ANTI-CD100 ANTIBODIES AND METHODS FOR USING THE SAME

BACKGROUND OF THE INVENTION

[0001] CD100, also known as semaphorin 4D (SEMA4D), is a transmembrane protein (*e.g.*, SEQ ID NO: 1 (human); SEQ ID NO: 2 (murine)) that belongs to the semaphorin gene family. CD100 is expressed on the cell surface as a homodimer, but upon cell activation CD100 can be released from the cell surface via proteolytic cleavage to generate active sCD100, a soluble form of the protein. See Suzuki *et al.*, *Nature Rev. Immunol. 3*:159-167 (2003); Kukutani *et al.*, *Nature Immunol. 9*:17-23 (2008).

[0002] CD100 was first identified by generating two mouse monoclonal antibodies, BD16 and BB18, against activated human T cell clones (Herold *et al.*, *Int. Immunol. 7*:1-8 (1994)). CD100 was the first example of a semaphorin expressed in the immune system. CD100 is expressed abundantly on the surface of resting T cells, and weakly on resting B cells, monocytes, and professional antigen-presenting cells, such as dendritic cells (DCs). Cellular activation can stimulate up-regulation of surface expression of CD100 on B cells and DCs, as well as the generation of sCD100. CD100 is thought to function as both a receptor, which signals through its cytoplasmic domain, and as a ligand (Hall *et al.*, *PNAS 93*:11780-11785 (1996)). One of the receptors identified for CD100 is Plexin-B1. Plexin-B1 is expressed in non-lymphoid tissues and is a high affinity (1 nM) receptor for CD100 (Tamagnone *et al.*, *Cell 99*:71-80 (1999)).

[0003] CD100 is an important mediator of T cell and B cell activation. CD100 knockout (CD100-/-) mice have reduced antibody responses to T-dependent antigens and impaired T cell priming. Both of these functions are restored upon the administration of sCD100 (Shi *et al.*, *Immunity 13*:633-642 (2000)).

[0004] In addition to the demonstrated effects of CD100 on immune cells, CD100 also appears to play a direct role in the demyelination and axonal degeneration seen in neuroinflammatory diseases. The pathogenesis of inflammatory demyelinating diseases, such as MS, includes both an inflammatory phase involving immune cells as well as phases of selective demyelination and neurodegeneration. CD100 is expressed in central nervous system (CNS) oligodendrocytes and is an inhibitor of axonal regeneration. CD100 expression is up-regulated in oligodendrocytes at the periphery of spinal cord

lesions (Moreau-Fauvarque *et al.*, *J. Neuroscience 23*:9229-9239 (2003)). Culturing chronically activated T cells expressing sCD100 with human multipotent neural precursors or primary oligodendrocytes from rat brain induces apoptosis and process extension collapse (Giraudon *et al.*, *J. Immunol. 172*:1246-1255 (2004); Giraudon *et al.*, *NeuroMolecular Med. 7*:207-216 (2005)). CD100 induced apoptosis of neural precursors can be inhibited by the BD16 anti-CD100 antibody.

[0005] CD100 knockout mice are resistant to the development of experimental allergic encephalomyelitis (EAE), which is a mouse model for human multiple sclerosis (MS) (Kumanogoh *et al.*, *J. Immulol. 169*:1175-1181 (2002)).

[0006] A number of other studies have demonstrated that CD100 induces growth cone collapse in neurons, and, in further support of the functional relevance of CD100 in neuroinflammation, it has been reported that there are highly elevated levels of sCD100 in cerebrospinal fluid (CSF) of HTLV-1 associated myelopathy/tropical spastic paraparesis (HAM/TSP) patients. Thus, there is a direct deleterious effect of sCD100 on oligodendrocyte and neural precursor integrity and CD100 may play a pathogenic role in demyelination. As an important mediator of both inflammatory responses and direct demyelination, there is a need in the art for CD100 neutralizing molecules, *e.g.*, anti-CD100 antibodies, for treatment of inflammatory and demyelinating diseases.

[0007] CD100 is also a potent pro-angiogenic molecule. Activation of Plexin-B1 through CD100 binding transactivates c-Met and promotes the invasive ability of tumor cells and promotes angiogenesis both *in vitro* and *in vivo*. Immunohistochemical analysis of CD100 in a large tumor sample collection revealed that CD100 overexpression is a very frequent event in head and neck, prostate, colon, breast, and lung cancers.

[0008] CD100/Plexin B1 signaling has also been shown to induce migration of endothelial cells and to promote migration of tumor cells (Conrotto *et al.*, *Blood 105*:4321-4329 (2005); Giordano *et al.*, *Nature Cell Biology 4*:720-724 (2002)). CD100 induced endothelial cell migration is prevented by CD100-blocking antibodies and by CD100 knockdown. Knocking down CD100 expression in head and neck squamous cell carcioma (HNSCC) cells with CD100 short hairpin RNA (shRNA) before grafting into nude mice caused a dramatic reduction in tumor vascularity and tumor growth (Basile *et al.*, *PNAS 103*:9017-9022 (2006)). Reports have recently pointed to a close correlation between inflammatory infiltration of the tumor stroma and a high vascular grade. CD100

is produced by inflammatory cells present in the tumor microenvironment. In an environment lacking CD100, the ability of mouse breast cancer cells to originate tumor masses and metastases was severely impaired, and the source of CD100 was tumor associated macrophages (Sierra *et al.*, *JEM 205*:1673-1685 (2008)). Thus, there is a further need in the art for CD100 neutralizing molecules, *e.g.*, anti-CD100 antibodies, for the treatment of CD100 cancer.

Field of the Invention

[0009] The invention relates to CD100 neutralizing antibodies, *e.g.*, humanized monoclonal antibodies, methods of using the antibodies, and methods for treatment of conditions and diseases associated with CD100-expressing cells.

BRIEF SUMMARY OF THE INVENTION

[0010] Compositions and methods are provided for treating diseases associated with CD100, including certain such as certain types of autoimmune diseases, inflammatory diseases, cancers and invasive angiogenesis. In particular, anti-CD100 monoclonal antibodies have been developed to neutralize CD100. Mouse MAb 67 demonstrated the ability to block CD100 activity *in vitro*, and, reduce the severity of clinical signs of experimental allergic encephalomyelitis (EAE), collagen-induced arthritis (CIA), and cancer in mouse models. MAb 2503 is a humanized version of MAb 67 which has demonstrated improved affinity to human and murine CD100 and similar CD100 blocking activity as MAb 67.

[0011] In one embodiment, the invention provides an isolated binding molecule which specifically binds to the same CD100 epitope as a reference monoclonal antibody selected from the group consisting of 2503, 67, or 76.

[0012] In another embodiment, the invention provides an isolated binding molecule which specifically binds to CD100, wherein said binding molecule competitively inhibits a reference monoclonal antibody selected from the group consisting of 2503, 67, or 76 from specifically binding to CD100.

[0013] In another embodiment, the invention provides an isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein said antibody or fragment thereof is monoclonal antibody 2503, 67, or 76.

[0014] In certain embodiments, the isolated antibody or antigen-binding fragment thereof of the invention which specifically binds to CD100, comprises a heavy chain variable region (VH) that has an amino acid sequence at least 90% identical to SEQ ID NO: 9, SEQ ID NO: 10, or SEQ ID NO: 25. In another aspect of the invention, the VH of said antibody or fragment thereof comprises an amino acid sequence identical, except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 9, SEQ ID NO: 10, or SEQ ID NO: 25. In yet another aspect of the invention, the VH of said antibody or fragment thereof comprises or consists of the amino acid sequence of SEQ ID NO: 9, SEQ ID NO: 10, or SEQ ID NO: 25.

[0015] In certain embodiments, the isolated antibody or antigen-binding fragment thereof of the invention which specifically binds to CD100, comprises a light chain variable region (VL) that has an amino acid sequence at least 90% identical to SEQ ID NO: 17, SEQ ID NO: 18, or SEQ ID NO: 29. In another aspect of the invention, the VL of said antibody or fragment thereof comprises an amino acid sequence identical, except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 17, SEQ ID NO: 18, or SEQ ID NO: 29. In yet another aspect of the invention, the VL of said antibody or fragment thereof comprises or consists of the amino acid sequence of SEQ ID NO: 17, SEQ ID NO: 18, or SEQ ID NO: 29.

[0016] In another embodiment, the invention provides an isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises at least one of the following CDRs: a Chothia-Kabat heavy chain complementarity determining region-1 (VH-CDR1) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 6, a Kabat heavy chain complementarity determining region-2 (VH-CDR2) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 7, or a Kabat heavy chain complementarity determining region-3 (VH-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 8.

[0017] In another embodiment, the invention provides an isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises at least one of the following CDRs: a Kabat light chain complementarity determining region-1 (VL-CDR1) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 14, a Kabat light chain

complementarity determining region-2 (VL-CDR2) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 15, or a Kabat light chain complementarity determining region-3 (VL-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 16.

[0018] In another aspect, the VH of an antibody or fragment thereof of the invention comprises VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences comprising SEQ ID NOs: 6, 7, and 8, respectively, except for four or fewer amino acid substitutions in one or more of said VH-CDRs. In a further aspect, the VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences are SEQ ID NOs: 6, 7, and 8, respectively.

[0019] In another aspect, the VL of an antibody or fragment thereof of the invention comprises VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences comprising SEQ ID NOs: 14, 15, and 16, respectively, except for four or fewer amino acid substitutions in one or more of said VL-CDRs. In a further aspect, the VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences are SEQ ID NOs: 14, 15, and 16, respectively.

[0020] In another embodiment, the invention provides an isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises at least one of the following CDRs: a Kabat heavy chain complementarity determining region-1 (VH-CDR1) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 26, a Kabat heavy chain complementarity determining region-2 (VH-CDR2) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 27, or a Kabat heavy chain complementarity determining region-3 (VH-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 28.

[0021] In another embodiment, the invention provides an isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises at least one of the following CDRs: a Kabat light chain complementarity determining region-1 (VL-CDR1) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 30, a Kabat light chain complementarity determining region-2 (VL-CDR2) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 31, or a Kabat light chain complementarity determining region-3 (VL-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 32.

[0022] In another aspect, the VH of an antibody or fragment thereof of the invention comprises VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences comprising SEQ ID NOs: 26, 27, and 28, respectively, except for four or fewer amino acid substitutions in one or more of said VH-CDRs. In a further aspect, the VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences are SEQ ID NOs: 26, 27, and 28, respectively.

[0023] In another aspect, the VL of an antibody or fragment thereof of the invention comprises VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences comprising SEQ ID NOs: 30, 31, and 32, respectively, except for four or fewer amino acid substitutions in one or more of said VL-CDRs. In a further aspect, the VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences are SEQ ID NOs: 30, 31, and 32, respectively.

[0024] In another aspect, an antibody or fragment thereof of the invention binds to human and murine CD100. In another aspect, the antibody or fragment thereof of the invention specifically binds to an CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide with an affinity characterized by a dissociation constant (K_D) no greater than 5×10^{-2} M, 10^{-2} M, 5×10^{-3} M, 10^{-3} M, 5×10^{-4} M, 10^{-4} M, 5×10^{-5} M, 10^{-5} M, 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 5.7×10^{-12} M, 8.4×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M, 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, or 10^{-15} M. In certain aspects, the CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is human or murine. In further aspects, a CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is human and said K_D is about 5×10^{-9} M to about 6×10^{-9} M. In yet another aspect, a CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is murine and said K_D is about 1×10^{-9} M to about 2×10^{-9} M.

[0025] In another aspect, the antibody or fragment thereof of the invention is humanized, primatized or chimeric.

[0026] In another embodiment, the invention provides a composition comprising an antibody or fragment thereof of the invention, and a carrier.

[0027] In another embodiment, the invention provides an isolated polynucleotide comprising a nucleic acid which encodes an antibody VH or VL polypeptide of the invention. In another aspect, the polynucleotide of the invention comprises or consists of a nucleic acid which encodes an antibody or fragment thereof of the invention. In yet

another aspect, the invention provides a vector comprising a polynucleotide of the invention. In another aspect, the invention provides a host cell comprising the vector of the invention. In another aspect, the invention provides a method of producing an antibody of the invention.

[0028] In another embodiment, the invention provides a method for treating an autoimmune disease or an inflammatory disease in an animal in need of treatment, comprising administering to said animal a composition comprising: the isolated antibody or fragment thereof of the invention and a pharmaceutically acceptable carrier. In further embodiments, the autoimmune disease or inflammatory disease is multiple sclerosis or arthritis.

[0029] In another embodiment, the invention provides a method for treating a cancer in an animal in need of treatment, comprising administering to said animal a composition comprising: the isolated antibody or fragment thereof of the invention and a pharmaceutically acceptable carrier.

[0030] In another embodiment, the invention provides a method for inhibiting angiogenesis in an animal in need of treatment for cancer, comprising administering to said animal a composition comprising: the isolated antibody or fragment thereof of the invention and a pharmaceutically acceptable carrier.

[0031] In a further aspect, the antibody or fragment thereof of the invention inhibits CD100 binding to a CD100 receptor. In yet another aspect of the invention, the CD100 receptor is Plexin-B1.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0032] Figure 1. Diagram of CD100 blocking assay. CD100-His shown binding to Plexin B1 on the cell surface of a stable cell line expressing Plexin B1 (293/Plexin). The CD100-His which is bound to Plexin B1 is detected using a biotin conjugated anti-His tag specific monoclonal antibody and streptavidin-APC. Anti-CD100 MAbs which are able to block binding of CD100-His to Plexin B1 result in lower fluorescence associated with the 293/Plexin cells as measured by flow cytometry.

[0033] Figure 2. Flow cytometry results for rabbit anti-His + streptavidin-APC (Rb anti-his +sAPC), mouse CD100 (muCD100 only), mouse CD100 + 0.625 μg/ml MAb (MAb 67, MAb 76, and mIgG isotype), and mouse CD100 + 0.156 μg/ml MAb (MAb 67, MAb

76, and mIgG isotype) tested in the CD100 blocking assay described in Figure 1 are shown. Monoclonal antibodies 67 and 76 block mouse CD100 binding to Plexin B1 receptor.

[0034] Figure 3. Monoclonal antibodies 67 and 76 block mouse CD100 mediated detachment of 293/Plexin B cells from a fibronectin coated plate, as shown by an increase in absorbance for both MAbs 67 (67-2) and 76 (76-1) compared to isotype control.

[0035] Figure 4. Treatment with 30 mg/kg anti-CD100 MAb 76 (1X/week or 2X/week) or MAb 67 (1X/week or 2X/week) attenuates relapsing remitting EAE in SJL mice compared to treatment with mouse IgG control as shown by reduction in clinical score (4A). The results are further illustrated by comparing percent reduction in Group Mean Score (GMS) for each MAb treatment between day 21 and study end (4B).

[0036] Figure 5. Treatment with 30 mg/kg anti-CD100 MAb 76 (1X/week) or MAb 67 (1X/week) attenuates relapsing remitting EAE in SJL mice compared to treatment with mouse IgG control as shown by reduction in clinical score (5A). The results are further illustrated by comparing percent reduction in Group Mean Score (GMS) for both MAb treatments between day 18 and study end (5B).

[0037] Figure 6. Treatment with 30 mg/kg anti-CD100 MAb 67 starting at day 7 post-immunization (1X/week) attenuates relapsing remitting EAE in SJL mice compared to treatment with mouse IgG control as shown by reduction in clinical score.

[0038] Figure 7. ELISA results showing percent (%) blocking of biotinylated 67 binding to human CD100 (7A) or mouse CD100 (7B) due to competitive binding of MAb 2503, MAb 67, or IgG control.

[0039] Figure 8. Flow cytometry results for streptavidin-APC (sAPC only), human CD100 (huCD100), marmoset CD100 (marmCD100), mouse CD100 (muCD100), 1.0 μg isotype, and 1.0μg MAb (67 or 2503) tested in the CD100 blocking assay described in Figure 1 are shown. MAb 67 and MAb 2503 block human CD100 (8A), marmoset (8B), or mouse (8C) CD100 from binding to Plexin B1 receptor.

[0040] Figure 9. A blocked reduction in absorbance caused by CD100 due to neutralization of CD100 by MAb 67, MAb 2503, and IgG control is shown. Anti-CD100 MAb 67 and MAb 2503 block human CD100 (9A) and marmoset CD100 (9B) mediated detachment of 293/Plexin cells from a fibronectin coated plate.

[0041] Figure 10. Change in tumor volume (mm^3) is shown for wild-type Balb/c mice and CD100-/- mice after 50,000 CT26 colon tumor cells were injected into the leg muscle of the mice.

[0042] Figure 11. Change in mean leg volume (mm^3) is shown for wild-type Balb/c mice treated with 1mg MAb 67 or 1mg control mouse IgG and CD100-/- mice ("KO") after 50,000 CT26 tumor cells were injected into the leg muscle of the mice.

[0043] Figure 12. A schematic showing a general treatment strategy for Collagen Induced Arthritis (CIA)

[0044] Figure 13. Reduction in arthritis disease development in CIA model was shown for groups treated with 600 μg MAb 67. Arthritic Index (AI) in mice treated with 600 μg MAb 67 was compared to AI in mice treated with 600 μg negative control (IgG1) and 600 μg positive control etanercept (Enbrel®) when treatment was started at day 20 (13A). Arthritic Index (AI) results for treatment with MAb 67 were compared to treatment with a negative control (IgG1) and positive control etanercept (Embrel®) when treatment was started either at day 20 or when the AI was ≥ 3 (13B).

[0045] Figure 14. In Balb/c mice immunized with (4-hydroxy-3-nitrophenyl) acetyl conjugated chicken gamma globulin precipitated with alum (aluminum-/magnesium-hydroxide) ("NP-CGG"), treatment with 600 μg MAb 67 decreased the number of germinal center (GC) B cells ("B220+CD38lowPNA+") in spleen (SP) and lymph nodes (LN) after both primary immunization (14A) and secondary immunization (14B). Results are also shown for CD100 -/- mice and Balb/c mice with and without NP-CGG immunization.

[0046] Figure 15. Change in tumor volume (mm^3) is shown for wild-type Balb/c mice mice after 50,000 CT26 colon tumor cells were injected into the leg muscle of the mice. Results are shown for mice injected with 1 mg MAb 67 weekly starting on day 1 compared to mice injected with IgG control. The study was carried out to an end point of tumor growth delay.

[0047] Figure 16. Change in tumor volume (mm^3) is shown for wild-type Balb/c mice and CD100-/- mice ("SEMA4D-/-") after 50,000 BCA34 fibroblastic tumor cells were s.c. injected into the abdominal region of the mice (16A). Change in mean thigh volume (mm^3) is shown for wild-type Balb/c mice treated with 1mg MAb 67 or 1mg control

mouse IgG after 50,000 BCA34 fibroblastic tumor cells were injected into the leg muscle of the mice (16B).

[0048] Figure 17. Change in tumor volume (mm^3) is shown for wild-type Balb/c mice and CD100-/- mice ("SEMA4D-/-") after 50,000 EMT6 mouse mammary carcinoma tumor cells were injected into the leg muscle of the mice.

[0049] Figure 18. Change in tumor volume (mm^3) is shown for athymic nude mice after two HN12 head and neck tumors/mouse were s.c. injected into the flank muscle of the mice. Results are shown for mice injected with 1 mg MAb 2503 weekly starting on day 1 post graft compared to mice injected with IgG4 control.

[0050] Figure 19. Change in tumor volume (mm^3) is shown for athymic nude mice after two HN6 HIF1a mODD head and neck tumors were s.c. injected into the leg muscle of the mice. Results are shown for mice injected with 1 mg MAb 2503 weekly starting on day 1 post graft compared to mice injected with IgG4 control (19A). Pictures of represenative tumors from IgG4 control and MAb 2503 treated mice are shown (19B).

[0051] Figure 20. Percent saturation results from single intravenous injection saturation analysis of MAb 2503 in rat. Sprague-Dawley rats were administered a single intravenous injection of MAb 2503 at doses of 0, 0.01, 0.1, 1.0, 10, and 100 mg/kg. A flow cytometry-based saturation assay was performed on lysed whole blood at various time points to determine the percent of the cellular target (SEMA4D) that was saturated with MAb 2503 in male (20A) and female (20B) rats.

[0052] Figure 21. Percent saturation results from single intravenous injection saturation analysis of MAb 2503 in cynomolgus monkey. Cynomolgus monkeys were administered a single intravenous injection of MAb 2503 at doses of 0, 0.01, 0.1, 1.0, 10, and 100 mg/kg. A flow cytometry-based saturation assay was performed on lysed whole blood at various time points to determine the percent of the cellular target (SEMA4D) that was saturated with MAb 2503 (male and female data were combined).

DETAILED DESCRIPTION OF THE INVENTION

I. Definitions

[0053] It is to be noted that the term "a" or "an" entity refers to one or more of that entity; for example, "an anti-CD100 antibody" is understood to represent one or more anti-

CD100 antibodies. As such, the terms "a" (or "an"), "one or more," and "at least one" can be used interchangeably herein.

[0054] As used herein, the term "tumor" refers to all neoplastic cell growth and proliferation, whether malignant or benign, and all cancerous and pre-cancerous cells and tissues.

[0055] "Invasive angiogenesis" refers to the formation of blood vessels for the support of pathological conditions, including malignant and non-malignant tumors as well as the abnormal formation of new blood vessels in macular degeneration.

[0056] The terms, "cancer" and "cancerous" 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 carcinomas, lymphomas and leukemias.

[0057] As used herein, the term "polypeptide" is intended to encompass a singular "polypeptide" as well as plural "polypeptides," and refers to a molecule composed of monomers (amino acids) linearly linked by amide bonds (also known as peptide bonds). The term "polypeptide" refers to any chain or chains of two or more amino acids, and does not refer to a specific length of the product. Thus, peptides, dipeptides, tripeptides, oligopeptides, "protein," "amino acid chain," or any other term used to refer to a chain or chains of two or more amino acids, are included within the definition of "polypeptide," and the term "polypeptide" may be used instead of, or interchangeably with any of these terms. The term "polypeptide" is also intended to refer to the products of post-expression modifications of the polypeptide, including without limitation glycosylation, acetylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, or modification by non-naturally occurring amino acids. A polypeptide may be derived from a natural biological source or produced by recombinant technology, but is not necessarily translated from a designated nucleic acid sequence. It may be generated in any manner, including by chemical synthesis.

[0058] A polypeptide of the invention may be of a size of about 3 or more, 5 or more, 10 or more, 20 or more, 25 or more, 50 or more, 75 or more, 100 or more, 200 or more, 500 or more, 1,000 or more, or 2,000 or more amino acids. Polypeptides may have a defined three-dimensional structure, although they do not necessarily have such structure. Polypeptides with a defined three-dimensional structure are referred to as folded, and polypeptides that do not possess a defined three-dimensional structure, but rather can

adopt a large number of different conformations, are referred to as unfolded. As used herein, the term glycoprotein refers to a protein coupled to at least one carbohydrate moiety that is attached to the protein via an oxygen-containing or a nitrogen-containing side chain of an amino acid residue, *e.g.*, a serine residue or an asparagine residue.

[0059] By an "isolated" polypeptide or a fragment, variant, or derivative thereof is intended a polypeptide that is not in its natural milieu. No particular level of purification is required. For example, an isolated polypeptide can be removed from its native or natural environment. Recombinantly produced polypeptides and proteins expressed in host cells are considered isolated for purpose of the invention, as are native or recombinant polypeptides that have been separated, fractionated, or partially or substantially purified by any suitable technique.

[0060] Also included as polypeptides of the present invention are fragments, derivatives, analogs, or variants of the foregoing polypeptides, and any combination thereof. The terms "fragment," "variant," "derivative," and "analog" when referring to anti-CD100 antibodies or antibody polypeptides of the present invention include any polypeptides that retain at least some of the antigen-binding properties of the corresponding antibody or antibody polypeptide of the invention. Fragments of polypeptides of the present invention include proteolytic fragments, as well as deletion fragments, in addition to specific antibody fragments discussed elsewhere herein. Variants of anti-CD100 antibodies and antibody polypeptides of the present invention include fragments as described above, and also polypeptides with altered amino acid sequences due to amino acid substitutions, deletions, or insertions. Variants may occur naturally or be non-naturally occurring. Non-naturally occurring variants may be produced using art-known mutagenesis techniques. Variant polypeptides may comprise conservative or non-conservative amino acid substitutions, deletions, or additions. Variant polypeptides may also be referred to herein as "polypeptide analogs." As used herein a "derivative" of an anti-CD100 antibody or antibody polypeptide refers to a subject polypeptide having one or more residues chemically derivatized by reaction of a functional side group. Also included as "derivatives" are those peptides that contain one or more naturally occurring amino acid derivatives of the twenty standard amino acids. For example, 4-hydroxyproline may be substituted for proline; 5-hydroxylysine may be substituted for lysine; 3-methylhistidine may be substituted for histidine; homoserine may be substituted

for serine; and ornithine may be substituted for lysine. Derivatives of anti-CD100 antibodies and antibody polypeptides of the present invention, may include polypeptides that have been altered so as to exhibit additional features not found on the reference antibody or antibody polypeptide of the invention.

[0061] The term "polynucleotide" is intended to encompass a singular nucleic acid as well as plural nucleic acids, and refers to an isolated nucleic acid molecule or construct, *e.g.*, messenger RNA (mRNA) or plasmid DNA (pDNA). A polynucleotide may comprise a conventional phosphodiester bond or a non-conventional bond (*e.g.*, an amide bond, such as found in peptide nucleic acids (PNA)). The term "nucleic acid" refers to any one or more nucleic acid segments, *e.g.*, DNA or RNA fragments, present in a polynucleotide. By "isolated" nucleic acid or polynucleotide is intended a nucleic acid molecule, DNA or RNA, that has been removed from its native environment. For example, a recombinant polynucleotide encoding an anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, contained in a vector is considered isolated for the purposes of the present invention. Further examples of an isolated polynucleotide include recombinant polynucleotides maintained in heterologous host cells or purified (partially or substantially) polynucleotides in solution. Isolated RNA molecules include *in vivo* or *in vitro* RNA transcripts of polynucleotides of the present invention. Isolated polynucleotides or nucleic acids according to the present invention further include such molecules produced synthetically. In addition, a polynucleotide or a nucleic acid may be or may include a regulatory element such as a promoter, ribosome binding site, or a transcription terminator.

[0062] As used herein, a "coding region" is a portion of nucleic acid that consists of codons translated into amino acids. Although a "stop codon" (TAG, TGA, or TAA) is not translated into an amino acid, it may be considered to be part of a coding region, but any flanking sequences, for example promoters, ribosome binding sites, transcriptional terminators, introns, and the like, are not part of a coding region. Two or more coding regions of the present invention can be present in a single polynucleotide construct, *e.g.*, on a single vector, or in separate polynucleotide constructs, *e.g.*, on separate (different) vectors. Furthermore, any vector may contain a single coding region, or may comprise two or more coding regions, *e.g.*, a single vector may separately encode an immunoglobulin heavy chain variable region and an immunoglobulin light chain variable

region. In addition, a vector, polynucleotide, or nucleic acid of the invention may encode heterologous coding regions, either fused or unfused to a nucleic acid encoding an anti-CD100 antibody or fragment, variant, or derivative thereof. Heterologous coding regions include without limitation specialized elements or motifs, such as a secretory signal peptide or a heterologous functional domain.

[0063] In certain embodiments, the polynucleotide or nucleic acid is DNA. In the case of DNA, a polynucleotide comprising a nucleic acid that encodes a polypeptide normally may include a promoter and/or other transcription or translation control elements operably associated with one or more coding regions. An operable association is when a coding region for a gene product, *e.g.*, a polypeptide, is associated with one or more regulatory sequences in such a way as to place expression of the gene product under the influence or control of the regulatory sequence(s). Two DNA fragments (such as a polypeptide coding region and a promoter associated therewith) are "operably associated" if induction of promoter function results in the transcription of mRNA encoding the desired gene product and if the nature of the linkage between the two DNA fragments does not interfere with the ability of the expression regulatory sequences to direct the expression of the gene product or interfere with the ability of the DNA template to be transcribed. Thus, a promoter region would be operably associated with a nucleic acid encoding a polypeptide if the promoter was capable of effecting transcription of that nucleic acid. The promoter may be a cell-specific promoter that directs substantial transcription of the DNA only in predetermined cells. Other transcription control elements, besides a promoter, for example enhancers, operators, repressors, and transcription termination signals, can be operably associated with the polynucleotide to direct cell-specific transcription. Suitable promoters and other transcription control regions are disclosed herein.

