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(56) Related Art
Valladeau et al (2001) Journal of Immunology, November, 167(10):5767-5774
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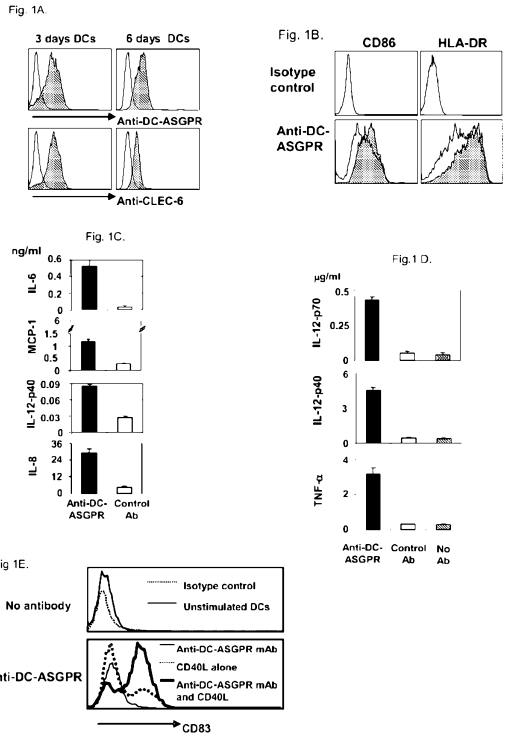
(54) Title: AGENTS THAT ENGAGE ANTIGEN - PRESENTING CELLS THROUGH DENDRITIC CELL ASIALOGLYCOPROTEIN RECEPTOR (DC- ASGPR)

(57) Abstract: The present invention includes compositions and methods for making and using anti DC- ASGPR antibodies that can, e.g., activate DCs and other cells.



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AGENTS THAT ENGAGE ANTIGEN-PRESENTING CELLS THROUGH DENDRITIC CELL ASIALOGLYCOPROTEIN RECEPTOR (DC-ASGPR)

TECHNICAL FIELD OF THE INVENTION

The present invention relates in general to the field of agents that engage antigen-presenting cells through dendritic cell asialoglycoprotein receptor (DC-ASGPR).

BACKGROUND OF THE INVENTION

Without limiting the scope of the invention, its background is described in connection with antigen presentation.

Dendritic Cells play a pivotal role in controlling the interface of innate and acquired immunity by providing soluble and intercellular signals, followed by recognition of pathogens. These functions of DCs are largely dependent on the expression of specialized surface receptors, 'pattern recognition receptors' (PRRs), represented, most notably, by toll-like receptors (TLRs) and C-type lectins or lectin-like receptors (LLRs) (1-3).

In the current paradigm, a major role of TLRs is to alert DCs to produce interleukin 12 (IL-12) and other inflammatory cytokines for initiating immune responses. C-type LLRs operate as constituents of the powerful antigen capture and uptake mechanism of macrophages and DCs (1). Compared to TLRs, however, LLRs might have broader ranges of biological functions that include cell migrations (4), intercellular interactions (5). These multiple functions of LLRs might be due to the facts that LLRs, unlike TLRs, can recognize both self and nonself. However, the complexity of LLRs, including the redundancy of a number of LLRs expressed in immune cells, has been one of the major obstacles to understand the detailed functions of individual LLRs. In addition, natural ligands for most of these receptors remain unidentified. Nonetheless, evidence from recent studies suggests that LLRs, in collaboration with TLRs, may contribute to the activation of immune cells during microbial infections (6-14).

Valladeau et al. (The Journal of Immunology, 2001, 167: 5767–5774) described a novel LLR receptor on immature human Dendritic Cells related to hepatic Asialoglycoprotein Receptor and demonstrated that it efficiently mediated endocytosis. DC-ASGPR mRNA was observed predominantly in immune tissues - in DC and granulocytes, but not in T, B, or NK cells,or monocytes. DC-ASGPR species were restricted to the CD14-derived DC obtained from CD34-derived progenitors, while absent from the CD1a-derived subset. Both monocyte-derived DC

and tonsillar interstitial-type DC expressed DC-ASGPR protein, while Langerhans-type cells did not. Furthermore, DC-ASGPR was a feature of immaturity, as expression was lost upon CD40 activation. In agreement with the presence of tyrosine-based and dileucine motifs in the intracytoplasmic domain, mAb against DC-ASGPR was rapidly internalized by DC at 37°C. Finally, intracellular DC-ASGPR was localized to early endosomes, suggesting that the receptor recycles to the cell surface following internalization of ligand. These findings identified DC-ASGPR/human macrophage lectin as a feature of immature DC, and as another lectin important for the specialized Ag-capture function of DC.

SUMMARY OF THE INVENTION

While DC-ASGPR is known to be capable of directing the internalization of surrogate antigen into human DC, the invention uses novel biological activities of DC-ASGPR to effect particularly desirable changes in the immune system, some in the context of antigen uptake (e.g., vaccination), others through the unique action of DC-ASGPR effectors (alone or in concert with other immune regulatory molecules) capable of eliciting signaling through this receptor on DC, B cells, and monocytes. The invention disclosure reveals means of developing unique agents capable of activating cells bearing DC-ASGPR, as well as the effect of the resulting changes in cells receiving these signals regards action on other cells in the immune system. These effects (either alone, or in concert with other signals (i.e., co-stimulation)) are highly predictive of therapeutic outcomes for certain disease states or for augmenting protective outcomes in the context of vaccination.

The present invention includes compositions and methods for increasing the effectiveness of antigen presentation by a DC-ASGPR-expressing antigen presenting cell by isolating and purifying a DC-ASGPR-specific antibody or fragment thereof to which a targeted agent is attached that forms an antibody-antigen complex, wherein the agent is processed and presented by, e.g., a dendritic cell, that has been contacted with the antibody-agent complex. In one embodiment, the antigen presenting cell is a dendritic cell and the DC-ASGPR-specific antibody or fragment thereof is bound to one half of a Coherin/Dockerin pair. The DC-ASGPR-specific antibody or fragment thereof may also be bound to one half of a Coherin/Dockerin pair and an antigen is bound to the complementary half of the Coherin/Dockerin pair to form a complex. Non-limiting examples agents include one or more peptides, proteins, lipids, carbohydrates, nucleic acids and combinations thereof.

The agent may one or more cytokine selected from interleukins, transforming growth factors (TGFs), fibroblast growth factors (FGFs), platelet derived growth factors (PDGFs), epidermal growth factors (EGFs), connective tissue activated peptides (CTAPs), osteogenic factors, and biologically active analogs, fragments, and derivatives of such growth factors, B/T-cell differentiation factors, B/T-cell growth factors, mitogenic cytokines, chemotactic cytokines, colony stimulating factors, angiogenesis factors, IFN-α, IFN-β, IFN-γ, IL1, IL2, IL3, IL4, IL5, IL6, IL7, IL8, IL9, IL10, IL11, IL12, IL13, IL14, IL15, IL16, IL17, IL18, etc., leptin, myostatin, macrophage stimulating protein, platelet-derived growth factor, TNF-α, TNF-β, NGF, CD40L, CD137L/4-1BBL, human lymphotoxin-β, G-CSF, M-CSF, GM-CSF, PDGF, IL-1α, IL1- β, IP-10, PF4, GRO, 9E3, erythropoietin, endostatin, angiostatin, VEGF, transforming growth factor (TGF) supergene family include the beta transforming growth factors (for example TGF-β1, TGF-β2, TGF-β3); bone morphogenetic proteins (for example, BMP-1, BMP-2, BMP-3, BMP-4, BMP-5, BMP-6, BMP-7, BMP-8, BMP-9); heparin-binding growth factors (fibroblast growth factor (FGF), epidermal growth factor (EGF), platelet-derived growth factor (PDGF), insulin-like growth factor (IGF)); Inhibins (for example, Inhibin A, Inhibin B); growth differentiating factors (for example, GDF-1); and Activins (for example, Activin A, Activin B, Activin AB). In another embodiment, the agent comprises an antigen that is a bacterial, viral, fungal, protozoan or cancer protein.

The present invention also includes compositions and methods for increasing the effectiveness of antigen presentation by dendritic cells comprising binding a DC-ASGPR-specific antibody or fragment thereof to which an antigen is attached that forms an antibody-antigen complex, wherein the antigen is processed and presented by a dendritic cell that has been contacted with the antibody-antigen complex. Another embodiment is the use of antibodies or other specific binding molecules directed to DC-ASGPR for delivering antigens to antigen-presenting cells for the purpose of eliciting protective or therapeutic immune responses. The use of antigen-targeting reagents specific to DC-ASGPR for vaccination via the skin; antigen-targeting reagents specific to DC-ASGPR in association with co-administered or linked adjuvant for vaccination or use for antigen-targeting (vaccination) purposes of specific antigens which can be expressed as recombinant antigen-antibody fusion proteins.

Another embodiment includes a method for increasing the effectiveness of dendritic cells by isolating patient dendritic cells; exposing the dendritic cells to activating amounts of anti-DC-ASGPR antibodies or fragments thereof and antigen to form antigen-loaded, activated dendritic cells; and reintroducing the antigen-loaded, activated dendritic cells into the patient. The antigen

may be a bacterial, viral, fungal, protozoan or cancer protein. The present invention also includes an anti-DC-ASGPR immunoglobulin or portion thereof that is secreted from mammalian cells and an antigen bound to the immunoglobulin. The immunoglobulin is bound to one half of a cohesin/dockerin domain, or it may also include a complementary half of the cohesin-dockerin binding pair bound to an antigen that forms a complex with the modular rAb carrier, or a complementary half of the cohesin-dockerin binding pair that is a fusion protein with an antigen. The antigen specific domain may be a full length antibody, an antibody variable region domain, an Fab fragment, a Fab' fragment, an $F(ab)_2$ fragment, and Fv fragment, and Fabc fragment and/or a Fab fragment with portions of the Fc domain. The anti-DC-ASGPR immunoglobulin may also be bound to a toxin selected from wherein the toxin is selected from the group consisting of a radioactive isotope, metal, enzyme, botulin, tetanus, ricin, cholera, diphtheria, aflatoxins, perfringens toxin, mycotoxins, shigatoxin, staphylococcal enterotoxin B, T2, seguitoxin, saxitoxin, abrin, cyanoginosin, alphatoxin, tetrodotoxin, aconotoxin, snake venom and spider venom. The antigen may be a fusion protein with the immunoglobulin or bound chemically covalently or not.

The present invention also includes compositions and methods for increasing the effectiveness of dendritic cells by isolating patient dendritic cells, exposing the dendritic cells to activating amounts of anti-DC-ASGPR antibodies or fragments thereof and antigen to form antigen-loaded, activated dendritic cells; and reintroducing the antigen-loaded, activated dendritic cells into the patient. The agents may be used to engage DC-ASGPR, alone or with co-activating agents, to activate antigen-presenting cells for therapeutic or protective applications, to bind DC-ASGPR and/or activating agents linked to antigens, alone or with co-activating agents, for protective or therapeutic vaccination. Another use of is the development of specific antibody V-region sequences capable of binding to and activating DC-ASGPR, for use as anti-DC-ASGPR agents linked to toxic agents for therapeutic purposes in the context of diseases known or suspected to result from inappropriate activation of immune cells via DC-ASGPR and as a vaccine with a DC-ASGPR-specific antibody or fragment thereof to which an antigen is attached that forms an antibody-antigen complex, wherein the antigen is processed and presented by a dendritic cell that has been contacted with the antibody-antigen complex.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the features and advantages of the present invention, reference is now made to the detailed description of the invention along with the accompanying figures and in which:

Figures 1A to 1E demonstrate signaling through lectin-like receptor DC-ASGPR activates DCs, resulting in increased levels of costimulatory molecules as well as cytokines and chemokines. Figure 1A shows three day and six day GM/IL-4 DCs were stained with FITC-labeled goat anti-mouse IgG followed by mouse monoclonal anti-human DC-ASGPR, antibody. Figure 1B shows six day GM/IL-4 DCs were cultured in plates coated with the anti-DC-ASGPR or control mAbs (1-2 ug/ml) for 16-18h. Cells were stained with anti-CD86 and HLA-DR antibodies labeled with fluorescent dyes. Open and filled bars in the histograms represent cells activated with isotype control mAbs and anti-lectin mAbs, respectively. Figure 1C shows six day GM/IL-4 DCs were cultured in plates coated with the mAbs for 12h, and subjected to RNA isolation and Affymetrix Gene Chip analysis, as described in Methods. Fold increases of gene expression by anti-lectin mAbs were compared with the gene expression levels in DCs stimulated with control mAbs. Figure 1D shows the cytokines and chemokines in the culture supernatants from the experiment shown in Figure 1B were measured by Luminex. Figure 1E shows six day GM/IL-4 DCs were cultured in plates coated with mAbs in the presence or absence of 50 ng/ml soluble CD40L, for 16-18h, and then stained with anti-CD83 antibodies. Cytokines and chemokines in the culture supernatants from the experiment shown in Figure 1E were measured by Luminex. Results shown are representative of three independent experiments using cells from different normal donors.

Figures 2A to 2D shows that DC-ASGPR expressed on DCs, contributes to enhanced humoral immune responses. Six day GM/IL-4 DCs, $5x10^3$/well, were incubated in 96 well plates coated with anti-DC- ASGPR or control mAb for 16-18h, and then $1x10^5$ autologous $CD19^+$ B cells stained with CFSE were co-cultured in the presence of 20 units/ml IL-2 and 50 nM CpG. Figure 2A is a FACS of day six cells stained with fluorescently labeled antibodies. $CD3^+$ and $7\text{-}AAD^+$ cells were gated out. $CD38^+$ and $CFSE^-$ cells were purified by FACS sorter and Giemsa staining was performed. Figure 2B are culture supernatants on day thirteen were analyzed for total IgM, IgG, and IgM by sandwich ELISA. Figure 1C shows DCs pulsed with 5 multiplicity of infection (moi) of heat-inactivated influenza virus (PR8), and cultured with B cells. Culture supernatant was analyzed for influenza-specific immunoglobulins (Igs) on day thirteen. Figure 1D shows DC

cultured with anti-DC- ASGPR or control mAb were stained for cell surface APRIL expression and the supernatants assayed for soluble APRIL.

Figures 3A to 3D shows the cell surface expression of DC-ASGPR on B cells contribute to B cell activation and immunoglobulin production. Figure 3A are PBMCs from buffy coats were stained with anti-CD19, anti-CD3, and anti- DC-ASGPR or control mAb. $CD19^+$ and $CD3^+$ cells were gated and the expression levels of the molecules on $CD19^+$ B cells were measured by flow cytometry. Figure 3B are $CD19^+$ B cells from buffy coats were cultured in plates coated with the mAbs for 12h, and subjected to RNA isolation and Affymetrix Gene Chip analysis as described in Methods. Fold increases of gene expression by anti- DC-ASGPR mAb were compared to the gene expression levels in $CD19^+$ B cells stimulated with control mAb. Figure 3C shows $CD19^+$ B cells were cultured in plates coated with the mAbs for 16-18h, and then culture supernatants were analyzed for cytokines and chemokines by Luminex. Figure 3D shows $1x10^5$ $CD19^+$ B cells were cultured in plates coated with the mAbs for thirteen days. Total Ig levels were measured by ELISA. Data are representative of two repeat experiments using cells from three different normal donors.

Figures 4A to 4D shows that the proliferation of purified allogeneic T cells was significantly enhanced by DCs stimulated with mAb specific for DC-ASGPR.

Figure 5 shows that certain anti-DC-ASGPR mAbs can activate DC. GM-CSF/IL-4. DC were incubated for 24 hrs with one of a panel of 12 pure anti-ASGPR mAbs. Cells were then tested for expression of cell surface CD86 (a DC activation marker) and supernatants were assayed for secreted cytokines. Three mAbs (36, 38, 43) from the anti-ASGPR mAb panel activated DC.

Figure 6 shows that different antigens can be expressed in the context of a DC-ASGPR rAb. Such an anti-DC-ASGPR rAb.Doc protein can be simply mixed with any Cohesin.fusion protein to assemble a stable non-covalent [rAb.Doc:Coh.fusion] complex that functions just as a rAb.fusion protein.

Figure 7 - GM-CSF/IFNa DCs (5,000/well) were loaded with 10 or 1 nM anti-DC-ASGPR.Doc:Coh.Flu M1, or hIgG4.Doc:Coh.Flu M1 complexes. After 6 h, autologous CD8+ T cells (200,000/well) were added into the cultures. At day 8, the CD8+ T cells were analyzed for expansion of cells bearing TCR specific for a HLA-A201 immuno-dominant peptide. The inner boxes indicate the percentage of tetramer-specific CD8+ T cells.

Figure 8 demonstrated the cross reactivity of the different antibodies with monkey ASGPR.

DETAILED DESCRIPTION OF THE INVENTION

While the making and using of various embodiments of the present invention are discussed in detail below, it should be appreciated that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed herein are merely illustrative of specific ways to make and use the invention and do not delimit the scope of the invention.

To facilitate the understanding of this invention, a number of terms are defined below. Terms defined herein have meanings as commonly understood by a person of ordinary skill in the areas relevant to the present invention. Terms such as "a", "an" and "the" are not intended to refer to only a singular entity, but include the general class of which a specific example may be used for illustration. The terminology herein is used to describe specific embodiments of the invention, but their usage does not delimit the invention, except as outlined in the claims.

Dendritic cells (DCs) are antigen-presenting cells that play a key role in regulating antigen-specific immunity (Mellman and Steinman 2001), (Banchereau, Briere et al. 2000), (Cella, Sallusto et al. 1997). DCs capture antigens, process them into peptides, and present these to T cells. Therefore delivering antigens directly to DC is a focus area for improving vaccines. One such example is the development of DC-based vaccines using ex-vivo antigen-loading of autologous DCs that are then re-administrated to patients (Banchereau, Schuler-Thurner et al. 2001), (Steinman and Dhodapkar 2001). Another strategy to improve vaccine efficacy is specific targeting to DC of antigen conjugated to antibodies against internalizing DC-specific receptors. The potential of targeting DCfor vaccination is highlighted by key mouse studies. In vivo, targeting with an anti-LOX-1 mAb coupled to ovalbumin (OVA) induced a protective CD8+ T cell response, via exogenous antigen cross-presentation toward the MHC class I pathway (Delneste, Magistrelli et al. 2002). Also, OVA conjugated to anti-DEC205 mAb in combination with a CD40L maturation stimulus enhanced the MHC class I-restricted presentation by DCs in vivo and led to the durable formation of effector memory CD8+ T cells (Bonifaz, Bonnyay et al. 2004). Both these studies showed dramatic dose-sparing (i.e., strong immune-responses at very low antigen doses) and suggested broader responses than normally seen with other types of OVA immunization. Recent work with targeting of HIV gag antigen to DC via DEC205 has extended these concepts to a clinically relevant antigen and confirmed the tenents of targeting antigen to DC – dramatic dose-sparing, protective responses from a single vaccination, and expansion of antigen-specific T cells in both the CD8 and CD4 compartments (Trumpfheller, Finke et al. 2006).

The present invention provides for the complexing of multiple antigens or proteins (engineered, expressed, and purified independently from the primary mAb) in a controlled, multivariable fashion, to one single primary recombinant mAb. Presently, there are methods for engineering site-specific biotinylation sites that provide for the addition of different proteins (each engineered separately linked to streptavidin) to the one primary mAb. However, the present invention provides for addition to the primary mAb of multiple combinations, in fixed equimolar ratios and locations, of separately engineered proteins.

As used herein, the term "modular rAb carrier" is used to describe a recombinant antibody system that has been engineered to provide the controlled modular addition of diverse antigens, activating proteins, or other antibodies to a single recombinant monoclonal antibody (mAb). The rAb may be a monoclonal antibody made using standard hybridoma techniques, recombinant antibody display, humanized monoclonal antibodies and the like. The modular rAb carrier can be used to, e.g., target (via one primary recombinant antibody against an internalizing receptor, e.g., a human dendritic cell receptor) multiple antigens and/or antigens and an activating cytokine to dendritic cells (DC). The modular rAb carrier may also be used to join two different recombinant mAbs end-to-end in a controlled and defined manner.

The antigen binding portion of the "modular rAb carrier" may be one or more variable domains, one or more variable and the first constant domain, an Fab fragment, a Fab' fragment, an $F(ab)_2$ fragment, and Fv fragment, and Fabc fragment and/or a Fab fragment with portions of the Fc domain to which the cognate modular binding portions are added to the amino acid sequence and/or bound. The antibody for use in the modular rAb carrier can be of any isotype or class, subclass or from any source (animal and/or recombinant).

In one non-limiting example, the modular rAb carrier is engineered to have one or more modular cohesin-dockerin protein domains for making specific and defined protein complexes in the context of engineered recombinant mAbs. The mAb is a portion of a fusion protein that includes one or more modular cohesin-dockerin protein domains carboxy from the antigen binding domains of the mAb. The cohesin-dockerin protein domains may even be attached post-translationally, e.g., by using chemical cross-linkers and/or disulfide bonding.

