CLAIMS

1. An isolated nucleic acid molecule encoding a chimeric antigen receptor (CAR), wherein the CAR comprises a CD20 binding doamain, a transmembrane domain, and an intracellular signaling domain, wherein said CD20 binding domain comprises a light chain complementarity determining region 1 (LCDR1), light chain complementarity determining region 2 (LCDR2), light chain complementarity determining region 3 (LCDR3), heavy chain complementarity determining region 1 (HCDR1), heavy chain complementarity determining region 2 (HCDR2), and heavy chain complementarity determining region 3 (HCDR3),wherein the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3 comprise:

(i) SEQ ID NOs: 228, 229, 230, 217, 218, and 219, respectively;

(ii) SEQ ID NOs: 231, 232, 233, 220, 221, and 222, respectively;

(iii) SEQ ID NOs: 234, 235, 236, 223, 224, and 225, respectively; or

(iv) SEQ ID NOs: 944, 945, 988, 941, 942, and 943, respectively.

2. The isolated nucleic acid molecule of claim 1, wherein the encoded CAR comprises a light chain variable region and a heavy chain variable region, wherein:

(i) the light chain variable region comprises the amino acid sequence of SEQ ID NO: 237, 264, 291, 318, or 443;

(ii) the light chain variable region comprises an amino acid sequence having one, two or three modifications within the framework regions of the light chain variable region of SEQ ID NO: 237, 264, 291, 318, or 443;

(iii) the light chain variable region comprises an amino acid sequence with at least 95% identity to the framework regions of the amino acid sequence of SEQ ID NO: 237, 264, 291, 318, or 443;

(iv) the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441;

(v) the heavy chain variable region comprises an amino acid sequence having one, two or three modifications within the framework regions of the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441;

(vi) the heavy chain variable region comprises an amino acid sequence with at least 95% identity to the framework regions of the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441; or

(vii) the light chain variable region and the heavy chain variable region comprise:

(a) SEQ ID NOs: 237 and 226, respectively;

(b) SEQ ID NOs: 264 and 253, respectively;

(c) SEQ ID NOs: 291 and 280, respectively;

(d) SEQ ID NOs: 318 and 307, respectively; or

(e) SEQ ID NOs: 443 and 441, respectively.

3. The isolated nucleic acid molecule of claim 1, wherein:

(i) the CD20 binding domain is a scFv;

(ii) the CD20 binding domain comprises the amino acid sequence of SEQ ID NO: 240, SEQ ID NO: 267, SEQ ID NO: 294, or SEQ ID NO: 321, or an amino acid sequence with at least 95% identity thereto, or an amino acid sequence having one, two or three modifications relative to any of the aforesaid amino acid sequences, wherein the modifications are not comprised in the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3; or

(iii) the nucleic acid sequence encoding the CD20 binding domain comprises the nucleotide sequence of SEQ ID NO: 241, SEQ ID NO: 268, SEQ ID NO: 295, or SEQ ID NO: 322, or a nucleotide sequence with at least 95% identity thereto.

4. The isolated nucleic acid molecule of claim 1, wherein the nucleic acid molecule comprises:

(i) the nucleotide sequence of SEQ ID NO: 227, SEQ ID NO: 254, SEQ ID NO: 281, SEQ ID NO: 308, SEQ ID NO: 442, SEQ ID NO: 238, SEQ ID NO: 265, SEQ ID NO: 292, SEQ ID NO: 319, or SEQ ID NO: 444, or a nucleotide sequence with at least 95% identity thereto; or

(ii) the nucleotide sequence of SEQ ID NOs: 238 and 227, SEQ ID NOs: 265 and 254, SEQ ID NOs: 292 and 281, SEQ ID NOs: 319 and 308, or SEQ ID NOs: 444 and 442.

