**Title:** ANTI-CD133 ANTIBODIES AND METHODS OF USING THE SAME

**Abstract:** Antibodies with a modified Fc region comprising the amino acid substitutions 239D and 332E to enhance antibody-dependent cell cytotoxicity (ADCC) of these antibodies. Pharmaceutical compositions containing these antibodies, nucleic acids encoding these antibodies as well as methods of using such antibodies.
ANTI-CD133 ANTIBODIES AND METHODS OF USING THE SAME

FIELD OF THE INVENTION

[0001] The present invention lies in the field of antibodies and relates to CD133 specific antibodies with a modified Fc region to enhance antibody-dependent cell cytotoxicity (ADCC) as well as methods of using such antibodies.

BACKGROUND OF THE INVENTION

[0002] The cholesterol-binding transmembrane glycoprotein CD133 expressed on the cell surface of somatic stem cells, including hematopoietic, neuronal and glial stem cells, as well as endothelial progenitor cells is associated with membrane microdomains (lipid rafts) and assumed to play an important role in the organization of plasma membrane protrusions. Additionally, it has been found that CD133 is strongly expressed in many hyperproliferative or malignant cells. In fact, CD133 is considered the most important cancer stem cell (CSC)-associated marker identified so far. The expression of CD133 has been shown for numerous different cancer types, such as glioma/glioblastoma, leukemias, colon cancer, pancreatic cancer, gastric cancer etc.. Based on these results, it is assumed that aberrant CD133 activity may be involved in the development and progression of cancer. There is thus need in the art for antibodies that can specifically target and destroy CD133-expressing cells.

[0003] Thus, one object of the inventors of the present invention was to provide anti-CD133 antibodies that can bind to and kill CD133-expressing cells in vivo.

SUMMARY OF THE INVENTION

[0004] The present invention is directed to antibodies against human CD133 and methods of using the same. In certain aspects, the antibodies include a variant Fc region. In further embodiments, the antibodies are chimeric or humanized antibodies. The present invention is further directed to pharmaceutical compositions comprising these
antibodies and methods of using the antibodies in various disease indications.

[0005] In a first aspect, the present invention is directed to an antibody that binds human CD133, wherein the antibody comprises at least one amino acid substitution in the constant region relative to a parent anti-CD133 antibody, wherein at least one amino acid substitution includes the amino acid substitutions 239D and 332E, wherein the positional numbering is according to the EU index (Kabat et al., 1983). In one specific embodiment, the substitutions are S239D and I332E.

[0006] In one embodiment, the antibody specifically binds to CD133. This means that it binds to human CD133 with significantly higher affinity than to non-target molecules. Preferably the affinity of the antibody for its target is at least about 50 nM (34).

[0007] In one embodiment of the invention, the anti-CD133 antibody has cell killing activity, such as, for example, antibody-dependent cell-mediated cytotoxicity (ADCC) effector function. That means that upon contact with CD133-expressing cells, the antibody is capable of facilitating cell death, for example by triggering activation of the complement system, phagocytosis or apoptosis.

[0008] In one embodiment, the antibody comprises a heavy and a light chain. The heavy chain may comprise a VH CDR1, a VH CDR2, and a VH CDR3 region and/or the light chain may comprise a VL CDR1, a VL CDR2, and/or a VL CDR3 region.

[0009] In one specific embodiment, the VL CDR1 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences SEQ ID NO:1 and SEQ ID NO:7; the VL CDR2 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:2 and SEQ ID NO:8; the VL CDR3 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:3 and SEQ ID NO:9; the VH CDR1 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:4 and SEQ ID NO:10; the VH CDR2 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:5 and SEQ ID NO:11; and the VH CDR3 comprises, consists
essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:6 and SEQ ID NO:12.

[00010] In another specific embodiment, the \( V_L \) CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:1; the \( V_L \) CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:2; the \( V_L \) CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:3; the \( V_H \) CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:4; the \( V_H \) CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:5; and the \( V_H \) CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:6.

[00011] In still another specific embodiment, the \( V_L \) CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:7; the \( V_L \) CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:8; the \( V_L \) CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:9; the \( V_H \) CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:10; the \( V_H \) CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:11; and the \( V_H \) CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:12.

[00012] In one embodiment of the invention, the heavy chain of the invented antibody comprises a \( V_H \) domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO:14 and/or the light chain of the invented antibody comprises a \( V_L \) domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO:13.

[00013] In another embodiment of the invention, the heavy chain of the invented antibody comprises a \( V_H \) domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO:30 and/or the light chain of the invented antibody comprises a \( V_L \) domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO:29.

[00014] In another embodiment of the invention, the claimed antibody is a chimeric antibody and comprises a heavy chain having the amino acid sequence set
forth in SEQ ID NO:27 and/or a light chain having the amino acid sequence set forth in
SEQ ID NO:23.

[00015] In another embodiment of the invention, the claimed antibody is a
chimeric antibody and comprises a heavy chain having the amino acid sequence set
forth in SEQ ID NO:43 and/or a light chain having the amino acid sequence set forth in
SEQ ID NO:39.

[00016] In certain embodiments of the invention, the antibody of the invention
comprising amino acid substitutions S239D/I332E binds with enhanced affinity to the
FcyRIIIa receptor or has enhanced ADCC effector function as compared to the parent
antibody without said substitution.

[00017] In further embodiments, the antibody comprises one or more further
amino acid modifications at a position selected from the group consisting of 221, 222,
223, 224, 225, 227, 228, 230, 231, 232, 233, 234, 235, 236, 237, 238, 240, 241, 243,
244, 245, 246, 247, 249, 255, 258, 260, 262, 263, 264, 265, 266, 267, 268, 269, 270,
271, 272, 273, 274, 275, 276, 278, 280, 281, 282, 283, 284, 285, 286, 288, 290, 291,
292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 313, 317, 318,
320, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 333, 334, 335, 336, and 337,
wherein the positional numbering is according to the EU index. These one or more
further amino acid modifications may be selected from the group of amino acid
substitutions consisting of 221K, 221Y, 222E, 222Y, 223E, 223K, 224E, 224Y, 225E,
236E, 236F, 236H, 2361, 236K, 236L, 236M, 236N, 236P, 236Q, 236R, 236S, 236T,
238K, 238L, 238M, 238N, 238Q, 238R, 238S, 238T, 238V, 238W, 238Y, 240A, 2401,
243R, 243W, 243Y, 244H, 245A, 246D, 246E, 246H, 246Y, 247G, 247V, 249H, 249Q,
In a specific embodiment, the antibody comprises one or more further amino acid modifications selected from the group consisting of: 236A, 268D, 268E, 330Y, and 330L.

In another aspect, the present invention features nucleic acid molecules that encode the heavy chain and/or the light chain of an antibody of the invention. These nucleic acid molecules may comprise a nucleotide sequence that encodes the variable domain of the light chain, such as that set forth in SEQ ID NO: 17 or SEQ ID NO:33, or a nucleotide sequence that encodes the variable domain of the heavy chain, such as that set forth in SEQ ID NO: 18 or SEQ ID NO:34.

In one specific embodiment, the nucleic acid encoding the light chain of the antibody of the invention has a nucleotide sequence selected from the group consisting of SEQ ID Nos. 24 and 40.

In another specific embodiment, the nucleic acid encoding the heavy chain of the antibody of the invention has a nucleotide sequence selected from the group consisting of SEQ ID Nos. 28 and 44.

In a further aspect, the present invention relates to a method of treating a CD133-related disease or disorder, wherein said method includes administering the antibody of the invention to a subject in need thereof. The subject may, for example, be an animal or human, preferably a mammal, such as a human.

In one embodiment, said disease or disorder is a cell proliferative disease or disorder. The cell-proliferative disease or disorder may, for example, be cancer. The cancer may be a solid tumor and may be selected from the group consisting of glioma/glioblastoma, melanoma, pancreatic cancer, gastric cancer, colon cancer, colorectal cancer, breast cancer, ovarian cancer, sarcoma, prostate carcinoma, liver cancer and lung cancer, or may be a haematological malignancy, such as a lymphoma or leukemia. The lymphoma or leukemia may be selected from the group consisting of: non-Hodgkin's lymphomas (NHL), chronic lymphocytic leukemia (CLL), B-cell acute lymphoblastic leukemia/lymphoma (B-ALL), mantle cell lymphoma (MCL), hairy cell leukemia (HCL), chronic myeloid leukemia (CML), acute myeloid leukemia, and multiple myeloma (MM). In a preferred embodiment, the lymphoma is chronic lymphocytic leukemia (CLL). In another embodiment, the disease or disorder is myelodysplastic syndrome (MDS).
[00025] In certain embodiments of the invented methods, the antibody may be administered in combination with at least one agent selected from the group consisting of a cytotoxic agent, a chemotherapeutic agent, a cytokine, a growth inhibitory agent, an anti-hormonal agent, a kinase inhibitor, an anti-angiogenic agent, a cardioprotectant, an immunostimulatory agent, an immunosuppressive agent, an angiogenesis inhibitor, a protein tyrosine kinase inhibitor, and second antibody.

[00026] In a still further aspect, the present invention also encompasses a pharmaceutical composition comprising an antibody according to the invention and a pharmaceutically acceptable carrier.

[00027] In another aspect, the present invention is directed to a method of inhibiting proliferation of a cell expressing CD133, wherein said method comprises contacting said cell with an antibody according to the invention. The method may be an in vitro method.

[00028] In a further aspect, the present invention relates to a method of enhancing antibody-dependent cell-mediated cytotoxicity toward a cell expressing CD133, wherein said method comprises contacting said cell with an antibody according to the invention.

[00029] A still further aspect of the invention is a method of depleting a mammal of at least one cell expressing CD133, wherein said method comprises administering to the mammal an antibody according to the invention.

[00030] The present invention also relates to the use of an antibody according to the present invention for treating a CD133-related disease or disorder. The CD133-related disease or disorder may be a cell proliferative disease or disorder. The cell-proliferative disease or disorder may, for example, be cancer. The cancer may be selected from the group consisting of glioma/glioblastoma, melanoma, pancreatic cancer, gastric cancer, colon cancer, colorectal cancer, breast cancer, ovarian cancer, sarcoma, prostate carcinoma, liver cancer, lung cancer and haematological malignancies, such as lymphomas and leukemias. The lymphoma or leukemia may be selected from the group consisting of: non-Hodgkin's lymphomas (NHL), chronic lymphocytic leukemia (CLL), B-cell acute lymphoblastic leukemia/lymphoma (B-ALL), mantle cell lymphoma (MCL), hairy cell leukemia (HCL), chronic myeloid leukemia (CML), acute myeloid leukemia, and multiple myeloma (MM). In a preferred
embodiment, the lymphoma is chronic lymphocytic leukemia (CLL). In another embodiment, the disease or disorder is myelodysplastic syndrome (MDS).

[00031] In another embodiment, the invention relates to the use of an antibody according to the invention for the targeting of a cell expressing CD133. The targeting may include the use of the antibody to deliver a drug or a toxin to the CD133-expressing cell.

[00032] In a still further aspect, the invention encompasses the use of an antibody according to the invention for the detection of a cell expressing CD133 in a biological sample. For such use, the antibody may be labeled with a detectable moiety, such as a fluorophore, chromophore, immunogenic tag and the like.

[00033] The present invention is also directed to a monoclonal antibody against CD133, wherein the antibody is produced by a transfected producer cell line, such as CHO or Sp2/0.

[00034] In a still further aspect, the invention features a transfected cell line producing an antibody according to the invention. The cell line may be a CHO or Sp2/0 cell line

**BRIEF DESCRIPTION OF THE DRAWINGS**

[00035] The invention will be better understood with reference to the detailed description when considered in conjunction with the non-limiting examples and the accompanying drawings.

[00036] Figure 1 shows a schematic representation of the cloning procedure for chimerization of monoclonal antibodies. Boxes represent exons, circle indicate enhancer elements and thin lines UT regions and intron sequences. P, promoter; L_1 and L_2, leader sequences encoded by two different exons; E, enhancer; V, variable region; D, diversity region; J, joining region; C_{1.3} exons of constant region; H, hinge region.

[00037] Figure 2 shows the parental vector containing the VJ region of the mouse light chain and the C region of human κ gene. The region relevant for the fragment exchange is shown enlarged in Figure 2A. The sequence context generated upon insertion of the VJ region of monoclonal antibodies 293AC1C3B9 or W6B3H10 into the expression vector chimCD133-light is shown by using W6B3H10 as an example in
Figure 2B. The cleavage site for secretory signal peptides is indicated by j; and exon-intron boundaries by [, ].

[00038] Figure 3 shows the original vector containing the human \( \gamma_1 \) isotype Ig heavy chain. The region relevant for cloning the VDJ fragment is shown enlarged (a). The MluI-SpI fragment to be exchanged (shown enlarged as b) contains the entire constant region of the human \( \gamma_1 \) heavy chain and two amino acid modifications in the CH2 domain as indicated (Ser\(_{129}\)-Asp; Iso\(_{332}\)-Glu). Figure 3B shows the sequence context generated upon insertion of the VDJ region of the heavy chain of monoclonal antibodies 293AC1C3B9 or W6B3H10 into the heavy chain expression vector chimCD133-heavy by means of using the sequence of W6B3H10 as an example. The cleavage site for secretory signal peptides is indicated by |; and exon-intron boundaries by [, ].

[00039] Figure 4 shows the cell killing effects of the Fc optimized chimeric antibodies chim293AC1C3B9-SDIE (A) and chimW6B3H10-SDIE (B) respectively and unstimulated human PBMCs against cultured CD133-expressing human WERI-Rbl cells in comparison to the unmodified chimeric antibodies chim293AC1C3B9 and chimW6B3H10. Fig. 4 C shows the cell killing effects of chimeric antibodies directed to NG2 that have been Fc optimized in the same positions as the above antibodies on human SKMel63-melanoma cells. Cytotoxicity was determined using a chromium release assay, duration of the assay and target-effector ratios are indicated.

[00040] Figure 5 shows the binding of CD133 antibody 293C3 (293AC1C3B9) to PBMC of 9 patients with chronic lymphatic leukemia (CLL), as determined by flow cytometry.

[00041] Figure 6 shows an amino acid sequence alignment of the light (A) and heavy (B) chain variable regions of the anti-CD133 antibody clones 293AC1C3B9 and W6B3H10.

DETAILED DESCRIPTION OF THE INVENTION

[00042] The terms used herein have, unless explicitly stated otherwise, the following meanings.

[00043] By "ADCC" or "antibody dependent cell-mediated cytotoxicity" as used
herein is meant the cell mediated reaction wherein cytotoxic cells that express FcγRs recognize bound antibody on a target cell and subsequently cause lysis of the target cell.

[00044] By "ADCP" or "antibody dependent cell-mediated phagocytosis" as used herein is meant the cell-mediated reaction wherein nonspecific cytotoxic cells that express FcγRs recognize bound antibody on a target cell and subsequently cause phagocytosis of the target cell.

[00045] By "amino acid" and "amino acid identity" as used herein is meant one of the 20 naturally occurring amino acids or any non-natural analogues that may be present at a specific, defined position. Thus "amino acid" as used herein is both naturally occurring and synthetic amino acids. For example, homophenylalanine, citrulline and noreleucine are considered amino acids for the purposes of the invention. "Amino acid" also includes imino acid residues such as proline and hydroxyproline. The side chain may be in either the (R) or the (S) configuration. In an embodiment, the amino acids are in the (S) or L-configuration. If non-naturally occurring side chains are used, non-amino acid substituents may be used, for example to prevent or retard in vivo degradation.

[00046] By "antibody" herein is meant a protein consisting of one or more polypeptides substantially encoded by all or part of the recognized immunoglobulin genes. The recognized immunoglobulin genes, for example in humans, include the kappa (κ), lambda (λ), and heavy chain genetic loci, which together comprise the myriad variable region genes, and the constant region genes μ (μ), delta (δ), gamma (γ), epsilon (ε), and alpha (α) which encode the IgM, IgD, IgG (IgG1, IgG2, IgG3, and IgG4), IgE, and IgA (IgA1 and IgA2) isotypes respectively. Antibody herein is meant to include full length antibodies and antibody fragments, and may refer to a natural antibody from any organism, an engineered antibody, or an antibody generated recombinantly for experimental, therapeutic, or other purposes.

[00047] By "B cell" or "B lymphocyte" as used herein is meant a type of lymphocyte developed in bone marrow that circulates in the blood and lymph, and provides humoral immunity. B cells recognize free antigen molecules and differentiate or mature into plasma cells that secrete immunoglobulin (antibodies) that inactivate the antigens. Memory cells are also generated that make the specific immunoglobulin (antibody) on subsequent encounters with such antigen.

[00048] By "T cell" or "T lymphocyte" as used herein is meant a type of
lymphocyte developed in bone marrow that circulates in the blood and the lymph, and provides cellular immunity. T cells comprise a T cell receptor that recognizes cell-bound antigen molecules. T cells can mature into helper T cells that secrete cytokines and activate other cell types or cytotoxic T cells that bind to and destroy other cells.

[00049] By "CD133", "Prominin 1" or "PROM1" as used interchangeably herein is meant a cholesterol-binding transmembrane glycoprotein. The protein is 846 amino acids long and spans the membrane 5 times and has two large extracellular loops. The N-terminus is located in the extracellular space and the C-terminus is located in the cytoplasm. It is expressed on the cell surface of somatic stem cells, including hematopoietic, neuronal and glial stem cells, as well as endothelial progenitor cells is associated with membrane microdomains (lipid rafts) and assumed to play an important role in the organization of plasma membrane protrusions. Additionally, it has been found that CD133 is strongly expressed in many hyperproliferative or malignant cells. In fact, CD133 is considered the most important cancer stem cell (CSC)-associated marker identified so far. The expression of CD133 has been shown for numerous different cancer types, such as glioma/glioblastoma, leukemias, such as chronic lymphatic leukemia, colon cancer, pancreatic cancer, gastric cancer etc.. Based on these results, it is assumed that aberrant CD133 activity may be involved in the development and progression of cancer. The sequence of human CD133 is provided in SEQ ID NO:71.

[00050] By "CDC" or "complement dependent cytotoxicity" as used herein is meant the reaction wherein one or more complement protein components recognize bound antibody on a target cell and subsequently cause lysis of the target cell.

[00051] By "constant region" of an antibody as defined herein is meant the region of the antibody that is encoded by one of the light or heavy chain immunoglobulin constant region genes.

[00052] By "constant light chain" or "light chain constant region" as used herein is meant the region of an antibody encoded by the kappa (Ck) or lambda (Ck) light chains. The constant light chain typically comprises a single domain, and as defined herein refers to positions 108-214 of Ck or lambda Ck, wherein numbering is according to the EU index.

[00053] By "constant heavy chain" or "heavy chain constant region" as used
herein is meant the region of an antibody encoded by the mu, delta, gamma, alpha, or epsilon genes to define the antibody's isotype as IgM, IgD, IgG, IgA, or IgE, respectively. For full length IgG antibodies, the constant heavy chain, as defined herein, refers to the N-terminus of the CH1 domain to the C-terminus of the CH3 domain, thus comprising positions 118-447, wherein numbering is according to the EU index.

[00054] By "effector function" as used herein is meant a biochemical event that results from the interaction of an antibody Fc region with an Fc receptor or ligand. Effector functions include FcyR-mediated effector functions such as ADCC and ADCP, and complement-mediated effector functions such as CDC.

[00055] By "effector cell" as used herein is meant a cell of the immune system that expresses one or more Fc receptors and mediates one or more effector functions. Effector cells include but are not limited to monocytes, macrophages, neutrophils, dendritic cells, eosinophils, mast cells, platelets, B cells, large granular lymphocytes, Langerhans' cells, natural killer (NK) cells, and T cells and may be from any organism including but not limited to humans, mice, rats rabbits, and monkeys.

[00056] By "Fab" or "Fab region" as used herein is meant the polypeptides that comprise the VH, CH1, VH, and CL immunoglobulin domains. Fab may refer to this region in isolation, or this region in the context of a full length antibody or antibody fragment.

[00057] By "Fc" or "Fc region", as used herein is meant the polypeptide comprising the constant region of an antibody excluding the first constant region immunoglobulin domain Thus Fc refers to the last two constant region immunoglobulin domains of IgA, IgD, and IgG, and the last three constant region immunoglobulin domains of IgE and IgM, and the flexible hinge N-terminal to these domains. For IgA and IgM, Fc may include the J chain. For IgG, Fc comprises immunoglobulin domains C\text{\gamma}2 and C\text{\gamma}3 and the hinge between C\text{\gamma}i and C\tau2. Although the boundaries of the Fc region may vary, the human IgG heavy chain Fc region is usually defined to comprise residues C226 or P230 to its carboxyl-terminus, wherein the numbering is according to the EU index as in Kabat. Fc may refer to this region in isolation, or this region in the context of an Fc polypeptide, for example an antibody.

[00058] By "Fc polypeptide" as used herein is meant a polypeptide that comprises all or part of an Fc region Fc polypeptides include antibodies Fc fusions, isolated Fes,
and Fc fragments.

[00059] By "Fc gamma receptor" or "FcyR" as used herein is meant any member of the family of proteins that bind the IgG antibody Fc region and are substantially encoded by the FcyR genes. In humans this family includes but is not limited to FcyRI (CD64), including isoforms FcyRIa, FcyRIb, and FcyRIc; FcyRII (CD32), including isoforms FcyRIIa (including allotypes H131 and R131), FcyRIIb (including FcyRIIb-1 and FcyRIIb-2), and FcyRIIc; and FcyRIII (CD16), including isoforms FcyRIIIa (including allotypes V158 and F158) and FcyRIIIb (including allotypes FcyRIIIb-NAl and FcyRIIIb-NA2) (Jefferis et al., 2002, Immunol Lett 82:57-65), as well as any undiscovered human FcyRs or FcyR isoforms or allotypes. Mouse FcyRs include but are not limited to FcyRI (CD64), FcyRII (CD32), FcyRIII (CD16), and FcyRIII-2 (CD16-2), as well as any undiscovered mouse FcyRs or FcyR isoforms or allotypes. An FcyR may be from any organism, including but not limited to humans, mice, rats, rabbits, and monkeys.