The term "antigen" as used herein refers to a molecule that can initiate a humoral and/or cellular immune response in a recipient of the antigen. Antigen may be used in two different contexts with the present invention: as a target for the antibody or other antigen recognition domain of the rAb or as the molecule that is carried to and/or into a cell or target by the rAb as part of a

dockerin/cohesin-molecule complement to the modular rAb carrier. The antigen is usually an agent that causes a disease for which a vaccination would be advantageous treatment. When the antigen is presented on MHC, the peptide is often about 8 to about 25 amino acids. Antigens include any type of biologic molecule, including, for example, simple intermediary metabolites, sugars, lipids and hormones as well as macromolecules such as complex carbohydrates, phospholipids, nucleic acids and proteins. Common categories of antigens include, but are not limited to, viral antigens, bacterial antigens, fungal antigens, protozoal and other parasitic antigens, tumor antigens, antigens involved in autoimmune disease, allergy and graft rejection, and other miscellaneous antigens.

The modular rAb carrier is able to carry any number of active agents, e.g., antibiotics, anti-infective agents, antiviral agents, anti-tumoral agents, antipyretics, analgesics, anti-inflammatory agents, therapeutic agents for osteoporosis, enzymes, cytokines, anticoagulants, polysaccharides, collagen, cells, and combinations of two or more of the foregoing active agents. Examples of antibiotics for delivery using the present invention include, without limitation, tetracycline, aminoglycosides, penicillins, cephalosporins, sulfonamide drugs, chloramphenicol sodium succinate, erythromycin, vancomycin, lincomycin, clindamycin, nystatin, amphotericin B, amantidine, idoxuridine, p-amino salicyclic acid, isoniazid, rifampin, antinomycin D, mithramycin, daunomycin, adriamycin, bleomycin, vinblastine, vincristine, procarbazine, imidazole carboxamide, and the like.

Examples of anti-tumor agents for delivery using the present invention include, without limitation, doxorubicin, Daunorubicin, taxol, methotrexate, and the like. Examples of antipyretics and analgesics include aspirin, Motrin®, Ibuprofen®, naprosyn, acetaminophen, and the like.

Examples of anti-inflammatory agents for delivery using the present invention include, without limitation, include NSAIDS, aspirin, steroids, dexamethasone, hydrocortisone, prednisolone, Diclofenac Na, and the like.

Examples of therapeutic agents for treating osteoporosis and other factors acting on bone and skeleton include for delivery using the present invention include, without limitation, calcium, alendronate, bone GLa peptide, parathyroid hormone and its active fragments, histone H4-related bone formation and proliferation peptide and mutations, derivatives and analogs thereof.

Examples of enzymes and enzyme cofactors for delivery using the present invention include, without limitation, pancrease, L-asparaginase, hyaluronidase, chymotrypsin, trypsin, tPA,

streptokinase, urokinase, pancreatin, collagenase, trypsinogen, chymotrypsinogen, plasminogen, streptokinase, adenyl cyclase, superoxide dismutase (SOD), and the like.

Examples of cytokines for delivery using the present invention include, without limitation, interleukins, transforming growth factors (TGFs), fibroblast growth factors (FGFs), platelet derived growth factors (PDGFs), epidermal growth factors (EGFs), connective tissue activated peptides (CTAPs), osteogenic factors, and biologically active analogs, fragments, and derivatives of such growth factors. Cytokines may be B/T-cell differentiation factors, B/T-cell growth factors, mitogenic cytokines, chemotactic cytokines, colony stimulating factors, angiogenesis factors, IFN-α, IFN-β, IFN-γ, IL1, IL2, IL3, IL4, IL5, IL6, IL7, IL8, IL9, IL10, IL11, IL12, IL13, IL14, IL15, IL16, IL17, IL18, etc., leptin, myostatin, macrophage stimulating protein, platelet-derived growth factor, TNF-α, TNF-β, NGF, CD40L, CD137L/4-1BBL, human lymphotoxin-β, G-CSF, M-CSF, GM-CSF, PDGF, IL-1α, IL1- β, IP-10, PF4, GRO, 9E3, erythropoietin, endostatin, angiostatin, VEGF or any fragments or combinations thereof. Other cytokines include members of the transforming growth factor (TGF) supergene family include the beta transforming growth factors (for example TGF-β1, TGF-β2, TGF-β3); bone morphogenetic proteins (for example, BMP-1, BMP-2, BMP-3, BMP-4, BMP-5, BMP-6, BMP-7, BMP-8, BMP-9); heparin-binding growth factors (for example, fibroblast growth factor (FGF), epidermal growth factor (EGF), platelet-derived growth factor (PDGF), insulin-like growth factor (IGF)); Inhibins (for example, Inhibin A, Inhibin B); growth differentiating factors (for example, GDF-1); and Activins (for example, Activin A, Activin B, Activin AB).

Examples of growth factors for delivery using the present invention include, without limitation, growth factors that can be isolated from native or natural sources, such as from mammalian cells, or can be prepared synthetically, such as by recombinant DNA techniques or by various chemical processes. In addition, analogs, fragments, or derivatives of these factors can be used, provided that they exhibit at least some of the biological activity of the native molecule. For example, analogs can be prepared by expression of genes altered by site-specific mutagenesis or other genetic engineering techniques.

Examples of anticoagulants for delivery using the present invention include, without limitation, include warfarin, heparin, Hirudin, and the like. Examples of factors acting on the immune system include for delivery using the present invention include, without limitation, factors which control inflammation and malignant neoplasms and factors which attack infective microorganisms, such as chemotactic peptides and bradykinins.

Examples of viral antigens include, but are not limited to, e.g., retroviral antigens such as retroviral antigens from the human immunodeficiency virus (HIV) antigens such as gene products of the gag, pol, and env genes, the Nef protein, reverse transcriptase, and other HIV components; hepatitis viral antigens such as the S, M, and L proteins of hepatitis B virus, the pre-S antigen of hepatitis B virus, and other hepatitis, e.g., hepatitis A, B, and C, viral components such as hepatitis C viral RNA; influenza viral antigens such as hemagglutinin and neuraminidase and other influenza viral components; measles viral antigens such as the measles virus fusion protein and other measles virus components; rubella viral antigens such as proteins E1 and E2 and other rubella virus components; rotaviral antigens such as VP7sc and other rotaviral components; cytomegaloviral antigens such as envelope glycoprotein B and other cytomegaloviral antigen components; respiratory syncytial viral antigens such as the RSV fusion protein, the M2 protein and other respiratory syncytial viral antigen components; herpes simplex viral antigens such as immediate early proteins, glycoprotein D, and other herpes simplex viral antigen components; varicella zoster viral antigens such as gpI, gpII, and other varicella zoster viral antigen components; Japanese encephalitis viral antigens such as proteins E, M-E, M-E-NS1, NS1, NS1-NS2A, 80% E, and other Japanese encephalitis viral antigen components; rabies viral antigens such as rabies glycoprotein, rabies nucleoprotein and other rabies viral antigen components. See Fundamental Virology, Second Edition, eds. Fields, B. N. and Knipe, D. M. (Raven Press, New York, 1991) for additional examples of viral antigens.

Antigenic targets that may be delivered using the rAb-DC/DC-antigen vaccines of the present invention include genes encoding antigens such as viral antigens, bacterial antigens, fungal antigens or parasitic antigens. Viruses include picornavirus, coronavirus, togavirus, flavirvirus, rhabdovirus, paramyxovirus, orthomyxovirus, bunyavirus, arenavirus, reovirus, retrovirus, papilomavirus, parvovirus, herpesvirus, poxvirus, hepadnavirus, and spongiform virus. Other viral targets include influenza, herpes simplex virus 1 and 2, measles, dengue, smallpox, polio or HIV. Pathogens include trypanosomes, tapeworms, roundworms, helminthes, malaria. Tumor markers, such as fetal antigen or prostate specific antigen, may be targeted in this manner. Other examples include: HIV env proteins and hepatitis B surface antigen. Administration of a vector according to the present invention for vaccination purposes would require that the vector-associated antigens be sufficiently non-immunogenic to enable long term expression of the transgene, for which a strong immune response would be desired. In some cases, vaccination of an individual may only be required infrequently, such as yearly or biennially, and provide long term immunologic protection against the infectious agent. Specific examples of organisms,

allergens and nucleic and amino sequences for use in vectors and ultimately as antigens with the present invention may be found in U.S. Patent No. 6,541,011, relevant portions incorporated herein by reference, in particular, the tables that match organisms and specific sequences that may be used with the present invention.

Bacterial antigens for use with the rAb vaccine disclosed herein include, but are not limited to, e.g., bacterial antigens such as pertussis toxin, filamentous hemagglutinin, pertactin, FIM2, FIM3, adenylate cyclase and other pertussis bacterial antigen components; diptheria bacterial antigens such as diptheria toxin or toxoid and other diptheria bacterial antigen components; tetanus bacterial antigens such as tetanus toxin or toxoid and other tetanus bacterial antigen components; streptococcal bacterial antigens such as M proteins and other streptococcal bacterial antigen components; gram-negative bacilli bacterial antigens such as lipopolysaccharides and other gram-negative bacterial antigen components, Mycobacterium tuberculosis bacterial antigens such as mycolic acid, heat shock protein 65 (HSP65), the 30 kDa major secreted protein, antigen 85A and other mycobacterial antigen components; Helicobacter pylori bacterial antigen components; pneumococcal bacterial antigens such as pneumolysin, pneumococcal capsular polysaccharides and other pneumococcal bacterial antigen components; haemophilus influenza bacterial antigens such as capsular polysaccharides and other haemophilus influenza bacterial antigen components; anthrax bacterial antigens such as anthrax protective antigen and other anthrax bacterial antigen components; rickettsiae bacterial antigens such as rompA and other rickettsiae bacterial antigen component. Also included with the bacterial antigens described herein are any other bacterial, mycobacterial, mycoplasmal, rickettsial, or chlamydial antigens. Partial or whole pathogens may also be: haemophilus influenza; Plasmodium falciparum; neisseria meningitidis; streptococcus pneumoniae; neisseria gonorrhoeae; salmonella serotype typhi; shigella; vibrio cholerae; Dengue Fever; Encephalitides; Japanese Encephalitis; lyme disease; Yersinia pestis; west nile virus; yellow fever; tularemia; hepatitis (viral; bacterial); RSV (respiratory syncytial virus); HPIV 1 and HPIV 3; adenovirus; small pox; allergies and cancers.

Fungal antigens for use with compositions and methods of the invention include, but are not limited to, e.g., candida fungal antigen components; histoplasma fungal antigens such as heat shock protein 60 (HSP60) and other histoplasma fungal antigen components; cryptococcal fungal antigens such as capsular polysaccharides and other cryptococcal fungal antigen components; coccidiodes fungal antigens such as spherule antigens and other coccidiodes fungal

antigen components; and tinea fungal antigens such as trichophytin and other coccidiodes fungal antigen components.

Examples of protozoal and other parasitic antigens include, but are not limited to, e.g., plasmodium falciparum antigens such as merozoite surface antigens, sporozoite surface antigens, circumsporozoite antigens, gametocyte/gamete surface antigens, blood-stage antigen pf 155/RESA and other plasmodial antigen components; toxoplasma antigens such as SAG-1, p30 and other toxoplasmal antigen components; schistosomae antigens such as glutathione-S-transferase, paramyosin, and other schistosomal antigen components; leishmania major and other leishmaniae antigens such as gp63, lipophosphoglycan and its associated protein and other leishmanial antigen components; and trypanosoma cruzi antigens such as the 75-77 kDa antigen, the 56 kDa antigen and other trypanosomal antigen components.

Antigen that can be targeted using the rAb of the present invention will generally be selected based on a number of factors, including: likelihood of internalization, level of immune cell specificity, type of immune cell targeted, level of immune cell maturity and/or activation and the like. Examples of cell surface markers for dendritic cells include, but are not limited to, MHC class I, MHC Class II, B7-2, CD18, CD29, CD31, CD43, CD44, CD45, CD54, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR and/or ASPGR and the like; while in some cases also having the absence of CD2, CD3, CD4, CD8, CD14, CD15, CD16, CD 19, CD20, CD56, and/or CD57. Examples of cell surface markers for antigen presenting cells include, but are not limited to, MHC class I, MHC Class II, CD40, CD45, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1 and/or Fcγ receptor. Examples of cell surface markers for T cells include, but are not limited to, CD3, CD4, CD8, CD 14, CD20, CD11b, CD16, CD45 and HLA-DR.

Target antigens on cell surfaces for delivery includes those characteristic of tumor antigens typically will be derived from the cell surface, cytoplasm, nucleus, organelles and the like of cells of tumor tissue. Examples of tumor targets for the antibody portion of the present invention include, without limitation, hematological cancers such as leukemias and lymphomas, neurological tumors such as astrocytomas or glioblastomas, melanoma, breast cancer, lung cancer, head and neck cancer, gastrointestinal tumors such as gastric or colon cancer, liver cancer, pancreatic cancer, genitourinary tumors such cervix, uterus, ovarian cancer, vaginal cancer, testicular cancer, prostate cancer or penile cancer, bone tumors, vascular tumors, or cancers of the lip, nasopharynx, pharynx and oral cavity, esophagus, rectum, gall bladder, biliary tree, larynx, lung and bronchus, bladder, kidney, brain and other parts of the nervous system, thyroid, Hodgkin's disease, non-Hodgkin's lymphoma, multiple myeloma and leukemia.

Examples of antigens that may be delivered alone or in combination to immune cells for antigen presentation using the present invention include tumor proteins, e.g., mutated oncogenes; viral proteins associated with tumors; and tumor mucins and glycolipids. The antigens may be viral proteins associated with tumors would be those from the classes of viruses noted above. Certain antigens may be characteristic of tumors (one subset being proteins not usually expressed by a tumor precursor cell), or may be a protein which is normally expressed in a tumor precursor cell, but having a mutation characteristic of a tumor. Other antigens include mutant variant(s) of the normal protein having an altered activity or subcellular distribution, e.g., mutations of genes giving rise to tumor antigens.

Specific non-limiting examples of tumor antigens include: CEA, prostate specific antigen (PSA), HER-2/neu, BAGE, GAGE, MAGE 1-4, 6 and 12, MUC (Mucin) (e.g., MUC-1, MUC-2, etc.), GM2 and GD2 gangliosides, ras, myc, tyrosinase, MART (melanoma antigen), Pmel 17(gp100), GnT-V intron V sequence (N-acetylglucoaminyltransferase V intron V sequence), Prostate Ca psm, PRAME (melanoma antigen), β-catenin, MUM-1-B (melanoma ubiquitous mutated gene product), GAGE (melanoma antigen) 1, BAGE (melanoma antigen) 2-10, c-ERB2 (Her2/neu), EBNA (Epstein-Barr Virus nuclear antigen) 1-6, gp75, human papilloma virus (HPV) E6 and E7, p53, lung resistance protein (LRP), Bcl-2, and Ki-67. In addition, the immunogenic molecule can be an autoantigen involved in the initiation and/or propagation of an autoimmune disease, the pathology of which is largely due to the activity of antibodies specific for a molecule expressed by the relevant target organ, tissue, or cells, e.g., SLE or MG. In such diseases, it can be desirable to direct an ongoing antibody-mediated (i.e., a Th2-type) immune response to the relevant autoantigen towards a cellular (i.e., a Th1-type) immune response. Alternatively, it can be desirable to prevent onset of or decrease the level of a Th2 response to the autoantigen in a subject not having, but who is suspected of being susceptible to, the relevant autoimmune disease by prophylactically inducing a Th1 response to the appropriate autoantigen. Autoantigens of interest include, without limitation: (a) with respect to SLE, the Smith protein, RNP ribonucleoprotein, and the SS-A and SS-B proteins; and (b) with respect to MG, the acetylcholine receptor.Examples of other miscellaneous antigens involved in one or more types of autoimmune response include, e.g., endogenous hormones such as luteinizing hormone, follicular stimulating hormone, testosterone, growth hormone, prolactin, and other hormones.

Antigens involved in autoimmune diseases, allergy, and graft rejection can be used in the compositions and methods of the invention. For example, an antigen involved in any one or more of the following autoimmune diseases or disorders can be used in the present invention:

diabetes, diabetes mellitus, arthritis (including rheumatoid arthritis, juvenile rheumatoid arthritis, osteoarthritis, psoriatic arthritis), multiple sclerosis, myasthenia gravis, systemic lupus erythematosis, autoimmune thyroiditis, dermatitis (including atopic dermatitis and eczematous dermatitis), psoriasis, Sjogren's Syndrome, including keratoconjunctivitis sicca secondary to Sjogren's Syndrome, alopecia areata, allergic responses due to arthropod bite reactions, Crohn's disease, aphthous ulcer, iritis, conjunctivitis, keratoconjunctivitis, ulcerative colitis, asthma, allergic asthma, cutaneous lupus erythematosus, scleroderma, vaginitis, proctitis, drug eruptions, leprosy reversal reactions, erythema nodosum leprosum, autoimmune uveitis, allergic encephalomyelitis, acute necrotizing hemorrhagic encephalopathy, idiopathic bilateral progressive sensorineural hearing loss, aplastic anemia, pure red cell anemia, idiopathic thrombocytopenia, polychondritis, Wegener's granulomatosis, chronic active hepatitis, Stevens-Johnson syndrome, idiopathic sprue, lichen planus, Crohn's disease, Graves ophthalmopathy, sarcoidosis, primary biliary cirrhosis, uveitis posterior, and interstitial lung fibrosis. Examples of antigens involved in autoimmune disease include glutamic acid decarboxylase 65 (GAD 65), native DNA, myelin basic protein, myelin proteolipid protein, acetylcholine receptor components, thyroglobulin, and the thyroid stimulating hormone (TSH) receptor. Examples of antigens involved in allergy include pollen antigens such as Japanese cedar pollen antigens, ragweed pollen antigens, rye grass pollen antigens, animal derived antigens such as dust mite antigens and feline antigens, histocompatiblity antigens, and penicillin and other therapeutic drugs. Examples of antigens involved in graft rejection include antigenic components of the graft to be transplanted into the graft recipient such as heart, lung, liver, pancreas, kidney, and neural graft components. The antigen may be an altered peptide ligand useful in treating an autoimmune disease.

As used herein, the term “epitope(s)” refer to a peptide or protein antigen that includes a primary, secondary or tertiary structure similar to an epitope located within any of a number of pathogen polypeptides encoded by the pathogen DNA or RNA. The level of similarity will generally be to such a degree that monoclonal or polyclonal antibodies directed against such polypeptides will also bind to, react with, or otherwise recognize, the peptide or protein antigen. Various immunoassay methods may be employed in conjunction with such antibodies, such as, for example, Western blotting, ELISA, RIA, and the like, all of which are known to those of skill in the art. The identification of pathogen epitopes, and/or their functional equivalents, suitable for use in vaccines is part of the present invention. Once isolated and identified, one may readily obtain functional equivalents. For example, one may employ the methods of Hopp,

as taught in U.S. Pat. No. 4,554,101, incorporated herein by reference, which teaches the identification and preparation of epitopes from amino acid sequences on the basis of hydrophilicity. The methods described in several other papers, and software programs based thereon, can also be used to identify epitopic core sequences (see, for example, Jameson and Wolf, 1988; Wolf et al., 1988; U.S. Pat. No. 4,554,101). The amino acid sequence of these "epitopic core sequences" may then be readily incorporated into peptides, either through the application of peptide synthesis or recombinant technology.

The preparation of vaccine compositions that includes the nucleic acids that encode antigens of the invention as the active ingredient, may be prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid prior to infection can also be prepared. The preparation may be emulsified, encapsulated in liposomes. The active immunogenic ingredients are often mixed with carriers which are pharmaceutically acceptable and compatible with the active ingredient.

The term "pharmaceutically acceptable carrier" refers to a carrier that does not cause an allergic reaction or other untoward effect in subjects to whom it is administered. Suitable pharmaceutically acceptable carriers include, for example, one or more of water, saline, phosphate buffered saline, dextrose, glycerol, ethanol, or the like and combinations thereof. In addition, if desired, the vaccine can contain minor amounts of auxiliary substances such as wetting or emulsifying agents, pH buffering agents, and/or adjuvants which enhance the effectiveness of the vaccine. Examples of adjuvants that may be effective include but are not limited to: aluminum hydroxide, N-acetyl-muramyl-L-threonyl-D-isoglutamine (thr-MDP), N-acetyl-nor-muramyl-L-alanyl-D-isoglutamine, MTP-PE and RIBI, which contains three components extracted from bacteria, monophosporyl lipid A, trehalose dimycolate and cell wall skeleton (MPL+TDM+CWS) in a 2% squalene/Tween 80 emulsion. Other examples of adjuvants include DDA (dimethyldioctadecylammonium bromide), Freund's complete and incomplete adjuvants and QuilA. In addition, immune modulating substances such as lymphokines (e.g., IFN-γ, IL-2 and IL-12) or synthetic IFN-γ inducers such as poly I:C can be used in combination with adjuvants described herein.

Pharmaceutical products that may include a naked polynucleotide with a single or multiple copies of the specific nucleotide sequences that bind to specific DNA-binding sites of the apolipoproteins present on plasma lipoproteins as described in the current invention. The polynucleotide may encode a biologically active peptide, antisense RNA, or ribozyme and will be provided in a physiologically acceptable administrable form. Another pharmaceutical

product that may spring from the current invention may include a highly purified plasma lipoprotein fraction, isolated according to the methodology, described herein from either the patients blood or other source, and a polynucleotide containing single or multiple copies of the specific nucleotide sequences that bind to specific DNA-binding sites of the apolipoproteins present on plasma lipoproteins, prebound to the purified lipoprotein fraction in a physiologically acceptable, administrable form.

