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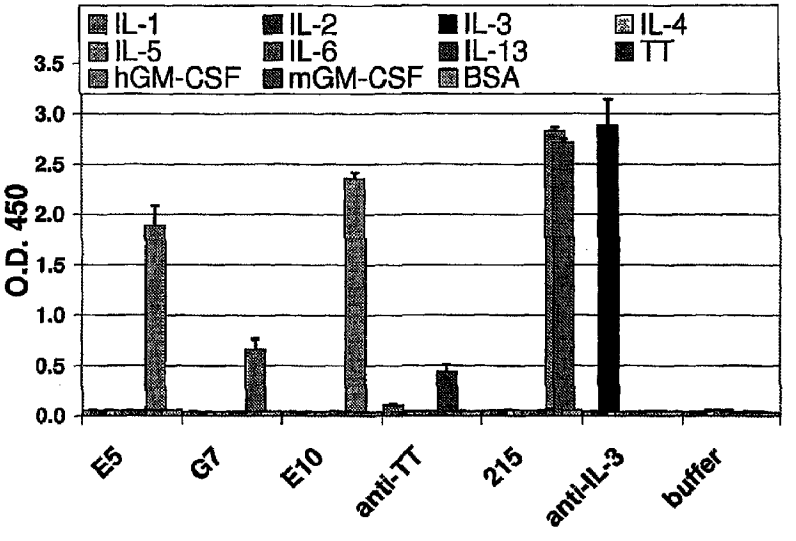

(57) **Abrégé/Abstract:**
Hybridoma lines that secrete human monoclonal antibodies with high binding specificity and biological activity, particularly neutralizing activity against granulocyte-macrophage colony stimulating factor, and methods of generating the hybridoma lines are

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provided. Target antigens and epitopes are also provided. The antibodies may be used in therapeutic methods, for example in the treatment of cancer, infectious disease, or autoimmune disease.

ABSTRACT

Hybridoma lines that secrete human monoclonal antibodies with high binding specificity and biological activity, particularly neutralizing activity against granulocyte-macrophage colony stimulating factor, and methods of generating the hybridoma lines are provided. Target antigens and epitopes are also provided. The antibodies may be used in therapeutic methods, for example in the treatment of cancer, infectious disease, or autoimmune disease.

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JUMBO APPLICATIONS / PATENTS

THIS SECTION OF THE APPLICATION / PATENT CONTAINS MORE THAN ONE VOLUME.

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ANTIGENIC GM-CSF PEPTIDES AND ANTIBODIES TO GM-CSF

FIELD OF THE INVENTION

[0002] The invention relates generally to the field of immunotherapeutics. More specifically, the invention relates to antigens for generating monoclonal antibodies, and monoclonal antibodies that can neutralize autoimmune and cancer cells, and can neutralize the inflammatory response.

[0004] Several disease-associated antigens are currently being targeted using therapeutic monoclonal antibodies (MAbs) because of their unique pharmacological and safety profiles. Among the disease-associated target antigens are CD20, Tumor Necrosis Factor alpha (TNF-α), Epidermal Growth Factor Receptors (EGFR), and granulocyte-macrophage colony stimulating factor.

[0005] Granulocyte macrophage-colony stimulating factor (GM-CSF) was originally discovered as a protein with the capacity to generate both granulocyte and macrophage colonies from precursor cells in mouse bone marrow, and was accordingly named (Burgess *et al.* (1980) Blood 56:947-58.). Subsequent studies have demonstrated a role of GM-CSF in potentiating the function of mature macrophages and granulocytes (Handman and Burgess (1979) J. Immunol. 122:1134-1137; Hamilton *et al.* (1980) J. Cell Physiol. 103:435-445; Gamble *et al.* (1985) Proc. Natl. Acad. Sci. USA 82:8667-8671), suggesting a role for GM-CSF in inflammatory responses (Hamilton *et al.* (1980) J. Cell Physiol. 103:435-445). As the molecule was studied it became clear that GM-CSF has other functions arising from its ability to affect the properties of more mature myeloid cells such as granulocytes, macrophages and eosinophils. The functions of GM-CSF are mediated by binding to CD116, the granulocyte-macrophage colony stimulating factor receptor, also known as colony stimulating factor 2 receptor alpha that binds GM-CSF with low affinity. The beta subunit, called CD131, which is also shared with the IL3 and IL5 receptors, has no detectable binding activity for GM-CSF by itself but is necessary for high affinity binding when in association with the alpha subunit and plays a fundamental role in signal transduction. The GM-CSF receptors are found on myeloid progenitors and mature myeloid cells including neutrophils, eosinophils, mononuclear phagocytes, and monocytes. In addition, GM-CSF receptor subunits have been shown to be present in normal, non-hematopoietic tissues such as human placenta, endothelium, and oligodendrocytes of the central nervous system.

[0006] GM-CSF plays a major biological role in the generation of granulocytes and macrophages from early bone marrow progenitors within the bone marrow. What was not appreciated at first but later uncovered was additional physiological functions of GM-CSF in host responses to external stimuli and in inflammatory and autoimmune conditions. In very early studies, GM-CSF was purified from lung tissue-conditioned medium following lipopolysaccharide (LPS) injection into mice (Burgess *et al.* (1977) J. Biol. Chem. 252:1998-2003). GM-CSF is considered by many investigators to be one of the major regulators of granulocyte, macrophage and eosinophil lineage cell number and activation state under normal physiological conditions. However, it has also been hypothesized that aberrant expression of GM-CSF may lead to altered immune and inflammatory responses with associated pathologic consequences. It was suggested several years ago that GM-CSF should be viewed as a proinflammatory cytokine (Hamilton *et al.*, 1980, J. Cell Physiol. 103:435-445). Furthermore, GM-CSF may play a role in the diathesis of a multitude of human inflammatory pathologies, such as rheumatoid arthritis, autoimmune pathologies, inflammatory renal disease and inflammatory lung disorders such as asthma and chronic obstructive pulmonary disease (COPD).

Interestingly, it has been proposed that there is a link between multiple sclerosis and GM-CSF (McQualter *et al.* (2001) J. Exp. Med., 194:873-881). In an experimental model of autoimmune encephalomyelitis, a model for multiple sclerosis, GM-CSF was found to be involved in the autoimmune-mediated demyelination.

[0007] *In vivo* studies following monocyte, macrophage and neutrophil treatment with GM-CSF have demonstrated that GM-CSF can activate these cell types and prolong their survival characteristics. Moreover, GM-CSF exposure results in release of inflammatory mediators from these cell types, and further studies have demonstrated the ability of these cells to kill certain organisms and even tumor cells (Hamilton (1993) Immunol. Today 14:18-24; Hamilton, (1993) Lancet 342:536-539; Takahashi, (1993) Blood 81:357-364). To determine if the *in vivo* studies were indicative of the function of GM-CSF *in vivo*, systemic administration was performed with rodents. It was shown that artificially increasing circulating levels of GM-CSF by intraperitoneal administration of the protein did result in increased numbers of both circulating neutrophils and cycling peritoneal macrophages and that there was an increase in the development and differentiation of CD5+ macrophages in the peritoneal cavity of rodents (Metcalf *et al.*, (1987) Exp. Hematol. 15:1-9).

[0008] It has also been shown that GM-CSF can "prime" cells to respond in a more robust, synergistic manner to a second stimulus, such as LPS or interferon-gamma (Hart *et al.*, 1988, J. Immunol. 141:1516-1521). Mice can be primed both in vitro as well as in vivo with GM-CSF so that they produce increased levels of circulating pro-inflammatory cytokines following subsequent challenge with LPS or TNF-alpha.

[0009] In a clinical setting, administration of GM-CSF into peritoneal dialysis patients resulted in a marked recruitment of macrophages (Selgas *et al.*, 1996, Kidney Int. 50:2070-2078). Interestingly, and as predicted from the rodent studies, administration of GM-CSF in a clinical setting can result in accentuated production of inflammatory cytokines and potential unwanted side effects. For example, when patients with rheumatoid arthritis were treated with GM-CSF to correct the neutropenia associated with Felty's syndrome, their arthritis was exacerbated (Hazenberg *et al.*, 1991, Blood 74:2769-2770). In another clinical setting, following cancer chemotherapy, GM-CSF treatment made rheumatoid arthritis worse (de Vries *et al.*, (1991) J. Immunol. 163: 4985-4993). Systemic administration of GM-CSF to human donors increased the ability of isolated granulocytes to produce superoxide, and both accentuated the cytotoxicity of circulating monocytes as well as led to an increase in the number of monocytes (Perkins *et al.*, 1993, Am J. Hematol. 43:279-285). Aberrant expression of GM-CSF is associated with disease of the lung in human as well. For example, it appears that upregulation

of GM-CSF in the lung by minor irritants, endotoxins or infections predisposes towards TH2 immune deviation and asthma (Eisenbarth *et al.* (2002) J. Exp. Med. 196:1645-1651). The studies summarized above suggest that GM-CSF plays a role in the activation of the inflammatory process through cell recruitment, increased cell survival and/or priming for activation.

[0010] Several association and experimental data suggest a role for GM-CSF in asthma. The use of neutralizing antibodies in a mouse model of asthma have demonstrated the ability to suppress asthmatic phenotypes (Yamashita (2002) Cell Immunol. 219:92), while several studies measuring cytokines in BAL fluid of asthmatic patients have found an increase in GM-CSF (Gajewska (2003) Curr Drug Targets Inflamm Allergy 2:279).

[0011] Rheumatoid arthritis (RA) is a chronic inflammatory autoimmune disease for which there is ample evidence that GM-CSF may be involved. GM-CSF has been found at elevated levels in RA lesions (Xu *et al.* (1989) J. Clin. Invest. 83:876) and is produced *in vitro* by resident joint cells (chondrocytes and synovial fibroblasts) following their stimulation with inflammatory cytokines such as IL-1 and TNF-alpha (Leizer *et al.* (1990) Blood 76:1989). Collagen-induced arthritis (CIA) in the mouse is an autoimmune model of RA that is dependent upon both humoral and cellular immune responses to type II collagen (CII) (Seki *et al.* (1988) J. Immunol. 140,1477). Historically this RA phenotype is restricted to mouse strains bearing the H-2q or H-2r haplotypes and is generally performed in DBA/1 mice (Wooley (1988) Methods Enzymol. 162:361). A series of studies were performed in transgenic mice that were homozygous null for the murine GM-CSF locus (Stanley *et al.* (1994) Proc. Natl. Acad. Sci. USA 91:5592). Interestingly, the GM-CSF-deficient mice are resistant to the induction of collagen- induced arthritis as compared to their wild-type control litter mates (Campbell *et al.* (1998) J. Immunol. 161:3639-3644).

[0012] Of further interest is that GM-CSF null mice have impaired surfactant clearance that leads to murine pulmonary alveolar proteinosis (PAP), which closely mimics the human condition as described herein. Moreover, the PAP phenotype can be corrected by lung-specific delivery of the GM-CSF gene (Zsengaller *et al.* (1998) Hum. Gene Ther. 9:2101-2109), aerosolization of GM-CSF or bone marrow transplantation for hematopoeitic reconstitution (Reed *et al.* (1999) Am. J. Physiol. 276:L556-L563; Nishinakamura *et al.* (1996) J. Exp. Med. 183:2657-2662).

[0013] Adult human pulmonary alveolar proteinosis (PAP) is a rare disease characterized by the accumulation of phospholipids and surfactant proteins in the alveoli. It has been hypothesized that PAP is due to the inability of the alveolar macrophages and type II

epithelial cells to clear excess surfactant (Mazzone *et al.* (2001) Clev. Clin. J. Med. 68:977-992). The diagnosis of PAP generally requires an open lung biopsy and the standard therapy for the disease is physical removal of the accumulated surfactant by whole-lung lavage (Shah *et al.* (2000) Thorax 55:67-77). Furthermore, patients with PAP have been shown to have circulating, neutralizing antibodies to GM-CSF, thereby implicating this cytokine as causative of the disease. Whether this autoimmune response is specific for GM-CSF is unclear. However, it has been shown that a subset of PAP patients improve with GM-CSF therapy, supporting the hypothesis that the absence of GM-CSF either by gene disruption or antibody-mediated neutralization results in the development of PAP.

[0014] There is also evidence to support a role for GM-CSF in cancer. For example, GM-CSF plays a role in the genesis and progression of leukemias, such as juvenile myelomonocytic leukemia (JMML); Emanuel PD (2004) Curr. Hematol. Rep. 3:203-209). JMML is characterized by disruption of normal hemopoiesis resulting in excessive, inappropriate proliferation of immature myeloid cells in the bone marrow. These proliferating hematopoietic cancer cells can metastasize to the spleen and liver. Interestingly, patients with JMML are hypersensitive to GM-CSF and exhibit pathologic features similar to those in transgenic mice that over-express GM-CSF (Lang *et al.* (1987) 51:675-86). Furthermore, GM-CSF has been shown to promote JMML cell growth and survival (Emanuel *et al.* (1991) Blood 77:925-9). In the transgenic mouse model of JMML, blockade of GM-CSF reduced JMML cell burden in the bone marrow, blood and spleen (Iversen *et al.* (1997) Blood, 90:4910-7).

[0015] It is clear from murine disease models in which GM-CSF is knocked-out as well as human diseases such as PAP in which circulating antibodies are generated in the systemic circulation to GM-CSF that this cytokine is an important mediator of pathology. Therefore an approach to develop a drug that can antagonize the activity of GM-CSF, either by developing an antibody to the cytokine itself or by blockade of the GM-CSF receptor, may be a valuable human therapeutic. Several polyclonal and monoclonal antibodies have been generated to the recombinant GM-CSF molecule. For example, Beffy *et al.* ((1994), Hybridoma 13:457-468), generated polyclonal antibodies to recombinant human GM-CSF in New Zealand White rabbits and monoclonal antibodies in Balb/c mice. These rabbit and some of the murine monoclonal antibodies were capable of neutralizing the activity of GM-CSF in an in vitro cell proliferation assay with MO7e cells. In further studies, Nice *et al.* (1990, Growth Factors 3,159-169) epitope-mapped the binding site of one neutralizing murine anti-GM-CSF antibody, LMM102. A well-defined epitope was delineated by generating a series of digestion products from recombinant, human GM-CSF, using reverse phase HPLC fractionation to separate the fragments, followed by

additional S. aureus V8 digestion of the tryptic fragments to define a product comprising two peptides linked by a disulphide bond. Three murine antibodies to human GM-CSF were generated by Dempsey *et al.* (1990, Hybridoma 9,545-558) that neutralized GM-CSF in an *in vitro* assay system with an EC50 in the 0.1 to 1.7 nanomolar range. These antibodies did not react with murine GM-CSF or other related cytokines. All of the above-described antibodies are useful reagents for the detection of GM-CSF in human serum as well as for *in vitro* assays to inhibit GM-CSF signaling. However, all of these antibodies have little value as therapeutics due to the fact that they are derived from either a murine or rabbit system. Attempts have been made to generate chimeric antibodies from murine counterparts by subcloning the variable domain from the murine anti-GM-CSF antibody into a human backbone. This strategy has led to a chimeric antibody that can neutralize GM-CSF *in vitro* and may be useful as a therapeutic (WO 03/068924 A2).

[0016] An important aspect of a therapeutic antibody is its ability to elicit immune effector functions, such as antibody dependent cellular cytotoxicity (ADCC). Rodent MAbs, for example, have been shown to poorly mediate effector functions in humans because of sequence differences in the Fc region and therefore chimerization or humanization are required to gain optimal pharmacological properties. In addition, MAbs with fully human sequences may still fail to support ADCC if they are produced in non-human host cells that may alter native glycosylation pattern of MAbs (Shinkawa *et al.* (2003) J. Biol. Chem. 278:3466-73).

[0017] In view of these facts, production of therapeutic antibodies by human B-cells is preferred. Methods for generation of hybridomas secreting human MAbs have been previously reported (WO2004/046330). Therapeutic MAbs generated by human B-cells are able to exert human effector functions and have very limited immunogenicity because of their native human structure. The generation of hybridoma or Epstein-Barr virus (EBV)-transformed lymphoblastoid lines derived from human B-cells has been previously reported (Kirman *et al.* (2002) Hybrid Hybridomics 21:405-14; Boerner *et al.* (1991) J. Immunol. 147:86-95; Zafiropoulos *et al.* (1997) J. Immunol. Methods 200:181-90); however, information on the characterization of these antibodies and the lines with respect to their long term stability, suitability to manufacturing processes, and the antibody's pharmacological properties is limited (van Dijk *et al.* (2001) Curr. Opin. Chem. Biol. 5:368-74).

[0018] There is thus a need for therapeutic human antibodies for the treatment of inflammation associated with infectious, inflammatory diseases, autoimmune disorders, and other diseases such as cancer. It is further desired that such antibodies would elicit immune

effector functions, as well as be well-tolerated in human patients. The present invention addresses these and other long felt needs.

SUMMARY OF THE INVENTION

[0019] The invention features isolated human antibodies that specifically bind to GM-CSF, . The antibodies can comprise a heavy chain CDR3 having SEQ ID NO:42 or 48. In some preferred embodiments, the antibodies can comprise a heavy chain having SEQ ID NO:8 or 16. In some preferred embodiments, the antibodies can comprise a light chain having SEQ ID NO:12 or 18. In some embodiments, the antibodies have two heavy chains. In some embodiments, the antibodies have two light chains. The antibodies are high affinity antibodies, and can have an affinity of less than about 1×10^{-8} M. Preferably, the antibodies are monoclonal antibodies, and more preferably, are human monoclonal antibodies. In highly preferred embodiments, the antibodies specifically bind to an epitope on a polypeptide comprising the amino acid sequence SEQ ID NO:3, 4, 5, 35, 36, 37, 38, or 39. Cells that express such antibodies, such as hybridoma cells are also provided.

[0020] The invention also features polynucleotides that encode antibodies that specifically bind to GM-CSF. In some preferred embodiments, the polynucleotides comprise a heavy chain sequence of SEQ ID NO:10 or 17. In some preferred embodiments, the polynucleotides comprise a light chain sequence of SEQ ID NO:14 or 19. Vectors comprising such polynucleotides are also provided.

[0021] The invention also features methods for treating GM-CSF-mediated inflammatory disease in a subject in need of such treatment. The methods comprise administering to the subject a composition comprising a pharmaceutically acceptable carrier and at least one antibody that specifically binds to GM-CSF in an amount effective to treat a GM-CSF-mediated inflammatory disease. In preferred aspects of these methods, the antibodies can comprise a heavy chain CDR3 having SEQ ID NO:42 or 48. In some preferred embodiments, the antibodies can comprise a heavy chain having SEQ ID NO:8 or 16. In some preferred embodiments, the antibodies can comprise a light chain having SEQ ID NO:12 or 18. The antibodies are high affinity antibodies, and can have an affinity of less than about 1×10^{-8} M.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Figure 1 illustrates the antigen panel ELISA for selection of antigen-specific human MAbs. Three GM-CSF-specific human MAbs (E5, G7, E10), reacted with human GM-CSF and none of the other antigens in the panel. Antibody 215 is a murine MAb that binds to human GM-CSF (hGM-CSF) and murine GM-CSF (mGM-CSF).

[0023] Figures 2A and 2B illustrate the high specificity of human MAbs to native human GM-CSF. As shown in Figure 2A, soluble human GM-CSF was bound to murine hybridoma cells presenting cell surface immunoglobulin (Ig) to human GM-CSF. MAb E5 was subsequently added to the reaction and its binding to human GM-CSF measured using FITC-conjugated goat anti-human Ig. E5 did not bind any of the surface proteins expressed by the murine hybridoma cells (middle panel) but only bound soluble GM-CSF captured by the cell surface Ig (lower panel). As shown in Figure 2B, phycoerythrin (PE)-labeled human GM-CSF (PE-GM) can react to Ig expressed on E10 cell surface. Excess of unlabeled GM-CSF (bottom panel) competed for PE-GM binding.

[0024] Figure 3 demonstrates secretion of antigen-binding IgG by class-switched hybridoma cells. Hybridoma E5 cells (parent) were treated as described in Materials and Methods. Hybridoma clones that had class-switched (switched) were identified using an ELISPOT-based screening method. An ELISA measuring specific binding to human GM-CSF coated onto plates was carried out to assess binding of either IgM or IgG. Switched IgG MAbs exhibited comparable binding to antigen as the parental IgM.

[0025] Figure 4 demonstrates GM-CSF-dependent growth inhibition of TF-1 cell lines with fully human MAbs. The human GM-CSF-dependent human erythroleukemia cell line TF-1 (ATCC, VA) was grown in complete RPMI 1640 containing 10 ng/mL recombinant human GM-CSF (PeproTech, NJ). On the day preceding the experiment, TF-1 cells were grown in 0.1% FBS in the absence of GM-CSF. The starved TF-1 cells were harvested and washed twice with assay medium (plain RPMI with 0.5% BSA). Cells were resuspended in assay medium and seeded in 96-well microplates at a concentration of 10,000 cell/well. Wells contained either assay medium, 100 pg/mL GM-CSF, or GM-CSF pre-incubated for one hour with test or isotype control Igs at concentrations indicated in the figure. After 3 days, 40 µL of Cell Titer reagent (Promega, WI) was added to each well, and plates were further incubated at 37°C for 1 hour. Optical density (O.D.) was measured at 490 nm in spectrophotometer and medium background was subtracted from samples. Percentage of GM-CSF neutralization was calculated as follows: 100 – [O.D. with Ig / O.D. without Ig)x 100].

[0026] Figure 5A illustrates ELISA results demonstrating that all E5-3D2 subclones tested secrete high levels of Ig. The hybridoma E5-3D2 line was grown for 60 generations and then stability of production was assessed by analyzing frequency of producing cells. Subclones (X1-X10) derived from 3D2 cells via limiting dilution were randomly chosen and their Ig production measured using an ELISA-based assay. Absorbance at 405 nm was normalized for colony size by visual inspection of the cell-containing wells. Figure 5B demonstrates that the

specific productivity measured during the log phase was 24 pg/cell/day following inoculation of 3D2 cells in a stirred bioreactor containing 1 liter of serum-free medium and Ig production and recordation of number of viable cells on day 1 through 5.

[0027] Figure 6A shows results of an example of a single nucleotide deletion in the BAT marker found in E5 hybridoma cells treated with mismatch repair inhibitors. Dotted lines crossing the central peak in the histogram represent the size of wild type (wt) or contracted (-1 nt) fragment. In Figure 6B, parental and mismatch repair-inhibited cells were seeded in microplates to yield 3,763 and 2,437 Ig-secreting clones (O.D. >0.2), respectively. Ig concentrations were determined by ELISA and the frequency of clones with O.D. values greater than 1 was recorded and expressed as percentage of total number of clones screened.

[[0028] Figure 7 provides a diagrammatic flow chart describing each step for the generation of a fully human hybridoma cell line.

[0029] Figure 8 illustrates an antigen panel ELISA for selection of antigen-specific human MAbs. Three GM-CSF specific huMAbs, E10, G9, and E5 (not described), reacted with human GM-CSF and none of the other antigens in the panel. Efficient antigen coating was optimized using specific MAbs to the various antigens for greater assay sensitivity. 615 and 215 are two anti-human GM-CSF murine MAbs.

[0030] Figure 9 demonstrates isotype determination of MAb E10. To determine the isotype of E10, a standard analysis was performed using anti-human IgG, IgG1, IgG2, IgG3, IgM, Lκ, and Lλ Fc specific antibodies to derive the isotype.

[0031] Figure 10 shows a Western analysis with E10 and G9 MAbs. The western blot analyses were performed with E10 and G9 to determine if the antibodies would cross-react with human recombinant GM-CSF. The mAb215 is mouse anti-human GM-CSF neutralizing monoclonal antibody as a positive control, Lane: 1 were loaded with tumor cell lysate as negative protein control, Lane:2 were loaded with 500ng rh GM-CSF (PeProTech, NJ USA), As shown in Fig.5 E10 and G9 reacted with human GM-CSF.

[0032] Figure 11 shows a BIACORE analysis for E10. E10.20 had an association rate constant (k_a) = 2.47 x 10^4, a dissociation rate constant (k_d) = 2.16 x 10^{-5} and an overall affinity (K_D) of 0.87 nM.

[0033] Figure 12 demonstrates isotype determination of MAb G9. To determine the isotype of G9, a standard analysis was performed using anti-human IgG, IgG1, IgG2, IgG3, IgM, Lκ, and Lλ specific antibodies to derive the isotype (in double samples, Fig 3).

[0034] Figure 13 shows a BIACORE analysis for G9. 10G9.1 had an association rate constant (k_a) = 8.47 x 10^6, a dissociation rate constant (k_d) = 9.27 x 10^{-5} and an overall affinity (K_D) of 0.87 nM.

[0035] Figure 14 illustrates a strategy to map G9 epitope. Overlapping peptides used to map G9 epitope binding location correspond to amino acid sequences of SEQ ID NOs: 35-38, and 64-85.

[0036] Figure 15 shows G9 epitope mapping analysis using Western blot analysis with overlapping peptides that cover human GM-CSF protein sequence corresponding to amino acid sequences of SEQ ID NOs: 35-38, and 65-86. Antibody positive peptides include SEQ ID NO: 35-38.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0037] Various terms relating to the methods and other aspects of the present invention are used throughout the specification and claims. Such terms are to be given their ordinary meaning in the art unless otherwise indicated. Other specifically defined terms are to be construed in a manner consistent with the definition provided herein.

[0038] It is to be understood that this invention is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to "a cell" includes a combination of two or more cells, and the like.

[0039] Each range recited herein includes all combinations and sub-combinations of ranges, as well as specific numerals contained therein.

[0040] The term "about" as used herein when referring to a measurable value such as an amount, a temporal duration, and the like, is meant to encompass variations of ±20% or ±10%, more preferably ±5%, even more preferably ±1%, and still more preferably ±0.1% from the specified value, as such variations are appropriate to perform the disclosed methods.

[0041] "Infectious disease" includes, but is not limited to, infection with a pathogen, virus, bacterium, fungus or parasite. Examples of viruses include, but are not limited to, severe acute respiratory syndrome (SARS; caused by SARS-associated coronavirus), hepatitis type B or type C, influenza, varicella, adenovirus, herpes simplex virus type I or type II, rinderpest, rhinovirus, echovirus, rotavirus, respiratory syncytial virus, papilloma virus, papova virus, cytomegalovirus, echinovirus, arbovirus, hantavirus, coxsachie virus, mumps virus, measles

virus, rubella virus, polio virus, and human immunodeficiency virus (HIV) type I or type II. Examples of bacteria include, but are not limited to, Ebola, Staphylococcus A-E, *Plasmodium* (malaria), *M. tuberculosis*, mycobacterium, mycoplasma, neisseria and legionella. Examples of parasites include, but are not limited to, rickettsia and chlamydia.

[0042] "Inflammatory diseases" include, but are not limited to, acute and chronic immune and autoimmune pathologies, such as, but not limited to, rheumatoid arthritis, autoimmune disease, inflammatory renal disease and inflammatory lung disorders such as asthma and chronic obstructive pulmonary disease (COPD), multiple sclerosis, and autoimmune encephalomyelitis.

