

Antibodies binding to CD3 and CD19

FIELD OF THE INVENTION

The present invention generally relates to antibodies that bind to CD3 and CD19, e.g. for activating T cells. In addition, the present invention relates to polynucleotides encoding such antibodies, and vectors and host cells comprising such polynucleotides. The invention further relates to methods
5 for producing the antibodies, and to methods of using them in the treatment of disease.

BACKGROUND

CD3 (cluster of differentiation 3) is a protein complex composed of four subunits, the CD3 γ chain, the CD3 δ chain, and two CD3 ϵ chains. CD3 associates with the T-cell receptor and the ζ chain to
10 generate an activation signal in T lymphocytes.

CD3 has been extensively explored as drug target. Monoclonal antibodies targeting CD3 have been used as immunosuppressant therapies in autoimmune diseases such as type I diabetes, or in the treatment of transplant rejection. The CD3 antibody muromonab-CD3 (OKT3) was the first monoclonal antibody ever approved for clinical use in humans, in 1985.

15 A more recent application of CD3 antibodies is in the form of bispecific antibodies, binding CD3 on the one hand and a target cell antigen such as CD19 on the other hand. The simultaneous binding of such an antibody to both of its targets will force a temporary interaction between target cell and T cell, causing activation of any cytotoxic T cell and subsequent lysis of the target cell. Bispecific antibodies binding to CD3 and CD19 are described e.g. in WO 2017/055314.

20 For therapeutic purposes, an important requirement that antibodies have to fulfill is sufficient stability both *in vitro* (for storage of the drug) and *in vivo* (after administration to the patient).

Modifications like asparagine deamidation are typical degradations for recombinant antibodies and can affect both *in vitro* stability and *in vivo* biological functions.

Given the tremendous therapeutic potential of antibodies, particularly bispecific antibodies for the
25 activation of T cells, there is a need for CD3 antibodies, including multispecific antibodies, with optimized properties.

SUMMARY OF THE INVENTION

The present invention provides antibodies, including multispecific (e.g. bispecific) antibodies, that bind to CD3 and are resistant to degradation by e.g. asparagine deamidation and thus particularly stable as required for therapeutic purposes. The (multispecific) antibodies provided further
5 combine good efficacy and produceability with low toxicity and favorable pharmacokinetic properties.

As is shown herein, the antibodies, including multispecific antibodies, that bind to CD3, provided by the present invention, retain more than about 90% binding activity to CD3 after 2 weeks at pH 7.4, 37°C, relative to the binding activity after 2 weeks at pH 6, -80°C, as determined by surface
10 plasmon resonance (SPR).

In one aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises (a) a first antigen binding domain that binds to CD3, comprising a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain
15 variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10; and (b) a second and optionally a third antigen binding domain that binds to CD19. In one aspect, the VH of the first antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 7, and/or the VL
20 of the first antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 11.

In a further aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises (a) a first antigen binding domain that binds to CD3 comprising a VH sequence of SEQ ID NO: 7 and a VL sequence of SEQ ID NO: 11; and (b) a second and optionally a third
25 antigen binding domain that binds to CD19.

In one aspect, the first, the second and/or, where present, the third antigen binding domain is a Fab molecule.

In one aspect, the antibody comprises an Fc domain composed of a first and a second subunit.

In one aspect the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1, particularly the variable domains VL and VH, of
30 the Fab light chain and the Fab heavy chain are replaced by each other.

In one aspect the second and, where present, the third antigen binding domain is a conventional Fab molecule.

In one aspect, the second and, where present, the third antigen binding domain is a Fab molecule wherein in the constant domain CL the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat) and the amino acid at position 123 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In one aspect, the first and the second antigen binding domain are fused to each other, optionally via a peptide linker.

In one aspect, the first and the second antigen binding domain are each a Fab molecule and either (i) the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain, or (ii) the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain.

In one aspect, the first, the second and, where present, the third antigen binding domain are each a Fab molecule and the antibody comprises an Fc domain composed of a first and a second subunit; and wherein either (i) the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain and the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first subunit of the Fc domain, or (ii) the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain and the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first subunit of the Fc domain; and the third antigen binding domain, where present, is fused at the C-terminus of the Fab heavy chain to the N-terminus of the second subunit of the Fc domain.

In one aspect, the Fc domain is an IgG, particularly an IgG₁, Fc domain. In one aspect the Fc domain is a human Fc domain. In one aspect, the Fc comprises a modification promoting the association of the first and the second subunit of the Fc domain. In one aspect, the Fc domain comprises one or more amino acid substitution that reduces binding to an Fc receptor and/or effector function.

In one aspect, the second and, where present, the third antigen binding domain comprises (i) a VH comprising a HCDR 1 of SEQ ID NO: 15, a HCDR 2 of SEQ ID NO: 16, and a HCDR 3 of SEQ

ID NO: 17, and a VL comprising a LCDR 1 of SEQ ID NO: 19, a LCDR 2 of SEQ ID NO: 20 and a LCDR 3 of SEQ ID NO: 21; or (ii) a VH comprising a HCDR 1 of SEQ ID NO: 28, a HCDR 2 of SEQ ID NO: 29, and a HCDR 3 of SEQ ID NO: 30, and a VL comprising a LCDR 1 of SEQ ID NO: 32, a LCDR 2 of SEQ ID NO: 33 and a LCDR 3 of SEQ ID NO: 34. In one aspect, the
5 second and, where present, the third antigen binding domain comprises (i) a VH comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 18, and/or a VL comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 22; or (ii) a VH comprising an amino acid sequence that is at least about 95%, 96%, 97%,
10 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 31, and/or a VL comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 35.

According to a further aspect of the invention there is provided an isolated polynucleotide encoding an antibody of the invention, and a host cell comprising the isolated polynucleotide of
15 the invention.

In another aspect is provided a method of producing an antibody that binds to CD3 and CD19, comprising the steps of (a) culturing the host cell of the invention under conditions suitable for the expression of the antibody and optionally (b) recovering the antibody. The invention also encompasses an antibody that binds to CD3 and CD19 produced by the method of the invention.
20 The invention further provides a pharmaceutical composition comprising the antibody of the invention and a pharmaceutically acceptable carrier.

Also encompassed by the invention are methods of using the antibody and pharmaceutical composition of the invention. In one aspect the invention provides an antibody or pharmaceutical composition according to the invention for use as a medicament. In one aspect is provided an
25 antibody or pharmaceutical composition according to the invention for use in the treatment of a disease. Also provided is the use of an antibody or pharmaceutical composition according to the invention in the manufacture of a medicament, and the use of an antibody or pharmaceutical composition according to the invention in the manufacture of a medicament for the treatment of a disease. The invention also provides a method of treating a disease in an individual, comprising
30 administering to said individual an effective amount of the antibody or pharmaceutical composition according to the invention. In certain aspects the disease is cancer. In other aspects the disease is an autoimmune disease.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1. Exemplary configurations of the (multispecific) antibodies of the invention. (A, D) Illustration of the “1+1 CrossMab” molecule. (B, E) Illustration of the “2+1 IgG Crossfab” molecule with alternative order of Crossfab and Fab components (“inverted”). (C, F) Illustration of the “2+1 IgG Crossfab” molecule. (G, K) Illustration of the “1+1 IgG Crossfab” molecule with alternative order of Crossfab and Fab components (“inverted”). (H, L) Illustration of the “1+1 IgG Crossfab” molecule. (I, M) Illustration of the “2+1 IgG Crossfab” molecule with two CrossFabs. (J, N) Illustration of the “2+1 IgG Crossfab” molecule with two CrossFabs and alternative order of Crossfab and Fab components (“inverted”). (O, S) Illustration of the “Fab-Crossfab” molecule. (P, T) Illustration of the “Crossfab-Fab” molecule. (Q, U) Illustration of the “(Fab)₂-Crossfab” molecule. (R, V) Illustration of the “Crossfab-(Fab)₂” molecule. (W, Y) Illustration of the “Fab-(Crossfab)₂” molecule. (X, Z) Illustration of the “(Crossfab)₂-Fab” molecule. Black dot: optional modification in the Fc domain promoting heterodimerization. ++, --: amino acids of opposite charges optionally introduced in the CH1 and CL domains. Crossfab molecules are depicted as comprising an exchange of VH and VL regions, but may – in aspects wherein no charge modifications are introduced in CH1 and CL domains – alternatively comprise an exchange of the CH1 and CL domains.

Figure 2. Relative binding activity of original and optimized CD3 binders, CD3_{orig} and CD3_{opt}, to recombinant CD3 as measured by SPR in unstressed condition, after 14 d at 40°C pH 6, or after 14 d at 37°C pH 7.4 (IgG format).

Figure 3. Binding of original and optimized CD3 binders, CD3_{orig} and CD3_{opt}, to Jurkat NFAT cells as measured by flow cytometry (IgG format). Antibodies bound to Jurkat NFAT cells were detected with a fluorescently labeled anti-human Fc specific secondary antibody.

Figure 4. Schematic illustration of the CD3 activation assay used in Example 3.

Figure 5. Jurkat NFAT activation with original and optimized CD3 binders, CD3_{orig} and CD3_{opt} (IgG format). Jurkat NFAT reporter cells were co-incubated with anti-PGLALA expressing CHO (CHO-PGLALA) cells in the presence of CD3_{orig} or CD3_{opt} IgG PGLALA, or CD3_{opt} IgG wt as negative control. CD3 activation was quantified by measuring luminescence after 24 h.

Figure 6. (A) Schematic illustration of the T-cell bispecific antibody (TCB) molecules used in the Examples. All tested TCB antibody molecules were produced as “2+1 IgG CrossFab, inverted” with charge modifications (VH/VL exchange in CD3 binder, charge modifications in target antigen binders, EE = 147E, 213E; RK = 123R, 124K). (B-E) Components for the assembly of the TCB: light chain of anti-TYRP1 Fab molecule with charge modifications in CH1 and CL (B), light

chain of anti-CD3 crossover Fab molecule (C), heavy chain with knob and PG LALA mutations in Fc region (D), heavy chain with hole and PG LALA mutations in Fc region (E).

Figure 7. Binding of CD19-TCB antibodies to CD3-expressing Jurkat cells (A) and to CD19-expressing Z-138 (B) and Nalm-6 (C) cells, as measured by flow cytometry.

5 **Figure 8.** Target-specific killing of CD19+ target cells induced by CD19-TCB antibodies. (A) Z-138 target cells, (B) Nalm-6 target cells.

Figure 9. T cell activation induced by CD19-TCB antibodies after killing of Z-138 target cells. (A) CD25 expression on CD4 T cells, (B) CD69 expression on CD4 T cells, (C) CD107 expression on CD4 T cells, (D) CD25 expression on CD8 T cells, (E) CD69 expression on CD8 T cells, (F) CD107 expression on CD8 T cells.

Figure 10. T cell activation induced by CD19-TCB antibodies after killing of Nalm-6 target cells. (A) CD25 expression on CD4 T cells, (B) CD69 expression on CD4 T cells, (C) CD107 expression on CD4 T cells, (D) CD25 expression on CD8 T cells, (E) CD69 expression on CD8 T cells, (F) CD107 expression on CD8 T cells.

15 **Figure 11.** Design of the *in vivo* study of Example 10.

Figure 12. Body weight change upon treatment with different doses of CD19-TCB or CD20-TCB, in the study of Example 10. n=3 mice per group. Mean +/- SEM.

Figure 13. Cytokine release in serum at 4 hours after treatment with CD19-TCB or CD20-TCB, with or without obinituzumab (Gazyva®) pre-treatment (GPT), in the study of Example 10. (A) MIP-1 β , (B) IL-6, (C) IFN- γ , (D) IL-5, (E) GM-CSF, (F) TNF- α , (G) IL-2, (H) IL-1 β , (I) IL-13, (J) MCP1, (K) IL-8, (L) IL-10, (M) G-CSF, (N) IL-12p70, (O) IL-17. Bars in each panel from left to right: CD19-TCB 0.5 mg/kg, CD19-TCB 0.15 mg/kg, CD19-TCB 0.05 mg/kg, GPT + CD19-TCB 0.5 mg/kg, CD20-TCB 0.15 mg/kg, GPT + CD20-TCB 0.15 mg/kg. Mean + SEM.

Figure 14. B cell counts in blood at 4 hours, 24 hours and 72 hours after treatment CD19-TCB or CD20-TCB, with or without obinituzumab (Gazyva®) pre-treatment (GPT), in the study of Example 10. Mean + SEM.

Figure 15. Treatment schedule and experimental set-up. Humanized NSG mice were subcutaneously engrafted with a lymphoma patient-derived xenograft (PDX) (5 million cells). Tumor volumes were calculated from caliper measurements. When they reached 200 mm³, mice were randomized in groups of 8 based on their tumor size. Mice were then weekly injected (i.v.) with vehicle or 0.5 mg/kg CD19-TCB.

Figure 16. Effect of CD19-TCB treatment on tumor growth. Tumor volumes were calculated from caliper measurements two (volume < 1000 mm³) or three times (volume $\geq$ 1000 mm³) per week

for n=7 mice in group B and n=8 mice in group A, as described in Figure 15. Mean + SD with *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001 by Mann-Whitney test. Arrows indicate each of the 4 treatments with CD19-TCB or vehicle.

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DETAILED DESCRIPTION OF THE INVENTION

I. DEFINITIONS

Terms are used herein as generally used in the art, unless otherwise defined in the following.

As used herein, the terms “first”, “second” or “third” with respect to antigen binding domains etc., are used for convenience of distinguishing when there is more than one of each type of moiety.

10 Use of these terms is not intended to confer a specific order or orientation of the moiety unless explicitly so stated.

The terms “anti-CD3 antibody” and “an antibody that binds to CD3” refer to an antibody that is capable of binding CD3 with sufficient affinity such that the antibody is useful as a diagnostic and/or therapeutic agent in targeting CD3. In one aspect, the extent of binding of an anti-CD3
15 antibody to an unrelated, non-CD3 protein is less than about 10% of the binding of the antibody to CD3 as measured, e.g., by surface plasmon resonance (SPR). In certain aspects, an antibody that binds to CD3 has a dissociation constant (K_D) of ≤ 1 μM, ≤ 500 nM, ≤ 200 nM, or ≤ 100 nM. An antibody is said to “specifically bind” to CD3 when the antibody has a K_D of 1 μM or less, as measured, e.g., by SPR. In certain aspects, an anti-CD3 antibody binds to an epitope of CD3 that
20 is conserved among CD3 from different species.

Similarly, the terms “anti-CD19 antibody” and “an antibody that binds to CD19” refer to an antibody that is capable of binding CD19 with sufficient affinity such that the antibody is useful as a diagnostic and/or therapeutic agent in targeting CD19. In one aspect, the extent of binding of an anti-CD19 antibody to an unrelated, non-CD19 protein is less than about 10% of the binding of
25 the antibody to CD19 as measured, e.g., by surface plasmon resonance (SPR). In certain aspects, an antibody that binds to CD19 has a dissociation constant (K_D) of ≤ 1 μM, ≤ 500 nM, ≤ 200 nM, or ≤ 100 nM. An antibody is said to “specifically bind” to CD19 when the antibody has a K_D of 1 μM or less, as measured, e.g., by SPR. In certain aspects, an anti-CD19 antibody binds to an epitope of CD19 that is conserved among CD19 from different species.

30 The term “antibody” herein is used in the broadest sense and encompasses various antibody structures, including but not limited to monoclonal antibodies, polyclonal antibodies, multispecific

antibodies (e.g. bispecific antibodies), and antibody fragments so long as they exhibit the desired antigen-binding activity.

An "antibody fragment" refers to a molecule other than an intact antibody that comprises a portion of an intact antibody that binds the antigen to which the intact antibody binds. Examples of antibody fragments include but are not limited to Fv, Fab, Fab', Fab'-SH, F(ab')₂, diabodies, linear antibodies, single-chain antibody molecules (e.g. scFv and scFab), single-domain antibodies, and multispecific antibodies formed from antibody fragments. For a review of certain antibody fragments, see Hollinger and Hudson, *Nature Biotechnology* 23:1126-1136 (2005).

The terms "full-length antibody," "intact antibody," and "whole antibody" are used herein interchangeably to refer to an antibody having a structure substantially similar to a native antibody structure.

The term "monoclonal antibody" as used herein refers to an antibody obtained from a population of substantially homogeneous antibodies, i.e. the individual antibodies comprised in the population are identical and/or bind the same epitope, except for possible variant antibodies, e.g., containing naturally occurring mutations or arising during production of a monoclonal antibody preparation, such variants generally being present in minor amounts. In contrast to polyclonal antibody preparations, which typically include different antibodies directed against different determinants (epitopes), each monoclonal antibody of a monoclonal antibody preparation is directed against a single determinant on an antigen. Thus, the modifier "monoclonal" indicates the character of the antibody as being obtained from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. For example, monoclonal antibodies may be made by a variety of techniques, including but not limited to the hybridoma method, recombinant DNA methods, phage-display methods, and methods utilizing transgenic animals containing all or part of the human immunoglobulin loci, such methods and other exemplary methods for making monoclonal antibodies being described herein.

An "isolated" antibody is one which has been separated from a component of its natural environment. In some aspects, an antibody is purified to greater than 95% or 99% purity as determined by, for example, electrophoretic (e.g., SDS-PAGE, isoelectric focusing (IEF), capillary electrophoresis) or chromatographic (e.g., ion exchange or reverse phase HPLC, affinity chromatography, size exclusion chromatography) methods. For review of methods for assessment of antibody purity, see, e.g., Flatman et al., *J. Chromatogr. B* 848:79-87 (2007). In some aspects, the antibodies provided by the present invention are isolated antibodies.

The term “chimeric” antibody refers to an antibody in which a portion of the heavy and/or light chain is derived from a particular source or species, while the remainder of the heavy and/or light chain is derived from a different source or species.

5 A “humanized” antibody refers to a chimeric antibody comprising amino acid residues from non-human CDRs and amino acid residues from human FRs. In certain aspects, a humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the CDRs correspond to those of a non-human antibody, and all or substantially all of the FRs correspond to those of a human antibody. Such variable domains are referred to herein as “humanized variable region”. A humanized antibody optionally may comprise at least a
10 portion of an antibody constant region derived from a human antibody. In some aspects, some FR residues in a humanized antibody are substituted with corresponding residues from a non-human antibody (e.g., the antibody from which the CDR residues are derived), e.g., to restore or improve antibody specificity or affinity. A “humanized form” of an antibody, e.g. of a non-human antibody, refers to an antibody that has undergone humanization.

15 A “human antibody” is one which possesses an amino acid sequence which corresponds to that of an antibody produced by a human or a human cell or derived from a non-human source that utilizes human antibody repertoires or other human antibody-encoding sequences. This definition of a human antibody specifically excludes a humanized antibody comprising non-human antigen-binding residues. In certain aspects, a human antibody is derived from a non-human transgenic mammal, for example a mouse, a rat, or a rabbit. In certain aspects, a human antibody is derived from a hybridoma cell line. Antibodies or antibody fragments isolated from human antibody
20 libraries are also considered human antibodies or human antibody fragments herein.

The term “antigen binding domain” refers to the part of an antibody that comprises the area which binds to and is complementary to part or all of an antigen. An antigen binding domain may be
25 provided by, for example, one or more antibody variable domains (also called antibody variable regions). In preferred aspects, an antigen binding domain comprises an antibody light chain variable domain (VL) and an antibody heavy chain variable domain (VH).

The term “variable region” or “variable domain” refers to the domain of an antibody heavy or light chain that is involved in binding the antibody to antigen. The variable domains of the heavy chain and light chain (VH and VL, respectively) of a native antibody generally have similar structures,
30 with each domain comprising four conserved framework regions (FRs) and complementarity determining regions (CDRs). See, e.g., Kindt et al., *Kuby Immunology*, 6th ed., W.H. Freeman & Co., page 91 (2007). A single VH or VL domain may be sufficient to confer antigen-binding

specificity. Furthermore, antibodies that bind a particular antigen may be isolated using a VH or VL domain from an antibody that binds the antigen to screen a library of complementary VL or VH domains, respectively. See, e.g., Portolano et al., *J. Immunol.* 150:880-887 (1993); Clarkson et al., *Nature* 352:624-628 (1991). As used herein in connection with variable region sequences,

5 "Kabat numbering" refers to the numbering system set forth by Kabat et al., *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD (1991).

As used herein, the amino acid positions of all constant regions and domains of the heavy and light chain are numbered according to the Kabat numbering system described in Kabat, et al., *Sequences of Proteins of Immunological Interest*, 5th ed., Public Health Service, National Institutes of Health, Bethesda, MD (1991), referred to as "numbering according to Kabat" or "Kabat numbering" herein. Specifically the Kabat numbering system (see pages 647-660 of Kabat, et al., *Sequences of Proteins of Immunological Interest*, 5th ed., Public Health Service, National Institutes of Health, Bethesda, MD (1991)) is used for the light chain constant domain CL of kappa and lambda isotype
10 of Proteins of Immunological Interest, 5th ed., Public Health Service, National Institutes of Health, Bethesda, MD (1991), referred to as "numbering according to Kabat" or "Kabat numbering" herein. Specifically the Kabat numbering system (see pages 647-660 of Kabat, et al., *Sequences of Proteins of Immunological Interest*, 5th ed., Public Health Service, National Institutes of Health, Bethesda, MD (1991)) is used for the light chain constant domain CL of kappa and lambda isotype
15 and the Kabat EU index numbering system (see pages 661-723) is used for the heavy chain constant domains (CH1, hinge, CH2 and CH3), which is herein further clarified by referring to "numbering according to Kabat EU index" or "Kabat EU index numbering" in this case.

The term "hypervariable region" or "HVR", as used herein, refers to each of the regions of an antibody variable domain which are hypervariable in sequence and which determine antigen
20 binding specificity, for example "complementarity determining regions" ("CDRs"). Generally, antibodies comprise six CDRs; three in the VH (HCDR1, HCDR2, HCDR3), and three in the VL (LCDR1, LCDR2, LCDR3). Exemplary CDRs herein include:

(a) hypervariable loops occurring at amino acid residues 26-32 (L1), 50-52 (L2), 91-96 (L3), 26-32 (H1), 53-55 (H2), and 96-101 (H3) (Chothia and Lesk, *J. Mol. Biol.* 196:901-917
25 (1987));

(b) CDRs occurring at amino acid residues 24-34 (L1), 50-56 (L2), 89-97 (L3), 31-35b (H1), 50-65 (H2), and 95-102 (H3) (Kabat et al., *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD (1991)); and

(c) antigen contacts occurring at amino acid residues 27c-36 (L1), 46-55 (L2), 89-96 (L3), 30-35b (H1), 47-58 (H2), and 93-101 (H3) (MacCallum et al. *J. Mol. Biol.* 262: 732-745
30 (1996)).

Unless otherwise indicated, the CDRs are determined according to Kabat et al., *supra*. One of skill in the art will understand that the CDR designations can also be determined according to Chothia, *supra*, McCallum, *supra*, or any other scientifically accepted nomenclature system.

"Framework" or "FR" refers to variable domain residues other than complementarity determining regions (CDRs). The FR of a variable domain generally consists of four FR domains: FR1, FR2, FR3, and FR4. Accordingly, the HVR and FR sequences generally appear in the following order in VH (or VL): FR1-HCDR1(LCDR1)-FR2-HCDR2(LCDR2)-FR3-HCDR3(LCDR3)-FR4.

Unless otherwise indicated, CDR residues and other residues in the variable domain (e.g., FR residues) are numbered herein according to Kabat et al., *supra*.

- 10 An "acceptor human framework" for the purposes herein is a framework comprising the amino acid sequence of a light chain variable domain (VL) framework or a heavy chain variable domain (VH) framework derived from a human immunoglobulin framework or a human consensus framework, as defined below. An acceptor human framework "derived from" a human immunoglobulin framework or a human consensus framework may comprise the same amino acid
15 sequence thereof, or it may contain amino acid sequence changes. In some aspects, the number of amino acid changes is 10 or less, 9 or less, 8 or less, 7 or less, 6 or less, 5 or less, 4 or less, 3 or less, or 2 or less. In some aspects, the VL acceptor human framework is identical in sequence to the VL human immunoglobulin framework sequence or human consensus framework sequence.

- A "human consensus framework" is a framework which represents the most commonly occurring
20 amino acid residues in a selection of human immunoglobulin VL or VH framework sequences. Generally, the selection of human immunoglobulin VL or VH sequences is from a subgroup of variable domain sequences. Generally, the subgroup of sequences is a subgroup as in Kabat et al., *Sequences of Proteins of Immunological Interest*, Fifth Edition, NIH Publication 91-3242, Bethesda MD (1991), vols. 1-3.

- 25 The term "immunoglobulin molecule" herein refers to a protein having the structure of a naturally occurring antibody. For example, immunoglobulins of the IgG class are heterotetrameric glycoproteins of about 150,000 daltons, composed of two light chains and two heavy chains that are disulfide-bonded. From N- to C-terminus, each heavy chain has a variable domain (VH), also called a variable heavy domain or a heavy chain variable region, followed by three constant
30 domains (CH1, CH2, and CH3), also called a heavy chain constant region. Similarly, from N- to C-terminus, each light chain has a variable domain (VL), also called a variable light domain or a light chain variable region, followed by a constant light (CL) domain, also called a light chain constant region. The heavy chain of an immunoglobulin may be assigned to one of five types,

called α (IgA), δ (IgD), ϵ (IgE), γ (IgG), or μ (IgM), some of which may be further divided into subtypes, e.g. γ_1 (IgG₁), γ_2 (IgG₂), γ_3 (IgG₃), γ_4 (IgG₄), α_1 (IgA₁) and α_2 (IgA₂). The light chain of an immunoglobulin may be assigned to one of two types, called kappa (κ) and lambda (λ), based on the amino acid sequence of its constant domain. An immunoglobulin essentially consists of two

5 Fab molecules and an Fc domain, linked via the immunoglobulin hinge region.

The “class” of an antibody or immunoglobulin refers to the type of constant domain or constant region possessed by its heavy chain. There are five major classes of antibodies: IgA, IgD, IgE, IgG, and IgM, and several of these may be further divided into subclasses (isotypes), e.g., IgG₁, IgG₂, IgG₃, IgG₄, IgA₁, and IgA₂. The heavy chain constant domains that correspond to the different

10 classes of immunoglobulins are called α , δ , ϵ , γ , and μ , respectively.

A “Fab molecule” refers to a protein consisting of the VH and CH1 domain of the heavy chain (the “Fab heavy chain”) and the VL and CL domain of the light chain (the “Fab light chain”) of an immunoglobulin.

By a “crossover” Fab molecule (also termed “Crossfab”) is meant a Fab molecule wherein the

15 variable domains or the constant domains of the Fab heavy and light chain are exchanged (i.e. replaced by each other), i.e. the crossover Fab molecule comprises a peptide chain composed of the light chain variable domain VL and the heavy chain constant domain 1 CH1 (VL-CH1, in N- to C-terminal direction), and a peptide chain composed of the heavy chain variable domain VH and the light chain constant domain CL (VH-CL, in N- to C-terminal direction). For clarity, in a

20 crossover Fab molecule wherein the variable domains of the Fab light chain and the Fab heavy chain are exchanged, the peptide chain comprising the heavy chain constant domain 1 CH1 is referred to herein as the “heavy chain” of the (crossover) Fab molecule. Conversely, in a crossover Fab molecule wherein the constant domains of the Fab light chain and the Fab heavy chain are exchanged, the peptide chain comprising the heavy chain variable domain VH is referred to herein

25 as the “heavy chain” of the (crossover) Fab molecule.

In contrast thereto, by a “conventional” Fab molecule is meant a Fab molecule in its natural format, i.e. comprising a heavy chain composed of the heavy chain variable and constant domains (VH-CH1, in N- to C-terminal direction), and a light chain composed of the light chain variable and constant domains (VL-CL, in N- to C-terminal direction).

30 The term “Fc domain” or “Fc region” herein is used to define a C-terminal region of an immunoglobulin heavy chain that contains at least a portion of the constant region. The term includes native sequence Fc regions and variant Fc regions. In one aspect, a human IgG heavy chain Fc region extends from Cys226, or from Pro230, to the carboxyl-terminus of the heavy chain.

However, antibodies produced by host cells may undergo post-translational cleavage of one or more, particularly one or two, amino acids from the C-terminus of the heavy chain. Therefore, an antibody produced by a host cell by expression of a specific nucleic acid molecule encoding a full-length heavy chain may include the full-length heavy chain, or it may include a cleaved variant of the full-length heavy chain. This may be the case where the final two C-terminal amino acids of the heavy chain are glycine (G446) and lysine (K447, numbering according to Kabat EU index). Therefore, the C-terminal lysine (Lys447), or the C-terminal glycine (Gly446) and lysine (Lys447), of the Fc region may or may not be present. Amino acid sequences of heavy chains including an Fc region (or a subunit of an Fc domain as defined herein) are denoted herein without C-terminal glycine-lysine dipeptide if not indicated otherwise. In one aspect, a heavy chain including an Fc region (subunit) as specified herein, comprised in an antibody according to the invention, comprises an additional C-terminal glycine-lysine dipeptide (G446 and K447, numbering according to Kabat EU index). In one aspect, a heavy chain including an Fc region (subunit) as specified herein, comprised in an antibody according to the invention, comprises an additional C-terminal glycine residue (G446, numbering according to Kabat EU index). Unless otherwise specified herein, numbering of amino acid residues in the Fc region or constant region is according to the EU numbering system, also called the EU index, as described in Kabat et al., *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD, 1991 (see also above). A “subunit” of an Fc domain as used herein refers to one of the two polypeptides forming the dimeric Fc domain, i.e. a polypeptide comprising C-terminal constant regions of an immunoglobulin heavy chain, capable of stable self-association. For example, a subunit of an IgG Fc domain comprises an IgG CH2 and an IgG CH3 constant domain. By “fused” is meant that the components (e.g. a Fab molecule and an Fc domain subunit) are linked by peptide bonds, either directly or via one or more peptide linkers.

The term “multispecific” means that the antibody is able to specifically bind to at least two distinct antigenic determinants. A multispecific antibody can be, for example, a bispecific antibody. Typically, a bispecific antibody comprises two antigen binding sites, each of which is specific for a different antigenic determinant. In certain aspects the multispecific (e.g. bispecific) antibody is capable of simultaneously binding two antigenic determinants, particularly two antigenic determinants expressed on two distinct cells.

The term “valent” as used herein denotes the presence of a specified number of antigen binding sites in an antigen binding molecule. As such, the term “monovalent binding to an antigen” denotes

the presence of one (and not more than one) antigen binding site specific for the antigen in the antigen binding molecule.

An “antigen binding site” refers to the site, i.e. one or more amino acid residues, of an antigen binding molecule which provides interaction with the antigen. For example, the antigen binding site of an antibody comprises amino acid residues from the complementarity determining regions (CDRs). A native immunoglobulin molecule typically has two antigen binding sites, a Fab molecule typically has a single antigen binding site.

As used herein, the term “antigenic determinant” or “antigen” refers to a site (e.g. a contiguous stretch of amino acids or a conformational configuration made up of different regions of non-contiguous amino acids) on a polypeptide macromolecule to which an antigen binding domain binds, forming an antigen binding domain-antigen complex. Useful antigenic determinants can be found, for example, on the surfaces of tumor cells, on the surfaces of virus-infected cells, on the surfaces of other diseased cells, on the surface of immune cells, free in blood serum, and/or in the extracellular matrix (ECM). In a preferred aspect, the antigen is a human protein.