5. The isolated nucleic acid molecule of claim 1, wherein:

(i) the transmembrane domain comprises a transmembrane domain of a protein selected from the group consisting of the alpha, beta or zeta chain of a T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD123, CD134, CD137 and CD154;

(ii) the transmembrane domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 801;

(iii) the transmembrane domain comprises the amino acid sequence of SEQ ID NO: 801;

(iv) the nucleic acid sequence encoding the transmembrane domain comprises the nucleotide sequence of SEQ ID NO: 802, or a nucleotide sequence with at least 95% identity thereto;

(v) the CD20 binding domain is connected to the transmembrane domain by a hinge region;

(vi) the CD20 binding domain is connected to the transmembrane domain by a hinge region, wherein the hinge region comprises the amino acid sequence of SEQ ID NO: 799, or SEQ ID NO: 814, or an amino acid sequence with at least 95% identity thereto; or

(vii) the CD20 binding domain is connected to the transmembrane domain by a hinge region, wherein the nucleic acid sequence encoding the hinge region comprises the nucleotide sequence of SEQ ID NO: 800 or SEQ ID NO: 815, or a nucleotide sequence with at least 95% identity thereto.

6. The isolated nucleic acid molecule of claim 1, wherein:

(i) the intracellular signaling domain comprises a costimulatory domain;

(ii) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain is a functional signaling domain obtained from a protein selected from the group consisting of OX40, CD2, CD27, CD28, ICAM-1, LFA-1 (CD11a/CD18), ICOS (CD278) and 4-1BB (CD137);

(iii) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 803;

(iv) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain comprises the amino acid sequence of SEQ ID NO: 803;

(v) the intracellular signaling domain comprises a costimulatory domain, wherein the nucleic acid sequence encoding the costimulatory domain comprises the nucleotide sequence of SEQ ID NO: 804, or a nucleotide sequence with at least 95% identity thereto;

(vi) the intracellular signaling domain comprises a primary signaling domain;

(vii) the intracellular signaling domain comprises a primary signaling domain, wherein the primary signaling domain comprises a functional signaling domain of CD3 zeta;

(viii) the intracellular signaling domain comprises a primary signaling domain, wherein the primary signaling domain comprises the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807;

(ix) the intracellular signaling domain comprises a functional signaling domain of 4-1BB or a functional signaling domain of CD3 zeta;

(x) the intracellular signaling domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 803 or the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807;

(xi) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO: 803 or the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807;

(xii) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO: 803 and the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807;

(xiii) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO: 803 and the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807, wherein the sequences comprising the intracellular signaling domain are expressed in the same frame and as a single polypeptide chain; or

(xiv) the nucleic acid sequence encoding the intracellular signaling domain comprises the nucleotide sequence of SEQ ID NO: 804, or a nucleotide sequence with at least 95% identity thereto, or the nucleotide sequence of SEQ ID NO: 893, 808, 806, or 1074, or a nucleotide sequence with at least 95% identity thereto.

7. The isolated nucleic acid molecule of claim 1, further comprising a leader sequence.

8. The isolated nucleic acid molecule of claim 7, wherein the leader sequence encodes a polypeptide comprising the amino acid sequence of SEQ ID NO: 797.

9. The isolated nucleic acid molecule of claim 1, wherein:

(i) the encoded CAR comprises the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, or an amino acid sequence with at least 95% identity thereto, or an amino acid sequence comprising one, two or three modifications of the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, wherein the modifications are not comprised in the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3, wherein the CAR comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797;

(ii) the encoded CAR comprises the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, wherein the CAR comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797;

(iii) the nucleic acid molecule comprises the nucleotide sequence of SEQ ID NO: 243, SEQ ID NO: 270, SEQ ID NO: 297, or SEQ ID NO: 324, or a nucleotide sequence with at least 95% identity thereto, wherein the nucleic acid molecule comprises or does not comprise the nucleotide sequence of SEQ ID NO: 798; or

(iv) the nucleic acid molecule comprises the nucleotide sequence of SEQ ID NO: 243, SEQ ID NO: 270, SEQ ID NO: 297, or SEQ ID NO: 324, wherein the nucleic acid molecule comprises or does not comprise the nucleotide sequence of SEQ ID NO: 798.