[0043] An "autoimmune disease" is a disease or disorder arising from and directed against an individual's own tissues or a co-segregate or manifestation thereof or resulting condition therefrom. Examples of autoimmune diseases include, but are not limited to arthritis (rheumatoid arthritis such as acute arthritis, chronic rheumatoid arthritis, gout or gouty arthritis, acute gouty arthritis, acute immunological arthritis, chronic inflammatory arthritis, degenerative arthritis, type II collagen-induced arthritis, infectious arthritis, Lyme arthritis, proliferative arthritis, psoriatic arthritis, Still's disease, vertebral arthritis, and juvenile-onset rheumatoid arthritis, osteoarthritis, arthritis chronica progrediente, arthritis deformans, polyarthritis chronica primaria, reactive arthritis, and ankylosing spondylitis), inflammatory hyperproliferative skin diseases, psoriasis such as plaque psoriasis, gutatte psoriasis, pustular psoriasis, and psoriasis of the nails, atopy including atopic diseases such as hay fever and Job's syndrome, dermatitis including contact dermatitis, chronic contact dermatitis, exfoliative dermatitis, allergic dermatitis, allergic contact dermatitis, dermatitis herpetiformis, nummular dermatitis, seborrheic dermatitis, non-specific dermatitis, primary irritant contact dermatitis, and atopic dermatitis, x-linked hyper IgM syndrome, allergic intraocular inflammatory diseases, urticaria such as chronic allergic urticaria and chronic idiopathic urticaria, including chronic autoimmune urticaria, myositis, polymyositis/dermatomyositis, juvenile dermatomyositis, toxic epidermal necrolysis, scleroderma (including systemic scleroderma), sclerosis such as systemic sclerosis, multiple sclerosis (MS) such as spino-optical MS, primary progressive MS (PPMS), and relapsing remitting MS (RRMS), progressive systemic sclerosis, atherosclerosis, arteriosclerosis, sclerosis disseminata, ataxic sclerosis, neuromyelitis optica (NMO), inflammatory bowel disease (IBD) (for example, Crohn's disease, autoimmune-mediated gastrointestinal diseases, colitis such as ulcerative colitis, colitis ulcerosa, microscopic colitis, collagenous colitis, colitis polyposa, necrotizing enterocolitis, and transmural colitis, and autoimmune inflammatory bowel disease), bowel inflammation, pyoderma gangrenosum, erythema nodosum, primary sclerosing

cholangitis, respiratory distress syndrome, including adult or acute respiratory distress syndrome (ARDS), meningitis, inflammation of all or part of the uvea, iritis, choroiditis, an autoimmune hematological disorder, rheumatoid spondylitis, rheumatoid synovitis, hereditary angioedema, cranial nerve damage as in meningitis, herpes gestationis, pemphigoid gestationis, pruritis scroti, autoimmune premature ovarian failure, sudden hearing loss due to an autoimmune condition, IgE-mediated diseases such as anaphylaxis and allergic and atopic rhinitis, encephalitis such as Rasmussen's encephalitis and limbic and/or brainstem encephalitis, uveitis, such as anterior uveitis, acute anterior uveitis, granulomatous uveitis, nongranulomatous uveitis, phacoantigenic uveitis, posterior uveitis, or autoimmune uveitis, glomerulonephritis (GN) with and without nephrotic syndrome such as chronic or acute glomerulonephritis such as primary GN, immune-mediated GN, membranous GN (membranous nephropathy), idiopathic membranous GN or idiopathic membranous nephropathy, membrano- or membranous proliferative GN (MPGN), including Type I and Type II, and rapidly progressive GN, proliferative nephritis, autoimmune polyglandular endocrine failure, balanitis including balanitis circumscripta plasmacellularis, balanoposthitis, erythema annulare centrifugum, erythema dyschromicum perstans, eythema multiform, granuloma annulare, lichen nitidus, lichen sclerosus et atrophicus, lichen simplex chronicus, lichen spinulosus, lichen planus, lamellar ichthyosis, epidermolytic hyperkeratosis, premalignant keratosis, pyoderma gangrenosum, allergic conditions and responses, allergic reaction, eczema including allergic or atopic eczema, asteatotic eczema, dyshidrotic eczema, and vesicular palmoplantar eczema, asthma such as asthma bronchiale, bronchial asthma, and auto-immune asthma, conditions involving infiltration of T cells and chronic inflammatory responses, immune reactions against foreign antigens such as fetal A-B--O blood groups during pregnancy, chronic pulmonary inflammatory disease, autoimmune myocarditis, leukocyte adhesion deficiency, lupus, including lupus nephritis, lupus cerebritis, pediatric lupus, non-renal lupus, extra-renal lupus, discoid lupus and discoid lupus erythematosus, alopecia lupus, systemic lupus erythematosus (SLE) such as cutaneous SLE or subacute cutaneous SLE, neonatal lupus syndrome (NLE), and lupus erythematosus disseminatus, juvenile onset (Type I) diabetes mellitus, including pediatric insulin-dependent diabetes mellitus (IDDM), adult onset diabetes mellitus (Type II diabetes), autoimmune diabetes, idiopathic diabetes insipidus, diabetic retinopathy, diabetic nephropathy, diabetic large-artery disorder, immune responses associated with acute and delayed hypersensitivity mediated by cytokines and T-lymphocytes, tuberculosis, sarcoidosis, granulomatosis including lymphomatoid granulomatosis, Wegener's granulomatosis, agranulocytosis, vasculitides, including vasculitis, large-vessel vasculitis (including polymyalgia rheumatica and giant-cell (Takayasu's) arteritis), medium-vessel vasculitis (including Kawasaki's

disease and polyarteritis nodosa/periarteritis nodosa), microscopic polyarteritis, immunovasculitis, CNS vasculitis, cutaneous vasculitis, hypersensitivity vasculitis, necrotizing vasculitis such as systemic necrotizing vasculitis, and ANCA-associated vasculitis, such as Churg-Strauss vasculitis or syndrome (CSS) and ANCA-associated small-vessel vasculitis, temporal arteritis, aplastic anemia, autoimmune aplastic anemia, Coombs positive anemia, Diamond Blackfan anemia, hemolytic anemia or immune hemolytic anemia including autoimmune hemolytic anemia (AIHA), pernicious anemia (anemia pemiciosa), Addison's disease, pure red cell anemia or aplasia (PRCA), Factor VIII deficiency, hemophilia A, autoimmune neutropenia, pancytopenia, leukopenia, diseases involving leukocyte diapedesis, CNS inflammatory disorders, multiple organ injury syndrome such as those secondary to septicemia, trauma or hemorrhage, antigen-antibody complex-mediated diseases, anti-glomerular basement membrane disease, anti-phospholipid antibody syndrome, allergic neuritis, Behcet's disease/syndrome, Castleman's syndrome, Goodpasture's syndrome, Reynaud's syndrome, Sjogren's syndrome, Stevens-Johnson syndrome, pemphigoid such as pemphigoid bullous and skin pemphigoid, pemphigus (including pemphigus vulgaris, pemphigus foliaceus, pemphigus mucus-membrane pemphigoid, and pemphigus erythematosus), autoimmune polyendocrinopathies, Reiter's disease or syndrome, thermal injury, preeclampsia, an immune complex disorder such as immune complex nephritis, antibody-mediated nephritis, polyneuropathies, chronic neuropathy such as IgM polyneuropathies or IgM-mediated neuropathy, thrombocytopenia (as developed by myocardial infarction patients, for example), including thrombotic thrombocytopenic purpura (TTP), post-transfusion purpura (PTP), heparin-induced thrombocytopenia, and autoimmune or immune-mediated thrombocytopenia such as idiopathic thrombocytopenic purpura (ITP) including chronic or acute ITP, scleritis such as idiopathic cerato-scleritis, episcleritis, autoimmune disease of the testis and ovary including autoimmune orchitis and oophoritis, primary hypothyroidism, hypoparathyroidism, autoimmune endocrine diseases including thyroiditis such as autoimmune thyroiditis, Hashimoto's disease, chronic thyroiditis (Hashimoto's thyroiditis), or subacute thyroiditis, autoimmune thyroid disease, idiopathic hypothyroidism, Grave's disease, polyglandular syndromes such as autoimmune polyglandular syndromes (or polyglandular endocrinopathy syndromes), paraneoplastic syndromes, including neurologic paraneoplastic syndromes such as Lambert-Eaton myasthenic syndrome or Eaton-Lambert syndrome, stiff-man or stiff-person syndrome, encephalomyelitis such as allergic encephalomyelitis or encephalomyelitis allergica and experimental allergic encephalomyelitis (EAE), myasthenia gravis such as thymoma-associated myasthenia gravis, cerebellar degeneration, neuromyotonia, opsoclonus or opsoclonus

myoclonus syndrome (OMS), and sensory neuropathy, multifocal motor neuropathy, Sheehan's syndrome, autoimmune hepatitis, chronic hepatitis, lupoid hepatitis, giant-cell hepatitis, chronic active hepatitis or autoimmune chronic active hepatitis, lymphoid interstitial pneumonitis (LIP), bronchiolitis obliterans (non-transplant) vs NSIP, Guillain-Barre syndrome, Berger's disease (IgA nephropathy), idiopathic IgA nephropathy, linear IgA dermatosis, acute febrile neutrophilic dermatosis, subcorneal pustular dermatosis, transient acantholytic dermatosis, cirrhosis such as primary biliary cirrhosis and pneumonocirrhosis, autoimmune enteropathy syndrome, Celiac or Coeliac disease, celiac sprue (gluten enteropathy), refractory sprue, idiopathic sprue, cryoglobulinemia, amylotrophic lateral sclerosis (ALS; Lou Gehrig's disease), coronary artery disease, autoimmune ear disease such as autoimmune inner ear disease (AIED), autoimmune hearing loss, polychondritis such as refractory or relapsed or relapsing polychondritis, pulmonary alveolar proteinosis, Cogan's syndrome/nonsyphilitic interstitial keratitis, Bell's palsy, Sweet's disease/syndrome, rosacea autoimmune, zoster-associated pain, amyloidosis, a non-cancerous lymphocytosis, a primary lymphocytosis, which includes monoclonal B cell lymphocytosis (*e.g.*, benign monoclonal gammopathy and monoclonal gammopathy of undetermined significance, MGUS), peripheral neuropathy, paraneoplastic syndrome, channelopathies such as epilepsy, migraine, arrhythmia, muscular disorders, deafness, blindness, periodic paralysis, and channelopathies of the CNS, autism, inflammatory myopathy, focal or segmental or focal segmental glomerulosclerosis (FSGS), endocrine ophthalmopathy, uveoretinitis, chorioretinitis, autoimmune hepatological disorder, fibromyalgia, multiple endocrine failure, Schmidt's syndrome, adrenalitis, gastric atrophy, presenile dementia, demyelinating diseases such as autoimmune demyelinating diseases and chronic inflammatory demyelinating polyneuropathy, Dressler's syndrome, alopecia areata, alopecia totalis, CREST syndrome (calcinosis, Raynaud's phenomenon, esophageal dysmotility, sclerodactyly, and telangiectasia), male and female autoimmune infertility, *e.g.*, due to anti-spermatozoan antibodies, mixed connective tissue disease, Chagas' disease, rheumatic fever, recurrent abortion, farmer's lung, erythema multiforme, post-cardiotomy syndrome, Cushing's syndrome, bird-fancier's lung, allergic granulomatous angiitis, benign lymphocytic angiitis, Alport's syndrome, alveolitis such as allergic alveolitis and fibrosing alveolitis, interstitial lung disease, transfusion reaction, leprosy, malaria, parasitic diseases such as leishmaniasis, kypanosomiasis, schistosomiasis, ascariasis, aspergillosis, Sampter's syndrome, Caplan's syndrome, dengue, endocarditis, endomyocardial fibrosis, diffuse interstitial pulmonary fibrosis, interstitial lung fibrosis, pulmonary fibrosis, idiopathic pulmonary fibrosis, cystic fibrosis, endophthalmitis, erythema elevatum et diutinum, erythroblastosis fetalis, eosinophilic faciitis, Shulman's syndrome, Felty's syndrome, flariasis,

cyclitis such as chronic cyclitis, heterochronic cyclitis, iridocyclitis (acute or chronic), or Fuch's cyclitis, Henoch-Schonlein purpura, human immunodeficiency virus (HIV) infection, SCID, acquired immune deficiency syndrome (AIDS), echovirus infection, sepsis, endotoxemia, pancreatitis, thyroxicosis, parvovirus infection, rubella virus infection, post-vaccination syndromes, congenital rubella infection, Epstein-Barr virus infection, mumps, Evan's syndrome, autoimmune gonadal failure, Sydenham's chorea, post-streptococcal nephritis, thromboangitis ubiterans, thyrotoxicosis, tabes dorsalis, chorioiditis, giant-cell polymyalgia, chronic hypersensitivity pneumonitis, keratoconjunctivitis sicca, epidemic keratoconjunctivitis, idiopathic nephritic syndrome, minimal change nephropathy, benign familial and ischemia-reperfusion injury, transplant organ reperfusion, retinal autoimmunity, joint inflammation, bronchitis, chronic obstructive airway/pulmonary disease, silicosis, aphthae, aphthous stomatitis, arteriosclerotic disorders, aspermiogenese, autoimmune hemolysis, Boeck's disease, cryoglobulinemia, Dupuytren's contracture, endophthalmia phacoanaphylactica, enteritis allergica, erythema nodosum leprosum, idiopathic facial paralysis, chronic fatigue syndrome, febris rheumatica, Hamman-Rich's disease, sensoneural hearing loss, haemoglobinuria paroxysmatica, hypogonadism, ileitis regionalis, leucopenia, mononucleosis infectiosa, traverse myelitis, primary idiopathic myxedema, nephrosis, ophthalmia symphatica, orchitis granulomatosa, pancreatitis, polyradiculitis acuta, pyoderma gangrenosum, Quervain's thyreoiditis, acquired spenic atrophy, non-malignant thymoma, vitiligo, toxic-shock syndrome, food poisoning, conditions involving infiltration of T cells, leukocyte-adhesion deficiency, immune responses associated with acute and delayed hypersensitivity mediated by cytokines and T-lymphocytes, diseases involving leukocyte diapedesis, multiple organ injury syndrome, antigen-antibody complex-mediated diseases, antiglomerular basement membrane disease, allergic neuritis, autoimmune polyendocrinopathies, oophoritis, primary myxedema, autoimmune atrophic gastritis, sympathetic ophthalmia, rheumatic diseases, mixed connective tissue disease, nephrotic syndrome, insulitis, polyendocrine failure, autoimmune polyglandular syndrome type I, adult-onset idiopathic hypoparathyroidism (AOIH), cardiomyopathy such as dilated cardiomyopathy, epidermolisis bullosa acquisita (EBA), hemochromatosis, myocarditis, nephrotic syndrome, primary sclerosing cholangitis, purulent or nonpurulent sinusitis, acute or chronic sinusitis, ethmoid, frontal, maxillary, or sphenoid sinusitis, an eosinophil-related disorder such as eosinophilia, pulmonary infiltration eosinophilia, eosinophilia-myalgia syndrome, Loffler's syndrome, chronic eosinophilic pneumonia, tropical pulmonary eosinophilia, bronchopneumonic aspergillosis, aspergilloma, or granulomas containing eosinophils, anaphylaxis, seronegative spondyloarthritides, polyendocrine autoimmune disease, sclerosing

cholangitis, sclera, episclera, chronic mucocutaneous candidiasis, Bruton's syndrome, transient hypogammaglobulinemia of infancy, Wiskott-Aldrich syndrome, ataxia telangiectasia syndrome, angiectasis, autoimmune disorders associated with collagen disease, rheumatism, neurological disease, lymphadenitis, reduction in blood pressure response, vascular dysfunction, tissue injury, cardiovascular ischemia, hyperalgesia, renal ischemia, cerebral ischemia, and disease accompanying vascularization, allergic hypersensitivity disorders, glomerulonephritides, reperfusion injury, ischemic re-perfusion disorder, reperfusion injury of myocardial or other tissues, lymphomatous tracheobronchitis, inflammatory dermatoses, dermatoses with acute inflammatory components, multiple organ failure, bullous diseases, renal cortical necrosis, acute purulent meningitis or other central nervous system inflammatory disorders, ocular and orbital inflammatory disorders, granulocyte transfusion-associated syndromes, cytokine-induced toxicity, narcolepsy, acute serious inflammation, chronic intractable inflammation, pyelitis, endarterial hyperplasia, peptic ulcer, valvulitis, and endometriosis.

[0044] "Conservatively modified variants" applies to both amino acid and nucleic acid sequences. With respect to particular nucleic acid sequences, conservatively modified variants refers to those nucleic acids which encode identical or essentially identical amino acid sequences, or where the nucleic acid does not encode an amino acid sequence, to essentially identical sequences. Because of the degeneracy of the genetic code, a large number of functionally identical nucleic acids encode any given protein. For instance, the codons GCA, GCC, GCG and GCU all encode the amino acid alanine. Thus, at every position where an alanine is specified by a codon, the codon can be altered to any of the corresponding codons described without altering the encoded polypeptide. Such nucleic acid variations are "silent variations," which are one species of conservatively modified variations. Every nucleic acid sequence herein which encodes a polypeptide also describes every possible silent variation of the nucleic acid. One of skill will recognize that each codon in a nucleic acid (except AUG, which is ordinarily the only codon for methionine, and TGG, which is ordinarily the only codon for tryptophan) can be modified to yield a functionally identical molecule. Accordingly, each silent variation of a nucleic acid which encodes a polypeptide is implicit in each described sequence with respect to the expression product, but not with respect to actual probe sequences.

[0045] "Recombinant" when used with reference, *e.g.*, to a cell, or nucleic acid, protein, or vector, indicates that the cell, nucleic acid, protein or vector, has been modified by the introduction of a heterologous nucleic acid or protein or the alteration of a native nucleic acid or protein, or that the cell is derived from a cell so modified. Thus, for example, recombinant cells

express genes that are not found within the native (non-recombinant) form of the cell or express native genes that are otherwise abnormally expressed, under expressed or not expressed at all.

[0046] The phrase "nucleic acid" or "polynucleotide sequence" refers to a single or double-stranded polymer of deoxyribonucleotide or ribonucleotide bases read from the 5' to the 3' end. Nucleic acids can also include modified nucleotides that permit correct read through by a polymerase and do not alter expression of a polypeptide encoded by that nucleic acid, including, for example, conservatively modified variants.

[0047] "Polypeptide," "peptide" and "protein" are used interchangeably herein to refer to a polymer of amino acid residues. The terms apply to amino acid polymers in which one or more amino acid residue is an artificial chemical mimetic of a corresponding naturally occurring amino acid, as well as to naturally occurring amino acid polymers and non-naturally occurring amino acid polymers. Polypeptides of the invention include conservatively modified variants. One of skill will recognize that substitutions, deletions or additions to a nucleic acid, peptide, polypeptide, or protein sequence which alter, add or delete a single amino acid or a small percentage of amino acids in the encoded sequence is a "conservatively modified variant" where the alteration results in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. Such conservatively modified variants are in addition to and do not exclude polymorphic variants, interspecies homologs, and alleles of the invention. The following eight groups each contain amino acids that are conservative substitutions for one another: 1) Alanine (A), Glycine (G); 2) Aspartic acid (D), Glutamic acid (E); 3) Asparagine (N), Glutamine (Q); 4) Arginine (R), Lysine (K); 5) Isoleucine (I), Leucine (L), Methionine (M), Valine (V); 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W); 7) Serine (S), Threonine (T); and 8) Cysteine (C), Methionine (M) (33). The term "conservative substitution" also includes the use of a substituted amino acid in place of an unsubstituted parent amino acid provided that such a polypeptide also displays the requisite binding activity.

[0048] "Amino acid" refers to naturally occurring and synthetic amino acids, as well as amino acid analogs and amino acid mimetics that function in a manner similar to the naturally occurring amino acids. Naturally occurring amino acids are those encoded by the genetic code, as well as those amino acids that are later modified, *e.g.*, hydroxyproline, γ-carboxyglutamate, and O-phosphoserine. "Amino acid analog" refers to compounds that have the same basic chemical structure as a naturally occurring amino acid, *i.e.*, an α carbon that is bound to a hydrogen, a carboxyl group, an amino group, and an R group, *e.g.*, homoserine, norleucine, methionine sulfoxide, methionine methyl sulfonium. Such analogs have modified R groups (*e.g.*,

norleucine) or modified peptide backbones but retain the same basic chemical structure as a naturally occurring amino acid. "Amino acid mimetic" refers to a chemical compound having a structure that is different from the general chemical structure of an amino acid but that functions in a manner similar to a naturally occurring amino acid.

[0049] Amino acids can be referred to herein by either their commonly known three letter symbols or by the one-letter symbols recommended by the IUPAC-IUB Biochemical Nomenclature Commission (see Table 1 below). Nucleotides, likewise, can be referred to by their commonly accepted single-letter codes.

TABLE 1

SYMBOL		
1 -Letter	3 -Letter	AMINO ACID
Y	Tyr	L-tyrosine
G	Gly	L-glycine
F	Phe	L-phenylalanine
M	Met	L-methionine
A	Ala	L-alanine
S	Ser	L-serine
I	Ile	L-isoleucine
L	Leu	L-leucine
T	Thr	L-threonine
V	Val	L-valine
P	Pro	L-proline
K	Lys	L-lysine
H	His	L-histidine
Q	Gln	L-glutamine
E	Glu	L-glutamic acid
W	Trp	L-tryptophan
R	Arg	L-arginine
D	Asp	L-aspartic acid
N	Asn	L-asparagine
C	Cys	L-cysteine

[0050] It should be noted that all amino acid sequences are represented herein by formulae whose left to right orientation is in the conventional direction of amino-terminus to carboxy-terminus.

[0051] As used herein, the term "*in vitro*" or "*ex vivo*" refers to an artificial environment and to processes or reactions that occur within an artificial environment, for example, but not limited to, test tubes and cell cultures. The term "*in vivo*" refers to a natural environment (*e.g.*, an animal or a cell) and to processes or reactions that occur within a natural environment.

[0052] "Pharmaceutically acceptable," "physiologically tolerable" and grammatical variations thereof, as they refer to compositions, carriers, diluents and reagents, are used interchangeably and represent that the materials are capable of administration to or upon a human without the production of undesirable physiological effects to a degree that would prohibit administration of the composition.

[0053] The term "pharmaceutically acceptable carrier" refers to reagents, excipients, cells, compounds, materials, compositions, and/or dosage forms which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of human beings and animals without excessive toxicity, irritation, allergic response, or other complication commensurate with a reasonable benefit/risk ratio. As described in greater detail herein, pharmaceutically acceptable carriers suitable for use in the present invention include gases, liquids, and semi-solid and solid materials.

[0054] Except when noted, "subject" or "patient" are used interchangeably and refer to mammals such as human patients and non-human primates, as well as experimental animals such as rabbits, dogs, cats, rats, mice, and other animals. Accordingly, "subject" or "patient" as used herein means any mammalian patient or subject to which the compositions of the invention can be administered. In some embodiments of the present invention, the patient will be suffering from an infectious or inflammatory disease, or an autoimmune disease. In some embodiments of the present invention, the patient will have been diagnosed with cancer. In an exemplary embodiment of the present invention, to identify candidate patients for treatment according to the invention, accepted screening methods are employed to determine the status of an existing disease or condition in a subject or risk factors associated with a targeted or suspected disease or condition. These screening methods include, for example, examinations to determine whether a subject is suffering from an infectious disease, an inflammatory disease, cancer, or an autoimmune disease. These and other routine methods allow the clinician to select subjects in need of therapy.

[0055] "Treating" refers to any indicia of success in the treatment or amelioration of, for example, an infectious disease, an inflammatory disease such as a GM-CSF-mediated inflammatory disease, cancer, or an autoimmune disease, including any objective or subjective parameter such as abatement; remission; diminishing of symptoms or making the disease condition more tolerable to the patient; slowing in the rate of degeneration or decline; or making the final point of degeneration less debilitating. The treatment or amelioration of symptoms can be based on objective or subjective parameters; including the results of an examination. Accordingly, the term "treating" includes the administration of the compounds or agents of the present invention to delay, to alleviate, or to arrest or inhibit development of the symptoms or conditions associated with cancer, an infectious disease, an inflammatory disease such as a GM-CSF-mediated inflammatory disease, or an autoimmune disease. Treating includes, for example, inhibition of growth of dysplastic cells, inhibition of the progression of cancer or neoplastic disease, maintenance of inhibited tumor growth, and induction of remission.

[0056] "Therapeutic compound" as used herein refers to a compound useful in the prophylaxis or treatment of a disease or condition such as cancer, an infectious disease, an inflammatory disease, or an autoimmune disease.

[0057] "Therapeutic effect" refers to the reduction, elimination, or prevention of the disease, symptoms of the disease, or side effects of the disease in the subject. "Effective amount" refers to an amount necessary to produce a desired effect. A "therapeutically effective amount" means the amount that, when administered to a subject for treating a disease, condition or disorder, is sufficient to effect treatment for that disease.

[0058] "Concomitant administration," "concurrent administration," or "co-administration" as used herein includes administration of the active agents (*e.g.*, MAbs, chemotherapeutic agents, biomolecules), in conjunction or combination, together, or before or after each other. The multiple agent(s) may be administered by the same or by different routes, simultaneously or sequentially, as long as they are given in a manner sufficient to allow all agents to achieve effective concentrations at the site of action. A person of ordinary skill in the art would have no difficulty determining the appropriate timing, sequence, and dosages of administration for particular drugs and compositions of the present invention.

[0059] "Donor cells" is used broadly to refer to cells fused to human B-cells to generate hybridomas. The cells include but are not limited to rodent myelomas as understood by those skilled in the art; rodent cell lines, human cell lines; avian cell lines. Cell lines may be derived by any means known by those skilled in the art.

[0060] "Immunoglobulin" or "antibody" is used broadly to refer to both antibody molecules and a variety of antibody-derived molecules and includes any member of a group of glycoproteins occurring in higher mammals that are major components of the immune system. The term "antibody" is used in the broadest sense and specifically covers monoclonal antibodies, antibody compositions with polyepitopic specificity, bispecific antibodies, diabodies, and single-chain molecules, as well as antibody fragments (*e.g.*, Fab, F(ab')2, and Fv), so long as they exhibit the desired biological activity. An immunoglobulin molecule includes antigen binding domains, which each include the light chains and the end-terminal portion of the heavy chain, and the Fc region, which is necessary for a variety of functions, such as complement fixation. There are five classes of immunoglobulins wherein the primary structure of the heavy chain, in the Fc region, determines the immunoglobulin class. Specifically, the alpha, delta, epsilon, gamma, and mu chains correspond to IgA, IgD, IgE, IgG and IgM, respectively. As used herein "immunoglobulin" or "antibody" includes all subclasses of alpha, delta, epsilon, gamma, and mu and also refers to any natural (*e.g.*, IgA and IgM) or synthetic multimers of the four-chain immunoglobulin structure. Antibodies non-covalently, specifically, and reversibly bind an antigen.