[0064] A variety of transcription control regions are known to those skilled in the art. These include, without limitation, transcription control regions that function in vertebrate cells, such as, but not limited to, promoter and enhancer segments from cytomegaloviruses (the immediate early promoter, in conjunction with intron-A), simian virus 40 (the early promoter), and retroviruses (such as Rous sarcoma virus). Other transcription control regions include those derived from vertebrate genes such as actin, heat shock protein, bovine growth hormone and rabbit β-globin, as well as other

sequences capable of controlling gene expression in eukaryotic cells. Additional suitable transcription control regions include tissue-specific promoters and enhancers as well as lymphokine-inducible promoters (*e.g.*, promoters inducible by interferons or interleukins).

[0065] Similarly, a variety of translation control elements are known to those of ordinary skill in the art. These include, but are not limited to, ribosome binding sites, translation initiation and termination codons, and elements derived from picornaviruses (particularly an internal ribosome entry site, or IRES, also referred to as a CITE sequence).

[0066] In other embodiments, a polynucleotide of the present invention is RNA, for example, in the form of messenger RNA (mRNA).

[0067] Polynucleotide and nucleic acid coding regions of the present invention may be associated with additional coding regions that encode secretory or signal peptides, which direct the secretion of a polypeptide encoded by a polynucleotide of the present invention. According to the signal hypothesis, proteins secreted by mammalian cells have a signal peptide or secretory leader sequence that is cleaved from the mature protein once export of the growing protein chain across the rough endoplasmic reticulum has been initiated. Those of ordinary skill in the art are aware that polypeptides secreted by vertebrate cells generally have a signal peptide fused to the N-terminus of the polypeptide, which is cleaved from the complete or "full length" polypeptide to produce a secreted or "mature" form of the polypeptide. In certain embodiments, the native signal peptide, *e.g.*, an immunoglobulin heavy chain or light chain signal peptide is used, or a functional derivative of that sequence that retains the ability to direct the secretion of the polypeptide that is operably associated with it. Alternatively, a heterologous mammalian signal peptide, or a functional derivative thereof, may be used. For example, the wild-type leader sequence may be substituted with the leader sequence of human tissue plasminogen activator (TPA) or mouse β-glucuronidase.

[0068] A "binding molecule" or "antigen binding molecule" of the present invention refers in its broadest sense to a molecule that specifically binds an antigenic determinant. In one embodiment, the binding molecule specifically binds to CD100, *e.g.*, a transmembrane CD100 polypeptide of about 150 kDa or a soluble CD100 polypeptide of about 120 kDa (commonly referred to as sCD100). In a another embodiment, a binding molecule of the invention is an antibody or an antigen binding fragment thereof. In

another embodiment, a binding molecule of the invention comprises at least one heavy or light chain CDR of an antibody molecule. In another embodiment, a binding molecule of the invention comprises at least two CDRs from one or more antibody molecules. In another embodiment, a binding molecule of the invention comprises at least three CDRs from one or more antibody molecules. In another embodiment, a binding molecule of the invention comprises at least four CDRs from one or more antibody molecules. In another embodiment, an a binding molecule of the invention comprises at least five CDRs from one or more antibody molecules. In another embodiment, a binding molecule of the invention comprises at least six CDRs from one or more antibody molecules.

[0069] The present invention is directed to certain anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof. Unless specifically referring to full-sized antibodies such as naturally occurring antibodies, the term "anti-CD100 antibodies" encompasses full-sized antibodies as well as antigen-binding fragments, variants, analogs, or derivatives of such antibodies, *e.g.*, naturally occurring antibody or immunoglobulin molecules or engineered antibody molecules or fragments that bind antigen in a manner similar to antibody molecules.

[0070] As used herein, "human" or "fully human" antibodies include antibodies having the amino acid sequence of a human immunoglobulin and include antibodies isolated from human immunoglobulin libraries or from animals transgenic for one or more human immunoglobulins and that do not express endogenous immunoglobulins, as described infra and, for example, in U.S. Pat. No. 5,939,598 by Kucherlapati *et al.* "Human" or "fully human" antibodies also include antibodies comprising at least the variable domain of a heavy chain, or at least the variable domains of a heavy chain and a light chain, where the variable domain(s) have the amino acid sequence of human immunoglobulin variable domain(s).

[0071] "Human" or "fully human" antibodies also include "human" or "fully human" antibodies, as described above, that comprise, consist essentially of, or consist of, variants (including derivatives) of antibody molecules (*e.g.*, the VH regions and/or VL regions) described herein, which antibodies or fragments thereof immunospecifically bind to a CD100 polypeptide or fragment or variant thereof. Standard techniques known to those of skill in the art can be used to introduce mutations in the nucleotide sequence encoding a human anti-CD100 antibody, including, but not limited to, site-directed mutagenesis

and PCR-mediated mutagenesis which result in amino acid substitutions. Preferably, the variants (including derivatives) encode less than 50 amino acid substitutions, less than 40 amino acid subsitutions, less than 30 amino acid substitutions, less than 25 amino acid substitutions, less than 20 amino acid substitutions, less than 15 amino acid substitutions, less than 10 amino acid substitutions, less than 5 amino acid substitutions, less than 4 amino acid substitutions, less than 3 amino acid substitutions, or less than 2 amino acid substitutions relative to the reference VH region, VHCDR1, VHCDR2, VHCDR3, VL region, VLCDR1, VLCDR2, or VLCDR3.

[0072] In certain embodiments, the amino acid substitutions are conservative amino acid substitution, discussed further below. Alternatively, mutations can be introduced randomly along all or part of the coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for biological activity to identify mutants that retain activity (e.g., the ability to bind a CD100 polypeptide, *e.g.*, human, murine, or both human and murine CD100). Such variants (or derivatives thereof) of "human" or "fully human" antibodies can also be referred to as human or fully human antibodies that are "optimized" or "optimized for antigen binding" and include antibodies that have improved affinity to antigen.

[0073] The terms "antibody" and "immunoglobulin" are used interchangeably herein. An antibody or immunoglobulin comprises at least the variable domain of a heavy chain, and normally comprises at least the variable domains of a heavy chain and a light chain. Basic immunoglobulin structures in vertebrate systems are relatively well understood. See, *e.g.*, Harlow et al. (1988) Antibodies: A Laboratory Manual (2nd ed.; Cold Spring Harbor Laboratory Press).

[0074] As will be discussed in more detail below, the term "immunoglobulin" comprises various broad classes of polypeptides that can be distinguished biochemically. Those skilled in the art will appreciate that heavy chains are classified as gamma, mu, alpha, delta, or epsilon, (γ, μ, α, δ, ε) with some subclasses among them (*e.g.*, γ1-γ4). It is the nature of this chain that determines the "class" of the antibody as IgG, IgM, IgA IgG, or IgE, respectively. The immunoglobulin subclasses (isotypes) *e.g.*, IgG1, IgG2, IgG3, IgG4, IgA1, etc. are well characterized and are known to confer functional specialization. Modified versions of each of these classes and isotypes are readily discernable to the skilled artisan in view of the instant disclosure and, accordingly, are within the scope of

the instant invention. All immunoglobulin classes are clearly within the scope of the present invention, the following discussion will generally be directed to the IgG class of immunoglobulin molecules. With regard to IgG, a standard immunoglobulin molecule comprises two identical light chain polypeptides of molecular weight approximately 23,000 Daltons, and two identical heavy chain polypeptides of molecular weight 53,000-70,000. The four chains are typically joined by disulfide bonds in a "Y" configuration wherein the light chains bracket the heavy chains starting at the mouth of the "Y" and continuing through the variable region.

[0075] Light chains are classified as either kappa or lambda (κ, λ). Each heavy chain class may be bound with either a kappa or lambda light chain. In general, the light and heavy chains are covalently bonded to each other, and the "tail" portions of the two heavy chains are bonded to each other by covalent disulfide linkages or non-covalent linkages when the immunoglobulins are generated either by hybridomas, B cells or genetically engineered host cells. In the heavy chain, the amino acid sequences run from an N-terminus at the forked ends of the Y configuration to the C-terminus at the bottom of each chain.

[0076] Both the light and heavy chains are divided into regions of structural and functional homology. The terms "constant" and "variable" are used functionally. In this regard, it will be appreciated that the variable domains of both the light (VL or VK) and heavy (VH) chain portions determine antigen recognition and specificity. Conversely, the constant domains of the light chain (CL) and the heavy chain (CH1, CH2 or CH3) confer important biological properties such as secretion, transplacental mobility, Fc receptor binding, complement binding, and the like. By convention the numbering of the constant region domains increases as they become more distal from the antigen binding site or amino-terminus of the antibody. The N-terminal portion is a variable region and at the C-terminal portion is a constant region; the CH3 and CL domains actually comprise the carboxy-terminus of the heavy and light chain, respectively.

[0077] As indicated above, the variable region allows the antibody to selectively recognize and specifically bind epitopes on antigens. That is, the VL domain and VH domain, or subset of the complementarity determining regions (CDRs) within these variable domains, of an antibody combine to form the variable region that defines a three dimensional antigen binding site. This quaternary antibody structure forms the antigen

binding site present at the end of each arm of the Y. More specifically, the antigen binding site is defined by three CDRs on each of the VH and VL chains. In some instances, *e.g.*, certain immunoglobulin molecules derived from camelid species or engineered based on camelid immunoglobulins, a complete immunoglobulin molecule may consist of heavy chains only, with no light chains. See, *e.g.*, Hamers-Casterman *et al.*, *Nature 363*:446-448 (1993).

[0078] In naturally occurring antibodies, the six "complementarity determining regions" or "CDRs" present in each antigen binding domain are short, non-contiguous sequences of amino acids that are specifically positioned to form the antigen binding domain as the antibody assumes its three dimensional configuration in an aqueous environment. The remainder of the amino acids in the antigen binding domains, referred to as "framework" regions, show less inter-molecular variability. The framework regions largely adopt a β-sheet conformation and the CDRs form loops that connect, and in some cases form part of, the β-sheet structure. Thus, framework regions act to form a scaffold that provides for positioning the CDRs in correct orientation by inter-chain, non-covalent interactions. The antigen binding domain formed by the positioned CDRs defines a surface complementary to the epitope on the immunoreactive antigen. This complementary surface promotes the non-covalent binding of the antibody to its cognate epitope. The amino acids comprising the CDRs and the framework regions, respectively, can be readily identified for any given heavy or light chain variable domain by one of ordinary skill in the art, since they have been precisely defined (see below).

[0079] In the case where there are two or more definitions of a term that is used and/or accepted within the art, the definition of the term as used herein is intended to include all such meanings unless explicitly stated to the contrary. A specific example is the use of the term "complementarity determining region" ("CDR") to describe the non-contiguous antigen combining sites found within the variable region of both heavy and light chain polypeptides. This particular region has been described by Kabat et al. (1983) U.S. Dept. of Health and Human Services, "Sequences of Proteins of Immunological Interest" and by Chothia and Lesk, *J. Mol. Biol. 196*:901-917 (1987), which are incorporated herein by reference, where the definitions include overlapping or subsets of amino acid residues when compared against each other. Nevertheless, application of either definition to refer to a CDR of an antibody or variants thereof is intended to be within the scope of the term

as defined and used herein. The appropriate amino acid residues that encompass the CDRs as defined by each of the above cited references are set forth below in **Table 1** as a comparison. The exact residue numbers that encompass a particular CDR will vary depending on the sequence and size of the CDR. Those skilled in the art can routinely determine which residues comprise a particular CDR given the variable region amino acid sequence of the antibody.

Table 1. CDR Definitions[1]

	Kabat	Chothia
VH CDR1	31-35	26-32
VH CDR2	50-65	52-58
VH CDR3	95-102	95-102
VL CDR1	24-34	26-32
VL CDR2	50-56	50-52
VL CDR3	89-97	91-96

[1]Numbering of all CDR definitions in Table 1 is according to the numbering conventions set forth by Kabat et al. (see below).

[0080] Kabat *et al.* also defined a numbering system for variable domain sequences that is applicable to any antibody. One of ordinary skill in the art can unambiguously assign this system of "Kabat numbering" to any variable domain sequence, without reliance on any experimental data beyond the sequence itself. As used herein, "Kabat numbering" refers to the numbering system set forth by Kabat *et al.* (1983) U.S. Dept. of Health and Human Services, "Sequence of Proteins of Immunological Interest." Unless otherwise specified, references to the numbering of specific amino acid residue positions in an anti-CD100 antibody or antigen-binding fragment, variant, or derivative thereof of the present invention are according to the Kabat numbering system.

[0081] Antibodies or antigen-binding fragments, variants, or derivatives thereof of the invention include, but are not limited to, polyclonal, monoclonal, multispecific, human, humanized, primatized, or chimeric antibodies, single-chain antibodies, epitope-binding fragments, *e.g.*, Fab, Fab' and $F(ab')_2$, Fd, Fvs, single-chain Fvs (scFv), disulfide-linked Fvs (sdFv), fragments comprising either a VL or VH domain, fragments produced by a Fab expression library, and anti-idiotypic (anti-Id) antibodies (including, *e.g.*, anti-Id antibodies to anti-CD100 antibodies disclosed herein). ScFv molecules are known in the art and are described, *e.g.*, in U.S. Pat. No. 5,892,019. Immunoglobulin or antibody molecules of the invention can be of any type (e.g., IgG, IgE, IgM, IgD, IgA, and IgY),

class (*e.g.*, IgG1, IgG2, IgG3, IgG4, IgA1, and IgA2, etc.), or subclass of immunoglobulin molecule.

[0082] As used herein, the term "heavy chain portion" includes amino acid sequences derived from an immunoglobulin heavy chain. A polypeptide comprising a heavy chain portion comprises at least one of: a CH1 domain, a hinge (*e.g.*, upper, middle, and/or lower hinge region) domain, a CH2 domain, a CH3 domain, or a variant or fragment thereof. For example, a binding polypeptide for use in the invention may comprise a polypeptide chain comprising a CH1 domain; a polypeptide chain comprising a CH1 domain, at least a portion of a hinge domain, and a CH2 domain; a polypeptide chain comprising a CH1 domain and a CH3 domain; a polypeptide chain comprising a CH1 domain, at least a portion of a hinge domain, and a CH3 domain, or a polypeptide chain comprising a CH1 domain, at least a portion of a hinge domain, a CH2 domain, and a CH3 domain. In another embodiment, a polypeptide of the invention comprises a polypeptide chain comprising a CH3 domain. Further, a binding polypeptide for use in the invention may lack at least a portion of a CH2 domain (*e.g.*, all or part of a CH2 domain). As set forth above, it will be understood by one of ordinary skill in the art that these domains (*e.g.*, the heavy chain portions) may be modified such that they vary in amino acid sequence from the naturally occurring immunoglobulin molecule.

[0083] In certain anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof disclosed herein, the heavy chain portions of one polypeptide chain of a multimer are identical to those on a second polypeptide chain of the multimer. Alternatively, heavy chain portion-containing monomers of the invention are not identical. For example, each monomer may comprise a different target binding site, forming, for example, a bispecific antibody.

[0084] The heavy chain portions of a binding molecule for use in the diagnostic and treatment methods disclosed herein may be derived from different immunoglobulin molecules. For example, a heavy chain portion of a polypeptide may comprise a C_{H1} domain derived from an IgG1 molecule and a hinge region derived from an IgG3 molecule. In another example, a heavy chain portion can comprise a hinge region derived, in part, from an IgG1 molecule and, in part, from an IgG3 molecule. In another example, a heavy chain portion can comprise a chimeric hinge derived, in part, from an IgG1 molecule and, in part, from an IgG4 molecule.

[0085] As used herein, the term "light chain portion" includes amino acid sequences derived from an immunoglobulin light chain, *e.g.*, a kappa or lambda light chain. Preferably, the light chain portion comprises at least one of a VL or CL domain.

[0086] Anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof disclosed herein may be described or specified in terms of the epitope(s) or portion(s) of an antigen, *e.g.*, a target polypeptide disclosed herein (*e.g.*, CD100) that they recognize or specifically bind. The portion of a target polypeptide that specifically interacts with the antigen binding domain of an antibody is an "epitope," or an "antigenic determinant." A target polypeptide may comprise a single epitope, but typically comprises at least two epitopes, and can include any number of epitopes, depending on the size, conformation, and type of antigen. Furthermore, it should be noted that an "epitope" on a target polypeptide may be or may include non-polypeptide elements, *e.g.*, an epitope may include a carbohydrate side chain.

[0087] The minimum size of a peptide or polypeptide epitope for an antibody is thought to be about four to five amino acids. Peptide or polypeptide epitopes preferably contain at least seven, more preferably at least nine and most preferably between at least about 15 to about 30 amino acids. Since a CDR can recognize an antigenic peptide or polypeptide in its tertiary form, the amino acids comprising an epitope need not be contiguous, and in some cases, may not even be on the same peptide chain. A peptide or polypeptide epitope recognized by anti-CD100 antibodies of the present invention may contain a sequence of at least 4, at least 5, at least 6, at least 7, more preferably at least 8, at least 9, at least 10, at least 15, at least 20, at least 25, or between about 15 to about 30 contiguous or non-contiguous amino acids of CD100.

[0088] By "specifically binds," it is generally meant that an antibody binds to an epitope via its antigen binding domain, and that the binding entails some complementarity between the antigen binding domain and the epitope. According to this definition, an antibody is said to "specifically bind" to an epitope when it binds to that epitope, via its antigen binding domain more readily than it would bind to a random, unrelated epitope. The term "specificity" is used herein to qualify the relative affinity by which a certain antibody binds to a certain epitope. For example, antibody "A" may be deemed to have a higher specificity for a given epitope than antibody "B," or antibody "A" may be said to bind to epitope "C" with a higher specificity than it has for related epitope "D."

[0089] By "preferentially binds," it is meant that the antibody specifically binds to an epitope more readily than it would bind to a related, similar, homologous, or analogous epitope. Thus, an antibody that "preferentially binds" to a given epitope would more likely bind to that epitope than to a related epitope, even though such an antibody may cross-react with the related epitope.

[0090] By way of non-limiting example, an antibody may be considered to bind a first epitope preferentially if it binds said first epitope with a dissociation constant (K_D) that is less than the antibody's K_D for the second epitope. In another non-limiting example, an antibody may be considered to bind a first antigen preferentially if it binds the first epitope with an affinity that is at least one order of magnitude less than the antibody's K_D for the second epitope. In another non-limiting example, an antibody may be considered to bind a first epitope preferentially if it binds the first epitope with an affinity that is at least two orders of magnitude less than the antibody's K_D for the second epitope.

[0091] In another non-limiting example, an antibody may be considered to bind a first epitope preferentially if it binds the first epitope with an off rate (k(off)) that is less than the antibody's k(off) for the second epitope. In another non-limiting example, an antibody may be considered to bind a first epitope preferentially if it binds the first epitope with an affinity that is at least one order of magnitude less than the antibody's k(off) for the second epitope. In another non-limiting example, an antibody may be considered to bind a first epitope preferentially if it binds the first epitope with an affinity that is at least two orders of magnitude less than the antibody's k(off) for the second epitope. An antibody or or antigen-binding fragment, variant, or derivative disclosed herein may be said to bind a target polypeptide disclosed herein (*e.g.*, CD100, *e.g.*, human, murine, or both human and murine CD100) or a fragment or variant thereof with an off rate (k(off)) of less than or equal to 5×10^{-2} sec^{-1}, 10^{-2} sec^{-1}, 5×10^{-3} sec^{-1} or 10^{-3} sec^{-1}. More preferably, an antibody of the invention may be said to bind a target polypeptide disclosed herein (*e.g.*, CD100, *e.g.*, human, murine, or both human and murine CD100) or a fragment or variant thereof with an off rate (k(off)) less than or equal to 5×10^{-4} sec^{-1}, 10^{-4} sec^{-1}, 5×10^{-5} sec^{-1}, or 10^{-5} sec^{-1}, 5×10^{-6} sec^{-1}, 10^{-6} sec^{-1}, 5×10^{-7} sec^{-1} or 10^{-7} sec^{-1}.

[0092] An antibody or or antigen-binding fragment, variant, or derivative disclosed herein may be said to bind a target polypeptide disclosed herein (*e.g.*, CD100, *e.g.*,

human, murine, or both human and murine CD100) or a fragment or variant thereof with an on rate (k(on)) of greater than or equal to 10^3 M^{-1} sec^{-1}, 5 X 10^3 M^{-1} sec^{-1}, 10^4 M^{-1} sec^{-1} or 5 X 10^4 M^{-1} sec^{-1}. More preferably, an antibody of the invention may be said to bind a target polypeptide disclosed herein (*e.g.*, CD100, *e.g.*, human, murine, or both human and murine CD100) or a fragment or variant thereof with an on rate (k(on)) greater than or equal to 10^5 M^{-1} sec^{-1}, 5 X 10^5 M^{-1} sec^{-1}, 10^6 M^{-1} sec^{-1}, or 5 X 10^6 M^{-1} sec^{-1} or 10^7 M^{-1} sec^{-1}.

[0093] An antibody is said to competitively inhibit binding of a reference antibody to a given epitope if it preferentially binds to that epitope to the extent that it blocks, to some degree, binding of the reference antibody to the epitope. Competitive inhibition may be determined by any method known in the art, for example, competition ELISA assays. An antibody may be said to competitively inhibit binding of the reference antibody to a given epitope by at least 90%, at least 80%, at least 70%, at least 60%, or at least 50%.

[0094] As used herein, the term "affinity" refers to a measure of the strength of the binding of an individual epitope with the CDR of an immunoglobulin molecule. See, *e.g.*, Harlow *et al.* (1988) Antibodies: A Laboratory Manual (Cold Spring Harbor Laboratory Press, 2nd ed.) pages 27-28. As used herein, the term "avidity" refers to the overall stability of the complex between a population of immunoglobulins and an antigen, that is, the functional combining strength of an immunoglobulin mixture with the antigen. See, *e.g.*, Harlow at pages 29-34. Avidity is related to both the affinity of individual immunoglobulin molecules in the population with specific epitopes, and also the valencies of the immunoglobulins and the antigen. For example, the interaction between a bivalent monoclonal antibody and an antigen with a highly repeating epitope structure, such as a polymer, would be one of high avidity.

[0095] Anti-CD100 antibodies or antigen-binding fragments, variants, or derivatives thereof of the invention may also be described or specified in terms of their cross-reactivity. As used herein, the term "cross-reactivity" refers to the ability of an antibody, specific for one antigen, to react with a second antigen; a measure of relatedness between two different antigenic substances. Thus, an antibody is cross reactive if it binds to an epitope other than the one that induced its formation. The cross reactive epitope generally contains many of the same complementary structural features as the inducing epitope, and in some cases, may actually fit better than the original.

[0096] For example, certain antibodies have some degree of cross-reactivity, in that they bind related, but non-identical epitopes, *e.g.*, epitopes with at least 95%, at least 90%, at least 85%, at least 80%, at least 75%, at least 70%, at least 65%, at least 60%, at least 55%, and at least 50% identity (as calculated using methods known in the art and described herein) to a reference epitope. An antibody may be said to have little or no cross-reactivity if it does not bind epitopes with less than 95%, less than 90%, less than 85%, less than 80%, less than 75%, less than 70%, less than 65%, less than 60%, less than 55%, and less than 50% identity (as calculated using methods known in the art and described herein) to a reference epitope. An antibody may be deemed "highly specific" for a certain epitope, if it does not bind any other analog, ortholog, or homolog of that epitope.

[0097] Anti-CD100 binding molecules, *e.g.*, antibodies or antigen-binding fragments, variants or derivatives thereof, of the invention may also be described or specified in terms of their binding affinity to a polypeptide of the invention, *e.g.*, CD100, *e.g.*, human, murine, or both human and murine CD100. Preferred binding affinities include those with a dissociation constant or Kd less than 5×10^{-2} M, 10^{-2} M, 5×10^{-3} M, 10^{-3} M, 5×10^{-4} M, 10^{-4} M, 5×10^{-5} M, 10^{-5} M, 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M, 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, or 10^{-15} M. In certain embodiments, the anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, of the invention binds human CD100 with a Kd of about 5×10^{-9} to about 6×10^{-9}. In another embodiment, the anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, of the invention binds murine CD100 with a Kd of about 1×10^{-9} to about 2×10^{-9}.

[0098] Anti-CD100 antibodies or antigen-binding fragments, variants or derivatives thereof of the invention may be "multispecific," *e.g.*, bispecific, trispecific, or of greater multispecificity, meaning that it recognizes and binds to two or more different epitopes present on one or more different antigens (*e.g.*, proteins) at the same time. Thus, whether an anti-CD100 antibody is "monospecific" or "multispecific," *e.g.*, "bispecific," refers to the number of different epitopes with which a binding polypeptide reacts. Multispecific antibodies may be specific for different epitopes of a target polypeptide described herein

or may be specific for a target polypeptide as well as for a heterologous epitope, such as a heterologous polypeptide or solid support material.

[0099] As used herein the term "valency" refers to the number of potential binding domains, e.g., antigen binding domains present in a binding polypeptide or CD100 binding molecule, e.g., an antibody or antigen binding fragment thereof. Each binding domain specifically binds one epitope. When a binding polypeptide or CD100 binding molecule comprises more than one binding domain, each binding domain may specifically bind the same epitope, for an antibody with two binding domains, termed "bivalent monospecific," or to different epitopes, for an antibody with two binding domains, termed "bivalent bispecific." An antibody or antigen binding fragment thereof may also be bispecific and bivalent for each specificity (termed "bispecific tetravalent antibodies"). In another embodiment, tetravalent minibodies or domain deleted antibodies can be made.

[0100] Bispecific bivalent antibodies, and methods of making them, are described, for instance in U.S. Pat. Nos. 5,731,168; 5,807,706; 5,821,333; and U.S. Patent Appl. Publ. Nos. 2003/020734 and 2002/0155537, the disclosures of all of which are incorporated by reference herein. Bispecific tetravalent antibodies, and methods of making them are described, for instance, in WO 02/096948 and WO 00/44788, the disclosures of both of which are incorporated by reference herein. See generally, PCT publications WO 93/17715; WO 92/08802; WO 91/00360; WO 92/05793; Tutt *et al.*, *J. Immunol. 147*:60-69 (1991); U.S. Pat. Nos. 4,474,893; 4,714,681; 4,925,648; 5,573,920; 5,601,819; Kostelny *et al.*, *J. Immunol. 148*: 1547-1553 (1992).

[0101] As previously indicated, the subunit structures and three dimensional configuration of the constant regions of the various immunoglobulin classes are well known. As used herein, the term "VH domain" includes the amino terminal variable domain of an immunoglobulin heavy chain and the term "CH1 domain" includes the first (most amino terminal) constant region domain of an immunoglobulin heavy chain. The CH1 domain is adjacent to the VH domain and is amino terminal to the hinge region of an immunoglobulin heavy chain molecule.

[0102] As used herein the term "CH2 domain" includes the portion of a heavy chain molecule that extends, *e.g.*, from about residue 244 to residue 360 of an antibody using conventional numbering schemes (residues 244 to 360, Kabat numbering system; and

residues 231-340, EU numbering system; see Kabat EA *et al.*). The CH2 domain is unique in that it is not closely paired with another domain. Rather, two N-linked branched carbohydrate chains are interposed between the two CH2 domains of an intact native IgG molecule. It is also well documented that the CH3 domain extends from the CH2 domain to the C-terminal of the IgG molecule and comprises approximately 108 residues.

[0103] As used herein, the term "hinge region" includes the portion of a heavy chain molecule that joins the CH1 domain to the CH2 domain. This hinge region comprises approximately 25 residues and is flexible, thus allowing the two N-terminal antigen binding regions to move independently. Hinge regions can be subdivided into three distinct domains: upper, middle, and lower hinge domains (Roux *et al.*, *J. Immunol. 161*:4083 (1998)).

[0104] As used herein the term "disulfide bond" includes the covalent bond formed between two sulfur atoms. The amino acid cysteine comprises a thiol group that can form a disulfide bond or bridge with a second thiol group. In most naturally occurring IgG molecules, the CH1 and CL regions are linked by a disulfide bond and the two heavy chains are linked by two disulfide bonds at positions corresponding to 239 and 242 using the Kabat numbering system (position 226 or 229, EU numbering system).

[0105] As used herein, the term "chimeric antibody" will be held to mean any antibody wherein the immunoreactive region or site is obtained or derived from a first species and the constant region (which may be intact, partial or modified in accordance with the instant invention) is obtained from a second species. In preferred embodiments the target binding region or site will be from a non-human source (*e.g.*, mouse or primate) and the constant region is human (for example, monoclonal antibody (MAb) 2368 described herein).

