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(54) Title: ANTIGEN PRESENTING CELL TARGETED VACCINES

(57) Abstract: The present invention includes compositions and methods for the expression, secretion and use of novel compositions for use as, e.g., vaccines and antigen delivery vectors, to delivery antigens to antigen presenting cells. In one embodiment, the vector is an anti-CD40 antibody, or fragments thereof, and one or more antigenic peptides linked to the anti-CD40 antibody or fragments thereof, including humanized antibodies.

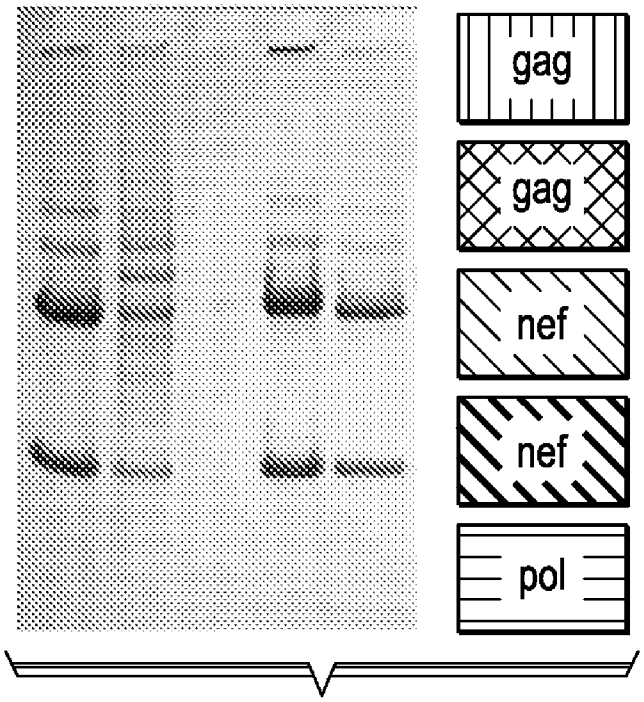

FIG. 1

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ANTIGEN PRESENTING CELL TARGETED VACCINES

Technical Field of the Invention

The present invention relates in general to the field of immunization, and more particularly, to novel anti-CD40 based vaccines.

Background Art

Without limiting the scope of the invention, its background is described in connection with antigen presentation. One example of vaccines and methods for antigen presentation is taught in United States Patent No. 7,118,751, issued to Ledbetter, et al., for DNA vaccines encoding an amino-terminus antigen linked to a carboxy-terminus domain that binds CD40. Briefly, vaccines are taught that target one or more antigens to a cell surface receptor to improve the antigen-specific humoral and cellular immune response. Antigen(s) linked to a domain that binds to a cell surface receptor are internalized, carrying antigen(s) into an intracellular compartment where the antigen(s) are digested into peptides and loaded onto MHC molecules. T cells specific for the peptide antigens are activated, leading to an enhanced immune response. The vaccine may comprise antigen(s) linked to a domain that binds at least one receptor or a DNA plasmid encoding antigen(s) linked to a domain that binds at least one receptor. A preferred embodiment of the invention targets HIV-1 env antigen to the CD40 receptor, resulting in delivery of antigen to CD40 positive cells, and selective activation of the CD40 receptor on cells presenting HIV-1 env antigens to T cells.

Another example is found in United States Patent Application No. 20080254026, filed by Li, et al., for antagonist anti-CD40 monoclonal antibodies and methods for their use. Briefly, compositions and methods are disclosed for use in therapy for treating diseases mediated by stimulation of CD40 signaling on CD40-expressing cells are provided. The methods comprise administering a therapeutically effective amount of an antagonist anti-CD40 antibody or antigen-binding fragment thereof to a patient in need thereof. The antagonist anti-CD40 antibody or antigen-binding fragment thereof is free of significant agonist activity, but exhibits antagonist activity when the antibody binds a CD40 antigen on a human CD40-expressing cell. Antagonist activity of the anti-CD40 antibody or antigen-binding fragment thereof beneficially inhibits proliferation and/or differentiation of human CD40-expressing cells, such as B cells.

Yet another example is taught in United States Patent Application No. 20080241139, filed by Delucia for an adjuvant combination comprising a microbial TLR agonist, a CD40 or 4-1BB agonist, and optionally an antigen and the use thereof for inducing a synergistic enhancement in cellular immunity. Briefly, this application is said to teach adjuvant combinations comprising at least one microbial TLR agonist such as a whole virus, bacterium or yeast or portion thereof such a membrane, spheroplast, cytoplast, or ghost, a CD40 or 4-1BB agonist and optionally an antigen wherein all 3 moieties may be

separate or comprise the same recombinant microorganism or virus are disclosed. The use of these immune adjuvants for treatment of various chronic diseases such as cancers and HIV infection is also provided.

United States Patent Application No. 20080199471, filed by Bernett, et al., is directed to optimized CD40 antibodies and methods of using the same. Briefly, this application is said to teach antibodies that target CD40, wherein the antibodies comprise at least one modification relative to a parent antibody, wherein the modification alters affinity to an FcγR or alters effector function as compared to the parent antibody. Also disclosed are methods of using the antibodies of the invention.

Finally, United States Patent Application No. 20080181915, file by Tripp, et al., is directed to a CD40 ligand adjuvant for respiratory syncytial virus. Briefly, this application is said to teach methods and adjuvants for enhancing an immune response to RSV in a host, wherein the methods and adjuvants comprise a source of a CD40 binding protein. Preferably, the CD40 binding protein is CD40L and the source is a vector comprising a promoter operatively linked to a CD40L coding region. The enhanced immune response produced by the adjuvants and methods of the current invention includes both increased expression of Th1 cytokines and increased production of antibody.

Disclosure of the Invention

In one embodiment, the present invention is a fusion protein comprising the formula: Antibody(Ab)-Peptide Linker (PL)-Antigen (Ag)*x*, Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)x-PL; or Ab-(Ag-PL)x-Ag; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site. In one aspect, Ag is selected from a viral antigen, a tumor antigen, an infectious disease antigen, an autoimmune antigen, a toxin or combinations thereof. In another aspect, the Ag is a peptide concatemer. In another aspect, the PL is a peptide concatemer. In another aspect, the -(PL–Ag)x, -(Ag-PL)x, -(PL-Ag-PL)x, or -(Ag-PL-Ag)*x* are located at the carboxy terminus of the Ab heavy chain or fragment thereof. In another aspect, the Ag elicits a humoral immune response and/or cellular immune response in a host. In one aspect, the Ab comprises at least the variable region of anti-CD40_12E12.3F3 (ATCC Accession No. PTA-9854), anti-CD40_12B4.2C10 (Deposit Submission No. HS446, ATCC Accession No. ____), and anti-CD40_11B6.1C3 (Deposit Submission No. HS440, ATCC Accession No. ____).

In one aspect, the Ag is selected from autoimmune diseases or disorders associated with antigens involved in autoimmune disease selected from 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. In another aspect, the Ag is selected from infectious disease antigens selected from bacterial, viral, parasitic, and fungal antigens. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19. In another aspect, the fusion protein comprises two or more Ags from different antigens separated by at least one PL. In another aspect, the fusion protein comprises two or more Ags separated by at least one PL comprising an alanine and a serine. In another aspect, the Ab is an antibody fragment selected from Fv, Fab, Fab', F(ab')2, Fc, or a ScFv.

In one aspect, the Ab binds specifically to an MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40, CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptor, or lectin. In another aspect, the Ab is an IgA, IgD, IgE, IgG or IgM or isotype thereof. In another aspect, the Ab is a human antibody or a humanized antibody. In another aspect, the PL comprises an alanine and a serine. In another aspect, the PL is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

Yet another embodiment of the present invention is a nucleic acid expression vector encoding a fusion protein comprising: a first polynucleotide encoding an antibody light chain or fragment thereof; and a second polynucleotide encoding an antibody heavy chain or fragment thereof; wherein the fusion protein comprises the following formula: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site. In one aspect, the (PL–Ag)*x* or (Ag-PL)*x* are located at the carboxy terminus of the Ab heavy chain or fragment thereof. In another aspect, the first and second polynucleotide are on a single expression vector. In another aspect, the Ag is selected from infectious disease antigens selected from bacterial, viral, parasitic, and fungal antigens. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19. In another aspect, the fusion protein comprises two or more Ags from different antigens separated by at least one PL. In another aspect, the fusion protein comprises two or more Ags separated by at least on PL comprising an alanine and a serine. In another aspect, the Ab is an antibody fragment selected from Fv, Fab, Fab', F(ab')2, Fc, or a ScFv. In another aspect, the Ab binds specifically to an MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40, CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptor, or lectin. In another

aspect, the Ab is an IgA, IgD, IgE, IgG or IgM or isotype thereof. In another aspect, the Ab is a human antibody or a humanized antibody. In another aspect, the PL is comprises an alanine and a serine and/or the PL is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14). In another aspect, the first and second polynucleotides are downstream from a constitutive promoter.

Yet another embodiment of the present invention is a stable, secretable fusion protein comprising the formula: NH_2-Ab-(PL–Ag)x-COOH or NH2-Ab-(Ag-PL)x-COOH; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one immunogenic antigen; and wherein *x* is an integer from 1 to 20, the fusion protein being stable and soluble in solution as compared to an Ab-Ag protein alone that is not soluble or stable.

Another embodiment is a method of stabilizing antigenic peptides comprising: incorporating one or more antigenic peptides that are unstable or insoluble into a fusion protein, wherein the fusion protein has the following structure: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20, the fusion protein being stable and soluble in solution wherein the Ab-Ag is not soluble or stable.

Yet another embodiment of the present invention is a host cell comprising a nucleic acid expression vector comprising: a first polynucleotide encoding an antibody light chain; and a second polynucleotide encoding an antibody heavy chain fusion protein, the fusion protein comprising the following formula: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20, the fusion protein having more stability is solution than the fusion protein without the glycosylation site. In another embodiment, the host cell comprises an expression vector that produces a fusion protein comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)x-PL; or Ab-(Ag-PL)x-Ag; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site.

The present invention also includes a pharmaceutical composition comprising the antibody having the formula comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)x-PL; or Ab-(Ag-PL)x-Ag; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen;

and wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site.

Yet another embodiment of the present invention is a fusion protein comprising the formula: Ab-(PL–Ag)x-(PLy-Agz)n; or Ab-(Ag–PL)x-(PLy-Agz)n; wherein Ab is an antibody or fragment thereof; wherein PL is at least one peptide linker comprising at least one glycosylation site; wherein Ag is at least one antigen; and wherein *x* is an integer from 1 to 20; wherein n is 0 to 19; and wherein y or z is 0 to 10, wherein the fusion protein has more stability in solution than the same fusion protein without the glycosylation site.

Another embodiment is an isolated and purified vaccine comprising: a heavy chain selected from at least one of SEQ ID NOS.: 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 36, 37, 96, 97, 98, 99, 110, 111, 112, 118, 119, 134, 136, 138, 146, and 147 that binds specifically to CD40; and a light chain that binds specifically to CD40. In one aspect, the antibody is defined further as a humanized antibody.

Yet another embodiment of the present invention is a fusion protein comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)x-PL; or Ab-(Ag-PL)x-Ag; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one viral antigen; and *x* is an integer from 1 to 20. In one aspect, the fusion protein has more stability is solution than the PL without the glycosylation site. In another aspect, the Ag comprises a peptide from an adenovirus, retrovirus, picornavirus, herpesvirus, rotaviruses, hantaviruses, coronavirus, togavirus, flavirvirus, rhabdovirus, paramyxovirus, orthomyxovirus, bunyavirus, arenavirus, reovirus, papilomavirus, parvovirus, poxvirus, hepadnavirus, or spongiform virus. In another aspect, the Ag comprises a peptide from at least one of HIV, CMV, hepatitis A, B, and C, influenza; measles, polio, smallpox, rubella, respiratory syncytial, herpes simplex, varicella zoster, Epstein-Barr, Japanese encephalitis, rabies, flu, or cold viruses.

In another aspect, the Ag is selected from: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35): EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5). In another aspect, the Ag is 19 to 32 residues. In another aspect, the Ag is selected from a cytotoxic T lymphocyte (CTL) epitope identified in the HIV-1 Nef, Gag and Env proteins presented in the context of MHC-class I molecules. In another aspect, the Ag is selected from HIV gp120, gp41, Gag, p17, p24, p2, p7, p1, p6, Tat, Rev, PR, RT, IN, Vif, Vpr, Vpx, Vpu and Nef. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 or 19. In another aspect, the Ag comprises virus peptides from different antigens separated by different peptide linkers. In another aspect, the Ag is separated by at least one PL

comprising an alanine and a serine. In another aspect, the fusion protein is selected from SEQ ID NOS.: 21, 22, 23, 24, 25, 26 or 36. In another aspect, the fusion protein is isolated from a cell that comprises a polynucleotide vector that encodes the fusion protein, the polynucleotide vector comprising SEQ ID NOS.: 21, 22, 23, 24, 25, 26 or 36. In another aspect, the Ab comprises SEQ ID NOS.: 37 and 38.

In another aspect, the fusion protein is isolated from a cell that comprises a polynucleotide vector that expresses the fusion protein and the Ab portion comprises SEQ ID NOS.: 39 and 40. In another aspect, Ag is selected from at least one of SEQ ID NOS.: 52-56, 58-60, 61-69, 70-72, or 73-77. In another aspect, the Ag is 17 to 60 residues. In another aspect, the Ag is 8, 10, 12, 14, 15, 16, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55 to 60 residues long. In another aspect, the Ag comprises at least one lipopeptide. In another aspect, the Ag is at the carboxy-terminus and further comprises a carboxy-terminus (Palm)-NH_2 group. In another aspect, the PL is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14). In another aspect, the PL comprises an alanine and a serine.

Another embodiment is the present invention is a viral antigen delivery vector comprising: a fusion protein comprising an anti-CD40 antibody or fragment thereof and one or more viral peptides at the carboxy-terminus of the anti-CD40 antibody, wherein when two or more viral peptides are present the viral peptides are separated by the one or more peptide linkers comprising at least one potential glycosylation site. In another aspect, an antigen delivery vector is an anti-CD40 antibody or fragment thereof and two or more viral peptides at the carboxy-terminus of the light chain, the heavy chain or both the light and heavy chains of the anti-CD40 antibody, wherein when two or more viral peptides are separated by the one or more peptide linkers that comprise at least one potential glycosylation site.

Yet another embodiment of the present invention is a method of stabilizing viral peptides comprising: incorporating one or more viral peptides that are unstable or insoluble into a fusion protein with an antibody, wherein the antibody and the viral peptides are separated by one or more peptide linkers that comprise one or more glycosylation sites. Yet another embodiment is a method of enhancing T cell responses comprising: immunizing a subject in need of vaccination with an effective amount of a vaccine comprising the formula: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one viral antigen; and *x* is an integer from 1 to 20. In one aspect, the fusion protein has more stability in solution than an identical fusion protein without the glycosylation site. In another aspect, the at least one viral antigen comprise peptides from adenovirus, retrovirus, picornavirus, herpesvirus, rotaviruses, hantaviruses, coronavirus, togavirus, flavirvirus, rhabdovirus, paramyxovirus, orthomyxovirus, bunyavirus, arenavirus, reovirus, papilomavirus, parvovirus, poxvirus, hepadnavirus, or spongiform virus. In another aspect, the at least one viral antigen comprise peptides from at least one of HIV, CMV,

hepatitis A, B, and C, influenza; measles, polio, smallpox, rubella; respiratory syncytial, herpes simplex, varicella zoster, Epstein-Barr, Japanese encephalitis, rabies, flu, or cold viruses.

In one aspect, the Ag is selected from: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35): EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); and/or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5). In another aspect, the Ag is 19 to 32 residues and is selected from a cytotoxic T lymphocyte (CTL) epitope identified in the HIV-1 Nef, Gag and Env proteins presented in the context of MHC-class I molecules. In another aspect, the Ag is selected from HIV gp120, gp41, Gag, p17, p24, p2, p7, p1, p6, Tat, Rev, PR, RT, IN, Vif, Vpr, Vpx, Vpu and Nef. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 or 19. In another aspect, the Ag comprises two or more viral antigens from different viruses. In another aspect, PL comprises an alanine and a serine. In another aspect, the vaccine is selected from SEQ ID NOS.: 21, 22, 23, 24, 25, 26 or 36. In another aspect, the Ab comprises SEQ ID NOS.: 37 and 38. In another aspect, the Ag is selected from at least one of SEQ ID NOS.: 52-56, 58-60, 61-69, 70-72, or 73-77. In another aspect, the Ag is 17 to 60 residues. In another aspect, the Ag is 8, 10, 12, 14, 15, 16, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55 to 60 residues long. In another aspect, the Ag is 8, 10, 12, 14, 15, 16, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55 to 60 residues long. In another aspect, the Ag comprise a lipopeptide. In another aspect, the Ag is at the carboxy-terminus and comprises a carboxy-terminus (Palm)-NH_2 group. In another aspect, the PL is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

Yet another embodiment of the present invention is a method of making HIV peptide-specific IFNγ producing T cells comprising: immunizing a subject with a fusion protein comprising an anti-CD40 antibody, or fragment thereof, with one or more HIV peptides at the carboxy-terminus of the antibody; and isolating peripheral blood mononuclear cells from the subject, wherein the isolated peripheral mononuclear cells are enriched for anti-HIV IFNγ producing T cells, wherein the anti-CD40 antibody comprises SEQ ID NOS.: 37 and 38 or fragments thereof. In one aspect, the subject is a patient suspected of having an HIV infection. In another aspect, the fusion protein comprises two or more HIV peptides and the peptides are separated by one or more peptide linkers. In another aspect, the fusion protein comprises two or more HIV peptides and the peptides are separated by the one or more peptide linkers comprise glycosylation sequences. In another aspect, the fusion protein comprises two or more HIV peptides and the peptides are separated by one or more peptide linkers comprising an alanine and a serine. In another aspect, the one or more HIV peptides comprise at least one lipopeptide. In another

aspect, the one or more HIV peptides comprise a carboxy-terminus (Palm)-NH_2 group. In another aspect, the one or more HIV peptides are 19- to 32-amino-acid long and are selected from a cytotoxic T lymphocyte (CTL) epitopes identified in the HIV-1 Nef, Gag and Env proteins in the context of different MHC-class I molecules. In another aspect, the one or more HIV peptides are selected from HIV gp120, gp41, Gag, p17, p24, p2, p7, p1, p6, Tat, Rev, PR, RT, IN, Vif, Vpr, Vpx, Vpu and Nef. In another aspect, the one or more viral peptides are selected from at least one of: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35): EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); and/or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5).

Yet another embodiment of the present invention is a fusion protein comprising an anti-CD40 antibody, or fragment thereof, with one or more viral peptides at the carboxy-terminus of the antibody separated by a PL comprising at least one alanine and one serine. In one aspect, the one or more viral peptides are HIV peptides. In another aspect, the one or more viral peptides are selected from at least one of: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35): EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); and/or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5).

The present invention also includes a method of making a fusion protein comprising: inserting into an expression vector a nucleic acid construct comprising polynucleotides that encode a protein having the formula: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one viral antigen; and *x* is an integer from 1 to 20; and culturing the vector under conditions sufficient to permit expression of the fusion protein. In one aspect, the fusion protein has more stability in solution than an identical fusion protein without the glycosylation site. In another aspect, the at least one viral antigen comprise peptides from an adenovirus, retrovirus, picornavirus, herpesvirus, rotaviruses, hantaviruses, coronavirus, togavirus, flavirvirus, rhabdovirus, paramyxovirus, orthomyxovirus, bunyavirus, arenavirus, reovirus, papilomavirus, parvovirus, poxvirus, hepadnavirus, or spongiform virus. In another aspect, the at least one viral antigen comprise peptides from at least one of HIV, CMV, hepatitis A, B, and C, influenza; measles, polio, smallpox, rubella, respiratory syncytial, herpes simplex, varicella zoster, Epstein-Barr, Japanese encephalitis, rabies, flu, or cold viruses. In another aspect, the fusion protein is the Ab's light chain, the Ab's heavy chain or both the Ab's light and heavy chains. In another aspect, the Ag is selected from: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35):

EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); and/or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5).

Yet another embodiment of the present invention includes a method of expanding antigen-specific T cells in vitro comprising: isolating PBMCs from an HIV patient; incubating the isolated PBMCs with an effective amount of a αCD40.LIPO5 HIV peptide vaccine; expanding the PBMCs in the presence of an effective amount of IL-2; harvesting the cells; and assessing the cytokine production by the cells to determine the presence of anti-HIV specific T cells. Another embodiment is an HIV antigen-specific T cells made by the method comprising: isolating PBMCs from an HIV patient; incubating the isolated PBMCs with an effective amount of a αCD40.LIPO5 HIV peptide vaccine; expanding the PBMCs in the presence of an effective amount of IL-2; harvesting the cells; and assessing the cytokine production by the cells to determine the presence of anti-HIV specific T cells. Another embodiment is a method of making a therapeutic vaccine comprising: loading a dendritic cell with αCD40.LIPO5 HIV peptide vaccine comprising: isolating HIV patient monocytes; differentiating the monocytes into dendritic cells with IFNα and GM-CSF; and exposing the differentiated dendritic cells to an αCD40.LIPO5 HIV peptide, wherein the loaded dendritic cells are capable of stimulating autologous HIV-peptide specific T cells in vitro.

The present invention also includes a therapeutic vaccine made by the method comprising: loading a dendritic cell with αCD40.LIPO5 HIV peptide vaccine comprising: isolating HIV patient monocytes; differentiating the monocytes into dendritic cells with IFNα and GM-CSF; and exposing the differentiated dendritic cells to an αCD40.LIPO5 HIV peptide, wherein the loaded dendritic cells are capable of stimulating autologous HIV-peptide specific T cells in vitro. Another embodiment is a therapeutic vaccine comprising a polypeptide comprising at least one of SEQ ID NOS.: 21, 22, 23, 24, 25, 26 or 36. Yet another embodiment is a therapeutic vaccine comprising a fusion protein comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)x-PL; or Ab-(Ag-PL)x-Ag; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one viral antigen; and *x* is an integer from 1 to 20.

Yet another embodiment of the present invention includes a fusion protein comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)*x*-PL; or Ab-(Ag-PL)*x*-Ag; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one cancer antigen; and *x* is an integer from 1 to 20. In one aspect, the fusion protein has more stability in solution than the same fusion protein without the glycosylation site. In another aspect, the Ag is selected from tumor associated antigens selected from CEA, prostate specific antigen (PSA), HER-2/neu, BAGE, GAGE, MAGE 1-4, 6 and 12, MUC-related protein (Mucin) (MUC-1, MUC-2, etc.), GM2 and GD2 gangliosides, ras, myc, tyrosinase, MART (melanoma

antigen), MARCO-MART, cyclin B1, cyclin D, Pmel 17(gp100), GnT-V intron V sequence (N-acetylglucoaminyltransferase V intron V sequence), Prostate Ca psm, prostate serum antigen (PSA), 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 another aspect, the Ag is selected from tumor associated antigens comprising antigens from leukemias and lymphomas, neurological tumors such as astrocytomas or glioblastomas, melanoma, breast cancer, lung cancer, head and neck cancer, gastrointestinal tumors, gastric cancer, 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, pharyn*x* 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.

In another aspect, the Ag is selected from at least one of: MWVPVVFLTLSVTWIGAAPLILSRIVGGWECEKHSQPWQVLVASRGRAVCGGVLVHPQWV (SEQ ID NO.:74); LTAAHCIRNKSVILLGRHSLFHPEDTGQVFQVSHSFPHPLYDMSLLKNRFLRPGDDSSHD (SEQ ID NO.:75); LMLLRLSEPAELTDAVKVMDLPTQEPALGTTCYASGWGSIEPEEFLTPKKLQCVDLHVIS (SEQ ID NO.:76); NDVCAQVHPQKVTKFMLCAGRWTGGKSTCSGDSGGPLVCNGVLQGITSWGSEPCALPERP (SEQ ID NO.:77); or SLYTKVVHYRKWIKDTIVANP (SEQ ID NO.:78), and fragments thereof. In another aspect, the Ag is selected from at least one of: IMDQVPFSV (SEQ ID NO.:113); ITDQVPFSV (SEQ ID NO.:114); YLEPGPVTV (SEQ ID NO.:115); YLEPGPVTA (SEQ ID NO.:116); KTWGQYWQV (SEQ ID NO.:117); DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRLDCWRGGQVSL KVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVYPQETDDACIFP DGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTMEVTVYHRRGS QSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQ (SEQ ID NO.:122); PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRAXVVTHTYLEPGPVTAQVVLQAAIPLTS CGSSPVPAS (SEQ ID NO.:124); GTTDGHRPTAEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPTTEVISTAPVQMPTAES TGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA (SEQ ID NO.:126); QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSLGPLLDGTATLRLVKRQVPLDCVLYRYG SFSVTLDIVQ (SEQ ID NO.:128); and GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQLVLHQI

LKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ (SEQ ID NO.:130), and fragments thereof.

In another aspect, the Ag is selected from at least one of: MEMKILRALNFGLGRPLPLHFLRRASKIGEVDVEQHTLAKYLMELTMLDY (SEQ ID NO.:132); and DWLVQVQMKFRLLQETMYMTVSIIDRFMQNNCVPKK (SEQ ID NO.:133). In another aspect, the Ag is selected from at least one of: MEHQLLCCEVETIRRAYPDANLLNDRVLRAMLKAEETCAPSVSYFKCV (SEQ ID NO.:141); QKEVLPSMRKIVATWMLEVCEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVAS KMKETIPLTAEKLCIYTDNSIRPEELLQMELL (SEQ ID NO.:142); LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQIIRKHAQTFVALCATDVKFISNPPSMV (SEQ ID NO.:143); and AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDCLRACQEQIEALLESSLRQAQQNM DPKAAEEEEEEEEEVDLACTPTDVRDVDI (SEQ ID NO.:144), and fragments thereof. In another aspect, the Ag is 19 to 32 amino acids long. In another aspect, the Ag is 17 to 60 amino acids long and is selected from a cytotoxic T lymphocyte (CTL) epitope identified in PSA or cyclin 1. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19. In another aspect, the Ag comprises two or more cancer peptides from different cancer antigens separated by the PL. In another aspect, the Ag is separated by at least one PL comprising an alanine and a serine. In another aspect, the Ag is selected from SEQ ID NOS.: 74-78, 79-86, 87-92, 93-95, 113-117, 122-130, 132-133, and 141-144. In another aspect, the Ab comprises SEQ ID NOS.: 38 and 39. In another aspect, the Ab is expressed by a nucleic acid expression vector comprising SEQ ID NOS.: 40 and 41. In another aspect, the PL is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14). In another aspect, the PL comprises an alanine and a serine.

Yet another embodiment of the present invention includes a antigen delivery vector that expresses an anti-CD40 antibody or fragment thereof and two or more cancer peptides at the carboxy-terminus of the light chain, the heavy chain or both the light and heavy chains of the anti-CD40 antibody, wherein when two or more cancer peptides are present, the cancer peptides are separated by the one or more peptide linkers that comprise at least one glycosylation site. In one aspect, the one or more peptide linkers are selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

Yet another embodiment of the present invention includes an anti-CD40 fusion protein comprising an anti-CD40 antibody or fragment thereof and one or more cancer peptides at the carboxy-terminus of the anti-CD40 antibody, wherein when two or more cancer peptides are present the cancer peptides are

separated by the one or more linker peptides that comprise at least one glycosylation site. In one aspect, the antibody fragment is selected from an Fv, Fab, Fab', $F(ab')_2$, Fc, or a ScFv fragment. In another aspect, the Ag is selected from SEQ ID NOS.: 74-78, 79-86, 87-92, 93-95, 113-117, 122-130, 132-133, and 141-144.

Yet another embodiment of the present invention includes a method of stabilizing cancer peptides comprising: incorporating one or more cancer peptides that are unstable or insoluble into a fusion protein with an antibody, wherein the antibody and the cancer peptides are separated by one or more peptide linkers that comprise one or more glycosylation sites. In another aspect, the fusion protein comprises two or more cancer peptides and the cancer peptides are separated by the one or more peptide linkers. In another aspect, the fusion protein comprises two or more cancer peptides and the peptides are separated by the one or more peptide linkers. In another aspect, the fusion protein comprises two or more cancer peptides and the peptides are separated by one or more linkers comprising an alanine and a serine. In another aspect, the cancer peptide is selected from tumor associated antigens selected from CEA, prostate specific antigen (PSA), HER-2/neu, BAGE, GAGE, MAGE 1-4, 6 and 12, MUC-related protein (Mucin) (MUC-1, MUC-2, etc.), GM2 and GD2 gangliosides, ras, myc, tyrosinase, MART (melanoma antigen), MARCO-MART, cyclin B1, cyclin D, Pmel 17(gp100), GnT-V intron V sequence (N-acetylglucoaminyltransferase V intron V sequence), Prostate Ca psm, prostate serum antigen (PSA), 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 another aspect, the Ag is selected from tumor associated antigens comprising antigens from leukemias and lymphomas, neurological tumors such as astrocytomas or glioblastomas, melanoma, breast cancer, lung cancer, head and neck cancer, gastrointestinal tumors, gastric cancer, 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.

In another aspect, the Ag is selected from at least one of: MWVPVVFLTLSVTWIGAAPLILSRIVGGWECEKHSQPWQVLVASRGRAVCGGVLVHPQWV (SEQ ID NO.:74); LTAAHCIRNKSVILLGRHSLFHPEDTGQVFQVSHSFPHPLYDMSLLKNRFLRPGDDSSHD (SEQ ID NO.:75); LMLLRLSEPAELTDAVKVMDLPTQEPALGTTCYASGWGSIEPEEFLTPKKLQCVDLHVIS (SEQ ID NO.:76);

NDVCAQVHPQKVTKFMLCAGRWTGGKSTCSGDSGGPLVCNGVLQGITSWGSEPCALPERP (SEQ ID NO.:77); or SLYTKVVHYRKWIKDTIVANP (SEQ ID NO.:78).

In another aspect, the Ag is selected from at least one of: IMDQVPFSV (SEQ ID NO.:113); ITDQVPFSV (SEQ ID NO.:114); YLEPGPVTV (SEQ ID NO.:115); YLEPGPVTA (SEQ ID NO.:116); KTWGQYWQV (SEQ ID NO.:117); DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRLDCWRGGQVSL KVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVYPQETDDACIFP DGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTMEVTVYHRRGS QSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQ (SEQ ID NO.:122); PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRAXVVTHTYLEPGPVTAQVVLQAAIPLTS CGSSPVPAS (SEQ ID NO.:124); GTTDGHRPTAEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPTTEVISTAPVQMPTAES TGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA (SEQ ID NO.:126); QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSLGPLLDGTATLRLVKRQVPLDCVLYRYG SFSVTLDIVQ (SEQ ID NO.:128); and GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQLVLHQI LKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ (SEQ ID NO.:130), and fragments thereof.

In another aspect, the Ag is selected from at least one of: MEMKILRALNFGLGRPLPLHFLRRASKIGEVDVEQHTLAKYLMELTMLDY (SEQ ID NO.:132); and DWLVQVQMKFRLLQETMYMTVSIIDRFMQNNCVPKK (SEQ ID NO.:133).

In another aspect, the Ag is selected from at least one of: MEHQLLCCEVETIRRAYPDANLLNDRVLRAMLKAEETCAPSVSYFKCV (SEQ ID NO.:141); QKEVLPSMRKIVATWMLEVCEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVAS KMKETIPLTAEKLCIYTDNSIRPEELLQMELL (SEQ ID NO.:142); LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQIIRKHAQTFVALCATDVKFISNPPSMV (SEQ ID NO.:143); and AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDCLRACQEQIEALLESSLRQAQQNM DPKAAEEEEEEEEEVDLACTPTDVRDVDI (SEQ ID NO.:144), and fragments thereof. In another aspect, the Ag is 19 to 32 amino acids long. In another aspect, the Ag is 17 to 60 amino acids long and is selected from a cytotoxic T lymphocyte (CTL) epitope identified in PSA or cyclin 1. In another aspect, *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19. In another aspect, the fusion protein comprises cancer peptides from different antigens separated by different peptide linkers. In another aspect, the fusion protein comprises two or more cancer peptides separated by one or more peptide linkers comprising an alanine and a serine. In another aspect, the antibody comprises SEQ ID NOS.: 38 and 39. In another aspect, the fusion protein is expressed by a nucleic acid expression vector

comprising SEQ ID NOS.: 40 and 41. In another aspect, the peptide linker is selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

Yet another embodiment of the present invention includes a method of enhancing T cell responses comprising: immunizing a subject in need of vaccination with an effective amount of a vaccine comprising a fusion protein comprising an anti-CD40 antibody or portion thereof and one or more cancer peptides linked to the carboxy-terminus of the anti-CD40 antibody. In another aspect, the cancer peptides are selected from tumor associated antigens selected from 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), MARCO-MART, cyclin B1, cyclin D, Pmel 17(gp100), GnT-V intron V sequence (N-acetylglucoaminyltransferase V intron V sequence), Prostate Ca psm, prostate serum antigen (PSA), 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 another aspect, the cancer peptides is selected from tumor associated antigens comprising antigens from leukemias and lymphomas, neurological tumors such as astrocytomas or glioblastomas, melanoma, breast cancer, lung cancer, head and neck cancer, gastrointestinal tumors, gastric cancer, 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.

Yet another embodiment of the present invention includes a method of making an anti-CD40-antigen fusion protein comprising: expressing a fusion protein comprising an anti-CD40 antibody or fragment thereof in a host cell, the fusion protein comprising one or more cancer peptides at the carboxy-terminus of the anti-CD40 antibody or fragment thereof, wherein when two or more cancer peptides are separated by one or more linkers, at least one linker comprising a glycosylation site; and isolating the fusion protein. In another aspect, the fusion protein expressed in the host is further isolated and purified. In another aspect, the host is a eukaryotic cell. In another aspect, the cancer peptides are selected from tumor associated antigens selected from CEA, prostate specific antigen (PSA), HER-2/neu, BAGE, GAGE, MAGE 1-4, 6 and 12, MUC-related protein (Mucin) (MUC-1, MUC-2, etc.), GM2 and GD2 gangliosides, ras, myc, tyrosinase, MART (melanoma antigen), MARCO-MART, cyclin B1, cyclin D, Pmel 17(gp100), GnT-V intron V sequence (N-acetylglucoaminyltransferase V intron V sequence), Prostate Ca psm, prostate serum antigen (PSA), 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 another aspect, the cancer peptides are selected from tumor associated antigens comprising antigens from leukemias and lymphomas, neurological tumors such as astrocytomas or glioblastomas, melanoma, breast cancer, lung cancer, head and neck cancer, gastrointestinal tumors, gastric cancer, 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. In another aspect, the cancer peptides are selected from at least one of: MWVPVVFLTLSVTWIGAAPLILSRIVGGWECEKHSQPWQVLVASRGRAVCGGVLVHPQWV (SEQ ID NO.:74); LTAAHCIRNKSVILLGRHSLFHPEDTGQVFQVSHSFPHPLYDMSLLKNRFLRPGDDSSHD (SEQ ID NO.:75); LMLLRLSEPAELTDAVKVMDLPTQEPALGTTCYASGWGSIEPEEFLTPKKLQCVDLHVIS (SEQ ID NO.:76); NDVCAQVHPQKVTKFMLCAGRWTGGKSTCSGDSGGPLVCNGVLQGITSWGSEPCALPERP (SEQ ID NO.:77); or SLYTKVVHYRKWIKDTIVANP (SEQ ID NO.:78).

In another aspect, the cancer peptides are selected from at least one of: IMDQVPFSV (SEQ ID NO.:113); ITDQVPFSV (SEQ ID NO.:114); YLEPGPVTV (SEQ ID NO.:115); YLEPGPVTA (SEQ ID NO.:116); KTWGQYWQV (SEQ ID NO.:117); DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRLDCWRGGQVSL KVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVYPQETDDACIFP DGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTMEVTVYHRRGS QSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQ (SEQ ID NO.:122); PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRAXVVTHTYLEPGPVTAQVVLQAAIPLTS CGSSPVPAS (SEQ ID NO.:124); GTTDGHRPTAEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPTTEVISTAPVQMPTAES TGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA (SEQ ID NO.:126); QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSLGPLLDGTATLRLVKRQVPLDCVLYRYG SFSVTLDIVQ (SEQ ID NO.:128); and GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQLVLHQI LKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ (SEQ ID NO.:130), and fragments thereof.

In another aspect, the cancer peptides are selected from at least one of: MEMKILRALNFGLGRPLPLHFLRRASKIGEVDVEQHTLAKYLMELTMLDY (SEQ ID NO.:132); and DWLVQVQMKFRLLQETMYMTVSIIDRFMQNNCVPKK (SEQ ID NO.:133).

In another aspect, the cancer peptides are selected from at least one of: MEHQLLCCEVETIRRAYPDANLLNDRVLRAMLKAEETCAPSVSYFKCV (SEQ ID NO.:141); QKEVLPSMRKIVATWMLEVCEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVAS KMKETIPLTAEKLCIYTDNSIRPEELLQMELL (SEQ ID NO.:142); LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQIIRKHAQTFVALCATDVKFISNPPSMV (SEQ ID NO.:143); and AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDCLRACQEQIEALLESSLRQAQQNM DPKAAEEEEEEEEEVDLACTPTDVRDVDI (SEQ ID NO.:144), and fragments thereof.

Yet another embodiment of the present invention includes a method of expanding antigen-specific T cells *in vitro* comprising: isolating peripheral blood mononuclear cells (PBMCs) from a cancer patient; incubating the isolated PBMCs with an immunogenic amount of an αCD40-(PL-Ag)*x* or αCD40-(Ag-PL)*x* vaccine, wherein Ag is a tumor associated antigen and *x* is an integer 1 to 20; expanding the PBMCs in the presence of an effective amount of IL-2; harvesting the cells; and assessing the cytokine production by the cells to determine the presence of anti-cancer specific T cells.

Yet another embodiment of the present invention includes a tumor associated antigen-specific T cells made by the method comprising: isolating peripheral blood mononuclear cells (PBMCs) from a cancer patient; incubating the isolated PBMCs with an immunogenic amount of an αCD40-(PL-Ag)*x* or αCD40-(Ag-PL)*x* vaccine, wherein Ag is a tumor associated antigen and *x* is an integer 1 to 20; expanding the PBMCs in the presence of an effective amount of IL-2; harvesting the cells; and assessing the cytokine production by the cells to determine the presence of tumor associated antigen-specific T cells.

Yet another embodiment of the present invention includes a therapeutic vaccine comprising a fusion protein comprising the formula: Ab-(PL–Ag)*x*; Ab-(Ag-PL)*x*; Ab-(PL-Ag-PL)*x*; Ab-(Ag-PL-Ag)*x*; Ab-(PL–Ag)*x*-PL; or Ab-(Ag-PL)*x*-Ag; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one cancer antigen; and x is an integer from 1 to 20.

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:

Figure 1 shows protein A affinity recombinant antibodies fused to various HIV peptides (lanes 1 to 5) secreted from transfected 293F cells, analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining.

Figure 2 shows protein A affinity purified recombinant antibodies fused to various HIV peptides (Lanes 1 and 2) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining.

Figure 3 shows protein A affinity purified recombinant antibodies fused to various HIV peptide strings (Lanes 1 to 5) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining.

Figure 4 shows protein A affinity purified recombinant antibodies fused to various HIV peptide strings (Lanes 1 to 6) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining.

Figure 5 describes the protocol used in vitro to assay the potency of αCD40.LIPO5 HIV peptide fusion recombinant antibody (αCD40.LIPO5 rAb) to elicit the expansion of antigen-specific T cells in the context of a PBMC culture.

Figure 6 shows HIV peptide-specific IFNγ production in PBMCs from HIV patients incubated with various concentrations of anti-CD40.LIPO5 peptide string vaccine. C is the control group, which received no vaccine, and defines the baseline response of the culture to each peptide.

Figure 7 is a summary of αCD40.LIPO5 peptide vaccine responses against the 5 peptide regions from 8 HIV patients.

Figure 8 shows that the αCD40.LIPO5 HIV peptide vaccine elicits expansion of HIV peptide-specific T cells capable of secreting multiple cytokines – a desirable feature in a vaccine. Figure 8 also shows that the αCD40.LIPO5 HIV peptide vaccine elicits gag253, nef66, nef116 and pol325 peptide-specific responses characterized by production of multiple cytokines (patient A5).

Figure 9 shows the protocol for testing αCD40.LIPO5 HIV peptide vaccine for its ability to direct the expansion of antigen-specific T cells resulting from targeted uptake by DCs and presentation of peptide epitopes on their surface MHC complex.

Figure 10 shows the cytokine secretion in response to HIV peptides from DC-T cell co-cultures treated with various doses of αCD40.LIPO5 HIV peptide vaccine (patient A10).

Figure 11 shows PBMCs from patient A4 treated with the αCD40.LIPO5 HIV peptide vaccine elicit expansion of antigen-specific T cells with specificity to the gag253 region, but not to the flexible linker sequences.

Figure 12A is the αCD40.LIPO5 HIV peptide vaccine heavy chain sequence showing flexible linker regions in bold, joining sequences underlined and HIV peptide regions shaded in grey. Figure 12A shows PBMCs from patient A3 treated with the αCD40.LIPO5 HIV peptide vaccine elicit expansion of antigen-specific T cells with specificities to the gag253, nef66, and nef116 regions, but not to the flexible linker sequences. Figure 12B shows HIV antigen-specific T cell responses evoked from HIV patient A17 PBMCs incubated with 30 nM of three different HIV5 peptide DC targeting vaccines. Figure 12C is a similar study to that show in Figure 12B, except that the PBMCs are from a different HIV patient (A2). Figure 12D shows 15 different HIV peptide responses [5 peptide regions sampled in 3 patients], it was found that the anti-CD40.HIV5pep vaccine was superior to anti-DCIR.HIV5pep, anti-LOX-1.HIV5pep and non-LIPO5 mix for eliciting a broad range of HIV peptide-specific CD8+ and CD4+ T responses.

Figure 13 shows the internalization of anti-CD40 mAb:IL-4DC. IL-4DCs were treated with 500 ng/ml of anti-CD40-Alexa 568.

Figure 14 shows CD4 and CD8 T cell proliferation by DCs targeted with anti-CD40-HA1. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-HA or control Ig-HA1 were co-cultured with CFSE-labeled autologous CD4+ or CD8+ T cells (2x10e5) for 7 days. Cells were then then stained with anti-CD4 or anti-CD8 antibodies. Cell proliferation was tested by measuring CFSE-dilution.

Figure 15 shows a titration of HA1 fusion protein on CD4+ T proliferation. IFNDCs (5K) loaded with fusion proteins were co-cultured with CFSE-labeled CD4+ T cells (200K) for 7 days.

Figure 16 shows IFNDCs targeted with anti-CD40-HA1 activate HA1-specific CD4+ T cells. CD4+ T cells were re-stimulated with DCs loaded with 5 uM of indicated peptides, and then intracellular IFNγ was stained.

Figure 17 shows IFNDCs targeted with anti-CD40-HA1 activate HA1-specific CD4+ T cells. CD4+ T cells were re-stimulated with DCs loaded with indicated peptides for 36h, and then culture supernatant was analyzed for measuring IFNγ.

Figure 18 shows that targeting CD40 results in enhanced cross-priming of MART-1 specific CD8+ T cells. IFNDCs (5K/well) loaded with fusion proteins were co-cultured with purified CD8+ T cells for 10 days. Cells were stained with anti-CD8 and tetramer. Cells are from healthy donors (HLA-A*0201+).

Figure 19 shows targeting CD40 results in enhanced cross-priming of MART-1 specific CD8+ T cells (Summary of 8-repeated experiments using cells from different healthy donors).

Figure 20 shows CD8+ CTL induced with IFNDCs targeted with anti-CD40-MART-1 are functional. CD8+ T cells co-cultured with IFNDCs targeted with fusion proteins were mixed with T2 cells loaded with 10 uM peptide epitope.

Figure 21 shows CD8+ CTL induced with IFNDCs targeted with anti-CD40-Flu M1 are functional. CD8+ T cells co-cultured with IFNDCs targeted with fusion proteins were mixed with T2 cells loaded with 1.0 nM peptide epitope.

Figure 22 shows an outline of protocol to test the ability a vaccine composed of anti-CD4012E12 linked to PSA (prostate specific antigen) to elicit the expansion from a naïve T cell population. PSA-specific CD4+ T cells corresponding to a broad array of PSA epitopes. Briefly, DCs derived by culture with IFNα and GM-CSF of monocytes from a healthy donor are incubated with the vaccine. The next day, cells are placed in fresh medium and pure CD4+ T cells from the same donor are added. Several days later, PSA peptides are added and, after four hours, secreted gamma-IFN levels in the culture supernatants are determined.

Figure 23 shows that many PSA peptides elicit potent gamma-IFN-production responses indicating that anti-CD4012E12 and similar anti-CD40 agents can efficiently deliver antigen to DCs, resulting in the priming of immune responses against multiple epitopes of the antigen.

Figure 24 shows DCs targeted with anti-CD40-PSA induce PSA-specific CD8+ T cell responses. IFNDCs were targeted with 1 ug mAb fusion protein with PSA. Purified autologous CD8+ T cells were co-cultured for 10 days. Cells were stained with anti-CD8 and PSA (KLQCVDLHV)-tetramer. Cells are from a HLA-A*0201 positive healthy donor. The results demonstrate that anti-CD40 effectively deliver PSA to the DCs, which in turn elicit the expansion of PSA-specific CD8+ T cells.

Figure 25 a scheme (left) and the IFNγ production by T cells of the pools of peptides and control for Donor 2. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-Cyclin D1 were co-cultured with purified autologous CD4+ T cells (2x10e5) for 8 days. Cells were then re-stimulated with with 5 uM of individual peptides derived from CyclinD1 for 5h in the presence of Brefeldin A. Cells were stained for measuring intracellular IFNγ expression.

Figure 26 shows a peptide scan and IFNγ production by T cells obtained from the pools of peptides shown in Figure 25 and control for Donor 2. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-Cyclin D1 were co-cultured with purified autologous CD4+ T cells (2x10e5) for 8 days. Cells were then re-stimulated with 5 uM of individual peptides derived from CyclinD1 for 5h in the presence of Brefeldin A. Cells were stained for measuring intracellular IFNγ expression.

Figure 27 shows the expression and construct design for anti-CD40-MART-1 peptide antibodies.

Figure 28 is a summary of the $CD4^+$ and $CD8^+$ immunodominant epitopes for MART-1.

Figure 29 shows the expression and construct design for anti-CD40-gp100 peptide antibodies.

Figure 30 shows the design for additional anti-CD40-gp100 peptide antibodies.

Figure 31 shows the expression and construct design for additional anti-CD40-gp100 peptide antibodies.

Figure 32 is a summary of the $CD4^+$ and $CD8^+$ immunodominant epitopes for gp100.

Figure 33 shows the expression and construct design for additional anti-CD40-gp100 peptide antibodies.

Figure 34A shows that full-length Cyclin B1 fused to the C-terminus of either antibody H chain or cohesion fail to be secreted from mammalian 293F cells. Figure 34B shows that full-length Cyclin B1 fused to the C-terminus of either antibody H chain or cohesion fail to be secreted from mammalian 293F cells.

Figure 35 shows Cyclin B1 segmentation strategy based on known or predicted structural domain regions.

Figure 36 shows that Cyclin D1 segments p1, p3, and p4, but not p2 express well as direct fusions to the H chain C-terminus.

Figure 37 shows the relative expression levels of various Cyclin D1 segments as direct fusions to the H chain C-terminus in various combinations with flexible linker sequences.

Figure 38 show a summary of various H chain-Cyclin D1 segment constructs and their relative expressibility as vaccines.

Figure 39 shows that full-length Cyclin D1 fused to the C-terminus of a DC targeting antibody H chain is very poorly expressed as a secreted recombinant antibody.

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.

The invention includes also variants and other modification of an antibody (or “Ab”) of fragments thereof, e.g., anti-CD40 fusion protein (antibody is used interchangeably with the term

"immunoglobulin"). As used herein, the term "antibodies or fragments thereof," includes whole antibodies or fragments of an antibody, e.g., Fv, Fab, Fab', $F(ab')_2$, Fc, and single chain Fv fragments (ScFv) or any biologically effective fragments of an immunoglobulins that binds specifically to, e.g., CD40. Antibodies from human origin or humanized antibodies have lowered or no immunogenicity in humans and have a lower number or no immunogenic epitopes compared to non-human antibodies. Antibodies and their fragments will generally be selected to have a reduced level or no antigenicity in humans.

