancers has improved only by about 10% in the past 20 years. Cancers, or malignant tumors, metastasize and grow rapidly in an uncontrolled manner, making treatment extremely difficult.

Multiple myeloma (MM) the second most common blood cancer in the US (after non-Hodgkin's lymphoma), with overall 5-year survival rate of approximately 50%, whereas types of genetic abnormalities determine the aggressiveness of MM, and older age at diagnosis, higher disease stage, and metastatic disease are associated with lower chances for survival (www.cancer.net).

MM is a multi-organ disease. In MM, the overgrowth of plasma cells in the bone marrow results in diminished normal hematopoiesis, leading to anemia, thrombocytopenia, and susceptibility to infections. Myeloma cells promote bone resorption by osteoclasts, leading to bone pain, bone loss, osteoporosis, fractures, and elevated blood calcium. Secretion of high level monoclonal immunoglobulins by myeloma cells leads to kidney damage and impaired kidney function. In addition, fractures of the vertebrae can cause elevated pressure on the nerve routes, causing neurologic symptoms, numbness tingling, pain, muscle weakness. MM is twice as prevalent in blacks as whites, and has a slight male predominance, with the median onset age is 66 years (Landgren O et al., Leukemia; Kyle R A et al., Mayo Clin Proc. 2003). An early abnormality leading to MM, termed monoclonal gammopathy of undetermined significance (MGUS), is an asymptomatic condition present in 3%-4% of the general population, which raises the risk of developing

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MM later in life by 1% per year (Kyle R. A et al., N Engl J Med. 2002 346.8 (2002): 564-569; Landgren O., et al., Blood. 2009 May 28; 113 (22): 5412-7). An intermediate stage condition leading up to the development of MM, smoldering multiple myeloma (SMM), is associated with 10% higher risk of progression to MM (Kyle R. A et al., N Engl J Med. 356.25 (2007): 2582-2590).

First line therapies of MM include combination regimens, often a combination therapy consisting of thalidomide, bortezomib and lenalidomide, and in some cases carfilzomib, pomalidomide and panobinostat. However, each of these medications carries a risk of toxicity. For example, in one MM study the combination of lenalidomide and dexamethasone was associated with grade 3+ toxicity in almost all patients enrolled in the study, as well as early mortality, and venous embolism (Blood 105:4050-4053, 2005). Furthermore, frail or elderly patients, may not be able to tolerate the triple regimen, bringing down the chances of successful therapy. For such patients, alternative treatment approaches are needed. In eligible patients, high dose chemotherapy in combination with autologous stem cell transplant is practiced (Attal M. et al., N Engl J Med. 1996; Child J. A. et al., N Engl J Med. 2003). In some cases, a tandem ASCT is administered, aiming to improve chances of survival (Krishnan A et al., Lancet Oncol. 2011; Fermand J et al., Hematol J. 2003; 4 (Suppl 1): S59). This approach, however, is associated with additional costs, medical risks and discomfort for the patients. If patients are not eligible for ASCT, however, their chances of recovery are low under currently available treatment options.

Treatment consolidation, and management of relapsed or refractory MM involves drug combinations, such as lenalidomide, pomalidomide, cyclophosphamide, prednisolone, which carry risk of treatment-related toxicities and are not curative.

Two monoclonal antibodies, daratumumab and SAR650984, targeting the CD38 molecule, have been used in relapsed and refractory MM (Sagar Lonial et J Clin Oncol. 2015;33 (suppl; abstr LBA8512); Plesner T, Jeckert J et al., CCR 2014, DOI: 10.1158/1078-0432.CCR-14-0695; Front Immunol. 2018; 9:1228. doi: 10.3389). A monoclonal antibody elotuzumab, targeting SLAMF7 (signaling lymphocytic activation molecule F7), has shown activity in relapsed MM when given is part of combination therapy (Lonial S, et al., N Engl J Med. 2015). However, better treatment options are necessary to improve success rate for relapsed or refractory disease, for the treatment of elderly or frail patients, and as an alternative to the currently accepted first-line therapies, in order to reduce side effects and improve efficacy.

B-cell maturation antigen (BCMA, CD269, TNFRSF17) is a marker of MM cells, and is expressed on early 100% MM tumor cells, while normal tissue expression is restricted to plasma cells and a subset of mature B-cells (Avery D T et al., J Clin Invest. 2003, 112 (2)). In addition to MM, BCMA is expressed on a subset of lymphoma clinical samples, and in many lymphoma cell lines, including Raji Non-Hodgkin's lymphoma line (Thompson J S et al., Exp Med. 2000 Jul. 3; 192 (1): 129-35.; Rennert P et al., J Exp Med. 2000 Dec. 4; 192 (11): 1677-84).

CAR approaches targeting BCMA are superior to small molecule combination therapy because they may achieve better efficacy in eliminating BCMA-positive tumor cells and tumor stem cells, and because they avoid the toxicities associated with combination therapy. In addition, CAR T treatment may obviate the need for hematopoietic stem cell

transplant, or a tandem transplant can and improve treatment's long-term tolerability, efficacy and survival.

Fully-human BCMA CARs represent an improvement over prior art because unique human ScFv sequences are used in the CAR design, as opposed to murine-derived ScFvs employed in CAR design elsewhere. Mouse-derived sequences carry the risk of immunogenicity, and may induce allergic or anaphylactic responses in patients, leading to CAR T elimination, or life-threatening anaphylaxis.

Chimeric Antigen Receptors (CARs) are hybrid molecules comprising three essential units: (1) an extracellular antigen-binding motif, (2) linking/transmembrane motifs, and (3) intracellular T-cell signaling motifs (Long A H, Haso W M, Orentas R J. Lessons learned from a highly-active CD22-specific chimeric antigen receptor. *Oncoimmunology*. 2013; 2 (4):e23621). The antigen-binding motif of a CAR is commonly fashioned after an single chain Fragment variable (ScFv), the minimal binding domain of an immunoglobulin (Ig) molecule. Alternate antigen-binding motifs, such as receptor ligands (i.e., IL-13 has been engineered to bind tumor expressed IL-13 receptor), intact immune receptors, library-derived peptides, and innate immune system effector molecules (such as NKG2D) also have been engineered. Alternate cell targets for CAR expression (such as NK or gamma-delta T cells) are also under development (Brown C E et al. *Clin Cancer Res*. 2012; 18 (8): 2199-209; Lehner M et al. *PLOS One*. 2012; 7 (2):e31210). There remains significant work with regard to defining the most active T-cell population to transduce with CAR vectors, determining the optimal culture and expansion techniques, and defining the molecular details of the CAR protein structure itself.

The linking motifs of a CAR can be a relatively stable structural domain, such as the constant domain of IgG, or designed to be an extended flexible linker. Structural motifs, such as those derived from IgG constant domains, can be used to extend the ScFv binding domain away from the T-cell plasma membrane surface. This may be important for some tumor targets where the binding domain is particularly close to the tumor cell surface membrane (such as for the disialoganglioside GD2; Orentas et al., unpublished observations). To date, the signaling motifs used in CARs always include the CD3-chain because this core motif is the key signal for T cell activation. The first reported second-generation CARs featured CD28 signaling domains and the CD28 transmembrane sequence. This motif was used in third-generation CARs containing CD137 (4-1BB) signaling motifs as well (Zhao Y et al. *J Immunol*. 2009; 183 (9): 5563-74). With the advent of new technology, the activation of T cells with beads linked to anti-CD3 and anti-CD28 antibody, and the presence of the canonical "signal 2" from CD28 was no longer required to be encoded by the CAR itself. Using bead activation, third-generation vectors were found to be not superior to second-generation vectors in in vitro assays, and they provided no clear benefit over second-generation vectors in mouse models of leukemia (Haso W, Lee D W, Shah N N, Stetler-Stevenson M, Yuan C M, Pastan I H, Dimitrov D S, Morgan R A, FitzGerald D J, Barrett D M, Wayne A S, Mackall C L, Orentas R J. Anti-CD22-chimeric antigen receptors targeting B cell precursor acute lymphoblastic leukemia. *Blood*. 2013; 121 (7): 1165-74; Kochenderfer J N et al. *Blood*. 2012; 119 (12): 2709-20). This is borne out by the clinical success of CD19-specific CARs that are in a second generation CD28/CD3- ζ (Lee D W et al. American Society of Hematology Annual Meeting. New Orleans, LA; Dec. 7-10, 2013) and a CD137/CD3- ζ signaling format (Porter D L et al. *N Engl J Med*. 2011; 365 (8): 725-33). In addition to CD137, other tumor necrosis

factor receptor superfamily members such as OX40 also are able to provide important persistence signals in CAR-transduced T cells (Yvon E et al. *Clin Cancer Res*. 2009; 15 (18): 5852-60). Equally important are the culture conditions under which the CAR T-cell populations were cultured.

Current challenges in the more widespread and effective adaptation of CAR therapy for cancer relate to a paucity of compelling targets. Creating binders to cell surface antigens is now readily achievable, but discovering a cell surface antigen that is specific for tumor while sparing normal tissues remains a formidable challenge. One potential way to imbue greater target cell specificity to CAR-expressing T cells is to use combinatorial CAR approaches. In one system, the CD3-2 and CD28 signal units are split between two different CAR constructs expressed in the same cell; in another, two CARs are expressed in the same T cell, but one has a lower affinity and thus requires the alternate CAR to be engaged first for full activity of the second (Lanitis E et al. *Cancer Immunol Res*. 2013; 1 (1): 43-53; Kloss C C et al. *Nat Biotechnol*. 2013; 31 (1): 71-5). A second challenge for the generation of a single ScFv-based CAR as an immunotherapeutic agent is tumor cell heterogeneity. At least one group has developed a CAR strategy for glioblastoma whereby the effector cell population targets multiple antigens (HER2, IL-13Ra, EphA2) at the same time in the hope of avoiding the outgrowth of target antigen-negative populations. (Hegde M et al. *Mol Ther*. 2013; 21 (11): 2087-101).

T-cell-based immunotherapy has become a new frontier in synthetic biology; multiple promoters and gene products are envisioned to steer these highly potent cells to the tumor microenvironment, where T cells can both evade negative regulatory signals and mediate effective tumor killing. The elimination of unwanted T cells through the drug-induced dimerization of inducible caspase 9 constructs with AP1903 demonstrates one way in which a powerful switch that can control T-cell populations can be initiated pharmacologically (Di Stasi A et al. *N Engl J Med*. 2011; 365 (18): 1673-83). The creation of effector T-cell populations that are immune to the negative regulatory effects of transforming growth factor- β by the expression of a decoy receptor further demonstrates that degree to which effector T cells can be engineered for optimal anti-tumor activity (Foster A E et al. *J Immunother*. 2008;31 (5): 500-5). Thus, while it appears that CARs can trigger T-cell activation in a manner similar to an endogenous T-cell receptor, a major impediment to the clinical application of this technology to date has been limited in vivo expansion of CAR+ T cells, rapid disappearance of the cells after infusion, and disappointing clinical activity. Accordingly, there is an urgent and long felt need in the art for discovering novel compositions and methods for treatment of MM using an approach that can exhibit specific and efficacious anti-tumor effect without the aforementioned short comings.

The present invention addresses these needs by providing CAR compositions and therapeutic methods that can be used to treat BCMA-positive cancers and other diseases and/or conditions. In particular, the present invention as disclosed and described herein provides CARs that may be used the treatment of BCMA-positive cancers, and which CARs contain BCMA antigen binding domains that exhibit a high surface expression on transduced T cells, exhibit a high degree of cytotoxicity and transduced T cell in vivo expansion and persistence.

SUMMARY

Novel anti-BCMA antibodies or antigen binding domains thereof and chimeric antigen receptors (CARs) that contain

such BCMA antigen binding domains are provided herein, as well as host cells (e.g., T cells) expressing the receptors, and nucleic acid molecules encoding the receptors. CAR may consist either of a single molecule expressed on the effector cell surface, or a CAR comprised of an effector cell-expressed signaling module and a soluble targeting module, such as when the soluble targeting module binds to the cell-expressed signaling module, a complete functional CAR is formed. The CARs exhibit a high surface expression on transduced T cells, with a high degree of cytotoxicity and transduced T cell expansion and persistence in vivo. Methods of using the disclosed CARs, host cells, and nucleic acid molecules are also provided, for example, to treat a cancer in a subject.

Thus, in one aspect, an isolated polynucleotide encoding a human anti-BCMA antibody or a fragment thereof is provided comprising a nucleic acid sequence selected from the group consisting of SEQ ID NOS: 1, 3, 5, 7, 9, 11, 15, 17, 19, 21, 23, 25, 69, 71, 73, 75, and 77.

In one embodiment, an isolated polynucleotide encoding a fully human anti-BCMA antibody or a fragment thereof is provided, wherein the antibody or a fragment thereof comprises a fragment selected from the group consisting of an Fab fragment, an F(ab') 2 fragment, an Fv fragment, and a single chain Fv (ScFv).

In one embodiment, an isolated polynucleotide encoding a fully human anti-BCMA antibody or a fragment thereof is provided, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78.

In one aspect, an isolated nucleic acid molecule encoding a chimeric antigen receptor (CAR) is provided comprising, from N-terminus to C-terminus, at least one BCMA antigen binding domain encoded by a nucleotide sequence comprising a nucleic acid sequence selected from the group consisting of SEQ ID NOS: 1, 3, 5, 7, 9, 11, 15, 17, 19, 21, 23, 25, 69, 71, 73, 75, and 77, at least one transmembrane domain, and at least one intracellular signaling domain.

In one embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded extracellular BCMA antigen binding domain comprises at least one single chain variable fragment of an antibody that binds to BCMA.

In another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded extracellular BCMA antigen binding domain comprises at least one heavy chain variable region of an antibody that binds to BCMA.

In another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded extracellular BCMA antigen binding domain comprises an ScFv.

In one embodiment, the targeting domain of the CAR is expressed separately in the form of monoclonal antibody, ScFv Fab, Fab'2 and is containing an antigen-targeting domain comprising a nucleic acid sequence selected from the group consisting of SEQ ID NOS: 1, 3, 5, 7, 9, 11, 15, 17, 19, 21, 23, 25, 69, 71, 73, 75, and 77, coupled to an additional binding tag or epitope, whereas the effector-cell expressed component of the CAR contains a binding domain specifically directed to bind the tag or epitope expressed on the soluble CAR module, such as specific binding on the soluble component of the CAR to the cell bound component of the CAR forms the full functional CAR structure.

In another embodiment, the targeting domain of the CAR is expressed separately in the form of a monoclonal antibody, ScFv Fab, Fab'2 and contains an antigen-targeting

domain comprising a nucleic acid sequence selected from the group consisting of SEQ ID NOS: 1, 3, 5, 7, 9, 11, 15, 17, 19, 21, 23, 25, 69, 71, 73, 75, and 77, and an additional ScFv, whereas the effector-cell expressed component of the CAR contains a tag or epitope specifically reactive with the additional ScFv expressed on the soluble CAR module, such as specific binding on the soluble component of the CAR to the cell bound component of the CAR forms the full functional CAR structure.

In yet another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded CAR extracellular BCMA antigen binding domain further comprises at least one lipocalin-based antigen binding antigen (anticalins) that binds to BCMA.

In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA antigen binding domain is connected to the transmembrane domain by a linker domain.

In another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded BCMA extracellular antigen binding domain is preceded by a sequence encoding a leader or signal peptide.

In yet another embodiment, an isolated nucleic acid molecule encoding the CAR is provided comprising at least one BCMA antigen binding domain encoded by a nucleotide sequence comprising a nucleic acid sequence selected from the group consisting of SEQ ID NOS: 1, 3, 5, 7, 9, 11, 15, 17, 19, 21, 23, 25, 69, 71, 73, 75, and 77, and wherein the CAR additionally encodes an extracellular antigen binding domain targets an antigen that includes, but is not limited to, CD19, CD20, CD22, ROR1, mesothelin, CD33, CD38, CD123 (IL3RA), CD138, GPC2, GPC3, FGFR4, c-Met, PSMA, Glycolipid F77, EGFRVIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or any combination thereof.

In certain embodiments, an isolated nucleic acid molecule encoding the CAR is provided wherein the additionally encoded extracellular antigen binding domain comprises an anti-CD19 ScFv antigen binding domain, an anti-CD20 ScFv antigen binding domain, an anti-CD22 ScFv antigen binding domain, an anti-ROR1 ScFv antigen binding domain, an anti-mesothelin ScFv antigen binding domain, an anti-CD33 ScFv antigen binding domain, an anti-CD38 ScFv antigen binding domain, an anti-CD123 (IL3RA) ScFv antigen binding domain, an anti-CD138 ScFv antigen binding domain, an anti-GPC2 ScFv antigen binding domain, an anti-GPC3 ScFv antigen binding domain, an anti-FGFR4 ScFv antigen binding domain, an anti-c-Met ScFv antigen binding domain, an anti-PSMA ScFv antigen binding domain, an anti-glycolipid F77 ScFv antigen binding domain, an anti-EGFRVIII ScFv antigen binding domain, an anti-GD-2 ScFv antigen binding domain, an anti-NY-ESO-1 TCR ScFv antigen binding domain, an anti-MAGE A3 TCR ScFv antigen binding domain, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, or any combination thereof.

In one aspect, the CARs provided herein further comprise a linker or spacer domain.

In one embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the extracellular BCMA antigen binding domain, the intracellular signaling domain, or both are connected to the transmembrane domain by a linker or spacer domain.

In one embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded linker domain is derived from the extracellular domain of CD8 or CD28, and is linked to a transmembrane domain.

In another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded CAR further comprises a transmembrane domain that comprises 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, or a combination thereof.

In yet another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded intracellular signaling domain further comprises a CD3 zeta intracellular domain.

In one embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded intracellular signaling domain is arranged on a C-terminal side relative to the CD3 zeta intracellular domain.

In another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded at least one intracellular signaling domain comprises a costimulatory domain, a primary signaling domain, or a combination thereof.

In further embodiments, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded at least one costimulatory domain comprises a functional signaling domain of OX40, CD70, CD27, CD28, CD5, ICAM-1, LFA-1 (CD11a/CD18), ICOS (CD278), DAP10, DAP12, and 4-1BB (CD137), or a combination thereof.

In one embodiment, an isolated nucleic acid molecule encoding the CAR is provided that further contains a leader sequence or signal peptide wherein the leader or signal peptide nucleotide sequence comprises the nucleotide sequence of SEQ ID NO: 13, SEQ ID NO: 39, SEQ ID NO: 41, or SEQ ID NO: 43.

In yet another embodiment, an isolated nucleic acid molecule encoding the CAR is provided wherein the encoded leader sequence comprises the amino acid sequence of SEQ ID NO: 14, SEQ ID NO: 40, SEQ ID NO: 42, or SEQ ID NO: 44.

In one aspect, a chimeric antigen receptor (CAR) is provided herein comprising, from N-terminus to C-terminus, at least one BCMA antigen binding domain, at least one transmembrane domain, and at least one intracellular signaling domain.

In one embodiment, a CAR is provided wherein the extracellular BCMA antigen binding domain comprises at least one single chain variable fragment of an antibody that binds to the antigen, or at least one heavy chain variable region of an antibody that binds to the antigen, or a combination thereof.

In another embodiment, a CAR is provided wherein the at least one transmembrane domain comprises 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, or a combination thereof.

In some embodiments, the CAR is provided wherein CAR additionally encodes an extracellular antigen binding domain comprising CD19, CD20, CD22, ROR1, mesothelin, CD33, CD38, CD123 (IL3RA), CD138, GPC2, GPC3, FGFR4, c-Met, PSMA, Glycolipid F77, EGFRVIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, or any combination thereof.

In one embodiment, the CAR is provided wherein the extracellular antigen binding domain additionally comprises an anti-CD19 ScFv antigen binding domain, an anti-CD20

ScFv antigen binding domain, an anti-CD22 ScFv antigen binding domain, an anti-ROR1 ScFv antigen binding domain, an anti-mesothelin ScFv antigen binding domain, an anti-CD33 ScFv antigen binding domain, an anti-CD38 ScFv antigen binding domain, an anti-CD123 (IL3RA) ScFv antigen binding domain, an anti-CD138 ScFv antigen binding domain, an anti-GPC2 ScFv antigen binding domain, an anti-GPC3 ScFv antigen binding domain, an anti-FGFR4 ScFv antigen binding domain, an anti-c-Met ScFv antigen binding domain, an anti-PMSA ScFv antigen binding domain, an anti-glycolipid F77 ScFv antigen binding domain, an anti-EGFRvIII ScFv antigen binding domain, an anti-GD-2 ScFv antigen binding domain, an anti-NY-ESO-1 TCR ScFv antigen binding domain, an anti-MAGE A3 TCR ScFv antigen binding domain, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, or any combination thereof.

In another embodiment, the CAR is provided wherein the extracellular antigen binding domain additionally comprises an immunoglobulin variable heavy chain only (VH) anti-CD19 antigen binding domain, an anti-CD20 VH antigen binding domain, an anti-CD22 VH antigen binding domain, an anti-ROR1 VH antigen binding domain, an anti-mesothelin VH antigen binding domain, an anti-CD33 VH antigen binding domain, an anti-CD38 VH antigen binding domain, an anti-CD123 (IL3RA) VH antigen binding domain, an anti-CD138 VH antigen binding domain, an anti-GPC2 VH antigen binding domain, an anti-GPC3 VH antigen binding domain, an anti-FGFR4 VH antigen binding domain, an anti-c-Met VH antigen binding domain, an anti-PMSA VH antigen binding domain, an anti-glycolipid F77 VH antigen binding domain, an anti-EGFRvIII VH antigen binding domain, an anti-GD-2 VH antigen binding domain, an anti-NY-ESO-1 TCR VH antigen binding domain, an anti-MAGE A3 TCR VH antigen binding domain, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, or any combination thereof.

In another embodiment, the CAR is provided wherein the extracellular antigen binding domain additionally comprises a protein or a peptide (P) sequence capable of specifically binding target antigen, which may be derived from a natural or a synthetic sequence comprising anti-CD19 P antigen binding domain, an anti-CD20 P antigen binding domain, an anti-CD22 P antigen binding domain, an anti-ROR1 P antigen binding domain, an anti-mesothelin P antigen binding domain, an anti-CD33 P antigen binding domain, an anti-CD38 P antigen binding domain, an anti-CD123 (IL3RA) P antigen binding domain, an anti-CD138 P antigen binding domain, an anti-BCMA (CD269) P antigen binding domain, an anti-GPC2 P antigen binding domain, an anti-GPC3 P antigen binding domain, an anti-FGFR4 P antigen binding domain, an anti-c-Met P antigen binding domain, an anti-PMSA P antigen binding domain, an anti-glycolipid F77 P antigen binding domain, an anti-EGFRvIII P antigen binding domain, an anti-GD-2 P antigen binding domain, an anti-NY-ESO-1 TCR P antigen binding domain, an anti-MAGE A3 TCR P antigen binding domain, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, or any combination thereof. In another embodiment, a CAR is provided wherein the at least one intracellular signaling domain comprises a costimulatory domain and a primary signaling domain.

In yet another embodiment, a CAR is provided wherein the at least one intracellular signaling domain comprises a costimulatory domain comprising a functional signaling domain of a protein selected from the group consisting of

OX40, CD70, CD27, CD28, CD5, ICAM-1, LFA-1 (CD11a/CD18), ICOS (CD278), DAP10, DAP12, and 4-1BB (CD137), or a combination thereof.

In one embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 87. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 88.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 89. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 90.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 91. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 92.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 93. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 94.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 95. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 96.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 97. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 98.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 99. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 100.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 101. In one embodiment, the nucleic acid sequence encodes a CAR comprising the amino acid sequence of SEQ ID NO: 102.

In one aspect, the CARs disclosed herein are modified to express or contain a detectable marker for use in diagnosis, monitoring, and/or predicting the treatment outcome such as progression free survival of cancer patients or for monitoring the progress of such treatment.

In one embodiment, the nucleic acid molecule encoding the disclosed CARs can be contained in a vector, such as a viral vector. The vector is a DNA vector, an RNA vector, a plasmid vector, a cosmid vector, a herpes virus vector, a measles virus vector, a lentivirus vector, an adenoviral vector, or a retrovirus vector, or a combination thereof.

In certain embodiments, the vector further comprises a promoter wherein the promoter is an inducible promoter, a tissue specific promoter, a constitutive promoter, a suicide promoter or any combination thereof.

In yet another embodiment, the vector expressing the CAR can be further modified to include one or more operative elements to control the expression of CAR T cells, or to eliminate CAR-T cells by virtue of a suicide switch. The suicide switch can include, for example, an apoptosis inducing signaling cascade or a drug that induces cell death. In a preferred embodiment, the vector expressing the CAR can be further modified to express an enzyme such thymidine kinase (TK) or cytosine deaminase (CD).

In another aspect, host cells including the nucleic acid molecule encoding the CAR are also provided. In some embodiments, the host cell is a T cell, such as a primary T cell obtained from a subject. In one embodiment, the host cell is a CD8+ T cell.

In yet another aspect, a pharmaceutical composition is provided comprising an anti-tumor effective amount of a population of human T cells, wherein the T cells comprise a nucleic acid sequence that encodes a chimeric antigen receptor (CAR), wherein the CAR comprises at least one extracellular antigen binding domain comprising a BCMA antigen binding domain comprising the amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78; at least one linker domain; at least one transmembrane domain; and at least one intracellular signaling domain, wherein the T cells are T cells of a human having a cancer. The cancer includes, inter alia, a hematological cancer such as leukemia (e.g., chronic lymphocytic leukemia (CLL), acute lymphocytic leukemia (ALL), or chronic myelogenous leukemia (CML)), lymphoma (e.g., mantle cell lymphoma, non-Hodgkin's lymphoma or Hodgkin's lymphoma) or multiple myeloma, or a combination thereof.

In one embodiment, a pharmaceutical composition is provided wherein the at least one transmembrane domain of the CAR contains 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, Mesothelin, CD33, CD37, CD64, CD80, CD86, CD134, CD137 and CD154, or a combination thereof.

In another embodiment, a pharmaceutical composition is provided wherein the human cancer includes an adult carcinoma comprising oral and pharynx cancer (tongue, mouth, pharynx, head and neck), digestive system cancers (esophagus, stomach, small intestine, colon, rectum, anus, liver, interhepatic bile duct, gallbladder, pancreas), respiratory system cancers (larynx, lung and bronchus), bones and joint cancers, soft tissue cancers, skin cancers (melanoma, basal and squamous cell carcinoma), pediatric tumors (neuroblastoma, rhabdomyosarcoma, osteosarcoma, Ewing's sarcoma), tumors of the central nervous system (brain, astrocytoma, glioblastoma, glioma), and cancers of the breast, the genital system (uterine cervix, uterine corpus, ovary, vulva, vagina, prostate, testis, penis, endometrium), the urinary system (urinary bladder, kidney and renal pelvis, ureter), the eye and orbit, the endocrine system (thyroid), and the brain and other nervous system, or any combination thereof.

In yet another embodiment, a pharmaceutical composition is provided comprising an anti-tumor effective amount of a population of human T cells of a human having a cancer wherein the cancer is a refractory cancer non-responsive to one or more chemotherapeutic agents. The cancer includes hematopoietic cancer, myelodysplastic syndrome pancreatic cancer, head and neck cancer, cutaneous tumors, minimal residual disease (MRD) in multiple myeloma (MM), smoldering multiple myeloma (SMM), monoclonal gammopathy of undetermined significance (MGUS), adult and pediatric hematologic malignancies, including acute lymphoblastic leukemia (ALL), CLL (Chronic lymphocytic leukemia), non-Hodgkin's lymphoma (NHL), including follicular lymphoma (FL), diffuse large B cell lymphoma (DLBCL), mantle cell lymphoma (MCL), Hodgkin's lymphoma (HL), chronic myelogenous leukemia (CML), lung cancer, breast cancer, ovarian cancer, prostate cancer, colon cancer, melanoma or other hematological cancer and solid tumors, or any combination thereof.

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In another aspect, methods of making CAR-containing T cells (hereinafter “CAR-T cells”) are provided. The methods include transducing a T cell with a vector or nucleic acid molecule encoding a disclosed CAR that specifically binds BCMA, thereby making the CAR-T cell.

In yet another aspect, a method of generating a population of RNA-engineered cells is provided that comprises introducing an *in vitro* transcribed RNA or synthetic RNA of a nucleic acid molecule encoding a disclosed CAR into a cell of a subject, thereby generating a CAR cell.

In yet another aspect, a method for diagnosing a disease, disorder or condition associated with the expression of BCMA on a cell, is provided comprising a) contacting the cell with a human anti-BCMA antibody or fragment thereof, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78; and b) detecting the presence of BCMA wherein the presence of BCMA diagnoses for the disease, disorder or condition associated with the expression of BCMA.

In one embodiment, the disease, disorder or condition associated with the expression of BCMA is cancer including hematopoietic cancer, myelodysplastic syndrome pancreatic cancer, head and neck cancer, cutaneous tumors, minimal residual disease (MRD) in acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), adult B cell malignancies including, CLL (chronic lymphocytic leukemia), CML (chronic myelogenous leukemia), non-Hodgkin's lymphoma (NHL), pediatric B cell malignancies (including B lineage ALL (acute lymphocytic leukemia)), multiple myeloma lung cancer, breast cancer, ovarian cancer, prostate cancer, colon cancer, melanoma or other hematological cancer and solid tumors, or any combination thereof.

In another embodiment, a method of diagnosing, prognosis, or determining risk of a BCMA-related disease in a mammal, is provided comprising detecting the expression of BCMA in a sample derived from the mammal comprising: a) contacting the sample with a human anti-BCMA antibody or fragment thereof, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78; and b) detecting the presence of BCMA wherein the presence of BCMA diagnoses for a BCMA-related disease in the mammal.

In another embodiment, a method of inhibiting BCMA-dependent T cell inhibition, is provided comprising contacting a cell with a human anti-BCMA antibody or fragment thereof, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78. In one embodiment, the cell is selected from the group consisting of a BCMA-expressing tumor cell, a tumor-associated macrophage, and any combination thereof.

In another embodiment, a method of blocking T-cell inhibition mediated by a BCMA-expressing cell and altering the tumor microenvironment to inhibit tumor growth in a mammal, is provided comprising administering to the mammal an effective amount of a composition comprising an isolated anti-BCMA antibody or fragment thereof, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78. In one embodiment, the cell is selected from the group consisting of a BCMA-expressing tumor cell, a tumor-associated macrophage, and any combination thereof.

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In another embodiment, a method of inhibiting, suppressing or preventing immunosuppression of an anti-tumor or anti-cancer immune response in a mammal, is provided comprising administering to the mammal an effective amount of a composition comprising an isolated anti-BCMA antibody or fragment thereof, wherein the antibody or a fragment thereof comprises an amino acid sequence selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78. In one embodiment, the antibody or fragment thereof inhibits the interaction between a first cell with a T cell, wherein the first cell is selected from the group consisting of a BCMA-expressing tumor cell, a tumor-associated macrophage, and any combination thereof.

In another aspect, a method is provided for inducing an anti-tumor immunity in a mammal comprising administering to the mammal a therapeutically effective amount of a T cell transduced with vector or nucleic acid molecule encoding a disclosed CAR.

In another embodiment, a method of treating or preventing cancer in a mammal is provided comprising administering to the mammal one or more of the disclosed CARs, in an amount effective to treat or prevent cancer in the mammal. The method includes administering to the subject a therapeutically effective amount of host cells expressing a disclosed CAR that specifically binds BCMA and/or one or more of the aforementioned antigens, under conditions sufficient to form an immune complex of the antigen binding domain on the CAR and the extracellular domain of BCMA and/or one or more of the aforementioned antigens in the subject.

In yet another embodiment, a method is provided for treating a mammal having a disease, disorder or condition associated with an elevated expression of a tumor antigen, the method comprising administering to the subject a pharmaceutical composition comprising an anti-tumor effective amount of a population of T cells, wherein the T cells comprise a nucleic acid sequence that encodes a chimeric antigen receptor (CAR), wherein the CAR includes at least one extracellular BCMA antigen binding domain comprising the amino acid sequence of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78, or any combination thereof, at least one linker or spacer domain, at least one transmembrane domain, at least one intracellular signaling domain, and wherein the T cells are T cells of the subject having cancer.

In yet another embodiment, a method is provided for treating cancer in a subject in need thereof comprising administering to the subject a pharmaceutical composition comprising an anti-tumor effective amount of a population of T cells, wherein the T cells comprise a nucleic acid sequence that encodes a chimeric antigen receptor (CAR), wherein the CAR comprises at least one BCMA antigen binding domain comprising the amino acid sequence of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78, or any combination thereof, at least one linker or spacer domain, at least one transmembrane domain, at least one intracellular signaling domain, wherein the T cells are T cells of the subject having cancer. In some embodiments of the aforementioned methods, the at least one transmembrane domain comprises a transmembrane the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, Mesothelin, CD33, CD37, CD64, CD80, CD86, CD134, CD137 and CD154, or a combination thereof.

In yet another embodiment, a method is provided for generating a persisting population of genetically engineered

T cells in a human diagnosed with cancer. In one embodiment, the method comprises administering to a human a T cell genetically engineered to express a CAR wherein the CAR comprises at least one BCMA antigen binding domain comprising the amino acid sequence of SEQ ID NOs: 2, 4, 6, 8, 10, 12, 16, 18, 20, 22, 24, 26, 70, 72, 74, 76, and 78, or any combination thereof; at least one transmembrane domain; and at least one intracellular signaling domain wherein the persisting population of genetically engineered T cells, or the population of progeny of the T cells, persists in the human for at least one month, two months, three months, four months, five months, six months, seven months, eight months, nine months, ten months, eleven months, twelve months, two years, or three years after administration.

In one embodiment, the progeny T cells in the human comprise a memory T cell. In another embodiment, the T cell is an autologous T cell.

In all of the aspects and embodiments of methods described herein, any of the aforementioned cancers, diseases, disorders or conditions associated with an elevated expression of a tumor antigen that may be treated or prevented or ameliorated using one or more of the CARs disclosed herein,

In yet another aspect, a kit is provided for making a chimeric antigen receptor T-cell as described supra or for preventing, treating, or ameliorating any of the cancers, diseases, disorders or conditions associated with an elevated expression of a tumor antigen in a subject as described supra, comprising a container comprising any one of the nucleic acid molecules, vectors, host cells, or compositions disclosed supra or any combination thereof, and instructions for using the kit.

It will be understood that the CARs, host cells, nucleic acids, and methods are useful beyond the specific aspects and embodiments that are described in detail herein. The foregoing features and advantages of the disclosure will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 depicts the construction of CARs targeting BCMA. The anti-BCMA ScFv targeting domain was linked in frame to CD8 hinge and transmembrane domain, the 4-1BB (CD137) signaling domain and the CD3 zeta signaling domain.

FIG. 2 depicts surface expression of BCMA-targeting CAR T constructs on human primary T cells. CAR T expression was determined by flow cytometry. T cells were activated with Miltenyi Biotec TransActTM CD3 CD28 reagent in the presence of IL-2, and transduced with LV as described in Materials and Methods. On culture day 8, viable transduced T cells (7-AAD negative) were assayed for CAR surface expression using the Protein L method (top panel) or the BCMA-Fc method (bottom panel). The CAR construct identifier (ScFv number) used in each transduction is listed above each figure. Bars represent the percentage of CAR T-positive populations in relation to non-transduced T cell control (UTD).

FIGS. 3A-C depict CAR T cytotoxicity in vitro. CARs are designated by their ScFv number, preceded by a prefix "BCMA". Luciferase-based cytotoxicity assays were performed using, BCMA-positive tumor lines RPMI-8226 (FIG. 3A), and MM1.S (FIG. 3B), or BCMA-negative cell

line 293T (FIG. 3C), stably transduced with firefly luciferase. Bars represent mean+SD values from three technical replicates.

FIGS. 4A-B depict surface expression of BCMA-targeting CAR T constructs on human primary T cells. T cells were isolated form a buffy coat via CD4+CD8+ positive selection using Miltenyi cell isolation reagents. CAR T expression was determined by flow cytometry. T cells were activated with Miltenyi Biotec TransActTM CD3 CD28 reagent in the presence of IL-2, and transduced with LV as described in Materials and Methods. On culture day 8, viable transduced T cells (7-AAD negative) were assayed for CAR surface expression using the BCMA-Fc method. CAR construct number is listed to the left of each figure. Expression of CAR T in CD8-(CD4+) and CD8+ cell population is shown in the left column (FIG. 4A), and the total CAR expression is shown in the histogram on the right (FIG. 4B). Bars on the right represent the percentage of CAR T-positive populations in relation to non-transduced T cell control (UTD, not shown).

FIGS. 5A-B depict the cytotoxicity of anti-BCMA CARs D0084, D0085, D0086, D0087, D0099, D0100 in vitro, in two separate donors. Luciferase-based cytotoxicity assays were performed using BCMA-positive tumor lines RPMI-8226, and MM1.S, or BCMA-negative cell line 293T, stably transduced with firefly luciferase. Bars represent mean+SD values from three technical replicates.

FIGS. 6A-G depict the superior functionality of the D100 BCMA CAR in comparison to the D085 BCMA CAR in a long-term in vitro co-incubation assay. (FIG. 6A) The structure of the BCMA CARs D100 and D085 includes an scFv CAR targeting domain linked to the CD8 extracellular and transmembrane domains, followed by the 4-1BB co-stimulatory molecule and the CD32 domain. (FIG. 6B) T-cells were transduced at various MOIs with lentiviral vectors harboring either the D100 or the D085 BCMA CAR constructs, and the cell surface expression of the CARs was assessed by flow cytometry. (FIG. 6C) In the long-term co-culture experiment, CAR T-cells were co-incubated with the target multiple myeloma cell line, MM1.S tagged with GFP, at an ETT ratio of 0.1. The co-culture was repeated for four rounds in the span of 20 days. The absolute counts of (FIG. 6D) T-cells and (FIG. 6E) target cells were assessed by flow cytometry at different time points during the four rounds of co-culture by quantifying the number of CD3+ cells and GFP+ cells, respectively. The absolute counts were determined by using CountBright Absolute Counting Beads. (FIG. 6F) The changes in the percentages of CAR+CD4+ and CD8+ at various timepoints during the long term co-culture were assessed by flow cytometry. (FIG. 6G) The production of IL-2, TNF α , and IFN γ in CD3+ cells was determined by intracellular staining and flow cytometric analysis on day 11 during the third round of co-culture (FIG. 6G).

FIGS. 7A-C depict in vivo evaluation of BCMA-targeting CAR Constructs. (FIG. 7A) Eight millions of RPMI-8226 cells were intradermally injected on the abdomen of NSG mice (all groups n=8, except untreated, n=5) and allowed to engraft for 17 days before the intravenous injection of five million/mouse CAR T-cells. The number of CAR T-cells that was infused was normalized based on CAR expression levels. On day 6, after T-cell infusion, 3 mice from each group were sacrificed for tumor harvest while the rest of the mice were monitored for (FIG. 7B) tumor growth and (FIG. 7C) survival.

FIGS. 8A-D depict in vitro characterization of CAR D153, incorporating the scFv sequence 4-1c. The scFv 4-1c

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was cloned into a CAR backbone comprised of CD8 extra-cellular and transmembrane domains, 4-1BB co-stimulatory domain, and CD35 activating domain, identical to that used in CARD100 and D085, as shown in FIG. 6A. (FIG. 8A) Lentiviral transduction efficiency of CAR D153, D100 and D085 in primary human T cells was measured by flow cytometry. (FIG. 8B) The cytotoxicity of anti-BCMA CARs D153, D100, D085, or non-transduced UTD control T cells in vitro. Luciferase-based cytotoxicity assays were performed using BCMA-positive tumor lines RPMI-8226, and MM1.S, stably transduced with firefly luciferase. (FIG. 8C). In vivo evaluation of BCMA-targeting CAR D153 as compared to BCMA CAR D100 in RPMI-8226 intradermal NSG xenograft model. (n=5) (FIG. 8D). Tumors were established for 17 days following intradermal injection of eight million RPMI-8226 cells per mouse. Tumor-bearing mice were distributed to groups with equal mean tumor volumes. Five million CAR T cells or UTD control were injected i.v., and tumor volume was recorded three times a week up to study day 40. Untreated-tumor only control.