[00060] By "Fc ligand" or "Fc receptor" as used herein is meant a molecule, e.g., a polypeptide, from any organism that binds to the Fc region of an antibody to form an Fc-ligand complex. Fc ligands include but are not limited to FcyRs, FcRn, C1q, C3, mannan binding lectin, mannos receptor, staphylococcal protein A, streptococcal protein G, and viral FcyR. Fc ligands also include Fc receptor homologs (FcRH), which are a family of Fc receptors that are homologous to the FcyRs (Davis et al., 2002, Immunological Reviews 190:123-136). Fc ligands may include undiscovered molecules that bind Fc.

[00061] By "IgG" as used herein is meant a polypeptide belonging to the class of antibodies that are substantially encoded by a recognized immunoglobulin gamma gene. In humans this class comprises IgG1, IgG2, IgG3, and IgG4. In mice this class comprises IgG1, IgG2a, IgG2b, IgG3.

[00062] By "immunoglobulin (Ig)" herein is meant a protein consisting of one or more polypeptides substantially encoded by immunoglobulin genes. Immunoglobulins include but are not limited to antibodies. Immunoglobulins may have a number of structural forms, including but not limited to full length antibodies, antibody fragments, and individual immunoglobulin domains.
By "immunoglobulin (Ig) domain" herein is meant a region of an immunoglobulin that exists as a distinct structural entity as ascertained by one skilled in the art of protein structure. Ig domains typically have a characteristic β-sandwich folding topology. The known Ig domains in the IgG class of antibodies are VH, Cy1, Cy2, Cy3, VL, and CL.

By "amino acid modification" herein is meant an amino acid substitution, insertion, and/or deletion in a polypeptide sequence.

By "amino acid substitution" or "substitution" herein is meant the replacement of an amino acid at a particular position in a parent polypeptide sequence with another amino acid. For example, the substitution I332E refers to a variant polypeptide, in this case a constant heavy chain variant, in which the isoleucine at position 332 is replaced with glutamic acid. The wildtype residue may or may not be designated. For the preceding example, 332E indicates the substitution of position 332 with a glutamic acid. For the purposes herein, multiple substitutions are typically separated by a slash. For example, 239D/332E refers to a double variant comprising the substitutions 239D and 332E.

By "amino acid insertion" or "insertion" as used herein is meant the addition of an amino acid at a particular position in a parent polypeptide sequence. For example, insert -236G designates an insertion of glycine at position 236.

By "amino acid deletion" or "deletion" as used herein is meant the removal of an amino acid at a particular position in a parent polypeptide sequence. For example, G236- designates the deletion of glycine at position 236.

By "parent polypeptide", "parent protein", "precursor polypeptide", or "precursor protein" as interchangeably used herein is meant a polypeptide that is subsequently modified to generate a variant, e.g., any polypeptide which serves as a template and/or basis for at least one amino acid modification described herein. The parent polypeptide may be a naturally occurring polypeptide, or a variant or engineered version of a naturally occurring polypeptide. Parent polypeptide may refer to the polypeptide itself, compositions that comprise the parent polypeptide, or the amino acid sequence that encodes it. Accordingly, by "parent antibody" or "parent immunoglobulin" as used herein is meant an antibody or immunoglobulin that is modified to generate a variant (e.g., a parent antibody may include, but is not limited to,
a protein comprising the constant region of a naturally occurring Ig).

[00069] By "protein" or "polypeptide" as used herein is meant at least two covalently attached amino acids, which includes proteins, polypeptides, oligopeptides and peptides. The protein may be made up of naturally occurring amino acids and peptide bonds, or synthetic peptidomimetic structures, i.e. "analogs", such as peptoids.

[00070] By "position" as used herein is meant a location in the sequence of a protein. Positions may be numbered sequentially, or according to an established format, for example the EU index as in Kabat (Kabat et al., 1983). If not indicated otherwise, all positions mentioned herein are numbered according to the EU index. Corresponding positions are determined as outlined herein, generally through alignment with other parent sequences.

[00071] By "residue" as used herein is meant a position in a protein and its associated aminoacid identity. For example, Serine 239 (also referred to as Ser239 and S239) is a residue at position 239 in the human antibody IgGl.

[00072] By "target antigen" or "target" or "antigen" as used herein is meant the molecule that is bound specifically by the variable region of a given antibody. A target antigen may be a protein, carbohydrate, lipid, or other chemical compound.

[00073] By "target cell" as used herein is meant a cell that expresses a target antigen.

[00074] By "variable region" as used herein is meant the region of an immunoglobulin that comprises one or more Ig domains substantially encoded by any of the VK, VL, and/or VH genes that make up the kappa, lambda, and heavy chain immunoglobulin genetic loci respectively.

[00075] By "variant protein", "protein variant", "variant polypeptide", or "polypeptide variant" as used herein is meant a polypeptide sequence that differs from that of a parent polypeptide sequence by virtue of at least one amino acid modification. Variant polypeptide may refer to the polypeptide itself, a composition comprising the polypeptide, or the amino sequence that encodes it. In one embodiment, the variant polypeptide has at least one amino acid modification compared to the parent polypeptide, e.g from about one to about ten amino acid modifications, e.g., from about one to about five amino acid modifications compared to the parent. The variant polypeptide sequence herein may possess at least about 80% homology with a parent
polypeptide sequence, e.g., at least about 90% homology, at least about 95% homology, etc. Accordingly, by "variant antibody" or "antibody variant" as used herein is meant an antibody sequence that differs from that of a parent antibody sequence by virtue of at least one amino acid modification. Variant antibody or antibody variant may refer to the antibody polypeptide itself, compositions comprising the antibody variant polypeptide, or the amino acid sequence that encodes it. Accordingly, by "constant heavy chain variant" or "constant light chain variant" or "Fc variant" as used herein is meant a constant heavy chain, constant light chain, or Fc region polypeptide or sequence, respectively, that differs in sequence from that of a parent sequence by virtue of at least one amino acid modification.

[00076] By "wild type" or "WT" herein is meant an amino acid sequence or a nucleotide sequence that is found in nature, including allelic variations. A WT protein, polypeptide, antibody, immunoglobulin, IgG, etc., has an amino acid sequence or a nucleotide sequence that has not been intentionally modified.

[00077] For all immunoglobulin heavy chain constant region positions discussed in the present invention, numbering is according to the EU index as in Kabat (Kabat et al., 1991, Sequences of Proteins of Immunological Interest, 5th Ed , United States Public Health Service, National Institutes of Health, Bethesda). The "EU index as in Kabat" refers to the residue numbering of the human IgG1 EU antibody, as described in Edelman et al., 1969, Biochemistry 63 78-85).

[00078] "Antigens" are macromolecules capable of generating an antibody response in an animal and being recognized by the resulting antibody. Both antigens and haptens comprise at least one antigenic determinant or "epitope", which is the region of the antigen or hapten which binds to the antibody. Typically, the epitope on a hapten is the entire molecule.

[00079] The term "sample", as used herein, refers to an aliquot of material, frequently biological matrices, an aqueous solution or an aqueous suspension derived from biological material. Samples to be assayed for the presence of an analyte by the methods of the present invention include, for example, cells, tissues, homogenates, lysates, extracts, and purified or partially purified proteins and other biological molecules and mixtures thereof.

[00080] Non-limiting examples of samples typically used in the methods of the
invention include human and animal body fluids such as whole blood, serum, plasma, cerebrospinal fluid, sputum, bronchial washing, bronchial aspirates, urine, semen, lymph fluids and various external secretions of the respiratory, intestinal and genitourinary tracts, tears, saliva, milk, white blood cells, myelomas and the like; biological fluids such as cell culture supernatants; tissue specimens which may or may not be fixed; and cell specimens which may or may not be fixed. The samples used in the methods of the present invention will vary based on the assay format and the nature of the tissues, cells, extracts or other materials, especially biological materials, to be assayed. Methods for preparing protein extracts from cells or samples are well known in the art and can be readily adapted in order to obtain a sample that is compatible with the methods of the invention.

[00081] "Specifically binding" and "specific binding", as used herein, mean that an antibody binds to its target (analyte) based on recognition of an epitope on the target molecule. The antibody preferably recognizes and binds to the target molecule with a higher binding affinity than it binds to other compounds that may be present. In various embodiments of the invention, "specifically binding" may mean that an antibody binds to a target molecule with at least about a $10^6$-fold greater affinity, preferably at least about a $10^7$-fold greater affinity, more preferably at least about a $10^8$-fold greater affinity, and most preferably at least about a $10^9$-fold greater affinity than it binds molecules unrelated to the target molecule. Typically, specific binding refers to affinities in the range of about $10^6$-fold to about $10^9$-fold greater than non-specific binding. In some embodiments, specific binding may be characterized by affinities greater than $10^9$-fold over non-specific binding. The binding affinity may be determined by any suitable method. Such methods are known in the art and include, without limitation, surface plasmon resonance and isothermal titration calorimetry. In a specific embodiment, the antibody uniquely recognizes and binds to the target analyte.

[00082] The term "monoclonal antibody", as used herein, refers to an antibody obtained from a population of substantially homogeneous antibodies, i.e., the individual antibodies comprising the population are identical except for possible naturally occurring mutations that may be present in minor amounts. Monoclonal antibodies are highly specific, being directed against a single antigenic site. Furthermore, in contrast to conventional (polyclonal) antibody preparations which typically include different
antibodies directed against different determinants (epitopes), each monoclonal antibody
is directed against a single determinant on the antigen. In addition to their specificity,
the monoclonal antibodies are advantageous in that they may be synthesized by
hybridoma culture, uncontaminated by other immunoglobulins. 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. The monoclonal
antibodies can include "chimeric" antibodies (U.S. Patent No. 4,816,567; and Morrison

[00083] Monoclonal antibodies may be obtained by any technique that provides
for the production of antibody molecules by continuous cell lines in culture. These
include, but are not limited to the hybridoma technique of Koehler and Milstein (1975),
Nature, 256: 495-7; and U. S. Patent No. 4,376,110), the human B-cell hybridoma
Natl. Acad. Sci. USA, 80: 2026-30), and the EBV-hybridoma technique (Cole, et al.
(1985), in Monoclonal Antibodies And Cancer Therapy, Alan R. Liss, Inc., New York,
pp. 77-96). The preparation of monoclonal antibodies specific for a target compound is
also described in Harlow and Lane, eds. (1988) Antibodies - A Laboratory Manual.
Cold Spring Harbor Laboratory, Chapter 6. Such antibodies may be of any
immunoglobulin class including IgG, IgM, IgE, IgA, IgD and any subclass thereof. The
hybridoma producing the mAb may be cultivated in vitro or in vivo. Production of high
titers of mAbs in vivo makes this a very effective method of production.

[00084] "Polyclonal antibodies" are heterogeneous populations of antibody
molecules derived from the sera of animals immunized with an antigen, or an antigenic
functional derivative thereof. For the production of polyclonal antibodies, host animals
such as rabbits, mice and goats, may be immunized by injection with an antigen or
hapten-carrier conjugate optionally supplemented with adjuvants.

[00085] Techniques described for the production of single chain antibodies (U. S.
be adapted to produce gene-single chain antibodies. Single chain antibodies are typically formed by linking the heavy and light chain fragments of the Fv region via an amino acid bridge, resulting in a single chain polypeptide.

**[00086]** Antibody fragments that recognize specific epitopes may be generated by known techniques. For example, such fragments include but are not limited to: the F(ab')2 fragments that can be produced by pepsin digestion of the antibody molecule and the Fab fragments that can be generated by reducing the disulfide bridges of the F(ab')2 fragments. Alternatively, Fab expression libraries may be constructed (Huse, et al. (1989), Science, 246: 1275-1281) to allow rapid and easy identification of monoclonal Fab fragments with the desired specificity.

**[00087]** The terms "polynucleotide" and "nucleic acid (molecule)" are used interchangeably herein to refer to polymeric forms of nucleotides of any length, including naturally occurring and non-naturally occurring nucleic acids. The polynucleotides may contain deoxyribonucleotides, ribonucleotides and/or their analogs. Methods for selection and preparation of nucleic acids are diverse and well described in standard biomolecular protocols. A typical way would be preparative PCR and chromatographic purification starting from existing template DNAs or stepwise synthesis of artificial nucleic acids. Typically, the nucleic acid molecules referred to herein are DNA molecules.

**[00088]** The term "at least one" as used herein in connection with amino acid substitutions relates to at least 1, but preferably at least 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30, 35, 40, 45, 50 or a plurality of amino acid substitutions.

**[00089]** The terms "contacting" or "incubating", as used interchangeably herein, refer generally to providing access of one component, reagent, analyte or sample to another.

**[00090]** The term "detecting" as used herein refers to any method of verifying the presence of a given molecule. The techniques used to accomplish this may include, but are not limited to, immunoassays, such as ELISA and Immuno PCR (IPCR).

**[00091]** Hematological malignancies are cancer types that affect blood, bone marrow, and lymph nodes. Hematological malignancies may derive from either of the two major blood cell lineages: myeloid and lymphoid cell lines. The myeloid cell line normally produces granulocytes, erythrocytes, thrombocytes, macrophages and mast
cells; the lymphoid cell line produces B, T, NK and plasma cells. Lymphomas, lymphocytic leukemias, and myeloma are from the lymphoid line, while acute and chronic myelogenous leukemia, myelodysplastic syndromes and myeloproliferative diseases are myeloid in origin.

[00092] Leukemia is a cancer of the blood or bone marrow and is characterized by an abnormal proliferation of blood cells, usually white blood cells (leukocytes). Leukemia is clinically and pathologically subdivided into a variety of large groups. Acute leukemia is characterized by the rapid increase of immature blood cells. This crowding makes the bone marrow unable to produce healthy blood cells. Immediate treatment is required in acute leukemia due to the rapid progression and accumulation of the malignant cells, which then spill over into the bloodstream and spread to other organs of the body. Acute forms of leukemia are the most common forms of leukemia in children. Chronic leukemia is distinguished by the excessive build up of relatively mature, but still abnormal, white blood cells. Typically taking months or years to progress, the cells are produced at a much higher rate than normal cells, resulting in many abnormal white blood cells in the blood. Whereas acute leukemia must be treated immediately, chronic forms are sometimes monitored for some time before treatment to ensure maximum effectiveness of therapy. Chronic leukemia mostly occurs in older people, but can theoretically occur in any age group. Additionally, the diseases are subdivided according to which kind of blood cell is affected. This split divides leukemias into lymphoblastic or lymphocytic leukemias and myeloid or myelogenous leukemias: In lymphoblastic or lymphocytic leukemias, the cancerous change takes place in a type of marrow cell that normally goes on to form lymphocytes, which are infection-fighting immune system cells. Most lymphocytic leukemias involve a specific subtype of lymphocyte, the B cell. In myeloid or myelogenous leukemias, the cancerous change takes place in a type of marrow cell that normally goes on to form red blood cells, some other types of white cells, and platelets.

[00093] B-cell chronic lymphocytic leukemia (B-CLL), also known as chronic lymphoid leukemia (CLL), is the most common type of leukemia. In CLL, immature B cells proliferate in an uncontrolled way and accumulate in the bone marrow and blood. CLL occurs mainly in adults, but in rare cases can also occur in teenagers and occasionally in children (inherited). Most (>75%) people newly diagnosed with CLL
are over the age of 50, and the majority are men. Most people are diagnosed without
symptoms as the result of a routine blood test that returns a high white blood cell count,
but as it advances CLL results in swollen lymph nodes, spleen, and liver, and eventually
anemia and infections. Currently, CLL is treated with chemotherapy and monoclonal
antibodies, for example alemtuzumab (directed against CD52) and rituximab (directed
against CD20).

[00094] Monoclonal antibodies are a class of therapeutic proteins that may be
used to treat cell-proliferative diseases and disorders, in particular those affecting the
hematopoietic system. A number of favorable properties of antibodies, including but not
limited to specificity for target, ability to mediate immune effector mechanisms, and
long half-life in serum, make antibodies powerful therapeutics. The present invention
describes antibodies against CD133.

[00095] CD133 has been found to be expressed among others on acute leukemia
cells.

[00096] The clinical success of antibodies directed against CD133 depends on
their potential mechanism(s) of action. There are a number of possible mechanisms by
which antibodies mediate cellular effects, including anti-proliferation via blockage of
needed growth pathways, intracellular signaling leading to apoptosis, enhanced down
regulation and/or turnover of receptors, complement-dependent cytotoxicity (CDC),
antibody-dependent cell- mediated cytotoxicity (ADCC), antibody-dependent cell-
mediated phagocytosis (ADCP) and promotion of an adaptive immune response (Cragg
403-410). Antibody efficacy may be due to a combination of these mechanisms, and
their relative importance in clinical therapy for oncology appears to be cancer
dependent.

[00097] The importance of FcyR-mediated effector functions for the activity of
some antibodies has been demonstrated in mice (Clynes et al., 1998, Proc Natl Acad Sci
U S A 95 652-656, Clynes et al., 2000, Nat Med 6 443-446,), and from observed
correlations between clinical efficacy in humans and their allotype of high (Vl58) or
low (F158) affinity polymorphic forms of FcyRIIIa (Cartron et al., 2002, Blood 99 754-
data suggest that an antibody that is optimized for binding to certain FcyRs may better
mediate effector functions, and thereby destroy target cells more effectively in patients. Thus a promising means for enhancing the anti-tumor potency of antibodies is via enhancement of their ability to mediate cytotoxic effector functions such as ADCC, ADCP, and CDC. Additionally, antibodies can mediate anti-tumor mechanism via growth inhibitory or apoptotic signaling that may occur when an antibody binds to its target on tumor cells. Such signaling may be potentiated when antibodies are presented to tumor cells bound to immune cells via FcyR. Therefore increased affinity of antibodies to FcyRs may result in enhanced antiproliferative effects.

[00098] Some success has been achieved at modifying antibodies with selectively enhanced binding to FcyRs to provide enhanced effector function. Antibody engineering for optimized effector function has been achieved using amino acid modifications (see for example USSN 10/672,280 and USSN 11/124,620.

[00099] Unfortunately, it is not known a priori which mechanisms of action may be optimal for a given target antigen. Furthermore, it is not known which antibodies may be capable of mediating a given mechanism of action against a target cell. In some cases a lack of antibody activity, either Fv-mediated or Fc-mediated, may be due to the targeting of an epitope on the target antigen that is poor for mediating such activity. In other cases, the targeted epitope may be amenable to a desired Fv-mediated or Fc-mediated activity, yet the affinity (affinity of the Fv region for antigen or affinity of the Fc region for Fc receptors) may be insufficient. Towards addressing this problem, the present invention describes modifications to anti-CD133 antibodies that provide optimized Fc-mediated activities.

[00100] Antibodies are immunological proteins that bind a specific antigen in most mammals, including humans and mice, antibodies are constructed from paired heavy and light polypeptide chains. The light and heavy chain variable regions show significant sequence diversity between antibodies, and are responsible for binding the target antigen. Each chain is made up of individual immunoglobulin (Ig) domains, and thus the generic term immunoglobulin is used for such proteins.

[00101] Natural antibody structural units typically comprise a tetramer. Each tetramer is typically composed of two identical pairs of polypeptide chains, each pair having one "light" chain (typically having a molecular weight of about 25 kDa) and one "heavy" chain (typically having a molecular weight of about 50-70 kDa). Each of the
light and heavy chains are made up of two distinct regions, referred to as the variable and constant regions. For the IgG class of immunoglobulins, the heavy chain is composed of four immunoglobulin domains linked from N- to C-terminus in the order VH-CH1-CH2-CH3, referring to the heavy chain variable domain, heavy chain constant domain 1, heavy chain constant domain 2, and heavy chain constant domain 3 respectively (also referred to as VH-Cyl-Cy2-Cy3, referring to the heavy chain variable domain, constant gamma 1 domain, constant gamma 2 domain, and constant gamma 3 domain respectively). The IgG light chain is composed of two immunoglobulin domains linked from N- to C-terminus in the order VL-CL, referring to the light chain variable domain and the light chain constant domain, respectively. The constant regions show less sequence diversity, and are responsible for binding a number of natural proteins to elicit important biochemical events.

[000102] The variable region of an antibody contains the antigen binding determinants of the molecule, and thus determines the specificity of an antibody for its target antigen. The variable region is so named because it is the most distinct in sequence from other antibodies within the same class. In the variable region, three loops are gathered for each of the V domains of the heavy chain and light chain to form an antigen-binding site. Each of the loops is referred to as a complementarity-determining region (hereinafter referred to as a "CDR"), in which the variation in the amino acid sequence is most significant. There are 6 CDRs total, three each per heavy and light chain, designated V_H CDR1, V_H CDR2, V_H CDR3, V_L CDR1, V_L CDR2, and V_L CDR3. The variable region outside of the CDRs is referred to as the framework (FR) region. Although not as diverse as the CDRs, sequence variability does occur in the FR region between different antibodies. Overall, this characteristic architecture of antibodies provides a stable scaffold (the FR region) upon which substantial antigen binding diversity (the CDRs) can be explored by the immune system to obtain specificity for a broad array of antigens. A number of high-resolution structures are available for a variety of variable region fragments from different organisms, some unbound and some in complex with antigen. Sequence and structural features of antibody variable regions are disclosed, for example, in Morea et al., 1997, Biophys Chem 68:9-16; Morea et al., 2000, Methods 20:267-279, and the conserved features of antibodies are disclosed, for example, in Maynard et al., 2000, Annu Rev Biomed Eng 2:339-376.
Antibodies are grouped into classes, also referred to as isotypes, as determined genetically by the constant region. Human constant light chains are classified as kappa (κκ) and lambda (λλ) light chains. Human heavy chains are classified as μμ, δδ, γγ, αα, or εε, and define the antibody's isotype as IgM, IgD, IgG, IgA, and IgE, respectively. The IgG class is the most commonly used for therapeutic purposes.