As used herein, the terms "Ag" or "antigen" refer to a substance capable of either binding to an antigen binding region of an immunoglobulin molecule or of eliciting an immune response, e.g., a T cell-mediated immune response by the presentation of the antigen on Major Histocompatibility Antigen (MHC) cellular proteins. As used herein, "antigen" includes, but is not limited to, antigenic determinants, haptens, and immunogens which may be peptides, small molecules, carbohydrates, lipids, nucleic acids or combinations thereof. The skilled immunologist will recognize that when discussing antigens that are processed for presentation to T cells, the term "antigen" refers to those portions of the antigen (e.g., a peptide fragment) that is a T cell epitope presented by MHC to the T cell receptor. When used in the context of a B cell mediated immune response in the form of an antibody that is specific for an "antigen", the portion of the antigen that binds to the complementarity determining regions of the variable domains of the antibody (light and heavy) the bound portion may be a linear or three-dimensional epitope. In the context of the present invention, the term antigen is used on both contexts, that is, the antibody is specific for a protein antigen (CD40), but also carries one or more peptide epitopes for presentation by MHC to T cells. In certain cases, the antigens delivered by the vaccine or fusion protein of the present invention are internalized and processed by antigen presenting cells prior to presentation, e.g., by cleavage of one or more portions of the antibody or fusion protein.

As used herein, the term "antigenic peptide" refers to that portion of a polypeptide antigen that is specifically recognized by either B-cells or T-cells. B-cells respond to foreign antigenic determinants via antibody production, whereas T-lymphocytes are the mediate cellular immunity. Thus, antigenic peptides are those parts of an antigen that are recognized by antibodies, or in the context of an MHC, by T-cell receptors.

As used herein, the term "epitope" refers to any protein determinant capable of specific binding to an immunoglobulin or of being presented by a Major Histocompatibility Complex (MHC) protein (e.g., Class I or Class II) to a T-cell receptor. Epitopic determinants are generally short peptides 5-30 amino acids long that fit within the groove of the MHC molecule that presents certain amino acid side groups toward the T cell receptor and has certain other residues in the groove, e.g., due to specific charge characteristics of the groove, the peptide side groups and the T cell receptor. Generally, an antibody specifically binds to an antigen when the dissociation constant is 1 mM, 100 nM or even 10 nM.

As used herein, the term "vector" is used in two different contexts. When using the term "vector" with reference to a vaccine, a vector is used to describe a non-antigenic portion that is used to direct or deliver the antigenic portion of the vaccine. For example, an antibody or fragments thereof may be bound to or form a fusion protein with the antigen that elicits the immune response. For cellular vaccines, the vector for delivery and/or presentation of the antigen is the antigen presenting cell, which is delivered by the cell that is loaded with antigen. In certain cases, the cellular vector itself may also process and present the antigen(s) to T cells and activate an antigen-specific immune response. When used in the context of nucleic acids, a "vector" refers a construct which is capable of delivering, and preferably expressing, one or more genes or polynucleotide sequences of interest in a host cell. Examples of vectors include, but are not limited to, viral vectors, naked DNA or RNA expression vectors, DNA or RNA expression vectors associated with cationic condensing agents, DNA or RNA expression vectors encapsulated in liposomes, and certain eukaryotic cells, such as producer cells.

The compositions and methods of the present invention can be used with a wide variety of peptides and/or protein in which the antibody or fragment thereof and the peptide linker or "PL" create a protein that is stable and/or soluble.

As used herein, the compositions and methods use an antigen delivery vector comprising the formula: Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*; wherein Ab is an antibody or fragment thereof; PL is at least one peptide linker comprising at least one glycosylation site; Ag is at least one viral antigen; and *x* is an integer from 1 to 20. One example of an antibody for use with the present invention comprises at least the variable region of anti-CD40_12E12.3F3 (ATCC Accession No. PTA-9854), anti-CD40_12B4.2C10 (Deposit No. HS446, ATCC Accession No. ____), and anti-CD40_11B6.1C3 (Deposit No. HS440, ATCC Accession No. ____).

As used herein, the terms "stable" and "unstable" when referring to proteins is used to describe a peptide or protein that maintains its three-dimensional structure and/or activity (stable) or that loses immediately or over time its three-dimensional structure and/or activity (unstable). As used herein, the term "insoluble" refers to those proteins that when produced in a cell (e.g., a recombinant protein expressed in a eukaryotic or prokaryotic cell or in vitro) are not soluble in solution absent the use of denaturing conditions or agents (e.g., heat or chemical denaturants, respectively). The antibody or fragment thereof and the linkers taught herein have been found to convert antibody fusion proteins with the peptides from insoluble and/or unstable into proteins that are stable and/or soluble. Another example of stability versus instability is when the domain of the protein with a stable conformation has a higher melting temperature (T_m) than the unstable domain of the protein when measured in the same solution. A domain is stable compared to another domain when the difference in the T_m is at least about 2° C, more preferably about 4° C, still more preferably about 7° C, yet more preferably about 10° C, even more preferably about 15° C, still more preferably about 20° C, even still more preferably about 25° C, and most preferably about 30° C, when measured in the same solution.

As used herein, "polynucleotide" or "nucleic acid" refers to a strand of deoxyribonucleotides or ribonucleotides in either a single- or a double-stranded form (including known analogs of natural nucleotides). A double-stranded nucleic acid sequence will include the complementary sequence. The polynucleotide sequence may encode variable and/or constant region domains of immunoglobulin that are formed into a fusion protein with one or more linkers. For use with the present invention, multiple cloning sites (MCS) may be engineered into the locations at the carboxy-terminal end of the heavy and/or light chains of the antibodies to allow for in-frame insertion of peptide for expression between the linkers. As used herein, the term "isolated polynucleotide" refers to a polynucleotide of genomic, cDNA, or synthetic origin or some combination thereof. By virtue of its origin the "isolated polynucleotide" (1) is not associated with all or a portion of a polynucleotide in which the "isolated polynucleotides" are found in nature, (2) is operably linked to a polynucleotide which it is not linked to in nature, or (3) does not occur in nature as part of a larger sequence. The skilled artisan will recognize that to design and implement a vector having the formula Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*, can be manipulated at the nucleic acid level by using techniques known in the art, such as those taught in Current Protocols in Molecular Biology, 2007 by John Wiley and Sons, relevant portions incorporated herein by reference. Briefly, the Ab, Ag and PL encoding nucleic acid sequences can be inserted using polymerase chain reaction, enzymatic insertion of oligonucleotides or polymerase chain reaction fragments in a vector, which may be an expression vector. To facilitate the insertion of (PL–Ag)*x* or (Ag-PL)*x* at the carboxy terminus of the antibody light chain, the heavy chain, or both, a multiple cloning site (MCS) may be engineered in sequence with the antibody sequences.

As used herein, the term "polypeptide" refers to a polymer of amino acids and does not refer to a specific length of the product; thus, peptides, oligopeptides, and proteins are included within the definition of polypeptide. This term also does not refer to or exclude post expression modifications of the polypeptide, for example, glycosylations, acetylations, phosphorylations and the like. Included within the definition are, for example, polypeptides containing one or more analogs of an amino acid (including, for example, unnatural amino acids, etc.), polypeptides with substituted linkages, as well as other modifications known in the art, both naturally occurring and non-naturally occurring. The term "domain," or "polypeptide domain" refers to that sequence of a polypeptide that folds into a single globular region in its native conformation, and that may exhibit discrete binding or functional properties.

[0100] A polypeptide or amino acid sequence "derived from" a designated nucleic acid sequence refers to a polypeptide having an amino acid sequence identical to that of a polypeptide encoded in the sequence, or a portion thereof wherein the portion consists of at least 3-5 amino acids, preferably at least 4-7 amino acids, more preferably at least 8-10 amino acids, and even more preferably at least 11-15 amino acids, or which is immunologically identifiable with a polypeptide encoded in the sequence. This terminology also includes a polypeptide expressed from a designated nucleic acid sequence.

[0101] As used herein, "pharmaceutically acceptable carrier" refers to any material that when combined with an immunoglobulin (Ig) fusion protein of the present invention allows the Ig to retain biological activity and is generally non-reactive with the subject's immune system. Examples include, but are not limited to, standard pharmaceutical carriers such as a phosphate buffered saline solution, water, emulsions such as an oil/water emulsion, and various types of wetting agents. Certain diluents may be used with the present invention, e.g., for aerosol or parenteral administration, that may be phosphate buffered saline or normal (0.85%) saline.

[0102] The invention provides an CD40 binding molecule comprising at least one immunoglobulin light chain variable domain (V_L) which comprises in sequence hypervariable regions $CDR1_L$, $CDR2_L$ and $CDR3_L$, the $CDR1_L$having the amino acid sequence SASQGISNYLN (SEQ ID NO.:41) the $CDR2_L$ having the amino acid sequence YTSILHS (SEQ ID NO.:42) and the $CDR3_L$ having the amino acid sequence QQFNKLPPT (SEQ ID NO.:43) the amino acid sequences of which are shown in SEQ ID NO. 37; and direct equivalent thereof.

[0103] Accordingly the invention provides an CD40 binding molecule which comprises an antigen binding site comprising at least one immunoglobulin heavy chain variable domain (V_H) which comprises in sequence hypervariable regions $CDR1_H$, $CDR2_H$ and $CDR3_H$, the $CDR1_H$ having the amino acid sequence GFTFSDYYMY (SEQ ID NO.:44), the $CDR2_H$ having the amino acid sequence YINSGGGSTYYPDTVKG (SEQ ID NO.:45), and the $CDR3_H$ having the amino acid sequence RGLPFHAMDY (SEQ ID NO.:46), the amino acid sequences of which are shown in SEQ ID NO. 38; and direct equivalents thereof.

[0104] In one aspect the invention provides a single domain CD40 binding molecule comprising an isolated immunoglobulin light chain comprising a heavy chain variable domain (V_L) as defined above. In another aspect the invention provides a single domain CD40 binding molecule comprising an isolated immunoglobulin heavy chain comprising a heavy chain variable domain (V_H) as defined above.

[0105] In another aspect the invention also provides an CD40 binding molecule comprising both heavy (V_H) and light chain (V_L) variable domains in which the CD40 binding molecule comprises at least one antigen binding site comprising: a) an immunoglobulin heavy chain variable domain (V_L) which comprises in sequence hypervariable regions $CDR1_L$, $CDR2_L$ and $CDR3_L$, the $CDR1_L$ having the amino acid sequence SASQGISNYLN (SEQ ID NO.:41), the $CDR2_L$ having the amino acid sequence YTSILHS (SEQ ID NO.:42), and the $CDR3_L$ having the amino acid sequence QQFNKLPPT (SEQ ID NO.:43), the amino acid sequences of which are shown in SEQ ID. NO. 1, and b) an immunoglobulin light chain variable domain (V_H) which comprises in sequence hypervariable regions $CDR1_H$, $CDR2_H$ and $CDR3_H$, the $CDR1_H$ having the amino acid sequence GFTFSDYYMY (SEQ ID NO.:44), the CDR2' having the amino acid sequence YINSGGGSTYYPDTVKG (SEQ ID NO.:45), and the $CDR3_H$ having

the amino acid sequence RGLPFHAMDY (SEQ ID NO.:46), the amino acid sequences of which are shown in SEQ ID NO. 38; and direct equivalents thereof.

[0106] Unless otherwise indicated, any polypeptide chain is herein described as having an amino acid sequence starting at the N-terminal end and ending at the C-terminal end. When the antigen binding site comprises both the V_H and V_L domains, these may be located on the same polypeptide molecule or, preferably, each domain may be on a different chain, the V_H domain being part of an immunoglobulin heavy chain or fragment thereof and the V_L being part of an immunoglobulin light chain or fragment thereof.

[0107] Non-limiting examples for antigens targeted by the antibodies of the present invention include, but are not limited to: cell surface marker selected from MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40,CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptors, lectins, or other immune cell receptors. In one specific example, the antigens that are targeted by the antibody portion of the present invention are specifically expressed by antigen presenting cells, e.g., dendritic cells, Langerhans cells, macrophages, and B cells.

[0108] As used herein, the term "CD40 binding molecule" refers to any molecule capable of binding to the CD40 antigen either alone or associated with other molecules having one or more the V_L and V_H CDRs taught herein, in some cases 2, 3, 4, 5, or all 6 CDRs. The binding reaction may be shown by standard methods (qualitative assays) including, for example, a bioassay for determining by blocking the binding of other molecules to CD40 or any kind of binding or activity assays (e.g., activation, reduction or modulation of an immune response), with reference to a negative control test in which an antibody of unrelated specificity but of the same isotype, e.g., an anti-CD25 or anti-CD80 antibody, is used.

[0109] The present invention may also be made into a single chain antibody having the variable domains of the heavy and light chains of an antibody covalently bound by a peptide linker usually including from 10 to 30 amino acids, preferably from 15 to 25 amino acids. Therefore, such a structure does not include the constant part of the heavy and light chains and it is believed that the small peptide spacer should be less antigenic than a whole constant part.

[0110] As used herein, the term "chimeric antibody" refers to an antibody in which the constant regions of heavy or light chains or both are of human origin while the variable domains of both heavy and light chains are of non-human (e.g., mouse, hamster or rat) origin or of human origin but derived from a different human antibody.

[0111] As used herein, the term "CDR-grafted antibody" refers to an antibody in which the hypervariable complementarity determining regions (CDRs) are derived from a donor antibody, such as

a non-human (e.g., mouse) antibody or a different human antibody, while all or substantially all the other parts of the immunoglobulin (e.g., the conserved regions of the variable domains, i.e., framework regions), are derived from an acceptor antibody (in the case of a humanized antibody -an antibody of human origin). A CDR-grafted antibody may include a few amino acids of the donor sequence in the framework regions, for instance in the parts of the framework regions adjacent to the hypervariable regions.

[0112] As used herein, the term "human antibody" refers to an antibody in which the constant and variable regions of both the heavy and light chains are all of human origin, or substantially identical to sequences of human origin, not necessarily from the same antibody and includes antibodies produced by mice in which the mouse, hamster or rat immunoglobulin variable and constant part genes have been replaced by their human counterparts, e.g. as described in general terms in EP 0546073 B1, U.S. Pat. No. 5,545,806, U.S. Pat. No. 5,569,825, U.S. Pat. No. 5,625,126, U.S. Pat. No. 5,633,425, U.S. Pat. No. 5,661,016, U.S. Pat. No. 5,770,429, EP 0 438474 B1 and EP 0 463151 B1, relevant portions incorporated herein by reference.

[0113] The CD40 binding molecule of the invention can be a humanized antibody that comprises the CDRs obtained from the anti-CD40_12E12.3F3, the anti-CD40_11B6.1C3, or the anti-CD40_12B4.2C10 antibodies. One example of a chimeric antibody includes the variable domains of both heavy and light chains are of human origin, for instance those variable domains of the anti-CD40_12E12.3F3 antibody that are part of SEQ ID NO.: 148 and SEQ ID NO.: 149, anti-CD40_12B4.2C10 in SEQ ID NO.: 150 and SEQ ID NO.: 151 or SEQ ID NO.: 152, and/or anti-CD40_11B6.1C3, SEQ ID NO.: 153 and SEQ ID NO.: 154, or combination thereof. The constant region domains preferably also comprise suitable human constant region domains, for instance as described in "Sequences of Proteins of Immunological Interest", Kabat E. A. et al, US Department of Health and Human Services, Public Health Service, National Institute of Health. The nucleic acid sequences can be found in, e.g., SEQ ID NOS.: 8 and 9.

[0114] Hypervariable regions may be associated with any kind of framework regions, e.g., of human origin. Suitable framework regions were described Kabat E. A. One heavy chain framework is a heavy chain framework, for instance that of anti-CD40_12E12.3F3 antibody that are part of SEQ ID NO.: 149; anti-CD40_12B4.2C10 - SEQ ID NO.: 151 or SEQ ID NO.: 152, and/or anti-CD40_11B6.1C3 - SEQ ID NO.: 154, or combination thereof, e.g., $FR1_L$, $FR2_L$, $FR3_L$ and $FR4_L$ regions. In a similar manner, SEQ ID NO. 148 shows the anti-CD40_12E12.3F3 (or the equivalents for anti-CD40_12B4.2C10 and anti-CD40_11B6.1C3, SEQ ID NOS.: 150 and 153, respectively) heavy chain framework that includes the sequence of $FR1_H$, $FR2_H$, $FR3_H$ and $FR4_H$ regions. The CDRs may be added to a human antibody framework, such as those described in 7,456,260, issued to Rybak, et al., which teach new human variable chain framework regions and humanized antibodies comprising the framework regions, relevant portions and framework sequences incorporated herein by reference. To accomplish the engraftment at

a genetic level, the present invention also includes the underlying nucleic acid sequences for the V_L AND V_H regions as well as the complete antibodies and the humanized versions thereof. The nucleic acid sequences of the present invention include SEQ ID NOS.: 155 and 156, which are the anti-CD40 antibody light and the heavy chains, respectively, as well as those nucleic acid sequences that include variable codon usage for the same amino acid sequences and conservative variations thereof having 85, 90, 95 or 100 % sequence identity at the nucleic or amino acid level. Likewise, the CDRs may have 85, 90, 95 or 100 % sequence identity at the nucleic or amino acid level, individually, in groups or 2, 3, 4 or 5 or all together.

[0115] Monoclonal antibodies raised against a protein naturally found in all humans are typically developed in a non-human system e.g. in mice, and as such are typically non-human proteins. As a direct consequence of this, a xenogenic antibody as produced by a hybridoma, when administered to humans, elicits an undesirable immune response that is predominantly mediated by the constant part of the xenogenic immunoglobulin. Xenogeneic antibodies tend to elicit a host immune response, thereby limiting the use of such antibodies as they cannot be administered over a prolonged period of time. Therefore, it is particularly useful to use single chain, single domain, chimeric, CDR-grafted, or especially human antibodies that are not likely to elicit a substantial allogenic response when administered to humans. The present invention includes antibodies with minor changes in an amino acid sequence such as deletion, addition or substitution of one, a few or even several amino acids which are merely allelic forms of the original protein having substantially identical properties.

[0116] The inhibition of the binding of CD40 to its receptor may be conveniently tested in various assays including such assays are described hereinafter in the text. By the term “to the same extent” is meant that the reference and the equivalent molecules exhibit, on a statistical basis, essentially identical CD40 binding inhibition curves in one of the assays referred to above. For example, the assay used may be an assay of competitive inhibition of binding of CD40 by the binding molecules of the invention.

[0117] Generally, the human anti-CD40 antibody comprises at least: (a) one light chain which comprises a variable domain having an amino acid sequence substantially identical to that shown in SEQ ID NO. 1 starting with the amino acid at position 1 and ending with the amino acid at position 107 and the constant part of a human light chain; and (b) one heavy chain which comprises a variable domain having an amino acid sequence substantially identical to that shown in SEQ ID NO. 2 and the constant part of a human heavy chain. The constant part of a human heavy chain may be of the γ1, γ2, γ3, γ4, μ, β2, or δ or ε type, preferably of the γ-type, whereas the constant part of a human light chain may be of the κ or λ type (which includes the λ_1, λ_2 and λ_3 subtypes) but is preferably of the κ type. The amino acid sequences of the general locations of the variable and constant domains are well known in the art and generally follow the Kabat nomenclature.

[0118] A CD40 binding molecule of the invention may be produced by recombinant DNA techniques. In view of this, one or more DNA molecules encoding the binding molecule must be constructed, placed under appropriate control sequences and transferred into a suitable host organism for expression.

[0119] In a very general manner, there are accordingly provided: (i) DNA molecules encoding a single domain CD40 binding molecule of the invention, a single chain CD40 binding molecule of the invention, a heavy or light chain or fragments thereof of a CD40 binding molecule of the invention; and (ii) the use of the DNA molecules of the invention for the production of a CD40 binding molecule of the invention by recombinant methods.

[0120] The present state of the art is such that the skilled worker in the art can synthesize the DNA molecules of the invention given the information provided herein, i.e., the amino acid sequences of the hypervariable regions and the DNA sequences coding for them. A method for constructing a variable domain gene is for example described in EPA 239 400, relevant portions incorporated herein by reference. Briefly, a gene encoding a variable domain of a MAb is cloned. The DNA segments encoding the framework and hypervariable regions are determined and the DNA segments encoding the hypervariable regions are removed so that the DNA segments encoding the framework regions are fused together with suitable restriction sites at the junctions. The restriction sites may be generated at the appropriate positions by mutagenesis of the DNA molecule by standard procedures. Double stranded synthetic CDR cassettes are prepared by DNA synthesis according to the sequences given in SEQ ID NO. 1 and 3 or 2 and 4 (amino acid and nucleic acid sequences, respectively). These cassettes are often provided with sticky ends so that they can be ligated at the junctions of the framework.

[0121] It is not necessary to have access to the mRNA from a producing hybridoma cell line in order to obtain a DNA construct coding for the CD40 binding molecules of the invention. For example, PCT application WO 90/07861 gives full instructions for the production of an antibody by recombinant DNA techniques given only written information as to the nucleotide sequence of the gene, relevant portions incorporated herein by reference. Briefly, the method comprises the synthesis of a number of oligonucleotides, their amplification by the PCR method, and their splicing to give the desired DNA sequence.

[0122] Expression vectors comprising a suitable promoter or genes encoding heavy and light chain constant parts are publicly available. Thus, once a DNA molecule of the invention is prepared it may be conveniently transferred in an appropriate expression vector. DNA molecules encoding single chain antibodies may also be prepared by standard methods, for example, as described in WO 88/1649. In view of the foregoing, no hybridoma or cell line deposit is necessary to comply with the criteria of sufficiency of description.

[0123] For example, first and second DNA constructs are made that bind specifically to CD40. Briefly, a first DNA construct encodes a light chain or fragment thereof and comprises a) a first part which

encodes a variable domain comprising alternatively framework and hypervariable regions, the hypervariable regions being in sequence $CDR1_L$, $CDR2_L$ and $CDR3_L$ the amino acid sequences of which are shown in SEQ ID NO. 1; this first part starting with a codon encoding the first amino acid of the variable domain and ending with a codon encoding the last amino acid of the variable domain, and b) a second part encoding a light chain constant part or fragment thereof which starts with a codon encoding the first amino acid of the constant part of the heavy chain and ends with a codon encoding the last amino acid of the constant part or fragment thereof, followed by a stop codon.

[0124] The first part encodes a variable domain having an amino acid sequence substantially identical to the amino acid sequence as shown in SEQ ID NO. 1. A second part encodes the constant part of a human heavy chain, more preferably the constant part of the human γ1 chain. This second part may be a DNA fragment of genomic origin (comprising introns) or a cDNA fragment (without introns).

[0125] The second DNA construct encodes a heavy chain or fragment thereof and comprises a) a first part which encodes a variable domain comprising alternatively framework and hypervariable regions; the hypervariable regions being $CDR1_H$ and optionally $CDR2_H$ and $CDR3_H$, the amino acid sequences of which are shown in SEQ ID NO. 2; this first part starting with a codon encoding the first amino acid of the variable domain and ending with a codon encoding the last amino acid of the variable domain, and b) a second part encoding a heavy chain constant part or fragment thereof which starts with a codon encoding the first amino acid of the constant part of the light chain and ends with a codon encoding the last amino acid of the constant part or fragment thereof followed by a stop codon.

[0126] The first part encodes a variable domain having an amino acid sequence substantially identical to the amino acid sequence as shown in SEQ ID NO. 2. The first part has the nucleotide sequence as shown in SEQ ID NO. 2 starting with the nucleotide at position 1 and ending with the nucleotide at position 321. Also preferably the second part encodes the constant part of a human light chain, more preferably the constant part of the human κ chain.

[0127] The invention also includes CD40 binding molecules in which one or more of the residues of $CDR1_L$, $CDR2_L$, $CDR3_L$, $CDR1_H$, $CDR2_H$ or $CDR3_H$ or the frameworks, typically only a few (e.g. $FR1\text{-}4_L$ or $_H$), are changed from the residues shown in SEQ ID NO. 37 and SEQ ID NO. 38; by, e.g., site directed mutagenesis of the corresponding DNA sequences. The invention includes the DNA sequences coding for such changed CD40 binding molecules. In particular the invention includes a CD40 binding molecules in which one or more residues of $CDR1_L$, $CDR2_L$ and/or $CDR3_L$ have been changed from the residues shown in SEQ ID NO. 37 and one or more residues of $CDR1_H$, $CDR2_H$ and/or $CDR3_H$ have been changed from the residues shown in SEQ ID NO. 38.

[0128] Each of the DNA constructs are placed under the control of suitable control sequences, in particular under the control of a suitable promoter. Any kind of promoter may be used, provided that it is adapted to the host organism in which the DNA constructs will be transferred for expression.

However, if expression is to take place in a mammalian cell, an immunoglobulin gene promoter may be used in B cells. The first and second parts may be separated by an intron, and, an enhancer may be conveniently located in the intron between the first and second parts. The presence of such an enhancer that is transcribed but not translated, may assist in efficient transcription. In particular embodiments the first and second DNA constructs comprise the enhancer of, e.g., a heavy chain human gene.

[0129] The desired antibody may be produced in a cell culture or in a transgenic animal. A suitable transgenic animal may be obtained according to standard methods that include micro injecting into eggs the first and second DNA constructs placed under suitable control sequences transferring the so prepared eggs into appropriate pseudo-pregnant females and selecting a descendant expressing the desired antibody.

[0130] The invention also provides an expression vector able to replicate in a prokaryotic or eukaryotic cell line, which comprises at least one of the DNA constructs above described. Each expression vector containing a DNA construct is then transferred into a suitable host organism. When the DNA constructs are separately inserted on two expression vectors, they may be transferred separately, i.e. one type of vector per cell, or co-transferred, this latter possibility being preferred. A suitable host organism may be a bacterium, a yeast or a mammalian cell line, this latter being preferred. More preferably, the mammalian cell line is of lymphoid origin, e.g., a myeloma, hybridoma or a normal immortalized B-cell, which conveniently does not express any endogenous antibody heavy or light chain.

[0131] When the antibody chains are produced in a cell culture, the DNA constructs must first be inserted into either a single expression vector or into two separate but compatible expression vectors, the latter possibility being preferred. For expression in mammalian cells it is preferred that the coding sequence of the CD40 binding molecule is integrated into the host cell DNA within a locus which permits or favors high level expression of the CD40 binding molecule.

[0132] In a further aspect of the invention there is provided a process for the product of a CD40 binding molecule that comprises: (i) culturing an organism which is transformed with an expression vector as defined above; and (ii) recovering the CD40 binding molecule from the culture.

[0133] In accordance with the present invention it has been found that the anti-CD40_12E12.3F3, anti-CD40_12B4.2C10 and/or anti-CD40_11B6.1C3 antibody appears to have binding specificity for the antigenic epitope of human CD40. It is therefore most surprising that antibodies to this epitope, e.g. the anti-CD40_12E12.3F3 antibody, are capable of delivering antigen efficiently into dendritic cells (DCs). Antibodies, in particular chimeric and CDR-grafted antibodies and especially human antibodies, which have binding specificity for the antigenic epitope of mature human CD40; and use of such antibodies for DC antigen loading are novel and are included within the scope of the present invention.

[0134] To use the anti-CD40 antibody of the present invention for treatment indications, the appropriate dosage will, of course, vary depending upon, for example, the antibody disclosed herein to

be employed, the host, the mode of administration and the nature and severity of the condition being treated. However, in prophylactic use, satisfactory results are generally found at dosages from about 0.05 mg to about 10 mg per kilogram body weight more usually from about 0.1 mg to about 5 mg per kilogram body weight. The frequency of dosing for prophylactic uses will normally be in the range from about once per week up to about once every 3 months, more usually in the range from about once every 2 weeks up to about once every 10 weeks, e.g., once every 4 to 8 weeks. The anti-CD40 antibody of the present can be administered parenterally, intravenously, e.g., into the antecubital or other peripheral vein, intramuscularly, or subcutaneously.

[0135] Pharmaceutical compositions of the invention may be manufactured in conventional manner, e.g., in a lyophilized form. For immediate administration it is dissolved in a suitable aqueous carrier, for example sterile water for injection or sterile buffered physiological saline. If it is considered desirable to make up a solution of larger volume for administration by infusion rather as a bolus injection, it is advantageous to incorporate human serum albumin or the patient's own heparinized blood into the saline at the time of formulation. The presence of an excess of such physiologically inert protein prevents loss of antibody by adsorption onto the walls of the container and tubing used with the infusion solution. If albumin is used, a suitable concentration is from 0.5 to 4.5% by weight of the saline solution.

[0136] One embodiment of the present invention provides an immunoconjugate comprising a humanized antibody of the invention, e.g., a humanized anti-CD40 antibody, linked to one or more effector molecules, antigen(s) and/or a detectable label(s). Preferably, the effector molecule is a therapeutic molecule such as, for example, one or more peptides that comprise one or more T cell epitopes, a toxin, a small molecule, a cytokine or a chemokine, an enzyme, or a radiolabel.

[0137] Exemplary toxins include, but are not limited to, Pseudomonas exotoxin or diphtheria toxin. Examples of small molecules include, but are not limited to, chemotherapeutic compounds such as taxol, doxorubicin, etoposide, and bleiomycin. Exemplary cytokines include, but are not limited to, IL-1, IL-2, IL-4, IL-5, IL-6, and IL-12, IL-17, and IL-25. Exemplary enzymes include, but are not limited to, RNAses, DNAses, proteases, kinases, and caspases. Exemplary radioisotopes include, but are not limited to, ^{32}P and ^{125}I.

[0138] As used herein, the term “epitope” refers to a molecule or substance capable of stimulating an immune response. In one example, epitopes include but are not limited to a polypeptide and a nucleic acid encoding a polypeptide, wherein expression of the nucleic acid into a polypeptide is capable of stimulating an immune response when the polypeptide is processed and presented on a Major Histocompatibility Complex (MHC) molecule. Generally, epitopes include peptides presented on the surface of cells non-covalently bound to the binding groove of Class I or Class II MHC, such that they can interact with T cell receptors and the respective T cell accessory molecules.

[0139] Proteolytic Processing of Antigens. Epitopes that are displayed by MHC on antigen presenting cells are cleavage peptides or products of larger peptide or protein antigen precursors. For MHC I epitopes, protein antigens are often digested by proteasomes resident in the cell. Intracellular proteasomal digestion produces peptide fragments of about 3 to 23 amino acids in length that are then loaded onto the MHC protein. Additional proteolytic activities within the cell, or in the extracellular milieu, can trim and process these fragments further. Processing of MHC Class II epitopes generally occurs via intracellular proteases from the lysosomal/endosomal compartment. The present invention includes, in one embodiment, pre-processed peptides that are attached to the anti-CD40 antibody (or fragment thereof) that directs the peptides against which an enhanced immune response is sought directly to antigen presenting cells.

[0140] To identify epitopes potentially effective as immunogenic compounds, predictions of MHC binding alone are useful but often insufficient. The present invention includes methods for specifically identifying the epitopes within antigens most likely to lead to the immune response sought for the specific sources of antigen presenting cells and responder T cells.

[0141] The present invention allows for a rapid and easy assay for the identification of those epitopes that are most likely to produce the desired immune response using the patient's own antigen presenting cells and T cell repertoire. The compositions and methods of the present invention are applicable to any protein sequence, allowing the user to identify the epitopes that are capable of binding to MHC and are properly presented to T cells that will respond to the antigen. Accordingly, the invention is not limited to any particular target or medical condition, but instead encompasses and MHC epitope(s) from any useful source.

[0142] As used herein, the term "veneered" refers to a humanized antibody framework onto which antigen-binding sites or CDRs obtained from non-human antibodies (e.g., mouse, rat or hamster), are placed into human heavy and light chain conserved structural framework regions (FRs), for example, in a light chain or heavy chain polynucleotide to "graft" the specificity of the non-human antibody into a human framework. The polynucleotide expression vector or vectors that express the veneered antibodies can be transfected mammalian cells for the expression of recombinant human antibodies which exhibit the antigen specificity of the non-human antibody and will undergo posttranslational modifications that will enhance their expression, stability, solubility, or combinations thereof.

[0143] Antigens.

[0144] Examples of viral antigens for use with the present invention include, but are not limited to, e.g., HIV, HCV, CMV, adenoviruses, retroviruses, picornaviruses, etc. Non-limiting example of 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. The at least one viral antigen may be peptides from an adenovirus, retrovirus, picornavirus, herpesvirus, rotaviruses, hantaviruses, coronavirus, togavirus, flavirvirus, rhabdovirus, paramyxovirus, orthomyxovirus, bunyavirus, arenavirus, reovirus, papilomavirus, parvovirus, poxvirus, hepadnavirus, or spongiform virus. In certain specific, non-limiting examples, the at least one viral antigen are peptides obtained from at least one of HIV, CMV, hepatitis A, B, and C, influenza, measles, polio, smallpox, rubella; respiratory syncytial, herpes simplex, varicella zoster, Epstein-Barr, Japanese encephalitis, rabies, flu, and/or cold viruses.

[0145] In one aspect, the one or more of the antigenic peptides are selected from at least one of: Nef (66-97): VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1); Nef (116-145): HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2); Gag p17 (17-35): EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3); Gag p17-p24 (253-284): NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4); or Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5). In one aspect, the fusion protein peptides are separated by one or more linkers selected from: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11); PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12); TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

[0146] Antigenic targets that may be delivered using the anti-CD40-antigen vaccines of the present invention include genes encoding antigens such as viral antigens, bacterial antigens, fungal antigens or parasitic antigens. 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.

[0147] Bacterial antigens for use with the anti-CD40-antigen vaccines 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.

[0148] 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.

[0149] 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.

[0150] Antigen that can be targeted using the anti-CD40-antigen vaccines 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. In this embodiment, the antibodies may be mono- or bi-specific antibodies that include one anti-CD40 binding domain and one binding domain against a second antigen, e.g., cell surface markers for dendritic cells such as, 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 Dectin-1 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, 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.

[0151] Target antigens on cell surfaces for delivery include 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.

[0152] Examples of antigens that may be delivered alone or in combination to immune cells for antigen presentation using the present invention includes 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 that 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.

[0153] Specific non-limiting examples of tumor antigens for use in an anti-CD40-fusion protein vaccine include, e.g., 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, MAGE, BAGE (melanoma antigen) 2-10, c-ERB2 (Her2/neu), DAGE, EBNA (Epstein-Barr Virus nuclear antigen) 1-6, gp75, human papilloma virus (HPV) E6 and E7, p53, lung resistance protein (LRP), Bcl-2, Ki-67, Cyclin B1, gp100, Survivin, and NYESO-1

[0154] 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.

[0155] 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.

[0156] 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.

[0157] It will be appreciated by those of skill in the art that the sequence of any protein effector molecule may be altered in a manner that does not substantially affect the functional advantages of the effector protein. For example, glycine and alanine are typically considered to be interchangeable as are aspartic acid and glutamic acid and asparagine and glutamine. One of skill in the art will recognize that many different variations of effector sequences will encode effectors with roughly the same activity as the native effector. The effector molecule and the antibody may be conjugated by chemical or by recombinant means as described above. Chemical modifications include, for example, derivitization for the purpose of linking the effector molecule and the antibody to each other, either directly or through a linking compound, by methods that are well known in the art of protein chemistry. Both covalent and noncovalent attachment means may be used with the humanized antibodies of the present invention.

[0158] The procedure for attaching an effector molecule to an antibody will vary according to the chemical structure of the moiety to be attached to the antibody. Polypeptides typically contain a variety of functional groups; e.g., carboxylic acid (COOH), free amine (--NH_2) or sulfhydryl (--SH) groups, which are available for reaction with a suitable functional group on an antibody to result in the binding of the effector molecule. Alternatively, the antibody can be derivatized to expose or to attach additional reactive functional groups, e.g., by attachment of any of a number of linker molecules such as those available from Pierce Chemical Company, Rockford Ill.

[0159] The linker is capable of forming covalent bonds to both the antibody and to the effector molecule. Suitable linkers are well known to those of skill in the art and include, but are not limited to, straight or branched-chain carbon linkers, heterocyclic carbon linkers, or peptide linkers. Where the antibody and the effector molecule are polypeptides, the linkers may be joined to the constituent amino acids through their side groups (e.g., through a disulfide linkage to cysteine). However, in a preferred

embodiment, the linkers will be joined to the alpha carbon amino and carboxyl groups of the terminal amino acids.

[0160] In some circumstances, it is desirable to free the effector molecule from the antibody when the immunoconjugate has reached its target site. Therefore, in these circumstances, immunoconjugates will comprise linkages that are cleavable in the vicinity of the target site. Cleavage of the linker to release the effector molecule from the antibody may be prompted by enzymatic activity or conditions to which the immunoconjugate is subjected either inside the target cell or in the vicinity of the target site. When the target site is a tumor, a linker that is cleavable under conditions present at the tumor site (e.g. when exposed to tumor-associated enzymes or acidic pH) may be used.

[0161] Exemplary chemical modifications of the effector molecule and the antibody of the present invention also include derivitization with polyethylene glycol (PEG) to extend time of residence in the circulatory system and reduce immunogenicity, according to well known methods (See for example, Lisi, et al., Applied Biochem. 4:19 (1982); Beauchamp, et al., Anal Biochem. 131:25 (1982); and Goodson, et al., Bio/Technology 8:343 (1990)).

[0162] The present invention contemplates vaccines for use in both active and passive immunization embodiments. Immunogenic compositions, proposed to be suitable for use as a vaccine, may be prepared most readily directly from immunogenic T-cell stimulating peptides prepared in a manner disclosed herein. The final vaccination material is dialyzed extensively to remove undesired small molecular weight molecules and/or lyophilized for more ready formulation into a desired vehicle. In certain embodiment of the present invention, the compositions and methods of the present invention are used to manufacture a cellular vaccine, e.g., the antigen-delivering anti-CD40 binding portion of the antibody is used to direct the antigen(s) to an antigen presenting cell, which then "loads" the antigen onto MHC proteins for presentation. The cellular vaccine is, therefore, the antigen presenting cell that has been loaded using the compositions of the present invention to generate antigen-loaded antigen presenting cells.

[0163] When the vaccine is the anti-CD40 binding protein itself, e.g., a complete antibody or fragments thereof, then these "active ingredients" can be made into vaccines using methods understood in the art, e.g., U.S. Patent Nos. 4,608,251; 4,601,903; 4,599,231; 4,599,230; and 4.578,770, relevant portions incorporated herein by reference. Typically, such vaccines are prepared as injectables, e.g., as liquid solutions or suspensions or solid forms suitable for re-suspension in liquid prior to injection. The preparation may also be emulsified. The active immunogenic ingredient is often mixed with excipients that are pharmaceutically acceptable and compatible with the active ingredient. Suitable excipients are, for example, water, saline, dextrose, glycerol, ethanol, or the like and combinations thereof. In addition, if desired, the vaccine may contain minor amounts of auxiliary substances such as wetting or emulsifying agents, pH buffering agents, or adjuvants that enhance the effectiveness of the vaccines.

[0164] The vaccines are administered in a manner compatible with the dosage formulation, and in such amount as will be therapeutically effective and immunogenic. The quantity to be administered depends on the subject to be treated, including, e.g., the capacity of the individual's immune system to generate an immune response. Precise amounts of cells or active ingredient required to be administered depend on the judgment of the practitioner. However, suitable dosage ranges are of the order of a few thousand cells (to millions of cells) for cellular vaccines. For standard epitope or epitope delivery vaccines then the vaccine may be several hundred micrograms active ingredient per vaccination. Suitable regimes for initial administration and booster shots are also variable, but are typified by an initial administration followed by subsequent inoculations or other administrations.

[0165] The manner of application may vary widely, however, certain embodiments herein will most likely be delivered intravenously or at the site of a tumor or infection directly. Regardless, any of the conventional methods for administration of a vaccine are applicable. The dosage of the vaccine will depend on the route of administration and will vary according to the size of the host.

[0166] In many instances, it will be desirable to have multiple administrations of the vaccine, e.g., four to six vaccinations provided weekly or every other week. A normal vaccination regimen will often occur in two to twelve week intervals or from three to six week intervals. Periodic boosters at intervals of 1-5 years, usually three years, may be desirable to maintain protective levels of the immune response or upon a likelihood of a remission or re-infection. The course of the immunization may be followed by assays for, e.g., T cell activation, cytokine secretion or even antibody production, most commonly conducted *in vitro*. These immune response assays are well known and may be found in a wide variety of patents and as taught herein.

[0167] The vaccine of the present invention 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 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.

[0168] Likewise, the amount of anti-CD40-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 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.

[0169] Antibodies of the present invention may optionally be covalently or non-covalently linked to a detectable label. Detectable labels suitable for such use include any composition detectable by spectroscopic, photochemical, biochemical, immunochemical, electrical, optical or chemical methods. Useful labels in the present invention include magnetic beads (e.g., DYNABEADS®), fluorescent dyes (e.g., fluorescein isothiocyanate, Texas red, rhodamine, green fluorescent protein, and the like), radiolabels (e.g., ^{3}H, ^{125}I, ^{35}S, ^{14}C, or ^{32}P), enzymes (e.g., horse radish peroxidase, alkaline phosphatase and others commonly used in an ELISA), and colorimetric labels such as colloidal gold or colored glass or plastic (e.g. polystyrene, polypropylene, latex, etc.) beads.

[0170] Methods of detecting such labels are well known to those of skill in the art. Thus, for example, radiolabels may be detected using photographic film or scintillation counters, fluorescent markers may be detected using a photodetector to detect emitted illumination. Enzymatic labels are typically detected by providing the enzyme with a substrate and detecting the reaction product produced by the action of the enzyme on the substrate, and colorimetric labels are detected by simply visualizing the colored label.

[0171] The antibody and/or immunoconjugate compositions of this invention are particularly useful for parenteral administration, such as intravenous administration or administration into a body cavity. The compositions for administration will commonly comprise a solution of the antibody and/or immunoconjugate dissolved in a pharmaceutically acceptable carrier, preferably an aqueous carrier. A variety of aqueous carriers can be used, e.g., buffered saline and the like. These solutions are sterile and generally free of undesirable matter. These compositions may be sterilized by conventional, well-known sterilization techniques. The compositions may contain pharmaceutically acceptable auxiliary substances as required to approximate physiological conditions such as pH adjusting and buffering agents, toxicity adjusting agents and the like, for example, sodium acetate, sodium chloride, potassium chloride, calcium chloride, sodium lactate and the like. The concentration of fusion protein in these formulations can vary widely, and will be selected primarily based on fluid volumes, viscosities, body weight and the like in accordance with the particular mode of administration selected and the patient's needs.

[0172] Thus, a typical pharmaceutical immunoconjugate composition of the present invention for intravenous administration would be about 0.1 to 10 mg per patient per day. Dosages from 0.1 up to about 100 mg per patient per day may be used. Actual methods for preparing administrable compositions will be known or apparent to those skilled in the art and are described in more detail in such publications as REMINGTON'S PHARMACEUTICAL SCIENCE, 19TH ED., Mack Publishing Company, Easton, Pa. (1995).

[0173] The compositions of the present invention can be administered for therapeutic treatments. In therapeutic applications, compositions are administered to a patient suffering from a disease, in an amount sufficient to cure or at least partially arrest the disease and its complications. An amount adequate to accomplish this is defined as a "therapeutically effective dose." Amounts effective for this use will depend upon the severity of the disease and the general state of the patient's health. An effective amount of the compound is that which provides either subjective relief of a symptom(s) or an objectively identifiable improvement as noted by the clinician or other qualified observer.

[0174] Single or multiple administrations of the compositions are administered depending on the dosage and frequency as required and tolerated by the patient. In any event, the composition should provide a sufficient quantity of the proteins of this invention to effectively treat the patient. Preferably, the dosage is administered once but may be applied periodically until either a therapeutic result is achieved or until side effects warrant discontinuation of therapy. Generally, the dose is sufficient to treat or ameliorate symptoms or signs of disease without producing unacceptable toxicity to the patient.

[0175] Controlled release parenteral formulations of the immunoconjugate compositions of the present invention can be made as implants, oily injections, or as particulate systems. For a broad overview of protein delivery systems see, Banga, A. J., THERAPEUTIC PEPTIDES AND PROTEINS: FORMULATION, PROCESSING, AND DELIVERY SYSTEMS, Technomic Publishing Company, Inc., Lancaster, Pa., (1995) incorporated herein by reference. Particulate systems include microspheres, microparticles, microcapsules, nanocapsules, nanospheres, and nanoparticles. Microcapsules contain the therapeutic protein as a central core. In microspheres the therapeutic is dispersed throughout the particle. Particles, microspheres, and microcapsules smaller than about 1 μm are generally referred to as nanoparticles, nanospheres, and nanocapsules, respectively. Capillaries have a diameter of approximately 5 μm so that only nanoparticles are administered intravenously. Microparticles are typically around 100 μm in diameter and are administered subcutaneously or intramuscularly.

[0176] Polymers can be used for ion-controlled release of immunoconjugate compositions of the present invention. Various degradable and non-degradable polymeric matrices for use in controlled drug delivery are known in the art (Langer, R., Accounts Chem. Res. 26:537-542 (1993)). For example, the block copolymer, poloxamer 407® exists as a viscous yet mobile liquid at low temperatures but forms a semisolid gel at body temperature, hydroxyapatite has been used as a microcarrier for controlled release

of proteins, and/or liposomes may be used for controlled release as well as drug targeting of the lipid-capsulated drug. Numerous additional systems for controlled delivery of therapeutic proteins are known. See, e.g., U.S. Pat. Nos. 5,055,303, 5,188,837, 4,235,871, 4,501,728, 4,837,028 4,957,735 and 5,019,369, 5,055,303; 5,514,670; 5,413,797; 5,268,164; 5,004,697; 4,902,505; 5,506,206, 5,271,961; 5,254,342 and 5,534,496, relevant portions of each of which are incorporated herein by reference.

[0177] Among various uses of the immunoconjugates of the invention are included a variety of disease conditions caused by specific human cells that may be eliminated by the toxic action of the fusion protein. For example, for the humanized anti-CD40_12E12.3F3 (ATCC Accession No. PTA-9854), anti-CD40_12B4.2C10 (ATCC Accession No. _____, Submission No. AB13-22.12B4.2C10 (HS446)), and anti-CD40_11B6.1C3 (ATCC Accession No. _____, Submission No. AB13-22.11B6.1C3 (HS440)), antibodies disclosed herein, one preferred application for immunoconjugates is the treatment of malignant cells expressing CD40.

[0178] In another embodiment, this invention provides kits for the delivery of antigens, e.g., CD40 or an immunoreactive fragment thereof, conjugated or in the form of a fusion protein with one or more T cell or B cell epitopes. A "biological sample" as used herein is a sample of biological tissue or fluid that contains the antigen. Such samples include, but are not limited to, tissue from biopsy, blood, and blood cells (e.g., white cells). Preferably, the cells are lymphocytes, e.g., dendritic cells. Biological samples also include sections of tissues, such as frozen sections taken for histological purposes. A biological sample is typically obtained from a multicellular eukaryote, preferably a mammal such as rat, mouse, cow, dog, guinea pig, or rabbit, and more preferably a primate, such as a macaque, chimpanzee, or human. Most preferably, the sample is from a human. The antibodies of the invention may also be used in vivo, for example, as a diagnostic tool for in vivo imaging.

[0179] Kits will typically comprise a nucleic acid sequence that encodes an antibody of the present invention (or fragment thereof) with one or more framework portions or multiple cloning sites at the carboxy-terminal end into which the coding sequences for one or more antigens may be inserted. In some embodiments, the antibody will be a humanized anti-CD40 Fv fragment, such as an scFv or dsFv fragment. In addition the kits will typically include instructional materials disclosing methods of use of an antibody of the present invention (e.g. for loading into dendritic cells prior to immunization with the dendritic cells, which can be autologous dendritic cells). The kits may also include additional components to facilitate the particular application for which the kit is designed. Thus, for example, the kit may additionally contain methods of detecting the label (e.g. enzyme substrates for enzymatic labels, filter sets to detect fluorescent labels, appropriate secondary labels such as a sheep anti-mouse-HRP, or the like). The kits may additionally include buffers and other reagents routinely used for the practice of a particular method. Such kits and appropriate contents are well known to those of skill in the art.

[0180] In another set of uses for the invention, immunoconjugates targeted by antibodies of the invention can be used to purge targeted cells from a population of cells in a culture. For example, if a specific population of T cells is preferred, the immunoconjugates of the present invention may be used to enrich a population of T cells having the opposite effect of the on-going immune response. Thus, for example, cells cultured from a patient having a cancer can be purged of cancer cells by providing the patient with dendritic cells that were antigen loaded using the antibodies of the invention as a targeting moiety for the antigens that will trigger an immune response against the cancer, virus or other pathogen. Likewise, the immunoconjugates can be used to increase the population of regulatory T cells or drive the immune response toward or away from a cytotoxic T cell response or even drive a B cell response.