Yet another pharmaceutical product may include a highly purified plasma lipoprotein fraction which contains recombinant apolipoprotein fragments containing single or multiple copies of specific DNA-binding motifs, prebound to a polynucleotide containing single or multiple copies of the specific nucleotide sequences, in a physiologically acceptable administrable form. Yet another pharmaceutical product may include a highly purified plasma lipoprotein fraction which contains recombinant apolipoprotein fragments containing single or multiple copies of specific DNA-binding motifs, prebound to a polynucleotide containing single or multiple copies of the specific nucleotide sequences, in a physiologically acceptable administrable form.

The dosage to be administered depends to a great extent on the body weight and physical condition of the subject being treated as well as the route of administration and frequency of treatment. A pharmaceutical composition that includes the naked polynucleotide prebound to a highly purified lipoprotein fraction may be administered in amounts ranging from 1 μg to 1 mg polynucleotide and 1 μg to 100 mg protein.

Administration of an rAb and rAb complexes a patient will follow general protocols for the administration of chemotherapeutics, taking into account the toxicity, if any, of the vector. It is anticipated that the treatment cycles would be repeated as necessary. It also is contemplated that various standard therapies, as well as surgical intervention, may be applied in combination with the described gene therapy.

Where clinical application of a gene therapy is contemplated, it will be necessary to prepare the complex as a pharmaceutical composition appropriate for the intended application. Generally this will entail preparing a pharmaceutical composition that is essentially free of pyrogens, as well as any other impurities that could be harmful to humans or animals. One also will generally desire to employ appropriate salts and buffers to render the complex stable and allow for complex uptake by target cells.

Aqueous compositions of the present invention may include an effective amount of the compound, dissolved or dispersed in a pharmaceutically acceptable carrier or aqueous medium.

Such compositions can also be referred to as inocula. The use of such media and agents for pharmaceutical active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active ingredient, its use in the therapeutic compositions is contemplated. Supplementary active ingredients also can be incorporated into the compositions. The compositions of the present invention may include classic pharmaceutical preparations. Dispersions also can be prepared in glycerol, liquid polyethylene glycols, and mixtures thereof and in oils. Under ordinary conditions of storage and use, these preparations contain a preservative to prevent the growth of microorganisms.

Disease States. Depending on the particular disease to be treated, administration of therapeutic compositions according to the present invention will be via any common route so long as the target tissue is available via that route in order to maximize the delivery of antigen to a site for maximum (or in some cases minimum) immune response. Administration will generally be by orthotopic, intradermal, subcutaneous, intramuscular, intraperitoneal or intravenous injection. Other areas for delivery include: oral, nasal, buccal, rectal, vaginal or topical. Topical administration would be particularly advantageous for treatment of skin cancers. Such compositions would normally be administered as pharmaceutically acceptable compositions that include physiologically acceptable carriers, buffers or other excipients.

Vaccine or treatment compositions of the invention may be administered parenterally, by injection, for example, either subcutaneously or intramuscularly. Additional formulations which are suitable for other modes of administration include suppositories, and in some cases, oral formulations or formulations suitable for distribution as aerosols. In the case of the oral formulations, the manipulation of T-cell subsets employing adjuvants, antigen packaging, or the addition of individual cytokines to various formulation that result in improved oral vaccines with optimized immune responses. For suppositories, traditional binders and carriers may include, for example, polyalkylene glycols or triglycerides; such suppositories may be formed from mixtures containing the active ingredient in the range of 0.5% to 10%, preferably 1%-2%. Oral formulations include such normally employed excipients as, for example, pharmaceutical grades of mannitol, lactose, starch magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, and the like. These compositions take the form of solutions, suspensions, tablets, pills, capsules, sustained release formulations or powders and contain 10%-95% of active ingredient, preferably 25-70%.

The antigen encoding nucleic acids of the invention may be formulated into the vaccine or treatment compositions as neutral or salt forms. Pharmaceutically acceptable salts include the

acid addition salts (formed with free amino groups of the peptide) and which are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or with organic acids such as acetic, oxalic, tartaric, maleic, and the like. Salts formed with the free carboxyl groups can also be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium, or ferric hydroides, and such organic bases as isopropylamine, trimethylamine, 2-ethylamino ethanol, histidine, procaine, and the like.

Vaccine or treatment compositions are administered in a manner compatible with the dosage formulation, and in such amount as will be prophylactically and/or therapeutically effective. The quantity to be administered depends on the subject to be treated, including, e.g., capacity of the subject's immune system to synthesize antibodies, and the degree of protection or treatment desired. Suitable dosage ranges are of the order of several hundred micrograms active ingredient per vaccination with a range from about 0.1 mg to 1000 mg, such as in the range from about 1 mg to 300 mg, and preferably in the range from about 10 mg to 50 mg. Suitable regiments for initial administration and booster shots are also variable but are typified by an initial administration followed by subsequent inoculations or other administrations. Precise amounts of active ingredient required to be administered depend on the judgment of the practitioner and may be peculiar to each subject. It will be apparent to those of skill in the art that the therapeutically effective amount of nucleic acid molecule or fusion polypeptides of this invention will depend, inter alia, upon the administration schedule, the unit dose of antigen administered, whether the nucleic acid molecule or fusion polypeptide is administered in combination with other therapeutic agents, the immune status and health of the recipient, and the therapeutic activity of the particular nucleic acid molecule or fusion polypeptide.

The compositions can be given in a single dose schedule or in a multiple dose schedule. A multiple dose schedule is one in which a primary course of vaccination may include, e.g., 1-10 separate doses, followed by other doses given at subsequent time intervals required to maintain and or reinforce the immune response, for example, at 1-4 months for a second dose, and if needed, a subsequent dose(s) after several months. Periodic boosters at intervals of 1-5 years, usually 3 years, are desirable to maintain the desired levels of protective immunity. The course of the immunization can be followed by in vitro proliferation assays of peripheral blood lymphocytes (PBLs) co-cultured with ESAT6 or ST-CF, and by measuring the levels of IFN-γ released from the primed lymphocytes. The assays may be performed using conventional labels, such as radionucleotides, enzymes, fluorescent labels and the like. These techniques are known

to one skilled in the art and can be found in U.S. Pat. Nos. 3,791,932, 4,174,384 and 3,949,064, relevant portions incorporated by reference.

The modular rAb carrier and/or conjugated rAb carrier-(cohesion/dockerin and/or dockerin-cohesin)-antigen complex (rAb-DC/DC-antigen vaccine) may be provided in one or more "unit doses" depending on whether the nucleic acid vectors are used, the final purified proteins, or the final vaccine form is used. Unit dose is defined as containing a predetermined-quantity of the therapeutic composition calculated to produce the desired responses in association with its administration, i.e., the appropriate route and treatment regimen. The quantity to be administered, and the particular route and formulation, are within the skill of those in the clinical arts. The subject to be treated may also be evaluated, in particular, the state of the subject's immune system and the protection desired. A unit dose need not be administered as a single injection but may include continuous infusion over a set period of time. Unit dose of the present invention may conveniently may be described in terms of DNA/kg (or protein/Kg) body weight, with ranges between about 0.05, 0.10, 0.15, 0.20, 0.25, 0.5, 1, 10, 50, 100, 1,000 or more mg/DNA or protein/kg body weight are administered. Likewise the amount of rAb-DC/DC-antigen vaccine delivered can vary from about 0.2 to about 8.0 mg/kg body weight. Thus, in particular embodiments, 0.4 mg, 0.5 mg, 0.8 mg, 1.0 mg, 1.5 mg, 2.0 mg, 2.5 mg, 3.0 mg, 4.0 mg, 5.0 mg, 5.5 mg, 6.0 mg, 6.5 mg, 7.0 mg and 7.5 mg of the vaccine may be delivered to an individual in vivo. The dosage of rAb-DC/DC-antigen vaccine to be administered depends to a great extent on the weight and physical condition of the subject being treated as well as the route of administration and the frequency of treatment. A pharmaceutical composition that includes a naked polynucleotide prebound to a liposomal or viral delivery vector may be administered in amounts ranging from 1 μg to 1 mg polynucleotide to 1 μg to 100 mg protein. Thus, particular compositions may include between about 1 μg, 5 μg, 10 μg, 20 μg, 30 μg, 40 μg, 50 μg, 60 μg, 70 μg, 80 μg, 100 μg, 150 μg, 200 μg, 250 μg, 500 μg, 600 μg, 700 μg, 800 μg, 900 μg or 1,000 μg polynucleotide or protein that is bound independently to 1 μg, 5 μg, 10 μg, 20 μg, 3.0 μg, 40 μg 50 μg, 60 μg, 70 μg, 80 μg, 100 μg, 150 μg, 200 μg, 250 μg, 500 μg, 600 μg, 700 μg, 800 μg, 900 μg, 1 mg, 1.5 mg, 5 mg, 10 mg, 20 mg, 30 mg, 40 mg, 50 mg, 60 mg, 70 mg, 80 mg, 90 mg or 100 mg vector.

The present invention was tested in an in vitro cellular system that measures immune stimulation of human Flu-specific T cells by dendritic cells to which Flu antigen has been targeted. The results shown herein demonstrate the specific expansion of such antigen specific cells at doses of the antigen which are by themselves ineffective in this system.

The present invention may also be used to make a modular rAb carrier that is, e.g., a recombinant humanized mAb (directed to a specific human dendritic cell receptor) complexed with protective antigens from Ricin, Anthrax toxin, and Staphylococcus B enterotoxin. The potential market for this entity is vaccination of all military personnel and stored vaccine held in reserve to administer to large population centers in response to any biothreat related to these agents. The invention has broad application to the design of vaccines in general, both for human and animal use. Industries of interest include the pharmaceutical and biotechnology industries.

The present invention includes compositions and methods, including vaccines, that specifically target (deliver) antigens to antigen-presenting cells (APCs) for the purpose of eliciting potent and broad immune responses directed against the antigen. These compositions evoke protective or therapeutic immune responses against the agent (pathogen or cancer) from which the antigen was derived. In addition the invention creates agents that are directly, or in concert with other agents, therapeutic through their specific engagement of a receptor called DC-ASGPR that is expressed on antigen-presenting cells.

The novel recombinant humanized mAb (directed to the specific human dendritic cell receptor DC-ASGPR) fused through the antibody (Ab) heavy chain to antigens known or suspected to encode protective antigens. These include as examples for vaccination against various agents - hemagglutinins from Influenza H5N1; HIV gag from attenuated toxins from Ricin, Anthrax toxin, and Staphylococcus B enterotoxin; 'strings' of antigenic peptides from melanona antigens, etc. The present invention may be used as a preventative or therapeutic vaccination for at risk or infected patients. The invention has broad application for vaccination against many diseases and cancers, both for human and animal use. Industries that can use the present invention include the pharmaceutical and biotechnological.

The present invention can be used to target antigens to APC for vaccination purposes. It is not known which antigen internalizing receptor will be best suited for this purpose. The invention describes particularly advantageous features of DC-ASGPR as for this purpose. Furthermore, the invention shows that engaging DC-ASGPR can be beneficial in the sense of activating the immune system with highly predicted significant therapeutic benefit.

The present invention includes the development of high affinity monoclonal antibodies against human DC-ASGPR. Receptor ectodomain.hIgG (human IgG1Fc) and AP (human placental alkaline phosphatase) fusion proteins were produced for immunization of mice and screening of mAbs, respectively. An expression construct for hDCIR ectodomain.IgG was described

previously (Bates, Fournier et al. 1999) and used the mouse SLAM (mSLAM) signal peptide to direct secretion (Bendtsen, Nielsen et al. 2004). An expression vector for hDCIR ectodomain.AP was generated using PCR to amplify AP resides 133-1581 (gb|BC009647|) while adding a proximal in-frame Xho I site and a distal TGA stop codon and Not I site. This Xho I – Not I fragment replaced the IgG coding sequence in the above hDCIR ectodomain.IgG vector. DC-ASGPR ectodomain constructs in the same Ig and AP vector series contained inserts encoding (bp 484-1251, gi|53832017). DC-ASGPR fusion proteins were produced using the FreeStyle™ 293 Expression System (Invitrogen) according to the manufacturer's protocol (1 mg total plasmid DNA with 1.3 ml 293 Fectin reagent /L of transfection). For rAb production, equal amounts of vector encoding the H and L chain were co-transfected. Transfected cells are cultured for 3 days, the culture supernatant was harvested and fresh media added with continued incubation for two days. The pooled supernatants were clarified by filtration. Receptor ectodomain.hIgG was purified by HiTrap protein A affinity chromatography with elution by 0.1 M glycine pH 2.7 and then dialyzed versus PBS. rAbs (recombinant antibodies described later)were purified similarly, by using HiTrap MabSelect™ columns. Mouse mAbs were generated by conventional cell fusion technology. Briefly, 6-week-old BALB/c mice were immunized intraperitonealy with 20 μg of receptor ectodomain.hIgGFc fusion protein with Ribi adjuvant, then boosts with 20 μg antigen 10 days and 15 days later. After 3 months, the mice were boosted again three days prior to taking the spleens. Alternately, mice were injected in the footpad with 1-10 μg antigen in Ribi adjuvant every 3-4 days over a 30-40 day period. 3-4 days after a final boost, draining lymph nodes were harvested. B cells from spleen or lymph node cells were fused with SP2/O-Ag 14 cells (Shulman, Wilde et al. 1978) using conventional techniques. ELISA was used to screen hybridoma supernatants against the receptor ectodomain fusion protein compared to the fusion partner alone, or versus the receptor ectodomain fused to AP (Bates, Fournier et al. 1999). Positive wells were then screened in FACS using 293F cells transiently transfected with expression plasmids encoding full-length receptor cDNAs. Selected hybridomas were single cell cloned and expanded in CELLine flasks (Intergra). Hybridoma supernatants were mixed with an equal volume of 1.5 M glycine, 3 M NaCl, 1x PBS, pH 7.8 and tumbled with MabSelect resin. The resin was washed with binding buffer and eluted with 0.1 M glycine, pH 2.7. Following neutralization with 2 M Tris, mAbs were dialyzed versus PBS.

Characterization of purified anti-DC-ASGPR monoclonal antibodies by direct ELISA. the relative affinities of several anti-DC-ASGPR mAbs by ELISA were determined (i.e., DC-ASGPR.Ig protein is immobilized on the microplate surface and the antibodies are tested in a

dose titration series for their ability to bind to DC-ASGPR.Ig (as detected by an anti-mouse IgG.HRP conjugate reagent. In this example, PAB42 and PAB44 show higher affinity binding than other mAbs. The same mAbs fail to bind significantly to human Ig bound to the microplate surface. This shows that the mAbs react to the DC-ASGPR ectodomain part of the DC-ASGPR.Ig fusion protein (data not shown).

Characterization of purified anti-DC-ASGPR monoclonal antibodies by indirect ELISA. Next, the relative affinities of several anti-DC-ASGPR mAbs were determined by ELISA (i.e., anti-DC-ASGPR mAb is immobilized on the microplate surface and tested in a dose titration series for their ability to bind to DC-ASGPR.AP reagent. It was found that the supernatants from the hybridomas listed as: PAB42, PAB44 and PAB54 show higher affinity binding than other mAbs (data not shown).

Characterization of anti-DC-ASGPR mAbs by FACS. The panel of mAbs was also tested by FACS versus 293F cells transfected with expression plasmid directing synthesis of cell surface DC-ASGPR. Mean fluorescence intensity of the signal was subtracted from the analogous signal versus non-transfected 293F cells. By this criterion, the mAbs are able to bind to specifically to the surface of cells bearing DC-ASGPR. Some mAbs, e.g., 37A7 appear particularly advantageous in this regard (data not shown).

Figures 1A to 1D shows that signaling through DC-ASGPR activates DCs. DCs are the primary immune cells that determine the results of immune responses, either induction or tolerance, depending on their activation (*15*). The role of LLRs in DC activation is not clear yet. Therefore, we tested whether triggering the LLR DC-ASGPR can result in the activation of DCs. Both three and six day in vitro cultured GM/IL-4 DCs express LOX-1, ASGPR, and CLEC-6 (Fig. 1A). Six day DCs were stimulated with mAb specific to DC-ASGPR, and data in Fig. 1B show that signals through DC-ASGPR could activate DCs, resulting in the increased expression of CD86 and HLA-DR. Triggering DC-ASGPR on DCs also resulted in the increased production of IL-6, MCP-1, IL-12p40, and IL-8 from DCs (Fig. 1C). Other cytokines and chemokines, TNFa, IP-10, MIP-1a, and IL-10, were also significantly increased (data not shown) by signaling through DC-ASGPR, suggesting that DC-ASGPR can deliver cellular signals to activate DCs. Consistently, DCs stimulated with DC-ASGPR specific mAb expressed increased levels of multiple genes, including co-stimulatory molecules as well as chemokine and cytokine-related genes (Fig. 1D). The possible contribution of LLRs in TLR2 and TLR4-mediated immune cell activation has been described previously (*13, 16*). We observed that signals through DC-ASGPR could synergize with signal through CD40 for a further activation of DCs (Fig. 1E). This is important

because LLRs could serve as co-stimulatory molecules during in vivo DC activation. Taken together, data in Fig. 1 prove that signaling through DC-ASGPR can activate DCs and that DC-ASGPR serves as a co-stimulatory molecule for the activation of DCs. DC-ASGPR engagement during CD40-CD40L interaction results in dramatically increased production of IL-12p70.

DCs stimulated through DC-ASGPR induce potent humoral immune responses. DCs play an important role in humoral immune responses by providing signals for both T-dependent and T-independent B cell responses (*19-22*) and by transferring antigens to B cells (*23, 24*). In addition to DCs, signaling through TLR9 as a third signal is necessary for efficient B cell responses (*25, 26*).

Therefore, we tested the role of DC-ASGPR in DCs-mediated humoral immune responses in the presence of TLR9 ligand, CpG. Six day GM/IL-4 DCs were stimulated with anti- DC-ASGPR mAb, and then purified B cells were co-cultured. As shown in Fig. 2A, DCs activated with anti-DC-ASGPR mAb resulted in remarkably enhanced B cell proliferation (CFSE dilution) and plasma cell differentiation ($CD38^+CD20^-$), compared to DCs stimulated with control mAb. $CD38^+CD20^-$ B cells have a typical morphology of plasma cells, but they do not express CD138. The majority of proliferating cells did not express CCR2, CCR4, CCR6, or CCR7. The amounts of total immunoglobulins (Igs) produced were measured by ELISA (Fig. 2B). Consistent with the data in Fig. 2A, B cells cultured with anti DC-ASGPR-stimulated DCs resulted in significantly increased production of total IgM, IgG, and IgA. In addition to the total Igs, we also observed that DCs activated by triggering DC-ASGPR are more potent than DCs stimulated with control mAb for the production of influenza-virus-specific IgM, IgG, and IgA (Fig. 2C) by B cells, suggesting that DC-ASGPR-mediated DC activation contributes to both total and antigen specific humoral immune responses. We tested the role of DC-ASGPR in ex vivo antigen presenting cells (APCs) in humoral immune responses. Parts of APCs in PBMCs, including $CD19^+$ and $CD14^+$ cells, express DC-ASGPR (Supplementary Fig. 2). PBMCs from buffy coats were cultured in the plates coated with anti- DC-ASGPR mAb, and the total Igs and B cell proliferation were measured. Consistent with the data generated from DCs (Fig. 2A), APCs stimulated through DC-ASGPR resulted in enhanced B cell proliferation and plasma cell differentiation in the absence (upper panels in Fig. 2d) or presence (lower panels in Fig. 2D) of TLR9 ligand. The total IgM, IgG, and IgA were also significantly increased when PBMCs were cultured in the plates coated with mAb against DC-ASGPR (Fig. 2e). As shown in Fig. 1, DCs activated by signaling through DC-ASGPR have matured phenotypes and produce large amounts of inflammatory cytokines and chemokines, and both matured DC phenotypes and soluble

factors from DCs could contribute to the enhanced B cells responses (Fig. 2). However, DC-derived B lymphocyte stimulator protein (BLyS, BAFF) and a proliferation-inducing ligand (APRIL) are also important molecules by which DCs can directly regulate human B cell proliferation and function (*27-30*). Therefore, we tested whether signals through DC-ASGPR could alter the expression levels of BLyS and APRIL. Data in Fig. 2d show that DCs stimulated through DC-ASGPR expressed increased levels of intracellular APRIL as well as APRIL secreted, but not BLyS (not shown). Expression levels of BLyS and APRIL receptors on B cells in the mixed cultures were measured, but there was no significant change (not shown).

DC-ASGPR contributes to B cell activation and Ig production. $CD19^+$ B cells express DC-ASGPR (Fig. 3A). Therefore, we tested the role of DC-ASGPR in B cell activation. Data in Fig. 3B show that B cells stimulated through DC-ASGPR produced significantly higher amounts of chemokines. In addition to IL-8 and MIP-1a, slight increases in IL-6 and TNFα were also observed when B cells were stimulated with the anti- DC-ASGPR mAb, compared to control mAb. Genes related to cell activation were also up-regulated (Fig. 3C). B cells produced IgM, IgG, and IgA when they were stimulated through DC-ASGPR (Fig. 3D), suggesting that DC-ASGPR could play an important role in the maintenance of normal immunoglobulin levels in vivo. However, signaling through DC-ASGPR alone did not induce significant B cell proliferation.