“CD3” refers to any native CD3 from any vertebrate source, including mammals such as primates (e.g. humans), non-human primates (e.g. cynomolgus monkeys) and rodents (e.g. mice and rats), unless otherwise indicated. The term encompasses “full-length,” unprocessed CD3 as well as any form of CD3 that results from processing in the cell. The term also encompasses naturally occurring variants of CD3, e.g., splice variants or allelic variants. In one aspect, CD3 is human CD3, particularly the epsilon subunit of human CD3 (CD3ε). The amino acid sequence of human CD3ε is shown in SEQ ID NO: 45 (without signal peptide). See also UniProt (www.uniprot.org) accession no. P07766 (version 209), or NCBI (www.ncbi.nlm.nih.gov/) RefSeq NP_000724.1. In another aspect, CD3 is cynomolgus (*Macaca fascicularis*) CD3, particularly cynomolgus CD3ε. The amino acid sequence of cynomolgus CD3ε is shown in SEQ ID NO: 46 (without signal peptide). See also NCBI GenBank no. BAB71849.1. In certain aspects the antibody of the invention binds to an epitope of CD3 that is conserved among the CD3 antigens from different species, particularly human and cynomolgus CD3. In preferred aspects, the antibody binds to human CD3.

A “target cell antigen” as used herein refers to an antigenic determinant presented on the surface of a target cell, for example a B-cell. Preferably, the target cell antigen is not CD3, and/or is expressed on a different cell than CD3. According to the invention, the target cell antigen is CD19, particularly human CD19.

“CD19” stands for cluster of differentiation 19 (also known as B-lymphocyte antigen CD19 or B-lymphocyte surface antigen B4) and refers to any native CD19 from any vertebrate source, including mammals such as primates (e.g. humans), non-human primates (e.g. cynomolgus monkeys) and rodents (e.g. mice and rats), unless otherwise indicated. The term encompasses
5 “full-length,” unprocessed CD19 as well as any form of CD19 that results from processing in the cell. The term also encompasses naturally occurring variants of CD19, e.g., splice variants or allelic variants. In one aspect, CD19 is human CD19. See for the human protein UniProt (www.uniprot.org) accession no. P15391 (version 211), or NCBI (www.ncbi.nlm.nih.gov/) RefSeq NP_001761.3. In certain aspects the antibody of the invention binds to an epitope of CD19
10 that is conserved among the CD19 antigens from different species, particularly human and cynomolgus CD19. In preferred aspects, the antibody binds to human CD19.

“Affinity” refers to the strength of the sum total of non-covalent interactions between a single binding site of a molecule (e.g., an antibody) and its binding partner (e.g., an antigen). Unless indicated otherwise, as used herein, “binding affinity” refers to intrinsic binding affinity which
15 reflects a 1:1 interaction between members of a binding pair (e.g., an antibody and an antigen). The affinity of a molecule X for its partner Y can generally be represented by the dissociation constant (K_D). Affinity can be measured by well-established methods known in the art, including those described herein. A preferred method for measuring affinity is Surface Plasmon Resonance (SPR).

20 An “affinity matured” antibody refers to an antibody with one or more alterations in one or more complementary determining regions (CDRs), compared to a parent antibody which does not possess such alterations, such alterations resulting in an improvement in the affinity of the antibody for antigen.

“Reduced binding”, for example reduced binding to an Fc receptor, refers to a decrease in affinity
25 for the respective interaction, as measured for example by SPR. For clarity, the term includes also reduction of the affinity to zero (or below the detection limit of the analytic method), i.e. complete abolishment of the interaction. Conversely, “increased binding” refers to an increase in binding affinity for the respective interaction.

“T cell activation” as used herein refers to one or more cellular response of a T lymphocyte,
30 particularly a cytotoxic T lymphocyte, selected from: proliferation, differentiation, cytokine secretion, cytotoxic effector molecule release, cytotoxic activity, and expression of activation markers. Suitable assays to measure T cell activation are known in the art and described herein.

A “modification promoting the association of the first and the second subunit of the Fc domain” is a manipulation of the peptide backbone or the post-translational modifications of an Fc domain subunit that reduces or prevents the association of a polypeptide comprising the Fc domain subunit with an identical polypeptide to form a homodimer. A modification promoting association as used
5 herein preferably includes separate modifications made to each of the two Fc domain subunits desired to associate (i.e. the first and the second subunit of the Fc domain), wherein the modifications are complementary to each other so as to promote association of the two Fc domain subunits. For example, a modification promoting association may alter the structure or charge of one or both of the Fc domain subunits so as to make their association sterically or electrostatically
10 favorable, respectively. Thus, (hetero)dimerization occurs between a polypeptide comprising the first Fc domain subunit and a polypeptide comprising the second Fc domain subunit, which may be non-identical in the sense that further components fused to each of the subunits (e.g. antigen binding domains) are not the same. In some aspects, the modification promoting the association of the first and the second subunit of the Fc domain comprises an amino acid mutation in the Fc
15 domain, specifically an amino acid substitution. In a preferred aspect, the modification promoting the association of the first and the second subunit of the Fc domain comprises a separate amino acid mutation, specifically an amino acid substitution, in each of the two subunits of the Fc domain. The term “effector functions” refers to those biological activities attributable to the Fc region of an antibody, which vary with the antibody isotype. Examples of antibody effector functions
20 include: C1q binding and complement dependent cytotoxicity (CDC), Fc receptor binding, antibody-dependent cell-mediated cytotoxicity (ADCC), antibody-dependent cellular phagocytosis (ADCP), cytokine secretion, immune complex-mediated antigen uptake by antigen presenting cells, down regulation of cell surface receptors (e.g. B cell receptor), and B cell activation.

25 An “activating Fc receptor” is an Fc receptor that following engagement by an Fc domain of an antibody elicits signaling events that stimulate the receptor-bearing cell to perform effector functions. Human activating Fc receptors include FcγRIIIa (CD16a), FcγRI (CD64), FcγRIIa (CD32), and FcαRI (CD89).

Antibody-dependent cell-mediated cytotoxicity (ADCC) is an immune mechanism leading to the
30 lysis of antibody-coated target cells by immune effector cells. The target cells are cells to which antibodies or derivatives thereof comprising an Fc region specifically bind, generally via the protein part that is N-terminal to the Fc region. As used herein, the term “reduced ADCC” is defined as either a reduction in the number of target cells that are lysed in a given time, at a given

concentration of antibody in the medium surrounding the target cells, by the mechanism of ADCC defined above, and/or an increase in the concentration of antibody in the medium surrounding the target cells, required to achieve the lysis of a given number of target cells in a given time, by the mechanism of ADCC. The reduction in ADCC is relative to the ADCC mediated by the same antibody produced by the same type of host cells, using the same standard production, purification, formulation and storage methods (which are known to those skilled in the art), but that has not been engineered. For example, the reduction in ADCC mediated by an antibody comprising in its Fc domain an amino acid substitution that reduces ADCC, is relative to the ADCC mediated by the same antibody without this amino acid substitution in the Fc domain. Suitable assays to measure ADCC are well known in the art (see e.g. PCT publication no. WO 2006/082515 or PCT publication no. WO 2012/130831).

As used herein, the terms “engineer, engineered, engineering”, are considered to include any manipulation of the peptide backbone or the post-translational modifications of a naturally occurring or recombinant polypeptide or fragment thereof. Engineering includes modifications of the amino acid sequence, of the glycosylation pattern, or of the side chain group of individual amino acids, as well as combinations of these approaches.

The term “amino acid mutation” as used herein is meant to encompass amino acid substitutions, deletions, insertions, and modifications. Any combination of substitution, deletion, insertion, and modification can be made to arrive at the final construct, provided that the final construct possesses the desired characteristics, e.g., reduced binding to an Fc receptor, or increased association with another peptide. Amino acid sequence deletions and insertions include amino- and/or carboxy-terminal deletions and insertions of amino acids. Preferred amino acid mutations are amino acid substitutions. For the purpose of altering e.g. the binding characteristics of an Fc region, non-conservative amino acid substitutions, i.e. replacing one amino acid with another amino acid having different structural and/or chemical properties, are particularly preferred. Amino acid substitutions include replacement by non-naturally occurring amino acids or by naturally occurring amino acid derivatives of the twenty standard amino acids (e.g. 4-hydroxyproline, 3-methylhistidine, ornithine, homoserine, 5-hydroxylysine). Amino acid mutations can be generated using genetic or chemical methods well known in the art. Genetic methods may include site-directed mutagenesis, PCR, gene synthesis and the like. It is contemplated that methods of altering the side chain group of an amino acid by methods other than genetic engineering, such as chemical modification, may also be useful. Various designations may be used herein to indicate the same

amino acid mutation. For example, a substitution from proline at position 329 of the Fc domain to glycine can be indicated as 329G, G329, G₃₂₉, P329G, or Pro329Gly.

“Percent (%) amino acid sequence identity” with respect to a reference polypeptide sequence is defined as the percentage of amino acid residues in a candidate sequence that are identical with the amino acid residues in the reference polypeptide sequence, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Alignment for purposes of determining percent amino acid sequence identity can be achieved in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST, BLAST-2, Clustal W, Megalign (DNASTAR) software or the FASTA program package. Those skilled in the art can determine appropriate parameters for aligning sequences, including any algorithms needed to achieve maximal alignment over the full length of the sequences being compared. Alternatively, the percent identity values can be generated using the sequence comparison computer program ALIGN-2. The ALIGN-2 sequence comparison computer program was authored by Genentech, Inc., and the source code has been filed with user documentation in the U.S. Copyright Office, Washington D.C., 20559, where it is registered under U.S. Copyright Registration No. TXU510087 and is described in WO 2001/007611.

Unless otherwise indicated, for purposes herein, % amino acid sequence identity values are generated using the ggsearch program of the FASTA package version 36.3.8c or later with a BLOSUM50 comparison matrix. The FASTA program package was authored by W. R. Pearson and D. J. Lipman (“Improved Tools for Biological Sequence Analysis”, PNAS 85 (1988) 2444-2448), W. R. Pearson (“Effective protein sequence comparison” Meth. Enzymol. 266 (1996) 227-258), and Pearson et. al. (Genomics 46 (1997) 24-36) and is publicly available from www.fasta.bioch.virginia.edu/fasta_www2/fasta_down.shtml or www.ebi.ac.uk/Tools/sss/fasta. Alternatively, a public server accessible at fasta.bioch.virginia.edu/fasta_www2/index.cgi can be used to compare the sequences, using the ggsearch (global protein:protein) program and default options (BLOSUM50; open: -10; ext: -2; Ktup = 2) to ensure a global, rather than local, alignment is performed. Percent amino acid identity is given in the output alignment header.

The term “polynucleotide” or “nucleic acid molecule” includes any compound and/or substance that comprises a polymer of nucleotides. Each nucleotide is composed of a base, specifically a purine- or pyrimidine base (i.e. cytosine (C), guanine (G), adenine (A), thymine (T) or uracil (U)), a sugar (i.e. deoxyribose or ribose), and a phosphate group. Often, the nucleic acid molecule is described by the sequence of bases, whereby said bases represent the primary structure (linear

structure) of a nucleic acid molecule. The sequence of bases is typically represented from 5' to 3'. Herein, the term nucleic acid molecule encompasses deoxyribonucleic acid (DNA) including e.g., complementary DNA (cDNA) and genomic DNA, ribonucleic acid (RNA), in particular messenger RNA (mRNA), synthetic forms of DNA or RNA, and mixed polymers comprising two or more of these molecules. The nucleic acid molecule may be linear or circular. In addition, the term nucleic acid molecule includes both, sense and antisense strands, as well as single stranded and double stranded forms. Moreover, the herein described nucleic acid molecule can contain naturally occurring or non-naturally occurring nucleotides. Examples of non-naturally occurring nucleotides include modified nucleotide bases with derivatized sugars or phosphate backbone linkages or chemically modified residues. Nucleic acid molecules also encompass DNA and RNA molecules which are suitable as a vector for direct expression of an antibody of the invention *in vitro* and/or *in vivo*, e.g., in a host or patient. Such DNA (e.g., cDNA) or RNA (e.g., mRNA) vectors, can be unmodified or modified. For example, mRNA can be chemically modified to enhance the stability of the RNA vector and/or expression of the encoded molecule so that mRNA can be injected into a subject to generate the antibody *in vivo* (see e.g., Stadler et al. (2017) Nature Medicine 23:815-817, or EP 2 101 823 B1).

An "isolated" nucleic acid molecule refers to a nucleic acid molecule that has been separated from a component of its natural environment. An isolated nucleic acid molecule includes a nucleic acid molecule contained in cells that ordinarily contain the nucleic acid molecule, but the nucleic acid molecule is present extrachromosomally or at a chromosomal location that is different from its natural chromosomal location.

"Isolated polynucleotide (or nucleic acid) encoding an antibody" refers to one or more polynucleotide molecules encoding antibody heavy and light chains (or fragments thereof), including such polynucleotide molecule(s) in a single vector or separate vectors, and such polynucleotide molecule(s) present at one or more locations in a host cell.

The term "vector", as used herein, refers to a nucleic acid molecule capable of propagating another nucleic acid to which it is linked. The term includes the vector as a self-replicating nucleic acid structure as well as the vector incorporated into the genome of a host cell into which it has been introduced. Certain vectors are capable of directing the expression of nucleic acids to which they are operatively linked. Such vectors are referred to herein as "expression vectors".

The terms "host cell", "host cell line," and "host cell culture" are used interchangeably and refer to cells into which exogenous nucleic acid has been introduced, including the progeny of such cells. Host cells include "transformants" and "transformed cells," which include the primary transformed

cell and progeny derived therefrom without regard to the number of passages. Progeny may not be completely identical in nucleic acid content to a parent cell, but may contain mutations. Mutant progeny that have the same function or biological activity as screened or selected for in the originally transformed cell are included herein. A host cell is any type of cellular system that can be used to generate the antibodies of the present invention. Host cells include cultured cells, *e.g.* mammalian cultured cells, such as HEK cells, CHO cells, BHK cells, NS0 cells, SP2/0 cells, YO myeloma cells, P3X63 mouse myeloma cells, PER cells, PER.C6 cells or hybridoma cells, yeast cells, insect cells, and plant cells, to name only a few, but also cells comprised within a transgenic animal, transgenic plant or cultured plant or animal tissue. In one aspect, the host cell of the invention is a eukaryotic cell, particularly a mammalian cell. In one aspect, the host cell is not a cell within a human body.

The term "pharmaceutical composition" or "pharmaceutical formulation" refers to a preparation which is in such form as to permit the biological activity of an active ingredient contained therein to be effective, and which contains no additional components which are unacceptably toxic to a subject to which the composition would be administered.

A "pharmaceutically acceptable carrier" refers to an ingredient in a pharmaceutical composition or formulation, other than an active ingredient, which is nontoxic to a subject. A pharmaceutically acceptable carrier includes, but is not limited to, a buffer, excipient, stabilizer, or preservative.

As used herein, "treatment" (and grammatical variations thereof such as "treat" or "treating") refers to clinical intervention in an attempt to alter the natural course of a disease in the individual being treated, and can be performed either for prophylaxis or during the course of clinical pathology. Desirable effects of treatment include, but are not limited to, preventing occurrence or recurrence of disease, alleviation of symptoms, diminishment of any direct or indirect pathological consequences of the disease, preventing metastasis, decreasing the rate of disease progression, amelioration or palliation of the disease state, and remission or improved prognosis. In some aspects, antibodies of the invention are used to delay development of a disease or to slow the progression of a disease.

An "individual" or "subject" is a mammal. Mammals include, but are not limited to, domesticated animals (*e.g.* cows, sheep, cats, dogs, and horses), primates (*e.g.* humans and non-human primates such as monkeys), rabbits, and rodents (*e.g.* mice and rats). In certain aspects, the individual or subject is a human.

An “effective amount” of an agent, e.g., a pharmaceutical composition, refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic or prophylactic result.

The term “package insert” is used to refer to instructions customarily included in commercial packages of therapeutic products, that contain information about the indications, usage, dosage, administration, combination therapy, contraindications and/or warnings concerning the use of such therapeutic products.

II. COMPOSITIONS AND METHODS

The invention provides antibodies that bind CD3 and CD19. The antibodies show superior stability, combined with other favorable properties for therapeutic application, e.g. with respect to efficacy and safety, pharmacokinetics, as well as produceability. Antibodies of the invention as useful, e.g., for the treatment of diseases such as cancer or autoimmune disease.

A. Anti-CD3 / CD19 antibodies

In one aspect, the invention provides antibodies that bind to CD3 and CD19. In one aspect, provided are isolated antibodies that bind to CD3 and CD19. In one aspect, the invention provides antibodies that specifically bind to CD3 and CD19. In certain aspects, the anti-CD3 / CD19 antibodies retain more than about 90% binding activity to CD3 after 2 weeks at pH 7.4, 37°C, relative to the binding activity after 2 weeks at pH 6, -80°C, as determined by surface plasmon resonance (SPR).

In one aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises (a) a first antigen binding domain that binds to CD3, comprising a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10.

In one aspect, the antibody is a humanized antibody. In one aspect, the first antigen binding domain is a humanized antigen binding domain (i.e. an antigen binding domain of a humanized antibody). In one aspect, the VH and/or the VL of the first antigen binding domain is a humanized variable region.

In one aspect, the VH and/or the VL of the first antigen binding domain comprises an acceptor human framework, e.g. a human immunoglobulin framework or a human consensus framework.

In one aspect, the VH of the first antigen binding domain comprises one or more heavy chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4 sequence) of the heavy chain variable region sequence of SEQ ID NO: 7. In one aspect, the VH of the first antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 7. In one aspect, the VH of the first antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 7. In one aspect, the VH of the first antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 7. In certain aspects, a VH sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD3. In certain aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 7. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VH of the first antigen binding domain comprises the amino acid sequence of SEQ ID NO: 7. Optionally, the VH of the first antigen binding domain comprises the amino acid sequence of SEQ ID NO: 7, including post-translational modifications of that sequence.

In one aspect, the VL of the first antigen binding domain comprises one or more light chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4 sequence) of the light chain variable region sequence of SEQ ID NO: 11. In one aspect, the VL of the first antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 11. In one aspect, the VL of the first antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 11. In one aspect, the VL of the first antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 11. In certain aspects, a VL sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD3. In certain aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 11. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VL of the first

antigen binding domain comprises the amino acid sequence of SEQ ID NO: 11. Optionally, the VL of the first antigen binding domain comprises the amino acid sequence of SEQ ID NO: 11, including post-translational modifications of that sequence.

In one aspect, the VH of the first antigen binding domain comprises an amino acid sequence that
5 is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 7, and the VL of the first antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 11. In one aspect, the VH of the first antigen binding domain comprises the amino acid sequence of SEQ ID NO: 7 and the VL of the first antigen binding domain comprises the amino acid
10 sequence of SEQ ID NO: 11.

In a further aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises a first antigen binding domain that binds to CD3 comprising a VH comprising the amino acid sequence of SEQ ID NO: 7 and a VL comprising the amino acid sequence of SEQ ID NO: 11.

15 In a further aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises a first antigen binding domain that binds to CD3 comprising a VH sequence of SEQ ID NO: 7 and a VL sequence of SEQ ID NO: 11.

In another aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises a first antigen binding domain that binds to CD3 comprising a VH comprising
20 the heavy chain CDR sequences of the VH of SEQ ID NO: 7, and a VL comprising the light chain CDR sequences of the VL of SEQ ID NO: 11.

In a further aspect, the first antigen binding domain comprises the HCDR1, HCDR2 and HCDR3 amino acid sequences of the VH of SEQ ID NO: 7 and the LCDR1, LCDR2 and LCDR3 amino acid sequences of the VL of SEQ ID NO: 11.

25 In one aspect, the VH of the first antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 7 and a framework of at least 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VH of SEQ ID NO: 7. In one aspect, the VH of the first antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 7 and a framework of at least 95% sequence identity to the framework sequence of the VH
30 of SEQ ID NO: 7. In another aspect, the VH of the first antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 7 and a framework of at least 98% sequence identity to the framework sequence of the VH of SEQ ID NO: 7.

In one aspect, the VL of the first antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 11 and a framework of at least 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VL of SEQ ID NO: 11. In one aspect, the VL of the first antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 11 and a framework of at least 95% sequence identity to the framework sequence of the VL of SEQ ID NO: 11. In another aspect, the VL of the first antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 11 and a framework of at least 98% sequence identity to the framework sequence of the VL of SEQ ID NO: 11.

In one aspect, the invention provides an antibody that binds to CD3 and CD19, wherein the antibody comprises a first antigen binding domain that binds to CD3 comprising a VH sequence as in any of the aspects provided above, and a VL sequence as in any of the aspects provided above. In one aspect, the antibody comprises a human constant region. In one aspect, the antibody is an immunoglobulin molecule comprising a human constant region, particularly an IgG class immunoglobulin molecule comprising a human CH1, CH2, CH3 and/or CL domain. Exemplary sequences of human constant domains are given in SEQ ID NOs 52 and 53 (human kappa and lambda CL domains, respectively) and SEQ ID NO: 54 (human IgG₁ heavy chain constant domains CH1-CH2-CH3). In one aspect, the antibody comprises a light chain constant region comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 52 or SEQ ID NO: 53, particularly the amino acid sequence of SEQ ID NO: 52. In one aspect, the antibody comprises a heavy chain constant region comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 54. Particularly, the heavy chain constant region may comprise amino acid mutations in the Fc domain as described herein.

In one aspect, the first antigen binding domain comprises a human constant region. In one aspect, the first antigen binding moiety is a Fab molecule comprising a human constant region, particularly a human CH1 and/or CL domain. In one aspect, the first antigen binding domain comprises a light chain constant region comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 52 or SEQ ID NO: 53, particularly the amino acid sequence of SEQ ID NO: 52. Particularly, the light chain constant region may comprise amino acid mutations as described herein under "charge modifications" and/or may comprise deletion or substitutions of one or more (particularly two) N-terminal amino acids if in a crossover Fab molecule. In some aspects, the first antigen binding domain comprises a heavy chain constant region comprising an amino acid sequence that is at least about 95%, 96%,

97%, 98%, 99% or 100% identical to the CH1 domain sequence comprised in the amino acid sequence of SEQ ID NO: 54. Particularly, the heavy chain constant region (specifically CH1 domain) may comprise amino acid mutations as described herein under “charge modifications”.

In one aspect, the antibody is a monoclonal antibody.

- 5 In one aspect, the antibody is an IgG, particularly an IgG₁, antibody. In one aspect, the antibody is a full-length antibody.

In another aspect, the antibody is an antibody fragment selected from the group of an Fv molecule, a scFv molecule, a Fab molecule, and a F(ab')₂ molecule; particularly a Fab molecule. In another aspect, the antibody fragment is a diabody, a triabody or a tetrabody.

- 10 In one aspect, the first antigen binding domain is a Fab molecule. In a preferred aspect the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1, particularly the variable domains VL and VH, of the Fab light chain and the Fab heavy chain are replaced by each other (i.e. the first antigen binding domain is a crossover Fab molecule).

- 15 In a further aspect, the antibody according to any of the above aspects may incorporate any of the features, singly or in combination, as described in sections II. A. 1.-8. below.

In a preferred aspect, the antibody comprises an Fc domain, particularly an IgG Fc domain, more particularly an IgG₁ Fc domain. In one aspect the Fc domain is a human Fc domain. In one aspect, the Fc domain is a human IgG₁ Fc domain. The Fc domain is composed of a first and a second

- 20 subunit and may incorporate any of the features, singly or in combination, described hereinbelow in relation to Fc domain variants (section II. A. 8.).

According to the invention, the antibody comprises a second and optionally a third antigen binding domain which binds to CD19 (i.e. the antibody is a multispecific antibody, as further described hereinbelow (section II. A. 7.).

25

1. Antibody Fragments

In certain aspects, an antibody provided herein is an antibody fragment.

In one aspect, the antibody fragment is a Fab, Fab', Fab'-SH, or F(ab')₂ molecule, in particular a Fab molecule as described herein. “Fab’ molecule” differ from Fab molecules by the addition of

- 30 residues at the carboxy terminus of the CH1 domain including one or more cysteines from the antibody hinge region. Fab'-SH are Fab' molecules in which the cysteine residue(s) of the constant domains bear a free thiol group. Pepsin treatment yields an F(ab')₂ molecule that has two antigen-binding sites (two Fab molecules) and a part of the Fc region.

In another aspect, the antibody fragment is a diabody, a triabody or a tetrabody. "Diabodies" are antibody fragments with two antigen-binding sites that may be bivalent or bispecific. See, for example, EP 404,097; WO 1993/01161; Hudson et al., Nat. Med. 9:129-134 (2003); and Hollinger et al., Proc. Natl. Acad. Sci. USA 90: 6444-6448 (1993). Triabodies and tetrabodies are also
5 described in Hudson et al., Nat. Med. 9:129-134 (2003).

In a further aspect, the antibody fragment is a single chain Fab molecule. A "single chain Fab molecule" or "scFab" is a polypeptide consisting of an antibody heavy chain variable domain (VH), an antibody heavy chain constant domain 1 (CH1), an antibody light chain variable domain (VL), an antibody light chain constant domain (CL) and a linker, wherein said antibody domains and
10 said linker have one of the following orders in N-terminal to C-terminal direction: a) VH-CH1-linker-VL-CL, b) VL-CL-linker-VH-CH1, c) VH-CL-linker-VL-CH1 or d) VL-CH1-linker-VH-CL. In particular, said linker is a polypeptide of at least 30 amino acids, preferably between 32 and 50 amino acids. Said single chain Fab molecules are stabilized via the natural disulfide bond between the CL domain and the CH1 domain. In addition, these single chain Fab molecules might
15 be further stabilized by generation of interchain disulfide bonds via insertion of cysteine residues (e.g., position 44 in the variable heavy chain and position 100 in the variable light chain according to Kabat numbering).

In another aspect, the antibody fragment is single-chain variable fragment (scFv). A "single-chain variable fragment" or "scFv" is a fusion protein of the variable domains of the heavy (VH) and
20 light chains (VL) of an antibody, connected by a linker. In particular, the linker is a short polypeptide of 10 to 25 amino acids and is usually rich in glycine for flexibility, as well as serine or threonine for solubility, and can either connect the N-terminus of the VH with the C-terminus of the VL, or *vice versa*. This protein retains the specificity of the original antibody, despite removal of the constant regions and the introduction of the linker. For a review of scFv fragments,
25 see, e.g., Plückthun, in The Pharmacology of Monoclonal Antibodies, vol. 113, Rosenberg and Moore eds., (Springer-Verlag, New York), pp. 269-315 (1994); see also WO 93/16185; and U.S. Patent Nos. 5,571,894 and 5,587,458.

In another aspect, the antibody fragment is a single-domain antibody. "Single-domain antibodies" are antibody fragments comprising all or a portion of the heavy chain variable domain or all or a
30 portion of the light chain variable domain of an antibody. In certain aspects, a single-domain antibody is a human single-domain antibody (Domantis, Inc., Waltham, MA; see, e.g., U.S. Patent No. 6,248,516 B1).

In certain aspects, an antibody provided herein is a humanized antibody. Typically, a non-human antibody is humanized to reduce immunogenicity to humans, while retaining the specificity and affinity of the parental non-human antibody. Generally, a humanized antibody comprises one or more variable domains in which the CDRs (or portions thereof) are derived from a non-human antibody, and FRs (or portions thereof) are derived from human antibody sequences. A humanized antibody optionally will also comprise at least a portion of a human constant region. In some aspects, some FR residues in a humanized antibody are substituted with corresponding residues from a non-human antibody (e.g., the antibody from which the CDR residues are derived), e.g., to restore or improve antibody specificity or affinity.

Human framework regions that may be used for humanization include but are not limited to: framework regions selected using the “best-fit” method (see, e.g., Sims et al. *J. Immunol.* 151:2296 (1993)); framework regions derived from the consensus sequence of human antibodies of a particular subgroup of light or heavy chain variable regions (see, e.g., Carter et al. *Proc. Natl. Acad. Sci. USA*, 89:4285 (1992); and Presta et al. *J. Immunol.*, 151:2623 (1993)); human mature (somatically mutated) framework regions or human germline framework regions (see, e.g., Almagro and Fransson, *Front. Biosci.* 13:1619-1633 (2008)); and framework regions derived from screening FR libraries (see, e.g., Baca et al., *J. Biol. Chem.* 272:10678-10684 (1997) and Rosok et al., *J. Biol. Chem.* 271:22611-22618 (1996)).

3. Glycosylation variants

In certain aspects, an antibody provided herein is altered to increase or decrease the extent to which the antibody is glycosylated. Addition or deletion of glycosylation sites to an antibody may be conveniently accomplished by altering the amino acid sequence such that one or more
5 glycosylation sites is created or removed.

Where the antibody comprises an Fc region, the oligosaccharide attached thereto may be altered. Native antibodies produced by mammalian cells typically comprise a branched, biantennary oligosaccharide that is generally attached by an N-linkage to Asn297 of the CH2 domain of the Fc region. See, e.g., Wright et al. *TIBTECH* 15:26-32 (1997). The oligosaccharide may include
10 various carbohydrates, e.g., mannose, N-acetyl glucosamine (GlcNAc), galactose, and sialic acid, as well as a fucose attached to a GlcNAc in the “stem” of the biantennary oligosaccharide structure. In some aspects, modifications of the oligosaccharide in an antibody of the invention may be made in order to create antibody variants with certain improved properties.

In one aspect, antibody variants are provided having a non-fucosylated oligosaccharide, i.e. an
15 oligosaccharide structure that lacks fucose attached (directly or indirectly) to an Fc region. Such non-fucosylated oligosaccharide (also referred to as “afucosylated” oligosaccharide) particularly is an N-linked oligosaccharide which lacks a fucose residue attached to the first GlcNAc in the stem of the biantennary oligosaccharide structure. In one aspect, antibody variants are provided having an increased proportion of non-fucosylated oligosaccharides in the Fc region as compared
20 to a native or parent antibody. For example, the proportion of non-fucosylated oligosaccharides may be at least about 20%, at least about 40%, at least about 60%, at least about 80%, or even about 100% (i.e. no fucosylated oligosaccharides are present). The percentage of non-fucosylated oligosaccharides is the (average) amount of oligosaccharides lacking fucose residues, relative to the sum of all oligosaccharides attached to Asn 297 (e. g. complex, hybrid and high mannose
25 structures) as measured by MALDI-TOF mass spectrometry, as described in WO 2006/082515, for example. Asn297 refers to the asparagine residue located at about position 297 in the Fc region (EU numbering of Fc region residues); however, Asn297 may also be located about ± 3 amino acids upstream or downstream of position 297, i.e., between positions 294 and 300, due to minor sequence variations in antibodies. Such antibodies having an increased proportion of non-
30 fucosylated oligosaccharides in the Fc region may have improved Fc γ RIIIa receptor binding and/or improved effector function, in particular improved ADCC function. See, e.g., US 2003/0157108; US 2004/0093621.