[0181] Example 1: Anti-CD40 - HIV peptides vaccine

[0182] Five 19- to 32-amino-acid long sequences were selected from a multiplicity of cytotoxic T lymphocyte (CTL) epitopes identified in the HIV-1 Nef, Gag and Env proteins in the context of different MHC-class I molecules. It has been reported that CTL responses can be induced efficiently by lipopeptide vaccines in mice, in primates, and in humans. The five HIV peptides were then modified in C-terminal position by a (Palm)-NH2 group and the five HIV peptide sequences have been well described in the scientific literature [e.g., Characterization of a multi-lipopeptides mixture used as an HIV-1 vaccine candidate (1999) Klinguer et al., Vaccine, Volume 18, 259-267] and in a patent application [Cytotoxic T lymphocyte-inducing lipopeptides and use as vaccines. Gras-Masse H. et al., Patent No. EP0491628 (1992-06-24); US 5871746 (1999-02-16)].

[0183] A very desirable HIV vaccine would be composed of recombinant anti-dendritic cell receptor antibody fused to the above HIV peptides. The present invention includes compositions and methods to efficiently produce proteins and HIV vaccines.

[0184] The sequences shown below are the amino-acid sequences of the five selected HIV peptides and the amino-acid positions within each HIV protein are in brackets.

[0185] Nef (66-97) is: VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL (SEQ ID NO.: 1)

[0186] Nef (116-145) is: HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL (SEQ ID NO.: 2)

[0187] Gag p17 (17-35) is: EKIRLRPGGKKKYKLKHIV (SEQ ID NO.: 3)

[0188] Gag p17-p24 (253-284) is: NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD (SEQ ID NO.: 4)

[0189] Pol 325-355 (RT 158-188) is: AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY (SEQ ID NO.: 5)

[0190] The sequence below is a hIgG4 heavy chain (H) – HIV gag17 fusion protein where the Gag p17 (17-35) region is shown in bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-gag17] C655 is:

QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**EKIRLRPGGKKKYKLKHIV**<u>AS</u>. (SEQ ID NO.: 6)

[0191] The sequence below is an H chain – HIV gag253 fusion protein where the Gag p17-p24 (253-284) region is shown in bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-gag253] C656 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD**<u>AS</u>. (SEQ ID NO.: 7)

[0192] The sequence below is an H chain – HIV nef116 fusion protein where the Nef (116-145) region is shown in bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-nef116] C680 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL**<u>AS</u>. (SEQ ID NO.: 8)

[0193] The sequence below is a H chain – HIV nef66 fusion protein where the Nef (66-97) region is shown shaded in bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-nef66] C679 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT

KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL**<u>AS</u>. (SEQ ID NO.: 9)

[0194] The sequence below is a H chain – HIV pol158 fusion protein where the Pol 325-355 (RT 158-188) region is shown in bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-pol158] C667 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY**<u>AS</u>. (SEQ ID NO.: 10)

[0195] Figure 1 shows protein A affinity purified recombinant antibodies fused to various HIV peptides (lanes 1 to 5) secreted from transfected 293F cells, analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining. Expression vectors for the H chains fused to various C-terminal HIV peptides coding regions were co-transfected with the matching light chain (L) plasmid into transient 293F cells for three days before harvesting the supernatant for subsequent purification. Cell number and DNA amount were constant between transfections. Since the protein A affinity matrix was used in excess, the SDS.PAGE analysis defines both the production yield and the H chain integrity of the various vaccine constructs. Lanes 1, 4 and 5 (upper bands) show that the H chains fused directly to HIV gag17, nef66 and pol158 peptides can be well-secreted. Lane 2 shows that the H chain fused directly to HIV gag253 peptide expresses poorly. Lane 3 shows that the H chain fused directly to HIV nef116 peptide is not expressed at all.

[0196] Surprisingly, it was found that the use of flexible potentially glycosylated inter-peptide coding region linker sequences improves the secretion of intact recombinant antibody-HIV peptides fusion proteins.

[0197] The flexible linker sequences used are derived from cellulosomal anchoring scaffoldin B precursor [Bacteroides cellulosolvens] and have been described by the present inventors in co-pending U.S. Patent Application Serial No. 61/081,234, relevant portions incorporated herein by reference.

[0198] The sequences shown below are the 25-amino-acid long sequences of the four selected peptide linker sequences. The underlined sequences are predicted N-linked glycosylation sites.

Flex1 is: SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11)

Flex2 is: PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12)

Flex3 is: TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13)

Flex4 is: TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14)

[0199] These sequences [the linkers shows in bold and underlined regions obtained from cohesion] are derived from the inter-cohesin domain spacers of the bacterial protein >gi|50656899|gb|AAT79550.1| cellulosomal anchoring scaffoldin B precursor [Bacteroides cellulosolvens]:

MQSPRLKRKILSVILAVCYIISSFSIQFAATPQVNIIIGSAQGIPGSTVKVPINLQNVPEIGINNCDFT
IKFDSDILDFNSVEAGDIVPLPVASFSSNNSKDIIKFLFSDATQGNMPINENGLFAVISFKIKDNAQ
KGISNIKVSSYGSFSGMSGKEMQSLSPTFFSGSIDVSDVSTSKLDVKVGNVEGIAGTEVNVPITFE
NVPDNGINNCNFTLSYDSNALEFLTTEAGNIIPLAIADYSSYRSMEGKIKFLFSDSSQGTRSIKND
GVFANIKFKIKGNAIRDTYRIDLSELGSFSSKQNNNLKSIATQFLSGSVNVKDIE**SSVSPTTSVHP**
TPTSVPPTPTKSSPGNKMKIQIGDVKANQGDTVIVPITFNEVPVMGVNNCNFTLAYDKNIMEFI
SADAGDIVTLPMANYSYNMPSDGLVKFLYNDQAQGAMSIKEDGTFANVKFKIKQSAAFGKYS
VGIKAIGSISALSNSKLIPIESIFKDGSITVTNKPIVNIEIGKVKVKAGDKIKVPVEIKDIPSIGINNCN
FTLKYNSNVLKYVSNEAGTIVPAPLANLSINKPDEGIIKLLFSDASQGGMPIKDNGIFVNLEFQA
VNDANIGVYGLELDTIGAFSGISSAKMTSIEPQFNNGSIEIFNSAQTPVPSNTEV**QTPTNTISVTP**
TNNSTPTNNSTPKPNPLYNLNVNIGEISGEAGGVIEVPIEFKNVPDFGINNCDFSVKYDKSIFEY
VTYEAGSIVKDSIVNLACMENSGIINLLFNDATQSSSPIKNNGVFAKLKFKINSNAASGTYQINAE
GYGKFSGNLNGKLTSINPIFENGIINIGNVTVK**PTSTPADSSTITPTATPTATPTIKG**TPTVTPIY
WMNVLIGNMNAAIGEEVVVPIEFKNVPPFGINNCDFKLVYDSNALELKKVEAGDIVPEPLANLS
SNKSEGKIQFLFNDASQGSMQIENGGVFAKITFKVKSTAASGIYNIRKDSVGSFSGLIDNKMTSIG
PKFTDGSIVVG**TVTPTATATPSAIVTTITPTATTKP**IATPTIKGTPTATPMYWMNVVIGKMNAE
VGGEVVVPIEFNNVPSFGINNCDFKLVYDATALELKNVEAGDIIKTPLANFSNNKSEEGKISFLF
NDASQGSMQIENGGVFAKITFKVKSTTATGVYDLRKDLVGSFSGLKDNKMTSIGAEF**TNGSIT**
VAATAPTVTPTVNATPSAATPTVTPTATATPSVTIPTVTPTATATPSVTIPTVTPTATATPSAATP
TVTPTATATPSVTIPTVTPTVTATPSDTIPTVTPTATATPSAIVTTITPTATAKPIATPTIKGTPTATP
MYWMNVVIGKMNAEVGGEVVVPIEFKNVPSFGINNCDFKLVYDATALELKNVEAGDIIKTPLA
NFSNNKSEEGKISFLFNDASQGSMQIENGGVSAKITFKVKSTTAIGVYDIRKDLIGSFSGLKDSK
MTSIGAEFTNGSITVATTAPTVTPTATATPSVTIPTVTPTATATPGTATPGTATPTATATPGAATP
TETATPSVMIPTVTPTATATPTATATPTVKGTPTIKPVYKMNVVIGRVNVVAGEEVVVPVEFKN
IPAIGVNNCNFVLEYDANVLEVKKVDAGEIVPDALINFGSNNSDEGKVYFLFNDALQGRMQIA
NDGIFANITFKVKSSAAAGIYNIRKDSVGAFSGLVDKLVPISAEFTDGSISVESAKSTPTATATGT
NVTPTVAATVTPTATPASTTPTATPTATSTVKGTPTATPLYSMNVIIGKVNAEASGEVVVPVEFK

DVPSIGINNCNFILEYDASALELDSAEAGEIVPVPLGNFSSNNKDEGKIYFLFSDGTQGRMQIVN
DGIFAKIKFKVKSTASDGTYYIRKDSVGAFSGLIEKKIIKIGAEFTDGSITVRSLTPTPTVTPNVAS
PTPTKVVAEPTSNQPAGPGPITGTIPTATTTATATPTKASVATATPTATPIVVVEPTIVRPGYNKD
ADLAVFISSDKSRYEESSIITYSIEYKNIGKVNATNVKIAAQIPKFTKVYDAAKGAVKGSEIVWMI
GNLAVGESYTKEYKVKVDSLTKSEEYTDNTVTISSDQTVDIPENITTGNDDKSTIRVMLYSNRFT
PGSHSSYILGYKDKTFKPKQNVTRAEVAAMFARIMGLTVKDGAKSSYKDVSNKHWALKYIEA
VTKSGIFKGYKDSTFHPNAPITRAELSTVIFNYLHLNNIAPSKVHFTDINKHWAKNYIEEIYRFKL
IQGYSDGSFKPNNNITRAEVVTMINRMLYRGPLKVKVGSFPDVSPKYWAYGDIEEASRNHKYT
RDEKDGSEILIE (SEQ ID NO.: 15).

[0200] The sequence below is a heavy chain (H) – HIV gag17-nef66-nef116 peptides fusion protein where the HIV gag17, nef66, nef116 peptide sequences are bold. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-gag17-nef66-nef116] C694 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS**EKIRLRPGGKKKYKLKHIV**AS**VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL**A
S**HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL**AS (SEQ ID NO.: 16).

[0201] The sequence below is an H chain – HIV gag17-nef116 peptides fusion protein where the HIV gag17 and nef116 peptide sequences [italics] are linked via a spacer f1 [shown in bold]. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-gag17-f1-nef116] C692 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS*EKIRLRPGGKKKYKLKHIV*AS**SSVSPTTSVHPTPTSVPPTPTKSSP**AS*HTQGYFPDWQNY*
*TPGPGVRYPLTFGWLYKL*AS (SEQ ID NO.: 17).

[0202] Figure 2 shows protein A affinity purified recombinant antibodies fused to various HIV peptides (Lanes 1 and 2) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining. Expression vectors for the H chains fused to various C-terminal HIV peptides coding regions were co-transfected with the matching L chain plasmid into transient 293F cells for three days before harvesting the supernatant for subsequent purification. Lanes 1 and 2 (upper bands) show that the H chains fused directly to a HIV peptide string of gag17-nef66-nef116 can be well-secreted. Also the H chain product containing a HIV peptide string of gag17 and nef116 separated by the flexible spacer f1 (Lane 2) is also well expressed. Thus HIV nef116 peptide, which is not expressed as a secreted product when directly fused to the H chain alone, can be well-expressed when appended in certain other peptide and flexible string contexts. Note that the H chain fused directly to gag17-f1-nef116 [82 residues] migrates slower than H chain with gag17-nef66-nef116 [89 residues] this suggests that the flexible linker f1 is glycosylated, possibly also enhancing the production of the secreted gag17-f1-nef116 fusion antibody versus gag17-nef66-nef116 fusion antibody.

[0203] The sequence below is an H chain – HIV peptides string of gag17-gag253-nef66 fusion protein where each HIV peptide sequence [shaded in italics] is separated by a inter-peptide spacer f [shown in bold]. In this case, a 27-amino-acid long linker flex-v1(v1) [shown in bold italics] derived from cellulosomal anchoring scaffoldin B precursor [Bacteroides cellulosolvens regions in bold-italics-underlined] was inserted between the H chain C-terminus and the HIV peptides-flexible spacers string. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1-Pep-gag17-f1-gag253-f2-nef66] C711 is:
QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS***QTPTNTISVTPTNNSTPTNNSNPKPNP***AS*EKIRLRPGGKKKYKLKHIV*AS**SSVSPTTSVH**
PTPTSVPPTPTKSSPAS*NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD*AS**PTSTPADSSTITPTATPT**
ATPTIKGAS*VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL*AS (SEQ ID NO.: 18).

[0204] The sequence below is an H chain – HIV peptides string of pol158-gag17-nef66-nef116-gag253 fusion protein where peptide sequences are shaded in grey. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-pol158-gag17-nef66-nef116-gag253] C713 is:

QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS**AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY**AS**EKIRLRPGGKKKYKLKHIV**AS**V
GFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL**AS**HTQGYFPDWQNYTPGPGVRYPLTFGW
LYKL**AS**NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD**AS** (SEQ ID NO.: 19).

[0205] Figure 3 shows protein A affinity purified recombinant antibodies fused to various HIV peptide strings (Lanes 1 to 5) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining. Expression vectors for the H chains fused to various C-terminal HIV peptides coding regions were co-transfected with the matching L chain plasmid into transient 293F cells for three days before harvesting the supernatant for subsequent purification. Lanes 1, 2 and 3 (upper bands) show that the 4 HIV peptides-flexible spacers fused to H chain via the flexible linker flex-v1 can be well-secreted. However, a string of 4 HIV peptides fused directly to H chain is not expressed at all (Lane 4, upper band). Also, lane 5 (upper band) shows that a string of 5 HIV peptides fused directly to H chain is not expressed at all. This result suggests that certain combinations and contexts of flexible linkers and HIV peptide coding sequences can enhance secretion of recombinant antibody-HIV peptide fusion proteins (Lanes 1, 2 and 3).

[0206] The sequence below is for an H chain – HIV peptides string of gag17-gag253-nef66-nef116-pol158 fusion protein where each HIV peptide sequence [shaded in italics] is separated by an inter-peptide spacer f [shown in bold]. The flexible linker flex-v1 (v1) [shown in bold-italics] was inserted between the H chain C-terminus and the HIV peptides-flexible spacers string. The underlined AS residues are joining sequences.

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-hIgG4H-Flex-v1-Pep-gag17-f1-gag253-f2-nef116-f3-nef66-f4-pol158] C825 is:

QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS***QTPTNTISVTPTNNSTPTNNSNPKPNP***AS*EKIRLRPGGKKKYKLKHIV*AS**SSVSPTTSVH**

PTPTSVPPTPTKSSPAS*NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD*AS**PTSTPADSSTITPTATPT ATPTIKG**AS*HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL*AS**TVTPTATATPSAIVTTITPTATT KP**AS*VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL*AS**TNGSITVAATAPTVTPTVNATPSAA**A** S*AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY*AS. (SEQ ID NO.: 20)

[0207] Figure 4 shows protein A affinity purified recombinant antibodies fused to various HIV peptide strings (Lanes 1 to 6) secreted from transfected 293F cells, then analyzed by reducing SDS.PAGE and Coomassie Brilliant Blue staining. Expression vectors for the H chains fused to various C-terminal HIV peptides coding regions were co-transfected with the matching L chain plasmid into transient 293F cells for three days before harvesting the supernatant for subsequent purification. Lanes 1, 3 and 5 (upper bands) show that the string of 4 HIV peptides-flexible spacers fused to H chain via the flexible linker flex-v1 can be well-secreted. Lanes 2 and 6 (upper bands) show that the string of 5 HIV peptides-flexible spacers fused to H chain via the flexible linker flex-v1 expresses poorly. However certain combinations and contexts of HIV peptide coding sequences enhance secretion of recombinant antibody-HIV peptide fusion proteins (Lanes 3 and 4). Thus H chain fused to a string of 5 HIV peptides-flexible spacers via the flexible linker flex-v1 can be well-expressed when appended in certain other peptide and flexible string contexts (Lane 4).

[0208] The present invention includes compositions and methods for flexible potentially glycosylated inter-peptide coding region linker sequences and combinations of such HIV peptide coding regions that are particularly favorable to efficient secretion of recombinant anti-DC receptor antibody-HIV peptide fusion vaccines.

[0209] The use of inter-structural domain linker sequences derived from cellulose-degrading bacteria as preferred inter-domain linker sequences in protein engineering – particularly those with highly predicted glycosylation sites. Desirable properties of these sequences are i) inherent flexibility, thereby facilitating separation of linked domains which should greatly help their correct folding and maintaining B cell receptor access to conformationally-dependent antigen epitopes; ii) glycosylation, thereby helping secretion and solubility of the intact produced fusion protein, and also protecting of the linker sequences from culture medium proteases.

[0210] Certain combinations of HIV peptide coding regions favor secretion and that particular flexible linker sequences inserted between the HIV peptide coding sequences can also help secretion of intact HIV peptide string vaccines - principles that can also be applied to solve similar issues for other preferred peptide antigens.

[0211] DNA sequences of preferred linker and antigen coding sequences. Joining sequence codons and stop codons are in bold:

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-gag17] C655 is:

GCTAGTGAGAAGATCCGGCTGCGGCCCGGCGGCAAGAAGAAGTACAAGCTGAAGCACAT CGTGGCTAGC**TGA** (SEQ ID NO.: 21)

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-nef66] C679 is:

GCTAGTGTGGGCTTCCCCGTGACCCCCCAGGTGCCCCTGCGGCCCATGACCTACAAGGCCG CCGTGGACCTGAGCCACTTCCTGAAGGAGAAGGGCGGCCTGGCTAGC**TGA** (SEQ ID NO.: 22)

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Pep-pol158] C667 is:

GCTAGTGCCATCTTCCAGAGCAGCATGACCAAGATCCTGGAGCCCTTCCGGAAGCAGAAC CCCGACATCGTGATCTACCAGTACATGGACGACCTGTACGCTAGC**TGA** (SEQ ID NO.: 23)

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1-Pep-gag253] C681 is:

GCTAGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACC AACAACAGCAACCCCAAGCCCAACCCC**GCTAGT**AACCCCCCCCATCCCCGTGGGCGAGATC TACAAGCGGTGGATCATCCTGGGCCTGAACAAGATCGTGCGGATGTACAGCCCCACCAGCA TCCTGGACGCTAGC**TGA** (SEQ ID NO.: 24)

[mAnti-DCIR_9E8_H-LV-hIgG4H-Flex-v1-Pep-gag17-nef116] C686 is:

GCTAGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACC AACAACAGCAACCCCAAGCCCAACCCC**GCTAGT**GAGAAGATCCGGCTGCGGCCCGGCGGC AAGAAGAAGTACAAGCTGAAGCACATCGTG**GCTAGT**CACACCCAGGGCTACTTCCCCGAC TGGCAGAACTACACCCCCGGCCCCGGCGTGCGGTACCCCCTGACCTTCGGCTGGCTGTACA AGCTGGCTAGC**TGA** (SEQ ID NO.: 25)

[mAnti-DCIR_9E8_H-LV-hIgG4H-C-hIgG4H-Flex-v1-Pep-gag17-f1-gag253-f2-nef116-f3-nef66-f4-pol158] C825 is:

GCTAGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACC AACAACAGCAACCCCAAGCCCAACCCC**GCTAGT**GAGAAGATCCGGCTGCGGCCCGGCGGC AAGAAGAAGTACAAGCTGAAGCACATCGTG**GCTAGT**AGCAGCGTGAGCCCCACCACCAGC GTGCACCCCACCCCCACCAGCGTGCCCCCCACCCCCACCAAGAGCAGCCCC**GCTAGT**AAC CCCCCCATCCCCGTGGGCGAGATCTACAAGCGGTGGATCATCCTGGGCCTGAACAAGATCG TGCGGATGTACAGCCCCACCAGCATCCTGGAC**GCTAGT**CCCACCAGCACCCCCGCCGACA GCAGCACCATCACCCCCACCGCCACCCCCACCGCCACCCCCACCATCAAGGGC**GCTAGT**C ACACCCAGGGCTACTTCCCCGACTGGCAGAACTACACCCCCGGCCCCGGCGTGCGGTACCC CCTGACCTTCGGCTGGCTGTACAAGCTG**GCTAGT**ACCGTGACCCCCACCGCCACCGCCACC CCCAGCGCCATCGTGACCACCATCACCCCCACCGCCACCACCAAGCCC**GCTAGT**GTGGGCT TCCCCGTGACCCCCCAGGTGCCCCTGCGGCCCATGACCTACAAGGCCGCCGTGGACCTGAG CCACTTCCTGAAGGAGAAGGGCGGCCTG**GCTAGT**ACCAACGGCAGCATCACCGTGGCCGC CACCGCCCCCACCGTGACCCCCACCGTGAACGCCACCCCCAGCGCCGCC**GCTAGT**GCCATC TTCCAGAGCAGCATGACCAAGATCCTGGAGCCCTTCCGGAAGCAGAACCCCGACATCGTGA TCTACCAGTACATGGACGACCTGTACGCTAGC**TGA.** (SEQ ID NO.: 26)

[0212] DNA sequences of preferred linker and antigen coding sequences. Joining sequence codons are in bold:

Nef (66-97) is:
GCTAGTGTGGGCTTCCCCGTGACCCCCCAGGTGCCCCTGCGGCCCATGACCTACAAGGCCG
CCGTGGACCTGAGCCACTTCCTGAAGGAGAAGGGCGGCCTG**GCTAGC** (SEQ ID NO.: 27)
Nef (116-145) is:
GCTAGTCACACCCAGGGCTACTTCCCCGACTGGCAGAACTACACCCCCGGCCCCGGCGTGC
GGTACCCCCTGACCTTCGGCTGGCTGTACAAGCTG**GCTAGC** (SEQ ID NO.: 28)
Gag p17 (17-35) is:
GCTAGTGAGAAGATCCGGCTGCGGCCCGGCGGCAAGAAGAAGTACAAGCTGAAGCACAT
CGTG**GCTAGC** (SEQ ID NO.: 29)
Gag p17-p24 (253-284) is:
GCTAGTAACCCCCCCATCCCCGTGGGCGAGATCTACAAGCGGTGGATCATCCTGGGCCTGA
ACAAGATCGTGCGGATGTACAGCCCCACCAGCATCCTGGAC**GCTAGC** (SEQ ID NO.: 30)
Pol 325-355 (RT 158-188) is:
GCTAGTGCCATCTTCCAGAGCAGCATGACCAAGATCCTGGAGCCCTTCCGGAAGCAGAAC
CCCGACATCGTGATCTACCAGTACATGGACGACCTGTAC**GCTAGC** (SEQ ID NO.: 31)
Flex1 is:
GCTAGTAGCAGCGTGAGCCCCACCACCAGCGTGCACCCCACCCCCACCAGCGTGCCCCCC
ACCCCCACCAAGAGCAGCCCC**GCTAGC** (SEQ ID NO.: 32)
Flex2 is:
GCTAGTCCCACCAGCACCCCCGCCGACAGCAGCACCATCACCCCCACCGCCACCCCCACC
GCCACCCCCACCATCAAGGGC**GCTAGC** (SEQ ID NO.: 33)
Flex3 is:
GCTAGTACCGTGACCCCCACCGCCACCGCCACCCCCAGCGCCATCGTGACCACCATCACCC
CCACCGCCACCACCAAGCCC**GCTAGC** (SEQ ID NO.: 34)
Flex4 is:
GCTAGTACCAACGGCAGCATCACCGTGGCCGCCACCGCCCCCACCGTGACCCCCACCGTG
AACGCCACCCCCAGCGCCGCC**GCTAGC** (SEQ ID NO.: 35)

[0213] The present invention includes compositions and methods for assembling constructs encoding HIV peptides and Flexible linker sequences. The H chain expression vectors typically have a Nhe I site [g|ctagc] appended to the H chain C-terminal residue codon, or [for flex- v1 vectors] to the C-terminal codon of the flex-v1 sequence. Flexible linker sequences or HIV peptide sequences have an Spe I site [a|ctagt] preceding the N-terminal flexible linker or HIV peptide codon, a Nhe I site appended to the C-terminal flexible linker or HIV peptide codon, followed by a TGA stop codon, followed by a Eco RI site, followed by a Not I site. Such flexible linker or HIV peptide Spe I – Not I fragments are inserted

into the H chain vector prepared with Nhe I – Not I digestion. Nhe I and Spe I are compatible sites, but when ligated [g|ctagt] is no longer either a Nhe I or Spe I site. Thus additional Spe I – Not I flexible linker or HIV peptide fragments can be inserted into the new Nhe I – Not I interval distal to the initial flexible linker or HIV peptide. In this way, strings of HIV peptide and/or flexible linker coding regions can be appended to the expression vector H chain coding region.

[0214] Example 2. HIV peptides vaccine – in vitro antigen-targeting biology

[0215] Anti-CD40.LIPO5 HIV peptides vaccine tests on HIV patients in vitro. To study the ability of αCD40.LIPO5 HIV peptide fusion recombinant antibody (αCD40.LIPO5 rAb) to mediate antigen presentation, the fusion rAb was added to blood cells from HIV-infected individuals and measured cytokine production form peripheral blood mononuclear cells (PBMCs).

[0216] Figure 5 describes the protocol used in vitro to assay the potency of αCD40.LIPO5 HIV peptide fusion recombinant antibody (αCD40.LIPO5 rAb) to elicit the expansion of antigen-specific T cells in the context of a PBMC culture. Briefly, PBMCs ($2x10^6$ cells/ml) from apheresis of HIV patients are incubated with a dose range of αCD40.LIPO5 HIV peptide vaccine. On day 2, 100 U/ml IL-2 are added to the culture and then, the media is refreshed every 2 days with 100 U/ml IL-2. On day 10, the expanded cells are challenged for 48 h with the individual long peptides corresponding to the 5 HIV peptide sequences incorporated in the αCD40.LIPO5 HIV peptide fusion rAb. Then, culture supernatants are harvested and assessed for cytokine production (by the T cells with T cell receptor [TCR] specificities for peptide sequences) using multiplex beads assay (Luminex). Antigen-specific cytokine production detected in such an assay, if it depends on the presence of the anti-CD40.LIPO5 HIV peptide vaccine, reflects vaccine uptake by antigen presenting cells [APC] in the culture, and processing [proteolytic degradation] and presentation of peptides on MHC. The antigen-MHC complexes are recognized by T cells with TCR that recognize only the particular HIV antigen-MHC complex. In a HIV patient, such cells are likely to be memory T cells that expanded in the patient in response to the HIV infection.

[0217] Epitopes from all 5 HIV peptide regions of the vaccine can be presented by APCs. The scheme in Figure 5 was used to assay the in vitro expansion of HIV peptide-specific T cells in response to anti-CD40.LIPO5 peptide vaccine. Results from 7 individuals are shown in Figure 6 and indicate that the αCD40.LIPO5 HIV peptide fusion rAb elicited HIV peptide-specific IFNγ responses in all of the patients studied. Thus, the α-CD40.LIPO5 HIV peptide fusion rAb allows DCs to cross-present at least 1 or 2 different peptides out of the 5 peptides within the vaccine to the T cells of each individual. However, the set of HIV peptides that stimulated IFNγ production was different for each patient - most likely reflecting different pools of memory T cells for HIV specificity.

[0218] Figure 6 shows the HIV peptide-specific IFNγ production in PBMCs from HIV patients incubated with various concentrations of anti-CD40.LIPO5 peptide string vaccine. C is the control group, which received no vaccine, and defines the baseline response of the culture to each peptide.

[0219] Figure 7 is a summary of αCD40.LIPO5 peptide vaccine responses against the 5 peptide regions from 8 HIV patients. The data are based on peptide-specific IFNγ production. Figure 7 shows that the antigen-specific responses observed in 8 HIV patients. The data demonstrate that all HIV peptide regions on the vaccine have the capacity to be processed and presented to T cells – assuming the likely situation that responses to these peptides will only be observed if the appropriate TCR-bearing cells are present. Thus, each patient has a characteristic spectrum of such cells.

[0220] The αCD40.LIPO5 peptide vaccine can evoke the proliferation of antigen-specific T cells capable of secreting a wide spectrum of cytokines

[0221] Figure 8 shows that αCD40.LIPO5 HIV peptide vaccine elicits expansion of HIV peptide-specific T cells capable of secreting multiple cytokines – a desirable feature in a vaccine. In Figure 8 αCD40.LIPO5 HIV peptide vaccine elicits gag253, nef66, nef116 and pol325 peptide-specific responses characterized by production of multiple cytokines. This is patient A5.

[0222] Anti-CD40.LIPO5 HIV peptide vaccination of ex vivo DCs.

[0223] Figure 9 shows the protocol for testing αCD40.LIPO5 HIV peptide vaccine for its ability to direct the expansion of antigen-specific T cells resulting from targeted uptake by DCs and presentation of peptide epitopes on their surface MHC complex. Briefly, HIV patient monocytes are differentiated into DCs by culture for 2 days with IFNα and GM-CSF. Different doses αCD40.LIPO5 HIV peptide vaccine or a mix of the 5 peptides are then added for 18 h. Autologous T cells were added to the co-culture (at a ratio of 1:20) on day 3. On day 5, 100 U/ml IL-2 are added to the culture and then, the media is refreshed every 2 days with 100 U/ml IL-2. On day 10, the expanded cells are rechallenged for 48 h with the individual long peptides corresponding to the 5 HIV peptide sequences incorporated in the αCD40.LIPO5 HIV peptide fusion rAb. Then, culture supernatants are harvested and assessed for cytokine production using Luminex.

[0224] Figure 10 shows the cytokine secretion in response to HIV peptides from DC-T cell co-cultures treated with various doses of αCD40.LIPO5 HIV peptide vaccine. This is patient A10. The results in the patient A10 shown in Figure 10 demonstrate expansion of antigen-specific T cells corresponding to epitopes within the gag17, gag253, and pol325 HIV peptide regions. In most instances, there is concordance of responses between αCD40.LIPO5 HIV peptide vaccine and non-LIPO5 vaccine [mixture of 5 non-lipidated HIV peptides with sequences corresponding to those in the αCD40.LIPO5 HIV peptide vaccine]. Thus, the αCD40.LIPO5 HIV peptide vaccine functions well in this in vitro setting where cultured DCs effectively process and present the HIV antigens to T cells. This exemplifies

use of the αCD40.LIPO5 HIV peptide vaccine for ex vivo vaccination, whereby the 'vaccinated DCs' would be cryopreserved for future re-injection into the same patient.

[0225] αCD40.LIPO5 HIV peptide vaccine – possible immune effect of the flexible linker regions. It is possible that the flexible linker sequences interspersing the HIV peptide sequences within the αCD40.LIPO5 HIV peptide vaccine themselves contain T cell epitopes. Figure 11 shows that patient A4 does not appear to have a significant pool of memory T cells with specificities to the five flexible linker sequences within αCD40.LIPO5 HIV peptide vaccine. In Figure 11, PBMCs from patient A4 treated with the αCD40.LIPO5 HIV peptide vaccine elicit expansion of antigen-specific T cells with specificity to the gag253 region, but not to the flexible linker sequences. The protocol describe in Figure 9 was used, with the flexible linker long peptides corresponding in sequence to the bold areas, the HIV peptides are in bold-italics, shown in the sequence below.

[0226] αCD40.LIPO5 HIV peptide vaccine heavy chain sequence showing flexible linker regions in bold, joining sequences underlined and HIV peptide regions shaded in bold italics.

QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDKRYNPSL
KSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVTVSSAKT
KGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV
VTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGK<u>AS</u>**QTPTNTISVTPTNNSTPTNNSNPKPNP**<u>AS</u>***EKIRLRPGGKKKYKLKHIV***<u>AS</u>**SSVSPTTSV**
HPTPTSVPPTPTKSSP<u>AS</u>***NPPIPVGEIYKRWIILGLNKIVRMYSPTSILD***<u>AS</u>**PTSTPADSSTITPTA**
TPTATPTIKG<u>AS</u>***HTQGYFPDWQNYTPGPGVRYPLTFGWLYKL***<u>AS</u>**TVTPTATATPSAIVTTITP**
TATTKP<u>AS</u>***VGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGL***<u>AS</u>**TNGSITVAATAPTVTPTVNA**
TPSAA<u>AS</u>***AIFQSSMTKILEPFRKQNPDIVIYQYMDDLY***<u>AS</u>. (SEQ ID NO.:36).

[0227] In Figure 12A, the PBMCs from patient A3 treated with the αCD40.LIPO5 HIV peptide vaccine elicit expansion of antigen-specific T cells with specificities to the gag253, nef66, and nef116 regions, but not to the flexible linker sequences. The protocol described in Figure 1 was used, with the flexible linker long peptides corresponding in sequence to the bold areas shown in Figure 8.

[0228] Figure 12B shows HIV antigen-specific T cell responses evoked from HIV patient A17 PBMCs incubated with 30 nM of three different HIV5 peptide DC targeting vaccines. Cells were cultured for 10 days with IL-2 and then stimulated with individual long peptides corresponding to the 5 HIV peptide sequences encompassed within the DC-targeting vaccines. After 1 hr brefeldin A was added and incubation continued for a further 5 hrs before staining for FACS analysis. The FACS plots show IFNγ and CD8 staining on CD3+ T cells. Circles indicate significant vaccine-evoked expansion of IFNγ+ cells

compared to cells from PBMCs cultured without vaccine. CD8- cells are CD4+ T cells. The data show that that anti-CD40.HIV5pep vaccine evokes a strong expansion of nef66 (N66)-specific CD8+ T cells which is not seen with the other DC targeting vehicles.

[0229] These are data based on the LIPO5 HIV peptide string. For example the anti-CD40 H chain is anti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1-Pep-gag17-f1-gag253-f2-nef116-f3-nef66-f4-pol158] with sequence:

EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGSTYYPD
TVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSAKTKG
PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT
VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMISR
TPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNG
KEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKASQTPTNTISVTPTNNSTPTNNSNPKPNPASEKIRLRPGGKKKYKLKHIVASSSVSPTTSVH
PTPTSVPPTPTKSSPASNPPIPVGEIYKRWIILGLNKIVRMYSPTSILDASPTSTPADSSTITPTATPT
ATPTIKGASHTQGYFPDWQNYTPGPGVRYPLTFGWLYKLASTVTPTATATPSAIVTTITPTATTK
PASVGFPVTPQVPLRPMTYKAAVDLSHFLKEKGGLASTNGSITVAATAPTVTPTVNATPSAAAS
AIFQSSMTKILEPFRKQNPDIVIYQYMDDLYAS (SEQ ID NO.: 37).

[0230] Figure 12C is a similar study to that show in Figure 12B, except that the PBMCs are from a different HIV patient (A2). The data show antigen-specific CD4+ and CD8+ T cell responses evoked by anti-CD40.HIV5pep but not the other DC-targeting vaccines, or by a mixture of the peptides themselves.

[0231] Figure 12D shows that, based on analysis of 15 different HIV peptide responses [5 peptide regions sampled in 3 patients], anti-CD40.HIV5pep vaccine is clearly superior to anti-DCIR.HIV5pep, anti-LOX-1.HIV5pep and non-LIPO5 mix for eliciting a broad range of HIV peptide-specific CD8+ and CD4+ T responses.

[0232] The immunogenicity of the flexible linker sequences is of concern for the αCD40.LIPO5 HIV peptide vaccine design. The limited datasets shown above, testing recall of T cells with specificities for epitopes within the flexible linker sequences, suggest that the human repertoire against these sequences is variable. Also, the ability of these sequences to prime responses de novo is untested. Responses to the αCD40.LIPO5 HIV peptide vaccine in monkeys can be tested using the present invention. If necessary, certain less desirable epitopes within these regions can be identified by a combination of predictive computational means and peptide stimulation scans, and then eliminated by introducing mutational changes that abrogate the TCR interaction.

[0233] The anti-CD40 binding molecule includes a light chain having the following amino acid sequence (SEQ ID NO. 38). The variable region of the antibody light chain is underlined and the CDRs are bolded (SEQ ID NOS.: 42, 43 and 44, respectively).

[0234] MMSSAQFLGLLLLCFQGTRCDIQMTQTTSSLSASLGDRVTISC**SASQGISNYLN**WYQQK PDGTVKLLIY**YTSILHS**GVPSRFSGSGSGTDYSLTIGNLEPEDIATYYC**QQFNKLPPT**FGGGTKL EIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDS KDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO.:38).

[0235] The anti-CD40 binding molecule includes a heavy chain having the following sequence. The variable region of the antibody light chain is underlined and the CDRs are bolded (SEQ ID NOS.: 45, 46 and 47, respectively).

[0236] MNLGLSLIFLVLVLKGVQCEVKLVESGGGLVQPGGSLKLSCAT**SGFTFSDYYM**YWVR QTPEKRLEWV**AYINSGGGSTYYPDTVK**GRFTISRDNAKNTLYLQMSRLKSEDTAMYYCA**RR GLPFHAMD**YWGQGTSVTVSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNS GALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCP PCPAPEFEGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKP REEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQ EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQ EGNVFSCSVMHEALHNHYTQKSLSLSLGKAS (SEQ ID NO.:39).

[0237] In one aspect the nucleic acid that encodes the light chain comprises the SEQ ID NO. The variable region of the antibody light chain nucleic acid sequence is underlined and the CDRs are bolded.

[0238] ATGATGTCCTCTGCTCAGTTCCTTGGTCTCCTGTTGCTCTGTTTTCAAGGTACCAGAT GTGATATCCAGATGACACAGACTACATCCTCCCTGTCTGCCTCTCTAGGAGACAGAGTCAC CATCAGTTGC**AGTGCAAGTCAGGGCATTAGCAATTATTTAAAC**TGGTATCAGCAGAAAC CAGATGGAACTGTTAAACTCCTGATCTAT**TACACATCAATTTTACACTCA**GGAGTCCCATC AAGGTTCAGTGGCAGTGGGTCTGGGACAGATTATTCTCTCACCATCGGCAACCTGGAACCT GAAGATATTGCCACTTACTATTGT**CAGCAGTTTAATAAGCTTCCTCCGACG**TTCGGTGGA GGCACCAAACTCGAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCAT CTGATGAGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCC AGAGAGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAG AGTGTCACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTG AGCAAAGCAGACTACGAGAAACACAAAGTCTATGCCTGCGAAGTCACCCATCAGGGCCTG AGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGTTAG (SEQ ID NO.: 40).

[0239] In one aspect the nucleic acid that encodes the heavy chain comprises the SEQ ID NO.:40. The variable region of the antibody heavy chain nucleic acid sequence is underlined and the CDRs are bolded.

[0240] ATGAACTTGGGGCTCAGCTTGATTTTCCTTGTCCTTGTTTTAAAAGGTGTCCAGTGT GAAGTGAAGCTGGTGGAGTCTGGGGGAGGCTTAGTGCAGCCTGGAGGGTCCCTGAAACTC TCCTGTGCAACCTCT**GGATTCACTTTCAGTGACTATTACATGTAT**TGGGTTCGCCAGACT CCAGAGAAGAGGCTGGAGTGGGTCGCA**TACATTAATTCTGGTGGTGGTAGCACCTATTA TCCAGACACTGTAAAGGGC**CGATTCACCATCTCCAGAGACAATGCCAAGAACACCCTGTA CCTGCAAATGAGCCGGCTGAAGTCTGAGGACACAGCCATGTATTACTGTGCAAGA**CGGGG GTTACCGTTCCATGCTATGGACTAT**TGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGC CAAAACGAAGGGCCCATCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGC ACAGCCGCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGA ACTCAGGCGCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACT CTACTCCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACC TGCAACGTAGATCACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATAT GGTCCCCCATGCCCACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGT TCCCCCCAAAACCCAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGT GGTGGACGTGAGCCAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGA GGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGT CAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGT CTCCAACAAAGGCCTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCC CGAGAGCCACAGGTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTC AGCCTGACCTGCCTGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCA ATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTT CTTCCTCTACAGCAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCA TGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTC TGGGTAAAGCTAGCTGA (SEQ ID NO.: 41).

[0241] A humanized antibody includes the heavy chain variable region (V_H) and a light chain variable region (V_L), wherein the framework regions of the heavy chain and light chain variable regions are from a donor human antibody, and wherein the light chain complementarity determining regions (CDRs) have at least 80%, 90%, 95% or higher identity to $CDR1_L$ having the amino acid sequence SASQGISNYLN (SEQ ID NO.:41), the $CDR2_L$ having the amino acid sequence YTSILHS (SEQ ID NO.:42) and the $CDR3_L$ having the amino acid sequence QQFNKLPPT (SEQ ID NO.:43); and wherein the heavy chain complementarity determining regions comprise at least 80%, 90%, 95% or higher identity to the $CDR1_H$, $CDR2_H$ and $CDR3_H$, the $CDR1_H$ having the amino acid sequence GFTFSDYYMY (SEQ ID NO.:45), the $CDR2_H$ having the amino acid sequence YINSGGGSTYYPDTVKG (SEQ ID NO.:46), and the $CDR3_H$ having the amino acid sequence RGLPFHAMDY (SEQ ID NO.:47). For example, the humanized antibody may comprise a VL framework having at least 95% identity to the framework of SEQ ID NO.:38 and a VH framework that has at least 95% identity to the framework of SEQ ID

NO.:39. In another aspect, the donor CDR sequences are from ANTI-CD40_12E12.3F3 and further, wherein the antibody or fragment thereof specifically binds to CD40.

[0242] Example 3. Prostate-specific antigen (PSA), Cycline D1, MART-1, influenza viral nucleoprotein (NP) and HA1 subunit of influenza viral hemagglutinin (H1N1, PR8) and peptide screen.

[0243] Internalization of anti-CD40 mAb. $1x10^6$ IL-4DCs were incubated for 1 h in ice with 3 mg/ml human gamma globulin in PBS containing 3% BSA to block non-specific binding. Cells were pulsed for 30 minutes on ice with Alexa 568 labeled anti-CD40 mAb (all at 20 ng/ml final concentration in non-specific block). Cells were then washed and allowed to internalize surface bound antibodies for different times, between 0 and 90 minutes, at 37°C. Following internalization, cells were washed twice with ice-cold PBS containing 1% BSA and 0.05% sodium azide (PBA) and fixed in ice-cold 1% methanol-free formaldehyde (MFF) in PBS overnight at 4°C. Cells were permeablized in PBS 3% BSA containing 0.5% saponin (PBAS) for 20 minutes at 4°C, and transferred to a 96-well round bottom polypropylene microtiter plate. After washing twice with ice-cold PBAS, cells were incubated for 1 h on ice with 3 mg/ml human gamma globulin in PBAS. BODIPY-phalloidin diluted in PBAS and incubated with cells for 1 hour in ice. Cells were further stained with TOPRO-II, as a nuclear counterstain. Slides were imaged on a Leica SP1 confocal microscope.

[0244] Cells. Monoclonal antibodies for cell surface staining were purchased from BD Biosciences (CA). Monocytes (1×10^6/ml) from healthy donors were cultured in Cellgenics media (France) containing GM-CSF (100 ng/ml) and IL-4 (50 ng/ml) or GM-CSF (100 ng/ml) and IFNα (500 Units/ml) (R&D, CA). For IFNDCs, cells were fed on day 1 with IFNα and GM-CSF. For IL-4DCs, the same amounts of cytokines were supplemented into the media on day one and day three. PBMCs were isolated from Buffy coats using Percoll™ gradients (GE Healthcare, Buckinghamshire, UK) by density gradient centrifugation. Total CD4+ and CD8+ T cells were purified by using StemCell kits (CA).

[0245] Peptides. 15-mers (11 amino acid overlapping) for prostate-specific antigen (PSA), Cycline D1, MART-1, influenza viral nucleoprotein (NP) and HA1 subunit of influenza viral hemagglutinin (H1N1, PR8), were synthesized (Mimotopes).

[0246] DCs and T cell co-culture and cytokine expressions. $5x10^3$ DCs loaded with recombinant fusion proteins (anti-CD40-HA1, Control Ig-HA1, anti-CD40-PSA, anti-CD40-Cyclin D1, anti-CD40-MART-1, anti-MARCO-MART-1, and control Ig-MART-1) were co-cultured with $2x10^5$ CFSE-labeled CD4+ T cells for 8 days. Proliferation was tested by measuring CFSE dilution after staining cells with anti-CD4 antibody labeled with APC.

[0247] For measuring the expression of intracellular IFNγ, CD4+ T cells were restimulated with 1-5 uM of indicated peptides for 5h in the presence of Brefeldin A. In separate experiments, CD4+ T cells

were restimulated with peptides indicated for 36h, and then cytokines secreted by CD4+ T cells were measured by the Luminex.

[0248] CD8+ T cells were co-cultured with DCs for 10 days in the presence of 20 units/ml IL-2 and 20 units/ml IL-7. On day 10 of the culture, CD8+ T cells were stained with anti-CD8 and tetramers indicated.

[0249] CTL assay. On day 10 of the culture, a 5-h ^{51}Cr release assay was performed. T2 cells pulsed with ^{51}Cr first and then labeled with 10 uM HLA-A2 epitope of MART-1 or 1 nM epitope of influenza viral M1. T2 cells without peptide were used as control. The mean of triplicate samples was calculated, and the percentage of specific lysis was determined using the following formula: percentage of specific lysis = 100 x (experimental ^{51}Cr release - control ^{51}Cr release)/(maximum ^{51}Cr release - control ^{51}Cr release). The maximum release refers to counts from targets in 2.5% Triton X-100.

[0250] Preparation of mAbs specific for human CD40. Receptor ectodomain.hIgG (human IgG1Fc) and AP (human placental alkaline phosphatase) fusion proteins were produced for immunizing mice and screening mAbs, respectively. A mammalian vector for human IgFc fusion proteins was engineered as described [*J. Immunol.* 163: 1973-1983 (1999)]. The mammalian expression vector for receptor ectodomain.AP proteins was generated using PCR to amplify cDNA for AP resides 133-1581 (gb|BC009647|) while adding a proximal in-frame Xho I site and a distal 6C-terminal His residues followed by a TGA stop codon and Not I site. This Xho I – Not I fragment replaced the human IgG Fc coding sequence in the above ectodomain.IgG vector. Fusion proteins were produced using the FreeStyle™ 293 Expression System (Invitrogen, CA) according to the manufacturer's protocol (1 mg total plasmid DNA with 1.3 ml 293Fectin reagent /L of transfection). Receptor ectodomain.hIgG was purified by 1 ml HiTrap protein A affinity chromatography (GE Healthcare, CA) eluted with 0.1 M glycine, pH 2.7. Fractions were neutralized with 2M Tris, and then dialyzed against PBS.

[0251] 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 boosted 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. Three to four days after a final boosting, draining lymph nodes (LN) were harvested. B cells from spleen or LN cells were fused with SP2/O-Ag 14 cells (ATCC). Hybridoma supernatants were screened to analyze mAbs specific to the receptor ectodomain fusion protein compared to the fusion partner alone, or to the receptor ectodomain fused to alkaline phosphatase [*J. Immunol.* 163: 1973-1983 (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 (Integra, CA). Hybridoma supernatants were mixed with an equal volume of 1.5 M glycine, 3 M NaCl, 1× PBS, pH 7.8 (binding buffer) and tumbled with MabSelect resin (GE Healthcare, CA) (800 μl /5ml supernatant). 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 against PBS.

[0252] Expression and purification of recombinant mAbs. Total RNA was prepared from hybridoma cells using RNeasy kit (Qiagen, CA) and used for cDNA synthesis and PCR (SMART RACE kit, BD Biosciences) using supplied 5' primers and gene specific 3' primers (mIgGκ, 5'ggatggtgggaagatggatacagttggtgcagcatc3' (SEQ ID NO.:48); mIgG2a, 5'ccaggcatcctagagtcaccgaggagccagt3') (SEQ ID NO.:49). PCR products were then cloned (pCR2.1 TA kit, Invitrogen) and characterized by DNA sequencing (MC Lab, CA). Using the derived sequences for the mouse heavy (H) and light (L) chain variable (V)-region cDNAs, specific primers were used to PCR amplify the signal peptide and V-regions while incorporating flanking restriction sites for cloning into expression vectors encoding downstream human IgGκ or IgG4H regions. The vector for expression of chimeric mVκ-hIgκ was built by amplifying residues 401-731 (gi|63101937|) flanked by Xho I and Not I sites and inserting this into the Xho I – Not I interval of pIRES2-DsRed2 (BD Biosciences). PCR was used to amplify the mAb Vκ region from the initiator codon, appending a Nhe I or Spe I site then CACC, to the region encoding (e.g., residue 126 of gi|76779294|), appending a distal Xho I site. The PCR fragment was then cloned into the Nhe I – Not I interval of the above vector. The control human IgGκ sequence corresponds to gi|49257887| residues 26-85 and gi|21669402| residues 67-709. The control human IgG4H vector corresponds to residues 12-1473 of gi|19684072| with S229P and L236E substitutions, which stabilize a disulphide bond and abrogate residual FcR interaction [*J. Immunol.* 164: 1925-1933 (2000)], inserted between the Bgl II and Not I sites of pIRES2-DsRed2 while adding the sequence 5'gctagctgattaattaa 3' instead of the stop codon. PCR was used to amplify the mAb VH region from the initiator codon, appending CACC then a Bgl II site, to the region encoding residue 473 of gi|19684072|. The PCR fragment was then cloned into the Bgl II – Apa I interval of the above vector.

