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FIG. 1A

Compositions and methods of use thereof for modulating LAIR-1 are provided. For example, immunomodulatory agents are provided that reduce LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. Such agents can be used to increase an immune response in a subject in need thereof. Exemplary agents include (i) a soluble LAIR-2 polypeptide or fusion protein, (ii) a soluble LAIR-1 polypeptide or fusion protein, (iii) a function blocking anti-LAIR-1 antibody, (iv) an antibody that depletes LAIR-1 positive cells, and (v) combinations thereof. Immunomodulatory agents are also provided that increase LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. Such agents can be used to reduce an immune response in a subject in need thereof. Exemplary agents include: (i) a function activating anti-LAIR-1 antibody, (ii) a function blocking anti-LAIR-2 antibody, and (iii) a combination thereof.

WO 2018/027039 A1

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).

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))
- with sequence listing part of description (Rule 5.2(a))

COMPOSITIONS AND METHODS FOR MODULATING LAIR SIGNAL TRANSDUCTION

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims benefit to and priority to US Provisional Patent
5 Application No. 62/370,334 filed on August 3, 2016 and US Provisional Patent
Application No. 62/450,300 filed on January 25, 2017, both of which are
incorporated by reference in their entireties.

REFERENCE TO SEQUENCE LISTING

The Sequence Listing submitted on August 3, 2017, as a text file named
10 "LAIR1ST25.txt" created on August 3, 2017, and having a size of 136 Kilobytes
is hereby incorporated by reference pursuant to 37 C.F.R. § 1.52(e)(5).

FIELD OF THE INVENTION

The invention is generally related to the field of immunomodulation, and
more particularly to compositions and methods for modulating LAIR-1
15 signaling to increase or decrease an immune response and for the treatment of
leukemias by direct regulation of leukemia cell survival and self-renewal.

BACKGROUND OF THE INVENTION

Leukocyte-associated immunoglobulin-like receptor-1 (LAIR-1) is an
inhibitory cell surface receptor that is expressed on many immune cells and
20 exerts inhibitory signaling through two cytoplasmic immunoreceptor tyrosine-
based inhibitory motif (ITIM) domains (Verbrugge et al., 2006, *J. Leukoc. Biol.*
79:828-836). LAIR-1 is cross-linked by multiple collagens, complement
component C1q, and surfactant protein D (SP-D) to induce negative signaling
that inhibits immune cell maturation, proliferation and degranulation (Lebbink et
25 al., 2009, *Matrix Biol.* 28:202-210; Meyaard., 2008, *J. Leukoc. Biol.* 83:799-
803). The human, but not mouse, genome encodes a soluble LAIR-2 protein
(Sun et al., 2014, *Gene* 552:140-145). The LAIR-2 protein binds the same
ligands as LAIR-1, and thus may function as a decoy to reduce inhibitory signals
through LAIR-1.

30 LAIR-1 inhibitory signaling may prevent autoimmune diseases such as
lupus erythematosus, rheumatoid arthritis, autoimmune thyroid disease and

atherosclerosis as well as contact hypersensitivity (Sun et al., 2014, *Gene* 552:140-145). Reduced expression of LAIR-1 on chronic lymphocytic leukemia cells is associated with increased disease (Poggi et al., 2008, *Leukemia* 22:980-988; Perbellini et al., 2014, *Haematologica* 99:881-887). LAIR-1 has also been
5 shown to be expressed on epithelial ovarian cancer cells and other human tumors, although the function of LAIR-1 expressed on solid tumors remains unclear (Meyaard et al., 1997, *Immunity* 7:283-290; Cao et al., 2015, *Biochem. Biophys. Res. Commun.* 458:399-404).

LAIR-1 expression on acute myeloid leukemia (AML) cells and
10 potentially acute lymphoblastic leukemia (ALL) cells has been shown to be essential for their growth through a phosphatase independent LAIR-1-SHP-1-CAMK1-CREB signaling pathway that inhibits apoptosis and differentiation of leukemia stem cells to retain the self-renewal capacity or 'stemness' of these cells (Kang et al., 2015, *Nat. Cell Biol.* 17:665-677).

15 Together, the accumulated data on LAIR-1 indicates an important role in immune homeostasis, however, there remains a need for compositions and methods of modulating LAIR-1 for the treatment of diseases and disorders.

Thus, it is an object of the invention to provide compositions that increase LAIR-1 negative signaling and methods of use thereof for the treatment
20 of inflammatory diseases and disorders and autoimmune diseases.

It is also an object of the invention to provide compositions that reduce LAIR-1 negative signaling and methods of use thereof for the treatment of cancer and infectious diseases.

SUMMARY OF THE INVENTION

25 Compositions and methods of use thereof for modulating LAIR-1 are provided. For example, immunomodulatory agents are provided that reduce LAIR-1 expression, ligand binding, crosslinking, signal transduction, or a combination thereof. LAIR-1 can be expressed by, for example, a myeloid cell, a T cell, a Natural Killer (NK) cell, or a combination thereof. The myeloid cell
30 can be an antigen-presenting cell, for example, a monocyte, macrophage, or

dendritic cell. In some embodiments, the compositions specifically target one or more of the foregoing cell types.

The disclosed agents can be used to increase an immune response in a subject in need thereof. An immune response can be, for example, a primary
5 immune response to an antigen or an increase in effector cell function such as increasing antigen-specific proliferation of T cells, enhancing cytokine production by T cells, stimulating differentiation, or a combination thereof. Exemplary agents include (i) a soluble LAIR-2 polypeptide or fusion protein, (ii) a soluble LAIR-1 polypeptide or fusion protein, (iii) a function blocking
10 anti-LAIR-1 antibody, (iv) an antibody that can be used to deplete LAIR-1 positive cells, and (v) combinations thereof. In some embodiments, the immunomodulatory agent is an antagonist of LAIR-1.

In particular embodiments the agent is a LAIR-2 fusion protein, for example a fusion protein that includes an extracellular domain of LAIR-2 or
15 functional variant thereof linked to an immunoglobulin domain. An exemplary fusion protein includes the amino acid sequence of SEQ ID NO:16.

In other embodiments the agent is a LAIR-2 protein or a functional fragment or variant thereof. For example, the LAIR-2 protein or functional fragment or variant thereof can have at least 80%, 90%, 95%, or 100% sequence
20 identity to SEQ ID NO:6.

The agent can be a LAIR-1 fusion protein, for example a fusion protein that includes an extracellular domain of LAIR-1 or functional variant thereof linked to an immunoglobulin domain. An exemplary LAIR-1 fusion protein includes the amino acid sequence of SEQ ID NO:9.

25 In other embodiments, the agent is a soluble LAIR-1 protein or a functional fragment or variant thereof. For example, the soluble LAIR-1 protein can consist of an extracellular domain of LAIR-1 or a functional fragment or variant thereof. An exemplary soluble protein has at least 80%, 90%, 95%, or 100% sequence identity to SEQ ID NO:2.

30 Methods of increasing an immune response in a subject typically include administering to a subject in need thereof an effective amount of an

immunomodulatory agent that reduces LAIR-1 expression, ligand binding, crosslinking, signal transduction, or a combination thereof. The subject can have, for example, cancer or an infectious disease.

In some embodiments, the subject, the cancer, or the disease is
5 characterized by increased expression of LAIR-1, increased expression of a LAIR-1 ligand, decreased expression of LAIR-2, or a combination thereof. In particular embodiments, the cancer is an ovarian, lung, gastrointestinal cancer, acute myeloid leukemia (AML) or acute lymphoid leukemia (ALL). The agent can be administered contemporaneously or in combination as a single
10 composition with a vaccine or a component thereof.

Immunomodulatory agents are also provided that increase LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. Such agents can be used to reduce an immune response in a subject in need thereof. Exemplary agents include: (i) a function activating anti-LAIR-1
15 antibody, (ii) a function blocking anti-LAIR-2 antibody, and (iii) a combination thereof.

One embodiment provides an anti-LAIR antibody produced by a hybridoma selected from the group consisting of 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b.

20 Another embodiment provides an anti-LAIR antibody having at least one light chain or at least one heavy chain of the antibody produced by one or more of the hybridomas selected from the group consisting of 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b.

Another embodiment provides an anti-LAIR antibody having a variable
25 light chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable light chain having an amino acid sequence according to SEQ ID NO: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115.

Another embodiment provides an anti-LAIR antibody having a variable
30 heavy chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable heavy chain having an amino acid sequence according to SEQ ID NO: 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111.

Another embodiment provides an anti-LAIR antibody having a variable light chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable light chain having an amino acid sequence according to SEQ ID NO: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115,
5 and a variable heavy chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to an amino acid sequence according to SEQ ID NO: 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111.

Another embodiment provides an anti-LAIR antibody having a complementarity-determining region (CDR) selected from the group of CDRs
10 having an amino acid sequence selected from the group consisting of SEQ ID NOs: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 104-106, 108-110, 112-114, and 116-118.

Another embodiment provides an anti-LAIR antibody having a plurality
15 of CDRs selected from the group consisting of SEQ ID NOs: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 104-106, 108-110, 112-114, and 116-117. The plurality of CDRs can be from 2 -12.

Another embodiment provides a chimeric antibody having a heavy chain
20 with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:120 or SEQ ID NO:122 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:124.

Another embodiment provides a chimeric antibody having a heavy chain
25 with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:126 or SEQ ID NO:128 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino
30 acid sequence set forth in SEQ ID NO:130.

Another embodiment provides a chimeric antibody having a heavy chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:132 or SEQ ID NO:134 and/or a light chain with an amino acid sequence at least 50,
 5 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:136.

Another embodiment provides a chimeric antibody having a heavy chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:138
 10 or SEQ ID NO:140 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:142.

Another embodiment provides a nucleic acid sequence encoding an antibody having a light chain amino acid sequence according to SEQ ID
 15 NO:124, 130, 136, or 142 and/or a heavy chain amino acid according to SEQ ID NO: 120, 122, 126, 128, 132, 134, 138 or 140.

Another embodiment provides a nucleic acid sequence encoding a variable light chain according to SEQ ID NOs 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115 and/or a variable heavy chain according to SEQ ID NOs 23,
 20 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111. The nucleic acids encoding the light chain and/or heavy chain can be part of an expression vector. The nucleic acids can be expressed by cell. Expression can be inducible or constitutive.

Another embodiment provides a cell constitutively- or inducibly- expressing an antibody or antigen binding fragment thereof that specifically
 25 binds to LAIR-1, wherein the cell has a nucleic acid or nucleic acids encoding an amino acid sequence according to SEQ ID NOs: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, 115, 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, 111, or a combination thereof.

Another embodiment provides a cell constitutively- or inducibly-
 30 expressing an antibody or antigen binding fragment thereof that specifically binds to LAIR-1, wherein the cell has a nucleic acid or nucleic acids encoding

an amino acid a sequence according to SEQ ID NOs: 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, or a combination thereof.

Methods of reducing an immune response in a subject typically include administering a subject in need thereof an effective amount of an immunomodulatory agent that increases LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. In some embodiments, the subject has inflammation, an autoimmune disorder. In a particular embodiment, the subject has rheumatoid arthritis.

In some embodiments, the subject or the disease or condition is characterized by reduced expression of LAIR-1, reduced expression of a LAIR-1 ligand, increased expression of LAIR-2, or a combination thereof.

Any of the disclosed methods can include administering to the subject an immunomodulatory agent alone or in combination with one or more additional therapeutic agents.

One embodiment provides a method for treating leukemia in a subject in need thereof by administering to the subject an effective amount of a pharmaceutical composition comprising a LAIR-1 monoclonal antibody, soluble LAIR-1 polypeptide, soluble LAIR-2 polypeptide, LAIR-1 fusion protein, LAIR-2 fusion protein, or combinations thereof to inhibit or reduce LAIR-1 signal transduction in leukemia cells and thereby inhibit leukemia cell survival or promote an anti-tumor immune response to the leukemia cells. The leukemia can be acute myeloid leukemia.

One embodiment provides a method for assessing or predicting the efficacy of a treatment using an anti-LAIR binding moiety by assaying the cells of a subject in need of treatment to determine whether the cells express LAIR, binding partners of LAIR, or both. Exemplary cells to be assayed include, but are not limited to cancer cells obtained from the subject. Exemplar cancer cells, include but are not limited to acute myeloid leukemia (AML) cells. Cancer cells expressing multiple interacting inhibitory receptors are believed to respond better to treatments using anti-LAIR binding moieties. Exemplary LAIR binding partners include, but are not limited to transmembrane collagens (XIII,

XVII and XXIII) and LILRB4. Figure 3 shows a predicted outcome of treatment based on the presence of LAIR-1 or binding partners of LAIR-1 on cancer cells.

One embodiment provides a fusion protein according to SEQ ID NO:9,
 5 10, 11, 12, 13, 14, 15, 16, 17, or 18.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1A is a table showing the amino acid sequence of variable light chains in anti-LAIR -1 antibodies from clones 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b. Figure 1B is a table showing
 10 the amino acid sequence of variable heavy chains in anti-LAIR -1 antibodies from clones 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, and 12E10 (a and b).

Figure 2A is a multiple way alignment graph of variable light chains from the indicated hybridomas. Figure 2B is a multiple way alignment graph of
 15 variable heavy chains from the indicated hybridomas.

Figure 3 is a table show projected treatment outcomes based on expressing of LAIR-1, LAIR-1 binding partners, or combinations thereof.

Figure 4 is a schematic diagram illustrating LAIR regulation of immune function and homeostasis.

20 Figure 5 is a schematic diagram of LAIR-2 Fc and LAIR-1 monoclonal antibodies (mAbs) as therapeutics.

Figure 6A shows an SDS PAGE gel of LAIR-2 Fc. Figure 6B shows a size exclusion chromatogram of LAIR-2 Fc.

Figure 7A is a fluorescence-activated cell sorting (FACS) histogram of
 25 K562-Col17 cells stained with LAIR-2 Fc followed by staining with anti-hIg-PE. Figure 7B is a FACS histogram of control cells stained with LAIR-2 Fc followed by staining with anti-hIg-PE. Figure 7C is a FACS histogram of control cells stained with LAIR-1 Fc followed by staining with anti-hIg-PE. Figure 7D is a FACS histogram of control cells stained with LAIR-1 Fc
 30 followed by staining with anti-hIg-PE. Figure 7E is a non-reducing SDS-PAGE

gel of LAIR-1 Fc and LAIR-2 Fc. Figure 7F is a reducing SDS-PAGE gel
LAIR-1 Fc and LAIR-2 Fc.

Figure 8A is a FACS histogram of Jurkat T cells stained with α -LAIR-1.
Figure 8B is a FACS histogram of Jurkat T cells stained with LAIR-1 Fc. Figure
5 8C is a FACS histogram of Jurkat T cells stained with LAIR-2 Fc. Figure 8D is
a FACS histogram of K562 Col 17 cells stained with α -LAIR-1. Figure 8E is a
FACS histogram of K562 Col 17 cells stained with LAIR-1 Fc. Figure 8F is a
FACS histogram of K562 Col 17 cells stained with LAIR-2 Fc. Figure 8G is a
FACS histogram of THP-1 AML cells stained with α -LAIR-1. Figure 8H is a
10 FACS histogram of K562 Col 17 cells stained with LAIR-1 Fc. Figure 8I is a
FACS histogram of K562 Col 17 cells stained with LAIR-2Fc.

Figure 9A is a line graph of % NF-kB-GFP+ versus anti-CD3 (μ g/ml).
LAIR-2 Fc (●), Control Fc (■), and Media (▲). Figure 9B is a line graph of
NFAT-Lucia (RLU) versus protein (μ g/ml). LAIR-2 Fc (●), and Control Fc (■).
15 Figure 9C is a bar graph of IL-2 (pg/ml) versus protein at 10 μ g/m; for LAIR-2
Fc on the left and control Fc on the right. Figure 9D is a bar graph of TNF- α
(pg/ml) versus protein at 10 μ g/m; for LAIR-2 Fc on the left and control Fc on
the right.

Figure 10A is a line graph of MFI versus protein (μ g/ml) showing that
20 LAIR-2 Fc (●) binds to THP-1 cells in a dose dependent manner compared to
control Fc (■). Figure 10B is a bar graph. Figure 10B is a bar graph of IRF
(interferon regulatory factor) Induction – RLU for THP-1 cells treated with 1
 μ g/ml LPS and LAIR-2 Fc (right column of each pair) or control Fc (left column
of each pair). Figure 10C is a bar graph of IRF Induction – RLU for THP-1
25 cells treated with RPMI media and LAIR-2 Fc (right column of each pair) or
control Fc (left column of each pair).

Figure 11A is a line graph of % T cell proliferation measured by CFSE
diluted cell population versus OKT3 (μ g/ml) for CD4+ T cells treated with
LAIR-2 Fc (●) or control Fc (▼). Figure 11B is a line graph of % T cell
30 proliferation CFSE proliferation versus OKT3 (μ g/ml) for CD8+ cells treated
with LAIR-Fc (●) or control Fc (▼).

Figure 12A is a histogram of Donor 1710 CD3+CD4+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12B is a histogram of Donor 1710 CD3+CD8+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12C is a histogram of Donor 1710 CD3-CD16+CD56+ NKC cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12D is a histogram of Donor 1710 CD14+ monocytes isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12E is a histogram of Donor 1711 CD3+CD4+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12F is a histogram of Donor 1711 CD3+CD8+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12G is a histogram of Donor 1711 CD3-CD16+CD56+ NKC cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12H is a histogram of Donor 1711 CD14+ monocytes isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12I is a histogram of Donor 1712 CD3+CD4+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12J is a histogram of Donor 1712 CD3+CD8+ T cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12CK is a histogram of Donor 1712 CD3-CD16+CD56+ NKC cells isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc. Figure 12L is a histogram of Donor 1712 CD14+ monocytes isolated from peripheral blood mononuclear cells (PBMCs) treated with LAIR-2 Fc.

Figure 13 is a diagram of a treatment for OT-1 T cell expansion in vivo. Figure 13B is a line graph of % OT-1 (donor) of total CD8+ T cells versus days of OT-1 transplantation for cells treated with LAIR-2 Fc (□) or control Fc (○).

Figure 14A is a flow cytometry histogram showing the pre-injection assessment of CFSE levels and ratio in mice challenged with CD45.1 splenocytes without ovalbumin (OVA) peptide. Figure 14B is a flow cytometry histogram showing the pre-injection assessment of CFSE levels and ratio in

mice challenged with CD45.1 splenocytes loaded with OVA peptide (CFSE hi). Figure 14C is a cytometry histogram showing the pre-injection assessment of CFSE levels and ratio in mice challenged with CD45.1 splenocytes loaded without OVA peptide (CFSE lo) and with OVA peptide (CFSE hi). Figure 14D is a cytometry histogram 48 hours after splenocyte transfer: assessment of labeled cells in the spleen (gated on CD45.1+ cells) (host cells are CD45.2) with naïve controls (no OT-1). Figure 14E is a cytometry histogram 48 hours after splenocyte transfer: assessment of labeled cells in the spleen (gated on CD45.1+ cells) (host cells are CD45.2) treated with OT-1 control Fc. Figure 14F is a cytometry histogram 48 hours after splenocyte transfer: assessment of labeled cells in the spleen (gated on CD45.1+ cells) (host cells are CD45.2) treated with OT-1 LAIR-2 Fc. Figure 14G is a bar graph of % specific lysis calculated as % specific lysis = $[1 - (\text{no OT-I control ratio}) / (\text{experimental ratio})] \times 100$ for mice treated with Fc (left column) and mice treated with LAIR-2 Fc (right column).

Figure 15A is a diagram of a treatment model with 5e6 ID8-OVA tumor cells intraperitoneal injection (ip) injected on day 0. OT-I T cells were injected ip 3 weeks after tumor. Treatment with 200 ug of LAIR-2 Fc or control Fc began one day after T cell transfer and every 4 days for a total of 5 doses. Figure 15B is a line graph of percentage of weight gain (tumor burden) versus days post ID8.OVA inoculation. control (○); LAIR-2 Fc (●). Figure 15C is a line graph of percent survival versus days post ID8.OVA inoculation. control (broken line), LAIR-2 Fc (solid line).

Figure 16 is a line graph of survival versus days post ID8.OVA inoculation in mice injected with ID8-OVA tumor cells and treated with 200 ug of LAIR-2 Fc or control Fc began one day after T cell transfer and every 4 days for a total of 5 doses or with the indicate treatment. The data show LAIR-2 Fc with anti-PD-1 is an effective combination immunotherapy in ovarian cancer. (□) cisplatin, (△) cisplatin + LAIR-2 Fc, (○) anti-PD-1 + LAIR-2 Fc, (▽) anti-PD-1, (◇) LAIR-2 Fc, (hexagon) control IgG.

Figure 17A is a diagram of an exemplary lymphoma treatment regime with LAIR-2 Fc. Figure 17B is a line graph of tumor volume versus days post

tumor inoculation in mice treated with control Fc (○) or LAIR-2 Fc (□). Figure 17C is a line graph of percent survival versus days post tumor inoculation in mice treated with control Fc (broken line) or LAIR-2 Fc (solid line).

Figure 18 is a bar graph of percent positive for binding of the indicated (monoclonal antibody) mAb to, from left to right for each group the following cell lines: HL-60 (LAIR-1 +), MV-4-11 (LAIR-1 +) K562-LAIR-1 transfected), and U266B1(Negative Control).

Figure 19 is a bar graph of absorbance (450 nm) for the indicated mAb showing blockade or enhancement of LAIR-1 Fc binding to collagen I and III. Collagen I is the left column and collagen III is the right column for each mAb.

Figure 20 is a bar graph of absorbance (450 nm) of the indicated mAbs for binding to C1q and SP-D. The left column for each set is C1q and the right column is SP-D.

Figure 21 is a table showing the results of LAIR-1 chimeric mAb epitope binning assay. Single underlined antibodies show no blocking. Double underlined antibodies show blocking. mAbs that bind the same epitope will be blocked from binding LAIR-1 Fc due to binding saturation, as can be observed when the same mAb is used as the first and second mAb (no underlined, stiped background).

Figure 22 is a diagram of LAIR-1 chimeric mAb binning map. This map demonstrates that there is significant overlap of mAbs, while many occupy distinct sites on the LAIR-1 molecule.

Figure 23 is a table showing optimized affinity assessments for the indicated LAIR-1 mAb performed using an Octet RED96 instrument (ForteBio).

Figure 24A is a bar graph of IRF induction – RLU for indicated LAIR-1 mAbs showing differential induction of interferon reporter activity in THP-1 cells when the mAbs are coated to the plate. Figure 24B is a bar graph of IRF induction – RLU for indicated LAIR-1 mAbs showing differential induction of interferon reporter activity in THP-1 cells when the mAbs are added as soluble proteins.

Figure 25A is a bar graph of NFAT induction – RLU for the indicated mAbs showing induction of Jurkat T cell reporter activity when plates are coated with anti-CD3 (OKT3 at 0.5 µg/ml. Following aspiration of OKT3, LAIR-1 mAbs or LAIR-2 Fc and control Fc were coated for 24 hours at 10 µg/ml. Prior to adding Jurkat T cell NFAT-Lucia pathway reporter cells (Invivogen), unbound proteins were aspirated. Jurkat T cells were plated at 50,000 cells/well in 200 µl total volume. At 48 hours, 10 µl of supernatant was removed and transferred to a separate plate. Quanti-Luc (Invivogen) was added according to protocol. Luminescence was assessed using a Perkin Elmer Envision plate reader. Figure 25B is a bar graph of NFAT induction – RLU for the indicated mAbs showing induction of Jurkat T cell reporter activity as in Figure 25a when LAIR-1 mAbs, LAIR-2 Fc, and control Fc are added in soluble form.

DETAILED DESCRIPTION OF THE INVENTION

I. Definitions

As used herein, a molecule is said to be able to “immunospecifically bind” a second molecule if such binding exhibits the specificity and affinity of an antibody to its cognate antigen. Antibodies are said to be capable of immunospecifically binding to a target region or conformation (“epitope”) of an antigen if such binding involves the antigen recognition site of the immunoglobulin molecule. An antibody that immunospecifically binds to a particular antigen may bind to other antigens with lower affinity if the other antigen has some sequence or conformational similarity that is recognized by the antigen recognition site as determined by, *e.g.*, immunoassays, BIACORE® assays, or other assays known in the art, but would not bind to a totally unrelated antigen. In some embodiments, however, antibodies (and their antigen binding fragments) will not cross-react with other antigens. Antibodies may also bind to other molecules in a way that is not immunospecific, such as to FcR receptors, by virtue of binding domains in other regions/domains of the molecule that do not involve the antigen recognition site, such as the Fc region.

As used herein, a molecule is said to “physiospecifically bind” a second molecule if such binding exhibits the specificity and affinity of a receptor to its

cognate binding ligand. A molecule can be capable of physiospecifically binding to more than one other molecule.

As used herein, the term “antibody” is intended to denote an immunoglobulin molecule that possesses a “variable region” antigen recognition site. The term “variable region” is intended to distinguish such domain of the immunoglobulin from domains that are broadly shared by antibodies (such as an antibody Fc domain). The variable region includes a “hypervariable region” whose residues are responsible for antigen binding. The hypervariable region includes amino acid residues from a “Complementarity Determining Region” or “CDR” (*i.e.*, typically at approximately residues 24-34 (L1), 50-56 (L2) and 89-97 (L3) in the light chain variable domain and at approximately residues 27-35 (H1), 50-65 (H2) and 95-102 (H3) in the heavy chain variable domain; Kabat *et al.*, *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD. (1991)) and/or those residues from a “hypervariable loop” (*i.e.*, residues 26-32 (L1), 50-52 (L2) and 91-96 (L3) in the light chain variable domain and 26-32 (H1), 53-55 (H2) and 96-101 (H3) in the heavy chain variable domain; Chothia and Lesk, 1987, *J. Mol. Biol.* 196:901-917). “Framework Region” or “FR” residues are those variable domain residues other than the hypervariable region residues as herein defined. The term antibody includes monoclonal antibodies, multi-specific antibodies, human antibodies, humanized antibodies, synthetic antibodies, chimeric antibodies, camelized antibodies (*See e.g.*, Muyldermans *et al.*, 2001, *Trends Biochem. Sci.* 26:230; Nuttall *et al.*, 2000, *Cur. Pharm. Biotech.* 1:253; Reichmann and Muyldermans, 1999, *J. Immunol. Meth.* 231:25; International Publication Nos. WO 94/04678 and WO 94/25591; U.S. Patent No. 6,005,079), single-chain Fvs (scFv) (*see, e.g., see* Pluckthun in *The Pharmacology of Monoclonal Antibodies*, vol. 113, Rosenberg and Moore eds. Springer-Verlag, New York, pp. 269-315 (1994)), single chain antibodies, disulfide-linked Fvs (sdFv), intrabodies, and anti-idiotypic (anti-Id) antibodies (including, *e.g.*, anti-Id and anti-anti-Id antibodies to antibodies). In particular, such antibodies

include immunoglobulin molecules of any type (*e.g.*, IgG, IgE, IgM, IgD, IgA and IgY), class (*e.g.*, IgG₁, IgG₂, IgG₃, IgG₄, IgA₁ and IgA₂) or subclass.

As used herein, the term “antigen binding fragment” of an antibody refers to one or more portions of an antibody that contain the antibody’s

5 Complementarity Determining Regions (“CDRs”) and optionally the framework residues that include the antibody’s “variable region” antigen recognition site, and exhibit an ability to immunospecifically bind antigen. Such fragments include Fab', F(ab')₂, Fv, single chain (ScFv), and mutants thereof, naturally occurring variants, and fusion proteins including the antibody’s “variable

10 region” antigen recognition site and a heterologous protein (*e.g.*, a toxin, an antigen recognition site for a different antigen, an enzyme, a receptor or receptor ligand, *etc.*).

As used herein, the term “fragment” refers to a peptide or polypeptide including an amino acid sequence of at least 5 contiguous amino acid residues,

15 at least 10 contiguous amino acid residues, at least 15 contiguous amino acid residues, at least 20 contiguous amino acid residues, at least 25 contiguous amino acid residues, at least 40 contiguous amino acid residues, at least 50 contiguous amino acid residues, at least 60 contiguous amino residues, at least 70 contiguous amino acid residues, at least 80 contiguous amino acid residues,

20 at least 90 contiguous amino acid residues, at least 100 contiguous amino acid residues, at least 125 contiguous amino acid residues, at least 150 contiguous amino acid residues, at least 175 contiguous amino acid residues, at least 200 contiguous amino acid residues, or at least 250 contiguous amino acid residues.

As used herein the term “modulate” relates to a capacity to alter an

25 effect, result, or activity (*e.g.*, signal transduction). Such modulation can be agonistic or antagonistic. Antagonistic modulation can be partial (*i.e.*, attenuating, but not abolishing) or it can completely abolish such activity (*e.g.*, neutralizing). Modulation can include internalization of a receptor following binding of an antibody or a reduction in expression of a receptor on the target

30 cell. Agonistic modulation can enhance or otherwise increase or enhance an activity (*e.g.*, signal transduction). In a still further embodiment, such

modulation can alter the nature of the interaction between a ligand and its cognate receptor so as to alter the nature of the elicited signal transduction. For example, the molecules can, by binding to the ligand or receptor, alter the ability of such molecules to bind to other ligands or receptors and thereby alter their overall activity. In some embodiments, such modulation will provide at least a 10% change in a measurable immune system activity, at least a 50% change in such activity, or at least a 2-fold, 5-fold, 10-fold, or at least a 100-fold change in such activity.

The term “substantially,” as used in the context of binding or exhibited effect, is intended to denote that the observed effect is physiologically or therapeutically relevant. Thus, for example, a molecule is able to substantially block an activity of a ligand or receptor if the extent of blockage is physiologically or therapeutically relevant (for example if such extent is greater than 60% complete, greater than 70% complete, greater than 75% complete, greater than 80% complete, greater than 85% complete, greater than 90% complete, greater than 95% complete, or greater than 97% complete). Similarly, a molecule is said to have substantially the same immunospecificity and/or characteristic as another molecule, if such immunospecificities and characteristics are greater than 60% identical, greater than 70% identical, greater than 75% identical, greater than 80% identical, greater than 85% identical, greater than 90% identical, greater than 95% identical, or greater than 97% identical).

As used herein, the “co-stimulatory” signals encompass positive co-stimulatory signals (e.g., signals that result in enhancing an activity) and negative co-stimulatory signals (e.g., signals that result in inhibiting an activity).

The term “derivative” refers to an antibody or antigen-binding fragment thereof that immunospecifically binds to the same target of a parent or reference antibody but which differs in amino acid sequence from the parent or reference antibody or antigen binding fragment thereof by including one, two, three, four, five or more amino acid substitutions, additions, deletions or modifications relative to the parent or reference antibody or antigen binding fragment thereof.

In some embodiments such derivatives will have substantially the same immunospecificity and/or characteristics, or the same immunospecificity and characteristics as the parent or reference antibody or antigen binding fragment thereof. The amino acid substitutions or additions of such derivatives can include naturally occurring (*i.e.*, DNA-encoded) or non-naturally occurring amino acid residues. The term “derivative” encompasses, for example, chimeric or humanized variants, as well as variants having altered CH1, hinge, CH2, CH3 or CH4 regions, so as to form, for example antibodies, *etc.*, having variant Fc regions that exhibit enhanced or impaired effector or binding characteristics.

As used herein, a “chimeric antibody” is a molecule in which different portions of the antibody are derived from different immunoglobulin molecules such as antibodies having a variable region derived from a non-human antibody and a human immunoglobulin constant region.

As used herein, the term “humanized antibody” refers to an immunoglobulin including a human framework region and one or more CDR’s from a non-human (usually a mouse or rat) immunoglobulin. The non-human immunoglobulin providing the CDR’s is called the “donor” and the human immunoglobulin providing the framework is called the “acceptor.” Constant regions need not be present, but if they are, they should be substantially identical to human immunoglobulin constant regions, *i.e.*, at least about 85-99%, or about 95% or more identical. Hence, all parts of a humanized immunoglobulin, except possibly the CDR’s, are substantially identical to corresponding parts of natural human immunoglobulin sequences. A humanized antibody is an antibody including a humanized light chain and a humanized heavy chain immunoglobulin. For example, a humanized antibody would not encompass a typical chimeric antibody, because, *e.g.*, the entire variable region of a chimeric antibody is non-human.

The term “endogenous concentration” refers to the level at which a molecule is natively expressed (*i.e.*, in the absence of expression vectors or recombinant promoters) by a cell (which cell can be a normal cell, a cancer cell or an infected cell).

As used herein, the terms “treat,” “treating,” “treatment” and “therapeutic use” refer to the elimination, reduction or amelioration of one or more symptoms of a disease or disorder. As used herein, a “therapeutically effective amount” refers to that amount of a therapeutic agent sufficient to
5 mediate a clinically relevant elimination, reduction or amelioration of such symptoms. An effect is clinically relevant if its magnitude is sufficient to impact the health or prognosis of a recipient subject. A therapeutically effective amount may refer to the amount of therapeutic agent sufficient to delay or minimize the onset of disease, e.g., delay or minimize the spread of cancer. A
10 therapeutically effective amount may also refer to the amount of the therapeutic agent that provides a therapeutic benefit in the treatment or management of a disease.

As used herein, the term “prophylactic agent” refers to an agent that can be used in the prevention of a disorder or disease prior to the detection of any
15 symptoms of such disorder or disease. A “prophylactically effective” amount is the amount of prophylactic agent sufficient to mediate such protection. A prophylactically effective amount may also refer to the amount of the prophylactic agent that provides a prophylactic benefit in the prevention of disease.

20 As used herein, the term “cancer” refers to a neoplasm or tumor resulting from abnormal uncontrolled growth of cells. As used herein, cancer explicitly includes, leukemias and lymphomas. The term “cancer” refers to a disease involving cells that have the potential to metastasize to distal sites and exhibit phenotypic traits that differ from those of non-cancer cells, for example,
25 formation of colonies in a three-dimensional substrate such as soft agar or the formation of tubular networks or web-like matrices in a three-dimensional basement membrane or extracellular matrix preparation. Non-cancer cells do not form colonies in soft agar and form distinct sphere-like structures in three-dimensional basement membrane or extracellular matrix preparations.

As used herein, an “immune cell” refers to any cell from the hemopoietic origin including, but not limited to, T cells, B cells, monocytes, dendritic cells, and macrophages.

As used herein, “inflammatory molecules” refer to molecules that result in inflammatory responses including, but not limited to, cytokines and metalloproteases such as including, but not limited to, IL-1 β , TNF- α , TGF-beta, IFN- γ , IL-18, IL-17, IL-6, IL-23, IL-22, IL-21, and MMPs.

As used herein, “valency” refers to the number of binding sites available per molecule.

As used herein, the terms “immunologic,” “immunological” or “immune” response is the development of a beneficial humoral (antibody mediated) and/or a cellular (mediated by antigen-specific T cells or their secretion products) response directed against a peptide in a recipient patient. Such a response can be an active response induced by administration of immunogen or a passive response induced by administration of antibody or primed T-cells. A cellular immune response is elicited by the presentation of polypeptide epitopes in association with Class I or Class II MHC molecules to activate antigen-specific CD4⁺ T helper cells and/or CD8⁺ cytotoxic T cells. The response may also involve activation of monocytes, macrophages, NK cells, basophils, dendritic cells, astrocytes, microglia cells, eosinophils, activation or recruitment of neutrophils or other components of innate immunity. The presence of a cell-mediated immunological response can be determined by proliferation assays (CD4⁺ T cells) or CTL (cytotoxic T lymphocyte) assays. The relative contributions of humoral and cellular responses to the protective or therapeutic effect of an immunogen can be distinguished by separately isolating antibodies and T-cells from an immunized syngeneic animal and measuring protective or therapeutic effect in a second subject.

An “immunogenic agent” or “immunogen” is capable of inducing an immunological response against itself on administration to a mammal, optionally in conjunction with an adjuvant.

As used herein, the terms “individual,” “host,” “subject,” and “patient” are used interchangeably herein, and refer to a mammal, including, but not limited to, humans, rodents, such as mice and rats, and other laboratory animals.

As used herein, the term “polypeptide” refers to a chain of amino acids of any length, regardless of modification (*e.g.*, phosphorylation or glycosylation). The term polypeptide includes proteins and fragments thereof. The polypeptides can be “exogenous,” meaning that they are “heterologous,” *i.e.*, foreign to the host cell being utilized, such as human polypeptide produced by a bacterial cell. Polypeptides are disclosed herein as amino acid residue sequences. Those sequences are written left to right in the direction from the amino to the carboxy terminus. In accordance with standard nomenclature, amino acid residue sequences are denominated by either a three letter or a single letter code as indicated as follows: Alanine (Ala, A), Arginine (Arg, R), Asparagine (Asn, N), Aspartic Acid (Asp, D), Cysteine (Cys, C), Glutamine (Gln, Q), Glutamic Acid (Glu, E), Glycine (Gly, G), Histidine (His, H), Isoleucine (Ile, I), Leucine (Leu, L), Lysine (Lys, K), Methionine (Met, M), Phenylalanine (Phe, F), Proline (Pro, P), Serine (Ser, S), Threonine (Thr, T), Tryptophan (Trp, W), Tyrosine (Tyr, Y), and Valine (Val, V).

As used herein, the term “variant” refers to a polypeptide or polynucleotide that differs from a reference polypeptide or polynucleotide, but retains essential properties. A typical variant of a polypeptide differs in amino acid sequence from another, reference polypeptide. Generally, differences are limited so that the sequences of the reference polypeptide and the variant are closely similar overall and, in many regions, identical. A variant and reference polypeptide may differ in amino acid sequence by one or more modifications (*e.g.*, substitutions, additions, and/or deletions). A substituted or inserted amino acid residue may or may not be one encoded by the genetic code. A variant of a polypeptide may be naturally occurring such as an allelic variant, or it may be a variant that is not known to occur naturally.

Modifications and changes can be made in the structure of the polypeptides of the disclosure and still obtain a molecule having similar

characteristics as the polypeptide (*e.g.*, a conservative amino acid substitution). For example, certain amino acids can be substituted for other amino acids in a sequence without appreciable loss of activity. Because it is the interactive capacity and nature of a polypeptide that defines that polypeptide's biological functional activity, certain amino acid sequence substitutions can be made in a polypeptide sequence and nevertheless obtain a polypeptide with like properties.

In making such changes, the hydropathic index of amino acids can be considered. The importance of the hydropathic amino acid index in conferring interactive biologic function on a polypeptide is generally understood in the art. It is known that certain amino acids can be substituted for other amino acids having a similar hydropathic index or score and still result in a polypeptide with similar biological activity. Each amino acid has been assigned a hydropathic index on the basis of its hydrophobicity and charge characteristics. Those indices are: isoleucine (+4.5); valine (+4.2); leucine (+3.8); phenylalanine (+2.8); cysteine/cystine (+2.5); methionine (+1.9); alanine (+1.8); glycine (-0.4); threonine (-0.7); serine (-0.8); tryptophan (-0.9); tyrosine (-1.3); proline (-1.6); histidine (-3.2); glutamate (-3.5); glutamine (-3.5); aspartate (-3.5); asparagine (-3.5); lysine (-3.9); and arginine (-4.5).

It is believed that the relative hydropathic character of the amino acid determines the secondary structure of the resultant polypeptide, which in turn defines the interaction of the polypeptide with other molecules, such as enzymes, substrates, receptors, antibodies, antigens, and cofactors. It is known in the art that an amino acid can be substituted by another amino acid having a similar hydropathic index and still obtain a functionally equivalent polypeptide. In such changes, the substitution of amino acids whose hydropathic indices are within ± 2 is preferred, those within ± 1 are particularly preferred, and those within ± 0.5 are even more particularly preferred.

Substitution of like amino acids can also be made on the basis of hydrophilicity, particularly where the biological functional equivalent polypeptide or peptide thereby created is intended for use in immunological embodiments. The following hydrophilicity values have been assigned to amino

acid residues: arginine (+3.0); lysine (+3.0); aspartate (+3.0 $\pm$ 1); glutamate (+3.0 $\pm$ 1); serine (+0.3); asparagine (+0.2); glutamine (+0.2); glycine (0); proline (-0.5 $\pm$ 1); threonine (-0.4); alanine (-0.5); histidine (-0.5); cysteine (-1.0); methionine (-1.3); valine (-1.5); leucine (-1.8); isoleucine (-1.8); tyrosine (-2.3); phenylalanine (-2.5); tryptophan (-3.4). It is understood that an amino acid can be substituted for another having a similar hydrophilicity value and still obtain a biologically equivalent, and in particular, an immunologically equivalent polypeptide. In such changes, the substitution of amino acids whose hydrophilicity values are within $\pm$ 2 is preferred, those within $\pm$ 1 are particularly preferred, and those within $\pm$ 0.5 are even more particularly preferred.

As outlined above, amino acid substitutions are generally based on the relative similarity of the amino acid side-chain substituents, for example, their hydrophobicity, hydrophilicity, charge, size, and the like. Exemplary substitutions that take various foregoing characteristics into consideration are well known to those of skill in the art and include (original residue: exemplary substitution): (Ala: Gly, Ser), (Arg: Lys), (Asn: Gln, His), (Asp: Glu, Cys, Ser), (Gln: Asn), (Glu: Asp), (Gly: Ala), (His: Asn, Gln), (Ile: Leu, Val), (Leu: Ile, Val), (Lys: Arg), (Met: Leu, Tyr), (Ser: Thr), (Thr: Ser), (Tyr: Trp, Phe), and (Val: Ile, Leu). Embodiments of this disclosure thus contemplate functional or biological equivalents of a polypeptide as set forth above. In particular, embodiments of the polypeptides can include variants having about 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98%, 99%, or more sequence identity to the polypeptide of interest.

The term “percent (%) sequence identity” is defined as the percentage of nucleotides or amino acids in a candidate sequence that are identical with the nucleotides or amino acids in a reference nucleic acid sequence, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity. Alignment for purposes of determining percent sequence identity can be achieved in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST,

5 For purposes herein, the % sequence identity of a given nucleotides or amino acids sequence C to, with, or against a given nucleic acid sequence D (which can alternatively be phrased as a given sequence C that has or comprises a certain % sequence identity to, with, or against a given sequence D) is calculated as follows:

As used herein, the term "pharmaceutically acceptable carrier" encompasses any of the standard pharmaceutical carriers, such as a phosphate buffered saline solution, water and emulsions such as an oil/water or water/oil emulsion, and various types of wetting agents.

LAIR binding moieties are provided that are useful for modulating signal transduction through LAIR proteins. Figure 4 shows LAIR regulation of immune function and homeostasis. Figure 5 shows how LAIR-1 mAbs and LAIR-2 Fc can be used as therapeutics.

LAIR-1 is an inhibitory cell surface receptor that is expressed on many immune cells and exerts inhibitory signaling through two cytoplasmic

immunoreceptor tyrosine-based inhibitory motifs (ITIMs) (Verbrugge et al., 2006) (Figure 4). Human and non-human primate, but not mouse, genomes encode a LAIR-2 gene that is a soluble homolog of LAIR-1 (Sun et al., 2014). LAIR-2 lacks transmembrane and cytoplasmic domains, but binds the same
 5 ligands as LAIR-1, and thus may function as a decoy to reduce inhibitory signals through LAIR-1 (Meyaard, 2008). LAIR-1 and LAIR-2 interact with multiple collagens, including fibrillar collagens I and III, and transmembrane collagens 13, 17 and 23, but may also bind other collagens to varying extents due to recognition of canonical Gly-Pro-Hyp hydroxyproline repeat (Meyaard, 2008).
 10 LAIR-1 and LAIR-2 also bind to complement component C1q, surfactant protein D (SP-D) and mannose binding lectin (MBL). Cross-linking of these molecules with LAIR-1 on the leukocyte plasma membrane induce negative signaling that inhibits immune cell maturation, proliferation and degranulation (Lebbink et al., 2009), Meyaard., (2008)).

15 LAIR-1 inhibitory signaling may prevent autoimmune diseases such as lupus erythematosus, rheumatoid arthritis, autoimmune thyroid disease and atherosclerosis as well as contact hypersensitivity (Sun et al., 2014). Meanwhile, overexpression of LAIR-2 may promote autoimmunity through decoy binding of LAIR-1 ligands. LAIR-2 binding of LAIR-1 ligands can essentially reduce the
 20 cell surface cross-linking of LAIR-1, delimiting inhibitory signaling pathways leading to over-reactive immune function. Conversely, it hypothesized that increased levels of LAIR-2 may promote anti-tumor immunity through the same mechanism.