Examples of cell lines capable of producing antibodies with reduced fucosylation include Lec13 CHO cells deficient in protein fucosylation (Ripka et al. *Arch. Biochem. Biophys.* 249:533-545 (1986); US 2003/0157108; and WO 2004/056312, especially at Example 11), and knockout cell lines, such as alpha-1,6-fucosyltransferase gene, *FUT8*, knockout CHO cells (see, e.g., Yamane-
5 Ohnuki et al. *Biotech. Bioeng.* 87:614-622 (2004); Kanda, Y. et al., *Biotechnol. Bioeng.*, 94(4):680-688 (2006); and WO 2003/085107), or cells with reduced or abolished activity of a GDP-fucose synthesis or transporter protein (see, e.g., US2004259150, US2005031613, US2004132140, US2004110282).

In a further aspect, antibody variants are provided with bisected oligosaccharides, e.g., in which a
10 biantennary oligosaccharide attached to the Fc region of the antibody is bisected by GlcNAc. Such antibody variants may have reduced fucosylation and/or improved ADCC function as described above. Examples of such antibody variants are described, e.g., in Umana et al., *Nat Biotechnol* 17, 176-180 (1999); Ferrara et al., *Biotechnol Bioeng* 93, 851-861 (2006); WO 99/54342; WO 2004/065540, WO 2003/011878.

15 Antibody variants with at least one galactose residue in the oligosaccharide attached to the Fc region are also provided. Such antibody variants may have improved CDC function. Such antibody variants are described, e.g., in WO 1997/30087; WO 1998/58964; and WO 1999/22764.

4. Cysteine engineered antibody variants

20 In certain aspects, it may be desirable to create cysteine engineered antibodies, e.g., THIOMAB™ antibodies, in which one or more residues of an antibody are substituted with cysteine residues. In preferred aspects, the substituted residues occur at accessible sites of the antibody. By substituting those residues with cysteine, reactive thiol groups are thereby positioned at accessible sites of the antibody and may be used to conjugate the antibody to other moieties, such as drug moieties or
25 linker-drug moieties, to create an immunoconjugate, as described further herein. Cysteine engineered antibodies may be generated as described, e.g., in U.S. Patent No. 7,521,541, 8,30,930, 7,855,275, 9,000,130, or WO 2016040856.

5. Antibody Derivatives

30 In certain aspects, an antibody provided herein may be further modified to contain additional non-proteinaceous moieties that are known in the art and readily available. The moieties suitable for derivatization of the antibody include but are not limited to water soluble polymers. Non-limiting

examples of water soluble polymers include, but are not limited to, polyethylene glycol (PEG), copolymers of ethylene glycol/propylene glycol, carboxymethylcellulose, dextran, polyvinyl alcohol, polyvinyl pyrrolidone, poly-1, 3-dioxolane, poly-1,3,6-trioxane, ethylene/maleic anhydride copolymer, polyaminoacids (either homopolymers or random copolymers), and dextran
5 or poly(n-vinyl pyrrolidone)polyethylene glycol, propylene glycol homopolymers, polypropylene oxide/ethylene oxide co-polymers, polyoxyethylated polyols (e.g., glycerol), polyvinyl alcohol, and mixtures thereof. Polyethylene glycol propionaldehyde may have advantages in manufacturing due to its stability in water. The polymer may be of any molecular weight, and may be branched or unbranched. The number of polymers attached to the antibody
10 may vary, and if more than one polymer are attached, they can be the same or different molecules. In general, the number and/or type of polymers used for derivatization can be determined based on considerations including, but not limited to, the particular properties or functions of the antibody to be improved, whether the antibody derivative will be used in a therapy under defined conditions, etc.

15

6. *Immunoconjugates*

The invention also provides immunoconjugates comprising an anti-CD3 / CD19 antibody herein conjugated (chemically bonded) to one or more therapeutic agents such as cytotoxic agents, chemotherapeutic agents, drugs, growth inhibitory agents, toxins (e.g., protein toxins,
20 enzymatically active toxins of bacterial, fungal, plant, or animal origin, or fragments thereof), or radioactive isotopes.

In one aspect, an immunoconjugate is an antibody-drug conjugate (ADC) in which an antibody is conjugated to one or more of the therapeutic agents mentioned above. The antibody is typically connected to one or more of the therapeutic agents using linkers. An overview of ADC technology
25 including examples of therapeutic agents and drugs and linkers is set forth in *Pharmacol Review* 68:3-19 (2016).

In another aspect, an immunoconjugate comprises an antibody of the invention conjugated to an enzymatically active toxin or fragment thereof, including but not limited to diphtheria A chain, nonbinding active fragments of diphtheria toxin, exotoxin A chain (from *Pseudomonas aeruginosa*), ricin A chain, abrin A chain, modeccin A chain, alpha-sarcin, Aleurites fordii proteins, dianthin proteins, *Phytolacca americana* proteins (PAPI, PAPII, and PAP-S), momordica charantia inhibitor, curcin, crotin, saponaria officinalis inhibitor, gelonin, mitogellin, restrictocin, phenomycin, enomycin, and the tricothecenes.

In another aspect, an immunoconjugate comprises an antibody of the invention conjugated to a radioactive atom to form a radioconjugate. A variety of radioactive isotopes are available for the production of radioconjugates. Examples include At²¹¹, I¹³¹, I¹²⁵, Y⁹⁰, Re¹⁸⁶, Re¹⁸⁸, Sm¹⁵³, Bi²¹², P³², Pb²¹² and radioactive isotopes of Lu. When the radioconjugate is used for detection, it may
 5 comprise a radioactive atom for scintigraphic studies, for example Tc^{99m} or I¹²³, or a spin label for nuclear magnetic resonance (NMR) imaging (also known as magnetic resonance imaging, MRI), such as I¹²³, I¹³¹, In¹¹¹, F¹⁹, C¹³, N¹⁵, O¹⁷, gadolinium, manganese or iron.

Conjugates of an antibody and cytotoxic agent may be made using a variety of bifunctional protein coupling agents such as N-succinimidyl-3-(2-pyridyldithio) propionate (SPDP), succinimidyl-4-
 10 (N-maleimidomethyl) cyclohexane-1-carboxylate (SMCC), iminothiolane (IT), bifunctional derivatives of imidoesters (such as dimethyl adipimidate HCl), active esters (such as disuccinimidyl suberate), aldehydes (such as glutaraldehyde), bis-azido compounds (such as bis (p-azidobenzoyl) hexanediamine), bis-diazonium derivatives (such as bis-(p-diazoniumbenzoyl)-ethylenediamine), diisocyanates (such as toluene 2,6-diisocyanate), and bis-active fluorine
 15 compounds (such as 1,5-difluoro-2,4-dinitrobenzene). For example, a ricin immunotoxin can be prepared as described in Vitetta et al., *Science* 238:1098 (1987). Carbon-14-labeled 1-isothiocyanatobenzyl-3-methyldiethylene triaminepentaacetic acid (MX-DTPA) is an exemplary chelating agent for conjugation of radionucleotide to the antibody. See WO 94/11026. The linker may be a "cleavable linker" facilitating release of a cytotoxic drug in the cell. For example, an
 20 acid-labile linker, peptidase-sensitive linker, photolabile linker, dimethyl linker or disulfide-containing linker (Chari et al., *Cancer Res.* 52:127-131 (1992); U.S. Patent No. 5,208,020) may be used.

The immunoconjugates or ADCs herein expressly contemplate, but are not limited to such conjugates prepared with cross-linker reagents including, but not limited to, BMPS, EMCS,
 25 GMBS, HBVS, LC-SMCC, MBS, MPBH, SBAP, SIA, SIAB, SMCC, SMPB, SMPH, sulfo-EMCS, sulfo-GMBS, sulfo-KMUS, sulfo-MBS, sulfo-SIAB, sulfo-SMCC, and sulfo-SMPB, and SVSB (succinimidyl-(4-vinylsulfone)benzoate) which are commercially available (e.g., from Pierce Biotechnology, Inc., Rockford, IL., U.S.A).

30 7. Multispecific Antibodies

An antibody provided herein is a multispecific antibody, particularly a bispecific antibody. Multispecific antibodies are monoclonal antibodies that have binding specificities for at least two different antigenic determinants (e.g., two different proteins, or two different epitopes on the same

protein). In certain aspects, the multispecific antibody has three or more binding specificities. According to the present invention, one of the binding specificities is for CD3 and the other specificity is for CD19.

Multispecific antibodies may be prepared as full length antibodies or antibody fragments.

- 5 Techniques for making multispecific antibodies include, but are not limited to, recombinant co-expression of two immunoglobulin heavy chain-light chain pairs having different specificities (see Milstein and Cuello, *Nature* 305: 537 (1983)) and “knob-in-hole” engineering (see, e.g., U.S. Patent No. 5,731,168, and Atwell et al., *J. Mol. Biol.* 270:26 (1997)). Multi-specific antibodies may also be made by engineering electrostatic steering effects for making antibody Fc-
- 10 heterodimeric molecules (see, e.g., WO 2009/089004); cross-linking two or more antibodies or fragments (see, e.g., US Patent No. 4,676,980, and Brennan et al., *Science*, 229: 81 (1985)); using leucine zippers to produce bi-specific antibodies (see, e.g., Kostelny et al., *J. Immunol.*, 148(5):1547-1553 (1992) and WO 2011/034605); using the common light chain technology for circumventing the light chain mis-pairing problem (see, e.g., WO 98/50431); using “diabody”
- 15 technology for making bispecific antibody fragments (see, e.g., Hollinger et al., *Proc. Natl. Acad. Sci. USA*, 90:6444-6448 (1993)); and using single-chain Fv (sFv) dimers (see, e.g., Gruber et al., *J. Immunol.*, 152:5368 (1994)); and preparing trispecific antibodies as described, e.g., in Tutt et al. *J. Immunol.* 147: 60 (1991).

- Engineered antibodies with three or more antigen binding sites, including for example, “Octopus antibodies”, or DVD-Ig are also included herein (see, e.g., WO 2001/77342 and WO 2008/024715).
- 20 Other examples of multispecific antibodies with three or more antigen binding sites can be found in WO 2010/115589, WO 2010/112193, WO 2010/136172, WO 2010/145792, and WO 2013/026831. The multispecific antibody or antigen binding fragment thereof also includes a “Dual Acting FAb” or “DAF” comprising an antigen binding site that binds to CD3 as well as
- 25 another different antigen, or two different epitopes of CD3 (see, e.g., US 2008/0069820 and WO 2015/095539).

- Multi-specific antibodies may also be provided in an asymmetric form with a domain crossover in one or more binding arms of the same antigen specificity (so-called “CrossMab” technology), i.e. by exchanging the VH/VL domains (see e.g., WO 2009/080252 and WO 2015/150447), the
- 30 CH1/CL domains (see e.g., WO 2009/080253) or the complete Fab arms (see e.g., WO 2009/080251, WO 2016/016299, also see Schaefer et al, *PNAS*, 108 (2011) 1187-1191, and Klein et al., *MAbs* 8 (2016) 1010-20). Asymmetrical Fab arms can also be engineered by introducing

charged or non-charged amino acid mutations into domain interfaces to direct correct Fab pairing. See e.g., WO 2016/172485.

Various further molecular formats for multispecific antibodies are known in the art and are included herein (see e.g., Spiess et al., *Mol Immunol* 67 (2015) 95-106).

- 5 A particular type of multispecific antibodies are bispecific antibodies designed to simultaneously bind to a surface antigen on a target cell, e.g., a B cell, and to an activating, invariant component of the T cell receptor (TCR) complex, such as CD3, for retargeting of T cells to kill target cells. Hence, the antibody provided herein is a multispecific antibody, particularly a bispecific antibody, wherein one of the binding specificities is for CD3 and the other is for CD19 as the target cell
10 antigen.

- Examples of bispecific antibody formats that may be useful for this purpose include, but are not limited to, the so-called "BiTE" (bispecific T cell engager) molecules wherein two scFv molecules are fused by a flexible linker (see, e.g., WO 2004/106381, WO 2005/061547, WO 2007/042261, and WO 2008/119567, Nagorsen and B  uerle, *Exp Cell Res* 317, 1255-1260 (2011)); diabodies
15 (Holliger et al., *Prot Eng* 9, 299-305 (1996)) and derivatives thereof, such as tandem diabodies ("TandAb"; Kipriyanov et al., *J Mol Biol* 293, 41-56 (1999)); "DART" (dual affinity retargeting) molecules which are based on the diabody format but feature a C-terminal disulfide bridge for additional stabilization (Johnson et al., *J Mol Biol* 399, 436-449 (2010)), and so-called triomabs, which are whole hybrid mouse/rat IgG molecules (reviewed in Seimetz et al., *Cancer Treat Rev*
20 36, 458-467 (2010)). Particular T cell bispecific antibody formats included herein are described in WO 2013/026833, WO 2013/026839, WO 2016/020309; Bacac et al., *Oncoimmunology* 5(8) (2016) e1203498.

Preferred aspects of the antibody of the present invention are described in the following.

- In one aspect, the invention provides an antibody that binds to CD3 and CD19, comprising a first
25 antigen binding domain that binds to CD3, as described herein, and comprising a second and optionally a third antigen binding domain that binds to CD19.

- According to preferred aspects of the invention, the antigen binding domains comprised in the antibody are Fab molecules (i.e. antigen binding domains composed of a heavy and a light chain, each comprising a variable and a constant domain). In one aspect, the first, the second and/or,
30 where present, the third antigen binding domain is a Fab molecule. In one aspect, said Fab molecule is human. In a preferred aspect, said Fab molecule is humanized. In yet another aspect, said Fab molecule comprises human heavy and light chain constant domains.

Preferably, at least one of the antigen binding domains is a crossover Fab molecule. Such modification reduces mispairing of heavy and light chains from different Fab molecules, thereby improving the yield and purity of the (multispecific) antibody of the invention in recombinant production. In a preferred crossover Fab molecule useful for the (multispecific) antibody of the invention, the variable domains of the Fab light chain and the Fab heavy chain (VL and VH, respectively) are exchanged. Even with this domain exchange, however, the preparation of the (multispecific) antibody may comprise certain side products due to a so-called Bence Jones-type interaction between mispaired heavy and light chains (see Schaefer et al, PNAS, 108 (2011) 11187-11191). To further reduce mispairing of heavy and light chains from different Fab molecules and thus increase the purity and yield of the desired (multispecific) antibody, charged amino acids with opposite charges may be introduced at specific amino acid positions in the CH1 and CL domains of either the Fab molecule binding to CD3, or the Fab molecule(s) binding to CD19, as further described herein. Charge modifications are made either in the conventional Fab molecule(s) comprised in the (multispecific) antibody (such as shown e.g. in **Figures 1 A-C, G-J**), or in the VH/VL crossover Fab molecule(s) comprised in the (multispecific) antibody (such as shown e.g. in **Figure 1 D-F, K-N**) (but not in both). In preferred aspects, the charge modifications are made in the conventional Fab molecule(s) comprised in the (multispecific) antibody (which in preferred aspects bind(s) to CD19).

In a preferred aspect according to the invention, the (multispecific) antibody is capable of simultaneous binding to CD3 and CD19. In one aspect, the (multispecific) antibody is capable of crosslinking a T cell and a target cell by simultaneous binding to CD3 and CD19. In an even more preferred aspect, such simultaneous binding results in lysis of the target cell, particularly a CD19-expressing target cell such as a B-cell. In one aspect, such simultaneous binding results in activation of the T cell. In other aspects, such simultaneous binding results in a cellular response of a T lymphocyte, particularly a cytotoxic T lymphocyte, selected from the group of: proliferation, differentiation, cytokine secretion, cytotoxic effector molecule release, cytotoxic activity, and expression of activation markers. In one aspect, binding of the (multispecific) antibody to CD3 without simultaneous binding to CD19 does not result in T cell activation.

In one aspect, the (multispecific) antibody is capable of re-directing cytotoxic activity of a T cell to a target cell. In a preferred aspect, said re-direction is independent of MHC-mediated peptide antigen presentation by the target cell and and/or specificity of the T cell.

Preferably, a T cell according to any of the aspects of the invention is a cytotoxic T cell. In some aspects the T cell is a CD4⁺ or a CD8⁺ T cell, particularly a CD8⁺ T cell.

a) First antigen binding domain

The (multispecific) antibody of the invention comprises at least one antigen binding domain (the first antigen binding domain) that binds to CD3. In preferred aspects, CD3 is human CD3 (SEQ ID NO: 45) or cynomolgus CD3 (SEQ ID NO: 46) most particularly human CD3. In one aspect

5 the first antigen binding domain is cross-reactive for (i.e. specifically binds to) human and cynomolgus CD3. In some aspects, CD3 is the epsilon subunit of CD3 (CD3 epsilon).

In a preferred aspect, the (multispecific) antibody comprises not more than one antigen binding domain that binds to CD3. In one aspect the (multispecific) antibody provides monovalent binding to CD3.

10 In one aspect, the antigen binding domain that binds to CD3 is an antibody fragment selected from the group of an Fv molecule, a scFv molecule, a Fab molecule, and a F(ab')₂ molecule. In a preferred aspect, the antigen binding domain that binds to CD3 is a Fab molecule.

In preferred aspects, the antigen binding domain that binds to CD3 is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CH1 and CL of the Fab heavy and light chains are exchanged / replaced by each other.

15 In such aspects, the antigen binding domain(s) that binds to CD19 is preferably a conventional Fab molecule. In aspects where there is more than one antigen binding domain, particularly Fab molecule, that binds to CD19 comprised in the (multispecific) antibody, the antigen binding domain that binds to CD3 preferably is a crossover Fab molecule and the antigen binding domain

20 that bind to CD19 are conventional Fab molecules.

In alternative aspects, the antigen binding domain that binds to CD3 is a conventional Fab molecule. In such aspects, the antigen binding domain(s) that binds CD19 is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CH1 and CL of the Fab heavy and light chains are exchanged / replaced by each

25 other. In aspects where there is more than one antigen binding domain, particularly Fab molecule, that binds to CD3 comprised in the (multispecific) antibody, the antigen binding domain that binds to CD19 preferably is a crossover Fab molecule and the antigen binding domains that bind to CD3 are conventional Fab molecules.

In preferred aspects, the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1, particularly the variable domains VL and VH, of the Fab light chain and the Fab heavy chain are replaced by each other (i.e. according

30 to such aspect, the first antigen binding domain is a crossover Fab molecule wherein the variable

or constant domains of the Fab light chain and the Fab heavy chain are exchanged). In one such aspect, the second (and the third, if any) antigen binding domain is a conventional Fab molecule. In one aspect, not more than one antigen binding domain that binds to CD3 is present in the (multispecific) antibody (i.e. the antibody provides monovalent binding to CD3).

5

b) Second (and third) antigen binding domain

The (multispecific) antibody of the invention comprises at least one antigen binding domain (the second and optionally the third antigen binding domain), particularly a Fab molecule, that binds to CD19. The second antigen binding domain is able to direct the (multispecific) antibody to a target site, for example to a specific type of cell that expresses CD19.

10 In one aspect, the antigen binding domain that binds to CD19 is an antibody fragment selected from the group of an Fv molecule, a scFv molecule, a Fab molecule, and a F(ab')₂ molecule. In a preferred aspect, the antigen binding domain that binds to CD19 is a Fab molecule.

In certain aspects, the (multispecific) antibody comprises two antigen binding domains, particularly Fab molecules, that bind to CD19. In a preferred aspect, all of these antigen binding
15 domains are identical, i.e. they have the same molecular format (e.g. conventional or crossover Fab molecule) and comprise the same amino acid sequences including the same amino acid substitutions in the CH1 and CL domain as described herein (if any). In one aspect, the (multispecific) antibody comprises not more than two antigen binding domains, particularly Fab molecules, that bind to CD19.

20 In preferred aspects, the antigen binding domain(s) that bind to CD19 is/are a conventional Fab molecule. In such aspects, the antigen binding domain(s) that binds to CD3 is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CH1 and CL of the Fab heavy and light chains are exchanged / replaced by each other.

25 In alternative aspects, the antigen binding domain(s) that bind to CD19 is/are a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CH1 and CL of the Fab heavy and light chains are exchanged / replaced by each other. In such aspects, the antigen binding domain(s) that binds to CD3 is a conventional Fab molecule.

30 In one aspect, the second (and, where present, third) antigen binding domain comprises a human constant region. In one aspect, the second (and, where present, third) antigen binding domain is a Fab molecule comprising a human constant region, particularly a human CH1 and/or CL domain. Exemplary sequences of human constant domains are given in SEQ ID NOs 52 and 53 (human

kappa and lambda CL domains, respectively) and SEQ ID NO: 54 (human IgG₁ heavy chain constant domains CH1-CH2-CH3). In one aspect, the second (and, where present, third) antigen binding domain comprises a light chain constant region comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the amino acid sequence of SEQ ID NO: 52 or SEQ ID NO: 53, particularly the amino acid sequence of SEQ ID NO: 52. Particularly, the light chain constant region may comprise amino acid mutations as described herein under “charge modifications” and/or may comprise deletion or substitutions of one or more (particularly two) N-terminal amino acids if in a crossover Fab molecule. In some aspects, the second (and, where present, third) antigen binding domain comprises a heavy chain constant region comprising an amino acid sequence that is at least about 95%, 96%, 97%, 98%, 99% or 100% identical to the CH1 domain sequence comprised in the amino acid sequence of SEQ ID NO: 54. Particularly, the heavy chain constant region (specifically CH1 domain) may comprise amino acid mutations as described herein under “charge modifications”.

In one aspect, the second (and, where present, the third) antigen binding domain comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 15, a HCDR 2 of SEQ ID NO: 16, and a HCDR 3 of SEQ ID NO: 17, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 19, a LCDR 2 of SEQ ID NO: 20 and a LCDR 3 of SEQ ID NO: 21.

In one aspect, the second (and, where present, third) antigen binding domain is (derived from) a humanized antibody. In one aspect, the second (and, where present, third) antigen binding domain is a humanized antigen binding domain (i.e. an antigen binding domain of a humanized antibody). In one aspect, the VH and/or the VL of the second (and, where present, third) antigen binding domain is a humanized variable region.

In one aspect, the VH and/or the VL of the second (and, where present, third) antigen binding domain comprises an acceptor human framework, e.g. a human immunoglobulin framework or a human consensus framework.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises one or more heavy chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4 sequence) of SEQ ID NO: 18. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 18. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 18. In one

aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 18. In certain aspects, a VH sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD19. In certain aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 18. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 18. Optionally, the VH of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 18, including post-translational modifications of that sequence.

In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises one or more light chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4 sequence) of SEQ ID NO: 22. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 22. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 22. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 22. In certain aspects, a VL sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD19. In certain aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 22. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 22. Optionally, the VL of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 22, including post-translational modifications of that sequence.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to

the amino acid sequence of SEQ ID NO: 18, and the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 22. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 18 and the VL of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 22.

In a further aspect, the second (and, where present, the third) antigen binding domain comprises a VH comprising the sequence of SEQ ID NO: 18 and a VL comprising the sequence of SEQ ID NO: 22.

10 In a further aspect, the second (and, where present, the third) antigen binding domain comprises a VH sequence of SEQ ID NO: 18 and a VL sequence of SEQ ID NO: 22.

In another aspect, the second (and, where present, the third) antigen binding domain comprises a VH comprising the heavy chain CDR sequences of the VH of SEQ ID NO: 18, and a VL comprising the light chain CDR sequences of the VL of SEQ ID NO: 22.

15 In a further aspect, the second (and, where present, the third) antigen binding domain comprises the HCDR1, HCDR2 and HCDR3 amino acid sequences of the VH of SEQ ID NO: 18 and the LCDR1, LCDR2 and LCDR3 amino acid sequences of the VL of SEQ ID NO: 22.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 18 and a framework of at least 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VH of SEQ ID NO: 18. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 18 and a framework of at least 95% sequence identity to the framework sequence of the VH of SEQ ID NO: 18. In another aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 18 and a framework of at least 98% sequence identity to the framework sequence of the VH of SEQ ID NO: 18.

In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 22 and a framework of at least 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VL of SEQ ID NO: 22. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 22 and a framework of at least 95% sequence identity to the framework sequence of the VL of SEQ ID NO: 22. In another aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light

chain CDR sequences of the VL of SEQ ID NO: 22 and a framework of at least 98% sequence identity to the framework sequence of the VL of SEQ ID NO: 22.

In another aspect, the second (and, where present, the third) antigen binding domain comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 28, a HCDR 2 of SEQ ID NO: 29, and a HCDR 3 of SEQ ID NO: 30, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 32, a LCDR 2 of SEQ ID NO: 33 and a LCDR 3 of SEQ ID NO: 34.

In one aspect, the second (and, where present, third) antigen binding domain is (derived from) a humanized antibody. In one aspect, the second (and, where present, third) antigen binding domain is a humanized antigen binding domain (i.e. an antigen binding domain of a humanized antibody). In one aspect, the VH and/or the VL of the second (and, where present, third) antigen binding domain is a humanized variable region.

In one aspect, the VH and/or the VL of the second (and, where present, third) antigen binding domain comprises an acceptor human framework, e.g. a human immunoglobulin framework or a human consensus framework.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises one or more heavy chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4 sequence) of SEQ ID NO: 31. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 31. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 31. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 31. In certain aspects, a VH sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD19. In certain aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 31. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 31. Optionally, the VH of the second (and, where present, the third) antigen binding

domain comprises the amino acid sequence of SEQ ID NO: 31, including post-translational modifications of that sequence.

In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises one or more light chain framework sequence (i.e. the FR1, FR2, FR3 and/or FR4
5 sequence) of SEQ ID NO: 35. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 35. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95% identical to the amino acid sequence of SEQ ID NO: 35. In one aspect,
10 the VL of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 98% identical to the amino acid sequence of SEQ ID NO: 35. In certain aspects, a VL sequence having at least 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an antibody comprising that sequence retains the ability to bind to CD19. In certain
15 aspects, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in the amino acid sequence of SEQ ID NO: 35. In certain aspects, substitutions, insertions, or deletions occur in regions outside the CDRs (i.e., in the FRs). In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 35. Optionally, the VL of the second (and, where present, the third) antigen binding domain comprises
20 the amino acid sequence of SEQ ID NO: 35, including post-translational modifications of that sequence.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 31, and the VL of the second (and, where present, the
25 third) antigen binding domain comprises an amino acid sequence that is at least about 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequence of SEQ ID NO: 35. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 31 and the VL of the second (and, where present, the third) antigen binding domain comprises the amino acid sequence of SEQ ID NO: 35.

30 In a further aspect, the second (and, where present, the third) antigen binding domain comprises a VH comprising the sequence of SEQ ID NO: 31 and a VL comprising the sequence of SEQ ID NO: 35.

In a further aspect, the second (and, where present, the third) antigen binding domain comprises a VH sequence of SEQ ID NO: 31 and a VL sequence of SEQ ID NO: 35.

In another aspect, the second (and, where present, the third) antigen binding domain comprises a VH comprising the heavy chain CDR sequences of the VH of SEQ ID NO: 31, and a VL
5 comprising the light chain CDR sequences of the VL of SEQ ID NO: 35.

In a further aspect, the second (and, where present, the third) antigen binding domain comprises the HCDR1, HCDR2 and HCDR3 amino acid sequences of the VH of SEQ ID NO: 31 and the LCDR1, LCDR2 and LCDR3 amino acid sequences of the VL of SEQ ID NO: 35.

In one aspect, the VH of the second (and, where present, the third) antigen binding domain
10 comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 31 and a framework of at least 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VH of SEQ ID NO: 31. In one aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 31 and a framework of at least 95% sequence identity to the framework sequence of the VH of SEQ ID NO: 31. In
15 another aspect, the VH of the second (and, where present, the third) antigen binding domain comprises the heavy chain CDR sequences of the VH of SEQ ID NO: 31 and a framework of at least 98% sequence identity to the framework sequence of the VH of SEQ ID NO: 31.

In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 35 and a framework of at least
20 95%, 96%, 97%, 98% or 99% sequence identity to the framework sequence of the VL of SEQ ID NO: 35. In one aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light chain CDR sequences of the VL of SEQ ID NO: 35 and a framework of at least 95% sequence identity to the framework sequence of the VL of SEQ ID NO: 35. In another aspect, the VL of the second (and, where present, the third) antigen binding domain comprises the light
25 chain CDR sequences of the VL of SEQ ID NO: 35 and a framework of at least 98% sequence identity to the framework sequence of the VL of SEQ ID NO: 35.

c) Charge modifications

The (multispecific) antibody of the invention may comprise amino acid substitutions in Fab molecules comprised therein which are particularly efficient in reducing mispairing of light chains
30 with non-matching heavy chains (Bence-Jones-type side products), which can occur in the production of Fab-based multispecific antibodies with a VH/VL exchange in one (or more, in case of molecules comprising more than two antigen-binding Fab molecules) of their binding arms (see also PCT publication no. WO 2015/150447, particularly the examples therein, incorporated herein

by reference in its entirety). The ratio of a desired (multispecific) antibody compared to undesired side products, in particular Bence Jones-type side products occurring in multispecific antibodies with a VH/VL domain exchange in one of their binding arms, can be improved by the introduction of charged amino acids with opposite charges at specific amino acid positions in the CH1 and CL domains (sometimes referred to herein as “charge modifications”).

- Accordingly, in some aspects wherein the first and the second (and, where present, the third) antigen binding domain of the (multispecific) antibody are both Fab molecules, and in one of the antigen binding domains (particularly the first antigen binding domain) the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other,
- 10 i) in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted by a positively charged amino acid (numbering according to Kabat), and wherein in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 or the amino acid at position 213 is substituted by a negatively charged amino acid (numbering according to Kabat EU index); or
 - 15 ii) in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted by a positively charged amino acid (numbering according to Kabat), and wherein in the constant domain CH1 of the first antigen binding domain the amino acid at position 147 or the amino acid at position 213 is substituted by a negatively charged amino acid (numbering according to Kabat EU index).
 - 20 The (multispecific) antibody does not comprise both modifications mentioned under i) and ii). The constant domains CL and CH1 of the antigen binding domain having the VH/VL exchange are not replaced by each other (i.e. remain unexchanged).

In a more specific aspect,

- 25 i) in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 or the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index); or
- 30 ii) in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the first antigen binding domain the amino acid at

position 147 or the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In one such aspect, in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 or the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In a further aspect, in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In a preferred aspect, in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat) and the amino acid at position 123 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In a more preferred aspect, in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where present, the third) antigen binding domain the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index).

In an even more preferred aspect, in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by arginine (R) (numbering according to Kabat), and in the constant domain CH1 of the second (and, where

present, the third) antigen binding domain the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index).

In preferred aspects, if amino acid substitutions according to the above aspects are made in the
5 constant domain CL and the constant domain CH1 of the second (and, where present, the third) antigen binding domain, the constant domain CL of the second (and, where present, the third) antigen binding domain is of kappa isotype.

Alternatively, the amino acid substitutions according to the above aspects may be made in the constant domain CL and the constant domain CH1 of the first antigen binding domain instead of
10 in the constant domain CL and the constant domain CH1 of the second (and, where present, the third) antigen binding domain. In preferred such aspects, the constant domain CL of the first antigen binding domain is of kappa isotype.