[0106] As used herein, the term "engineered antibody" refers to an antibody in which the variable domain in either the heavy or light chain or both is altered by at least partial replacement of one or more CDRs from an antibody of known specificity and, if necessary, by partial framework region replacement and sequence changing. Although the CDRs may be derived from an antibody of the same class or even subclass as the antibody from which the framework regions are derived, it is envisaged that the CDRs will be derived from an antibody of different class and preferably from an antibody from

a different species. An engineered antibody in which one or more "donor" CDRs from a non-human antibody of known specificity is grafted into a human heavy or light chain framework region is referred to herein as a "humanized antibody." It may not be necessary to replace all of the CDRs with the complete CDRs from the donor variable domain to transfer the antigen binding capacity of one variable domain to another. Rather, it may only be necessary to transfer those residues that are necessary to maintain the activity of the target binding site.

[0107] It is further recognized that the framework regions within the variable domain in a heavy or light chain, or both, of a humanized antibody may comprise solely residues of human origin, in which case these framework regions of the humanized antibody are referred to as "fully human framework regions" (for example, MAb 2503). Alternatively, one or more residues of the framework region(s) of the donor variable domain can be engineered within the corresponding position of the human framework region(s) of a variable domain in a heavy or light chain, or both, of a humanized antibody if necessary to maintain proper binding or to enhance binding to the CD100 antigen. A human framework region that has been engineered in this manner would thus comprise a mixture of human and donor framework residues, and is referred to herein as a "partially human framework region."

[0108] For example, humanization of an anti-CD100 antibody can be essentially performed following the method of Winter and co-workers (Jones *et al.*, *Nature 321*:522-525 (1986); Riechmann *et al.*, *Nature 332*:323-327 (1988); Verhoeyen *et al.*, *Science 239*:1534-1536 (1988)), by substituting rodent or mutant rodent CDRs or CDR sequences for the corresponding sequences of a human anti-CD100 antibody. See also U.S. Pat. Nos. 5,225,539; 5,585,089; 5,693,761; 5,693,762; 5,859,205; herein incorporated by reference. The resulting humanized anti-CD100 antibody would comprise at least one rodent or mutant rodent CDR within the fully human framework regions of the variable domain of the heavy and/or light chain of the humanized antibody. In some instances, residues within the framework regions of one or more variable domains of the humanized anti-CD100 antibody are replaced by corresponding non-human (for example, rodent) residues (see, for example, U.S. Pat. Nos. 5,585,089; 5,693,761; 5,693,762; and 6,180,370), in which case the resulting humanized anti-CD100 antibody would comprise

partially human framework regions within the variable domain of the heavy and/or light chain.

[0109] Furthermore, humanized antibodies may comprise residues that are not found in the recipient antibody or in the donor antibody. These modifications are made to further refine antibody performance (*e.g.*, to obtain desired affinity). In general, the humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the CDRs correspond to those of a non-human immunoglobulin and all or substantially all of the framework regions are those of a human immunoglobulin sequence. The humanized antibody optionally also will comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. For further details see Jones *et al.*, *Nature 331*:522-525 (1986); Riechmann *et al.*, *Nature 332*:323-329 (1988); and Presta, *Curr. Op. Struct. Biol. 2*:593-596 (1992); herein incorporated by reference. Accordingly, such "humanized" antibodies may include antibodies wherein substantially less than an intact human variable domain has been substituted by the corresponding sequence from a non-human species. In practice, humanized antibodies are typically human antibodies in which some CDR residues and possibly some framework residues are substituted by residues from analogous sites in rodent antibodies. See, for example, U.S. Pat. Nos. 5,225,539; 5,585,089; 5,693,761; 5,693,762; 5,859,205. See also U.S. Pat. No. 6,180,370, and International Publication No. WO 01/27160, where humanized antibodies and techniques for producing humanized antibodies having improved affinity for a predetermined antigen are disclosed.

[0110] As used herein, the terms "linked," "fused," or "fusion" are used interchangeably. These terms refer to the joining together of two more elements or components, by whatever means including chemical conjugation or recombinant means. An "in-frame fusion" refers to the joining of two or more polynucleotide open reading frames (ORFs) to form a continuous longer ORF, in a manner that maintains the correct translational reading frame of the original ORFs. Thus, a recombinant fusion protein is a single protein containing two or more segments that correspond to polypeptides encoded by the original ORFs (which segments are not normally so joined in nature). Although the reading frame is thus made continuous throughout the fused segments, the segments may be physically or spatially separated by, for example, in-frame linker sequence. For

example, polynucleotides encoding the CDRs of an immunoglobulin variable region may be fused, in-frame, but be separated by a polynucleotide encoding at least one immunoglobulin framework region or additional CDR regions, as long as the "fused" CDRs are co-translated as part of a continuous polypeptide.

[0111] In the context of polypeptides, a "linear sequence" or a "sequence" is an order of amino acids in a polypeptide in an amino to carboxyl terminal direction in which residues that neighbor each other in the sequence are contiguous in the primary structure of the polypeptide.

[0112] The term "expression" as used herein refers to a process by which a gene produces a biochemical, for example, a polypeptide. The process includes any manifestation of the functional presence of the gene within the cell including, without limitation, gene knockdown as well as both transient expression and stable expression. It includes without limitation transcription of the gene into messenger RNA (mRNA), and the translation of such mRNA into polypeptide(s). If the final desired product is a biochemical, expression includes the creation of that biochemical and any precursors. Expression of a gene produces a "gene product." As used herein, a gene product can be either a nucleic acid, *e.g.*, a messenger RNA produced by transcription of a gene, or a polypeptide which is translated from a transcript. Gene products described herein further include nucleic acids with post transcriptional modifications, *e.g.*, polyadenylation, or polypeptides with post translational modifications, *e.g.*, methylation, glycosylation, the addition of lipids, association with other protein subunits, proteolytic cleavage, and the like.

[0113] As used herein, the terms "treat" or "treatment" refer to both therapeutic treatment and prophylactic or preventative measures, wherein the object is to prevent or slow down (lessen) an undesired physiological change or disorder, such as the progression of multiple sclerosis, arthritis, or cancer. Beneficial or desired clinical results include, but are not limited to, alleviation of symptoms, diminishment of extent of disease, stabilized (*i.e.*, not worsening) state of disease, delay or slowing of disease progression, amelioration or palliation of the disease state, and remission (whether partial or total), whether detectable or undetectable. "Treatment" can also mean prolonging survival as compared to expected survival if not receiving treatment. Those in need of treatment include those already with the condition or disorder as well as those prone to have the condition or disorder or those in which the condition or disorder is to be prevented.

[0114] By "subject" or "individual" or "animal" or "patient" or "mammal," is meant any subject, particularly a mammalian subject, for whom diagnosis, prognosis, or therapy is desired. Mammalian subjects include humans, domestic animals, farm animals, and zoo, sports, or pet animals such as dogs, cats, guinea pigs, rabbits, rats, mice, horses, cattle, cows, and so on.

[0115] As used herein, phrases such as "a subject that would benefit from administration of an anti-CD100 antibody" and "an animal in need of treatment" includes subjects, such as mammalian subjects, that would benefit from administration of an anti-CD100 antibody used, *e.g.*, for detection of an anti-CD100 polypeptide (*e.g.*, for a diagnostic procedure) and/or from treatment, *i.e.*, palliation or prevention of a disease, with an anti-CD100 antibody. As described in more detail herein, an anti-CD100 antibody can be used in unconjugated form or can be conjugated, *e.g.*, to a drug, prodrug, or an isotope.

II. Target Polypeptide Description

[0116] As used herein, the terms "CD100" and "CD100 polypeptide" are used interchangably. In certain embodiments, CD100 is expressed on the surface of or secreted by a cell. In another embodiment, CD100 is membrane bound. In another embodiments, CD100 is soluble, *e.g.*, sCD100. In another embodiments, CD100 may include a full-sized CD100 or a fragment thereof, or a CD100 variant polypeptide, wherein the fragment of CD100 or CD100 variant polypeptide retains some or all functional properties of the full-sized CD100.

[0117] The full-sized human CD100 protein is a homodimeric transmembrane protein consisting of two polypeptide chains of 150 kDa. CD100 belongs to the semaphorin family of cell surface receptors and is also referred to as SEMA4D. Both human and mouse Sema4D/CD100 are proteolytically cleaved from their transmembrane form to generate 120-kDa soluble forms, indicating the existence of two Sema4D isoforms (Kumanogoh *et al.*, *J. Cell Science 116*(7):3464 (2003)). Semaphorins consist of soluble and membrane-bound proteins that were originally defined as axonal-guidance factors which play an important role in establishing precise connections between neurons and their appropriate target. Structurally considered a class IV semaphorin, CD100 consists of an amino-terminal signal sequence followed by a characteristic 'Sema' domain, which

contains 17 conserved cysteine residues, an Ig-like domain, a lysine-rich stretch, a hydrophobic transmembrane region, and a cytoplasmic tail.

[0118] Each polypeptide chain of CD100 includes a signal sequence of about 13 amino acids followed by a semaphorin domain of about 512 amino acids, an immunoglobulin-like (Ig-like) domain of about 65 amino acids, a lysine-rich stretch of 104 amino acids, a hydrophobic transmembrane region of about 19 amino acids, and a cytoplasmic tail of 110 amino acids. A consensus site for tyrosine phosphorylation in the cytoplasmic tail supports the predicted association of CD100 with a tyrosine kinase (Schlossman, et al., Eds. (1995) Leucocyte Typing V (Oxford University Press, Oxford).

[0119] Two types of receptors have been identified for CD100. One of the receptors, Plexin-B1, is expressed in non-lymphoid tissues and has been shown to be a high affinity (1 nM) receptor for CD100 (Tamagnone *et al.*, *Cell 99*:71-80 (1999)). CD100 stimulation of Plexin B1 signaling has been shown to induce growth cone collapse of neurons, and to induce process extension collapse and apoptosis of oligodendrocytes (Giraudon *et al.*, *J. Immunol. 172*:1246-1255 (2004); Giraudon *et al.*, *NeuroMolecular Med. 7*:207-216 (2005)). After binding to CD100, Plexin B1 signaling mediates the inactivation of R-Ras, leading to a decrease in the integrin mediated attachment to the extracellular Matrix, as well as to activation of Rho, leading to cell collapse by reorganization of the cytoskeleton. See Kruger *et al.*, *Nature Rev. Mol. Cell Biol. 6*:789-800 (2005); Pasterkamp, *TRENDS in Cell Biology 15*:61-64 (2005)).

[0120] In lymphoid tissues CD72 is utilized as a low affinity (300nM) CD100 receptor (Kumanogoh *et al.*, *Immunity 13*:621-631 (2000)). B cells and APCs express CD72, and anti-CD72 antibodies have many of the same effects as sCD100, such as enhancement of CD40-induced B cell responses and B cell shedding of CD23. CD72 is thought to act as a negative regulator of B cell responses by recruiting the tyrosine phosphatase SHP-1, which can associate with many inhibitory receptors. Interaction of CD100 with CD72 results in the dissociation of SHP-1, and the loss of this negative activation signal. CD100 has been shown to promote T cell stimulation and B cell aggregation and survival *in vitro*. The addition of CD100-expressing cells or sCD100 enhances CD40-induced B cell proliferation and immunoglobulin production *in vitro*, and accelerates *in vivo* antibody responses (Ishida *et al.*, *Inter. Immunol. 15*:1027-1034 (2003); Kumanogoh and H. Kukutani, *Trends in Immunol. 22*:670-676 (2001)). sCD100 enhances the CD40

induced maturation of DCs, including up-regulation of costimulatory molecules and increased secretion of IL-12. In addition, sCD100 can inhibit immune cell migration, which can be reversed by addition of blocking anti-CD100 mouse antibodies (Elhabazi *et al.*, *J. Immunol.* 166:4341-4347 (2001); Delaire *et al.*, *J. Immunol.* 166:4348-4354 (2001)).

[0121] Sema4D is expressed at high levels in lymphoid organs, including the spleen, thymus, and lymph nodes, and in non-lymphoid organs, such as the brain, heart, and kidney. In lymphoid organs, Sema4D is abundantly expressed on resting T cells but only weakly expressed on resting B cells and antigen-presenting cells (APCs), such as dendritic cells (DCs).

[0122] Cellular activation increases the surface expression of CD100 as well as the generation of soluble CD100 (sCD100). The expression pattern of CD100 suggests that it plays an important physiological as well as pathological role in the immune system. CD100 has been shown to promote B cell activation, aggregation and survival; enhance CD40-induced proliferation and antibody production; enhance antibody response to T cell dependent antigens; increase T cell proliferation; enhance dendritic cell maturation and ability to stimulate T cells; and is directly implicated in demyelination and axonal degeneration (Shi *et al.*, *Immunity 13*:633-642 (2000); Kumanogoh *et al.*, *J Immunol 169*:1175-1181 (2002); and Watanabe *et al.*, *J Immunol 167*:4321-4328 (2001)).

[0123] CD100 knock out (CD100-/-) mice have provided additional evidence that CD100 plays an important role in both humoral and cellular immune responses. There are no known abnormalities of non-lymphoid tissues in CD100-/- mice. Dendritic cells (DCs) from the CD100-/- mice have poor allostimulatory ability and show defects in expression of costimulatory molecules, which can be rescued by the addition of sCD100. Mice deficient in CD100 (CD100-/-) fail to develop experimental autoimmune encephalomyelitis induced by myelin oligodendrocyte glycoprotein peptide, because myelin oligodendrocyte glycoprotein-specific T cells are not generated in the absence of CD100 (Kumanogoh *et al.*, *J Immunol 169*:1175-1181 (2002)). A significant amount of soluble CD100 is also detected in the sera of autoimmunity-prone MRL/lpr mice (model of systemic autoimmune diseases such as SLE), but not in normal mice. Further, the levels of sCD100 correlate with levels of auto-antibodies and increase with age (Wang *et al.*, *Blood 97*:3498-3504 (2001)). Soluble CD100 has also been shown to accumulate in

the cerebral spinal fluid and sera of patients with demyelinating disease, and sCD100 induces apoptosis of human pluripotent neural precursors (Dev cells), and both inhibits process extension and induces apoptosis of rat oligodendrocytes *in vitro* (Giraudon *et al.*, *J Immunol 172*(2):1246-1255 (2004)). This apoptosis was blocked by an anti-CD100 MAb.

III. Anti-CD100 Antibodies

[0124] Antibodies that bind CD100 have been described the art. See, for example, US Publ. No. 2008/0219971 A1, International Patent Application WO 93/14125 and Herold *et al., Int. Immunol. 7*(1): 1-8 (1995), each of which is herein incorporated in its entirety by reference.

[0125] The antibodies of the invention comprise anti-CD100 antibodies or antigen-binding fragments, variants, or derivatives thereof that bind to CD100, *e.g.*, MAb 2503, MAb 67, and MAb 76. In certain embodiments the anti-CD100 antibodies bind human, murine, or both human and murine CD100. In other embodiments, the anti-CD100 antibodies block CD100 binding to its receptor, *e.g.*, Plexin-B.

[0126] In one embodiment, the present invention provides an isolated binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, which specifically binds to the same CD100 epitope as monoclonal antibody 2503, 67, or 76. In another embodiment, the present invention provides an isolated binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, which specifically binds to CD100, and competitively inhibits monoclonal antibody 2503, 67, or 76 from specifically binding to CD100, *e.g.*, human, murine, or both human and murine CD100.

[0127] In certain embodiments, the binding molecule of the invention has an amino acid sequence that has at least about 80%, about 85%, about 88%, about 89%, about 90%, about 91%, about 92%, about 93%, about 94%, or about 95% sequence identity to the amino acid sequence for the reference anti-CD100 antibody molecule. In a further embodiment, the binding molecule shares at least about 96%, about 97%, about 98%, about 99%, or 100% sequence identity to the reference antibody.

[0128] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin heavy chain variable domain (VH domain), where at least one of the

CDRs of the VH domain has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to CDR1, CDR2 or CDR3 of SEQ ID NO: 9 or 10.

[0129] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin heavy chain variable domain (VH domain), where at least one of the CDRs of the VH domain has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to SEQ ID NO: 6, SEQ ID NO: 7, or SEQ ID NO: 8.

[0130] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin heavy chain variable domain (VH domain), where at least one of the CDRs of the VH domain has an amino acid sequence identical, except for 1, 2, 3, 4, or 5 conservative amino acid substitutions, to SEQ ID NO: 6, SEQ ID NO: 7, or SEQ ID NO: 8.

[0131] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of a VH domain that has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or 100% identical to SEQ ID NO: 9 or SEQ ID NO: 10, wherein an anti-CD100 antibody comprising the encoded VH domain specifically or preferentially binds to CD100.

[0132] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin light chain variable domain (VL domain), where at least one of the CDRs of the VL domain has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to CDR1, CDR2 or CDR3 of SEQ ID NO: 17 or 18.

[0133] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin light chain variable domain (VL domain), where at least one of the CDRs of the VL domain has an amino acid sequence that is at least about 80%, about

85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to SEQ ID NO: 14, SEQ ID NO: 15, or SEQ ID NO: 16.

[0134] In another embodiment, the present invention provides an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of an immunoglobulin light chain variable domain (VL domain), where at least one of the CDRs of the VL domain has an amino acid sequence identical, except for 1, 2, 3, 4, or 5 conservative amino acid substitutions, to SEQ ID NO: 14, SEQ ID NO: 15, or SEQ ID NO: 16.

[0135] In a further embodiment, the present invention includes an isolated antibody or antigen-binding fragment thereof comprising, consisting essentially of, or consisting of a VL domain that has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or 100% identical to SEQ ID NO: 17 or SEQ ID NO: 18, wherein an anti-CD100 antibody comprising the encoded VL domain specifically or preferentially binds to CD100.

[0136] Suitable biologically active variants of the anti-CD100 antibodies of the invention can be used in the methods of the present invention. Such variants will retain the desired binding properties of the parent anti-CD100 antibody. Methods for making antibody variants are generally available in the art.

[0137] Methods for mutagenesis and nucleotide sequence alterations are well known in the art. See, for example, Walker and Gaastra, eds. (1983) Techniques in Molecular Biology (MacMillan Publishing Company, New York); Kunkel, Proc. *Natl. Acad. Sci. USA 82*:488-492 (1985); Kunkel *et al.*, *Methods Enzymol. 154*:367-382 (1987); Sambrook *et al.* (1989) Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, N.Y.); U.S. Pat. No. 4,873,192; and the references cited therein; herein incorporated by reference. Guidance as to appropriate amino acid substitutions that do not affect biological activity of the polypeptide of interest may be found in the model of Dayhoff *et al.* (1978) in Atlas of Protein Sequence and Structure (Natl. Biomed. Res. Found., Washington, D.C.), pp. 345-352, herein incorporated by reference in its entirety. The model of Dayhoff *et al.* uses the Point Accepted Mutation (PAM) amino acid similarity matrix (PAM 250 matrix) to determine suitable conservative amino acid substitutions. Conservative substitutions, such as exchanging one amino acid with another having

similar properties, may be preferred. Examples of conservative amino acid substitutions as taught by the PAM 250 matrix of the Dayhoff *et al.* model include, but are not limited to, Gly↔Ala, Val↔Ile↔Leu, Asp↔Glu, Lys↔Arg, Asn↔Gln, and Phe↔Trp↔Tyr.

[0138] In constructing variants of the anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment thereof, polypeptides of interest, modifications are made such that variants continue to possess the desired properties, *e.g.*, being capable of specifically binding to a CD100, *e.g.*, human, murine, or both human and murine CD100, *e.g.*, expressed on the surface of or secreted by a cell and having CD100 blocking activity, as described herein. Obviously, any mutations made in the DNA encoding the variant polypeptide must not place the sequence out of reading frame and preferably will not create complementary regions that could produce secondary mRNA structure. See EP Patent Application Publication No. 75,444.

[0139] Methods for measuring anti-CD100 binding molecule, e.g., an antibody or antigen-binding fragment thereof, binding specificity include, but are not limited to, standard competitive binding assays, assays for monitoring immunoglobulin secretion by T cells or B cells, T cell proliferation assays, apoptosis assays, ELISA assays, and the like. See, for example, such assays disclosed in WO 93/14125; Shi *et al.*, *Immunity 13*:633-642 (2000); Kumanogoh *et al.*, *J Immunol 169*:1175-1181 (2002); Watanabe *et al.*, *J Immunol 167*:4321-4328 (2001); Wang *et al.*, *Blood 97*:3498-3504 (2001); and Giraudon *et al.*, *J Immunol 172*(2):1246-1255 (2004), all of which are herein incorporated by reference.

[0140] When discussed herein whether any particular polypeptide, including the constant regions, CDRs, VH domains, or VL domains disclosed herein, is at least about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or even about 100% identical to another polypeptide, the % identity can be determined using methods and computer programs/software known in the art such as, but not limited to, the BESTFIT program (Wisconsin Sequence Analysis Package, Version 8 for Unix, Genetics Computer Group, University Research Park, 575 Science Drive, Madison, Wis. 53711). BESTFIT uses the local homology algorithm of Smith and Waterman (1981) Adv. Appl. Math. 2:482-489, to find the best segment of homology between two sequences. When using BESTFIT or any other sequence alignment program to determine whether a

particular sequence is, for example, 95% identical to a reference sequence according to the present invention, the parameters are set, of course, such that the percentage of identity is calculated over the full length of the reference polypeptide sequence and that gaps in homology of up to 5% of the total number of amino acids in the reference sequence are allowed.

[0141] For purposes of the present invention, percent sequence identity may be determined using the Smith-Waterman homology search algorithm using an affine gap search with a gap open penalty of 12 and a gap extension penalty of 2, BLOSUM matrix of 62. The Smith-Waterman homology search algorithm is taught in Smith and Waterman (1981) Adv. Appl. Math. 2:482-489. A variant may, for example, differ from a reference anti-CD100 antibody (*e.g.*, MAb 2503, 67 or 76) by as few as 1 to 15 amino acid residues, as few as 1 to 10 amino acid residues, such as 6-10, as few as 5, as few as 4, 3, 2, or even 1 amino acid residue.

[0142] The precise chemical structure of a polypeptide capable of specifically binding CD100 and retaining the desired CD100 blocking activity depends on a number of factors. As ionizable amino and carboxyl groups are present in the molecule, a particular polypeptide may be obtained as an acidic or basic salt, or in neutral form. All such preparations that retain their biological activity when placed in suitable environmental conditions are included in the definition of anti-CD100 antibodies as used herein. Further, the primary amino acid sequence of the polypeptide may be augmented by derivatization using sugar moieties (glycosylation) or by other supplementary molecules such as lipids, phosphate, acetyl groups and the like. It may also be augmented by conjugation with saccharides. Certain aspects of such augmentation are accomplished through post-translational processing systems of the producing host; other such modifications may be introduced in vitro. In any event, such modifications are included in the definition of an anti-CD100 antibody used herein so long as the desired properties of the anti-CD100 antibody are not destroyed. It is expected that such modifications may quantitatively or qualitatively affect the activity, either by enhancing or diminishing the activity of the polypeptide, in the various assays. Further, individual amino acid residues in the chain may be modified by oxidation, reduction, or other derivatization, and the polypeptide may be cleaved to obtain fragments that retain activity. Such alterations that do not destroy the desired properties (*e.g.*, binding specificity for CD100, binding

affinity, and CD100 blocking activity) do not remove the polypeptide sequence from the definition of anti-CD100 antibodies of interest as used herein.

[0143] The art provides substantial guidance regarding the preparation and use of polypeptide variants. In preparing the anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment thereof, variants, one of skill in the art can readily determine which modifications to the native protein's nucleotide or amino acid sequence will result in a variant that is suitable for use as a therapeutically active component of a pharmaceutical composition used in the methods of the present invention.

[0144] The constant region of an anti-CD100 antibody may be mutated to alter effector function in a number of ways. For example, see U.S. Pat. No. 6,737,056B1 and U.S. Patent Application Publication No. 2004/0132101A1, which disclose Fc mutations that optimize antibody binding to Fc receptors.

[0145] In certain anti-CD100 antibodies, the Fc portion may be mutated to decrease effector function using techniques known in the art. For example, the deletion or inactivation (through point mutations or other means) of a constant region domain may reduce Fc receptor binding of the circulating modified antibody thereby increasing tumor localization. In other cases it may be that constant region modifications consistent with the instant invention moderate complement binding and thus reduce the serum half life and nonspecific association of a conjugated cytotoxin. Yet other modifications of the constant region may be used to modify disulfide linkages or oligosaccharide moieties that allow for enhanced localization due to increased antigen specificity or antibody flexibility. The resulting physiological profile, bioavailability and other biochemical effects of the modifications, such as tumor localization, biodistribution and serum half-life, may easily be measured and quantified using well known immunological techniques without undue experimentation.

[0146] Anti-CD100 antibodies of the invention also include derivatives that are modified, *e.g.*, by the covalent attachment of any type of molecule to the antibody such that covalent attachment does not prevent the antibody from specifically binding to its cognate epitope. For example, but not by way of limitation, the antibody derivatives include antibodies that have been modified, *e.g.*, by glycosylation, acetylation, pegylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to a cellular ligand or other protein, etc. Any of numerous

chemical modifications may be carried out by known techniques, including, but not limited to specific chemical cleavage, acetylation, formylation, etc. Additionally, the derivative may contain one or more non-classical amino acids.

[0147] A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a side chain with a similar charge. Families of amino acid residues having side chains with similar charges have been defined in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine, histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (*e.g.*, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Alternatively, mutations can be introduced randomly along all or part of the coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for biological activity to identify mutants that retain activity (*e.g.*, the ability to bind an anti-CD100 polypeptide).

[0148] For example, it is possible to introduce mutations only in framework regions or only in CDR regions of an antibody molecule. Introduced mutations may be silent or neutral missense mutations, *i.e.*, have no, or little, effect on an antibody's ability to bind antigen. These types of mutations may be useful to optimize codon usage, or improve a hybridoma's antibody production. Alternatively, non-neutral missense mutations may alter an antibody's ability to bind antigen. The location of most silent and neutral missense mutations is likely to be in the framework regions, while the location of most non-neutral missense mutations is likely to be in CDR, though this is not an absolute requirement. One of skill in the art would be able to design and test mutant molecules with desired properties such as no alteration in antigen binding activity or alteration in binding activity (e.g., improvements in antigen binding activity or change in antibody specificity). Following mutagenesis, the encoded protein may routinely be expressed and the functional and/or biological activity of the encoded protein, (*e.g.*, ability to immunospecifically bind at least one epitope of a CD100 polypeptide) can be determined using techniques described herein or by routinely modifying techniques known in the art.

[0149] In certain embodiments, the anti-CD100 antibodies of the invention comprise at least one optimized complementarity-determining region (CDR). By "optimized CDR" is intended that the CDR has been modified and optimized sequences selected based on the sustained or improved binding affinity and/or anti-CD100 activity that is imparted to an anti-CD100 antibody comprising the optimized CDR. "Anti-CD100 activity" or "CD100 blocking activity" can include activity which modulates one or more of the following activities associated with CD100: B cell activation, aggregation and survival; CD40-induced proliferation and antibody production; antibody response to T cell dependent antigens; T cell or other immune cell proliferation; dendritic cell maturation; demyelination and axonal degeneration; apoptosis of pluripotent neural precursors and/or oligodendrocytes; induction of endothelial cell migration; inhibition of spontaneous monocyte migration; binding to cell surface plexin B1; or any other activity association with soluble CD100 or CD100 that is expressed on the surface of CD100+ cells. Anti-CD100 activity can also be attributed to a decrease in incidence or severity of diseases associated with CD100 expression, including, but not limited to, certain types of lymphomas, autoimmune diseases, inflammatory diseases including central nervous system (CNS) and peripheral nervous system (PNS) inflammatory diseases, transplant rejections, and invasive angiogenesis. Examples of optimized antibodies based on murine anti-CD100 MAbs BD16 and BB18, were described in US Publ. No. 2008/0219971 A1, International Patent Application WO 93/14125 and Herold *et al.*, *Int. Immunol.* 7(1): 1-8 (1995), each of which are herein incorporated by reference in their entirety. The modifications may involve replacement of amino acid residues within the CDR such that an anti-CD100 antibody retains specificity for the CD100 antigen and has improved binding affinity and/or improved anti-CD100 activity.

IV. Polynucleotides Encoding Anti-CD100 Antibodies

[0150] The present invention also provides for nucleic acid molecules encoding anti-CD100 antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof.

[0151] In one embodiment, the present invention provides an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding an immunoglobulin heavy chain variable domain (VH domain), where at least one of the

CDRs of the VH domain has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to a polynucleotide sequence selected from the group consisting of SEQ ID NO: 3, SEQ ID NO: 4, or SEQ ID NO: 5.