[0253] Expression and purification of Flu HA1 fusion protein. The Flu HA1 antigen coding sequence is a CipA protein [*Clostridium. thermocellum*] gi|479126| residues 147-160 preceding hemagglutinin [Influenza A virus (A/Puerto Rico/8/34(H1N1))] gi|126599271| residues 18-331 with a P321L change and with 6 C-terminal His residues was inserted between the H chain vector Nhe I and Not I sites to encode recombinant antibody-HA1 fusion proteins (rAb.HA1). Similarly, recombinant antibody-PSA fusion proteins (rAb.PSA) were encoded by inserting gi|34784812| prostate specific antigen residues 101-832 with proximal sequence GCTAGCGATACAACAGAACCTGCAACACCTACAACACCTGTAACAACACCGACAACAACA CTTCTAGCGC (SEQ ID NO.:50) (Nhe I site and CipA spacer) and a distal Not I site into the same H chain vector. Recombinant antibody proteins were expressed and purified as described above for hFc fusion proteins. In some cases the rAb.antigen coding region and the corresponding L chain coding region were transferred to separate cetHS-puro UCOE vectors (Millipore, CA). The use of UCOE vectors in combination with a preadapted serum free, suspension cell line allowed for rapid production

of large quantities of protein [*Cytotechnology* 38, 43–46 (2002).] CHO-S cells grown in CD-CHO with GlutaMAX and HT media supplement (Invitrogen) were seeded at $5x10^5$ ml 24h prior to transfection in 500 ml Corning Ehrlenmyer flasks and incubated in 8% CO_2 at 125 rpm. On the day of transfection, 1.2×10^7 cells with viability at least 95% were added to a final volume of 30 ml in a 125 ml flask in CD-CHO with GlutaMAX. 48 µl of FreeStyle Max reagent (Invitrogen) in 0.6 ml of OptiPRO SFM (Invitrogen) was added with gentle mixing to 24 µg of Sce I-linearized light chain vector and 24 µg of Sce I-linearized H chain vector mixed and sterile filtered in 0.6 ml of OptiPRO SFM. After 20 min, the DNA-lipid complex was slowly added to the 125 ml CHO-S culture flask with swirling. Cells were incubated 24h before adding 30 ml of a combined media solution of CD-CHO with CHO-M5 (Sigma, C0363 component of CHO Kit 1) containing 5 µg/ml of puromycin (A.G. Scientific, CA), 2×GlutaMAX and 0.25×Pen/Strep (Invitrogen). At day 2, another 5 µg/ml of puromycin was added directly to the culture and selection was allowed to proceed ~10-14 days while following cell viability from six days post transfection. The viable cell count dropped and when the viable density is ~$2\text{-}3\times10^6$/ml, the cells were transferred to fresh selection medium (CD CHO-S + CHO M5 with 2X GlutaMAX, 0.25×Pen/Strep, 10 µg/ml Puromycin) at 1E6/ml. Frozen cell stocks were prepared when viability reached >90%. Cells were split in selection medium when cell density exceeded 2×10^6/ml until scaled to 4×250 ml in 500 ml flasks. Supernatant was harvested when cell viability dropped below 80% with a maximum final cell density ~7×10^6/ml. Endotoxin levels were less than 0.2 units/ml.

[0254] 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

GACACCACCGAGGCCCGCCACCCCCACCCCCCCGTGACCACCCCCACCACCACCGACCGGA
AGGGCACCACCGCCGAGGAGCTGGCCGGCATCGGCATCCTGACCGTGATCCTGGGCGGCA
AGCGGACCAACAACAGCACCCCCACCAAGGGCGAATTCTGCAGATATCCATCACACTGGC
GGCCG (SEQ ID NO.:51) (encoding

DTTEARHPHPPVTTPTTDRKGTTAE*ELAGIGILTV*ILGGKRTNNSTPTKGEFCRYPSHWRP (SEQ ID NO.:52)- the italicized 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 1 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.

[0255] Figure 13 shows the internalization of anti-CD40 mAb:IL-4DC. IL-4DCs were treated with 500 ng/ml of anti-CD40-Alexa 568.

[0256] Figure 14 shows CD4 and CD8 T cell proliferation by DCs targeted with anti-CD40-HA1. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-HA or control Ig-HA1 were co-cultured with CFSE-labeled autologous CD4+ or CD8+ T cells (2x10e5) for 7 days. Cells were then then stained with anti-CD4 or anti-CD8 antibodies. Cell proliferation was tested by measuring CFSE-dilution.

[0257] Figure 15 shows a titration of HA1 fusion protein on CD4+ T proliferation. IFNDCs (5K) loaded with fusion proteins were co-cultured with CFSE-labeled CD4+ T cells (200K) for 7 days.

[0258] Figure 16 shows IFNDCs targeted with anti-CD40-HA1 activate HA1-specific CD4+ T cells. CD4+ T cells were restimulated with DCs loaded with 5 uM of indicated peptides, and then intracellular IFNγ was stained.

[0259] Figure 17 shows IFNDCs targeted with anti-CD40-HA1 activate HA1-specific CD4+ T cells. CD4+ T cells were restimulated with DCs loaded with indicated peptides for 36h, and then culture supernatant was analyzed for measuring IFNγ.

[0260] Figure 18 shows that targeting CD40 results in enhanced cross-priming of MART-1 specific CD8+ T cells. IFNDCs (5K/well) loaded with fusion proteins were co-cultured with purified CD8+ T

cells for 10 days. Cells were stained with anti-CD8 and tetramer. Cells are from healthy donors (HLA-A*0201+).

[0261] Figure 19 shows targeting CD40 results in enhanced cross-priming of MART-1 specific CD8+ T cells (Summary of 8-repeated experiments using cells from different healthy donors).

[0262] Figure 20 shows CD8+ CTL induced with IFNDCs targeted with anti-CD40-MART-1 are functional. CD8+ T cells co-cultured with IFNDCs targeted with fusion proteins were mixed with T2 cells loaded with 10 uM peptide epitope.

[0263] Figure 21 shows CD8+ CTL induced with IFNDCs targeted with anti-CD40-Flu M1 are functional. CD8+ T cells co-cultured with IFNDCs targeted with fusion proteins were mixed with T2 cells loaded with 1.0 nM peptide epitope.

[0264] Figure 22 shows an outline of protocol to test the ability a vaccine composed of anti-CD4012E12 linked to PSA (prostate specific antigen) to elicit the expansion from a naïve T cell population. PSA-specific CD4+ T cells corresponding to a broad array of PSA epitopes. Briefly, DCs derived by culture with IFNα and GM-CSF of monocytes from a healthy donor are incubated with the vaccine. The next day, cells are placed in fresh medium and pure CD4+ T cells from the same donor are added. Several days later, PSA peptides are added and, after four hours, secreted gamma-IFN levels in the culture supernatants are determined.

[0265] Figure 23 shows that many PSA peptides elicit potent gamma-IFN-production responses indicating that anti-CD4012E12 and similar anti-CD40 agents can efficiently deliver antigen to DCs, resulting in the priming of immune responses against multiple epitopes of the antigen. The peptide mapping of PSA antigens. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-PSA were co-cultured with purified autologous CD4+ T cells (2x10e5) for 8 days. Cells were then restimulated with 5 uM of individual peptides derived from PSA for 36h. The amount of IFNγ was measured by Luminex. Cells are from healthy donors.

[0266] Figure 24 shows DCs targeted with anti-CD40-PSA induce PSA-specific CD8+ T cell responses. IFNDCs were targeted with 1 ug mAb fusion protein with PSA. Purified autologous CD8+ T cells were co-cultured for 10 days. Cells were stained with anti-CD8 and PSA (KLQCVDLHV)-tetramer. Cells are from a HLA-A*0201 positive healthy donor. The results demonstrate that anti-CD40 effectively deliver PSA to the DCs, which in turn elicit the expansion of PSA-specific CD8+ T cells. Briefly, 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-PSA were co-cultured with purified autologous CD8+ T cells (2x10e5) for 10 days. Cells were then stained with tetramer. Cells are from HLA-0*201 positive healthy donor.

[0267] Figure 25 a scheme (left) and the IFNγ production by T cells of the pools of peptides and control for Donor 2. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-Cyclin D1 were co-cultured

with purified autologous CD4+ T cells (2x10e5) for 8 days. Cells were then restimulated with with 5 uM of individual peptides derived from CyclinD1 for 5h in the presence of Brefeldin A. Cells were stained for measuring intracellular IFNγ expression.

[0268] Figure 26 shows a peptide scan and IFNγ production by T cells obtained from the pools of peptides shown in Figure 25 and control for Donor 2. 5x10e3 IFNDCs loaded with 2 ug/ml of anti-CD40-Cyclin D1 were co-cultured with purified autologous CD4+ T cells (2x10e5) for 8 days. Cells were then restimulated with with 5 uM of individual peptides derived from CyclinD1 for 5h in the presence of Brefeldin A. Cells were stained for measuring intracellular IFNγ expression.

[0269] In conclusion, delivering antigens to DCs, the most potent antigen presenting cells, via CD40 is an efficient way to induce and activate antigen specific both CD4+ and CD8+ T cell-mediated immunity. Thus, vaccines made of anti-CD40 mAb will induce potent immunity against cancer and infections.

[0270] Peptide information:

[0271] HA1 sequences:

[0272] MKANLLVLLCALAAADADTICIGYHANNSTDTVDTVLEKNVTVTHSVNLLEDSHNGK LCR (SEQ ID NO.:53)

[0273] LKGIAPLQLGKCNIAGWLLGNPECDPLLPVRSWSYIVETPNSENGICYPGDFIDYEELRE (SEQ ID NO.:54)

[0274] QLSSVSSFERFEIFPKESSWPNHNTNGVTAACSHEGKSSFYRNLLWLTEKEGSYPKLKNS (SEQ ID NO.:55)

[0275] YVNKKGKEVLVLWGIHHPPNSKEQQNLYQNENAYVSVVTSNYNRRFTPEIAERPKVRD QA (SEQ ID NO.:56)

[0276] GRMNYYWTLLKPGDTIIFEANGNLIAPMYAFALSRGFGSGIITSNASMHECNTKCQTPL G (SEQ ID NO.:57)

[0277] AINSSLPYQNIHPVTIGECPKYVRSAKLRMVTGLRNIPSI (SEQ ID NO.:58)

[0278] Sequences of peptides in Figure 17

[0279] Peptide 22: SSFERFEIFPKESSWPN (SEQ ID NO.:59)

[0280] Peptide 45: GNLIAPWYAFALSRGFG (SEQ ID NO.:60)

[0281] Peptide 46: WYAFALSRGFGSGIITS (SEQ ID NO.:61)

[0282] NP sequences:

[0283] MASQGTKRSYEQMETDGERQNATEIRASVGKMIGGIGRFYIQMCTELKLSDYEGRLIQ NS (SEQ ID NO.:62)

[0284] LTIERMVLSAFDERRNKYLEEHPSAGKDPKKTGGPIYRRVNGKWMRELILYDKEEIRRI W (SEQ ID NO.:63)

[0285] RQANNGDDATAGLTHMMIWHSNLNDATYQRTRALVRTGMDPRMCSLMQGSTLPRRS GAAG (SEQ ID NO.:64)

[0286] AAVKGVGTMVMELVRMIKRGINDRNFWRGENGRKTRIAYERMCNILKGKFQTAAQK AMMD (SEQ ID NO.:65)

[0287] QVRESRNPGNAEFEDLTFLARSALILRGSVAHKSCLPACVYGPAVASGYDFEREGYSLV G (SEQ ID NO.:66)

[0288] IDPFRLLQNSQVYSLIRPNENPAHKSQLVWMACHSAAFEDLRVLSFIKGTKVLPRGKLS T (SEQ ID NO.:67)

[0289] RGVQIASNENMETMESSTLELRSRYWAIRTRSGGNTNQQRASAGQISIQPTFSVQRNLPF (SEQ ID NO.:68)

[0290] DRTTIMAAFNGNTEGRTSDMRTEIIRMMESARPEDVSFQGRGVFELSDEKAASPIVPSFD (SEQ ID NO.:69)

[0291] MSNEGSYFFGDNAEEYDN (SEQ ID NO.:70)

[0292] Sequences of peptides in Figure 23

[0293] Peptide 22: GKWVRELVLYDKEEIRR (SEQ ID NO.:71)

[0294] Peptide 33: RTGMDPRMCSLMQGSTL (SEQ ID NO.:72)

[0295] Peptide 46: MCNILKGKFQTAAQKAM (SEQ ID NO.:73)

[0296] Prostate specific antigen (PSA) sequence

[0297] MWVPVVFLTLSVTWIGAAPLILSRIVGGWECEKHSQPWQVLVASRGRAVCGGVLVHP QWV (SEQ ID NO.:74)

[0298] LTAAHCIRNKSVILLGRHSLFHPEDTGQVFQVSHSFPHPLYDMSLLKNRFLRPGDDSSH D (SEQ ID NO.:75)

[0299] LMLLRLSEPAELTDAVKVMDLPTQEPALGTTCYASGWGSIEPEEFLTPKKLQCVDLHVI S (SEQ ID NO.:76)

[0300] NDVCAQVHPQKVTKFMLCAGRWTGGKSTCSGDSGGPLVCNGVLQGITSWGSEPCALP ERP (SEQ ID NO.:77)

[0301] SLYTKVVHYRKWIKDTIVANP (SEQ ID NO.:78)

[0302] Sequences of peptides in Figure 23

[0303] Peptide 1: APLILSRIVGGWECE (SEQ ID NO.:79)

[0304] Peptide 4:ECEKHSQPWQVLVAS (SEQ ID NO.:80)

[0305] Peptide 25:GDDSSHDLMLLRLSE (SEQ ID NO.:81)

[0306] Peptide 26: SHDLMLLRLSEPAEL (SEQ ID NO.:82)

[0307] Peptide 49: SGDSGGPLVCNGVLQ (SEQ ID NO.:83)

[0308] Peptide 54: GSEPCALPERPSLYT (SEQ ID NO.:84)

[0309] Peptide 56 : ERPSLYTKVVHYRKW (SEQ ID NO.:85)

[0310] Peptide 58 : VVHYRKWIKDTIVAN (SEQ ID NO.:86)

[0311] Cyclin D1 sequence

[0312] MRSYRFSDYLHMSVSFSNDMDLFCGEDSGVFSGESTVDFSSSEVDSWPGDSIACFIEDE R (SEQ ID NO.:87)

[0313] HFVPGHDYLSRFQTRSLDASAREDSVAWILKVQAYYNFQPLTAYLAVNYMDRFLYAR RLP (SEQ ID NO.:88)

[0314] ETSGWPMQLLAVACLSLAAKMEEILVPSLFDFQVAGVKYLFEAKTIKRMELLVLSVLD WR (SEQ ID NO.:89)

[0315] LRSVTPFDFISFFAYKIDPSGTFLGFFISHATEIILSNIKEASFLEYWPSSIAAAAILCV (SEQ ID NO.:90)

[0316] ANELPSLSSVVNPHESPETWCDGLSKEKIVRCYRLMKAMAIENNRLNTPKVIAKLRVSV R (SEQ ID NO.:91)

[0317] ASSTLTRPSDESSFSSSSPCKRRKLSGYSWVGDETSTSN (SEQ ID NO.:92)

[0318] Sequences of peptides in Figure 26.

[0319] Peptide 7: DRVLRAMLKAEETCA (SEQ ID NO.:93)

[0320] Peptide 8: RAMLKAEETCAPSVS (SEQ ID NO.:94)

[0321] Peptide 10: TCAPSVSYFKCVQKE (SEQ ID NO.:95)

[0322] MART-1 Antigen. MART-1 is a tumor-associated melanocytic differentiation antigen. Vaccination with MART-1 antigen may stimulate a host cytotoxic T-cell response against tumor cells expressing the melanocytic differentiation antigen, resulting in tumor cell lysis.

[0323] Figure 27 shows the expression and construct design for anti-CD40-MART-1 peptide antibodies. Figure 28 is a summary of the $CD4^+$ and $CD8^+$ immunodominant epitopes for MART-1.

Figures 27 and 28 show the use of the flexible linker technology to permit the successful expression of recombinant anti-DC receptor targeting antibodies fused to significant (~2/3) parts of human MART-1. Recombinant antibody fused at the H chain C-terminus to the entire MART-1 coding region is not at all secreted from production mammalian cells [not shown]. The Flex-v1-hMART-1-Pep-3-f4-Pep-1 adduct is particularly well expressed and is one preferred embodiment of a MART-1-targeting vaccine, as is the Flex-v1-hMART-1-Pep-3-f4-Pep-1-f3-Pep-2 adduct which bears a maximum load of MART-1 epitopes. Slide 2 of the MART-1 powerpoint presentation shows that these adducts can be successfully appended to multiple anti-DC receptor vehicles.

[0324] The sequence below is a H chain – hMART-1 peptides string of pep3-pep1-pep2 fusion protein where each hMART1 peptide sequence [bold-italics] is separated by a inter-peptide spacer f [shown in bold]. In this case, a 27-amino-acid long linker flex-v1(v1) [italics] derived from cellulosomal anchoring scaffoldin B precursor [Bacteroides cellulosolvens- described in the gag-nef vaccine invention disclosure] was inserted between the H chain C-terminus and the hMART1 peptides-flexible spaces string. The underlined AS residues are joining sequences.

[0325] [manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3-f4-Pep-1] C981 is:

[0326] EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGST YYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSA KTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLS SVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTL MISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDW LNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIA VEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKS LSLSLGKAS*QTPTNTISVTPTNNSTPTNNSNPKPNP*AS***GFDHRDSKVSLQEKNCEPVVPNAPPAYE KLSAEQSPPPYSP***AS**TNGSITVAATAPTVTPTVNATPSAA**AS*MPREDAHFIYGYPKKGHGHSY TTAEEAAGIGILTVILGAS*** (SEQ ID NO.:96)

[0327] [manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3-f4-Pep-1-f3-Pep-2] C978 is:

[0328] EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGST YYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSA KTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLS SVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTL MISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDW LNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIA VEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKS LSLSLGKAS*QTPTNTISVTPTNNSTPTNNSNPKPNP*AS***GFDHRDSKVSLQEKNCEPVVPNAPPAYE**

KLSAEQSPPPYSPAS**TNGSITVAATAPTVTPTVNATPSAA**AS***MPREDAHFIYGYPKKGHGHSY TTAEEAAGIGILTVILG***AS**TVTPTATATPSAIVTTITPTATTKP**AS***VLLLIGCWYCRRRNGYRAL MDKSLHVGTQCALTRRCPQEG***AS (SEQ ID NO.:97)

[0329] [mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3-f4-Pep-1] C1012 is:

[0330] QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDK RYNPSLKSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVT VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKP KDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVL HQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGF YPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNH YTQKSLSLSLGKAS*QTPTNTISVTPTNNSTPTNNSNPKPNP*AS***GFDHRDSKVSLQEKNCEPVVPNA PPAYEKLSAEQSPPPYSP***AS**TNGSITVAATAPTVTPTVNATPSAA**AS***MPREDAHFIYGYPKKGH GHSYTTAEEAAGIGILTVILG***AS (SEQ ID NO.:98)

[0331] [mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3-f4-Pep-1-f3-Pep-2] C1013 is:

[0332] QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDK RYNPSLKSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVT VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKP KDTLMISRTPEVTCVVVDVSQPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQ KSLSLSLGKAS*QTPTNTISVTPTNNSTPTNNSNPKPNP*AS***GFDHRDSKVSLQEKNCEPVVPNAPPA YEKLSAEQSPPPYSP***AS**TNGSITVAATAPTVTPTVNATPSAA**AS***MPREDAHFIYGYPKKGHGH SYTTAEEAAGIGILTVILG***AS**TVTPTATATPSAIVTTITPTATTKP**AS***VLLLIGCWYCRRRNGYR ALMDKSLHVGTQCALTRRCPQEG***AS (SEQ ID NO.:99)

[0333] MART-1 DNA Sequence:

MART-1 constructs with 3 peptides, Start/stop sites are underlined, peptide 1 is bold, peptide 2 is bold-italics and peptide 3 is bold-underlined:

AACACCGACAACAACAGATGATCTGGATGCAGCTAGT**GGGTTTGATCATCGGGACAGCA AAGTGTCTCTTCAAGAGAAAAACTGTGAACCTGTGGTTCCCAATGCTCCACCTGCTTA TGAGAAACTCTCTGCAGAACAGTCACCACCACCTTATTCACCT**GCTAGTACCAACGGCA GCATCACCGTGGCCGCCACCGCCCCCACCGTGACCCCCACCGTGAACGCCACCCCCAGCGC CGCCGCTAGT***ATGCCAAGAGAAGATGCTCACTTCATCTATGGTTACCCCAAGAAGGGGCACG***

GCCACTCTTACACCACGGCTGAAGAGGCCGCTGGGATCGGCATCCTGACAGTGATCCTGGGA
GCTAGTACCGTGACCCCCACCGCCACCGCCACCCCCAGCGCCATCGTGACCACCATCACCC
CCACCGCCACCACCAAGCCCGCTAGT**GTCTTACTGCTCATCGGCTGTTGGTATTGTAGA**
AGACGAAATGGATACAGAGCCTTGATGGATAAAAGTCTTCATGTTGGCACTCAATGTG
CCTTAACAAGAAGATGCCCACAAGAAGGGtgaGCGGCCGCATCGAAGAGCTCGGTACCCG
GGGATCCTCTAGAGTCGACCTGCAGGCATGC (SEQ ID NO.:100)

Peptide 3 is bold followed by the Flex-4 amino acid sequence –underlined.

GFDHRDSKVSLQEKNCEPVVPNAPPAYEKLSAEQSPPPYSPASTNGSITVAATAPTVTPT (SEQ ID NO.:101)

Peptide 1 is bold followed by the Flex-3 amino acid sequence –underlined.

VNATPSAAAS**MPREDAHFIYGYPKKGHGHSYTTAEEAAGIGILTVILG**ASTVTPTATATP (SEQ ID NO.:102)

Peptide 3 is bold.

SAIVTTITPTATTKPAS**VLLLIGCWYCRRRNGYRALMDKSLHVGTQCALTRRCPQEG** (SEQ ID NO.:103)

[0334] MART1-Peptide 3, the italicized portion is the CD4+ immunodominant epitope.

GFDHRDSKVSLQE*KNCEPVVPNAPPAYEKLSAE*QSPPPYSP (SEQ ID NO.:104)

[0335] Flex-4

ASTNGSITVAATAPTVTPTVNATPSAAAS (SEQ ID NO.:105)

[0336] MART1-Peptide 1 the italicized portion is the CD4+ immunodominant epitope and the underlined-italicized portion is the CD8+ immunodominant epitope

*MPREDAHFIYGYPKKGHGHS*YTT*AEEAAGIGILTVILG* (SEQ ID NO.:106)

Flex-3: ASTVTPTATATPSAIVTTITPTATTKPAS (SEQ ID NO.:107)

[0337] MART1 - Peptide 2 the italicized portion is the CD4+ immunodominant epitope.

VLLLIGCWYCRR*RNGYRALMDKSLHVGTQCALTRR*CPQEG (SEQ ID NO.:108)

[0338] MART1 constructs with two peptides:

[0339] Peptide 3 is bold-italics-underlined, flex-4 is bold and Peptide 1 is bold-italics-underlined:

***GFDHRDSKVSLQEKNCEPVVPNAPPAYEKLSAEQSPPPYSP*ASTNGSITVAATAPTVTPTVNA**
TPSAAAS*MPREDAHFIYGYPKKGHGHSYTTAEEAAGIGILTVILG*AS (SEQ ID NO.:109)

[0340] Protein Sequence: C978. rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3 (bold-italics-underlined)-f4 (bold)-Pep-1 (bold-italics)-f3 (italics)-Pep-2 (bold-underlined)]

MNLGLSLIFLVLVLKGVQCEVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKR
LEWVAYINSGGGSTYYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAM
DYWGQGTSVTVSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGV
HTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFE
GGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNS
TYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKN
QVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSC
SVMHEALHNHYTQKSLSLSLGKASQTPTNTISVTPTNNSTPTNNSNPKPNPAS***<u>GFDHRDSKVSL</u>***
<u>QEKNCEPVVPNAPPAYEKLSAEQSPPPYSP</u>**ASTNGSITVAATAPTVTPTVNATPSAAAS*****MPRE***
DAHFIYGYPKKGHGHSYTTAEEAAGIGILTVILG*ASTVTPTATATPSAIVTTITPTATTKPAS***<u>**VLLLIG**</u>
<u>**CWYCRRRNGYRALMDKSLHVGTQCALTRRCPQEGAS**</u> (SEQ ID NO.:110)

[0341] Protein Sequence: C981. rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1-hMART-1-Pep-3 (bold-italics-underlined)-f4-(bold)-Pep-1](bold-underlined)

MNLGLSLIFLVLVLKGVQCEVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKR
LEWVAYINSGGGSTYYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAM
DYWGQGTSVTVSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGV
HTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFE
GGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNS
TYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKN
QVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSC
SVMHEALHNHYTQKSLSLSLGKASQTPTNTISVTPTNNSTPTNNSNPKPNPAS***<u>GFDHRDSKVSL</u>***
<u>QEKNCEPVVPNAPPAYEKLSAEQSPPPYSP</u>**ASTNGSITVAATAPTVTPTVNATPSAAAS<u>MPRE</u>**
<u>DAHFIYGYPKKGHGHSYTTAEEAAGIGILTVILGAS</u> (SEQ ID NO.:111)

[0342] GP100 Antigen. GP100 antigen is a melanoma-associated antigen. When administered in a vaccine formulation, gp100 antigen may stimulate a cytotoxic T cell HLA-A2.1-restricted immune response against tumors that express this antigen, which may result in a reduction in tumor size.

[0343] GP100 ectodomain coding region fused to recombinant antibody H chain coding region is not at all secreted by production mammalian cells [not shown]. The total sequence is shown below – italics residues are the leader sequence and the transmembrane domain, the peptides are in bold-italics and the transmembrane domain is italics-underlined.

[0344] *MDLVLKRCLLHLAVIGALLAVGA*TKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRL
DCWRGGQVSLKVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPV

YPQETDDA**C**IFPDGGP**C**PSGSWSQKRSFVYVW***KTWGQYWQV***LGGPVSGLSIGTGRAMLGTHT
MEVTVYHRRGSRSYVPLAHSSSAFT***ITDQVPFSV***SVSQLRALDGGNKHFLRNQPLTFALQLHDP
SGYLAEADLSYTWDFGDSSGTLISRALVVTHT***YLEPGPVTA***QVVLQAAIPLTS**C**GSSPVPGTTD
GHRPTAEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPTTEVISTAPVQMPTAESTGMT
PEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAAQVTTTEWVETTARELPIPEPEGP
DASSIMSTESITGSLGPLLDGTATLRLVKRQVPLD**C**VLYRYGSFSVTLDIVQGIESAEILQAVPSG
EGDAFELTVS**C**QGGLPKEACMEISSPGCQPPAQRLCQPVLPSPA**C**QLVLHQILKGGSGTY**C**LNV
SLADTNSLAVVSTQLIMPGQEAGLGQ*VPLIVGILLVLMAVVLASLI*YRRRLMKQDFSVPQLPHSSS
HWLRLPRIFCSCPIGENSPLLSGQQV (SEQ ID NO.:112)

[0345] Known HLA-A0201 restricted peptides sequences are: GP100 M: 209-217 (2M): IMDQVPFSV (SEQ ID NO.:113); 209–217 WT: ITDQVPFSV (SEQ ID NO.:114) GP100 M: 280-288 (9V): YLEPGPVTV (SEQ ID NO.:115) 280-288 WT: YLEPGPVTA (SEQ ID NO.:116) GP100 WT: 154-162: KTWGQYWQV (SEQ ID NO.:117)

[0346] Figure 29-33 show the gp100 adducts which were successfully expressed as secreted anti-DC receptor targeting vaccines. These employed the use of the flexible linker sequences and fragmentation and shuffling of the gp100 ectodomain coding region. Preferred embodiments of gp100 vaccine adducts are described.

[0347] Figure 29 shows the expression and construct design for anti-CD40-gp100 peptide antibodies. Figure 30 shows the design for additional anti-CD40-gp100 peptide antibodies. Figure 31 shows the expression and construct design for additional anti-CD40-gp100 peptide antibodies. Figure 32 is a summary of the $CD4^+$ and $CD8^+$ immunodominant epitopes for gp100. Figure 33 shows the expression and construct design for additional anti-CD40-gp100 peptide antibodies.

[0348] rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-hgp100-Pep-1-f4-Pep-3-f3-Pep-4-f4-Pep-5-f3-Pep-2] C1285, the peptides are bold-italics, flexible linkers are bold and the underlined AS residues are joining sequences:

[0349] EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGST
YYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSA
KTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLS
SVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTL
MISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDW
LNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIA
VEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKS
LSLSLGK<u>AS</u>***DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRLDC***
WRGGQVSLKVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVYPQ
ETDDACIFPDGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTMEV

TVYHRRGSQSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQAS**TNGSITVAATAP TVTPTVNATPSAA**AS***GTTDGHRPTTEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPT TEVISTAPVQMPTAESTGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA***AS**T VTPTATATPSAIVTTITPTATTK**PAS***QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSLG PLLDGTATLRLVKRQVPLDCVLYRYGSFSVTLDIVQ***AS**TNGSITVAATAPTVTPTVNATPSAA**A**S***GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQLVLH QILKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ***AS**TVTPTATATPSAIVTTIT PTATTKP**AS***PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRALVVTHTYLEPGPVTAQVV LQAAIPLTSCGSSPVP***AS** (SEQ ID NO.:118)

[0350] rAB-cetHS-puro[hIgG4H-C-Flex-hgp100-Pep-1-f4-Pep-3-f3-Pep-4-f4-Pep-5-f3-Pep-2] C1286:

[0351] RLQLQESGPGLLKPSVTLSLTCTVSGDSVASSSYYWGWVRQPPGKGLEWIGTINFSGN MYYSPSLRSRVTMSADMSENSFYLKLDSVTAADTAVYYCAAGHLVMGFGAHWGQGKLVSVS PASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKD TLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQ KSLSLSLGK**AS***DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRL DCWRGGQVSLKVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVY PQETDDACIFPDGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTM EVTVYHRRGSQSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQ***AS**TNGSITVAAT APTVTPTVNATPSAA**AS***GTTDGHRPTTEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQV PTTEVISTAPVQMPTAESTGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA***A**S**TVTPTATATPSAIVTTITPTATTKP**AS***QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSL GPLLDGTATLRLVKRQVPLDCVLYRYGSFSVTLDIVQ***AS**TNGSITVAATAPTVTPTVNATPSAA **AS***GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQLVL HQILKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ***AS**TVTPTATATPSAIVTTI TPTATTKP**AS***PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRALVVTHTYLEPGPVTAQV VLQAAIPLTSCGSSPVP***AS** (SEQ ID NO.:119)

[0352] gp100: – Nucleic Acid Sequence. Peptide 1-underlined, Peptide 2-italics, Peptide 3-bold, Peptide 4-bold-underlined, Peptide 5 bold-italics.

GATACAACAGAACCTGCAACACCTACAACACCTGTAACAACACCGACAACAACAAAAGTA CCCAGAAACCAGGACTGGCTTGGTGTCTCAAGGCAACTCAGAACCAAAGCCTGGAACAGG CAGCTGTATCCAGAGTGGACAGAAGCCCAGAGACTTGACTGCTGGAGAGGTGGTCAAGTG TCCCTCAAGGTCAGTAATGATGGGCCTACACTGATTGGTGCAAATGCCTCCTTCTCTATTGC

CTTGAACTTCCCTGGAAGCCAAAAGGTATTGCCAGATGGGCAGGTTATCTGGGTCAACAAT
ACCATCATCAATGGGAGCCAGGTGTGGGGAGGACAGCCAGTGTATCCCCAGGAAACTGAC
GATGCCTGCATCTTCCCTGATGGTGGACCTTGCCCATCTGGCTCTTGGTCTCAGAAGAGAAG
CTTTGTTTATGTCTGGAAGACCTGGGGCCAATACTGGCAAGTTCTAGGGGGCCCAGTGTCT
GGGCTGAGCATTGGGACAGGCAGGGCAATGCTGGGCACACACACCATGGAAGTGACTGTC
TACCATCGCCGGGGATCCCAGAGCTATGTGCCTCTTGCTCATTCCAGCTCAGCCTTCACCAT
TACTGACCAGGTGCCTTTCTCCGTGAGCGTGTCCCAGTTGCGGGCCTTGGATGGAGGGAAC
AAGCACTTCCTGAGAAATCAGGCTAGTACCAACGGCAGCATCACCGTGGCCGCCACCGCCC
CCACCGTGACCCCCACCGTGAACGCCACCCCCAGCGCCGCCGCTAGT*GGCACCACAGATGG*
GCACAGGCCAACTGCAGAGGCCCCTAACACCACAGCTGGCCAAGTGCCTACTACAGAAGTTGTG
GGTACTACACCTGGTCAGGCGCCAACTGCAGAGCCCTCTGGAACCACATCTGTGCAGGTGCCAA
CCACTGAAGTCATAAGCACTGCACCTGTGCAGATGCCAACTGCAGAGAGCACAGGTATGACACCT
GAGAAGGTGCCAGTTTCAGAGGTCATGGGTACCACACTGGCAGAGATGTCAACTCCAGAGGCTA
*CAGGTATGACACCTGCAGAGGTATCAATTGTGGTGCTTTCTGGAACCACAGCTGCA*GCTAGTACC
GTGACCCCCACCGCCACCGCCACCCCCAGCGCCATCGTGACCACCATCACCCCCACCGCCA
CCACCAAGCCCGCTAGT**CAGGTAACAACTACAGAGTGGGTGGAGACCACAGCTAGAGA**
GCTACCTATCCCTGAGCCTGAAGGTCCAGATGCCAGCTCAATCATGTCTACGGAAAGT
ATTACAGGTTCCCTGGGCCCCCTGCTGGATGGTACAGCCACCTTAAGGCTGGTGAAG
AGACAAGTCCCCCTGGATTGTGTTCTGTATCGATATGGTTCCTTTTCCGTCACCCTGG
ACATTGTCCAGGCTAGTACCAACGGCAGCATCACCGTGGCCGCCACCGCCCCCACCGTGA
CCCCCACCGTGAACGCCACCCCCAGCGCCGCCGCTAGT**GGTATTGAAAGTGCCGAGATCC**
TGCAGGCTGTGCCGTCCGGTGAGGGGGATGCATTTGAGCTGACTGTGTCCTGCCAAG
GCGGGCTGCCCAAGGAAGCCTGCATGGAGATCTCATCGCCAGGGTGCCAGCCCCCTG
CCCAGCGGCTGTGCCAGCCTGTGCTACCCAGCCCAGCCTGCCAGCTGGTTCTGCACC
AGATACTGAAGGGTGGCTCGGGGACATACTGCCTCAATGTGTCTCTGGCTGATACCA
ACAGCCTGGCAGTGGTCAGCACCCAGCTTATCGTGCCTGGGATTCTTCTCACAGGTCA
AGAAGCAGGCCTTGGGCAGTAAGCTAGTACCGTGACCCCCACCGCCACCGCCACCCCCA
GCGCCATCGTGACCACCATCACCCCCACCGCCACCACCAAGCCCGCTAGT***CCTCTGACCTTT***
GCCCTCCAGCTCCATGACCCTAGTGGCTATCTGGCTGAAGCTGACCTCTCCTACACCTGGGA
CTTTGGAGACAGTAGTGGAACCCTGATCTCTCGGGCACYTGTGGTCACTCATACTTACCTGGA
GCCTGGCCCAGTCACTGCCCAGGTGGTCCTGCAGGCTGCCATTCCTCTCACCTCCTGTGGCT
CCTCCCCAGTTCCA GCTAGC TGA (SEQ ID NO.:120)

[0353] GP100-Peptide 1 – Nucleic Acid Sequence.

[0354] GATACAACAGAACCTGCAACACCTACAACACCTGTAACAACACCGACAACAACAA
AAGTACCCAGAAACCAGGACTGGCTTGGTGTCTCAAGGCAACTCAGAACCAAAGCCTGGA
ACAGGCAGCTGTATCCAGAGTGGACAGAAGCCCAGAGACTTGACTGCTGGAGAGGTGGTC

AAGTGTCCCTCAAGGTCAGTAATGATGGGCCTACACTGATTGGTGCAAATGCCTCCTTCTCT
ATTGCCTTGAACTTCCCTGGAAGCCAAAAGGTATTGCCAGATGGGCAGGTTATCTGGGTCA
ACAATACCATCATCAATGGGAGCCAGGTGTGGGGAGGACAGCCAGTGTATCCCCAGGAAA
CTGACGATGCCTGCATCTTCCCTGATGGTGGACCTTGCCCATCTGGCTCTTGGTCTCAGAAG
AGAAGCTTTGTTTATGTCTGGAAGACCTGGGGCCAATACTGGCAAGTTCTAGGGGGCCCAG
TGTCTGGGCTGAGCATTGGGACAGGCAGGGCAATGCTGGGCACACACACCATGGAAGTGA
CTGTCTACCATCGCCGGGGATCCCAGAGCTATGTGCCTCTTGCTCATTCCAGCTCAGCCTTC
ACCATTACTGACCAGGTGCCTTTCTCCGTGAGCGTGTCCCAGTTGCGGGCCTTGGATGGAG
GGAACAAGCACTTCCTGAGAAATCAG (SEQ ID NO.:121)

[0355] Protein Sequence:

DTTEPATPTTPVTTPTTTKVPRNQDWLGVSRQLRTKAWNRQLYPEWTEAQRLDCWRGGQVSL
KVSNDGPTLIGANASFSIALNFPGSQKVLPDGQVIWVNNTIINGSQVWGGQPVYPQETDDACIFP
DGGPCPSGSWSQKRSFVYVWKTWGQYWQVLGGPVSGLSIGTGRAMLGTHTMEVTVYHRRGS
QSYVPLAHSSSAFTITDQVPFSVSVSQLRALDGGNKHFLRNQ (SEQ ID NO.:122)

[0356] GP100-Peptide 3

[0357] GGCACCACAGATGGGCACAGGCCAACTGCAGAGGCCCCTAACACCACAGCTGGCC
AAGTGCCTACTACAGAAGTTGTGGGTACTACACCTGGTCAGGCGCCAACTGCAGAGCCCTC
TGGAACCACATCTGTGCAGGTGCCAACCACTGAAGTCATAAGCACTGCACCTGTGCAGATG
CCAACTGCAGAGAGCACAGGTATGACACCTGAGAAGGTGCCAGTTTCAGAGGTCATGGGT
ACCACACTGGCAGAGATGTCAACTCCAGAGGCTACAGGTATGACACCTGCAGAGGTATCA
ATTGTGGTGCTTTCTGGAACCACAGCTGCA (SEQ ID NO.:123)

[0358] Protein Sequence:

[0359] GTTDGHRPTAEAPNTTAGQVPTTEVVGTTPGQAPTAEPSGTTSVQVPTTEVISTAPVQM
PTAESTGMTPEKVPVSEVMGTTLAEMSTPEATGMTPAEVSIVVLSGTTAA (SEQ ID NO.:124)

[0360] GP100-Peptide 4:

[0361] CAGGTAACAACTACAGAGTGGGTGGAGACCACAGCTAGAGAGCTACCTATCCCTGA
GCCTGAAGGTCCAGATGCCAGCTCAATCATGTCTACGGAAAGTATTACAGGTTCCCTGGGC
CCCCTGCTGGATGGTACAGCCACCTTAAGGCTGGTGAAGAGACAAGTCCCCCTGGATTGTG
TTCTGTATCGATATGGTTCCTTTTCCGTCACCCTGGACATTGTCCAG (SEQ ID NO.:125)

[0362] Protein Sequence:

[0363] QVTTTEWVETTARELPIPEPEGPDASSIMSTESITGSLGPLLDGTATLRLVKRQVPLDCVL
YRYGSFSVTLDIVQ (SEQ ID NO.:126)

[0364] GP100-Peptide 5

[0365] GGTATTGAAAGTGCCGAGATCCTGCAGGCTGTGCCGTCCGGTGAGGGGGATGCATT TGAGCTGACTGTGTCCTGCCAAGGCGGGCTGCCCAAGGAAGCCTGCATGGAGATCTCATCG CCAGGGTGCCAGCCCCCTGCCCAGCGGCTGTGCCAGCCTGTGCTACCCAGCCCAGCCTGCC AGCTGGTTCTGCACCAGATACTGAAGGGTGGCTCGGGGACATACTGCCTCAATGTGTCTCT GGCTGATACCAACAGCCTGGCAGTGGTCAGCACCCAGCTTATCGTGCCTGGGATTCTTCTC ACAGGTCAAGAAGCAGGCCTTGGGCAG (SEQ ID NO.:127)

[0366] Protein Sequence:

[0367] GIESAEILQAVPSGEGDAFELTVSCQGGLPKEACMEISSPGCQPPAQRLCQPVLPSPACQ LVLHQILKGGSGTYCLNVSLADTNSLAVVSTQLIVPGILLTGQEAGLGQ (SEQ ID NO.:128)

[0368] GP100-Peptide 2

[0369] CCTCTGACCTTTGCCCTCCAGCTCCATGACCCTAGTGGCTATCTGGCTGAAGCTGAC CTCTCCTACACCTGGGACTTTGGAGACAGTAGTGGAACCCTGATCTCTCGGGCACYTGTGG TCACTCATACTTACCTGGAGCCTGGCCCAGTCACTGCCCAGGTGGTCCTGCAGGCTGCCATT CCTCTCACCTCCTGTGGCTCCTCCCCAGTTCCAGCTAGC (SEQ ID NO.:129)

[0370] Protein Sequence:

PLTFALQLHDPSGYLAEADLSYTWDFGDSSGTLISRAXVVTHTYLEPGPVTAQVVLQAAIPLTS CGSSPVPAS (SEQ ID NO.:130)

[0371] Cyclin B1 Antigen. Cyclin B1, also known as CCNB1, is a human gene that encodes a regulatory protein involved in mitosis. Cyclin B1 complexes with p34(cdc2) to form the maturation-promoting factor (MPF). Two alternative transcripts are known that are the result of alternative transcription initiation sites. A first transcript encodes a constitutively expressed transcript. The second transcript is a cell cycle-regulated transcript expressed predominantly during G2/M phase.

[0372] Figures 34A and 34B shows that full-length Cyclin B1 fused to the C-terminus of either antibody H chain or cohesion fail to be secreted from mammalian 293F cells. The data are anti-human Fc and anti-cohesin ELISA on serial dilutions of transfection supernatants. rAb.Cyclin B1 and Coh.Cyclin B1 proteins are poorly expressed as products secreted from mammalian cells.

[0373] The following amino acid sequence is human cyclin B1. Two peptide regions known to contain T cell epitopes are highlighted in bold-underlined and italics-underlined.

[0374] MALRVTRNSKINAENKAKINMAGAKRVPTAPAATSKPGLRPRTALGDIGNKVSEQLQA KMPMKKEAKPSATGKVIDKKLPKPLEKVPMLVPVPVSEPVPEPEPEPEPEPVKEEKLSPEPILVD TASPSPMETSGCAPAEEDLCQAFSDVILAVNDVDAEDGADPNLCSEYVKDIYAYLRQLEEEQA VRPKYLLGREVTGNMRAILI**<u>DWLVQVQMKFRLLQETMYMTVSIIDRFMQNNCVPKK</u>**MLQL VGVTAMFIASKYEEMYPPEIGDFAFVTDNTYTKHQIRQ***<u>MEMKILRALNFGLGRPLPLHFLRRA</u>*

SKIGEVDVEQHTLAKYLMETMLDYDMVHFPPSQIAAGAFCLALKILDNGEWTPTLQHYLSYTE ESLLPVMQHLAKNVVMVNQGLTKHMTVKNKYATSKHAKISTLPQLNSALVQDLAKAVAKVH HHHHH (SEQ ID NO.:131)

[0375] Peptide-1 MEMKILRALNFGLGRPLPLHFLRRASKIGEVDVEQHTLAKYLMELTMLDY (SEQ ID NO.:132)

[0376] Peptide-2

DWLVQVQMKFRLLQETMYMTVSIIDRFMQNNCVPKK (SEQ ID NO.:133)

[0377] Figure 35 shows a summary of relative expression levels of prototype Cyclin B1 vaccines secreted from transfected mammalian 293F cells. The flexible linker sequences facilitate secretion.

[0378] C1189 rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinB1-Peptide-2(italics)-Peptide-1 (bold –italics)-f4 (bold)] [AS linkers –underlined]

EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGSTYYPD TVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSAKTKG PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMISR TPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL SLGKAS**QTPTNTISVTPTNNSTPTNNSNPKPNP**AS*DWLVQVQMKFRLLQETMYMTVSIIDRFMQ NNCVPKK*AS*MEMKILRALNFGLGRPLPLHFLRR*AS***KIGEVDVEQHTLAKYLMELTMLDY**AS**TND SITVAATAPTVTPTVNATPSAA**AS (SEQ ID NO.:134)

[0379] Above is the sequence of the mature secreted H chain for one form of anti-CD4012E12-cyclin B1 vaccine. The AS residues are from joining restriction sites. The DNA coding sequence is shown below, and this includes the signal peptide.

ATGAACTTGGGGCTCAGCTTGATTTTCCTTGTCCTTGTTTTAAAAGGTGTCCAGTGTGAAGT GAAGCTGGTGGAGTCTGGGGGAGGCTTAGTGCAGCCCGGAGGGTCCCTGAAACTCTCCTGT GCAACCTCTGGATTCACTTTCAGTGACTATTACATGTATTGGGTTCGCCAGACTCCAGAGAA GAGGCTGGAGTGGGTCGCATACATTAATTCTGGTGGTGGTAGCACCTATTATCCAGACACT GTAAAGGGCCGATTCACCATCTCCAGAGACAATGCCAAGAACACCCTGTACCTGCAAATGA GCCGGCTGAAGTCTGAGGACACAGCCATGTATTACTGTGCAAGACGGGGGTTACCGTTCCA TGCTATGGACTATTGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGCCAAAACGAAGGGC CCATCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGCACAGCCGCCCTGG GCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCT GACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGC

AGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACCTGCAACGTAGATC
ACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATATGGTCCCCCATGCC
CACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGTTCCCCCCAAAACC
CAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGTGGTGGACGTGAGC
CAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGAGGTGCATAATGCC
AAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGTCAGCGTCCTCACC
GTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGGC
CTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAGCCACAG
GTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTCAGCCTGACCTGCC
TGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGG
AGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCTCTACAG
CAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCATGCTCCGTGAT
GCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTCTGGGTAAAGCT
AGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACCAAC
AACAGCAACCCCAAGCCCAACCCCGCTAGTGACTGGCTAGTACAGGTTCAAATGAAATTCA
GGTTGTTGCAGGAGACCATGTACATGACTGTCTCCATTATTGATCGGTTCATGCAGAATAAT
TGTGTGCCCAAGAAGGCTAGTATGGAAATGAAGATTCTAAGAGCTTTAAACTTTGGTCTGG
GTCGGCCTCTACCTTTGCACTTCCTTCGGAGAGCATCTAAGATTGGAGAGGTTGATGTCGA
GCAACATACTTTGGCCAAATACCTGATGGAACTAACTATGTTGGACTATGCTAGTACCAAC
GACAGCATCACCGTGGCCGCCACCGCCCCCACCGTGACCCCCACCGTGAACGCCACCCCCA
GCGCCGCCGCTAGC**TGA** (SEQ ID NO.:135)

[0380] C1143 rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinB1-Peptide-2(italics)-f3 (bold)] [AS linkers –underlined].

EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGSTYYPD
TVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSAKTKG
PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT
VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMISR
TPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNG
KEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
SLGKAS**QTPTNTISVTPTNNSTPTNNSNPKPNP**AS*DWLVQVQMKFRLLQETMYMTVSIIDRFMQ*
*NNCVPKK*AS**TVTPTATATPSAIVTTITPTATTK**PAS (SEQ ID NO.:136)

[0381] Above is the sequence of the mature secreted H chain for one form of anti-CD4012E12-cyclin B1 vaccine. The AS residues are from joining restriction sites. The DNA coding sequence is shown below, and this includes the signal peptide.

