



(51) International Patent Classification:

C07K 16/28 (2006.01) *A61K 39/00* (2006.01)
A61P 35/00 (2006.01)

(21) International Application Number:

PCT/IB2017/000393

(22) International Filing Date:

6 April 2017 (06.04.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/319,605 7 April 2016 (07.04.2016) US

(71) Applicant: JANSSEN PHARMACEUTICA NV
[BE/BE]; Turnhoutseweg 30, 2340 Beerse (BE).

(72) Inventors: SNYDER, Linda, A.; 1795 Honeysuckle Lane,
Pottstown, PA 19465 (US). POWERS, Gordon; 9 Lloyd
Avenue, Malvern, PA 19355 (US). ZUDAIRE UBANI,
Enrique; 264 Almwich Place, Ambler, PA 19002 (US).
MARVEL, Douglas, Matthew; 119 Devonshire Drive,
Landsdale, PA 19446 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))

(54) Title: ANTI-VISTA ANTIBODIES AND FRAGMENTS, USES THEREOF, AND METHODS OF IDENTIFYING SAME

(57) Abstract: The present invention relates to antibodies and fragments that bind to a V-domain Ig Suppressor of T cell Activation (VISTA), and methods of eliciting certain biological responses using the antibodies. Compositions and methods of using anti-VISTA antibodies in combination with one or more antibodies that bind to immune checkpoint proteins are also provided.



ANTI-VISTA ANTIBODIES AND FRAGMENTS, USES THEREOF, AND METHODS OF IDENTIFYING SAME

RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 62/319,605, filed on April 07, 2016. The entire teachings of the above application are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The expression of negative immune regulators by cancer cells or immune cells in the tumor microenvironment can suppress the host's immune response against the tumor. To effectively combat the cancer, it is desirable to block tumor-mediated suppression of the host immune response. Accordingly, there is a need for new and effective therapeutic agents that inhibit negative immune regulators in the tumor microenvironment that suppress anti-tumor immune responses.

SUMMARY OF THE INVENTION

[0003] The present invention provides, in an embodiment, a pharmaceutical composition comprising a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a V-domain Ig Suppressor of T cell Activation (VISTA); b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein; and c) a pharmaceutically acceptable carrier, diluent, or excipient.

[0004] In some embodiments, the present invention provides a pharmaceutical composition comprising a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to VISTA; b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a PD-1 protein, and c) a pharmaceutically acceptable carrier, diluent, or excipient.

[0005] In other embodiments, the present invention provides a method of enhancing an immune response in an individual in need thereof, comprising administering to the individual a therapeutically effective amount of a) an antibody or an antibody fragment thereof comprising an antigen binding region that binds VISTA; and b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint

protein, thereby enhancing an immune response to the cancer. In a particular embodiment, the immune checkpoint protein is PD-1. In certain embodiments, the individual in need thereof has cancer.

[0006] The compositions and methods of the present invention are useful for, *e.g.*, enhancing immune responses (*e.g.*, T cell responses, anti-tumor responses) in individuals (*e.g.* humans) having cancer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1A-1C: Graphs showing VISTA expression on TF1 AML Cells
Expression of VISTA protein by flow cytometry is shown in the TF-1 AML cell line.

[0008] Figure 2A-2E: Graphs showing staining and gating strategies for identification of Human Myeloid and Lymphoid Subsets.

[0009] Figure 3A-3G: Graphs showing expression of VISTA on Human Myeloid and Lymphoid Subsets from one healthy normal donor.

[0010] Figure 4: Graph showing expression of VISTA on Human Myeloid and Lymphoid Subsets across multiple healthy normal donors.

[0011] Figure 5A-5B: Graph showing staining and gating strategies for identification of expression of VISTA on Human Monocytes and Macrophages.

[0012] Figure 6A-6C: Graphs showing expression of VISTA on Human Monocytes and Macrophages.

[0013] Figure 7A-7E: Graphs showing staining and gating strategies for identification of expression of VISTA on Human T and NK Cell Subsets.

[0014] Figure 8A-8G: Graphs showing expression of VISTA on Human T and NK Cell Subsets from one healthy normal donor.

[0015] Figure 9: Graph showing expression of VISTA on Human T and NK Cell Subsets across multiple healthy normal donors.

[0016] Figure 10A-10D: Graphs showing staining and gating strategies for identification of expression of VISTA on Human Dendritic Cell subsets.

[0017] Figure 11A-11C: Graphs showing expression of VISTA on Human Dendritic Cell subsets and basophils from one healthy normal donor.

[0018] Figure 12: Graph showing expression of VISTA on Human Dendritic Cell Subsets and basophils across multiple healthy normal donors.

[0019] Figure 13A-13D: Analysis of VISTA expression on healthy human peripheral blood cells. Profile of VISTA expression on healthy human peripheral blood cells using multicolor flow cytometry analysis: Whole blood samples from 2 different individuals were analyzed for VISTA expression on (Figure 13A) monocytes $\text{SSC}^{\text{lo}}\text{CD11b}^{\text{hi}}\text{CD14}^{\text{hi}}\text{CD16}^{-\text{ve}}\text{CD33}^{+\text{ve}}\text{HLA-DR}^{+\text{ve}}\text{CD19}^{-\text{ve}}$ (Figure 13B) neutrophils ($\text{SSC}^{\text{hi}}\text{CD177}^{+}\text{CD11b}^{\text{hi}}\text{CD14}^{\text{lo}}\text{CD16}^{+\text{ve}}\text{CD33}^{+\text{ve}}\text{HLA-DR}^{-\text{ve}}\text{CD19}^{-\text{ve}}$). Peripheral blood mononuclear cells were isolated using Ficoll gradient for analysis of (Figure 13C) CD4+ T cells ($\text{CD3}^{+\text{ve}}\text{CD4}^{+\text{ve}}$), and (Figure 13D) CD8+ T cells ($\text{CD3}^{+\text{ve}}\text{CD8}^{+\text{ve}}$).

[0020] Figure 14A-14C: Analysis of VISTA expression on peripheral blood cells from a lung cancer patient and a healthy control donor. Profile of VISTA expression on lung cancer patient peripheral blood cells using multicolor flow cytometry analysis: Representative FACS plot (Figure 14A) from one individual is shown. Peripheral blood mononuclear cells were isolated by Ficoll and analyzed for VISTA expression on (Figure 14B) monocytes ($\text{CD14}^{+}\text{CD11b}^{+}\text{CD33}^{+}\text{HLADR}^{+}\text{CD15}^{-}$) and (Figure 14C) myeloid derived suppressor cells ($\text{CD14}^{-}\text{CD11b}^{+}\text{CD33}^{-}\text{HLADR}^{-}\text{CD15}^{+}\text{CD16}^{+}$).

[0021] Figure 15A-15C: Profile of VISTA expression in peripheral blood cells from a patient with colon cancer, using multicolor flow cytometry analysis: Representative FACS plot (Figure 15A) from one individual is shown. Peripheral blood mononuclear cells were isolated by Ficoll and analyzed for VISTA expression on (Figure 15B) monocytes ($\text{CD14}^{+}\text{CD11b}^{+}\text{CD33}^{+}\text{HLADR}^{+}\text{CD15}^{-}$) and (Figure 15C) myeloid derived suppressor cells ($\text{CD14}^{-}\text{CD11b}^{+}\text{CD33}^{-}\text{HLADR}^{-}\text{CD15}^{+}\text{CD16}^{+}$).

[0022] Figure 16A-16D: Profile of VISTA expression on Cynomolgus monkey peripheral blood cells using multicolor flow cytometry analysis: Whole blood from 4 different monkeys was analyzed for VISTA expression on (Figure 16A) monocytes ($\text{SSC}^{\text{lo}}\text{CD11b}^{\text{hi}}\text{CD14}^{\text{hi}}\text{HLA-DR}^{\text{hi}}\text{CD16}^{-\text{ve}}\text{CD19}^{-\text{ve}}$ and (Figure 16B) neutrophils $\text{CD11b}^{\text{hi}}\text{CD14}^{\text{lo}}\text{HLA-DR}^{-\text{ve}}\text{CD16}^{-\text{ve}}\text{CD19}^{-\text{ve}}$. Peripheral blood mononuclear cells from three monkeys were isolated using Ficoll gradient for analysis of (Figure 16C) CD4+ T cells ($\text{TCR}\alpha/\beta^{+\text{ve}}\text{CD4}^{+\text{ve}}$) and (Figure 16D) CD8+ T cells ($\text{TCR}\alpha/\beta^{+\text{ve}}\text{CD8}^{+\text{ve}}$).

[0023] Figure 17: Graph showing absolute expression values of VISTA RNA in Heme cell lines.

[0024] Figure 18: Mouse A20 cells were stably transfected with either GFP or human VISTA. They were incubated with ova peptide and with DO11.10 T cells. CD25 expression by the T cells was measured 24 hours after incubation began. The A20-huVISTA cells

suppress CD25 expression by the T cells, but this readout is significantly restored by incubation with VSTB95.

[0025] Figure 19A-19F: Graphs showing Human VISTA ELISA results.

[0026] Figure 20A-20F: Human VISTA FACS results, showing anti-VISTA antibodies binding to cells expressing human VISTA.

[0027] Figure 21A-21D: Dilution study of 6 anti-VISTA antibody candidates in the mixed lymphocyte reaction from 30 $\mu\text{g/ml}$ to 0.0 $\mu\text{g/ml}$.

[0028] Figure 22A-22B: Dilution studies of 6 anti-VISTA antibody candidates in the SEB assay (individual CPM counts and IFN-g concentrations) from 30 $\mu\text{g/ml}$ to 0.0 $\mu\text{g/ml}$.

[0029] Figure 23: Sensorgram plot using anti-VISTA antibody VSTB85 coated on a Proteon SPR chip and VISTA protein with the indicated competitors run over the chip (competitors listed in Table 16).

[0030] Figure 24: Experimental design for MB49 murine bladder tumor model

[0031] Figure 25A-25B: MB49 tumor growth in female C57Bl/6 mice. Graphs illustrate tumor growth in individual mice treated with anti-mouse VISTA antibody (Figure 25B) or control IgG (Figure 25A).

[0032] Figure 26: Amino acid sequence of human VISTA (SEQ ID NO:46).

[0033] Figure 27: Multiple sequence alignment of VISTA orthologues

[0034] Figure 28: Regions of human VISTA bound by VSTB50 and VSTB60 antibodies (top) or VSTB95 and VSTB112 antibodies (bottom), as determined by HDX

[0035] Figure 29: VISTA Epitope bound by VSTB112. (Top) VISTA is shown in cartoon with strands labeled. Residues having at least one atom within 5 Å of VSTB112 in the complex are colored blue. Blue and orange spheres highlight a chain break, and the cyan and green spheres mark the N- and C-termini of the VISTA structure, respectively. (Bottom) Sequence of VISTA construct used in structure determination. Circles below the sequence are used to indicate residues which make only main chain contacts with VSTB112, triangles indicate a side chain contact, and squares indicate the side chain contact results in either a hydrogen bond or salt bridge interaction as calculated by PISA. Shapes are colored to indicate the CDR having the greatest number of atoms contacted by the given residue with CDR colors defined in Figure 59. Secondary structural elements are as defined in the program MOE with yellow arrows representing β -strands and red rectangles indicating α -helices.

[0036] Figure 30: VSTB112 Paratope. (Top) VISTA antigen is shown in illustration and VSTB112 within 5 angstrom (Å) of VISTA is shown in surface with colors used to designate CDR identity as specified in the sequence below. Contacting framework residues adjacent to a CDR are colored similarly to the corresponding CDR (Bottom) Sequence of VSTB112 Fv region. Colored backgrounds specify CDRs according to Kabat definitions. Circles below the sequence are used to indicate residues which make main chain only contacts with VISTA, triangles indicate a side-chain contact, and squares indicate the side chain contact results in either a hydrogen bond or salt bridge interaction as calculated by PISA.

[0037] Figure 31: Comparison of epitope regions identified by crystallography and hydrogen deuterium exchange (HDX). Sequence of VISTA construct used in structure determination. Circles below the sequence are used to indicate residues which make only main chain contacts with VSTB112, triangles indicate a side chain contact, and squares indicate the side chain contact results in either a hydrogen bond or salt bridge interaction as calculated by PISA.

[0038] Figure 32: Activation of CD14+ monocytes in whole PBMC by VSTB174 (derived from VSTB112). In each part of the experiment, cells were incubated with PBS, IgG1 control antibody, or VSTB174 at 1, 0.1 or 0.01 ug/ml. Left panel shows CD80 MFI; right panel shows HLA-DR MFI (two donors tested with representative results shown).

[0039] Figure 33: Graph showing ADCC activity of VSTB174 directed against K562-VISTA cells.

[0040] Figure 34: Graph showing ADCP activity of VSTB174 directed against K562-VISTA cells. Both antibodies depicted have the same Fab, but VSTB174 has an IgG1 Fc and VSTB140 has Fc silent IgG2 .

[0041] Figure 35: Graph showing phagocytosis mediated by VSTB174, VSTB149 or VSTB140 mAbs against K562-VISTA. Each mAb was tested with 7 half log doses, ranging from 0.0008 µg/ml to 0.56 ug/ml.

[0042] Figure 36: Graph showing phagocytosis mediated by VSTB174, VSTB149 or VSTB140 mAbs against myeloma cell line K562 cells. Each mAb was tested with 7 half log doses, ranging from 0.0008 µg/ml to 0.56 ug/ml.

[0043] Figure 37: MB49 tumor efficacy study evaluating VSTB123 1, 5, 7.5, and 10 mg/kg in female VISTA-KI mice. Tumor volumes were approximately 50 mm³ when dosing began at day 6 after implant. VSTB123 is the VSTB112 Fab grafted onto a mouse Fc scaffold and binds to human VISTA in the VISTA-KI mouse.

[0044] Figure 38: Graph shows that CD14⁺ cells expressing high/intermediate levels of VISTA are found in 13/13 lung cancer samples, as well as in distant lung tissue and peripheral blood of patients.

[0045] Figure 39: IHC staining for VISTA in Lung Cancer using GG8.

[0046] Figure 40: Anti-VISTA antibody triggers monocyte activation via CD16 crosslinking. PD-L1 expression is used as a marker of myeloid activation using human PBMCs. Anti-CD16, used as the positive control, induced robust monocyte activation; Fc block (mix of Fc IgG1 fragments), used as the negative control, blocked monocyte activation. VSTB112, but not VSTB140, induces monocyte activation compared to the human IgG1 control.

[0047] Figure 41: Schematic of study design for VSTB123 or VSTB124 effect on the growth of established MB49 tumors in hVISTA KI (knock-in) mice. Antibodies were injected on study days 5, 7, 10, 12, 14, 17, 19, 21, 24, and 26. Blood samples were collected on days -2, -1, 0, 4, 7, 11, 14, 18, 24, 31, and 39. If blood samples were taken on the same day as an antibody injection, blood samples were taken first.

[0048] Figures 42A and 42B: MB49 tumor growth in hVISTA KI female mice (Figure 42A) and survival of mice bearing MB49 tumors after treatment with VSTB123 or VSTB124 in hVISTA KI female mice (Figure 42B). In Figure 42A, mean tumor volume measurements (mm^3) are shown for female mice treated with VSTB123 or VSTB124 as compared to the mouse IgG2a control group. The treatment period was from day 5-26. Mean $\pm$ SEM shown. Note that the y axes differ among the graphs. Data for the female mice are graphed until day 33, when $>70\%$ of mice were still alive in each group ($n=6$ or 7 per group). In Figure 42B, the percent survival of hVISTA KI female mice is graphed, VSTB123 10 mg/kg, $p = 0.0108$. The treatment period was from day 5-26.

[0049] Figure 43: Fold-change in expression of 41 cytokines by PBMC treated with VSTB174. Whole PBMC from three healthy human donors were treated with VSTB174 or IgG1 control antibodies for 24 hours at the indicated concentrations. Cytokine production was analyzed by a 41-cytokine multiplex kit. Average fold-change in expression over the IgG1 control is shown as a heat map with a log color scale. Asterisks indicate significant differences between treatment and control sample means. * $p<0.05$, ** $p<0.01$, *** $p<0.001$, **** $p<0.0001$. Out-of-range (OOR) denotes that all samples for that cytokine in that donor were beyond the limits of accurate detection ($>$ above, $<$ below).

[0050] Figures 44A and 44B: Macrophage activation in MB49 tumors. Figure 44A shows a schematic of the study design. In Figure 44B indicates increased CD80+ macrophages in the tumor microenvironment with VSTB123, but not VSTB124. MB49 tumor-bearing hVISTA KI mice were treated with VSTB123, VSTB124, or control mIgG2a and their tumors were analyzed, 24h post-third dose, to determine the relative expression of CD80 on tumor-infiltrating macrophages. Each group contained 5 mice. Horizontal bars indicate means. * $p < 0.05$.

[0051] Figure 45: Migration of MPO+ cells to the tumor microenvironment.

[0052] Figure 46: VSTB174 induces transient decrease in neutrophils.

[0053] Figure 47: Anti-VISTA antibody (*e.g.*, VSTB174) proposed mechanism of action.

[0054] Figure 48: Expression profile of activation markers on immune cells, as indicated (CD80 on monocytes; CD69+ on CD8 T and NK cells; CD25+ on CD4 T cells) at 24 hours after treatment, as indicated (*e.g.*, VSTB174 or VSTB140 or corresponding controls).

[0055] Figure 49: Myeloid depletion study design - treatment and analysis schedule schematic. Mice were injected with MB49 tumor cells on day 0. Administration of VSTB123 or mouse IgG2a (mIgG2a) occurred on day 7, 9 and 11 (downward-pointing arrows). Anti-GR1 antibody was administered for 7 doses EOD (day 5, 7, 9, 11, 13, 15 and 17) to deplete monocytes and granulocytes. Clodronate liposomes were administered on day 4, 10 and 16 to deplete macrophages and dendritic cells. All antibodies and therapies were injected via intraperitoneal route. Blood was drawn on days 7 and 22 to evaluate immune cell depletion.

[0056] Figure 50: Effects of macrophage (left), CD4+ T cell (middle), or CD8+ T cell (right) depletion on efficacy of VSTB123 in MB49 bladder carcinoma model.

[0057] Figure 51: T cell and NK cell depletion study design treatment and analysis schedule schematic. Mice were injected with MB49 tumor cells on day 0, and randomized among the groups on day 4. Therapeutic antibody administration (VSTB123 or mIgG2a control) occurred on days 7, 9 and 11. Depleting antibodies were administered on days 5, 7, 12, 17, 22, and 27. Blood was collected from 10 mice for baseline evaluation on day -4 and from 5 mice/group on day 7 prior to re-dosing with depleting antibodies. N=10 mice/group.

[0058] Figure 52: Anti-VISTA and anti-PD-1 combination study design. FFPE = formalin fixed paraffin embedded; ICS = intracellular cytokine staining.

[0059] Figure 53: Synergistic effect of anti-VISTA antibody and anti-PD-1 antibody (RMP1-14) on tumor growth inhibition and survival on MB49 bladder carcinoma in male VISTA KI mice.

[0060] DETAILED DESCRIPTION OF THE INVENTION

[0061] A description of example embodiments of the invention follows.

[0062] The present invention relates to antibodies to novel Immunoglobulin family ligand designated V-domain Immunoglobulin Suppressor of T cell Activation (VISTA) (Genbank: JN602184) (Wang et al., 2010, 2011). VISTA bears homology to PD-L1 but displays a unique expression pattern that is restricted to the hematopoietic compartment. Specifically, VISTA is constitutively and highly expressed on CD11b^{high} myeloid cells, and expressed at lower levels on CD4⁺ and CD8⁺ T cells. The human homologue shares approximately 85% homology with murine VISTA and has similar expression patterns (Lines et al., Cancer Research 74:1924, 2014). VISTA expressed on antigen presenting cells (APCs) suppresses CD4⁺ and CD8⁺ T cell proliferation and cytokine production via a cognate receptor independent of PD-1. In a passive EAE (experimental autoimmune encephalomyelitis) disease model, a VISTA specific monoclonal antibody enhanced T-cell dependent immune responses and exacerbated disease. VISTA over-expression on tumor cells impaired protective anti-tumor immunity in tumor-bearing hosts. Studies of human VISTA confirmed its suppressive function on human T cells (Lines et al Cancer Research 74:1924, 2014,. Studies from Flies et al. also identified VISTA (named PD-1H) as a potent immune suppressive molecule (Flies et al., 2011). VISTA is described in further detail in U.S. Published application US 20130177557 A1 and U.S. Patent Nos. 7,919,585 and 8,236,304, all of which are incorporated herein by reference in their entirety.

[0063] VISTA is a novel negative immune regulator that suppresses immune responses. As described, for example, in Example 12 herein, treatment with a VISTA-specific monoclonal antibody in murine tumor models has been shown to reverse the suppressive character of the tumor immune microenvironment and enhance protective anti-tumor immunity, thus, demonstrating the potential of a VISTA monoclonal antibody as a novel therapeutic for cancer immunotherapy.

[0064] ANTIBODIES AND FRAGMENTS OF THE PRESENT INVENTION

[0065] The term "antibody" is meant to include polyclonal antibodies, monoclonal antibodies (mAbs), chimeric antibodies, humanized antibodies, human antibodies and anti-idiotypic (anti-Id) antibodies, as well as fragments, regions or derivatives thereof, provided by any known technique, such as, but not limited to, enzymatic cleavage, peptide synthesis or recombinant techniques. Anti-VISTA antibodies of the present invention are capable of binding portions of VISTA that modulate, regulate, or enhance an immune response. In some

embodiments, the antibodies competitively inhibit one or more of the anti-VISTA antibodies described herein. Methods for determining whether two or more antibodies compete for binding to the same target are known in the art. For example, a competitive binding assay can be used to determine whether one antibody blocks the binding of another antibody to the target. Typically, a competitive binding assay involves the use of purified target antigen (*e.g.*, PD-1) bound either to a solid substrate or cells, an unlabeled test binding molecule, and a labeled reference binding molecule. Competitive inhibition is measured by determining the amount of label bound to the solid surface or cells in the presence of the test binding molecule. Usually the test binding molecule is present in excess. Typically, when a competing binding molecule is present in excess, it will inhibit specific binding of a reference binding molecule to a common antigen by at least 50-55%, 55-60%, 60-65%, 65-70%, 70-75%, or more. In some embodiments, competitive inhibition is determined using a competitive inhibition ELISA assay.

[0066] Polyclonal antibodies are heterogeneous populations of antibody molecules derived from the sera of animals immunized with an antigen. A monoclonal antibody contains a substantially homogeneous population of antibodies specific to antigens, which population contains substantially similar epitope binding sites. Monoclonal antibodies may be obtained by methods known to those skilled in the art. See, for example Kohler and Milstein, *Nature*, 256:495-497 (1975); U.S. Pat. No. 4,376,110; Ausubel et al., eds., *Current Protocols in Molecular Biology*, Greene Publishing Assoc. and Wiley Interscience, N.Y., (1987, 1992); and Harlow and Lane *ANTIBODIES: A Laboratory Manual* Cold Spring Harbor Laboratory (1988); Colligan et al., eds., *Current Protocols in Immunology*, Greene Publishing Assoc. and Wiley Interscience, N.Y., (1992, 1993), the contents of all of which are incorporated entirely herein by reference. Such antibodies may be of any immunoglobulin class including IgG, IgM, IgE, IgA, GILD and any subclass thereof. A hybridoma producing a monoclonal antibody of the present invention may be cultivated *in vitro*, *in situ* or *in vivo*.

[0067] The invention also encompasses digestion fragments, specified portions and variants thereof, including antibody mimetics or comprising portions of antibodies that mimic the structure and/or function of an antibody or specified fragment or portion thereof, including single chain antibodies and fragments thereof. Functional fragments include antigen-binding fragments that bind to a mammalian VISTA protein. For example, antibody fragments capable of binding to VISTA or portions thereof, including, but not limited to Fab (*e.g.*, by papain digestion), Fab' (*e.g.*, by pepsin digestion and partial reduction) and F(ab')₂

(*e.g.*, by pepsin digestion), *fab* (*e.g.*, by plasmin digestion), *pFc'* (*e.g.*, by pepsin or plasmin digestion), *Fd* (*e.g.*, by pepsin digestion, partial reduction and reaggregation), *Fv* or *scFv* (*e.g.*, by molecular biology techniques) fragments, are encompassed by the invention (see, *e.g.*, Colligan, Immunology, *supra*). Antibody fragments of the present invention also include those discussed and described in Aaron L. Nelson, *mAbs* 2:1, 77-83 (January/February 2010), the contents of which are incorporated by reference in their entirety.

[0068] Such fragments can be produced, for example, by enzymatic cleavage, synthetic or recombinant techniques, as known in the art and/or as described herein. antibodies can also be produced in a variety of truncated forms using antibody genes in which one or more stop codons have been introduced upstream of the natural stop site. For example, a combination gene encoding a *F(ab')*₂ heavy chain portion can be designed to include DNA sequences encoding the CH1 domain and/or hinge region of the heavy chain. The various portions of antibodies can be joined together chemically by conventional techniques, or can be prepared as a contiguous protein using genetic engineering techniques.

[0069] In one embodiment, the amino acid sequence of an immunoglobulin chain, or portion thereof (*e.g.*, variable region, CDR) has about 70-100% identity (*e.g.*, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100 or any range or value therein) to the amino acid sequence of the corresponding variable sequence chain described herein. Preferably, 70-100% amino acid identity (*e.g.*, 85, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100 or any range or value therein) is determined using a suitable computer algorithm, as known in the art.

[0070] Examples of heavy chain and light chain variable regions sequences are provided herein.

[0071] The antibodies of the present invention, or specified variants thereof, can comprise any number of contiguous amino acid residues from an antibody of the present invention, wherein that number is selected from the group of integers consisting of from 10-100% of the number of contiguous residues in an anti-TNF antibody. Optionally, this subsequence of contiguous amino acids is at least about 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250 or more amino acids in length, or any range or value therein. Further, the number of such subsequences can be any integer selected from the group consisting of from 1 to 20, such as at least 2, 3, 4, or 5.

[0072] As those of skill will appreciate, the present invention includes at least one biologically active antibody of the present invention. Biologically active antibodies have a specific activity at least 20%, 30%, or 40%, and preferably at least 50%, 60%, or 70%, and most preferably at least 80%, 90%, or 95%-100% of that of the native (non-synthetic), endogenous or related and known antibody. Methods of assaying and quantifying measures of enzymatic activity and substrate specificity, are well known to those of skill in the art.

[0073] Substantial similarity refers to a compound having at least 85% (*e.g.*, at least 95%) identity and at least 85% (*e.g.*, at least 95%) of activity of the native (non-synthetic), endogenous or related and known antibody.

[0074] As used herein, the term "human antibody" refers to an antibody in which substantially every part of the protein (*e.g.*, CDR, framework, CL, CH domains (*e.g.*, CH1, CH2, CH3), hinge, (VL, VH)) is substantially non-immunogenic in humans, with only minor sequence changes or variations. Similarly, antibodies designated primate (monkey, baboon, chimpanzee, and the like), rodent (mouse, rat, and the like) and other mammals designate such species, sub-genus, genus, sub-family, family specific antibodies. Further, chimeric antibodies can include any combination of the above. Such changes or variations optionally and preferably retain or reduce the immunogenicity in humans or other species relative to non-modified antibodies. Thus, a human antibody is distinct from a chimeric or humanized antibody. It is pointed out that a human antibody can be produced by a non-human animal or prokaryotic or eukaryotic cell that is capable of expressing functionally rearranged human immunoglobulin (*e.g.*, heavy chain and/or light chain) genes. Further, when a human antibody is a single chain antibody, it can comprise a linker peptide that is not found in native human antibodies. For example, an Fv can comprise a linker peptide, such as two to about eight glycine or other amino acid residues, which connects the variable region of the heavy chain and the variable region of the light chain. Such linker peptides are considered to be of human origin.

[0075] Bispecific, heterospecific, heteroconjugate or similar antibodies can also be used that are monoclonal, preferably human or humanized, antibodies that have binding specificities for at least two different antigens. In the present case, one of the binding specificities is for at least one VISTA protein, the other one is for any other antigen. Methods for making bispecific antibodies are known in the art. The recombinant production of bispecific antibodies can be based on the co-expression of two immunoglobulin heavy chain-light chain pairs, where the two heavy chains have different specificities (Milstein and

Cuello, Nature 305:537 (1983)). See also WO 93/08829, U.S. Pat. Nos. 6,210,668, 6,193,967, 6,132,992, 6,106,833, 6,060,285, 6,037,453, 6,010,902, 5,989,530, 5,959,084, 5,959,083, 5,932,448, 5,833,985, 5,821,333, 5,807,706, 5,643,759, 5,601,819, 5,582,996, 5,496,549, 4,676,980, WO 91/00360, WO 92/00373, EP 03089, Traunecker et al., EMBO J. 10:3655 (1991), Suresh et al., Methods in Enzymology 121:210 (1986), each entirely incorporated herein by reference.

[0076] In one embodiment, the invention relates to a bispecific antibody targeting VISTA and a second target protein (*e.g.*, an immune checkpoint protein). Exemplary bispecific antibodies include a bispecific antibody targeting VISTA and PD-L1 and a bispecific antibody targeting VISTA and PD-L2.

[0077] Human antibodies that are specific for human VISTA proteins or fragments thereof can be raised against an appropriate immunogenic antigen, such as VISTA protein or a portion thereof (including synthetic molecules, such as synthetic peptides).

[0078] Other specific or general mammalian antibodies can be similarly raised. Immunogenic antigens preparation and monoclonal antibody production can be performed using any suitable technique.

[0079] For example, a hybridoma is produced by fusing a suitable immortal cell line (*e.g.*, a myeloma cell line such as, but not limited to, Sp2/0, Sp2/0-AG14, NSO, NS1, NS2, AE-1, L.5, >243, P3X63Ag8.653, Sp2 SA3, Sp2 MAI, Sp2 SS1, Sp2 SA5, U937, MLA 144, ACT IV, MOLT4, DA-1, JURKAT, WEHI, K-562, COS, RAJI, NIH 3T3, HL-60, MLA 144, NAMAIWA, NEURO 2A, or the like, or heteromyelomas, fusion products thereof, or any cell or fusion cell derived therefrom, or any other suitable cell line as known in the art, See, *e.g.*, www.atcc.org, with antibody-producing cells. Antibody-producing cells can include isolated or cloned spleen, peripheral blood, lymph, tonsil, or other immune cells (*e.g.*, B cells), or any other cells expressing heavy or light chain constant or variable or framework or complementarity determining region (CDR) sequences. Such antibody-producing cells can be recombinant or endogenous cells, and can also be prokaryotic or eukaryotic (*e.g.*, mammalian, such as, rodent, equine, ovine, goat, sheep, primate). See, *e.g.*, Ausubel, *supra*, and Colligan, *Immunology, supra*, chapter 2, entirely incorporated herein by reference.

[0080] Antibody producing cells can also be obtained from the peripheral blood or, the spleen or lymph nodes, of humans or other suitable animals that have been immunized with the antigen of interest. Any other suitable host cell can also be used for expressing heterologous or endogenous nucleic acid encoding an antibody, specified fragment or variant

thereof, of the present invention. Fused cells (hybridomas) or recombinant cells can be isolated using selective culture conditions or other suitable known methods, and cloned by limiting dilution or cell sorting, or other known methods. Cells which produce antibodies with the desired specificity can be selected by a suitable assay (*e.g.*, enzyme-linked immunosorbent assay (ELISA)).

[0081] Other suitable methods of producing or isolating antibodies of the requisite specificity can be used, including, but not limited to, methods that select recombinant antibody from a peptide or protein library (*e.g.*, but not limited to, a bacteriophage, ribosome, oligonucleotide, RNA, cDNA, or the like, display library; *e.g.*, as available from Cambridge antibody Technologies, Cambridgeshire, UK; MorphoSys, Martinsreid/Planegg, DE; Biovation, Aberdeen, Scotland, UK; Bioinvent, Lund, Sweden; Dyax Corp., Enzon, Affymax/Biosite; Xoma, Berkeley, Calif.; Ixsys. See, *e.g.*, PCT/GB91/01134; PCT/GB92/01755; PCT/GB92/002240; PCT/GB92/00883; PCT/GB93/00605; PCT/GB94/01422; PCT/GB94/02662; PCT/GB97/01835; WO90/14443; WO90/14424; WO90/14430; PCT/U594/1234; WO92/18619; WO96/07754; EP 614 989 ; WO95/16027 ; WO88/06630; WO90/3809 ; U.S. Pat. No. 4,704,692 ; PCT/US91/02989 ; WO89/06283; EP 371 998; EP 550 400; EP 229 046; PCT/US91/07149 ; or stochastically-generated peptides or proteins--U.S. Patent Nos. 5,723,323; 5,763,192; 5,814,476; 5,817,483; 5,824,514; 5,976,862; WO 86/05803, EP 590 689, each entirely incorporated herein by reference, or that rely upon immunization of transgenic animals (*e.g.*, SCID mice, Nguyen et al., Microbiol. Immunol. 41:901-907 (1997); Sandhu et al., Crit. Rev. Biotechnol. 16:95-118 (1996); Eren et al., Immunol. 93:154-161 (1998), each entirely incorporated by reference as well as related patents and applications) that are capable of producing a repertoire of human antibodies, as known in the art and/or as described herein. Such techniques, include, but are not limited to, ribosome display (Hanes et al., Proc. Natl. Acad. Sci. USA, 94:4937-4942 (May 1997); Hanes et al., Proc. Natl. Acad. Sci. USA, 95:14130-14135 (November 1998)); single cell antibody producing technologies (U.S. Pat. No. 5,627,052, Wen et al., J. Immunol. 17:887-892 (1987); Babcook et al., Proc. Natl. Acad. Sci. USA 93:7843-7848 (1996)); gel microdroplet and flow cytometry (Powell et al., Biotechnol. 8:333-337 (1990); One Cell Systems, Cambridge, Mass.; Gray et al., J. Imm. Meth. 182:155-163 (1995); Kenny et al., Bio/Technol. 13:787-790 (1995)); B-cell selection (Steenbakkers et al., Molec. Biol. Reports 19:125-134 (1994); Jonak et al., Progress Biotech, Vol. 5, In Vitro Immunization in

Hybridoma Technology, Borrebaeck, ed., Elsevier Science Publishers B.V., Amsterdam, Netherlands (1988)).

[0082] Methods for engineering or humanizing non-human or human antibodies can also be used and are well known in the art. Generally, a humanized or engineered antibody has one or more amino acid residues from a source which is non-human, *e.g.*, but not limited to mouse, rat, rabbit, non-human primate or other mammal. These human amino acid residues are often referred to as "import" residues, which are typically taken from an "import" variable, constant or other domain of a known human sequence. Known human Ig sequences are disclosed, *e.g.*, www.ncbi.nlm.nih.gov/entrez/query.fcgi; www.atcc.org/phage/hdb.html, each entirely incorporated herein by reference.

[0083] Such imported sequences can be used to reduce immunogenicity or reduce, enhance or modify binding, affinity, avidity, specificity, half-life, or any other suitable characteristic, as known in the art. Generally part or all of the non-human or human CDR sequences are maintained while part or all of the non-human sequences of the framework and/or constant regions are replaced with human or other amino acids. Antibodies can also optionally be humanized with retention of high affinity for the antigen and other favorable biological properties using three-dimensional immunoglobulin models that are known to those skilled in the art. Computer programs are available which illustrate and display probable three-dimensional conformational structures of selected candidate immunoglobulin sequences. Inspection of these displays permits analysis of the likely role of the residues in the functioning of the candidate immunoglobulin sequence, *i.e.*, the analysis of residues that influence the ability of the candidate immunoglobulin to bind its antigen. In this way, framework (FR) residues can be selected and combined from the consensus and import sequences so that the desired antibody characteristic, such as increased affinity for the target antigen(s), is achieved. In general, the CDR residues are directly and most substantially involved in influencing antigen binding. Humanization or engineering of antibodies of the present invention can be performed using any known method, such as but not limited to those described in, for example, Winter (Jones et al., *Nature* 321:522 (1986); Riechmann et al., *Nature* 332:323 (1988); Verhoeyen et al., *Science* 239:1534 (1988)), Sims et al., *J. Immunol.* 151: 2296 (1993); Chothia and Lesk, *J. Mol. Biol.* 196:901 (1987), Carter et al., *Proc. Natl. Acad. Sci. U.S.A.* 89:4285 (1992); Presta et al., *J. Immunol.* 151:2623 (1993), U.S. Pat. Nos. 5,723,323, 5,976,862, 5,824,514, 5,817,483, 5,814,476, 5,763,192, 5,723,323, 5,766,886,

5,714,352, 6,204,023, 6,180,370, 5,693,762, 5,530,101, 5,585,089, 5,225,539; 4,816,567, each entirely incorporated herein by reference, included references cited therein.

[0084] The anti-VISTA antibody can also be optionally generated by immunization of a transgenic animal (*e.g.*, mouse, rat, rabbit, hamster, non-human primate, and the like) capable of producing a repertoire of human antibodies, as described herein and/or as known in the art. Cells that produce a human anti-VISTA antibody can be isolated from such animals and immortalized using suitable methods, such as the methods described herein.

[0085] Transgenic animals that can produce a repertoire of human antibodies that bind to human antigens can be produced by known methods (*e.g.*, but not limited to, U.S. Pat. Nos. 5,770,428, 5,569,825, 5,545,806, 5,625,126, 5,625,825, 5,633,425, 5,661,016 and 5,789,650 issued to Lonberg et al.; Jakobovits et al. WO 98/50433, Jakobovits et al. WO 98/24893, Lonberg et al. WO 98/24884, Lonberg et al. WO 97/13852, Lonberg et al. WO 94/25585, Kucherlapate et al. WO 96/34096, Kucherlapate et al. EP 0463 151 B1, Kucherlapate et al. EP 0710 719 A1, Surani et al. U.S. Pat. No. 5,545,807, Bruggemann et al. WO 90/04036, Bruggemann et al. EP 0438 474 B1, Lonberg et al. EP 0814 259 A2, Lonberg et al. GB 2 272 440 A, Lonberg et al. Nature 368:856-859 (1994), Taylor et al., Int. Immunol. 6(4):579-591 (1994), Green et al, Nature Genetics 7:13-21 (1994), Mendez et al., Nature Genetics 15:146-156 (1997), Taylor et al., Nucleic Acids Research 20(23):6287-6295 (1992), Tuaillon et al., Proc Natl Acad Sci USA 90(8):3720-3724 (1993), Lonberg et al., Int Rev Immunol 13(1):65-93 (1995) and Fishwald et al., Nat Biotechnol 14(7):845-851 (1996), which are each entirely incorporated herein by reference). Generally, these mice comprise at least one transgene comprising DNA from at least one human immunoglobulin locus that is functionally rearranged, or which can undergo functional rearrangement. The endogenous immunoglobulin loci in such mice can be disrupted or deleted to eliminate the capacity of the animal to produce antibodies encoded by endogenous genes.

[0086] Screening antibodies for specific binding to similar proteins or fragments can be conveniently achieved using peptide display libraries. This method involves the screening of large collections of peptides for individual members having the desired function or structure. Antibody screening of peptide display libraries is well known in the art. The displayed peptide sequences can be from 3 to 5000 or more amino acids in length, frequently from 5-100 amino acids long, and often from about 8 to 25 amino acids long. In addition to direct chemical synthetic methods for generating peptide libraries, several recombinant DNA methods have been described. One type involves the display of a peptide sequence on the

surface of a bacteriophage or cell. Each bacteriophage or cell contains the nucleotide sequence encoding the particular displayed peptide sequence. Such methods are described in PCT Patent Publication Nos. 91/17271, 91/18980, 91/19818, and 93/08278. Other systems for generating libraries of peptides have aspects of both *in vitro* chemical synthesis and recombinant methods. See, PCT Patent Publication Nos. 92/05258, 92/14843, and 96/19256. See also, U.S. Patent Nos. 5,658,754; and 5,643,768. Peptide display libraries, vector, and screening kits are commercially available from such suppliers as Invitrogen (Carlsbad, Calif.), and Cambridge antibody Technologies (Cambridgeshire, UK). See, *e.g.*, U.S. Patent Nos. 4,704,692, 4,939,666, 4,946,778, 5,260,203, 5,455,030, 5,518,889, 5,534,621, 5,656,730, 5,763,733, 5,767,260, 5,856,456; 5,223,409, 5,403,484, 5,571,698, 5,837,500, assigned to Dyax, 5,427,908, 5,580,717; 5,885,793, assigned to Cambridge antibody Technologies; 5,750,373, assigned to Genentech, 5,618,920, 5,595,898, 5,576,195, 5,698,435, 5,693,493, and 5,698,417.

[0087] Antibodies of the present invention can also be prepared using at least one anti-VISTA antibody encoding nucleic acid to provide transgenic animals, such as goats, cows, sheep, and the like, that produce such antibodies in their milk. Such animals can be provided using known methods. See, *e.g.*, but not limited to, U.S. Pat. Nos. 5,827,690; 5,849,992; 4,873,316; 5,849,992; 5,994,616; 5,565,362; 5,304,489, and the like, each of which is entirely incorporated herein by reference.

[0088] The anti-VISTA antibodies of the present invention can also be produced using transgenic plants, according to known methods. See also, *e.g.*, Fischer et al., *Biotechnol. Appl. Biochem.* 30:99-108 (October, 1999), Cramer et al., *Curr. Top. Microbol. Immunol.* 240:95-118 (1999) and references cited therein; Ma et al., *Trends Biotechnol.* 13:522-7 (1995); Ma et al., *Plant Physiol.* 109:341-6 (1995); Whitelam et al., *Biochem. Soc. Trans.* 22:940-944 (1994); and references cited therein. Each of the above references is entirely incorporated herein by reference.

[0089] The antibodies of the invention can bind human VISTA with a wide range of affinities (K_D). In a preferred embodiment, at least one human monoclonal antibody of the present invention can optionally bind human VISTA with high affinity. For example, a human monoclonal antibody can bind human VISTA with a K_D equal to or less than about 10^{-7} M, such as but not limited to, 0.1-9.9 (or any range or value therein) $\times 10^{-7}$, 10^{-8} , 10^{-9} , 10^{-10} , 10^{-11} , 10^{-12} , 10^{-13} or any range or value therein. In some embodiments, the antibody or

antibody fragment can binds human VISTA with an affinity of at least 1×10^{-7} liter/mole, for example, at least 1×10^{-8} liter/mole, for example, at least 1×10^{-9} liter/mole liter/mole.

[0090] The affinity or avidity of an antibody for an antigen can be determined experimentally using any suitable method. (See, for example, Berzofsky, et al., "Antibody-Antigen Interactions," In Fundamental Immunology, Paul, W. E., Ed., Raven Press: New York, N.Y. (1984); Kuby, Janis Immunology, W.H. Freeman and Company: New York, N.Y. (1992); and methods described herein). The measured affinity of a particular antibody-antigen interaction can vary if measured under different conditions (*e.g.*, salt concentration, pH). Thus, measurements of affinity and other antigen-binding parameters (*e.g.*, K_D , K_a , K_d) are preferably made with standardized solutions of antibody and antigen, and a standardized buffer.

[0091] NUCLEIC ACID MOLECULES

[0092] Using the information provided herein, such as the nucleotide sequences encoding at least 70-100% of the contiguous amino acids of at least one of specified fragments, variants or consensus sequences thereof, or a deposited vector comprising at least one of these sequences, a nucleic acid molecule of the present invention encoding at least one anti-VISTA antibody comprising all of the heavy chain variable CDR regions of SEQ ID NOS:1, 2 and 3 and/or all of the light chain variable CDR regions of SEQ ID NOS:4, 5 and 6 can be obtained using methods described herein or as known in the art.

[0093] Nucleic acid molecules of the present invention can be in the form of RNA, such as mRNA, hnRNA, tRNA or any other form, or in the form of DNA, including, but not limited to, cDNA and genomic DNA obtained by cloning or produced synthetically, or any combinations thereof. The DNA can be triple-stranded, double-stranded or single-stranded, or any combination thereof. Any portion of at least one strand of the DNA or RNA can be the coding strand, also known as the sense strand, or it can be the non-coding strand, also referred to as the anti-sense strand.

[0094] Isolated nucleic acid molecules of the present invention can include nucleic acid molecules comprising an open reading frame (ORF), for example, but not limited to, at least one specified portion of at least one CDR, as CDR1, CDR2 and/or CDR3 of at least one heavy chain or light chain; nucleic acid molecules comprising the coding sequence for an anti-VISTA antibody or fragment, *e.g.*, a fragment comprising a variable region; and nucleic acid molecules which comprise a nucleotide sequence different from those described above but which, due to the degeneracy of the genetic code, still encode at least one anti-VISTA

antibody as described herein and/or as known in the art. It would be routine for one skilled in the art to generate such degenerate nucleic acid variants that code for specific anti-VISTA antibodies of the present invention. See, *e.g.*, Ausubel, et al., *supra*, and such nucleic acid variants are included in the present invention.

[0095] As indicated herein, nucleic acid molecules of the present invention which comprise a nucleic acid encoding an anti-VISTA antibody can include, but are not limited to, those encoding the amino acid sequence of an antibody fragment; the coding sequence for the entire antibody or a portion thereof; the coding sequence for an antibody, fragment or portion, as well as additional sequences, such as the coding sequence of at least one signal leader or fusion peptide, with or without the aforementioned additional coding sequences, such as at least one intron, together with additional, non-coding sequences, including but not limited to, non-coding 5' and 3' sequences, such as the transcribed, non-translated sequences that play a role in transcription, mRNA processing, including splicing and polyadenylation signals (for example--ribosome binding and stability of mRNA); an additional coding sequence that codes for additional amino acids, such as those that provide additional functionalities. Thus, the sequence encoding an antibody can be fused to a marker sequence, such as a sequence encoding a peptide that facilitates purification of the fused antibody comprising an antibody fragment or portion.

[0096] Human genes which encode the constant (C) regions of the antibodies, fragments and regions of the present invention can be derived from a human fetal liver library, by known methods. Human C regions genes can be derived from any human cell including those which express and produce human immunoglobulins. The human C_H region can be derived from any of the known classes or isotypes of human H chains, including γ , μ , α , δ or ϵ and subtypes thereof, such as G1, G2, G3 and G4. Since the H chain isotype is responsible for the various effector functions of an antibody, the choice of C_H region will be guided by the desired effector functions, such as complement fixation, or activity in antibody-dependent cellular cytotoxicity (ADCC).

[0097] COMPOSITIONS

[0098] The pharmaceutical compositions disclosed herein are prepared in accordance with standard procedures and are administered at dosages that are selected to treat, *e.g.*, reduce, prevent, or eliminate, or to slow or halt the progression of, the condition being treated (See, *e.g.*, Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, PA, and Goodman and Gilman's The Pharmaceutical Basis of Therapeutics, McGraw-Hill, New

York, N.Y., the contents of which are incorporated herein by reference, for a general description of the methods for administering various agents for human therapy). The compositions comprising the disclosed antibodies and agents can be delivered using controlled or sustained-release delivery systems (*e.g.*, capsules, biodegradable matrices). Examples of delayed-release delivery systems for drug delivery that would be suitable for administration of the compositions of the disclosed compounds are described in, *e.g.*, U.S. Patent Nos. US 5,990,092; 5,039,660; 4,452,775; and 3,854,480, the entire teachings of which are incorporated herein by reference.

[0099] For preparing pharmaceutical compositions from the anti-VISTA antibodies and/or fragments of the present invention, pharmaceutically acceptable carriers can be solid or liquid. Solid form preparations include powders, tablets, pills, capsules, cachets, suppositories, and dispersible granules. For example, the compounds of the present invention can be in powder form for reconstitution at the time of delivery. A solid carrier can be one or more substances which can also act as diluents, flavoring agents, solubilizers, lubricants, suspending agents, binders, preservatives, tablet disintegrating agents, or an encapsulating material. In powders, the carrier is a finely divided solid which is in a mixture with the finely divided active ingredient.

[00100] The powders and tablets preferably contain from about one to about seventy percent of the active ingredient. Suitable carriers are magnesium carbonate, magnesium stearate, talc, sugar, lactose, pectin, dextrin, starch, gelatin, tragacanth, methylcellulose, sodium caboxymethylcellulose, a low-melting wax, cocoa butter, and the like. Tablets, powders, cachets, lozenges, fast-melt strips, capsules and pills can be used as solid dosage forms containing the active ingredient suitable for oral administration.

[00101] Liquid form preparations include solutions, suspensions, retention enemas, and emulsions, for example, water or water propylene glycol solutions. For parenteral injection, liquid preparations can be formulated in solution in aqueous polyethylene glycol solution.

[00102] The pharmaceutical composition can be in unit dosage form. In such form, the composition is subdivided into unit doses containing appropriate quantities of the active ingredient. The unit dosage form can be a packaged preparation, the package containing discrete quantities of unit doses. The dosages can be varied depending upon the requirements of the patient, the severity of the condition being treated, the compound and the route of administration being employed. Determination of the proper dosage for a particular situation is within the skill in the art.

[00103] Also, the pharmaceutical composition can contain, if desired, other compatible agents, *e.g.*, pharmaceutical, therapeutic or prophylactic agents. Therapeutic or prophylactic agents include, but are not limited to, peptides, polypeptides, proteins, fusion proteins, nucleic acid molecules, small molecules, mimetic agents, synthetic drugs, inorganic molecules, and organic molecules. Examples of the classes of such agents (*e.g.*, anti-cancer agents) include, but are not limited to, cytotoxins, angiogenesis inhibitors, immunomodulatory agents, immuno-oncology agents, and agents used to provide relief from pain or to offset the deleterious effects of one or more therapeutic agents (*e.g.*, bisphosphonate use to reduce the hypercalcemic effects of glucocorticoids).

[00104] Angiogenesis inhibitors, agents and therapies that are suitable for use in the compositions and methods described herein include, but are not limited to, angiostatin (plasminogen fragment); antiangiogenic antithrombin III; angiozyme. Bisphosphonates include, but are not limited to, alendronate, clodronate, etidronate, ibandronate, pamidronate, risedronate, tiludronate, and zoledronate.

[00105] Immunomodulatory agents and therapies that are suitable for use in the compositions and methods described herein include, but are not limited to, anti-T cell receptor antibodies such as anti-CD3 antibodies (*e.g.* Nuvion (Protein Design Labs), OKT3 (Johnson & Johnson), or anti-CD20 antibodies Rituxan (IDEC)), anti-CD52 antibodies (*e.g.* CAMPATH 1H (Ilex)), anti-CD11a antibodies (*e.g.* Xanelim (Genentech)); anti-cytokine or anti-cytokine receptor antibodies and antagonists such as anti-IL-2 receptor antibodies (Zenapax (Protein Design Labs)), anti-IL-6 receptor antibodies (*e.g.* MRA (Chugai)), and anti-IL-12 antibodies (CNTO1275(Janssen)), anti-TNFalpha antibodies (Remicade(Janssen)) or TNF receptor antagonist (Enbrel (Immunex)), anti-IL-6 antibodies (BE8 (Diacione) and siltuximab (CNTO32 (Centocor))), and antibodies that immunospecifically bind to tumor-associated antigens (*e.g.*, trastuzimab (Genentech)).

[00106] Immuno-oncology agents that are suitable for use in the compositions and methods described herein include, but are not limited to, ipilimumab (anti-CTLA-4), nivolumab (anti-PD-1), pembrolizumab (anti-PD-1), anti-PD-L1 antibodies, and anti-LAG-3 antibodies.