[0152] In other embodiments, the present invention provides an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding an immunoglobulin VH domain, where at least one of the CDRs of the VH domain is selected from the group consisting of: (a) a CDR1 comprising the amino acid sequence set forth in SEQ ID NO: 6; (b) a CDR2 comprising the amino acid sequence set forth in SEQ ID NO: 7; and (c) a CDR3 comprising the amino acid sequence set forth in SEQ ID NO: 8.

[0153] In a further embodiment, the present invention includes an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding a VH domain that has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or 100% identical to a reference VH domain polypeptide sequence comprising SEQ ID NO: 9 or SEQ ID NO: 10, wherein an anti-CD100 antibody comprising the encoded VH domain specifically or preferentially binds to CD100.

[0154] In one embodiment, the present invention provides an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding an immunoglobulin light chain variable domain (VL domain), where at least one of the CDRs of the VL domain has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 95%, about 96%, about 97%, about 98%, about 99%, or identical to a polynucleotide sequence selected from the group consisting of SEQ ID NO: 11, SEQ ID NO: 12, and SEQ ID NO: 13.

[0155] In other embodiments, the present invention provides an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding an immunoglobulin VL domain, where at least one of the CDRs of the VL domain is selected from the group consisting of: (a) a CDR1 comprising the amino acid sequence set forth in SEQ ID NO: 14; (b) a CDR2 comprising the amino acid sequence set forth in SEQ ID NO: 15; and (c) a CDR3 comprising the amino acid sequence set forth in SEQ ID NO: 16.

[0156] In a further embodiment, the present invention includes an isolated polynucleotide comprising, consisting essentially of, or consisting of a nucleic acid encoding a VL domain that has an amino acid sequence that is at least about 80%, about 85%, about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, or 100% identical to a reference VL domain polypeptide sequence comprising SEQ ID NO: 17 or SEQ ID NO: 18, wherein an anti-CD100 antibody comprising the encoded VL domain specifically or preferentially binds to CD100.

[0157] Any of the polynucleotides described above may further include additional nucleic acids, encoding, *e.g.*, a signal peptide to direct secretion of the encoded polypeptide, antibody constant regions as described herein, or other heterologous polypeptides as described herein. Also, as described in more detail elsewhere herein, the present invention includes compositions comprising one or more of the polynucleotides described above.

[0158] In one embodiment, the invention includes compositions comprising a first polynucleotide and second polynucleotide wherein said first polynucleotide encodes a VH domain as described herein and wherein said second polynucleotide encodes a VL domain as described herein. Specifically a composition which comprises, consists essentially of, or consists of a VH domain-encoding polynucleotide, as set forth in SEQ ID NO: 19 or SEQ ID NO: 20, and a VL domain-encoding polynucleotide, for example, a polynucleotide encoding the VL domain as set forth in SEQ ID NO: 21 or SEQ ID NO: 22.

[0159] The present invention also includes fragments of the polynucleotides of the invention, as described elsewhere. Additionally polynucleotides that encode fusion polypolypeptides, Fab fragments, and other derivatives, as described herein, are also contemplated by the invention.

[0160] The polynucleotides may be produced or manufactured by any method known in the art. For example, if the nucleotide sequence of the antibody is known, a polynucleotide encoding the antibody may be assembled from chemically synthesized oligonucleotides (*e.g.*, as described in Kutmeier *et al.*, *Bio Techniques 17*:242 (1994)), which, briefly, involves the synthesis of overlapping oligonucleotides containing portions

of the sequence encoding the antibody, annealing and ligating of those oligonucleotides, and then amplification of the ligated oligonucleotides by PCR.

[0161] Alternatively, a polynucleotide encoding an anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof of the invention, may be generated from nucleic acid from a suitable source. If a clone containing a nucleic acid encoding a particular antibody is not available, but the sequence of the antibody molecule is known, a nucleic acid encoding the antibody may be chemically synthesized or obtained from a suitable source (*e.g.*, an antibody cDNA library, or a cDNA library generated from, or nucleic acid, preferably poly A+RNA, isolated from, any tissue or cells expressing the antibody or other anti-CD100 antibody, such as hybridoma cells selected to express an antibody) by PCR amplification using synthetic primers hybridizable to the 3' and 5' ends of the sequence or by cloning using an oligonucleotide probe specific for the particular gene sequence to identify, *e.g.*, a cDNA clone from a cDNA library that encodes the antibody or other anti-CD100 antibody. Amplified nucleic acids generated by PCR may then be cloned into replicable cloning vectors using any method well known in the art.

[0162] Once the nucleotide sequence and corresponding amino acid sequence of the anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof is determined, its nucleotide sequence may be manipulated using methods well known in the art for the manipulation of nucleotide sequences, *e.g.*, recombinant DNA techniques, site directed mutagenesis, PCR, etc. (see, for example, the techniques described in Sambrook et al. (1990) Molecular Cloning, A Laboratory Manual (2nd ed.; Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y.) and Ausubel et al., eds. (1998) Current Protocols in Molecular Biology (John Wiley & Sons, NY), which are both incorporated by reference herein in their entireties), to generate antibodies having a different amino acid sequence, for example to create amino acid substitutions, deletions, and/or insertions.

[0163] A polynucleotide encoding an anti-CD100 binding molecule, *e.g.*, an antibody, or antigen-binding fragment, variant, or derivative thereof, can be composed of any polyribonucleotide or polydeoxyribonucleotide, which may be unmodified RNA or DNA or modified RNA or DNA. For example, a polynucleotide encoding anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof can be composed of single- and double-stranded DNA, DNA that is a mixture of single- and double-stranded regions, single- and double-stranded RNA, and RNA that is mixture of single- and

double-stranded regions, hybrid molecules comprising DNA and RNA that may be single-stranded or, more typically, double-stranded or a mixture of single- and double-stranded regions. In addition, a polynucleotide encoding an anti-CD100 binding molecule, *e.g.*, an antibody, or antigen-binding fragment, variant, or derivative thereof can be composed of triple-stranded regions comprising RNA or DNA or both RNA and DNA. A polynucleotide encoding an anti-CD100 binding molecule, *e.g.*, antibody, or antigen-binding fragment, variant, or derivative thereof, may also contain one or more modified bases or DNA or RNA backbones modified for stability or for other reasons. "Modified" bases include, for example, tritylated bases and unusual bases such as inosine. A variety of modifications can be made to DNA and RNA; thus, "polynucleotide" embraces chemically, enzymatically, or metabolically modified forms.

[0164] An isolated polynucleotide encoding a non-natural variant of a polypeptide derived from an immunoglobulin (*e.g.*, an immunoglobulin heavy chain portion or light chain portion) can be created by introducing one or more nucleotide substitutions, additions or deletions into the nucleotide sequence of the immunoglobulin such that one or more amino acid substitutions, additions or deletions are introduced into the encoded protein. Mutations may be introduced by standard techniques, such as site-directed mutagenesis and PCR-mediated mutagenesis. Preferably, conservative amino acid substitutions are made at one or more non-essential amino acid residues.

V. Fusion Proteins and Antibody Conjugates

[0165] As discussed in more detail elsewhere herein, anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, may further be recombinantly fused to a heterologous polypeptide at the N- or C-terminus or chemically conjugated (including covalent and non-covalent conjugations) to polypeptides or other compositions. For example, anti-CD100 antibodies may be recombinantly fused or conjugated to molecules useful as labels in detection assays and effector molecules such as heterologous polypeptides, drugs, radionuclides, or toxins. See, *e.g.*, PCT publications WO 92/08495; WO 91/14438; WO 89/12624; U.S. Pat. No. 5,314,995; and EP 396,387.

[0166] Anti-CD100 antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, may include derivatives that are modified, *i.e.*, by the covalent

attachment of any type of molecule to the antibody such that covalent attachment does not prevent the antibody binding anti-CD100. For example, but not by way of limitation, the antibody derivatives include antibodies that have been modified, *e.g.*, by glycosylation, acetylation, pegylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to a cellular ligand or other protein, etc. Any of numerous chemical modifications may be carried out by known techniques, including, but not limited to specific chemical cleavage, acetylation, formylation, etc. Additionally, the derivative may contain one or more non-classical amino acids.

[0167] Anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, can be composed of amino acids joined to each other by peptide bonds or modified peptide bonds, *i.e.*, peptide isosteres, and may contain amino acids other than the 20 gene-encoded amino acids. For example, anti-CD100 antibodies may be modified by natural processes, such as posttranslational processing, or by chemical modification techniques that are well known in the art. Such modifications are well described in basic texts and in more detailed monographs, as well as in a voluminous research literature. Modifications can occur anywhere in the anti-CD100 binding molecule, including the peptide backbone, the amino acid side-chains and the amino or carboxyl termini, or on moieties such as carbohydrates. It will be appreciated that the same type of modification may be present in the same or varying degrees at several sites in a given anti-CD100 binding molecule. Also, a given anti-CD100 binding molecule may contain many types of modifications. Anti-CD100 binding molecules may be branched, for example, as a result of ubiquitination, and they may be cyclic, with or without branching. Cyclic, branched, and branched cyclic anti-CD100 binding molecule may result from posttranslation natural processes or may be made by synthetic methods. Modifications include acetylation, acylation, ADP-ribosylation, amidation, covalent attachment of flavin, covalent attachment of a heme moiety, covalent attachment of a nucleotide or nucleotide derivative, covalent attachment of a lipid or lipid derivative, covalent attachment of phosphotidylinositol, cross-linking, cyclization, disulfide bond formation, demethylation, formation of covalent cross-links, formation of cysteine, formation of pyroglutamate, formylation, gamma-carboxylation, glycosylation, GPI anchor formation, hydroxylation, iodination, methylation, myristoylation, oxidation,

pegylation, proteolytic processing, phosphorylation, prenylation, racemization, selenoylation, sulfation, transfer-RNA mediated addition of amino acids to proteins such as arginylation, and ubiquitination. (See, for instance, Proteins--Structure and Molecular Properties, T. E. Creighton, W. H. Freeman and Company, NY; 2nd ed. (1993); Johnson, ed. (1983) Posttranslational Covalent Modification of Proteins (Academic Press, NY), pgs. 1-12; Seifter *et al.*, *Meth. Enzymol. 182*:626-646 (1990); Rattan *et al.*, *Ann. NY Acad. Sci. 663*:48-62 (1992)).

[0168] The present invention also provides for fusion proteins comprising an anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof, and a heterologous polypeptide. The heterologous polypeptide to which the antibody is fused may be useful for function or is useful to target the anti-CD100 polypeptide expressing cells.

[0169] In one embodiment, a fusion protein of the invention comprises, consists essentially of, or consists of, a polypeptide having the amino acid sequence of any one or more of the VH domains of an antibody of the invention or the amino acid sequence of any one or more of the VL domains of an antibody of the invention or fragments or variants thereof, and a heterologous polypeptide sequence.

[0170] In another embodiment, a fusion protein for use in the diagnostic and treatment methods disclosed herein comprises, consists essentially of, or consists of a polypeptide having the amino acid sequence of any one, two, three of the CDRs of the VH domain of an anti-CD100 antibody, or fragments, variants, or derivatives thereof, or the amino acid sequence of any one, two, three of the CDRs of the VL domain an anti-CD100 antibody, or fragments, variants, or derivatives thereof, and a heterologous polypeptide sequence. In one embodiment, a fusion protein comprises a polypeptide having the amino acid sequence of at least one VH domain of an anti-CD100 antibody of the invention and the amino acid sequence of at least one VL domain of an anti-CD100 antibody of the invention or fragments, derivatives or variants thereof, and a heterologous polypeptide sequence. Preferably, the VH and VL domains of the fusion protein correspond to a single source antibody (or scFv or Fab fragment) that specifically binds at least one epitope of CD100. In yet another embodiment, a fusion protein for use in the diagnostic and treatment methods disclosed herein comprises a polypeptide having the amino acid sequence of any one, two, three or more of the CDRs of the VH domain of an anti-CD100 antibody and the amino acid sequence of any one, two, three or more of the CDRs of the

VL domain of an anti-CD100 antibody, or fragments or variants thereof, and a heterologous polypeptide sequence. Preferably, two, three, four, five, six, or more of the CDR(s) of the VH domain or VL domain correspond to single source antibody (or scFv or Fab fragment) of the invention. Nucleic acid molecules encoding these fusion proteins are also encompassed by the invention.

[0171] Exemplary fusion proteins reported in the literature include fusions of the T cell receptor (Gascoigne *et al., Proc. Natl. Acad. Sci. USA 84*:2936-2940 (1987)); CD4 (Capon *et al., Nature 337*:525-531 (1989); Traunecker *et al., Nature 339*:68-70 (1989); Zettmeissl *et al., DNA Cell Biol. USA 9*:347-353 (1990); and Byrn *et al., Nature 344*:667-670(1990)); L-selectin (homing receptor) (Watson et al., *J. Cell. Biol. 110*:2221-2229 (1990); and Watson *et al., Nature 349*:164-167 (1991)); CD44 (Aruffo *et al., Cell 61*:1303-1313 (1990)); CD28 and B7 (Linsley *et al., J. Exp. Med. 173*:721-730 (1991)); CTLA-4 (Lisley *et al., J. Exp. Med. 174*:561-569 (1991)); CD22 (Stamenkovic *et al., Cell 66*:1133-1144 (1991)); TNF receptor (Ashkenazi *et al., Proc. Natl. Acad. Sci. USA 88*:10535-10539 (1991); Lesslauer *et al., Eur. J. Immunol. 27*:2883-2886 (1991); and Peppel *et al., J. Exp. Med. 174*:1483-1489 (1991)); and IgE receptor a (Ridgway and Gorman, J. Cell. Biol. Vol. 115, Abstract No. 1448 (1991)).

[0172] As discussed elsewhere herein, anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, may be fused to heterologous polypeptides to increase the *in vivo* half life of the polypeptides or for use in immunoassays using methods known in the art. For example, in one embodiment, PEG can be conjugated to the anti-CD100 antibodies of the invention to increase their half-life *in vivo*. See Leong *et al., Cytokine 16*:106 (2001); Adv. in Drug Deliv. Rev. 54:531 (2002); or Weir *et al., Biochem. Soc. Transactions 30*:512 (2002).

[0173] Moreover, anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, can be fused to marker sequences, such as a peptide to facilitate their purification or detection. In preferred embodiments, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (QIAGEN, Inc., 9259 Eton Avenue, Chatsworth, Calif., 91311), among others, many of which are commercially available. As described in Gentz *et al., Proc. Natl. Acad. Sci. USA 86*:821-824 (1989), for instance, hexa-histidine provides for convenient purification of the fusion protein. Other peptide tags useful for purification

include, but are not limited to, the "HA" tag, which corresponds to an epitope derived from the influenza hemagglutinin protein (Wilson *et al.*, *Cell 37*:767 (1984)) and the "flag" tag.

[0174] Fusion proteins can be prepared using methods that are well known in the art (see for example U.S. Pat. Nos. 5,116,964 and 5,225,538). The precise site at which the fusion is made may be selected empirically to optimize the secretion or binding characteristics of the fusion protein. DNA encoding the fusion protein is then transfected into a host cell for expression.

[0175] Anti-CD100 binding molecules, *e.g.*, antibodies of the present invention, or antigen-binding fragments, variants, or derivatives thereof, may be used in non-conjugated form or may be conjugated to at least one of a variety of molecules, *e.g.*, to improve the therapeutic properties of the molecule, to facilitate target detection, or for imaging or therapy of the patient. Anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, can be labeled or conjugated either before or after purification, or when purification is performed.

[0176] In particular, anti-CD100 antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, may be conjugated to therapeutic agents, prodrugs, peptides, proteins, enzymes, viruses, lipids, biological response modifiers, pharmaceutical agents, or PEG.

[0177] Those skilled in the art will appreciate that conjugates may also be assembled using a variety of techniques depending on the selected agent to be conjugated. For example, conjugates with biotin are prepared, *e.g.*, by reacting a binding polypeptide with an activated ester of biotin such as the biotin N-hydroxysuccinimide ester. Similarly, conjugates with a fluorescent marker may be prepared in the presence of a coupling agent, *e.g.*, those listed herein, or by reaction with an isothiocyanate, preferably fluorescein-isothiocyanate. Conjugates of the anti-CD100 antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, are prepared in an analogous manner.

[0178] The present invention further encompasses anti-CD100 binding molecules, *e.g.*, antibodies of the invention, or antigen-binding fragments, variants, or derivatives thereof, conjugated to a diagnostic or therapeutic agent. The anti-CD100 antibodies, including antigen-binding fragments, variants, and derivatives thereof, can be used diagnostically

to, for example, monitor the development or progression of a disease as part of a clinical testing procedure to, *e.g.*, determine the efficacy of a given treatment and/or prevention regimen. For example, detection can be facilitated by coupling the anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof, to a detectable substance. Examples of detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, radioactive materials, positron emitting metals using various positron emission tomographies, and nonradioactive paramagnetic metal ions. See, for example, U.S. Pat. No. 4,741,900 for metal ions which can be conjugated to antibodies for use as diagnostics according to the present invention. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β-galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; an example of a luminescent material includes luminol; examples of bioluminescent materials include luciferase, luciferin, and aequorin; and examples of suitable radioactive material include ^{125}I, ^{131}I, ^{111}In, ^{90}Y, or ^{99}Tc.

[0179] An anti-CD100 binding molecule, *e.g.*, an antibody, or antigen-binding fragment, variant, or derivative thereof, may be conjugated to a therapeutic moiety such as a cytotoxin, a therapeutic agent or a radioactive metal ion. A cytotoxin or cytotoxic agent includes any agent that is detrimental to cells.

[0180] An anti-CD100 binding molecule, *e.g.*, an antibody, or antigen-binding fragment, variant, or derivative thereof, also can be detectably labeled by coupling it to a chemiluminescent compound. The presence of the chemiluminescent-tagged anti-CD100 binding molecule is then determined by detecting the presence of luminescence that arises during the course of a chemical reaction. Examples of particularly useful chemiluminescent labeling compounds are luminol, isoluminol, theromatic acridinium ester, imidazole, acridinium salt and oxalate ester.

[0181] One of the ways in which an anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof, can be detectably labeled is by linking the same to an enzyme and using the linked product in an enzyme immunoassay (EIA) (Voller, A., "The Enzyme Linked Immunosorbent Assay (ELISA)" Microbiological Associates Quarterly

Publication, Walkersville, Md.; Diagnostic Horizons 2:1-7 (1978); Voller *et al.*, *J. Clin. Pathol. 31*:507-520 (1978); Butler, *Meth. Enzymol. 73*:482-523 (1981); Maggio, ed. (1980) Enzyme Immunoassay, CRC Press, Boca Raton, Fla.; Ishikawa et al., eds. (1981) Enzyme Immunoassay (Kgaku Shoin, Tokyo). The enzyme, which is bound to the anti-CD100 antibody will react with an appropriate substrate, preferably a chromogenic substrate, in such a manner as to produce a chemical moiety which can be detected, for example, by spectrophotometric, fluorimetric or by visual means. Enzymes which can be used to detectably label the antibody include, but are not limited to, malate dehydrogenase, staphylococcal nuclease, delta-5-steroid isomerase, yeast alcohol dehydrogenase, alpha-glycerophosphate, dehydrogenase, triose phosphate isomerase, horseradish peroxidase, alkaline phosphatase, asparaginase, glucose oxidase, beta-galactosidase, ribonuclease, urease, catalase, glucose-6-phosphate dehydrogenase, glucoamylase and acetylcholinesterase. Additionally, the detection can be accomplished by colorimetric methods which employ a chromogenic substrate for the enzyme. Detection may also be accomplished by visual comparison of the extent of enzymatic reaction of a substrate in comparison with similarly prepared standards.

[0182] Detection may also be accomplished using any of a variety of other immunoassays. For example, by radioactively labeling the anti-CD100 binding molecule, *e.g.*, antibody, or antigen-binding fragment, variant, or derivative thereof, it is possible to detect the binding molecule through the use of a radioimmunoassay (RIA) (see, for example, Weintraub (March, 1986) Principles of Radioimmunoassays, Seventh Training Course on Radioligand Assay Techniques (The Endocrine Society), which is incorporated by reference herein). The radioactive isotope can be detected by means including, but not limited to, a gamma counter, a scintillation counter, or autoradiography.

[0183] An anti-CD100 binding molecule, *e.g.*, antibody, or antigen-binding fragment, variant, or derivative thereof, can also be detectably labeled using fluorescence emitting metals such as 152Eu, or others of the lanthanide series. These metals can be attached to the binding molecule using such metal chelating groups as diethylenetriaminepentacetic acid (DTPA) or ethylenediaminetetraacetic acid (EDTA).

[0184] Techniques for conjugating various moieties to an antibody (*e.g.*, an anti-CD100 antibody), or antigen-binding fragment, variant, or derivative thereof, are well known, see, *e.g.*, Amon et al. (1985) "Monoclonal Antibodies for Immunotargeting of Drugs in

Cancer Therapy," in Monoclonal Antibodies and Cancer Therapy, ed. Reisfeld et al. (Alan R. Liss, Inc.), pp. 243-56; Hellstrom et al. (1987) "Antibodies for Drug Delivery," in Controlled Drug Delivery, ed. Robinson et al. (2nd ed.; Marcel Dekker, Inc.), pp. 623-53); Thorpe (1985) "Antibody Carriers of Cytotoxic Agents in Cancer Therapy: A Review," in Monoclonal Antibodies '84: Biological and Clinical Applications, ed. Pinchera et al., pp. 475-506; "Analysis, Results, and Future Prospective of the Therapeutic Use of Radiolabeled Antibody in Cancer Therapy," in Monoclonal Antibodies for Cancer Detection and Therapy, ed. Baldwin et al., Academic Press, pp. 303-16 (1985); and Thorpe et al. (1982) "The Preparation and Cytotoxic Properties of Antibody-Toxin Conjugates," Immunol. Rev. 62:119-58.

VI. Expression of Antibody Polypeptides

[0185] DNA sequences that encode the light and the heavy chains of the antibody may be made, either simultaneously or separately, using reverse transcriptase and DNA polymerase in accordance with well known methods. PCR may be initiated by consensus constant region primers or by more specific primers based on the published heavy and light chain DNA and amino acid sequences. As discussed above, PCR also may be used to isolate DNA clones encoding the antibody light and heavy chains. In this case the libraries may be screened by consensus primers or larger homologous probes, such as mouse constant region probes.

[0186] DNA, typically plasmid DNA, may be isolated from the cells using techniques known in the art, restriction mapped and sequenced in accordance with standard, well known techniques set forth in detail, *e.g.*, in the foregoing references relating to recombinant DNA techniques. Of course, the DNA may be synthetic according to the present invention at any point during the isolation process or subsequent analysis.

[0187] Following manipulation of the isolated genetic material to provide anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof, of the invention, the polynucleotides encoding the anti-CD100 antibodies are typically inserted in an expression vector for introduction into host cells that may be used to produce the desired quantity of anti-CD100 antibody.

[0188] Recombinant expression of an antibody, or fragment, derivative or analog thereof, *e.g.*, a heavy or light chain of an antibody that binds to a target molecule described herein,

e.g., CD100, requires construction of an expression vector containing a polynucleotide that encodes the antibody. Once a polynucleotide encoding an antibody molecule or a heavy or light chain of an antibody, or portion thereof (preferably containing the heavy or light chain variable domain), of the invention has been obtained, the vector for the production of the antibody molecule may be produced by recombinant DNA technology using techniques well known in the art. Thus, methods for preparing a protein by expressing a polynucleotide containing an antibody encoding nucleotide sequence are described herein. Methods that are well known to those skilled in the art can be used to construct expression vectors containing antibody coding sequences and appropriate transcriptional and translational control signals. These methods include, for example, in vitro recombinant DNA techniques, synthetic techniques, and in vivo genetic recombination. The invention, thus, provides replicable vectors comprising a nucleotide sequence encoding an antibody molecule of the invention, or a heavy or light chain thereof, or a heavy or light chain variable domain, operably linked to a promoter. Such vectors may include the nucleotide sequence encoding the constant region of the antibody molecule (see, *e.g.*, PCT Publication WO 86/05807; PCT Publication WO 89/01036; and U.S. Pat. No. 5,122,464) and the variable domain of the antibody may be cloned into such a vector for expression of the entire heavy or light chain.

[0189] The term "vector" or "expression vector" is used herein to mean vectors used in accordance with the present invention as a vehicle for introducing into and expressing a desired gene in a host cell. As known to those skilled in the art, such vectors may easily be selected from the group consisting of plasmids, phages, viruses and retroviruses. In general, vectors compatible with the instant invention will comprise a selection marker, appropriate restriction sites to facilitate cloning of the desired gene and the ability to enter and/or replicate in eukaryotic or prokaryotic cells.

[0190] For the purposes of this invention, numerous expression vector systems may be employed. For example, one class of vector utilizes DNA elements that are derived from animal viruses such as bovine papilloma virus, polyoma virus, adenovirus, vaccinia virus, baculovirus, retroviruses (RSV, MMTV or MOMLV) or SV40 virus. Others involve the use of polycistronic systems with internal ribosome binding sites. Additionally, cells that have integrated the DNA into their chromosomes may be selected by introducing one or more markers which allow selection of transfected host cells. The marker may provide

for prototrophy to an auxotrophic host, biocide resistance (*e.g.*, antibiotics) or resistance to heavy metals such as copper. The selectable marker gene can either be directly linked to the DNA sequences to be expressed, or introduced into the same cell by cotransformation. Additional elements may also be needed for optimal synthesis of mRNA. These elements may include signal sequences, splice signals, as well as transcriptional promoters, enhancers, and termination signals.

[0191] In particularly preferred embodiments the cloned variable region genes are inserted into an expression vector along with the heavy and light chain constant region genes (preferably human) synthesized as discussed above. Of course, any expression vector that is capable of eliciting expression in eukaryotic cells may be used in the present invention. Examples of suitable vectors include, but are not limited to plasmids pcDNA3, pHCMV/Zeo, pCR3.1, pEF 1/His, pIND/GS, pRc/HCMV2, pSV40/Zeo2, pTRACER-HCMV, pUB6/V5-His, pVAX1, and pZeoSV2 (available from Invitrogen, San Diego, Calif.), and plasmid pCI (available from Promega, Madison, Wis.). In general, screening large numbers of transformed cells for those that express suitably high levels if immunoglobulin heavy and light chains is routine experimentation that can be carried out, for example, by robotic systems.

[0192] More generally, once the vector or DNA sequence encoding a monomeric subunit of the anti-CD100 antibody has been prepared, the expression vector may be introduced into an appropriate host cell. Introduction of the plasmid into the host cell can be accomplished by various techniques well known to those of skill in the art. These include, but are not limited to, transfection (including electrophoresis and electroporation), protoplast fusion, calcium phosphate precipitation, cell fusion with enveloped DNA, microinjection, and infection with intact virus. See, Ridgway (1988) "Mammalian Expression Vectors" in Vectors, ed. Rodriguez and Denhardt (Butterworths, Boston, Mass.), Chapter 24.2, pp. 470-472. Typically, plasmid introduction into the host is via electroporation. The host cells harboring the expression construct are grown under conditions appropriate to the production of the light chains and heavy chains, and assayed for heavy and/or light chain protein synthesis. Exemplary assay techniques include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), or fluorescence-activated cell sorter analysis (FACS), immunohistochemistry and the like.

[0193] The expression vector is transferred to a host cell by conventional techniques, and the transfected cells are then cultured by conventional techniques to produce an antibody for use in the methods described herein. Thus, the invention includes host cells containing a polynucleotide encoding an antibody of the invention, or a heavy or light chain thereof, operably linked to a heterologous promoter. In preferred embodiments for the expression of double-chained antibodies, vectors encoding both the heavy and light chains may be co-expressed in the host cell for expression of the entire immunoglobulin molecule, as detailed below.

[0194] As used herein, "host cells" refers to cells that harbor vectors constructed using recombinant DNA techniques and encoding at least one heterologous gene. In descriptions of processes for isolation of antibodies from recombinant hosts, the terms "cell" and "cell culture" are used interchangeably to denote the source of antibody unless it is clearly specified otherwise. In other words, recovery of polypeptide from the "cells" may mean either from spun down whole cells, or from the cell culture containing both the medium and the suspended cells.