ATGAACTTGGGGCTCAGCTTGATTTTCCTTGTCCTTGTTTTAAAAGGTGTCCAGTGTGAAGT
GAAGCTGGTGGAGTCTGGGGGAGGCTTAGTGCAGCCCGGAGGGTCCCTGAAACTCTCCTGT
GCAACCTCTGGATTCACTTTCAGTGACTATTACATGTATTGGGTTCGCCAGACTCCAGAGAA
GAGGCTGGAGTGGGTCGCATACATTAATTCTGGTGGTGGTAGCACCTATTATCCAGACACT
GTAAAGGGCCGATTCACCATCTCCAGAGACAATGCCAAGAACACCCTGTACCTGCAAATGA
GCCGGCTGAAGTCTGAGGACACAGCCATGTATTACTGTGCAAGACGGGGGTTACCGTTCCA
TGCTATGGACTATTGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGCCAAAACGAAGGGC
CCATCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGCACAGCCGCCCTGG
GCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCT
GACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGC
AGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACCTGCAACGTAGATC
ACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATATGGTCCCCCATGCC
CACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGTTCCCCCCAAAACC
CAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGTGGTGGACGTGAGC
CAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGAGGTGCATAATGCC
AAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGTCAGCGTCCTCACC
GTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGGC
CTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAGCCACAG
GTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTCAGCCTGACCTGCC
TGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGG
AGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCTCTACAG
CAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCATGCTCCGTGAT
GCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTCTGGGTAAAGCT
AGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACCAAC
AACAGCAACCCCAAGCCCAACCCCGCTAGTGACTGGCTAGTACAGGTTCAAATGAAATTCA
GGTTGTTGCAGGAGACCATGTACATGACTGTCTCCATTATTGATCGGTTCATGCAGAATAAT
TGTGTGCCCAAGAAGGCTAGTACCGTGACCCCCACCGCCACCGCCACCCCCAGCGCCATCG
TGACCACCATCACCCCCACCGCCACCACCAAGCCCGCTAGC**TGA** (SEQ ID NO.:137)

[0382] C911 rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinB1-Peptide-1 (italics)-f4 (bold)]

EVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQTPEKRLEWVAYINSGGGSTYYPD
TVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLPFHAMDYWGQGTSVTVSSAKTKG
PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT
VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKPKDTLMISR
TPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNG
KEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE

WESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL SLGKAS**QTPTNTISVTPTNNSTPTNNSNPKPNP**AS*MEMKILRALNFGLGRPLPLHFLRR*AS*KIGE VDVEQHTLAKYLMELTMLDY*AS**TNGSITVAATAPTVTPTVNATPSAA**AS (SEQ ID NO.:138)

[0383] C911 rAB-cetHS-puro[manti-CD40_12E12.3F3_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinB1-Peptide-1 (italics)-f4 (bold)] nucleic acid sequence.

ATGAACTTGGGGCTCAGCTTGATTTTCCTTGTCCTTGTTTTAAAAGGTGTCCAGTGTGAAGT
GAAGCTGGTGGAGTCTGGGGGAGGCTTAGTGCAGCCCGGAGGGTCCCTGAAACTCTCCTGT
GCAACCTCTGGATTCACTTTCAGTGACTATTACATGTATTGGGTTCGCCAGACTCCAGAGAA
GAGGCTGGAGTGGGTCGCATACATTAATTCTGGTGGTGGTAGCACCTATTATCCAGACACT
GTAAAGGGCCGATTCACCATCTCCAGAGACAATGCCAAGAACACCCTGTACCTGCAAATGA
GCCGGCTGAAGTCTGAGGACACAGCCATGTATTACTGTGCAAGACGGGGGTTACCGTTCCA
TGCTATGGACTATTGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGCCAAAACGAAGGGC
CCATCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGCACAGCCGCCCTGG
GCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCT
GACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGC
AGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACCTGCAACGTAGATC
ACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATATGGTCCCCCATGCC
CACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGTTCCCCCCAAAACC
CAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGTGGTGGACGTGAGC
CAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGAGGTGCATAATGCC
AAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGTCAGCGTCCTCACC
GTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGGC
CTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAGCCACAG
GTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTCAGCCTGACCTGCC
TGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGG
AGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCTCTACAG
CAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCATGCTCCGTGAT
GCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTCTGGGTAAAGCT
AGTCAGACCCCCACCAACACCATCAGCGTGACCCCCACCAACAACAGCACCCCCACCAAC
AACAGCAACCCCAAGCCCAACCCCGCTAGTATGGAAATGAAGATTCTAAGAGCTTTAAACT
TTGGTCTGGGTCGGCCTCTACCTTTGCACTTCCTTCGGAGAGCATCTAAGATTGGAGAGGTT
GATGTCGAGCAACATACTTTGGCCAAATACCTGATGGAACTAACTATGTTGGACTATGCTA
GTACCAACGGCAGCATCACCGTGGCCGCCACCGCCCCCACCGTGACCCCCACCGTGAACGC
CACCCCCAGCGCCGCCGCTAGC**TGA** (SEQ ID NO.:139)

[0384] D-type Cyclin Antigen. D-type cyclins are predominantly expressed in the G1 phase of the cell cycle. The expression pattern of cyclin D1 has been extensively studied in certain cancer types including

lymphoma and non-small cell lung cancer. Approximately 30 percent of breast carcinomas are Cyclin D1 positive. Over expression of Cyclin D1 is now a well established criterion for the diagnosis of Mantle Cell Lymphoma, a malignant, non-Hodgkin's lymphoma which is characterized by a unique chromosomal translocation t(11;14).

[0385] Cyclin D1 – Peptide 1-bold, Peptide 2-bold-underlined, Peptide-3 italics, Peptide 4-underlined.

[0386] **MEHQLLCCEVETIRRAYPDANLLNDRVLRAMLKAEETCAPSVSYFKCV<u>QKEVLPS MRKIVATWMLEVCEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVASKM KETIPLTAEKLCIYTDNSIRPEELLQMELL</u>***LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQII RKHAQTFVALCATDVKFISNPPSMV*<u>AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDC LRACQEQIEALLESSLRQAQQNMDPKAAEEEEEEEEEVDLACTPTDVRDVDI</u> (SEQ ID NO.:140)

[0387] Pep-1:

MEHQLLCCEVETIRRAYPDANLLNDRVLRAMLKAEETCAPSVSYFKCV (SEQ ID NO.:141)

[0388] Pep-2

QKEVLPSMRKIVATWMLEVCEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVAS KMKETIPLTAEKLCIYTDNSIRPEELLQMELL (SEQ ID NO.:142)

[0389] Pep-3

LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQIIRKHAQTFVALCATDVKFISNPPSMV (SEQ ID NO.:143)

[0390] Pep-4

AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDCLRACQEQIEALLESSLRQAQQNM DPKAAEEEEEEEEEVDLACTPTDVRDVDI (SEQ ID NO.:144)

[0391] Flex-4 sequence

TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14)

[0392] Flex-3 sequence

TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13)

[0393] Flex-var1

QTPTNTISVTPTNNSTPTNNSNPKPNP (SEQ ID NO.:145)

[0394] Figure 35 shows Cyclin B1 segmentation strategy based on known or predicted structural domain regions.

[0395] Figure 36 shows that Cyclin D1 segments p1, p3, and p4, but not p2 express well as direct fusions to the H chain C-terminus. These are transient transfections of the H chain vectors co-transfected

with the L chain expression vector into 293F cells and the supernatants harvested after 48-72 hours of expression. The Cyclin D1 p3+p4 segments joined together at the H chain C-terminus also express well, but various other combinations, with and without interspersed flex segments do not express, or express very poorly.

[0396] Figure 37 shows the relative expression levels of various Cyclin D1 segments as direct fusions to the H chain C-terminus in various combinations with flexible linker sequences. These are transient transfections of the H chain vectors co-transfected with the L chain expression vector into 293F cells and the supernatants harvested after 48-72 hours of expression. The Cyclin D1 p2+p3+p4+f4 segments joined together at the H chain C-terminus also express well enough for vaccine production.

[0397] Sequences of useful anti-DCIR 9E8 – cyclin D1H chain fusion proteins are below.

[0398] 1082 is rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinD1-Pep-1 (italics)-f4 (bold)--]

[0399] QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDK
RYNPSLKSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVT
VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL
YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKP
KDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVL
HQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGF
YPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNH
YTQKSLSLSLGK**AS**__**QTPTNTISVTPTNNSTPTNNSNPKPNP**__**AS***MEHQLLCCEVETIRRAYPDANL*
*LNDRVLRAMLKAEETCAPSVSYFKCV*__**AS**__**TNGSITVAATAPTVTPTVNATPSAA**__**AS**__(SEQ ID NO.:146)

[0400] C1086 is rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1 (bold)-hCyclinD1-Pep-2-(bold)-Pep-3(bold-underlined)-Pep-4 (italics)-f4)(bold)]

[0401] QVTLKESGPGILQPSQTLSLTCSFSGFSLSTSGMGLSWIRQPSGKGLEWLAHIYWDDDK
RYNPSLKSRLTISKDTSSNQVFLKITIVDTADAATYYCARSSHYYGYGYGGYFDVWGAGTTVT
VSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL
YSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFEGGPSVFLFPPKP
KDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVL
HQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGF
YPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNH
YTQKSLSLSLGK**AS**__**QTPTNTISVTPTNNSTPTNNSNPKPNP**__**AS**__**QKEVLPSMRKIVATWMLEV**
CEEQKCEEEVFPLAMNYLDRFLSLEPVKKSRLQLLGATCMFVASKMKETIPLTAEKLCIY
TDNSIRPEELLQMELL__**LVNKLKWNLAAMTPHDFIEHFLSKMPEAEENKQIIRKHAQTFVA**
__**LCATDVKFISNPPSMV**__***AAGSVVAAVQGLNLRSPNNFLSYYRLTRFLSRVIKCDPDCLRACQEQIEAL***

*LESSLRQAQQNMDPKAAEEEEEEEEEEVDLACTPTDVRDVDI*AS**TNGSITVAATAPTVTPTVNATP SAA**AS (SEQ ID NO.:147)

[0402] Figure 38 show a summary of various H chain-Cyclin D1 segment constructs and their relative expressibility as vaccines.

[0403] Figure 39 above shows that full-length Cyclin D1 fused to the C-terminus of a DC targeting antibody H chain is very poorly expressed as a secreted recombinant antibody.

[0404] anti-CD40_12E12.3F3

[0405] anti-CD40_12E12.3F3_H-V-hIgG4H-C – underlined region shows the Heavy chain V region amino acid sequence:

[0406] MNLGLSLIFLVLVLKGVQCEVKLVESGGGLVQPGGSLKLSCATSGFTFSDYYMYWVRQ TPEKRLEWVAYINSGGGSTYYPDTVKGRFTISRDNAKNTLYLQMSRLKSEDTAMYYCARRGLP FHAMDYWGQGTSVTFVSSAKTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGA LTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCP APEFEGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPRE EQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEE MTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEG NVFSCSVMHEALHNHYTQKSLSLSLGKAS **(SEQ ID NO.: 148)**

[0407] anti-CD40_12E12.3F3_K-V-hIgGK-C – underlined region shows the Light chain V region amino acid sequence

[0408] MMSSAQFLGLLLLCFQGTRCDIQMTQTTSSLSASLGDRVTISCSASQGISNYLNWYQQK PDGTVKLLIYYTSILHSGVPSRFSGSGSGTDYSLTIGNLEPEDIATYYCQQFNKLPPTFGGGTKLEI KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSK DSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC- **(SEQ ID NO.: 149)**

[0409] anti-CD40_12B4.2C10

[0410] anti-CD40_12B4.2C10 Heavy Chain:

[0411] MEWSWIFLFLLSGTAGVHSEVQLQQSGPELVKPGASVKMSCKASGYTFTDYVLHWVK QKPGQGLEWIGYINPYNDGTKYNEKFKGKATLTSDKSSSTAYMELSSLTSEDSAVYYCARGYP AYSGYAMDYWGQGTSVTVSSAKTTPPSVYPLAPGSAAQTNSMVTLGCLVKGYFPEPVTVTWN SGSLSSGVHTFPAVLQKGEFV (SEQ ID No.: 150)

[0412] anti-CD40_12B4.2C10 Light Chain:

[0413] MMSSAQFLGLLLLCFQGTRCDIQMTQTTSSLSASLGDRVTISCRASQDISNYLNWYQQK PDGTVKLLIYYTSRLHSGVPSRFSGSGSGTDYSLTISNLEQEDIATYFCHHGNTLPWTFGGGTKL

EIKRADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQNGVLNSWTDQDS KDSTYSMSSTLTLTKDEYERHNSYTCEATHKTSTSPIVKSFNRNEC (SEQ ID No.: 151)

[0414] anti-CD40_12B4.2C10 Light Chain - alternative clone (17K6)

[0415] MDFQVQIFSFLLISASVIMSRGQIVLTQSPAILSASPGEKVTMTCSASSSVSYMYRYQQK PGSSPKPWIYGTSNLASGVPARFSGSGSGTSYSLTISSMEAEDAATYYCQQYHSYPLTFGAGTKL ELKRADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQNGVLNSWTDQDS KDSTYSMSSTLTLTKDEYERHNSYTCEATHKTSTSPIVKSFNRNEC (SEQ ID No.: 152)

[0416] anti-CD40_11B6.1C3

[0417] anti-CD40_11B6.1C3 Heavy Chain:

[0418] MGWSWIFLFLLSGTAGVLSEVQLQQSGPELVKPGASVKISCKASGYSFTGYYMHWVK QSHVKSLEWIGRINPYNGATSYNQNFKDKASLTVDKSSSTAYMELHSLTSEDSAVYYCAREDY VYWGQGTTLTVSSAKTTPPSVYPLAPGSAAQTNSMVTLGCLVKGYFPEPVTVTWNSGSLSSGV HTFPAVLQKGEFV (SEQ ID No.: 153)

[0419] anti-CD40_11B6.1C3 Light Chain:

[0420] MKLPVRLLVLMFWIPASSSDVVMTQTPLSLPVSLGDQASISCRSSQSLVHSNGNTYLHW YLQKPGQSPKLLIYKVSNRFSGVPDRFSGSGSGTDFALKISRVEAEDLGVYFCSQSTHVPWTFG GGTKLEIKRADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQNGVLNSW TDQDSKDSTYSMSSTLTLTKDEYERHNSYTCEATHKTSTSPIVKSFNRNEC (SEQ ID No.: 154)

[0421] [anti-CD40_12E12.3F3_K-V-hIgGK-C] – underlined region shows the Light chain V region sequence

[0422] **ATG**ATGTCCTCTGCTCAGTTCCTTGGTCTCCTGTTGCTCTGTTTTCAAGGTACCAGAT GTGATATCCAGATGACACAGACTACATCCTCCCTGTCTGCCTCTCTAGGAGACAGAGTCAC CATCAGTTGCAGTGCAAGTCAGGGCATTAGCAATTATTTAAACTGGTATCAGCAGAAACCA GATGGAACTGTTAAACTCCTGATCTATTACACATCAATTTTACACTCAGGAGTCCCATCAAG GTTCAGTGGCAGTGGGTCTGGGACAGATTATTCTCTCACCATCGGCAACCTGGAACCTGAA GATATTGCCACTTACTATTGTCAGCAGTTTAATAAGCTTCCTCCGACGTTCGGTGGAGGCAC CAAACTCGAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATG AGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGA GGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGT CACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAA AGCAGACTACGAGAAACACAAAGTCTATGCCTGCGAAGTCACCCATCAGGGCCTGAGCTC GCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT**TAG (SEQ ID NO.: 155)**

[0423] [anti-CD40_12E12.3F3_H-V-hIgG4H-C] – underlined region shows the Heavy chain V region sequence:

[0424] **ATG**AACTTGGGGCTCAGCTTGATTTTCCTTGTCCTTGTTTTAAAAGGTGTCCAGTGT
GAAGTGAAGCTGGTGGAGTCTGGGGGAGGCTTAGTGCAGCCTGGAGGGTCCCTGAAACTC
TCCTGTGCAACCTCTGGATTCACTTTCAGTGACTATTACATGTATTGGGTTCGCCAGACTCC
AGAGAAGAGGCTGGAGTGGGTCGCATACATTAATTCTGGTGGTGGTAGCACCTATTATCCA
GACACTGTAAAGGGCCGATTCACCATCTCCAGAGACAATGCCAAGAACACCCTGTACCTGC
AAATGAGCCGGCTGAAGTCTGAGGACACAGCCATGTATTACTGTGCAAGACGGGGGTTAC
CGTTCCATGCTATGGACTATTGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGCCAAAAC
GAAGGGCCCATCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGCACAGCC
GCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAG
GCGCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCC
CTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACCTGCAACG
TAGATCACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATATGGTCCCC
CATGCCCACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGTTCCCCCC
AAAACCCAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGTGGTGGAC
GTGAGCCAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGAGGTGCAT
AATGCCAAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGTCAGCGTC
CTCACCGTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGTCTCCAAC
AAAGGCCTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAG
CCACAGGTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTCAGCCTG
ACCTGCCTGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGC
AGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCT
CTACAGCAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCATGCTC
CGTGATGCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTCTGGGT
AAAGCTAGC**TGA (SEQ ID NO.: 156)**

[0425] anti-CD40_12B4.2C10_H-V-hIgG4H-C heavy chain

[0426] **ATG**GAATGGAGTTGGATATTTCTCTTTCTTCTGTCAGGAACTGCAGGTGTCCACTCT
GAGGTCCAGCTGCAGCAGTCTGGACCTGAGCTGGTAAAGCCTGGGGCTTCAGTGAAGATGT
CCTGCAAGGCTTCTGGATACACATTCACTGACTATGTTTTGCACTGGGTGAAACAGAAGCC
TGGGCAGGGCCTTGAGTGGATTGGATATATTAATCCTTACAATGATGGTACTAAGTACAAT
GAGAAGTTCAAAGGCAAGGCCACACTGACTTCAGACAAATCCTCCAGCACAGCCTACATG
GAGCTCAGCAGCCTGACCTCTGAGGACTCTGCGGTCTATTACTGTGCAAGGGGCTATCCGG
CCTACTCTGGGTATGCTATGGACTACTGGGGTCAAGGAACCTCAGTCACCGTCTCCTCAGC
CAAAACG<u>AAGGGCCCA</u>TCCGTCTTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGC
ACAGCCGCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGA

ACTCAGGCGCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACT
CTACTCCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACC
TGCAACGTAGATCACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATAT
GGTCCCCCATGCCCACCCTGCCCAGCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGT
TCCCCCCAAAACCCAAGGACACTCTCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGT
GGTGGACGTGAGCCAGGAAGACCCCGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGA
GGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGT
CAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGT
CTCCAACAAAGGCCTCCCGTCCTCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCC
CGAGAGCCACAGGTGTACACCCTGCCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTC
AGCCTGACCTGCCTGGTCAAAGGCTTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCA
ATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTT
CTTCCTCTACAGCAGGCTAACCGTGGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCA
TGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACACAGAAGAGCCTCTCCCTGTCTC
TGGGTAAAGCTAGC**TGA (SEQ ID NO.: 157)**

[0427] anti-CD40_12B4.2C10_K-V-hIgGK-C (variant 1) light chain

[0428] **ATG**GATTTTCAAGTGCAGATTTTCAGCTTCCTGCTAATCAGTGCCTCAGTCATAATG
TCCAGGGGACAAATTGTTCTCACCCAGTCTCCAGCAATCCTGTCTGCATCTCCAGGGGAGA
AGGTCACCATGACCTGCAGTGCCAGCTCAAGTGTAAGTTACATGTACAGGTACCAGCAGAA
GCCAGGATCCTCACCCAAACCCTGGATTTATGGCACATCCAACCTGGCTTCTGGAGTCCCT
GCTCGCTTCAGTGGCAGTGGATCTGGGACCTCTTATTCTCTCACAATCAGCAGCATGGAGG
CTGAAGATGCTGCCACTTATTACTGCCAGCAATATCATAGTTACCCGCTCACGTTCGGTGCT
GGGACCAAGCTCGAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCAT
CTGATGAGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCC
AGAGAGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAG
AGTGTCACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTG
AGCAAAGCAGACTACGAGAAACACAAAGTCTATGCCTGCGAAGTCACCCATCAGGGCCTG
AGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT**TAG (SEQ ID NO.: 158)**

[0429] anti-CD40_12B4.2C10_K-V-hIgGK-C (Variant 2) light chain

[0430] **ATG**ATGTCCTCTGCTCAGTTCCTTGGTCTCCTGTTGCTCTGTTTTCAAGGTACCAGAT
GTGATATCCAGATGACACAGACTACATCCTCCCTGTCTGCCTCTCTGGGAGACAGAGTCAC
CATCAGTTGCAGGGCAAGTCAGGACATTAGCAATTATTTAAACTGGTATCAGCAGAAACCA
GATGGAACTGTTAAACTCCTGATCTACTACACATCAAGATTACACTCAGGAGTCCCATCAA
GGTTCAGTGGCAGTGGGTCTGGAACAGATTATTCTCTCACCATTAGCAACCTGGAGCAAGA
AGATATTGCCACTTACTTTTGCCATCATGGTAATACGCTTCCGTGGACGTTCGGTGGAGGCA

CCAAGCTCGAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGAT
GAGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAG
AGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTG
TCACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCA
AAGCAGACTACGAGAAACACAAAGTCTATGCCTGCGAAGTCACCCATCAGGGCCTGAGCT
CGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT**TAG (SEQ ID NO.: 159)**

[0431] anti-CD40_11B6.1C3_H-V-hIgG4H-C heavy chain

[0432] **ATG**GGATGGAGCTGGATCTTTCTCTTTCTCCTGTCAGGAACTGCAGGTGTCCTCTCT
GAGGTCCAGCTGCAACAGTCTGGACCTGAGCTGGTGAAGCCTGGGGCTTCAGTGAAGATAT
CCTGCAAGGCTTCTGGTTACTCATTCACTGGCTACTACATGCACTGGGTGAAGCAAAGCCA
TGTAAAGAGCCTTGAGTGGATTGGACGTATTAATCCTTACAATGGTGCTACTAGCTACAAC
CAGAATTTCAAGGACAAGGCCAGCTTGACTGTAGATAAGTCCTCCAGCACAGCCTACATGG
AGCTCCACAGCCTGACATCTGAGGACTCTGCAGTCTATTACTGTGCAAGAGAGGACTACGT
CTACTGGGGCCAAGGCACCACTCTCACAGTCTCCTCAGCCAAAACGAAGGGCCCATCCGTC
TTCCCCCTGGCGCCCTGCTCCAGGAGCACCTCCGAGAGCACAGCCGCCCTGGGCTGCCTGG
TCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCTGACCAGCGG
CGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGGTGA
CCGTGCCCTCCAGCAGCTTGGGCACGAAGACCTACACCTGCAACGTAGATCACAAGCCCAG
CAACACCAAGGTGGACAAGAGAGTTGAGTCCAAATATGGTCCCCCATGCCCACCCTGCCCA
GCACCTGAGTTCGAAGGGGGACCATCAGTCTTCCTGTTCCCCCCAAAACCCAAGGACACTC
TCATGATCTCCCGGACCCCTGAGGTCACGTGCGTGGTGGTGGACGTGAGCCAGGAAGACCC
CGAGGTCCAGTTCAACTGGTACGTGGATGGCGTGGAGGTGCATAATGCCAAGACAAAGCC
GCGGGAGGAGCAGTTCAACAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAG
GACTGGCTGAACGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGGCCTCCCGTCCTCC
ATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAGCCACAGGTGTACACCCTG
CCCCCATCCCAGGAGGAGATGACCAAGAACCAGGTCAGCCTGACCTGCCTGGTCAAAGGC
TTCTACCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGGAGAACAACTAC
AAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCTCTACAGCAGGCTAACCGT
GGACAAGAGCAGGTGGCAGGAGGGGAATGTCTTCTCATGCTCCGTGATGCATGAGGCTCTG
CACAACCACTACACACAGAAGAGCCTCTCCCTGTCTCTGGGTAAAGCTAGC**TGA (SEQ ID NO.: 160)**

[0433] anti-CD40_11B6.1C3_K-V-hIgGK-C light chain

[0434] **ATG**AAGTTGCCTGTTAGGCTGTTGGTGCTGATGTTCTGGATTCCTGCTTCCAGCAGT
GATGTTGTGATGACCCAAACTCCACTCTCCCTGCCTGTCAGTCTTGGAGATCAAGCCTCCAT
CTCTTGCAGATCTAGTCAGAGCCTTGTACACAGTAATGGAAACACCTATTTACATTGGTACC

TGCAGAAGCCAGGCCAGTCTCCAAAGCTCCTGATCTACAAAGTTTCCAACCGATTTTCTGG
GGTCCCAGACAGGTTCAGTGGCAGTGGATCAGGGACAGATTTCGCACTCAAGATCAGTAG
AGTGGAGGCTGAGGATCTGGGAGTTTATTTCTGCTCTCAAAGTACACATGTTCCGTGGACG
TTCGGTGGAGGCACCAAGCTCGAGATCAAACGAACTGTGGCTGCACCATCTGTCTTCATCT
TCCCGCCATCTGATGAGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAAC
TTCTATCCCAGAGAGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACT
CCCAGGAGAGTGTCACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCC
TGACGCTGAGCAAAGCAGACTACGAGAAACACAAAGTCTATGCCTGCGAAGTCACCCATC
AGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT**TAG (SEQ ID NO:161)**

[0435] 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.

[0436] 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.

[0437] 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.

[0438] 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.

[0439] 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.

[0440] 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.

[0441] 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.

CLAIMS:

1. A fusion protein comprising the formula:

Ab-(PL–Ag)*x*;

Ab-(Ag-PL)*x*;

Ab-(PL-Ag-PL)*x*;

Ab-(Ag-PL-Ag)*x*;

Ab-(PL–Ag)*x*-PL; or

Ab-(Ag-PL)*x*-Ag;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one antigen; and

wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site.

2. The fusion protein of claim 1, wherein the Ag is selected from a viral antigen, a tumor antigen, an infectious disease antigen, an autoimmune antigen, a toxin or combinations thereof.

3. The fusion protein of claim 1, wherein at least one of the Ag or the PL is a peptide concatemer.

4. The fusion protein of claim 1, wherein the -(PL–Ag)*x*, -(Ag-PL)*x*, -(PL-Ag-PL)*x*, or -(Ag-PL-Ag)*x* are located at the carboxy terminus of the Ab heavy chain or fragment thereof.

5. The fusion protein of claim 1, wherein the Ag elicits at least one of a humoral or a cellular immune response in a host.

6. The fusion protein of claim 1, wherein the Ab is an anti-CD40 antibody.

7. The fusion protein of claim 1, wherein the Ab comprises at least the variable region of the antibody anti-CD40_12E12.3F3 (ATCC Accession No. PTA-9854), anti-CD40_12B4.2C10 (ATCC Submission No. HS446, Accession No. _____), and anti-CD40_11B6.1C3 (ATCC Submission No. HS440, Accession No. _____).

8. The fusion protein of claim 1, wherein the Ab comprises at least one variable domain having 90, 95 99 or 100% sequence identity with a heavy chain variable domain of SEQ ID NOS.: 148, 150 and 153 or a light chain variable domains of SEQ ID NOS.: 149, 151, 152 or 154, or both.

9. The fusion protein of claim 1, wherein the Ag is selected from autoimmune diseases or disorders associated with antigens involved in autoimmune disease selected from 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.

10. The fusion protein of claim 1, wherein the Ag is selected from infectious disease antigens selected from bacterial, viral, parasitic, and fungal antigens.

11. The fusion protein of claim 1, wherein *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19.

12. The fusion protein of claim 1, wherein the fusion protein comprises two or more Ags from different antigens separated by at least one PL.

13. The fusion protein of claim 1, wherein the fusion protein comprises two or more Ags separated by at least one PL comprising an alanine and a serine.

14. The fusion protein of claim 1, wherein the Ab is an antibody fragment selected from Fv, Fab, Fab', $F(ab')_2$, Fc, or a ScFv.

15. The fusion protein of claim 1, wherein the Ab binds specifically to an MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40,CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptor, or lectin.

16. The fusion protein of claim 1, wherein the Ab is an IgA, IgD, IgE, IgG or IgM or isotype thereof.

17. The fusion protein of claim 1, wherein the Ab is a human antibody or a humanized antibody.

18. The fusion protein of claim 1, wherein the PL comprises an alanine and a serine.

19. The fusion protein of claim 1, wherein the PL is selected from:

SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11);
PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12);
TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or
TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

20. A nucleic acid expression vector encoding a fusion protein comprising:

a first polynucleotide encoding an antibody light chain or fragment thereof; and

a second polynucleotide encoding an antibody heavy chain or fragment thereof;

wherein the fusion protein comprises the following formula:

Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one antigen; and

wherein *x* is an integer from 1 to 20, the fusion protein having more stability in solution than the same fusion protein without the glycosylation site.

21. The vector of claim 20, wherein the (PL–Ag)*x* or (Ag-PL)*x* are located at the carboxy terminus of the Ab heavy chain or fragment thereof.

22. The vector of claim 20, wherein the first and second polynucleotide are on a single expression vector.

23. The vector of claim 20, wherein the Ag is selected from infectious disease antigens selected from bacterial, viral, parasitic, and fungal antigens.

24. The vector of claim 20, wherein *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19.

25. The vector of claim 20, wherein the fusion protein comprises two or more Ags from different antigens separated by at least one PL.

26. The vector of claim 20, wherein the fusion protein comprises two or more Ags separated by at least on PL comprising an alanine and a serine.

27. The vector of claim 20, wherein the Ab is an antibody fragment selected from Fv, Fab, Fab', $F(ab')_2$, Fc, or a ScFv.

28. The vector of claim 20, wherein the Ab binds specifically to an MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40,CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptor, or lectin.

29. The vector of claim 20, wherein the Ab is an IgA, IgD, IgE, IgG or IgM or isotype thereof.

30. The vector of claim 20, wherein the Ab is a human antibody or a humanized antibody.

31. The vector of claim 20, wherein the PL is comprises an alanine and a serine.

32. The vector of claim 20, wherein the PL is selected from:

SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11);
PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12);

TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or

TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

33. The vector of claim 20, wherein the first and second polynucleotides are downstream from a constitutive promoter.

34. A stable, secretable fusion protein comprising the formula:

NH_2-Ab-(PL–Ag)*x*-COOH or NH_2-Ab-(Ag-PL)*x*-COOH;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one immunogenic antigen; and

wherein *x* is an integer from 1 to 20, the fusion protein being stable and soluble in solution as compared to an Ab-Ag protein alone that is not soluble or stable.

35. A method of stabilizing antigenic peptides comprising:

incorporating one or more antigenic peptides that are unstable or insoluble into a fusion protein, wherein the fusion protein has the following structure:

Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one antigen; and

wherein *x* is an integer from 1 to 20, the fusion protein being stable and soluble in solution wherein the Ab-Ag is not soluble or stable.

36. The method of claim 35, wherein the Ag is selected from a viral antigen, a tumor antigen, an infectious disease antigen, an autoimmune antigen, a toxin or combinations thereof.

37. The method of claim 35, wherein the -(PL–Ag)*x*, -(Ag-PL)*x*, -(PL-Ag-PL)*x*, or -(Ag-PL-Ag)*x* are located at the carboxy terminus of the Ab heavy chain or fragment thereof.

38. The method of claim 35, wherein the Ag elicits a humoral immune response in a host.

39. The method of claim 35, wherein the Ag elicits a cellular immune response in a host.

40. The method of claim 35, wherein the Ag is selected from autoimmune diseases or disorders comprising antigens involved in autoimmune disease selected from 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.

41. The method of claim 35, wherein the Ag is selected from infectious disease antigens selected from bacterial, viral, parasitic, and fungal antigens.

42. The method of claim 35, wherein *x* comprises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, or 19.

43. The method of claim 35, wherein the fusion protein comprises two or more Ags from different antigens separated by at least one PL.

44. The method of claim 35, wherein the fusion protein comprises two or more Ags separated by at least on PL comprising an alanine and a serine.

45. The method of claim 35, wherein the Ab is an antibody fragment selected from Fv, Fab, Fab', $F(ab')_2$, Fc, or a ScFv.

46. The method of claim 35, wherein the Ab is an anti-CD40 antibody.

47. The method of claim 35, wherein the Ab comprises at least the variable region of the antibody anti-CD40_12E12.3F3 (ATCC Accession No. PTA-9854), anti-CD40_12B4.2C10 (ATCC Submission No. HS446, Accession No. _____), and anti-CD40_11B6.1C3 (ATCC Submission No. HS440, Accession No. _____).

48. The method of claim 35, wherein the PL is selected from:

SSVSPTTSVHPTPTSVPPTPTKSSP (SEQ ID NO.: 11);
PTSTPADSSTITPTATPTATPTIKG (SEQ ID NO.: 12);
TVTPTATATPSAIVTTITPTATTKP (SEQ ID NO.: 13); or
TNGSITVAATAPTVTPTVNATPSAA (SEQ ID NO.: 14).

49. The method of claim 35, wherein the Ab binds specifically to an MHC class I, MHC class II, CD1, CD2, CD3, CD4, CD8, CD11b, CD14, CD15, CD16, CD 19, CD20, CD29, CD31, CD40,CD43, CD44, CD45, CD54, CD56, CD57, CD58, CD83, CD86, CMRF-44, CMRF-56, DCIR, DC-ASPGR, CLEC-6, CD40, BDCA-2, MARCO, DEC-205, mannose receptor, Langerin, DECTIN-1, B7-1, B7-2, IFN-γ receptor and IL-2 receptor, ICAM-1, Fcγ receptor, T cell receptor, or lectin.

50. The method of claim 35, wherein the Ab is an IgA, IgD, IgE, IgG or IgM or isotype thereof.

51. The method of claim 35, wherein the Ab is a human antibody or a humanized antibody.

52. A host cell comprising a nucleic acid expression vector comprising:

a first polynucleotide encoding an antibody light chain; and

a second polynucleotide encoding an antibody heavy chain fusion protein, the fusion protein comprising the following formula:

Ab-(PL–Ag)*x* or Ab-(Ag-PL)*x*;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one antigen; and

wherein *x* is an integer from 1 to 20, the fusion protein having more stability is solution than the fusion protein without the glycosylation site.

53. A pharmaceutical composition comprising the antibody of claim 1.

54. A fusion protein comprising the formula:

Ab-(PL–Ag)*x*-(PL*y*-Ag*z*)*n*; or

Ab-(Ag–PL)*x*-(PL*y*-Ag*z*)*n*;

wherein Ab is an antibody or fragment thereof;

wherein PL is at least one peptide linker comprising at least one glycosylation site;

wherein Ag is at least one antigen; and

wherein *x* is an integer from 1 to 20;

wherein *n* is 0 to 19; and

wherein *y* or *z* is 0 to 10, wherein the fusion protein has more stability in solution than the same fusion protein without the glycosylation site.

55. An isolated and purified vaccine comprising:

a heavy chain selected from at least one of SEQ ID NOS.: 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 36, 37, 96, 97, 98, 99, 110, 111, 112, 118, 119, 134, 136, 138, 146, and 147 that binds specifically to CD40; and

a light chain that binds specifically to CD40.

56. The antibody of claim 55, wherein the antibody is defined further as a humanized antibody.

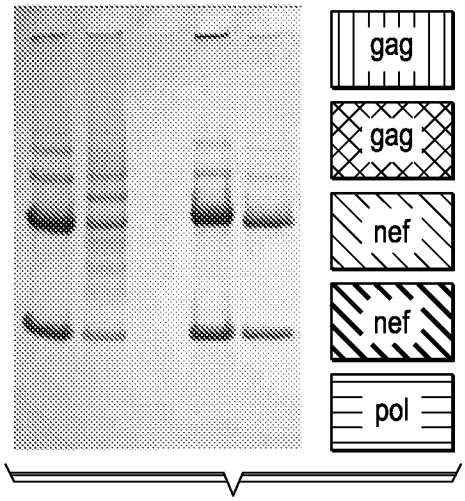

FIG. 1

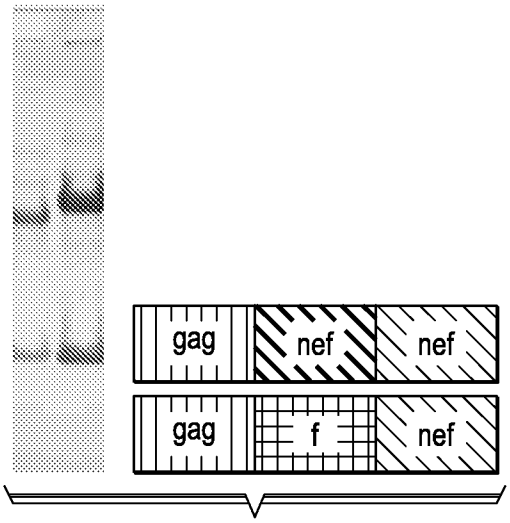

FIG. 2

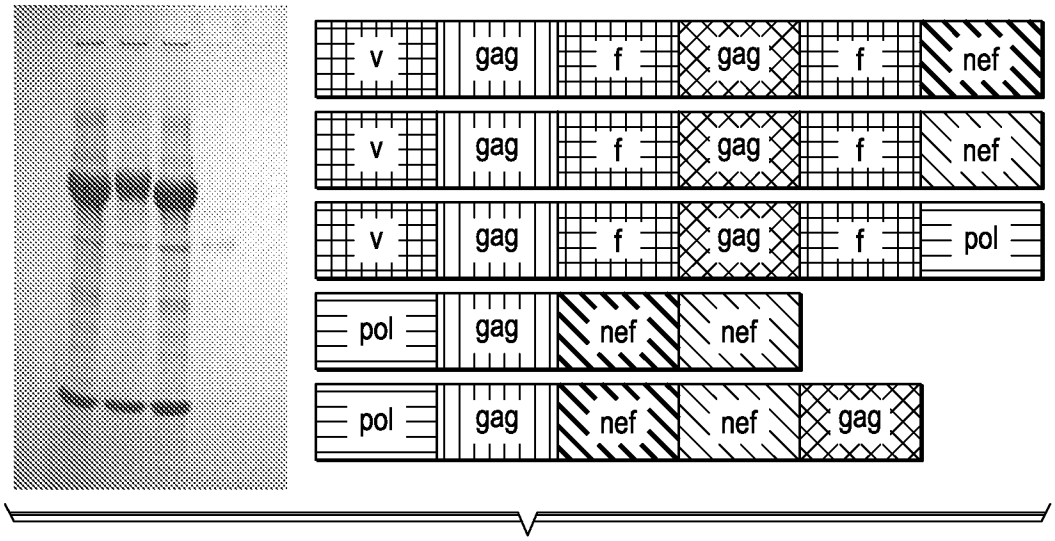

FIG. 3

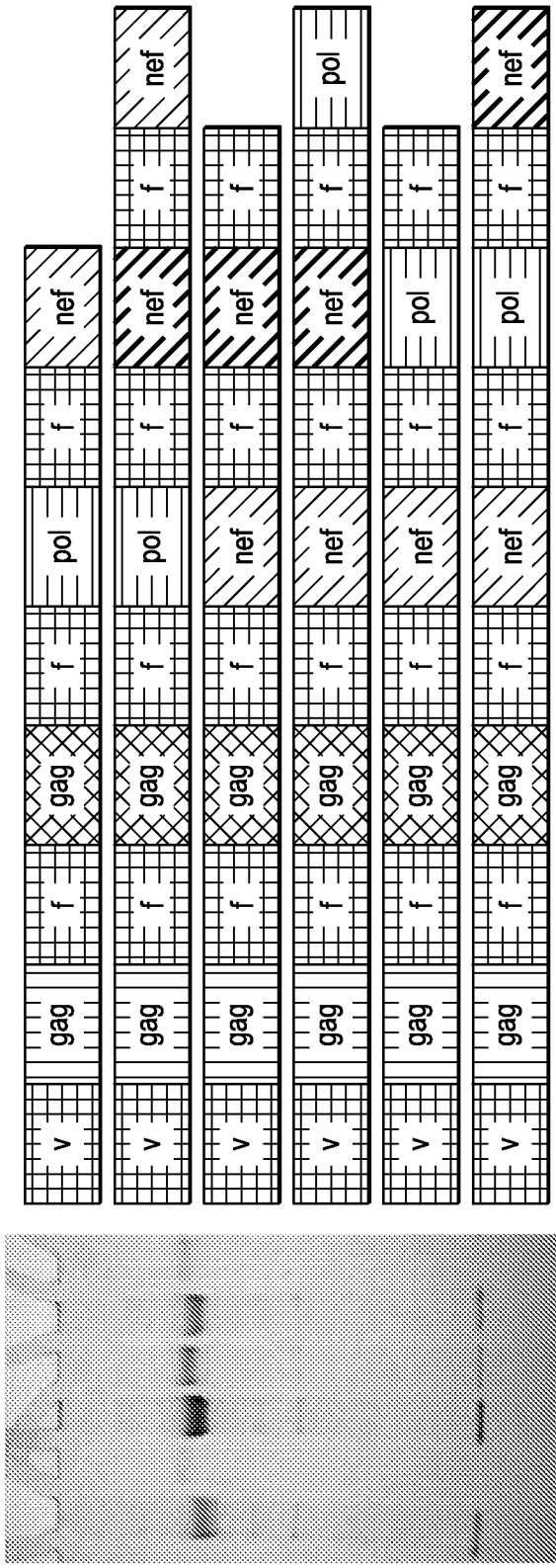

FIG. 4

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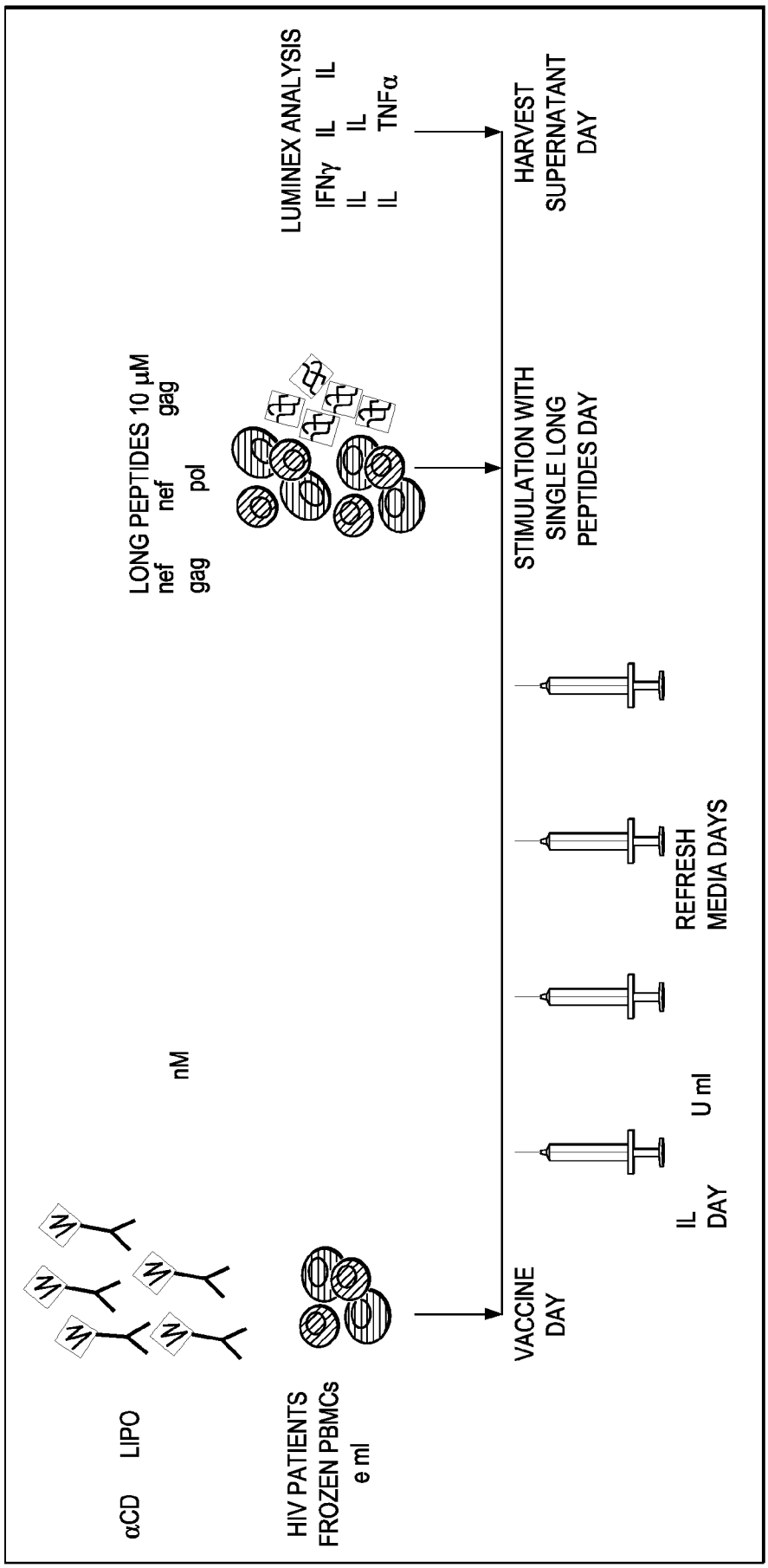
αCD LIPO
HIV PATIENTS
FROZEN PBMCs
e ml
nM
LONG PEPTIDES 10 µM
nef gag
gag pol
VACCINE
DAY
IL
DAY
U ml
REFRESH
MEDIA DAYS
STIMULATION WITH
SINGLE LONG
PEPTIDES DAY
LUMINEX ANALYSIS
IFNγ IL
IL IL
IL TNFα
HARVEST
SUPERNATANT
DAY

FIG. 5

FIG. 6A

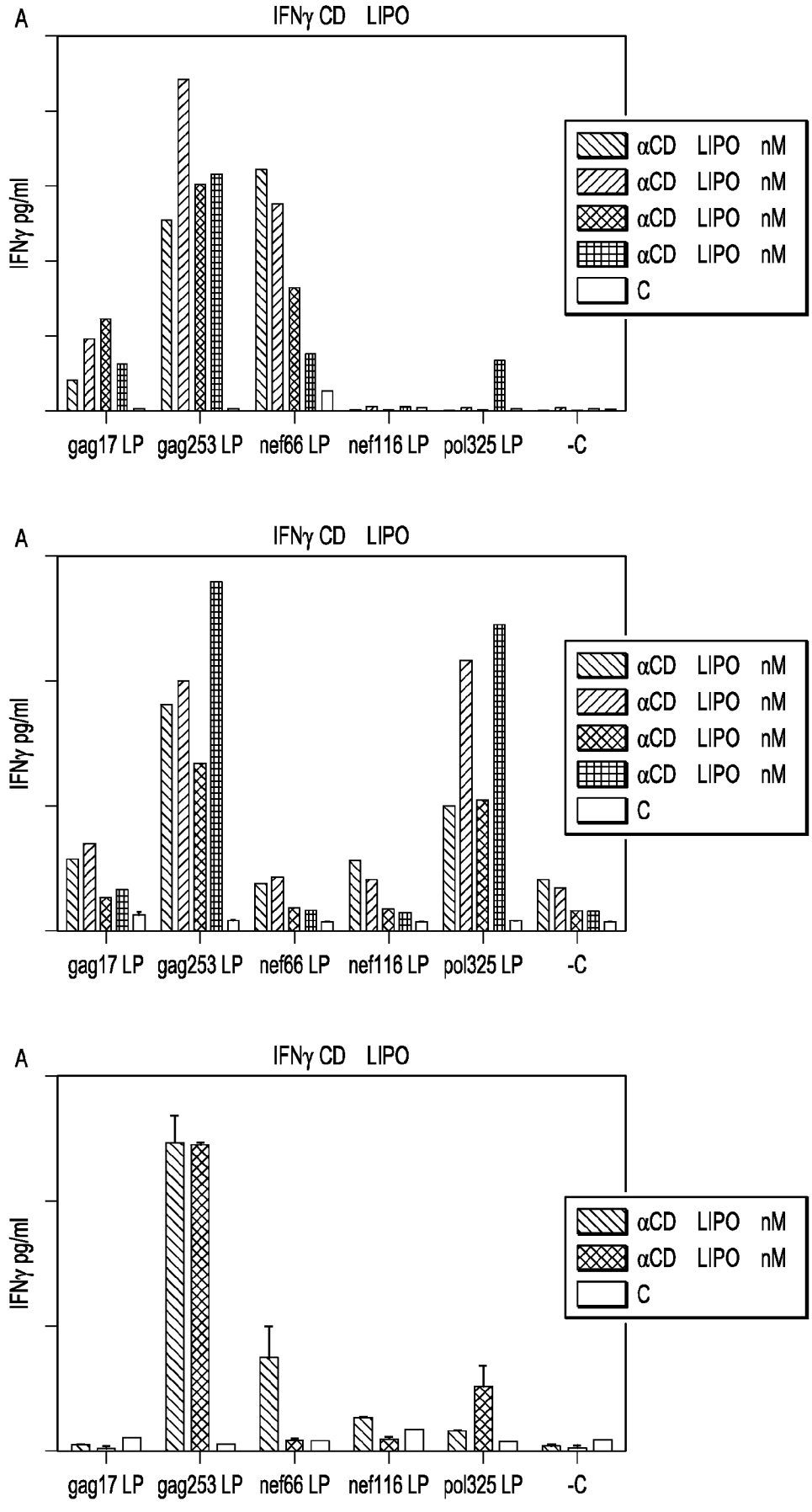
A
IFNγ CD LIPO
IFNγ pg/ml
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
A
IFNγ CD LIPO
IFNγ pg/ml
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
A
IFNγ CD LIPO
IFNγ pg/ml
αCD LIPO nM
αCD LIPO nM
C
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C