By "IgG" as used herein is meant a polypeptide belonging to the class of antibodies that are substantially encoded by a recognized immunoglobulin gamma gene. In humans this class comprises subclasses IgGλ, IgGδ, IgGγ, and IgGε. In mice this class comprises subclasses IgGλ, IgGδ1, IgGδ2 and IgGγ. IgM has subclasses, including, but not limited to, IgMγ and IgMδ. IgA has several subclasses, including but not limited to IgAλ and IgAδ. Thus, "isotype" as used herein is meant any of the classes or subclasses of immunoglobulins defined by the chemical and antigenic characteristics of their constant regions. The known human immunoglobulin isotypes are IgGλ, IgGδ, IgGγ, IgAλ, IgAδ, IgMγ, IgMδ, and IgE.

Also useful for the invention may be IgGs that are hybrid compositions of the natural human IgG isotypes. Effector functions such as ADCC, ADCP, CDC, and serum half-life differ significantly between the different classes of antibodies, including for example human IgGλ, IgGδ, IgGγ, IgGε, IgAλ, IgAδ, IgMγ, IgMδ, and IgM (Michaelsen et al., 1992, Molecular Immunology, 29(3): 319-326). A number of studies have explored IgGλ, IgGδ, IgGγ, and IgGε variants in order to investigate the determinants of the effector function differences between them. See for example Canfield & Morrison, 1991, J. Exp. Med. 173: 1483-1491; Chappel et al., 1991, Proc. Natl. Acad. Sci. USA 88(20): 9036-9040; Chappel et al., 1993, Journal of Biological Chemistry 268:25124-25131; Tao et al., 1991, J. Exp. Med. 173: 1025-1028; Tao et al., 1993, J. Exp. Med. 178: 661-667; Redpath et al., 1998, Human Immunology, 59, 720-727.

As described in USSN 11/256,060, filed Oct. 21, 2005, entitled "IgG Immunoglobulin Variants with Optimized Effector Function", it is possible to engineer amino acid modifications in an antibody that comprise constant regions from other immunoglobulin classes. Such engineered hybrid IgG compositions may provide improved effector function properties, including improved ADCC, phagocytosis, CDC,
and serum half-life.

[000107] As is well known in the art, immunoglobulin polymorphisms exist in the human population. Gm polymorphism is determined by the IGHG1, IGHG2 and IGHG3 genes which have alleles encoding allotypic antigenic determinants referred to as Glm, G2m, and G3m allotypes for markers of the human IgG1, IgG2 and IgG3 molecules (no Gm allotypes have been found on the gamma 4 chain). Markers may be classified into "allotypes" and "isoallotypes". These are distinguished on different serological bases dependent upon the strong sequence homologies between isotypes. Allotypes are antigenic determinants specified by allelic forms of the Ig genes. Allotypes represent slight differences in the amino acid sequences of heavy or light chains of different individuals. Even a single amino acid difference can give rise to an allotypic determinant, although in many cases there are several amino acid substitutions that have occurred. Allotypes are sequence differences between alleles of a subclass whereby the antisera recognize only the allelic differences An isoallotype is an allele in one isotype which produces an epitope which is shared with a non-polyorphic homologous region of one or more other isotypes and because of this the antisera will react with both the relevant allotypes and the relevant homologous isotypes (Clark, 1997, IgG effector mechanisms, Chem. Immunol. 65-88-1 10, Gorman & Clark, 1990, Semin. Immunol. 2(6):457-66).

[000108] Allelic forms of human immunoglobulins have been well-characterized. Additionally, other polymorphisms have been characterized (Kim, et al, 2001, J. Mol. Evol. 54 1-9, incorporated herein it its entirety by reference) At present, 18 Gm allotypes are known: Glm (1, 2, 3, 17) or Glm (a, x, f, z), G2m (23) or G2m (n), G3m (5, 6, 10, 1 1, 13, 14, 15, 16, 2 1, 24, 26, 27, 28) or G3m (bl, c3, b5, bO, b3, b4, s, t, gl, c5, u, v, g5) (Lefranc, et al, The human IgG subclasses: molecular analysis of structure, function and regulation Pergamon, Oxford, pp 43-78 (1990), Lefranc, G et al, 1979, Hum. Genet.: 50, 199-21 1). Allotypes that are inherited in fixed combinations are called Gm haplotypes. The antibodies of the present invention may be substantially encoded by any allotype, isoallotype, or haplotype of any immunoglobulin gene Antibodies of the present invention may be substantially encoded by genes from any organism, e.g., mammals, including but not limited to humans, rodents including but not limited to mice and rats, lagomorphs including but not limited to rabbits and hares,
camelidae including but not limited to camels, llamas, and dromedaries, and non-human primates, including but not limited to Prosimians, Platyrhini (New World monkeys), Cercopithecoida (Old World monkeys), and Hominoidea including the Gibbons and Lesser and Great Apes.

[000109] In one embodiment, the antibodies of the present invention are substantially human. The antibodies of the present invention may be substantially encoded by immunoglobulin genes belonging to any of the antibody classes. In one embodiment, the antibodies of the present invention comprise sequences belonging to the IgG class of antibodies, including human subclasses IgG1, IgG2, IgG3, and IgG4. In an alternate embodiment, the antibodies of the present invention comprise sequences belonging to the IgA (including human subclasses IgAI and IgA2), IgD, IgE, IgG, or IgM classes of antibodies. The antibodies of the present invention may comprise more than one protein chain. That is, the present invention may find use in an antibody that is a monomer or an oligomer, including a homo- or hetero-oligomer.

[000110] In one embodiment, the antibodies of the invention are based on human IgG sequences, and thus human IgG sequences are used as the "base" sequences against which other sequences are compared, including but not limited to sequences from other organisms, for example rodent and primate sequences, as well as sequences from other immunoglobulin classes such as IgA, IgE, IgD, IgM, and the like. It is contemplated that, although the antibodies of the present invention are engineered in the context of one parent antibody, the variants may be engineered in or "transferred' to the context of another, second parent antibody. This is done by determining the "equivalent" or "corresponding" residues and substitutions between the first and second antibodies, typically based on sequence or structural homology between the sequences of the two antibodies. In order to establish homology, the amino acid sequence of a first antibody outlined herein is directly compared to the sequence of a second antibody. After aligning the sequences, using one or more of the homology alignment programs known in the art (for example using conserved residues as between species), allowing for necessary insertions and deletions in order to maintain alignment (i.e., avoiding the elimination of conserved residues through arbitrary deletion and insertion), the residues equivalent to particular amino acids in the primary sequence of the first antibody are defined. Alignment of conserved residues may conserve 100% of such residues.
However, alignment of greater than 75% or as little as 50% of conserved residues is also adequate to define equivalent residues. Equivalent residues may also be defined by determining structural homology between a first and second antibody that is at the level of tertiary structure for antibodies whose structures have been determined. In this case, equivalent residues are defined as those for which the atomic coordinates of two or more of the main chain atoms of a particular amino acid residue of the parent or precursor (N on N, CA on CA, C on C and O on O) are within 0.13 nm, e.g., 0.1 nm, after alignment. Alignment is achieved after the best model has been oriented and positioned to give the maximum overlap of atomic coordinates of non-hydrogen protein atoms of the proteins. Regardless of how equivalent or corresponding residues are determined, and regardless of the identity of the parent antibody in which the antibodies are made, what is meant to be conveyed is that the antibodies discovered by the present invention may be engineered into any second parent antibody that has significant sequence or structural homology with the antibody. Thus, for example, if a variant antibody is generated wherein the parent antibody is human IgGl, by using the methods described above or other methods for determining equivalent residues, the variant antibody may be engineered in a human IgG2 parent antibody, a human IgA parent antibody, a mouse IgG2a or IgG2b parent antibody, and the like. Again, as described above, the context of the parent antibody does not affect the ability to transfer the antibodies of the present invention to other parent antibodies. For example, the variant antibodies that are engineered in a human IgGl antibody that targets one antigen epitope may be transferred into a human IgG2 antibody that targets a different antigen epitope, and so forth.

[000111] In the IgGl class of immunoglobulins, there are several immunoglobulin domains in the heavy chain. By "immunoglobulin (Ig) domain" herein is meant a region of an immunoglobulin having a distinct tertiary structure. Of interest in the present invention are the domains of the constant heavy chain, including, the constant heavy (CH) domains and the hinge. In the context of IgG antibodies, the IgG isotypes each have three CH regions: "CHI" refers to positions 118-220, "CH2" refers to positions 237-340, and "CH3" refers to positions 341-447 according to the EU index as in Kabat. By "hinge" or "hinge region" or "antibody hinge region" or "immunoglobulin hinge region" herein is meant the flexible polypeptide comprising the amino acids between the
first and second constant domains of an antibody. Structurally, the IgG CHI domain ends at EU position 220, and the IgG CH2 domain begins at residue EU position 237. Thus for IgG the hinge is herein defined to include positions 221 (D221 in IgGl) to 236 (G236 in IgGl), wherein the numbering is according to the EU index as in Kabat. In some embodiments, for example in the context of an Fc region, the lower hinge is included, with the "lower hinge" generally referring to positions 226 or 230. The constant heavy chain, as defined herein, refers to the N-terminus of the CHI domain to the C-terminus of the CH3 domain, thus comprising positions 118-447, wherein numbering is according to the EU index. The constant light chain comprises a single domain, and as defined herein refers to positions 108-214 of CK or C\lambda, wherein numbering is according to the EU index.

[000112] Specifically included within the definition of "antibody" are full-length antibodies. By "full length antibody" herein is meant the structure that constitutes the natural biological form of an antibody, including variable and constant regions. For example, in most mammals, including humans and mice, the full length antibody of the IgG class is a tetramer and consists of two identical pairs of two immunoglobulin chains, each pair having one light and one heavy chain, each light chain comprising immunoglobulin domains VL and CL, and each heavy chain comprising immunoglobulin domains VH, CH1 (C\gamma1), CH2 (C\gamma2), and CH3 (C\gamma3). In some mammals, for example in camels and llamas, IgG antibodies may consist of only two heavy chains, each heavy chain comprising a variable domain attached to the Fc region.

[000113] Alternatively, the antibodies can be a variety of structures, including, but not limited to antibody fragments. Antibody fragments include but are not limited to bispecific antibodies, minibodies, domain antibodies, synthetic antibodies, antibody mimetics, chimeric antibodies, antibody fusions (sometimes referred to as "antibody conjugates"), and fragments of each, respectively. Specific antibody fragments include, but are not limited to, (i) the Fab fragment consisting of VL, VH, CL and CHI domains, (ii) the Fd fragment consisting of the VH and CHI domains, (iii) the Fv fragment consisting of the VL and VH domains of a single antibody; (iv) the dAb fragment, which consists of a single variable region, (v) isolated CDR regions, (vi) F(ab')\textsubscript{2} fragments, a bivalent fragment comprising two linked Fab fragments (vii) single chain Fv molecules (scFv), wherein a VH domain and a VL domain are linked by a peptide
linker which allows the two domains to associate to form an antigen binding site (viii) bispecific single chain Fv dimers and (ix) "diabodies" or "triabodies", multivalent or multispecific fragments constructed by gene fusion. The antibody fragments may be modified. For example, the molecules may be stabilized by the incorporation of disulfide bridges linking the VH and VL domains. Examples of antibody formats and architectures are described in Holliger & Hudson, 2006, Nature Biotechnology 23(9):1126-1136, and Carter 2006, Nature Reviews Immunology 6:343-357 and references cited therein.

[000114] Antibodies of the invention may include multispecific antibodies, notably bispecific antibodies, also sometimes referred to as "diabodies". These are antibodies that bind to two (or more) different antigens. Diabodies can be manufactured in a variety of ways known in the art, e.g., prepared chemically or from hybrid hybridomas. In one embodiment, the antibody is a minibody. Minibodies are minimized antibody-like proteins comprising a scFv joined to a CH3 domain. In some cases, the scFv can be joined to the Fc region, and may include some or all of the hinge region. For a description of multispecific antibodies see Holliger & Hudson, 2006, Nature Biotechnology 23(9):1126-1136 and references cited therein.

[000115] In one embodiment, the antibody of the invention is an antibody fragment. Of particular interest are antibodies that comprise Fc regions, Fc fusions, and the constant region of the heavy chain (CH1-hinge-CH2-CH3). Antibodies of the present invention may comprise Fc fragments. An Fc fragment of the present invention may comprise from 1 - 90% of the Fc region, e.g., 10 - 90%, 30 - 90%, etc. Thus for example, an Fc fragment of the present invention may comprise an IgGl Cy2 domain, an IgGl Cy2 domain and hinge region, an IgGl Cy3 domain, and so forth. In one embodiment, an Fc fragment of the present invention additionally comprises a fusion partner, effectively making it an Fc fragment fusion. Fc fragments may or may not contain extra polypeptide sequence.

[000116] Immunogenicity is the result of a complex series of responses to a substance that is perceived as foreign, and may include production of neutralizing and non-neutralizing antibodies, formation of immune complexes, complement activation, mast cell activation, inflammation, hypersensitivity responses, and anaphylaxis. Several factors can contribute to protein immunogenicity, including but not limited to protein
sequence, route and frequency of administration, and patient population. Immunogenicity may limit the efficacy and safety of a protein therapeutic in multiple ways. Efficacy can be reduced directly by the formation of neutralizing antibodies. Efficacy may also be reduced indirectly, as binding to either neutralizing or non-neutralizing antibodies typically leads to rapid clearance from serum. Severe side effects and even death may occur when an immune reaction is raised. Thus in one embodiment, protein engineering is used to reduce the immunogenicity of the antibodies of the present invention.

[000117] In some embodiments, the scaffold components can be a mixture from different species. Such antibody may be a chimeric antibody and/or a humanized antibody. In general, both "chimeric antibodies" and "humanized antibodies" refer to antibodies that combine regions from more than one species. "Chimeric antibodies" traditionally comprise variable region(s) from a mouse (or rat, in some cases) and the constant region(s) from a human (Morrison et al., 1984, Proc Natl Acad Sci USA 81 6851-6855).

[000118] By "humanized" antibody as used herein is meant an antibody comprising a human framework region (FR) and one or more complementarity determining regions (CDRs) from a non-human (usually mouse or rat) antibody. The non-human antibody providing the CDRs is called the "donor" and the human immunoglobulin providing the framework is called the "acceptor". Humanization relies principally on the grafting of donor CDRs onto acceptor (human) VL and VH frameworks (Winter US 5,225,539). This strategy is referred to as "CDR grafting". "Backmutation" of selected acceptor framework residues to the corresponding donor residues is often required to regain affinity that is lost in the initial grafted construct (US 5,693,762). The humanized antibody optimally also will comprise at least a portion of an immunoglobulin constant region, typically that of a human immunoglobulin, and thus will typically comprise a human Fc region. A variety of techniques and methods for humanizing and reshaping non-human antibodies are well known in the art (See Tsurushita & Vasquez, 2004, Humanization of Monoclonal Antibodies, Molecular Biology of B Cells, 533-545, Elsevier Science (USA), and references cited therein). Humanization or other methods of reducing the immunogenicity of nonhuman antibody variable regions may include resurfacing methods, as described for example in Roguska
et al., 1994, Proc Natl Acad Sci USA 91 969-973). In one embodiment, selection based methods may be employed to humanize and/or affinity mature antibody variable regions, that is, to increase the affinity of the variable region for its target antigen. Other humanization methods may involve the grafting of only parts of the CDRs, including but not limited to methods described in USSN 09/810,502, Tan et al., 2002, J Immunol 169 1119-1 125, De Pascalis et al., 2002, J Immunol 169 3076-3084. Structure-based methods may be employed for humanization and affinity maturation, for example as described in USSN 10/153,159 and related applications.

[000119] In certain variations, the immunogenicity of the antibody is reduced using a method described in USSN 11/004,590, entitled "Methods of Generating Variant Proteins with Increased Host String Content and Compositions Thereof, filed on December 3, 2004.

[000120] Modifications to reduce immunogenicity may include modifications that reduce binding of processed peptides derived from the parent sequence to MHC proteins. For example, amino acid modifications would be engineered such that there are no or a minimal number of immune epitopes that are predicted to bind, with high affinity, to any prevalent MHC alleles. Several methods of identifying MHC-binding epitopes in protein sequences are known in the art and may be used to score epitopes in an antibody of the present invention. See for example USSN 09/903,378, USSN 10/754,296, USSN 1 1/249,692, and references cited therein.

[000121] In an alternate embodiment, the antibodies of the present invention may be fully human, that is the sequences of the antibodies are completely or substantially human. "Fully human antibody" or "complete human antibody" refers to a human antibody having the gene sequence of an antibody derived from a human chromosome with the modifications outlined herein. A number of methods are known in the art for generating fully human antibodies, including the use of transgenic mice (Bruggemann et al., 1997, Curr Opin Biotechnol 8:455-458,) or human antibody libraries coupled with selection methods (Griffiths et al., 1998, Curr Opin Biotechnol 9:102-108).

[000122] The antibodies of the present invention target CD133 and may comprise the variable regions (e.g., the CDRs) of any known or undiscovered anti-CD133 antibody. Antibodies of the invention may display selectivity for CD133. Examples include full-length versus splice variants, cell-surface vs. soluble forms, selectivity for
various polymorphic variants, or selectivity for specific conformational forms of a target. An antibody of the present invention may bind any epitope or region on CD133 and may be specific for fragments, mutant forms, splice forms, or aberrant forms of the antigens. A number of useful antibodies have been discovered that target CD133 that may find use in the present invention.

[000123] The antibodies of the present invention may find use in a wide range of products. In one embodiment the antibody of the invention is a therapeutic, a diagnostic, or a research reagent. In one embodiment, an antibody of the invention is a therapeutic. An antibody of the present invention may find use in an antibody composition that is monoclonal or polyclonal. In one embodiment, the antibodies of the present invention are used to kill target cells that bear the target antigen, for example cancer cells. In an alternate embodiment, the antibodies of the present invention are used to block, antagonize, or agonize the target antigen. In an alternate embodiment, the antibodies of the present invention are used to block, antagonize, or agonize the target antigen and kill the target cells that bear the target antigen.

[000124] It will be recognized that the sequences of the variable domains including the CDRs identified herein can be combined in any combination in an antibody. Further, these sequences may be independently modified by adding all or part of an Fc region or Fc variant as disclosed herein. The modified sequences can also be combined in any combination in an antibody.

[000125] The present invention is directed to antibodies comprising modifications, wherein the modifications alter affinity to one or more Fc receptors, and/or alter the ability of the antibody to mediate one or more effector functions. Modifications of the invention include amino acid modifications.

[000126] The inventors of the present invention have surprisingly found that by introducing the amino acid substitutions 239D and 332E in the CH2 domain of the Fc part of known anti-CD133 antibodies, such as W6B3 und 293-C3, the cell killing activity of these antibodies can be significantly increased. In one embodiment, the amino acid substitutions are S239D and I332E. This is surprising, as it has been experimentally shown that the same modifications do not generally increase cell killing activity. In other words, in different antibodies directed to a different target antigen, the introduction of these substitutions had no measurable effect on cell killing.
In addition, such modified antibodies can comprise further amino acid modifications at heavy chain constant region positions 221, 222, 223, 224, 225, 227, 228, 230, 231, 232, 233, 234, 235, 236, 237, 238, 240, 241, 243, 244, 245, 246, 247, 249, 255, 258, 260, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 278, 280, 281, 282, 283, 284, 285, 286, 288, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 313, 317, 318, 320, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 333, 334, 335, 336, and 337, which have been found to allow modification of FcR binding properties, effector function, and potentially clinical properties of antibodies (See USSR 11/124,620, filed May 5, 2005, entitled “Optimized Fc Variants”).

In particular, variants that alter binding to one or more human Fc

[000132] Additional substitutions that may also be used in the present invention include other substitutions that modulate Fc receptor affinity, FcyR-mediated effector function, and/or complement mediated effector function include but are not limited to 298A, 298T, 326A, 326D, 326E, 326W, 326Y, 333A, 333S, 334L, and 334A (US 6,737,056; Shields et al., Journal of Biological Chemistry, 2001, 276(9):6591-6604; US 6,528,624; Idusogie et al, 2001, J. Immunology 166:2571-2572), 247L, 255L, 270E, 392T, 396L, and 421 K (USSN 10/754,922; USSN 10/902,588), and 280H, 280Q, and 280Y (USSN 10/370,749).

[000133] In other embodiments, antibodies of the present invention may be combined with constant heavy chain variants that alter FcRn binding. These include modifications that modify FcRn affinity in a pH-specific manner. In particular, variants that increase Fc binding to FcRn include but are not limited to: 250E, 250Q, 428L, 428F, 250Q/428L (Hinton et al., 2004, J. Biol. Chem. 279(8): 6213-6216, Hinton et al. 2006 Journal of Immunology 176:346-356, USSN 11/102621, PCT/US2003/033037,

[000134] In some embodiments of the invention, antibodies may comprise isotypic modifications, that is modifications in a parent IgG to the amino acid type in an alternate IgG.