FIGS. 9A-E depict the resistance to immunosuppressive TGF β effects exhibited by the armored BCMA CAR incorporating the truncated TGFBRII dominant negative receptor. (FIG. 9A) The sequence of the extracellular binding and transmembrane domains of TGFBRII, but excluding the intracellular kinase domain, was cloned into the D100 BCMA CAR construct. A P2A element was utilized to allow for the separate co-expression of the BCMA CAR and the TGFBRII DN. (FIG. 9B) T-cells were transduced with lentiviral vectors containing either the D100 BCMA CAR construct or the armored BCMA CAR construct combining the D100 CAR with the TGFBRII DN element (D158) at MOI 10 and 80, respectively. The cell surface expression of the BCMA CAR (upper panel) and TGFBRII (lower panel) was assessed by flow cytometry. (FIG. 9C) In the long term co-culture experiment, CAR T-cells were co-incubated with the target cells, MM1.S-GFP, at an ETT ratio of 0.1, and the media was treated with 10 ng/ml of TGF-beta or remained untreated. When the target cells were eliminated on day 6, the co-culture was extended for a second round at an initial ETT ratio of 0.1. The absolute counts of (FIG. 9D) T-cells and (FIG. 9E) target cells at different time points during the long-term co-culture was assessed by quantifying the number of CD3+ and GFP+ cells via flow cytometry using absolute counting beads.

FIGS. 10A-H depict the superior efficacy of the armored BCMA CAR D158 incorporating the truncated TGFBRII dominant negative element in eradicating tumors in vivo. (FIG. 10A) Multiple myeloma cell lines, RPMI-8226 and MM1.S, were cultured for 4 days, and supernatants were collected and treated with 1 M HCl to activate latent TGF β , or the supernatants remained untreated. The presence of active TGF β , in the supernatants was detected by ELISA. (FIG. 10B) NSG mice were intradermally injected on the abdomen with 8e6 RPMI-8226 cells (n=8 except untreated, n=5). On day 17 after tumor injection, 5e6 CAR+ T-cells were intravenously injected. The differences in CAR expression levels were normalized by adjusting the total number of infused T-cells. On day 7 after T-cell infusion, 3 mice from each group (except the untreated group) were sacrificed for tumor harvest, while the rest were monitored for (FIG. 10C) tumor progression and (FIG. 10D) survival. (FIG. 10E) The absolute counts of CD3+ cells, (FIG. 10F) the percentage of CD3+CAR+, (FIG. 10G) CD3+PDI+, and (FIG. 10H) CD3+CD45RO+ cells in the tumors on day 6 were determined by flow cytometry.

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DETAILED DESCRIPTION

Definitions

- 5 As used herein, the singular forms "a," "an," and "the," refer to both the singular as well as plural, unless the context clearly indicates otherwise. For example, the term "an antigen" includes single or plural antigens and can be considered equivalent to the phrase "at least one antigen."
- 10 15 As used herein, the term "comprises" means "includes." Thus, "comprising an antigen" means "including an antigen" without excluding other elements. The phrase "and/or" means "and" or "or." It is further to be understood that any and all base sizes or amino acid sizes, and all molecular weight or molecular mass values, given for nucleic acids or polypeptides are approximate, and are provided for descriptive purposes, unless otherwise indicated. Although many methods and materials similar or equivalent to those described herein can be used, particular suitable methods and materials are described below. In case of conflict, the present specification, including explanations of terms, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting. To facilitate review of the various embodiments, the following 20 25 explanations of terms are provided:

The term "about" when referring to a measurable value such as an amount, a temporal duration, and the like, is meant to encompass variations of +− 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.

30 Unless otherwise noted, the technical terms herein are used according to conventional usage. Definitions of common terms in molecular biology can be found in Benjamin Lewin, *Genes VII*, published by Oxford University Press, 1999; Kendrew et al. (eds.), *The Encyclopedia of Molecular Biology*, published by Blackwell Science Ltd., 1994; and Robert A. Meyers (ed.), *Molecular Biology and Biotechnology: a Comprehensive Desk Reference*, published by VCH Publishers, Inc., 1995; and other similar references.

35 The present disclosure provides for BCMA antibodies or fragments thereof as well as chimeric antigen receptors (CARs) having such BCMA antigen binding domains. The enhancement of the functional activity of the CAR directly relates to the enhancement of functional activity of the CAR-expressing T cell. As a result of one or more of these modifications, the CARs exhibit both a high degree of cytokine-induced cytolysis and cell surface expression on transduced T cells, along with an increased level of in vivo 40 T cell expansion and persistence of the transduced CAR-expressing T cell.

45 The unique ability to combine functional moieties derived from different protein domains has been a key innovative feature of Chimeric Antigen Receptors (CARs). The choice of each of these protein domains is a key design feature, as is the way in which they are specifically combined. Each design domain is an essential component that can be used across different CAR platforms to engineer the function of lymphocytes. For example, the choice of the extracellular binding domain can make an otherwise ineffective CAR be effective.

50 55 60 65 The invariable framework components of the immunoglobulin-derived protein sequences used to create the extracellular antigen binding domain of a CAR can either be entirely neutral, or they can self-associate and drive the T cell to a state of metabolic exhaustion, thus making the

therapeutic T cell expressing that CAR far less effective. This occurs independently of the antigen binding function of this CAR domain. Furthermore, the choice of the intracellular signaling domain(s) also can govern the activity and the durability of the therapeutic lymphocyte population used for immunotherapy. While the ability to bind target antigen and the ability to transmit an activation signal to the T cell through these extracellular and intracellular domains, respectively, are important CAR design aspects, what has also become apparent is that the choice of the source of the extracellular antigen binding fragments can have a significant effect on the efficacy of the CAR and thereby have a defining role for the function and clinical utility of the CAR.

Surprisingly and unexpectedly it has now been discovered that use of an entirely human antigen binding domain in a CAR, rather than using mouse-derived antigen binding fragments which are prone to induce anti-mouse immune response and CAR T elimination in a host (c.f., the UPenn-sponsored clinical trial using mouse derived SS1 ScFv sequence, NCT02159716), may also determine the functional activity of a CAR-expressing T cell.

The CARs disclosed herein are expressed at a high level in a cell. A cell expressing the CAR has a high *in vivo* proliferation rate, produces large amounts of cytokines, and has a high cytotoxic activity against a cell having, on its surface, a BCMA antigen to which a CAR binds. The use of a human extracellular BCMA antigen binding domain results in generation of a CAR that functions better *in vivo*, while avoiding the induction of anti-CAR immunity in the host immune response and the killing of the CAR T cell population. The CARs expressing the entirely human extracellular BCMA ScFv antigen binding domain exhibit superior activities/properties including i) prevention of poor CAR T persistence and function as seen with mouse-derived binding sequences; ii) lack of regional (i.e. intrapleural) delivery of the CAR to be efficacious; and iii) ability to generate CAR T cell designs based both on binders with high and low affinity to BCMA. This latter property allows investigators to better tune efficacy vs toxicity, and/or tissue specificity of the CAR T product, since lower-affinity binders may have higher specificity to tumors vs normal tissues due to higher expression of BCMA on tumors than normal tissue, which may prevent on-target off tumor toxicity and bystander cell killing.

What follows is a detailed description of the inventive CARs including a description of their extracellular BCMA antigen binding domain, the transmembrane domain and the intracellular domain, along with additional description of the CARs, antibodies and antigen binding fragments thereof, conjugates, nucleotides, expression, vectors, and host cells, methods of treatment, compositions, and kits employing the disclosed CARs.

A. Chimeric Antigen Receptors (CARs)

The CARs disclosed herein comprise at least one BCMA antigen binding domain capable of binding to BCMA, at least one transmembrane domain, and at least one intracellular domain.

A chimeric antigen receptor (CAR) is an artificially constructed hybrid protein or polypeptide containing the antigen binding domains of an antibody (e.g., single chain variable fragment (ScFv)) linked to T-cell signaling domains via the transmembrane domain. Characteristics of CARs include their ability to redirect T-cell specificity and reactivity toward a selected target in a non-MHC-restricted manner, and exploiting the antigen-binding properties of monoclonal antibodies. The non-MHC-restricted antigen recognition gives T cells expressing CARs the ability to

recognize antigen independent of antigen processing, thus bypassing a major mechanism of tumor escape. Moreover, when expressed in T-cells, CARs advantageously do not dimerize with endogenous T cell receptor (TCR) alpha and beta chains.

As disclosed herein, the intracellular T cell signaling domains of the CARs can include, for example, a T cell receptor signaling domain, a T cell costimulatory signaling domain, or both. The T cell receptor signaling domain refers to a portion of the CAR comprising the intracellular domain of a T cell receptor, such as, for example, and not by way of limitation, the intracellular portion of the CD3 zeta protein. The costimulatory signaling domain refers to a portion of the CAR comprising the intracellular domain of a costimulatory molecule, which is a cell surface molecule other than an antigen receptor or their ligands that are required for an efficient response of lymphocytes to antigen.

1. Extracellular Domain

In one embodiment, the CAR comprises a target-specific binding element otherwise referred to as an antigen binding domain or moiety. The choice of domain 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 a ligand 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 the CAR include those associated with viral, bacterial and parasitic infections, autoimmune disease and cancer cells.

In one embodiment, the CAR can be engineered to target a tumor antigen of interest by way of engineering a desired antigen binding domain that specifically binds to an antigen on a tumor cell. Tumor antigens are proteins that are produced by tumor cells that elicit an immune response, particularly T-cell mediated immune responses. The selection of the antigen binding domain will depend on the particular type of cancer to be treated. Tumor antigens include, for example, a glioma-associated antigen, carcinoembryonic antigen (CEA), .beta.-human chorionic gonadotropin, alphafetoprotein (AFP), lectin-reactive AFP, thyroglobulin, RAGE-1, MN-CA IX, human telomerase reverse transcriptase, RU1, RU2 (AS), intestinal carboxyl esterase, mut hsp70-2, M-CSF, prostase, prostate-specific antigen (PSA), PAP, NY-ESO-1, LAGE-1a, p53, prostein, PSMA, Her2/neu, survivin and telomerase, prostate-carcinoma tumor antigen-1 (PCTA-1), MAGE, ELF2M, neutrophil elastase, ephrinB2, CD22, insulin growth factor (IGF)-I, IGF-II, IGF-I receptor and BCMA. The tumor antigens disclosed herein are merely included by way of example. The list is not intended to be exclusive and further examples will be readily apparent to those of skill in the art.

In one embodiment, the tumor antigen comprises one or more antigenic cancer epitopes associated with a malignant tumor. Malignant tumors express a number of proteins that can serve as target antigens for an immune attack. These molecules include, but are not limited to, tissue-specific antigens such as MART-1, tyrosinase and GP 100 in melanoma and prostatic acid phosphatase (PAP) and prostate-specific antigen (PSA) in prostate cancer. Other target molecules belong to the group of transformation-related molecules such as the oncogene HER-2/Neu/ErbB-2. Yet another group of target antigens are onco-fetal antigens such as carcinoembryonic antigen (CEA). In B-cell lymphoma the tumor-specific idiotypic immunoglobulin constitutes a truly tumor-specific immunoglobulin antigen that is unique to the individual tumor. B-cell differentiation antigens such as CD19, CD20 and CD37 are other candidates for target

antigens in B-cell lymphoma. Some of these antigens (CEA, HER-2, CD19, CD20, idiotype) have been used as targets for passive immunotherapy with monoclonal antibodies with limited success.

In one preferred embodiment, the tumor antigen is BCMA and the tumors associated with expression of BCMA comprise lung mesothelioma, ovarian, and pancreatic cancers that express high levels of the extracellular protein BCMA, or any combination thereof.

The type of tumor antigen may also be a tumor-specific antigen (TSA) or a tumor-associated antigen (TAA). A TSA is unique to tumor cells and does not occur on other cells in the body. A TAA is not unique to a tumor cell and instead is also expressed on a normal cell under conditions that fail to induce a state of immunologic tolerance to the antigen. The expression of the antigen on the tumor may occur under conditions that enable the immune system to respond to the antigen. TAAs may be antigens that are expressed on normal cells during fetal development when the immune system is immature and unable to respond or they may be antigens that are normally present at extremely low levels on normal cells but which are expressed at much higher levels on tumor cells.

Non-limiting examples of TSAs or TAAs include the following: Differentiation antigens such as MART-1/MelanA (MART-I), gp100 (Pmel 17), tyrosinase, TRP-1, TRP-2 and tumor-specific multi-lineage antigens such as MAGE-1, MAGE-3, BAGE, GAGE-1, GAGE-2, p15; overexpressed embryonic antigens such as CEA; overexpressed oncogenes and mutated tumor-suppressor genes such as p53, Ras, HER-2/neu; unique tumor antigens resulting from chromosomal translocations; such as BCR-ABL, E2A-PRL, H4-RET, IGH-IGK, MYL-RAR; and viral antigens, such as the Epstein Barr virus antigens EBVA and the human papillomavirus (HPV) antigens E6 and E7. Other large, protein-based antigens include TSP-180, MAGE-4, MAGE-5, MAGE-6, RAGE, NY-ESO, p185erbB2, p180erbB-3, c-met, nm-23H1, PSA, TAG-72, CA 19-9, CA 72-4, CAM 17.1, NuMa, K-ras, beta-Catenin, CDK4, Mum-1, p 15, p 16, 43-9F, 5T4, 791Tgp72, alpha-fetoprotein, beta-HCG, BCA225, BTAA, CA 125, CA 15-3\CA 27.29\BCAA, CA 195, CA 242, CA-50, CAM43, CD68\P1, CO-029, FGF-5, G250, Ga733\EpCAM, HTgp-175, M344, MA-50, MG7-Ag, MOV18, NB/70K, NY-CO-1, RCASI, SDCCAG16, TA-90\Mac-2 binding protein\cyclophilin C-associated protein, TAAL6, TAG72, TLP, and TPS.

In one embodiment, the antigen binding domain portion of the CAR targets an antigen that includes but is not limited to CD19, CD20, CD22, ROR1, CD33, c-Met, PSMA, Glycolipid F77, EGFRVIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, and the like.

In a preferred embodiment, the antigen binding domain portion of the CAR targets the extracellular BCMA antigen.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 5 D0084 antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 9, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 5 D0084 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 10, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 10.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 16 D0085 antigen binding domain comprises a nucleotide

sequence of SEQ ID NO: 17, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 16 D0085 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 18, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 18.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 37 D0086 antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 23, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 37 D0086 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 24, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 24.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 40 D0087 antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 69, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 40 D0087 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 70, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 70.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 4-12 D0099 antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 75, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 4-12 D0099 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 76, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 76.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular BCMA ScFv Clone 4-45 D0100 antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 77, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular BCMA ScFv Clone 4-45 D0100 antigen binding domain comprises an amino acid sequence of SEQ ID NO: 78, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 78.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular 4-1c VH antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 103, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular 4-1c VH antigen binding domain comprises an amino acid sequence of SEQ ID NO: 104, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 104.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular 4-1c VL antigen binding domain comprises a nucleotide sequence of SEQ ID NO: 105, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated

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nucleic acid molecule is provided wherein the encoded extracellular 4-1c VL antigen binding domain comprises an amino acid sequence of SEQ ID NO: 106, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 106.

In one preferred embodiment, the isolated nucleic acid molecule encoding the extracellular TGFBR IIIdn domain comprises a nucleotide sequence of SEQ ID NO: 109, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof. In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded extracellular TGFBR IIIdn domain comprises an amino acid sequence of SEQ ID NO: 110, or an amino acid sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity to an amino acid sequence of SEQ ID NO: 110.

The generation and binding characteristics of the specific BCMA ScFv antigen binding fragments described herein is shown in Example 1.

In the various embodiments of the BCMA-specific CARs disclosed herein, the general scheme is set forth in FIG. 1 and includes, from the N-terminus to the C-terminus, a signal or leader peptide, anti-BCMA ScFv, extracellular linker, CD8 transmembrane, 4-1BB, CD3 zeta, wherein the bolded text represents the cloning sites for linking domains.

In one embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 87, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 88.

In one embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 87, or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 88 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 89, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 90.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 89 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 90 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 91, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 92.

In another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 91 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 92 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 93, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 94.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 93 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR

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comprising the amino acid sequence as set forth in SEQ ID NO: 94 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 95, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 96.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 95 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 96 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 97, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 98.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 99, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 100.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 101, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 102.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 97 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 98 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 99 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 100 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

In yet another embodiment, the nucleic acid sequence encoding a CAR comprises the nucleic acid sequence of SEQ ID NO: 101 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof, and encodes the CAR comprising the amino acid sequence as set forth in SEQ ID NO: 102 or a sequence with 85%, 90%, 95%, 96%, 97%, 98% or 99% identity thereof.

The surface expression of anti-BCMA CARs incorporating immunoglobulin single chain fragment variable (ScFv) sequences reactive with BCMA antigen, is shown in Example 2 infra. The expression level for each ScFv-containing CAR was determined by flow cytometric analysis of LV-transduced T cells from healthy donors using a recombinant BCMA-Fc peptide, followed by anti-human Fc F(ab')² fragment conjugated to AF647, and detected in the APC channel, (c.f., Example 2, FIG. 2). Alternatively, CAR detection was performed using protein L-biotin conjugate, followed by Streptavidin-PE, with similar results (Example 2, FIG. 2). Further confirmation of CAR expression for constructs selected for further investigation was performed using the BCMA-Fc staining method (Example 2, FIG. 4). All anti-BCMA CAR constructs were readily detected on the surface of T cells, except for the sequence 15 CAR construct, demonstrating robust CAR expression. By contrast, no CAR expression was detected in the negative control

non-transduced T cells (UTD), thus demonstrating the specificity of the detection method used (c.f., Example 2, FIG. 2, FIG. 4).

Without being intended to limit to any particular mechanism of action, it is believed that possible reasons for the enhanced therapeutic function associated with the exemplary CARs of the invention include, for example, and not by way of limitation, a) improved lateral movement within the plasma membrane allowing for more efficient signal transduction, b) superior location within plasma membrane microdomains, such as lipid rafts, and greater ability to interact with transmembrane signaling cascades associated with T cell activation, c) superior location within the plasma membrane by preferential movement away from dampening or down-modulatory interactions, such as less proximity to or interaction with phosphatases such as CD45, and d) superior assembly into T cell receptor signaling complexes (i.e. the immune synapse), or any combination thereof.

While the disclosure has been illustrated with an exemplary extracellular BCMA ScFv antigen binding domains, other nucleotide and/or amino acid variants within the BCMA variable ScFv antigen binding domains may be used to derive the BCMA antigen binding domains for use in the CARs described herein.

Depending on the desired antigen to be targeted, the CAR can be additionally engineered to include the appropriate antigen binding domain that is specific to the desired antigen target. For example, if CD19 is the desired antigen that is to be targeted, an antibody for CD19 can be used as the antigen bind domain incorporation into the CAR.

In one exemplary embodiment, the antigen binding domain portion of the CAR additionally targets CD19. Preferably, the antigen binding domain in the CAR is anti-CD19 ScFv, wherein the nucleic acid sequence of the anti-CD19 ScFv comprises the sequence set forth in SEQ ID NO: 37. In one embodiment, the anti-CD19 ScFv comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 30. In another embodiment, the anti-CD19 ScFv portion of the CAR comprises the amino acid sequence set forth in SEQ ID NO: 38.

In one aspect of the present invention, there is provided a CAR capable of binding to a non-TSA or non-TAA including, for example and not by way of limitation, an antigen derived from Retroviridae (e.g. human immunodeficiency viruses such as HIV-1 and HIV-LP), Picornaviridae (e.g. poliovirus, hepatitis A virus, enterovirus, human coxsackievirus, rhinovirus, and echovirus), rubella virus, coronavirus, vesicular stomatitis virus, rabies virus, Ebola virus, parainfluenza virus, mumps virus, measles virus, respiratory syncytial virus, influenza virus, hepatitis B virus, parvovirus, Adenoviridae, Herpesviridae [e.g. type 1 and type 2 herpes simplex virus (HSV), varicella-zoster virus, cytomegalovirus (CMV), and herpes virus], Poxviridae (e.g. smallpox virus, vaccinia virus, and pox virus), or hepatitis C virus, or any combination thereof.

In another aspect of the present invention, there is provided a CAR capable of binding to an antigen derived from a bacterial strain of Staphylococci, *Streptococcus*, *Escherichia coli*, *Pseudomonas*, or *Salmonella*. Particularly, there is provided a CAR capable of binding to an antigen derived from an infectious bacterium, for example, *Helicobacter pyloris*, *Legionella pneumophila*, a bacterial strain of Mycobacteria sps. (e.g. *M. tuberculosis*, *M. avium*, *M. intracellulare*, *M. kansaii*, or *M. gordonea*), *Staphylococcus aureus*, *Neisseria gonorrhoeae*, *Neisseria meningitidis*, *Listeria monocytogenes*, *Streptococcus pyogenes*, Group A

Streptococcus, Group B *Streptococcus* (*Streptococcus agalactiae*), *Streptococcus pneumoniae*, or *Clostridium tetani*, or a combination thereof.

2. Transmembrane Domain

With respect to the transmembrane domain, the CAR comprises one or more transmembrane domains fused to the extracellular BCMA antigen binding domain of the CAR.

The transmembrane domain may be derived either from a natural or from a synthetic source. Where the source is natural, the domain may be derived from any membrane-bound or transmembrane protein.

Transmembrane regions of particular use in the CARs described herein may be derived from (i.e. comprise at least the transmembrane region(s) of) the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, mesothelin, CD33, CD37, CD64, CD80, CD86, CD134, CD137, CD154. Alternatively, the transmembrane domain may be synthetic, in which case it will comprise predominantly hydrophobic residues such as leucine and valine. Preferably a triplet of phenylalanine, tryptophan and valine will be found at each end of a synthetic transmembrane domain. Optionally, a short oligo- or polypeptide linker, preferably between 2 and 10 amino acids in length may form the linkage between the transmembrane domain and the cytoplasmic signaling domain of the CAR. A glycine-serine doublet provides a particularly suitable linker.

In one embodiment, the transmembrane domain that naturally is associated with one of the domains in the CAR is used in addition to the transmembrane domains described supra.

In some instances, the transmembrane domain can be selected by amino acid substitution to avoid binding of such domains to the transmembrane domains of the same or different surface membrane proteins to minimize interactions with other members of the receptor complex.

In one embodiment, the transmembrane domain in the CAR of the invention is the CD8 transmembrane domain. In one embodiment, the CD8 transmembrane domain comprises the nucleic acid sequence of SEQ ID NO: 27. In one embodiment, the CD8 transmembrane domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 28. In another embodiment, the CD8 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 28.

In one embodiment, the encoded transmembrane 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: 28, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO: 28.

In some instances, the transmembrane domain of the CAR comprises the CD8.alpha.hinge domain. In one embodiment, the CD8 hinge domain comprises the nucleic acid sequence of SEQ ID NO: 29. In one embodiment, the CD8 hinge domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 30. In another embodiment, the CD8 hinge domain comprises the amino acid sequence of SEQ ID NO: 30, or a sequence with 95-99% identify thereof.

In one embodiment, an isolated nucleic acid molecule is provided wherein the encoded linker domain is derived from the extracellular domain of CD8, and is linked to the transmembrane CD8 domain, the transmembrane CD28 domain, or a combination thereof.

In one embodiment, the transmembrane domain in the CAR of the invention is the TNFRSF19 transmembrane domain. In one embodiment, the TNFRSF19 transmembrane domain comprises the nucleic acid sequence of SEQ ID NO: 51. In one embodiment, the TNFRSF19 transmembrane domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 52. In another embodiment, the TNFRSF19 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 52.

In one embodiment, the encoded transmembrane 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: 52, or a sequence with 95-99% identity to an amino acid sequence of SEQ ID NO: 52.

3. Spacer Domain

In the CAR, a spacer domain, also termed hinge domain, can be arranged between the extracellular domain and the transmembrane domain, or between the intracellular domain and the transmembrane domain. The spacer domain means any oligopeptide or polypeptide that serves to link the transmembrane domain with the extracellular domain and/or the transmembrane domain with the intracellular domain. The spacer domain comprises up to 300 amino acids, preferably 10 to 100 amino acids, and most preferably 25 to 50 amino acids.

In several embodiments, the linker can include a spacer element, which, when present, increases the size of the linker such that the distance between the effector molecule or the detectable marker and the antibody or antigen binding fragment is increased. Exemplary spacers are known to the person of ordinary skill, and include those listed in U.S. Pat. Nos. 7,964,5667, 498,298, 6,884,869, 6,323,315, 6,239,104, 6,034,065, 5,780,588, 5,665,860, 5,663,149, 5,635,483, 5,599,902, 5,554,725, 5,530,097, 5,521,284, 5,504,191, 5,410,024, 5,138,036, 5,076,973, 4,986,988, 4,978,744, 4,879,278, 4,816,444, and 4,486,414, as well as U.S. Pat. Pub. Nos. 20110212088 and 20110070248, each of which is incorporated by reference herein in its entirety.

The spacer domain preferably has a sequence that promotes binding of a CAR with an antigen and enhances signaling into a cell. Examples of an amino acid that is expected to promote the binding include cysteine, a charged amino acid, and serine and threonine in a potential glycosylation site, and these amino acids can be used as an amino acid constituting the spacer domain.

As the spacer domain, the entire or a part of amino acid numbers 118 to 178 (SEQ ID NO: 31) which is a hinge region of CD8.alpha. (NCBI RefSeq: NP.sub.-001759.3), amino acid numbers 135 to 195 of CD8.beta. (GenBank: AAA35664.1), amino acid numbers 315 to 396 of CD4 (NCBI RefSeq: NP.sub.-000607.1), or amino acid numbers 137 to 152 of CD28 (NCBI RefSeq: NP.sub.-006130.1) can be used. Also, as the spacer domain, a part of a constant region of an antibody H chain or L chain (CH1 region or CL region, for example, a peptide having an amino acid sequence shown in SEQ ID NO: 32) can be used. Further, the spacer domain may be an artificially synthesized sequence.

In addition, an entire or a part of amino acids comprising the constant region of a human IgG4 (UniProt ID: P01861), including CH1, (amino acid numbers 1-98), hinge, SEQ ID NO: 80, and the corresponding nucleotide SEQ ID NO: 79, (amino acid numbers 99-110), CH2, amino acid SEQ ID NO: 81 and corresponding nucleotide SEQ ID NO: 80,

(amino acid numbers 111-220) and CH3, SEQ ID NO: 84 and corresponding nucleotide SEQ ID NO: 83, (amino acid numbers 221-327) or a combination thereof, such as IgG4 Hinge CH2 CH3 domain, SEQ ID NO: 86, and the corresponding nucleotide SEQ ID NO: 85, can be used.

In one embodiment, the spacer domain of the CAR comprises the TNFRSF19 hinge domain which comprises the nucleic acid sequence of SEQ ID NO: 53. In one embodiment, the TNFRSF19 hinge domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 54. In another embodiment, the TNFRSF19 hinge domain comprises the amino acid sequence of SEQ ID NO: 54, or a sequence with 95-99% identify thereof.

In one embodiment, the spacer domain of the CAR comprises the TNFRSF19 truncated hinge domain comprises the nucleic acid sequence of SEQ ID NO: 55. In one embodiment, the TNFRSF19 truncated hinge domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 56. In another embodiment, the TNFRSF19 truncated hinge domain comprises the amino acid sequence of SEQ ID NO: 56, or a sequence with 95-99% identify thereof.

In one embodiment, the TNFRSF19 hinge and transmembrane domains comprise the nucleic acid sequence of SEQ ID NO: 49. In one embodiment, the TNFRSF19 hinge and transmembrane domains comprise the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 50. In another embodiment, the TNFRSF19 hinge and transmembrane domains comprise the amino acid sequence of SEQ ID NO: 50, or a sequence with 95-99% identify thereof.

In one embodiment, a CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprising the nucleic acid sequence of SEQ ID NO: 57. In one embodiment, the CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 58. In another embodiment, the CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 58, or a sequence with 95-99% identify thereof.

Further, in the CAR, a signal peptide sequence, also termed leader peptide, can be linked to the N-terminus. The signal peptide sequence exists at the N-terminus of many secretory proteins and membrane proteins, and has a length of 15 to 30 amino acids. Since many of the protein molecules mentioned above as the intracellular domain have signal peptide sequences, the signal peptides can be used as a signal peptide for the CAR. In one embodiment, the signal peptide comprises the amino acid sequence shown in SEQ ID NO: 14).

In one embodiment, the CD8 alpha leader peptide, is comprising the nucleic acid sequence of SEQ ID NO: 43. In one embodiment, CD8 alpha leader peptide comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 44. In another embodiment, the CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 44, or a sequence with 95-99% identify thereof.

In another embodiment, the GMCSF leader peptide, is comprising the nucleic acid sequence of SEQ ID NO: 39. In one embodiment, the GMCSF leader peptide, comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 40. In another embodiment, the CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 40, or a sequence with 95-99% identify thereof.

In another embodiment, the TNFRSF19 leader peptide is comprising the nucleic acid sequence of SEQ ID NO: 41. In one embodiment, TNFRSF19 leader peptide, and CD8 alpha leader peptide comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 42. In another embodiment, the CD8a hinge domain is fused to a TNFRSF19 transmembrane domain comprises the amino acid sequence of SEQ ID NO: 42, or a sequence with 95-99% identify thereof.

In one embodiment, a tag sequence encoding a truncated sequence of epidermal growth factor receptor (EGFR) is comprising the nucleic acid sequence of SEQ ID NO: 67. In one embodiment, tEGFR comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 68. In another embodiment, the tEGFR tag comprises the amino acid sequence of SEQ ID NO: 68, or a sequence with 95-99% identify thereof.

In one embodiment, a furin recognition site and downstream T2A self-cleaving peptide sequence, designed for simultaneous bicistronic expression of the tag sequence and the CAR sequence, is comprising the nucleic acid sequence of SEQ ID NO: 65. In one embodiment, furin and T2A sequence comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 66. In another embodiment, the tEGFR tag comprises the amino acid sequence of SEQ ID NO: 66 or a sequence with 95-99% identify thereof.

In one embodiment, an upstream furin recognition site and T2A self-cleaving peptide sequence and a furin recognition downstream site, designed for simultaneous bicistronic expression of the tag sequence and the CAR sequence, is comprising the nucleic acid sequence of SEQ ID NO: 67. In one embodiment, furin and T2A sequence comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 68. In another embodiment, the tEGFR tag comprises the amino acid sequence of SEQ ID NO: 68 or a sequence with 95-99% identify thereof.

In one embodiment, the targeting domain of the CAR is expressed separately in the form of monoclonal antibody, ScFv Fab, Fab'2 and is containing at binding tag or epitope, whereas the effector-cell expressed component of the CAR contains a binding domain specifically directed to bind the tag or epitope expressed on the soluble CAR module, such as specific binding on the soluble component of the CAR to the cell bound component forms the full functional CAR structure.

4. Intracellular Domain

The cytoplasmic domain or otherwise the intracellular signaling domain of the CAR is responsible for activation of at least one of the normal effector functions of the immune cell in which the CAR has been placed in. 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. Thus, the term "intracellular signaling domain" refers to the portion of a protein which transduces the effector function signal and directs the cell to perform a specialized function. While usually 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.

Preferred examples of intracellular signaling domains for use in the CAR 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 synthetic sequence that has the same functional capability.

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

Primary cytoplasmic signaling sequences regulate primary activation of the TCR complex either in a stimulatory way, or in an inhibitory way. Primary cytoplasmic signaling sequences that act in a stimulatory manner may contain signaling motifs which are known as immunoreceptor tyrosine-based activation motifs or ITAMs.

Examples of ITAM containing primary cytoplasmic signaling sequences that are of particular use in the CARs disclosed herein include those derived from TCR zeta (CD3 Zeta), FcR gamma, FcR beta, CD3 gamma, CD3 delta, CD3 epsilon, CD5, CD22, CD79a, CD79b, and CD66d. Specific, non-limiting examples, of the ITAM include peptides having sequences of amino acid numbers 51 to 164 of CD3.zeta. (NCBI RefSeq: NP.sub.-932170.1), amino acid numbers 45 to 86 of Fc.epsilon.RI.gamma. (NCBI RefSeq: NP.sub.-004097.1), amino acid numbers 201 to 244 of Fc. epsilon.RI.beta. (NCBI RefSeq: NP.sub.-000130.1), amino acid numbers 139 to 182 of CD3.gamma. (NCBI RefSeq: NP.sub.-000064.1), amino acid numbers 128 to 171 of CD3.delta. (NCBI RefSeq: NP.sub.-000723.1), amino acid numbers 153 to 207 of CD3.epsilon. (NCBI RefSeq: NP.sub.-000724.1), amino acid numbers 402 to 495 of CD5 (NCBI RefSeq: NP.sub.-055022.2), amino acid numbers 707 to 847 of 0022 (NCBI RefSeq: NP.sub.-001762.2), amino acid numbers 166 to 226 of CD79a (NCBI RefSeq: NP.sub.-001774.1), amino acid numbers 182 to 229 of CD79b (NCBI RefSeq: NP.sub.-000617.1), and amino acid numbers 177 to 252 of CD66d (NCBI RefSeq: NP.sub.-001806.2), and their variants having the same function as these peptides have. The amino acid number based on amino acid sequence information of NCBI RefSeq ID or GenBank described herein is numbered based on the full length of the precursor (comprising a signal peptide sequence etc.) of each protein. In one embodiment, the cytoplasmic signaling molecule in the CAR comprises a cytoplasmic signaling sequence derived from CD3 zeta.

In a preferred embodiment, the intracellular domain of the CAR can be designed to comprise the CD3-zeta signaling domain by itself or combined with any other desired cytoplasmic domain(s) useful in the context of the CAR. For example, the intracellular domain of the CAR can comprise a CD3 zeta chain portion and a costimulatory signaling region. The costimulatory signaling region 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 their ligands that is required for an efficient response of lymphocytes to an antigen. Examples of such costimulatory molecules include CD27, CD28, 4-1BB (CD137), OX40, CD30, CD40, PD-1, ICOS, lymphocyte function-associated anti-

gen-1 (LFA-1), CD2, CD7, LIGHT, NKG2C, B7-H3, and a ligand that specifically binds with CD83, and the like. Specific, non-limiting examples, of such costimulatory molecules include peptides having sequences of amino acid numbers 236 to 351 of CD2 (NCBI RefSeq: NP.sub.-001758.2), amino acid numbers 421 to 458 of CD4 (NCBI RefSeq: NP.sub.-000607.1), amino acid numbers 402 to 495 of CD5 (NCBI RefSeq: NP.sub.-055022.2), amino acid numbers 207 to 235 of CD8.alpha. (NCBI RefSeq: NP.sub.-001759.3), amino acid numbers 196 to 210 of CD83 (GenBank: AAA35664.1), amino acid numbers 181 to 220 of CD28 (NCBI RefSeq: NP.sub.-006130.1), amino acid numbers 214 to 255 of CD137 (4-1BB, NCBI RefSeq: NP.sub.-001552.2), amino acid numbers 241 to 277 of CD134 (OX40, NCBI RefSeq: NP.sub.-003318.1), and amino acid numbers 166 to 199 of ICOS (NCBI RefSeq: NP.sub.-036224.1), and their variants having the same function as these peptides have. Thus, while the disclosure herein is exemplified primarily with 4-1BB as the co-stimulatory signaling element, other costimulatory elements are within the scope of the disclosure.

The cytoplasmic signalling sequences within the cytoplasmic signalling portion of the CAR may be linked to each other in a random or specified order. Optionally, a short oligo- or polypeptide linker, preferably between 2 and 10 amino acids in length may form the linkage. A glycine-serine doublet provides a particularly suitable linker.

In one embodiment, the intracellular domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of CD28. In another embodiment, the intracellular domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of 4-1BB. In yet another embodiment, the intracellular domain is designed to comprise the signaling domain of CD3-zeta and the signaling domain of CD28 and 4-1BB.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of 4-1BB and the signaling domain of CD3-zeta, wherein the signaling domain of 4-1BB comprises the nucleic acid sequence set forth in SEQ ID NO: 33, SEQ ID NO: 45, or SEQ ID NO: 59, respectively and the signaling domain of CD3-zeta comprises the nucleic acid sequence set forth in SEQ ID NO: 35, SEQ ID NO: 47, or SEQ ID NO: 61, respectively.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of 4-1BB and the signaling domain of CD3-zeta, wherein the signaling domain of 4-1BB comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 34, SEQ ID NO: 46, or SEQ ID NO: 60, respectively and the signaling domain of CD3-zeta comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 36, or SEQ ID NO: 48, or SEQ ID NO: 62.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of 4-1BB and the signaling domain of CD3-zeta, wherein the signaling domain of 4-1BB comprises the amino acid sequence set forth in SEQ ID NO: 34, SEQ ID NO: 46, or SEQ ID NO: 60, respectively and the signaling domain of CD3-zeta comprises the amino acid sequence set forth in SEQ ID NO: 36, SEQ ID NO: 48, or SEQ ID NO: 62, respectively.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of CD28 and the signaling domain of CD3-zeta, wherein the signaling domain of CD28 comprises the nucleic acid sequence set forth in SEQ ID NO: 45, or SEQ ID NO: 59, respectively, and the signaling domain of CD3-zeta comprises the nucleic

acid sequence set forth in SEQ ID NO: 35, SEQ ID NO: 47, or SEQ ID NO: 61, respectively.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of CD28 and the signaling domain of CD3-zeta, wherein the signaling domain of CD28 comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 46, or SEQ ID NO: 60, respectively and the signaling domain of CD3-zeta comprises the nucleic acid sequence that encodes the amino acid sequence of SEQ ID NO: 36, or SEQ ID NO: 48, or SEQ ID NO: 62.

In one embodiment, the intracellular domain in the CAR is designed to comprise the signaling domain of CD28 and the signaling domain of CD3-zeta, wherein the signaling domain of CD28 comprises the amino acid sequence set forth in SEQ ID NO: 46, or SEQ ID NO: 60, respectively and the signaling domain of CD3-zeta comprises the amino acid sequence set forth in SEQ ID NO: 36, SEQ ID NO: 48, or SEQ ID NO: 62, respectively.

5. Additional Description of CARs

Also expressly included within the scope of the invention are functional portions of the CARs disclosed herein. The term "functional portion" when used in reference to a CAR refers to any part or fragment of one or more of the CARs disclosed herein, which part or fragment retains the biological activity of the CAR of which it is a part (the parent CAR). Functional portions encompass, for example, those parts of a CAR that retain the ability to recognize target cells, or detect, treat, or prevent a disease, to a similar extent, the same extent, or to a higher extent, as the parent CAR. In reference to the parent CAR, the functional portion can comprise, for instance, about 10%, 25%, 30%, 50%, 68%, 80%, 90%, 95%, or more, of the parent CAR.

The functional portion can comprise additional amino acids at the amino or carboxy terminus of the portion, or at both termini, which additional amino acids are not found in the amino acid sequence of the parent CAR. Desirably, the additional amino acids do not interfere with the biological function of the functional portion, e.g., recognize target cells, detect cancer, treat or prevent cancer, etc. More desirably, the additional amino acids enhance the biological activity, as compared to the biological activity of the parent CAR.

Included in the scope of the disclosure are functional variants of the CARs disclosed herein. The term "functional variant" as used herein refers to a CAR, polypeptide, or protein having substantial or significant sequence identity or similarity to a parent CAR, which functional variant retains the biological activity of the CAR of which it is a variant. Functional variants encompass, for example, those variants of the CAR described herein (the parent CAR) that retain the ability to recognize target cells to a similar extent, the same extent, or to a higher extent, as the parent CAR. In reference to the parent CAR, the functional variant can, for instance, be at least about 30%, 50%, 75%, 80%, 90%, 98% or more identical in amino acid sequence to the parent CAR.

A functional variant can, for example, comprise the amino acid sequence of the parent CAR with at least one conservative amino acid substitution. Alternatively or additionally, the functional variants can comprise the amino acid sequence of the parent CAR with at least one non-conservative amino acid substitution. In this case, it is preferable for the non-conservative amino acid substitution to not interfere with or inhibit the biological activity of the functional variant. The non-conservative amino acid substitution may enhance the biological activity of the functional variant,

such that the biological activity of the functional variant is increased as compared to the parent CAR.