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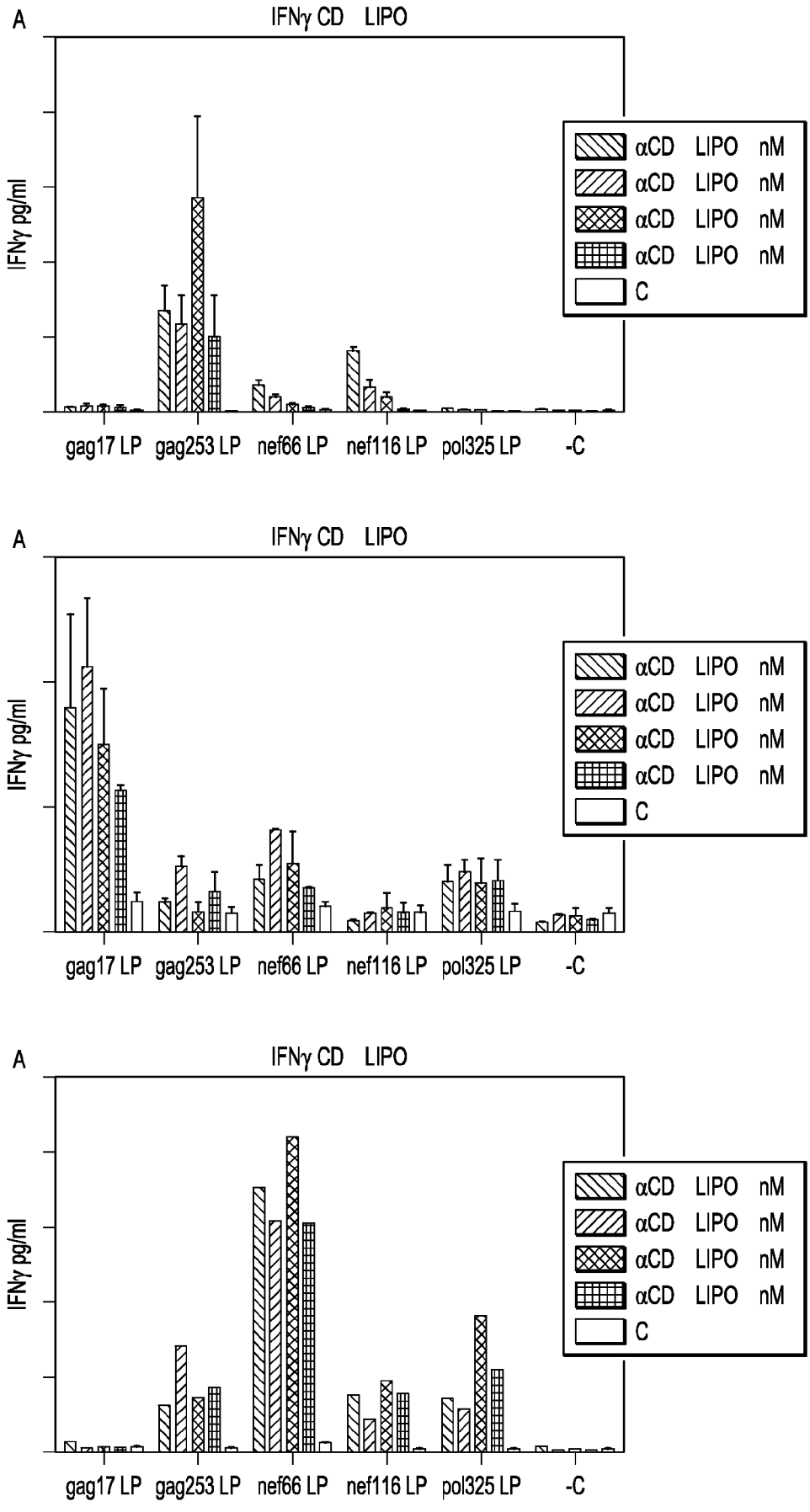
FIG. 6B


A
IFNγ CD LIPO
IFNγ pg/ml
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C

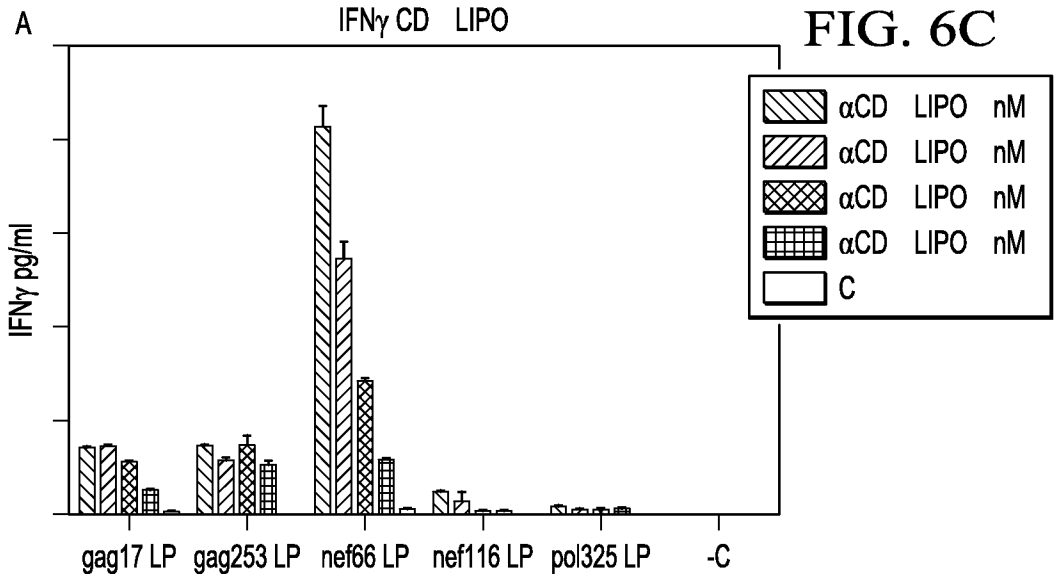

A
IFNγ CD LIPO
IFNγ pg/ml
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C

FIG. 6C

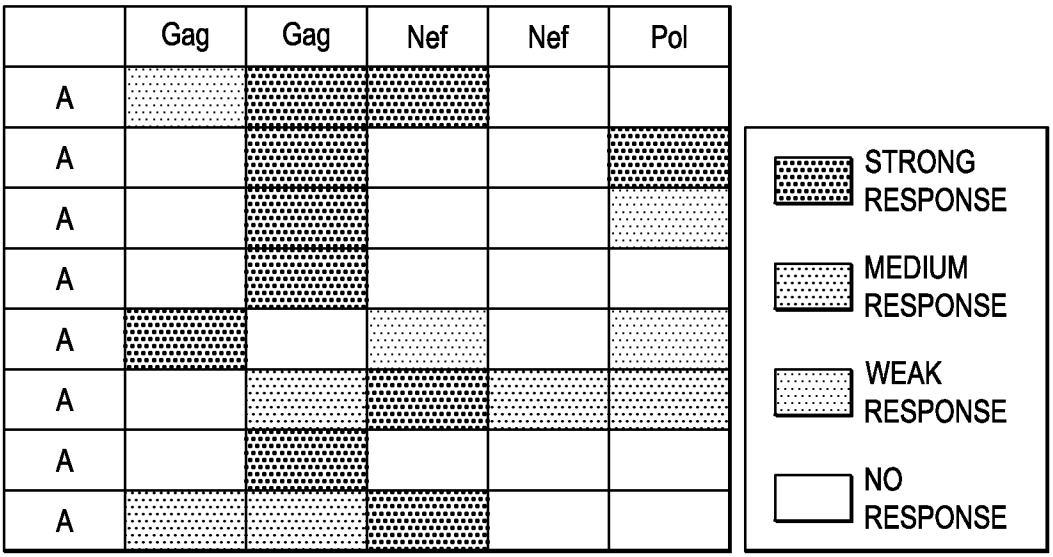

Gag
Gag
Nef
Nef
Pol
A
A
A
A
A
A
A
A
STRONG RESPONSE
MEDIUM RESPONSE
WEAK RESPONSE
NO RESPONSE

FIG. 7

FIG. 8A

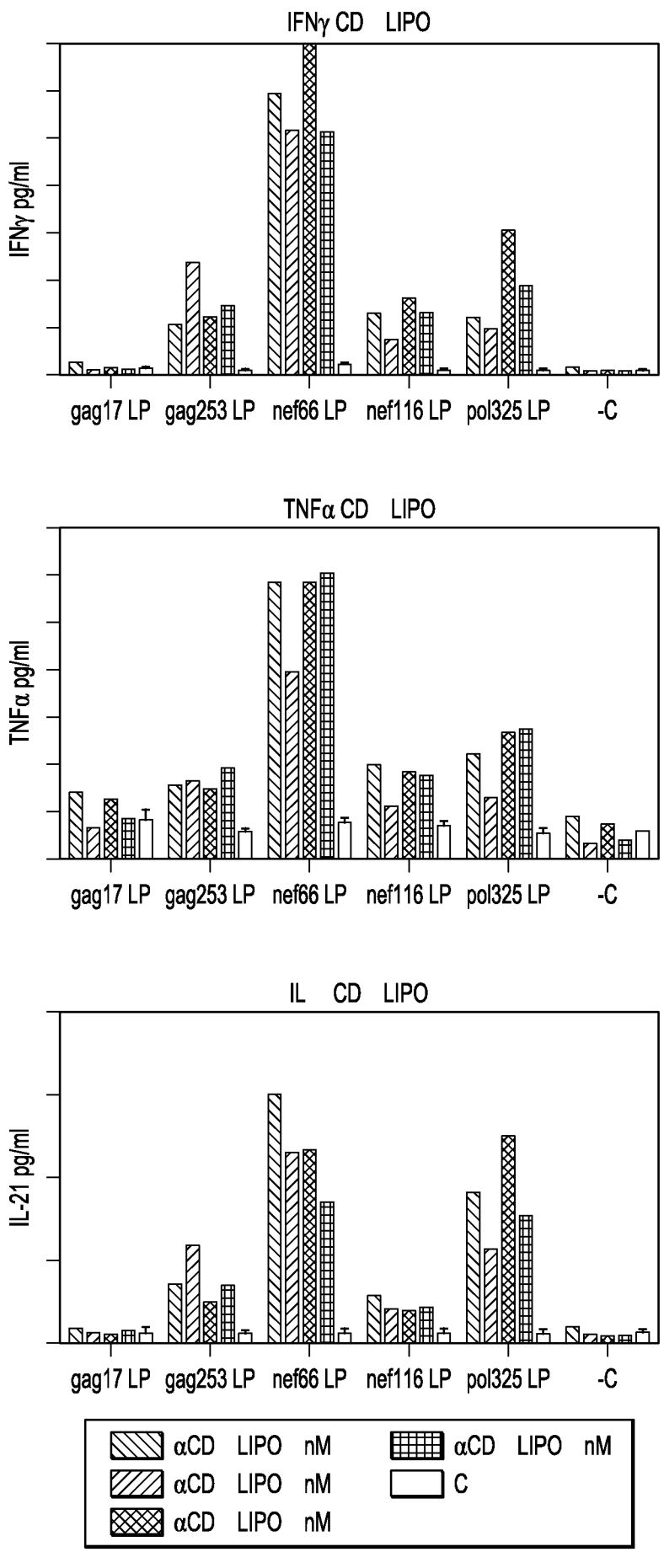
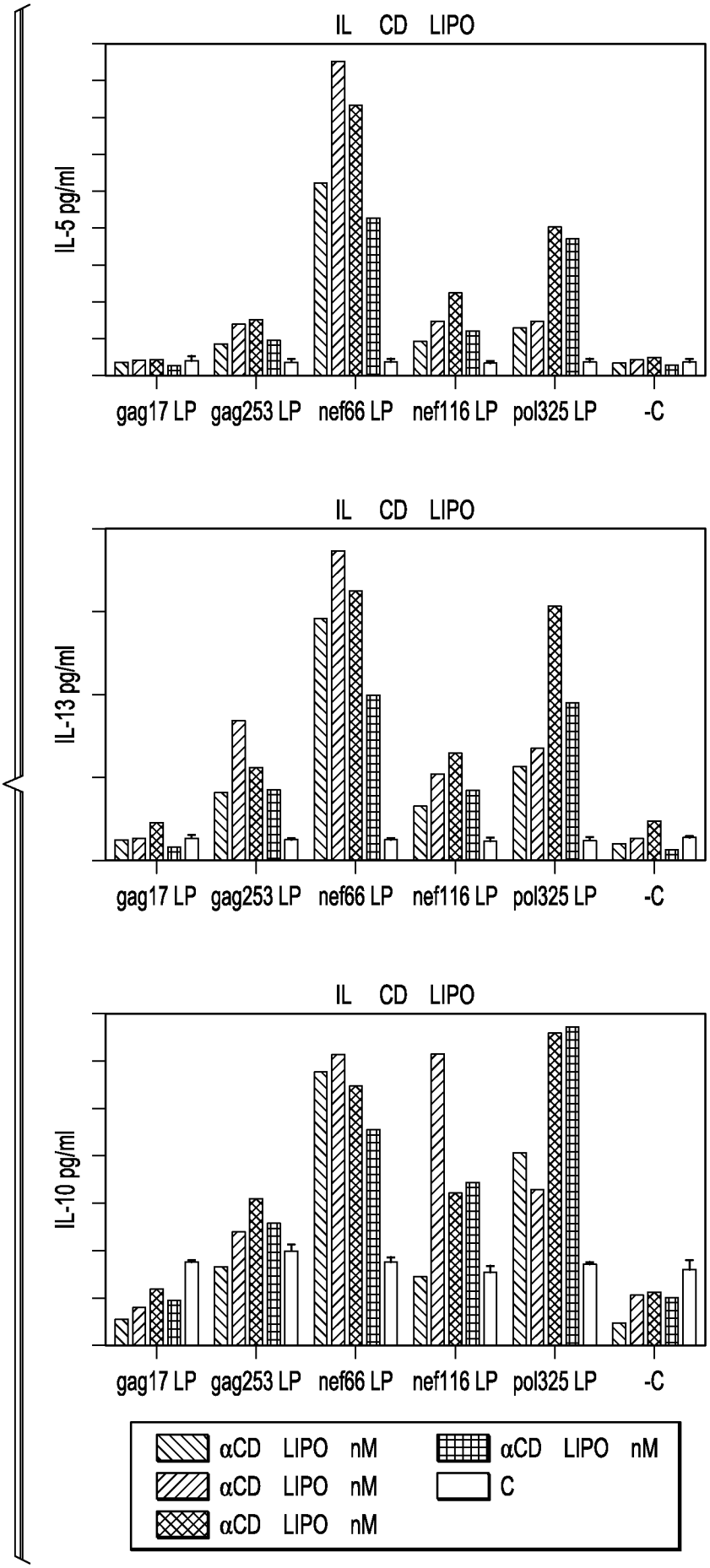

IFNγ CD LIPO
IFNγ pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
TNFα CD LIPO
TNFα pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-21 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C

FIG. 8B


IL CD LIPO
IL-5 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-13 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-10 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
C

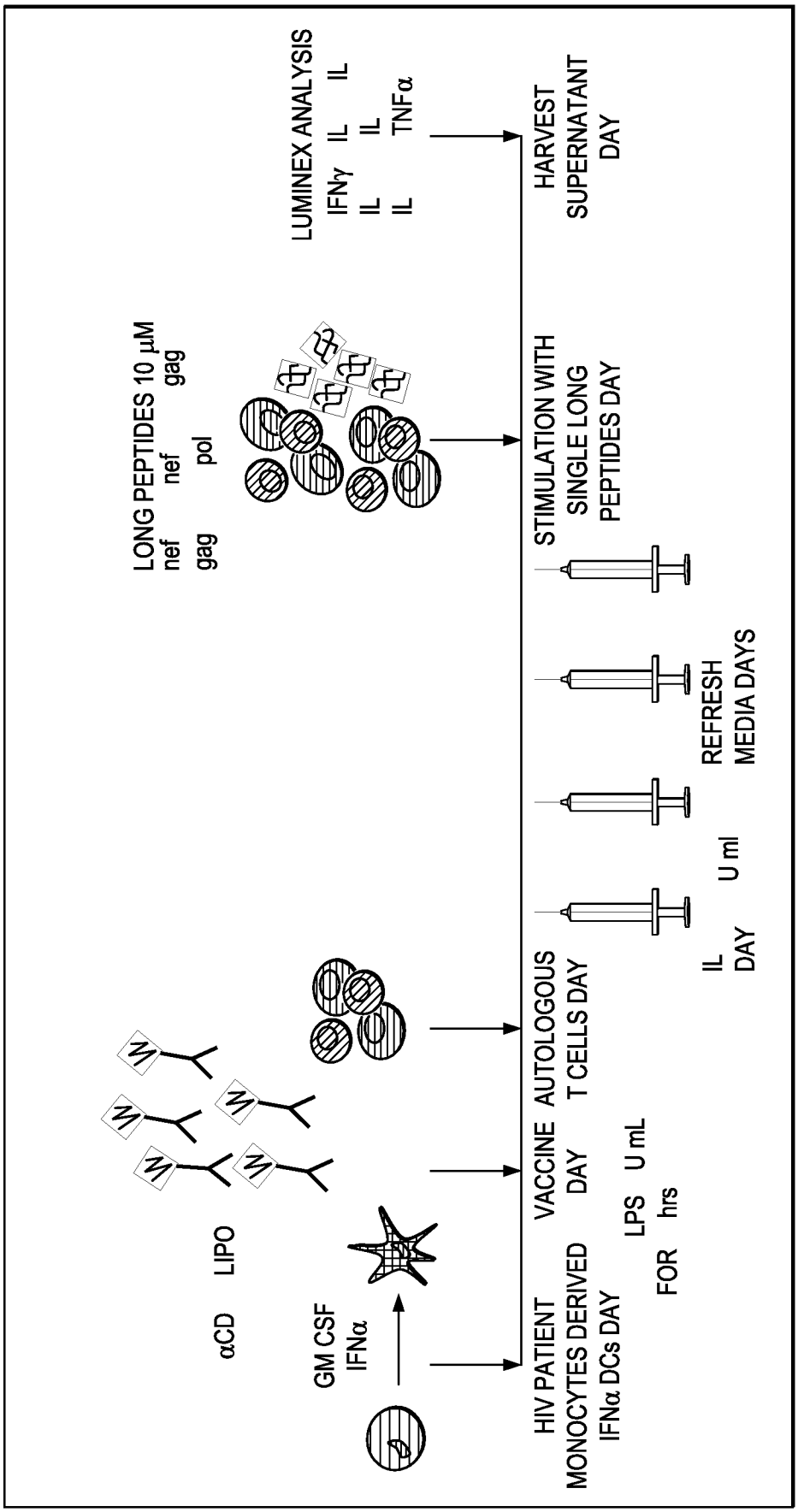

HIV PATIENT
MONOCYTES DERIVED
IFNα DCs DAY
GM CSF
IFNα
αCD
LIPO
VACCINE
DAY
AUTOLOGOUS
T CELLS DAY
LPS
U mL
FOR
hrs
IL
DAY
U ml
REFRESH
MEDIA DAYS
STIMULATION WITH
SINGLE LONG
PEPTIDES DAY
LONG PEPTIDES 10 µM
nef
gag
gag
pol
LUMINEX ANALYSIS
IFNγ
IL
IL
IL
IL
TNFα
HARVEST
SUPERNATANT
DAY

FIG. 9

FIG. 10A

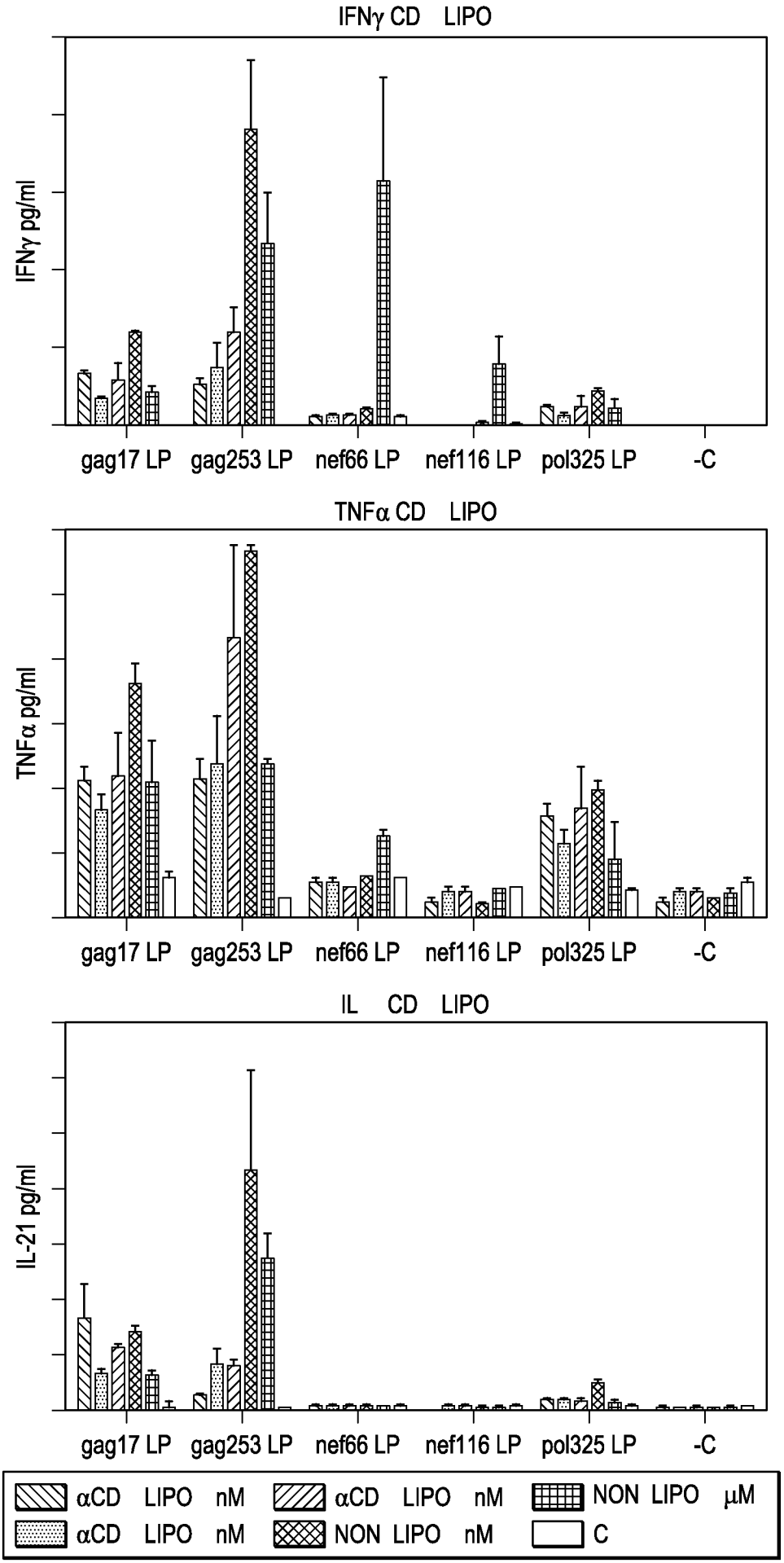

IFNγ CD LIPO
IFNγ pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
TNFα CD LIPO
TNFα pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-21 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
NON LIPO nM
NON LIPO μM
C

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FIG. 10B

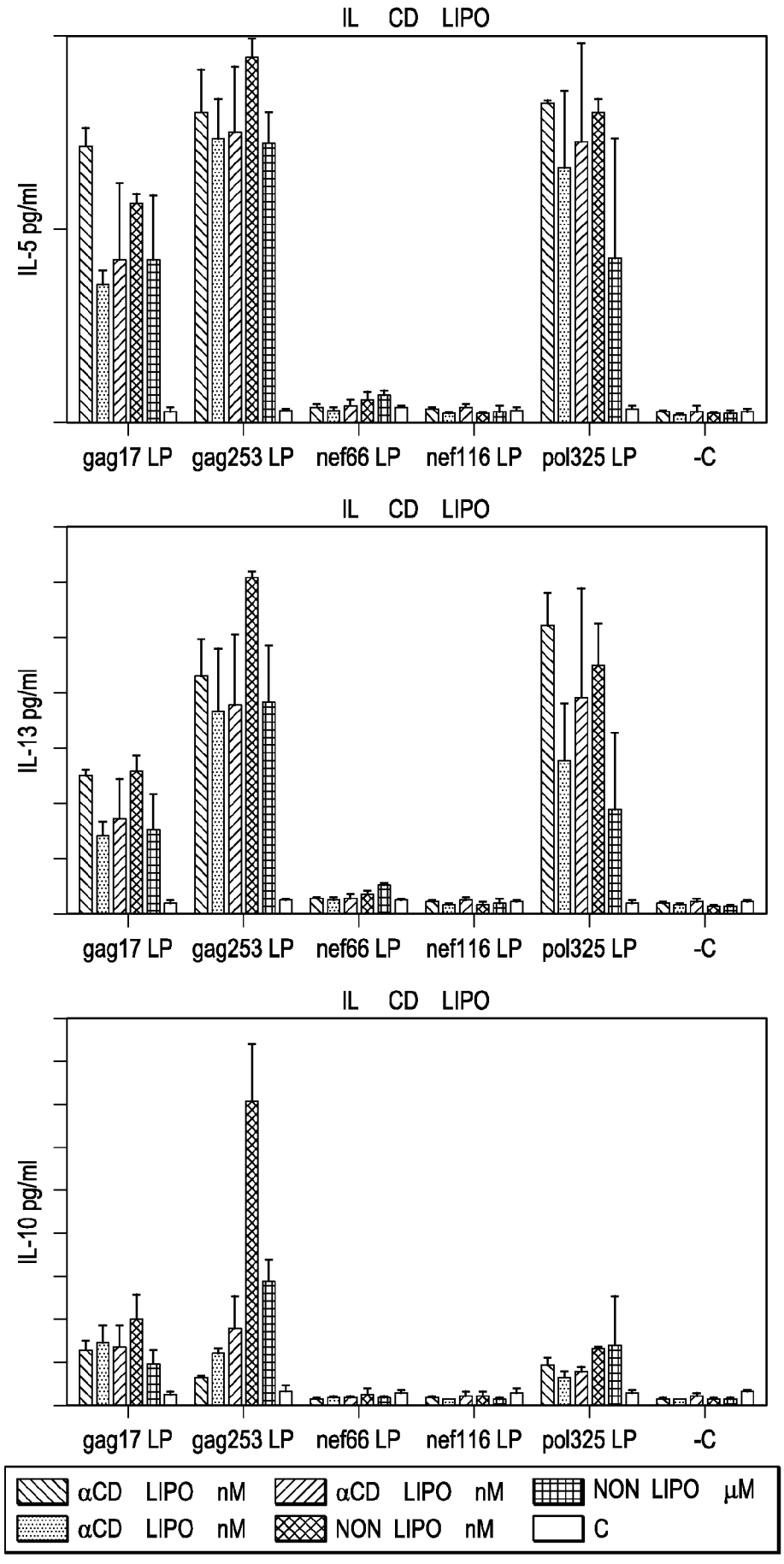

IL CD LIPO
IL-5 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-13 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
IL CD LIPO
IL-10 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
-C
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
NON LIPO nM
NON LIPO μM
C

FIG. 11A

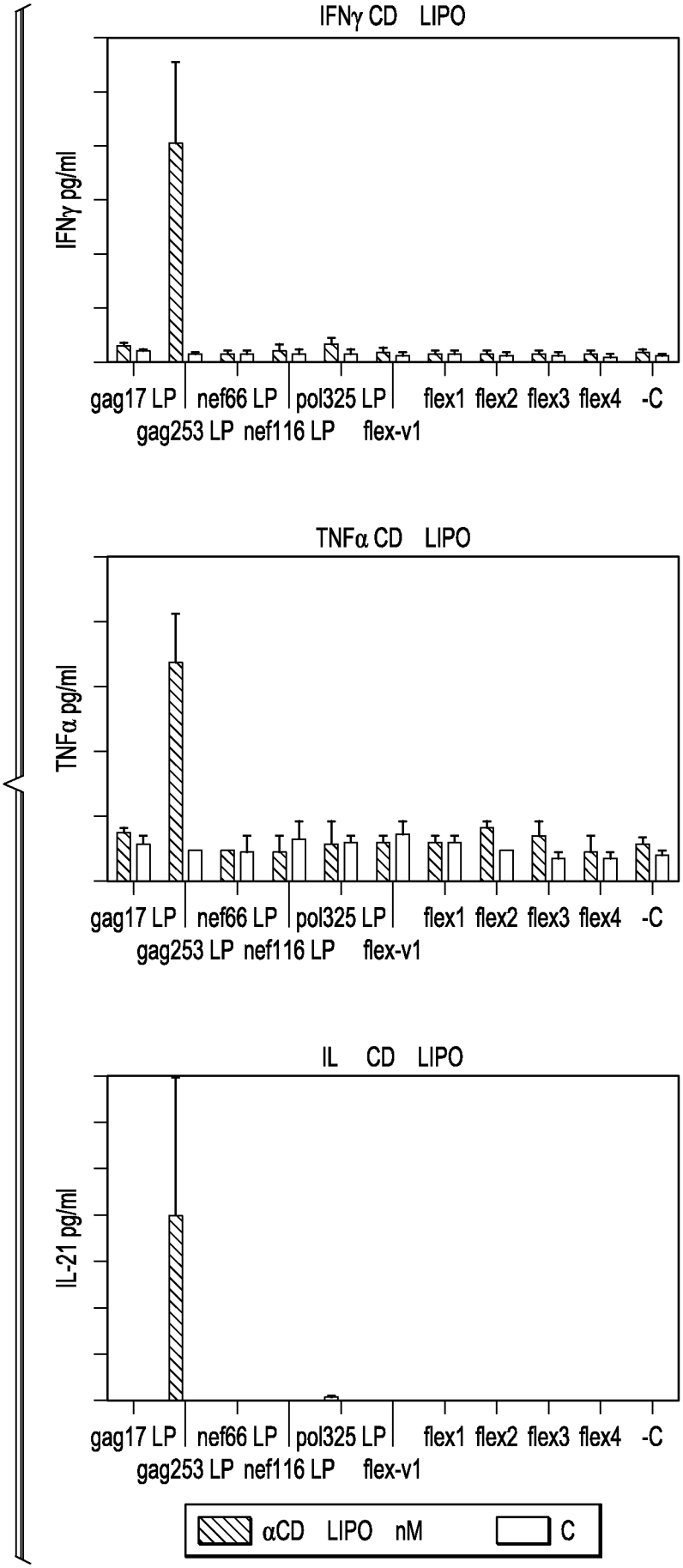

IFNγ CD LIPO
IFNγ pg/ml
gag17 LP
nef66 LP
pol325 LP
flex1
flex2
flex3
flex4
-C
gag253 LP
nef116 LP
flex-v1
TNFα CD LIPO
TNFα pg/ml
gag17 LP
nef66 LP
pol325 LP
flex1
flex2
flex3
flex4
-C
gag253 LP
nef116 LP
flex-v1
IL CD LIPO
IL-21 pg/ml
gag17 LP
nef66 LP
pol325 LP
flex1
flex2
flex3
flex4
-C
gag253 LP
nef116 LP
flex-v1
αCD LIPO nM
C

FIG. 11B

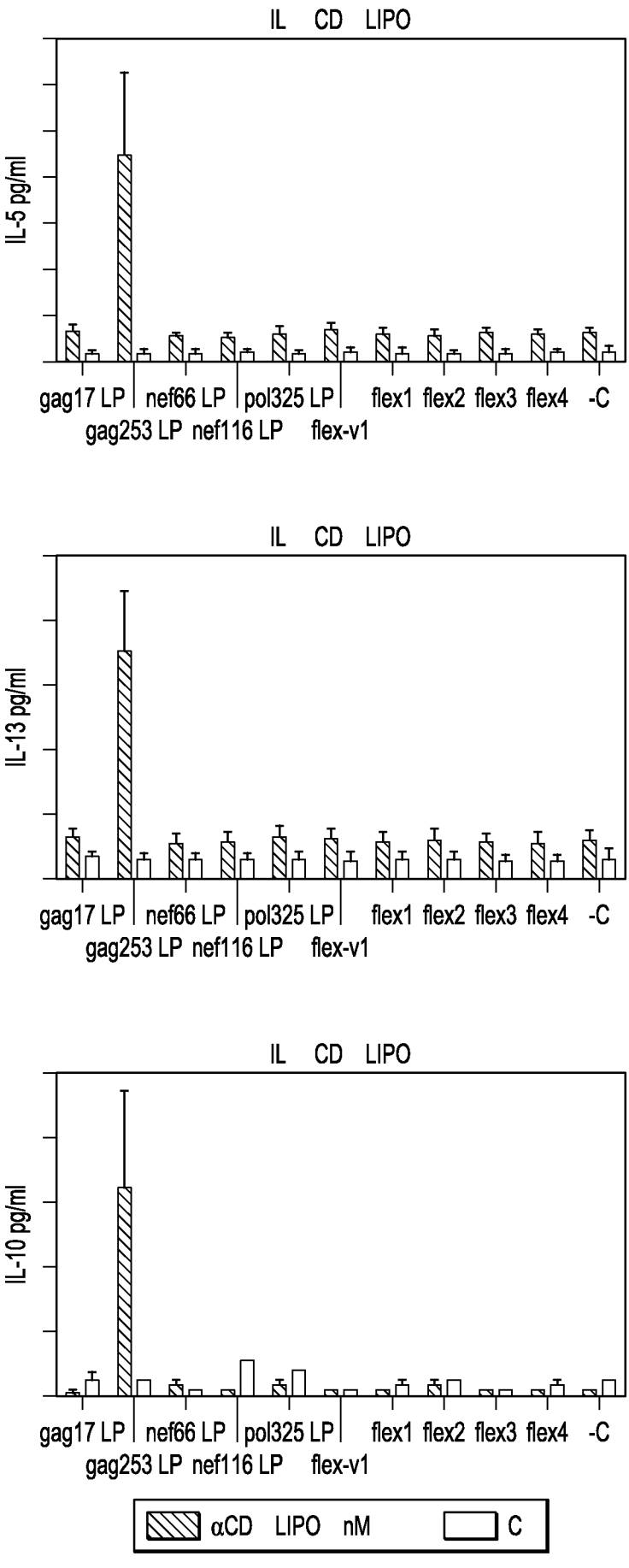
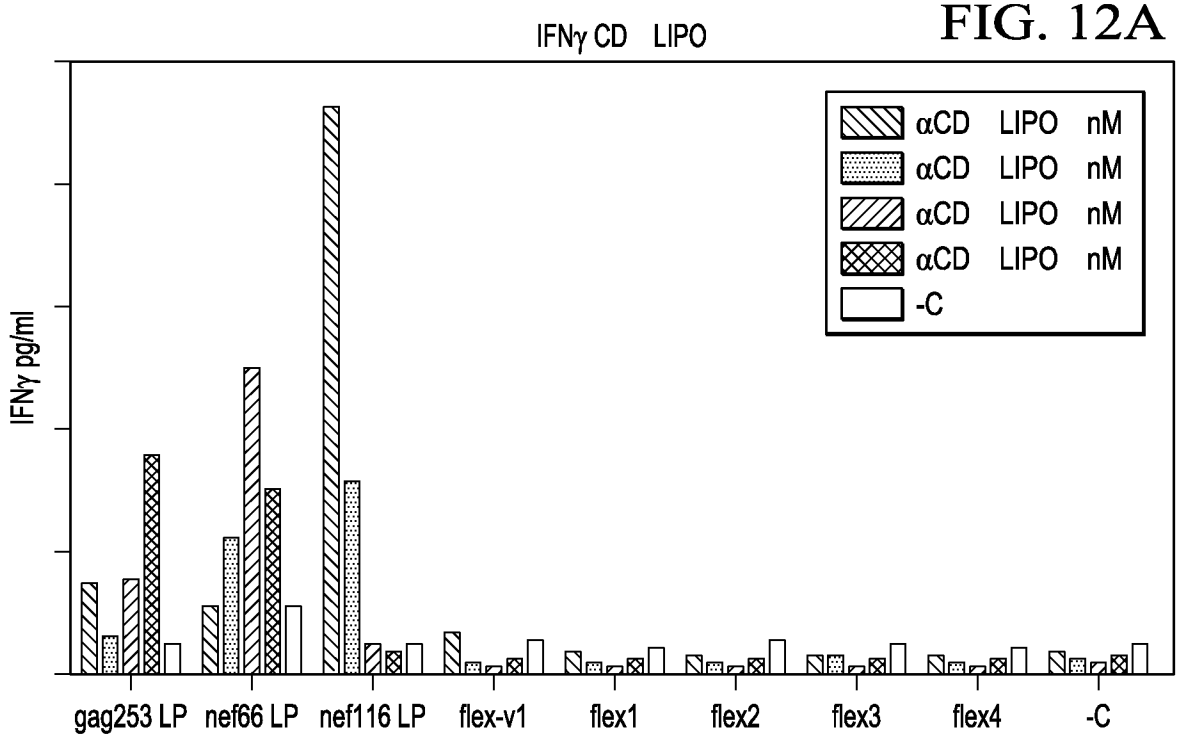

IL CD LIPO
IL-5 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
flex-v1
flex1
flex2
flex3
flex4
-C
IL CD LIPO
IL-13 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
flex-v1
flex1
flex2
flex3
flex4
-C
IL CD LIPO
IL-10 pg/ml
gag17 LP
gag253 LP
nef66 LP
nef116 LP
pol325 LP
flex-v1
flex1
flex2
flex3
flex4
-C
αCD LIPO nM
C

FIG. 12A


IFNγ CD LIPO
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
αCD LIPO nM
-C
IFNγ pg/ml
gag253 LP
nef66 LP
nef116 LP
flex-v1
flex1
flex2
flex3
flex4
-C

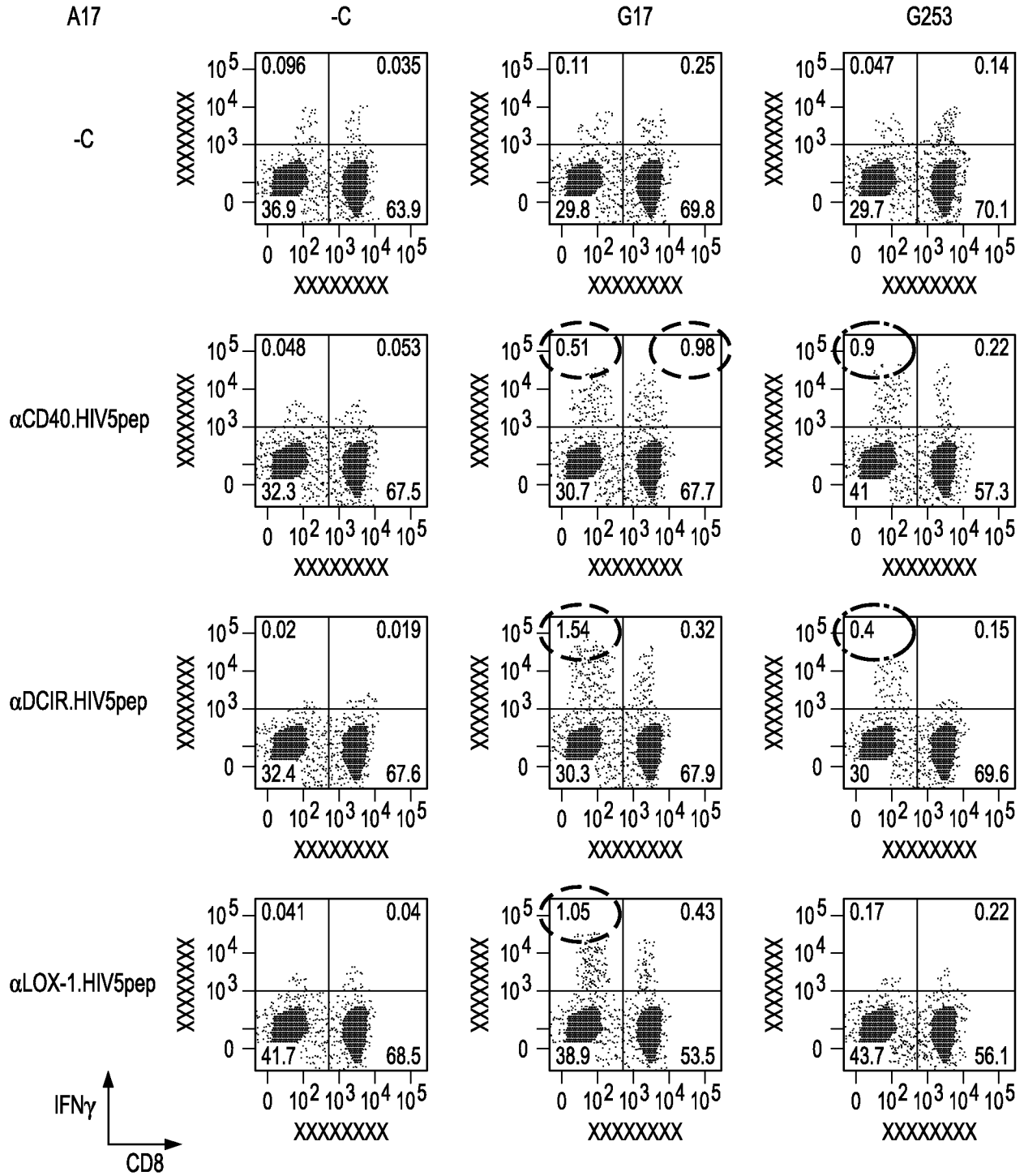

A17
-C
G17
G253
-C
αCD40.HIV5pep
αDCIR.HIV5pep
αLOX-1.HIV5pep
0.096
0.035
36.9
63.9
0.11
0.25
29.8
69.8
0.047
0.14
29.7
70.1
0.048
0.053
32.3
67.5
0.51
0.98
30.7
67.7
0.9
0.22
41
57.3
0.02
0.019
32.4
67.6
1.54
0.32
30.3
67.9
0.4
0.15
30
69.6
0.041
0.04
41.7
68.5
1.05
0.43
38.9
53.5
0.17
0.22
43.7
56.1
XXXXXXX
XXXXXXXX
IFNγ
CD8

FIG. 12B-1

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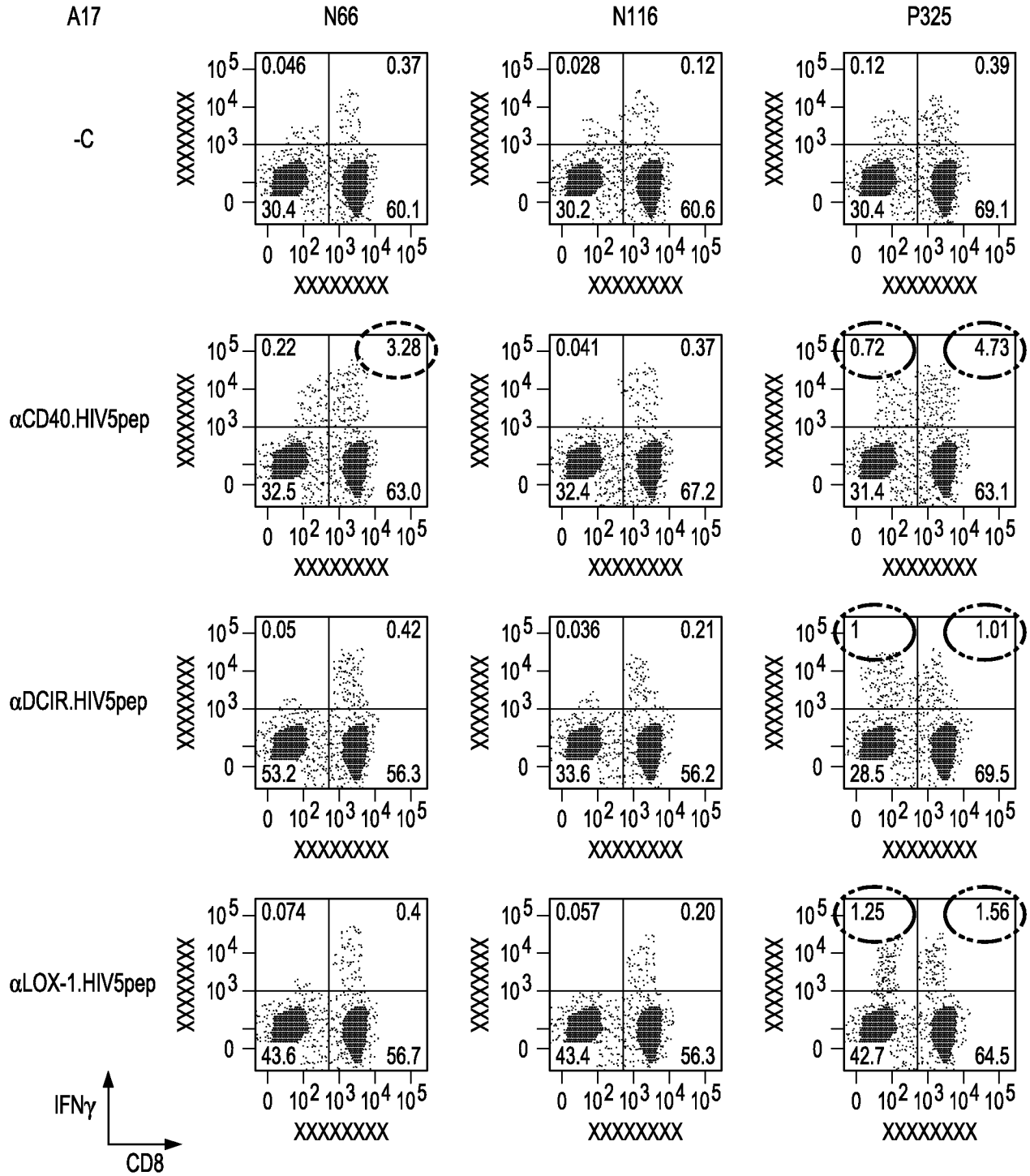