Reduced expression of LAIR-1 on chronic lymphocytic leukemia (CLL)
 25 cells is associated with increased disease (Poggi et al., 2008; Perbellini et al., 2014). Conversely, studies suggest that increased expression of LAIR-1 on acute myeloid leukemia (AML) promotes AML survival by maintaining a stem-like state and preventing differentiation and apoptosis (Kang et al., 2015). IN support of this notion, other studies have also indicated that LAIR-1 is increased
 30 on AML and acute lymphoblastic leukemia (ALL) cancers (Mirkowska et al, Blood, 2013; Chen et al, Nature, 2015; Zhang et al., review in

life.scietchina.com, 2015). LAIR-1 has also been shown to be expressed on epithelial ovarian cancer cells and other human tumors, although the function of LAIR-1 expressed on solid tumors remains unclear (Meyaard et al., 1997; Cao et al., 2015).

5 Tumor microenvironments are often rich in extracellular matrix proteins (ECMs), including the collagens (Rygiel et al., 2011). Therefore, LAIR-1 expressing cells localized to tumor microenvironments may be particularly suppressed through collagen cross-linking of LAIR-1 and subsequent inhibitory signaling. Interestingly, both collagen and C1q have been shown to limit or alter
10 antigen-presenting cell (monocyte/macrophage/DC) differentiation and activation through LAIR-1. Studies have indicated that cross-linking LAIR-1 on NK cells that T cells can inhibit proliferation and function. However, the role LAIR-1 in the regulation anti-tumor immunity requires further study.

Together, the accumulated data on LAIR-1 indicates an important role in
15 immune modulation. However, differential expression of LAIR-1 on murine and human cells, as well as the presence of LAIR-2 in humans, but not in mice, have suggested that mouse studies may not be indicative of the function of LAIR-1/LAIR-2 in humans. Whereas, it is hypothesized that the human system may be more easily exploited therapeutically because of the presence of LAIR-
20 2. In other words, LAIR-2 may be utilized therapeutically to modulate LAIR-1 function in humans, which is not possible in the murine system. Therefore, LAIR-2 Fc decoy proteins or blocking (antagonist) LAIR-1 mAbs may be effective for cancer immunotherapy to enhance immune function by preventing signaling through cell surface LAIR-1 (Figure 5). Conversely, agonist LAIR-1
25 mAbs, or blockade of LAIR-2 by mAbs could be utilized for treatment of autoimmune disease, as this would essentially increase signaling through LAIR-1, thus downregulating immune responses.

1. LAIR-1

Sequences for LAIR-1 are provided. In some embodiments, the leading
30 methionine amino acid is cleaved in the post-translation form of the protein.

a. Human LAIR-1

Sequences for human LAIR-1 are known in the art. For example, a consensus sequence for LAIR-1a (isoform 1) is

MSPHPTALLGLVLCLAQTINTQEE~~DLPRPSISAE~~PGTVIPLGSHVTFVCRGPGVGVQTFRL
 ERESRSTYNDTEDVSQASPSSESEARFRIDSVSEGNAGPYRCIYYKPKWSEQSDYLELLV
 5 KETSGGPDSPDTEPGSSAGPTQRPSDNSHNEHAPASQGLKAEHL~~YILIGVSVVFLFC~~LL
 LVLFCLHRQNIKQGPFRSKDEEQKFQRPDLAVDVLEREADKATVNGLPEKDRETDTSA
 LAAGSSQEVTYAQLDHWALTQRTARAVSPQSTKPMAESITYAAVARH

(SEQ ID NO:1, UniProtKB - Q6GTX8 (LAIR1_HUMAN)), where amino

acids 1-21 are a signal sequence, amino acids 22-165 (underlined) are an

10 extracellular domain, amino acids 166-186 are a transmembrane domain, and
 amino acids 187-287 are a cytoplasmic domain. Amino acids 29-117 form an
 Ig-like C2-domain. Amino acids 249-254 and 279-284 form ITIM motif 1 and
 2, respectively. LAIR-1b (also known as isoform 2) is missing amino acids
 122-138 relative to SEQ ID NO:1. LAIR-1c (also known as isoform 3) is
 15 missing amino acids 23-23 and 122-138 relative to SEQ ID NO:1. LAIR-1d
 (also known as isoform 4) is missing amino acids 210-287 relative to SEQ ID
 NO:1.

As introduced above, an extracellular domain for human LAIR-1 can be

QEE~~DLPRPSISAE~~PGTVIPLGSHVTFVCRGPGVGVQTFRLERESRSTYNDTEDVSQASPSSESEARFRIDSV
 20 EGNAGPYRCIYYKPKWSEQSDYLELLVKETSGGPDSPDTEPGSSAGPTQRPSDNSHNEHAPASQGLKAEH
 LY

(SEQ ID NO:2), or a fragment thereof, for example, the Ig-like C2-domain
 (underlined amino acids 8-96 of SEQ ID NO:2), or the region framed by the
 cysteines that form the disulfide bond between amino acids 49-101 of SEQ ID
 25 NO:1 (amino acids 28-80 of SEQ ID NO:2, illustrated in italics).

Known variants and mutants of LAIR-1 include E63D, Y251F, and
 Y251F, relative to SEQ ID NO:1. Evidence shows that Y215F reduced tyrosine
 phosphorylation and loss of binding to PTPN6 and CSK as well as complete loss
 of inhibitory activity, as well as loss of phosphorylation and of inhibition of
 30 calcium mobilization when associated with F-281 (Xu, et al., *J. Biol. Chem.*
 275:17440-17446 (2000), Verbrugge, et al., *Int. Immunol.*, 15:1349-1358
 (2003), Verbrugge, et al., *Eur. J. Immunol.*, 36:190-198 (2006)). Y281F shows

reduced tyrosine phosphorylation and loss of binding to PTPN6, and partial inhibition of cytotoxic activity.

Meyaard, 2008, *J. Leukoc. Biol.* 83:799-803 indicates that LAIR-1 is broadly expressed on human immune cells. An examination of actual flow
 5 cytometry expression data in research papers shows that LAIR-1 is much more highly expressed on myeloid lineage cells such as monocytes, macrophages and dendritic cells, than on T cells and NK cells (Meyaard et al., 1997, *Immunity* 7:283-290). However, B cells differentially express high levels of LAIR-1 during differentiation (van der Vuurst de Vries et al., 1999, *Eur. J. Immunol.*
 10 29:3160-3167). LAIR-1 has also been found to be expressed on acute myeloid leukemia cells, acute lymphoblastic leukemia cells and chronic lymphocytic leukemia cells (van der Vuurst de Vries et al., 1999, *Eur. J. Immunol.* 29:3160-3167; Poggi et al., 2000, *Eur. J. Immunol.* 30:2751-2758; Zocchi et al., 2001, *Eur. J. Immunol.* 31:3667-3675; Perbellini et al., 2014, *Haematologica*, 99:881-
 15 887; (Kang et al., 2015, *Nat. Cell Biol.* 17:665-677). Finally, LAIR-1 was shown to be expressed on several human tumor cell lines (Meyaard et al., 1997, *Immunity* 7:283-290; Cao et al., 2015, *Biochem. Biophys. Res. Commun.* 458:399-404; (Kang et al., 2015, *Nat. Cell Biol.* 17:665-677).

In humans and mice, LAIR-1 binds several types of collagen with high
 20 affinity (Meyaard, 2008, *J. Leukoc. Biol.* 83:799-803 and Meyaard, 2010, *Immunol. Lett.* 128:26-28). In humans, LAIR-1 has also been shown to bind the complement component C1q (Son et al., 2012, *Proc. Natl. Acad. Sci. USA* 109:E3160-3167) and the collagenous C-type lectin, surfactant protein-D (SP-D), a collagenous carbohydrate binding glycoprotein (collectin) that plays
 25 important roles in the lung's innate immune response to microbial and antigenic challenge (Olde Nordkamp et al., 2014, *J. Leukoc. Biol.* 96:105-111). The ability of murine LAIR-1 to bind C1q and SP-D has not been examined.

Systemic lupus erythematosus (SLE) is a prototypic autoimmune disease characterized by the loss of immune tolerance. An immunosuppressive role for
 30 C1q is supported by the high percentage of C1q-deficient individuals who develop SLE. Dr. Son and her Feinstein Institute collaborators Dr. Betty

Diamond, Dr. Frances Santiago-Schwarz and Dr. Yousef Al-Abed have shown that C1q is a functional ligand for LAIR-1, which is known as a universal collagen receptor. They have further shown that C1q promotes tolerance by inhibition of monocyte to DC differentiation and pDC activation through engagement of LAIR-1 (Son and Diamond, *Mol. Med.*, 2015, 20:559-568; Son et al., *PNAS*, 109(46):E3160-3167). This discovery has a high impact on the lupus field, because these findings elucidate the mechanism by which the complement system regulates tolerance and prevents autoimmune diseases, such as lupus.

All collagens are composed of 3 polypeptide chains that are characterized by a repeating Gly-X-X' sequence, where X is often proline and X' frequently 4-R-hydroxyproline (Hyp, O) (Brondijk, *Blood*, 115(7):1364-1373 (2010). The GPO triplets are an almost exclusive feature of collagens and allow the formation of the characteristic triplehelical collagen structure.

The ectodomains of the known immunoglobulin superfamily collagen receptors, LAIR-1, GPVI, and OSCAR, consist of 1 or 2 immunoglobulin-like domains. Although GPVI and LAIR-1 are functionally different, they are similar in their collagen-binding properties. However, as discussed in Zhou, et al., *Blood*, 127(5):529-537 (2016), despite their structural homogeneity, the three proteins have very different collagen recognition sites. GPVI binds most strongly to the model collagen-related peptide with sequence glycine-proline-hydroxyproline (GPO)-rich tracts of collagen III (GPO)₁₀ and to a few Toolkit peptides (III-1, III-30, and III-40), which contain 1 or 2 GPO triplets (Jarvis, et al., *Blood*, 111(10):4986-4996 (2008)). LAIR-1 also displays high affinity for III-30 and for a subset of amino acid-rich peptides, but binds III-1 and collagen related peptide less tightly (Lebbink, et al., *Matrix Biol.*, 28(4):202-210 (2009)).

Mutagenesis and nuclear magnetic resonance titration indicated a patch of residues on the membrane-distal region of LAIR-1 that contact the model triple-helical peptide (THP), residing in a groove composed of strands C, C9, F, and the FG loop (Brondijk, *Blood*, 115(7):1364-1373 (2010), which is specifically incorporated by reference in its entirety). For example, adhesion to

immobilized collagens I, III, and IV was significantly reduced in the R59A, E61A, R65A, and E111A mutants, although the magnitude of the effect depended on the type of collagen tested. In addition, adhesion was somewhat reduced for mutants R62A and N69A, which showed near wild-type collagen binding in the flow cytometric assay. Brondijk, et al., reports that LAIR-1 residues E61, S66, Y68, I102, W109, and Y115 provide Van derWaals interactions, whereas hydrogen bonds to the ligand frequently involve LAIR-1 residues R59, E63, R100, E111, and Q112, and concludes that R59, E61, and also W109 make up the core of the collagen-binding site, whereas more peripheral residues such as E111 contribute less to binding (residues with reference, for example, to SEQ ID NO:1).

b. Mouse LAIR-1

Sequences for mouse LAIR-1 (mLAIR-1) are known in the art. For example, a consensus sequence for mLAIR-1a (isoform 1) is

MSLHPVILLVLLCLGKINTQEGSLPDITIFPNSSLMISQGTFTVTVVCSYSDKHDLYNM
 VRLEKDGSTFMEKSTEPYKTEDEFEIGPVNETITGHYSCTYSGITWSEPSKTELEKVIK
 ENVIQTTFAPGPTSDTSWLKTYSLYIFTVVSVIFLLCLLSALLFCFLRHRQKQGLPNNKRO
 QQRPEERLNLATNGLEMTFDDIVADDRLPEDRWTEWTWTFVAGDLQEVTYIQLDHHSLSLQRA
 VGAVTSQSTDMAESSTYAAIRH

(SEQ ID NO:3, UniProtKB - Q8BG84 (LAIR1_MOUSE)), where amino acids 1-21 are a signal sequence, amino acids 22-144 (underlined) are an extracellular domain, amino acids 145-165 are a transmembrane domain, and amino acids 166-263 are a cytoplasmic domain. Amino acids 27-115 form an Ig-like C2-domain. Amino acids 226-231 and 255-260 form ITIM motif 1 and 2, respectively. mLAIR-1b (also known as isoform 2) is missing amino acids 124-133 relative to SEQ ID NO:3. Isoform 3 has amino acids 25-56 [SLPDITIFPNSSLMISQGTFTVTVVCSYSDRHD (SEQ ID NO:7) of SEQ ID NO:3]] replaced with ELCLWFLYPWATLELIMCTWDAWKETLEYFL (SEQ ID NO:8) and is missing amino acids 57-263 relative to SEQ ID NO:3. mLAIR-1d (also known as isoform 5) is missing amino acids 24-172 relative to SEQ ID NO:3. mLAIR-1e (also known as isoform 6) is missing amino acids 134-172.

As introduced above, an extracellular domain for murine LAIR-1 can be

QEGSLPDITIFPNSSLMISQGTFTVTVVCSYSDKHDLNMMVRLEKDGSTFMEKSTPEYKTEDEFEIGPVNET
ITGHYSCTIYSGKITWSERSKTLELKVIKENVIQTAPGPTSDTSLWKTYSIY

(SEQ ID NO:4), or a fragment thereof, for example, the Ig-like C2-domain
 (underlined amino acids 6-94 of SEQ ID NO:4), or the region framed by the
 5 cysteines that form the disulfide bond between amino acids 49-99 of SEQ ID
 NO:3 (amino acids 28-78 of SEQ ID NO:4, illustrated in italics). An exemplary
 alignment of the human and mouse extracellular domains is shown below:

Score	Expect	Method	Identities	Positives	Gaps
45.6 bits(109)	2e-12	Compositional matrix adjust.	35/104(34%)	49/104(47%)	7/104(6%)
Query 1	QEEHLPRPSISAEPGTVIPLGSHVTFVCRGPVGVQTFRLERESR--STYNDTEDEVSQASP 58				
	QE LP +I +I G+ VT VC + + R + ST+ + P				
Sbjct 1	QEGSLPDITIFPNSSLMISQGTFTVTVVCSYSDKHDLNMMVRLEKDGSTFME---KSTEP 56				
Query 59	SESEARFRIDSVSSEGNAGPVRCIYYPPKNSQSDYLEL-LVKE 101				
	++E F I V+E G Y C I Y K WSE+S LEL ++KE				
Sbjct 57	YKTEDEFEIGPVNETITGHYSCTIYSGKITWSERSKTLELKVKE 100				

Query 1 is SEQ ID NO:2 and Sbjct is SEQ ID NO:4.

10 Known variants and mutants of LAIR-1 include IYI → MYM at amino
 acid positions 143-145, V149G, L154P, and H263R relative to SEQ ID NO:3.

Meyaard (2008, *J. Leukoc. Biol.* 83:799-803) indicates broad expression
 of LAIR-1 on mouse immune cells, with one major difference being that LAIR-
 1 appears negative on B cells, as opposed to being highly expressed on subsets
 15 of human B cells. As with the human expression pattern, when examining the
 actual flow cytometry data of LAIR-1 expression, it is found that once again,
 LAIR-1 is highly expressed on monocytes, macrophages and DCs, while T cells,
 NK cells and Gr-1+ cells express LAIR-1 at relatively lower levels (Lebbink et
 al., 2007 *Int. Immunol.* 19:1011-1019; Tang et al., 2012, *J. Immunol.* 188:548-
 20 558).

Tang et al. (2012, *J. Immunol.* 188:548-558) investigated the phenotype
 of LAIR-1 deficient mice. KO mice are healthy and fertile, and display
 indications of altered immune function, but without gross autoimmunity or
 inflammation that is observed in CTLA-4 KO mice. LAIR-1 KO mice have
 25 increased numbers of dendritic cells, splenic B cells and regulatory T cells, as
 well as a higher frequency of activated and memory T cells, suggesting
 enhanced T cell reactivity. However, there was no difference in EAE and colitis
 disease models in LAIR-1 wt and KO mice. These disease models may not have

been optimal for investigating LAIR-1 KO phenotype, and in vitro functional studies of LAIR-1 deficient immune cell subsets were not performed. It is also speculated that LAIR-1 KO mice may not be indicative of the role of LAIR-1 in humans due to differential expression and the presence of soluble LAIR-2 in humans. Differences between LAIR-1 genetic pathways in murine and human internal organs are discussed in Sun, et al., *Gene*, 552:14-145 (2014), and can be accounted for when designing and evaluating experiments utilizing a mouse model.

2. LAIR-2

Sequences for LAIR-2 and fusion proteins thereof are provided. In some embodiments, the leading methionine amino acid is cleaved in the post-translation form of the protein.

Sequences for human LAIR-2 are known in the art. For example, a consensus sequence for LAIR-2a (isoform 1) is

MSFHLTALLGLVLCIAQTHTQEGALPRPSISAEFGTVISPGSHVTFCRGPVGVQTFRL
EPREDRAKYKDSYNVFRGLGPSESEARFHIDSVSSEGNAGLYRCLYKPPGWSEHSDFLLELV
KSSGGPDSPDTEPGSSAGTVPGTEASGFDAP

(SEQ ID NO:5, UniProtKB - Q6ISS4 (LAIR2_HUMAN)), where amino acids 1-21 are a signal sequence, amino acids 22-152 (underlined) are the Leukocyte-associated immunoglobulin-like receptor 2 domain. Amino acids 29-117 form an Ig-like C2-domain. LAIR-2b (also known as isoform 2) is missing amino acids 122-138 relative to SEQ ID NO:5.

As introduced above, a Leukocyte-associated immunoglobulin-like receptor 2 domain for human LAIR-2 can be

QEGALPRPSISAEFGTVISPGSHVTFCRGPVGVQTFRLEREDRAKYKDSYNVFRGLGPSE
SEARFHIDSVSSEGNAGLYRCLYKPPGWSEHSDFLLELVKSSGGPDSPDTEPGSSAGTV
 PGTEASGFDAP

(SEQ ID NO:6), or a fragment thereof, for example, the Ig-like C2-domain (underlined amino acids 8-96 of SEQ ID NO:6), or the region framed by the cysteines that form the disulfide bond between amino acids 49-101 of SEQ ID NO:1 (amino acids 28-80 of SEQ ID NO:6, illustrated in italics).

Known variants and mutants of LAIR-2 include G78S, H87R, and F115Y, relative to SEQ ID NO:5.

LAIR-2 in humans has been shown to bind collagen and SP-D with higher affinity than LAIR-1 (Meyaard, 2008, *J. Leukoc. Biol.* 83:799-803). Dr. Linde Meyaard has demonstrated that LAIR-2 also binds C1q and mannose-binding lectin (MBL), both of which contain collagen-like domains (Olde Nordkamp et al., *J. Innate Immun.*, 2014, 6(3):284-92). This finding confirms evidence by Son et al that LAIR-2 binds C1q (Son et al., 2012, *Proc. Natl. Acad. Sci. USA* 109:E3160-3167). While collagens and C1q are ubiquitously expressed, SP-D is largely restricted to mucosal surfaces (lung alveolar surface and GI tract) where it functions as a first-line innate defense against pathogens (Herias et al., 2007, *Mol. Immunol.* 44:3324-3332).

An exemplary alignment of the human LAIR-1 and human LAIR-2 extracellular domains is shown below:

Score	Expect	Method	Identities	Positives	Gaps
194 bits(493)	4e-70	Compositional matrix adjust.	95/118(81%)	103/118(87%)	0/118(0%)
Query 1	QFEDLPRPSISAEPSTVIPLGSHVTFVCRGPGVGVQTFRLERERSTYNDTEVDSQASPSE 68				
Sbjct 1	QE LPRPSISAEPSTVI GSHVTF+CRGPGVGVQTFRLERE R+ Y D+ +V + PSE 68				
Query 61	SEARFRIDSVSEGNAGPYRCIYKPPKWSQSDYLELLVKETSGGPDSPDTEPGSSAG 118				
Sbjct 61	SEARFIDSVSEGNAG YRC+YKPP WSE SD+LELLVKE+SGGPDSPDTEPGSSAG 118				

Query is SEQ ID NO:2 and Sbjct is SEQ ID NO:6.

15 B. Immunomodulatory Agents

Immunomodulatory agents including agonists and antagonists of LAIR-1 and antagonists of LAIR-2 are provided. An agonist of LAIR-1 typically induces, potentiates, or activates LAIR-1 negative signaling. An antagonist of LAIR-1 typically prevents, reduces, or blocks LAIR-1 negative signaling. An antagonist of LAIR-2 typically reduces or prevents the ability of LAIR-2 to bind a ligand thereof, including ligands shared by LAIR-1 and LAIR-2. The compositions and methods can be used to modulate LAIR-1 negative signaling on, for example, myeloid cells including antigen-presenting cells (e.g., monocyte, macrophage, or dendritic cell), T cells, Natural Killer (NK) cells, or a combination thereof. In some embodiments, the compositions are specifically targeted one or more cells types. Exemplary molecules that can be an agonist or antagonist of LAIR-1 and an antagonist of LAIR-2 are discussed in more detail below.

In some embodiments, the LAIR-1 antagonists, including anti-LAIR-1 function blocking antibodies, bind to or otherwise interfere with a collagen binding domain, a C1q binding domain, a SP-D binding domain, or a combination thereof of LAIR-1. For example, in some embodiments, the LAIR-1 antagonist binds to, blocks, creates a conformational change, or otherwise interferes with LAIR-1 residue R59, E61, R62, E63, R65, S66, Y68, N69, I102, R100, W109, E111, Q112, and Y115 or any combination of any of the foregoing. In some embodiments, a LAIR-1 function blocking antibody or functional fragment thereof specifically binds to an epitope including one or more of R59, E61, R62, E63, R65, S66, Y68, N69, I102, R100, W109, E111, Q112, and Y115 (e.g., relative to SEQ ID NO:1). In some embodiments, the immunomodulatory agent does not interfere with OSCAR binding or activity, GPVI binding or activity, or a combination thereof.

1. Antibodies

The immunomodulatory agent can be an antibody. Suitable antibodies are known in the art or can be prepared by one of skill in the art. Nucleic acid and polypeptide sequences for LAIR-1 and LAIR-2 are known in the art, and exemplary protein sequences are provided above. The sequences can be used, as discussed in more detail below, by one of skill in the art to prepare an antibody or antigen binding fragment thereof specific for LAIR-1 or LAIR-2. The antibody, or antigen binding fragment thereof, can be an agonist or antagonist of LAIR-1 or an antagonist of LAIR-2.

The activity (*i.e.*, agonist or antagonist) of an antibody or antigen binding fragment thereof that is specific for LAIR-1 or LAIR-2, can be determined using functional assays that are known in the art, and include the assays discussed below. Typically the assays include determining if the antibody or antigen binding fragment thereof increases (*i.e.*, agonist) or decreases (*i.e.*, antagonist) signaling through LAIR-1. In some embodiments the assay includes determining if the antibody or antigen binding fragment thereof decreases (*i.e.*, agonist) or increases (*i.e.*, antagonist) an immune response negatively regulated by LAIR-1.

In some embodiments, the disclosed antibodies and antigen binding fragments thereof immunospecifically bind to LAIR-1 or LAIR-2 (e.g., any one of SEQ ID NO:1-6). In some embodiments, the antibody binds to an extracellular domain of LAIR-1 or LAIR-2.

5 For example, molecules are provided that can immunospecifically bind to LAIR-1:

- (I) arrayed on the surface of a cell (especially a live cell);
- (II) arrayed on the surface of a cell (especially a live cell) at an endogenous concentration;
- 10 (III) arrayed on the surface of a live cell, and modulates binding between LAIR-1 and a ligand thereof;
- (IV) arrayed on the surface of a live cell, and reduces or inhibits immune suppression by LAIR-1;
- (V) arrayed on the surface of a live cell, and induces or enhances
- 15 immune suppression by LAIR-1;
- (VI) arrayed on the surface of a live cell, wherein the cell is a myeloid cell including antigen-presenting cells (e.g., monocyte, macrophage, or dendritic cell), a T cell, a Natural Killer (NK) cell, or a combination thereof;
- (VII) combinations of I-IV and VI;
- 20 (VIII) combinations of I-III and V-IV; and
- (IX) arrayed on the surface of a live myeloid or lymphoid derived cancer cells (AML or ALL), and enhances apoptosis and differentiation resulting in reduced self-renewal of cancer stem cells.

Molecules are also provided that can immunospecifically bind to soluble

25 endogenous LAIR-2. In some embodiments the molecules reduce or prevent the LAIR-2 from binding or otherwise interacting with its ligand.

In some embodiments, the molecules are capable of inducing antibody dependent cell cytotoxicity (ADCC), complement dependent cytotoxicity (CDC) or cellular apoptosis through other mechanisms, of LAIR-1 expressing cell.

30 To prepare an antibody or antigen binding fragment thereof that specifically binds to LAIR-1 or LAIR-2, purified proteins, polypeptides,

fragments, fusions, or epitopes to LAIR-1 or LAIR-2, or polypeptides expressed from nucleic acid sequences thereof, can be used. The antibodies or antigen binding fragments thereof can be prepared using any suitable methods known in the art such as those discussed in more detail below.

5 **a. Human and Humanized Antibodies**

Many non-human antibodies (*e.g.*, those derived from mice, rats, or rabbits) are naturally antigenic in humans, and thus can give rise to undesirable immune responses when administered to humans. Therefore, the use of human or humanized antibodies in the methods serves to lessen the chance that an antibody administered to a human will evoke an undesirable immune response.

Transgenic animals (*e.g.*, mice) that are capable, upon immunization, of producing a full repertoire of human antibodies in the absence of endogenous immunoglobulin production can be employed. For example, it has been described that the homozygous deletion of the antibody heavy chain joining region (J(H)) gene in chimeric and germ-line mutant mice results in complete inhibition of endogenous antibody production. Transfer of the human germ-line immunoglobulin gene array in such germ-line mutant mice will result in the production of human antibodies upon antigen challenge.

Optionally, the antibodies are generated in other species and “humanized” for administration in humans. Humanized forms of non-human (*e.g.*, murine) antibodies are chimeric immunoglobulins, immunoglobulin chains or fragments thereof (such as Fv, Fab, Fab', F(ab')₂, or other antigen-binding subsequences of antibodies) which contain minimal sequence derived from non-human immunoglobulin. Humanized antibodies include human immunoglobulins (recipient antibody) in which residues from a complementarity determining region (CDR) of the recipient antibody are replaced by residues from a CDR of a non-human species (donor antibody) such as mouse, rat or rabbit having the desired specificity, affinity and capacity. In some instances, Fv framework residues of the human immunoglobulin are replaced by corresponding non-human residues. Humanized antibodies may also contain residues that are found neither in the recipient antibody nor in the imported CDR

or framework sequences. In general, the humanized antibody will contain substantially all of at least one, and typically two, variable domains, in which all or substantially all, of the CDR regions correspond to those of a non-human immunoglobulin and all or substantially all of the FR regions are those of a human immunoglobulin consensus sequence. The humanized antibody
5 optimally also will contain at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin.

Methods for humanizing non-human antibodies are well known in the art. See for example, Jones, P.T., et al. (1986). Replacing the complementarity-determining regions in a human antibody with those from a mouse. *Nature* 321,
10 522–525. Generally, a humanized antibody has one or more amino acid residues introduced into it from a source that is non-human. These non-human amino acid residues are often referred to as “import” residues, which are typically taken from an “import” variable domain. Antibody humanization techniques
15 generally involve the use of recombinant DNA technology to manipulate the DNA sequence encoding one or more polypeptide chains of an antibody molecule. Humanization can be essentially performed by substituting rodent CDRs or CDR sequences for the corresponding sequences of a human antibody. Accordingly, a humanized form of a nonhuman antibody (or a fragment thereof)
20 is a chimeric antibody or fragment, wherein substantially less than an intact human variable domain has been substituted by the corresponding sequence from a non-human species. In practice, humanized antibodies are typically human antibodies in which some CDR residues and possibly some FR residues are substituted by residues from analogous sites in rodent antibodies.

25 The choice of human variable domains, both light and heavy, to be used in making the humanized antibodies is very important in order to reduce antigenicity. According to the “best-fit” method, the sequence of the variable domain of a rodent antibody is screened against the entire library of known human variable domain sequences. The human sequence which is closest to that
30 of the rodent is then accepted as the human framework (FR) for the humanized antibody. Another method uses a particular framework derived from the

consensus sequence of all human antibodies of a particular subgroup of light or heavy chains. The same framework may be used for several different humanized antibodies.

It is further important that antibodies be humanized with retention of high affinity for the antigen and other favorable biological properties. To achieve this goal, humanized antibodies can be prepared by a process of analysis of the parental sequences and various conceptual humanized products using three dimensional models of the parental and humanized sequences. Three dimensional immunoglobulin models are commonly available and are familiar 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, FR residues can be selected and combined from the consensus and import sequence 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.

The antibody can be bound to a substrate or labeled with a detectable moiety or both bound and labeled. The detectable moieties contemplated with the present compositions include fluorescent, enzymatic and radioactive markers.

b. Single-Chain Antibodies

Methods for the production of single-chain antibodies are well known to those of skill in the art. A single chain antibody is created by fusing together the variable domains of the heavy and light chains using a short peptide linker, thereby reconstituting an antigen binding site on a single molecule. Single-chain antibody variable fragments (scFvs) in which the C-terminus of one variable domain is tethered to the N-terminus of the other variable domain via a 15 to 25 amino acid peptide or linker have been developed without significantly

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the respective component antibodies, or by recombinant techniques. Such hybrids may, of course, also be formed using chimeric chains.

e. Conjugates or Fusions of Antibody Fragments

The targeting function of the antibody can be used therapeutically by
 5 coupling the antibody or a fragment thereof with a therapeutic agent. Such coupling of the antibody or fragment (*e.g.*, at least a portion of an immunoglobulin constant region (Fc)) with the therapeutic agent can be achieved by making an immunoconjugate or by making a fusion protein, comprising the antibody or antibody fragment and the therapeutic agent.
 10 Such coupling of the antibody or fragment with the therapeutic agent can be achieved by making an immunoconjugate or by making a fusion protein, or by linking the antibody or fragment to a nucleic acid such as an siRNA, comprising the antibody or antibody fragment and the therapeutic agent.

In some embodiments, the antibody is modified to alter its half-life. In
 15 some embodiments, it is desirable to increase the half-life of the antibody so that it is present in the circulation or at the site of treatment for longer periods of time. For example, it may be desirable to maintain titers of the antibody in the circulation or in the location to be treated for extended periods of time. Antibodies can be engineered with Fc variants that extend half-life, *e.g.*, using
 20 Xtend™ antibody half-life prolongation technology (Xencor, Monrovia, CA). In other embodiments, the half-life of the anti-DNA antibody is decreased to reduce potential side effects. The conjugates disclosed can be used for modifying a given biological response. The drug moiety is not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety
 25 may be a protein or polypeptide possessing a desired biological activity. Such proteins may include, for example, a toxin such as abrin, ricin A, pseudomonas exotoxin, or diphtheria toxin.

f. Exemplary Antibodies

One embodiment provides an anti-LAIR antibody produced by a hybridoma
 30 selected from the group consisting of 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b.

Another embodiment provides an anti-LAIR antibody having at least one light chain or at least one heavy chain of the antibody produced by one or more of the hybridomas selected from the group consisting of 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b.

5 Another embodiment provides an anti-LAIR antibody having a variable light chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable light chain having an amino acid sequence according to SEQ ID NO: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115.

10 Another embodiment provides an anti-LAIR antibody having a variable heavy chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable heavy chain having an amino acid sequence according to SEQ ID NO: 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111.

15 Another embodiment provides an anti-LAIR antibody having a variable light chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to a variable light chain having an amino acid sequence according to SEQ ID NO: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115, and a variable heavy chain having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to an amino acid sequence according to SEQ ID NO: 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111.

20 Another embodiment provides an anti-LAIR antibody having a complementarity-determining region (CDR) selected from the group of CDRs having an amino acid sequence selected from the group consisting of SEQ ID NOs: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 25 104-106, 108-110, 112-114, and 116-118.

Another embodiment provides an anti-LAIR antibody having a plurality of CDRs selected from the group consisting of SEQ ID NOs: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 104-106, 108-110, 112-30 114, and 116-117. The plurality of CDRs can be from 2 -12.

Another embodiment provides a chimeric antibody having a heavy chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:120 or SEQ ID NO:122 and/or a light chain with an amino acid sequence at least 50,
5 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:124.

Another embodiment provides a chimeric antibody having a heavy chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:126
10 or SEQ ID NO:128 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:130.

Another embodiment provides a chimeric antibody having a heavy chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or
15 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:132 or SEQ ID NO:134 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:136.

Another embodiment provides a chimeric antibody having a heavy chain
20 with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:138 or SEQ ID NO:140 and/or a light chain with an amino acid sequence at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:142.

25 Another embodiment provides a nucleic acid sequence encoding an antibody having a light chain amino acid sequence according to SEQ ID NO:124, 130, 136, or 142 and/or a heavy chain amino acid according to SEQ ID NO: 120, 122, 126, 128, 132, 134, 138 or 140.

Another embodiment provides a nucleic acid sequence encoding a
30 variable light chain according to SEQ ID NOs 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115 and/or a variable heavy chain according to SEQ ID NOs 23,

31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111. The nucleic acids encoding the light chain and/or heavy chain can be part of an expression vector. The nucleic acids can be expressed by cell. Expression can be inducible or constitutive.

2. Proteins and Polypeptides

5 a. Protein and Polypeptide Compositions

The immunomodulatory agent can be a protein, polypeptide, or fusion protein. For example, the immunomodulatory agent can be an isolated or recombinant protein or polypeptide, or functional fragment, variant, or fusion protein thereof of LAIR-1 or LAIR-2.

10 The protein or polypeptide, or functional fragment, variant, or fusion protein thereof can be an agonist or an antagonist. For example, in some embodiments an antagonist of LAIR-1 is a LAIR-1 or LAIR-2 polypeptide or a fragment or fusion protein thereof that binds to a ligand of LAIR-1. The polypeptide can be a soluble fragment, for example the extracellular domain of
15 LAIR-1 or LAIR-2, or a functional fragment thereof, or a fusion protein thereof. In some embodiments, a soluble ligand of LAIR-1 may serve as an agonist, increasing signal transduction through LAIR-1.

The activity (*i.e.*, agonist or antagonist) of a protein or polypeptide of LAIR-1 or LAIR-2, or any fragment, variant or fusion protein thereof can be
20 determined using functional assays that are known in the art, and include the assays discussed below. Typically the assays include determining if the protein, polypeptide or fragment, variant or fusion protein thereof increases (*i.e.*, agonist) or decreases (*i.e.*, antagonist) signaling through the LAIR-1 receptor. In some
25 embodiments the assay includes determining if the protein, polypeptide or fragment, variant, or fusion protein thereof increases (*i.e.*, agonist) or decreases (*i.e.*, antagonist) the immune response (*i.e.*, costimulatory or coinhibitory) associated with LAIR-1. Typically the assays include determining if the protein, polypeptide or fragment, variant, or fusion protein thereof increases (*i.e.*,
30 agonist) or decreases (*i.e.*, antagonist) signaling through LAIR-1. In some embodiments the assay includes determining if the protein, polypeptide or fragment, variant, or fusion protein thereof decreases (*i.e.*, agonist) or increases

Nucleic acid and polypeptide sequences for LAIR-1 and LAIR-2 are known in the art and exemplary protein and peptide sequences are provided above. The sequences can be used, as discussed in more detail below, by one of skill in the art to prepare any protein or polypeptide of LAIR-1 or LAIR-2, or any fragment, variant, or fusion protein thereof. Generally, the proteins, polypeptides, fragments, variants, and fusions thereof of LAIR-1 and LAIR-2 are expressed from nucleic acids that include sequences that encode a signal sequence. The signal sequence is generally cleaved from the immature polypeptide to produce the mature polypeptide lacking the signal sequence. The signal sequence can be replaced by the signal sequence of another polypeptide using standard molecule biology techniques to affect the expression levels, secretion, solubility, or other property of the polypeptide. LAIR-1 and LAIR-2 both with and without a signal sequence are disclosed. It is understood that in some cases, the mature protein as it is known or described in the art, *i.e.*, the protein sequence without the signal sequence, is a putative mature protein. During normal cell expression, a signal sequence can be removed by a cellular peptidase to yield a mature protein. The sequence of the mature protein can be determined or confirmed using methods that are known in the art.

As used herein, a fragment of LAIR-1 or LAIR-2 refers to any subset of the polypeptide that is at least one amino acid shorter than full length protein. Useful fragments include those that retain the ability to bind to their natural ligand or ligands. A polypeptide that is a fragment of any full-length LAIR-1 or LAIR-2 typically has at least 20 percent, 30 percent, 40 percent, 50 percent, 60 percent, 70 percent, 80 percent, 90 percent, 95 percent, 98 percent, 99 percent,

100 percent, or even more than 100 percent of the ability to bind its natural ligand respectively as compared to the full-length protein.

Fragments of LAIR-1 and LAIR-2 include cell free fragments. Cell free polypeptide can be fragments of full-length, transmembrane, polypeptides that
5 may be shed, secreted or otherwise extracted from the producing cells. Cell free fragments of polypeptides can include some or all of the extracellular domain of the polypeptide, and lack some or all of the intracellular and/or transmembrane domains of the full-length protein. In one embodiment, polypeptide fragments include the entire extracellular domain of the full-length protein. In other
10 embodiments, the cell free fragments of the polypeptides include fragments of the extracellular domain that retain biological activity of full-length protein. The extracellular domain can include 1, 2, 3, 4, or 5 contiguous amino acids from the transmembrane domain, and/or 1, 2, 3, 4, or 5 contiguous amino acids from the signal sequence. Alternatively, the extracellular domain can have 1, 2,
15 3, 4, 5 or more amino acids removed from the C-terminus, N-terminus, or both. In some embodiments the extracellular domain is the only functional domain of the fragment (e.g., the ligand binding domain).

ii. Variants

Variants of LAIR-1 and LAIR-2, and fragments thereof are also
20 provided. In some embodiments, the variant is at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, or 99 percent identical to any one of SEQ ID NO:1-6. Useful variants include those that increase biological activity, as indicated by any of the assays described herein, or that increase half-life or stability of the protein. The protein and polypeptides of LAIR-1 or LAIR-2, and fragments, variants, and
25 fusion proteins thereof can be engineered to increase biological activity. For example, in some embodiments, a LAIR-2 polypeptide, protein, or fragment, variant or fusion thereof has been modified with at least one amino acid substitution, deletion, or insertion that increases a function thereof.

Other variants are those that are engineered to selectively bind to one or
30 more type of LAIR-1 and/or LAIR-2 ligands versus other LAIR-1 and/or LAIR-2 ligands. For example, the variants can be engineered to bind preferentially to

one or more collagens, SP-D, C1q or MBL, or a specific combination thereof.

Preferential binding refers to binding that is at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, or greater for one type of ligand over another type of ligand.

5 Still other variants can be engineered to have reduced binding to one ligand compared to another. These variants can be used in combination with variants having stronger binding properties to modulate the immune response with a moderate impact.

In still other embodiments, the variants can be engineered to have
10 reduced binding to one or more collagen binds sites relative others. As discussed in Brondijk, et al., *Blood*, 18(115):1364-73 (2010), mutation of residues with LAIR-1 can have differential effect on binding to different collagen ligands. For example, adhesion to immobilized collagens I, III, and IV was significantly reduced in the R59A, E61A, R65A, and E111A mutants,
15 although the magnitude of the effect depended on the type of collagen tested. In addition, adhesion was somewhat reduced for mutants R62A and N69A. In some embodiments, the variant is mutated at one or more of R59, E61, R62, E63, R65, S66, Y68, N69, I102, R100, W109, E111, Q112, and Y115 relative to SEQ ID NO:1. In some embodiments, the variant is mutated at one or more of
20 R59, E61, R65, E111, R62A, and N69A. In particular embodiments, the mutation(s) is substitution with an alanine.

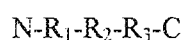
Finally, variant polypeptides can be engineered to have an increased half-life relative to wildtype. These variants typically are modified to resist enzymatic degradation. Exemplary modifications include modified amino acid
25 residues and modified peptide bonds that resist enzymatic degradation. Various modifications to achieve this are known in the art. The variants can be modified to adjust for effects of affinity for the receptor on the half-life of proteins, polypeptides, fragments, or fusions thereof at serum and endosomal pH.

iii. Fusion Proteins

30 Fusion polypeptides have a first fusion partner comprising all or a part of a polypeptide LAIR-1 or Liar-2 fused to a second polypeptide directly or via a

linker peptide sequence that is fused to the second polypeptide. The fusion proteins optionally contain a domain that functions to dimerize or multimerize two or more fusion proteins. The peptide/polypeptide linker domain can either be a separate domain, or alternatively can be contained within one of the other domains (first polypeptide or second polypeptide) of the fusion protein. Similarly, the domain that functions to dimerize or multimerize the fusion proteins can either be a separate domain, or alternatively can be contained within one of the other domains (first polypeptide, second polypeptide or peptide/polypeptide linker domain) of the fusion protein. In one embodiment, the dimerization/multimerization domain and the peptide/polypeptide linker domain are the same.

Fusion proteins disclosed herein are of formula I:



wherein "N" represents the N-terminus of the fusion protein, "C" represents the C-terminus of the fusion protein. In some embodiments, "R₁" is a polypeptide or protein of LAIR-1 or Liar-2, or fragment or variant thereof, "R₂" is an optional peptide/polypeptide linker domain, and "R₃" is a second polypeptide. Alternatively, R₃ may be a polypeptide or protein of LAIR-1 or Liar-2, or fragment or variant thereof and R₁ may be a second polypeptide. In some embodiments, the LAIR-1 or Liar-2 polypeptide is the extracellular domain or a fragment thereof such as the Ig-like C2-domain, or the region framed by the cysteines that form a disulfide bond as discussed above.

Dimerization or multimerization can occur between or among two or more fusion proteins through dimerization or multimerization domains. Alternatively, dimerization or multimerization of fusion proteins can occur by chemical crosslinking. The dimers or multimers that are formed can be homodimeric/homomultimeric or heterodimeric/heteromultimeric.

In some embodiments, the fusion protein includes the extracellular domain of LAIR-1 or LAIR-2, or a fragment or variant thereof, fused to an Ig Fc region. Recombinant Ig fusion proteins can be prepared by fusing the coding region of the extracellular domain of an extracellular domain or a fragment or

variant thereof to the Fc region of human IgG1, IgG2, IgG3 or IgG4 or mouse IgG2a, or other suitable Ig domain, as described previously (Chapoval, et al., *Methods Mol. Med.*, 45:247-255 (2000)).

iv. Exemplary Fusion Proteins

Exemplary fusion proteins are provided below. The signal sequence is indicated by double underlining, the LAIR-1 or LAIR-2 extracellular domain by single underlining, and the Ig domain by italics. The signal sequence is typically removed in the mature protein. Additionally, signal peptides from other polypeptides or organisms can be used (e.g., substituted) to enhance the secretion of the fusion protein from a host during manufacture.

hLAIR1.hG1

In some embodiments, a human LAIR1-hIg fusion protein (hIgG1) (hLAIR1.hG1) has at least 80%, 85%, 90%, 95%, 99%, or 100% sequence identity to the amino acid sequence:

MEWSWVFLFFLSVTTGVHSQEEDLPRPSISAEPGTVIPLGSHVTFVCRGPFVGVQTFRLERESRSTYNDTED
VSQASPSSESEARFRIDSVSEGNAGPYRCIYYKPPKWSEQSDYLELLVKETSGGPDSPDTEPGSSAGPTQRP
SDNSHNEHAPASQGLKAEHDKHTTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPE
VKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQRP
REPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDK
SRWQQGNVFSCSVMHEALHNHYTQKSLSLSPG (SEQ ID NO: 9), with or without the signal
sequence.

SEQ ID NO:9 without the signal sequence is

QEEDLPRPSISAEPGTVIPLGSHVTFVCRGPFVGVQTFRLERESRSTYNDTEDVSQASPSSESEARFRIDSVS
EGNAGPYRCIYYKPPKWSEQSDYLELLVKETSGGPDSPDTEPGSSAGPTQRPSDNSHNEHAPASQGLKAEH
DKHTTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKP
REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALH
NHYTQKSLSLSPG (SEQ ID NO:10).

Human LAIR1-hIg (hIgG1) (hLAIR1.hG1) can be an antagonist for LAIR-1 signaling by serving as a decoy for LAIR-1 ligands, and can be utilized for the treatment of cancer or an infectious disease. hLAIR1.hG1 can also be a control for testing the activity of hLAIR2.hG1.

hLAIR1.mG2a

In some embodiments, human LAIR1-mIg fusion protein (mIgG2a) (hLAIR1.mG2a) has at least 80%, 85%, 90%, 95%, 99%, or 100% sequence identity to the amino acid sequence:

5 MEWSWVFLFFLSVTTGVHSQEEDLPRPSISAEPGTVIPLGSHVTFVCRGPVGVQTFRLERESRSTYNDTED
VSQASPSESEARFRIDSVSEGNAGPYRCIYYKPPKWSEQSDYLELLVKETSGGPDSPDTEPGSSAGPTQRP
SDNSHNEHAPASQGLKAEHEPRGPTIKPCPPCKCPAPNLLGGPSVFIFPPKIKDVLMLISLSPIVTCVVVDV
SEDDPDVQISWVFNNEVHTAQQTQTHREDYNSTLRVVSALPIQHQDWMGKEFKCKVNNKDLPAPIERTIS
KPKGSVRAPQVYVLPPEEEMTKQVTLTCMVTDFMPEDIYVEWTNNGKTELNYKNTPEVLDSGSGYFMY
KLRVEKKNWVERNSYSCSVVHEGLHNHHTTKSFSRTPG

10 (SEQ ID NO: 11), with or without the signal sequence.