Amino acid substitutions of the CARs are preferably conservative amino acid substitutions. Conservative amino acid substitutions are known in the art, and include amino acid substitutions in which one amino acid having certain physical and/or chemical properties is exchanged for another amino acid that has the same or similar chemical or physical properties. For instance, the conservative amino acid substitution can be an acidic/negatively charged polar amino acid substituted for another acidic/negatively charged polar amino acid (e.g., Asp or Glu), an amino acid with a nonpolar side chain substituted for another amino acid with a nonpolar side chain (e.g., Ala, Gly, Val, He, Leu, Met, Phe, Pro, Trp, Cys, Val, etc.), a basic/positively charged polar amino acid substituted for another basic/positively charged polar amino acid (e.g. Lys, His, Arg, etc.), an uncharged amino acid with a polar side chain substituted for another uncharged amino acid with a polar side chain (e.g., Asn, Gin, Ser, Thr, Tyr, etc.), an amino acid with a beta-branched side-chain substituted for another amino acid with a beta-branched side-chain (e.g., He, Thr, and Val), an amino acid with an aromatic side-chain substituted for another amino acid with an aromatic side chain (e.g., His, Phe, Trp, and Tyr), etc.

The CAR can consist essentially of the specified amino acid sequence or sequences described herein, such that other components, e.g., other amino acids, do not materially change the biological activity of the functional variant.

The CARs (including functional portions and functional variants) can be of any length, i.e., can comprise any number of amino acids, provided that the CARs (or functional portions or functional variants thereof) retain their biological activity, e.g., the ability to specifically bind to antigen, detect diseased cells in a mammal, or treat or prevent disease in a mammal, etc. For example, the CAR can be about 50 to about 5000 amino acids long, such as 50, 70, 75, 100, 125, 150, 175, 200, 300, 400, 500, 600, 700, 800, 900, 1000 or more amino acids in length.

The CARs (including functional portions and functional variants of the invention) can comprise synthetic amino acids in place of one or more naturally-occurring amino acids. Such synthetic amino acids are known in the art, and include, for example, aminocyclohexane carboxylic acid, norleucine,-amino n-decanoic acid, homoserine, S-acetyl-laminomethyl-cysteine, trans-3- and trans-4-hydroxyproline, 4-aminophenylalanine, 4-nitrophenylalanine, 4-chlorophenylalanine, 4-carboxyphenylalanine, β -phenylserine β -hydroxyphenylalanine, phenylglycine, a-naphthylalanine, cyclohexylalanine, cyclohexylglycine, indoline-2-carboxylic acid, 1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid, aminomalonic acid, aminomalonic acid monoamide, N'-benzyl-N'-methyl-lysine, N',N'-dibenzyl-lysine, 6-hydroxylsine, ornithine,-aminocyclopentane carboxylic acid, α -aminocyclohexane carboxylic acid, α -aminocycloheptane carboxylic acid, a-(2-amino-2-norbornane)-carboxylic acid, γ -diaminobutyric acid, β -diaminopropionic acid, homophenylalanine, and a-tert-butylglycine.

The CARs (including functional portions and functional variants) can be glycosylated, amidated, carboxylated, phosphorylated, esterified, N-acylated, cyclized via, e.g., a disulfide bridge, or converted into an acid addition salt and/or optionally dimerized or polymerized, or conjugated.

The CARs (including functional portions and functional variants thereof) can be obtained by methods known in the art. The CARs may be made by any suitable method of making polypeptides or proteins. Suitable methods of de-

novo synthesizing polypeptides and proteins are described in references, such as Chan et al., Fmoc Solid Phase Peptide Synthesis, Oxford University Press, Oxford, United Kingdom, 2000; Peptide and Protein Drug Analysis, ed. Reid, R.,

5 Marcel Dekker, Inc., 2000; Epitope Mapping, ed. Westwood et al., Oxford University Press, Oxford, United Kingdom, 2001; and U.S. Pat. No. 5,449,752. Also, polypeptides and proteins can be recombinantly produced using the nucleic acids described herein using standard recombinant methods.

10 See, for instance, Sambrook et al., Molecular Cloning: A Laboratory Manual, 3rd ed., Cold Spring Harbor Press, Cold Spring Harbor, NY 2001; and Ausubel et al., Current Protocols in Molecular Biology, Greene Publishing Associates and John Wiley & Sons, NY, 1994. Further, some of the

15 CARs (including functional portions and functional variants thereof) can be isolated and/or purified from a source, such as a plant, a bacterium, an insect, a mammal, e.g., a rat, a human, etc. Methods of isolation and purification are well-known in the art. Alternatively, the CARs described herein 20 (including functional portions and functional variants thereof) can be commercially synthesized by companies. In this respect, the CARs can be synthetic, recombinant, isolated, and/or purified.

B. Antibodies and Antigen Binding Fragments

25 One embodiment further provides a CAR, a T cell expressing a CAR, an antibody, or antigen binding domain or portion thereof, which specifically binds to one or more of the antigens disclosed herein. As used herein, a “T cell expressing a CAR,” or a “CAR T cell” means a T cell 30 expressing a CAR, and has antigen specificity determined by, for example, the antibody-derived targeting domain of the CAR.

As used herein, and “antigen binding domain” can include an antibody and antigen binding fragments thereof. The term 35 “antibody” is used herein in the broadest sense and encompasses various antibody structures, including but not limited to monoclonal antibodies, polyclonal antibodies, multi-specific antibodies (e.g., bispecific antibodies), and antigen binding fragments thereof, so long as they exhibit the desired antigen-binding activity. Non-limiting examples of antibodies include, for example, intact immunoglobulins and variants and fragments thereof known in the art that retain binding affinity for the antigen.

40 A “monoclonal antibody” is an antibody obtained from a population of substantially homogeneous antibodies, i.e., the individual antibodies comprising the population are identical except for possible naturally occurring mutations that may be present in minor amounts. Monoclonal antibodies are highly specific, being directed against a single antigenic epitope. The modifier “monoclonal” indicates the character 45 of the antibody as being obtained from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. In some examples, a monoclonal antibody 50 is an antibody produced by a single clone of B lymphocytes or by a cell into which nucleic acid encoding the light and heavy variable regions of the antibody of a single antibody (or an antigen binding fragment thereof) have been transfected, or a progeny thereof. In some 55 examples monoclonal antibodies are isolated from a subject. Monoclonal antibodies can have conservative amino acid substitutions which have substantially no effect on antigen binding or other immunoglobulin functions. Exemplary 60 methods of production of monoclonal antibodies are known, for example, see Harlow & Lane, Antibodies, A Laboratory Manual, 2nd ed. Cold Spring Harbor Publications, New York (2013).

Typically, an immunoglobulin has heavy (H) chains and light (L) chains interconnected by disulfide bonds. Immunoglobulin genes include the kappa, lambda, alpha, gamma, delta, epsilon and mu constant region genes, as well as the myriad immunoglobulin variable domain genes. There are two types of light chain, lambda (λ) and kappa (κ). There are five main heavy chain classes (or isotypes) which determine the functional activity of an antibody molecule: IgM, IgD, IgG, IgA and IgE.

Each heavy and light chain contains a constant region (or constant domain) and a variable region (or variable domain; see, e.g., Kindt et al. Kuby Immunology, 6th ed., W. H. Freeman and Co., page 91 (2007).) In several embodiments, the heavy and the light chain variable regions combine to specifically bind the antigen. In additional embodiments, only the heavy chain variable region is required. For example, naturally occurring camelid antibodies consisting of a heavy chain only are functional and stable in the absence of light chain (see, e.g., Hamers-Casterman et al., Nature, 363:446-448, 1993; Sheriff et al., Nat. Struct. Biol., 3:733-736, 1996). References to "VH" or "VH" refer to the variable region of an antibody heavy chain, including that of an antigen binding fragment, such as Fv, ScFv, dsFv or Fab. References to "VL" or "VL" refer to the variable domain of an antibody light chain, including that of an Fv, ScFv, dsFv or Fab. Light and heavy chain variable regions contain a "framework" region interrupted by three hypervariable regions, also called "complementarity-determining regions" or "CDRs" (see, e.g., Kabat et al., Sequences of Proteins of Immunological Interest, U.S. Department of Health and Human Services, 1991). The sequences of the framework regions of different light or heavy chains are relatively conserved within a species. The framework region of an antibody, that is the combined framework regions of the constituent light and heavy chains, serves to position and align the CDRs in three-dimensional space.

The CDRs are primarily responsible for binding to an epitope of an antigen. The amino acid sequence boundaries of a given CDR can be readily determined using any of a number of well-known schemes, including those described by Kabat et al. ("Sequences of Proteins of Immunological Interest," 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD, 1991; "Kabat" numbering scheme), Al-Lazikani et al., (JMB 273:927-948, 1997; "Chothia" numbering scheme), and Lefranc et al. ("IMGT unique numbering for immunoglobulin and T cell receptor variable domains and Ig superfamily V-like domains," Dev. Comp. Immunol., 27:55-77, 2003; "IMGT" numbering scheme). The CDRs of each chain are typically referred to as CDR1, CDR2, and CDR3 (from the N-terminus to C-terminus), and are also typically identified by the chain in which the particular CDR is located. Thus, a VH CDR3 is the CDR3 from the variable domain of the heavy chain of the antibody in which it is found, whereas a VL CDR1 is the CDR1 from the variable domain of the light chain of the antibody in which it is found. Light chain CDRs are sometimes referred to as LCDR1, LCDR2, and LCDR3. Heavy chain CDRs are sometimes referred to as HCDR1, HCDR2, and HCDR3.

An "antigen binding fragment" is a portion of a full length antibody that retains the ability to specifically recognize the cognate antigen, as well as various combinations of such portions. Non-limiting examples of antigen binding fragments include Fv, Fab, Fab', Fab'-SH, F(ab') 2; diabodies; linear antibodies; single-chain antibody molecules (e.g. ScFv); and multi-specific antibodies formed from antibody fragments. Antibody fragments include antigen binding

fragments either produced by the modification of whole antibodies or those synthesized de novo using recombinant DNA methodologies (see, e.g., Kontermann and Dubel (Ed), Antibody Engineering, Vols. 1-2, 2nd Ed., Springer Press, 2010).

A single-chain antibody (ScFv) is a genetically engineered molecule containing the VH and VL domains of one or more antibody(ies) linked by a suitable polypeptide linker as a genetically fused single chain molecule (see, for example, Bird et al., Science, 242:423 426, 1988; Huston et al., Proc. Natl. Acad. Sci., 85:5879 5883, 1988; Ahmad et al., Clin. Dev. Immunol., 2012, doi: 10.1155/2012/980250; Marbry, Idrugs, 13:543-549, 2010). The intramolecular orientation of the VH-domain and the VL-domain in a ScFv, is typically not decisive for ScFvs. Thus, ScFvs with both possible arrangements (VH-domain-linker domain-VL-domain; VL-domain-linker domain-VH-domain) may be used.

In a dsFv, the heavy and light chain variable chains have been mutated to introduce a disulfide bond to stabilize the association of the chains. Diabodies also are included, which are bivalent, bispecific antibodies in which VH and VL domains are expressed on a single polypeptide chain, but using a linker that is too short to allow for pairing between the two domains on the same chain, thereby forcing the domains to pair with complementary domains of another chain and creating two antigen binding sites (see, for example, Holliger et al., Proc. Natl. Acad. Sci., 90:6444 6448, 1993; Poljak et al., Structure, 2:1121 1123, 1994).

Antibodies also include genetically engineered forms such as chimeric antibodies (such as humanized murine antibodies) and heteroconjugate antibodies (such as bispecific antibodies). See also, Pierce Catalog and Handbook, 1994-1995 (Pierce Chemical Co., Rockford, IL); Kuby, J., Immunology, 3rd Ed., W. H. Freeman & Co., New York, 1997.

Non-naturally occurring antibodies can be constructed using solid phase peptide synthesis, can be produced recombinantly, or can be obtained, for example, by screening combinatorial libraries consisting of variable heavy chains and variable light chains as described by Huse et al., Science 246:1275-1281 (1989), which is incorporated herein by reference. These and other methods of making, for example, chimeric, humanized, CDR-grafted, single chain, and bifunctional antibodies, are well known to those skilled in the art (Winter and Harris, Immunol. Today 14:243-246 (1993); Ward et al., Nature 341:544-546 (1989); Harlow and Lane, supra, 1988; Hilyard et al., Protein Engineering: A practical approach (IRL Press 1992); Borrebeck, Antibody Engineering, 2d ed. (Oxford University Press 1995); each of which is incorporated herein by reference).

An "antibody that binds to the same epitope" as a reference antibody refers to an antibody that blocks binding of the reference antibody to its antigen in a competition assay by 50% or more, and conversely, the reference antibody blocks binding of the antibody to its antigen in a competition assay by 50% or more. Antibody competition assays are known, and an exemplary competition assay is provided herein.

A "humanized" antibody or antigen binding fragment includes a human framework region and one or more CDRs from a non-human (such as a mouse, rat, or synthetic) antibody or antigen binding fragment. The non-human antibody or antigen binding fragment providing the CDRs is termed a "donor," and the human antibody or antigen binding fragment providing the framework is termed an "acceptor." In one embodiment, all the CDRs are from the donor immunoglobulin in a humanized immunoglobulin.

Constant regions need not be present, but if they are, they can be substantially identical to human immunoglobulin constant regions, such as at least about 85-90%, such as about 95% or more identical. Hence, all parts of a humanized antibody or antigen binding fragment, except possibly the CDRs, are substantially identical to corresponding parts of natural human antibody sequences.

A "chimeric antibody" is an antibody which includes sequences derived from two different antibodies, which typically are of different species. In some examples, a chimeric antibody includes one or more CDRs and/or framework regions from one human antibody and CDRs and/or framework regions from another human antibody.

A "fully human antibody" or "human antibody" is an antibody which includes sequences from (or derived from) the human genome, and does not include sequence from another species. In some embodiments, a human antibody includes CDRs, framework regions, and (if present) an Fc region from (or derived from) the human genome. Human antibodies can be identified and isolated using technologies for creating antibodies based on sequences derived from the human genome, for example by phage display or using transgenic animals (see, e.g., Barbas et al. *Phage display: A Laboratory Manuel*. 1st Ed. New York: Cold Spring Harbor Laboratory Press, 2004. Print.; Lonberg, Nat. Biotech., 23:1117-1125, 2005; Lonenberg, *Curr. Opin. Immunol.*, 20:450-459, 2008).

An antibody may have one or more binding sites. If there is more than one binding site, the binding sites may be identical to one another or may be different. For instance, a naturally-occurring immunoglobulin has two identical binding sites, a single-chain antibody or Fab fragment has one binding site, while a bispecific or bifunctional antibody has two different binding sites.

Methods of testing antibodies for the ability to bind to any functional portion of the CAR are known in the art and include any antibody-antigen binding assay, such as, for example, radioimmunoassay (RIA), ELISA, Western blot, immunoprecipitation, and competitive inhibition assays (see, e.g., Janeway et al., *infra*, U.S. Patent Application Publication No. 2002/0197266 A1, and U.S. Pat. No. 7,338,929).

Also, a CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, can be modified to comprise a detectable label, such as, for instance, a radioisotope, a fluorophore (e.g., fluorescein isothiocyanate (FITC), phycoerythrin (PE)), an enzyme (e.g., alkaline phosphatase, horseradish peroxidase), and element particles (e.g., gold particles).

C. Conjugates

A CAR, a T cell expressing a CAR, or monoclonal antibodies, or antigen binding fragments thereof, specific for one or more of the antigens disclosed herein, can be conjugated to an agent, such as an effector molecule or detectable marker, using any number of means known to those of skill in the art. Both covalent and noncovalent attachment means may be used. Conjugates include, but are not limited to, molecules in which there is a covalent linkage of an effector molecule or a detectable marker to an antibody or antigen binding fragment that specifically binds one or more of the antigens disclosed herein. One of skill in the art will appreciate that various effector molecules and detectable markers can be used, including (but not limited to) chemotherapeutic agents, anti-angiogenic agents, toxins, radioactive agents such as ¹²⁵I, ³²P, ¹⁴C, ³H and ³⁵S and other labels, target moieties and ligands, etc.

The choice of a particular effector molecule or detectable marker depends on the particular target molecule or cell, and the desired biological effect. Thus, for example, the effector molecule can be a cytotoxin that is used to bring about the death of a particular target cell (such as a tumor cell).

The procedure for attaching an effector molecule or detectable marker to an antibody or antigen binding fragment varies according to the chemical structure of the effector. Polypeptides typically contain a variety of functional groups; such as carboxylic acid (COOH), free amine (—NH₂) or sulfhydryl (—SH) groups, which are available for reaction with a suitable functional group on an antibody to result in the binding of the effector molecule or detectable marker. Alternatively, the antibody or antigen binding fragment is derivatized to expose or attach additional reactive functional groups. The derivatization may involve attachment of any of a number of known linker molecules such as those available from Pierce Chemical Company, Rockford, IL. The linker can be any molecule used to join the antibody or antigen binding fragment to the effector molecule or detectable marker. The linker is capable of forming covalent bonds to both the antibody or antigen binding fragment and to the effector molecule or detectable marker. Suitable linkers are well known to those of skill in the art and include, but are not limited to, straight or branched-chain carbon linkers, heterocyclic carbon linkers, or peptide linkers. Where the antibody or antigen binding fragment and the effector molecule or detectable marker are polypeptides, the linkers may be joined to the constituent amino acids through their side groups (such as through a disulfide linkage to cysteine) or to the alpha carbon amino and carboxyl groups of the terminal amino acids.

In several embodiments, the linker can include a spacer element, which, when present, increases the size of the linker such that the distance between the effector molecule or the detectable marker and the antibody or antigen binding fragment is increased. Exemplary spacers are known to the person of ordinary skill, and include those listed in U.S. Pat. Nos. 7,964,5667, 498,298, 6,884,869, 6,323,315, 6,239,104, 6,034,065, 5,780,588, 5,665,860, 5,663,149, 5,635,483, 5,599,902, 5,554,725, 5,530,097, 5,521,284, 5,504,191, 5,410,024, 5,138,036, 5,076,973, 4,986,988, 4,978,744, 4,879,278, 4,816,444, and 4,486,414, as well as U.S. Pat. Pub. Nos. 20110212088 and 20110070248, each of which is incorporated by reference herein in its entirety.

In some embodiments, the linker is cleavable under intracellular conditions, such that cleavage of the linker releases the effector molecule or detectable marker from the antibody or antigen binding fragment in the intracellular environment. In yet other embodiments, the linker is not cleavable and the effector molecule or detectable marker is released, for example, by antibody degradation. In some embodiments, the linker is cleavable by a cleaving agent that is present in the intracellular environment (for example, within a lysosome or endosome or caveolea). The linker can be, for example, a peptide linker that is cleaved by an intracellular peptidase or protease enzyme, including, but not limited to, a lysosomal or endosomal protease. In some embodiments, the peptide linker is at least two amino acids long or at least three amino acids long. However, the linker can be 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 amino acids long, such as 1-2, 1-3, 2-5, 3-10, 3-15, 1-5, 1-10, 1-15 amino acids long. Proteases can include cathepsins B and D and plasmin, all of which are known to hydrolyze dipeptide drug derivatives resulting in the release of active drug inside target cells (see, for example, Dubowchik and Walker, 1999, *Pharm. Therapeutics* 83:67-123). For example, a peptide

linker that is cleavable by the thiol-dependent protease cathepsin-B, can be used (for example, a Phenylalanine-Leucine or a Glycine-Phenylalanine-Leucine-Glycine linker). Other examples of such linkers are described, for example, in U.S. Pat. No. 6,214,345, incorporated herein by reference. In a specific embodiment, the peptide linker cleavable by an intracellular protease is a Valine-Citruline linker or a Phenylalanine-Lysine linker (see, for example, U.S. Pat. No. 6,214,345, which describes the synthesis of doxorubicin with the Valine-Citruline linker).

In other embodiments, the cleavable linker is pH-sensitive, i.e., sensitive to hydrolysis at certain pH values. Typically, the pH-sensitive linker is hydrolyzable under acidic conditions. For example, an acid-labile linker that is hydrolyzable in the lysosome (for example, a hydrazone, semicarbazone, thiosemicarbazone, cis-aconitic amide, orthoester, acetal, ketal, or the like) can be used. (See, for example, U.S. Pat. Nos. 5,122,368; 5,824,805; 5,622,929; Dubowchik and Walker, 1999, *Pharm. Therapeutics* 83:67-123; Neville et al., 1989, *Biol. Chem.* 264:14653-14661.) Such linkers are relatively stable under neutral pH conditions, such as those in the blood, but are unstable at below pH 5.5 or 5.0, the approximate pH of the lysosome. In certain embodiments, the hydrolyzable linker is a thioether linker (such as, for example, a thioether attached to the therapeutic agent via an acylhydrazone bond (see, for example, U.S. Pat. No. 5,622,929).

In other embodiments, the linker is cleavable under reducing conditions (for example, a disulfide linker). A variety of disulfide linkers are known in the art, including, for example, those that can be formed using SATA (N-succinimidyl-S-acetylthioacetate), SPDP (N-succinimidyl-3-(2-pyridylidithio) propionate), SPDB (N-succinimidyl-3-(2-pyridylidithio) butyrate) and SMPT (N-succinimidyl-oxycarbonyl-alpha-methyl-alpha-(2-pyridyl-dithio) toluene)-, SPDB and SMPT. (See, for example, Thorpe et al., 1987, *Cancer Res.* 47:5924-5931; Wawrzynczak et al., In *Immunoconjugates: Antibody Conjugates in Radioimaging and Therapy of Cancer* (C. W. Vogel ed., Oxford U. Press, 1987); Phillips et al., *Cancer Res.* 68:92809290, 2008). See also U.S. Pat. No. 4,880,935.)

In yet other specific embodiments, the linker is a malonate linker (Johnson et al., 1995, *Anticancer Res.* 15:1387-93), a maleimidobenzoyl linker (Lau et al., 1995, *Bioorg-Med-Chem.* 3 (10): 1299-1304), or a 3'-N-amide analog (Lau et al., 1995, *Bioorg-Med-Chem.* 3 (10): 1305-12).

In yet other embodiments, the linker is not cleavable and the effector molecule or detectable marker is released by antibody degradation. (See U.S. Publication No. 2005/0238649 incorporated by reference herein in its entirety).

In several embodiments, the linker is resistant to cleavage in an extracellular environment. For example, no more than about 20%, no more than about 15%, no more than about 10%, no more than about 5%, no more than about 3%, or no more than about 1% of the linkers, in a sample of conjugate, are cleaved when the conjugate is present in an extracellular environment (for example, in plasma). Whether or not a linker is resistant to cleavage in an extracellular environment can be determined, for example, by incubating the conjugate containing the linker of interest with plasma for a predetermined time period (for example, 2, 4, 8, 16, or 24 hours) and then quantitating the amount of free effector molecule or detectable marker present in the plasma. A variety of exemplary linkers that can be used in conjugates are described in WO 2004-010957, U.S. Publication No. 2006/0074008,

U.S. Publication No. 20050238649, and U.S. Publication No. 2006/0024317, each of which is incorporated by reference herein in its entirety.

In several embodiments, conjugates of a CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, and one or more small molecule toxins, such as a calicheamicin, maytansinoids, dolastatins, auristatins, a trichothecene, and CC1065, and the derivatives of these toxins that have toxin activity, are provided.

Maytansine compounds suitable for use as maytansinoid toxin moieties are well known in the art, and can be isolated from natural sources according to known methods, produced using genetic engineering techniques (see Yu et al., (2002) PNAS 99:7968-7973), or maytansinol and maytansinol analogues prepared synthetically according to known methods. Maytansinoids are mitotic inhibitors which act by inhibiting tubulin polymerization. Maytansine was first isolated from the east African shrub *Maytenus serrata* (U.S. Pat. No. 3,896,111). Subsequently, it was discovered that certain microbes also produce maytansinoids, such as maytansinol and C-3 maytansinol esters (U.S. Pat. No. 4,151,042). Synthetic maytansinol and derivatives and analogues thereof are disclosed, for example, in U.S. Pat. Nos. 4,137,230; 4,248,870; 4,256,746; 4,260,608; 4,265,814; 4,294,757; 4,307,016; 4,308,268; 4,308,269; 4,309,428; 4,313,946; 4,315,929; 4,317,821; 4,322,348; 4,331,598; 4,361,650; 4,364,866; 4,424,219; 4,450,254; 4,362,663; and 4,371,533, each of which is incorporated herein by reference. Conjugates containing maytansinoids, methods of making same, and their therapeutic use are disclosed, for example, in U.S. Pat. Nos. 5,208,020; 5,416,064; 6,441,163 and European Patent EP 0 425 235 B1, the disclosures of which are hereby expressly incorporated by reference.

Additional toxins can be employed with a CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof. Exemplary toxins include *Pseudomonas* exotoxin (PE), ricin, abrin, diphtheria toxin and subunits thereof, ribotoxin, ribonuclease, saporin, and calicheamicin, as well as botulinum toxins A through F. These toxins are well known in the art and many are readily available from commercial sources (for example, Sigma Chemical Company, St. Louis, MO). Contemplated toxins also include variants of the toxins (see, for example, see, U.S. Pat. Nos. 5,079,163 and 4,689,401).

Saporin is a toxin derived from *Saponaria officinalis* that disrupts protein synthesis by inactivating the 60S portion of the ribosomal complex (Stirpe et al., Bio/Technology, 10:405-412, 1992). However, the toxin has no mechanism for specific entry into cells, and therefore requires conjugation to an antibody or antigen binding fragment that recognizes a cell-surface protein that is internalized in order to be efficiently taken up by cells.

Diphtheria toxin is isolated from *Corynebacterium diphtheriae*. Typically, diphtheria toxin for use in immunotoxins is mutated to reduce or to eliminate non-specific toxicity. A mutant known as CRM107, which has full enzymatic activity but markedly reduced non-specific toxicity, has been known since the 1970's (Laird and Groman, J. Virol. 19:220, 1976), and has been used in human clinical trials. See, U.S. Pat. Nos. 5,792,458 and 5,208,021.

Ricin is the lectin RCA60 from *Ricinus communis* (Castor bean). For examples of ricin, see, U.S. Pat. Nos. 5,079,163 and 4,689,401. *Ricinus communis* agglutinin (RCA) occurs in two forms designated RCA60 and RCA120 according to their molecular weights of approximately 65 and 120 kD, respectively (Nicholson & Blaustein, J. Biochim. Biophys. Acta 266:543, 1972). The A chain is responsible for inacti-

vating protein synthesis and killing cells. The B chain binds ricin to cell-surface galactose residues and facilitates transport of the A chain into the cytosol (Olsnes et al., *Nature* 249:627-631, 1974 and U.S. Pat. No. 3,060,165).

Ribonucleases have also been conjugated to targeting molecules for use as immunotoxins (see Suzuki et al., *Nat. Biotech.* 17:265-70, 1999). Exemplary ribotoxins such as α -sarcin and restrictocin are discussed in, for example Rathore et al., *Gene* 190:31-5, 1997; and Goyal and Batra, *Biochem.* 345 Pt 2:247-54, 2000. Calicheamicins were first isolated from *Micromonospora echinospora* and are members of the enediyne antitumor antibiotic family that cause double strand breaks in DNA that lead to apoptosis (see, for example Lee et al., *J. Antibiot.* 42:1070-87, 1989). The drug is the toxic moiety of an immunotoxin in clinical trials (see, for example, Gillespie et al., *Ann. Oncol.* 11:735-41, 2000).

Abrin includes toxic lectins from *Abrus precatorius*. The toxic principles, abrin a, b, c, and d, have a molecular weight of from about 63 and 67 kD and are composed of two disulfide-linked polypeptide chains A and B. The A chain inhibits protein synthesis; the B chain (abrin-b) binds to D-galactose residues (see, Funatsu et al., *Agr. Biol. Chem.* 52:1095, 1988; and Olsnes, *Methods Enzymol.* 50:330-335, 1978).

A CAR, a T cell expressing a CAR, monoclonal antibodies, antigen binding fragments thereof, specific for one or more of the antigens disclosed herein, can also be conjugated with a detectable marker; for example, a detectable marker capable of detection by ELISA, spectrophotometry, flow cytometry, microscopy or diagnostic imaging techniques (such as computed tomography (CT), computed axial tomography (CAT) scans, magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), magnetic resonance tomography (MTR), ultrasound, fiberoptic examination, and laparoscopic examination). Specific, non-limiting examples of detectable markers include fluorophores, chemiluminescent agents, enzymatic linkages, radioactive isotopes and heavy metals or compounds (for example super paramagnetic iron oxide nanocrystals for detection by MRI). For example, useful detectable markers include fluorescent compounds, including fluorescein, fluorescein isothiocyanate, rhodamine, 5-dimethylamine-1-naphthalenesulfonyl chloride, phycoerythrin, lanthanide phosphors and the like. Bioluminescent markers are also of use, such as luciferase, Green fluorescent protein (GFP), Yellow fluorescent protein (YFP). A CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, can also be conjugated with enzymes that are useful for detection, such as horseradish peroxidase, β -galactosidase, luciferase, alkaline phosphatase, glucose oxidase and the like. When a CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, is conjugated with a detectable enzyme, it can be detected by adding additional reagents that the enzyme uses to produce a reaction product that can be discerned. For example, when the agent horseradish peroxidase is present the addition of hydrogen peroxide and diaminobenzidine leads to a colored reaction product, which is visually detectable. A CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, may also be conjugated with biotin, and detected through indirect measurement of avidin or streptavidin binding. It should be noted that the avidin itself can be conjugated with an enzyme or a fluorescent label.

A CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, may be conjugated with a paramagnetic agent, such as gadolinium. Paramagnetic agents such as superparamagnetic iron oxide are also of use

as labels. Antibodies can also be conjugated with lanthanides (such as europium and dysprosium), and manganese. An antibody or antigen binding fragment may also be labeled with a predetermined polypeptide epitope recognized by a secondary reporter (such as leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains, epitope tags).

A CAR, a T cell expressing a CAR, an antibody, or antigen binding portion thereof, can also be conjugated with a radiolabeled amino acid. The radiolabel may be used for both diagnostic and therapeutic purposes. For instance, the radiolabel may be used to detect one or more of the antigens disclosed herein and antigen expressing cells by x-ray, emission spectra, or other diagnostic techniques. Further, the radiolabel may be used therapeutically as a toxin for treatment of tumors in a subject, for example for treatment of a neuroblastoma. Examples of labels for polypeptides include, but are not limited to, the following radioisotopes or radio-nucleotides: ^3H , ^{14}C , ^{15}N , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I .

Means of detecting such detectable markers are well known to those of skill in the art. Thus, for example, radiolabels may be detected using photographic film or scintillation counters, fluorescent markers may be detected using a photodetector to detect emitted illumination. Enzymatic labels are typically detected by providing the enzyme with a substrate and detecting the reaction product produced by the action of the enzyme on the substrate, and colorimetric labels are detected by simply visualizing the colored label.

30 D. Nucleotides, Expression, Vectors, and Host Cells

Further provided by an embodiment of the invention is a nucleic acid comprising a nucleotide sequence encoding any of the CARs, an antibody, or antigen binding portion thereof, described herein (including functional portions and functional variants thereof). The nucleic acids of the invention may comprise a nucleotide sequence encoding any of the leader sequences, antigen binding domains, transmembrane domains, and/or intracellular T cell signaling domains described herein.

40 In some embodiments, the nucleotide sequence may be codon-modified. Without being bound to a particular theory, it is believed that codon optimization of the nucleotide sequence increases the translation efficiency of the mRNA transcripts. Codon optimization of the nucleotide sequence may involve substituting a native codon for another codon that encodes the same amino acid, but can be translated by tRNA that is more readily available within a cell, thus increasing translation efficiency. Optimization of the nucleotide sequence may also reduce secondary mRNA structures that would interfere with translation, thus increasing translation efficiency.

In an embodiment of the invention, the nucleic acid may comprise a codon-modified nucleotide sequence that encodes the antigen binding domain of the inventive CAR.

55 In another embodiment of the invention, the nucleic acid may comprise a codon-modified nucleotide sequence that encodes any of the CARs described herein (including functional portions and functional variants thereof).

“Nucleic acid” as used herein includes “polynucleotide,” “oligonucleotide,” and “nucleic acid molecule,” and generally means a polymer of DNA or RNA, which can be single-stranded or double-stranded, synthesized or obtained (e.g., isolated and/or purified) from natural sources, which can contain natural, non-natural or altered nucleotides, and which can contain a natural, non-natural or altered internucleotide linkage, such as a phosphoroamidate linkage or a phosphorothioate linkage, instead of the phosphodiester

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found between the nucleotides of an unmodified oligonucleotide. In some embodiments, the nucleic acid does not comprise any insertions, deletions, inversions, and/or substitutions. However, it may be suitable in some instances, as discussed herein, for the nucleic acid to comprise one or more insertions, deletions, inversions, and/or substitutions.

A recombinant nucleic acid may be one that has a sequence that is not naturally occurring or has a sequence that is made by an artificial combination of two otherwise separated segments of sequence. This artificial combination is often accomplished by chemical synthesis or, more commonly, by the artificial manipulation of isolated segments of nucleic acids, e.g., by genetic engineering techniques, such as those described in Sambrook et al., *supra*. The nucleic acids can be constructed based on chemical synthesis and/or enzymatic ligation reactions using procedures known in the art. See, for example, Sambrook et al., *supra*, and Ausubel et al., *supra*. For example, a nucleic acid can be chemically synthesized using naturally occurring nucleotides or variously modified nucleotides designed to increase the biological stability of the molecules or to increase the physical stability of the duplex formed upon hybridization (e.g., phosphorothioate derivatives and acridine substituted nucleotides). Examples of modified nucleotides that can be used to generate the nucleic acids include, but are not limited to, 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine, 5-(carboxyhydroxymethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-substituted adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, 3-(3-amino-3-N-2-carboxypropyl) uracil, and 2,6-diaminopurine. Alternatively, one or more of the nucleic acids of the invention can be purchased from companies, such as Integrated DNA Technologies (Coralville, IA, USA).

The nucleic acid can comprise any isolated or purified nucleotide sequence which encodes any of the CARs or functional portions or functional variants thereof. Alternatively, the nucleotide sequence can comprise a nucleotide sequence which is degenerate to any of the sequences or a combination of degenerate sequences.

An embodiment also provides an isolated or purified nucleic acid comprising a nucleotide sequence which is complementary to the nucleotide sequence of any of the nucleic acids described herein or a nucleotide sequence which hybridizes under stringent conditions to the nucleotide sequence of any of the nucleic acids described herein.

The nucleotide sequence which hybridizes under stringent conditions may hybridize under high stringency conditions. By "high stringency conditions" is meant that the nucleotide sequence specifically hybridizes to a target sequence (the nucleotide sequence of any of the nucleic acids described herein) in an amount that is detectably stronger than non-specific hybridization. High stringency conditions include conditions which would distinguish a polynucleotide with an exact complementary sequence, or one containing only a few scattered mismatches from a random sequence that happened to have a few small regions (e.g., 3-10 bases) that

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matched the nucleotide sequence. Such small regions of complementarity are more easily melted than a full-length complement of 14-17 or more bases, and high stringency hybridization makes them easily distinguishable. Relatively high stringency conditions would include, for example, low salt and/or high temperature conditions, such as provided by about 0.02-0.1 M NaCl or the equivalent, at temperatures of about 50-70° C. Such high stringency conditions tolerate little, if any, mismatch between the nucleotide sequence and the template or target strand, and are particularly suitable for detecting expression of any of the inventive CARs. It is generally appreciated that conditions can be rendered more stringent by the addition of increasing amounts of formamide.

Also provided is a nucleic acid comprising a nucleotide sequence that is at least about 70% or more, e.g., about 80%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, or about 99% identical to any of the nucleic acids described herein.

In an embodiment, the nucleic acids can be incorporated into a recombinant expression vector. In this regard, an embodiment provides recombinant expression vectors comprising any of the nucleic acids. For purposes herein, the term "recombinant expression vector" means a genetically-modified oligonucleotide or polynucleotide construct that permits the expression of an mRNA, protein, polypeptide, or peptide by a host cell, when the construct comprises a nucleotide sequence encoding the mRNA, protein, polypeptide, or peptide, and the vector is contacted with the cell under conditions sufficient to have the mRNA, protein, polypeptide, or peptide expressed within the cell. The vectors are not naturally-occurring as a whole.

However, parts of the vectors can be naturally-occurring. The recombinant expression vectors can comprise any type of nucleotides, including, but not limited to DNA and RNA, which can be single-stranded or double-stranded, synthesized or obtained in part from natural sources, and which can contain natural, non-natural or altered nucleotides. The recombinant expression vectors can comprise naturally-occurring or non-naturally-occurring internucleotide linkages, or both types of linkages. Preferably, the non-naturally occurring or altered nucleotides or internucleotide linkages do not hinder the transcription or replication of the vector.

In an embodiment, the recombinant expression vector can be any suitable recombinant expression vector, and can be used to transform or transfect any suitable host cell. Suitable vectors include those designed for propagation and expansion or for expression or both, such as plasmids and viruses. The vector can be selected from the group consisting of the pUC series (Fermentas Life Sciences, Glen Burnie, MD), the pBluescript series (Stratagene, LaJolla, CA), the pET series (Novagen, Madison, WI), the pGEX series (Pharmacia Biotech, Uppsala, Sweden), and the pEX series (Clontech, Palo Alto, CA).

Bacteriophage vectors, such as λUTI0, λUTI 1, λZapII (Stratagene), EMBL4, and λNMI 149, also can be used. Examples of plant expression vectors include pBIOI, pBI101.2, pBHO1.3, pBI121 and pBIN19 (Clontech). Examples of animal expression vectors include pEUK-Cl, pMAM, and pMAMneo (Clontech). The recombinant expression vector may be a viral vector, e.g., a retroviral vector or a lentiviral vector. A lentiviral vector is 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, for example, and not by way of

limitation, the LENTIVECTOR.RTM. gene delivery technology from Oxford BioMedica plc, the LENTIMAX.TM. 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.

A number of transfection techniques are generally known in the art (see, e.g., Graham et al., *Virology*, 52:456-467 (1973); Sambrook et al., *supra*; Davis et al., *Basic Methods in Molecular Biology*, Elsevier (1986); and Chu et al., *Gene*, 13:97 (1981)).

Transfection methods include calcium phosphate co-precipitation (see, e.g., Graham et al., *supra*), direct micro injection into cultured cells (see, e.g., Copechetti, *Cell*, 22:479-488 (1980)), electroporation (see, e.g., Shigekawa et al., *BioTechniques*, 6:742-751 (1988)), liposome mediated gene transfer (see, e.g., Mannino et al., *BioTechniques*, 6:682-690 (1988)), lipid mediated transduction (see, e.g., Feigner et al., *Proc. Natl. Acad. Sci. USA*, 84:7413-7417 (1987)), and nucleic acid delivery using high velocity micro-projectiles (see, e.g., Klein et al., *Nature*, 327:70-73 (1987)).

In an embodiment, the recombinant expression vectors can be prepared using standard recombinant DNA techniques described in, for example, Sambrook et al., *supra*, and Ausubel et al., *supra*. Constructs of expression vectors, which are circular or linear, can be prepared to contain a replication system functional in a prokaryotic or eukaryotic host cell. Replication systems can be derived, e.g., from CoIE1, 2μ plasmid, λ , SV40, bovine papilloma virus, and the like.

The recombinant expression vector may comprise regulatory sequences, such as transcription and translation initiation and termination codons, which are specific to the type of host cell (e.g., bacterium, fungus, plant, or animal) into which the vector is to be introduced, as appropriate, and taking into consideration whether the vector is DNA- or RNA-based. The recombinant expression vector may comprise restriction sites to facilitate cloning.

The recombinant expression vector can include one or more marker genes, which allow for selection of transformed or transfected host cells. Marker genes include biocide resistance, e.g., resistance to antibiotics, heavy metals, etc., complementation in an auxotrophic host to provide prototrophy, and the like. Suitable marker genes for the inventive expression vectors include, for instance, neomycin/G418 resistance genes, hygromycin resistance genes, histidinol resistance genes, tetracycline resistance genes, and ampicillin resistance genes.

The recombinant expression vector can comprise a native or nonnative promoter operably linked to the nucleotide sequence encoding the CAR (including functional portions and functional variants thereof), or to the nucleotide sequence which is complementary to or which hybridizes to the nucleotide sequence encoding the CAR. The selection of promoters, e.g., strong, weak, inducible, tissue-specific and developmental-specific, is within the ordinary skill of the artisan. Similarly, the combining of a nucleotide sequence with a promoter is also within the skill of the artisan. The promoter can be a non-viral promoter or a viral promoter, e.g., a cytomegalovirus (CMV) promoter, an SV40 promoter, an RSV promoter, or a promoter found in the long-terminal repeat of the murine stem cell virus.