[0061] The term "monoclonal antibody" as used herein refers to an antibody obtained from a population of substantially homogeneous antibodies, *i.e.*, the individual antibodies comprising the population are identical except for possible naturally occurring mutations that can be present in minor amounts. For example, monoclonal antibodies may be produced by a single clone of antibody-producing cells. Unlike polyclonal antibodies, monoclonal antibodies are monospecific (*e.g.*, specific for a single epitope of a single antigen). 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 can be made by the hybridoma method first described by Kohler *et al.*, *Nature*, 256: 495, 1975, or can be made by recombinant DNA methods. The "monoclonal antibodies" can also be isolated from phage antibody libraries using the techniques described in Marks *et al.*, *J. Mol. Biol.*, 222: 581-597, 1991, for example.

[0062] As used herein "chimerized" refers to an immunoglobulin, wherein the heavy and light chain variable regions are not of human origin and wherein the constant regions of the heavy and light chains are of human origin.

[0063] "Humanized" refers to an immunoglobulin such as an antibody, wherein the amino acids directly involved in antigen binding, the complementarity determining regions

(CDR), of the heavy and light chains are not of human origin, while the rest of the immunoglobulin molecule, the framework regions of the variable heavy and light chains and the constant regions of the heavy and light chains, are of human origin.

[0064] "Fully human" refers to an immunoglobulin, such as an antibody, where the whole molecule is of human origin or consists of an amino acid sequence identical to a human form of the antibody.

[0065] "Epitope" refers to an immunological determinant of an antigen that serves as an antibody-binding site. As used herein, the term "conformational epitope" refers to a discontinuous epitope formed by a spatial relationship between amino acids of an antigen other than an unbroken series of amino acids.

[0066] "Hybridoma" refers to the product of a cell-fusion between a cultured neoplastic lymphocyte and a primed B- or T-lymphocyte which expresses the specific immune potential of the parent cell.

[0067] "GM-CSF" refers to a family of glycoprotein growth factors that control the production, differentiation, and function of granulocytes and monocytes-macrophages. Exemplary, but by no means the only form of such molecules, can be seen in U.S. Pat. No. 5,602,007 (34).

[0068] As used herein the term "biomolecule" refers to any molecule that can be conjugated to, coadministered with, administered before or after administering an antibody, or otherwise used in association with an antibody of the invention. Biomolecules include, but are not limited to, enzymes, proteins, peptides, amino acids, nucleic acids, lipids, carbohydrates, and fragments, homologs, analogs, or derivatives, and combinations thereof. Examples of biomolecules include but are not limited to interleukin-2, interferon alpha, interferon beta, interferon gamma, rituxan, zevalin, herceptin, erbitux, and avastin. The biomolecules can be native, recombinant, or synthesized, and may be modified from their native form with, for example, glycosylations, acetylations, phosphorylations, myristylations, and the like. The term biomolecule as it is used herein is not limited to naturally occurring molecules, and includes synthetic molecules having no biological origin.

[0069] Polypeptides in accordance with the present invention can be synthesized from amino acids by techniques known to those skilled in the polypeptide art. In general, these methods comprise the sequential addition of one or more amino acid residues or suitably protected amino acid residues to a growing peptide chain. Normally, either the amino or carboxyl group of the first amino acid residue is protected by a suitable, selectively removable protecting

group. A different, selectively removable protecting group is utilized for amino acids containing a reactive side group (*e.g.*, lysine).

[0070] Various methods of preparing polypeptides of the present invention are known in the art (WO 89/06657; WO 92/22315; WO 98/49191; U.S. Patent Nos. 5,260,273; 5,164,369; 5,407,914; 5,789,381; 5,952,303; 6,013,619; 6,013,764; 6,120,795; 6,613,734.).

[0071] Additional residues can be added at either terminus of a polypeptide of the present invention, such as for the purpose of providing a "linker" by which such a polypeptide can be conveniently affixed to a label or solid matrix, or carrier. Labels, solid matrices and carriers that can be used with the polypeptides of this invention are known in the art; some examples are also described herein.

[0072] Amino acid residue linkers are usually at least one residue and can be 40 or more residues, more often 1 to 10 residues. Typical amino acid residues used for linking are tyrosine, cysteine, lysine, glutamic and aspartic acid, or the like. In addition, a polypeptide sequence of this invention can differ from the natural sequence by the sequence being modified by terminal-NH_2 acylation, *e.g.*, acetylation, or thioglycolic acid amidation, terminal-carboxylamidation, *e.g.*, ammonia, methylamine, and the like.

[0073] While it is appreciated that many useful polypeptides disclosed herein, *e.g.*, SEQ ID NOs:1-5, it is also true that a wide variety of other molecules, including uncommon but naturally occurring amino acids, metabolites and catabolites of natural amino acids, substituted amino acids, and amino acid analogs, as well as amino acids in the "D" configuration, are useful in molecules and compositions of the present invention. In addition, "designed" amino acid derivatives, analogs and mimetics are also useful in various compounds, compositions and methods of the present invention, as well as polymers including backbone structures composed of non-amide linkages.

[0074] As used herein, "analogs" and "derivatives" of polypeptides and amino acid residues are intended to encompass metabolites and catabolites of amino acids, as well as molecules which include linkages, backbones, side-chains or side-groups which differ from those ordinarily found in what are termed "naturally-occurring" L-form amino acids. (The terms "analog" and "derivative" can also conveniently be used interchangeably herein.). Thus, D-amino acids, molecules which mimic amino acids and amino acids with "designed" side chains (*i.e.*, that can substitute for one or more amino acids in a molecule having surfactant activity) are also encompassed by the terms "analogs" and "derivatives" herein.

[0075] For example, in addition to the L-amino acids listed in Table 1, amino acid metabolites such as homoarginine, citrulline, ornithine, and α-aminobutanoic acid are also useful in molecules and compositions of the present invention.

[0076] In another variation, one can wish to construct a molecule that adopts a more "rigid" conformation; one means of accomplishing this would be to add methyl or other groups to the α carbon atom of the amino acids.

[0077] Further, substituted amino acids which are not generally derived from proteins, but which are known in nature, are useful as disclosed herein, include the following examples: L-canavanine; 1-methyl-L-histidine; 3-methyl-L-histidine; 2-methyl L-histidine; α,ε-diaminopimelic acid (L form, meso form, or both); sarcosine; L-ornithine betaine; betaine of histidine (herzynine); L-citrulline; L-phosphoarginine; D-octopine; o-carbamyl-D-serine; γ-aminobutanoic acid; and β-lysine. D-amino acids and D-amino acid analogs, including the following, are also useful in proteins, peptides and compositions of the present invention: D-alanine, D-serine, D-valine, D-leucine, D-isoleucine, D-alloisoleucine, D-phenylalanine, D-glutamic acid, D-proline, and D-allohydroxyproline, and the like. The foregoing can also be used in GM-CSF polypeptides according to the present invention.

[0078] It should also be appreciated that the present invention encompasses a wide variety of modified amino acids, including analogs, metabolites, catabolites, and derivatives, irrespective of the time or location at which modification occurs. In essence, one can place modified amino acids into three categories: (1) catabolites and metabolites of amino acids; (2) modified amino acids generated via posttranslational modification (*e.g.*, modification of side chains); and (3) modifications made to amino acids via non-metabolic or non-catabolic processes (*e.g.*, the synthesis of modified amino acids or derivatives in the laboratory).

[0079] The present invention also contemplates that one can readily design side chains of the amino acids of residue units that include longer or shortened side chains by adding or subtracting methylene groups in either linear, branched chain, or hydrocarbon or heterocyclic ring arrangements. The linear and branched chain structures can also contain non-carbon atoms such as S, O, or N. Fatty acids can also be useful constituents of surfactant molecules herein. The designed side chains can terminate with (R') or without (R) charged or polar group appendages.

[0080] Analogs, including molecules resulting from the use of different linkers, are also useful in the peptides of the invention. Molecules with side chains linked together via linkages other than the amide linkage, *e.g.*, molecules containing amino acid side chains or other side chains (R- or R'-) wherein the components are linked via carboxy- or phospho-esters, ethylene, methylene, ketone or ether linkages, to name a few examples, are also useful as disclosed herein.

In essence, any amino acid side chain, R or R' group-containing molecule can be useful as disclosed herein.

[0081] The present invention also contemplates molecules comprising peptide dimers joined by an appropriate linker, *e.g.*, peptide dimers linked by cysteine molecules. (As those of skill in the art are aware, two cysteine molecules can be linked together by a disulfide bridge formed by oxidation of their thiol groups.). Such linkers or bridges can thus cross-link different polypeptide chains, dimers, trimers, and the like. Other useful linkers which can be used to connect peptide dimers and/or other peptide multimers include those listed above, *e.g.*, carboxy- or phospho-ester, ethylene, methylene, ketone or ether linkages, and the like.

[0082] One of skill in the art will appreciate that one can make a variety of modifications to individual amino acids, to the linkages, and/or to the chain itself, which modifications will produce molecules falling within the scope of the present invention, as long as the resulting molecule possesses biological (*e.g.*, antigenic) activity as described herein.

[0083] Preferred antigenic polypeptides of the invention are antigenic peptides of GM-CSF (SEQ ID NO:1), and preferably of mature GM-CSF (SEQ ID NO:2). In some embodiments, the antigenic peptide comprises at least 5 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the antigenic peptide comprises at least 10 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the antigenic peptide comprises at least 15 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the immunogenic portion comprises at least 20 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In still other embodiments, the immunogenic portion comprises at least 25 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In certain preferred embodiments of the invention, the antigenic peptide of the GM-CSF protein is amino acids 14-28 (SEQ ID NO:3), amino acids 9-23 (SEQ ID NO:4), or amino acids 80-94 (SEQ ID NO:5) of the amino acid sequence of mature GM-CSF (SEQ ID NO:2).

[0084] In some embodiments of the invention, GM-CSF or antigenic peptides thereof are conjugated to an immunogenic protein to enhance the immunogenicity of the antigen. The immunogenic protein may be any protein that enhances the immune response of the cells, such as, but not limited to tetanus toxoid C (TT), keyhole limpet hemocyanin (KLH), albumin, ovalbumin, chick albumin (CAB), bovine serum albumin, thyroglobulin, diptheria toxoid, BCG, cholera toxin and the like. In some embodiments, the antigen is generated by denaturing the mature protein.

[0085] Previously reported methods for generation of hybridomas secreting human MAbs (WO2004/046330) using primary human B-cells were employed herein. Peripheral blood mononuclear cells, preferably human PBMCs, are immunized *ex vivo* in the presence of target antigen and then immortalized via cell fusion with donor cells. Alternatively, selected PBMCs are identified whose sera have high immune reactivity to antigen of interest.

[0086] Hybrid cells derived from the donor cells are screened for secretion of target antigen-specific MAbs. In some embodiments are provided methods for producing hybridoma cells producing monoclonal antibodies against a target antigen from *ex vivo* immunized immunoglobulin-producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with a target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with donor cells to form hybridoma cells; (c) determining binding of antigen by antibodies produced from the hybridoma cells; and (d) selecting hybridoma cells that produce antibodies that bind the target antigen; thereby generating hybridoma cells that produce antibodies against the target antigen. In a preferred embodiment, the PBMCs are from healthy donors. The target antigen is preferably GM-CSF and more preferably comprises an amino acid sequence of one of SEQ ID NOs:35-38.

[0087] Alternatively, methods for generating hybridomas that produce monoclonal antibodies against target disease-associated antigen comprise the steps of: (a) fusing *ex vivo* peripheral blood mononuclear cells comprising immunoglobulin-producing B-cells derived from a patient having a disease or an antigen-exposed donor with donor cells to form hybridoma cells; (b) determining binding by the antibodies produced from the hybridoma cells to target antigen; and (c) selecting hybridoma cells that produce antibodies that bind to the target antigen; thereby producing hybridoma cells that express antibodies against the target disease. Preferably, the target antigen is a disease-associated antigen, and preferably is associated with cancer, an infectious disease, or an autoimmune disease. More preferably, the disease associated antigen is GM-CSF. The target antigen is preferably GM-CSF and more preferably comprises an amino acid sequence of one of SEQ ID NOs:35-38. In a preferred embodiment, the antigen-exposed donor has been exposed to GM-CSF or may have pulmonary alveolar proteinosis (PAP).

[0088] The invention provides methods for producing hybridoma cells producing antibodies to target antigen (*e.g.*, GM-CSF or antigenic peptides thereof) from *ex vivo*-immunized immunoglobulin-producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with donor cells to form hybridoma cells; (c) performing a screen for binding of immunoglobulins produced by the hybridoma cells to target

antigen; thereby producing hybridoma cells producing antibodies to target antigen. In a preferred embodiment, the PBMCs are from healthy donors. In some embodiments, the target antigen comprises an antigenic polypeptide of the invention. The target antigen preferably comprises an amino acid sequence of one of SEQ ID NOs:1-5, preferably any one of SEQ ID NOs:3-5.

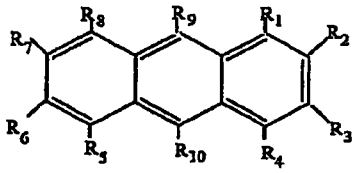
[0089] Alternatively, the invention provides methods for producing hybridoma cells producing antibodies to a target antigen (*e.g.*, GM-CSF, or antigenic peptides thereof) comprising: (a) selecting peripheral blood mononuclear cells comprising immunoglobulin-producing cells from an antigen-exposed donor; (b) fusing the immunoglobulin-producing cells with myeloma cells to form hybridoma cells; (c) performing a screen for binding of immunoglobulins produced by the hybridoma cells to a target antigen; thereby producing hybridoma cells producing antibodies to the target antigen. In some embodiments, the target antigen comprises an antigenic polypeptide of the invention. The target antigen preferably comprises an amino acid sequence of one of SEQ ID NOs:1-5, more preferably SEQ ID NOs:3-5. In a preferred embodiment, the donor has been exposed to GM-CSF, or antigenic peptides thereof, or may have pulmonary alveolar proteinosis (PAP).

[0090] In some embodiments, the donor (*e.g.*, myeloma) cells express a protein inhibitor of mismatch repair. In some aspects, the hybridoma cells express a protein inhibitor of mismatch repair. In some embodiments of the method of the invention, the protein inhibitor of mismatch repair is introduced into the hybridoma cell after the fusion of the myeloma with the immunoglobulin-producing cells. In other embodiments, the protein inhibitor of mismatch repair is introduced into the donor or myeloma cell prior to the fusion with the immunoglobulin-producing cells. In still other embodiments, the donor or myeloma cells or antibody producing cells are naturally deficient in mismatch repair.

[0091] Protein inhibitors of mismatch repair include dominant negative alleles of mismatch repair genes. Dominant negative alleles of mismatch repair genes include but are not limited to dominant negative alleles of PMS2, PMS1, PMSR3, PMSR2, PMSR6, MLH1, GTBP, MSH3, MSH2, MLH3, or MSH1, and homologs of mutL and mutS genes. In addition, polypeptides capable of interfering in mismatch repair may be used. For example, a dominant negative allele of mutL PMS2 comprises the first 133 amino acids PMS2. Further delineation of amino acids in mutL homologs reveals amino acids LSTAVKELVENSLDAGATNIDLKLKDYGVDLIEVSDNGCGVEEENFE (SEQ ID NO:6) and LRQVLSNLLDNAIKYTPEGGEITVSLERDGDHLEITVEDNGPGIPEEDLE (SEQ ID NO:7) or fragments thereof. Protein inhibitors of mismatch repair thus include polypeptides of

SEQ ID NOs: 6 and 7 and fragments thereof. In preferred embodiments, the protein inhibitor of mismatch repair is inactivated. For example, the protein inhibitor of mismatch repair may be inactivated before or after identification of a hybridoma cell that generates monoclonal antibodies to the target antigen. Inactivation of the protein inhibitor of mismatch repair may be by any means known in the art, for example, removal of an inducer or removal of the protein inhibitor of mismatch repair from the cell (*i.e.*, curing the cell of the protein inhibitor of mismatch repair). Inactivation of the inhibitor of mismatch repair stabilizes the genome of the hypermutated hybridoma.

[0092] In some embodiments of the methods of generating hybridoma cells of the invention, the hybridoma cells are exposed to a chemical inhibitor of mismatch repair. Chemical inhibitors of mismatch repair used in certain embodiments of the methods of the invention include, but are not limited to, at least one of an anthracene, an ATPase inhibitor, a nuclease inhibitor, an RNA interference molecule, a polymerase inhibitor and an antisense oligonucleotide that specifically hybridizes to a nucleotide encoding a mismatch repair protein (WO2004/046330). In preferred embodiments, the chemical inhibitor is an anthracene compound having the formula:



wherein R_1-R_{10} are independently hydrogen, hydroxyl, amino, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, O-alkyl, S-alkyl, N-alkyl, O-alkenyl, S-alkenyl, N-alkenyl, O-alkynyl, S-alkynyl, N-alkynyl, aryl, substituted aryl, aryloxy, substituted aryloxy, heteroaryl, substituted heteroaryl, aralkyloxy, arylalkyl, alkylaryl, alkylaryloxy, arylsulfonyl, alkylsulfonyl, alkoxycarbonyl, aryloxycarbonyl, guanidino, carboxy, an alcohol, an amino acid, sulfonate, alkyl sulfonate, CN, NO_2, an aldehyde group, an ester, an ether, a crown ether, a ketone, an organosulfur compound, an organometallic group, a carboxylic acid, an organosilicon or a carbohydrate that optionally contains one or more alkylated hydroxyl groups; wherein said heteroalkyl, heteroaryl, and substituted heteroaryl contain at least one heteroatom that is oxygen, sulfur, a metal atom, phosphorus, silicon or nitrogen; and wherein said substituents of said substituted alkyl, substituted alkenyl, substituted alkynyl, substituted aryl, and substituted

heteroaryl are halogen, CN, NO_2, lower alkyl, aryl, heteroaryl, aralkyl, aralkoxy, guanidino, alkoxycarbonyl, alkoxy, hydroxy, carboxy and amino; and wherein said amino groups are optionally substituted with an acyl group, or 1 to 3 aryl or lower alkyl groups. In certain embodiments, R_5 and R_6 are hydrogen. In other embodiments, R_1-R_{10} are independently hydrogen, hydroxyl, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, phenyl, tolyl, hydroxymethyl, hydroxypropyl, or hydroxybutyl. Non-limiting examples of the anthracenes include 1,2-dimethylanthracene, 9,10-dimethylanthracene, 7,8-dimethylanthracene, 9,10-duphenylanthracene, 9,10-dihydroxymethylanthracene, 9-hydroxymethyl-10-methylanthracene, dimethylanthracene-1,2-diol, 9-hydroxymethyl-10-methylanthracene-1,2-diol, 9-hydroxymethyl-10-methylanthracene-3,4-diol, and 9,10-di-*m*-tolylanthracene.

[0093] The chemical inhibitor may be introduced into the growth medium of the cells. In some embodiments, the chemical inhibitor may be withdrawn from the hypermutated hybridoma cells in order to re-stabilize the genome of the cells. Alternatively, the method may comprise inactivation of the chemical inhibitor of mismatch repair, thereby stabilizing the genome of the hypermutated hybridoma.

[0094] In some embodiments, the methods further comprise cloning the immunoglobulin-producing genes from the antibody-producing cells and transfecting the immunoglobulin genes into a mammalian expression cell, wherein the immunoglobulin genes are operably linked to expression control sequences.

[0095] The invention also provides methods for producing mammalian expression cells that produce high affinity antibodies to target antigen from *ex vivo* immunized immunoglobulin-producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with a target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with donor cells to form hybridoma cells; (c) determining binding of antigen by antibodies produced from the hybridoma cells; (d) optimizing antibody production of the hybridoma by inhibiting mismatch repair; or cloning immunoglobulin genes from the hybridoma into a mammalian expression cell, wherein the mismatch repair of the mammalian expression cell is inhibited; and (e) selecting hybridoma cells that produce antibodies that bind the target antigen; thereby generating hybridoma cells that produce antibodies against the target antigen. As an alternative to steps (a) and (b), fusion *ex vivo* of peripheral blood mononuclear cells comprising immunoglobulin-producing B-cells derived from a patient having a disease or an antigen-exposed donor with donor cells to form hybridoma cells may be used.

[0096] The invention also provides methods for producing mammalian expression cells that produce high affinity antibodies to target antigen from *ex vivo* immunized immunoglobulin-

producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with myeloma cells to form hybridoma cells; (c) performing a screen for binding of antibodies produced from said hybridoma cells to target antigen; (d) optimizing production of the hybridoma by inhibiting mismatch repair; or cloning immunoglobulin genes from the hybridoma into a mammalian expression cell, wherein the mismatch repair of the mammalian expression cell is inhibited; and (e) performing a screen for mammalian expression cells that secrete antibodies with higher affinity for target antigen as compared to antibodies produced from the hybridoma or recombinant cells.

[0097] The invention also provides a method for producing mammalian expression cells that produce high titers of high-affinity antibodies from *ex vivo* immunized immunoglobulin-producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with a target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with donor cells to form hybridoma cells; (c) determining binding of antigen by antibodies produced from the hybridoma cells; (d) cloning immunoglobulin genes from the hybridoma into a parental mammalian expression cell, wherein mismatch repair of the mammalian expression cell is inhibited; (e) incubating the parental mammalian cell or hybridoma expression cell to allow for mutagenesis, thereby forming hypermutated mammalian expression cells; (f) selecting hypermutable mammalian expression cells that secrete antibodies with higher affinity for target antigen as compared to antibodies produced from the parental hybridoma cells or selecting hypermutable mammalian expression cells that secrete higher titers of antibodies than parental mammalian expression cells; thereby producing mammalian expression cells that produce antibodies to target antigen from *ex vivo* immunized immunoglobulin-producing cells. As an alternative to steps (a) and (b), fusion *ex vivo* of peripheral blood mononuclear cells comprising immunoglobulin-producing B-cells derived from a patient having a disease or an antigen-exposed donor with donor cells to form hybridoma cells may be used.

[0098] The invention also provides a method for producing mammalian expression cells that produce high titers of high-affinity antibodies from *ex vivo* immunized immunoglobulin-producing cells comprising: (a) combining peripheral blood mononuclear cells comprising immunoglobulin-producing cells with target antigen *ex vivo*; (b) fusing the immunoglobulin-producing cells with myeloma cells to form hybridoma cells; (c) performing a screen for binding of antibodies produced from the hybridoma cells to antigen; (d) cloning immunoglobulin genes from the hybridoma into a parental mammalian expression cell, wherein

mismatch repair of the mammalian expression cell is inhibited or optimizing production of the hybridoma by inhibiting mismatch repair; (e) incubating the parental mammalian cell or hybridoma expression cell to allow for mutagenesis, thereby forming hypermutated mammalian expression cells; (f) performing a screen of hypermutable mammalian expression cells that secrete antibodies with higher affinity for target antigen as compared to antibodies produced from the hybridoma cells; and (g) performing a screen of hypermutable mammalian expression cells that secrete higher titers of antibodies than parental mammalian expression cells; thereby producing mammalian expression cells that produce high titers of high-affinity antibodies from *ex vivo* immunized immunoglobulin-producing cells.

[0099] In some embodiments of the method of the invention, antibodies are screened using an ELISA-based assay or other assays that can measure antibody-antigen binding known in the art. Crowther, J. R. (2001) The ELISA guidebook, 1st ed. Humana Press, Totowa, NJ.

[0100] In some embodiments, the screening assays screen for hypermutated hybridomas that produce higher affinity antibodies than those produced by the parental hybridomas.

[0101] In some embodiments, the method of the invention further comprises selecting hypermutated antibody-producing cells having higher titers of antibodies than that produced by the originally selected cells.

[0102] Methods of fusion of immunoglobulin-producing cells to myeloma cells and myeloma cells useful in such methods also are known in the art. Kohler & Milstein, *Eur. J. Immunol.* 1976. 6:511-9. Derivation of specific antibody-producing tissue culture and tumor lines by cell fusion.

[0103] Human B-cells used for the generation of MAbs designed for administration to humans may represent a potential vehicle of viral transmission. Fusion partner cells and peripheral blood mononuclear cells (PBMCs) from donors may be pre-screened to confirm absence of viral DNA, for example, by PCR, including immunodeficiency-1 and 2, hepatitis B and C, cytomegalo-, herpes-6, and Epstein Barr viruses.

[0104] Hybridoma cells produced according to the methods of the invention are included within the scope of the invention.

[0105] The invention also comprises antibodies to target antigens produced by the hybridoma cells generated according to the methods of the invention. Antibodies of the invention also comprise antibodies produced recombinantly using the polynucleotides of the invention. Preferred antibodies of the invention are monoclonal antibodies. Antibodies of the invention preferably are fully human, more preferably fully human monoclonal antibodies.

[0106] Preferred antibodies of the invention specifically bind an epitope, for example a conformational epitope, of a target antigen. The antibodies of the invention preferably are directed against disease-associated antigen, for example, but not limited to GM-CSF, preferably human GM-CSF (SEQ ID NO:1), more preferably mature human GM-CSF (SEQ ID NO:2). In some embodiments, the epitope to which the antibody binds comprises at least 5 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the epitope to which the antibody binds comprises at least 10 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the epitope to which the antibody binds comprises at least 15 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In other embodiments, the epitope to which the antibody binds comprises at least 20 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In still other embodiments, the epitope to which the antibody binds comprises at least 25 consecutive amino acids of the amino acid sequence shown in SEQ ID NO:1 or SEQ ID NO:2. In certain preferred embodiments of the invention, the epitope of GM-CSF to which the antibody binds comprises an amino acid sequence of at least one of SEQ ID NOs:33-36. Antibody-producing cells have been placed with the Amer. Type Cult. Coll. (10801 University Blvd., Manassas, Virginia 20110-2209) on January 18, 2007 (10G9), and on February 2, 2007 (E10) and have been assigned Access. Nos. PTA-8173 and PTA-8193, respectively. Examples of anti-GM-CSF antibodies of the invention are antibodies produced by such cells.

[0107] Those of skill in the art will recognize that antibody specificity is primarily determined by the six CDR regions, especially H chain CDR3 (Kala M *et al.* (2002) J. Biochem. 132:535-41; Morea V *et al.* (1998) J. Mol. Biol. 275:269-94; and, Chothia C *et al.* (1987) J. Mol. Biol. 196:901-17). Antibody framework regions, however, can play a role in antigen-antibody interactions (Panka DJ *et al.* (1988) Proc. Natl. Acad. Sci. USA 85:3080-4), particularly with respect to their role in conformation of CDR loops (Foote J *et al.* (1992) J. Mol. Biol. 224:487-99). Thus, the inventive antibodies can comprise any combination of H or L chain CDR or FWR regions that confer antibody specificity for GM-CSF. Domain shuffling experiments, which are routinely carried out in the art (Jirholt P *et al.* (1998) Gene 215:471-6; Söderlind E *et al.* (2000) Nature Biotechnology 18:852-6), can be employed to generate antibodies that specifically bind GM-CSF according to the specifications described and exemplified herein. Antibodies generated by such domain shuffling experiments are within the scope of the present invention.