SEQ ID NO:11 without the signal sequence is

QEEDLPRPSISAEPGTVIPLGSHVTFVCRGPVGVQTFRLERESRSTYNDTEDVSQASPSESEARFRIDSVS
EGNAGPYRCIYYKPPKWSEQSDYLELLVKETSGGPDSPDTEPGSSAGPTQRP
SDNSHNEHAPASQGLKAEHEPRGPTIKPCPPCKCPAPNLLGGPSVFIFPPKIKDVLMLISLSPIVTCVVVDV
SEDDPDVQISWVFNNEVHTAQQTQTHREDYNSTLRVVSALPIQHQDWMGKEFKCKVNNKDLPAPIERTIS
KPKGSVRAPQVYVLPPEEEMTKQVTLTCMVTDFMPEDIYVEWTNNGKTELNYKNTPEVLDSGSGYFMY
KLRVEKKNWVERNSYSCSVVHEGLHNHHTTKSFSRTPG

15

(SEQ ID NO:12).

In some embodiments, human LAIR1-mIg fusion protein (mIgG2a) (hLAIR1.mG2a) is used to generate anti-hLAIR1 antibodies. The antibodies can be, for example, LAIR-1 antagonist antibodies (e.g., mAb, or fragments thereof), which can be used for the treatment of cancer, or LAIR-1 agonist antibodies (e.g., mAb, or fragments thereof), which can be used for the treatment of autoimmune diseases.

25 **mLAIR1.mG2a**

In some embodiments, mouse LAIR1-mIg fusion protein (mLAIR1.mG2a) has at least 80%, 85%, 90%, 95%, 99%, or 100% sequence identity to the amino acid sequence:

30 MEWSWVFLFFLSVTTGVHSQEGSLPDITIFPNSSLMISQGTFTVVCSYSKHDLYNMVRLKDGSTFMEK
STEPYKTEDEFEIGPVNETITGHYSCIYSKGITWSEKSKTLELKVIKENVIQTPAPGPTSDTSLWKTYSIY
EPRGPTIKPCPPCKCPAPNLLGGPSVFIFPPKIKDVLMLISLSPIVTCVVVDVSEDDPDVQISWVFNNEVHT
TAQTQTHREDYNSTLRVVSALPIQHQDWMGKEFKCKVNNKDLPAPIERTISKPKGSVRAPQVYVLPPEE
EMTKQVTLTCMVTDFMPEDIYVEWTNNGKTELNYKNTPEVLDSGSGYFMYKLRVEKKNWVERNSYSCSV
VHEGLHNHHTTKSFSRTPG (SEQ ID NO: 13), with or without the signal sequence.

35 SEQ ID NO:13 without the signal sequence is

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QEGSLPDITIFFNSSLMISQGTFTVTVVCSYSDKHDLYNMVRLEKDGSTFMEKSTEPYKTEDEFEIGPVNET
 ITGHYSCIYSKGITWSERSKTLELKVIKENVIQTPAPGPTSDTSWLKTYSIYEPRGPTIKPCPPCKCPAPN
 LLGGPSVFIFFPKIKDVLMISSLPIVTCVVVDVSEDDPDVQISWVNNVEVHTAQQTQTHREDYNSTLRVVS
 ALPIQHQQDWMMSGKEFKCKVNNKDLPAPIERTISKPKGSVRAPQVYVLPPEEEMTKKQVTLTCMVTDPMPE
 5 DIYVEWTNNGKTELNYKNTEPVLDSDGSYFMYSKLRVEKKNWVERNSYSCSVVHEGLHHHTTKSFSRTPG
 (SEQ ID NO:14).

In some embodiments, mouse LAIR1-mIg fusion protein is the mouse
 analog used for *in vivo* studies in a mouse model.

hLAIR2.hG1

In some embodiments, human LAIR2-hIg fusion protein (hIgG1) (hLAIR2.hG1) has at least 80%, 85%, 90%, 95%, 99%, or 100% sequence identity to the amino acid sequence:

5 MEWSWVFLFFLSVTTGVHSOEGALPRPSISAEPGTVISPGSHVTFMCRGPFVGVQTFRLEREDRAKYKDSYN
VFRLGPSESEARFHIDSVSEGNAGLYRCLYYKPPGWSEHSDFLELLVKESSGGPDSPDTEPGSSAGTVPGT
EASGFDAPDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVE
VHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS
RDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFC
10 SVMHEALHNHYTQKSLSLSPG

(SEQ ID NO: 15), with or without the signal sequence.

SEQ ID NO:15 without the signal sequence is

QEGALPRPSISAEPGTVISPGSHVTFMCRGPFVGVQTFRLEREDRAKYKDSYNVFRLGPSESEARFHIDSVS
EGNAGLYRCLYYKPPGWSEHSDFLELLVKESSGGPDSPDTEPGSSAGTVPGTEASGFDAPDKTHTCPPCPA
15 PELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRV
VSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFY
PSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFC
SVMHEALHNHYTQKSLSL
PG

(SEQ ID NO:16).

20 Human LAIR2-hIg fusion protein (hIgG1) (hLAIR2.hG1) can be an antagonist for Liar-1 signaling by serving as a decoy for LAIR-1 ligands, and can be utilized for the treatment of cancer or an infectious disease.

LAIR2.mIg

In some embodiments, human LAIR2.mIg fusion protein (mIgG2a) has
25 at least 80%, 85%, 90%, 95%, 99%, or 100% sequence identity to the amino acid sequence:

MEWSWVFLFFLSVTTGVHSOEGALPRPSISAEPGTVISPGSHVTFMCRGPFVGVQTFRLEREDRAKYKDSYN
VFRLGPSESEARFHIDSVSEGNAGLYRCLYYKPPGWSEHSDFLELLVKESSGGPDSPDTEPGSSAGTVPGT
EASGFDAPEPRGPTIKPCPPCKCPAPNLLGGPSVFIFPPKIKDVLMISLSPIVTCVVVDVSEDDPDVQISW
30 EVNNVEVHTAQTQTHREDYNSTLRVVSALPIQHQQDWMSGKEFKCKVNNKDLPAPIERTISKPKGSVRAPQV
YVLPPEEEMTKQVTLTCMVTDEMPEDIYVEWTNNGKTELNKNTEPVLDSDGSYFMYSKLAVEKKNWVE
RNSYSCSVVHEGLHNHHTTKSFSRTPG

(SEQ ID NO: 17), with or without the signal sequence.

SEQ ID NO:17 without the signal sequence is

QEGALPRPSISAEPGTVISPGSHVTFCRGPVGVQTFRLEREDRAKYKDSYNVFRLGPFSESEARFHDVS
EGNAGLYRCLYKPPGWSEHSDFLELLVKESGGPDSPDTEPGSSAGTVPGTEASGFDAP EPRGPTIKPCP
PKCPCAPNLLGGPSVFIFFPKIKDVLMSISPIVTCVVVDVSEDDPDVQISWVFNVEVHTAQTQTHREDY
5 NSTLRVVSALPIQHQDWMSGKEFKCKVNNKDLPAPIERTISKPKGSVRAPQVYVLPPEEEMTKKQVTLTC
MVTDFMPEDIYVEWTNNGKTELNYKNTEFVLDSGGSYFMYSKLRVEKKNWVERNSYSCSVVHEGLHHHTT
KSFSTRTPG

(SEQ ID NO:18).

Human LAIR2.mIg fusion protein (mIgG2a) can be used to generate
10 antagonistic anti-LAIR2 (e.g., mAb, or fragments thereof), which can be used
for the treatment of autoimmune diseases.

v. Polypeptide Modifications

The polypeptides and fusion proteins may be modified by chemical
moieties that may be present in polypeptides in a normal cellular environment,
15 for example, phosphorylation, methylation, amidation, sulfation, acylation,
glycosylation, sumoylation and ubiquitylation. Fusion proteins may also be
modified with a label capable of providing a detectable signal, either directly or
indirectly, including, but not limited to, radioisotopes and fluorescent
compounds.

20 The polypeptides and fusion proteins may also be modified by chemical
moieties that are not normally added to polypeptides in a cellular environment.
For example, the disclosed fusion proteins may also be modified by covalent
attachment of polymer chains, including, but not limited to, polyethylene glycol
polymer (PEG) chains (*i.e.*, pegylation). Conjugation of macromolecules to
25 PEG has emerged recently as an effective strategy to alter the pharmacokinetic
(PK) profiles of a variety of drugs, and thereby to improve their therapeutic
potential. PEG conjugation increases retention of drugs in the circulation by
protecting against enzymatic digestion, slowing filtration by the kidneys and
reducing the generation of neutralizing antibodies. In addition, PEG conjugates
30 can be used to allow multimerization of the fusion proteins.

Modifications may be introduced into the molecule by reacting targeted
amino acid residues of the polypeptide with an organic derivatizing agent that is

capable of reacting with selected side chains or terminal residues. Another modification is cyclization of the protein.

Examples of chemical derivatives of the polypeptides include lysinyl and amino terminal residues derivatized with succinic or other carboxylic acid anhydrides. Derivatization with a cyclic carboxylic anhydride has the effect of reversing the charge of the lysinyl residues. Other suitable reagents for derivatizing amino-containing residues include imidoesters such as methyl picolinimide; pyridoxal phosphate; pyridoxal; chloroborohydride; trinitrobenzenesulfonic acid; *O*-methylisourea; 2,4 pentanedione; and transaminase-catalyzed reaction with glyoxylate. Carboxyl side groups, aspartyl or glutamyl, may be selectively modified by reaction with carbodiimides ($R-N=C=N-R'$) such as 1-cyclohexyl-3-(2-morpholinyl-(4-ethyl)carbodiimide or 1-ethyl-3-(4-azonia-4,4-dimethylpentyl) carbodiimide. Furthermore, aspartyl and glutamyl residues can be converted to asparaginyl and glutaminyl residues by reaction with ammonia. Fusion proteins may also include one or more D-amino acids that are substituted for one or more L-amino acids.

vi. Modified Binding Properties

Binding properties of the proteins, polypeptides, fragments, variants and fusions thereof are relevant to the dose and dose regimen to be administered. In one embodiment the disclosed the proteins, polypeptides, fragments, variants and fusions thereof have binding properties to a LAIR-1 ligand that demonstrate a higher term, or higher percentage, of occupancy of a binding site (e.g., on the ligand) relative to other receptor molecules that bind thereto. In other embodiments, the disclosed proteins, polypeptides, fragments, variants and fusions thereof have reduced binding affinity to a LAIR-1 ligand relative to wildtype protein.

In some embodiments the proteins, polypeptides, fragments, variants and fusions thereof have a relatively high affinity for LAIR-1 ligand, and may therefore have a relatively slow off rate. In other embodiments, the proteins polypeptides, fragments, variants and fusions thereof are administered intermittently over a period of days, weeks or months to dampen immune

responses which are allowed to recover prior to the next administration, which may serve to alter the immune response without completely turning the immune response on or off and may avoid long term side effects.

3. Isolated Nucleic Acid Molecules

5 Isolated nucleic acid sequences encoding the proteins, polypeptides, fragments, variants and fusions thereof are disclosed herein. As used herein, “isolated nucleic acid” refers to a nucleic acid that is separated from other nucleic acid molecules that are present in a mammalian genome, including nucleic acids that normally flank one or both sides of the nucleic acid in a
10 mammalian genome. The term “isolated” as used herein with respect to nucleic acids also includes the combination with any non-naturally-occurring nucleic acid sequence, since such non-naturally-occurring sequences are not found in nature and do not have immediately contiguous sequences in a naturally-occurring genome.

15 An isolated nucleic acid can be, for example, a DNA molecule, provided one of the nucleic acid sequences normally found immediately flanking that DNA molecule in a naturally-occurring genome is removed or absent. Thus, an isolated nucleic acid includes, without limitation, a DNA molecule that exists as a separate molecule independent of other sequences (*e.g.*, a chemically
20 synthesized nucleic acid, or a cDNA or genomic DNA fragment produced by PCR or restriction endonuclease treatment), as well as recombinant DNA that is incorporated into a vector, an autonomously replicating plasmid, a virus (*e.g.*, a retrovirus, lentivirus, adenovirus, or herpes virus), or into the genomic DNA of a prokaryote or eukaryote. In addition, an isolated nucleic acid can include an
25 engineered nucleic acid such as a recombinant DNA molecule that is part of a hybrid or fusion nucleic acid. A nucleic acid existing among hundreds to millions of other nucleic acids within, for example, a cDNA library or a genomic library, or a gel slice containing a genomic DNA restriction digest, is not to be considered an isolated nucleic acid.

30 Nucleic acids encoding the proteins, polypeptides, fragments, variants and fusions thereof may be optimized for expression in the expression host of

choice. Codons may be substituted with alternative codons encoding the same amino acid to account for differences in codon usage between the mammal from which the nucleic acid sequence is derived and the expression host. In this manner, the nucleic acids may be synthesized using expression host-preferred
5 codons.

Nucleic acids can be in sense or antisense orientation, or can be complementary to a reference sequence encoding a polypeptide or protein of LAIR-1 or LAIR-2. Nucleic acids can be DNA, RNA, or nucleic acid analogs. Nucleic acid analogs can be modified at the base moiety, sugar moiety, or
10 phosphate backbone. Such modification can improve, for example, stability, hybridization, or solubility of the nucleic acid. Modifications at the base moiety can include deoxyuridine for deoxythymidine, and 5-methyl-2'-deoxycytidine or 5-bromo-2'-deoxycytidine for deoxycytidine. Modifications of the sugar moiety can include modification of the 2' hydroxyl of the ribose sugar to form 2'-O-
15 methyl or 2'-O-allyl sugars. The deoxyribose phosphate backbone can be modified to produce morpholino nucleic acids, in which each base moiety is linked to a six membered, morpholino ring, or peptide nucleic acids, in which the deoxyphosphate backbone is replaced by a pseudopeptide backbone and the four bases are retained. *See, for example, Summerton and Weller (1997)*
20 *Antisense Nucleic Acid Drug Dev.* 7:187-195; and Hyrup *et al.* (1996) *Bioorgan. Med. Chem.* 4:5-23. In addition, the deoxyphosphate backbone can be replaced with, for example, a phosphorothioate or phosphorodithioate backbone, a phosphoroamidite, or an alkyl phosphotriester backbone.

Nucleic acids encoding polypeptides can be administered to subjects in
25 need thereof. Nucleic delivery involves introduction of "foreign" nucleic acids into a cell and ultimately, into a live animal. Compositions and methods for delivering nucleic acids to a subject are known in the art (*see Understanding Gene Therapy*, Lemoine, N.R., ed., BIOS Scientific Publishers, Oxford, 2008).

4. Vectors and Host Cells

30 Vectors encoding the proteins, polypeptides, fragments, variants and fusions thereof are also provided. Nucleic acids, such as those described above,

can be inserted into vectors for expression in cells. As used herein, a “vector” is a replicon, such as a plasmid, phage, virus or cosmid, into which another DNA segment may be inserted so as to bring about the replication of the inserted segment. Vectors can be expression vectors. An “expression vector” is a vector
5 that includes one or more expression control sequences, and an “expression control sequence” is a DNA sequence that controls and regulates the transcription and/or translation of another DNA sequence.

Nucleic acids in vectors can be operably linked to one or more expression control sequences. As used herein, “operably linked” means
10 incorporated into a genetic construct so that expression control sequences effectively control expression of a coding sequence of interest. Examples of expression control sequences include promoters, enhancers, and transcription terminating regions. A promoter is an expression control sequence composed of a region of a DNA molecule, typically within 100 nucleotides upstream of the
15 point at which transcription starts (generally near the initiation site for RNA polymerase II). To bring a coding sequence under the control of a promoter, it is necessary to position the translation initiation site of the translational reading frame of the polypeptide between one and about fifty nucleotides downstream of the promoter. Enhancers provide expression specificity in terms of time,
20 location, and level. Unlike promoters, enhancers can function when located at various distances from the transcription site. An enhancer also can be located downstream from the transcription initiation site. A coding sequence is “operably linked” and “under the control” of expression control sequences in a cell when RNA polymerase is able to transcribe the coding sequence into
25 mRNA, which then can be translated into the protein encoded by the coding sequence.

Suitable expression vectors include, without limitation, plasmids and viral vectors derived from, for example, bacteriophage, baculoviruses, tobacco mosaic virus, herpes viruses, cytomegalo virus, retroviruses, vaccinia viruses,
30 adenoviruses, and adeno-associated viruses. Numerous vectors and expression systems are commercially available from such corporations as Novagen

(Madison, WI), Clontech (Palo Alto, CA), Stratagene (La Jolla, CA), and Invitrogen Life Technologies (Carlsbad, CA).

An expression vector can include a tag sequence. Tag sequences, are typically expressed as a fusion with the encoded polypeptide. Such tags can be
5 inserted anywhere within the polypeptide including at either the carboxyl or amino terminus. Examples of useful tags include, but are not limited to, green fluorescent protein (GFP), glutathione S-transferase (GST), polyhistidine, c-myc, hemagglutinin, Flag™ tag (Kodak, New Haven, CT), maltose E binding protein and protein A. In one embodiment, a nucleic acid molecule encoding
10 one of the disclosed polypeptides is present in a vector containing nucleic acids that encode one or more domains of an Ig heavy chain constant region, for example, having an amino acid sequence corresponding to the hinge, C_H2 and C_H3 regions of a human immunoglobulin C_γ1 chain.

Vectors containing nucleic acids to be expressed can be transferred into
15 host cells. The term “host cell” is intended to include prokaryotic and eukaryotic cells into which a recombinant expression vector can be introduced. As used herein, “transformed” and “transfected” encompass the introduction of a nucleic acid molecule (*e.g.*, a vector) into a cell by one of a number of techniques. Although not limited to a particular technique, a number of these
20 techniques are well established within the art. Prokaryotic cells can be transformed with nucleic acids by, for example, electroporation or calcium chloride mediated transformation. Nucleic acids can be transfected into mammalian cells by techniques including, for example, calcium phosphate co-precipitation, DEAE-dextran-mediated transfection, lipofection, electroporation,
25 or microinjection. Host cells (*e.g.*, a prokaryotic cell or a eukaryotic cell such as a CHO cell) can be used to, for example, produce the proteins, polypeptides, fragments, variants and fusions thereof described herein.

The vectors described can be used to express the proteins, polypeptides, fragments, variants and fusions thereof in cells. An exemplary vector includes,
30 but is not limited to, an adenoviral vector. One approach includes nucleic acid transfer into primary cells in culture followed by autologous transplantation of

the *ex vivo* transformed cells into the host, either systemically or into a particular organ or tissue. *Ex vivo* methods can include, for example, the steps of harvesting cells from a subject, culturing the cells, transducing them with an expression vector, and maintaining the cells under conditions suitable for
5 expression of the encoded polypeptides. These methods are known in the art of molecular biology. The transduction step can be accomplished by any standard means used for *ex vivo* gene therapy, including, for example, calcium phosphate, lipofection, electroporation, viral infection, and biolistic gene transfer. Alternatively, liposomes or polymeric microparticles can be used. Cells that
10 have been successfully transduced then can be selected, for example, for expression of the coding sequence or of a drug resistance gene. The cells then can be lethally irradiated (if desired) and injected or implanted into the subject. In one embodiment, expression vectors containing nucleic acids encoding fusion proteins are transfected into cells that are administered to a subject in need
15 thereof.

In vivo nucleic acid therapy can be accomplished by direct transfer of a functionally active DNA into mammalian somatic tissue or organ *in vivo*. For example, nucleic acids encoding polypeptides disclosed herein can be administered directly to lymphoid tissues. Alternatively, lymphoid tissue
20 specific targeting can be achieved using lymphoid tissue-specific transcriptional regulatory elements (TREs) such as a B lymphocyte-, T lymphocyte-, or dendritic cell-specific TRE. Lymphoid tissue specific TREs are known in the art.

Nucleic acids may also be administered *in vivo* by viral means. Nucleic
25 acid molecules encoding fusion proteins may be packaged into retrovirus vectors using packaging cell lines that produce replication-defective retroviruses, as is well-known in the art. Other virus vectors may also be used, including recombinant adenoviruses and vaccinia virus, which can be rendered non-replicating. In addition to naked DNA or RNA, or viral vectors, engineered
30 bacteria may be used as vectors.

Nucleic acids may also be delivered by other carriers, including liposomes, polymeric micro- and nanoparticles and polycations such as asialoglycoprotein/polylysine.

In addition to virus- and carrier-mediated gene transfer *in vivo*, physical means well-known in the art can be used for direct transfer of DNA, including administration of plasmid DNA and particle-bombardment mediated gene transfer.

One embodiment provides a cell constitutively- or inducibly-expressing an antibody or antigen binding fragment thereof that specifically binds to LAIR-1, wherein the cell has a nucleic acid or nucleic acids encoding an amino acid sequence according to SEQ ID NOs: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, 115, 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, 111, or a combination thereof.

5. Small Molecules

The immunomodulatory agent can be a small molecule. Small molecules agonists and antagonists LAIR-1 and antagonists of LAIR-2 are known in the art or can be identified using routine screening methods.

In some embodiments, screening assays can include random screening of large libraries of test compounds. Alternatively, the assays may be used to focus on particular classes of compounds suspected of modulating the level of LAIR-1 or LAIR-2. Assays can include determinations of LAIR-1 signaling activity, or inhibitory response mediated LAIR-1. Other assays can include determinations of nucleic acid transcription or translation, mRNA levels, mRNA stability, mRNA degradation, transcription rates, and translation rates.

25 C. Pharmaceutical Compositions

Pharmaceutical compositions including the disclosed immunomodulatory agents are provided. Pharmaceutical compositions containing the immunomodulatory agent can be for administration by parenteral (intramuscular, intraperitoneal, intravenous (IV) or subcutaneous injection), transdermal (either passively or using iontophoresis or electroporation), or transmucosal (nasal, vaginal, rectal, or sublingual) routes of administration or

using bioerodible inserts and can be formulated in dosage forms appropriate for each route of administration.

In some *in vivo* approaches, the compositions disclosed herein are administered to a subject in a therapeutically effective amount. As used herein
5 the term “effective amount” or “therapeutically effective amount” means a dosage sufficient to treat, inhibit, or alleviate one or more symptoms of the disorder being treated or to otherwise provide a desired pharmacologic and/or physiologic effect. The precise dosage will vary according to a variety of factors such as subject-dependent variables (*e.g.*, age, immune system health,
10 etc.), the disease, and the treatment being effected.

For the disclosed immunomodulatory agents, as further studies are conducted, information will emerge regarding appropriate dosage levels for treatment of various conditions in various patients, and the ordinary skilled worker, considering the therapeutic context, age, and general health of the
15 recipient, will be able to ascertain proper dosing. The selected dosage depends upon the desired therapeutic effect, on the route of administration, and on the duration of the treatment desired. For the disclosed immunomodulatory agents, generally dosage levels of 0.001 to 20 mg/kg of body weight daily are administered to mammals. Generally, for intravenous injection or infusion,
20 dosage may be lower.

In certain embodiments, the immunomodulatory agent is administered locally, for example by injection directly into a site to be treated. Typically, the injection causes an increased localized concentration of the immunomodulatory agent composition which is greater than that which can be achieved by systemic
25 administration. The immunomodulatory agent compositions can be combined with a matrix as described above to assist in creating an increased localized concentration of the polypeptide compositions by reducing the passive diffusion of the polypeptides out of the site to be treated.

1. Formulations for Parenteral Administration

30 In some embodiments, compositions disclosed herein, including those containing peptides and polypeptides, are administered in an aqueous solution,

by parenteral injection. The formulation may also be in the form of a suspension or emulsion. In general, pharmaceutical compositions are provided including effective amounts of a peptide or polypeptide, and optionally include pharmaceutically acceptable diluents, preservatives, solubilizers, emulsifiers, 5 adjuvants and/or carriers. Such compositions optionally include one or more for the following: diluents, sterile water, buffered saline of various buffer content (*e.g.*, Tris-HCl, acetate, phosphate), pH and ionic strength; and additives such as detergents and solubilizing agents (*e.g.*, TWEEN 20 (polysorbate-20), TWEEN 80 (polysorbate-80)), anti-oxidants (*e.g.*, ascorbic acid, sodium metabisulfite), 10 and preservatives (*e.g.*, Thimersol, benzyl alcohol) and bulking substances (*e.g.*, lactose, mannitol). Examples of non-aqueous solvents or vehicles are propylene glycol, polyethylene glycol, vegetable oils, such as olive oil and corn oil, gelatin, and injectable organic esters such as ethyl oleate. The formulations may be lyophilized and redissolved/resuspended immediately before use. The 15 formulation may be sterilized by, for example, filtration through a bacteria retaining filter, by incorporating sterilizing agents into the compositions, by irradiating the compositions, or by heating the compositions.

2. Formulations for Oral Administration

In embodiments the compositions are formulated for oral delivery. Oral 20 solid dosage forms are described generally in Remington's Pharmaceutical Sciences, 18th Ed. 1990 (Mack Publishing Co. Easton Pa. 18042) at Chapter 89. Solid dosage forms include tablets, capsules, pills, troches or lozenges, cachets, pellets, powders, or granules or incorporation of the material into particulate preparations of polymeric compounds such as polylactic acid, polyglycolic acid, 25 etc. or into liposomes. Such compositions may influence the physical state, stability, rate of *in vivo* release, and rate of *in vivo* clearance of the disclosed. *See, e.g.*, Remington's Pharmaceutical Sciences, 18th Ed. (1990, Mack Publishing Co., Easton, Pa. 18042) pages 1435-1712 which are herein incorporated by reference. The compositions may be prepared in liquid form, or 30 may be in dried powder (*e.g.*, lyophilized) form. Liposomal or proteinoid encapsulation may be used to formulate the compositions. Liposomal

encapsulation may be used and the liposomes may be derivatized with various polymers (*e.g.*, U.S. Patent No. 5,013,556). See also Marshall, K. In: Modern Pharmaceutics Edited by G. S. Banker and C. T. Rhodes Chapter 10, 1979. In general, the formulation will include the peptide (or chemically modified forms thereof) and inert ingredients which protect peptide in the stomach environment, and release of the biologically active material in the intestine.

The agents can be chemically modified so that oral delivery of the derivative is efficacious. Generally, the chemical modification contemplated is the attachment of at least one moiety to the component molecule itself, where the moiety permits uptake into the blood stream from the stomach or intestine, or uptake directly into the intestinal mucosa. Also desired is the increase in overall stability of the component or components and increase in circulation time in the body. PEGylation is an exemplary chemical modification for pharmaceutical usage. Other moieties that may be used include: propylene glycol, copolymers of ethylene glycol and propylene glycol, carboxymethyl cellulose, dextran, polyvinyl alcohol, polyvinyl pyrrolidone, polyproline, poly-1,3-dioxolane and poly-1,3,6-tioxocane [*see, e.g.*, Abuchowski and Davis (1981) "Soluble Polymer-Enzyme Adducts," in Enzymes as Drugs. Hocenberg and Roberts, eds. (Wiley-Interscience: New York, N.Y.) pp. 367-383; and Newmark, et al. (1982) *J. Appl. Biochem.* 4:185-189].

Another embodiment provides liquid dosage forms for oral administration, including pharmaceutically acceptable emulsions, solutions, suspensions, and syrups, which may contain other components including inert diluents; adjuvants such as wetting agents, emulsifying and suspending agents; and sweetening, flavoring, and perfuming agents.

Controlled release oral formulations may be desirable. The agent can be incorporated into an inert matrix which permits release by either diffusion or leaching mechanisms, *e.g.*, gums. Slowly degenerating matrices may also be incorporated into the formulation. Another form of a controlled release is based on the Oros therapeutic system (Alza Corp.), *i.e.*, the drug is enclosed in a

semipermeable membrane which allows water to enter and push drug out through a single small opening due to osmotic effects.

For oral formulations, the location of release may be the stomach, the small intestine (the duodenum, the jejunum, or the ileum), or the large intestine.

5 In some embodiments, the release will avoid the deleterious effects of the stomach environment, either by protection of the agent (or derivative) or by release of the agent (or derivative) beyond the stomach environment, such as in the intestine. To ensure full gastric resistance a coating impermeable to at least pH 5.0 is essential. Examples of the more common inert ingredients that are
10 used as enteric coatings are cellulose acetate trimellitate (CAT), hydroxypropylmethylcellulose phthalate (HPMCP), HPMCP 50, HPMCP 55, polyvinyl acetate phthalate (PVAP), Eudragit L30D™, Aquateric™, cellulose acetate phthalate (CAP), Eudragit L™, Eudragit S™, and Shellac™. These coatings may be used as mixed films.

15 3. Formulations for Topical Administration

The disclosed immunomodulatory agents can be applied topically. Topical administration does not work well for most peptide formulations, although it can be effective especially if applied to the lungs, nasal, oral (sublingual, buccal), vaginal, or rectal mucosa.

20 Compositions can be delivered to the lungs while inhaling and traverse across the lung epithelial lining to the blood stream when delivered either as an aerosol or spray dried particles having an aerodynamic diameter of less than about 5 microns.

A wide range of mechanical devices designed for pulmonary delivery of
25 therapeutic products can be used, including but not limited to nebulizers, metered dose inhalers, and powder inhalers, all of which are familiar to those skilled in the art. Some specific examples of commercially available devices are the Ultravent nebulizer (Mallinckrodt Inc., St. Louis, Mo.); the Acorn II nebulizer (Marquest Medical Products, Englewood, Colo.); the Ventolin
30 metered dose inhaler (Glaxo Inc., Research Triangle Park, N.C.); and the Spinhaler powder inhaler (Fisons Corp., Bedford, Mass.). Nektar, Alkermes and

Mankind all have inhalable insulin powder preparations approved or in clinical trials where the technology could be applied to the formulations described herein.

Formulations for administration to the mucosa will typically be spray
5 dried drug particles, which may be incorporated into a tablet, gel, capsule, suspension or emulsion. Standard pharmaceutical excipients are available from any formulator.

Transdermal formulations may also be prepared. These will typically be ointments, lotions, sprays, or patches, all of which can be prepared using
10 standard technology. Transdermal formulations may require the inclusion of penetration enhancers.

4. Controlled Delivery Polymeric Matrices

The immunomodulatory agents disclosed herein can also be administered in controlled release formulations. Controlled release polymeric devices can be
15 made for long term release systemically following implantation of a polymeric device (rod, cylinder, film, disk) or injection (microparticles). The matrix can be in the form of microparticles such as microspheres, where the agent is dispersed within a solid polymeric matrix or microcapsules, where the core is of a different material than the polymeric shell, and the peptide is dispersed or
20 suspended in the core, which may be liquid or solid in nature. Unless specifically defined herein, microparticles, microspheres, and microcapsules are used interchangeably. Alternatively, the polymer may be cast as a thin slab or film, ranging from nanometers to four centimeters, a powder produced by grinding or other standard techniques, or even a gel such as a hydrogel.

25 Either non-biodegradable or biodegradable matrices can be used for delivery of fusion polypeptides or nucleic acids encoding the fusion polypeptides, although in some embodiments biodegradable matrices are preferred. These may be natural or synthetic polymers, although synthetic polymers are preferred in some embodiments due to the better characterization
30 of degradation and release profiles. The polymer is selected based on the period over which release is desired. In some cases linear release may be most useful,

although in others a pulse release or “bulk release” may provide more effective results. The polymer may be in the form of a hydrogel (typically in absorbing up to about 90% by weight of water), and can optionally be crosslinked with multivalent ions or polymers.

5 The matrices can be formed by solvent evaporation, spray drying, solvent extraction and other methods known to those skilled in the art. Bioerodible microspheres can be prepared using any of the methods developed for making microspheres for drug delivery, for example, as described by Mathiowitz and Langer, *J. Controlled Release*, 5:13-22 (1987); Mathiowitz, et
10 al., *Reactive Polymers*, 6:275-283 (1987); and Mathiowitz, et al., *J. Appl. Polymer Sci.*, 35:755-774 (1988).

The devices can be formulated for local release to treat the area of implantation or injection – which will typically deliver a dosage that is much less than the dosage for treatment of an entire body – or systemic delivery.

15 These can be implanted or injected subcutaneously, into the muscle, fat, or swallowed.

III. Methods of Manufacture

A. Methods of Making Antibodies

The antibodies can be generated in cell culture, in phage, or in various
20 animals, including but not limited to cows, rabbits, goats, mice, rats, hamsters, guinea pigs, sheep, dogs, cats, monkeys, chimpanzees, apes. Therefore, in one embodiment, an antibody is a mammalian antibody. Phage techniques can be used to isolate an initial antibody or to generate variants with altered specificity or avidity characteristics. Such techniques are routine and well known in the art.
25 In one embodiment, the antibody is produced by recombinant means known in the art. For example, a recombinant antibody can be produced by transfecting a host cell with a vector comprising a DNA sequence encoding the antibody. One or more vectors can be used to transfect the DNA sequence expressing at least one VL and one VH region in the host cell. Exemplary descriptions of
30 recombinant means of antibody generation and production include Delves, Antibody Production: Essential Techniques (Wiley, 1997); Shephard, et al.,

Monoclonal Antibodies (Oxford University Press, 2000); Goding, Monoclonal Antibodies: Principles And Practice (Academic Press, 1993); Current Protocols In Immunology (John Wiley & Sons, most recent edition).

The disclosed antibodies can be modified by recombinant means to increase greater efficacy of the antibody in mediating the desired function. Thus, it is within the scope of the invention that antibodies can be modified by substitutions using recombinant means. Typically, the substitutions will be conservative substitutions. For example, at least one amino acid in the constant region of the antibody can be replaced with a different residue. *See, e.g.*, U.S. Pat. No. 5,624,821, U.S. Pat. No. 6,194,551, Application No. WO 9958572; and Angal, et al., *Mol. Immunol.* 30:105-08 (1993). The modification in amino acids includes deletions, additions, and substitutions of amino acids. In some cases, such changes are made to reduce undesired activities, *e.g.*, complement-dependent cytotoxicity. Frequently, the antibodies are labeled by joining, either covalently or non-covalently, a substance which provides for a detectable signal. A wide variety of labels and conjugation techniques are known and are reported extensively in both the scientific and patent literature. These antibodies can be screened for binding to proteins, polypeptides, or fusion proteins of LAIR-1 or LAIR-2. *See, e.g.*, Antibody Engineering: A Practical Approach (Oxford University Press, 1996).

For example, suitable antibodies with the desired biologic activities can be identified using *in vitro* assays including but not limited to: proliferation, migration, adhesion, soft agar growth, angiogenesis, cell-cell communication, apoptosis, transport, signal transduction, and *in vivo* assays such as the inhibition of tumor growth. The antibodies provided herein can also be useful in diagnostic applications. As capture or non-neutralizing antibodies, they can be screened for the ability to bind to the specific antigen without inhibiting the receptor-binding or biological activity of the antigen. As neutralizing antibodies, the antibodies can be useful in competitive binding assays.

Antibodies that can be used in the disclosed compositions and methods include whole immunoglobulin (*i.e.*, an intact antibody) of any class, fragments

thereof, and synthetic proteins containing at least the antigen binding variable domain of an antibody. The variable domains differ in sequence among antibodies and are used in the binding and specificity of each particular antibody for its particular antigen. However, the variability is not usually evenly
5 distributed through the variable domains of antibodies. It is typically concentrated in three segments called complementarity determining regions (CDRs) or hypervariable regions both in the light chain and the heavy chain variable domains. The more highly conserved portions of the variable domains are called the framework (FR). The variable domains of native heavy and light
10 chains each comprise four FR regions, largely adopting a beta-sheet configuration, connected by three CDRs, which form loops connecting, and in some cases forming part of, the beta-sheet structure. The CDRs in each chain are held together in close proximity by the FR regions and, with the CDRs from the other chain, contribute to the formation of the antigen binding site of
15 antibodies.

Also disclosed are fragments of antibodies which have bioactivity. The fragments, whether attached to other sequences or not, include insertions, deletions, substitutions, or other selected modifications of particular regions or specific amino acids residues, provided the activity of the fragment is not
20 significantly altered or impaired compared to the nonmodified antibody or antibody fragment.

Techniques can also be adapted for the production of single-chain antibodies specific to an antigenic peptide. Methods for the production of single-chain antibodies are well known to those of skill in the art. A single chain
25 antibody can be created by fusing together the variable domains of the heavy and light chains using a short peptide linker, thereby reconstituting an antigen binding site on a single molecule. Single-chain antibody variable fragments (scFvs) in which the C-terminus of one variable domain is tethered to the N-terminus of the other variable domain via a 15 to 25 amino acid peptide or linker
30 have been developed without significantly disrupting antigen binding or

specificity of the binding. The linker is chosen to permit the heavy chain and light chain to bind together in their proper conformational orientation.

Divalent single-chain variable fragments (di-scFvs) can be engineered by linking two scFvs. This can be done by producing a single peptide chain with two VH and two VL regions, yielding tandem scFvs. ScFvs can also be designed with linker peptides that are too short for the two variable regions to fold together (about five amino acids), forcing scFvs to dimerize. This type is known as diabodies. Diabodies have been shown to have dissociation constants up to 40-fold lower than corresponding scFvs, meaning that they have a much higher affinity to their target. Still shorter linkers (one or two amino acids) lead to the formation of trimers (triabodies or tribodies). Tetrabodies have also been produced. They exhibit an even higher affinity to their targets than diabodies.

A monoclonal antibody is obtained from a substantially homogeneous population of antibodies, *i.e.*, the individual antibodies within the population are identical except for possible naturally occurring mutations that may be present in a small subset of the antibody molecules. Monoclonal antibodies include “chimeric” antibodies in which a portion of the heavy and/or light chain is identical with or homologous to corresponding sequences in antibodies derived from a particular species or belonging to a particular antibody class or subclass, while the remainder of the chain(s) is identical with or homologous to corresponding sequences in antibodies derived from another species or belonging to another antibody class or subclass, as well as fragments of such antibodies, as long as they exhibit the desired antagonistic activity.

Monoclonal antibodies can be made using any procedure which produces monoclonal antibodies. In a hybridoma method, a mouse or other appropriate host animal is typically immunized with an immunizing agent to elicit lymphocytes that produce or are capable of producing antibodies that will specifically bind to the immunizing agent. Alternatively, the lymphocytes may be immunized *in vitro*.

Antibodies may also be made by recombinant DNA methods. DNA encoding the disclosed antibodies can be readily isolated and sequenced using

conventional procedures (*e.g.*, by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of murine antibodies). Libraries of antibodies or active antibody fragments can also be generated and screened using phage display techniques.

5 Methods of making antibodies using protein chemistry are also known in the art. One method of producing proteins comprising the antibodies is to link two or more peptides or polypeptides together by protein chemistry techniques. For example, peptides or polypeptides can be chemically synthesized using currently available laboratory equipment using either Fmoc (9-
10 fluorenylmethyloxycarbonyl) or Boc (tert -butyloxycarbonyl) chemistry. (Applied Biosystems, Inc., Foster City, CA). One skilled in the art can readily appreciate that a peptide or polypeptide corresponding to the antibody, for example, can be synthesized by standard chemical reactions. For example, a peptide or polypeptide can be synthesized and not cleaved from its synthesis
15 resin whereas the other fragment of an antibody can be synthesized and subsequently cleaved from the resin, thereby exposing a terminal group which is functionally blocked on the other fragment. By peptide condensation reactions, these two fragments can be covalently joined via a peptide bond at their carboxyl and amino termini, respectively, to form an antibody, or fragment
20 thereof. Alternatively, the peptide or polypeptide is independently synthesized *in vivo* as described above. Once isolated, these independent peptides or polypeptides may be linked to form an antibody or antigen binding fragment thereof via similar peptide condensation reactions.

 For example, enzymatic ligation of cloned or synthetic peptide segments
25 allow relatively short peptide fragments to be joined to produce larger peptide fragments, polypeptides or whole protein domains. Alternatively, native chemical ligation of synthetic peptides can be utilized to synthetically construct large peptides or polypeptides from shorter peptide fragments. This method consists of a two-step chemical reaction. The first step is the chemoselective
30 reaction of an unprotected synthetic peptide-alpha-thioester with another unprotected peptide segment containing an amino-terminal Cys residue to give a

thioester-linked intermediate as the initial covalent product. Without a change in the reaction conditions, this intermediate undergoes spontaneous, rapid intramolecular reaction to form a native peptide bond at the ligation site.

B. Methods for Producing Proteins

5 The disclosed proteins, polypeptides, fragments, variants and fusions thereof can be manufactured using conventional techniques that are known in the art. Isolated fusion proteins can be obtained by, for example, chemical synthesis or by recombinant production in a host cell. To recombinantly produce a protein, polypeptide, fragment, variant or fusion thereof, a nucleic acid containing a nucleotide sequence encoding the protein, polypeptide, 10 fragment, variant or fusion thereof can be used to transform, transduce, or transfect a bacterial or eukaryotic host cell (*e.g.*, an insect, yeast, or mammalian cell). In general, nucleic acid constructs include a regulatory sequence operably linked to a nucleotide sequence encoding the protein, polypeptide, fragment, 15 variant or fusion thereof. Regulatory sequences (also referred to herein as expression control sequences) typically do not encode a gene product, but instead affect the expression of the nucleic acid sequences to which they are operably linked.

Useful prokaryotic and eukaryotic systems for expressing and producing 20 polypeptides are well known in the art include, for example, *Escherichia coli* strains such as BL-21, and cultured mammalian cells such as CHO cells.

In eukaryotic host cells, a number of viral-based expression systems can be utilized to express fusion proteins. Viral based expression systems are well known in the art and include, but are not limited to, baculoviral, SV40, 25 retroviral, or vaccinia based viral vectors.

Mammalian cell lines that stably express proteins, polypeptides, fragments, variants or fusions thereof, can be produced using expression vectors with appropriate control elements and a selectable marker. For example, the eukaryotic expression vectors pCR3.1 (Invitrogen Life Technologies) and 30 p91023(B) (see Wong *et al.* (1985) *Science* 228:810-815) are suitable for expression of proteins, polypeptides, fragments, variants or fusions thereof, in,

for example, Chinese hamster ovary (CHO) cells, COS-1 cells, human embryonic kidney 293 cells, NIH3T3 cells, BHK21 cells, MDCK cells, and human vascular endothelial cells (HUVEC). Additional suitable expression systems include the GS Gene Expression System™ available through Lonza
5 Group Ltd.

Following introduction of an expression vector by electroporation, lipofection, calcium phosphate, or calcium chloride co-precipitation, DEAE dextran, or other suitable transfection method, stable cell lines can be selected (e.g., by metabolic selection, or antibiotic resistance to G418, kanamycin, or
10 hygromycin). The transfected cells can be cultured such that the polypeptide of interest is expressed, and the polypeptide can be recovered from, for example, the cell culture supernatant or from lysed cells. Alternatively, a protein, polypeptide, fragment, variant or fusion thereof, can be produced by (a) ligating amplified sequences into a mammalian expression vector such as pcDNA3
15 (Invitrogen Life Technologies), and (b) transcribing and translating *in vitro* using wheat germ extract or rabbit reticulocyte lysate.

Proteins, polypeptides, fragments, variants or fusions thereof, can be isolated using, for example, chromatographic methods such as affinity chromatography, ion exchange chromatography, hydrophobic interaction
20 chromatography, DEAE ion exchange, gel filtration, and hydroxylapatite chromatography. In some embodiments, Proteins, polypeptides, fragments, variants or fusions thereof can be engineered to contain an additional domain containing amino acid sequence that allows the polypeptides to be captured onto an affinity matrix. For example, an Fc-fusion polypeptide in a cell culture
25 supernatant or a cytoplasmic extract can be isolated using a protein A column. In addition, a tag such as c-myc, hemagglutinin, polyhistidine, or Flag™ (Kodak) can be used to aid polypeptide purification. Such tags can be inserted anywhere within the polypeptide, including at either the carboxyl or amino terminus. Other fusions that can be useful include enzymes that aid in the
30 detection of the polypeptide, such as alkaline phosphatase. Immunoaffinity chromatography also can be used to purify polypeptides. Fusion proteins can

additionally be engineered to contain a secretory signal (if there is not a secretory signal already present) that causes the Proteins, polypeptides, fragments, variants or fusions thereof to be secreted by the cells in which it is produced. The secreted Proteins, polypeptides, fragments, variants or fusions thereof can then conveniently be isolated from the cell media.