Accordingly, in one aspect, in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H)
15 (numbering according to Kabat), and in the constant domain CH1 of the first antigen binding domain the amino acid at position 147 or the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).
In a further aspect, in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering
20 according to Kabat), and in the constant domain CH1 of the first antigen binding domain the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

In still another aspect, in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H)
25 (numbering according to Kabat) and the amino acid at position 123 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat), and in the constant domain CH1 of the first antigen binding domain the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic
30 acid (D) (numbering according to Kabat EU index).

In one aspect, in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) (numbering according to Kabat), and in the constant

domain CH1 of the first antigen binding domain the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index).

In another aspect, in the constant domain CL of the first antigen binding domain the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by arginine (R) (numbering according to Kabat), and in the constant domain CH1 of the first antigen binding domain the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index).

- 10 In a preferred aspect, the (multispecific) antibody of the invention comprises
- (a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10, and
- (b) a second and optionally a third antigen binding domain that binds CD19;
- wherein in the constant domain CL of the second (and, where present, the third) antigen binding domain the amino acid at position 124 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat) (in a preferred aspect independently by lysine (K) or arginine (R)) and the amino acid at position 123 is substituted independently by lysine (K), arginine (R) or histidine (H) (numbering according to Kabat) (in a preferred aspect independently by lysine (K) or arginine (R)), and in the constant domain CH1 of the second (and, where present, third) antigen binding domain the amino acid at position 147 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted independently by glutamic acid (E), or aspartic acid (D) (numbering according to Kabat EU index).

30 **d) Multispecific antibody formats**

The (multispecific) antibody according to the present invention can have a variety of configurations. Exemplary configurations are depicted in **Figure 1**.

In preferred aspects, the antigen binding domains comprised in the (multispecific) antibody are Fab molecules. In such aspects, the first, second, third etc. antigen binding domain may be referred to herein as first, second, third etc. Fab molecule, respectively.

In one aspect, the first and the second antigen binding domain of the (multispecific) antibody are fused to each other, optionally via a peptide linker. In preferred aspects, the first and the second antigen binding domain are each a Fab molecule. In one such aspect, the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain. In another such aspect, the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain. In aspects wherein either (i) the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain or (ii) the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain, additionally the Fab light chain of the first antigen binding domain and the Fab light chain of the second antigen binding domain may be fused to each other, optionally via a peptide linker.

A (multispecific) antibody with a single antigen binding domain (such as a Fab molecule) capable of specific binding to a second antigen, e.g. a target cell antigen such as CD19, (for example as shown in **Figure 1A, D, G, H, K, L**) is useful, particularly in cases where internalization of the second antigen is to be expected following binding of a high affinity antigen binding domain. In such cases, the presence of more than one antigen binding domain specific for the second antigen may enhance internalization of the second antigen, thereby reducing its availability.

In other cases, however, it will be advantageous to have a (multispecific) antibody comprising two or more antigen binding domains (such as Fab molecules) specific for a second antigen, e.g. a target cell antigen such as CD19 (see examples shown in **Figure 1B, 1C, 1E, 1F, 1I, 1J, 1M or 1N**), for example to optimize targeting to the target site or to allow crosslinking of target cell antigens.

Accordingly, in preferred aspects, the (multispecific) antibody according to the present invention comprises a third antigen binding domain.

In one aspect, the third antigen binding domain binds to CD19. In one aspect, the third antigen binding domain is a Fab molecule.

In one aspect, the third antigen domain is identical to the second antigen binding domain.

In some aspects, the third and the second antigen binding domain are each a Fab molecule and the third antigen binding domain is identical to the second antigen binding domain. Thus, in these

aspects, the second and the third antigen binding domain comprise the same heavy and light chain amino acid sequences and have the same arrangement of domains (i.e. conventional or crossover). Furthermore, in these aspects, the third antigen binding domain comprises the same amino acid substitutions, if any, as the second antigen binding domain. For example, the amino acid substitutions described herein as “charge modifications” will be made in the constant domain CL and the constant domain CH1 of each of the second antigen binding domain and the third antigen binding domain. Alternatively, said amino acid substitutions may be made in the constant domain CL and the constant domain CH1 of the first antigen binding domain (which in preferred aspects is also a Fab molecule), but not in the constant domain CL and the constant domain CH1 of the second antigen binding domain and the third antigen binding domain.

Like the second antigen binding domain, the third antigen binding domain preferably is a conventional Fab molecule. Aspects wherein the second and the third antigen binding domains are crossover Fab molecules (and the first antigen binding domain is a conventional Fab molecule) are, however, also contemplated. Thus, in preferred aspects, the second and the third antigen binding domains are each a conventional Fab molecule, and the first antigen binding domain is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CL and CH1 of the Fab heavy and light chains are exchanged / replaced by each other. In other aspects, the second and the third antigen binding domains are each a crossover Fab molecule and the first antigen binding domain is a conventional Fab molecule.

If a third antigen binding domain is present, in a preferred aspect the first antigen domain binds to CD3, and the second and third antigen binding domain bind to CD19.

In preferred aspects, the (multispecific) antibody of the invention comprises an Fc domain composed of a first and a second subunit. The first and the second subunit of the Fc domain are capable of stable association.

The (multispecific) antibody according to the invention can have different configurations, i.e. the first, second (and optionally third) antigen binding domain may be fused to each other and to the Fc domain in different ways. The components may be fused to each other directly or, preferably, via one or more suitable peptide linkers. Where fusion of a Fab molecule is to the N-terminus of a subunit of the Fc domain, it is typically via an immunoglobulin hinge region.

In some aspects, the first and the second antigen binding domain are each a Fab molecule and the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain. In such aspects, the second antigen binding domain may be fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy

chain of the first antigen binding domain or to the N-terminus of the other one of the subunits of the Fc domain. In preferred such aspects, the second antigen binding domain is a conventional Fab molecule, and the first antigen binding domain is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CL and CH1 of the Fab heavy and light chains are exchanged / replaced by each other. In other such aspects, the second antigen binding domain is a crossover Fab molecule and the first antigen binding domain is a conventional Fab molecule.

In one aspect, the first and the second antigen binding domain are each a Fab molecule, the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain, and the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain. In a specific aspect, the (multispecific) antibody essentially consists of the first and the second Fab molecule, the Fc domain composed of a first and a second subunit, and optionally one or more peptide linkers, wherein the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first Fab molecule, and the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain. Such a configuration is schematically depicted in **Figures 1G** and **1K** (with the first antigen binding domain in these examples being a VH/VL crossover Fab molecule). Optionally, the Fab light chain of the first Fab molecule and the Fab light chain of the second Fab molecule may additionally be fused to each other.

In another aspect, the first and the second antigen binding domain are each a Fab molecule and the first and the second antigen binding domain are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain. In a specific aspect, the (multispecific) antibody essentially consists of the first and the second Fab molecule, the Fc domain composed of a first and a second subunit, and optionally one or more peptide linkers, wherein the first and the second Fab molecule are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain. Such a configuration is schematically depicted in **Figures 1A** and **1D** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second antigen binding domain being a conventional Fab molecule). The first and the second Fab molecule may be fused to the Fc domain directly or through a peptide linker. In a preferred aspect the first and the second Fab molecule are each fused to the Fc domain through an immunoglobulin hinge region. In a specific aspect, the

immunoglobulin hinge region is a human IgG₁ hinge region, particularly where the Fc domain is an IgG₁ Fc domain.

In some aspects, the first and the second antigen binding domain are each a Fab molecule and the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain. In such aspects, the first antigen binding domain may be fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain or (as described above) to the N-terminus of the other one of the subunits of the Fc domain. In preferred such aspects, said second antigen binding domain is a conventional Fab molecule, and the first antigen binding domain is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CL and CH1 of the Fab heavy and light chains are exchanged / replaced by each other. In other such aspects, said second antigen binding domain is a crossover Fab molecule and the first antigen binding domain is a conventional Fab molecule.

In one aspect, the first and the second antigen binding domain are each a Fab molecule, the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain, and the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain. In a specific aspect, the (multispecific) antibody essentially consists of the first and the second Fab molecule, the Fc domain composed of a first and a second subunit, and optionally one or more peptide linkers, wherein the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule, and the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or the second subunit of the Fc domain. Such a configuration is schematically depicted in **Figures 1H** and **1L** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second antigen binding domain being a conventional Fab molecule). Optionally, the Fab light chain of the first Fab molecule and the Fab light chain of the second Fab molecule may additionally be fused to each other.

In some aspects, a third antigen binding domain, particularly a third Fab molecule, is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first or second subunit of the Fc domain. In preferred such aspects, said second and third antigen binding domains are each a conventional Fab molecule, and the first antigen binding domain is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CL and CH1 of the Fab heavy and light chains are exchanged / replaced by each other. In other such

aspects, said second and third antigen binding domains are each a crossover Fab molecule and the first antigen binding domain is a conventional Fab molecule.

In a preferred such aspect, the first and the third antigen binding domain are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain, and the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first Fab molecule. In a specific aspect, the (multispecific) antibody essentially consists of the first, the second and the third Fab molecule, the Fc domain composed of a first and a second subunit, and optionally one or more peptide linkers, wherein the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first Fab molecule, and the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first subunit of the Fc domain, and wherein the third Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the second subunit of the Fc domain. Such a configuration is schematically depicted in **Figure 1B** and **1E** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule, and the second and the third antigen binding domain being a conventional Fab molecule), and **Figure 1J** and **1N** (in these examples with the first antigen binding domain being a conventional Fab molecule, and the second and the third antigen binding domain being a VH/VL crossover Fab molecule). The first and the third Fab molecule may be fused to the Fc domain directly or through a peptide linker. In a preferred aspect, the first and the third Fab molecule are each fused to the Fc domain through an immunoglobulin hinge region. In a specific aspect, the immunoglobulin hinge region is a human IgG₁ hinge region, particularly where the Fc domain is an IgG₁ Fc domain. Optionally, the Fab light chain of the first Fab molecule and the Fab light chain of the second Fab molecule may additionally be fused to each other.

In another such aspect, the second and the third antigen binding domain are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain, and the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain. In a specific aspect, the (multispecific) antibody essentially consists of the first, the second and the third Fab molecule, the Fc domain composed of a first and a second subunit, and optionally one or more peptide linkers, wherein the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule, and the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the first subunit of the Fc domain, and wherein the third Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus

of the second subunit of the Fc domain. Such a configuration is schematically depicted in **Figure 1C** and **1F** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule, and the second and the third antigen binding domain being a conventional Fab molecule) and in **Figure 1I** and **1M** (in these examples with the first antigen binding domain being a conventional Fab molecule, and the second and the third antigen binding domain being a VH/VL crossover Fab molecule). The second and the third Fab molecule may be fused to the Fc domain directly or through a peptide linker. In a preferred aspect the second and the third Fab molecule are each fused to the Fc domain through an immunoglobulin hinge region. In a specific aspect, the immunoglobulin hinge region is a human IgG₁ hinge region, particularly where the Fc domain is an IgG₁ Fc domain. Optionally, the Fab light chain of the first Fab molecule and the Fab light chain of the second Fab molecule may additionally be fused to each other.

In configurations of the (multispecific) antibody wherein a Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of each of the subunits of the Fc domain through an immunoglobulin hinge region, the two Fab molecules, the hinge regions and the Fc domain essentially form an immunoglobulin molecule. In a preferred aspect the immunoglobulin molecule is an IgG class immunoglobulin. In an even more preferred aspect the immunoglobulin is an IgG₁ subclass immunoglobulin. In another aspect the immunoglobulin is an IgG₄ subclass immunoglobulin. In a further preferred aspect the immunoglobulin is a human immunoglobulin. In other aspects the immunoglobulin is a chimeric immunoglobulin or a humanized immunoglobulin. In one aspect, the immunoglobulin comprises a human constant region, particularly a human Fc region.

In some of the (multispecific) antibodies of the invention, the Fab light chain of the first Fab molecule and the Fab light chain of the second Fab molecule are fused to each other, optionally via a peptide linker. Depending on the configuration of the first and the second Fab molecule, the Fab light chain of the first Fab molecule may be fused at its C-terminus to the N-terminus of the Fab light chain of the second Fab molecule, or the Fab light chain of the second Fab molecule may be fused at its C-terminus to the N-terminus of the Fab light chain of the first Fab molecule. Fusion of the Fab light chains of the first and the second Fab molecule further reduces mispairing of unmatched Fab heavy and light chains, and also reduces the number of plasmids needed for expression of some of the (multispecific) antibody of the invention.

The antigen binding domains may be fused to the Fc domain or to each other directly or through a peptide linker, comprising one or more amino acids, typically about 2-20 amino acids. Peptide linkers are known in the art and are described herein. Suitable, non-immunogenic peptide linkers

include, for example, $(G_4S)_n$, $(SG_4)_n$, $(G_4S)_n$, $G_4(SG_4)_n$ or $(G_4S)_nG_5$ peptide linkers. "n" is generally an integer from 1 to 10, typically from 2 to 4. In one aspect said peptide linker has a length of at least 5 amino acids, in one aspect a length of 5 to 100, in a further aspect of 10 to 50 amino acids. In one aspect said peptide linker is $(G_xS)_n$ or $(G_xS)_nG_m$ with G=glycine, S=serine, and ($x=3$, $n=3$, 4, 5 or 6, and $m=0$, 1, 2 or 3) or ($x=4$, $n=1$, 2, 3, 4 or 5 and $m=0$, 1, 2, 3, 4 or 5), in one aspect $x=4$ and $n=2$ or 3, in a further aspect $x=4$ and $n=2$, in yet a further aspect $x=4$, $n=1$ and $m=5$. In one aspect said peptide linker is $(G_4S)_2$. In another aspect, said peptide linker is G_4SG_5 . A particularly suitable peptide linker for fusing the Fab light chains of the first and the second Fab molecule to each other is $(G_4S)_2$. An exemplary peptide linker suitable for connecting the Fab heavy chains of the first and the second Fab fragments comprises the sequence (D)- $(G_4S)_2$ (SEQ ID NOs 48 and 49). Another particularly suitable such linker comprises the sequence (D)- G_4SG_5 (SEQ ID NOs 50 and 51). Additionally, linkers may comprise (a portion of) an immunoglobulin hinge region. Particularly where a Fab molecule is fused to the N-terminus of an Fc domain subunit, it may be fused via an immunoglobulin hinge region or a portion thereof, with or without an additional peptide linker.

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit ($VL_{(1)}-CH1_{(1)}-CH2-CH3(-CH4)$), and a polypeptide wherein the Fab heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond with an Fc domain subunit ($VH_{(2)}-CH1_{(2)}-CH2-CH3(-CH4)$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule ($VH_{(1)}-CL_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$). In certain aspects the polypeptides are covalently linked, e.g., by a disulfide bond.

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit ($VH_{(1)}-CL_{(1)}-CH2-CH3(-CH4)$), and a polypeptide wherein the Fab

heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond with an Fc domain subunit ($VH_{(2)}-CH1_{(2)}-CH2-CH3(-CH4)$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule ($VL_{(1)}-CH1_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$). In certain aspects the polypeptides are covalently linked, e.g., by a disulfide bond.

In some aspects, the (multispecific) antibody comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit ($VL_{(1)}-CH1_{(1)}-VH_{(2)}-CH1_{(2)}-CH2-CH3(-CH4)$). In other aspects, the (multispecific) antibody comprises a polypeptide wherein the Fab heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain variable region of the first Fab molecule which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit ($VH_{(2)}-CH1_{(2)}-VL_{(1)}-CH1_{(1)}-CH2-CH3(-CH4)$). In some of these aspects the (multispecific) antibody further comprises a crossover Fab light chain polypeptide of the first Fab molecule, wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule ($VH_{(1)}-CL_{(1)}$), and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$). In others of these aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule which in turn shares a carboxy-terminal peptide bond with the Fab light chain polypeptide of the second Fab molecule ($VH_{(1)}-CL_{(1)}-VL_{(2)}-CL_{(2)}$), or a polypeptide wherein the Fab light chain polypeptide of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the first Fab molecule which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule ($VL_{(2)}-CL_{(2)}-VH_{(1)}-CL_{(1)}$), as appropriate. The (multispecific) antibody according to these aspects may further comprise (i) an Fc domain subunit polypeptide ($CH2-CH3(-CH4)$), or (ii) a polypeptide

wherein the Fab heavy chain of a third Fab molecule shares a carboxy-terminal peptide bond with an Fc domain subunit (VH₍₃₎-CH1₍₃₎-CH2-CH3(-CH4)) and the Fab light chain polypeptide of a third Fab molecule (VL₍₃₎-CL₍₃₎). In certain aspects the polypeptides are covalently linked, e.g., by a disulfide bond.

- 5 In some aspects, the (multispecific) antibody comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the
- 10 second Fab molecule, which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit (VH₍₁₎-CL₍₁₎-VH₍₂₎-CH1₍₂₎-CH2-CH3(-CH4)). In other aspects, the (multispecific) antibody comprises a polypeptide wherein the Fab heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the first Fab molecule which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of
- 15 the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with an Fc domain subunit (VH₍₂₎-CH1₍₂₎-VH₍₁₎-CL₍₁₎-CH2-CH3(-CH4)). In some of these aspects the (multispecific) antibody further comprises a crossover Fab light chain polypeptide of the first Fab molecule, wherein the Fab light chain variable region
- 20 of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (VL₍₁₎-CH1₍₁₎), and the Fab light chain polypeptide of the second Fab molecule (VL₍₂₎-CL₍₂₎). In others of these aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab
- 25 molecule which in turn shares a carboxy-terminal peptide bond with the Fab light chain polypeptide of the second Fab molecule (VL₍₁₎-CH1₍₁₎-VL₍₂₎-CL₍₂₎), or a polypeptide wherein the Fab light chain polypeptide of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the first Fab molecule which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (VL₍₂₎-
- 30 CL₍₂₎-VH₍₁₎-CL₍₁₎), as appropriate. The (multispecific) antibody according to these aspects may further comprise (i) an Fc domain subunit polypeptide (CH2-CH3(-CH4)), or (ii) a polypeptide wherein the Fab heavy chain of a third Fab molecule shares a carboxy-terminal peptide bond with an Fc domain subunit (VH₍₃₎-CH1₍₃₎-CH2-CH3(-CH4)) and the Fab light chain polypeptide of a

third Fab molecule (VL₍₃₎-CL₍₃₎). In certain aspects the polypeptides are covalently linked, e.g., by a disulfide bond.

In certain aspects, the (multispecific) antibody does not comprise an Fc domain. In preferred such aspects, said second and, if present, third antigen binding domains are each a conventional Fab molecule, and the first antigen binding domain is a crossover Fab molecule as described herein, i.e. a Fab molecule wherein the variable domains VH and VL or the constant domains CL and CH1 of the Fab heavy and light chains are exchanged / replaced by each other. In other such aspects, said second and, if present, third antigen binding domains are each a crossover Fab molecule and the first antigen binding domain is a conventional Fab molecule.

10 In one such aspect, the (multispecific) antibody essentially consists of the first and the second antigen binding domain, and optionally one or more peptide linkers, wherein the first and the second antigen binding domain are both Fab molecules and the second antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain. Such a configuration is schematically depicted in **Figures 1O** and
15 **1S** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second antigen binding domain being a conventional Fab molecule).

In another such aspect, the (multispecific) antibody essentially consists of the first and the second antigen binding domain, and optionally one or more peptide linkers, wherein the first and the second antigen binding domain are both Fab molecules and the first antigen binding domain is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain. Such a configuration is schematically depicted in **Figures 1P** and
20 **1T** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second antigen binding domain being a conventional Fab molecule).

In some aspects, the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first Fab molecule, and the (multispecific) antibody further comprises a third antigen binding domain, particularly a third Fab molecule, wherein said third Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule. In certain such aspects, the (multispecific) antibody essentially consists of the first, the second and the third Fab molecule, and optionally one or more peptide linkers, wherein the second Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first Fab molecule, and the third Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule. Such a configuration is schematically depicted in **Figures 1Q** and **1U** (in
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these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second and the third antigen binding domain each being a conventional Fab molecule), or **Figures 1X** and **1Z** (in these examples with the first antigen binding domain being a conventional Fab molecule and the second and the third antigen binding domain each being a VH/VL crossover Fab molecule).

In some aspects, the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule, and the (multispecific) antibody further comprises a third antigen binding domain, particularly a third Fab molecule, wherein said third Fab molecule is fused at the N-terminus of the Fab heavy chain to the C-terminus of the Fab heavy chain of the second Fab molecule. In certain such aspects, the (multispecific) antibody essentially consists of the first, the second and the third Fab molecule, and optionally one or more peptide linkers, wherein the first Fab molecule is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second Fab molecule, and the third Fab molecule is fused at the N-terminus of the Fab heavy chain to the C-terminus of the Fab heavy chain of the second Fab molecule. Such a configuration is schematically depicted in **Figures 1R** and **1V** (in these examples with the first antigen binding domain being a VH/VL crossover Fab molecule and the second and the third antigen binding domain each being a conventional Fab molecule), or **Figures 1W** and **1Y** (in these examples with the first antigen binding domain being a conventional Fab molecule and the second and the third antigen binding domain each being a VH/VL crossover Fab molecule).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain variable region of the first Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region) ($VH_{(2)}-CH1_{(2)}-VL_{(1)}-CH1_{(1)}$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule ($VH_{(1)}-CL_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab

molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule ($VL_{(1)}-CH1_{(1)}-VH_{(2)}-CH1_{(2)}$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable
5 region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule ($VH_{(1)}-CL_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of the second Fab molecule shares a carboxy-terminal peptide bond
10 with the Fab heavy chain variable region of the first Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region) ($VH_{(2)}-CH1_{(2)}-VH_{(1)}-CL_{(1)}$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable
15 region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule ($VL_{(1)}-CH1_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal
20 peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule ($VH_{(1)}-CL_{(1)}-VH_{(2)}-CH1_{(2)}$). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable
25 region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule ($VL_{(1)}-CH1_{(1)}$) and the Fab light chain polypeptide of the second Fab molecule ($VL_{(2)}-CL_{(2)}$).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of a third Fab molecule shares a carboxy-terminal peptide bond with
30 the Fab heavy chain of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab light chain variable region of the first Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain

variable region is replaced by a light chain variable region) (VH₍₃₎-CH1₍₃₎-VH₍₂₎-CH1₍₂₎-VL₍₁₎-CH1₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (VH₍₁₎-CL₍₁₎) and the Fab light chain polypeptide of the second Fab molecule (VL₍₂₎-CL₍₂₎). In some aspects the (multispecific) antibody further comprises the Fab light chain polypeptide of a third Fab molecule (VL₍₃₎-CL₍₃₎). In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the first Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region) (VH₍₃₎-CH1₍₃₎-VH₍₂₎-CH1₍₂₎-VH₍₁₎-CL₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (VL₍₁₎-CH1₍₁₎) and the Fab light chain polypeptide of the second Fab molecule (VL₍₂₎-CL₍₂₎). In some aspects the (multispecific) antibody further comprises the Fab light chain polypeptide of a third Fab molecule (VL₍₃₎-CL₍₃₎). In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (i.e. the first Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of a third Fab molecule (VL₍₁₎-CH1₍₁₎-VH₍₂₎-CH1₍₂₎-VH₍₃₎-CH1₍₃₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (VH₍₁₎-CL₍₁₎) and the Fab light chain polypeptide of the second Fab molecule (VL₍₂₎-CL₍₂₎). In some aspects the (multispecific) antibody further comprises the Fab light chain polypeptide of a third Fab molecule (VL₍₃₎-CL₍₃₎). In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the first Fab molecule (i.e. the first Fab

molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of a third Fab molecule (VH₍₁₎-CL₍₁₎-VH₍₂₎-CH1₍₂₎-VH₍₃₎-CH1₍₃₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the first Fab molecule (VL₍₁₎-CH1₍₁₎) and the Fab light chain polypeptide of the second Fab molecule (VL₍₂₎-CL₍₂₎). In some aspects the (multispecific) antibody further comprises the Fab light chain polypeptide of a third Fab molecule (VL₍₃₎-CL₍₃₎).

10 In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain variable region of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the second Fab molecule (i.e. the second Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable

15 region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab light chain variable region of a third Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of a third Fab molecule (i.e. the third Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region) (VH₍₁₎-CH1₍₁₎-VL₍₂₎-CH1₍₂₎-VL₍₃₎-CH1₍₃₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the second Fab molecule (VH₍₂₎-CL₍₂₎) and the Fab light chain polypeptide of the first Fab molecule (VL₍₁₎-CL₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable

25 region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of a third Fab molecule (VH₍₃₎-CL₍₃₎).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain of the first Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab light chain constant region of the second Fab molecule (i.e. the second Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of a third Fab molecule, which in turn shares a

30

carboxy-terminal peptide bond with the Fab light chain constant region of a third Fab molecule (i.e. the third Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region) (VH₍₁₎-CH1₍₁₎-VH₍₂₎-CL₍₂₎-VH₍₃₎-CL₍₃₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the second Fab molecule (VL₍₂₎-CH1₍₂₎) and the Fab light chain polypeptide of the first Fab molecule (VL₍₁₎-CL₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of a third Fab molecule (VL₍₃₎-CH1₍₃₎).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab light chain variable region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of a third Fab molecule (i.e. the third Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab light chain variable region of the second Fab molecule, which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the second Fab molecule (i.e. the second Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain variable region is replaced by a light chain variable region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the first Fab molecule (VL₍₃₎-CH1₍₃₎-VL₍₂₎-CH1₍₂₎-VH₍₁₎-CH1₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of the second Fab molecule (VH₍₂₎-CL₍₂₎) and the Fab light chain polypeptide of the first Fab molecule (VL₍₁₎-CL₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab heavy chain variable region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of a third Fab molecule (VH₍₃₎-CL₍₃₎).

In certain aspects the (multispecific) antibody according to the invention comprises a polypeptide wherein the Fab heavy chain variable region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab light chain constant region of a third Fab molecule (i.e. the third Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain variable region of the second Fab molecule, which in turn shares a

carboxy-terminal peptide bond with the Fab light chain constant region of the second Fab molecule (i.e. the second Fab molecule comprises a crossover Fab heavy chain, wherein the heavy chain constant region is replaced by a light chain constant region), which in turn shares a carboxy-terminal peptide bond with the Fab heavy chain of the first Fab molecule (VH₍₃₎-CL₍₃₎-VH₍₂₎-CL₍₂₎-VH₍₁₎-CH1₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of the second Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of the second Fab molecule (VL₍₂₎-CH1₍₂₎) and the Fab light chain polypeptide of the first Fab molecule (VL₍₁₎-CL₍₁₎). In some aspects the (multispecific) antibody further comprises a polypeptide wherein the Fab light chain variable region of a third Fab molecule shares a carboxy-terminal peptide bond with the Fab heavy chain constant region of a third Fab molecule (VL₍₃₎-CH1₍₃₎).

In one aspect, the invention provides a (multispecific) antibody comprising

- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1 of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- b) a second antigen binding domain that binds to CD19, wherein the second antigen binding domain is a (conventional) Fab molecule;
- c) an Fc domain composed of a first and a second subunit;

wherein

- (i) the first antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain under b), and the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c), or
- (ii) the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

In a preferred aspect, the invention provides a (multispecific) antibody comprising

- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1 of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- b) a second and a third antigen binding domain that bind to CD19, wherein the second and the third antigen binding domain are each a (conventional) Fab molecule; and
- 10 c) an Fc domain composed of a first and a second subunit;
- wherein
- (i) the first antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain under b), and the second antigen binding domain under b) and the third antigen binding domain under b) are each
- 15 fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c), or
- (ii) the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at
- 20 the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

In another aspect, the invention provides a (multispecific) antibody comprising

- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH or the constant domains CL and CH1 of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- 25 b) a second antigen binding domain that binds to CD19, wherein the second antigen binding domain is a (conventional) Fab molecule;
- c) an Fc domain composed of a first and a second subunit;
- 30 wherein

(i) the first antigen binding domain under a) and the second antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

In all of the different configurations of the (multispecific) antibody according to the invention, the amino acid substitutions ("charge modifications") described herein, if present, may either be in the CH1 and CL domains of the second and (if present) the third antigen binding domain/Fab molecule, or in the CH1 and CL domains of the first antigen binding domain/Fab molecule. Preferably, they are in the CH1 and CL domains of the second and (if present) the third antigen binding domain/Fab molecule. In accordance with the concept of the invention, if amino acid substitutions as described herein are made in the second (and, if present, the third) antigen binding domain/Fab molecule, no such amino acid substitutions are made in the first antigen binding domain/Fab molecule. Conversely, if amino acid substitutions as described herein are made in the first antigen binding domain/Fab molecule, no such amino acid substitutions are made in the second (and, if present, the third) antigen binding domain/Fab molecule. Amino acid substitutions are preferably made in (multispecific) antibodies comprising a Fab molecule wherein the variable domains VL and VH1 of the Fab light chain and the Fab heavy chain are replaced by each other.

In preferred aspects of the (multispecific) antibody according to the invention, particularly wherein amino acid substitutions as described herein are made in the second (and, if present, the third) antigen binding domain/Fab molecule, the constant domain CL of the second (and, if present, the third) Fab molecule is of kappa isotype. In other aspects of the (multispecific) antibody according to the invention, particularly wherein amino acid substitutions as described herein are made in the first antigen binding domain/Fab molecule, the constant domain CL of the first antigen binding domain/Fab molecule is of kappa isotype. In some aspects, the constant domain CL of the second (and, if present, the third) antigen binding domain/Fab molecule and the constant domain CL of the first antigen binding domain/Fab molecule are of kappa isotype.

In one aspect, the invention provides a (multispecific) antibody comprising
a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a

- light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- b) a second antigen binding domain that binds to CD19, wherein the second antigen binding domain is a (conventional) Fab molecule;
- 5 c) an Fc domain composed of a first and a second subunit;
- wherein in the constant domain CL of the second antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat) (most preferably by arginine (R)), and wherein in the constant domain CH1 of the second antigen binding
- 10 domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index); and
- wherein
- (i) the first antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to
- 15 the N-terminus of the Fab heavy chain of the second antigen binding domain under b), and the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c), or
- (ii) the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first
- 20 antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

- In a preferred aspect, the invention provides a (multispecific) antibody comprising
- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy
- 25 chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- 30 b) a second and a third antigen binding domain that bind to CD19, wherein the second and third antigen binding domain are each a (conventional) Fab molecule; and
- c) an Fc domain composed of a first and a second subunit;

- wherein in the constant domain CL of the second antigen binding domain under b) and the third antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat) (most preferably by arginine (R)), and wherein in the
- 5 constant domain CH1 of the second antigen binding domain under b) and the third antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index); and
- wherein
- 10 (i) the first antigen binding domain under a) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the second antigen binding domain under b), and the second antigen binding domain under b) and the third antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c), or
- 15 (ii) the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).
- 20 In another aspect, the invention provides a (multispecific) antibody comprising
- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ
- 25 ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- b) a second antigen binding domain that binds to CD19, wherein the second antigen binding domain is a (conventional) Fab molecule;
- 30 c) an Fc domain composed of a first and a second subunit;
- wherein in the constant domain CL of the second antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat) (most

preferably by arginine (R)), and wherein in the constant domain CH1 of the second antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index); and

- 5 wherein the first antigen binding domain under a) and the second antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

According to any of the above aspects, components of the (multispecific) antibody (e.g. Fab molecules, Fc domain) may be fused directly or through various linkers, particularly peptide
10 linkers comprising one or more amino acids, typically about 2-20 amino acids, that are described herein or are known in the art. Suitable, non-immunogenic peptide linkers include, for example, $(G_4S)_n$, $(SG_4)_n$, $(G_4S)_n$, $G_4(SG_4)_n$ or $(G_4S)_nG_5$ peptide linkers, wherein n is generally an integer from 1 to 10, typically from 2 to 4.