[00107] The composition is preferably made in the form of a dosage unit containing a therapeutically effective amount of the antibody or fragment. Examples of dosage units are tablets and capsules. For therapeutic purposes, the tablets and capsules can contain, in addition to the active ingredient, conventional carriers such as binding agents, for example,

acacia gum, gelatin, polyvinylpyrrolidone, sorbitol, or tragacanth; fillers, for example, calcium phosphate, glycine, lactose, maize-starch, sorbitol, or sucrose; lubricants, for example, magnesium stearate, polyethylene glycol, silica, or talc; disintegrants, for example potato starch, flavoring or coloring agents, or acceptable wetting agents. Oral liquid preparations generally in the form of aqueous or oily solutions, suspensions, emulsions, syrups or elixirs can contain conventional additives such as suspending agents, emulsifying agents, non-aqueous agents, preservatives, coloring agents and flavoring agents. Examples of additives for liquid preparations include acacia, almond oil, ethyl alcohol, fractionated coconut oil, gelatin, glucose syrup, glycerin, hydrogenated edible fats, lecithin, methyl cellulose, methyl or propyl para-hydroxybenzoate, propylene glycol, sorbitol, or sorbic acid.

[00108] Other general details regarding methods of making and using the compounds and compositions described herein are well-known in the art. See, *e.g.*, U.S. Patent No. 7,820,169, the contents of which are incorporated in their entirety.

[00109] METHODS OF TREATMENT

[00110] One of skill in the art, *e.g.*, a clinician, can determine the suitable dosage and route of administration for a particular antibody, fragment or composition for administration to an individual, considering the agents chosen, pharmaceutical formulation and route of administration, various patient factors and other considerations. Preferably, the dosage does not cause or produces minimal or no adverse side effects. In standard multi-dosing regimens, a pharmacological agent may be administered on a dosage schedule that is designed to maintain a pre-determined or optimal plasma concentration in the subject undergoing treatment. The antibodies, fragments and compositions can be added at any appropriate dosage ranges or therapeutically effective amount, for example, 0.1 mg/kg, 0.2 mg/kg, 0.3 mg/kg, 0.4 mg/kg, 0.5 mg/kg, 0.6 mg/kg, 0.7 mg/kg, 0.8 mg/kg, 0.9 mg/kg, 1.0 mg/kg, 1.5 mg/kg, 2.0 mg/kg, 2.5 mg/kg, 3.0 mg/kg, 4.0 mg/kg, 5.0 mg/kg, 6.0 mg/kg, 7.0 mg/kg, 8.0 mg/kg, 9.0 mg/kg, 10.0 mg/kg, 11.0 mg/kg, 12.0 mg/kg, 13.0 mg/kg, 14.0 mg/kg, 15.0 mg/kg, 16.0 mg/kg, 17.0 mg/kg, 18.0 mg/kg, 19.0 mg/kg, 20.0 mg/kg, 30 mg/kg, 40 mg/kg, 50 mg/kg, 60 mg/kg, 70 mg/kg, 80 mg/kg, 90 mg/kg and 100 mg/kg. In one embodiment, the dosage of the administered composition, antibody or fragment is 0.1-15 mg/kg per administration.

[00111] The antibody or fragment can be administered once, at least once, twice, at least twice, three times, or at least three times per day. The antibody or fragment can be administered once, at least once, twice, at least twice, three times, at least three times, four

times, at least four times, five times, at least five times, six times per week, or at least six times per week. The antibody or fragment can be administered once per month, at least once per month, twice per month, at least twice per month, three times per month or at least three times per month. The antibody or antibody fragment can be administered once per year, at least once per year, twice per year, at least twice per year, three times per year, at least three times per year, four times per year, at least four times per year, five times per year, at least five times per year, six times per year or at least six times per year.

[00112] The anti-VISTA antibodies, fragments and compositions can, for example, be administered through parenteral or nonparenteral means, including, but not limited to, intravenously, subcutaneously, orally, rectally, intramuscularly, intraperitoneally, transmucosally, transdermally, intrathecally, nasally, or topically. One of ordinary skill in the art will recognize that the following dosage forms can comprise as the active ingredient, either compounds or a corresponding pharmaceutically acceptable salt of a compound of the present invention. In some embodiments, the dosage forms can comprise as the active ingredient, either a compound or a corresponding pharmaceutically acceptable salt of a compound.

[00113] The anti-VISTA antibodies of the invention can be administered as part of a combination therapy (*e.g.*, with each other, or with one or more other therapeutic agents). The compounds of the invention can be administered before, after or concurrently with one or more other therapeutic agents. In some embodiments, a compound of the invention and other therapeutic agent can be co-administered simultaneously (*e.g.*, concurrently) as either separate formulations or as a joint formulation. Alternatively, the agents can be administered sequentially, as separate compositions, within an appropriate time frame, as determined by the skilled clinician (*e.g.*, a time sufficient to allow an overlap of the pharmaceutical effects of the therapies). A compound of the invention and one or more other therapeutic agents can be administered in a single dose or in multiple doses, in an order and on a schedule suitable to achieve a desired therapeutic effect.

[00114] The present invention also provides a method for modulating or treating at least one malignant disease in a cell, tissue, organ, animal or patient. In some embodiments, the compounds and compositions of the present invention are used to treat or prevent cancer. Cancer can include any malignant or benign tumor of any organ or body system. Examples include, but are not limited to, the following: breast, digestive/gastrointestinal, endocrine, neuroendocrine, eye, genitourinary, germ cell, gynecologic, head and neck,

hematologic/blood, musculoskeletal, neurologic, respiratory/thoracic, bladder, colon, rectal, lung, endometrial, kidney, pancreatic, liver, stomach, testicular, esophageal, prostate, brain, cervical, ovarian and thyroid cancers. Other cancers can include leukemias, melanomas, and lymphomas, and any cancer described herein. In some embodiments, the solid tumor is infiltrated with myeloid and/or T-cells. In some embodiments, the cancer is a leukemia, lymphoma, myelodysplastic syndrome and/or myeloma. In some embodiments, the cancer can be any kind or type of leukemia, including a lymphocytic leukemia or a myelogenous leukemia, such as, *e.g.*, acute lymphoblastic leukemia (ALL), chronic lymphocytic leukemia (CLL), acute myeloid (myelogenous) leukemia (AML), chronic myelogenous leukemia (CML), hairy cell leukemia, T-cell prolymphocytic leukemia, large granular lymphocytic leukemia, or adult T-cell leukemia. In some embodiments, the lymphoma is a histocytic lymphoma, follicular lymphoma or Hodgkin lymphoma, and in some embodiments, the cancer is a multiple myeloma. In some embodiments, the cancer is a solid tumor, for example, a melanoma, or bladder cancer. In a particular embodiment, the cancer is a lung cancer, such as a non-small cell lung cancer (NSCLC).

[00115] The present invention also provides a method for modulating or treating at least one malignant disease in a cell, tissue, organ, animal or patient, including, but not limited to, at least one of: leukemia, acute leukemia, acute lymphoblastic leukemia (ALL), B-cell, T-cell or FAB ALL, acute myeloid leukemia (AML), chronic myelocytic leukemia (CML), chronic lymphocytic leukemia (CLL), hairy cell leukemia, myelodysplastic syndrome (MDS), a lymphoma, Hodgkin's disease, a malignant lymphoma, non-hodgkin's lymphoma, Burkitt's lymphoma, multiple myeloma, Kaposi's sarcoma, colorectal carcinoma, pancreatic carcinoma, nasopharyngeal carcinoma, malignant histiocytosis, paraneoplastic syndrome/hypercalcemia of malignancy, solid tumors, adenocarcinomas, sarcomas, malignant melanoma, hemangioma, metastatic disease, cancer related bone resorption, cancer-related bone pain, and the like. In some embodiments, the solid tumor is infiltrated with myeloid and/or T-cells. In a particular embodiment, the solid tumor is a lung cancer, such as a non-small cell lung cancer (NSCLC).

[00116] In some embodiments, the compounds and therapies described herein are co-administered with a vaccine (such as a viral vector vaccine, bacterial vaccine, cell-based vaccine, DNA vaccine, RNA vaccine, peptide vaccine, or protein vaccine). Such vaccines are well known in the art. *See, e.g.*, Jeffrey Schlom, "Therapeutic Cancer Vaccines: Current

Status and Moving Forward,” *J Natl Cancer Inst*; 104:599–613 (2012), the contents of which are incorporated herein in their entirety.

[00117] In some embodiments, the compounds and therapies described herein are co-administered with agents for chemotherapy, hormone therapies and biological therapies, and/or bisphosphonates. In some embodiments, the agent(s) for chemotherapy include one or more of the following: carboplatin (Paraplatin), cisplatin (Platinol, Platinol-AQ), cyclophosphamide (Cytosan, Neosar), doxorubicin (Adriamycin), etoposide (VePesid), fluorouracil (5-FU), gemcitabine (Gemzar), irinotecan (Camptosar), paclitaxel (Taxol), topotecan (Hycamtin), vincristine (Oncovin, Vincasar PFS), vinblastine (Velban).

[00118] In other embodiments, the anti-VISTA compounds and therapies described herein are co-administered with one or more immune checkpoint antibodies, such as, for example, nivolumab, pembrolizumab, tremelimumab, ipilimumab, anti-PD-L1 antibody, anti-PD-L2 antibody, anti-TIM-3 antibody, anti-LAG-3, anti-OX40 antibody and anti-GITR antibody.

[00119] In another embodiment, the anti-VISTA compounds and therapies described herein are co-administered with a small molecule inhibitor of indoleamine 2,3-dioxygenase (IDO).

[00120] The anti-VISTA compounds and composition of the invention may be administered to a subject in need thereof to prevent (including preventing the recurrence of cancer) or treat (*e.g.*, manage or ameliorate a cancer or one or more symptoms thereof) cancer. Any agent or therapy (*e.g.*, chemotherapies, radiation therapies, targeted therapies, such as imatinib, sorafenib and vemurafenib, hormonal therapies, and/or biological therapies or immunotherapies) which is known to be useful, or which has been used or is currently being used for the prevention, treatment, management or amelioration of cancer or one or more symptoms thereof can be used in combination with a compound or composition of the invention described herein. Anti-cancer agents, but not limited to: 5-fluorouracil; acivicin; aldesleukin; altretamine; aminoglutethimide; amsacrine; anastrozole; anthramycin; asparaginase; azacitidine; azetepa; azotomycin; batimastat; bicalutamide; bleomycin sulfate; brequinar sodium; bropiramine; busulfan; carboplatin; carmustine; carubicin hydrochloride; carzelesin; cedefingol; chlorambucil; cirolemycin; cisplatin; cladribine; crisnatol mesylate; cyclophosphamide; cytarabine; dacarbazine; dactinomycin; daunorubicin hydrochloride; decitabine; dexormaplatin; dezaguanine; dezaguanine mesylate; diaziquone; docetaxel; doxorubicin; doxorubicin hydrochloride; droloxifene; droloxifene citrate; dromostanolone propionate; duazomycin; edatrexate; eflornithine hydrochloride; enloplatin; enpromate;

epipropidine; epirubicin hydrochloride; erbulozole; esorubicin hydrochloride; estramustine; estramustine phosphate sodium; etanidazole; etoposide; etoposide phosphate; fazarabine; fenretinide; floxuridine; fludarabine phosphate; fluorouracil; flurocitabine; fosquidone; fostriecin sodium; gemcitabine; gemcitabine hydrochloride; hydroxyurea; idarubicin hydrochloride; ifosfamide; ilmofosine; interleukin II (including recombinant interleukin II, or rIL2) , interferon alpha-2a; interferon alpha-2b; interferon alpha-m; interferon alpha-n3; interferon beta-I a; interferon gamma-I b; iproplatin; irinotecan hydrochloride; lanreotide acetate; letrozole; leuprolide acetate; liarozole hydrochloride; lometrexol sodium; lomustine; losoxantrone hydrochloride; masoprocil; mechlorethamine hydrochloride; megestrol acetate; melengestrol acetate; melphalan; menogaril; mercaptopurine; methotrexate; methotrexate sodium; metoprine; meturedapa; mitomycin; mitosper; mitotane; mitoxantrone hydrochloride; mycophenolic acid; nocodazole; ormaplatin; paclitaxel; pegaspargase; porfromycin; prednimustine; procarbazine hydrochloride; puromycin; rogletimide; safingol hydrochloride; semustine; simtrazene; sparfosate sodium; sparsomycin; spiromustine; spiroplatin; streptonigrin; streptozocin; sulofenur; talisomycin; tegafur; teloxantrone hydrochloride; temoporfin; teniposide; teroxirone; testolactone; thiamiprine; thioguanine; thiotepa; tiazofurin; tirapazamine; topotecan; trimetrexate; trimetrexate glucuronate; triptorelin; uracil mustard; uredepa; vapreotide; verteporfin; vinblastine sulfate; vincristine sulfate; vindesine; vindesine sulfate; vinepidine sulfate; vinglycinate sulfate; vinleurosine sulfate; vinorelbine tartrate; vinrosidine sulfate; vinzolidine sulfate; vorozole; zeniplatin; zinostatin; zorubicin hydrochloride. Targeted therapies include, but are not limited to, tyrosine kinase inhibitors (*e.g.*, imatinib, sorafenib, and vemurafenib). The invention also encompasses administration of an anti-VISTA compound of the invention in combination with radiation therapy comprising the use of x-rays, gamma rays and other sources of radiation to destroy the cancer cells. Cancer treatments are known in the art and have been described in such literature as the Physician's Desk Reference (57th ed., 2003).

[00121] The anti-VISTA antibodies described herein are also useful, for example, in the treatment of chronic infectious diseases, such as HIV, HBV, HCV, and HSV, among others.

[00122] Various properties and sequence information for select anti-VISTA antibodies of the invention are provided in Tables 1A, 1B and 2 herein.

[00123] Table 1A: CDR Sequences of Select Fully Human or Humanized anti-human VISTA antibodies

mAb ID	VH family	Heavy-chain cdr1 (Imgt)	Heavy-chain cdr2 (Imgt)	Heavy-chain cdr3 (Imgt)	Light-chain cdr1 (Imgt)	Light-chain cdr2 (Imgt)	Light-chain cdr3 (Imgt)
VSTB50	B	GYFTNNG (SEQ ID NO:1)	INPYTGEP (SEQ ID NO:2)	AREGYGNYIFPY (SEQ ID NO:3)	ESVDTYANSL (SEQ ID NO:4)	RAS (SEQ ID NO:5)	QQTNEPRT (SEQ ID NO:6)
VSTB53		GYFTNNG (SEQ ID NO:7)	IIPSSGYS (SEQ ID NO:8)	ARGAYDDYYDYAMDY (SEQ ID NO:9)	QTIVHNSGNTY (SEQ ID NO:10)	KVS (SEQ ID NO:11)	FQASHVPWT(SEQ ID NO:12)
VSTB60	B	GYFTNNG (SEQ ID NO:13)	INTYTGES (SEQ ID NO:14)	ARDYYGIYVSAY (SEQ ID NO:15)	ESVDNYANSF (SEQ ID NO:16)	RAS (SEQ ID NO:17)	QQSHEDPYT (SEQ ID NO:18)
VSTB95		GFTFRNNG (SEQ ID NO:19)	IISGGSYT (SEQ ID NO:20)	ARIYDHGDYYAMDY (SEQ ID NO:21)	QSIVHNSGNTY (SEQ ID NO:22)	KVS (SEQ ID NO:23)	FQGSHPWT (SEQ ID NO:24)
VSTB112	D	GGTFSSYA (SEQ ID NO:25)	IPIFGTA (SEQ ID NO:26)	ARSSYGWSEFDY (SEQ ID NO:27)	QSIDTR (SEQ ID NO:28)	SAS (SEQ ID NO:29)	QQSAYNPIT (SEQ ID NO:30)
VSTB116	D	GGTFSSYA (SEQ ID NO:31)	IPIFGTA (SEQ ID NO:32)	ARSSYGWSEFDY (SEQ ID NO:33)	QSINTN (SEQ ID NO:34)	AAS (SEQ ID NO:35)	QQARDTPIT(SEQ ID NO:36)

[00124] Table 1B: Heavy and Light Chain Sequences of Select Fully Human or Humanized anti-human VISTA antibodies

Protein ID	Heavy-chain AA CDS	Light-chain AA CDS
VSTB50	QVQLVQSGSELKPGASVKVCKASGYFTNNGLNWVRQAPGQGLEW MGWINPYTGEPYADDFKGRFVSLDTSVSTAYLQICSLKAEDTAVYYCA REGYGNIFYPYWGQGLTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT QTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPP KPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPRE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPR EPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFCSCVMHEALHNHYTQKSLSL SPGK (SEQ ID NO:47)	DIVMTQTPLSLSVTPGQPASISCRASESDVT YANSLMHWYLQKPGQPPQLLIYRASNL GVPDRFSGSGSGTDFTLKISRVEAEDVGVY YCAQTNEPRTFGQGTLEIKRTVAAPSVF IFPPSDEQLKSGTASVVCCLNNFYPREAKVQ WKVDNALQSGNSQESVTEQDSKDSTYSLS STLTLSKADYEKHKVYACEVTHQGLSSPVTK SFNRGEC (SEQ ID NO:48)
VSTB53	QVQLVQSGAEVKKPGASVKVCKASGYFTNNGHWNVRQAPGQGLEW MGYIIPSSGYSEYNQKFKDRVTMTSDTSTVYMELSSLRSEDTAVYYCA RGAYDDYYDYAMDYWGQGLTVSSASTKGPSVFPLAPSSKSTSGGTA ALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPS SSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSV FLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTK KPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKG QPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFCSCVMHEALHNHYTQKSLSLSPGK (SEQ ID NO:49)	DIVMTQSPLSLPVTPGEPASISCRSSQTIVH SNGNTYLEWYLQKPGQSPQLLIYKVSNRFS GVPDRFSGSGSGTDFTLKISRVEAEDVGVY YCAQASHVPWTFGQGTLEIKRTVAAPSVF IFPPSDEQLKSGTASVVCCLNNFYPREAKVQ WKVDNALQSGNSQESVTEQDSKDSTYSLS STLTLSKADYEKHKVYACEVTHQGLSSPVTK SFNRGEC (SEQ ID NO:50)

VSTB60	QVQLVQSGSELKKPGASVKVSCASGYTFTNYGMTWVRQAPGQGLEW MGWINTYTGESTYADDFKGRFVFLDTSVSTAYLQICSLKAEDTAVYYCA RDYYGIYVSAYWGQGLTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT QTYICNVNHKPSNTKVDKKVEPKSCDKHTCTPPCPAPELLGGPSVFLFPP KPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPR EPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSL SPGK (SEQ ID NO:51)	DIVMTQTPLSLSVTPGQPASISCRASESD NYANSFMHWYLQKPGQSPQLLIYRASNLE SGVPDRFSGSGSGTDFTLKISRVEAEDVGV YYCQSHEDPYTFGQGTKEIKRTVAAPSV FIFPPSDEQLKSGTASVCLNNFYPREAKV QWKVDNALQSGNSQESVTEQDSKDSYSTLS SSTLTLSKADYEKHKVYACEVTHQGLSSPVT KSFNRGEC (SEQ ID NO:52)
VSTB95	EVQLVESGGGLVQPGGSLRLSCAASGFTFRNYGMSWVRQAPGKGLEW VASIISGGSYTYPPDSVKGRFTISRDNAKNSLYLQMNLSRAEDTAVYYCAR IYDHDGDYAMDYWGQGTITVTVSSASTKGPSVFPLAPSSKSTSGGTAAL GCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSL GTQTYICNVNHKPSNTKVDKKVEPKSCDKHTCTPPCPAPELLGGPSVFLF PPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKP REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKG QPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENN YKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK (SEQ ID NO:53)	DIVMTQSPLSLPVTGPGEASISCRSSQSIH SNGNTYLEWYLQKPGQSPQLLIYKVSNRFS GVPDRFSGSGSGTDFTLKISRVEAEDVGVY YCFQGSHPVWTFGQGTKEIKRTVAAPSVF IFPPSDEQLKSGTASVCLNNFYPREAKVQ WKVDNALQSGNSQESVTEQDSKDSYSTLS STLTLSKADYEKHKVYACEVTHQGLSSPVT KSFNRGEC (SEQ ID NO:54)
VSTB112	QVQLVQSGAEVKKPGSSVKVSCASGGTSSYIAISWVRQAPGQGLEW MGGIPIFGTANYAQKFQGRVTITADESTAYMELSSLRSEDTAVYYCAR SSYGWSEFYDWGQGLTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT QTYICNVNHKPSNTKVDKKVEPKSCDKHTCTPPCPAPELLGGPSVFLFPP KPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPR EPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSL SPGK (SEQ ID NO:55)	DIQMTQSPSSLSASVGDRTITCRASQSIDT RLNWWYQQKPGKAPKLLIYASSLSQSGVPSR FSGSGSGTDFTLTISLQPEDFATYYCQQA YNPITFGQGTKEIKRTVAAPSVFIFPPSDE QLKSGTASVCLNNFYPREAKVQWKVDN ALQSGNSQESVTEQDSKDSYSTLSSTLTLSK ADYEKHKVYACEVTHQGLSSPVTKSFNRGE C (SEQ ID NO:56)
VSTB116	QVQLVQSGAEVKKPGSSVKVSCASGGTSSYIAISWVRQAPGQGLEW MGGIPIFGTANYAQKFQGRVTITADESTAYMELSSLRSEDTAVYYCAR SSYGWSEFYDWGQGLTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT QTYICNVNHKPSNTKVDKKVEPKSCDKHTCTPPCPAPELLGGPSVFLFPP KPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE QYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPR EPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSL SPGK (SEQ ID NO:57)	DIQMTQSPSSLSASVGDRTITCRASQSIINT NLNWWYQQKPGKAPKLLIYAASSLSQSGVPSR FSGSGSGTDFTLTISLQPEDFATYYCQQA DTPITFGQGTKEIKRTVAAPSVFIFPPSDE QLKSGTASVCLNNFYPREAKVQWKVDN ALQSGNSQESVTEQDSKDSYSTLSSTLTLSK ADYEKHKVYACEVTHQGLSSPVTKSFNRGE C (SEQ ID NO:58)
VSTB140*	QVQLVQSGAEVKKPGSSVKVSCASGGTSSYIAISWVRQAPGQGLEW MGGIPIFGTANYAQKFQGRVTITADESTAYMELSSLRSEDTAVYYCAR SSYGWSEFYDWGQGLTVTVSSASTKGPSVFPLAPCSRSTSESTAALGCL VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSNFGT QTYTCNVNHHKPSNTKVDKTVKCCVECPAPPAAASSVFLFPPKPKD TLMISRTPEVTCVVDVSAEDPEVQFNWYVDGVEVHNAKTKPREEQFN	DIQMTQSPSSLSASVGDRTITCRASQSIDT RLNWWYQQKPGKAPKLLIYASSLSQSGVPSR FSGSGSGTDFTLTISLQPEDFATYYCQQA YNPITFGQGTKEIKRTVAAPSVFIFPPSDE QLKSGTASVCLNNFYPREAKVQWKVDN ALQSGNSQESVTEQDSKDSYSTLSSTLTLSK

	<u>STFRVVSVLTVLHQDWLNGKEYCKVSNKGLPSSIEKTISKTKGQPREPQ</u> <u>VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPP</u> <u>MLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSL</u> <u>SPGK (SEQ ID NO:59)</u>	<u>ADYEKHKVYACEVTHQGLSSPVTKSFNRGE</u> <u>C (SEQ ID NO:56)</u>
VSTB149* ^Δ	QVQLVQSGAEVKKPGSSVKVCKASGGTFSSYAISWVRQAPGQGLEW MGGIPIFGTANYAQKFQGRVTITADESTSTAYMELSSLRSEDAVYYCAR SSYGWSYEFDYWGQGLTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL <u>VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT</u> <u>QTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPPVAGPDVFLFPP</u> <u>KPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE</u> <u>QYNSTYRVVSVLTVLHQDWLNGKEYCKVSNALPAPIAKTISKAKGQPR</u> <u>REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYK</u> <u>TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS</u> <u>LSLSPGK (SEQ ID NO:60)</u>	DIQMTQSPSSLSASVGDRVTITCRASQSIDT RLNWKYQKPKGKAPKLLIYSASSLQSGVPSR FSGSGSGTDFTLTISLQPEDFATYYCQQA YNPITFGQGTKEIKRTVAAPSFIAPPDE <u>QLKSGTASVCLNNFYPREAKVQWKVDN</u> <u>ALQSGNSQESVTEQDSKSTYSLSSTLTLSK</u> <u>ADYEKHKVYACEVTHQGLSSPVTKSFNRGE</u> <u>C (SEQ ID NO:56)</u>
VSTB174*	QVQLVQSGAEVKKPGSSVKVCKASGGTFSSYAISWVRQAPGQGLEW MGGIPIFGTANYAQKFQGRVTITADESTSTAYMELSSLRSEDAVYYCAR SSYGWSYEFDYWGQGLTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCL <u>VKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGT</u> <u>QTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPPELLGGPSVFLFPP</u> <u>KPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREE</u> <u>QYNSTYRVVSVLTVLHQDWLNGKEYCKVSNKALPAPIEKTISKAKGQPR</u> <u>EPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT</u> <u>TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS</u> <u>LSLSPGK (SEQ ID NO:61)</u>	DIQMTQSPSSLSASVGDRVTITCRASQSIDT RLNWKYQKPKGKAPKLLIYSASSLQSGVPSR FSGSGSGTDFTLTISLQPEDFATYYCQQA YNPITFGQGTKEIKRTVAAPSFIAPPDE <u>QLKSGTASVCLNNFYPREAKVQWKVDN</u> <u>ALQSGNSQESVTEQDSKSTYSLSSTLTLSK</u> <u>ADYEKHKVYACEVTHQGLSSPVTKSFNRGE</u> <u>C (SEQ ID NO:56)</u>

*Constant region sequences in VSTB140, VSTB149 and VSTB174 are underlined. ^ΔAmino acid residues conferring protease resistance in the heavy chain of VSTB149 are indicated in bold.

[00125] Table 2: Dissociation constant (K_D) for select anti-VISTA antibodies

Sample	K_D (M)	k_{a1} (1/Ms)	k_{d1} (1/s)			
S1	1.71E-10	1.69E+06	2.89E-04	1.09E-10	1.11E+06	1.21E-04
S40	5.07E-10	1.46E+05	7.40E-05	6.96E-10	1.39E+05	9.69E-05
S41	6.32E-10	4.82E+05	3.05E-04	3.10E-10	7.08E+05	2.19E-04
S42	1.04E-10	1.05E+06	1.09E-04	2.65E-10	5.13E+05	1.36E-04
S43	2.64E-11	1.25E+06	3.30E-05	5.28E-11	1.18E+06	6.22E-05
S44	2.53E-11	1.23E+06	3.12E-05	6.40E-11	9.93E+05	6.36E-05
S45	2.35E-11	1.58E+06	3.72E-05	2.58E-11	1.46E+06	3.77E-05
S46	1.06E-10	1.56E+06	1.66E-04	2.96E-10	1.50E+06	4.44E-04
S47	3.56E-10	5.14E+05	1.83E-04	2.52E-10	5.69E+05	1.43E-04
S33	8.30E-10	1.23E+06	1.02E-03	1.22E-09	8.96E+05	1.10E-03
S34	1.08E-09	5.95E+05	6.43E-04	2.80E-09	5.20E+05	1.46E-03
S35	8.06E-11	2.08E+06	1.68E-04	1.35E-10	1.78E+06	2.41E-04
S36	6.29E-11	1.77E+06	1.12E-04	2.90E-11	1.58E+06	4.58E-05
S37	2.23E-09	5.10E+05	1.14E-03	4.43E-09	3.94E+05	1.75E-03
S38	2.26E-09	5.18E+05	1.17E-03	2.03E-09	5.37E+05	1.09E-03
S39	5.62E-10	3.97E+05	2.23E-04	3.47E-10	4.15E+05	1.44E-04
S25	1.31E-09	6.21E+05	8.12E-04	1.10E-09	5.65E+05	6.24E-04
S26	No Binding			3.53E-09	2.38E+05	8.41E-04
S27	1.13E-09	8.86E+05	9.97E-04	1.61E-09	7.12E+05	1.15E-03
S48	3.12E-10	1.24E+06	3.87E-04	1.21E-09	8.78E+05	1.06E-03
S28	2.03E-09	1.08E+06	2.19E-03	2.03E-09	9.30E+05	1.88E-03
S29	3.78E-11	1.42E+06	5.38E-05	8.90E-11	9.06E+05	8.06E-05
S30	No Binding			No Binding		
S31	Weak Binding			Weak Binding		
S32	Weak Binding			Weak Binding		
S15	9.34E-11	6.46E+05	6.04E-05	5.13E-10	3.50E+05	1.80E-04
S16	1.26E-10	5.54E+05	6.99E-05	1.92E-10	4.43E+05	8.53E-05
S17	7.68E-10	9.88E+05	7.59E-04	4.10E-10	7.09E+05	2.91E-04
S18	2.28E-09	4.90E+05	1.12E-03	1.05E-09	3.13E+05	3.29E-04
S19	1.54E-09	1.02E+06	1.58E-03	2.86E-10	7.03E+05	2.01E-04
S20	1.48E-09	6.67E+05	9.85E-04	4.57E-10	6.36E+05	2.91E-04
S21	3.18E-09	3.16E+05	1.00E-03	1.34E-09	2.70E+05	3.60E-04
S22	2.98E-09	1.09E+06	3.25E-03	1.27E-09	1.25E+06	1.59E-03
S6	6.36E-10	5.28E+05	3.36E-04	3.02E-10	5.98E+05	1.80E-04
S7	6.75E-10	1.31E+06	8.87E-04	3.27E-10	1.15E+06	3.75E-04
S8	1.15E-10	1.89E+06	2.18E-04	5.97E-11	1.25E+06	7.48E-05
S9	1.67E-10	1.87E+06	3.11E-04	9.31E-11	1.27E+06	1.18E-04
S10	8.90E-11	1.55E+06	1.38E-04	4.30E-11	1.22E+06	5.27E-05
S12	4.94E-10	1.57E+06	7.76E-04	2.39E-10	1.19E+06	2.86E-04
S13	1.02E-10	1.42E+06	1.44E-04	6.46E-11	9.55E+05	6.17E-05
S14	2.02E-10	1.26E+06	2.55E-04	7.55E-11	1.12E+06	8.43E-05

S1	2.06E-10	1.60E+06	3.29E-04	8.35E-11	1.21E+06	1.01E-04
S2	1.56E-10	9.74E+05	1.52E-04	8.66E-11	7.25E+05	6.28E-05
S3	4.33E-11	9.07E+05	3.93E-05	4.89E-11	7.41E+05	3.63E-05
S4	1.52E-10	8.98E+05	1.36E-04	7.54E-11	6.93E+05	5.23E-05
S49	1.45E-10	1.01E+06	1.46E-04	1.04E-10	7.28E+05	7.60E-05
S5	2.13E-10	1.25E+06	2.67E-04	1.37E-10	8.51E+05	1.17E-04

METHODS OF ELICITING A BIOLOGICAL RESPONSE

[00126] In an embodiment, the present invention provides a method of eliciting a biological response in a subject using an antibody that binds a V-domain Ig Suppressor of T cell Activation (VISTA) protein. The method comprises the steps of administering to a subject an antibody that binds a VISTA protein, or an antigen-binding fragment thereof, in an amount sufficient to elicit a biological response in the subject.

[00127] In certain embodiments, the biological response that is elicited by the antibody, or antigen-binding fragment, that binds VISTA is a decrease in the number of circulating immune cells; a decrease in the number of granulocytes in bone marrow and/or spleen; an increase in the number of neutrophils, macrophages, T cells, or a combination thereof in a tumor microenvironment (TME); an increase in the level of one or more cytokines; or any combination of these responses.

[00128] In an embodiment, the biological response that is elicited is a decrease in the number of circulating immune cells. The circulating immune cells that are decreased can be, for example, monocytes, neutrophils, lymphocytes, eosinophils, basophils, or any combination thereof. In one embodiment, the decrease in the number of circulating immune cells is transient.

[00129] As used herein, a “transient” decrease in the number of circulating immune cells refers to a temporary decrease relative to a level prior to administration of the antibody, or antigen-binding fragment, wherein the decreased level is restored to, or surpasses, the prior level at a subsequent time point.

[00130] In an embodiment, the biological response that is elicited is a decrease in the number of granulocytes in one or more tissues (*e.g.*, bone marrow) and/or organs (*e.g.*, spleen) of the subject.

[00131] In an embodiment, the biological response that is elicited is an increase in the number of immune cells in a tumor microenvironment (TME). The immune cells that are

increased in the TME can include, but are not limited to, neutrophils, macrophages, T cells, or any combination thereof.

[00132] In an embodiment, the biological response that is elicited is an increase in the level of one or more cytokines (*e.g.*, one or more chemokines). Examples of cytokines that can be increased in response to administration of an anti-VISTA antibody or antigen-binding fragment include, for example, IL-6, TNF α , MCP-3, MDC, MIP-1 β , IP-10, IL-1R α , GM-CSF, IL-12p70, GRO, MIP-1 α , IL-1 β , RANTES, G-CSF, IL-1 α , IL-7, IL-12p40, IL-13, IFN γ , TNF β , IFN α , IL-4, IL-10, FGF-2, fractalkine, VEGF, IL-17A, Flt3L, IL-9, TGF α , IL-15, EGF, PDGF- $\alpha\alpha$, MCP-1, IL-8, sCD40L, eotaxin, IL-2, IL-3, and IL-5, and PDGF-BB.

[00133] In a particular embodiment, the antibody that binds VISTA, or antigen-binding fragment thereof, that is administered to the subject comprises an Fc region having effector function (*e.g.*, binds to an Fc receptor on a cell). In a particular embodiment, the antibody or antigen-binding fragment thereof, binds to a CD16 receptor (*e.g.*, Fc γ RIIIa, Fc γ RIIIb) on an immune cell (*e.g.*, NK cell).

[00134] In an embodiment, the antibody that binds VISTA, or antigen-binding fragment thereof, that is administered to the subject comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30. In a particular embodiment, the antibody is VSTB174, or an antigen-binding fragment thereof.

[00135] In an embodiment, the subject to which the antibody that binds VISTA, or antigen-binding fragment thereof, is administered is a mammal. In one embodiment, the mammal is a human. In another embodiment, the mammal is a non-human primate. In yet another embodiment, the mammal is a rodent (*e.g.*, a mouse, a rat).

[00136] In an embodiment, the subject has cancer (*e.g.*, a solid tumor, a leukemia, a lymphoma). In some embodiments, the cancer is a leukemia, lymphoma, myelodysplastic syndrome and/or myeloma. In some embodiments, the cancer can be any kind or type of leukemia, including a lymphocytic leukemia or a myelogenous leukemia, such as, *e.g.*, acute lymphoblastic leukemia (ALL), chronic lymphocytic leukemia (CLL), acute myeloid (myelogenous) leukemia (AML), chronic myelogenous leukemia (CML), hairy cell leukemia, T-cell prolymphocytic leukemia, large granular lymphocytic leukemia, or adult T-cell

leukemia. In some embodiments, the lymphoma is a histocytic lymphoma, and in some embodiments, the cancer is a multiple myeloma. In some embodiments, the cancer is a solid tumor, for example, a melanoma, a breast cancer or bladder cancer. In some embodiments, the cancer is a lung cancer (*e.g.*, a non-small cell lung carcinoma (NSCLC)). In some embodiments, the cancer is a bladder cancer. In some embodiments, the cancer is a breast cancer.

[00137] The antibody or fragment thereof can be administered by any suitable parenteral or nonparenteral means including, for example, intravenously (IV), subcutaneously (SQ) or orally (PO).

METHODS OF SCREENING FOR ANTI-VISTA ANTIBODIES

[00138] The present invention provides, in an embodiment, a method of identifying an antibody that binds a V-domain Ig Suppressor of T cell Activation (VISTA) protein and elicits a biological response. The method comprises the steps of providing an antibody that binds VISTA, or an antibody fragment thereof, to *e.g.*, a cell, tissue, organ and/or organism, and determining whether the antibody or antibody fragment thereof induces a biological response in the cell, tissue, organ or organism.

[00139] In an embodiment, the biological response to be determined includes activation of monocytes; activation of T cells; a decrease in the number of circulating immune cells; a decrease in the number of granulocytes in bone marrow and spleen; an increase in the number of neutrophils, macrophages, T cells, or a combination thereof in a tumor microenvironment (TME); an increase in the level of one or more cytokines; or any combination of these responses.

[00140] In an embodiment, the antibody that binds VISTA, or antigen-binding fragment thereof, to be identified according to the present method comprises an Fc region having effector function (*e.g.*, binds to an Fc receptor on a cell). In a particular embodiment, the antibody or antigen-binding fragment thereof, binds to a CD16 receptor (*e.g.*, FcγRIIIa, FcγRIIIb) on an immune cell (*e.g.*, NK cell).

[00141] In an embodiment, the antibody that binds VISTA, or antigen-binding fragment thereof, to be identified according to the present method comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the

amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30.

[00142] In an embodiment, the biological response can be assayed in various types of samples, including but not limited to, a tissue sample, a biological fluid sample (*e.g.* mammalian plasma, serum, lymph, whole blood, spinal, amniotic, or other animal-derived fluid), a cell(s) (*e.g.*, a tumor cell, an immune cell) sample, and the like. Samples can include, for instance: (a) preparations comprising un-fixed fresh tissues and/or cells; (b) fixed and embedded tissue specimens, such as archived material; and (c) frozen tissues or cells. Thus, samples can be fresh or preserved, for example, in liquid solution, flash-frozen or lyophilized, smeared or dried, embedded, or fixed on slides or other supports.

[00143] In some embodiments, tissue or cell samples are fixed or embedded. Fixatives are used, for example, to preserve cells and tissues in a reproducible and life-like manner. Fixatives also stabilize cells and tissues, thereby protecting them from the rigors of processing and staining techniques. For example, samples comprising tissue blocks, sections, or smears can be immersed in a fixative fluid, or in the case of smears, dried.

[00144] Any means of sampling from a subject, for example, by blood draw, spinal tap, tissue smear or scrape, or tissue biopsy can be used to obtain a sample. Thus, the sample can be a biopsy specimen (*e.g.*, tumor, polyp, mass (solid, cell)), aspirate, smear or blood sample. The sample can be a tissue that has a tumor (*e.g.*, cancerous growth) and/or tumor cells, or is suspected of having a tumor and/or tumor cells. For example, a tumor biopsy can be obtained in an open biopsy, a procedure in which an entire (excisional biopsy) or partial (incisional biopsy) mass is removed from a target area. Alternatively, a tumor sample can be obtained through a percutaneous biopsy, a procedure performed with a needle-like instrument through a small incision or puncture (with or without the aid of a imaging device) to obtain individual cells or clusters of cells (*e.g.*, a fine needle aspiration (FNA)) or a core or fragment of tissues (core biopsy).

[00145] The samples can be examined cytologically (*e.g.*, smear), histologically (*e.g.*, frozen or paraffin section) or using any other suitable method (*e.g.*, molecular diagnostic methods). A tumor sample can also be obtained by *in vitro* harvest of cultured human cells derived from an individual's tissue. Tumor samples can, if desired, be stored before analysis by suitable storage means that preserve a sample's protein and/or nucleic acid in an analyzable condition, such as quick freezing, or a controlled freezing regime. If desired, freezing can be performed in the presence of a cryoprotectant, for example, dimethyl

sulfoxide (DMSO), glycerol, or propanediol-sucrose. Tumor samples can be pooled, as appropriate, before or after storage for purposes of analysis.

[00146] In an embodiment, the biological response can be determined using an *in vitro* assay including, for example, immunological and immunochemical methods including, but not limited to, flow cytometry (*e.g.*, FACS analysis), a cytokine release assay, a chemokine release assay, a cell activation assay, a cell proliferation assay, a cell migration assay, enzyme-linked immunosorbent assays (ELISA), including chemiluminescence assays, radioimmunoassay, immunoblot (*e.g.*, Western blot), immunohistochemistry (IHC), immunoprecipitation and other antibody-based quantitative methods (*e.g.*, Luminex[®] beads-based assays). Other suitable methods include, for example, mass spectroscopy.

[00147] In an embodiment, the biological response can be determined *in vivo* in a non-human animal. In one embodiment, the non-human animal is a non-human primate. In yet another embodiment, the non-human animal is a rodent (*e.g.*, a mouse, a rat). In some embodiments, the non-human animal is a transgenic animal.

[00148] In an embodiment, the non-human animal has cancer (*e.g.*, a solid tumor, a leukemia, a lymphoma). In some embodiments, the cancer is a leukemia, lymphoma, myelodysplastic syndrome and/or myeloma. In some embodiments, the cancer can be any kind or type of leukemia, including a lymphocytic leukemia or a myelogenous leukemia, such as, *e.g.*, acute lymphoblastic leukemia (ALL), chronic lymphocytic leukemia (CLL), acute myeloid (myelogenous) leukemia (AML), chronic myelogenous leukemia (CML), hairy cell leukemia, T-cell prolymphocytic leukemia, large granular lymphocytic leukemia, or adult T-cell leukemia. In some embodiments, the lymphoma is a histocytic lymphoma, and in some embodiments, the cancer is a multiple myeloma. In some embodiments, the cancer is a solid tumor, for example, a melanoma, a breast cancer or bladder cancer. In some embodiments, the cancer is a lung cancer (*e.g.*, a non-small cell lung carcinoma (NSCLC)). In some embodiments, the cancer is a bladder cancer. In some embodiments, the cancer is a breast cancer.

[00149] In an embodiment, the biological response to be assayed is a decrease in the number of circulating immune cells. The circulating immune cells that are decreased can be, for example, monocytes, neutrophils, lymphocytes, eosinophils, basophils, or any combination thereof. In one embodiment, the decrease in the number of circulating immune cells is transient.

[00150] In an embodiment, the biological response to be assayed is a decrease in the number of granulocytes in one or more tissues (*e.g.*, bone marrow) or organs (*e.g.*, spleen) of the subject.

[00151] In an embodiment, the biological response to be assayed is an increase in the number of immune cells in a tumor microenvironment (TME). The immune cells that are increased in the TME can include, but are not limited to, neutrophils, macrophages, T cells, or any combination thereof.

[00152] In an embodiment, the biological response to be assayed is an increase in the level of one or more cytokines (*e.g.*, one or more chemokines). Examples of cytokines that can be increased in response to administration of an anti-VISTA antibody or antigen-binding fragment include, for example, IL-6, TNF α , MCP-3, MDC, MIP-1 β , IP-10, IL-1R α , GM-CSF, IL-12p70, GRO, MIP-1 α , IL-1 β , RANTES, G-CSF, IL-1 α , IL-7, IL-12p40, IL-13, IFN γ , TNF β , IFN α , IL-4, IL-10, FGF-2, fractalkine, VEGF, IL-17A, Flt3L, IL-9, TGF α , IL-15, EGF, PDGF- $\alpha\alpha$, MCP-1, IL-8, sCD40L, eotaxin, IL-2, IL-3, and IL-5, and PDGF-BB.

ANTI-VISTA ANTIBODY COMBINATION THERAPIES AND COMPOSITIONS

[00153] As described herein, certain immune responses can be enhanced using a combination of an anti-VISTA antibody of the invention with one or more agents (*e.g.*, antibodies) that bind to one or more immune checkpoint proteins. Accordingly, in an embodiment, the present invention provides a pharmaceutical composition comprising a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to VISTA; b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein; and c) a pharmaceutically acceptable carrier, diluent, or excipient.

[00154] In some embodiments, the antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein maintains or enhances T cell activation in an individual. As readily understood by those of skill in the art, T cell activation can include, for example, an increase in the number of T cells and/or an increase in T cell function. Methods of determining an increase in T cell number, or an increase in T cell function (*e.g.*, as determined by a decrease or increase in one or more markers of immune activation) can be readily determined by those of skill in the art, and as described herein.

[00155] Immune checkpoint proteins are known in the art, and include, for example, PD-1, PD-L1, PD-L2, CTLA-4, TIM-3, LAG-3, OX40 and GITR. Examples of antibodies that are

known to bind to an immune checkpoint protein include, *e.g.*, nivolumab, pembrolizumab, tremelimumab, and ipilimumab.

[00156] In an embodiment, the pharmaceutical composition comprises a bispecific antibody that comprises the antibody or antibody fragment thereof that binds to VISTA and the antibody or antibody fragment thereof that binds to an immune checkpoint protein. For example, the bispecific antibody can comprise an anti-VISTA antibody of the present invention, and an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein selected from, *e.g.*, PD-1, PD-L1, PD-L2, CTLA-4, TIM-3, LAG-3, OX40 and GITR.

[00157] In one embodiment, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30. In some embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VH domain comprising SEQ ID NO:37. In some embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VL domain comprising SEQ ID NO:44.

[00158] In some embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.

[00159] In an embodiment, the present invention provides a pharmaceutical composition comprising a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to VISTA; b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a PD-1 protein; and c) a pharmaceutically acceptable carrier, diluent, or excipient.

[00160] In some embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence

of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30.

[00161] In an embodiment, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.

[00162] Various antibodies that bind to PD-1 are known in the art and include, for example, nivolumab and pembrolizumab.

[00163] In an embodiment, the present invention also provides a method of enhancing an immune response in an individual in need thereof, comprising administering to the individual a therapeutically effective amount of a) an antibody or an antibody fragment thereof comprising an antigen binding region that binds VISTA; and b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein, thereby enhancing an immune response to the cancer.

[00164] In some embodiments, the antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein maintains or enhances T cell activation.

[00165] In an embodiment, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30. In some embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VH domain comprising SEQ ID NO:37. In an embodiment, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody VL domain comprising SEQ ID NO:44. In certain embodiments, the antibody or antibody fragment thereof that binds to VISTA comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.

[00166] In some embodiments, the antibody or antibody fragment thereof that binds to an immune checkpoint protein binds to an immune checkpoint protein selected from, *e.g.*, PD-1, PD-L1, PD-L2, CTLA-4, TIM-3, LAG-3, OX40 and GITR. In one embodiment, the

antibody that binds to an immune checkpoint protein is, *e.g.*, nivolumab, pembrolizumab, tremelimumab, or ipilimumab.

[00167] In some embodiments, the immune response is an antitumor immune response. In certain embodiments, the immune response is a T cell response.

[00168] In one embodiment, the individual has a cancer, such as, for example, a solid tumor (*e.g.*, lung tumor, bladder tumor or breast tumor), a leukemia, a lymphoma, a myelodysplastic syndrome or a myeloma.

[00169] An anti-VISTA antibody of the present invention can be administered before, after or concurrently with one or more antibodies (*e.g.*, an anti-PD-1 antibody), or fragment thereof, that bind to an immune checkpoint protein. In some embodiments, the anti-VISTA antibody of the present invention and one or more antibodies that bind to an immune checkpoint protein can be co-administered simultaneously (*e.g.*, concurrently), as either separate formulations or as a joint formulation. Alternatively, the anti-VISTA antibody of the present invention and one or more antibodies that bind to an immune checkpoint protein can be administered sequentially, as separate formulations, within an appropriate time frame, as determined by the skilled clinician (*e.g.*, a time sufficient to allow an overlap of the pharmaceutical effects of the therapies). An anti-VISTA antibody of the invention and one or more antibodies that bind an immune checkpoint protein can be administered in a single dose or in multiple doses, in an order and on a schedule suitable to achieve a desired therapeutic effect.

EXAMPLES

[00170] EXAMPLE 1: ANALYSIS OF VISTA EXPRESSION ON HUMAN HEMATOPOIETIC CELLS

[00171] Methods:

[00172] Preparation and Staining of Fresh Human PBMCs For VISTA Expression

[00173] Expression of VISTA was tested on freshly isolated human PBMCs (peripheral blood mononuclear cells) from several donors. Anti-Human VISTA-biotin (GA-1) was used for staining (5 µg/ml). Mouse IgG1, K-biotin (Clone MOPC-21 at 5 µg/ml) was used as an isotype control.

[00174] Donor Material

[00175] Blood samples were obtained from Biological Specialty Corp. (Colmar, PA) and were collected and analyzed the same day. 10 ml of whole blood containing heparin sulfate were couriered for analysis.

[00176] Sample Preparation

[00177] Blood was diluted 1:1 in sterile PBS. 22 ml diluted cord blood was layered onto 20ml sterile Ficoll-Hypaque (GE Healthcare Cat# 17-144003) in 50 ml conical tubes. Tubes were centrifuged at 1800 rpm for 20 minutes at room temperature. Mononuclear cells at the interface following centrifugation were harvested using a 1 ml pipettor and combined into two 50 ml conical tubes. Sterile PBS was added to each tube to make the volume up to 50 ml and the cells were centrifuged at 300g for 10 minutes at 4°C. Supernatant was discarded. Cells were resuspended in 50 ml of sterile PBS and tubes were spun at 300g for 10 minutes at 4°C. Supernatant was discarded. Cells were combined and resuspended in 50 ml sterile PBS prior to counting.

[00178] Staining Protocol: A frozen vial containing 5×10^7 PBMCs was used for compensation controls and as a control for staining.

[00179] The following reagents and/or consumables were used:

[00180] FACS Stain Buffer (BSA) from BD Biosciences (Cat# 554657) supplemented with 0.2% EDTA; Phosphate-Buffered saline (PBS) (Gibco cat#14190); 96-well polypropylene round-bottomed plate (BD #3077); 1.2 ml polypropylene cluster tubes (Corning #4451); biotinylated Anti-VISTA clone GA-1 from ImmunoNext Lot# 080612B (used at 5 µg/ml); biotinylated mIgG1, K isotype control (Clone MOPC-21); Biolegend cat#400104, Lot#B116649 (used at 5 µg/ml); anti-human antibodies (See staining table below); near-Infrared live/dead dye (Invitrogen, cat# L10119); and streptavidin reagents including STP-APC (BD Biosciences cat#554067, Lot#04251) (used at 1:200 dilution in FACS buffer), STP-PE (Biolegend cat# 405203, Lot#B139688) (used at 1:200 dilution in FACS buffer), STP-PE Cy7 (showed non-specific binding in isotype control samples), STP-Q605 (Invitrogen cat# Q10101MP, Lot#53449A) (used at 1:200 dilution in FACS buffer).

[00181] Cell Surface Staining Protocol

[00182] Prior to staining, 1×10^6 cells were transferred into 96-well round-bottomed plates and were washed with 150 µl PBS. Plates were then centrifuged at 1300 rpm at 4°C for 3 minutes.

[00183] Subsequently, cells were washed again in PBS and centrifuged as described above.

[00184] Live/dead staining was then performed in 50 μ l PBS containing 0.25 μ l of near-infrared live/dead dye. After 10 minutes at room temperature the wells were washed with 150 μ l FACs staining buffer and centrifuged at 1300 rpm at 4°C for 3 minutes. Supernatant was discarded.

[00185] Cells were blocked with human serum at 1:100 in 50 μ l FACS staining buffer. Plates were incubated at 4°C for 15 minutes. Wells were then washed with 150 μ l FACs staining buffer and centrifuged at 1300rpm at 4°C for 3 minutes. Supernatant was discarded.

[00186] A cocktail containing the following antibodies was then added to each well for surface staining: The cocktails are described in Tables 3-6 below. Each cocktail would be utilized separately from the others depending on the populations of interest.

