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(54) Title: ANTI-CD79B ANTIBODIES AND CHIMERIC ANTIGEN RECEPTORS AND METHODS OF USE THEREOF

(57) Abstract: Provided herein are CD79b antibodies and CD79b-specific chimeric antigen receptors (CARs). Further provided herein are T cells expressing the CD79b-specific CARs and methods of treating cancer by administering the CD79b-specific CAR T cells.

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ANTI-CD79B ANTIBODIES AND CHIMERIC ANTIGEN RECEPTORS AND METHODS OF USE THEREOF

[0001] This application claims the benefit of United States Provisional Application No. 62/752,889, filed October 30, 2018, the entirety of which is incorporated herein by reference.

INCORPORATION OF SEQUENCE LISTING

[0002] The sequence listing that is contained in the file named "UTFCP1405WO_ST25.txt", which is 73 KB (as measured in Microsoft Windows®) and was created on October 29, 2019, is filed herewith by electronic submission and is incorporated by reference herein.

BACKGROUND

1. Field

[0003] The present invention relates generally to the fields of immunology and medicine. More particularly, it concerns CD79b chimeric antigen receptors and methods of use thereof.

2. Description of Related Art

[0004] Chimeric antigen receptor (CAR) T cells targeting CD19 are highly effective in B cell malignancies. Recently, two anti-CD19 CAR T-cell therapy products were approved by the US FDA for relapsed or refractory B cell acute lymphoblastic leukemia (ALL) and/or large B cell lymphoma. In pivotal trials, durable remissions lasting more than 1 year have been observed in ~40-50% of these patients. However, relapse or progression occurs in ~50- 60% and a major cause of resistance appears to be due to CD19 antigen loss. Thus, there is an urgent need to develop CAR T cell therapies against novel targets to further improve outcomes in these patients.

SUMMARY

[0005] In a first embodiment, the present disclosure provides an isolated monoclonal antibody, wherein the antibody specifically binds to CD79b and comprises: (I): (a) a first V_H CDR is identical to SEQ ID NO: 3; (b) a second V_H CDR is identical to SEQ ID NO: 4; (c) a

third V_H CDR is identical to SEQ ID NO: 5; (d) a first V_L CDR is identical to SEQ ID NO: 8; (e) a second V_L CDR is identical to SEQ ID NO: 9; and (f) a third V_L CDR is identical to SEQ ID NO: 10; (II): (a) a first V_H CDR is identical to SEQ ID NO: 13; (b) a second V_H CDR is identical to SEQ ID NO: 14; (c) a third V_H CDR is identical to SEQ ID NO: 15; (d) a first V_L CDR is identical to SEQ ID NO: 18; (e) a second V_L CDR is identical to SEQ ID NO: 19; and (f) a third V_L CDR is identical to SEQ ID NO: 20; or (III): (a) a first V_H CDR is identical to SEQ ID NO: 23; (b) a second V_H CDR is identical to SEQ ID NO: 24; (c) a third V_H CDR is identical to SEQ ID NO: 25; (d) a first V_L CDR is identical to SEQ ID NO: 28; (e) a second V_L CDR is identical to SEQ ID NO: 29; and (f) a third V_L CDR is identical to SEQ ID NO: 30.

[0006] In some aspects, the antibody comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 2 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 7. In certain aspects, the antibody comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 12 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 17. In some aspects, the antibody comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 22 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 27.

[0007] In certain aspects, the antibody is recombinant. The antibody may be an IgG, IgM, IgA or an antigen binding fragment thereof. The antibody may be a Fab', a F(ab')2, a F(ab')3, a monovalent scFv, a bivalent scFv, or a single domain antibody. In certain aspects, the antibody is a human, humanized antibody or de-immunized antibody. The antibody may be conjugated to an imaging agent, a chemotherapeutic agent, a toxin or a radionuclide. A further embodiment provides a composition comprising a CD79b antibody of the embodiments in a pharmaceutically acceptable carrier. Also provided herein is an isolated polynucleotide molecule comprising a nucleic acid sequence encoding a CD79 antibody of the embodiments.

[0008] Another embodiment provides a recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 14 (SEQ ID NOs: 3, 4, and 5) and CDRs 1-3 of the V_H domain of Clone 14 (SEQ ID NOs: 8, 9, and 10). A further

embodiment provides a recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 16a (SEQ ID NOs: 13, 14, and 15) and CDRs 1-3 of the V_H domain of Clone 16a (SEQ ID NOs: 18, 19, and 20). Further provided herein is a recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 45 (SEQ ID NOs: 23, 24, and 25) and CDRs 1-3 of the V_H domain of Clone 45 (SEQ ID NOs: 28, 29, and 30). A further embodiment provides an isolated polynucleotide molecule comprising a nucleic acid sequence encoding a CD79b polypeptide of the embodiments. Also provided herein is a host cell comprising one or more polynucleotide molecule(s) encoding a CD79b antibody or a recombinant polypeptide of the embodiments. The host cell may be a mammalian cell, a yeast cell, a bacterial cell, a ciliate cell or an insect cell.

[0009] Another embodiment provides a method for treating a subject having a cancer comprising administering an effective amount of a CD79b antibody of the embodiments to the subject. In some aspects, the cancer is B cell malignancy. In certain aspects, the antibody is in a pharmaceutically acceptable composition. In some aspects, the antibody is administered systemically. The antibody may be administered intravenously, intradermally, intratumorally, intramuscularly, intraperitoneally, subcutaneously, or locally. In additional aspects, the method further comprises administering at least a second anticancer therapy to the subject. In some aspects, the second anticancer therapy is a surgical therapy, chemotherapy, radiation therapy, cryotherapy, hormonal therapy, immunotherapy or cytokine therapy. In certain aspects, the second anticancer therapy comprises an adoptive T-cell therapy.

[0010] A further embodiment provides an engineered CD79b-targeted chimeric antigen receptor (CAR) comprising CD3ζ, CD28, 4-1BB, and/or OX40 signaling domains. The CD3ζ signaling domain may be at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to SEQ ID NO: 80 or 81). The CD28 signaling domain may be at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to SEQ ID NO: 74 or 75). The 4-1BB signaling domain may be at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to SEQ ID NO: 76 or 77). The 4-1BB signaling domain may be at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%,

88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to SEQ ID NO: 78 or 79).

[0011] In some aspects, the CAR is encoded by a viral vector, such as a lentiviral vector. In particular aspects, the CAR comprises an antigen-binding domain selected from the group consisting of F(ab')2, Fab', Fab, Fv, and scFv. The antigen-binding domain may comprise a CD79b antibody of the embodiments or a fragment thereof, such as an scFV.

[0012] In some aspects, the antigen-binding domain comprises (I): (a) a first V_H CDR is identical to SEQ ID NO: 3; (b) a second V_H CDR is identical to SEQ ID NO: 4; (c) a third V_H CDR is identical to SEQ ID NO: 5; (d) a first V_L CDR is identical to SEQ ID NO: 8; (e) a second V_L CDR is identical to SEQ ID NO: 9; and (f) a third V_L CDR is identical to SEQ ID NO: 10; (II): (a) a first V_H CDR is identical to SEQ ID NO: 13; (b) a second V_H CDR is identical to SEQ ID NO: 14; (c) a third V_H CDR is identical to SEQ ID NO: 15; (d) a first V_L CDR is identical to SEQ ID NO: 18; (e) a second V_L CDR is identical to SEQ ID NO: 19; and (f) a third V_L CDR is identical to SEQ ID NO: 20; or (III): (a) a first V_H CDR is identical to SEQ ID NO: 23; (b) a second V_H CDR is identical to SEQ ID NO: 24; (c) a third V_H CDR is identical to SEQ ID NO: 25; (d) a first V_L CDR is identical to SEQ ID NO: 28; (e) a second V_L CDR is identical to SEQ ID NO: 29; and (f) a third V_L CDR is identical to SEQ ID NO: 30. In certain aspects, the antigen-binding domain comprises an scFV having at least 90% (e.g., 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to amino acid sequence of SEQ ID NOs: 31, 32, or 33.

[0013] In additional aspects, the CAR further comprises a transduction marker and/or safety switch. The transduction marker may be enhanced green fluorescent protein (eGFP) (e.g., SEQ ID NO:82 or 83). In certain aspects, the transduction marker and/or safety switch is truncated epidermal growth factor (EGFR) (e.g., SEQ ID NO:40 or 41). In some aspects, the transduction marker and/or safety switch is linked to the CAR by a cleavage peptide, such as 2A peptide. In some aspects, the 2A peptide is a T2A peptide (SEQ ID NO:84 or 85).

[0014] In some aspects, the CAR comprises a sequence having at least 90% (e.g., 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identity to the amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

[0015] In certain aspects, the CAR further comprises a second antigen binding domain. In some aspects, the second antigen binding domain is a CD19, CD20, or CD22 antigen binding domain.

[0016] In some aspects, the CAR comprises a linker. For example, the linker, may be Linker 1 (SEQ ID NOs: 44 or 45), Linker 2 (SEQ ID NOs:46 or 47), Linker 3 (SEQ ID NOs:48 or 49), or Linker 4 (SEQ ID NOs:50 or 51). In certain aspects, the CAR comprises a hinge. For example, the hinge may be CD8 Hinge 1 (SEQ ID NOs:52 or 53), CD8 Hinge 2 (SEQ ID NOs:54 or 55), CD8 Hinge 3 (SEQ ID NOs:56 or 57), CD28 Hinge (SEQ ID NOs:58 or 59), IgG4 Hinge (SEQ ID NOs:60 or 61), IgG4 CH2 (SEQ ID NOs:62 or 63), IgG4 CH2CH3 (SEQ ID NOs:64 or 65), or IgG4 CH1CH2CH3 (SEQ ID NOs:66 or 67). In particular aspects, the CAR comprises a transmembrane domain (TM). For example, the TM may be CD8 TM1 (SEQ ID NOs:68 or 69), CD8 TM2 (SEQ ID NOs:70 or 71), or CD28 TM (SEQ ID NOs:72 or 73). In some aspects, the CAR construct comprises V_L-Linker1-V_H; V_L-Linker2-V_H; V_L-Linker3-V_H; V_L-Linker4-V_H; V_H-Linker1-V_L; V_H-Linker2-V_L; V_H-Linker3-V_L; or V_H-Linker4-V_L. In certain aspects, the CAR comprises a V_L--linker-- V_H--hinge—TM--signaling domain. In other aspects, the CAR comprises V_H--linker—V_L--hinge—TM--signaling domain.

[0017] In another embodiment, there is provided an engineered CD79b CAR or T-cell receptor (TCR) having an antigen binding domain comprising (I): (a) a first V_H CDR is identical to SEQ ID NO: 3; (b) a second V_H CDR is identical to SEQ ID NO: 4; (c) a third V_H CDR is identical to SEQ ID NO: 5; (d) a first V_L CDR is identical to SEQ ID NO: 8; (e) a second V_L CDR is identical to SEQ ID NO: 9; and (f) a third V_L CDR is identical to SEQ ID NO: 10; (II): (a) a first V_H CDR is identical to SEQ ID NO: 13; (b) a second V_H CDR is identical to SEQ ID NO: 14; (c) a third V_H CDR is identical to SEQ ID NO: 15; (d) a first V_L CDR is identical to SEQ ID NO: 18; (e) a second V_L CDR is identical to SEQ ID NO: 19; and (f) a third V_L CDR is identical to SEQ ID NO: 20; or (III): (a) a first V_H CDR is identical to SEQ ID NO: 23; (b) a second V_H CDR is identical to SEQ ID NO: 24; (c) a third V_H CDR is identical to SEQ ID NO: 25; (d) a first V_L CDR is identical to SEQ ID NO: 28; (e) a second V_L CDR is identical to SEQ ID NO: 29; and (f) a third V_L CDR is identical to SEQ ID NO: 30.

[0018] In some aspects, the antigen-binding domain comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 2 and

a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 7. In certain aspects, the antigen-binding domain comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 12 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 17. In some aspects, the antigen-binding domain comprises a V_H domain at least about 80% (e.g., 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to the V_H domain of SEQ ID NO: 22 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 27.

[0019] In some aspects, the CAR comprises one or more signaling domains CD3ξ, CD28, OX40/CD134, 4-1BB/CD137, or a combination thereof. In particular aspects, the CAR comprises CD3ζ and CD28 signaling domains. In some aspects, the CAR comprises CD3ζ and 4-1BB signaling domains. In some aspects, the CAR comprises CD3ζ and OX40 signaling domains.

[0020] In certain aspects, the CAR is encoded by a viral vector, such as a lentiviral vector.

[0021] In certain aspects, the antigen-binding domain comprises an scFV having at least 90% (e.g., 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identical to amino acid sequence of SEQ ID NOs: 31, 32, or 33.

[0022] In additional aspects, the CAR further comprises a transduction marker and/or safety switch. The transduction marker may be enhanced green fluorescent protein (eGFP) (e.g., SEQ ID NO:82 or 83). In certain aspects, the transduction marker and/or safety switch is truncated epidermal growth factor (EGFR) (e.g., SEQ ID NO:40 or 41). In some aspects, the transduction marker and/or safety switch is linked to the CAR by a cleavage peptide, such as 2A peptide. In some aspects, the 2A peptide is a T2A peptide (SEQ ID NO:84 or 85).

[0023] In some aspects, the CAR comprises a linker. For example, the linker, may be Linker 1 (SEQ ID NOs: 44 or 45), Linker 2 (SEQ ID NOs:46 or 47), Linker 3 (SEQ ID NOs:48 or 49), or Linker 4 (SEQ ID NOs:50 or 51). In certain aspects, the CAR comprises a hinge. For example, the hinge may be CD8 Hinge 1 (SEQ ID NOs:52 or 53), CD8 Hinge 2 (SEQ ID NOs:54 or 55), CD8 Hinge 3 (SEQ ID NOs:56 or 57), CD28 Hinge (SEQ ID NOs:58 or 59), IgG4 Hinge (SEQ ID NOs:60 or 61), IgG4 CH2 (SEQ ID NOs:62 or 63), IgG4 CH2CH3 (SEQ

ID NOs:64 or 65), or IgG4 CH1CH2CH3 (SEQ ID NOs:66 or 67). In particular aspects, the CAR comprises a transmembrane domain (TM). For example, the TM may be CD8 TM1 (SEQ ID NOs:68 or 69), CD8 TM2 (SEQ ID NOs:70 or 71), or CD28 TM (SEQ ID NOs:72 or 73). In some aspects, the CAR construct comprises V_L-Linker1-V_H; V_L-Linker2-V_H; V_L-Linker3-V_H; V_L-Linker4-V_H; V_H-Linker1-V_L; V_H-Linker2-V_L; V_H-Linker3-V_L; or V_H-Linker4-V_L. In certain aspects, the CAR comprises a V_L--linker-- V_H--hinge—TM--signaling domain. In other aspects, the CAR comprises V_H--linker—V_L--hinge—TM--signaling domain.

[0024] In some aspects, the CAR comprises a sequence having at least 90% (e.g., 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%) identity to the amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

[0025] In certain aspects, the CAR further comprises a second antigen binding domain. In some aspects, the second antigen binding domain is a CD19, CD20, or CD22 antigen binding domain.

[0026] In another embodiment, there is provided an expression vector encoding a CD79b CAR of the present embodiments.

[0027] Further provided herein is a host cell engineered to express a CD79b CAR or TCR, such as a CD79b of the present embodiments. In some aspects, the host cell is an immune cell, such as a T cell. In some aspects, the T cell is a primary human T cell or a TIL. In certain aspects, the T cell is a CD4+ T cell or CD8+ T cell. In some aspects, the primary human T cell is obtained from a healthy donor. The T cell may be autologous or allogeneic. In some aspects, the cell is engineered (e.g., with CAR or TCR) using a CRISPR or transposase system.

[0028] Also provided herein is a pharmaceutical composition comprising CD79b CAR T cells, such as CAR T cells of the present embodiments, and a pharmaceutical carrier. Further provided herein is a composition comprising an effective amount of CD79b CAR T cells, such as CAR T cells of the present embodiments, for the treatment of cancer in a subject. In another embodiments, there is provided the use of a composition comprising an effective amount of CD79b CAR T cells, such as CAR T cells of the present embodiments, for the treatment of cancer in a subject.

[0029] In a further embodiment, there is provided a method for treating cancer in a subject comprising administering an effective amount of CD79b CAR T cells, such as CAR T

cells of the present embodiments, to the subject. In some aspects, the cancer is a B cell malignancy, such as B cell acute lymphoblastic leukemia (ALL), diffuse, large B cell lymphoma, follicular lymphoma, marginal zone lymphoma, lymphoplasmacytic lymphoma, Burkitt lymphoma, or chronic lymphocytic leukemia. In certain aspects, the cancer is a CD79b-expressing cancer.

[0030] In some aspects, the subject has been previously administered a CD19 CAR therapy. In certain aspects, the subject is resistant to CD19 CAR therapy, such as due to CD19 antigen loss. In certain aspects, the subject has relapsed with a CD19-negative tumor.

[0031] In certain aspects, the CD79b CAR T cells are administered intravenously, intradermally, intratumorally, intramuscularly, intraperitoneally, subcutaneously, or locally. In additional aspects, the method further comprises administering at least a second anticancer therapy to the subject. In some aspects, the second anticancer therapy is a surgical therapy, chemotherapy, radiation therapy, cryotherapy, hormonal therapy, immunotherapy or cytokine therapy.

[0032] Other objects, features and advantages of the present invention will become apparent from the following detailed description. It should be understood, however, that the detailed description and the specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The following drawings form part of the present specification and are included to further demonstrate certain aspects of the present invention. The invention may be better understood by reference to one or more of these drawings in combination with the detailed description of specific embodiments presented herein.

[0034] FIGS. 1A-1D: (**A**) CD79b expression in cell lines. (**B**) CD79b expression in human tissues. (**C**) CD79b expression in leukemias. (**D**) CD79b expression in lymphomas.

[0035] FIGS. 2A-2D: (**A**) Flow cytometry analysis of cells transduced with CD79b. (**B**) Binding affinity of CD79b monoclonal antibodies. (**C**) Characterization of CD79b monoclonal antibodies. (**D**) Clone 14 staining of lymphoma cell lines.

[0036] FIGS. 3A-3D: (**A**) Schematic depicting constructs for CD79b CARs. (**B**) Flow cytometry analysis of CD79b CAR and CD19 CAR. (**C**) Percent cytotoxicity of CD79b CAR and CD19 CAR with untransduced T cells as control. (**D**) Flow cytometry of CD79b CAR and CD19 CAR with untransduced T cells as control.

[0037] FIGS. 4A-4D: (**A**) T cells co-cultured with CD79b CAR and CD19 Exon 2Δ splice variant. (**B**) Flow cytometry analysis of efficacy of CAR at Effector:Target ratio of 5:1 incubated for 4 days. (**C**) Absolute cell count of Daudi cells with CD79b CAR. (**D**) Absolute cell count of CD19 knockdown cells with CD79b CAR.

[0038] FIGS. 5A-5C: (**A**) Schematic of pre-clinical study. (**B**) Bioluminescence images of mice during study. (**C**) Percent survival of mice during study.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0039] CD79b is a pan B cell linage marker and an important component of the B cell receptor complex. CD79b is broadly expressed in normal B cells and B cell malignancies and its expression is usually retained in CD19 negative tumors relapsing after CD19-specific CAR T cell therapy. Accordingly, in certain embodiments, the present disclosure provides CD79b monoclonal antibodies and CD79b-specific CARs, such as for CD79b-CAR T cells.

[0040] The present studies demonstrated the efficacy of the present CD79b-specific CAR T cell product in *in vitro* and *in vivo* models. Three murine monoclonal antibodies were developed against human CD79b by hybridoma technology and it was demonstrated that they bind specifically to recombinant human CD79b, have high affinity (Kd range of 1.44-17.8 nM), and stain multiple lymphoma cell lines. Next, the variable regions of the heavy and light chains of the CD79b antibodies were cloned, and lentiviral constructs were developed for the anti-CD79b CARs with CD3ζ and CD28/4-1BB costimulatory domains. It was demonstrated that the anti-CD79b CAR constructs can be transduced into primary $CD4^+$ and $CD8^+$ T cells from healthy donors using lentivirus to more than 70% transduction efficiency.

[0041] It was observed that the anti-CD79b CAR T cells but not untransduced T cells demonstrated significant cytotoxic activity that was comparable to control anti-CD19 CAR T cells against Daudi Burkitt lymphoma and Mino mantle cell lymphoma cell lines. More importantly, anti-CD79b but not anti-CD19 CAR T cells lysed CD19-CD79b+ lymphoma cells. Significant degranulation was also observed in both $CD4^+$ and $CD8^+$ anti-CD79b CAR T cells when they were co-cultured with lymphoma cells. The efficacy of anti-CD79b CAR T cells was also examined *in vivo* against Mino lymphoma xenograft model in NSG mice. Luciferase-labeled Mino mantle cell lymphoma cells were injected IV into NSG mice at $2x10^6$ tumor cells/mouse. After 18 days, mice were treated with untransduced primary T cells, anti-CD19 CAR T cells, or anti-CD79b CAR T cells via tail vein at $10x10^6$ T cells/mouse. Bioluminescence imaging was used to assess tumor burden. The results showed progressive tumor growth in mice treated with untransduced T cells. While in mice treated with anti-CD19- and anti-CD79b CAR T cells tumor growth was inhibited and survival was improved. Thus, these results showed the efficacy of this novel anti-CD79b CAR T cell therapy in patients with B cell malignancies which could be a novel strategy to overcome resistance due to CD19 loss after CD19-specific CAR T-cell therapy.

[0042] In some aspects, the present anti-CD79b CAR construct is encoded by a lentiviral vector. The vector may be transduced into immune cells, such as T cells. The construct may comprise CD28, CD3ζ, and/or 4-1BB signaling domains. The construct can comprise a transduction marker, such as eGFP or a truncated EGFR domain. The transduction marker may be linked to the CAR by a cleavage peptide, such as a 2A peptide.

[0043] Further provided herein are methods of treating cancer by administering the CD79b-specific CAR immune cells, such as T cells, provided herein. The cancer may be a B cell malignancy, such as B cell acute lymphoblastic leukemia (ALL), diffuse large B cell lymphoma, follicular lymphoma, marginal zone lymphoma, lymphoplasmacytic lymphoma, Burkitt lymphoma, or chronic lymphocytic leukemia that express CD79b. The present therapy may be used to treat subjects with a B cell malignancy who has relapsed with CD19 negative tumors after anti-CD19-CAR T cell therapy.

I. Definitions

[0044] As used herein, "essentially free," in terms of a specified component, is used herein to mean that none of the specified component has been purposefully formulated into a

composition and/or is present only as a contaminant or in trace amounts. The total amount of the specified component resulting from any unintended contamination of a composition is therefore well below 0.05%, preferably below 0.01%. Most preferred is a composition in which no amount of the specified component can be detected with standard analytical methods.

[0045] As used herein the specification, "a" or "an" may mean one or more. As used herein in the claim(s), when used in conjunction with the word "comprising," the words "a" or "an" may mean one or more than one.

[0046] The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and "and/or." As used herein "another" may mean at least a second or more. The terms "about", "substantially" and "approximately" mean, in general, the stated value plus or minus 5%.

[0047] "Treating" or treatment of a disease or condition refers to executing a protocol, which may include administering one or more drugs to a patient, in an effort to alleviate signs or symptoms of the disease. Desirable effects of treatment include decreasing the rate of disease progression, ameliorating or palliating the disease state, and remission or improved prognosis. Alleviation can occur prior to signs or symptoms of the disease or condition appearing, as well as after their appearance. Thus, "treating" or "treatment" may include "preventing" or "prevention" of disease or undesirable condition. In addition, "treating" or "treatment" does not require complete alleviation of signs or symptoms, does not require a cure, and specifically includes protocols that have only a marginal effect on the patient.

[0048] The term "therapeutic benefit" or "therapeutically effective" as used throughout this application refers to anything that promotes or enhances the well-being of the subject with respect to the medical treatment of this condition. This includes, but is not limited to, a reduction in the frequency or severity of the signs or symptoms of a disease. For example, treatment of cancer may involve, for example, a reduction in the size of a tumor, a reduction in the invasiveness of a tumor, reduction in the growth rate of the cancer, or prevention of metastasis. Treatment of cancer may also refer to prolonging survival of a subject with cancer.

[0049] "Subject" and "patient" refer to either a human or non-human, such as primates, mammals, and vertebrates. In particular embodiments, the subject is a human.

[0050] The phrases "pharmaceutical or pharmacologically acceptable" refers to molecular entities and compositions that do not produce an adverse, allergic, or other untoward reaction when administered to an animal, such as a human, as appropriate. The preparation of a pharmaceutical composition comprising an antibody or additional active ingredient will be known to those of skill in the art in light of the present disclosure. Moreover, for animal (*e.g.*, human) administration, it will be understood that preparations should meet sterility, pyrogenicity, general safety, and purity standards as required by FDA Office of Biological Standards.

[0051] As used herein, "pharmaceutically acceptable carrier" includes any and all aqueous solvents (*e.g.*, water, alcoholic/aqueous solutions, saline solutions, parenteral vehicles, such as sodium chloride, Ringer's dextrose, etc.), non-aqueous solvents (*e.g.*, propylene glycol, polyethylene glycol, vegetable oil, and injectable organic esters, such as ethyloleate), dispersion media, coatings, surfactants, antioxidants, preservatives (*e.g.*, antibacterial or antifungal agents, anti-oxidants, chelating agents, and inert gases), isotonic agents, absorption delaying agents, salts, drugs, drug stabilizers, gels, binders, excipients, disintegration agents, lubricants, sweetening agents, flavoring agents, dyes, fluid and nutrient replenishers, such like materials and combinations thereof, as would be known to one of ordinary skill in the art. The pH and exact concentration of the various components in a pharmaceutical composition are adjusted according to well-known parameters.