Role of DC-ASGPR in T cell responses. DCs stimulated through DC-ASGPR express enhanced levels of co-stimulatory molecules and produce increased amounts of cytokines and chemokines (see Fig. 1), suggesting that DC-ASGPR contributes to cellular immune responses as well as humoral immune responses. This was tested by a mixed lymphocyte reaction (MLR). Proliferation of purified allogeneic T cells was significantly enhanced by DCs stimulated with mAb specific for DC-ASGPR (Fig. 4A). DCs activated through DC-ASGPR could also prime Mart-1-specific CD8 T cells more efficiently than DC stimulated with control mAb (upper panels in Fig. 4B). More importantly, signaling through DC-ASGPR permitted DCs to cross-prime Mart-1 peptides to CD8 T cells (lower panels in Fig. 4B). This indicates that DC-ASGPR plays an important role in enhancing DC function, resulting in better priming and cross-priming of antigens to CD8 T cells. The role of DC-ASGPR expressed on the mixture of APCs in PBMCs in activation of T cell responses is shown in Fig. 4C where PBMCs stimulated with mAb to DC-ASGPR resulted in an increased frequency of Flu M1 tetramer specific CD8 T cells compared to DCs stimulated with control mAb. This enhanced antigen specific CD8 T cell

response was supported by the data in Fig. 4D, showing that DCs stimulated through DC-ASGPR significantly increase CD4 T cell proliferation.

Materials and Methods.

Antibodies and tetramers -Antibodies (Abs) for surface staining of DCs and B cells, including isotype control Abs, were purchased from BD Biosciences (CA). Abs for ELISA were purchased from Bethyl (TX). Anti-BLyS and anti-APRIL were from PeproTech (NJ). Tetramers, HLA-A*0201–GILGFVFTL (SEQ ID NO.: 1) (Flu M1) and HLA-A*0201-ELAGIGILTV (SEQ ID NO.: 2) (Mart-1), were purchased from Beckman Coulter (CA).

Cells and cultures - Monocytes ($1x10^6$/ml) from normal donors were cultured in Cellgenics (France) media containing GM-CSF (100 ng/ml) and IL-4 (50 ng/ml) (R&D, CA). For day three and day six, DCs, the same amounts of cytokines were supplemented into the media on day one and day three, respectively. B cells were purified with a negative isolation kit (BD). CD4 and CD8 T cells were purified with magnetic beads coated with anti-CD4 or CD8 (Milteniy, CA). PBMCs were isolated from Buffy coats using Percoll™ gradients (GE Healthcare UK Ltd, Buckinghamshire, UK) by density gradient centrifugation. For DC activation, $1x10^5$ DCs were cultured in the mAb-coated 96-well plate for 16-18h. mAbs (1-2 μg/well) in carbonate buffer, pH 9.4, were incubated for at least 3h at 37°C. Culture supernatants were harvested and cytokines / chemokines were measured by Luminex (Biorad, CA). For gene analysis, DCs were cultured in the plates coated with mAbs for 8h. In some experiments, soluble 50 ng/ml of CD40L (R&D, CA) or 50 nM CpG (InVivogen, CA) was added into the cultures. In the DCs and B cell co-cultures, $5x10^3$ DCs resuspended in RPMI 1640 with 10% FCS and antibiotics (Biosource, CA) were first cultured in the plates coated with mAbs for at least 6h, and then $1x10^5$ purified autologous B cells labeled with CFSE (Molecular Probes, OR) were added. In some experiments, DCs were pulsed with 5 moi (multiplicity of infection) of heat-inactivated influenza virus (A/PR/8 H1N1) for 2h, and then mixed with B cells. For the DCs and T cell co-cultures, $5x10^3$ DCs were cultured with $1x10^5$ purified autologous CD8 T cells or mixed allogeneic T cells. Allogeneic T cells were pulsed with 1 μCi/well ^{3}[H]-thymidine for the final 18h of incubation, and then cpm were measured by a μ-counter (Wallac, MN). $5x10^5$ PBMCs /well were cultured in the plates coated with mAbs. The frequency of Mart-1 and Flu M1 specific CD8 T cells was measured by staining cells with anti-CD8 and tetramers on day ten and day seven of the cultures, respectively. 10 μM of Mart-1 peptide (ELAGIGILTV) (SEQ ID NO.: 2) and 20 nM of recombinant protein containing Mart-1 peptides (see below) were added to the

DC and CD8 T cell cultures. 20 nM purified recombinant Flu M1 protein (see below) was add to the PBMC cultures.

Monoclonal antibodies - Mouse mAbs were generated by conventional technology. Briefly, six-week-old BALB/c mice were immunized i.p. with 20 μg of receptor ectodomain.hIgGFc fusion protein with Ribi adjuvant, then boosts with 20 μg antigen ten days and fifteen days later. After three months, the mice were boosted again three days prior to taking the spleens. Alternately, mice were injected in the footpad with 1-10 μg antigen in Ribi adjuvant every three to four days over a thirty to forty day period. Three to four days after a final boost, draining lymph nodes were harvested. B cells from spleen or lymph node cells were fused with SP2/O-Ag 14 cells. Hybridoma supernatants were screened to analyze Abs to the receptor ectodomain fusion protein compared to the fusion partner alone, or the receptor ectodomain fused to alkaline phosphatase (*44*). Positive wells were then screened in FACS using 293F cells transiently transfected with expression plasmids encoding full-length receptor cDNAs. Selected hybridomas were single cell cloned and expanded in CELLine flasks (Integra, CA). Hybridoma supernatants were mixed with an equal volume of 1.5 M glycine, 3 M NaCl, 1x PBS, pH 7.8 and tumbled with MabSelect resin. The resin was washed with binding buffer and eluted with 0.1 M glycine, pH 2.7. Following neutralization with 2 M Tris, mAbs were dialyzed versus PBS.

ELISA - Sandwich ELISA was performed to measure total IgM, IgG, and IgA as well as flu-specific immunoglobulins (Igs). Standard human serum (Bethyl) containing known amounts of Igs and human AB serum were used as standard for total Igs and flu-specific Igs, respectively. Flu specific Ab titers, units, in samples were defined as dilution factor of AB serum that shows an identical optical density. The amounts of BAFF and BLyS were measured by ELISA kits (Bender MedSystem, CA).

RNA purification and gene analysis - Total RNA extracted with RNeasy columns (Qiagen), and analyzed with the 2100 Bioanalyser (Agilent). Biotin-labeled cRNA targets were prepared using the Illumina totalprep labeling kit (Ambion) and hybridized to Sentrix Human6 BeadChips (46K transcripts). These microarrays consist of 50mer oligonucleotide probes attached to 3μm beads which are lodged into microwells etched at the surface of a silicon wafer. After staining with Streptavidin-Cy3, the array surface is imaged using a sub-micron resolution scanner manufactured by Illumina (Beadstation 500X). A gene expression analysis software program, GeneSpring, Version 7.1 (Agilent), was used to perform data analysis.

Expression and purification of recombinant Flu M1 and MART-1 proteins - PCR was used to amplify the ORF of Influenza A/Puerto Rico/8/34/Mount Sinai (H1N1) M1 gene while incorporating an Nhe I site distal to the initiator codon and a Not I site distal to the stop codon. The digested fragment was cloned into pET-28b(+) (Novagen), placing the M1 ORF in-frame with a His6 tag, thus encoding His.Flu M1 protein. A pET28b (+) derivative encoding an N-terminal 169 residue cohesin domain from *C. thermocellum* (unpublished) inserted between the Nco I and Nhe I sites expressed Coh.His. For expression of Cohesin-Flex-hMART-1-PeptideA-His, the sequence GACACCACCGAGGCCCGCCACCCCCACCCCCCCGTGACCACCCCCACCACCACCGA CCGGAAGGGCACCACCGCCGAGGAGCTGGCCGGCATCGGCATCCTGACCGTGATCC TGGGCGGCAAGCGGACCAACAACAGCACCCCCACCAAGGGCGAATTCTGCAGATAT CCATCACACTGGCGGCCG (SEQ ID NO.: 3) (encoding DTTEARHPHPPVTTPTTDRKGTTAEELAGIGILTVILGGKRTNNSTPTKGEFCRYPSHWR P (SEQ ID NO.: 4) - the shaded residues are the immunodominant HLA-A2-restricted peptide and the underlined residues surrounding the peptide are from MART-1) was inserted between the Nhe I and Xho I sites of the above vector. The proteins were expressed in *E. coli* strain BL21 (DE3) (Novagen) or T7 Express (NEB), grown in LB at 37°C with selection for kanamycin resistance (40 μg/ml) and shaking at 200 rounds/min to mid log phase growth when 120 mg/L IPTG was added. After three hours, the cells were harvested by centrifugation and stored at -80°C. *E. coli* cells from each l L fermentation were resuspended in 30 ml ice-cold 50 mM Tris, 1 mM EDTA pH 8.0 (buffer B) with 0.1 ml of protease inhibitor Cocktail II (Calbiochem, CA). The cells were sonicated on ice 2x 5 min at setting 18 (Fisher Sonic Dismembrator 60) with a 5 min rest period and then spun at 17,000 r.p.m. (Sorvall SA-600) for 20 min at 4°C. For His.Flu M1 purification the 50 ml cell lysate supernatant fraction was passed through 5 ml Q Sepharose beads and 6.25 ml 160 mM Tris, 40 mM imidazole, 4 M NaCl pH 7.9 was added to the Q Sepharose flow through. This was loaded at 4 ml/min onto a 5 ml HiTrap chelating HP column charged with Ni++. The column-bound protein was washed with 20 mM $NaPO_4$, 300 mM NaCl pH 7.6 (buffer D) followed by another wash with 100 mM H_3COONa pH 4.0. Bound protein was eluted with 100 mM H_3COONa pH 4.0. The peak fractions were pooled and loaded at 4 ml/min onto a 5 ml HiTrap S column equilibrated with 100 mM H_3COONa pH 5.5, and washed with the equilibration buffer followed by elution with a gradient from 0 - 1 M NaCl in 50 mM $NaPO_4$ pH 5.5. Peak fractions eluting at about 500 mM NaCl were pooled. For Coh.Flu M1.His purification, cells from 2 L of culture were lysed as above. After centrifugation, 2.5 ml of Triton

X114 was added to the supernatant with incubation on ice for 5 min. After further incubation at 25°C for 5 min, the supernatant was separated from the Triton X114 following centrifugation at 25°C. The extraction was repeated and the supernatant was passed through 5 ml of Q Sepharose beads and 6.25 ml 160 mM Tris, 40 mM imidazole, 4 M NaCl pH 7.9 was added to the Q Sepharose flow through. The protein was then purified by Ni^{++} chelating chromatography as described above and eluted with 0-500 mM imidazole in buffer D.

Only particular anti-DC-ASGPR mAbs have DC activation properties – The invention discloses that DC activation is not a general property of anti-DC-ASGPR antibodies, rather only certain anti-DC-ASGPR mAbs have this function. Figure 5 shows that only certain mAbs activate DCS through the DC-ASGPR, which must be characterized by screening against actual DCs.

Particular sequences corresponding to the L and H variable regions of anti-DC-ASGPR mAbs – The invention encompasses particular amino acid sequences shown below corresponding to anti-DC-ASGPR monoclonal antibodies that are desirable components (in the context of e.g., humanized recombinant antibodies) of therapeutic or protective products. The following are such sequences in the context of chimeric mouse V region – human C region recombinant antibodies. [mAnti-ASGPR_49C11_7H-LV-hIgG4H-C] is

DVQLQESGPDLVKPSQSLSLTCTVTGYSITSGYSWHWIRQFPGNKLEWMGYILFSGSTN
YNPSLKSRISITRDTSKNQFFLQLNSVTTEDTATYFCARSNYGSFASWGQGTLVTVSAAK
TTGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL
YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFL
FPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTY
RVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMT
KNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQ
EGNVFSCSVMHEALHNHYTQKSLSLSLGKAS (SEQ ID NO.: 5). The above sequence is a chimera between the H chain V-region of the mAb 49C11 (shown underlined) and the C region of hIgG4. [mAnti-ASGPR_49C11_7K-LV-hIgGK-C] is the corresponding L chain chimera –

QIVLTQSPAIMSASPGEKVTMTCSASSSVSHMHWYQQKSGTSPKRWIYDTSRLASGVPA
RFSGSGSGTSYSLTISSMEAEDAATYYCQQWSSHPWSFGGGTKLEIKRTVAAPSVFIFPP
SDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSST
LTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO.: 6). [mAnti-ASGPR_4G2.2_Hv-V-hIgG4H-C] is –

QIQLVQSGPELKKPGETVKISCKASGYTFTNYGMNWVKQVPGKGLRWMGWMDTFTG
EPTYADDFKGRFAFSLETSASTAYLQINSLKNEDTATYFCARGGILRLNYFDYWGQGTT

LTVSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPA
VLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFE
GGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPRE
EQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLP
PSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLT
VDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGKAS (SEQ ID NO.: 7). [mAnti-
ASGPR_4G2.2_Kv-V-hIgGK-C] is –
DIQMTQSSSSFSVSLGDRVTITCKASEDIYNRLGWYQQKPGNAPRLLISGATSLETGVPS
RFSGSGSGKDYALSITSLQTEDLATYYCQQCWTSPYTFGGGTKLEIKRTVAAPSVFIFPPS
DEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTL
TLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO.: 8). [mAnti-
ASGPR_5F10H-LV-hIgG4H-C] is –
EVQLQQSGPELVKPGASVKMSCKASGYTFTDYYMKWVKQSHGKSLEWIGDINPNYGD
TFYNQKFEGKATLTVDKSSRTAYMQLNSLTSEDSAVYYCGRGDYGYFDVWGAGTTVT
VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVL
QSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQF
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQ
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDK
SRWQEGNVFSCSVMHEALHNHYTQKSLLSLGKAS (SEQ ID NO.: 9). [mAnti-
ASGPR_5F10K-LV-hIgGK-C] is –
DIVMTQSHKFMSTSVGDRVSITCKASQDVGTAVAWYQQKPGQSPKLLIYWASTRHTGV
PDRFTGSGSGTDFTLTINNVQSEDLADYFCQQYSSNPYMFGGGTKLEIKRTVAAPSVFIF
PPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLS
STLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO.: 10). [mAnti-
ASGPR1H11H-V-hIgG4H-C] is –
QLQQSGPELVKPGASVKISCKTSGYTFTEYTMHWVRQSHGKSLEWIGGINPINGGPTYN
QKFKGKATLTVDKSSSTAYMELRSLTSEDSAVYYCARWDYGSRDVMDYWGQGTSVT
VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVL
QSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQF
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQ
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDK

SRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGKAS (SEQ ID NO.: 11). [mAnti-ASGPR1H11K-LV-hIgGK-C] is –

NIVMTQSPKSMSMSVGERVTLSCKASENVGTYVSWYQQRPEQSPKLLIYGASNRYTGV
PDRFTGSGSATDFTLTISSVQAEDLADYHCGQTYSYIFTFGSGTKLEIKRTVAAPSVFIFPP
SDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSST
LTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO.: 12). The invention envisions these V-region sequences and related sequences modified by those well versed in the art to e.g., enhance affinity for DC-ASGPR and/or integrated into human V-region framework sequences to be engineered into expression vectors to direct the expression of protein forms that can bind to DC-ASGPR on antigen presenting cells.

Engineered recombinant anti-DC-ASGPR recombinant antibody - antigen fusion proteins ((rAb.antigen) are efficacious prototype vaccines in vitro – Expression vectors can be constructed with diverse protein coding sequence e.g., fused in-frame to the H chain coding sequence. For example, antigens such as Influenza HA5, Influenza M1, HIV gag, or immuno-dominant peptides from cancer antigens, or cytokines, can be expressed subsequently as rAb.antigen or rAb.cytokine fusion proteins, which in the context of this invention, can have utility derived from using the anti-DC-ASGPR V-region sequence to bring the antigen or cytokine (or toxin) directly to the surface of the antigen presenting cell bearing DC-ASGPR. This permits internalization of e.g., antigen – sometimes associated with activation of the receptor and ensuing initiation of therapeutic or protective action (e.g., via initiation of a potent immune response, or via killing of the targeted cell. An exemplative prototype vaccine based on this concept could use a H chain vector such as [mAnti-ASGPR_5F10H-LV-hIgG4H-C-Flex-FluHA5-1-6xHis] or –

EVQLQQSGPELVKPGASVKMSCKASGYTFTDYYMKWVKQSHGKSLEWIGDINPNYGD
TFYNQKFEGKATLTVDKSSRTAYMQLNSLTSEDSAVYYCGRGDYGYFDVWGAGTTVT
VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVL
QSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQF
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQ
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDK
SRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGKA*SDTTEPATPTTPVTT***DQICIGYHAN**
NSTEQVDTIMEKNVTVTHAQDILEKKHNGKLCDLDGVKPLILRDCSVAGWLLGNP
MCDEFINVPEWSYIVEKANPVNDLCYPGDFNDYEELKHLLSRINHFEKIQIIPKSSW

SSHEASLGVSSACPYQGKSSFFRNVVWLIKKNSTYPTIKRSYNNTNQEDLLVLWGIH HPNDAAEQTKLYQNPTTYISVGTSTLNQRLVPRIATRSKVNGQSGRMEFFWTILKP NDAINFESNGNFIAPEYAYKIVKKGDSTIMKSELEYGNCNTKCQTPMGAINSSMPFH NIHPLTIGECPKYVKSNRLVLAHHHHHH (SEQ ID NO.: 13). The above sequence corresponds to the chimeric H chain shown already fused via a flexible linker sequence (shown italicized) to HA-1 domain of avian Flu HA5 (shown in bold). This can be co-expressed with the corresponding L chain chimeric sequence already shown above. Similarly, the sequence [mAnti-ASGPR_49C11_7H-LV-hIgG4H-C-Dockerin] – DVQLQESGPDLVKPSQSLSLTCTVTGYSITSGYSWHWIRQFPGNKLEWMGYILFSGSTN YNPSLKSRISITRDTSKNQFFLQLNSVTTEDTATYFCARSNYGSFASWGQGTLVTVSAAK TKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFL FPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTY RVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMT KNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQ EGNVFSCSVMHEALHNHYTQKSLSLSLGKASNSPQNEVLYGDVNDDGKVNSTDLTLLK RYVLKAVSTLPSSKAEKNADVNRDGRVNSSDVTILSRYLIRVIEKLPI (SEQ ID NO.: 14) can be used to express via co-transfection of the corresponding L chain sequence already shown above a rAb.Dockerin fusion protein.

Figure 6 shows that different antigens can be expressed in the context of a DC-ASGPR rAb. Such an anti-DC-ASGPR rAb.Doc protein can be simply mixed with any Cohesin.fusion protein to assemble a stable non-covalent [rAb.Doc:Coh.fusion] complex that functions just as a rAb.fusion protein. Figure 6 shows that such a [rAb.Doc:Coh.fusion] complex can focus antigen to the surface of cells expressing DC-ASGPR. The figure also shows anti-DC-ASGPR.Doc:Coh.Flu M1 complexes deliver Flu M1 to the surface of 293F cells transfected with DC-ASGPR cDNA. 1 μg/ml (right panel) of anti-DC-ASGPR.Doc rAb (shown in green) or control hIgG4.Doc rAb (shown in blue) were incubated with biotinylated Coh.Flu M1 (2 μg/ml) for 1 hr at R.T. transfected 293F cells were added and incubation continued for 20 min on ice. Cells were then washed and stained with PE-labeled streptavidin. Cells were then analyzed for PE fluorescence.

Anti-DC-ASGPR rAb complexed to Flu M1 via Dockerin:Cohesin interaction targets the antigen to human DCs and results in the expansion of Flu M1-specific CD8+ T cells – the potential utility of anti-DC-ASGPR rAbs as devices to deliver antigen to e.g., DC is shown in the figure

below. Figure 7 shows the dramatic expansion of Flu M1-specific CD8+ cells is highly predictive of potency of such an agent as a vaccine directed to eliciting protective immune responses against Flu M1.

Figure 8 demonstrated the cross reactivity of the different antibodies with monkey ASGPR. For pIRES_ ASGPR-mon (monkey) was cloned by inserting the PCR product into NheI-NotI sites of pIRES vector. The sequence of final product is base on clone 5S10. Most other clones are either similar to this with one aa difference or identical to this. However, one clone, 5S1, has an A deletion near the 3' end, which generated a shortened and different C' terminus and maybe used as a second variant. To clone the monkey ASGPR, the following oligos were used: DC-ASGPR_MoN: gaattcgctagcCACCATGACATATGAAAACTTCCAAGACTTGGAGAGTGAGGAGAAAGT CCAAGGGG (SEQ ID NO.: 15); and DC-ASGPR_Mo: CGAATTCGCGGCCGCTCAGTGACTCTCCTGGCTGGCCTGGGTCAGACCAGCCTCGCA GACCC (SEQ ID NO.: 16), which is a reverse complement of GGGTCTGCGAGGCTGGTCTGACCCAGGCCAGCCAGGAGAGTCACTGAGCGGCCGCG AATTCG (SEQ ID NO.: 17). Sequence comparisons indicate the likely regions of overlap and, hence, the cross-reactivity, as is known to those if skill in the art.