10. An isolated polypeptide molecule encoded by the nucleic acid molecule of claim 1.

11. An isolated CAR molecule comprising a CD20 binding domain, a transmembrane domain, and an intracellular signaling domain, wherein the CD20 binding domain comprises a light chain complementarity determining region 1 (LCDR1), light chain complementarity determining region 2 (LCDR2), light chain complementarity determining region 3 (LCDR3), heavy chain complementarity determining region 1 (HCDR1), heavy chain complementarity determining region 2 (HCDR2), and heavy chain complementarity determining region 3 (HCDR3), wherein the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3 comprise:

(i) SEQ ID NOs: 228, 229, 230, 217, 218, and 219, respectively;

(ii) SEQ ID NOs: 231, 232, 233, 220, 221, and 222, respectively;

(iii) SEQ ID NOs: 234, 235, 236, 223, 224, and 225, respectively; or

(iv) SEQ ID NOs: 944, 945, 988, 941, 942, and 943, respectively.

12. The isolated CAR molecule of claim 11, wherein the CAR molecule comprises a light chain variable region and a heavy chain variable region, wherein:

(i) the light chain variable region comprises the amino acid sequence of SEQ ID NO: 237, 264, 291, 318, or 443;

(ii) the light chain variable region comprises an amino acid sequence having one, two or three modifications within the framework regions of the light chain variable region of SEQ ID NO: 237, 264, 291, 318, or 443;

(iii) the light chain variable region comprises an amino acid sequence with at least 95% identity to the framework regions of the amino acid sequence of SEQ ID NO: 237, 264, 291, 318, or 443;

(iv) the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441;

(v) the heavy chain variable region comprises an amino acid sequence having one, two or three modifications within the framework regions of the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441;

(vi) the heavy chain variable region comprises an amino acid sequence with at least 95% identity to the framework regions of the amino acid sequence of SEQ ID NO: 226, 253, 280, 307, or 441; or

(vii) the light chain variable region and the heavy chain variable region comprise:

(a) SEQ ID NOs: 237 and 226, respectively;

(b) SEQ ID NOs: 264 and 253, respectively;

(c) SEQ ID NOs: 291 and 280, respectively;

(d) SEQ ID NOs: 318 and 307, respectively; or

(e) SEQ ID NOs: 443 and 441, respectively.

13. The isolated CAR molecule of claim 11, wherein:

(i) the CD20 binding domain is an scFv; or

(ii) the CD20 binding domain comprises the amino acid sequence of SEQ ID NO: 240, SEQ ID NO: 267, SEQ ID NO: 294, or SEQ ID NO: 321, or an amino acid sequence with at least 95% identity thereto, or an amino acid sequence having one, two or three modifications relative to any of the aforesaid amino acid sequences, wherein the modifications are not comprised in the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3.

14. The isolated CAR molecule of claim 11, wherein:

(i) the CAR molecule comprises a transmembrane domain of a protein selected from the group consisting of the alpha, beta or zeta chain of a T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD16, CD22, CD33, CD37, CD64, CD80, CD86, CD123, CD134, CD137 and CD154;

(ii) the transmembrane domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 801;

(iii) the transmembrane domain comprises the amino acid sequence of SEQ ID NO: 801; or

(iv) the CD20 binding domain is connected to the transmembrane domain by a hinge region, wherein the hinge region comprises the amino acid sequence of SEQ ID NO: 799, or SEQ ID NO: 814, or an amino acid sequence with at least 95% identity thereto.

15. The isolated CAR molecule of claim 11, wherein:

(i) the intracellular signaling domain comprises a costimulatory domain;

(ii) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain comprises a functional signaling domain of a protein selected from the group consisting of OX40, CD2, CD27, CD28, ICAM-1, LFA-1 (CD11a/CD18), ICOS (CD278) and 4-1BB (CD137);

(iii) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 803;

(iv) the intracellular signaling domain comprises a costimulatory domain, wherein the costimulatory domain comprises the amino acid sequence of SEQ ID NO: 803;

(v) the intracellular signaling domain comprises a primary signaling domain;

(vi) the intracellular signaling domain comprises a primary signaling domain, wherein the primary signaling domain comprises a functional signaling domain of CD3 zeta;

(vii) the intracellular signaling domain comprises a primary signaling domain, wherein the primary signaling domain comprises the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807;