II. CD79b Antibodies

[0052] In certain embodiments, an antibody or a fragment thereof that binds to at least a portion of CD79b and inhibits CD79b signaling are contemplated. As used herein, the term "antibody" is intended to refer broadly to any immunologic binding agent, such as IgG, IgM, IgA, IgD, IgE, and genetically modified IgG as well as polypeptides comprising antibody CDR domains that retain antigen binding activity. The antibody may be selected from the group consisting of a chimeric antibody, an affinity matured antibody, a polyclonal antibody, a monoclonal antibody, a humanized antibody, a human antibody, or an antigen-binding antibody fragment or a natural or synthetic ligand. Preferably, the anti-CD79b antibody is a monoclonal antibody or a humanized antibody.

[0053] Thus, by known means and as described herein, polyclonal or monoclonal antibodies, antibody fragments, and binding domains and CDRs (including engineered forms

of any of the foregoing) may be created that are specific to CD79b, one or more of its respective epitopes, or conjugates of any of the foregoing, whether such antigens or epitopes are isolated from natural sources or are synthetic derivatives or variants of the natural compounds.

[0054] Examples of antibody fragments suitable for the present embodiments include, without limitation: (i) the Fab fragment, consisting of V_L, V_H, C_L, and C_{H1} domains; (ii) the "Fd" fragment consisting of the V_H and C_{H1} domains; (iii) the "Fv" fragment consisting of the V_L and V_H domains of a single antibody; (iv) the "dAb" fragment, which consists of a V_H domain; (v) isolated CDR regions; (vi) F(ab')2 fragments, a bivalent fragment comprising two linked Fab fragments; (vii) single chain Fv molecules ("scFv"), wherein a V_H domain and a V_L domain are linked by a peptide linker that allows the two domains to associate to form a binding domain; (viii) bi-specific single chain Fv dimers (see U.S. Pat. No. 5,091,513); and (ix) diabodies, multivalent or multispecific fragments constructed by gene fusion (US Patent App. Pub. 20050214860). Fv, scFv, or diabody molecules may be stabilized by the incorporation of disulphide bridges linking the V_H and V_L domains. Minibodies comprising a scFv joined to a CH3 domain may also be made.

[0055] Antibody-like binding peptidomimetics are also contemplated in embodiments. Liu *et al.* (2003) describe "antibody like binding peptidomimetics" (ABiPs), which are peptides that act as pared-down antibodies and have certain advantages of longer serum half-life as well as less cumbersome synthesis methods.

[0056] Animals may be inoculated with an antigen, such as a CD79b extracellular domain (ECD) protein, in order to produce antibodies specific for CD79b. Frequently an antigen is bound or conjugated to another molecule to enhance the immune response. As used herein, a conjugate is any peptide, polypeptide, protein, or non-proteinaceous substance bound to an antigen that is used to elicit an immune response in an animal. Antibodies produced in an animal in response to antigen inoculation comprise a variety of non-identical molecules (polyclonal antibodies) made from a variety of individual antibody producing B lymphocytes. A polyclonal antibody is a mixed population of antibody species, each of which may recognize a different epitope on the same antigen. Given the correct conditions for polyclonal antibody production in an animal, most of the antibodies in the animal's serum will recognize the collective epitopes on the antigenic compound to which the animal has been immunized. This specificity is further enhanced by affinity purification to select only those antibodies that recognize the antigen or epitope of interest.

[0057] A monoclonal antibody is a single species of antibody wherein every antibody molecule recognizes the same epitope because all antibody producing cells are derived from a single B-lymphocyte cell line. The methods for generating monoclonal antibodies (MAbs) generally begin along the same lines as those for preparing polyclonal antibodies. In some embodiments, rodents such as mice and rats are used in generating monoclonal antibodies. In some embodiments, rabbit, sheep, or frog cells are used in generating monoclonal antibodies. The use of rats is well known and may provide certain advantages. Mice (e.g., BALB/c mice) are routinely used and generally give a high percentage of stable fusions.

[0058] Hybridoma technology involves the fusion of a single B lymphocyte from a mouse previously immunized with a CD79b antigen with an immortal myeloma cell (usually mouse myeloma). This technology provides a method to propagate a single antibody-producing cell for an indefinite number of generations, such that unlimited quantities of structurally identical antibodies having the same antigen or epitope specificity (monoclonal antibodies) may be produced.

[0059] Plasma B cells ($CD45^+CD5^-CD19^+$) may be isolated from freshly prepared rabbit peripheral blood mononuclear cells of immunized rabbits and further selected for CD79b binding cells. After enrichment of antibody producing B cells, total RNA may be isolated and cDNA synthesized. DNA sequences of antibody variable regions from both heavy chains and light chains may be amplified, constructed into a phage display Fab expression vector, and transformed into *E. coli.* CD79b specific binding Fab may be selected out through multiple rounds enrichment panning and sequenced. Selected CD79b binding hits may be expressed as full-length IgG in rabbit and rabbit/human chimeric forms using a mammalian expression vector system in human embryonic kidney (HEK293) cells (Invitrogen) and purified using a protein G resin with a fast protein liquid chromatography (FPLC) separation unit.

[0060] In one embodiment, the antibody is a chimeric antibody, for example, an antibody comprising antigen binding sequences from a non-human donor grafted to a heterologous non-human, human, or humanized sequence (e.g., framework and/or constant domain sequences). Methods have been developed to replace light and heavy chain constant domains of the monoclonal antibody with analogous domains of human origin, leaving the variable regions of the foreign antibody intact. Alternatively, "fully human" monoclonal antibodies are produced in mice transgenic for human immunoglobulin genes. Methods have also been developed to convert variable domains of monoclonal antibodies to more human

form by recombinantly constructing antibody variable domains having both rodent, for example, mouse, and human amino acid sequences. In "humanized" monoclonal antibodies, only the hypervariable CDR is derived from mouse monoclonal antibodies, and the framework and constant regions are derived from human amino acid sequences (see U.S. Pat. Nos. 5,091,513 and 6,881,557). It is thought that replacing amino acid sequences in the antibody that are characteristic of rodents with amino acid sequences found in the corresponding position of human antibodies will reduce the likelihood of adverse immune reaction during therapeutic use. A hybridoma or other cell producing an antibody may also be subject to genetic mutation or other changes, which may or may not alter the binding specificity of antibodies produced by the hybridoma.

[0061] Methods for producing polyclonal antibodies in various animal species, as well as for producing monoclonal antibodies of various types, including humanized, chimeric, and fully human, are well known in the art and highly predictable. For example, the following U.S. patents and patent applications provide enabling descriptions of such methods: U.S. Patent Application Nos. 2004/0126828 and 2002/0172677; and U.S. Pat. Nos. 3,817,837; 3,850,752; 3,939,350; 3,996,345; 4,196,265; 4,275,149; 4,277,437; 4,366,241; 4,469,797; 4,472,509; 4,606,855; 4,703,003; 4,742,159; 4,767,720; 4,816,567; 4,867,973; 4,938,948; 4,946,778; 5,021,236; 5,164,296; 5,196,066; 5,223,409; 5,403,484; 5,420,253; 5,565,332; 5,571,698; 5,627,052; 5,656,434; 5,770,376; 5,789,208; 5,821,337; 5,844,091; 5,858,657; 5,861,155; 5,871,907; 5,969,108; 6,054,297; 6,165,464; 6,365,157; 6,406,867; 6,709,659; 6,709,873; 6,753,407; 6,814,965; 6,849,259; 6,861,572; 6,875,434; and 6,891,024. All patents, patent application publications, and other publications cited herein and therein are hereby incorporated by reference in the present application.

[0062] Antibodies may be produced from any animal source, including birds and mammals. Preferably, the antibodies are ovine, murine (e.g., mouse and rat), rabbit, goat, guinea pig, camel, horse, or chicken. In addition, newer technology permits the development of and screening for human antibodies from human combinatorial antibody libraries. For example, bacteriophage antibody expression technology allows specific antibodies to be produced in the absence of animal immunization, as described in U.S. Pat. No. 6,946,546, which is incorporated herein by reference.

[0063] It is fully expected that antibodies to CD79b will have the ability to neutralize or counteract the effects of CD79b regardless of the animal species, monoclonal cell line, or

other source of the antibody. Certain animal species may be less preferable for generating therapeutic antibodies because they may be more likely to cause allergic response due to activation of the complement system through the "Fc" portion of the antibody. However, whole antibodies may be enzymatically digested into "Fc" (complement binding) fragment, and into antibody fragments having the binding domain or CDR. Removal of the Fc portion reduces the likelihood that the antigen antibody fragment will elicit an undesirable immunological response, and thus, antibodies without Fc may be preferential for prophylactic or therapeutic treatments. As described above, antibodies may also be constructed so as to be chimeric or partially or fully human, so as to reduce or eliminate the adverse immunological consequences resulting from administering to an animal an antibody that has been produced in, or has sequences from, other species.

[0064] Substitutional variants typically contain the exchange of one amino acid for another at one or more sites within the protein, and may be designed to modulate one or more properties of the polypeptide, with or without the loss of other functions or properties. Substitutions may be conservative, that is, one amino acid is replaced with one of similar shape and charge. Conservative substitutions are well known in the art and include, for example, the changes of: alanine to serine; arginine to lysine; asparagine to glutamine or histidine; aspartate to glutamate; cysteine to serine; glutamine to asparagine; glutamate to aspartate; glycine to proline; histidine to asparagine or glutamine; isoleucine to leucine or valine; leucine to valine or isoleucine; lysine to arginine; methionine to leucine or isoleucine; phenylalanine to tyrosine, leucine or methionine; serine to threonine; threonine to serine; tryptophan to tyrosine; tyrosine to tryptophan or phenylalanine; and valine to isoleucine or leucine. Alternatively, substitutions may be non-conservative such that a function or activity of the polypeptide is affected. Non-conservative changes typically involve substituting a residue with one that is chemically dissimilar, such as a polar or charged amino acid for a nonpolar or uncharged amino acid, and vice versa.

[0065] Proteins may be recombinant, or synthesized in vitro. Alternatively, a non-recombinant or recombinant protein may be isolated from bacteria. It is also contemplated that a bacteria containing such a variant may be implemented in compositions and methods. Consequently, a protein need not be isolated.

[0066] It is contemplated that in compositions there is between about 0.001 mg and about 10 mg of total polypeptide, peptide, and/or protein per ml. Thus, the concentration of

protein in a composition can be about, at least about or at most about 0.001, 0.010, 0.050, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0 mg/ml or more (or any range derivable therein). Of this, about, at least about, or at most about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100% may be an antibody that binds CD79b .

[0067] An antibody or preferably an immunological portion of an antibody, can be chemically conjugated to, or expressed as, a fusion protein with other proteins. For purposes of this specification and the accompanying claims, all such fused proteins are included in the definition of antibodies or an immunological portion of an antibody.

[0068] Embodiments provide antibodies and antibody-like molecules against CD79b, polypeptides and peptides that are linked to at least one agent to form an antibody conjugate or payload. In order to increase the efficacy of antibody molecules as diagnostic or therapeutic agents, it is conventional to link or covalently bind or complex at least one desired molecule or moiety. Such a molecule or moiety may be, but is not limited to, at least one effector or reporter molecule. Effector molecules comprise molecules having a desired activity, e.g., cytotoxic activity. Non-limiting examples of effector molecules that have been attached to antibodies include toxins, therapeutic enzymes, antibiotics, radio-labeled nucleotides and the like. By contrast, a reporter molecule is defined as any moiety that may be detected using an assay. Non-limiting examples of reporter molecules that have been conjugated to antibodies include enzymes, radiolabels, haptens, fluorescent labels, phosphorescent molecules, chemiluminescent molecules, chromophores, luminescent molecules, photoaffinity molecules, colored particles or ligands, such as biotin.

[0069] Several methods are known in the art for the attachment or conjugation of an antibody to its conjugate moiety. Some attachment methods involve the use of a metal chelate complex employing, for example, an organic chelating agent such a diethylenetriaminepentaacetic acid anhydride (DTPA); ethylenetriaminetetraacetic acid; N-chloro-p-toluenesulfonamide; and/or tetrachloro-3-6-diphenylglycouril-3 attached to the antibody. Monoclonal antibodies may also be reacted with an enzyme in the presence of a

coupling agent such as glutaraldehyde or periodate. Conjugates with fluorescein markers are prepared in the presence of these coupling agents or by reaction with an isothiocyanate.

III. T Cell Therapy

[0070] Certain embodiments of the present disclosure concern obtaining and administering T cells to a subject as an immunotherapy to target cancer cells. Several basic approaches for the derivation, activation and expansion of functional anti-tumor effector T cells have been described in the last two decades. These include: autologous cells, such as tumor-infiltrating lymphocytes (TILs); T cells activated *ex-vivo* using autologous DCs, lymphocytes, artificial antigen-presenting cells (APCs) or beads coated with T cell ligands and activating antibodies, or cells isolated by virtue of capturing target cell membrane; allogeneic cells naturally expressing anti-host tumor T cell receptor (TCR); and non-tumor-specific autologous or allogeneic cells genetically reprogrammed or "redirected" to express tumor-reactive TCR or chimeric TCR molecules displaying antibody-like tumor recognition capacity known as "T-bodies". These approaches have given rise to numerous protocols for T cell preparation and immunization which can be used in the methods of the present disclosure.

A. T Cell Preparation

[0071] In some embodiments, the T cells are derived from the blood, bone marrow, lymph, or lymphoid organs. In some aspects, the cells are human cells. The cells typically are primary cells, such as those isolated directly from a subject and/or isolated from a subject and frozen. In some embodiments, the cells include one or more subsets of T cells or other cell types, such as whole T cell populations, $CD4^+$ cells, $CD8^+$ cells, and subpopulations thereof, such as those defined by function, activation state, maturity, potential for differentiation, expansion, recirculation, localization, and/or persistence capacities, antigen- specificity, type of antigen receptor, presence in a particular organ or compartment, marker or cytokine secretion profile, and/or degree of differentiation. With reference to the subject to be treated, the cells may be allogeneic and/or autologous. In some aspects, such as for off-the-shelf technologies, the cells are pluripotent and/or multipotent, such as stem cells, such as induced pluripotent stem cells (iPSCs). In some embodiments, the methods include isolating cells from the subject, preparing, processing, culturing, and/or engineering them, as described herein, and re-introducing them into the same patient, before or after cryopreservation.

[0072] Among the sub-types and subpopulations of T cells (*e.g.*, $CD4^+$ and/or $CD8^+$ T cells) are naive T (T_N) cells, effector T cells (T_{EFF}), memory T cells and sub-types thereof, such as stem cell memory T (TSC_M), central memory T (T_{CM}), effector memory T (T_{EM}), or terminally differentiated effector memory T (T_{TEMRA})cells, tumor-infiltrating lymphocytes (TIL), immature T cells, mature T cells, helper T cells, cytotoxic T cells, mucosa-associated invariant T (MAIT) cells, naturally occurring and adaptive regulatory T (Treg) cells, helper T cells, such as TH1 cells, TH2 cells, TH3 cells, TH17 cells, TH9 cells, TH22 cells, follicular helper T cells, alpha/beta T cells, and delta/gamma T cells.

[0073] In some embodiments, one or more of the T cell populations is enriched for or depleted of cells that are positive for a specific marker, such as surface markers, or that are negative for a specific marker. In some cases, such markers are those that are absent or expressed at relatively low levels on certain populations of T cells (*e.g.*, non-memory cells) but are present or expressed at relatively higher levels on certain other populations of T cells (*e.g.*, memory cells). In one embodiment, the cells (*e.g.*, $CD8^+$ cells or $CD3^+$ cells) are enriched for (*i.e.*, positively selected for) cells that are positive or expressing high surface levels of CD45RO, CCR7, CD28, CD27, CD44, CD127, and/or CD62L and/or depleted of (*e.g.*, negatively selected for) cells that are positive for or express high surface levels of CD45RA. In some embodiments, cells are enriched for or depleted of cells positive or expressing high surface levels of CD122, CD95, CD25, CD27, and/or IL7-Ra (CD127). In some examples, $CD8^+$ T cells are enriched for cells positive for CD45RO (or negative for CD45RA) and for CD62L.

[0074] In some embodiments, T cells are separated from a PBMC sample by negative selection of markers expressed on non-T cells, such as B cells, monocytes, or other white blood cells, such as CD14. In some aspects, a $CD4^+$ or $CD8^+$ selection step is used to separate $CD4^+$ helper and $CD8^+$ cytotoxic T cells. Such $CD4^+$ and $CD8^+$ populations can be further sorted into sub-populations by positive or negative selection for markers expressed or expressed to a relatively higher degree on one or more naive, memory, and/or effector T cell subpopulations.

[0075] In some embodiments, $CD8^+$ cells are further enriched for or depleted of naive, central memory, effector memory, and/or central memory stem cells, such as by positive or negative selection based on surface antigens associated with the respective subpopulation. In some embodiments, enrichment for central memory T (T_{CM}) cells is carried out to increase efficacy, such as to improve long-term survival, expansion, and/or engraftment following

administration, which in some aspects is particularly robust in such sub-populations. In some embodiments, combining T_{CM}- enriched $CD8^+$ T cells and $CD4^+$ T cells further enhances efficacy.

[0076] In some embodiments, the T cells are autologous T cells. In this method, tumor samples are obtained from patients and a single cell suspension is obtained. The single cell suspension can be obtained in any suitable manner, *e.g.,* mechanically (disaggregating the tumor using, *e.g.*, a gentleMACS™ Dissociator, Miltenyi Biotec, Auburn, Calif.) or enzymatically (*e.g.*, collagenase or DNase). Single-cell suspensions of tumor enzymatic digests are cultured in interleukin-2 (IL-2). The cells are cultured until confluence (*e.g.*, about 2×10^6 lymphocytes), *e.g.*, from about 5 to about 21 days, preferably from about 10 to about 14 days. For example, the cells may be cultured from 5 days, 5.5 days, or 5.8 days to 21 days, 21.5 days, or 21.8 days, such as from 10 days, 10.5 days, or 10.8 days to 14 days, 14.5 days, or 14.8 days.

[0077] The cultured T cells can be pooled and rapidly expanded. Rapid expansion provides an increase in the number of antigen-specific T-cells of at least about 50-fold (*e.g.*, 50-, 60-, 70-, 80-, 90-, or 100-fold, or greater) over a period of about 10 to about 14 days, preferably about 14 days. More preferably, rapid expansion provides an increase of at least about 200-fold (e.g., 200-, 300-, 400-, 500-, 600-, 700-, 800-, 900-, or greater) over a period of about 10 to about 14 days, preferably about 14 days.

[0078] Expansion can be accomplished by any of a number of methods as are known in the art. For example, T cells can be rapidly expanded using non-specific T-cell receptor stimulation in the presence of feeder lymphocytes and either interleukin-2 (IL-2) or interleukin-15 (IL-15), with IL-2 being preferred. The non-specific T-cell receptor stimulus can include around 30 ng/ml of OKT3, a mouse monoclonal anti-CD3 antibody (available from Ortho-McNeil®, Raritan, N.J.). Alternatively, T cells can be rapidly expanded by stimulation of peripheral blood mononuclear cells (PBMC) *in vitro* with one or more antigens (including antigenic portions thereof, such as epitope(s), or a cell) of the cancer, which can be optionally expressed from a vector, such as an human leukocyte antigen A2 (HLA-A2) binding peptide, in the presence of a T-cell growth factor, such as 300 IU/ml IL-2 or IL-15, with IL-2 being preferred. The *in vitro*-induced T-cells are rapidly expanded by re-stimulation with the same antigen(s) of the cancer pulsed onto HLA-A2-expressing antigen-presenting cells. Alternatively, the T-cells can be re-stimulated with irradiated, autologous lymphocytes or with irradiated HLA-A2+ allogeneic lymphocytes and IL-2, for example.

[0079] The autologous T-cells can be modified to express a T-cell growth factor that promotes the growth and activation of the autologous T-cells. Suitable T-cell growth factors include, for example, interleukin (IL)-2, IL-7, IL-15, and IL-12. Suitable methods of modification are known in the art. See, for instance, Sambrook et al., *Molecular Cloning: A Laboratory Manual,* 3rd ed., Cold Spring Harbor Press, Cold Spring Harbor, N.Y. 2001; and Ausubel et al., *Current Protocols in Molecular Biology*, Greene Publishing Associates and John Wiley & Sons, NY, 1994. In particular aspects, modified autologous T-cells express the T-cell growth factor at high levels. T-cell growth factor coding sequences, such as that of IL-12, are readily available in the art, as are promoters, the operable linkage of which to a T-cell growth factor coding sequence promote high-level expression.

B. Genetically Engineered Antigen Receptors

[0080] The T cell can be genetically engineered to express antigen receptors such as engineered TCRs or chimeric antigen receptors (CARs). For example, the autologous T-cells are modified to express a T cell receptor (TCR) having antigenic specificity for a cancer antigen, such as CD79b. Suitable TCRs include, for example, those with antigenic specificity for a melanoma antigen, e.g., gp100 or MART-1. Suitable methods of modification are known in the art. See, for instance, Sambrook and Ausubel, supra. For example, the T cells may be transduced to express a TCR having antigenic specificity for a cancer antigen using transduction techniques described in Heemskerk et al. *Hum Gene Ther.* 19:496-510 (2008) and Johnson et al. *Blood* 114:535-46 (2009).

[0081] In some embodiments, the T cells comprise one or more nucleic acids introduced via genetic engineering that encode one or more antigen receptors, and genetically engineered products of such nucleic acids. In some embodiments, the nucleic acids are heterologous, *i.e.*, normally not present in a cell or sample obtained from the cell, such as one obtained from another organism or cell, which for example, is not ordinarily found in the cell being engineered and/or an organism from which such cell is derived. In some embodiments, the nucleic acids are not naturally occurring, such as a nucleic acid not found in nature (*e.g.,* chimeric).

[0082] In some embodiments, the CAR contains an extracellular antigen-recognition domain that specifically binds to CD79b. In some embodiments, the antigen is a protein expressed on the surface of cells. In some embodiments, the CAR is a TCR-like CAR and the antigen is a processed peptide antigen, such as a peptide antigen of an intracellular protein,

which, like a TCR, is recognized on the cell surface in the context of a major histocompatibility complex (MHC) molecule.

[0083] Exemplary antigen receptors, including CARs and recombinant TCRs, as well as methods for engineering and introducing the receptors into cells, include those described, for example, in international patent application publication numbers WO200014257, WO2013126726, WO2012/129514, WO2014031687, WO2013/166321, WO2013/071154, WO2013/123061 U.S. patent application publication numbers US2002131960, US2013287748, US20130149337, U.S. Patent Nos.: 6,451,995, 7,446,190, 8,252,592, 8,339,645, 8,398,282, 7,446,179, 6,410,319, 7,070,995, 7,265,209, 7,354,762, 7,446,191, 8,324,353, and 8,479,118, and European patent application number EP2537416, and/or those described by Sadelain *et al.,* 2013; Davila *et al.*, 2013; Turtle *et al.*, 2012; Wu *et al.*, 2012. In some aspects, the genetically engineered antigen receptors include a CAR as described in U.S. Patent No.: 7,446,190, and those described in International Patent Application Publication No.: WO/2014055668 Al.

1. Chimeric Antigen Receptors

[0084] In some embodiments, the CAR comprises: a) an intracellular signaling domain, b) a transmembrane domain, and c) an extracellular domain comprising an antigen binding region.

[0085] In some embodiments, the engineered antigen receptors include CARs, including activating or stimulatory CARs, costimulatory CARs (see WO2014/055668), and/or inhibitory CARs (iCARs, see Fedorov *et al.*, 2013). The CARs generally include an extracellular antigen (or ligand) binding domain linked to one or more intracellular signaling components, in some aspects via linkers and/or transmembrane domain(s). Such molecules typically mimic or approximate a signal through a natural antigen receptor, a signal through such a receptor in combination with a costimulatory receptor, and/or a signal through a costimulatory receptor alone.

[0086] Certain embodiments of the present disclosure concern the use of nucleic acids, including nucleic acids encoding an antigen-specific CAR polypeptide, including a CAR that has been humanized to reduce immunogenicity (hCAR), comprising an intracellular signaling domain, a transmembrane domain, and an extracellular domain comprising one or more signaling motifs. In certain embodiments, the CAR may recognize an epitope comprising the

shared space between one or more antigens. In certain embodiments, the binding region can comprise complementary determining regions of a monoclonal antibody, variable regions of a monoclonal antibody, and/or antigen binding fragments thereof. In another embodiment, that specificity is derived from a peptide (*e.g.*, cytokine) that binds to a receptor.

[0087] It is contemplated that the human CAR nucleic acids may be human genes used to enhance cellular immunotherapy for human patients. In a specific embodiment, the invention includes a full-length CAR cDNA or coding region. The antigen binding regions or domain can comprise a fragment of the V_H and V_L chains of a single-chain variable fragment (scFv) derived from a particular human monoclonal antibody, such as those described in U.S. Patent 7,109,304, incorporated herein by reference. The fragment can also be any number of different antigen binding domains of a human antigen-specific antibody. In a more specific embodiment, the fragment is an antigen-specific scFv encoded by a sequence that is optimized for human codon usage for expression in human cells.