[000135] The present invention provides variant antibodies that are optimized for a number of therapeutically relevant properties. A variant antibody comprises one or more amino acid modifications relative to a parent antibody, wherein the amino acid modification(s) provide one or more optimized properties. Thus the antibodies of the present invention are variant antibodies. An antibody of the present invention differs in amino acid sequence from its parent antibody by virtue of at least the two amino acid modifications 239D and 332E. Additionally, the variant antibodies of the present invention may comprise more than the two afore-mentioned amino acid modifications as compared to the parent, for example from about three to fifty amino acid modifications, e.g., from about three to ten amino acid modifications, from about three to about five amino acid modifications, etc., compared to the parent. Thus the sequences of the variant antibodies and those of the parent antibodies are substantially homologous. For example, the variant antibody sequences herein will possess about 80% homology with the parent antibody sequence, e.g., at least about 90% homology, e at least about 95% homology, etc.

[000136] The antibodies of the present invention may comprise amino acid
modifications that provide optimized effector function properties relative to the parent. Substitutions and optimized effector function properties are described in USSN 10/672,280, PCT US03/30249, and USSN 10/822,231, and USSN 60/627,774, filed 11/12/2004 and entitled "Optimized Fc Variants". Properties that may be optimized include but are not limited to enhanced or reduced affinity for an FcyR. In one embodiment, the antibodies of the present invention are optimized to possess enhanced affinity for a human activating FcyR, e.g., FcyRI, FcyRIIa, FcyRIIc, FcyRIIIa, and FcyRIIIb. In one embodiment, an antibody of the invention is optimized to possess enhanced affinity for a human FcyRIIIa. In an alternate embodiment, the antibodies are optimized to possess reduced affinity for the human inhibitory receptor FcyRIIb. These embodiments are anticipated to provide antibodies with enhanced therapeutic properties in humans, for example enhanced effector function and greater anti-cancer potency.

[000137] In other embodiments, antibodies of the present invention provide enhanced affinity for one or more FcyRs, yet reduced affinity for one or more other FcyRs. For example, an antibody of the present invention may have enhanced binding to FcyRIIIa, yet reduced binding to FcyRIIb. Alternately, an antibody of the present invention may have enhanced binding to FcyRIIa and FcyRI, yet reduced binding to FcyRIIb.

[000138] The modifications of the invention may enhance binding affinity for one or more FcyRs. By "greater affinity" or 'improved affinity" or "enhanced affinity" or "better affinity" than a parent immunoglobulin, as used herein is meant that an Fc variant binds to an Fc receptor with a significantly higher equilibrium constant of association (Ka) or lower equilibrium constant of dissociation (Kd) than the parent polypeptide when the amounts of variant and parent polypeptide in the binding assay are essentially the same. For example, the Fc variant with improved FcyR binding affinity may display from about 5 fold to about 1000 fold, e.g. from about 10 fold to about 500 fold improvement in Fc receptor binding affinity compared to the parent polypeptide, where Fc receptor binding affinity is determined by methods known in the art. Accordingly, by "reduced affinity" as compared to a parent Fc polypeptide as used herein is meant that an Fc variant binds an Fc receptor with significantly lower Ka or higher Kd than the parent polypeptide.
Embodiments comprise optimization of Fc binding to a human FcyR, however in alternate embodiments the antibodies of the present invention possess enhanced or reduced affinity for FcyRs from nonhuman organisms, including but not limited to rodents and non-human primates. Antibodies that are optimized for binding to a nonhuman FcyR may find use in experimentation. For example, mouse models are available for a variety of diseases that enable testing of properties such as efficacy, toxicity, and pharmacokinetics for a given drug candidate. As is known in the art, cancer cells can be grafted or injected into mice to mimic a human cancer, a process referred to as xenografting. Testing of antibodies that comprise antibodies that are optimized for one or more mouse FcyRs, may provide valuable information with regard to the efficacy of the protein, its mechanism of action, and the like. The antibodies of the present invention may also be optimized for enhanced functionality and/or solution properties in aglycosylated form. In one embodiment, the aglycosylated antibodies of the present invention bind an Fc ligand with greater affinity than the aglycosylated form of the parent antibody. The Fc ligands include but are not limited to FcyRs, C1q, FcRn, and proteins A and G, and may be from any source including but not limited to human, mouse, rat, rabbit, or monkey. In an alternate embodiment, the antibodies are optimized to be more stable and/or more soluble than the aglycosylated form of the parent antibody.

Antibodies of the invention may comprise modifications that modulate interaction with Fc ligands other than FcyRs, including but not limited to complement proteins, FcRn, and Fc receptor homologs (FcRHs). FcRHs include but are not limited to FcRH1, FcRH2, FcRH3, FcRH4, FcRH5, and FcRH6 (Davis et al, 2002, Immunol. Reviews 190:123-136).

Antibodies of the present invention may comprise one or more modifications that provide optimized properties that are not specifically related to effector function per se. The modifications may be amino acid modifications, or may be modifications that are made enzymatically or chemically. Such modification(s) likely provide some improvement in the antibody, for example an enhancement in its stability, solubility, function, or clinical use. The present invention contemplates a variety of improvements that may be made by coupling the antibodies of the present invention with additional modifications.
In one embodiment, the variable region of an antibody of the present invention may be affinity matured, that is to say that amino acid modifications have been made in the V\text{H} and/or VL domains of the antibody to enhance binding of the antibody to its target antigen. Such types of modifications may improve the association and/or the dissociation kinetics for binding to the target antigen. Other modifications include those that improve selectivity for target antigen vs. alternative targets. These include modifications that improve selectivity for antigen expressed on target vs non-target cells. Other improvements to the target recognition properties may be provided by additional modifications. Such properties may include, but are not limited to, specific kinetic properties (i.e. association and dissociation kinetics), selectivity for the particular target versus alternative targets, and selectivity for a specific form of target versus alternative forms. Examples include full-length versus splice variants, cell-surface vs. soluble forms, selectivity for various polymorphic variants, or selectivity for specific conformational forms of the target antigen.

Antibodies of the invention may comprise one or more modifications that provide reduced or enhanced internalization of an antibody. In one embodiment, antibodies of the present invention can be utilized or combined with additional modifications in order to reduce the cellular internalization of an antibody that occurs via interaction with one or more Fc ligands. This property might be expected to enhance effector function, and potentially reduce immunogenicity of the antibodies of the invention. Alternatively, antibodies of the present invention can be utilized directly or combined with additional modifications in order to enhance the cellular internalization of an antibody that occurs via interaction with one or more Fc ligands.

In one embodiment, modifications are made to improve biophysical properties of the antibodies of the present invention, including but not limited to stability, solubility, and oligomeric state. Modifications can include, for example, substitutions that provide more favorable intramolecular interactions in the antibody such as to provide greater stability, or substitution of exposed nonpolar amino acids with polar amino acids for higher solubility. A number of optimization goals and methods are described in USSN 10/379,392, that may find use for engineering additional modifications to further optimize the antibodies of the present invention. The antibodies of the present invention can also be combined with additional modifications.
that reduce oligomeric state or size, such that tumor penetration is enhanced, or in vivo clearance rates are increased as desired.

[000145] Other modifications to the antibodies of the present invention include those that enable the specific formation or homodimeric or homomultimeric molecules. Such modifications include but are not limited to engineered disulfides, as well as chemical modifications or aggregation methods which may provide a mechanism for generating covalent homodimeric or homomultimers. For example, methods of engineering and compositions of such molecules are described in Kan et al., 2001, J. Immunol., 2001, 166: 1320-1326; Stevenson et al., 2002, Recent Results Cancer Res. 159 104-12; US 5,681,566; Caron et al., 1992, J. Exp. Med. 176:1 191-1 195, and Shopes, 1992, J. Immunol. 148(9):2918-22. Additional modifications to the variants of the present invention include those that enable the specific formation or heterodimeric, heteromultimeric, bifunctional, and/or multifunctional molecules. Such modifications include, but are not limited to, one or more amino acid substitutions in the CH3 domain, in which the substitutions reduce homodimer formation and increase heterodimer formation. For example, methods of engineering and compositions of such molecules are described in Atwell et al., 1997, J. Mol. Biol. 270(l):26-35, and Carter et al., 2001, J. Immunol. Methods 248:7-15, each incorporated herein in its entirety by reference. Additional modifications include modifications in the hinge and CH3 domains, in which the modifications reduce the propensity to form dimers.

[000146] In further embodiments, the antibodies of the present invention comprise modifications that remove proteolytic degradation sites. These may include, for example, protease sites that reduce production yields, as well as protease sites that degrade the administered protein in vivo. In one embodiment, additional modifications are made to remove covalent degradation sites such as deamidation (i.e. deamidation of glutaminyl and asparaginyl residues to the corresponding glutamyl and aspartyl residues), oxidation, and proteolytic degradation sites. Deamidation sites that are particularly useful to remove are those that have enhance propensity for deamidation, including, but not limited to asparaginyl and glutamyl residues followed by glycines (NG and QG motifs, respectively). In such cases, substitution of either residue can significantly reduce the tendency for deamidation. Common oxidation sites include methionine and cysteine residues. Other covalent modifications, that can either be
introduced or removed, include hydroxylation of proline and lysine, phosphorylation of hydroxyl groups of seryl or threonyl residues, methylation of the "-amino groups of lysine, arginine, and histidine side chains (T.E. Creighton, Proteins: Structure and Molecular Properties, W. H. Freeman & Co., San Francisco, pp. 79-86 (1983)), acetylation of the N-terminal amine, and amidation of any C-terminal carboxyl group. Additional modifications also may include but are not limited to posttranslational modifications such as N-linked or O-linked glycosylation and phosphorylation.

[000147] Modifications may include those that improve expression and/or purification yields from hosts or host cells commonly used for production of biologies. These include, but are not limited to various mammalian cell lines (e.g. CHO), yeast cell lines, bacterial cell lines, and plants. Additional modifications include modifications that remove or reduce the ability of heavy chains to form inter-chain disulfide linkages. Additional modifications include modifications that remove or reduce the ability of heavy chains to form intra-chain disulfide linkages.

[000148] The antibodies of the present invention may comprise modifications that include the use of unnatural amino acids incorporated using, for example, the technologies developed by Schultz and colleagues, including but not limited to methods described by Cropp & Shultz, 2004, Trends Genet. 20(12):625-30, Anderson et al., 2004, Proc. Natl. Acad. Sci. U.S.A. 101 (2):7566-71, Zhang et al., 2003, 303(5656):371-3, and Chin et al., 2003, Science 301(5635):964-7. In some embodiments, these modifications enable manipulation of various functional, biophysical, immunological, or manufacturing properties discussed above. In additional embodiments, these modifications enable additional chemical modification for other purposes. Other modifications are contemplated herein. For example, the antibody may be linked to one of a variety of nonproteinaceous polymers, e.g., polyethylene glycol (PEG), polypropylene glycol, poloyoalkylenes, or copolymers of polyethylene glycol and polypropylene glycol. Additional amino acid modifications may be made to enable specific or non-specific chemical or posttranslational modification of the antibodies. Such modifications, include, but are not limited to PEGylation and glycosylation. Specific substitutions that can be utilized to enable PEGylation include, but are not limited to, introduction of novel cysteine residues or unnatural amino acids such that efficient and specific coupling chemistries can be used to attach a PEG or otherwise
polymeric moiety. Introduction of specific glycosylation sites can be achieved by introducing novel N-X-T/S sequences into the antibodies of the present invention.

[000149] Covalent modifications of antibodies are included within the scope of this invention, and are generally, but not always, done post-translationally. For example, several types of covalent modifications of the antibody are introduced into the molecule by reacting specific amino acid residues of the antibody with an organic derivatizing agent that is capable of reacting with selected side chains or the N- or C-terminal residues.

[000150] In some embodiments, the covalent modification of the antibodies of the invention comprises the addition of one or more labels. The term "labeling group" is any detectable label. In some embodiments, the labeling group is coupled to the antibody via spacer arms of various lengths to reduce potential steric hindrance. Various methods for labeling proteins are known in the art and may be used in performing the present invention. In general, labels fall into a variety of classes, depending on the assay in which they are to be detected: a) isotopic labels, which may be radioactive or heavy isotopes; b) magnetic labels (e.g., magnetic particles); c) redox active moieties; d) optical dyes; enzymatic groups (e.g., horseradish peroxidase, [beta]-galactosidase, luciferase, alkaline phosphatase); e) biotinylated groups; and f) predetermined polypeptide epitopes recognized by a secondary reporter (e.g., leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains, epitope tags, etc.). In some embodiments, the labeling group is coupled to the antibody via spacer arms of various lengths to reduce potential steric hindrance. Various methods for labeling proteins are known in the art and may be used in performing the present invention. Specific labels include optical dyes, including, but not limited to, chromophores, phosphors and fluorophores, with the latter being specific in many instances. Fluorophores can be either "small molecule" fluoros, or proteinaceous fluoros. By "fluorescent label" is meant any molecule that may be detected via its inherent fluorescent properties.

[000151] In one embodiment, the antibodies of the invention are antibody "fusion proteins", sometimes referred to herein as "antibody conjugates". The fusion partner or conjugate partner can be proteinaceous or non-proteinaceous; the latter generally being generated using functional groups on the antibody and on the conjugate partner.
Conjugate and fusion partners may be any molecule, including small molecule chemical compounds and polypeptides. For example, a variety of antibody conjugates and methods are described in Trail et al., 1999, Curr. Opin. Immunol. 11:584-588. Possible conjugate partners include but are not limited to cytokines, cytotoxic agents, toxins, radioisotopes, chemotherapeutic agent, anti-angiogenic agents, a tyrosine kinase inhibitors, and other therapeutically active agents. In some embodiments, conjugate partners may be thought of more as payloads, that is to say that the goal of a conjugate is targeted delivery of the conjugate partner to a targeted cell, for example a cancer cell or immune cell, by the antibody. Thus, for example, the conjugation of a toxin to an antibody targets the delivery of the toxin to cells expressing the target antigen. As will be appreciated by one skilled in the art, in reality the concepts and definitions of fusion and conjugate are overlapping. The designation of an antibody as a fusion or conjugate is not meant to constrain it to any particular embodiment of the present invention. Rather, these terms are used loosely to convey the broad concept that any antibody of the present invention may be linked genetically, chemically, or otherwise, to one or more polypeptides or molecules to provide some desirable property.

[000152] Suitable conjugates include, but are not limited to, labels as described below, drugs and cytotoxic agents including, but not limited to, cytotoxic drugs (e.g., chemotherapeutic agents) or toxins or active fragments of such toxins. Suitable toxins and their corresponding fragments include diptheria A chain, exotoxin A chain, ricin A chain, abrin A chain, curcin, crotin, phenomycin, enomycin and the like. Cytotoxic agents also include radiochemicals made by conjugating radioisotopes to antibodies, or binding of a radionuclide to a chelating agent that has been covalently attached to the antibody. Additional embodiments utilize calicheamicin, aunstatins, geldanamycin, maytansine, and duocarmycins and analogs; for the latter, see U.S. 2003/005033 i.

[000153] In one embodiment, the antibodies of the present invention are fused or conjugated to a cytokine. By "cytokine" as used herein is meant a generic term for proteins released by one cell population that act on another cell as intercellular mediators. For example, as described in Penichet et al., 2001, J Immunol Methods 248-91-101, cytokines may be fused to antibody to provide an array of desirable properties. Examples of such cytokines are lymphokines, monokines, and traditional polypeptide hormones. Included among the cytokines are growth hormone such as human growth
hormone, N-methionyl human growth hormone, and bovine growth hormone; parathyroid hormone, thyroxine; insulin; proinsulin; relaxin, prorelaxin; glycoprotein hormones such as follicle stimulating hormone (FSH), thyroid stimulating hormone (TSH), and luteinizing hormone (LH); hepatic growth factor; fibroblast growth factor, prolactin, placental lactogen; tumor necrosis factor-alpha and -beta; mullerian-inhibiting substance, mouse gonadotropin-associated peptide; inhibin; activin, vascular endothelial growth factor; integrin; thrombopoietin (TPO); nerve growth factors such as NGF-beta; platelet-growth factor, transforming growth factors (TGFs) such as TGF-alpha and TGF-beta; insulin-like growth factor-1 and -II; erythropoietin (EPO); osteoinductive factors, interferons such as interferon-alpha, beta, and -gamma; colony stimulating factors (CSFs) such as macrophage- CSF (M-CSF), granulocyte-macrophage-CSF (GM-CSF); and granulocyte-CSF (G-CSF), interleukins (ILs) such as IL-1, IL-1 alpha, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12, IL-15, a tumor necrosis factor such as TNF-alpha or TNF-beta; C5a; and other polypeptide factors including LIF and kit ligand (KL). As used herein, the term cytokine includes proteins from natural sources or from recombinant cell culture, and biologically active equivalents of the native sequence cytokines.

[000154] In an alternate embodiment, the antibodies of the present invention are fused, conjugated, or operably linked to a toxin, including but not limited to small molecule toxins and enzymatically active toxins of bacterial, fungal, plant or animal origin, including fragments and/or variants thereof. For example, a variety of immunotoxins and immunotoxin methods are described in Thrush et al., 1996, Arm. Rev. Immunol. 14:49-71. Small molecule toxins include but are not limited to calicheamicin, maytansine (US 5,208,020), trichothene, and CC1065. In one embodiment of the invention, the antibody is conjugated to one or more maytansine molecules (e.g. about 1 to about 10 maytansine molecules per antibody molecule). Maytansine may, for example, be converted to May-SS-Me which may be reduced to May-SH3 and reacted with modified antibody (Chan et al., 1992, Cancer Research 52 127-131) to generate a maytansinoid-antibody conjugate. Another conjugate of interest comprises an antibody conjugated to one or more calicheamicin molecules. The calicheamicin family of antibiotics are capable of producing double-stranded DNA breaks at sub-picomolar concentrations. Structural analogues of calicheamicin that may
be used include are, for example, disclosed in Hinman et al., 1993, Cancer Research 53 3336-3342, Lode et al., 1998, Cancer Research 58 2925-2928, US 5,714,586; US 5,712,374, US 5,264,586; and US 5,773,001. Dolastatin 10 analogs such as auristatin E (AE) and monomethylauristatin E (MMAE) may find use as conjugates for the antibodies of the present invention (Doronina et al., 2003, Nat Biotechnol 21(7):778-84; Francisco et al., 2003 Blood 102(4):1458-65). Useful enzymatically active toxins include but are 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, Phytolaca americana proteins (PAPI, PAPII, and PAP-S), momordica charantia inhibitor, curcin, crotin, sapaonaria officinalis inhibitor, gelonin, mitogellin, restrictocin, phenomycin, enomycin and the tricothecenes. See, for example, PCT WO 93/21232. The present invention further contemplates a conjugate between an antibody of the present invention and a compound with nucleolytic activity, for example a ribonuclease or DNA endonuclease such as a deoxyribonuclease (Dnase).

[000155] In an alternate embodiment, an antibody of the present invention may be fused, conjugated, or operably linked to a radioisotope to form a radioconjugate. A variety of radioactive isotopes are available for the production of radioconjugate antibodies. Examples include, but are not limited to, At211, 1131, 1125, Y90, Rel86, Rel88, Sml53, Bi212, P32, and radioactive isotopes of Lu.

[000156] In yet another embodiment, an antibody of the present invention may be conjugated to a "receptor" (such as streptavidin) for utilization in tumor pretargeting wherein the antibody-receptor conjugate is administered to the patient, followed by removal of unbound conjugate from the circulation using a clearing agent and then administration of a "ligand" (e.g. avidin) which is conjugated to a cytotoxic agent (e.g. a radionucleotide). In an alternate embodiment, the antibody is conjugated or operably linked to an enzyme in order to employ Antibody Dependent Enzyme Mediated Prodrug Therapy (ADEPT). ADEPT may be used by conjugating or operably linking the antibody to a prodrug-activating enzyme that converts a prodrug (e.g. a peptidyl chemotherapeutic agent, see PCT WO 81/01145, incorporated herein in its entirety by reference) to an active anti-cancer drug. See, for example, PCT WO 88/07378 and US 4,975,278, each incorporated herein in its entirety by reference. The enzyme component
of the immunoconjugate useful for ADEPT includes any enzyme capable of acting on a prodrug in such a way so as to covert it into its more active, cytotoxic form. Enzymes that are useful in the method of this invention include but are not limited to alkaline phosphatase useful for converting phosphate-containing prodrugs into free drugs; arylsulfatase useful for converting sulfate-containing prodrugs into free drugs; cytosine deaminase useful for converting non-toxic 5-fluorocytosine into the anti-cancer drug, 5-fluorouracil; proteases, such as serratia protease, thermolysin, subtilisin, carboxypeptidases and cathepsins (such as cathepsins B and L), that are useful for converting peptide-containing prodrugs into free drugs; D-alanylcarboxypeptidases, useful for converting prodrugs that contain D-amino acid substituents, carbohydrate-cleaving enzymes such as beta-galactosidase and neuraminidase useful for converting glycosylated prodrugs into free drugs, beta-lactamase useful for converting drugs derivatized with alpha-lactams into free drugs, and penicillin amidases, such as penicillin V amidase or penicillin G amidase, useful for converting drugs derivatized at their amine nitrogens with phenoxyacetyl or phenylacetyl groups, respectively, into free drugs. Alternatively, antibodies with enzymatic activity, also known in the art as "abzymes", can be used to convert the prodrugs of the invention into free active drugs (see, for example, Massey, 1987, Nature 328, 457-458, incorporated herein it its entirety by reference) Antibody-abzyme conjugates can be prepared for delivery of the abzyme to a tumor cell population. A variety of additional conjugates are contemplated for the antibodies of the present invention. A variety of chemotherapeutic agents, anti-angiogenic agents, tyrosine kinase inhibitors, and other therapeutic agents are described below, which may find use as antibody conjugates.