The recombinant expression vectors can be designed for either transient expression, for stable expression, or for both. Also, the recombinant expression vectors can be made for constitutive expression or for inducible expression.

Further, the recombinant expression vectors can be made to include a suicide gene. As used herein, the term "suicide

gene" refers to a gene that causes the cell expressing the suicide gene to die. The suicide gene can be a gene that confers sensitivity to an agent, e.g., a drug, upon the cell in which the gene is expressed, and causes the cell to die when the cell is contacted with or exposed to the agent. Suicide genes are known in the art (see, for example, *Suicide Gene Therapy: Methods and Reviews*, Springer, Caroline J. (Cancer Research UK Centre for Cancer Therapeutics at the Institute of Cancer Research, Sutton, Surrey, UK), Humana Press, 2004) and include, for example, the Herpes Simplex Virus (HSV) thymidine kinase (TK) gene, cytosine deaminase, purine nucleoside phosphorylase, and nitroreductase.

An embodiment further provides a host cell comprising any of the recombinant expression vectors described herein. 15 As used herein, the term "host cell" refers to any type of cell that can contain the inventive recombinant expression vector. The host cell can be a eukaryotic cell, e.g., plant, animal, fungi, or algae, or can be a prokaryotic cell, e.g., bacteria or protozoa. The host cell can be a cultured cell or a primary cell, i.e., isolated directly from an organism, e.g., a human. The host cell can be an adherent cell or a suspended cell, i.e., a cell that grows in suspension. Suitable host cells are known in the art and include, for instance, DH5a *E. coli* cells, Chinese hamster ovarian cells, monkey VERO cells, COS cells, HEK293 cells, and the like. For purposes of amplifying or replicating the recombinant expression vector, the host cell may be a prokaryotic cell, e.g., a DH5a cell. For purposes of producing a recombinant CAR, the host cell may be a mammalian cell. The host cell may be a human cell. While the host cell can be of any cell type, can originate from any type of tissue, and can be of any developmental stage, the host cell may be a peripheral blood lymphocyte (PBL) or a peripheral blood mononuclear cell (PBMC). The host cell may be a T cell.

For purposes herein, the T cell can be any T cell, such as a cultured T cell, e.g., a primary T cell, or a T cell from a cultured T cell line, e.g., Jurkat, SupT1, etc., or a T cell obtained from a mammal. If obtained from a mammal, the T cell can be obtained from numerous sources, including but not limited to blood, bone marrow, lymph node, the thymus, or other tissues or fluids. T cells can also be enriched for or purified. The T cell may be a human T cell. The T cell may be a T cell isolated from a human. The T cell can be any type of T cell and can be of any developmental stage, including but not limited to, CD4⁺/CD8⁺ double positive T cells, CD4⁺ helper T cells, e.g., Th1 and Th2 cells, CD8⁺ T cells (e.g., cytotoxic T cells), tumor infiltrating cells, memory T cells, memory stem cells, i.e. Tscm, naive T cells, and the like. The T cell may be a CD8⁺ T cell or a CD4⁺ T cell.

50 In an embodiment, the CARs as described herein can be used in suitable non-T cells. Such cells are those with an immune-effector function, such as, for example, NK cells, and T-like cells generated from pluripotent stem cells.

Also provided by an embodiment is a population of cells comprising at least one host cell described herein. The population of cells can be a heterogeneous population comprising the host cell comprising any of the recombinant expression vectors described, in addition to at least one other cell, e.g., a host cell (e.g., a T cell), which does not comprise any of the recombinant expression vectors, or a cell other than a T cell, e.g., a B cell, a macrophage, a neutrophil, an erythrocyte, a hepatocyte, an endothelial cell, an epithelial cell, a muscle cell, a brain cell, etc. Alternatively, the population of cells can be a substantially homogeneous population, in which the population comprises mainly host cells (e.g., consisting essentially of) comprising the recombinant expression vector. The population also can be a clonal

population of cells, in which all cells of the population are clones of a single host cell comprising a recombinant expression vector, such that all cells of the population comprise the recombinant expression vector. In one embodiment of the invention, the population of cells is a clonal population comprising host cells comprising a recombinant expression vector as described herein.

CARs (including functional portions and variants thereof), nucleic acids, recombinant expression vectors, host cells (including populations thereof), and antibodies (including antigen binding portions thereof), can be isolated and/or purified. For example, a purified (or isolated) host cell preparation is one in which the host cell is more pure than cells in their natural environment within the body. Such host cells may be produced, for example, by standard purification techniques. In some embodiments, a preparation of a host cell is purified such that the host cell represents at least about 50%, for example at least about 70%, of the total cell content of the preparation. For example, the purity can be at least about 50%, can be greater than about 60%, about 70% or about 80%, or can be about 100%.

E. Methods of Treatment

It is contemplated that the CARs disclosed herein can be used in methods of treating or preventing a disease in a mammal. In this regard, an embodiment provides a method of treating or preventing cancer in a mammal, comprising administering to the mammal the CARs, the nucleic acids, the recombinant expression vectors, the host cells, the population of cells, the antibodies and/or the antigen binding portions thereof, and/or the pharmaceutical compositions in an amount effective to treat or prevent cancer in the mammal.

An embodiment further comprises lymphodepleting the mammal prior to administering the CARs disclosed herein. Examples of lymphodepletion include, but may not be limited to, nonmyeloablative lymphodepleting chemotherapy, myeloablative lymphodepleting chemotherapy, total body irradiation, etc.

For purposes of the methods, wherein host cells or populations of cells are administered, the cells can be cells that are allogeneic or autologous to the mammal. Preferably, the cells are autologous to the mammal. As used herein, allogeneic means 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. As used herein, "autologous" means any material derived from the same individual to whom it is later to be re-introduced into the individual.

The mammal referred to herein can be any mammal. As used herein, the term "mammal" refers to any mammal, including, but not limited to, mammals of the order Rodentia, such as mice and hamsters, and mammals of the order Logomorpha, such as rabbits. The mammals may be from the order Carnivora, including Felines (cats) and Canines (dogs). The mammals may be from the order Artiodactyla, including Bovines (cows) and Swines (pigs) or of the order Perissodactyla, including Equines (horses). The mammals may be of the order Primates, Ceboids, or Simoids (monkeys) or of the order Anthropoids (humans and apes). Preferably, the mammal is a human.

With respect to the methods, the cancer can be any cancer, including any of acute lymphocytic cancer, acute myeloid leukemia, alveolar rhabdomyosarcoma, bladder cancer (e.g., bladder carcinoma), bone cancer, brain cancer (e.g.,

medulloblastoma), breast cancer, cancer of the anus, anal canal, or anorectum, cancer of the eye, cancer of the intrahepatic bile duct, cancer of the joints, cancer of the neck, gallbladder, or pleura, cancer of the nose, nasal cavity, or middle ear, cancer of the oral cavity, cancer of the vulva, chronic lymphocytic leukemia, chronic myeloid cancer, colon cancer, esophageal cancer, cervical cancer, fibrosarcoma, gastrointestinal carcinoid tumor, head and neck cancer (e.g., head and neck squamous cell carcinoma), Hodgkin lymphoma, hypopharynx cancer, kidney cancer, larynx cancer, leukemia, liquid tumors, liver cancer, lung cancer (e.g., non-small cell lung carcinoma and lung adenocarcinoma), lymphoma, mesothelioma, mastocytoma, melanoma, multiple myeloma, nasopharynx cancer, non-Hodgkin lymphoma, B-chronic lymphocytic leukemia, hairy cell leukemia, acute lymphocytic leukemia (ALL), and Burkitt's lymphoma, ovarian cancer, pancreatic cancer, peritoneum, omentum, and mesentery cancer, pharynx cancer, prostate cancer, rectal cancer, renal cancer, skin cancer, small intestine cancer, soft tissue cancer, solid tumors, synovial sarcoma, gastric cancer, testicular cancer, thyroid cancer, and ureter cancer.

The terms "treat," and "prevent" as well as words stemming therefrom, as used herein, do not necessarily imply 100% or complete treatment or prevention. Rather, there are varying degrees of treatment or prevention of which one of ordinary skill in the art recognizes as having a potential benefit or therapeutic effect. In this respect, the methods can provide any amount or any level of treatment or prevention of cancer in a mammal.

Furthermore, the treatment or prevention provided by the method can include treatment or prevention of one or more conditions or symptoms of the disease, e.g., cancer, being treated or prevented. Also, for purposes herein, "prevention" can encompass delaying the onset of the disease, or a symptom or condition thereof.

Another embodiment provides a method of detecting the presence of cancer in a mammal, comprising: (a) contacting 40 a sample comprising one or more cells from the mammal with the CARs, the nucleic acids, the recombinant expression vectors, the host cells, the population of cells, the antibodies, and/or the antigen binding portions thereof, or the pharmaceutical compositions, thereby forming a complex, (b) and detecting the complex, wherein detection of the complex is indicative of the presence of cancer in the mammal.

The sample may be obtained by any suitable method, e.g., biopsy or necropsy. A biopsy is the removal of tissue and/or cells from an individual. Such removal may be to collect tissue and/or cells from the individual in order to perform experimentation on the removed tissue and/or cells. This experimentation may include experiments to determine if the individual has and/or is suffering from a certain condition or disease-state. The condition or disease may be, e.g., cancer.

With respect to an embodiment of the method of detecting the presence of a proliferative disorder, e.g., cancer, in a mammal, the sample comprising cells of the mammal can be 60 a sample comprising whole cells, lysates thereof, or a fraction of the whole cell lysates, e.g., a nuclear or cytoplasmic fraction, a whole protein fraction, or a nucleic acid fraction. If the sample comprises whole cells, the cells can be any cells of the mammal, e.g., the cells of any organ or tissue, including blood cells or endothelial cells.

The contacting can take place in vitro or in vivo with respect to the mammal. Preferably, the contacting is in vitro.

Also, detection of the complex can occur through any number of ways known in the art. For instance, the CARs disclosed herein, polypeptides, proteins, nucleic acids, recombinant expression vectors, host cells, populations of cells, or antibodies, or antigen binding portions thereof, described herein, can be labeled with a detectable label such as, for instance, a radioisotope, a fluorophore (e.g., fluorescein isothiocyanate (FITC), phycoerythrin (PE)), an enzyme (e.g., alkaline phosphatase, horseradish peroxidase), and element particles (e.g., gold particles) as disclosed supra.

Methods of testing a CAR for the ability to recognize target cells and for antigen specificity are known in the art. For instance, Clay et al., *J. Immunol.*, 163:507-513 (1999), teaches methods of measuring the release of cytokines (e.g., interferon- γ , granulocyte/monocyte colony stimulating factor (GM-CSF), tumor necrosis factor α (TNF- α) or interleukin 2 (IL-2)). In addition, CAR function can be evaluated by measurement of cellular cytotoxicity, as described in Zhao et al., *J. Immunol.*, 174:4415-4423 (2005).

Another embodiment provides for the use of the CARs, nucleic acids, recombinant expression vectors, host cells, populations of cells, antibodies, or antigen binding portions thereof, and/or pharmaceutical compositions of the invention, for the treatment or prevention of a proliferative disorder, e.g., cancer, in a mammal. The cancer may be any of the cancers described herein.

Any method of administration can be used for the disclosed therapeutic agents, including local and systemic administration. For example, topical, oral, intravascular such as intravenous, intramuscular, intraperitoneal, intranasal, intradermal, intrathecal and subcutaneous administration can be used. The particular mode of administration and the dosage regimen will be selected by the attending clinician, taking into account the particulars of the case (for example the subject, the disease, the disease state involved, and whether the treatment is prophylactic). In cases in which more than one agent or composition is being administered, one or more routes of administration may be used; for example, a chemotherapeutic agent may be administered orally and an antibody or antigen binding fragment or conjugate or composition may be administered intravenously.

Methods of administration include injection for which the CAR, CAR T Cell, conjugates, antibodies, antigen binding fragments, or compositions are provided in a nontoxic pharmaceutically acceptable carrier such as water, saline, Ringer's solution, dextrose solution, 5% human serum albumin, fixed oils, ethyl oleate, or liposomes. In some embodiments, local administration of the disclosed compounds can be used, for instance by applying the antibody or antigen binding fragment to a region of tissue from which a tumor has been removed, or a region suspected of being prone to tumor development. In some embodiments, sustained intra-tumoral (or near-tumoral) release of the pharmaceutical preparation that includes a therapeutically effective amount of the antibody or antigen binding fragment may be beneficial. In other examples, the conjugate is applied as an eye drop topically to the cornea, or intravitreally into the eye.

The disclosed therapeutic agents can be formulated in unit dosage form suitable for individual administration of precise dosages. In addition, the disclosed therapeutic agents may be administered in a single dose or in a multiple dose schedule. A multiple dose schedule is one in which a primary course of treatment may be with more than one separate dose, for instance 1-10 doses, followed by other doses given at subsequent time intervals as needed to maintain or reinforce the action of the compositions. Treatment can involve daily

or multi-daily doses of compound(s) over a period of a few days to months, or even years. Thus, the dosage regime will also, at least in part, be determined based on the particular needs of the subject to be treated and will be dependent upon the judgment of the administering practitioner.

Typical dosages of the antibodies or conjugates can range from about 0.01 to about 30 mg/kg, such as from about 0.1 to about 10 mg/kg.

In particular examples, the subject is administered a

therapeutic composition that includes one or more of the conjugates, antibodies, compositions, CARs, CAR T cells or additional agents, on a multiple daily dosing schedule, such as at least two consecutive days, 10 consecutive days, and so forth, for example for a period of weeks, months, or years.

In one example, the subject is administered the conjugates, antibodies, compositions or additional agents for a period of at least 30 days, such as at least 2 months, at least 4 months, at least 6 months, at least 12 months, at least 24 months, or at least 36 months.

In some embodiments, the disclosed methods include providing surgery, radiation therapy, and/or chemotherapy to the subject in combination with a disclosed antibody, antigen binding fragment, conjugate, CAR or T cell expressing a CAR (for example, sequentially, substantially simultaneously, or simultaneously). Methods and therapeutic dosages of such agents and treatments are known to those skilled in the art, and can be determined by a skilled clinician. Preparation and dosing schedules for the additional agent may be used according to manufacturer's instructions or as determined empirically by the skilled practitioner. Preparation and dosing schedules for such chemotherapy are also described in *Cancer Chemotherapy Service*, (1992) Ed., M. C. Perry, Williams & Wilkins, Baltimore, Md.

In some embodiments, the combination therapy can include administration of a therapeutically effective amount of an additional cancer inhibitor to a subject. Non-limiting examples of additional therapeutic agents that can be used with the combination therapy include microtubule binding agents, DNA intercalators or cross-linkers, DNA synthesis inhibitors, DNA and RNA transcription inhibitors, antibodies, enzymes, enzyme inhibitors, gene regulators, and angiogenesis inhibitors. These agents (which are administered at a therapeutically effective amount) and treatments can be used alone or in combination. For example, any suitable anti-cancer or anti-angiogenic agent can be administered in combination with the CARs, CAR-T cells, antibodies, antigen binding fragment, or conjugates disclosed herein. Methods and therapeutic dosages of such agents are known to those skilled in the art, and can be determined by a skilled clinician.

Additional chemotherapeutic agents include, but are not limited to alkylating agents, such as nitrogen mustards (for example, chlorambucil, chlormethine, cyclophosphamide, ifosfamide, and melphalan), nitrosoureas (for example, carmustine, fotemustine, lomustine, and streptozocin), platinum compounds (for example, carboplatin, cisplatin, oxaliplatin, and BBR3464), busulfan, dacarbazine, mechlorethamine, procarbazine, temozolomide, thiotepa, and uramustine; antimetabolites, such as folic acid (for example, methotrexate, pemetrexed, and raltitrexed), purine (for example, cladribine, clofarabine, fludarabine, mercaptopurine, and tioguanine), pyrimidine (for example, capecitabine), cytarabine, fluorouracil, and gemcitabine; plant alkaloids, such as podophyllium (for example, etoposide, and teniposide), taxane (for example, docetaxel and paclitaxel), vinca (for example, vinblastine, vincristine, vindesine, and

vinorelbine); cytotoxic/antitumor antibiotics, such as anthracycline family members (for example, daunorubicin, doxorubicin, epirubicin, idarubicin, mitoxantrone, and valrubicin), bleomycin, rifampicin, hydroxyurea, and mitomycin; topoisomerase inhibitors, such as topotecan and irinotecan; monoclonal antibodies, such as alemtuzumab, bevacizumab, cetuximab, gemtuzumab, rituximab, panitumumab, pertuzumab, and trastuzumab; photosensitizers, such as amineolevulinic acid, methyl aminolevulinate, porfimer sodium, and verteporfin; and other agents, such as altretinoin, altretamine, amsacrine, anagrelide, arsenic trioxide, asparaginase, axitinib, bexarotene, bevacizumab, bortezomib, celecoxib, denileukin diftitox, erlotinib, estramustine, gefitinib, hydroxycarbamide, imatinib, lapatinib, pazopanib, pentostatin, masoprocol, mitotane, pegaspargase, tamoxifen, sorafenib, sunitinib, vemurafenib, vandetanib, and tretinoin. Selection and therapeutic dosages of such agents are known to those skilled in the art, and can be determined by a skilled clinician.

The combination therapy may provide synergy and prove synergistic, that is, the effect achieved when the active ingredients used together is greater than the sum of the effects that results from using the compounds separately. A synergistic effect may be attained when the active ingredients are: (1) co-formulated and administered or delivered simultaneously in a combined, unit dosage formulation; (2) delivered by alternation or in parallel as separate formulations; or (3) by some other regimen. When delivered in alternation, a synergistic effect may be attained when the compounds are administered or delivered sequentially, for example by different injections in separate syringes. In general, during alternation, an effective dosage of each active ingredient is administered sequentially, i.e. serially, whereas in combination therapy, effective dosages of two or more active ingredients are administered together.

In one embodiment, an effective amount of an antibody or antigen binding fragment that specifically binds to one or more of the antigens disclosed herein or a conjugate thereof is administered to a subject having a tumor following anti-cancer treatment. After a sufficient amount of time has elapsed to allow for the administered antibody or antigen binding fragment or conjugate to form an immune complex with the antigen expressed on the respective cancer cell, the immune complex is detected. The presence (or absence) of the immune complex indicates the effectiveness of the treatment. For example, an increase in the immune complex compared to a control taken prior to the treatment indicates that the treatment is not effective, whereas a decrease in the immune complex compared to a control taken prior to the treatment indicates that the treatment is effective.

F. Biopharmaceutical Compositions

Biopharmaceutical or biologics compositions (hereinafter, "compositions") are provided herein for use in gene therapy, immunotherapy and/or cell therapy that include one or more of the disclosed CARs, or T cells expressing a CAR, antibodies, antigen binding fragments, conjugates, CARs, or T cells expressing a CAR that specifically bind to one or more antigens disclosed herein, in a carrier (such as a pharmaceutically acceptable carrier). The compositions can be prepared in unit dosage forms for administration to a subject. The amount and timing of administration are at the discretion of the treating clinician to achieve the desired outcome. The compositions can be formulated for systemic (such as intravenous) or local (such as intra-tumor) administration. In one example, a disclosed CARs, or T cells expressing a CAR, antibody, antigen binding fragment, conjugate, is formulated for parenteral administration, such

as intravenous administration. Compositions including a CAR, or T cell expressing a CAR, a conjugate, antibody or antigen binding fragment as disclosed herein are of use, for example, for the treatment and detection of a tumor, for example, and not by way of limitation, a neuroblastoma. In some examples, the compositions are useful for the treatment or detection of a carcinoma. The compositions including a CAR, or T cell expressing a CAR, a conjugate, antibody or antigen binding fragment as disclosed herein are also of use, for example, for the detection of pathological angiogenesis.

The compositions for administration can include a solution of the CAR, or T cell expressing a CAR, conjugate, antibody or antigen binding fragment dissolved in a pharmaceutically acceptable carrier, such as an aqueous carrier. A variety of aqueous carriers can be used, for example, buffered saline and the like. These solutions are sterile and generally free of undesirable matter. These compositions may be sterilized by conventional, well known sterilization techniques. The compositions may contain pharmaceutically acceptable auxiliary substances as required to approximate physiological conditions such as pH adjusting and buffering agents, toxicity adjusting agents, adjuvant agents, and the like, for example, sodium acetate, sodium chloride, potassium chloride, calcium chloride, sodium lactate and the like. The concentration of a CAR, or T cell expressing a CAR, antibody or antigen binding fragment or conjugate in these formulations can vary widely, and will be selected primarily based on fluid volumes, viscosities, body weight and the like in accordance with the particular mode of administration selected and the subject's needs. Actual methods of preparing such dosage forms for use in gene therapy, immunotherapy and/or cell therapy are known, or will be apparent, to those skilled in the art.

A typical composition for intravenous administration includes about 0.01 to about 30 mg/kg of antibody or antigen binding fragment or conjugate per subject per day (or the corresponding dose of a CAR, or T cell expressing a CAR, conjugate including the antibody or antigen binding fragment). Actual methods for preparing administrable compositions will be known or apparent to those skilled in the art and are described in more detail in such publications as Remington's Pharmaceutical Science, 19th ed., Mack Publishing Company, Easton, PA (1995).

A CAR, or T cell expressing a CAR, antibodies, antigen binding fragments, or conjugates may be provided in lyophilized form and rehydrated with sterile water before administration, although they are also provided in sterile solutions of known concentration. The CARs, or T cells expressing a CAR, antibody or antigen binding fragment or conjugate solution is then added to an infusion bag containing 0.9% sodium chloride, USP, and in some cases administered at a dosage of from 0.5 to 15 mg/kg of body weight. Considerable experience is available in the art in the administration of antibody or antigen binding fragment and conjugate drugs; for example, antibody drugs have been marketed in the U.S. since the approval of RITUXAN® in 1997. A CAR, or T cell expressing a CAR, antibodies, antigen binding fragments and conjugates thereof can be administered by slow infusion, rather than in an intravenous push or bolus. In one example, a higher loading dose is administered, with subsequent, maintenance doses being administered at a lower level. For example, an initial loading dose of 4 mg/kg antibody or antigen binding fragment (or the corresponding dose of a conjugate including the antibody or antigen binding fragment) may be infused over a period of some 90 minutes, followed by weekly maintenance doses

for 4-8 weeks of 2 mg/kg infused over a 30 minute period if the previous dose was well tolerated.

Controlled release parenteral formulations can be made as implants, oily injections, or as particulate systems. For a broad overview of protein delivery systems see, Banga, A. J., *Therapeutic Peptides and Proteins: Formulation, Processing, and Delivery Systems*, Technomic Publishing Company, Inc., Lancaster, PA, (1995). Particulate systems include microspheres, microparticles, microcapsules, nanocapsules, nanospheres, and nanoparticles. Microcapsules contain the therapeutic protein, such as a cytotoxin or a drug, as a central core. In microspheres, the therapeutic is dispersed throughout the particle. Particles, microspheres, and microcapsules smaller than about 1 μm are generally referred to as nanoparticles, nanospheres, and nanocapsules, respectively. Capillaries have a diameter of approximately 5 μm so that only nanoparticles are administered intravenously. Microparticles are typically around 100 μm in diameter and are administered subcutaneously or intramuscularly. See, for example, Kreuter, J., *Colloidal Drug Delivery Systems*, J. Kreuter, ed., Marcel Dekker, Inc., New York, NY, pp. 219-342 (1994); and Tice & Tabibi, *Treatise on Controlled Drug Delivery*, A. Kydonieus, ed., Marcel Dekker, Inc. New York, NY, pp. 315-339, (1992).

Polymers can be used for ion-controlled release of the CARs, or T cells expressing a CAR, antibody or antigen binding fragment or conjugate compositions disclosed herein. Various degradable and nondegradable polymeric matrices for use in controlled drug delivery are known in the art (Langer, *Accounts Chem. Res.* 26:537-542, 1993). For example, the block copolymer, poloxamer 407, exists as a viscous yet mobile liquid at low temperatures but forms a semisolid gel at body temperature. It has been shown to be an effective vehicle for formulation and sustained delivery of recombinant interleukin-2 and urease (Johnston et al., *Pharm. Res.* 9:425-434, 1992; and Pec et al., *J. Parent. Sci. Tech.* 44 (2): 58-65, 1990). Alternatively, hydroxyapatite has been used as a microcarrier for controlled release of proteins (Ijntema et al., *Int. J. Pharm.* 112:215-224, 1994). In yet another aspect, liposomes are used for controlled release as well as drug targeting of the lipid-capsulated drug (Betageri et al., *Liposome Drug Delivery Systems*, Technomic Publishing Co., Inc., Lancaster, PA (1993)). Numerous additional systems for controlled delivery of therapeutic proteins are known (see U.S. Pat. Nos. 5,055,303; 5,188,837; 4,235,871; 4,501,728; 4,837,028; 4,957,735; 5,019,369; 5,055,303; 5,514,670; 5,413,797; 5,268,164; 5,004,697; 4,902,505; 5,506,206; 5,271,961; 5,254,342 and 5,534,496).

G. Kits

In one aspect, kits employing the CARs disclosed herein are also provided. For example, kits for treating a tumor in a subject, or making a CAR T cell that expresses one or more of the CARs disclosed herein. The kits will typically include a disclosed antibody, antigen binding fragment, conjugate, nucleic acid molecule, CAR or T cell expressing a CAR as disclosed herein. More than one of the disclosed antibodies, antigen binding fragments, conjugates, nucleic acid molecules, CARs or T cells expressing a CAR can be included in the kit.

The kit can include a container and a label or package insert on or associated with the container. Suitable containers include, for example, bottles, vials, syringes, etc. The containers may be formed from a variety of materials such as glass or plastic. The container typically holds a composition including one or more of the disclosed antibodies, antigen binding fragments, conjugates, nucleic acid molecules, CARs or T cells expressing a CAR. In several

embodiments the container may have a sterile access port (for example the container may be an intravenous solution bag or a vial having a stopper pierceable by a hypodermic injection needle). A label or package insert indicates that the composition is used for treating the particular condition.

The label or package insert typically will further include instructions for use of a disclosed antibodies, antigen binding fragments, conjugates, nucleic acid molecules, CARs or T cells expressing a CAR, for example, in a method of treating or preventing a tumor or of making a CAR T cell. The package insert typically includes instructions customarily included in commercial packages of therapeutic products that contain information about the indications, usage, dosage, administration, contraindications and/or warnings concerning the use of such therapeutic products. The instructional materials may be written, in an electronic form (such as a computer diskette or compact disk) or may be visual (such as video files). The kits may also include additional components to facilitate the particular application for which the kit is designed. Thus, for example, the kit may additionally contain means of detecting a label (such as enzyme substrates for enzymatic labels, filter sets to detect fluorescent labels, appropriate secondary labels such as a secondary antibody, or the like). The kits may additionally include buffers and other reagents routinely used for the practice of a particular method. Such kits and appropriate contents are well known to those of skill in the art.

EXAMPLES

This invention is further illustrated by the following examples, which are not to be construed in any way as imposing limitations upon the scope thereof. On the contrary, it is to be clearly understood that resort may be had to various other embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to those skilled in the art without departing from the spirit of the present invention and/or the scope of the appended claims.

Example 1

Derivation of Human BCMA-Specific Binders from a Fully Human Yeast Display Library

Materials and Methods

A large yeast display human naive single chain variable fragment (ScFv) antibody library was used to isolate anti-human BCMA antibodies described herein. The library was constructed using a collection of human antibody gene repertoires from more than 60 individuals. Three rounds of magnetic-activated cell sorting (MACS) were performed to enrich human ScFv binders to the recombinant human BCMA (ectodomain)-Fc. For the first round of yeast library panning, the yeast display ScFv library (5×10^{10} cells) was incubated with 5 $\mu\text{g}/\text{ml}$ BCMA-Fc in 15 ml PBSA (consisting of 0.1% Bovine Serum Albumin (BSA) in Dulbecco's phosphate-buffered saline (PBS) buffer), at room temperature on a rotator for 1.5 hours. After two times washing with 25 ml PBSA, the yeast library mix was incubated with 100 μL Protein G microbeads (Miltenyi Biotec) at room temperature on a rotator for 30 minutes. After one time washing, the library mix was resuspended in 50 ml of PBSA and loaded onto the MACS cell separation column (LS column). After three times washing with 10 ml PBSA. The yeast displayed ScFv binders to the column were then eluted two

times with 2 ml PBSA. These eluted yeast cells were combined and then resuspended into 50 ml SDCAA medium (20 g D-glucose, 6.7 g BD Difco™ Yeast Nitrogen Base without Amino Acids, 5 g Bacto™ Casamino Acids, 5.4 g Na₂HPO₄, and 8.56 g NaH₂PO₄·H₂O in 1 L water) and amplified with shaking at 225 rpm at 30° C. for 20 hours. The amplified pool was then induced in SGCAA medium (consisting of the same composition of SDCAA medium, but containing galactose instead of glucose), with shaking at 225 rpm at 30° C. for another 16 hours and used for next round of panning. The same process was repeated two more times to enrich the BCMA-Fc specific binders.

To further enrich the binders with higher affinity and better specificity, FACS based sorting was employed to isolate the strongest binders from the pool. The induced pool was incubated with 0.1 µg/ml of biotinylated BCMA-Fc at room temperature for 1 hour and then stained with Anti-c-Myc-Alexa 488 and Streptavidin-PE conjugates, the top 1% of the pool with the highest PE versus FITC signal was gated and sorted. The sorted pool was amplified in SDCAA medium and yeast plasmid DNA was extracted and transformed into bacterial for single clone DNA sequencing. 50 random clones were sequenced and 48 unique sequences were identified. 17 clones designated as MTB-1, MTB-2, MTB-3, MTB-4, MTB-5, MTB-14, MTB-15, MTB-16, MTB-25, MTB-28, MTB-37, MTB-39, MTB-40, MTB-49, MTB-50, MTB-4-12 and MTB-4-45 were cloned into CAR constructs for CAR-T function screening.

Example 2

Generation and Testing of BCMA-Targeting CAR T Constructs Incorporating Fully Human Binder ScFv Sequences

This Example 2 describes the creation of a CAR T cells targeting the tumor antigen BCMA for the treatment if MM and other BCMA-positive malignancies.

Schema of BCMA CAR design is shown in FIG. 1. Fully human ScFv binders targeting BCMA were linked in frame to CD8 hinge and transmembrane domain, 4-1BB costimulatory domain and CD3 zeta activation domain. CAR sequences were incorporated into third-generation lentiviral vectors and which were used in transduction of human primary T cells to generate the BCMA CAR T cells.

Table 1 below lists the BCMA CAR constructs built, designated by ScFv sequence used in CAR design in the left column, and the corresponding designation of the ScFv clone nomenclature in each construct in the right column.

TABLE 1

List of ScFv Clones used in CAR designs	
ScFv Sequence Designation	ScFv Clone nomenclature
sequence 1	MTB-1
sequence 2	MTB-2
sequence 3	MTB-3
sequence 4	MTB-4
sequence 5	MTB-5
sequence 14	MTB-14
sequence 15	MTB-15
sequence 16	MTB-16
sequence 25	MTB-25
sequence 28	MTB-28
sequence 37	MTB-37
sequence 39	MTB-39
sequence 40	MTB-40

TABLE 1-continued

List of ScFv Clones used in CAR designs	
ScFv Sequence Designation	ScFv Clone nomenclature
sequence 49	MTB-49
sequence 50	MTB-50
sequence 4-12	MTB-4-12
sequence 4-45	MTB-4-45

The surface expression of anti-BCMA CARs incorporating single chain fragment variable 5 (ScFv) sequences, is shown in FIG. 2. The expression level for each ScFv-containing CAR was determined by flow cytometric analysis of LV-transduced T cells from healthy donors using either Protein L detection method, or the BCMA—Fc method. In a Protein L detection method, CAR T cells and controls were stained in a two-step procedure with: step 1) protein L-biotin conjugate, followed by step 2) streptavidin—PE reagent. In a BCMA-Fc method, cells were stained with: step 1: BCMA-Fc peptide; followed by step 2: anti-Fc APC reagent. Results from 10 both methods were taken into account when analyzing CAR expression. All CAR constructs were successfully expressed in human primary T cells, with the exception of CAR construct with ScFv sequence 15, which could not be detected by either of the staining methods (FIG. 2). Untransduced cells (UTD) were used as a negative staining control indicating the specificity of CAR T staining. Next, the cytolytic function of anti BCMA CARs was evaluated in a luciferase-based killing assay (FIG. 3).

CAR T cells were incubated with multiple myeloma BCMA-positive tumor lines RPMI-8226-luc, or MM1.S-luc, or with a BCMA-negative line 293T-luc, in order to control for non-specific CAR activation.

Effector CAR T cells and tumor cells were combined at effector to target (E:T) ratio of 5:1 or 10:1 in order to compare and contrast the potency of the different CAR constructs (FIG. 3). RPMI-8226 cells were most susceptible cell line to BCMA CAR-mediated tumor killing, with most CAR constructs achieving over 40% tumor lysis at the lowest E:T ratio of 5 (FIG. 3A), except for CARs containing ScFv sequence 1, sequence 2, sequence 15, or sequence 25, whereas the negative control untransduced T cells, the UTD group, caused no appreciable tumor lysis (FIG. 3A). In multiple myeloma MM1.S cells, which are less susceptible to cytolysis, strong killing function of CARs with ScFv sequence 5, sequence 16, sequence 37, and sequence 40 was observed, but not for the other constructs. The UTD group caused no appreciable tumor killing, indicating that the killing is CAR-specific (FIG. 3B). No killing of 293T cells, which lack the BCMA target antigen was seen, indicating the specificity of killing response (FIG. 3C).

Based on these results, CAR T constructs D0084, D0085, D0087, D0099, DO100, incorporating ScFv binder sequences 5, 16, 37, 40, 4-12, and 4-45, respectively, were used for further testing (Table 2).

TABLE 2

CAR Construct Numbers and the Corresponding ScFv sequences		
CAR Construct Number	LTG Number	ScFv Sequence Designation
D0084	LTG2860	sequence 5
D0085	LTG2861	sequence 16
D0086	LTG2862	sequence 37
D0087	LTG2863	sequence 40

TABLE 2-continued

CAR Construct Numbers and the Corresponding ScFv sequences		
CAR Construct Number	LTG Number	ScFv Sequence Designation
D0099	LTG2944	sequence 4-12
D0100	LTG2945	sequence 4-45

Next, expression of BCMA CAR constructs was evaluated by transduction of human CD4+CD8+ T cells at a fixed multiplicity of infection of 40 (FIG. 4). T cells were isolated from a human buffy coat product and transduced with lentiviral vectors encoding the CARs as described in Materials and Methods. CAR+ T cells were detected using BCMA-Fc peptide, followed by anti-Fc APC. Cells were counterstained with CD8 antibody-FL in order to confirm CAR expression among CD8+ and CD8-(CD4+) T cells. All constructs were expressed robustly, in CD4+ as well as CD8+ T cells. The total CAR expression frequencies ranged from 19.5% to 49.3% (FIG. 4). Data for one representative donor out of three transduction experiments is shown.

Then, CAR constructs D0084, D0085, D0087, D0099, D0100 were compared in terms of their tumor cytolytic capacity in a luciferase-based killing assay. Target lines stably expressing firefly luciferase were used, as above. CAR T cells from two separate donors are shown in order to demonstrate robustness and reproducibility of the results (FIG. 5).

Robust killing capacity of CARs D0084, D0085, D0087, D0099, D0100 was demonstrated in the BCMA-positive multiple myeloma cell lines MM1.S and RPMI-8226. No appreciable killing was observed in UTD negative control groups, indicating the dependence of the killing on CAR expression. Moreover, no killing was seen against BCMA-negative 293T cells, demonstrating that the killing is BCMA-dependent (FIG. 5).

Example 3

In Vivo Testing of BCMA-Targeting CAR T Constructs Incorporating Fully Human Binder ScFv Sequences

Example 3 describes long-term in vitro, and xenograft model in vivo evaluation of a CAR T cells targeting the tumor antigen BCMA for the treatment in multiple myeloma and other BCMA-positive malignancies. These testing modalities provide a more stringent environment for CAR T evaluation, and better approximate the conditions that CAR T cells may encounter in human patients.

Note: for clarity and brevity, in this and the following Examples, one zero was omitted from CAR construct names shown in Table 2. Therefore, CAR construct D0100 became D100, CAR construct D0085 became D085, etc.

Materials and Methods

T-Cell Transduction and Culture

Primary CD4 and CD8 T-cells were activated with TransAct (Miltenyi Biotec, Auburn CA) according to the manufacturer's protocol. The cells were cultured overnight at a density of 1e6 cells/ml in TexMACS media (Miltenyi Biotec) supplemented with 30 U/ml of recombinant human IL-2 (Miltenyi Biotec). After 18-24 hours, the T-cells were transduced with lentiviral vectors containing the CAR constructs. The T-cells were incubated with the lentiviral vectors for 2

days, and the cultures were subsequently washed and re-suspended in fresh TexMACS media with IL-2 and maintained at a density of 0.5e6 cells/ml. On day 6 or 7 after the start of T-cell culture, the cell surface expression of the CARs was assessed by flow cytometry.

Flow Cytometry Staining

To assess the cell surface expression of BCMA CARs, 0.5-1e6 CAR T-cells were resuspended in FACS buffer (Miltenyi Biotec's autoMACS Rinsing Solution+MACS BSA Stock Solution) and incubated with 0.5 µg of recombinant human BCMA Fc Chimera Protein (RNDsystems) for 20 mins at 4° C. Cells were washed twice and re-suspended in FACS buffer and incubated for 20 mins at 4° C. with anti-Fc-Alexa Fluor 647 at 1:200 dilution. Cells were again washed twice and resuspended in FACS buffer and incubated for 20 mins at 4° C. with anti-CD4-Vioblu or anti-CD8-Viogreen (Miltenyi Biotec) at 1:50 dilution and 7AAD at 1:20 dilution. Cells were subsequently washed and analyzed using the MACSQuant® Analyzer 10 flow cytometer (Miltenyi Biotec).

For exhaustion marker staining, CAR T-cells were resuspended in FACS buffer and incubated with anti-PD-1-Pevio770 (Miltenyi Biotec) and anti-LAG-3-APC (Biolegend) at 1:30 dilution. Memory markers were stained by incubating CAR T-cells with anti-CD45RO-Pevio770, anti-CD45RA-APC, and CD62L-PE (Miltenyi Biotec) at 1:30 dilution. For both exhaustion and memory staining panels, cells were additionally stained with CD8-Viogreen, CD3-Vioblu, and 7AAD. Cells were incubated with the antibodies for 20 mins at 4° C., and subsequently washed then acquired using the MACSQuant Analyzer 10 flow cytometer.

For intracellular cytokine staining, T-cells were incubated with target cells for 5-6 hours at 37° C. in the presence of Brefeldin A (BD Biosciences, CA). Cells were subsequently stained as previously described with cell surface markers CD8-Viogreen and CD3-Vioblu. After cell surface staining, cells were fixed and permeabilized with Fixation/Permeabilization Solution Kit (BD Biosciences) according to the manufacturer's protocol. Cells were then stained with anti-IFN-gamma-APC, anti-TNF-APCvio770, and IL-2-PE (Miltenyi Biotec) at dilutions suggested by the manufacturer. After staining, cells were analyzed using the MACSQuant Analyzer 10 flow cytometer.

Long-Term Co-Culture

For the long term co-culture experiment, CAR T-cells were co-cultured with target cells, MM1.S or RPMI-8226 expressing GFP, at an ETT ratio of 0.1-0.3. The cells were cultured in 6-well plates with TexMACS media that was either treated with 10 ng/ml of human recombinant TGF-β (Miltenyi Biotec) or remained untreated. The co-culture was fed by adding TGF-β-treated media or untreated media every 2-3 days. The absolute counts of T-cells and target cells at different time points during the long-term co-culture was assessed by quantifying the number of CD3+ cells and GFP+ cells using flow cytometry. The absolute counts were determined by normalizing the number of acquired cells using CountBright Absolute Counting Beads (Molecular Probes). When less than 15% of the target cells remained, T-cells from the co-culture were added to fresh target cells at an ETT ratio of 0.1-0.3 to initiate the subsequent round of co-culture. Additional rounds of co-culture were done until the T-cells no longer proliferated.