(viii) the intracellular signaling domain comprises a functional signaling domain of 4-1BB or a functional signaling domain of CD3 zeta;

(ix) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO: 803 or the amino acid sequence of SEQ ID NO: 805;

(x) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO:803 or the amino acid sequence of SEQ ID NO:807;

(xi) the intracellular signaling domain comprises an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 803 or the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807; or

(xii) the intracellular signaling domain comprises the amino acid sequence of SEQ ID NO: 803 and the amino acid sequence of SEQ ID NO: 805 or SEQ ID NO: 807, wherein the sequences comprising the intracellular signaling domain are expressed in the same frame and as a single polypeptide chain.

16. The isolated CAR molecule of claim 11, further comprising a leader sequence.

17. The isolated CAR molecule of claim 16, wherein the leader sequence comprises the amino acid sequence of SEQ ID NO: 797, or an amino acid sequence with at least 95% identity to the amino acid sequence of SEQ ID NO: 797.

18. The isolated CAR molecule of claim 11, comprising:

(i) the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, or an amino acid sequence with at least 95% identity thereto or an amino acid sequence comprising one, two or three modifications of the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, wherein the modifications are not comprised in the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3, and wherein the

CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797; or

(ii) the amino acid sequence of SEQ ID NO: 242, SEQ ID NO: 269, SEQ ID NO: 296, or SEQ ID NO: 323, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

19. A CD20 binding domain comprising a light chain complementarity determining region 1 (LCDR1), light chain complementarity determining region 2 (LCDR2), light chain complementarity determining region 3 (LCDR3), heavy chain complementarity determining region 1 (HCDR1), heavy chain complementarity determining region 2 (HCDR2), and heavy chain complementarity determining region 3 (HCDR3), wherein the LCDR1, LCDR2, LCDR3, HCDR1, HCDR2, and HCDR3 comprise:

(i) SEQ ID NOs: 228, 229, 230, 217, 218, and 219, respectively;

(ii) SEQ ID NOs: 231, 232, 233, 220, 221, and 222, respectively;

(iii) SEQ ID NOs: 234, 235, 236, 223, 224, and 225, respectively; or

(iv) SEQ ID NOs: 944, 945, 988, 941, 942, and 943, respectively.

20. The CD20 binding domain of claim 19, wherein:

(i) the CD20 binding domain is a scFv;

(ii) the CD20 binding domain comprises a light chain variable region and a heavy chain variable region, wherein the amino acid sequences of the light chain variable region and the heavy chain variable region comprise:

(a) SEQ ID NOs: 237 and 226;

(b) SEQ ID NOs: 264 and 253;

(c) SEQ ID NOs: 291 and 280;

(d) SEQ ID NOs: 318 and 307; or

(e) SEQ ID NOs: 443 and 441;

(iii) the CD20 binding domain comprises: a light chain variable region comprising an amino acid sequence having one, two or three modifications within the framework regions of the amino acid sequence of SEQ ID NO: 237, SEQ ID NO: 264, SEQ ID NO: 291, SEQ ID NO: 318, or SEQ ID NO: 443, or an amino acid sequence with at least 95% identity to the framework

regions of the amino acid sequence of SEQ ID NO: 237, SEQ ID NO: 264, SEQ ID NO: 291, SEQ ID NO: 318, or SEQ ID NO: 443; or a heavy chain variable region comprising an amino acid sequence having one, two or three modifications within the framework regions of the amino acid sequence of SEQ ID NO: 226, SEQ ID NO: 253, SEQ ID NO: 280, SEQ ID NO: 307, or SEQ ID NO: 441, or an amino acid sequence with at least 95% identity to the framework regions of the amino acid sequence of SEQ ID NO: 226, SEQ ID NO: 253, SEQ ID NO: 280, SEQ ID NO: 307, or SEQ ID NO: 441; or

(iv) the CD20 binding domain comprises the amino acid sequence of SEQ ID NO: 240, SEQ ID NO: 267, SEQ ID NO: 294, or SEQ ID NO: 321, or an amino acid sequence with at least 95% identity thereto.