[0088] The arrangement could be multimeric, such as a diabody or multimers. The multimers are most likely formed by cross pairing of the variable portion of the light and heavy chains into a diabody. The hinge portion of the construct can have multiple alternatives from being totally deleted, to having the first cysteine maintained, to a proline rather than a serine substitution, to being truncated up to the first cysteine. The Fc portion can be deleted. Any protein that is stable and/or dimerizes can serve this purpose. One could use just one of the Fc domains, *e.g.*, either the CH2 or CH3 domain from human immunoglobulin. One could also use the hinge, CH2 and CH3 region of a human immunoglobulin that has been modified to improve dimerization. One could also use just the hinge portion of an immunoglobulin. One could also use portions of CD8alpha.

[0089] In some embodiments, the CAR nucleic acid comprises a sequence encoding other costimulatory receptors, such as a transmembrane domain and a modified CD28 intracellular signaling domain. Other costimulatory receptors include, but are not limited to one or more of CD28, CD27, OX-40 (CD134), and 4-1BB (CD137).

[0090] In some embodiments, CAR is constructed with a specificity for a particular antigen (or marker or ligand), such as an antigen expressed in a particular cell type to be targeted by adoptive therapy, *e.g.*, a cancer marker, and/or an antigen intended to induce a dampening response, such as an antigen expressed on a normal or non-diseased cell type. Thus,

the CAR typically includes in its extracellular portion one or more antigen binding molecules, such as one or more antigen-binding fragment, domain, or portion, or one or more antibody variable domains, and/or antibody molecules. In some embodiments, the CAR includes an antigen-binding portion or portions of an antibody molecule, such as a single-chain antibody fragment (scFv) derived from the variable heavy (VH) and variable light (VL) chains of a monoclonal antibody (mAb).

[0091] The sequence of the open reading frame encoding the chimeric receptor can be obtained from a genomic DNA source, a cDNA source, or can be synthesized (*e.g.*, *via* PCR), or combinations thereof. Depending upon the size of the genomic DNA and the number of introns, it may be desirable to use cDNA or a combination thereof as it is found that introns stabilize the mRNA. Also, it may be further advantageous to use endogenous or exogenous non-coding regions to stabilize the mRNA.

[0092] It is contemplated that the chimeric construct can be introduced into immune cells as naked DNA or in a suitable vector. Methods of stably transfecting cells by electroporation using naked DNA are known in the art. See, *e.g.*, U.S. Patent No. 6,410,319. Naked DNA generally refers to the DNA encoding a chimeric receptor contained in a plasmid expression vector in proper orientation for expression.

[0093] Alternatively, a viral vector (*e.g.*, a retroviral vector, adenoviral vector, adeno-associated viral vector, or lentiviral vector) can be used to introduce the chimeric construct into immune cells. Suitable vectors for use in accordance with the method of the present disclosure are non-replicating in the immune cells. A large number of vectors are known that are based on viruses, where the copy number of the virus maintained in the cell is low enough to maintain the viability of the cell, such as, for example, vectors based on HIV, SV40, EBV, HSV, or BPV.

[0094] In some aspects, the antigen-specific binding, or recognition component is linked to one or more transmembrane and intracellular signaling domains. In some embodiments, the CAR includes a transmembrane domain fused to the extracellular domain of the CAR. In one embodiment, the transmembrane domain that naturally is associated with one of the domains in the CAR is used. In some instances, the transmembrane domain is selected or modified by amino acid substitution to avoid binding of such domains to the transmembrane

domains of the same or different surface membrane proteins to minimize interactions with other members of the receptor complex.

[0095] The transmembrane domain in some embodiments is derived either from a natural or from a synthetic source. Where the source is natural, the domain in some aspects is derived from any membrane-bound or transmembrane protein. Transmembrane regions include those 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 zeta, CD3 epsilon, CD3 gamma, and CD3 delta. Alternatively, the transmembrane domain in some embodiments is synthetic. In some aspects, the synthetic transmembrane domain comprises predominantly hydrophobic residues such as leucine and valine. In some aspects, a triplet of phenylalanine, tryptophan and valine will be found at each end of a synthetic transmembrane domain.

[0096] In specific embodiments, the present CAR constructs comprise a light chain-linker-heavy chain-hinge-transmembrane domain-signaling domain. The linkers may be Linker 1 (SEQ ID NOs: 44 or 45), Linker 2 (SEQ ID NOs:46 or 47), Linker 3 (SEQ ID NOs:48 or 49), or Linker 4 (SEQ ID NOs:50 or 51). The hinge may be CD8 Hinge 1 (SEQ ID NOs:52 or 53), CD8 Hinge 2 (SEQ ID NOs:54 or 55), CD8 Hinge 3 (SEQ ID NOs:56 or 57), CD28 Hinge (SEQ ID NOs:58 or 59), IgG4 Hinge (SEQ ID NOs:60 or 61), IgG4 CH2 (SEQ ID NOs:62 or 63), IgG4 CH2CH3 (SEQ ID NOs:64 or 65), or IgG4 CH1CH2CH3 (SEQ ID NOs:66 or 67). The transmembrane domain may be CD8 TM1 (SEQ ID NOs:68 or 69), CD8 TM2 (SEQ ID NOs:70 or 71), or CD28 TM (SEQ ID NOs:72 or 73). The signaling domains may be CD28 (SEQ ID NOs: 74 or 75), 4-1BB (SEQ ID NOs:76 or 77), OX-40 (SEQ ID NOs:78 or 79), and/or CD3 intracellular (SEQ ID NOs:80 or 81). The CAR constructs may further comprise GFP (SEQ ID NOs:82 or 83), T2A (SEQ ID NOs:84 or 85), and/or EGFR (SEQ ID NOs:40 or 41). Exemplary heavy chain (HC), linker, and light chain (LC) combinations may include but are not limited to: LC-Linker1-HC; LC-Linker2-HC; LC-Linker3-HC; LC-Linker4-HC; HC-Linker1-LC; HC-Linker2-LC; HC-Linker3-LC; or HC-Linker4-LC.

2. T Cell Receptor (TCR)

[0097] In some embodiments, the genetically engineered antigen receptors include recombinant TCRs and/or TCRs cloned from naturally occurring T cells. A "T cell receptor" or "TCR" refers to a molecule that contains a variable a and β chains (also known as TCRα and TCRβ, respectively) or a variable γ and δ chains (also known as TCRγ and TCRδ, respectively)

and that is capable of specifically binding to an antigen peptide bound to a MHC receptor. In some embodiments, the TCR is in the αβ form.

[0098] Typically, TCRs that exist in αβ and γδ forms are generally structurally similar, but T cells expressing them may have distinct anatomical locations or functions. A TCR can be found on the surface of a cell or in soluble form. Generally, a TCR is found on the surface of T cells (or T lymphocytes) where it is generally responsible for recognizing antigens bound to major histocompatibility complex (MHC) molecules. In some embodiments, a TCR also can contain a constant domain, a transmembrane domain and/or a short cytoplasmic tail (see, *e.g.,* Janeway *et al*, 1997). For example, in some aspects, each chain of the TCR can possess one N-terminal immunoglobulin variable domain, one immunoglobulin constant domain, a transmembrane region, and a short cytoplasmic tail at the C-terminal end. In some embodiments, a TCR is associated with invariant proteins of the CD3 complex involved in mediating signal transduction. Unless otherwise stated, the term "TCR" should be understood to encompass functional TCR fragments thereof. The term also encompasses intact or full-length TCRs, including TCRs in the αβ form or γδ form.

[0099] Thus, for purposes herein, reference to a TCR includes any TCR or functional fragment, such as an antigen-binding portion of a TCR that binds to a specific antigenic peptide bound in an MHC molecule, *i.e.* MHC-peptide complex. An "antigen-binding portion" or antigen- binding fragment" of a TCR, which can be used interchangeably, refers to a molecule that contains a portion of the structural domains of a TCR, but that binds the antigen (*e.g.* MHC-peptide complex) to which the full TCR binds. In some cases, an antigen-binding portion contains the variable domains of a TCR, such as variable a chain and variable β chain of a TCR, sufficient to form a binding site for binding to a specific MHC-peptide complex, such as generally where each chain contains three complementarity determining regions.

[00100] In some embodiments, the variable domains of the TCR chains associate to form loops, or complementarity determining regions (CDRs) analogous to immunoglobulins, which confer antigen recognition and determine peptide specificity by forming the binding site of the TCR molecule and determine peptide specificity. Typically, like immunoglobulins, the CDRs are separated by framework regions (FRs) (see, *e.g.*, Jores *et al.,* 1990; Chothia *et al.*, 1988; Lefranc *et al.*, 2003). In some embodiments, CDR3 is the main CDR responsible for recognizing processed antigen, although CDR1 of the alpha chain has also been shown to interact with the N-terminal part of the antigenic peptide, whereas CDR1

of the beta chain interacts with the C-terminal part of the peptide. CDR2 is thought to recognize the MHC molecule. In some embodiments, the variable region of the β-chain can contain a further hypervariability (HV4) region.

[00101] In some embodiments, the TCR chains contain a constant domain. For example, like immunoglobulins, the extracellular portion of TCR chains (*e.g.*, a-chain, β-chain) can contain two immunoglobulin domains, a variable domain (*e.g.*, V_a or Vp; typically amino acids 1 to 116 based on Kabat numbering Kabat *et al.*, "Sequences of Proteins of Immunological Interest, US Dept. Health and Human Services, Public Health Service National Institutes of Health, 1991, 5th ed.) at the N-terminus, and one constant domain (*e.g.*, a-chain constant domain or C_a, typically amino acids 117 to 259 based on Kabat, β-chain constant domain or Cp, typically amino acids 117 to 295 based on Kabat) adjacent to the cell membrane. For example, in some cases, the extracellular portion of the TCR formed by the two chains contains two membrane-proximal constant domains, and two membrane-distal variable domains containing CDRs. The constant domain of the TCR domain contains short connecting sequences in which a cysteine residue forms a disulfide bond, making a link between the two chains. In some embodiments, a TCR may have an additional cysteine residue in each of the α and β chains such that the TCR contains two disulfide bonds in the constant domains.

[00102] In some embodiments, the TCR chains can contain a transmembrane domain. In some embodiments, the transmembrane domain is positively charged. In some cases, the TCR chains contains a cytoplasmic tail. In some cases, the structure allows the TCR to associate with other molecules like CD3. For example, a TCR containing constant domains with a transmembrane region can anchor the protein in the cell membrane and associate with invariant subunits of the CD3 signaling apparatus or complex.

[00103] Generally, CD3 is a multi-protein complex that can possess three distinct chains (γ, δ, and ε) in mammals and the ζ-chain. For example, in mammals the complex can contain a CD3γ chain, a CD3δ chain, two CD3ε chains, and a homodimer of CD3ζ chains. The CD3γ, CD3δ, and CD3ε chains are highly related cell surface proteins of the immunoglobulin superfamily containing a single immunoglobulin domain. The transmembrane regions of the CD3γ, CD3δ, and CD3ε chains are negatively charged, which is a characteristic that allows these chains to associate with the positively charged T cell receptor chains. The intracellular tails of the CD3γ, CD3δ, and CD3ε chains each contain a single conserved motif known as an immunoreceptor tyrosine -based activation motif or ITAM,

whereas each CD3ζ chain has three. Generally, ITAMs are involved in the signaling capacity of the TCR complex. These accessory molecules have negatively charged transmembrane regions and play a role in propagating the signal from the TCR into the cell. The CD3- and ζ-chains, together with the TCR, form what is known as the T cell receptor complex.

[00104] In some embodiments, the TCR may be a heterodimer of two chains α and β (or optionally γ and δ) or it may be a single chain TCR construct. In some embodiments, the TCR is a heterodimer containing two separate chains (α and β chains or γ and δ chains) that are linked, such as by a disulfide bond or disulfide bonds. In some embodiments, a TCR for a target antigen (*e.g.*, a cancer antigen) is identified and introduced into the cells. In some embodiments, nucleic acid encoding the TCR can be obtained from a variety of sources, such as by polymerase chain reaction (PCR) amplification of publicly available TCR DNA sequences. In some embodiments, the TCR is obtained from a biological source, such as from cells such as from a T cell (*e.g.* cytotoxic T cell), T cell hybridomas or other publicly available source. In some embodiments, the T cells can be obtained from *in vivo* isolated cells. In some embodiments, a high-affinity T cell clone can be isolated from a patient, and the TCR isolated. In some embodiments, the T cells can be a cultured T cell hybridoma or clone. In some embodiments, the TCR clone for a target antigen has been generated in transgenic mice engineered with human immune system genes (*e.g.,* the human leukocyte antigen system, or HLA). In some embodiments, phage display is used to isolate TCRs against a target antigen. In some embodiments, the TCR or antigen-binding portion thereof can be synthetically generated from knowledge of the sequence of the TCR.

C. Methods of Delivery

[00105] One of skill in the art would be well-equipped to construct a vector through standard recombinant techniques (see, for example, Sambrook *et al.*, 2001 and Ausubel *et al.,* 1996, both incorporated herein by reference) for the expression of the antigen receptors of the present disclosure. Vectors include but are not limited to, plasmids, cosmids, viruses (bacteriophage, animal viruses, and plant viruses), and artificial chromosomes (*e.g.,* YACs), such as retroviral vectors (*e.g.* derived from Moloney murine leukemia virus vectors (MoMLV), MSCV, SFFV, MPSV, SNV *etc*), lentiviral vectors (*e.g.* derived from HIV-1, HIV-2, SIV, BIV, FIV *etc.*), adenoviral (Ad) vectors including replication competent, replication deficient and gutless forms thereof, adeno-associated viral (AAV) vectors, simian virus 40 (SV-40) vectors, bovine papilloma virus vectors, Epstein-Barr virus vectors, herpes virus

vectors, vaccinia virus vectors, Harvey murine sarcoma virus vectors, murine mammary tumor virus vectors, Rous sarcoma virus vectors, parvovirus vectors, polio virus vectors, vesicular stomatitis virus vectors, maraba virus vectors and group B adenovirus enadenotucirev vectors.

a. Viral Vectors

[00106] Viral vectors encoding an antigen receptor may be provided in certain aspects of the present disclosure. In generating recombinant viral vectors, non-essential genes are typically replaced with a gene or coding sequence for a heterologous (or non-native) protein. A viral vector is a kind of expression construct that utilizes viral sequences to introduce nucleic acid and possibly proteins into a cell. The ability of certain viruses to infect cells or enter cells via receptor mediated- endocytosis, and to integrate into host cell genomes and express viral genes stably and efficiently have made them attractive candidates for the transfer of foreign nucleic acids into cells (*e.g.*, mammalian cells). Non-limiting examples of virus vectors that may be used to deliver a nucleic acid of certain aspects of the present invention are described below.

[00107] Lentiviruses are complex retroviruses, which, in addition to the common retroviral genes *gag, pol*, and *env*, contain other genes with regulatory or structural function. Lentiviral vectors are well known in the art (see, for example, U.S. Patents 6,013,516 and 5,994,136).

[00108] Recombinant lentiviral vectors are capable of infecting non-dividing cells and can be used for both *in vivo* and *ex vivo* gene transfer and expression of nucleic acid sequences. For example, recombinant lentivirus capable of infecting a non-dividing cell—wherein a suitable host cell is transfected with two or more vectors carrying the packaging functions, namely gag, pol and env, as well as rev and tat—is described in U.S. Patent 5,994,136, incorporated herein by reference.

b. Regulatory Elements

[00109] Expression cassettes included in vectors useful in the present disclosure in particular contain (in a 5'-to-3' direction) a eukaryotic transcriptional promoter operably linked to a protein-coding sequence, splice signals including intervening sequences, and a transcriptional termination/polyadenylation sequence. The promoters and enhancers that control the transcription of protein encoding genes in eukaryotic cells are composed of multiple genetic elements. The cellular machinery is able to gather and integrate the regulatory

information conveyed by each element, allowing different genes to evolve distinct, often complex patterns of transcriptional regulation. A promoter used in the context of the present disclosure includes constitutive, inducible, and tissue-specific promoters.

(i) Promoter/Enhancers

[00110] The expression constructs provided herein comprise a promoter to drive expression of the antigen receptor. A promoter generally comprises a sequence that functions to position the start site for RNA synthesis. The best known example of this is the TATA box, but in some promoters lacking a TATA box, such as, for example, the promoter for the mammalian terminal deoxynucleotidyl transferase gene and the promoter for the SV40 late genes, a discrete element overlying the start site itself helps to fix the place of initiation. Additional promoter elements regulate the frequency of transcriptional initiation. Typically, these are located in the region 30110 bp- upstream of the start site, although a number of promoters have been shown to contain functional elements downstream of the start site as well. To bring a coding sequence "under the control of" a promoter, one positions the 5′ end of the transcription initiation site of the transcriptional reading frame "downstream" of (*i.e.*, 3′ of) the chosen promoter. The "upstream" promoter stimulates transcription of the DNA and promotes expression of the encoded RNA.

[00111] The spacing between promoter elements frequently is flexible, so that promoter function is preserved when elements are inverted or moved relative to one another. In the tk promoter, the spacing between promoter elements can be increased to 50 bp apart before activity begins to decline. Depending on the promoter, it appears that individual elements can function either cooperatively or independently to activate transcription. A promoter may or may not be used in conjunction with an "enhancer," which refers to a cis-acting regulatory sequence involved in the transcriptional activation of a nucleic acid sequence.

[00112] A promoter may be one naturally associated with a nucleic acid sequence, as may be obtained by isolating the 5′ non-coding sequences located upstream of the coding segment and/or exon. Such a promoter can be referred to as "endogenous." Similarly, an enhancer may be one naturally associated with a nucleic acid sequence, located either downstream or upstream of that sequence. Alternatively, certain advantages will be gained by positioning the coding nucleic acid segment under the control of a recombinant or heterologous promoter, which refers to a promoter that is not normally associated with a nucleic acid

sequence in its natural environment. A recombinant or heterologous enhancer refers also to an enhancer not normally associated with a nucleic acid sequence in its natural environment. Such promoters or enhancers may include promoters or enhancers of other genes, and promoters or enhancers isolated from any other virus, or prokaryotic or eukaryotic cell, and promoters or enhancers not "naturally occurring," *i.e.,* containing different elements of different transcriptional regulatory regions, and/or mutations that alter expression. For example, promoters that are most commonly used in recombinant DNA construction include the βlactamase (penicillinase), lactose and tryptophan (trp-) promoter systems. In addition to producing nucleic acid sequences of promoters and enhancers synthetically, sequences may be produced using recombinant cloning and/or nucleic acid amplification technology, including PCR™, in connection with the compositions disclosed herein. Furthermore, it is contemplated that the control sequences that direct transcription and/or expression of sequences within non-nuclear organelles such as mitochondria, chloroplasts, and the like, can be employed as well.

[00113] Naturally, it will be important to employ a promoter and/or enhancer that effectively directs the expression of the DNA segment in the organelle, cell type, tissue, organ, or organism chosen for expression. Those of skill in the art of molecular biology generally know the use of promoters, enhancers, and cell type combinations for protein expression, (*see*, for example Sambrook *et al.* 1989, incorporated herein by reference). The promoters employed may be constitutive, tissue-specific, inducible, and/or useful under the appropriate conditions to direct high level expression of the introduced DNA segment, such as is advantageous in the large-scale production of recombinant proteins and/or peptides. The promoter may be heterologous or endogenous.

[00114] Additionally, any promoter/enhancer combination (as per, for example, the Eukaryotic Promoter Data Base EPDB, through world wide web at epd.isb-sib.ch/) could also be used to drive expression. Use of a T3, T7 or SP6 cytoplasmic expression system is another possible embodiment. Eukaryotic cells can support cytoplasmic transcription from certain bacterial promoters if the appropriate bacterial polymerase is provided, either as part of the delivery complex or as an additional genetic expression construct.

[00115] Non-limiting examples of promoters include early or late viral promoters, such as, SV40 early or late promoters, cytomegalovirus (CMV) immediate early promoters, Rous Sarcoma Virus (RSV) early promoters; eukaryotic cell promoters, such as, *e. g.*, beta actin promoter, GADPH promoter, metallothionein promoter; and concatenated

response element promoters, such as cyclic AMP response element promoters (cre), serum response element promoter (sre), phorbol ester promoter (TPA) and response element promoters (tre) near a minimal TATA box. It is also possible to use human growth hormone promoter sequences (*e.g.*, the human growth hormone minimal promoter described at Genbank, accession no. X05244, nucleotide 283-341) or a mouse mammary tumor promoter (available from the ATCC, Cat. No. ATCC 45007). In certain embodiments, the promoter is CMV IE, dectin-1, dectin-2, human CD11c, F4/80, SM22, RSV, SV40, Ad MLP, beta-actin, MHC class I or MHC class II promoter, however any other promoter that is useful to drive expression of the therapeutic gene is applicable to the practice of the present disclosure.

[00116] In certain aspects, methods of the disclosure also concern enhancer sequences, *i.e.*, nucleic acid sequences that increase a promoter's activity and that have the potential to act in cis, and regardless of their orientation, even over relatively long distances (up to several kilobases away from the target promoter). However, enhancer function is not necessarily restricted to such long distances as they may also function in close proximity to a given promoter.

(ii) Initiation Signals and Linked Expression

[00117] A specific initiation signal also may be used in the expression constructs provided in the present disclosure for efficient translation of coding sequences. These signals include the ATG initiation codon or adjacent sequences. Exogenous translational control signals, including the ATG initiation codon, may need to be provided. One of ordinary skill in the art would readily be capable of determining this and providing the necessary signals. It is well known that the initiation codon must be "in-frame" with the reading frame of the desired coding sequence to ensure translation of the entire insert. The exogenous translational control signals and initiation codons can be either natural or synthetic. The efficiency of expression may be enhanced by the inclusion of appropriate transcription enhancer elements.

[00118] In certain embodiments, the use of internal ribosome entry sites (IRES) elements are used to create multigene, or polycistronic, messages. IRES elements are able to bypass the ribosome scanning model of 5′ methylated Cap dependent translation and begin translation at internal sites. IRES elements from two members of the picornavirus family (polio and encephalomyocarditis) have been described, as well an IRES from a mammalian message. IRES elements can be linked to heterologous open reading frames. Multiple open reading frames can be transcribed together, each separated by an IRES, creating polycistronic

messages. By virtue of the IRES element, each open reading frame is accessible to ribosomes for efficient translation. Multiple genes can be efficiently expressed using a single promoter/enhancer to transcribe a single message.

[00119] Additionally, certain 2A sequence elements could be used to create linked- or co-expression of genes in the constructs provided in the present disclosure. For example, cleavage sequences could be used to co-express genes by linking open reading frames to form a single cistron. An exemplary cleavage sequence is the F2A (Foot-and-mouth diease virus 2A) or a "2A-like" sequence (*e.g., Thosea asigna* virus 2A; T2A).

(iii)Origins of Replication

In order to propagate a vector in a host cell, it may contain one or more origins of replication sites (often termed "ori"), for example, a nucleic acid sequence corresponding to oriP of EBV as described above or a genetically engineered oriP with a similar or elevated function in programming, which is a specific nucleic acid sequence at which replication is initiated. Alternatively a replication origin of other extra-chromosomally replicating virus as described above or an autonomously replicating sequence (ARS) can be employed.

c. Selection and Screenable Markers

[00120] In some embodiments, cells containing a construct of the present disclosure may be identified *in vitro* or *in vivo* by including a marker in the expression vector. Such markers would confer an identifiable change to the cell permitting easy identification of cells containing the expression vector. Generally, a selection marker is one that confers a property that allows for selection. A positive selection marker is one in which the presence of the marker allows for its selection, while a negative selection marker is one in which its presence prevents its selection. An example of a positive selection marker is a drug resistance marker.

[00121] Usually the inclusion of a drug selection marker aids in the cloning and identification of transformants, for example, genes that confer resistance to neomycin, puromycin, hygromycin, DHFR, GPT, zeocin and histidinol are useful selection markers. In addition to markers conferring a phenotype that allows for the discrimination of transformants based on the implementation of conditions, other types of markers including screenable markers such as GFP, whose basis is colorimetric analysis, are also contemplated. Alternatively, screenable enzymes as negative selection markers such as herpes simplex virus

thymidine kinase (*tk*) or chloramphenicol acetyltransferase (CAT) may be utilized. One of skill in the art would also know how to employ immunologic markers, possibly in conjunction with FACS analysis. The marker used is not believed to be important, so long as it is capable of being expressed simultaneously with the nucleic acid encoding a gene product. Further examples of selection and screenable markers are well known to one of skill in the art.

d. Other Methods of Nucleic Acid Delivery

[00122] In addition to viral delivery of the nucleic acids encoding the antigen receptor, the following are additional methods of recombinant gene delivery to a given host cell and are thus considered in the present disclosure.

[00123] Introduction of a nucleic acid, such as DNA or RNA, into the immune cells of the current disclosure may use any suitable methods for nucleic acid delivery for transformation of a cell, as described herein or as would be known to one of ordinary skill in the art. Such methods include, but are not limited to, direct delivery of DNA such as by *ex vivo* transfection, by injection, including microinjection); by electroporation; by calcium phosphate precipitation; by using DEAE-dextran followed by polyethylene glycol; by direct sonic loading; by liposome mediated transfection and receptor-mediated transfection; by microprojectile bombardment; by agitation with silicon carbide fibers; by *Agrobacterium*-mediated transformation; by desiccation/inhibition-mediated DNA uptake, and any combination of such methods. Through the application of techniques such as these, organelle(s), cell(s), tissue(s) or organism(s) may be stably or transiently transformed.

IV. Methods of Treatment

[00124] Certain aspects of the present embodiments can be used to prevent or treat a disease or disorder associated with CD79b signaling. Signaling of CD79b may be reduced by any suitable drugs to prevent cancer cell proliferation. Preferably, such substances would be an anti-CD79b antibody or anti-CD79b CAR T cells.