[000157] Also contemplated as fusion and conjugate partners are Fc polypeptides. Thus an antibody may be a multimeric Fc polypeptide, comprising two or more Fc regions. The advantage of such a molecule is that it provides multiple binding sites for Fc receptors with a single protein molecule. In one embodiment, Fc regions may be linked using a chemical engineering approach. For example, Fab's and Fc's may be linked by thioether bonds originating at cysteine residues in the hinges, generating molecules such as FabFc2. Fc regions may be linked using disulfide engineering and/or chemical cross-linking. In one embodiment, Fc regions may be linked genetically. In one embodiment, Fc regions in an antibody are linked genetically to generated tandemly
linked Fc regions as described in USSN 11/022,289, filed 12/21/2004, entitled "Fc polypeptides with novel Fc ligand binding sites". Tandemly linked Fc polypeptides may comprise two or more Fc regions, e.g., one to three, two, etc., Fc regions. It may be advantageous to explore a number of engineering constructs in order to obtain homo- or hetero- tandemly linked antibodies with the most favorable structural and functional properties. Tandemly linked antibodies may be homo-tandemly linked antibodies, that is an antibody of one isotype is fused genetically to another antibody of the same isotype. It is anticipated that because there are multiple FcyR, Clq, and/or FcRn binding sites on tandemly linked Fc polypeptides, effector functions and/or pharmacokinetics may be enhanced. In an alternate embodiment, antibodies from different isotypes may be tandemly linked, referred to as hetero- tandemly linked antibodies. For example, because of the capacity to target FcyR and FcyRI receptors, an antibody that binds both FcyRs and FcyRI may provide a significant clinical improvement.

[000158] Fusion and conjugate partners may be linked to any region of an antibody of the present invention, including at the N- or C- termini, or at some residue in-between the termini. In one embodiment, a fusion or conjugate partner is linked at the N- or C-terminus of the antibody, e.g., the N-terminus. A variety of linkers may find use in the present invention to covalently link antibodies to a fusion or conjugate partner. By "linker", "linker sequence", "spacer", "tethering sequence" or grammatical equivalents thereof, herein is meant a molecule or group of molecules (such as a monomer or polymer) that connects two molecules and often serves to place the two molecules in a desirable configuration. Linkers are known in the art, for example, homo- or hetero-bifunctional linkers as are well known (see, 1994 Pierce Chemical Company catalog, technical section on cross-linkers, pages 155-200). A number of strategies may be used to covalently link molecules together. These include, but are not limited to polypeptide linkages between N- and C-termini of proteins or protein domains, linkage via disulfide bonds, and linkage via chemical cross-linking reagents. In one aspect of this embodiment, the linker is a peptide bond, generated by recombinant techniques or peptide synthesis. The linker may contain amino acid residues that provide flexibility. Thus, the linker peptide may predominantly include the following amino acid residues Gly, Ser, Ala, or Thr. The linker peptide should have a length that is adequate to link two molecules in such a way that they assume the correct
conformation relative to one another so that they retain the desired activity. Suitable
lengths for this purpose include at least one and not more than 50 amino acid residues.
In one embodiment, the linker is from about 1 to 30 amino acids in length, with linkers
of 1 to 20 amino acids in length being desirable. Useful linkers include glycine-serine
polymers (including, for example, (GS)n, (GSGGS)n, (GGGGS)n and (GGS)n, where
n is an integer of at least one), glycine-alanine polymers, alanine-serine polymers, and
other flexible linkers, as will be appreciated by those in the art. Alternatively, a variety
of nonproteinaceous polymers, including but not limited to polyethylene glycol (PEG),
polypropylene glycol, polyoxyalkylenes, or copolymers of polyethylene glycol and
polypropylene glycol, may find use as linkers, that is may find use to link the antibodies
of the present invention to a fusion or conjugate partner, or to link the antibodies of the
present invention to a conjugate.

[000159] The present invention provides methods for producing and
experimentally testing antibodies. The described methods are not meant to constrain the
present invention to any particular application or theory of operation. Rather, the
provided methods are meant to illustrate generally that one or more antibodies may be
produced and experimentally tested to obtain variant antibodies. General methods for
antibody molecular biology, expression, purification, and screening are described in
Antibody Engineering, edited by Duebel & Kontermann, Springer-Verlag, Heidelberg,

[000160] In one embodiment of the present invention, nucleic acids are created
that encode the antibodies, and that may then be cloned into host cells, expressed and
assayed, if desired. Thus, nucleic acids, and particularly DNA, maybe made that encode
each protein sequence. These practices are carried out using well-known procedures.
For example, a variety of methods that may find use in the present invention are
described in Molecular Cloning - A Laboratory Manual, 3rd Ed. (Maniatis, Cold Spring
Harbor Laboratory Press, New York, 2001), and Current Protocols in Molecular
Biology (John Wiley & Sons). As will be appreciated by those skilled in the art, the
generation of exact sequences for a library comprising a large number of sequences is
potentially expensive and time consuming. By "library" herein is meant a set of variants
in any form, including but not limited to a list of nucleic acid or amino acid sequences, a list of nucleic acid or amino acid substitutions at variable positions, a physical library comprising nucleic acids that encode the library sequences, or a physical library comprising the variant proteins, either in purified or unpurified form. Accordingly, there are a variety of techniques that may be used to efficiently generate libraries of the present invention. Such methods that may find use in the present invention are described or referenced in US 6,403,312; USSN 09/782,004, USSN 09/927,790; USSN 10/218,102; PCT WO 01/40091; and PCT WO 02/25588. Such methods include but are not limited to gene assembly methods, PCR-based method and methods which use variations of PCR, ligase chain reaction-based methods, pooled oligo methods such as those used in synthetic shuffling, error-prone amplification methods and methods which use oligos with random mutations, classical site-directed mutagenesis methods, cassette mutagenesis, and other amplification and gene synthesis methods. As is known in the art, there are a variety of commercially available kits and methods for gene assembly, mutagenesis, vector subcloning, and the like, and such commercial products find use in the present invention for generating nucleic acids that encode antibodies.

[000161] The antibodies of the present invention may be produced by culturing a host cell transformed with nucleic acid, e.g., an expression vector, containing nucleic acid encoding the antibodies, under the appropriate conditions to induce or cause expression of the protein. The conditions appropriate for expression will vary with the choice of the expression vector and the host cell, and will be easily ascertained by one skilled in the art through routine experimentation. A wide variety of appropriate host cells may be used, including but not limited to mammalian cells, bacteria, insect cells, and yeast. For example, a variety of cell lines that may find use in the present invention are described in the ATCC cell line catalog, available from the American Type Culture Collection.

[000162] In one embodiment, the antibodies are expressed in mammalian expression systems, including systems in which the expression constructs are introduced into the mammalian cells using virus such as retrovirus or adenovirus. Any mammalian cells may be used, e.g., human, mouse, rat, hamster, primate cells, etc.. Suitable cells also include known research cells, including but not limited to Jurkat T cells, NIH3T3, CHO, BHK, COS, HEK293, PER C.6, HeLa, Sp2/0, NSO cells and variants thereof. In
an alternate embodiment, library proteins are expressed in bacterial cells. Bacterial
expression systems are well known in the art, and include Escherichia coli (E. coli).
Bacillus subtilis, Streptococcus cremoris, and Streptococcus lividans. In alternate
embodiments, antibodies are produced in insect cells (e.g Sf21/Sf9) or yeast cells (e.g.
S. cerevisiae, Pichia, etc.). In an alternate embodiment, antibodies are expressed in vitro
using cell free translation systems. In vitro translation systems derived from both
prokaryotic (e.g. E. coli) and eukaryotic (e.g. wheat germ, rabbit reticulocytes) cells are
available and may be chosen based on the expression levels and functional properties of
the protein of interest. For example, as appreciated by those skilled in the art, in vitro
translation is required for some display technologies, for example ribosome display. In
addition, the antibodies may be produced by chemical synthesis methods. Also
transgenic expression systems both animal (e.g. cow, sheep or goat milk, embryonated
hen’s eggs, whole insect larvae, etc.) and plant (e.g. corn, tobacco, duckweed, etc.). The
nucleic acids that encode the antibodies of the present invention may be incorporated
into an expression vector in order to express the protein. A variety of expression vectors
may be utilized for protein expression. Expression vectors may comprise self-
replicating extra-chromosomal vectors or vectors which integrate into a host genome.
Expression vectors are constructed to be compatible with the host cell type. Thus
expression vectors which find use in the present invention include but are not limited to
those which enable protein expression in mammalian cells, bacteria, insect cells, yeast,
and in in vitro systems. As is known in the art, a variety of expression vectors are
available, commercially or otherwise, that may find use in the present invention for
expressing antibodies.

[000163] Expression vectors typically comprise a protein operably linked with
control or regulatory sequences, selectable markers, any fusion partners, and/or
additional elements. By "operably linked" herein is meant that the nucleic acid is placed
into a functional relationship with another nucleic acid sequence. Generally, these
expression vectors include transcriptional and translational regulatory nucleic acid
operably linked to the nucleic acid encoding the antibody, and are typically appropriate
to the host cell used to express the protein, in general, the transcriptional and
translational regulatory sequences may include promoter sequences, ribosomal binding
sites, transcriptional start and stop sequences, translational start and stop sequences, and
enhancer or activator sequences. As is also known in the art, expression vectors typically contain a selection gene or marker to allow the selection of transformed host cells containing the expression vector. Selection genes are well known in the art and will vary with the host cell used.

[000164] Antibodies may be operably linked to a fusion partner to enable targeting of the expressed protein, purification, screening, display, and the like. Fusion partners may be linked to the antibody sequence via a linker sequence. The linker sequence will generally comprise a small number of amino acids, typically less than ten, although longer linkers may also be used. Typically, linker sequences are selected to be flexible and resistant to degradation. As will be appreciated by those skilled in the art, any of a wide variety of sequences may be used as linkers. For example, a common linker sequence comprises the amino acid sequence GGGGS. A fusion partner may be a targeting or signal sequence that directs antibody and any associated fusion partners to a desired cellular location or to the extracellular media. As is known in the art, certain signaling sequences may target a protein to be either secreted into the growth media, or into the periplasmic space, located between the inner and outer membrane of the cell. A fusion partner may also be a sequence that encodes a peptide or protein that enables purification and/or screening. Such fusion partners include but are not limited to polyhistidine tags (His-tags) (for example H6 and H10 or other tags for use with Immobilized Metal Affinity Chromatography (IMAC) systems (e.g. Ni$^{2+}$ affinity columns)), GST fusions, MBP fusions, Strep-tag, the BSP biotinylation target sequence of the bacterial enzyme BirA, and epitope tags which are targeted by antibodies (for example c-myc tags, flag-tags, and the like). As will be appreciated by those skilled in the art, such tags may be useful for purification, for screening, or both. For example, an antibody may be purified using a His-tag by immobilizing it to a Ni$^{2+}$ affinity column, and then after purification the same His-tag may be used to immobilize the antibody to a Ni$^{2+}$-coated plate to perform an ELISA or other binding assay (as described below). A fusion partner may enable the use of a selection method to screen antibodies (see below). Fusion partners that enable a variety of selection methods are well-known in the art, and all of these find use in the present invention. For example, by fusing the members of an antibody library to the gene III protein, phage display can be employed (Kay et al., Phage display of peptides and proteins: a laboratory manual, Academic
Press, San Diego, CA, 1996; Lowman et al., 1991, Biochemistry 30: 10832-10838; Smith, 1985, Science 228:1315-1317). Fusion partners may enable antibodies to be labeled. Alternatively, a fusion partner may bind to a specific sequence on the expression vector, enabling the fusion partner and associated antibody to be linked covalently or noncovalently with the nucleic acid that encodes them.

[000165] The methods of introducing exogenous nucleic acid into host cells are well known in the art, and will vary with the host cell used. Techniques include but are not limited to dextran-mediated transfection, calcium phosphate precipitation, calcium chloride treatment, polybrened mediated transfection, protoplast fusion, electroporation, viral or phage infection, encapsulation of the polynucleotide(s) in liposomes, and direct microinjection of the DNA into nuclei. In the case of mammalian cells, transfection may be either transient or stable.

[000166] In one embodiment, antibodies are purified or isolated after expression. Proteins may be isolated or purified in a variety of ways known to those skilled in the art. Standard purification methods include chromatographic techniques, including ion exchange, hydrophobic interaction, affinity, sizing or gel filtration, and reversed-phase, carried out at atmospheric pressure or at high pressure using systems such as FPLC and HPLC. Purification methods also include electrophoretic, immunological, precipitation, dialysis, and chromatofocusing techniques. Ultrafiltration and diafiltration techniques, in conjunction with protein concentration, are also useful. As is well known in the art, a variety of natural proteins bind Fc and antibodies, and these proteins can find use in the present invention for purification of antibodies. For example, the bacterial proteins A and G bind to the Fc region. Likewise, the bacterial protein L binds to the Fab region of some antibodies, as of course does the antibody's target antigen. Purification can often be enabled by a particular fusion partner. For example, antibodies may be purified using glutathione resin if a GST fusion is employed, Ni$_2^+$-affinity chromatography if a His-tag is employed, or immobilized anti-flag antibody if a flag-tag is used. For general guidance in suitable purification techniques, see, e.g. Protein Purification: Principles and Practice, 3rd Ed., Scopes, Springer-Verlag, NY, 1994. The degree of purification necessary will vary depending on the screen or use of the antibodies. In some instances no purification is necessary. For example in one embodiment, if the antibodies are secreted, screening may take place directly from the media. As is well known in the art,
some methods of selection do not involve purification of proteins. Thus, for example, if a library of antibodies is made into a phage display library, protein purification may not be performed.

[000167] Antibodies may be screened using a variety of methods, including but not limited to those that use in vitro assays, in vivo and cell-based assays, and selection technologies. Automation and high-throughput screening technologies may be utilized in the screening procedures. Screening may employ the use of a fusion partner or label. The use of fusion partners has been discussed above. By "labeled" herein is meant that the antibodies of the invention have one or more elements, isotopes, or chemical compounds attached to enable the detection in a screen. In general, labels fall into three classes: a) immune labels, which maybe an epitope incorporated as a fusion partner that is recognized by an antibody, b) isotopic labels, which may be radioactive or heavy isotopes, and c) small molecule labels, which may include fluorescent and colorimetric dyes, or molecules such as biotin that enable other labeling methods. Labels may be incorporated into the compound at any position and may be incorporated in vitro or in vivo during protein expression.

[000168] In one embodiment, the functional and/or biophysical properties of antibodies are screened in an in vitro assay. In vitro assays may allow a broad dynamic range for screening properties of interest. Properties of antibodies that may be screened include but are not limited to stability, solubility, and affinity for Fc ligands, for example FcyRs. Multiple properties may be screened simultaneously or individually. Proteins may be purified or unpurified, depending on the requirements of the assay. In one embodiment, the screen is a qualitative or quantitative binding assay for binding of antibodies to a protein or nonprotein molecule that is known or thought to bind the antibody. In one embodiment, the screen is a binding assay for measuring binding to the target antigen. In an alternate embodiment, the screen is an assay for binding of antibodies to an Fc ligand, including but not limited to the family of FcyRs, the neonatal receptor FcRn, the complement protein Clq, and the bacterial proteins A and G. The Fc ligands may be from any organism, e.g., humans, mice, rats, rabbits, monkeys, etc. Binding assays can be carried out using a variety of methods known in the art, including but not limited to FRET (Fluorescence Resonance Energy Transfer) and BRET (Bioluminescence Resonance Energy Transfer)-based assays, AlphaScreen(TM)
(Amplified Luminescent Proximity Homogeneous Assay), Scintillation Proximity Assay, ELISA (Enzyme-Linked Immunosorbent Assay), SPR (Surface Plasmon Resonance, also known as Biacore(TM)), isothermal titration calorimetry, differential scanning calorimetry, gel electrophoresis, and chromatography including gel filtration. These and other methods may take advantage of some fusion partner or label of the antibody. Assays may employ a variety of detection methods including but not limited to chromogenic, fluorescent, luminescent, or isotopic labels.

[000169] The biophysical properties of antibodies, for example stability and solubility, may be screened using a variety of methods known in the art. Protein stability may be determined by measuring the thermodynamic equilibrium between folded and unfolded states. For example, antibodies of the present invention may be unfolded using chemical denaturant, heat, or pH, and this transition may be monitored using methods including, but not limited to, circular dichroism spectroscopy, fluorescence spectroscopy, absorbance spectroscopy, NMR spectroscopy, calorimetry, and proteolysis. As will be appreciated by those skilled in the art, the kinetic parameters of the folding and unfolding transitions may also be monitored using these and other techniques. The solubility and overall structural integrity of an antibody may be quantitatively or qualitatively determined using a wide range of methods that are known in the art. Methods which may find use in the present invention for characterizing the biophysical properties of antibodies include gel electrophoresis, isoelectric focusing, capillary electrophoresis, chromatography such as size exclusion chromatography, ion-exchange chromatography, and reversed-phase high performance liquid chromatography, peptide mapping, oligosaccharide mapping, mass spectrometry, ultraviolet absorbance spectroscopy, fluorescence spectroscopy, circular dichroism spectroscopy, isothermal titration calorimetry, differential scanning calorimetry, analytical ultra-centrifugation, dynamic light scattering, proteolysis, and cross-linking, turbidity measurement, filter retardation assays, immunological assays, fluorescent dye binding assays, protein-staining assays, microscopy, and detection of aggregates via ELISA or other binding assay. Structural analysis employing X-ray crystallographic techniques and NMR spectroscopy may also find use. In one embodiment, stability and/or solubility may be measured by determining the amount of protein solution after some defined period of time. In this assay, the protein may or may not be exposed to
some extreme condition, for example elevated temperature, low pH, or the presence of
denaturant. Because function typically requires a stable, soluble, and/or well-
folded/structured protein, the aforementioned functional and binding assays also provide
ways to perform such a measurement. For example, a solution comprising an antibody
could be assayed for its ability to bind target antigen, then exposed to elevated
temperature for one or more defined periods of time, then assayed for antigen binding
again. Because unfolded and aggregated protein is not expected to be capable of binding
antigen, the amount of activity remaining provides a measure of the antibody's stability
and solubility.

[000170] The biological properties of the antibodies of the present invention may
be characterized in cell, tissue, and whole organism experiments. As is known in the art,
drugs are often tested in animals, including but not limited to mice, rats, rabbits, dogs,
cats, pigs, and monkeys, in order to measure a drug's efficacy for treatment against a
disease or disease model, or to measure a drug's pharmacokinetics, toxicity, and other
properties. The animals may be referred to as disease models. With respect to the
antibodies of the present invention, a particular challenge arises when using animal
models to evaluate the potential for in-human efficacy of candidate polypeptides - this is
due, at least in part, to the fact that antibodies that have a specific effect on the affinity
for a human Fc receptor may not have a similar affinity effect with the orthologous
animal receptor. These problems can be further exacerbated by the inevitable
ambiguities associated with correct assignment of true orthologs (Mechetina et al.,
Immunogenetics, 2002 54:463-468), and the fact that some orthologs simply do not
exist in the animal (e.g. humans possess an FcγRⅡa whereas mice do not). Therapeutics
are often tested in mice, including but not limited to nude mice, SCID mice, xenograft
mice, and transgenic mice (including knockins and knockouts). For example, an
antibody of the present invention that is intended as an anti-cancer therapeutic may be
tested in a mouse cancer model, for example a xenograft mouse. In this method, a tumor
or tumor cell line is grafted onto or injected into a mouse, and subsequently the mouse
is treated with the therapeutic to determine the ability of the antibody to reduce or
inhibit cancer growth and metastasis. An alternative approach is the use of a SCID
murine model in which immune-deficient mice are injected with human Peripheral
Blood Lymphocytes (PBLs), conferring a semi-functional and human immune system -
with an appropriate array of human FcRs - to the mice that have subsequently been injected with antibodies or Fc-polypeptides that target injected human tumor cells. In such a model, the Fc-polypeptides that target the desired antigen interact with human PBLs within the mice to engage tumoricidal effector functions. Such experimentation may provide meaningful data for determination of the potential of the antibody to be used as a therapeutic. Any organism, e.g., mammals, may be used for testing. For example because of their genetic similarity to humans, monkeys can be suitable therapeutic models, and thus may be used to test the efficacy, toxicity, pharmacokinetics, or other property of the antibodies of the present invention. Tests of the antibodies of the present invention in humans are ultimately required for approval as drugs, and thus of course these experiments are contemplated. Thus the antibodies of the present invention may be tested in humans to determine their therapeutic efficacy, toxicity, pharmacokinetics, and/or other clinical properties.