The following table demonstrated the binding of the DC-ASGPR 334998 200ug/ml 12.05.07 cfg#558 anti-Human IgG PE

Glycan number	Glycan name	Avg w/o Max & Min	StDev w/o Max & Min	SEM w/o Max & Min	%CV
82	GalNAcα1-3(Fucα1-2)Galβ1-4GlcNAcβ–Sp8	52930	10265	5132	19
210	Neu5Acα2-3(GalNAcβ1-4)Galβ1-4GlcNAcβ-Sp8	49937	4969	2484	10
86	GalNAcα1-3Galβ–Sp8	49067	4672	2336	10
89	GalNAcβ1-3(Fucα1-2)Galβ-Sp8	47375	5453	2726	12
84	GalNAcα1-3(Fucα1-2)Galβ–Sp8	46555	6618	3309	14
209	Neu5Acα2-3(GalNAcβ1-4)Galβ1-4GlcNAcβ-Sp0	46169	2121	1060	5
175	GlcNAcβ1-6GalNAcα–Sp8	44809	1939	969	4
301	GalNAcα1-3(Fucα1-2)Galβ–Sp18	44147	6003	3002	14

211	Neu5Acα2-3(GalNAcβ1-4)Galβ1-4Glcβ–Sp0	43603	3517	1759	8
10	α-GalNAc–Sp8	43514	2476	1238	6
128	Galβ1-3GalNAcβ1-4(Neu5Acα2-3)Galβ1-4Glcβ-Sp0	43152	13339	6669	31
151	Galβ1-4GlcNAcβ1-6GalNAcα–Sp8	42871	2466	1233	6
92	GalNAcβ1-4GlcNAcβ–Sp0	42845	3394	1697	8
93	GalNAcβ1-4GlcNAcβ–Sp8	41764	7340	3670	18
87	GalNAcα1-4(Fucα1-2)Galβ1-4GlcNAcβ-Sp8	41584	2925	1462	7
79	GalNAcα1-3(Fucα1-2)Galβ1-3GlcNAcβ-Sp0	41406	14134	7067	34
20	β-GalNAc–Sp8	40803	2388	1194	6
206	Neu5Acα2-8Neu5Acα2-3(GalNAcβ1-4)Galβ1-4Glcβ–Sp0	38720	2736	1368	7
242	Neu5Acα2-6GalNAcα–Sp8	37500	1934	967	5
91	GalNAcβ1-4(Fucα1-3)GlcNAcβ-Sp0	37286	5046	2523	14
204	Neu5Acα2-8Neu5Acα2-8Neu5Acα2-3(GalNAcβ1-4)Galβ1-4Glcβ-Sp0	37237	995	497	3
203	NeuAcα2-8NeuAcα2-8NeuAcα2-8NeuAcα2-3(GalNAcβ1-4)Galβ1-4Glcβ-Sp0	36746	2399	1200	7
243	Neu5Acα2-6GalNAcβ1-4GlcNAcβ-Sp0	36375	1661	830	5
59	Fucα1-2Galβ1-3GalNAcβ1-4(Neu5Acα2-3)Galβ1-4Glcβ-Sp0	35701	6903	3452	19
90	GalNAcβ1-3Galα1-4Galβ1-4GlcNAcβ-Sp0	34350	760	380	2
83	GalNAcα1-3(Fucα1-2)Galβ1-4Glcβ-Sp0	28846	9844	4922	34
302	GalNAcβ1-3Galβ-Sp8	28745	15727	7864	55
300	GalNAcα-Sp15	18125	18847	9424	104
127	Galβ1-3GalNAcβ1-3Galα1-4Galβ1-4Glcβ-Sp0	17999	9798	4899	54
85	GalNAcα1-3GalNAcβ–Sp8	12643	10843	5422	86
173	GlcNAcβ1-4GlcNAcβ1-4GlcNAcβ–Sp8	8673	940	470	11
81	GalNAcα1-3(Fucα1-2)Galβ1-4GlcNAcβ-Sp0	7672	12937	6469	169
30	[3OSO3]Galβ1-4(6OSO3)Glcβ–Sp8	7394	292	146	4
120	Galβ1-3(Galβ1-4GlcNAcβ1-6)GalNAcα-Sp8	5664	1311	655	23
80	GalNAcα1-3(Fucα1-2)Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	5444	907	454	17

147	Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ–Sp0	4927	410	205	8
29	[3OSO3]Galβ1-4(6OSO3)Glcβ–Sp0	4871	908	454	19
101	Galα1-3GalNAcα-Sp8	4815	3163	1581	66
214	Neu5Acα2-3GalNAcα–Sp8	4109	569	284	14
287	[3OSO3][4OSO3]Galβ1-4GlcNacβ-SpSp0	3959	1646	823	42
40	[4OSO3]Galβ1-4GlcNAcβ-Sp8	3848	673	337	17
45	[6OSO3]Galβ1-4[6OSO3]Glcβ-Sp8	3790	993	497	26
166	GlcNAcβ1-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	3720	435	218	12
227	Neu5Acα2-3Galβ1-4[6OSO3]GlcNAcβ-Sp8	3576	793	397	22
218	NeuAcα2-3Galβ1-3(Fucα1-4)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ Sp0	3360	104	52	3
240	Neu5Acα2-3Galβ1-4Glcβ–Sp8	3313	976	488	29
149	Galβ1-4GlcNAcβ1-3Galβ1-4Glcβ–Sp8	3233	263	132	8
244	Neu5Acα2-6Galβ1-4[6OSO3]GlcNAcβ-Sp8	3195	757	379	24
270	Fucα1-2Galβ1-4[6OSO3]GlcNAc-Sp8	3161	2563	1282	81
42	[6OSO3]Galβ1-4Glcβ–Sp0	3084	529	264	17
271	Fucα1-2[6OSO3]Galβ1-4[6OSO3]Glc-Sp0	3063	377	188	12
172	(GlcNAcβ1-4)5β-Sp8	3032	1058	529	35
47	[6OSO3]GlcNAcβ–Sp8	3008	159	80	5
143	Neu5Acα2-3Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-3Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	3008	309	155	10
265	[3OSO3]Galβ1-4(Fucα1-3)(6OSO3)Glc-Sp0	2995	1841	921	61
139	Galβ1-4[6OSO3]Glcβ–Sp0	2988	1070	535	36
27	[3OSO3][6OSO3]Galβ1-4GlcNAcβ-Sp0	2930	317	158	11
273	Fucα1-2-Galβ1-4[6OSO3]Glc-Sp0	2919	495	247	17
319	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	2730	993	497	36
35	[3OSO3]Galβ1-4[6OSO3]GlcNAcβ-Sp8	2722	516	258	19
28	[3OSO3]Galβ1-4Glcβ-Sp8	2674	197	98	7

38	[3OSO3]Galβ–Sp8	2652	1680	840	63
253	Neu5Acα2-8Neu5Acα2-3Galβ1-4Glcβ–Sp0	2631	1136	568	43
289	6-H2PO3Glcβ-Sp10	2611	674	337	26
26	[3OSO3][6OSO3]Galβ1-4[6OSO3]GlcNAcβ-Sp0	2550	153	76	6
266	[3OSO3]Galβ1-4(Fucα1-3)Glc-Sp0	2529	444	222	18
54	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp8	2476	300	150	12
303	GlcAβ1-3GlcNAcβ-Sp8	2463	130	65	5
32	[3OSO3]Galβ1-3GalNAcα–Sp8	2461	622	311	25
53	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp13	2455	283	142	12
181	Glcβ1-6Glcβ-Sp8	2455	154	77	6
267	[3OSO3]Galβ1-4[Fucα1-3][6OSO3]GlcNAc-Sp8	2447	1065	532	44
293	Galβ1-3(Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ1-6)GalNAc–Sp14	2359	648	324	27
202	Neu5Acα2-3Galβ1-3GalNAcα-Sp8	2349	928	464	40
163	GlcNAcβ1-3Galβ1-3GalNAcα-Sp8	2347	375	188	16
1	Neu5Acα2-8Neu5Acα-Sp8	2339	1539	769	66
31	[3OSO3]Galβ1-3(Fucα1-4)GlcNAcβ–Sp8	2332	319	160	14
230	Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ–Sp0	2306	164	82	7
286	[3OSO3]Galβ1-4[6OSO3]GlcNAcβ-Sp0	2290	472	236	21
318	Neu5Acα2-3Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	2262	246	123	11
199	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-3Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	2217	138	69	6
39	[4OSO3][6OSO3]Galβ1-4GlcNAcβ-Sp0	2215	619	310	28
77	Fucα1-4GlcNAcβ–Sp8	2207	83	42	4

285	Neu5Acα2-3Galβ1-4GlcNAcβ1-3Galβ1-3GlcNAcβ-Sp0	2193	1679	839	77
262	Neu5Gcα2-6GalNAcα–Sp0	2192	734	367	33
216	Neu5Acα2-3Galβ1-3(6OSO3)GlcNAc-Sp8	2163	1062	531	49
43	[6OSO3]Galβ1-4Glcβ–Sp8	2149	700	350	33
297	Galβ1-4GlcNAcβ1-3(GlcNAcβ1-6)Galβ1-4GlcNAc-Sp0	2141	983	491	46
224	NeuAcα2-3Galβ1-3GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	2133	1208	604	57
3	Neu5Acα2-8Neu5Acα2-8Neu5Acβ-Sp8	2117	611	306	29
171	(GlcNAcβ1-4)6β-Sp8	2112	302	151	14
316	Neu5Acα2-3Galβ1-3(Neu5Acα2-6)GalNAc-Sp14	2105	1171	585	56
15	α-Neu5Ac–Sp11	2099	250	125	12
52	Galβ1-4GlcNAcβ1-2Manα1-3(Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp13	2092	429	215	21
268	[3OSO3]Galβ1-4[Fucα1-3]GlcNAc-Sp0	2085	955	477	46
313	Manα1-2Manα1-2Manα1-3(Manα1-2Manα1-6(Manα1-3)Manα1-6)Manα-Sp9	2020	812	406	40
225	Neu5Acα2-3Galβ1-3GlcNAcβ–Sp0	2019	1052	526	52
36	[3OSO3]Galβ1-4GlcNAcβ–Sp0	2012	389	194	19
263	Neu5Gcα2-6Galβ1-4GlcNAcβ–Sp0	1999	664	332	33
141	Galβ1-4GalNAcα1-3(Fucα1-2)Galβ1-4GlcNAcβ-Sp8	1968	772	386	39
274	Galβ1-3(Fucα1-4)GlcNAcβ1-3Galβ1-3(Fucα1-4)GlcNAcβ-Sp0	1961	78	39	4
275	Galβ1-3-(Galβ1-4GlcNacβ1-6)GalNAc-Sp14	1953	409	205	21
7	α-D-Gal–Sp8	1925	636	318	33
41	6-H2PO3Manα–Sp8	1919	223	111	12
247	Neu5Acα2-6Galβ1-4GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1914	169	85	9
311	Manα1-6Manβ-Sp10	1906	522	261	27
205	Neu5Acα2-8Neu5Acα2-8Neu5Acα2-3Galβ1-4Glcβ–Sp0	1902	222	111	12
280	Galβ1-4[Fucα1-3][6OSO3]GlcNAc-Sp0	1881	982	491	52
152	Galβ1-4GlcNAcβ–Sp0	1868	924	462	49

113	Galα1-6Glcβ-Sp8	1864	321	161	17
115	Galβ1-3(Fucα1-4)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1855	338	169	18
251	Neu5Acα2-6Galβ–Sp8	1842	316	158	17
116	Galβ1-3(Fucα1-4)GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	1836	798	399	43
194	Manα1-2Manα1-2Manα1-3(Manα1-2Manα1-3(Manα1-2Manα1-6)Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1829	176	88	10
33	[3OSO3]Galβ1-3GlcNAcβ–Sp8	1812	889	445	49
272	Fucα1-2-(6OSO3)-Galβ1-4Glc-Sp0	1805	86	43	5
207	Neu5Acα2-8Neu5Acα2-8Neu5Acα-Sp8	1804	454	227	25
74	Fucα1-2Galβ–Sp8	1796	648	324	36
213	Neu5Acα2-3(Neu5Acα2-6)GalNAcα–Sp8	1768	312	156	18
234	Neu5Acα2-3Galβ1-4GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAc-Sp0	1767	178	89	10
50	Manα1-3(Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp13	1759	553	277	31
111	Galα1-4Galβ1-4Glcβ–Sp0	1740	635	318	36
291	Galα1-3GalNAcα-Sp16	1738	1090	545	63
296	Galβ1-4GlcNAcβ1-3(Galβ1-4GlcNAcβ1-6)Galβ1-4GlcNAc-Sp0	1726	850	425	49
154	Galβ1-4Glcβ–Sp0	1725	457	229	27
56	Fucα1-2Galβ1-3GalNAcβ1-3Galα1-4Galβ1-4Glcβ-Sp9	1719	384	192	22
66	Fucα1-2Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1703	224	112	13
299	Galβ1-4GlcNAcβ1-6Galβ1-4GlcNAcβ-Sp0	1658	820	410	49
44	[6OSO3]Galβ1-4GlcNAcβ–Sp8	1632	242	121	15
237	Neu5Acα2-3Galβ1-4GlcNAcβ–Sp8	1632	1049	524	64
233	Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp8	1620	862	431	53
192	Manα1-6(Manα1-2Manα1-3)Manα1-6(Manα2Manα1-3)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1608	903	452	56
64	Fucα1-2Galβ1-3GlcNAcβ–Sp8	1602	625	313	39

62	Fucα1-2Galβ1-3GlcNAcβ1-3Galβ1-4Glcβ–Sp8	1580	417	208	26
148	Galβ1-4GlcNAcβ1-3Galβ1-4Glcβ–Sp0	1568	617	308	39
295	Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1556	190	95	12
137	Galβ1-4(Fucα1-3)GlcNAcβ1-4Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1552	1313	656	85
17	β-D-Gal–Sp8	1544	871	435	56
168	GlcNAcβ1-4MDPLys	1542	345	172	22
254	Neu5Acβ2-6GalNAcα–Sp8	1541	688	344	45
231	Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	1534	257	129	17
125	Galβ1-3GalNAcα-Sp8	1483	1025	512	69
269	Fucα1-2[6OSO3]Galβ1-4GlcNAc-Sp0	1473	191	96	13
182	G-ol-Sp8	1471	264	132	18
37	[3OSO3]Galβ1-4GlcNAcβ-Sp8	1462	1187	593	81
229	Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ–Sp0	1451	333	167	23
315	Neu5Acα2-3Galβ1-3(Neu5Acα2-3Galβ1-4GlcNAcβ1-6)GalNAc–Sp14	1448	1476	738	102
65	Fucα1-2Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1442	748	374	52
164	GlcNAcβ1-3Galβ1-4GlcNAcβ–Sp0	1436	1332	666	93
305	GlcNAcβ1-2Manα1-3(GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1428	288	144	20
304	GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1428	499	249	35
145	Galβ1-4GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	1422	323	162	23
117	Galβ1-3(Fucα1-4)GlcNAc–Sp0	1407	681	341	48
193	Manα1-2Manα1-6(Manα1-3)Manα1-6(Manα2Manα2Manα1-3)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1404	285	142	20
19	β-D-Man–Sp8	1389	635	317	46

176	GlcNAcβ1-6Galβ1-4GlcNAcβ-Sp8	1383	1000	500	72
232	Neu5Acα2-3Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ-Sp8	1355	374	187	28
219	Neu5Acα2-3Galβ1-3(Neu5Acα2-3Galβ1-4)GlcNAcβ-Sp8	1350	753	377	56
123	Galβ1-3(Neu5Acβ2-6)GalNAcα-Sp8	1350	852	426	63
276	Galβ1-3(GlcNacβ1-6)GalNAc-Sp14	1345	353	176	26
208	Neu5Acα2-3(6-O-Su)Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	1341	642	321	48
55	Fucα1-2Galβ1-3GalNAcβ1-3Galα-Sp9	1331	466	233	35
257	Neu5Gca2-3Galβ1-3(Fucα1-4)GlcNAcβ-Sp0	1315	108	54	8
201	Fucα1-3(Galβ1-4)GlcNAcβ1-2Manα1-3(Fucα1-3(Galβ1-4)GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp20	1294	289	144	22
97	Galα1-3(Fucα1-2)Galβ1-4GlcNAc-Sp0	1282	583	291	45
150	Galβ1-4GlcNAcβ1-6(Galβ1-3)GalNAcα–Sp8	1265	778	389	62
60	Fucα1-2Galβ1-3GalNAcβ1-4(Neu5Acα2-3)Galβ1-4Glcβ-Sp9	1261	738	369	59
317	Neu5Acα2-3Galβ1-3GalNAc–Sp14	1239	780	390	63
23	β-GlcN(Gc)-Sp8	1219	436	218	36
279	Galβ1-3GlcNAcβ1-3Galβ1-3GlcNAcβ-Sp0	1219	570	285	47
190	Manα1-2Manα1-3(Manα1-2Manα1-6)Manα-Sp9	1217	1305	653	107
178	Glcα1-4Glca–Sp8	1216	560	280	46
146	Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ–Sp0	1211	1315	658	109
292	Galβ1-3GalNAcα-Sp16	1198	370	185	31
221	Neu5Acα2-3Galβ1-3(Neu5Acα2-6)GalNAcα–Sp8	1194	238	119	20
99	Galα1-3(Fucα1-2)Galβ–Sp8	1189	767	383	64
309	HOOC(CH3)CH-3-O-GlcNAcβ1-4GlcNAcβ-Sp10	1186	1108	554	93
248	Neu5Acα2-6Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	1181	334	167	28
107	Galα1-3Galβ–Sp8	1148	688	344	60
236	Neu5Acα2-3Galβ1-4GlcNAcβ–Sp0	1148	441	220	38
320	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1142	55	27	5

197	Manα1-6(Manα1-3)Manα1-6(Manα2Manα1-3)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	1134	200	100	18
185	GlcAβ1-3Galβ-Sp8	1133	470	235	42
34	[3OSO3]Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	1117	980	490	88
109	Galα1-4Galβ1-4GlcNAcβ–Sp0	1094	499	250	46
235	Neu5Acα2-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ–Sp0	1092	1077	539	99
228	Neu5Acα2-3Galβ1-4(Fucα1-3)(6OSO3)GlcNAcβ–Sp8	1090	771	385	71
184	GlcAβ-Sp8	1072	476	238	44
282	Galβ1-4(Fucα1-3)GlcNAcβ1-3Galβ1-3(Fucα1-4)GlcNAcβ-Sp0	1062	239	120	23
2	Neu5Acα2-8Neu5Acβ-Sp17	1060	84	42	8
174	GlcNAcβ1-6(Galβ1-3)GalNAcα–Sp8	1039	913	456	88
261	Neu5Gcα2-3Galβ1-4Glcβ–Sp0	1034	440	220	43
18	β-D-Glc–Sp8	1024	335	167	33
217	Neu5Acα2-3Galβ1-3(Fucα1-4)GlcNAcβ–Sp8	1023	646	323	63
260	Neu5Gcα2-3Galβ1-4GlcNAcβ–Sp0	1020	208	104	20
104	Galα1-3Galβ1-3GlcNAcβ-Sp0	1017	297	149	29
245	Neu5Acα2-6Galβ1-4GlcNAcβ–Sp0	1010	394	197	39
14	α-Neu5Ac–Sp8	998	1046	523	105
283	Galβ1-4GlcNAcβ1-3Galβ1-3GlcNAcβ-Sp0	978	514	257	53
156	GlcNAcα1-3Galβ1-4GlcNAcβ-Sp8	969	276	138	29
310	Manα1-3(Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	965	238	119	25
183	GlcAa-Sp8	960	463	232	48
138	Galβ1-4(Fucα1-3)GlcNAcβ1-4Galβ1-4(Fucα1-3)GlcNAcβ1-4Galβ1-4(Fucα1-3)GlcNAcβ–Sp0	948	595	297	63
96	Galα1-3(Fucα1-2)Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	948	260	130	27
6	Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp12	943	351	176	37

306	GlcNAcβ1-3Man-Sp10	938	153	77	16
121	Galβ1-3(GlcNAcβ1-6)GalNAcα-Sp8	936	748	374	80
258	Neu5Gca2-3Galβ1-3GlcNAcβ-Sp0	932	375	188	40
246	Neu5Acα2-6Galβ1-4GlcNAcβ–Sp8	931	635	317	68
200	Manβ1-4GlcNAcβ-Sp0	920	322	161	35
78	Fucβ1-3GlcNAcβ-Sp8	911	464	232	51
94	Galα1-2Galβ–Sp8	911	393	197	43
256	Galβ1-4GlcNAcβ1-2Manα1-3(Neu5Acα2-6Galβ1-4GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp21	909	428	214	47
95	Galα1-3(Fucα1-2)Galβ1-3GlcNAcβ-Sp0	908	245	123	27
8	α-D-Glc–Sp8	904	417	209	46
103	Galα1-3Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	893	445	222	50
118	Galβ1-3(Fucα1-4)GlcNAc–Sp8	890	624	312	70
9	α-D-Man–Sp8	881	403	201	46
16	β-Neu5Ac-Sp8	876	935	468	107
119	Galβ1-3(Fucα1-4)GlcNAcβ–Sp8	872	283	141	32
278	Galβ1-3GalNAc-Sp14	851	144	72	17
187	KDNα2-3Galβ1-3GlcNAcβ–Sp0	839	386	193	46
69	Fucα1-2Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAc–Sp0	837	328	164	39
76	Fucα1-3GlcNAcβ-Sp8	836	276	138	33
108	Galα1-4(Fucα1-2)Galβ1-4GlcNAcβ-Sp8	819	58	29	7
212	NeuAcα2-3(NeuAcα2-3Galβ1-3GalNAcβ1-4)Galβ1-4Glcβ-Sp0	818	1442	721	176
132	Galβ1-3GlcNAcβ1-3Galβ1-4Glcβ–Sp10	816	353	176	43
105	Galα1-3Galβ1-4GlcNAcβ–Sp8	806	184	92	23
308	GlcNAcβ1-4GlcNAcβ-Sp12	796	360	180	45
160	GlcNAcβ1-3(GlcNAcβ1-6)Galβ1-4GlcNAcβ–Sp8	794	416	208	52
284	Neu5Acα2-3Galβ1-3GlcNAcβ1-3Galβ1-3GlcNAcβ-Sp0	777	491	245	63
188	KDNα2-3Galβ1-4GlcNAcβ–Sp0	774	320	160	41