[00125] In some embodiments, the present disclosure provides methods for immunotherapy comprising administering an effective amount of the CAR T cells of the present disclosure. In one embodiments, a medical disease or disorder is treated by transfer of a CAR T cell population that elicits an immune response. In certain embodiments of the present disclosure, cancer is treated by transfer of a CAR T cell population that elicits an immune

response. Provided herein are methods for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount an antigen-specific cell therapy. The present methods may be applied for the treatment of immune disorders, solid cancers, and hematologic cancers. Specifically, the cancer may be a B cell malignancy, such as B cell acute lymphoblastic leukemia (ALL), diffuse, large B cell lymphoma, follicular lymphoma, marginal zone lymphoma, lymphoplasmacytic lymphoma, Burkitt lymphoma, and chronic lymphocytic leukemia.

[00126] Tumors for which the present treatment methods are useful include any malignant cell type, such as those found in a solid tumor or a hematological tumor. Exemplary solid tumors can include, but are not limited to, a tumor of an organ selected from the group consisting of pancreas, colon, cecum, stomach, brain, head, neck, ovary, kidney, larynx, sarcoma, lung, bladder, melanoma, prostate, and breast. Exemplary hematological tumors include tumors of the bone marrow, T or B cell malignancies, leukemias, lymphomas, blastomas, myelomas, and the like. Further examples of cancers that may be treated using the methods provided herein include, but are not limited to, lung cancer (including small-cell lung cancer, non-small cell lung cancer, adenocarcinoma of the lung, and squamous carcinoma of the lung), cancer of the peritoneum, gastric or stomach cancer (including gastrointestinal cancer and gastrointestinal stromal cancer), pancreatic cancer, cervical cancer, ovarian cancer, liver cancer, bladder cancer, breast cancer, colon cancer, colorectal cancer, endometrial or uterine carcinoma, salivary gland carcinoma, kidney or renal cancer, prostate cancer, vulval cancer, thyroid cancer, various types of head and neck cancer, and melanoma.

[00127] The cancer may specifically be of the following histological type, though it is not limited to these: neoplasm, malignant; carcinoma; carcinoma, undifferentiated; giant and spindle cell carcinoma; small cell carcinoma; papillary carcinoma; squamous cell carcinoma; lymphoepithelial carcinoma; basal cell carcinoma; pilomatrix carcinoma; transitional cell carcinoma; papillary transitional cell carcinoma; adenocarcinoma; gastrinoma, malignant; cholangiocarcinoma; hepatocellular carcinoma; combined hepatocellular carcinoma and cholangiocarcinoma; trabecular adenocarcinoma; adenoid cystic carcinoma; adenocarcinoma in adenomatous polyp; adenocarcinoma, familial polyposis coli; solid carcinoma; carcinoid tumor, malignant; branchiolo-alveolar adenocarcinoma; papillary adenocarcinoma; chromophobe carcinoma; acidophil carcinoma; oxyphilic adenocarcinoma; basophil carcinoma; clear cell adenocarcinoma; granular cell carcinoma; follicular

adenocarcinoma; papillary and follicular adenocarcinoma; nonencapsulating sclerosing carcinoma; adrenal cortical carcinoma; endometroid carcinoma; skin appendage carcinoma; apocrine adenocarcinoma; sebaceous adenocarcinoma; ceruminous adenocarcinoma; mucoepidermoid carcinoma; cystadenocarcinoma; papillary cystadenocarcinoma; papillary serous cystadenocarcinoma; mucinous cystadenocarcinoma; mucinous adenocarcinoma; signet ring cell carcinoma; infiltrating duct carcinoma; medullary carcinoma; lobular carcinoma; inflammatory carcinoma; paget's disease, mammary; acinar cell carcinoma; adenosquamous carcinoma; adenocarcinoma w/squamous metaplasia; thymoma, malignant; ovarian stromal tumor, malignant; thecoma, malignant; granulosa cell tumor, malignant; androblastoma, malignant; sertoli cell carcinoma; leydig cell tumor, malignant; lipid cell tumor, malignant; paraganglioma, malignant; extra-mammary paraganglioma, malignant; pheochromocytoma; glomangiosarcoma; malignant melanoma; amelanotic melanoma; superficial spreading melanoma; lentigo malignant melanoma; acral lentiginous melanomas; nodular melanomas; malignant melanoma in giant pigmented nevus; epithelioid cell melanoma; blue nevus, malignant; sarcoma; fibrosarcoma; fibrous histiocytoma, malignant; myxosarcoma; liposarcoma; leiomyosarcoma; rhabdomyosarcoma; embryonal rhabdomyosarcoma; alveolar rhabdomyosarcoma; stromal sarcoma; mixed tumor, malignant; mullerian mixed tumor; nephroblastoma; hepatoblastoma; carcinosarcoma; mesenchymoma, malignant; brenner tumor, malignant; phyllodes tumor, malignant; synovial sarcoma; mesothelioma, malignant; dysgerminoma; embryonal carcinoma; teratoma, malignant; struma ovarii, malignant; choriocarcinoma; mesonephroma, malignant; hemangiosarcoma; hemangioendothelioma, malignant; kaposi's sarcoma; hemangiopericytoma, malignant; lymphangiosarcoma; osteosarcoma; juxtacortical osteosarcoma; chondrosarcoma; chondroblastoma, malignant; mesenchymal chondrosarcoma; giant cell tumor of bone; ewing's sarcoma; odontogenic tumor, malignant; ameloblastic odontosarcoma; ameloblastoma, malignant; ameloblastic fibrosarcoma; pinealoma, malignant; chordoma; glioma, malignant; ependymoma; astrocytoma; protoplasmic astrocytoma; fibrillary astrocytoma; astroblastoma; glioblastoma; oligodendroglioma; oligodendroblastoma; primitive neuroectodermal; cerebellar sarcoma; ganglioneuroblastoma; neuroblastoma; retinoblastoma; olfactory neurogenic tumor; meningioma, malignant; neurofibrosarcoma; neurilemmoma, malignant; granular cell tumor, malignant; malignant lymphoma; hodgkin's disease; hodgkin's; paragranuloma; malignant lymphoma, small lymphocytic; malignant lymphoma, large cell, diffuse; malignant lymphoma, follicular; mycosis fungoides; other specified non-hodgkin's lymphomas; B cell lymphoma; low grade/follicular non-Hodgkin's lymphoma (NHL); small lymphocytic (SL) NHL;

intermediate grade/follicular NHL; intermediate grade diffuse NHL; high grade immunoblastic NHL; high grade lymphoblastic NHL; high grade small non-cleaved cell NHL; bulky disease NHL; mantle cell lymphoma; AIDS-related lymphoma; Waldenstrom's macroglobulinemia; malignant histiocytosis; multiple myeloma; mast cell sarcoma; immunoproliferative small intestinal disease; leukemia; lymphoid leukemia; plasma cell leukemia; erythroleukemia; lymphosarcoma cell leukemia; myeloid leukemia; basophilic leukemia; eosinophilic leukemia; monocytic leukemia; mast cell leukemia; megakaryoblastic leukemia; myeloid sarcoma; hairy cell leukemia; chronic lymphocytic leukemia (CLL); acute lymphoblastic leukemia (ALL); acute myeloid leukemia (AML); and chronic myeloblastic leukemia.

[00128] Particular embodiments concern methods of treatment of leukemia. Leukemia is a cancer of the blood or bone marrow and is characterized by an abnormal proliferation (production by multiplication) of blood cells, usually white blood cells (leukocytes). It is part of the broad group of diseases called hematological neoplasms. Leukemia is a broad term covering a spectrum of diseases. Leukemia is clinically and pathologically split into its acute and chronic forms.

[00129] In some embodiments of the methods of the present disclosure, activated CD4 and/or CD8 T cells in the individual are characterized by γ-IFN producing CD4 and/or CD8 T cells and/or enhanced cytolytic activity relative to prior to the administration of the combination. γ-IFN may be measured by any means known in the art, including, *e.g.*, intracellular cytokine staining (ICS) involving cell fixation, permeabilization, and staining with an antibody against γ-IFN. Cytolytic activity may be measured by any means known in the art, *e.g.*, using a cell killing assay with mixed effector and target cells.

[00130] In some embodiments, the subject can be administered nonmyeloablative lymphodepleting chemotherapy prior to the T cell therapy. The nonmyeloablative lymphodepleting chemotherapy can be any suitable such therapy, which can be administered by any suitable route. The nonmyeloablative lymphodepleting chemotherapy can comprise, for example, the administration of cyclophosphamide and fludarabine, particularly if the cancer is melanoma, which can be metastatic. An exemplary route of administering cyclophosphamide and fludarabine is intravenously. Likewise, any suitable dose of cyclophosphamide and fludarabine can be administered. In particular aspects, around 60 mg/kg of cyclophosphamide is administered for two days after which around 25 mg/m^2 fludarabine is administered for five days.

[00131] In certain embodiments, a T cell growth factor that promotes the growth and activation of the autologous T cells is administered to the subject either concomitantly with the autologous T cells or subsequently to the autologous T cells. The T cell growth factor can be any suitable growth factor that promotes the growth and activation of the autologous T cells. Examples of suitable T-cell growth factors include interleukin (IL)-2, IL-7, IL-15, and IL-12, which can be used alone or in various combinations, such as IL-2 and IL-7, IL-2 and IL-15, IL-7 and IL-15, IL-2, IL-7 and IL-15, IL-12 and IL-7, IL-12 and IL-15, or IL-12 and IL2. IL-12 is a preferred T-cell growth factor.

[00132] Therapeutically effective amounts of immune cells can be administered by a number of routes, including parenteral administration, for example, intravenous, intraperitoneal, intramuscular, intrasternal, or intraarticular injection, or infusion.

[00133] Intratumoral injection, or injection into the tumor vasculature is specifically contemplated for discrete, solid, accessible tumors. Local, regional or systemic administration also may be appropriate. For tumors of >4 cm, the volume to be administered will be about 4-10 ml (in particular 10 ml), while for tumors of <4 cm, a volume of about 1-3 ml will be used (in particular 3 ml). Multiple injections delivered as single dose comprise about 0.1 to about 0.5 ml volumes.

[00134] The T cell population can be administered in treatment regimens consistent with the disease, for example a single or a few doses over one to several days to ameliorate a disease state or periodic doses over an extended time to inhibit disease progression and prevent disease recurrence. The precise dose to be employed in the formulation will also depend on the route of administration, and the seriousness of the disease or disorder, and should be decided according to the judgment of the practitioner and each patient's circumstances. The therapeutically effective amount of T cells will be dependent on the subject being treated, the severity and type of the affliction, and the manner of administration. In some embodiments, doses that could be used in the treatment of human subjects range from at least 3.8×10^4, at least 3.8×10^5, at least 3.8×10^6, at least 3.8×10^7, at least 3.8×10^8, at least 3.8×10^9, or at least 3.8×10^{10} T cells/m^2. In a certain embodiment, the dose used in the treatment of human subjects ranges from about 3.8×10^9 to about 3.8×10^{10} T cells/m^2. In additional embodiments, a therapeutically effective amount of T cells can vary from about 5×10^6 cells per kg body weight to about 7.5×10^8 cells per kg body weight, such as about 2×10^7 cells to about 5×10^8 cells per kg body weight, or about 5×10^7 cells to about 2×10^8 cells per kg body weight. The exact amount of T cells is readily

determined by one of skill in the art based on the age, weight, sex, and physiological condition of the subject. Effective doses can be extrapolated from dose-response curves derived from *in vitro* or animal model test systems.

A. Pharmaceutical Compositions

[00135] Also provided herein are pharmaceutical compositions and formulations comprising CAR T cells and a pharmaceutically acceptable carrier.

[00136] Pharmaceutical compositions and formulations as described herein can be prepared by mixing the active ingredients (such as an antibody or a polypeptide) having the desired degree of purity with one or more optional pharmaceutically acceptable carriers (Remington's Pharmaceutical Sciences 22nd edition, 2012), in the form of lyophilized formulations or aqueous solutions. Pharmaceutically acceptable carriers are generally nontoxic to recipients at the dosages and concentrations employed, and include, but are not limited to: buffers such as phosphate, citrate, and other organic acids; antioxidants including ascorbic acid and methionine; preservatives (such as octadecyldimethylbenzyl ammonium chloride; hexamethonium chloride; benzalkonium chloride; benzethonium chloride; phenol, butyl or benzyl alcohol; alkyl parabens such as methyl or propyl paraben; catechol; resorcinol; cyclohexanol; 3-pentanol; and m-cresol); low molecular weight (less than about 10 residues) polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine, glutamine, asparagine, histidine, arginine, or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrins; chelating agents such as EDTA; sugars such as sucrose, mannitol, trehalose or sorbitol; salt-forming counter-ions such as sodium; metal complexes (*e.g.* Zn- protein complexes); and/or non-ionic surfactants such as polyethylene glycol (PEG). Exemplary pharmaceutically acceptable carriers herein further include insterstitial drug dispersion agents such as soluble neutral-active hyaluronidase glycoproteins (sHASEGP), for example, human soluble PH-20 hyaluronidase glycoproteins, such as rHuPH20 (HYLENEX®, Baxter International, Inc.). In one aspect, a sHASEGP is combined with one or more additional glycosaminoglycanases such as chondroitinases.

B. Combination Therapies

[00137] In certain embodiments, the compositions and methods of the present embodiments involve a T cell population in combination with at least one additional therapy.

The additional therapy may be radiation therapy, surgery (*e.g.*, lumpectomy and a mastectomy), chemotherapy, gene therapy, DNA therapy, viral therapy, RNA therapy, immunotherapy, bone marrow transplantation, nanotherapy, monoclonal antibody therapy, or a combination of the foregoing. The additional therapy may be in the form of adjuvant or neoadjuvant therapy.

[00138] In some embodiments, the additional therapy is the administration of small molecule enzymatic inhibitor or anti-metastatic agent. In some embodiments, the additional therapy is the administration of side- effect limiting agents (*e.g.*, agents intended to lessen the occurrence and/or severity of side effects of treatment, such as anti-nausea agents, *etc.*). In some embodiments, the additional therapy is radiation therapy. In some embodiments, the additional therapy is surgery. In some embodiments, the additional therapy is a combination of radiation therapy and surgery. In some embodiments, the additional therapy is gamma irradiation. In some embodiments, the additional therapy is therapy targeting PBK/AKT/mTOR pathway, HSP90 inhibitor, tubulin inhibitor, apoptosis inhibitor, and/or chemopreventative agent. The additional therapy may be one or more of the chemotherapeutic agents known in the art.

[00139] An immune cell therapy may be administered before, during, after, or in various combinations relative to an additional cancer therapy, such as immune checkpoint therapy. The administrations may be in intervals ranging from concurrently to minutes to days to weeks. In embodiments where the immune cell therapy is provided to a patient separately from an additional therapeutic agent, one would generally ensure that a significant period of time did not expire between the time of each delivery, such that the two compounds would still be able to exert an advantageously combined effect on the patient. In such instances, it is contemplated that one may provide a patient with the antibody therapy and the anti-cancer therapy within about 12 to 24 or 72 h of each other and, more particularly, within about 6-12 h of each other. In some situations it may be desirable to extend the time period for treatment significantly where several days (2, 3, 4, 5, 6, or 7) to several weeks (1, 2, 3, 4, 5, 6, 7, or 8) lapse between respective administrations.

[00140] Various combinations may be employed. For the example below an immune cell therapy is "A" and an anti-cancer therapy is "B":

A/B/A B/A/B B/B/A A/A/B A/B/B B/A/A A/B/B/B B/A/B/B
B/B/B/A B/B/A/B A/A/B/B A/B/A/B A/B/B/A B/B/A/A

B/A/B/A B/A/A/B A/A/A/B B/A/A/A A/B/A/A A/A/B/A

[00141] Administration of any compound or therapy of the present embodiments to a patient will follow general protocols for the administration of such compounds, taking into account the toxicity, if any, of the agents. Therefore, in some embodiments there is a step of monitoring toxicity that is attributable to combination therapy.

1. Chemotherapy

[00142] A wide variety of chemotherapeutic agents may be used in accordance with the present embodiments. Examples of chemotherapeutic agents include alkylating agents, such as thiotepa and cyclosphosphamide; alkyl sulfonates, such as busulfan, improsulfan, and piposulfan; aziridines, such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines, including altretamine, triethylenemelamine, trietylenephosphoramide, triethiylenethiophosphoramide, and trimethylolomelamine; acetogenins (especially bullatacin and bullatacinone); a camptothecin (including the synthetic analogue topotecan); bryostatin; callystatin; CC-1065 (including its adozelesin, carzelesin and bizelesin synthetic analogues); cryptophycins (particularly cryptophycin 1 and cryptophycin 8); dolastatin; duocarmycin (including the synthetic analogues, KW-2189 and CB1-TM1); eleutherobin; pancratistatin; a sarcodictyin; spongistatin; nitrogen mustards, such as chlorambucil, chlornaphazine, cholophosphamide, estramustine, ifosfamide, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, and uracil mustard; nitrosureas, such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, and ranimnustine; antibiotics, such as the enediyne antibiotics (*e.g.*, calicheamicin, especially calicheamicin gammaII and calicheamicin omegaI1); dynemicin, including dynemicin A; bisphosphonates, such as clodronate; an esperamicin; as well as neocarzinostatin chromophore and related chromoprotein enediyne antiobiotic chromophores, aclacinomysins, actinomycin, authrarnycin, azaserine, bleomycins, cactinomycin, carabicin, carminomycin, carzinophilin, chromomycinis, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, doxorubicin (including morpholino-doxorubicin, cyanomorpholino-doxorubicin, 2-pyrrolino-doxorubicin and deoxydoxorubicin), epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins, such as mitomycin C, mycophenolic acid, nogalarnycin, olivomycins, peplomycin, potfiromycin, puromycin, quelamycin, rodorubicin, streptonigrin, streptozocin, tubercidin, ubenimex, zinostatin, and zorubicin; anti-metabolites, such as methotrexate and 5-fluorouracil (5-FU); folic acid

analogues, such as denopterin, pteropterin, and trimetrexate; purine analogs, such as fludarabine, 6-mercaptopurine, thiamiprine, and thioguanine; pyrimidine analogs, such as ancitabine, azacitidine, 6-azauridine, carmofur, cytarabine, dideoxyuridine, doxifluridine, enocitabine, and floxuridine; androgens, such as calusterone, dromostanolone propionate, epitiostanol, mepitiostane, and testolactone; anti-adrenals, such as mitotane and trilostane; folic acid replenisher, such as frolinic acid; aceglatone; aldophosphamide glycoside; aminolevulinic acid; eniluracil; amsacrine; bestrabucil; bisantrene; edatraxate; defofamine; demecolcine; diaziquone; elformithine; elliptinium acetate; an epothilone; etoglucid; gallium nitrate; hydroxyurea; lentinan; lonidainine; maytansinoids, such as maytansine and ansamitocins; mitoguazone; mitoxantrone; mopidanmol; nitraerine; pentostatin; phenamet; pirarubicin; losoxantrone; podophyllinic acid; 2-ethylhydrazide; procarbazine; PSKpolysaccharide complex; razoxane; rhizoxin; sizofiran; spirogermanium; tenuazonic acid; triaziquone; 2,2',2"-trichlorotriethylamine; trichothecenes (especially T-2 toxin, verracurin A, roridin A and anguidine); urethan; vindesine; dacarbazine; mannomustine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); cyclophosphamide; taxoids, *e.g.*, paclitaxel and docetaxel gemcitabine; 6-thioguanine; mercaptopurine; platinum coordination complexes, such as cisplatin, oxaliplatin, and carboplatin; vinblastine; platinum; etoposide (VP-16); ifosfamide; mitoxantrone; vincristine; vinorelbine; novantrone; teniposide; edatrexate; daunomycin; aminopterin; xeloda; ibandronate; irinotecan (*e.g.*, CPT-11); topoisomerase inhibitor RFS 2000; difluorometlhylornithine (DMFO); retinoids, such as retinoic acid; capecitabine; carboplatin, procarbazine,plicomycin, gemcitabien, navelbine, farnesyl-protein tansferase inhibitors, transplatinum, and pharmaceutically acceptable salts, acids, or derivatives of any of the above.

2. Radiotherapy

[00143] Other factors that cause DNA damage and have been used extensively include what are commonly known as γ-rays, X-rays, and/or the directed delivery of radioisotopes to tumor cells. Other forms of DNA damaging factors are also contemplated, such as microwaves, proton beam irradiation, and UV-irradiation. It is most likely that all of these factors affect a broad range of damage on DNA, on the precursors of DNA, on the replication and repair of DNA, and on the assembly and maintenance of chromosomes. Dosage ranges for X-rays range from daily doses of 50 to 200 roentgens for prolonged periods of time (3 to 4 wk), to single doses of 2000 to 6000 roentgens. Dosage ranges for radioisotopes vary

widely, and depend on the half-life of the isotope, the strength and type of radiation emitted, and the uptake by the neoplastic cells.

3. Immunotherapy

[00144] The skilled artisan will understand that immunotherapies may be used in combination or in conjunction with methods of the embodiments. In the context of cancer treatment, immunotherapeutics, generally, rely on the use of immune effector cells and molecules to target and destroy cancer cells. Rituximab (RITUXAN®) is such an example. The immune effector may be, for example, an antibody specific for some marker on the surface of a tumor cell. The antibody alone may serve as an effector of therapy or it may recruit other cells to actually affect cell killing. The antibody also may be conjugated to a drug or toxin (chemotherapeutic, radionuclide, ricin A chain, cholera toxin, pertussis toxin, etc.) and serve as a targeting agent. Alternatively, the effector may be a lymphocyte carrying a surface molecule that interacts, either directly or indirectly, with a tumor cell target. Various effector cells include cytotoxic T cells and NK cells

[00145] Antibody–drug conjugates (ADCs) comprise monoclonal antibodies (MAbs) that are covalently linked to cell-killing drugs and may be used in combination therapies. This approach combines the high specificity of MAbs against their antigen targets with highly potent cytotoxic drugs, resulting in "armed" MAbs that deliver the payload (drug) to tumor cells with enriched levels of the antigen. Targeted delivery of the drug also minimizes its exposure in normal tissues, resulting in decreased toxicity and improved therapeutic index. Exemplary ADC drugs inlcude ADCETRIS® (brentuximab vedotin) and KADCYLA® (trastuzumab emtansine or T-DM1).

[00146] In one aspect of immunotherapy, the tumor cell must bear some marker that is amenable to targeting, *i.e.*, is not present on the majority of other cells. Many tumor markers exist and any of these may be suitable for targeting in the context of the present embodiments. Common tumor markers include CD20, carcinoembryonic antigen, tyrosinase (p97), gp68, TAG-72, HMFG, Sialyl Lewis Antigen, MucA, MucB, PLAP, laminin receptor, erb B, erb b2 and p155. An alternative aspect of immunotherapy is to combine anticancer effects with immune stimulatory effects. Immune stimulating molecules also exist including: cytokines, such as IL-2, IL-4, IL-12, GM-CSF, gamma-IFN, chemokines, such as MIP-1, MCP-1, IL-8, and growth factors, such as FLT3 ligand.

[00147] Examples of immunotherapies include immune adjuvants, *e.g.*, Mycobacterium bovis, Plasmodium falciparum, dinitrochlorobenzene, and aromatic compounds); cytokine therapy, *e.g.*, interferons α, β, and γ, IL-1, GM-CSF, and TNF; gene therapy, *e.g.*, TNF, IL-1, IL-2, and p53; and monoclonal antibodies, *e.g.*, anti-CD20, anti-ganglioside GM2, and anti-p185. It is contemplated that one or more anti-cancer therapies may be employed with the antibody therapies described herein.

[00148] In some embodiments, the immunotherapy may be an immune checkpoint inhibitor. Immune checkpoints either turn up a signal (*e.g.*, co-stimulatory molecules) or turn down a signal. Inhibitory immune checkpoints that may be targeted by immune checkpoint blockade include adenosine A2A receptor (A2AR), B7-H3 (also known as CD276), B and T lymphocyte attenuator (BTLA), cytotoxic T-lymphocyte-associated protein 4 (CTLA-4, also known as CD152), indoleamine 2,3-dioxygenase (IDO), killer-cell immunoglobulin (KIR), lymphocyte activation gene-3 (LAG3), programmed death 1 (PD-1), T-cell immunoglobulin domain and mucin domain 3 (TIM-3) and V-domain Ig suppressor of T cell activation (VISTA). In particular, the immune checkpoint inhibitors target the PD-1 axis and/or CTLA-4.

[00149] The immune checkpoint inhibitors may be drugs such as small molecules, recombinant forms of ligand or receptors, or, in particular, are antibodies, such as human antibodies. Known inhibitors of the immune checkpoint proteins or analogs thereof may be used, in particular chimerized, humanized or human forms of antibodies may be used. As the skilled person will know, alternative and/or equivalent names may be in use for certain antibodies mentioned in the present disclosure. Such alternative and/or equivalent names are interchangeable in the context of the present disclosure. For example, it is known that lambrolizumab is also known under the alternative and equivalent names MK-3475 and pembrolizumab.

[00150] In some embodiments, the PD-1 binding antagonist is a molecule that inhibits the binding of PD-1 to its ligand binding partners. In a specific aspect, the PD-1 ligand binding partners are PDL1 and/or PDL2. In another embodiment, a PDL1 binding antagonist is a molecule that inhibits the binding of PDL1 to its binding partners. In a specific aspect, PDL1 binding partners are PD-1 and/or B7-1. In another embodiment, the PDL2 binding antagonist is a molecule that inhibits the binding of PDL2 to its binding partners. In a specific

aspect, a PDL2 binding partner is PD-1. The antagonist may be an antibody, an antigen binding fragment thereof, an immunoadhesin, a fusion protein, or oligopeptide.