[000171] Toxicity studies are performed to determine the antibody or Fc-fusion related-effects that cannot be evaluated in standard pharmacology profile or occur only after repeated administration of the agent. Most toxicity tests are performed in two species - a rodent and a non-rodent - to ensure that any unexpected adverse effects are not overlooked before new therapeutic entities are introduced into man. In general, these models may measure a variety of toxicities including genotoxicity, chronic toxicity, immunogenicity, reproductive/developmental toxicity, and carcinogenicity. Included within the aforementioned parameters are standard measurement of food consumption, bodyweight, antibody formation, clinical chemistry, and macro- and microscopic examination of standard organs/tissues (e.g. cardiotoxicity). Additional parameters of measurement are injection site trauma and the measurement of neutralizing antibodies, if any. Traditionally, monoclonal antibody therapeutics, naked or conjugated are evaluated for cross-reactivity with normal tissues, immunogenicity/antibody production, conjugate or linker toxicity and 'bystander' toxicity of radiolabeled species. Nonetheless, such studies may have to be individualized to address specific concerns and following the guidance set by ICH S6 (Safety studies for biotechnological products also noted above). As such, the general principles are that the products are sufficiently well characterized and for which impurities/contaminants have been removed, that the test material is comparable throughout development, and GLP compliance.
The pharmacokinetics (PK) of the antibodies of the invention can be studied in a variety of animal systems, with the most relevant being non-human primates such as the cynomolgous and rhesus monkeys. Single or repeated i.v./s.c. administrations over a dose range of 6000-fold (0.05-300 mg/kg) can be evaluated for the half-life (days to weeks) using plasma concentration and clearance as well as volume of distribution at a steady state and level of systemic absorbance can be measured. Examples of such parameters of measurement generally include maximum observed plasma concentration (Cmax), the time to reach Cmax (Tmax), the area under the plasma concentration-time curve from time 0 to infinity [AUCo-inf] and apparent elimination half-life (T1/2). Additional measured parameters could include compartmental analysis of concentration-time data obtained following i.v. administration and bioavailability. Examples of pharmacological/toxicological studies using cynomolgus have been established for Rituxan® and Zevalm® in which monoclonal antibodies to CD20 are cross-reactive. Biodistribution, dosimetry (for radiolabeled antibodies), and PK studies can also be done in rodent models. Such studies would evaluate tolerance at all doses administered, toxicity to local tissues, localization to rodent xenograft animal models, depletion of target cells. The antibodies of the present invention may confer superior pharmacokinetics in animal systems or in humans. For example, increased binding to FcRn may increase the half-life and exposure of the therapeutic antibody. Alternatively, decreased binding to FcRn may decrease the half-life and exposure of the Fc-containing drug in cases where reduced exposure is favorable such as when such drug has side effects. It is known in the art that the array of Fc receptors is differentially expressed on various immune cell types, as well as in different tissues. Differential tissue distribution of Fc receptors may ultimately have an impact on the pharmacodynamic (PD) and pharmacokinetic (PK) properties of antibodies of the present invention. Because antibodies of the presentation have varying affinities for the array of Fc receptors, further screening of the polypeptides for PD and/or PK properties may be extremely useful for defining the optimal balance of PD, PK, and therapeutic efficacy conferred by each candidate polypeptide.

Pharmacodynamic studies may include, but are not limited to, targeting specific tumor cells or blocking signaling mechanisms, measuring depletion of target
antigen expressing cells or signals, etc.. Such pharmacodynamic effects may be demonstrated in animal models or in humans.

[000174] The antibodies of the present invention may be used for therapeutic purposes. As will be appreciated by those in the art, the antibodies of the present invention may be used for any therapeutic purpose that uses antibodies and the like. In one embodiment, the antibodies are administered to a patient to treat disorders including but not limited to cancer.

[000175] A 'patient' for the purposes of the present invention includes both humans and other animals, e.g., mammals, e.g., humans. Thus the antibodies of the present invention have both human therapy and veterinary applications. The term "treatment" or "treating" in the present invention is meant to include therapeutic treatment, as well as prophylactic, or suppressive measures for a disease or disorder. Thus, for example, successful administration of an antibody prior to onset of the disease results in treatment of the disease. As another example, successful administration of an optimized antibody after clinical manifestation of the disease to combat the symptoms of the disease comprises treatment of the disease. "Treatment" and "treating" also encompasses administration of an optimized antibody after the appearance of the disease in order to eradicate the disease. Successful administration of an agent after onset and after clinical symptoms have developed, with possible abatement of clinical symptoms and perhaps amelioration of the disease, comprises treatment of the disease. Those "in need of treatment" include mammals already having the disease or disorder, as well as those prone to having the disease or disorder, including those in which the disease or disorder is to be prevented.

[000176] In one embodiment, an antibody of the present invention is administered to a patient having a disease involving inappropriate expression of a protein or other molecule, such as CD133. Within the scope of the present invention this is meant to include diseases and disorders characterized by aberrant proteins, due for example to alterations in the amount of a protein present, protein localization, posttranslational modification, conformational state, the presence of a mutant protein, etc.. An overabundance may be due to any cause, including but not limited to overexpression at the molecular level, prolonged or accumulated appearance at the site of action, or increased activity of a protein relative to normal. Included within this definition are
diseases and disorders characterized by a reduction of a protein. This reduction may be due to any cause, including but not limited to reduced expression at the molecular level, shortened or reduced appearance at the site of action, mutant forms of a protein, or decreased activity of a protein relative to normal. Such an overabundance or reduction of a protein can be measured relative to normal expression, appearance, or activity of a protein, and the measurement may play an important role in the development and/or clinical testing of the antibodies of the present invention.

[000177] By "cancer" and "cancerous" herein refer to or describe the physiological condition in mammals that is typically characterized by unregulated cell growth. Examples of cancer include but are not limited to carcinoma, lymphoma, blastoma, sarcoma (including liposarcoma), neuroendocrine tumors, mesothelioma, schwannoma, menigioma, adenocarcinoma, melanoma, and leukemia or lymphoid malignancies.

[000178] More particular examples of such cancers include hematologic malignancies, such as non-Hodgkin's lymphomas (NHL), B-cell acute lymphoblastic leukemia/lymphoma (B-ALL), and T-cell acute lymphoblastic leukemia/lymphoma (T-ALL), thymoma, Langerhans cell histocytosis, multiple myeloma (MM), myeloid neoplasias such as acute myelogenous leukemias (AML), including AML with maturation, AML without differentiation, acute promyelocytic leukemia, acute myelomonocytic leukemia, and acute monocytic leukemias, myelodysplastic syndromes, and chronic myeloproliferative disorders (MDS), including chronic myelogenous leukemia (CML).

[000179] The target of the antibodies of the present invention may be polymorphic in the human population. For a given patient or population of patients, the efficacy of the antibodies of the present invention may thus be affected by the presence or absence of specific polymorphisms in proteins. For example, FcγRIIIA is polymorphic at position 158, which is commonly either V (high affinity) or F (low affinity). Patients with the V/V homozygous genotype are observed to have a better clinical response to treatment with the anti-CD20 antibody Rituxan® (rituximab), likely because these patients mount a stronger NK response (Dall'Ozzo et al. (2004) Cancer Res. 64-4664-9). Additional polymorphisms include but are not limited to FcγRIIA R131 or H131, and such polymorphisms are known to either increase or decrease Fc binding and subsequent biological activity, depending on the polymorphism. Antibodies of the
present invention may bind to a particular polymorphic form of a receptor, for example FcγRIIIA 158 V, or to bind with equivalent affinity to all of the polymorphisms at a particular position in the receptor, for example both the 158V and 158F polymorphisms of FcγRIIIA. In one embodiment, antibodies of the present invention may have equivalent binding to polymorphisms that may be used in an antibody to eliminate the differential efficacy seen in patients with different polymorphisms. Such a property may give greater consistency in therapeutic response and reduce non-responding patient populations. Such variant Fc with identical binding to receptor polymorphisms may have increased biological activity, such as ADCC, CDC or circulating half-life, or alternatively decreased activity, via modulation of the binding to the relevant Fc receptors. In one embodiment, antibodies of the present invention may bind with higher or lower affinity to one of the polymorphisms of a receptor, either accentuating the existing difference in binding or reversing the difference. Such a property may allow creation of therapeutics particularly tailored for efficacy with a patient population possessing such polymorphism. For example, a patient population possessing a polymorphism with a higher affinity for an inhibitory receptor such as FcγRIIb could receive a drug containing an antibody with reduced binding to such polymorphic form of the receptor, creating a more efficacious drug.

[000180] In one embodiment, patients are screened for one or more polymorphisms in order to predict the efficacy of the antibodies of the present invention. This information may be used, for example, to select patients to include or exclude from clinical trials or, post-approval, to provide guidance to physicians and patients regarding appropriate dosages and treatment options. In one embodiment, patients are selected for inclusion in clinical trials for an antibody of the present invention if their genotype indicates that they are likely to respond significantly better to an antibody of the present invention as compared to one or more currently used antibody therapeutics. In another embodiment, appropriate dosages and treatment regimens are determined using such genotype information. In another embodiment, patients are selected for inclusion in a clinical trial or for receipt of therapy post-approval based on their polymorphism genotype, where such therapy contains an antibody engineered to be specifically efficacious for such population, or alternatively where such therapy contains an antibody that does not show differential activity to the
different forms of the polymorphism.

[000181] Included in the present invention are diagnostic tests to identify patients who are likely to show a favorable clinical response to an antibody of the present invention, or who are likely to exhibit a significantly better response when treated with an antibody of the present invention versus one or more currently used antibody therapeutics. Any of a number of methods for determining FcγR polymorphisms in humans known in the art may be used.

[000182] Furthermore, the present invention comprises prognostic tests performed on clinical samples such as blood and tissue samples. Such tests may assay for effector function activity, including but not limited to ADCC, CDC, phagocytosis, and opsonization, or for killing, regardless of mechanism, of cancerous or otherwise pathogenic cells. In one embodiment, ADCC assays, such as those described previously, are used to predict, for a specific patient, the efficacy of a given antibody of the present invention. Such information may be used to identify patients for inclusion or exclusion in clinical trials, or to inform decisions regarding appropriate dosages and treatment regimens. Such information may also be used to select a drug that contains a particular antibody that shows superior activity in such assay.

[000183] Pharmaceutical compositions are contemplated wherein an antibody of the present invention and one or more therapeutically active agents are formulated. Formulations of the antibodies of the present invention are prepared for storage by mixing the antibody having the desired degree of purity with optional pharmaceutically acceptable carriers, excipients or stabilizers (Remington's Pharmaceutical Sciences 16th edition, Osol, A. Ed., 1980), in the form of lyophilized formulations or aqueous solutions. Acceptable carriers, excipients, or stabilizers are nontoxic to recipients at the dosages and concentrations employed, and include buffers such as phosphate, citrate, acetate, and other organic acids; antioxidants including ascorbic acid and methionine; preservatives (such as octadecyldimethylbenzyl ammonium chloride; hexamethonium chloride; benzalkonium chloride, benzethonium chloride; phenol, butyl or benzyl alcohol; alkyl parabens such as methyl or propyl paraben; catechol; resorcinol; cyclohexanol; 3-pentanol; and m-cresol); low molecular weight (less than about 10 residues) polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine,
glutamine, asparagine, histidine, arginine, or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrins; chelating agents such as EDTA; sugars such as sucrose, mannitol, trehalose or sorbitol; sweeteners and other flavoring agents; fillers such as microcrystalline cellulose, lactose, corn and other starches; binding agents; additives; coloring agents; salt- forming counter-ions such as sodium; metal complexes (e.g. Zn-protein complexes); and/or non-ionic surfactants such as TWEEN™, PLURONICS™ or polyethylene glycol (PEG). In one embodiment, the pharmaceutical composition that comprises the antibody of the present invention may be in a water-soluble form, such as being present as pharmaceutically acceptable salts, which is meant to include both acid and base addition salts. "Pharmaceutically acceptable acid addition salt" refers to those salts that retain the biological effectiveness of the free bases and that are not biologically or otherwise undesirable, formed with inorganic acids such as hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid and the like, and organic acids such as acetic acid, propionic acid, glycolic acid, pyruvic acid, oxalic acid, maleic acid, malonic acid, succinic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid and the like. "Pharmaceutically acceptable base addition salts" include those derived from inorganic bases such as sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Particularly useful are the ammonium, potassium, sodium, calcium, and magnesium salts. Salts derived from pharmaceutically acceptable organic nontoxic bases include salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, and ethanolamine. The formulations to be used for in vivo administration should be sterile. This is readily accomplished by filtration through sterile filtration membranes or other methods.

[000184] The antibodies disclosed herein may also be formulated as immunoliposomes. A liposome is a small vesicle comprising various types of lipids, phospholipids and/or surfactant that is useful for delivery of a therapeutic agent to a mammal. Liposomes containing the antibody are prepared by methods known in the art, such as described in Epstein et al., 1985, Proc Natl Acad Sci USA, 82:3688; Hwang et
Liposomes with enhanced circulation time are disclosed in US 5,013,556. The components of the liposome are commonly arranged in a bilayer formation, similar to the lipid arrangement of biological membranes. Particularly useful liposomes can be generated by the reverse phase evaporation method with a lipid composition comprising phosphatidylcholine, cholesterol and PEG-derivatized phosphatidylethanolamine (PEG-PE). Liposomes are extruded through filters of defined pore size to yield liposomes with the desired diameter. A chemotherapeutic agent or other therapeutically active agent is optionally contained within the liposome (Gabizon et al., 1989, J National Cancer Inst 81:1484).

The antibody and other therapeutically active agents may also be entrapped in microcapsules prepared by methods including but not limited to coacervation techniques, interfacial polymerization (for example using hydroxymethylcellulose or gelatin- microcapsules, or poly-(methylmethacrylate) microcapsules), colloidal drug delivery systems (for example, liposomes, albumin microspheres, microemulsions, nano-particles and nanocapsules), and macroemulsions. Such techniques are disclosed in Remington's Pharmaceutical Sciences 16th edition, Osol, A. Ed., 1980. Sustained-release preparations may be prepared. Suitable examples of sustained-release preparations include semipermeable matrices of solid hydrophobic polymer, which matrices are in the form of shaped articles, e.g. films, or microcapsules. Examples of sustained-release matrices include polyesters, hydrogels (for example poly(2- hydroxyethyl-methacrylate), or poly(vinylalcohol)), polylactides (US 3,773,919), copolymers of L-glutamic acid and gamma ethyl-L- glutamate, non-degradable ethylene-vinyl acetate, degradable lactic acid-glycolic acid copolymers such as the Lupron Depot® (which are injectable microspheres composed of lactic acid-glycolic acid copolymer and leuprolide acetate), poly-D(-)-3-hydroxybutyric acid, and ProLease® (commercially available from Alkermes), which is a microsphere-based delivery system composed of the desired bioactive molecule incorporated into a matrix of poly-DL-lactide-co-glycolide (PLG).

Administration of the pharmaceutical composition comprising an antibody of the present invention, e.g., in the form of a sterile aqueous solution, may be done in a variety of ways, including, but not limited to orally, subcutaneously,
intravenously, intranasally, intraorally, transdermally, topically (e.g., gels, salves, lotions, creams, etc.), intraperitoneally, intramuscularly, intrapulmonary, vaginally, parenterally, rectally, or intraocularly. As is known in the art, the pharmaceutical composition may be formulated accordingly depending upon the manner of introduction.

[000187] As is known in the art, protein therapeutics are often delivered by IV infusion or bolus. The antibodies of the present invention may also be delivered using such methods. For example, administration may be by intravenous infusion with 0.9% sodium chloride as an infusion vehicle.

[000188] In addition, any of a number of delivery systems are known in the art and may be used to administer the antibodies of the present invention. Examples include, but are not limited to, encapsulation in liposomes, microparticles, microspheres (e.g. PLA/PGA microspheres), and the like. Alternatively, an implant of a porous, non-porous, or gelatinous material, including membranes or fibers, may be used. Sustained release systems may comprise a polymeric material or matrix such as polyesters, hydrogels, poly(vinylalcohol), polylactides, copolymers of L-glutamic acid and ethyl-L-glutamate,ethylene-vinyl acetate, lactic acid-glycolic acid copolymers such as the Lupron Depot®, and poly-D-(-)-3-hydroxyburyric acid. It is also possible to administer a nucleic acid encoding the antibody of the current invention, for example by retroviral infection, direct injection, or coating with lipids, cell surface receptors, or other transfection agents. In all cases, controlled release systems may be used to release the antibody at or close to the desired location of action.

[000189] The dosing amounts and frequencies of administration are, in one embodiment, selected to be therapeutically or prophylactically effective. As is known in the art, adjustments for protein degradation, systemic versus localized delivery, and rate of new protease synthesis, as well as the age, body weight, general health, sex, diet, time of administration, drug interaction and the severity of the condition may be necessary, and will be ascertainable with routine experimentation by those skilled in the art.

[000190] The concentration of the therapeutically active antibody in the formulation may vary from about 0.1 to 100 weight %. In one embodiment, the concentration of the antibody is in the range of 0.003 µM to 1.0 molar. In order to treat
a patient, a therapeutically effective dose of the antibody of the present invention may be administered. By "therapeutically effective dose" herein is meant a dose that produces the effects for which it is administered. The exact dose will depend on the purpose of the treatment, and will be ascertainable by one skilled in the art using known techniques. Dosages may range from 0.0001 to 100 mg/kg of body weight or greater, for example 0.1, 1, 10, or 50 mg/kg of body weight, e.g., 1 to 10mg/kg of body weight.

[000191] In some embodiments, only a single dose of the antibody is used. In other embodiments, multiple doses of the antibody are administered. The elapsed time between administrations may be less than 1 hour, about 1 hour, about 1-2 hours, about 2-3 hours, about 3-4 hours, about 6 hours, about 12 hours, about 24 hours, about 48 hours, about 2-4 days, about 4-6 days, about 1 week, about 2 weeks, or more than 2 weeks.

[000192] In other embodiments the antibodies of the present invention are administered in metronomic dosing regimes, either by continuous infusion or frequent administration without extended rest periods. Such metronomic administration may involve dosing at constant intervals without rest periods. Typically such regimens encompass chronic low-dose or continuous infusion for an extended period of time, for example 1-2 days, 1-2 weeks, 1-2 months, or up to 6 months or more. The use of lower doses may minimize side effects and the need for rest periods.

[000193] In certain embodiments the antibody of the present invention and one or more other prophylactic or therapeutic agents are cyclically administered to the patient. Cycling therapy involves administration of a first agent at one time, a second agent at a second time, optionally additional agents at additional times, optionally a rest period, and then repeating this sequence of administration one or more times. The number of cycles is typically from 2 - 10. Cycling therapy may reduce the development of resistance to one or more agents, may minimize side effects, or may improve treatment efficacy.

[000194] The antibodies of the present invention may be administered concomitantly with one or more other therapeutic regimens or agents. The additional therapeutic regimes or agents may be used to improve the efficacy or safety of the antibody. Also, the additional therapeutic regimes or agents may be used to treat the same disease or a comorbidity rather than to alter the action of the antibody. For
example, an antibody of the present invention may be administered to the patient along with chemotherapy, radiation therapy, or both chemotherapy and radiation therapy. The antibody of the present invention may be administered in combination with one or more other prophylactic or therapeutic agents, including but not limited to cytotoxic agents, chemotherapeutic agents, cytokines, growth inhibitory agents, anti-hormonal agents, kinase inhibitors, anti-angiogenic agents, cardioprotectants, immunostimulatory agents, immunosuppressive agents, agents that promote proliferation of hematological cells, angiogenesis inhibitors, protein tyrosine kinase (PTK) inhibitors, additional antibodies, FcYRIIb or other Fc receptor inhibitors, or other therapeutic agents.

[000195] The terms "in combination with" and "co-administration" are not limited to the administration of the prophylactic or therapeutic agents at exactly the same time. Instead, it is meant that the antibody of the present invention and the other agent or agents are administered in a sequence and within a time interval such that they may act together to provide a benefit that is increased versus treatment with only either the antibody of the present invention or the other agent or agents. In one embodiment, that the antibody and the other agent or agents act additively, e.g., they act synergistically. Such molecules are suitably present in combination in amounts that are effective for the purpose intended. The skilled medical practitioner can determine empirically, or by considering the pharmacokinetics and modes of action of the agents, the appropriate dose or doses of each therapeutic agent, as well as the appropriate timings and methods of administration.

[000196] In one embodiment, the antibodies of the present invention are administered with one or more additional molecules comprising antibodies or Fc. The antibodies of the present invention may be co-administered with one or more other antibodies that have efficacy in treating the same disease or an additional comorbidity, for example two antibodies may be administered that recognize two antigens that are overexpressed in a given type of cancer.