C. Methods for Producing Isolated Nucleic Acid Molecules

Isolated nucleic acid molecules can be produced by standard techniques, including, without limitation, common molecular cloning and chemical nucleic acid synthesis techniques. For example, polymerase chain reaction (PCR) techniques can be used to obtain an isolated nucleic acid encoding a variant polypeptide. PCR is a technique in which target nucleic acids are enzymatically amplified. Typically, sequence information from the ends of the region of interest or beyond can be employed to design oligonucleotide primers that are identical in sequence to opposite strands of the template to be amplified. PCR can be used to amplify specific sequences from DNA as well as RNA, including sequences from total genomic DNA or total cellular RNA. Primers typically are 14 to 40 nucleotides in length, but can range from 10 nucleotides to hundreds of nucleotides in length. General PCR techniques are described, for example in PCR Primer: A Laboratory Manual, ed. by Dieffenbach and Dveksler, Cold Spring Harbor Laboratory Press, 1995. When using RNA as a source of template, reverse transcriptase can be used to synthesize a complementary DNA (cDNA) strand. Ligase chain reaction, strand displacement amplification, self-sustained sequence replication or nucleic acid sequence-based amplification also can be used to obtain isolated nucleic acids. See, for example, Lewis (1992) *Genetic Engineering News* 12:1; Guatelli *et al.* (1990) *Proc. Natl. Acad. Sci. USA* 87:1874-1878; and Weiss (1991) *Science* 254:1292-1293.

Isolated nucleic acids can be chemically synthesized, either as a single nucleic acid molecule or as a series of oligonucleotides (*e.g.*, using phosphoramidite technology for automated DNA synthesis in the 3' to 5' direction). For example, one or more pairs of long oligonucleotides (*e.g.*, >100 nucleotides) can be synthesized that contain the desired sequence, with each pair

containing a short segment of complementarity (e.g., about 15 nucleotides) such that a duplex is formed when the oligonucleotide pair is annealed. DNA polymerase can be used to extend the oligonucleotides, resulting in a single, double-stranded nucleic acid molecule per oligonucleotide pair, which then can be ligated into a vector. Isolated nucleic acids can also be obtained by mutagenesis. Protein-encoding nucleic acids can be mutated using standard techniques, including oligonucleotide-directed mutagenesis and/or site-directed mutagenesis through PCR. *See, Short Protocols in Molecular Biology*, Chapter 8, Green Publishing Associates and John Wiley & Sons, edited by Ausubel *et al*, 1992.

IV. Assays and Antibody Screening

Production of LAIR-2 Fc fusion protein ("LAIR-2-Fc") for cancer therapy bypasses the need for development and screening of LAIR-1 mAbs. Because LAIR-2 has greater affinity than LAIR-1, in some embodiments, LAIR-2-Fc is selected as a therapeutic treatment over a LAIR-1 Fc fusion protein ("LAIR-1-Fc"). In some embodiments, LAIR-1-Fc may be utilized in mouse pre-clinical models because LAIR-2 does not exist in the mouse.

A. Assays for LAIR-2-Fc

1. Confirmation of the ability to bind multiple forms of collagen, SP-D, C1q and MBL by ELISA.
2. Confirmation of the ability of LAIR-2-Fc to inhibit binding of multiple collagens, SP-D and C1q to LAIR-1. This can be tested by: 1) ELISA competition assays, and 2) flow cytometry using LAIR-1 transfected cells incubated in the presence of titrated amounts of LAIR-2-Fc and fluorescently labeled LAIR ligands.
3. Analysis of binding affinity of LAIR-2-Fc to ligands in comparison to LAIR-1.
4. Functional assays to confirm LAIR-2-Fc prevents signaling by LAIR-1 expressing cells. Reporter cells may be utilized for these assays, or primary LAIR-1+ cells are another option.

B. Assays and antibody screening for LAIR-2 blocking mAbs

Because LAIR-2 is not present in mice, wild type mice can be utilized for the generation of high affinity mAbs against LAIR-2. Because LAIR-2 is soluble and binds to soluble ligands, screening of transfected cells is not an option for this molecule.

- 5 1. Phase I screening: mAb binding to LAIR-2, but not LAIR-1 by ELISA. These mAbs should be highly specific for LAIR-2.
2. Phase II screening: LAIR-2 specific mAbs must block the binding of LAIR-2 to multiple collagens, SP-D, C1q and MBL. It is possible that no single mAb will block binding of all three ligands, and therefore, multiple LAIR-2 mAbs may have to be used simultaneously as a formulation to block all interactions for maximal therapeutic effect.
- 10 3. Phase III screening: Functional assays to confirm that LAIR-2 mAbs or combination of mAbs increases LAIR-1 signaling in the presence of titrated amounts of soluble LAIR-2 in the presence of titrated amounts of multiple collagens, SP-D, C1q and MBL. (i.e. LAIR-2 mAbs should block ligand access to soluble LAIR-2, thus resulting in binding of ligands to LAIR-1 on cell surface and inducing negative signaling pathways).

Phase II and III assays can be used to predict the concentrations of LAIR-2 mAb(s) required to block physiological levels of ligands in vivo.

C. Assays and antibody screening for LAIR-1 blocking mAbs or LAIR-1 depleting mAbs

LAIR-1 deficient ("knockout") mice or wild type mice can be utilized for the generation of high affinity mAbs against LAIR-1 using proprietary immunization techniques.

- 25 1. **Phase I screening:** mAb binding to LAIR-1, but not LAIR-2 by ELISA. mAb binding to cell lines transfected to express cell surface LAIR-1. Additionally, mAbs should have the capacity to bind endogenously expressed LAIR-1 on the surface of primary human cell subsets. These mAbs should be highly specific for LAIR-1.
- 30

2. **Phase II screening:** LAIR-1 specific mAbs should block the binding of LAIR-1 to one or more of multiple collagens, SP-D and C1q. It is possible that no single mAb will block binding of all three ligands, and therefore, multiple LAIR-1 mAbs may have to be used simultaneously as a formulation to block all interactions for maximal therapeutic effect.

3. **Phase III screening:** Functional assays to confirm that LAIR-1 mAbs or combination of mAbs decreases LAIR-1 signaling in the presence of titrated amounts of multiple collagens, SP-D and C1q (antagonist or blocking mAbs). These assays will utilize cell lines that express endogenous LAIR-1, such as THP-1 cells, or primary cells such as human monocytes, macrophages and dendritic cell subsets to assess function in the presence of LAIR-1 mAbs. Additionally, reporter cell lines may be used to determine if signaling pathways such as NFkB (NFkB reporter) or NFAT (NFAT reporter) are altered following culture with LAIR-1 mAbs.

4. **Phase IV screening:** Functional assays to determine if LAIR-1 mAbs are capable of inducing antibody dependent cell cytotoxicity (ADCC), complement dependent cytotoxicity (CDC) or cellular apoptosis through other mechanisms, of LAIR-1 expressing cell lines. In particular, LAIR-1 mAbs will be tested for the ability to deplete through one of these methods leukemia cell lines, such as THP-1, known to express LAIR-1 on the cell surface. LAIR-1 mAbs may also be engineered to deplete LAIR-1 expressing cells and tested as described later in this document through known methods.

5. **Phase V screening:** Functional assays to determine if LAIR-1 mAbs are capable of delivering or inducing a negative signal (agonist) via LAIR-1 into LAIR-1 expressing cells to inhibit cellular function. Cell lines such as THP-1 or U937 that endogenously express LAIR-1, or transfectants of cell lines such as K562 will be assessed for inhibition following culture with LAIR-1 mAbs. In other assays,

reporter cell lines will be used to determine if LAIR-1 mAbs dampen positive signaling pathways such as NF- κ B (NF- κ B reporter) or other known cell signaling reporters. Induction of apoptosis in cell lines such as THP-1 and U937 will be also be evaluated.

- 5 Phase II and III assays can be used to predict the concentrations of LAIR-1 mAb(s) required to block physiological levels of ligands in vivo.

V. Method of Use

Evidence to date illustrates an inhibitory role for the LAIR-1 cell surface receptor and that LAIR-2 antagonized the function of LAIR-1 indirectly by binding identical ligands as LAIR-1, thus serving essentially as a decoy receptor. Tumor microenvironments are often rich in extracellular matrix proteins (ECMs), including the LAIR-1 ligand collagen (Rygiel et al., 2011, *Mol. Immunol.* 49:402-406). Therefore, LAIR-1 expressing cells localized to tumor microenvironments may be particularly suppressed through collagen cross-linking of LAIR-1 and subsequent inhibitory signaling. Increased LAIR-1 expression and signaling has been shown to inhibit the proliferation, differentiation and function of several immune cell subsets, and thus is believed to suppress anti-tumor immunity, particularly in tumor microenvironments with high levels of the LAIR-1 ligands collagen, C1q and SP-D.

Both collagen and C1q have been shown to limit or alter antigen-presenting cell (monocyte/macrophage/dendritic cell (DC)) differentiation and activation through LAIR-1. LAIR-1 has also been found to be expressed on NK and T cells, but at much lower levels than on APCs. Nevertheless, studies have indicated that cross-linking LAIR-1 on NK cells and T cells can inhibit proliferation and function. Thus it is believed that reducing LAIR-1 crosslinking can increase an immune response against cancer and infectious diseases. Increased levels of LAIR-2 are believed to promote anti-tumor immunity through the same mechanism. Therefore, soluble LAIR-1 and soluble LAIR-2 including LAIR-1 and LAIR-2 polypeptides and LAIR-1 and LAIR-2 fusion proteins, can be utilized for therapy of human diseases. For example, LAIR-2Fc proteins can be used for cancer immunotherapy to enhance immune function by preventing ligand binding to LAIR-1. This strategy is particularly promising because LAIR-2 binds ligands with a higher affinity than LAIR-1.

Alternately, signaling through LAIR-1 on AML cancer cells that express high levels of LAIR-1 sustain the self-renewal capacity, or 'stemness', of AML cells by inhibiting apoptosis and differentiation through a unique LAIR-1-SHP-1-CAMK1-CREB pathway (Kang et al., 2015, *Nat. Cell Biol.* 17:665-677). In

these cancers, decreased LAIR-1 signaling leads to AML cell death. Therefore, blockade (i.e. antagonism) of LAIR-1 signaling on leukemias is thought to be a treatment for the eradication of leukemias. As such, blockade of LAIR-1 signaling with LAIR-1 monoclonal antibodies, or with soluble LAIR-1 and soluble LAIR-2 including LAIR-1 and LAIR-2 polypeptides and LAIR-1 and LAIR-2 fusion proteins may be utilized for the treatment of leukemias by direct inhibition of cancer cell survival, as well as by promoting the anti-tumor immune response.

Conversely, decreased LAIR-1 expression or function is associated with several autoimmune manifestations, meanwhile, overexpression of LAIR-2 may promote autoimmunity through decoy binding of LAIR-1 ligands. LAIR-2 binding of LAIR-1 ligands can essentially reduce the cell surface cross-linking of LAIR-1, delimiting inhibitory signaling pathways leading to over-reactive immune function. Thus it is believed that increasing LAIR-1 crosslinking can decrease an overactive or inappropriate immune response, for example in cases of autoimmune disease or inflammation. For example, blockade of LAIR-2 by mAbs could be utilized for treatment of autoimmune disease, as this would increase ligand binding to LAIR-1, thus downregulating immune responses. Targeting LAIR-2 would be particularly effective in diseases in which there is an imbalance between the expression of cell surface LAIR-1 and soluble LAIR-2, as has been shown for rheumatoid arthritis (Lebbink et al., 2008, *J. Immunol* 180:1662-1669).

Exemplary methods are discussed in more detail below.

A. Immune Response Stimulating

1. Therapeutic Strategies

Methods of inducing or enhancing an immune response in a subject are provided. Typically, the methods include administering a subject an effective amount of immunomodulatory agent, or cells primed *ex vivo* with the immunomodulatory agent. The immune response can be, for example, a primary immune response to an antigen or an increase effector cell function such as increasing antigen-specific proliferation of T cells, enhancing cytokine

production by T cells, stimulating differentiation, or a combination thereof. In some embodiments, the agent can increase the development of naïve T cells into Th1, Th17, Th22, or other cells that secrete, or cause other cells to secrete, inflammatory molecules, including, but not limited to, IL-1 β , TNF- α , TGF-beta, IFN- γ , IL-17, IL-6, IL-23, IL-22, IL-21, and MMPs. In some embodiments, the agent can reduce or inhibit the activity of Tregs, reduce the production of cytokines such as IL-10 from Tregs, reduce the differentiation of Tregs, reduce the number of Tregs, reduce the ratio of Tregs within an immune cell population, or reduce the survival of Tregs. The immunomodulatory agent can be administered to a subject in need thereof in an effective amount to overcome T cell exhaustion and/or T cell anergy. Overcoming T cell exhaustion or T cell anergy can be determined by measuring T cell function using known techniques.

The methods can be used *in vivo* or *ex vivo* as immune response-stimulating therapeutic applications. Thus in some embodiments, the agent, or nucleic acid encoding the agent, is administered directly to the subject. In some embodiments, the agent or nucleic acid encoding the agent, is contacted with cells (e.g., immune cells) *ex vivo*, and the treat cells are administered to the subject (e.g. adoptive transfer). In general, the disclosed immunomodulatory agents can be used for treating a subject having or being predisposed to any disease or disorder to which the subject's immune system mounts an immune response. The agents can enable a more robust immune response to be possible. The disclosed compositions are useful to stimulate or enhance immune responses involving T cells.

The immunomodulatory agents utilized for increasing an immune response are typically those that reduce LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. For example, the agent can be an antagonist of LAIR-1, such as an antagonist (blocking) anti-LAIR-1 antibody or antigen binding fragment thereof. In some embodiments, the antagonist binds to a LAIR-1 collagen binding domain (see, e.g., Brondijk, et al., *Blood*, 18(115):1364-73 (2010), and Zhou, et al., *Blood*, 127(5):529-537 (2016) and its supplemental information, which are specifically incorporated by

reference in their entirety). In some embodiments, a LAIR-1 antagonist such as a function blocking antibody or functional fragment thereof specifically binds to an epitope including one or more of R59, E61, R62, E63, R65, S66, Y68, N69, I102, R100, W109, E111, Q112, and Y115 of LAIR-1 (e.g., relative to
5 SEQ ID NO:1). The agent can also be a LAIR-1 polypeptide, for example, a soluble polypeptide, or fusion protein thereof that can serve as a decoy receptor for one or more LAIR-1 ligands. The agent can also be LAIR-2 or a functional fragment or fusion protein thereof that can serve as a decoy receptor for one or more LAIR-1 ligands.

10 For example, in some embodiments an effective amount of a LAIR-2 fusion protein, for example LAIR-2-Fc, is administered to a subject with cancer or an infection. Treating patients with LAIR-2-Fc would result in decreased cross-linking of the LAIR-1 receptor, and subsequently, decreased inhibitory signaling of LAIR-1+ cells and improved immune function. Tipping the ratio
15 towards increased levels of soluble LAIR-2 in comparison to cell surface LAIR-1, particularly in tumor microenvironments where the expression of LAIR-1/2 ligands are highly expressed, would favor enhanced anti-tumor immunity.

Tumor microenvironments with high levels of both collagens, SP-D and/or C1q, and with immune infiltrates that express high levels of LAIR-1
20 would be ideal for the disclosed immunotherapies, (e.g., LAIR-2-Fc immunotherapy). While ovarian cancers have high levels of collagen, it is unclear whether SP-D and C1q levels are high. Whereas, lung and GI cancers may have high levels of both collagens and SP-D, and therefore may be cancers to target with LAIR-2-Fc. In other embodiments, soluble LAIR-2, soluble
25 LAIR-1, or a LAIR-1 fusion protein (e.g., LAIR-1-Fc) is utilized. In some embodiments, LAIR-2-based molecules may be selected because LAIR-2 binds ligands with a higher affinity than LAIR-1.

LAIR-1 blockade, for example using function blocking anti-LAIR-1 antibodies, can be an alternative agent or complementary agent to soluble LAIR-
30 1 and LAIR-2 polypeptides and fusion proteins. For example, in some embodiments, LAIR-1 blockade and is combined with a decoy receptor such as

soluble LAIR-1 or LAIR-2 or fusion protein thereof. The combined treatment (e.g., LAIR-2-Fc and LAIR-1 blockade) may be complementary.

In some embodiments, immune response stimulating therapy (e.g., in the treatment of cancer or infections) includes depletion of LAIR-1+ cells. LAIR-1
5 is highly expressed in mouse and human ovarian cancer ascites. The upregulation of LAIR-1 is restricted to immunoregulatory macrophages and F4/80+ DCs, both of which coexpress high levels of PD-L1. Therefore, targeting the depletion of LAIR-1 expressing cells would improve the overall condition of the tumor microenvironment by removal of immunoregulatory
10 populations. While expression of LAIR-1 on other cell subsets in ovarian cancer have not been observed, because LAIR-1 is universally inhibitory, depletion of other LAIR-1+ cells would also have the effect of decreasing immune inhibition and improving anti-tumor immunity. LAIR-1 has also been shown to be expressed on the surface of, and is crucial for the development of
15 acute myeloid leukemia cancers (Kang et al, Nature Cell Biology, Vol17, No 5, 2015; pp 665-679). Therefore, depletion of hematopoietic ('blood') cancers with LAIR-1 depleting mAbs would have the direct effect of reducing or eradicating LAIR-1 positive cancers.

Development and identification of LAIR-1 depleting mAbs can be
20 carried out according to known construction and screening methods including those discussed herein. See, for example, Reff, et al, *Blood*. Vol83, No 2, 1994: pp 435-445, which describes preparation of an anti-CD20 chimeric antibody that binds to human Clq, and mediates complement-dependent cell lysis (CDCC) in the presence of human complement, and anti-body-dependent cellular
25 cytotoxicity (ADCC) with human effector cells. Rituximab destroys B cells and is therefore used to treat diseases which are characterized by overactive, dysfunctional, or excessive numbers of B cells. Other B cell-depleting antibodies include ocrelizumab and ofatumumab. In another example, CD3 Abs can preferentially target and deplete activated effector T cells while preserving
30 CD4⁺Foxp3⁺ Tregs. The antibodies transiently deplete T cells although they display no or little complement-dependent and antibody-dependent cellular

cytotoxicity. Redirected cell lysis due to the ability to crosslink CD3 molecules expressed by two different cells (cytotoxic CD8⁺ T cells on one side and other target T cells on the other side) has been shown, however, T cell depletion mostly results from AICD (reviewed in You, *Front Immunol.* 2015; 6: 242).

5 In some embodiments, the cell-depleting antibodies reduce the number of LAIR-1 positive macrophages, F4/80⁺ DCs, cancer cells or a combination thereof.

2. Subjects to be Treated

a. Treatment of Cancer

10 The disclosed compositions and methods can be used to treat cancer. Generally, the agents are used to stimulate or enhance an immune response to cancer in the subject by administering to the subject an amount of an immunomodulatory agent that reduces LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. The method can
15 reduce or more symptoms of the cancer.

The immune system is a proven defense against cancer initiation and growth. The regulation of immune responses are governed by cell surface interactions that direct immune cell function along specific pathways, including activation or inhibition against cancer cells. LAIR-1 is an inhibitory receptor on
20 the surface of several immune cell (leukocyte) subsets that prevents optimal immune responses. Whereas, LAIR-2 is a soluble homolog that functions as a decoy to block LAIR-1 mediated inhibition.

In one embodiment, LAIR-2 Fc fusion protein promotes immune responses *in vitro* and *in vivo*. In another embodiment, LAIR-2 Fc reduces
25 tumor growth and promotes survival. In still another embodiment, LAIR-2 Fc promotes anti-PD-1 immunotherapy. The data provided herein demonstrate that LAIR-1 mAbs have *in vitro* activity in human T cell and myeloid cell lines, showing specific agonist and antagonist activity for specific mAb clones. These findings demonstrate the potential LAIR-1 pathway modulation by LAIR-2 Fc
30 or LAIR-1 mAbs for immunotherapeutic intervention in cancer and other diseases.

In another embodiment, LAIR-Fc increases primary human T cell responsiveness to TCR stimulation. In another embodiment, LAIR-2 Fc increases antigen specific T cell responses in vivo.

Cancer cells acquire a characteristic set of functional capabilities during their development, albeit through various mechanisms. Such capabilities include evading apoptosis, self-sufficiency in growth signals, insensitivity to anti-growth signals, tissue invasion/metastasis, limitless explicative potential, and sustained angiogenesis. The term "cancer cell" is meant to encompass both pre-malignant and malignant cancer cells. In some embodiments, cancer refers to a benign tumor, which has remained localized. In other embodiments, cancer refers to a malignant tumor, which has invaded and destroyed neighboring body structures and spread to distant sites. In yet other embodiments, the cancer is associated with a specific cancer antigen (e.g., pan-carcinoma antigen (KS 1/4), ovarian carcinoma antigen (CA125), prostate specific antigen (PSA), carcinoembryonic antigen (CEA), CD19, CD20, HER2/neu, etc.).

The methods and compositions disclosed herein are useful in the treatment or prevention of a variety of cancers or other abnormal proliferative diseases, including (but not limited to) the following: carcinoma, including that of the bladder, breast, colon, kidney, liver, lung, ovary, pancreas, stomach, cervix, thyroid and skin; including squamous cell carcinoma; hematopoietic tumors of lymphoid lineage, including leukemia, acute lymphocytic leukemia, acute lymphoblastic leukemia, B-cell lymphoma, T-cell lymphoma, Burkett's lymphoma; hematopoietic tumors of myeloid lineage, including acute and chronic myelogenous leukemias and promyelocytic leukemia; tumors of mesenchymal origin, including fibrosarcoma and rhabdomyosarcoma; other tumors, including melanoma, seminoma, teratocarcinoma, neuroblastoma and glioma; tumors of the central and peripheral nervous system, including astrocytoma, neuroblastoma, glioma, and schwannomas; tumors of mesenchymal origin, including fibrosarcoma, rhabdomyosarcoma, and osteosarcoma; and other tumors, including melanoma, xenoderma

pegmentosum, keratoactanthoma, seminoma, thyroid follicular cancer and teratocarcinoma.

Cancers caused by aberrations in apoptosis can also be treated by the disclosed methods and compositions. Such cancers may include, but are not be
 5 limited to, follicular lymphomas, carcinomas with p53 mutations, hormone dependent tumors of the breast, prostate and ovary, and precancerous lesions such as familial adenomatous polyposis, and myelodysplastic syndromes. In specific embodiments, malignancy or dysproliferative changes (such as metaplasias and dysplasias), or hyperproliferative disorders, are treated or
 10 prevented by the methods and compositions in the ovary, bladder, breast, colon, lung, skin, pancreas, or uterus. In other specific embodiments, sarcoma, melanoma, or leukemia is treated or prevented by the methods and compositions.

The disclosed compositions and methods are particularly useful for the
 15 treatment of cancers that are associated with cells that express abnormally high levels of LAIR-1, high levels of LAIR-1 ligand, low levels of LAIR-2, or a combination thereof.

Specific cancers and related disorders that can be treated or prevented by methods and compositions disclosed herein include, but are not limited to,
 20 leukemias including, but not limited to, acute leukemia, acute lymphocytic leukemia, acute myelocytic leukemias such as myeloblastic, promyelocytic, myelomonocytic, monocytic, erythroleukemia leukemias and myelodysplastic syndrome, chronic leukemias such as but not limited to, chronic myelocytic (granulocytic) leukemia, chronic lymphocytic leukemia, hairy cell leukemia;
 25 polycythemia vera; lymphomas such as, but not limited to, Hodgkin's disease or non-Hodgkin's disease lymphomas (e.g., diffuse anaplastic lymphoma kinase (ALK) negative, large B-cell lymphoma (DLBCL); diffuse anaplastic lymphoma kinase (ALK) positive, large B-cell lymphoma (DLBCL); anaplastic lymphoma kinase (ALK) positive, ALK+ anaplastic large-cell lymphoma (ALCL), acute
 30 myeloid lymphoma (AML)); multiple myelomas such as, but not limited to, smoldering multiple myeloma, nonsecretory myeloma, osteosclerotic myeloma,

plasma cell leukemia, solitary plasmacytoma and extramedullary plasmacytoma; Waldenstrom's macroglobulinemia; monoclonal gammopathy of undetermined significance; benign monoclonal gammopathy; heavy chain disease; bone and connective tissue sarcomas such as, but not limited to, bone sarcoma,

5 osteosarcoma, chondrosarcoma, Ewing's sarcoma, malignant giant cell tumor, fibrosarcoma of bone, chordoma, periosteal sarcoma, soft-tissue sarcomas, angiosarcoma (hemangiosarcoma), fibrosarcoma, Kaposi's sarcoma, leiomyosarcoma, liposarcoma, lymphangiosarcoma, neurilemmoma, rhabdomyosarcoma, synovial sarcoma; brain tumors including but not limited

10 to, glioma, astrocytoma, brain stem glioma, ependymoma, oligodendroglioma, nonglial tumor, acoustic neurinoma, craniopharyngioma, medulloblastoma, meningioma, pineocytoma, pineoblastoma, primary brain lymphoma; breast cancer including, but not limited to, adenocarcinoma, lobular (small cell) carcinoma, intraductal carcinoma, medullary breast cancer, mucinous breast

15 cancer, tubular breast cancer, papillary breast cancer, Paget's disease, and inflammatory breast cancer; adrenal cancer, including but not limited to, pheochromocytom and adrenocortical carcinoma; thyroid cancer such as but not limited to papillary or follicular thyroid cancer, medullary thyroid cancer and anaplastic thyroid cancer; pancreatic cancer, including but not limited to,

20 insulinoma, gastrinoma, glucagonoma, vipoma, somatostatin-secreting tumor, and carcinoid or islet cell tumor; pituitary cancers including but not limited to, Cushing's disease, prolactin-secreting tumor, acromegaly, and diabetes insipidus; eye cancers including, but not limited to, ocular melanoma such as iris melanoma, choroidal melanoma, and ciliary body melanoma, and

25 retinoblastoma; vaginal cancers, including, but not limited to, squamous cell carcinoma, adenocarcinoma, and melanoma; vulvar cancer, including but not limited to, squamous cell carcinoma, melanoma, adenocarcinoma, basal cell carcinoma, sarcoma, and Paget's disease; cervical cancers including, but not limited to, squamous cell carcinoma, and adenocarcinoma; uterine cancers

30 including, but not limited to, endometrial carcinoma and uterine sarcoma; ovarian cancers including, but not limited to, ovarian epithelial carcinoma,

borderline tumor, germ cell tumor, and stromal tumor; esophageal cancers including, but not limited to, squamous cancer, adenocarcinoma, adenoid cystic carcinoma, mucoepidermoid carcinoma, adenosquamous carcinoma, sarcoma, melanoma, plasmacytoma, verrucous carcinoma, and oat cell (small cell)

5 carcinoma; stomach cancers including, but not limited to, adenocarcinoma, fungating (polypoid), ulcerating, superficial spreading, diffusely spreading, malignant lymphoma, liposarcoma, fibrosarcoma, and carcinosarcoma; colon cancers; rectal cancers; liver cancers including, but not limited to, hepatocellular carcinoma and hepatoblastoma, gallbladder cancers including, but not limited to,

10 adenocarcinoma; cholangiocarcinomas including, but not limited to, papillary, nodular, and diffuse; lung cancers including but not limited to, non-small cell lung cancer, squamous cell carcinoma (epidermoid carcinoma), adenocarcinoma, large-cell carcinoma and small-cell lung cancer; testicular cancers including, but not limited to, germinal tumor, seminoma, anaplastic,

15 classic (typical), spermatocytic, nonseminoma, embryonal carcinoma, teratoma carcinoma, choriocarcinoma (yolk-sac tumor), prostate cancers including, but not limited to, adenocarcinoma, leiomyosarcoma, and rhabdomyosarcoma; penile cancers; oral cancers including, but not limited to, squamous cell carcinoma; basal cancers; salivary gland cancers including, but not limited to,

20 adenocarcinoma, mucoepidermoid carcinoma, and adenoidcystic carcinoma; pharynx cancers including, but not limited to, squamous cell cancer, and verrucous; skin cancers including, but not limited to, basal cell carcinoma, squamous cell carcinoma and melanoma, superficial spreading melanoma, nodular melanoma, lentigo malignant melanoma, acral lentiginous melanoma;

25 kidney cancers including, but not limited to, renal cell cancer, adenocarcinoma, hypernephroma, fibrosarcoma, transitional cell cancer (renal pelvis and/or uterine); Wilms' tumor; bladder cancers including, but not limited to, transitional cell carcinoma, squamous cell cancer, adenocarcinoma, carcinosarcoma. In addition, cancers include myxosarcoma, osteogenic sarcoma,

30 endotheliosarcoma, lymphangioendotheliosarcoma, mesothelioma, synovioma, hemangioblastoma, epithelial carcinoma, cystadenocarcinoma, bronchogenic

carcinoma, sweat gland carcinoma, sebaceous gland carcinoma, papillary carcinoma and papillary adenocarcinomas (for a review of such disorders, see Fishman et al., 1985, Medicine, 2d Ed., J.B. Lippincott Co., Philadelphia and Murphy et al., 1997, Informed Decisions: The Complete Book of Cancer
 5 Diagnosis, Treatment, and Recovery, Viking Penguin, Penguin Books U.S.A., Inc., United States of America).

b. Treatment of Infections

The disclosed compositions and methods can be used to treat infections and infectious diseases. Generally, the agents are used to stimulate or enhance
 10 an immune response to infection causing agent in the subject by administering to the subject an amount of an immunomodulatory agent that reduces LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. The method can reduce one or more symptoms of the infection. In addition, because soluble LAIR-1 and/or LAIR-2 can bind complement factor
 15 C1q, subjects that express abnormally high levels of soluble LAIR-1 or LAIR-2 may have reduced complement-mediated immune clearance of infections in some cases. Therefore, subjects with abnormally high levels of LAIR-1 or LAIR-2, and found to exhibit decreased complement function, can be administered agents such as LAIR-1 and LAIR-2 mAbs that block LAIR-1 and
 20 LAIR-2 binding to complement factor C1q, respectively, in order to improve the complement cascade and thus, improve the innate immune response to infection.

The infection or disease can be caused by a bacterium, virus, protozoan, helminth, or other microbial pathogen that enters intracellularly and is attacked, *i.e.*, by cytotoxic T lymphocytes.

25 The infection or disease can be acute or chronic. An acute infection is typically an infection of short duration. During an acute microbial infection, immune cells begin expressing immunomodulatory receptors. Accordingly, in some embodiments, the method includes increasing an immune stimulatory response against an acute infection.

30 The infection can be caused by, for example, but not limited to *Candida albicans*, *Listeria monocytogenes*, *Streptococcus pyogenes*, *Streptococcus*

pneumoniae, Neisseria meningitidis, Staphylococcus aureus, Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa or Mycobacterium.

In some embodiments, the disclosed compositions are used to treat chronic infections, for example infections in which T cell exhaustion or T cell
 5 anergy has occurred causing the infection to remain with the host over a prolonged period of time.

Exemplary infections to be treated are chronic infections caused by a hepatitis virus, a human immunodeficiency virus (HIV), a human T-lymphotrophic virus (HTLV), a herpes virus, an Epstein-Barr virus, or a human
 10 papilloma virus.

Because viral infections are cleared primarily by T cells, an increase in T-cell activity would be therapeutically useful in situations where more rapid or thorough clearance of an infective viral agent would be beneficial to an animal or human subject. Thus, the disclosed compositions can be administered for the
 15 treatment of local or systemic viral infections, including, but not limited to, immunodeficiency (e.g., HIV), papilloma (e.g., HPV), herpes (e.g., HSV), encephalitis, influenza (e.g., human influenza virus A), and common cold (e.g., human rhinovirus) and other viral infections, caused by, for example, HTLV, hepatitis virus, respiratory syncytial virus, vaccinia virus, and rabies virus. The
 20 molecules can be administered topically to treat viral skin diseases such as herpes lesions or shingles, or genital warts. The molecules can also be administered systemically to treat systemic viral diseases, including, but not limited to, AIDS, influenza, the common cold, or encephalitis.

Representative infections that can be treated, include but are not limited
 25 to infections caused by microorganisms including, but not limited to, *Actinomyces, Anabaena, Bacillus, Bacteroides, Bdellovibrio, Bordetella, Borrelia, Campylobacter, Caulobacter, Chlamydia, Chlorobium, Chromatium, Clostridium, Corynebacterium, Cytophaga, Deinococcus, Escherichia, Francisella, Halobacterium, Helicobacter, Haemophilus, Hemophilus influenza type B (HIB), Hyphomicrobium, Legionella, Leptospiriosis, Listeria,*
 30 *Meningococcus A, B and C, Methanobacterium, Micrococcus, Mycobacterium,*

- Mycoplasma, Myxococcus, Neisseria, Nitrobacter, Oscillatoria, Prochloron, Proteus, Pseudomonas, Phodospirillum, Rickettsia, Salmonella, Shigella, Spirillum, Spirochaeta, Staphylococcus, Streptococcus, Streptomyces, Sulfolobus, Thermoplasma, Thiobacillus, and Treponema, Vibrio, Yersinia,*
- 5 *Cryptococcus neoformans, Histoplasma capsulatum, Candida albicans, Candida tropicalis, Nocardia asteroides, Rickettsia rickettsii, Rickettsia typhi, Mycoplasma pneumoniae, Chlamydial psittaci, Chlamydial trachomatis, Plasmodium falciparum, Trypanosoma brucei, Entamoeba histolytica, Toxoplasma gondii, Trichomonas vaginalis and Schistosoma mansoni.*
- 10 Other microorganisms that can be treated using the disclosed compositions and methods include, bacteria, such as those of *Klebsiella, Serratia, Pasteurella*; pathogens associated with cholera, tetanus, botulism, anthrax, plague, and Lyme disease; or fungal or parasitic pathogens, such as *Candida (albicans, krusei, glabrata, tropicalis, etc.), Cryptococcus, Aspergillus*
- 15 *(fumigatus, niger, etc.), Genus Mucorales (mucor, absidia, rhizophus), Sporothrix (schenkii), Blastomyces (dermatitidis), Paracoccidioides (brasiliensis), Coccidioides (immitis) and Histoplasma (capsulatum), Entamoeba, histolytica, Balantidium coli, Naegleria fowleri, Acanthamoeba sp., Giardia lamblia, Cryptosporidium sp., Pneumocystis carinii, Plasmodium vivax,*
- 20 *Babesia microti, Trypanosoma brucei, Trypanosoma cruzi, Toxoplasma gondi, etc.), Sporothrix, Blastomyces, Paracoccidioides, Coccidioides, Histoplasma, Entamoeba, Histolytica, Balantidium, Naegleria, Acanthamoeba, Giardia, Cryptosporidium, Pneumocystis, Plasmodium, Babesia, or Trypanosoma, etc.*

B. Immune Response Inhibiting

25 1. Therapeutic Strategies

Methods of reducing or inhibiting an immune response in a subject are provided. Typically the methods include administering a subject an effective amount of immunomodulatory agent, or cells primed *ex vivo* with the immunomodulatory agent. The immune response can be, for example, a

30 primary immune response to an antigen or an increase effector cell function such as increasing antigen-specific proliferation of T cells, enhancing cytokine

production by T cells, stimulating differentiation, or a combination thereof.

Thus in some embodiments, the agent reduces T cell proliferation, T cell cytokine production, T cell differentiation, or a combination thereof. In some embodiments, the agent can reduce the development of naïve T cells into Th1, 5 Th17, Th22, or other cells that secrete, or cause other cells to secrete, inflammatory molecules, including, but not limited to, IL-1 β , TNF- α , TGF-beta, IFN- γ , IL-17, IL-6, IL-23, IL-22, IL-21, and MMPs. In some embodiments, the agent can increase or promote the activity of Tregs, increase the production of cytokines such as IL-10 from Tregs, increase the differentiation of Tregs, 10 increase the number of Tregs, increase the ratio of Tregs within an immune cell population, or increase the survival of Tregs.

The methods can be used *in vivo* or *ex vivo* as immune response-inhibiting therapeutic applications. Thus in some embodiments, the agent, or nucleic acid encoding the agent, is administered directly to the subject. In some 15 embodiments, the agent or nucleic acid encoding the agent, is contacted with cells (e.g., immune cells) *ex vivo*, and the treated cells are administered to the subject (e.g., adoptive transfer). In general, the disclosed immunomodulatory agents can be used for treating a subject having or being predisposed to any disease or disorder to which the subject's immune system mounts an overactive 20 or inappropriate immune response. The agents can enable a less robust immune response to be possible. The disclosed compositions are useful to reduce or inhibit immune responses involving T cells.

The immunomodulatory agents utilized for reducing an immune response are typically those that increase LAIR-1 expression, ligand binding, 25 crosslinking, negative signaling, or a combination thereof. For example, the agent can be an agonist of LAIR-1, such as an agonist (stimulating) anti-LAIR-1 antibody or antigen binding fragment thereof. The agent can also be an antagonist of LAIR-2, such as an antagonistic (blocking) anti-LAIR-2 antibody, that reduces the ability of LAIR-2 to serve as a decoy receptor for one or more 30 LAIR-1 ligands.

For example, in some embodiments, an effective amount of an agent that induces LAIR-2 blockade is administered to a subject with an autoimmune disease or inflammatory disease or disorder. LAIR-1 signaling functions to delimit immune responses, which is particularly important to prevent autoimmune and immune autoreactive manifestations. Therefore, decreased LAIR-1 expression may result in increased autoimmunity. Alternately, increased levels of LAIR-2 can promote autoimmunity by preventing ligand cross-linking and inhibitory signaling by LAIR-1. Indeed, increased levels of LAIR-2 have been reported in patients with rheumatoid arthritis (Olde Nordkamp et al. 2011, *Arthritis Rheum.* 63:3749-3757). As such, despite increased levels of LAIR-1 in RA patients, because LAIR-2 has higher ligand affinity, the increase in LAIR-1 expression will have little effect. Therefore, blockade of LAIR-2 binding to collagens, SP-D and C1q would result in increased cross-linking of LAIR-1, with a subsequent decrease in immune inflammatory pathways. mAbs that deplete LAIR-2 or block LAIR-2 ligand binding may be particularly effective for the treatment of autoimmune diseases in which systemic or localized levels of LAIR-2 are increased. In fact, autoimmune diseases with increased expression of both LAIR-2 and LAIR-1 would have the greatest chance for success with LAIR-2 mAb immunotherapy because once LAIR-2 is neutralized, high levels of LAIR-1 would have a greater inhibitory effect than in diseases with low levels of LAIR-1 expression. Thus in some embodiments, LAIR-2 mAb immunotherapy is utilized to treat a subject with rheumatoid arthritis.

a. Inflammatory Responses

The disclosed compositions and methods can be used to treat inflammation. Generally, the agents are used to reduce or inhibit an immune response in the subject by administering to the subject an amount of an immunomodulatory agent that increases LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof. The method can reduce or more symptoms of the inflammation. Inflammation can be acute, chronic, or persistent inflammation.

In some embodiments, the immunomodulatory agents slow down the immune system. For example, agent can be used to control hyper-inflammatory response causing damage healthy tissues. Accordingly, in some embodiments, the agents are administered to a subject undergoing a hyper-inflammatory response. In such cases, controlling excessive immune responses can be beneficial to the subject.

b. Inflammatory and Autoimmune Diseases/disorders

Agents that increase LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof can also be used to treat inflammatory or autoimmune diseases and disorders. Representative inflammatory or autoimmune diseases/disorders include, but are not limited to, rheumatoid arthritis, systemic lupus erythematosus, alopecia areata, ankylosing spondylitis, antiphospholipid syndrome, autoimmune Addison's disease, autoimmune hemolytic anemia, autoimmune hepatitis, autoimmune inner ear disease, autoimmune lymphoproliferative syndrome (alps), autoimmune thrombocytopenic purpura (ATP), Behcet's disease, bullous pemphigoid, cardiomyopathy, celiac sprue-dermatitis, chronic fatigue syndrome immune deficiency, syndrome (CFIDS), chronic inflammatory demyelinating polyneuropathy, cicatricial pemphigoid, cold agglutinin disease, Crest syndrome, Crohn's disease, Dego's disease, dermatomyositis, dermatomyositis - juvenile, discoid lupus, essential mixed cryoglobulinemia, fibromyalgia - fibromyositis, grave's disease, guillain-barre, hashimoto's thyroiditis, idiopathic pulmonary fibrosis, idiopathic thrombocytopenia purpura (ITP), Iga nephropathy, insulin dependent diabetes (Type I), juvenile arthritis, Meniere's disease, mixed connective tissue disease, multiple sclerosis, myasthenia gravis, pemphigus vulgaris, pernicious anemia, polyarteritis nodosa, polychondritis, polyglancular syndromes, polymyalgia rheumatica, polymyositis and dermatomyositis, primary agammaglobulinemia, primary biliary cirrhosis, psoriasis, Raynaud's phenomenon, Reiter's syndrome, rheumatic fever, sarcoidosis, scleroderma, Sjogren's syndrome, stiff-man syndrome, Takayasu

arteritis, temporal arteritis/giant cell arteritis, ulcerative colitis, uveitis, vasculitis, vitiligo, and Wegener's granulomatosis.

In some embodiments the inflammation or autoimmune disease is caused by a pathogen, or is the result of an infection.

5 V. Combination Therapies

The disclosed immunomodulatory agents can be administered to a subject in need thereof alone or in combination with one or more additional therapeutic agents. In some embodiments, the immunomodulatory agent and the additional therapeutic agent are administered separately, but simultaneously.

- 10 The immunomodulatory agent and the additional therapeutic agent can also be administered as part of the same composition. In other embodiments, the immunomodulatory agent and the second therapeutic agent are administered separately and at different times, but as part of the same treatment regime.

- The subject can be administered a first therapeutic agent 1, 2, 3, 4, 5, 6, 15 or more hours, or 1, 2, 3, 4, 5, 6, 7, or more days before administration of a second therapeutic agent. In some embodiments, the subject can be administered one or more doses of the first agent every 1, 2, 3, 4, 5, 6, 7, 14, 21, 28, 35, or 48 days prior to a first administration of second agent. The immunomodulatory agent can be the first or the second therapeutic agent.

- 20 The immunomodulatory agent and the additional therapeutic agent can be administered as part of a therapeutic regimen. For example, if a first therapeutic agent can be administered to a subject every fourth day, the second therapeutic agent can be administered on the first, second, third, or fourth day, or combinations thereof. The first therapeutic agent or second therapeutic agent 25 may be repeatedly administered throughout the entire treatment regimen.

- Exemplary molecules include, but are not limited to, cytokines, chemotherapeutic agents, radionuclides, other immunotherapeutics, enzymes, antibiotics, antivirals (especially protease inhibitors alone or in combination with nucleosides for treatment of HIV or Hepatitis B or C), anti-parasites 30 (helminths, protozoans), growth factors, growth inhibitors, hormones, hormone antagonists, antibodies and bioactive fragments thereof (including humanized,

single chain, and chimeric antibodies), antigen and vaccine formulations (including adjuvants), peptide drugs, anti-inflammatories, ligands that bind to Toll-Like Receptors (including but not limited to CpG oligonucleotides) to activate the innate immune system, molecules that mobilize and optimize the
5 adaptive immune system, other molecules that activate or up-regulate the action of cytotoxic T lymphocytes, natural killer cells and helper T-cells, and other molecules that deactivate or down-regulate suppressor or regulatory T-cells.

The additional therapeutic agents are selected based on the condition, disorder or disease to be treated. For example, the immunomodulatory agent
10 can be co-administered with one or more additional agents that function to enhance or promote an immune response or reduce or inhibit an immune response.

A. Increasing Immune Responses

1. Antimicrobials

For example, a LAIR-1 or LAIR-2 immunomodulatory agent can be
15 used in a preventive or prophylactic role in the treatment and prevention of disease as discussed above, and also in the context of severe trauma injuries like major burn, open bone fracture, accidental amputation or other wounds. Therefore, the LAIR-1 or LAIR-2 immunomodulatory agents can be
20 administered to the subject in combination with an antimicrobial such as an antibiotic, an antifungal, an antiviral, an antiparasitics, or essential oil.

In some embodiments, the subject is administered the LAIR-1 or LAIR-2 immunomodulatory agent and/or the antimicrobial at time of admission to the hospital to prevent further bacterial, fungal or viral complications. The antibiotic
25 can target pathogens and the LAIR-1 or LAIR-2 immunomodulatory agent can stimulate the immune system to provide an enhanced response to treat or prevent further infection or disease.