[00151] In some embodiments, the PD-1 binding antagonist is an anti-PD-1 antibody (*e.g.*, a human antibody, a humanized antibody, or a chimeric antibody). In some embodiments, the anti-PD-1 antibody is selected from the group consisting of nivolumab, pembrolizumab, and CT-011. In some embodiments, the PD-1 binding antagonist is an immunoadhesin (*e.g.*, an immunoadhesin comprising an extracellular or PD-1 binding portion of PDL1 or PDL2 fused to a constant region (*e.g.*, an Fc region of an immunoglobulin sequence). In some embodiments, the PD-1 binding antagonist is AMP-224. Nivolumab, also known as MDX-1106-04, MDX-1106, ONO-4538, BMS-936558, and OPDIVO®, is an anti-PD-1 antibody that may be used. Pembrolizumab, also known as MK-3475, Merck 3475, lambrolizumab, KEYTRUDA®, and SCH-900475, is an exemplary anti-PD-1 antibody. CT-011, also known as hBAT or hBAT-1, is also an anti-PD-1 antibody. AMP-224, also known as B7-DCIg, is a PDL2-Fc fusion soluble receptor.

[00152] Another immune checkpoint that can be targeted in the methods provided herein is the cytotoxic T-lymphocyte-associated protein 4 (CTLA-4), also known as CD152. The complete cDNA sequence of human CTLA-4 has the Genbank accession number L15006. CTLA-4 is found on the surface of T cells and acts as an "off" switch when bound to CD80 or CD86 on the surface of antigen-presenting cells. CTLA4 is a member of the immunoglobulin superfamily that is expressed on the surface of Helper T cells and transmits an inhibitory signal to T cells. CTLA4 is similar to the T-cell co-stimulatory protein, CD28, and both molecules bind to CD80 and CD86, also called B7-1 and B7-2 respectively, on antigen-presenting cells. CTLA4 transmits an inhibitory signal to T cells, whereas CD28 transmits a stimulatory signal. Intracellular CTLA4 is also found in regulatory T cells and may be important to their function. T cell activation through the T cell receptor and CD28 leads to increased expression of CTLA-4, an inhibitory receptor for B7 molecules.

[00153] In some embodiments, the immune checkpoint inhibitor is an anti-CTLA-4 antibody (*e.g.*, a human antibody, a humanized antibody, or a chimeric antibody), an antigen binding fragment thereof, an immunoadhesin, a fusion protein, or oligopeptide.

[00154] Anti-human-CTLA-4 antibodies (or VH and/or VL domains derived therefrom) suitable for use in the present methods can be generated using methods well known

in the art. Alternatively, art recognized anti-CTLA-4 antibodies can be used. An exemplary anti-CTLA-4 antibody is ipilimumab (also known as 10D1, MDX-010, MDX-101, and Yervoy®) or antigen binding fragments and variants thereof. In other embodiments, the antibody comprises the heavy and light chain CDRs or VRs of ipilimumab. Accordingly, in one embodiment, the antibody comprises the CDR1, CDR2, and CDR3 domains of the VH region of ipilimumab, and the CDR1, CDR2 and CDR3 domains of the VL region of ipilimumab. In another embodiment, the antibody competes for binding with and/or binds to the same epitope on CTLA-4 as the above-mentioned antibodies. In another embodiment, the antibody has at least about 90% variable region amino acid sequence identity with the above-mentioned antibodies (*e.g.*, at least about 90%, 95%, or 99% variable region identity with ipilimumab).

4. Surgery

[00155] Approximately 60% of persons with cancer will undergo surgery of some type, which includes preventative, diagnostic or staging, curative, and palliative surgery. Curative surgery includes resection in which all or part of cancerous tissue is physically removed, excised, and/or destroyed and may be used in conjunction with other therapies, such as the treatment of the present embodiments, chemotherapy, radiotherapy, hormonal therapy, gene therapy, immunotherapy, and/or alternative therapies. Tumor resection refers to physical removal of at least part of a tumor. In addition to tumor resection, treatment by surgery includes laser surgery, cryosurgery, electrosurgery, and microscopically-controlled surgery (Mohs' surgery).

[00156] Upon excision of part or all of cancerous cells, tissue, or tumor, a cavity may be formed in the body. Treatment may be accomplished by perfusion, direct injection, or local application of the area with an additional anti-cancer therapy. Such treatment may be repeated, for example, every 1, 2, 3, 4, 5, 6, or 7 days, or every 1, 2, 3, 4, and 5 weeks or every 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 months. These treatments may be of varying dosages as well.

5. Other Agents

[00157] It is contemplated that other agents may be used in combination with certain aspects of the present embodiments to improve the therapeutic efficacy of treatment. These additional agents include agents that affect the upregulation of cell surface receptors and

GAP junctions, cytostatic and differentiation agents, inhibitors of cell adhesion, agents that increase the sensitivity of the hyperproliferative cells to apoptotic inducers, or other biological agents. Increases in intercellular signaling by elevating the number of GAP junctions would increase the anti-hyperproliferative effects on the neighboring hyperproliferative cell population. In other embodiments, cytostatic or differentiation agents can be used in combination with certain aspects of the present embodiments to improve the anti-hyperproliferative efficacy of the treatments. Inhibitors of cell adhesion are contemplated to improve the efficacy of the present embodiments. Examples of cell adhesion inhibitors are focal adhesion kinase (FAKs) inhibitors and Lovastatin.

V. Articles of Manufacture or Kits

[00158] An article of manufacture or a kit is provided comprising immune cells is also provided herein. The article of manufacture or kit can further comprise a package insert comprising instructions for using the immune cells to treat or delay progression of cancer in an individual or to enhance immune function of an individual having cancer. Any of the antigen-specific immune cells described herein may be included in the article of manufacture or kits. Suitable containers include, for example, bottles, vials, bags and syringes. The container may be formed from a variety of materials such as glass, plastic (such as polyvinyl chloride or polyolefin), or metal alloy (such as stainless steel or hastelloy). In some embodiments, the container holds the formulation and the label on, or associated with, the container may indicate directions for use. The article of manufacture or kit may further include other materials desirable from a commercial and user standpoint, including other buffers, diluents, filters, needles, syringes, and package inserts with instructions for use. In some embodiments, the article of manufacture further includes one or more of another agent (*e.g.,* a chemotherapeutic agent, and anti-neoplastic agent). Suitable containers for the one or more agent include, for example, bottles, vials, bags and syringes.

VI. Examples

[00159] The following examples are included to demonstrate preferred embodiments of the invention. It should be appreciated by those of skill in the art that the techniques disclosed in the examples which follow represent techniques discovered by the inventor to function well in the practice of the invention, and thus can be considered to constitute preferred modes for its practice. However, those of skill in the art should, in light of the present

disclosure, appreciate that many changes can be made in the specific embodiments which are disclosed and still obtain a like or similar result without departing from the spirit and scope of the invention.

Example 1 – Development of CD79b Antibodies and CARs

[00160] CD79b expression is restricted to B cell linage: Using real-time PCR, it was found that CD79b is expressed in a broad range of B cell lymphoma cell lines including Mino, Daudi, HBC-1, Jeko, SUDHL6, SUDHL4, and U2932 but has no expression in Jurkat and J76 T-cell lymphoma/leukemia cell lines (FIG. 1A). To determine whether CD79b was expressed on normal tissues, the FirstChoice Human Total RNA Survey Panel containing 20 normal human tissue total RNA was obtained from Applied Biosystems. Total RNA was extracted from purified B and T cells from human tonsil samples and used as positive and negative controls, respectively. It was found that CD79b transcripts are only present in lymphoid tissues such as spleen and lymph node but are absent in all nonlymphoid normal tissues (FIG. 1B).

[00161] Using publicly available gene expression datasets (Oncomine), it was found that CD79b is highly expressed in ALL and chronic lymphocytic leukemia (FIG. 1C) and multiple B cell lymphoma subtypes such as Burkitt's lymphoma, diffuse large B cell lymphoma, follicular lymphoma, and mantle cell lymphoma (FIG. 1D). The number of samples for each tumor type is shown in brackets.

[00162] Generation of multiple monoclonal antibodies against human CD79b and identification of heavy and light chain sequences of antibodies: Anti-human CD79b monoclonal antibodies were generated by hybridoma technology by immunizing mice with human CD79b-expressing mouse fibroblast L cells (FIG. 2A). By ELISA, three clones were identified with high binding capacity to recombinant human CD79b protein (FIG. 2B). The affinity of these three monoclonal antibodies were further determined by Octet Assay and three clones, 14 (IgG1), 16A (IgG2) and 45 (IgG2) with Kd value at 1.44, 17.8 and 2.0 nM, respectively were selected for further development (FIG. 2C). The monoclonal antibody clone #14 was conjugated with a fluorochrome and shown to stain B cell lymphoma cell lines comparable to the commercial anti-CD79b antibody from BD Biosciences (FIG. 2D). Total RNA of the hybridomas of the monoclonal antibodies was extracted, cDNA was synthesized. 5'-RACE PCR (rapid amplification of cDNA ends) was used to clone V-genes for heavy and

light chains. Protein sequences were predicted by DNA sequences. Hybridoma culture supernatants were purified and heavy chain and light chain protein sequences were confirmed by mass spectrometry from MD Anderson Proteomics Core Facility.

[00163] Generation of anti-CD79b CAR T cells: Using the specific sequences of single chain fragments of variable region (scFv), several constructs of anti-CD79b CAR were generated. In order to detect CAR expression in transduced T cells, CAR-enhanced green fluorescent protein (eGFP) fusion construct or the truncated human epidermal growth factor receptor (huEGFRt) were used (FIG. 3A). The latter can also serve as a safety switch to eliminate CAR T cells in case of severe toxicity. CD3-zeta (CD3z) chain was incorporated to provide signal 1 for activation of T cells and the costimulatory domains CD28 or 4-1BB were incorporated to provide signal 2 (FIG. 3A).

[00164] These constructs were cloned into lentivirus vector pHR_SFFV, which was then used to transduce primary healthy donor T cells. Representative transduction efficiency (>70%) as determined by eGFP expression in $CD4^+$ and $CD8^+$ T cells using Clone 45-CD79b-CD28-CAR is shown in FIG. 3B. Anti-CD19-CAR T cells were used as control.

[00165] Cytotoxic activity of CAR T cells against Daudi cells labeled with CellTrace Far Red was determined by Aqua staining in a 16-hour flow cytometry assay at the indicated Effector:Target (E:T) ratios (FIG. 3C). Representative dot plots with percent dead cells (upper right quadrant) for the various culture conditions at an E:T ratio of 20:1 is shown in FIG. 3D. The data show that both anti-CD19-CAR T cells and anti- CD79b-CAR T cells were highly cytotoxic to Daudi Burkitt lymphoma cells compared with untransduced control T cells.

[00166] Anti-CD79b CAR T cells are cytotoxic to both $CD19^+$ and $CD19^-$ lymphoma cells: To determine the efficacy of anti-CD79b CAR T cells against CD19 negative ($CD19^-$) lymphoma cells, degranulation and cytotoxicity assays were performed with a diffuse large B cell lymphoma cell line, SUDHL6, lacking CD19. First, CD19 was knocked out by CRISPR-Cas9 (CD19KOSUDHL6) and then these lymphoma cells were transduced with CD19 splice variant lacking exon 2 (CD19Dex2) which is the binding site for anti-CD19 antibody clone, FMC63, used in anti CD19 CAR constructs.

[00167] Untransduced primary T cells (Ctrl T), clone-14-CD79b-CD28 CAR, 14- CD79b-4-1BB CAR, and FMC63-CD19-CD28 CAR were co-cultured with Daudi or the

above SUDHL6 cells (CD19KOSUDHL6-CD19Dex2) at an E:T ratio of 5:1. T cells were labeled with CellTrace Far Red and target cells were labeled with CellTrace Violet. After 2 hours, Golgi inhibitor and degranulation marker (CD107a/b) were added to the cultures to determine degranulation of T cells. Cytotoxic activity against tumor cells was determined after 4 days of coculture. The 14-CD79b-CD28 and 14-CD79b-4-1BB CAR T cells but not control T cells showed markedly increased degranulation and cytotoxic activity against both cell lines (FIG. 4A and B). In contrast, FMC63-CD19-CD28 CAR was cytotoxic to $CD19^+$ Daudi but not CD19KOSUDHL6- CD19Dex2 tumor cells.

[00168] Using CountBright Absolute Counting Beads for flow cytometry the absolute number of live tumor cells was also determined after the 4-day co-culture (FIG. 4C). The results were consistent with the observed percentages of live tumor cells (FIG. 4B). Representative dot plots of target cells and effector T cells are shown (FIG.s 4A and B). The experiments were repeated at least 3 times with similar results.

[00169] Anti-CD79b CAR T cells exhibit *in vivo* efficacy against lymphoma xenografts: To test the efficacy of anti-CD79b CAR T cells *in vivo*, Mino mantle cell lymphoma cell line expressing firefly luciferase gene was injected IV into NSG mice at 2 x 10^6 tumor cells/mouse. After 18 days, mice were treated with untransduced primary T cells, anti-CD19-CD28 CAR T cells, or Clone 45 anti-CD79b-CD28 CAR T cells via tail vein injection at 10 x 10^6 CAR^+ T cells or untransduced T cells/mouse. Bioluminescence imaging was used to assess tumor burden (FIG. 5A). The results showed progressive tumor growth in mice treated with untransduced T cells. In contrast, good tumor control and markedly improved survival ($p<0.05$) was observed in mice treated with both anti-CD19- and anti-CD79b CAR T cells (FIG. 5B and C). The *in vitro* results have been verified at least three times for each individual experiment and *in vivo* results were verified twice. Thus, anti-CD79b CAR therapy can be used for the treatment of B cell malignancy with or without CD19 expression.

* * *

[00170] All of the methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the methods and in the steps or in the sequence of steps of the method described herein without departing from the

concept, spirit and scope of the invention. More specifically, it will be apparent that certain agents which are both chemically and physiologically related may be substituted for the agents described herein while the same or similar results would be achieved. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the invention as defined by the appended claims.

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CLAIMS

1. An isolated monoclonal antibody, wherein the antibody specifically binds to CD79b and comprises:

(I):

(a) a first V_H CDR is identical to SEQ ID NO: 3;

(b) a second V_H CDR is identical to SEQ ID NO: 4;

(c) a third V_H CDR is identical to SEQ ID NO: 5;

(d) a first V_L CDR is identical to SEQ ID NO: 8;

(e) a second V_L CDR is identical to SEQ ID NO: 9; and

(f) a third V_L CDR is identical to SEQ ID NO: 10;

(II):

(a) a first V_H CDR is identical to SEQ ID NO: 13;

(b) a second V_H CDR is identical to SEQ ID NO: 14;

(c) a third V_H CDR is identical to SEQ ID NO: 15;

(d) a first V_L CDR is identical to SEQ ID NO: 18;

(e) a second V_L CDR is identical to SEQ ID NO: 19; and

(f) a third V_L CDR is identical to SEQ ID NO: 20; or

(III):

(a) a first V_H CDR is identical to SEQ ID NO: 23;

(b) a second V_H CDR is identical to SEQ ID NO: 24;

(c) a third V_H CDR is identical to SEQ ID NO: 25;

(d) a first V_L CDR is identical to SEQ ID NO: 28;

(e) a second V_L CDR is identical to SEQ ID NO: 29; and

(f) a third V_L CDR is identical to SEQ ID NO: 30.

2. The antibody of claim 1, wherein the antibody comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 3;

(b) a second V_H CDR is identical to SEQ ID NO: 4;

(c) a third V_H CDR is identical to SEQ ID NO: 5;

(d) a first V_L CDR is identical to SEQ ID NO: 8;

(e) a second V_L CDR is identical to SEQ ID NO: 9; and

(f) a third V_L CDR is identical to SEQ ID NO: 10.

3. The antibody of claim 2, wherein the antibody comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 2 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 7.

4. The antibody of claim 2, wherein the antibody comprises a V_H domain identical to the V_H domain of SEQ ID NO: 2 and a V_L domain identical to the V_L domain of SEQ ID NO: 7.

5. The antibody of claim 1, wherein the antibody comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 13;

(b) a second V_H CDR is identical to SEQ ID NO: 14;

(c) a third V_H CDR is identical to SEQ ID NO: 15;

(d) a first V_L CDR is identical to SEQ ID NO: 18;

(e) a second V_L CDR is identical to SEQ ID NO: 19; and

(f) a third V_L CDR is identical to SEQ ID NO: 20.

6. The antibody of claim 5, wherein the antibody comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 12 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 17.

7. The antibody of claim 5, wherein the antibody comprises a V_H domain identical to the V_H domain of SEQ ID NO: 12 and a V_L domain identical to the V_L domain SEQ ID NO: 17.

8. The antibody of claim 1, wherein the antibody comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 23;

(b) a second V_H CDR is identical to SEQ ID NO: 24;

(c) a third V_H CDR is identical to SEQ ID NO: 25;

(d) a first V_L CDR is identical to SEQ ID NO: 28;

(e) a second V_L CDR is identical to SEQ ID NO: 29; and

(f) a third V_L CDR is identical to SEQ ID NO: 30.

9. The antibody of claim 8, wherein the antibody comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 22 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 27.

10. The antibody of claim 8, wherein the antibody comprises a V_H domain identical to the V_H domain of SEQ ID NO: 22 and a V_L domain identical to the V_L domain SEQ ID NO: 27.

11. The antibody of any one of claims 1-10, wherein the antibody is recombinant.

12. The antibody of claim 1, wherein the antibody is an IgG, IgM, IgA or an antigen binding fragment thereof.

13. The antibody of any one of claims 1-10, wherein the antibody is a Fab', a F(ab')2, a F(ab')3, a monovalent scFv, a bivalent scFv, or a single domain antibody.

14. The antibody of any one of claims 1-12, wherein the antibody is a human, humanized antibody or de-immunized antibody.

15. The antibody of any one of claims 1-14, wherein the antibody is conjugated to an imaging agent, a chemotherapeutic agent, a toxin or a radionuclide.

16. A composition comprising an antibody of any one of claims 1-15 in a pharmaceutically acceptable carrier.

17. An isolated polynucleotide molecule comprising a nucleic acid sequence encoding an antibody of any one of claims 1-14.

18. A recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 14 (SEQ ID NOs: 3, 4, and 5) and CDRs 1-3 of the V_H domain of Clone 14 (SEQ ID NOs: 8, 9, and 10).

19. A recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 16a (SEQ ID NOs: 13, 14, and 15) and CDRs 1-3 of the V_H domain of Clone 16a (SEQ ID NOs: 18, 19, and 20).

20. A recombinant polypeptide comprising an antibody V_H domain comprising CDRs 1-3 of the V_H domain of Clone 45 (SEQ ID NOs: 23, 24, and 25) and CDRs 1-3 of the V_H domain of Clone 45 (SEQ ID NOs: 28, 29, and 30).

21. An isolated polynucleotide molecule comprising a nucleic acid sequence encoding a polypeptide of any of claims 18-20.

22. A host cell comprising one or more polynucleotide molecule(s) encoding an antibody of any one of claims 1-14 or a recombinant polypeptide of any of claims 18-20.

23. The host cell of claim 22, wherein the host cell is a mammalian cell, a yeast cell, a bacterial cell, a ciliate cell or an insect cell.

24. A method for treating a subject having a cancer comprising administering an effective amount of an antibody of any one of claims 1-13 to the subject.

25. The method of claim 24, wherein the cancer is B cell malignancy.

26. The method of claim 24, wherein the antibody is in a pharmaceutically acceptable composition.

27. The method of claim 24, wherein the antibody is administered systemically.

28. The method of claim 24, wherein the antibody is administered intravenously, intradermally, intratumorally, intramuscularly, intraperitoneally, subcutaneously, or locally.

29. The method of claim 24, further comprising administering at least a second anticancer therapy to the subject.

30. The method of claim 29, wherein the second anticancer therapy is a surgical therapy, chemotherapy, radiation therapy, cryotherapy, hormonal therapy, immunotherapy or cytokine therapy.

31. The method of claim 29, wherein the second anticancer therapy comprises an adoptive T-cell therapy.

32. An engineered CD79b-targeted chimeric antigen receptor (CAR) comprising CD3ζ, CD28, 4-1BB, and/or OX40 signaling domains.

33. The CAR of claim 32, wherein the CAR comprises CD3ζ and CD28 signaling domains.

34. The CAR of claim 32, wherein the CAR comprises CD3ζ and 4-1BB signaling domains.

35. The CAR of claim 32, wherein the CAR comprises CD3ζ and OX-40 signaling domains.

36. The CAR of claim 32, wherein the CAR is encoded by a viral vector.

37. The CAR of claim 36, wherein the viral vector is a lentiviral vector.

38. The CAR of any of claims 32-37, wherein the CAR comprises an antigen-binding domain selected from the group consisting of F(ab')2, Fab', Fab, Fv, and scFv.

39. The CAR of claim 32, wherein the antigen-binding domain comprises an antibody of any one of claims 1-14 or a fragment thereof.

40. The CAR of claim 39, wherein the antigen-binding domain comprises:

(I):

(a) a first V_H CDR is identical to SEQ ID NO: 3;
(b) a second V_H CDR is identical to SEQ ID NO: 4;
(c) a third V_H CDR is identical to SEQ ID NO: 5;
(d) a first V_L CDR is identical to SEQ ID NO: 8;
(e) a second V_L CDR is identical to SEQ ID NO: 9; and
(f) a third V_L CDR is identical to SEQ ID NO: 10;

(II):

(a) a first V_H CDR is identical to SEQ ID NO: 13;
(b) a second V_H CDR is identical to SEQ ID NO: 14;
(c) a third V_H CDR is identical to SEQ ID NO: 15;
(d) a first V_L CDR is identical to SEQ ID NO: 18;
(e) a second V_L CDR is identical to SEQ ID NO: 19; and
(f) a third V_L CDR is identical to SEQ ID NO: 20; or

(III):

(a) a first V_H CDR is identical to SEQ ID NO: 23;
(b) a second V_H CDR is identical to SEQ ID NO: 24;
(c) a third V_H CDR is identical to SEQ ID NO: 25;
(d) a first V_L CDR is identical to SEQ ID NO: 28;
(e) a second V_L CDR is identical to SEQ ID NO: 29; and
(f) a third V_L CDR is identical to SEQ ID NO: 30.

41. The CAR of claim 39, wherein the antigen-binding domain comprises an scFV having at least 90% identity to the amino acid sequence of SEQ ID NOs: 31, 32, or 33.

42. The CAR of claim 39, wherein the antigen-binding domain comprises an scFV having an amino acid sequence of SEQ ID NOs: 31, 32, or 33.

43. The CAR of claim any of claims 33-42, wherein the antigen-binding domain comprises a V_H domain linked to a V_L domain by a linker.

44. The CAR of claim 43, wherein the linker is Linker 1 (SEQ ID NOs: 44 or 45), Linker 2 (SEQ ID NOs:46 or 47), Linker 3 (SEQ ID NOs:48 or 49), or Linker 4 (SEQ ID NOs:50 or 51).

45. The CAR of any of claim 43, wherein the CAR comprises V_L-Linker1-V_H, V_L-Linker2-V_H, V_L-Linker3-V_H, V_L-Linker4-V_H, V_H-Linker1-V_L, V_H-Linker2-V_L, V_H-Linker3-V_L, or V_H-Linker4-V_L.

46. The CAR of any of claims 32-45, wherein the CAR comprises a hinge.

47. The CAR of claim 46, wherein the hinge is CD8 Hinge 1 (SEQ ID NOs:52 or 53), CD8 Hinge 2 (SEQ ID NOs:54 or 55), CD8 Hinge 3 (SEQ ID NOs:56 or 57), CD28 Hinge (SEQ ID NOs:58 or 59), IgG4 Hinge (SEQ ID NOs:60 or 61), IgG4 CH2 (SEQ ID NOs:62 or 63), IgG4 CH2CH3 (SEQ ID NOs:64 or 65), or IgG4 CH1CH2CH3 (SEQ ID NOs:66 or 67).

48. The CAR of any of claims 32-47, wherein the CAR comprises a transmembrane domain.

49. The CAR of claim 48, wherein the transmembrane domain is CD8 TM1 (SEQ ID NOs:68 or 69), CD8 TM2 (SEQ ID NOs:70 or 71), or CD28 TM (SEQ ID NOs:72 or 73).

50. The CAR of any of claims 32-49, further comprising a transduction marker and/or safety switch.

51. The CAR of claim 50, wherein the transduction marker is enhanced green fluorescent protein (eGFP).

52. The CAR of claim 51, wherein the eGFP has an amino acid sequence of SEQ ID NO:83.

53. The CAR of claim 50, wherein the transduction marker and/or safety switch is truncated epidermal growth factor (EGFR).

54. The CAR of claim 53, wherein the EGFR has an amino acid sequence of SEQ ID NO:41.

55. The CAR of claim 50, wherein the transduction marker and/or safety switch is linked to the CAR by a cleavage peptide.

