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(54) Title: ANTI-MCSP ANTIBODIES

(57) Abstract: The invention provides anti-MCSP antibodies and methods of using the same.

ANTI-MCSP ANTIBODIES

FIELD OF THE INVENTION

The present invention relates to anti-MCSP antibodies and methods of using the same in the treatment and diagnosis of diseases.

BACKGROUND

MCSP

Melanoma chondroitin sulfate proteoglycan (MCSP) is a large transmembrane proteoglycan that is expressed in the majority of melanoma cancers. MCSP is also expressed on other cancers, including glioblastomas, osteosarcomsa, chondrosarcomas, some types of ALL and AML, and in basel cell carcinomas. It serves as an early cell surface melanoma progression marker and is involved in stimulating tumor cell proliferation, metastasis, migration, invasion, and angiogenesis. Staube, E. et al., FEBS Letters, 527: 114-118 (2002); Campoli, M. et al., Crit. Rev. Immun. 24:267-296 (2004); Vergilis, I. J., J Invest Dermatol, 125: 526-531 (2005); Yang, J., JCB, 165: 881-891 (2004); Luo, W., J. Immuno., 176: 6046-6054 (2006).

Antibody Glycosylation

The oligosaccharide component can significantly affect properties relevant to the efficacy of a therapeutic glycoprotein, including physical stability, resistance to protease attack, interactions with the immune system, pharmacokinetics, and specific biological activity. Such properties may depend not only on the presence or absence, but also on the specific structures, of oligosaccharides. Some generalizations between oligosaccharide structure and glycoprotein function can be made. For example, certain oligosaccharide structures mediate rapid clearance of the glycoprotein from the bloodstream through interactions with specific carbohydrate binding proteins, while others can be bound by antibodies and trigger undesired immune reactions (Jenkins et al., Nat Biotechnol 14, 975-81 (1996)).

IgG1 type antibodies, the most commonly used antibodies in cancer immunotherapy, are glycoproteins that have a conserved N-linked glycosylation site at Asn 297 in each CH2 domain. The two complex biantennary oligosaccharides attached to Asn 297 are buried between the CH2 domains, forming extensive contacts with the polypeptide backbone, and their presence is essential for the antibody to mediate effector functions such as antibody dependent cell-mediated cytotoxicity (ADCC) (Lifely et al., Glycobiology 5, 813-822 (1995); Jefferis et al., Immunol Rev 163, 59-76 (1998); Wright and Morrison, Trends Biotechnol 15, 26-32 (1997)).

Cell-mediated effector functions of monoclonal antibodies can be enhanced by engineering their oligosaccharide component as described in Umana et al., Nat Biotechnol 17, 176-180 (1999) and U.S. Pat. No. 6,602,684 (WO 99/54342). Umana et al. showed that overexpression of .beta.(1,4)-N-acetylglucosaminyltransferase III (GnTIII), a glycosyltransferase catalyzing the formation of bisected oligosaccharides, in Chinese hamster ovary (CHO) cells significantly increases the in vitro ADCC activity of antibodies produced in those cells. Alterations in the composition of the Asn 297 carbohydrate or its elimination also affect binding of the antibody Fc-domain to Fc.gamma.R and C1q protein (Umana et al., Nat Biotechnol 17, 176-180 (1999); Davies et al., Biotechnol Bioeng 74, 288-294 (2001); Mimura et al., J Biol Chem 276, 45539-45547 (2001); Radaev et al., J Biol Chem 276, 16478-16483 (2001); Shields et al., J Biol Chem 276, 6591-6604 (2001); Shields et al., J Biol Chem 277, 26733-26740 (2002); Simmons et al., J Immunol Methods 263, 133-147 (2002)).

SUMMARY

The invention provides anti-MCSP antibodies and methods of using the same. One aspect of the invention provides for an isolated antibody that binds to a membrane proximal epitope of human MCSP comprising a CSPG repeat-containing domain, wherein the antibody binds to MCSP with a Kd of $5x10^{-9}$ M or less. In one embodiment, the antibody binds to MCSP with a Kd of $2x10^{-9}$ M or less.

Another aspect of the invention provides for an isolated antibody that binds to a membrane proximal epitope of human MCSP comprising a CSPG repeat-containing domain, wherein the antibody binds to MCSP with an increased affinity of at least 2 fold as compared to the anti-MCSP antibody M4-3/ML2. In one embodiment, the antibody binds to MCSP with an increased affinity of at least 4 fold as compared to the anti-MCSP antibody M4-3/ML2.

In one embodiment, the CSPG repeat-containing domain comprises CSPG repeat 14 (SEQ ID NO: 3). In one embodiment, the antibody is a bispecific antibody. In one embodiment, the antibody is an scFv fragment, an Fv fragment, or a $F(ab')_2$ fragment. In one embodiment, the antibody is a human, humanized, or chimeric antibody. In one embodiment, the the antibody comprises an Fc region. In one embodiment, the antibody is a full-length IgG class antibody. In one embodiment, the antibody has been glycoengineered to modify the oligosaccharides in the Fc region. In one embodiment, the Fc region has a reduced number of fucose residues as compared to the nonglycoengineered antibody. In one embodiment, the antibody has an increased ratio of GlcNAc residues to fucose residues in the Fc region compared to the non-glycoengineered antibody. In one embodiment, the Fc region has an increased proportion of bisected oligosaccharides as compared to the non-glycoengineered antibody. In one embodiment, the Fc region has an increased proportion of bisected oligosaccharides as compared to the non-glycoengineered antibody. In one

embodiment, the antibody has an increased effector function compared to the nonglycoengineere antibody. In one embodiment, the effector function is increased antibody-dependent cell-mediated cytotoxicity (ADCC) activity. In one embodiment, the effector function is increased binding affinity to an Fc receptor.

In one embodiment, the anti-MCSP antibody comprises (a) an HVR-H1 comprising an amino acid sequence selected from among SEQ ID NO: 48 and SEQ ID NO: 58; (b) an HVR-H2 comprising an amino acid sequence selected from among SEQ ID NO: 49, SEQ ID NO: 56, SEQ ID NO: 59, and SEQ ID NO: 61; (c) an HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50; (d) an HVR-L1 comprising an amino acid sequence selected from among SEQ ID NO: 52, SEQ ID NO: 64, and SEQ ID NO: 68; (e) an HVR-L2 comprising an amino acid sequence selected from among SEQ ID NO: 53 and SEQ ID NO: 69; (f) an HVR-L3 comprising an amino acid sequence selected from among SEQ ID NO: 54, SEQ ID NO: 65, and SEQ ID NO: 70.

In one embodiment, the anti-MCSP antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In one embodiment, the anti-MCSP antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54. In one embodiment, the anti-MCSP antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50 and (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54.

In one embodiment, the anti-MCSP antibody comprises (a) a VH sequence having at least 95% sequence identity to the amino acid sequence of SEQ ID NO: 47; (b) a VL sequence having at least 95% sequence identity to the amino acid sequence of SEQ ID NO: 51; or (c) a VH sequence as in (a) and a VL sequence as in (b). In one embodiment, the anti-MCSP antibody comprises a VH sequence of SEQ ID NO: 47. In one embodiment, the anti-MCSP antibody comprises a VL sequence of SEQ ID NO: 51. In one embodiment, the anti-MCSP antibody comprises VH sequence of SEQ ID NO: 47 and a VL sequence of SEQ ID NO: 51.

Another aspect of the invention provides for an isolated nucleic acid encoding an anti-MCSP antibody as described above. Another aspect of the invention provides for a host cell comprising such a nucleic acid. Another aspect of the invention provides for a method of producing an antibody comprising culturing such a host cell so that the antibody is produced.

Another aspect of the invention provides for an immunoconjugate comprising an anti-MCSP antibody as described above and a cytotoxic agent. Another aspect of the invention provides for an immunoconjugate comprising an anti-MCSP antibody as described above and a pharmaceutically acceptable carrier.

Another aspect of the invention provides for an anti-MCSP antibody as described above or immunoconjugate thereof for use as a medicament. Another aspect of the invention provides for an anti-MCSP antibody as described above or an immunoconjugate thereof for treating a cancer, in particular those cancers that express MCSP, including skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML).

Another aspect of the invention provides for use of an anti-MCSP antibody as described above for inducing cell lysis. Another aspect of the invention provides for use of an anti-MCSP antibody as described above or immunoconjugate thereof in the manufacture of a medicament, such as a medicament for treatment of cancer, or for inducing cell lysis.

Another aspect of the invention provides for a method of treating an individual having cancer comprising administering to the individual an effective amount of an anti-MCSP antibody as described above or immunoconjugate thereof. The cancer is, for example, a cancer that expresses MCSP, such as skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML).

Another aspect of the invention provides for a method of inducing cell lysis in an individual comprising administering to the individual an effective amount of an anti-MCSP antibody as described above or immunoconjugate thereof to induce cell lysis.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a graph depicting the results of a FACs assay showing binding affinity of chimeric antibody LC007 for surface MCSP in Colo38 cells.

Figure 2 is a graph depicting the results of a FACs assay showing binding affinity of chimeric antibody LC007 for surface MCSP in A2058 and A375 cancer cells.

Figure 3 is a schematic of the CSPG repeat containing structure of MCSP.

Figure 4 is a graph showing binding specificity of LC007 for MCSP CSPG repeat constructs.

Figure 5 is a graph depicting the results of a FACs assay showing that antibody LC007 binds with similar affinity to the cynomolgus construct as to the corresponding human expression construct.

Figure 6 is a graph showing the ADCC effect of both the non-glycoengineered and glycoengineered LC007 antibody.

Figure 7 is a graph showing that the ADCC effect of the glycoengineered LC007 antibody is observed in the human U86MG glioblastoma cell-line.

Figure 8 is a graph showing the binding properties of several humanized variants of the LC007 antibody.

Figure 9 is a graph showing that the humanized variants of LC007 retain the ADCC activity of the parent glycoengineered LC007 antibody.

Figure 10 is a graph showing that the humanized variants of LC007 retain the ADCC activity of the parent glycoengineered LC007 antibody.

Figure 11 depicts a survival curve showing that a humanized glyco-engineered anti-MCSP antibody significantly increases survival time in FcgR3A transgenic SCID mice harboring a MV3 tumor cell line as compared to the vehicle control.

Figure 12 depicts a survival curve showing that a chimeric glyco-engineered anti-MCSP antibody significantly increases survival time in FcgR3A transgenic SCID mice harboring a MDA-MB-435 tumor cell line as compared to the vehicle control.

Figure 13 depicts a survival curve showing that both the chimeric glyco-engineered anti-MCSP antibody and humanized variant thereof, M4-3 ML2, significantly increase survival time in FcgR3A transgenic SCID mice harboring a MDA-MB-435 tumor cell line as compared to the vehicle control.

Figure 14 depicts an alignment of affinity matured anti-MCSP clones compared to the non-matured parental clone (M4-3 ML2).

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

I. DEFINITIONS

An "acceptor human framework" for the purposes herein is a framework comprising the amino acid sequence of a light chain variable domain (VL) framework or a heavy chain variable domain (VH) framework derived from a human immunoglobulin framework or a human consensus framework, as defined below. An acceptor human framework "derived from" a human immunoglobulin framework or a human consensus framework may comprise the same amino acid sequence thereof, or it may contain amino acid sequence changes. In some embodiments, the number of amino acid changes are 10 or less, 9 or less, 8 or

less, 7 or less, 6 or less, 5 or less, 4 or less, 3 or less, or 2 or less. In some embodiments, the VL acceptor human framework is identical in sequence to the VL human immunoglobulin framework sequence or human consensus framework sequence.

"Affinity" refers to the strength of the sum total of noncovalent interactions between a single binding site of a molecule (e.g., an antibody) and its binding partner (e.g., an antigen). Unless indicated otherwise, as used herein, "binding affinity" refers to intrinsic binding affinity which reflects a 1:1 interaction between members of a binding pair (e.g., antibody and antigen). The affinity of a molecule X for its partner Y can generally be represented by the dissociation constant (Kd). Affinity can be measured by common methods known in the art, including those described herein. Specific illustrative and exemplary embodiments for measuring binding affinity are described in the following.

An "affinity matured" antibody refers to an antibody with one or more alterations in one or more hypervariable regions (HVRs), compared to a parent antibody which does not possess such alterations, such alterations resulting in an improvement in the affinity of the antibody for antigen

An "angiogenic disorder" refers to any dysregulation of angiogenesis, including both non-neoplastic and neoplastic conditions. Neoplastic conditions include but are not limited those described below. Non-neoplastic disorders include but are not limited to undesired or aberrant hypertrophy, arthritis, rheumatoid arthritis (RA), psoriasis, psoriatic plaques, sarcoidosis, atherosclerosis, atherosclerotic plaques, diabetic and other proliferative retinopathies including retinopathy of prematurity, retrolental fibroplasia, neovascular glaucoma, age-related macular degeneration, diabetic macular edema, corneal neovascularization, corneal graft neovascularization, corneal graft rejection, retinal/choroidal neovascularization, neovascularization of the angle (rubeosis), ocular neovascular disease, vascular restenosis, arteriovenous malformations (AVM), meningioma, hemangioma, angiofibroma, thyroid hyperplasias (including Grave's disease), corneal and other tissue transplantation, chronic inflammation, lung inflammation, acute lung injury/ARDS, sepsis, primary pulmonary hypertension, malignant pulmonary effusions, cerebral edema (e.g., associated with acute stroke/ closed head injury/ trauma), synovial inflammation, pannus formation in RA, myositis ossificans, hypertropic bone formation, osteoarthritis (OA), refractory ascites, polycystic ovarian disease, endometriosis, 3rd spacing of fluid diseases (pancreatitis, compartment syndrome, burns, bowel disease), uterine fibroids, premature labor, chronic inflammation such as IBD (Crohn's disease and ulcerative colitis), renal allograft rejection, inflammatory bowel disease, nephrotic syndrome, undesired or aberrant tissue mass growth (non-cancer), hemophilic joints, hypertrophic scars, inhibition of hair growth, Osler-Weber syndrome, pyogenic granuloma retrolental fibroplasias, scleroderma, trachoma, vascular adhesions, synovitis, dermatitis, preeclampsia, ascites, pericardial effusion (such as that associated with pericarditis), and pleural effusion.

The terms “anti-MCSP antibody” and “an antibody that binds to MCSP” refer to an antibody that is capable of binding MCSP with sufficient affinity such that the antibody is useful as a diagnostic and/or therapeutic agent in targeting MCSP. In one embodiment, the extent of binding of an anti-MCSP antibody to an unrelated, non-MCSP protein is less than about 10% of the binding of the antibody to MCSP as measured, e.g., by a radioimmunoassay (RIA). In certain embodiments, an antibody that binds to MCSP has a dissociation constant (Kd) of ≤ 1μM, ≤ 100 nM, ≤ 10 nM, ≤ 5 nM, ≤ 2 nM , ≤ 1 nM, ≤ 0.5 nM, ≤ 0.1 nM, ≤ 0.05 nM, ≤ 0.01 nM, or ≤ 0.001 nM (e.g. 10^{-8} M or less, e.g. from 10^{-8} M to 10^{-13} M, e.g., from 10^{-9} M to 10^{-13} M). In certain embodiments, an anti-MCSP antibody binds to an epitope of MCSP that is conserved among MCSP from different species.

The term "antibody" herein is used in the broadest sense and encompasses various antibody structures, including but not limited to monoclonal antibodies, polyclonal antibodies, multispecific antibodies (e.g., bispecific antibodies), and antibody fragments so long as they exhibit the desired antigen-binding activity.

An "antibody fragment" refers to a molecule other than an intact antibody that comprises a portion of an intact antibody that binds the antigen to which the intact antibody binds. Examples of antibody fragments include but are not limited to Fv, Fab, Fab', Fab’-SH, $F(ab')_2$; diabodies; linear antibodies; single-chain antibody molecules (e.g. scFv); and multispecific antibodies formed from antibody fragments.

An “antibody that binds to the same epitope” as a reference antibody refers to an antibody that blocks binding of the reference antibody to its antigen in a competition assay by 50% or more, and conversely, the reference antibody blocks binding of the antibody to its antigen in a competition assay by 50% or more. An exemplary competition assay is provided herein.

The terms "cancer" and "cancerous" refer to or describe the physiological condition in mammals that is typically characterized by unregulated cell growth/proliferation. Examples of cancer include, but are not limited to, carcinoma, lymphoma (e.g., Hodgkin’s and non-Hodgkin’s lymphoma), blastoma, sarcoma, and leukemia. More particular examples of such cancers include squamous cell cancer, small-cell lung cancer, non-small cell lung cancer, adenocarcinoma of the lung, squamous carcinoma of the lung, cancer of the peritoneum, hepatocellular cancer, cancer of the bone (e.g. osteosarcomas, chondrosarcoma, Ewing’s sarcoma), gastrointestinal cancer, pancreatic cancer, glioma, cervical cancer, ovarian cancer, liver cancer, bladder cancer, hepatoma, breast cancer, colon cancer, colorectal cancer, endometrial or uterine carcinoma, salivary gland carcinoma, kidney cancer, liver cancer, prostate cancer, skin cancer (e.g. melanoma and basel cell carcinoma), vulval cancer, thyroid cancer, hepatic carcinoma, leukemia and other lymphoproliferative disorders, and various types of head and neck cancer.

The terms "cell proliferative disorder" and "proliferative disorder" refer to disorders that are associated with some degree of abnormal cell proliferation. In one embodiment, the cell proliferative disorder is cancer.

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

The "class" of an antibody refers to the type of constant domain or constant region possessed by its heavy chain. There are five major classes of antibodies: IgA, IgD, IgE, IgG, and IgM, and several of these may be further divided into subclasses (isotypes), e.g., IgG_1, IgG_2, IgG_3, IgG_4, IgA_1, and IgA_2. The heavy chain constant domains that correspond to the different classes of immunoglobulins are called α, δ, ε, γ, and μ, respectively.

The term "cytotoxic agent" as used herein refers to a substance that inhibits or prevents a cellular function and/or causes cell death or destruction. Cytotoxic agents include, but are not limited to, radioactive isotopes (e.g., At^{211}, I^{131}, I^{125}, Y^{90}, Re^{186}, Re^{188}, Sm^{153}, Bi^{212}, P^{32}, Pb^{212} and radioactive isotopes of Lu); chemotherapeutic agents or drugs (e.g., methotrexate, adriamicin, vinca alkaloids (vincristine, vinblastine, etoposide), doxorubicin, melphalan, mitomycin C, chlorambucil, daunorubicin or other intercalating agents); growth inhibitory agents; enzymes and fragments thereof such as nucleolytic enzymes; antibiotics; toxins such as small molecule toxins or enzymatically active toxins of bacterial, fungal, plant or animal origin, including fragments and/or variants thereof; and the various antitumor or anticancer agents disclosed below.

"Effector functions" refer to those biological activities attributable to the Fc region of an antibody, which vary with the antibody isotype. Examples of antibody effector functions include: C1q binding and complement dependent cytotoxicity (CDC); Fc receptor binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (e.g. B cell receptor); and B cell activation.

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

The term "Fc region" herein is used to define a C-terminal region of an immunoglobulin heavy chain that contains at least a portion of the constant region. The term includes native sequence Fc regions and variant Fc regions. In one embodiment, a human IgG heavy chain Fc region extends from Cys226, or from Pro230, to the carboxyl-terminus of the heavy chain. However, the C-terminal lysine (Lys447) of the Fc region may or may not be present. Unless otherwise specified herein, numbering of amino acid residues in the Fc region or constant region is according to the EU numbering system, also called the EU index, as

described in Kabat et al., *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD, 1991.

"Framework" or "FR" refers to variable domain residues other than hypervariable region (HVR) residues. The FR of a variable domain generally consists of four FR domains: FR1, FR2, FR3, and FR4. Accordingly, the HVR and FR sequences generally appear in the following sequence in VH (or VL): FR1-H1(L1)-FR2-H2(L2)-FR3-H3(L3)-FR4.

The terms "full length antibody," "intact antibody," and "whole antibody" are used herein interchangeably to refer to an antibody having a structure substantially similar to a native antibody structure or having heavy chains that contain an Fc region as defined herein.

The terms "host cell," "host cell line," and "host cell culture" are used interchangeably and refer to cells into which exogenous nucleic acid has been introduced, including the progeny of such cells. Host cells include "transformants" and "transformed cells," which include the primary transformed cell and progeny derived therefrom without regard to the number of passages. Progeny may not be completely identical in nucleic acid content to a parent cell, but may contain mutations. Mutant progeny that have the same function or biological activity as screened or selected for in the originally transformed cell are included herein.

A "human antibody" is one which possesses an amino acid sequence which corresponds to that of an antibody produced by a human or a human cell or derived from a non-human source that utilizes human antibody repertoires or other human antibody-encoding sequences. This definition of a human antibody specifically excludes a humanized antibody comprising non-human antigen-binding residues.

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

A "humanized" antibody refers to a chimeric antibody comprising amino acid residues from non-human HVRs and amino acid residues from human FRs. In certain embodiments, a humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the HVRs (e.g., CDRs) correspond to those of a non-human antibody, and all or substantially all of the FRs correspond to those of a human antibody. A humanized antibody optionally may comprise at least a portion of an antibody constant region derived from a human antibody. A "humanized form" of an antibody, e.g., a non-human antibody, refers to an antibody that has undergone humanization.

The term "hypervariable region" or "HVR," as used herein, refers to each of the regions of an antibody variable domain which are hypervariable in sequence and/or form structurally defined loops ("hypervariable loops"). Generally, native four-chain antibodies comprise six HVRs; three in the VH (H1, H2, H3), and three in the VL (L1, L2, L3). HVRs generally comprise amino acid residues from the hypervariable loops and/or from the "complementarity determining regions" (CDRs), the latter being of highest sequence variability and/or involved in antigen recognition. Exemplary hypervariable loops occur at amino acid residues 26-32 (L1), 50-52 (L2), 91-96 (L3), 26-32 (H1), 53-55 (H2), and 96-101 (H3). (Chothia and Lesk, *J. Mol. Biol.* 196:901-917 (1987).) Exemplary CDRs (CDR-L1, CDR-L2, CDR-L3, CDR-H1, CDR-H2, and CDR-H3) occur at amino acid residues 24-34 of L1, 50-56 of L2, 89-97 of L3, 31-35B of H1, 50-65 of H2, and 95-102 of H3. (Kabat et al., *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD (1991).) With the exception of CDR1 in VH, CDRs generally comprise the amino acid residues that form the hypervariable loops. CDRs also comprise "specificity determining residues," or "SDRs," which are residues that contact antigen. SDRs are contained within regions of the CDRs called abbreviated-CDRs, or a-CDRs. Exemplary a-CDRs (a-CDR-L1, a-CDR-L2, a-CDR-L3, a-CDR-H1, a-CDR-H2, and a-CDR-H3) occur at amino acid residues 31-34 of L1, 50-55 of L2, 89-96 of L3, 31-35B of H1, 50-58 of H2, and 95-102 of H3. (See Almagro and Fransson, *Front. Biosci.* 13:1619-1633 (2008).) Unless otherwise indicated, HVR residues and other residues in the variable domain (e.g., FR residues) are numbered herein according to Kabat et al., *supra*.

An "immunoconjugate" is an antibody conjugated to one or more heterologous molecule(s), including but not limited to a cytotoxic agent.

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

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

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

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

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

A "naked antibody" refers to an antibody that is not conjugated to a heterologous moiety (e.g., a cytotoxic moiety) or radiolabel. The naked antibody may be present in a pharmaceutical formulation.

"Native antibodies" refer to naturally occurring immunoglobulin molecules with varying structures. For example, native IgG antibodies are heterotetrameric glycoproteins of about 150,000 daltons, composed of two identical light chains and two identical heavy chains that are disulfide-bonded. From N- to C-terminus, each heavy chain has a variable region (VH), also called a variable heavy domain or a heavy chain variable domain, followed by three constant domains (CH1, CH2, and CH3). Similarly, from N- to C-terminus, each light chain has a variable region (VL), also called a variable light domain or a light chain variable domain, followed by a constant light (CL) domain. The light chain of an antibody may be assigned to one of two types, called kappa (κ) and lambda (λ), based on the amino acid sequence of its constant domain.

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

"Percent (%) amino acid sequence identity" with respect to a reference polypeptide sequence is defined as the percentage of amino acid residues in a candidate sequence that are identical with the amino acid residues in the reference polypeptide sequence, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Alignment for purposes of determining percent amino acid sequence identity can be achieved in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST, BLAST-2, ALIGN or Megalign (DNASTAR) software. Those skilled in the art can determine appropriate parameters for aligning sequences, including any algorithms needed to achieve maximal alignment over the full length of the sequences being compared. For purposes herein, however, % amino acid sequence identity values are generated using the sequence comparison computer program ALIGN-2. The ALIGN-2 sequence comparison computer program was authored by Genentech, Inc., and the source code has been filed with user documentation in the U.S. Copyright Office, Washington D.C., 20559, where it is registered under U.S. Copyright Registration No. TXU510087. The ALIGN-2 program is publicly available from Genentech, Inc., South San Francisco, California, or may be compiled from the source code. The ALIGN-2 program should be compiled for use on a UNIX operating system, including digital UNIX V4.0D. All sequence comparison parameters are set by the ALIGN-2 program and do not vary.

In situations where ALIGN-2 is employed for amino acid sequence comparisons, the % amino acid sequence identity of a given amino acid sequence A to, with, or against a given amino acid sequence B (which can alternatively be phrased as a given amino acid sequence A that has or comprises a certain % amino acid sequence identity to, with, or against a given amino acid sequence B) is calculated as follows:

100 times the fraction X/Y

where X is the number of amino acid residues scored as identical matches by the sequence alignment program ALIGN-2 in that program's alignment of A and B, and where Y is the total number of amino acid residues in B. It will be appreciated that where the length of amino acid sequence A is not equal to the length of amino acid sequence B, the % amino acid sequence identity of A to B will not equal the % amino acid sequence identity of B to A. Unless specifically stated otherwise, all % amino acid sequence identity values used herein are obtained as described in the immediately preceding paragraph using the ALIGN-2 computer program.

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

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

The term "MCSP," as used herein, refers to any native MCSP (Melanoma Chondroitin Sulfate Proteoglycan) from any vertebrate source, including mammals such as primates (e.g. humans) and rodents (e.g., mice and rats), unless otherwise indicated. The term encompasses "full-length," unprocessed MCSP as well as any form of MCSP that results from processing in the cell. The term also encompasses naturally occurring variants of MCSP, e.g., splice variants or allelic variants. MCSP is also known as chondroitin sulfate proteoglycan 4 (CSPG4), chondroitin sulfate proteoglycan NG2, high molecular weight-melanoma associated antigen (HMW-MAA), and melanoma chondroitin sulfate proteoglycan. The amino acid sequence of an exemplary human MCSP is shown in SEQ ID NO: 1. See also Pluschke G., et al., Molecular cloning of a human melanoma-associated chondroitin sulfate proteoglycan, Proc. Natl. Acad. Sci. U.S.A. 93:9710-9715(1996), Staub E., et al., A novel repeat in the melanoma-associated chondroitin sulfate proteoglycan defines a new protein family, FEBS Lett. 527:114-118(2002); Genbank AccessionNo: NP_001888.