In Vivo Tumor Model

Female 7 to 8-week old NSG mice NOD.Cg-Prkdc^{scid}Il2rg^{tm1W^yJ}/SzJ from Jackson Laboratory (Bar Harbor, ME) were intradermally injected on the abdomen with

8e6 RPMI-8226 cells. T-cells were intravenously injected after the tumors were allowed to engraft for 18-20 days and have reached volume sizes of >60 mm³ as measured via caliper. For groups receiving CAR T-cells, 5e6 CAR T-cells were infused, and the differences in CAR expression levels between groups were normalized by adjusting the number of total T-cells that was injected. The number of T-cells that was infused in the UTD group was the mean of the total T-cells that was injected in the CAR T-cell groups. On day 6-7 after T-cell infusion, 3-5 mice from each group (except the untreated group) were sacrificed for tumor harvest, while the rest were monitored for tumor progression and survival. Tumor sizes and body weights were measured every 2-3 days. Mice with tumor sizes reaching >1200 mm were sacrificed.

CAR constructs D100 and D085 were compared side-by side in a long-term co-incubation with targets in vitro. This assay facilitates long-term exposure of CAR-T cells to target antigens such as may occur in vivo and in the clinic, and may help identify critical differences in long-term function of CAR T cells. D100 and D085 CARs were comprised CD8 extracellular and transmembrane domain, 4-1BB/CD137 co-stimulation domain and CD3 activation domains, and differed only in the scFv sequence (FIG. 6A). Both CAR constructs achieved robust expression at MOI (multiplicity of infection) 10, 20, or 40. CAR T lines with similar CAR surface expression were chosen for the long term assay: 84.6% for D100, 81.5% for D085, (FIG. 6B).

CAR T and target cells were combined at the beginning of the first round of co-culture at E:T ratio of 0.1:1, then fresh target RPMI-8226 cells were spiked into the culture at the beginning of each consecutive round, to replace target cells which have been killed by CAR T cells, and maintain the desired E:T ratio (FIG. 6C). The BCMA CAR D100 demonstrated greater T cell expansion in the 1st, 3rd, and 4th round of the long-term co-culture as compared to CAR D085 (FIG. 6D). In addition, CAR D100 mediated superior target cell killing in the long term, as seen in the 4th co-culture round (FIG. 6E). Of note, in the course of the 20-day co-culture period, the percentage of CD8+ T cell subsets of both CAR D085 and D100 continued to increase, whereas the percentage of CD4+T in CAR D085 and D100 populations decreased, especially at the later stages of co-incubation (FIG. 6F). This is to be expected, as CD8+ T cells are known to dominate the later stages of the anti-tumor response. However, the percentage of both CD4+T and CD8+T subsets in CAR100 co-cultures with target cells remained higher than the respective T cell subsets in CAR085 (FIG. 6F). Finally, the production of inflammatory cytokines IL-2, and TNF α crucial for CAR T function, was greater in the CAR100 T cells, as compared to CAR085, whereas the levels of IFN γ were similar (FIG. 6G). Overall, the BCMA CAR D100 demonstrated superior target cell killing, expansion of CD4+T and CD8+T subsets, and cytokine elaboration, as compared to the BCMACAR D085.

The in vivo anti-tumor function of BCMACAR D085 and D100 were then evaluated in an RPMI-8226 intradermal xenograft mouse model. Mice were implanted with RPMI-8226 cells seventeen days prior to CAR T administration. Mice with established RPMI-8226 were treated with CAR T cells or untransduced cells (UTD) intravenously, and maintained for tumor progression analysis. Tumors were harvested from a subset of mice in each group six days after CAR administration, for CAR T function analysis (FIG. 7A). Tumor progression as recorded for a period of fifty days after tumor implant (FIG. 7B). Whereas both CAR D085 and CAR100 mediated tumor rejection in this xenograft model,

the BCMA CAR D100 was more efficient and reduced tumor size to below the detection limit by study day 35, whereas in mice treated with CAR D085 tumors shrank but were still detectable at the conclusion of the observation period (FIG. 7B). CAR D100 and CAR D085 both mediated 100% survival in this model, in contrast to untreated mice and the negative UTD control mice which have met sacrifice criteria (FIG. 7C). Therefore, CAR 100 was superior in anti-tumor function to CAR D085 in vivo, and showed no adverse toxicity.

An additional CAR candidate, CAR D153, was developed utilizing an scFv sequence 4-1c. The 4-1c scFv sequence was derived as described in Example 1. The 4-1c scFv sequence was incorporated into an identical CAR architecture to that used in CAR D100 and D085 as shown in FUGIRE 6A. Transduction of CAR D153 lentiviral vector into primary human T cells achieved comparable CAR expression levels to CAR D085 and CARD100 (FIG. 8A). Moreover, CAR D153 mediated potent lysis of BCMA-positive multiple myeloma target cell lines RPMI-8226 and MM1.S, similarly to CAR D100 and CARD085 (FIG. 8B). In the intradermal xenograft RPMI-8226 in vivo model (FIG. 7A), CAR D153 demonstrated potency equal or greater to that of the BCMA CAR D100 (FIG. 8C). Therefore, CAR D153 represents another highly efficient candidate for the treatment of BCMA-positive malignancies.

Example 4

Generation and Testing of an Armored BCMA CAR Incorporating a TGF β Decoy Receptor for Improved CAR Potency in Suppressive Tumor Microenvironment

Example 4 describes the development and characterization of an armored BCMA CAR incorporating a TGF β RII DN, a dominant-negative form of the TGF β receptor, for superior anti-tumor performance.

Materials and Methods

Generation of the TGF β RII Dominant Negative BCMA CAR

The sequence of the extracellular and transmembrane domains of the human TGF β RII (GenBank ID: AHI94914.1, amino acid residues 1-191), was cloned downstream of the BCMA D100 CAR. The CAR and the TGF β RII sequences were separated by a ribosome skip site (P2A), which was derived from the porcine teschovirus-1 polyprotein (AA 976-997, GenBank ID: CAB40546.1, mutated residue P977S). P2A is flanked on each side with a furin cleavage site (amino acids: RAKR). All DNA sequences were codone-optimized (IDT DNA, Coralville, IA).

Results

Clinical studies have revealed that resistance to BCMA CAR T therapy may emerge due to tumor-suppressive microenvironment, in part in the bone marrow. To better equip the BCMA CAR T cells for tumor-suppressive scenarios, the D100 CAR sequence has been combined with a decoy TGF β receptor, to generate an armored BCMA CAR (FIG. 9A). The TGF β RII DN decoy receptor is comprised of the extracellular ligand binding domain and the transmembrane region of the TGF β RII, but lacks the intracellular signaling kinase domain of the TGF β receptor. The BCMA CAR100 and the TGF β decoy sequence were combined in a bicistronic expression cassette in a lentiviral vector backbone under the control of EF-1 α promoter, to facilitate equal

co-expression of both the CAR and the decoy receptor polyproteins in T cells (FIG. 9A). This armored BCMA CAR construct is termed D158. Successful transduction of the D158 construct into human primary T cells was achieved (FIG. 9B). To evaluate the armored BCMA CAR D158 function, an experimental co-culture with RPMI-8226 target cells was performed for two rounds of target addition (FIG. 9C). CAR D100, which shares the CAR sequence with the armored CAR construct D158, but lacks the armored decoy element, was included for comparison (FIG. 9D, 9E). A subset of co-cultures was treated with 10 ng/ml soluble TGF β during co-incubation, to mimic the immunosuppressive tumor microenvironment. In both the first and the second round of co-incubation, the expansion of D100 BCMA CAR in the presence of soluble TGF β was suppressed as compared to TGF β -free culture. By contrast, the expansion of the armored BCMA CAR construct D158 remained unaffected by TGF β addition (FIG. 9D). Subsequently, target cell counts remained similarly repressed between experimental groups in the first round of co-incubation, but have resurged in the second round in CAR 100 group spiked with soluble TGF β , whereas the armored CAR maintained strong repression of tumor cells expansion regardless of TGF β addition throughout the experiment (FIG. 9E). These findings demonstrate the protective effects of TGF β armored BCMA CAR T cells in TGF β -rich, T-cell suppressive tumor environment.

The sources of TGF β in tumor microenvironment may include the tumor cells or the stromal cells. The RPMI-8226 multiple myeloma cells are capable of producing TGF β in its inactive form (FIG. 10A), which may then be converted to its active form by other elements of tumor microenvironment in vivo.

The armored BCMA CAR D158 and the respective non-armored D100 BCMA CAR were evaluated in the RPMI-8226 intradermal xenograft model in vivo (FIG. 10B). Despite an unexpected anti-tumor effect observed in the mice treated with untransduced T cells (UTD), the armored CAR D158 demonstrated a superior tumor control as compared to the non-armored CAR version with same CAR sequence, D100 (FIG. 10C). Both the armored CAR D158 and the non-armored CAR D100 mediated 100% survival in this mouse model (FIG. 10D). In tumor tissue harvested six days after CAR administration, tumors of mice treated with the armored BCMA CAR D158 contained greater absolute T cell counts (FIG. 10E), and T cell percentage (FIG. 10F) than tumors of mice treated with the non-armored CAR D100. In addition, the armored CAR D158 mediated greater PD-1 expression on tumor-infiltrating lymphocytes (TIL)

(FIG. 10G), and greater TIL memory cell fraction (FIG. 10H). These observations point to a stronger T cell activation and greater memory formation by the armored CAR D158, as compared to the non-armored CAR D100. Overall, the armored BCMA CAR D158 demonstrates a more potent anti-tumor activity in vivo as compared to the non-armored CAR D100, greater tumor infiltration, stronger activation and memory formation. All these features suggest a potential greater clinical benefit of the armored CAR D158.

Each of the applications and patents cited in this text, as well as each document or reference cited in each of the applications and patents (including during the prosecution of each issued patent; "application cited documents"), and each of the PCT and foreign applications or patents corresponding to and/or claiming priority from any of these applications and patents, and each of the documents cited or referenced in each of the application cited documents, are hereby expressly incorporated herein by reference, and may be employed in the practice of the invention. More generally, documents or references are cited in this text, either in a Reference List before the claims, or in the text itself; and, each of these documents or references ("herein cited references"), as well as each document or reference cited in each of the herein cited references (including any manufacturer's specifications, instructions, etc.), is hereby expressly incorporated herein by reference.

The foregoing description of some specific embodiments provides sufficient information that others can, by applying current knowledge, readily modify or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. In the drawings and the description, there have been disclosed exemplary embodiments and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the claims therefore not being so limited. Moreover, one skilled in the art will appreciate that certain steps of the methods discussed herein may be sequenced in alternative order or steps may be combined. Therefore, it is intended that the appended claims not be limited to the particular embodiment disclosed herein. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the embodiments of the invention described herein. Such equivalents are encompassed by the following claims.

SEQUENCE LISTING

<160> NUMBER OF SEQ ID NOS: 110

<210> SEQ ID NO 1
<211> LENGTH: 727
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-1

<400> SEQUENCE: 1

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tcctgtgcag cgtctggatt cacttcagt agctatggca tgcactgggt ccgcaggct 120

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ccaggcaagg ggctggagtg ggtggcattt atacggatcg atggaaagtaa taaatactat	180
gcagactccg tgaaggcccg attcaccatc tccagagaca attccaagaa cacgctgtat	240
ctgcaaatga acagcctgag agctgatgac acggctgtgt attactgtgc gagagatgg	300
gaggggctatg agggaggggt gaaatggggc cagggcaccc tggtcaccgt ctccctcagga	360
ggtgtggcgat ctgggtggagg cggttagcggt ggtggcgat cccgaaatgt tgctgactca	420
gtctccatcc tccctgtctg catctgttagg agacagagtc accatcaattt gccaggcgag	480
tcaggacattt agcaactatt taaattggta tcagcagaaa ccaggaaag cccctaagct	540
cctgatctac gatgcatttca atttggaaac aggggtcccc tcaagggttca gtggaaagtgg	600
atctgggaca gattttactt tcaccatcg cagcctgcag cctgaagata ttgcaacata	660
ttactgtcaa cagttatgata atctctcgta cactttggc caggggacca agctggagat	720
caaacgt	727

<210> SEQ ID NO 2

<211> LENGTH: 242

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-1

<400> SEQUENCE: 2

Glu Val Gln Leu Val Glu Thr Gly Gly Val Val Gln Pro Gly Gly			
1	5	10	15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr			
20	25	30	

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val			
35	40	45	

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val			
50	55	60	

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr			
65	70	75	80

Leu Gln Met Asn Ser Leu Arg Ala Asp Asp Thr Ala Val Tyr Tyr Cys			
85	90	95	

Ala Arg Asp Trp Glu Gly Tyr Glu Gly Val Lys Trp Gly Gln Gly			
100	105	110	

Thr Leu Val Thr Val Ser Ser Gly Gly Ser Gly Gly Gly			
115	120	125	

Ser Gly Gly Gly Ser Glu Ile Val Leu Thr Gln Ser Pro Ser Ser			
130	135	140	

Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Gln Ala Ser			
145	150	155	160

Gln Asp Ile Ser Asn Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly Lys			
165	170	175	

Ala Pro Lys Leu Leu Ile Tyr Asp Ala Ser Asn Leu Glu Thr Gly Val			
180	185	190	

Pro Ser Arg Phe Ser Gly Ser Gly Thr Asp Phe Thr Phe Thr			
195	200	205	

Ile Ser Ser Leu Gln Pro Glu Asp Ile Ala Thr Tyr Tyr Cys Gln Gln			
210	215	220	

Tyr Asp Asn Leu Ser Tyr Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile			
225	230	235	240

Lys Arg

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<210> SEQ ID NO 3
<211> LENGTH: 729
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-2

<400> SEQUENCE: 3

gagggtgcagc	tgggtcaatc	tgggggaggo	tgggtccagc	cgggggggtc	cctgagactc	60
tccctgtgcag	cctctggatt	cacctttagt	agctatttga	tgagctgggt	ccgccaggct	120
ccagggaaagg	ggctggagtg	ggtctcgagg	attaatggga	gtggcgatag	aacatattac	180
gcagactccg	tgaaggggccg	gttcaccatc	tccagagaca	attccaagaa	cacgctctat	240
ctgcaaata	atagcctgag	acggcaagac	acggccgtat	attactgtgc	gaactataat	300
tacgatgata	atagtggta	tggcttgggc	cagggAACCC	tggtcaccgt	ctcctcagga	360
ggtggcggat	ctgggtggagg	cggttagcggt	ggtggcggat	cccagtctgt	gctgactcag	420
ccaccctcg	tgtcagtggc	cccaggaaag	acggccagga	ttacctgtgg	gggaaacaac	480
atttggaaagta	aaagtgtgca	ctggtaccag	cagaagccag	gccaggcccc	tgtgctggc	540
atcttatgtat	atagcgaccg	gcctcaggg	atccctgagc	gattctctgg	ctccaactct	600
gggaaacacag	ccaccctgac	catcagcagg	gtcgaagccg	gggatgaagc	cgactattac	660
tgtcaggtgt	gggacagtag	tagtgcata	tgggtgttcg	gcggaggggac	caaggtcacc	720
gtccttaggt						729

<210> SEQ ID NO 4
<211> LENGTH: 243
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-2

<400> SEQUENCE: 4

Glu	Val	Gln	Leu	Val	Gln	Ser	Gly	Gly	Gly	Leu	Val	Gln	Pro	Gly	Gly
1							5			10			15		
Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly	Phe	Thr	Phe	Ser	Ser	Tyr
										20	25				30
Trp	Met	Ser	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Leu	Glu	Trp	Val
										35	40				45
Ser	Gly	Ile	Asn	Gly	Ser	Gly	Asp	Arg	Thr	Tyr	Tyr	Ala	Asp	Ser	Val
										50	55				60
Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn	Ser	Lys	Asn	Thr	Leu	Tyr
										65	70				80
Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	Tyr	Tyr	Cys
										85	90				95
Ala	Asn	Tyr	Asn	Tyr	Asp	Asp	Asn	Ser	Gly	Tyr	Gly	Leu	Gln	Gly	
										100	105				110
Thr	Leu	Val	Thr	Val	Ser	Ser	Gly	Gly	Gly	Ser	Gly	Gly	Gly		
										115	120				125
Ser	Gly	Gly	Gly	Ser	Gln	Ser	Val	Leu	Thr	Gln	Pro	Pro	Ser	Val	
										130	135				
Ser	Val	Ala	Pro	Gly	Lys	Thr	Ala	Arg	Ile	Thr	Cys	Gly	Asn	Asn	
										145	150				160
Ile	Gly	Ser	Lys	Ser	Val	His	Trp	Tyr	Gln	Gln	Lys	Pro	Gly	Gln	Ala
										165	170				175

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Pro Val Leu Val Ile Tyr Asp Asp Ser Asp Arg Pro Ser Gly Ile Pro
180 185 190

Glu Arg Phe Ser Gly Ser Asn Ser Gly Asn Thr Ala Thr Leu Thr Ile
195 200 205

Ser Arg Val Glu Ala Gly Asp Glu Ala Asp Tyr Tyr Cys Gln Val Trp
210 215 220

Asp Ser Ser Ser Asp His Trp Val Phe Gly Gly Thr Lys Val Thr
225 230 235 240

Val Leu Gly

<210> SEQ ID NO 5

<211> LENGTH: 729

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-3

<400> SEQUENCE: 5

gaggtgcagc tgggtggagtc cgggggaggo	gtggtccagc ctggggggtc	cctgagactc	60
tcctgtgcag catctggatt caccttcagt agctatggca	tgcactgggt	ccggcaggct	120
ccaggcaagg ggctggagtg ggtggcattt atacggtagt	atggaaagtaa	taaataactac	180
gcagactccg tgaaggggccg attcaccatc	tccagagaca	attccaagaa	240
ctgc当地atga acagcctgag	agctgaggac	acggctgtgt	300
tacgggtgta actccgaggg	tgactactgg	ggccaggggaa	360
ggagggggcg gatctggtgg	aggcggtago	ggtggtggcg	420
cagtctccag ccaccctgtc	tgtgtctcta	ggagagagag	480
agtcagatgt ttagcaacag	cttagcctgg	tatcagcaga	540
ctc当地catct atgatgc当地	cacgaggccc	actggcatcc	600
gggtctggga	cagagttcac	tctc当地atc	660
tatttctgtc aacagactta	cagccccccg	atcaccttcg	720
attaaacga			729

<210> SEQ ID NO 6

<211> LENGTH: 243

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-3

<400> SEQUENCE: 6

Glu Val Gln Leu Val Glu Ser Gly Gly Val Val Gln Pro Gly Gly
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
20 25 30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Lys Asp Asp Tyr Gly Gly Asn Ser Glu Gly Asp Tyr Trp Gly Gln

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100	105	110	
Gly Thr Leu Val Thr Val Ser Ser Gly	Gly Gly Gly Ser Gly	Gly Gly Gly	
115	120	125	
Gly Ser Gly Gly Gly Ser Glu Ile Val	Leu Thr Gln Ser Pro Ala		
130	135	140	
Thr Leu Ser Val Ser Leu Gly Glu Arg	Ala Thr Leu Ser Cys	Arg Ala	
145	150	155	160
Ser Gln Ser Val Ser Asn Ser Leu Ala	Trp Tyr Gln Gln Lys	Pro Gly	
165	170	175	
Gln Ala Pro Arg Leu Leu Ile Tyr Asp	Ala Ser Thr Arg Ala	Thr Gly	
180	185	190	
Ile Pro Ala Arg Phe Ser Gly Ser Gly	Thr Glu Phe Thr Leu		
195	200	205	
Thr Ile Ser Ser Leu Gln Pro Glu Asp	Phe Ala Thr Tyr Phe	Cys Gln	
210	215	220	
Gln Thr Tyr Ser Pro Pro Ile Thr Phe	Gly Gln Gly Thr Arg	Leu Glu	
225	230	235	240
Ile Lys Arg			

<210> SEQ ID NO 7

<211> LENGTH: 726

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-4

<400> SEQUENCE: 7

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gaggtgcagc tggtgagac tggggaggc gtggtccagc ctgggggtc cctgagactc      60
tcctgtcgag cgtctggatt cacctcagt agctatggc tgcactgggt ccgccaggct     120
ccaggcaagg ggctggatg ggtggcattt atacggatg atggaaagtaa taaatactat    180
gcagactccg tgaaggccg attcaccatc tccagagaca attccaagaa cacgctgtat    240
ctgcaaatga acagcctgag agctgatgac acggctgtgt attactgtgc gagagattgg   300
gagggctatg agggaggggt gaaatggggc cagggcaccc tggtcaccgt ctcctcagga   360
ggtagggat ctggtgaggc cggttagcggt ggtggcgat ccgaaattgt gctgactcag   420
tctccatctt ccctgtctgc atctgttagga gacagagtca ccatcaactg ccaggcgagt  480
caggacatta gcaactatTT aaattggat cagcagaaac cagggaaagc ccctaagctc   540
ctgtatctacg atgcatccaa ttggaaaca ggggtcccat caaggttcag tggaagtgg   600
tctggacag atttacttt caccatcagc agectgcagc ctgaagatat tgcaacatat   660
tactgtcaac agtatgataa tctctcgatc actttggcc aggggaccaa gctggagatc   720
aaacgt                                         726

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<210> SEQ ID NO 8

<211> LENGTH: 242

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-4

<400> SEQUENCE: 8

Glu Val Gln Leu Val Glu Thr Gly	Gly Gly Val Val Gln Pro	Gly Gly	
1	5	10	15
Ser Leu Arg Leu Ser Cys Ala Ala	Ser Gly Phe Thr Phe	Ser Ser Tyr	
20	25	30	

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Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
 35 40 45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
 50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
 65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Asp Asp Thr Ala Val Tyr Tyr Cys
 85 90 95

Ala Arg Asp Trp Glu Gly Tyr Glu Gly Val Lys Trp Gly Gln Gly
 100 105 110

Thr Leu Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly
 115 120 125

Ser Gly Gly Gly Ser Glu Ile Val Leu Thr Gln Ser Pro Ser Ser
 130 135 140

Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Gln Ala Ser
 145 150 155 160

Gln Asp Ile Ser Asn Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly Lys
 165 170 175

Ala Pro Lys Leu Leu Ile Tyr Asp Ala Ser Asn Leu Glu Thr Gly Val
 180 185 190

Pro Ser Arg Phe Ser Gly Ser Gly Thr Asp Phe Thr Phe Thr
 195 200 205

Ile Ser Ser Leu Gln Pro Glu Asp Ile Ala Thr Tyr Tyr Cys Gln Gln
 210 215 220

Tyr Asp Asn Leu Ser Tyr Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile
 225 230 235 240

Lys Arg

<210> SEQ ID NO 9

<211> LENGTH: 753

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MB-5

<400> SEQUENCE: 9

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tccctgtcag cgtctggatt caccttcagt agctatggca tgcactgggt ccggcaggct	120
ccaggcaagg ggcttgagtg ggtggcattt atacggatcg atggaaagtaa taaatactat	180
gcagactccg tgaagggccg attcaccatc tccagagaca attccaagaa cacgctgtat	240
ctgcaaatga acagcctgag agctgaggac acggctgtgt attactgtgc gagagattgg	300
gccccggatt gtactaatgg ccaatgcggc gtctactggg gccaggaaac cctggtcacc	360
gtctcctcag gaggtggccgg atctgggtga ggcggttagcg gtgggtggccg atccgaaatt	420
gtgttgacgc agtctccact ctccctgccc gtacccctg gagagccggc ctccatctcc	480
tgcaggctca gtcagggcct cctgcatagt aatggataca actatggta ttggtagctg	540
cagaagccag ggcagtcctc acagctcctg atctatttgg gttctaatacg ggcctccggg	600
gtccctgaca ggttcagtgg cagtggatca ggcacagatt ttacactgaa aatcagcaga	660
gtggaggctg aggatgttgg ggtttattac tgcatacgca ctctacaaac tccgtacact	720
tttggccagg ggaccaagct ggagatcaaa cgt	753

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<210> SEQ ID NO 10
<211> LENGTH: 251
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-5

<400> SEQUENCE: 10

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Glu Val Gln Leu Val Gln Ser Gly Gly Gly Val Val Gln Pro Gly Gly
 1           5           10          15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
 20          25          30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
 35          40          45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
 50          55          60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
 65          70          75          80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
 85          90          95

Ala Arg Asp Trp Ala Gly Asp Cys Thr Asn Gly Gln Cys Gly Val Tyr
100         105         110

Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Gly Gly Gly Ser
115         120         125

Gly Gly Gly Ser Gly Gly Gly Ser Glu Ile Val Leu Thr Gln
130         135         140

Ser Pro Leu Ser Leu Pro Val Thr Pro Gly Glu Pro Ala Ser Ile Ser
145         150         155         160

Cys Arg Ser Ser Gln Ser Leu Leu His Ser Asn Gly Tyr Asn Tyr Leu
165         170         175

Asp Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Gln Leu Ile Tyr
180         185         190

Leu Gly Ser Asn Arg Ala Ser Gly Val Pro Asp Arg Phe Ser Gly Ser
195         200         205

Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu
210         215         220

Asp Val Gly Val Tyr Tyr Cys Met Gln Ala Leu Gln Thr Pro Tyr Thr
225         230         235         240

Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys Arg
245         250

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<210> SEQ ID NO 11
<211> LENGTH: 729
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-14

<400> SEQUENCE: 11

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gaggtgcagc tggtgaggc tgggggaggc gtgggtccagc ctggggaggc cctgagactc      60
tcctgtgcag cgtctggatt cacttcagt agctatggca tgcactgggt ccgccaggct     120
ccaggcaagg ggctggaggc ggtggcatt atacggtagt atggaaagtaa taaatactat     180
gcagactccg tgaaggggccg attcaccatc tccagagaca attccaagaa cacgctgtat    240
ctgcaaatga acagcctgag agctgaggac acggctgtgt attactgtgt gagcgatgac
tacggtggtt actccgggac tagctactgg ggccaggaa ccctggtcac cgtctccctca   360

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ggaggtggcg gatctggtgg	aggcggtagc ggtggggcg	gatccgacat ccagatgacc	420
cagtctccat cctccctgtc	tgcatactgtc ggagacagag	tcaccatcac ttgccaggcg	480
agtcaaggaca ttagcaacta	tttaaattgg tatcagcaga	agccaggaa agcccctaag	540
ctcctgatct acgatgcata	caattggaa acaggggtcc	catcaagggtt cagtggcagt	600
ggatctggga cagattcac	tctcaccatc agcagtcgc	aacctgaaga ttttgcact	660
tactactgtc aacagagttt	cagtaccccc gtgacgttcg	gcggaggac caagctgacc	720
gtccttaggt			729

<210> SEQ ID NO 12

<211> LENGTH: 243

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-14

<400> SEQUENCE: 12

Glu Val Gln Leu Val Glu Ser Gly Gly	Gly Val Val Gln Pro Gly Arg		
1	5	10	15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr		
20	25	30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val		
35	40	45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val		
50	55	60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr			
65	70	75	80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys		
85	90	95

Val Ser Asp Asp Tyr Gly Gly Asn Ser Gly Thr Ser Tyr Trp Gly Gln		
100	105	110

Gly Thr Leu Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly		
115	120	125

Gly Ser Gly Gly Gly Ser Asp Ile Gln Met Thr Gln Ser Pro Ser		
130	135	140

Ser Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Gln Ala			
145	150	155	160

Ser Gln Asp Ile Ser Asn Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly		
165	170	175

Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala Ser Asn Leu Glu Thr Gly		
180	185	190

Val Pro Ser Arg Phe Ser Gly Ser Gly Thr Asp Phe Thr Leu		
195	200	205

Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln		
210	215	220

Gln Ser Tyr Ser Thr Pro Val Thr Phe Gly Gly Thr Lys Leu Thr			
225	230	235	240

Val Leu Gly

<210> SEQ ID NO 13

<211> LENGTH: 66

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: leader/signal peptide sequence

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<400> SEQUENCE: 13

atgctgtgc tggtgaccag cctgctgctg tgegaactgc cgcacccggc gtttctgctg	60
attccg	66

<210> SEQ ID NO 14

<211> LENGTH: 22

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: leader/signal peptide sequence

<400> SEQUENCE: 14

Met Leu Leu Leu Val Thr Ser Leu Leu Cys Glu Leu Pro His Pro			
1	5	10	15

Ala Phe Leu Leu Ile Pro	
	20

<210> SEQ ID NO 15

<211> LENGTH: 735

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-15

<400> SEQUENCE: 15

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tccctgtgcag cgtctggatt cacttcaagt agctatggca tgcactgggt ccgccaggct	120
ccaggcaagg ggctggagtg ggtggcattt atacggatg atggaaatgaa taaatactat	180
gcagactccg tgaagggccg attcaccatc tccagagaca attccaagaa cacgctgtat	240
ctgcaaatgaa acagcctgag agctgaggac acggctgtgtt attactgtgc gaaagatgg	300
gattgtactg gtgggtatg ccccccttggg ggctggggcc agggaaacctt ggtcacccgtc	360
tcctcaggag gtggcggtatc tggtgaggo ggtagcggtg gtggcggtatc cgacatccag	420
ttgacccttgtt ctccatcttc cctgtctgca tctgttaggag acagagtac catcaacttgc	480
cgggcaagtc agagcattag tggctattta aattggatc acgagaaacc agggaaagcc	540
ctaagctcc tgatctatgc tgcattttt ttgcaaatggt gggtcccatc aaggttcaat	600
ggcagtttatc ctgggacaga gttcaacttc accatcgacat gtctgcagcc tgaagattt	660
gcaacttatt tctgtcaaca gacttacagt ccccgatca ctttcggccaa agggacacgaa	720
ctggagatata aacgaa	735

<210> SEQ ID NO 16

<211> LENGTH: 245

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-15

<400> SEQUENCE: 16

Gln Val Gln Leu Val Glu Thr Gly Gly Val Val Gln Pro Gly Gly			
1	5	10	15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr			
	20	25	30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val			
	35	40	45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val			
	50	55	60

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Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Lys Asp Trp Asp Cys Thr Gly Gly Val Cys Pro Leu Gly Gly Trp
100 105 110

Gly Gln Gly Thr Leu Val Thr Val Ser Ser Gly Gly Gly Ser Gly
115 120 125

Gly Gly Ser Gly Gly Ser Asp Ile Gln Leu Thr Gln Ser
130 135 140

Pro Ser Ser Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys
145 150 155 160

Arg Ala Ser Gln Ser Ile Ser Gly Tyr Leu Asn Trp Tyr Gln Gln Lys
165 170 175

Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser Leu Gln
180 185 190

Ser Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Glu Phe
195 200 205

Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Phe
210 215 220

Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly Gln Gly Thr Arg
225 230 235 240

Leu Glu Ile Lys Arg
245

<210> SEQ ID NO 17
<211> LENGTH: 729
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-16

<400> SEQUENCE: 17

gagggtccagc tggtgcagtc tgggggaggo gtgggtccagc ctggggggtc cctgagactc	60
tcctgtgcag cgtctggatt cacttcagt agctatggca tgcactgggt ccgccaggct	120
ccaggcaagg ggctggagtg ggtggcattt atacggatgt atggaaagtaa taaaactac	180
gcagactccg tgaaggggccg attcaccatc tccagagaca attccaagaa cacgctgtat	240
ctgcaaatga acagccttag agctgaggac acggctgtgt attactgtgc gagagacatt	300
aatgactacg gtgacccgccc cccttactgg ggccagggaa ccctggtcac cgtctcccta	360
ggagggggcg gatctggatgg aggcggtagc ggtggggcg gatccgacat ccagatgacc	420
cagtctccat cctccctgtc tgcattctgtt ggagacagag tcaccatcac ttggccggca	480
agtcagagca ttagcagcta tttaaattgg tatcagcaga aaccagggaa agcccctaag	540
ctcctgatct acgatgcata caatttggaa acagggtct catcaagggtt cagtggcagt	600
ggatctggga cagagttcac tctcaccatc agcagtctgc agcctgaaga ttttgcaact	660
tatttctgtc aacagactta cagcccccg atcaccttcg gcacaggac acgactggag	720
attnaacgaa	729

<210> SEQ ID NO 18
<211> LENGTH: 243
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:

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<223> OTHER INFORMATION: BCMA ScFv binder MTB-16

<400> SEQUENCE: 18

Glu	Val	Gln	Leu	Val	Gln	Ser	Gly	Gly	Gly	Val	Val	Gln	Pro	Gly	Gly
1							5		10				15		

Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly	Phe	Thr	Phe	Ser	Ser	Tyr
								20		25		30			

Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Leu	Glu	Trp	Val
35							40			45					

Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys	Tyr	Tyr	Ala	Asp	Ser	Val
50							55		60						

Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn	Ser	Lys	Asn	Thr	Leu	Tyr
65							70		75		80				

Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	Tyr	Tyr	Cys
							85		90		95				

Ala	Arg	Asp	Leu	Asn	Asp	Tyr	Gly	Asp	Pro	Pro	Pro	Tyr	Trp	Gly	Gln
							100		105		110				

Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	Gly	Gly	Gly	Ser	Gly	Gly	Gly	
115							120			125					

Gly	Ser	Gly	Gly	Gly	Ser	Asp	Ile	Gln	Met	Thr	Gln	Ser	Pro	Ser	
130							135		140						

Ser	Leu	Ser	Ala	Ser	Val	Gly	Asp	Arg	Val	Thr	Ile	Thr	Cys	Arg	Ala
145							150		155		160				

Ser	Gln	Ser	Ile	Ser	Ser	Tyr	Leu	Asn	Trp	Tyr	Gln	Gln	Lys	Pro	Gly
							165		170		175				

Lys	Ala	Pro	Lys	Leu	Leu	Ile	Tyr	Asp	Ala	Ser	Asn	Leu	Glu	Thr	Gly
							180		185		190				

Val	Ser	Ser	Arg	Phe	Ser	Gly	Ser	Gly	Thr	Glu	Phe	Thr	Leu		
							195		200		205				

Thr	Ile	Ser	Ser	Leu	Gln	Pro	Glu	Asp	Phe	Ala	Thr	Tyr	Phe	Cys	Gln
							210		215		220				

Gln	Thr	Tyr	Ser	Pro	Pro	Ile	Thr	Phe	Gly	Gln	Gly	Thr	Arg	Leu	Glu
225							230		235		240				

Ile Lys Arg

<210> SEQ ID NO 19

<211> LENGTH: 732

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-25

<400> SEQUENCE: 19

gaggtgcagc	tggtggagtc	cgggggaggc	ttagttcagc	ctggggggtc	cctgagactc	60
------------	------------	------------	------------	------------	------------	----

tcctgtgcag	cgtctggatt	caccttcagt	agctatggca	tgcactgggt	ccgccaggct	120
------------	------------	------------	------------	------------	------------	-----

ccaggcaagg	ggctggagtg	ggtggcattt	atacggtatg	atggaaagtaa	taaatactat	180
------------	------------	------------	------------	-------------	------------	-----

gcagactccg	tgaaggcccg	attcaccatc	tccagagaca	attccaagaa	cacgctgtat	240
------------	------------	------------	------------	------------	------------	-----

ctgcaaatga	acagccctgag	agctgaggac	acggctgtgt	attactgtgc	gagagatctc	300
------------	-------------	------------	------------	------------	------------	-----

gaaatgactg	actactgggg	ccagggaaacc	ctggtcaccc	tctcctcagg	agggtggccga	360
------------	------------	-------------	------------	------------	-------------	-----

tctggtaggg	gcggtagccgg	tggtggccga	tccgaaattt	tgctgactca	gtctccactc	420
------------	-------------	------------	------------	------------	------------	-----

tccctgccc	tcacccctgg	agagccggcc	tccatatttt	gttaggtctag	tcagagtctc	480
-----------	------------	------------	------------	-------------	------------	-----

ctgcatgaaa	atggatacaa	ctatttggat	tggtacctgc	agaagccagg	gcagtctcca	540
------------	------------	------------	------------	------------	------------	-----

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cagctcctga tctatgggg ttctaatcg gcctccgggg tccctgacag gttcagtggc	600
agtggatcat gcacagatcc tacactgaaa atcagcagag tggaggctga ggatgttggg	660
gttttattact gcatgcaagc tctacaaacc cctcgaactt ttggccaggg gaccaagctg	720
gaaaccacaaac gt	732

<210> SEQ ID NO 20
<211> LENGTH: 244
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-25

<400> SEQUENCE: 20

Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly	
1 5 10 15	
Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr	
20 25 30	
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val	
35 40 45	
Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val	
50 55 60	
Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr	
65 70 75 80	
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys	
85 90 95	
Ala Arg Asp Leu Glu Met Thr Asp Tyr Trp Gly Gln Gly Thr Leu Val	
100 105 110	
Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly Ser Gly Gly	
115 120 125	
Gly Gly Ser Glu Ile Val Leu Thr Gln Ser Pro Leu Ser Leu Pro Val	
130 135 140	
Thr Pro Gly Glu Pro Ala Ser Ile Phe Cys Arg Ser Ser Gln Ser Leu	
145 150 155 160	
Leu His Glu Asn Gly Tyr Asn Tyr Leu Asp Trp Tyr Leu Gln Lys Pro	
165 170 175	
Gly Gln Ser Pro Gln Leu Leu Ile Tyr Leu Gly Ser Asn Arg Ala Ser	
180 185 190	
Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr	
195 200 205	
Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys	
210 215 220	
Met Gln Ala Leu Gln Thr Pro Arg Thr Phe Gly Gln Gly Thr Lys Leu	
225 230 235 240	
Glu Thr Lys Arg	

<210> SEQ ID NO 21
<211> LENGTH: 750
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-28

<400> SEQUENCE: 21

caggtgcagc tgggtggagtc tgggggaggo gtgggtccagc ctggggggtc cctgagactc	60
tcctgtgcag cgtctggatt caccttcagt agctatggca tgcactgggt ccgccagct	120

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ccaggcaagg ggctggagtg ggtggcattt atacggatgat	180
gcagactccg tgaagggcgcg attcaccatc tccagagaca attccaaagaa cacgctgtat	240
ctgcaaatacg acagccgtgag agctgaggac acggctgtgtt attactgtgc gagagattcg	300
tatagcagca gcggggaccc ccgggcgttc gacccctggg gccaggaaac cctggtcacc	360
gtctccctcg gaggtggcgg atctgggtga ggcggtagcg tggtggcgg atccaatttt	420
atgctgactc agccccactc tgtgtcgag tctccgggaa agacggtaac catctcctgc	480
accggcagca gtggcagcat tgccagaaac tatgtgcagt ggtaccagca gcgccggc	540
agtccccctt ccactgtcat ctggaggat aaccaaagac cctctgggtt ccctggtcgg	600
ttctctggct ccgtcgacag gtcctccaaac tctgcctccc tcacatctc tggactgaag	660
actgaggacg aggctgacta ctattgtcag tcttatgata gcaacaatcg gggctgttc	720
qqcqqaqqqaa ccaaqgtcac cqtcctqaqt	750

<210> SEQ ID NO 22

<210> SEQ ID NO 2
<211> LENGTH: 250

<212> TYPE: PRT

<213> TITLE: TRI

<219> ORGANISM

<223> OTHER INFORMATION: BCMA ScFv binder MTB-28

<400> SEQUENCE: 22

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Gly
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
20 25 30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35 40 45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
 65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85 90 95

Ala Arg Asp Ser Tyr Ser Ser Ser Gly Asp Pro Arg Ala Phe Asp Pro
100 105 110

Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Gly Gly Gly Gly Ser
 115 120 125

Gly Gly Gly Ser Gly Gly Gly Ser Asn Phe Met Leu Thr Gln
130 135 140

Pro His Ser Val Ser Glu Ser Pro Gly Lys Thr Val Thr Ile Ser Cys
 145 150 155 160

Thr Gly Ser Ser Gly Ser Ile Ala Ser Asn Tyr Val Gln Trp Tyr Gln
165 170 175

Gln Arg Pro Gly Ser Ala Pro Ser Thr Val Ile Phe Glu Asp Asn Gln
180 185 190

Arg Pro Ser Gly Val Pro Gly Arg Phe Ser Gly Ser Val Asp Arg Ser
165 200 235

Ser Asn Ser Ala Ser Leu Thr Ile Ser Gly Leu Lys Thr Glu Asp Glu

Ala Asp Tyr Tyr Cys Gln Ser Tyr Asp Ser Asn Asn Arg Gly Leu Phe

Gly Gly Gly Thr Lys Val Thr Val Leu Gly

249 250

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<210> SEQ ID NO 23
<211> LENGTH: 732
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-37