56. The CAR of claim 55, wherein the cleavage peptide is a 2A peptide.

57. The CAR of claim 56, wherein the 2A peptide if a T2A peptide.

58. The CAR of claim 57, wherein the T2A peptide has an amino acid sequence of SEQ ID NO:85.

59. The CAR of any of claims 32-58, wherein the CAR comprises a sequence having at least 90% identity to the amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

60. The CAR of any of claims 32-58, wherein the CAR comprises a sequence having an amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

61. The CAR of any of claims 32-60, wherein the CAR further comprises a second antigen binding domain.

62. The CAR of claim 61, wherein the second antigen binding domain is a CD19, CD20, or CD22 antigen binding domain.

63. An engineered CD79b CAR or TCR having an antigen binding domain comprising:

(I):

(a) a first V_H CDR is identical to SEQ ID NO: 3;
(b) a second V_H CDR is identical to SEQ ID NO: 4;
(c) a third V_H CDR is identical to SEQ ID NO: 5;
(d) a first V_L CDR is identical to SEQ ID NO: 8;
(e) a second V_L CDR is identical to SEQ ID NO: 9; and
(f) a third V_L CDR is identical to SEQ ID NO: 10;

(II):

(a) a first V_H CDR is identical to SEQ ID NO: 13;

(b) a second V_H CDR is identical to SEQ ID NO: 14;

(c) a third V_H CDR is identical to SEQ ID NO: 15;

(d) a first V_L CDR is identical to SEQ ID NO: 18;

(e) a second V_L CDR is identical to SEQ ID NO: 19; and

(f) a third V_L CDR is identical to SEQ ID NO: 20; or

(III):

(a) a first V_H CDR is identical to SEQ ID NO: 23;

(b) a second V_H CDR is identical to SEQ ID NO: 24;

(c) a third V_H CDR is identical to SEQ ID NO: 25;

(d) a first V_L CDR is identical to SEQ ID NO: 28;

(e) a second V_L CDR is identical to SEQ ID NO: 29; and

(f) a third V_L CDR is identical to SEQ ID NO: 30.

64. The CAR of claim 63, wherein the antigen-binding domain comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 3;

(b) a second V_H CDR is identical to SEQ ID NO: 4;

(c) a third V_H CDR is identical to SEQ ID NO: 5;

(d) a first V_L CDR is identical to SEQ ID NO: 8;

(e) a second V_L CDR is identical to SEQ ID NO: 9; and

(f) a third V_L CDR is identical to SEQ ID NO: 10.

65. The CAR or TCR of claim 64, wherein the antigen-binding domain comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 2 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 7.

66. The CAR or TCR of claim 64, wherein the antigen-binding domain comprises a V_H domain identical to the V_H domain of SEQ ID NO: 2 and a V_L domain identical to the V_L domain of SEQ ID NO: 7.

67. The CAR or TCR of claim 63, wherein the antibody comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 13;

(b) a second V_H CDR is identical to SEQ ID NO: 14;

(c) a third V_H CDR is identical to SEQ ID NO: 15;

(d) a first V_L CDR is identical to SEQ ID NO: 18;

(e) a second V_L CDR is identical to SEQ ID NO: 19; and

(f) a third V_L CDR is identical to SEQ ID NO: 20.

68. The CAR or TCR of claim 67, wherein the antigen-binding domain comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 12 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 17.

69. The CAR or TCR of claim 67, wherein the antigen-binding domain comprises a V_H domain identical to the V_H domain of SEQ ID NO: 12 and a V_L domain identical to the V_L domain SEQ ID NO: 17.

70. The CAR or TCR of claim 63, wherein the antigen-binding domain comprises:

(a) a first V_H CDR is identical to SEQ ID NO: 23;

(b) a second V_H CDR is identical to SEQ ID NO: 24;

(c) a third V_H CDR is identical to SEQ ID NO: 25;

(d) a first V_L CDR is identical to SEQ ID NO: 28;

(e) a second V_L CDR is identical to SEQ ID NO: 29; and

(f) a third V_L CDR is identical to SEQ ID NO: 30.

71. The CAR or TCR of claim 70, wherein the antigen-binding domain comprises a V_H domain at least about 80% identical to the V_H domain of SEQ ID NO: 22 and a V_L domain at least about 80% identical to the V_L domain of SEQ ID NO: 27.

72. The CAR or TCR of claim 70, wherein the antigen-binding domain comprises a V_H domain identical to the V_H domain of SEQ ID NO: 22 and a V_L domain identical to the V_L domain SEQ ID NO: 27.

73. The CAR or TCR of claim 63, wherein the CAR comprises one or more signaling domains CD3ξ, CD28, OX40/CD134, 4-1BB/CD137, or a combination thereof.

74. The CAR or TCR of claim 63, wherein the CAR comprises CD3ζ and CD28 signaling domains.

75. The CAR or TCR of claim 63, wherein the CAR comprises CD3ζ and 4-1BB signaling domains.

76. The CAR or TCR of claim 63, wherein the CAR comprises CD3ζ and OX-40 signaling domains.

77. The CAR or TCR of claim 63, wherein the CAR or TCR is encoded by a viral vector.

78. The CAR or TCR of claim 77, wherein the viral vector is a lentiviral vector.

79. The CAR or TCR of claim 63, wherein the antigen-binding domain comprises an scFV having at least 90% identity to the amino acid sequence of SEQ ID NOs: 31, 32, or 33.

80. The CAR or TCR of claim 63, wherein the antigen-binding domain comprises an scFV having an amino acid sequence of SEQ ID NOs: 31, 32, or 33.

81. The CAR or TCR of claim any of claims 63-80, wherein the antigen-binding domain comprises a V_H domain linked to a V_L domain by a linker.

82. The CAR or TCR of claim 81, wherein the linker is Linker 1 (SEQ ID NOs: 44 or 45), Linker 2 (SEQ ID NOs:46 or 47), Linker 3 (SEQ ID NOs:48 or 49), or Linker 4 (SEQ ID NOs:50 or 51).

83. The CAR or TCR of any of claims 63-82, wherein the CAR comprises V_L-Linker1-V_H, V_L-Linker2-V_H, V_L-Linker3-V_H, V_L-Linker4-V_H, V_H-Linker1-V_L, V_H-Linker2-V_L, V_H-Linker3-V_L, or V_H-Linker4-V_L.

84. The CAR or TCR of any of claims 63-83, wherein the CAR or TCR comprises a hinge.

85. The CAR or TCR of claim 84, wherein the hinge is CD8 Hinge 1 (SEQ ID NOs:52 or 53), CD8 Hinge 2 (SEQ ID NOs:54 or 55), CD8 Hinge 3 (SEQ ID NOs:56 or 57), CD28 Hinge (SEQ ID NOs:58 or 59), IgG4 Hinge (SEQ ID NOs:60 or 61), IgG4 CH2 (SEQ ID NOs:62 or 63), IgG4 CH2CH3 (SEQ ID NOs:64 or 65), or IgG4 CH1CH2CH3 (SEQ ID NOs:66 or 67).

86. The CAR or TCR of any of claims 63-85, wherein the CAR comprises a transmembrane domain.

87. The CAR or TCR of claim 86, wherein the transmembrane domain is CD8 TM1 (SEQ ID NOs:68 or 69), CD8 TM2 (SEQ ID NOs:70 or 71), or CD28 TM (SEQ ID NOs:72 or 73).

88. The CAR or TCR of claim 63, further comprising a transduction marker and/or safety switch.

89. The CAR or TCR of claim 88, wherein the transduction marker is enhanced green fluorescent protein (eGFP).

90. The CAR or TCR of claim 89, wherein the eGFP has an amino acid sequence of SEQ ID NO:83.

91. The CAR of claim 88, wherein the transduction marker and/or safety switch is truncated epidermal growth factor (EGFR).

92. The CAR or TCR of claim 91, wherein the EGFR has an amino acid sequence of SEQ ID NO:41.

93. The CAR or TCR of claim 88, wherein the transduction marker and/or safety switch is linked to the CAR by a cleavage peptide.

94. The CAR or TCR of claim 93, wherein the cleavage peptide is a 2A peptide.

95. The CAR or TCR of claim 94, wherein the 2A peptide if a T2A peptide.

96. The CAR or TCR of claim 95, wherein the T2A peptide has an amino acid sequence of SEQ ID NO:85.

97. The CAR or TCR of claim 63, wherein the CAR comprises a sequence having at least 90% identity to the amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

98. The CAR or TCR of claim 63, wherein the CAR comprises a sequence having an amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87, or 88.

99. The CAR or TCR of claim 63, wherein the CAR further comprises a second antigen binding domain.

100. The CAR or TCR of claim 99, wherein the second antigen binding domain is a CD19, CD20, or CD22 antigen binding domain.

101. An expression vector encoding the CAR or TCR of any one of claims 32-100.

102. A host cell engineered to express a CD79b CAR or a CD79b TCR.

103. The cell of claim 102, wherein the cell is engineered to express a CAR of any one of claims 30-100.

104. The cell of claim 102, wherein the host cell is an immune cell.

105. The cell of claim 104, wherein the immune cell is a T cell.

106. The cell of claim 105, wherein the T cell is a primary human T cell or a TIL.

107. The cell of claim 105, wherein the T cell is a CD4+ T cell or CD8+ T cell.

108. The cell of claim 106, wherein the primary human T cell is obtained from a healthy donor.

109. The cell of claim 105, wherein the T cell is autologous.

110. The cell of claim 105, wherein the T cell is allogeneic.

111. The cell of claims 102, wherein the cell is engineered using a CRISPR or transposase system.

112. A pharmaceutical composition comprising CD79b CAR T cells and a pharmaceutical carrier.

113. The composition of claim 112, wherein the CD79b CAR T cells are engineered to express a CAR of any one of claims 32-100.

114. A composition comprising an effective amount of CD79b CAR T cells for the treatment of cancer in a subject.

115. The composition of claim 114, wherein the CD79b CAR T cells are engineered to express a CAR of any one of claims 32-100.

116. The use of a composition comprising an effective amount of CD79b CAR T cells for the treatment of cancer in a subject.

117. The use of claim 114, wherein the CD79b CAR T cells are engineered to express a CAR of any one of claims 32-100.

118. A method for treating cancer in a subject comprising administering an effective amount of CD79b CAR T cells to the subject.

119. The method of claim 118, wherein the CD79b CAR T cells are engineered to express a CAR of any one of claims 32-100.

120. The method of claim 118, wherein the cancer is a B cell malignancy.

121. The method of claim 120, wherein the B cell malignancy is B cell acute lymphoblastic leukemia (ALL), diffuse, large B cell lymphoma, follicular lymphoma, marginal zone lymphoma, lymphoplasmacytic lymphoma, Burkitt lymphoma, or chronic lymphocytic leukemia.

122. The method of claim 118, wherein the subject has been previously administered a CD19 CAR therapy.

123. The method of claim 122, wherein the subject is resistant to CD19 CAR therapy.

124. The method of claim 123, wherein the subject has CD19 antigen loss.

125. The method of claim 124, wherein the subject has relapsed with a CD19-negative tumor.

126. The method of claim 118, wherein the CD79b CAR T cells are administered intravenously, intradermally, intratumorally, intramuscularly, intraperitoneally, subcutaneously, or locally.

127. The method of claim 118, wherein the CD79b CAR T cells are administered intravenously.

128. The method of claim 118, further comprising administering at least a second anticancer therapy to the subject.

129. The method of claim 128, wherein the second anticancer therapy is a surgical therapy, chemotherapy, radiation therapy, cryotherapy, hormonal therapy, immunotherapy or cytokine therapy.

130. The method of claim 118, wherein the cancer is a CD79b-expressing cancer.

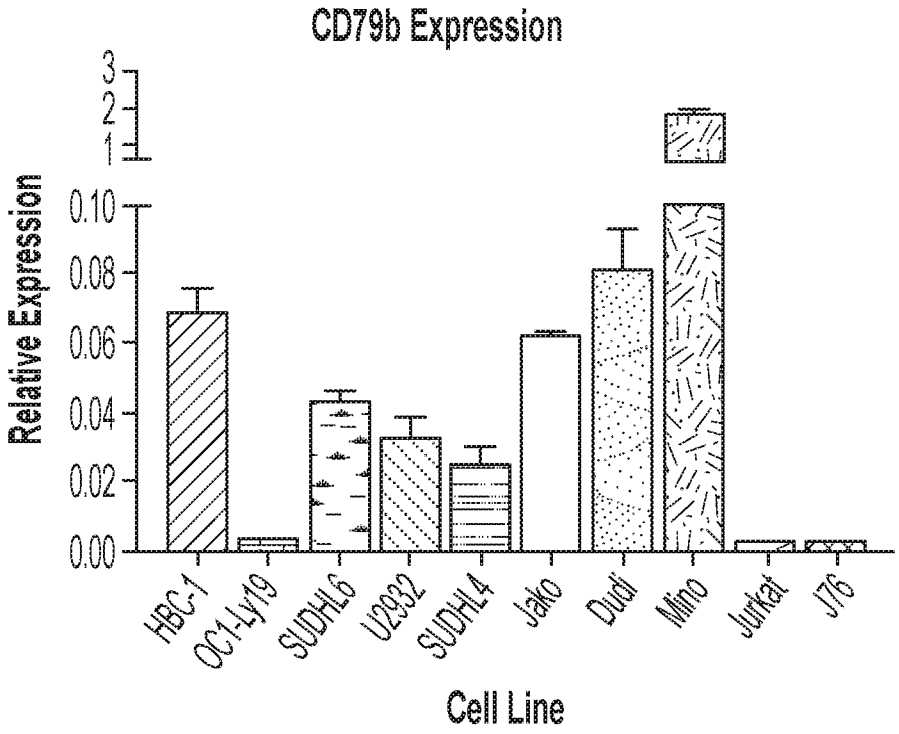

CD79b Expression
Relative Expression
3
2
1
0.10
0.08
0.06
0.04
0.02
0.00
HBC-1
OC1-Ly19
SUDHL6
U2932
SUDHL4
Jako
Dudi
Mino
Jurkat
J76
Cell Line

FIG. 1A

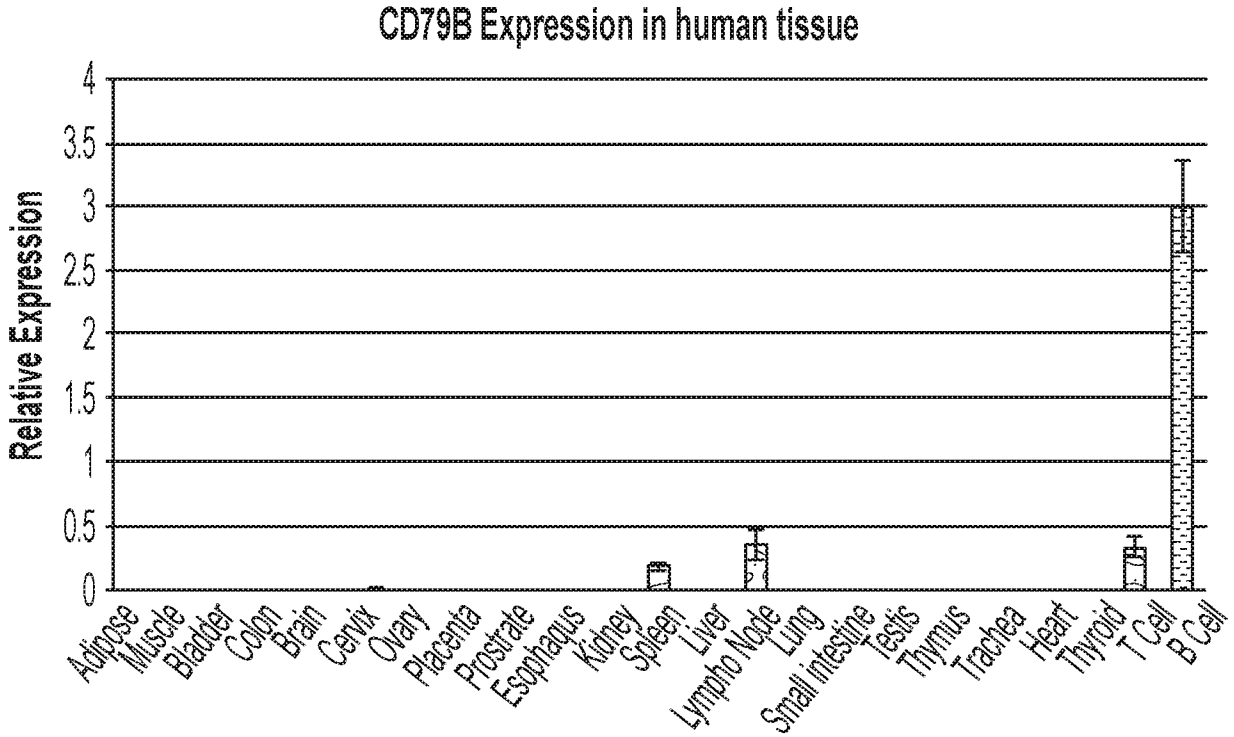

CD79B Expression in human tissue
Relative Expression
4
3.5
3
2.5
2
1.5
1
0.5
0
Adipose
Muscle
Bladder
Colon
Brain
Cervix
Ovary
Placenta
Prostate
Esophagus
Kidney
Spleen
Liver
Lympho Node
Lung
Small intestine
Testis
Thymus
Trachea
Heart
Thyroid
T Cell
B Cell

FIG. 1B

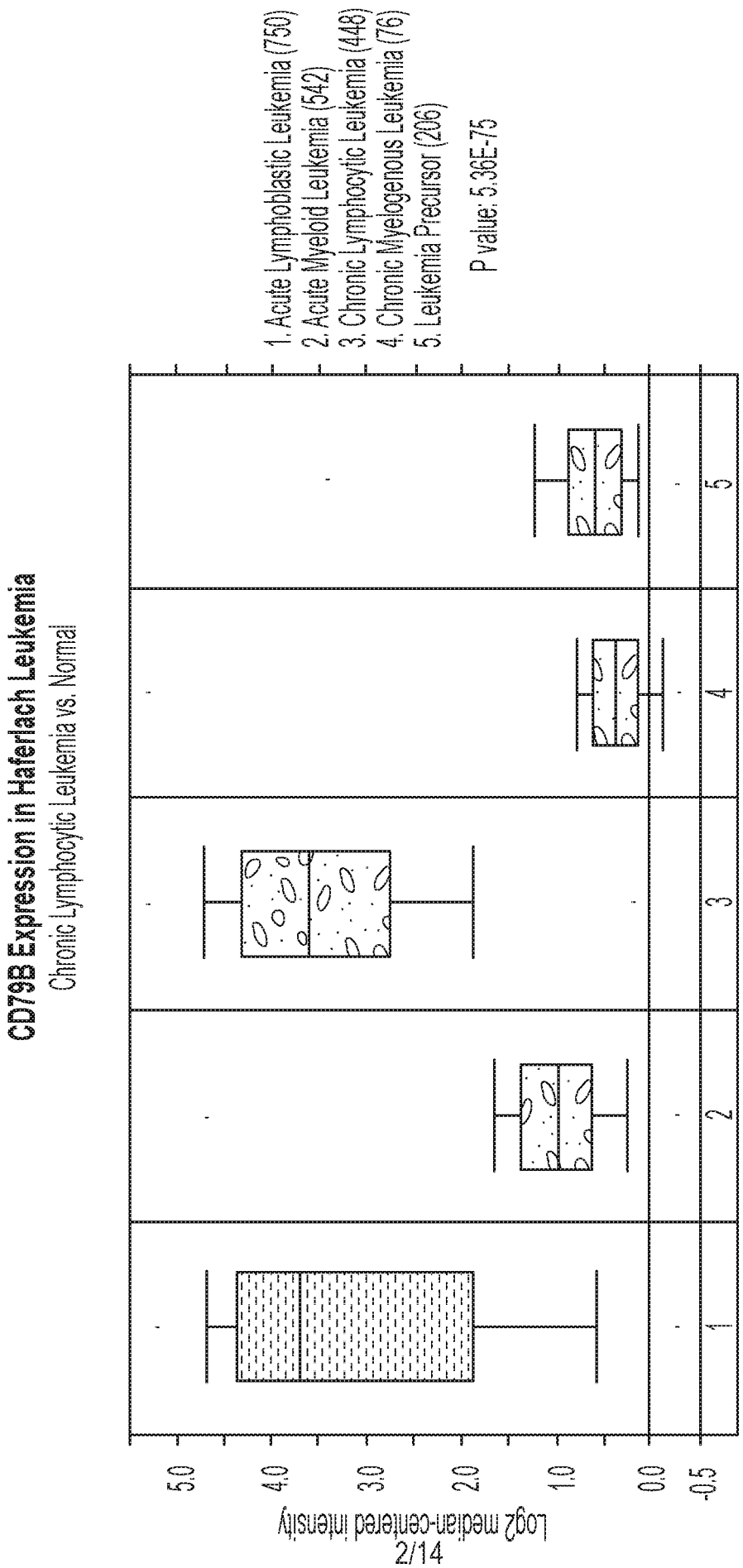

CD79B Expression in Haferlach Leukemia
Chronic Lymphocytic Leukemia vs. Normal
1. Acute Lymphoblastic Leukemia (750)
2. Acute Myeloid Leukemia (542)
3. Chronic Lymphocytic Leukemia (448)
4. Chronic Myelogenous Leukemia (76)
5. Leukemia Precursor (206)
P value: 5.36E-75
Log2 median-centered intensity
5.0
4.0
3.0
2.0
1.0
0.0
-0.5
1
2
3
4
5

FIG. 1C

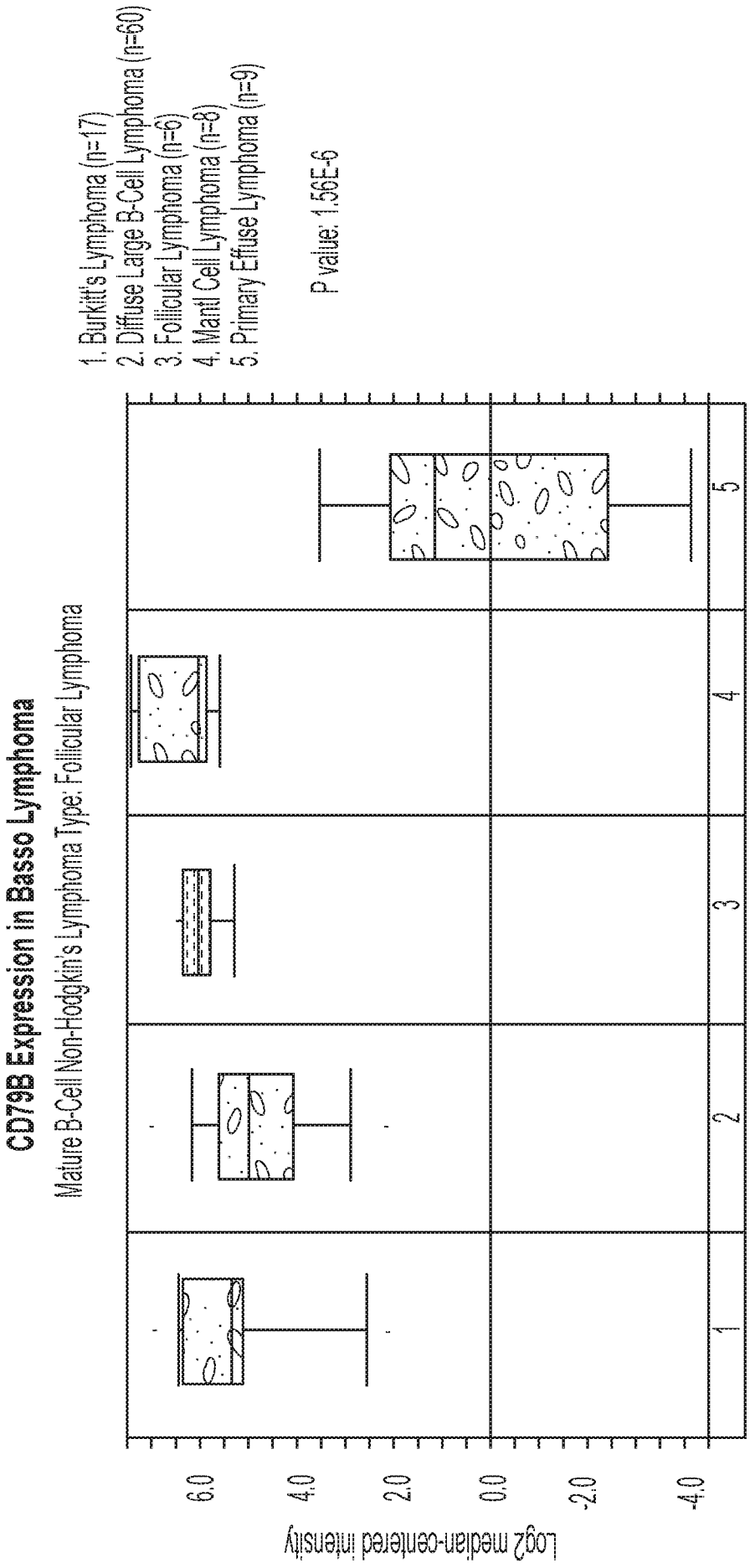

CD79B Expression in Basso Lymphoma
Mature B-Cell Non-Hodgkin's Lymphoma Type: Follicular Lymphoma
1. Burkitt's Lymphoma (n=17)
2. Diffuse Large B-Cell Lymphoma (n=60)
3. Follicular Lymphoma (n=6)
4. Mantl Cell Lymphoma (n=8)
5. Primary Effuse Lymphoma (n=9)
P value: 1.56E-6
Log2 median-centered intensity
6.0
4.0
2.0
0.0
-2.0
-4.0
1
2
3
4
5