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

The term "variable region" or "variable domain" refers to the domain of an antibody heavy or light chain that is involved in binding the antibody to antigen. The variable domains of the heavy chain and light chain (VH and VL, respectively) of a native antibody generally have similar structures, with each domain comprising four conserved framework regions (FRs) and three hypervariable regions (HVRs). (See, e.g., Kindt et al. *Kuby Immunology*, 6th ed., W.H. Freeman and Co., page 91 (2007).) A single VH or VL domain may be sufficient to confer antigen-binding specificity. Furthermore, antibodies that bind a particular antigen may be isolated using a VH or VL domain from an antibody that binds the antigen to screen a library of complementary VL or VH domains, respectively. See, e.g., Portolano et al., *J. Immunol.* 150:880-887 (1993); Clarkson et al., *Nature* 352:624-628 (1991).

The term "vector," as used herein, refers to a nucleic acid molecule capable of propagating another nucleic acid to which it is linked. The term includes the vector as a self-replicating nucleic acid structure as

well as the vector incorporated into the genome of a host cell into which it has been introduced. Certain vectors are capable of directing the expression of nucleic acids to which they are operatively linked. Such vectors are referred to herein as "expression vectors."

II. COMPOSITIONS AND METHODS

The invention provides anti-MCSP antibodies that find use in treating and/or diagnosing cell proliferative diseases, such as cancer. In certain embodiments, antibodies that bind to the membrane proximal epitope of MCSP are provided. In certain embodiments, antibodies with enhanced effector function that bind to MCSP are provided.

A. Exemplary Anti-MCSP Antibodies

In one aspect, the invention provides isolated antibodies that bind to MCSP. In particular, the anti-MCSP antibodies provided for in the invention bind to a membrane proximal epitope of human MCSP. As discussed in Staub E., et al., FEBS Lett. 527:114-118(2002), the membrane proximal region of MCSP is comprised of multiple novel repeated domains, referred to as CSPG repeat domains. Figure 3. The anti-MCSP antibodies of the invention bind to an epitope present in the membrane proximal domain of human MCSP comprising a CSPG repeat-containing domain. In one embodiment, the CSPG repeat-containing domain comprises CSPG repeat 14, which corresponds to amino acids amino acids 1937-2043 of human MCSP. In one embodiment, the CSPG repeat 14 domain has the amino acid sequence shown in SEQ ID NO: 3. In another embodiment, the CSPG repeat-containing domain comprises CSPG repeat 14 and at least a portion of CSPG repeat 15. The CSPG repeat 15 domain corresponds to amino acids 2044-2246 of human MCSP. In one embodiment, the CSPG repeat-15 domain has the amino acid sequence of SEQ ID NO: 4. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 5. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 5 without the native transmembrane domain. In one embodiment, the CSPG repeat-containing domain comprises CSPG repeat 13-15. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 6. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 6 without the native transmembrane domain. In one embodiment, the CSPG repeat-containing domain comprises CSPG repeat 12-15. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 7. In one embodiment, the CSPG repeat-containing domain comprises the amino acid sequence of SEQ ID NO: 7 without the native transmembrane domain. In certain embodiments, the native transmembrane domain is VIIPMC LVLLLLALIL PLLFY (UniProt entry Q6UVK1) (SEQ ID NO: 44).

In one embodiment, the anti-MCSP antibodies induce lysis of cells expressing MCSP. Lysis can be induced by any mechanism, such as by mediating an effector function, such as C1q binding and complement dependent cytotoxicity (CDC); Fc receptor binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (e.g. B cell receptor); and B cell activation, or by directly inducing apoptosis of the cells.

In one embodiment, the anti-MCSP antibody is glycoengineered to have at least one increase in effector function as compared to the non-glycoengineered parent anti-MCSP antibody. The increase in effector function is increased binding affinity to an Fc receptor, increased antibody-dependent cellular cytotoxicity (ADCC); increased binding to NK cells; increased binding to macrophages; increased binding to polymorphonuclear cells; increased binding to monocytes; direct signaling inducing apoptosis; increased dendritic cell maturation; or increased T cell priming. The glycoengineered anti-MCSP antibodies provide a survival benefit in subjects suffering from cancers which express MCSP as compared to non-glycoengineered antibodies directed to the same epitope of MCSP.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, two, three, four, five, or six HVRs selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, at least two, or all three VH HVR sequences selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16. In a further embodiment, the antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, an anti-MCSP antibody of the invention comprises (a) a VH domain comprising at least one, at least two, or all three VH HVR sequences selected from (i) HVR-H1 comprising the amino acid

sequence of SEQ ID NO: 14, (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15, and (iii) HVR-H3 comprising an amino acid sequence selected from SEQ ID NO: 16; and (b) a VL domain comprising at least one, at least two, or all three VL HVR sequences selected from (i) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10, (ii) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, the invention provides an anti-MCSP antibody comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 12.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, two, three, four, five, or six HVRs selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, at least two, or all three VH HVR sequences selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16. In a further embodiment, the antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16.

In one aspect, the invention provides an anti-MCSP antibody comprising at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, an anti-MCSP antibody of the invention comprises (a) a VH domain comprising at least one, at least two, or all three VH HVR sequences selected from (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17, (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18, and (iii) HVR-H3 comprising an amino acid sequence selected from SEQ ID NO: 16; and (b) a VL domain comprising at least one, at least two, or all three VL HVR sequences selected from (i) HVR-L1 comprising

the amino acid sequence of SEQ ID NO: 13, (ii) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, the invention provides an anti-MCSP antibody comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 12.

In another aspect, the invention provides an anti-MCSP antibody comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 12.

In another aspect, the invention provides an anti-MCSP antibody comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 12.

In another aspect, the invention provides an anti-MCSP antibody comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 12.

In one aspect, an anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 27. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 27. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 27, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ

ID NO: 14, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 15, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a light chain variable domain (VL) having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 26. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 26. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 26, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a VH as in any of the embodiments provided above, and a VL as in any of the embodiments provided above. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 27 and a VL sequence in SEQ ID NO: 26, including post-translational modifications of those sequences.

In another aspect, an anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 32. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 32. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 32, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 17, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16.

In another aspect, an anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID

NO: 31 In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 31. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence in SEQ ID NO: 31, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 13, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a VH as in any of the embodiments provided above, and a VL as in any of the embodiments provided above. In one embodiment, the antibody comprises the VH comprising the amino acid sequence of SEQ ID NO: 32 and a VL comprising the amino acid sequence of SEQ ID NO: 31, including post-translational modifications of those sequences.

In another aspect, an anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 29. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 29. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 29, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 14, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 18, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 16.

In another aspect, an anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 28. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to

bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 28. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence in SEQ ID NO: 28, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 10, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 11, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 12.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a VH as in any of the embodiments provided above, and a VL as in any of the embodiments provided above. In one embodiment, the antibody comprises the VH comprising the amino acid sequence of SEQ ID NO: 29 and a VL comprising the amino acid sequence of SEQ ID NO: 28, including post-translational modifications of those sequences.

In another aspect, an anti-MCSP antibody comprises a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 35. In certain embodiments, a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 35. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the heavy chain sequence of SEQ ID NO: 35, including post-translational modifications of that sequence.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a light chain having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 34. In certain embodiments, a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 34. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the light chain sequence of SEQ ID NO: 34, including post-translational modifications of that sequence.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a heavy chain as in any of the embodiments provided above, and a light chain in any of the embodiments provided above. In one embodiment, the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 35 and a light chain sequence comprising the amino acide sequence of SEQ ID NO: 34, including post-translational modifications of those sequences.

In another aspect, an anti-MCSP antibody comprises a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 37. In certain embodiments, a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 37. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the heavy chain sequence of SEQ ID NO: 37, including post-translational modifications of that sequence.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a light chain having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 36. In certain embodiments, a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 36. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the light chain sequence of SEQ ID NO: 36, including post-translational modifications of that sequence.

In another aspect, an anti-MCSP antibody is provided, wherein the antibody comprises a heavy chain as in any of the embodiments provided above, and a light chain in any of the embodiments provided above. In one embodiment, the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 37 and a light chain sequence comprising the amino acide sequence of SEQ ID NO: 36, including post-translational modifications of those sequencesIn a further aspect, the invention provides an antibody that binds to the same epitope or epitopes as an anti-MCSP antibody provided herein.

In one embodiment, an antibody is provided that binds to the same epitope as an anti-MCSP antibody having a VH comprising the amino acid sequence of SEQ ID NO: 27 and a VL comprising the amino acid

sequence of SEQ ID NO: 26 In another embodiment, an antibody is provided that binds to the same epitope as an anti-MCSP antibody having a VH comprising the amino acid sequence of SEQ ID NO: 32 and a VL comprising the amino acid sequence of SEQ ID NO: 31.

Another aspect of the invention provides for an anti-MCSP antibody with an increased affinity for its MCSP target, for example, the affinity matured anti-MCSP antibodies described in Example 10. These antibodies bind to MCSP with a Kd of $\leq 5 \times 10^{-9}$ M, $\leq 2 \times 10^{-9}$ M, $\leq 1 \times 10^{-9}$ M, $\leq 5 \times 10^{-10}$ M, $\leq 2 \times 10^{-9}$ M, $\leq 1 \times 10^{-10}$ M, $\leq 5 \times 10^{-11}$ M, $\leq 1 \times 10^{-11}$ M, $\leq 5 \times 10^{-12}$ M, $\leq 1 \times 10^{-12}$ M, or less.

In one embodiment, the invention provides an anti-MCSP antibody which has an increased affinity of at least 1.5 fold, 2 fold, 2.5 fold, 3 fold, 4 fold, 5 fold, 10 fold, 20 fold or greater as compared to the anti-MCSP antibody M4-3/ML2 (SEQ ID NOs: 37 and 36/ SEQ ID NOs: 32 and 31).

In one embodiment of this aspect, the invention provides an anti-MCSP antibody comprising (a) an HVR-H1 comprising an amino acid sequence selected from among SEQ ID NO: 48 and SEQ ID NO: 58; (b) an HVR-H2 comprising an amino acid sequence selected from among SEQ ID NO: 49, SEQ ID NO: 56, SEQ ID NO: 59, and SEQ ID NO: 61; (c) an HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50; (d) an HVR-L1 comprising an amino acid sequence selected from among SEQ ID NO: 52, SEQ ID NO: 64, and SEQ ID NO: 68; (e) an HVR-L2 comprising an amino acid sequence selected from among SEQ ID NO: 53 and SEQ ID NO: 69; (f) an HVR-L3 comprising an amino acid sequence selected from among SEQ ID NO: 54, SEQ ID NO: 65, and SEQ ID NO: 70.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VH HVR sequences selected from an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In a further embodiment, the antibody comprises an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54.

In one embodiment, the anti-MCSP antibody comprises (a) a VH domain comprising at least one, at least two, or all three VH HVR sequences selected from (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48, (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49, and (iii) HVR-H3

comprising an amino acid sequence selected from SEQ ID NO: 50; and (b) a VL domain comprising at least one, at least two, or all three VL HVR sequences selected from (i) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52, (ii) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54.

In one embodiment, the anti-MCSP antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (f) HVR-L3 comprising an amino acid sequence selected from SEQ ID NO: 54.

In one embodiment, the anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 47. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 47. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 47, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises a light chain variable domain (VL) having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 51. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 51. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 51, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54.

In one embodiment, the anti-MCSP antibody comprises a VH as in any of the embodiments provided above, and a VL as in any of the embodiments provided above. In one embodiment, the antibody comprises the VH comprising the amino acid sequence of SEQ ID NO: 47 and a VL comprising the amino acid sequence of SEQ ID NO: 51, including post-translational modifications of those sequences.

In one embodiment, the anti-MCSP antibody comprises a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 45. In certain embodiments, a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 45. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the heavy chain sequence of SEQ ID NO: 45, including post-translational modifications of that sequence.

In one embodiment, the anti-MCSP antibody comprises a light chain having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 46. In certain embodiments, a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 46. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the light chain sequence of SEQ ID NO: 46, including post-translational modifications of that sequence.

In one embodiment, the anti-MCSP antibody comprises a heavy chain as in any of the embodiments provided above, and a light chain in any of the embodiments provided above. In one embodiment, the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 45 and a light chain sequence comprising the amino acide sequence of SEQ ID NO: 46, including post-translational modifications of those sequences.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VH HVR sequences selected from an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 56; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In a further embodiment, the antibody comprises an (a) HVR-H1

comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 56; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 55. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 55. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 55, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 56, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VH HVR sequences selected from an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 58; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In a further embodiment, the antibody comprises an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 58; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 57. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 57. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 57, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 58, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VH HVR sequences selected from an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 61; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In a further embodiment, the antibody comprises an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 61; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 60. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 60. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence of SEQ ID NO: 60, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 61, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VH HVR sequences selected from an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50. In a further embodiment, the antibody comprises an (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 62. In certain embodiments, a VH sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 62. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VH sequence

of SEQ ID NO: 62, including post-translational modifications of that sequence. In a particular embodiment, the VH comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48, (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 59, and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 63. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 63. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 63, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 70. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 70.

In one embodiment, the anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 67. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to

bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 67. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 67, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 70.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 66. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 66. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 66, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 64, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises at least one, at least two, or all three VL HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69 and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65. In one embodiment, the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ

ID NO: 71. In certain embodiments, a VL sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (e.g., conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-MCSP antibody comprising that sequence retains the ability to bind to MCSP. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 71. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the anti-MCSP antibody comprises the VL sequence of SEQ ID NO: 71, including post-translational modifications of that sequence. In a particular embodiment, the VL comprises one, two or three HVRs selected from: (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 68, (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 69, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 65.

In one embodiment, the anti-MCSP antibody comprises a VH as in any of the embodiments provided above, and a VL as in any of the embodiments provided above. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 47 and a VL comprising the amino acid sequence of SEQ ID NO: 63, including post-translational modifications of those sequences. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 57 and a VL comprising the amino acid sequence of SEQ ID NO: 51, including post-translational modifications of those sequences. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 57 and a VL comprising the amino acid sequence of SEQ ID NO: 63, including post-translational modifications of those sequences. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 47 and a VL comprising the amino acid sequence of SEQ ID NO: 67, including post-translational modifications of those sequences. In one embodiment, the antibody comprises a VH comprising the amino acid sequence of SEQ ID NO: 57 and a VL comprising the amino acid sequence of SEQ ID NO: 67, including post-translational modifications of those sequences.

In other embodiments, an antibody is provided that competes for binding to the same epitope as an anti-MCSP antibody as described herein.

In one embodiment, the antibody that binds to the same epitope, and/or competes for binding to the same epitope as an anti-MCSP antibody exhibits effector function activities, such as, for example, Fc-mediated cellular cytotoxicity , including ADCC activity.

In one embodiment, the anti-MCSP antibody binds to a membrane proximal epitope of human MCSP. In one embodiment, the anti-MCSP antibody binds to a membrane proximal epitope of human MCSP comprising a CSPG repeat-containing domain. In one embodiment, anti-MCSP antibody binds to membrane proximal epitope of human MCSP that is from, within, or overlapping the amino acid sequence of SEQ ID NO: 5. In one embodiment, anti-MCSP antibody binds to membrane proximal epitope of human

MCSP that is from, within, or overlapping the amino acid sequence of SEQ ID NO: 4. In one embodiment, anti-MCSP antibody binds to membrane proximal epitope of human MCSP that is from, within, or overlapping the amino acid sequence of SEQ ID NO: 3.

In a further aspect of the invention, an anti-MCSP antibody according to any of the above embodiments is a monoclonal antibody, including a chimeric, humanized or human antibody. In one embodiment, an anti-MCSP antibody is an antibody fragment, e.g., a Fv, Fab, Fab', scFv, diabody, or $F(ab')_2$ fragment. In another embodiment, the antibody is a full length antibody, e.g., an intact IgG1 antibody or other antibody class or isotype as defined herein.

In one embodiment, the anti-MCSP antibody is the mouse monoclonal antibody LC007. The nucleic acid sequences for the heavy and light chains of this antibody are presented in SEQ ID NOs: 37 and 36, respectively. In one embodiment, the anti-MSCP antibody is a chimeric antibody derived from mouse monoclonal antibody LC007. In one embodiment, the anti-MSCP antibody is a humanized antibody derived from mouse monoclonal antibody LC007. In one embodiment, the anti-MSCP antibody is a human antibody derived from mouse monoclonal antibody LC007.

In a further aspect, an anti-MCSP antibody according to any of the above embodiments may incorporate any of the features, singly or in combination, as described in Sections 1-7 below:

1. Antibody Affinity

In certain embodiments, an antibody provided herein has a dissociation constant (Kd) of $\leq$ 1μM, $\leq$ 100 nM, $\leq$ 10 nM, $\leq$ 5 nM, $\leq$ 2 nM , $\leq$ 1 nM, $\leq$ 0.5 nM, $\leq$ 0.1 nM, $\leq$ 0.05 nM, $\leq$ 0.01 nM, or $\leq$ 0.001 nM (e.g. 10^{-8} M or less, e.g. from 10^{-8} M to 10^{-13} M, e.g., from 10^{-9} M to 10^{-13} M).

In one embodiment, Kd is measured by a radiolabeled antigen binding assay (RIA) performed with the Fab version of an antibody of interest and its antigen as described by the following assay. Solution binding affinity of Fabs for antigen is measured by equilibrating Fab with a minimal concentration of (^{125}I)-labeled antigen in the presence of a titration series of unlabeled antigen, then capturing bound antigen with an anti-Fab antibody-coated plate (see, e.g., Chen et al., *J. Mol. Biol.* 293:865-881(1999)). To establish conditions for the assay, MICROTITER® multi-well plates (Thermo Scientific) are coated overnight with 5 μg/ml of a capturing anti-Fab antibody (Cappel Labs) in 50 mM sodium carbonate (pH 9.6), and subsequently blocked with 2% (w/v) bovine serum albumin in PBS for two to five hours at room temperature (approximately 23°C). In a non-adsorbent plate (Nunc #269620), 100 pM or 26 pM [^{125}I]-antigen are mixed with serial dilutions of a Fab of interest (e.g., consistent with assessment of the anti-VEGF antibody, Fab-12, in Presta et al., *Cancer Res.* 57:4593-4599 (1997)). The Fab of interest is then incubated overnight; however, the incubation may continue for a longer period (e.g., about 65 hours) to ensure that equilibrium is reached.

Thereafter, the mixtures are transferred to the capture plate for incubation at room temperature (e.g., for one hour). The solution is then removed and the plate washed eight times with 0.1% polysorbate 20 (TWEEN-20®) in PBS. When the plates have dried, 150 µl/well of scintillant (MICROSCINT-20™; Packard) is added, and the plates are counted on a TOPCOUNT™ gamma counter (Packard) for ten minutes. Concentrations of each Fab that give less than or equal to 20% of maximal binding are chosen for use in competitive binding assays.

According to another embodiment, Kd is measured using surface plasmon resonance assays using a BIACORE®-2000 or a BIACORE®-3000 (BIAcore, Inc., Piscataway, NJ) at 25°C with immobilized antigen CM5 chips at ~10 response units (RU). Briefly, carboxymethylated dextran biosensor chips (CM5, BIACORE, Inc.) are activated with *N*-ethyl-*N'*- (3-dimethylaminopropyl)-carbodiimide hydrochloride (EDC) and *N*-hydroxysuccinimide (NHS) according to the supplier's instructions. Antigen is diluted with 10 mM sodium acetate, pH 4.8, to 5 µg/ml (~0.2 µM) before injection at a flow rate of 5 µl/minute to achieve approximately 10 response units (RU) of coupled protein. Following the injection of antigen, 1 M ethanolamine is injected to block unreacted groups. For kinetics measurements, two-fold serial dilutions of Fab (0.78 nM to 500 nM) are injected in PBS with 0.05% polysorbate 20 (TWEEN-20™) surfactant (PBST) at 25°C at a flow rate of approximately 25 µl/min. Association rates (k_{on}) and dissociation rates (k_{off}) are calculated using a simple one-to-one Langmuir binding model (BIACORE® Evaluation Software version 3.2) by simultaneously fitting the association and dissociation sensorgrams. The equilibrium dissociation constant (Kd) is calculated as the ratio k_{off}/k_{on}. See, e.g., Chen et al., *J. Mol. Biol.* 293:865-881 (1999). If the on-rate exceeds 10^6 M^{-1} s^{-1} by the surface plasmon resonance assay above, then the on-rate can be determined by using a fluorescent quenching technique that measures the increase or decrease in fluorescence emission intensity (excitation = 295 nm; emission = 340 nm, 16 nm band-pass) at 25°C of a 20 nM anti-antigen antibody (Fab form) in PBS, pH 7.2, in the presence of increasing concentrations of antigen as measured in a spectrometer, such as a stop-flow equipped spectrophometer (Aviv Instruments) or a 8000-series SLM-AMINCO™ spectrophotometer (ThermoSpectronic) with a stirred cuvette.

2. *Antibody Fragments*

In certain embodiments, an antibody provided herein is an antibody fragment. Antibody fragments include, but are not limited to, Fab, Fab', Fab'-SH, $F(ab')_2$, Fv, and scFv fragments, and other fragments described below. For a review of certain antibody fragments, see Hudson et al. *Nat. Med.* 9:129-134 (2003). For a review of scFv fragments, see, e.g., Pluckthün, in *The Pharmacology of Monoclonal Antibodies*, vol. 113, Rosenburg and Moore eds., (Springer-Verlag, New York), pp. 269-315 (1994); see also WO 93/16185; and U.S. Patent Nos. 5,571,894 and 5,587,458. For discussion of Fab and $F(ab')_2$ fragments comprising

salvage receptor binding epitope residues and having increased in vivo half-life, see U.S. Patent No. 5,869,046.

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

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

Antibody fragments can be made by various techniques, including but not limited to proteolytic digestion of an intact antibody as well as production by recombinant host cells (e.g. *E. coli* or phage), as described herein.

3. Chimeric and Humanized Antibodies

In certain embodiments, an antibody provided herein is a chimeric antibody. Certain chimeric antibodies are described, e.g., in U.S. Patent No. 4,816,567; and Morrison et al., *Proc. Natl. Acad. Sci. USA*, 81:6851-6855 (1984)). In one example, a chimeric antibody comprises a non-human variable region (e.g., a variable region derived from a mouse, rat, hamster, rabbit, or non-human primate, such as a monkey) and a human constant region. In a further example, a chimeric antibody is a "class switched" antibody in which the class or subclass has been changed from that of the parent antibody. Chimeric antibodies include antigen-binding fragments thereof.

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

Humanized antibodies and methods of making them are reviewed, e.g., in Almagro and Fransson, *Front. Biosci.* 13:1619-1633 (2008), and are further described, e.g., in Riechmann et al., *Nature* 332:323-329 (1988); Queen et al., *Proc. Nat'l Acad. Sci. USA* 86:10029-10033 (1989); US Patent Nos. 5, 821,337,

7,527,791, 6,982,321, and 7,087,409; Kashmiri *et al.*, *Methods* 36:25-34 (2005) (describing SDR (a-CDR) grafting); Padlan, *Mol. Immunol.* 28:489-498 (1991) (describing "resurfacing"); Dall'Acqua et al., *Methods* 36:43-60 (2005) (describing "FR shuffling"); and Osbourn et al., *Methods* 36:61-68 (2005) and Klimka et al., *Br. J. Cancer*, 83:252-260 (2000) (describing the "guided selection" approach to FR shuffling).

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

4. Human Antibodies

In certain embodiments, an antibody provided herein is a human antibody. Human antibodies can be produced using various techniques known in the art. Human antibodies are described generally in van Dijk and van de Winkel, *Curr. Opin. Pharmacol.* 5: 368-74 (2001) and Lonberg, *Curr. Opin. Immunol.* 20:450-459 (2008).

Human antibodies may be prepared by administering an immunogen to a transgenic animal that has been modified to produce intact human antibodies or intact antibodies with human variable regions in response to antigenic challenge. Such animals typically contain all or a portion of the human immunoglobulin loci, which replace the endogenous immunoglobulin loci, or which are present extrachromosomally or integrated randomly into the animal's chromosomes. In such transgenic mice, the endogenous immunoglobulin loci have generally been inactivated. For review of methods for obtaining human antibodies from transgenic animals, see Lonberg, *Nat. Biotech.* 23:1117-1125 (2005). See also, e.g., U.S. Patent Nos. 6,075,181 and 6,150,584 describing XENOMOUSE™ technology; U.S. Patent No. 5,770,429 describing HUMAB® technology; U.S. Patent No. 7,041,870 describing K-M MOUSE® technology, and U.S. Patent Application Publication No. US 2007/0061900, describing VELOCIMOUSE® technology). Human variable regions from intact antibodies generated by such animals may be further modified, e.g., by combining with a different human constant region.

Human antibodies can also be made by hybridoma-based methods. Human myeloma and mouse-human heteromyeloma cell lines for the production of human monoclonal antibodies have been described. (See, e.g., Kozbor *J. Immunol.*, 133: 3001 (1984); Brodeur et al., *Monoclonal Antibody Production Techniques and Applications*, pp. 51-63 (Marcel Dekker, Inc., New York, 1987); and Boerner et al., *J.*

Immunol., 147: 86 (1991).) Human antibodies generated via human B-cell hybridoma technology are also described in Li et al., *Proc. Natl. Acad. Sci. USA*, 103:3557-3562 (2006). Additional methods include those described, for example, in U.S. Patent No. 7,189,826 (describing production of monoclonal human IgM antibodies from hybridoma cell lines) and Ni, *Xiandai Mianyixue*, 26(4):265-268 (2006) (describing human-human hybridomas). Human hybridoma technology (Trioma technology) is also described in Vollmers and Brandlein, *Histology and Histopathology*, 20(3):927-937 (2005) and Vollmers and Brandlein, *Methods and Findings in Experimental and Clinical Pharmacology*, 27(3):185-91 (2005).

Human antibodies may also be generated by isolating Fv clone variable domain sequences selected from human-derived phage display libraries. Such variable domain sequences may then be combined with a desired human constant domain. Techniques for selecting human antibodies from antibody libraries are described below.

5. Library-Derived Antibodies

Antibodies of the invention may be isolated by screening combinatorial libraries for antibodies with the desired activity or activities. For example, a variety of methods are known in the art for generating phage display libraries and screening such libraries for antibodies possessing the desired binding characteristics. Such methods are reviewed, e.g., in Hoogenboom et al. in *Methods in Molecular Biology* 178:1-37 (O'Brien et al., ed., Human Press, Totowa, NJ, 2001) and further described, e.g., in the McCafferty et al., *Nature* 348:552-554; Clackson et al., *Nature* 352: 624-628 (1991); Marks et al., *J. Mol. Biol.* 222: 581-597 (1992); Marks and Bradbury, in *Methods in Molecular Biology* 248:161-175 (Lo, ed., Human Press, Totowa, NJ, 2003); Sidhu et al., *J. Mol. Biol.* 338(2): 299-310 (2004); Lee et al., *J. Mol. Biol.* 340(5): 1073-1093 (2004); Fellouse, *Proc. Natl. Acad. Sci. USA* 101(34): 12467-12472 (2004); and Lee et al., *J. Immunol. Methods* 284(1-2): 119-132(2004).