21. A nucleic acid molecule comprising:

(i) a first nucleic acid molecule encoding the CAR molecule of claim 11, and

(ii) a second nucleic acid molecule encoding a CAR molecule that binds a B-cell antigen.

22. The nucleic acid molecule of claim 21, wherein the first and the second nucleic acid molecules are disposed on a single nucleic acid molecule or the first and the second nucleic acid molecules are disposed on separate nucleic acid molecules.

23. The nucleic acid molecule of claim 21, wherein the B-cell antigen is:

(i) CD19, CD22, CD10, CD34, CD123, FLT-3, ROR-1, CD79b, CD79a, or CD179b; or

(ii) CD19 or CD22.

24. The nucleic acid molecule of claim 21, wherein the CAR molecule that binds to a B-cell antigen binds to CD19 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising SEQ ID NOs: 773, 774, 775, 776, 777, and 778, respectively;

(ii) a scFv comprising the amino acid sequence of SEQ ID NO: 765; or

(iii) a CAR comprising the amino acid sequence of SEQ ID NO: 764, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

25. The nucleic acid molecule of claim 21, wherein the CAR molecule that binds to a B-cell antigen binds to CD19 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising SEQ ID NOs: 785, 786, 787, 788, 789, and 790, respectively;

(ii) a scFv comprising the amino acid sequence of SEQ ID NO: 1047; or

(iii) a CAR comprising the amino acid sequence of SEQ ID NO: 1049, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

26. The nucleic acid molecule of claim 21, wherein the CAR molecule that binds to a B-cell antigen binds to CD22 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising:

(a) SEQ ID NOs: 719, 720, 721, 730, 731, and 732, respectively;

(b) SEQ ID NOs: 722, 723, 724, 733, 734, and 735, respectively;

(c) SEQ ID NOs: 725, 726, 727, 736, 737, and 738, respectively; or

(d) SEQ ID NOs: 1036, 1037, 1038, 1039, 1040, and 1041, respectively;

(ii) a light chain variable region (VL) and a heavy chain variable region (VH), wherein the VL and VH comprise:

(a) SEQ ID NOs: 840 and 839, respectively; or

(b) SEQ ID NOs: 739 and 728, respectively;

(iii) a scFv comprising the amino acid sequence of SEQ ID NO: 742, 835, 836, or 837; or

(iv) a CAR comprising the amino acid sequence of SEQ ID NO: 744, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

27. The nucleic acid molecule of claim 26, wherein:

(i) the VH and VL sequences are connected directly without a linker;

(ii) the VH and VL sequences are connected via a (Gly4-Ser)n linker, wherein n is 0, 1, 2, 3, 4, 5, or 6;

(iii) the VH and VL sequences are connected via a linker, wherein the linker comprises the amino acid sequence of SEQ ID NO: 834; or

(iv) the VH and VL sequences are connected via a linker, wherein the linker comprises the amino acid sequence of SEQ ID NO: 741.

28. The nucleic acid molecule of claim 21, wherein:

(i) a nucleotide sequence encoding a cleavable peptide or a nucleotide sequence encoding an IRES is disposed between the first nucleic acid molecule and the second nucleic acid molecule;

(ii) the first nucleic acid molecule and the second nucleic acid molecule comprise a single promoter;

(iii) the first nucleic acid molecule and the second nucleic acid molecule comprise a single promoter, wherein the single promoter is an EF-1α promoter;

(iv) the first nucleic acid molecule comprises a first promoter and the second nucleic acid molecule comprises a second promoter; or

(v) the nucleic acid molecule comprises RNA or DNA.

29. The nucleic acid molecule of claim 28, wherein:

(i) the cleavable peptide is a P2A or F2A;

(ii) the first nucleic acid molecule and the second nucleic acid molecule comprise a bicistronic transcription product; or

(iii) the EF-1α promoter comprises the nucleotide sequence of SEQ ID NO: 833.

30. An isolated polypeptide molecule encoded by the nucleic acid molecule of claim 21.

31. A multispecific antibody molecule having a first binding specificity for CD20 and a second binding specificity for one or more of CD19, CD22, CD10, CD34, CD123, FLT-3, ROR1, CD79b, CD179b, or CD79a, wherein the first binding specificity comprises the CD20 binding domain of claim 19.