FIG. 1D

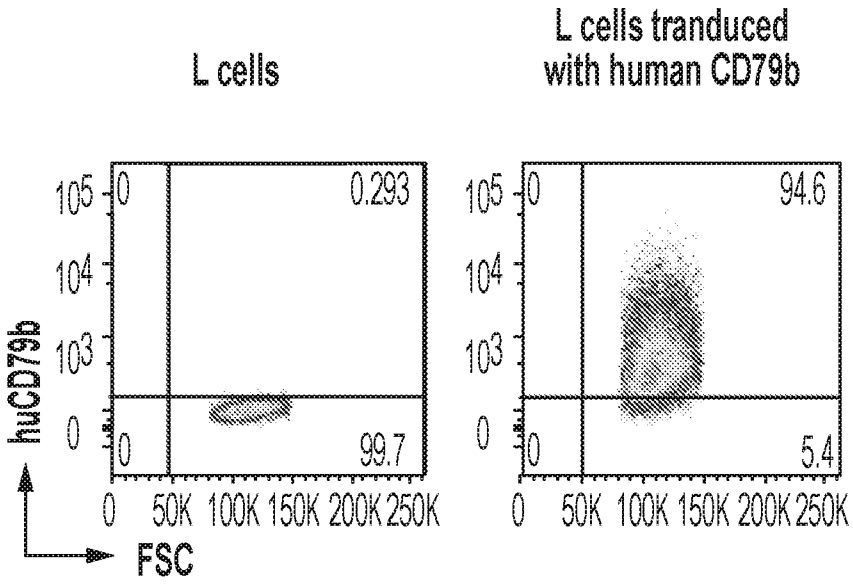

L cells
L cells tranduced with human CD79b
huCD79b
FSC
0
0.293
99.7
94.6
5.4
50K
100K
150K
200K
250K

FIG. 2A

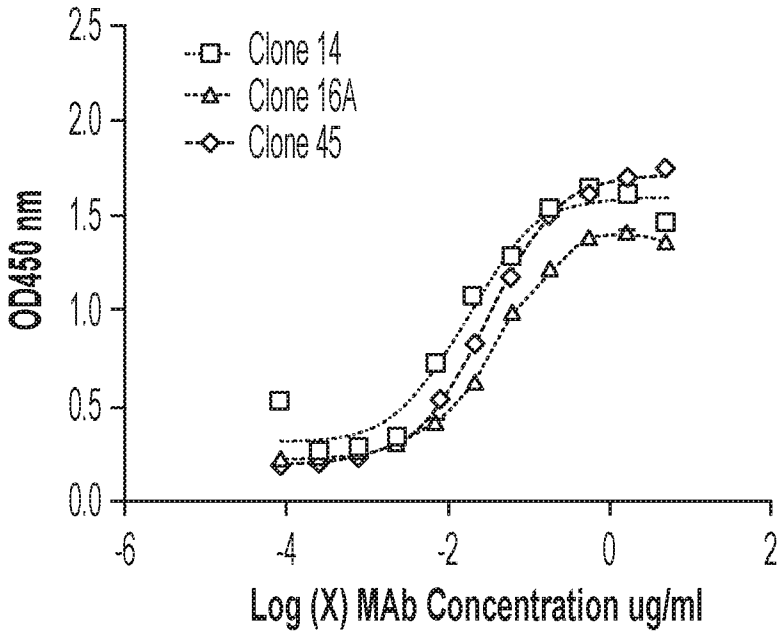
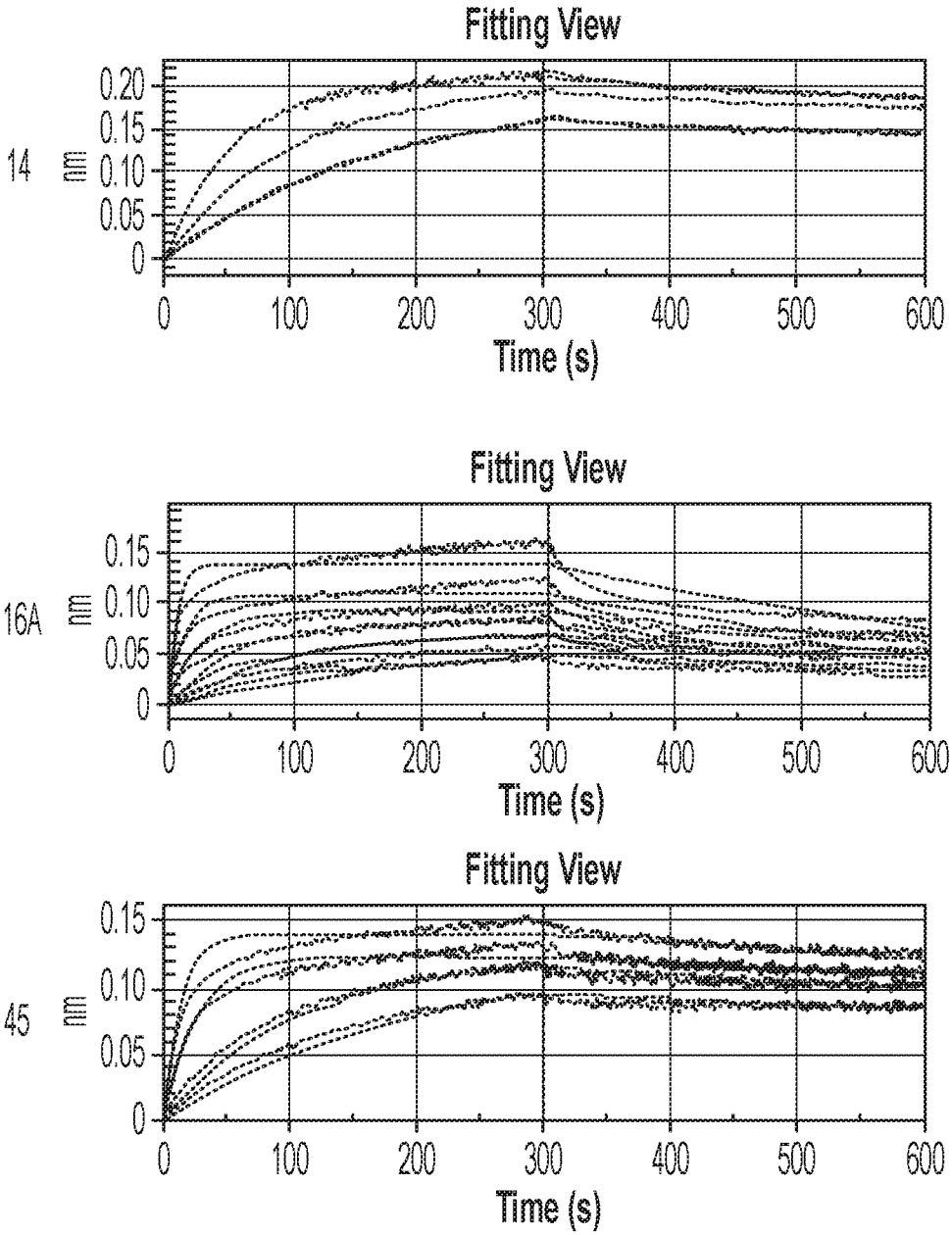

Clone 14
Clone 16A
Clone 45
OD450 nm
Log (X) MAb Concentration ug/ml

FIG. 2B



Clone	Isotype	EC50(ng/ml)	KD (nM)
260A-14	IgG1	16.17	1.44
260B-16A	IgG2	35.69	17.8
260B-45	IgG2	30.13	2.0

FIG. 2C

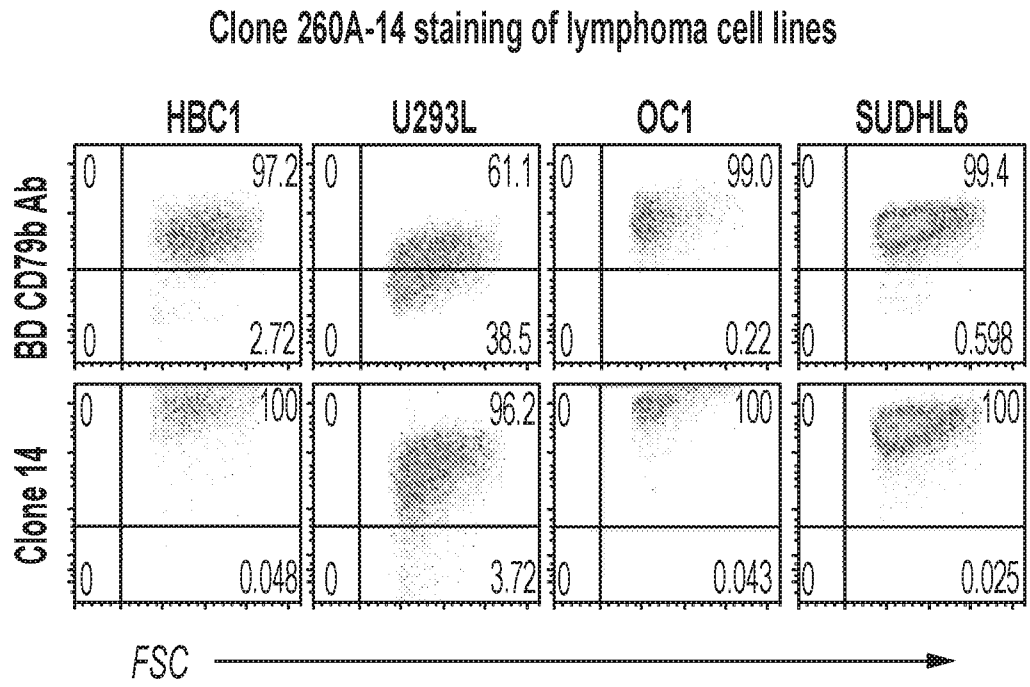

Clone 260A-14 staining of lymphoma cell lines
HBC1
U293L
OC1
SUDHL6
BD CD79b Ab
Clone 14
97.2
2.72
61.1
38.5
99.0
0.22
99.4
0.598
100
0.048
96.2
3.72
100
0.043
100
0.025
FSC

FIG. 2D

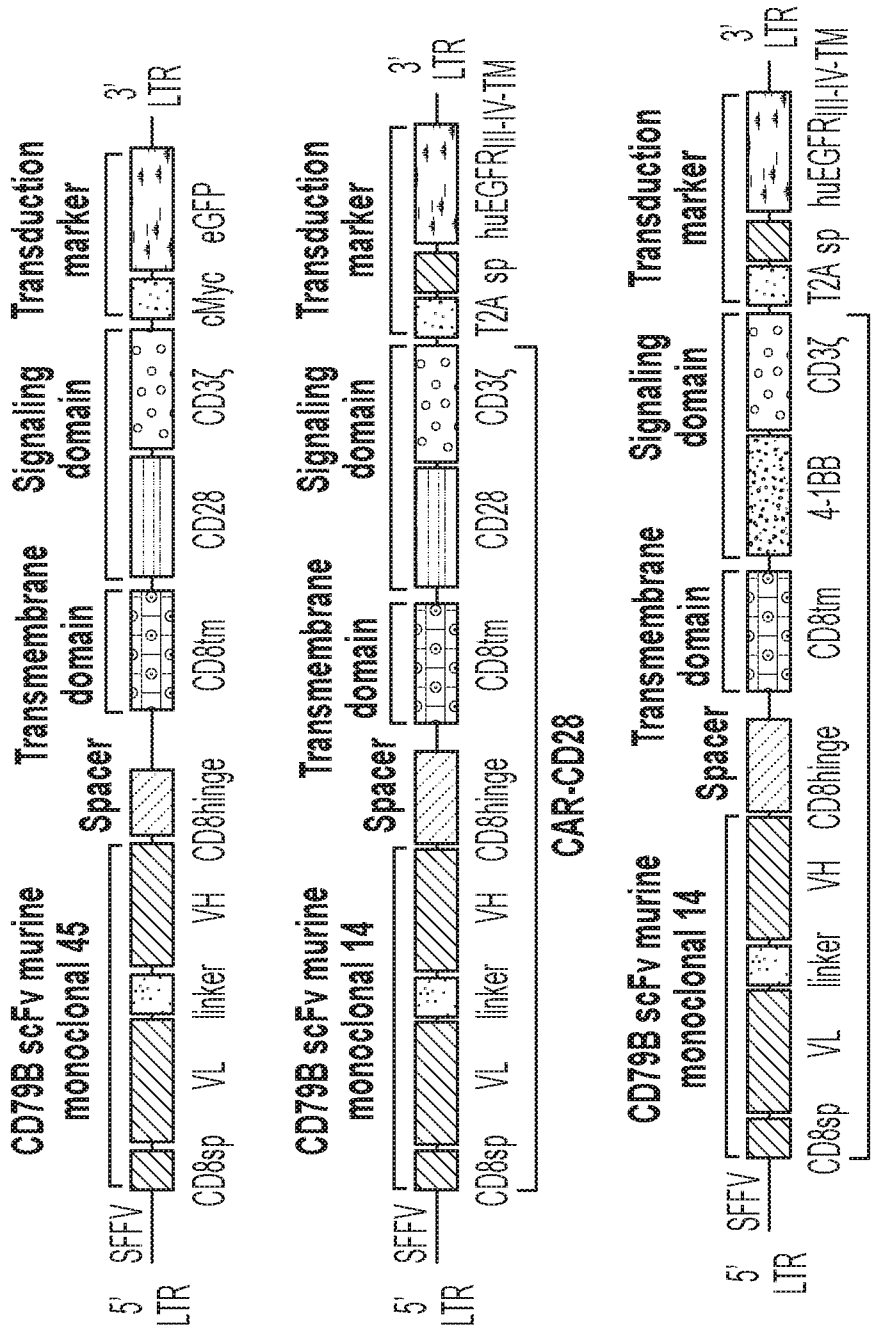

CD79B scFv murine monoclonal 45
Spacer
Transmembrane domain
Signaling domain
Transduction marker
5' LTR
SFFV
CD8sp
VL
linker
VH
CD8hinge
CD8tm
CD28
CD3ζ
cMyc
eGFP
3' LTR
CD79B scFv murine monoclonal 14
CAR-CD28
T2A sp
huEGFRIII-IV-TM
CAR-4-1BB
4-1BB

FIG. 3A

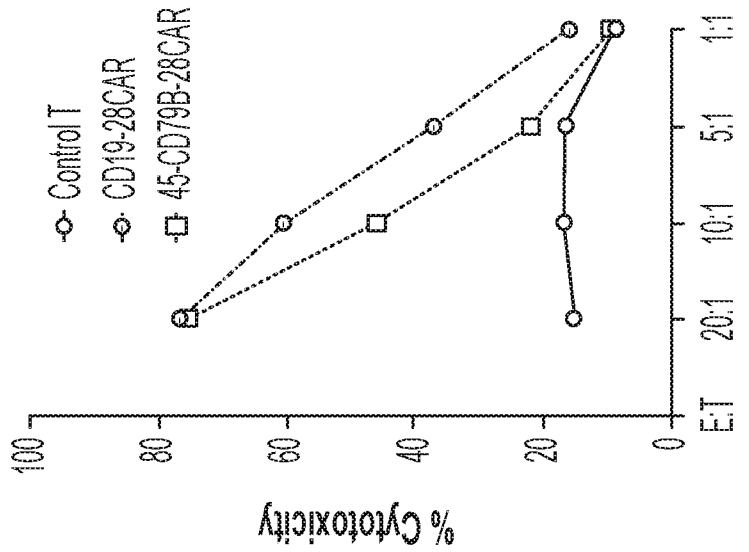

Control T
CD19-28CAR
45-CD79B-28CAR
% Cytotoxicity
100
80
60
40
20
0
E:T
20:1
10:1
5:1
1:1

FIG. 3C

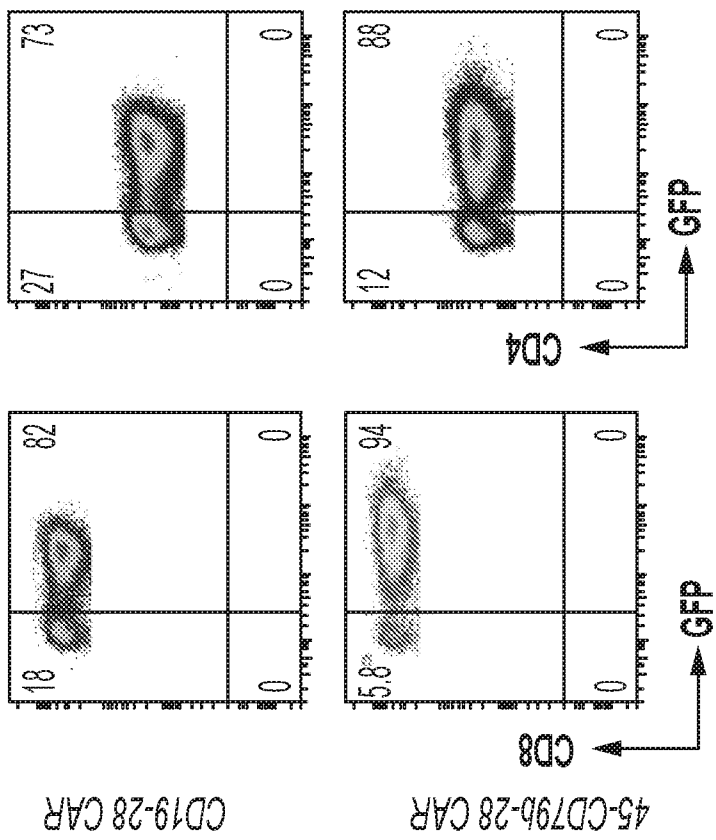

CD19-28 CAR
45-CD79b-28 CAR
CD8
GFP
CD4
GFP
18
82
15.8
94
12
88
27
73

FIG. 3B

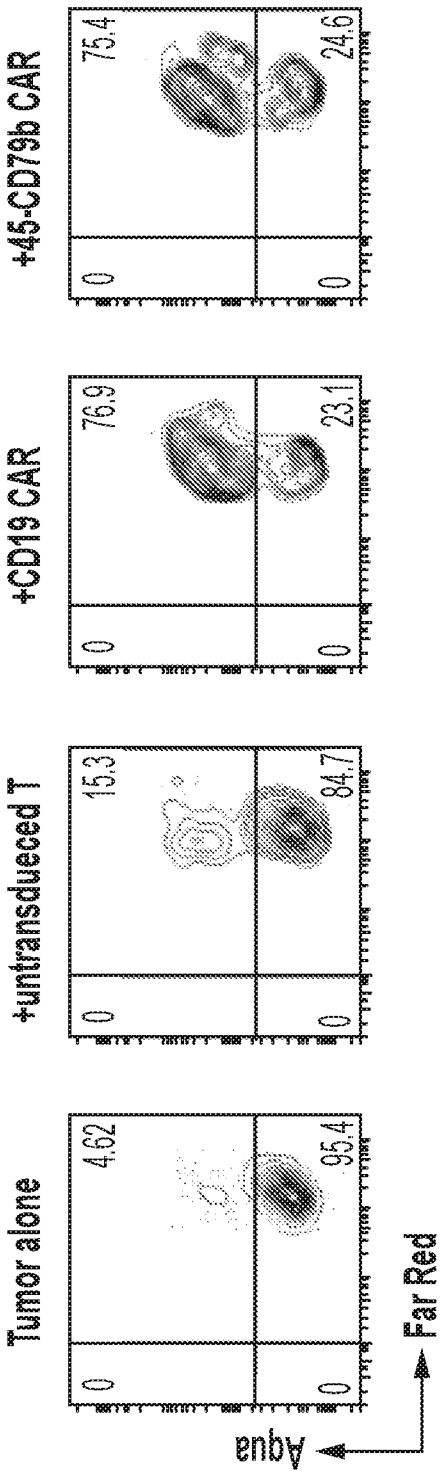

Tumor alone
+untransdueced T
+CD19 CAR
+45-CD79b CAR
4.62
95.4
15.3
84.7
76.9
23.1
75.4
24.6
0
0
0
0
0
0
0
0
Aqua
Far Red

FIG. 3D

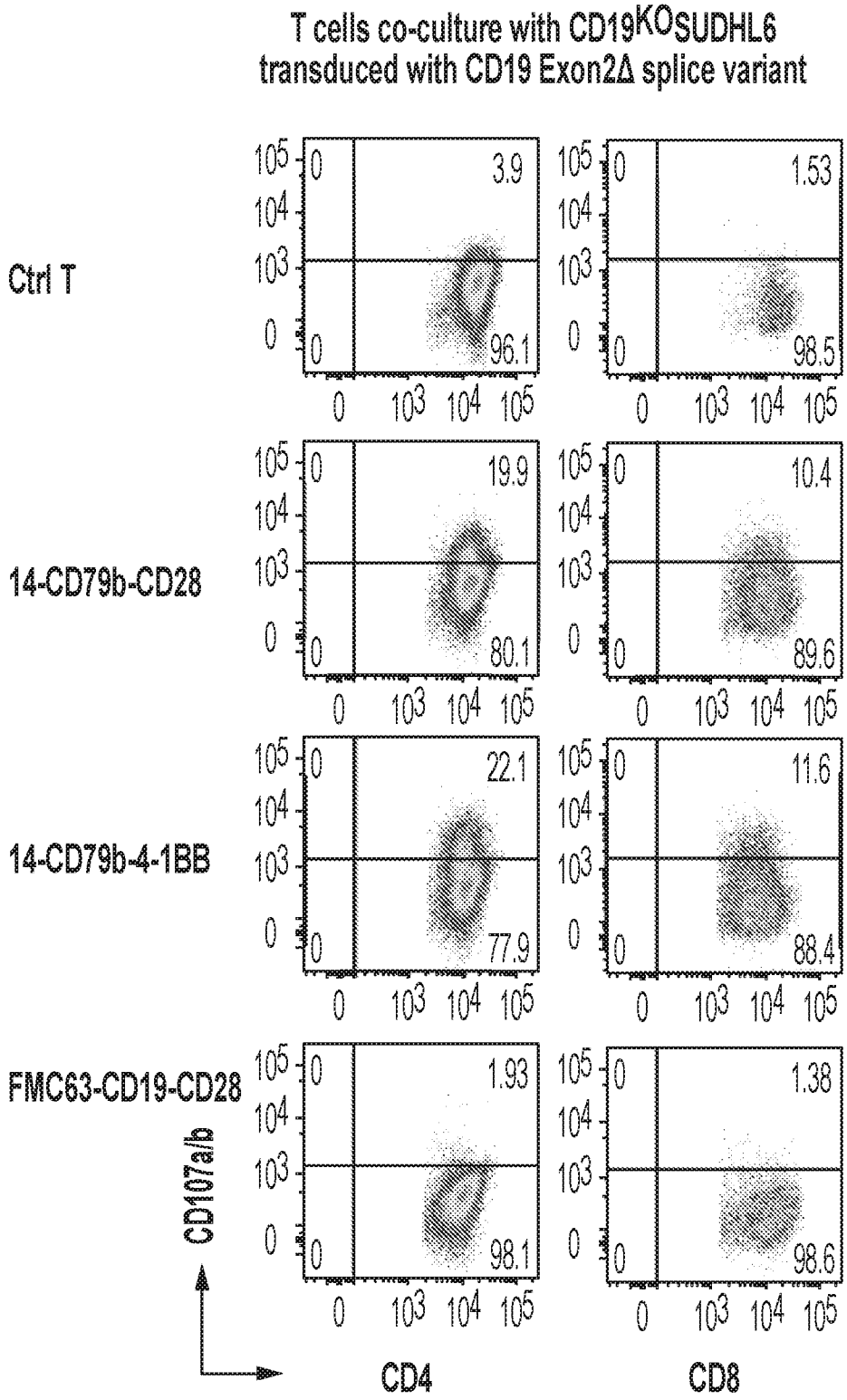

T cells co-culture with CD19KOSUDHL6
transduced with CD19 Exon2Δ splice variant
Ctrl T
14-CD79b-CD28
14-CD79b-4-1BB
FMC63-CD19-CD28
3.9
96.1
1.53
98.5
19.9
80.1
10.4
89.6
22.1
77.9
11.6
88.4
1.93
98.1
1.38
98.6
CD107a/b
CD4
CD8