2. Chemotherapeutic Agents

The LAIR-1 or LAIR-2 immunomodulatory agents can be combined
30 with one or more chemotherapeutic agents and pro-apoptotic agents. Representative chemotherapeutic agents include, but are not limited to

amsacrine, bleomycin, busulfan, capecitabine, carboplatin, carmustine, chlorambucil, cisplatin, cladribine, clofarabine, crisantaspase, cyclophosphamide, cytarabine, dacarbazine, dactinomycin, daunorubicin, docetaxel, doxorubicin, epirubicin, etoposide, fludarabine, fluorouracil, gemcitabine, hydroxycarbamide, idarubicin, ifosfamide, irinotecan, leucovorin, liposomal doxorubicin, liposomal daunorubicin, lomustine, melphalan, mercaptopurine, mesna, methotrexate, mitomycin, mitoxantrone, oxaliplatin, paclitaxel, pemetrexed, pentostatin, procarbazine, raltitrexed, satraplatin, streptozocin, tegafur-uracil, temozolomide, teniposide, thiotepa, tioguanine, topotecan, treosulfan, vinblastine, vincristine, vindesine, vinorelbine, or a combination thereof. Representative pro-apoptotic agents include, but are not limited to fludarabinetaurosporine, cycloheximide, actinomycin D, lactosylceramide, 15d-PGJ(2) and combinations thereof.

3. Other Immunomodulators

a. PD-1 antagonists

In some embodiments, LAIR-1 or LAIR-2 immunomodulatory agents are co-administered with a PD-1 antagonist. Programmed Death-1 (PD-1) is a member of the CD28 family of receptors that delivers a negative immune response when induced on T cells. Contact between PD-1 and one of its ligands (B7-H1 or B7-DC) induces an inhibitory response that decreases T cell multiplication and/or the strength and/or duration of a T cell response. Suitable PD-1 antagonists are described in U.S. Patent Nos. 8,114,845, 8,609,089, and 8,709,416, which are specifically incorporated by reference herein in their entities, and include compounds or agents that either bind to and block a ligand of PD-1 to interfere with or inhibit the binding of the ligand to the PD-1 receptor, or bind directly to and block the PD-1 receptor without inducing inhibitory signal transduction through the PD-1 receptor.

In some embodiments, the PD-1 receptor antagonist binds directly to the PD-1 receptor without triggering inhibitory signal transduction and also binds to a ligand of the PD-1 receptor to reduce or inhibit the ligand from triggering signal transduction through the PD-1 receptor. By reducing the number and/or

amount of ligands that bind to PD-1 receptor and trigger the transduction of an inhibitory signal, fewer cells are attenuated by the negative signal delivered by PD-1 signal transduction and a more robust immune response can be achieved.

It is believed that PD-1 signaling is driven by binding to a PD-1 ligand (such as B7-H1 or B7-DC) in close proximity to a peptide antigen presented by major histocompatibility complex (MHC) (see, for example, Freeman, *Proc. Natl. Acad. Sci. U. S. A.*, 105:10275-10276 (2008)). Therefore, proteins, antibodies or small molecules that prevent co-ligation of PD-1 and TCR on the T cell membrane are also useful PD-1 antagonists.

In some embodiments, the PD-1 receptor antagonists are small molecule antagonists or antibodies that reduce or interfere with PD-1 receptor signal transduction by binding to ligands of PD-1 or to PD-1 itself, especially where co-ligation of PD-1 with TCR does not follow such binding, thereby not triggering inhibitory signal transduction through the PD-1 receptor.

Other PD-1 antagonists contemplated by the methods of this invention include antibodies that bind to PD-1 or ligands of PD-1, and other antibodies.

Suitable anti-PD-1 antibodies include, but are not limited to, those described in the following publications:

PCT/IL03/00425 (Hardy et al., WO/2003/099196)
 PCT/JP2006/309606 (Korman et al., WO/2006/121168)
 PCT/US2008/008925 (Li et al., WO/2009/014708)
 PCT/JP03/08420 (Honjo et al., WO/2004/004771)
 PCT/JP04/00549 (Honjo et al., WO/2004/072286)
 PCT/IB2003/006304 (Collins et al., WO/2004/056875)
 PCT/US2007/088851 (Ahmed et al., WO/2008/083174)
 PCT/US2006/026046 (Korman et al., WO/2007/005874)
 PCT/US2008/084923 (Terrett et al., WO/2009/073533)

Berger et al., *Clin. Cancer Res.*, 14:30443051 (2008).

A specific example of an anti-PD-1 antibody is an antibody described in Kosak, US 20070166281 (pub. 19 July 2007) at par. 42), a human anti-PD-1 antibody, which in some embodiments is administered at a dose of 3 mg/kg.

Exemplary anti-B7-H1 antibodies include, but are not limited to, those described in the following publications:

PCT/US06/022423 (WO/2006/133396, pub. 14 December 2006)

PCT/US07/088851 (WO/2008/083174, pub. 10 July 2008)

5 US 2006/0110383 (pub. 25 May 2006)

A specific example of an anti-B7-H1 antibody is an antibody described (WO/2007/005874, published 11 January 2007)), a human anti-B7-H1 antibody.

Additional anti-PD-1 and anti-B7-H1 antibodies are disclosed in 2014/0044738, which is specifically incorporated by reference herein in its
10 entirety.

For anti-B7-DC antibodies see 7,411,051, 7,052,694, 7,390,888, and U.S. Published Application No. 2006/0099203.

Other exemplary PD-1 receptor antagonists include, but are not limited to B7-DC polypeptides, including homologs and variants of these, as well as active
15 fragments of any of the foregoing, and fusion proteins that incorporate any of these. In some embodiments, the fusion protein includes the soluble portion of B7-DC coupled to the Fc portion of an antibody, such as human IgG, and does not incorporate all or part of the transmembrane portion of human B7-DC.

The PD-1 antagonist can also be a fragment of a mammalian B7-H1, for
20 example from mouse or primate, such as a human, wherein the fragment binds to and blocks PD-1 but does not result in inhibitory signal transduction through PD-1. The fragments can also be part of a fusion protein, for example an Ig fusion protein.

Other useful polypeptides PD-1 antagonists include those that bind to the
25 ligands of the PD-1 receptor. These include the PD-1 receptor protein, or soluble fragments thereof, which can bind to the PD-1 ligands, such as B7-H1 or B7-DC, and prevent binding to the endogenous PD-1 receptor, thereby preventing inhibitory signal transduction. B7-H1 has also been shown to bind the protein B7.1 (Butte et al., *Immunity*, Vol. 27, pp. 111-122, (2007)). Such fragments also
30 include the soluble ECD portion of the PD-1 protein that includes mutations, such as the A99L mutation, that increases binding to the natural ligands (Molnar

et al., *PNAS*, 105:10483-10488 (2008)). B7-1 or soluble fragments thereof, which can bind to the B7-H1 ligand and prevent binding to the endogenous PD-1 receptor, thereby preventing inhibitory signal transduction, are also useful.

PD-1 and B7-H1 anti-sense nucleic acids, both DNA and RNA, as well as siRNA molecules can also be PD-1 antagonists. Such anti-sense molecules prevent expression of PD-1 on T cells as well as production of T cell ligands, such as B7-H1, PD-L1 and/or PD-L2. For example, siRNA (for example, of about 21 nucleotides in length, which is specific for the gene encoding PD-1, or encoding a PD-1 ligand, and which oligonucleotides can be readily purchased commercially) complexed with carriers, such as polyethyleneimine (see Cubillos-Ruiz et al., *J. Clin. Invest.* 119(8): 2231-2244 (2009), are readily taken up by cells that express PD-1 as well as ligands of PD-1 and reduce expression of these receptors and ligands to achieve a decrease in inhibitory signal transduction in T cells, thereby activating T cells.

b. CTLA4 antagonists

Other molecules useful in mediating the effects of T cells in an immune response are also contemplated as additional therapeutic agents. In some embodiments, the molecule is an antagonist of CTLA4, for example an antagonistic anti-CTLA4 antibody. An example of an anti-CTLA4 antibody contemplated for use in the methods of the invention includes an antibody as described in PCT/US2006/043690 (Fischkoff et al., WO/2007/056539).

Dosages for anti-PD-1, anti-B7-H1, and anti-CTLA4 antibody, are known in the art and can be in the range of, for example, 0.1 to 100 mg/kg, or with shorter ranges of 1 to 50 mg/kg, or 10 to 20 mg/kg. An appropriate dose for a human subject can be between 5 and 15 mg/kg, with 10 mg/kg of antibody (for example, human anti-PD-1 antibody) being a specific embodiment.

Specific examples of an anti-CTLA4 antibody useful in the methods of the invention are Ipilimumab, a human anti-CTLA4 antibody, administered at a dose of, for example, about 10 mg/kg, and Tremelimumab a human anti-CTLA4 antibody, administered at a dose of, for example, about 15 mg/kg. See also

Sammartino, et al., *Clinical Kidney Journal*, 3(2):135-137 (2010), published online December 2009.

In other embodiments, the antagonist is a small molecule. A series of small organic compounds have been shown to bind to the B7-1 ligand to prevent
5 binding to CTLA4 (see Erbe et al., *J. Biol. Chem.*, 277:7363-7368 (2002). Such small organics could be administered alone or together with an anti-CTLA4 antibody to reduce inhibitory signal transduction of T cells.

4. Potentiating Agents

In some embodiments, additional therapeutic agents include a
10 potentiating agent. The potentiating agent acts to increase efficacy the immune response up-regulator, possibly by more than one mechanism, although the precise mechanism of action is not essential to the broad practice of the present invention.

In some embodiments, the potentiating agent is cyclophosphamide.
15 Cyclophosphamide (CTX, Cytosan[®], or Neosar[®]) is an oxazaphosphorine drug and analogs include ifosfamide (IFO, Ifex), perfosfamide, trophosphamide (trofosfamide; Ixoten), and pharmaceutically acceptable salts, solvates, prodrugs and metabolites thereof (US patent application 20070202077 which is incorporated in its entirety). Ifosfamide (MITOXANA[®]) is a structural analog of
20 cyclophosphamide and its mechanism of action is considered to be identical or substantially similar to that of cyclophosphamide. Perfosfamide (4-hydroperoxycyclophosphamide) and trophosphamide are also alkylating agents, which are structurally related to cyclophosphamide. For example, perfosfamide alkylates DNA, thereby inhibiting DNA replication and RNA and protein
25 synthesis. New oxazaphosphorines derivatives have been designed and evaluated with an attempt to improve the selectivity and response with reduced host toxicity (Liang J, Huang M, Duan W, Yu XQ, Zhou S. Design of new oxazaphosphorine anticancer drugs. *Curr Pharm Des.* 2007;13(9):963-78. Review). These include mafosfamide (NSC 345842), glufosfamide (D19575,
30 beta-D-glucosylisophosphoramidate mustard), S-(-)-bromofosfamide (CBM-11), NSC 612567 (aldophosphamide perhydrothiazine) and NSC 613060

(aldophosphamide thiazolidine). Mafosfamide is an oxazaphosphorine analog that is a chemically stable 4-thioethane sulfonic acid salt of 4-hydroxy-CPA. Glufosfamide is IFO derivative in which the isophosphoramidate mustard, the alkylating metabolite of IFO, is glycosidically linked to a beta-D-glucose molecule. Additional cyclophosphamide analogs are described in US patent 5,190,929 entitled "Cyclophosphamide analogs useful as anti-tumor agents" which is incorporated herein by reference in its entirety.

While CTX itself is nontoxic, some of its metabolites are cytotoxic alkylating agents that induce DNA crosslinking and, at higher doses, strand breaks. Many cells are resistant to CTX because they express high levels of the detoxifying enzyme aldehyde dehydrogenase (ALDH). CTX targets proliferating lymphocytes, as lymphocytes (but not hematopoietic stem cells) express only low levels of ALDH, and cycling cells are most sensitive to DNA alkylation agents.

Low doses of CTX (< 200 mg/kg) can have immune stimulatory effects, including stimulation of anti-tumor immune responses in humans and mouse models of cancer (Brode & Cooke *Crit Rev. Immunol.* 28:109-126 (2008)). These low doses are sub-therapeutic and do not have a direct anti-tumor activity. In contrast, high doses of CTX inhibit the anti-tumor response. Several mechanisms may explain the role of CTX in potentiation of anti-tumor immune response: (a) depletion of CD4+CD25+FoxP3+ Treg (and specifically proliferating Treg, which may be especially suppressive), (b) depletion of B lymphocytes; (c) induction of nitric oxide (NO), resulting in suppression of tumor cell growth; (d) mobilization and expansion of CD11b+Gr-1+ MDSC. These primary effects have numerous secondary effects; for example following Treg depletion macrophages produce more IFN- γ and less IL-10. CTX has also been shown to induce type I IFN expression and promote homeostatic proliferation of lymphocytes.

Treg depletion is most often cited as the mechanism by which CTX potentiates the anti-tumor immune response. This conclusion is based in part by the results of adoptive transfer experiments. In the AB1-HA tumor model, CTX

treatment at Day 9 gives a 75% cure rate. Transfer of purified Treg at Day 12 almost completely inhibited the CTX response (van der Most et al. *Cancer Immunol. Immunother.* 58:1219-1228 (2009). A similar result was observed in the HHD2 tumor model: adoptive transfer of CD4+CD25+ Treg after CTX pretreatment eliminated therapeutic response to vaccine (Taieb, J. *J. Immunol.* 176:2722-2729 (2006)).

Numerous human clinical trials have demonstrated that low dose CTX is a safe, well-tolerated, and effective agent for promoting anti-tumor immune responses (Bas, & Mastrangelo *Cancer Immunol. Immunother.* 47:1-12 (1998)).

The optimal dose for CTX to potentiate an anti-tumor immune response, is one that lowers overall T cell counts by lowering Treg levels below the normal range but is subtherapeutic (see Machiels et al. *Cancer Res.* 61:3689-3697 (2001)).

In human clinical trials where CTX has been used as an immunopotentiating agent, a dose of 300 mg/m² has usually been used. For an average male (6 ft, 170 pound (78 kg) with a body surface area of 1.98 m²), 300 mg/m² is 8 mg/kg, or 624 mg of total protein. In mouse models of cancer, efficacy has been seen at doses ranging from 15 – 150 mg/kg, which relates to 0.45 – 4.5 mg of total protein in a 30g mouse (Machiels et al. *Cancer Res.* 61:3689-3697 (2001), Hengst et al *Cancer Res.* 41:2163-2167 (1981), Hengst *Cancer Res.* 40:2135-2141 (1980)).

For larger mammals, such as a primate, such as a human, patient, such mg/m² doses may be used but unit doses administered over a finite time interval may also be used. Such unit doses may be administered on a daily basis for a finite time period, such as up to 3 days, or up to 5 days, or up to 7 days, or up to 10 days, or up to 15 days or up to 20 days or up to 25 days, are all specifically contemplated by the invention. The same regimen may be applied for the other potentiating agents recited herein.

In other embodiments, the potentiating agent is an agent that reduces activity and/or number of regulatory T lymphocytes (T-regs), such as Sunitinib

(SUTENT[®]), anti-TGF β or Imatinib (GLEEVAC[®]). The recited treatment regimen may also include administering an adjuvant.

Useful potentiating agents also include mitosis inhibitors, such as paclitaxol, aromatase inhibitors (e.g. Letrozole) and angiogenesis inhibitors (VEGF inhibitors e.g. Avastin, VEGF-Trap) (see, for example, Li et al., Vascular endothelial growth factor blockade reduces intratumoral regulatory T cells and enhances the efficacy of a GM-CSF-secreting cancer immunotherapy. Clin Cancer Res. 2006 Nov 15; 12(22):6808-16.), anthracyclines, oxaliplatin, doxorubicin, TLR4 antagonists, and IL-18 antagonists.

10 **B. Reducing Immune Responses**

1. Immunosuppressive Agents

In some embodiments, the immune response, or inflammatory/autoimmune disease/disorder is treated by administering to the subject a LAIR-1 or LAIR-2 immunomodulatory agent and a second agent that is an immune suppressant. Immunosuppressive agents include, but are not limited to antibodies against other lymphocyte surface markers (e.g., CD40, alpha-4 integrin) or against cytokines), fusion proteins (e.g., CTLA-4-Ig (Orencia[®]), TNFR-Ig (Enbrel[®])), TNF- α blockers such as Enbrel, Remicade, Cimzia and Humira, cyclophosphamide (CTX) (i.e., Endoxan[®], Cytosan[®], Neosar[®], Procytox[®], Revimmune[™]), methotrexate (MTX) (i.e., Rheumatrex[®], Trexall[®]), belimumab (i.e., Benlysta[®]), or other immunosuppressive drugs (e.g., cyclosporin A, FK506-like compounds, rapamycin compounds, or steroids), anti-proliferatives, cytotoxic agents, or other compounds that may assist in immunosuppression.

The therapeutic agent can be a CTLA-4 fusion protein, such as CTLA-4-Ig (abatacept). CTLA-4-Ig fusion proteins compete with the co-stimulatory receptor, CD28, on T cells for binding to CD80/CD86 (B7-1/B7-2) on antigen presenting cells, and thus function to inhibit T cell activation. In another embodiment, the therapeutic agent is a CTLA-4-Ig fusion protein known as belatacept. Belatacept contains two amino acid substitutions (L104E and A29Y)

that markedly increase its avidity to CD86 *in vivo*. In another embodiment, the therapeutic agent is Maxy-4.

In another embodiment, the therapeutic agent is cyclophosphamide (CTX). Cyclophosphamide (the generic name for Endoxan®, Cytosan®, Neosar®, Procytox®, Revimmune™), also known as cytophosphane, is a nitrogen mustard alkylating agent from the oxazophorines group. It is used to treat various types of cancer and some autoimmune disorders.

Cyclophosphamide (CTX) is the primary drug used for diffuse proliferative glomerulonephritis in patients with renal lupus.

10 The therapeutic agent can be administered in an effective amount to reduce the blood or serum levels of anti-double stranded DNA (anti-ds DNA) auto antibodies and/or to reduce proteinuria in a patient in need thereof.

In another embodiment, the therapeutic agent increases the amount of adenosine in the serum, see, for example, WO 08/147482. For example, the second therapeutic agent can be CD73-Ig, recombinant CD73, or another agent (e.g., a cytokine or monoclonal antibody or small molecule) that increases the expression of CD73, see for example WO 04/084933. In another embodiment the therapeutic agent is Interferon-beta.

20 The therapeutic agent can be a small molecule that inhibits or reduces differentiation, proliferation, activity, and/or cytokine production and/or secretion by Th1, Th17, Th22, and/or other cells that secrete, or cause other cells to secrete, inflammatory molecules, including, but not limited to, IL-1 β , TNF- α , TGF-beta, IFN- γ , IL-18 IL-17, IL-6, IL-23, IL-22, IL-21, and MMPs. In another embodiment, the therapeutic agent is a small molecule that interacts with Tregs, enhances Treg activity, promotes or enhances IL-10 secretion by Tregs, increases the number of Tregs, increases the suppressive capacity of Tregs, or combinations thereof.

In some embodiments, the composition increases Treg activity or production. Exemplary Treg enhancing agents include but are not limited to glucocorticoid fluticasone, salmeterol, antibodies to IL-12, IFN- γ , and IL-4; vitamin D3, and dexamethasone, and combinations thereof.

30

In some embodiments, the therapeutic agent is an antibody, for example, a functions blocking antibody against a proinflammatory molecule such as IL-6, IL-23, IL-22 or IL-21.

As used herein the term “rapamycin compound” includes the neutral
 5 tricyclic compound rapamycin, rapamycin derivatives, rapamycin analogs, and
 other macrolide compounds which are thought to have the same mechanism of
 action as rapamycin (*e.g.*, inhibition of cytokine function). The language
 “rapamycin compounds” includes compounds with structural similarity to
 rapamycin, *e.g.*, compounds with a similar macrocyclic structure, which have
 10 been modified to enhance their therapeutic effectiveness. Exemplary
 Rapamycin compounds are known in the art (*See, e.g.* WO95122972, WO
 95116691, WO 95104738, U.S. Patent No. 6,015,809; 5,989,591; U.S. Patent
 No. 5,567,709; 5,559,112; 5,530,006; 5,484,790; 5,385,908; 5,202,332;
 5,162,333; 5,780,462; 5,120,727).

15 The language “FK506-like compounds” includes FK506, and FK506
 derivatives and analogs, *e.g.*, compounds with structural similarity to FK506,
e.g., compounds with a similar macrocyclic structure which have been modified
 to enhance their therapeutic effectiveness. Examples of FK506-like compounds
 include, for example, those described in WO 00101385. In some embodiments,
 20 the language “rapamycin compound” as used herein does not include FK506-
 like compounds.

2. Anti-inflammatories

Other suitable therapeutic agents include, but are not limited to, anti-
 inflammatory agents. The anti-inflammatory agent can be non-steroidal,
 25 steroidal, or a combination thereof. One embodiment provides oral
 compositions containing about 1% (w/w) to about 5% (w/w), typically about 2.5
 % (w/w) or an anti-inflammatory agent. Representative examples of non-
 steroidal anti-inflammatory agents include, without limitation, oxicams, such as
 piroxicam, isoxicam, tenoxicam, sudoxicam; salicylates, such as aspirin,
 30 disalcid, benorylate, trilisate, safapryn, solprin, diflunisal, and fendosal; acetic
 acid derivatives, such as diclofenac, fenclofenac, indomethacin, sulindac,

tolmetin, isoxepac, furofenac, tiopinac, zidometacin, acematacin, fentiazac, zomepirac, clindanac, oxepinac, felbinac, and ketorolac; fenamates, such as mefenamic, meclofenamic, flufenamic, niflumic, and tolfenamic acids; propionic acid derivatives, such as ibuprofen, naproxen, benoxaprofen,

5 flurbiprofen, ketoprofen, fenoprofen, fenbufen, indoprofen, piroprofen, carprofen, oxaprozin, pranoprofen, miroprofen, tiroxaprofen, suprofen, alminoprofen, and tiaprofenic; pyrazoles, such as phenylbutazone, oxyphenbutazone, feprazone, azapropazone, and trimethazone. Mixtures of these non-steroidal anti-inflammatory agents may also be employed.

10 Representative examples of steroidal anti-inflammatory drugs include, without limitation, corticosteroids such as hydrocortisone, hydroxyl-triamcinolone, alpha-methyl dexamethasone, dexamethasone-phosphate, beclomethasone dipropionates, clobetasol valerate, desonide, desoxymethasone, desoxycorticosterone acetate, dexamethasone, dichlorisone, diflorasone

15 diacetate, diflucortolone valerate, fluadrenolone, flucolorolone acetonide, fludrocortisone, flumethasone pivalate, fluosinolone acetonide, fluocinonide, flucortine butylesters, fluocortolone, fluprednidene (fluprednylidene) acetate, flurandrenolone, halcinonide, hydrocortisone acetate, hydrocortisone butyrate, methylprednisolone, triamcinolone acetonide, cortisone, cortodoxone,

20 flucetonide, fludrocortisone, difluorosone diacetate, fluradrenolone, fludrocortisone, difluorosone diacetate, fluradrenolone acetonide, medrysone, amcinafel, amcinafide, betamethasone and the balance of its esters, chloroprednisone, chlorprednisone acetate, clocortelone, clescincolone, dichlorisone, diflurprednate, flucoloronide, flunisolide, fluoromethalone,

25 fluperolone, fluprednisolone, hydrocortisone valerate, hydrocortisone cyclopentylpropionate, hydrocortamate, meprednisone, paramethasone, prednisolone, prednisone, beclomethasone dipropionate, triamcinolone, and mixtures thereof.

VI. AML Biomarkers

30 One embodiment provides a method for assessing or predicting the efficacy of a treatment using an anti-LAIR binding moiety by assaying the cells

of a subject in need of treatment to determine whether the cells express LAIR, binding partners of LAIR, or both. Exemplary cells to be assayed include, but are not limited to cancer cells obtained from the subjected. Exemplar cancer cells, include but are not limited to acute myeloid leukemia (AML) cells.

- 5 Cancer cells expressing multiple interacting inhibitory receptors are believed to respond better to treatments using anti-LAIR binding moieties. Exemplary LAIR binding partners include, but are not limited to transmembrane collagens (XIII, XVII and XXIII) and LILRB4. Figure 3 shows a predicted outcome of treatment based on the presence of LAIR-1 or binding partners of LAIR-1 on
- 10 cancer cells.

VII. Kits

- The disclosed LAIR-1 and LAIR-2 immunomodulatory agents can be packaged in a hermetically sealed container, such as an ampoule or sachette, indicating the quantity. The agent can be supplied as a dry sterilized lyophilized
- 15 powder or water free concentrate in a hermetically sealed container and can be reconstituted, e.g., with water or saline to the appropriate concentration for administration to a subject. For example, the agent can be supplied as a dry sterile lyophilized powder in a hermetically sealed container at a unit dosage of at least 5 mg, or at least 10 mg, at least 15 mg, at least 25 mg, at least 35 mg, at
- 20 least 45 mg, at least 50 mg, or at least 75 mg. The lyophilized agent can be stored at between 2 and 8°C in their original container and are typically administered within 12 hours, or within 6 hours, or within 5 hours, or within 3 hours, or within 1 hour after being reconstituted.

- In an alternative embodiment, agent supplied in liquid form in a
- 25 hermetically sealed container indicating the quantity and concentration. In some embodiments, the liquid form of the agent supplied in a hermetically sealed container including at least 1 mg/ml, or at least 2.5 mg/ml, at least 5 mg/ml, at least 8 mg/ml, at least 10 mg/ml, at least 15 mg/ml, at least 25 mg/ml, at least 50 mg/ml, at least 100 mg/ml, at least 150 mg/ml, at least 200 mg/ml of the agent.

- 30 Pharmaceutical packs and kits including one or more containers filled with agent are also provided. Additionally, one or more other prophylactic or

therapeutic agents useful for the treatment of a disease can also be included in the pharmaceutical pack or kit. The pharmaceutical pack or kit can also include one or more containers filled with one or more of the ingredients of the disclosed pharmaceutical compositions. Optionally associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration.

Kits designed for the above-described methods are also provided. Embodiments typically include one or more LAIR-1 and/or LAIR-2 immunomodulatory agents. In particular embodiments, a kit also includes one or more other prophylactic or therapeutic agents useful for the treatment of cancer, in one or more containers. In other embodiments, a kit also includes one or more anti-inflammatory agents useful for the treatment inflammatory and autoimmune diseases, in one or more containers.

Examples

Example 1: LAIR Antibodies and Heavy and Light Chains Sequences Thereof

Materials and Methods

20 *Mouse anti-human LAIR-1 monoclonal antibodies*

Mice were immunized with soluble human LAIR-1 (soluble LAIR-1 refers to the extracellular domain of LAIR-1) fused to a murine G2a Fc (SEQ ID NO:10). Mice were challenged with the same immunogen 2 weeks later. Mice received a 3rd dose of antigen two weeks later. Three days after the final boost, mouse splenocytes were harvested and resuspended in RPMI supplemented with 10% FBS and glutamine, and later fused to form hybridomas.

RACE

RACE (Rapid Amplification of cDNA Ends) identification of the heavy and light chains was performed according to the following protocol: (1) mRNA denaturing, (2) cDNA synthesis, (3) 5'RACE Reaction, (4) analyzed PCR results (on an agarose gel to visualize the amplified DNA fragment - the correct

antibody variable region DNA fragments should have a size between 500-700 base pairs, (5) TOPO cloned PCR positive bands; (6) PCR-amplified TOPO clones, followed by gel electrophoresis and recovery from agarose gel, (7) sequenced 218 clones in total, (8) performed CDR analysis using sequencing data (CDR regions were defined using VBASE2 available through vbase2.org).

Results

Antibodies were cloned using RACE methods. Antibody sequence analysis identified one variable heavy chain and one variable light chain for 13 antibody hybridomas referred to herein as 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b. The sequences are provided below and above. Heavy and light chain sequences and CDRs are provided above, below, and illustrated in Figures 1A and 1B.

1E11 SEQUENCES

1E11 VL Amino Acid Sequence

DIVMTQAAFSNPVTLGTSASISCRSSKSLHNSGITYLYWYLQKPGQSPQ
VLIYQMSSLASGVDPDRFSSSGSGTEFTLRISRVEAEDVGVYYCAQNLELP
LTFGAGTKLELK (SEQ ID NO:19)

CDR1 of 1E11 VL

The amino acid of CDR1 of 1E11 VL includes

RSSKSLHNSGITYLY (SEQ ID NO:20)

CDR2 of 1E11 VL

The amino acid of CDR2 of 1E11 VL includes

QMSSLAS (SEQ ID NO:21).

CDR3 of 1E11 VL

The amino acid of CDR3 of 1E11 VL includes

AQNLELPLT (SEQ ID NO:22).

1E11 VH Amino Acid Sequence

QVQLQQSGPELVKPGASVKLSCKASGYTFTSYDINWVKQRPGQGLEWI
GWIYPRDGSTKYNEKLKGKATLTVDTSRTAYMELHSLTSEDSAVYFC
ARGGYYDYDGYWGQGLTVTSA (SEQ ID NO:23)

CDR1 of 1E11 VH

The amino acid of CDR1 of 1E11VH includes
SYDIN (SEQ ID NO:24).

CDR2 of 1E11 VH

The amino acid of CDR2 of 1E11VH includes
5 WIYPRDGSTKYNEKLKG (SEQ ID NO:25).

CDR3 of 1E11 VH

The amino acid of CDR3 of 1E11VH includes
GGYYDYDGY (SEQ NO:26).

1G7 SEQUENCES

10 1G7 VL Amino Acid Sequence

DIQMTQSPASQSASLGESVTITCLASQTIGTWLAWYQQKPGKSPQLLIYA
ATSLADGVPSRFSGSGSGTKFSFKISLQAEDFVSYYCQQLYSTPLTFGA
GTKLELK (SEQ ID NO:27).

CDR1 of 1G7 VL

15 The amino acid of CDR1 of 1G7 VL includes
LASQTIGTWLA (SEQ ID NO:28).

CDR2 of 1G7 VL

The amino acid of CDR2 of 1G7 VL includes
AATSLAD (SEQ ID NO:29).

20 CDR3 of 1G7 VL

The amino acid of CDR3 of 1G7 VL includes
QQLYSTPLT (SEQ ID NO:30).

1G7 VH Amino Acid Sequence

EVQLVESGGGLVQPKGSLKLSAASGFTFNTNAMYWVRQAPGKGLEW
25 VARIRSKSSNYATYYADSVKDRFTISRDDSQSMLYLQMNNLKTEDTAR
YYCVRGGSGFFAYWGQGTLLTVSA (SEQ ID NO:31).

CDR1 of 1G7 VH

The amino acid of CDR1 of 1G7 VH includes
TNAMY (SEQ ID NO:32).

30 CDR2 of 1G7 VH

The amino acid of CDR2 of 1G7 VH includes

RIRSKSSNYATYYADSVKD (SEQ ID NO:33).

CDR3 of 1G7 VH

The amino acid of CDR3 of 1G7 VH includes
GGSGFFAY (SEQ ID NO:34).

5 **4B3 Sequences**

4B3 VL Amino Acid Sequence

DIVMKQSPSSLRVSAGEKVTMSCKSSQSLLNSGNQKNYLAWYQQKPGQ
PPKLLIYGASTRESGVPDRFTGSGSGTDFALTISSVQAEDLAVYYCQNDH
SYPFTFGSGTKLEIK (SEQ ID NO:35)

10 CDR1 of 4B3 VL

The amino acid of CDR1 of 4B3 VL includes
KSSQSLLNSGNQKNYLA (SEQ ID NO:36).

CDR2 of 4B3 VL

The amino acid of CDR2 of 4B3 VL includes

15 GASTRES (SEQ ID NO:37).

CDR3 of 4B3 VL

The amino acid of CDR3 of 4B3 VL includes
QNDHSYPFT (SEQ ID NO:38).

4B3 VH Amino Acid Sequence

20 QIQLQQSGAELARPGASVKLPCKASDYIFISYGLNWVRQTTGQGLEWIG
EIYPRSGHTYYNEKFKGKATLTADKSSSTAYMELRSLTSEDSAVYFCAR
RSVFYDYDKNGFDYWGQGTTLTVSS (SEQ ID NO:39).

CDR1 of 4B3 VH

The amino acid of CDR1 of 4B3 VH includes

25 SYGLN (SEQ ID NO:40).

CDR2 of 4B3 VH

The amino acid of CDR2 of 4B3 VH includes
EIYPRSGHTYYNEKFKG (SEQ ID NO:41).

CDR3 of 4B3 VH

30 The amino acid of CDR3 of 4B3 VH includes
RSVFYDYDKNGFDY (SEQ ID NO:42).

5A6 Sequences5A6 VL Amino Acid Sequence

DIQMTQSPSSLSASLGERVSFSCRASQDIGSSLNWLQQEPDGTIKRLIYAT
 SSLDSGVPKRFSGRSGSDYSLTISSESEDFVEYYCLQYDSFPYTFGGGT

5 KLEIK (SEQ ID NO:43).

CDR1 of 5A6 VL

The amino acid of CDR1 of 5A6 VL includes

RASQDIGSSLN (SEQ ID NO:44).

CDR2 of 5A6 VL

10 The amino acid of CDR2 of 5A6 VL includes

ATSSLDS (SEQ ID NO:45).

CDR3 of 5A6 VL

The amino acid of CDR3 of 5A6 VL includes

LQYDSFPYT (SEQ ID NO:46).

15 5A6 VH Amino Acid Sequence

QVQLQQSGAELARPGASVKLSCKASGYTFTSYGISWVKQRTGQGLEWI
 GEIYPRRGNTYYNEKFKGKATLTADKSSSTAYMELRSLTSEDSAVYFCA
 RQLFAYWGQGTTLTVSA (SEQ ID NO:47).

CDR1 of 5A6 VH

20 The amino acid of CDR1 of 5A6 VH includes

SYGIS (SEQ ID NO:48).

CDR2 of 5A6 VH

The amino acid of CDR2 of 5A6 VH includes

EIYPRRGNTYYNEKFKG (SEQ ID NO:49).

25 CDR3 of 5A6 VH

The amino acid of CDR3 of 5A6 VH includes

QLFAY (SEQ ID NO:50).

5E1 Sequences5E1 VL Amino Acid Sequence

DIQMTQTTSSLSASLGDRVTISCRASQDISNYLNWYQQKPDGTVKLLIYY
 TSRLHSGVPSRFSGSGSGTDYSLTISNLEQEDIATYFCQQGNTLPRTFGGG
 TKLEIK (SEQ ID NO:51).

CDR1 of 5E1 VL

- 5 The amino acid sequence for CDR1 of 5E1 VL includes
 RASQDISNYLN (SEQ ID NO:52).

CDR2 of 5E1 VL

The amino acid sequence for CDR2 of 5E1 VL includes
 YTSRLHS (SEQ ID NO:53).

- 10 CDR3 of 5E1 VL

The amino acid sequence for CDR3 of 5E1 VL includes
 QQGNTLPRT (SEQ ID NO:54).

5E1 VH Amino Acid Sequence

- EVQLQQSGPELVKPGASVKISCKASGYSFTGYFMNWVKQSPEKSLEWIG
 15 EIHPSTGSIIYNQKFKAKATLTIDKSSSTAYMQLKSLTSEDSAVYYCARFD
 YSNSFAYWGQGLTVSA (SEQ ID NO:55).

CDR1 for 5E1 VH

The amino acid sequence for CDR1 of 5E1 VH includes
 GYFMN (SEQ ID NO:56).

- 20 CDR2 for 5E1 VH

The amino acid sequence for CDR2 of 5E1 VH includes
 EIHPSTGSIIYNQKFKA (SEQ ID NO:57).

CDR3 for 5E1 VH

- The amino acid sequence for CDR3 of 5E1 VH includes
 25 FDYSNSFAY (SEQ ID NO:58).

6B2 Sequences

6B2 VL Amino Acid Sequences

- DIQMTQSPASQSASLGESVTITCLASQTIGTWLAWYQQKPGKSPQLLIYA
 ATSLADGVPSRFSGSGSGTKFSFKISLQAEDFVSYYCQQLYSTPLTFGA
 30 GTKLELK (SEQ ID NO:59).

CDR1 of 6B2 VL

The amino acid sequence of CDR1 for 6B2 VL includes
LASQTIGTWLA (SEQ ID NO:60).

CDR2 of 6B2 VL

The amino acid sequence of CDR2 for 6B2 VL includes
5 AATSLAD (SEQ ID NO:61).

CDR3 of 6B2 VL

The amino acid sequence of CDR3 for 6B2 VL includes
QQLYSTPLT (SEQ ID NO:62).

6B2 VH Amino Acid Sequences

10 EVQLVESGGGLVQPKGSLKLSCAASGFSFNINAMNWVRQAPGKGLEWV
ARIRSKSNYYETYYADSVKDRFTISRDDSESMVYLQMNNLKTEDTAMY
YCVRSLSWFVYWGQGLVTVSA (SEQ ID NO:63).

CDR1 for 6B2 VH

The amino acid sequence for CDR1 of 6B2 VH includes
15 INAMN (SEQ ID NO:64).

CDR2 for 6B2 VH

The amino acid sequence for CDR2 of 6B2 VH includes
RIRSKSNYYETYYADSVKD (SEQ ID NO:65).

CDR3 for 6B2 VH

20 The amino acid sequence for CDR3 of 6B2 VH includes
SLWVY (SEQ ID NO:66).

6F4 Sequences

6F4 VL Amino Acid Sequences

DIKMTQSPSSMYASLGERVTITCKASQDINSYLSWVQKPGKSPKTLIDR
25 ANRLVDGVPSRFSGSGSGQDYSLTISSEYEDMGIYYCLQYDEFPPYTFG
GGTKLEIK (SEQ ID NO:67).

CDR1 of 6F4 VL

The amino acid sequence of CDR1 for 6F4 includes
KASQDINSYLS (SEQ ID NO:68).

30 CDR2 of 6F4 VL

The amino acid sequence of CDR2 for 6F4 includes

RANRLVD (SEQ ID NO:69).

CDR3 of 6F4 VL

The amino acid sequence of CDR3 for 6F4 includes

LQYDEFPPYT (SEQ ID NO:70).

5 6F4 VH Amino Acid Sequences

QVQLQQSGAELAKPGASVKLSCKASGYTFTSYWMHWVKQRPGQGLE
WIGYINPFSGHTKYNQKFKDKATLTADKSSSTAYMQLSSLTYEDSAVYY
CARNFDQWGQGTTTLTVSS (SEQ ID NO:71).

CDR1 for 6F4 VH

10 The amino acid sequence for CDR1 of 6F4 VH includes
SYWMH (SEQ ID NO:72).

CDR2 for 6F4 VH

The amino acid sequence for CDR2 of 6F4 VH includes
YINPFSGHTKYNQKFKD (SEQ ID NO:73).

15 CDR3 for 6F4 VH

The amino acid sequence for CDR3 of 6F4 VH includes
NFDQ (SEQ ID NO:74).

6G6 Sequences

6G6 VL Amino Acid Sequences

20 DIVMTQSHKFMSTSVGDRVSITCKASQNVGTAVAWYQQKPGQSPKLLI
YWASIRHTGVPDRFTGSGSGTDFLTISNVQSEDLADYFCQQYSSHPYTF
GGGTKLEIK (SEQ ID NO:75).

CDR1 for 6G6 VL

The amino acid sequence for CDR1 of 6G6 VL includes
25 KASQNVGTAVA (SEQ ID NO:76).

CDR2 for 6G6 VL

The amino acid sequence for CDR2 of 6G6 VL includes
WASIRHT (SEQ ID NO:77).

CDR3 for 6G6 VL

30 The amino acid sequence for CDR3 of 6G6 VL includes
QQYSSHPYT (SEQ ID NO:78).

G6G VH Amino Acid Sequences

EVQLQQSGPELVKPGASVKISCKASGYTFTTYMNVVKQSHGKSLEWI
GNINPDNGITSYNQKFKGKATLTVDKSSSTAYMELRSLTSEDSAVYYCA
RGKSLAYWGQGTLLTVSA (SEQ ID NO:79).

5 CDR1 for 6G6 VH

The amino acid sequence for CDR1 of 6G6 VH includes
TTYMN (SEQ ID NO:80).

CDR2 for 6G6 VH

The amino acid sequence for CDR2 of 6G6 VH includes
10 NINPDNGITSYNQKFKG (SEQ ID NO:81).

CDR3 for 6G6 VH

The amino acid sequence for CDR3 of 6G6 VH includes
GKSLAY (SEQ ID NO:82).

7G3 Sequences15 7G3 VL Amino Acid Sequences

DIVMTQAAFSNPVTLGTSASISCRSSKSLHNSGITYLYWYLQKPGQSPQ
VLIYQMSNLA SGVPDRFSSSGSGTEFTLRISRVEAEDVGVYYCAQNLEFP
LTFGAGTKLELK (SEQ ID NO:83).

CDR1 for 7G3 VL

20 The amino acid sequence for CDR1 of 7G3 VL includes
RSSKSLHNSGITYLY (SEQ ID NO:84).

CDR2 for 7G3 VL

The amino acid sequence for CDR2 of 7G3 VL includes
QMSNLA (SEQ ID NO:85).

25 CDR3 for 7G3 VL

The amino acid sequence for CDR3 of 7G3 VL includes
AQNLEFPLT (SEQ ID NO:86).

7G3 VH Amino Acid Sequences

QVQLQQSGPELVKPGASVKLSCKASGYTFTTYDINWVKQRPQGLEWI
30 GWIYPRDGTTKYNEKFKGKATLTVDTSSSTAYMELHSLTSEDSAVYFCA
RGGYYDYDGYWGQGTLLTVSA (SEQ ID NO:87).

CDR1 for 7G3 VH

The amino acid sequence for CDR1 of 7G3 VH includes
TYDIN (SEQ ID NO:88).

CDR2 for 7G3 VH

5 The amino acid sequence for CDR2 of 7G3 VH includes
WIYPRDGTTKYNEKFKG (SEQ ID NO:89).

CDR3 for 7G3 VH

The amino acid sequence for CDR3 of 7G3 VH includes
GGYYDYDGY (SEQ ID NO:90).

10 **9H6 Sequences**9H6 VL Amino Acid Sequences

DIQMTQSPASQSASLGESVTITCLASQTIGTWLAWYQQKPGRSPQLLIYA
ATSLADGVPSRFGSGSGTKFSFKINSLQAEDFVSYQCQLYSTPFTFGS
GTKLEIK (SEQ ID NO:91).

15 CDR1 for 9H6 VL

The amino acid sequence for CDR1 of 9H6 VL includes
LASQTIGTWLA (SEQ ID NO:92).

CDR2 for 9H6 VL

The amino acid sequence for CDR2 of 9H6 VL includes
20 AATSLAD (SEQ ID NO:93).

CDR3 for 9H6 VL

The amino acid sequence for CDR3 of 9H6 VL includes
QQLYSTPFT (SEQ ID NO:94).

9H6 VH Amino Acid Sequences

25 EVQLVESGGGLVQPKGSLKLSAASGFSFNTHAMNWVRQAPGKGLEW
VARIRTKSNNYATYYADSVKDRFIISRDDSENMVYLMNNLKTEDTAIY
YCVRLRGGFLDYWGQGTTLTVSS (SEQ ID NO:95).

CDR1 of 9H6 VH

The amino acid sequence for CDR1 of 9H6 VH includes
30 THAMN (SEQ ID NO:96).

CDR2 of 9H6 VH

The amino acid sequence for CDR2 of 9H6 VH includes
RIRTKSNYYATYYADSVKD (SEQ ID NO:97).

CDR3 of 9H6 VH

The amino acid sequence for CDR3 of 9H6 VH includes
5 LRGGFLDY (SEQ ID NO:98).

11B3 Sequences

11B3 VL Amino Acid Sequences

DIQMAQSSSSFSVSLGDRVTTITCKASEDIYIRLAWYQQKPGNAPRLLISTA
TSLETGVPSRFSGSGSGKDYTLSTLSLQTEDVATYYCQQYWSTPYTFGGG
10 TRLEIK (SEQ ID NO:99).

CDR1 of 11B3 VL

The amino acid sequence for CDR1 of 11B3 VL includes
KASEDIYIRLA (SEQ ID NO:100).

CDR2 of 11B3 VL

15 The amino acid sequence for CDR2 of 11B3 VL includes
TATSLET (SEQ ID NO:101).

CDR3 of 11B3 VL

The amino acid sequence for CDR3 of 11B3 VL includes
QQYWSTPYT (SEQ ID NO:102).

20 11B3 VH Amino Acid Sequences

EVQLVESGGGLVQPKGSLKLSAASDFTFNTYAMHWVRQAPGKGLEW
VARIRTKSNYYATYYADSVKDRTISRDDSQSMLYLQMNNLTEDTAM
YYCVRDRYGGAMDYWGQGTSVTVSS (SEQ ID NO:103)

CDR1 for 11B3 VH

25 The amino acid sequence for CDR1 of 11B3 VH includes
TYAMH (SEQ ID NO:104).

CDR2 for 11B3 VH

The amino acid sequence for CDR2 of 11B3 VH includes
RIRTKSNYYATYYADSVKD (SEQ ID NO:105).

30 CDR3 for 11B3 VH

The amino acid sequence for CDR3 of 11B3 VH includes

DRYGGAMDY (SEQ ID NO:106).