[00187] Table 3: Lineage Stain

Fluoro	Antigen	Target			Isotype	Clone	Supplier	Cat No.	Lot No.	Titer (μ l/ 10^6 Cells)
		Mouse	Rat	Human						
FITC/AF488	CD19			X	mIgG1	H1B19	Biologend	302206	B123019	2
PE	CD11b			X	mIgG1, K	ICRF44	BD Bio.	555388	45134	2
PerCP-Cy5.5	HLA-DR			X	mIgG2a, K	G46-6	BD Bio.	560652	25161	0.5
PE Cy7	CD16			X	mIgG1, K	3G8	BD Bio.	557744	87825	0.2
APC Cy7	NIR Live/Dead			X						
AF700	CD56			X	mIgG1, K	B159	BD Bio.	557919	19470	1
APC/AF647	VISTA-Bio			X						
PB/V450	CD3			X	mIgG1, K	UCHT1	BD Bio.	558117	90926	0.5
Q605	CD14			X	mIgG2a, K	TuK4	Invitrogen	Q10013	1049158	0.2

[00188] Table 4: T Cell Stain

Fluoro	Antigen	Target			Isotype	Clone	Supplier	Cat No.	Lot No.	Titer (μ l/ 10^6 Cells)
		Mouse	Rat	Human						
FITC/AF488	CD4			X	mIgG1, K	RPA-T4	BD Bio.	555346	38460	2
PE	VISTA-Bio			X						
PerCP-Cy5.5	CD8			X	mIgG1, K	RPA-T8	BD Bio.	560662	1037	0.5
PE Cy7	CD56			X	mIgG1, K	B159	BD Bio.	557747	47968	0.5
APC Cy7	NIR			X						
AF700	CD45RO			X	mIgG2a, K	UCHL1	Biologend	304218	B143062	1
APC/AF647	TCRgd			X	mIgG, K	B1	Biologend	331212	B126473	2

PB/V450	CD45RA			X	mlgG2b, K	HI100	BD Bio.	560363	90928	0.5
Q655	CD3			X	mlgG2a	S4.1	Invitroge n	Q10012	982352	0.5

[00189] Table 5: DC Stain

Fluoro	Antigen	Target			Isotype	Clone	Supplier	Cat No.	Lot No.	Titer (μ l/10 ⁶ Cells)
		Mouse	Rat	Human						
FITC/AF488	Lin1			X	Mix	Mix	BD Bio.	340546	2152758	5
PE	CD11c			X	mlgG1, K		BD Bio.	555392	45123	2
PerCP- Cy5.5	HLA-DR			X	mlgG2a , K	G46-6	BD Bio.	560652	25161	0.5
APC Cy7	NIR			X						
APC/AF647	CD83			X	mlgG1, K	HB15 e	BD Bio.	551073	57688	2
BV421	CD123			X	mlgG1, K	6H6	Biolegend	306017	B148193	0.5
Q605	VISTA-Bio			X						

[00190] Table 6: Myeloid Stain

Fluoro	Antigen	Target			Isotype	Clone	Supplier	Cat No.	Lot No.	Titer (μ l/10 ⁶ Cells)
		Mous e	Rat	Human						
FITC/AF488	CD33			X	mlgG1	HM3- 4	Biolegend	303304	B100963	3
PE	CD11b			X	mlgG1, K	ICRF4 4	BD Bio.	555388	45134	2
APC Cy7	NIR			X						
APC/AF647	VISTA-Bio			X						
Q605	CD45			X	mlgG1, K	HI30	Invitrogen	Q1005 1	880470	1

[00191] Following the surface staining, cells were washed twice as previously described with FACS staining buffer and centrifuged at 1300 rpm at 4°C for 5 minutes. Samples were resuspended in 50 μ l of FACS staining buffer containing the appropriate fluorescently-labeled streptavidin. Samples were incubated at 4°C for 30 minutes. Cells were washed with 150 μ l FACS staining buffer and centrifuged at 1300 rpm at 4°C for 5 minutes. This wash step was repeated before samples were resuspended in 250 μ l of FACS staining buffer. Samples were analyzed on a BD LSRFortessa™ cell analyzer (BD Biosciences) the same day.

[00192] Data Analysis

[00193] Flow cytometry data was reanalyzed using FlowJo Version 9 software to gate specific phenotypic populations. Enumeration of geometric mean was used to compare VISTA expression in different cell subsets. Each population was normalized for background by subtracting isotype control values from the mean values of the anti-VISTA treated samples. Graphs were prepared in Prism and statistics were performed using either student's T-test if only two samples were compared, or one-way ANOVA with Bonferroni post-tests.

[00194] Results:

[00195] Expression of VISTA on Human Myeloid and Lymphoid Subsets:

[00196] As shown in Figures 2A-2E, 3A-3G, 4, 5A-5B and 6A-6C, VISTA expression on CD14⁺ monocytes was significantly different from all other populations ($p < 0.001$). No significant differences between other populations were seen. Monocytes expressed the highest levels of VISTA in peripheral blood, with the CD14⁺CD16⁻ subset having significantly higher expression than CD14^{lo}CD16⁺ cells. While APCs showed moderate expression of VISTA, lymphoid subsets showed low expression levels.

[00197] Expression of VISTA on Human T and NK Subsets:

[00198] As shown in Figures 7A-7E, 8A-8G and 9, with NK subsets, CD56^{lo} cells exhibited significantly higher expression levels of VISTA than CD56^{Hi} NK cells. Of T cell subsets, CD8⁺ memory cells expressed the highest expression levels, although they are not significantly higher than CD8⁺ naive or CD4⁺ T cells.

[00199] Expression of VISTA on Human Dendritic Cell Subsets:

[00200] As shown in Figures 10A-10D, 11A-11C and 12, no significant differences in VISTA expression seen; DCs and basophils exhibited low expression of VISTA, with plasmacytoid dendritic cells (pDCs) generally being higher but not to a significant extent.

[00201] Conclusion: These results show expression of VISTA on various immune cell subsets, and that VISTA is expressed on monocytes most highly, with some expression on different T cell subsets and NK cells, and little to no expression on B cells.

[00202] EXAMPLE 2: VISTA EXPRESSION ON PERIPHERAL BLOOD CELLS

[00203] Methods:

[00204] Staining of whole blood: Freshly isolated whole blood (100 μ l) was stained with antibody cocktails as indicated below by incubation for 30 minutes at 4°C. Red blood cells (RBCs) were lysed with RBC lysis buffer and the remaining cells were washed 1x with staining buffer. Cells were re-suspended in 200 μ l of staining buffer. The data were collected using a MACSQuant flow cytometer and analyzed using FlowJo analysis software.

[00205] Staining of peripheral blood mononuclear cells (PBMCs): Peripheral blood mononuclear cells were isolated from whole blood using Ficoll gradient. Freshly isolated 1×10^6 PBMCs were stained with antibody cocktails in 100 μ l of staining buffer. Samples were incubated for 30 minutes at 4°C then washed once with staining buffer. Cells were re-suspended in 100 μ l of staining buffer. The data were collected using MACSQuant® flow cytometer (Miltenyi Biotec) and analyzed using FlowJo analysis software.

[00206] The antibodies used were CD11b, CD33, CD177, CD16, CD15, CD14, CD20, HLADR, CD3, CD4, CD8, CD127, CD69, and FOXP3 antibodies (Biolegend, San Diego, CA). The APC-conjugated mouse anti-human VISTA (clone GG8) was made by ImmuneNext (Lebanon, NH).

[00207] Conclusions:

[00208] Expression of VISTA on healthy human peripheral blood cells

[00209] Whole blood and peripheral blood mononuclear cells were analyzed for VISTA expression using multicolor flow cytometry. As shown in Fig. 15A and 15B, the highest level of VISTA expression was detected on monocytes followed by neutrophils. Both the CD4⁺ and CD8⁺ T cells expressed low level of VISTA as shown in Figure 13C and 13D.

[00210] Expression of VISTA on cancer patient peripheral blood cells

[00211] As shown in Figures 14A-C, peripheral blood mononuclear cells (PBMCs) from lung cancer patients were analyzed. Figure 14A is a representative FACS plot showing analysis of CD14⁺ monocytes and CD15⁺ myeloid derived suppressive cells (MDSCs). The results suggest that phenotypically CD15⁺ cells are neutrophil derived MDSCs. Additionally, these cells are absent in healthy blood samples. Figure 14B is a representative histogram of VISTA expression on healthy and cancer patient derived monocytes, suggesting a higher level of VISTA expression on cancer patient cells compared to healthy controls. Similarly higher level of VISTA was found on MDSCs in cancer patients, as shown in Figure 14C.

[00212] Figure 15A is a representative FACS plot showing the presence of neutrophil derived MDSCs in the blood of colon cancer patients. Figure 15B and 15C are representative histograms showing higher level of VISTA expression on cancer patients' monocytes compared to healthy donor blood samples.

[00213] Expression of VISTA on cynomolgus monkey peripheral blood cells

[00214] As shown in Figure 16A and 16B flow cytometry analysis of monkey whole blood revealed the VISTA expression pattern similar to human cells. Both monocytes and

neutrophils expressed the highest level of VISTA compared to CD4⁺ (Figure 16C) and CD8⁺ (Figure 16D) T cells.

[00215] EXAMPLE 3: VISTA EXPRESSION IN HEME MALIGNANCY CELL LINES AT THE RNA LEVEL AND PROTEIN LEVEL

[00216] Because VISTA is expressed in heme malignancies, an anti-VISTA antibody could potentially target the malignant cells for destruction, as well as block VISTA and promote anti-tumor immune responses.

[00217] The data includes RNAseq analysis of ~140 heme malignancy cell lines (some cell lines are repeated in the analysis). The data is shown in Figure 17.

[00218] The RNAseq values are listed as FPKM (Fragments Per Kilobase of exon per Million fragments mapped) values.

[00219] In essence, this means that all reads falling in the exonic regions of a gene were counted and normalized by both the length of the gene and the total number of reads per sample (to account for inter-sample differences). The cutoff value is 1; above 1 is positive for VISTA expression (at the RNA level), below 1 is negative for VISTA expression.

[00220] The results indicated that many cell lines are positive at the RNA level, primarily acute myeloid leukemias and chronic myelogenous leukemias. This may be expected since VISTA is highly expressed in normal myeloid cells, and because its function is believed to dampen immune responses, including anti-tumor immune responses.

[00221] EXAMPLE 4: GENERATION OF MONOCLONAL ANTIBODIES AGAINST VISTA

[00222] Phage Panning

[00223] Twenty four phage panning experiments were carried out to enrich for phage reactive to Cyno VISTA-His. The cynomolgus VISTA protein was used for these experiments as it showed better biotin conjugation than the human VISTA protein. To determine the success of the phage experiments, phage pools from the individual panning rounds were added to neutravidin plates coated with biotinylated cyno VISTA-His and detected with a HRP-conjugated anti-M13 antibody. Individual colonies were picked from the phage selection rounds and Fabs proteins were produced in 96 well plates. The expressed Fab supernatants were assayed for binding to biotinylated cyno VISTA-His. This resulted in more than 200 hits.

[00224] The VH and VL regions from the Fab plates were amplified, submitted for DNA sequencing and were exported as FASTA files. When picking the clones that should be

converted and tested as MABs, the clones were chosen based on sequence diversity as well as having limited post-translational modification risks and as few hydrophobic residues as possible.

[00225] The VH and VL from the phage clones were sub-cloned into mammalian IgG1/kappa expression vectors and transfected into HEK293 cells. The antibodies were purified on Protein A Sepharose Fast Flow affinity resin. The concentration of the phage MABs was determined by quantitative ELISA using Nanodrop measurements, The antibody panel was expressed at high levels. SDS-PAGE analysis demonstrated the integrity of each expressed antibody variant.

[00226] In-line maturation of the phage antibodies was done by amplifying the VH domains from the polyclonal antibody mixes from the last round of panning for cloning into phage vectors that have diversity in the VL. This resulted in an enriched VH pool which was sampled with additional diversity in the VL. The phage were taken through 1-2 rounds of stringent panning with the expectation to identify very high affinity binders to VISTA ECD His protein. A monoclonal Fab ELISA was run to determine the success of the maturation. ELISA and expression data was normalized to a reference clone set to 100% from the original de novo panning experiment and affinity matured clones with higher binding signal to cyno VISTA antigen than the reference clone were identified. This process generated several clones that demonstrated up to 200% binding when screened at low antigen concentration (1 nM), the clones with highest affinity were sequenced and produced as MABs.

[00227] Hybridoma generation

[00228] One group of BALB/cAnNCrl mice received one intraperitoneal (IP) injection of 50 µg Hu VISTA-Ig recombinant protein (Sino) emulsified in Complete Freund's Adjuvant followed two weeks later by one IP injection of 50 µg Hu VISTA-Ig recombinant protein emulsified in Incomplete Freund's Adjuvant. Two weeks later the mice received one IP injection of 50 µg cyno VISTA-Fc recombinant protein emulsified in Incomplete Freund's Adjuvant. All mice received a final injection of 25 µg human and 25 µg cyno VISTA at the base of tail in PBS, five days prior to splenic harvest for fusion.

[00229] Another group of BALB/cAnNCrl mice received one IP injection of 50 µg Hu VISTA-His recombinant protein emulsified in Complete Freund's Adjuvant. Two weeks later the mice received one IP injection of 50 µg Hu VISTA-His recombinant protein emulsified in Incomplete Freund's Adjuvant. Two weeks later the mice received one IP

injection of 50 µg Cyno VISTA-His recombinant protein emulsified in Incomplete Freund's Adjuvant. Two weeks later all mice received a final injection of 25 µg Hu VISTA-His and 25 µg Cyno VISTA-His in PBS, three days prior to splenic harvest for fusion.

[00230] On the day of fusion, mice were euthanized by CO₂ asphyxiation, the spleens were removed and placed into 10 mL of cold phosphate-buffered saline. A single cell suspension of splenocytes was prepared by grinding spleens through a fine mesh screen with a small pestle and rinsing with PBS at room temperature. Cells were washed once in PBS and subjected to RBC lysis. Briefly, cells were resuspended in 3mL of RBC lysis buffer (Sigma #R7757) per every spleen and placed on ice for 5 minutes. Cells were again washed once in PBS at room temperature and labeled for magnetic sorting. As per manufacturer's instructions, cells were labeled with anti-murine Thy1.2, anti-murine CD11b and anti-murine IgM magnetic beads (Miltenyi Biotec # 130-049-101, 130-049-601 and 130-047-301 respectively) then sorted using a MS column with a Midi MACS. The negative cell fractions (positive cell fractions were discarded) were fused to FO cells. Fusion was carried out at a 1:1 ratio of murine myeloma cells to viable spleen cells. Briefly, spleen and myeloma cells were mixed together, pelleted and washed once in 50 mL of PBS. The pellet was resuspended with 1 mL of polyethylene glycol (PEG) solution (2 g PEG molecular weight 4000, 2 mL DMEM, 0.4 mL DMSO) per 10⁸ splenocytes at 37°C for 30 seconds. The cell/fusion mixture was then immersed in a 37°C water bath for approximately 60 seconds with gentle agitation. The fusion reaction was stopped by slowly adding 37°C DMEM over 1 minute. The fused cells were allowed to rest for 5 minutes at room temperature and then centrifuged at 150 x g for 5 minutes. Cells were then resuspended in Medium E-HAT (MediumE (StemCell Technologies cat#03805) containing HAT (Sigma cat#H0262) and seeded in 96-well flat bottom polystyrene tissue culture plates (Corning # 3997).

[00231] A capture EIA was used to screen hybridoma supernatants for antibodies specific for cyno VISTA. Briefly, plates (Nunc-Maxisorp #446612) were coated at 4 µg/ml for at least 60 minutes with goat anti-mouse IgG (Fc) antibody (Jackson #115-006-071) in coating buffer (Thermo 28382). Plates were blocked with 200 µl/well of 0.4% (w/v) bovine serum albumin (BSA) in PBS at for 30 minutes at RT. Plates were washed once and 50 µl/well of hybridoma supernatant was added and incubated at room temperature for at least 30 minutes. Plates were washed once and 50 µl/well of 0.1 µg/mL of cyno VISTA-huIg was added and incubated at RT for 30 minutes. Plates were washed once and 1:40,000 Streptavidin HRP (Jackson 016-030-084) in 0.4% BSA/PBS was added to plates and incubated for 30 minutes

at RT. Plates were washed 3x and subsequently developed using 100µl/well TMB Turbo substrate (Thermo Scientific 34022) incubating approximately 10 minutes at RT. The reaction was stopped using 25µl/well 4N Sulfuric Acid and absorbance was measured at 450 nm using an automated plate spectrophotometer. Fifteen of the primary hits were selected for subcloning by limiting dilution and were screened in the same primary screen format.

[00232] All cyno VISTA reactive hybridoma cell lines were cross screened using human VISTA-Ig to assess cross-reactivity. Briefly, plates (Nunc-Maxisorp #446612) were coated at 4µg/mL with goat anti-ms Fc (Jackson#115-006-071) in 0.1M sodium carbonate-bicarbonate buffer, pH 9.4 (Pierce 28382 BupH™) O/N at 4°C. Without washing, the wells were blocked with 200 µl of block (0.4% BSA (Sigma) (w/v) in PBS (Invitrogen)) overnight at 4°C. After removing block solution, undiluted hybridoma supernatants were incubated on coated plates for 30 minutes at RT. Plates were washed once with PBST (0.02% Tween 20 (Sigma) (w/v) in PBS), and then incubated for 30 minutes with Hu VISTA-Ig diluted to 100 ng/ml in block. Plates were washed once with and probed with Goat antihuman-Fc-HRP (Jackson #109-036-098) diluted 1:10,000 in block for 30 minutes at RT. Plates were again washed and subsequently developed using 100µl/well TMB Turbo substrate (Thermo Scientific 34022) incubating approximately 10 minutes at RT. The reaction was stopped using 25µl/well 4N Sulfuric Acid and absorbance was measured at 450 nm using an automated plate spectrophotometer.

[00233] Hybridomas that were shown to be reactive to both human and cynomolgus VISTA had their V region antibody sequences cloned. Hybridoma cells were prepared prior to the reverse transcriptase (RT) reactions with Invitrogen's SuperScript III cells Direct cDNA System. Briefly, the culture medium was discarded and the plate placed on ice and resuspended in 200 µl cold PBS. Forty microliters was transferred to a MicroAmp fast 96 well Reaction PCR plate and the plate was placed on a cold metal plate base, sealed with plastic film and spun at 700 rpm for 3 minutes. The PBS was discarded and to each well, 10 µl Resuspension Buffer and 1 µl Lysis Enhancer was added. The plate was sealed and incubated at 75°C for 10 min and stored at -80°C.

[00234] For the RT reaction, each well contained 5 µl water, 1.6 µl 10X DNase Buffer, 1.2 µl 50 mM EDTA, 2 µl Oligo(dT)20 (50 mM) and 1 µl 10 mM dNTP Mix. The plate was incubated at 70°C for 5 min, followed by incubation on ice for 2 min, then the following reagents were added for each well; 6 µl 5X RT Buffer, 1µl RNaseOUT™ (40 U/µl), 1 µl SuperScript™ III RT (200 U/µl) and 1 µl of 0.1M DTT. The plate was sealed and placed on a

thermal cycler preheated to 50°C and incubated at 50°C for 50 minutes, followed by inactivation (5 min incubation at 85°C). The reaction was chilled on ice and the single-stranded cDNA was stored at –80°C until further use.

[00235] For V region amplifications, 20 µl PCR reactions were set up. Each well contained 16.2 µl water, 2.0 µl 10X PCR Reaction buffer, 0.8 µl MgSO₄ (50 mM), 0.4 µl 10mM dNTP, 0.15 µl 100 uM Forward primer mix 0.05 µl 100 uM Reverse primer, 0.2 µl HiFi Tag enzyme. The cDNA, prepared as described above, was transferred (2 µl/well) to the PCR components mixture, the plate was sealed and an amplification reaction was run; for VH the program was (i) 94°C for 1 min (ii) 94°C for 15 sec (iii) 55°C for 30 sec (iv) 68°C for 1 min. Steps (ii – iv) were repeated for a total of 35 cycles followed by a final extension at 68°C for 3 min. for VL the program was (i) 94°C for 1 min (ii) 94°C for 15 sec (iii) 55°C for 30 sec (iv) 65°C for 30 sec, (v) 68°C for 1 min. Steps (ii – v) were repeated for a total of 35 cycles followed by a final extension at 68°C for 3 min.

[00236] Forward primers were pre-mixed and such mixture was used in ration 3:1 with the reverse primer. PCR products were verified on an agarose gel. The reactions were prepared for infusion cloning by the addition of Enhancer (In-Fusion HC Cloning Kit, cat #639650, Clontech). Five microliters of the PCR reaction was transferred to a PCR plate followed by the transfer of 2 µl of enhancer/well. The plate was sealed and incubated in a thermal cycler (15 min at 37°C and 15 min at 80°C). The destination vector (vDR243 or vDR301) was prepared by Esp3I digestion; (1.5µg vector was digested in 3 µl Tango Buffer, 2 l Esp3I and water in a 30 µl reaction at 37°C for 2 hours).

[00237] For infusion cloning, 2 µl of enhancer treated PCR product was mixed with 100 ng Esp3I digested vector and 2 µl of 5X infusion enzyme (Clontech). The infusion reaction was done in 96-well PCR plate format. The plate was incubated for 15 min at 50°C on a PCR machine and Stella competent cells were transformed by heat shock for 40 seconds at 42°C without shaking and spread on LB agar plates with select antibiotic and incubated overnight at 37°C. Next day, colonies were picked into 96-well deep well plates containing LB/Carbenicillin media and grown overnight at 37°C. Frozen stocks were made from overnight culture mixing with equal volume of 30% w/v glycerol. The V regions were sequenced using sequencing primer SPF0052. The sequences were analyzed, one positive well per hybridoma vH and vL was chosen, re-arrayed in new plates and grown overnight in rich medium with ampicillin. Clones then had miniprep DNA prepared for small scale transfection in 96-well plate.

[00238] Forty eight selected mouse hybridoma sequences for both heavy and light chain were human framework adapted using an internal software program. One human framework was chosen for each one of the mouse vH or vL. V region DNA sequences were obtained through back-translation. Synthetic DNA regions corresponding to the HFA amino acid sequences were ordered from Integrated DNA Technologies (Coralville, IA). Cloning was performed into pre-cut vDR149 and vDR157, human IgG1 and human kappa respectively. Qiagen Endo-free Maxi-prep kits were used to prepare the DNA. Expi293 (100 ml) cultures were used to express this antibody panel.

[00239] EXAMPLE 5: PROTOCOL FOR HUMAN VISTA-IG T CELL SUPPRESSION ASSAY *IN VITRO*

[00240] Mouse A20 cells were stably transfected with either GFP or human VISTA. They were incubated with ova peptide and with DO11.10 T cells. CD25 expression by the T cells was measured 24 hours after incubation began. The A20-huVISTA cells suppress CD25 expression by the T cells, but this readout is significantly restored by incubation with VSTB95 (Figure 18).

[00241] EXAMPLE 6: HUMAN FRAMEWORK REGIONS ADAPTATION OF ANTI-VISTA ANTIBODIES

[00242] Mouse hybridoma sequences for both heavy and light chain were human framework adapted by CDR-grafting (Jones, et al. *Nature*, 321: 522-525 (1986) using an internal software program. The program delineates the complementarity determining regions (CDRs) of the V region sequences according to the Kabat definitions (Wu, T. T. & Kabat, E. A. (1970). *J Exp Med*, 132, 211-50) and compares the framework regions with the human germline genes using Blast. The human germline with the highest sequence identity to the mouse frameworks was chosen as the acceptor gene for human framework adaptation (HFA). In a few cases, closely related human germline genes were chosen instead, based on previous experience with well-expressed human frameworks. DNA sequences for the human frameworks chosen for each one of the mouse vH or vL V regions were obtained through back-translation. Synthetic DNA regions corresponding to the HFA amino acid sequences were ordered from Integrated DNA Technologies (Coralville, IA). Cloning was performed into human IgG1 and human kappa, respectively.

[00243] EXAMPLE 7: ANTI-VISTA ANTIBODY CONSTRUCTS

[00244] Plasmid and sequence information for the molecules for cell line development: Plasmid constructs were generated for anti-VISTA antibodies having the VSTB112 variable

regions and an IgG1κ constant regions (VSTB174, new number due to an allotypic change in the constant region), an IgG2sigma constant region (VSTB140) or an IgG1 protease-resistant constant region (VSTB149).

[00245] Lonza Vectors

[00246] The pEE6.4 and pEE12.4 Chinese hamster ovary (CHO) expression vector system (Lonza Biologics, PLC) was established in Biologics Research (BR) and Pharmaceutical Development & Manufacturing Sciences (PDMS) as the primary expression system for generation of therapeutic mAbs in mammalian expression cell lines. Each vector contains a human cytomegalovirus (huCMV-MIE) promoter to drive the expression of the heavy chain (HC) or light chain (LC) and contains the ampicillin resistance gene. pEE12.4 vector also includes the gene encoding the glutamine synthetase (GS) enzyme. Growth conditions which require glutamine synthetase activity places selective pressure on the cells to maintain the expression vector (GS Gene Expression System Manual Version 4.0). pEE6.4 was used to clone the HC gene and pEE12.4 to clone the LC gene as single gene vectors. The Lonza double gene plasmid is created from these two Lonza single genes vectors.

[00247] **Amino Acid Sequences of Variable Heavy Chain Regions of Select VISTA mAbs**

[00248] > VSTB112 heavy chain (SEQ ID NO:37)

[00249] QVQLVQSGAEVKKPGSSVKVSCKASGGTFSSYAISWVRQAPGQGLEWM
GGIPIFGTANYAQKFQGRVTITADESTSTAYMELSSLRSED TAVYYCARSSYGWSYE
FDYWGQGTLVTVSS

[00250] > VSTB50 heavy chain (SEQ ID NO:38)

[00251] QVQLVQSGSELKKPGASVKVSCKASGYTFTNYGLNWVRQAPGQGLEWM
GWINPYTGEPTYADDFKGRFVFSLDTSVSTAYLQICSLKAEDTAVYYCAREGYGNYI
FPYWGQGTLVTVSS

[00252] > VSTB53 heavy chain (SEQ ID NO:39)

[00253] QVQLVQSGAEVKKPGASVKVSCKASGYTFTHYTIHWVRQAPGQGLEWM
GYIIPSSGYSEYNQKFKDRVMTTRDTSTSTVYMELSSLRSED TAVYYCARGAYDDYY
DYYAMDYWGQGTLVTVSS

[00254] > VSTB95 heavy chain (SEQ ID NO:40)

[00255] EVQLVESGGGLVQPGGSLRLSCAASGFTFRNYGMSWVRQAPGKGLEWV
ASIISSGSYTYYPDSVKGRFTISRDNKNSLYLQMNSLRAEDTAVYYCARIYDHDGD
YYAMDYWGQGT TTVTVSS

[00256] Amino Acid Sequences of Variable Light Chain Regions of Select VISTA mAbs

[00257] >VSTB50 light chain (SEQ ID NO:41)

[00258] DIVMTQTPLSLSVTPGQPASISCRASESVDTYANSLMHWYLQKPGQPPQL
LIYRASNL ESGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCQQTNEDPRTFGQGTKL
EIK

[00259] >VSTB53 light chain (SEQ ID NO:42)

[00260] DIVMTQSPLSLPVTGPASISCRSSQTIVHSNGNTYLEWYLQKPGQSPQLL
IYKVS NRFS GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQASHVPWTFGQGTKL
EIK

[00261] >VSTB95 light chain (SEQ ID NO:43)

[00262] DIVMTQSPLSLPVTGPASISCRSSQSIVHSNGNTYLEWYLQKPGQSPQLL
IYKVS NRFS GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPWTFGQGTKL
EIK

[00263] >VSTB112 light chain (SEQ ID NO:44)

[00264] DIQMTQSPSSLSASVGDRVTITCRASQSIDTRLN WYQQKPGKAPKLLIYSA
SSLQSGVPSRFS GSGSGTDFTLTIS SLQPEDFATYYCQQA YNPITFGQGTKVEIK

[00265] >VSTB116 light chain (SEQ ID NO:45)

[00266] DIQMTQSPSSLSASVGDRVTITCRASQSINTNLN WYQQKPGKAPKLLIYAA
SSLQSGVPSRFS GSGSGTDFTLTIS SLQPEDFATYYCQQA RDPITFGQGTKVEIK

[00267] EXAMPLE 8: ELISA and FACS SCREENING OF ANTI-VISTA ANTIBODIES

[00268] These experiments were to determine the ability of the produced antibodies to bind human or cynomolgus VISTA protein in an ELISA, as well as to determine, using FACS screening, the ability of the antibodies to bind VISTA protein on the surface of K562 cells (human myelogenous leukemia cell line) expressing human or cynomolgus VISTA proteins.

[00269] Methods:

[00270] ELISA procedure summary: Plates were coated overnight at 4°C with 1 µg/ml SB0361 (human) or SB0361 (cyno (cynomolgus)) proteins, which are the extracellular domains of VISTA from the respective species. Antibodies were diluted to 1 µg/ml as a starting concentration with 1:4 step-wise dilutions for a total of 4 concentrations and incubated at room temperature room temperature (RT) for 2 hours. Mouse anti-human IgG1-

HRP (horseradish peroxidase) was used for detection and incubated for 1 hour at RT. All washes were performed using PBS-Tween (0.05%).

[00271] FACS procedure summary: 2×10^5 K562-G8 (human) or K562-C7 (cyno) cells were stained with 5 $\mu\text{g/ml}$ of each test antibody and incubated for 30 minutes at 4°C. Goat anti-human IgG1-PE (phycoerythrin) antibody was used as a secondary detection antibody at 5 $\mu\text{g/ml}$. Cells were run on a BD Fortessa and analyzed using FlowJo software (Tree Star, Inc., Ashland, OR) for MFI (mean fluorescence intensity) of the live population.

[00272] Data Analysis/Results: For each antibody, a subjective score (Yes/No) was given relating to whether the antibody bound robustly or not for both the ELISA and FACS analysis for each of the 4 assays. If an antibody gave a “No” result for binding in either assay, it was repeated to confirm that it was negative. The results are shown in Table 7 below and in Figures 19A-19F and 20A-20F.

[00273] Table 7.

INX Code	Hu ELISA	Cyno ELISA	Hu FACS	Cyno FACS
1	Y	Y	Y	Y
2	Y	Y	Y	Y
3	Y	Y	Y	Y
4	Y	Y	Y	Y
5	Y	Y	Y	Y
6	Y	Y	Y	Y
7	Y	Y	Y	Y
8	Y	Y	Y	Y
9	Y	Y	Y	Y
10	Y	Y	Y	Y
11	N	N	N	N
12	Y	Y	Y	Y
14	Y	Y	Y	Y
16	Y	Y	Y	Y
17	Y	Y	Y	Y
18	Y	Y	Y	Y
19	Y	Y	Y	Y
20	Y	Y	Y	Y
21	Y	Y	Y	Y
22	Y	Y	Y	Y
23	N	N	N	N
24	N	N	N	N
25	Y	Y	Y	Y
26	N	Y	N	Y
28	Y	Y	Y	Y
30	N	N	N	N
31	N	N	N	N
32	N	N	N	N

33	Y	Y	Y	Y
34	Y	Y	Y	Y
35	Y	Y	Y	Y
36	Y	Y	Y	Y
37	Y	Y	Y	Y
38	Y	Y	Y	Y
39	Y	Y	N	N
40	Y	Y	Y	Y
41	Y	Y	Y	Y
42	Y	Y	Y	Y
43	Y	Y	Y	Y
44	Y	Y	Y	Y
45	Y	Y	Y	Y
46	Y	Y	Y	Y
47	Y	Y	Y	Y
48	Y	Y	Y	Y
49	Y	Y	Y	Y

[00274] EXAMPLE 9: SCREENING RESULTS OF ANTI-HUMAN VISTA ANTIBODIES USING THE MIXED LYMPHOCYTE REACTION (MLR) AND *STAPHYLOCOCCUS* ENTEROTOXIN B (SEB) ACTIVATION ASSAYS

[00275] The purpose of this study was to present data supporting the identification of multiple functional α -VISTA antibodies that enhance cellular immune responses in the mixed lymphocyte reaction (MLR) assay, as well as the *staphylococcus* enterotoxin B activation (SEB) assay.

[00276] The mixed lymphocyte reaction (MLR) is a standard immunological assay that depends upon MHC class I and II mismatching to drive an allogeneic T cell response. Peripheral blood mononuclear cells are isolated from two mismatched individuals, incubated together and as a result of these mismatches, proliferation and cytokine production occurs.

[00277] Material and Methods:

[00278] 10% AB Media was prepared by combining 500 ml of RPMI with 50 ml of human AB serum, 5 ml of Penicillin/Streptomycin (10,000 U/ml), 5 ml of L-glutamine (100x) and 10 ml of HEPES (1M). Media was stored for no longer than 14 days. 1 mCi tritiated thymidine was prepared by diluting 0.2 ml of thymidine stock (1 mCi/ml) in 9.8 ml of RPMI.

[00279] Soluble VISTA antibodies were diluted to 20 μ g/ml in 10% AB serum media. 100 μ l of the appropriate antibody solutions was added to the appropriate wells of a 96 well U-bottom plate (Falcon product #353077 or equivalent). After the various cellular populations were added, the final concentration was 10 μ g/ml.

[00280] Isolation of white blood cells: Donors were at least 18 years of age, generally healthy and selected randomly from the local population. Transferred donor blood from isolation tubes to 50 ml conicals. Under-laid 15 ml of Ficoll 1077 per 25 ml of blood being careful not to mix with the blood. Centrifuged the cells at 1250g for 25 minutes at room temperature with no brake. White blood cells were isolated at the interphase of the Ficoll and the serum and diluted the cells into 40 ml of Hanks Balanced Salt Solution (HBSS). Centrifuged the cells at 453g (1500 rpm) for 10 minutes at 4°C. Resuspended the cells in 50 ml of HBSS and counted by transferring 500 µl to a separate tube.

[00281] Mixed lymphocyte reaction (MLR) 96 well plate setup: Determined the appropriate number of “stimulator cells” and “responder cells” needed for the assay based on the number of samples to be analyzed. The stimulator population is seeded at 0.5×10^5 cells/well and the responder population is seeded at 1.0×10^5 cells/well of a 96 well U-bottom plate. All conditions must be performed in triplicate. The appropriate number of “stimulator cells” were pipetted into a new conical and centrifuged as previously described. Resuspended cells in 10 ml and irradiated with 4000 rads. Centrifuged cells as previously described and resuspended at a concentration of 1×10^6 /ml in 10% AB serum media and added 50 µl to appropriate wells. Isolated the required number of responder cells and centrifuged as previously described and resuspended at a concentration of 2×10^6 /ml in 10% AB serum media and added 50 µl to appropriate wells. Incubated the cells for 5 days at 37°C and 5% CO₂. On the fifth day, removed 30 µl of supernatant for analysis of interferon gamma (IFN-γ) production. On the fifth day, added 25 µl of a 40 µCi/ml tritiated thymidine solution to each well and incubated for 8 hours at 37°C and 5% CO₂. Transferred cells to the 96 well micro scintillation plate per manufacturer’s instructions. Counted using the micro scintillation counter per manufacturer’s instructions. IFN-γ concentration was determined by ELISA (eBioscience cat# 88-7316-88) using manufacturer’s protocol.

[00282] Data analysis: Calculated the average counts per minute (CPM) or IFN-γ concentration for the non-treated wells. Calculated the average CPM or IFN-γ for each of the test groups. Log₁₀ transform the data set. Using 12 MLR fold-scores for each compound, calculated the average for the set of 12 test groups of each compound Average score for 12 experiments = $\Sigma [(\log_{10} (\text{Average CPM of triplicate for test compound})) - (\log_{10} (\text{Average CPM of triplicate for No Treatment}))]/12$

[00283] Acceptance criteria: All test reagents and appropriate controls were tested for endotoxin prior to running the assay and have levels of < 0.1 EU/mg. The responder cells alone had CPM counts below 700 CPM on average indicating that the cells were quiescent when incubated alone. The CPM for the MLR group was at least 2 fold higher than the CPM for responder cells incubated alone indicating that a reaction had occurred and that the donors are a mismatch. All MLR assays included a human IgG1 negative control protein. The result of the human IgG1 negative control was not statistically different from the non-treated samples based upon use of a student's t-test.

[00284] Screening of anti-VISTA antibodies in the MLR: Initial screen of all compounds. Prior to running the MLR with the anti-VISTA antibodies, antibodies were confirmed to bind both cell bound VISTA via FACS analysis and VISTA protein via ELISA. Antibodies S26 (VSTB77), S30 (VSTB86), S31 (VSTB88), S32 (VSTB90) and S39 (VSTB74) failed this initial screen but were still tested in the assay. For the purpose of initial screening, all antibodies were tested at 10 µg/ml in the MLR with proliferation and IFN-γ being the parameters measured (Figures 21A-21D and 22A-22B).

[00285] Selection of six lead antibodies. From the initial screen, six candidates were chosen for further analysis: VSTB112 (S2), VSTB116 (S5), VSTB95 (S16), VSTB50 (S41), VSTB53 (S43) and VSTB60 (S47).

[00286] Dilution studies of the top six candidates in the MLR: Protocol adjustments. The protocol is identical as previously described with the adjustment that antibodies were diluted to the following concentrations: 30, 10, 3, 1, 0.3, 0.1, 0.03, 0.01 and 0 µg/ml.

[00287] Determination of IC₅₀ values: Raw CPM counts and IFN-γ concentrations were used to determine the IC₅₀ for each of the antibodies. Calculations of IC₅₀ were determined through use of the program "EZ-R stats." Six individual responders were used to determine the IC₅₀ values. Individual CPM counts and IFN-γ concentrations in the MLR with dose titrations of the lead candidates.

[00288] Table 8: IC₅₀ values for both CPM and IFN-γ in the MLR

	VSTB112 (S2)	VSTB116 (S5)	VSTB95 (S16)	VSTB50 (S41)	VSTB53 (S43)	VSTB60 (S47)
CPM	-0.67	-0.78	-0.54	-0.12	-0.33	0.02
Gamma	-0.42	-0.16	0.22	0.06	0.27	0.4

** Values are in log₁₀ of antibody concentrations.

[00289] Conclusion: The initial screen indicated that multiple VISTA specific antibodies were capable of enhancing the MLR cellular immune response. Antibodies were then ranked

based upon efficacy and variance and based upon these results, VSTB112, VSTB116, VSTB95, VSTB50, VSTB53 and VSTB60 were chosen to evaluate in dose-titration experiments. VSTB60 induced a weaker response than the other five antibodies in the dose-titration experiments.

[00290] The *staphylococcus* enterotoxin B (SEB) activation assay: SEB is a bacterial super-antigen that induces activation of specific V β + T cells. Peripheral blood mononuclear cells are isolated and incubated with the SEB antigen in culture, which induces robust cytokine production. This assay was conducted on the five lead candidates.

[00291] Preparation of 10% AB Media, preparation of 1 mCi tritiated thymidine, preparation of soluble VISTA antibodies, and isolation of white blood cells were all performed as previously described above in the MLR.

[00292] SEB 96 well plate setup: Determined the appropriate number of responder cells needed for the assay based on the number of samples to be analyzed. The responder population is seeded at 2.0×10^5 cells/well of a 96 well U-bottom plate. All conditions must be performed in triplicate. Centrifuged cells as previously described and resuspended at a concentration of 4×10^6 /ml in 10% AB serum media and added 50 μ l to the appropriate wells. Added 50 μ l of 10% AB serum media containing the SEB antigen at a concentration of 40 ng/ml. In the described experiments, SEB was obtained from Sigma Aldrich (cat# S0812). The final concentration in the well was at 10 ng/ml. Incubated the cells for 3 days at 37°C and 5% CO₂. On the third day, removed 30 μ l of supernatant for analysis of IFN- γ production. Added 25 μ l of a 1 mCi/ml tritiated thymidine solution to each well and incubated for 8 hours at 37°C and 5% CO₂. Cells were transferred to the 96 well micro scintillation plate per manufacturer's instructions. Counted using the micro scintillation counter per manufacturer's instructions. IFN- γ concentration was determined by ELISA (eBioscience cat # 88-7316-88) using manufacturer's protocol.

[00293] Protocol: Data analysis. Calculated the average counts per minute (CPM) or IFN- γ concentration for each of antibodies at all concentrations. Acceptance criteria were performed as previously described. Determination of IC₅₀ values was performed as described. Individual CPM counts and IFN- γ concentrations in the SEB assay with dose titrations of the lead candidates.

[00294] Table 9: IC₅₀ values for both CPM and IFN- γ in the SEB.

	VSTB112 (S2)	VSTB116 (S5)	VSTB95 (S16)	VSTB50 (S41)	VSTB53 (S43)	VSTB60 (S47)
--	--------------	--------------	--------------	--------------	--------------	--------------

CPM	-1.16	-1.44	-1.12	-0.74	-1.06	not done
Gamma	-1.24	-0.35	0.05	1.69	-1.05	not done

**Values are in log10 of antibody concentrations.

[00295] Conclusions: VISTA specific antibodies enhanced cytokine production and proliferation in a dose dependent manner in the SEB assay. IC₅₀ values from the SEB study were generally similar to the results from the MLR dilution studies.

[00296] EXAMPLE 10: EPITOPE BINNING ASSAY

[00297] Methods: ProteOn XPR36 system (BioRad) was used to perform epitope binning. ProteOn GLC chips (BioRad, Cat#176-5011) were coated with two sets of 6 monoclonal antibodies (mAbs) using the manufacturer instructions for amine-coupling chemistry (BioRad, cat #176-2410).

[00298] Competing mAbs were pre-incubated in excess (250 nM final concentration) with human VISTA (25 nM final concentration) for 4 hours at room temperature and 6 at a time were run over the chip coated with the panels of coated mAbs with an association time of 4 minutes followed by dissociation for 5 minutes. Following each run, the chips were regenerated with 100 mM phosphoric acid.

[00299] The data analysis involved grouping all sensorgrams by ligand and applying an alignment wizard, which automatically performs an X and Y axis alignment, and artifact removal. An Interspot correction was then applied to the data.

[00300] A non-competing mAb was defined as having a binding signal the same or > A1 signal (binding to human VISTA only).

[00301] A competing mAb was defined as having binding signal << A1 signal (*i.e.*, binding to human VISTA only).

[00302] Results: In the example sensorgram shown in Figure 23, the VSTB85 antibody was coated on the Proteon SPR chip and VISTA protein preincubated with the indicated competitors was run over the chip. VSTB50 is an example of a non-competitive antibody, as a positive response was seen when the VISTA/VSTB50 complex was run. GG8, VSTB49 and VSTB51 complexed with VISTA did not bind to the VSTB85 coated on the chip and were therefore classified as competing for the same binding site on VISTA as VSTB85.

[00303] Table 10:

		Sample Set #1: coupled to sensor						Sample Set #2: coupled to sensor					
		L1	L2	L3	L4	L5	L6	L1	L2	L3	L4	L5	L6
Samples	Group	GG8	B85	B95	B104	B112	B113	B50	B53	B66	B67	IE8	B116
GG8	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y

VSTB100.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB101.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB102.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB103.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB104.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB105.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB106.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB107.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB108.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB109.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB110.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB111.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB112.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB113.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB114.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB115.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB116.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB49.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB51.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB53.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB59.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB65.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB67.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB70.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB81.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB92.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB95.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB97.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB98.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB99.001	1	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
VSTB50.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB54.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB56.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB60.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB63.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB66.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB73.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB76.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB78.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB84.001	2	N	N	N	N	N	N	Y	N	Y	N	N	N
VSTB85.001	3	Y	Y	Y	Y	Y	Y	N	Y	N	Y	I	Y
VSTB74.001	4	N	N	N	N	N	N	N	N	N	N	N	N
IE8	5	Y	I	Y	Y	Y	Y	N	Y	N	Y	Y	Y

mAb immobilized on sensor

Y = Yes competed (signal << than A1- human VISTA only)

N = No competed (signal > than A1- human VISTA only)

I = Inconclusive (signal similar to A1-human VISTA only)

[00304] EXAMPLE 11: PROTEON AFFINITY DETERMINATION

[00305] Antibodies were captured on ProteOn chips using anti-IgG Fc coated surfaces. The antibodies were tested for binding of human and cynomolgus (cyno) VISTA extracellular domains (ECDs) at concentrations of VISTA proteins ranging from 0.39 nM to 100 nM. The antigens were allowed to bind/associate to the antibody-coated chips for 4 minutes after which time dissociation was monitored for 30 minutes. Chips were regenerated with two treatments of 100 mM phosphoric acid for 18 seconds. All experiments were run at 25°C and data was fit to 1:1 Langmuir binding model.

[00306] EXAMPLE 12: EFFECTS OF ANTI-VISTA TREATMENT IN A MB49 MURINE BLADDER TUMOR MODEL

[00307] Methods:

[00308] C57Bl/6 mice were injected with MB49 tumor cells. Once the tumors were established, anti-VISTA treatment was initiated. Tumor growth was then monitored 3 times/week. Mice were euthanized, in accordance with IACUC regulations, once the tumors reached 15 mm in any dimension.

[00309] For each experiment, a frozen vial of MB49 cells was thawed and grown in RPMI 1640 (+ L-Glut) with 10% serum and penicillin/streptomycin antibiotics. After three days in culture, the cells were harvested using StemPro Accutase and resuspended in RPMI at a concentration of 5×10^6 cells/ml and 50 μ l injected per mouse.

[00310] Female C57Bl/6 mice, aged 6-8 weeks were purchased from the National Cancer Institute. Upon arrival they were allowed to acclimatize for one day prior to having their right flanks shaved and their tails tattooed. They were then injected three-five days later.

[00311] Tumor Injection (Intradermal): Mice were injected intradermally (i.d.) on their shaved flank with 50 μ l of MB49 cell suspension (~250,000 cells).

[00312] Monitoring Tumor Growth: Tumor growth was measured using electronic calipers first across the widest dimension (L) and secondly at a 90° angle to the first measurement (W). Tumor volume derived as follows:

[00313]
$$\text{Volume} = (L^2 * W^2) / 2$$

[00314] Tumors were considered established once they reached ~5mm in diameter (~60 mm³ volume). Once established, treatment was initiated. Tumor growth was measured three times per week over the course of treatment and until the experiment was terminated.

[00315] Anti-VISTA Treatment: Chimerized 13F3-mIgG2a monoclonal antibody was injected intraperitoneally at 10 mg/kg. Injection schedules were thrice weekly for four weeks.

[00316] Euthanizing Mice: As per IACUC requirements, animals were euthanized once their tumors reached 15mm in the longest dimension.

[00317] Analyzing Efficacy: Mouse tumor volumes were analyzed using Excel for data management, and GraphPad Prism for graphing. Statistical analysis was performed using a macro for R statistical computing software.

[00318] The experimental design is shown in Figure 24.

[00319] Results:

[00320] Ch13F3-mIgG2a treatment in female mice led to complete tumor rejection (CR) in 70% of the animals and partial remission (PR) in 30% (n=7) (Table 13 and Figure 25B). In contrast, all of the control mIgG2a-treated mice showed progressive growth of the tumors (6/6)(Figure 25A). These data demonstrate that anti-VISTA treatment can have a profound effect on tumor growth.

[00321] Table 11: Complete remission (CR) versus partial remission (PR)

	Female 13F3 IgG2a (n=7)
CR	5
PR	2 till day 32

[00322] The human VISTA sequence is shown in Figures 26 and 27, adapted from Wang *et al.*, 2011, *supra*, the contents of which are incorporated herein in their entirety.

[00323] EXAMPLE 13: EPITOPE MAPPING OF ANTI-VISTA ANTIBODIES USING HYDROGEN/DEUTERIUM (H/D) EXCHANGE STUDIES

[00324] To identify the epitopes for VSTB50, 60, 95 and 112 on human VISTA, solution hydrogen/deuterium exchange-mass spectrometry (HDX-MS) was performed using the corresponding Fabs. For H/D exchange, the procedures used to analyze the Fab perturbation were similar to that described previously (Hamuro *et al.*, J. Biomol. Techniques 14:171–182, 2003; Horn *et al.*, Biochemistry 45:8488-8498, 2006) with some modifications. Fabs were prepared from the IgGs with papain digestion and Protein A capture using Pierce Fab Preparation Kit (Thermo Scientific, Cat# 44985). The human VISTA protein sequence contains six N-linked glycosylation sites. To improve the sequence coverage, the protein was deglycosylated with PNGase F. The deglycosylated VISTA protein was incubated in a deuterated water solution for predetermined times resulting in deuterium incorporation at

exchangeable hydrogen atoms. The deuterated VISTA protein was in complex with either Fab of VSTB50, VSTB60, VSTB95 or VSTB112 in 46 μ L deuterium oxide (D_2O) at 4 °C for 30 sec, 2 min, 10 min and 60 min. The exchange reaction was quenched by low pH and the proteins were digested with pepsin. The deuterium levels at the identified peptides were monitored from the mass shift on LC-MS. As a reference control, VISTA protein was processed similarly except that it was not in complex with the Fab molecules. Regions bound to the Fab were inferred to be those sites relatively protected from exchange and, thus, containing a higher fraction of deuterium than the reference VISTA protein. About 94% of the protein could be mapped to specific peptides.

[00325] The solution HDX-MS perturbation maps of VISTA with VSTB50 / VSTB60, and VSTB95 / VSTB112 are shown in Figure 28 top and bottom, respectively. Two epitope groups were identified. Anti-VISTA VSTB50 recognizes the same epitope as VSTB60 does; VSTB95 binds to another epitope region as VSTB112 does on VISTA. Anti-VISTA VSTB50 and 60 share the same epitope which comprises segments, $_{103}NLTLDSGL_{111}$ (SEQ ID NO:62), and $_{136}VQTGKDAPSNC_{146}$ (SEQ ID NO:63) (Figure 28 top). Anti-VISTA VSTB95 and 112 appear to target similar epitopes, comprising segments $_{27}PVDKGHDVTF_{36}$ (SEQ ID NO:75), and $_{54}RRPIRDLTFQDL_{65}$ (SEQ ID NO:65) (Figure 28 bottom). There are two other segments showing weak perturbation by VSTB95 and 112, including residues 39-52 and 118-134. However, the levels of the reduction are not as strong as the previous regions (27-36 and 54-65) in the differential map. Although one peptide, $_{100}TMR_{102}$ showing strong perturbation by VSTB95 and 112, is located on the other face of VISTA surface, it is distant from the epitope regions, 27-36 and 54-65. This perturbation could be due to allosteric effect. These HDX-MS results provide the peptide level epitopes for anti-VISTA antibodies. There were no overlapping epitope regions for these two epitope groups. These results are in agreement with the previous competition binning data in that they do not compete with each other.

[00326] EXAMPLE 14: STRUCTURE DETERMINATION OF THE HUMAN VISTA ECD:VSTB112 FAB COMPLEX BY PROTEIN CRYSTALLOGRAPHY

[00327] In an effort to determine the VISTA structure and to delineate the epitope and paratope defining the interaction between VISTA extracellular domain (ECD) and the Fab fragment of lead antibody VSTB112, the complex was crystallized and structure determined to 1.85 Å resolution. The structure of the ECD of human VISTA in complex with the Fab fragment of the antibody VSTB112 was determined in an effort both to determine the structure of VISTA ECD itself and to define the epitope/paratope for this interaction. The

structure reveals VISTA to adopt an IgV fold with a chain topology similar to the TCR V α chain. In addition to the canonical disulfide bond bridging B and F strands in the back and front faces of the β -sandwich, the structure reveals the ECD to have two additional disulfide bonds, one tethering the CC' loop to the front sheet and a second between the A' and G' strands. Although crystal contacts between VISTA molecules are present, they are minor and there is no evidence for a dimer of VISTA ECDs based on this structure. The VSTB112 epitope is shown to comprise the portions of the VISTA BC, CC', and FG loops together with residues of the front beta sheet (C'CFG) nearest those loops. The paratope is biased largely toward heavy chain interactions with CDR L3 making minimal contact.