32. A nucleic acid molecule encoding the multispecific antibody molecule of claim 31.

33. A vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31.

34. The vector of claim 33, wherein the vector is selected from the group consisting of a DNA, a RNA, a plasmid, a lentivirus vector, an adenoviral vector, and a retrovirus vector.

35. A population of immune effector cells, comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, the polypeptide molecule of claim 10 or 30, the CAR molecule of any one of claims 11-18, the CD20 binding domain of claim 19 or 20, the multispecific antibody molecule of claim 31, or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31.

36. A method of making a population of immune effector cells, comprising transducing a T cell or an NK cell with the nucleic acid molecule of any one of claims 1-9, 21-29, or 32 or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31.

37. A method of generating a population of RNA-engineered cells comprising introducing an in vitro transcribed RNA or synthetic RNA into a cell, wherein the RNA comprises the nucleic acid molecule of any one of claims 1-9, 21-29, or 32.

38. A population of immune effector cells, comprising:

(i) a first cell population comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, the polypeptide molecule of claim 10 or 30, the CAR molecule of any one of claims 11-18, the CD20 binding domain of claim 19 or 20, or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31; and

(ii) a second cell population comprising a nucleic acid molecule encoding a CAR that binds a B-cell antigen.

39. The population of claim 38, wherein the B-cell antigen is:

(i) CD19, CD22, CD10, CD34, CD123, FLT-3, ROR-1, CD79b, CD79a, or CD179b; or

(ii) CD19 or CD22.

40. The population of claim 38, wherein the CAR that binds a B-cell antigen binds CD19 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising SEQ ID NOs: 773, 774, 775, 776, 777, and 778, respectively;

(ii) a scFv comprising the amino acid sequence of SEQ ID NO: 765; or

(iii) the amino acid sequence of SEQ ID NO: 764, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

41. The population of claim 38, wherein the CAR that binds a B-cell antigen binds CD19 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising SEQ ID NOs: 785, 786, 787, 788, 789, and 790, respectively;

(ii) a scFv comprising the amino acid sequence of SEQ ID NO: 1047; or

(iii) the amino acid sequence of SEQ ID NO: 1049, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

42. The population of claim 38, wherein the CAR that binds a B-cell antigen binds CD22 and comprises:

(i) a HCDR1, HCDR2, HCDR3, LCDR1, LCDR2, and LCDR3 comprising:

(a) SEQ ID NOs: 719, 720, 721, 730, 731, and 732, respectively;

(b) SEQ ID NOs: 722, 723, 724, 733, 734, and 735, respectively;

(c) SEQ ID NOs: 725, 726, 727, 736, 737, and 738, respectively; or

(d) SEQ ID NOs: 1036, 1037, 1038, 1039, 1040, and 1041, respectively;

(ii) a scFv comprising the amino acid sequence of SEQ ID NO: 742, 835, 836, or 837; or

(iii) the amino acid sequence of SEQ ID NO: 744, wherein the CAR molecule comprises or does not comprise a signal peptide comprising the amino acid sequence of SEQ ID NO: 797.

43. A composition comprising a population of immune effector cells, comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, the polypeptide of claim 10 or 30, the CAR molecule of any of one claims 11-18, the CD20 binding domain of claim 19 or 20, the multispecific antibody molecule of claim 31, or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31, for use in providing anti-tumor immunity in a subject.

44. A composition comprising a population of immune effector cells, comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, the polypeptide of claim 10 or 30, the CAR molecule of any one of claims 11-18, the CD20 binding domain of claim 19 or 20, the multispecific antibody molecule of claim 31, or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-

18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31, for use in treating a subject having a cancer or a disease associated with expression of CD20.