[0108] Accordingly, in some embodiments, the antibodies comprise a heavy chain CDR1 amino acid sequence substantially the same as or identical to SEQ ID NO:40 or 46. In

some embodiments, the antibodies comprise a heavy chain CDR2 amino acid sequence substantially the same as or identical to SEQ ID NO:41 or 47. In some particularly preferred embodiments, the antibodies comprise a heavy chain CDR3 amino acid sequence substantially the same as or identical to SEQ ID NO:42 or 48. In some embodiments, the antibodies comprise a light chain CDR1 amino acid sequence substantially the same as or identical to SEQ ID NO:43 or 49. In some embodiments, the antibodies comprise a light chain CDR2 amino acid sequence substantially the same as or identical to SEQ ID NO:44 or 50. In some embodiments, the antibodies comprise a light chain CDR3 amino acid sequence substantially the same as or identical to SEQ ID NO:45 or 51. In some embodiments, the antibodies comprise a heavy chain FWR1 amino acid sequence substantially the same as or identical to SEQ ID NO:52 or 58. In some embodiments, the antibodies comprise a heavy chain FWR2 amino acid sequence substantially the same as or identical to SEQ ID NO:53 or 59. In some embodiments, the antibodies comprise a heavy chain FWR3 amino acid sequence substantially the same as or identical to SEQ ID NO:54 or 60. In some embodiments, the antibodies comprise a light chain FWR1 amino acid sequence substantially the same as or identical to SEQ ID NO:55 or 61. In some embodiments, the antibodies comprise a light chain FWR2 amino acid sequence substantially the same as or identical to SEQ ID NO:56 or 62. In some embodiments, the antibodies comprise a light chain FWR3 amino acid sequence substantially the same as or identical to SEQ ID NO:57 or 63.

[0109] In some preferred embodiments, the antibody of the invention comprises a heavy chain comprising an amino acid sequence of SEQ ID NO:8, 9, or 16. The heavy chain can be encoded by a nucleic acid sequence comprising a nucleotide sequence of SEQ ID NO:10, 11, or 17. In some preferred embodiments, the antibody of the invention comprises a light chain comprising an amino acid sequence of SEQ ID NO:12, 13, or 18. The light chain can be encoded by a nucleic acid sequence comprising a nucleotide sequence of SEQ ID NO:14, 15, or 19.

[0110] It is to be understood that because of the natural sequence variation likely to exist among heavy and light chains and the genes encoding them, one skilled in the art would expect to find some level of variation within the amino acid sequences or the genes encoding them, while still maintaining the unique binding properties (*e.g.*, specificity and affinity) of the antibodies of the present invention. Such an expectation is due in part to the degeneracy of the genetic code, as well as to the known evolutionary success of conservative amino acid sequence variations, which do not appreciably alter the nature of the encoded protein. Accordingly, such

variants and homologs are considered substantially the same as one another and are included within the scope of the present invention.

[0111] The antibodies of the invention thus include variants having single or multiple amino acid substitutions, deletions, additions, or replacements that retain the biological properties (*e.g.*, binding affinity or immune effector activity) of the antibodies of the invention. The skilled person can produce variants having single or multiple amino acid substitutions, deletions, additions or replacements. These variants may include, *inter alia*: (a) variants in which one or more amino acid residues are substituted with conservative or nonconservative amino acids, (b) variants in which one or more amino acids are added to or deleted from the polypeptide, (c) variants in which one or more amino acids include a substituent group, and (d) variants in which the polypeptide is fused with another peptide or polypeptide such as a fusion partner, a protein tag or other chemical moiety, that may confer useful properties to the polypeptide, such as, for example, an epitope for an antibody, a polyhistidine sequence, a biotin moiety and the like. Antibodies of the invention may include variants in which amino acid residues from one species are substituted for the corresponding residue in another species, either at the conserved or nonconserved positions. In other embodiments, amino acid residues at nonconserved positions are substituted with conservative or nonconservative residues. The techniques for obtaining these variants, including genetic (suppressions, deletions, mutations, etc.), chemical, and enzymatic techniques, are known to the person having ordinary skill in the art.

[0112] In some preferred embodiments, the antibodies can comprise a heavy chain that comprises the amino acid sequence of SEQ ID NO:8 and a light chain that comprises the amino acid sequence of SEQ ID NO:12. In some preferred embodiments, the antibodies can comprise a heavy chain that comprises the amino acid sequence of SEQ ID NO:16 and a light chain that comprises the amino acid sequence of SEQ ID NO:18. In some embodiments, the antibodies can comprise a heavy chain that comprises the amino acid sequence of SEQ ID NO:9 and a light chain that comprises the amino acid sequence of SEQ ID NO:13. Those of skill in the art will recognize, however, that in some cases, the pairing of a given heavy with various light chains, or the pairing of a given light chain with various heavy chains will produce antibodies with the same or better specificity and/or affinity than the native combination. Accordingly, the invention is not limited to the preferred combinations of H and L chain pairs, and the inventive antibodies thus encompass different combinations of H and L chain pairs, including without limitation, the H and L chains described herein, or other H or L chains that would be known to those of skill in

the art, or otherwise experimentally determined to be compatible with the H and L chains described herein in order to obtain specific and high affinity binding to GM-CSF.

[0113] Preferred antibodies of the invention comprise two heavy chains. Preferred antibodies of the invention comprise two light chains. More preferred are antibodies comprising two heavy chains and two light chains of the invention.

[0114] The antibodies of the invention include variants having single or multiple amino acid substitutions, deletions, additions, or replacements that retain the biological properties (*e.g.*, binding affinity or immune effector activity) of the antibodies of the invention. The skilled person can produce variants having single or multiple amino acid substitutions, deletions, additions or replacements. These variants may include, inter alia: (a) variants in which one or more amino acid residues are substituted with conservative or nonconservative amino acids, (b) variants in which one or more amino acids are added to or deleted from the polypeptide, (c) variants in which one or more amino acids include a substituent group, and (d) variants in which the polypeptide is fused with another peptide or polypeptide such as a fusion partner, a protein tag or other chemical moiety, that may confer useful properties to the polypeptide, such as, for example, an epitope for an antibody, a polyhistidine sequence, a biotin moiety and the like. Antibodies of the invention may include variants in which amino acid residues from one species are substituted for the corresponding residue in another species, either at the conserved or nonconserved positions. In another embodiment, amino acid residues at nonconserved positions are substituted with conservative or nonconservative residues. The techniques for obtaining these variants, including genetic (suppressions, deletions, mutations, etc.), chemical, and enzymatic techniques, are known to the person having ordinary skill in the art. Antibodies of the invention also include antibody fragments. A "fragment" refers to polypeptide sequences which are preferably at least about 40, more preferably at least to about 50, more preferably at least about 60, more preferably at least about 70, more preferably at least about 80, more preferably at least about 90, and more preferably at least about 100 amino acids in length, and which retain some biological activity or immunological activity of the full-length sequence, for example, binding affinity or avidity and immune effector activity.

[0115] The antibodies of the invention have binding affinities for target antigen that include a dissociation constant (K_D) of less than 1×10^{-2}. In some embodiments, the K_D is less than 1×10^{-3}. In other embodiments, the K_D is less than 1×10^{-4}. In some embodiments, the K_D is less than 1×10^{-5}. In still other embodiments, the K_D is less than 1×10^{-6}. In other embodiments, the K_D is less than 1×10^{-7}. In other embodiments, the K_D is less than 1×10^{-8}. In other embodiments, the K_D is less than 1×10^{-9}. In other embodiments, the K_D is less than $1 \times$

10^{-10}. In still other embodiments, the K_D is less than 1×10^{-11}. In some embodiments, the K_D is less than 1×10^{-12}. In other embodiments, the K_D is less than 1×10^{-13}. In other embodiments, the K_D is less than 1×10^{-14}. In still other embodiments, the K_D is less than 1×10^{-15}.

[0116] Antibodies of the invention include derivatives that are modified, *e.g.*, by the covalent attachment of any type of molecule to the antibody such that covalent attachment does not prevent the antibody from binding to its epitope. Examples of suitable derivatives include, but are not limited to glycosylated antibodies and fragments, acetylated antibodies and fragments, pegylated antibodies and fragments, phosphorylated antibodies and fragments, and amidated antibodies and fragments. The antibodies of the invention may themselves be derivatized by known protecting/blocking groups, proteolytic cleavage, linkage to a cellular ligand or other proteins, and the like. Further, the antibodies of the invention may contain one or more non-classical amino acids as described above. In some embodiments of the invention, GM-CSF or epitopes thereof are conjugated to an immunogenic protein to enhance the immunogenicity of the antigen. The immunogenic protein may be any protein that enhances the immune response of the cells, such as, but not limited to tetanus toxoid C (TT), keyhole limpet hemocyanin (KLH), albumin, ovalbumin, chick albumin (CAB), bovine serum albumin, thyroglobulin, diptheria toxoid, BCG, cholera toxin and the like. In some embodiments, the antigen is generated by denaturing the mature protein.

[0117] The antibodies of the invention may have post-translational moieties that improve upon antibody activity or stability. These moieties include sulfur, methyl, carbohydrate, phosphorus as well as other chemical groups commonly found on immunoglobulin molecules.

[0118] Antibodies of the invention may be of any isotype. Whereby isotype of antibody can be changes using *in vivo* class switching or by genetic engineering.

[0119] Nucleotide sequences that encode polypeptides of the invention are provided. Nucleic acids of the invention include but are not limited to genomic DNA, DNA, cDNA, RNA, double- and single-stranded nucleic acids, and complementary sequences thereof.

[0120] Preferred polynucleotides of the invention include nucleic acid sequences encoding an amino acid sequence of SEQ ID NO:8 and/or SEQ ID NO:12. In some embodiments, the heavy chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:10. In some embodiments, the light chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:14. Polynucleotides comprising a nucleic acid sequence encoding an amino acid sequence of SEQ ID NO:8 and an amino acid sequence of SEQ ID NO:12 also are provided. Preferably such a polynucleotide comprises a nucleic acid sequence of SEQ ID NO:10 and/or SEQ ID NO:14.

[0121] Preferred polynucleotides of the invention include nucleic acid sequences encoding an amino acid sequence of SEQ ID NO:16 and/or SEQ ID NO:18. In some embodiments, the heavy chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:17. In some embodiments, the light chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:19. Polynucleotides comprising a nucleic acid sequence encoding an amino acid sequence of SEQ ID NO:16 and an amino acid sequence of SEQ ID NO:18 also are provided. Preferably such a polynucleotide comprises a nucleic acid sequence of SEQ ID NO:17 and/or SEQ ID NO:19.

[0122] In some embodiments, polynucleotides of the invention (and the peptides they encode) include a leader sequence. Any leader sequence known in the art may be employed. The leader sequence may include but is not limited to a restriction site and/or a translation start site. For example, the invention provides nucleic acid sequences encoding an amino acid sequence of SEQ ID NO:9 and/or SEQ ID NO:13. In some embodiments, the heavy chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:11. In some embodiments, the light chain of the antibody is encoded by a polynucleotide comprising SEQ ID NO:15. Polynucleotides comprising a nucleic acid sequence encoding an amino acid sequence of SEQ ID NO:9 and an amino acid sequence of SEQ ID NO:13 also are provided. Preferably such a polynucleotide comprises a nucleic acid sequence of SEQ ID NO:11 and/or SEQ ID NO:15.

[0123] Also contemplated by the invention are expression vectors comprising the polynucleotides of the invention and host cells, such as but not limited to recombinant host cells, expressing the polynucleotides of the invention.

[0124] Recombinant expression vectors containing a sequence encoding a polypeptide of interest are provided. The expression vector may contain one or more additional sequences such as but not limited to regulatory sequences (*e.g.*, promoter, enhancer), a selection marker, and a polyadenylation signal.

[0125] Recombinant expression vectors of the invention include synthetic, genomic, or cDNA-derived nucleic acid fragments that encode at least one recombinant protein which may be operably linked to suitable regulatory elements. Such regulatory elements may include a transcriptional promoter, sequences encoding suitable mRNA ribosomal binding sites, and sequences that control the termination of transcription and translation. Expression vectors, especially mammalian expression vectors, may also include one or more nontranscribed elements such as an origin of replication, a suitable promoter and enhancer linked to the gene to be expressed, other 5' or 3' flanking nontranscribed sequences, 5' or 3' nontranslated sequences (such as necessary ribosome binding sites), a polyadenylation site, splice donor and acceptor

sites, or transcriptional termination sequences. An origin of replication that confers the ability to replicate in a host may also be incorporated.

[0126] The transcriptional and translational control sequences in expression vectors to be used in transforming vertebrate cells may be provided by viral sources. Exemplary vectors can be constructed as described in Okayama and Berg (1983) *Mol. Cell. Biol.* 3:280.

[0127] Selection markers that can be used in the system include those known in the art, such as positive and negative selection markers, such as but not limited to antibiotic resistance genes (*e.g.*, neomycin resistance gene, a hygromycin resistance gene, a kanamycin resistance gene, a tetracycline resistance gene, a penicillin resistance gene), HSV-TK, HSV-TK derivatives for ganciclovir selection, or bacterial purine nucleoside phosphorylase gene for 6-methylpurine selection (Gadi *et al.* (2000) *Gene Ther.* 7:1738-1743). [0034] A nucleic acid sequence encoding a selection marker or the cloning site therefor may be upstream or downstream of a nucleic acid sequence encoding a polypeptide of interest or cloning site therefor.

[0128] In some embodiments, the vector includes one or more promoters, such as but not limited to a constitutive, inducible, host-specific, and/or tissue-specific promoter. For example, commonly used promoters and enhancers are derived from human cytomegalovirus (CMV), Adenovirus 2, Simian Virus 40 (SV40), and Polyoma. Viral genomic promoters, control and/or signal sequences may be utilized to drive expression which are dependent upon compatible host cells. Promoters derived from house-keeping genes can also be used (*e.g.*, the β-globin, thymidine kinase, and the EF-1α promoters), depending on the identity of the cell type in which the vector is to be expressed. In some embodiments, a promoter is upstream of a nucleic acid sequence encoding one or more polypeptides of interest.

[0129] Vectors of the invention may contain one or more Internal Ribosome Entry Site(s) (IRES). Inclusion of an IRES sequence into fusion vectors may be beneficial for enhancing expression of some proteins.

[0130] In some embodiments the vector system will include one or more polyadenylation sites (*e.g.*, SV40), which may be upstream or downstream of any of the aforementioned nucleic acid sequences.

[0131] Vector components may be contiguously linked, or arranged in a manner that provides optimal spacing for expressing the gene products (*i.e.*, by the introduction of "spacer" nucleotides between the ORFs), or positioned in another way. Regulatory elements, such as the IRES motif, can also be arranged to provide optimal spacing for expression.

[0132] Cells transfected with expression vectors of the invention can be selected under positive selection conditions and/or screened for recombinant protein expression. Recombinant-positive cells are expanded and screened for subclones exhibiting a desired phenotype.

[0133] Cells, including eukaryotic and prokaryotic cells, can be transformed with the expression vectors of the invention. Accordingly, another embodiment of the invention provides a host cell transformed with an expression vector of the instant invention. Cells of the invention are preferably eukaryotic cells, more preferably cells of plant, rodent, or human origin, for example but not limited to NSO, CHO, perC.6, Tk-ts13, BHK, HEK293 cells, COS-7, T98G, CV-1/EBNA, L cells, C127, 3T3, HeLa, NS1, Sp2/0 myeloma cells, and BHK cell lines, among others.

[0134] In general, transfection will be carried out using a suspension of cells, or a single cell, although other methods can also be applied to the extent that sufficient fraction of the treated cells or tissue incorporates the polynucleotide, thereby allowing transfected cells to be grown and utilized. Techniques for transfection are well known. Several transformation protocols are known in the art. *See, e.g.,* Kaufman (1988) *Meth. Enzymology* 185:537. As is readily understood by those skilled in the art, the appropriate transformation protocol is determined by the host cell type and the nature of the gene of interest. The basic components of any such protocol include introducing nucleic acid sequence encoding the protein of interest into a suitable host cell, and then identifying and isolating host cells which have incorporated the vector DNA in a stable, expressible manner. Techniques for introducing polynucleotides include but are not limited to electroporation, transduction, cell fusion, the use of calcium chloride, and packaging of the polynucleotide together with lipid for fusion with the cells of interest. If the transfection is stable, such that the selectable marker gene is expressed at a consistent level for multiple cell generations, then a cell line results.

[0135] One common method for transfection into mammalian cells in particular is calcium phosphate precipitation. Another method is polyethylene glycol (PEG)-induced fusion of bacterial protoplasts with mammalian cells. Schaffner *et al.* (1980) *Proc. Natl. Acad. Sci. USA* 77:2163. Yet another method is electroporation, which can also be used to introduce DNA directly into the cytoplasm of a host cell, as described, for example, in Potter *et al.* (1988) *Proc. Natl. Acad. Sci. USA* 81:7161.

[0136] Transfection of DNA can also be carried out using polyliposome reagents such as Lipofectin and Lipofectamine (available from Gibco BRL, Gaithersburg, MD) which form lipid-nucleic acid complexes (or liposomes), which, when applied to cultured cells, facilitate uptake of the nucleic acid into the cells.

[0137] Once a cell expressing the desired protein is identified, it can be expanded and selected. Transfected cells may be selected in a number of ways. For example, cells may be selected for expression of the polypeptide of interest. For cells in which the vector also contains an antibiotic resistance gene, the cells may be selected for antibiotic resistance, which positively selects for cells containing the vector. In other embodiments, the cells may be allowed to grow under selective conditions.

[0138] Once a clone producing a protein is identified, the line can be further screened to identify subclones having one or more desired phenotypes, such as but not limited to cells that exhibit high-titer expression, enhanced growth properties, and/or the ability to yield proteins with desired biochemical characteristics, for example, due to protein modification and/or altered post-translational modifications. These phenotypes may be due to inherent properties of a given subclone or to mutagenesis. Mutagenesis can be effected through the use of chemicals, UV-wavelength light, radiation, viruses, insertional mutagens, defective DNA repair, or a combination of such methods.

[0139] Another aspect of the invention features pharmaceuticals composition of antibodies of the invention. The pharmaceutical compositions may be used to treat a disease, for example, cancer, an infectious disease, or an inflammatory disease in a patient.

[0140] The invention provides pharmaceutical compositions comprising one or more MAbs for the treatment of disease, such as but not limited to cancer, an infectious disease, or an inflammatory disease, formulated together with a pharmaceutically acceptable carrier.

[0141] In prophylactic applications, pharmaceutical compositions are administered to a patient susceptible to, or otherwise at risk of a disease or condition (*e.g.*, cancer, an infectious disease, or an inflammatory disease) in a prophylactically effective amount. At-risk individuals include, but are not limited to, individuals with a family history of cancer, an infectious disease, or an inflammatory disease, individuals who have previously been treated for cancer, an infectious disease, or an inflammatory disease, and individuals presenting any other clinical indicia suggesting that they have an increased likelihood of developing cancer, an infectious disease, or an inflammatory disease. Alternatively stated, an at-risk individual is any individual who is believed to be at a higher risk than the general population for developing cancer, an infectious disease, or an inflammatory disease. The term "prophylactically effective amount" is meant to refer to an amount of a formulation which produces an effect observed as the prevention of the onset or recurrence of cancer, an infectious disease, or an inflammatory disease. Prophylactically effective amounts of a formulation are typically determined by the

effect they have compared to the effect observed when a second formulation lacking the active agent is administered to a similarly situated individual.

[0142] In therapeutic applications, compositions are administered to a patient suspected of, or already suffering from such a disease in a therapeutically effective amount sufficient to cure, or at least partially arrest, the symptoms of the disease (biochemical and/or histological), including its complications and intermediate pathological phenotypes in development of the disease.

[0143] In both prophylactic and therapeutic regimes, agents are usually administered in several dosages until a sufficient response has been achieved. Typically, the response is monitored and repeated dosages are given if the response starts to wane.

[0144] Effective doses of a monoclonal antibody for the treatment of disease, *e.g.*, cancer, an infectious disease, or an inflammatory disease, as described herein, vary depending upon many different factors, including means of administration, target site, physiological state of the patient, whether the patient is human or an animal, other medications administered, and whether treatment is prophylactic or therapeutic. Usually, the patient is a human but nonhuman mammals can also be treated.

[0145] Dosing is dependent on severity and responsiveness of the disease state to be treated, with the course of treatment lasting from days to several days to several months, or until a cure is effected or a diminution of the disease state is achieved. Optimal dosing schedules can be calculated from measurements of drug accumulation in the body of a patient or subject. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and repetition rates. Optimum dosages can vary depending on the relative potency of individual antibodies and, in the case of concomitant administration, the relative potency of known drugs used in the treatment of disease. Optimum dosages can generally be estimated based on EC50s found to be effective in *in vitro* and *in vivo* animal models.

[0146] In general, dosage is from 0.01 μg to 100 g per kg of body weight and can be given once or more daily, weekly, monthly or yearly, or even once every 2 to 20 years. The dosage and frequency of administration can vary depending on whether the treatment is prophylactic or therapeutic. In prophylactic applications, a relatively low dosage is administered at relatively infrequent intervals over a long period of time. Some patients continue to receive treatment for the rest of their lives. In therapeutic applications, a relatively high dosage at relatively short intervals is sometimes required until progression of the disease is reduced or terminated, and preferably until the patient shows partial or complete amelioration of symptoms of disease. Thereafter, the patient can be administered a prophylactic regime.

[0147] Although individual needs can vary, determination of optimal ranges for effective amounts of formulations is within the skill of the art. Human doses can be extrapolated from animal studies (REMINGTON'S PHARMACEUTICAL SCIENCES, 20TH ED., Gennaro, ed., Mack Publishing Co., Easton, PA, 2000). Generally the dosage required to provide an effective amount of a formulation, which can be adjusted by one skilled in the art, will vary depending on the age, health, physical condition, weight, type and extent of the disease or disorder of the recipient, frequency of treatment, the nature of concurrent therapy (if any) and the nature and scope of the desired effect(s).

[0148] Pharmaceutical compositions of the invention may be formulated with a pharmaceutically acceptable carrier. Suitable pharmaceutically acceptable carriers include water, PBS, salt solution (such as Ringer's solution), alcohols, oils, gelatins, and carbohydrates, such as lactose, amylose, or starch, fatty acid esters, hydroxymethylcellulose, and polyvinyl pyrolidine. Such preparations can be sterilized, and if desired, mixed with auxiliary agents such as lubricants, preservatives, stabilizers, wetting agents, emulsifiers, salts for influencing osmotic pressure, buffers, and coloring. Pharmaceutical carriers suitable for use in the present invention are known in the art (REMINGTON'S PHARMACEUTICAL SCIENCES, 20TH ED., Gennaro, ed., Mack Publishing Co., Easton, PA, 2000).

[0149] The pharmaceutical formulations, which can conveniently be presented in unit dosage form, can be prepared according to conventional techniques well known in the pharmaceutical industry. Such techniques include the step of bringing into association the active ingredients with the pharmaceutical carrier(s). In general the formulations are prepared by uniformly and intimately bringing into association the active ingredients with liquid carriers or finely divided solid carriers or both. The formulations can be presented in unit-dose or multi-dose containers, for example sealed ampoules and vials, and can be stored in a frozen or freeze-dried (lyophilized) condition requiring only the addition of sterile liquid carrier immediately prior to use.

[0150] The pharmaceutical compositions are generally formulated as sterile, substantially isotonic and in full compliance with all Good Manufacturing Practice (GMP) regulations of the U.S. Food and Drug Administration.

[0151] Additional guidance regarding formulation, dose and administration regimen is available in the art (Berkow *et al.*, 1997, THE MERCK MANUAL OF MEDICAL INFORMATION, Home, ed., Merck Research Laboratories, Whitehouse Station, N.J.; Goodman *et al.*, 1996, GOODMAN & GILMAN'S THE PHARMACOLOGICAL BASIS OF THERAPEUTICS, 9th ed. McGraw-Hill Health Professions Division, New York; Ebadi, 1998, CRC DESK REFERENCE OF CLINICAL

PHARMACOLOGY, CRC Press, Boca Raton, Fla.; Katzung, 2001, BASIC & CLINICAL PHARMACOLOGY, 8TH ED. Lange Medical Books/McGraw-Hill Medical Pub. Division, New York; Speight *et al.*, 1997, AVERV'S DRUG TREATMENT: A GUIDE TO THE PROPERTIES, CHOICE, THERAPEUTIC USE AND ECONOMIC VALUE OF DRUGS IN DISEASE MANAGEMENT, 4TH ED. Adis International, Auckland/Philadelphia, PA).

[0152] When used as a pharmaceutical treatment, the compositions of the present invention can be administered either alone or co-administered with other compounds or compositions that are used in the treatment of disease, for cancer, an infectious disease, or an inflammatory disease. Examples of such compounds, referred to herein as "supplemental compounds," or "supplemental compositions," include, but are not limited to, antibiotics, anti-cytokines, anti-asthma drugs, antiphospholipases (*e.g.*, inhibitors of phospholipase), vasodilators (*e.g.*, adenosine, beta-adrenergic agonists or antagonists, β-adrenergic blockers, α-adrenergic blockers, diuretics, smooth muscle vasodilators, nitrates, and angiotensin-converting enzyme inhibitors), biomolecules, cytostatic agents, and chemotherapeutic agents. Pharmaceutical compositions of the invention may comprise, for example, one or more supplemental compounds. In some embodiments, the antibody is conjugated to the supplemental compound.

[0153] According to yet another aspect of the invention, kits are provided, for example, for the treatment of cancer, an infectious disease, or an inflammatory disease.

[0154] The kits of the invention comprise antibody or an antibody composition of the invention and instructions for using the kit in a method for treating cancer, an infectious disease, or an inflammatory disease in a patient or for inhibiting the biological activity of target antigen (*e.g.*, GM-CSF). The kit may comprise at least one supplemental compound. The kit may comprise instructions and/or means for administering the antibody or antibody composition, for example, by injection.

[0155] Antibodies of the invention may be used to detect antigen in a biological sample such as but not limited to blood serum. Any method known in the art may be used, such as but not limited to flow cytometry. For example, a biological sample may be incubated with antibody of the invention followed by washing and incubation with a labelled secondary antibody. For example, the secondary antibody may be directed to the light chain and conjugated to either FITC or phycoerythrin for purpose of detection.

[0156] Antigen neutralizing activity of antibodies of the invention may be tested in an antigen neutralization assay by any method known in the art. For example, neutralization activity of the antibodies may be assessed using antigen-dependent cell lines. Examples of GM-CSF-dependent cell lines include but are not limited to TF-1 and AML-193.

[0157] In a first antigen neutralization assay, antigen-dependent cells are suspended in assay medium, assay medium, antigen, or antigen pre-incubated for one hour with test or isotype control antibodies. Following the incubation period, growth inhibition is evaluated by any method known in the art. For example, Cell Titer reagent (Promega, WI) may be added followed by further incubation and measurement of optical density (O.D.) at 490 nm in a spectrophotometer and subtraction of medium background from samples. Percentage of antigen neutralization is calculated as follows: 100 – [O.D. with Ig / O.D. without Ig)x 100].

[0158] In another neutralization assay, antigen is mixed with anti-antigen antibodies of the invention. Antigen-dependent cells are added to the mixture, followed by incubation. After this incubation period, growth inhibition is measured. For example, the DNA proliferation marker MTS may be added followed by measurement of dye incorporation. Decreased dye incorporation in the presence of antibody relative to that in the absence of the anti-antigen antibody indicates neutralization of antigen.

[0159] Alternatively, antigen-dependent cells are grown in the presence of antigen followed by addition of increasing amounts of antibody to the culture media and assessment of neutralizing activity as described above.