<400> SEQUENCE: 23

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gaggtgcagc tgggtggagtc tgggggaggc ttggtcaagc ctggagggtc cctgagactc      60
tcctgtgcag cgtctggatt cacttcagt agctatggca tgcactgggt ccgcaggct      120
ccaggcaagg ggctggagtg ggtggcattt atacggatg atggaaagtaa taaatactat      180
gcagactccg tgaagggccg attcaccatc tccagagaca attccaagaa cacgctgtat      240
ctgcaaatga acagcctgag agctgaggac acggctgtgtt attactgtgc gaaagatgg      300
gaatatatgtg gctacgatgc ccacccgggg tggggccagg gaaccctggt caccgtctcc      360
tcaggaggtg gcggatctgg tggaggcggtt agcgggtggt gcggatccga catccagtt      420
acccagtctc catcctccct gtctgcattt gtaggagaca gagtcaccat cacttgcgg      480
gcaagtccagg gcattagcag tgcttagec ttggtatcagc agaaaccagg gaaagctccct      540
aagctccctga tctatgtatgc ctccagtttg gaaaagtgggg tccccatcaag gttcagtggc      600
agtggatctg ggacagagtt cactctcacc atcagcagtc tgcagectga agatttgca      660
acttattttct gtcaacagac ttacagtccc ccgatcacct tccggccaagg gacacgactg      720
gagattaaac ga                                         732

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<210> SEQ ID NO 24
<211> LENGTH: 244
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-37

<400> SEQUENCE: 24

Glu	Val	Gln	Leu	Val	Glu	Ser	Gly	Gly	Gly	Ley	Val	Lys	Pro	Gly	Gly
1					5			10				15			
Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly	Phe	Thr	Phe	Ser	Ser	Tyr
					20			25				30			
Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Ley	Glu	Trp	Val
					35			40				45			
Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys	Tyr	Tyr	Ala	Asp	Ser	Val
					50			55				60			
Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn	Ser	Lys	Asn	Thr	Leu	Tyr
					65			70				75			80
Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	Tyr	Tyr	Cys
					85			90				95			
Ala	Lys	Asp	Trp	Glu	Tyr	Ser	Gly	Tyr	Asp	Ala	His	Pro	Gly	Trp	Gly
					100			105				110			
Gln	Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	Gly	Gly	Gly	Ser	Gly	Gly	
					115			120				125			
Gly	Gly	Ser	Gly	Gly	Gly	Ser	Asp	Ile	Gln	Ley	Thr	Gln	Ser	Pro	
					130			135				140			
Ser	Ser	Leu	Ser	Ala	Ser	Val	Gly	Asp	Arg	Val	Thr	Ile	Thr	Cys	Arg
					145			150				155			160
Ala	Ser	Gln	Gly	Ile	Ser	Ser	Ala	Leu	Ala	Trp	Tyr	Gln	Gln	Lys	Pro
					165			170				175			

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Gly Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala Ser Ser Leu Glu Ser
 180 185 190

Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Glu Phe Thr
 195 200 205

Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Phe Cys
 210 215 220

Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly Gln Gly Thr Arg Leu
 225 230 235 240

Glu Ile Lys Arg

<210> SEQ ID NO 25

<211> LENGTH: 729

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-39

<400> SEQUENCE: 25

gaggtgcagc	tggtgaggc	tgggggaggc	gtggtccagc	ctggggggtc	cctgagactc	60
tcctgtgcag	cgtctggatt	cacttcagt	ggctatggca	tgcactgggt	ccggcaggct	120
ccaggcaagg	ggctggaggc	ggtggcattt	atacggtatg	atggaaagtaa	taaatactat	180
gcagactccg	tgaaggcccg	attcaccatc	tccagagaca	attccaagaa	cacgctgtat	240
ctgcaaatga	acagcctgag	agctgaggac	acggctgtgt	attactgtgc	gagagatggg	300
gtcggaaatg	attactgggg	ccaggcacc	ctggtcaccc	tctcctcagg	agggtggcga	360
tctggtaggg	gcccggcgg	tggggcgg	tccaattttt	tgctgactca	gccccactct	420
gtgtcggagt	ctccggggaa	gacggtaacc	atctcctgca	cccgccggcag	ttggcaggatt	480
gccagcaact	atgtcagtg	gtaccagcag	cgtccggcaca	gtggcccccac	cactgtgatc	540
tatgaggata	accaaagacc	ctctgggtc	cctgatecggt	tctctggctc	catcgacagc	600
tcctccaact	ctgcctccct	caccatctct	ggactgaaga	ctgaggacga	ggctgactac	660
tactgtcaga	cttatgtga	caacaatcat	gtcattttcg	gcccggggac	ccagctcacc	720
gttttaggt						729

<210> SEQ ID NO 26

<211> LENGTH: 243

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-39

<400> SEQUENCE: 26

Glu Val Gln	Leu Val Glu	Ser Gly	Gly Val Val	Gln Pro Gly	Gly
1	5	10	15		
Ser Leu Arg	Leu Ser Cys	Ala Ala Ser	Gly Phe Thr	Phe Ser Gly	Tyr
20	25	30			
Gly Met His Trp Val Arg	Gln Ala Pro	Gly Lys Gly	Leu Glu Trp Val		
35	40	45			
Ala Phe Ile Arg Tyr Asp	Gly Ser Asn	Lys Tyr Tyr	Ala Asp Ser Val		
50	55	60			
Lys Gly Arg Phe Thr	Ile Ser Arg Asp	Asn Ser Lys Asn	Thr Leu Tyr		
65	70	75	80		
Leu Gln Met Asn Ser	Leu Arg Ala	Glu Asp Thr	Ala Val Tyr Tyr Cys		
85	90	95			

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Ala Arg Asp Gly Ala Arg Asn Asp Tyr Trp Gly Gln Gly Thr Leu Val
100 105 110

Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly Ser Gly Gly
115 120 125

Gly Gly Ser Asn Phe Met Leu Thr Gln Pro His Ser Val Ser Glu Ser
130 135 140

Pro Gly Lys Thr Val Thr Ile Ser Cys Thr Arg Ser Ser Gly Ser Ile
145 150 155 160

Ala Ser Asn Tyr Val Gln Trp Tyr Gln Gln Arg Pro Gly Ser Ala Pro
165 170 175

Thr Thr Val Ile Tyr Glu Asp Asn Gln Arg Pro Ser Gly Val Pro Asp
180 185 190

Arg Phe Ser Gly Ser Ile Asp Ser Ser Ser Asn Ser Ala Ser Leu Thr
195 200 205

Ile Ser Gly Leu Lys Thr Glu Asp Glu Ala Asp Tyr Tyr Cys Gln Thr
210 215 220

Tyr Asp Asp Asn Asn His Val Ile Phe Gly Gly Thr Gln Leu Thr
225 230 235 240

Val Leu Gly

<210> SEQ ID NO 27

<211> LENGTH: 72

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: CD8 transmembrane domain

<400> SEQUENCE: 27

atctacatct gggcgccctt ggccggact tgggggtcc ttctcctgtc actggttatc 60

accctttaact gc 72

<210> SEQ ID NO 28

<211> LENGTH: 22

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: CD8 transmembrane domain

<400> SEQUENCE: 28

Ile Trp Ala Pro Leu Ala Gly Thr Cys Gly Val Leu Leu Ser Leu
1 5 10 15

Val Ile Thr Leu Tyr Cys
20

<210> SEQ ID NO 29

<211> LENGTH: 135

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: CD8 hinge domain

<400> SEQUENCE: 29

accacgacgc cagcgccgcg accaccaaca ccggcgccca ccatcgogtc gcagccctg 60

tccctgcgcc cagaggcggtc ccggccagcg gcggggggcg cagtgcacac gagggggctg 120

gacttcgcct gtgat 135

<210> SEQ ID NO 30

<211> LENGTH: 47

<212> TYPE: PRT

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<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: CD8 hinge domain

<400> SEQUENCE: 30

Thr	Thr	Thr	Pro	Ala	Pro	Arg	Pro	Pro	Thr	Pro	Ala	Pro	Thr	Ile	Ala
1				5				10					15		
Ser	Gln	Pro	Leu	Ser	Leu	Arg	Pro	Glu	Ala	Cys	Arg	Pro	Ala	Ala	Gly
	20					25				30					
Gly	Ala	Val	His	Thr	Arg	Gly	Leu	Asp	Phe	Ala	Cys	Asp	Ile	Tyr	
	35				40				45						

<210> SEQ ID NO 31

<211> LENGTH: 42

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 31

Lys	Arg	Gly	Arg	Lys	Lys	Leu	Leu	Tyr	Ile	Phe	Lys	Gln	Pro	Phe	Met
1				5				10				15			
Arg	Pro	Val	Gln	Thr	Thr	Gln	Glu	Glu	Asp	Gly	Cys	Ser	Cys	Arg	Phe
	20				25			30							
Pro	Glu	Glu	Glu	Gly	Gly	Cys	Glu	Leu							
	35				40										

<210> SEQ ID NO 32

<211> LENGTH: 106

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 32

Gly	Gln	Pro	Lys	Ala	Ala	Pro	Ser	Val	Thr	Leu	Phe	Pro	Pro	Ser	Ser
1			5			10			15						
Glu	Glu	Leu	Gln	Ala	Asn	Lys	Ala	Thr	Leu	Val	Cys	Leu	Ile	Ser	Asp
	20				25			30							
Phe	Tyr	Pro	Gly	Ala	Val	Thr	Val	Ala	Trp	Lys	Ala	Asp	Ser	Ser	Pro
	35				40			45							
Val	Lys	Ala	Gly	Val	Glu	Thr	Thr	Pro	Ser	Lys	Gln	Ser	Asn	Asn	
	50				55			60							
Lys	Tyr	Ala	Ala	Ser	Ser	Tyr	Leu	Ser	Leu	Thr	Pro	Glu	Gln	Trp	Lys
	65				70			75		80					
Ser	His	Arg	Ser	Tyr	Ser	Cys	Gln	Val	Thr	His	Glu	Gly	Ser	Thr	Val
	85				90			95							
Glu	Lys	Thr	Val	Ala	Pro	Thr	Glu	Cys	Ser						
	100				105										

<210> SEQ ID NO 33

<211> LENGTH: 126

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: signaling domain of 4-1BB

<400> SEQUENCE: 33

aaacggggca	gaaagaaaact	cctgtatata	ttcaaacaac	catttatgag	accagtacaa	60
actactcaag	aggaagatgg	ctgttagctgc	cgatttccag	aagaagaaga	aggaggatgt	120
gaactg						126

<210> SEQ ID NO 34

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<211> LENGTH: 42
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: signaling domain of 4-1BB

<400> SEQUENCE: 34

Lys	Arg	Gly	Arg	Lys	Lys	Leu	Leu	Tyr	Ile	Phe	Lys	Gln	Pro	Phe	Met
1															15
Arg	Pro	Val	Gln	Thr	Thr	Gln	Glu	Glu	Asp	Gly	Cys	Ser	Cys	Arg	Phe
															30
Pro	Glu	Glu	Glu	Gly	Gly	Cys	Glu	Leu							
35															40

<210> SEQ ID NO 35
<211> LENGTH: 336
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: signaling domain of CD3-zeta

<400> SEQUENCE: 35

agagtgaagt	tca	tcaggag	cgc	agacgccc	cccg	cgtaca	agc	aggggcca	gaacc	agctc					60
tataacg	gac	tcaatctagg	acg	aagagag	gag	tacgtat	ttt	ggacaa	gag	acgtggc					120
cgggac	cctg	agatgggggg	aa	agccgaga	agg	aagaacc	ctc	aggaaagg	cct	gtacaat					180
gaactgc	aga	aagataagat	gg	cgaggccc	ta	cgtgaga	tt	ggatgaa	agg	cgagcgc					240
cgaggggc	ca	aggggcacg	tgg	cattac	cagg	gtctca	gt	acagccac	caagg	acacc					300
tacgacg	ccc	ttcacatg	ca	ggcc	ctg	cccc	cct	cg							336

<210> SEQ ID NO 36
<211> LENGTH: 112
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD3zeta

<400> SEQUENCE: 36

Arg	Val	Lys	Phe	Ser	Arg	Ser	Ala	Asp	Ala	Pro	Ala	Tyr	Lys	Gln	Gly
1															15
Gln	Asn	Gln	Leu	Tyr	Asn	Glu	Leu	Asn	Leu	Gly	Arg	Arg	Glu	Glu	Tyr
															30
Asp	Val	Leu	Asp	Lys	Arg	Arg	Gly	Arg	Asp	Pro	Glu	Met	Gly	Gly	Lys
															45
Pro	Arg	Arg	Lys	Asn	Pro	Gln	Glu	Gly	Leu	Tyr	Asn	Glu	Leu	Gln	Lys
															50
Asp	Lys	Met	Ala	Glu	Ala	Tyr	Ser	Glu	Ile	Gly	Met	Lys	Gly	Glu	Arg
															65
Arg	Arg	Gly	Lys	Gly	His	Asp	Gly	Leu	Tyr	Gln	Gly	Leu	Ser	Thr	Ala
															85
Thr	Lys	Asp	Thr	Tyr	Asp	Ala	Leu	His	Met	Gln	Ala	Leu	Pro	Pro	Arg
															100
															105
															110

<210> SEQ ID NO 37
<211> LENGTH: 726
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: ScFv CD 19

<400> SEQUENCE: 37

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gacatccaga tgacacagac tacatcctcc ctgtctgcct ctctggaga cagagtacc	60
atcgagttca gggcaagtca ggacattagt aaatatattaa attggtatca gcagaaacca	120
gatggaactg ttaaactcct gatctaccat acatcaagat tacactcagg agtcccata	180
aggttcagtg gcagtgggtc tggAACAGAT tattctctca ccattAGCAA CCTGGAGCAA	240
gaagatattg ccacttactt ttgccaacag ggtAAACAGC ttccgtacac gttcggaggg	300
gggaccaAGC tggAGATCAC AGGTGGCGGT GGTCGGGCG GTGGTGGGTC GGGTGGCGC	360
ggatctgagg tgAAACTGCA ggAGTCAGGA CCTGGCTGG TGGCGCCCTC ACAGAGCCTG	420
tccgtcacat gcactgtctc agggttctca ttacccgact atgggtgtaag ctggattcgc	480
cagcctccac gaaAGGGTCT ggAGTGGCTG ggAGTAATAAT ggggtAGTGA aaccacatac	540
tataattcag ctctcaaATC cagactgacc atcatcaagg acaactccaa gagccaagtt	600
ttctttaaaa tgaacagtct gcaAACTGAT gacacagCCA tttactactg tgccaaacat	660
tattactacg gtggtagcta tgctatggac tactggggc aaggAACCTC agtcaccgTC	720
tcctca	726

<210> SEQ ID NO 38

<211> LENGTH: 242

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: ScFv CD 19

<400> SEQUENCE: 38

Asp Ile Gln Met Thr Gln Thr Thr Ser Ser Leu Ser Ala Ser Leu Gly			
1	5	10	15

Asp Arg Val Thr Ile Ser Cys Arg Ala Ser Gln Asp Ile Ser Lys Tyr			
20	25	30	

Leu Asn Trp Tyr Gln Gln Lys Pro Asp Gly Thr Val Lys Leu Leu Ile			
35	40	45	

Tyr His Thr Ser Arg Leu His Ser Gly Val Pro Ser Arg Phe Ser Gly			
50	55	60	

Ser Gly Ser Gly Thr Asp Tyr Ser Leu Thr Ile Ser Asn Leu Glu Gln			
65	70	75	80

Glu Asp Ile Ala Thr Tyr Phe Cys Gln Gln Gly Asn Thr Leu Pro Tyr			
85	90	95	

Thr Phe Gly Gly Thr Lys Leu Glu Ile Thr Gly Gly Gly Ser			
100	105	110	

Gly Gly Gly Ser Gly Gly Gly Ser Glu Val Lys Leu Gln Glu			
115	120	125	

Ser Gly Pro Gly Leu Val Ala Pro Ser Gln Ser Leu Ser Val Thr Cys			
130	135	140	

Thr Val Ser Gly Val Ser Leu Pro Asp Tyr Gly Val Ser Trp Ile Arg			
145	150	155	160

Gln Pro Pro Arg Lys Gly Leu Glu Trp Leu Gly Val Ile Trp Gly Ser			
165	170	175	

Glu Thr Thr Tyr Tyr Asn Ser Ala Leu Lys Ser Arg Leu Thr Ile Ile			
180	185	190	

Lys Asp Asn Ser Lys Ser Gln Val Phe Leu Lys Met Asn Ser Leu Gln			
195	200	205	

Thr Asp Asp Thr Ala Ile Tyr Tyr Cys Ala Lys His Tyr Tyr Tyr Gly			
210	215	220	

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Gly Ser Tyr Ala Met Asp Tyr Trp Gly Gln Gly Thr Ser Val Thr Val			
225	230	235	240

Ser Ser

<210> SEQ ID NO 39
<211> LENGTH: 66
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: GMCSF leader peptide

<400> SEQUENCE: 39

atgctgtgc tggtgaccag cctgtgtcg tgcgaaactgc cgcatccggc gtttctgctg	60
attccg	66

<210> SEQ ID NO 40
<211> LENGTH: 22
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: GMCSF leader peptide

<400> SEQUENCE: 40

Met Leu Leu Leu Val Thr Ser Leu Leu Leu Cys Glu Leu Pro His Pro			
1	5	10	15

Ala Phe Leu Leu Ile Pro
20

<210> SEQ ID NO 41
<211> LENGTH: 85
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 leader peptide

<400> SEQUENCE: 41

ggctctgaaa gtgttgtgg aacaagaaaa gaccttcttc accttgcctg tggctggg	60
gtacctgtcc tgcaaagtca cctgt	85

<210> SEQ ID NO 42
<211> LENGTH: 29
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 leader peptide

<400> SEQUENCE: 42

Met Ala Leu Lys Val Leu Leu Glu Gln Glu Lys Thr Phe Phe Thr Leu			
1	5	10	15

Leu Val Leu Leu Gly Tyr Leu Ser Cys Lys Val Thr Cys
20 25

<210> SEQ ID NO 43
<211> LENGTH: 63
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD8 alpha leader peptide

<400> SEQUENCE: 43

atggcgctgc cggtgaccgc gctgtgtcg ccgctggcgc tgctgtgca tgccggcgc	60
ccg	63

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<210> SEQ ID NO 44
<211> LENGTH: 21
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD8 alpha leader peptide

<400> SEQUENCE: 44

Met	Ala	Leu	Pro	Val	Thr	Ala	Leu	Leu	Leu	Pro	Leu	Ala	Leu	Leu	Leu
1							5				10				15
His	Ala	Ala	Arg	Pro											
					20										

<210> SEQ ID NO 45
<211> LENGTH: 123
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD28 co-stimulatory domain

<400> SEQUENCE: 45

cggtcgaaga	ggtccagact	cttgcactcc	gactacatga	acatgactcc	tagaaggccc	60
ggacccacta	gaaagcacta	ccagccgtac	gcccctcctc	gggatttcgc	cgcataaccgg	120
tcc						123

<210> SEQ ID NO 46
<211> LENGTH: 41
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD28 co-stimulatory domain

<400> SEQUENCE: 46

Arg	Ser	Lys	Arg	Ser	Arg	Leu	Leu	His	Ser	Asp	Tyr	Met	Asn	Met	Thr
1						5			10						15
Pro	Arg	Arg	Pro	Gly	Pro	Thr	Arg	Lys	His	Tyr	Gln	Pro	Tyr	Ala	Pro
						20			25						30
Pro	Arg	Asp	Phe	Ala	Ala	Tyr	Arg	Ser							
				35		40									

<210> SEQ ID NO 47
<211> LENGTH: 336
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD3 zeta activation domain

<400> SEQUENCE: 47

agagtgaagt	ttagccgctc	agccgatgca	ccggcctacc	agcagggaca	gaaccagctc	60
tacaacgagc	tcaacctggg	tcggcgggaa	aatatgacg	tgctggacaa	acggcgccgc	120
agagatccgg	agatgggggg	aaagccgagg	aggaagaacc	ctcaagaggg	cctgtacaac	180
gaactgcaga	aggacaagat	ggcggaaagcc	tactccgaga	tcggcatgaa	gggagaacgc	240
cggagagggg	agggtcatga	cggactgtac	cagggcctgt	caactgocac	taaggacact	300
tacgatgcgc	tccatatgca	agctttgcc	ccgcgg			336

<210> SEQ ID NO 48
<211> LENGTH: 112
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:

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<223> OTHER INFORMATION: CD3 zeta activation domain

<400> SEQUENCE: 48

Arg	Val	Lys	Phe	Ser	Arg	Ser	Ala	Asp	Ala	Pro	Ala	Tyr	Gln	Gln	Gly
1															
													10	15	

Gln	Asn	Gln	Leu	Tyr	Asn	Glu	Leu	Asn	Leu	Gly	Arg	Arg	Glu	Glu	Tyr
													20	25	30

Asp	Val	Leu	Asp	Lys	Arg	Arg	Gly	Arg	Asp	Pro	Glu	Met	Gly	Gly	Lys
													35	40	45

Pro	Arg	Arg	Lys	Asn	Pro	Gln	Glu	Gly	Leu	Tyr	Asn	Glu	Leu	Gln	Lys
													50	55	60

Asp	Lys	Met	Ala	Glu	Ala	Tyr	Ser	Glu	Ile	Gly	Met	Lys	Gly	Glu	Arg	
													65	70	75	80

Arg	Arg	Gly	Gly	His	Asp	Gly	Leu	Tyr	Gln	Gly	Leu	Ser	Thr	Ala	
													85	90	95

Thr	Lys	Asp	Thr	Tyr	Asp	Ala	Leu	His	Met	Gln	Ala	Leu	Pro	Pro	Arg
													100	105	110

<210> SEQ ID NO 49

<211> LENGTH: 201

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: TNFRSF19 hinge and transmembrane domain

<400> SEQUENCE: 49

gcggccgcgg	tcggattcca	agacatggaa	tgcgtgcctt	gcggcgaccc	gccacccctt	60
tacgagccgc	actgcgcatac	gaaggtaaac	ctcgtgaaga	tgcgtgcac	cgcgtccca	120
ccccgggata	ctgctctggc	cggcgtgatt	tgttccgcct	tggccaccgt	gtttctggcc	180
ctgctgatcc	tctgtgtatc	c				201

<210> SEQ ID NO 50

<211> LENGTH: 67

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: TNFRSF19 hinge and transmembrane domain

<400> SEQUENCE: 50

Ala	Ala	Ala	Val	Gly	Phe	Gln	Asp	Met	Glu	Cys	Val	Pro	Cys	Gly	Asp
1															
													10	15	

Pro	Pro	Pro	Pro	Tyr	Glu	Pro	His	Cys	Ala	Ser	Lys	Val	Asn	Leu	Val
													20	25	30

Lys	Ile	Ala	Ser	Thr	Ala	Ser	Ser	Pro	Arg	Asp	Thr	Ala	Leu	Ala	Ala
													35	40	45

Val	Ile	Cys	Ser	Ala	Leu	Ala	Thr	Val	Leu	Leu	Ala	Leu	Leu	Ile	Leu
													50	55	60

Cys Val Ile

65

<210> SEQ ID NO 51

<211> LENGTH: 63

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: TNFRSF19 transmembrane domain

<400> SEQUENCE: 51

ggccgcgtga tttgttccgc cttggccacc gtgtttctgg ccctgtat cctctgttg 60

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atc

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<210> SEQ ID NO 52
<211> LENGTH: 21
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 transmembrane domain

<400> SEQUENCE: 52

```

Ala Ala Val Ile Cys Ser Ala Leu Ala Thr Val Leu Leu Ala Leu Leu
1           5          10          15
Ile Leu Cys Val Ile
20

```

<210> SEQ ID NO 53
<211> LENGTH: 138
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 hinge domain

<400> SEQUENCE: 53

```

gcggccgggg tcggattcca agacatggaa tgcgtgcctt gggcgaccc gccacctct    60
tacgagccgc actgcgcatac gaaggtaaac ctctgtgaaga tgcgcgacac cgcttccta    120
ccccgggata ctgctctg                                         138

```

<210> SEQ ID NO 54
<211> LENGTH: 46
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 hinge domain

<400> SEQUENCE: 54

```

Ala Ala Ala Val Gly Phe Gln Asp Met Glu Cys Val Pro Cys Gly Asp
1           5          10          15
Pro Pro Pro Pro Tyr Glu Pro His Cys Ala Ser Lys Val Asn Leu Val
20          25          30
Lys Ile Ala Ser Thr Ala Ser Ser Pro Arg Asp Thr Ala Leu
35          40          45

```

<210> SEQ ID NO 55
<211> LENGTH: 80
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: truncated TNFRSF19 hinge domain

<400> SEQUENCE: 55

```

tacgagccctc actgcgcctt cttttttttt cttttttttt tttttttttt tttttttttt    60
cctcgggaca ctgctctggc                                         80

```

<210> SEQ ID NO 56
<211> LENGTH: 26
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: TNFRSF19 hinge domain

<400> SEQUENCE: 56

```

Tyr Glu Pro His Cys Ala Ser Lys Val Asn Leu Val Lys Ile Ala Ser

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1	5	10	15
---	---	----	----

Thr Ala Ser Ser Pro Arg Asp Thr Ala Leu
20 25

<210> SEQ ID NO 57
<211> LENGTH: 222
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD8a hinge domain fused to TNFRSF19
transmembrane

<400> SEQUENCE: 57

gcggccgcgc cggccccctcg gcccccgact cctgccccga cgatcgcttc ccaacctctc	60
tcgtcgcccg cggaaagcatg cggggccggcc gccgggtggcg ctgtccacac tcgcggactg	120
gactttgata cccgactggc ggccgtgatc tgtagcgcgg tggccaccgt gctgtggcg	180
ctgctcatcc tttgcgtgat ctactgcaag cggcagccta gg	222

<210> SEQ ID NO 58
<211> LENGTH: 74
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD8a hinge domain fused to TNFRSF19
transmembrane

<400> SEQUENCE: 58

Ala Ala Ala Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala	
1 5 10 15	
Ser Gln Pro Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly	
20 25 30	
Gly Ala Val His Thr Arg Gly Leu Asp Phe Asp Thr Ala Leu Ala Ala	
35 40 45	
Val Ile Cys Ser Ala Leu Ala Thr Val Leu Leu Ala Leu Ile Leu	
50 55 60	
Cys Val Ile Tyr Cys Lys Arg Gln Pro Arg	
65 70	

<210> SEQ ID NO 59
<211> LENGTH: 123
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD28 co-stimulatory domain

<400> SEQUENCE: 59

cggtcgaaga ggtccagact cttgcactcc gactacatga acatgactcc tagaaggccc	60
ggacccacta gaaagcacta ccagccgtac gcccctcctc gggatttcgc cgcataccgg	120
tcc	123

<210> SEQ ID NO 60
<211> LENGTH: 41
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD28 co-stimulatory domain

<400> SEQUENCE: 60

Arg Ser Lys Arg Ser Arg Leu Leu His Ser Asp Tyr Met Asn Met Thr	
1 5 10 15	

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Pro	Arg	Arg	Pro	Gly	Pro	Thr	Arg	Lys	His	Tyr	Gln	Pro	Tyr	Ala	Pro
20					25									30	

Pro	Arg	Asp	Phe	Ala	Ala	Tyr	Arg	Ser
35						40		

<210> SEQ ID NO 61
<211> LENGTH: 336
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD3 zeta version 2

<400> SEQUENCE: 61

cgcgtgaaat	ttagccgcag	cgcggatgcg	ccggcgatc	agcaggccca	gaaccagctg	60
tataacgaac	tgaacctggg	ccgcccgcgaa	aatatgtat	tgcgtggataa	acgcccggc	120
cgcgatccgg	aatgggcgg	caaaccgcgc	cgcaaaaacc	cgcaggaaagg	cctgtataac	180
gaaactgcaga	aagataaaat	ggcggaaagcg	tatagcgaaa	ttggcatgaa	aggcgaacgc	240
cgcgcgcgcca	aaggccatga	tggcctgtat	cagggcctga	gcaccgcgac	caaagatacc	300
tatgatgcgc	tgcataatgca	ggcgctgcgc	ccgcgc			336

<210> SEQ ID NO 62
<211> LENGTH: 112
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: CD3 zeta version 2

<400> SEQUENCE: 62

Arg	Val	Lys	Phe	Ser	Arg	Ser	Ala	Asp	Ala	Pro	Ala	Tyr	Gln	Gln	Gly
1					5			10					15		

Gln	Asn	Gln	Leu	Tyr	Asn	Glu	Leu	Asn	Leu	Gly	Arg	Arg	Glu	Glu	Tyr
					20			25					30		

Asp	Val	Leu	Asp	Lys	Arg	Arg	Gly	Arg	Asp	Pro	Glu	Met	Gly	Gly	Lys
35					40							45			

Pro	Arg	Arg	Lys	Asn	Pro	Gln	Glu	Gly	Leu	Tyr	Asn	Glu	Leu	Gln	Lys
50					55						60				

Asp	Lys	Met	Ala	Glu	Ala	Tyr	Ser	Glu	Ile	Gly	Met	Lys	Gly	Glu	Arg
65					70				75				80		

Arg	Arg	Gly	Lys	Gly	His	Asp	Gly	Leu	Tyr	Gln	Gly	Leu	Ser	Thr	Ala
					85			90					95		

Thr	Lys	Asp	Thr	Tyr	Asp	Ala	Leu	His	Met	Gln	Ala	Leu	Pro	Pro	Arg
					100				105				110		

<210> SEQ ID NO 63
<211> LENGTH: 93
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: Furin P2A Furin

<400> SEQUENCE: 63

cgcgcgaaac	gcagcggcag	cggcgccgacc	aacttttagcc	tgctgaaaca	ggcgccccat	60
gttggaaagaaa	accggggccc	gcgagcaaag	agg			93

<210> SEQ ID NO 64
<211> LENGTH: 31
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:

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<223> OTHER INFORMATION: Furin P2A Furin

<400> SEQUENCE: 64

Arg Ala Lys Arg Ser Gly Ser Gly Ala Thr Asn Phe Ser Leu Leu Lys	10	15
1	5	
Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro Arg Ala Lys Arg	25	30
20		

<210> SEQ ID NO 65

<211> LENGTH: 78

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: Furin T2A

<400> SEQUENCE: 65

agagcttaaac gctctgggtc tggtaagga cgaggttagcc ttcttacgtg cggagacgtg	60
gaggaaaacc caggaccc	78

<210> SEQ ID NO 66

<211> LENGTH: 26

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: Furin T2A

<400> SEQUENCE: 66

Arg Ala Lys Arg Ser Gly Ser Gly Glu Gly Arg Gly Ser Leu Leu Thr	10	15
1	5	
Cys Gly Asp Val Glu Glu Asn Pro Gly Pro	25	
20		

<210> SEQ ID NO 67

<211> LENGTH: 1005

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: truncated EGFR (tEGFR) tag

<400> SEQUENCE: 67

aggaaggttt gcaatggaat cggtataggg gagtttaagg attcaacttag cataaacgct	60
actaatatta aacactcaa aaactgtacg agtataagt gagatcttc catttgccg	120
gttgcattcc gaggcgattc attcacccac acgccaccgc ttgaccacaca agaattggat	180
attcttaaaa ccgttaaaga aataacgggg ttttgctca ttcaagcgtg gccagaaaaat	240
cgcactgacc tccatgctt cgagaacctg gagattataa gaggacgaac taagcagcat	300
ggtcaattct cccttgcgtgt ggtcagcctg aacatcacca gtcttggtt gcggccctc	360
aaggaaattt cagatggaga tgtcatcata agcggcaaca agaatttgta ctatgcaa	420
accataaaact ggaaaaaaact gtttggact tcggccaga aaaccaagat tatttcaa	480
cgggggtgaga acagctgcaa agccaccggc cagggttgtc atgccttgt ctctccgaa	540
ggctgttggg ggccagaacc caggactgc gtcagttgc gaaacgtctc aagaggccgc	600
gaatgcgttg acaagtgtaa cctcctttag ggtgagccac gagagttgt tgagaacagc	660
gagtgtatac aatgtcaccc tgaatgtttt ccccaggcta tgaatataac ctgcacaggc	720
cgccggccgt ataactgcat ccagtgtgtcattacatag atggacatca ctgtgtgaaa	780
acctgccccg ccggagttat gggagaaaac aacactctgg tggtaataa cgctgatgca	840
ggccacgtgt gccacccat tcaaccgaat tgtacatatg ggtgtaccgg tcctggactt	900

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gaaagggtgcc ctaccaatgg ccctaaaata cccagtatcg caactggcat ggtggcgct 960
 cttctcttgc tcttggtagt tgctctggc ataggtcttt ttatg 1005

<210> SEQ ID NO 68
 <211> LENGTH: 335
 <212> TYPE: PRT
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: truncated EGFR (tEGFR) tag

<400> SEQUENCE: 68

Arg	Lys	Val	Cys	Asn	Gly	Ile	Gly	Ile	Gly	Glu	Phe	Lys	Asp	Ser	Leu
1						5			10					15	
Ser	Ile	Asn	Ala	Thr	Asn	Ile	Lys	His	Phe	Lys	Asn	Cys	Thr	Ser	Ile
	20						25					30			
Ser	Gly	Asp	Leu	His	Ile	Leu	Pro	Val	Ala	Phe	Arg	Gly	Asp	Ser	Phe
	35					40				45					
Thr	His	Thr	Pro	Pro	Leu	Asp	Pro	Gln	Glu	Leu	Asp	Ile	Leu	Lys	Thr
	50					55				60					
Val	Lys	Glu	Ile	Thr	Gly	Phe	Leu	Leu	Ile	Gln	Ala	Trp	Pro	Glu	Asn
	65					70			75			80			
Arg	Thr	Asp	Leu	His	Ala	Phe	Glu	Asn	Leu	Glu	Ile	Ile	Arg	Gly	Arg
	85					90				95					
Thr	Lys	Gln	His	Gly	Gln	Phe	Ser	Leu	Ala	Val	Val	Ser	Leu	Asn	Ile
	100					105				110					
Thr	Ser	Leu	Gly	Leu	Arg	Ser	Leu	Lys	Glu	Ile	Ser	Asp	Gly	Asp	Val
	115					120				125					
Ile	Ile	Ser	Gly	Asn	Lys	Asn	Leu	Cys	Tyr	Ala	Asn	Thr	Ile	Asn	Trp
	130					135				140					
Lys	Lys	Leu	Phe	Gly	Thr	Ser	Gly	Gln	Lys	Thr	Lys	Ile	Ile	Ser	Asn
	145					150			155			160			
Arg	Gly	Glu	Asn	Ser	Cys	Lys	Ala	Thr	Gly	Gln	Val	Cys	His	Ala	Leu
	165					170				175					
Cys	Ser	Pro	Glu	Gly	Cys	Trp	Gly	Pro	Glu	Pro	Arg	Asp	Cys	Val	Ser
	180					185				190					
Cys	Arg	Asn	Val	Ser	Arg	Gly	Arg	Glu	Cys	Val	Asp	Lys	Cys	Asn	Leu
	195					200				205					
Leu	Glu	Gly	Glu	Pro	Arg	Glu	Phe	Val	Glu	Asn	Ser	Glu	Cys	Ile	Gln
	210					215				220					
Cys	His	Pro	Glu	Cys	Leu	Pro	Gln	Ala	Met	Asn	Ile	Thr	Cys	Thr	Gly
	225					230			235			240			
Arg	Gly	Pro	Asp	Asn	Cys	Ile	Gln	Cys	Ala	His	Tyr	Ile	Asp	Gly	Pro
	245					250				255					
His	Cys	Val	Lys	Thr	Cys	Pro	Ala	Gly	Val	Met	Gly	Glu	Asn	Asn	Thr
	260					265				270					
Leu	Val	Trp	Lys	Tyr	Ala	Asp	Ala	Gly	His	Val	Cys	His	Leu	Cys	His
	275					280				285					
Pro	Asn	Cys	Thr	Tyr	Gly	Cys	Thr	Gly	Pro	Gly	Leu	Glu	Gly	Cys	Pro
	290					295			300						
Thr	Asn	Gly	Pro	Lys	Ile	Pro	Ser	Ile	Ala	Thr	Gly	Met	Val	Gly	Ala
	305					310				315			320		
Leu	Leu	Leu	Leu	Val	Val	Ala	Leu	Gly	Ile	Gly	Leu	Phe	Met		
	325					330				335					

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<210> SEQ ID NO 69
<211> LENGTH: 744
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-40

<400> SEQUENCE: 69

```
caggcggccg aggtgcagct ggtgcagtct gggggaggcg tggccagcc tggggggtcc      60
ctgagactct cctgtgcagc gtctggattc accttcagta gctatggcat gcactggtc      120
cggcaggctc caggcaaggg gctggagtgg gtggcattta tacggatga tggaagtaat      180
aaataactacg cagactccgt gaagggccga ttccaccatct ccagagacaa ttccaagaac      240
acgctgtatc tgcaaattgaa cagcctgaga gctgaggaca cggctgtgtt ttactgtgcg      300
aaagaacccc ccgagtttata ctatgatgt agtggttatt cgtggggcca gggAACCTG      360
gtcaccgtct cctcaggagg tggcggatct ggtggaggcg gtagcgggtgg tggcggatcc      420
gacatccagt tgacccagtc tccatcctcc ctgtctgcat ctgttaggaga cagagtccacc      480
atcacttgcc aggccgagtca ggacattgac acctattaa actggatca gcagaaacca      540
ggaaagcccc ctaagtcct gatctatgt gcatccagg tgcggatgg ggtctcatca      600
aggttcagtg cagtggttgc tggcacagag ttcaactctca ccatcagcag tctgcagcct      660
gaagattttgc caacttattt ctgtcaacag acttacagtc ccccgatcac cttcggccaa      720
gggacacgac tggagattaa acga                                         744
```

<210> SEQ ID NO 70
<211> LENGTH: 248
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-40

<400> SEQUENCE: 70

Gln	Ala	Ala	Glu	Val	Gln	Leu	Val	Gln	Ser	Gly	Gly	Gly	Val	Val	Gln	
1																15

Pro	Gly	Gly	Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly	Phe	Thr	Phe	
20																30

Ser	Ser	Tyr	Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Leu	
35																45

Glu	Trp	Val	Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys	Tyr	Tyr	Ala	
50																60

Asp	Ser	Val	Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn	Ser	Lys	Asn	
65																80

Thr	Leu	Tyr	Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	
85																95

Tyr	Tyr	Cys	Ala	Lys	Glu	Pro	Pro	Glu	Tyr	Tyr	Tyr	Asp	Ser	Ser	Gly	
100																110

Tyr	Ser	Trp	Gly	Gln	Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	Gly	Gly		
115																125

Gly	Ser	Gly	Gly	Gly	Ser	Gly	Gly	Gly	Ser	Asp	Ile	Gln	Leu			
130																140

Thr	Gln	Ser	Pro	Ser	Ser	Leu	Ser	Ala	Ser	Val	Gly	Asp	Arg	Val	Thr	
145																160

Ile	Thr	Cys	Gln	Ala	Ser	Gln	Asp	Ile	Asp	Thr	Tyr	Leu	Asn	Trp	Tyr	
165																175

Gln	Gln	Lys	Pro	Gly	Lys	Ala	Pro	Lys	Leu	Leu	Ile	Tyr	Ala	Ala	Ser
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

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180 185 190

Ser Leu Gln Ser Gly Val Ser Ser Arg Phe Ser Gly Ser Gly
 195 200 205

Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala
 210 215 220

Thr Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly Gln
 225 230 235 240

Gly Thr Arg Leu Glu Ile Lys Arg
 245

<210> SEQ ID NO 71

<211> LENGTH: 729

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-49

<400> SEQUENCE: 71

gaggtgcagc tgggtggagtc tgggggaggc	gtggtccagc ctggggaggc	cctgagactc	60
tcctgtgcag cgtctggatt caccttcagt agctatggca	tgcactgggt	ccgcccaggct	120
ccaggcaagg ggctggagtg ggtggcattt atacggtagt	atggaaagtaa	taaataactat	180
gcagactccg tgaaggggccg attcaccatc	tccagagaca	attccaagaa	240
ctgc当地atga acagcctgag agctgaggac	acggctgtgt	attactgtgt	300
tacgggtgta actccggac tagctactgg	ggccagggaa	ccctggtcac	360
ggagggggcg gatctggtgg	aggcggtagc	ggtggtggcg	420
cagtctccat cttccctgtc	tgc当地ctgtc	ggagacagag	480
agtcaggaca ttagcaacta tt当地aaattgg	tatcagcaga	agccagggaa	540
ctc当地tgc当地t acgatgc当地tcaat	ttggc当地tgg	catcaagggtt	600
ggatctggga cagattcac tctc当地accatc	agcagtc当地tgc	aacctgaaga	660
tactactgtc aacagagttt	cagtaaaaaa	gtgacgttgc	720
gtc当地taggtt		gcggaggggac	729

<210> SEQ ID NO 72

<211> LENGTH: 243

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-49

<400> SEQUENCE: 72

Glu Val Gln Leu Val Glu Ser Gly	Gly Gly Val Val Gln Pro Gly Arg		
1	5	10	15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly	Phe Thr Phe Ser Ser Tyr	
20	25	30

Gly Met His Trp Val Arg Gln Ala Pro Gly	Lys Gly Leu Glu Trp Val	
35	40	45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys	Tyr Tyr Ala Asp Ser Val	
50	55	60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser	Lys Asn Thr Leu Tyr		
65	70	75	80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr	Ala Val Tyr Tyr Cys	
85	90	95

Val Ser Asp Asp Tyr Gly Gly Asn Ser Gly	Thr Ser Tyr Trp Gly Gln	
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100	105	110	
Gly Thr Leu Val Thr Val Ser Ser Gly	Gly Gly Gly Ser Gly	Gly Gly Gly	
115	120	125	
Gly Ser Gly Gly Gly Ser Asp Ile Gln Met	Thr Gln Ser Pro Ser		
130	135	140	
Ser Leu Ser Ala Ser Val Gly Asp Arg Val	Thr Ile Thr Cys Gln Ala		
145	150	155	160
Ser Gln Asp Ile Ser Asn Tyr Leu Asn Trp	Tyr Gln Gln Lys Pro Gly		
165	170	175	
Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala Ser Asn Leu	Glu Thr Gly		
180	185	190	
Val Pro Ser Arg Phe Ser Gly Ser Gly Thr Asp Phe Thr Leu			
195	200	205	
Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln			
210	215	220	
Gln Ser Tyr Ser Thr Pro Val Thr Phe Gly Gly Thr Lys Leu Thr			
225	230	235	240
Val Leu Gly			

<210> SEQ ID NO 73
<211> LENGTH: 711
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-50

<400> SEQUENCE: 73