[0195] A variety of host-expression vector systems may be utilized to express antibody molecules for use in the methods described herein. Such host-expression systems represent vehicles by which the coding sequences of interest may be produced and subsequently purified, but also represent cells that may, when transformed or transfected with the appropriate nucleotide coding sequences, express an antibody molecule of the invention in situ. These include, but are not limited to, microorganisms such as bacteria (*e.g.*, *E. coli*, *B. subtilis*) transformed with recombinant bacteriophage DNA, plasmid DNA or cosmid DNA expression vectors containing antibody coding sequences; yeast (*e.g.*, Saccharomyces, Pichia) transformed with recombinant yeast expression vectors containing antibody coding sequences; insect cell systems infected with recombinant virus expression vectors (e.g., baculovirus) containing antibody coding sequences; plant cell systems infected with recombinant virus expression vectors (*e.g.*, cauliflower mosaic virus, CaMV; tobacco mosaic virus, TMV) or transformed with recombinant plasmid expression vectors (*e.g.*, Ti plasmid) containing antibody coding sequences; or mammalian cell systems (e.g., COS, CHO, BLK, 293, 3T3 cells) harboring recombinant expression constructs containing promoters derived from the genome of mammalian cells (*e.g.*, metallothionein promoter) or from mammalian viruses (*e.g.*, the adenovirus late

promoter; the vaccinia virus 7.5K promoter). Preferably, bacterial cells such as Escherichia coli, and more preferably, eukaryotic cells, especially for the expression of whole recombinant antibody molecule, are used for the expression of a recombinant antibody molecule. For example, mammalian cells such as Chinese hamster ovary cells (CHO), in conjunction with a vector such as the major intermediate early gene promoter element from human cytomegalovirus is an effective expression system for antibodies (Foecking *et al.*, *Gene 45*:101 (1986); Cockett *et al.*, *Bio/Technology 8*:2 (1990)).

[0196] The host cell line used for protein expression is often of mammalian origin; those skilled in the art are credited with ability to preferentially determine particular host cell lines that are best suited for the desired gene product to be expressed therein. Exemplary host cell lines include, but are not limited to, CHO (Chinese Hamster Ovary), DG44 and DUXB11 (Chinese Hamster Ovary lines, DHFR minus), HELA (human cervical carcinoma), CVI (monkey kidney line), COS (a derivative of CVI with SV40 T antigen), VERY, BHK (baby hamster kidney), MDCK, 293, WI38, R1610 (Chinese hamster fibroblast) BALBC/3T3 (mouse fibroblast), HAK (hamster kidney line), SP2/O (mouse myeloma), P3.times.63-Ag3.653 (mouse myeloma), BFA-1c1BPT (bovine endothelial cells), RAJI (human lymphocyte) and 293 (human kidney). Host cell lines are typically available from commercial services, the American Tissue Culture Collection or from published literature.

[0197] In addition, a host cell strain may be chosen that modulates the expression of the inserted sequences, or modifies and processes the gene product in the specific fashion desired. Such modifications (*e.g.*, glycosylation) and processing (*e.g.*, cleavage) of protein products may be important for the function of the protein. Different host cells have characteristic and specific mechanisms for the post-translational processing and modification of proteins and gene products. Appropriate cell lines or host systems can be chosen to ensure the correct modification and processing of the foreign protein expressed. To this end, eukaryotic host cells that possess the cellular machinery for proper processing of the primary transcript, glycosylation, and phosphorylation of the gene product may be used.

[0198] For long-term, high-yield production of recombinant proteins, stable expression is preferred. For example, cell lines that stably express the antibody molecule may be engineered. Rather than using expression vectors that contain viral origins of replication,

host cells can be transformed with DNA controlled by appropriate expression control elements (*e.g.*, promoter, enhancer, sequences, transcription terminators, polyadenylation sites, etc.), and a selectable marker. Following the introduction of the foreign DNA, engineered cells may be allowed to grow for 1-2 days in an enriched media, and then are switched to a selective media. The selectable marker in the recombinant plasmid confers resistance to the selection and allows cells to stably integrate the plasmid into their chromosomes and grow to form foci which in turn can be cloned and expanded into cell lines. This method may advantageously be used to engineer cell lines which stably express the antibody molecule.

[0199] A number of selection systems may be used, including, but not limited to, the herpes simplex virus thymidine kinase (Wigler *et al.*, *Cell 11*:223 (1977)), hypoxanthine-guanine phosphoribosyltransferase (Szybalska and Szybalski, *Proc. Natl. Acad. Sci. USA 48*:202 (1992)), and adenine phosphoribosyltransferase (Lowy *et al.*, *Cell 22*:817 (1980)) genes can be employed in tk-, hgprt- or aprt-cells, respectively. Also, antimetabolite resistance can be used as the basis of selection for the following genes: dhfr, which confers resistance to methotrexate (Wigler *et al.*, *Natl. Acad. Sci. USA 77*:357 (1980); O'Hare *et al.*, *Proc. Natl. Acad. Sci. USA 78*:1527 (1981)); gpt, which confers resistance to mycophenolic acid (Mulligan and Berg, *Proc. Natl. Acad. Sci. USA 78*:2072 (1981)); neo, which confers resistance to the aminoglycoside G-418 Clinical Pharmacy 12:488-505; Wu and Wu, *Biotherapy 3*:87-95 (1991); Tolstoshev, *Ann. Rev. Pharmacol. Toxicol. 32*:573-596 (1993); Mulligan, *Science 260*:926-932 (1993); and Morgan and Anderson, *Ann. Rev. Biochem. 62*:191-217 (1993); TIB TECH 11(5):155-215 (May, 1993); and hygro, which confers resistance to hygromycin (Santerre *et al.*, *Gene 30*:147 (1984). Methods commonly known in the art of recombinant DNA technology which can be used are described in Ausubel et al. (1993) Current Protocols in Molecular Biology (John Wiley & Sons, NY); Kriegler (1990) "Gene Transfer and Expression" in A Laboratory Manual (Stockton Press, NY); Dracopoli et al. (eds) (1994) Current Protocols in Human Genetics (John Wiley & Sons, NY) Chapters 12 and 13; Colberre-Garapin et al. (1981) J. Mol. Biol. 150:1, which are incorporated by reference herein in their entireties.

[0200] The expression levels of an antibody molecule can be increased by vector amplification (for a review, see Bebbington and Hentschel (1987) "The Use of Vectors Based on Gene Amplification for the Expression of Cloned Genes in Mammalian Cells in

DNA Cloning" (Academic Press, NY) Vol. 3. When a marker in the vector system expressing antibody is amplifiable, increase in the level of inhibitor present in culture of host cell will increase the number of copies of the marker gene. Since the amplified region is associated with the antibody gene, production of the antibody will also increase (Crouse *et al.*, *Mol. Cell. Biol. 3*:257 (1983)).

[0201] *In vitro* production allows scale-up to give large amounts of the desired polypeptides. Techniques for mammalian cell cultivation under tissue culture conditions are known in the art and include homogeneous suspension culture, *e.g.* in an airlift reactor or in a continuous stirrer reactor, or immobilized or entrapped cell culture, e.g. in hollow fibers, microcapsules, on agarose microbeads or ceramic cartridges. If necessary and/or desired, the solutions of polypeptides can be purified by the customary chromatography methods, for example gel filtration, ion-exchange chromatography, chromatography over DEAE-cellulose or (immuno-)affinity chromatography, *e.g.*, after preferential biosynthesis of a synthetic hinge region polypeptide or prior to or subsequent to the HIC chromatography step described herein.

[0202] Genes encoding anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof of the invention can also be expressed in non-mammalian cells such as insect, bacteria or yeast or plant cells. Bacteria that readily take up nucleic acids include members of the enterobacteriaceae, such as strains of *Escherichia coli* or *Salmonella*; *Bacillaceae*, such as *Bacillus subtilis*; *Pneumococcus*; *Streptococcus*, and *Haemophilus influenzae*. It will further be appreciated that, when expressed in bacteria, the heterologous polypeptides typically become part of inclusion bodies. The heterologous polypeptides must be isolated, purified and then assembled into functional molecules. Where tetravalent forms of antibodies are desired, the subunits will then self-assemble into tetravalent antibodies (WO 02/096948A2).

[0203] In bacterial systems, a number of expression vectors may be advantageously selected depending upon the use intended for the antibody molecule being expressed. For example, when a large quantity of such a protein is to be produced, for the generation of pharmaceutical compositions of an antibody molecule, vectors which direct the expression of high levels of fusion protein products that are readily purified may be desirable. Such vectors include, but are not limited, to the *E. coli* expression vector pUR278 (Ruther *et al.*, *EMBO J. 2*:1791 (1983)), in which the antibody coding sequence

may be ligated individually into the vector in frame with the lacZ coding region so that a fusion protein is produced; pIN vectors (Inouye and Inouye, *Nucleic Acids Res. 13*:3101-3109 (1985); Van Heeke and Schuster, *J. Biol. Chem. 24*:5503-5509 (1989)); and the like. pGEX vectors may also be used to express foreign polypeptides as fusion proteins with glutathione S-transferase (GST). In general, such fusion proteins are soluble and can easily be purified from lysed cells by adsorption and binding to a matrix glutathione-agarose beads followed by elution in the presence of free glutathione. The pGEX vectors are designed to include thrombin or factor Xa protease cleavage sites so that the cloned target gene product can be released from the GST moiety.

[0204] In addition to prokaryotes, eukaryotic microbes may also be used. *Saccharomyces cerevisiae*, or common baker's yeast, is the most commonly used among eukaryotic microorganisms although a number of other strains are commonly available, *e.g.*, *Pichia pastoris*.

[0205] For expression in *Saccharomyces*, the plasmid YRp7, for example, (Stinchcomb et al., *Nature 282*:39 (1979); Kingsman *et al.*, *Gene 7*:141 (1979); Tschemper *et al.*, *Gene 10*:157 (1980)) is commonly used. This plasmid already contains the TRP1 gene, which provides a selection marker for a mutant strain of yeast lacking the ability to grow in tryptophan, for example ATCC No. 44076 or PEP4-1 (Jones, *Genetics 85*:12 (1977)). The presence of the trp1 lesion as a characteristic of the yeast host cell genome then provides an effective environment for detecting transformation by growth in the absence of tryptophan.

[0206] In an insect system, *Autographa californica* nuclear polyhedrosis virus (AcNPV) is typically used as a vector to express foreign genes. The virus grows in *Spodoptera frugiperda* cells. The antibody coding sequence may be cloned individually into non-essential regions (for example the polyhedrin gene) of the virus and placed under control of an AcNPV promoter (for example the polyhedrin promoter).

[0207] Once an antibody molecule of the invention has been recombinantly expressed, it may be purified by any method known in the art for purification of an immunoglobulin molecule, for example, by chromatography (*e.g.*, ion exchange, affinity, particularly by affinity for the specific antigen after Protein A, and sizing column chromatography), centrifugation, differential solubility, or by any other standard technique for the purification of proteins. Alternatively, a preferred method for increasing the affinity of

antibodies of the invention is disclosed in U.S. Patent Application Publication No. 2002 0123057 A1.

VII. Treatment Methods Using Therapeutic Anti-CD100 Antibodies

[0208] Methods of the invention are directed to the use of anti-CD100 binding molecules, *e.g.*, antibodies, including antigen-binding fragments, variants, and derivatives thereof, to treat patients having a disease associated with soluble CD100 secreted from or expressed on CD100-expressing cells. By "CD100-expressing cell" is intended normal and malignant cells expressing CD100 antigen. Methods for detecting CD100 expression in cells are well known in the art and include, but are not limited to, PCR techniques, immunohistochemistry, flow cytometry, Western blot, ELISA, and the like.

[0209] Though the following discussion refers to diagnostic methods and treatment of various diseases and disorders with an anti-CD100 antibody of the invention, the methods described herein are also applicable to the antigen-binding fragments, variants, and derivatives of these anti-CD100 antibodies that retain the desired properties of the anti-CD100 antibodies of the invention, *e.g.*, capable of specifically binding CD100, *e.g.*, human, mouse, or human and mouse CD100, and having CD100 neutralizing activity.

[0210] In one embodiment, treatment includes the application or administration of an anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, of the current invention to a patient, or application or administration of the anti-CD100 binding molecule to an isolated tissue or cell line from a patient, where the patient has a disease, a symptom of a disease, or a predisposition toward a disease. In another embodiment, treatment is also intended to include the application or administration of a pharmaceutical composition comprising the anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, of the current invention to a patient, or application or administration of a pharmaceutical composition comprising the anti-CD100 binding molecule to an isolated tissue or cell line from a patient, who has a disease, a symptom of a disease, or a predisposition toward a disease.

[0211] The anti-CD100 binding molecules, *e.g.*, antibodies or binding fragments thereof, of the present invention are useful for the treatment of various malignant and non-malignant tumors. By "anti-tumor activity" is intended a reduction in the rate of malignant CD100-expressing cell proliferation or accumulation, and hence a decline in

growth rate of an existing tumor or in a tumor that arises during therapy, and/or destruction of existing neoplastic (tumor) cells or newly formed neoplastic cells, and hence a decrease in the overall size of a tumor during therapy. For example, therapy with at least one anti-CD100 antibody causes a physiological response, for example, a reduction in angiogenesis, that is beneficial with respect to treatment of disease states associated with CD100-expressing cells in a human.

[0212] In one embodiment, the invention relates to anti-CD100 binding molecules, *e.g.*, antibodies or binding fragments thereof, according to the present invention for use as a medicament, in particular for use in the treatment or prophylaxis of cancer or for use in a precancerous condition or lesion. In certain embodiments, an anti-CD100 binding molecule, *e.g.*, an antibody or binding fragment thereof, of the invention is used for the treatment of a CD100 over-expressing cancer. In certain embodiments, an anti-CD100 binding molecule, *e.g.*, an antibody or binding fragment thereof, of the invention is used for the treatment of a CD100 over-expressing head and neck or colon cancer.

[0213] Further, anti-CD100 binding molecules, *e.g.*, antibodies or binding fragments thereof, of the present invention can also be used to inhibit angiogenesis for the treatment of pathological conditions dependent upon the formation of new blood vessels, including tumor development and macular degeneration. Angiogenesis is a complex multistep morphogenetic event during which endothelial cells, stimulated by major determinants of vascular remodeling, dynamically modify their cell-to-cell and cell-to-matrix contacts and move directionally to be reorganized into a mature vascular tree (Bussolino *et al.*, *Trends Biochem Sci. 22*:251-256 (1997); Risau, *Nature 386*:671-674 (1997); Jain, *Nat. Med. 9*:685-693 (2003)). The formation of new blood vessels is a key step during embryo development, but it also occurs in adults in physiologic and in pathologic conditions, such as retinopathy, rheumatoid arthritis, ischemia, and particularly tumor growth and metastasis (Carmeliet, *Nat. Med. 9*:653-660 (2003)). This pathological formation of new blood vessels is herein referred to as "invasive angiogenesis." Basile *et al.*, *PNAS 103*(24):9017-9022 (2006)) demonstrated that, when shed from HNSCC cells, CD100 stimulates endothelial cell migration, which was prevented by CD100-blocking antibodies and by CD100 knockdown. CD100 overexpression was also noted in prostate, colon, breast, and lung cancers, suggesting that expression of CD100 is a frequently used strategy by which a wide variety of carcinomas may promote angiogenesis.

[0214] In accordance with the methods of the present invention, at least one anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, as defined elsewhere herein is used to promote a positive therapeutic response with respect to a malignant human cell. By "positive therapeutic response" with respect to cancer treatment is intended an improvement in the disease in association with the anti-tumor activity of these binding molecules, *e.g.*, antibodies or fragments thereof, and/or an improvement in the symptoms associated with the disease. That is, an anti-proliferative effect, the prevention of further tumor outgrowths, a reduction in tumor size, a decrease in tumor vasculature, a reduction in the number of cancer cells, and/or a decrease in one or more symptoms associated with the disease can be observed. Thus, for example, an improvement in the disease may be characterized as a complete response. By "complete response" is intended an absence of clinically detectable disease with normalization of any previously abnormal radiographic studies, bone marrow, and cerebrospinal fluid (CSF). Such a response must persist for at least one month following treatment according to the methods of the invention. Alternatively, an improvement in the disease may be categorized as being a partial response. By "partial response" is intended at least about a 50% decrease in all measurable tumor burden (*i.e.*, the number of tumor cells present in the subject) in the absence of new lesions and persisting for at least one month. Such a response is applicable to measurable tumors only.

[0215] Tumor response can be assessed for changes in tumor morphology (*i.e.*, overall tumor burden, tumor cell count, and the like) using screening techniques such as bioluminescent imaging, for example, luciferase imaging, bone scan imaging, and tumor biopsy sampling including bone marrow aspiration (BMA). In addition to these positive therapeutic responses, the subject undergoing therapy with the anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment thereof, may experience the beneficial effect of an improvement in the symptoms associated with the disease. For example, the subject may experience a decrease in the so-called B symptoms, *e.g.*, night sweats, fever, weight loss, and/or urticaria.

[0216] The anti-CD100 binding molecules, *e.g.*, antibodies or antigen binding fragments thereof, described herein may also find use in the treatment of inflammatory diseases and deficiencies or disorders of the immune system that are associated with CD100 expressing cells. Inflammatory diseases are characterized by inflammation and tissue

destruction, or a combination thereof. By "anti-inflammatory activity" is intended a reduction or prevention of inflammation. "Inflammatory disease" includes any inflammatory immune-mediated process where the initiating event or target of the immune response involves non-self antigen(s), including, for example, alloantigens, xenoantigens, viral antigens, bacterial antigens, unknown antigens, or allergens. In one embodiment, the inflammatory disease is an inflammatory disorder of the peripheral or central nervous system. In another embodiment, the inflammatory disease is an inflammatory disorder of the joints.

[0217] Further, for purposes of the present invention, the term "inflammatory disease(s)" includes "autoimmune disease(s)." As used herein, the term "autoimmunity" is generally understood to encompass inflammatory immune-mediated processes involving "self" antigens. In autoimmune diseases, self antigen(s) trigger host immune responses. An autoimmune disease can result from an inappropriate immune response directed against a self antigen (an autoantigen), which is a deviation from the normal state of self-tolerance. In general, antibodies (particularly, but not exclusively, IgG antibodies), acting as cytotoxic molecules or as immune complexes, are the principal mediators of various autoimmune diseases, many of which can be debilitating or life-threatening.

[0218] In one embodiment, the anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment, of the invention is use to treat multiple sclerosis (MS). MS, also known as disseminated sclerosis or encephalomyelitis disseminata, is an autoimmune condition in which the immune system attacks the central nervous system, leading to demyelination. The name multiple sclerosis refers to the scars (scleroses, also referred to as plaques or lesions) that form in the nervous system. MS lesions commonly involve white matter areas close to the ventricles of the cerebellum, brain stem, basal ganglia and spinal cord, and the optic nerve. MS results in destruction of oligodendrocytes, the cells responsible for creating and maintaining the myelin sheath. MS results in a thinning or complete loss of myelin and, as the disease advances, transection of axons.

[0219] Neurological symptom can vary with MS, and the disease often progresses to physical and cognitive disability. MS takes several forms, with new symptoms occurring either in discrete attacks (relapsing forms) or slowly accumulating over time (progressive forms). Between attacks, symptoms may go away completely, but permanent neurological damage often results, especially as the disease advances.

[0220] Neutralization of CD100 using an anti-CD100 monoclonal antibody of the invention, *e.g.*, MAb 2503, MAb 67 or MAb 76, may be used to reduce the severity of MS through several different mechanisms, *e.g.*, anti-CD100 monoclonal antibodies may block immune maturation and activation by CD100 to reduce the rate of relapse by reducing secondary immune responses to CNS antigens, and anti-CD100 monoclonal antibodies may block the effect of soluble CD100 in mediating apoptosis of oligodendrocytes in the CNS may reduce disease severity by reducing demyelination.

[0221] In one embodiment, the anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment, of the invention is used to treat arthritis. Arthritis, is an inflammatory disease of the joints, which can be caused by an autoimmune condition in which the immune system attacks the joints. In certain embodiments, the arthritis is selected from the group consisting of osteoarthritis, gouty arthritis, ankylosing spondylitis, psoriatic arthritis, reactive arthritis, rheumatoid arthritis, juvenile onset rheumatoid arthritis, infectious arthritis, inflammatory arthritis, septic arthritis, degenerative arthritis, arthritis mutilans, and lyme arthritis. In one embodiment, the arthritis is rheumatoid arthritis (RA).

[0222] The present invention includes methods of treating or preventing arthritis by administering to a subject an anti-CD100 binding molecule of the invention, *e.g.*, MAb 2503, MAb 67 or MAb 76. Methods of the present invention may reduce the pain, swelling, or stiffness associated with arthritis, *e.g.*, rheumatoid arthritis. The present invention is also directed to methods for improving joint performance, function, and health. In some embodiments of the present invention, treatment results in a decrease in arthritis severity scores, a decrease in arthritis severity/area under curve, a decrease in histopathology parameters associated with arthritis (inflammation, pannus, cartilage damage, and bone damage), a decrease in serum arachidonic acid levels, or a decrease in anti-collagen antibodies. In certain embodiments, beneficial or desired clinical results include, but are not limited to, alleviation of symptoms associated with arthritis; prevention of arthritis; delay in the onset of arthritis; reduced incidence of arthritis in a population; diminishment of the extent of the condition associated with arthritis; stabilization (i.e., not worsening) of the state of the condition, disorder or disease associated with arthritis; delay in onset or slowing of the condition, disorder or disease progression associated with arthritis; amelioration of the condition, disorder or disease

state, remission (whether partial or total) of the condition, disorder or disease associated with arthritis, whether detectable or undetectable; or enhancement or improvement of the condition, disorder or disease associated with arthritis.

[0223] The method of the present invention can be administered to individuals who have arthritis or individuals who are at risk for developing arthritis. Thus, in some embodiments the invention is directed to a method of treating a subject having normal joints, borderline arthritic joints, or very arthritic joints, the method comprising administering an anti-CD100 binding molecule of the invention, *e.g.*, MAb 2503, MAb 67 or MAb 76, to a subject as described herein. In some embodiments, the method of the present invention can be used to treat chronic arthritis for the remainder of the life of the subject.

[0224] In accordance with the methods of the present invention, at least one anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, as defined elsewhere herein is used to promote a positive therapeutic response with respect to treatment or prevention of an autoimmune disease and/or inflammatory disease. By "positive therapeutic response" with respect to an autoimmune disease and/or inflammatory disease is intended an improvement in the disease in association with the anti-inflammatory activity, anti-angiogenic activity, anti-apoptotic activity, or the like, of these antibodies, and/or an improvement in the symptoms associated with the disease. That is, an anti-proliferative effect, the prevention of further proliferation of the CD100-expressing cell, a reduction in the inflammatory response including but not limited to reduced secretion of inflammatory cytokines, adhesion molecules, proteases, immunoglobulins (in instances where the CD100 bearing cell is a B cell), combinations thereof, and the like, increased production of anti-inflammatory proteins, a reduction in the number of autoreactive cells, an increase in immune tolerance, inhibition of autoreactive cell survival, reduction in apoptosis, reduction in endothelial cell migration, increase in spontaneous monocyte migration, reduction in and/or a decrease in one or more symptoms mediated by stimulation of sCD100 or CD100-expressing cells can be observed. Such positive therapeutic responses are not limited to the route of administration and may comprise administration to the donor, the donor tissue (such as for example organ perfusion), the host, any combination thereof, and the like.

[0225] Clinical response can be assessed using screening techniques such as magnetic resonance imaging (MRI) scan, x-radiographic imaging, computed tomographic (CT) scan, flow cytometry or fluorescence-activated cell sorter (FACS) analysis, histology, gross pathology, and blood chemistry, including but not limited to changes detectable by ELISA, RIA, chromatography, and the like. In addition to these positive therapeutic responses, the subject undergoing therapy with the anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment thereof, may experience the beneficial effect of an improvement in the symptoms associated with the disease.

[0226] The anti-CD100 binding molecules, *e.g.*, antibodies or antigen binding fragments thereof, can be used in combination with at least one other cancer therapy, including, but not limited to, surgery or surgical procedures (*e.g.* splenectomy, hepatectomy, lymphadenectomy, leukophoresis, bone marrow transplantation, and the like); radiation therapy; chemotherapy, optionally in combination with autologous bone marrow transplant, or other cancer therapy; where the additional cancer therapy is administered prior to, during, or subsequent to the anti-CD100 binding molecule, *e.g.*, antibody or antigen binding fragment thereof, therapy. Thus, where the combined therapies comprise administration of an anti-CD100 binding molecule, *e.g.*, an antibody or antigen binding fragment thereof, of the invention in combination with administration of another therapeutic agent, as with chemotherapy, radiation therapy, other anti-cancer antibody therapy, small molecule-based cancer therapy, or vaccine/immunotherapy-based cancer therapy, the methods of the invention encompass coadministration, using separate formulations or a single pharmaceutical formulation, or and consecutive administration in either order.

[0227] The anti-CD100 binding molecules, *e.g.*, antibodies or binding fragments thereof, of the invention can be used in combination with any known therapies for autoimmune and inflammatory diseases, including any agent or combination of agents that are known to be useful, or which have been used or are currently in use, for treatment of autoimmune and inflammatory diseases. Thus, where the combined therapies comprise administration of an anti-CD100 binding molecules in combination with administration of another therapeutic agent, the methods of the invention encompass coadministration, using separate formulations or a single pharmaceutical formulation, and consecutive administration in either order. In some embodiments of the invention, the anti-CD100

antibodies described herein are administered in combination with immunosuppressive drugs or anti-inflammatory drugs, wherein the antibody and the therapeutic agent(s) may be administered sequentially, in either order, or simultaneously (*i.e.*, concurrently or within the same time frame).

[0228] In some other embodiments, the anti-CD100 binding molecules, *e.g.*, antibodies or antigen binding fragments thereof, of the invention may be used alone or in combination with immunosuppressive drugs to treat and/or prevent rheumatoid arthritis. Thus, in some embodiments where the anti-CD100 antibodies of the invention are used to treat rheumatoid arthritis, the antibodies may used in combination with suitable immunosuppressive drugs. As discussed above, treatment effectiveness may be assessed using any means and includes, but is not limited to, effectiveness as measured by clinical responses defined by the American College of Rheumatology criteria, the European League of Rheumatism criteria, or any other criteria. See for example, Felson *et al.*, *Arthritis. Rheum. 38*:727-35 (1995) and van Gestel *et al.*, *Arthritis Rheum. 39*:34-40 (1996).

[0229] In yet other embodiments, the anti-CD100 antibodies of the invention may be used alone or in combination with immunosuppressive drugs to treat and/or prevent multiple sclerosis. Thus in some embodiments where the anti-CD100 antibodies of the invention are used to treat multiple sclerosis, the antibodies may used in combination with suitable immunosuppressive drugs.

[0230] A further embodiment of the invention is the use of anti-CD100 binding molecule, *e.g.*, antibodies or antigen binding fragments thereof, for diagnostic monitoring of protein levels in tissue as part of a clinical testing procedure, *e.g.*, to determine the efficacy of a given treatment regimen. For example, detection can be facilitated by coupling the antibody to a detectable substance. Examples of detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, and radioactive materials. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β-galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; an example of a luminescent material includes luminol; examples of

bioluminescent materials include luciferase, luciferin, and aequorin; and examples of suitable radioactive material include ^{125}I, ^{131}I, ^{35}S, or ^{3}H.

VIII. Pharmaceutical Compositions and Administration Methods

[0231] Methods of preparing and administering the anti-CD100 binding molecule, *e.g.*, antibodies, or antigen-binding fragments, variants, or derivatives thereof, of the invention to a subject in need thereof are well known to or are readily determined by those skilled in the art. The route of administration of the anti-CD100 binding molecule, *e.g*, antibody, or antigen-binding fragment, variant, or derivative thereof, may be, for example, oral, parenteral, by inhalation or topical. The term parenteral as used herein includes, *e.g.*, intravenous, intraarterial, intraperitoneal, intramuscular, subcutaneous, rectal, or vaginal administration. While all these forms of administration are clearly contemplated as being within the scope of the invention, an example of a form for administration would be a solution for injection, in particular for intravenous or intraarterial injection or drip. Usually, a suitable pharmaceutical composition for injection may comprise a buffer (*e.g.* acetate, phosphate or citrate buffer), a surfactant (*e.g.* polysorbate), optionally a stabilizer agent (*e.g.* human albumin), etc. However, in other methods compatible with the teachings herein, anti-CD100 binding molecules, *e.g.*, antibodies, or antigen-binding fragments, variants, or derivatives thereof, of the invention can be delivered directly to the site of the adverse cellular population thereby increasing the exposure of the diseased tissue to the therapeutic agent.