12E10a Sequences

Clone 12E10 was found to have two light chains (12E10a and 12E10b). mb

12E10a VL Amino Acid Sequences

- 5 DIVMTQSQKFMSTSVGDRVSITCKASQNVRSAAVAWYQQKPGQSPKTLIY
LASNRHTGVPDRFTGSGSGTDFLTISNVQSEDLADYFCLQHWNYPLTF
GAGTKLELK (SEQ ID NO:107).

CDR1 of 12E10a VL

The amino acid sequence of CDR1 of 12E10a VL includes

- 10 KASQNVRSAAVA (SEQ ID NO:108).

CDR2 of 12E10a VL

The amino acid sequence of CDR2 of 12E10a VL includes

LASNRHT (SEQ ID NO:109).

CDR3 of 12E10a VL

- 15 The amino acid sequence of CDR3 of 12E10a VL includes
LQHWNYPLT (SEQ ID NO:110).

12E10(a and b) VH Amino Acid Sequences

- QVQLQQSGAELARPGTSVKLSCKASGYTFTSCGLSWVKQRTGQGLEWI
GEIYPSNGNSYYSDKVKDKATLTADKSSSTAYMELRSLTSEDSAVYFCA
20 RAYYTNGYYAMDYWGQGTSTVTVSS (SEQ ID NO:111).

CDR1 of 12E10 VH

The amino acid sequence of CDR1 for 12E10 VH includes

SCGLS (SEQ ID NO:112).

CDR2 of 12E10 VH

- 25 The amino acid sequence of CDR2 for 12E10 VH includes
EIYPSNGNSYYSDKVKD (SEQ ID NO:113).

CDR3 of 12E10 VH

The amino acid sequence of CDR3 for 12E10 VH includes

AYYTNGYYAMDY (SEQ ID NO:114).

- 30 12E10b VL Amino Acid Sequences

DIVLTQSPATLSVTPGDSVSLSCRASQSSISNNLHWYQQKSHESPRLLIKY
 ASQSISGIPSRFSGSGSGTDFTLINSVETEDFGMYFCQQSNSWPLTFGAG
 TKLELK (SEQ ID NO:115).

CDR1 for 12E10b VL

5 The amino acid sequence for CDR1 of 12E10b VL includes
 RASQSISNNLH (SEQ ID NO:116).

CDR2 for 12E10b VL

The amino acid sequence for CDR2 of 12E10b VL includes
 YASQSIS (SEQ ID NO:117).

10 CDR3 for 12E10b VL

The amino acid sequence for CDR3 of 12E10b VL includes
 QQSNSWPLT (SEQ ID NO:118).

Example 2: Purification of LAIR-2 Fc

Methods and Materials

15 LAIR-2 hIgG1 (hereafter termed LAIR-2 Fc) was generated by using
 CHOK1SV KO parent lines transfected with the Lonza GS Vector. This cell
 line was used to express both the lead candidate, LAIR-2 hIgG1 (native IgG1),
 and a mutated Fc versions LAIR2-hIgG1 Fc (L145A/L146A). LAIR-2 Fc was
 purified by protein A chromatography and assessed by SDS-PAGE (Figure 6A)
 20 and Size-Exclusion chromatogram for purity (Figure 6B). LAIR-1 Fc was
 prepared similarly as a control LAIR-2 Fc was purified by size-exclusion
 chromatography and visualized using SDS PAGE.

Results

Figure 6A is an SDS-PAGE gel showing LAIR-2 Fc under reducing and
 25 non-reducing conditions. Figure 6B is a chromatogram showing a single, major
 peak at 38.550 minutes. The data confirm the expected size of LAIR-2 Fc, and
 the high level of purity of the LAIR-2 Fc protein used in studies described here.

Example 3: LAIR-2Fc binds to collagen

Materials and Methods

30 K562 AML cell line with stable expression of collagen 17 or controls
 lacking collagen 17 were stained with 1 ug of LAIR-2 Fc and LAIR-1 Fc,

incubated for 30 minutes on ice, followed by washing of cells in FACS buffer (PBS + 1% FBS), then stained with 0.05 ug anti-hIgG-PE for 30 minutes on ice. Cells were washed, resuspended in FACS fixing buffer (3% paraformaldehyde in PBS) and assessed by flow cytometry.

5 **Results**

LAIR-2 Fc (Figures 7A and 7B) and LAIR-1 Fc (Figures 7C and 7D) functionality was assessed by ability to bind endogenous transmembrane ligand collagen 17 expressed on the surface of K562 cells. SDS-PAGE analysis of LAIR-2 Fc and LAIR-1 Fc was used to assess purity of proteins used in this and
10 following studies (Figures 7E and 7F). Greater than 95% purity of LAIR-2 Fc and LAIR-1 Fc was standard for all data shown here.

Example 4: LAIR-1 expression on AML cell lines and LAIR-1 Fc and LAIR-2 Fc binding

Methods and Materials

15 Jurkat T cells, K562 Col 17 cells, and THP-1 cells were stained with 10 mg/mL anti-LAIR-1-PE (eBioscience, NKTA255) or with 10 mg/mL Biotinylated LAIR-1 Fc or LAIR-2 Fc following blockade of Fc receptors with TruStain FcX (Biolegend) and hIgG (Innovative Research). After 30 minutes incubation, cells were washed with FACS buffer and stained with 0.4 ug/mL
20 Streptavidin-PE. Expression was assessed by flow cytometry.

Results

LAIR-1 is confirmed to be highly expressed on specific AML cells lines. LAIR-2 Fc binds to unknown molecules on the surface of specific AML cell lines, whereas LAIR-1 Fc binding was not observed.

25 In order to assess cell lines useful for in vitro assays, hematopoietic-derived AML cell lines were assessed for LAIR-1 expression, as well as potential binding by LAIR-2 Fc and LAIR-1 Fc binding (Figures 8A-8I).

Figures 8A-8I are histograms of flow cytometry of the indicated cell line treated with anti-LAIR-1, LAIR-1 Fc, or LAIR-2 Fc. Figures 8A-8C show
30 Jurkat cells treated with anti-LAIR-1, LAIR-1 Fc, and LAIR-2 Fc, respectively.

Figures 8D-8F show K562 Col 17 cells treated with anti-LAIR-1, LAIR-1 Fc, and LAIR-2 Fc, respectively.

Figures 8G-8I show THP-1 cells treated with anti-LAIR-1, LAIR-1 Fc, and LAIR-2 Fc, respectively.

5 As indicated, Jurkat T cells, a T cell leukemia, and THP-1 cells, a monocytic leukemia, both expressed high levels of LAIR-1, whereas K562 cells do not. Furthermore, LAIR-2 Fc bound to THP-1 cells, as well as the positive control K562-collagen 17 expressing cells, but not Jurkat T cells. From these results Jurkat T cells and THP-1 cells transduced with signaling pathway
10 reporters were selected for in vitro studies.

Example 5: LAIR-2 Fc induces NF- κ B and NFAT signaling in Jurkat T cells.

Materials and Methods

96-well flat-bottom plates were coated with titrated amounts of anti-CD3
15 (OKT3) overnight followed by aspiration prior to addition of cells. Jurkat T cells with NF- κ B-GFP pathway reporter were plated at 50,000 cells/well/200 μ l RPMI-C in the presence of 10 μ g/ml LAIR-2 Fc, control Fc or without proteins. Cells were cultured 1 day. Cell were harvested from plates and assessed for GFP expression by flow cytometry.

20 Jurkat T cells with an NFAT pathway reporter were cultured in the presence of 0.5 μ g/mL coated anti-CD3 and titrated amounts of soluble LAIR-2 Fc or control Fc. At approximately 24 hours, supernatants were assessed for secreted Lucia levels according to protocol (Invivogen). Readings were recorded with a Perkin-Elmer Envision plate reader.

25 Supernatants from Jurkat-NFAT-Lucia T cells treated with 10 μ g/ml LAIR-2 Fc or control Fc were assessed for IL-2 and TNF levels by MSD cytokine analysis.

Results

In vitro assays indicate that LAIR-2 Fc is capable of inducing activity in
30 hematopoietic derived leukemia cell lines. Jurkat T cells with an NF- κ B-GFP pathway reporter were cultured with titrated concentrations of coated anti-CD3

in the presence of 10 ug/ml of LAIR-2 Fc, control Fc, or media control and assessed for NF-kB induction by analysis of percent GFP+ cells by flow cytometry (Figure 9A). This assay shows that LAIR-2 Fc promotes the induction of NF-kB signaling in Jurkat T cells. This effect occurs without appreciable binding of LAIR-2 Fc to Jurkat T cells, thus indicating that LAIR-2 Fc acts as a decoy for ligand binding to LAIR-1 expressed on the plasma membrane of Jurkat T cells.

Using a second Jurkat T cell line with an NFAT-Lucia pathway reporter, it was demonstrated that NFAT was induced in a LAIR-2 Fc dose dependent manner in the presence of a set concentration of anti-CD3 (Figure 9B)

Supernatants from Jurkat T cells in the NFAT reporter assay in the presence of 10 ug/ml of LAIR-2 Fc or control Fc were tested for IL-2 and TNF cytokine levels (Figures 9C and 9D). LAIR-2 Fc cultured Jurkat T cells displayed higher levels of both cytokines, consistent with pathway reporter induction. Because LAIR-2 Fc was not shown to bind directly to Jurkat T cells, it is posited that LAIR-2 Fc is disrupting LAIR-1 interactions with a soluble factor, or disruption of LAIR-1 inhibitory signaling through other mechanisms in order to enhance Jurkat reporter activity.

Example 6: LAIR-2 Fc binds to THP-1 cells and induces reporter activity.

Materials and Methods

0.1 ug/ml of biotinylated LAIR-2 Fc were added to THP-1 cells on ice following Fc receptor blockade with TruStain FcX (Biolegend) and hIgG (Innovative Research). Cells were subsequently washed with FACS buffer, and stained with 0.4 ug/mL Streptavidin-PE secondary (Biolegend) for 30 minutes on ice. Cells were washed, fixed and analyzed by flow cytometry.

THP-1 cells were added to 96-well flat bottom plates at 50,000 cells/well. 1 ug/ml final concentration of LPS, or RPMI-complete media, was added followed by 10 ug/ml final concentration of LAIR-2 Fc or control Fc. All wells contained a final volume of 200 ul. Cells were incubated for indicated number of days followed by analysis of supernatant for secreted Lucia according

to protocol (Invivogen). Readings were performed using a Perkin-Elmer Envision plate reader.

Results

THP-1 pathway reporter cells also assessed for response in the presence
5 of LAIR-2 Fc or control Fc. Interestingly, it was found that in addition to
LAIR-1 expression, LAIR-2 Fc binds to THP-1 cells in a dose dependent
fashion (Figure 10A). This is likely because THP-1 cells express
transmembrane collagens (data not shown) that are known LAIR-2 ligands.
THP-1 cells were culture with or without a Toll-Like Receptor ligand, LPS, that
10 is known to induce the Interferon pathway in THP-1 cells. In the presence of
LPS and LAIR-2 Fc, Interferon Regulatory Factor (IRF) induction was
significantly increased in comparison to LPS with control Fc (Figure 10B).
Moreover, LAIR-2 Fc was capable of inducing interferon signaling induction
even in the absence of LPS, showing a direct effect on THP-1 cells without the
15 need for cosignaling (Figure 10C). The mechanism of action is likely blockade
of LAIR-1 binding to transmembrane collagens, as it remains unlikely that
LAIR-2 Fc can induce signaling through transmembrane collagens.

Example 7: LAIR-2 Fc enhances primary T cell proliferation.

Materials and Methods

20 Pan T cells including CD4+ and CD8+ T cells were isolated from healthy
donor PBMCs. CD4+ T cells and CD8+ T cells were isolated from total
PBMCs by MACS magnetic bead enrichment (Miltenyi), labeled with 1 uM
CFSE (LifeTechnologies) and added to 96-well plates precoated with titrated
amounts of anti-CD3 (OKT3) overnight at 4 degrees. LAIR-2 Fc or control Fc
25 was added at 10 ug/ml and cells were culture for 72 hours followed by analysis
by flow cytometry. For flow cytometric analysis of specific T cell subsets, cells
were stained with anti-CD4 and anti-CD8 mAbs. CD4 and CD8 T cell subsets
were thus gated and assessed for CFSE dilution as a measure of proliferation.

30

Results

LAIR-2 Fc was next assessed for effects on primary human T cells. Results indicate increased proliferation by both CD4+ T cells and CD8+ T cells in the presence of LAIR-2 Fc (Figures 11A and 11B).

5 **Example 8: LAIR-2 Fc does not bind directly to human PBMC cell subsets.**

Material and Methods

Fresh human PBMCs from three normal healthy donor were stained with CD3+CD4+ T cells, CD3+CD8+ T cells, CD3-CD16+CD56+ NK cells, and CD14+ monocytes, and analyzed with flow cytometry.

10 **Results**

In order to determine if this effect was due to direct binding of LAIR-2 Fc to T cells, healthy donor PBMCs were stained with LAIR-2 Fc. Figures 12A-12D show CD4, CD8, NK cells, and monocytes respectively from Donor 1710 treated with LAIR-2 Fc. Figures 12E-12H show CD4, CD8, NK cells, and monocytes respectively from Donor 1711 treated with LAIR-2 Fc. Figures 12I-12L show CD4, CD8, NK cells, and monocytes respectively from Donor 1712 treated with LAIR-2 Fc.

The data show that LAIR-2 Fc did not bind directly to human T cells. Moreover, LAIR-2 Fc does not appear to bind any PBMC cell subsets at substantial levels. As such, it is likely that LAIR-2 Fc is disrupting LAIR-1 interaction with LAIR ligands present or expressed in this culture system. These findings also suggest that LAIR-2 Fc should not have any effect on hematopoietic cell depletion *in vivo*, while cells expression transmembrane LAIR ligands could potentially be depleted or directly affected in other ways yet to be investigated.

25 **Example 9: LAIR-2 Fc promotes antigen-specific CD8+ T cell expansion *in vivo*.**

Materials and Methods

CD8+ T cells that are specific for a model antigen, chicken egg ovalbumin (OVA), in the context of murine C57BL/6 MHC class I (H-2Kb) were used. The CD8+ OT-I T cells recognize the OVA peptide SIINFEKL(SEQ

ID NO:119) when bound to H-2Kb. In the presence of adjuvant, OT-I T cells undergo an expansion phase, followed by a contraction phase. OVA and polyI:C adjuvant were used to determine if OT-I expansion was increased and/or whether contraction was delayed.

5 The experimental design is illustrated in Figure 13A. Ten mice/group were treated on day -2 and 5 with 500 ug of control Fc or LAIR-2 Fc. On day 0, CD8⁺ T cells were isolated from OT-I x Ly5.1 F1 mice by MACS separation (Miltenyi) and 2e5 cells were injected ip. On day 1, 100 ug of SIINFEKL (SEQ ID NO:119) peptide (Peptides International) and 150 ug of polyI:C adjuvant
10 (Invivogen) were injected ip in a total volume of 300 ul/mouse. Mice were bled on day 0 prior to immunization, and on days 1, 3, 5, 7, 10 and 14 and OT-I T cells in blood were analyzed by flow cytometry by gating on TCR Vbeta2+CD8⁺ T cells and Ly5.1 (CD45.1).

Results

15 LAIR-2 Fc was next tested *in vivo* to determine whether LAIR-2 Fc would enhance antigen-specific T cell responses. Figure 13B shows that the percentage of OT-I of total CD8⁺ T cells increases significantly by day 5 relative to control Fc. Results indicate that OT-I T cells undergo significantly enhanced expansion in the presence of LAIR-2 Fc in comparison to mice treated
20 with control Fc (Figure 13B). These results are directly relevant to OVA expressing tumor models to assess tumor antigen specific T cell responses.

Example 10: LAIR-2 Fc treated mice have significantly improved antigen-specific recall response.

Materials and Methods

25 At ~10 weeks after initial expansion, mice were challenged with equal numbers (1e6 each) of CD45.1 splenocytes either loaded with OVA peptide (CFSE hi) or without peptide (CFSE lo). 48 hours later, mice were euthanized and splenocytes were assessed by flow cytometry for ratio of unloaded vs OVA loaded splenocytes as a measure of OT-I mediated antigen-specific memory
30 CTL killing activity.

Results

Mice from the OT-I expansion experiment (Example 9) were rested for ~10 weeks and then assessed for antigen-specific memory CTL recall responses to determine if LAIR-2 Fc enhanced expansion translated into an enhanced functional recall response illustrated by CTL killing of antigen loaded splenocytes.

Non-injected controls were assessed for CFSE peak gating and starting ratio (Figure Figures 14A to 14C). Representative examples of CFSE hi to lo ratios in each group are shown in Figures 14D to 14F. Results show that mice treated with LAIR-2 Fc during initial expansion of OT-I T cells (note that no treatment was administered during recall response) have a significantly better recall response calculated as specific lysis of OVA loaded splenocytes (Figure 14C).

Example 11: LAIR-2 Fc controls 1D8-OVA ovarian cancer growth and prolongs survival.

Materials and Methods

C57BL/6 mice were injected ip with 5e6 ID8-OVA cells, followed by ip injection 3 weeks later with 1e6 CD8+ OT-I T cells. Mice were then treated with LAIR-2 Fc or control Fc starting one day after OT-I transfer and every four days for a total of 5 treatments. Weight gain was monitored every 2-3 days. To assess survivability, mice were euthanized when ascites production was observed and mice had a 50% increased from starting weight. Figure 15A is a diagram of an exemplary treatment regimen 5e6 ID8-OVA tumor cells were ip injection on day 0.

Results

Whether an improved antigen-specific T cell response mediated by LAIR-2 Fc treatment translated into an improved anti-tumor immunity using an OVA-expressing tumor model and OT-I T cells was investigated. It was previously determined that OT-I T cells transferred 3 weeks after tumor inoculation are not protective and that OT-I T cells develop a dysfunctional, or exhausted phenotype. Therefore, this is a useful model to determine

immunotherapeutics can promote antigen-specific T cell responses and/or reverse/prevent exhaustion from occurring.

Results showed significantly delayed weight gain and significantly increase in long-term survival (Figures 15B and 15C). 60% of mice survived
5 long-term in comparison to 20% of controls suggestion a significant overall cure with LAIR-2 Fc (Figure 15C).

Example 12: LAIR-2 Fc with anti-PD-1 is an effective combination immunotherapy in ovarian cancer.

Materials and Methods

10 Mice were treated as in Figure 15A except that more (6e6) ID8-OVA tumor cells were ip injected on day 0, and fewer OT-I T cells (5e5) were adoptively transferred at 3 weeks. Treatment of 200 ug of LAIR-2 Fc or control Fc began one day after T cell transfer and every 4 days for a total of 5 doses. Mice weight was monitored every 2-3 days, and mice were euthanized when
15 ascites production was observed and mice had a 50% increased from starting weight.

Results

LAIR-2 Fc alone in comparison to anti-PD-1 immunotherapy and Cisplatin chemotherapy, as well as in combination with PD-1 and Cisplatin was
20 investigated to examine synergistic effects (Figure 16). Results show a modest effect with LAIR-2 Fc alone in this model. However, the best response observed was with a combination of LAIR-2 Fc and anti-PD-1, with 50% of mice surviving past day 13 weeks. No mice in other single or combo therapies survived to 13 weeks.

25 **Example 13: LAIR-2 Fc delays tumor growth and increases survival in a subcutaneous lymphoma model.**

Materials and Methods

4e5 A20 tumor cells were implanted subcutaneous (sc) on day 0. 200 ug of LAIR-2 Fc or control Fc was administered ip beginning on day 4 and every 4
30 days for 5 treatments. Tumor growth was monitored and measure 2-3 times/week and mice were sacrificed when average tumor diameter reached 15

mm or 2000 mm³. Figure 17A is an exemplary treatment regimen using the A20 tumor model.

Results

Results show that tumor growth was significantly delayed (Figure 17B).

- 5 Additionally, there was a significant extension of survival, with one animal remaining tumor free long-term (Figure 17C).

Example 14. Generation, selection and characterization of LAIR-1 mAbs.

Materials and Methods

- Immunization, Fusion and cloning of anti-human LAIR-1 mAbs was
 10 performed with service from Precision Antibody CRO. NextCure produced human LAIR-1 mG2a Fc fusion protein for immunization and boosting of five SJL strain mice at Precision Antibody. Electrofusion was performed with splenocytes and lymph nodes from two mice with high titer. Approximately 1200 hybridoma clones were screened by ELISA for binding to human LAIR-1
 15 hG1 Fc fusion protein, and by flow cytometry for binding to AML tumor cell lines that express endogenous LAIR-1 (Jurkat, HL-60).

- Anti-human LAIR-1 hybridoma clone supernatants were incubated with cell lines known to express LAIR-1 (HL-60, MV-4-11), A cell line negative for LAIR-1 that was transfected for LAIR-1 (K562-LAIR-1) to test for specificity,
 20 and a cell line known to be negative for LAIR-1 expression (U266B1). Briefly, 50 ul of supernatant was incubated with 1e5 cells in 96-well round bottom plates for 30 minutes. Cells were washed with FACS buffer (PBS+1% FBS), and stained with 0.05 ug anti-mouse IgG-PE secondary antibody (Ab) for 30 minutes. Cells were washed and fixed in 100 ul 3% paraformaldehyde in PBS
 25 for flow cytometry analysis. Data shown is the percentage of cells staining above background media + secondary staining control (last column).

Results

Results are shown for the final 15 selected clones (Figure 18).

- Supernatants from hybridomas have differential levels of binding to specific cell
 30 types. This may be due to varying levels of mAbs in cell supernatant, or varying strength (avidity) of binding to LAIR-1 on the plasma membrane. However,

because some supernatants bound at higher levels to LAIR-1 on certain cell types, it remains possible that LAIR-1 mAb clones are binding to specific glycoforms or otherwise modified forms of LAIR-1 on tumor cell lines.

- 5 In the following sequences, bold and underlined text represents the leader sequence. In some embodiments, the leader sequence is removed.

Sequences for chimeric 1E11:

hG1 HC

The amino acid sequence for hG1 heavy chain is

- 10 MEWSWVFLFFLSVTTGVHSQVQLQQSGPELVKPGASVKLSCKASGYTFTSYDINWVKQRP
GQGLEWIGWIYPRDGSTKYNEKLKGKATLTVDTSSTAYMELHSLTSEDSAVYFCARGGY
YDYGWYGQGLTVSAASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTWSNS
GALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSC
DKTHTCPPCPAPPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVD
15 GVEVHNAKTKPREEQYNSTYRVVSVLTVHLQDNLNGKEYKCKVSNKALPAPIEKTISKAK
GQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDS
DGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPG* (SEQ ID NO: 120)

The nucleic acid sequence for hG1 heavy chain is

- 20 atggaatggtcctcctgggtgttccctgttcttccctgtctgtgaccaccggcggtgcactctcag
gttcagttgcagcagctctggccctgagcttgtgaaacctggcgctctgtgaagctgtct
tgcaaggcctctggtacaccttcaccagctacgacatcaactgggtcaagcagaggcct
ggacagggactcgagtggatcggtggatctacctagagatggctccaccaagtacaac
25 gagaagctgaagggaagctacctgaccgtggacacctctctcgaccgcttacatg
gaactgcactccctgacctctgaggactccgctgtacttttgtgccagaggcggtac
tacgactacgatggctattggggacagggcacctgggtcacagtgtctgtctcttacc
aaggggcccctccgtgttccctctggccccttcagcaagtctacctctggcggaacagcc
gctctgggctgcctcgtgaaggactacttccccgagcctgtgaccgtgtcctggaactct
30 ggcgctctgacatccggcggtgcacaccttccctgctgtgctgcagtcctccggcctgtac
tccctgtcctccgtcgtgaccgtgccttccagctctctgggcaaccagacctacatctgc
aacgtgaaccacaagccctccaacaccaagggtggacaagaagggtggaaccaagtctctgc
gacaagaccacacctgtccccctgtcctgcccctgaactgctgggcggaccacagcgtg
ttcctgttcccccaagcccaaggacacctgatgatctccggacccccgaagtgaac
35 tgcgtggtggtggatgtgtcccaaggagacctgaagtgaagttcaattggtacgtggac

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ggcgtggaagtgcacaacgccaaagaccaagcctagagaggaaacagtacaactccacctac
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 tgcaagggtgtccaacaaggccctgctgcccccatcgaaaagaccatctccaaggccaag
 ggccagccccgggaaccccagggtgtacacactgccccctagcagggacgagctgaccaag
 5 aaccagggtgtccctgacctgtctcgtgaaaggcttctacccctccgatatcgccgtggaa
 tgggagtgccaacggccagcctgagaacaactacaagaccacccccctgtgtggactcc
 gacggctcattcttctgtacagcaagctgacagtggacaagtcccggtggcagcagggc
 aacgtgttctcctgtcctgtgatgcacgaggccctgcacaaccactacaccagaagtcc
 ctgtccctgagccccggctga
 10 (SEQ ID NO: 121)

hG4P HC

The amino acid sequence for hG4P heavy chain is:

MEWSWVFLFFLSVTTGVHSQVQLQQSGPELVKPGASVKLSCKASGYTFTSYDINWVKQRP
 15 GQGLEWIGWIYPRDGSTKYNEKLKGKATLTVDTSRTAYMELHSLTSEDSAVYFCARGGY
 YDYDGYWGQGLTVTVSAASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNS
 GALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGKTYTCNVDHKPSNTKVDKRVESKYG
 PPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSDQEDPEVQFNWYVDGVE
 VHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYCKVSNKGLPSSIEKTIKAKGQP
 20 REPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGS
 FFLYSRLTVDKSRWQEGNVFSCSVMEALHNHYTQKSLSLSLG*
 (SEQ ID NO: 122)

The nucleic acid sequence for hG4P is:

25 atggaatggtcctggtgttctgttcttctgtctgtgaccaccggcgtgcaactctcag
gttcagttgcagcagctctggccctgagcttgtgaaacctggcgctctgtgaagctgtct
 tgcaaggcctctggtacaccttcaccagctacgacatcaactgggtcaagcagaggcct
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 gctctgggtgctcctcgtgaaggactacttccccgagcctgtgaccgtgtcctggaactct
 ggcgtctgtacctctggcgtgcacaccttccctgtgtgtgtgcagtcctccggcctgtac
 35 tccctgtcctccgtcgtgaccgtgccttcagctctctgggcaccaagacctacacctgt
 aacgtggaccacaagccctccaacaccaaggtggacaagcgggtggaatctaagtacggc
 cctccctgccctccttgcccagccctgaatttctgggcggaccagcgtgttctgttc

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cccccaaagcccaaggacacccctgatgatctcccggaaccccggaagtgaacctgcgtggtg
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 gtgcacaacgccaagaccaagcctagagaggaacagttcaactccacctaccgggtggtg
 tccgtgctgacctgctgcaccaggattggctgaacggcaaagagtacaagtgaagggtg
 5 tccaacaagggtcctgccagctccatcgaaaagaccatctccaaggccaagggtccagccc
 cgggaaccccagggtgtacacactgcctccaagccaggaagagatgaccaagaaccagggtg
 tccctgacctgtctcgtgaaaggcttctacccctccgatatgcctggaatgggagtc
 aacggccagcctgagaacaactacaagaccacccccctgtgctggactccgacggctcc
 ttcttctgtactctgcctgacctggacaagtcccggtggcaggaaggcaacgtgttc
 10 tctgtctcgtgatgcaagaggccctgcacaaccactacaccagaagtcctgtccctg
 tctctgggatga

(SEQ ID NO: 123)

Light Chain

15 The amino acid sequence for the light chain for chimeric 1E11 is:

MSVPTQVLGLLLLWLTDARCDIVMTQAAFSNPVTLGTSASISCRSSKSLHNSGITYLYW
 YLQKPGQSPQVLIYQMSSLASGVDPDRFSSSGSGTEFTLRISRVEAEDVGVIYCAQNLELP
 LTFGAGTKLELKRITVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQ
 SGNSQESVTEQDSKDSSTLSKADYEKHKVYACEVTHQGLSSPVTKSFENRGE*

20 (SEQ ID NO: 124)

The nucleic acid sequence for light chain for chimeric 1E11 is:

atgtccgtgcctacacaggttctgggactgctgctgctgtggctgaccgacgctagatgc
 gatatcgtgatgacccaggccgccttcagcaatcctgtgacactgggaacctccgcctcc
 25 atctcctgcagatcctctaagtcctgctgcactccaacggcatcacctacctgtactgg
 tatctgcagaagccggccagttctcctcaggtgctgatctaccagatgtcctctctggcc
 tctggcgtgccgacagattctcttctctggtctgtggcaccgagttcacctgoggatc
 tctagagtggaaagctgaggacgtggcgctgtactactgcgcccagaatctggaactgcct
 ctgacctttggcgtggcaccgaagctggaactgaagcgtacggtggcgcctccctccgtg
 30 ttcattctccaccttccgacgagcagctgaagtcggcaccgcttctgtcgtgtgcctg
 ctgaacaacttctacccccgcgagccaagggtgcagtggaaaggtggacaacgcctgcag
 tccggcaactcccaggaatccgtgaccgagcaggactccaaggacagcacctaactcctg
 tctccaccctgacctgtccaaggccgactacgagaagcacaaggtgtacgcctgcgaa
 gtgacccaccaggccctgtctagccccgtgaccaagtctttcaaccggggcgagtgtga

35 (SEQ ID NO: 125)

Sequences for chimeric 5E1

hG1 HC

5 The amino acid sequence for hG1 heavy chain is:

MEWSWVFLFFLSVTTGVHSEVQLQQSGPELVKPGASVKISCKASGYSFTGYFMNWVKQSP
 EKSLEWIGEIHPTGSI IYNQKFKAKATLTIDKSSSTAYMQLKSLTSEDSAVYYCARFDY
 SNSFAYWGQGTLLTVSAASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTWSNS
 10 GALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSC
 DKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVD
 GVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYCKVSNKALPAPIEKTISKAK
 GQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDS
 DGSFFLYSKLTVDKSRWQQGNVFSVMHEALHNHYTQKSLSLSPG* (SEQ ID NO: 126)

15

The nucleic acid sequence for hG1 heavy chain is:

atggaatgggtcctgggtgttccctgtttcttccctgtctgtgaccacggcggtgcactctgaa
gttcagttgcagcagctctggccccgagcttctgtgaaacctggcgccctctgtgaagatctcc
 20 tgaaggcctctggtactccttccacggctacttcatgaactgggtcaagcagtcctcc
 gagaagtcctggaatggatcggcgagatccatccttccacggcagcatcatctacaac
 cagaagttcaaggccaaggtaccctgaccatcgacaagtcctcttccacggcctacatg
 cagctgaagtctctgacctctgaggactccggcgtgtactactgcgccagattcgactac
 tccaaactccttcgcttattggggccagggcaccctggttacogtgtctgtctcttacc
 25 aaggggcccctccgtgttccctctggccccctccagcaagtctacctctggcgccacagcc
 gctctgggtgctcctcgtgaaggactacttccccgagcctgtgacogtgtcctggaactct
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 tccctgtcctccgtcgtgacogtgccttccagctctctgggcacccagacctacatctgc
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 30 gacaagaccacacctgtccccctgtcctgccccctgaactgctgggcggacccagcgtg
 ttccctgttcccccaaggcccaaggacacctgatgatctcccgacccccgaagtgacc
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 35 tgaagggtgtccaacaaggccctgctgcccccatcgaaaagaccatctccaaggccaag
 ggccagccccgggaacccccaggtgtacacactgccccctagcaggagcagctgaccaag
 aaccaggtgtccctgacctgtctcgtgaaaggcttctacccctccgatatcgccgtggaa
 tgggagttccaacggccagcctgagaacaactacaagaccacccccctgtgctggactcc

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gacggctcattcttctgtacagcaagctgacagtggacaagtcccggtggcagcagggc
aacgtgttctctgtctcgtgatgcacgagggcctgcacaaccactacaccagaagtc
ctgtccctgagccccggctga

(SEQ ID NO: 127)

5

hG4P HC

The amino acid sequence for hG4P heavy chain is:

10 MEWSWVFLFFLSVTGVSSEVQLQQSGPELVKPGASVKISCKASGYSFTGYFMNWVKQSP
EKSLEWIGEIHPTSGSIIYNQKFKAKATLTIDKSSSTAYMQLKSLTSEDSAVYYCARFDY
SNSFAYWGQGLTVTVSAASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNS
GALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGKTYTCNVDPKPSNTKVDKRVESKYG
PPCPFCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSDQEDPEVQFNWYVDGVE
15 VHNAKTKPREEQFNSTYRVVSVLTVTLHQDWLNGKEYCKVSNKGLPSSIEKTIKAKGQP
REPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSDGS
FFLYSRLTVDKSRWQEGNVFSCSVMEALHNHYTQKSLSLSLG*

(SEQ ID NO: 128)

20 The nucleic acid sequence for hG4P heavy chain is:

atggaatggtcctgggtgttcctgttcttctgtctgtgaccacggcgtgcactctgaa
gttccagttgcagcagtcctggccccgagcttctgtgaaacctggcgctctgtgaagatctcc
tgcaaggcctctggctactccttcacggctacttcatgaactgggtcaagcagtcacct
25 gagaagtcctggaatggatcgccgagatccatccttcacgggcagcatcatctacaac
cagaagttcaaggccaaggctacctgacctcgacaagtcctcttcacggcctacatg
cagctgaagtcctgcacctctgaggactccggcgtgtactactgcgccagattcgactac
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aaggggccccctcggtgttcctctgtggcccccttgctccagatccacctccgagtcctaccgcc
30 gctctgggctgcctcgtgaaggactacttccccgagcctgtgacctgtcctggaactct
ggcgctctgacctctggcgtgcacaccttccctgtgtgtctgcagtcctccggcctgtac
tccctgtcctccgtcgtgacctgtccttcagctctctgggcaccaagacctacacctgt
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cctccctgccccctctggccagccctgaatttctgggcggaccagcgtgttctgttc
35 ccccaagcccaaggacacctgatgatctcccgacccccgaagtgaacctgcgtgggtg
gtggatgtgtcccaggaagatcccagggtgcagttcaattggtacgtggacggcgtggaa
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tccaacaagggcctgcccagctccatcgaaaagaccatctccaaggccaagggccagccc
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 tccctgacctgtctcgtgaaaggcttctacccctccgatatcgccgtggaatgggagtcc
 aacggccagcctgagaacaactacaagaccacccccctgtgctggactccgacggctcc
 5 ttcttctgtactctcgctgacctggacaagtcctcggtggcaggaaggcaacgtgttc
 tctgtctcgtgatgcaagggccctgcacaaccactacaccagaagtcctgtccctg
 tctctgggatga

(SEQ ID NO: 129)

10 Light Chain

The amino acid sequence for the light chain for chimeric 5E1 is:

MSVPTQVLGLLLWLTDARCDIQMTQTSSLSASLGDRVTISCRASQDISNYLNWYQQKP
 15 DGTVKLLIYYTSRLHSGVPSRFSGSGSGTDYSLTISNLEQEDIATYFCQQGNTLPRTFGG
 GTKLEIKRTVAAPSVFIFFPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQ
 ESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC*

(SEQ ID NO: 130)

20 The nucleic acid sequence for the light chain for chimeric 1E5 is:

atgtccgtgcctacacaggttctgggactgctgctgctggtgacctgacctagatgc
 gatatccagatgaccagaccacctccagcctgtctgcttctctgggcgacagagtgacc
 atctcctgcagagcctctcaggacatctccaaactacctgaactggtatcagcagaaaccc
 gacggcacccgtgaagctgctgatctactacacctccagactgcactccggcgtgacctct
 25 agatcttctggctctggatctggcaccgactactcctgaccatcagcaacctggaacaa
 gaggatatcgctacctacttctgcccagcaaggcaacacctgcctagaacctttggcgga
 ggcaccaagctggaaatcaagcgtacgggtggccgctccctccgtgttcatcttccacct
 tccgacgagcagctgaagtcgggcaccgcttctgtcgtgtgctgctgaacaacttctac
 ccccgcgaggccaaggtgcagtgggaaggtggacaacgccctgcagtccggcaactcccag
 30 gaatccgtgaccgagcaggactccaaggacagcacctactcctgtcctccacctgacc
 ctgtccaaggccgactacgagaagcacaaggtgtacgctgcgaagtgaccaccagggc
 ctgtctagccccgtgaccaagtctttcaaccggggcgagtgtga

(SEQ ID NO: 131)

35 Sequences for chimeric 6G6

hG1 heavy chain

WO 2018/027039

PCT/US2017/045310

The amino acid sequence for the hG1 heavy chain is:

MEWSWVLFFLSVTTGVHSEVQLQQSGPELVKPGASVKISCKASGYTFTTYYMNWVKQSH
 GKSLEWIGNINPDNGITSYNQKFKGKATLTVDKSSSTAYMELRSLTSEDSAVYYCARGKS
 LAYWGQGTLLTVSAASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTVSWNSGAL
 5 TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKT
 HTCPCPAPELLGGPSVFLFPPKPKDTLMI SRTPEVTCVVVDVSHEDPEVKFNWYVDGVE
 VHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYCKVSNKALPAPIEKTISKAKGQP
 REPQVYTLPPSRDELTKNQVSLTCLVKGEFYPDSIAVEWESNGQPENNYKTTPVLDSDGS
 FFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPG*
 10 (SEQ ID NO: 132)

The nucleic acid sequence for the hG1 heavy chain is:

atggaatggctcctgggtgttcctgttcttctgtctgtgaccaccggcgtgcactctgaa
gttccagttgcagcagctctggccccgagcttgtgaaacctggcgctctgtgaagatctcc
 15 tgcaaggcctctggctacacctcaccacctaactacatgaactgggtcaagcagtcaccac
 ggcaagtccctggaatggatcggaacatcaaccccgacaacggcatcacctcctacaac
 cagaagttcaaggcaagctaccctgaccgtggacaagtcctcctccaccgcctacatg
 gaactgagatccctgacctctgaggactccgcgtgtactactgtgccagaggcaagtct
 ctggttattggggccagggcacactgggtcacagtgtctgtctgcttccaccaaggggccc
 20 tccgtgttccctctggccccctccagcaagtctacctctggcgccacagccgctctgggc
 tgcctcgtgaaggactacttccccgagcctgtgaccgtgtcctggaactctggcgctctg
 acatccggcgtgcacaccttccctgctgtgctgcagtcctccggcctgtactccctgtcc
 tccgtcgtgaccgtgccttccagctctctgggcaaccagacctacatctgcaacgtgaac
 cacaagccctccaacaccaaggtggacaagaaggtggaaccaagtccctgcgacaagacc
 25 cacacctgtccccctgtcctgccccctgaactgctggcgaggaccagcgtgttccctgttc
 ccccaagcccaaggacacctgatgatctccgggacccccgaagtgcctgcgtgggtg
 gtggatgtgtcccacgaggacctgaagtgaagttcaattggtacgtggacggcgtggaa
 gtgcacaacgccaagaccaagcctagagaggaaacagtacaactccacctaccgggtggtg
 tccgtgctgaccgtgctgcaccaggattggctgaaacggcaagagtacaagtgaaggtg
 30 tccaacaaggccctgcctgcccccatcgaaaagaccatctccaaggccaaggccagccc
 cgggaaccccgaggtgtacacactgccccctagcagggaacgagctgaccaagaaccaggtg
 tccctgacctgtctcgtgaaaggcttctacctctccgatatcgccgtggaatgggagtcc
 aacggccagcctgagaacaactacaagaccacccccctgtgctggactccgacggctca
 ttcttctgtacagcaagctgacagtggaagaagtcctgggtggcagcagggcaacgtgttc
 35 tctgtctccgtgatgcacgaggccctgcacaaccactacaccagaagtccctgtccctg
 agccccggctga

(SEQ ID NO: 133)

The amino acid sequence for hG4P heavy chain is:

MEWSWVFLFFLSVTTGVHSEVQLQQSGPELVKPGASVKISCKASGYTFETTYMNVVKQSH
 GKSLEWIGNINPDNGITSYNQKFKGKATLTVDKSSSTAYMELRSLTSEDSAVYYCARGKS
 5 LAYWGQGTLLTVSAASTKGPSVFELAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGAL
 TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTRKTYTCNVDPKPSNTKVDKRVESKYGPPC
 PPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHN
 AKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTIKAKGQPREP
 QVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFL
 10 YSRLTVDKSRWQEGRVFSVMHEALHNHYTQKSLSLSLG*
 (SEQ ID NO: 134)

The nucleic acid sequence for hG4P heavy chain is:

atggaatggctcctgggtgttctctgttcttctgtctgtgaccaccggcgtgcactctgaa
 15 gttcagttgcagcagctctggccccgagcttgtgaaacctggcgccctctgtgaagatctcc
 tgcaaggccctctggctacaccttcaccacctactacatgaactgggtcaagcagtcaccac
 ggcaagtccctggaatggatcggcaacatcaaccccgacaacggcatcacctcctacaac
 cagaagttcaagggaagctacccctgacccgtggacaagtcctcctccaccgcctacatg
 gaactgagatccctgacctctgaggactccgccgtgtactactgtgccagaggcaagtct
 20 ctggcttattggggccagggcacactggtcacagtgtctgtctgcttccaccaagggccc
 tccgtgttccctctggcccccttgcctccagatccacctccgagtcctaccgccgctctgggc
 tgccctgtgaaggactacttccccgagccctgtgaccgtgtcctggaactctggcgctctg
 acctctggcgtgcacaccttccctgtgtgtgtgcagtcctccggcctgtactccctgtcc
 tccgtctgtgaccgtgccttccagctctctgggcaccaagacctacacctgtaacgtggac
 25 cacaagccctccaacaccaagggtggacaagcgggtggaatctaagtacggccctccctgc
 cctccttgcccagccctgaatttctggggcgaccacagcgtgttccctgttccccccaaag
 cccaaggacaccctgatgatctcccggaaccccggaagtgaacctgcgtgggtggatgtg
 tcccaggaagatcccaggtgcagttcaatttggtacgtggacggcgtggaagtgcacaac
 gccaaagaccaagcctagagaggaacagttcaactccacctaccgggtgggtgtccgtgtg
 30 accgtgtctgcaccaggattggtgaacggcaagagtacaagtgaagggtgtccaacaag
 ggccctgcccagctccatcgaaaagaccatctccaaggccaaggccagccccgggaaccc
 cagggtgtacacactgcctccaagccaggaagagatgaccaagaaccaggtgtccctgacc
 tgtctcgtgaaaggcttctacccctccgatatcgccgtggaatgggagtccaacggccag
 cctgagaacaactacaagaccacccccctgtgtgtggaactccgacggctccttcttctg
 35 tactctgcctgaccgtggacaagtcctgggtggcaggaaggcaacgtgttctcctgtctcc
 gtgatgcacgaggccctgcacaaccactacaccagaagtcctgtccctgtctctggga
 tga (SEQ ID NO: 135)

WO 2018/027039

PCT/US2017/045310

The amino acid for the light chain is:

MSVPTQVLGLLLLWLTDARCDIVMTQSHKFMSTSVGDRVSITCKASQNVGTAVAWYQQKP
 GQSPKLLIYWASIRHTGVPDRFTGSGSGTDFTLTISNVQSEDLADYFCQQYSSHPYTFGG
 5 GTKLEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQ
 ESVTEQDSKDSSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC*
 (SEQ ID NO: 136)

The nucleic acid sequence for the light chain is:

10 atgtccgtgcctacacaggttctgggactgctgctgctgtggtgaccgaagctagatgc
 gacatcgtgatgacccagagccacaagttcatgtccacctccgtggcgacagagtgtcc
 atcacatgcaaggcctctcagaatgtgggcaccgccgttgccctggatcagcagaaacct
 ggccagtctcctaagctgctgatctactgggcctccatcagacacaccggcgtgccagat
 agattcaccggctctggctctggcaccgacttcacccctgaccatctctaacgtgcagtct
 15 gaggacctggccgactacttctgccagcagtagcgtctcaccctacacctttggcgga
 ggcaccaagctggaaatcaagcgtacgggtggccgctccctccgtgttcattctccacct
 tccgacgagcagctgaagtcggcaccgcttctgtcgtgtgctgctgaacaacttctac
 ccccgcgaggccaaggtgcagtgggaaggtggacaacgcctgcagtccggcaactcccag
 gaatccgtgaccgagcaggactccaaggacagcacctaactccctgtctccaccctgacc
 20 ctgtccaaggccgactacgagaagcacaaggtgtacgcctgcgaagtgaccaccagggc
 ctgtctagcccgtagaccaagtctttcaaccggggcgagtgtga
 (SEQ ID NO: 137)

Sequences for chimeric 11B3

25

hG1 HC

The amino acid sequence for hG1 heavy chain is:

30 MEWSWVFLFFLSVTTGVHSEVQLVESGGGLVQPKGSLKLSCAASDFTNTYAMHWVRQAP
 GKGLEWVARIRTKSNNYATYYADSVKDRFTISRDDSQSMYLYLMNNLTEDTAMYYCVRD
 RYGGAMDYWGQGSVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSW
 NSGALTSGVHTFPAVLQSSGLYSLSSVTVFSSSLGTQTYICNVNHKPSNTKVDKKVEPK
 SCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWY
 35 VDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISK
 AKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPFPVL
 DSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPG* (SEQ ID NO: 138)

The nucleic acid sequence for hG1 heavy chain is:

atggaatggctcctgggtgttccctgtttcttctgtctgtgaccaccggcgtgcaactctgaa
 5 gtgcagttggttgaatctggcgccggaactggtgcagcctaagggatctctgaagctgtct
 tgcgcgcctccgaacttcaccttcaatacctacgccatgcaactgggtccgacaggccct
 ggaaaaggactggaatgggtcgccagaatccggaccaagtccaacaactacgccacctac
 tacgccgactccgtgaaggacagattcaccatctctcgggacgactcccagtcocatgtg
 tacctgcagatgaacaacctgaccaccgaggacaccgccatgtactactgctgctgggat
 10 agatatggcgcgctatggattattggggccagggcacatctgtgaccgtgtcctctgct.
 tccaccaaggggcccctccgtgttccctctggccccttccagcaagtctacctctggcggc
 acagccgctctgggtgctcgtgaaggactacttccccgagcctgtgaccgtgtcctgg
 aactctggcgctctgacatccggcgtgcacaccttccctgctgtgctgcagtcctccggc
 ctgtactccctgtcctccgtcgtgaccgtgcttccagctctctgggcacccagacctac
 15 atctgcaacgtgaaccacaagccctccaacaccaagggtggacaagaagggtggaacccaag
 tcttgogacaagaccacacctgtcccccctgtcctgcccctgaactgctggcggaacc
 agcgtgttccctgttcccccaagcccaaggacacccctgatgatctcccggaaccccgaa
 gtgacctgcgtggtggtgatgtgtcccacgaggaccctgaagtgaagttcaattggtac
 gtggacggcgtggaagtgcacaacgcccaagaccaagcctagagaggaaacagtacaactcc
 20 acctaccgggtggtgtccgtgctgaccgtgctgcaccaggattggctgaacggcaagag
 tacaagtgaagggtgtccaacaaggccctgctgccccatcgaaaagaccatctccaag
 gccaaagggccagccccgggaaccccagggtgtacacactgccccctagcagggacgagctg
 accaagaaccagggtgtccctgacctgtctcgtgaaaggcttctacccctccgatatcgcc
 gtggaatgggagtgccaacggccagcctgagaacaactacaagaccacccccctgtgctg
 25 gactccgaacggtcattcttctgtacagcaagctgacagtggaacaagtcccggtggcag
 cagggcaacgtgttctcctgctccgtgatgcacgaggccctgcacaaccactacaccag
 aagtcctctgtccctgagccccggtga

(SEQ ID NO: 139)

30 hG4P HC

The amino acid sequence for hG4P heavy chain is:

MEWSWVFLFFLSVTTGVHSEVQLVESGGGLVQPKGSLKLSCAASDFTFNTYAMHWVRQAP
 35 GKGLEWVARIRTKSNNYATYYADSVKDRFTISRDDSQSMLYLQMNLTEDTAMYYCVRD
 RYGGAMDYWGQGTSVTVSSASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPTVSW
 NSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESK

YGPPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVVSQEDPEVQFNWYVDG
 VEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTI SKAKG
 QPREPQVYFLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSD
 GSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLGLG* (SEQ ID NO: 140)

5

The nucleic acid sequence for hG4P heavy chain is:

atggaatggctcctgggtgttctctgttcttctgtctgtgaccaccggcgtgcaactctgaa
gtgcagttggttgaatctggcggcggaactggtgcagcctaagggatctctgaagctgtct
 10 tgcgcgcgcctccgacttcaccttcaatacctacgccatgcaactgggtccgacaggccct
 ggaaaaggactggaatgggtcgccagaatccggaccaagtccaacaactacgccacctac
 tacgccgactccgtgaaggacagattcaccatctctcgggacgactcccagtcctatgctg
 tacctgcagatgaacaacctgaccaccgaggacaccgccatgtactactgcgtgcgggat
 agatatggcggcgctatggattattggggccaggggcacatctgtgaccgtgtcctctgct
 15 tccaccaaggggcccctccgtgttccctctggccccttgcctccagatccacctccgagtct
 accgcgcgtctgggtgcctcgtgaaggactacttccccgagcctgtgaccgtgtcctgg
 aactctggcgtctgacctctggcgtgcacaccttccctgctgtgctgcagtcctccggc
 ctgtactccctgtcctccgtcgtgaccgtgccttccagctctctgggcaccaagacctac
 acctgtaacgtggaccacaagccctccaacaccaaggtggacaagcgggtggaatctaag
 20 tacggccctccctgcctccttgcgccagccctgaatttctgggcggaccacagcgtgttc
 ctgttccccccaaagcccaaggacacctgatgatctcccgacccccgaagtgcctgc
 gtggtggtggatgtgtcccaggaaagatcccgagggtgcagttcaattggtacgtggacggc
 gtggaagtgcacaacgccaagaccaagcctagagaggaacagttcaactccacctaccgg
 gtggtgtccgtgctgacctgctgcaccaggattggctgaacggcaagagtacaagtgc
 25 aagggtgtccaacaaggccctgccagctccatcgaaaagaccatctccaaggccaagggc
 cagccccgggaaccccagggtgtacacactgcctccaagccagggaagagatgaccaagaac
 cagggtgtccctgacctgtctcgtgaaaggcttctacccctccgatatcgccgtggaatgg
 gagtccaacggccagcctgagaacaactacaagaccacccccctgtgctggactccgac
 ggctccttcttctgtactctcgctgacctggacaagtcccgggtggcaggaaggcaac
 30 gtgttctcctgctccgtgatgcacgaggccctgcacaacctacaccagaagtcctgt
 tccctgtctctgggatga

(SEQ ID NO: 141)

Light Chain

The amino acid sequence for the light chain is:

5 MSVPTQVLGLLLLWLTDARCDIQMAQSSSSFSVSLGDRVTITCKASEDIYIRLAWYQQKP
GNAPRLLISTATSLETGVPSRFSGSGSGKDYTLSTLSLQTEDVATYYCQQYWSTPYTFGG
GTRLEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQ
ESVTEQDSKDSSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC*
(SEQ ID NO: 142)

10

The nucleic acid sequence for the light chain is:

atgtccgtgcctacacaggttctgggactgctgctgctgctggtgacccagcctagatgt
gatatccagatggcccagtcctcctccagcttctctgtgtctctgggcgacagagtgacc
15 atccatgcaaggcctccgaggacatctacatccggtggcctggtatcagcagaagcct
ggaaacgccctcggctgctgatctctaccgctacatctctggaaaccggcgtgccctct
agattctctggtctggtatctggcaaggactacaccctgtctatcaccagcctgcagacc
gaggatgtggccacctactactgcccagcagtactggtctaccctttacaccttggcggc
ggaacccggctggaaatcaaacgtaecggtggcgcctccctccgtgttcattctccacct
20 tccgacgagcagctgaagtcggcaccgcttctgtcgtgtgctgctgaacaacttctac
ccccgcgaggccaaggtgcagtggaaggtggacaacgcctgagtcggcgaactcccag
gaatccgtgaccgagcaggactccaaggacagcaactactccctgtcctccacctgacc
ctgtccaaggccgactacgagaagcacaaggtgtacgcctgcgaagtgaaccaccagggc
ctgtctagccccgtgaccaagtctttcaaccggggcgagtgtga
25 (SEQ ID NO: 143)

The chimeric antibodies are produced by combining the light chain with one of the disclosed heavy chains.

30 **Example 15: Screening of LAIR-1 hybridoma supernatants for blockade or enhancement of LAIR-1 Fc binding to collagen I and III.**

Materials and Methods

1 ug/ml of collagen I or collagen III (Millipore) was coated (in separate plates for separate screens) overnight in PBS. Plates were washed, blocked with
35 ELISA blocking buffer (5% BSA in PBS). After washing, 50 ul of LAIR-1

hybridoma supernatant was added to plates, followed by addition of 50 ul of 2 ug/ml human LAIR-1Fc-biotin. Plates were washed and SA-HRP was added (eBio) at 1:10000 dilution. Following 30 minute incubation and was, TMB was added followed by stop solution. Absorbance was determined with PerkinElmer
5 Envision analyzer.

Results

Figure 19 shows the results of the LAIR-1 hybridoma screening. Clones P1-A4, P1-D6, and P6-F4 were identified as enhancers of binding of LAIR-1 Fc binding to collagen I and III. Clones P1-E11, P2-A10, P4-B3, P5-A6, P5-E1,
10 P6-B2, P6-G6, P7-G3, P9-H6, P10-G7, P11-B3 and P12-E10 were found to be blockers of LAIR-1 Fc binding to collagen I and III.

Example 16: Screening of LAIR-1 hybridoma supernatants for blockade or enhancement of LAIR-1 Fc binding to C1q and SP-D.

Materials and Methods

15 1 ug/ml of C1q (Sigma) or SP-D (R&D Systems) were coated (in separate plates for separate screens) overnight in PBS. Plates were washed, blocked with ELISA blocking buffer (5% BSA in PBS). After washing, 50 ul of LAIR-1 hybridoma supernatant was added to plates, followed by addition of 50 ul of 2 ug/ml human LAIR-1Fc-biotin. Plates were washed and SA-HRP was
20 added (eBio) at 1:10000 dilution. Following 30 minute incubation, TMB was added followed by stop solution. Absorbance was determined with PerkinElmer Envision analyzer.

Results

Figure 20 shows the results of the screening assay. Clones P1-A4, P1-
25 D6, and P6-F4 were found to enhance LAIR-1 Fc binding to C1q and SP-D. Clones P1-E11, P2-A10, P4-B3, P5-A6, P5-E1, P6-B2, P6-G6, P7-G3, P9-H6, P10-G7, P11-B3, and P12-E10 were found to be blockers of LAIR-1 Fc binding to C1q and SP-D.

Example 17: LAIR-1 chimeric mAb binning.**Methods and Materials**

An Octet RED96 instrument (ForteBio) was used for binning assays. LAIR-1 Fc (hIgG1) was bound to anti-human IgG sensor. After confirming stability of LAIR-1 Fc on sensor, the sensor was dipped in a well with the first mAb listed on the left side column. Binding of first mAb was saturated by binding excess mAb to LAIR-1 Fc. Next, the sensor was placed in a well containing the 2nd mAb, as shown across the top row. mAbs that bind the same epitope will be blocked from binding LAIR-1 Fc due to binding saturation, as can be observed when the same mAb is used as the first and second mAb (Figure 21, no underlining and stippled cells). No blockade indicated distant epitopes, as well as lack of steric hindrance. Partial blockade is likely due to slightly overlapping epitopes or steric hindrance of binding due to proximity of mAb binding sites. Based on very weak binding (low avidity), three of the clones were removed from further study, leaving 12 clones. Two commercial anti-human LAIR-1 clones, DX26 and NKTA were included for comparison purposes.

Results

Figure 21 shows the results of LAIR-1 chimeric Ab binning. No blocking is indicated by single underline. Blocking is indicated by double underline. The data allowed for the identification of mAbs that bind to similar, overlapping or distinct sites (epitopes) on the extracellular domain (ECD) of LAIR-1, and allowed for the construction of a epitope map of LAIR-1 mAb binding.

From the binning results, it was determined that four primary bins of mAbs existed within this set of 12 clones (Figure 22). These are: bin 1: 11B3, 6B2, 6F4; bin 2: 5E1 and 4B3; bin 3: 5A6 and 6G6; bin 4: 1E11, 7G3, 1A4, and 10G7.

Example 18: LAIR-1 chimeric mAb binning map.**Materials and Methods**

Using the binning data generated in Figure 21, a map of binding sites was constructed in 2D format for visualization of relative binding sites.

Results

Using the binning data generated in Example 17, a map of binding sites was constructed in 2D format for visualization of relative binding sites (Figure 22). This map demonstrates that there is significant overlap of mAbs.

- 5 Simultaneously, many mAbs occupy distinct sites on the LAIR-1 molecule. The mAbs with the greatest overlap and blockade of binding to LAIR-1 are considered a bin. Together, this data suggests the mAb panel covers a major portion of the LAIR-1 protein.

Example 19: Optimized affinity assessments were performed using an
 10 **Octet RED96 instrument (ForteBio).**

Materials and Methods

- Anti-human IgG capture sensors were used to bind to chimeric LAIR-1 mAbs at a density to ensure 1:1 binding to monomeric LAIR-1-His (R&D Systems) in solution at various concentrations. Assay buffer was PBS with
 15 0.05% Tween-20 and regeneration buffer was 10 mM glycine pH 1.5. First, chimeric LAIR-1 mAbs were loaded to sensor. This was followed by association step with LAIR-1-His, and a dissociation step in a separate LAIR-1-His free well. Data was processed using ForteBio data analysis software 9.0. A global fit was used following subtraction of reference wells. The reported average KD
 20 values are from at least three independent Octet runs with high confidence of accuracy based on X2 and R2 values. Note the two chimeric versions of 12E10 were tested. Both had relatively low affinity, while the 12E10V2 mAb was removed from usage due to very low affinity.

Results

- 25 Figure 23 shows the results of the affinity assessments. The dissociation constant (Kd) is shown in nM values in the third column based on the dissociation (Kdis) and association (Kon) rates. Most mAbs had very strong association rates, but also relatively fast dissociation rates. 1E11, 7G3 and 11B3, 5E1 and 6G6 all had Kd values of < 5nM, indicating very strong affinity
 30 to LAIR-1.

Example 20: LAIR-1 mAbs demonstrate differential induction of interferon reporter activity in THP-1 cells.

Materials and Methods

THP-1-Dual cells (Invivogen) with an interferon regulatory factor (IRF) reporter were plated at 25,000 cells/well of a 96-well plate to either plates that had been pre-coated with LAIR-1 mAbs (10 ug/ml) (Figure 24A) or left uncoated (Figure 24B). For Figure 24B LAIR-1 mAbs were added as soluble proteins at 10 ug/ml. LAIR-2 Fc or control Fc was also coated (Figure 24A) or added as soluble proteins (Figure 24B) as positive and negative controls.

LPS was added as 1 ug/ml for low level IRF induction in order to test whether LAIR-1 mAbs enhanced or inhibited IRF pathway induction. At 72 hours, 10 ul of supernatant was removed from assay plates and transferred to a separate plate for analysis. Quanti-luc (Invivogen) was added according to protocol and luminescence was measured with a PerkinElmer Envision

Results

Plate bound LAIR-1 mAbs indicated that three mAbs, 11B3, 6G6 and 5E1 may enhance IRF signaling, whereas two mAbs, 1E11 and 7G3 had little effect or may actually inhibit IRF induction (Figure 24A). The mAbs had a similar effect in soluble form (Figure 24B). Interestingly, 1E11 and 7G3, which fall into the same bin, appear to have similar function. Conversely, 11B3, 6G6 and 5E1 fall into separate bins, but appear to have similar function, which contrasts with clones 1E11 and 7G3.

Example 21: LAIR-1 mAbs Screening for Induction of Jurkat T Cell Reporter Activity.

Materials and Methods

96-well plates were coated overnight at 4 degrees C with anti-CD3 (OKT3) at 0.5 ug/ml. Unbound CD3 was removed by aspiration. Following aspiration of OKT3, LAIR-1 mAbs or LAIR-2 Fc and control Fc were coated for 24 hours at 10 ug/ml (Figure 25A). Prior to adding Jurkat T cell NFAT-Lucia pathway reporter cells (Invivogen), unbound proteins were aspirated. Jurkat T cells were plated at 50,000 cells/well in 200 ul total volume. At 48 hours, 10 ul

of supernatant was removed and transferred to a separate plate. Quanti-Luc (Invivogen) was added according to protocol. Luminescence was assessed using a Perkin Elmer Envision plate reader. For Figure 25B was performed the same as Figure 25A, but proteins were added in soluble form rather than coating
5 on the plate.

Results

Results showed that 1E11 had little or no effect on NFAT reporter induction, whereas 11B3, 6G6 and 5E1 induced NFAT induction (Figure 25A). In a similar assay, LAIR-1 mAbs or LAIR-2 Fc and control Fc were added as
10 soluble proteins (Figure 25B). In this assay little effect was observed with any of the treatments. Note that 7G3 was only tested in the THP-1 assay, but not in the Jurkat assay.

Collectively, the data in the Examples show specific functionality of LAIR-1 mAbs in cell line pathway reporter-based assays.

15 Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of skill in the art to which the disclosed invention belongs. Publications cited herein and the materials for which they are cited are specifically incorporated by reference.

Those skilled in the art will recognize, or be able to ascertain using no
20 more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.

We claim:

1. A pharmaceutical composition comprising an effective amount of an immunomodulatory agent that reduces LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof selected from the group consisting of:

- (i) a soluble LAIR-2 polypeptide or fusion protein,
- (ii) a soluble LAIR-1 polypeptide or fusion protein,
- (iii) a LAIR-1 mAb that increases an immune response.
- (iv) an antibody that depletes LAIR-1 positive cells, and
- (iv) combinations thereof;

to increase an immune response in a subject in need thereof.

2. The pharmaceutical composition of claim 1, wherein the immunomodulatory agent is a LAIR-2 fusion protein.

3. The pharmaceutical composition of claim 2, wherein the LAIR-2 fusion protein comprises an extracellular domain of LAIR-2 for functional variant thereof linked to an immunoglobulin domain.

4. The pharmaceutical composition of claim 3, wherein the LAIR-2 fusion protein comprises the amino acid sequence of SEQ ID NO:16.

5. The pharmaceutical composition of claim 1, wherein the immunomodulatory agent is a LAIR-1 fusion protein.

6. The pharmaceutical composition of claim 5, wherein the LAIR-1 fusion protein comprises an extracellular domain of LAIR-1 or functional variant thereof linked to an immunoglobulin domain.

7. The pharmaceutical composition of claim 6, wherein the LAIR-1 fusion protein comprises the amino acid sequence of SEQ ID NO:9.

8. The pharmaceutical composition of claim 1, wherein the immunomodulatory agent is a LAIR-2 protein or a functional fragment or variant thereof.

9. The pharmaceutical composition of claim 2, wherein the LAIR-2 protein or functional fragment or variant thereof comprises at least 80%, 90%, 95%, or 100% sequence identity to SEQ ID NO:6.
10. The pharmaceutical composition of claim 1, wherein the immunomodulatory agent is a soluble LAIR-1 protein or a functional fragment or variant thereof.
11. The pharmaceutical composition of claim 10, wherein the LAIR-1 protein consists of an extracellular domain of LAIR-1 or a functional fragment or variant thereof.
12. The pharmaceutical composition of claim 10, wherein the LAIR-1 protein or functional fragment or variant thereof comprises at least 80%, 90%, 95%, or 100% sequence identity to SEQ ID NO:2.
13. The pharmaceutical composition of any one of claims 1-12, wherein the immune response is a primary immune response to an antigen or an increase effector cell function such as increasing antigen-specific proliferation of T cells, enhancing cytokine production by T cells, stimulating differentiation, or a combination thereof.
14. A method of increasing an immune response in a subject in need thereof comprising administering to the subject the pharmaceutical composition of any one of claims 1-13.
15. The method of claim 14, wherein the subject has cancer.
16. The method of claim 15, wherein the cancer is characterized by increased expression of LAIR-1, increased expression of a LAIR-1 ligand, decreased expression of LAIR-2, or a combination thereof.
17. The method of claims 14 or 15, wherein the cancer is an ovarian, lung, or gastrointestinal cancer.
18. The method of claim 14, wherein the subject has an infectious disease.
19. The method of any one of claims 14-18, wherein the subject is administered the pharmaceutical composition contemporaneously with a vaccine or a component thereof.

20. The method of any one of claims 14-19, further comprising administering to the subject a second therapeutic agent.
21. A pharmaceutical composition comprising an effective amount of an immunomodulatory agent that increases LAIR-1 expression, ligand binding, crosslinking, negative signaling, or a combination thereof selected from the group consisting of:
- (i) a function activating anti-LAIR-1 antibody,
 - (ii) a function blocking anti-LAIR-2 antibody, and
 - (iii) a combination thereof;
- to decrease an immune response in a subject in need thereof.
22. The pharmaceutical composition of claim 21, wherein the immune response is a primary immune response to an antigen or an increase effector cell function such as increasing antigen-specific proliferation of T cells, enhancing cytokine production by T cells, stimulating differentiation, or a combination thereof.
23. A method of reducing an immune response in a subject in need thereof comprising administering to the subject the pharmaceutical composition of claim 21 or 22.
24. The method of claim 23, wherein the subject has inflammation.
25. The method of claim 23, wherein the subject has an autoimmune disorder.
26. The method of claim 25, wherein the autoimmune disorder is rheumatoid arthritis.
27. The method of any one of claims 21-26, wherein the subject or a disease or condition characterized reduced expression of LAIR-1, reduced expression of a LAIR-1 ligand, increased expression of LAIR-2, or a combination thereof.
28. The method of any one of claims 21-27, further comprising administering to the subject a second therapeutic agent.

29. The composition or method of any of the foregoing claims wherein the LAIR-1 is expressed on a myeloid cell, a T cell, a Natural Killer (NK) cell, or a combination thereof.
30. The composition or method of claim 29, wherein the myeloid cell is an antigen-presenting cell.
31. The composition or method of claim 30, wherein the antigen presenting cell is a monocyte, macrophage, or dendritic cell.
32. A method for treating leukemia in a subject in need thereof, comprising:
administering to the subject an effective amount of a pharmaceutical composition comprising a LAIR-1 monoclonal antibody, soluble LAIR-1 polypeptide, soluble LAIR-2 polypeptide, LAIR-1 fusion protein, LAIR-2 fusion protein, or combinations thereof to inhibit or reduce LAIR-1 signal transduction in leukemia cells to thereby inhibit leukemia cell survival or to promote an anti-tumor immune response to the leukemia cells.
33. The method of claim 32, wherein the leukemia is acute myeloid leukemia.
34. An anti-LAIR antibody produced by a hybridoma selected from the group consisting of 1E11, 1G7, 4B3, 5A6, 5E1, 6B2, 6F4, 6G6, 7G3, 9H6, 11B3, 12E10a, and 12E10b.
35. An anti-LAIR antibody comprising at least one light chain or at least one heavy chain of the antibody of claim 34.
36. An anti-LAIR antibody comprising a variable light chain having at least 95 % sequence identity to a variable light chain having an amino acid sequence selected from the group of variable light chains consisting of SEQ ID NOs 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, and 115.
37. An anti-LAIR antibody comprising a variable heavy chain having at least 95 % sequence identity to a variable heavy chain having an amino acid sequence selected from the group of variable heavy chains consisting of SEQ ID NOs 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, and 111.

38. An anti-LAIR antibody comprising a complementarity-determining region (CDR) selected from the group of CDRs having an amino acid sequence selected from the group consisting of SEQ ID NO: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 104-106, 108-110, 112-114, and 116-118.

39. A anti-LAIR antibody having a plurality of CDRs selected from the group consisting of SEQ ID NO: 20-22, 24-26, 28-30, 32-34, 36-38, 40-42, 44-46, 48-50, 52-54, 56-58, 60-62, 64-66, 68-70, 72-74, 76-78, 80-82, 84-86, 88-90, 92-94, 96-98, 100-102, 104-106, 108-110, 112-114, and 116-118.

40. The antibody of claim 39, wherein the plurality of CDRs is from 2-12 CDRs.

41. A method for treating cancer comprising administering to a subject in need thereof an effective amount of LAIR-2 Fc in combination or alternation with an anti-PD-1 antibody or antigen binding fragment thereof.

42. The method of claim 40, wherein the cancer is ovarian cancer.

43. A method for reducing tumor burden in a subject in need thereof comprising administering to a subject in need thereof an effective amount of LAIR-2 Fc in combination or alternation with an anti-PD-1 antibody or antigen binding fragment thereof.

44. The method of claim 43, wherein the tumor is an ovarian tumor.

45. The method of any one of claims 41 or 43, wherein the cancer or tumor is lymphoma.

46. A method for promoting primary T-cell expansion in a subject in need thereof comprising administering to the host a therapeutically effective amount of LAIR-2 Fc.

47. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:20, SEQ ID NO.:21 and SEQ ID NO.:22

and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:24, SEQ ID NO.:25 and SEQ ID NO.:26.

48. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:28, SEQ ID NO.:29 and SEQ ID NO.:30 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:32, SEQ ID NO.:33 and SEQ ID NO.:34.

49. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:36, SEQ ID NO.:37 and SEQ ID NO.:38 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:40, SEQ ID NO.:41 and SEQ ID NO.:42.

50. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:44, SEQ ID NO.:45 and SEQ ID NO.:46 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:48, SEQ ID NO.:49 and SEQ ID NO.:50.

51. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:52, SEQ ID NO.:53 and SEQ ID NO.:54 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:56, SEQ ID NO.:57 and SEQ ID NO.:58.

52. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:60, SEQ ID NO.:61 and SEQ ID NO.:62

and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:64, SEQ ID NO.:65 and SEQ ID NO.:66.

53. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:68, SEQ ID NO.:69 and SEQ ID NO.:70 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:72, SEQ ID NO.:73 and SEQ ID NO.:74.

54. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:76, SEQ ID NO.:77 and SEQ ID NO.:78 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:80, SEQ ID NO.:81 and SEQ ID NO.:82.

55. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:84, SEQ ID NO.:85 and SEQ ID NO.:86 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:88, SEQ ID NO.:89 and SEQ ID NO.:90.

56. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:92, SEQ ID NO.:93 and SEQ ID NO.:94 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:96, SEQ ID NO.:97 and SEQ ID NO.:98.

57. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:100, SEQ ID NO.:101 and SEQ ID

NO.:102 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:104, SEQ ID NO.:105 and SEQ ID NO.:106.

58. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:108, SEQ ID NO.:109 and SEQ ID NO.:110 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:112, SEQ ID NO.:113 and SEQ ID NO.:114.

59. An antibody or an antigen binding fragment thereof that specifically binds to LAIR-1, wherein the antibody or antigen binding fragment thereof comprises light chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:116, SEQ ID NO.:117 and SEQ ID NO.:118 and heavy chain complementarity determining regions having the amino acid sequence set forth in SEQ ID NO.:112, SEQ ID NO.:113 and SEQ ID NO.:114.

60. The antibody of any one of claims 47-59, wherein the antibody comprises a human Fc domain.

61. An antibody comprising a heavy chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:120 or SEQ ID NO:122 and/or a light chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:123.

62. An antibody comprising a heavy chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:126 or SEQ ID NO:128 and/or a light chain with an amino acid sequence having at least 50, 60,

70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:130.

63. An antibody comprising a heavy chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:132 or SEQ ID NO:134 and/or a light chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:136.

64. An antibody comprising a heavy chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:138 or SEQ ID NO:140 and/or a light chain with an amino acid sequence having at least 50, 60, 70, 80, 85, 90, 95, 96, 97, 98, 99, or 100% sequence identity to the amino acid sequence set forth in SEQ ID NO:142.

65. A nucleic acid sequence encoding an antibody comprising a light chain amino acid sequence according to SEQ ID NO:124, 130, 136, or 142 and/or a heavy chain amino acid according to SEQ ID NO: 120, 122, 126, 128, 132, 134, 138, or 140.

66. A nucleic acid sequence encoding a variable light chain according to SEQ ID NOs 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, or 115 and/or a variable heavy chain according to SEQ ID NOs 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, or 111.

67. A cell constitutively- or inducibly-expressing an antibody or antigen binding fragment thereof that specifically binds to LAIR-1, wherein the cell comprises a nucleic acid or nucleic acids encoding an amino acid sequence according to SEQ ID NOs: 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, 115, 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, 111, or a combination thereof.

68. A cell constitutively- or inducibly-expressing an antibody or antigen binding fragment thereof that specifically binds to LAIR-1, wherein the cell comprises a nucleic acid or nucleic acids encoding an amino acid a sequence

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according to SEQ ID NOs: 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, or a combination thereof.

[illegible]

FIG. 1A

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[illegible][illegible]

FIG. 1B

Alignment Results

Data Name:
Description:
File Name:

anti-Lair1 VL Tree Alignment
Multi-way Protein alignment, 13 sequences
\\corp.nextcure.com\corpdata\Users\$\...\anti-Lair1 VL Tree Alignment.am4

Alignment:
Parameters:

Multi-way Protein alignment.
Scoring matrix: BLOSUM 62

Number of sequences to align: 13
Total length of aligned sequences with gaps: 114 aas

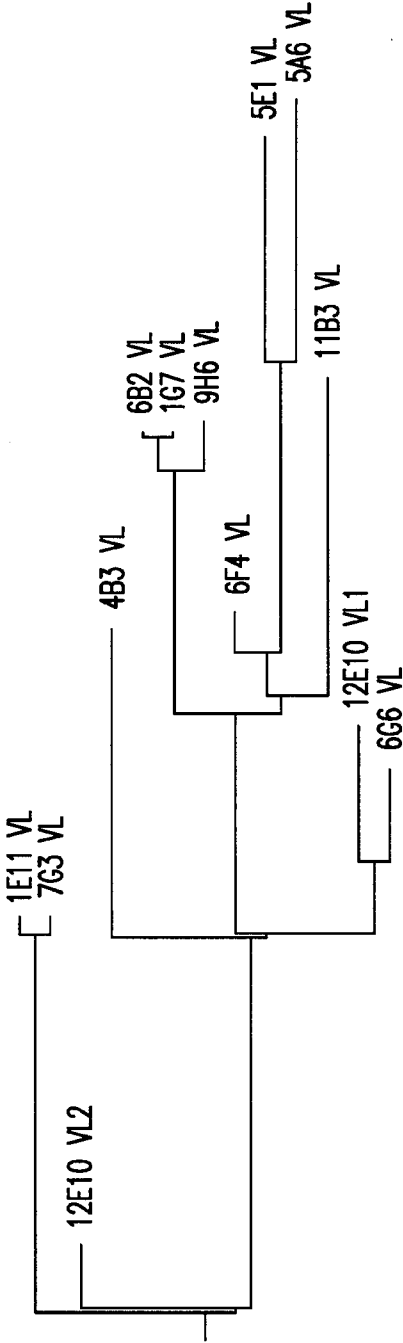


FIG. 2A

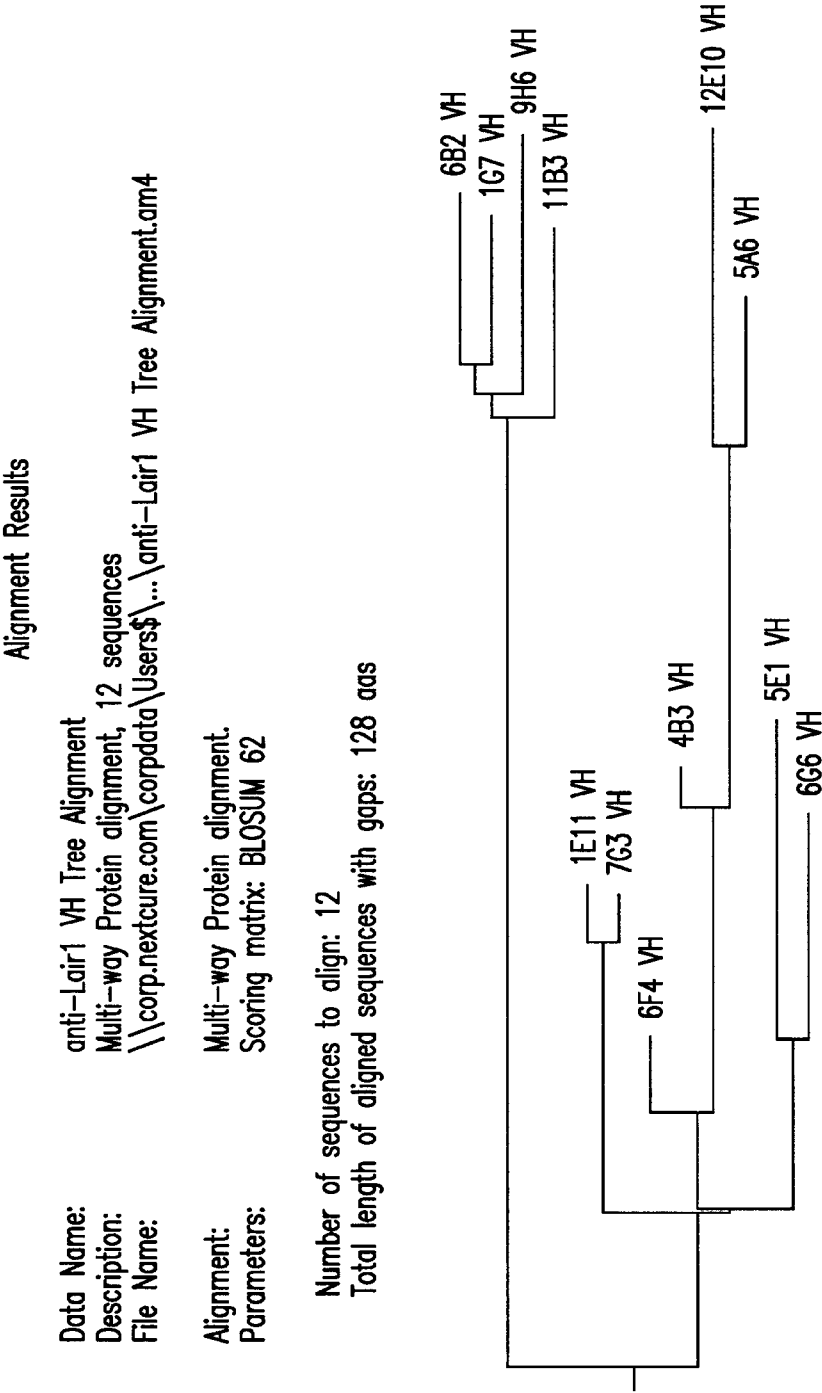


FIG. 2B

● Cancer cells expressing multiple interacting inhibitory receptors may respond better to therapies disrupting these interactions

○ Cis/Trans interactions?

○ Tonic Signaling

LAIR-1	TM collagen (3)	LILRB4	Anti-tumor effect
(-)	(-)	(-)	(-)
(+)	(-)	(-)	(+/-)
(+)	(+)	(-)	(+)
(+)	(-)	(+)	(++)
(+)	(+)	(+)	(+++)

FIG. 3

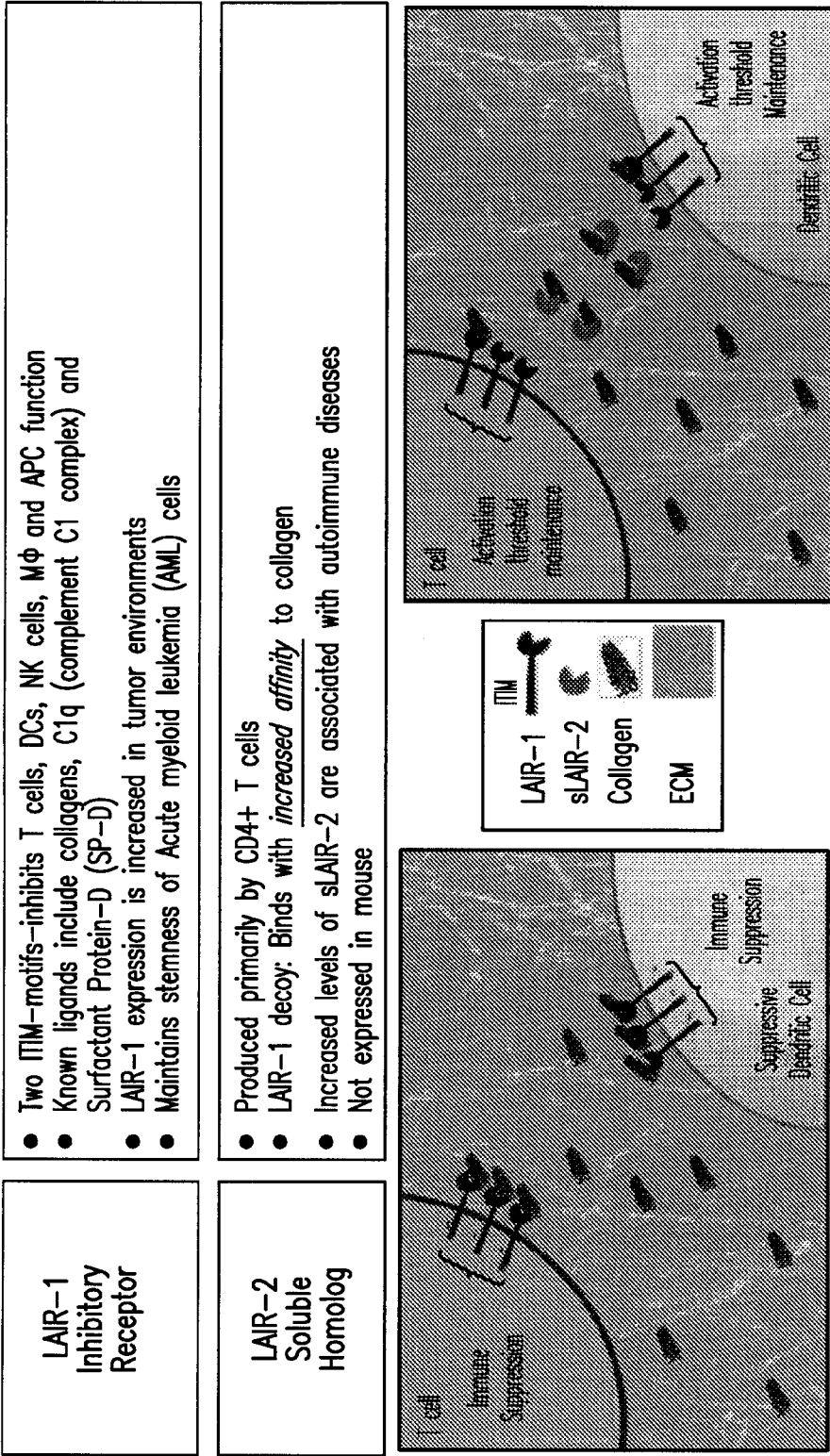


FIG. 4

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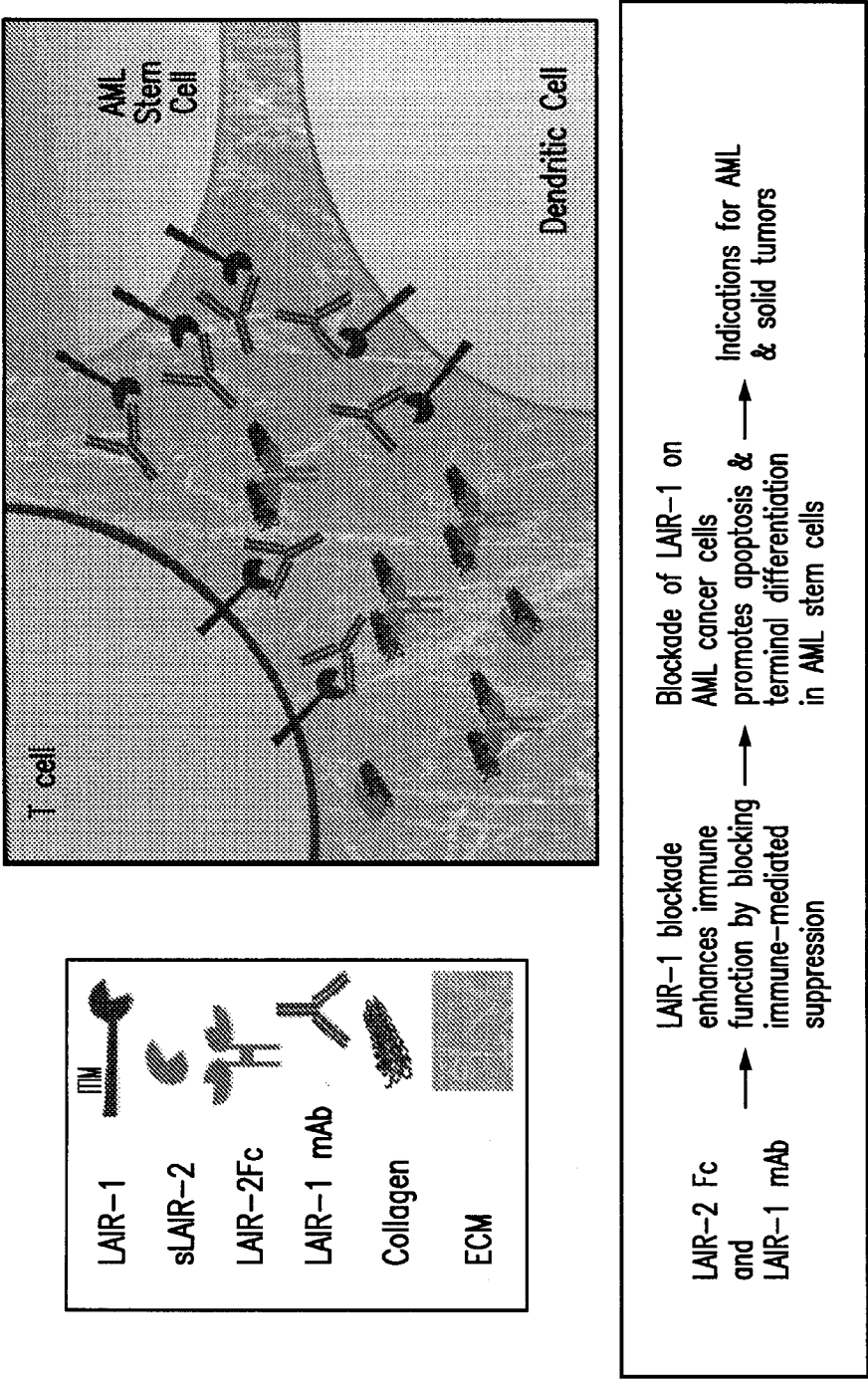


FIG. 5

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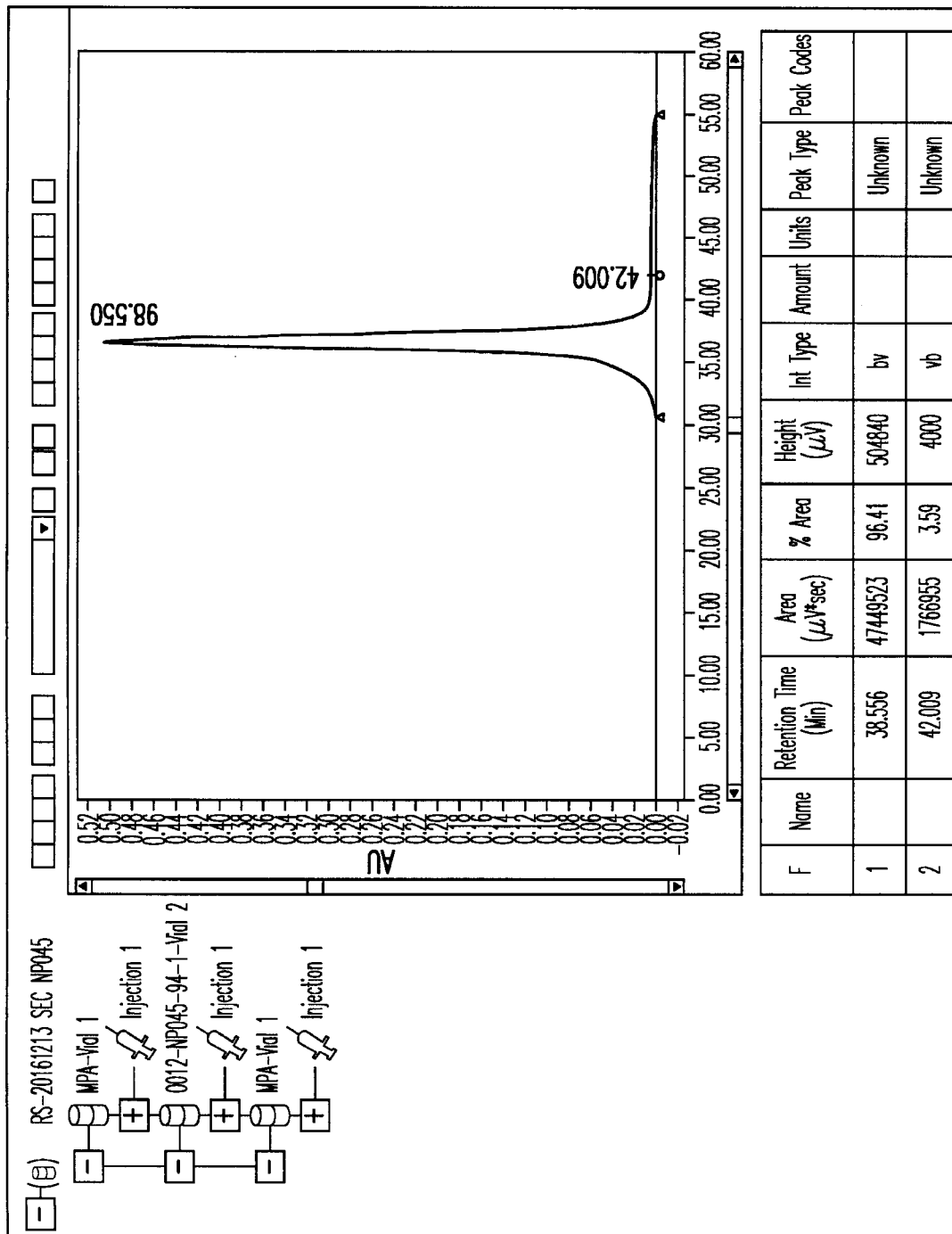