In certain phage display methods, repertoires of VH and VL genes are separately cloned by polymerase chain reaction (PCR) and recombined randomly in phage libraries, which can then be screened for antigen-binding phage as described in Winter et al., *Ann. Rev. Immunol.*, 12: 433-455 (1994). Phage typically display antibody fragments, either as single-chain Fv (scFv) fragments or as Fab fragments. Libraries from immunized sources provide high-affinity antibodies to the immunogen without the requirement of constructing hybridomas. Alternatively, the naive repertoire can be cloned (e.g., from human) to provide a single source of antibodies to a wide range of non-self and also self antigens without any immunization as described by Griffiths et al., *EMBO J,* 12: 725-734 (1993). Finally, naive libraries can also be made synthetically by cloning unrearranged V-gene segments from stem cells, and using PCR primers containing random sequence to encode the highly variable CDR3 regions and to accomplish rearrangement *in vitro*, as described by Hoogenboom and Winter, *J. Mol. Biol.*, 227: 381-388 (1992). Patent publications

describing human antibody phage libraries include, for example: US Patent No. 5,750,373, and US Patent Publication Nos. 2005/0079574, 2005/0119455, 2005/0266000, 2007/0117126, 2007/0160598, 2007/0237764, 2007/0292936, and 2009/0002360.

Antibodies or antibody fragments isolated from human antibody libraries are considered human antibodies or human antibody fragments herein.

6. Multispecific Antibodies

In certain embodiments, an antibody provided herein is a multispecific antibody, e.g. a bispecific antibody. Multispecific antibodies are monoclonal antibodies that have binding specificities for at least two different sites. In certain embodiments, one of the binding specificities is for MCSP and the other is for any other antigen. In certain embodiments, bispecific antibodies may bind to two different epitopes of MCSP. Bispecific antibodies may also be used to localize cytotoxic agents to cells which express MCSP. Bispecific antibodies can be prepared as full length antibodies or antibody fragments.

Techniques for making multispecific antibodies include, but are not limited to, recombinant co-expression of two immunoglobulin heavy chain-light chain pairs having different specificities (see Milstein and Cuello, *Nature* 305: 537 (1983)), WO 93/08829, and Traunecker et al., *EMBO J.* 10: 3655 (1991)), and "knob-in-hole" engineering (see, e.g., U.S. Patent No. 5,731,168). Multi-specific antibodies may also be made by engineering electrostatic steering effects for making antibody Fc-heterodimeric molecules (WO 2009/089004A1); cross-linking two or more antibodies or fragments (see, e.g., US Patent No. 4,676,980, and Brennan et al., *Science*, 229: 81 (1985)); using leucine zippers to produce bi-specific antibodies (see, e.g., Kostelny et al., *J. Immunol.*, 148(5):1547-1553 (1992)); using "diabody" technology for making bispecific antibody fragments (see, e.g., Hollinger et al., *Proc. Natl. Acad. Sci. USA*, 90:6444-6448 (1993)); and using single-chain Fv (sFv) dimers (see,e.g. Gruber et al., *J. Immunol.*, 152:5368 (1994)); and preparing trispecific antibodies as described, e.g., in Tutt et al. *J. Immunol.* 147: 60 (1991).

Engineered antibodies with three or more functional antigen binding sites, including "Octopus antibodies," are also included herein (see, e.g. US 2006/0025576A1).

The antibody or fragment herein also includes a "Dual Acting FAb" or "DAF" comprising an antigen binding site that binds to MCSP as well as another, different antigen (see, US 2008/0069820, for example).

7. Antibody Variants

In certain embodiments, amino acid sequence variants of the antibodies provided herein are contemplated. For example, it may be desirable to improve the binding affinity and/or other biological properties of the antibody. Amino acid sequence variants of an antibody may be prepared by introducing appropriate modifications into the nucleotide sequence encoding the antibody, or by peptide synthesis. Such

modifications include, for example, deletions from, and/or insertions into and/or substitutions of residues within the amino acid sequences of the antibody. Any combination of deletion, insertion, and substitution can be made to arrive at the final construct, provided that the final construct possesses the desired characteristics, e.g., antigen-binding.

a) **Substitution, Insertion, and Deletion Variants**

In certain embodiments, antibody variants having one or more amino acid substitutions are provided. Sites of interest for substitutional mutagenesis include the HVRs and FRs. Conservative substitutions are shown in Table 1 under the heading of "conservative substitutions." More substantial changes are provided in Table 1 under the heading of "exemplary substitutions," and as further described below in reference to amino acid side chain classes. Amino acid substitutions may be introduced into an antibody of interest and the products screened for a desired activity, e.g., retained/improved antigen binding, decreased immunogenicity, or improved ADCC or CDC.

TABLE 1

Original Residue	Exemplary Substitutions	Preferred Substitutions
Ala (A)	Val; Leu; Ile	Val
Arg (R)	Lys; Gln; Asn	Lys
Asn (N)	Gln; His; Asp, Lys; Arg	Gln
Asp (D)	Glu; Asn	Glu
Cys (C)	Ser; Ala	Ser
Gln (Q)	Asn; Glu	Asn
Glu (E)	Asp; Gln	Asp
Gly (G)	Ala	Ala
His (H)	Asn; Gln; Lys; Arg	Arg
Ile (I)	Leu; Val; Met; Ala; Phe; Norleucine	Leu
Leu (L)	Norleucine; Ile; Val; Met; Ala; Phe	Ile
Lys (K)	Arg; Gln; Asn	Arg
Met (M)	Leu; Phe; Ile	Leu
Phe (F)	Trp; Leu; Val; Ile; Ala; Tyr	Tyr
Pro (P)	Ala	Ala

Original Residue	Exemplary Substitutions	Preferred Substitutions
Ser (S)	Thr	Thr
Thr (T)	Val; Ser	Ser
Trp (W)	Tyr; Phe	Tyr
Tyr (Y)	Trp; Phe; Thr; Ser	Phe
Val (V)	Ile; Leu; Met; Phe; Ala; Norleucine	Leu

Amino acids may be grouped according to common side-chain properties:

(1) hydrophobic: Norleucine, Met, Ala, Val, Leu, Ile;

(2) neutral hydrophilic: Cys, Ser, Thr, Asn, Gln;

(3) acidic: Asp, Glu;

(4) basic: His, Lys, Arg;

(5) residues that influence chain orientation: Gly, Pro;

(6) aromatic: Trp, Tyr, Phe.

Non-conservative substitutions will entail exchanging a member of one of these classes for another class.

One type of substitutional variant involves substituting one or more hypervariable region residues of a parent antibody (*e.g.* a humanized or human antibody). Generally, the resulting variant(s) selected for further study will have modifications (e.g., improvements) in certain biological properties (e.g., increased affinity, reduced immunogenicity) relative to the parent antibody and/or will have substantially retained certain biological properties of the parent antibody. An exemplary substitutional variant is an affinity matured antibody, which may be conveniently generated, e.g., using phage display-based affinity maturation techniques such as those described herein. Briefly, one or more HVR residues are mutated and the variant antibodies displayed on phage and screened for a particular biological activity (e.g. binding affinity).

Alterations (e.g., substitutions) may be made in HVRs, e.g., to improve antibody affinity. Such alterations may be made in HVR "hotspots," i.e., residues encoded by codons that undergo mutation at high frequency during the somatic maturation process (see, e.g., Chowdhury, *Methods Mol. Biol.* 207:179-196 (2008)), and/or SDRs (a-CDRs), with the resulting variant VH or VL being tested for binding affinity. Affinity maturation by constructing and reselecting from secondary libraries has been described, e.g., in Hoogenboom et al. in *Methods in Molecular Biology* 178:1-37 (O'Brien et al., ed., Human Press, Totowa, NJ, (2001).) In some embodiments of affinity maturation, diversity is introduced into the variable genes chosen for maturation by any of a variety of methods (e.g., error-prone PCR, chain shuffling, or

oligonucleotide-directed mutagenesis). A secondary library is then created. The library is then screened to identify any antibody variants with the desired affinity. Another method to introduce diversity involves HVR-directed approaches, in which several HVR residues (e.g., 4-6 residues at a time) are randomized. HVR residues involved in antigen binding may be specifically identified, e.g., using alanine scanning mutagenesis or modeling. CDR-H3 and CDR-L3 in particular are often targeted.

In certain embodiments, substitutions, insertions, or deletions may occur within one or more HVRs so long as such alterations do not substantially reduce the ability of the antibody to bind antigen. For example, conservative alterations (e.g., conservative substitutions as provided herein) that do not substantially reduce binding affinity may be made in HVRs. Such alterations may be outside of HVR "hotspots" or SDRs. In certain embodiments of the variant VH and VL sequences provided above, each HVR either is unaltered, or contains no more than one, two or three amino acid substitutions.

A useful method for identification of residues or regions of an antibody that may be targeted for mutagenesis is called "alanine scanning mutagenesis" as described by Cunningham and Wells (1989) *Science*, 244:1081-1085. In this method, a residue or group of target residues (e.g., charged residues such as arg, asp, his, lys, and glu) are identified and replaced by a neutral or negatively charged amino acid (e.g., alanine or polyalanine) to determine whether the interaction of the antibody with antigen is affected. Further substitutions may be introduced at the amino acid locations demonstrating functional sensitivity to the initial substitutions. Alternatively, or additionally, a crystal structure of an antigen-antibody complex to identify contact points between the antibody and antigen. Such contact residues and neighboring residues may be targeted or eliminated as candidates for substitution. Variants may be screened to determine whether they contain the desired properties.

Amino acid sequence insertions include amino- and/or carboxyl-terminal fusions ranging in length from one residue to polypeptides containing a hundred or more residues, as well as intrasequence insertions of single or multiple amino acid residues. Examples of terminal insertions include an antibody with an N-terminal methionyl residue. Other insertional variants of the antibody molecule include the fusion to the N- or C-terminus of the antibody to an enzyme (e.g. for ADEPT) or a polypeptide which increases the serum half-life of the antibody.

b) Glycosylation variants

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

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

In one embodiment, antibody variants are provided having a carbohydrate structure that lacks fucose attached (directly or indirectly) to an Fc region. For example, the amount of fucose in such antibody may be from 1% to 80%, from 1% to 65%, from 5% to 65% or from 20% to 40%. The amount of fucose is determined by calculating the average amount of fucose within the sugar chain at Asn297, relative to the sum of all glycostructures attached to Asn 297 (e. g. complex, hybrid and high mannose structures) as measured by MALDI-TOF mass spectrometry, as described in WO 2008/077546, for example. Asn297 refers to the asparagine residue located at about position 297 in the Fc region (Eu numbering of Fc region residues); however, Asn297 may also be located about ± 3 amino acids upstream or downstream of position 297, i.e., between positions 294 and 300, due to minor sequence variations in antibodies. Such fucosylation variants may have improved ADCC function. See, e.g., US Patent Publication Nos. US 2003/0157108 (Presta, L.); US 2004/0093621 (Kyowa Hakko Kogyo Co., Ltd). Examples of publications related to "defucosylated" or "fucose-deficient" antibody variants include: US 2003/0157108; WO 2000/61739; WO 2001/29246; US 2003/0115614; US 2002/0164328; US 2004/0093621; US 2004/0132140; US 2004/0110704; US 2004/0110282; US 2004/0109865; WO 2003/085119; WO 2003/084570; WO 2005/035586; WO 2005/035778; WO2005/053742; WO2002/031140; Okazaki et al. *J. Mol. Biol.* 336:1239-1249 (2004); Yamane-Ohnuki et al. *Biotech. Bioeng.* 87: 614 (2004). Examples of cell lines capable of producing defucosylated antibodies include Lec13 CHO cells deficient in protein fucosylation (Ripka et al. *Arch. Biochem. Biophys.* 249:533-545 (1986); US Pat Appl No US 2003/0157108 A1, Presta, L; and WO 2004/056312 A1, Adams *et al.*, especially at Example 11), and knockout cell lines, such as alpha-1,6-fucosyltransferase gene, *FUT8,* knockout CHO cells (see, e.g., Yamane-Ohnuki et al. *Biotech. Bioeng.* 87: 614 (2004); Kanda, Y. et al., *Biotechnol. Bioeng.*, 94(4):680-688 (2006); and WO2003/085107).

Antibodies variants are further provided with bisected oligosaccharides, e.g., in which a biantennary oligosaccharide attached to the Fc region of the antibody is bisected by GlcNAc. Such antibody variants may have reduced fucosylation and/or improved ADCC function. Examples of such antibody variants are described, e.g., in WO 2003/011878 (Jean-Mairet et al.); US Patent No. 6,602,684 (Umana et al.); and US

2005/0123546 (Umana *et al.*). Antibody variants with at least one galactose residue in the oligosaccharide attached to the Fc region are also provided. Such antibody variants may have improved CDC function. Such antibody variants are described, e.g., in WO 1997/30087 (Patel et al.); WO 1998/58964 (Raju, S.); and WO 1999/22764 (Raju, S.).

Accordingly, the present invention is further directed to a method for modifying the glycosylation profile of the anti-MCSP antibodies of the present invention that are produced by a host cell, comprising expressing in said host cell a nucleic acid encoding an anti-MCSP antibody of the invention and a nucleic acid encoding a polypeptide with a glycosyltransferase activity, or a vector comprising such nucleic acids. Genes with glycosyltransferase activity include β(1,4)-N-acetylglucosaminyltransferase III (GnTII), α-mannosidase II (ManII), β(1,4)-galactosyltransferase (GalT), β(1,2)-N-acetylglucosaminyltransferase I (GnTI), and β(1,2)-N-acetylglucosaminyltransferase II (GnTII). In one embodiment, a combination of genes with glycosyltransferase activity are expressed in the host cell (e.g., GnTIII and Man II). Likewise, the method also encompasses expression of one or more polynucleotide(s) encoding an anti-MCSP antibody in a host cell in which a glycosyltransferase gene has been disrupted or otherwise deactivated (e.g., a host cell in which the activity of the gene encoding α1-6 core fucosyltransferase has been knocked out). In another embodiment, the anti-MCSP antibodies of the present invention can be produced in a host cell that further expresses a polynucleotide encoding a polypeptide having GnTIII activity to modify the glycosylation pattern. In a specific embodiment, the polypeptide having GnTIII activity is a fusion polypeptide comprising the Golgi localization domain of a Golgi resident polypeptide. The term Golgi localization domain refers to the amino acid sequence of a Golgi resident polypeptide which is responsible for anchoring the polypeptide in location within the Golgi complex. Generally, localization domains comprise amino terminal "tails" of an enzyme. In another preferred embodiment, the expression of the anti-MCSP antibodies of the present invention in a host cell that expresses a polynucleotide encoding a polypeptide having GnTIII activity results in anti-MCSP antibodies with increased Fc receptor binding affinity and increased effector function. Accordingly, in one embodiment, the present invention is directed to a host cell comprising (a) an isolated nucleic acid comprising a sequence encoding a polypeptide having GnTIII activity; and (b) an isolated polynucleotide encoding an anti-MCSP antibody of the present invention, such as a chimeric, primatized or humanized antibody that binds human MCSP. In a preferred embodiment, the polypeptide having GnTIII activity is a fusion polypeptide comprising the catalytic domain of GnTIII and the Golgi localization domain is the localization domain of mannosidase II. Methods for generating such fusion polypeptides and using them to produce antibodies with increased effector functions are disclosed in U.S. Provisional Pat. Appl. No. 60/495,142 and U.S. Pat. Appl. Publ. No. 2004/0241817, the entire contents of which are expressly incorporated herein by reference. In a particular embodiment, the modified anti-MCSP antibody produced by

the host cell has an IgG constant region or a fragment thereof comprising the Fc region. In another particular embodiment the anti-MCSP antibody is a humanized antibody or a fragment thereof comprising an Fc region.

Anti-MCSP antibodies with altered glycosylation produced by the host cells of the invention typically exhibit increased Fc receptor binding affinity and/or increased effector function as a result of the modification of the host cell (e.g., by expression of a glycosyltransferase gene). Preferably, the increased Fc receptor binding affinity is increased binding to a Fcγ activating receptor, such as the FcγRIIIa receptor. The increased effector function is preferably an increase in one or more of the following: increased antibody-dependent cellular cytotoxicity, increased antibody-dependent cellular phagocytosis (ADCP), increased cytokine secretion, increased immune-complex-mediated antigen uptake by antigen-presenting cells, increased Fc-mediated cellular cytotoxicity, increased binding to NK cells, increased binding to macrophages, increased binding to polymorphonuclear cells (PMNs), increased binding to monocytes, increased crosslinking of target-bound antibodies, increased direct signaling inducing apoptosis, increased dendritic cell maturation, and increased T cell priming.

In one aspect, the present invention provides glycoforms of an anti-MCSP antibody (e.g., variant antibody) having increased effector function as compared to the anti-MCSP antibody that has not been glycoengineered, including antibody-dependent cellular cytotoxicity. Glycosylation engineering of antibodies has been previously described. See, e.g., U.S. Patent No. 6,602,684, incorporated herein by reference in its entirety. Methods of producing anti-MCSP antibodies from host cells that have altered activity of genes involved in glyocsylation are also described herein in detail (See, e.g, preceding section entitled "Expression Vectors and Host Cells"). Increases in ADCC of the anti-MCSP antibodies of the present invention is also achieved by increasing affinity of the antibody for MCSP, for example by affinity maturation or other methods of improving affinity (see Tang et al., J. Immunol. 2007, 179:2815-2823). Combinations of these approaches are also encompassed by the present invention.

Clinical trials of unconjugated monoclonal antibodies (mAbs) for the treatment of some types of cancer have recently yielded encouraging results. Dillman, Cancer Biother. & Radiopharm. 12:223-25 (1997); Deo et al., Immunology Today 18:127 (1997). A chimeric, unconjugated IgG1 has been approved for low-grade or follicular B-cell non-Hodgkin's lymphoma. Dillman, Cancer Biother. & Radiopharm. 12:223-25 (1997), while another unconjugated mAb, a humanized IgG1 targeting solid breast tumors, has also showed promising results in phase III clinical trials. Deo et al., Immunology Today 18:127 (1997). The antigens of these two mAbs are highly expressed in their respective tumor cells and the antibodies mediate potent tumor destruction by effector cells in vitro and in vivo. In contrast, many other unconjugated mAbs with fine tumor specificities cannot trigger effector functions of sufficient potency to be clinically useful. Frost et al., Cancer 80:317-33 (1997); Surfus et al., J. Immunother. 19:184-91 (1996). For some of these weaker mAbs, adjunct

cytokine therapy is currently being tested. Addition of cytokines can stimulate antibody-dependent cellular cytotoxicity (ADCC) by increasing the activity and number of circulating lymphocytes. Frost et al., Cancer 80:317-33 (1997); Surfus et al., J. Immunother. 19:184-91 (1996). ADCC, a lytic attack on targeted cells, is triggered upon binding of leukocyte receptors to the constant region (Fc) of antibodies. Deo et al., Immunology Today 18:127 (1997).

A different, but complementary, approach to increase ADCC activity of unconjugated IgG1s is to engineer the Fc region of the antibody. Protein engineering studies have shown that FcγRs interact with the lower hinge region of the IgG CH2 domain. Lund et al., J. Immunol. 157:4963-69 (1996). However, FcγR binding also requires the presence of oligosaccharides covalently attached at the conserved Asn 297 in the CH2 region. Lund et al., J. Immunol. 157:4963-69 (1996); Wright and Morrison, Trends Biotech. 15:26-31 (1997), suggesting that either oligosaccharide and polypeptide both directly contribute to the interaction site or that the oligosaccharide is required to maintain an active CH2 polypeptide conformation. Modification of the oligosaccharide structure can therefore be explored as a means to increase the affinity of the interaction.

An IgG molecule carries two N-linked oligosaccharides in its Fc region, one on each heavy chain. As any glycoprotein, an antibody is produced as a population of glycoforms which share the same polypeptide backbone but have different oligosaccharides attached to the glycosylation sites. The oligosaccharides normally found in the Fc region of serum IgG are of complex bi-antennary type (Wormald et al., Biochemistry 36:130-38 (1997), with a low level of terminal sialic acid and bisecting N-acetylglucosamine (GlcNAc), and a variable degree of terminal galactosylation and core fucosylation. Some studies suggest that the minimal carbohydrate structure required for FcγR binding lies within the oligosaccharide core. Lund et al., J. Immunol. 157:4963-69 (1996).

The mouse- or hamster-derived cell lines used in industry and academia for production of unconjugated therapeutic mAbs normally attach the required oligosaccharide determinants to Fc sites. IgGs expressed in these cell lines lack, however, the bisecting GlcNAc found in low amounts in serum IgGs. Lifely et al., Glycobiology 318:813-22 (1995). In contrast, it was recently observed that a rat myeloma-produced, humanized IgG1 (CAMPATH-1H) carried a bisecting GlcNAc in some of its glycoforms. Lifely et al., Glycobiology 318:813-22 (1995). The rat cell-derived antibody reached a similar maximal in vitro ADCC activity as CAMPATH-1H antibodies produced in standard cell lines, but at significantly lower antibody concentrations.

The CAMPATH antigen is normally present at high levels on lymphoma cells, and this chimeric mAb has high ADCC activity in the absence of a bisecting GlcNAc. Lifely et al., Glycobiology 318:813-22 (1995). In the N-linked glycosylation pathway, a bisecting GlcNAc is added by GnTIII. Schachter, Biochem. Cell Biol. 64:163-81 (1986).

Previous studies used a single, antibody-producing CHO cell line that was previously engineered to express, in an externally-regulated fashion, different levels of a cloned GnTIII enzyme gene (Umaña, P., et al., Nature Biotechnol. 17:176-180 (1999)). This approach established for the first time a rigorous correlation between expression of a glycosyltransferase (e.g., GnTIII) and the ADCC activity of the modified antibody. Thus, the invention contemplates an anti-MCSP antibody, comprising an Fc region or region equivalent to an Fc region having altered glycosylation resulting from changing the expression level of a glycosyltransferase gene in the antibody-producing host cell. In a specific embodiment, the change in gene expression level is an increase in GnTIII activity. Increased GnTIII activity results in an increase in the percentage of bisected oligosaccharides, as well as a decrease in the percentage of fucose residues, in the Fc region of the antibody. This antibody, or fragment thereof, has increased Fc receptor binding affinity and increased effector function.

The present invention is also directed to a method for producing an anti-MCSP antibody of the present invention having modified oligosaccharides, comprising (a) culturing a host cell engineered to express at least one nucleic acid encoding a polypeptide having glycosyltransferase activity under conditions which permit the production of an anti-MCSP antibody according to the present invention, wherein said polypeptide having glycosyltransferase activity is expressed in an amount sufficient to modify the oligosaccharides in the Fc region of said anti-MCSP antibody produced by said host cell; and (b) isolating said anti-MCSP antibody. In one embodiment, the polypeptide having glycosyltransferase activity is GnTIII. In another embodiment, there are two polypeptides having glycosyltransferase activity. In a particular embodiment, the two peptides having glycosyltransferase activity are GnTIII and ManII. In another embodiment, the polypeptide having glycosltransferase activity is a fusion polypeptide comprising the catalytic domain of GnTIII. In a more specific embodiment, the fusion polypeptide further comprises the Golgi localization domain of a Golgi resident polypeptide. Preferably, the Golgi localization domain is the localization domain of mannosidase II or GnTI. Alternatively, the Golgi localization domain is selected from the group consisting of: the localization domain of mannosidase I, the localization domain of GnTII, and the localization domain of α 1-6 core fucosyltransferase. The anti-MCSP antibodies produced by the methods of the present invention have increased Fc receptor binding affinity and/or increased effector function. Generally, the increased effector function is one or more of the following: increased Fc-mediated cellular cytotoxicity (including increased antibody-dependent cellular cytotoxicity), increased antibody-dependent cellular phagocytosis (ADCP), increased cytokine secretion, increased immune-complex-mediated antigen uptake by antigen-presenting cells, increased binding to NK cells, increased binding to macrophages, increased binding to monocytes, increased binding to polymorphonuclear cells, increased direct signaling inducing apoptosis, increased crosslinking of target-bound antibodies, increased dendritic cell maturation, or

increased T cell priming. The increased Fc receptor binding affinity is preferably increased binding to Fc activating receptors such as FcγRIIIa. In a particularly preferred embodiment the ABM is a humanized antibody or a fragment thereof.

In one embodiment, the percentage of bisected N-linked oligosaccharides in the Fc region of the anti-MCSP antibody is at least about 10% to about 100%, specifically at least about 50%, more specifically, at least about 60%, at least about 70%, at least about 80%, or at least about 90-95% of the total oligosaccharides. In yet another embodiment, the antibody produced by the methods of the invention has an increased proportion of nonfucosylated oligosaccharides in the Fc region as a result of the modification of its oligosaccharides by the methods of the present invention. In one embodiment, the percentage of nonfucosylated oligosaccharides is at least about 20% to about 100%, specifically at least about 50%, at least about 60% to about 70%, and more specifically, at least about 75%. The nonfucosylated oligosaccharides may be of the hybrid or complex type. In yet another embodiment, the antibody produced by the methods of the invention has an increased proportion of bisected oligosaccharides in the Fc region as a result of the modification of its oligosaccharides by the methods of the present invention. In one embodiment, the percentage of bisected oligosaccharides is at least about 20% to about 100%, specifically at least about 50%, at least about 60% to about 70%, and more specifically, at least about 75%. In a particularly preferred embodiment, the anti-MCSP antibody produced by the host cells and methods of the invention has an increased proportion of bisected, nonfucosylated oligosaccharides in the Fc region. The bisected, nonfucosylated oligosaccharides may be either hybrid or complex. Specifically, the methods of the present invention may be used to produce antibodies in which at least about 10% to about 100%, specifically at least about 15%, more specifically at least about 20% to about 50%, more specifically at least about 20% to about 25%, and more specifically at least about 30% to about 35% of the oligosaccharides in the Fc region of the antibody are bisected, nonfucosylated. The anti-MCSP antibodies of the present invention may also comprise an Fc region in which at least about 10% to about 100%, specifically at least about15%, more specifically at least about 20% to about 25%, and more specifically at least about 30% to about 35% of the oligosaccharides in the Fc region of the anti-MCSP antibody are bisected hybrid nonfucosylated.