FIG. 12B-2

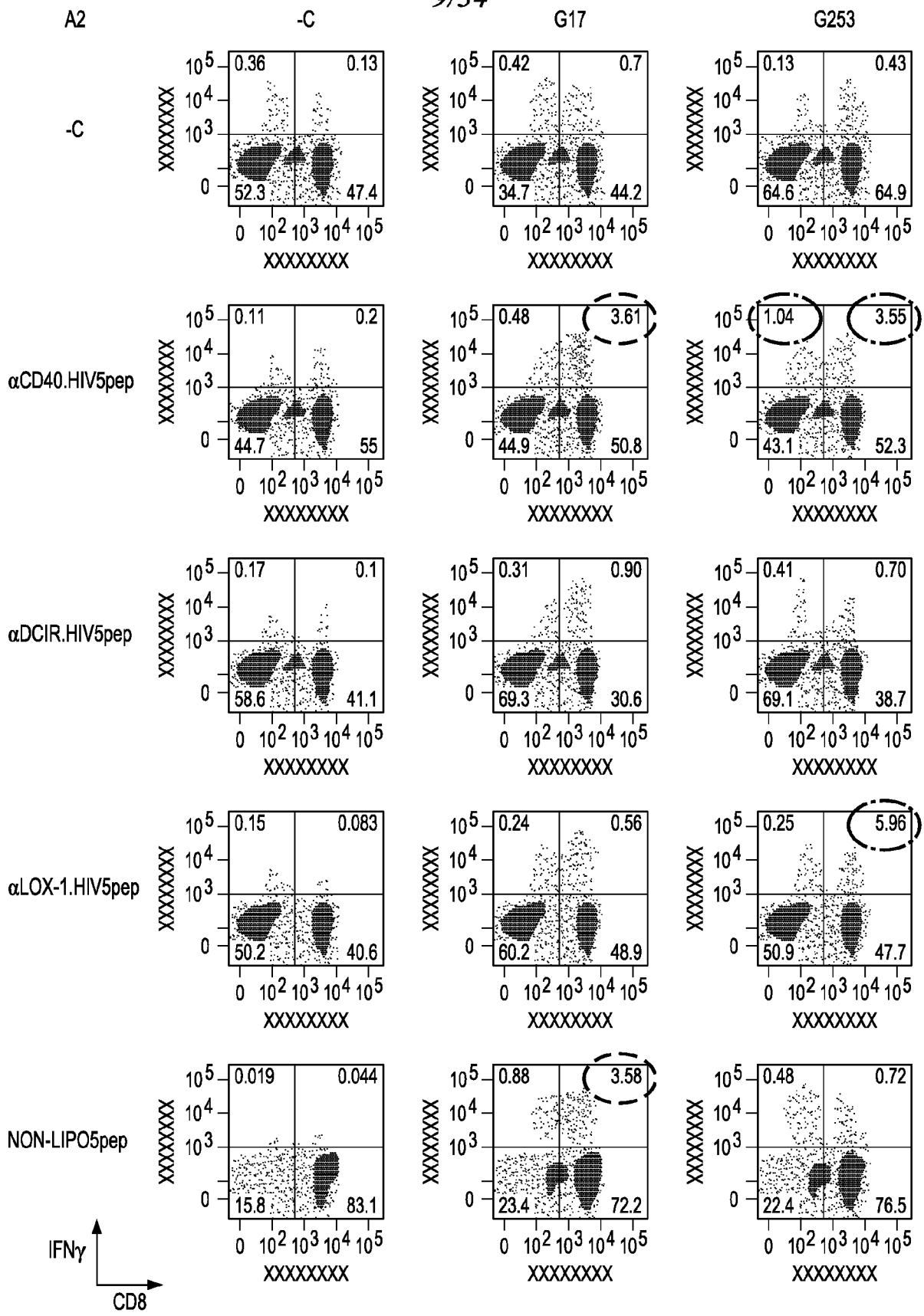
A2
-C
G17
G253
-C
αCD40.HIV5pep
αDCIR.HIV5pep
αLOX-1.HIV5pep
NON-LIPO5pep
0.36
0.13
52.3
47.4
0.42
0.7
34.7
44.2
0.13
0.43
64.6
64.9
0.11
0.2
44.7
55
0.48
3.61
44.9
50.8
1.04
3.55
43.1
52.3
0.17
0.1
58.6
41.1
0.31
0.90
69.3
30.6
0.41
0.70
69.1
38.7
0.15
0.083
50.2
40.6
0.24
0.56
60.2
48.9
0.25
5.96
50.9
47.7
0.019
0.044
15.8
83.1
0.88
3.58
23.4
72.2
0.48
0.72
22.4
76.5
XXXXXXX
XXXXXXXX
IFNγ
CD8

FIG. 12C-1

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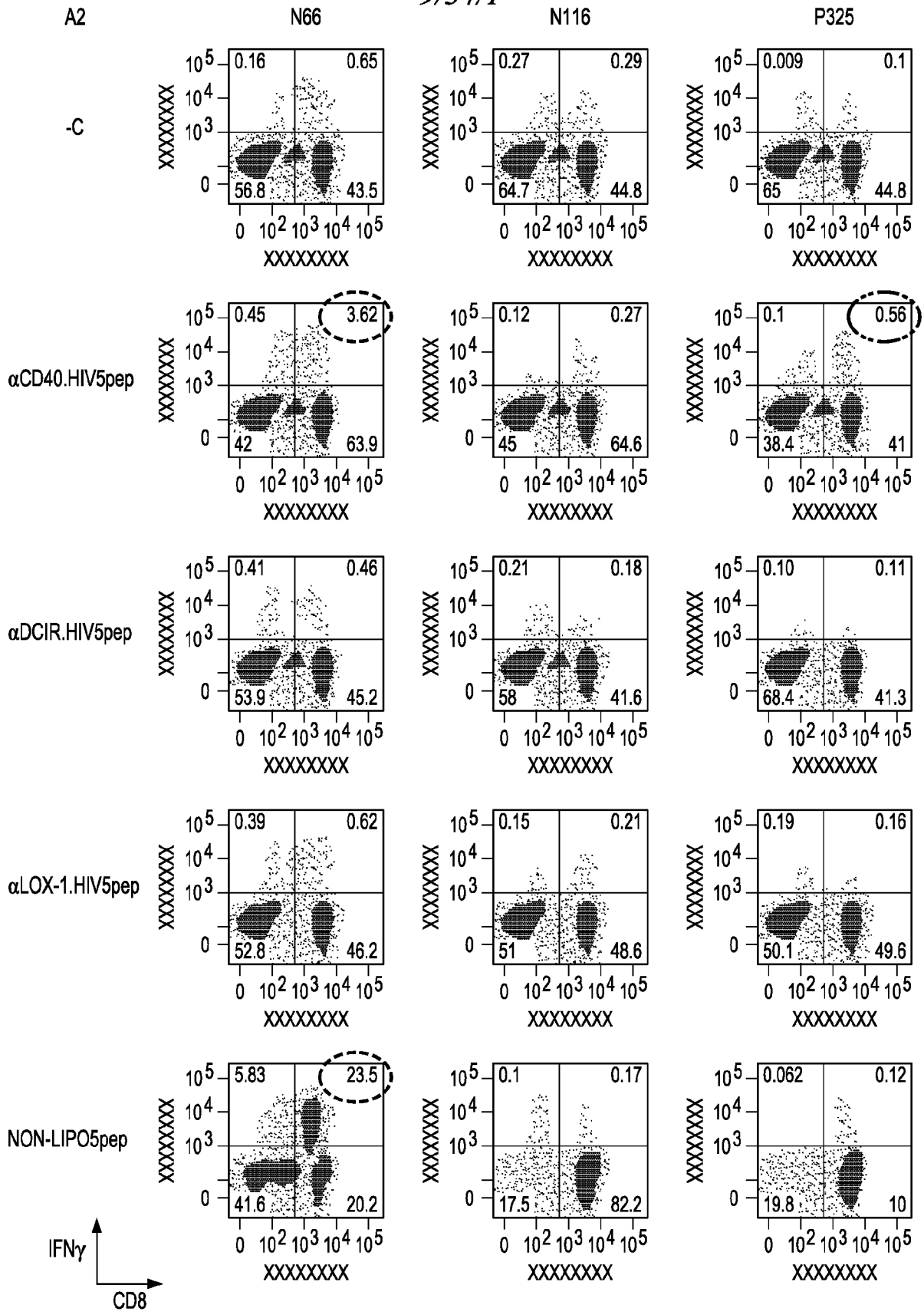


FIG. 12C-2

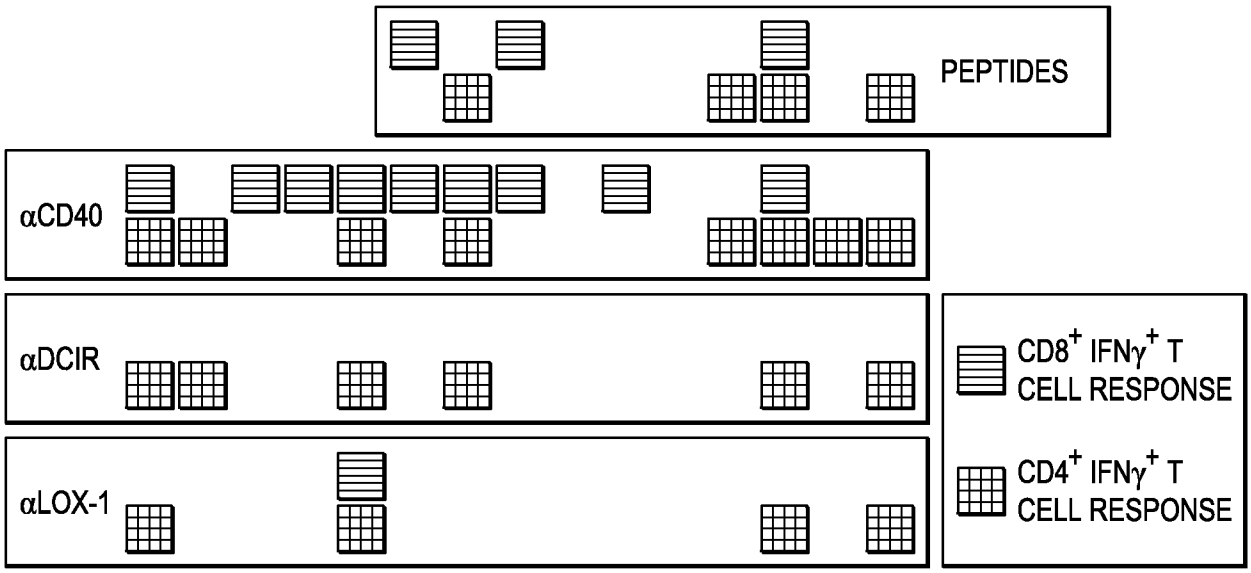

PEPTIDES
αCD40
αDCIR
αLOX-1
CD8+ IFNγ+ T CELL RESPONSE
CD4+ IFNγ+ T CELL RESPONSE

FIG. 12D

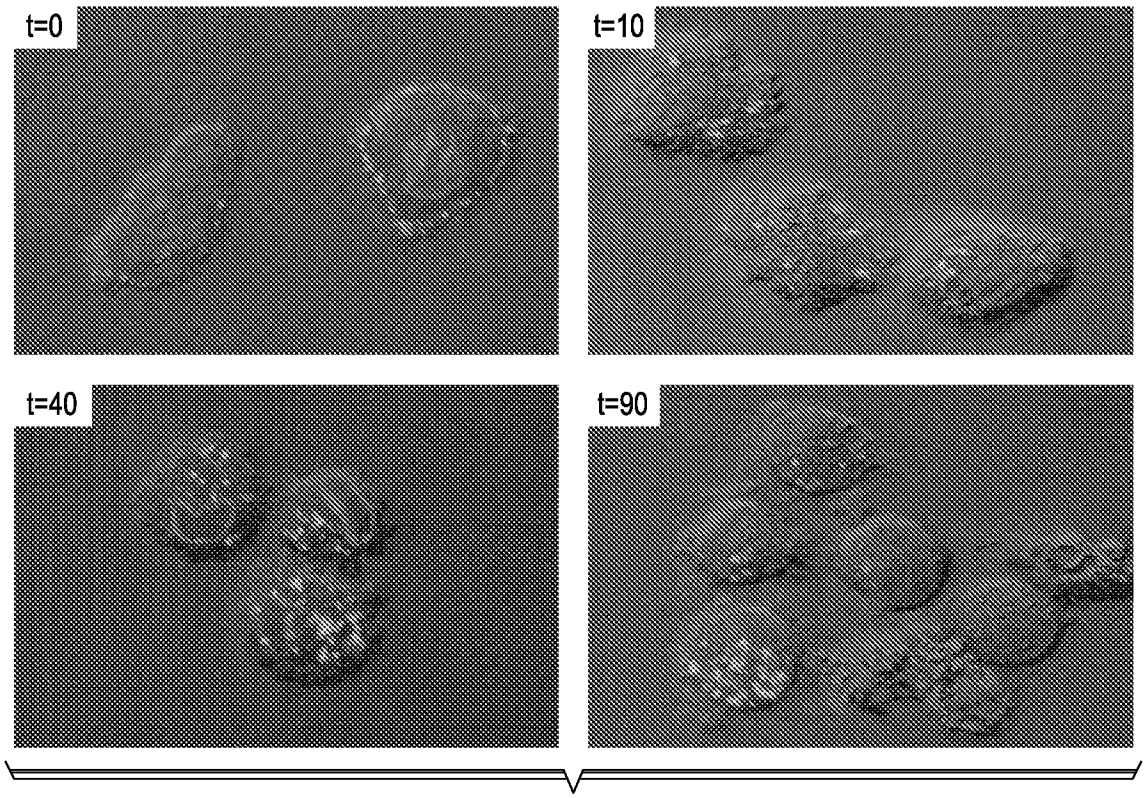


FIG. 13

FIG. 14

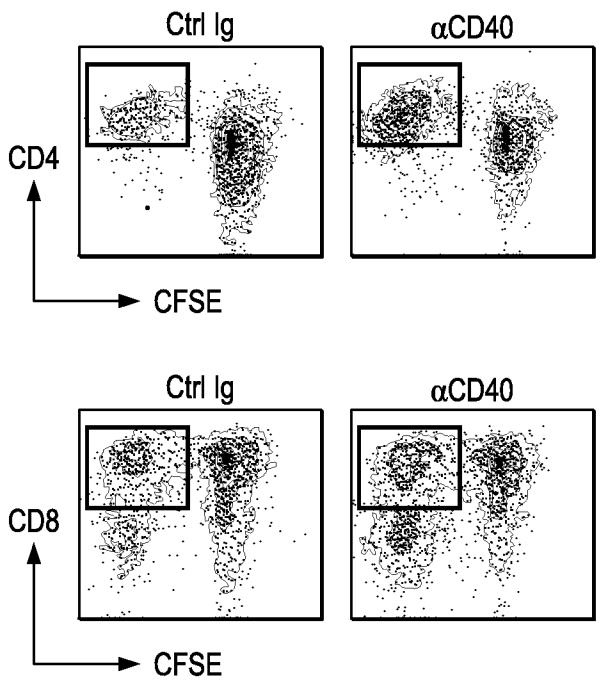
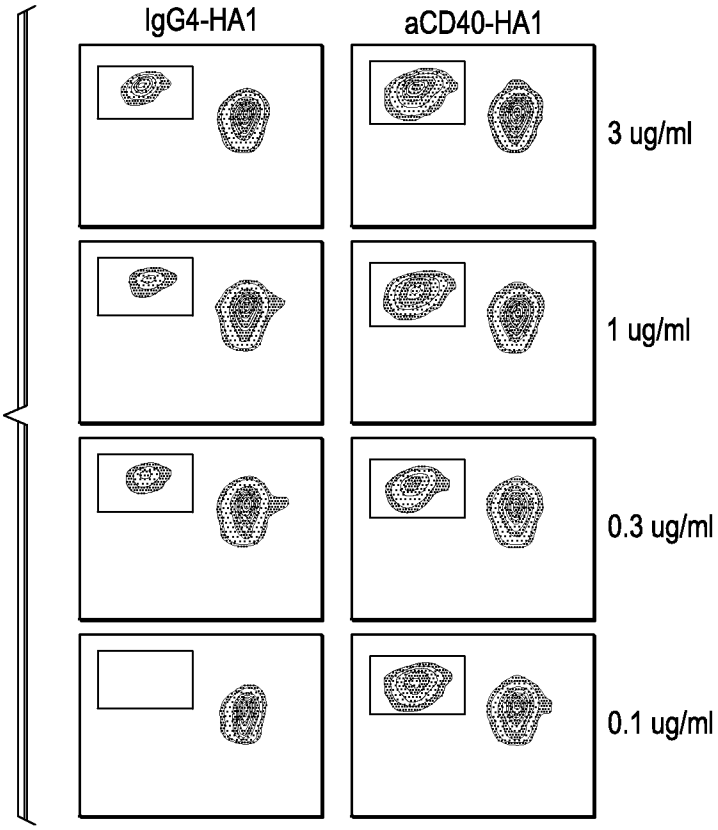


FIG. 15



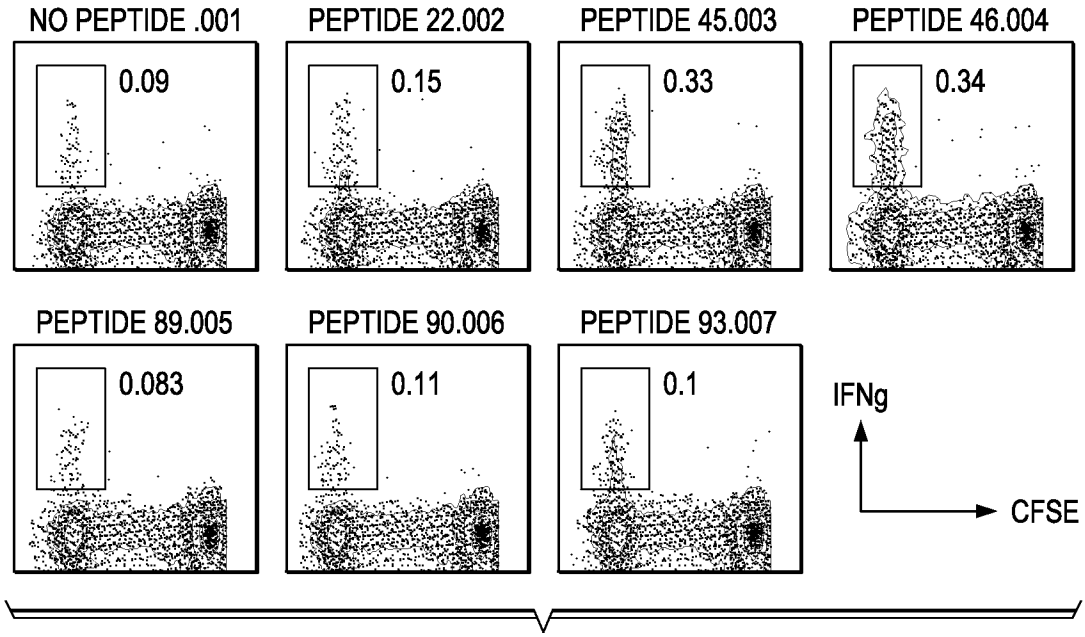
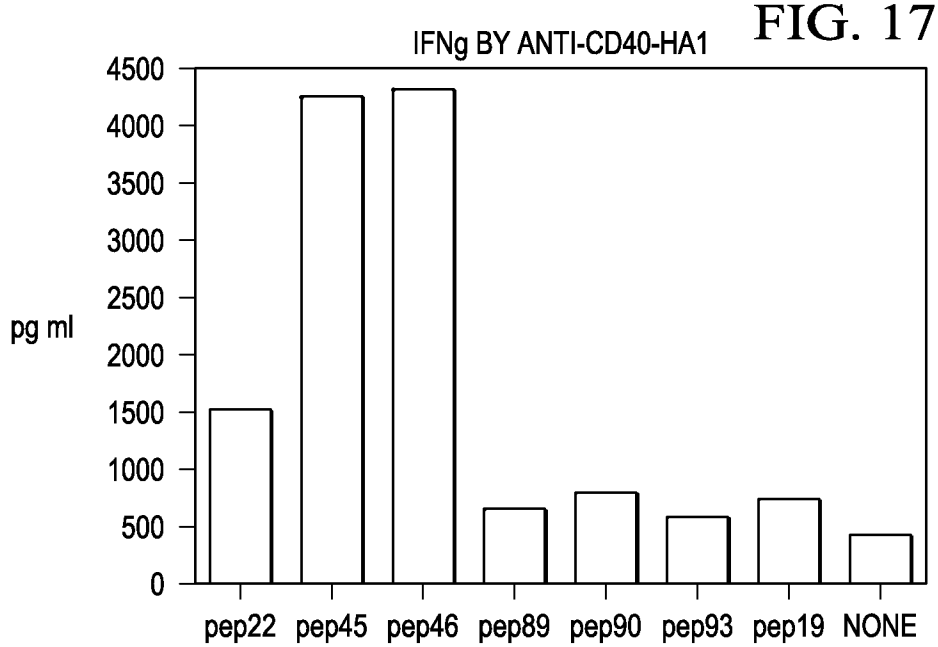

NO PEPTIDE .001
0.09
PEPTIDE 22.002
0.15
PEPTIDE 45.003
0.33
PEPTIDE 46.004
0.34
PEPTIDE 89.005
0.083
PEPTIDE 90.006
0.11
PEPTIDE 93.007
0.1
IFNg
CFSE

FIG. 16

FIG. 17


IFNg BY ANTI-CD40-HA1
pg ml
4500
4000
3500
3000
2500
2000
1500
1000
500
0
pep22
pep45
pep46
pep89
pep90
pep93
pep19
NONE

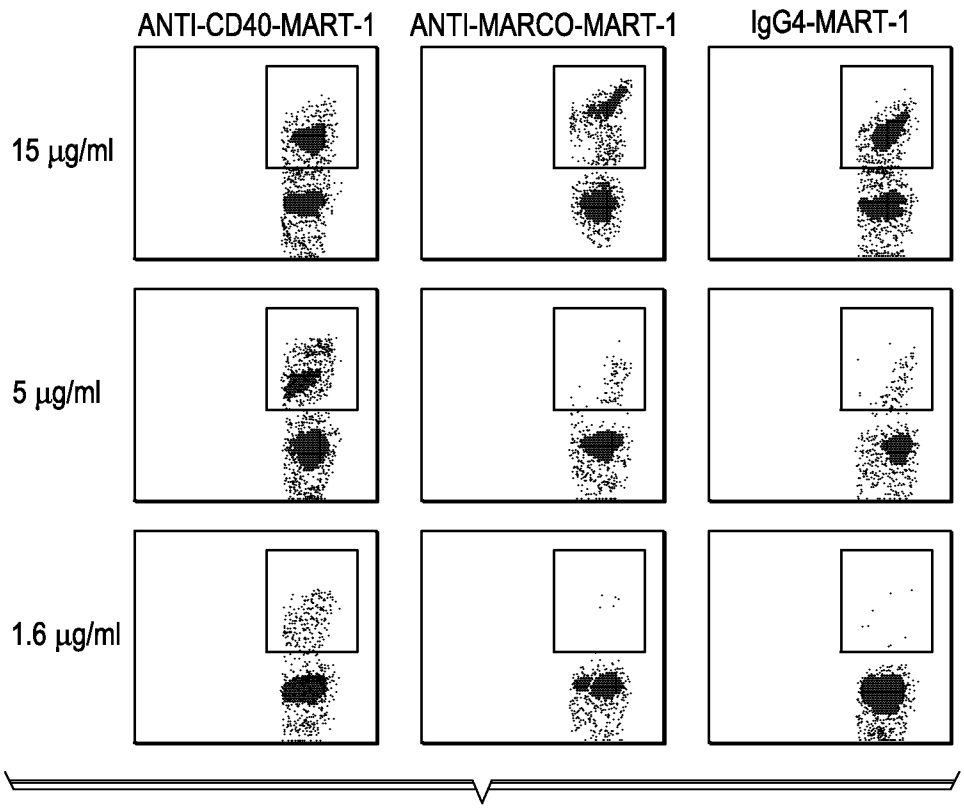

ANTI-CD40-MART-1
ANTI-MARCO-MART-1
IgG4-MART-1
15 μg/ml
5 μg/ml
1.6 μg/ml

FIG. 18

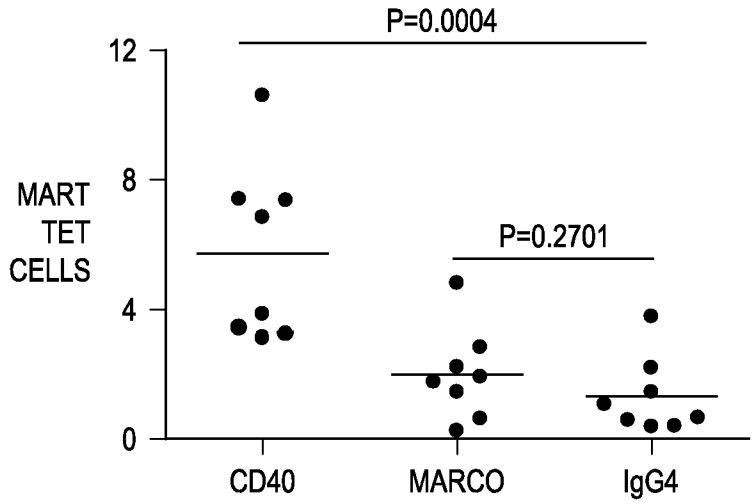


FIG. 19

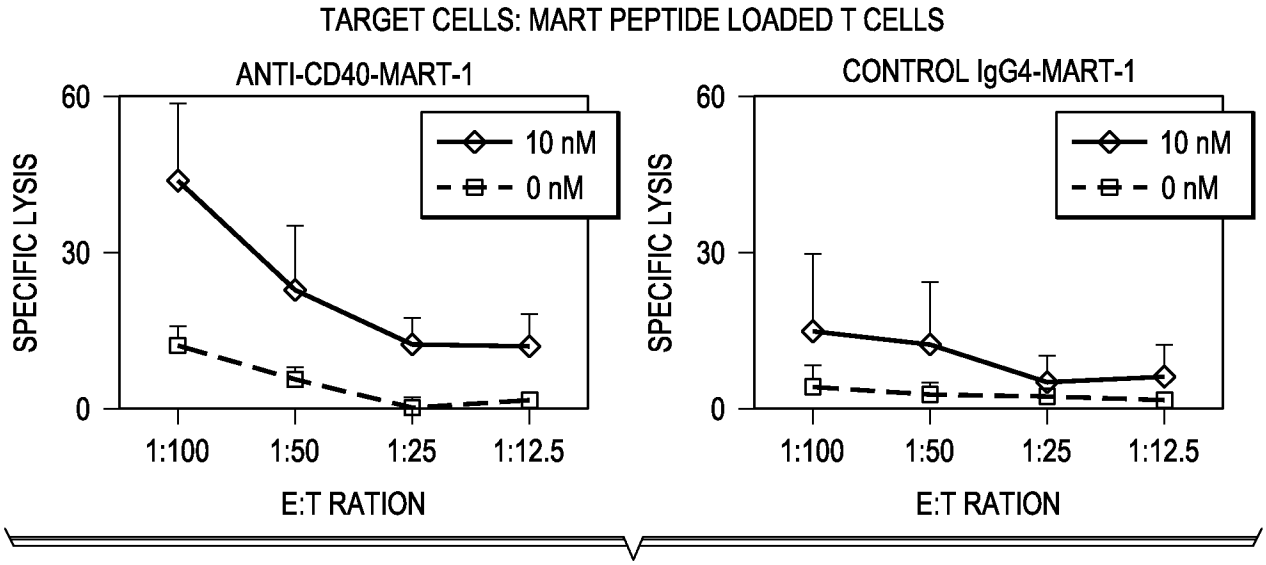

TARGET CELLS: MART PEPTIDE LOADED T CELLS
ANTI-CD40-MART-1
CONTROL IgG4-MART-1
SPECIFIC LYSIS
60
30
0
10 nM
0 nM
1:100
1:50
1:25
1:12.5
E:T RATION

FIG. 20

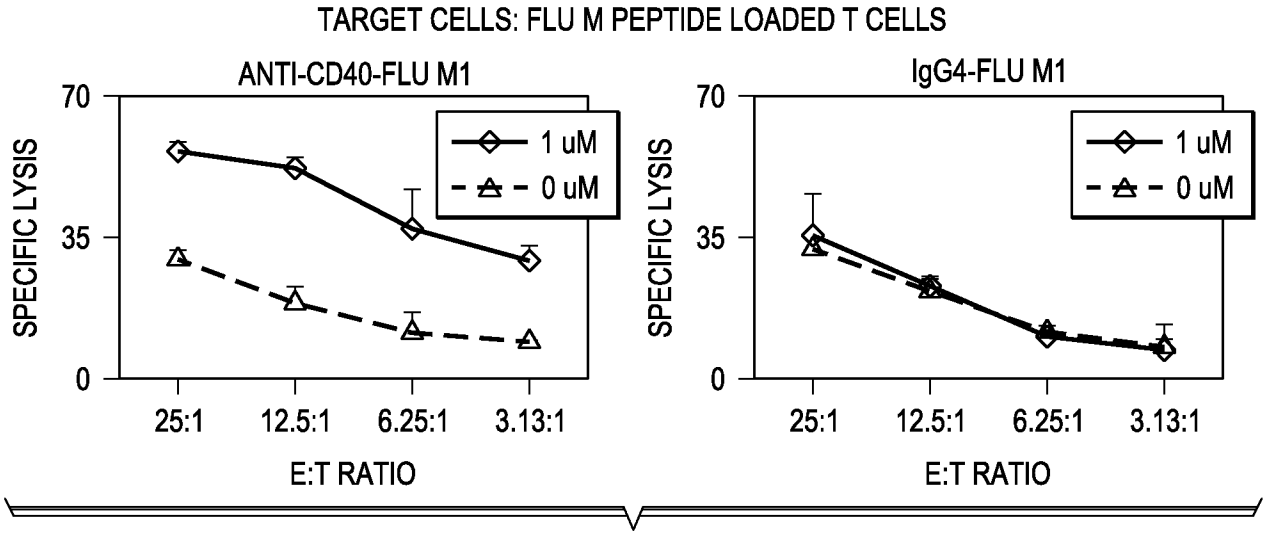

TARGET CELLS: FLU M PEPTIDE LOADED T CELLS
ANTI-CD40-FLU M1
IgG4-FLU M1
SPECIFIC LYSIS
70
35
0
1 uM
0 uM
25:1
12.5:1
6.25:1
3.13:1
E:T RATIO

FIG. 21

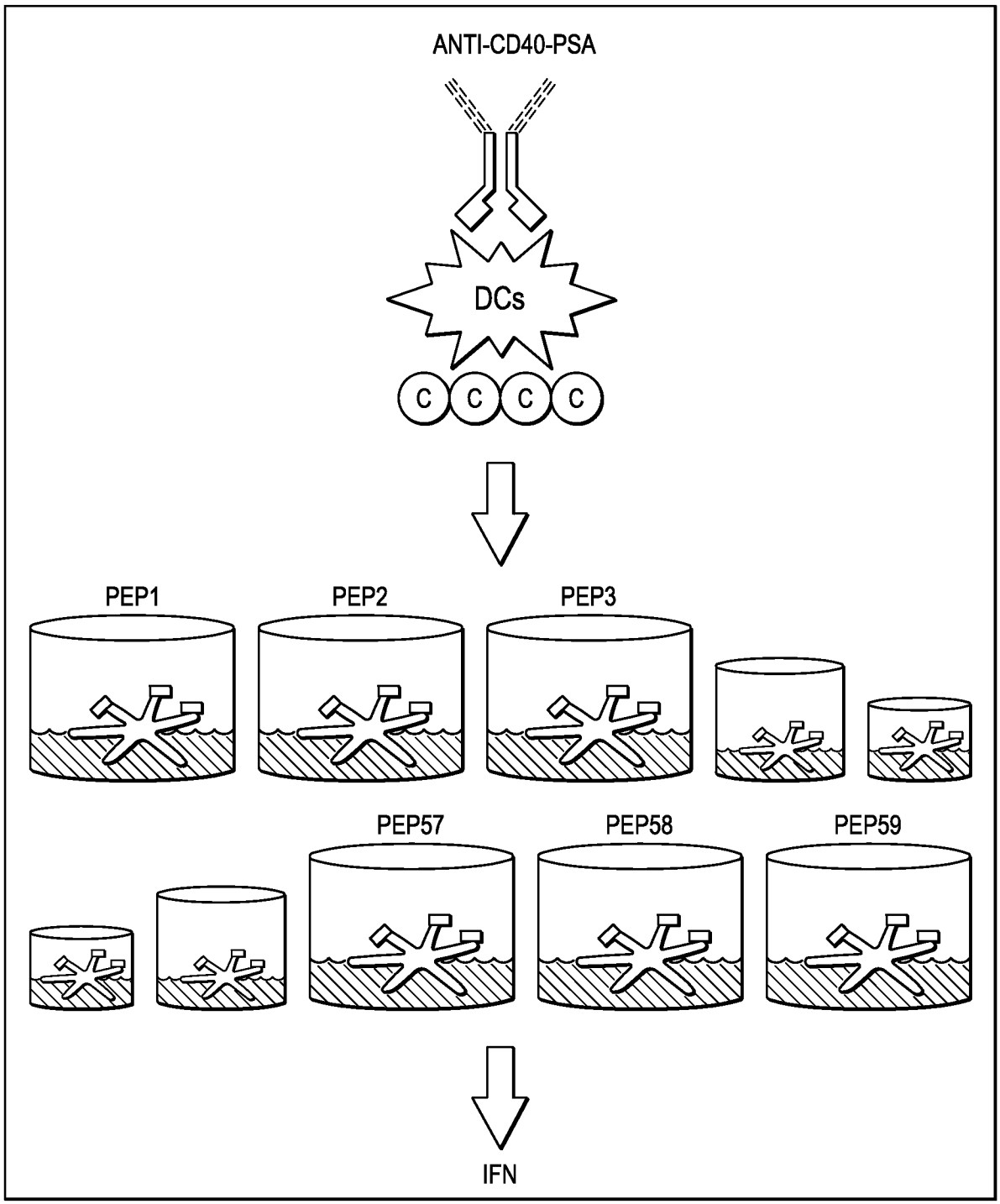
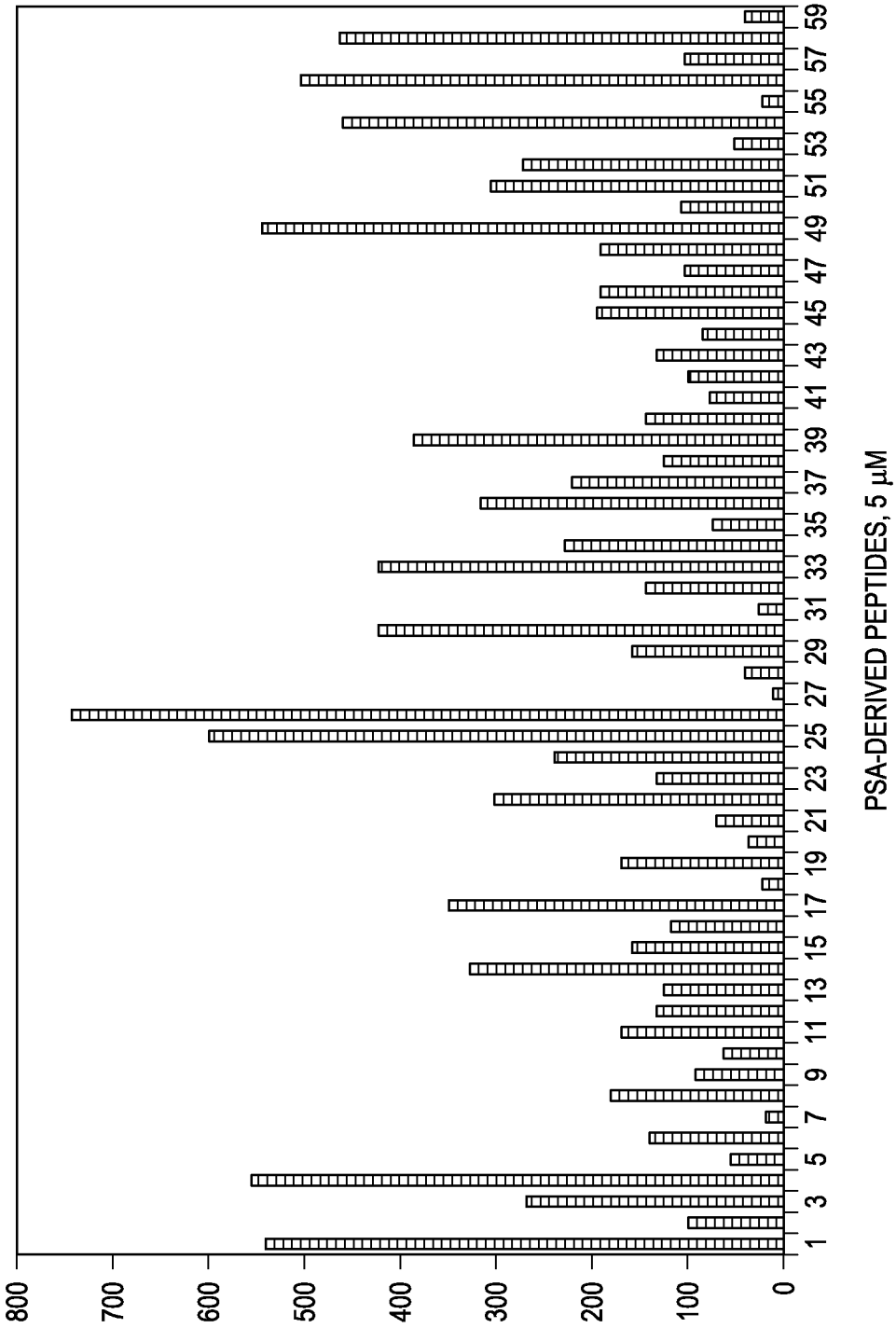


FIG. 22

FIG. 23


800
700
600
500
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
PSA-DERIVED PEPTIDES, 5 µM

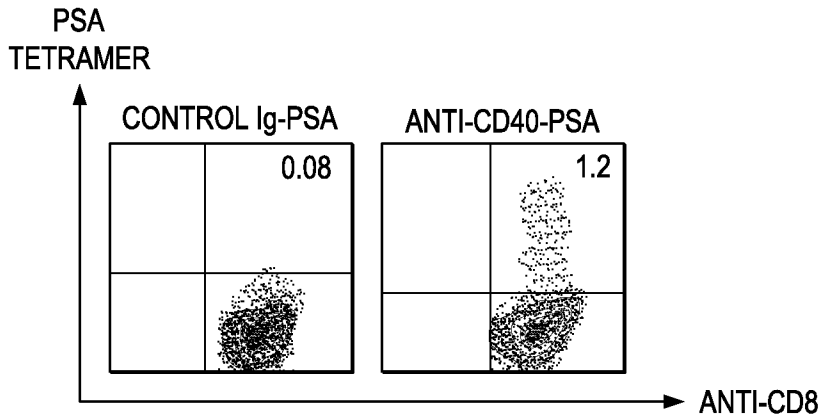
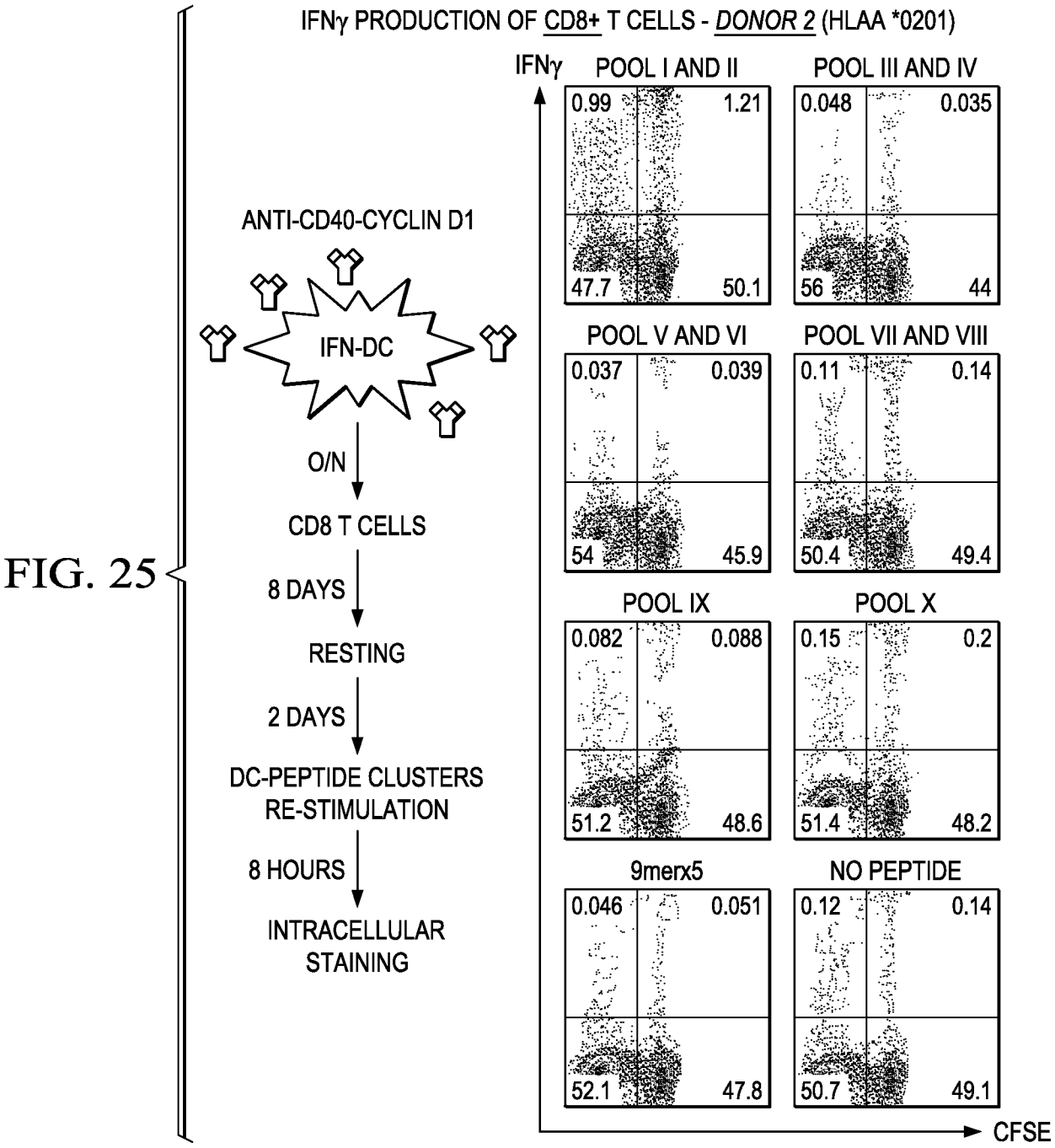


FIG. 24

FIG. 25


IFNγ PRODUCTION OF CD8+ T CELLS - DONOR 2 (HLAA *0201)
ANTI-CD40-CYCLIN D1
IFN-DC
O/N
CD8 T CELLS
8 DAYS
RESTING
2 DAYS
DC-PEPTIDE CLUSTERS
RE-STIMULATION
8 HOURS
INTRACELLULAR
STAINING
IFNγ
POOL I AND II
0.99
1.21
47.7
50.1
POOL III AND IV
0.048
0.035
56
44
POOL V AND VI
0.037
0.039
54
45.9
POOL VII AND VIII
0.11
0.14
50.4
49.4
POOL IX
0.082
0.088
51.2
48.6
POOL X
0.15
0.2
51.4
48.2
9merx5
0.046
0.051
52.1
47.8
NO PEPTIDE
0.12
0.14
50.7
49.1
CFSE

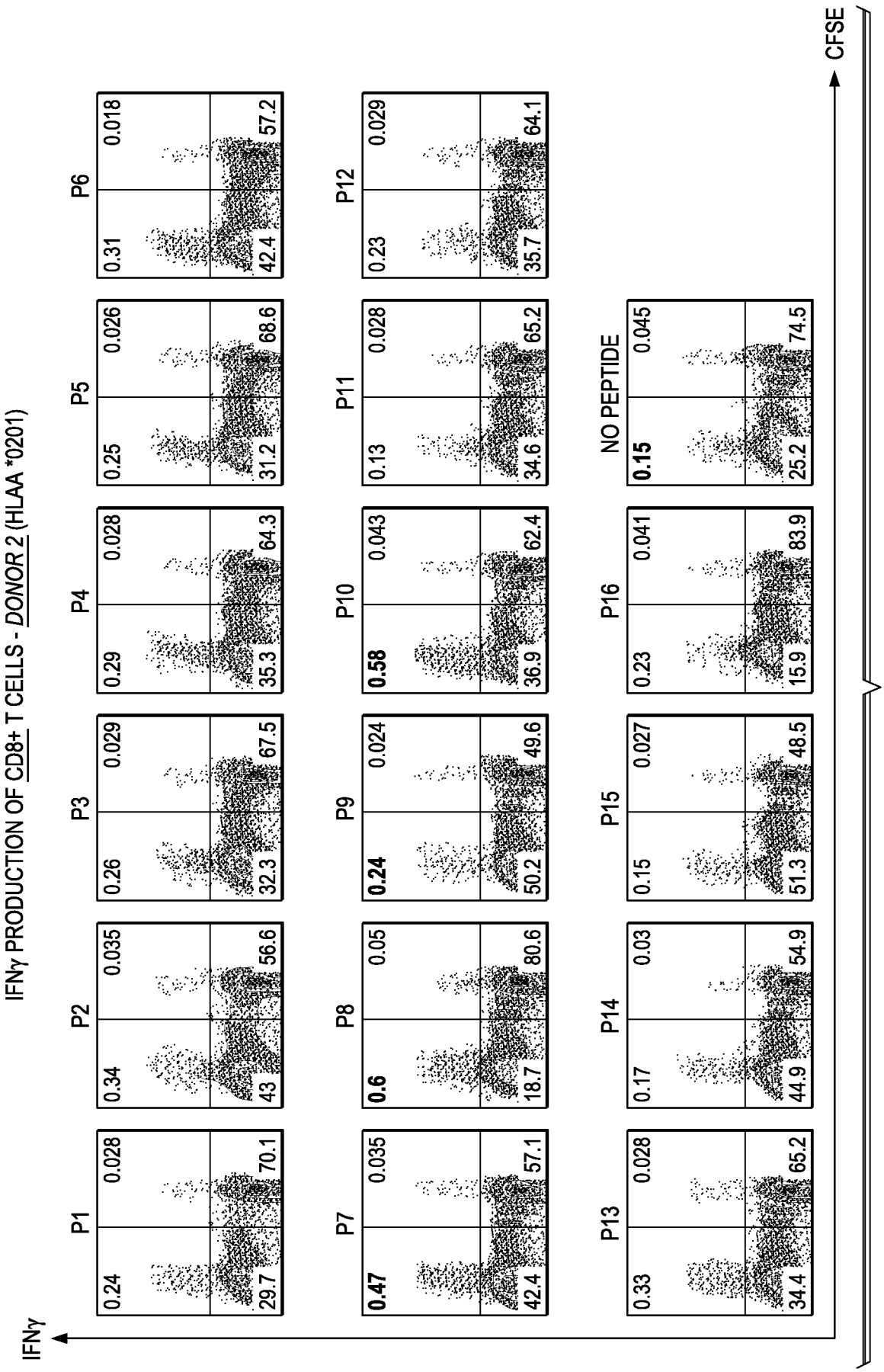

IFNγ PRODUCTION OF CD8+ T CELLS - DONOR 2 (HLAA *0201)
IFNγ
CFSE
P1
0.24
0.028
29.7
70.1
P2
0.34
0.035
43
56.6
P3
0.26
0.029
32.3
67.5
P4
0.29
0.028
35.3
64.3
P5
0.25
0.026
31.2
68.6
P6
0.31
0.018
42.4
57.2
P7
0.47
0.035
42.4
57.1
P8
0.6
0.05
18.7
80.6
P9
0.24
0.024
50.2
49.6
P10
0.58
0.043
36.9
62.4
P11
0.13
0.028
34.6
65.2
P12
0.23
0.029
35.7
64.1
P13
0.33
0.028
34.4
65.2
P14
0.17
0.03
44.9
54.9
P15
0.15
0.027
51.3
48.5
P16
0.23
0.041
15.9
83.9
NO PEPTIDE
0.15
0.045
25.2
74.5

FIG. 26

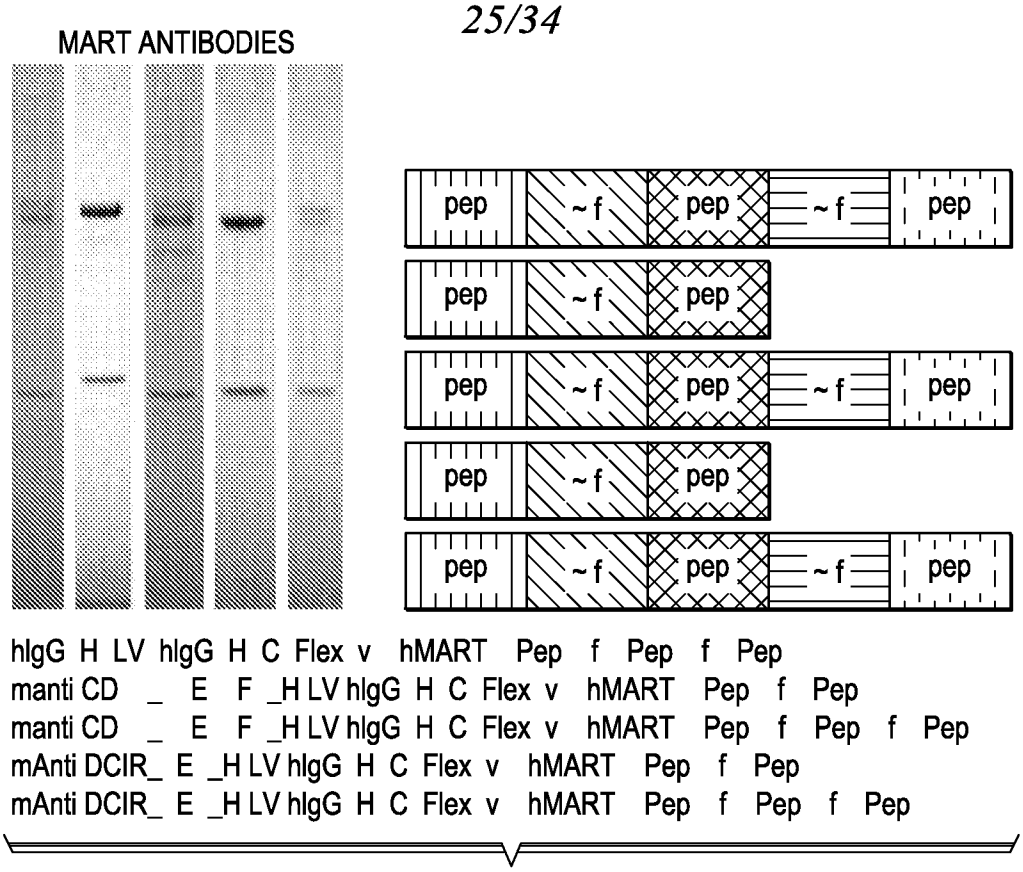

MART ANTIBODIES
pep
~f
pep
~f
pep
hIgG H LV hIgG H C Flex v hMART Pep f Pep f Pep
manti CD _ E F _H LV hIgG H C Flex v hMART Pep f Pep
manti CD _ E F _H LV hIgG H C Flex v hMART Pep f Pep f Pep
mAnti DCIR_ E _H LV hIgG H C Flex v hMART Pep f Pep
mAnti DCIR_ E _H LV hIgG H C Flex v hMART Pep f Pep f Pep