In a preferred aspect, the invention provides a (multispecific) antibody comprising

- 15 a) a first antigen binding domain that binds CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain
20 complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;
- b) a second and a third antigen binding domain that bind to CD19, wherein the second and the third antigen binding domain are each a (conventional) Fab molecule, and comprise a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of
25 SEQ ID NO: 15, a HCDR 2 of SEQ ID NO: 16, and a HCDR 3 of SEQ ID NO: 17, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 19, a LCDR 2 of SEQ ID NO: 20 and a LCDR 3 of SEQ ID NO: 21;
- c) an Fc domain composed of a first and a second subunit;
- wherein
- 30 in the constant domain CL of the second and the third antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat)

(most preferably by arginine (R)), and wherein in the constant domain CH1 of the second and the third antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index);

5 and wherein further

the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain
10 under c).

In a further preferred aspect, the invention provides a (multispecific) antibody comprising

a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 7 and a light chain variable region comprising the amino acid
15 sequence of SEQ ID NO: 11;

b) a second and a third antigen binding domain that bind to CD19, wherein the second and the third antigen binding domain are each a (conventional) Fab molecule, and comprise a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 18 and a light chain variable
20 region comprising the amino acid sequence of SEQ ID NO: 22;

c) an Fc domain composed of a first and a second subunit;

wherein

in the constant domain CL of the second and the third antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat)
25 (most preferably by arginine (R)), and wherein in the constant domain CH1 of the second and the third antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index);

30 and wherein further

the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at

the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

In a further preferred aspect, the invention provides a (multispecific) antibody comprising

a) a first antigen binding domain that binds CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 2, a HCDR 2 of SEQ ID NO: 3, and a HCDR 3 of SEQ ID NO: 5, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 8, a LCDR 2 of SEQ ID NO: 9 and a LCDR 3 of SEQ ID NO: 10;

b) a second and a third antigen binding domain that bind to CD19, wherein the second and the third antigen binding domain are each a (conventional) Fab molecule, and comprise a heavy chain variable region (VH) comprising a heavy chain complementary determining region (HCDR) 1 of SEQ ID NO: 28, a HCDR 2 of SEQ ID NO: 29, and a HCDR 3 of SEQ ID NO: 30, and a light chain variable region (VL) comprising a light chain complementarity determining region (LCDR) 1 of SEQ ID NO: 32, a LCDR 2 of SEQ ID NO: 33 and a LCDR 3 of SEQ ID NO: 34;

c) an Fc domain composed of a first and a second subunit;

wherein

in the constant domain CL of the second and the third antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat) (most preferably by arginine (R)), and wherein in the constant domain CH1 of the second and the third antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index);

and wherein further

the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).

In a yet further preferred aspect, the invention provides a (multispecific) antibody comprising

- a) a first antigen binding domain that binds to CD3, wherein the first antigen binding domain is a Fab molecule wherein the variable domains VL and VH of the Fab light chain and the Fab heavy chain are replaced by each other, and comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 7 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 11;
- b) a second and a third antigen binding domain that bind to CD19, wherein the second and the third antigen binding domain are each a (conventional) Fab molecule, and comprise a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 31 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 35;
- c) an Fc domain composed of a first and a second subunit;
- wherein
- in the constant domain CL of the second and the third antigen binding domain under b) the amino acid at position 124 is substituted by lysine (K) (numbering according to Kabat) and the amino acid at position 123 is substituted by lysine (K) or arginine (R) (numbering according to Kabat) (most preferably by arginine (R)), and wherein in the constant domain CH1 of the second and the third antigen binding domain under b) the amino acid at position 147 is substituted by glutamic acid (E) (numbering according to Kabat EU index) and the amino acid at position 213 is substituted by glutamic acid (E) (numbering according to Kabat EU index);
- and wherein further
- the second antigen binding domain under b) is fused at the C-terminus of the Fab heavy chain to the N-terminus of the Fab heavy chain of the first antigen binding domain under a), and the first antigen binding domain under a) and the third antigen binding domain under b) are each fused at the C-terminus of the Fab heavy chain to the N-terminus of one of the subunits of the Fc domain under c).
- In one aspect according to these aspects of the invention, in the first subunit of the Fc domain the threonine residue at position 366 is replaced with a tryptophan residue (T366W), and in the second subunit of the Fc domain the tyrosine residue at position 407 is replaced with a valine residue (Y407V) and optionally the threonine residue at position 366 is replaced with a serine residue (T366S) and the leucine residue at position 368 is replaced with an alanine residue (L368A) (numberings according to Kabat EU index).
- In a further aspect according to these aspects of the invention, in the first subunit of the Fc domain additionally the serine residue at position 354 is replaced with a cysteine residue (S354C) or the glutamic acid residue at position 356 is replaced with a cysteine residue (E356C) (particularly the

serine residue at position 354 is replaced with a cysteine residue), and in the second subunit of the Fc domain additionally the tyrosine residue at position 349 is replaced by a cysteine residue (Y349C) (numberings according to Kabat EU index).

In still a further aspect according to these aspects of the invention, in each of the first and the second subunit of the Fc domain the leucine residue at position 234 is replaced with an alanine residue (L234A), the leucine residue at position 235 is replaced with an alanine residue (L235A) and the proline residue at position 329 is replaced by a glycine residue (P329G) (numbering according to Kabat EU index).

In still a further aspect according to these aspects of the invention, the Fc domain is a human IgG₁ Fc domain.

In a preferred specific aspect, the (multispecific) antibody comprises a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 23 or SEQ ID NO: 39 (particularly SEQ ID NO: 39), a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 24, a polypeptide (particularly two polypeptides) comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 25, and a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 27. In a further preferred specific aspect, the (multispecific) antibody comprises a polypeptide comprising the amino acid sequence of SEQ ID NO: 23 or SEQ ID NO: 39 (particularly SEQ ID NO: 39), a polypeptide comprising the amino acid sequence of SEQ ID NO: 24, a polypeptide (particularly two polypeptides) comprising the amino acid sequence of SEQ ID NO: 25 and a polypeptide comprising the amino acid sequence of SEQ ID NO: 27.

In one aspect the invention provides a (multispecific) antibody that binds to CD3 and CD19, comprising a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 23 or SEQ ID NO: 39 (particularly SEQ ID NO: 39), a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 24, a polypeptide (particularly two polypeptides) comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 25, and a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 27. In one aspect the invention provides a (multispecific) antibody that binds to CD3 and CD19, comprising a polypeptide comprising the amino acid sequence of SEQ ID NO: 23 or SEQ ID NO: 39

(particularly SEQ ID NO: 39), a polypeptide comprising the amino acid sequence of SEQ ID NO: 24, a polypeptide (particularly two polypeptides) comprising the amino acid sequence of SEQ ID NO: 25 and a polypeptide comprising the amino acid sequence of SEQ ID NO: 27.

In a preferred specific aspect, the (multispecific) antibody comprises a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 36 or SEQ ID NO: 40 (particularly SEQ ID NO: 36), a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 37, a polypeptide (particularly two polypeptides) comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 38, and a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 27. In a further preferred specific aspect, the (multispecific) antibody comprises a polypeptide comprising the amino acid sequence of SEQ ID NO: 36 or SEQ ID NO: 40 (particularly SEQ ID NO: 36), a polypeptide comprising the amino acid sequence of SEQ ID NO: 37, a polypeptide (particularly two polypeptides) comprising the amino acid sequence of SEQ ID NO: 38 and a polypeptide comprising the amino acid sequence of SEQ ID NO: 27.

In one aspect the invention provides a (multispecific) antibody that binds to CD3 and CD19, comprising a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 36 or SEQ ID NO: 40 (particularly SEQ ID NO: 36), a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 37, a polypeptide (particularly two polypeptides) comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 38, and a polypeptide comprising an amino acid sequence that is at least 95%, 96%, 97%, 98%, or 99% identical to the sequence of SEQ ID NO: 27. In one aspect the invention provides a (multispecific) antibody that binds to CD3 and CD19, comprising a polypeptide comprising the amino acid sequence of SEQ ID NO: 36 or SEQ ID NO: 40 (particularly SEQ ID NO: 36), a polypeptide comprising the amino acid sequence of SEQ ID NO: 37, a polypeptide (particularly two polypeptides) comprising the amino acid sequence of SEQ ID NO: 38 and a polypeptide comprising the amino acid sequence of SEQ ID NO: 27.

8. *Fc domain variants*

In preferred aspects, the (multispecific) antibody of the invention comprises an Fc domain composed of a first and a second subunit.

- The Fc domain of the (multispecific) antibody consists of a pair of polypeptide chains comprising heavy chain domains of an immunoglobulin molecule. For example, the Fc domain of an immunoglobulin G (IgG) molecule is a dimer, each subunit of which comprises the CH2 and CH3 IgG heavy chain constant domains. The two subunits of the Fc domain are capable of stable association with each other. In one aspect, the (multispecific) antibody of the invention comprises not more than one Fc domain.
- 10 In one aspect, the Fc domain of the (multispecific) antibody is an IgG Fc domain. In a preferred aspect, the Fc domain is an IgG₁ Fc domain. In another aspect the Fc domain is an IgG₄ Fc domain. In a more specific aspect, the Fc domain is an IgG₄ Fc domain comprising an amino acid substitution at position S228 (Kabat EU index numbering), particularly the amino acid substitution S228P. This amino acid substitution reduces *in vivo* Fab arm exchange of IgG₄ antibodies (see
- 15 Stubenrauch et al., Drug Metabolism and Disposition 38, 84-91 (2010)). In a further preferred aspect, the Fc domain is a human Fc domain. In an even more preferred aspect, the Fc domain is a human IgG₁ Fc domain. An exemplary sequence of a human IgG₁ Fc region is given in SEQ ID NO: 47.

a) Fc domain modifications promoting heterodimerization

- 20 (Multispecific) antibodies according to the invention comprise different antigen binding domains, which may be fused to one or the other of the two subunits of the Fc domain, thus the two subunits of the Fc domain are typically comprised in two non-identical polypeptide chains. Recombinant co-expression of these polypeptides and subsequent dimerization leads to several possible combinations of the two polypeptides. To improve the yield and purity of (multispecific)
- 25 antibodies in recombinant production, it will thus be advantageous to introduce in the Fc domain of the (multispecific) antibody a modification promoting the association of the desired polypeptides.
- Accordingly, in preferred aspects, the Fc domain of the (multispecific) antibody according to the invention comprises a modification promoting the association of the first and the second subunit
- 30 of the Fc domain. The site of most extensive protein-protein interaction between the two subunits of a human IgG Fc domain is in the CH3 domain of the Fc domain. Thus, in one aspect said modification is in the CH3 domain of the Fc domain.

There exist several approaches for modifications in the CH3 domain of the Fc domain in order to enforce heterodimerization, which are well described e.g. in WO 96/27011, WO 98/050431, EP 1870459, WO 2007/110205, WO 2007/147901, WO 2009/089004, WO 2010/129304, WO 2011/90754, WO 2011/143545, WO 2012058768, WO 2013157954, WO 2013096291.

- 5 Typically, in all such approaches the CH3 domain of the first subunit of the Fc domain and the CH3 domain of the second subunit of the Fc domain are both engineered in a complementary manner so that each CH3 domain (or the heavy chain comprising it) can no longer homodimerize with itself but is forced to heterodimerize with the complementarily engineered other CH3 domain (so that the first and second CH3 domain heterodimerize and no homodimers between the two first
10 or the two second CH3 domains are formed). These different approaches for improved heavy chain heterodimerization are contemplated as different alternatives in combination with the heavy-light chain modifications (e.g. VH and VL exchange/replacement in one binding arm and the introduction of substitutions of charged amino acids with opposite charges in the CH1/CL interface) in the (multispecific) antibody which reduce heavy/light chain mispairing and Bence
15 Jones-type side products.

In a specific aspect said modification promoting the association of the first and the second subunit of the Fc domain is a so-called “knob-into-hole” modification, comprising a “knob” modification in one of the two subunits of the Fc domain and a “hole” modification in the other one of the two subunits of the Fc domain.

- 20 The knob-into-hole technology is described e.g. in US 5,731,168; US 7,695,936; Ridgway et al., Prot Eng 9, 617-621 (1996) and Carter, J Immunol Meth 248, 7-15 (2001). Generally, the method involves introducing a protuberance (“knob”) at the interface of a first polypeptide and a corresponding cavity (“hole”) in the interface of a second polypeptide, such that the protuberance can be positioned in the cavity so as to promote heterodimer formation and hinder homodimer
25 formation. Protuberances are constructed by replacing small amino acid side chains from the interface of the first polypeptide with larger side chains (e.g. tyrosine or tryptophan). Compensatory cavities of identical or similar size to the protuberances are created in the interface of the second polypeptide by replacing large amino acid side chains with smaller ones (e.g. alanine or threonine).
- 30 Accordingly, in a preferred aspect, in the CH3 domain of the first subunit of the Fc domain of the (multispecific) antibody an amino acid residue is replaced with an amino acid residue having a larger side chain volume, thereby generating a protuberance within the CH3 domain of the first subunit which is positionable in a cavity within the CH3 domain of the second subunit, and in the

CH3 domain of the second subunit of the Fc domain an amino acid residue is replaced with an amino acid residue having a smaller side chain volume, thereby generating a cavity within the CH3 domain of the second subunit within which the protuberance within the CH3 domain of the first subunit is positionable.

- 5 Preferably said amino acid residue having a larger side chain volume is selected from the group consisting of arginine (R), phenylalanine (F), tyrosine (Y), and tryptophan (W).

Preferably said amino acid residue having a smaller side chain volume is selected from the group consisting of alanine (A), serine (S), threonine (T), and valine (V).

- The protuberance and cavity can be made by altering the nucleic acid encoding the polypeptides,
10 e.g. by site-specific mutagenesis, or by peptide synthesis.

- In a specific aspect, in (the CH3 domain of) the first subunit of the Fc domain (the “knobs” subunit) the threonine residue at position 366 is replaced with a tryptophan residue (T366W), and in (the CH3 domain of) the second subunit of the Fc domain (the “hole” subunit) the tyrosine residue at position 407 is replaced with a valine residue (Y407V). In one aspect, in the second subunit of the
15 Fc domain additionally the threonine residue at position 366 is replaced with a serine residue (T366S) and the leucine residue at position 368 is replaced with an alanine residue (L368A) (numberings according to Kabat EU index).

- In yet a further aspect, in the first subunit of the Fc domain additionally the serine residue at position 354 is replaced with a cysteine residue (S354C) or the glutamic acid residue at position
20 356 is replaced with a cysteine residue (E356C) (particularly the serine residue at position 354 is replaced with a cysteine residue), and in the second subunit of the Fc domain additionally the tyrosine residue at position 349 is replaced by a cysteine residue (Y349C) (numberings according to Kabat EU index). Introduction of these two cysteine residues results in formation of a disulfide bridge between the two subunits of the Fc domain, further stabilizing the dimer (Carter, J Immunol
25 Methods 248, 7-15 (2001)).

In a preferred aspect, the first subunit of the Fc domain comprises the amino acid substitutions S354C and T366W, and the second subunit of the Fc domain comprises the amino acid substitutions Y349C, T366S, L368A and Y407V (numbering according to Kabat EU index).

- In a preferred aspect the antigen binding domain that binds to CD3 is fused (optionally via the
30 second antigen binding domain, which binds to CD19, and/or a peptide linker) to the first subunit of the Fc domain (comprising the “knob” modification). Without wishing to be bound by theory, fusion of the antigen binding domain that binds CD3 to the knob-containing subunit of the Fc

domain will (further) minimize the generation of antibodies comprising two antigen binding domains that bind to CD3 (steric clash of two knob-containing polypeptides).

Other techniques of CH3-modification for enforcing the heterodimerization are contemplated as alternatives according to the invention and are described e.g. in WO 96/27011, WO 98/050431, EP 1870459, WO 2007/110205, WO 2007/147901, WO 2009/089004, WO 2010/129304, WO 2011/90754, WO 2011/143545, WO 2012/058768, WO 2013/157954, WO 2013/096291.

In one aspect, the heterodimerization approach described in EP 1870459, is used alternatively. This approach is based on the introduction of charged amino acids with opposite charges at specific amino acid positions in the CH3/CH3 domain interface between the two subunits of the Fc domain.

10 A particular aspect for the (multispecific) antibody of the invention are amino acid mutations R409D; K370E in one of the two CH3 domains (of the Fc domain) and amino acid mutations D399K; E357K in the other one of the CH3 domains of the Fc domain (numbering according to Kabat EU index).

In another aspect, the (multispecific) antibody of the invention comprises amino acid mutation 15 T366W in the CH3 domain of the first subunit of the Fc domain and amino acid mutations T366S, L368A, Y407V in the CH3 domain of the second subunit of the Fc domain, and additionally amino acid mutations R409D; K370E in the CH3 domain of the first subunit of the Fc domain and amino acid mutations D399K; E357K in the CH3 domain of the second subunit of the Fc domain (numberings according to Kabat EU index).

20 In another aspect, the (multispecific) antibody of the invention comprises amino acid mutations S354C, T366W in the CH3 domain of the first subunit of the Fc domain and amino acid mutations Y349C, T366S, L368A, Y407V in the CH3 domain of the second subunit of the Fc domain, or said (multispecific) antibody comprises amino acid mutations Y349C, T366W in the CH3 domain of the first subunit of the Fc domain and amino acid mutations S354C, T366S, L368A, Y407V in 25 the CH3 domains of the second subunit of the Fc domain and additionally amino acid mutations R409D; K370E in the CH3 domain of the first subunit of the Fc domain and amino acid mutations D399K; E357K in the CH3 domain of the second subunit of the Fc domain (all numberings according to Kabat EU index).

In one aspect, the heterodimerization approach described in WO 2013/157953 is used 30 alternatively. In one aspect, a first CH3 domain comprises amino acid mutation T366K and a second CH3 domain comprises amino acid mutation L351D (numberings according to Kabat EU index). In a further aspect, the first CH3 domain comprises further amino acid mutation L351K.

In a further aspect, the second CH3 domain comprises further an amino acid mutation selected from Y349E, Y349D and L368E (particularly L368E) (numberings according to Kabat EU index). In one aspect, the heterodimerization approach described in WO 2012/058768 is used alternatively. In one aspect a first CH3 domain comprises amino acid mutations L351Y, Y407A and a second CH3 domain comprises amino acid mutations T366A, K409F. In a further aspect the second CH3 domain comprises a further amino acid mutation at position T411, D399, S400, F405, N390, or K392, e.g. selected from a) T411N, T411R, T411Q, T411K, T411D, T411E or T411W, b) D399R, D399W, D399Y or D399K, c) S400E, S400D, S400R, or S400K, d) F405I, F405M, F405T, F405S, F405V or F405W, e) N390R, N390K or N390D, f) K392V, K392M, K392R, K392L, K392F or K392E (numberings according to Kabat EU index). In a further aspect a first CH3 domain comprises amino acid mutations L351Y, Y407A and a second CH3 domain comprises amino acid mutations T366V, K409F. In a further aspect, a first CH3 domain comprises amino acid mutation Y407A and a second CH3 domain comprises amino acid mutations T366A, K409F. In a further aspect, the second CH3 domain further comprises amino acid mutations K392E, T411E, D399R and S400R (numberings according to Kabat EU index). In one aspect, the heterodimerization approach described in WO 2011/143545 is used alternatively, e.g. with the amino acid modification at a position selected from the group consisting of 368 and 409 (numbering according to Kabat EU index). In one aspect, the heterodimerization approach described in WO 2011/090762, which also uses the knobs-into-holes technology described above, is used alternatively. In one aspect a first CH3 domain comprises amino acid mutation T366W and a second CH3 domain comprises amino acid mutation Y407A. In one aspect, a first CH3 domain comprises amino acid mutation T366Y and a second CH3 domain comprises amino acid mutation Y407T (numberings according to Kabat EU index). In one aspect, the (multispecific) antibody or its Fc domain is of IgG₂ subclass and the heterodimerization approach described in WO 2010/129304 is used alternatively. In an alternative aspect, a modification promoting association of the first and the second subunit of the Fc domain comprises a modification mediating electrostatic steering effects, e.g. as described in PCT publication WO 2009/089004. Generally, this method involves replacement of one or more amino acid residues at the interface of the two Fc domain subunits by charged amino acid residues so that homodimer formation becomes electrostatically unfavorable but heterodimerization electrostatically favorable. In one such aspect, a first CH3 domain comprises amino acid substitution of K392 or N392 with a negatively charged amino acid (e.g. glutamic acid

-78-

(E), or aspartic acid (D), particularly K392D or N392D) and a second CH3 domain comprises amino acid substitution of D399, E356, D356, or E357 with a positively charged amino acid (e.g. lysine (K) or arginine (R), particularly D399K, E356K, D356K, or E357K, and more particularly D399K and E356K). In a further aspect, the first CH3 domain further comprises amino acid
5 substitution of K409 or R409 with a negatively charged amino acid (e.g. glutamic acid (E), or aspartic acid (D), particularly K409D or R409D). In a further aspect the first CH3 domain further or alternatively comprises amino acid substitution of K439 and/or K370 with a negatively charged amino acid (e.g. glutamic acid (E), or aspartic acid (D)) (all numberings according to Kabat EU index).

10 In yet a further aspect, the heterodimerization approach described in WO 2007/147901 is used alternatively. In one aspect, a first CH3 domain comprises amino acid mutations K253E, D282K, and K322D and a second CH3 domain comprises amino acid mutations D239K, E240K, and K292D (numberings according to Kabat EU index).

In still another aspect, the heterodimerization approach described in WO 2007/110205 can be used
15 alternatively.

In one aspect, the first subunit of the Fc domain comprises amino acid substitutions K392D and K409D, and the second subunit of the Fc domain comprises amino acid substitutions D356K and D399K (numbering according to Kabat EU index).

20 **b) Fc domain modifications reducing Fc receptor binding and/or effector function**

The Fc domain confers to the (multispecific) antibody favorable pharmacokinetic properties, including a long serum half-life which contributes to good accumulation in the target tissue and a favorable tissue-blood distribution ratio. At the same time it may, however, lead to undesirable targeting of the (multispecific) antibody to cells expressing Fc receptors rather than to the preferred
25 antigen-bearing cells. Moreover, the co-activation of Fc receptor signaling pathways may lead to cytokine release which, in combination with the T cell activating properties and the long half-life of the (multispecific) antibody, results in excessive activation of cytokine receptors and severe side effects upon systemic administration. Activation of (Fc receptor-bearing) immune cells other than T cells may even reduce efficacy of the (multispecific) antibody due to the potential
30 destruction of T cells e.g. by NK cells.

Accordingly, in preferred aspects, the Fc domain of the (multispecific) antibody according to the invention exhibits reduced binding affinity to an Fc receptor and/or reduced effector function, as compared to a native IgG₁ Fc domain. In one such aspect the Fc domain (or the (multispecific)

antibody comprising said Fc domain) exhibits less than 50%, particularly less than 20%, more particularly less than 10% and most particularly less than 5% of the binding affinity to an Fc receptor, as compared to a native IgG₁ Fc domain (or a (multispecific) antibody comprising a native IgG₁ Fc domain), and/or less than 50%, particularly less than 20%, more particularly less than 10% and most particularly less than 5% of the effector function, as compared to a native IgG₁ Fc domain domain (or a (multispecific) antibody comprising a native IgG₁ Fc domain). In one aspect, the Fc domain domain (or the (multispecific) antibody comprising said Fc domain) does not substantially bind to an Fc receptor and/or induce effector function. In a preferred aspect the Fc receptor is an Fc γ receptor. In one aspect the Fc receptor is a human Fc receptor. In one aspect the Fc receptor is an activating Fc receptor. In a specific aspect the Fc receptor is an activating human Fc γ receptor, more specifically human Fc γ RIIIa, Fc γ RI or Fc γ RIIa, most specifically human Fc γ RIIIa. In one aspect the effector function is one or more selected from the group of CDC, ADCC, ADCP, and cytokine secretion. In a preferred aspect, the effector function is ADCC. In one aspect, the Fc domain domain exhibits substantially similar binding affinity to neonatal Fc receptor (FcRn), as compared to a native IgG₁ Fc domain domain. Substantially similar binding to FcRn is achieved when the Fc domain (or the (multispecific) antibody comprising said Fc domain) exhibits greater than about 70%, particularly greater than about 80%, more particularly greater than about 90% of the binding affinity of a native IgG₁ Fc domain (or the (multispecific) antibody comprising a native IgG₁ Fc domain) to FcRn.

In certain aspects the Fc domain is engineered to have reduced binding affinity to an Fc receptor and/or reduced effector function, as compared to a non-engineered Fc domain. In preferred aspects, the Fc domain of the (multispecific) antibody comprises one or more amino acid mutation that reduces the binding affinity of the Fc domain to an Fc receptor and/or effector function. Typically, the same one or more amino acid mutation is present in each of the two subunits of the Fc domain.

In one aspect, the amino acid mutation reduces the binding affinity of the Fc domain to an Fc receptor. In one aspect, the amino acid mutation reduces the binding affinity of the Fc domain to an Fc receptor by at least 2-fold, at least 5-fold, or at least 10-fold. In aspects where there is more than one amino acid mutation that reduces the binding affinity of the Fc domain to the Fc receptor, the combination of these amino acid mutations may reduce the binding affinity of the Fc domain to an Fc receptor by at least 10-fold, at least 20-fold, or even at least 50-fold. In one aspect the (multispecific) antibody comprising an engineered Fc domain exhibits less than 20%, particularly less than 10%, more particularly less than 5% of the binding affinity to an Fc receptor as compared to a (multispecific) antibody comprising a non-engineered Fc domain. In a preferred aspect, the

Fc receptor is an Fc γ receptor. In some aspects, the Fc receptor is a human Fc receptor. In some aspects, the Fc receptor is an activating Fc receptor. In a specific aspect, the Fc receptor is an activating human Fc γ receptor, more specifically human Fc γ RIIIa, Fc γ RI or Fc γ RIIa, most specifically human Fc γ RIIIa. Preferably, binding to each of these receptors is reduced. In some aspects, binding affinity to a complement component, specifically binding affinity to C1q, is also reduced. In one aspect, binding affinity to neonatal Fc receptor (FcRn) is not reduced. Substantially similar binding to FcRn, i.e. preservation of the binding affinity of the Fc domain to said receptor, is achieved when the Fc domain (or the (multispecific) antibody comprising said Fc domain) exhibits greater than about 70% of the binding affinity of a non-engineered form of the Fc domain (or the (multispecific) antibody comprising said non-engineered form of the Fc domain) to FcRn. The Fc domain, or (multispecific) antibodies of the invention comprising said Fc domain, may exhibit greater than about 80% and even greater than about 90% of such affinity. In certain aspects, the Fc domain of the (multispecific) antibody is engineered to have reduced effector function, as compared to a non-engineered Fc domain. The reduced effector function can include, but is not limited to, one or more of the following: reduced complement dependent cytotoxicity (CDC), reduced antibody-dependent cell-mediated cytotoxicity (ADCC), reduced antibody-dependent cellular phagocytosis (ADCP), reduced cytokine secretion, reduced immune complex-mediated antigen uptake by antigen-presenting cells, reduced binding to NK cells, reduced binding to macrophages, reduced binding to monocytes, reduced binding to polymorphonuclear cells, reduced direct signaling inducing apoptosis, reduced crosslinking of target-bound antibodies, reduced dendritic cell maturation, or reduced T cell priming. In one aspect, the reduced effector function is one or more selected from the group of reduced CDC, reduced ADCC, reduced ADCP, and reduced cytokine secretion. In a preferred aspect, the reduced effector function is reduced ADCC. In one aspect the reduced ADCC is less than 20% of the ADCC induced by a non-engineered Fc domain (or a (multispecific) antibody comprising a non-engineered Fc domain). In one aspect, the amino acid mutation that reduces the binding affinity of the Fc domain to an Fc receptor and/or effector function is an amino acid substitution. In one aspect, the Fc domain comprises an amino acid substitution at a position selected from the group of E233, L234, L235, N297, P331 and P329 (numberings according to Kabat EU index). In a more specific aspect, the Fc domain comprises an amino acid substitution at a position selected from the group of L234, L235 and P329 (numberings according to Kabat EU index). In some aspects, the Fc domain comprises the amino acid substitutions L234A and L235A (numberings according to Kabat EU index). In one such aspect, the Fc domain is an IgG₁ Fc domain, particularly a human IgG₁ Fc

domain. In one aspect, the Fc domain comprises an amino acid substitution at position P329. In a more specific aspect, the amino acid substitution is P329A or P329G, particularly P329G (numberings according to Kabat EU index). In one aspect, the Fc domain comprises an amino acid substitution at position P329 and a further amino acid substitution at a position selected from E233, L234, L235, N297 and P331 (numberings according to Kabat EU index). In a more specific aspect, the further amino acid substitution is E233P, L234A, L235A, L235E, N297A, N297D or P331S. In preferred aspects, the Fc domain comprises amino acid substitutions at positions P329, L234 and L235 (numberings according to Kabat EU index). In more preferred aspects, the Fc domain comprises the amino acid mutations L234A, L235A and P329G ("P329G LALA", "PGLALA" or "LALAPG"). Specifically, in preferred aspects, each subunit of the Fc domain comprises the amino acid substitutions L234A, L235A and P329G (Kabat EU index numbering), i.e. in each of the first and the second subunit of the Fc domain the leucine residue at position 234 is replaced with an alanine residue (L234A), the leucine residue at position 235 is replaced with an alanine residue (L235A) and the proline residue at position 329 is replaced by a glycine residue (P329G) (numbering according to Kabat EU index).

In one such aspect, the Fc domain is an IgG₁ Fc domain, particularly a human IgG₁ Fc domain. The "P329G LALA" combination of amino acid substitutions almost completely abolishes Fcγ receptor (as well as complement) binding of a human IgG₁ Fc domain, as described in PCT publication no. WO 2012/130831, which is incorporated herein by reference in its entirety. WO 2012/130831 also describes methods of preparing such mutant Fc domains and methods for determining its properties such as Fc receptor binding or effector functions.

IgG₄ antibodies exhibit reduced binding affinity to Fc receptors and reduced effector functions as compared to IgG₁ antibodies. Hence, in some aspects, the Fc domain of the (multispecific) antibodies of the invention is an IgG₄ Fc domain, particularly a human IgG₄ Fc domain. In one aspect, the IgG₄ Fc domain comprises an amino acid substitution at position S228, specifically the amino acid substitution S228P (numberings according to Kabat EU index). To further reduce its binding affinity to an Fc receptor and/or its effector function, in one aspect, the IgG₄ Fc domain comprises an amino acid substitution at position L235, specifically the amino acid substitution L235E (numberings according to Kabat EU index). In another aspect, the IgG₄ Fc domain comprises an amino acid substitution at position P329, specifically the amino acid substitution P329G (numberings according to Kabat EU index). In a preferred aspect, the IgG₄ Fc domain comprises amino acid substitutions at positions S228, L235 and P329, specifically amino acid substitutions S228P, L235E and P329G (numberings according to Kabat EU index). Such IgG₄ Fc

domain mutants and their Fc γ receptor binding properties are described in PCT publication no. WO 2012/130831, incorporated herein by reference in its entirety.