[000197] In one embodiment, the antibodies of the present invention are administered with a chemotherapeutic agent. By "chemotherapeutic agent" as used herein is meant a chemical compound useful in the treatment of cancer. Examples of chemotherapeutic agents include but are not limited to alkylating agents such as thiotepa and cyclophosphamide; alkyl sulfonates such as busulfan, imposulfan and piposulfan,
androgens such as calusterone, dromostanolone propionate, epitriostanol, mepitiostane, testolactone, anti-adrenals such as aminoglutethimide, mitotane, triolostane, anti-androgens such as flutamide, nilutamide, bicalutamide, leuprolide, and goserelin; antibiotics such as aclacinomysins, actinomycin, authramycin, azasenne, bleomycins, cactinomycin, calicheamicin, carabnici, caminomycin, carzinophilms, chromomycins, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, doxorubicin, epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins, mycophenolic acid, nogalamycin, olivomycins, peplomycin, potiriomycin, puromycin, quelamycin, rodorubicin, streptonigrin, etreptozocin, tubercidin, ubenimex, zinostatin, zorubicin; anti-estrogens including for example tamoxifen, raloxifene, aromatase inhibiting 4(5)imidazoles, 4-hydroxytamoxifen, trioxifene, keoxifene, L17018, onapristone, and toremifene (Fareston); anti-metabolites such as methotrexate and 5-fluorouracil (5-FU); folic acid analogues such as denopterin, methotrexate, pteropterin, trimetrexate; aziridines such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines including altretamine, triethylenemelamine, trietylneophosphoramid, thethyleneitiophosphaoramid and trimethylolomelamine; folic acid replenisher such as frolinic acid; nitrogen mustards such as chlorambucil, chlornaphazine, chlophosphamide, estramustine, ifosfamide, mechlorethamine, mechloretamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, uracil mustard; nitro ureas such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, ranimustine; platinum analogs such as cisplatin and carboplatin; vinblastine; platinum; proteins such as arginine deiminase and asparaginase; purine analogs such as fludarabine, 6-mercaptopurine, thiamiprine, thioguanine; pyrimidine analogs such as fludarabine, 6-mercaptopurine, thiamiprine, thioguanine; pyrimidine analogs such as ancitabine, azacitidine, 6-azauridine, carmofur, cytarabine, dideoxyuridine, doxifluridine, enocitabine, floxuridine, 5-FU; taxanes, e.g. paclitaxel (TAXOL®, Bristol-Myers Squibb Oncology, Princeton, N.J.) and docetaxel (TAXOTERE®, Rhne-Poulenc Rorer, Antony, France); topoisomerase inhibitor RFS 2000; thymidylate synthase inhibitor (such as Tomudex); additional chemotherapeutics including aceglatone; aldophosphamide glycoside; aminolevulinic acid; amsacrine; bestrabucil; bisantrene; etadatraxate; defofamine; demecolcine; diaziqurone; difluromethylornithine (DMFO); elformithine; elliptinium acetate; etoglocid; gallium nitrate; hydroxyurea; lentian; lonidamine; mitoguazone; mitoxantrone; mopidamol;
nitracrine; pentostatin; phenamet; pirarubicin; podophyllinic acid; 2-ethylhydrazide; procarbazine; PSK®; razoxane; sizofuran; spirogermanium; tenuazonic acid; triaziquone; 2, 2',2''-trichlorotriethylamine; urethan; vindesine; dacarbazine; mannomustine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); cyclophosphamide; thiotepa; chlorambucil; gemcitabine; 6-thioguanine; mercaptopurine; methotrexate; etoposide (VP-16); ifosfamide; mitomycin C; mitoxantrone; vincristine; vinorelbine; navelbine; novantrone; teniposide; daunomycin; aminopterin; xeloda; ibandronate; CPT-11; retinoic acid; esperamicins; capecitabine. Pharmaceutically acceptable salts, acids, or derivatives of any of the above may also be used.

[000198] A chemotherapeutic or other cytotoxic agent may be administered as a prodrug. By "prodrug" as used herein is meant a precursor or derivative form of a pharmaceutically active substance that is less cytotoxic to tumor cells compared to the parent drug and is capable of being enzymatically activated or converted into the more active parent form. See, for example Wilman, 1986, Biochemical Society Transactions, 615th Meeting Belfast, 14:375-382; Stella et al., "Prodrugs: A Chemical Approach to Targeted Drug Delivery," Directed Drug Delivery; and Borchardt et al., (ed.): 247-267, Humana Press, 1985. The prodrugs that may find use with the present invention include but are not limited to phosphate-containing prodrugs, thiophosphate-containing prodrugs, sulfate-containing prodrugs, peptide-containing prodrugs, D-amino acid-modified prodrugs, glycosylated prodrugs, beta-lactam-containing prodrugs, optionally substituted phenoxyacetamide-containing prodrugs or optionally substituted phenylacetamide-containing prodrugs, 5-fluorocytosine and other 5-fluorouridine prodrugs which can be converted into the more active cytotoxic free drug. Examples of cytotoxic drugs that can be derivatized into a prodrug form for use with the antibodies of the present invention include but are not limited to any of the aforementioned chemotherapeutic agents.

[000199] In another embodiment, the antibody is administered with one or more immunomodulatory agents. Such agents may increase or decrease production of one or more cytokines, up- or down-regulate self-antigen presentation, mask MHC antigens, or promote the proliferation, differentiation, migration, or activation state of one or more types of immune cells. Immunomodulatory agents include but are not limited to non-
steroidal anti-inflammatory drugs (NSAIDs) such as aspirin, ibuprofen, celecoxib, diclofenac, etodolac, fenoprofen, indomethacin, ketoralac, oxaprozin, nabumetone, sulindac, tolmetin, rofecoxib, naproxen, ketoprofen, and nabumetone, steroids (e.g. glucocorticoids, dexamethasone, cortisone, hydrocortisone, methylprednisolone, prednisone, prednisolone, trimcinolone, azulfidineicosanoids such as prostaglandins, thromboxanes, and leukotrienes, as well as topical steroids such as anthrahn, calcipotriene, clobetasol, and tazarotene), cytokines such as TGFβ, IFNα, IFNp, IFNγ, IL-2, IL-4, IL-10, cytokine, chemokine, or receptor antagonists including antibodies, soluble receptors, and receptor-Fc fusions against BAFF, B7, CCR2, CCR5, CD2, CD3, CD4, CD6, CD7, CD8, CD11, CD14, CD15, CD17, CD18, CD20, CD23, CD28, CD40, CD40L, CD44, CD45, CD402, CD64, CD80, CD86, CD147, CD152, complement factors (C5, D) CTLA4, eotaxin, Fas, ICAM, ICOS, IFNa, IFNp, IFNγ, IFNAR, IgE, IL-1, IL-2, IL-2R, IL-4, IL-5R, IL-6, IL-8, IL-9 IL-12, IL-13, IL-13R1, IL-15, IL-18R, IL-23, integrins, LFA-1, LFA-3, MHC, selectins, TGFβ, TNFa, TNFp, TNF-R1, T-cell receptor, including Enbrel® (etanercept), Humira® (adalimumab), and Remicade® (infliximab), heterologous anti-lymphocyte globulin; other immunomodulatory molecules such as 2-amino-6-aryl-5 substituted pyrimidines, anti-idiotypic antibodies for MHC binding peptides and MHC fragments, azathioprine, brequinar, bromocryptine, cyclophosphamide, cyclosporine A, D-penicillamine, deoxyaspergualm, Fk506, glutaraldehyde, gold, hydroxychloroquine, leflunomide, malononitroamides (e.g. leflunomide), methotrexate, minocycline, mizoribine, mycophenolate mofetil, rapamycin, and sulfasasazine.

[000200] In an alternate embodiment, antibodies of the present invention are administered with a cytokine. By "cytokine" as used herein is meant a generic term for proteins released by one cell population that act on another cell as intercellular mediators. Examples of such cytokines are lymphokines, monokines, and traditional polypeptide hormones. Included among the cytokines are growth hormones such as human growth hormone, N-methionyl human growth hormone, and bovine growth hormone; parathyroid hormone, thyroxine; insulin; proinsulin, relaxin, prorelaxin, glycoprotein hormones such as follicle stimulating hormone (FSH), thyroid stimulating hormone (TSH), and luteinizing hormone (LH), hepatic growth factor, fibroblast growth factor; prolactin, placental lactogen, tumor necrosis factor- alpha and -beta; mullerian-
inhibiting substance, mouse gonadotropin-associated peptide, inhibin; activin, vascular endothelial growth factor; integrin; thrombopoietin (TPO); nerve growth factors such as NGF-beta; platelet-growth factor, transforming growth factors (TGFs) such as TGF-alpha and TGF-beta, insulin-like growth factor-1 and -II; erythropoietin (EPO), osteoinductive factors, interferons such as interferon-alpha, beta, and -gamma, colony stimulating factors (CSFs) such as macrophage-CSF (M-CSF), granulocyte-macrophage-CSF (GM-CSF), and granulocyte-CSF (G-CSF), interleukins (ILs) such as IL-1, IL-1 alpha, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12, IL-15, a tumor necrosis factor such as TNF-alpha or TNF-beta, and other polypeptide factors including LIF and kit ligand (KL) As used herein, the term cytokine includes proteins from natural sources or from recombinant cell culture, and biologically active equivalents of the native sequence cytokines.

[000201] In one embodiment, cytokines or other agents that stimulate cells of the immune system are co-administered with the antibody of the present invention. Such a mode of treatment may enhance desired effector function. For example, agents that stimulate NK cells, including but not limited to IL-2 may be co-administered. In another embodiment, agents that stimulate macrophages, including but not limited to C5a, formyl peptides such as N-formyl-methionyl-leucyl-phenylalanine (Beigier-Bompadre et al. (2003) Scand J. Immunol. 57. 221-8), may be co-administered. Also, agents that stimulate neutrophils, including but not limited to G-CSF, GM-CSF, and the like may be administered. Furthermore, agents that promote migration of such immunostimulatory cytokines may be used. Also additional agents including but not limited to interferon gamma, IL-3 and IL-7 may promote one or more effector functions.

[000202] In an alternate embodiment, cytokines or other agents that inhibit effector cell function are co-administered with the antibody of the present invention. Such a mode of treatment may limit unwanted effector function.

[000203] The antibodies of the present invention may be combined with other therapeutic regimens. For example, in one embodiment, the patient to be treated with an antibody of the present invention may also receive radiation therapy. Radiation therapy can be administered according to protocols commonly employed in the art and known to the skilled artisan. Such therapy includes but is not limited to cesium, iridium, iodine, or cobalt radiation. The radiation therapy may be whole body irradiation, or may be
directed locally to a specific site or tissue in or on the body, such as the lung, bladder, or prostate. Typically, radiation therapy is administered in pulses over a period of time from about 1 to 2 weeks. The radiation therapy may, however, be administered over longer periods of time. For instance, radiation therapy may be administered to patients having head and neck cancer for about 6 to about 7 weeks. Optionally, the radiation therapy may be administered as a single dose or as multiple, sequential doses. The skilled medical practitioner can determine empirically the appropriate dose or doses of radiation therapy useful herein. In accordance with another embodiment of the invention, the antibody of the present invention and one or more other anti-cancer therapies are employed to treat cancer cells ex vivo. It is contemplated that such ex vivo treatment may be useful in bone marrow transplantation and particularly, autologous bone marrow transplantation. For instance, treatment of cells or tissue(s) containing cancer cells with antibody and one or more other anti-cancer therapies, such as described above, can be employed to deplete or substantially deplete the cancer cells prior to transplantation in a recipient patient.

[000204] It is of course contemplated that the antibodies of the invention may employ in combination with still other therapeutic techniques such as surgery or phototherapy.

[000205] The present invention is further illustrated by the following examples. However, it should be understood, that the invention is not limited to the exemplified embodiments.
EXAMPLES

Materials and methods

A. Bacterial strains and Plasmids

[000206] *Escherichia coli* DH5a (Invitrogen, Karlsruhe, Germany) was used for the amplification of plasmids and cloning.

B. Cell lines

[000207] Mouse myeloma cell line Sp2/0-Agl4 (ATCC, American Type Culture Collection, Manassas, VA, USA) used for production of recombinant hum-CD133 (Prominin) specific antibody derivatives was cultured in IMDM (PAN-Biotech, Aidenbach, Germany) supplemented with 10% fetal calf serum (PAN-Biotech, Aidenbach, Germany), 1% penicillin and streptomycin (Lonza, Basel, Switzerland). Stable transfectants were selected with 1 mg/ml G418 (Invitrogen, Karlsruhe, Germany).

[000208] Hybridoma cell line 293AC1C3H9 secreting mouse IgG2b\kappa and hybridoma cell line W6B3H10 secreting mouse IgGl/\kappa anti human CD133 (Prominin) specific antibodies (from Dr. Hans-Jorg Buhring, UKT Tubingen, Germany) were grown in IMDM-medium supplemented with 10% fetal calf serum (PAN-Biotech, Aidenbach, Germany), 1% penicillin and streptomycin (Lonza, Basel, Switzerland).

[000209] Both, cloning of the antigen specific V regions (example 1) and insertion of these gene segments into suitable expression vectors (example 2) are the steps neccessary for the construction of chimeric monoclonal antibodies and their optimized derivatives.

Example 1: Identification of unknown sequences from CD133 specific antibodies

A. Cloning of the DNA encoding V regions

[000210] The cloning of the V regions was done by PCR. Most techniques start from mRNA and make use of the similarity of antibody V regions (Kabat, E.A., Wu, T.T., Reid-Mtller, M., Perry, H.M., Gottesman, K.S. Sequences of Proteins of

[000211] Cytoplasmatic RNAs were prepared from the hybridoma cell lines 293AC1C3H9 and W6B3H10 using the RNeasy Kit (Qiagen, Hilden, Germany) applying a modified protocol for the isolation of cytoplasmatic RNA only.

[000212] Using oligo (dT)$_{15}$ primer, double-stranded cDNA (ds-cDNA) was prepared from 0,3-2 μg of mRNA using the cDNA Synthesis System (Roche, Mannheim, Germany). To permit blunt-end formation on the DNA strands the ds-cDNA was incubated with T4-DNA polymerase. The reaction mixture was extracted once with an equal volume phenol-chloroform-isoamylalcohol (25:24:1) and precipitated with ethanol. The dissolved ds-cDNA pellet was incubated with T4 DNA ligase (Roche,
Mannheim, Germany) to circularize the cDNA (Uematsu Y. A novel and rapid cloning method for the T-cell receptor variable region sequences. In immunity, 34:174-178, 1991). The 3’ poly(A) tail is ligated to the unknown 5’ end of the cDNA by circularization.

B. PCR amplification of immunoglobulin variable region cDNAs

[000213] The use of two outward-directed constant region specific primers (summarized in Table 1) in an iPCR reaction allowed the amplification of the entire cDNA of rearranged light and heavy chain gene segments. 1-5 µl of circularized ds-cDNA were included in a 50 µl standard PCR reaction (HotStar Taq DNA Polymerase, Qiagen, Hilden, Germany) with primer pair Ck-for and Ck-back for the light chain and primer pair gamma2b-for and gamma2b-rev (isotyp IgG2b) and primer pair gamma1-for and gammal-back (isotype IgG1) for the heavy chain amplification. Fourty amplification cycles were performed at the following conditions: 30 sec 94°C, 1 min 56°C, 2 min 72°C. The DNA obtained from the inverse PCR was separated on 1% agarose gels. The DNA bands of corresponding size (light chain approx. 1000 bp; heavy chain approx. 1600 bp) were cut out, isolated by standard techniques (Maniatis et al. 1982) and cloned into the pGEM-T Easy vector (Promega, Madison, WI, USA). For sequence determination standard primers for the vector system and immunoglobulin constant region specific primers (light chain: k-for1 and k-for 2; gammal heavy chain: CGI-for1, CGI-for2, CGI-rev1, CGI-rev2; gamma2b heavy chain: 2b-Seql, 2b-Seq2, 2b-Seq3, 2b-Seq4) were used (summarized in Table 1).

Table 1: Primers used for amplification and sequencing of VJ and VDJ regions of CD133 specific antibodies

<table>
<thead>
<tr>
<th>Oligonucleotides used for the inverse PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>A’</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A’</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B’</td>
</tr>
</tbody>
</table>
## Oligonucleotides used for sequencing

<table>
<thead>
<tr>
<th>Oligonucleotide</th>
<th>Sequencing Primer (SEQ)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>k-for1</td>
<td>5'-CCT GTT GAA GCT CTT GAC AAT GGG-3' (SEQ ID NO:51)</td>
<td></td>
</tr>
<tr>
<td>k-for2</td>
<td>5'-ATG TCT TGT GAG TGG CCTCACAGG-3' (SEQ ID NO:52)</td>
<td></td>
</tr>
<tr>
<td>CG1-for1</td>
<td>5'-CGT CTA CAG CAA GCT CAA TGTGC-3' (SEQ ID NO:53)</td>
<td></td>
</tr>
<tr>
<td>CG1-for2</td>
<td>5'-CGT CTA CAG CAA GCT CAA TGTGC-3' (SEQ ID NO:54)</td>
<td></td>
</tr>
<tr>
<td>CG1-rev1</td>
<td>5'-CCC GGT CAC TGT CAC TGG CTC AGG-3' (SEQ ID NO:55)</td>
<td></td>
</tr>
<tr>
<td>CG1-rev2</td>
<td>5'-CGT CTA CAG CAA GCT CAA TGTGC-3' (SEQ ID NO:56)</td>
<td></td>
</tr>
<tr>
<td>2b-Seq1</td>
<td>5'-GAG TGG CAA GGA GTT CAA ATG C-3' (SEQ ID NO:57)</td>
<td></td>
</tr>
<tr>
<td>2b-Seq2</td>
<td>5'-CAT GCA ACG TGA GAC ACG AGG G-3' (SEQ ID NO:58)</td>
<td></td>
</tr>
<tr>
<td>2b-Seq3</td>
<td>5'-CGG AGG AAC CAG TTG TAT CTC C-3' (SEQ ID NO:59)</td>
<td></td>
</tr>
<tr>
<td>2b-Seq4</td>
<td>5'-CCC GGA GAC CGG GAG ATG GTC TTC-3' (SEQ ID NO:60)</td>
<td></td>
</tr>
</tbody>
</table>

[000214] Thus, the complete light chains and heavy chains of murine antibodies secreted by hybridoma cell line 293AC1C3H9 (light chain amino acid sequence set forth in SEQ ID NO:15 including the variable domain (SEQ ID NO:13), the variable domain including CDR1 (SEQ ID NO:1), CDR2 (SEQ ID NO:2) and CDR3 (SEQ ID NO:3); heavy chain amino acid sequence set forth in SEQ ID NO:16, including the variable domain (SEQ ID NO:14), the variable domain including CDR1 (SEQ ID NO:4), CDR2 (SEQ ID NO:5) and CDR3 (SEQ ID NO:6)) and hybridoma cell line W6B3H10 (light chain amino acid sequence set forth in SEQ ID NO:31 including the variable domain (SEQ ID NO:29), the variable domain including CDR1 (SEQ ID NO:7), CDR2 (SEQ ID NO:8) and CDR3 (SEQ ID NO:9); heavy chain amino acid sequence set forth in SEQ ID NO:32 including the variable domain (SEQ ID NO:30), the variable domain including CDR1 (SEQ ID NO:10), CDR2 (SEQ ID NO:11) and CDR3 (SEQ ID NO:12) were identified.

[000215] The light chain of murine antibody 293AC1C3H9 is encoded by the nucleotide sequence set forth in SEQ ID NO:19 (complete cDNA sequence set forth in SEQ ID NO:20), wherein the variable domain is encoded by the nucleotide sequence set forth in SED ID NO:17. The heavy chain of antibody 293AC1C3H9 is encoded by the nucleotide sequence set forth in SEQ ID NO:21 (complete cDNA sequence set forth in SEQ ID NO:22), wherein the variable domain is encoded by the nucleotide sequence set forth in SEQ ID NO:18.

[000216] The light chain of murine antibody W6B3H10 is encoded by the nucleotide sequence set forth in SEQ ID NO:35 (complete cDNA sequence set forth in SEQ ID NO:36), wherein the variable domain is encoded by the nucleotide sequence set forth in SED ID NO:33. The heavy chain of antibody W6B3H10 is encoded by the
nucleotide sequence set forth in SEQ ID NO:37 (complete cDNA sequence set forth in SEQ ID NO:38), wherein the variable domain is encoded by the nucleotide sequence set forth in SEQ ID NO:34.

Example 2: Construction and expression of chimeric CD133 specific antibodies and their derivatives

[000217] In the second construction step of recombinant antibodies, the cloned V regions were combined with the desired C regions in an expression vector. The cloning procedure performed here allows the introduction of complete Ig V regions and their expression in lymphoid cells without any alterations of their amino acid sequence. For this, The nucleotide sequence of the amplicon obtained in Example 1 was determined after subcloning by sequencing (primer in Table 1) and used for design of primer pairs (C C'; D D'; Table 2). The reamplified DNA fragments of the V segments is cut with appropriate restriction nucleases (summarized in Table 2) and then ligated into the expression vectors. The vectors (Figure 2 and 3) contain human light and heavy constant region genes. Thus insertion of the amplified and recut V segments reconstitutes the original genomic organisation of the Ig genes on the vectors without altering any amino acid of the V regions.

[000218] The parental vector for the light chain contains the VJ region of the mouse light chain and the C region of human κ gene. Restriction sites were introduced at the required locations (Xhol and Spel) in order to substitute the light chain Xhol-Spel fragment with the appropriate VJ fragment of the light chain of monoclonal antibodies 293AC1C3H9 or W6B3H10 or any other monoclonal antibody. The region relevant for the fragment exchange is shown enlarged in Figure 2. The fragment to be exchanged contains part of the second exon of the leader sequence, an appropriate site (Xhol) for in frame fusion, the VJ region and part of the second intron with restriction site Spel.

[000219] The original vector for the heavy chain contains the human γδ isotype Ig heavy chain. Restriction sites were introduced at the required positions in intron I and II for exchange of the Aatll-Clal fragment with the VDJ fragment of the heavy chain of monoclonal antibodies 293AC1C3H9 or W6B3H10 or any other monoclonal antibody. The region relevant for cloning the VDJ fragment is shown enlarged in Figure 3a. The fragment to be exchanged contains parts of the first intron with an Aatll restriction site,
the second exon of the leader sequence, the VDJ region and part of the second intron with the restriction site Clal. For the substitution of all exons of the constant region, restriction sites were introduced at the required position in intron II (Mlul) and intron VI (Spel). The Mlul-Spel fragment to be exchanged (shown enlarged in Figure 3b) contains the entire constant region of the human γ1 heavy chain and two amino acid modifications in the CH2 domain as indicated (Ser219-Asp; Ile332-Glu)

 Furthermore, with the expression vectors used, it is possible to exchange the entire constant region of the human Igγ1 isotype (Mlul-Spel fragment; see Figure 3) either against constant regions of all other antibody isotypes or against Fc parts with optimized or reduced effector function. In the case of antibodies optimized for triggering ADCC a S239D and I332E (amino acid position according to Kabat nomenclature) exchange were introduced in the CH2 domain of human γ1 constant region. This was done according the publication of Lazar et al. (Lazar G.A., Dang W, Karči S, Vafa O, Peng J.S., Hyun L, Chan C, Chung H.S., Eivazi A, Yoder S.C., Vielmetter J, Carmichael D.F., Hayes R.J., Dahiyat B.I. Engineered antibody Fc variants with enhanced effector function. Proc. Natl. Acad. Sci. USA 103: 4005-4010, 2006).