FIG. 27

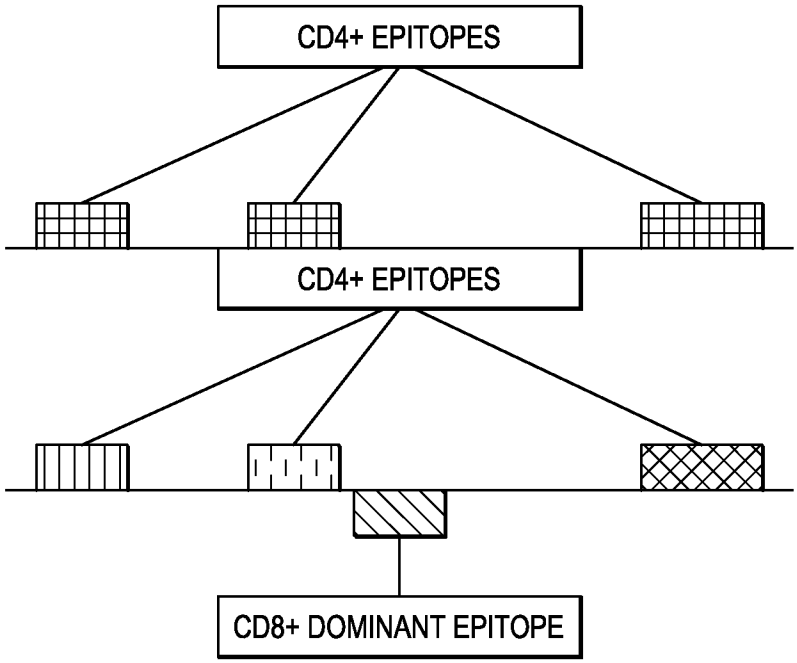

CD4+ EPITOPES
CD4+ EPITOPES
CD8+ DOMINANT EPITOPE

FIG. 28

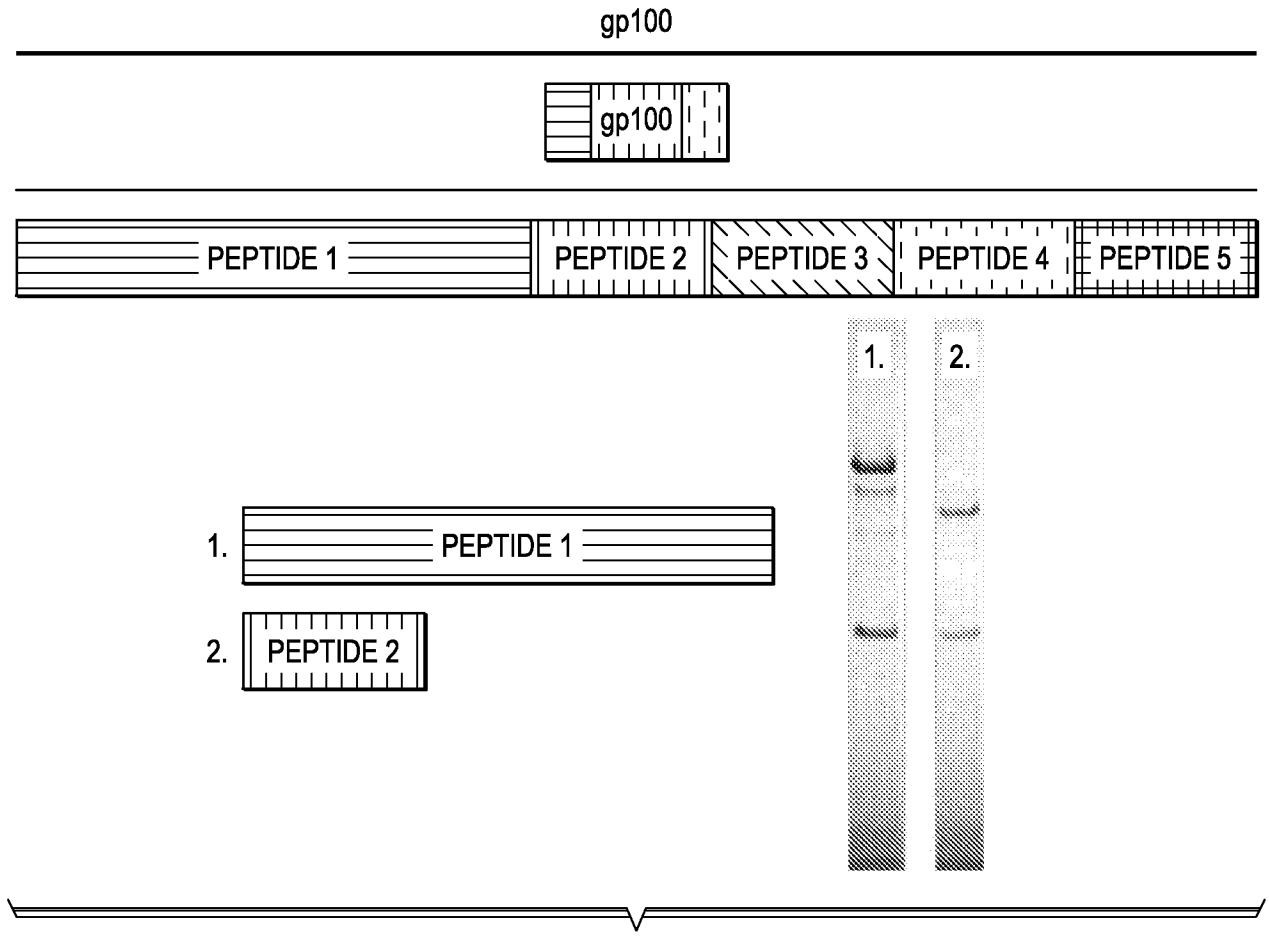

gp100
gp100
PEPTIDE 1
PEPTIDE 2
PEPTIDE 3
PEPTIDE 4
PEPTIDE 5
1.
2.
1.
PEPTIDE 1
2.
PEPTIDE 2

FIG. 29

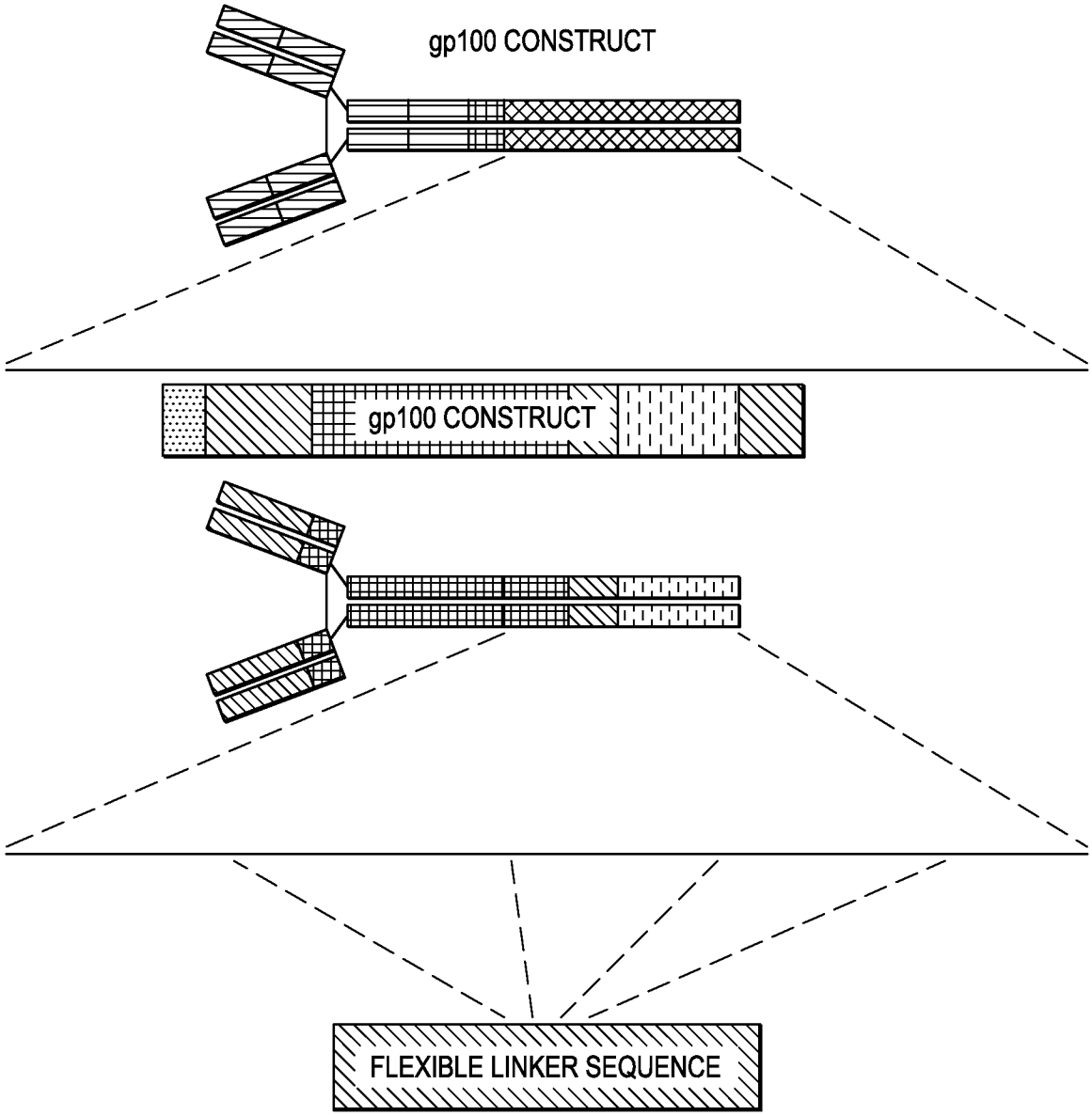

gp100 CONSTRUCT
gp100 CONSTRUCT
FLEXIBLE LINKER SEQUENCE

FIG. 30

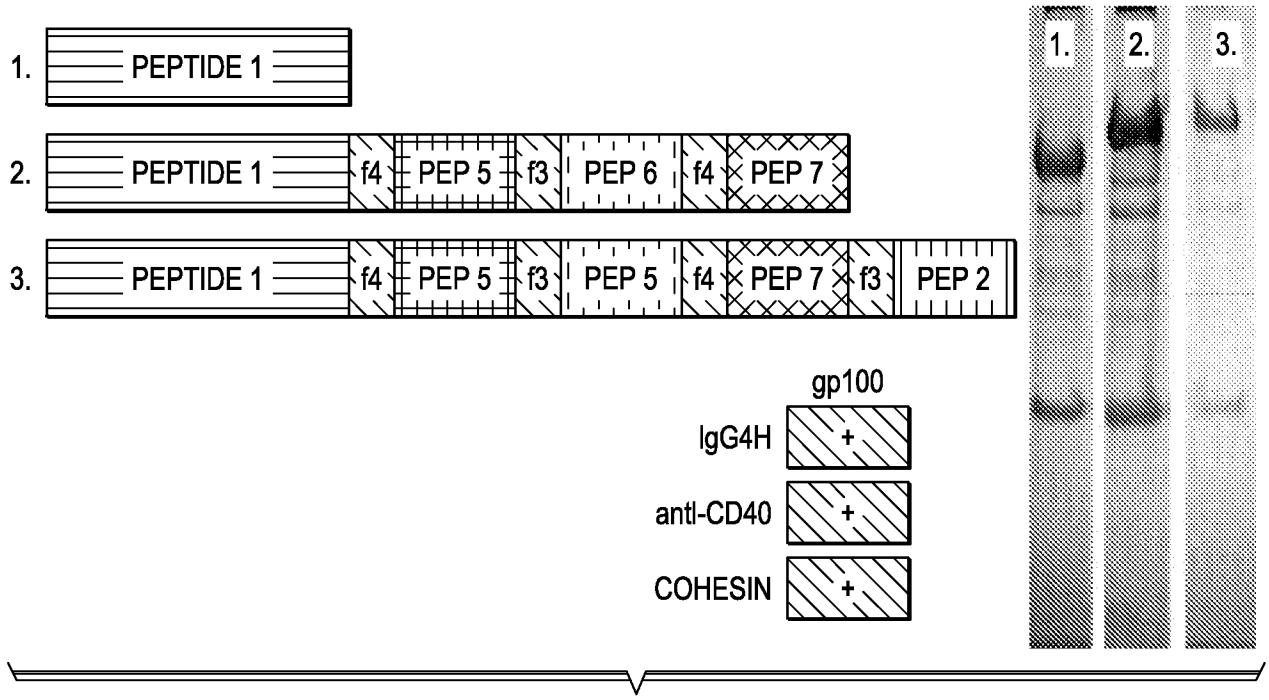

1.
PEPTIDE 1
2.
PEPTIDE 1
f4
PEP 5
f3
PEP 6
f4
PEP 7
3.
PEPTIDE 1
f4
PEP 5
f3
PEP 5
f4
PEP 7
f3
PEP 2
gp100
IgG4H
+
antI-CD40
+
COHESIN
+
1.
2.
3.

FIG. 31

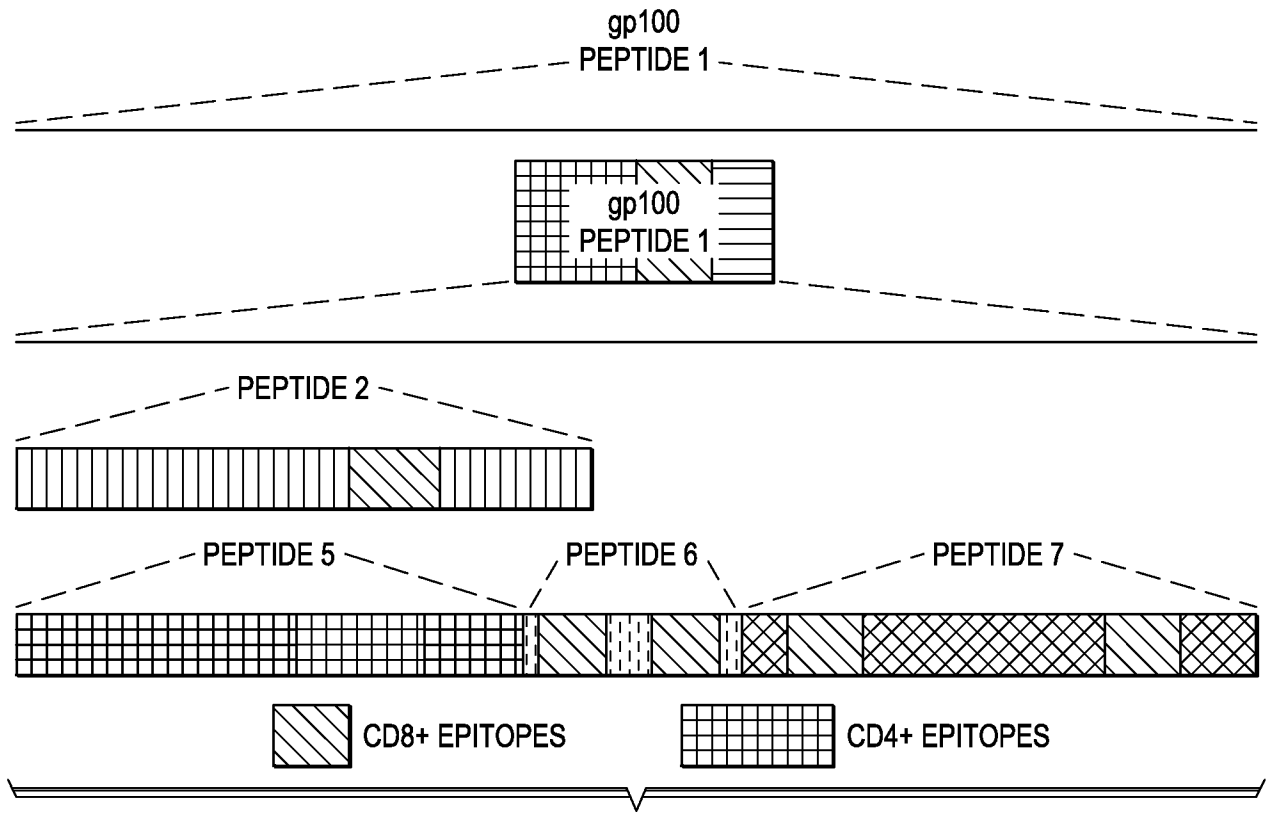

gp100
PEPTIDE 1
gp100
PEPTIDE 1
PEPTIDE 2
PEPTIDE 5
PEPTIDE 6
PEPTIDE 7
CD8+ EPITOPES
CD4+ EPITOPES

FIG. 32

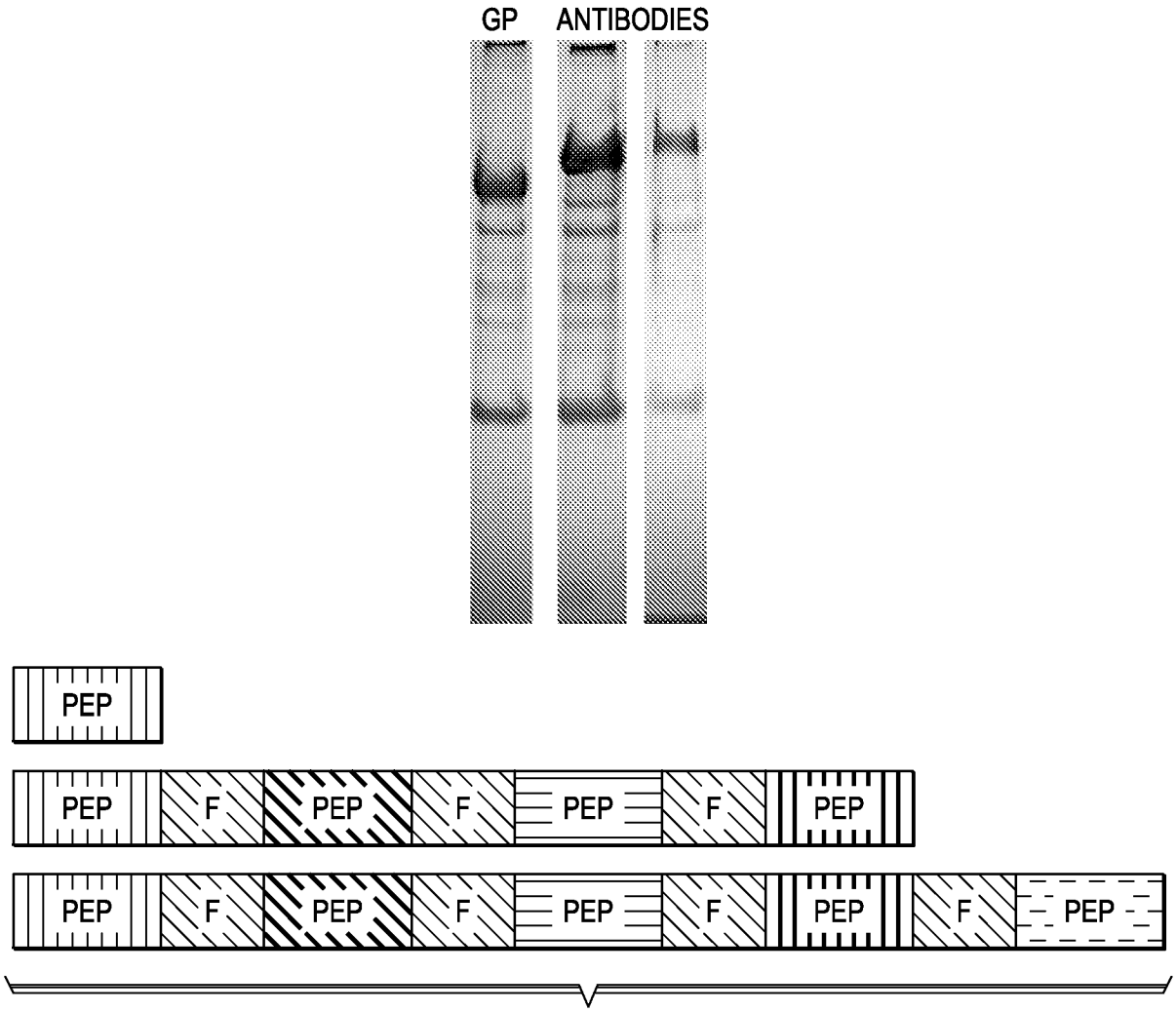


FIG. 33

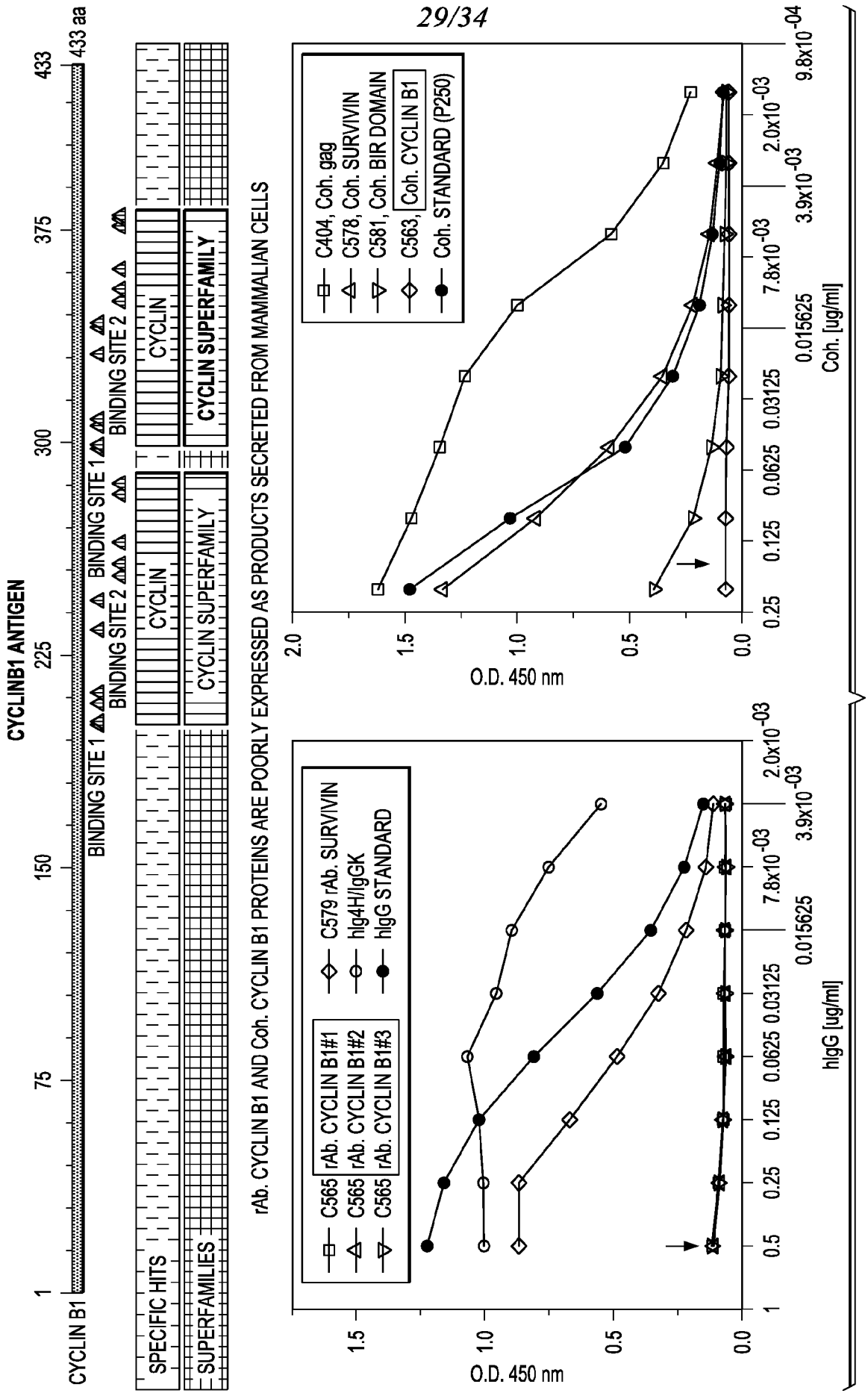

CYCLINB1 ANTIGEN
CYCLIN B1
1
75
150
225
300
375
433
433 aa
BINDING SITE 1
BINDING SITE 2
CYCLIN
CYCLIN SUPERFAMILY
SPECIFIC HITS
SUPERFAMILIES
rAb. CYCLIN B1 AND Coh. CYCLIN B1 PROTEINS ARE POORLY EXPRESSED AS PRODUCTS SECRETED FROM MAMMALIAN CELLS
C565 rAb. CYCLIN B1#1
C565 rAb. CYCLIN B1#2
C565 rAb. CYCLIN B1#3
C579 rAb. SURVIVIN
hIg4H/IgGK
hIgG STANDARD
O.D. 450 nm
hIgG [ug/ml]
C404, Coh. gag
C578, Coh. SURVIVIN
C581, Coh. BIR DOMAIN
C563, Coh. CYCLIN B1
Coh. STANDARD (P250)
Coh. [ug/ml]

FIG. 34A

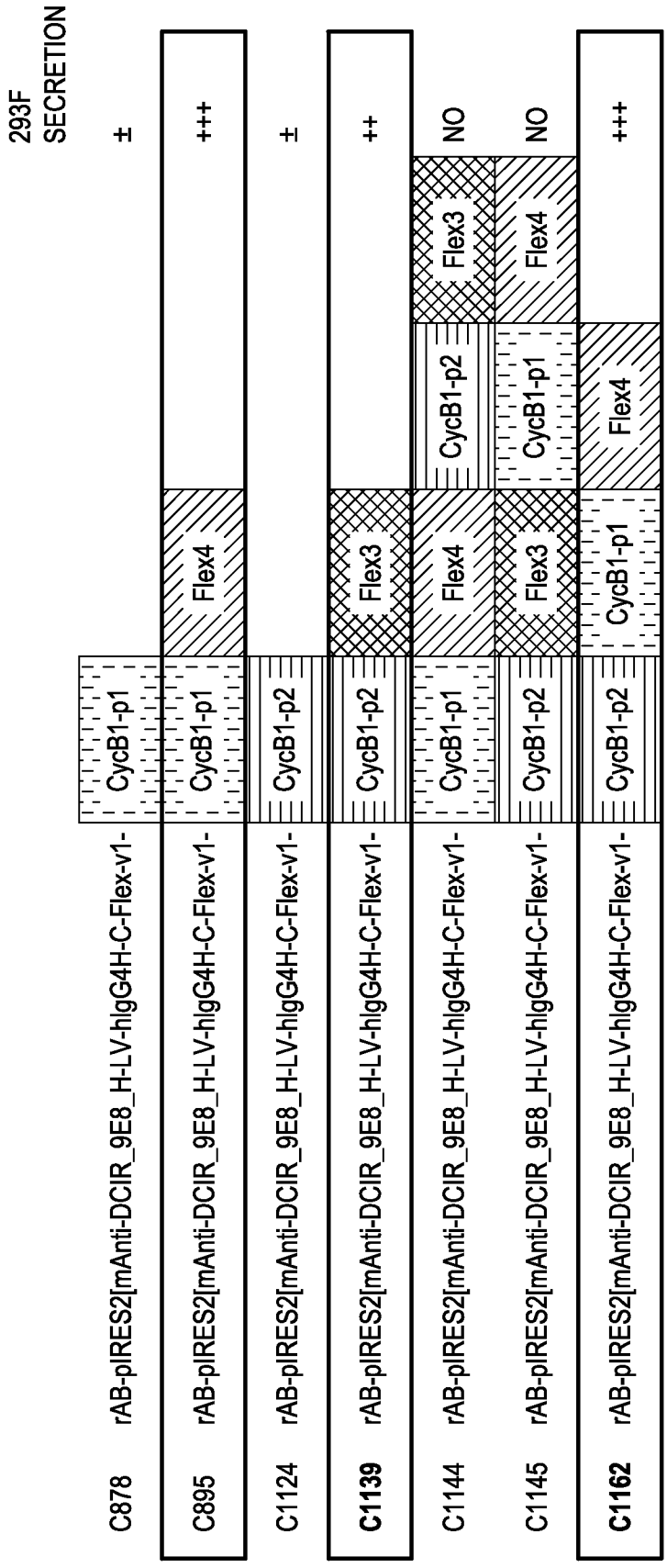

293F SECRETION
C878 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p1 ±
C895 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p1 Flex4 +++
C1124 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p2 ±
C1139 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p2 Flex3 ++
C1144 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p1 Flex4 CycB1-p2 Flex3 NO
C1145 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p2 Flex3 CycB1-p1 Flex4 NO
C1162 rAB-pIRES2[mAnti-DCIR_9E8_H-LV-hIgG4H-C-Flex-v1- CycB1-p2 CycB1-p1 Flex4 +++

FIG. 34B

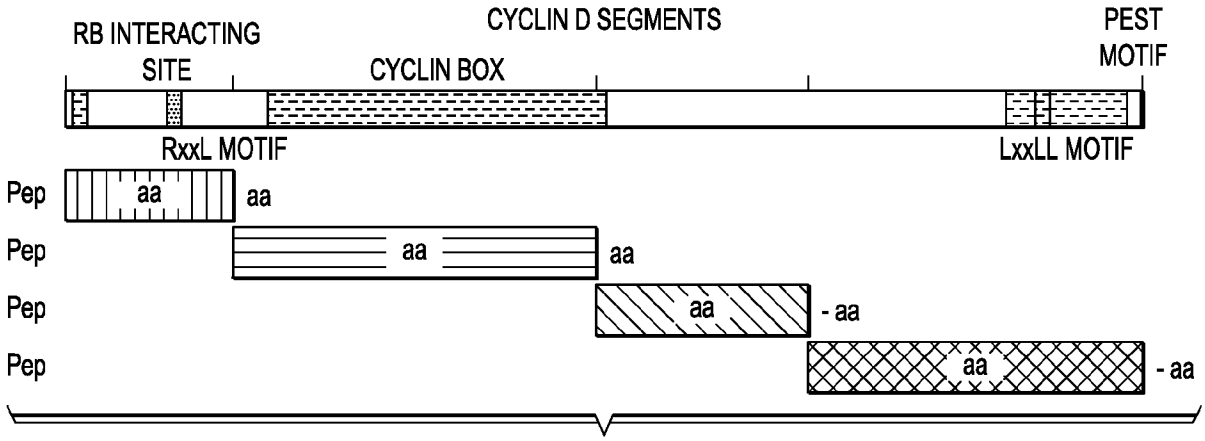

RB INTERACTING SITE
CYCLIN D SEGMENTS
CYCLIN BOX
PEST MOTIF
RxxL MOTIF
LxxLL MOTIF
Pep
aa
aa
Pep
aa
aa
Pep
aa
- aa
Pep
aa
- aa

FIG. 35

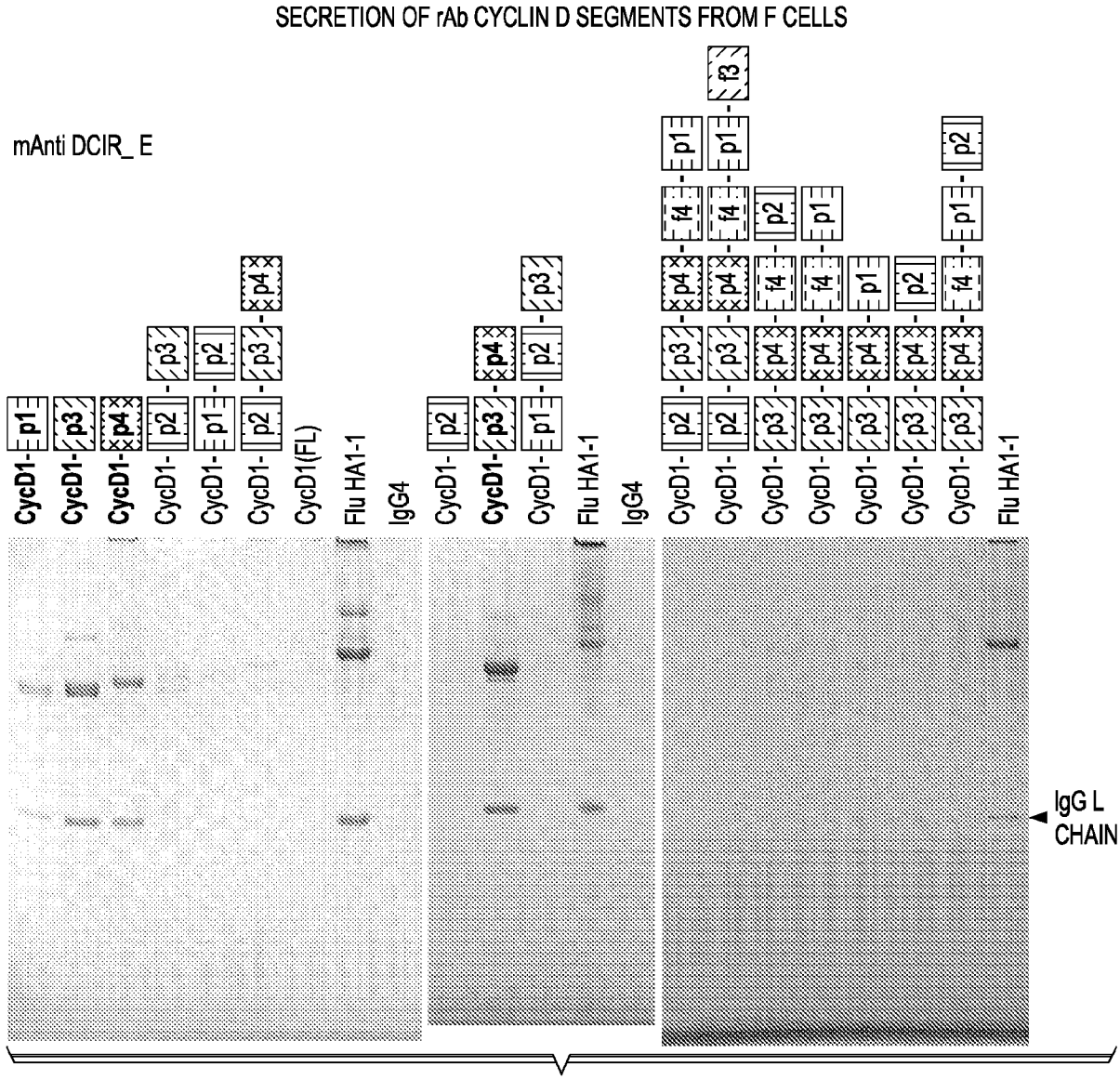

SECRETION OF rAb CYCLIN D SEGMENTS FROM F CELLS
mAnti DCIR_ E
CycD1(FL)
Flu HA1-1
IgG4
IgG L CHAIN

FIG. 36

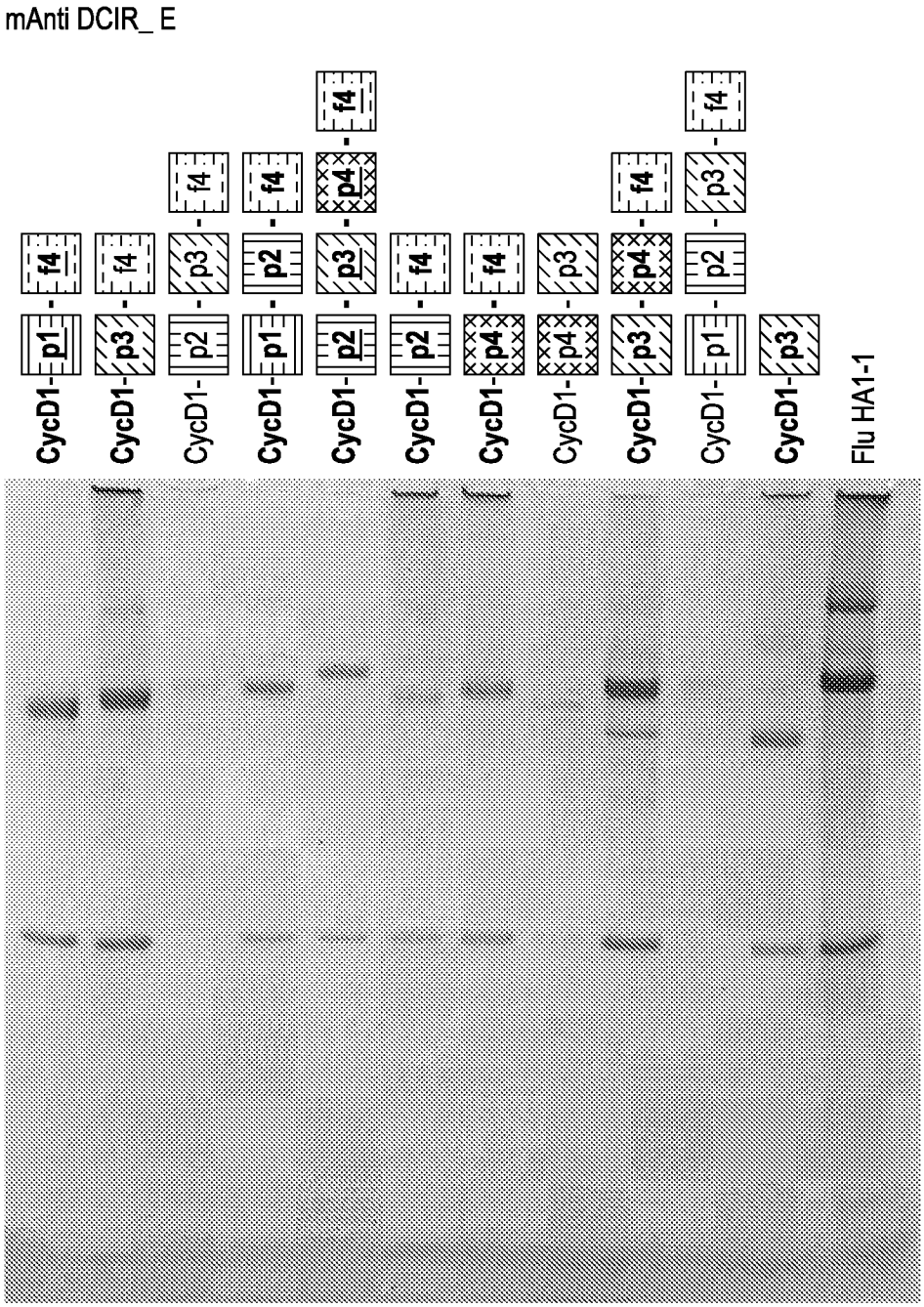

mAnti DCIR_ E
CycD1-p1-f4
CycD1-p3-f4
CycD1-p2-p3-f4
CycD1-p1-p2-f4
CycD1-p2-p3-p4-f4
CycD1-p2-f4
CycD1-p4-f4
CycD1-p4-p3
CycD1-p3-p4-f4
CycD1-p1-p2-p3-f4
CycD1-p3
Flu HA1-1

FIG. 37

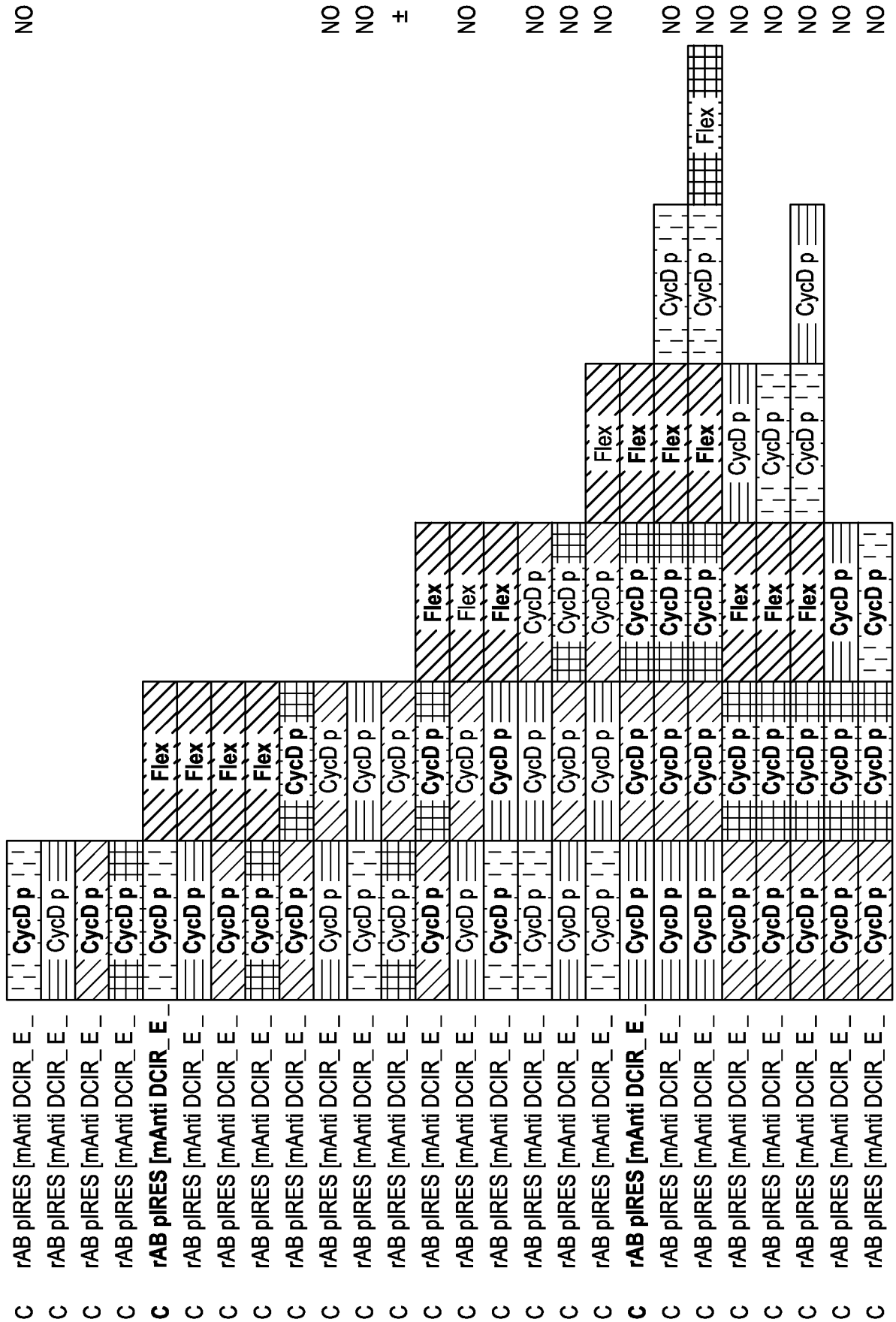

C rAB pIRES [mAnti DCIR_E_ CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p ±
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex NO
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p Flex NO
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p Flex
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO
C rAB pIRES [mAnti DCIR_E_ CycD p CycD p NO

FIG. 38

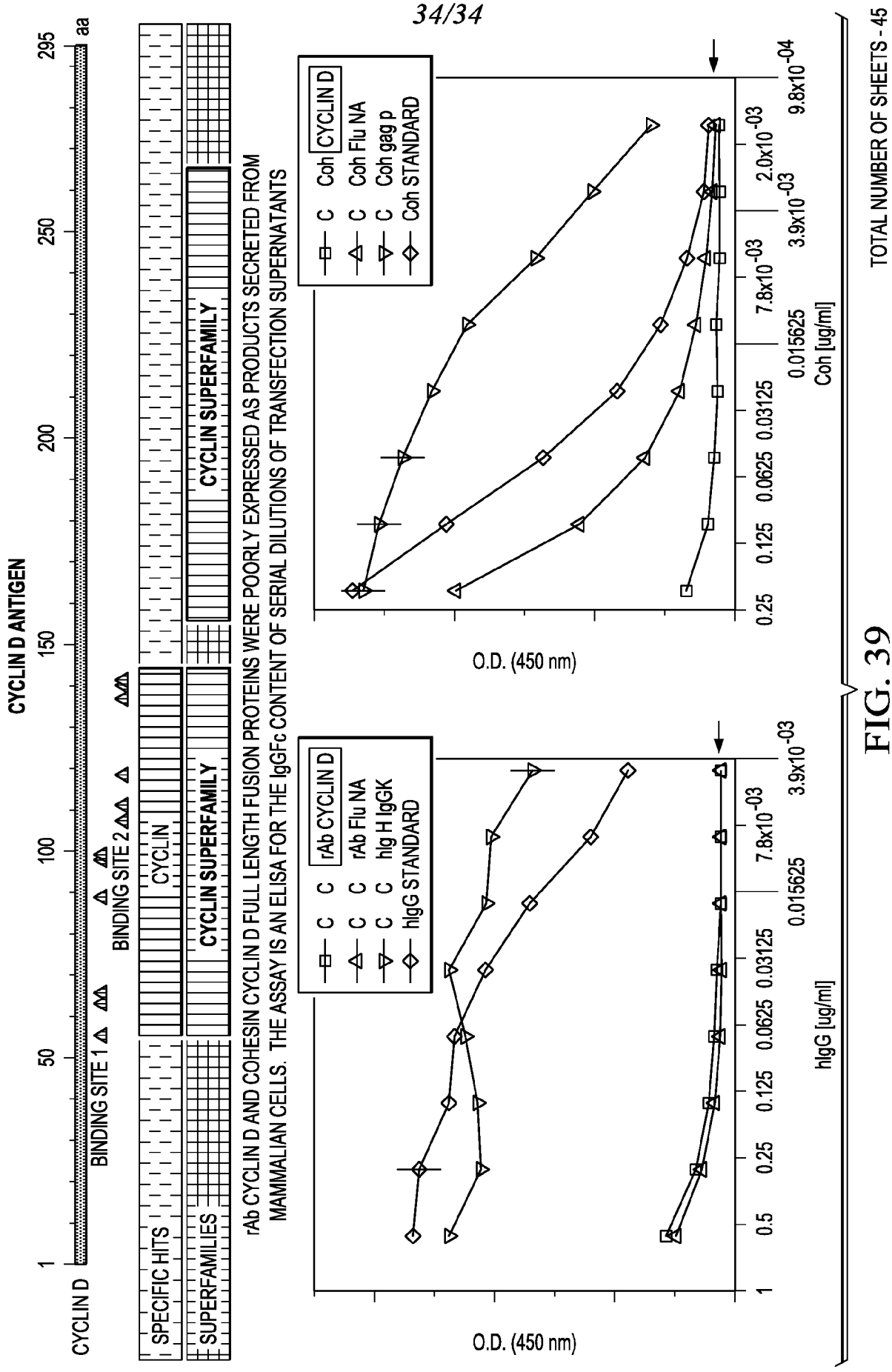

CYCLIN D ANTIGEN
CYCLIN D
1
50
100
150
200
250
295
aa
BINDING SITE 1
BINDING SITE 2
SPECIFIC HITS
CYCLIN
SUPERFAMILIES
CYCLIN SUPERFAMILY
CYCLIN SUPERFAMILY
rAb CYCLIN D AND COHESIN CYCLIN D FULL LENGTH FUSION PROTEINS WERE POORLY EXPRESSED AS PRODUCTS SECRETED FROM MAMMALIAN CELLS. THE ASSAY IS AN ELISA FOR THE IgGFc CONTENT OF SERIAL DILUTIONS OF TRANSFECTION SUPERNATANTS
C C C rAb CYCLIN D
C C rAb Flu NA
C C hIg H IgGK
hIgG STANDARD
O.D. (450 nm)
1
0.5
0.25
0.125
0.0625
0.03125
0.015625
7.8x10-03
3.9x10-03
hIgG [ug/ml]
C Coh CYCLIN D
C Coh Flu NA
C Coh gag p
Coh STANDARD
O.D. (450 nm)
0.25
0.125
0.0625
0.03125
0.015625
7.8x10-03
3.9x10-03
2.0x10-03
9.8x10-04
Coh [ug/ml]
TOTAL NUMBER OF SHEETS - 45

FIG. 39