In a preferred aspect, the Fc domain exhibiting reduced binding affinity to an Fc receptor and/or reduced effector function, as compared to a native IgG₁ Fc domain, is a human IgG₁ Fc domain comprising the amino acid substitutions L234A, L235A and optionally P329G, or a human IgG₄ Fc domain comprising the amino acid substitutions S228P, L235E and optionally P329G (numberings according to Kabat EU index).

In certain aspects, N-glycosylation of the Fc domain has been eliminated. In one such aspect, the Fc domain comprises an amino acid mutation at position N297, particularly an amino acid substitution replacing asparagine by alanine (N297A) or aspartic acid (N297D) (numberings according to Kabat EU index).

In addition to the Fc domains described hereinabove and in PCT publication no. WO 2012/130831, Fc domains with reduced Fc receptor binding and/or effector function also include those with substitution of one or more of Fc domain residues 238, 265, 269, 270, 297, 327 and 329 (U.S. Patent No. 6,737,056) (numberings according to Kabat EU index). Such Fc mutants include Fc mutants with substitutions at two or more of amino acid positions 265, 269, 270, 297 and 327, including the so-called "DANA" Fc mutant with substitution of residues 265 and 297 to alanine (US Patent No. 7,332,581).

Mutant Fc domains can be prepared by amino acid deletion, substitution, insertion or modification using genetic or chemical methods well known in the art. Genetic methods may include site-specific mutagenesis of the encoding DNA sequence, PCR, gene synthesis, and the like. The correct nucleotide changes can be verified for example by sequencing.

Binding to Fc receptors can be easily determined e.g. by ELISA, or by Surface Plasmon Resonance (SPR) using standard instrumentation such as a BIAcore instrument (GE Healthcare), and Fc receptors such as may be obtained by recombinant expression. Alternatively, binding affinity of Fc domains or (multispecific) antibodies comprising an Fc domain for Fc receptors may be evaluated using cell lines known to express particular Fc receptors, such as human NK cells expressing Fc γ IIIa receptor.

Effector function of an Fc domain, or a (multispecific) antibody comprising an Fc domain, can be measured by methods known in the art. Examples of *in vitro* assays to assess ADCC activity of a molecule of interest are described in U.S. Patent No. 5,500,362; Hellstrom et al. Proc Natl Acad Sci USA 83, 7059-7063 (1986) and Hellstrom et al., Proc Natl Acad Sci USA 82, 1499-1502 (1985); U.S. Patent No. 5,821,337; Bruggemann et al., J Exp Med 166, 1351-1361 (1987).

Alternatively, non-radioactive assays may be employed (see, for example, ACTIT[™] non-radioactive cytotoxicity assay for flow cytometry (CellTechnology, Inc. Mountain View, CA); and CytoTox 96[®] non-radioactive cytotoxicity assay (Promega, Madison, WI)). Useful effector cells for such assays include peripheral blood mononuclear cells (PBMC) and Natural Killer (NK) cells.

- 5 Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed *in vivo*, e.g. in a animal model such as that disclosed in Clynes et al., Proc Natl Acad Sci USA 95, 652-656 (1998).

In some aspects, binding of the Fc domain to a complement component, specifically to C1q, is reduced. Accordingly, in some aspects wherein the Fc domain is engineered to have reduced
10 effector function, said reduced effector function includes reduced CDC. C1q binding assays may be carried out to determine whether the Fc domain, or the (multispecific) antibody comprising the Fc domain, is able to bind C1q and hence has CDC activity. See e.g., C1q and C3c binding ELISA in WO 2006/029879 and WO 2005/100402. To assess complement activation, a CDC assay may be performed (see, for example, Gazzano-Santoro et al., J Immunol Methods 202, 163 (1996);
15 Cragg et al., Blood 101, 1045-1052 (2003); and Cragg and Glennie, Blood 103, 2738-2743 (2004)). FcRn binding and *in vivo* clearance/half life determinations can also be performed using methods known in the art (see, e.g., Petkova, S.B. et al., *Int'l. Immunol.* 18(12):1759-1769 (2006); WO 2013/120929).

20 **B. Polynucleotides**

The invention further provides an isolated polynucleotide encoding an antibody of the invention. Said isolated polynucleotide may be a single polynucleotide or a plurality of polynucleotides.

- The polynucleotides encoding (multispecific) antibodies of the invention may be expressed as a single polynucleotide that encodes the entire antibody or as multiple (e.g., two or more)
25 polynucleotides that are co-expressed. Polypeptides encoded by polynucleotides that are co-expressed may associate through, e.g., disulfide bonds or other means to form a functional antibody. For example, the light chain portion of an antibody may be encoded by a separate polynucleotide from the portion of the antibody comprising the heavy chain of the antibody. When co-expressed, the heavy chain polypeptides will associate with the light chain polypeptides to form
30 the antibody. In another example, the portion of the antibody comprising one of the two Fc domain subunits and optionally (part of) one or more Fab molecules could be encoded by a separate polynucleotide from the portion of the antibody comprising the other of the two Fc domain

subunits and optionally (part of) a Fab molecule. When co-expressed, the Fc domain subunits will associate to form the Fc domain.

In some aspects, the isolated polynucleotide encodes the entire antibody molecule according to the invention as described herein. In other aspects, the isolated polynucleotide encodes a polypeptide
5 comprised in the antibody according to the invention as described herein.

In certain aspects the polynucleotide or nucleic acid is DNA. In other aspects, a polynucleotide of the present invention is RNA, for example, in the form of messenger RNA (mRNA). RNA of the present invention may be single stranded or double stranded.

10 C. Recombinant Methods

Antibodies of the invention may be obtained, for example, by solid-state peptide synthesis (e.g. Merrifield solid phase synthesis) or recombinant production. For recombinant production one or more polynucleotide encoding the antibody, e.g., as described above, is isolated and inserted into one or more vectors for further cloning and/or expression in a host cell. Such polynucleotide may
15 be readily isolated and sequenced using conventional procedures. In one aspect a vector, particularly an expression vector, comprising the polynucleotide (i.e. a single polynucleotide or a plurality of polynucleotides) of the invention is provided. Methods which are well known to those skilled in the art can be used to construct expression vectors containing the coding sequence of an antibody along with appropriate transcriptional/translational control signals. These methods
20 include *in vitro* recombinant DNA techniques, synthetic techniques and *in vivo* recombination/genetic recombination. See, for example, the techniques described in Maniatis et al., MOLECULAR CLONING: A LABORATORY MANUAL, Cold Spring Harbor Laboratory, N.Y. (1989); and Ausubel et al., CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, Greene Publishing Associates and Wiley Interscience, N.Y (1989). The expression vector can be part of a plasmid,
25 virus, or may be a nucleic acid fragment. The expression vector includes an expression cassette into which the polynucleotide encoding the antibody (i.e. the coding region) is cloned in operable association with a promoter and/or other transcription or translation control elements. As used herein, a "coding region" is a portion of nucleic acid which consists of codons translated into amino acids. Although a "stop codon" (TAG, TGA, or TAA) is not translated into an amino acid, it may
30 be considered to be part of a coding region, if present, but any flanking sequences, for example promoters, ribosome binding sites, transcriptional terminators, introns, 5' and 3' untranslated regions, and the like, are not part of a coding region. Two or more coding regions can be present in a single polynucleotide construct, e.g. on a single vector, or in separate polynucleotide

constructs, e.g. on separate (different) vectors. Furthermore, any vector may contain a single coding region, or may comprise two or more coding regions, e.g. a vector of the present invention may encode one or more polypeptides, which are post- or co-translationally separated into the final proteins via proteolytic cleavage. In addition, a vector, polynucleotide, or nucleic acid of the invention may encode heterologous coding regions, either fused or unfused to a polynucleotide encoding the antibody of the invention, or variant or derivative thereof. Heterologous coding regions include without limitation specialized elements or motifs, such as a secretory signal peptide or a heterologous functional domain. An operable association is when a coding region for a gene product, e.g. a polypeptide, is associated with one or more regulatory sequences in such a way as to place expression of the gene product under the influence or control of the regulatory sequence(s). Two DNA fragments (such as a polypeptide coding region and a promoter associated therewith) are "operably associated" if induction of promoter function results in the transcription of mRNA encoding the desired gene product and if the nature of the linkage between the two DNA fragments does not interfere with the ability of the expression regulatory sequences to direct the expression of the gene product or interfere with the ability of the DNA template to be transcribed. Thus, a promoter region would be operably associated with a nucleic acid encoding a polypeptide if the promoter was capable of effecting transcription of that nucleic acid. The promoter may be a cell-specific promoter that directs substantial transcription of the DNA only in predetermined cells. Other transcription control elements, besides a promoter, for example enhancers, operators, repressors, and transcription termination signals, can be operably associated with the polynucleotide to direct cell-specific transcription. Suitable promoters and other transcription control regions are disclosed herein. A variety of transcription control regions are known to those skilled in the art. These include, without limitation, transcription control regions, which function in vertebrate cells, such as, but not limited to, promoter and enhancer segments from cytomegaloviruses (e.g. the immediate early promoter, in conjunction with intron-A), simian virus 40 (e.g. the early promoter), and retroviruses (such as, e.g. Rous sarcoma virus). Other transcription control regions include those derived from vertebrate genes such as actin, heat shock protein, bovine growth hormone and rabbit β -globin, as well as other sequences capable of controlling gene expression in eukaryotic cells. Additional suitable transcription control regions include tissue-specific promoters and enhancers as well as inducible promoters (e.g. promoters inducible by tetracyclins). Similarly, a variety of translation control elements are known to those of ordinary skill in the art. These include, but are not limited to ribosome binding sites, translation initiation and termination codons, and elements derived from viral systems (particularly an internal

ribosome entry site, or IRES, also referred to as a CITE sequence). The expression cassette may also include other features such as an origin of replication, and/or chromosome integration elements such as retroviral long terminal repeats (LTRs), or adeno-associated viral (AAV) inverted terminal repeats (ITRs).

- 5 Polynucleotide and nucleic acid coding regions of the present invention may be associated with additional coding regions which encode secretory or signal peptides, which direct the secretion of a polypeptide encoded by a polynucleotide of the present invention. For example, if secretion of the antibody is desired, DNA encoding a signal sequence may be placed upstream of the nucleic acid encoding an antibody of the invention or a fragment thereof. According to the signal
10 hypothesis, proteins secreted by mammalian cells have a signal peptide or secretory leader sequence which is cleaved from the mature protein once export of the growing protein chain across the rough endoplasmic reticulum has been initiated. Those of ordinary skill in the art are aware that polypeptides secreted by vertebrate cells generally have a signal peptide fused to the N-terminus of the polypeptide, which is cleaved from the translated polypeptide to produce a secreted
15 or "mature" form of the polypeptide. In certain aspects, the native signal peptide, *e.g.* an immunoglobulin heavy chain or light chain signal peptide is used, or a functional derivative of that sequence that retains the ability to direct the secretion of the polypeptide that is operably associated with it. Alternatively, a heterologous mammalian signal peptide, or a functional derivative thereof, may be used. For example, the wild-type leader sequence may be substituted with the leader
20 sequence of human tissue plasminogen activator (TPA) or mouse β -glucuronidase.

DNA encoding a short protein sequence that could be used to facilitate later purification (*e.g.* a histidine tag) or assist in labeling the antibody may be included within or at the ends of the antibody (fragment) encoding polynucleotide.

- In a further aspect, a host cell comprising a polynucleotide (*i.e.* a single polynucleotide or a
25 plurality of polynucleotides) of the invention is provided. In certain aspects a host cell comprising a vector of the invention is provided. The polynucleotides and vectors may incorporate any of the features, singly or in combination, described herein in relation to polynucleotides and vectors, respectively. In one such aspect a host cell comprises (*e.g.* has been transformed or transfected with) one or more vector comprising one or more polynucleotide that encodes (part of) an antibody
30 of the invention. As used herein, the term "host cell" refers to any kind of cellular system which can be engineered to generate the antibody of the invention or fragments thereof. Host cells suitable for replicating and for supporting expression of antibodies are well known in the art. Such cells may be transfected or transduced as appropriate with the particular expression vector and

large quantities of vector containing cells can be grown for seeding large scale fermenters to obtain sufficient quantities of the antibody for clinical applications. Suitable host cells include prokaryotic microorganisms, such as *E. coli*, or various eukaryotic cells, such as Chinese hamster ovary cells (CHO), insect cells, or the like. For example, polypeptides may be produced in bacteria
5 in particular when glycosylation is not needed. After expression, the polypeptide may be isolated from the bacterial cell paste in a soluble fraction and can be further purified. In addition to prokaryotes, eukaryotic microbes such as filamentous fungi or yeast are suitable cloning or expression hosts for polypeptide-encoding vectors, including fungi and yeast strains whose glycosylation pathways have been “humanized”, resulting in the production of a polypeptide with
10 a partially or fully human glycosylation pattern. See Gerngross, Nat Biotech 22, 1409-1414 (2004), and Li et al., Nat Biotech 24, 210-215 (2006). Suitable host cells for the expression of (glycosylated) polypeptides are also derived from multicellular organisms (invertebrates and vertebrates). Examples of invertebrate cells include plant and insect cells. Numerous baculoviral strains have been identified which may be used in conjunction with insect cells, particularly for
15 transfection of *Spodoptera frugiperda* cells. Plant cell cultures can also be utilized as hosts. See e.g. US Patent Nos. 5,959,177, 6,040,498, 6,420,548, 7,125,978, and 6,417,429 (describing PLANTIBODIES™ technology for producing antibodies in transgenic plants). Vertebrate cells may also be used as hosts. For example, mammalian cell lines that are adapted to grow in suspension may be useful. Other examples of useful mammalian host cell lines are monkey kidney
20 CV1 line transformed by SV40 (COS-7); human embryonic kidney line (293 or 293T cells as described, e.g., in Graham et al., J Gen Virol 36, 59 (1977)), baby hamster kidney cells (BHK), mouse sertoli cells (TM4 cells as described, e.g., in Mather, Biol Reprod 23, 243-251 (1980)), monkey kidney cells (CV1), African green monkey kidney cells (VERO-76), human cervical carcinoma cells (HELA), canine kidney cells (MDCK), buffalo rat liver cells (BRL 3A), human
25 lung cells (W138), human liver cells (Hep G2), mouse mammary tumor cells (MMT 060562), TRI cells (as described, e.g., in Mather et al., Annals N.Y. Acad Sci 383, 44-68 (1982)), MRC 5 cells, and FS4 cells. Other useful mammalian host cell lines include Chinese hamster ovary (CHO) cells, including dhfr⁻ CHO cells (Urlaub et al., Proc Natl Acad Sci USA 77, 4216 (1980)); and myeloma cell lines such as YO, NS0, P3X63 and Sp2/0. For a review of certain mammalian host cell lines
30 suitable for protein production, see, e.g., Yazaki and Wu, Methods in Molecular Biology, Vol. 248 (B.K.C. Lo, ed., Humana Press, Totowa, NJ), pp. 255-268 (2003). Host cells include cultured cells, e.g., mammalian cultured cells, yeast cells, insect cells, bacterial cells and plant cells, to name only a few, but also cells comprised within a transgenic animal, transgenic plant or cultured plant or

animal tissue. In one aspect, the host cell is a eukaryotic cell, particularly a mammalian cell, such as a Chinese Hamster Ovary (CHO) cell, a human embryonic kidney (HEK) cell or a lymphoid cell (e.g., Y0, NS0, Sp20 cell). In one aspect, the host cell is not a cell within a human body.

Standard technologies are known in the art to express foreign genes in these systems. Cells
5 expressing a polypeptide comprising either the heavy or the light chain of an antigen binding domain such as an antibody, may be engineered so as to also express the other of the antibody chains such that the expressed product is an antibody that has both a heavy and a light chain.

In one aspect, a method of producing an antibody according to the invention is provided, wherein the method comprises culturing a host cell comprising a polynucleotide encoding the antibody, as
10 provided herein, under conditions suitable for expression of the antibody, and optionally recovering the antibody from the host cell (or host cell culture medium).

The components of the (multispecific) antibody of the invention may be genetically fused to each other. The (multispecific) antibody can be designed such that its components are fused directly to each other or indirectly through a linker sequence. The composition and length of the linker may
15 be determined in accordance with methods well known in the art and may be tested for efficacy. Examples of linker sequences between different components of (multispecific) antibodies are provided herein. Additional sequences may also be included to incorporate a cleavage site to separate the individual components of the fusion if desired, for example an endopeptidase recognition sequence.

20 Antibodies prepared as described herein may be purified by art-known techniques such as high performance liquid chromatography, ion exchange chromatography, gel electrophoresis, affinity chromatography, size exclusion chromatography, and the like. The actual conditions used to purify a particular protein will depend, in part, on factors such as net charge, hydrophobicity, hydrophilicity etc., and will be apparent to those having skill in the art. For affinity
25 chromatography purification, an antibody, ligand, receptor or antigen can be used to which the antibody binds. For example, for affinity chromatography purification of antibodies of the invention, a matrix with protein A or protein G may be used. Sequential Protein A or G affinity chromatography and size exclusion chromatography can be used to isolate an antibody essentially as described in the Examples. The purity of the antibody can be determined by any of a variety of
30 well-known analytical methods including gel electrophoresis, high pressure liquid chromatography, and the like.

D. Assays

Antibodies provided herein may be identified, screened for, or characterized for their physical/chemical properties and/or biological activities by various assays known in the art.

5

1. Binding assays

The binding (affinity) of the antibody to an Fc receptor or a target antigen can be determined for example by surface plasmon resonance (SPR), using standard instrumentation such as a BIAcore instrument (GE Healthcare), and receptors or target proteins such as may be obtained by recombinant expression. Alternatively, binding of antibodies to different receptors or target
10 antigens may be evaluated using cell lines expressing the particular receptor or target antigen, for example by flow cytometry (FACS). A specific illustrative and exemplary aspect for measuring binding activity to CD3 is described in the following.

In one aspect, the binding activity to CD3 is determined by SPR as follows:

SPR is performed on a Biacore T200 instrument (GE Healthcare). Anti-Fab capturing antibody
15 (GE Healthcare, #28958325) is immobilized on a Series S Sensor Chip CM5 (GE Healthcare) using standard amine coupling chemistry, at a surface density of 4000 – 6000 resonance units (RU). As running and dilution buffer, HBS-P+ (10 mM HEPES, 150 mM NaCl pH 7.4, 0.05% Surfactant P20) is used. CD3 antibodies with a concentration of 2 µg/ml (in 20 mM His, 140 mM NaCl, pH 6.0) are injected for about 60 s at a flow rate of 5 µl/min. The CD3 antigen used is a heterodimer
20 of CD3 delta and CD3 epsilon ectodomains fused to a human Fc domain with knob-into-hole modifications and a C-terminal Avi-tag (see SEQ ID NOs 41 and 42). CD3 antigen is injected at a concentration of 10 µg/ml for 120 s and dissociation is monitored at a flow rate of 5 µl/min for about 120 s. The chip surface is regenerated by two consecutive injections of 10 mM glycine pH 2.1 for about 60 s each. Bulk refractive index differences are corrected by subtracting blank
25 injections and by subtracting the response obtained from the blank control flow cell. For evaluation, the binding response is taken 5 seconds after injection end. To normalize the binding signal, the CD3 binding is divided by the anti-Fab response (the signal (RU) obtained upon capture of the CD3 antibody on the immobilized anti-Fab antibody). The binding activity to CD3 of an antibody after a certain treatment, relative to the binding activity to CD3 of the antibody after a different
30 treatment (also referred to as relative active concentration (RAC)) is calculated by referencing the binding activity of a sample of the antibody after the certain treatment to the binding activity of a corresponding sample of the antibody after the different treatment.

2. Activity assays

Biological activity of the (multispecific) antibodies of the invention can be measured by various assays as described in the Examples. Biological activities may for example include the induction of proliferation of T cells, the induction of signaling in T cells, the induction of expression of
5 activation markers in T cells, the induction of cytokine secretion by T cells, the induction of lysis of target cells such as B-cells, and the induction of tumor regression and/or the improvement of survival.

E. Compositions, Formulations, and Routes of Administration

10 In a further aspect, the invention provides pharmaceutical compositions comprising any of the antibodies provided herein, e.g., for use in any of the below therapeutic methods. In one aspect, a pharmaceutical composition comprises an antibody according to the invention and a pharmaceutically acceptable carrier. In another aspect, a pharmaceutical composition comprises an antibody according to the invention and at least one additional therapeutic agent, e.g., as
15 described below.

Further provided is a method of producing an antibody of the invention in a form suitable for administration *in vivo*, the method comprising (a) obtaining an antibody according to the invention, and (b) formulating the antibody with at least one pharmaceutically acceptable carrier, whereby a preparation of antibody is formulated for administration *in vivo*.

20 Pharmaceutical compositions of the present invention comprise an effective amount of antibody dissolved or dispersed in a pharmaceutically acceptable carrier. The phrase "pharmaceutically acceptable" refers to molecular entities and compositions that are generally non-toxic to recipients at the dosages and concentrations employed, i.e. do not produce an adverse, allergic or other untoward reaction when administered to an animal, such as, for example, a human, as appropriate.

25 The preparation of a pharmaceutical composition that contains an antibody and optionally an additional active ingredient will be known to those of skill in the art in light of the present disclosure, as exemplified by Remington's Pharmaceutical Sciences, 18th Ed. Mack Printing Company, 1990, incorporated herein by reference. Moreover, for animal (e.g., human) administration, it will be understood that preparations should meet sterility, pyrogenicity, general
30 safety and purity standards as required by FDA Office of Biological Standards or corresponding authorities in other countries. Preferred compositions are lyophilized formulations or aqueous solutions. As used herein, "pharmaceutically acceptable carrier" includes any and all solvents,

5 buffers, dispersion media, coatings, surfactants, antioxidants, preservatives (*e.g.* antibacterial agents, antifungal agents), isotonic agents, absorption delaying agents, salts, preservatives, antioxidants, proteins, drugs, drug stabilizers, polymers, gels, binders, excipients, disintegration agents, lubricants, sweetening agents, flavoring agents, dyes, such like materials and combinations thereof, as would be known to one of ordinary skill in the art (see, for example, Remington's Pharmaceutical Sciences, 18th Ed. Mack Printing Company, 1990, pp. 1289-1329, incorporated herein by reference). Except insofar as any conventional carrier is incompatible with the active ingredient, its use in the pharmaceutical compositions is contemplated.

10 An antibody of the invention (and any additional therapeutic agent) can be administered by any suitable means, including parenteral, intrapulmonary, and intranasal, and, if desired for local treatment, intralesional administration. Parenteral infusions include intramuscular, intravenous, intraarterial, intraperitoneal, or subcutaneous administration. Dosing can be by any suitable route, *e.g.* by injections, such as intravenous or subcutaneous injections, depending in part on whether the administration is brief or chronic.

15 Parenteral compositions include those designed for administration by injection, *e.g.* subcutaneous, intradermal, intralesional, intravenous, intraarterial intramuscular, intrathecal or intraperitoneal injection. For injection, the antibodies of the invention may be formulated in aqueous solutions, particularly in physiologically compatible buffers such as Hanks' solution, Ringer's solution, or physiological saline buffer. The solution may contain formulatory agents such as suspending, 20 stabilizing and/or dispersing agents. Alternatively, the antibodies may be in powder form for constitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water, before use. Sterile injectable solutions are prepared by incorporating the antibodies of the invention in the required amount in the appropriate solvent with various of the other ingredients enumerated below, as required. Sterility may be readily accomplished, *e.g.*, by filtration through sterile filtration membranes.

25 Generally, dispersions are prepared by incorporating the various sterilized active ingredients into a sterile vehicle which contains the basic dispersion medium and/or the other ingredients. In the case of sterile powders for the preparation of sterile injectable solutions, suspensions or emulsion, the preferred methods of preparation are vacuum-drying or freeze-drying techniques which yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile- 30 filtered liquid medium thereof. The liquid medium should be suitably buffered if necessary and the liquid diluent first rendered isotonic prior to injection with sufficient saline or glucose. The composition must be stable under the conditions of manufacture and storage, and preserved against the contaminating action of microorganisms, such as bacteria and fungi. It will be appreciated that

endotoxin contamination should be kept minimally at a safe level, for example, less than 0.5 ng/mg protein. Suitable pharmaceutically acceptable carriers 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 dextrans; 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). Aqueous injection suspensions may contain compounds which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, dextran, or the like. Optionally, the suspension may also contain suitable stabilizers or agents which increase the solubility of the compounds to allow for the preparation of highly concentrated solutions. Additionally, suspensions of the active compounds may be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl cleats or triglycerides, or liposomes.

Active ingredients may be entrapped in microcapsules prepared, for example, by coacervation techniques or by interfacial polymerization, for example, hydroxymethylcellulose or gelatin-microcapsules and poly-(methylmethacrylate) microcapsules, respectively, in colloidal drug delivery systems (for example, liposomes, albumin microspheres, microemulsions, nano-particles and nanocapsules) or in macroemulsions. Such techniques are disclosed in Remington's Pharmaceutical Sciences (18th Ed. Mack Printing Company, 1990). Sustained-release preparations may be prepared. Suitable examples of sustained-release preparations include semipermeable matrices of solid hydrophobic polymers containing the polypeptide, which matrices are in the form of shaped articles, e.g. films, or microcapsules. In particular aspects, prolonged absorption of an injectable composition can be brought about by the use in the compositions of agents delaying absorption, such as, for example, aluminum monostearate, gelatin or combinations thereof.

In addition to the compositions described previously, the antibodies may also be formulated as a depot preparation. Such long acting formulations may be administered by implantation (for

example subcutaneously or intramuscularly) or by intramuscular injection. Thus, for example, the antibodies may be formulated with suitable polymeric or hydrophobic materials (for example as an emulsion in an acceptable oil) or ion exchange resins, or as sparingly soluble derivatives, for example, as a sparingly soluble salt.

- 5 Pharmaceutical compositions comprising the antibodies of the invention may be manufactured by means of conventional mixing, dissolving, emulsifying, encapsulating, entrapping or lyophilizing processes. Pharmaceutical compositions may be formulated in conventional manner using one or more physiologically acceptable carriers, diluents, excipients or auxiliaries which facilitate processing of the proteins into preparations that can be used pharmaceutically. Proper formulation
10 is dependent upon the route of administration chosen.

The antibodies may be formulated into a composition in a free acid or base, neutral or salt form. Pharmaceutically acceptable salts are salts that substantially retain the biological activity of the free acid or base. These include the acid addition salts, e.g., those formed with the free amino groups of a proteinaceous composition, or which are formed with inorganic acids such as for
15 example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric or mandelic acid. Salts formed with the free carboxyl groups can also be derived from inorganic bases such as for example, sodium, potassium, ammonium, calcium or ferric hydroxides; or such organic bases as isopropylamine, trimethylamine, histidine or procaine. Pharmaceutical salts tend to be more soluble in aqueous and other protic solvents than are the corresponding free base forms.

20

F. Therapeutic Methods and Compositions

Any of the antibodies provided herein may be used in therapeutic methods. Antibodies of the invention may be used as immunotherapeutic agents, for example in the treatment of cancers or autoimmune diseases.

- 25 For use in therapeutic methods, antibodies of the invention would be formulated, dosed, and administered in a fashion consistent with good medical practice. Factors for consideration in this context include the particular disorder being treated, the particular mammal being treated, the clinical condition of the individual patient, the cause of the disorder, the site of delivery of the agent, the method of administration, the scheduling of administration, and other factors known to
30 medical practitioners.

In one aspect, antibodies of the invention for use as a medicament are provided. In further aspects, antibodies of the invention for use in treating a disease are provided. In certain aspects, antibodies of the invention for use in a method of treatment are provided. In one aspect, the invention provides

an antibody of the invention for use in the treatment of a disease in an individual in need thereof. In certain aspects, the invention provides an antibody for use in a method of treating an individual having a disease comprising administering to the individual an effective amount of the antibody. In certain aspects the disease is a proliferative disorder. In certain aspects the disease is cancer, particularly a CD19-expressing cancer. In a specific aspect the cancer is a B-cell cancer. The B-cell cancer in one aspect is a B-cell lymphoma or a B-cell leukemia. In one aspect the B-cell cancer is non-Hodgkin lymphoma or acute lymphoblastic leukemia or chronic lymphocytic leukemia. In other aspects the disease is an autoimmune disease. In a specific aspect the disease is lupus, in particular systemic lupus erythematosus (SLE) or lupus nephritis (LN).

10 In certain aspects the method further comprises administering to the individual an effective amount of at least one additional therapeutic agent, e.g., an anti-cancer agent if the disease to be treated is cancer or an immunosuppressive agent if the the disease to be treated is an autoimmune disease. In further aspects, the invention provides an antibody of the invention for use in inducing lysis of a target cell, particularly a B-cell. In certain aspects, the invention provides an antibody of the

15 invention for use in a method of inducing lysis of a target cell, particularly a B-cell, in an individual comprising administering to the individual an effective amount of the antibody to induce lysis of a target cell. An "individual" according to any of the above aspects is a mammal, preferably a human.

In a further aspect, the invention provides for the use of an antibody of the invention in the

20 manufacture or preparation of a medicament. In one aspect the medicament is for the treatment of a disease in an individual in need thereof. In a further aspect, the medicament is for use in a method of treating a disease comprising administering to an individual having the disease an effective amount of the medicament. In certain aspects the disease is a proliferative disorder. In certain aspects the disease is cancer, particularly a CD19-expressing cancer. In a specific aspect the cancer

25 is a B-cell cancer. The B-cell cancer in one aspect is a B-cell lymphoma or a B-cell leukemia. In one aspect the B-cell cancer is non-Hodgkin lymphoma or acute lymphoblastic leukemia or chronic lymphocytic leukemia. In other aspects the disease is an autoimmune disease. In a specific aspect the disease is lupus, in particular systemic lupus erythematosus (SLE) or lupus nephritis (LN). In one aspect, the method further comprises administering to the individual an effective

30 amount of at least one additional therapeutic agent, e.g., an anti-cancer agent if the disease to be treated is cancer or an immunosuppressive agent if the the disease to be treated is an autoimmune disease. In a further aspect, the medicament is for inducing lysis of a target cell, particularly a B-cell. In still a further aspect, the medicament is for use in a method of inducing lysis of a target

cell, particularly a B-cell, in an individual comprising administering to the individual an effective amount of the medicament to induce lysis of a target cell. An "individual" according to any of the above aspects may be a mammal, preferably a human.