[0160] Therapeutic methods of the invention include methods of inhibiting the biological activity of a target antigen, for example, GM-CSF and methods of treating a disease such as but not limited to cancer, an infectious disease, or an inflammatory disease by administering the pharmaceutical compositions of the antibodies of the invention to a patient or subject in need thereof. Biological activity of GM-CSF includes but is not limited to binding to the GM-CSF receptor. The methods may be employed, for example, to effect prophylactic or therapeutic treatment of a disease such as, but not limited to, cancer, an infectious disease, or an inflammatory disease.

[0161] The therapeutic methods of the invention are suitable for use in humans and non-human animals. Non-human animals which benefit from the invention include pets, exotic (*e.g.*, zoo animals) and domestic livestock. Preferably the non-human animals are mammals.

[0162] The antibodies for use in the invention may be administered orally in any acceptable dosage form such as capsules, tablets, aqueous suspensions, solutions or the like. The antibodies may also be administered parenterally. That is via the following routes of administration: subcutaneous, intravenous, intramuscular, intra-articular, intra-synovial, intrasternal, intranasal, topically, intrathecal, intrahepatic, intralesional, and intracranial injection or infusion techniques. Generally, the antibodies will be provided as an intramuscular or intravenous injection.

[0163] The antibodies of the invention may be administered alone or with a pharmaceutically acceptable carrier, including acceptable adjuvants, vehicles and excipients.

[0164] The antibodies of the invention may be administered before, after, or simultaneously with another therapeutic agent. For example, the antibodies of the invention may be administered alone or co-administered with a supplemental compound.

[0165] The antibodies of the invention may be administered as a homogenous mixture of unconjugated or conjugated antibody or as a heterogeneous mixture of unconjugated and conjugated antibody.

[0166] Effective treatment may be assessed in a variety of ways. In one embodiment, effective treatment of cancer, an infectious disease, or an inflammatory disease is determined by a slowed progression of the disease. In still other embodiments, effective therapy is measured by increased well-being of the patient including such signs as weight gain, regained strength, decreased pain, thriving, and subjective indications from the patient of better health.

[0167] The following examples are provided to describe the invention in greater detail. They are intended to illustrate, not to limit, the invention.

Example 1

Generation of Antigen-Specific Human MAbs to GM-CSF

Materials and Methods

[0168] **Human B-cells, *ex-vivo* immunization and cell culturing.** In all procedures followed, cells were grown in 5% CO_2 at 37°C. Leukopacks were obtained from tetanus toxoid (TT)-vaccinated healthy individuals. PBMCs were purified by Ficoll-Plaque (Amersham BioSciences) and CD19 positive B-cells and CD4 positive T-cells were isolated from PBMCs by EasySep® human CD4 and CD19 selection kit (StemCell Technologies), respectively, and mixed to make a B-cell/T-cell pool (BT4 cells). BT4 cells were cultured in complete RPMI1640 (Invitrogen, CA), which contained 10% heat-inactivated human serum AB (Nabi, FL), 2mM L-glutamine, 0.1 mM non-essential amino acids, 1 mM sodium pyruvate, 55 μM 2-mercaptoethanol (Invitrogen, CA).

[0169] For *ex-vivo* immunizations, BT4 cells were co-cultured in the presence of T- and B-cell epitopes. Briefly, BT4 cells were seeded at a density of 10^6/mL in complete RPMI containing 1 Lf/mL of tetanus toxoid (TT) (Cylex, MD) in the presence of irradiated autologous PBMCs at a 1:1 ratio to produce activated T cells (T-pool). To generate antigen-activated B-cells (B-pool), BT4 cells were seeded at a density of 3 x 10^6 cells/mL in complete RPMI containing 10% human serum AB, 5% condition medium from activated T-cells, 20 U/mL IL-2, 0.5 ng/mL

IL-6, 100 U/mL IL-10 (PrepoTech, NJ), and 250 ng/mL of a cocktail of peptides (bio-World, OH) representing various regions of the targeted antigen, synthesized to contain both T- and B-cell epitopes as previously described (Zafiropoulos *et al.* (1997) J. Immunol. Methods 200:181-90).

[0170] The selected B-cell epitopes for GM-CSF were: EHVNAIQEARRLLNL (SEQ ID NO:3), STQPWEHVNAIQEAR (SEQ ID NO:4), MASHYKQHCPPTPET (SEQ ID NO:5).

[0171] T- and B-pools were separately cultured for 7 days and then co-cultured (10^6 cell/mL) at a 1:10 ratio, respectively, on a monolayer of irradiated CHO feeder cells, in complete RPMI containing 10% heat-inactivated human AB serum and 400 U/ml IL-4 (PeproTech, NJ). After five days, co-cultured T- and B-pools were fused to generate hybridomas as described.

[0172] For the immortalization of pulmonary alveolar proteinosis (PAP) patients' B-cells, 100 mL of whole blood was processed to purify PBMCs. Lymphocytes were cultured for 7-10 days in complete RPMI containing 10% heat inactivated fetal bovine serum (FBS), (JRH Biosciences, KS), 2 ng/mL IL-4 (PeproTech, NJ), 2 mM L-glutamine, 0.1 mM non-essential amino acids, 1 mM sodium pyruvate, 55 μM 2-mercaptoethanol (Invitrogen, CA), 50 μg/mL transferrin, 5 ng/mL phorbol myristate acetate (PMA), and 0.5 μg/mL cyclosporine A (Sigma, MO), in the presence of irradiated CHO feeder cells. Lymphocytes were then electro-fused as described below.

[0173] **Cell fusion and Enzyme-Linked Immunosorbent Assay (ELISA) screening of antigen-reacting hybridomas.** Human B-cells used for the generation of MAbs designed for administration to humans may represent a potential vehicle of viral transmission. Fusion partner cells and PBMCs from healthy donors were pre-screened to confirm absence of viral DNA by PCR, including immunodeficiency-1 and 2, hepatitis B and C, cytomegalo-, herpes-6, and Epstein Barr viruses. Lymphocytes were fused with K6H6/B5 cells (ATCC, VA) using the CYTOPULSE CEEF-50 apparatus (Cyto Pulse Sciences, Inc., MD) at 1:1 lymphocytes to K6H6/B5 ratio.

[0174] After fusion, cells were seeded in flat-bottom 96-well microplates at ~5,000 cells/well in complete RPMI containing 10% heat inactivated FBS, 2mM L-glutamine, 0.1 mM non-essential amino acids, 1 mM sodium pyruvate, 55 μM 2-mercaptoethanol (Invitrogen, CA), 100 μM hypoxanthine, 0.4 μM aminopterin, and 16 μM thymidine (HAT, Sigma, MO). Medium was replaced weekly and HAT selection was maintained until completion of antigen reactivity screening (3-5 weeks).

[0175] For the identification of antigen-reacting MAbs, ELISA-based screenings were performed robotically using a BIOMEK FX liquid handling system integrated with plate washer

and spectrophotometer. Briefly, microtiter plates were coated at room temperature for 6 hours with 50 µL/well of in-house produced recombinant antigen (1 µg/mL GM-CSF) diluted in coating buffer (50 mM carbonate-bicarbonate, pH 9.4). Plates were then blocked with binding buffer (PBS containing 1% BSA (Sigma, MO) and 0.05% Tween 20 (BioRad, CA)) for 2 hours at room temperature. Plates were washed once with washing buffer (PBS containing 0.05% Tween 20) and 50 µL/well of hybridoma supernatant was transferred into the ELISA plates. Binding reaction was carried out at room temperature for 2 hours. Subsequently, plates were washed 4 times and 100 µL of horseradish peroxidase (HRP)-conjugated goat anti-human IgG+M (Jackson ImmunoResearch Laboratories, PA) diluted 1:10,000 in binding buffer was added and reactions carried out at room temperature for 1.5 hours. Finally, plates were washed 4 times and 100 µL/well of SureBlue substrate (KPL, MD) was added for 10 min. Reactions were stopped by adding 50 µL/well of 1 N sulfuric acid and the absorbance was determined at 450 nm.

[0176] Fluorescent-activated cell sorting (FACS) analyses. Ig binding and cell washing steps were conducted using ice-cold binding buffer (DPBS) without calcium or magnesium, 0.5% BSA), reactions were set up in V-bottom microplates, and samples were analyzed using a FACSAria apparatus (BD Biosciences, NJ). For the FACS experiment shown in Fig. 3A, 10^6 murine anti-GM-CSF hybridoma cells (Mul19/2) were loaded with 100 ng/reaction of GM-CSF and then incubated with anti-GM-CSF human MAb E5. The binding of GM-CSF specific MAbs were detected with 10 µg/mL FITC-labeled goat anti-human Ig (SouthernBiotech, AL). For the FACS experiment shown in Fig. 3B, the E10 hybridoma cells were washed and seeded at 500,000 cells/well in a volume of 90 µL. Ten µL of phycoerythrin (PE)-labeled GM-CSF (R&D System, MN) was then added in each well and cells were incubated on ice for one hour. For unlabeled GM-CSF competition, the hybridoma cells were pre-incubated with 5 µg/mL recombinant human GM-CSF (PeproTech, NJ) at room temperature for one hour, washed three times, and then incubated with PE-GM-CSF as above before analysis. For the FACS experiment shown in Fig. 4, A431 and A431-K5 cells (gift of Dr. Ira Pastan, National Cancer Institute) were stained with 10 µg/mL of C12 MAb or normal human IgM (Jackson ImmunoResearch Laboratories, PA) diluted in binding buffer and reactions were carried out as above.

[0177] GM-CSF neutralization bioassay. The GM-CSF-dependent human erythroleukemia cell line TF-1 (ATCC, VA) was grown in complete RPMI 1640 (see above) containing 10 ng/mL recombinant human GM-CSF (PeproTech, NJ). On the day preceding the experiment, TF-1 cells were grown in 0.1% FBS in the absence of GM-CSF. Starved cells were washed twice, resuspended in assay medium, and seeded in 96-well microplates at a concentration of 10,000 cell/well. Wells contained either assay medium, 100 pg/mL GM-CSF, or

GM-CSF pre-incubated for one hour with test or isotype control Ig at concentrations indicated in the figure legends. After 3 days, 40 µL of Cell Titer reagent (Promega, WI) was added to each well, and plates were further incubated at 37°C for 1 hour. Optical density (O.D.) was measured at 490 nm in spectrophotometer and medium background was subtracted to all samples. Percentage of GM-CSF neutralization was calculated as follows: 100 – (O.D. with Ig / O.D. without Ig x 100).

[0178] Antibody class-switch. Hybridoma cells were washed once with 10 mL PBS, resuspended in complete RPMI, seeded into flat bottom 96-well microplates and incubated at 37°C in 5% CO_2. After four days, cells were resuspended by pipetting and 100 µL transferred to 20 ELISPOT plates (Millipore, MA) coated with 2.3 µg/mL goat anti-human IgG (H+L) (Jackson Immunoresearch, PA). The remaining cells in the tissue plates were fed with an additional 100 µL complete RPMI. After overnight incubation, ELISPOT plates were washed three times with PBS containing 0.05% Tween (PBST), then 100 µL of 2 µg/mL goat anti-human IgG (H+L)-HRP was added and the plates incubated one hour at room temperature with shaking. Plates were washed three times with PBST then 100 µL of AEC substrate solution (Sigma, St. Louis, MO) was added to wells and incubated 90 minutes at room temperature with shaking. Substrate was aspirated and plates were washed with dH_20 and allowed to air dry. Clones from wells exhibiting positive spots (indicating IgG production) were expanded. The above step was sequentially repeated by reseeding positive clones at 1000, 100, 10, and 0.25 cells/well while tracking positive wells until a single-cell colony was identified that secreted IgG.

[0179] Fermentation using hollow fibers and stirred bioreactor. Cells were seeded at 2.5 x 10^5/mL in a 2 L bioreactor (B Braun Stat B-DU) containing 1 L HyQCDM4NS0 serum free medium (HyClone, UT) maintaining glucose and glutamine at 6 g/L and 4 mM respectively. Controlled set points were: pH 7.1, dO_2 40% saturation with air, temperature 37°C, and agitation rates at 80 rpm. Two mLs of sample was harvested daily, 1 mL for cell counting using a Cedex apparatus, and 1 mL used to measure Ig concentrations by ELISA. For the hollow fiber run, 10^8 viable cells were seeded in a FiberCell system (Bellco, NJ) containing 15 mL of complete RPMI and re-fed using an inline reservoir containing one liter of fresh medium when 50% of the glucose was consumed.

[0180] Mismatch repair inhibition to increase genetic diversity of hybridoma lines. Hybridoma cells were grown in complete RPMI (negative control) or complete RPMI containing 250 µM or 500 µM of MMR-inhibiting anthracene compound. Cells were passed at a 1:5 dilution every three to four days in fresh media with or without morphocene and after three weeks cells were harvested and resuspended at 2 x 10^6 cells/mL in FACS buffer (PBS with 1%

BSA). Cells were stained with 10 µg/mL FITC-conjugated goat anti-human Ig (Jackson Immunoresearch) for 30 minutes on ice. Cells were washed with 10 mL ice cold FACS buffer and resuspended in 3 mL FACS buffer. 10 µL Viaprobe (Becton Dickinson, Franklin Lakes, NJ) was added for 5 minutes on ice and viable cells were sorted for high Ig surface staining on a FACSAria cell sorter (Becton Dickinson). The gate was set to sort cells representing the 5% subpopulation with the highest Ig surface staining. For selection of clones with enhanced titers, FACS sorted cells were seeded in U-bottom 96 well plates and incubated for one week at 37°C in 5% CO_2. Fifty µL of supernatants were harvested from wells and analyzed for IgM production via ELISA using goat anti-human IgM+G coated plates. As an internal control, 3 wells of each ELISA plate were seeded with 50 µL of 10 ng/mL human IgM (Jackson Immunoresearch). O.D. values obtained at 450 nm were normalized to the mean values of internal control wells. Wells exhibiting high IgM signals were expanded for further analysis. For microsatellite instability (MSI) analysis, DNA was extracted from parental or morphocene-treated cells using the Qiagen DNeasy Tissue kit (Qiagen). The BAT poly A repeat marker (7) was amplified using the D4 fluorescent-labeled BAT-26-F (5'-tcaccatccattgcacagtt-3') (SEQ ID NO:20) and BAT-26-R (5'-ctgcgagaaggtactcaccc-3') (SEQ ID NO:21) primers, pfuUltra™ high-fidelity polymerase (Stratagene, CA), and reactions incubated as follows: 5 min. at 95°C; 9 cycles of 1 min. at 94°C, 1 min. at 60°C and 2 min. at 72°C, with the annealing temperature decreasing by 1°C each cycle; 30 cycles of 1 min. at 94°C, 1 min. at 52°C, and 2 min. at 72°C; final extension of 10 min. at 72°C. Single-copies of the marker allele were obtained by using a dilution of DNA that yielded an amplicon in only 50% of the PCR reactions. PCR products were diluted 1:10 with CEQ sample load solution and then loaded into the Beckman CEQ 8000 Genetic Analysis System for fragment analysis.

[0181] Generation of antigen-specific human MAbs. *Ex-vivo* immunizations were carried out using cryo-preserved B-cells obtained from volunteer subjects (healthy donors) as described above. Alternatively, B-cells were obtained from human subjects whose sera contained high titers of MAbs specific to an antigen of interest. The rationale of the latter approach stems from the possibility that some antigen-specific MAbs could result from an abnormal immune response (as in the case of autoimmune patients), or derive from an *in vivo* immune response to tumor, microbial, or vaccine antigens.

[0182] Several antigen-reacting human MAbs were identified after fusion of *ex-vivo* immunized cells and from hybridoma libraries generated from PAP patients B-cells. Four hybridoma lines, E5 (IgM), G7 (IgM), E10 (IgG), and G9 (IgG) were selected for further studies and the human MAbs they produce were tested for specificity by ELISA. **Fig. 1** shows that E5,

G7, and E10 human MAbs only reacted with human GM-CSF and none of the other ten unrelated antigens tested, including murine GM-CSF, which shares a 53% identity with the human homolog. Similar results were obtained for the G9 hybridoma. FACS analyses were carried out to confirm specificity of these human MAbs. Human GM-CSF was allowed to bind to the surface of mouse hybridoma cells, which express membrane bound-MAbs specific to human GM-CSF at a different epitope. E5 MAb bound the surface of these cells under these conditions, as indicated by the fluorescence intensity shift (**Fig. 2A**, bottom panel). This result demonstrates the ability of E5 MAb to bind native human GM-CSF. In absence of cell-bound GM-CSF, E5 MAb did not cross-react with any of the membrane bound proteins expressed by these hybridoma cells (**Fig. 2A**, middle panel). Similarly, E10 MAb showed high specificity via FACS analysis. In addition, since E10 MAb was found associated to the hybridoma cell membrane, its ability to bind soluble, phycoerythrin (PE)-labeled GM-CSF was shown by FACS (**Fig. 2B**, middle panel). Binding specificity was demonstrated by pre-incubation of the E10 hybridoma cells with an excess of unlabeled GM-CSF (**Fig. 2B**, lower panel).

[0183] ***De novo*** **class-switch of human MAbs.** Using the two strategies described above, IgG and IgM human MAbs to a variety of human and nonhuman antigens have been generated. Although most therapeutic antibodies in the market are of the IgG isotype, cancer trials testing potentially therapeutic IgM MAbs have shown regression of tumors *in vivo* (16, 17). These clinical responses can be attributable to the ability of IgM to strongly fix and activate the complement pathway and effectively kill tumor cells. IgG binds to the Fc receptors on macrophages and NK cells and thus can mediate ADCC activity against tumor cells. Both IgG and IgM with identical specificity (same antigen and epitope) can be tested for best pharmacological activity *in vivo*. In the case where an IgG isotype is preferred, a quick robust procedure (see Materials and Methods) for *de novo* class-switching of IgM has been followed. Using the E5 line as an example, a subset of cells that had class-switched to an IgG isotype under the growth conditions used was identified. The E5 IgG showed identical nucleotide sequence in its variable region and similar reactivity to GM-CSF (**Fig. 3**) as the parental E5 IgM.

[0184] **Biological activities of human MAbs.** Pharmacological properties sought for therapeutic MAbs that target soluble mediators of disease include the ability to neutralize growth factors. As mentioned above, one such example is GM-CSF as a mediator of RA (9-11). The ability of the human MAbs to block GM-CSF function using a cell-based assay whereby the growth of human erythroblastoid cells (TF1) is dependent on the presence of this cytokine in their culture medium was assessed. As shown in **Fig. 4**, both E10 and G9 significantly inhibited GM-CSF-dependent cell growth, whereas the human IgG isotype control showed no effect. The

difference in potency seen between E10 and G9 correlates well with their apparent affinities of 870 and 14 picomolar, respectively. The E5 MAb only showed minimal neutralizing activity consistent with its lower affinity (5 nM).

[0185] Assessment of titers and stability of hybridomas secreting human MAbs. An important property of a MAb manufacturing line is stability of Ig secretion during the entire batch manufacturing cycle. In one scenario where the cycle duration is about two months, a line doubling every 24 hours would go through about 60 generations from thawing to harvest. An E5 line was used as a model for testing MAb titers and production stability of hybridoma generated using our method. A clone derived from this line, 3D2, showed a doubling time of 24 hours and was re-cloned by limiting dilutions after more than two months of continuous culturing. The frequency of producing clones was determined via ELISA, measuring Ig concentrations in their conditioned media normalized for cell densities. **Fig. 5A** shows that all E5-3D2 subclones tested secrete high levels of Ig, demonstrating homogeneous retention of Ig production in this cell population after 60 generations. Ig production was then assessed using a small scale (15 mL) hollow fiber system. Cells were inoculated in a hollow fiber cartridge and continuously fed using an inline reservoir containing one liter of fresh medium. Starting on day 5, all conditioned medium from the cartridge (15 mL) was harvested daily and replaced with fresh medium. Fermentation was carried out for additional 4 days, while daily Ig titers were determined by ELISA using an Ig standard of known concentration. A cumulative titer of 1.2 g/L during the 4-day run was recorded. Between day 8 and 9, glucose consumption was at its peak (2 gram/L a day), indicating that cells tolerated well the extremely high cell densities. Production performance was also evaluated in a 1-liter scale fed-batch run using a stirred bioreactor system. Cells from a frozen ampule were first thawed and inoculated in a shake flask and later seeded in stirred bioreactor (Bauer) containing 1 liter of serum-free medium. Fermentation was carried out until cell viability dropped below 60% (day 6). Ig production and cell densities were recorded between day 1 and 5 and are shown in **Fig. 5B**. During the log phase (day 1-4), a specific productivity of 24 pg/cell/day with a doubling time averaging 23.4 hours was measured, suggesting good scalability of these cells from flask to bioreactor while maintaining higher titers.

[0186] Genetic optimization of hybridoma secreting human MAbs via mismatch repair regulation. The usefulness of improving the quality of MAb-producing cell lines using a process, termed morphogenics, which entails the transient regulation of MMR has been previously demonstrated (Nicolaides *et al.* (1995) Genomics 30:195-206; and, Nicolaides *et al.* (1998) Mol. Cell. Biol. 18:1635-41.). After increasing the genetic diversity of the cell pool using this method, high throughput screenings were carried out to identify subclones exhibiting higher

titer, affinity (Grasso *et al.* (2004) Bioprocess Int. 2:58-64; and, Nicolaides *et al.* (2005) Ann. N.Y. Acad. Sci. 1059:1-11), or enhanced growth rates (Grasso, L. personal observation). E5 cells were subjected to morphogenics to demonstrate the ability to increase phenotypic diversity in the MAb-secreting lines generated using our hybridoma strategy. MMR inhibition was monitored by detecting microsatellite instability (MSI) in the BAT poly-A repeat marker. Of the 24 BAT alleles analyzed in cells exposed to the morphogenics process, 3 alleles showed alterations that included single nucleotide deletions, shown in **Fig. 6A**, and insertions. No MSI was detected in any of the 24 BAT alleles in parental cells. Subsequently, parental or morphogenics-treated cells were seeded by limiting dilutions in microplates. Cell clones were allowed to secret MAbs for one week and their conditioned medium analyzed for Ig concentrations by ELISA. The frequency of clones with O.D. greater than 1 (high Ig secretion) was determined from the total number of clones screened (3,763 for parental and 2,437 for morphocene pool) and found to have increased by 260% ($p = 0.0014$) in the morphogenics-treated population (**Fig. 6B**).

Summary

[0187] This study represents a viable strategy for developing human MAbs for immunotherapies using an optimized *ex-vivo* immunization and human B-cell immortalization process combined with inhibition of mismatch repair. With this approach, highly specific and biologically active MAbs secreted by stable hybridoma lines can be generated.

[0188] According to the methods of the invention, stable MAb production for over 60 doublings and production of over 1 gram of MAb per liter during a 4-day hollow fiber fermentation run has been achieved, suggesting that hybridoma cells generated by the present methods are suited for perfusion systems and potentially large scale manufacturing. Moreover, hybridomas generated by this process have performed well in fed-batch bioreactor runs, suggesting a potential use of these lines for commercial applications. In summary, the platform process presented here offers an alternative approach for a rapid and cost-effective development of good quality, fully human antibodies for immunotherapeutic use.

Example 2

Generation of Fully Human Anti-GM-CSF Antibody; Isolation of PAP Cells

[0189] Patients with adult human pulmonary alveolar proteinosis (PAP) accumulate phospholipids and surfactant proteins in the alveoli. It has been hypothesized that PAP is due to the inability of the alveolar macrophages and type II epithelial cells to clear excess surfactant. As described above, the role for GM-CSF in the control of lung surfactant homeostasis has been established in the murine model, and by extension is causative of the human pathology.

Furthermore, patients with PAP have been shown to have circulating, neutralizing antibodies to GM-CSF, thereby implicating this cytokine as causative of the disease. Whether this autoimmune response is specific for GM-CSF is unclear. However, it has been shown that a subset of PAP patients improve with GM-CSF therapy, supporting the hypothesis that the absence of GM-CSF either by gene disruption or antibody-mediated neutralization results in the development of PAP.

[0190] Isolation of GM-CSF-specific antibodies. Peripheral blood mononuclear cells (PBMCs) were isolated from PAP patients. Briefly, the PAP patient's B cells were recovered from the whole blood. The whole blood was diluted with equal volume PBS-/- and the contents was mixed gently by inverting the container. 25 ml diluted blood was overlayed onto a 50 ml tube that contained 25 ml Ficoll-Paque (Amersham Biosciences AB, Uppsala Sweden). The tubes were centrifuged at 2,000 rpm for 30 mins at room temperature. PBMCs were collected from the interface layer using a 10-ml pipette, transferred to new 50-ml tubes, and washed twice with PBS-/- . The PBMC pellet was re-suspended in 10 ml ACK Lysing Buffer (150 mM NH_4Cl, 10 mM $KHCO_3$, 0.1 mM Na_2EDTA, pH 7.2), incubated for 5 min. at room temperature to lyse the red cells, and washed twice with PBS-/-.

[0191] Fusion of PAP B-Cells with Myeloma Cell Line to Generate Hybridoma. Enriched B-cells from PAP patients were fused with a variety of myeloma cells (human –mouse heterohybridoma, ATCC, VA, USA); CBF-7 cells (human –mouse heterohybridoma); HEK293; human myeloma cells by the following method. The B cells and fusion partner cells should have good viability (≥90% viable and in log phase). Both cell types in their original medium were counted and mixed in 15 ml tubes at 1:1 ratio, followed by centrifugation at 1,000 RPM for 6 min at 4°C. Cells were washed 3 times using 10-15 ml cold CPFM (CYTOPULSE fusion medium, Cyto Pulse Sciences, MD USA). The final pellet was resuspended in $10x10^6$ cells/ml CPFM. Electro-fusion was performed using CYTOPULSE CEEF-50 (Cyto Pulse Sciences, MD USA). Fusion parameters were optimized following manufacturer and empirical guidelines, and fusion efficiency averaged one hybrid in 5,000 cells pulsed. After fusion, cells were seeded in flat-bottom 96-well microplates at ~5,000 cell/well in complete RPMI containing 10% heat inactivated FBS, 100 μM hypoxanthine, 0.4 μM aminopterin, and 16 μM thymidine (HAT, Sigma, MO USA). Medium was replaced weekly and HAT selection was maintained until completion of antigen reactivity.

[0192] ELISA Screening Assay. For the identification of antigen-reacting MAbs, ELISA-based screenings were performed robotically using a BIOMEK FX liquid handling system integrated with plate washer and spectrophotometer. Briefly, microtiter plates were

coated at room temperature for 6 hours with 50 µL/well of in-house produced recombinant antigens (1 µg/mL GM-CSF) diluted in coating buffer (50 mM carbonate-bicarbonate, pH 9.4). Plates were then blocked with binding buffer (PBS containing 3% BSA (Sigma, MO) and 0.05% Tween 20 (BioRad, CA)) for 2 hours at room temperature. Plates were washed once with washing buffer (PBS containing 0.05% Tween 20) and 50 µL/well of hybridoma supernatant was transferred into the ELISA plates. Binding reaction was carried out at room temperature for 2 hours. Subsequently, plates were washed 4 times and 100 µL of HRP-conjugated goat anti-human IgG+M (Jackson ImmunoResearch Laboratories, PA) diluted 1:10,000 in binding buffer was added and reactions carried out at room temperature for 1.5 hours. Finally, plates were washed 4 times and 100 µL/well of SUREBLUE substrate (KPL, MD) was added for 10 min. Reactions were stopped by adding 50 µL/well of 1 N sulfuric acid and the absorbance was determined at 450 nm.