In another embodiment, the present invention is directed to an anti-MCSP antibody engineered to have increased effector function and/or increased Fc receptor binding affinity, produced by the methods of the invention. The increased effector function can include, but is not limited to one or more of the following: increased Fc-mediated cellular cytotoxicity (including increased antibody-dependent cellular cytotoxicity), increased antibody-dependent cellular phagocytosis (ADCP), increased cytokine secretion, increased immune-complex-mediated antigen uptake by antigen-presenting cells, increased binding to NK cells, increased binding to macrophages, increased binding to monocytes, increased binding to polymorphonuclear

cells, increased direct signaling inducing apoptosis, increased crosslinking of target-bound antibodies, increased dendritic cell maturation, or increased T cell priming. In a preferred embodiment, the increased Fc receptor binding affinity is increased binding to an Fc activating receptor, most preferably FcγRIIIa. In one embodiment, the antibody is an intact antibody. In one embodiment, the antibody is an antibody fragment containing the Fc region, or a fusion protein that includes a region equivalent to the Fc region of an immunoglobulin.

The present invention further provides methods for the generation and use of host cell systems for the production of glycoforms of the antibodies of the present invention, having increased Fc receptor binding affinity, preferably increased binding to Fc activating receptors, and/or having increased effector functions, including antibody-dependent cellular cytotoxicity. The glycoengineering methodology that can be used with the antibodies of the present invention has been described in greater detail in U.S. Pat. No. 6,602,684, U.S. Pat. Appl. Publ. No. 2004/0241817 A1, U.S. Pat. Appl. Publ. No. 2003/0175884 A1, Provisional U.S. Patent Application No. 60/441,307 and WO 2004/065540, the entire contents of each of which is incorporated herein by reference in its entirety. The antibodies of the present invention can alternatively be glycoengineered to have reduced fucose residues in the Fc region according to the techniques disclosed in U.S. Pat. Appl. Pub. No. 2003/0157108 (Genentech), or in EP 1 176 195 A1 , WO 03/084570, WO 03/085119 and U.S. Pat. Appl. Pub. Nos. 2003/0115614, 2004/093621, 2004/110282, 2004/110704, 2004/132140 (Kyowa). The contents of each of these documents are herein incorporated by reference in their entireties. Glycoengineered antibodies of the invention may also be produced in expression systems that produce modified glycoproteins, such as those taught in U.S. Pat. Appl. Pub. No. 60/344,169 and WO 03/056914 (GlycoFi, Inc.) or in WO 2004/057002 and WO 2004/024927 (Greenovation), the contents of each of which are hereby incorporated by reference in their entirety.

In another aspect, the present invention provides host cell expression systems for the generation of the antibodies of the present invention having modified glycosylation patterns. In particular, the present invention provides host cell systems for the generation of glycoforms of the antibodies of the present invention having an improved therapeutic value. Therefore, the invention provides host cell expression systems selected or engineered to express a polypeptide having a glycosyltransferase activity. In a specific embodiment, the glycosyltransferase activity is a GnTIII activity. In one embodiment, the polypeptide having GnTIII activity is a fusion polypeptide comprising the Golgi localization domain of a heterologous Golgi resident polypeptide. Specifically, such host cell expression systems may be engineered to comprise a recombinant nucleic acid molecule encoding a polypeptide having GnTIII, operatively linked to a constitutive or regulated promoter system.

In one specific embodiment, the present invention provides a host cell that has been engineered to express at least one nucleic acid encoding a fusion polypeptide having GnTIII activity and comprising the Golgi localization domain of a heterologous Golgi resident polypeptide. In one aspect, the host cell is engineered with a nucleic acid molecule comprising at least one gene encoding a fusion polypeptide having GnTIII activity and comprising the Golgi localization domain of a heterologous Golgi resident polypeptide.

Generally, any type of cultured cell line, including the cell lines discussed above, can be used as a background to engineer the host cell lines of the present invention. In a preferred embodiment, CHO cells, BHK cells, NS0 cells, SP2/0 cells, YO myeloma cells, P3X63 mouse myeloma cells, PER cells, PER.C6 cells or hybridoma cells, other mammalian cells, yeast cells, insect cells, or plant cells are used as the background cell line to generate the engineered host cells of the invention.

The invention is contemplated to encompass any engineered host cells expressing a polypeptide having glycosyltransferase activity, e.g., GnTIII activity, including a fusion polypeptide that comprises the Golgi localization domain of a heterologous Golgi resident polypeptide as defined herein.

One or several nucleic acids encoding a polypeptide having glycosyltransferase activity, e.g., GnTIII activity, may be expressed under the control of a constitutive promoter or, alternately, a regulated expression system. Such systems are well known in the art, and include the systems discussed above. If several different nucleic acids encoding fusion polypeptides having glycosyltransferase activity, e.g., GnTIII activity, and comprising the Golgi localization domain of a heterologous Golgi resident polypeptide are comprised within the host cell system, some of them may be expressed under the control of a constitutive promoter, while others are expressed under the control of a regulated promoter. Expression levels of the fusion polypeptides having glycosyltransferase activity, e.g., GnTIII activity, are determined by methods generally known in the art, including Western blot analysis, Northern blot analysis, reporter gene expression analysis or measurement of glycosyltransferase activity, e.g., GnTIII activity. Alternatively, a lectin may be employed which binds to biosynthetic products of the GnTIII, for example, E4-PHA lectin. Alternatively, a functional assay which measures the increased Fc receptor binding or increased effector function mediated by antibodies produced by the cells engineered with the nucleic acid encoding a polypeptide with glycosyltransferase activity, e.g., GnTIII activity, may be used.

The host cells which contain the coding sequence of an antibody of the invention and which express the biologically active gene products may be identified by at least four general approaches; (a) DNA-DNA or DNA-RNA hybridization; (b) the presence or absence of "marker" gene functions; (c) assessing the level of transcription as measured by the expression of the respective mRNA transcripts in the host cell; and (d) detection of the gene product as measured by immunoassay or by its biological activity.

In the first approach, the presence of the coding sequence of an anti-MCSP antibody and/or the coding sequence of the polypeptide having glycosyltransferase (e.g.,GnTIII) activity can be detected by DNA-DNA or DNA-RNA hybridization using probes comprising nucleotide sequences that are homologous to the respective coding sequences, respectively, or portions or derivatives thereof.

In the second approach, the recombinant expression vector/host system can be identified and selected based upon the presence or absence of certain "marker" gene functions (e.g., thymidine kinase activity, resistance to antibiotics, resistance to methotrexate, transformation phenotype, occlusion body formation in baculovirus, etc.). For example, if the coding sequence of the antibody of the invention, or a fragment thereof, and/or the coding sequence of the polypeptide having glycosyltransferase (e.g.,GnTIII) activity are inserted within a marker gene sequence of the vector, recombinants containing the respective coding sequences can be identified by the absence of the marker gene function. Alternatively, a marker gene can be placed in tandem with the coding sequences under the control of the same or different promoter used to control the expression of the coding sequences. Expression of the marker in response to induction or selection indicates expression of the coding sequence of the antibody of the invention and/or the coding sequence of the polypeptide having glycosyltransferase (e.g.,GnTIII) activity.

In the third approach, transcriptional activity for the coding region of the antibody of the invention, or a fragment thereof, and/or the coding sequence of the polypeptide having glycosyltransferase (e.g.,GnTIII) activity can be assessed by hybridization assays. For example, RNA can be isolated and analyzed by Northern blot using a probe homologous to the coding sequences of the antibody of the invention, or a fragment thereof, and/or the coding sequence of the polypeptide having glycosyltransferase (e.g.,GnTIII) activity or particular portions thereof. Alternatively, total nucleic acids of the host cell may be extracted and assayed for hybridization to such probes.

In the fourth approach, the expression of the protein products can be assessed immunologically, for example by Western blots, immunoassays such as radioimmuno-precipitation, enzyme-linked immunoassays and the like. The ultimate test of the success of the expression system, however, involves the detection of the biologically active gene products.

c) Fc region variants

In certain embodiments, one or more amino acid modifications may be introduced into the Fc region of an antibody provided herein, thereby generating an Fc region variant. The Fc region variant may comprise a human Fc region sequence (*e.g.*, a human IgG1, IgG2, IgG3 or IgG4 Fc region) comprising an amino acid modification (*e.g.* a substitution) at one or more amino acid positions.

In certain embodiments, the invention contemplates an antibody variant that possesses some but not all effector functions, which make it a desirable candidate for applications in which the half life of the

antibody *in vivo* is important yet certain effector functions (such as complement and ADCC) are unnecessary or deleterious. *In vitro* and/or *in vivo* cytotoxicity assays can be conducted to confirm the reduction/depletion of CDC and/or ADCC activities. For example, Fc receptor (FcR) binding assays can be conducted to ensure that the antibody lacks FcγR binding (hence likely lacking ADCC activity), but retains FcRn binding ability. The primary cells for mediating ADCC, NK cells, express Fc(RIII only, whereas monocytes express Fc(RI, Fc(RII and Fc(RIII. FcR expression on hematopoietic cells is summarized in Table 3 on page 464 of Ravetch and Kinet, *Annu. Rev. Immunol.* 9:457-492 (1991). Non-limiting examples of *in vitro* assays to assess ADCC activity of a molecule of interest is described in U.S. Patent No. 5,500,362 (see, e.g. Hellstrom, I. et al. *Proc. Nat'l Acad. Sci. USA* 83:7059-7063 (1986)) and Hellstrom, I et al., *Proc. Nat'l Acad. Sci. USA* 82:1499-1502 (1985); 5,821,337 (see Bruggemann, M. et al., *J. Exp. Med.* 166:1351-1361 (1987)). Alternatively, non-radioactive assays methods may be employed (see, for example, ACTI™ non-radioactive cytotoxicity assay for flow cytometry (CellTechnology, Inc. Mountain View, CA; and CytoTox 96® non-radioactive cytotoxicity assay (Promega, Madison, WI). Useful effector cells for such assays include peripheral blood mononuclear cells (PBMC) and Natural Killer (NK) cells. Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed *in vivo*, *e.g.*, in a animal model such as that disclosed in Clynes et al. *Proc. Nat'l Acad. Sci. USA* 95:652-656 (1998). C1q binding assays may also be carried out to confirm that the antibody is unable to bind C1q and hence lacks CDC activity. See, e.g., C1q and C3c binding ELISA in WO 2006/029879 and WO 2005/100402. To assess complement activation, a CDC assay may be performed (see, for example, Gazzano-Santoro *et al.*, *J. Immunol. Methods* 202:163 (1996); Cragg, M.S. et al., *Blood* 101:1045-1052 (2003); and Cragg, M.S. and M.J. Glennie, *Blood* 103:2738-2743 (2004)). FcRn binding and *in vivo* clearance/half life determinations can also be performed using methods known in the art (see, e.g., Petkova, S.B. et al., *Int'l. Immunol.* 18(12):1759-1769 (2006)).

One accepted in vitro ADCC assay is as follows:

1) the assay uses target cells that are known to express the target antigen recognized by the antigen-binding region of the antibody;

2) the assay uses human peripheral blood mononuclear cells (PBMCs), isolated from blood of a randomly chosen healthy donor, as effector cells;

3) the assay is carried out according to following protocol:

i) the PBMCs are isolated using standard density centrifugation procedures and are suspended at 5 x 106 cells/ml in RPMI cell culture medium;

ii) the target cells are grown by standard tissue culture methods, harvested from the exponential growth phase with a viability higher than 90%, washed in RPMI cell culture medium, labeled

with 100 micro-Curies of 51Cr, washed twice with cell culture medium, and resuspended in cell culture medium at a density of 105 cells/ml;

iii) 100 microliters of the final target cell suspension above are transferred to each well of a 96-well microtiter plate;

iv) the antibody is serially-diluted from 4000 ng/ml to 0.04 ng/ml in cell culture medium and 50 microliters of the resulting antibody solutions are added to the target cells in the 96-well microtiter plate, testing in triplicate various antibody concentrations covering the whole concentration range above;

v) for the maximum release (MR) controls, 3 additional wells in the plate containing the labeled target cells, receive 50 microliters of a 2% (V/V) aqueous solution of non-ionic detergent (Nonidet, Sigma, St. Louis), instead of the antibody solution (point iv above);

vi) for the spontaneous release (SR) controls, 3 additional wells in the plate containing the labeled target cells, receive 50 microliters of RPMI cell culture medium instead of the antibody solution (point iv above);

vii) the 96-well microtiter plate is then centrifuged at 50 x g for 1 minute and incubated for 1 hour at 4oC;

viii) 50 microliters of the PBMC suspension (point i above) are added to each well to yield an effector:target cell ratio of 25:1 and the plates are placed in an incubator under 5% CO2 atmosphere at 37oC for 4 hours;

ix) the cell-free supernatant from each well is harvested and the experimentally released radioactivity (ER) is quantified using a gamma counter;

x) the percentage of specific lysis is calculated for each antibody concentration according to the formula (ER-MR)/(MR-SR) x 100, where ER is the average radioactivity quantified (see point ix above) for that antibody concentration, MR is the average radioactivity quantified (see point ix above) for the MR controls (see point v above), and SR is the average radioactivity quantified (see point ix above) for the SR controls (see point vi above);

4) "increased ADCC" is defined as either an increase in the maximum percentage of specific lysis observed within the antibody concentration range tested above, and/or a reduction in the concentration of antibody required to achieve one half of the maximum percentage of specific lysis observed within the antibody concentration range tested above. The increase in ADCC is relative to the ADCC, measured with the above assay, mediated by the same antibody, produced by the same type of host cells, using the same standard production, purification, formulation and storage methods, which are known to those skilled in the art, but that has not been produced by host cells engineered to overexpress GnTIII.

Antibodies with reduced effector function include those with substitution of one or more of Fc region residues 238, 265, 269, 270, 297, 327 and 329 (U.S. Patent No. 6,737,056). Such Fc mutants include Fc mutants with substitutions at two or more of amino acid positions 265, 269, 270, 297 and 327, including the so-called "DANA" Fc mutant with substitution of residues 265 and 297 to alanine (US Patent No. 7,332,581).

Certain antibody variants with improved or diminished binding to FcRs are described. (See, e.g., U.S. Patent No. 6,737,056; WO 2004/056312, and Shields et al., *J. Biol. Chem.* 9(2): 6591-6604 (2001).)

In certain embodiments, an antibody variant comprises an Fc region with one or more amino acid substitutions which improve ADCC, e.g., substitutions at positions 298, 333, and/or 334 of the Fc region (EU numbering of residues).

In some embodiments, alterations are made in the Fc region that result in altered (*i.e.*, either improved or diminished) C1q binding and/or Complement Dependent Cytotoxicity (CDC), e.g., as described in US Patent No. 6,194,551, WO 99/51642, and Idusogie et al. *J. Immunol.* 164: 4178-4184 (2000).

Antibodies with increased half lives and improved binding to the neonatal Fc receptor (FcRn), which is responsible for the transfer of maternal IgGs to the fetus (Guyer et al., *J. Immunol.* 117:587 (1976) and Kim et al., *J. Immunol.* 24:249 (1994)), are described in US2005/0014934A1 (Hinton et al.). Those antibodies comprise an Fc region with one or more substitutions therein which improve binding of the Fc region to FcRn. Such Fc variants include those with substitutions at one or more of Fc region residues: 238, 256, 265, 272, 286, 303, 305, 307, 311, 312, 317, 340, 356, 360, 362, 376, 378, 380, 382, 413, 424 or 434, e.g., substitution of Fc region residue 434 (US Patent No. 7,371,826).

See also Duncan & Winter, *Nature* 322:738-40 (1988); U.S. Patent No. 5,648,260; U.S. Patent No. 5,624,821; and WO 94/29351 concerning other examples of Fc region variants.

d) Cysteine engineered antibody variants

In certain embodiments, it may be desirable to create cysteine engineered antibodies, e.g., "thioMAbs," in which one or more residues of an antibody are substituted with cysteine residues. In particular embodiments, the substituted residues occur at accessible sites of the antibody. By substituting those residues with cysteine, reactive thiol groups are thereby positioned at accessible sites of the antibody and may be used to conjugate the antibody to other moieties, such as drug moieties or linker-drug moieties, to create an immunoconjugate, as described further herein. In certain embodiments, any one or more of the following residues may be substituted with cysteine: V205 (Kabat numbering) of the light chain; A118 (EU numbering) of the heavy chain; and S400 (EU numbering) of the heavy chain Fc region. Cysteine engineered antibodies may be generated as described, e.g., in U.S. Patent No. 7,521,541.

e) **Antibody Derivatives**

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

In another embodiment, conjugates of an antibody and nonproteinaceous moiety that may be selectively heated by exposure to radiation are provided. In one embodiment, the nonproteinaceous moiety is a carbon nanotube (Kam et al., *Proc. Natl. Acad. Sci. USA* 102: 11600-11605 (2005)). The radiation may be of any wavelength, and includes, but is not limited to, wavelengths that do not harm ordinary cells, but which heat the nonproteinaceous moiety to a temperature at which cells proximal to the antibody-nonproteinaceous moiety are killed.

B. Recombinant Methods and Compositions

Antibodies may be produced using recombinant methods and compositions, e.g., as described in U.S. Patent No. 4,816,567. In one embodiment, isolated nucleic acid encoding an anti-MCSP antibody described herein is provided. Such nucleic acid may encode an amino acid sequence comprising the VL and/or an amino acid sequence comprising the VH of the antibody (e.g., the light and/or heavy chains of the antibody). In a further embodiment, one or more vectors (e.g., expression vectors) comprising such nucleic acid are provided. In a further embodiment, a host cell comprising such nucleic acid is provided. In one such embodiment, a host cell comprises (e.g., has been transformed with): (1) a vector comprising a nucleic acid that encodes an amino acid sequence comprising the VL of the antibody and an amino acid sequence comprising the VH of the antibody, or (2) a first vector comprising a nucleic acid that encodes an amino acid

sequence comprising the VL of the antibody and a second vector comprising a nucleic acid that encodes an amino acid sequence comprising the VH of the antibody. In one embodiment, the host cell is eukaryotic, e.g. a Chinese Hamster Ovary (CHO) cell or lymphoid cell (e.g., Y0, NS0, Sp20 cell). In one embodiment, a method of making an anti-MCSP antibody is provided, wherein the method comprises culturing a host cell comprising a nucleic acid encoding the antibody, as provided above, under conditions suitable for expression of the antibody, and optionally recovering the antibody from the host cell (or host cell culture medium).

For recombinant production of an anti-MCSP antibody, nucleic acid encoding an antibody, e.g., as described above, is isolated and inserted into one or more vectors for further cloning and/or expression in a host cell. Such nucleic acid may be readily isolated and sequenced using conventional procedures (e.g., by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of the antibody).

Suitable host cells for cloning or expression of antibody-encoding vectors include prokaryotic or eukaryotic cells described herein. For example, antibodies may be produced in bacteria, in particular when glycosylation and Fc effector function are not needed. For expression of antibody fragments and polypeptides in bacteria, see, e.g., U.S. Patent Nos. 5,648,237, 5,789,199, and 5,840,523. (See also Charlton, *Methods in Molecular Biology, Vol. 248* (B.K.C. Lo, ed., Humana Press, Totowa, NJ, 2003), pp. 245-254, describing expression of antibody fragments in *E. coli*.) After expression, the antibody may be isolated from the bacterial cell paste in a soluble fraction and can be further purified.

In addition to prokaryotes, eukaryotic microbes such as filamentous fungi or yeast are suitable cloning or expression hosts for antibody-encoding vectors, including fungi and yeast strains whose glycosylation pathways have been "humanized," resulting in the production of an antibody with a partially or fully human glycosylation pattern. See Gerngross, *Nat. Biotech.* 22:1409-1414 (2004), and Li et al., *Nat. Biotech.* 24:210-215 (2006).

Suitable host cells for the expression of glycosylated antibody are also derived from multicellular organisms (invertebrates and vertebrates). Examples of invertebrate cells include plant and insect cells. Numerous baculoviral strains have been identified which may be used in conjunction with insect cells, particularly for transfection of *Spodoptera frugiperda* cells.

Plant cell cultures can also be utilized as hosts. *See,* e.g., US Patent Nos. 5,959,177, 6,040,498, 6,420,548, 7,125,978, and 6,417,429 (describing PLANTIBODIES™ technology for producing antibodies in transgenic plants).

Vertebrate cells may also be used as hosts. For example, mammalian cell lines that are adapted to grow in suspension may be useful. Other examples of useful mammalian host cell lines are monkey kidney CV1 line transformed by SV40 (COS-7); human embryonic kidney line (293 or 293 cells as described, e.g.,

in Graham et al., *J. Gen Virol.* 36:59 (1977)); baby hamster kidney cells (BHK); mouse sertoli cells (TM4 cells as described, e.g., in Mather, *Biol. Reprod.* 23:243-251 (1980)); monkey kidney cells (CV1); African green monkey kidney cells (VERO-76); human cervical carcinoma cells (HELA); canine kidney cells (MDCK; buffalo rat liver cells (BRL 3A); human lung cells (W138); human liver cells (Hep G2); mouse mammary tumor (MMT 060562); TRI cells, as described, e.g., in Mather et al., *Annals N.Y. Acad. Sci.* 383:44-68 (1982); MRC 5 cells; and FS4 cells. Other useful mammalian host cell lines include Chinese hamster ovary (CHO) cells, including $DHFR^-$ CHO cells (Urlaub et al., *Proc. Natl. Acad. Sci. USA* 77:4216 (1980)); and myeloma cell lines such as Y0, NS0 and Sp2/0. For a review of certain mammalian host cell lines suitable for antibody production, see, e.g., Yazaki and Wu, *Methods in Molecular Biology, Vol. 248* (B.K.C. Lo, ed., Humana Press, Totowa, NJ), pp. 255-268 (2003).

C. Assays

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

1. Binding assays and other assays

In one aspect, an antibody of the invention is tested for its antigen binding activity, e.g., by known methods such as ELISA, Western blot, etc.

In another aspect, competition assays may be used to identify an antibody that competes with the anti-MCSP antibodies described herein for binding to MCSP. In certain embodiments, such a competing antibody binds to the same epitope (e.g., a linear or a conformational epitope) that is bound by the anti-MCSP antibodies described herein. Detailed exemplary methods for mapping an epitope to which an antibody binds are provided in Morris (1996) "Epitope Mapping Protocols," in *Methods in Molecular Biology* vol. 66 (Humana Press, Totowa, NJ).

In an exemplary competition assay, immobilized MCSP is incubated in a solution comprising a first labeled antibody that binds to MCSP and a second unlabeled antibody that is being tested for its ability to compete with the first antibody for binding to MCSP. The second antibody may be present in a hybridoma supernatant. As a control, immobilized MCSP is incubated in a solution comprising the first labeled antibody but not the second unlabeled antibody. After incubation under conditions permissive for binding of the first antibody to MCSP, excess unbound antibody is removed, and the amount of label associated with immobilized MCSP is measured. If the amount of label associated with immobilized MCSP is substantially reduced in the test sample relative to the control sample, then that indicates that the second antibody is competing with the first antibody for binding to MCSP. See Harlow and Lane (1988) *Antibodies: A Laboratory Manual* ch.14 (Cold Spring Harbor Laboratory, Cold Spring Harbor, NY).

2. *Activity assays*

In one aspect, assays are provided for identifying anti-MCSP antibodies thereof having biological activity. Antibodies having such biological activity in vivo and/or in vitro are also provided.

In certain embodiments, an antibody of the invention is tested for such biological activity.

D. Immunoconjugates

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

In one embodiment, an immunoconjugate is an antibody-drug conjugate (ADC) in which an antibody is conjugated to one or more drugs, including but not limited to a maytansinoid (see U.S. Patent Nos. 5,208,020, 5,416,064 and European Patent EP 0 425 235 B1); an auristatin such as monomethylauristatin drug moieties DE and DF (MMAE and MMAF) (see U.S. Patent Nos. 5,635,483 and 5,780,588, and 7,498,298); a dolastatin; a calicheamicin or derivative thereof (see U.S. Patent Nos. 5,712,374, 5,714,586, 5,739,116, 5,767,285, 5,770,701, 5,770,710, 5,773,001, and 5,877,296; Hinman et al., *Cancer Res.* 53:3336-3342 (1993); and Lode et al., *Cancer Res.* 58:2925-2928 (1998)); an anthracycline such as daunomycin or doxorubicin (see Kratz et al., *Current Med. Chem.* 13:477-523 (2006); Jeffrey et al., *Bioorganic & Med. Chem. Letters* 16:358-362 (2006); Torgov et al., *Bioconj. Chem.* 16:717-721 (2005); Nagy et al., *Proc. Natl. Acad. Sci. USA* 97:829-834 (2000); Dubowchik et al., *Bioorg. & Med. Chem. Letters* 12:1529-1532 (2002); King et al., *J. Med. Chem.* 45:4336-4343 (2002); and U.S. Patent No. 6,630,579); methotrexate; vindesine; a taxane such as docetaxel, paclitaxel, larotaxel, tesetaxel, and ortataxel; a trichothecene; and CC1065.

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

In another embodiment, an immunoconjugate comprises an antibody as described herein conjugated to a radioactive atom to form a radioconjugate. A variety of radioactive isotopes are available for the production of radioconjugates. Examples include At^{211}, I^{131}, I^{125}, Y^{90}, Re^{186}, Re^{188}, Sm^{153}, Bi^{212}, P^{32}, Pb^{212} and radioactive isotopes of Lu. When the radioconjugate is used for detection, it may comprise a radioactive atom for scintigraphic studies, for example tc99m or I123, or a spin label for nuclear magnetic resonance

(NMR) imaging (also known as magnetic resonance imaging, mri), such as iodine-123 again, iodine-131, indium-111, fluorine-19, carbon-13, nitrogen-15, oxygen-17, gadolinium, manganese or iron.

Conjugates of an antibody and cytotoxic agent may be made using a variety of bifunctional protein coupling agents such as N-succinimidyl-3-(2-pyridyldithio) propionate (SPDP), succinimidyl-4-(N-maleimidomethyl) cyclohexane-1-carboxylate (SMCC), iminothiolane (IT), bifunctional derivatives of imidoesters (such as dimethyl adipimidate HCl), active esters (such as disuccinimidyl suberate), aldehydes (such as glutaraldehyde), bis-azido compounds (such as bis (p-azidobenzoyl) hexanediamine), bis-diazonium derivatives (such as bis-(p-diazoniumbenzoyl)-ethylenediamine), diisocyanates (such as toluene 2,6-diisocyanate), and bis-active fluorine compounds (such as 1,5-difluoro-2,4-dinitrobenzene). For example, a ricin immunotoxin can be prepared as described in Vitetta et al., *Science* 238:1098 (1987). Carbon-14-labeled 1-isothiocyanatobenzyl-3-methyldiethylene triaminepentaacetic acid (MX-DTPA) is an exemplary chelating agent for conjugation of radionucleotide to the antibody. See WO94/11026. The linker may be a "cleavable linker" facilitating release of a cytotoxic drug in the cell. For example, an acid-labile linker, peptidase-sensitive linker, photolabile linker, dimethyl linker or disulfide-containing linker (Chari et al., *Cancer Res.* 52:127-131 (1992); U.S. Patent No. 5,208,020) may be used.