[00328] Epitope/paratope defining VISTA:VSTB112 interaction

[00329] VSTB112 Fab buries a surface area of 1024.3 Å² upon binding VISTA ECD, with burial of the heavy chain surface accounting for 715.3 Å² of this total. Seven hydrogen bonds and 4 salt bridge interactions are formed between VISTA and VSTB112 light chain and 10 hydrogens and 2 salt bridge interactions between VISTA and VSTB112 heavy chain. VSTB112 recognizes residues in the front sheet strands C', C, F, and G on the ends proximal to the FG loop as well as residues in the BC, FG, and CC' loops (Figures 29 and 30). Interactions with the CC' loop account for most of the contacts with the Fab light chain with only residues E125 and R127 in the FG loop making additional light chain interactions. Residues 119 to 127 corresponding to the VISTA FG loop account for 38% of the total 1034.8 Å² of surface area buried upon binding VSTB112. Notably, this loop is highly polar, comprised of the following sequence –IRHHHSEHR– (SEQ ID NO:76). Additionally, W103 in the VSTB112 CDR H3 packs nicely against the backbone of VISTA residues H122 and H123, and VISTA H121 makes an edge on interaction with the aromatic ring of F55 in CDR H2.

[00330] A comparison of epitope regions identified by crystallography and HDX is shown in Figure 31.

[00331] EXAMPLE 15: ACTIVATION OF T CELLS AND MONOCYTES BY ANTI-VISTA ANTIBODIES

[00332] The functional effect of anti-VISTA antibodies was evaluated in two *in vitro* assays, mixed leukocyte reaction (MLR) and SEB (*Staphylococcus enterotoxin B*). Both assays measure T cell proliferation and cytokine induction as their primary readouts, but these effects are due to different mechanisms. In the MLR, peripheral blood mononuclear cells (PBMCs) from two different human donors are incubated together, and major

histocompatibility complex (MHC) mismatch between T cells of one donor and dendritic cells of the other donor results in T cell proliferation and interferon (IFN γ) production. In the SEB assay, PBMCs from a single donor are incubated with a bacterial superantigen, which directly links MHC Class II protein on the surface of antigen-presenting cells (APC) to the T-cell receptor (TCR) on T cells, causing T cell activation, proliferation, and cytokine secretion. In both assays, VSTB112, which is the parent molecule of VSTB174, demonstrated dose-dependent induction of T cell proliferation and cytokine production, and was most potent among the candidates (Figures 21A-21D, Table 12).

[00333] Table 12. EC₅₀ values for the MLR assay readouts. VSTB112 (parent of VSTB174) was the most potent molecule.

Candidate	EC ₅₀ proliferation (μ g/ml)	EC ₅₀ IFN γ production (μ g/ml)
VSTB112	0.21	0.38
VSTB116	0.17	0.69
VSTB95	0.29	1.67
VSTB50	0.77	1.14
VSTB53	0.47	1.88
VSTB60	1.04	2.48

[00334] Monocyte Activation Assays

[00335] The assay data, shown in Table 12, was generated with VSTB112, the parent molecule of VSTB174. To better understand the activity of VSTB174, monocyte activation assays were conducted. The results showed that incubation of VSTB174 with whole PBMCs induced upregulation of activation markers (CD80 and HLA-DR) on CD14⁺ monocytes, indicating an effect of antibody binding to an immune cell subset known to express high levels of VISTA (Figure 32). A further question is whether the effects on monocyte activation in whole PBMC could be facilitated by any antibody that binds VISTA and has an IgG1 Fc. Antibodies VSTB103 and VSTB63 bind to VISTA with high affinity (K_D 6.36E-10 and 8.30E-10 respectively) and to cells expressing VISTA protein, similar to VSTB112 and VSTB111. VSTB103 is in the same epitope bin as VSTB112, while VSTB63 is in a different epitope bin; neither antibody facilitated monocyte activation. Taken together, these results show that one mechanism by which VSTB174 may exert its effect on T cell activation/proliferation is via monocyte activation facilitated by NK cells.

[00336] Preparation of Media

[00337] 500 ml of RPMI 1640 (Corning, 10-040-CV) was combined with 50 ml of human AB serum (Valley Biomedical, Inc, Lot # 3C0405), 5 ml of Penicillin/Streptomycin (Lonza, 17-602E) 10,000 U/ml, 5 ml of L-glutamine (100x) (Gibco, 25030-081) and 10 ml of HEPES (1M) (Fisher BP299-100, Lot#-1). Media was stored for no longer than 14 days at 4°C.

[00338] Preparation of soluble VISTA and control antibodies

[00339] Antibodies were diluted to 2X desired concentration in 10% AB serum media:
VSTB174: lot VSTB174.003

[00340] Added 100 µl of the appropriate antibody solutions to the appropriate wells of a 96 well U-bottom plate (Falcon, 353077). After the various cellular populations were added in 100 µl, the final concentration of each antibody was 1, 0.1 or 0.01 g/ml. IgG1 control antibody CNTO 3930 (Lot 6405, ENDO <0.1 EU/mg) was added at a final concentration of 1 µg/ml.

[00341] The PBMCs were isolated

[00342] Donors were at least 18 years of age, generally healthy and selected randomly from the local population.

[00343] Donor blood was transferred from isolation tube to 50 ml conicals.

[00344] 15 mls of Ficoll 1077 (SIGMA, 10771) were under-laid being careful not to mix with the blood. This was per 25 mls of blood.

[00345] The cells were centrifuged at 1250g for 25 minutes at room temperature with no brake.

[00346] The white blood cells were isolated at the interphase of the Ficoll and the serum and the cells were diluted into 40 ml of Hanks Balanced Salt Solution (HBSS).

[00347] The cells were centrifuged at 453g (1500 rpm) for 10 minutes at 4 C.

[00348] The cells were resuspended in 50 mls of HBSS and were counted by transferring 500 l to a separate eppendorf tube.

[00349] Additionally, a Pan Monocyte isolation kit from Miltenyi was used per manufacturer's instructions (cat# 130-096-537) to isolate CD14+ cells by negative selection in several treatment groups.

[00350] *In vitro* culture setup

[00351] The appropriate number of cells needed was determined for the assay based on the number of samples to be analyzed. The responder population was seeded at 2.0×10^5 cells/well of a 96-well U-bottom plate. For the CD14 negatively selected population, 0.5×10^5 cells were seeded. All conditions were performed in triplicate.

[00352] The cells were centrifuged as described above and resuspended at a concentration of 2×10^6 /ml for the whole PBMC population and 0.5×10^6 /ml for the CD14 negatively selected population in 10% AB serum media and added 100 μ l of test antibody to appropriate wells bringing the total volume in each well to 200 μ l.

[00353] The cells were incubated for 1, 2, or 3 days at 37° C and 5% CO₂.

[00354] Antibody staining and flow cytometry

[00355] The 96 well U-bottom plate was centrifuged for 5 minutes at 453g and removed the supernatant.

[00356] Cells were washed with 200 μ l PBS and centrifuged as in step 5.5.1.

[00357] The supernatant was discarded and resuspended in 50 μ l of PBS containing the following antibodies:

- CD14-APC (clone HCD14) 1:250 (Biolegend cat #325608)
- HLA-DR-PE Cy7 (clone L243) 1:250 (Biolegend cat # 307616)
- CD80-PE (clone 2D10) 1:250 (Biolegend cat # 305208)
- Hu FcR binding inhibitor (eBioscience cat # 14-9161-73)

[00358] Was incubated for 20 minutes on wet ice in the dark.

[00359] 150 μ l of PBS was added and centrifuged as in step 5.5.1.

[00360] 150 μ l of PBS buffer was added and analyzed via FACS.

[00361] Samples were run on a Miltenyi MACSQuant 10-parameter flow cytometer and analyzed using FlowJo 9.7.5 for expression of HLA-DR and CD80 on the CD14+ population. Geometric mean fluorescence intensity (MFI), a statistic that defines the central tendency of a set of numbers, was used as the defining statistic to compare treatments.

[00362] Statistical Analysis

[00363] All statistics were carried out in Prism GraphPad, version 6. Pair-wise comparisons amongst the groups were made at each of the time-points using One-Way ANOVA with Tukey correction for multiplicity. P-values less than 0.05 for all tests and comparisons were deemed significant. For all graphs and tables, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$.

[00364] EXAMPLE 16: ADCC AND ADCP ACTIVITIES OF ANTI-VISTA ANTIBODIES

[00365] VSTB174 has an IgG1 Fc, which can confer antibody-dependent cell-mediated cytotoxicity (ADCC) and antibody-dependent cell-mediated phagocytosis (ADCP) activity. Both types of assays were conducted and showed that VSTB174 could lyse or phagocytose

K562-VISTA cells (Figures 33-34), but not K562 myeloma cell line parental cells (data not shown). An additional mechanism of action of VSTB174 to modulate the inhibitory action of VISTA may be the lysis or engulfment of cells expressing high levels of VISTA, thus removing them from the local microenvironment.

[00366] EXAMPLE 17: ADCP ACTIVITIES OF ADDITIONAL ANTI-VISTA ANTIBODIES

[00367] An *in vitro* phagocytosis assay was used to study the enhancement of macrophage-mediated phagocytosis of cells ectopically expressing VISTA by anti-human VISTA mAbs (VSTB173 and VSTB174). These mAbs were cloned into different Fc backbones (IgG1 WT (wild type), IgG1 PR (protease resistant), and IgG2 σ) and were postulated to potentially have different activities with respect to enhancing phagocytosis. The IgG1 and IgG1 PR backbones are capable of binding to Fc receptors and have the potential to cause ADCP, while the IgG2 σ does not bind to Fc receptors and should not mediate ADCP.

[00368] Anti-VISTA antibodies were tested in ADCP assays with K562 parental and K562-VISTA target cells. As shown in Figures 35-36, VSTB174, VSTB149, VSTB173 and VSTB145 enhanced hMac phagocytosis of K562-VISTA cells. VISTA antibodies VSTB140 or VSTB132, with the IgG2 σ Fc that did not bind Fc receptors, did not enhance phagocytosis as expected. VISTA mAbs VSTB174 and VSTB173 with IgG1 Fc showed more robust phagocytosis than VSTB149 and VSTB145 with the IgG1PR Fc (see Tables 13 and 14 for EC₅₀ values).

[00369] Table 13. Anti-human VISTA mAb EC₅₀ values.

Treatment	VSTB174	VSTB149	VSTB140
EC ₅₀	0.0782	0.1142	NA

[00370] Table 14. Anti-human VISTA mAb EC₅₀ values.

Treatment	VSTB173	VSTB145	VSTB132
EC ₅₀	0.0146	0.1075	NA

[00371] VSTB174 and VSTB173 showed weak enhancement of phagocytosis of K562 parental cells at the highest concentration (Figures 35-36), which may be due to low expression of VISTA by the K562 cells. The other anti-VISTA antibodies did not enhance phagocytosis of the K562 cells.

[00372] The negative control antibodies were each tested at two different concentrations in the K562-VISTA phagocytosis assay, but did not induce any phagocytosis. This result indicates that the phagocytosis mediated by the anti-VISTA antibodies is specific and due to VISTA antigen expression by the K562-VISTA cells.

[00373] EXAMPLE 18: ADCC ACTIVITIES OF ADDITIONAL ANTI-VISTA ANTIBODIES

[00374] In order to test their ability to induce ADCC, the following three human anti-VISTA antibodies were tested:

VSTB174 (IgG1)

VSTB149 (IgG1 PR)

VSTB174.LF (IgG1 LF (low fucose)).

[00375] Each antibody was tested at six different concentrations within the same plate, in triplicate over two separate experiments for a total of six data points.

[00376] VSTB174, VSTB149, and VSTB174.LF each demonstrated measurable ADCC activity at 10, 1, 0.1 and 0.01 $\mu\text{g/mL}$, while only the LF antibody demonstrated measurable ADCC activity at 0.001 $\mu\text{g/mL}$; none of the antibodies demonstrated ADCC at 0.0001 $\mu\text{g/mL}$. As each of these antibodies has an IgG1 or IgG1 variant Fc, this result is expected. The LF antibody demonstrated increased ADCC potency as evidenced by the smaller EC_{50} value for the LF antibody curve (0.002293 $\mu\text{g/mL}$) as compared to the regular IgG1 antibody curve (0.02381 $\mu\text{g/mL}$). The IgG1 PR antibody curve had an EC_{50} value similar to the regular IgG1 curve (0.01846 $\mu\text{g/mL}$).

[00377] Table 15. EC_{50} values ($\mu\text{g/mL}$) of three tested anti-VISTA antibodies as determined by ADCC analysis.

anti-VISTA Antibody	EC_{50} ($\mu\text{g/mL}$)
VSTB174 (IgG1)	0.02381
VSTB149 (IgG1 PR)	0.01846
VSTB174.LF (IgG1 LF)	0.002293

[00378] The human IgG1, human IgG1 PR and human IgG1 LF antibodies all showed measurable ADCC mediated killing at the 10, 1, 0.1 and 0.01 $\mu\text{g/mL}$ antibody concentrations, while only the LF antibody showed killing at the 0.001 $\mu\text{g/mL}$ antibody concentration. None of the anti-VISTA antibodies showed killing at the 0.0001 $\mu\text{g/mL}$ antibody concentration.

[00379] The LF antibody showed approximately 10 times more potent ADCC killing than either the regular IgG1 antibody or the IgG1 PR antibody, as seen in the EC_{50} values.

[00380] EXAMPLE 19: AFFINITY OF VSTB174 FOR HUMAN AND CYNOMOLGUS VISTA

[00381] The affinity of VSTB174 for human and cynomolgus monkey VISTA extracellular domain (ECD) was determined by surface plasmon resonance (SPR) methods on a ProteOn instrument. VSTB174 displayed very similar KD values for each protein, 1.56E-10 M for human VISTA ECD and 8.66E-11 M for cynomolgus VISTA.

[00382] EXAMPLE 20: VISTA ANTIBODIES EXHIBIT EFFICACY IN MURINE TUMOR MODELS

[00383] Mouse Strains, Reagents and Tumor Models

[00384] For the *in vivo* studies, human VISTA knockin (VISTA-KI) mice back-crossed onto a C57Bl/6 background were used.

[00385] An anti-human VISTA antibody was generated to enable testing in the VISTA-KI mice, using the VSTB174 variable region grafted onto mouse Fc IgG2a (VSTB123).

[00386] The MB49 bladder cancer was evaluated in the VISTA KI mice,

[00387] In addition to published studies demonstrating that anti-VISTA antibody therapy inhibits tumor growth in wild type mice (Le Mercier et al., 2014), anti-tumor efficacy has been demonstrated with the surrogate hamster antibody in wt mice using different dosing schedules, and in the VISTA-KI mice treated with VSTB123.

[00388] *In Vivo* Efficacy Studies in the MB49 Tumor Model in VISTA-KI Mice

[00389] MB49 efficacy studies were conducted in female VISTA-KI mice, testing VSTB123 at several doses ranging from 1- 10 mg/kg. Mice were injected intradermally with 250,000 MB49 tumor cells on day 0. On day 6, dosing began as indicated in Figure 37 (either 10 mg/kg of the isotype control mIgG2a, or the indicated doses of VSTB123; 10 mice/group).

[00390] VSTB123 was more effective at higher vs lower doses, as shown in Figure 37. Doses of 10 mg/kg and 7.5 mg/kg were equivalent, while tumors grew more quickly in the mice dosed at 5 or 1 mg/kg.

[00391] EXAMPLE 21: DETECTION OF VISTA EXPRESSION IN HUMAN TUMORS WITH ANTI-VISTA ANTIBODIES

Figure 1 shows VISTA expression by an AML tumor cell line—this and the RNA seq expression data in Figure 17 support the idea that VISTA is expressed by AML cells and that anti-VISTA drug be efficacious through directly targeting these cells for immune modulation or antibody-mediated killing.

[00392] Data to evaluate VISTA expression in lung cancer was obtained from lung tumor samples from surgical resections. Cells were dissociated and characterized for expression of VISTA and many other markers. Results showed that 13/13 lung tumors (squamous or adenocarcinomas) contained CD14+ VISTA+ myeloid cells, (Figure 38).

[00393] EXAMPLE 22: DETECTION OF VISTA EXPRESSION IN LUNG TUMORS USING ANTI-VISTA ANTIBODIES

[00394] An immunohistochemistry assay was developed using clone GG8, an anti-human VISTA mouse IgG1. This mAb was used to investigate the staining of VISTA in non small cell lung cancer (NSCLC) FFPE tumor sections.

[00395] FFPE tumor sections were treated with standard antigen retrieval methods prior to staining. GG8 mouse anti-human VISTA antibody was used at a 1:500 dilution. GG8 binding was detected using a rabbit anti-mouse polyclonal antibody, followed by anti-rabbit polymer HRP. Counterstain with hematoxylin followed, then tumor sections were scored.

[00396] VISTA expression in lung cancer was mostly restricted to the immune infiltrate (example shown in Figure 39) and high levels of VISTA positive cells were present in many lung cancer samples

[00397] EXAMPLE 23: STRUCTURE OF THE EXTRACELLULAR DOMAIN (ECD) OF HUMAN VISTA IN COMPLEX WITH THE FAB FRAGMENT OF VSTB174

[00398] VISTA antigen variants were generated and purified for crystallography. Recombinant his-tagged VSTB174 Fab was internally expressed and purified. Crystals were generated and used to collect higher resolution data for the VISTA ECD:VSTB174 Fab complex using synchrotron radiation and the structural determination was solved using combinations of homology modeling and electron density analyses (Figure 29(Top)).

[00399] The structure of the VISTA ECD:VSTB174 Fab complex was determined by x-ray crystallography to a resolution of 1.85Å, providing the first structure of the VISTA ECD and delineating the VSTB174 epitope and paratope. The VISTA ECD adopts an IgV fold with a topology similar to CTLA-4 ECD, but possesses a unique G' strand that extends the front sheet of the β -sandwich. A' and G' are further tethered chemically via a disulfide bridge formed between residues C12 in the A' strand and C146 in the G' strand. Six cysteines were found to be engaged in three intramolecular disulfide bonds, and, based on crystal contacts, there is no evidence for a dimeric VISTA.

[00400] VSTB174 recognizes residues in the front sheet strands C', C, F, and G on the ends proximal to the FG loop as well as residues in the BC, FG, and CC' loops.

[00401] EXAMPLE 24: MONOCYTE ACTIVATION BY ANTI-VISTA ANTIBODIES REQUIRES CD16 (FcγRIII) CROSS-LINKING

[00402] The present study was designed to evaluate the ability of anti-VISTA antibodies to activate monocytes in culture. Monocyte activation was assessed by the upregulation of surface expression of canonical markers of monocyte activation: CD80, CD86, HLA-DR, and PD-L1. Given that VSTB174 has an active Fc, the roles of CD16 and other Fc receptors in anti-VISTA-mediated monocyte activation were studied. In particular, the ability of anti-CD16, anti-CD32, and anti-CD64 antibodies in blocking anti-VISTA-mediated monocyte activation was examined, in which VSTB112 (HuIgG1 active Fc) or VSTB140 (IgG2sigma silent Fc) was used to elicit monocyte activation. Soluble Fc fragments were also used in the same assay to block Fc binding non-specifically.

[00403] CD16 expression on PBMC (which lack neutrophils) is typically restricted to NK cells and inflammatory monocytes (CD14+/-, CD16+). NK cells were depleted to determine their role in anti-VISTA induced monocyte activation. Additionally, IFN-γ, a major product of activated NK cells capable of monocyte activation was blocked to assess its individual contribution.

[00404] Methods

[00405] Preparation of Media

[00406] All dilutions and culturing were done in RPMI (Life Technologies; cat# 11875-093) containing 10% Human AB serum (Sigma-Aldrich, Cat# H5667) and 1% Penn/Strep (Life Technologies; cat# 15140-122).

[00407] Blocking Antibodies

[00408] Anti-CD16 (Biolegend Cat# 302050, Clone 3G8), anti-CD32 (BD Cat# 552930, Clone FLI8.26), and anti-CD64 (Biolegend Cat# 305016, clone 10.1) were diluted to 20 μg/ml in complete media as indicated. The in-house block (IHB) was diluted to 8 mg/mL, also in complete medium.

[00409] 50 μl of these stocks were plated out in triplicate on a 96 well plate for each activating/blocking condition indicated. 50 μL of media containing no antibodies was used for the “no block control”.

[00410] Cell Preparation

[00411] 2 vials of frozen PBMC (HemaCare PB009C-1, 10×10^6 cells per vial) per each donor indicated were thawed in a 37 degree water bath, diluted to 10mL in complete media, and centrifuged @1500RPM for 5 minutes.

[00412] The media containing diluted freezing media was removed and cells were washed with 10 mL of fresh media and spun down as above. Prior to this spin, a 10 μ L sample was retained for each sample.

[00413] Cell counts were determined by diluting samples 1:2 in trypan blue and counting on a Countess™ Automated Cell Counter (Cat #C10227). Cells were resuspended in complete media at a concentration of 2×10^6 cells/mL. 100 μ L of this cell preparation was added to all experimental wells. The cell/blocking antibody mixture-containing plates were incubated for 15 minutes at 37 degrees C.

[00414] Activation

[00415] VSTB112, VSTB140, and HuIgG1 isotype control (11.76 mg/mL) were all diluted to 20 μ g/mL in complete media. After completion of the incubation step, 50 μ L of the activating antibody stocks were added to the appropriate well containing cells and blocking reagents. Final concentration of blocking and activating antibodies was 5 μ g/mL. Final concentration of IHB was 2 mg/mL. Cells were incubated at 37 degrees C overnight (20 hours).

[00416] Analysis

[00417] After incubation, all experimental plates were spun down at 1500RPM for 5 minutes. 150 μ L of the medium was removed via pipetting and stored at -80° C for later analysis. 150 μ L of FACS buffer (Becton Dickinson; cat #554657) was added to each well, mixed by pipetting, and samples were spun down once more at 1500 RPM for 5 minutes. Cells were resuspended in 50uL of FACS buffer containing 2 mg/mL of the IHB and were incubated at 4 degrees C in the dark for 20 minutes. After incubation, 50 μ L of the following staining mix diluted in FACS buffer was added to all samples (all antibodies diluted 1:25): CD14 –APC (Biolegend, clone HCD14); CD80-PE (Biolegend, clone CD10); CD86-FITC (Biolegend, clone IT2.2); HLA-DR – APCCy7 (Biolegend, clone L243); PD-L1 – PeCy7 (Biolegend, clone 29E2A3). Samples were incubated for 30 minutes at 4 degrees C in the dark. Following incubation, 100 μ L of FACS buffer was added to each well and plates were spun down @1500 RPM for 5 minutes. Cells were washed 1X as described above and finally resuspended in 200 μ L of FACS buffer containing Aqua LIVE/DEAD® (LifeTechnologies,

Cat# L34957) per the manufacturer's instructions. Samples were run on a BD FACS Canto™ II and analyzed with FlowJo ver9.2.

[00418] Results

[00419] After the completion of culture, viable CD14⁺ cells were analyzed for expression of CD80, CD86, HLA-DR, and PD-L1 (Figure 40, showing PD-L1 expression). Compared to monocytes in PBMC cultures that were treated with the HuIgG1 isotype control, monocytes in cultures treated with VSTB112 had increased levels of each of these markers. The level of this increase varied from donor to donor (data not shown). Monocytes in cultures treated with VSTB140 did not show elevated levels of activating markers indicating that an active Fc domain is required for the effect (Figure 40). Further, the addition of competitive binding inhibitor Fc fragments (IHB) to the cultures muted and, in some cases, completely abrogated VSTB112-mediated activation. This effect was not CD32 or CD64-dependent as antibodies blocking these receptors did not block VSTB112-mediated monocyte activation (data not shown).

[00420] CD16 expression on PBMC (which lack neutrophils) is typically restricted to NK cells and inflammatory monocytes (CD14⁺/CD16⁺). Preliminary data had identified a role for NK cells in the *in vitro* activation of monocytes by anti-VISTA antibodies. Depletion of NK cells or blockade of the IFN γ receptor significantly reduced the extent of anti-VISTA induced monocyte activation, suggesting that both NK cells and IFN γ contribute to anti-VISTA-mediated monocyte activation *in vitro* (data not shown).

[00421] In summary, using CD80, CD86, HLA-DR, and PD-L1 as markers of monocyte activation, the ability of VSTB112 (parent molecule of antibody VSTB174) and its silent Fc derivative, VSTB140, to activate monocytes in PBMC cultures was compared with a non-specific human IgG1 control antibody (CNTO 3930). By all parameters, monocytes were activated by VSTB112 and not by VSTB140. This activity appears to be Fc dependent due to the inability of VSTB140 to activate and the ability of soluble Fc fragments to partially mute the activating capabilities of VSTB112 (Figure 40, showing PD-L1 as marker of monocyte activation). Additionally, this activation was dependent on the presence of NK cells in these cultures and on antibody-induced production of IFN- γ as removal of either of these components from the *in vitro* culture system markedly attenuated monocyte activation (data not shown). As shown herein, the mechanism of activation appears to be dependent on

crosslinking of the Fc receptor CD16, as it can be completely and robustly mimicked by the addition of antibodies that crosslink CD16, even in the absence of VISTA-binding antibodies.

[00422] EXAMPLE 25: TUMOR GROWTH INHIBITION BY ANTI-VISTA ANTIBODY REQUIRES EFFECTOR FUNCTION

[00423] VISTA, a negative regulator of T cells, is expressed on many hematopoietic cells and highly expressed in the tumor microenvironment (Le Mercier, *et al.*, Cancer Research 74(7):1933-44, 2014). Treatment of mice bearing tumors with an anti-mouse VISTA antibody *in vivo* results in significantly reduced tumor growth (Le Mercier, *et al.*).

[00424] This study was conducted to determine the effect of anti-human VISTA antibodies VSTB123 and VSTB124 on the growth of established MB49 tumors in male or female hVISTA KI (knock-in) mice. These mice have the human VISTA cDNA knocked-in in place of the mouse VISTA gene, and express only human VISTA both at RNA and protein level. MB49 tumor cells express male H-Y antigen (Wasiuk *et al.*, Cancer Immunol Immunother 61:2273-82, 2012), a self-antigen in male mice but a foreign antigen in female mice. Treatment was initiated when tumors reached 3-5 mm in diameter. Anti-VISTA or control antibodies were dosed 3 times per week at 10 and 5 mg/kg for ten doses. All mouse groups were evaluated for tumor volume, survival, weight and changes in immune populations in peripheral blood during the course of the experiment. Drug pharmacokinetics (PK) and anti-drug antibody (ADA) development were also evaluated.

[00425] Methods

[00426] Study design

[00427] Parallel and identical studies were conducted in male and female hVISTA KI mice. For each gender, the mice were divided in 5 groups of 6-7 mice treated respectively with VSTB123 or VSTB124, either at 10 or 5 mg/kg, or mIgG2a control antibody at 10 mg/kg. See Figure 41 for experimental design.

[00428] Cell source and preparation

[00429] The MB49 cells were confirmed to be free of mycoplasma and other contaminants (IMPACT™ SC testing at IDDEX RADIL Case # 22209-2014). One cell vial was thawed and grown in RPMI 1640 (+ L-Glut) with 10% FBS and pen/strep antibiotics. After three days in culture, cells were harvested by brief incubation with StemPro® Accutase®, washed twice and resuspended in cold RPMI at 5×10^6 cells/ml prior to injection into the mice. All culture reagents were purchased from Gibco and Hyclone.

[00430] Test agents and dosage

[00431] VSTB123 and VSTB124 are chimeric anti-human VISTA antibodies made by Janssen. Each has the same anti-human VISTA variable region, derived from VSTB174, but cloned into a mouse IgG2a Fc (VSTB123) or a mouse IgG2a ala/ala silent Fc (VSTB124). Antibodies and mIgG2a (BioXcell BE0085, clone C1.18.14 lot# 5035/0514) controls were diluted in PBS and administered by intraperitoneal injection in a volume of 0.2ml to deliver a dose of 10 or 5 mg/kg.

[00432] Mice

[00433] hVISTA KI mice were bred at Sage Labs (Boyertown, PA). The mice, aged 8-12 weeks, first transited for 3 weeks in the quarantine facility, and then were transferred to the regular facility. They were acclimated for 2 days prior to having their right flanks shaved and their tails tattooed. Tumor cells were injected 5 days later.

[00434] Intradermal cell injection

[00435] Mice were injected intradermally in their shaved right flank with 50 μ l of MB49 cell suspension (~250,000 cells). All mice in which the injection went poorly (leak from injection site or subcutaneous injection instead of intradermal) were removed from the experiment.

[00436] Randomization, treatment initiation and tumor measurement

[00437] Tumors were measured on day 4 post-injection in most male mice, when tumors had reached a diameter between 3 mm and 5 mm. Based on the observation that most mice showed evidence of tumor growth by measurement or visual inspection, the mice were randomly assigned to treatment groups. Treatment was initiated on day 5. Tumor growth was monitored 2-3 times a week over the course of treatment and until the experiment was terminated. The formula $(L \times W^2)/2$ was used to determine tumor volume (L is the length or longest dimension, and W is the width of the tumor).

[00438] Partial remission (PR) was reached when tumor was half (or more reduced in size but greater than 13.5 mm³) of the initial volume for 3 consecutive measurements. Complete remission was reached when any tumor was less than 13.5 mm³ for 3 consecutive measurements.

[00439] Results

[00440] As shown in Figure 42A (left), female mice treated with VSTB123 at 10mg/kg showed significant reductions in tumor volume as compared to the control group. The effect on tumor growth could be detected as early as day 13, after 3 doses of antibody. In addition, some mice in each VSTB123 treatment group showed complete and durable tumor

regressions: 5/7 mice in the 10mg/kg group and 3/6 mice in the 5mg/kg group. None of the 6 control group mice regressed (data not shown).

[00441] VSTB124 treatment did not inhibit tumor growth in females at either dose (Figure 42A, right). As VSTB123 has a mouse IgG2a that can bind to Fc receptors, while VSTB124 has a silent Fc, this result suggests that Fc binding is important for efficacy in this model.

[00442] The mice were monitored for survival for 52 days (Figure 42B). For female mice, survival comparisons were more difficult because two of six control animals were still alive at 52 days. However, 7/7 mice treated with VSTB123 at 10 mg/kg were alive at day 52 ($p=0.0108$), while 4/6 mice treated with VSTB123 at 5 mg/kg were still alive at that day. Treatment of female mice with VSTB124 did not result in survival improvement.

[00443] As demonstrated herein, treatment with VSTB123 in female hVISTA KI mice bearing MB49 tumors led to complete remission (CR) in 85% (5/7 mice) of the group at 10 mg/kg, with a significant increase in survival ($p=0.0108$); VSTB123 treatment at 5 mg/kg led to CR in 3 out of 6 mice (50%). In contrast, VSTB124 did not significantly affect tumor growth or survival. This result, compared with results of VSTB123, suggests that efficacy with anti-VISTA antibody in the MB49 model may require an active Fc.

[00444] EXAMPLE 26: VSTB174 TRIGGERS RELEASE OF CYTOKINES

[00445] Anti-VISTA antibodies induce activation of CD14⁺ monocytes in whole PBMC cultures, as measured by upregulation of costimulatory markers such as CD80 and HLADR. The present study determined changes, if any, in cytokines in human PBMC cultures cultured with anti-VISTA antibody VSTB174.

[00446] Monocytes are innate leukocytes that represent ~10-30% of the peripheral blood isolated by Ficoll density centrifugation. Monocytes have been shown to play important roles in both inflammatory and anti-inflammatory responses based upon the level of costimulatory proteins and cytokines they express. Anti-VISTA antibodies (including VSTB174) activate CD14⁺ monocytes in whole PBMC cultures as measured by upregulation of costimulatory markers on the cell surface, such as CD80 and HLA-DR. To determine whether anti-VISTA antibody treatment would alter the production of cytokines in the assay, whole PBMCs were treated for 24 hours with VSTB174 and the supernatants were analyzed by Luminex® for the differential expression of 41 cytokines.

[00447] As shown herein, culture of the anti-human VISTA antibody VSTB174 with whole PBMC resulted in significantly increased expression of many cytokines in human PBMCs *in vitro*.

[00448] Methods**[00449]** Preparation of media

[00450] Combined 500 ml of RPMI 1640 (Corning, 10-040-CV) with 50 ml of human AB serum (Valley Biomedical, Inc., Lot # 3C0405), 5 ml of Penicillin/Streptomycin (Lonza, 17-602E) 10,000 U/ml, 5 ml of L-glutamine (100x) (Gibco, 25030-081) and 10 ml of HEPES (1M) (Fisher BP299-100, Lot#-1). Media was stored for no longer than 14 days at 4°C.

[00451] Preparation of anti-VISTA VSTB174 and control antibodies

[00452] Antibodies were diluted to 2X desired concentration in 10% AB serum media. Added 100 µl of the appropriate antibody solutions to the appropriate wells of a 96 well U-bottom plate (Falcon, 353077). After the cells were added in 100 µl, the final concentration of each antibody was 10, 1, 0.1 or 0.01 µg/ml. IgG1 control antibody CNTO 3930 (Lot 6405, ENDO <0.1 EU/mg) was added at a final concentration of 10 µg/ml. Each condition was run in triplicate.

[00453] Isolation of PBMCs

[00454] Donors were at least 18 years of age, generally healthy and selected randomly from the local population. Three donors provided PBMCs for this study. Transferred donor blood from isolation tube to 50 ml conicals. Under-laid 15 mls of Ficoll 1077 (SIGMA, 10771) being careful not to mix with the blood. This was per 25 mls of blood. Cells were centrifuged at 1250g for 25 minutes at room temperature with no brake. Isolated the white blood cells at the interphase of the Ficoll and the serum and diluted the cells into 40 ml of Hanks Balanced Salt Solution (HBSS). Cells were centrifuged at 453g (1500 rpm) for 10 minutes at 4°C. Cells were resuspended the cells in 50 mls of HBSS and counted by transferring 500 µl to a separate Eppendorf tube.

[00455] *In vitro* culture setup

[00456] The appropriate number of cells needed for the assay was determined based on the number of samples to be analyzed. The PBMCs were seeded at 2.0×10^5 cells/well of a 96-well U-bottom plate. All conditions were performed in technical triplicates.

[00457] Cells were centrifuged at 453g (1500 rpm) for 10 minutes at 4°C and resuspended at a concentration of 2×10^6 /ml in 10% AB serum media and added 100 µl to appropriate wells bringing the total volume in each well to 200 µl. Cells were incubated for 24 hours at 37°C and 5% CO₂. Collected 100 µl of supernatant for analysis by Luminex®.

[00458] Multiplex analysis

[00459] Cytokines were measured using Millipore Human cyto/chemo MAG Premix 41 Plex kit (Cat# HCYTMAG-60K-PX41, EMD Millipore Corporation, Billerica, MA). Calibration curves from recombinant cytokine standards were prepared with three-fold dilution steps in the same matrix as the samples. High and low spikes (supernatants from stimulated human PBMCs and dendritic cells) were included to determine cytokine recovery. Standards and quality controls were measured in technical triplicate, each triplicate test sample was measured once, and blank values were subtracted from all readings. All assays were carried out directly in a 96-well filtration plate (Millipore, Billerica, MA) at room temperature and protected from light. Briefly, wells were pre-wet with 100 μ l PBS containing 1% BSA, then beads, together with a standard, sample, spikes, or blank were added in a final volume of 100 μ l, and incubated together at room temperature for 30 minutes with continuous shaking. Beads were washed three times with 100 μ l PBS containing 1% BSA and 0.05% Tween 20. A cocktail of biotinylated antibodies (50 μ l/well) was added to beads for 30-minute incubation at room temperature with continuous shaking. Beads were washed three times, then streptavidin-PE was added for 10 minutes. Beads were again washed three times and resuspended in 125 μ l of PBS containing 1% BSA and 0.05% Tween 20. The fluorescence intensity of the beads was measured using the Bio-Plex® array reader. Bio-Plex® Manager software with five parametric-curve fitting was used for data analysis.

[00460] Statistical analysis

[00461] All statistics were carried out in R Statistical Computing Language. Cytokine concentration values below detection (<OOR) were rescaled to the lowest detectable concentration, and values above accurate quantitation (>OOR) were rescaled to the maximum linearly quantifiable concentration. Statistical outliers were removed prior to statistical analysis on the basis of Grubbs' $p < 0.05$ and outlier distance of greater than 1 standard deviation from the group mean using a single step. Pair-wise comparisons amongst the groups were made at each of the time-points using One-Way ANOVA with Tukey Honest Significant Differences. P-values less than 0.05 for all tests and comparisons were deemed significant. For all graphs and tables, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$. Figure 43 was produced with complete hierarchical clustering of cytokines using the heatmap.2 function in the g-plots package in R.

[00462] Results

[00463] To determine effects of anti-VISTA antibodies on whole PBMCs, VSTB174 was added to cell cultures at different concentrations for 24 hours, and supernatants were analyzed

for levels of 41 cytokines. Whole PBMCs treated with VSTB174 had statistically significant increases in the expression of a large number of cytokines, many of which are canonically expressed by monocytic and granulocytic cells (Figure 43). Each donor PBMC response was unique in the intensity of the response driven by VSTB174. Donors 1 and 2 showed significant increases in many more analytes than Donor 3 did (Figure 43). Also, when all three donors showed significant increases in a particular analyte, the fold change over baseline was usually lowest for Donor 3 (data not shown).

[00464] Effects of VSTB174 were most likely to be detected when the drug was present between 0.1- 10 µg/ml, with few analytes significantly upregulated at 0.01 µg/ml (Figure 43).

[00465] The cytokines significantly elevated over the IgG1 control for all donors were the following: IL-6, TNFα, MCP-3, MDC, MIP-1β, IP-10, IL-1Rα, GM-CSF, IL-12p70 and GRO.

[00466] Some cytokines were significantly elevated only in Donors 1 and 2: MIP-1α, IL-1β, RANTES, G-CSF, IL-1α, IL-7, IL-12p40, IL-13, IFNγ, TNFβ, IFNα (elevated in donor 3 but still close to baseline), IL-4, IL-10, FGF-2, fractalkine, VEGF, IL-17, Flt3L, IL-9, TGFα, IL-15, EGF, and PDGF-αα.

[00467] Two cytokines, MCP-1 and IL-8, were significantly elevated only in Donor 3. The baseline levels of these cytokines were above the range that could be quantitated in the assay for Donors 1 and 2, so it is possible that the analytes became elevated with VSTB174 treatment, but it was not measurable (listed as OOR>). The baseline and treatment levels of MCP-1 and IL-8 were within the dynamic range of the assay for Donor 3.

[00468] There were several cytokines that did not change compared to baseline in any donor with VSTB174 treatment: sCD40L, eotaxin, IL-5, PDGF-ββ, IL-2, IL-3. IL-2, IL-3 and sCD40L were significantly elevated in Donor 1 with drug treatment, but the levels of IL-2 and IL-3 still remained very low. sCD40L only became elevated in Donor 1 at the 0.1 µg/ml dose, and not at any other doses.

[00469] As demonstrated herein, VSTB174 induced enhanced production of many cytokines from PBMCs in multiple human donor samples, in a dose-dependent fashion.

[00470] Further, *in vivo* studies in female hVISTA KI mice also showed increased production of proinflammatory cytokines (*e.g.*, MCP-1, IP-10, IL-8, IL-6, MIP-1b, IL-10, IL-7, IFN-γ, G-CSF, RANTES, IL-15, TNFα, IL-1β, MIP-1a, IL-1a, GM-CSF, IL-12p40, IL-13, and/or eotaxin) in response to VSTB123. In particular, the upregulated cytokines have been

shown to be involved in recruitment, migration or activation of myeloid cells. Both hVISTA KI mice implanted with MB49 tumor cells as well as naïve hVISTA KI mice showed similar cytokine release profiles (data not shown).

[00471] EXAMPLE 27: VSTB123 INDUCES MIGRATION OF CD80+ MACROPHAGES TO THE TUMOR ENVIRONMENT

[00472] VISTA is a negative regulator of T cells that is expressed on most hematopoietic cells. The present study was conducted to identify changes in immune population numbers and activation phenotype in MB49 tumor-bearing hVISTA KI mice in response to treatment with anti-human VISTA VSTB123 or VSTB124 antibodies. The hVISTA KI mice have the human VISTA cDNA knocked-in in place of the mouse VISTA gene, and were previously confirmed to express only human VISTA both at RNA and protein level. MB49 tumor cells express male H-Y antigen, a self-antigen in male mice but a foreign antigen in female mice and highly expressed in the tumor microenvironment. As shown herein, mice with tumors responded with increased myeloid infiltration after treatment with either VSTB123 or VSTB124, and increased expression of CD80 activation marker on tumor-infiltrating macrophages with VSTB123 treatment.

[00473] Methods

[00474] Study design

[00475] The hVISTA KI mice were divided into 3 groups of 5 female mice each. Each mouse was injected with MB49 tumor cells in the right flank on day 0. At day 7, 9, and 11, mice were injected with 10 mg/kg of mIgG2a control antibody, VSTB123, or VSTB124. At day 12, mice were euthanized and blood, spleens, and tumors were analyzed by multiple parameters. Figure 44A illustrates this experimental design.

[00476] Mice

[00477] The hVISTA KI mice are bred at Sage Labs (Boyertown, PA). The mice, aged 8-12 weeks, first transited for 3 weeks in the quarantine facility, and then were transferred to the regular facility. They were acclimated for 2 days prior to having their right flanks shaved and their tails tattooed. Tumor cells were injected 5 days later.

[00478] Cell source and preparation

[00479] The MB49 cells were confirmed to be free of mycoplasma and other contaminants (IMPACT™ SC testing at IDDEX RADIL Case # 22209-2014). One cell vial was thawed and grown in RPMI 1640 (+ L-Glut) with 10% FBS and pen/strep antibiotics. After three days in culture, cells were harvested by brief incubation with StemPro® Accutase®, washed

twice and resuspended in cold RPMI at a concentration of 5×10^6 cells/ml, and 50 μ l (2.5×10^5 cells) injected per mouse. All culture reagents were purchased from Gibco and Hyclone.

[00480] Intradermal cell injection

[00481] Mice were injected intradermally in their shaved flank with 50 μ l of MB49 cell suspension ($\sim 250,000$ cells). All mice in which the injection went poorly (leak from injection site or subcutaneous injection instead of intradermal) were removed from the experiment.

[00482] Test agents and dosing

[00483] VSTB123 and VSTB124 were generated by Janssen. VSTB123 is an anti-human VISTA antibody comprised of the VSTB174 variable region on a mIgG2a Fc scaffold. VSTB124 is an anti-human VISTA antibody comprised of the VSTB174 variable region on a mIgG2a Fc scaffold with ala/ala mutations that silence the Fc. Control mouse antibody (mIgG2a) was generated by BioXcell, clone C1.18.4, Lot # 5386-2/1014, 8.4 mg/ml 1x in PBS.

[00484] Antibodies were diluted in PBS to 1 mg/ml for dosing. Mice were injected intraperitoneally with a volume of 0.2 ml, to deliver a final concentration of 10 mg/kg. As outlined in Figure 44A, mice received antibody therapy on days 7, 9, and 11 post tumor injection.

[00485] Tissue harvest

[00486] Mice were euthanized using CO₂ in compliance with the Dartmouth IACUC protocol. Mice were exsanguinated by cardiac puncture and blood collected. Spleen and tumors were dissected.

[00487] Spleens were dissociated using collagenase (1 mg/ml, Sigma Aldrich) in HBSS and the gentle MACS™ dissociator (Miltenyi Biotec) in accordance with the manufacturer's instructions. Cells were passed through a 40 μ m filter, then subjected to red blood cell lysis in 3 ml ACK lysis buffer (Lonza, Lot No. 0000400419) for 5 minutes. After 1 wash in HBSS, cells were resuspended in PBS and immunostained.

[00488] Tumors were dissociated using the Tumor Dissociation Kit and the gentle MACS™ dissociator (Miltenyi Biotec), following manufacturer instructions. Following dissociation, cells were passed over a 40 μ m filter, then subjected to red blood cell lysis using ACK lysis buffer. After 1 wash in HBSS, cells were resuspended in a tracked volume of PBS and immunostained.

[00489] Single cell suspensions from the draining lymph node were prepared by mechanical disruption and passage through a 40 μ m filter. Cells were washed, counted, and resuspended in RPMI.

[00490] Blood samples were spun down to separate plasma and whole blood cells. Plasma was collected and subsequently frozen and kept at -80°C to be used for cytokine and ANA ELISA analysis. Whole blood cells were subjected to red blood cell lysis in 3 ml ACK lysis buffer (Lonza, Lot No. 0000400419) for 5 minutes. After 1 wash in HBSS, cells were resuspended in PBS and used for immunostaining.

[00491] Flow cytometry

[00492] Single-cell suspensions were Fc-blocked with anti-murine CD16/32 (Miltenyi) (1:200) for 15 minutes at 4°C. Cells were incubated with antibody cocktails diluted in PBS for 30 minutes. After 2 washes in PBS, cells were resuspended in Fix/Permeabilization working solution (eBioscience) for 30 minutes on ice. Cells were spun, supernatant discarded and resuspended in PBS and incubated overnight.

[00493] Myeloid Panel:

- Live/Dead Yellow (Life Technologies) (1:1000)
- Ly6G-FITC (Biolegend, 1A8) (1:200)
- CD45-PE (Biolegend, 30-F11) (1:800)
- CD80-PE/CF594 (BD Biosciences, 16-10A1) (1:200)
- Ly6C-PerCP/Cy5.5 (Biolegend, HK1.4) (1:100)
- CD11c-PE/Cy7 (Biolegend, N418)(1/200)
- MHC class II-Alexa Fluor 647 (Biolegend, M5/114.15.2) (1/400)
- CD86- Alexa Fluor 700 (Biolegend, GL-1) (1/200)
- F4/80-APC/Cy7 (Biolegend, BM8) (1/200)
- CD11b-BrV421 (Biolegend, M1/70) (1/100)

[00494] Cells were rinsed and run on a Gallios 10-color flow cytometer. All cells were gated on live/dead and positive CD45 staining. Granulocytes were CD11b⁺, Ly6G⁺ and Ly6C⁻. Monocytes were CD11b⁺, Ly6G⁻, and Ly6C⁺. Macrophages were CD11b⁺, Ly6G⁻, Ly6C⁻, and F4/80⁺. Dendritic cells were gated on Ly6G⁻, Ly6C⁻, CD11c⁺ and were CD11b medium or high. Flow cytometry data were analyzed using FlowJo.

[00495] Statistical analysis

[00496] All statistics were carried out in Prism GraphPad, version 6. For each condition, values were compared using ANOVA with Tukey correction. In all cases comparisons were

made to the mIgG2a control-treated animals. Significance is summarized by asterisks using GraphPad standards, with one asterisk indicating $*P < 0.05$, two $**$ indicating $P < 0.01$, three $***$ indicating $P < 0.001$, and four $****$ indicating $P < 0.0001$.

[00497] Results

[00498] Tumors dissected from the flanks of anti-VISTA or control antibody-treated animals were analyzed to determine effects upon cellular populations by flow cytometry. Tumor-infiltrating macrophages were examined for anti-VISTA induced changes in expression of activation markers CD80, CD86, and MHC class II. Figure 44B illustrates the results of the flow cytometry analysis. Tumor-infiltrating macrophages, regardless of treatment, expressed higher levels of CD86 than did splenic macrophages (data not shown), but did not further upregulate CD86 as a function of anti-VISTA treatment. Conversely, CD80 expression was significantly increased on tumor-infiltrating macrophages of hVISTA KI mice treated with VSTB123, but not on those treated with VSTB124 (Figure 44B).

[00499] EXAMPLE 28: VSTB123 INDUCES MIGRATION OF MPO+ CELLS TO THE TUMOR MICROENVIRONMENT

[00500] The present study was conducted to identify changes, if any, in the tumor environment in MB49 tumor-bearing hVISTA KI mice in response to treatment with anti-human VISTA VSTB123 or VSTB124 antibodies. As shown herein, VSTB123 induced migration of myeloperoxidase-stained cells to the tumor environment.

[00501] Methods

[00502] Tumors and spleen were rapidly dissected after death from MB49 tumor-bearing hVISTA KI mice that were treated as described in Example 27. Tumor and spleen samples were then put into cassettes and fixed for 2-3 weeks (and typically fixed for 4 days or less) in 10% Formalin at room temperature, then briefly washed in PBS and transferred and kept into 70% Ethanol (Fisher Scientifics) prior to being transferred to the Pathology Translational Research Core at the Geisel School of Medicine at Dartmouth where they were paraffin embedded, sectioned and then stained.

[00503] Paraffin embedded tissue sections (4 μ m) were stained using a Leica BOND RX automated stainer. After dewaxing, the sections were subjected to antigen retrieval (Bond epitope retrieval solution 2, 100°C, 20 minutes) and incubated with the primary antibody (see dilution in Table 17, below) for 30-60 minutes, at room temperature in Leica diluent. Slides were then washed 3 x 5 min washes in PBS and incubated with secondary antibody (from Leica Bond Refine detection kit, DS9800). After 3 final washes in PBS the sections were

incubated with DAB (Leica Bond polymer detection kit), rinsed, counterstained with hematoxylin and mounted.

[00504] Slides were scanned with a Leica (Aperio® AT2, SCN400) whole slide scanner.

Whole slide scans were quantified using HALO software (Indica Labs).

[00505] Table 17: Antibodies used in staining

Specificity	Ig type	Clone/Format	Catalog #	Company	Retrieval	Dilution
mouse CD3	rabbit	polyclonal	AB5690	Abcam	EDTA	1:300
mouse CD4	rabbit	clone 1	50134-R001	SinoBiologicals	EDTA	1:400
mouse MPO	rabbit	polyclonal	A0398	Dako	EDTA	1:1000
mouse CD11b	rabbit	polyclonal	ab-75476	Abcam	EDTA	1:300
mouse F4/80	rabbit	clone SP115	NBP2-12506	Novus	EDTA	1:100

[00506] Results

[00507] Myeloperoxidase (MPO)-stained slides were scanned as described herein and evaluated in Aperio® ImageScope. The twelve tumor samples (6 mIgG2a, 6 VSTB123 tumors) were visualized singly and in aggregate. MPO-stained positive cells had morphology consistent with neutrophils. In IgG-treated controls, MPO cells showed dense but focal, well-demarcated clusters located throughout the tumor tissue. Typically, these dense aggregates surrounded a single adipocyte. More MPO-positive cells were observed in VSTB123-treated tumors, showing a much broader infiltrative distribution into the tumor parenchyma compared to mIgG2a controls.

[00508] EXAMPLE 29: VSTB174 INDUCES TRANSIENT NEUTROPHIL DECREASE IN BLOOD

[00509] VSTB174 (CNTO 8548) was administered to cynomolgus monkeys by intravenous bolus injection for 1 month to evaluate potential toxicity and to evaluate the potential reversibility of toxicity, if any. Clinical pathology parameters (*e.g.*, hematology) were measured, including red blood cell mass and white blood cell counts. As shown herein, VSTB174 induced a transient decrease in circulating neutrophils.

[00510] Methods

[00511] For purposes of this study, procedures described herein apply to all animals through Day 36.

[00512] Test article: VSTB174, at 50 mg/ml, maintained at -70 °C and protected from light. On each day of dosing, new vials of stock test article were removed from frozen

storage, equilibrated for approximately 1 hour to ambient room temperature and the vial was swirled gently (was not shaken or vortexed) to mix the solution until it was homogeneous. The nominal concentration (50 mg/mL) of the test article was used for dilution calculations for preparation of the dose solutions. The formulations were prepared by diluting the test article with the control article (0.9% Sodium Chloride) while under a biosafety hood. The final test article formulation was filtered through a 0.22 micron syringe filter (PVDF membrane) and held for no longer than 4 hours prior to filling appropriately-sized syringes for dosing. Syringe size was the smallest possible for the volume to be administered. The prepared dosing syringes were used within 4 hours of preparation. The preparation procedure was maintained in the raw data. Residual volumes were discarded.