[0193] FACS Analysis and Sorting. In every study, Ig binding and cell washing steps were conducted using ice-cold binding buffer (DPBS without calcium or magnesium, 0.5% BSA).The PBMC or hybridoma cells were washed and seeded at 500,000 cell/well. The FITC and phycoerythrin(PE)-labeled anti-human CD3, CD19, CD20(SouthernBiotech, AL), and PE-labeled GM-CSF (R&D System, MN) were added (10 – 100 diluted), and incubated on ice for one hour. The cells were then washed three times with binding buffer, and analyzed or sorted using a FACSARIA apparatus (BD Biosciences, NJ). Results of isotype analysis of Mab E10 are shown in Figure 9. To determine the isotype of E10, a standard analysis was performed using anti-human IgG, IgG1, IgG2, IgG3, IgM, Lκ, and Lλ Fc specific antibodies to derive the isotype.

[0194] GM-CSF Neutralization Bioassay. The human GM-CSF-dependent human erythroleukemia cell line TF-1 (ATCC, VA) was grown in complete RPMI 1640 (see above) containing 10 ng/mL recombinant human GM-CSF (PeproTech, NJ). On the day preceding the experiment, TF-1 cells were grown in 0.5% FBS in the absence of GM-CSF. The starved TF-1 cells were harvested and washed twice with assay medium (plain RPMI with 0.5% BSA). Cells were resuspended in assay medium and seeded in 96-well microplates at a concentration of 10,000 cells/well. Wells contained either assay medium, 100 pg/mL GM-CSF, or GM-CSF pre-incubated for one hour with test or isotype control Igs at concentrations indicated in the figure. After 3 days, 40 µL of Cell Titer reagent (Promega, WI) was added to each well, and plates were further incubated at 37°C for 1 hour. Optical density (O.D.) was measured at 490 nm in a spectrophotometer and medium background was subtracted from all samples. Percentage of GM-CSF neutralization was calculated as follows: 100 – [(O.D. with Ig / O.D. without Ig) x 100)].

Figure 4 demonstrates GM-CSF-dependent growth inhibition of TF-1 cell lines with fully human MAbs.

[0195] Inhibition of Mismatch Repair to Increase Genetic Diversity of Hybridoma Cell Lines. Inhibition of mismatch repair can lead to genetically diverse sibling cells with enhanced production, cell growth, or antibody activity. To improve MAb activity and cell growth, hybridoma cells were grown in complete RPMI (negative control) or complete RPMI containing 250 μM or 500 uM of the mismatch repair inhibitor morphocene (9,10-dimethyl anthracene, MP Biomedicals, CA). Cells were passed at a 1:5 dilution every three to four days in fresh media with or without morphocene and after three weeks cells were harvested and resuspended at 2 x 10^6 cells/mL in FACS buffer (PBS with 1% BSA). Cells were stained with 10 μg/mL FITC-conjugated goat anti-human Ig (Jackson Immunoresearch) for 30 minutes on ice. Cells were washed with 10 mL ice cold FACS buffer and resuspended in 3 mL FACS buffer. 10 μL VIAPROBE (Becton Dickinson, Franklin Lakes, NJ) was added for 5 minutes on ice and viable cells were sorted for high Ig surface staining on a FACSARIA cell sorter (Becton Dickinson). The gate was set to sort cells representing the 5% sub-population with the highest Ig surface staining. This population was expanded for one week in the presence or absence of chemical inhibitor of mismatch repair (MMR) and the procedure repeated two additional times. For selection of clones with enhanced titers, FACS sorted cells were seeded in U-bottom 96 well plates at 0.8 cells/well in 200 μL complete RPMI. Plates were incubated for one week at 37°C in 5% CO_2. 50 μL of supernatants were harvested from wells and analyzed for IgM production via ELISA using goat anti-human IgM+G coated plates. As an internal control, 3 wells of each ELISA plate were seeded with 50 μL of 10 ng/mL human IgM (Jackson Immunoresearch). O.D. values obtained at 450 nm were normalized to the mean values of internal control wells. Wells exhibiting high IgM signals were expanded for further analysis. For MSI analysis, DNA was extracted from parental or MMR inhibitor-treated cells using the Qiagen DNeasy Tissue kit (Qiagen). The BAT poly A repeat marker was amplified using the D4 fluorescent-labeled mBAT-26-F (5'-tcaccatccattgcacagtt-3') (SEQ ID NO:20) and mBAT-26-R (5'-ctgcgagaaggtactcaccc-3') (SEQ ID NO:21) primers, pfuUltra™ high-fidelity polymerase (Stratagene, CA), and reactions incubated as follows: 5 min. at 95°C; 9 cycles of 1 min. at 94°C, 1 min. at 60°C and 2 min. at 72°C, with the annealing temperature decreasing by 1°C each cycle; 30 cycles of 1 min. at 94°C, 1 min. at 52°C, and 2 min. at 72°C; final extension of 10 min. at 72°C. Single-copy of the marker's alleles were obtained by using a dilution of DNA that yielded an amplicon in only 50% of the PCR reactions. PCR products were diluted 1:10 with CEQ sample load solution and then loaded into the Beckman CEQ 8000 Genetic Analysis System for

fragment analysis. (Blake *et al.* Stepwise deletions of polyA sequences in mismatch repair-deficient colorectal cancers. (2001) *Am. J. Pathol.* 158:1867-70.)

Example 3

Generation of Monoclonal Antibody E10 with High Specificity to GM-CSF

[0196] Several antibodies were derived from B-cells of patients with PAP. These antibodies were of the IgM, IgG isotype. Each of these antibodies were found to specifically bind to GM-CSF using the assays for specificity described herein. One anti-GM-CSF human IgG1 monoclonal antibody E10 was generated from Pulmonary alveolar proteinosis (PAP) patient's B cells fused with either myeloma cells then subsequently screened for anti-human GM-CSF monoclonal antibodies by ELISA as described above.

[0197] Blood from a PAP patient (91 ml whole blood) was used to isolate a total of 49.5 million PBMCs. The viability of these cells was 99.0%. The results from a FACS analysis are shown in Table 2. The B cells were expanded by culturing approximately 25 million PBMCs in cRPMI1640 (10 ml) with IL-4 2 ng/ml (PeproTech), transferrin 50 ug/ml (Sigma), PMA 5 ng/ml(Sigma), and cyclosporine A 0.5 ug/ml (Sigma) with feeder cells. After 11 days of culture, 12 million cells remained and were subsequently fused with a myeloma cell by electro-fusion (CytoPulse CEEF-50). FACS analysis results are set forth in Table 2.

Table 2. Generation of E10 monoclonal antibody and analysis by FACS

	FITC-CD3(%)	FITC-CD20(%)	PE-GMCSF(%)	CD20/GMCSF
PBMC	62.6	14.4	5.9	6.3
11 day culture	77.2	17.0	0.7	0.1

[0198] The fused cells were cultured in RPMI 1640 (Invitrogen, CA, USA) with 10% FBS, heat inactivated (JRH Biosciences, KS USA); L-glutamine, 200 mM (Invitrogen, CA, USA); non-essential amino acids, 10 mM (Invitrogen, CA, USA); sodium pyruvate solution, 100 mM (Invitrogen, CA, USA); Pen-Strep (Invitrogen, CA, USA); 2-Mercaptoethanol, 55 mM (Invitrogen, CA, USA); and 1x HAT (Sigma, MO USA).

[0199] After 12 days culture, about 48% of the hybridoma culture showed growth. Next, the hybridomas were screened using a GM-CSF specific ELISA with recombinant GM-

CSF (PeproTech, NJ, USA). Several clones were isolated, including those that were positive for GM-CSF. These clones were tested again by ELISA to confirm that they were specific for the recombinant GM-CSF and not for tetanus toxin (TT). Clone 4E10 showed specifically reaction with GM-CSF, but not TT. Clone 4E10 was subsequently subcloned. After 3 weeks the cultured subclones were screened by ELISA to confirm specificity to GM-CSF was maintained and then further characterized as described below.

[0200] Characterization of E10. To determine the specificity of the anti-GM-CSF antibodies E10, an antigen-specific ELISA was performed with a range of antigens (**Figure 8**). Figure 8 compares binding to the following antigens: hIL-1a, h IL-2, h IL-3, h IL-4, h IL-5, IL-6, hIL-13, hGM-CSF, mGM-CSF, BSA, and TT. In subsequent studies, the binding of anti-GM-CSF antibodies was compared to human GM-CSF, human Mesothilin, SEB, BGG, CAB, HEL, TT, BSA, Goat IgG, human mucin, and Mouse IgG (data not shown). In both studies 4E10 only reacted with human GM-CSF.

[0201] To determine the isotype of E10, a standard analysis was performed using anti-human IgG, IgG1, IgG2, IgG3, IgM, Lκ, and Lλ to derive the isotype. This analysis demonstrated that 4E10 is an IgG1 and Kappa antibody (see **Figure 9**).

[0202] The ability of E10 to neutralize the biological activity of GM-CSF *in vitro* was tested by using a cell line, TF-1, that is dependent upon this cytokine for survival and growth (see **Figure 8**). The human GM-CSF-dependent human erythroleukemia cell line TF-1 (ATCC, VA) was grown in complete RPMI 1640 containing 10 ng/mL recombinant human GM-CSF (PeproTech, NJ). On the day preceding the experiment, TF-1 cells were grown in 0.1% FBS in the absence of GM-CSF. The starved TF-1 cells were harvested and washed twice with assay medium (plain RPMI with 0.5% BSA). Cells were suspended in assay medium and seeded in 96-well microplates at a concentration of 10,000 cell/well. Wells contained either assay medium, 100 pg/mL GM-CSF, or GM-CSF pre-incubated for one hour with test or isotype control Igs at concentrations ranging from 20 μg/mL to 0.315 μg/mL. After 3 days, 40 uL of CELL TITER reagent (Promega, WI) was added to each well, and plates were further incubated at 37°C for 1 hour. Optical density (O.D.) was measured at 490 nm in spectrophotometer and medium background was subtracted from all samples. Percentage of GM-CSF neutralization was calculated as follows: 100 – [(O.D. with Ig / O.D. without Ig) x 100]. The antibody 4E10 was capable of neutralizing the activity of GM-CSF *in vitro* at a concentration of 100pg/ml.

[0203] A Western blot analysis was performed with E10 to determine if the antibody would cross-react with human recombinant GM-CSF. As shown in **Figure 10**, E10 cross-reacts with human GM-CSF under reducing conditions.

[0204] To determine the binding affinity of E10, a BIACORE analysis was performed as follows. The binding constant for E10 is about 870 pM (**Figure 11**).

Example 4

Generation of Monoclonal Antibody G9 with High Specificity to GM-CSF

[0205] The anti-GM-CSF human IgG1 monoclonal antibody G9 was generated from Pulmonary alveolar proteinosis (PAP) patient's B cells fused with either K6 or CBF-7 then subsequently screened for anti-human GM-CSF monoclonal antibodies by ELISA as described above.

[0206] Blood from a PAP patient (91 ml whole blood) was used to isolate a total of 49.5 million PBMCs. The viability of these cells was 99.0% (data not shown). The B cells were expanded by culturing approximately 25 million PBMCs in cRPMI1640 (10 ml) with IL-4 2 ng/ml (PeproTech); transferrin 50 ug/ml (Sigma); PMA 5 ng/ml(Sigma); and cyclosporine A 0.5 ug/ml (Sigma) with feeder cells. After 11 days of culture, 12 million cells remained and were subsequently fused to myeloma cells by electro-fusion (CytoPulse CEEF-50).

[0207] The fused cells were cultured in RPMI 1640 (Invitrogen, CA, USA) with 10% FBS, heat inactivated (JRH Biosciences, KS USA); L-glutamine, 200 mM (Invitrogen, CA, USA); non-essential amino acids, 10 mM (Invitrogen, CA, USA); sodium pyruvate solution, 100 mM (Invitrogen, CA, USA); Pen-Strep (Invitrogen, CA, USA); 2-Mercaptoethanol, 55 mM (Invitrogen, CA, USA); and 1x HAT (Sigma, MO USA).

[0208] After 12 days culture, about 48% of the hybridoma culture showed growth. Next, the hybridomas were screened using a GM-CSF-specific ELISA with recombinant GM-CSF (PeproTech, NJ, USA). Several clones were isolated, including those that were positive for GM-CSF. These clones were tested again by ELISA to confirm that they were specific for the recombinant GM-CSF and not for tetanus toxin (TT). The G9 population showed highly specific reactivity with GM-CSF, but not TT. Next, the G9 population was subcloned to obtain a pure culture. After 3 weeks the cultured subclones were screened by ELISA to confirm specificity to GM-CSF was maintained and then further characterized as described below.

[0209] **Characterization of G9.** To determine the specificity of the anti-GM-CSF antibodies G9, an antigen specific ELISA was performed with a range of antigens (**Figure 8**). Figure 8 compares binding to the following antigens: hIL-1a, h IL-2, h IL-3, h IL-4, h IL-5, IL-6, hIL-13, hGM-CSF, mGM-CSF, BSA, and TT. In subsequent studies the binding of anti-GM-CSF antibodies was compared to human GM-CSF, human mesothelin, SEB, BGG, CAB, HEL,

TT, BSA, Goat IgG, human mucin, and Mouse IgG (data not shown). In both studies G9 only reacted with human GM-CSF.

[0210] To determine the isotype of G9, a standard analysis was performed using anti-human IgG, IgG1, IgG2, IgG3, IgM, Lκ, and Lλ to derive the isotype. This analysis demonstrated that G9 is an IgG1 and Kappa antibody (**Figure 12**).

[0211] **G9 Neutralization Bioassay.** The ability of G9 to neutralize the biological activity of GM-CSF *in vitro* was tested by using a cell line, TF-1, that is dependent upon this cytokine for survival and growth (**Figure 4**). The human GM-CSF-dependent human erythroleukemia cell line TF-1 (ATCC, VA) was grown in complete RPMI 1640 containing 10 ng/mL recombinant human GM-CSF (PeproTech, NJ). On the day preceding the experiment, TF-1 cells were grown in 0.1% FBS in the absence of GM-CSF. The starved TF-1 cells were harvested and washed twice with assay medium (plain RPMI with 0.5% BSA). Cells were suspended in assay medium and seeded in 96-well microplates at a concentration of 10,000 cell/well. Wells contained either assay medium, 100 pg/mL GM-CSF, or GM-CSF pre-incubated for one hour with test or isotype control Igs at concentrations ranging from 20 µg/mL to 0.315 µg/mL. After 3 days, 40 uL of CELL TITER reagent (Promega, WI) was added to each well, and plates were further incubated at 37°C for 1 hour. Optical density (O.D.) was measured at 490 nm in spectrophotometer and medium background was subtracted from all samples. Percentage of GM-CSF neutralization was calculated as follows: 100 – [O.D. with Ig / O.D. without Ig) x 100]. The antibody G9 was capable of neutralizing the activity of GM-CSF *in vitro* at a concentration of 100pg/ml.

[0212] A Western blot analysis was performed with G9 to determine if the antibody would cross-react with human recombinant GM-CSF. As shown in **Figure 10**, G9 cross-reacts with human GM-CSF under reducing conditions.

[0213] To determine the binding affinity of G9, BIACORE analysis was performed as described above. The binding constant for G9 is about 11 – 17 pM (**Figure 13**).

Example 5

Nucleotide Sequences Encoding Fully Human Anti-GM-CSF Antibody G9 and E10

[0214] *Antibody G9.* Nucleotide and amino acid sequences for fully human anti-GM-CSF antibody G9 was obtained by standard methods. Briefly, total RNA was isolated from hybridoma G9 using Trizol reagent (Invitrogen) according to the manufacturer's instructions. The message was synthesized to cDNA using Superscript II reverse transcriptase (Invitrogen) according to the manufacturer's instructions. To amplify the light and heavy chain variable

regions, PCR reactions were carried out with Herculase DNA polymerase (Stratagene) using primers SEQ ID NO:22 and SEQ ID NO:23 for the light chain and SEQ ID NO:24 and SEQ ID NO:25 for the heavy chain. PCR products were cloned into pCR4-TOPO vector (Invitrogen), transformed into *E. coli* Mach1 cells and transformants selected on LB Kanamycin plates. Colonies were screened for inserts with the same primer pairs as above and four positive colonies each were used to generate template DNA for DNA sequence determination, using TempliPhi reagent (GE Healthcare). DNA inserts were sequenced with primers SEQ ID NO:26 and SEQ ID NO:27 using Beckman Coulter DTCS sequencing reagent followed by data acquisition and analysis on a Beckman Coulter CEQ2000. In order to add a leader peptide sequence to the light chain, a positive clone was re-amplified with primers SEQ ID NO:28 and SEQ ID NO:23 using Herculase DNA polymerase. To generate a full length heavy chain (SEQ ID NO:11), including a leader peptide sequence, PCR was carried out with primers SEQ ID NO:29 and SEQ ID NO:30 using the original cDNA as template. The resulting PCR product was TA cloned, transformed into Mach1 cells and positive clones were identified as described above. Full length G9 heavy chain cDNA was sequenced with primers SEQ ID NO:25, SEQ ID NO:26, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:27 and SEQ ID NO:30 using template DNA generated with TempliPhi reagent. The resulting DNA sequences for full length heavy chain for G9 (SEQ ID NO:11) and full length light chain for G9 (SEQ ID NO:15) are shown below. The predicted translation products derived from SEQ ID NO:11 and SEQ ID NO:15 are shown in SEQ ID NO:9 and SEQ ID NO:13, respectively. The predicted translation products derived from SEQ ID NO:10 and SEQ ID NO:14 are shown in SEQ ID NO:8 and SEQ ID NO:12, respectively. The underlined sequences of SEQ ID NOs: 11 and 15 represent the leader sequence added by PCR. The polynucleotide sequences of SEQ ID NO:10 and 14 encode the heavy and light chains of the G9 antibody, respectively, without the added leader sequences. The lower case sequences of SEQ ID NOs:9 and 13 represent the human leader peptides added by the PCR reaction. The underlined sequences of SEQ ID NOs: 8, 9, 12, and 13 represent the CDR regions. The remaining sequences of SEQ ID NOs:8, 9, 12 and 13 are the frameworks of the variable regions and the constant regions. The constant region for heavy chain starts with amino acid sequence WGQG (amino acid 111 of SEQ ID NO:8 or 130 of SEQ ID NO:9), and the constant region for the light chain starts with amino acid sequence FGQG (amino acid 98 of SEQ ID NO:12 or 117 of SEQ ID NO:13).

[0215] *Antibody E10.* Nucleotide and amino acid sequences for fully human anti-GM-CSF antibody E10 was obtained by standard methods. Briefly, total RNA was isolated from hybridoma E10 using Trizol reagent (Invitrogen) according to the manufacturer's instructions.

The message was synthesized to cDNA using Superscript II reverse transcriptase (Invitrogen) according to the manufacturer's instructions. To amplify the light and heavy chain variable regions, PCR reactions were carried out with Herculase DNA polymerase (Stratagene) using primers SEQ ID NO:22 and SEQ ID NO:23 for the light chain and SEQ ID NO:24 and SEQ ID NO:25 for the heavy chain. PCR products were cloned into pCR4-TOPO vector (Invitrogen), transformed into *E. coli* Mach1 cells and transformants selected on LB Kanamycin plates. Colonies were screened for inserts with the same primer pairs as above and four positive colonies each were used to generate template DNA for DNA sequence determination, using TempliPhi reagent (GE Healthcare). DNA inserts were sequenced with primers SEQ ID NO:26 and SEQ ID NO:27 using Beckman Coulter DTCS sequencing reagent followed by data acquisition and analysis on a Beckman Coulter CEQ2000. The resulting DNA sequences encoding the heavy chain variable region for E10 (SEQ ID NO:17) and full length light chain for E10 (SEQ ID NO:19) are shown below. The predicted translation products derived from SEQ ID NO:17 and SEQ ID NO:19 are shown in SEQ ID NO:16 and SEQ ID NO:18, respectively. The underlined sequences of SEQ ID NOs: 16 and 18 represent the CDR regions. The remaining sequences of SEQ ID NOs: 16 and 18 are the framework of the variable region and the constant regions. The constant region for heavy chain starts with amino acid sequence WGQG (amino acid 115 of SEQ ID NO:16), and the constant region for the light chain starts with amino acid sequence FGQG (amino acid 98 of SEQ ID NO:18).

Example 6

Epitope Mapping of Anti-GM-CSF Antibody

[0216] To map the epitope of GM-CSF to which G9 binds, a series of overlapping peptides were generated that span the length of human GM-CSF (Figure 14). Briefly, twenty-five overlapping 12-mer peptides encompassing the human GM-CSF sequence (GenBank Accession # AAA52578, residues 14 to144) were designed to contain 7 amino acid overlaps. Peptides were generated as individual 3.7 mm X 3.7 mm spots by solid phase synthesis via attachment of the C-terminus of each peptide to the surface of a derivatized cellulose membrane (SPOTs technology, Sigma Genosys). A standard Western blot analysis was employed to determine which peptides cross-react with G9 (Figure 15). The cellulose membrane was wetted in methanol and blocked in Blocking Solution (5% BSA, 1X TBS, 0.1% Tween-20, 0.1% NaN_3) overnight at 4°C. Fresh Blocking Solution containing 1 mg/ml purified 10G9 antibody was added, and the blot was incubated overnight at 4°C. The blot was washed three times, 5 min

each, in TBS-T (1X TBS, 0.1% Tween-20), and incubated for one hour in a 1:10,000 dilution of HRP-conjugated goat anti-human IgG (H+L) (Jackson ImmunoResearch cat. 109-035-088) in diluent (5% BSA, 1X TBS, 0.1% Tween-20). The blot was developed using SuperSignal West Femto ECL Substrate Kit (Pierce cat. 34095), followed by a one second exposure to BioMAX film (Kodak). By this method, peptides # 6, 13, 14, 15, and possibly peptide # 23 were specifically recognized by the G9 antibody, which correspond to SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:21, and SEQ ID NO:47, respectively.

[0217] The present invention is not limited to the embodiments described and exemplified above, but is capable of variation and modification within the scope of the appended claims.

-- Sequence Listing:

SEQ ID NO:1:

MWLQSLLLLGTVACSISAPARSPSPSTQPWEHVNAIQEARRLLNLSRDTAAEMNETVEVISEMF
DLQEPTCLQTRLELYKQGLRGSLTKLKGPLTMMASHYKQHCPPTPETSCATQIITFESFKENLK
DFLLVIPFDCWEPVQE

SEQ ID NO:2:

APARSPSPSTQPWEHVNAIQEARRLLNLSRDTAAEMNETVEVISEMFDLQEPTCLQTRLELYKQ
GLRGSLTKLKGPLTMMASHYKQHCPPTPETSCATQIITFESFKENLKDFLLVIPFDCWEPVQE

SEQ ID NO:3: EHVNAIQEARRLLNL

SEQ ID NO:4: STQPWEHVNAIQEAR

SEQ ID NO:5: MASHYKQHCPPTPET

SEQ ID NO:6: LSTAVKELVENSLDAGATNIDLKLKDYGVDLIEVSDNGCGVEEENFE

SEQ ID NO:7: LRQVLSNLLDNAIKYTPEGGEITVSLERDGDHLEITVEDNGPGIPEEDLE

SEQ ID NO:8: G9 Predicted Heavy Chain Amino Acid Sequence

EVQLVESGGGLVQPGGSLRLSCAASGFTFSRHWMHWLRQVPGKGPVWVSRINGAGTSITYADSV
RGRFTISRDNANNTLFLQMNSLRADDTALYFCARANSVWFRGLFDYWGQGTPVTVSSASTKGPS
VFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTV

PSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLM
ISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG
KEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLS
PGK*

SEQ ID NO:9: G9 Predicted Heavy Chain Amino Acid Sequence (w/ Leader)

mgwsciilflvatatgvhsEVQLVESGGGLVQPGGSLRLSCAASGFTFSRHWMHWLRQVPGKGP
VWVSRINGAGTSITYADSVRGRFTISRDNANNTLFLQMNSLRADDTALYFCARANSVWFRGLFD
YWGQGTPVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHT
FPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPE
LLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYN
STYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKN
QVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSC
SVMHEALHNHYTQKSLSLSPGK*

SEQ ID NO:10: G9 Heavy Chain Nucleic Acid Sequence

GAGGTGCAGCTGGTGGAGTCTGGGGGAGGCTTAGTTCAGCCGGGGGGGTCCCTGAGACTCTCCT
GTGCAGCCTCTGGATTCACTTTCAGTAGACACTGGATGCACTGGCTTCGCCAGGTTCCAGGTAA
GGGGCCGGTCTGGGTCTCACGTATCAATGGTGCTGGGACTTCCATAACCTACGCGGACTCCGTG
AGGGGCCGATTCACCATCTCCAGAGACAACGCCAACAACACACTGTTTCTGCAAATGAACAGTC
TGAGAGCCGACGACACGGCTCTTTATTTCTGTGCAAGAGCGAACAGCGTCTGGTTCCGGGGCCT
CTTTGACTACTGGGGCCAGGGAACCCCGGTCACCGTCTCCTCAGCCTCCACCAAGGGCCCATCG
GTCTTCCCCCTGGCACCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCCTGGGCTGCCTGG
TCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCTGACCAGCGGCGT
GCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGGTGACCGTG
CCCTCCAGCAGCTTGGGCACCCAGACCTACATCTGCAACGTGAATCACAAGCCCAGCAACACCA
AGGTGGACAAGAAAGTTGAGCCCAAATCTTGTGACAAAACTCACACATGCCCACCGTGCCCAGC

ACCTGAACTCCTGGGGGGACCGTCAGTCTTCCTCTTCCCCCCAAAACCCAAGGACACCCTCATG
ATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACGAAGACCCTGAGGTCA
AGTTCAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCA
GTACAACAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGAATGGC
AAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCCAGCCCCCATCGAGAAAACCATCTCCA
AAGCCAAAGGGCAGCCCCGAGAACCACAGGTGTACACCCTGCCCCCATCCCGGGATGAGCTGAC
CAAGAACCAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAG
TGGGAGAGCAATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACG
GCTCCTTCTTCCTCTACAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCAGGGGAACGTCTT
CTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACGCAGAAGAGCCTCTCCCTGTCT
CCCGGGAAATGA