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

E. Methods and Compositions for Diagnostics and Detection

In certain embodiments, any of the anti-MCSP antibodies provided herein is useful for detecting the presence of MCSP in a biological sample. The term "detecting" as used herein encompasses quantitative or qualitative detection.

In one embodiment, an anti-MCSP antibody for use in a method of diagnosis or detection is provided. In a further aspect, a method of detecting the presence of MCSP in a biological sample is provided. In certain embodiments, the method comprises contacting the biological sample with an anti-MCSP antibody as described herein under conditions permissive for binding of the anti-MCSP antibody to MCSP, and detecting whether a complex is formed between the anti-MCSP antibody and MCSP. Such method may be an *in vitro* or *in vivo* method. In one embodiment, an anti-MCSP antibody is used to select

subjects eligible for therapy with an anti-MCSP antibody, e.g. where MCSP is a biomarker for selection of patients.

Exemplary disorders that may be diagnosed using an antibody of the invention include disorders characterized by expression of MCSP, including cell proliferative disorders or angiogenic disorders. In one embodiment, the disorder is a cancer, such as a skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML).

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

F. Pharmaceutical Formulations

Pharmaceutical formulations of an anti-MCSP antibody as described herein are prepared by mixing such antibody having the desired degree of purity with one or more optional pharmaceutically acceptable carriers (*Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980)), in the form of lyophilized formulations or aqueous solutions. Pharmaceutically acceptable carriers are generally nontoxic to recipients at the dosages and concentrations employed, and include, but are not limited to: buffers such as phosphate, citrate, and other organic acids; antioxidants including ascorbic acid and methionine; preservatives (such as octadecyldimethylbenzyl ammonium chloride; hexamethonium chloride; benzalkonium chloride; benzethonium chloride; phenol, butyl or benzyl alcohol; alkyl parabens such as methyl or propyl paraben; catechol; resorcinol; cyclohexanol; 3-pentanol; and m-cresol); low molecular weight (less than about 10 residues) polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine, glutamine, asparagine, histidine, arginine, or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrins;

chelating agents such as EDTA; sugars such as sucrose, mannitol, trehalose or sorbitol; salt-forming counter-ions such as sodium; metal complexes (*e.g.* Zn-protein complexes); and/or non-ionic surfactants such as polyethylene glycol (PEG). Exemplary pharmaceutically acceptable carriers herein further include insterstitial drug dispersion agents such as soluble neutral-active hyaluronidase glycoproteins (sHASEGP), for example, human soluble PH-20 hyaluronidase glycoproteins, such as rHuPH20 (HYLENEX®, Baxter International, Inc.). Certain exemplary sHASEGPs and methods of use, including rHuPH20, are described in US Patent Publication Nos. 2005/0260186 and 2006/0104968. In one aspect, a sHASEGP is combined with one or more additional glycosaminoglycanases such as chondroitinases.

Exemplary lyophilized antibody formulations are described in US Patent No. 6,267,958. Aqueous antibody formulations include those described in US Patent No. 6,171,586 and WO2006/044908, the latter formulations including a histidine-acetate buffer.

The formulation herein may also contain more than one active ingredients as necessary for the particular indication being treated, preferably those with complementary activities that do not adversely affect each other. Such active ingredients are suitably present in combination in amounts that are effective for the purpose intended.

Active ingredients may be entrapped in microcapsules prepared, for example, by coacervation techniques or by interfacial polymerization, for example, hydroxymethylcellulose or gelatin-microcapsules and poly-(methylmethacylate) microcapsules, respectively, in colloidal drug delivery systems (for example, liposomes, albumin microspheres, microemulsions, nano-particles and nanocapsules) or in macroemulsions. Such techniques are disclosed in *Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980).

Sustained-release preparations may be prepared. Suitable examples of sustained-release preparations include semipermeable matrices of solid hydrophobic polymers containing the antibody, which matrices are in the form of shaped articles, *e.g.* films, or microcapsules.

The formulations to be used for *in vivo* administration are generally sterile. Sterility may be readily accomplished, e.g., by filtration through sterile filtration membranes.

G. Therapeutic Methods and Compositions

Any of the anti-MCSP antibodies provided herein may be used in therapeutic methods.

In one aspect, an anti-MCSP antibody for use as a medicament is provided. In further aspects, an anti-MCSP antibody for use in treating cancer is provided. In certain embodiments, an anti-MCSP antibody for use in a method of treatment is provided. In certain embodiments, the invention provides an anti-MCSP antibody for use in a method of treating an individual having cancer comprising administering to the individual an effective amount of the anti-MCSP antibody. In one such embodiment, the method further

comprises administering to the individual an effective amount of at least one additional therapeutic agent, e.g., as described below. In further embodiments, the invention provides an anti-MCSP antibody for use in treating melanoma. An "individual" according to any of the above embodiments is preferably a human.

In a further aspect, the invention provides for the use of an anti-MCSP antibody in the manufacture or preparation of a medicament. In one embodiment, the medicament is for treatment of cancer. In a further embodiment, the medicament is for use in a method of treating cancer comprising administering to an individual having cancer an effective amount of the medicament. In one such embodiment, the method further comprises administering to the individual an effective amount of at least one additional therapeutic agent, e.g., as described below. An "individual" according to any of the above embodiments may be a human.

In a further aspect, the invention provides a method for treating cancer. In one embodiment, the method comprises administering to an individual having such cancer an effective amount of an anti-MCSP antibody. In one such embodiment, the method further comprises administering to the individual an effective amount of at least one additional therapeutic agent, as described below. An "individual" according to any of the above embodiments may be a human.

In one embodiment, the cancer in the above aspects, expresses MCSP on the surface of its constituent cells. In one embodiment, the cancer in the above aspects is selected from among skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML). In one embodiment, the cancer in the above aspects is melanoma.

In a further aspect, the invention provides pharmaceutical formulations comprising any of the anti-MCSP antibodies provided herein, e.g., for use in any of the above therapeutic methods. In one embodiment, a pharmaceutical formulation comprises any of the anti-MCSP antibodies provided herein and a pharmaceutically acceptable carrier. In another embodiment, a pharmaceutical formulation comprises any of the anti-MCSP antibodies provided herein and at least one additional therapeutic agent, e.g., as described below.

Antibodies of the invention can be used either alone or in combination with other agents in a therapy. For instance, an antibody of the invention may be co-administered with at least one additional therapeutic agent.

Such combination therapies noted above encompass combined administration (where two or more therapeutic agents are included in the same or separate formulations), and separate administration, in which case, administration of the antibody of the invention can occur prior to, simultaneously, and/or following,

administration of the additional therapeutic agent and/or adjuvant. Antibodies of the invention can also be used in combination with radiation therapy.

An antibody of the invention (and any additional therapeutic agent) can be administered by any suitable means, including parenteral, intrapulmonary, and intranasal, and, if desired for local treatment, intralesional administration. Parenteral infusions include intramuscular, intravenous, intraarterial, intraperitoneal, or subcutaneous administration. Dosing can be by any suitable route, e.g. by injections, such as intravenous or subcutaneous injections, depending in part on whether the administration is brief or chronic. Various dosing schedules including but not limited to single or multiple administrations over various time-points, bolus administration, and pulse infusion are contemplated herein.

Antibodies of the invention would be formulated, dosed, and administered in a fashion consistent with good medical practice. Factors for consideration in this context include the particular disorder being treated, the particular mammal being treated, the clinical condition of the individual patient, the cause of the disorder, the site of delivery of the agent, the method of administration, the scheduling of administration, and other factors known to medical practitioners. The antibody need not be, but is optionally formulated with one or more agents currently used to prevent or treat the disorder in question. The effective amount of such other agents depends on the amount of antibody present in the formulation, the type of disorder or treatment, and other factors discussed above. These are generally used in the same dosages and with administration routes as described herein, or about from 1 to 99% of the dosages described herein, or in any dosage and by any route that is empirically/clinically determined to be appropriate.

For the prevention or treatment of disease, the appropriate dosage of an antibody of the invention (when used alone or in combination with one or more other additional therapeutic agents) will depend on the type of disease to be treated, the type of antibody, the severity and course of the disease, whether the antibody is administered for preventive or therapeutic purposes, previous therapy, the patient's clinical history and response to the antibody, and the discretion of the attending physician. The antibody is suitably administered to the patient at one time or over a series of treatments. Depending on the type and severity of the disease, about 1 µg/kg to 15 mg/kg (e.g. 0.1mg/kg-10mg/kg) of antibody can be an initial candidate dosage for administration to the patient, whether, for example, by one or more separate administrations, or by continuous infusion. One typical daily dosage might range from about 1 µg/kg to 100 mg/kg or more, depending on the factors mentioned above. For repeated administrations over several days or longer, depending on the condition, the treatment would generally be sustained until a desired suppression of disease symptoms occurs. One exemplary dosage of the antibody would be in the range from about 0.05 mg/kg to about 10 mg/kg. Thus, one or more doses of about 0.5 mg/kg, 2.0 mg/kg, 4.0 mg/kg or 10 mg/kg (or any combination thereof) may be administered to the patient. Such doses may be administered intermittently, e.g.

every week or every three weeks (*e.g.* such that the patient receives from about two to about twenty, or *e.g.* about six doses of the antibody). An initial higher loading dose, followed by one or more lower doses may be administered. The progress of this therapy is easily monitored by conventional techniques and assays.

It is understood that any of the above formulations or therapeutic methods may be carried out using an immunoconjugate of the invention in place of or in addition to an anti-MCSP antibody.

H. Articles of Manufacture

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

It is understood that any of the above articles of manufacture may include an immunoconjugate of the invention in place of or in addition to an anti-MCSP antibody.

EXAMPLES

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

Example 1 – Generation of anti-MCSP Antibodies

Immunization and hybridoma generation

Balb/c mice were immunized i.p. with a synthetic peptide corresponding to aa 2177-2221 of the human MCSP sequence coupled to KLH (SVPE AARTEAGKPE SSTPTGEPGPMASSPEPAVA KGGFLSFLEAN (SEQ ID NO: 2)) every 4 weeks for 4 times followed by two immunizations with Colo38 cells (Giacomini P, Natali P, Ferrone S J Immunol. 1985 Jul;135(1):696-702) expressing MCSP. The initial immunization was performed in CFA, all following boosts in IFA.

Serum test bleeds were taken and half-maximal serum titer was determined using the MCSP peptide aa2177-2221 coupled to biotin and coated onto Streptavidin ELISA microtiter plates. Mice with a half-maximal titer of 1:50,000 were selected for i.v. boost. An i.v. boost on day 4 before fusion was performed using 20µg of the MCSP peptide and Colo38 cells. Three days following the i.v. boost, splenocytes were harvested, and fused with Ag8 myeloma cells.

Screening and hybridoma characterization

Screening for MCSP specific antibodies was started by identifying antibodies binding to MCSP-biotin peptide aa 2177-2221 (SEQ ID NO: 2) coated onto streptavidin microtiter plates. Positive clones binding to immobilized MCSP peptide were then expanded in serum free medium (Hyclone ADCF-Mab - Thermo Scientific, Cat. No. SH30349.02).

Binding to the native form of MCSP was performed by FACS analysis on Colo38 cells naturally overexpressing high levels of human MCSP. The prostate carcinoma line PC3 that does not express detectable levels of MCSP was used as negative control. To further characterize the specificity of the lead antibodies, double immunocytochemistry analysis was performed on Colo38 cells using an established commercial anti-MCSP antibody (Invitrogen Corp., Catalog No. 41-2000, Clone LHM2) for doublestaining in combination with chimeric lead antibodies (expressing human Fc). As shown by immunofluorescence labeling, one antibody, LC007, strongly stained surface MCSP in Colo38 cells, but was negative on PC3 cells.

Example 2: Chimerization

mRNA was isolated from the hybridoma cell line expressing antibody clone LC007 and converted into cDNA using commercial available kits. The cDNA isolates for heavy (SEQ ID NO: 39) and light chain (SEQ ID NO: 38) were sequenced and each segment was fused to the constant regions of human IgG1 and kappa.

Sequences were expressed, using signal peptides from human immunoglobulins, in HEK-EBNA cells, and purified using conventional proteinA and size exclusion chromatography (SEC).

Binding activity was determined by the following method. Target cells were detached from culture flask with cell dissociation buffer, counted and checked for viability. Cells were resuspended and adjusted to $1.111x10^6$ (viable) cells/ml in PBS-0.1%BSA. 180µl of this suspension were transferred to each well (200,000 cells/well) in a round bottom 96-well-plate, centrifuged for 4 min, at 400g, and resuspended. 20 µl of antibody dilutions in PBS-0.1% BSA (from 10µg/ml to 0.002µg/ml) were added to each well. The samples were centrifuged for 4 min, at 400g, and resuspended. Secondary antibody, FITC-conjugated AffiniPure F(ab')2 fragment goat anti-human IgG Fcg Fragment Specific (Jackson Immuno Research Lab # 109-096-098)), was added and the sample centrifuged for 4 min, at 400g, and resuspended. Fluorescence was measured in flow cytometer (e.g. FACS Canto II). Results of titration are shown in Figures 1 and 2. Antibody 9.2.27 , described in Morgan AC Jr, Galloway DR, Reisfeld RA. Hybridoma. 1981;1(1):27-36. ; GenBank Accession Numbers: GI:20797193 and GI:20797189 for light and heavy chain respectively, was used as a reference (Figure 2). Human melanoma cell-lines Colo38, A2058, and A375 were used. Giacomini et al. 1985 (for Colo38). Marquardt H, Todaro GJ. J Biol Chem. 1982 May 10;257(9):5220-5 (for A2058). Geiser M, Schultz D, Le Cardinal A, Voshol H, García-Echeverría C. Cancer Res. 1999 Feb 15;59(4):905-10 (for A375).

Example 3: Determination of binding epitope of LC007 antibody on MCSP antigen

The LC007 antibody showed good binding on melanoma cells, but only weak binding on the original immunogen. Therefore, an epitope mapping of antibody LC007 was undertaken in order to determine the exact binding site on the antigen. For this several truncated versions of the MCSP antigen were generated, each containing varying numbers of the membrane proximal repeat region of human MCSP, referred to as the CSPG repeat. Staub E., et al., FEBS Lett. 527:114-118(2002).

Construct 1 contained CSPG repeat 15 (SEQ ID NO: 4), Construct 2 contained CSPG repeat 14-15 (SEQ ID NO: 5), Construct 3 contained CSPG repeat 13-15 (SEQ ID NO: 6), and Construct 4 contained CSPG repeat 12-15 (SEQ ID NO: 7). Figure 3 provides a schematic of the CSPG repeat containing structure of MCSP. These constructs contained the original transmembrane region and were expressed on HEK-EBNA cells for detection of LC007 binding by FACS. Figure 4 shows the outcome of this experiment. The construct including only the MCSP repeat 15 and the natural transmembrane domain did not show any significant binding. In contrast, all constructs including domains 14 and 15 showed significant binding. This indicates that the binding epitope either is within repeat 14, or is only reconstituted when repeat 14 is present

and potentially includes also parts of repeat 15 or the unstructured region between the CSPG repeats and the transmembrane domain.

Example 4: Determination of crossreactivity with human and cynomolgus antigen

An expression construct was generated that included the C-terminal part of the cynomolgus MCSP protein, a signal peptide for secretion and a N-terminal FLAG-tag (SEQ ID NO: 8) to test for crossreactivity towards the cynomolgus antigen. This domain was referred to as the D3 domain Tillet, F. et. Al, J. Biol. Chem. 272: 10769–10776 (1997). A similar construct was done for the human counterpart (SEQ ID NO: 9). An expression plasmid encoding for these two construct was electroporated into HEK-EBNA cells, and expression was confirmed with an anti-FLAG antibody. Binding of LC007 antibody was then tested by flow cytometry. Figure 5 shows that antibody LC007 binds with similar affinity to the cynomolgus construct as to the corresponding human expression construct.

Example 5: Glycoengineered LC007 antibody

Glycoengineered variants of the LC007 antibody were produced by co-transfection of the antibody expression vectors together with a GnT-III glycosyltransferase expression vector, or together with a GnT-III expression vector plus a Golgi mannosidase II expression vector.

Example 6 ADCC of glycoengineered LC007 antibody

ADCC assay

Lysis of Colo38 human malignant melanoma cells (target) by human lymphocytes (effector), at a target:effector ratio of 1:19, during a 16 h incubation at 37^0C in the presence of different concentrations of the glycoengineered LC007 antibody and control antibody samples, was measured via retention of a fluorescent dye. Kolber et al, 1988, J. Immunol. Methods 108: 255-264. IMR-32 cells were labeled with the fluorescent dye Calcein AM for 20 min (final concentration 3.3 µM). The labeled cells (80,000 cells/well) were incubated for 1 h with different concentrations of the glycoengineered LC007 antibody and control antibody samples. Then, monocyte depleted mononuclear cells were added (1,500,000 cells/well) and the cell mixture was incubated for 16 h at 37^0C in a 5% $C0_2$ atmosphere. The supernatant was discarded and the cells were washed once with HBSS and lysed in Triton X-100 (0.1%). Retention of the fluorescent dye in Colo38 cells was measured with a fluorometer (Perkin Elmer, Luminscence Spectrometer LS 50B, (Foster City, Calif.) and specific lysis was calculated relative to a total lysis control, resulting from exposure of the target to a detergent instead of exposure to antibody. The signal in the absence of antibody was set to 0% cytotoxicity. Each antibody concentration was analyzed by triplicate, and the assay was repeated three separate times. As shown in Figure 6, the non-glycoengineered LC007 antibody (LC007 wt) exhibited an

ADCC effect. The glycoengineered LC007 antibody (LC007 g2) showed increased ADCC as compared to the non-glycoengineered LC007. Thus, the non-glycoengineered LC007 antibody per se shows some ADCC activity, which can further be enhanced by glycoengineering. In contrast, anti-MCSP antibody MHLG KV9 G2, which is a humanized version of antibody 225.28S described in Buraggi G, et al. Int J Biol Markers. 1986 Jan-Apr;1(1):47-54), did not show any significant ADCC induction in this assay. The binding epitope of the 225.28 antibody was determined to be within the N-terminal part, or membrane distal portion, of the MCSP antigen. The glycoengineered GA201 antibody that binds to the EGF Receptor, which is absent on the Colo38 cells, was included as a control. Absence of ADCC with this antibody shows that activation of NK cells must occur via the target present on the tumor cell.

Figure 7 shows the ADCC of the glycoengineered LC007 antibody is observed also for the human U86MG glioblastoma cell-line.

Example 7 Humanization of glycoengineered LC007 antibody

The humanization procedure was done following the classical loop-grafting procedure (Jones PT, Dear PH, Foote J, Neuberger MS, Winter G. Nature. 1986 May 29-Jun 4;321(6069):522-5. P. Carter et al.; Proc. Natl. Acad. Sci. USA; Vol. 89, pp. 4285-4289, May 1992). In brief, the CDRs (SEQ ID NOs. 10, 11, 12, 14, 15, and 16) of the murine antibody were grafted onto the human framework sequences: IMGT Acc No. IGKV1D-39*01 and IGKJ1 for the light chain, and IMGT Acc No: IGHV4-31*02 and IGHJ4 for the heavy chain, resulting in an antibody that had a heavy chain comprising the amino acid sequence of SEQ ID NO: 29 and a light chain comprising the amino acid sequence of SEQ ID NO: 28.

The antibody constructs were optimized to retain binding affinity to the target MCSP antigen. Figure 8 shows the binding properties of the different humanized variants. The human residues Val71 and Arg94 were replaced by their corresponding murine counterparts, arginine and aspartic acid, respectively, as it was determined that antibody constructs with the human residues exhibited reduced binding to antigen. As shown in Figure 8, the constructs M4-2 ML1, having a Arg at position 94 in the heavy chain (Kabat numbering) (SEQ ID NO: 30(corresponding to D98R in this sequence)) and M4-6 ML1, having a Val at position 74 in the heavy chain (Kabat numbering) (SEQ ID NO: 33 (corresponding to R72V in this sequence)) showed reduced binding to the MCSP antigen, indicating the relevance of these residues to the binding specifity of the antibodies. Those constructs which had the corresponding murine counterparts, arginine and aspartic acid, in those positions respectively, retained binding activity, for example those antibodies having the heavy chain constructs of M4-1 (SEQ ID NO: 29) and M4-3 (SEQ ID NO: 32).

The CDR-H1 residue Asn35 was substituted towards the corresponding human germ-line serine residue. As shown in Figure 8, construct M4-7 ML1 (SEQ ID NO: 25), which contains this substitution,

showed a reduction in binding to the target MCSP antigen, indicating that this residue is also involved in retaining the antigen binding strength.

Additional constructs indicated the relevance of other residues in the binding properties of the anti-MCSP antibodies. Replacing the arginine residue with a serine at position 7 in HVR-L1 (SEQ ID NO: 21) resulted in a reduced binding activity for the MCSP antigen. Replacing the aspartic acid tyrosine with an aspartic acid at position 1 and replacing the alanine with threonine at postion 2 of HVR-L2 SEQ ID NO: 21 also resulted in a reduced binding activity for the MCSP antigen.

Example 8 ADCC of humanized variants of glycoengineered LC007 antibody

ADCC activity for the humanized variants for the glycoengineered LC007 antibody was measured by lactate dehydrogenase using Colo38 cells as the target cells. Human peripheral blood mononuclear cells (PBMC) were used as effector cells and were prepared using Histopaque-1077 (Sigma Diagnostics Inc., St. Louis, Mo. 63178 USA) following essentially the manufacturer's instructions. In brief, venous blood was taken with heparinized syringes from healthy volunteers. The blood was diluted 1:0.75-1.3 with PBS (not containing Ca^{++} or Mg^{++}) and layered on Histopaque-1077. The gradient was centrifuged at 400 x g for 30 min at room temperature (RT) without breaks. The interphase containing the PBMC was collected and washed with PBS (50 ml per cells from two gradients) and harvested by centrifugation at 300.times.g for 10 minutes at RT. After resuspension of the pellet with PBS, the PBMC were counted and washed a second time by centrifugation at 200 x g for 10 minutes at RT. The cells were then resuspended in the appropriate medium for the subsequent procedures.

The effector to target ratio used for the ADCC assays was 25:1 and 10:1 for PBMC and NK cells, respectively. The effector cells were prepared in AIM-V medium at the appropriate concentration in order to add 50 µl per well of round bottom 96 well plates. Target cells were Colo30 cells. Target cells were washed in PBS, counted and resuspended in AIM-V at 0.3 million per ml in order to add 30,000 cells in 100 µl per microwell. Antibodies were diluted in AIM-V, added in 50 µl to the pre-plated target cells and allowed to bind to the targets for 10 minutes at RT. Then the effector cells were added and the plate was incubated for 4 hours at 37^0C in a humidified atmosphere containing 5% CO2. Killing of target cells was assessed by measurement of lactate dehydrogenase (LDH) release from damaged cells using the Cytotoxicity Detection kit (Roche Diagnostics, Rotkreuz, Switzerland). After the 4-hour incubation the plates were centrifuged at 800 x g. 100 µl supernatant from each well was transferred to a new transparent flat bottom 96 well plate. 100 µl color substrate buffer from the kit were added per well. The Vmax values of the color reaction were determined in an ELISA reader at 490 nm for at least 10 min using SOFTmax PRO software (Molecular Devices, Sunnyvale, Calif. 94089, USA). Spontaneous LDH release was measured from wells containing

only target and effector cells but no antibodies. Maximal release was determined from wells containing only target cells and 1% Triton X-100. Percentage of specific antibody-mediated killing was calculated as follows: ((x-SR)/(MR-SR)*100, where x is the mean of Vmax at a specific antibody concentration, SR is the mean of Vmax of the spontaneous release and MR is the mean of Vmax of the maximal release.

Figure 9 shows the results of this assay and confirms that the humanized variants retained the ADCC activity of the parent glycoengineered LC007 antibody.

The surviving target cells were further quantified by calcein measurement (Wallac Victor3 1420 Multilabel Counter) after washing and cell lysis using 5 mM borate Buffer containing 0.1 % Triton X-100 using the assay as described in Example 6. The results of this assay are shown in Figure 10.

Example 9 Mouse Xenograft Assays

9.1 MV3 cells in FcgR3 transgenic SCID mice

20 FcgR3A tg SCID mice (purchased from Charles River, Lyon, France) were maintained under IVC (Isolated Ventilated Cages) conditions with daily cycles of 12 h light /12 h darkness according to committed guidelines (GV-Solas; Felasa; TierschG). Experimental study protocol was reviewed and approved by local government (P 2005086). After arrival animals were maintained for one week to get accustomed to new environment and for observation. Continuous health monitoring was carried out on regular basis.

MV3 tumor cell lines(van Muijen GN, et al., Int J Cancer. 48(1):85-91 (1991)). were routinely cultured in DMEM medium (GIBCO, Switzerland) supplemented with 10 % fetal bovine serum (Invitrogen, Switzerland) at 37 °C in a water-saturated atmosphere at 5 % CO2. Culture passage was performed with trypsin / EDTA 1x (GIBCO, Switzerland) splitting every third day. At day of injection, the tumor cells were harvested using trypsin-EDTA (Gibco, Switzerland) from culture flasks (Greiner Bio-One) and transferred into 50 ml culture medium, washed once and resuspended in AIM V (Gibco, Switzerland). After an additional washing with AIM V, cell concentration was determined using a cell counter. $0.2x10^6$ cells in 200 ul of Aim V medium were injected into tail vein of each FcgR3A tg SCID mice.

Therapy

The xenograph mice were assigned to either a treatment group or a vehicle control group, each group consisting of nine mice. The treatment group was administered 25 mg/kg of the humanized glyco-engineered anti-MCSP mAb M4-3 ML2intravenously. The vehicle control group was intravenously administered the vehicle only. Both groups received three doses, on day 7, 14, and 21.

Statistical analysis was performed on the data obtained from the therapy using a log-rank (Mantel-Cox) Test: p=0.0033 and Gehan-Breslow-Wilcoxon Test: p=0.0039.

Results

As shown in Figure 11, the humanized glyco-engineered anti-MCSP antibody significantly increases survival time in this model as compared to the vehicle control.

9.2 MDA-MB-435 cells in FcgR3 transgenic SCID mice

MDA-MB435 cells were originally obtained from ATCC and after expansion deposited in the Glycart internal cell bank. MDA-MB435 tumor cell lines were routinely cultured in RPMI medium (GIBCO, Switzerland) supplemented with 10 % fetal bovine serum (Invitrogen, Switzerland) and 1% Glutamax at 37 °C in a water-saturated atmosphere at 5 % CO2. Culture passage was performed with trypsin / EDTA 1x (GIBCO, Switzerland) splitting every third day.

FcgR3A tg SCID mice (purchased from Charles River, Lyon, France) were maintained under IVC (Isolated Ventilated Cages) conditions with daily cycles of 12 h light /12 h darkness according to committed guidelines (GV-Solas; Felasa; TierschG). Experimental study protocol was reviewed and approved by local government (P 2005086). After arrival animals were maintained for one week to get accustomed to new environment and for observation. Continuous health monitoring was carried out on regular basis.