```

gaggtgcagc tggtcagtc tggggaggt gtggtaacggc ctggggggc cctgagactc      60
tcctgtcgac cctctggatt caccttcagt acttatgaaa tgaactgggt ccgccaggct     120
ccagggaaagg ggctggagtg gcttgcatac attggaggtt gtggtagtcc catatactac    180
gcagactctg tgaggggccc attcaccatc tccagagaca acaccaagaa ttcaactatTT    240
ctccaaatga gcagcctgag agccgaggac accgctgttt actattgtgt ggaagggtgg   300
tttgacaagt ggggcctggg aaccctggtc accgtctccat caggaggtgg cggatctggg  360
ggaggcggta gcgggtggtgg cggatccgac atccagttga cccagtctcc atccacctcg  420
tctgcacatcg taggagacag agtcaccatc acttgcgggg caagtcagag cattagcagc  480
tatTTaaatt ggtatcagca gaaaccaggg aaagccccta agctcctgtat ctacgtgca  540
tccaatttgg agacaggggc cccatcaagg ttcaagtggaa gtggatctgg gacagattc  600
actctcacca tcagcagtct gcaacctgaa gatTTTgcaa cttactactg tcaacagagt  660
tacagtaccc cgtacacttt tggccagggg accaagctgg aaatcaaacg t           711

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<210> SEQ ID NO 74
<211> LENGTH: 237
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-50

<400> SEQUENCE: 74

```

Glu Val Gln Leu Val Gln Ser Gly Gly Val Val Arg Pro Gly Gly
1          5          10          15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Thr Tyr
20         25          30

Glu Met Asn Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu

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35	40	45
Ala Tyr Ile Gly Gly Ser Gly Ser Pro Ile Tyr Tyr Ala Asp Ser Val		
50	55	60
Arg Gly Arg Phe Thr Ile Ser Arg Asp Asn Thr Lys Asn Ser Leu Phe		
65	70	75
Leu Gln Met Ser Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys		
85	90	95
Val Glu Gly Trp Phe Asp Lys Trp Gly Leu Gly Thr Leu Val Thr Val		
100	105	110
Ser Ser Gly Gly Gly Ser Gly Gly Gly Ser Gly Gly Gly Gly		
115	120	125
Ser Asp Ile Gln Leu Thr Gln Ser Pro Ser Thr Leu Ser Ala Ser Val		
130	135	140
Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Ser Ile Ser Ser		
145	150	155
Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu		
165	170	175
Ile Tyr Asp Ala Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser		
180	185	190
Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln		
195	200	205
Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Ser Tyr Ser Thr Pro		
210	215	220
Tyr Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys Arg		
225	230	235

<210> SEQ ID NO 75
<211> LENGTH: 732
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-4-12

<400> SEQUENCE: 75

caggtgcagc tgggtcagtc tgggggaggc gtgggtccagc ctggggggtc cctgagactc	60
tccctgtcgag cctctggatt caccttcagt agttacgtta tacattgggt ccgccaggt	120
ccaggcaagg ggctggagtg ggtggcagct atatcgcatg atggaaagcaa taaatactac	180
gcagactccg tgaagggccg attcaccatc tccagagaca attccaagaa cacgctgtat	240
cttcaaatga gcagtctgag cgctgaggac acggctatgt attactgtgt gaaaactagt	300
agtgattatt actacgccta ctggggccag ggaaccctgg tcaccgtctc ctcaggaggt	360
ggcgggtctg gtggaggcgg tagcggttgt ggccggatccc agactgttgt gactcaggag	420
ccatcgttct cagtgtcccc tggagggaca gtcacactca cttgtggctt gagctctggc	480
tcagtctcta ctggcaactc ccccacctgg taccagcaga ccccaaggcca ggctccacgc	540
acgctcatct acagcacaaa cactcgctt tctggggtcc ctgatcgctt ctctggctcc	600
atccttggga acaaagctgc cctcaccatc acgggggccc aggcagatga tgaatctgat	660
tattactgtg tgctgtatat gggtagtgttattgggtgt tcggcggagg gaccaaggtc	720
accgtcctag gt	732

<210> SEQ ID NO 76
<211> LENGTH: 244
<212> TYPE: PRT
<213> ORGANISM: Artificial

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<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-4-12

<400> SEQUENCE: 76

Gln Val Gln Leu Val Gln Ser Gly Gly Gly Val Val Gln Pro Gly Gly
 1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
 20 25 30

Val Ile His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
 35 40 45

Ala Ala Ile Ser His Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
 50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
 65 70 75 80

Leu Gln Met Ser Ser Leu Ser Ala Glu Asp Thr Ala Met Tyr Tyr Cys
 85 90 95

Val Lys Thr Ser Ser Asp Tyr Tyr Ala Tyr Trp Gly Gln Gly Thr
 100 105 110

Leu Val Thr Val Ser Ser Gly Gly Ser Gly Gly Ser Gly Ser
 115 120 125

Gly Gly Gly Ser Gln Thr Val Val Thr Gln Glu Pro Ser Phe Ser
 130 135 140

Val Ser Pro Gly Gly Thr Val Thr Leu Thr Cys Gly Leu Ser Ser Gly
 145 150 155 160

Ser Val Ser Thr Gly Asn Ser Pro Thr Trp Tyr Gln Gln Thr Pro Gly
 165 170 175

Gln Ala Pro Arg Thr Leu Ile Tyr Ser Thr Asn Thr Arg Ser Ser Gly
 180 185 190

Val Pro Asp Arg Phe Ser Gly Ser Ile Leu Gly Asn Lys Ala Ala Leu
 195 200 205

Thr Ile Thr Gly Ala Gln Ala Asp Asp Glu Ser Asp Tyr Tyr Cys Val
 210 215 220

Leu Tyr Met Gly Ser Gly Tyr Trp Val Phe Gly Gly Gly Thr Lys Val
 225 230 235 240

Thr Val Leu Gly

<210> SEQ ID NO 77

<211> LENGTH: 723

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: BCMA ScFv binder MTB-4-45

<400> SEQUENCE: 77

gaggtgcagc tggtgcaagtc tggggctgag gtgaagaagc ctggggccctc agtgaaggtt 60
 tcctgcaagg catctggata cacctccacc agctactata tgcactgggt gcgacaggcc 120
 cctggacaag ggcttgagt gatgggaata atcaacccta gtgggtggtag cacaagctac 180
 gcacagaagt tccagggcag agtcaccatg accagggaca cgtccacgag cacagtctac 240
 atggagctga gcagcttgag atctgaggac acggccgtgt attactgtgc gagagattt 300
 ggtgatggcg cttttgcata ctggggccaa gggacaatgg tcaccgtctc ttcaggaggt 360
 ggccgggtctg gtggaggccg tagcggtggt ggccggatccg acatccagat gacccagtt 420
 ctatccccc tgtctgcata tgttaggagac agagtcacca tcgcttgccg ggcaagtca 480
 accatttagta ggtatataa ttggtatcag cagaaaccag ggaaagcccc taagtcctg 540

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atcttatgtcg catccagttt gcaaagtggg gtctcatcaa ggttcagtgg cagtggatct	600
gggacagagt tcacttcac catcagcagt ctgcagcctg aagatttgc aacttatttc	660
tgtcaacaga cttacagtcc cccgatcacc ttccggccaag ggacacgact ggagattaaa	720
cga	723

<210> SEQ ID NO 78
<211> LENGTH: 241
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: BCMA ScFv binder MTB-4-45

<400> SEQUENCE: 78

Glu Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala			
1	5	10	15

Ser Val Lys Val Ser Cys Lys Ala Ser Gly Tyr Thr Ser Thr Ser Tyr			
20	25	30	

Tyr Met His Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met			
35	40	45	

Gly Ile Ile Asn Pro Ser Gly Gly Ser Thr Ser Tyr Ala Gln Lys Phe			
50	55	60	

Gln Gly Arg Val Thr Met Thr Arg Asp Thr Ser Thr Ser Thr Val Tyr			
65	70	75	80

Met Glu Leu Ser Ser Leu Arg Ser Glu Asp Thr Ala Val Tyr Tyr Cys			
85	90	95	

Ala Arg Asp Leu Gly Asp Gly Ala Phe Asp Ile Trp Gly Gln Gly Thr			
100	105	110	

Met Val Thr Val Ser Ser Gly Gly Ser Gly Gly Ser Gly Ser			
115	120	125	

Gly Gly Gly Ser Asp Ile Gln Met Thr Gln Ser Leu Ser Ser Leu			
130	135	140	

Ser Ala Ser Val Gly Asp Arg Val Thr Ile Ala Cys Arg Ala Ser Gln			
145	150	155	160

Thr Ile Ser Arg Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly Lys Ala			
165	170	175	

Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Ser			
180	185	190	

Ser Arg Phe Ser Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile			
195	200	205	

Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Phe Cys Gln Gln Thr			
210	215	220	

Tyr Ser Pro Pro Ile Thr Phe Gly Gln Gly Thr Arg Leu Glu Ile Lys			
225	230	235	240

Arg

<210> SEQ ID NO 79
<211> LENGTH: 36
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 79

gagagcaaat acggggccgc atgtcccccg tgtccg	36
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<210> SEQ ID NO 80
<211> LENGTH: 12

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<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 80

Glu	Ser	Lys	Tyr	Gly	Pro	Pro	Cys	Pro	Pro	Cys	Pro
1				5				10			

<210> SEQ ID NO 81

<211> LENGTH: 327

<212> TYPE: DNA

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 81

gcaccaccag	ttgctggccc	tagtgtcttc	ttgttccctc	ccaagccaa	agacaccc	tg	60
atgatttcca	gaactcctga	ggttacctgc	gttgtcgtag	atgtttctca	ggaggaccca		120
gaggtccaa	ttaactggta	cgttgatggg	gtggaagtgc	acaatgcgaa	gacaaaggccg		180
cggaaagaac	aatttcagtc	cacttaccgg	gttgtcagcg	ttctgacgg	attgcataa		240
gactggctta	atggaaagga	atataagtgt	aagggtgtcca	acaaagggttt	gccgagcagt		300
attgagaaga	ccatatcaaa	ggcgaag					327

<210> SEQ ID NO 82

<211> LENGTH: 109

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 82

Ala	Pro	Pro	Val	Ala	Gly	Pro	Ser	Val	Phe	Leu	Phe	Pro	Pro	Lys	Pro
1						5			10			15			

Lys	Asp	Thr	Leu	Met	Ile	Ser	Arg	Thr	Pro	Glu	Val	Thr	Cys	Val	Val
								20		25		30			

Val	Asp	Val	Ser	Gln	Glu	Asp	Pro	Glu	Val	Gln	Phe	Asn	Trp	Tyr	Val
						35		40		45					

Asp	Gly	Val	Glu	Val	His	Asn	Ala	Lys	Thr	Lys	Pro	Arg	Glu	Gln
					50		55		60					

Phe	Gln	Ser	Thr	Tyr	Arg	Val	Val	Ser	Val	Leu	Thr	Val	Leu	His	Gln
					65		70		75		80				

Asp	Trp	Leu	Asn	Gly	Lys	Glu	Tyr	Lys	Cys	Lys	Val	Ser	Asn	Lys	Gly
					85		90		95						

Leu	Pro	Ser	Ser	Ile	Glu	Lys	Thr	Ile	Ser	Lys	Ala	Lys
						100		105				

<210> SEQ ID NO 83

<211> LENGTH: 321

<212> TYPE: DNA

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 83

gggcagccgc	gogagccaca	agtttacact	ttggccgcat	ctcaagagga	aatgactaaa	60
aaccaggat	ccttgacatg	cctcgtaaaa	ggattttatc	catctgatat	tgctgtggaa	120
tgggagtcta	acggcagcc	ggaaaataat	tacaaaacta	caccacotgt	gctcgattca	180
gatggaaagt	tcttcctta	cagtagactt	acggtgacca	aatcttaggt	gcaggaagg	240
aatgtgttta	gttgttgt	aatgcacgag	gcacttcata	accactatac	acagaagtca	300
ctgagtttga	gtcttggcaa	a				321

<210> SEQ ID NO 84

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<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 84

Gly	Gln	Pro	Arg	Glu	Pro	Gln	Val	Tyr	Thr	Leu	Pro	Pro	Ser	Gln	Glu
1				5					10					15	

Glu Met Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly Phe

	20				25				30						
--	----	--	--	--	----	--	--	--	----	--	--	--	--	--	--

Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gln Pro Glu

	35				40				45						
--	----	--	--	--	----	--	--	--	----	--	--	--	--	--	--

Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser Phe

	50				55				60						
--	----	--	--	--	----	--	--	--	----	--	--	--	--	--	--

Phe Leu Tyr Ser Arg Leu Thr Val Asp Lys Ser Arg Trp Gln Glu Gly

	65				70				75					80	
--	----	--	--	--	----	--	--	--	----	--	--	--	--	----	--

Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His Tyr

	85				90				95						
--	----	--	--	--	----	--	--	--	----	--	--	--	--	--	--

Thr Gln Lys Ser Leu Ser Leu Ser Leu Gly Lys

	100				105										
--	-----	--	--	--	-----	--	--	--	--	--	--	--	--	--	--

<210> SEQ ID NO 85
<211> LENGTH: 684
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 85

gagagcaat	acggccgc	atgtcccccg	tgtccggc	caccagg	ttgc	tggccct	agt	60								
gtcttctt	gt	ccctccaa	gcccaa	agac	ac	tttccaga	ac	120								
ac	tcgtt	tcgt	tagatgt	ttctcagg	gaccc	cagg	tccaa	ctgg	ta	180						
gatgggtt	gg	aagtt	cacaa	tgcga	agaca	aagccgc	gg	aaca	att	tcag	tccact	240				
taccgggtt	tg	tcagcgtt	c	gacgg	tatt	g	catca	agact	gg	ctta	atgg	aaagga	at	300		
aagtgt	aa	agg	tt	gcg	tttgc	gc	ag	tttgc	tttgc	at	caaa	agg	gc	360		
aagggg	cc	cg	cc	cg	ac	tttgc	cc	at	ctc	a	aa	gg	aaat	gact	420	
aaaaacc	agg	tat	cctt	tgac	at	gc	c	t	cgta	aa	agg	at	ttt	t	480	
gaatgg	gt	ctaa	cgg	ca	gc	ccg	aa	at	tttgc	tttgc	at	ccat	ct	tg	540	
tcagatgg	aa	gtt	tctt	cct	tt	ac	at	gt	tttgc	tttgc	at	ccat	ct	tg	600	
ggaatgt	gt	tta	gtt	tag	tg	ta	at	gc	tttgc	tttgc	at	acc	act	ta	660	
tcactgag	tt	tg	at	gtt	tg	tg	ta	at	gc	tttgc	tttgc	at	acc	act	ta	684

<210> SEQ ID NO 86
<211> LENGTH: 228
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 86

Glu	Ser	Lys	Tyr	Gly	Pro	Pro	Cys	Pro	Pro	Cys	Pro	Ala	Pro	Pro	Val
1					5			10			15				

Ala Gly Pro Ser Val Phe Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu

	20				25						30				
--	----	--	--	--	----	--	--	--	--	--	----	--	--	--	--

Met Ile Ser Arg Thr Pro Glu Val Thr Cys Val Val Val Val Asp Val Ser

	35				40						45				
--	----	--	--	--	----	--	--	--	--	--	----	--	--	--	--

Gln Glu Asp Pro Glu Val Gln Phe Asn Trp Tyr Val Asp Gly Val Glu

	50				55						60				
--	----	--	--	--	----	--	--	--	--	--	----	--	--	--	--

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Val His Asn Ala Lys Thr Lys Pro Arg Glu Glu Gln Phe Gln Ser Thr
65 70 75 80

Tyr Arg Val Val Ser Val Leu Thr Val Leu His Gln Asp Trp Leu Asn
85 90 95

Gly Lys Glu Tyr Lys Cys Lys Val Ser Asn Lys Gly Leu Pro Ser Ser
100 105 110

Ile Glu Lys Thr Ile Ser Lys Ala Lys Gly Gln Pro Arg Glu Pro Gln
115 120 125

Val Tyr Thr Leu Pro Pro Ser Gln Glu Glu Met Thr Lys Asn Gln Val
130 135 140

Ser Leu Thr Cys Leu Val Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val
145 150 155 160

Glu Trp Glu Ser Asn Gly Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro
165 170 175

Pro Val Leu Asp Ser Asp Gly Ser Phe Phe Leu Tyr Ser Arg Leu Thr
180 185 190

Val Asp Lys Ser Arg Trp Gln Glu Gly Asn Val Phe Ser Cys Ser Val
195 200 205

Met His Glu Ala Leu His Asn His Tyr Thr Gln Lys Ser Leu Ser Leu
210 215 220

Ser Leu Gly Lys
225

<210> SEQ ID NO 87
<211> LENGTH: 1497
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0084 (Ef1a-BCMA sequence 5 CD8 BBz)

<400> SEQUENCE: 87

atgctgtgc tggcaccag cctgtttctg tgtgaactgc cgcacccggc gtttctgtc	60
attccggagg tccagctgggt gcagtctggaa ggaggcggtgg tccagcctgg tgggtccctg	120
agactctctt gtgcacgcgtc tggattcacc ttcaagtagtc atggcatgca ctgggtccgc	180
caggctccag gcaaggggct ggagtgggtg gcatttatac ggtatgtatgg aagtaataaa	240
tactatcgac actccgtgaa gggccgatcc accatctcca gagacaatcc caagaacacg	300
ctgttatctgc aaatgaacag cctgagagct gaggacacgg ctgtgtatata ctgtgcgaga	360
gattggggcc gggattgtac taatggccaa tgccggcttc actggggaca gggAACCTG	420
gtcacccgtct cctcaggagg tggcggatct ggtggaggcg gtagcgggtgg tggcggatcc	480
gaaaattgtgt tgacgcagtc tccactctcc ctgcccgtca cccctggaga gccggccctcc	540
atctcctgca ggtcttagtca gagccctctg catagtatgc gataacaacta tttggatgg	600
tacctgcaga agccaggggca gtctccacag ctctgtatctt atttgggttc taatcgggcc	660
tccgggggtcc ctgacagggtt cagtgccagtg ggatcaggca cagatttac actgaaaatc	720
agcagagtggtt aggctgagga tgttgggtt tattactgca tgcaagcttc acaaaactccg	780
taacattttg gccaggggac caagttggag atcaaacgtt cggccgcaac gaccactctt	840
gcaccccccctt ctccgactcc gggcccaacc attgccagcc agccccgttc cctgcggccg	900
gaaggcctgca gaccggctgc cggccggagcc gtccataccg gggactggaa ttccgcctgc	960
gatatctata tctggcacc actcgccgaa acctgtggag tgctgtgtc gtcccttg	1020
atcaccctgt actgcaagcg cggacggaaag aaactcttgc acatcttcaa gcagccgttc	1080

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atgcgccctg	tgcaaaccac	ccaagaagag	gacgggtgct	cctgcccgtt	cccgaaagag	1140
gaagaggggc	gctgcgaact	gcgcgtgaag	ttttcccggt	ccgcccacgc	tccggcgta	1200
cagcaggggc	aaaaccagct	gtacaacgaa	cttaacctcg	gtgcceggga	agaatatgac	1260
gtgctggaca	agcggcgggg	aagagatccc	gagatgggtg	gaaageccg	gcggaagaac	1320
cctcaggagg	gcttgtacaa	cgactgcaa	aaggacaaaa	tggccgaagc	ctactccgag	1380
attggcatga	agggagagcg	cagacgcggg	aaggcacacg	atggactgta	ccagggactg	1440
tcaaccgcga	ctaaggacac	ttacgacgcc	ctgcacatgc	aggccctgcc	cccgcgc	1497

<210> SEQ ID NO 88
<211> LENGTH: 499
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0084 (Ef1a-BCMA sequence 5 CD8 BBz)

<400> SEQUENCE: 88

Met	Leu	Leu	Leu	Val	Thr	Ser	Leu	Leu	Leu	Cys	Glu	Leu	Pro	His	Pro
1							5		10						15

Ala	Phe	Leu	Leu	Ile	Pro	Glu	Val	Gln	Leu	Val	Gln	Ser	Gly	Gly	Gly
							20		25						30

Val	Val	Gln	Pro	Gly	Gly	Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly
							35		40						45

Phe	Thr	Phe	Ser	Ser	Tyr	Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly
							50		55						60

Lys	Gly	Leu	Glu	Trp	Val	Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys
							65		70						80

Tyr	Tyr	Ala	Asp	Ser	Val	Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn
							85		90						95

Ser	Lys	Asn	Thr	Leu	Tyr	Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp
							100		105						110

Thr	Ala	Val	Tyr	Tyr	Cys	Ala	Arg	Asp	Trp	Ala	Gly	Asp	Cys	Thr	Asn
							115		120						125

Gly	Gln	Cys	Gly	Val	Tyr	Trp	Gly	Gln	Gly	Thr	Leu	Val	Thr	Val	Ser
							130		135						140

Ser	Gly	Gly	Gly	Ser	Gly	Gly	Ser	Gly	Gly	Gly	Ser				
							145		150						160

Glu	Ile	Val	Leu	Thr	Gln	Ser	Pro	Leu	Ser	Leu	Pro	Val	Thr	Pro	Gly
							165		170						175

Glu	Pro	Ala	Ser	Ile	Ser	Cys	Arg	Ser	Ser	Gln	Ser	Leu	Leu	His	Ser
							180		185						190

Asn	Gly	Tyr	Asn	Tyr	Leu	Asp	Trp	Tyr	Leu	Gln	Lys	Pro	Gly	Gln	Ser
							195		200						205

Pro	Gln	Leu	Leu	Ile	Tyr	Leu	Gly	Ser	Asn	Arg	Ala	Ser	Gly	Val	Pro
							210		215						220

Asp	Arg	Phe	Ser	Gly	Ser	Gly	Ser	Gly	Thr	Asp	Phe	Thr	Leu	Lys	Ile
							225		230						240

Ser	Arg	Val	Glu	Ala	Glu	Asp	Val	Gly	Val	Tyr	Tyr	Cys	Met	Gln	Ala
							245		250						255

Leu	Gln	Thr	Pro	Tyr	Thr	Phe	Gly	Gln	Gly	Thr	Lys	Leu	Glu	Ile	Lys
							260		265						270

Arg	Ala	Ala	Ala	Thr	Thr	Pro	Ala	Pro	Arg	Pro	Pro	Thr	Pro	Ala	
							275		280						285

Pro	Thr	Ile	Ala	Ser	Gln	Pro	Leu	Ser	Leu	Arg	Pro	Glu	Ala	Cys	Arg
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

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300

Pro Ala Ala Gly Gly Ala Val His Thr Arg Gly Leu Asp Phe Ala Cys
 305 310 315 320

Asp Ile Tyr Ile Trp Ala Pro Leu Ala Gly Thr Cys Gly Val Leu Leu
 325 330 335

Leu Ser Leu Val Ile Thr Leu Tyr Cys Lys Arg Gly Arg Lys Lys Leu
 340 345 350

Leu Tyr Ile Phe Lys Gln Pro Phe Met Arg Pro Val Gln Thr Thr Gln
 355 360 365

Glu Glu Asp Gly Cys Ser Cys Arg Phe Pro Glu Glu Glu Gly Gly
 370 375 380

Cys Glu Leu Arg Val Lys Phe Ser Arg Ser Ala Asp Ala Pro Ala Tyr
 385 390 395 400

Gln Gln Gly Gln Asn Gln Leu Tyr Asn Glu Leu Asn Leu Gly Arg Arg
 405 410 415

Glu Glu Tyr Asp Val Leu Asp Lys Arg Arg Gly Arg Asp Pro Glu Met
 420 425 430

Gly Gly Lys Pro Arg Arg Lys Asn Pro Gln Glu Gly Leu Tyr Asn Glu
 435 440 445

Leu Gln Lys Asp Lys Met Ala Glu Ala Tyr Ser Glu Ile Gly Met Lys
 450 455 460

Gly Glu Arg Arg Arg Gly Lys Gly His Asp Gly Leu Tyr Gln Gly Leu
 465 470 475 480

Ser Thr Ala Thr Lys Asp Thr Tyr Asp Ala Leu His Met Gln Ala Leu
 485 490 495

Pro Pro Arg

<210> SEQ ID NO 89
 <211> LENGTH: 1473
 <212> TYPE: DNA
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D0085 (Ef1a-BCMA sequence 16 CD8 BBz)

<400> SEQUENCE: 89

atgctgtc	tgggaccag	cctgtttctg	tgcgaactgc	cgcacccggc	60
attccggagg	tccagctgg	gcagtctggg	ggaggcgctgg	tccagectgg	120
agactctcct	gtgcacgc	tggattcacc	ttcagtagct	atggcatgca	180
caggctccag	gcaaggggct	ggagtgggtg	gcatttatac	ggtatgtatgg	240
tactacgcag	actccgtgaa	gggccgattc	accatctcca	gagacaattc	300
ctgttatctgc	aatgaacag	cctgagagct	gaggacacgg	ctgtgtat	360
gaccttaatg	actacggtga	cccacccct	tactggggcc	agggAACCT	420
tcctcaggag	gtggcggtc	tggggaggtc	ggtagcggtg	gtggcggtc	480
atgacccagt	ctccatcctc	cctgtctgca	tctgttaggag	acagagtac	540
cgggcaagtc	agagcattag	cagctattta	aatttgtatc	agcagaaaacc	600
cctaagctcc	tgtatctacga	tgcattcaat	ttggaaacag	gggtctcatc	660
ggcagtggat	ctgggacaga	gttcaactctc	accatcagca	gtctgcagcc	720
gcaacttatt	tctgtcaaca	gacttacagt	cccccgatca	ccttcggcca	780
ctggagatta	aacgagcggc	cgcaacgacc	actcctgcac	cccgccctcc	840
ccaaccattg	ccagccagcc	cctgtccctg	cggccggaag	cctgcagacc	900

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ggagccgtcc atacccgggg actggatttc gcctgcgata tctatatctg ggcaccactc      960
gccggaaacct gtggagtgtct gctgtgttcc ctttgtatca ccctgtactg caagcgccga     1020
cgaaagaaac tcttgtacat cttcaagcag ccgttcatgc gccctgtgca aaccacccaa     1080
gaagaggacg ggtgtccctg ccgttcccg gaagaggaag agggcggctg cgaactgcgc     1140
gtgaagttt cccggtccgc cgacgctccg gcgtaccagc aggggcaaaa ccagctgtac     1200
aacgaactta acctcggtcg ccggaaagaa tatgacgtgc tggacaagcg gcgggaaaga     1260
gatcccaga tgggtggaaa gcccggcgg aagaaccctc aggaggcgtt gtacaacgag     1320
ctgcaaaagg acaaataatggc cgaaggctac tccgagatgg gcatgaaggg agagcgcaga     1380
cgccggaaagg gacacgatgg actgtaccag ggactgtcaa ccgcgactaa ggacacttac     1440
gacgcccgtc acatgcaggc cctgcccccg cgc                                         1473

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<210> SEQ ID NO 90
 <211> LENGTH: 491
 <212> TYPE: PRT
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D0085 (Ef1a-BCMA sequence 16 CD8 BBz)

<400> SEQUENCE: 90

```

Met Leu Leu Leu Val Thr Ser Leu Leu Leu Cys Glu Leu Pro His Pro
1           5           10          15

Ala Phe Leu Leu Ile Pro Glu Val Gln Leu Val Gln Ser Gly Gly Gly
20          25          30

Val Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly
35          40          45

Phe Thr Phe Ser Ser Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly
50          55          60

Lys Gly Leu Glu Trp Val Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys
65          70          75          80

Tyr Tyr Ala Asp Ser Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn
85          90          95

Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp
100         105         110

Thr Ala Val Tyr Tyr Cys Ala Arg Asp Leu Asn Asp Tyr Gly Asp Pro
115         120         125

Pro Pro Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Gly Gly
130         135         140

Gly Gly Ser Gly Gly Ser Gly Gly Ser Asp Ile Gln
145         150         155         160

Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly Asp Arg Val
165         170         175

Thr Ile Thr Cys Arg Ala Ser Gln Ser Ile Ser Ser Tyr Leu Asn Trp
180         185         190

Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala
195         200         205

Ser Asn Leu Glu Thr Gly Val Ser Ser Arg Phe Ser Gly Ser Gly Ser
210         215         220

Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe
225         230         235         240

Ala Thr Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly
245         250         255

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Gln Gly Thr Arg Leu Glu Ile Lys Arg Ala Ala Ala Thr Thr Thr Pro
260 265 270

Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln Pro Leu
275 280 285

Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala Val His
290 295 300

Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala Pro Leu
305 310 315 320

Ala Gly Thr Cys Gly Val Leu Leu Ser Leu Val Ile Thr Leu Tyr
325 330 335

Cys Lys Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln Pro Phe
340 345 350

Met Arg Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser Cys Arg
355 360 365

Phe Pro Glu Glu Glu Gly Gly Cys Glu Leu Arg Val Lys Phe Ser
370 375 380

Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu Tyr
385 390 395 400

Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp Lys
405 410 415

Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys Asn
420 425 430

Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met Ala Glu
435 440 445

Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Arg Gly Lys Gly
450 455 460

His Asp Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr Lys Asp Thr Tyr
465 470 475 480

Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
485 490

<210> SEQ ID NO 91
<211> LENGTH: 1476
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0086 (Ef1a-BCMA sequence 37 CD8 BBz) (Ef1a-BCMA sequence 37 CD8 BBz)

<400> SEQUENCE: 91

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atgctgtgc tgggtgaccag cctgtttctg tgcgaaactgc cgcatccggc gtttctgttg      60
attccggagg tgcagctggt ggagtctggg ggaggcttgg tcaagectgg agggtcctg      120
agactctcct gtgcagcgtc tggattcacc ttcaatgtatc atggcatgca ctgggtccgc      180
caggctccag gcaaggggct ggagtgggtg gcatttatac ggtatgtatgg aagtaataaa      240
tactatcgac actccgtgaa gggccgatcc accatctcca gagacaattc caagaacacg      300
ctgttatctgc aaatgaacacg cctgagagct gaggacacgg ctgtgtatata ctgtgcgaaa      360
gattggaaat atatgtggata cgatgcacac ccggatggg gtcaggaaac cctggtcacc      420
gtctcttcag gaggtgggtgg gtctgggtgg ggcggtagcg gtgggtggcgg atccgacatc      480
cagttgaccc agtctccatc ctccctgtct gcatctgttag gagacagagt caccatca      540
tgccggggcaa gtcagggtatc tagcgtgtct ttagcgtgtt atcagcggaa accaggaaaa      600
gctcctaagc tcctgatcta tgatgcctcc agtttggaaa gtggggtccc atcaagggttc      660
agtggcagtg gatctgggac agatctcaact ctcaccatca gcagtcgtca gcctgaagat      720

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tttgcacatt atttctgtca acagacttac agtccccgga tcaccccgga ccaaggaca    780
cgactggaga ttaaacgagc ggccgcaacg accactcctg caccggccc tccgactccg    840
gccccaaacca ttgccagcca gcccctgtcc ctgcggccgg aagcctgcag accggctgcc    900
ggcggagccg tccatacccg gggactggat ttccgcctgcg atatctatat ctgggcacca    960
ctcgcggaa cctgtggagt gctgtgtctg tcccttgtca tcaccctgtta ctgcaagcgc   1020
ggacggaaga aactttgtta catttcaag cagccgttca tgccgcctgt gcaaaccacc   1080
caagaagagg acgggtgtc ctgcgggttc cggaaagagg aagagggccg ctgcgaactg   1140
cgcggtgaagt ttcccggtc cgccgacgt ccggcgtacc agcaggggca aaaccagctg   1200
tacaacgaac ttaacctcggtccggaa gaatatgacg tgctggacaa gcggccggga   1260
agagatcccg agatgggtgg aaagccgcgg cggaaagacc ctcaggaggg cttgtacaac   1320
gagctgcaaa aggacaaaat ggccgaagcc tactccgaga ttggcatgaa gggagagcgc   1380
agacgcggga agggacacga tggactgtac cagggactgt caaccgcgac taaggacact   1440
tacgacgccc tgcacatgca ggccctgccc ccgcgc   1476

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<210> SEQ ID NO 92

<211> LENGTH: 492

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: D0086 (Ef1a-BCMA sequence 37 CD8 BBz) (Ef1a-BCMA sequence 37 CD8 BBz)

<400> SEQUENCE: 92

Met	Leu	Leu	Leu	Val	Thr	Ser	Leu	Leu	Leu	Cys	Glu	Leu	Pro	His	Pro
1				5			10					15			

Ala	Phe	Leu	Leu	Ile	Pro	Glu	Val	Gln	Leu	Val	Glu	Ser	Gly	Gly	Gly
				20			25				30				

Leu	Val	Lys	Pro	Gly	Gly	Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly
		35				40					45				

Phe	Thr	Phe	Ser	Ser	Tyr	Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly
50					55				60						

Lys	Gly	Leu	Glu	Trp	Val	Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys
65				70				75			80				

Tyr	Tyr	Ala	Asp	Ser	Val	Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn
				85			90				95				

Ser	Lys	Asn	Thr	Leu	Tyr	Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp
				100			105				110				

Thr	Ala	Val	Tyr	Tyr	Cys	Ala	Lys	Asp	Trp	Glu	Tyr	Ser	Gly	Tyr	Asp
115				120			125								

Ala	His	Pro	Gly	Trp	Gly	Gln	Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	Gly
130					135				140						

Gly	Gly	Gly	Ser	Gly	Gly	Gly	Ser	Gly	Gly	Gly	Gly	Ser	Asp	Ile	
145				150			155				160				

Gln	Leu	Thr	Gln	Ser	Pro	Ser	Ser	Leu	Ser	Ala	Ser	Val	Gly	Asp	Arg
					165			170			175				

Val	Thr	Ile	Thr	Cys	Arg	Ala	Ser	Gln	Gly	Ile	Ser	Ser	Ala	Leu	Ala
				180			185			190					

Trp	Tyr	Gln	Gln	Lys	Pro	Gly	Lys	Ala	Pro	Lys	Leu	Leu	Ile	Tyr	Asp
195					200				205						

Ala	Ser	Ser	Leu	Glu	Ser	Gly	Val	Pro	Ser	Arg	Phe	Ser	Gly	Ser	Gly
210					215				220						

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Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp
225 230 235 240

Phe Ala Thr Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe
245 250 255

Gly Gln Gly Thr Arg Leu Glu Ile Lys Arg Ala Ala Ala Thr Thr Thr
260 265 270

Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln Pro
275 280 285

Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala Val
290 295 300

His Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala Pro
305 310 315 320

Leu Ala Gly Thr Cys Gly Val Leu Leu Ser Leu Val Ile Thr Leu
325 330 335

Tyr Cys Lys Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln Pro
340 345 350

Phe Met Arg Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser Cys
355 360 365

Arg Phe Pro Glu Glu Glu Gly Gly Cys Glu Leu Arg Val Lys Phe
370 375 380

Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu
385 390 395 400

Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp
405 410 415

Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys
420 425 430

Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met Ala
435 440 445

Glu Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Arg Gly Lys
450 455 460

Gly His Asp Gly Leu Tyr Gln Gln Gly Leu Ser Thr Ala Thr Lys Asp Thr
465 470 475 480

Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
485 490

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<210> SEQ ID NO 93
<211> LENGTH: 1479
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0087_LTG2092 (Ef1a-BCMA sequence 40 CD8 BBz)

<400> SEQUENCE: 93

atgtctgtgc tggtgaccag cctggttctg tgcgaaactgc cgcatccggc gtttcttctg     60
attccggagg tgcagctggt gcagtctggg ggaggcggtgg tccagctgg ggggtccctg     120
agactctcct gtgcagcgtc tggattcacc ttcaagtagct atggcatgca ctgggtccgc     180
caggctccag gcaaggggct ggagtgggtg gcatttatac ggtatgtatgg aagtaataaa     240
tactacgcag actccgtgaa gggccgattc accatctcca gagacaattc caagaacacg     300
ctgttatctgc aatgaacag cctgagagct gaggacacgg ctgtgtattna ctgtgcgaaa     360
gaaccccccg agtattacta tgatagtagt ggttattctg ggggccaggg aaccctggtc     420
accgtctcct caggaggtgg cgggtctgg ggaggcggtt ggggtggc cggatccgac     480
atccagttga cccagttcc atcctccctg tctgcatttg taggagacag agtcaccatc     540

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acttgccagg cgagtcagga cattgacacc tatttaaact ggtatcagca gaaaccaggg	600
aaagcccccta agctcctgat ctatgctgca tccagttgc aaagtggggt ctcatcaagg	660
ttcagtgcca gtggatctgg gacagagttc actctcacca tcagcagtct gcagcctgaa	720
gattttgcaa cttatttctg tcaacagact tacagcccc ccatcacctt cggccaaggg	780
acacgactgg agattaaacg agcggccgca acgaccactc ctgcaccccg ccctccgact	840
ccggccccaa ccattgccag ccagccccctg tccctgcggc cggaaagccctg cagaccggct	900
gccccgggag ccgtccatac cccggggactg gatttcgcct gcatatatcta tatctggca	960
ccactcgcgg agaacctgtgg agtgcgtct ctgtcccttg tgatcacctt gtactgcaag	1020
cggggacgga agaaaactctt gtacatcttc aagcagccgt tcatgegccc tgtgcaaaacc	1080
acccaagaag aggacgggtg ctccctgcgg tccccggaaag aggaagaggg cggctgcgaa	1140
ctgcgcgtga agttttcccg gtcggccgac gctccggcgt accagcaggg gcaaaaccag	1200
ctgtacaacg aacttaaacct cggtgccgg gaagaatatgc acgtgcgtgg caagcggcgg	1260
ggaagagatc ccgagatggg tggaaagccg cggccgaaaga accctcagga gggcttgtac	1320
aacgagactgc aaaaggacaa aatggccgaa gcctactccg agattggcat gaagggagag	1380
cgcagacgacg ggaaggggaca cgatggactg taccaggac tgtcaaccgc gactaaggac	1440
acttacgacg ccctgcacat gcaggccctg ccccccgcgc	1479