215	Neu5Acα2-3GalNAcβ1-4GlcNAcβ-Sp0	762	252	126	33
294	Galβ1-3Galβ1-4GlcNAcβ-Sp8	746	255	128	34
196	Manα1-3(Manα1-2Manα1-2Manα1-6)Manα-Sp9	744	177	88	24
189	Manα1-2Manα1-2Manα1-3Manα-Sp9	743	207	103	28
25	GlcNAcβ1-3(GlcNAcβ1-4)(GlcNAcβ1-6)GlcNAc-Sp8	735	270	135	37
131	Galβ1-3GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	728	290	145	40
277	Galβ1-3-(Neu5Aa2-3Galβ1-4GlcNacβ1-6)GalNAc-Sp14	722	324	162	45
136	Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	718	93	46	13
70	Fucα1-2Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	713	861	430	121
110	Galα1-4Galβ1-4GlcNAcβ–Sp8	712	183	91	26
129	Galβ1-3GalNAcβ1-4Galβ1-4Glcβ–Sp8	702	224	112	32
71	Fucα1-2Galβ1-4GlcNAcβ–Sp0	686	160	80	23
169	GlcNAcβ1-4(GlcNAcβ1-6)GalNAcα-Sp8	686	229	115	33
122	Galβ1-3(Neu5Acα2-6)GalNAcα-Sp8	679	157	79	23
106	Galα1-3Galβ1-4Glcβ–Sp0	678	137	69	20
255	Neu5Acβ2-6Galβ1-4GlcNAcβ-Sp8	671	153	76	23
130	Galβ1-3Galβ–Sp8	668	285	143	43
144	Galβ1-4GlcNAcβ1-3GalNAcα–Sp8	663	227	113	34
13	α-L-Rhα–Sp8	662	245	123	37
22	β-GlcNAc–Sp8	655	313	157	48
72	Fucα1-2Galβ1-4GlcNAcβ–Sp8	646	95	47	15
157	GlcNAcα1-6Galβ1-4GlcNAcβ-Sp8	644	323	162	50
307	GlcNAcβ1-4GlcNAcβ-Sp10	640	336	168	53
180	Glcβ1-4Glcβ-Sp8	608	316	158	52
191	Manα1-2Manα1-3Manα-Sp9	607	104	52	17
134	Galβ1-3GlcNAcβ–Sp8	603	103	51	17
21	β-GlcNAc–Sp0	595	285	142	48
24	(Galβ1-4GlcNAcβ)2-3,6-GalNAcα–Sp8	590	240	120	41

223	NeuAcα2-3Galβ1-3GalNAcβ1-3Galα1-4Galβ1-4Glcβ-Sp0	580	191	95	33
162	GlcNAcβ1-3Galβ-Sp8	577	435	217	75
135	Galβ1-4(Fucα1-3)GlcNAcβ–Sp0	561	139	70	25
249	Neu5Acα2-6Galβ1-4Glcβ–Sp0	560	377	189	67
48	9NAcNeu5Acα-Sp8	556	470	235	85
158	GlcNAcβ1-2Galβ1-3GalNAcα–Sp8	550	417	208	76
264	Neu5Gcα–Sp8	550	305	152	55
46	NeuAcα2-3[6OSO3]Galβ1-4GlcNAcβ–Sp8	545	363	182	67
68	Fucα1-2Galβ1-4(Fucα1-3)GlcNAcβ–Sp8	541	208	104	38
222	Neu5Acα2-3Galβ-Sp8	526	277	139	53
298	Galβ1-4GlcNAcα1-6Galβ1-4GlcNAcβ-Sp0	494	335	167	68
98	Galα1-3(Fucα1-2)Galβ1-4Glcβ-Sp0	482	112	56	23
312	Manα1-6(Manα1-3)Manα1-6(Manα1-3)Manβ-Sp10	453	292	146	64
133	Galβ1-3GlcNAcβ–Sp0	452	165	82	36
57	Fucα1-2Galβ1-3(Fucα1-4)GlcNAcβ–Sp8	450	268	134	60
114	Galβ1-2Galβ–Sp8	449	324	162	72
198	Manα1-6(Manα1-3)Manα1-6(Manα1-3)Manβ1-4GlcNAcβ1-4 GlcNAcβ-Sp12	448	204	102	45
161	GlcNAcβ1-3GalNAcα–Sp8	442	156	78	35
281	Galβ1-4[Fucα1-3][6OSO3]Glc-Sp0	439	144	72	33
259	Neu5Gca2-3Galβ1-4(Fucα1-3)GlcNAcβ-Sp0	433	357	179	83
67	Fucα1-2Galβ1-4(Fucα1-3)GlcNAcβ–Sp0	420	94	47	22
12	α-L-Fuc–Sp9	410	303	151	74
159	GlcNAcβ1-3(GlcNAcβ1-6)GalNAcα–Sp8	407	88	44	22
75	Fucα1-3GlcNAcβ-Sp8	399	182	91	46
239	Neu5Acα2-3Galβ1-4Glcβ–Sp0	395	156	78	39
290	Galα1-3(Fucα1-2)Galβ–Sp18	389	246	123	63
11	α-L-Fuc–Sp8	387	231	115	60
51	GlcNAcβ1-2Manα1-3(GlcNAcβ1-2Manα1-6)Manβ1-	383	164	82	43

	4GlcNAcβ1-4GlcNAcβ-Sp13				
5	Galβ1-3GlcNAcβ1-2Manα1-3(Galβ1-3GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp19	381	529	265	139
63	Fucα1-2Galβ1-3GlcNAcβ–Sp0	362	187	93	52
241	Galβ1-4GlcNAcβ1-2Manα1-3(Fucα1-3(Galβ1-4)GlcNAcβ1-2Manα1-6)Manβ1-4GlcNAcβ1-4GlcNAcβ-Sp20	352	68	34	19
155	Galβ1-4Glcβ–Sp8	315	105	53	33
126	Galβ1-3GalNAcβ–Sp8	288	265	132	92
195	Manα1-3(Manα1-6)Manα–Sp9	269	92	46	34
88	GalNAcβ1-3GalNAcα–Sp8	262	107	54	41
252	Neu5Acα2-8Neu5Acα-Sp8	260	214	107	82
167	GlcNAcβ1-3Galβ1-4Glcβ–Sp0	257	129	64	50
140	Galβ1-4[6OSO3]Glcβ–Sp8	256	345	172	135
177	Glcα1-4Glcβ–Sp8	246	113	57	46
179	Glcα1-6Glcα1-6Glcβ-Sp8	225	380	190	168
314	Manα1-2Manα1-2Manα1-3(Manα1-2Manα1-6(Manα1-2Manα1-3)Manα1-6)Manα-Sp9	221	329	165	149
238	Neu5Acα2-3Galβ1-4GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp0	212	200	100	94
220	Neu5Acα2-3Galβ1-3[6OSO3]GalNAcα-Sp8	210	153	77	73
142	Galβ1-4GalNAcβ1-3(Fucα1-2)Galβ1-4GlcNAcβ-Sp8	204	126	63	62
61	Fucα1-2Galβ1-3GlcNAcβ1-3Galβ1-4Glcβ–Sp10	196	67	34	34
102	Galα1-3GalNAcβ–Sp8	188	198	99	105
170	GlcNAcβ1-4Galβ1-4GlcNAcβ-Sp8	184	127	64	69
124	Galβ1-3(Neu5Acα2-6)GlcNAcβ1-4Galβ1-4Glcβ-Sp10	173	146	73	84
100	Galα1-3(Galα1-4)Galβ1-4GlcNAcβ-Sp8	168	112	56	66
186	GlcAβ1-6Galβ-Sp8	158	171	86	108
4	Neu5Gcβ2-6Galβ1-4GlcNAc-Sp8	152	96	48	63
73	Fucα1-2Galβ1-4Glcβ–Sp0	148	205	103	139
49	9NAcNeu5Acα2-6Galβ1-4GlcNAcβ-Sp8	146	159	79	108
58	Fucα1-2Galβ1-3GalNAcα–Sp8	136	171	86	126

250	Neu5Acα2-6Galβ1-4Glcβ–Sp8	122	144	72	119
112	Galα1-4GlcNAcβ–Sp8	115	82	41	72
165	GlcNAcβ1-3Galβ1-4GlcNAcβ-Sp8	84	68	34	81
226	Neu5Acα2-3Galβ1-3GlcNAcβ–Sp8	76	85	42	112
288	[6OSO3]Galβ1-4[6OSO3]GlcNacβ-Sp0	72	130	65	180
153	Galβ1-4GlcNAcβ–Sp8	48	58	29	120

It is contemplated that any embodiment discussed in this specification can be implemented with respect to any method, kit, reagent, or composition of the invention, and vice versa. Furthermore, compositions of the invention can be used to achieve methods of the invention.

It will be understood that particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention can be employed in various embodiments without departing from the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, numerous equivalents to the specific procedures described herein. Such equivalents are considered to be within the scope of this invention and are covered by the claims.

All publications and patent applications mentioned in the specification are indicative of the level of skill of those skilled in the art to which this invention pertains. All publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

The use of the word “a” or “an” when used in conjunction with the term “comprising” in the claims and/or the specification may mean “one,” but it is also consistent with the meaning of “one or more,” “at least one,” and “one or more than one.” The use of the term “or” in the claims is used to mean “and/or” unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and “and/or.” Throughout this application, the term “about” is used to indicate that a value includes the inherent variation of error for the device, the method being employed to determine the value, or the variation that exists among the study subjects.

As used in this specification and claim(s), the words “comprising” (and any form of comprising, such as “comprise” and “comprises”), “having” (and any form of having, such as “have” and

"has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, unrecited elements or method steps.

The term "or combinations thereof" as used herein refers to all permutations and combinations of the listed items preceding the term. For example, "A, B, C, or combinations thereof" is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, MB, BBC, AAABCCCC, CBBAAA, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

All of the compositions and/or methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the invention as defined by the appended claims.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge in Australia.

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What is claimed is:

1. A method for increasing the effectiveness of antigen presentation by a dendritic cell, comprising the steps of

obtaining an isolated and purified DC-ASGPR-specific antibody or fragment thereof to which an antigen is attached, the antigen characterized in that it comprises at least one bacterial, viral, fungal, protozoan or cancer antigen, wherein the antigen is a fusion protein with the DC-ASGPR-specific antibody or fragment thereof, and

contacting the isolated antigen presenting cell with the DC-ASGPR-specific antibody or fragment and antigen, wherein the antigen is processed and presented by the dendritic cell that has been contacted with the antibody-antigen complex.

2. The method of claim 1, wherein DC-ASGPR-specific antibody or fragment thereof is bound to one half of a Coherin/Dockerin pair.

3. The method of claim 1, wherein DC-ASGPR-specific antibody or fragment thereof is bound to one half of a Coherin/Dockerin pair and an antigen is bound to the complementary half of the Coherin/Dockerin pair to form a complex.

4. The method of claim 1, wherein the antigen is selected from a peptide, protein, lipid, carbohydrate, nucleic acid, and combinations thereof.

5. The method of claim 1, wherein increased effectiveness of the dendritic cells is determined used allogeneic $CD8^+$ T cells.

6. The use of antibodies or other specific binding molecules directed to DC-ASGPR for delivering antigens to antigen-presenting cells for the purpose of eliciting protective or therapeutic immune responses, wherein the antibodies or other specific binding molecule is in a fusion protein with the antigen, and the antigen comprises at least one bacterial, viral, fungal, protozoan or cancer antigen.

7. The use of antigen-targeting reagents specific to DC-ASGPR for vaccination via the skin, wherein the antigen-targeting reagents specific to DC-ASGPR is in a fusion protein with

an antigen, and the antigen comprises at least one bacterial, viral, fungal, protozoan or cancer antigen.

8. The use of claim 7, in association with co-administered or linked adjuvant for vaccination.

9. The use of claim 7, wherein the fusion protein can be expressed as recombinant antigen-antibody fusion proteins.

10. An isolated antigen specific anti-DC-ASGPR immunoglobulin or fragment thereof that is secreted from mammalian cells and an antigen bound to the immunoglobulin, wherein the immunoglobulin is in a fusion protein with the antigen, and the antigen comprises at least one bacterial, viral, fungal, protozoan or cancer antigen.

11. The immunoglobulin of claim 10, wherein the immunoglobulin is bound to one half of a cohesin/dockerin domain.

12. The immunoglobulin of claim 10, further comprising a complementary half of the cohesin-dockerin binding pair bound to an antigen that forms a complex with the modular rAb carrier.

13. The immunoglobulin of claim 10, further comprising a complementary half of the cohesin-dockerin binding pair that is a fusion protein with an antigen.

14. The immunoglobulin of claim 10, wherein the antigen specific domain comprises a full length antibody, an antibody variable region domain, an Fab fragment, a Fab' fragment, an F(ab)2 fragment, and Fv fragment, and Fabc fragment and/or a Fab fragment with portions of the Fc domain.

15. The immunoglobulin of claim 10, wherein the antigen is a toxin selected from the group consisting of a radioactive isotope, metal, enzyme, botulin, tetanus, ricin, cholera, diphtheria, aflatoxins, perfringens toxin, mycotoxins, shigatoxin, staphylococcal enterotoxin B, T2, seguitoxin, saxitoxin, abrin, cyanoginosin, alphatoxin, tetrodotoxin, aconotoxin, snake venom and spider venom.

16. The immunoglobulin of claim 10, wherein the antigen comprises a portion of a cancer cell selected from T- and B cell lymphoproliferative diseases, ovarian cancer, pancreatic cancer, head and neck cancer, squamous cell carcinoma, gastrointestinal cancer, breast cancer, prostate, cancer or non small cell lung cancer.

17. A method for increasing the effectiveness of dendritic cells comprising:
obtaining isolated patient dendritic cells
exposing the dendritic cells to activating amounts of anti-DC-ASGPR antibodies or fragments thereof and antigen to form antigen-loaded, activated dendritic cells, wherein the anti-DC-ASGPR antibodies or fragments thereof is in a fusion protein with the antigen, and the antigen comprises at least one bacterial, viral, fungal, protozoan or cancer antigen; and
providing the antigen-loaded, activated dendritic cells to be later reintroduced into the patient.

18. Use of agents that engage DC-ASGPR, alone or with co-activating agents, to activate antigen-presenting cells for therapeutic or protective applications, wherein the DC-ASGPR binding and/or activating agents are linked to antigens, alone or with co-activating agents, for protective or therapeutic vaccination, wherein the DC-ASGPR binding and/or activating agents are in a fusion protein with the antigens, and the antigens comprises at least one bacterial, viral, fungal, protozoan or cancer antigen.

19. The method of claim 17, wherein the specific antibody V-region sequences is capable of binding to and activating DC-ASGPR.

20. Use of anti-DC-ASGPR agents linked to toxic agents for therapeutic purposes in the context of diseases known or suspected to result from inappropriate activation of immune cells via DC-ASGPR.

21. A vaccine comprising a DC-ASGPR-specific antibody or fragment thereof to which an antigen is attached, wherein the DC-ASGPR-specific antibody or fragment thereof is in a fusion protein with the antigen, and the antigen comprises at least one bacterial, viral, fungal, protozoan or cancer antigen, wherein the antigen is processed and presented by a dendritic cell that has been contacted with the antibody-antigen complex.

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22. The method for increasing the effectiveness of antigen presentation by dendritic cells of claim 1, substantially as herein described with reference to the Drawings.

23. The use of antibodies or other specific binding molecules directed to DC-ASGPR for delivering antigens to antigen-presenting cells for the purpose of eliciting protective or therapeutic immune responses of claim 6 substantially as herein described with reference to the Drawings.

24. A vaccine comprising a DC-ASGPR -specific antibody or fragment thereof to which an antigen is attached of claim 21, substantially as herein described with reference to the Drawings.

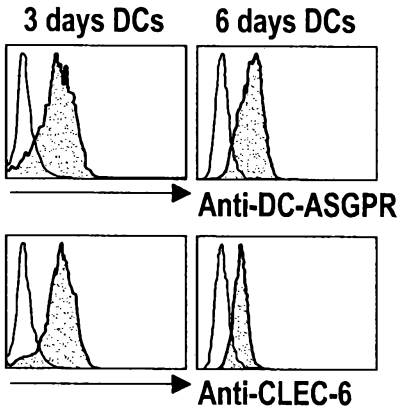

FIG. 1A

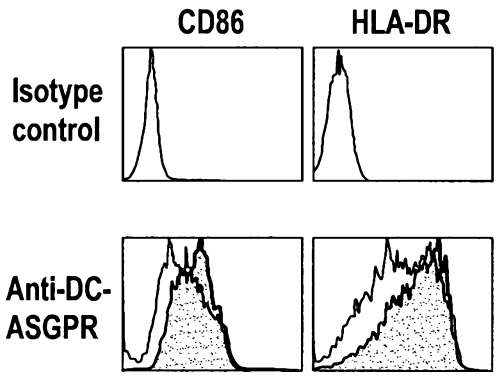

FIG. 1B

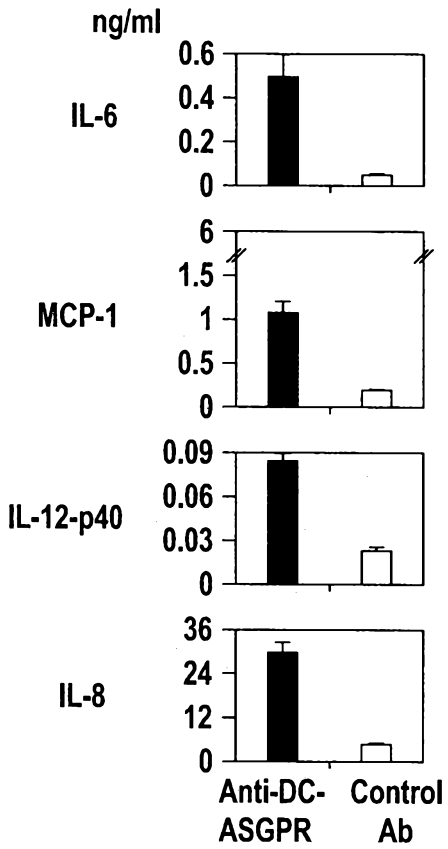

FIG. 1C

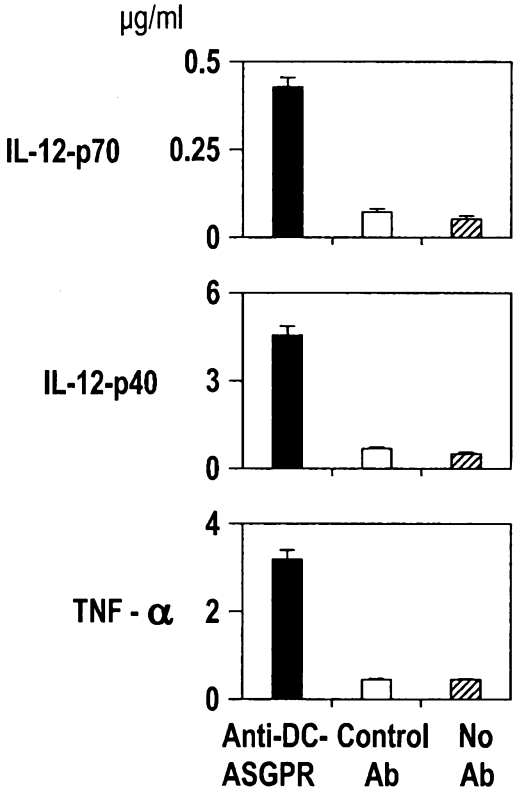

FIG. 1D

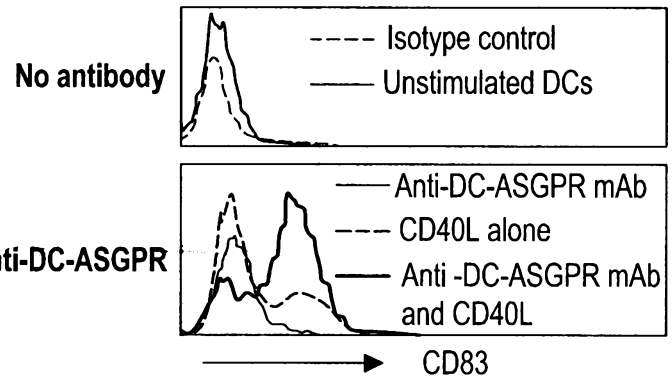

FIG. 1E

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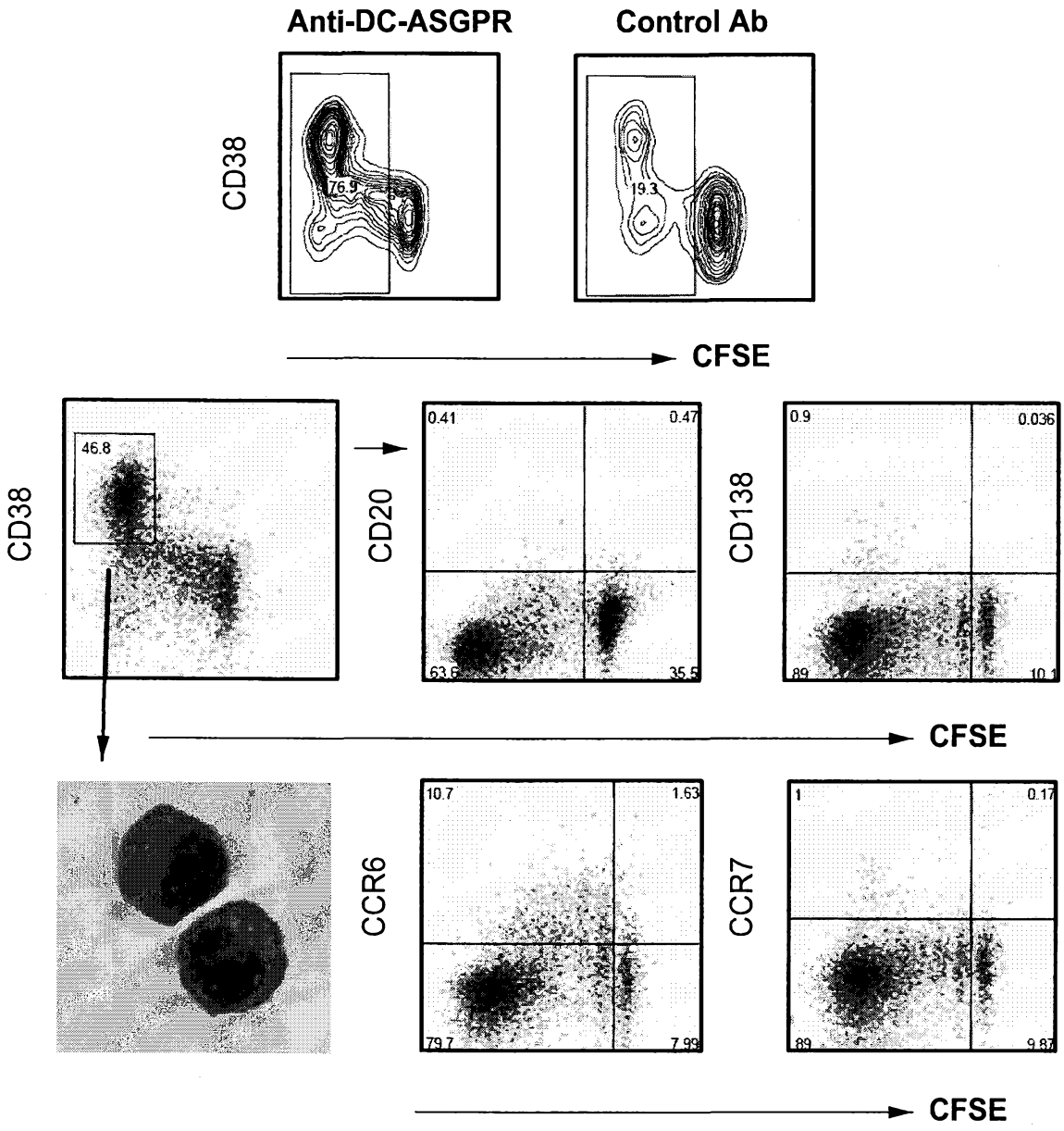