Table 2: Oligonucleotides used for amplification of VJ and VDJ segments obtained by iPCR for the insertion into expression vectors

<table>
<thead>
<tr>
<th>Oligonucleotides used for the heavy chain VDJ segment</th>
<th>Oligonucleotides used for the light chain VJ segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>W6B3-H-hin 5'-ctg ttc ttc tct tca cag gtg tcc tct ccc aga tcc aac tac agc agt ctc gac cgg acc-3' (SEQ ID NO:61)</td>
</tr>
<tr>
<td>C'</td>
<td>W6B3-H-rev 5'-tag aat ggg aga agg tag gag tca cct gag gag agc gtt acc ggc gtc cct ccc ggc cag-3' (SEQ ID NO:62)</td>
</tr>
<tr>
<td>C</td>
<td>293-H-hin 5'-ctg ttc ttc tca cag gtg tcc tct ccc aga tcc aac tac agc agt ctc gac cgg acc-3' (SEQ ID NO:63)</td>
</tr>
<tr>
<td>C'</td>
<td>293-H-rev 5'-tag aat ggg aga agg tag gag tca cct gag gag agc gtt acc gac att ccc cgg cag-3' (SEQ ID NO:64)</td>
</tr>
<tr>
<td>C</td>
<td>universal for (AatII) 5'-aga cgt cca ctc tgt ctt ctt ccc cag agg tgt cct ccc c-3' (SEQ ID NO:65)</td>
</tr>
<tr>
<td>C'</td>
<td>universal rev (ClaI) 5'-tat cga ttg aga atg gga gaa ggt agg act cac-3' (SEQ ID NO:66)</td>
</tr>
<tr>
<td>D</td>
<td>W6B3-kappa-hin (Xhol) 5'-act cga gga gag acc tga atg acc cca tct ccc aca tcc cgg acc-3' (SEQ ID NO:67)</td>
</tr>
<tr>
<td>D'</td>
<td>W6B3-kappa-rev (Spel) 5'-tac tag tac cga cta cag aac tgc gca cga cgc aac gtt cgg agg-3' (SEQ ID NO:68)</td>
</tr>
<tr>
<td>D</td>
<td>293-kappa-hin (Xhol) 5'-act cga gga caa att gtt ctc acc cag tcc cca gca aca atg-3' (SEQ ID NO:69)</td>
</tr>
<tr>
<td>D'</td>
<td>293-kappa-rev (Spel) 5'-tac tag tac cgt ttg att tct cag tgg gtc ccc cct ccc cag acc atg-3'</td>
</tr>
</tbody>
</table>
Thus, chimeric antibodies 293AC1C3H9 or W6B3H10 and the Fc optimized variants SD1E 293 and SD1E W6B3 were obtained. These comprise the following amino acid and nucleotide sequences:

Chimeric antibody 293AC1C3H9: light chain amino acid sequence as set forth in SEQ ID NO:23 and as encoded by the nucleotide sequence set forth in SEQ ID NO:24, heavy chain amino acid sequence as set forth in SEQ ID NO:25 and as encoded by the nucleotide sequence set forth in SEQ ID NO:26.

SD1E 293 (chimeric, Fc optimized antibody): light chain amino acid sequence set forth in SEQ ID NO:23 and encoded by the nucleotide sequence set forth in SEQ ID NO:24, heavy chain amino acid sequence set forth in SEQ ID NO:27 and encoded by the nucleotide sequence set forth in SEQ ID NO:28.

Chimeric antibody W6B3H10: light chain amino acid sequence as set forth in SEQ ID NO:39 and as encoded by the nucleotide sequence set forth in SEQ ID NO:40, heavy chain amino acid sequence as set forth in SEQ ID NO:41 and as encoded by the nucleotide sequence set forth in SEQ ID NO:42.

SD1E W6B3 (chimeric, Fc optimized antibody): light chain amino acid sequence set forth in SEQ ID NO:39 and encoded by the nucleotide sequence set forth in SEQ ID NO:40, heavy chain amino acid sequence set forth in SEQ ID NO:43 and encoded by the nucleotide sequence set forth in SEQ ID NO:44.

Example 3: Expression and purification of anti-CD133 antibodies

Cotransfection of the expression vectors encoding the chimeric heavy and light chain (IgGl/κ) or modified heavy chains into the non-Ig-producing myeloma cell line Sp2/0 yielded stable transfectomas secreting chimeric monoclonal antibodies which are able to bind specifically to CD133.

Chimeric antibodies were purified from cell culture supernatant by affinity chromatography on Protein A.

Example 4: ADCC effector function of anti-CD133 antibodies

The ADCC effector function of the Fc optimized, chimeric anti-CD133
antibodies 293AC1C3B9-SDIE and W6B3H10-SDIE in comparison to the corresponding chimeric antibodies without Fc optimization (Figure 4 A and B) as well as an chimeric anti-NG2 antibody comprising the same Fc modification (Figure 4C) was demonstrated using chromium release assays. The target cells used were:

- **WERI-Rbl**: Cells were originally described by McFall RC et al., Cancer Res. 37,1003-1010 (1977) and provided by Dr. H.-J. Buhring, Department of Internal Medicine II, University of Tubingen.

- **SK-Mel63**: Human melanoma cell line, original supplier: Dr. A. Knuth, Nordwestkrankenhaus Frankfurt/Main, Germany.

- **PBMC**: The effector cells used were peripheral blood mononuclear cells isolated from the blood of normal healthy donors.

The chromium release assay was performed as follows: 10^6 target cells were labeled with sodium chromate (\(^{51}\)Cr, 150\(\mu\)Ci/mL) for 1 hr, washed and plated in 96-well microtiter plates (10,000 cells per well). PBMC and antibodies were then added at the indicated concentrations. After 4 and 20 hrs respectively supernatant was harvested and counted in a MicroBeta Counter. Cytotoxicity was determined according to the standard formula: 

\[
\text{%specific } {^{51}\text{Cr}}\text{-release} = \frac{(\text{experimental release} - \text{spontaneous release})}{(\text{total release} - \text{spontaneous release})} \times 100.
\]

Spontaneous and total release were determined by incubating target cells in medium with and without 2 % Triton-X100, respectively.

The results depicted in Figure 4 clearly show that the introduction of the Fc modifications S239D and I332E into the CH2 domain of the heavy chain of chimeric anti-CD133 antibodies 293AC1C3B9 and W6B3H10 could induce significant cell killing activity in both antibodies. In contrast to these results, the introduction of the same modifications into a chimeric anti-NG2 antibody had no such effect. Accordingly, there is no general principle that the two modifications used can confer cell killing activity to any given antibody, but rather have to be carefully selected for each individual monoclonal antibody.

**Example 5: Binding of two different anti-CD133 antibodies to PBMCs of chronic lymphatic leukemia (CLL) patients**

The binding of the two different anti-CD133 antibodies, W6B3...
(W6B3H10) and 293C3 (293AC1C3B9), to PBMCs of 9 patients with chronic lymphatic leukemia (CLL), was determined by flow cytometry. Binding was determined by incubating CLL cells purified by density gradient centrifugation with the respective mouse antibodies (1μg/ml). Cells were then incubated with PE-labeled goat anti mouse antibodies and fluorescence was assessed using fluorescence activated cell sorting (FACS). The results depicted in Figure 5 show that only the anti-CD133 antibody 293C3 (293AC1C3B9) could bind these cells.

[000235] The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein. Other embodiments are within the following claims. In addition, where features or aspects of the invention are described in terms of Markush groups, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[000236] One skilled in the art would readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. Further, it will be readily apparent to one skilled in the art that varying substitutions and modifications may be made to the invention disclosed herein without departing from the scope and spirit of the invention. The compositions, methods, procedures, treatments, molecules and specific compounds described herein are presently representative of preferred embodiments are exemplary and are not intended as limitations on the scope of the invention. Changes therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention are defined by the scope of the claims. The listing or discussion of a previously published document in this specification should not necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge.

[000237] The invention illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including,"
containing", etc. shall be read expansively and without limitation. The word "comprise" or variations such as "comprises" or "comprising" will accordingly be understood to imply the inclusion of a stated integer or groups of integers but not the exclusion of any other integer or group of integers. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by exemplary embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention.

[000238] The content of all documents and patent documents cited herein is incorporated by reference in their entirety.
CLAIMS

What is claimed is:

1. An antibody that binds human CD133, said antibody comprising a heavy chain and/or a light chain and at least one amino acid substitution in the constant region relative to a parent anti-CD133 antibody, wherein said at least one amino acid substitution comprises the amino acid substitutions S239D and I332E, wherein the positional numbering is according to the EU index.

2. The antibody of claim 1, wherein the antibody has antibody-dependent cell-mediated cytotoxicity (ADCC) effector function.

3. The antibody of claim 1 or 2, wherein said antibody comprises a heavy chain and a light chain, the heavy chain comprising a $V_H$ CDR1, a $V_H$ CDR2, and a $V_H$ CDR3 region, and the light chain comprising a $V_L$ CDR1, a $V_L$ CDR2, and a $V_L$ CDR3, wherein

   said $V_L$ CDR1 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences SEQ ID NO:1 and SEQ ID NO:7;

   said $V_L$ CDR2 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:2 and SEQ ID NO:8;

   said $V_L$ CDR3 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:3 and SEQ ID NO:9;

   said $V_H$ CDR1 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:4 and SEQ ID NO:10;

   said $V_H$ CDR2 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:5 and SEQ ID NO:11; and
said $V_H$ CDR3 comprises, consists essentially of or consists of an amino acid sequence selected from the group consisting of the amino acid sequences of SEQ ID NO:6 and SEQ ID NO: 12.

4. The antibody of claim 3, wherein the $V_L$ CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:1; the $V_L$ CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:2; the $V_L$ CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:3; the $V_H$ CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:4; the $V_H$ CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:5; and the $V_H$ CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:6.

5. The antibody of claim 3, wherein the $V_L$ CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:7; the $V_L$ CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:8; the $V_L$ CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:9; the $V_H$ CDR1 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:10; the $V_H$ CDR2 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO:11; and the $V_H$ CDR3 comprises, consists essentially of or consists of the amino acid sequence set forth in SEQ ID NO: 12.

6. The antibody of claim 3 or 4, wherein the heavy chain comprises a $V_H$ domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO: 14 and the light chain comprises a $V_L$ domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO: 13.

7. The antibody of claim 3 or 5, wherein the heavy chain comprises a $V_H$ domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO: 30 and the light chain comprises a $V_L$ domain comprising, consisting essentially of or consisting of the amino acid sequence set forth in SEQ ID NO:29.
8. The antibody of claim 3, wherein the antibody is a chimeric antibody and comprises a heavy chain having the amino acid sequence set forth in SEQ ID NO:27 and a light chain having the amino acid sequence set forth in SEQ ID NO:23.

9. The antibody of claim 3, wherein the antibody is a chimeric antibody and comprises a heavy chain having the amino acid sequence set forth in SEQ ID NO:43 and/or a light chain having the amino acid sequence set forth in SEQ ID NO:39.

10. The antibody of any one of claims 1-9, wherein said antibody binds with enhanced affinity to the FcγRIIIa receptor or has enhanced ADCC effector function as compared to the parent antibody.

11. An antibody according to any one of claims 1-10, comprising one or more further amino acid modifications at a position selected from the group consisting of 221, 222, 223, 224, 225, 227, 228, 230, 231, 232, 233, 234, 235, 236, 237, 238, 240, 241, 243, 244, 245, 246, 247, 249, 255, 258, 260, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 278, 280, 281, 282, 283, 284, 285, 286, 288, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 313, 317, 318, 320, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 333, 334, 335, 336, and 337, wherein the positional numbering is according to the EU index.


13. The antibody of claim 11, wherein said one or more further amino acid modifications are at a position selected from the group consisting of 221, 222, 223, 224, 225, 228, 230, 231, 232, 240, 244, 245, 247, 262, 263, 266, 271, 273, 275, 281, 284, 291, 299, 302, 304, 313, 323, 325, 328, and 336, wherein the positional numbering is according to the EU index.

15. An antibody according to claim 11, wherein the one or more further amino acid modifications are selected from the group consisting of: 236A, 268D, 268E, 330Y, and 330L.

16. A nucleic acid molecule encoding a heavy or light chain of the antibody of any one of claims 1-15.

17. The nucleic acid molecule of claim 16, wherein the nucleic acid molecule comprises a nucleotide sequence encoding the variable domain of the light chain selected from the group of nucleotide sequences set forth in SEQ ID NO: 17 and SEQ ID NO:33.

18. The nucleic acid molecule of claim 16, wherein the nucleic acid molecule comprises a nucleotide sequence encoding the variable domain of the heavy chain selected from the group of nucleotide sequences set forth in SEQ ID NO: 18 and SEQ ID NO:34.

19. The nucleic acid molecule of claim 16, wherein the nucleic acid molecule encoding the light chain of the antibody of the invention has a nucleotide sequence selected from the group consisting of SEQ ID Nos. 24 and 40.

20. The nucleic acid molecule of claim 16, wherein the nucleic acid molecule encoding the heavy chain of the antibody of the invention has a nucleotide sequence selected from the group consisting of SEQ ID Nos. 28 and 44.
21. A method of treating a CD133-related disease or disorder, wherein said method comprises administering an antibody according to any one of claims 1-15 to a subject in need thereof.

22. The method of claim 21, wherein said subject is a mammal.

23. The method of claim 22, wherein said mammal is a human.

24. The method of any one of claims 21-23, wherein said disease or disorder is a cell proliferative disease or disorder.

25. The method of claim 24, wherein the cell-proliferative disease or disorder is cancer or myelodysplastic syndrome (MDS).

26. The method of claim 25, wherein the cancer is selected from the group consisting of glioma/glioblastoma, melanoma, pancreatic cancer, gastric cancer, colon cancer, colorectal cancer, breast cancer, ovarian cancer, sarcoma, prostate carcinoma, liver cancer, lung cancer and haematological malignancies.

27. The method of claim 26, wherein the haematological malignancy is a lymphoma or leukemia.

28. The method of claim 27, wherein the lymphoma or leukemia is selected from the group consisting of: non-Hodgkin's lymphomas (NHL), chronic lymphocytic leukemia (CLL), B-cell acute lymphoblastic leukemia/lymphoma (B-ALL), mantle cell lymphoma (MCL), hairy cell leukemia (HCL), chronic myeloid leukemia (CML), acute myeloid leukemia (AML), and multiple myeloma (MM).

29. The method of any one of claims 21-28, wherein said antibody is administered in combination with at least one agent selected from the group consisting of a cytotoxic agent, a chemotherapeutic agent, a cytokine, a growth inhibitory agent, an anti-hormonal agent, a kinase inhibitor, an anti-angiogenic agent, a cardioprotectant, an immunostimulatory agent, an immunosuppressive agent, an angiogenesis inhibitor, a protein tyrosine kinase inhibitor, and second antibody.
30. A pharmaceutical composition comprising an antibody according to any one of claims 1-15 and a pharmaceutically acceptable carrier.

31. A method of inhibiting proliferation of a cell expressing CD133, wherein said method comprises contacting said cell with an antibody according to any one of claims 1-15.

32. A method of enhancing antibody dependent cell cytotoxicity toward a cell expressing CD133, wherein said method comprises contacting said cell with an antibody according to any one of claims 1-15.

33. A method of depleting a mammal of at least one cell expressing CD133, wherein said method comprises administering to the mammal an antibody according to any one of claims 1-15.

34. Use of an antibody according to any one of claims 1-15 for the manufacture of a pharmaceutical for treating a CD133-related disease or disorder.

35. The use of claim 34, wherein the disease or disorder is a cell proliferative disease or disorder.

36. The use of claim 35, wherein the cell-proliferative disease or disorder is cancer or myelodysplastic syndrome (MDS).

37. The use of claim 36, wherein the cancer is selected from the group consisting of glioma/glioblastoma, melanoma, pancreatic cancer, gastric cancer, colon cancer, colorectal cancer, breast cancer, ovarian cancer, sarcoma, prostate carcinoma, liver cancer, lung cancer and haematological malignancies.

38. The use of claim 37, wherein the haematological malignancy is a lymphoma or leukemia.

39. The use of claim 38, wherein the lymphoma or leukemia is selected from the group consisting of: non-Hodgkin's lymphomas (NHL), chronic lymphocytic leukemia (CLL), B-cell acute lymphoblastic leukemia/lymphoma (B-ALL), mantle cell
lymphoma (MCL), hairy cell leukemia (HCL), chronic myeloid leukemia (CML), acute myeloid leukemia (AML), and multiple myeloma (MM).

40. The use of an antibody according to any one of claims 1-15 for the targeting of a cell expressing CD133.

41. The use of an antibody according to any one of claims 1-15 for the detection of a cell expressing CD133 in a biological sample.

42. A monoclonal antibody according to any one of claims 1-15, wherein the antibody is produced by a transfected cell line.

43. Transfected cell line producing an antibody according to any one of claims 1-15.
FIGURES

Figure 1

heavy chain gene

light chain gene

transcription

mRNA transcribed into ds-cDNA

circularization by ligation

inverse PCR, subcloning, sequencing

amplification, restriction endonuclease cleavage,

insertion into the expression vectors

SUBSTITUTE SHEET (RULE 26)
Figure 2

Vector for expression of chimeric kappa chain of anti-CD133 specific antibodies in lymphoid cells

ATG GTT TTC ACA CCT CRG ATA CTT GGA CTT ATG CTT TTT TGG ATT TCA G]gtatgactgctt........intron I...
Met Val Phe Thr Pro Gin Ile Leu Gly Leu Met Leu Phe Trp Ile Ser G
-20

XhoI
..tttccag[GT GCT CGA GGA]GA........VJ exon (as amplified by iPCR)........AAA C]gtaagtaagtactagttttt...intron II.....
ly Ala Arg Gly Asp +1

SpeI

Lys A
Figure 3

Vector for expression of chimeric heavy chain (γ1) of anti-CD133 specific antibodies in lymphoid cells

A

B

ATG GGA TGG AGC TGG ATC TTT CTC TTT CTC CTG TCA GGA ACT GCA G]gtaggggct........intron I...
Met Gly Trp Ser Trp Ile Phe Leu Phe Leu Leu Ser Gly Thr Ala G

-19

AatII

....tgacgtcactctgtttttcttttccacag[GT GTC CTC TCC]CAG....VDJ exon....TCA G]gtgagctctactttcctccattctaatcgat........
ly Val Leu Ser Gln Ser A intron II

+1
Figure 4

A

Targets: WERI-Rb1 (CD133++)
Effectors: PBMC, 1:40, t = 4 hrs

B

Targets: W6B3H10 = anti-CD133

C

Targets: SK-Mel 63 (NG2++)
Effectors: PBMC, 1:40, t = 4 hrs

Specific Grl Release [%]

spontaneous NK activity

antibody concentration [ng/ml]

0.001 0.1 1 10 100 1000 10000

0 10 20 30 40

0 10 20 30 40 50

9.2.27 = anti-NG2

specific Grl Release [%]
Figure 5

![Graph showing mean fluorescence intensity for different patients. The x-axis represents Patient with labels KM-1, SK-2, RG-1, NW-1, KG-1, SH-2, SB-1, NR-1, and LW-1. The y-axis represents mean fluorescence intensity with values ranging from 0 to 120. Two samples are compared: W6B3 and 293-C3.]
1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application and necessary to the claimed invention, the international search was carried out on the basis of:
   a. (means)
      - [ ] on paper
      - [x] in electronic form
   b. (time)
      - [x] in the international application as filed
      - [ ] together with the international application in electronic form
      - [ ] subsequently to this Authority for the purpose of search

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

3. Additional comments:
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

**INV.** C07K16/28  C07K16/46

**ADD.**

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C07K

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BIOSIS, EMBASE, WPI Data, Sequence Search

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>X</td>
<td>wo 2009/001840 AI (FORERUNNER PHARMA RES LTD [JP]; YOSHIIDA KENJI [JP]) 31 December 2008 (2008-12-31)</td>
<td>16, 17, 19</td>
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<td>Y</td>
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<td>&amp; EP 2 175 016 AI (FORERUNNER PHARMA RES LTD [JP]) 14 April 2010 (2010-04-14)</td>
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[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
  
  "A" document defining the general state of the art which is not considered to be of particular relevance
  
  "B" earlier document but published on or after the international filing date
  
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  
  "O" document referring to an oral disclosure, use, exhibition or other means
  
  "P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search: 12 April 2011

Date of mailing of the international search report: 20/04/2011

Name and mailing address of the ISA:

European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer:

Luyten, Kattie

Form PCT/ISA/210 (second sheet) (April 2005)
<table>
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<tr>
<td>Y</td>
<td>LAZAR G A ET AL: &quot;Engineered anti body Fc variants with enhanced effector function&quot;, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES (PNAS), NATIONAL ACADEMY OF SCIENCES, US, vol. 103, no. 11, 1 March 2006 (2006-03-01), pages 4005-4010, XP002403708, ISSN: 0027-8424, DOI: DOI: 10.1073/PNAS.0508123103 cited in the application wholly document, especially Figure 3</td>
<td>1-43</td>
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<td>WO 2008/098115 A2 (XENCOR INC [US]; CHAMBERLAIN AARON K [US]; DANG WEI [US]; LAZAR GREGOR) 14 August 2008 (2008-08-14) figure 6; example 1</td>
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