<210> SEQ ID NO 94

<211> LENGTH: 493

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: D0087_LTG2092 (Ef1a-BCMA sequence 40 CD8 BBz)

<400> SEQUENCE: 94

Met Leu Leu Leu Val Thr Ser Leu Leu Leu Cys Glu Leu Pro His Pro			
1	5	10	15

Ala Phe Leu Leu Ile Pro Glu Val Gln Leu Val Gln Ser Gly Gly		
20	25	30

Val Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly		
35	40	45

Phe Thr Phe Ser Ser Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly		
50	55	60

Lys Gly Leu Glu Trp Val Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys			
65	70	75	80

Tyr Tyr Ala Asp Ser Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn		
85	90	95

Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp		
100	105	110

Thr Ala Val Tyr Tyr Cys Ala Lys Glu Pro Pro Glu Tyr Tyr Tyr Asp		
115	120	125

Ser Ser Gly Tyr Ser Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser		
130	135	140

Gly Gly Gly Ser Gly Gly Ser Gly Gly Ser Gly Gly Ser Asp			
145	150	155	160

Ile Gln Leu Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly Asp		
165	170	175

Arg Val Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Asp Thr Tyr Leu		
180	185	190

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Asn Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr
 195 200 205
 Ala Ala Ser Ser Leu Gln Ser Gly Val Ser Ser Arg Phe Ser Gly Ser
 210 215 220
 Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu
 225 230 235 240
 Asp Phe Ala Thr Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr
 245 250 255
 Phe Gly Gln Gly Thr Arg Leu Glu Ile Lys Arg Ala Ala Thr Thr
 260 265 270
 Thr Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln
 275 280 285
 Pro Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala
 290 295 300
 Val His Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala
 305 310 315 320
 Pro Leu Ala Gly Thr Cys Gly Val Leu Leu Ser Leu Val Ile Thr
 325 330 335
 Leu Tyr Cys Lys Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln
 340 345 350
 Pro Phe Met Arg Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser
 355 360 365
 Cys Arg Phe Pro Glu Glu Glu Gly Cys Glu Leu Arg Val Lys
 370 375 380
 Phe Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln
 385 390 395 400
 Leu Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu
 405 410 415
 Asp Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg
 420 425 430
 Lys Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met
 435 440 445
 Ala Glu Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Arg Gly
 450 455 460
 Lys Gly His Asp Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr Lys Asp
 465 470 475 480
 Thr Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
 485 490

<210> SEQ ID NO 95
 <211> LENGTH: 1476
 <212> TYPE: DNA
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D0099_LTG2944 (Ef1a-BCMA sequence 4-12 CD8 BBz)
 <400> SEQUENCE: 95

atgcgtgtgc	tggtgaccag	cctgtgtctg	tgcgaactgc	cgcacccggc	gtttctgtcg	60
attccgcagg	tgcagctgg	gcagtctggg	ggaggcggtgg	tccagctgg	ggggtcctg	120
agactctcct	gtgcagccctc	tggattcacc	ttagttagt	acgttataca	ttgggtccgc	180
caggctccag	gcaaggggct	ggagtgggtg	gcagctatat	cgcatgtgg	aagcaataaa	240
tactacgcag	actccgtgaa	gggccgattc	accatctcca	gagacaattc	caagaacacg	300
ctgttatcttc	aatgagcag	tctgagcgct	gaggacacgg	ctatgttatta	ctgtgtgaaa	360

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actagtagtg attattacta cgccctactgg ggccaggaa ccctggtcac cgtctcctca    420
ggagggcg ggtctggtgg aggeggtagc ggtgggtggc gatcccagac tgggtgact    480
caggagccat cgttctcagt gtcccctgga gggacagtca cactcactg tggcttgcg     540
tctggctcag tctctactgg caactcccc acctggtacc agcagacccc aggccaggct   600
ccacgcacgc tcatactacag cacaacact cgctcttctg gggctccctga tcgcttctct  660
ggctccatcc ttggaaacaa agctgccctc accatcaegg gggcccaggc agatgtgaa   720
tctgattatt actgtgtgct gtatatgggt agtggctatt ggggtttcgg cggagggacc  780
aagggtcaccc tccttaggtgc ggccgcaacg accactctcg caccccgccc tccgactccg 840
gcccccaacca ttgccagcca gccccctgtcc ctgcggccgg aagcctgcag accggctgcc 900
ggcggagccg tccatacccg gggactggat ttgcctgcg atatctatat ctgggcacca  960
ctcgccggaa cctgtggagt gctgctgctg tcccttgcgta tcaccctgta ctgcaagcgc 1020
ggacggaaga aactcttgcgta catcttcaag cagccgttca tgcccccgt gcaaaccacc 1080
caagaagagg acgggtgctc ctgcgggttc cccgaagagg aagaggccgg ctgcgaactg 1140
cgcgtaagt tttcccggtc cggcgacgct cggcggtacc agcaggggca aaaccagctg 1200
tacaacgaac ttaacctcgg tcgccccggaa gaatatgacg tgctggacaa gcggccggga 1260
agagatcccg agatgggtgg aaagccgcgg cggagaacc ctcaggaggg cttgtacaac 1320
gagctgcaaa aggacaaaat ggccgaagcc tactccgaga ttggcatgaa gggagagcgc 1380
agacgcggga agggacacga tggactgtac cagggactgt caaccgcgac taaggacact 1440
tacgacgccc tgcacatgca ggccctgccc ccgcgc                                1476

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<210> SEQ_ID NO 96
<211> LENGTH: 492
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0099_LTG2944 (Ef1a-BCMA sequence 4-12 CD8 BBz)

<400> SEQUENCE: 96

Met	Leu	Leu	Leu	Val	Thr	Ser	Leu	Leu	Leu	Cys	Glu	Leu	Pro	His	Pro
1				5			10				15				

Ala	Phe	Leu	Leu	Ile	Pro	Gln	Val	Gln	Leu	Val	Gln	Ser	Gly	Gly	Gly
				20			25				30				

Val	Val	Gln	Pro	Gly	Gly	Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly
		35				40				45					

Phe	Thr	Phe	Ser	Ser	Tyr	Val	Ile	His	Trp	Val	Arg	Gln	Ala	Pro	Gly
50					55				60						

Lys	Gly	Leu	Glu	Trp	Val	Ala	Ala	Ile	Ser	His	Asp	Gly	Ser	Asn	Lys
65					70				75		80				

Tyr	Tyr	Ala	Asp	Ser	Val	Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn
					85			90			95				

Ser	Lys	Asn	Thr	Leu	Tyr	Leu	Gln	Met	Ser	Ser	Leu	Ser	Ala	Glu	Asp
						100			105		110				

Thr	Ala	Met	Tyr	Tyr	Cys	Val	Lys	Thr	Ser	Ser	Asp	Tyr	Tyr	Tyr	Ala
		115				120				125					

Tyr	Trp	Gly	Gln	Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	Gly	Gly	Gly	Gly
		130				135				140					

Ser	Gly	Gly	Gly	Ser	Gly	Gly	Ser	Gln	Thr	Val	Val	Thr			
145					150			155		160					

Gln	Glu	Pro	Ser	Phe	Ser	Val	Ser	Pro	Gly	Gly	Thr	Val	Thr	Leu	Thr
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

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165	170	175	
Cys Gly Leu Ser Ser Gly Ser Val Ser Thr Gly Asn Ser Pro Thr Trp			
180	185	190	
Tyr Gln Gln Thr Pro Gly Gln Ala Pro Arg Thr Leu Ile Tyr Ser Thr			
195	200	205	
Asn Thr Arg Ser Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Ile Leu			
210	215	220	
Gly Asn Lys Ala Ala Leu Thr Ile Thr Gly Ala Gln Ala Asp Asp Glu			
225	230	235	240
Ser Asp Tyr Tyr Cys Val Leu Tyr Met Gly Ser Gly Tyr Trp Val Phe			
245	250	255	
Gly Gly Gly Thr Lys Val Thr Val Leu Gly Ala Ala Ala Thr Thr Thr			
260	265	270	
Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln Pro			
275	280	285	
Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala Val			
290	295	300	
His Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala Pro			
305	310	315	320
Leu Ala Gly Thr Cys Gly Val Leu Leu Leu Ser Leu Val Ile Thr Leu			
325	330	335	
Tyr Cys Lys Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln Pro			
340	345	350	
Phe Met Arg Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser Cys			
355	360	365	
Arg Phe Pro Glu Glu Glu Gly Gly Cys Glu Leu Arg Val Lys Phe			
370	375	380	
Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu			
385	390	395	400
Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp			
405	410	415	
Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys			
420	425	430	
Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met Ala			
435	440	445	
Glu Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Arg Gly Lys			
450	455	460	
Gly His Asp Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr Lys Asp Thr			
465	470	475	480
Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg			
485	490		

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<210> SEQ_ID NO 97
<211> LENGTH: 1467
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: D0100_LTG2945 (Ef1a-BCMA sequence 4-45 CD8 BBz)

<400> SEQUENCE: 97

atgctgctgc tgggtgaccag cctgctgctg tgcgaactgc cgcatccggc gtttctgctg      60
attccggagg tgcagctgggt gcagtctggg gctgagggtga agaaggctgg ggcctcatgt      120
aagggttcct gcaaggcata tggatacaccc tccaccagct actatatgca ctgggtgcga      180
caggccccctg gacaagggtct tgagtggatg ggaataatca acccttagtgg tggtagcaca      240

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agctacgcac agaagttcca gggcagagtc accatgacca gggacacgtc cacgagcaca      300
gtctacatgg agctgagcag ctttagatctt gaggacacgg ccgtgtattt ctgtgcgaga      360
gatttgggtg atggcgctt tgatatctgg ggccaaggaa caatggcac cgtctttca      420
ggagggccg ggtctgggtgg aggccgttgc ggtggtggcg gatccgacat ccagatgacc      480
cagtctctat cttccctgtc tgcattgtt ggagacagag tcaccatcgc ttggccggca      540
agtcagacca ttagtaggta tttaaattgg tatcagcaga aaccaggaa agccctaag      600
ctcctgtatc atgctgcata cagtttgc aaatgggtctt catcaagggtt cagtggcagt      660
ggatctggga cagatctcac tctcaccatc agcagtctgc agcctgaaga ttttgcact      720
tatttctgtc aacagactta cagccccccg atcaccttcg gccaaggaa acgactggag      780
attaaacgag cggccgcaac gaccactctt gcaccccccctt ccggactcc gggcccaacc      840
attgccagcc agccccctgtc cctggggccg gaaggctgca gaccggctgc cggccggagcc      900
gtccataccccc ggggacttggaa ttgcgttgc gatatctata tctgggacc actggccggaa      960
acctgtggag tgctgtgtgt gtcccttgc atcacctgtt actgcaagcg cggacggaaag      1020
aaactcttgtt acatcttcaa gcacgcgttc atgcggccctt tgcaaaaccac ccaagaagag      1080
gacgggtgtt cctggccgtt cccggaaagag gaagagggcg gtcgtcaact gtcgtgtt      1140
ttttcccggtt cccggacgc tccggcgtac cagcaggggc aaaaccagct gtacaacgaa      1200
cttaacctcg gtggccggga agaatatgac gtgtggaca agcggccggg aagagatccc      1260
gagatgggtg gaaagccgcg gccaagaac cctcaggagg gtcgttacaa cgacgtgca      1320
aaggacaaaa tggccgaagc ctactccgag attggcatga agggagagcg cagacgcggg      1380
aaggacacg atggactgtt ccaggactg tcaaccgcg ctaaggacac ttacgacgccc      1440
ctgcacatgc agggccctgcc cccgcgc      1467

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<210> SEQ ID NO 98

<211> LENGTH: 489

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: D0100_LTG2945 (Ef1a-BCMA sequence 4-45 CD8 BBz)

<400> SEQUENCE: 98

Met	Leu	Leu	Leu	Val	Thr	Ser	Leu	Leu	Leu	Cys	Glu	Leu	Pro	His	Pro
1				5				10					15		

Ala	Phe	Leu	Leu	Ile	Pro	Glu	Val	Gln	Leu	Val	Gln	Ser	Gly	Ala	Glu
				20			25			30					

Val	Lys	Lys	Pro	Gly	Ala	Ser	Val	Lys	Val	Ser	Cys	Lys	Ala	Ser	Gly
				35			40			45					

Tyr	Thr	Ser	Thr	Ser	Tyr	Tyr	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly
					50		55		60						

Gln	Gly	Leu	Glu	Trp	Met	Gly	Ile	Ile	Asn	Pro	Ser	Gly	Gly	Ser	Thr
				65			70		75			80			

Ser	Tyr	Ala	Gln	Lys	Phe	Gln	Gly	Arg	Val	Thr	Met	Thr	Arg	Asp	Thr
					85		90		95						

Ser	Thr	Ser	Thr	Val	Tyr	Met	Glu	Leu	Ser	Ser	Leu	Arg	Ser	Glu	Asp
				100			105			110					

Thr	Ala	Val	Tyr	Tyr	Cys	Ala	Arg	Asp	Leu	Gly	Asp	Gly	Ala	Phe	Asp
					115		120		125						

Ile	Trp	Gly	Gln	Gly	Thr	Met	Val	Thr	Val	Ser	Ser	Gly	Gly	Gly	Gly
					130		135		140						

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Ser Gly Gly Gly Ser Gly Gly Gly Ser Asp Ile Gln Met Thr
 145 150 155 160

Gln Ser Leu Ser Ser Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile
 165 170 175

Ala Cys Arg Ala Ser Gln Thr Ile Ser Arg Tyr Leu Asn Trp Tyr Gln
 180 185 190

Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser
 195 200 205

Leu Gln Ser Gly Val Ser Ser Arg Phe Ser Gly Ser Gly Thr
 210 215 220

Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr
 225 230 235 240

Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly Gln Gly
 245 250 255

Thr Arg Leu Glu Ile Lys Arg Ala Ala Ala Thr Thr Thr Pro Ala Pro
 260 265 270

Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln Pro Leu Ser Leu
 275 280 285

Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala Val His Thr Arg
 290 295 300

Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala Pro Leu Ala Gly
 305 310 315 320

Thr Cys Gly Val Leu Leu Ser Leu Val Ile Thr Leu Tyr Cys Lys
 325 330 335

Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln Pro Phe Met Arg
 340 345 350

Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser Cys Arg Phe Pro
 355 360 365

Glu Glu Glu Gly Gly Cys Glu Leu Arg Val Lys Phe Ser Arg Ser
 370 375 380

Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu Tyr Asn Glu
 385 390 395 400

Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp Lys Arg Arg
 405 410 415

Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys Asn Pro Gln
 420 425 430

Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met Ala Glu Ala Tyr
 435 440 445

Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Gly Lys Gly His Asp
 450 455 460

Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr Lys Asp Thr Tyr Asp Ala
 465 470 475 480

Leu His Met Gln Ala Leu Pro Pro Arg
 485

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<210> SEQ ID NO 99
 <211> LENGTH: 1485
 <212> TYPE: DNA
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D0153 (BCMA 4-1c CD8 BBz)

<400> SEQUENCE: 99

atgctgctgc tggtgaccag cctgctgctg tgcgaactgc cgcatccggc gtttctgctg 60

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attccggagg	tgca	ctgggt	ggagacccggg	ggaggcgtgg	tccagectgg	ggggtcctg	120
agactctct	gtgc	cacgcgtc	tggattcacc	ttagtgcgt	atggcatgca	ctgggtccgc	180
caggctccag	gca	aggggct	ggagtgggtg	gcatttatac	ggtatgtatgg	aagtaataaa	240
tactacgcag	actccgtgaa	gggccgatc	accatctcca	gagacaatc	caagaacacg		300
ctgtatctgc	aatgaacag	cctgagagct	gaggacacgg	ctgtgtat	ctgtgcgaaa		360
gattggata	cgtattacta	ttagtgcgt	ggttatgatc	gggcctgggg	ccagggaaacc		420
ctggtcaccc	tctcctcagg	agg	ggcgccggg	tctggtgag	gcccgtacgg	ttgtggcgga	480
tccgacatcc	agatgaccca	gtctccctcc	tccctgtctg	catctgtagg	agacagagtc		540
accatca	ccaggcgcag	tcaggacatt	aacaactatt	taaattggta	tcagcagaaa		600
ccagggaaag	cccctaagct	cctgtatctat	gctgcaccca	gttgcaaaag	ttgggtctca		660
tcaagggttca	gtggcagtgg	atctggaca	gagttcactc	tcaccatcag	cagtctgcag		720
cctgaagatt	ttgcaactt	tttctgtcaa	cagacttaca	gtcccccgat	caccccccgc		780
caagggacac	gactggagat	taaacggacg	gcccacacg	ccactctgc	accccccct		840
ccgactccgg	cccccaaccat	tgccagccag	ccccctgtcc	tgccgcggg	agcctgcaga		900
ccggctgcgg	goggagccgt	ccatacccg	ggactggatt	tcgcctgcga	tatctatatc		960
tgggcaccac	tcgcccgaac	ctgtggagt	ctgctgtgt	cccttgtat	caccctgtac		1020
tgcaagcgcg	gacggaaagaa	actcttgc	atcttcaac	agccgttcat	gcgcctgt		1080
caaaccaccc	aagaagagga	cgggtgtcc	tgccgttcc	cggaaagagga	agagggccgc		1140
tgcgaaactgc	gcgtgaagtt	ttcccggtcc	gcccacgctc	cggcgtacca	gcagggccaa		1200
aaccagctgt	acaacgaact	taacctcggt	cggcggaaag	aatatgacgt	gtggacaag		1260
cggcggggaa	gagatcccga	gatgggtgg	aagccgcggc	ggaagaaccc	tcaggaggc		1320
ttgtacaacg	agctgc	aaaaatg	gccgaagct	actccgagat	tggcatgaag		1380
ggagagcgc	gacgcgggaa	gggacacgt	ggactgtacc	agggactgtc	aaccgcgact		1440
aaggacactt	acgacgc	ccctgcac	gcacatgcag	ccctgc	cgcgc		1485

<210> SEQ ID NO 100

<211> LENGTH: 495

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: D0153 (BCMA 4-1c CD8 BBz)

<400> SEQUENCE: 100

Met	Leu	Leu	Leu	Val	Thr	Ser	Leu	Leu	Cys	Glu	Leu	Pro	His	Pro
1							5	10			15			

Ala	Phe	Leu	Leu	Ile	Pro	Glu	Val	Gln	Leu	Val	Glu	Thr	Gly	Gly
							20		25		30			

Val	Val	Gln	Pro	Gly	Gly	Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly
							35		40		45				

Phe	Thr	Phe	Ser	Ser	Tyr	Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly
							50		55		60				

Lys	Gly	Leu	Glu	Trp	Val	Ala	Phe	Ile	Arg	Tyr	Asp	Gly	Ser	Asn	Lys
							65		70		75		80		

Tyr	Tyr	Ala	Asp	Ser	Val	Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn
							85		90		95				

Ser	Lys	Asn	Thr	Leu	Tyr	Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp
							100		105		110				

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Thr Ala Val Tyr Tyr Cys Ala Lys Asp Trp Asp Thr Tyr Tyr Tyr Asp
 115 120 125
 Ser Ser Gly Tyr Asp Arg Ala Trp Gly Gln Gly Thr Leu Val Thr Val
 130 135 140
 Ser Ser Gly Gly Gly Ser Gly Gly Gly Ser Gly Gly Gly Gly
 145 150 155 160
 Ser Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val
 165 170 175
 Gly Asp Arg Val Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Asn Asn
 180 185 190
 Tyr Leu Asn Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu
 195 200 205
 Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Ser Ser Arg Phe Ser
 210 215 220
 Gly Ser Gly Ser Gly Thr Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln
 225 230 235 240
 Pro Glu Asp Phe Ala Thr Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro
 245 250 255
 Ile Thr Phe Gly Gln Gly Thr Arg Leu Glu Ile Lys Arg Ala Ala Ala
 260 265 270
 Thr Thr Thr Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala
 275 280 285
 Ser Gln Pro Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly
 290 295 300
 Gly Ala Val His Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile
 305 310 315 320
 Trp Ala Pro Leu Ala Gly Thr Cys Gly Val Leu Leu Leu Ser Leu Val
 325 330 335
 Ile Thr Leu Tyr Cys Lys Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe
 340 345 350
 Lys Gln Pro Phe Met Arg Pro Val Gln Thr Thr Gln Glu Glu Asp Gly
 355 360 365
 Cys Ser Cys Arg Phe Pro Glu Glu Glu Gly Gly Cys Glu Leu Arg
 370 375 380
 Val Lys Phe Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln
 385 390 395 400
 Asn Gln Leu Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp
 405 410 415
 Val Leu Asp Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Lys Pro
 420 425 430
 Arg Arg Lys Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp
 435 440 445
 Lys Met Ala Glu Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg Arg
 450 455 460
 Arg Gly Lys Gly His Asp Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr
 465 470 475 480
 Lys Asp Thr Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
 485 490 495

<210> SEQ ID NO 101
 <211> LENGTH: 2142
 <212> TYPE: DNA
 <213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D158 (BCMA 4-45 CD8 BBz 2A TGFBRIIdn)

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-continued

<400> SEQUENCE: 101

atgctgtgc	tgggtgaccag	cctgtgtcg	tgcgaaactgc	cgcattccggc	60
attccggagg	tgcagctgg	gcagtctggg	gctgaggtga	agaagcctgg	120
aaggtttct	gcaaggcata	tggatacaccc	tccaccagct	actatatgca	180
caggccccctg	gacaagggct	tgagtggatg	ggaataatca	accctagttg	240
agctacgcac	agaagttca	gggcagagtc	accatgacca	gggacacgac	300
gtctacatgg	agctgaggcag	ctttagatct	gaggacacgg	ccgtgttata	360
gatttgggtg	atggcgctt	tgatatctgg	ggccaaggga	aatggtcac	420
ggaggtggcg	ggtctggtgg	aggcggttgc	ggtggtggcg	gatccgacat	480
cagtcttat	cctccctgtc	tgcatctgt	ggagacagag	tcaccatcgc	540
agtcagacca	ttagtaggt	tttaaattgg	tatcagcaga	aaccaggaa	600
ctcctgtat	atgctgcata	cagtttgc	agtgggtct	catcaagg	660
ggatctggga	cagagttcac	tctcaccatc	agcagttcgc	agcctgaaga	720
tatttctgtc	aacagactta	cagtccttc	atcaccttc	gccaaggac	780
attnaacagag	ggggcgctac	cacaacccc	gcccggggc	ctccatcccc	840
attgcttc	aaccttttc	actccgac	gaggctgt	gacctgcac	900
gtccacacac	ggggactcga	cttcgctt	gatataata	tttggggccc	960
acttgtggag	ttcttttgc	ctctttgtt	atcacattt	actgcaagcg	1020
aaattgtttt	acattttaa	gcagccgtt	atgcgacc	tacagactac	1080
gatgggtgt	cttgcgggtt	cccgaaagaa	gaagagggt	gttgcgagtt	1140
ttctcccgct	ctggcgacgc	accggcatat	cagcaggac	aaaaccag	1200
ttgaacctgg	gtcggeggga	agaatatgac	gtgctcgata	agcggegggg	1260
gaaatgggag	gcaaaccgc	caggaaaaat	ccacaggagg	gacttataa	1320
aaggataaga	tggcagaggc	atacagcga	atcggatg	aaggcgag	1380
aaagggcac	atggctttt	ccagggctt	tctaccgca	cgaaggatac	1440
ctccatatgc	aagacttcc	tccttagacgg	gcaaaageggg	gctcaggggc	1500
tcactgttga	agcaggccgg	ggatgtggag	gagaatctg	gtcctagac	1560
gacatggaa	gagggtgt	ccgaggctt	tggccgttgc	atattgtt	1620
atagcgagta	caatcccgc	tcacgtcga	aaatcgtt	ataacgac	1680
gacaacaatg	gcfgcgtt	attccgcag	cttgcataa	tctgtgtat	1740
acgtgcgata	accagaaaa	ctgtatgtcc	aactgcac	tcacatca	1800
ccccaaagg	tatgtgtggc	cgtctggcga	aagaatgac	aaaatatcac	1860
gtttgtc	atcctaaact	cccttatcat	gactttattc	tggaaagac	1920
aagtgtataa	tgaaagagaa	gaagaagcct	ggagagac	tttcatgt	1980
tcagatgagt	gtaatgacaa	catcat	tccgaggagt	acaatacg	2040
ctcctgtgg	ttatccca	ggtaaccggc	atcagttt	tgccccact	2100
atcagtgtaa	taatcatatt	ttattgttac	cgggtgtat	aa	2142

<210> SEQ ID NO 102

<211> LENGTH: 712

<212> TYPE: PRT

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161**162**

-continued

<213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: D158 (BCMA 4-45 CD8 BBz 2A TGFBR1Idn)

<400> SEQUENCE: 102

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Met Leu Leu Leu Val Thr Ser Leu Leu Leu Cys Glu Leu Pro His Pro
1           5           10          15

Ala Phe Leu Leu Ile Pro Glu Val Gln Leu Val Gln Ser Gly Ala Glu
20          25          30

Val Lys Pro Gly Ala Ser Val Lys Val Ser Cys Lys Ala Ser Gly
35          40          45

Tyr Thr Ser Thr Ser Tyr Tyr Met His Trp Val Arg Gln Ala Pro Gly
50          55          60

Gln Gly Leu Glu Trp Met Gly Ile Ile Asn Pro Ser Gly Gly Ser Thr
65          70          75          80

Ser Tyr Ala Gln Lys Phe Gln Gly Arg Val Thr Met Thr Arg Asp Thr
85          90          95

Ser Thr Ser Thr Val Tyr Met Glu Leu Ser Ser Leu Arg Ser Glu Asp
100         105         110

Thr Ala Val Tyr Tyr Cys Ala Arg Asp Leu Gly Asp Gly Ala Phe Asp
115         120         125

Ile Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser Gly Gly Gly
130         135         140

Ser Gly Gly Gly Ser Gly Gly Gly Ser Asp Ile Gln Met Thr
145         150         155         160

Gln Ser Leu Ser Ser Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile
165         170         175

Ala Cys Arg Ala Ser Gln Thr Ile Ser Arg Tyr Leu Asn Trp Tyr Gln
180         185         190

Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser
195         200         205

Leu Gln Ser Gly Val Ser Ser Arg Phe Ser Gly Ser Gly Thr
210         215         220

Glu Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr
225         230         235         240

Tyr Phe Cys Gln Gln Thr Tyr Ser Pro Pro Ile Thr Phe Gly Gln Gly
245         250         255

Thr Arg Leu Glu Ile Lys Arg Ala Ala Ala Thr Thr Thr Pro Ala Pro
260         265         270

Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala Ser Gln Pro Leu Ser Leu
275         280         285

Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly Gly Ala Val His Thr Arg
290         295         300

Gly Leu Asp Phe Ala Cys Asp Ile Tyr Ile Trp Ala Pro Leu Ala Gly
305         310         315         320

Thr Cys Gly Val Leu Leu Ser Leu Val Ile Thr Leu Tyr Cys Lys
325         330         335

Arg Gly Arg Lys Lys Leu Leu Tyr Ile Phe Lys Gln Pro Phe Met Arg
340         345         350

Pro Val Gln Thr Thr Gln Glu Glu Asp Gly Cys Ser Cys Arg Phe Pro
355         360         365

Glu Glu Glu Gly Gly Cys Glu Leu Arg Val Lys Phe Ser Arg Ser
370         375         380

Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu Tyr Asn Glu

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-continued

385	390	395	400
Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val	Leu Asp Lys Arg Arg		
405	410	415	
Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg	Lys Asn Pro Gln		
420	425	430	
Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met	Ala Glu Ala Tyr		
435	440	445	
Ser Glu Ile Gly Met Lys Gly Glu Arg Arg Arg	Gly Lys Gly His Asp		
450	455	460	
Gly Leu Tyr Gln Gly Leu Ser Thr Ala Thr Lys Asp	Thr Tyr Asp Ala		
465	470	475	480
Leu His Met Gln Ala Leu Pro Pro Arg Arg Ala Lys	Arg Gly Ser Gly		
485	490	495	
Ala Thr Asn Phe Ser Leu Leu Lys Gln Ala Gly Asp	Val Glu Glu Asn		
500	505	510	
Pro Gly Pro Arg Ala Lys Arg Val Asp Met Gly Arg	Gly Leu Leu Arg		
515	520	525	
Gly Leu Trp Pro Leu His Ile Val Leu Trp Thr Arg	Ile Ala Ser Thr		
530	535	540	
Ile Pro Pro His Val Gln Lys Ser Val Asn Asn Asp	Met Ile Val Thr		
545	550	555	560
Asp Asn Asn Gly Ala Val Lys Phe Pro Gln Leu Cys	Lys Phe Cys Asp		
565	570	575	
Val Arg Phe Ser Thr Cys Asp Asn Gln Lys Ser Cys	Met Ser Asn Cys		
580	585	590	
Ser Ile Thr Ser Ile Cys Glu Lys Pro Gln Glu Val	Cys Val Ala Val		
595	600	605	
Trp Arg Lys Asn Asp Glu Asn Ile Thr Leu Glu Thr	Val Cys His Asp		
610	615	620	
Pro Lys Leu Pro Tyr His Asp Phe Ile Leu Glu Asp	Ala Ala Ser Pro		
625	630	635	640
Lys Cys Ile Met Lys Glu Lys Lys Pro Gly Glu Thr	Phe Phe Met		
645	650	655	
Cys Ser Cys Ser Ser Asp Glu Cys Asn Asp Asn Ile	Ile Phe Ser Glu		
660	665	670	
Glu Tyr Asn Thr Ser Asn Pro Asp Leu Leu Leu Val	Ile Phe Gln Val		
675	680	685	
Thr Gly Ile Ser Leu Leu Pro Pro Leu Gly Val Ala	Ile Ser Val Ile		
690	695	700	
Ile Ile Phe Tyr Cys Tyr Arg Val			
705	710		

<210> SEQ ID NO 103

<211> LENGTH: 372

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: Binder 4-1c VH

<400> SEQUENCE: 103

gaggtgcagc tggtgagac cggggaggc gtggccagc ctgggggtc cctgagactc	60
tccctgtcgat cgtctggatt cacttcagt agctatggca tgcactgggt ccgccaggct	120
ccaggcaagg ggctggagt ggtggcattt atacggtagt atggaagtaa taaatactac	180
gcagactccg tgaaggcccg attcaccatc tccagagaca attccaagaa cacgctgtat	240

-continued

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ctgcaaatga acagcctgag agctgaggac acggctgtgt attactgtgc gaaagattgg      300
gatacgtatt actatgatag tagtggttat gatcggccct ggggccaggg aaccctggtc      360
accgtctcct ca                                         372

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<210> SEQ ID NO 104
<211> LENGTH: 124
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: Binder 4-1c VH

<400> SEQUENCE: 104

Glu Val Gln Leu Val Glu Thr Gly Gly Val Val Gln Pro Gly Gly
1           5           10          15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr
20          25          30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
35          40          45

Ala Phe Ile Arg Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val
50          55          60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
65          70          75          80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
85          90          95

Ala Lys Asp Trp Asp Thr Tyr Tyr Asp Ser Ser Gly Tyr Asp Arg
100         105         110

Ala Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser
115         120

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<210> SEQ ID NO 105
<211> LENGTH: 326
<212> TYPE: DNA
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: Binder 4-1c VL

<400> SEQUENCE: 105

gacatccaga tgacccagtc tccctcctcc ctgtctgcat ctgttaggaga cagagtccacc      60
atcacttgcc aggcgagtca ggacattnaac aactattaa attggtatca gcagaaaacca      120
ggaaagcccc ctaagtcct gatctatgtc gcatccaggat tgcaaagtgg ggtctcatca      180
aggttcagtg gcagtggtatc tggcacagag ttcaactctca ccatcagcag tctgcagcct      240
gaagattttg caacttattt ctgtcaacag acttacagtc ccccgatcac cttcggccaa      300
gggacacgac tggagattaa acgagc                                         326

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<210> SEQ ID NO 106
<211> LENGTH: 108
<212> TYPE: PRT
<213> ORGANISM: Artificial
<220> FEATURE:
<223> OTHER INFORMATION: Binder 4-1c VL

<400> SEQUENCE: 106

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Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly
1           5           10          15

Asp Arg Val Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Asn Asn Tyr
20          25          30

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-continued

Leu	Asn	Trp	Tyr	Gln	Gln	Lys	Pro	Gly	Lys	Ala	Pro	Lys	Leu	Leu	Ile
35						40						45			

Tyr	Ala	Ala	Ser	Ser	Leu	Gln	Ser	Gly	Val	Ser	Ser	Arg	Phe	Ser	Gly
50						55						60			

Ser	Gly	Ser	Gly	Thr	Glu	Phe	Thr	Leu	Thr	Ile	Ser	Ser	Leu	Gln	Pro
65						70				75				80	

Glu	Asp	Phe	Ala	Thr	Tyr	Phe	Cys	Gln	Gln	Thr	Tyr	Ser	Pro	Pro	Ile
85								90				95			

Thr	Phe	Gly	Gln	Gly	Thr	Arg	Leu	Glu	Ile	Lys	Arg				
100										105					

<210> SEQ ID NO 107

<211> LENGTH: 90

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: Furin P2A Furin

<400> SEQUENCE: 107

cgggcaaagc	ggggctcagg	ggcgactaac	ttttactgt	tgaagcaggc	cggggatgtg	60
gaggagaatc	ctggtcttag	agctaagcga				90

<210> SEQ ID NO 108

<211> LENGTH: 30

<212> TYPE: PRT

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: Furin P2A Furin

<400> SEQUENCE: 108

Arg	Ala	Lys	Arg	Gly	Ser	Gly	Ala	Thr	Asn	Phe	Ser	Leu	Leu	Lys	Gln
1							5		10			15			

Ala	Gly	Asp	Val	Glu	Glu	Asn	Pro	Gly	Pro	Arg	Ala	Lys	Arg		
			20				25				30				

<210> SEQ ID NO 109

<211> LENGTH: 573

<212> TYPE: DNA

<213> ORGANISM: Artificial

<220> FEATURE:

<223> OTHER INFORMATION: TGFBR1Idn

<400> SEQUENCE: 109

atgggaagag	ggctgtccg	aggcttgtgg	ccgttgcata	ttgtattgtg	gacgcccata	60
gcgagtacaa	tcccgctca	cgtcaaaaa	tcagttataa	acgacatgtat	cgttactgac	120
aacaatggcg	cagttaaatt	tccgcagctt	tgttaattct	gtgtatgtaa	attttcaacg	180
tgcgataacc	agaaaagctg	tatgtccaaac	tgcagcatca	catcaatctg	tgaaaaaccc	240
caagaggat	gtgtggccgt	ctggcgaaag	aatgacgaaa	atatcacact	ggagaccgtt	300
tgtcacgatc	ctaaactccc	ttatcatgac	tttattctgg	aagacgcagc	gtcaccgaag	360
tgtataatga	aagagaagaa	gaagcctgga	gagacgtttt	tcatgtgcag	ttgctcctca	420
gatgagtgtt	atgacaacat	catttttcc	gaggagtaca	atacgagtaa	cccagacactc	480
ctgctggta	ttttcaggt	aaccggcata	agtttgtgc	ccccactggg	tgttgcaatc	540
agtgtataaa	tcatatcca	ttgttaccgg	gtg			573

<210> SEQ ID NO 110

<211> LENGTH: 191

<212> TYPE: PRT

-continued

<213> ORGANISM: Artificial
 <220> FEATURE:
 <223> OTHER INFORMATION: TGFBR1Idn

<400> SEQUENCE: 110

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Met Gly Arg Gly Leu Leu Arg Gly Leu Trp Pro Leu His Ile Val Leu
1           5          10          15

Trp Thr Arg Ile Ala Ser Thr Ile Pro Pro His Val Gln Lys Ser Val
20          25          30

Asn Asn Asp Met Ile Val Thr Asp Asn Asn Gly Ala Val Lys Phe Pro
35          40          45

Gln Leu Cys Lys Phe Cys Asp Val Arg Phe Ser Thr Cys Asp Asn Gln
50          55          60

Lys Ser Cys Met Ser Asn Cys Ser Ile Thr Ser Ile Cys Glu Lys Pro
65          70          75          80

Gln Glu Val Cys Val Ala Val Trp Arg Lys Asn Asp Glu Asn Ile Thr
85          90          95

Leu Glu Thr Val Cys His Asp Pro Lys Leu Pro Tyr His Asp Phe Ile
100         105         110

Leu Glu Asp Ala Ala Ser Pro Lys Cys Ile Met Lys Glu Lys Lys Lys
115         120         125

Pro Gly Glu Thr Phe Phe Met Cys Ser Cys Ser Asp Glu Cys Asn
130         135         140

Asp Asn Ile Ile Phe Ser Glu Glu Tyr Asn Thr Ser Asn Pro Asp Leu
145         150         155         160

Leu Leu Val Ile Phe Gln Val Thr Gly Ile Ser Leu Leu Pro Pro Leu
165         170         175

Gly Val Ala Ile Ser Val Ile Ile Phe Tyr Cys Tyr Arg Val
180         185         190

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What is claimed is:

1. An isolated nucleic acid molecule encoding a chimeric antigen receptor (CAR) comprising the amino acid sequence of SEQ ID NO: 78.

2. A vector comprising the nucleic acid molecule of claim 1.

3. The vector of claim 2, wherein the vector is selected from the group consisting of a DNA vector, an RNA vector, a plasmid vector, a cosmid vector, a herpes virus vector, a measles virus vector, a lentivirus vector, an adenoviral vector, and a retrovirus vector.

4. The vector of claim 2, further comprising a promoter.

5. The vector of claim 4, wherein the promoter is an inducible promoter, a constitutive promoter, a tissue specific promoter, a suicide promoter or any combination thereof.

6. An isolated cell comprising the vector of claim 2.

7. The isolated cell of claim 6, wherein the cell is a T cell.

8. The isolated cell of claim 6, wherein the T cell is a CD8⁺ T cell.

9. The isolated cell of claim 6, wherein the cell is a human cell.

10. The isolated nucleic acid molecule of claim 1, wherein the isolated nucleic acid molecule encodes a chimeric antigen receptor (CAR) comprising the amino acid sequence of SEQ ID NO: 98 or SEQ ID NO: 102.

11. A pharmaceutical composition comprising an anti-tumor effective amount of a population of isolated human T cells, wherein the T cells comprise a nucleic acid sequence that encodes a CAR encoded by the isolated nucleic acid molecule of claim 1, and wherein the T cells are T cells of a human having a cancer.

12. The pharmaceutical composition of claim 11, wherein the T cells are T cells of a human having a hematological cancer.

13. The pharmaceutical composition of claim 12, wherein the hematological cancer is leukemia or lymphoma.

14. The pharmaceutical composition of claim 13, wherein the leukemia is acute myeloid leukemia (AML), blastic plasmacytoid dendritic cell neoplasm (BPDCN), chronic myelogenous leukemia (CML), chronic lymphocytic leukemia (CLL), acute lymphoblastic T cell leukemia (T-ALL), or acute lymphoblastic B cell leukemia (B-ALL).

15. The pharmaceutical composition of claim 13, wherein the lymphoma is mantle cell lymphoma, non-Hodgkin's lymphoma or Hodgkin's lymphoma.

16. The pharmaceutical composition of claim 12, wherein the hematological cancer is multiple myeloma.

17. The pharmaceutical composition of claim 11, wherein the human cancer is an oral and pharynx cancer, a digestive system cancer, a respiratory system cancer, a bone and joint cancer, a soft tissue cancer, a skin cancer, a pediatric cancer, a cancer of the central nervous system, a cancer of the breast, a cancer of the genital system, a cancer of the urinary system, a cancer of the eye and orbit, a cancer of the endocrine system, and a cancer of the brain.

18. A CAR encoded by the isolated nucleic acid molecule of claim 1.

19. A method of making a cell comprising transducing a T cell with a vector of claim 2.

20. A method of generating a population of RNA-engineered cells comprising introducing an in vitro transcribed

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RNA or a synthetic RNA into a cell *in vitro*, wherein the RNA comprises the nucleic acid molecule of claim 1.

21. A process for producing a CAR-expressing cell, the process comprising introducing the isolated nucleic acid of claim 1 into an isolated cell. 5

22. The process for producing a CAR-expressing cell according to claim 21, wherein the cell is an isolated T cell or an isolated cell population containing a T cell.

23. An isolated nucleic acid molecule encoding a chimeric antigen receptor (CAR) comprising the amino acid sequence 10 of SEQ ID NO: 98 or SEQ ID NO: 102.

* * * * *

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