[0232] As discussed herein, anti-CD100 binding molecules, *e.g.*, antibodies, or antigen-binding fragments, variants, or derivatives thereof, of the invention may be administered in a pharmaceutically effective amount for the *in vivo* treatment of CD100-expressing cell-mediated diseases such as certain types of cancers, autoimmune diseases, inflammatory diseases including central nervous system (CNS) and peripheral nervous system (PNS) inflammatory diseases, and invasive angiogenesis. In this regard, it will be appreciated that the disclosed binding molecules of the invention will be formulated so as to facilitate administration and promote stability of the active agent. Preferably, pharmaceutical compositions in accordance with the present invention comprise a pharmaceutically acceptable, non-toxic, sterile carrier such as physiological saline, non-toxic buffers, preservatives and the like. For the purposes of the instant application, a

pharmaceutically effective amount of an anti-CD100 binding molecule, *e.g.*, an antibody, or antigen-binding fragment, variant, or derivative thereof, conjugated or unconjugated, shall be held to mean an amount sufficient to achieve effective binding to a target and to achieve a benefit, *e.g.*, to ameliorate symptoms of a disease or disorder or to detect a substance or a cell.

[0233] The pharmaceutical compositions used in this invention comprise pharmaceutically acceptable carriers, including, *e.g.*, ion exchangers, alumina, aluminum stearate, lecithin, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycine, sorbic acid, potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulfate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate, polyvinyl pyrrolidone, cellulose-based substances, polyethylene glycol, sodium carboxymethylcellulose, polyacrylates, waxes, polyethylene-polyoxypropylene-block polymers, polyethylene glycol, and wool fat.

[0234] Preparations for parenteral administration includes sterile aqueous or non-aqueous solutions, suspensions, and emulsions. Examples of non-aqueous solvents are propylene glycol, polyethylene glycol, vegetable oils such as olive oil, and injectable organic esters such as ethyl oleate. Aqueous carriers include, *e.g.*, water, alcoholic/aqueous solutions, emulsions or suspensions, including saline and buffered media. In the subject invention, pharmaceutically acceptable carriers include, but are not limited to, 0.01-0.1 M and preferably 0.05 M phosphate buffer or 0.8% saline. Other common parenteral vehicles include sodium phosphate solutions, Ringer's dextrose, dextrose and sodium chloride, lactated Ringer's, or fixed oils. Intravenous vehicles include fluid and nutrient replenishers, electrolyte replenishers, such as those based on Ringer's dextrose, and the like. Preservatives and other additives may also be present such as, for example, antimicrobials, antioxidants, chelating agents, and inert gases and the like.

[0235] More particularly, pharmaceutical compositions suitable for injectable use include sterile aqueous solutions (where water soluble) or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersions. In such cases, the composition must be sterile and should be fluid to the extent that easy syringability exists. It should be stable under the conditions of manufacture and storage and will preferably be preserved against the contaminating action of microorganisms, such as

bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (*e.g.*, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Suitable formulations for use in the therapeutic methods disclosed herein are described in Remington's Pharmaceutical Sciences (Mack Publishing Co.) 16th ed. (1980).

[0236] Prevention of the action of microorganisms can be achieved by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, ascorbic acid, thimerosal and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols, such as mannitol, sorbitol, or sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

[0237] In any case, sterile injectable solutions can be prepared by incorporating an active compound (*e.g.*, an anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof, by itself or in combination with other active agents) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated herein, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle, which contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and freeze-drying, which yields a powder of an active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof. The preparations for injections are processed, filled into containers such as ampoules, bags, bottles, syringes or vials, and sealed under aseptic conditions according to methods known in the art. Further, the preparations may be packaged and sold in the form of a kit such as those described in U.S. patent application Ser. No. 09/259,337. Such articles of manufacture will preferably have labels or package inserts indicating that the associated compositions are useful for treating a subject suffering from, or predisposed to a disease or disorder.

[0238] Parenteral formulations may be a single bolus dose, an infusion or a loading bolus dose followed with a maintenance dose. These compositions may be administered at specific fixed or variable intervals, *e.g.*, once a day, or on an "as needed" basis.

[0239] Certain pharmaceutical compositions used in this invention may be orally administered in an acceptable dosage form including, *e.g.*, capsules, tablets, aqueous suspensions or solutions. Certain pharmaceutical compositions also may be administered by nasal aerosol or inhalation. Such compositions may be prepared as solutions in saline, employing benzyl alcohol or other suitable preservatives, absorption promoters to enhance bioavailability, and/or other conventional solubilizing or dispersing agents.

[0240] The amount of an anti-CD100 binding molecule, *e.g.*, antibody, or fragment, variant, or derivative thereof, that may be combined with the carrier materials to produce a single dosage form will vary depending upon the host treated and the particular mode of administration. The composition may be administered as a single dose, multiple doses or over an established period of time in an infusion. Dosage regimens also may be adjusted to provide the optimum desired response (*e.g.*, a therapeutic or prophylactic response).

[0241] In keeping with the scope of the present disclosure, anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof of the invention may be administered to a human or other animal in accordance with the aforementioned methods of treatment in an amount sufficient to produce a therapeutic effect. The anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof of the invention can be administered to such human or other animal in a conventional dosage form prepared by combining the antibody of the invention with a conventional pharmaceutically acceptable carrier or diluent according to known techniques. It will be recognized by one of skill in the art that the form and character of the pharmaceutically acceptable carrier or diluent is dictated by the amount of active ingredient with which it is to be combined, the route of administration and other well-known variables. Those skilled in the art will further appreciate that a cocktail comprising one or more species of anti-CD100 binding molecules, *e.g.*, antibodies, or antigen-binding fragments, variants, or derivatives thereof, of the invention may prove to be particularly effective.

[0242] By "therapeutically effective dose or amount" or "effective amount" is intended an amount of anti-CD100 binding molecule, *e.g.*, antibody or antigen binding fragment

thereof, that when administered brings about a positive therapeutic response with respect to treatment of a patient with a disease to be treated.

[0243] Therapeutically effective doses of the compositions of the present invention, for treatment of CD100-expressing cell-mediated diseases such as certain types of cancers, *e.g.*, head and neck, prostate, colon, breast, and lung cancers; autoimmune diseases, *e.g.*, arthritis, multiple sclerosis, inflammatory diseases including central nervous system (CNS) and peripheral nervous system (PNS) inflammatory diseases; and invasive angiogenesis, vary depending upon many different factors, including means of administration, target site, physiological state of the patient, whether the patient is human or an animal, other medications administered, and whether treatment is prophylactic or therapeutic. Usually, the patient is a human, but non-human mammals including transgenic mammals can also be treated. Treatment dosages may be titrated using routine methods known to those of skill in the art to optimize safety and efficacy.

[0244] The amount of at least one anti-CD100 binding molecule, *e.g.*, antibody or binding fragment thereof, to be administered is readily determined by one of ordinary skill in the art without undue experimentation given the disclosure of the present invention. Factors influencing the mode of administration and the respective amount of at least one anti-CD100 binding molecule, *e.g.*, antibody, antigen-binding fragment, variant or derivative thereof include, but are not limited to, the severity of the disease, the history of the disease, and the age, height, weight, health, and physical condition of the individual undergoing therapy. Similarly, the amount of anti-CD100 binding molecule, *e.g.*, antibody, or fragment, variant, or derivative thereof, to be administered will be dependent upon the mode of administration and whether the subject will undergo a single dose or multiple doses of this agent.

[0245] The present invention also provides for the use of an anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment, variant, or derivative thereof, in the manufacture of a medicament for treating an autoimmune disease and/or inflammatory disease, including, *e.g.*, arthritis, multiple sclerosis, CNS and PNS inflammatory diseases, or a cancer.

[0246] The invention also provides for the use of an anti-CD100 binding molecule, *e.g.*, antibody of the invention, or antigen-binding fragment, variant, or derivative thereof, in the manufacture of a medicament for treating a subject for treating an autoimmune

disease and/or inflammatory disease, or for treating a cancer, wherein the medicament is used in a subject that has been pretreated with at least one other therapy. By "pretreated" or "pretreatment" is intended the subject has received one or more other therapies (*e.g.*, been treated with at least one other cancer therapy) prior to receiving the medicament comprising the anti-CD100 binding molecule, *e.g.*, antibody or antigen-binding fragment, variant, or derivative thereof. "Pretreated" or "pretreatment" includes subjects that have been treated with at least one other therapy within 2 years, within 18 months, within 1 year, within 6 months, within 2 months, within 6 weeks, within 1 month, within 4 weeks, within 3 weeks, within 2 weeks, within 1 week, within 6 days, within 5 days, within 4 days, within 3 days, within 2 days, or even within 1 day prior to initiation of treatment with the medicament comprising the anti-CD100 binding molecule, for example, the monoclonal antibody 2503 disclosed herein, or antigen-binding fragment, variant, or derivative thereof. It is not necessary that the subject was a responder to pretreatment with the prior therapy or therapies. Thus, the subject that receives the medicament comprising the anti-CD100 binding molecule, *e.g.*, an antibody or antigen-binding fragment, variant, or derivative thereof could have responded, or could have failed to respond (*e.g.*, the cancer was refractory), to pretreatment with the prior therapy, or to one or more of the prior therapies where pretreatment comprised multiple therapies. Examples of other cancer therapies for which a subject can have received pretreatment prior to receiving the medicament comprising the anti-CD100 binding molecule, *e.g.*, antibody or antigen-binding fragment, variant, or derivative thereof include, but are not limited to, surgery; radiation therapy; chemotherapy, optionally in combination with autologous bone marrow transplant, where suitable chemotherapeutic agents include, but are not limited to, those listed herein above; other anti-cancer monoclonal antibody therapy; small molecule-based cancer therapy, including, but not limited to, the small molecules listed herein above; vaccine/immunotherapy-based cancer therapies; steroid therapy; other cancer therapy; or any combination thereof.

IX. Diagnostics

[0247] The invention further provides a diagnostic method useful during diagnosis of CD100-expressing cell-mediated diseases such as certain types of cancers, autoimmune diseases, inflammatory diseases including, *e.g.*, arthritis, multiple sclerosis, central

nervous system (CNS) and peripheral nervous system (PNS) inflammatory diseases, and invasive angiogenesis, which involves measuring the expression level of CD100 protein or transcript in tissue or other cells or body fluid from an individual and comparing the measured expression level with a standard CD100 expression level in normal tissue or body fluid, whereby an increase in the expression level compared to the standard is indicative of a disorder.

[0248] The anti-CD100 antibodies of the invention and antigen-binding fragments, variants, and derivatives thereof, can be used to assay CD100 protein levels in a biological sample using classical immunohistological methods known to those of skill in the art (*e.g.*, see Jalkanen, *et al.*, *J. Cell. Biol. 101*:976-985 (1985); Jalkanen *et al.*, *J. Cell Biol.* 105:3087-3096 (1987)). Other antibody-based methods useful for detecting CD100 protein expression include immunoassays, such as the enzyme linked immunosorbent assay (ELISA), immunoprecipitation, or Western blotting. Suitable assays are described in more detail elsewhere herein.

[0249] By "assaying the expression level of CD100 polypeptide" is intended qualitatively or quantitatively measuring or estimating the level of CD100 polypeptide in a first biological sample either directly (*e.g.*, by determining or estimating absolute protein level) or relatively (*e.g.*, by comparing to the disease associated polypeptide level in a second biological sample). Preferably, CD100 polypeptide expression level in the first biological sample is measured or estimated and compared to a standard CD100 polypeptide level, the standard being taken from a second biological sample obtained from an individual not having the disorder or being determined by averaging levels from a population of individuals not having the disorder. As will be appreciated in the art, once the "standard" CD100 polypeptide level is known, it can be used repeatedly as a standard for comparison.

[0250] By "biological sample" is intended any biological sample obtained from an individual, cell line, tissue culture, or other source of cells potentially expressing CD100. Methods for obtaining tissue biopsies and body fluids from mammals are well known in the art.

X. Immunoassays

[0251] Anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof of the invention may be assayed for immunospecific binding by any method known in the art. The immunoassays that can be used include but are not limited to competitive and non-competitive assay systems using techniques such as Western blots, radioimmunoassays, ELISA (enzyme linked immunosorbent assay), "sandwich" immunoassays, immunoprecipitation assays, precipitin reactions, gel diffusion precipitin reactions, immunodiffusion assays, agglutination assays, complement-fixation assays, immunoradiometric assays, fluorescent immunoassays, protein A immunoassays, to name but a few. Such assays are routine and well known in the art (see, e.g., Ausubel *et al.*, eds, (1994) Current Protocols in Molecular Biology (John Wiley & Sons, Inc., NY) Vol. 1, which is incorporated by reference herein in its entirety). Exemplary immunoassays are described briefly below (but are not intended by way of limitation).

[0252] Immunoprecipitation protocols generally comprise lysing a population of cells in a lysis buffer such as RIPA buffer (1% NP-40 or Triton X-100, 1% sodium deoxycholate, 0.1% SDS, 0.15 M NaCl, 0.01 M sodium phosphate at pH 7.2, 1% Trasylol) supplemented with protein phosphatase and/or protease inhibitors (*e.g.*, EDTA, PMSF, aprotinin, sodium vanadate), adding the antibody of interest to the cell lysate, incubating for a period of time (e.g., 1-4 hours) at 4°C, adding protein A and/or protein G sepharose beads to the cell lysate, incubating for about an hour or more at 4°C, washing the beads in lysis buffer and resuspending the beads in SDS/sample buffer. The ability of the antibody of interest to immunoprecipitate a particular antigen can be assessed by, *e.g.*, western blot analysis. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the binding of the antibody to an antigen and decrease the background (*e.g.*, pre-clearing the cell lysate with sepharose beads). For further discussion regarding immunoprecipitation protocols see, *e.g.*, Ausubel et al., eds, (1994) Current Protocols in Molecular Biology (John Wiley & Sons, Inc., NY) Vol. 1 at 10.16.1.

[0253] Western blot analysis generally comprises preparing protein samples, electrophoresis of the protein samples in a polyacrylamide gel (*e.g.*, 8%-20% SDS-PAGE depending on the molecular weight of the antigen), transferring the protein sample from the polyacrylamide gel to a membrane such as nitrocellulose, PVDF or nylon, blocking the membrane in blocking solution (*e.g.*, PBS with 3% BSA or non-fat milk), washing the

membrane in washing buffer (*e.g.*, PBS-Tween 20), blocking the membrane with primary antibody (the antibody of interest) diluted in blocking buffer, washing the membrane in washing buffer, blocking the membrane with a secondary antibody (which recognizes the primary antibody, *e.g.*, an anti-human antibody) conjugated to an enzymatic substrate (*e.g.*, horseradish peroxidase or alkaline phosphatase) or radioactive molecule (*e.g.*, ^{32}P or ^{125}I) diluted in blocking buffer, washing the membrane in wash buffer, and detecting the presence of the antigen. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the signal detected and to reduce the background noise. For further discussion regarding western blot protocols see, *e.g.*, Ausubel et al., eds, (1994) Current Protocols in Molecular Biology (John Wiley & Sons, Inc., NY) Vol. 1 at 10.8.1.

[0254] ELISAs comprise preparing antigen, coating the well of a 96-well microtiter plate with the antigen, adding the antibody of interest conjugated to a detectable compound such as an enzymatic substrate (*e.g.*, horseradish peroxidase or alkaline phosphatase) to the well and incubating for a period of time, and detecting the presence of the antigen. In ELISAs the antibody of interest does not have to be conjugated to a detectable compound; instead, a second antibody (which recognizes the antibody of interest) conjugated to a detectable compound may be added to the well. Further, instead of coating the well with the antigen, the antibody may be coated to the well. In this case, a second antibody conjugated to a detectable compound may be added following the addition of the antigen of interest to the coated well. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the signal detected as well as other variations of ELISAs known in the art. For further discussion regarding ELISAs see, *e.g.*, Ausubel et al., eds, (1994) Current Protocols in Molecular Biology (John Wiley & Sons, Inc., NY) Vol. 1 at 11.2.1.

[0255] The binding affinity of an antibody to an antigen and the off-rate of an antibody-antigen interaction can be determined by competitive binding assays. One example of a competitive binding assay is a radioimmunoassay comprising the incubation of labeled antigen (*e.g.*, ^{3}H or ^{125}I) with the antibody of interest in the presence of increasing amounts of unlabeled antigen, and the detection of the antibody bound to the labeled antigen. The affinity of the antibody of interest for a particular antigen and the binding off-rates can be determined from the data by scatchard plot analysis. Competition with a

second antibody can also be determined using radioimmunoassays. In this case, the antigen is incubated with antibody of interest is conjugated to a labeled compound (*e.g.*, ^{3}H or ^{125}I) in the presence of increasing amounts of an unlabeled second antibody.

[0256] Anti-CD100 antibodies, or antigen-binding fragments, variants, or derivatives thereof of the invention, additionally, can be employed histologically, as in immunofluorescence, immunoelectron microscopy or non-immunological assays, for in situ detection of CD100 protein or conserved variants or peptide fragments thereof. In situ detection may be accomplished by removing a histological specimen from a patient, and applying thereto a labeled anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof, preferably applied by overlaying the labeled antibody (or fragment) onto a biological sample. Through the use of such a procedure, it is possible to determine not only the presence of CD100 protein, or conserved variants or peptide fragments, but also its distribution in the examined tissue. Using the present invention, those of ordinary skill will readily perceive that any of a wide variety of histological methods (such as staining procedures) can be modified in order to achieve such in situ detection.

[0257] Immunoassays and non-immunoassays for CD100 gene products or conserved variants or peptide fragments thereof will typically comprise incubating a sample, such as a biological fluid, a tissue extract, freshly harvested cells, or lysates of cells which have been incubated in cell culture, in the presence of a detectably labeled antibody capable of binding to CD100 or conserved variants or peptide fragments thereof, and detecting the bound antibody by any of a number of techniques well known in the art.

[0258] The biological sample may be brought in contact with and immobilized onto a solid phase support or carrier such as nitrocellulose, or other solid support which is capable of immobilizing cells, cell particles or soluble proteins. The support may then be washed with suitable buffers followed by treatment with the detectably labeled anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof. The solid phase support may then be washed with the buffer a second time to remove unbound antibody. Optionally the antibody is subsequently labeled. The amount of bound label on solid support may then be detected by conventional means.

[0259] By "solid phase support or carrier" is intended any support capable of binding an antigen or an antibody. Well-known supports or carriers include glass, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses,

polyacrylamides, gabbros, and magnetite. The nature of the carrier can be either soluble to some extent or insoluble for the purposes of the present invention. The support material may have virtually any possible structural configuration so long as the coupled molecule is capable of binding to an antigen or antibody. Thus, the support configuration may be spherical, as in a bead, or cylindrical, as in the inside surface of a test tube, or the external surface of a rod. Alternatively, the surface may be flat such as a sheet, test strip, etc. Preferred supports include polystyrene beads. Those skilled in the art will know many other suitable carriers for binding antibody or antigen, or will be able to ascertain the same by use of routine experimentation.

[0260] The binding activity of a given lot of anti-CD100 antibody, or antigen-binding fragment, variant, or derivative thereof may be determined according to well known methods. Those skilled in the art will be able to determine operative and optimal assay conditions for each determination by employing routine experimentation.

[0261] There are a variety of methods available for measuring the affinity of an antibody-antigen interaction, but relatively few for determining rate constants. Most of the methods rely on either labeling antibody or antigen, which inevitably complicates routine measurements and introduces uncertainties in the measured quantities.

[0262] Surface plasmon reasonance (SPR) as performed on BIACORE® offers a number of advantages over conventional methods of measuring the affinity of antibody-antigen interactions: (i) no requirement to label either antibody or antigen; (ii) antibodies do not need to be purified in advance, cell culture supernatant can be used directly; (iii) real-time measurements, allowing rapid semi-quantitative comparison of different monoclonal antibody interactions, are enabled and are sufficient for many evaluation purposes; (iv) biospecific surface can be regenerated so that a series of different monoclonal antibodies can easily be compared under identical conditions; (v) analytical procedures are fully automated, and extensive series of measurements can be performed without user intervention. BIAapplications Handbook, version AB (reprinted 1998), BIACORE® code No. BR-1001-86; BIAtechnology Handbook, version AB (reprinted 1998), BIACORE® code No. BR-1001-84. SPR based binding studies require that one member of a binding pair be immobilized on a sensor surface. The binding partner immobilized is referred to as the ligand. The binding partner in solution is referred to as the analyte. In some cases, the ligand is attached indirectly to the surface through binding to another

immobilized molecule, which is referred as the capturing molecule. SPR response reflects a change in mass concentration at the detector surface as analytes bind or dissociate.

[0263] Based on SPR, real-time BIACORE® measurements monitor interactions directly as they happen. The technique is well suited to determination of kinetic parameters. Comparative affinity ranking is simple to perform, and both kinetic and affinity constants can be derived from the sensorgram data.

[0264] When analyte is injected in a discrete pulse across a ligand surface, the resulting sensorgram can be divided into three essential phases: (i) Association of analyte with ligand during sample injection; (ii) Equilibrium or steady state during sample injection, where the rate of analyte binding is balanced by dissociation from the complex; (iii) Dissociation of analyte from the surface during buffer flow.

[0265] The association and dissociation phases provide information on the kinetics of analyte-ligand interaction (k_a and k_d, the rates of complex formation and dissociation, $k_d/k_a=K_D$). The equilibrium phase provides information on the affinity of the analyte-ligand interaction (K_D).

[0266] BIAevaluation software provides comprehensive facilities for curve fitting using both numerical integration and global fitting algorithms. With suitable analysis of the data, separate rate and affinity constants for interaction can be obtained from simple BIACORE® investigations. The range of affinities measurable by this technique is very broad ranging from mM to pM.

[0267] Epitope specificity is an important characteristic of a monoclonal antibody. Epitope mapping with BIACORE®, in contrast to conventional techniques using radioimmunoassay, ELISA or other surface adsorption methods, does not require labeling or purified antibodies, and allows multi-site specificity tests using a sequence of several monoclonal antibodies. Additionally, large numbers of analyses can be processed automatically.

[0268] Pair-wise binding experiments test the ability of two MAbs to bind simultaneously to the same antigen. MAbs directed against separate epitopes will bind independently, whereas MAbs directed against identical or closely related epitopes will interfere with each other's binding. These binding experiments with BIACORE® are straightforward to carry out.

[0269] For example, one can use a capture molecule to bind the first Mab, followed by addition of antigen and second MAb sequentially. The sensorgrams will reveal: (1) how much of the antigen binds to first Mab, (2) to what extent the second MAb binds to the surface-attached antigen, (3) if the second MAb does not bind, whether reversing the order of the pair-wise test alters the results.

[0270] Peptide inhibition is another technique used for epitope mapping. This method can complement pair-wise antibody binding studies, and can relate functional epitopes to structural features when the primary sequence of the antigen is known. Peptides or antigen fragments are tested for inhibition of binding of different MAbs to immobilized antigen. Peptides which interfere with binding of a given MAb are assumed to be structurally related to the epitope defined by that MAb.

[0271] The practice of the present invention will employ, unless otherwise indicated, conventional techniques of cell biology, cell culture, molecular biology, transgenic biology, microbiology, recombinant DNA, and immunology, which are within the skill of the art. Such techniques are explained fully in the literature. See, for example, Sambrook et al., ed. (1989) Molecular Cloning A Laboratory Manual (2nd ed.; Cold Spring Harbor Laboratory Press); Sambrook et al., ed. (1992) Molecular Cloning: A Laboratory Manual, (Cold Springs Harbor Laboratory, NY); D. N. Glover ed., (1985) DNA Cloning, Volumes I and II; Gait, ed. (1984) Oligonucleotide Synthesis; Mullis et al. U.S. Pat. No. 4,683,195; Hames and Higgins, eds. (1984) Nucleic Acid Hybridization; Hames and Higgins, eds. (1984) Transcription And Translation; Freshney (1987) Culture Of Animal Cells (Alan R. Liss, Inc.); Immobilized Cells And Enzymes (IRL Press) (1986); Perbal (1984) A Practical Guide To Molecular Cloning; the treatise, Methods In Enzymology (Academic Press, Inc., N.Y.); Miller and Calos eds. (1987) Gene Transfer Vectors For Mammalian Cells, (Cold Spring Harbor Laboratory); Wu et al., eds., Methods In Enzymology, Vols. 154 and 155; Mayer and Walker, eds. (1987) Immunochemical Methods In Cell And Molecular Biology (Academic Press, London); Weir and Blackwell, eds., (1986) Handbook Of Experimental Immunology, Volumes I-IV; Manipulating the Mouse Embryo, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., (1986); and in Ausubel et al. (1989) Current Protocols in Molecular Biology (John Wiley and Sons, Baltimore, Md.).

[0272] General principles of antibody engineering are set forth in Borrebaeck, ed. (1995) Antibody Engineering (2nd ed.; Oxford Univ. Press). General principles of protein engineering are set forth in Rickwood et al., eds. (1995) Protein Engineering, A Practical Approach (IRL Press at Oxford Univ. Press, Oxford, Eng.). General principles of antibodies and antibody-hapten binding are set forth in: Nisonoff (1984) Molecular Immunology (2nd ed.; Sinauer Associates, Sunderland, Mass.); and Steward (1984) Antibodies, Their Structure and Function (Chapman and Hall, New York, N.Y.). Additionally, standard methods in immunology known in the art and not specifically described are generally followed as in Current Protocols in Immunology, John Wiley & Sons, New York; Stites et al., eds. (1994) Basic and Clinical Immunology (8th ed; Appleton & Lange, Norwalk, Conn.) and Mishell and Shiigi (eds) (1980) Selected Methods in Cellular Immunology (W.H. Freeman and Co., NY).

[0273] Standard reference works setting forth general principles of immunology include Current Protocols in Immunology, John Wiley & Sons, New York; Klein (1982) J., Immunology: The Science of Self-Nonself Discrimination (John Wiley & Sons, NY); Kennett et al., eds. (1980) Monoclonal Antibodies, Hybridoma: A New Dimension in Biological Analyses (Plenum Press, NY); Campbell (1984) "Monoclonal Antibody Technology" in Laboratory Techniques in Biochemistry and Molecular Biology, ed. Burden et al., (Elsevere, Amsterdam); Goldsby et al., eds. (2000) Kuby Immunnology (4th ed.; H. Freemand & Co.); Roitt et al. (2001) Immunology (6th ed.; London: Mosby); Abbas et al. (2005) Cellular and Molecular Immunology (5th ed.; Elsevier Health Sciences Division); Kontermann and Dubel (2001) Antibody Engineering (Springer Verlan); Sambrook and Russell (2001) Molecular Cloning: A Laboratory Manual (Cold Spring Harbor Press); Lewin (2003) Genes VIII (Prentice Hall2003); Harlow and Lane (1988) Antibodies: A Laboratory Manual (Cold Spring Harbor Press); Dieffenbach and Dveksler (2003) PCR Primer (Cold Spring Harbor Press).

[0274] All of the references cited above, as well as all references cited herein, are incorporated herein by reference in their entireties.

[0275] The following examples are offered by way of illustration and not by way of limitation.

EXAMPLES

Example 1

Selection and characterization of antibodies specific for CD100

[0276] Mouse anti-CD100 antibodies recognizing human, monkey and murine CD100 and were generated using the methods described below.

[0277] The "Line 1" cell line was derived from a spontaneous lung tumor in a BALB/c mouse. The inventors previously showed that injecting BALB/c mice with live Line 1 cells transfected with a foreign cDNA was an effective way to induce immune responses (unpublished data). The Line 1 cell line was transfected with an expression plasmid encoding full length human CD100 cDNA (SEQ ID NO: 23). A stable line expressing human CD100 was isolated from the transfected cell line (Line1.CD100). CD100 deficient mice (BALB/c background, see Kumanogoh *et al., J. Immunol. 169*:1175-1181 (2002)) were primed by immunization with purified mouse CD100-His (the extracellular domain of mouse CD100 with a C-terminal 6X his tag for purification) emulsified in complete Freund's adjuvant (CFA). One week following this immunization, the mice were injected intramuscularly (i.m.) with 200,000 live Line1.CD100 cells. Nineteen days after the Line1.CD100 injection the mice were sacrificed and spleens were harvested and fused with P3X63Ag8.653 fusion partner (ATCC# CRL-1580) following standard procedures to generate hybridomas. Hybridoma clones were screened by ELISA for binding to human and mouse CD100. In particular, a hybridoma cell line, specific for MAb 67, was prepared using hybridoma technology. (Kohler *et al., Nature 256*:495 (1975); Kohler *et al., Eur. J. Immunol. 6*:511 (1976); Kohler *et al., Eur. J. Immunol.* 6:292 (1976); Hammerling *et al.*, in: Monoclonal Antibodies and T-Cell Hybridomas, Elsevier, N.Y., pp. 571-681 (1981)). A large panel of mouse CD100 specific antibodies was generated. Most of these antibodies also bound with high affinity to human CD100. Two hybridomas, clones 67-2 and 76-1, produced monoclonal antibodies (called MAb 67 and MAb 76, respectively) that exhibited high affinity for both mouse and human CD100 (**See Table 2**).