45. A composition comprising a population of immune effector cells, comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, the polypeptide of claim 10 or 30, the CAR molecule of any one of claims 11-18, the CD20 binding domain of claim 19 or 20, the multispecific antibody molecule of claim 31, or a vector comprising the nucleic acid molecule of any one of claims 1-9, 21-29, or 32, a nucleic acid molecule encoding the polypeptide molecule of claim 10 or 30, a nucleic acid molecule encoding the CAR molecule of any one of claims 11-18, a nucleic acid molecule encoding the CD20 binding domain of claim 19 or 20, or a nucleic acid molecule encoding the multispecific antibody molecule of claim 31, for use in treating a cancer in a subject.

46. The composition for use of claim 45, wherein the cancer is:

(i) a hematologic cancer, or

(ii) a leukemia or lymphoma.

47. The composition for use of claim 44, wherein:

(i) the cancer or disease is a hematologic cancer;

(ii) the cancer or disease is a leukemia or lymphoma;

(iii) the cancer or disease is acute myeloid leukemia (AML), B-cell acute lymphoblastic leukemia (BALL), small lymphocytic lymphoma (SLL), acute lymphoblastic leukemia (ALL), chronic myelogenous leukemia (CML), chronic lymphocytic leukemia (CLL), mantle cell lymphoma (MCL), B cell prolymphocytic leukemia, blastic plasmacytoid dendritic cell neoplasm, Burkitt's lymphoma, diffuse large B cell lymphoma (DLBCL), follicular lymphoma, hairy cell leukemia, small cell-lymphoma, large cell-follicular lymphoma, a malignant lymphoproliferative condition, MALT lymphoma, Marginal zone lymphoma, multiple myeloma, myelodysplasia, or myelodysplastic syndrome, myeloproliferative neoplasm, non-Hodgkin’s lymphoma, Hodgkin’s lymphoma, plasmablastic lymphoma, plasmacytoid dendritic cell neoplasm, Waldenstrom macroglobulinemia, preleukemia, or a combination thereof;

(iv) the cancer or disease is lymphoma; or

(v) the cancer or disease is a B-cell malignancy.

48. The composition for use of claim 43, further comprising administering to the subject a B-cell inhibitor chosen from one or more of an inhibitor of CD19, CD22, CD10, CD34, CD123, FLT-3, ROR-1, CD79b, CD79a, or CD179b.

49. The composition for use of claim 48, wherein:

(i) the B-cell inhibitor is a small molecule inhibitor;

(ii) the B-cell inhibitor is a polypeptide, a soluble ligand, an antibody, or antigen-binding fragment thereof that binds to one or more of CD10, CD19, CD22, CD34, CD123, FLT-3, ROR1, CD79b, CD179b, or CD79a;

(iii) the B-cell inhibitor is an inhibitory nucleic acid, wherein the inhibitory nucleic acid comprises a dsRNA, a siRNA, or an shRNA;

(iv) the B-cell inhibitor is a second population of immune effector cells expressing a CAR that binds a B-cell antigen, wherein the B-cell antigen comprises CD19, CD22, CD10, CD34, CD123, FLT-3, ROR-1, CD79b, CD79a, or CD179b;

(v) the B-cell inhibitor is administered prior to the population of immune effector cells;

(vi) the B-cell inhibitor is administered concurrently with the population of immune effector cells; or

(vii) the B-cell inhibitor is administered after the population of immune effector cells.

50. The composition for use of claim 44, wherein the cell is administered in combination with:

(i) an agent that increases the efficacy of the cell;

(ii) an agent that ameliorates one or more side effects associated with administration of the cell; or

(iii) an agent that treats the disease associated with CD20.

51. The population of cells of claim 35, further expressing:

(i) an inhibitory molecule that comprises a first polypeptide that comprises at least a portion of an inhibitory molecule, associated with a second polypeptide that comprises a positive signal from an intracellular signaling domain; or

(ii) an inhibitory molecule that comprises a first polypeptide that comprises at least a portion of PD1 and a second polypeptide comprising a costimulatory domain and a primary signaling domain.

52. A composition comprising an inhibitor of CD20 for use in treating a subject who is a non-responder, partial responder, or relapser to a CD19 inhibitor, wherein the inhibitor of CD20 is encoded by the nucleic acid molecule of any one of claims 1-9, 21-29, or 32.

53. The composition of claim 52, wherein the CD19 inhibitor is a CD19 CAR therapy.