SEQ ID NO:11: G9 Heavy Chain Nucleic Acid Sequence (w/ Leader)

aagcttgccgccaccATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACAGGTG
TACACAGCGAGGTGCAGCTGGTGGAGTCTGGGGGAGGCTTAGTTCAGCCGGGGGGGTCCCTGAG
ACTCTCCTGTGCAGCCTCTGGATTCACTTTCAGTAGACACTGGATGCACTGGCTTCGCCAGGTT
CCAGGTAAGGGGCCGGTCTGGGTCTCACGTATCAATGGTGCTGGGACTTCCATAACCTACGCGG
ACTCCGTGAGGGGCCGATTCACCATCTCCAGAGACAACGCCAACAACACACTGTTTCTGCAAAT
GAACAGTCTGAGAGCCGACGACACGGCTCTTTATTTCTGTGCAAGAGCGAACAGCGTCTGGTTC
CGGGGCCTCTTTGACTACTGGGGCCAGGGAACCCCGGTCACCGTCTCCTCAGCCTCCACCAAGG
GCCCATCGGTCTTCCCCCTGGCACCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCCTGGG
CTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCTGACC
AGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGG
TGACCGTGCCCTCCAGCAGCTTGGGCACCCAGACCTACATCTGCAACGTGAATCACAAGCCCAG
CAACACCAAGGTGGACAAGAAAGTTGAGCCCAAATCTTGTGACAAAACTCACACATGCCCACCG
TGCCCAGCACCTGAACTCCTGGGGGGGACCGTCAGTCTTCCTCTTCCCCCCAAAACCCAAGGACA
CCCTCATGATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACGAAGACCC
TGAGGTCAAGTTCAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGG
GAGGAGCAGTACAACAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGC

TGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCCAGCCCCCATCGAGAAAAC
CATCTCCAAAGCCAAAGGGCAGCCCCGAGAACCACAGGTGTACACCCTGCCCCCATCCCGGGAT
GAGCTGACCAAGAACCAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCG
CCGTGGAGTGGGAGAGCAATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGA
CTCCGACGGCTCCTTCTTCCTCTACAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCAGGGG
AACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACGCAGAAGAGCCTCT
CCCTGTCTCCCGGGAAATGAgaattc

SEQ ID NO:12: G9 Predicted Light Chain Amino Acid Sequence
EIVLTQSPVTLSVSPGERVTLSCRASQSVSTNLAWYQQKLGQGPRLLIYGASTRATDIPARFSG
SGSETEFTLTISSLQSEDFAVYYCQQYDKWPDTFGQGTKLEIKRTVAAPSVFIFPPSDEQLKSG
TASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVY
ACEVTHQGLSSPVTKSFNRGEC*

SEQ ID NO:13: G9 Predicted Light Chain Amino Acid Sequence (w/ Leader)
mgwsciilflvatatgvhsEIVLTQSPVTLSVSPGERVTLSCRASQSVSTNLAWYQQKLGQGPR
LLIYGASTRATDIPARFSGSGSETEFTLTISSLQSEDFAVYYCQQYDKWPDTFGQGTKLEIKRT
VAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTY
SLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC*

SEQ ID NO:14 G9 Light Chain Nucleic Acid Sequence
GAAATTGTGCTGACTCAGTCTCCAGTCACCCTGTCTGTGTCTCCAGGGGAAAGAGTCACTCTCT
CCTGCAGGGCCAGTCAGAGTGTTAGCACCAACTTAGCCTGGTATCAGCAGAAACTTGGCCAGGG
TCCCAGGCTCCTCATTTATGGTGCATCCACCAGGGCCACTGATATCCCAGCCAGGTTCAGTGGC
AGTGGGTCTGAGACAGAGTTCACTCTCACCATCAGCAGCCTGCAGTCTGAAGATTTTGCAGTTT
ATTACTGTCAGCAATATGATAAGTGGCCGGACACTTTTGGCCAGGGGACCAAGCTGGAGATCAA
ACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTGGA
ACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAGTGGAAGG

TGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCACAGAGCAGGACAGCAAGGACAG
CACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAGAAACACAAAGTCTAC
GCCTGCGAAGTCACCCATCAGGGCCTGAGTTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGT
GTTAA

SEQ ID NO:15 G9 Light Chain Nucleic Acid Sequence (w/ Leader)
aagcttgccgccaccATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACAGGTG
TACACAGCGAAATTGTGCTGACTCAGTCTCCAGTCACCCTGTCTGTGTCTCCAGGGGAAAGAGT
CACTCTCTCCTGCAGGGCCAGTCAGAGTGTTAGCACCAACTTAGCCTGGTATCAGCAGAAACTT
GGCCAGGGTCCCAGGCTCCTCATTTATGGTGCATCCACCAGGGCCACTGATATCCCAGCCAGGT
TCAGTGGCAGTGGGTCTGAGACAGAGTTCACTCTCACCATCAGCAGCCTGCAGTCTGAAGATTT
TGCAGTTTATTACTGTCAGCAATATGATAAGTGGCCGGACACTTTTGGCCAGGGGACCAAGCTG
GAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGA
AATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACA
GTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCACAGAGCAGGACAGC
AAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAGAAACACA
AAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGTTCGCCCGTCACAAAGAGCTTCAACAG
GGGAGAGTGTTAAgaattc

SEQ ID NO:16 Predicted E10 Heavy Chain Amino Acid Sequence
QVQLEESGGGVVQPGRSLRLSCAASGFTFTNYGMHWVRQAPGKGLEWLALISYDGNRQYYADSV
KGRFTVSRDNPNNTLHLEMKSLRAEDSAIYYCARGAGVLLWFGDLSWFDPWGQGTLVTVSSAST
KGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSS
VVTVPSSSLGTQTYICNVNHKPSNTKVD

SEQ ID NO: 17 E10 Heavy Chain Nucleic Acid Sequence
CAGGTACAGCTGGAGGAGTCAGGGGGAGGCGTGGTCCAGCCTGGGAGGTCCCTCAGACTCTCCT
GTGCAGCGTCTGGATTCACCTTCACTAATTATGGCATGCACTGGGTCCGCCAGGCTCCAGGCAA
GGGACTCGAGTGGCTGGCACTCATATCCTATGATGGAAATAGGCAATACTATGCAGACTCCGTG

AAGGGCCGATTCACCGTCTCCAGAGACAATCCCAACAACACACTGCATCTGGAGATGAAGAGCC
TGCGAGCCGAAGACTCGGCTATATATTACTGTGCGAGAGGGGCTGGGGTATTACTGTGGTTCGG
CGACTTATCCTGGTTCGACCCCTGGGGCCAGGGAACCCTGGTCACCGTCTCCTCAGCCTCCACC
AAGGGCCCATCGGTCTTCCCCCTGGCACCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCC
TGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCT
GACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGCAGC
GTGGTGACCGTGCCCTCCAGCAGCTTGGGCACCCAGACCTACATCTGCAACGTGAATCACAAGC
CCAGCAACACCAAGGTGGAC

SEQ ID NO:18 Predicted E10 Light Chain Amino Acid Sequence
DIQMTQSPSNLSASVGDRVTITCRASQNINTWLAWYQHKPGKPPKLRIYQASTLESGVPSRFSG
SGSGTIFTLTISSLQPDDFGTYYCQQNNSYPYTFGQGTKLEINRTVAAPSVFIFPPSDEQLKSG
TASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSMDSTYSLSSTLTLSKADYEKHKVY
ACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:19 E10 Light Chain Nucleic Acid Sequence
GATATCCAGATGACCCAGTCTCCTTCCAACCTGTCTGCATCTGTAGGAGACAGAGTCACAATCA
CTTGTCGGGCCAGTCAAAATATTAATACCTGGCTGGCCTGGTATCAGCACAAACCAGGGAAACC
CCCTAAGCTCCGGATATATCAGGCGTCTACGTTAGAAAGTGGGGTCCCTTCAAGGTTCAGCGGC
AGTGGATCTGGGACGATATTCACTCTCACCATCAGCAGCCTGCAGCCTGATGATTTTGGAACTT
ATTACTGCCAACAGAATAATAGTTACCCGTACACTTTTGGCCAGGGGACCAAGCTGGAGATCAA
CCGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTGGA
ACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAGTGGAAGG
TGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCACAGAGCAGGACAGCATGGACAG
CACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAGAAACACAAAGTCTAC
GCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGT
GTTAA

SEQ ID NO:20: TCACCATCCATTGCACAGTT

SEQ ID NO:21: CTGCGAGAAGGTACTCACCC

SEQ ID NO:22: GAHRTYSWGHTGACBCAGTCTCC

SEQ ID NO:23:
GATCGAATTCTTAACACTCTCCCCTGTTGAAGCTCTTTGTGACGGGCGAGCTCAGGCC

SEQ ID NO:24: AGGTRCAGCTGBWGSAGTCDG

SEQ ID NO:25: GTCCACCTTGGTGTTGCTGGGCTT

SEQ ID NO:26: AGCGGATAACAATTTCACACAGG

SEQ ID NO:27: CGCCAGGGTTTTCCCAGTCACGAC

SEQ ID NO:28:
GATCGGATCCGCCGCCACCATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACA
GGTGTACACAGCGAAATTGTGCTGACTCAGTCTCC

SEQ ID NO:29: GATCGAATTCTCATTTCCCGGGAGACAGGGAGAGG

SEQ ID NO:30:
GATCGGATCCAAGCTTGCCGCCACCATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACA
GCTACAGGTGTACACAGCGAGGTGCAGCTGGTGGAGTCTGG

SEQ ID NO:31: GGACAAGAAAGTTGAGCCCA
SEQ ID NO:32: TGCAAGGTCTCCAACAAAGC
SEQ ID NO:33: CCTGGTTCTTGGTCAGCTCA

SEQ ID NO:34: GGCACGGTGGGCATGTGTGA

SEQ ID NO:35: ARRLLNLSRDTA

SEQ ID NO:36: TRLELYKQGLRG

SEQ ID NO:37: YKQGLRGSLTKL

SEQ ID NO:38: RGSLTKLKGPLT

SEQ ID NO:39: KENLKDFLLVIP

SEQ ID NO:40 (G9 H CDR1) GFTFSRHWMH

SEQ ID NO:41 (G9 H CDR2) RINGAGTSITYADSVRG

SEQ ID NO:42 (G9 H CDR3) ANSVWFRGLFDY

SEQ ID NO:43 (G9 L CDR1) RASQSVSTNLA

SEQ ID NO:44 (G9 L CDR2) GASTRAT

SEQ ID NO:45 (G9 L CDR3) QQYDKWPDT

SEQ ID NO:46 (E10 H CDR1) GFTFTNYGMH

SEQ ID NO:47 (E10 H CDR2) LISYDGNRQYYADSVKG

SEQ ID NO:48 (E10 H CDR3) GAGVLLWFGDLSWFDP

SEQ ID NO:49 (E10 L CDR1) RASQNINTWLA

SEQ ID NO:50 (E10 L CDR2) QASTLES

SEQ ID NO:51 (E10 L CDR3) QQNNSYPYT

SEQ ID NO:52 (G9 H FWR1) EVQLVESGGGLVQPGGSLRLSCAAS

SEQ ID NO:53 (G9 H FWR2) WLRQVPGKGPVWVS

SEQ ID NO:54 (G9 H FWR3) RFTISRDNANNTLFLQMNSLRADDTALYFCAR

SEQ ID NO:55 (G9 L FWR1) EIVLTQSPVTLSVSPGERVTLSC

SEQ ID NO:56 (G9 L FWR2) WYQQKLGQGPRLLIY

SEQ ID NO:57 (G9 L FWR3) DIPARFSGSGSETEFTLTISSLQSEDFAVYYC

SEQ ID NO:58 (E10 H FWR1) QVQLEESGGGVVQPGRSLRLSCAAS

SEQ ID NO:59 (E10 H FWR2) WVRQAPGKGLEWLA

SEQ ID NO:60 (E10 H FWR3) RFTVSRDNPNNTLHLEMKSLRAEDSAIYYCAR

SEQ ID NO:61 (E10 L FWR1) DIQMTQSPSNLSASVGDRVTITC

SEQ ID NO:62 (E10 L FWR2) WYQHKPGKPPKLRIY

DEMANDES OU BREVETS VOLUMINEUX

LA PRÉSENTE PARTIE DE CETTE DEMANDE OU CE BREVETS COMPREND PLUS D'UN TOME.

CECI EST LE TOME __1___ DE __2 __

NOTE: Pour les tomes additionels, veillez contacter le Bureau Canadien des Brevets.

JUMBO APPLICATIONS / PATENTS

THIS SECTION OF THE APPLICATION / PATENT CONTAINS MORE THAN ONE VOLUME.

THIS IS VOLUME __1___ OF __2___

NOTE: For additional volumes please contact the Canadian Patent Office.

What is claimed is:

1. An isolated human monoclonal antibody that specifically binds to GM-CSF wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51.

2. The antibody of claim 1, wherein said antibody comprises a heavy chain variable domain comprising amino acids 1 to 114 of SEQ ID NO: 16 and a light chain variable domain comprising amino acids 1 to 97 of SEQ ID NO: 18.

3. The antibody of claim 1, wherein said antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 16 and a light chain comprising the amino acid sequence of SEQ ID NO: 18.

4. The antibody of claim 1, wherein the heavy chain comprises the amino acid sequence of SEQ ID NO:16.

5. The antibody of claim 1, wherein the light chain comprises the amino acid sequence of SEQ ID NO:18.

6. The antibody of claim 1, wherein the affinity of the antibody is less than 1×10^{-8} M.

7. The antibody of claim 1, comprising two heavy chains.

8. The antibody of claim 1, comprising two light chains.

9. A composition comprising the antibody of claim 1 and a pharmaceutically acceptable carrier.

10. A polynucleotide encoding the antibody of claim 1.

11. The polynucleotide of claim 10, wherein the nucleic acid sequence encoding the heavy chain comprises SEQ ID NO:17 or wherein the nucleic acid sequence encoding the light chain comprises SEQ ID NO: 19.

12. A vector comprising the polynucleotide sequence of claim 10.

13. A cell that transfected with the polynucleotide of claim 10.

14. A method of making an antibody that specifically binds to GM-CSF wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, the method comprising culturing a host cell of claim 13 under conditions suitable to produce the antibody, and recovering the antibody from the cell culture.

15. Use of a composition comprising a pharmaceutically acceptable carrier and at least one antibody that specifically binds to GM-CSF wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51 in the treatment of GM-CSF-mediated inflammatory disease.

16. Use of an antibody that specifically binds GM-CSF, wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, in the manufacture of a medicament for treatment for GM-CSF-mediated inflammatory disease.

17. The use of claim 15 or 16, wherein the GM-CSF-mediated inflammatory disease is rheumatoid arthritis, multiple sclerosis, asthma, pulmonary alveolar proteinosis, colon cancer, lung cancer, breast cancer, pancreatic cancer, or leukemia.

18. The use of claim 17 wherein said leukemia is juvenile myelomonocytic leukemia.

19. Use of a composition comprising a pharmaceutically acceptable carrier and an antibody that specifically binds GM-CSF, wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, in the treatment of GM-CSF-mediated cancer.

20. Use of an antibody that specifically binds GM-CSF, wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, in the manufacture of a medicament for treatment for GM-CSF-mediated cancer.

21. The use of claim 19 or 20 wherein said cancer is leukemia.

22. The use of claim 19 or 20 wherein said cancer is juvenile myelomonocytic leukemia.

23. The use of claim 19 wherein said composition further comprises a chemotherapeutic agent.

24. The use of claim 23 wherein said antibody is conjugated to said chemotherapeutic agent.

25. Use of a composition comprising a pharmaceutically acceptable carrier and an antibody that specifically binds GM-CSF, wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, in the treatment of GM-CSF-mediated infectious disease.

26. Use of an antibody that specifically binds GM-CSF, wherein said antibody comprises a heavy chain comprising a CDR1 of SEQ ID NO:46, a CDR2 of SEQ ID NO:47, and a CDR3 of SEQ ID NO:48 and a light chain comprising a CDR1 of SEQ ID NO:49, a CDR2 of SEQ ID NO:50, and a CDR3 of SEQ ID NO:51, in the manufacture of a medicament for treatment for GM-CSF-mediated infectious disease.

27. The use of claim 25 or 26 wherein said infectious disease is septic shock.

28. The use of any one of claims 15 to 27, wherein said antibody comprises a heavy chain variable domain comprising amino acids 1 to 114 of SEQ ID NO: 16 and a light chain variable domain comprising amino acids 1 to 97 of SEQ ID NO: 18.

29. The use of any one of claims 15 to 27, wherein said antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 16 and a light chain comprising the amino acid sequence of SEQ ID NO: 18.

Figure 1

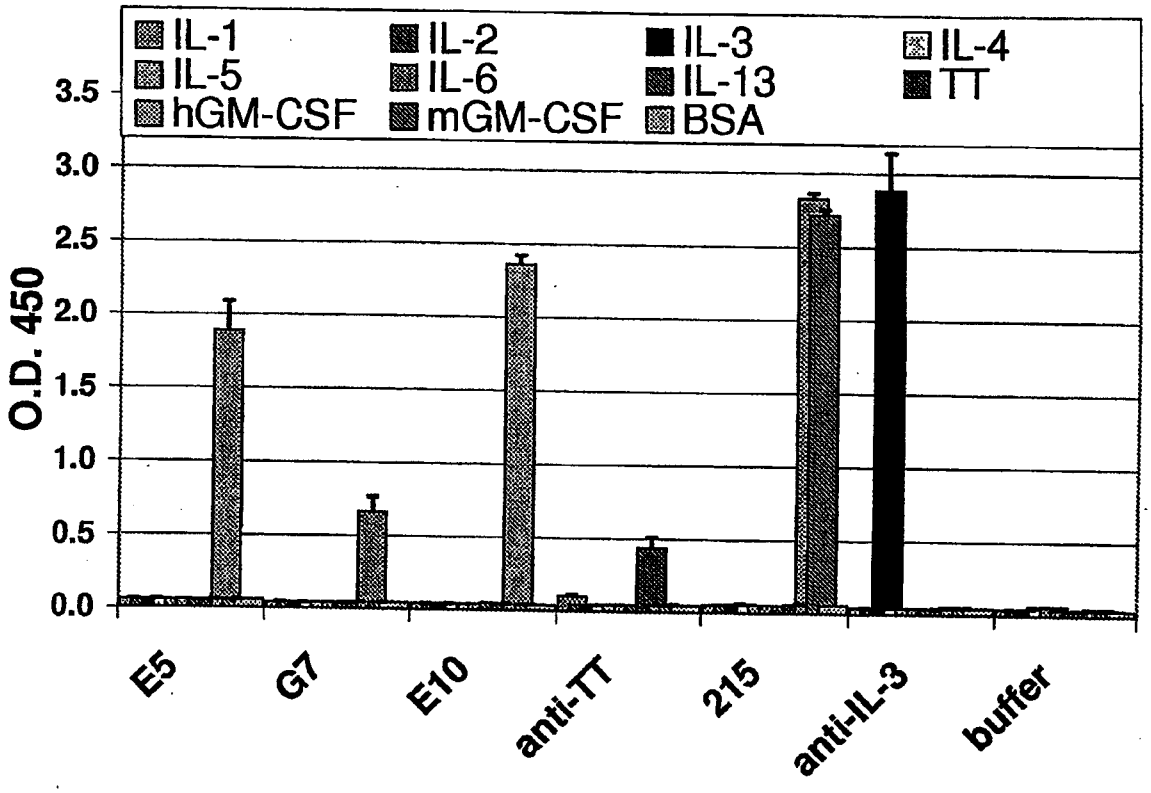
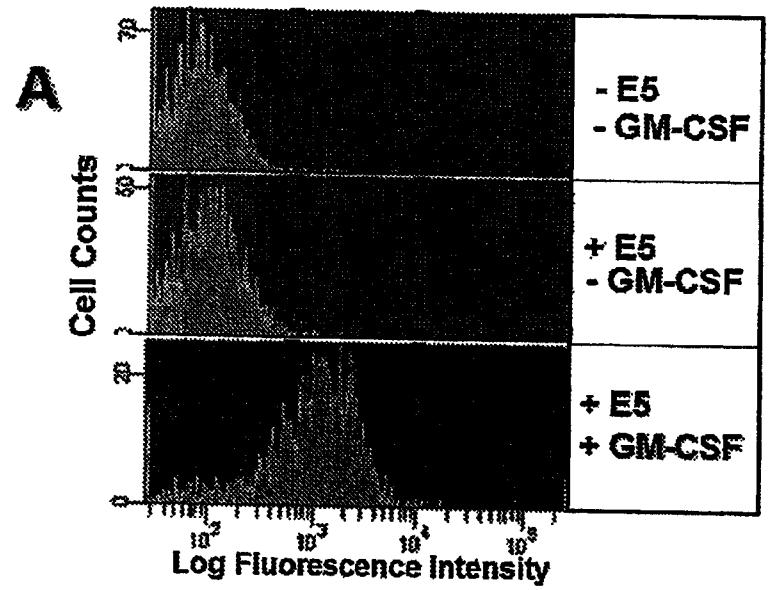

IL-1
IL-2
IL-3
IL-4
IL-5
IL-6
IL-13
TT
hGM-CSF
mGM-CSF
BSA
O.D. 450
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
E5
G7
E10
anti-TT
215
anti-IL-3
buffer

Figure 2


A
- E5
- GM-CSF
+ E5
- GM-CSF
+ E5
+ GM-CSF
Cell Counts
Log Fluorescence Intensity

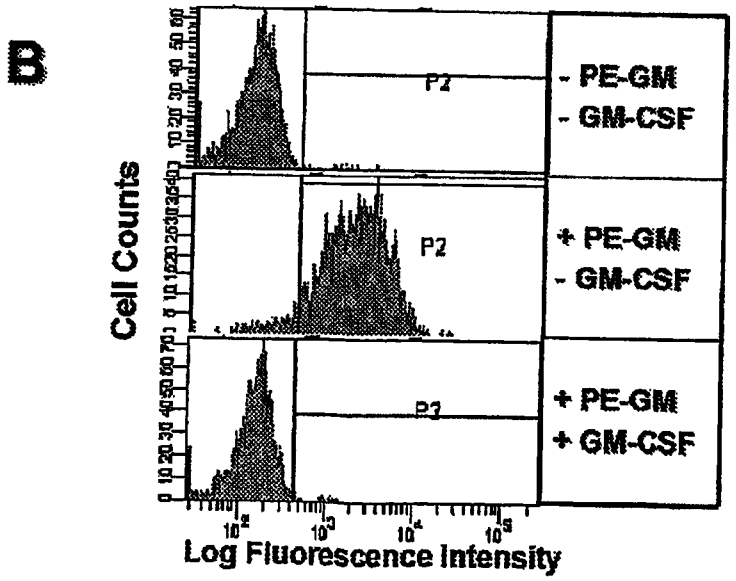

B
P2
P2
P3
- PE-GM
- GM-CSF
+ PE-GM
- GM-CSF
+ PE-GM
+ GM-CSF
Cell Counts
Log Fluorescence Intensity

Figure 3

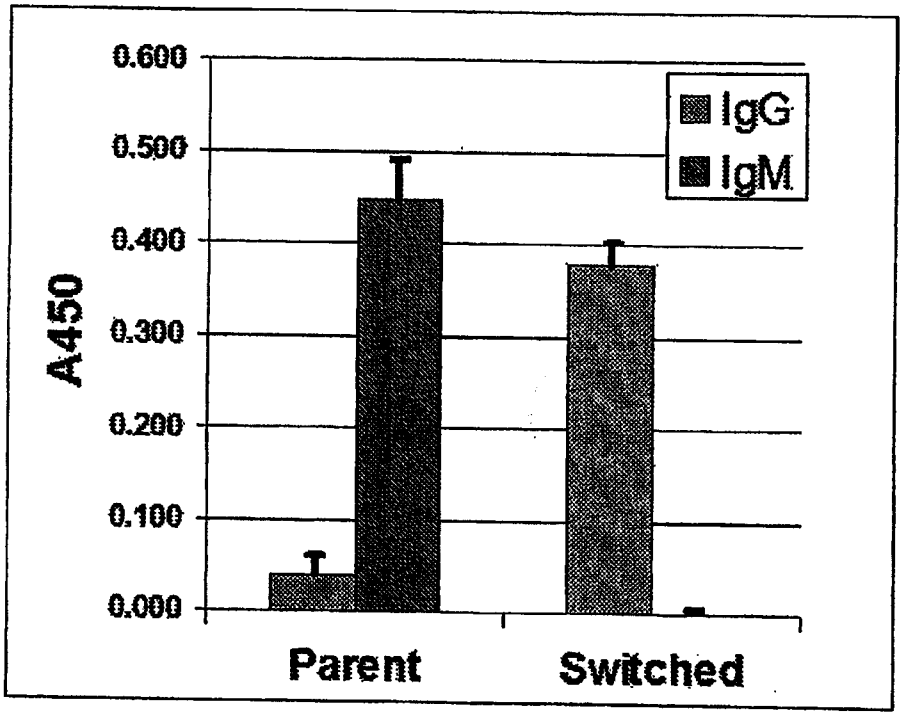

0.600
0.500
0.400
0.300
0.200
0.100
0.000
A450
IgG
IgM
Parent
Switched

Figure 4

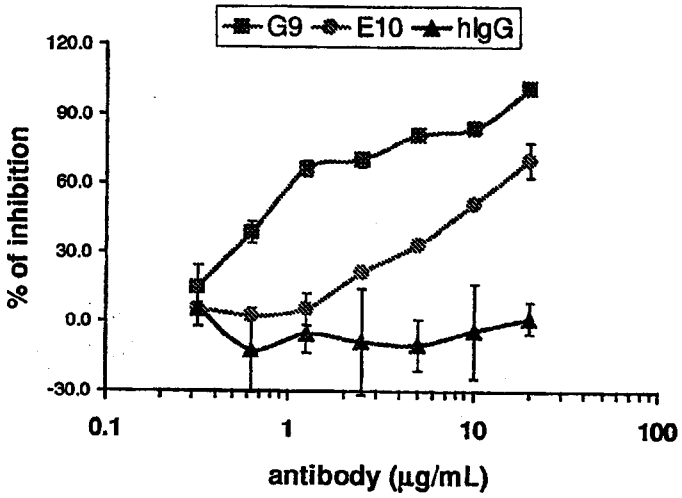

G9
E10
hIgG
120.0
90.0
60.0
30.0
0.0
-30.0
% of inhibition
0.1
1
10
100
antibody (µg/mL)