[00513] Control article: 0.9% sodium chloride for injection, USP; batch number P326603, stored at room temperature.

[00514] The experimental design is shown in Table 18.

[00515] Table 18: Experimental design

Group No.	Test Material	Dose Route	Dose Level (mg/kg/week)	Dose Volume (mL/kg)	Dose Conc. (mg/mL)	No. of Animals			
						Mani Study		Recovery Study	
						Males	Females	Males	Females
1	VSTB174	IV	0	2	0	3	3	2	2
2	VSTB174	IV	10		5	3	3	2	2
3	VSTB174	IV	30		15	3	3	2	2
4	VSTB174	IV	100		50	3	3	2	2

[00516] Administration of test and control articles

[00517] The test or control articles were administered to the appropriate animals in Groups 1, 2, 3, and 4 via intravenous (slow bolus) injection into a suitable peripheral vein once weekly for 5 weeks (*i.e.*, Days 1, 8, 15, 22, and 29) for a total of 5 doses. The dose volume for each animal was based on the most recent body weight measurement obtained up to the day prior to dosing. The animals were temporarily restrained for dose administration and were not sedated. Disposable sterile syringes were used for each animal/dose. The first day of dosing was designated as Day 1.

[00518] Sample collection

[00519] Blood was collected by venipuncture. Urine was collected by drainage from special stainless steel cage pans pretreatment and on the day of necropsy. When cage pan collection was unsuccessful, urine was collected by cystocentesis at necropsy. After collection, samples were transferred to the appropriate laboratory for processing. Animals were fasted prior to clinical chemistry blood collections. Samples were collected as follows: Week (-2), Week (-1), Day 1 (4 hours post dose), Day 2, Day 4, Day 8 (pre), Day 15 (pre), Day 22 (pre), Day 29 (4 hours post dose), Day 31, Day 34, Week 6, Week 7, and Week 8.

[00520] Hematology

[00521] Blood samples were analyzed for neutrophil count (absolute). A blood smear was prepared from each hematology sample. Blood smears were labeled, stained, stored, and archived.

[00522] Results

[00523] Generally, administration of VSTB174 by once-weekly intravenous (slow bolus) injection for 5 weeks (*i.e.*, Days 1, 8, 15, 22, and 29) for a total of 5 doses was generally well tolerated in cynomolgus monkeys at levels ≤ 30 mg/kg/week. Neutrophils were markedly decreased beginning on Day 2 with a gradual return to baseline by Day 29 followed by post-dose decreases at 100 mg/kg/week on Days 31 and 34 (Figure 46).

[00524] EXAMPLE 30: VSTB174 INDUCES ACTIVATION OF NK CELLS, MONOCYTES, AND T CELLS

[00525] As described herein (*e.g.*, Example 26), VSTB174 induces significant activation of monocytes in whole PMBC cultures as indicated by cell surface markers and cytokine production. The present study was designed to determine the time course for activation of monocytes, T cells and NK cells across three unique donors. Correlative expression of cytokines was also analyzed for comparison to the *in vivo* mouse studies described in Example 26. VSTB140 was also tested to determine the contribution of FcR binding.

[00526] Methods

[00527] Preparation of media

[00528] 500 ml of RPMI 1640 (Corning, 10-040-CV) were combined with 50 ml of human AB serum (Valley Biomedical, Inc, Lot # 3C0405), 5 ml of Penicillin/Streptomycin (Lonza, 17-602E) 10,000 U/ml, 5 ml of L-glutamine (100x) (Gibco, 25030-081) and 10 ml of HEPES (1M) (Fisher BP299-100, Lot#-1). Media was stored for no longer than 14 days at 4°C.

[00529] Preparation of anti-VISTA and control antibodies

[00530] Antibodies (VSTB174 or VSTB140) were diluted to 2X desired concentration in 10% AB serum media. Added 100 µl of the appropriate antibody solutions to the appropriate wells of a 96 well U-bottom plate (Falcon, 353077). After the cells were added in 100 µl, the final concentration of each antibody was 10, 1, 0.1 or 0.01 µg/ml. IgG1 control antibody CNTO 3930 (Lot 6405, ENDO <0.1 EU/mg) or IgG2σ control antibody CNTO 8937 (Lot 7421, ENDO <0.1 EU/mg) was added at a final concentration of 10 µg/ml. Each condition was run in triplicate.

[00531] Isolation of PBMC

[00532] Donors were at least 18 years of age, generally healthy and selected randomly from the local population. Three donors provided PBMCs for this study. Donor blood was transferred from isolation tube to 50 ml conicals and under-laid with 15 mls of Ficoll 1077 (SIGMA, 10771) being careful not to mix with the blood. This was per 25 mls of blood. The cells were centrifuged at 1250g for 25 minutes at room temperature with no brake. White blood cells were isolated at the interphase of the Ficoll and the serum and diluted the cells into 40 ml of Hanks Balanced Salt Solution (HBSS). Cells were centrifuged at 453g (1500 rpm) for 10 minutes at 4°C. Cells were resuspended in 50 mls of HBSS and counted by transferring 500 µl to a separate eppendorf tube.

[00533] In vitro culture setup

[00534] The appropriate number of cells needed for the assay was determined based on the number of samples to be analyzed. The PBMCs were seeded at 2.0×10^5 cells/well of a 96 well U-bottom plate. All conditions were performed in technical triplicates. Cells were centrifuged T 453G (1500 rpm) for 10 minutes at 4 °C, and resuspended at a concentration of 2×10^6 /ml in 10% AB serum media and added 100 µl to appropriate wells bringing the total volume in each well to 200 µl. Cells were incubated for 24 hours at 37°C and 5% CO₂. Collected 100 µl of supernatant for analysis by Luminex.

[00535] Multiplex analysis was carried out according to the method described in Example 26.

[00536] Antibody staining and flow cytometry

[00537] The 96 well U-bottom plate was centrifuged for 5 minutes at 453g and removed the supernatant. Cells were washed with 200 µl PBS and centrifuged again under the same conditions. Supernatant was discarded and cells were resuspended in 50 µl of PBS containing the following antibodies:

Monocytes

- CD14-APC (clone HCD14) 1:250 (Biolegend cat #325608)
- HLA-DR-PE Cy7 (clone L243) 1:250 (Biolegend cat # 307616)
- CD80-PE (clone 2D10) 1:250 (Biolegend cat # 305208)
- Hu FcR binding inhibitor (eBioscience cat # 14-9161-73)

NK cells

- CD3 (clone UCHT1) 1:200 (Biolegend cat# 300420)
- CD56 (clone HCD56) 1:200 (Biolegend cat#318327)
- CD25 (clone M-A251) 1:200 (Biolegend cat# 356110)
- CD69 (clone FN50) 1:200 (Biolegend cat#310906)

T cells

- CD3 (clone SK7) 1:200 (Biolegend cat# 344814)
- CD4 (clone OKT4) 1:200 (Biolegend cat# 317414)
- CD8 (clone SK1) 1:200 (Biolegend cat # 344713)
- CD25 (M-A251) 1:200 (Biolegend cat # 356110)
- CD69 (clone FN50) 1:200 (Biolegend cat # 310916)
- CD62L (clone DREG-56) 1:200 (Biolegend 304827)

[00538] Cells were incubated for 20 minutes on wet ice in the dark. 150 µl of PBS were added and cells were centrifuged for 5 minutes at 453g. The cells were washed again with 200 µl of PBS and centrifuged under the same conditions; 120 µl of PBS were added. Samples were run on a Miltenyi MACSQuant 10-parameter flow cytometer and analyzed using FlowJo 9.7.5 for expression of HLA-DR, CD80 and Annexin-V on the CD14+ population. Median fluorescence intensity (MFI), a statistic that defines the central tendency of a set of numbers, was used as the defining statistic to compare treatments.

[00539] Statistical analysis

[00540] All statistics for the cytokine analysis were carried out in R Statistical Computing Language. Cytokine concentration values below detection (<OOR) were rescaled to the lowest detectable concentration, and values above accurate quantitation (>OOR) were rescaled to the maximum linearly quantifiable concentration. Statistical outliers were removed prior to statistical analysis on the basis of Grubbs' $p < 0.05$ and outlier distance of greater than 1 standard deviation from the group mean using a single step. Pair-wise comparisons amongst the groups were made at each of the time-points using One-Way ANOVA with Tukey Honest Significant Differences. P-values less than 0.05 for all tests and

comparisons were deemed significant. Using the heatmap.2 function in the g-plots package in R, complete hierarchical clustering of cytokines was assessed to generate a heatmap (data not shown).

[00541] All statistics for the flow cytometric analysis were carried out in Prism GraphPad, version 6. Pair-wise comparisons amongst the groups were made at each of the time-points using Two-Way ANOVA with Tukey correction for multiplicity for comparing concentrations between groups and a Dunnett's post-test for comparisons of each group within each time point. P-values less than 0.05 for all tests and comparisons were deemed significant. For all graphs and tables, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$.

[00542] Results

[00543] Whole PBMCs were isolated from three unique donors and incubated with either VSTB174 or VSTB140 at a range of concentrations described herein. At 3, 6 and 24 hours, the supernatants were collected and frozen while the PBMCs were stained with a range of antibodies for activation markers on monocytes, T cells or NK cells.

[00544] NK cell activation was measured by the expression of CD25 and CD69 on the CD56⁺ CD3⁻ population of cells. At 3 hours, CD69 was slightly upregulated in the VSTB174 treated group. By 6 hours VSTB174 treatment enhanced expression of CD69 on NK cells from donors 301 and 302, and to a lesser extent in donor 303. CD25 expression was decreased in these early time points for donors 301 and 302 with minimal changes observed for donor 303. By 24 hours VSTB174 treatment resulted in strong upregulation of both CD69 and CD25 in donors 301 and 302, however donor 303 had upregulated CD69, but decreased expression of CD25. A dose response of NK cell activation was observed with statistically significant changes between 10 and 0.1 $\mu\text{g/ml}$. VSTB140 did not induce significant upregulation of any markers.

[00545] Monocyte activation was measured by the expression of CD80, HLA-DR and PD-L1 on the CD14⁺ population of cells. At 3 hours, no sign of activation was observed for any marker in the three donors with either antibody. At 6 hours VSTB174 treatment enhanced expression of PD-L1 on monocytes from donors 301 and 302, but not in donor 303. CD80 and HLA-DR also showed small signs of enhanced expression at this time point. By 24 hours VSTB174 treatment resulted in upregulation of CD80, HLA-DR and PD-L1 in donors 301 and 302. Donor 303 also upregulated all three markers but to a lesser extent. In all cases, a dose response of monocyte activation was observed with statistically significant

changes between 10 and 0.1 µg/ml. VSTB140 did not induce significant upregulation of any markers.

[00546] T cell activation was measured by the expression of CD69, CD25 and CD62L on the CD3+CD4+ and CD3+CD8+ population of T cells. At 3 hours, no sign of activation was observed for any marker on either CD4 or CD8 T cells, with the exception of donor 301 where CD69 was modestly upregulated. At 6 hours, no consistent activation was observed on the CD4+ population of T cells, however the CD8+ T cells had increased expression of CD69 for donors 301 and 302. By 24 hours, both the CD4+ and CD8+ T cell populations had increased expression of CD69 and CD25 in donors 301 and 302. While donor 303 tended to have elevated levels of CD25 and CD69 on the CD4+ population, no statistical difference was observed for any parameter. CD62L expression was not changed at any time point with VSTB174. VSTB140 did not induce any consistent changes in expression of CD69, CD25 or CD62L at any time point across the donors.

[00547] As shown herein, VSTB174, but not VSTB140, induced activation of NK cells, T cells and monocytes. Activation of NK cells was seen as early as 3 hours. Monocyte and T cell activation was observed starting at 6 hours. For all three populations, maximal activation was observed at the 24 hour time point. Representative *in vitro* induction of monocyte, NK, and T cell activation from donor 302 at 24 hours post VSTB174 treatment is shown in Figure 48. Further, VSTB174, but not VSTB140, induced enhanced production of multiple cytokines and chemokines from PBMCs in multiple human donor samples, in a dose-dependent fashion. Cytokine production was observed as early as 3 hours, with the largest fold changes observed at 24 hours (data not shown).

[00548] EXAMPLE 31: MACROPHAGES CONTRIBUTE TO ANTI-VISTA
MECHANISM OF ACTION IN THE MB49 TUMOR MODEL

[00549] The present study was conducted to determine whether macrophages, monocytes and/or granulocytes play a role in MB49 tumor growth control mediated by an anti-hVISTA antibody, VSTB123, in female hVISTA KI mice.

[00550] Methods

[00551] Study design

[00552] The hVISTA KI female mice were divided into 8 treatment groups (Table 19). Each mouse was injected with MB49 tumor cells in the right flank on day 0. At days 7, 9, and 11, mice were treated by ip injection with 10 mg/kg of mIgG2a control antibody or VSTB123. Groups 1 and 2 served as simple negative and positive controls to demonstrate

the therapeutic effect of VSTB123, with no additional treatment to deplete myeloid subsets. Groups 3 and 4 received control rIgG2b and groups 7 and 8 received anti-GR1 antibody on days 5, 7, 9, 11, 13, 15 and 17 post tumor injection. Groups 3 and 4 received control liposomes and groups 5 and 6 received clodronate liposomes on days 4, 10, and 16. Blood from mice was analyzed on days 7 and 22 to confirm immune cell depletion. Tumors were measured 2 times per week for four weeks to monitor efficacy. Survival was monitored to day 78. Figure 49 shows a schematic of the study design.

[00553] Table 19: Study design summary

Group	Treatment	N (early deaths)
1 (negative control for VSTB123)	mIgG2a	8
2 (positive control)	VSTB123	9
3 (negative controls for both depletion modalities and for VSTB123)	mIgG2a, rIgG2b, control liposome	8 (1 mouse died early)
4 (negative control for both depletion modalities; with VSTB123 treatment)	VSTB123, rIgG2b, control liposome	9
5 (macrophage/DC depletion and negative control mAb for VSTB123)	mIgG2a, clodronate liposome	14 (6 died due to liposome toxicity)
6 (macrophage/DC depletion and VSTB123)	VSTB123, clodronate liposome	14 (7 died due to liposome toxicity)
7 (granulocyte/monocyte depletion and negative control for VSTB123)	mIgG2a, anti-GR1	10
8 (granulocyte/monocyte depletion and VSTB123)	VSTB123, anti-GR1	10

[00554] Mice

[00555] hVISTA KI mice have the human VISTA cDNA sequence inserted into the existing mouse VISTA locus in place of the mouse VISTA gene. The mice express only human VISTA RNA and protein. Breeding and mouse husbandry was contracted to Sage Labs (PA, USA). Prior to use, all mice incoming from Sage were quarantined for 3 weeks and screened against infection. After clearing quarantine, all mice were transferred to the regular facility. The mice were acclimated for a minimum of 2 days prior to having their flanks shaved, their tails tattooed, and tumor cells injected.

[00556] Tumors

[00557] The MB49 cells were confirmed to be free of mycoplasma and other contaminants (IMPACT SC testing at IDDEX RADIL Case # 22209-2014). One cell vial was thawed and

grown in RPMI 1640 (+ L-Glut) with 10% FBS, non-essential amino acids and pen/strep antibiotics. After three days in culture, cells were harvested by brief incubation with StemPro Accutase, washed twice and resuspended in cold RPMI at a concentration of 4.0×10^6 cells/ml, and 50 μ l (2×10^5 cells) injected per mouse. All culture reagents were purchased from Gibco and Hyclone. Mice were injected intradermally in their shaved flank with 50 μ l of MB49 cell suspension (~200,000 cells).

[00558] Test agents, depleting antibodies, and clodronate liposomes

[00559] VSTB123 is an anti-human VISTA antibody comprised of the VSTB174 variable region on a mIgG2a Fc scaffold. Control mouse antibody (mIgG2a) was generated by BioXcell (clone C1.18.4, lot # 5386-2/1014). Mice were dosed with VSTB123 or mIgG2a isotype control at 10 mg/kg.

[00560] Anti-GR1 antibody was generated by BioXcell (clone RB6-8C5, lot # 5246/1114; rat IgG2b) and depletes monocytes, granulocytes, and MDSC expressing GR1 antigen. Control rat IgG2b was procured from BioXcell (clone LTF-2, lot # 5535-3-6-7/0515). Mice were dosed with anti-GR1 or rIgG2b isotype control at 12.5 mg/kg.

[00561] Clodronate liposomes or control liposomes were purchased from ClodronateLiposomes.com (lot #3574E). Mice were dosed with 200 μ g clodronate liposomes or control liposomes, diluted in PBS.

[00562] Tumor measurement

[00563] Tumor growth was evaluated two times per week for four weeks (day 38). The formula $(L \times W^2)/2$ was used to determine tumor volume (L is the length and W the width of the tumor). As per Dartmouth's IACUC requirements, animals were euthanized as soon as their tumors reached 15 mm in the longest dimension or showed any sign of distress or weight loss over 20% of their normal body weight. Mouse deaths were recorded throughout the experiment.

[00564] Partial regression (PR) was reached when tumor was half (or more reduced in size but greater than 13.5 mm^3) of the initial volume for 3 consecutive measurements. Complete regression was reached when any tumor was less than 13.5 mm^3 for 3 consecutive measurements. Mice that were alive on day 38 were observed for survival to day 78.

[00565] Blood recovery and flow cytometry

[00566] Mice were bled from the retro-orbital cavity on days 7 and 22 to confirm the depleting effects of anti-GR1 or clodronate treatments, using Pasteur pipettes dipped in heparin. Five mice were bled per group and blood was analyzed by flow cytometry. Blood

was subjected to red blood cell lysis in 3 ml ACK lysis buffer (Lonza, Lot No. 0000400419) for 5 minutes. After 1 wash in HBSS, cells were resuspended in PBS and used for immunostaining.

[00567] Single-cell suspensions were Fc-blocked with anti-murine CD16/32 (Miltenyi) (1:200) for 15 minutes at 4°C. Cells were incubated with antibody cocktails diluted in flow buffer (PBS with 5 mM EDTA and 0.5% w/v BSA) for 30 min.

Panel:

- - Live/Dead Yellow (Life Technologies) (1:1000)
- - Ly6G-FITC (Biolegend, 1A8) (1:200)
- - CD45-PE (Biolegend, 30-F11) (1:800)
- - Ly6C-PerCP/Cy5.5 (Biolegend, HK1.4) (1:100),
- - CD11b PE/Cy7 (Biolegend, M1/70)(1:200),
- - F4/80-APC/Cy7 (Biolegend, BM8) (1:200),

[00568] After 2 washes in PBS, cells were resuspended in flow buffer and run on a MACS Quant flow cytometer. All cells were gated on live/dead and positive CD45 staining. Granulocytes were CD11b+, Ly6G+ and Ly6C-. Monocytes were CD11b+, Ly6G-, and Ly6C+. Macrophages were CD11b+, Ly6G-, Ly6C-, and F4/80+. The CD11c marker was not included so effects of clodronate liposomes on dendritic cells cannot be determined. Flow cytometry data was analyzed using Flow Jo v9.

[00569] Statistical analysis

[00570] Statistical analysis of tumor growth rates were conducted using R 3.0 and a macro, *inference.R*. Survival curves were compared using Log-rank (Mantel Cox) analysis from Prism v6.0. p values <0.05 were considered significant.

[00571] Results

[00572] The depletion regimens were monitored on day 7 and 22 for impact on relevant circulating blood populations. Macrophages as a percentage of CD45+ cells were reduced by about 40% with clodronate liposome treatment, when measured on day 7, three days after depletion. Since the depletion was less than complete and/or not sustained, the contribution of macrophages (and dendritic cells) to VSTB123-mediated anti-tumor efficacy may be underestimated in the results.

[00573] Anti-GR1 treatment reduced monocytes by ~75% and granulocytes by ~98% two days after depletion started on day 5. It is possible that this treatment would underestimate

somewhat the effect of monocytes in VSTB123-mediated anti-tumor efficacy, though granulocytes were well-depleted. All populations recovered by day 22, 6-7 days after the last depletion treatment.

[00574] As a baseline, the efficacy of VSTB123 was compared to isotype control antibody in the absence of any myeloid depleting treatments. MB49-tumor bearing female hVISTA KI mice dosed with VSTB123 had significantly reduced tumor burden compared to control mIgG2a treated animals (interaction P value = 0.000177; data not shown). In addition, on day 31 there were 5/9 CR and 3/9 PR in the VSTB123 group, while there was just 1/8 PR in the mIgG2a group.

[00575] To determine if liposome vehicle and isotype rat control antibody had an effect on tumor burden, animals treated with these controls plus either mIgG2a or VSTB123 were compared to animals treated with mIgG2a or VSTB123 alone. The negative control treatments did not affect tumor volume of mice treated with mIgG2a (interaction p value = 0.306; data not shown). However, VSTB123 was significantly less efficacious in the presence of control liposomes/rIgG2b (interaction P-value = 0.049). The negative effect of the control agents on VSTB123 efficacy is supported by reduced incidence of CR (3/9) and PR (2/9) in this group, as compared to mice treated only with VSTB123. This suggests that the control liposomes and/or rat control antibody had an adverse effect on efficacy mediated by VSTB123, more likely the control liposomes.

[00576] Clodronate liposome treatment, which depletes macrophages and dendritic cells, eliminated the anti-tumor effect of VSTB123 (Figure 50, left panel; interaction P value = 0.100 for mIgG2a/clodronate liposomes vs VSTB123/clodronate liposomes). However, this may be an underestimate of the importance of macrophages and dendritic cells, as depletion using clodronate liposomes was not complete or sustained (data not shown). This result is consistent with a reduced incidence of CR (0/7) and PR (1/7) on day 31 in the VSTB123/clodronate liposome mice. Clodronate and control liposome mIgG2a treatment groups showed significant interaction p values with the mouse IgG2a group, but both groups showed aggressive tumor growth similar to mIgG2a (Figure 50, left panel). This result suggests that macrophages/DC do not play a prominent role in controlling or promoting tumor growth in the natural MB49 tumor model. However, the results of clodronate liposome treatment in VSTB123-treated mice suggest that anti-VISTA treatment may enhance macrophage/DC activity as a mechanism to control MB49 tumor growth.

[00577] The anti-GR1 antibody is expected to deplete monocytes and granulocytes, and myeloid derived suppressor cells (MDSC); the latter cell type is expected to support tumor growth. Substantial depletion of monocytes and granulocytes was observed after one dose of anti-GR1 antibody (data not shown). Treatment of VSTB123 mice with anti-GR1 antibody did not adversely affect efficacy mediated by the anti-VISTA antibody, and the tumor volume suggests a non-significant positive impact. The incidence of CR (7/10) and PR (2/10) in the GR1/VSTB123 group is somewhat higher than in the VSTB123 group alone. In addition, depletion of monocytes/granulocytes significantly reduced tumor growth in the mIgG2a control group (data not shown). The increased incidence of CR (2/10) and PR (2/10) in the GR1 depleted mIgG2a group as compared to mIgG2a alone is further support for a positive impact of the GR1 depleting antibody. The results suggest that monocytes/granulocytes/MDSC promote MB49 tumor growth, but these cells do not seem to be affected by VSTB123 treatment, or part of the anti-tumor mechanism induced by VSTB123. The incidence of complete regression (CR) and partial regression (PR) is summarized in Table 20.

[00578] Table 20: Incidence of CR and PR in the treatment groups at day 31.

	mIgG2a	VSTB123	mIgG2a, ctrl lipo, rIgG2b	VSTB123, ctrl lipo, rIgG2b	mIgG2a, clodronate liposomes	VSTB123, clodronate liposomes	mIgG2a, anti-GR1	VSTB123, anti-GR1
CR	0/8	5/9	1/7	3/9	1/8	0/7	2/10	7/10
PR	1/8	3/9	0/7	2/9	0/8	1/7	2/10	2/10

[00579] Survival analysis was performed on MB49-tumor bearing animals treated with mIgG2a or VSTB123 in the presence or absence of depleting GR1 antibody or clodronate liposomes. The survival curves generated for the present analysis only included animals that died as a direct result of tumor burden. Animals that died from clodronate treatment or who had to be euthanized early due to veterinarian's instructions have been removed from the analysis.

[00580] Survival curves for mIgG2a and VSTB123 were significantly different ($P=0.0279$; data not shown), consistent with the significant reductions in tumor burden achieved with VSTB123. Survival curves for mIgG2a and VSTB123 in the presence of control liposome and rat isotype control antibody were not found to be different (data not shown), suggesting a negative effect of the control PBS-loaded liposome treatments on VSTB123 control of tumor growth.

[00581] Survival curves between mIgG2a and VSTB123 in the presence of clodronate liposomes were also not found to be different (data not shown), suggesting clodronate liposomes were negatively affecting VSTB123-mediated efficacy. In addition, survival was significantly different when comparing VSTB123 vs VSTB123/clodronate liposomes (increased survival with VSTB123 alone; data not shown). This result indicates that depletion of macrophages/dendritic cells had a significant impact on the anti-tumor response induced by VSTB123.

[00582] The effect of depleting monocytes/granulocytes/MDSC on survival was also assessed. Survival was significantly increased in mice treated with VSTB123/anti-GR1 as compared with mIgG2a/anti-GR1 ($p=0.0055$; data not shown). Survival approached significance for mIgG2a vs mIgG2a/anti-GR1 ($p=0.0880$), suggesting that the depletion of monocytes/granulocytes/MDSC had a beneficial effect on survival in the MB49 tumor model, independent of VSTB123 treatment. Survival was not significantly different in mice treated with VSTB123 vs VSTB123/anti-GR1 ($p=0.4368$). The results indicate that monocytes/granulocytes/MDSC do not play a significant role in anti-tumor efficacy mediated by VSTB123.

[00583] To summarize, VSTB123 treatment significantly reduced tumor volume and prolonged survival when compared to mice treated with mIgG2a control antibody. Monocytes, granulocytes, and MDSC were depleted in mice using an anti-GR1 antibody. Depletion of these cells did not significantly affect VSTB123-mediated efficacy as measured by tumor volume and survival, indicating that these cells do not contribute to anti-VISTA mechanism of action in the MB49 tumor model. Macrophages were depleted in anti-VISTA treated mice using clodronate liposomes. Macrophage depletion significantly reduced VSTB123-mediated efficacy as measured by tumor volume and survival, indicating that macrophages contribute to anti-VISTA mechanism of action in the MB49 tumor model.

[00584] EXAMPLE 32: CD4⁺ AND CD8⁺ T CELLS CONTRIBUTE TO ANTI-VISTA MECHANISM OF ACTION IN THE MB49 TUMOR MODEL

[00585] The present study was conducted to determine the efficacy of VSTB123 in the MB49 tumor model in female hVISTA KI mice depleted of CD4⁺ T cells, CD8⁺ T cells, or NK cells. As described herein, this knock-in mouse line has the human VISTA cDNA knocked-in in place of the mouse VISTA gene, and expresses only human VISTA both at RNA and protein level. MB49 tumor cells express male H-Y antigen, a self-antigen in male mice but a foreign antigen in female mice.

[00586] Mice were injected with MB49 cells and then depleted of lymphocyte subsets prior to the initiation of VSTB123 treatment. The mice received 3 doses of VSTB123 or control antibodies at 10 mg/Kg every other day for three doses. Cell subset targeted depletion was done through the use of depleting antibodies against cell surface markers CD4 (clone GK1.5), CD8 (clone 2.43), or NK1.1 (clone PK136). Tumor volume and survival were monitored.

[00587] Methods

[00588] hVISTA KI mice were divided into 8 groups as indicated in Table 21. Groups 1 and 2 were treated with VSTB123 or control mIgG2a antibodies, and served as the baseline controls for tumor growth with and without anti-VISTA treatment. Both the anti-CD4 (GK1.5) and anti-CD8 (2.43) depleting antibodies are of the rat IgG2b isotype, so groups 1 and 2 were dosed with rIgG2b isotype control for the depleting antibodies. The NK1.1 antibody is a mouse IgG2a, so the mIgG2a control antibody for VSTB123 served as a control for NK depletion. Groups 3 and 4 were depleted of CD4+ T cells, while groups 5 and 6 were depleted of CD8+ T cells. Anti-NK1.1 was used to deplete NK cells in groups 7 and 8.

[00589] Table 21: Treatment groups – following MB49 cell injection, mice were randomized into 8 groups of 10 mice per group and treated with the indicated antibodies.

Group	Treatment	N
1	Control mIgG2a, rat IgG2b	10
2	VSTB123, mIgG2a, rIgG2b	10
3	mIgG2a, aCD4 (GK1.5)	10
4	VSTB123, aCD4 (GK1.5)	10
5	mIgG2a, aCD8 (2.43)	10
6	VSTB123, aCD8 (2.43)	10
7	mIgG2a, aNK1.1 (PK136)	10
8	VSTB123, aNK1.1 (PK136)	10

[00590] Five days after MB49 tumor cell implantation in hVISTA KI female mice, initiation of the depletion regimen began. Depleting antibodies were administered on day 5, 2 days prior to the first VSTB123 or mIgG2a treatment on day 7, and then throughout the study (Figure 51). Tumor measurements were made 2 times a week for four weeks. Each group of mice was treated with 3 doses of VSTB123 or mIgG2a control antibody at 10 mg/Kg on days 7, 9 and 11. See Figure 51 for experimental design.

[00591] Cell source and preparation

[00592] The MB49 cells were confirmed to be free of mycoplasma and other contaminants (IMPACT SC testing at IDDEX RADIL Case # 22209-2014). One cell vial was thawed and grown in RPMI 1640 (+ L-Glut) with 10% FBS and pen/strep antibiotics. After three days in culture, cells were harvested by brief incubation with StemPro Accutase, washed twice and resuspended in cold RPMI at 4×10^6 cells/ml prior to injection into the mice. All culture reagents were purchased from Gibco and Hyclone.

[00593] Test agents and dosage

[00594] As described herein, VSTB123 is a chimeric anti-human VISTA antibody that contains the anti-human VISTA variable region derived from VSTB174, cloned into a mouse IgG2a Fc backbone. VSTB123 and mIgG2a (BioXcell BE0085, clone C1.18.14, lot# 5386-2/1014) were diluted in PBS and injected via intraperitoneal route in a volume of 0.2 ml to deliver a dose of 10 mg/kg. Animals received a total of 3 doses injected every other day. For depletion of lymphoid cells, mice were treated with anti-CD4 (clone GK1.5; BioXCell; lot # 4912/0114), anti-CD8 (clone 2.43; BioXCell; lot # 4933/1213), or anti-NK1.1 (clone pk136; BioXCell; lot #4945/0114) as indicated in Figure 51. Depleting antibodies were diluted in PBS to a concentration of 1.25 mg/ml and injected via intraperitoneal route in a volume of 0.2 ml to deliver 250 μ g/mouse.

[00595] Mice

[00596] The hVISTA KI female mice are bred at Sage Labs (Boyertown, PA). The mice, aged 8-12 weeks, first transited for 3 weeks in the quarantine facility, and then were transferred to the regular facility. They were acclimated for 2 days prior to having their right flanks shaved and their tails tattooed. Tumor cells were injected 2 days later.

[00597] Intradermal cell injection and randomization

[00598] Mice were injected intradermally in their shaved right flank with 50 μ l of MB49 cell suspension (~200,000 cells). All mice in which the injection went poorly (leak from injection site or subcutaneous injection instead of intradermal) were removed from the experiment. Mice were randomized into eight groups on day 4.

[00599] Treatment initiation and tumor measurement

[00600] On day 5 after tumor cell injection, cell subset depletion was initiated via administration of depleting antibodies against the surface markers CD4, CD8, or NK1.1. VSTB123 or control antibody treatment was initiated on day 7 post- MB49 cell injection. The animals received 3 VSTB123 or mIgG2a doses and tumor growth was monitored 2 times a week for 4 weeks following VSTB123/mIgG2a treatment. Tumors were measured starting

on day 7 post-MB49 cell-injection. The formula $(L \times W^2)/2$ was used to determine tumor volume (L is the length or longest dimension, and W is the width of the tumor).

[00601] Partial regression (PR) was reached when tumor was half (or more reduced in size but greater than 13.5 mm^3) of the initial volume for 3 consecutive measurements. Complete regression was reached when any tumor was less than 13.5 mm^3 for 3 consecutive measurements.

[00602] Euthanasia criteria

[00603] As per Dartmouth's IACUC requirements, animals were euthanized as soon as their tumors reached 15 mm in the longest dimension or showed any sign of distress or weight loss over 20% of their normal body weight. Mouse deaths were recorded throughout the experiment.

[00604] Blood collection and flow cytometry analysis

[00605] Mice were bled from the retro-orbital cavity 4 days prior to MB49 cell implantation and again on day 7-post cell implantation to confirm the depleting effects of anti-CD4, anti-CD8, and anti-NK1.1 antibodies via flow cytometry. Blood was placed into Eppendorf tubes containing 25 μl of heparin and stained with the following cocktail of antibodies in FACs buffer (2% BSA, 1 mM EDTA, 0.02% sodium azide):

- αCD335 (NKp46) (clone 29A1.4) – BV421 (1:200)
- αCD3 – FITC (1:200)
- αCD45 – PE (1:800)
- αCD4 (clone RM4-5) – PerCP-Cy5.5 (1:400)
- αCD8 (clone 53-6.7) – APC (1:400)
- Fc block – 1:200

[00606] Following staining with antibody clones that bind to noncompeting epitopes of the depleting antibodies, blood was subjected to red blood cell lysis in ACK lysis buffer (Lonza) for 5 minutes. After 2 washes in FACs buffer, cells were resuspended in PBS and run on a MACSQuant cytometer. Flow cytometry data was analyzed with FlowJo version 9.5.

[00607] Statistical analysis

[00608] Mouse tumor volumes were analyzed using Excel for data management and GraphPad Prism for graphing. Statistical analysis was performed using a macro for R statistical computing software that measures divergence in tumor volume between two groups of differentially treated mice and is named 'mixed effect repeated measures'. Significance

was reached when either the main p value or the interaction p value was less than 0.05.

Survival analysis was performed in GraphPad Prism using the Log-rank (Mantel-Cox) test.

Significance was reached when the p value was less than 0.05.

[00609] Results

[00610] CD8+ and CD4+ T cells were necessary for the anti-tumor response induced by VSTB123 in the MB49 model (Figure 50, middle and right panels). Depletion of CD8+ or CD4+ T cells abrogated VSTB123-mediated effects on tumor volume and survival. In mice treated with mIgG2a antibody, only the depletion of CD8+ T cells affected tumor growth and survival. This indicates that VSTB123 treatment promoted a broader immune response that included CD4+ T cells, as well as CD8+ T cells. Depletion of NK cells did not affect VSTB123-mediated efficacy as measured by tumor volume or survival. Depletion of NK cells significantly reduced tumor volume in the mIgG2a group, but this did not translate into a survival benefit. The incidence of complete or partial remission in the treatment groups are shown in Table 22.

[00611] Table 22: Incidence of CR and PR in the treatment groups at day 31.

	mIgG2a	VSTB123	mIgG2a CD4 dep	VSTB123 CD4 dep	mIgG2a CD8 dep	VSTB123 CD8 dep	mIgG2a NK dep	VSTB123 NK dep
CR	1/10	6/10	0/10	0/10	0/10	0/10	3/10	5/10
PR	1/10	1/10	1/10	1/10	0/10	0/10	0/10	1/10

[00612] EXAMPLE 33: VSTB123 DEMONSTRATES SYNERGY WITH ANTI-PD1 ANTIBODY IN VIVO

[00613] The present study examined the effectiveness of an anti-VISTA antibody (VSTB123) combined with an anti-PD1 antibody in treating MB49 tumors in male mice.

[00614] Method

[00615] Mice

[00616] VISTA KI male mice (n = 132 to have 3 extra mice per group). Mice were born between 7/13-27/15 and 6/15-29/15 and were randomized between the different groups.

[00617] Tumors

[00618] Each mouse received 250,000 MB49 tumor cells, injected intradermally in the right flank.

[00619] Table 23: Treatment groups

Group	Treatment	N
-------	-----------	---

1	mouse IgG2a and rat IgG2a (2A3)	30
2	Anti-VISTA (VSTB123) and rat IgG2a (2A3)	30
3	anti-PD1 (RPMI-14) and mouse IgG2a	30
4	Anti-VISTA (VSTB123) and anti-PD1 (RPMI-14)	30

[00620] Antibody treatments

[00621] Both antibodies (VSTB123 and anti-PD1) and controls were dosed at 10 mg/kg. Treatment began on day 6 post-implantation. Anti-PD1 (RMP1-14 –BioXcell catalog # BE0146) and rat IgG2a were dosed 2x per week. Anti-VISTA and mouse IgG2a were dosed 3x per week and treatment proceeded for 3 weeks. Figure 52 shows a schematic of the treatment schedule.

[00622] Efficacy study

[00623] Tumor volume was measured 2-3 times per week for a period of 4 weeks. Mice whose tumors reached 15mm in the longest direction were euthanized in accordance with IACUC requirements. Mice that displayed significant signs of distress (hunched posture, unresponsiveness, *etc.*) were euthanized at the veterinarian's discretion.

[00624] Survival analysis

[00625] All deaths were recorded and annotated for the cause of death (mice euthanized due to tumor burden vs. death due to sickness/distress) for survival analysis. When possible, the lungs of the animals to be euthanized were collected, mets counted and then processed for paraffin embedding.

[00626] Early cytokine response

[00627] Mice were bled at 6 hours post 1st and 3rd dosage of VSTB123 (1st and 2nd anti-PD1 dosage) and plasma was stored at -80°C for cytokine analysis on a Luminex mouse 32-plex (Eotaxin, G-CSF, GM-CSF, IFN- γ , IL-10, IL-12 (p40), IL-12 (p70), IL-13, IL-15, IL-17, IL-1 α , IL-1 β , IL-2, IL-2, IL-4, IL-5, IL-6, IL-7, IL-9, IP-10, KC, LIF, LIX, M-CSF, MCP-1, MIG, MIP-1 α , MIP-1 β , MIP-2, RANTES, TNF- α , VEGF).

[00628] Mechanism of action studies

[00629] At 24h post 1 dose and 3 doses, 10 mice were sacrificed per group:

- 5 for flow cytometry on tumor and on terminal cardiac blood
- 5 for paraffin and frozen embedding of tumors lung and liver), and ICS on cardiac blood

[00630] Flow panel for blood analyses

T-Cell Panel	Myeloid Panel
CD25	4-1BBL
CD3	CD11b
CD4	CD11c
CD44	CD45
CD45	CD80
CD62L	CD86
CD69	F4/80
CD8	Ly6C
FoxP3	Ly6G
Live/Dead	Live/Dead

[00631] Flow panel for tumor analyses

T-Cell Panel	Myeloid Panel
CD11c	4-1BBL
CD25	CD11b
CD3	CD11c
CD4	CD45
CD45	CD80
CD69	F4/80
CD8	MHC class II
FoxP3	Ly6C
Ki67	Ly6G
Live/Dead	Live/Dead

[00632] Intracellular cytokine staining analysis

[00633] Collected blood cells were stimulated with MB49 cell lysate or PMA/ionomycin for 4-6 hours in the presence of Brefeldin A. Following stimulation, cells were stained for cell surface antigens and live/dead dye, fixed and RBCs lysed. Cells were then be permeabilized and stained for intracellular cytokines. ICS flow panel was as follows: Live/Dead, CD45, CD3, CD4, CD8, IL-2, IFN γ , TNF α .

[00634] Results

[00635] As shown in Figure 53, the combined effects of anti-VISTA and anti-PD-1 on tumor growth and survival were synergistic when compared to the effects of either antibody alone.

[00636] The teachings of all patents, published applications and references cited herein are incorporated by reference in their entirety.

[00637] While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

CLAIMS

What is claimed:

1. A pharmaceutical composition comprising:
 - a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a V-domain Ig Suppressor of T cell Activation (VISTA);
 - b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein; and
 - c) a pharmaceutically acceptable carrier, diluent, or excipient.
2. The pharmaceutical composition of Claim 1, wherein the antibody or antibody fragment thereof in b) maintains or enhances T cell activation.
3. The pharmaceutical composition of Claim 1 or 2, wherein the immune checkpoint protein is selected from PD-1, PD-L1, PD-L2, CTLA-4, TIM-3, LAG-3, OX40 and GITR.
4. The pharmaceutical composition of any one of Claims 1-3, wherein the antibody or antibody fragment thereof in b) is nivolumab, pembrolizumab, tremelimumab, or ipilimumab.
5. The pharmaceutical composition of any one of Claims 1-3, comprising a bispecific antibody that comprises the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b).
6. The pharmaceutical composition of any of the preceding claims, wherein the antibody or antibody fragment thereof in a) comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30.

7. The pharmaceutical composition of Claim 6, wherein the antibody or antibody fragment thereof in a) comprises an antibody VH domain comprising SEQ ID NO:37.
8. The pharmaceutical composition of Claim 6 or 7, wherein the antibody or antibody fragment thereof in a) comprises an antibody VL domain comprising SEQ ID NO:44.
9. The pharmaceutical composition of any one of Claims 6-8, wherein the antibody or antibody fragment thereof in a) comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.
10. A pharmaceutical composition comprising:
 - a) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a V-domain Ig Suppressor of T cell Activation (VISTA);
 - b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to a PD-1 protein; and
 - c) a pharmaceutically acceptable carrier, diluent, or excipient.
11. The pharmaceutical composition of Claim 10, wherein the antibody or antibody fragment thereof in a) comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30.
12. The pharmaceutical composition of Claim 10 or 11, wherein the antibody or antibody fragment thereof in a) comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.
13. The pharmaceutical composition of any one of Claims 10-12, wherein the antibody or antibody fragment thereof comprising an antigen binding region that binds to a PD-1 protein is nivolumab or pembrolizumab.

14. A method of enhancing an immune response in an individual in need thereof, comprising administering to the individual a therapeutically effective amount of:
 - a) an antibody or an antibody fragment thereof comprising an antigen binding region that binds V-domain Ig Suppressor of T cell Activation (VISTA); and
 - b) an antibody or antibody fragment thereof comprising an antigen binding region that binds to an immune checkpoint protein,thereby enhancing an immune response to the cancer.
15. The method of Claim 14, wherein the antibody or antibody fragment thereof in b) maintains or enhances T cell activation.
16. The method of Claim 14 or 15, wherein the antibody or antibody fragment thereof in a) comprises an antibody VH domain comprising a VH CDR1 having the amino acid sequence of SEQ ID NO:25, a VH CDR2 having the amino acid sequence of SEQ ID NO:26 and a VH CDR3 having the amino acid sequence of SEQ ID NO:27, and which further comprises an antibody VL domain comprising a VL CDR1 having the amino acid sequence of SEQ ID NO:28, a VL CDR2 having the amino acid sequence of SEQ ID NO:29 and a VL CDR3 having the amino acid sequence of SEQ ID NO:30.
17. The method of Claim 14, 15 or 16, wherein the antibody or antibody fragment thereof in a) comprises an antibody VH domain comprising SEQ ID NO:37.
18. The method of any one of Claims 14-17, wherein the antibody or antibody fragment thereof in a) comprises an antibody VL domain comprising SEQ ID NO:44.
19. The method of any one of Claims 14-18, wherein the antibody or antibody fragment thereof in a) comprises an antibody heavy chain comprising SEQ ID NO:61 and an antibody light chain comprising SEQ ID NO:56.
20. The method of any one of Claims 14-19, wherein the immune checkpoint protein is selected from PD-1, PD-L1, PD-L2, CTLA-4, TIM-3, LAG-3, OX40 and GITR.

21. The method of any one of Claims 14-20, wherein the antibody or antibody fragment thereof in b) is nivolumab, pembrolizumab, tremelimumab, or ipilimumab.
22. The method of any one of Claims 14-21, wherein the immune response is an antitumor immune response.
23. The method of any one of Claims 14-22, wherein the immune response is a T cell response.
24. The method of any one of Claims 14-23, wherein the individual has cancer.
25. The method of Claim 24, wherein the cancer is a solid tumor, a leukemia, a lymphoma, a myelodysplastic syndrome or a myeloma.
26. The method of Claim 25, wherein the solid tumor is a lung tumor, bladder tumor or breast tumor.
27. The method of any one of Claims 14-26, wherein the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b) are administered simultaneously.
28. The method of any one of Claims 14-26, wherein the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b) are administered in sequentially.
29. The method of any one of Claims 14-27, wherein the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b) are administered in the same formulation.
30. The method of any one of Claims 14-28, wherein the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b) are administered in separate formulations.

31. The method of any one of Claims 14-30, wherein the antibody or antibody fragment thereof in a) and the antibody or antibody fragment thereof in b) are administered intravenously.