Table 2. Affinity measurements for mouse anti-CD100 MAbs

MAb	Isotype	Affinity for Mouse CD100 (nM)*	Affinity for Human CD100 (nM)*
67	IgG1	1.00	5.7
76	IgG2b	0.33	0.12

* Affinity was measured using BIACORE® surface plasmon resonance technology

[0278] An antibody cross-blocking ELISA demonstrated that MAb 67 and MAb 76 recognize distinct epitopes on CD100. In addition, MAbs 67 and 76 recognize an epitope that is distinct from that recognized by the independently derived murine anti-human CD100 antibody BD16 (described in US 2008/0219971 A1). Thus, two independent mouse anti-CD100 antibodies, MAb 76 (see SEQ ID NOs: 25-40) and MAb 67 (see SEQ ID NOs: 3-8; 10; 11-16; 18; 20 and 22), were generated.

Example 2

MAbs 67 and 76 block activity of mouse and human CD100 *in vitro*

[0279] CD100 specific antibodies were screened for their ability to inhibit CD100 binding in a fluorescence blocking assay. An illustration of the method used to test whether the CD100 specific antibodies blocked CD100 from binding to Plexin B1 is shown in **Figure 1**. Human 293 cells were transfected with cDNA encoding a CD100 receptor: Plexin B1. A stable cell line expressing Plexin B1 was selected (293/Plexin). CD100-His bound to Plexin B1 on the cell surface was detected by flow cytometry using a biotin conjugated His tag specific monoclonal antibody and streptavidin-APC. When a tested anti-CD100 MAb was able to block binding of CD100 to Plexin B1, then less CD100-His was detected on the cell, resulting in lower fluorescence.

[0280] Forty nanograms (ng) of human or mouse CD100-His (C-terminal His tag) were incubated alone or with various concentrations of anti-CD100 MAb overnight at 4°C. The next morning, either (1) CD100 only or (2) CD100 pre-incubated with an anti-CD100 MAb (67 or 76) was combined with the 293/Plexin cells and incubated for 30 minutes on ice. CD100 that bound to the cell through Plexin B1 was detected using biotinylated polyclonal rabbit anti-His MAb, followed by streptavidin-APC, and cells were analyzed

by flow cytometry. The results indicated that neutralization of CD100 resulted in lower fluorescence. In particular, pre-incubating CD100 with MAb 67 or MAb 76 resulted in lower fluorescence compared to CD100 only (**Figure 2**). Increasing the concentration of anti-CD100 MAb 67 or 76 from 0.156 μg/ml to 0.625 μg/ml resulted in a further reduction in fluorescence. Similar blocking of human CD100 was also observed (data not shown). Thus, these results showed that MAb 67 and MAb 76 were both able to block human and mouse CD100 from binding to Plexin B1.

[0281] CD100/Plexin B1 signaling has been shown to induce detachment from the extracellular matrix and cell collapse by inducing reorganization of actin filaments (*See* Kruger *et al.*, *Nature Reviews Molecular Cell Biology 6*:789-800 (2005)). A heterologous assay to determine cellular detachment following binding to an extracellular matrix was used to determine whether anti-CD100 antibodies could block CD100 induced detachment of 293/Plexin cells from Fibronectin coated plates.

[0282] For the cell detachment assay, 293/plexin cells (normally grown as a suspension cell line) were plated at a density of 40,000 cells/well onto a fibronectin coated 96 well plate and allowed to attach overnight. Two (2) μg/ml of mouse CD100-His (C-terminal His tag) was incubated alone or with various concentrations of an anti-CD100 MAb (67 or 76) for 6 hours at 4°C. CD100 samples were then brought up to room temperature before addition to the 293/plexin cells. Cells were treated with CD100 or CD100 pre-incubated with antibody for 30 minutes at 37 °C, washed twice with PBS, and stained with crystal violet for 15 minutes. Cells were then washed twice with PBS and dried. Images were taken on a scanner for documentation. The crystal violet was then solubilized for 15 minutes at RT with 100μl of 33% glacial acetic acid, and pipetted into a new plate. Absorbance was read at 570nm. CD100 causes a reduction in the number of cells attached to the plate, and thus a reduced absorbance, while neutralization of CD100 results in an increase in absorbance.

[0283] As shown in **Figure 3,** both MAb 67 and MAb 76 were able to block mouse CD100 mediated cell detachment and increase absorbance compared to isotype control. Similarly, both MAbs were also able to block cell detachment mediated by human CD100 (data not shown).

[0284] MAbs 67 and 76 blocked binding of CD100 to cell surface Plexin B1 and induced detachment of 293/Plexin cells from Fibronectin coated plates. The results of the *in vitro*

functional assays described above showed that MAb 67 and MAb 76 were able to block the function of mouse and human CD100 *in vitro*.

Example 3

Evaluation of anti-CD100 monoclonal antibodies in mouse disease models

[0285] Anti-CD100 neutralizing monoclonal antibodies (76 and 67) were tested *in vivo* in the SJL EAE animal model. Relapsing experimental autoimmune encephalomyelitis (R-EAE) is a CD4+ T cell-mediated disease characterized by inflammation and demyelination within the central nervous system. In SJL mice, R-EAE can be induced by immunization with a peptide epitope of proteolipid protein ($PLP_{139-151}$) (HSLGKWLGHPDKF; SEQ ID NO: 24). This model is characterized by a moderate to severe acute paralytic phase followed by remission and subsequent relapses. Disease severity was scored using the scale shown in **Table 3**.

Table 3. Evaluation of the EAE clinical signs

Score	Signs	Description
0	Normal behavior	No neurological signs.
1	Distal limp tail	The distal part of the tail is limp and droopy.
1.5	Complete limp tail	The whole tail is loose and droopy.
2	Righting reflex	Animal has difficulties rolling onto its feet when laid on its back.
3	Ataxia	Wobbly walk - when the mouse walks the hind legs are unsteady.
4	Early paralysis	The mouse has difficulties standing on its hind legs but still has remnants of movement.
5	Full paralysis	The mouse can't move its legs at all, it looks thiner and emaciated.
6	Moribund/Death	Death.

[0286] SJL mice were immunized with 100μg $PLP_{139-151}$ in CFA. Pertussis toxin was administered on Day 0 and again 48 hours later. Mice were treated with 30mg/kg MAb 76, 67 or isotype control antibody twice per week starting on Day 0, or once per week

starting at Day 7. Scoring of EAE clinical signs was initiated from the 10th day post-EAE induction.

[0287] As shown in **Figure 4A**, treatment with MAb 76 or MAb 67 reduced the severity of EAE in SJL mice compared to mouse IgG control. The percent reduction in Group Mean Score (GMS) between Day 21 and the end of the study for MAbs 76 and 67 at 1X/week and 2x/week each is shown in **Figure 4B**. As shown in Figure 4B, MAb 76 (1X/week) had a percent inhibition of GMS of 35-40%; MAb 67 (1X/week) had a percent inhibition of GMS of 65-70%; MAb 76 (2X/week) had a percent inhibition of GMS of 40-50%; and MAb 67 (2X/week) had a percent inhibition of GMS of 45-50%. These results show that both MAb 67 and MAb 76 attenuated relapsing remitting EAE in SJL mice.

[0288] The SJL EAE study was repeated using MAb 76 at 30mg/kg dose and dosing 1X/week. The results further demonstrated that MAb 76 was able to reduce the severity of EAE in SJL mice compared to mouse IgG (data not shown). The percent reduction in Group Mean Score (GMS) between Day 21 and the end of the study was between 50-60%. Furthermore, the SJL EAE study was repeated using MAb 76 or MAb 67 at 30mg/kg dosing 1X/week. Treatment with MAb 67 or MAb 76 resulted in a percent reduction in GMS of between 30-40% between Day 18 and the end of the study. The results in **Figure 5A** and **5B** further demonstrate that MAb 76 and MAb 67 were able to reduce the severity of EAE in SJL mice.

[0289] The SJL EAE study was repeated using MAb 67 at 30 mg/kg dosing 1X/week where treatment started at day 7 post-immunization. Treatment with MAb 67 starting at day 7 resulted in a percent reduction in GMS of about 50% between Day 12 and the end of the study. The results are shown in **Figure 6**.

[0290] The results from these *in vivo* studies demonstrate that neutralization of CD100 using MAb 76 or MAb 67 reduced the clinical signs of EAE in different murine EAE experiments. The results for MAb 76 and MAb 67 were similar to one another in these experiments.

[0291] These results demonstrated that MAb 76 and MAb 67 have the ability to block CD100 activity *in vitro*, and, importantly, the ability to reduce the severity of EAE in different dosing experiments in the mouse EAE model.

Example 4

Preparation of chimeric and humanized anti-CD100 monoclonal antibodies

[0292] The murine monoclonal antibody clone 67, described above, has been shown to have the ability to neutralize both human and mouse CD100 *in vitro* and to ameliorate EAE in murine models *in vivo*.

[0293] The variable heavy (VH) and variable light (VK) genes were cloned from the clone 67 hybridoma and their sequence was determined. The amino acid sequences of the MAb 67 VH and VK genes are shown below with the CDR1, CDR2 and CDR3 regions underlined.

MAb 67 VH:

QVQLQQSGPELVKPGASVKISCKASGYSFSDYYMHWVKQSPENSLEWIGQINPTT GGASYNQKFKGKATLTVDKSSSTAYMQLKSLTSEESAVYYCTRYYYGRHFDVW GQGTTVTVSS (SEQ ID NO: 10)

MAb 67 VK:

DIVMTQSPASLAVSLGQRATISCKASQSVDYDGDSYMNWYQQKPGQPPKLLIYA ASNLESGIPARFSGSGSGTDFTLNIHPVEEEDAATYYCQQSNEDPYTFGGGTKLEI K (SEQ ID NO: 18)

[0294] The MAb 67 VH gene was cloned into a mammalian expression vector that contained the human gamma 4 heavy chain constant region coding sequence, creating a full length chimeric heavy chain. The MAb 67 VK was cloned into a mammalian expression vector that had the human Kappa constant region coding sequence, creating a full length chimeric light chain. In order to make a chimeric antibody, the expression vectors containing the chimeric heavy chain and the chimeric light chain were co-transfected into CHO-S cells. The monoclonal antibody that was produced was secreted from the cells and harvested after a 3 - 6 day expression period. The resulting MAb was purified using Protein A chromatography and characterized. The resulting chimeric MAb (MAb 2368) was demonstrated to be specific for CD100 by flow cytometry and by ELISA, and was shown to be able to compete with murine MAb 67 for binding to CD100. Collectively, these data demonstrate that the correct VH and VK genes encoding the 67 MAb were isolated.

[0295] The MAb 67 variable CDR regions were used to create a humanized monoclonal antibody. The humanized VH and VK genes were respectively cloned into vectors containing the human gamma 4 and human kappa constant domains. The pairing of the humanized VH and the humanized VK created the IgG4/kappa MAb 2503. The amino acid sequences of the humanized MAb 67 VH (H2160) and VK (L553) are shown below with the CDR1, CDR2 and CDR3 regions underlined.

Sequence of H2160:

QVQLVQSGAEVKKPGSSVKVSCKASGYSFSDYYMHWVRQAPGQGLEWMGQIN PTTGGASYNQKFKGKATITVDKSTSTAYMELSSLRSEDTAVYYCARYYYGRHFD VWGQGTTVTVSS (SEQ ID NO: 9)

Sequence of L553:

DIVMTQSPDSLAVSLGERATINCKASQSVDYDGDSYMNWYQQKPGQPPKLLIYA ASNLESGVPDRFSGSGSGTDFTLTISSLQAEDVAVYYCQQSNEDPYTFGQGTKLEI K (SEQ ID NO: 17)

[0296] Polynucleotides encoding the VH (Human Immunoglobulin gene with human gamma; H2160) and VK (Human Immunoglobulin gene with human kappa; L553) regions of MAb 2503 antibody were cloned into pCMV-Script (Stratagene) vectors and were deposited with the American Type Culture Collection ("ATCC") on May 7, 2009, and given ATCC Deposit Numbers PTA-10004 and PTA-10005, respectively. The ATCC is located at 10801 University Boulevard, Manassas, VA 20110-2209, USA. The ATCC deposits were made pursuant to the terms of the Budapest Treaty on the international recognition of the deposit of microorganisms for purposes of patent procedure.

Example 5

Characterization of humanizaed anti-CD100 monoclonal antibody 2503

[0297] Specificity of MAb 2503 was characterized by ELISA and Flow Cytometry. MAb 2503 was tested in an epitope competition assay with MAb 67 and in an affinity determination assay using BIACORE® surface plasmon resonance technology.

[0298] The epitope specificity of MAb 2503 and MAb 67 were determined by competition ELISA. For the ELISA protocol, an ELISA plate was coated with CD100-

Fc. Mouse 67 or humanized 2503 MAbs were titrated. The antibodies were allowed to bind to CD100 and unbound antibody was wash away. Biotinylated MAb 67 was added. The antibodies were allowed to bind to CD100 and unbound antibody was wash away. Biotinylated MAb 67 bound to CD100 was detected using Streptavidin-HRP. The ability of MAb 2503 or MAb 67 to block binding of biotinylated 67 to human CD100 (shown in **Figure 7A**) and mouse CD100 (shown in **Figure 7B**) was analyzed by ELISA.

[0299] Binding affinities of anti-CD100 MAbs were determined using BIACORE® surface plasmon resonance technology. MAb 2503 was shown to only bind CD100 (human, mouse and marmoset) and CD100 expressing cell lines, indicating that MAb 2503 is specific for CD100. MAb 2503 showed an increased affinity for human and mouse CD100 compared to MAb 67. A summary of the affinity characteristics of MAb 2503 and MAb 67 is presented below in **Table 4**.

Table 4. Affinities of anti-CD100 MAbs for human, marmoset and mouse CD100

MAb	Affinity for Human CD100 (nM)*	Affinity for Marmoset CD100 (nM)*	Affinity for Mouse CD100 (nM)*
67	5.1	2.7	1.3
2503	5.4	2.4	1.5

* Affinity was measured using BIACORE® surface plasmon resonance technology

[0300] These assays show that MAb 2503 is CD100 specific and binds to the same epitope as mouse MAb 67. MAb 2503 was shown to bind both mouse and human CD100, thus an advantage of MAb 2503 is that it can be tested for safety and efficacy in mice and also in humans. Furthermore, it was shown that MAb 2305 bound to human, monkey, and mouse CD100.

Example 6

MAb 2503 blocks activity of mouse and human CD100 *in vitro*

[0301] MAb 2503 was tested for the ability to block the function of CD100 using the assays described above in Example 2, including (1) the flow cytometry blocking assay and (2) the cell detachment assay.

[0302] CD100 specific antibodies, MAb 67 and MAb 2503, were screened for their ability to inhibit CD100 binding to Plexin B1 in a fluorescence blocking assay. The method used to test whether the CD100 specific antibodies blocked CD100 from binding to Plexin B1 was shown in **Figure 1** (Example 2). Pre-incubating CD100 with MAb 67 or MAb 2503 resulted in lower fluorescence compared to CD100 only. MAb 2503 was able to block binding of human (see **Figure 8A**), marmoset (see **Figure 8B**) and mouse (see **Figure 8C**) CD100 *in vitro*. Thus, these results showed that MAb 67 and MAb 2503 were both able to block human, monkey and mouse CD100 from binding to Plexin B1.

[0303] The ability of anti-CD100 MAbs to block human and monkey CD100 mediated detachment of 293/Plexin cells from a fibronectin coated plate was determined using the cell detachment assay described in Example 2. CD100 causes a reduction in the number of cells attached to the plate, and thus a reduced absorbance. Neutralization of human CD100 and marmoset CD100 with MAb2503 or MAb 67 resulted in an increase in absorbance as shown in **Figures 9A** and **9B**, respectively. MAb 2503 and MAb 67 also neutralized mouse CD100 in this assay (Data not shown).

[0304] MAb 2503 blocked binding of human, mouse and monkey CD100 to cell surface Plexin B1 and induced detachment of 293/Plexin cells from Fibronectin coated plates. Thus, these results show that MAb 2503 was able to functionally neutralize human, mouse and monkey CD100.

Example 7

Anti-CD100 antibody inhibits angiogenesis *in vivo*

[0305] CD100 is a potent pro-angiogenic molecule and activation of Plexin B1 through CD100 binding transactivates c-Met and promotes the invasive ability of tumor cells and promotes angiogenesis.

[0306] To demonstrate the *in vivo* effect of the absence of CD100 on tumor growth, CT26 tumor cells were injected into the leg muscle of wild-type Balb/c or CD100-/- mice and the resulting tumor growth was measured. As shown in **Figure 10**, the tumor volume in CD100-/- mice was decreased compared to wild-type Balb/c mice in this study. These results demonstrated that a mouse colon cancer cell line (CT26) has impaired growth in an environment lacking CD100.

[0307] Next, the ability of MAb 67 to reduce the growth of CT26 tumor cells in wild-type Balb/c mice was tested. CT26 tumor cells were injected into the leg muscle of wild-type Balb/c (n =48) or CD100-/- (n=9) mice. Following injection, the wild-type mice were split into 2 groups of 24 mice each. One group was treated starting on Day 1 by i.p. injection with 1mg MAb 67, and the other group was treated by i.p. injection with 1mg mouse IgG. Treatments were repeated every 7 days. The mice were analyzed for tumor growth. As shown in **Figure 11**, treatment with MAb 67 reduced the growth of CT26 tumors in Balb/c mice compared to the mouse IgG control group.

[0308] Thus, these results show that an antibody having the structural and functional characteristics of MAb 67 reduced tumor growth *in vivo*.

Example 8

Anti-CD100 antibody inhibits collagen induced arthritis *in vivo*

[0309] MAb 67 was tested for its ability to reduce arthritis is the Collagen Induced Arthritis (CIA) mouse model. The collagen-induced arthritis (CIA) model is a preclinical animal inflammation model of rheumatoid arthritis (RA) that is widely used to address disease pathogenesis and validate therapeutic RA targets (Brand *et al.*, *Nat. Protoc.* *2*(5):1269-75 (2007)). The general CIA procedure is illustrated in **Figure 12** (any modifications to this general procedure are described below). Briefly, arthritis was induced at day 0 by intradermal tail injection of an emulsion comprising collagen and Complete Freund's Adjuvant (CFA). Thereafter, the control and test treatments were administered by subcutaneous (s.c.) or intraperitoneal (i.p.) injection twice weekly starting on day 20. The test groups for Study 1 are described below in **Table 5**.

Table 5. Collagen Induced Arthritis (CIA) Study 1 test groups

Group #	# Animals	Treatment	Dose	Treatment Days
1	10	Mouse IgG Isotype control	600μg i.p.	2X/week starting on Day 20
2	10	MAb 67	600μg i.p.	2X/week starting on Day 20
3	10	etanercept	600ug s.c.	2X/week starting on Day 20

[0310] The disease severity was scored using the scale shown in **Table 6**. Each mouse paw received a score (macroscopic signs of arthritis were evaluated 3-times weekly). The Arthritic Index (AI) was calculated by addition of individual paw scores (maximum AI = 16). Typically, the first signs of arthritis appear in the CIA model 21-28 days after immunization.

Table 6. CIA Scoring Method

Score	Description
0	no visible effects of arthritis
1	edema and/or erythema of 1 digit
2	edema and/or erythema of 2 digits
3	edema and/or erythema of more than 2 digit
4	severe arthritis of entire paw and digits

[0311] The results of Study 1 showed a reduction in arthritis disease development in the CIA model in groups treated with 600 μg MAb 67. Arthritic Index (AI) in mice treated with 600 μg MAb 67 was compared to AI in mice treated with 600 μg negative control (IgG1) and 600 μg positive control (etanercept) where treatment was started at day 20. Results are shown in **Figure 13A**. These results show that MAb 67 was as good as or better than etanercept at reducing arthritis disease development in the CIA model.

[0312] A second study (Study 2) included MAb 67 and positive control treatments where the treatment was delayed, *i.e.*, started when the Arthritis Index was ≥3. The test groups for Study 2 are described below in **Table 7**.

Table 7. Collagen Induced Arthritis (CIA) Study 2 test groups

Group #	# Animals	Treatment	Dose	Treatment Days
1	10	Mouse IgG Isotype control	600μg i.p.	2X/week starting on Day 20
2	10	MAb 67	600μg i.p.	2X/week starting on Day 20
3	10	MAb 67	600μg i.p.	2X/week starting when Arthritis Index is ≥3
4	10	etanercept	600ug s.c.	2X/week starting when Arthritis Index is ≥3

[0313] For Study 2, the AI results for treatment with MAb 67 (treatment started at day 20 or when the AI was ≥3) were compared to treatment with a negative control (IgG1) and positive control (etanercept; treatment started when the AI was ≥3). The results are shown in **Figure 13B**. These results show that MAb 67 was as good as or better than etanercept at reducing arthritis disease development in the CIA model when treatment was started at day 20 or delayed to AI ≥3. Thus, MAb 67 was shown to prevent arthritis disease development, as well as treat arthritis disease when administered once AI was ≥3 in the CIA model.

Example 9

Anti-CD100 antibody blocks primary and memory B cell responses *in vivo*

[0314] Balb/c and CD100-/- mice were immunized with (4-hydroxy-3-nitrophenyl) acetyl conjugated chicken gamma globulin precipitated with alum (aluminum-/magnesium-hydroxide) ("NP-CGG") followed by treatment with control IgG1 (Balb/c and CD100-/-) or MAb 67 (Balb/c only). The test groups are shown below in **Table 8**.

Table 8. Primary and memory B-cell response test groups

Group	Strain	# animals	challenge	Ab treatment	dose	Ab Injection
1	CD100 -/-	6	N/A	N/A	N/A	N/A
2	CD100 -/-	6	NP-CGG/Alum	Control IgG1	N/A	Day (-7), 0, 7, 14, 21, 28
3	Balb/c	6	N/A	N/A	N/A	N/A
4	Balb/c	6	NP-CGG/Alum	Control IgG1	600ug	Day (-7), 0, 7, 14, 21, 28
5	Balb/c	6	NP-CGG/Alum	MAb 67	600 ug	Day (-7), 0, 7, 14, 21, 28

[0315] The mice were treated as described above in Table 8 starting on Day -7 and were immunized with NP-CGG on Day 0. Three mice per group were euthanized on Day 10, and the spleen and lymph nodes were analyzed for germinal center (GC) B cells ("B220+CD38lowPNA+"). Each spleen was analyzed separately, and the lymph nodes from all three mice were combined into one sample for analysis. Treatment of the remaining mice was continued as shown in Table 8. On Day 21 the mice were boosted with the same NP-CGG in Alum. On Day 31 the remaining mice were euthanized and the spleen and lymph nodes were analyzed for germinal center (GC) B cells ("B220+CD38lowPNA+"). Each spleen was analyzed separately, and the lymph nodes from all three mice were combined into one sample for analysis. The results in **Figures 14A and B** show that treatment with 600 μg MAb 67 decreased the number of GC B cells in spleen (SP) and lymph nodes (LN) after both primary immunization (14A) and secondary immunization (14B), respectively. Thus, MAb 67 was shown to block primary and memory B cell responses *in vivo*.

Example 10

Anti-CD100 antibody slows tumor growth *in vivo*

[0316] Reduction of tumor growth by MAb 67 was tested in CT26 and BCA34 mouse xenograft tumor models. For these studies, tumor cells were injected intramuscularly into the legs of Balb/c mice. Starting 1 day post-graft, mice were treated by intraperitoneal (i.p.) injection 1X per week with 1 mg MAb 67 antibody or negative control (IgG) in 0.2 ml volume. Change in tumor volume (mm^3) and/or thigh volume (mm^3) was measured to

determine tumor growth rates. The tumor growth rate for MAb 67 treated mice compared to the tumor growth rate in negative control mice was used to calculate tumor growth delay (TGD).

[0317] The ability of BCA34 and EMT6 tumor cells to grow in an environment lacking CD100 was also tested. For these studies, tumor cells were injected into the legs of Balb/c and CD100-/- (SEMA4D-/-) mice and tumor growth was measured.

CT26 colon tumor cells

[0318] CT26 tumor cells are derived from murine colon tumors and express very low levels of CD100. 50,000 CT26 colon tumor cells were injected s.c. into wild-type Balb/c mice (20 mice/treatment group). The change in tumor volume (mm^3) was measured in mice treated with 1 mg MAb 67 weekly starting on Day 1 post-graft compared to mice injected with IgG control. The results (mean tumor volume over time) are shown in **Figure 15**. The TGD for mice treated with MAb 67 was 17% (p=0.0317). These results show that CT26 tumor growth was reduced in MAb 67 treated mice.

BCA34 fibroblastic tumor cells

[0319] BCA34 tumor cells express low levels of CD100. First, 50,000 BCA34 tumor cells were s.c. injected into the abdominal region of wild-type Balb/c mice or CD100-/- ("SEMA4D-/-") mice. The change in tumor volume (mm^3) was measured in these mice, and the results are shown in **Figure 16A**. These results showed that BCA34 tumor cells had impaired growth in an environment lacking CD100.

[0320] In a separate experiment, 50,000 BCA34 tumor cells were injected into the leg muscles of wild-type Balb/c mice (21 mice/treatment group). The change in tumor volume (mm^3) was measured in mice treated with 1 mg MAb 67 weekly starting on Day 1 post-graft compared to mice injected with IgG control. The results (mean thigh volume over time) are shown in **Figure 16B**. The TGD for mice treated with MAb 67 was 18% (p=0.009). These results show that BCA34 tumor growth was reduced in MAb 67-treated mice.

EMT6 mammary carcinoma tumor cells

[0321] EMT6 tumor cells are derived from murine mammary carcinoma tumors and express moderate levels of CD100. 50,000 EMT6 tumor cells were injected into the leg

muscles of wild-type Balb/c mice or CD100-/- ("SEMA4D-/-") mice. The change in tumor volume (mm^3) was measured in these mice, and the results are show in **Figure 17**. Change in tumor volume (mm^3) is shown for wild-type Balb/c mice and CD100-/- mice ("SEMA4D-/-"). These results showed that EMT6 tumor cells had impaired growth in an environment lacking CD100.

Example 11

Anti-CD100 antibody slows human tumor growth *in vivo*

[0322] Reduction of tumor growth by MAb 2503 was tested in HN12 and HN6 HIF1a mODD human xenograft tumor models. HN12 and HN6 HIF1a mODD are derived from human head and neck tumors, and both xenografts express high levels of HIF1a and CD100. The HN6 HIF-1a mODD xenograft model is described in Sun *et al.*, *J Biol Chem 284*(46):32066-74 (2009). For these experiments, 2 tumors/mouse were s.c. injected into athymic nude mice (10 mice/treatment group). Starting 1 day post-graft, mice were treated by i.p. injection 1X per week with 1 mg MAb 2503 antibody or negative control (IgG4) in 0.2 ml volume. Change in tumor volume (mm^3) was measured. The tumor growth rate for MAb 2503-treated HN6 HIF-1a mODD mice compared to the growth rate in negative control mice was used to calculate tumor growth delay (TGD).

[0323] The endpoint for this experiment was TGD. Tumor growth results for MAb 2503 treatment in HN12 and HN6 HIF-1a mODD xenograft models are shown in **Figures 18 and 19A**, respectively. The TGD in HN6 HIF-1a mODD xenograft mice treated with MAb 2503 was 13% ($p=0.0008$). Furthermore, pictures of representative tumors from HN6 HIF-1a mODD xenograft mice treated with IgG4 control and MAb 2505 are shown in **Figure 19B**. These results show that treatment with MAb 2503 reduced human head and neck tumor growth *in vivo*.

Example 12

Stable CHO-S cell line for expressing high titers of MAb 2503

[0324] A stable CHO-S cell line was derived for expressing high titers of MAb 2503. Complementary DNA (cDNA) for the heavy and light chains of the humanized anti-CD100 monoclonal antibody 2503 were used to produce several Chinese hamster ovary

(CHO-S) expression cell lines constructed using GPEx™ technology (Catalent Pharma Solutions, Madison, Wisconsin) and progenitor CHO-S cells (*see* Bleck *et al.*, "An Alternative Method for the Rapid Generation of Stable, High-Expressing Mammalian Cell Lines," BioProcessing Journal (September/October 2005)).