Figure 5A

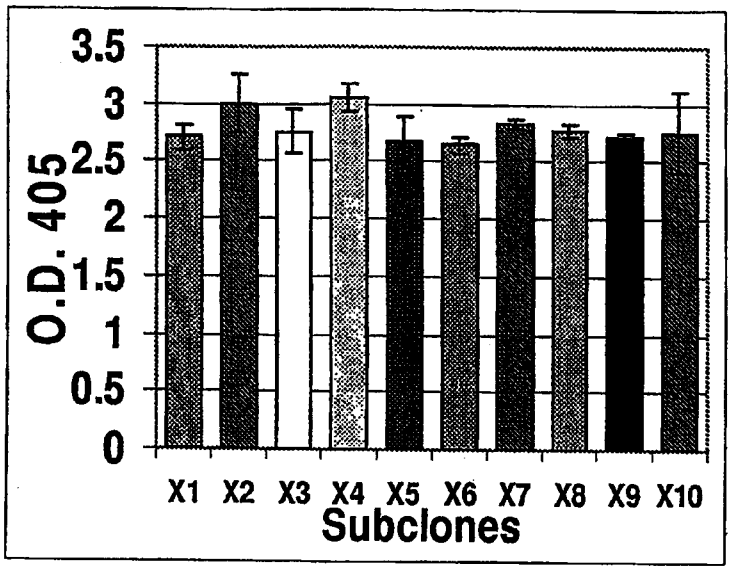


Figure 5B

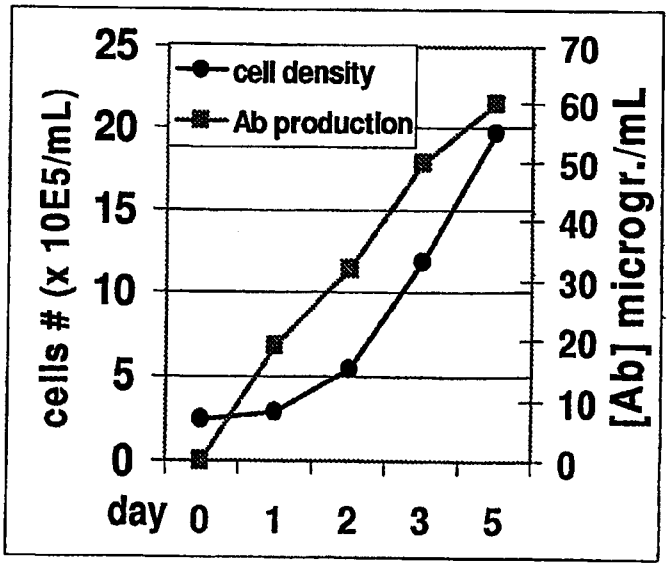


Figure 6

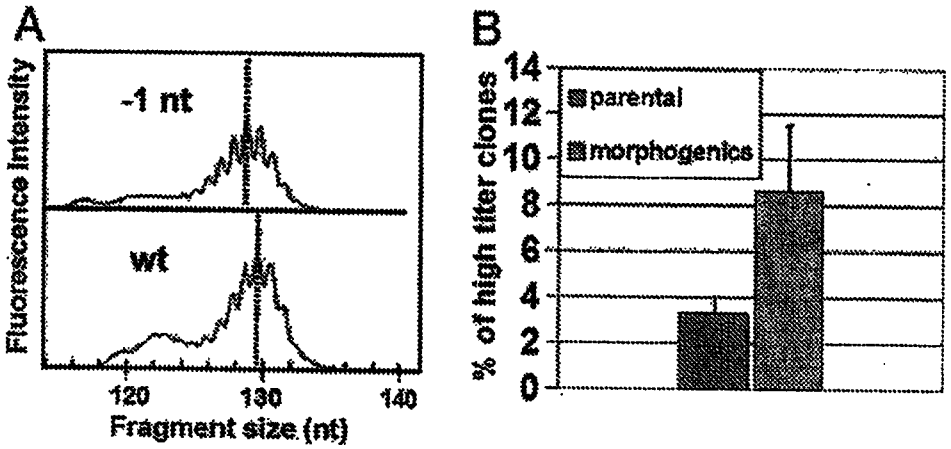
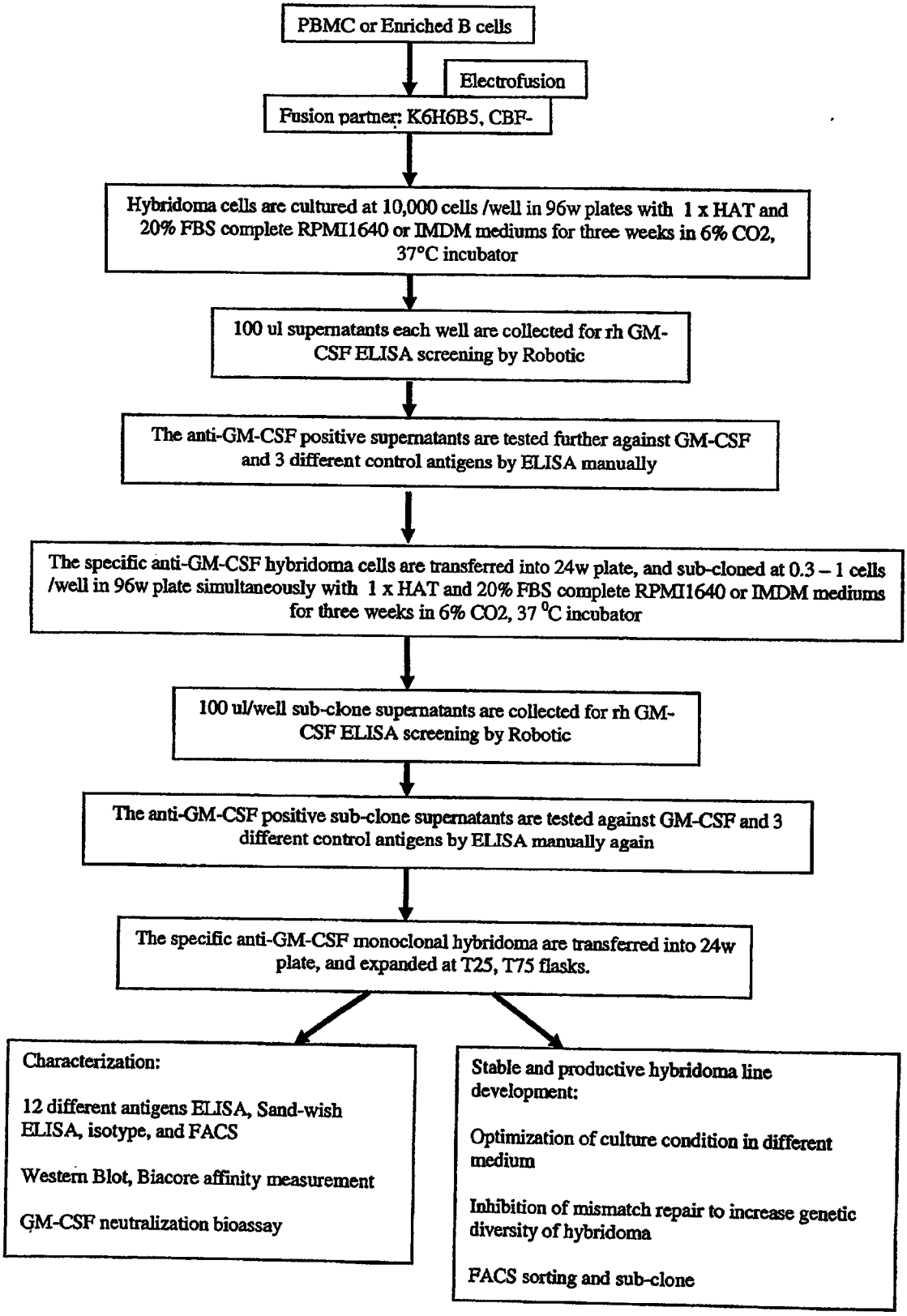

A
Fluorescence Intensity
-1 nt
wt
120
130
140
Fragment size (nt)
B
% of high titer clones
parental
morphogenics
0
2
4
6
8
10
12
14

Figure 7


PBMC or Enriched B cells
Electrofusion
Fusion partner: K6H6B5, CBF-
Hybridoma cells are cultured at 10,000 cells /well in 96w plates with 1 x HAT and 20% FBS complete RPMI1640 or IMDM mediums for three weeks in 6% CO2, 37°C incubator
100 ul supernatants each well are collected for rh GM-CSF ELISA screening by Robotic
The anti-GM-CSF positive supernatants are tested further against GM-CSF and 3 different control antigens by ELISA manually
The specific anti-GM-CSF hybridoma cells are transferred into 24w plate, and sub-cloned at 0.3 – 1 cells /well in 96w plate simultaneously with 1 x HAT and 20% FBS complete RPMI1640 or IMDM mediums for three weeks in 6% CO2, 37 °C incubator
100 ul/well sub-clone supernatants are collected for rh GM-CSF ELISA screening by Robotic
The anti-GM-CSF positive sub-clone supernatants are tested against GM-CSF and 3 different control antigens by ELISA manually again
The specific anti-GM-CSF monoclonal hybridoma are transferred into 24w plate, and expanded at T25, T75 flasks.
Characterization:
12 different antigens ELISA, Sand-wish ELISA, isotype, and FACS
Western Blot, Biacore affinity measurement
GM-CSF neutralization bioassay
Stable and productive hybridoma line development:
Optimization of culture condition in different medium
Inhibition of mismatch repair to increase genetic diversity of hybridoma
FACS sorting and sub-clone

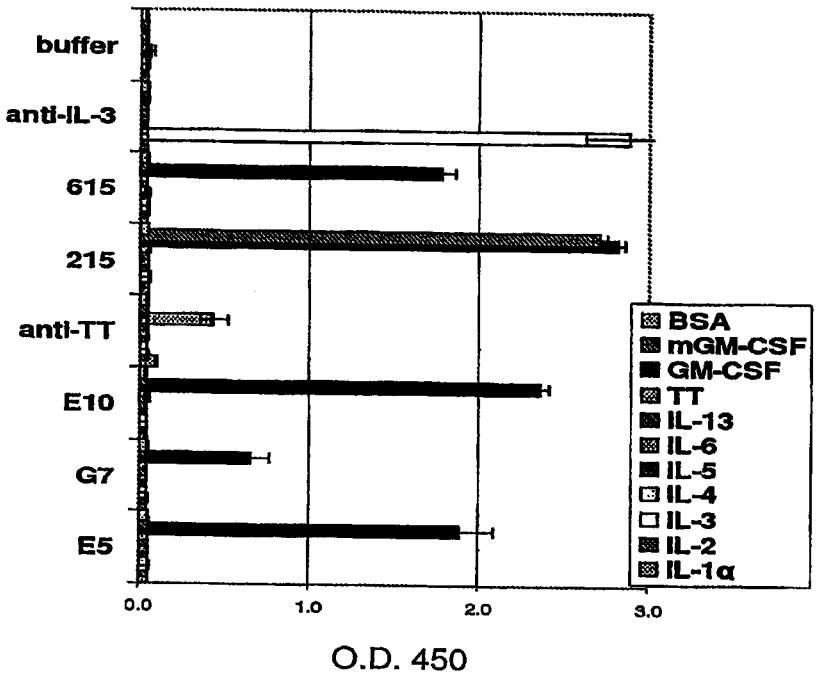

buffer
anti-IL-3
615
215
anti-TT
E10
G7
E5
BSA
mGM-CSF
GM-CSF
TT
IL-13
IL-6
IL-5
IL-4
IL-3
IL-2
IL-1α
0.0
1.0
2.0
3.0
O.D. 450

Figure 8

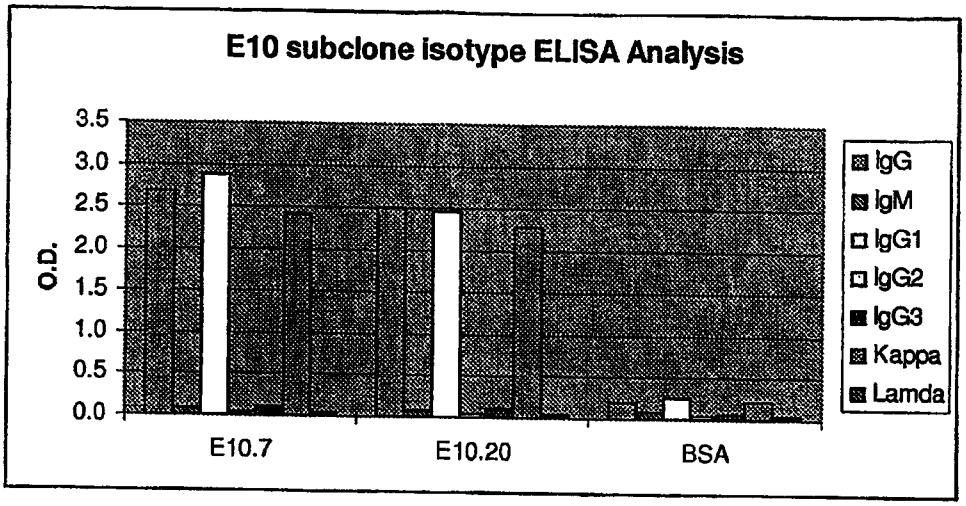

E10 subclone isotype ELISA Analysis
O.D.
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
E10.7
E10.20
BSA
IgG
IgM
IgG1
IgG2
IgG3
Kappa
Lamda

Figure 9

Figure 10

Fig 10. E10 and G9 Western Blot Analysis

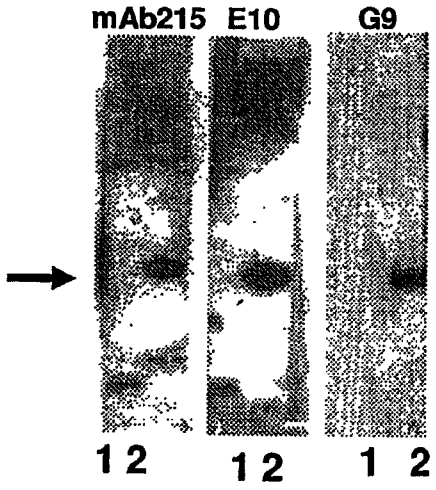


Figure 11

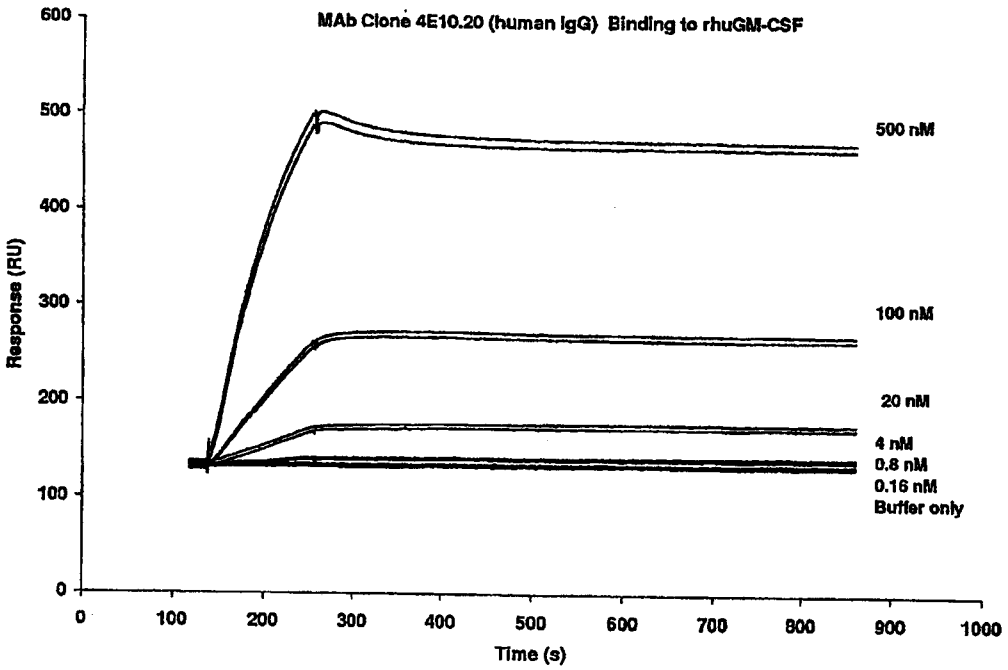

MAb Clone 4E10.20 (human IgG) Binding to rhuGM-CSF
Response (RU)
Time (s)
500 nM
100 nM
20 nM
4 nM
0.8 nM
0.16 nM
Buffer only
0
100
200
300
400
500
600
700
800
900
1000

Figure 12

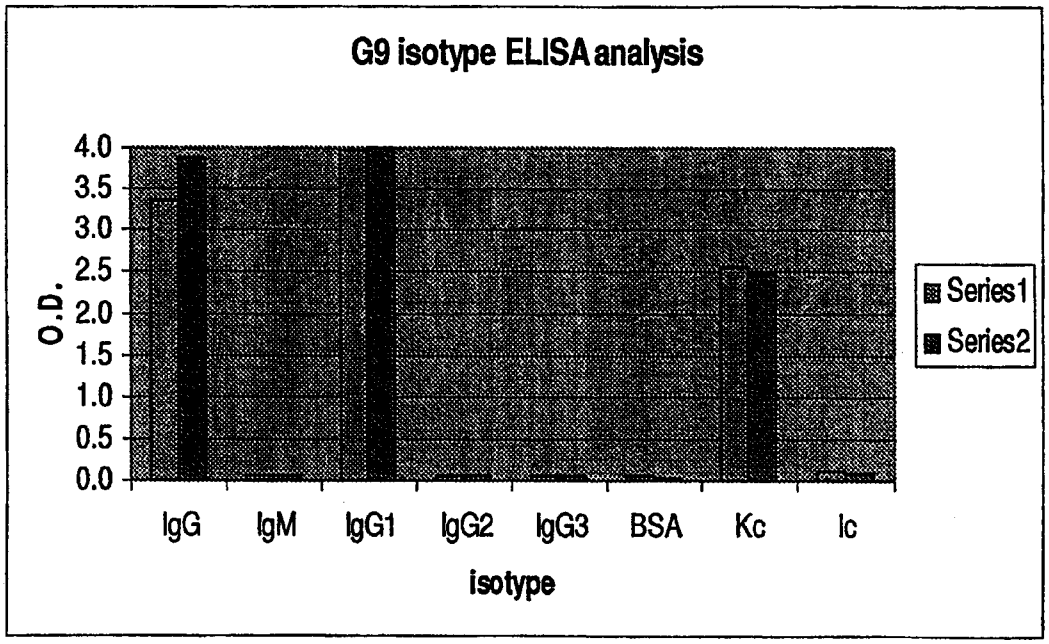

G9 isotype ELISA analysis
O.D.
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
IgG
IgM
IgG1
IgG2
IgG3
BSA
Kc
Ic
isotype
Series1
Series2

Figure 13

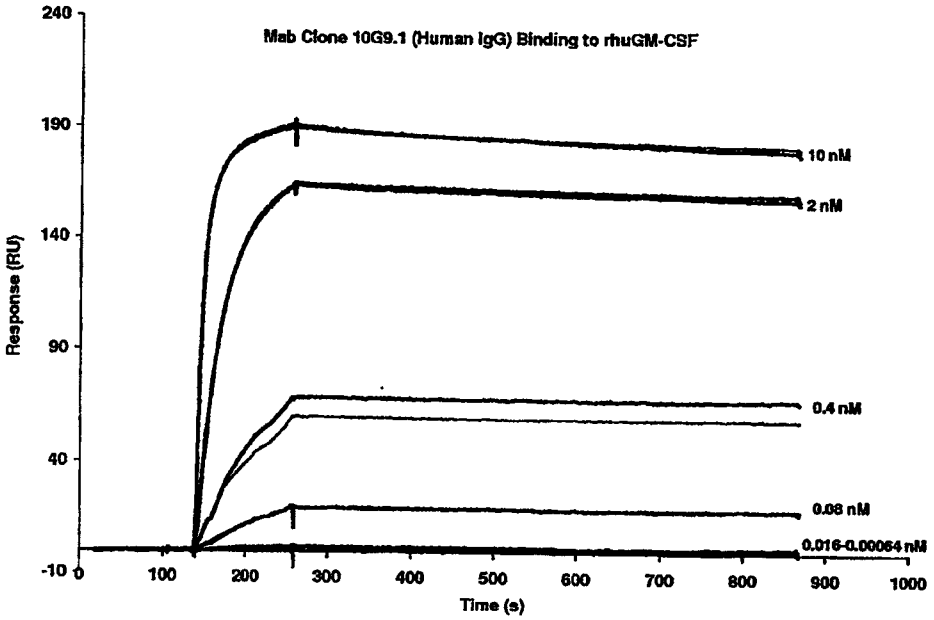
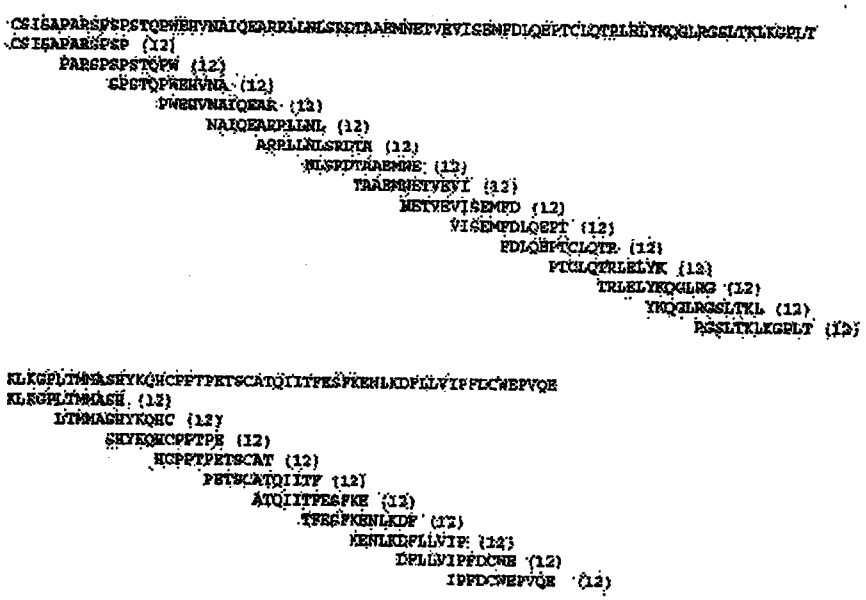

Mab Clone 10G9.1 (Human IgG) Binding to rhuGM-CSF
Response (RU)
Time (s)
10 nM
2 nM
0.4 nM
0.08 nM
0.016-0.00064 nM
240
190
140
90
40
-10
0
100
200
300
400
500
600
700
800
900
1000

Figure 14

G9 Epitope Mapping



G9 Epitope Mapping

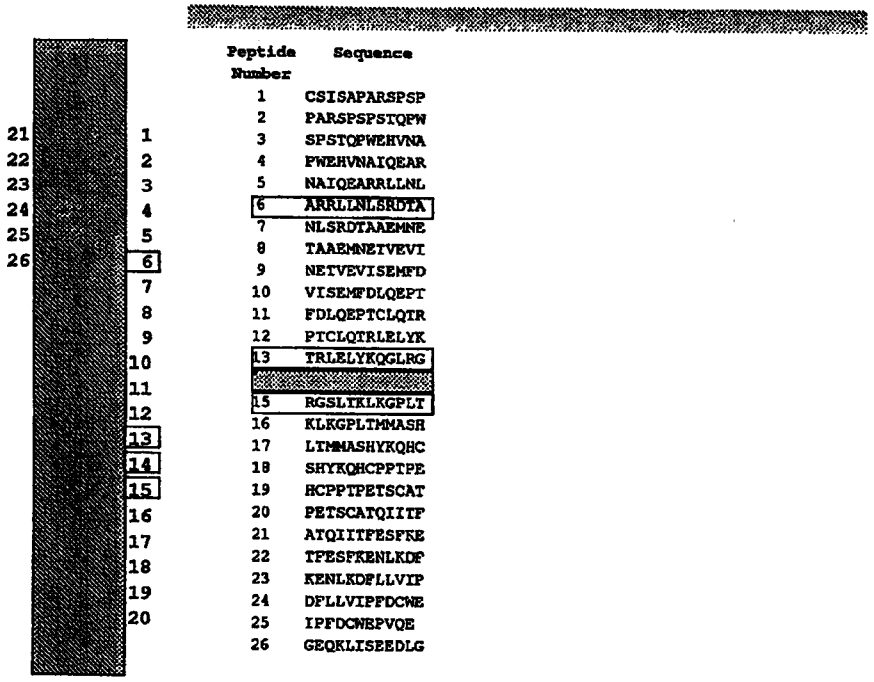
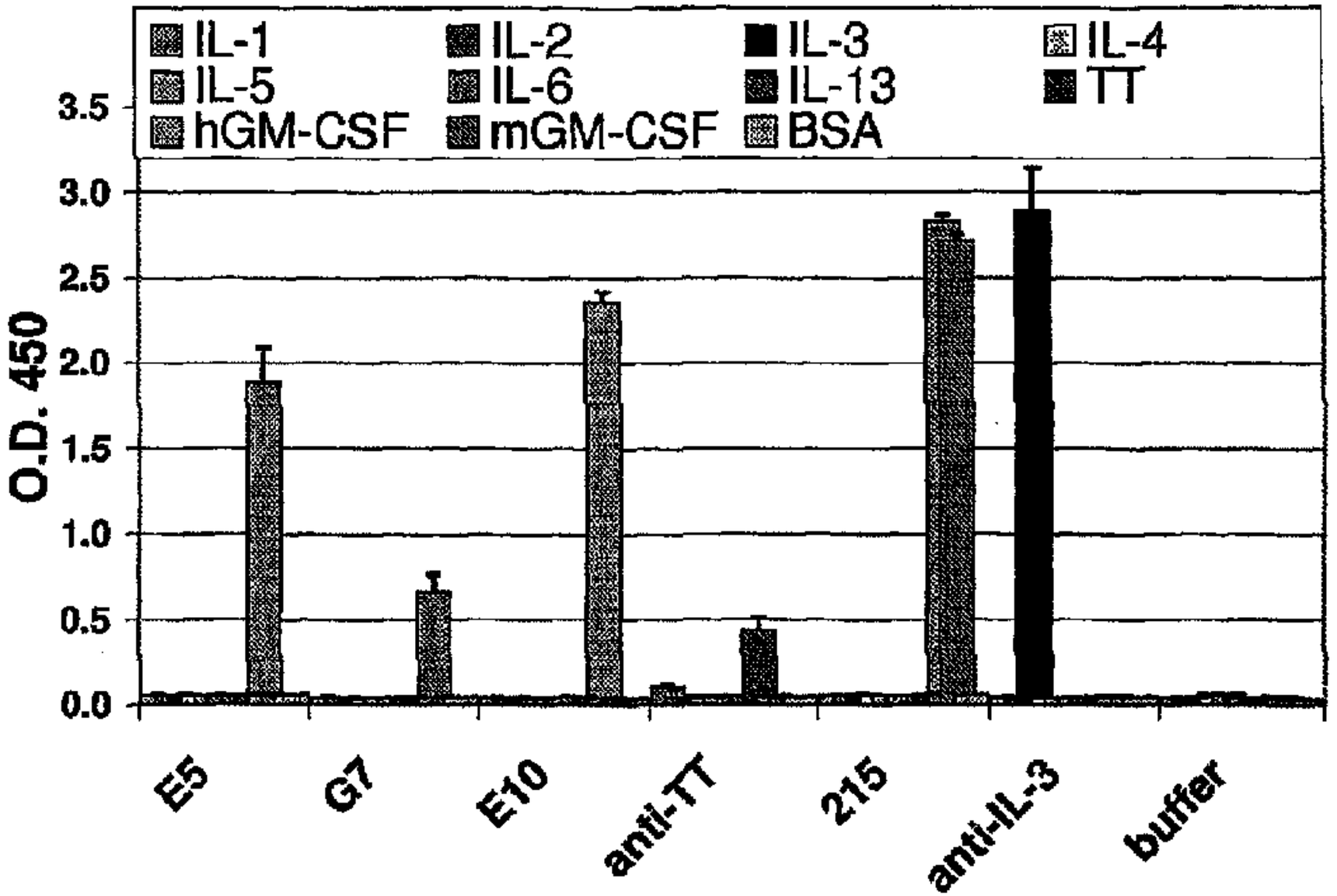


Figure 15


IL-1
IL-2
IL-3
IL-4
IL-5
IL-6
IL-13
TT
hGM-CSF
mGM-CSF
BSA
O.D. 450
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
E5
G7
E10
anti-TT
215
anti-IL-3
buffer