At day of injection, the tumor cells were harvested using trypsin-EDTA (Gibco, Switzerland) from culture flasks (Greiner Bio-One) and transferred into 50 ml culture medium, washed once and resuspended in AIM V (Gibco, Switzerland). After an additional washing with AIM V, cell concentration was determined using a cell counter. $0.2x10^6$ cells in 200 ul of Aim V medium were injected into tail vein of each FcgR3A tg SCID mice.

Therapy

The xenograph mice were assigned to either a treatment group or a vehicle control group.. The treatment group was administered 25 mg/kg of t chimeric glyco-engineered anti-MCSP mAb intravenously. The vehicle control group was intravenously administered the vehicle only. Both groups received three doses, on day 7, 14, and 21.

Results

As shown in Figure 12, the chimeric glyco-engineered anti-MCSP antibody significantly increases survival time in this model as compared to the vehicle control.

9.3 MDA-MB-435 cells in FcgR3 transgenic SCID mice

The same protocol as in Example 9.2 was followed, except that humanized antibody M4-3 ML2 (comprising the VH of SEQ ID NO: 32 and the VL of SEQ ID NO: 31) was compared to its parental, chimeric antibody LC007. Both of these antibodies are glycoengineered.

Results

As shown in Figure 13 both the parental, chimeric antibody LC007 and humanized glyco-engineered variant thereof significantly increase survival time in this model as compared to the vehicle control.

Example 10 Affinity maturation of anti-MCSP antibody M4-3 / ML2

Affinity maturation was performed via the oligonucleotide-directed mutagenesis procedure. For this procedure, the heavy chain variant M4-3, and the light chain variant ML2 were cloned into a phagemid vector, similar to those described by Hoogenboom, (Hoogenboom et al., Nucleic Acids Res. 1991, 19, 4133–4137). Residues to be randomized were identified by first generating a 3D model of that antibody via classical homology modeling and then identifying the solvent accessible residues of the complementary determining regions (CDRs) of heavy and light chain. Oligonucleotides with randomization based on trinucleotide synthesis were purchased from Ella-biotech (Munich, Germany). Three independent sublibraries were generated via classical PCR, and comprised randomization in CDR-H1 together with CDR-H2, or CDR-L1 together with CDR-L2, CDR-L3 was randomized in a separate approach. The DNA fragments of those libraries were cloned into the phagemid via restriction digest and ligation, and subsequently electroporated into TG1 bacteria.

Library selection.

The antibody variants thus generated were displayed in a monovalent fashion from filamentous phage particles as fusions to the gene III product of M13 packaged within each particle. The phage-displayed variants were then screened for their biological activities (here: binding affinity) and candidates that had improved activities were used for further development. Methods for making phage display libraries can be found in Lee et al., J. Mol. Biol. (2004) 340, 1073–1093),

Selections with all affinity maturation libraries were carried out in solution according to the following procedure: 1. binding of ~ 1012 phagemid particles of each affinity maturation libraries to 100nM biotinylated hu-MCSP(D3 domain)-avi-his for 0.5 h in a total volume of 1ml, 2. capture of biotinylated hu-MCSP(D3 domain)-avi-his and specifically bound phage particles by addition of 5.4 × 107 streptavidin-coated magnetic beads for 10 min, 3. washing of beads using 5-10x 1ml PBS/Tween20 and 5-10x 1ml PBS, 4. elution of phage particles by addition of 1ml 100mM TEA (triethylamine) for 10 min and neutralization by adding 500ul 1M Tris/HCl pH 7.4 and 5. re-infection of exponentially growing E. coli TG1 bacteria,

infection with helper phage VCSM13 and subsequent PEG/NaCl precipitation of phagemid particles to be used in subsequent selection rounds. Selections were carried out over 3-5 rounds using either constant or decreasing (from 10-7M to 2x10-9M) antigen concentrations. In round 2, capture of antigen: phage complexes was performed using neutravidin plates instead of streptavidin beads. Specific binders were identified by ELISA as follows: 100 ul of 10nM biotinylated hu-MCSP(D3 domain)-avi-his per well were coated on neutravidin plates. Fab-containing bacterial supernatants were added and binding Fabs were detected via their Flag-tags by using an anti-Flag/HRP secondary antibody. ELISA-positive clones were bacterially expressed as soluble Fab fragments in 96-well format and supernatants were subjected to a kinetic screening experiment by SPR-analysis using ProteOn XPR36 (BioRad). Clones expressing Fabs with the highest affinity constants were identified and the corresponding phagemids were sequenced.

Figure 14 shows an alignment of affinity matured anti-MCSP clones compared to the non-matured parental clone (M4-3 ML2). Heavy chain randomization was performed only in the CDR1 and 2. Light chain randomization was performed in CDR1 and 2, and independently in CDR3. During selection, a few mutations in the frameworks occured like F71Y in clone G3 or Y87H in clone E10.

Production and purification of human IgG1

The variable region of heavy and light chain DNA sequences of the affinity matured variants were subcloned in frame with either the constant heavy chain or the constant light chain pre-inserted into the respective recipient mammalian expression vector. The antibody expression was driven by an MPSV promoter and carries a synthetic polyA signal sequence at the 3' end of the CDS. In addition each vector contained an EBV OriP sequence.

The molecule was produced by co-transfecting HEK293-EBNA cells with the mammalian expression vectors using polyethylenimine. The cells were transfected with the corresponding expression vectors in a 1:1 ratio. For transfection HEK293 EBNA cells were cultivated in suspension serum free in CD CHO culture medium. For the production in 500 ml shake flask 400 million HEK293 EBNA cells were seeded 24 hours before transfection. For transfection cells were centrifuged for 5 min by 210 x g, supernatant was replaced by pre-warmed 20 ml CD CHO medium. Expression vectors were mixed in 20 ml CD CHO medium to a final amount of 200 µg DNA. After addition of 540 µl PEI solution was vortexed for 15 s and subsequently incubated for 10 min at room temperature. Afterwards cells were mixed with the DNA/PEI solution, transferred to a 500 ml shake flask and incubated for 3 hours by 37 °C in an incubator with a 5 % CO2 atmosphere. After incubation time 160 ml F17 medium was added and cell were cultivated for 24 hours. One day after transfection 1 mM valporic acid and 7 % Feed 1 was added. After 7 days cultivation supernatant

was collected for purification by centrifugation for 15 min at 210 x g, the solution was sterile filtered (0.22 µm filter) and sodium azide in a final concentration of 0.01 % w/v was added, and kept at 4°C.

The secreted protein was purified from cell culture supernatants by affinity chromatography using ProteinA. Supernatant was loaded on a HiTrap ProteinA HP column (CV=5 mL, GE Healthcare) equilibrated with 40 ml 20 mM sodium phosphate, 20 mM sodium citrate, 0.5 M sodium chloride, pH 7.5. Unbound protein was removed by washing with at least 10 column volume 20 mM sodium phosphate, 20 mM sodium citrate, 0.5 M sodium chloride, pH 7.5. Target protein was eluted during a gradient over 20 column volume from 20 mM sodium citrate, 0.5 M sodium chloride, pH 7.5 to 20 mM sodium citrate, 0.5 M sodium chloride, pH 2.5. Protein solution was neutralized by adding 1/10 of 0.5 M sodium phosphate, pH 8. Target protein was concentrated and filtrated prior loading on a HiLoad Superdex 200 column (GE Healthcare) equilibrated with 20 mM Histidine, 140 mM sodium chloride solution of pH 6.0.

The protein concentration of purified protein samples was determined by measuring the optical density (OD) at 280 nm, using the molar extinction coefficient calculated on the basis of the amino acid sequence. Purity and molecular weight of molecules were analyzed by CE-SDS analyses in the presence and absence of a reducing agent. The Caliper LabChip GXII system (Caliper lifescience) was used according to the manufacturer's instruction. 2ug sample is used for analyses. The aggregate content of antibody samples is analyzed using a TSKgel G3000 SW XL analytical size-exclusion column (Tosoh) in 25 mM K2HPO4, 125 mM NaCl, 200 mM L-Arginine Monohydrocloride, 0.02 % (w/v) NaN3, pH 6.7 running buffer at 25°C. The data is shown in Table 2.

Table 2: Production and purification of affinity matured anti -MCSP IgGs

Construct	Yield [mg/l]	HMW [%]	LMW [%]	Monomer [%]
M4-3(C1) ML2(G3)	43.9	0	0	100
M4-3(C1) ML2(E10)	59.5	0	0	100
M4-3(C1) ML2(C5)	68.9	0	0.8	99.2

Affinity determination by Surface plasmon resonance (SPR) using Biacore T200

Surface plasmon resonance (SPR) experiments to determine the affinity of the affinity matured IgGs were performed on a Biacore T200 at 25 °C with HBS-EP as running buffer (0.01 M HEPES pH 7.4, 0.15 M NaCl, 3 mM EDTA, 0.005% Surfactant P20, Biacore, Freiburg/Germany).

IgGs were captured on a CM5 sensorchip surface with immobilized anti human Fab. Capture IgG was coupled to the sensorchip surface by direct immobilization of around 10,000 resonance units (RU) at pH 5.0 using the standard amine coupling kit (Biacore, Freiburg/Germany). IgGs are captured for 60 s at 30 nM with 10 µl/min. Human and cynomolgus MCSP D3 were passed at a concentration of 0.49 - 1000 nM with a flowrate of 30 µl/min through the flow cells over 180 s. The dissociation is monitored for 210 s. Bulk refractive index differences were corrected for by subtracting the response obtained on reference flow cell. Here, the antigens were flown over a surface with immobilized anti-human Fab antibody but on which HBS-EP has been injected rather than anti MCSP IgGs.

Kinetic constants were derived using the Biacore T200 Evaluation Software (vAA, Biacore AB, Uppsala/Sweden), to fit rate equations for 1:1 Langmuir binding by numerical integration.

Higher affinity to human and cynomolgus MCSP D3 by the affinity matured variants was confirmed, with data shown in Table 3.

Table 3. Affinity of anti MCSP IgGs to human MCSP-D3 and cynomolgus MCSP D3.

K_D in nM T = 25°C	**Human MCSP D3**	**Cynomolgus MCSP D3**
	Affinity	**Affinity**
M4-3 (C1) ML2 (G3)	1.6	1.3
M4-3 (C1) ML2 (E10)	3.9	4.5
M4-3 (C1) ML2 (C5)	0.003	0.12
M4-3 ML2 (E10)	21.4	62.8
M4-3 ML2 (E10/G3)	5.5	12.2
M4-3 ML2 (C5)	0.8	5.7
M4-3 ML2 (C5/G3)	4.2	12.8
M4-3 (D6) ML2	15.1	24.6
M4-3 (A7) ML2	7.1	16.3

M4-3 (B7) ML2	12.6	9.9
M4-3 (B8) ML2	19.2	28.8
M4-3 (C1) ML2	7.2	9.8
M4-3 (A7) ML2 (G3)	0.009	1.5
M4-3 (A7) ML2 (E10)	3.1	8.5
M4-3 (A7) ML2 (C5)	0.002	1.1
M4-3 ML2 (parental)	24.2	82.5

TABLE A : Sequence Listing Description

SEQ ID	Description
SEQ ID NO: 1	Human MCSP
SEQ ID NO: 2	MCSP Peptide (amino acids 2177-2221 of human MCSP)
SEQ ID NO: 3	CSPG repeat 14 (amino acids 1937-2043 of human MCSP)
SEQ ID NO: 4	CSPG repeat 15 (amino acids 2044-2246 of human MCSP)
SEQ ID NO: 5	CSPG repeat 14-15 (amino acids 1937-2246 of human MCSP)
SEQ ID NO: 6	CSPG repeat 13-15 (amino acids 1828-2246 of human MCSP)
SEQ ID NO: 7	CSPG repeat 12-15 (amino acids 1702-2246 of human MCSP)
SEQ ID NO: 8	D3 domain of cynomologus MCSP (extracellular part)
SEQ ID NO: 9	D3 domain of human MCSP (extracellular part)
SEQ ID NO: 10	LC007 chimeric antibody HVR-L1 ML1 HVR-L1
SEQ ID NO: 11	LC007 chimeric antibody HVR-L2 ML1 HVR-L2 ML2 HVR-L2
SEQ ID NO: 12	LC007 chimeric antibody HVR-L3 LC007 humanized antibody ML1 HVR-L3 LC007 humanized antibody ML2 HVR-L3
SEQ ID NO: 13	LC007 humanized antibody ML2 HVR-L1
SEQ ID NO:14	LC007 chimeric antibody HVR-H1 LC007 humanized antibody M4-1 HVR-H1
SEQ ID NO: 15	LC007 chimeric antibody HVR-H2
SEQ ID NO: 16	LC007 chimeric antibody HVR-H3 LC007 humanized antibody M4-1 HVR-H3 LC007 humanized antibody M4-3 HVR-H3
SEQ ID NO: 17	LC007 humanized antibody M4-3 HVR-H1
SEQ ID NO: 18	LC007 humanized antibody M4-1 HVR-H2 LC007 humanized antibody M4-3 HVR-H2
SEQ ID NO: 19	LC007 humanized antibody ML3 HVR-L1
SEQ ID NO: 20	LC007 humanized antibody L7A HVR-L1

SEQ ID	Description
SEQ ID NO: 21	LC007 humanized antibody L7B HVR-L1
SEQ ID NO: 22	LC007 humanized antibody ML5 HVR-L2
SEQ ID NO: 23	LC007 humanized antibody L7C HVR-L2
SEQ ID NO: 24	LC007 humanized antibody L7D HVR-L2
SEQ ID NO: 25	LC007 humanized antibody M4-7 HVR-H1
SEQ ID NO: 26	LC007 chimeric antibody VL
SEQ ID NO: 27	LC007 chimeric antibody VH
SEQ ID NO: 28	LC007 humanized antibody ML1 VL
SEQ ID NO: 29	LC007 humanized antibody M4-1 VH
SEQ ID NO: 30	LC007 humanized antibody M4-2 VH
SEQ ID NO: 31	LC007 humanized antibody ML2 VL
SEQ ID NO: 32	LC007 humanized antibody M4-3 VH
SEQ ID NO: 33	LC007 humanized antibody M4-6 VH
SEQ ID NO: 34	LC007 chimeric antibody light chain
SEQ ID NO: 35	LC007 chimeric antibody heavy chain
SEQ ID NO: 36	LC007 humanized antibody ML2 light chain
SEQ ID NO: 37	LC007 humanized antibody M4-3 heavy chain
SEQ ID NO: 38	LC007 murine antibody light chain nucleic acid sequence
SEQ ID NO: 39	LC007 murine antibody heavy chain nucleic acid sequence
SEQ ID NO: 40	LC007 chimeric antibody light chain nucleic acid sequence
SEQ ID NO: 41	LC007 chimeric antibody heavy chain nucleic acid sequence
SEQ ID NO: 42	LC007 humanized antibody ML2 light chain nucleic acid sequence
SEQ ID NO: 43	LC007 humanized antibody M4-3 heavy chain nucleic acid sequence
SEQ ID NO: 44	MCSP Transmembrane domain
SEQ ID NO: 45	Affinity matured variant M4-3 (C1) heavy chain
SEQ ID NO: 46	Affinity matured variant ML2 (G3) light chain
SEQ ID NO: 47	Affinity matured variant M4-3 (C1) VH
SEQ ID NO: 48	Affinity matured variant M4-3 (C1) HVR-H1 M4-3 (D6) HVR-H1 M4-3 (B7) HVR-H1 M4-3 (B8) HVR-H1
SEQ ID NO: 49	Affinity matured variant M4-3 (C1) HVR-H2

SEQ ID	Description
SEQ ID NO: 50	Affinity matured variant M4-3 (C1) HVR-H3 M4-3 (A7) HVR-H3 M4-3 (D6) HVR-H3 M4-3 (B7) HVR-H3 M4-3 (B8) HVR-H3
SEQ ID NO: 51	Affinity matured variant ML2 (G3) VL
SEQ ID NO: 52	Affinity matured variant ML2 (G3) HVR-L1
SEQ ID NO: 53	Affinity matured variant ML2 (G3) HVR-L2 ML2 (E10) HVR-L2 ML2 (E10-G3) HVR-L2
SEQ ID NO: 54	Affinity matured variant ML2 (G3) HVR-L3
SEQ ID NO: 55	Affinity matured variant M4-3 (D6) VH
SEQ ID NO: 56	Affinity matured variant M4-3 (D6) HVR-H2
SEQ ID NO: 57	Affinity matured variant M4-3 (A7) VH
SEQ ID NO: 58	Affinity matured variant M4-3 (A7) HVR-H1
SEQ ID NO: 59	Affinity matured variant M4-3 (A7) HVR-H2 M4-3 (B8) HVR-H2
SEQ ID NO: 60	Affinity matured variant M4-3 (B7) VH
SEQ ID NO: 61	Affinity matured variant M4-3 (B7) HVR-H2
SEQ ID NO: 62	Affinity matured variant M4-3 (B8) VH
SEQ ID NO: 63	Affinity matured variant ML2 (E10) VL
SEQ ID NO: 64	Affinity matured variant ML2 (E10) HVR-L1 ML2 (E10-G3) HVR-L1
SEQ ID NO: 65	Affinity matured variant ML2 (E10) HVR-L3 ML2 (E10-G3) HVR-L3 ML2 (C5-G3) HVR-L3
SEQ ID NO: 66	Affinity matured variant ML2 (E10-G3) VL
SEQ ID NO: 67	Affinity matured variant ML2 (C5) VL
SEQ ID NO: 68	Affinity matured variant ML2 (C5) HVR-L1 ML2 (C5-G3) HVR-L1
SEQ ID NO: 69	Affinity matured variant ML2 (C5) HVR-L2 ML2 (C5-G3) HVR-L2
SEQ ID NO: 70	Affinity matured variant ML2 (C5) HVR-L3
SEQ ID NO: 71	Affinity matured variant ML2 (C5-G3) VL

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

WHAT IS CLAIMED IS:

1. An isolated antibody that binds to a membrane proximal epitope of human MCSP comprising a CSPG repeat-containing domain, wherein the antibody binds to MCSP with a Kd of $5x10^{-9}$ M or less.

2. The antibody of claim 1, wherein the antibody binds to MCSP with a Kd of $2x10^{-9}$ M or less.

3. The antibody of claim 1or claim 2, wherein the CSPG repeat-containing domain comprises CSPG repeat 14 (SEQ ID NO: 3).

4. The antibody of any of claims 1-3, wherein the antibody is a bispecific antibody.

5. The antibody of any of claims 1-4, wherein the antibody is an scFv fragment, an Fv fragment, or a $F(ab')_2$ fragment.

6. The antibody of any of claims 1-5 wherein the antibody is a human, humanized, or chimeric antibody.

7. The antibody of any of claims 1-4 or 6, wherein the antibody comprises an Fc region.

8. The antibody of claim 7, wherein the antibody is a full-length IgG class antibody.

9. The antibody of claim 7 or 8, wherein the antibody has been glycoengineered to modify the oligosaccharides in the Fc region.

10. The antibody of claim 9, wherein the Fc region has a reduced number of fucose residues as compared to the nonglycoengineered antibody.

11. The antibody of claim 9 or claim 10, wherein the antibody has an increased ratio of GlcNAc residues to fucose residues in the Fc region compared to the non-glycoengineered antibody.

12. The antibody of any of claims 9-11, wherein the Fc region has an increased proportion of bisected oligosaccharides as compared to the non-glycoengineered antibody.

13. The antibody of any of claims 9-12, wherein the Fc region has an increased proportion of bisected oligosaccharides as compared to the non-glycoengineered antibody.

14. The antibody of any of claims 9-13, wherein the antibody has an increased effector function compared to the nonglycoengineere antibody.

15. The antibody of claim 14, wherein the effector function is increased antibody-dependent cell-mediated cytotoxicity (ADCC) activity.

16. The antibody of claim 14, wherein the effector function is increased binding affinity to an Fc receptor.

17. The antibody of any of claims 1-16, wherein the antibody comprises (a) an HVR-H1 comprising an amino acid sequence selected from among SEQ ID NO: 48 and SEQ ID NO: 58; (b) an HVR-H2 comprising an amino acid sequence selected from among SEQ ID NO: 49, SEQ ID NO: 56, SEQ ID NO:

59, and SEQ ID NO: 61; (c) an HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50; (d) an HVR-L1 comprising an amino acid sequence selected from among SEQ ID NO: 52, SEQ ID NO: 64, and SEQ ID NO: 68; (e) an HVR-L2 comprising an amino acid sequence selected from among SEQ ID NO: 53 and SEQ ID NO: 69; (f) an HVR-L3 comprising an amino acid sequence selected from among SEQ ID NO: 54, SEQ ID NO: 65, and SEQ ID NO: 70.

18. The antibody of claim 17, wherein the antibody comprises (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 48; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 49; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 50.

19. The antibody of claim 17 or 18, wherein the antibody comprises (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 52; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 53; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 54.

20. The antibody of any of claims 1-19, comprising (a) a VH sequence having at least 95% sequence identity to the amino acid sequence of SEQ ID NO: 47; (b) a VL sequence having at least 95% sequence identity to the amino acid sequence of SEQ ID NO: 51; or (c) a VH sequence as in (a) and a VL sequence as in (b).

21. The antibody of claim 20, comprising a VH sequence of SEQ ID NO: 47.

22. The antibody of claim 20, comprising a VL sequence of SEQ ID NO: 51.

23. The antibody of claim 20, comprising a VH sequence of SEQ ID NO: 47 and a VL sequence of SEQ ID NO: 51.

24. An isolated nucleic acid encoding the antibody of any of claims 1-23.

25. A host cell comprising the nucleic acid of claim 24.

26. A method of producing an antibody comprising culturing the host cell of claim 25 so that the antibody is produced .

27. An immunoconjugate comprising the antibody of any of claims 1-23 and a cytotoxic agent.

28. A pharmaceutical formulation comprising the antibody of any of claims 1-23 or the immunoconjugate of claim 27 and a pharmaceutically acceptable carrier.

29. The antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28 for use as a medicament.

30. Use the antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28 for treating cancer.

31. The use of claim 30, wherein the cancer is a cancer that expresses MCSP.

32. The use of claim 31, wherein the cancer is selected from the group consisting of a skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML).

33. Use of the antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28 for inducing cell lysis.

34. Use of the antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28 in the manufacture of a medicament.

35. The use of claim 34, wherein the medicament is for treatment of cancer.

36. The use of claim 34, wherein the medicament is for inducing cell lysis.

37. A method of treating an individual having cancer comprising administering to the individual an effective amount of antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28.

38. The method of claim 37, wherein the cancer is a cancer that expresses MCSP.

39. The method of claim 39, wherein the cancer is selected from the group consisting of skin cancer (including melanoma and basel cell carcinomas), gliomas (including glioblastomas), bone cancer (such as osteosarcomas), and leukemia (including ALL and AML).

40. A method of inducing cell lysis in an individual comprising administering to the individual an effective amount of the antibody of any of claims 1-23, the immunoconjugate of claim 27, or the pharmaceutical formulation of claim 28.