FIG. 2A

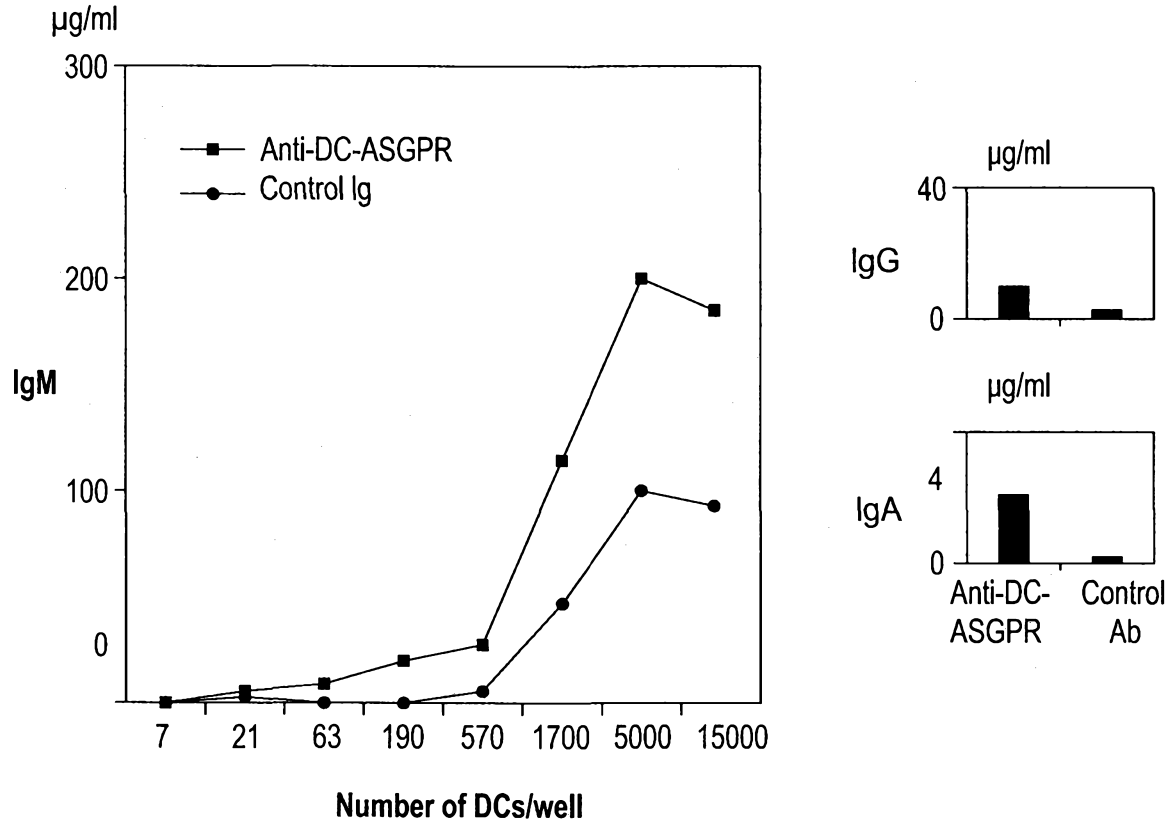


FIG. 2B

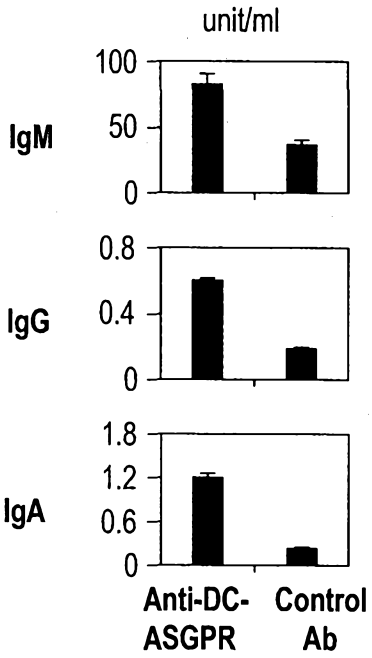


FIG. 2C

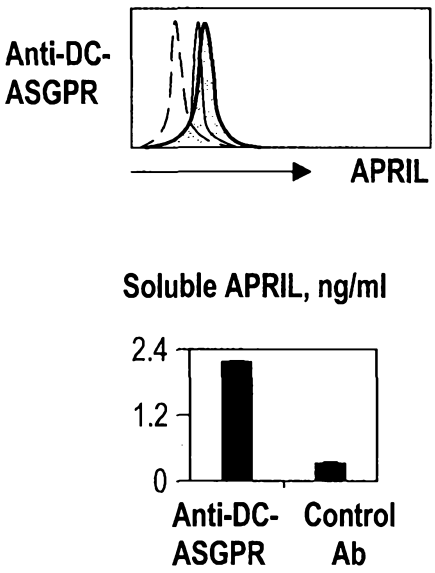


FIG. 2D

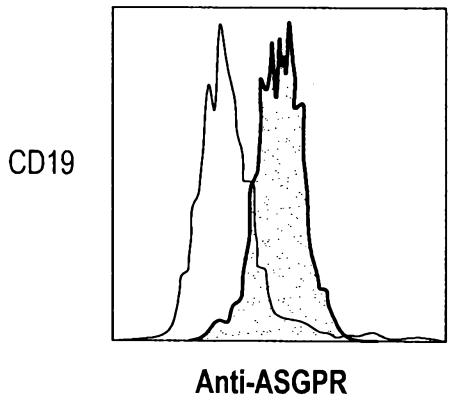


FIG. 3A

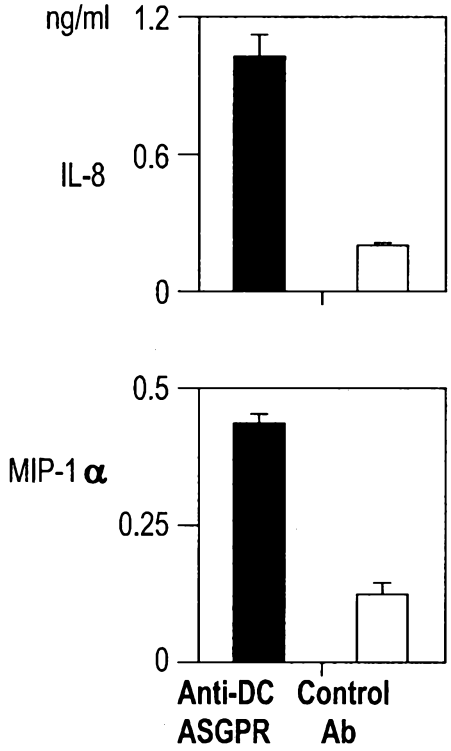


FIG. 3B

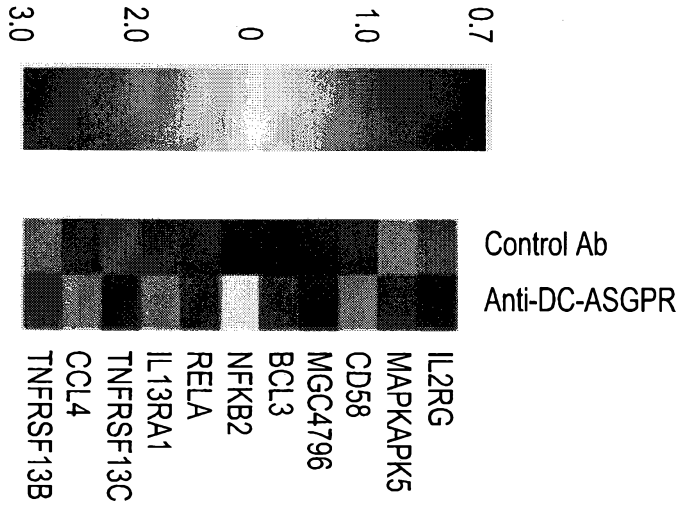


FIG. 3C

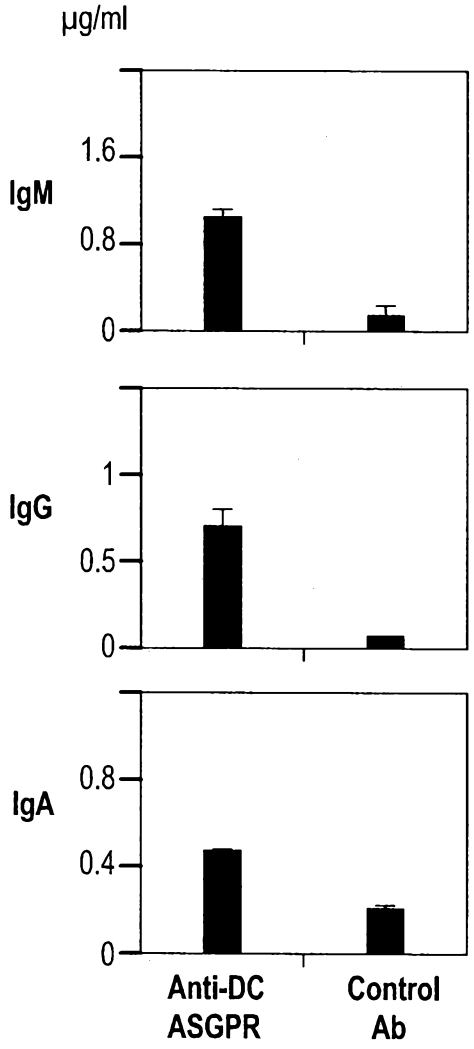


FIG. 3D

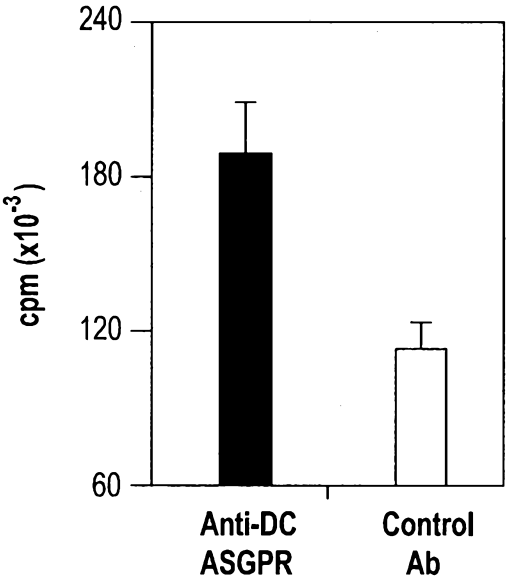
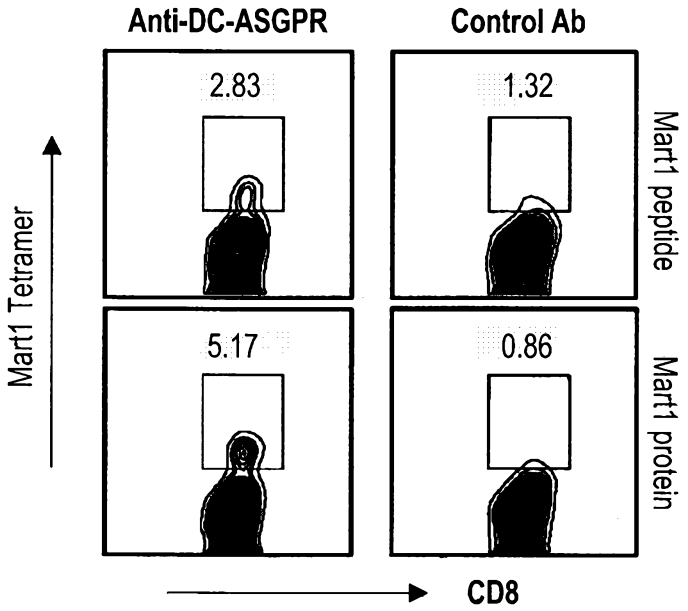


FIG. 4A

FIG. 4B



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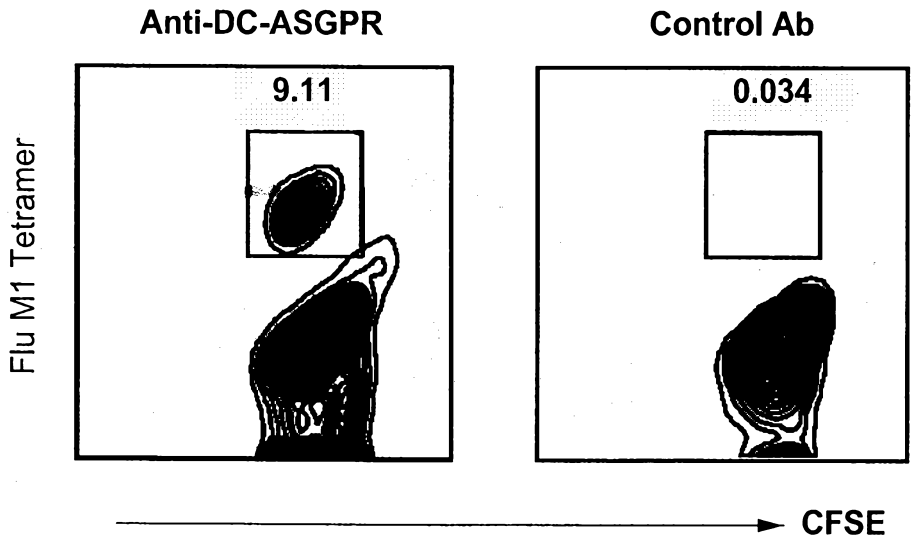


FIG. 4C

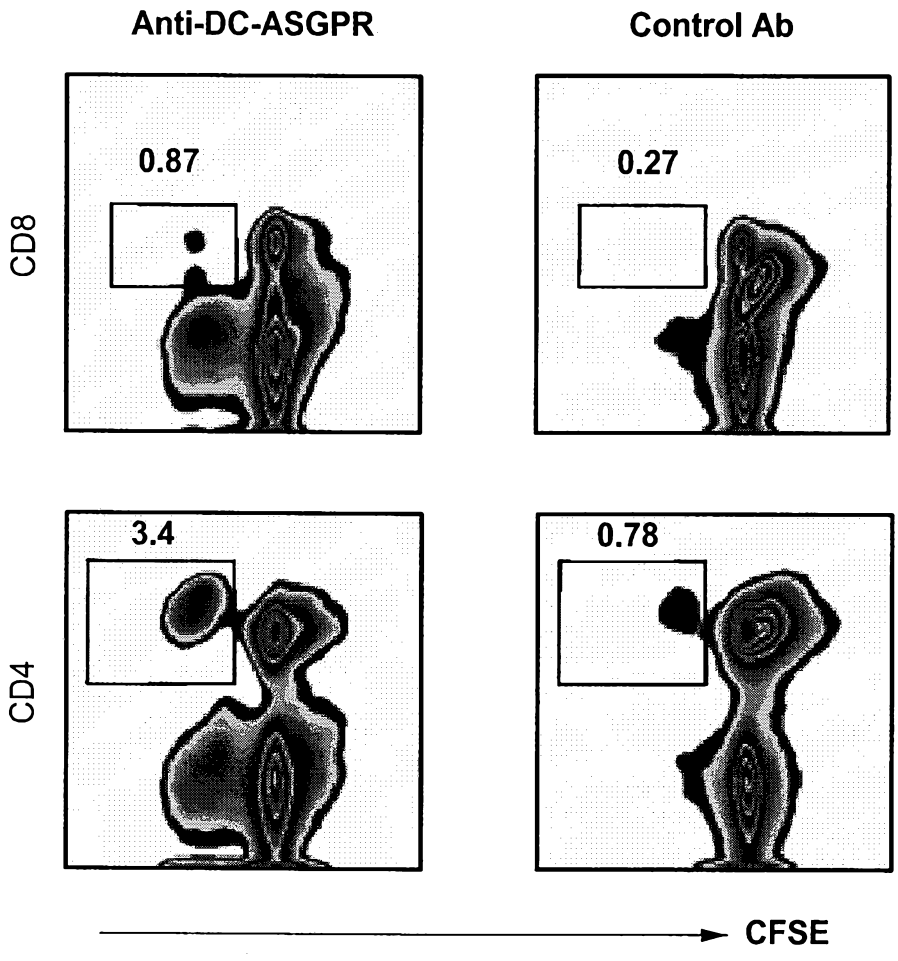
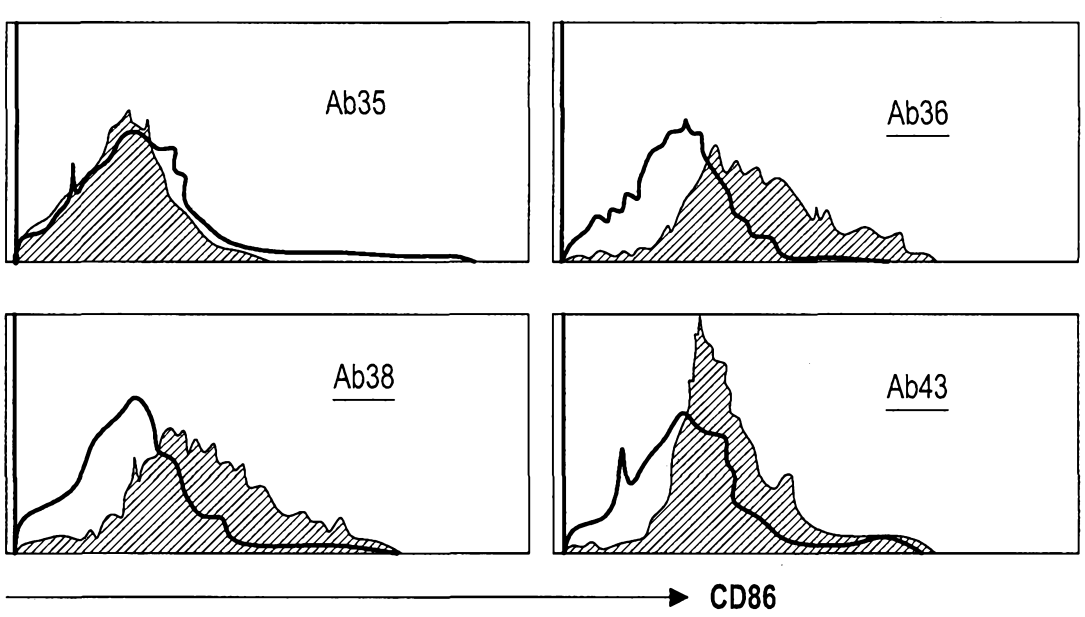