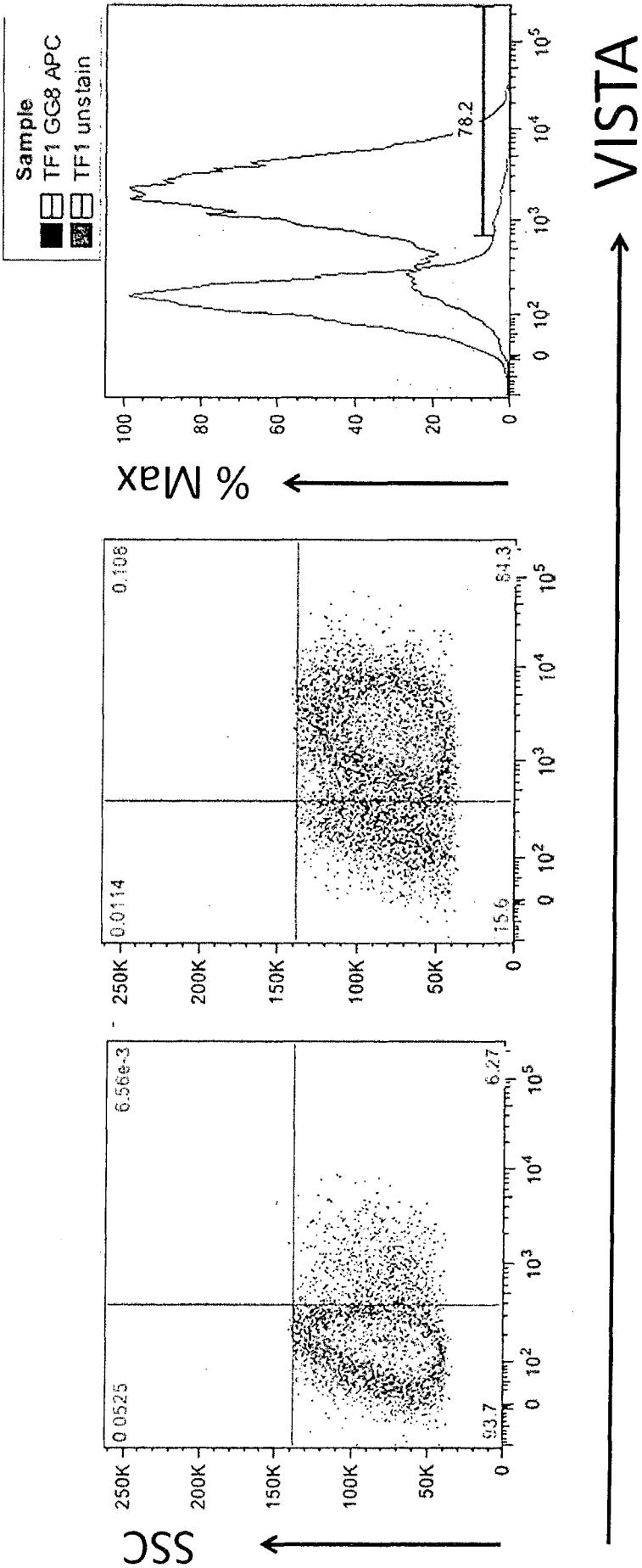


Figure 1A

Figure 1B

Figure 1C

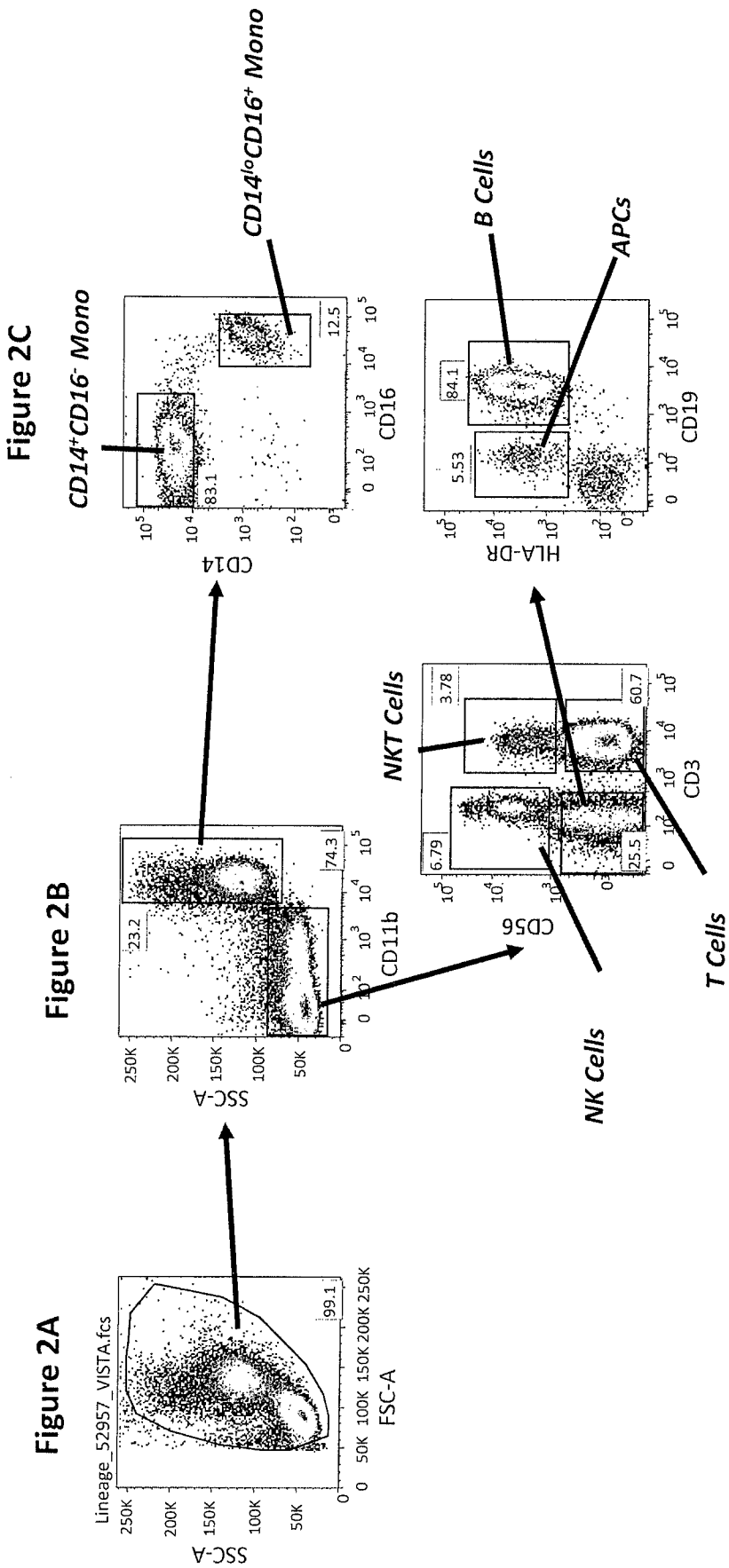


Figure 3A

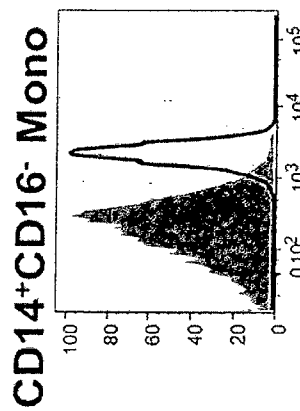


Figure 3B

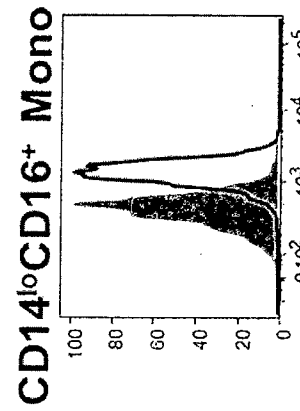


Figure 3C

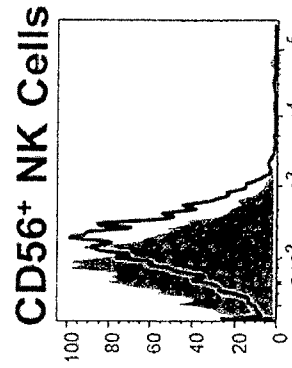
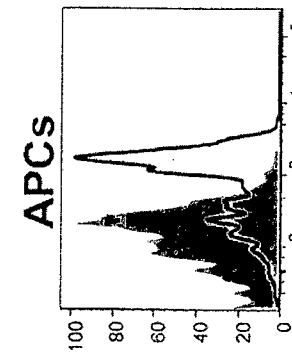
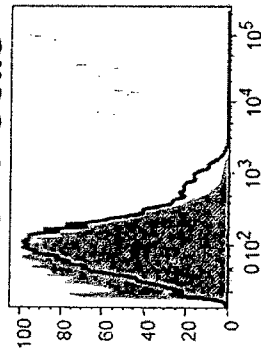


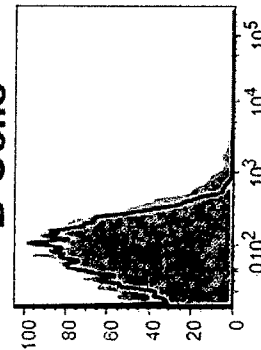
Figure 3D



CD3⁺ T Cells



B Cells



NKT cells



Isotype Control
— VISTA

VISTA

Figure 3E

Figure 3F

Figure 3G

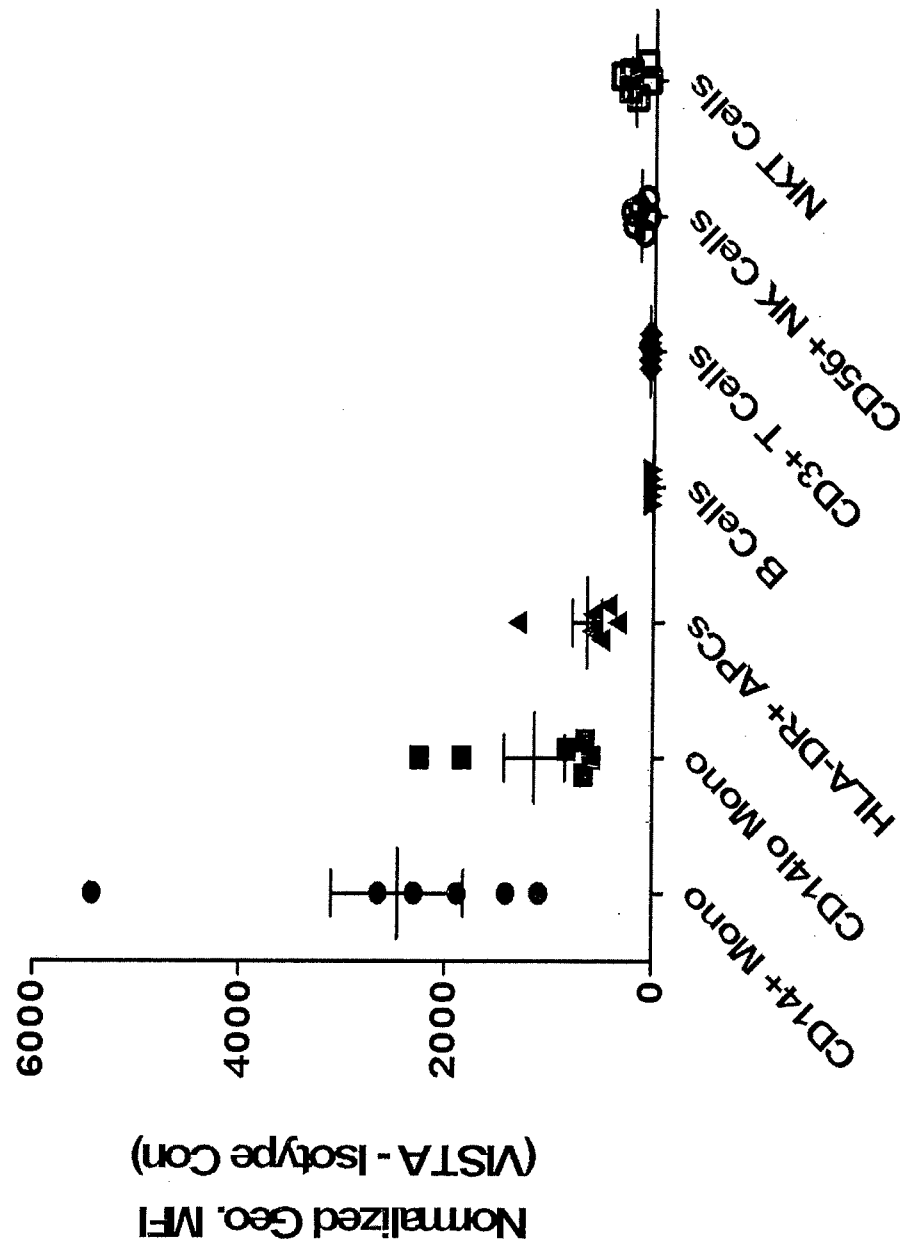


Figure 4

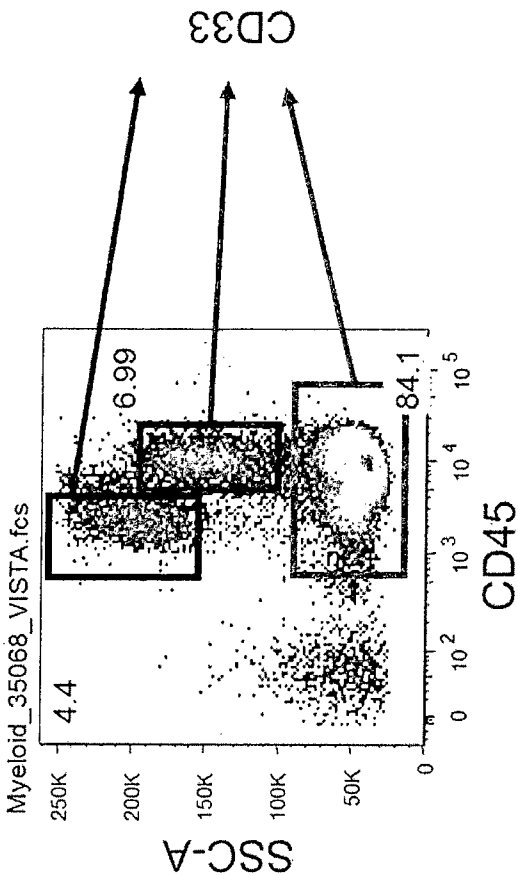


Figure 5A

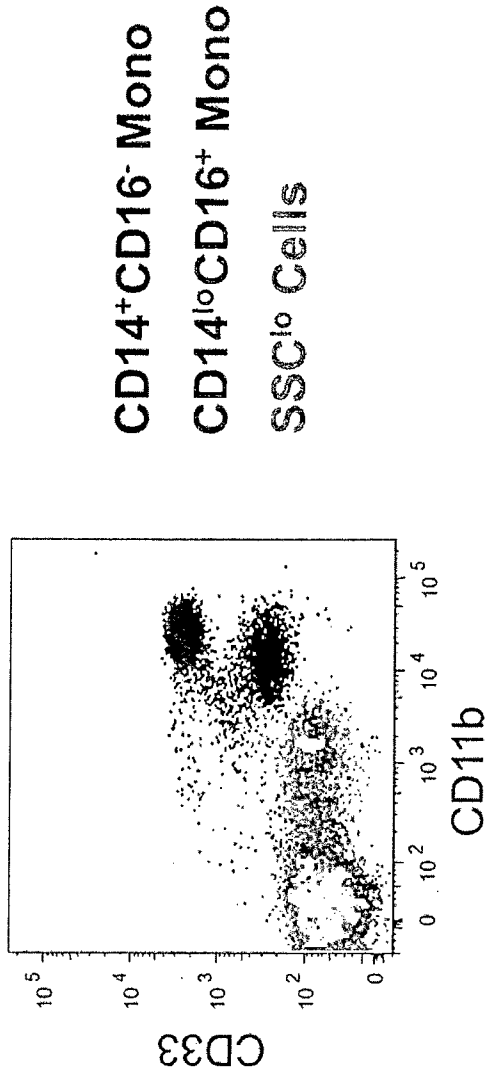
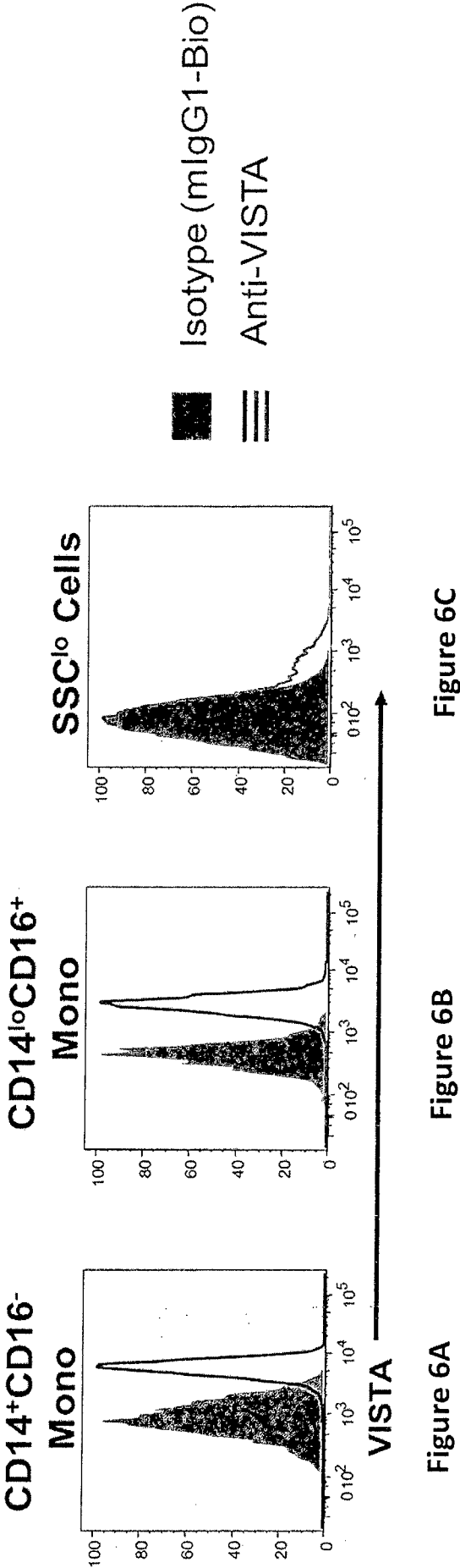
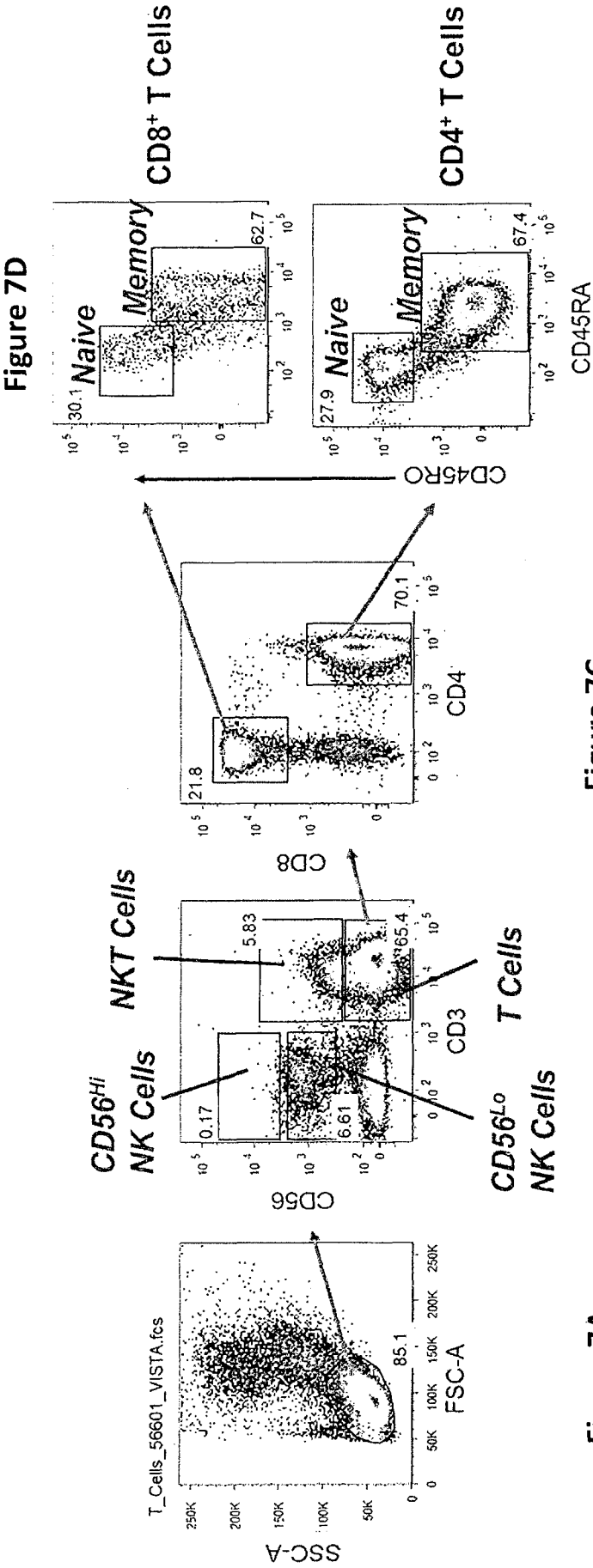
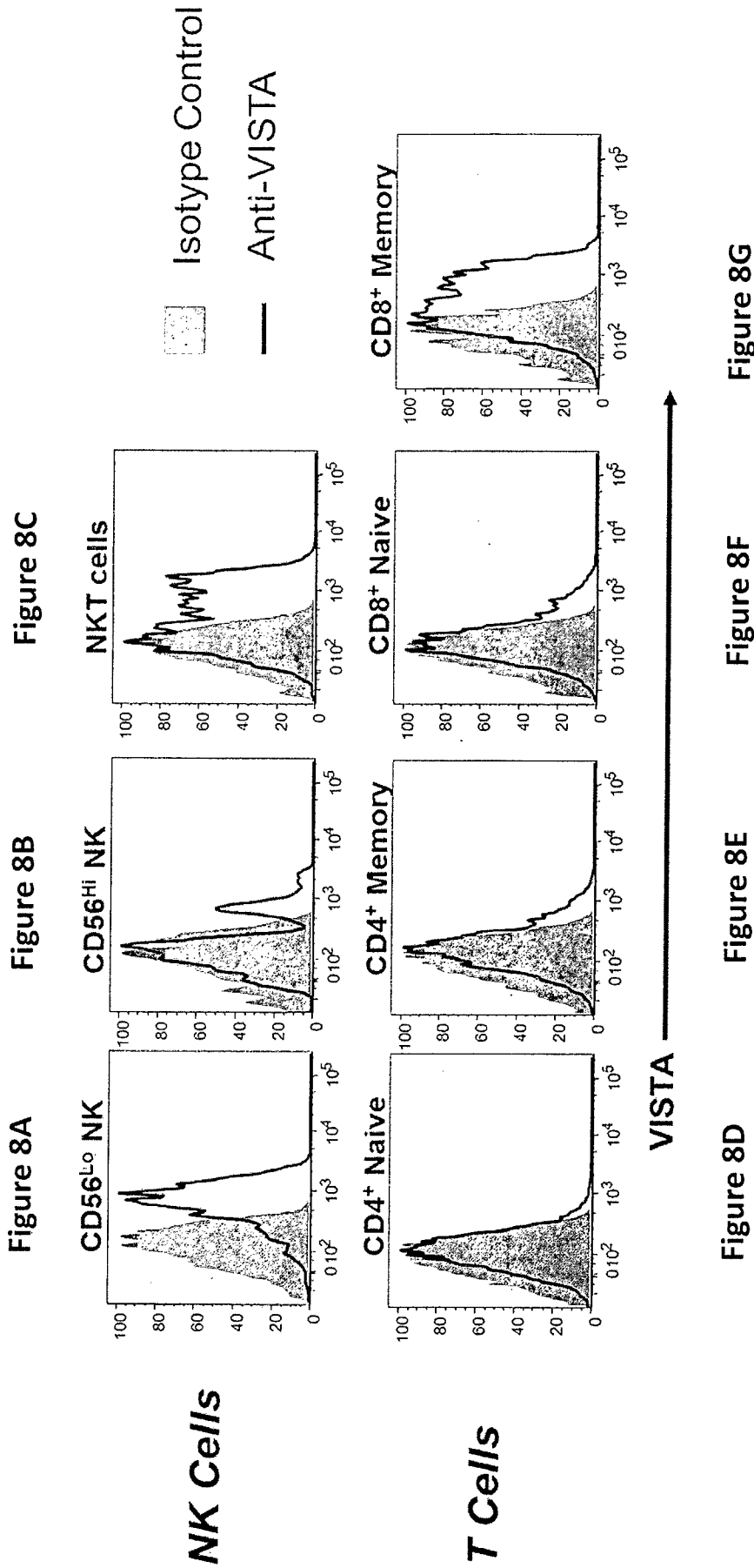
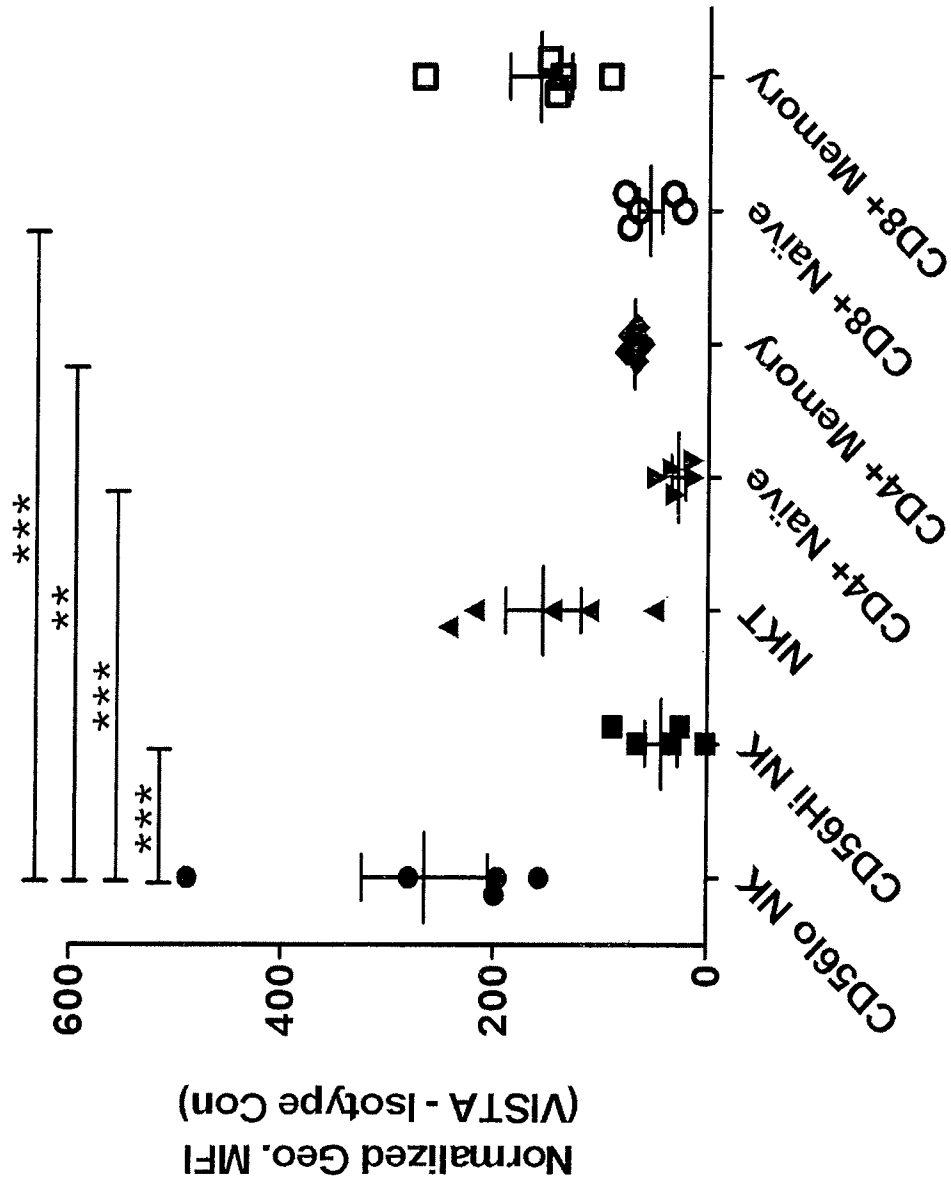


Figure 5B









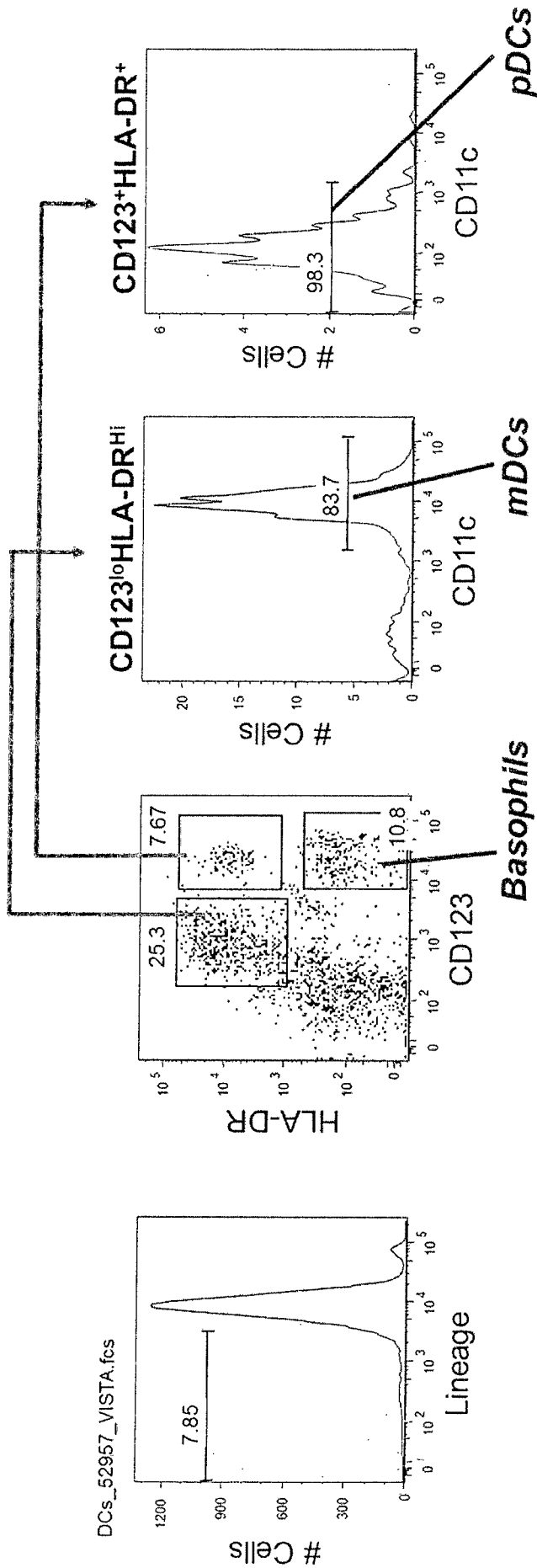


Figure 10A

Figure 10B

Figure 10C

Figure 10D

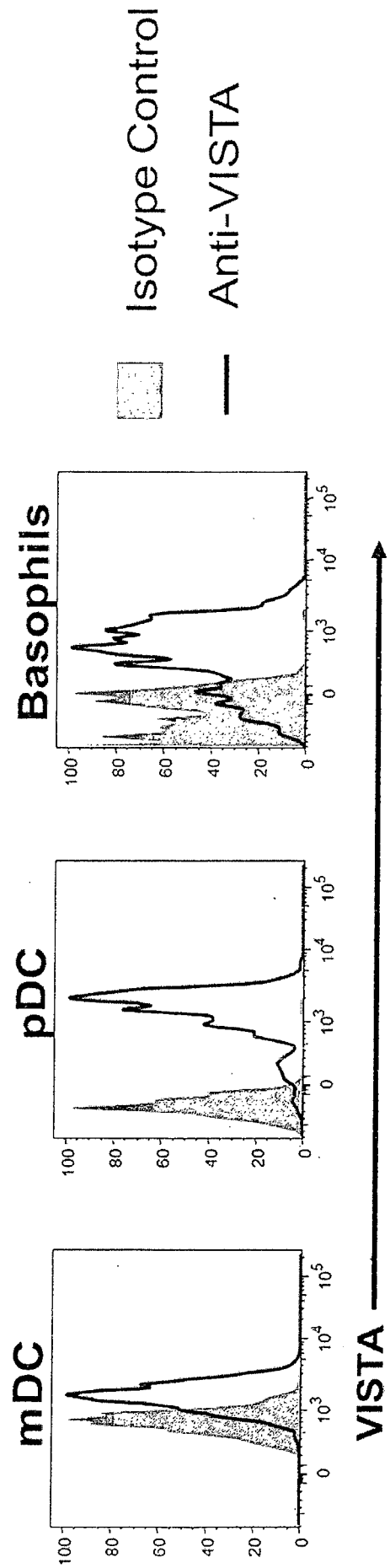


Figure 11A

Figure 11B

Figure 11C

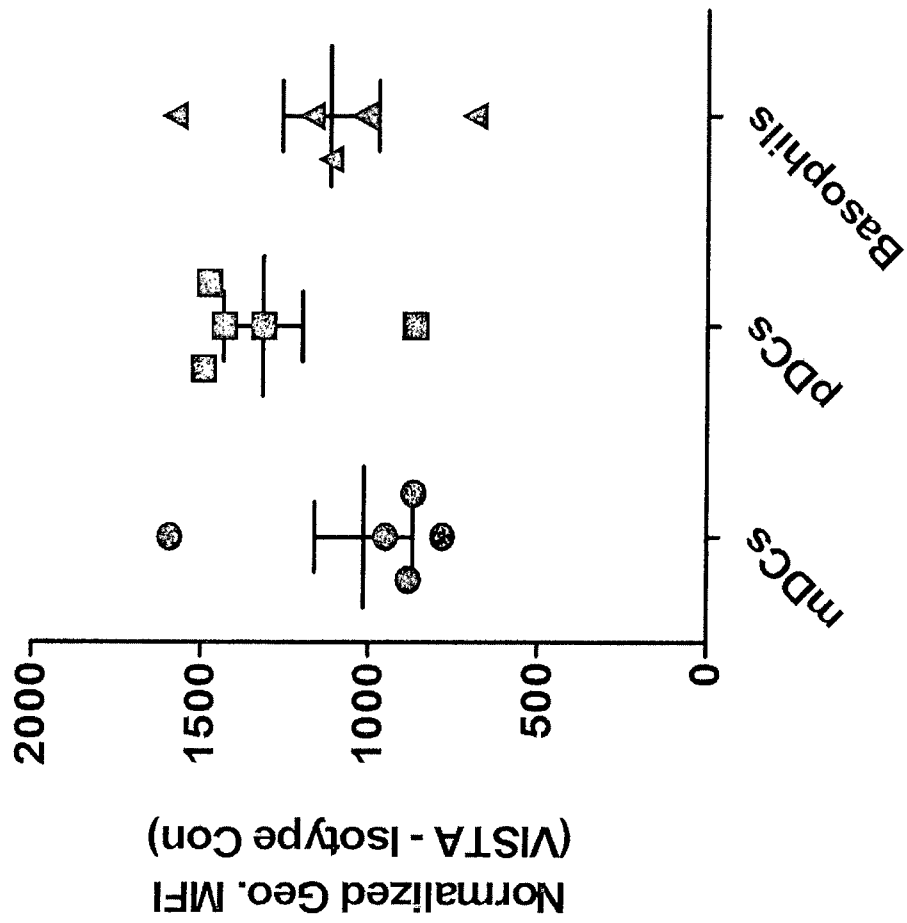


Figure 12

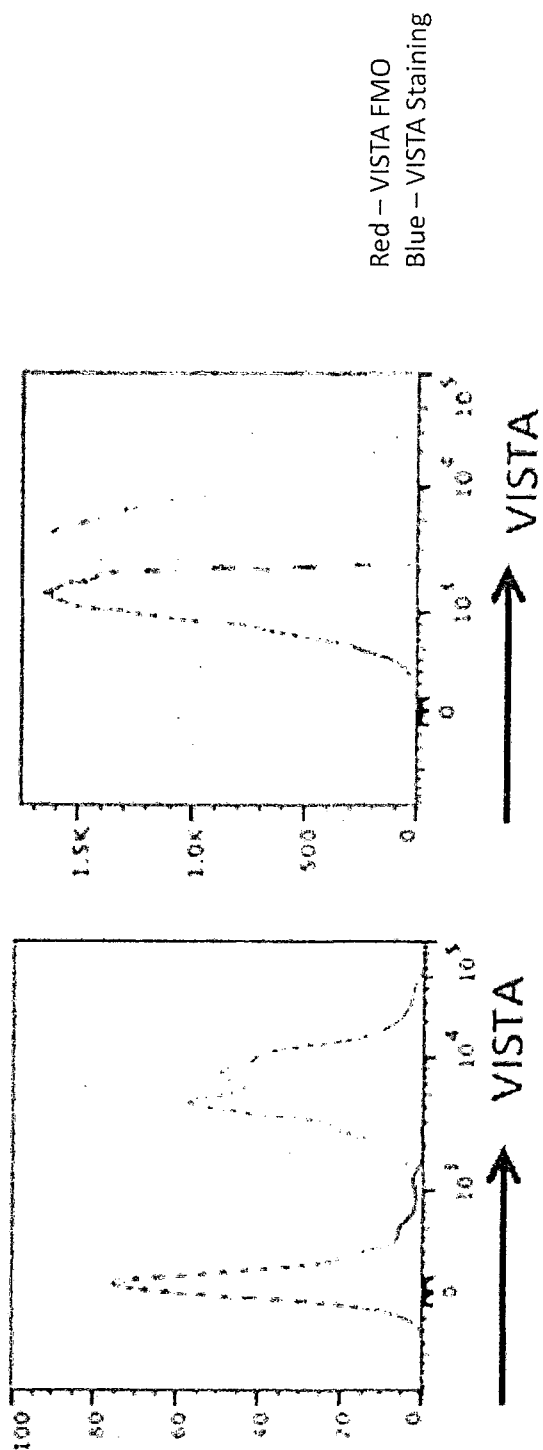


Figure 13B

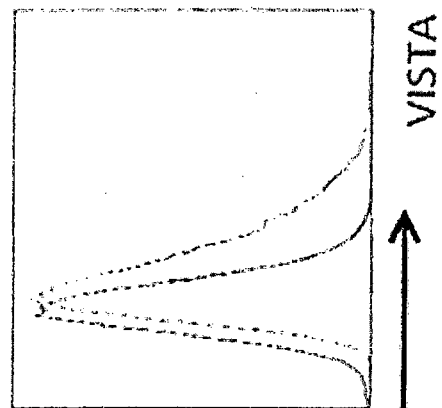


Figure 13D

Figure 13A

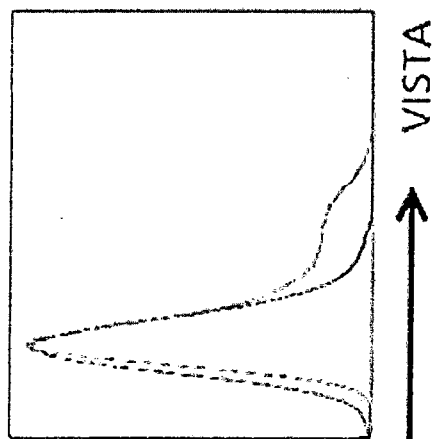


Figure 13C

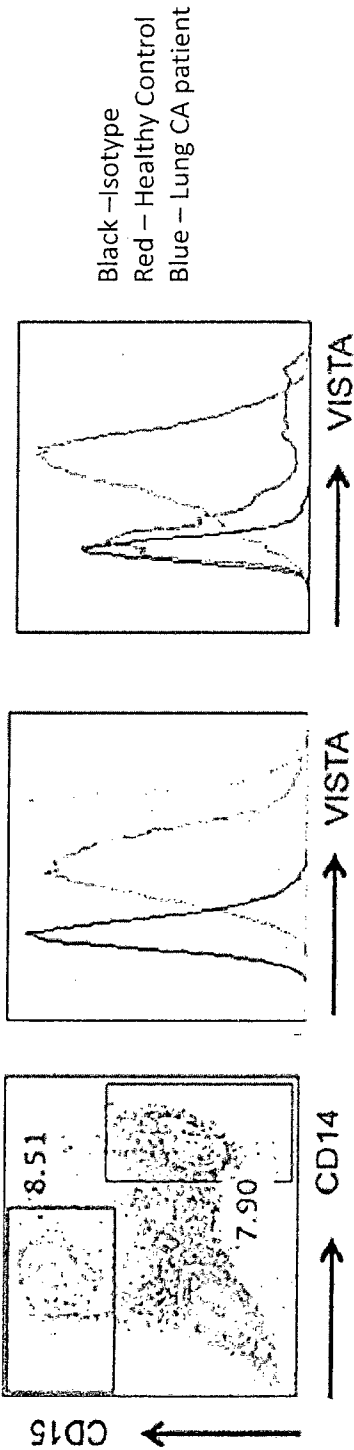


Figure 14C

Figure 14B

Figure 14A

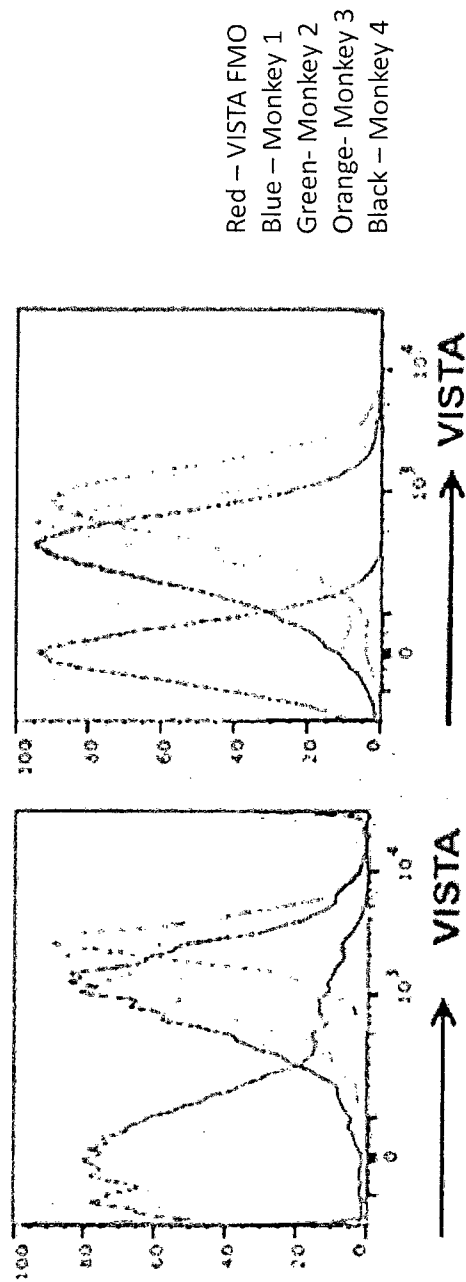


Figure 16B

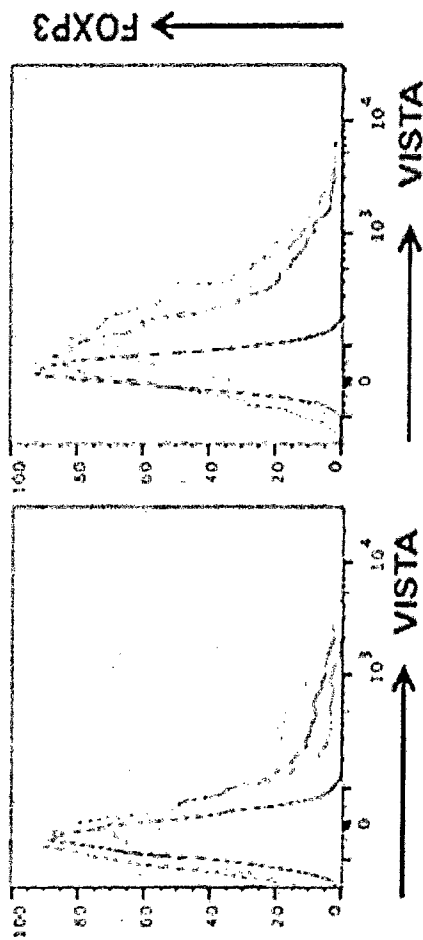


Figure 16A

Figure 16D

Figure 16C

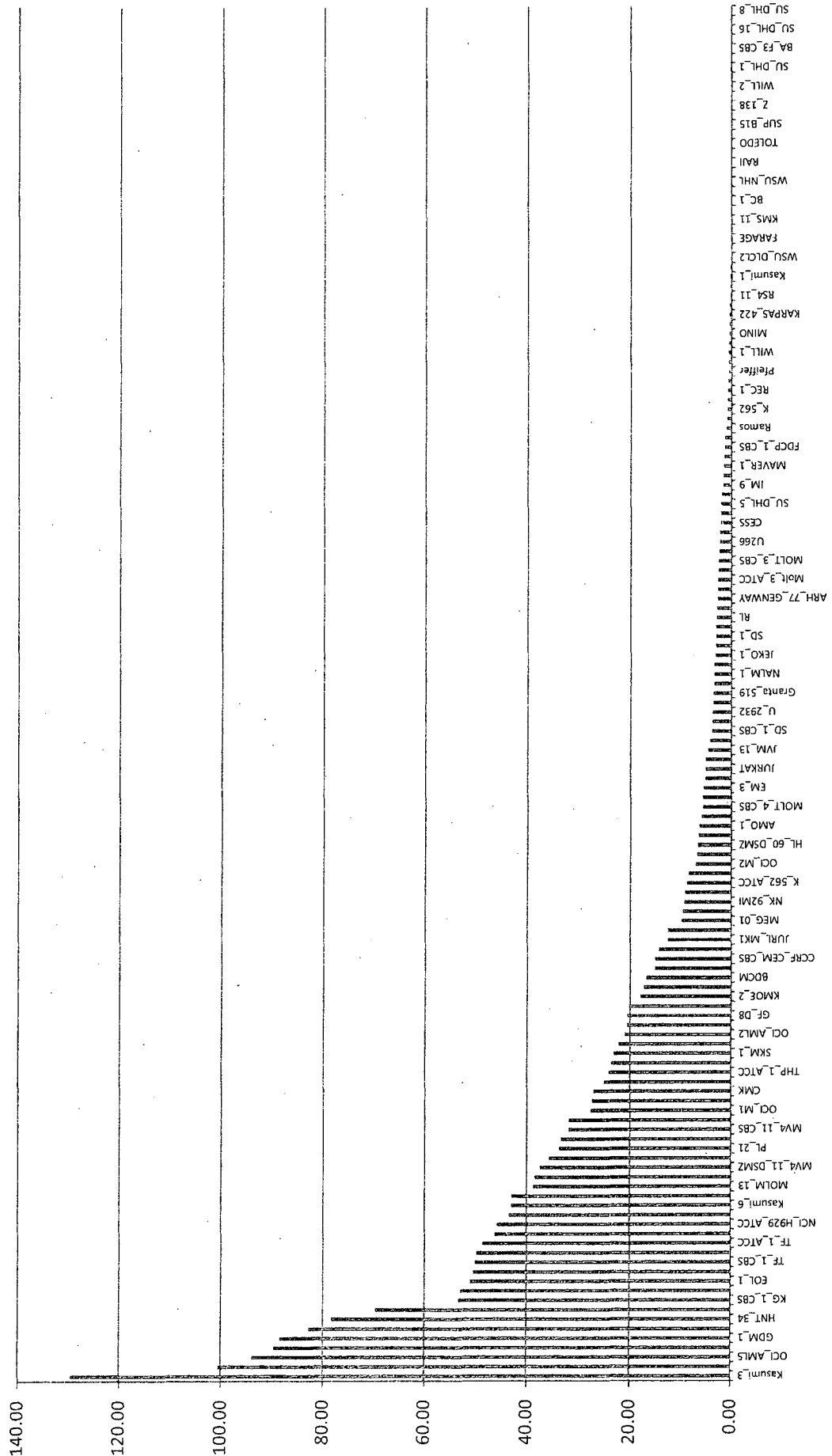


Figure 17

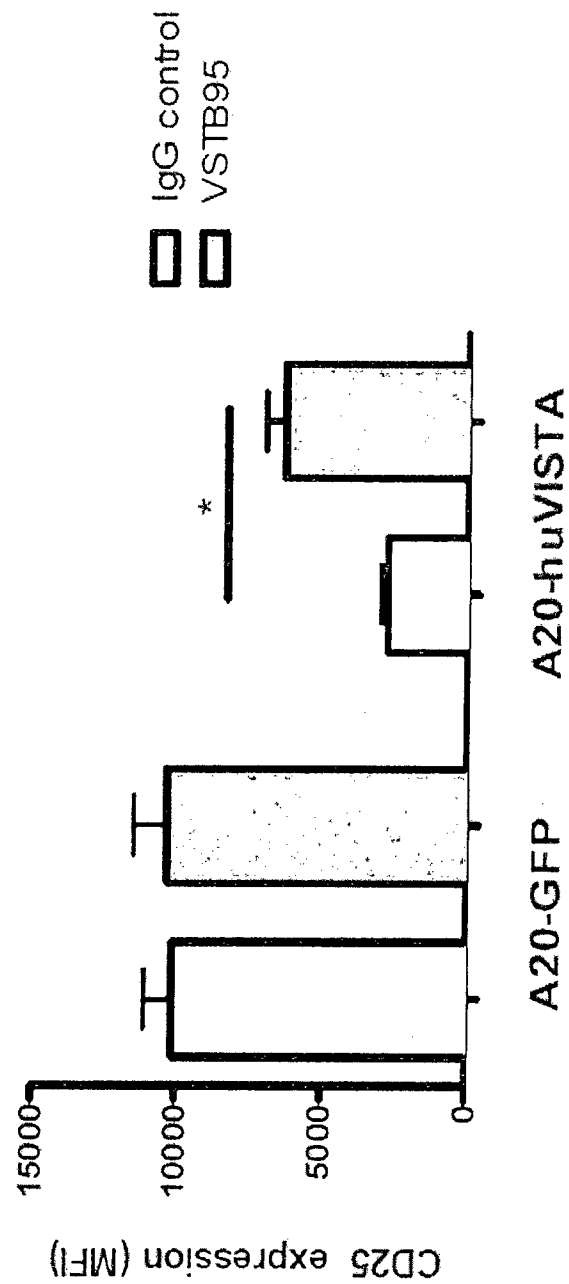


Figure 18

Figure 19A

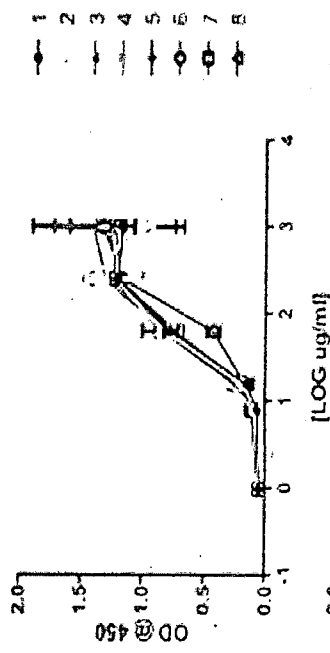


Figure 19B

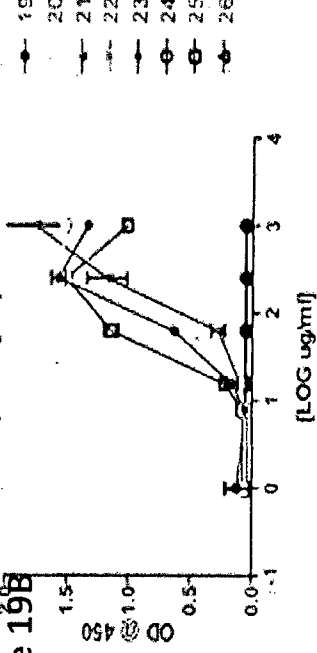


Figure 19C

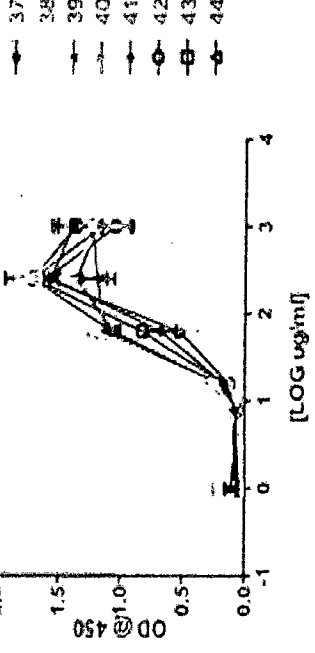


Figure 19D

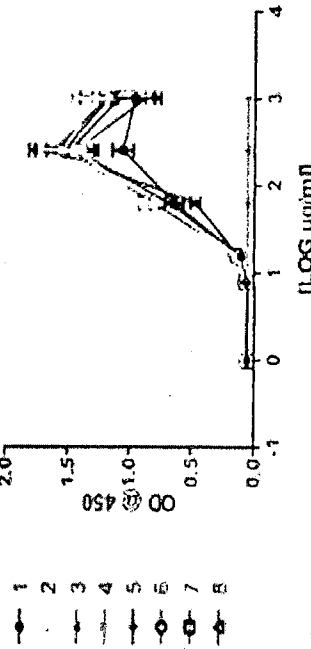


Figure 19E

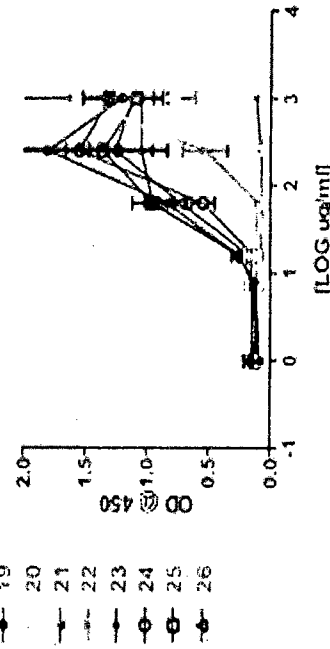
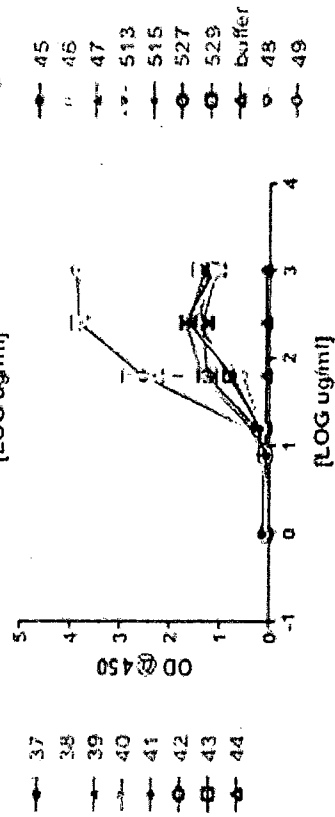