41. The invention as described hereinbefore.

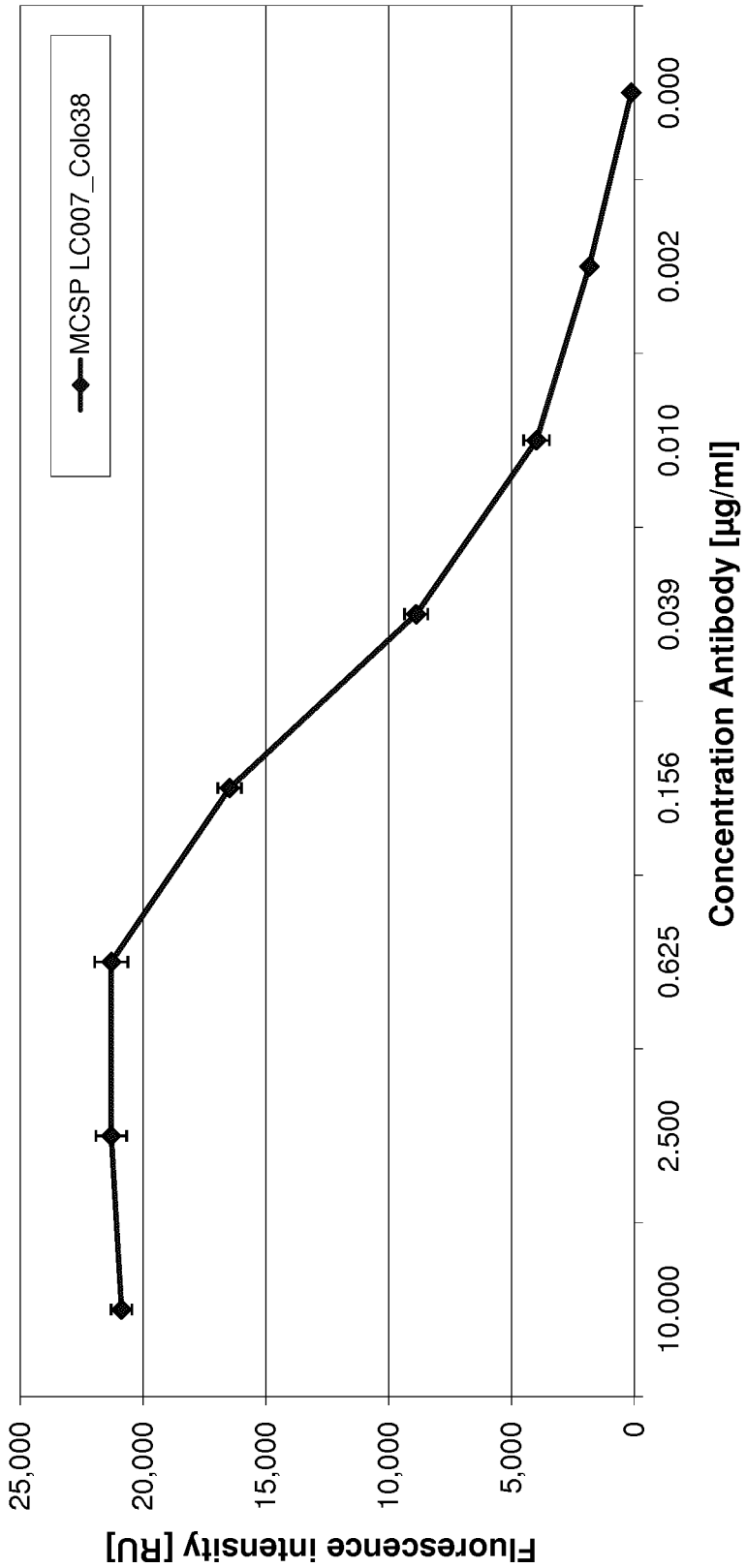
MCSP LC007_Col038
Fluorescence intensity [RU]
25,000
20,000
15,000
10,000
5,000
0
Concentration Antibody [µg/ml]
10.000
2.500
0.625
0.156
0.039
0.010
0.002
0.000

Figure 1

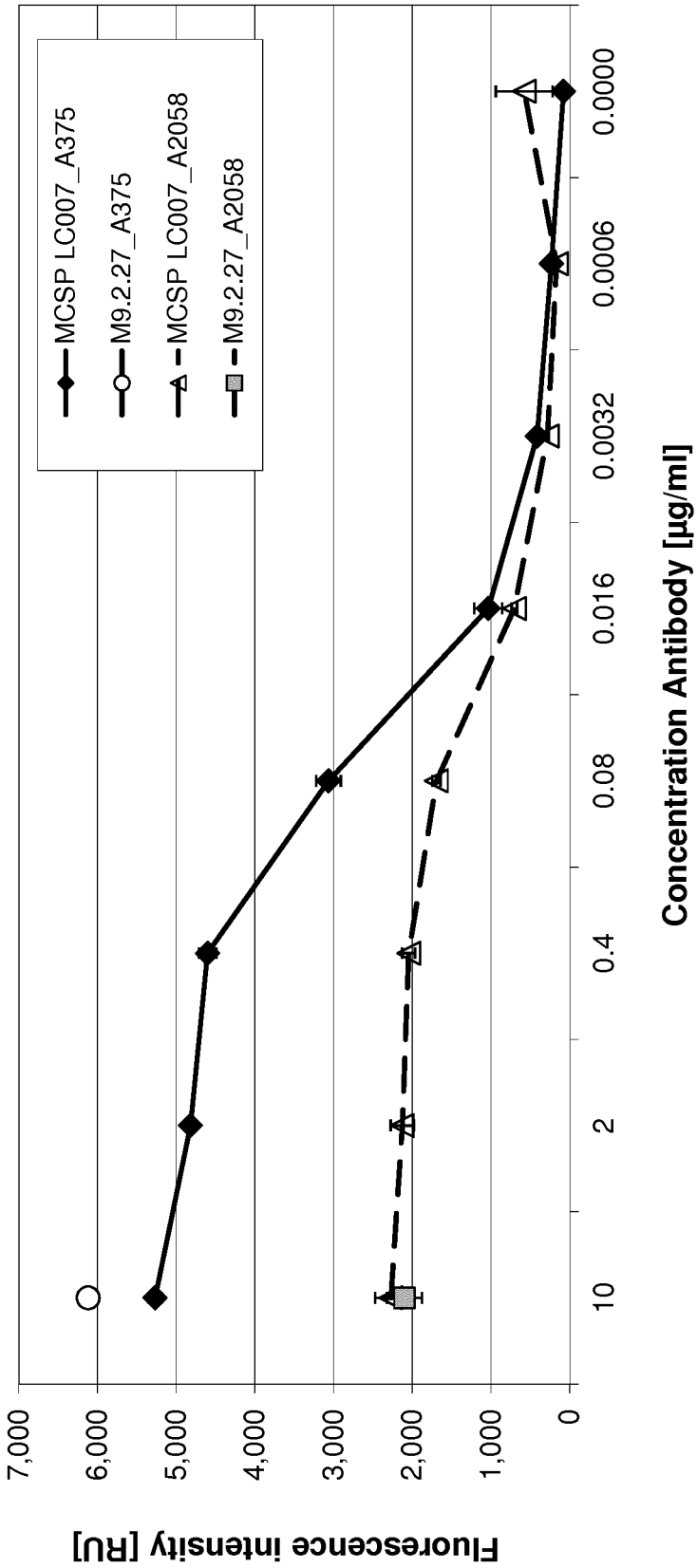
MCSP LC007_A375
M9.2.27_A375
MCSP LC007_A2058
M9.2.27_A2058
Fluorescence intensity [RU]
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Concentration Antibody [µg/ml]
10
2
0.4
0.08
0.016
0.0032
0.0006
0.0000

Figure 2

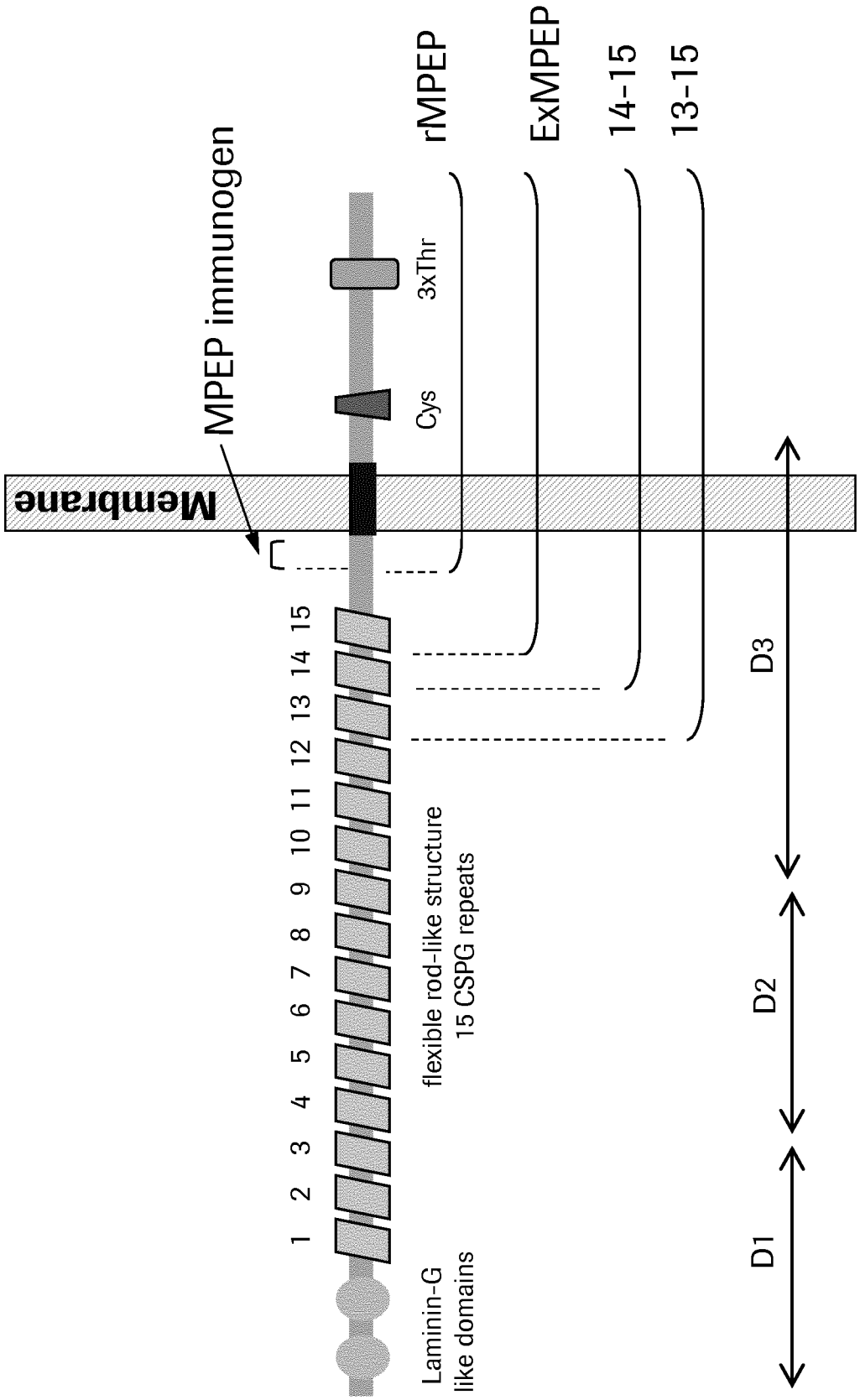
MPEP immunogen
Membrane
Cys
3xThr
rMPEP
ExMPEP
14-15
13-15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Laminin-G
like domains
flexible rod-like structure
15 CSPG repeats
D1
D2
D3

Figure 3

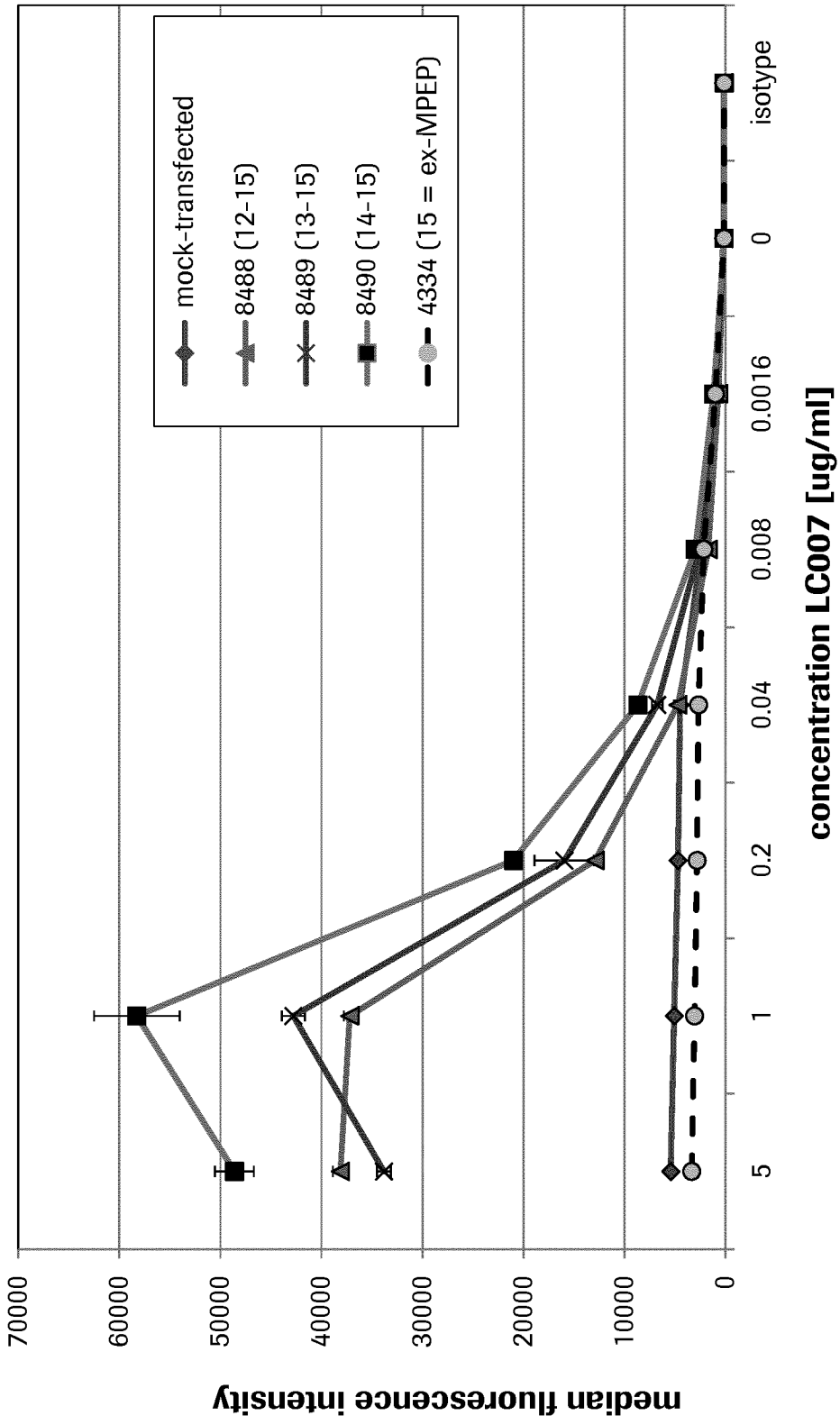
median fluorescence intensity
70000
60000
50000
40000
30000
20000
10000
0
mock-transfected
8488 (12-15)
8489 (13-15)
8490 (14-15)
4334 (15 = ex-MPEP)
5
1
0.2
0.04
0.008
0.0016
0
isotype
concentration LC007 [ug/ml]

Figure 4

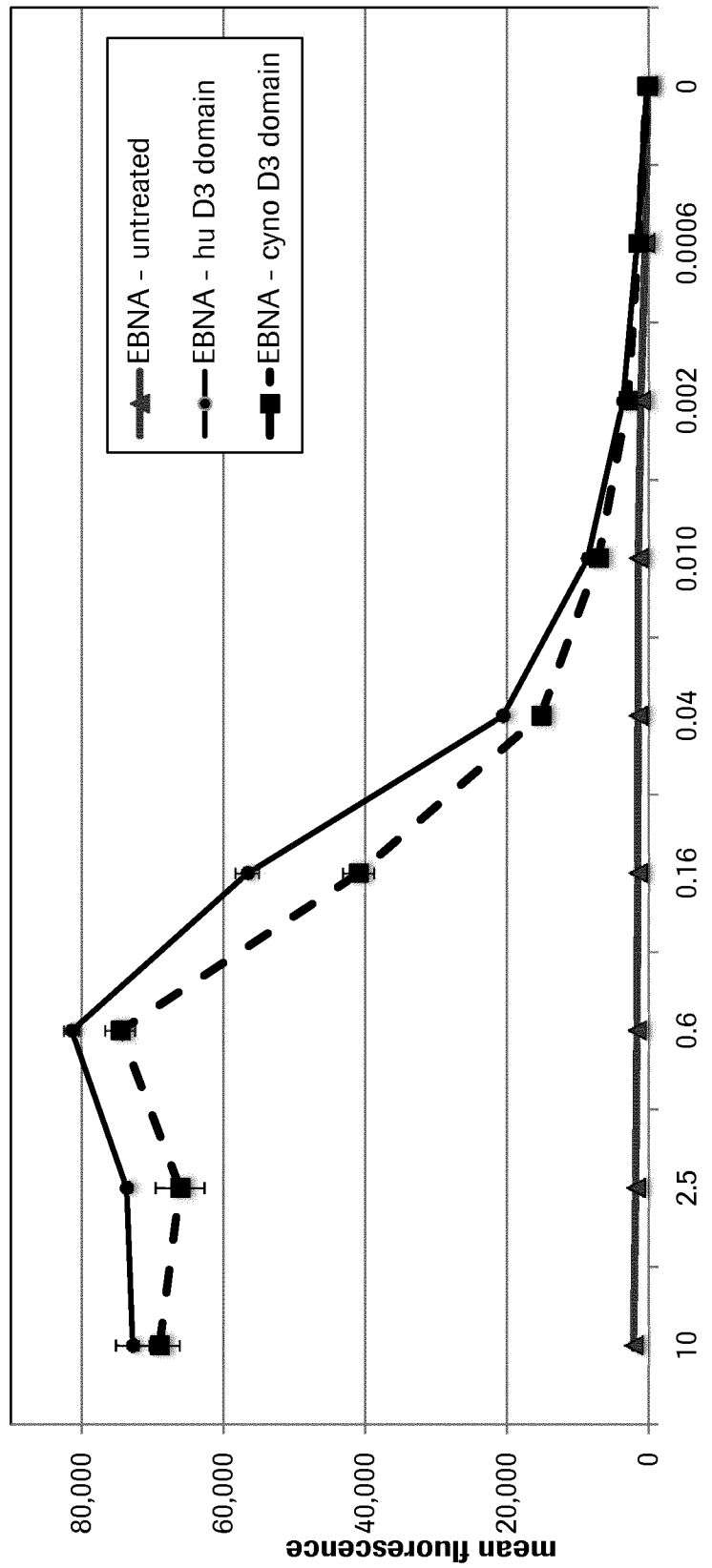
EBNA - untreated
EBNA - hu D3 domain
EBNA - cyno D3 domain
mean fluorescence
80,000
60,000
40,000
20,000
0
10
2.5
0.6
0.16
0.04
0.010
0.002
0.0006
0
LC007 Concentration (µg/ml)

Figure 5

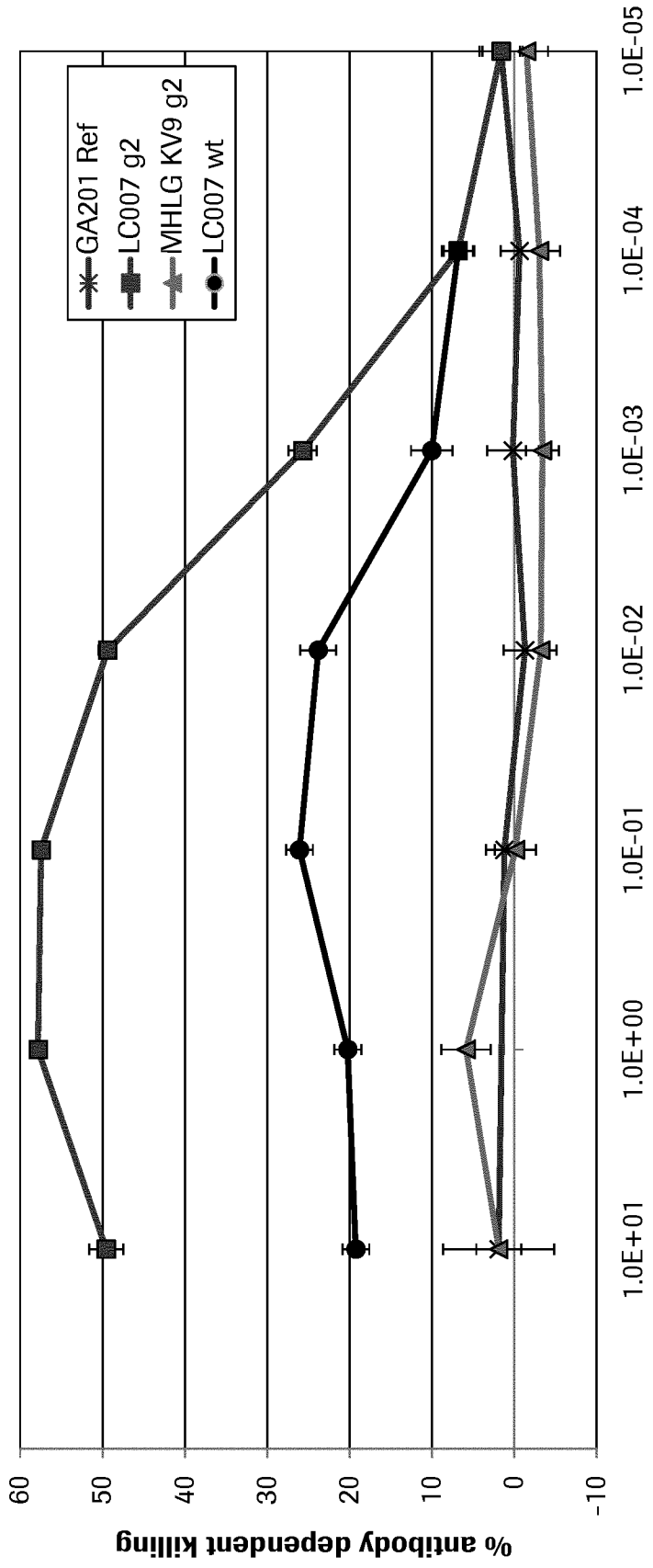
GA201 Ref
LC007 g2
MHLG KV9 g2
LC007 wt
% antibody dependent killing
60
50
40
30
20
10
0
-10
1.0E+01
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
antibody concentration (µg/ml)

Figure 6

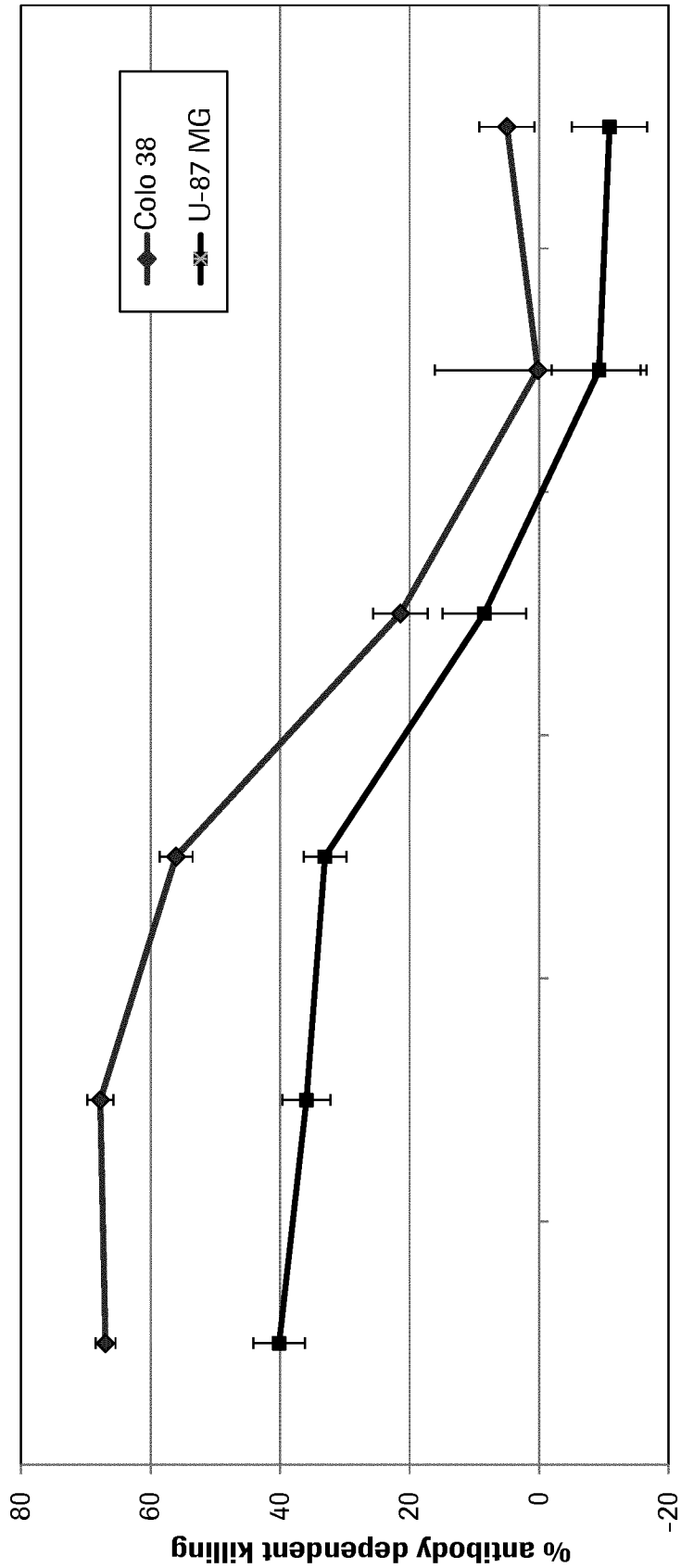
Colo 38
U-87 MG
% antibody dependent killing
80
60
40
20
0
-20
1
0.1
0.01
0.001
0.0001
0.00001
antibody concentration (µg/ml)

Figure 7

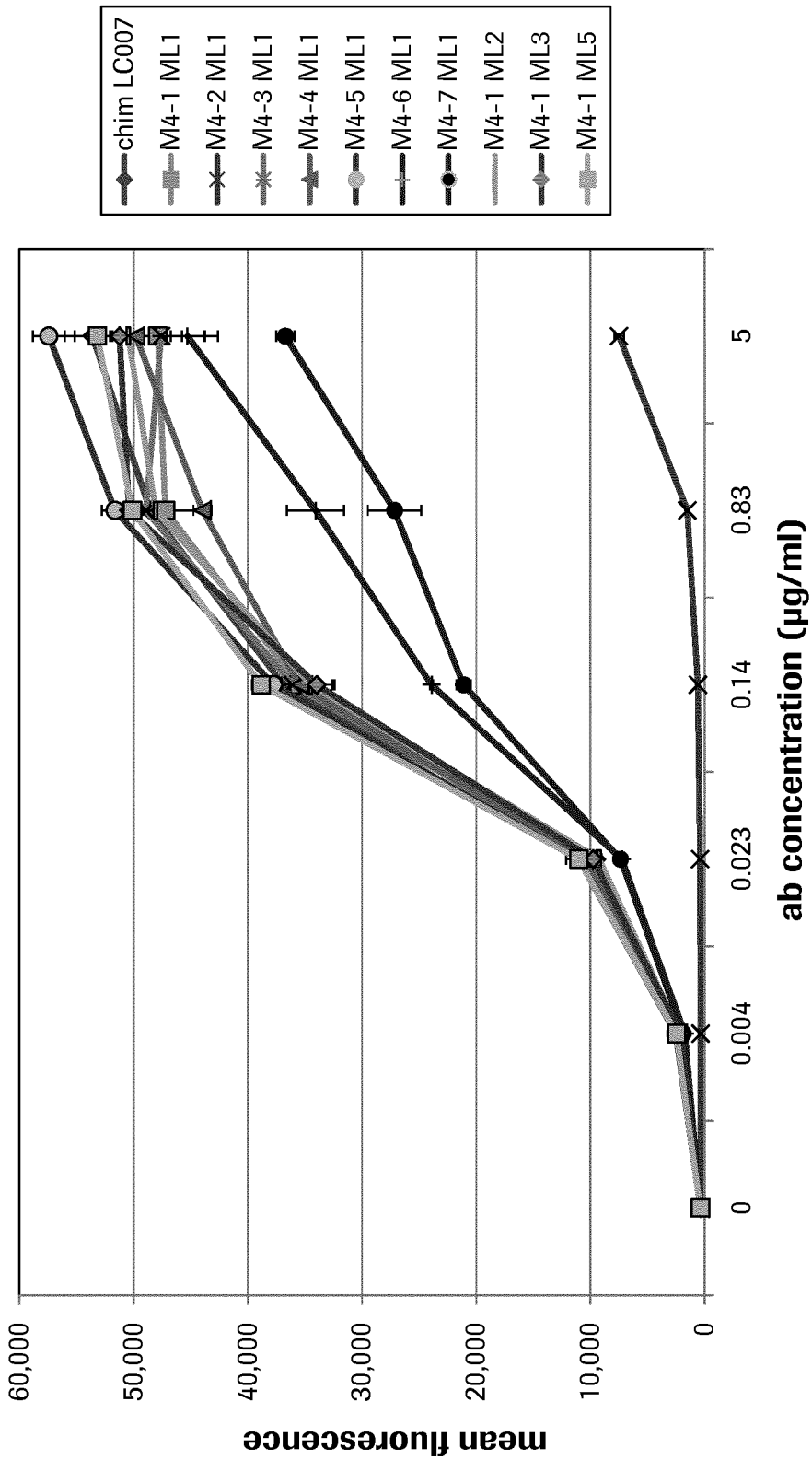
chim LC007
M4-1 ML1
M4-2 ML1
M4-3 ML1
M4-4 ML1
M4-5 ML1
M4-6 ML1
M4-7 ML1
M4-1 ML2
M4-1 ML3
M4-1 ML5
mean fluorescence
60,000
50,000
40,000
30,000
20,000
10,000
0
0
0.004
0.023
0.14
0.83
5
ab concentration (µg/ml)