FIG. 4D



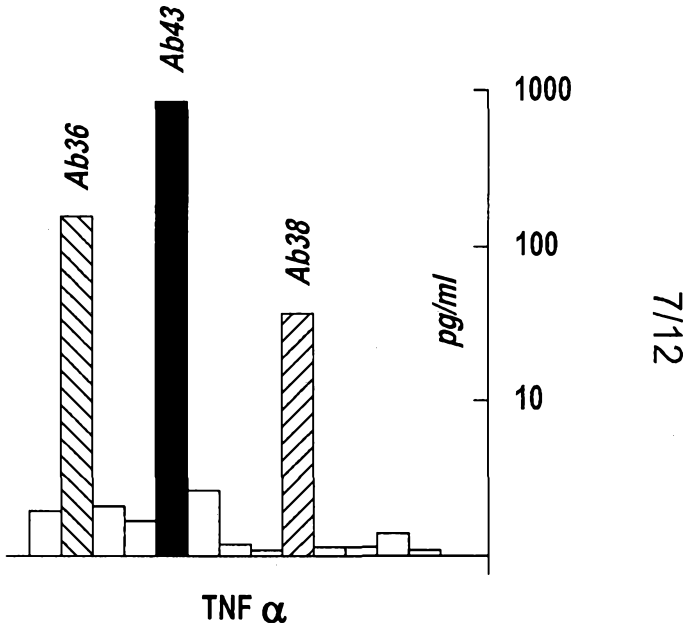


FIG. 5

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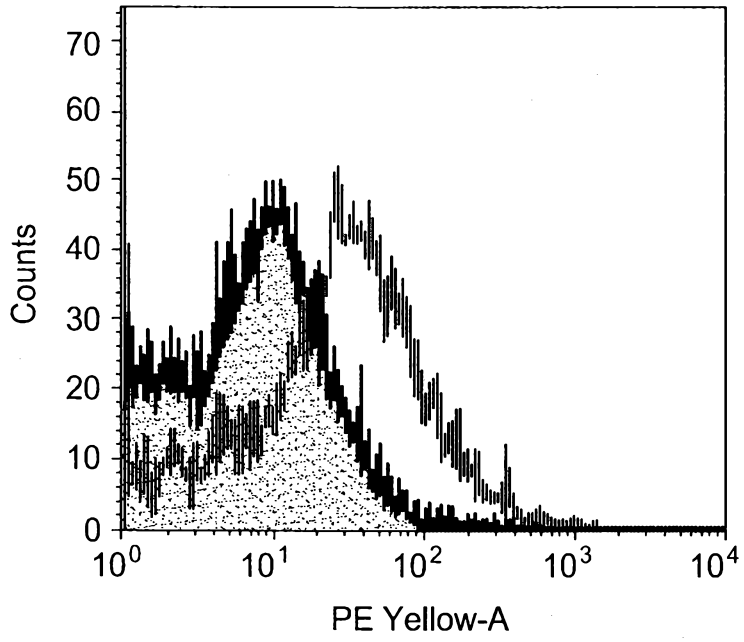

FIG. 6

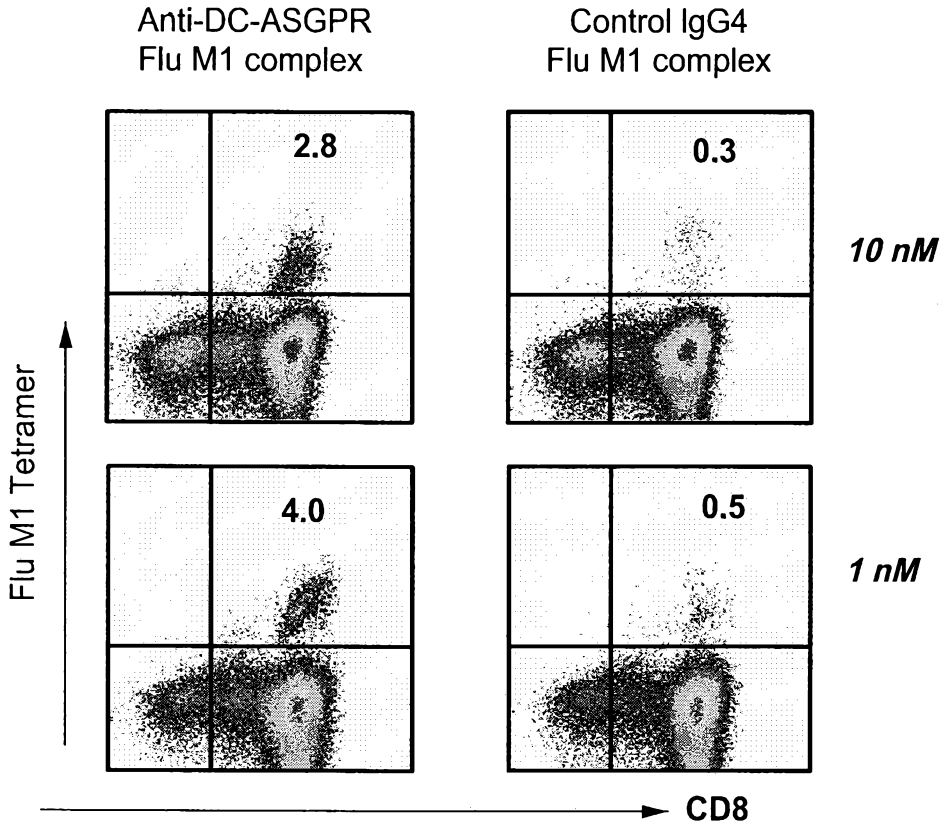

FIG. 7

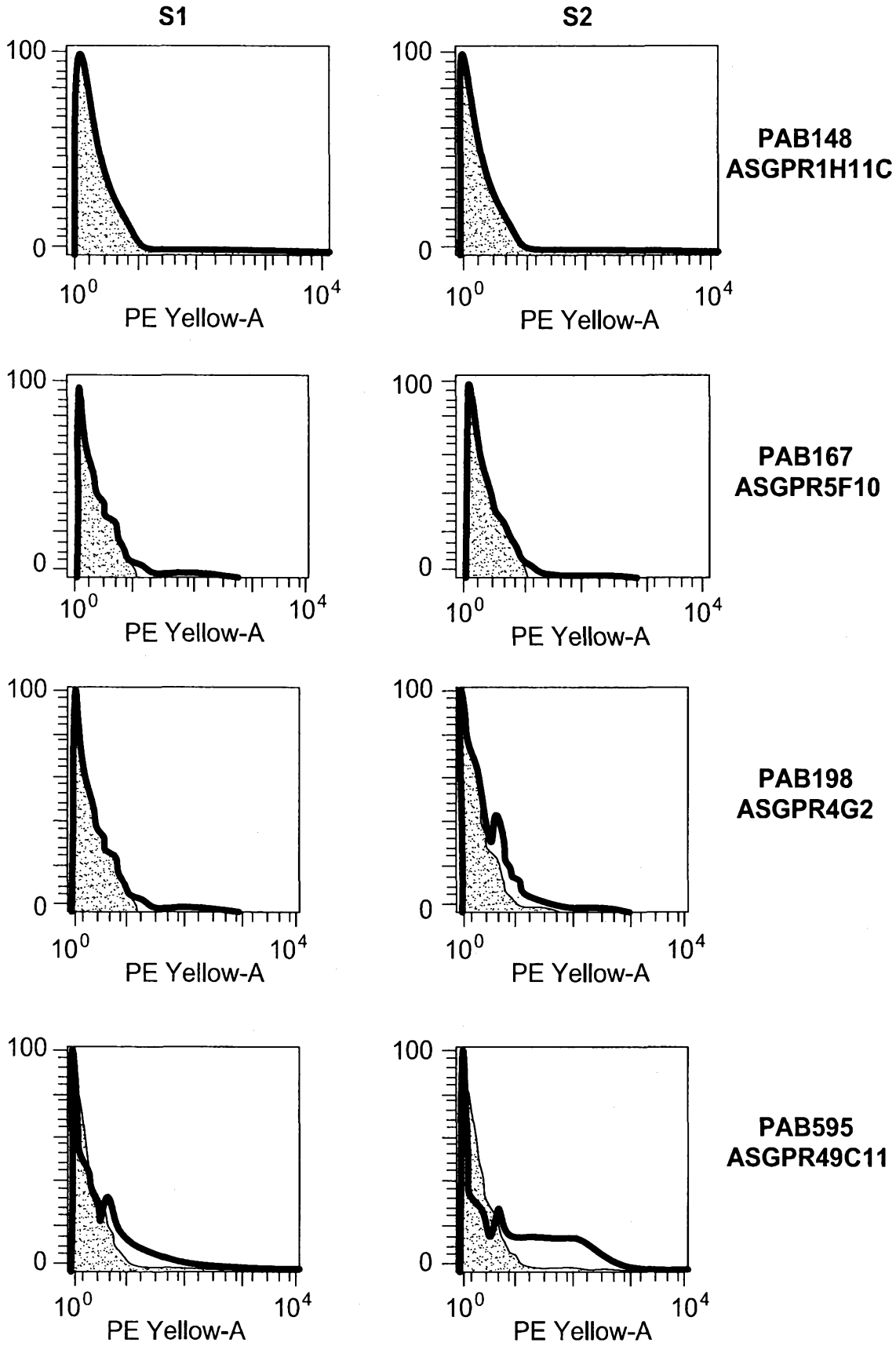
S1
S2
100
0
10^0
10^4
PE Yellow-A
PAB148
ASGPR1H11C
PAB167
ASGPR5F10
PAB198
ASGPR4G2
PAB595
ASGPR49C11

FIG. 8A

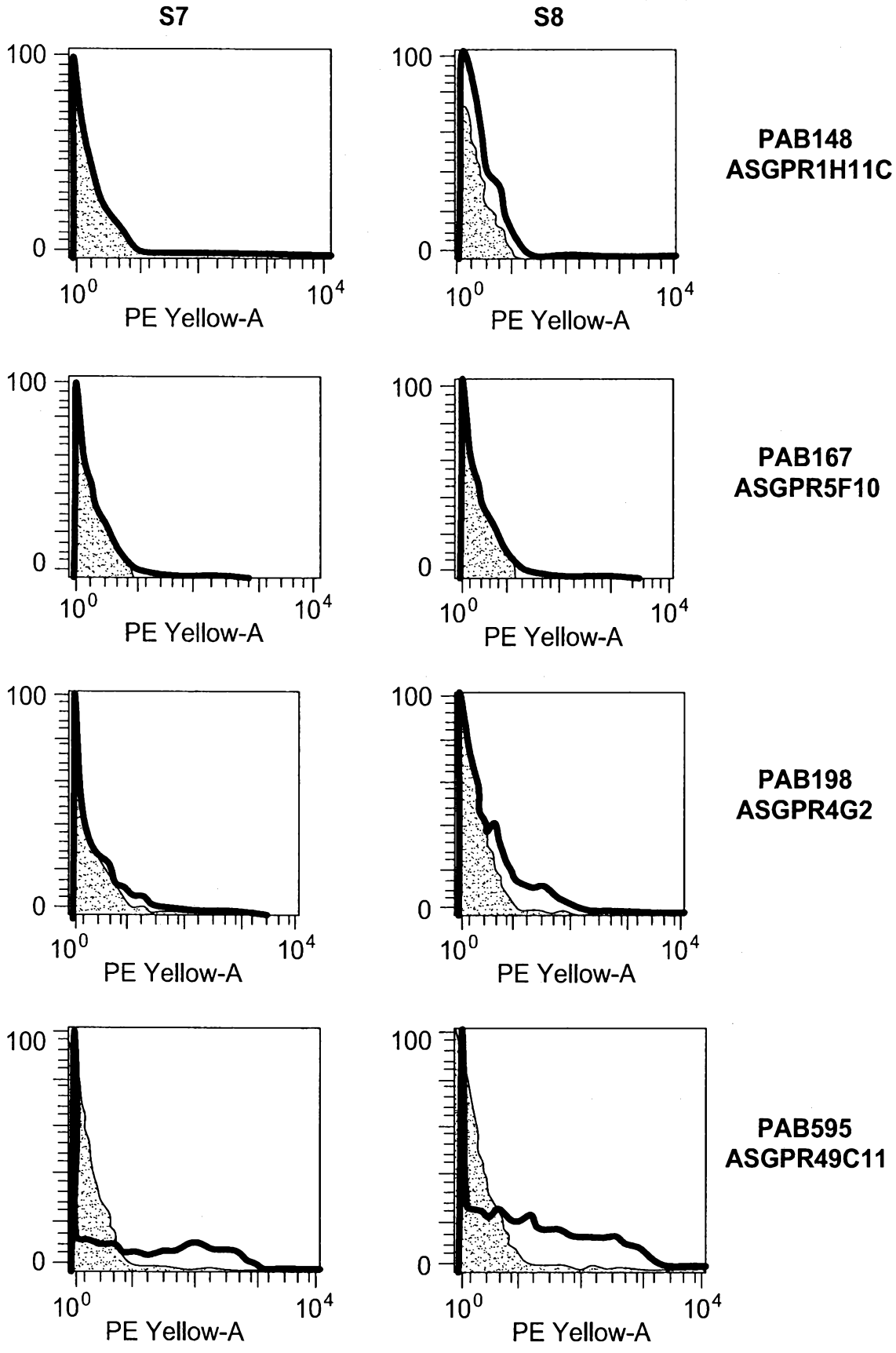
S7
S8
100
0
10^0
10^4
PE Yellow-A
PAB148
ASGPR1H11C
PAB167
ASGPR5F10
PAB198
ASGPR4G2
PAB595
ASGPR49C11

FIG. 8B

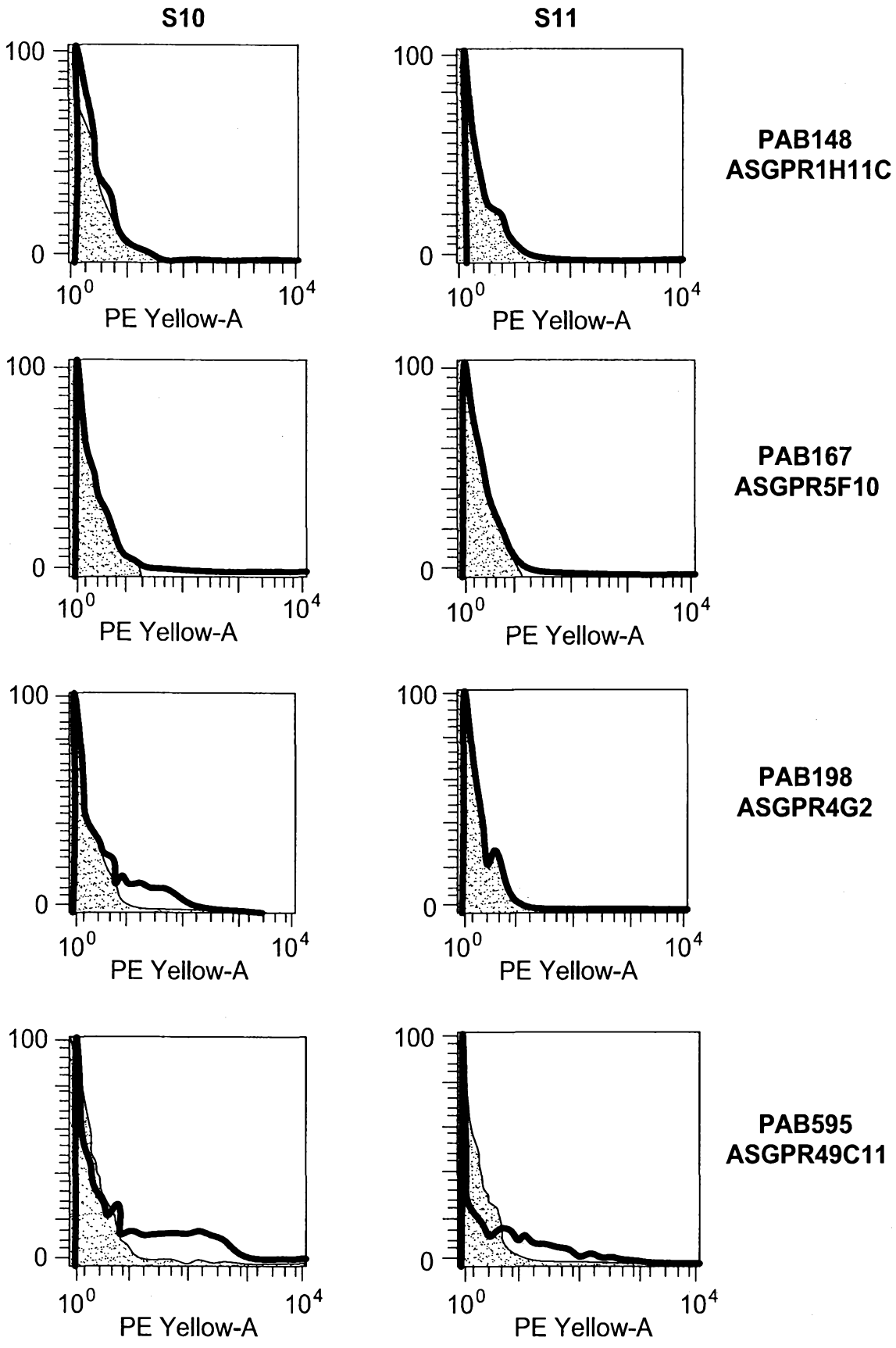
S10
S11
100
0
10^0
10^4
PE Yellow-A
PAB148
ASGPR1H11C
PAB167
ASGPR5F10
PAB198
ASGPR4G2
PAB595
ASGPR49C11

FIG. 8C

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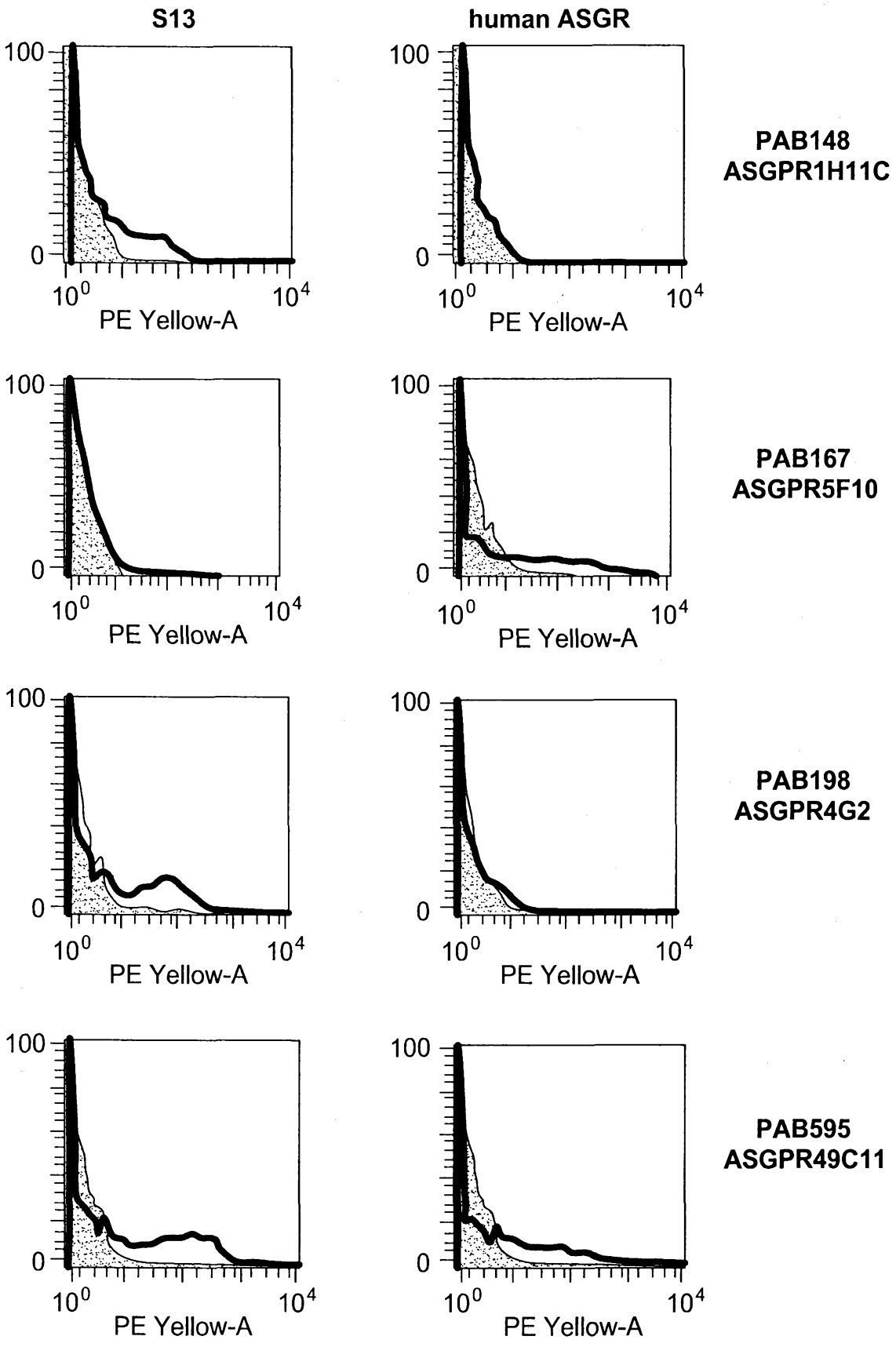

FIG. 8D