Figure 19F



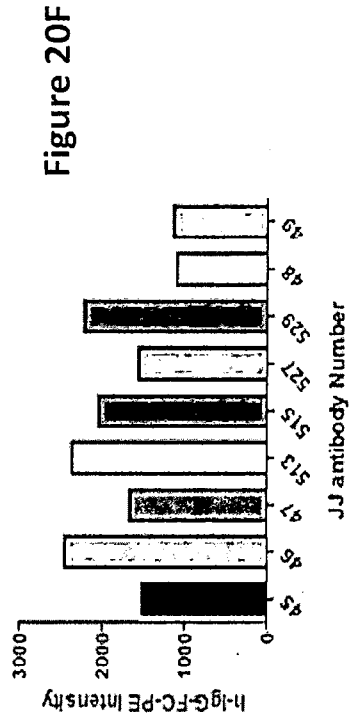
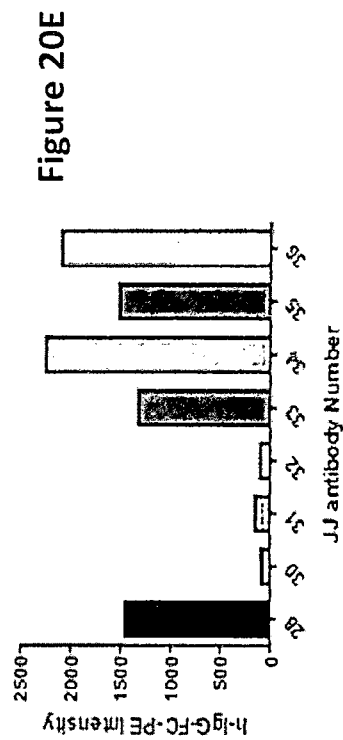
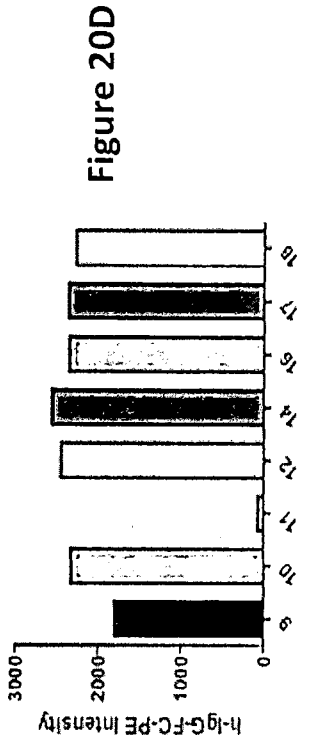
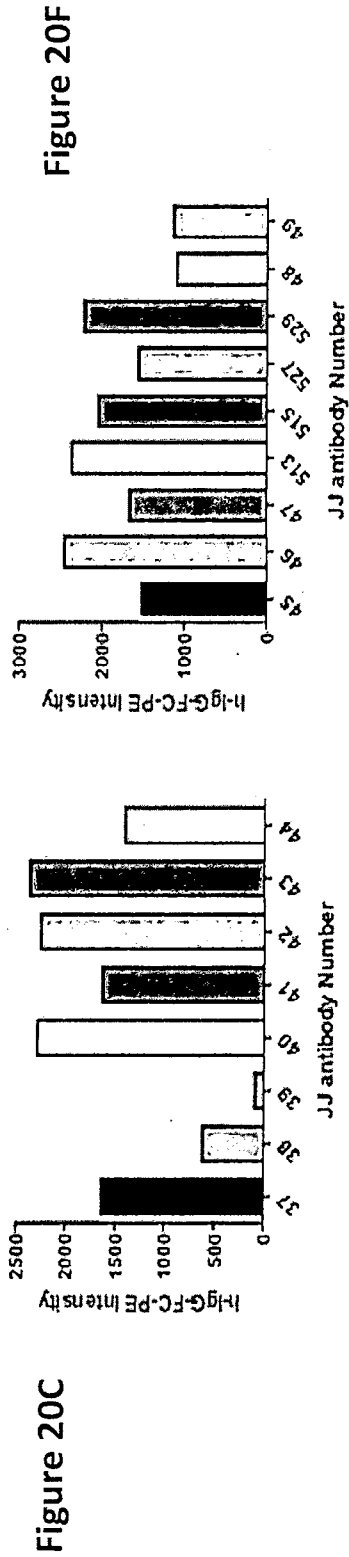
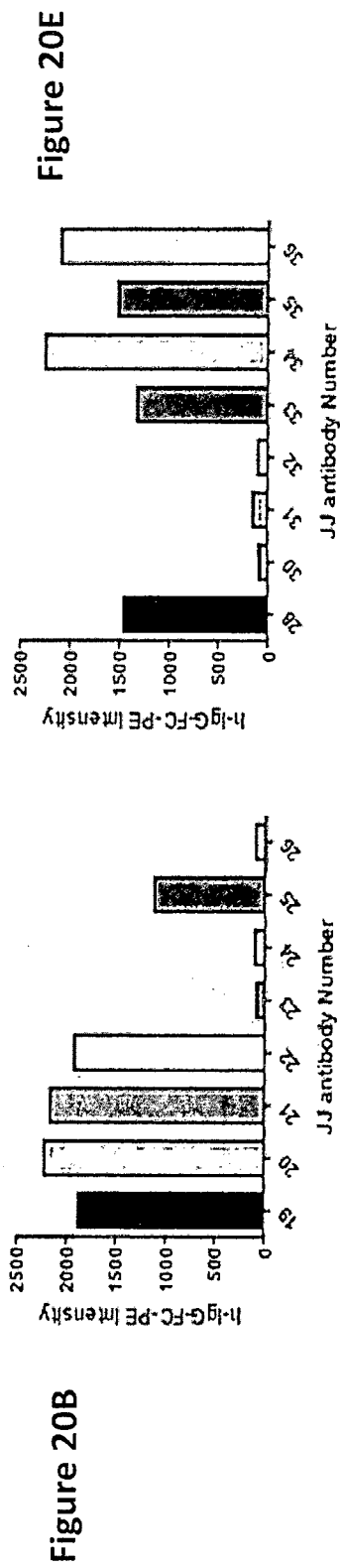
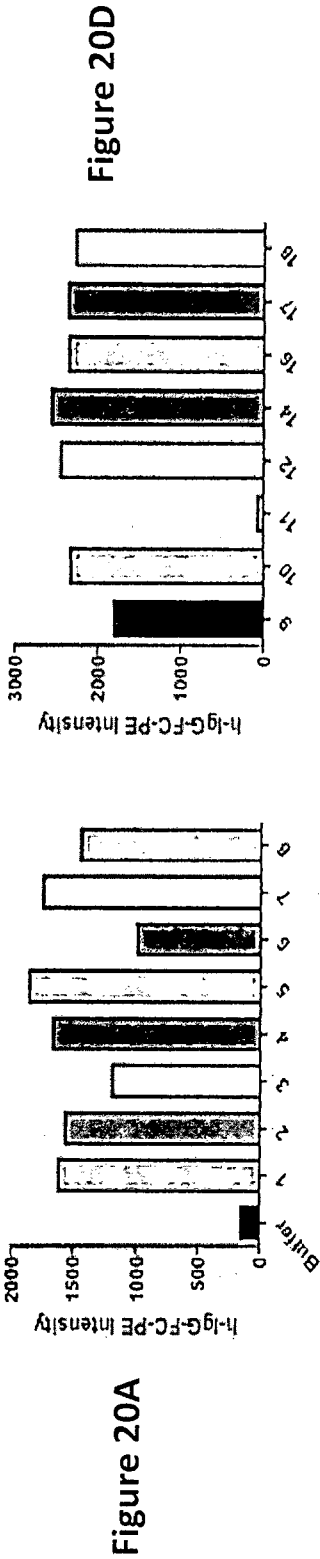


Figure 21A
Donor 60-> Donor 62

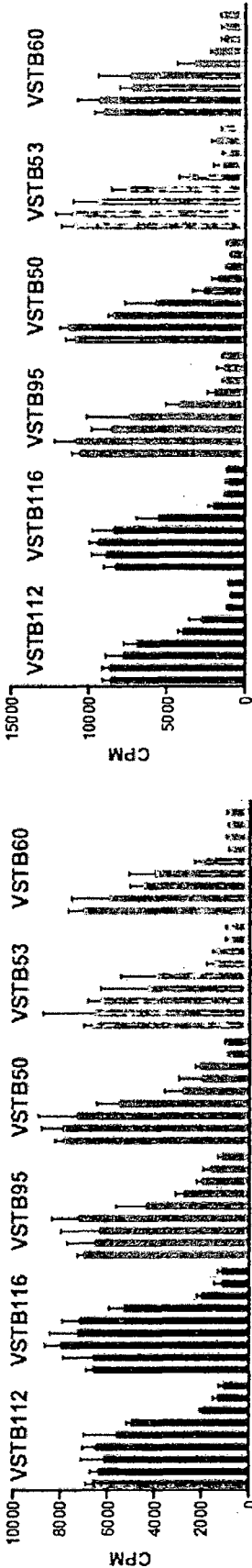


Figure 21B

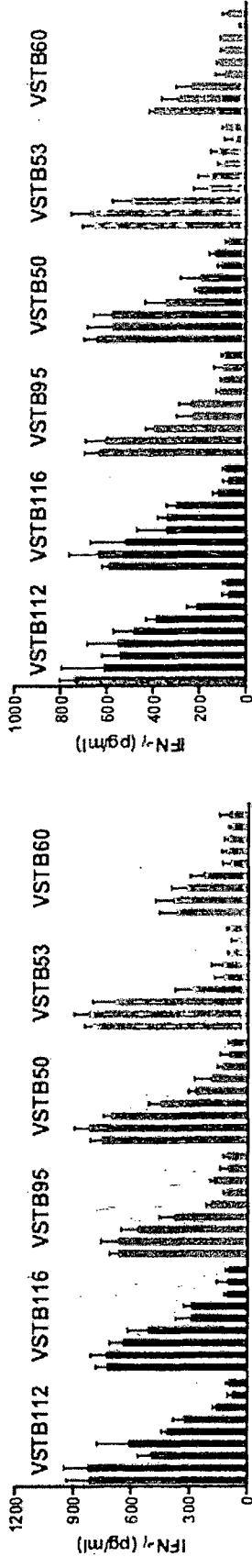
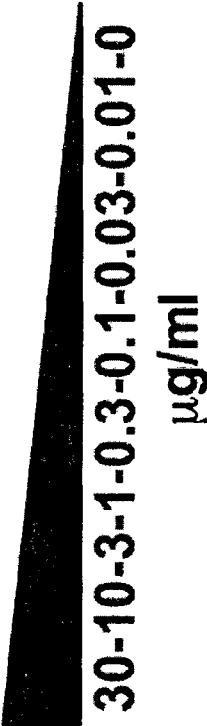


Figure 21C



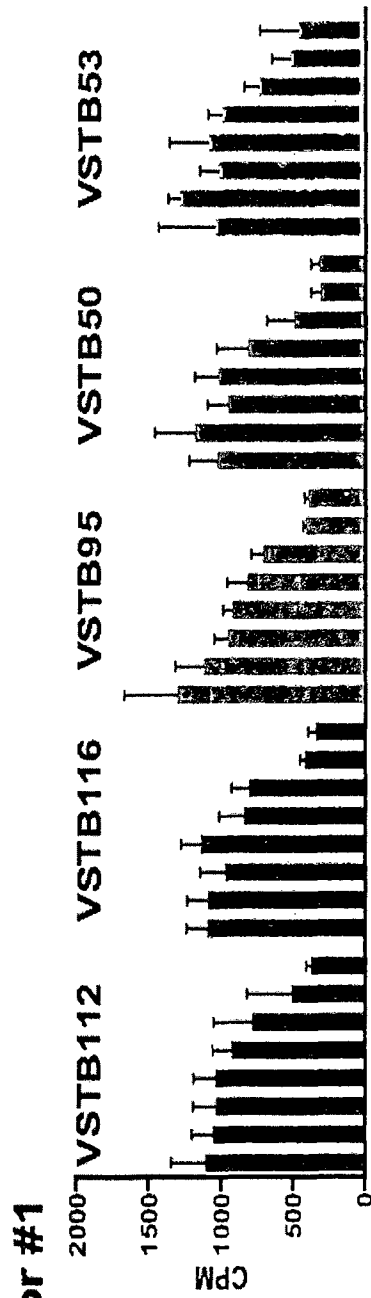


Figure 22A

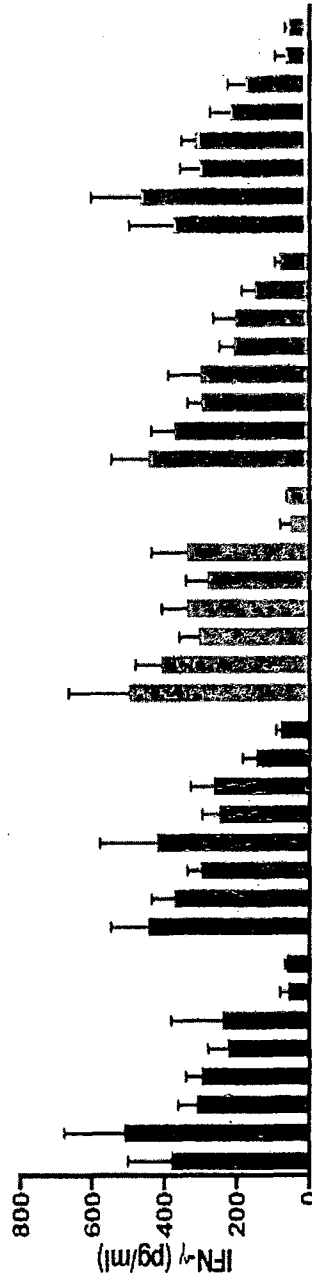


Figure 22B

10-3-1-0.3-0.1-0.03-0.01-0
µg/ml

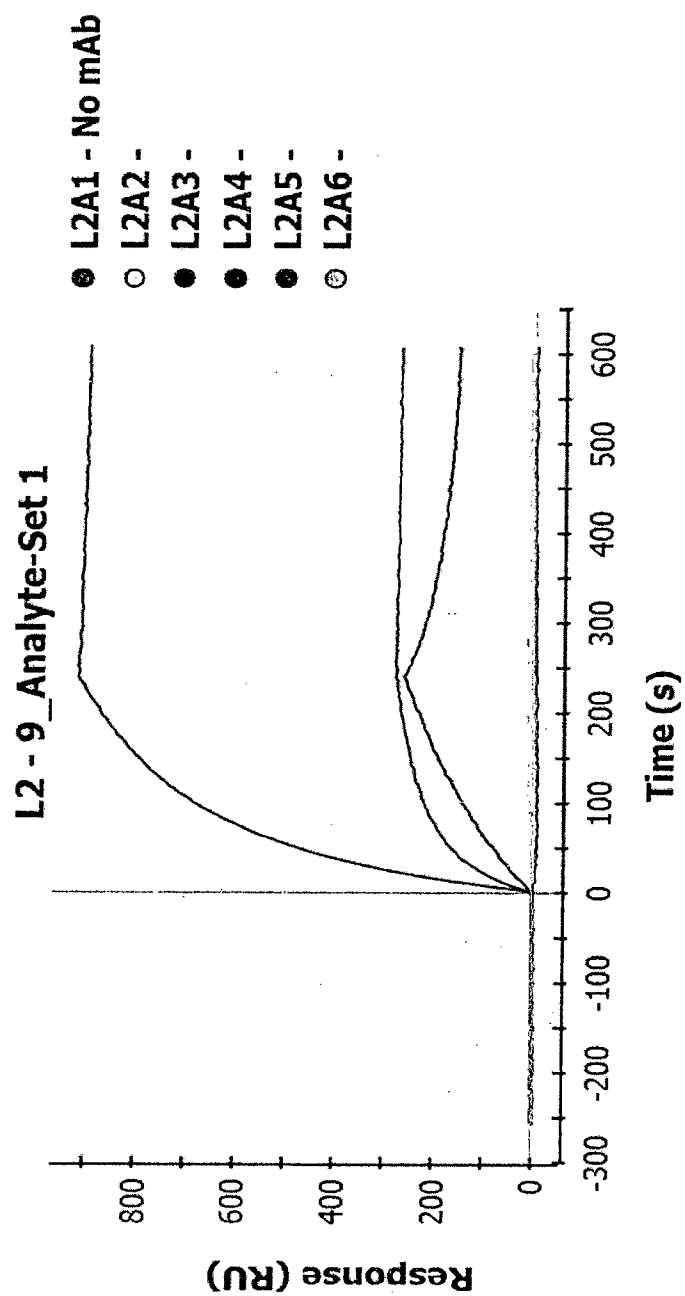


Figure 23

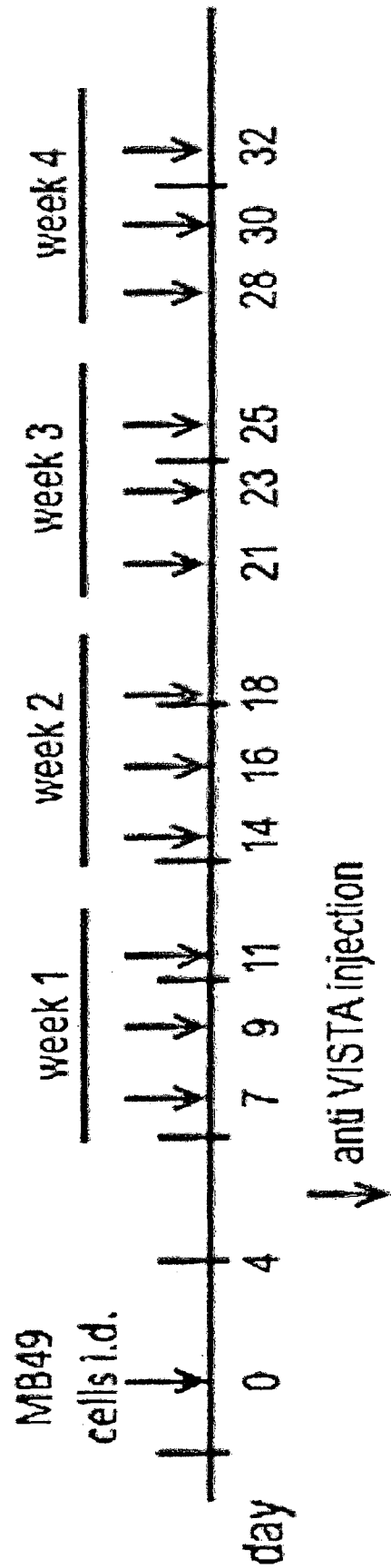


Figure 24

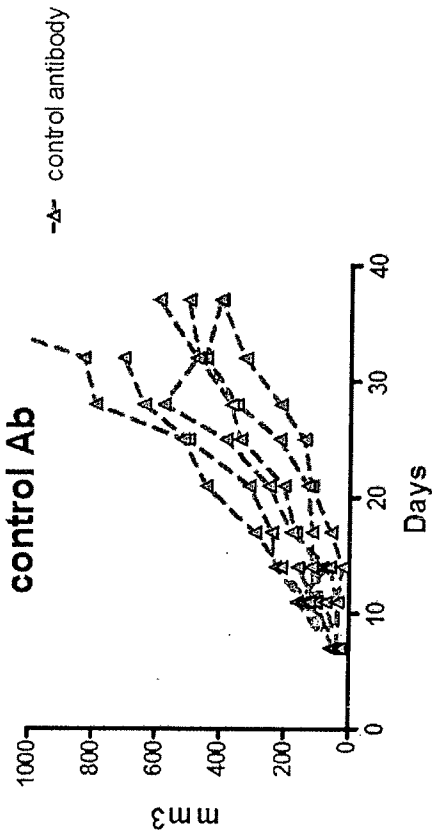


Figure 25A

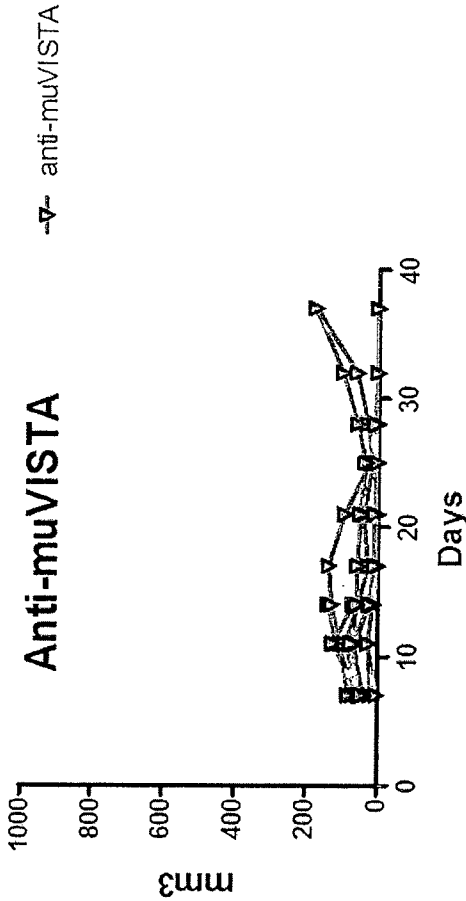


Figure 25B

MGVPTALEAGSWRWGSLLFALFLAASLGPVAAFKVATPYSLSLVCPEGQ
NVTLCRLLGPVDKGGHDVTFYKWTWYRSSRGEVQTCSERRPIRNLTFQDL
HLHGGHQAAANTSHDLAQRHGLEASDHHGNFSITMRNLTLDDSGLY
CCLVVEIRHHHSEHRVHGAMELQVQTGKDAPSNVCVYPSSSQESENIT
AAALATGACIVGILCLPLILLVYKQ
RQAASNRRAQELVRMDSNIQGIENPGFEASPPAQGIPEAKVRHPLSYV
AQRQPSESGRHLHLLSEPSTPLSPPPGPGDVF (SEQ ID NO:46)

Figure 26

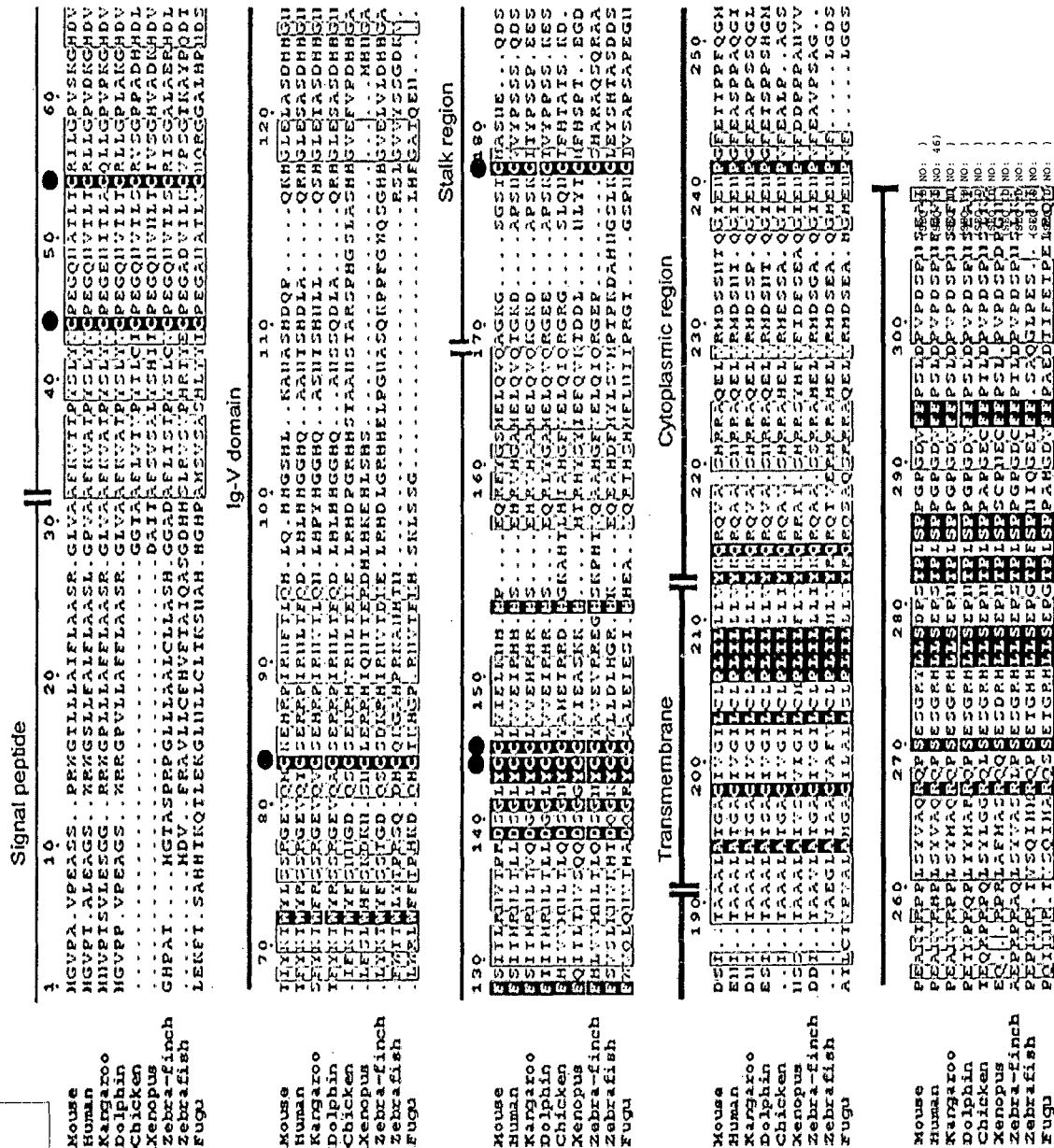


Figure 27

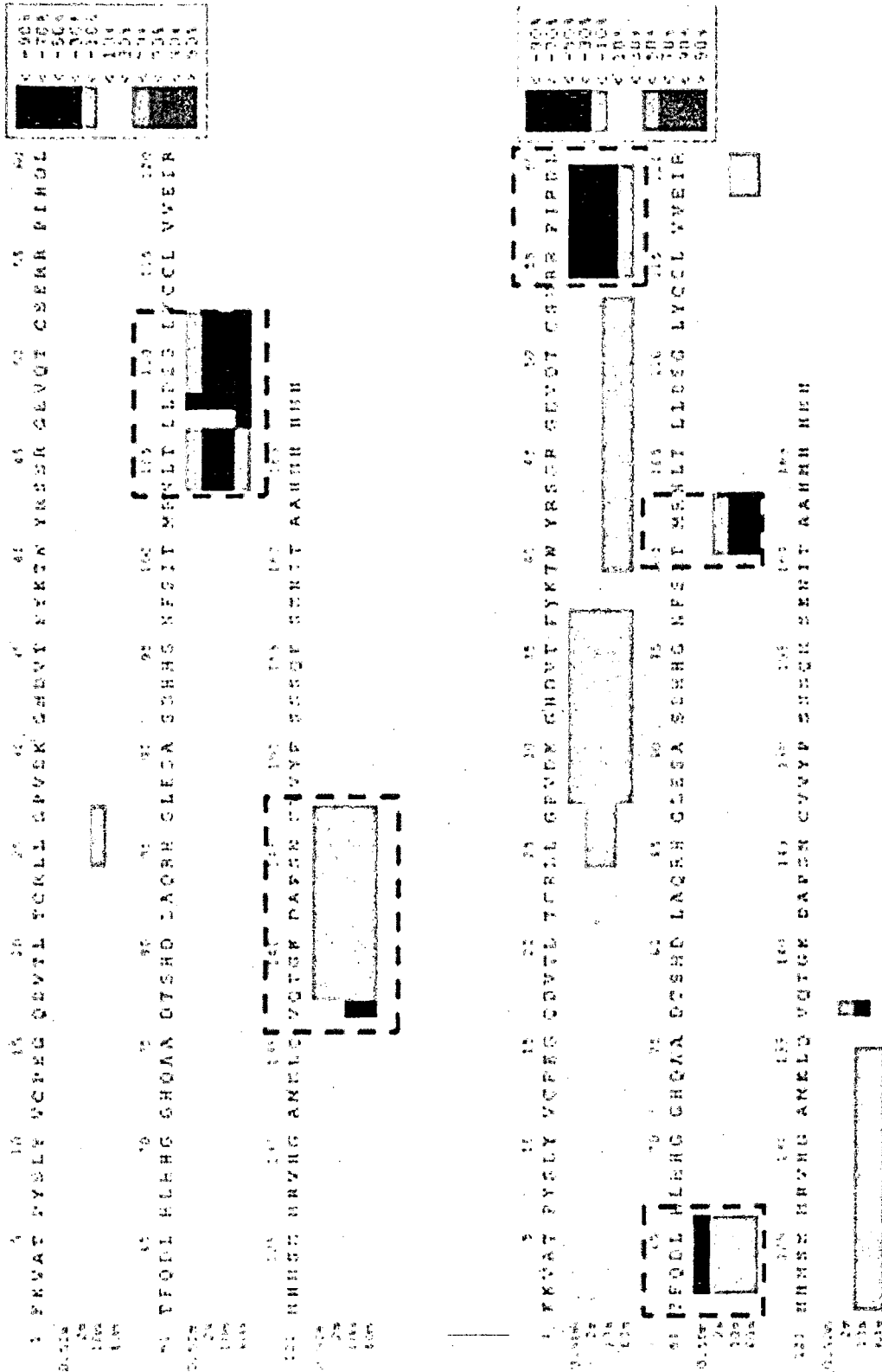


Figure 28

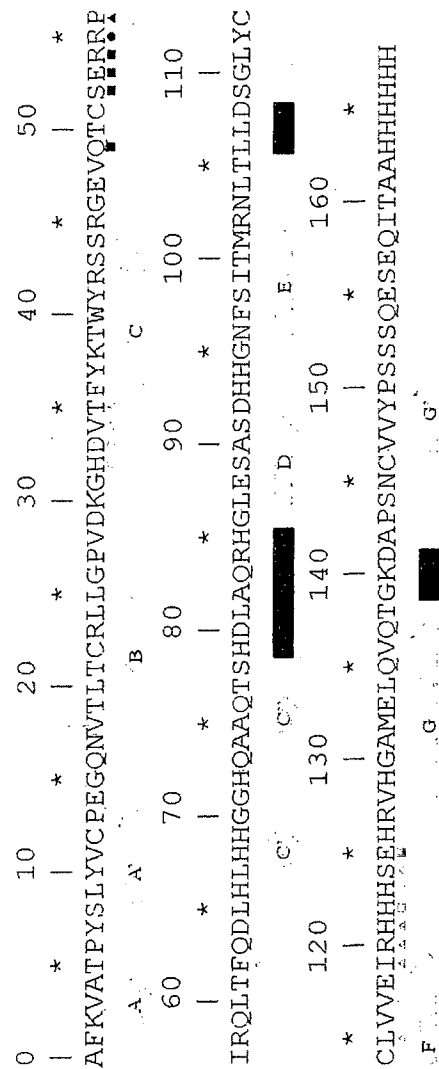
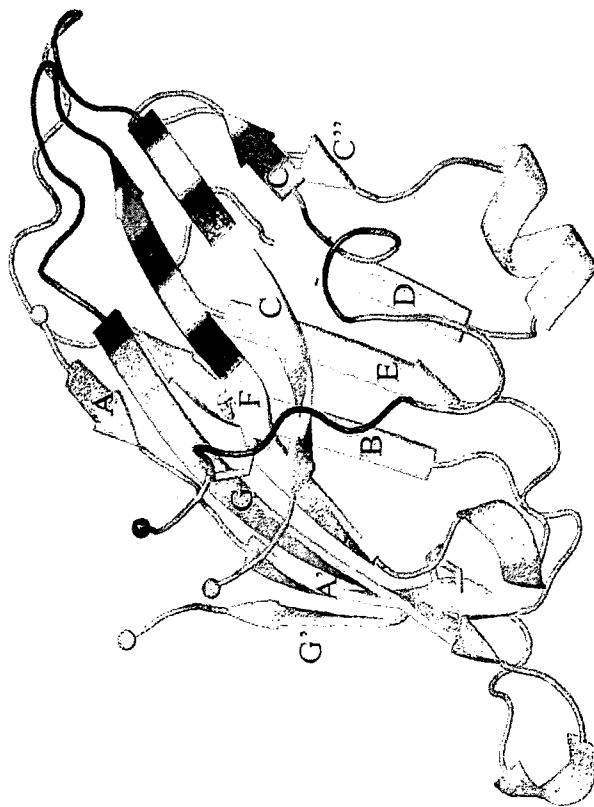