FIG. 4A

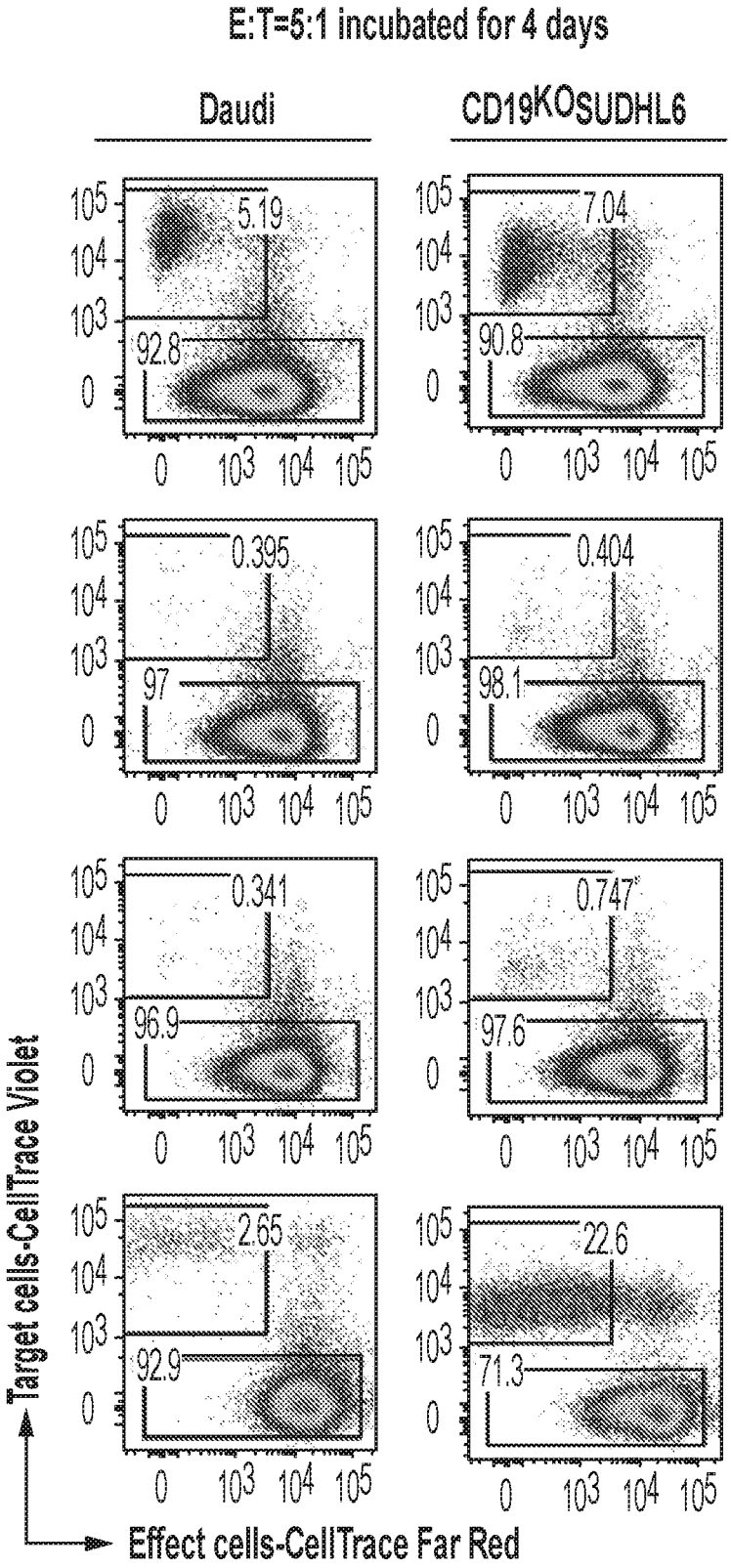

E:T=5:1 incubated for 4 days
Daudi
CD19KOSUDHL6
5.19
92.8
7.04
90.8
0.395
97
0.404
98.1
0.341
96.9
0.747
97.6
2.65
92.9
22.6
71.3
Target cells-CellTrace Violet
Effect cells-CellTrace Far Red

FIG. 4B

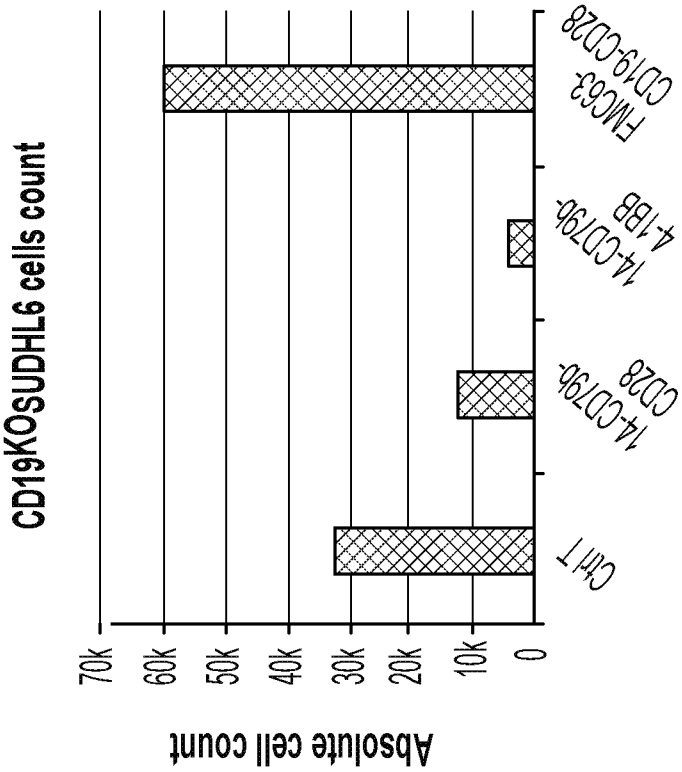

CD19KOSUDHL6 cells count
Absolute cell count
70k
60k
50k
40k
30k
20k
10k
0
CAR T
14-CD79b-CD28
14-CD79b-4-1BB
FMC63-CD19-CD28

FIG. 4D

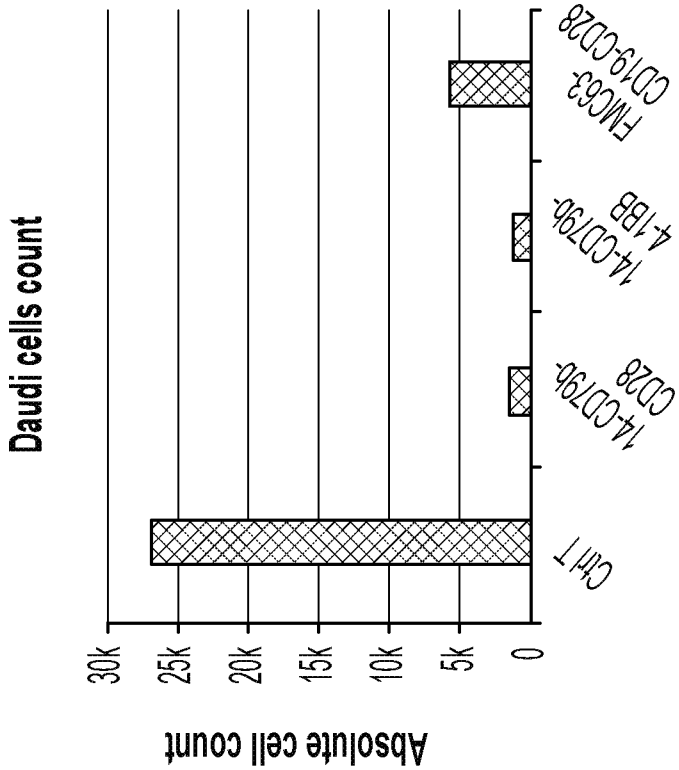

Daudi cells count
Absolute cell count
30k
25k
20k
15k
10k
5k
0
CAR T
14-CD79b-CD28
14-CD79b-4-1BB
FMC63-CD19-CD28

FIG. 4C

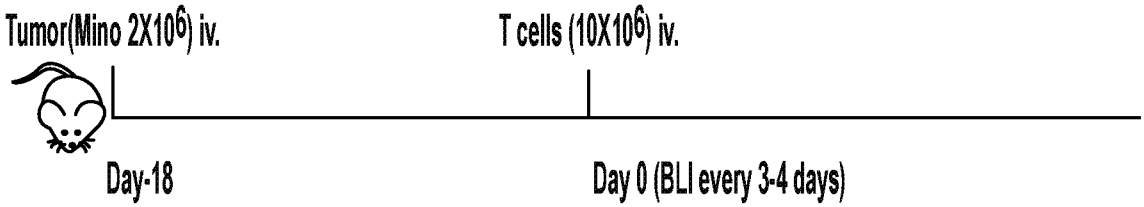

Tumor(Mino 2X10^6) iv.
T cells (10X10^6) iv.
Day-18
Day 0 (BLI every 3-4 days)

FIG. 5A

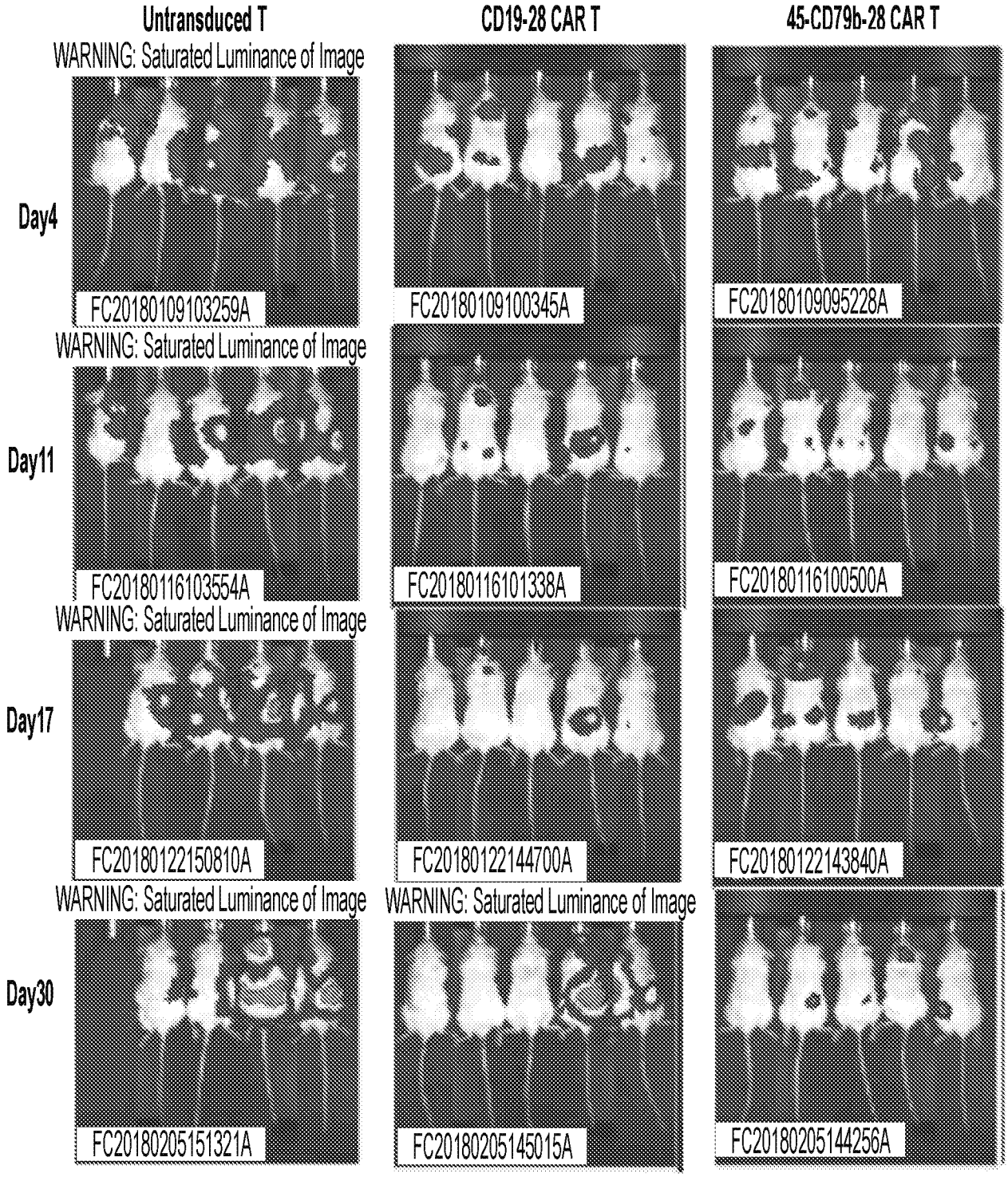

Untransduced T
CD19-28 CAR T
45-CD79b-28 CAR T
WARNING: Saturated Luminance of Image
Day4
FC20180109103259A
FC20180109100345A
FC20180109095228A
WARNING: Saturated Luminance of Image
Day11
FC20180116103554A
FC20180116101338A
FC20180116100500A
WARNING: Saturated Luminance of Image
Day17
FC20180122150810A
FC20180122144700A
FC20180122143840A
WARNING: Saturated Luminance of Image
WARNING: Saturated Luminance of Image
Day30
FC20180205151321A
FC20180205145015A
FC20180205144256A

FIG. 5B

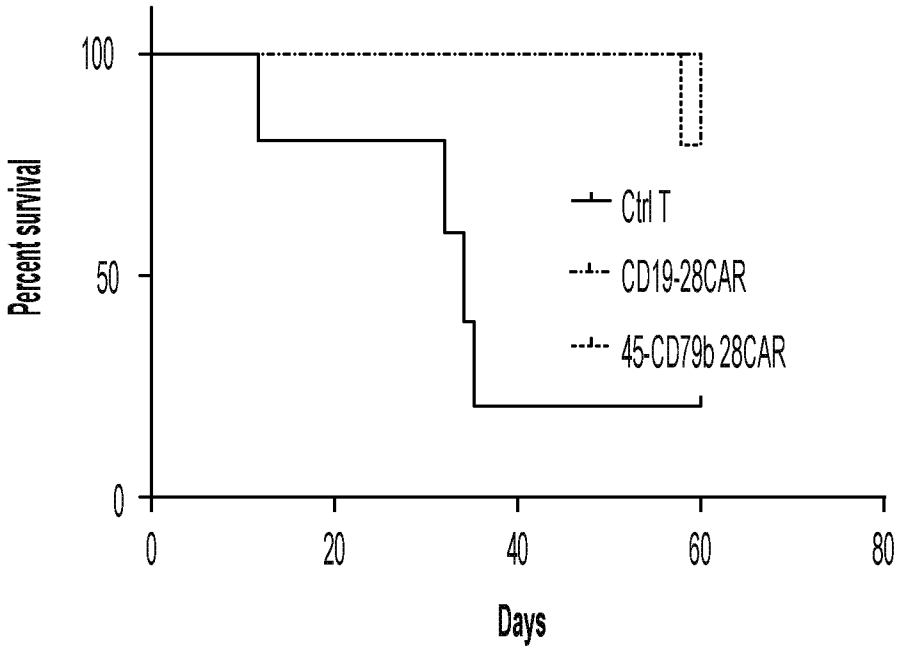

100
50
0
Percent survival
0
20
40
60
80
Days
Ctrl T
CD19-28CAR
45-CD79b 28CAR

FIG. 5C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/58710

A. CLASSIFICATION OF SUBJECT MATTER

IPC - C07K 16/28; C07K 19/00; C12N 5/0783; A61K 35/17 (2020.01)

CPC - C07K 16/28; C07K 14/7051; C07K 2317/622; C07K 2317/56; C07K 2317/565; C12N 5/0636; C12N 2740/13043; A61K 35/17

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- A	US 2016/0361360 A1 (IMMUNOMEDICS, INC.) 15 December 2016 (15.12.2016). Especially para [0004], [0008], [0020]	32, 36, 37, 38/(32,36,37) --- 63-66, 73, 77-80, (81,82)/(63-66,73,77-80), 88-98
A	US 2016/0159906 A1 (GENENTECH, INC.) 9 June 2016 (09.06.2016). Especially para [0014], claim 1.	1-4, 11/(1-4), 12, 13/(1-4), 18, 21/18
A	WO 2017/120280 A1 (VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.) 13 July 2017 (13.07.2017). Especially SEQ ID NO: 2	1-4, 11/(1-4), 12, 13/(1-4), 18, 21/18, 63-66, 73, 77-80, (81,82)/(63-66,73,77-80), 88-98
A	US 2018/0057595 A1 (CELLDEX THERAPEUTICS, INC.) 1 March 2018 (01.03.2018). Especially SEQ ID NO: 58	1-4, 11/(1-4), 12, 13/(1-4), 18, 21/18, 63-66, 73, 77-80, (81,82)/(63-66,73,77-80), 88-98

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2020	18 MAR 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Lee Young Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/58710

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing:

   a. ☒ forming part of the international application as filed:

      ☒ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

2. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments:
GenCore ver 6.4.1 SEQ ID NOs: 2 and 7 were searched.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/58710

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 14-17, 22-31, 39-62, 83-87, 101, 103, 113, 115, 117, 119
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
------Go to Extra Sheet for continuation-------

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-4, 11 (in part), 12, 13 (in part), 18, 21 (in part), 32, 36, 37, 38 (in part), 63-66, 73, 77-80, (81, 82)(in part), 88-98, limited to SEQ ID NOs: 2-5, 7-10, and signaling domain CD3.zeta.

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US 19/58710

Continuation of Box III: Observations where Unity of Invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I+: Claims 1-13, 18-21, 32-38, 63-82, 88-100 drawn to an isolated monoclonal antibody, CAR or TCR polypeptide comprising an antigen binding domain that specifically binds CD79b.
The isolated monoclonal antibody or CAR will be searched to the extent that the VH CDR-1,2,3 are the first named, SEQ ID NOs: 3, 4, 5 respectively (claim 1 (I); as comprised by VH domain SEQ ID NO: 2 (claim 4), and the VL CDR-1,2,3 are SEQ ID NOs: 8, 9, 10 respectively (claim 1(I), as comprised by VL domain SEQ ID NO: 7 (claim 4), and first named signaling domain, CD3.zeta (claim 32). It is believed that claims 1-4, 11 (in part), 12, 13 (in part), 18, 21 (in part), 32, 36, 37, 38 (in part), 63-66, 73, 77-80, (81, 82)(in part), 88-98 [note: claims 99-100 are excluded from the first invention because it encompasses a second antigen binding domain] read on this first named invention and thus these claims will be searched without fee to the extent that they encompass VH CDR-1,2,3 SEQ ID NOs: 3, 4, 5 respectively, VL domain SEQ ID NO: 2, VL CDR-1,2,3 SEQ ID NOs: 8, 9, 10, VL domain SEQ ID NO: 7, and signaling domain CD3.zeta. Additional VH CDR-1,2,3, VH domain, VL CDR-1,2,3, VL domain sequences and signaling domains will be searched upon payment of additional fees. Applicant must specify the claims that encompass any additional VH CDR-1,2,3, VH domain, VL CDR-1,2,3, VL domain sequences and signaling domains. Applicants must further indicate, if applicable, the claims which read on the first named invention if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched/examined. An exemplary election would be: VH CDR-1,2,3 SEQ ID NOs: 13, 14, 14 respectively, VH domain SEQ ID NO: 12, VL CDRs 1,2,3 SEQ ID NOs: 18, 19, 20 respectively, VL domain SEQ ID NO: 17, signaling domain OX40 (claims 1, 5-7, 11 (in part), 12, 13 (in part), 19, 21 (in part), 32, 35, 36, 37, 38 (in part), 63, 67-69, 73, 76, 77-80, (81, 82) (in part), 88-98 [note: claims 99-100 are excluded from the exemplary invention because it encompasses a second antigen binding domain]).

Group II: Claims 102, 104-112, 114, drawn to a host cell engineered to express a CD79b CR or a CD79b TCR.

Group III: Claims 116, 118, 120-130, drawn to a method of treating cancer.

The inventions listed as Groups I+, II, III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Technical Features

Group I+ has the special technical feature of an antigen binding domain with specific VH, H-CDR1,2,3 and VL, L-CDR1,2,3 subdomains, not required by Groups II, III.

Group I+ has the specific technical feature of an engineered CD79b-targeted chimeric antigen receptor comprising one or more signaling domains, not required by Groups II, III.

Group II has the special technical feature of a host cell engineered to express a CAR or TCR, not required by Groups I+, III.

Group III has the specific technical feature of administering an effective amount of CD79b CAR T cells to a subject, not required by Groups I+, II.

Among the inventions listed as Groups I+ are the specific signaling domains recited therein. Each invention requires a specific signaling domain not required by any other inventions.

No technical features are shared between the VH CDR-1,2,3 and VL CDR 1,2,3 polypeptide sequences of Group I+ and, accordingly, this groups lack unity a priori.

Additionally, even if Groups I+, II, III were considered to share the technical features of:

1. Group I+ inventions share the technical feature of a monoclonal antibody that specifically binds to CD79b.

2. Groups I+, II, III share the technical feature of a CAR that specifically binds to CD79b.

3. Group I+ inventions share the technical feature of specific VH CDR-1,2,3 and VL CDR-1,2,3 sequences (claim 1 or claim 64).

4. Group I+ inventions share the technical feature of a CAR that comprises one or more signaling domains (claim 32).

5. Groups II and III share the technical feature of an engineered CAR T cell.

these shared technical features are previously disclosed by US 2016/0159906 A1 to Genentech, Inc. (hereinafter "Genentech"), in view of US 2018/0079824 A1 to Baylor College of Medicine (hereinafter "Baylor") [published 22 March 2018]

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As to shared technical features #1 and #3, Genentech discloses a monoclonal antibody that specifically binds to CD79b, where the monoclonal antibody has specifically defined VH CDR-1,2,3 and VL CDR-1,2,3 sequences (claim 1; "1. An isolated anti-CD79b antibody, wherein the antibody comprises a CD79b binding domain comprising the following six hypervariable regions (HVRs) [i.e. CDRs, see Genentech para [0063]]:
(a) an HVR-H1 comprising the amino acid sequence of SEQ ID NO: 5;
(b) an HVR-H2 comprising the amino acid sequence of SEQ ID NO: 8;
(c) an HVR-H3 comprising the amino acid sequence of SEQ ID NO: 9;
(d) an HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10;
(e) an HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and
(f) an HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12").

As to shared technical feature #2, a CAR that specifically binds to CD79b, the feature is obvious, based on the disclosure of shared technical feature #1, as indicated above, because Genentech discloses a scFv (para [0014]; "the antibody is an antibody fragment that binds CD79b. In some embodiments, the antibody fragment is a ... scFv"). Further, using antibody scFv domains derived from monoclonal antibodies directed to specific targets as ectodomain components of chimeric antigen receptors was well-known in the art, as disclosed by Baylor (para [0010]; "In specific embodiments, the HER2-specific CAR comprises a scFv derived from trastuzmab, FRP5, 800E6, F5cys, pertuzumab or a combination thereof, for example").

As to shared technical feature #4, a CAR that comprises one or more signaling domains (instant application claim 32), Baylor discloses (claim 32), an engineered CD79b-targeted chimeric antigen receptor (CAR)[as disclosed in shared technical feature #2] comprising CD3.zeta., CD28, 4-1BB, and/or OX40 signaling domains (claims 2, 5; "2. The polynucleotide of claim 1, wherein the chimeric antigen receptor comprises a transmembrane domain selected from the group consisting of CD3-zeta, CD28. CD8, 4-1BB, CTLA4, CD27, and a combination thereof" "5. The polynucleotide of claim 1, wherein the chimeric antigen receptor comprises co-stimulatory molecule endodomains selected from the group consisting of CD28, CD27, 4-1BB, OX40, ICOS, Myd88, CD40, and a combination thereof").

As to shared technical feature #5, Baylor discloses an engineered CAR T cell (para [0005]; "Adoptive transfer of T cells, genetically modified to express chimeric antigen receptors (CARs), has shown great promise in early phase clinical studies").

As the shared technical features were known in the art at the time of the invention, they cannot be considered shared special technical features that would otherwise unify the groups. The inventions lack unity with one another.

Therefore, Groups I+, II, III lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature.

Note concerning claim 18: Claim 18 excerpt "VH domain of clone 14 (SEQ ID NOs: 8, 9, 10)" is reconstrued as "VL domain of clone 14(SEQ ID NOs: 8, 9, 10)", because SEQ ID NOs: 8, 9, 10 are indicated to be derived from the VL domain (see for example instant application claim 1 (I)).

Note concerning claim 19: Claim 19 excerpt "VH domain of clone 16a (SEQ ID NOs: 18, 19, 20)" is reconstrued as "VL domain of clone 16a(SEQ ID NOs: 18, 19, 20)", because SEQ ID NOs: 18, 19, 20 are indicated to be derived from the VL domain (see for example instant application claim 1 (II)).

Note concerning claim 20: Claim 20 excerpt "VH domain of clone 45 (SEQ ID NOs: 18, 19, 20)" is reconstrued as "VL domain of clone 45 (SEQ ID NOs: 28, 29, 30)", because SEQ ID NOs: 28, 29, 30 are indicated to be derived from the VL domain (see for example instant application claim 1 (III)).

Note concerning claim 79: Claim 79 is written "an scFv having at least 90% identity to the amino acid sequence of SEQ ID NOs: 31, 32, 33". However, SEQ ID NOs: 31, 32, 31 are all nucleic acid sequences. For the purposes of the international search, the claim is reconstrued as "encoding a scFv having at least 90% identity to the nucleic acid sequence of SEQ ID NOs: 31, 32, 33".

Note concerning claim 80: Claim 79 is written "an scFv having at having an amino acid sequence of SEQ ID NOs: 31, 32, 33". However, SEQ ID NOs: 31, 32, 31 are all nucleic acid sequences. For the purposes of the international search, the claim is reconstrued as "encoding a scFv having a nucleic acid sequence of SEQ ID NOs: 31, 32, 33".

Note concerning claim 82: Claim 82 is written "the Linker 1 (SEQ ID NO: 44 or 45)" etc. However, it is not specified that SEQ ID NO: 44 is a nucleic acid sequence and that SEQ ID NO: 45 is a peptide sequence, for instance. For the purposes of the international search, the claim is reconstrued as "the Linker 1 having a nucleic acid SEQ ID NO: 44 or peptide SEQ ID NO 45, Linker 2 having a nucleic acid SEQ ID NO: 46 or peptide SEQ ID NO 47, Linker 3 having a nucleic acid SEQ ID NO: 48 or peptide SEQ ID NO 49, or Linker 4 having a nucleic acid SEQ ID NO: 50 or peptide SEQ ID NO 51".

Note concerning claim 97: Claim 97 is written "the CAR comprises a sequence having at least 90% sequence identity to the amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87 or 88". However, all of said sequences are nucleic acid sequences. For the purposes of the international search claim 97 is reconstrued as "the CAR comprises a sequence having at least 90% sequence identity to the nucleic acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87 or 88".

Note concerning claim 98: Claim 97 is written "the CAR comprises a sequence having an amino acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87 or 88". However, all of said sequences are nucleic acid sequences. For the purposes of the international search claim 98 is reconstrued as "the CAR having a nucleic acid sequence of SEQ ID NOs: 34, 35, 36, 37, 38, 39, 86, 87 or 88".

Item 4 (cont.): Claims 14-17, 22-31, 39-62, 83-87, 101, 103, 113, 115, 117, 119 are multiple dependent claims and are not drafted according to the second and third sentences of PCT Rule 6.4(a).