In a further aspect, the invention provides a method for treating a disease. In one aspect, the method
5 comprises administering to an individual having such disease an effective amount of an antibody of the invention. In one aspect a composition is administered to said individual, comprising the antibody of the invention in a pharmaceutically acceptable form. In certain aspects the disease is a proliferative disorder. In certain aspects the disease is cancer, particularly a CD19-expressing cancer. In a specific aspect the cancer is a B-cell cancer. The B-cell cancer in one aspect is a B-
10 cell lymphoma or a B-cell leukemia. In one aspect the B-cell cancer is non-Hodgkin lymphoma or acute lymphoblastic leukemia or chronic lymphocytic leukemia. In other aspects the disease is an autoimmune disease. In a specific aspect the disease is lupus, in particular systemic lupus erythematosus (SLE) or lupus nephritis (LN). In certain aspects the method further comprises administering to the individual an effective amount of at least one additional therapeutic agent,
15 e.g., an anti-cancer agent if the disease to be treated is cancer or an immunosuppressive agent if the the disease to be treated is an autoimmune disease. An "individual" according to any of the above aspects may be a mammal, preferably a human.

In a further aspect, the invention provides a method for inducing lysis of a target cell, particularly a CD19-expressing cell such as a B-cell. In one aspect the method comprises contacting a target
20 cell with an antibody of the invention in the presence of a T cell, particularly a cytotoxic T cell. In a further aspect, a method for inducing lysis of a target cell, particularly a CD19-expressing cell such as a B-cell, in an individual is provided. In one such aspect, the method comprises administering to the individual an effective amount of an antibody of the invention to induce lysis of a target cell. In one aspect, an "individual" is a human.

25 A skilled artisan readily recognizes that in many cases the antibody may not provide a cure but may only provide partial benefit. In some aspects, a physiological change having some benefit is also considered therapeutically beneficial. Thus, in some aspects, an amount of antibody that provides a physiological change is considered an "effective amount". The subject, patient, or individual in need of treatment is typically a mammal, more specifically a human.

30 In some aspects, an effective amount of an antibody of the invention is administered to an individual for the treatment of disease.

For the prevention or treatment of disease, the appropriate dosage of an antibody of the invention (when used alone or in combination with one or more other additional therapeutic agents) will

depend on the type of disease to be treated, the route of administration, the body weight of the patient, the type of antibody, the severity and course of the disease, whether the antibody is administered for preventive or therapeutic purposes, previous or concurrent therapeutic interventions, the patient's clinical history and response to the antibody, and the discretion of the attending physician. The practitioner responsible for administration will, in any event, determine the concentration of active ingredient(s) in a composition and appropriate dose(s) for the individual subject. Various dosing schedules including but not limited to single or multiple administrations over various time-points, bolus administration, and pulse infusion are contemplated herein.

The antibody is suitably administered to the patient at one time or over a series of treatments. Depending on the type and severity of the disease, about 1 µg/kg to 15 mg/kg (e.g. 0.1 mg/kg – 10 mg/kg) of antibody can be an initial candidate dosage for administration to the patient, whether, for example, by one or more separate administrations, or by continuous infusion. One typical daily dosage might range from about 1 µg/kg to 100 mg/kg or more, depending on the factors mentioned above. For repeated administrations over several days or longer, depending on the condition, the treatment would generally be sustained until a desired suppression of disease symptoms occurs. One exemplary dosage of the antibody would be in the range from about 0.005 mg/kg to about 10 mg/kg. In other non-limiting examples, a dose may also comprise from about 1 microgram/kg body weight, about 5 microgram/kg body weight, about 10 microgram/kg body weight, about 50 microgram/kg body weight, about 100 microgram/kg body weight, about 200 microgram/kg body weight, about 350 microgram/kg body weight, about 500 microgram/kg body weight, about 1 milligram/kg body weight, about 5 milligram/kg body weight, about 10 milligram/kg body weight, about 50 milligram/kg body weight, about 100 milligram/kg body weight, about 200 milligram/kg body weight, about 350 milligram/kg body weight, about 500 milligram/kg body weight, to about 1000 mg/kg body weight or more per administration, and any range derivable therein. In non-limiting examples of a derivable range from the numbers listed herein, a range of about 5 mg/kg body weight to about 100 mg/kg body weight, about 5 microgram/kg body weight to about 500 milligram/kg body weight, etc., can be administered, based on the numbers described above. Thus, one or more doses of about 0.5 mg/kg, 2.0 mg/kg, 5.0 mg/kg or 10 mg/kg (or any combination thereof) may be administered to the patient. Such doses may be administered intermittently, e.g. every week or every three weeks (e.g. such that the patient receives from about two to about twenty, or e.g. about six doses of the antibody). An initial higher loading dose, followed by one or more lower doses may be administered. However, other dosage regimens may be useful. The progress of this therapy is easily monitored by conventional techniques and assays.

The antibodies of the invention will generally be used in an amount effective to achieve the intended purpose. For use to treat or prevent a disease condition, the antibodies of the invention, or pharmaceutical compositions thereof, are administered or applied in an effective amount.

For systemic administration, an effective dose can be estimated initially from *in vitro* assays, such as cell culture assays. A dose can then be formulated in animal models to achieve a circulating concentration range that includes the IC_{50} as determined in cell culture. Such information can be used to more accurately determine useful doses in humans.

Initial dosages can also be estimated from *in vivo* data, *e.g.*, animal models, using techniques that are well known in the art.

- 10 Dosage amount and interval may be adjusted individually to provide plasma levels of the antibodies which are sufficient to maintain therapeutic effect. Usual patient dosages for administration by injection range from about 0.1 to 50 mg/kg/day, typically from about 0.5 to 1 mg/kg/day. Therapeutically effective plasma levels may be achieved by administering multiple doses each day. Levels in plasma may be measured, for example, by HPLC.
- 15 An effective dose of the antibodies of the invention will generally provide therapeutic benefit without causing substantial toxicity. Toxicity and therapeutic efficacy of an antibody can be determined by standard pharmaceutical procedures in cell culture or experimental animals. Cell culture assays and animal studies can be used to determine the LD_{50} (the dose lethal to 50% of a population) and the ED_{50} (the dose therapeutically effective in 50% of a population). The dose ratio between toxic and therapeutic effects is the therapeutic index, which can be expressed as the ratio LD_{50}/ED_{50} . Antibodies that exhibit large therapeutic indices are preferred. In one aspect, the antibody according to the present invention exhibits a high therapeutic index. The data obtained from cell culture assays and animal studies can be used in formulating a range of dosages suitable for use in humans. The dosage lies preferably within a range of circulating concentrations that include the ED_{50} with little or no toxicity. The dosage may vary within this range depending upon a variety of factors, *e.g.*, the dosage form employed, the route of administration utilized, the condition of the subject, and the like. The exact formulation, route of administration and dosage can be chosen by the individual physician in view of the patient's condition (see, *e.g.*, Fingl et al., 1975, in: *The Pharmacological Basis of Therapeutics*, Ch. 1, p. 1, incorporated herein by reference in its entirety).
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The attending physician for patients treated with antibodies of the invention would know how and when to terminate, interrupt, or adjust administration due to toxicity, organ dysfunction, and the like. Conversely, the attending physician would also know to adjust treatment to higher levels if

the clinical response were not adequate (precluding toxicity). The magnitude of an administered dose in the management of the disorder of interest will vary with the severity of the condition to be treated, with the route of administration, and the like. The severity of the condition may, for example, be evaluated, in part, by standard prognostic evaluation methods. Further, the dose and perhaps dose frequency will also vary according to the age, body weight, and response of the individual patient.

The antibodies of the invention may be administered in combination with one or more other agents in therapy. For instance, an antibody of the invention may be co-administered with at least one additional therapeutic agent. The term "therapeutic agent" encompasses any agent administered to treat a symptom or disease in an individual in need of such treatment. Such additional therapeutic agent may comprise any active ingredients suitable for the particular disease being treated, preferably those with complementary activities that do not adversely affect each other. In certain aspects, an additional therapeutic agent is an immunomodulatory agent, a cytostatic agent, an inhibitor of cell adhesion, a cytotoxic agent, an activator of cell apoptosis, or an agent that increases the sensitivity of cells to apoptotic inducers. In certain aspects, the additional therapeutic agent is an anti-cancer agent, for example a microtubule disruptor, an antimetabolite, a topoisomerase inhibitor, a DNA intercalator, an alkylating agent, a hormonal therapy, a kinase inhibitor, a receptor antagonist, an activator of tumor cell apoptosis, or an antiangiogenic agent. In other aspects, the additional therapeutic agent is an immunosuppressive agent. In a specific aspect, the additional therapeutic agent is one or more selected from the group of corticosteroids, hydroxychloroquine, mycophenolate mofetil, mycophenolic acid, methotrexate, azathioprine, cyclophosphamide, calcineurin inhibitors, belimumab, rituximab and obinutuzumab.

Such other agents are suitably present in combination in amounts that are effective for the purpose intended. The effective amount of such other agents depends on the amount of antibody used, the type of disorder or treatment, and other factors discussed above. The antibodies are generally used in the same dosages and with administration routes as described herein, or about from 1 to 99% of the dosages described herein, or in any dosage and by any route that is empirically/clinically determined to be appropriate.

Such combination therapies noted above encompass combined administration (where two or more therapeutic agents are included in the same or separate compositions), and separate administration, in which case, administration of the antibody of the invention can occur prior to, simultaneously, and/or following, administration of the additional therapeutic agent and/or adjuvant. Antibodies of the invention may also be used in combination with radiation therapy.

G. Articles of Manufacture

In another aspect of the invention, an article of manufacture containing materials useful for the treatment, prevention and/or diagnosis of the disorders described above is provided. The article of manufacture comprises a container and a label or package insert on or associated with the container. Suitable containers include, for example, bottles, vials, syringes, IV solution bags, etc. The containers may be formed from a variety of materials such as glass or plastic. The container holds a composition which is by itself or combined with another composition effective for treating, preventing and/or diagnosing the condition and may have a sterile access port (for example the container may be an intravenous solution bag or a vial having a stopper pierceable by a hypodermic injection needle). At least one active agent in the composition is an antibody of the invention. The label or package insert indicates that the composition is used for treating the condition of choice. Moreover, the article of manufacture may comprise (a) a first container with a composition contained therein, wherein the composition comprises an antibody of the invention; and (b) a second container with a composition contained therein, wherein the composition comprises a further cytotoxic or otherwise therapeutic agent. The article of manufacture in this aspect of the invention may further comprise a package insert indicating that the compositions can be used to treat a particular condition. Alternatively, or additionally, the article of manufacture may further comprise a second (or third) container comprising a pharmaceutically-acceptable buffer, such as bacteriostatic water for injection (BWFI), phosphate-buffered saline, Ringer's solution and dextrose solution. It may further include other materials desirable from a commercial and user standpoint, including other buffers, diluents, filters, needles, and syringes.

H. Methods and Compositions for Diagnostics and Detection

In certain aspects, any of the antibodies provided herein is useful for detecting the presence of its target (e.g. CD3 or CD19) in a biological sample. The term "detecting" as used herein encompasses quantitative or qualitative detection. In certain aspects, a biological sample comprises a cell or tissue, such as prostate tissue.

In one aspect, an antibody according to the invention for use in a method of diagnosis or detection is provided. In a further aspect, a method of detecting the presence of CD3 or CD19 in a biological sample is provided. In certain aspects, the method comprises contacting the biological sample with an antibody of the present invention under conditions permissive for binding of the antibody to

CD3 or CD19, and detecting whether a complex is formed between the antibody and CD3 or CD19. Such method may be an *in vitro* or *in vivo* method. In one aspect, an antibody of the invention is used to select subjects eligible for therapy with an antibody that binds CD3 and/or CD19, e.g. where CD3 and/or CD19 is a biomarker for selection of patients.

- 5 Exemplary disorders that may be diagnosed using an antibody of the invention include cancer, particularly B-cell cancer.

In certain aspects, an antibody according to the present invention is provided, wherein the antibody is labelled. Labels include, but are not limited to, labels or moieties that are detected directly (such as fluorescent, chromophoric, electron-dense, chemiluminescent, and radioactive labels), as well
10 as moieties, such as enzymes or ligands, that are detected indirectly, e.g., through an enzymatic reaction or molecular interaction. Exemplary labels include, but are not limited to, the radioisotopes ³²P, ¹⁴C, ¹²⁵I, ³H, and ¹³¹I, fluorophores such as rare earth chelates or fluorescein and its derivatives, rhodamine and its derivatives, dansyl, umbelliferone, luciferases, e.g., firefly luciferase and bacterial luciferase (U.S. Patent No. 4,737,456), luciferin, 2,3-
15 dihydrophthalazinediones, horseradish peroxidase (HRP), alkaline phosphatase, β -galactosidase, glucoamylase, lysozyme, saccharide oxidases, e.g., glucose oxidase, galactose oxidase, and glucose-6-phosphate dehydrogenase, heterocyclic oxidases such as uricase and xanthine oxidase, coupled with an enzyme that employs hydrogen peroxide to oxidize a dye precursor such as HRP, lactoperoxidase, or microperoxidase, biotin/avidin, spin labels, bacteriophage labels, stable free
20 radicals, and the like.

III. SEQUENCES

	Amino Acid Sequence	SEQ ID NO
CD3 _{orig} HCDR1	TYAMN	1
CD3 _{opt} HCDR1	SYAMN	2
CD3 _{orig} / CD3 _{opt} HCDR2	RIRSKYNNYATYYADSVKG	3
CD3 _{orig} HCDR3	HGNFGNSYVSWFAY	4
CD3 _{opt} HCDR3	HTTFPSSYVSYYGY	5
CD3 _{orig} VH	EVQLLESGGGLVQPGGSLRLSCAASGFTFSTYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHGNFGNSYVSWFAYWGQG TLVTVSS	6
CD3 _{opt} VH	EVQLLESGGGLVQPGGSLRLSCAASGFQFSSYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHTTFPSSYVSYYGYWGQGT LVTVSS	7
CD3 _{orig} / CD3 _{opt} LCDR1	GSSTGAVTTSNYAN	8
CD3 _{orig} / CD3 _{opt} LCDR2	GTNKRAP	9
CD3 _{orig} / CD3 _{opt} LCDR3	ALWYSNLWV	10
CD3 _{orig} / CD3 _{opt} VL	QAVVTQEPLTVSPGGTVTLTCGSSTGAVTTSNYANWVQE KPGQAFRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQ PEDEAEYYCALWYSNLWVFGGGTKLTVL	11
CD3 _{orig} IgG HC	EVQLLESGGGLVQPGGSLRLSCAASGFTFSTYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHGNFGNSYVSWFAYWGQG TLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPE PVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSL GTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEL LGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKF NWKYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDW LNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS RDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHN HYTQKSLSLSP	12

CD3 _{opt} IgG HC	EVQLLESGGGLVQPGGSLRLSCAASGFQFSSYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHTTFPSSYVSYYGYWGQGT LVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEP VTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLG TQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEA AGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKF NWWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDW LNGKEYKCKVSNKALGAPIEKTISKAKGQPREPQVYTLPPS RDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHN HYTQKSLSLSP	13
CD3 _{orig} / CD3 _{opt} IgG LC	QAVVTQEPSLTVSPGGTVTLTCGSSTGAVTTSNYANWVQE KPGQAFRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQ PEDEAEYYCALWYSNLWVFGGGTKLTVLRTVAAPSVFIFP PSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGN SQESVTEQDSKSTYSLSSSTLTLSKADYEKHKVYACEVTH QGLSSPVTKSFNRGEC	14
CD19(2B11) HCDR1	DYIMH	15
CD19(2B11) HCDR2	YINPYNDGSKYTEKFQG	16
CD19(2B11) HCDR3	GTYYYGPQLFDY	17
CD19(2B11) VH	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGPQLFDYWGQGT T V T VSS	18
CD19(2B11) LCDR1	KSSQSLETSTGTTYLN	19
CD19(2B11) LCDR2	RVSKRFS	20
CD19(2B11) LCDR3	LQLEDPYT	21
CD19(2B11) VL	DIVMTQTPLSLSVTPGQPASISCKSSQSLETSTGTTYLNWYL QKPGQSPQLLIYRVSKRFSGVPDRFSGSGSGTDFTLKISRVE AEDVGVYYCLQLEDPYTFGQGTKLEIK	22
CD19(2B11) VH-CH1(EF) - CD3 _{orig} /CD3 _o pt VL-CH1 - Fc (knob, PGLALA)	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGPQLFDYWGQGT T V T VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT VSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT YICNVNHKPSNTKVDKVEPKSCDGGGGSGGGGGQAVVT QEPSLTVSPGGTVTLTCGSSTGAVTTSNYANWVQEKPGQA FRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQPEDEA EYYCALWYSNLWVFGGGTKLTVLSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPA VLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDK KVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMISR	23

	TPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALGAPIE KTISKAKGQPREPQVYTLPPCRDELTKNQVSLWCLVKGFY PSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSP	
CD19(2B11) VH-CH1(EE) -Fc (hole, PGLALA)	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLSDDTAVYYCARGTYYYGPQLFDYWGQGTTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT SWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT YICNVNHKPSNTKVKDEKVEPKSCDKTHCTPPCPAPEAAGGP SVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYV DGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKE YKCKVSNKALGAPIEKTISKAKGQPREPQVCTLPPSRDEL TKNQVSLSCAVKGFYPSDIAVEWESNGQPENNYKTTPPVLD SDGSFFLVSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSP	24
CD19(2B11) VL-CL(RK)	DIVMTQTPLSLSVTPGQPASISCKSSQSLETSTGTTYLNWYL QKPGQSPQLLIYRVSKRFSGVPDRFSGSGSGTDFTLKISRVE AEDVGVYYCLQLEDPYTFGQGTKLEIKRTVAAPSVFIFPPS DRKLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQ ESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQG LSSPVTKSFNRGEC	25
CD3 _{orig} VH- CL	EVQLLESGGGLVQPGGSLRLSCAASGFTFSTYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHGNFGNSYVSWFAYWGQG TLVTVSSASVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPR EAKVQWKVDNALQSGNSQESVTEQDSKDYSLSSSTLTLS KADYEKHKVYACEVTHQGLSSPVTKSFNRGEC	26
CD3 _{opt} VH- CL	EVQLLESGGGLVQPGGSLRLSCAASGFQFSSYAMNWVRQA PGKGLEWVSRIRSKYNNYATYYADSVKGRFTISRDDSKNT LYLQMNSLRAEDTAVYYCVRHTTFPSSYVSYYGYWGQGT LVTVSSASVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPRE AKVQWKVDNALQSGNSQESVTEQDSKDYSLSSSTLTLSK ADYEKHKVYACEVTHQGLSSPVTKSFNRGEC	27
CD19(018) HCDR1	DYIMH	28
CD19(018) HCDR2	YINPYNDGSKYTEKFQG	29
CD19(018) HCDR3	GTYYYGSALFDY	30
CD19(018) VH	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLSDDTAVYYCARGTYYYGSALFDYWGQGTTVT VSS	31
CD19(018) LCDR1	KSSQSLENPNGNTYLN	32
CD19(018) LCDR2	RVSKRFS	33

CD19(018) LCDR3	LQLTHVPYT	34
CD19(018) VL	DIVMTQTPLSLSVTPGQPASISCKSSQSLENPNGNTYLNWY LQKPGQSPQLLIYRVSKRFSGVPDRFSGSGSGTDFTLKISR EAEDVG VYYCLQLTHVPYTFGQGTKLEIK	35
CD19(018) VH-CH1(EF) – CD3 _{orig} /CD3 _o pt VL-CH1 – Fc (knob, PGLALA)	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGSALFDYWGQGT TTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT SWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT YICNVNHKPSNTKVDEKVEPKSCDGGGSGGGGQAVVT QEPSLTVSPGGTVTLTCSSTGAVTTSNYANWVQEKPGQA FRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQPEDEA EYYCALWYSLWVFGGGTKLTVLSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPA VLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDEK KVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMISR TPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALGAPIE KTISKAKGQPREPQVYTLPPCRDELTKNQVSLWCLVKGFY PSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSP	36
CD19(018) VH-CH1(EF) –Fc (hole, PGLALA)	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGSALFDYWGQGT TTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT SWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT YICNVNHKPSNTKVDEKVEPKSCDKTHTCPPCPAPEAAGGP SVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYV DGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKE YKCKVSNKALGAPIEKTISKAKGQPREPQVCTLPSPRDEL KNQVSLSCAVKGFYPSDIAVEWESNGQPENNYKTTTPVLD SDGSFFLVSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSP	37
CD19(018) VL-CL(RK)	DIVMTQTPLSLSVTPGQPASISCKSSQSLENPNGNTYLNWY LQKPGQSPQLLIYRVSKRFSGVPDRFSGSGSGTDFTLKISR EAEDVG VYYCLQLTHVPYTFGQGTKLEIKRTVAAPSVFIFP PSDRKLKSGTASVCLLNFPYFPAKVKQWKVDNALQSGN SQESVTEQDSKSTYLSSTLTLSKADYEKHKVYACEVTH QGLSSPVTKSFNRGEC	38
CD19(2B11) VH-CH1(EF) – CD3 _{orig} /CD3 _o pt VL-CH1 – Fc (knob, PGLALA)	QVQLVQSGAEVKKPGASVKVSCKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGPQLFDYWGQGT TTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT SWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQT YICNVNHKPSNTKVDEKVEPKSCDGGGSGGGGQAVVT QEPSLTVSPGGTVTLTCSSTGAVTTSNYANWVQEKPGQA FRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQPEDEA EYYCALWYSLWVFGGGTKLTVLSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPA	39

	VLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKV KVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMIS RTPPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPRE EQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALGAPIE KTISKAKGQPREPQVYTLPPCRDELTKNQVSLWCLVKGFY PSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSP	
CD19(018) VH-CH1(EE) – CD3 _{orig} /CD3 _o pt VL-CH1 – Fc (knob, PGLALA	QVQLVQSGAEVKKPGASVKVCSKASGYTFTDYIMHWVRQ APGQGLEWMGYINPYNDGSKYTEKFQGRVTMTSDTSISTA YMELSRRLRSDDTAVYYCARGTYYYGSALFDYWGQGTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVEDYFPEPVT VSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQ TYICNVNHKPSNTKVDEKVEPKSCDGGGSGGGGSQAVVT QEPSLTVSPGGTVTLTCGSSTGAVTTSNYANWVQEKPGQA FRGLIGGTNKRAPGTPARFSGSLLGGKAALTLGAQPEDEA EYYCALWYSLWVFGGGTKLTVLSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPA VLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKV DKKVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMIS RTPPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPRE EQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALGAPIE KTISKAKGQPREPQVYTLPPCRDELTKNQVSLWCLVKGFY PSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSP	40
Human CD3 epsilon stalk – Fc(knob) – Avi	QDGNEMGGITQTPYKVSISGTTVILTCQYPGSEILWQHN DKNIGGEDDDKNIGSDEDHLSLKEFSELEQSGYYVCYPRGS KPEDANFYLYLRARVSENCVDEQLYFQGGSPKSADKTHC PPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSH EDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLT VLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPCRDELTKNQVSLWCLVKGFYPSDIAVEWESNGQP ENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCS VMHEALHNHYTQKSLSLSPGKSGGLNDIFEAQKIEWHE	41
Human CD3 delta stalk – Fc (hole) – Avi	FKIPIEELEDVFNVCNTSITWVEGTGTLSDITRLDLGKRI LDPRGIYRCNGTDIYKDKESTVQVHYRMCRESQLYFQGD KTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCV VDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVV SVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQ PREPQVCTLPSPRDELTKNQVSLSCAVKGFYPSDIAVEWES NGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCSVMHEALHNHYTQKSLSLSPGKSGGLNDIFEAQKIEWHE	42
CD19 ECD – Fc (knob) – Avi	PEEPLVVKVEEGDNAVLQCLKGTSDGPTQQLTWSRESPLK PFLKLSLGLPGLGIHMRPLAIWLFIFNVSSQMGGFYLCQPG PPSEKAWQPGWTVNVEGSGELFRWNVSDLGGLGCGLKNR SSEGPSSPSGKLMSPKLYVWAKDRPEIWEGETPCLPPRDSL NQSLSQDLTMAPGSTLWLSGCVPPDSVSRGPLSWTHVHPK GPKSLLSLELKDDRPARDMWVWVETGLLLPRATAQDAGKY YCHRGNTMSFHLEITARPVLWHWLLRTGGWKVDASGGS PTPPTPGGGSADKTHTCPPCPAPELLGGPSVFLFPPKPKDTL MISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTK	43

	PREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALP APIEKTISKAKGQPREPQVYTLPPCRDELTKNQVSLWCLVK GFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGKSGG LNDIFEAQKIEWHE	
Fc (hole)	DKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCV VVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKG QPREPQVCTLPSSRDELTKNQVSLSCAVKGFYPSDIAVEWE SNGQPENNYKTTTPVLDSDGSFFLVSKLTVDKSRWQQGNV FSCSVMHEALHNRFQKSLSLSP	44
Human CD3	QDGNEEMGGITQTPYKVSISGTTVILTCPQYPGSEILWQHN DKNIGGEDDDKNIGSDEDHLSLKEFSELEQSGYYVCYPRGS KPEDANFYLYLRARVCENCMEMDMVSVATIVIVDICITGG LLLLVYYWSKNRKAKAKPVTRGAGAGGRQGRGQNKERPPP VPNPDIPIRKQQRDLYSGLNQRI	45
Cynomolgus CD3	QDGNEEMGSITQTPYQVSISGTTVILTCQHLGSEAQWQHN GKNKEDSGDRLFLPEFSEMEQSGYYVCYPRGSNPEDASHH LYLKARVCENCMEMDMVAVATIVIVDICITLGLLLL VYYW SKNRKAKAKPVTRGAGAGGRQGRGQNKERPPPVPNPDIPI RKQQRDLYSGLNQRI	46
hIgG ₁ Fc region	DKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCV VVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKG QPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWE SNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNV FSCSVMHEALHNHYTQKSLSLSP	47
linker	GGGGSGGGGS	48
linker	DGGGGSGGGGS	49
linker	GGGGSGGGGG	50
linker	DGGGGSGGGGG	51
Human kappa CL domain	RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQW KVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEK HKVYACEVTHQGLSSPVTKSFNRGEC	52
Human lambda CL domain	QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAW KADSSPVKAGVETTTPSKQSNNKYAASSYLSLTPEQWKSH RSYSCQVTHEGSTVEKTVAPTECS	53
Human IgG ₁ heavy chain constant region (CH1- CH2-CH3)	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSW NSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYIC NVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVF LFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDG VEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYK CKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKN QVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSD GSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSP	54

IV. EXAMPLES

The following are examples of methods and compositions of the invention. It is understood that various other aspects may be practiced, given the general description provided above.

5 **Example 1 - Generation of optimized CD3 binder**

Starting from a previously described (see e.g. WO 2014/131712, incorporated herein by reference) CD3 binder, termed “CD3_{orig}” herein and comprising the VH and VL sequences of SEQ ID NOs 6 and 11, respectively, we aimed at optimizing properties of this binder by removal of two asparagine deamidation sequence motifs at Kabat positions 97 and 100 of the heavy chain CDR3.

- 10 To this aim, we generated an antibody library, suitable for phage display, of the heavy chain with both asparagines at Kabat position 97 and 100 removed, and in addition the CDRs H1, H2, and H3 randomized in order to compensate for loss of affinity caused by replacing Asn97 and Asn100 through an affinity-maturation process.

This library was put on a filamentous phage via fusion to minor coat protein p3 (Marks et al. (1991)

- 15 *J Mol Biol* **222**, 581-597) and selected for binding to recombinant CD3ε.

10 candidate clones were identified in the initial screening, showing acceptable binding on recombinant antigen as measured by SPR as Fab fragments (produced in *E. coli*).

Only one of these clones, however, showed acceptable binding activity to CD3 expressing cells as measured by flow cytometry after conversion to IgG format.

- 20 The selected clone, termed “CD3_{opt}” herein and comprising the VH and VL sequences of SEQ ID NOs 7 and 11, respectively, was further evaluated and converted into bispecific format as described in the following.

Example 2 - Binding of optimized CD3 binder to CD3

- 25 Binding to recombinant CD3

Binding to recombinant CD3 was determined by surface plasmon resonance (SPR) for the optimized CD3 binder “CD3_{opt}” and the original CD3 binder “CD3_{orig}”, both in human IgG₁ format

with P329G L234A L235A ("PGLALA", EU numbering) mutations in the Fc region (SEQ ID NOs 12 and 14 (CD3_{orig}) and SEQ ID NOs 13 and 14 (CD3_{opt})).

In order to assess the effect of the deamidation site removal and its effect on the stability of the antibodies, binding of the original and the optimized CD3 binder to recombinant CD3 was tested after temperature stress for 14 days at 37°C or 40°C. Samples stored at -80°C were used as reference. The reference samples and the samples stressed at 40°C were in 20 mM His, 140 mM NaCl, pH 6.0, and the samples stressed at 37°C in PBS, pH 7.4, all at a concentration of 1.2-1.3 mg/ml. After the stress period (14 days) samples in PBS were dialyzed back to 20 mM His, 140 mM NaCl, pH 6.0 for further analysis.

Relative Active Concentration (RAC) of the samples was determined by SPR as follows.

SPR was performed on a Biacore T200 instrument (GE Healthcare). Anti-Fab capturing antibody (GE Healthcare, #28958325) was immobilized on a Series S Sensor Chip CM5 (GE Healthcare) using standard amine coupling chemistry, resulting in a surface density of 4000 – 6000 resonance units (RU). As running and dilution buffer, HBS-P+ (10 mM HEPES, 150 mM NaCl pH 7.4, 0.05% Surfactant P20) was used. CD3 antibodies with a concentration of 2 µg/ml were injected for 60 s at a flow rate of 5 µl/min. CD3 antigen (see below) was injected at a concentration of 10 µg/ml for 120 s and dissociation was monitored at a flow rate of 5 µl/min for 120 s. The chip surface was regenerated by two consecutive injections of 10 mM glycine pH 2.1 for 60 s each. Bulk refractive index differences were corrected by subtracting blank injections and by subtracting the response obtained from the blank control flow cell. For evaluation, the binding response was taken 5 seconds after injection end. To normalize the binding signal, the CD3 binding was divided by the anti-Fab response (the signal (RU) obtained upon capture of the CD3 antibody on the immobilized anti-Fab antibody). The relative active concentration was calculated by referencing each temperature stressed sample to the corresponding, non-stressed sample.

The antigen used was a heterodimer of CD3 delta and CD3 epsilon ectodomains fused to a human Fc domain with knob-into-hole modifications and a C-terminal Avi-tag (see SEQ ID NOs 41 and 42).

The results of this experiment are shown in **Figure 2**. As can be seen, the optimized CD3 binder CD3_{opt} showed strongly improved binding to CD3 after temperature stress (2 weeks at 37°C, pH 7.4) as compared to the original CD3 binder CD3_{orig}. This result demonstrates that the deamidation

site removal was successful, and has yielded an antibody with superior stability properties, relevant for in vivo half-life, as well as formulation of the antibody at neutral pH.

Binding to CD3 on Jurkat cells

- 5 Binding to CD3 on the human reporter T-cell line Jurkat NFAT was determined by FACS for the optimized CD3 binder “CD3_{opt}” and the original CD3 binder “CD3_{orig}”, both in human IgG₁ format with P329G L234A L235A (“PGLALA”, EU numbering) mutations in the Fc region (SEQ ID NOs 12 and 14 (CD3_{orig}) and SEQ ID NOs 13 and 14 (CD3_{opt})).