Figure 29

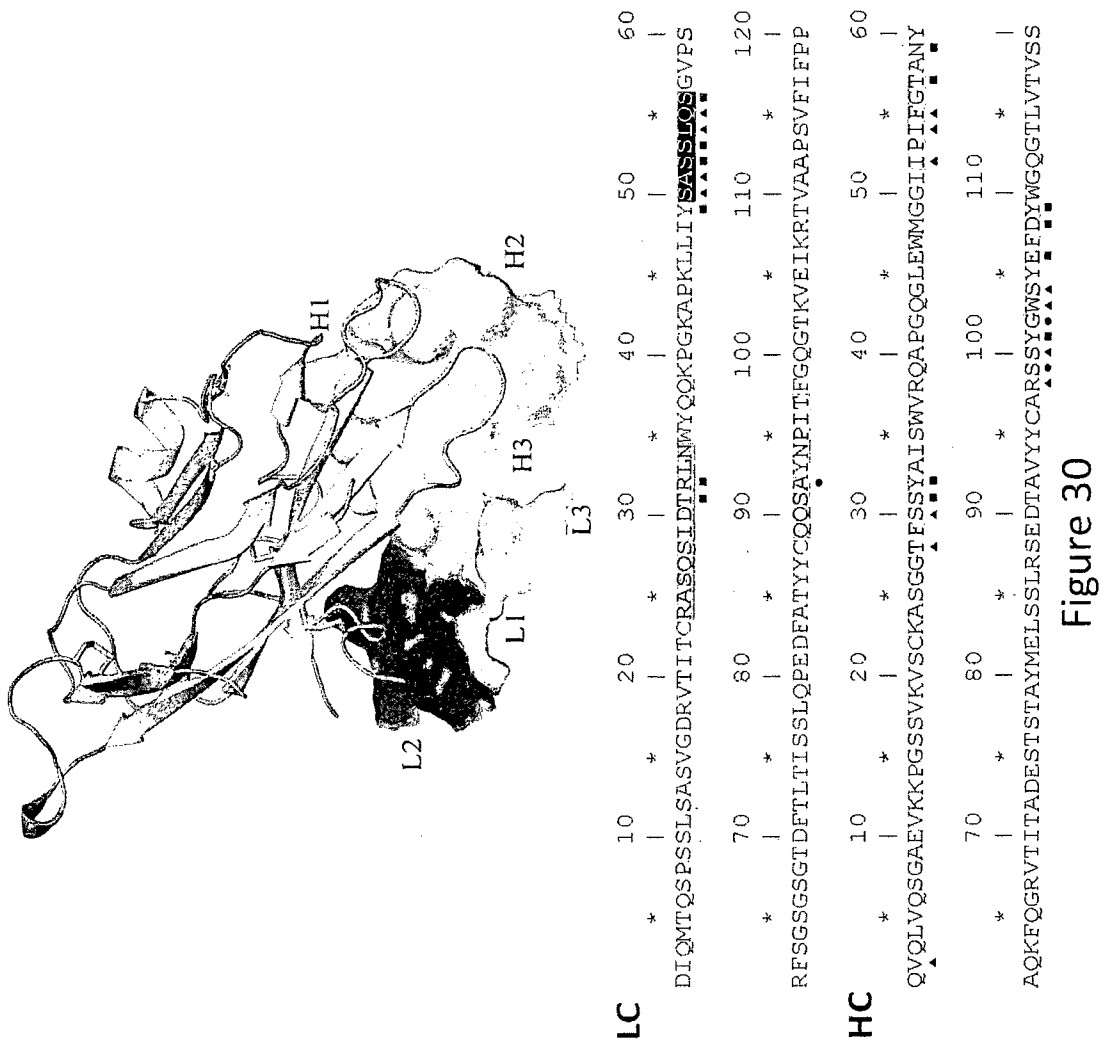


Figure 30

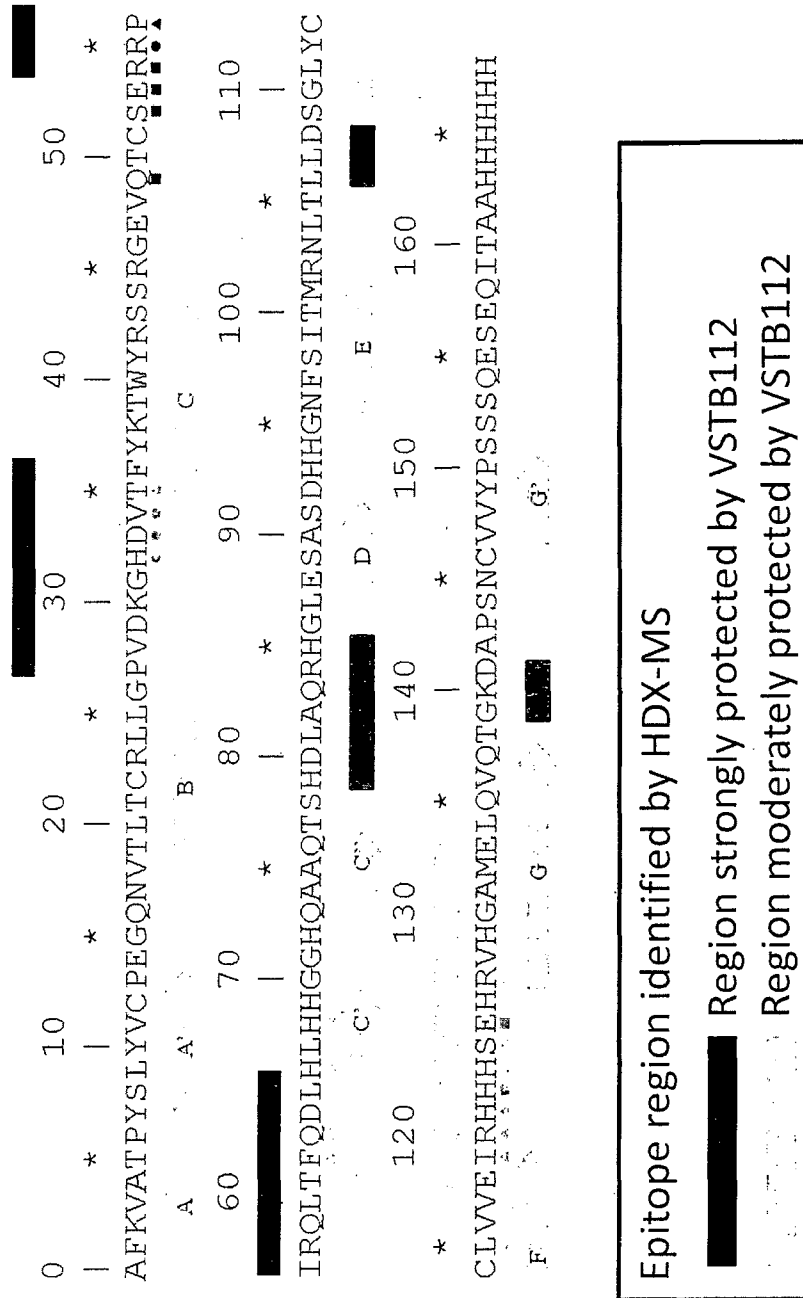


Figure 31

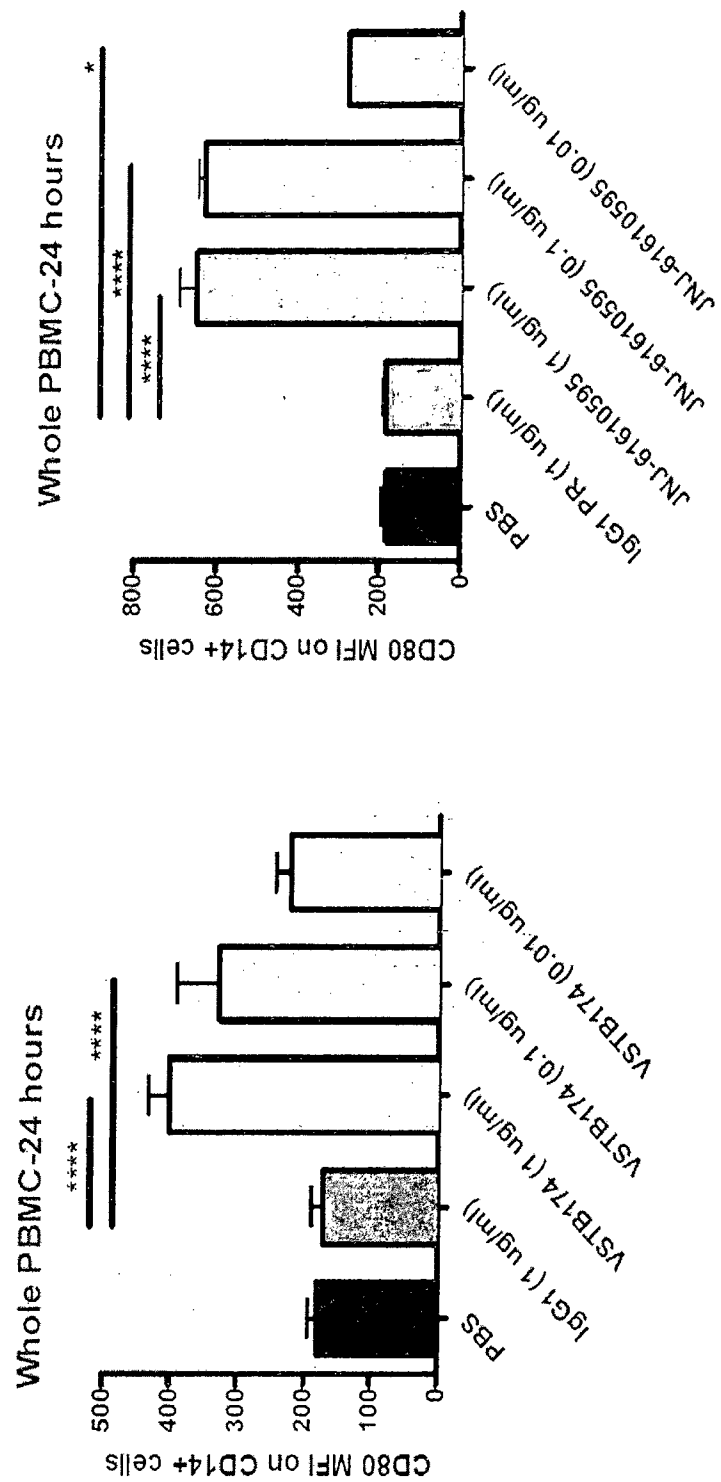


Figure 32

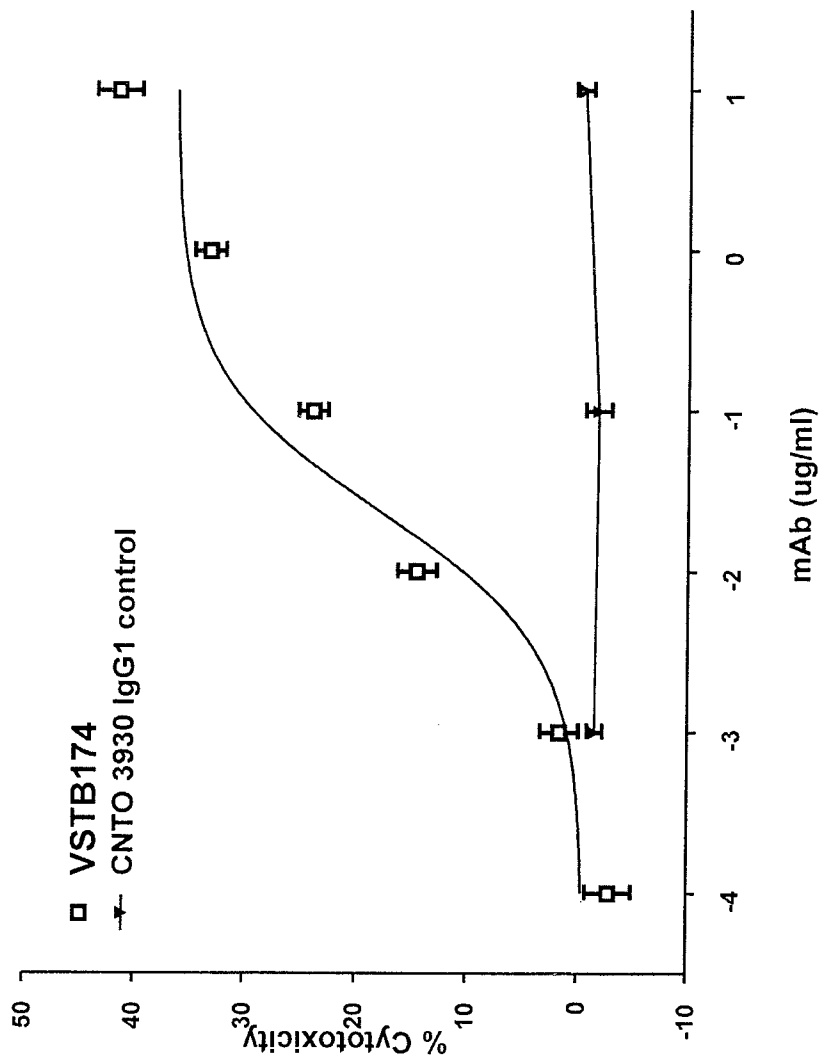


Figure 33

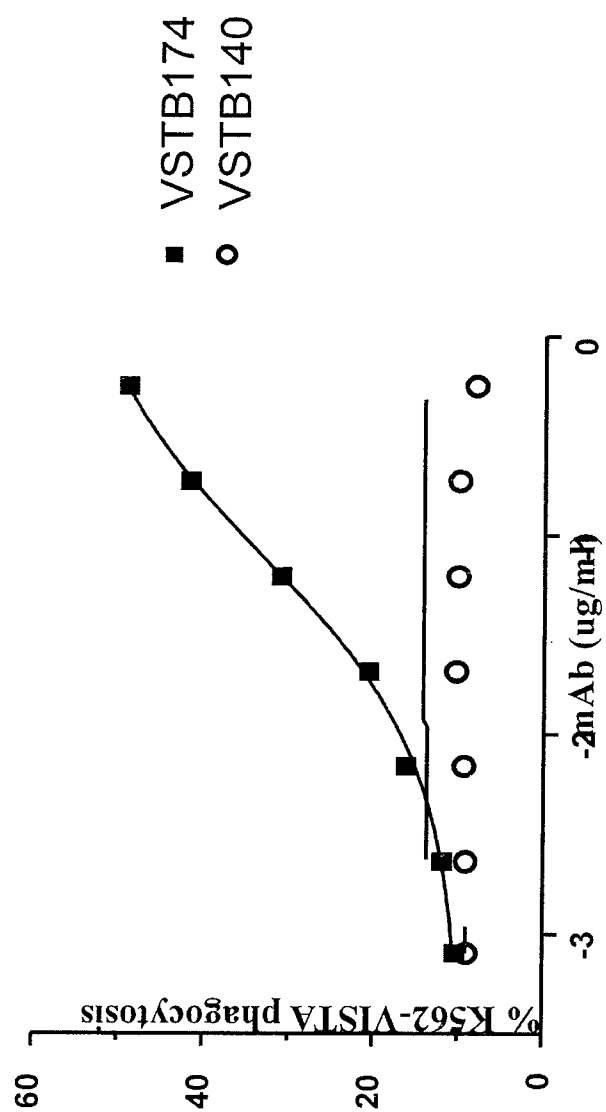


Figure 34

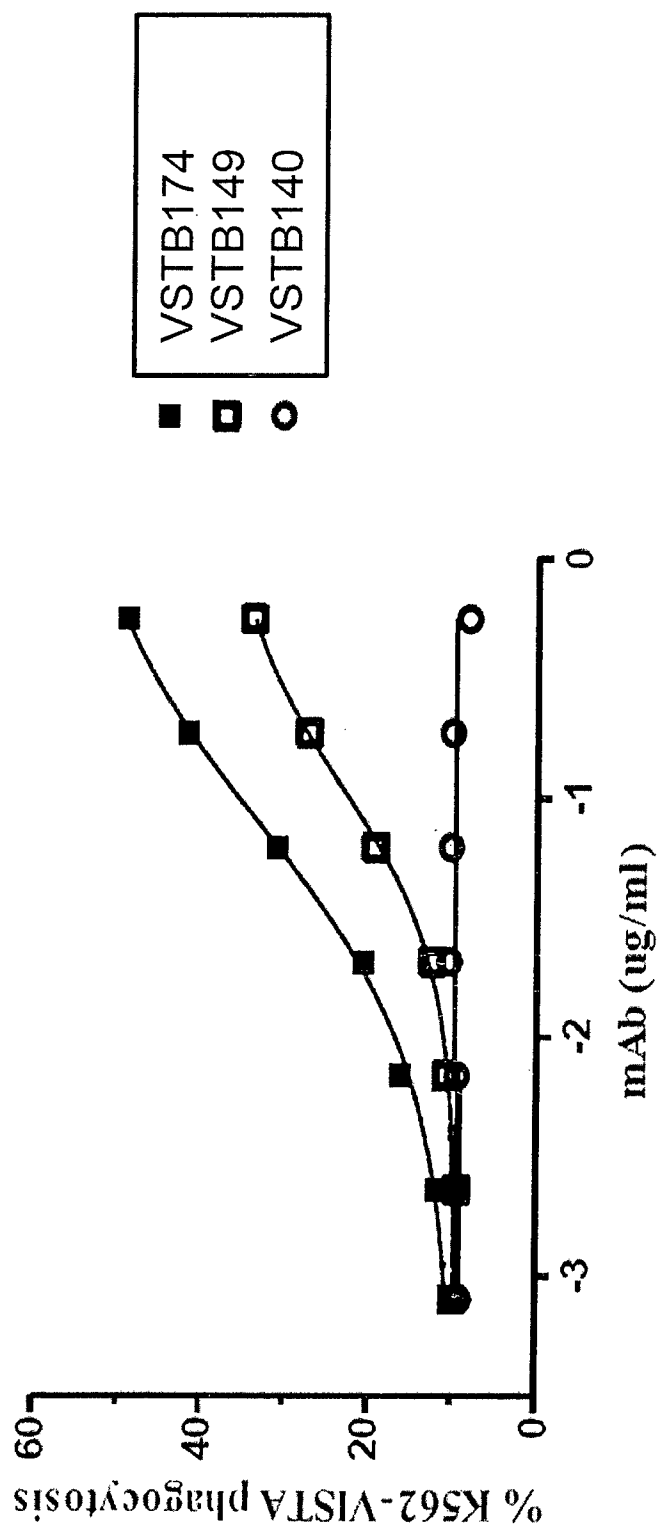


Figure 35

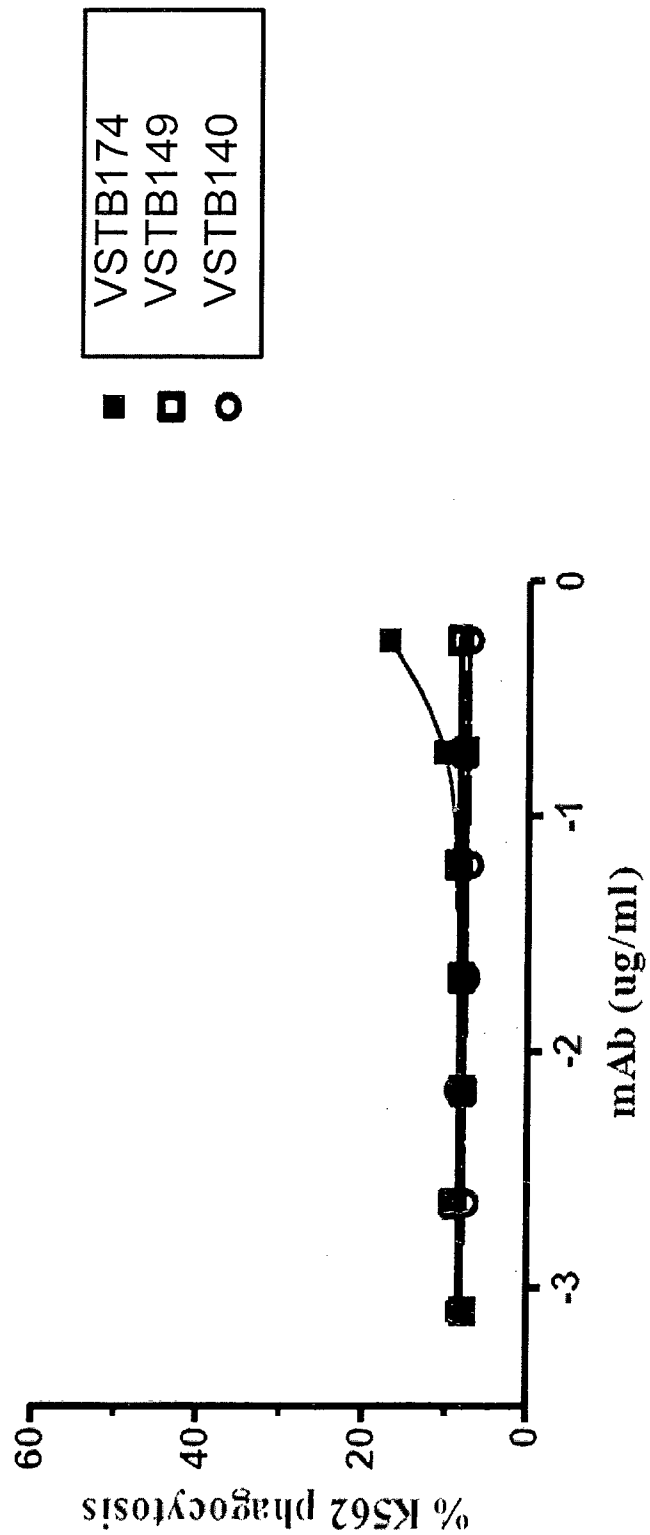


Figure 36

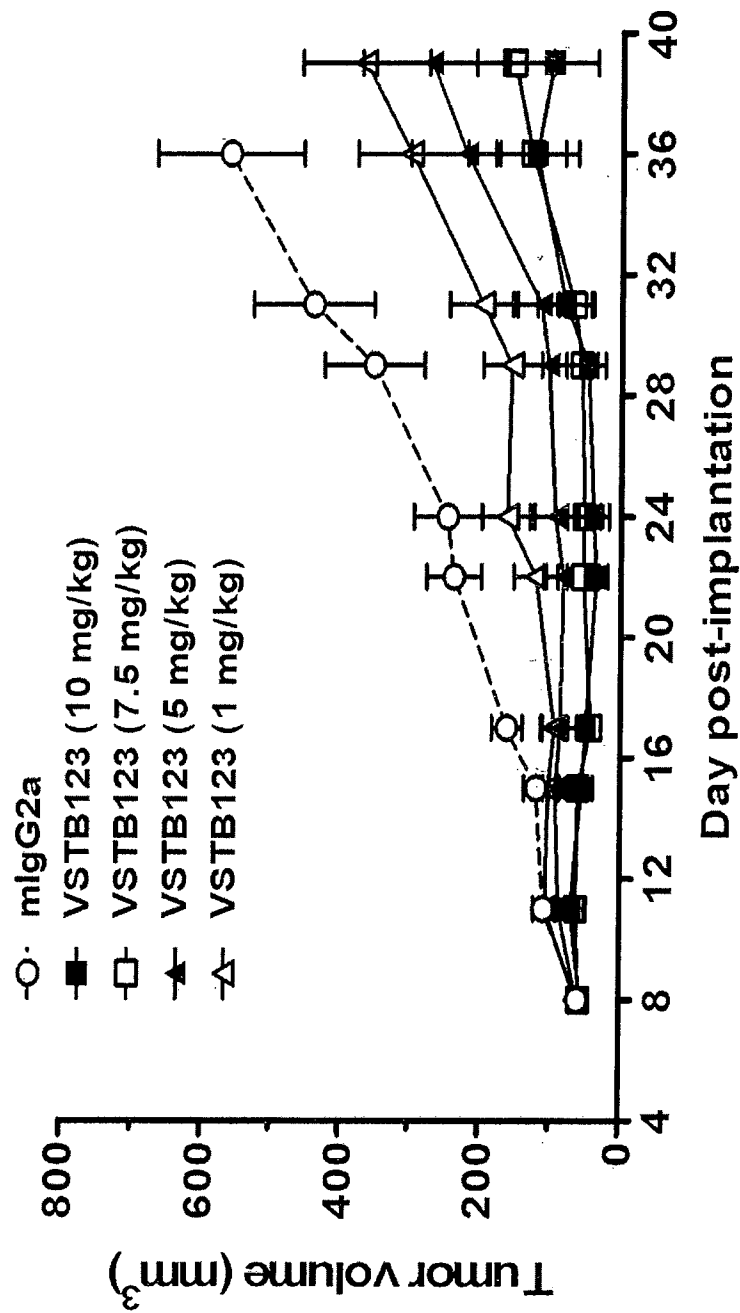


Figure 37

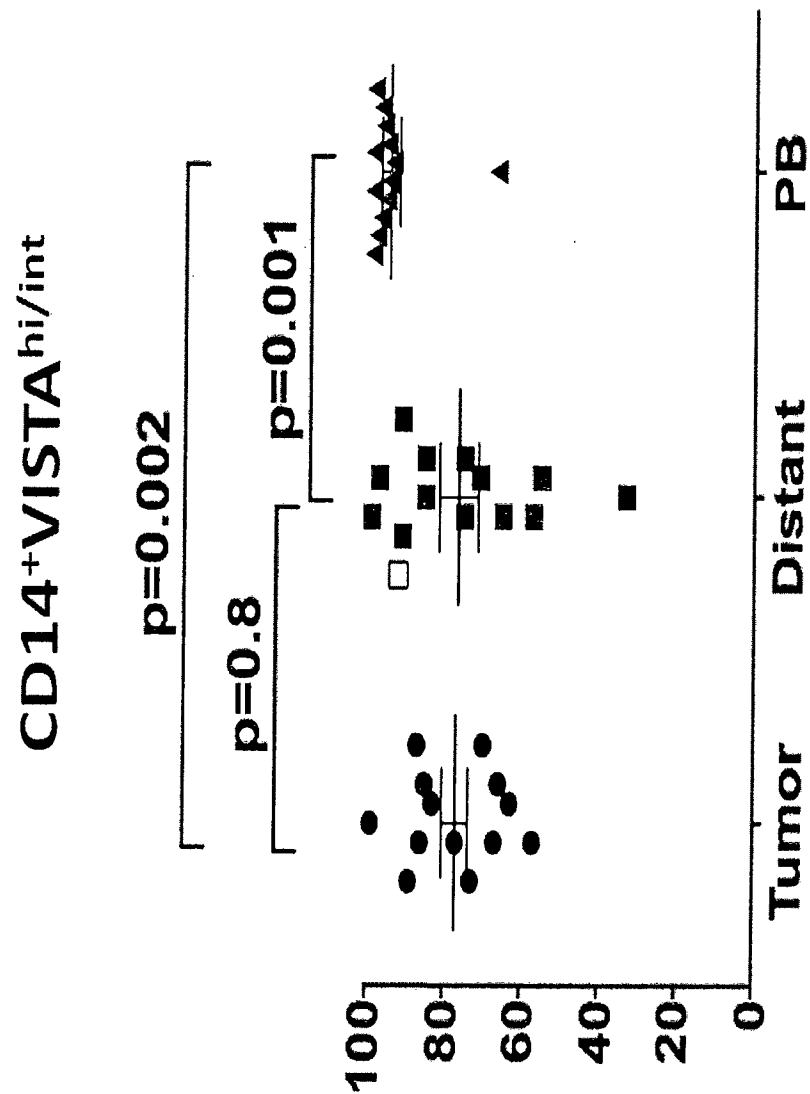


Figure 38

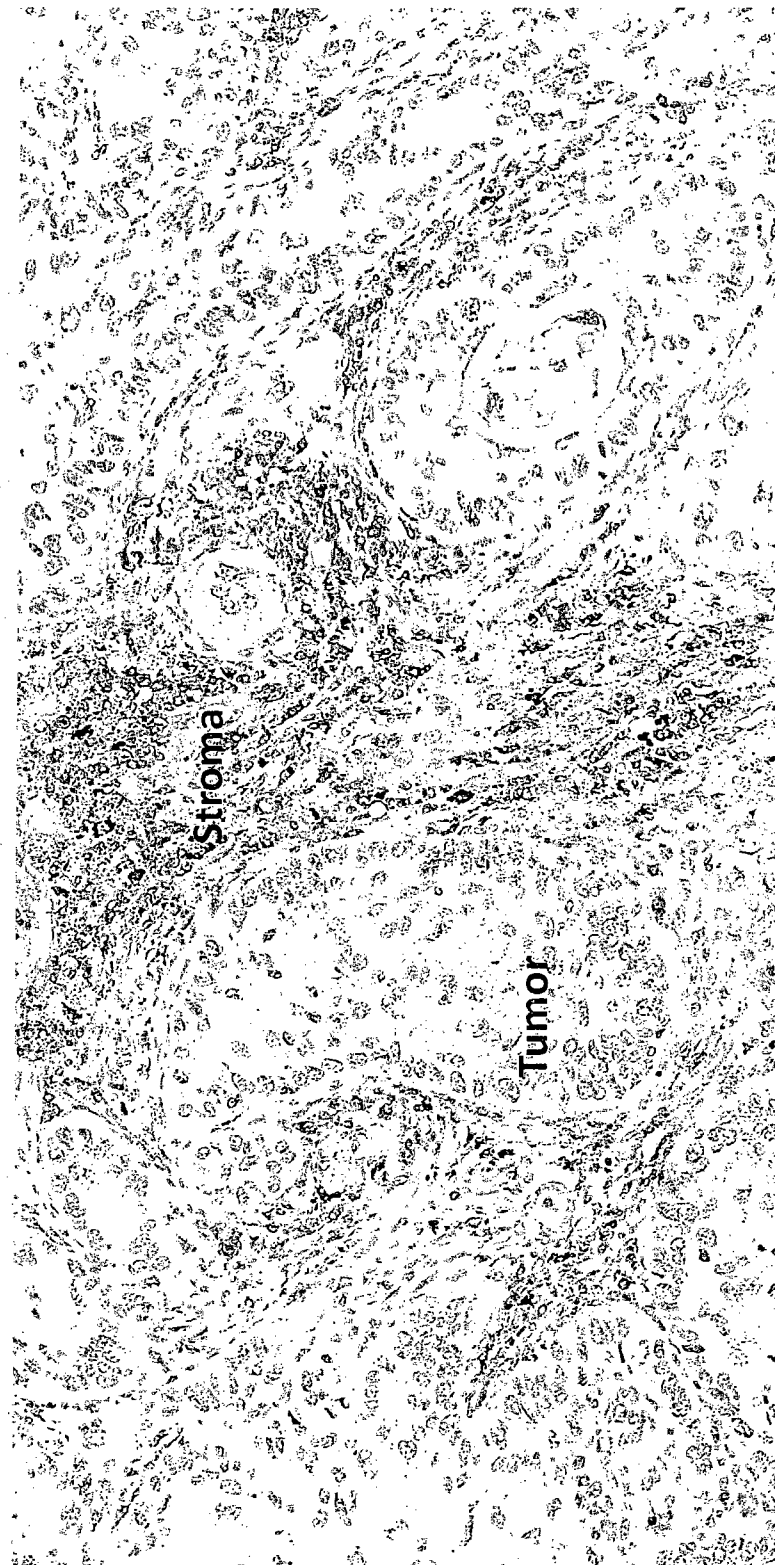


Figure 39

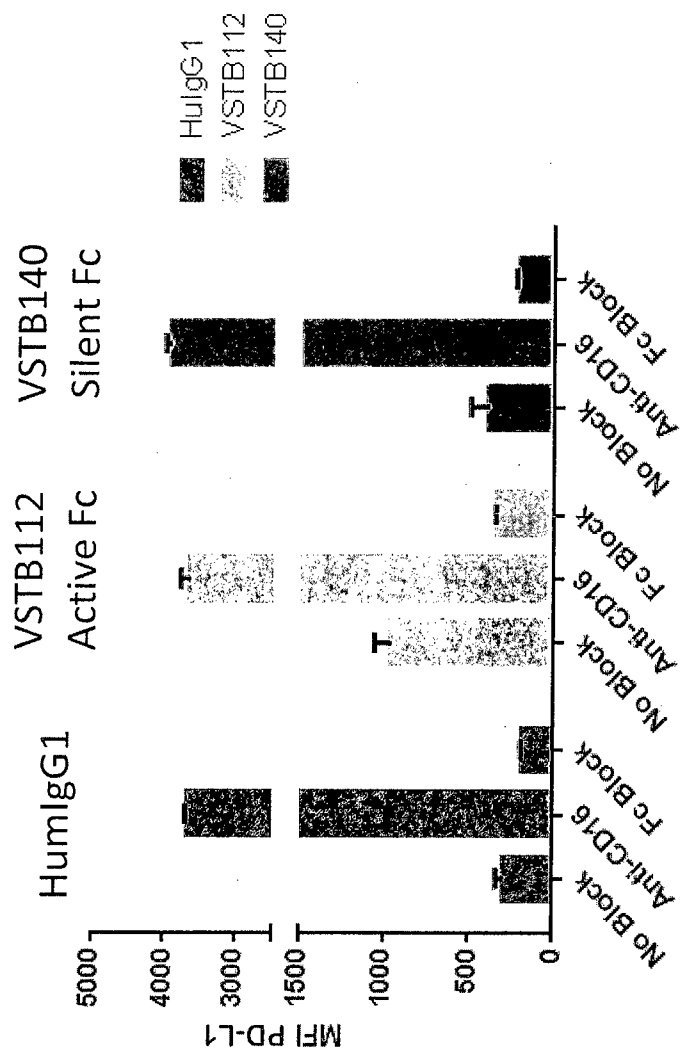


Figure 40

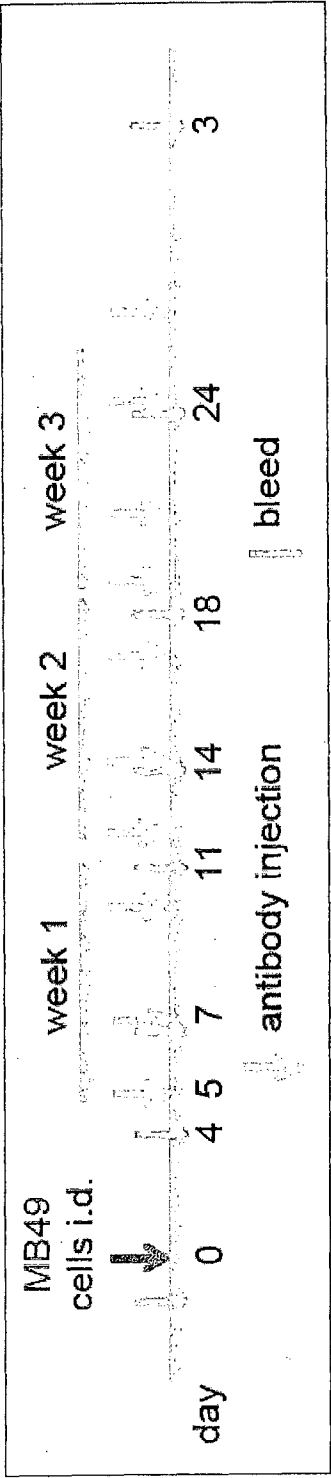
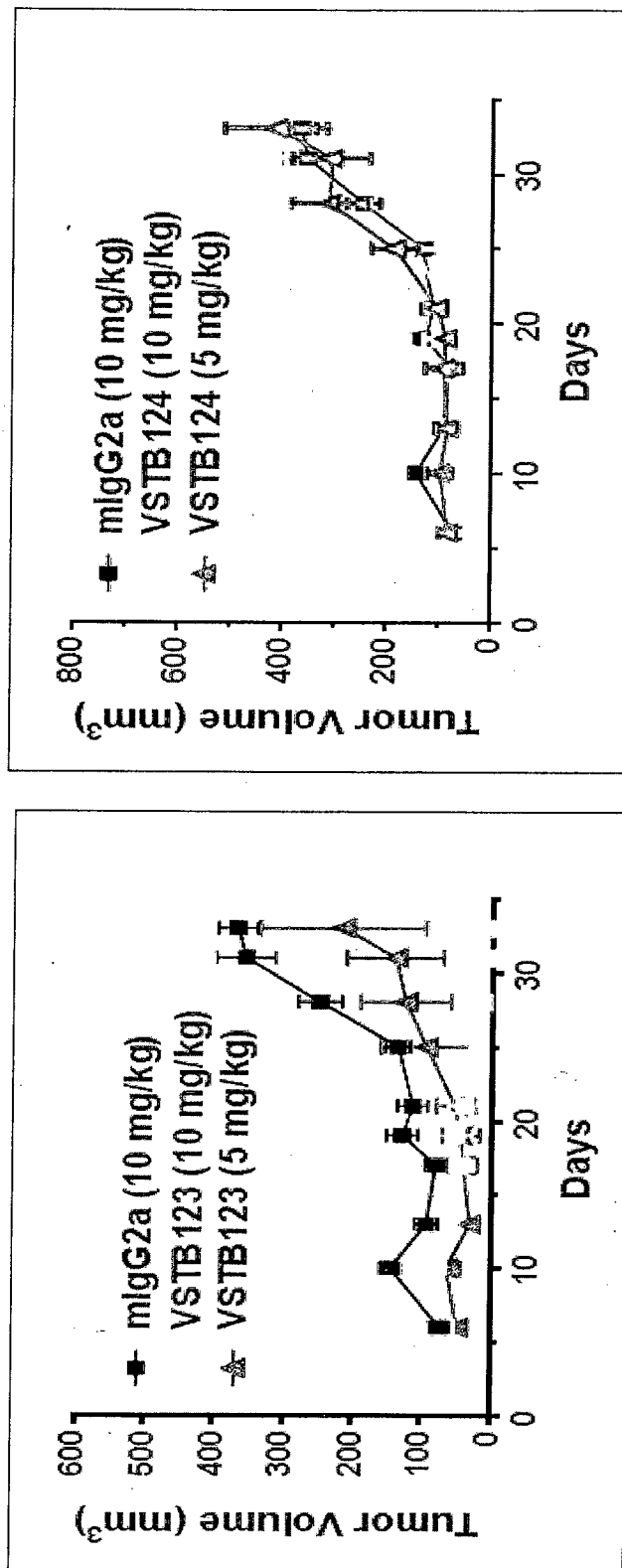


Figure 41



VSTB123 = Fc competent anti-VISTA Ab
VSTB174 murine surrogate

VSTB124 = Fc silent version of VSTB123

Figure 42A

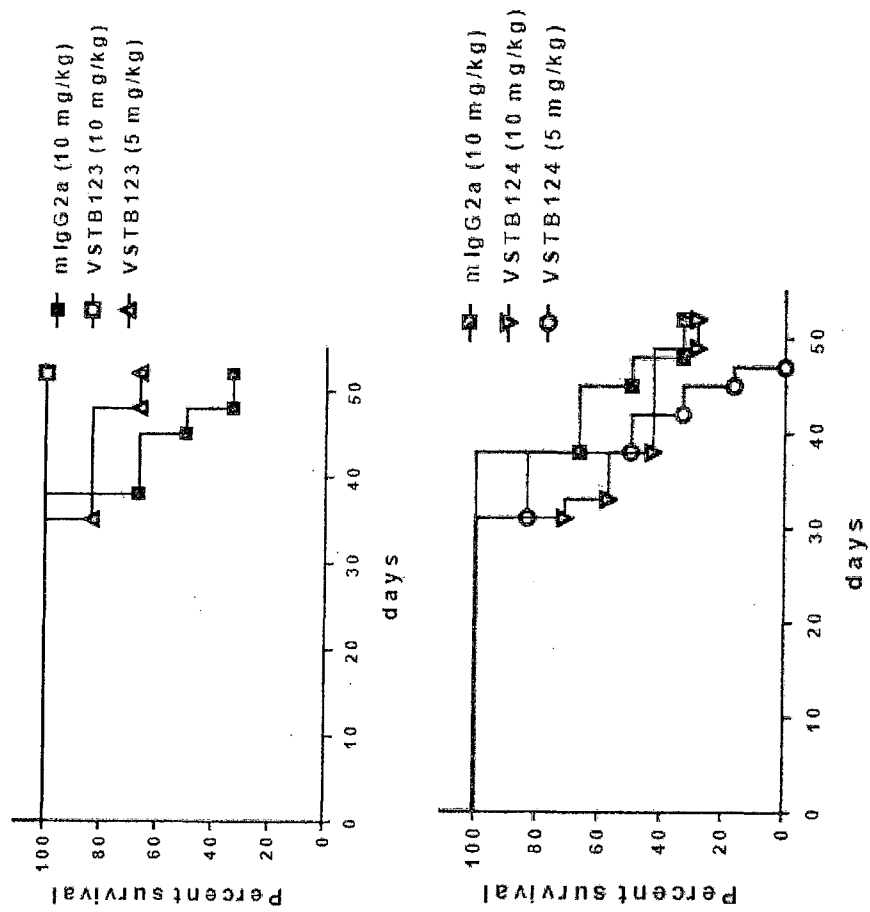


Figure 42B

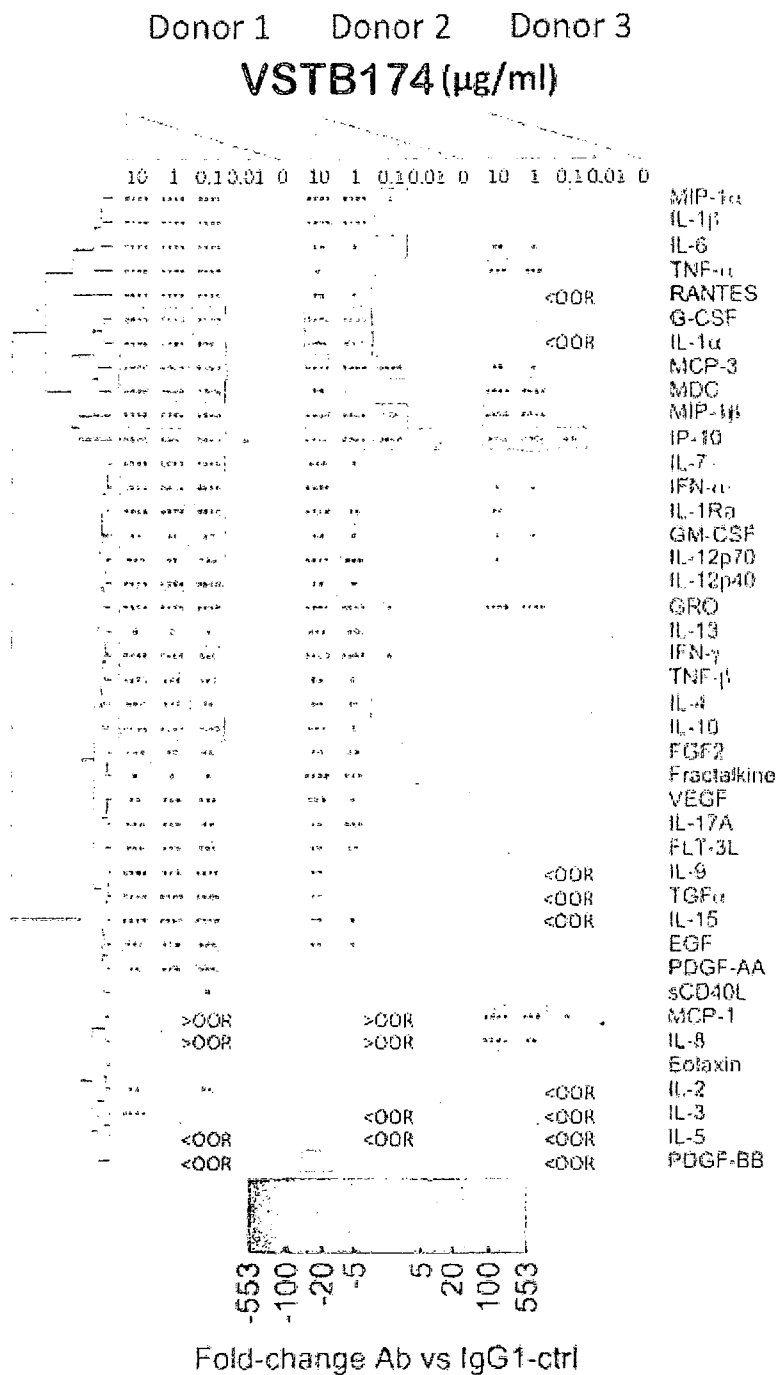


Figure 43

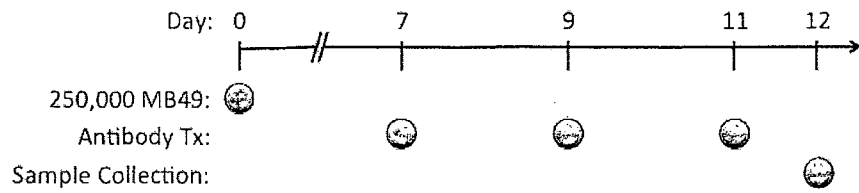


FIGURE 44A

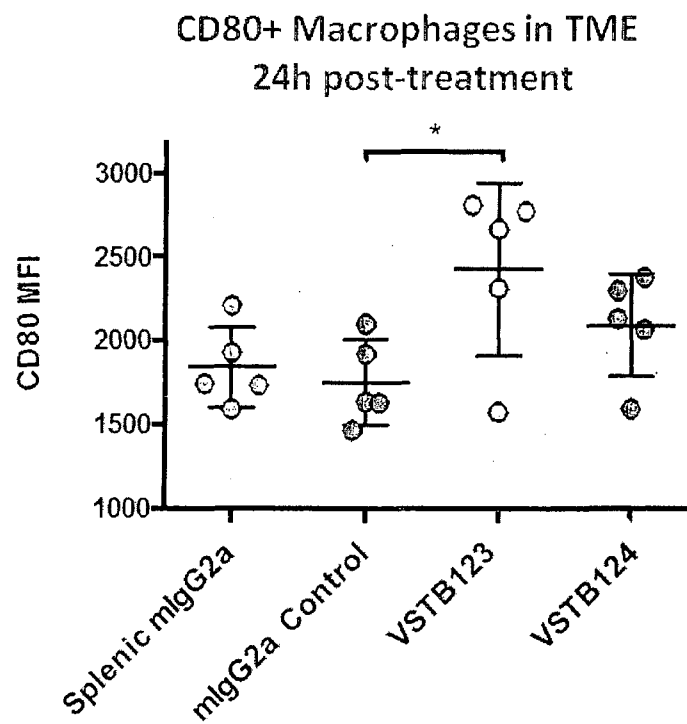


Figure 44B

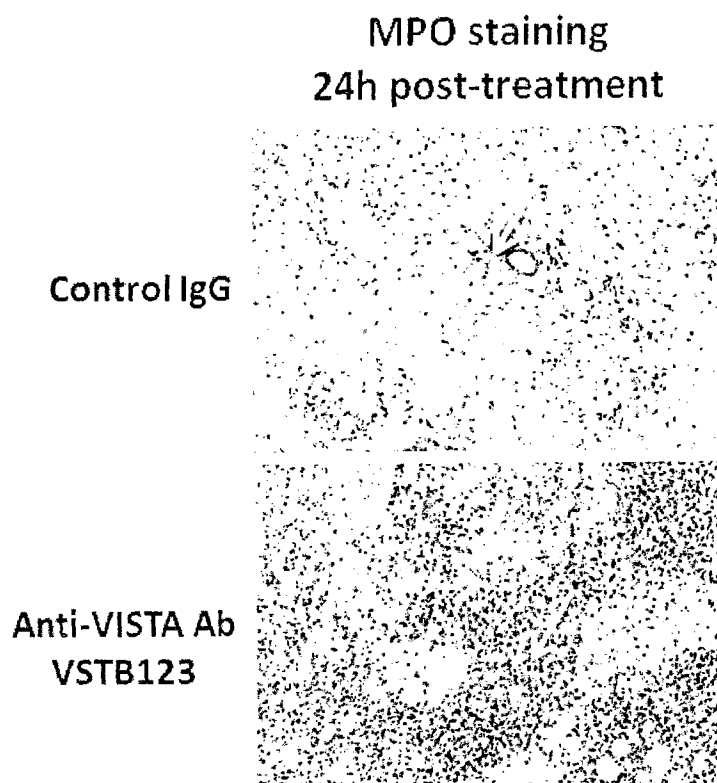


Figure 45

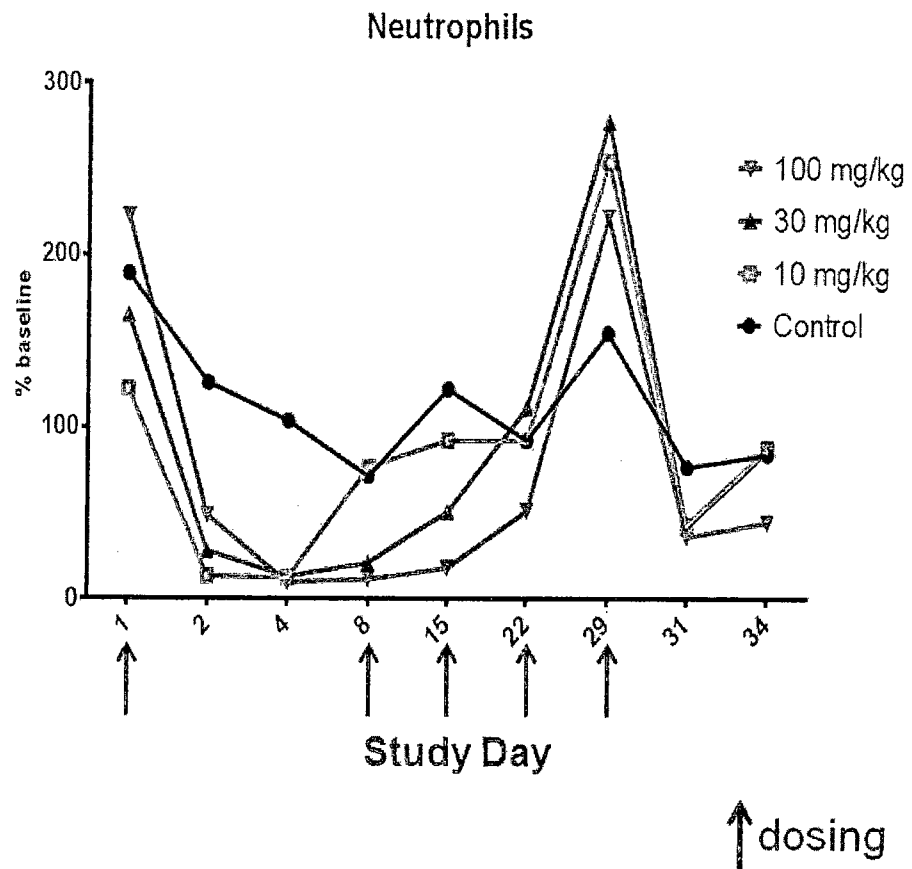


Figure 46

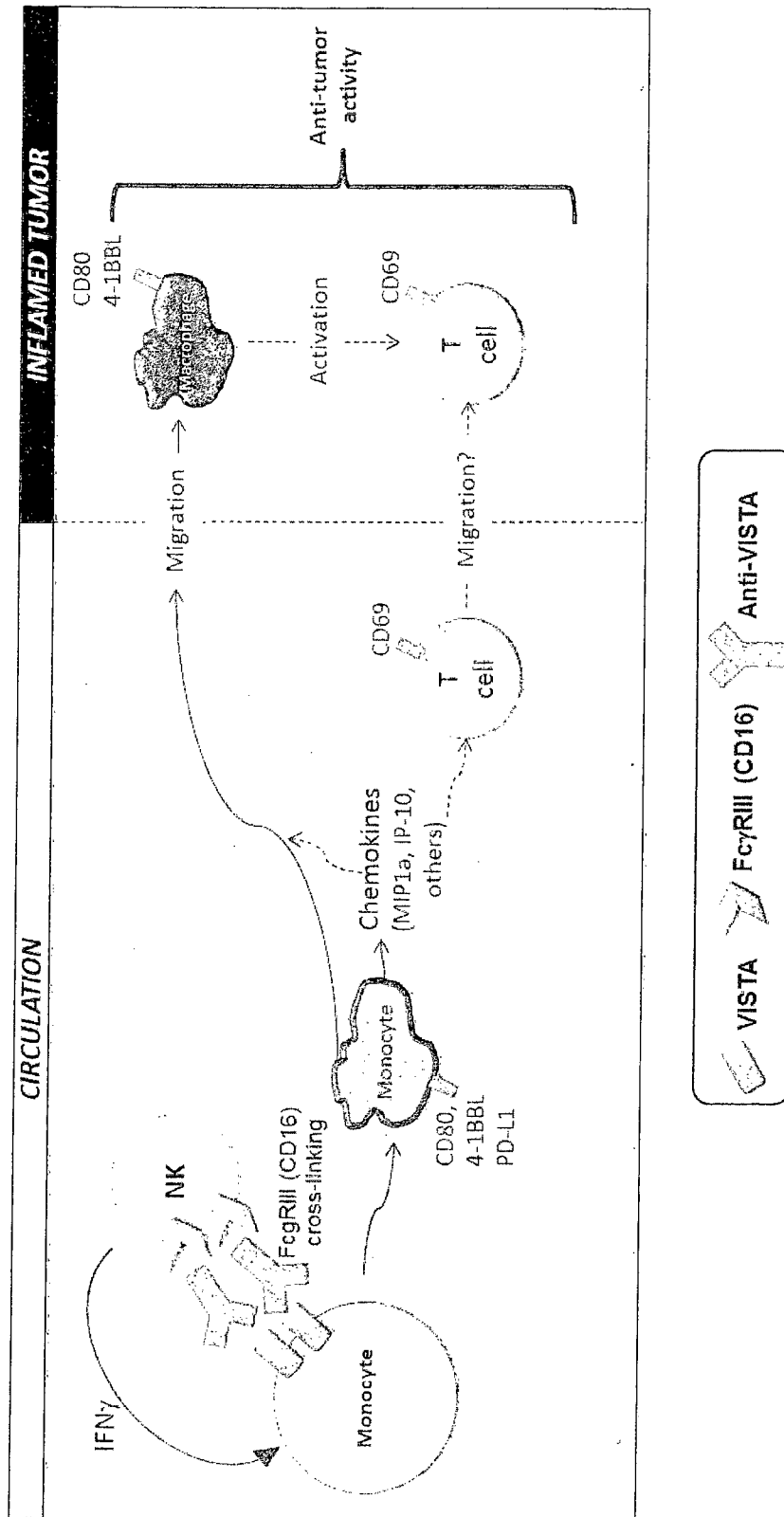


Figure 47

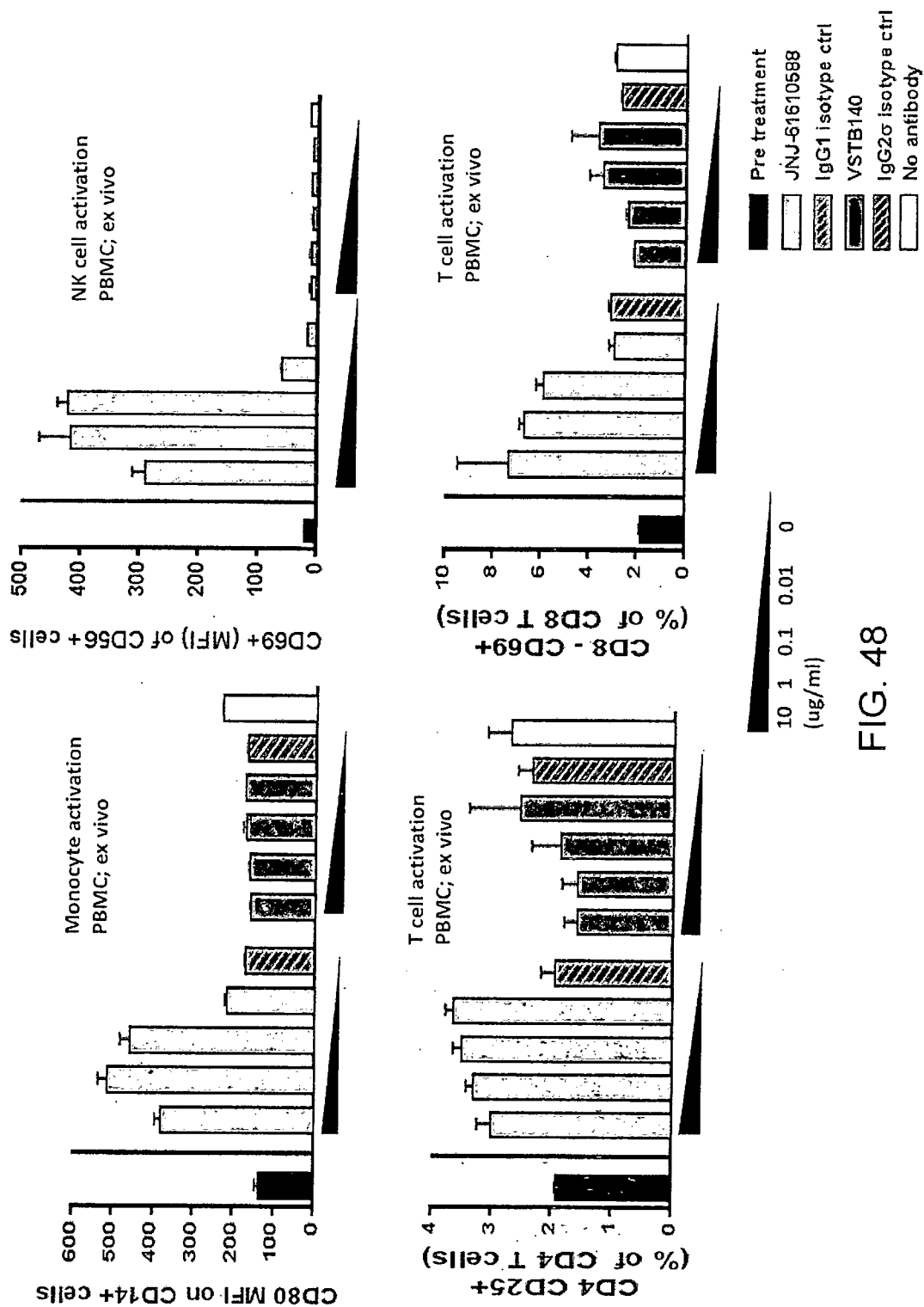


FIG. 48

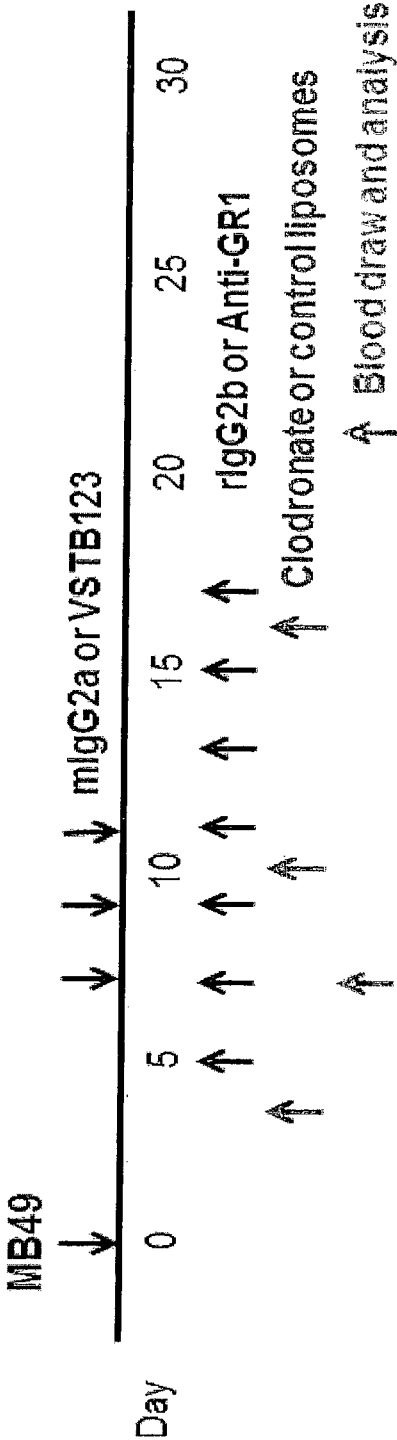
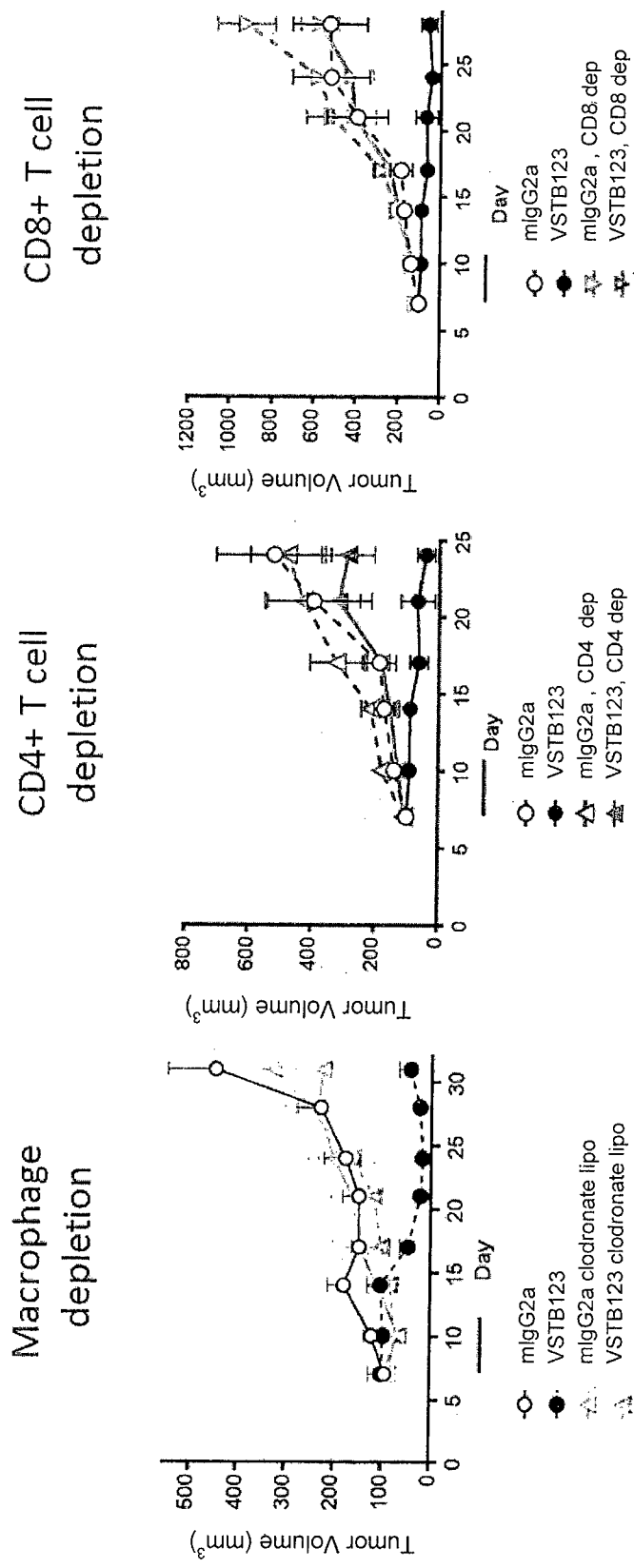


FIG. 49



Model: MB49 bladder carcinoma grown in female VISTA KI mice

FIG. 50

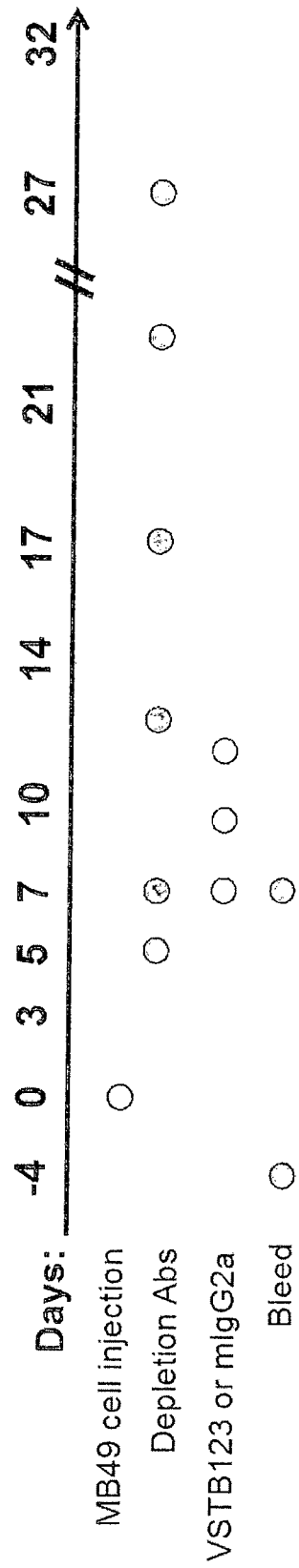


FIG. 51

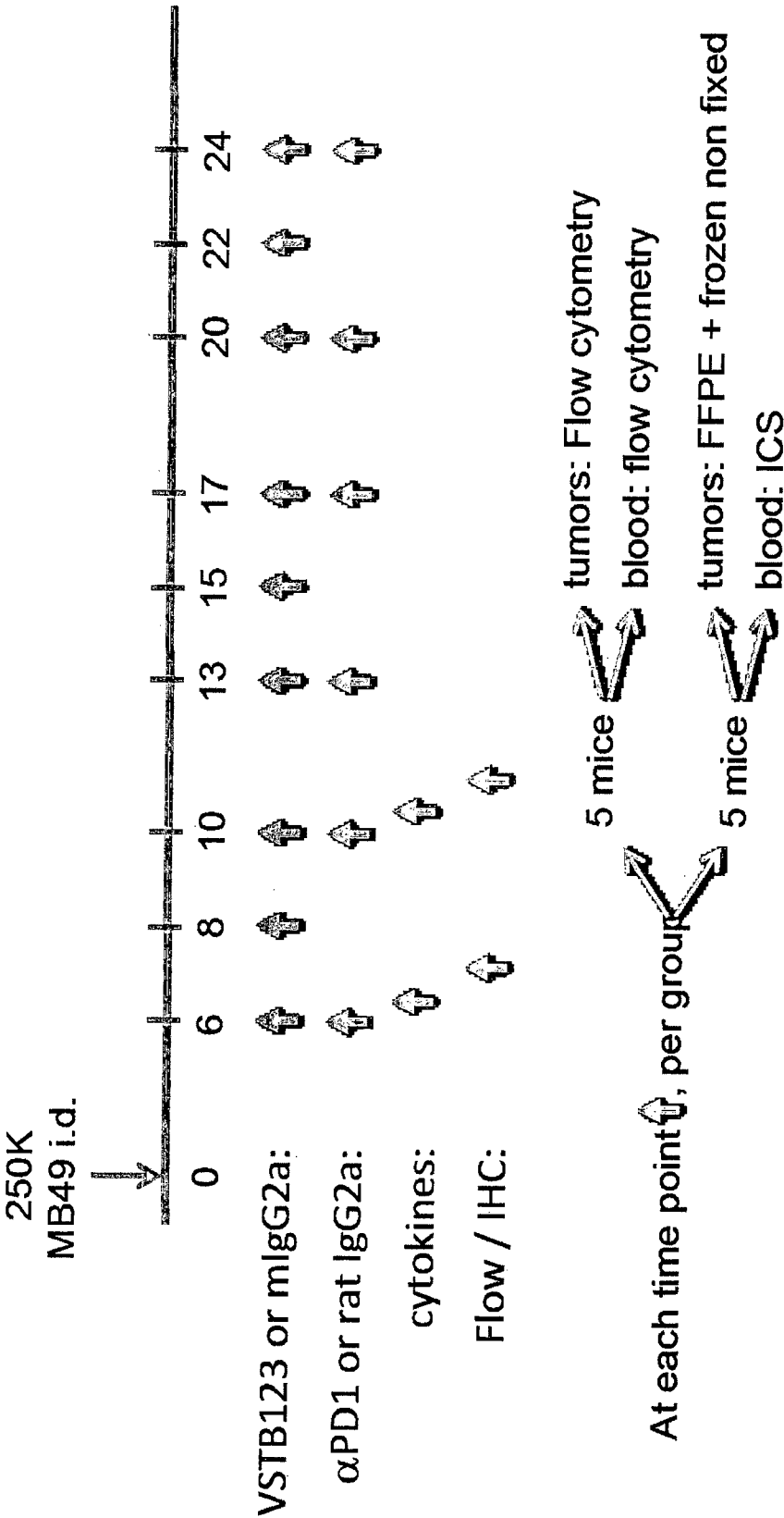
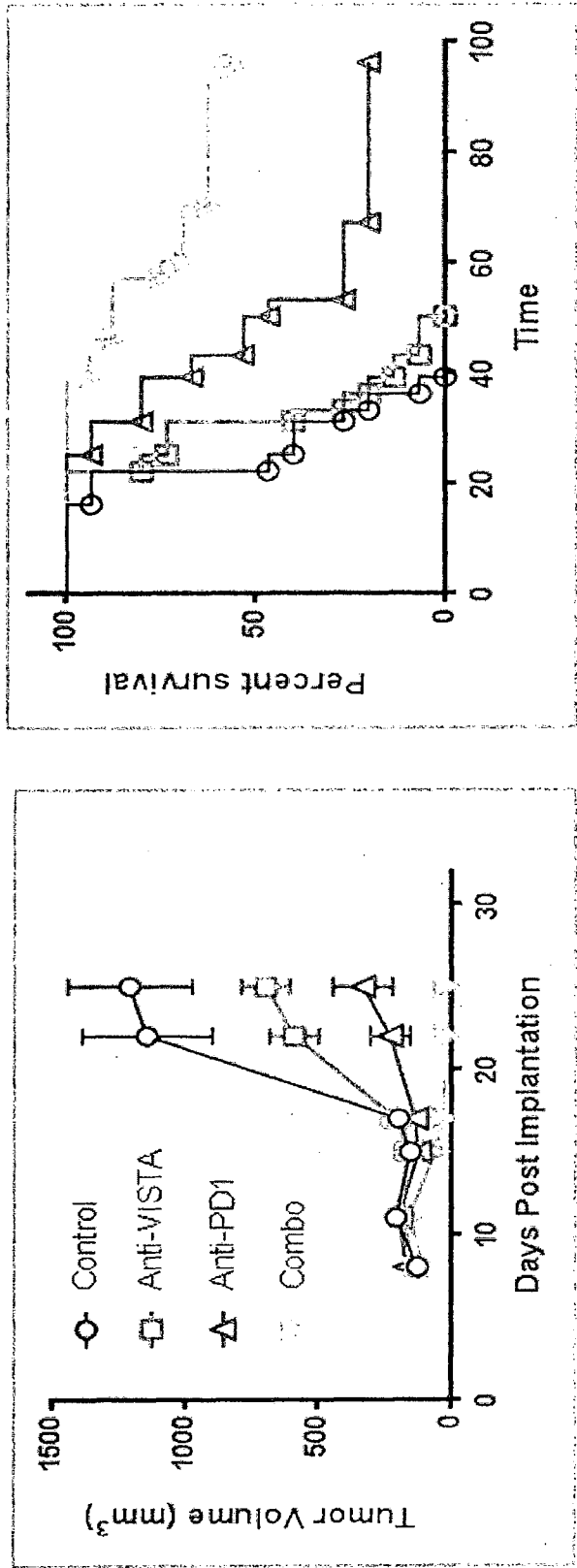


FIG. 52



Model: MB49 bladder carcinoma grown in male VISTA KI mice

□ Anti-VISTAAb (VSTB123)
△ Anti-PD-1Ab (RMP1-14)
○ Anti-VISTAAb + Anti-PD-1Ab
Dosing – anti-PD-1 2/week for 3 weeks
anti-VISTA 3/week for 3 weeks

FIG. 53

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/000393

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K16/28 A61P35/00
ADD. A61K39/00

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

B. FIELDS SEARCHED

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

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

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

EPO-Internal, BIOSIS, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JUN LIU ET AL: "Immune-checkpoint proteins VISTA and PD-1 nonredundantly regulate murine T-cell responses", PROCEEDINGS NATIONAL ACADEMY OF SCIENCES PNAS, vol. 112, no. 21, 11 May 2015 (2015-05-11), pages 6682-6687, XP055393238, US ISSN: 0027-8424, DOI: 10.1073/pnas.1420370112 e.g. abstract; page 6687, left-hand column, paragraph 3; the whole document	1-31
Y	US 2016/083472 A1 (NOELLE RANDOLPH J [US] ET AL) 24 March 2016 (2016-03-24) e.g. paragraph 202; the whole document	1-31
----- -/-		

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

25 July 2017

Date of mailing of the international search report

28/09/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gruber, Andreas

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/000393

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2014/039983 A1 (DARTMOUTH COLLEGE [US]) 13 March 2014 (2014-03-13) e.g. paragraphs 775, 777 -----	1-31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2017/000393

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

10-13(completely); 1-9, 14-31(partially)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 10-13(completely); 1-9, 14-31(partially)

composition of claim 1,10, method of claim 14, all comprising an antibody to VISTA and an antibody to PD-1

2-8. claims: 1-9, 14-31(all partially)

composition of claim 1, method of claim 14, all comprising an antibody to VISTA and an antibody against an immune checkpoint protein selected from PD-L1 (invention 2), PD-L2 (invention 3), CTLA-4 (invention 4), TIM-3 (invention 5), LAG-3 (invention 6), OX40 (invention 7) and GITR (invention 8), each immune checkpoint protein being a separate invention

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/000393

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016083472 A1	24-03-2016	NONE	

WO 2014039983 A1	13-03-2014	AU 2013312211 A1	16-04-2015
		CA 2884704 A1	13-03-2014
		CN 105246507 A	13-01-2016
		EP 2892558 A1	15-07-2015
		JP 2015533796 A	26-11-2015
		US 2014105912 A1	17-04-2014
		US 2017112929 A1	27-04-2017
		WO 2014039983 A1	13-03-2014