Figure 8

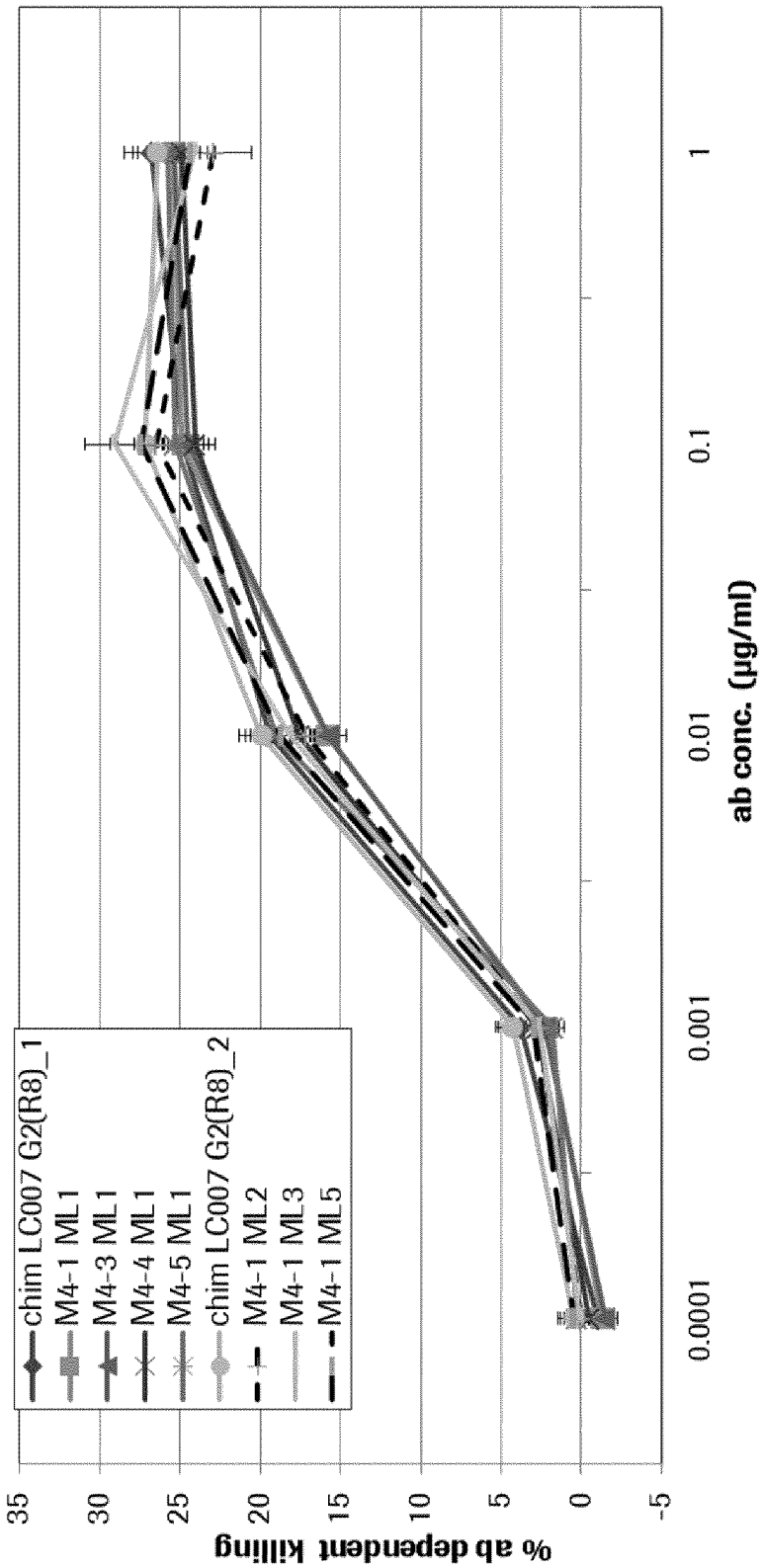
% ab dependent killing
35
30
25
20
15
10
5
0
-5
0.0001
0.001
0.01
0.1
1
ab conc. (µg/ml)
chim LC007 G2(R8)_1
M4-1 ML1
M4-3 ML1
M4-4 ML1
M4-5 ML1
chim LC007 G2(R8)_2
M4-1 ML2
M4-1 ML3
M4-1 ML5

Figure 9

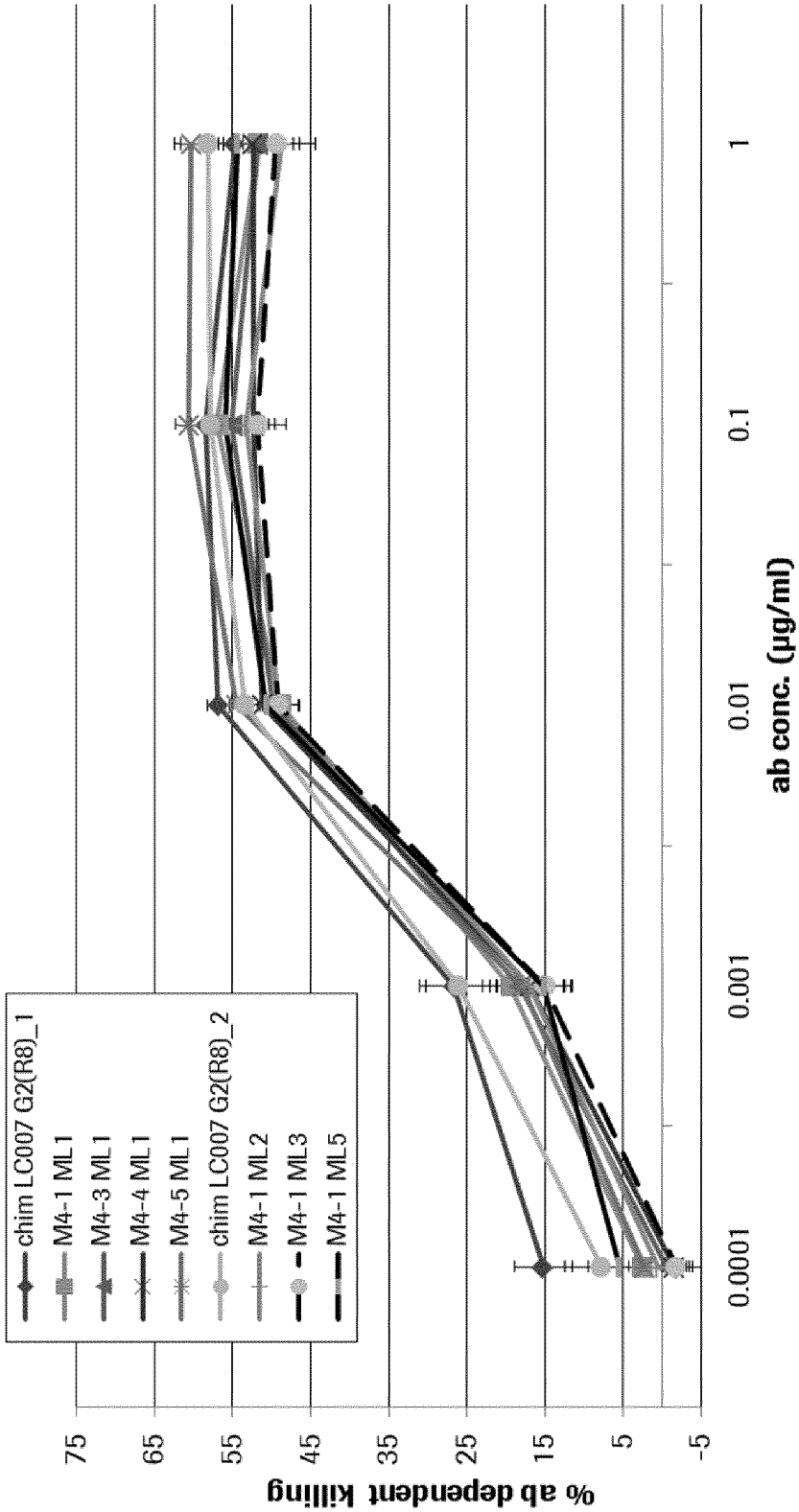
% ab dependent killing
75
65
55
45
35
25
15
5
-5
0.0001
0.001
0.01
0.1
1
ab conc. (µg/ml)
chim LC007 G2(R8)_1
M4-1 ML1
M4-3 ML1
M4-4 ML1
M4-5 ML1
chim LC007 G2(R8)_2
M4-1 ML2
M4-1 ML3
M4-1 ML5

Figure 10

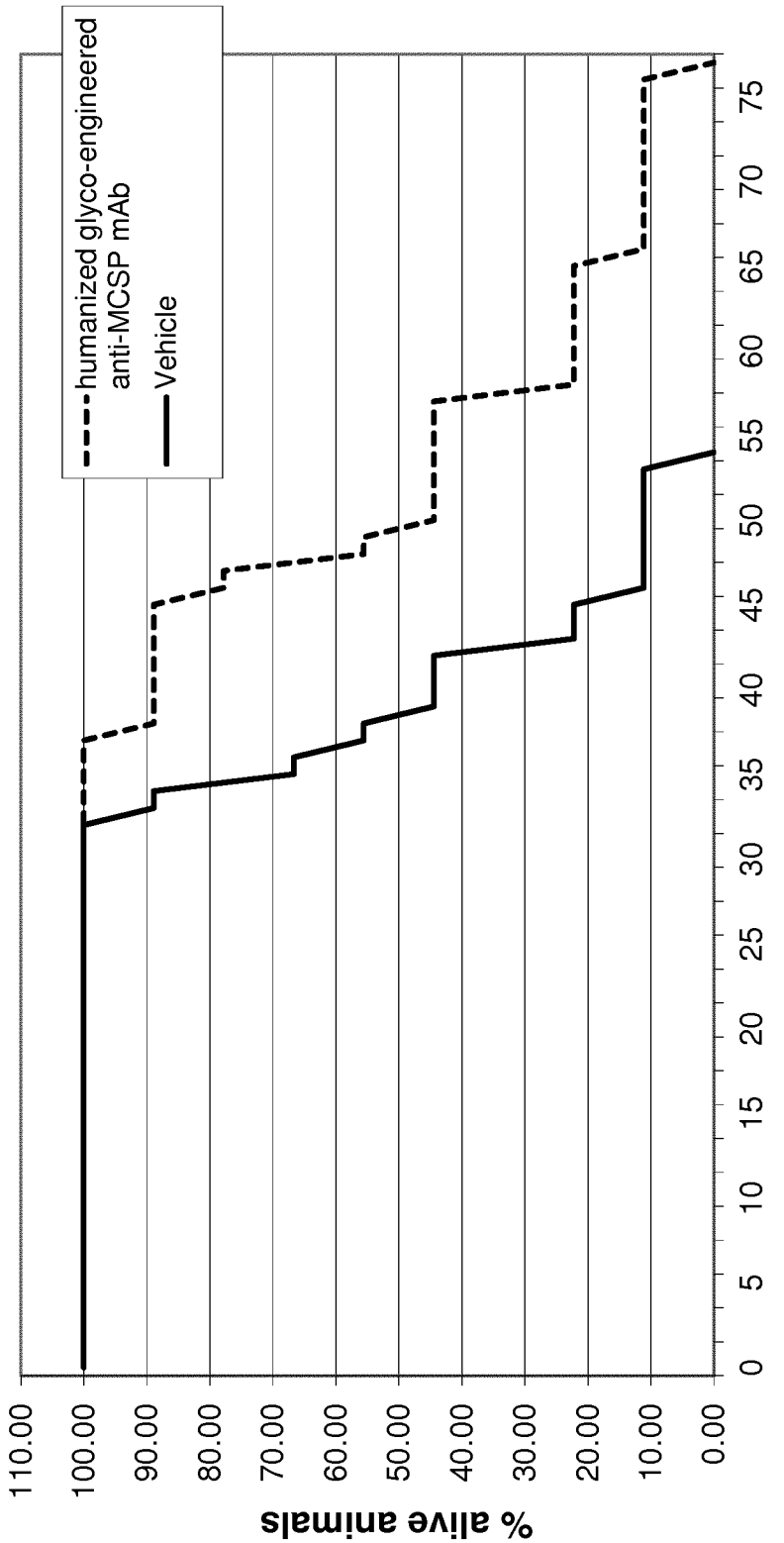
humanized glyco-engineered anti-MCSP mAb
Vehicle
% alive animals
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
Time in days

Figure 11

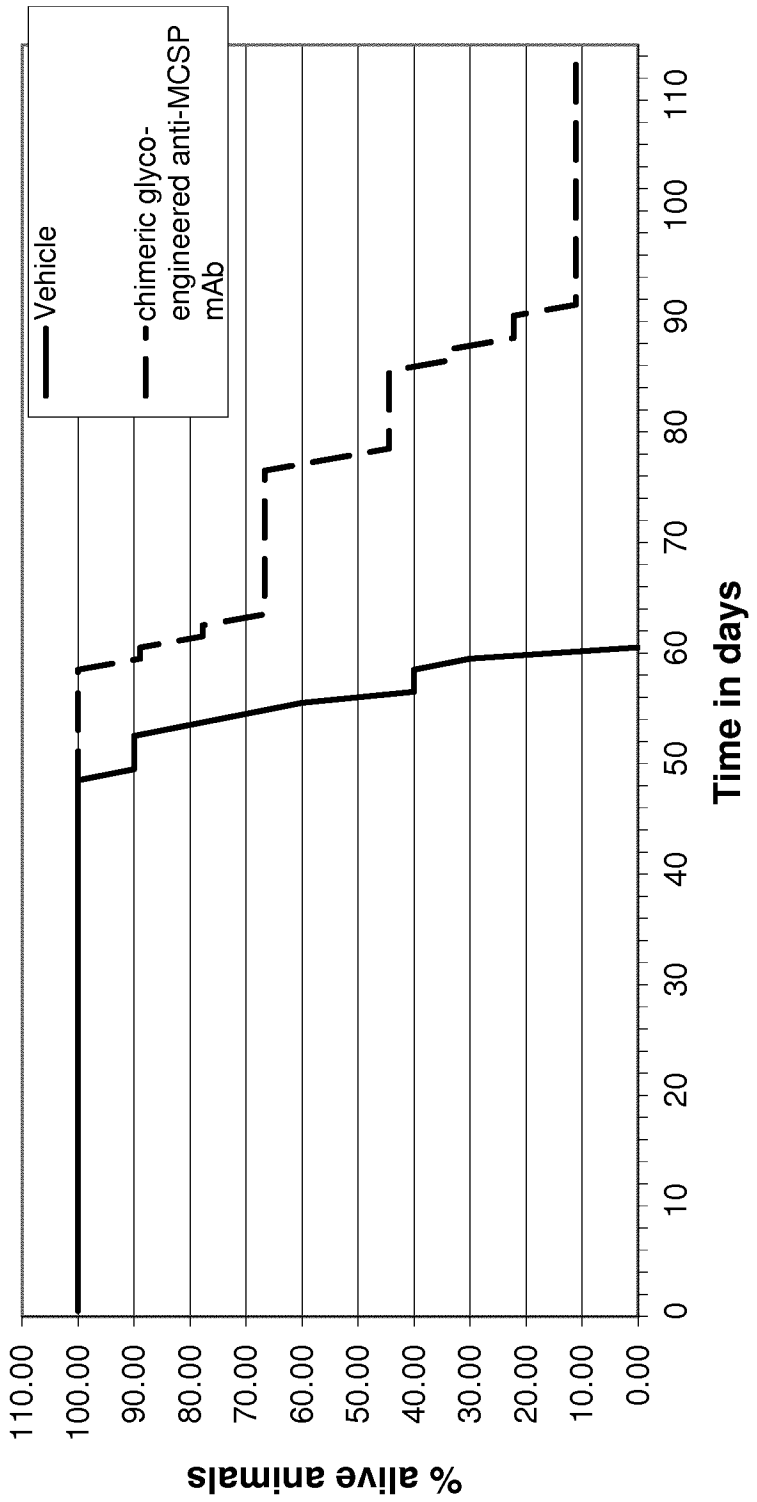
Vehicle
chimeric glyco-engineered anti-MCSP mAb
% alive animals
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
10
20
30
40
50
60
70
80
90
100
110
Time in days

Figure 12

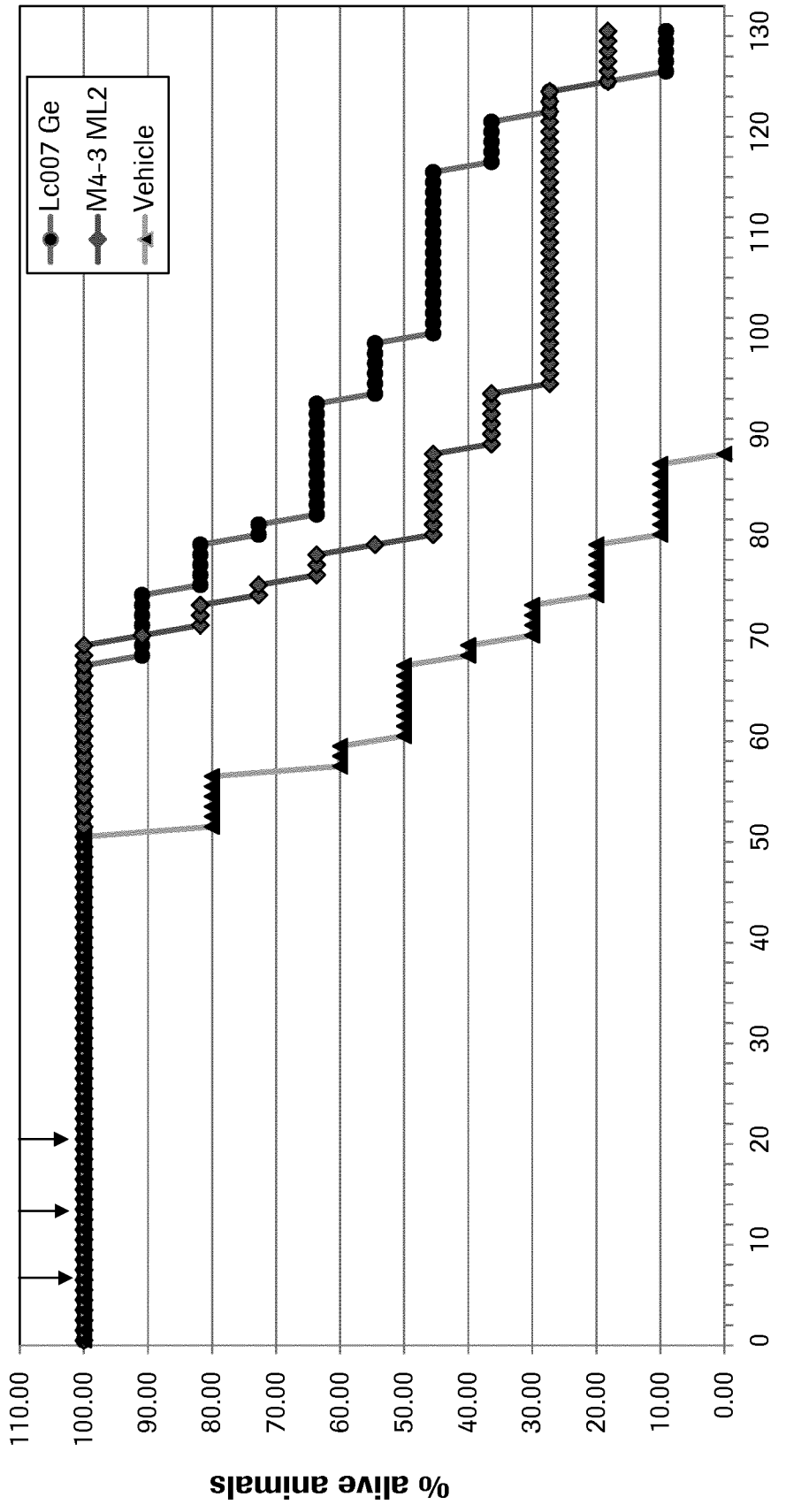
Lc007 Ge
M4-3 ML2
Vehicle
% alive animals
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Time in days

Figure 13

```
parental HC          1 QVQLQESGPGLVKPSQTLSLTCTVSGGSITSGYYWNWIRQHPGKGLEWIGYITYDGSNNYNPSLKSRVTISRDTSKNQFSLKLSSVTAADTAVYYCADFDYWGQGTLVTVSS
D6 (SEQ ID NO 55)    1 ..................................................F..K..................................................
A7 (SEQ ID NO 57)    1 ............................D.....................F..R..................................................
B7 (SEQ ID NO 60)    1 ..................................................F..I..................................................
B8 (SEQ ID NO 62)    1 ..................................................F..R..................................................
C1 (SEQ ID NO 47)    1 ..................................................F..................................................
```

```
parental LC            1 DIQMTQSPSSLSASVGDRVTITCRASQGIRNYLNWYQQKPGKAPKLLIYYTSSLHSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYSKLPWTFGQGTKVEIK
G3 (SEQ ID NO 51)      1 ..................................................................Y.....................A..............
E10(SEQ ID NO 63)      1 ........................Y...G.....................................................H.....................
E10-G3 (SEQ ID NO 66)  1 ........................Y...G.....................................................H.....A..............
C5 (SEQ ID NO 67)      1 ........................R...E...................G.....................................E..............
C5-G3 (SEQ ID NO 71)   1 ........................R...E...................G.....................................A..............
```

Figure 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/053495

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K16/30 A61K39/395 A61P35/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K A61K

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

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

EPO-Internal, BIOSIS, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EKKEHARD MÖSSNER ET AL: "M4-3-ML2, a novel glycoengineered humanized IgG1 antibody, targeting a membrane-proximal epitope of MCSP/CSPG4 exhibits potent ADCC induction in vitro and in vivo anti-tumoral efficacy in disseminated melanoma models", CANCER RESEARCH; PROCEEDINGS: AACR 103RD ANNUAL MEETING 2012-- MAR 31-APR 4, 2012; CHICAGO, IL, AMERICAN ASSOCIATION FOR CANCER RESEARCH, US , vol. 72, no. 8, suppl. 1 15 April 2012 (2012-04-15), page 1, XP002685066, ISSN: 0008-5472, DOI: 10.1158/1538-7445.AM2012-LB-236 Retrieved from the Internet: URL:http://cancerres.aacrjournals.org/cgi/ -/--	1-41

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 2014	05/06/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Le Flao, Katell

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	content/short/72/8_MeetingAbstracts/LB-236 ?rss=1 [retrieved on 2012-10-11] abstract -----	
X	WO 2011/009090 A1 (XOMA TECHNOLOGY LTD [US]; HORWITZ ARNOLD H [US]) 20 January 2011 (2011-01-20) page 1, paragraph 2; examples 1-5 -----	1-3,5-8
X	TORISU-ITAKURA HITOE ET AL: "Redirected Lysis of Human Melanoma Cells by a MCSP/CD3-bispecific BiTE Antibody That Engages Patient-derived T Cells", JOURNAL OF IMMUNOTHERAPY, LIPPINCOTT WILLIAMS & WILKINS, HAGERSTOWN, MD, US, vol. 34, no. 8, 1 October 2011 (2011-10-01), pages 597-605, XP009169634, ISSN: 1524-9557 page 597, left-hand column - page 598, left-hand column, paragraph 1 -----	1-41
X	BLUEMEL C ET AL: "Impact of binding epitope and antigen size on the cytotoxic activity of MCSP-specific Bite antibodies for treatment of melanoma", PROCEEDINGS OF THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR CANCER RESEARCH, AMERICAN ASSOCIATION FOR CANCER RESEARCH, US, no. 51, 1 January 2010 (2010-01-01), page 1294, XP001526314, ISSN: 0197-016X abstract -----	1-6
X	WO 2006/100582 A1 (GLYCART BIOTECHNOLOGY AG [CH]; UMANA PABLO [CH]; MOSSNER EKKEHARD [CH]) 28 September 2006 (2006-09-28) paragraphs [0098] - [0104], [0161], [0219]; claims 1-36,38-69,165,166; examples 1,2 page 20, paragraph 58 - page 22, paragraph 67 paragraph [0315] -----	1-26, 28-41
X	WO 2008/030625 A2 (CELLDEX THERAPEUTICS INC [US]; KELER TIBOR [US]; VITALE LAURA A [US];) 13 March 2008 (2008-03-13) claims 1-28; examples 1-8 -----	1-8,27
	-/--	

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/053495

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	BUMOL T F ET AL: "Monoclonal antibody and an antibody-toxin conjugate to a cell surface proteoglycan of melanoma cells suppress in vivo tumor growth", PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF SCIENCES, US, vol. 80, no. 2, 1 January 1983 (1983-01-01), pages 529-533, XP002479535, ISSN: 0027-8424, DOI: 10.1073/PNAS.80.2.529 page 532, left-hand column, paragraph 1; figure 3	1-41
A	SCHULZ G ET AL: "Eradication of established human melanoma tumors in nude mice by antibody-directed effector cells", THE JOURNAL OF EXPERIMENTAL MEDICINE, ROCKEFELLER UNIVERSITY PRESS, US, vol. 161, no. 6, 1 June 1985 (1985-06-01), pages 1315-1325, XP002479533, ISSN: 0022-1007, DOI: 10.1084/JEM.161.6.1315 abstract	1-41
A	WANG BAIYANG ET AL: "Human single-chain Fv immunoconjugates targeted to a melanoma-associated chondroitin sulfate proteoglycan mediate specific lysis of human melanoma cells by natural killer cells and complement", PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF SCIENCES, US, vol. 96, 16 February 1999 (1999-02-16), pages 1627-1632, XP002143248, ISSN: 0027-8424, DOI: 10.1073/PNAS.96.4.1627 page 1627, left-hand column - right-hand column	1-41
X,P	WO 2013/026832 A1 (ROCHE GLYCART AG [CH]; FREYTAG OLIVIER [CH]; GEORGES GUY [DE]; MOESSNE) 28 February 2013 (2013-02-28) examples 1-9; sequences 36,37	1-22, 24-41

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/053495

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011009090 A1	20-01-2011	US 2012171226 A1	05-07-2012
		WO 2011009090 A1	20-01-2011
WO 2006100582 A1	28-09-2006	AR 052714 A1	28-03-2007
		AU 2006226060 A1	28-09-2006
		BR PI0608468 A2	05-01-2010
		CA 2601858 A1	28-09-2006
		CN 101146909 A	19-03-2008
		EP 1871882 A1	02-01-2008
		JP 2008533985 A	28-08-2008
		KR 20070114324 A	30-11-2007
		US 2006223096 A1	05-10-2006
		WO 2006100582 A1	28-09-2006
		ZA 200707989 A	30-09-2009
WO 2008030625 A2	13-03-2008	US 2010303816 A1	02-12-2010
		WO 2008030625 A2	13-03-2008
WO 2013026832 A1	28-02-2013	AR 087634 A1	09-04-2014
		CA 2844141 A1	28-02-2013
		KR 20140048292 A	23-04-2014
		US 2013078251 A1	28-03-2013
		WO 2013026832 A1	28-02-2013