- 10 Jurkat-NFAT reporter cells (GloResponse Jurkat NFAT-RE-luc2P; Promega #CS176501) are a human acute lymphatic leukemia reporter cell line with a NFAT promoter, expressing human CD3. The cells were cultured in RPMI1640, 2g/l glucose, 2 g/l NaHCO₃, 10% FCS, 25 mM HEPES, 2 mM L-glutamine, 1 x NEAA, 1 x sodium-pyruvate at 0.1-0.5 mio cells per ml. A final concentration of 200 µg per ml hygromycin B was added whenever cells were passaged.

- 15 For the binding assay, Jurkat NFAT cells were harvested, washed with PBS and resuspended in FACS buffer. The antibody staining was performed in a 96-well round bottom plate. Therefore 100'000 to 200'000 cells were seeded per well. The plate was centrifuged for 4 min at 400 x g and the supernatant was removed. The test antibodies were diluted in FACS buffer and 20 µl of the antibody solution were added to the cells for 30 min at 4°C. To remove unbound antibody, the cells were washed twice with FACS buffer before addition of the diluted secondary antibody (PE-
- 20 conjugated AffiniPure F(ab')₂ Fragment goat anti-human IgG Fcg Fragment Specific; Jackson ImmunoResearch #109-116-170). After 30 min incubation at 4°C unbound secondary antibody was washed away. Before measurement the cells were resuspended in 200 µl FACS buffer and then analyzed by flow cytometry using a BD Canto II device.

- As shown in **Figure 3**, the optimized CD3 binder “CD3_{opt}” and the original CD3 binder “CD3_{orig}”
- 25 bound comparably well to CD3 on Jurkat cells.

Example 3 – Functional activity of optimized CD3 binder

The functional activity of the optimized CD3 binder “CD3_{opt}” was tested in a Jurkat reporter cell assay and compared to the activity of the original CD3 binder “CD3_{orig}”. To test the functional

activity of the IgGs, anti-PGLALA expressing CHO cells were co-incubated with Jurkat NFAT reporter cells in the presence of increasing concentrations of CD3_{opt} human IgG₁ PGLALA or CD3_{orig} human IgG₁ PGLALA. Activation of CD3 on the Jurkat NFAT reporter cells upon T cell cross-linking induces the production of luciferase and luminescence can be measured as an activation marker. CD3_{orig} human IgG₁ wt was included as negative control which cannot bind to anti-PGLALA expressing CHO cells and therefore cannot be crosslinked on Jurkat NFAT cells. A schematic illustration of the assay is provided in **Figure 4**.

Anti-PGLALA expressing CHO cells are CHO-K1 cells engineered to express on their surface an antibody that specifically binds human IgG₁ Fc(PGLALA) (see WO 2017/072210, incorporated herein by reference). These cells were cultured in DMEM/F12 medium containing 5% FCS + 1% GluMax. The Jurkat NFAT reporter cells are as described in Example 2.

Upon simultaneous binding of the CD3 huIgG₁ PGLALA to anti-PGLALA expressed on CHO and CD3 expressed on Jurkat-NFAT reporter cells, the NFAT promoter is activated and leads to expression of active firefly luciferase. The intensity of luminescence signal (obtained upon addition of luciferase substrate) is proportional to the intensity of CD3 activation and signaling. Jurkat-NFAT reporter cells grow in suspension and were cultured in RPMI1640, 2g/l glucose, 2 g/l NaHCO₃, 10 % FCS, 25 mM HEPES, 2 mM L-glutamin, 1 x NEAA, 1 x sodium-pyruvate at 0.1-0.5 mio cells per ml, 200 µg per ml hygromycin. For the assay, CHO cells were harvested and viability determined using ViCell. 30 000 target cells/well were plated in a flat-bottom, white-walled 96-well-plate (Greiner bio-one #655098) in 100 µl medium and 50 µl/well of diluted antibodies or medium (for controls) were added to the CHO cells. Subsequently, Jurkat-NFAT reporter cells were harvested and viability assessed using ViCell. Cells were resuspended at 1.2 mio cells/ml in cell culture medium without hygromycin B and added to CHO cells at 60 000 cells/well (50 µl/well) to obtain a final effector-to-target (E:T) ratio of 2:1 and a final volume of 200 µl per well. Then, 4 µl of GloSensor (Promega #E1291) was added to each well (2% of final volume). Cells were incubated for 24 h at 37°C in a humidified incubator. At the end of incubation time, luminescence was detected using TECAN Spark 10M.

As shown in **Figure 5**, the optimized CD3 binder CD3_{opt} had a similar activity on Jurkat NFAT cells upon crosslinking as CD3_{orig}.

30

Example 4 - Generation of T-cell bispecific antibody comprising optimized CD3 binder

The optimized CD3 binder identified in Example 1 (“CD3_{opt}”, SEQ ID NOs 7 (VH) and 11 (VL)) was used to generate T-cell bispecific antibodies (TCBs) targeting CD3 and CD19 (“CD19-TCB”), using anti-CD19 antibodies 2B11 or 018 as CD19 binding moiety (SEQ ID NOs 15-22 or 28-35, respectively).

- 5 A schematic illustration of the TCB molecules is provided in **Figure 6A**, and their full sequences are given in SEQ ID NOs 39, 24, 25 and 27 (2B11), and SEQ ID NOs 36, 37, 38 and 27 (018).

Corresponding molecules comprising either of the above-mentioned anti-CD19 antibodies as target cell antigen binding moiety and CD3_{orig} as CD3 binder were also prepared (SEQ ID NOs 39, 24, 25 and 26 (2B11), and SEQ ID NOs 40, 37, 38 and 26 (018)).

- 10 The variable region of heavy and light chain DNA sequences were subcloned in frame with either the constant heavy chain or the constant light chain pre-inserted into the respective recipient mammalian expression vectors as shown in **Figure 6 B-E**.

To improve correct pairing of the light chains with the corresponding heavy chains, mutations were introduced in the human CL (E123R, Q124K) and the human CH1 (K147E, K213E) of the

- 15 CD19 binding Fab molecule.

For correct pairing of the heavy chains (formation of a heterodimeric molecule), knob-into-hole mutations were introduced in the constant region of the antibody heavy chains (T366W/S354C and T366S/L368A/Y407V/ Y349C, respectively).

Furthermore, the P329G, L234A and L235A mutations were introduced in the constant region of

- 20 the antibody heavy chains to abrogate binding to Fcγ receptors.

The TCBs were prepared by Evitria (Switzerland) using their proprietary vector system with conventional (non-PCR based) cloning techniques and using suspension-adapted CHO K1 cells (originally received from ATCC and adapted to serum-free growth in suspension culture at Evitria). For the production, Evitria used its proprietary, animal-component free and serum-free media

25 (eviGrow and eviMake2) and its proprietary transfection reagent (eviFect). The cells were transfected with the corresponding expression vectors in a 1:1:2:1 (“vector knob heavy chain”:“vector hole heavy chain”:“vector CD3 light chain”:“vector CD19 light chain”). Supernatant was harvested by centrifugation and subsequent filtration (0.2 μm filter).

As an alternative to the preparation at Evitria, TCB molecules were prepared in-house by transient

- 30 transfection of HEK293 EBNA cells. Cells were centrifuged and, medium was replaced by pre-

warmed CD CHO medium (Thermo Fisher, #10743029). Expression vectors were mixed in CD CHO medium, polyethylenimine (PEI; Polysciences Inc, #23966-1) was added, the solution vortexed and incubated for 10 minutes at room temperature. Afterwards, cells (2 mio/ml) were mixed with the vector/PEI solution, transferred to a flask and incubated for 3 hours at 37°C in a shaking incubator with a 5% CO₂ atmosphere. After the incubation, Excell medium with supplements (80% of total volume) was added (W. Zhou and A. Kantardjieff, Mammalian Cell Cultures for Biologics Manufacturing, DOI: 10.1007/978-3-642-54050-9; 2014). One day after transfection, supplements (Feed, 12% of total volume) were added. Cell supernatants were harvested after 7 days by centrifugation and subsequent filtration (0.2 µm filter).

Proteins were purified from the harvested supernatant by standard methods. In brief, Fc containing proteins were purified from filtered cell culture supernatants by Protein A-affinity chromatography (equilibration buffer: 20 mM sodium citrate, 20 mM sodium phosphate, pH 7.5; elution buffer: 20 mM sodium citrate, pH 3.0). Elution was achieved at pH 3.0 followed by immediate pH neutralization of the sample. The protein was concentrated by centrifugation (Millipore Amicon® ULTRA-15, #UFC903096), and aggregated protein was separated from monomeric protein by size exclusion chromatography in 20 mM histidine, 140 mM sodium chloride, pH 6.0.

The concentrations of purified proteins were determined by measuring the absorption at 280 nm using the mass extinction coefficient calculated on the basis of the amino acid sequence according to Pace, et al., Protein Science, 1995, 4, 2411-1423. Purity and molecular weight of the proteins were analyzed by CE-SDS in the presence and absence of a reducing agent using a LabChipGXII (Perkin Elmer). Determination of the aggregate content was performed by HPLC chromatography at 25°C using analytical size-exclusion column (TSKgel G3000 SW XL or UP-SW3000) equilibrated in running buffer (25 mM K₂HPO₄, 125 mM NaCl, 200 mM L-arginine monohydrochloride, pH 6.7 or 200 mM KH₂PO₄, 250 mM KCl pH 6.2, respectively).

Results from the biochemical and biophysical analysis of the prepared TCB molecules are given in **Table 1**.

All four TCB molecules could be produced in good quality.

Table 1. Biochemical and biophysical analysis of anti-CD3 antibody CD3_{opt} in CD19-TCB format. Monomer content determined by analytical size exclusion chromatography. Purity determined by non-reducing CE-SDS.

Molecule	Monomer [%]	Purity [%]
CD19(018) CD3 _{orig}	91	97
CD19(2B11) CD3 _{orig}	96	97
CD19(2B11) CD3 _{opt}	98	99
CD19(018) CD3 _{opt}	98	99

Example 5 – Functional characterization of optimized anti-CD3 (multispecific) antibodies by surface plasmon resonance (SPR)

SPR experiments were performed, using the CD19-TCB molecules prepared in Example 4, on a Biacore T200 instrument at 25°C with HBS-EP+ as running buffer (0.01 M HEPES pH 7.4, 0.15 M NaCl, 0.005% Surfactant P20 (GE Healthcare, #BR-1006-69)). Anti-Fc(P329G) IgG (an antibody that specifically binds human IgG₁ Fc(P329G); “anti-PG antibody” - see WO 2017/072210, incorporated herein by reference) was directly immobilized by amine coupling on a C1 chip (GE Healthcare). The different TCB molecules were captured at 25 nM. Three-fold dilution series (in HBS-EP from 0.14 to 100 nM) of the CD19 antigen (human CD19 extracellular domain (ECD) – Fc fusion; see SEQ ID NOs 43 and 44) or the CD3 antigen (CD3 ϵ/δ – Fc fusion; see Example 2, SEQ ID NOs 41 and 42) were passed over the ligand at 30 μ l/min for 240 s to record the association phase. The dissociation phase was monitored for 1500 s (CD19 antigen) or 800 s (CD3 antigen)s and triggered by switching from the sample solution to HBS-EP+. The chip surface was regenerated after every cycle using two injections of 10 mM glycine pH 2.1 for 60 sec. Bulk refractive index differences were corrected for by subtracting the response obtained on the reference flow cell (without captured TCB). The affinity constants were derived from the kinetic rate constants by fitting to a 1:1 Langmuir binding using the Biaeval software (GE Healthcare). The measurement was performed with three independent dilution series.

The kinetic constants for a 1:1 Langmuir binding were determined for the four tested TCBs to recombinant human CD19 (**Table 2**) and to recombinant human CD3 (**Table 3**).

Table 2. Binding to human CD19: Kinetic constants. Average and standard deviation (in parenthesis) of independent dilutions series in the same run.

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Molecule	k_{on} (1/Ms)	k_{off} (1/s)	K_D (M)	$t_{1/2}$ (min)
CD19(018) CD3 _{orig}	3.33E+05 (1.17E+04)	3.16E-04 (9.54E-06)	9.5E-10 (6E-11)	36.6
CD19(2B11) CD3 _{orig}	4.34E+05 (1.20E+04)	1.76E-04 (5.77E-07)	4.0E-10 (1E-11)	65.6
CD19(2B11) CD3 _{opt}	4.10E+05 (1.10E+04)	1.46E-04 (1.53E-06)	3.6E-10 (1E-11)	79.1
CD19(018) CD3 _{opt}	3.35E+05 (9.64E+03)	3.83E-04 (7.37E-06)	1.14E-09 (6E-11)	30.2

Table 3. Binding to human CD3: Kinetic constants. Average and standard deviation (in parenthesis) of independent dilutions series in the same run.

Molecule	k_{on} (1/Ms)	k_{off} (1/s)	K_D (M)	$t_{1/2}$ (min)
CD19(018) CD3 _{orig}	9.33E+05 (2.57E+04)	3.33E-03 (1.01E-04)	3.57E-09 (1.7E-10)	3.5
CD19(2B11) CD3 _{orig}	1.13E+06 (5.77E+03)	3.78E-03 (1.10E-04)	3.36E-09 (1.1E-10)	3.1
CD19(2B11) CD3 _{opt}	2.37E+06 (1.93E+05)	8.38E-03 (1.49E-04)	3.55E-09 (2.2E-10)	1.4
CD19(018) CD3 _{opt}	4.39E+06 (7.22E+05)	1.30E-02 (1.00E-03)	2.98E-09 (2.5E-10)	0.9

- 5 The different binders show similar affinities in the different TCBs. The CD19 binder 2B11 has a K_D of around 0.4 nM in the respective TCBs. The CD19 binder 018 is of slightly lower affinity with a K_D around 1.1 nM in the respective TCBs. The TCBs with CD3 binder CD3_{orig} or CD3_{opt} have comparable affinity to CD3 with a K_D around 3.4 nM. While the K_D of the interaction with

CD19 and CD3 antigens are similar, the kinetic is different. CD19 dissociates slower than CD3 does, but CD3 associates faster than CD19 does, thus leading to similar K_D values.

Example 6 – Binding of CD19-TCB molecules with optimized anti-CD3 antibody to human

5 CD19- and human CD3-expressing cells

The binding of the CD19-TCB molecules prepared in Example 4 to human CD19- and CD3-expressing target cells was tested. Two CD19-expressing cell lines with different levels of CD19 expression were used. Nalm-6, an acute lymphoblastic leukemia (ALL) cell line with high CD 19 expression and Z-138 (Mantle cell lymphoma) with average expression levels. CD3-binding was assessed using immortalized T lymphocyte line (Jurkat cell line). Briefly, cells were harvested, counted, checked for viability and resuspended at 1×10^6 cells/ml in FACS buffer (PBS + 2% FCS + 5 mM EDTA + 0.25% sodium azide). 100 μ l of cell suspension (containing 0.1×10^6 cells) were incubated in round-bottom 96-well plate for 30 min at 4°C with increasing concentrations of CD19-TCB molecules (200 nM – 0.05nM on Jurkat cells; 200 nM – 0.0002 nM on Z-128 and

15 Nalm-6 cells), washed twice with cold FACS buffer, re-incubated for further 30 min at 4°C with the PE-conjugated AffiniPure F(ab')₂ Fragment goat anti-human IgG Fc γ fragment specific secondary antibody (Jackson Immuno Research Lab PE #109-116-170), washed twice with cold FACS buffer and immediately analyzed by FACS using a FACS CantoII (software FlowJo 10.5.3). Binding curves and the EC50 values related to binding were calculated using GraphPad Prism 7.

20 The results are shown in **Figure 7** and **Table 4** and **5**. The CD19-TCB molecules comprising CD3_{opt} as CD3 binder show comparable (or slightly better) CD3 binding to molecules comprising the CD3 binder CD3_{orig} (**Figure 7A** and **Table 4**).

The CD19-TCB molecules (comprising either 2B11 or 018 as CD19 binders) show comparable binding to CD19-expressing cells (**Figure 7B, C** and **Table 5**). For Z-138 cells, the EC50 values

25 could not be calculated since the binding curve did not reach saturation.

Table 4. EC50 values (nM) of binding of CD19-TCBs to human CD3-expressing Jurkat cells.

Antibodies	EC50 [nM]
CD19(2B11) CD3 _{opt}	53.45
CD19(018) CD3 _{opt}	126.5

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CD19(2B11) CD3 _{orig}	203.4
CD19(018) CD3 _{orig}	115.1

Table 5. EC50 values (nM) of binding of CD19-TCBs to human CD19-expressing target Nalm-6 cells.

Antibodies	EC50 [nM]
CD19(2B11) CD3 _{opt}	0.6
CD19(018) CD3 _{opt}	1
CD19(2B11) CD3 _{orig}	0.7
CD19(018) CD3 _{orig}	1.5

5

Example 7 – Tumor cell lysis and T cell activation, induced by CD19-TCB molecules with optimized anti-CD3 antibody

The lysis of CD19-expressing tumor cells and subsequent T cell activation mediated by the CD19-TCB molecules prepared in Example 4 was assessed on Nalm-6 cells (ALL) and Z-138 cells (Mantle cell lymphoma). Human PBMCs were used as effectors and tumor lysis was detected at 20 h of incubation with the different TCB molecules.

Peripheral blood mononuclear cells (PBMCs) were prepared by Histopaque density centrifugation of enriched lymphocyte preparations (buffy coats) obtained from a healthy human donor. Fresh blood was diluted with sterile PBS and layered over Histopaque gradient (Sigma, #H8889). After centrifugation (450 x g, 30 minutes, no brake, room temperature), the plasma above the PBMC-containing interphase was discarded and PBMCs transferred in a new falcon tube subsequently filled with 50 ml of PBS. The mixture was centrifuged (350 x g, 10 minutes, room temperature), the supernatant discarded and the PBMC pellet incubated in erythrocyte lysing solution for 5 min at 37°C before washing with sterile PBS (centrifugation 300 x g, 10 minutes). The resulting PBMC population was resuspended in PBS and counted automatically (ViCell). 50 mio PBMCs per cyrovial were frozen in RPMI1640 medium (Gibco, #21870076) containing 10% FCS and 1% GlutaMAX (Gibco) containing 10% DMSO (Sigma, #D2650). PBMCs were thawed the day of the assay and counted again automatically (ViCell). The amount needed was washed once with

sterile PBS. B cell depletion was performed using CD20 microbeads (Miltenyi, #130-091-104) according to the manufacturer's instructions. B cell depleted PBMCs were counted (ViCell) and resuspended at 5×10^6 cells / ml in RPMI1640 medium containing 10% FCS and 1% GlutaMAX.

For the killing assay, 0.25 mio B cell-depleted PBMCs were added to the U-bottom 96-well plates.

- 5 Briefly, target cells were harvested, washed, and plated at density of 50 000 cells/well resulting in an final effector-to-target (E:T) ratio of 5:1. The TCB molecules were added at the indicated concentrations (range of 0.02 pM – 1000 pM, in triplicates). CD107a (LAMP-1) was directly stained already in the assay (PE anti-human CD107a; Biolegend, #328608).

- 10 Tumor cell lysis was assessed after 20 h of incubation at 37°C, 5% CO₂ by quantification of LDH released into cell supernatants by apoptotic/necrotic cells (LDH detection kit, Roche Applied Science, #11 644 793 001). Maximal lysis of the target cells (= 100%) was achieved by incubation of target cells with 1% Triton X-100. Minimal lysis (= 0%) refers to target cells co-incubated with effector cells without bispecific construct.

- For the assessment of T cell activation occurring upon tumor cell lysis, PBMCs were centrifuged
15 at 400 x g for 4 min and washed twice with FACS buffer. Briefly, cells were washed twice with PBS, followed by live/dead staining (Zombie Aqua Fixable Viability kit; Biolegend, #423102, 20 min at RT). After repeated washing first with PBS followed by FACS Buffer the surface staining for CD3 (PE-Cy5 anti-human CD3; BD Pharmigen, #555341), CD4 (BV605 anti-human CD4; Biolegend, #317438), CD8 (BV711 anti-human CD8; Biolegend, #301044), CD25 (PE-Cy7 anti-
20 human CD25; Biolegend, #302612) and CD69 (BV421 anti-human CD69; Biolegend, #310930) was performed according to the suppliers' indications. Cells were washed twice with 150 µl/well FACS buffer and fixed with 120 µl/well 1x lysing solution (BD Biosciences # 349202). Samples were analyzed at BD FACS Fortessa (Software FlowJo 10.5.3).

Figure 8 shows that CD19-TCB molecules induced target-specific killing of CD19+ target cells.

- 25 The four different CD19-TCB molecules were overall comparable in inducing lysis of CD19-expressing tumor cells. **Figure 9** and **10** show that the CD19-TCBs containing the CD3_{opt} binder show slightly superior induction of T cell activation after tumor killing (CD25, CD69 and CD107 expression on CD8 and CD4 T cells upon killing of Nalm-6 or Z-138 target cells) compared to molecules containing the CD3_{orig} binder. No effect on T cell activation of the CD19 binders 2B11
30 and 018 was observed.

Table 6. EC50 values (pM) of tumor cell lysis mediated by CD19-TCB molecules evaluated on CD19-expressing tumor target cells.

EC50 (pM)	Nalm-6	Z-138
CD19(2B11) CD3 _{opt}	0.24	2.9
CD19(018) CD3 _{opt}	0.4	3
CD19(2B11) CD3 _{orig}	0.3	4.8
CD19(018) CD3 _{orig}	0.3	5.4

Table 7. EC50 values (pM) of T cell activation upon tumor cell lysis mediated by CD19-TCB molecules using Z-138 as target cells.

Activation marker	CD19(2B11) CD3 _{opt}	CD19(018) CD3 _{opt}	CD19(2B11) CD3 _{orig}	CD19(018) CD3 _{orig}
CD25/CD4	1.3	1.4	2	2
CD69/CD4	0.3	0.5	0.6	0.7
CD107a/CD4	0.6	0.8	1.3	1.4
CD25/CD8	0.9	1	1.5	1.7
CD69/CD8	0.2	0.4	0.6	0.8
CD107a/CD8	0.5	0.7	1.3	1.4

Table 8. EC50 values (pM) of T cell activation upon tumor cell lysis mediated by CD19-TCB molecules using Nalm-6 as target cells.

Activation marker	CD19(2B11) CD3 _{opt}	CD19(018) CD3 _{opt}	CD19(2B11) CD3 _{orig}	CD19(018) CD3 _{orig}
CD25/CD4	8	11	12	7
CD69/CD4	0.9	1.2	1.9	1.7
CD107a/CD4	4.1	3.6	6.9	5.5
CD25/CD8	2.1	2.4	3.4	2.8
CD69/CD8	0.2	0.4	0.7	0.4
CD107a/CD8	1.2	1.4	2.1	1.9

Example 8 – Determination of thermal stability of CD19-TCB molecule with optimized anti-CD3 antibody

Thermal stability of the CD19-TCB molecule comprising the optimized anti-CD3 antibody CD3_{opt} (and the CD19 binder 2B11, see Example 4) was monitored by Static Light Scattering (SLS) by applying a temperature ramp using an Uncle system (Unchained Labs, USA).

9 µl of filtered protein sample with a protein concentration of 1 mg/ml was applied to the Uncle device. The temperature was ramped from 30 to 90°C at 0.1°C/min, with scattering intensity at 266 nm being collected.

The result is shown in **Table 9**.

Table 9. Thermal stability of CD19-TCB molecule as measured by static light scattering.

anti-CD3 antibody	T _{agg} [°C]
CD3 _{opt}	64.8

Example 9 – Characterization of CD19-TCB molecule with optimized anti-CD3 antibody by surface plasmon resonance (SPR) after stress

In order to confirm the effect of the deamidation site removal and its effect on the stability of the antibody, the CD19-TCB molecule comprising the optimized anti-CD3 antibody CD3_{opt} (and the CD19 binder 2B11, see Example 4) was incubated for 14 days at 37°C, pH 7.4 and at 40°C, pH 6 and further analyzed by SPR for their binding capability to human CD3ε/δ. Samples stored at -80°C pH 6 were used as reference. The reference samples and the samples stressed at 40°C were in 20 mM His, 140 mM NaCl, pH 6.0, and the samples stressed at 37°C in PBS, pH 7.4, all at a concentration of 1.0 mg/ml. After the stress period (14 days) samples in PBS were dialyzed back to 20 mM His, 140 mM NaCl, pH 6.0 for further analysis.

All SPR experiments were performed on a Biacore T200 instrument (GE Healthcare) at 25°C with HBS-P+ (10 mM HEPES, 150 mM NaCl pH 7.4, 0.05% Surfactant P20) as running and dilution buffer. Biotinylated human CD3ε/δ (see Examples 2, SEQ ID NOs 41 and 42) as well as biotinylated anti-huIgG (Capture Select, Thermo Scientific, #7103262100) were immobilized on a Series S Sensor Chip SA (GE Healthcare, #29104992), resulting in surface densities of at least 1000 resonance units (RU). TCBs with a concentration of 2 µg/ml were injected for 30 s at a flow

rate of 5 μ l/min, and dissociation was monitored for 120 s. The surface was regenerated by injecting 10 mM glycine pH 1.5 for 60 s. Bulk refractive index differences were corrected by subtracting blank injections and by subtracting the response obtained from a blank control flow cell. For evaluation, the binding response 5 seconds after injection end was taken. To normalize the binding signal, the CD3 binding was divided by the anti-huIgG response (the signal (RU) obtained upon capture of the TCB on the immobilized anti-huIgG antibody). The relative binding activity was calculated by referencing each temperature stressed sample to the corresponding, non-stressed sample.

As shown in **Table 10**, binding of the CD19-TCB comprising the optimized anti-CD3 binder CD3_{opt} to CD3 ϵ/δ is essentially unaffected upon stress, in line with the results for the CD3 binder as such (Example 2).

Table 10. Binding activity of CD19-TCB molecule to human CD3 ϵ/δ after incubation at pH 6/40°C or pH 7.4/37°C for 2 weeks.

anti-CD3 antibody	binding activity [%]	
	2 weeks at pH 6.0/40°C	2 weeks at pH 7.4/37°C
CD3 _{opt}	98	98

15

Example 10 – *in vivo* B cell depletion and cytokine release induced by CD19-TCB molecule with optimized anti-CD3 antibody

To understand the potency and safety profile of the CD19-TCB molecule comprising the the optimized anti-CD3 antibody CD3_{opt} and the 2B11 CD19 binder, an *in vivo* mode of action study was conducted assessing peripheral B cell depletion and cytokine release in humanized NSG mice.

Female NSG mice, age 4-5 weeks at start of the experiment (Jackson Laboratory), were maintained under specific-pathogen-free condition with daily cycles of 12 h light / 12 h darkness according to committed guidelines (GV-Solas; Felasa; TierschG). The experimental study protocol was reviewed and approved by local government (ZH223-17). After arrival, animals were maintained

for one week to get accustomed to the new environment and for observation. Continuous health monitoring was carried out on a regular basis.

- Female NSG mice were injected i.p. with 15 mg/kg of Busulfan followed one day later by an i.v. injection of 1×10^5 human hematopoietic stem cells isolated from cord blood. At week 14-16 after stem cell injection, mice were bled sublingual and blood was analyzed by flow cytometry for successful humanization. Efficiently engrafted mice were randomized according to their human T cell frequencies into the different treatment groups. Following randomization, mice from three groups were pre-treated once with obinutuzumab (Gazyva®) (30mg/kg), as a measure to prevent excessive cytokine release.
- 7 days after this pre-treatment, on day 0, all groups received the CD19-TCB at different doses, CD20-TCB (a TCB targeting CD20 and comprising the CD3 binder CD3_{orig}), or vehicle. Three different doses (0.5, 0.15 and 0.05 mg/kg) of CD19-TCB were injected. CD20-TCB (0.15 mg/kg) with and without Gazyva® pre-treatment was used as comparison agent. All mice were injected i.v. with 200 µl of the appropriate solution. Three mice per group were bled at 4 h, 24 h and 72 h after therapy (day 0).

The study design is shown in **Figure 11**, and the study groups are summarized in **Table 11**.

Table 11. Study groups (number of animals per group = 3, treatment administration = i.v.)

Group	Treatment	Dose (mg/kg)
A	Vehicle	-
B	CD19-TCB	0.5
C	CD19-TCB	0.15
D	CD19-TCB	0.05
E	Obinutuzumab (Gazyva®) CD19-TCB	30 0.5
F	CD20-TCB	0.15
G	Obinutuzumab (Gazyva®) CD20-TCB	30 0.15

- At termination (day 3), mice were sacrificed and spleen, lymph nodes (LN) and bone marrow (BM) were harvested, weighed, and single cell suspensions were prepared through an enzymatic

digestion with Liberase and DNase for subsequent FACS analysis. Spleen single cells as well as all blood samples were stained for human CD45, CD19, CD20 and analyzed at the BD Fortessa flow cytometer. Additionally, serum from the three bleeding time points were analyzed for cytokine content by Multiplex analysis.

- 5 **Figure 12** shows the body weight change (%) in the treatment groups. The CD19-TCB molecule induced less body weight drop compared to CD20-TCB treatment. This body weight drop was independent of the dose used. Furthermore, cytokine analysis in the sera of treated animals revealed a peak of elevated cytokine levels at 4 h after treatment with the CD20-TCB molecule (which could be reduced by pre-treatment with Gazyva® (GPT)), whereas only low levels of
10 cytokines were detected for the CD19-TCB molecule (**Figure 13**).

- The Immuno-PD data (**Figure 14**) on the kinetics of B cell depletion in blood revealed strong depletion of CD19+CD20+B cells (mean counts of CD19+ or CD20+ cells/ μ l blood $\pm$ SEM) over time by CD19-TCB and suggested a dose-dependency. This B cell depletion effect was also seen in all lymphatic organs analyzed at 72 h upon treatment with CD19-TCB being as potent as
15 CD20-TCB (data not shown).

Example 11 – Tumor growth control in mouse xenograft experiment by CD19-TCB molecule with optimized anti-CD3 antibody

- To evaluate the anti-tumor efficacy of CD19-TCB molecule comprising the the optimized anti-
20 CD3 antibody CD3_{opt} and the 2B11 CD19 binder *in vivo*, humanized NSG mice were engrafted with CD19+ lymphoma patient derived xenograft (PDX) cells from a patient who relapsed R-CHOP treatment. When the tumor volume reached 200 mm³, mice were randomized in groups of 8 based on their tumor size. They were then weekly injected with 0.5 mg/kg CD19-TCB or vehicle (i.v.) as illustrated in **Figure 15**. To assess the effect of CD19-TCB on tumor growth, tumor
25 volumes were calculated from caliper measurements twice or three times per week.

As a result, weekly treatment CD19-TCB exerted a significant tumor growth control as compared to treatment with vehicle (**Figure 16**). This data demonstrate that the weekly dosing with 0.5 mg/kg CD19-TCB is efficacious in lymphoma PDX-bearing huNSG mice, and suggest that lymphoma patients relapsing R-CHOP treatment could benefit from CD19-TCB treatment.

* * *

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, the descriptions and examples should not be
5 construed as limiting the scope of the invention. The disclosures of all patent and scientific literature cited herein are expressly incorporated in their entirety by reference.