[0325] Following single cell cloning, one expression clone was selected based on growth in culture and antibody production, and a research bank of vialed expression cells was produced. The expressed antibody produced by this clone was characterized for potency and specificity using *in vitro* and *in vivo* functional assays (*e.g.*, flow blocking and detachment assays). Subsequently, cells from the selected CHO expression clone were expanded in culture and a second (Parental Seed Stock) bank prepared and frozen. Cells from one vial from the parental seed stock bank were subsequently expanded in culture and used for cGMP production of the Master Cell Bank (MCB).

Example 13

Anti-CD100 antibody dosage and PK studies in rat and cynomolgus monkey

[0326] Single intravenous injection saturation analysis of MAb 2503 in rat and cymonolgus monkey was performed.

[0327] Rat Study: 36 Sprague-Dawley rats (3/sex/group) were administered a single intravenous injection of MAb 2503 ranging from 0.01 to 100 mg/kg. A flow cytometry-based saturation assay was performed on lysed whole blood at various time points to determine the percent of the cellular target (SEMA4D) that was saturated with MAb 2503. There was good data correlation with the amount of MAb detected in the serum, suggesting that saturation was dependent on the amount of free-drug in the serum, and that cells were saturated when approximately 1 to 5 ug/ml of free drug is detected in the serum. The percent saturation of SEMA4D at MAb 2503 doses of 0, 0.01, 0.1, 1.0, 10, and 100 mg/kg in male and female rats is shown in **Figures 20A and 20B**, respectively.

[0328] Primate Study: 28 cynomolgus monkeys (2/sex/group; 4/sex/control group) were administered a single intravenous injection of MAb 2503 ranging from 0.01 to 100 mg/kg. A flow cytometry-based saturation assay was performed on lysed whole blood at various time points to determine the percent of the cellular target (SEMA4D) that was saturated with MAb 2503. There was good data correlation with the amount of MAb

detected in the serum, suggesting that saturation was dependent on the amount of free-drug in the serum, and that cells were saturated when approximately 1 to 5 ug/ml of free drug was detected in the serum. The percent saturation of SEMA4D at MAb 2503 doses of 0, 0.01, 0.1, 1.0, 10, and 100 mg/kg in male and female rats (combined) is shown in **Figure 21**. The rat and primate saturation results were very similar.

[0329] Pharmacokinetic (PK) results including biological half-life (hours (days)), plasma antibody concentration at time zero following injection (C_0), and area under the plasma concentration curve from time zero to time t (AUC_{0-t}) for single intravenous injections of 0.01, 0.1, 1.0, 10, or 100 mg/kg MAb 2503 in rat and primate are shown in **Table 9**.

Table 9. PK Values for 2503 antibody in rat and primate (cynomolgus monkey)

Dose (mg/kg)	Half-life (hours (days))		C_0 (μg/mL)		AUC_{0-t}	
	Cyno	Rat	Cyno	Rat	Cyno	Rat
0.01			0.1051	No data	0.3573	No data
Phase A	0.1649 (0.01)	No data				
Phase B	43.21 (1.80)	No data				
0.1			3.356	1.99	23.09	11.40
Phase A	0.1659 (0.01)	3.47 (0.14)				
Phase B	6.829 (0.28)	No data				
1.0			39.35	34.14	1,974	834.7
Phase A	3.175 (0.13)	0.636 (0.026)				
Phase B	43.69 (1.82)	27.77 (1.2)				
10			327.1	317.7	38,741	27,431
Phase A	3.075 (0.13)	5.85 (0.24)				
Phase B	109.4 (4.56)	105.7 (4.4)				
100			3,681	3,305	477,154	488,194
Phase A	6.978 (0.29)	9.20 (0.38)				
Phase B	239.8 (9.99)	246.2 (10.3)				

[0330] The MAb 2503 elimination phase half life was found to be similar between rat and cynomolgus monkey, and ranged from about 6 hours to about 10 days in a dose dependent fashion. Both the saturation and PK results appear to be dose dependent and

suggest a remarkably similar profile between rat and cynomolgus monkey. Furthermore, no significant toxicity for MAb 2503 at doses ranging from 0.01 to 100 mg/kg was observed in rat or cynomolgus monkey.

[0331] The foregoing description of the specific embodiments will so fully reveal the general nature of the invention that others can, by applying knowledge within the skill of the art, readily modify and/or adapt for various applications such specific embodiments, without undue experimentation, without departing from the general concept of the present invention. Therefore, such adaptations and modifications are intended to be within the meaning and range of equivalents of the disclosed embodiments, based on the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and not of limitation, such that the terminology or phraseology of the present specification is to be interpreted by the skilled artisan in light of the teachings and guidance.

[0332] The breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. An isolated binding molecule which specifically binds to the same CD100 epitope as a reference monoclonal antibody selected from the group consisting of 2503 or 67.

2. An isolated binding molecule which specifically binds to CD100, wherein said binding molecule competitively inhibits a reference monoclonal antibody selected from the group consisting of 2503 or 67 from specifically binding to CD100.

3. The binding molecule of claim 1 or 2 which comprises an antibody or antigen-binding fragment thereof.

4. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein said antibody or fragment thereof is monoclonal antibody 2503 or 67.

5. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the heavy chain variable region (VH) of said antibody or fragment thereof comprises an amino acid sequence at least 90% identical to SEQ ID NO: 9 or SEQ ID NO: 10.

6. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the light chain variable region (VL) of said antibody or fragment thereof comprises an amino acid sequence at least 90% identical to SEQ ID NO: 17 or SEQ ID NO: 18.

7. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises an amino acid sequence identical,

except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 9 or SEQ ID NO: 10.

8. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises an amino acid sequence identical, except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 17 or SEQ ID NO: 18.

9. The antibody or antigen-binding fragment thereof according to claim 5, wherein the VH of said antibody or fragment thereof comprises the amino acid sequence of SEQ ID NO: 9 or SEQ ID NO: 10.

10. The antibody or antigen-binding fragment thereof according to claim 6, wherein the VL of said antibody or fragment thereof comprises the amino acid sequence of SEQ ID NO: 17 or SEQ ID NO: 18.

11. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH and VL of said antibody or fragment thereof comprise amino acid sequences at least 90% identical to SEQ ID NO: 9 and SEQ ID NO: 10, respectively, or SEQ ID NO: 17 and SEQ ID NO: 18, respectively.

12. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH and VL of said antibody or fragment thereof comprise amino acid sequences identical, except for 20 or fewer conservative amino acid substitutions each, to SEQ ID NO: 9 and SEQ ID NO: 10, respectively, or SEQ ID NO: 17 and SEQ ID NO: 18, respectively.

13. The isolated antibody or antigen-binding fragment thereof according to claim 11, wherein the VH and VL of said antibody or fragment thereof comprise amino acid sequences identical to SEQ ID NO: 9 and SEQ ID NO: 10, respectively, or SEQ ID NO: 17 and SEQ ID NO: 18, respectively.

14. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises a Chothia-Kabat heavy chain complementarity determining region-1 (VH-CDR1) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 6.

15. The antibody or fragment thereof according to claim 14, wherein said VH-CDR1 amino acid sequence is SEQ ID NO: 6.

16. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises a Kabat heavy chain complementarity determining region-2 (VH-CDR2) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 7.

17. The antibody or fragment thereof according to claim 16, wherein said VH-CDR2 amino acid sequence is SEQ ID NO: 7.

18. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises a Kabat heavy chain complementarity determining region-3 (VH-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 8.

19. The antibody or fragment thereof according to claim 18, wherein said VH-CDR3 amino acid sequence is SEQ ID NO: 8.

20. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises a Kabat light chain complementarity determining region-1 (VL-CDR1) amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 14.

21. The antibody or fragment thereof according to claim 20, wherein said VL-CDR1 amino acid sequence is SEQ ID NO: 14.

22. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises a Kabat light chain complementarity determining region-2 (VL-CDR2) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 15.

23. The antibody or fragment thereof according to claim 22, wherein said VL-CDR2 amino acid sequence is SEQ ID NO: 15.

24. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises a Kabat light chain complementarity determining region-3 (VL-CDR3) amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 16.

25. The antibody or fragment thereof according to claim 24, wherein said VL-CDR3 amino acid sequence is SEQ ID NO: 16.

26. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VH of said antibody or fragment thereof comprises VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences comprising SEQ ID NOs: 6, 7, and 8, respectively, except for four or fewer amino acid substitutions in one or more of said VH-CDRs.

27. The isolated antibody of claim 26, wherein the VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences are SEQ ID NOs: 6, 7, and 8, respectively.

28. An isolated antibody or antigen-binding fragment thereof which specifically binds to CD100, wherein the VL of said antibody or fragment thereof comprises VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences comprising SEQ ID NOs: 14, 15, and 16, respectively, except for four or fewer amino acid substitutions in one or more of said VL-CDRs.

29. The isolated antibody of claim 28, wherein the VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences are SEQ ID NOs: 14, 15, and 16, respectively.

30. The antibody or fragment thereof according to any one of claims 4, 6, 8, 11 to 13, wherein the VH framework regions have five or fewer amino acid substitutions.

31. The antibody or fragment thereof according to any one of claims 5, 7, 9, and 10 to 13, wherein the VL framework regions have five or fewer amino acid substitutions.

32. The antibody or fragment thereof according to any one of claims 3 to 31, which binds to a linear epitope.

33. The antibody or fragment thereof according to any one of claims 3 to 31, which binds to a non-linear conformational epitope.

34. The antibody or fragment thereof according to any one of claims 3 to 33, which is multispecific.

35. The antibody or fragment thereof according to claim 34, which is bispecific.

36. The antibody or fragment thereof according to any one of claims 3 to 35, which is an Fab fragment.

37. The antibody or fragment thereof according to any one of claims 3 to 35, which is an $F(ab)_2$ fragment.

38. The antibody or fragment thereof according to any one of claims 3 to 35, which is an Fv fragment.

39. The antibody or fragment thereof according to any one of claims 3 to 35, which is a single chain antibody.

40. The antibody or fragment thereof according to any one of claims 3 to 35, which is multivalent and comprises at least two heavy chains and at least two light chains.

41. The antibody or fragment thereof according to any one of claims 3 to 35, 39 and 40, which comprises a light chain constant region selected from the group consisting of a human kappa constant region and a human lambda constant region.

42. The antibody or fragment thereof according to any one of claims 3 to 35 and 39 to 41, which comprises a heavy chain constant region or fragment thereof.

43. The antibody or fragment thereof according to claim 42, wherein said heavy chain constant region or fragment thereof is human IgG1, IgG2, IgG3, IgG4, IgM, IgA1, IgA2, IgE or IgD.

44. The antibody or fragment thereof according to any one of claims 3 to 43, which binds to human and murine CD100.

45. The antibody or fragment thereof according to any one of claims 3 to 44, which specifically binds to an CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide with an affinity characterized by a dissociation constant (K_D) no greater than 5×10^{-2} M, 10^{-2} M, 5×10^{-3} M, 10^{-3} M, 5×10^{-4} M, 10^{-4} M, 5×10^{-5} M, 10^{-5} M, 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 5.7×10^{-12} M, 8.4×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M, 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, or 10^{-15} M.

46. The antibody or fragment thereof according to claim 45, wherein said CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is human or murine.

47. The antibody or fragment thereof according to claim 46, wherein said CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is human and said K_D is about 5×10^{-9} M to about 6×10^{-9} M.

48. The antibody or fragment thereof according to claim 46, wherein said CD100 polypeptide or fragment thereof, or a CD100 variant polypeptide is murine and said K_D is about 1×10^{-9} M to about 2×10^{-9} M.

49. The antibody or fragment thereof according to any one of claims 3 to 48, which inhibits CD100 from binding to a CD100 receptor.

50. The antibody or fragment thereof according to claim 49, wherein said CD100 receptor is Plexin-B1.

51. The antibody or fragment thereof according to any one of claims 3 to 50, wherein said antibody or fragment thereof is humanized, primatized or chimeric.

52. The antibody or fragment thereof according to claim 51, wherein said antibody or fragment thereof is humanized.

53. The antibody or fragment thereof according to any one of claims 3 to 52, further comprising a heterologous polypeptide fused thereto.

54. The antibody or fragment thereof according to any one of claims 3 to 53, wherein said antibody or fragment thereof is conjugated to an agent selected from the group consisting of a cytotoxic agent, a therapeutic agent, a cytostatic agent, a biological toxin, a prodrug, a peptide, a

protein, an enzyme, a virus, a lipid, a biological response modifier, a pharmaceutical agent, a lymphokine, a heterologous antibody or fragment thereof, a detectable label, polyethylene glycol (PEG), and a combination of two or more of any said agents.

55. The antibody or fragment thereof according to claim 54, wherein said cytotoxic agent is selected from the group consisting of a radionuclide, a biotoxin, an enzymatically active toxin, or a combination of two or more of any said cytotoxic agents.

56. The antibody or fragment thereof according to claim 54, wherein said detectable label is selected from the group consisting of an enzyme, a fluorescent label, a chemiluminescent label, a bioluminescent label, a radioactive label, or a combination of two or more of any said detectable labels.

57. A composition comprising the antibody or fragment thereof according to any one of claims 1 to 56, and a carrier.

58. A composition of claim 57, wherein said carrier is selected from the group consisting of saline, buffered saline, dextrose, water, glycerol, and combinations thereof.

59. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VH polypeptide, wherein the amino acid sequence of said VH polypeptide is at least 90% identical to SEQ ID NO: 19 or SEQ ID NO: 20; and wherein an antibody or antigen binding fragment thereof comprising said VH polypeptide specifically binds to CD100.

60. The polynucleotide of claim 59, wherein the nucleotide sequence encoding said VH polypeptide is optimized for increased expression without changing the amino acid sequence of said VH polypeptide.

61. The polynucleotide of claim 60, wherein said optimization comprises identification and removal of splice donor and splice acceptor sites.

62. The polynucleotide claim 60, wherein said optimization comprises optimization of codon usage for the cells expressing said polynucleotide.

63. The polynucleotide of any one of claims 59 to 62, wherein said nucleic acid comprises a nucleotide sequence comprising SEQ ID NO: 19 or SEQ ID NO: 20.

64. The polynucleotide of any claim 63, wherein said nucleic acid comprises a nucleotide sequence consisting of SEQ ID NO: 19 or SEQ ID NO: 20.

65. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VL polypeptide, wherein the amino acid sequence of said VL polypeptide is at least 90% identical to SEQ ID NO: 21 or SEQ ID NO: 22; and wherein an antibody or antigen binding fragment thereof comprising said VL polypeptide specifically binds to CD100.

66. The polynucleotide of claim 65, wherein the nucleotide sequence encoding said VL polypeptide is optimized for increased expression without changing the amino acid sequence of said VL polypeptide.

67. The polynucleotide of claim 66, wherein said optimization comprises identification and removal of splice donor and splice acceptor sites.

68. The polynucleotide of claim 66, wherein said optimization comprises optimization of codon usage for the cells expressing said polynucleotide.

69. The polynucleotide of any one of claims 65 to 68, wherein said nucleic acid comprises a nucleotide sequence comprising SEQ ID NO: 21 or SEQ ID NO: 22.

70. The polynucleotide of any claim 69, wherein said nucleic acid comprises a nucleotide sequence consisting of SEQ ID NO: 21 or SEQ ID NO: 22.

71. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VH polypeptide, wherein the amino acid sequence of said VH polypeptide is identical, except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 9 or SEQ ID NO: 10; and wherein an antibody or antigen binding fragment thereof comprising said VH polypeptide specifically binds to CD100.

72. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VL polypeptide, wherein the amino acid sequence of said VL polypeptide is identical, except for 20 or fewer conservative amino acid substitutions, to SEQ ID NO: 17 or SEQ ID NO: 18; and wherein an antibody or antigen binding fragment thereof comprising said VL polypeptide specifically binds to CD100.

73. An isolated polynucleotide comprising a nucleic acid which encodes a VH-CDR1 amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 6; and

wherein an antibody or antigen binding fragment thereof comprising said VH-CDR1 specifically binds to CD100.

74. The polynucleotide or fragment thereof of claim 73, wherein said VH-CDR1 amino acid sequence is SEQ ID NO: 6.

75. An isolated polynucleotide comprising a nucleic acid which encodes a VH-CDR2 amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 7; and wherein an antibody or antigen binding fragment thereof comprising said VH-CDR2 specifically binds to CD100.

76. The polynucleotide or fragment thereof of claim 75, wherein said VH-CDR2 amino acid sequence is SEQ ID NO: 7.

77. An isolated polynucleotide comprising a nucleic acid which encodes a VH-CDR3 amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 8; and wherein an antibody or antigen binding fragment thereof comprising said VH-CDR3 specifically binds to CD100.

78. The polynucleotide or fragment thereof of claim 77, wherein said VH-CDR3 amino acid sequence is SEQ ID NO: 8.

79. An isolated polynucleotide comprising a nucleic acid which encodes a VL-CDR1 amino acid sequence identical, except for four or fewer amino acid substitutions, to SEQ ID NO: 14; and wherein an antibody or antigen binding fragment thereof comprising said VL-CDR1 specifically binds to CD100.

80. The polynucleotide or fragment thereof of claim 79, wherein said VL-CDR1 amino acid sequence SEQ ID NO: 14.

81. An isolated polynucleotide comprising a nucleic acid which encodes a VL-CDR2 amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 15; and wherein an antibody or antigen binding fragment thereof comprising said VL-CDR2 specifically binds to CD100.

82. The polynucleotide or fragment thereof of claim 81, wherein said VL-CDR2 amino acid sequence is SEQ ID NO: 15.

83. An isolated polynucleotide comprising a nucleic acid which encodes a VL-CDR3 amino acid sequence identical, except for two or fewer amino acid substitutions, to SEQ ID NO: 16; and wherein an antibody or antigen binding fragment thereof comprising said VL-CDR3 specifically binds to CD100.

84. The polynucleotide or fragment thereof of claim 83, wherein said VL-CDR3 amino acid sequence is SEQ ID NO: 16.

85. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VH polypeptide, wherein said VH polypeptide comprises VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences comprising SEQ ID NOs: 6, 7, and 8, respectively; and wherein an antibody or antigen binding fragment thereof specifically binds to CD100.

86. An isolated polynucleotide comprising a nucleic acid which encodes an antibody VL polypeptide, wherein said VL polypeptide comprises VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences comprising SEQ ID NOs: 14, 15, and 16, respectively; and wherein an antibody or antigen binding fragment thereof specifically binds to CD100.

87. The polynucleotide of any one of claims 59 to 64, 71, 73 to 78 and 85, further comprising a nucleic acid encoding a signal peptide fused to the antibody VH polypeptide.

88. The polynucleotide of any one of claims 65 to 69, 72, 79 to 84 and 86, further comprising a nucleic acid encoding a signal peptide fused to the antibody VL polypeptide.

89. The polynucleotide of any one of claims 59 to 64, 71 to 78, 85 and 87, further comprising a nucleic acid encoding a heavy chain constant region CH1 domain fused to the antibody VH polypeptide.

90. The polynucleotide of any one of claims 59 to 64, 71 to 78, 85, 87 and 89, further comprising a nucleic acid encoding a heavy chain constant region CH2 domain fused to the antibody VH polypeptide.

91. The polynucleotide of any one of claims 59 to 64, 71 to 78, 85, 87, 89 and 90, further comprising a nucleic acid encoding a heavy chain constant region CH3 domain fused to said VH polypeptide.

92. The polynucleotide of any one of claims 59 to 64, 71 to 78, 85, 87, and 89 to 91, further comprising a nucleic acid encoding a heavy chain hinge region fused to said VH polypeptide.

93. The polynucleotide of any one of claims 91 to 92, wherein said heavy chain constant region is human IgG1, IgG2, IgG3, IgG4, IgM, IgA1, IgA2, IgE or IgD.

94. The polynucleotide of any one of claims 65 to 70, 72, 79-84, 86 and 88, further comprising a nucleic acid encoding a light chain constant region domain fused to said VL polypeptide.

95. The polynucleotide of claim 94, wherein said light chain constant region is human kappa.

96. The polynucleotide of any one of claims 59 to 95, wherein said antibody or antigen binding fragment thereof specifically binds to human and murine CD100.

97. A vector comprising the polynucleotide of any one of claims 59 to 96.

98. The vector of claim 97, wherein said polynucleotide is operably associated with a promoter.

99. A host cell comprising the vector of claim 97 or 98.

100. A method of producing an antibody or fragment thereof which specifically binds CD100, comprising culturing the host cell of claim 99, and recovering said antibody, or fragment thereof.

101. An isolated polypeptide produced by the method of claim 100.

102. An isolated polypeptide encoded by the polynucleotide of any one of claims 59 to 96.

103. An isolated antibody or fragment thereof comprising the polypeptide of claim 101 or 102.

104. A composition comprising an isolated VH encoding polynucleotide and an isolated VL encoding polynucleotide, wherein said VH encoding polynucleotide and said VL encoding polynucleotide comprise nucleic acids encoding amino acid sequences at least 90% identical to SEQ ID NO: 9 and SEQ ID NO: 17, respectively, or SEQ ID NO: 10 and SEQ ID NO: 18, respectively; and wherein an antibody or fragment thereof encoded by said VH and VL encoding polynucleotides specifically binds CD100.

105. The composition of claim 104, wherein said VH encoding polynucleotide and said VL encoding polynucleotide comprise nucleic acids encoding amino acid sequences consisting of SEQ ID NO: 9 and SEQ ID NO: 17, respectively, or SEQ ID NO: 10 and SEQ ID NO: 18, respectively.

106. A composition comprising an isolated VH encoding polynucleotide and an isolated VL encoding polynucleotide, wherein said VH encoding polynucleotide and said VL encoding polynucleotide comprise nucleic acids encoding amino acid sequences identical, except for less than 20 conservative amino acid substitutions, to SEQ ID NO: 9 and SEQ ID NO: 17, respectively, or SEQ ID NO: 10 and SEQ ID NO: 18, respectively; and wherein an antibody or fragment thereof encoded by said VH and VL encoding polynucleotides specifically binds CD100.

107. The composition of claim 106, wherein said VH and VL amino acid sequences are SEQ ID NO: 9 and SEQ ID NO: 17, respectively, or SEQ ID NO: 10 and SEQ ID NO: 18, respectively.

108. A composition comprising an isolated VH encoding polynucleotide and an isolated VL encoding polynucleotide, wherein said VH encoding polynucleotide encodes a VH polypeptide

comprising VH-CDR1, VH-CDR2, and VH-CDR3 amino acid sequences consisting of SEQ ID NOs: 6, 7, and 8, respectively; wherein said VL encoding polynucleotide encodes a VL polypeptide comprising VL-CDR1, VL-CDR2, and VL-CDR3 amino acid sequences consisting of SEQ ID NOs: 14, 15, and 16, respectively; and wherein an antibody or fragment thereof encoded by said VH and VL encoding polynucleotides specifically binds CD100.

109. The composition of any one of claims 104 to 108, wherein said VH encoding polynucleotide further comprises a nucleic acid encoding a signal peptide fused to said antibody VH polypeptide.

110. The composition of any one of claims 104 to 108, wherein said VL encoding polynucleotide further comprises a nucleic acid encoding a signal peptide fused to said antibody VL polypeptide.

111. The composition of any one of claims 104 to 110, wherein said VH encoding polynucleotide further comprises a nucleic acid encoding a heavy chain constant region CH1 domain fused to said VH polypeptide.

112. The composition of any one of claims 104 to 111, wherein said VH encoding polynucleotide further comprises a nucleic acid encoding a heavy chain constant region CH2 domain fused to said VH polypeptide.

113. The composition of any one of claims 104 to 112, wherein said VH encoding polynucleotide further comprises a nucleic acid encoding a heavy chain constant region CH3 domain fused to said VH polypeptide.

114. The composition of any one of claims 104 to 113, wherein said VH encoding polynucleotide further comprises a nucleic acid encoding a heavy chain hinge region fused to said VH polypeptide.

115. The composition of claim 113 or 114, wherein said heavy chain constant region is human IgG1, IgG2, IgG3, IgG4, IgM, IgA1, IgA2, IgE or IgD.

116. The composition of any one of claims 104 to 115, wherein said VL encoding polynucleotide further comprises a nucleic acid encoding a light chain constant region domain fused to said VL polypeptide.

117. The composition of claim 116, wherein said light chain constant region is human kappa.

118. The composition of any one of claims 104 to 117 wherein said VH encoding polynucleotide and said VL encoding polynucleotide are contained on a single vector.

119. The composition of any one of claims 104 to 117, wherein said VH encoding polynucleotide is contained on a first vector and said VL encoding polynucleotide is contained on a second vector which is non-identical to said first vector.

120. The composition of claim 118 or 119, wherein said VH encoding polynucleotide is operably associated with a first promoter and said VL encoding polynucleotide is operably associated with a second promoter.

121. The composition of claim 120, wherein said first and second promoters are copies of the same promoter.

122. The composition of claim 120, wherein said first and second promoters non-identical.

123. The composition of any one of claims 118 to 122, wherein said first vector and said second vector are contained in a single host cell.

124. The composition of any one of claims 118 to 122, wherein said first vector and said second vector are contained in separate host cells.

125. The composition of any one of claims 104 to 124, wherein said antibody or antigen binding fragment thereof specifically binds to human and murine CD100.

126. A vector according to claim 118.

127. A first vector according to claim 119.

128. A second vector according to claim 119.

129. The vector of claim 126, wherein said VH encoding polynucleotide and said VL encoding polynucleotide are fused in frame, are co-transcribed from a single promoter operably associated therewith, and are cotranslated into a single chain antibody or antigen-binding fragment thereof.

130. The vector of claim 126, wherein said VH encoding polynucleotide and said VL encoding polynucleotide are co-transcribed from a single promoter operably associated therewith, but are separately translated.

131. The vector of claim 126, further comprising an IRES sequence disposed between said VH encoding polynucleotide and said VL encoding polynucleotide.

132. The vector of claim 126, wherein said polynucleotide encoding a VH and said polynucleotide encoding a VL are separately transcribed, each being operably associated with a separate promoter.

133. A method of producing an antibody or fragment thereof which specifically binds CD100, comprising culturing the host cell of claim 121, and recovering said antibody, or fragment thereof.

134. A method of producing an antibody or fragment thereof which specifically binds CD100, comprising co-culturing the separate host cells of claim 123, and recovering said antibody, or fragment thereof.

135. A method of producing an antibody or fragment thereof which specifically binds CD100, comprising separately culturing the separate host cells of claim 124, combining said VH and VL encoding polypeptides, and recovering said antibody, or fragment thereof.

136. A host cell comprising the vector of any one of claims 126 or 129 to 132, the first vector of claim 127 or the second vector of claim 128.

137. A method of producing an antibody or fragment thereof which specifically binds CD100, comprising culturing the host cell of claim 136 and recovering said antibody, or fragment thereof.

138. An antibody or fragment thereof which specifically binds CD100, produced by the method of claim 137.

139. A method for neutralizing CD100 in an animal, comprising administering to said animal a composition comprising:

a) the isolated antibody or fragment thereof of any one of claims 3 to 56, 103, and 138; and

b) a pharmaceutically acceptable carrier.

140. A method for treating an autoimmune disease or an inflammatory disease in an animal in need of treatment, comprising administering to said animal a composition comprising:

a) the isolated antibody or fragment thereof of any one of claims 3 to 56, 103, and 138; and

b) a pharmaceutically acceptable carrier.

141. The method of claim 140, wherein said autoimmune disease or said inflammatory disease is multiple sclerosis.

142. The method of claim 140, wherein said autoimmune disease or said inflammatory disease is arthritis.

143. An method of claim 142, wherein said autoimmune disease or said inflammatory disease is rheumatoid arthritis.

144. A method for treating a cancer in an animal in need of treatment, comprising administering to said animal a composition comprising:

a) the isolated antibody or fragment thereof of any one of claims 3 to 56, 103, and 138; and

b) a pharmaceutically acceptable carrier.

145. A method for inhibiting angiogenesis in an animal in need of treatment for cancer, comprising administering to said animal a composition comprising:

a) the isolated antibody or fragment thereof of any one of claims 3 to 56, 103, and 138; and

b) a pharmaceutically acceptable carrier.

146. The method of any one of claims 139 to 145, wherein said antibody or fragment thereof inhibits CD100 binding to a CD100 receptor.

147. The method of claim 146, wherein said CD100 receptor is Plexin-B1.

148. The method of any one of claims 139 to 147, wherein said animal is a mammal.

149. The method of claim 148, wherein said mammal is a human.