FIG. 6B

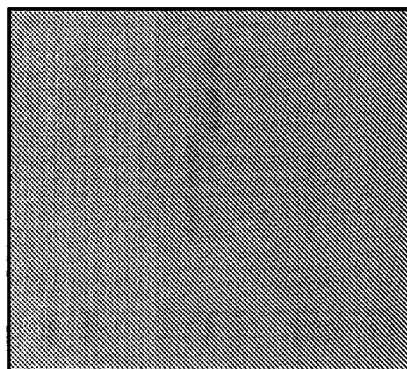


FIG. 6A

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K562-Col17

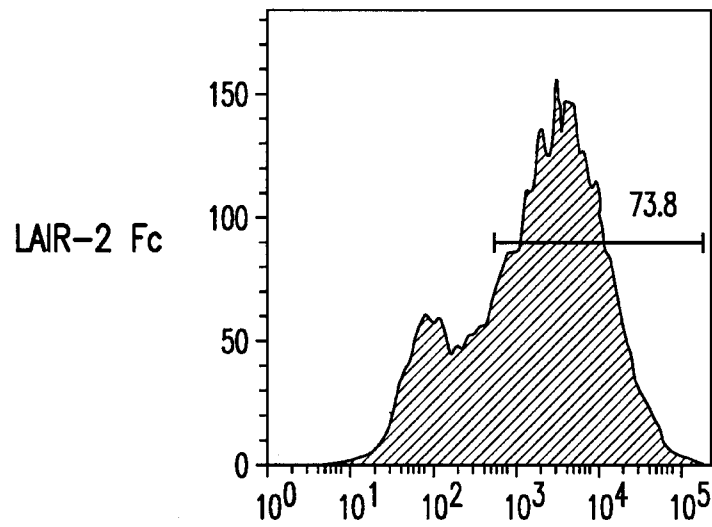


FIG. 7A

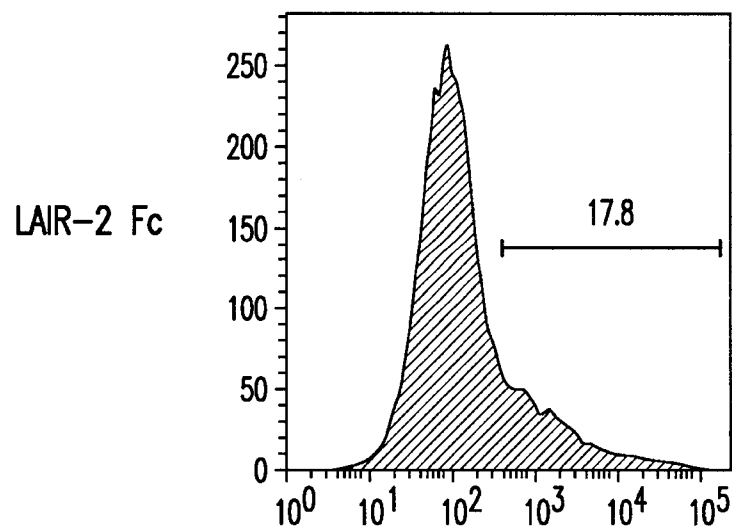
Negative
control

FIG. 7B

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K562-Col17

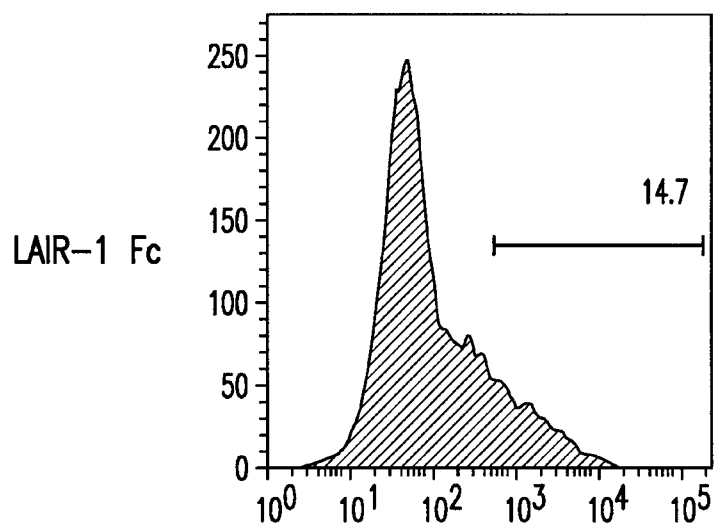


FIG. 7C

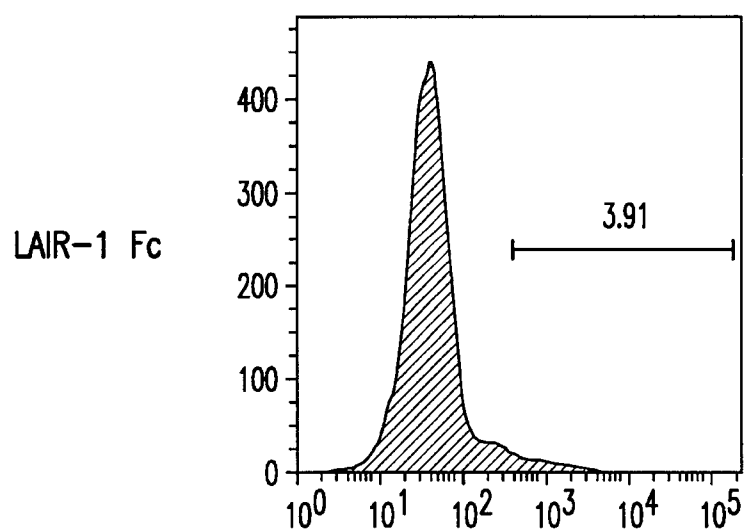
Negative
control

FIG. 7D

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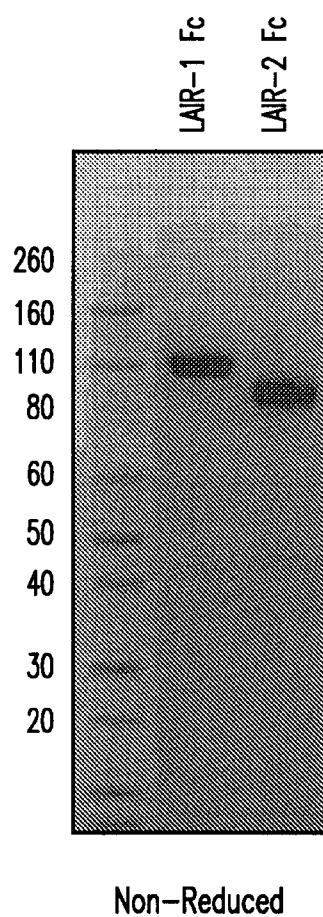


FIG. 7E

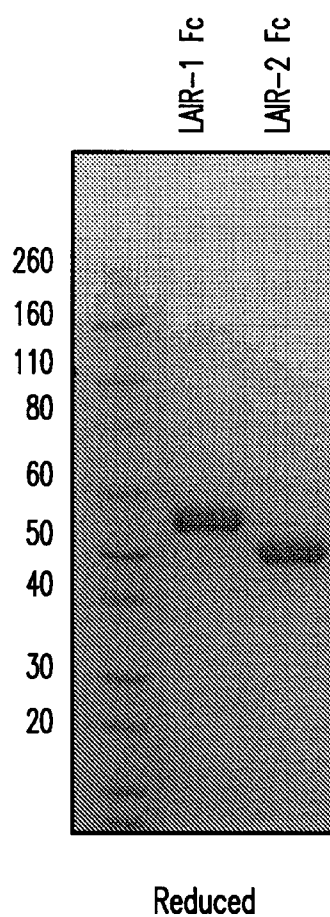
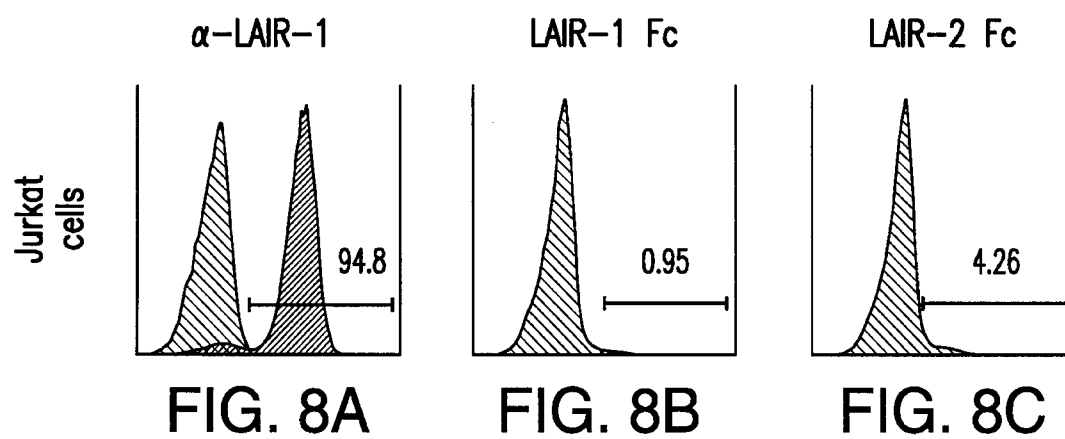


FIG. 7F



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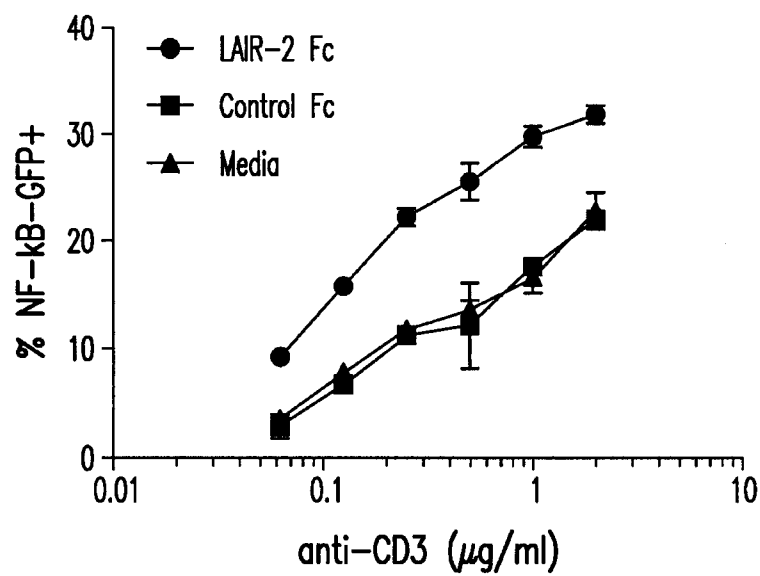
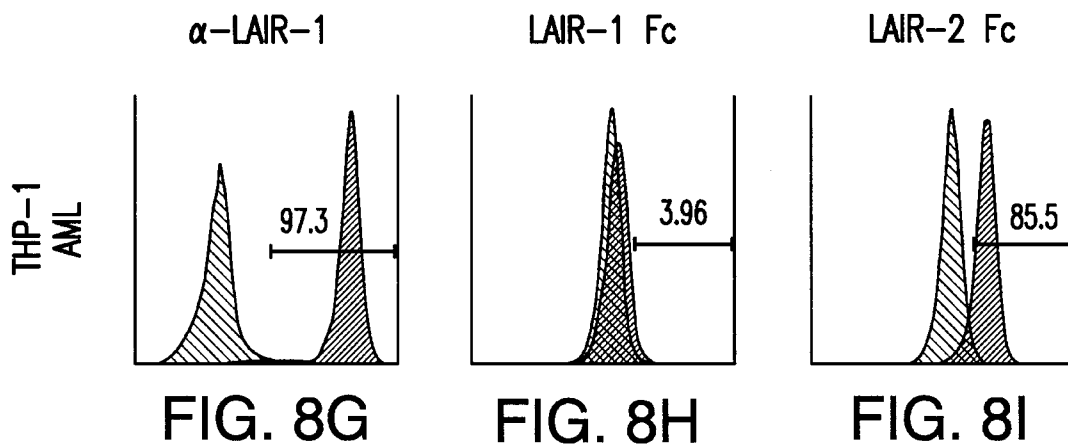
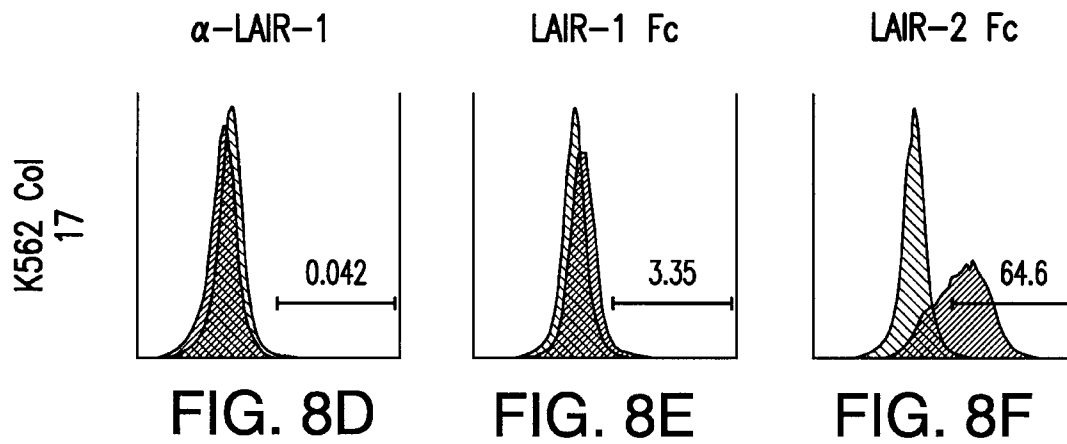


FIG. 9A

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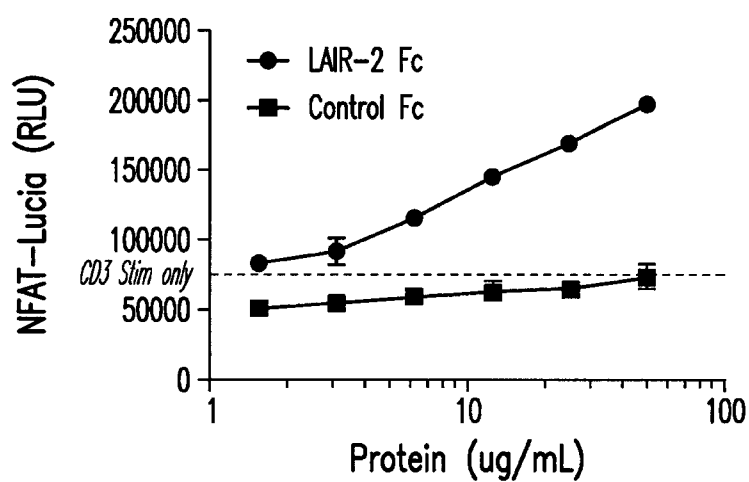


FIG. 9B

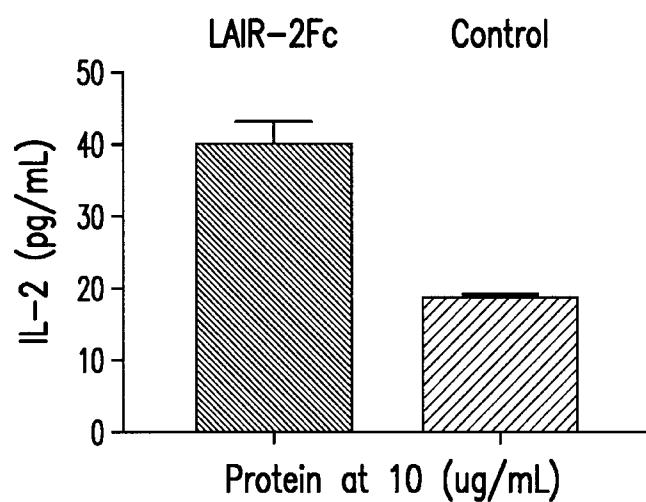


FIG. 9C

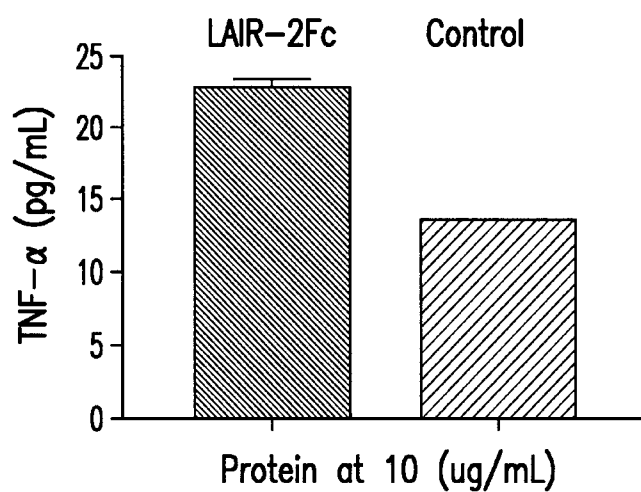


FIG. 9D

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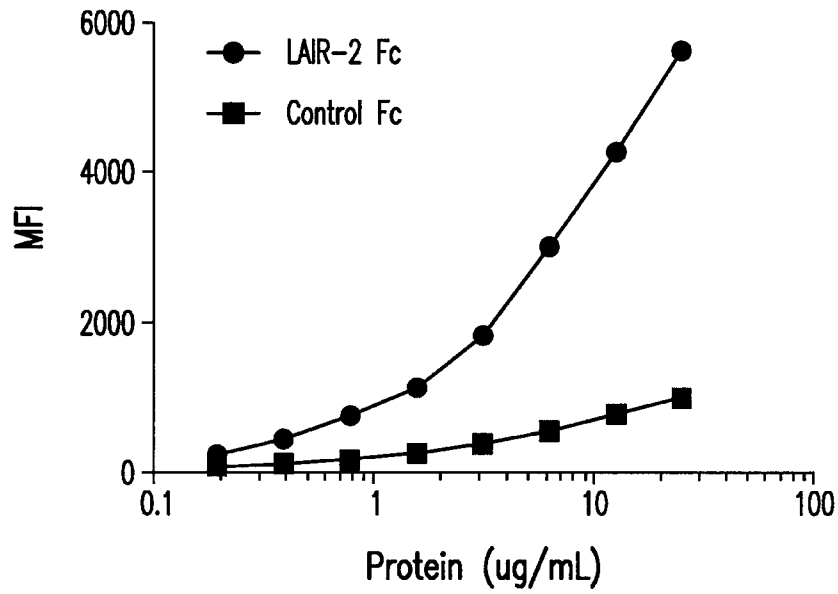


FIG. 10A

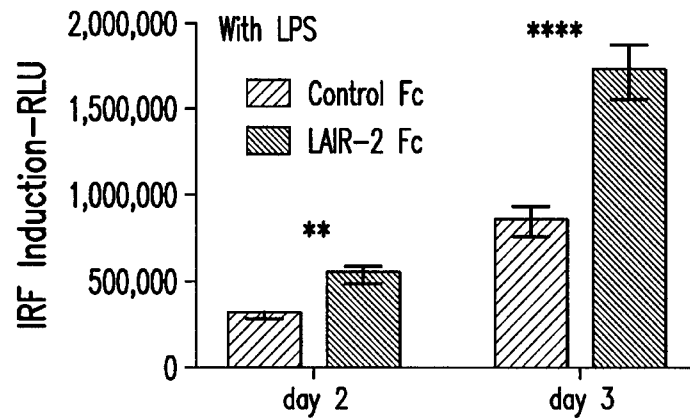


FIG. 10B

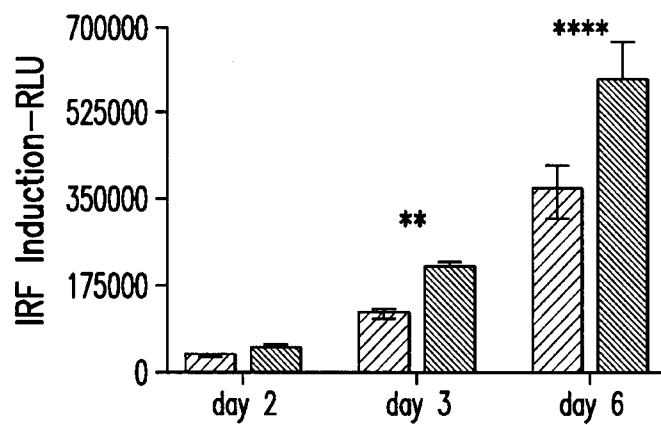


FIG. 10C

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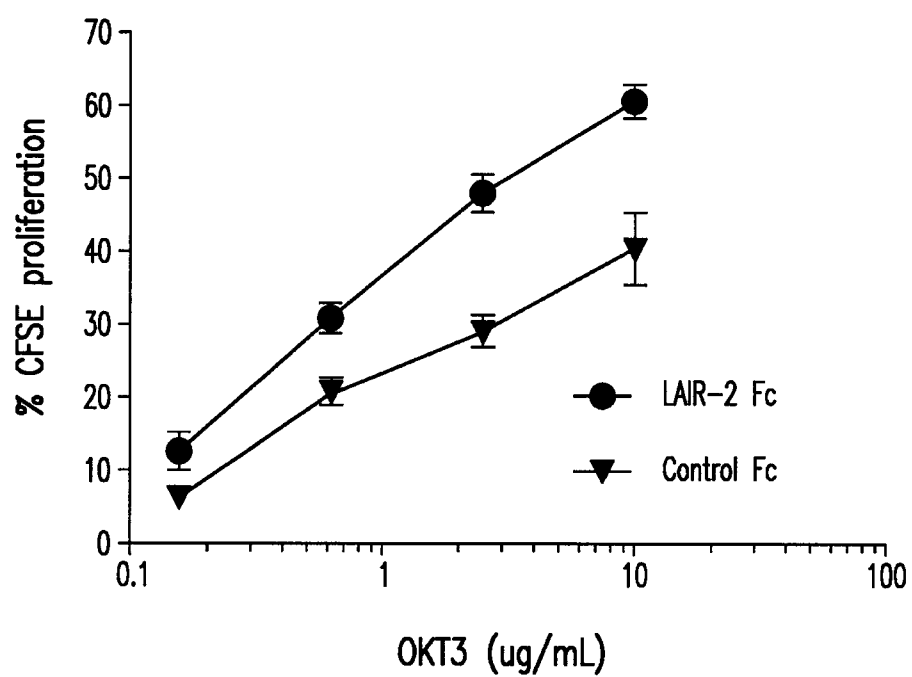


FIG. 11A

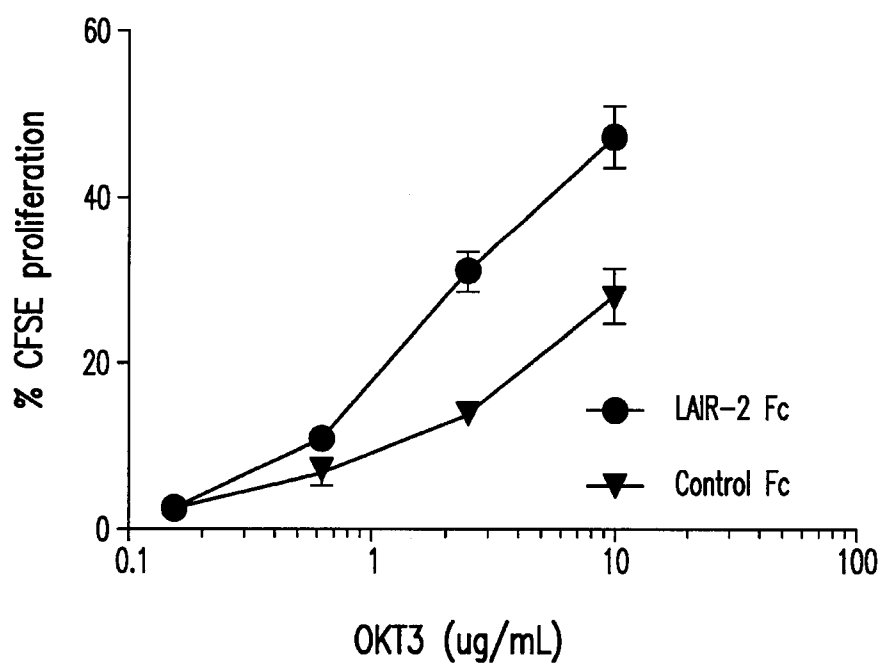


FIG. 11B

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CD4

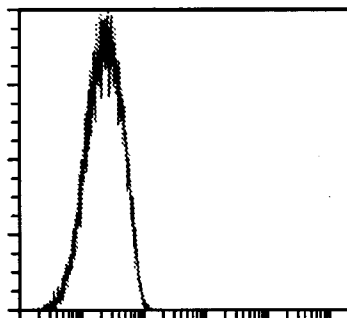
Donor
1710

FIG. 12A

CD8

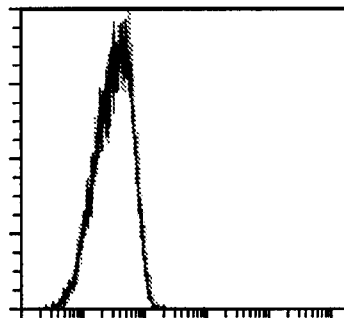
Donor
1710

FIG. 12B

NK cells

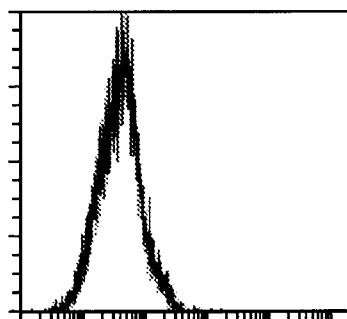
Donor
1710

FIG. 12C

Monocytes

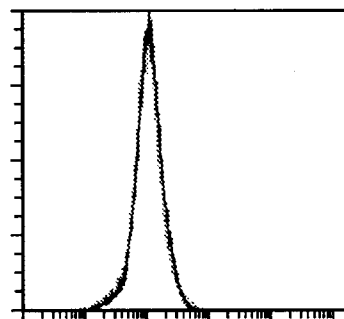
Donor
1710

FIG. 12D

CD4

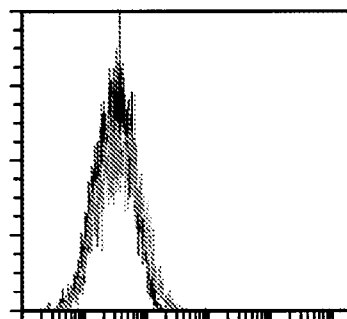
Donor
1711

FIG. 12E

CD8

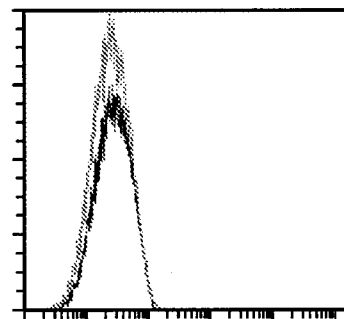
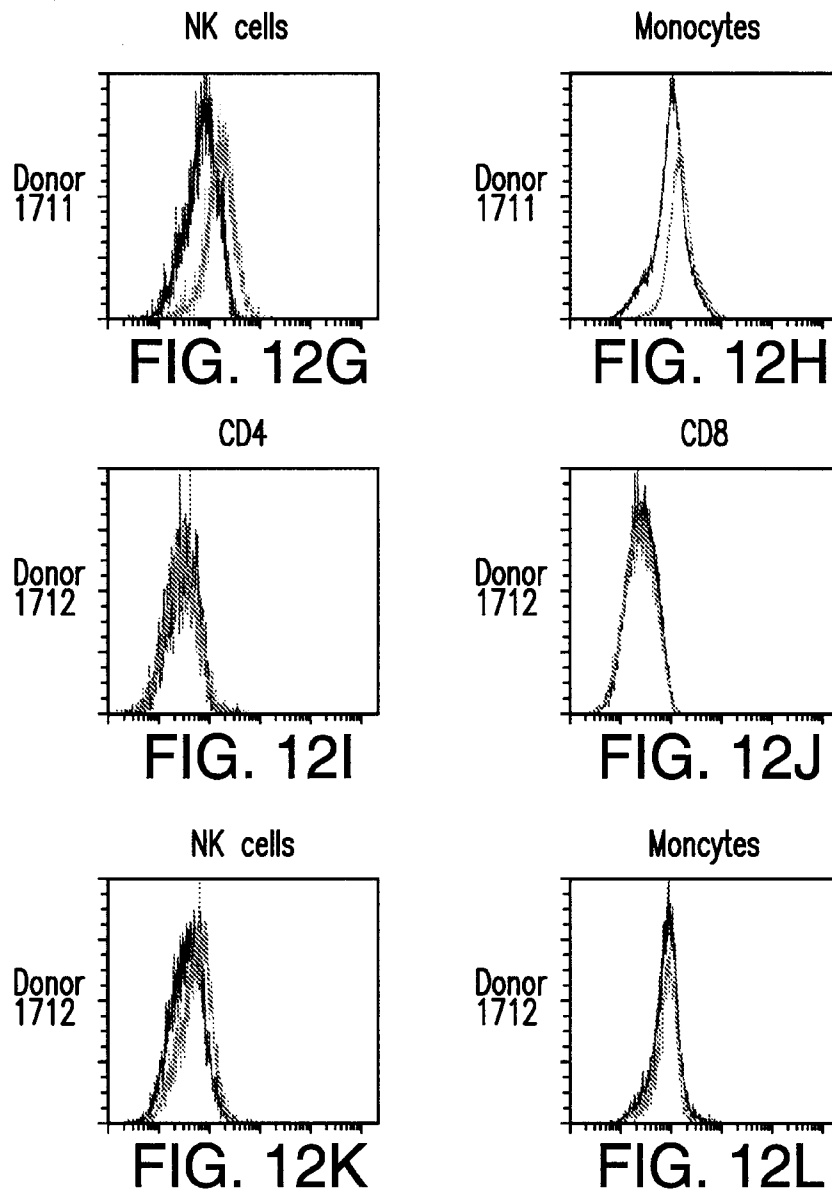
Donor
1711

FIG. 12F

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Treatment groups:
(10 mice/group)

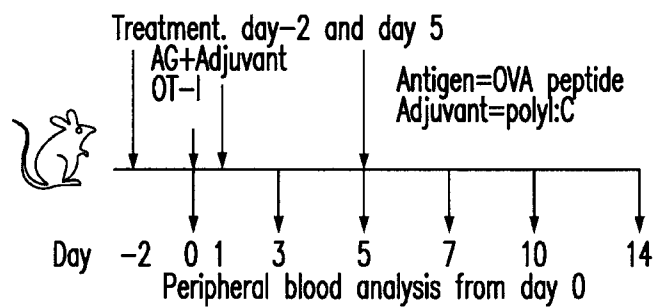


FIG. 13A

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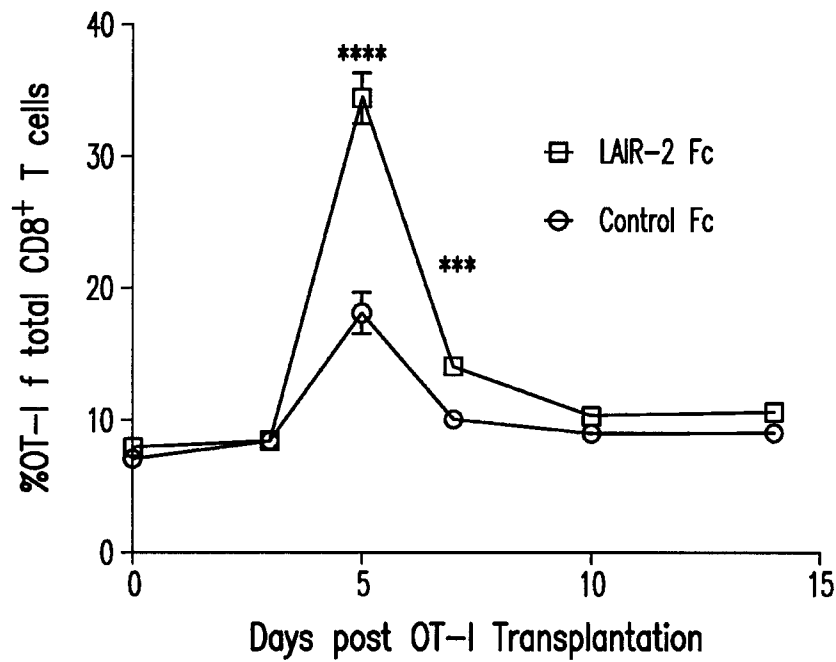


FIG. 13B

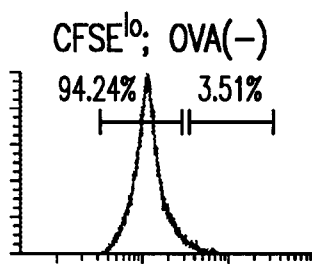


FIG. 14A

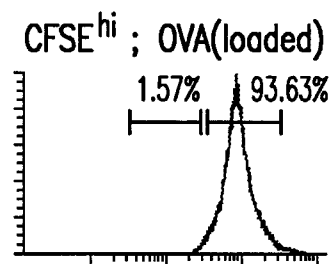


FIG. 14B

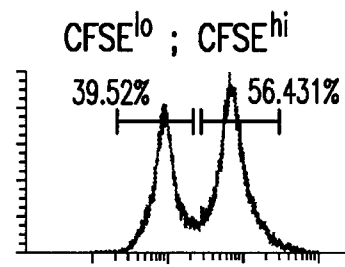


FIG. 14C

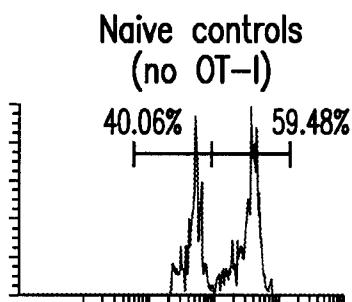


FIG. 14D

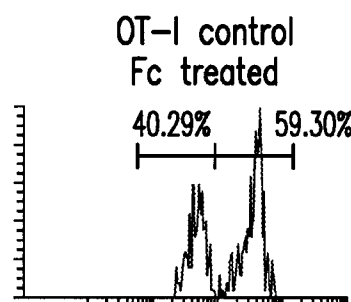


FIG. 14E

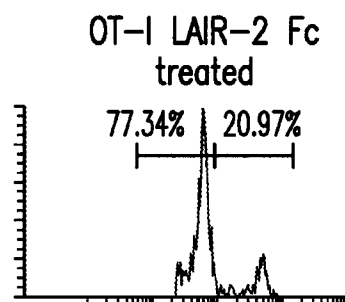


FIG. 14F

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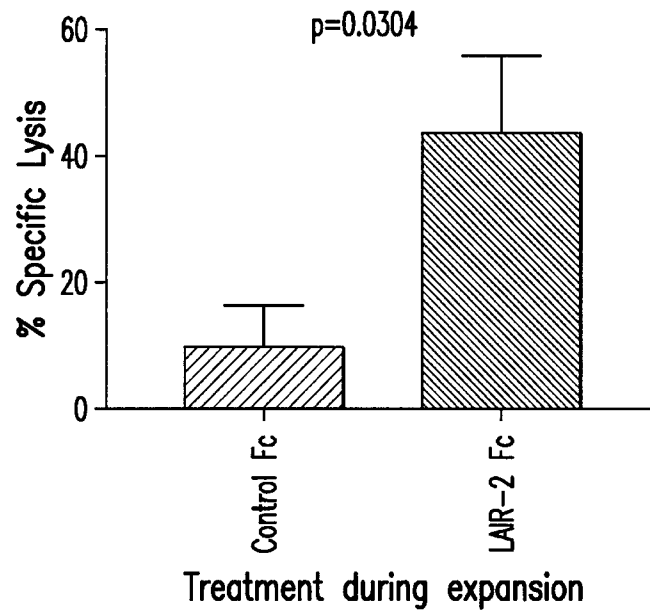


FIG. 14G

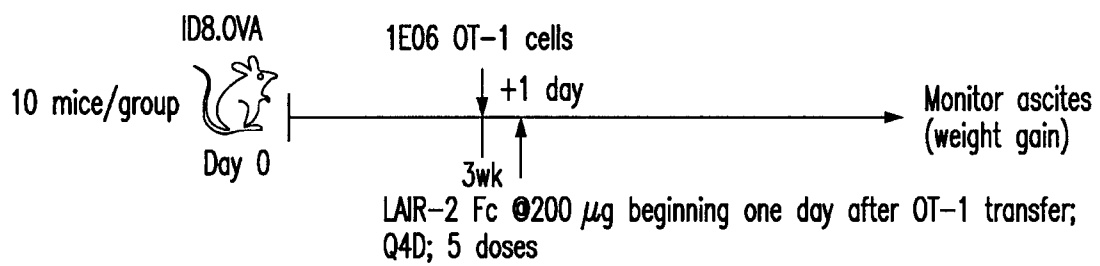


FIG. 15A

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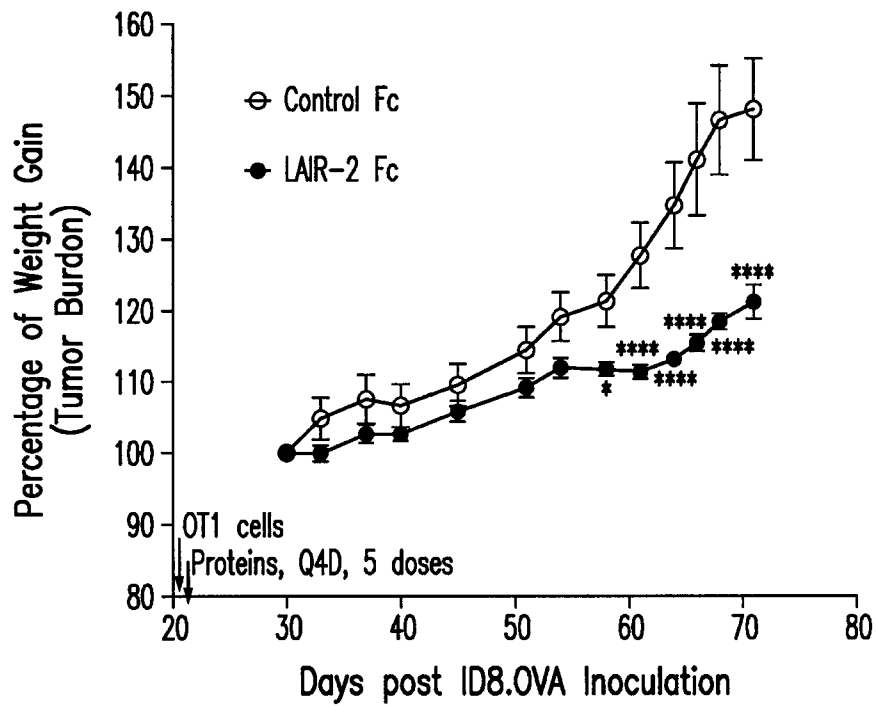


FIG. 15B

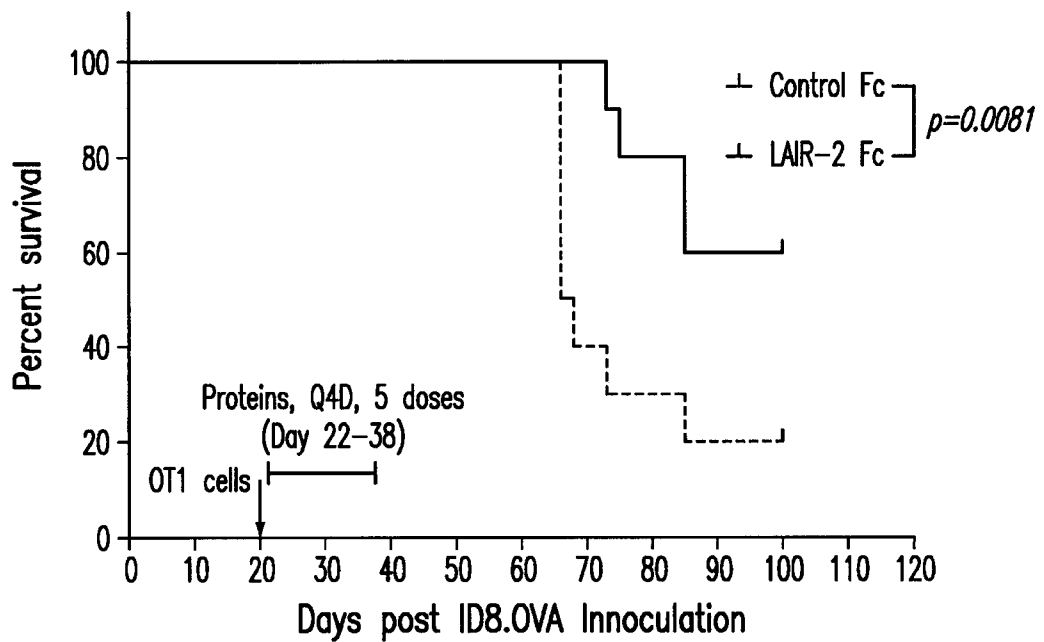


FIG. 15C

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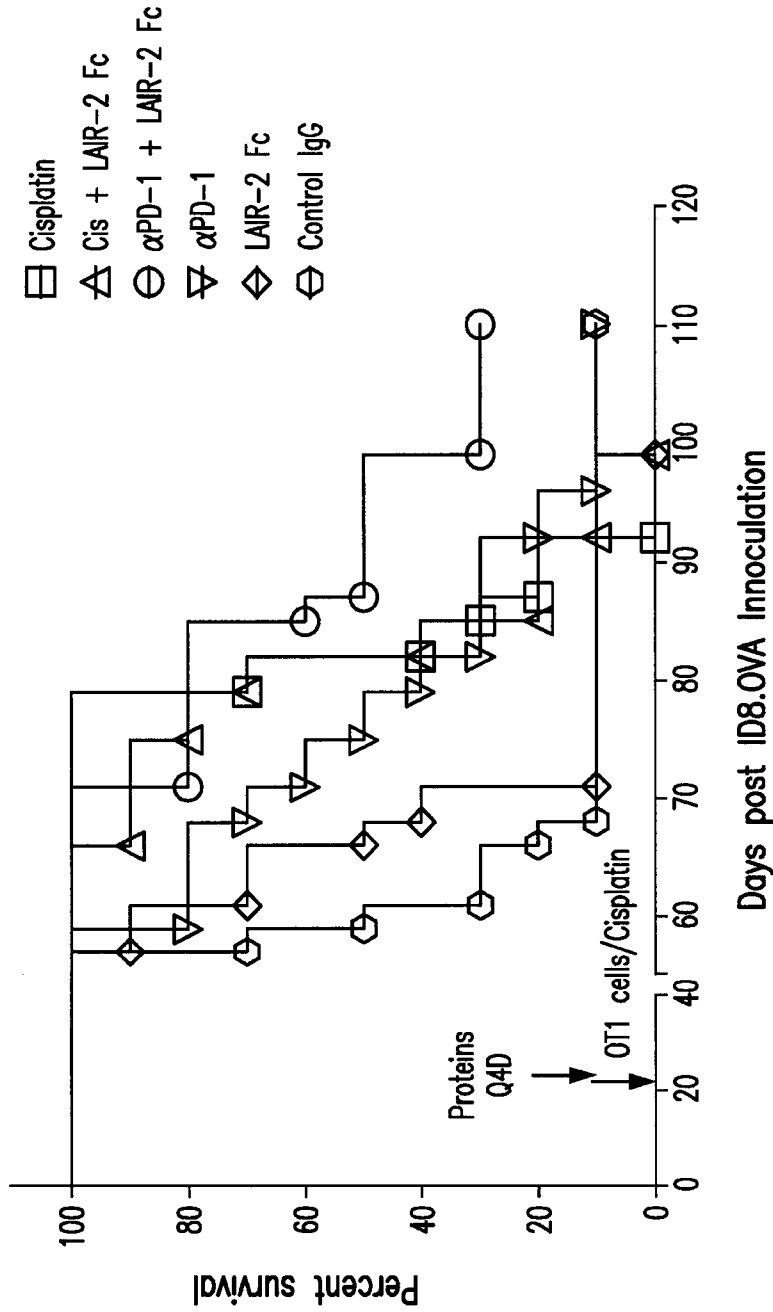


FIG. 16

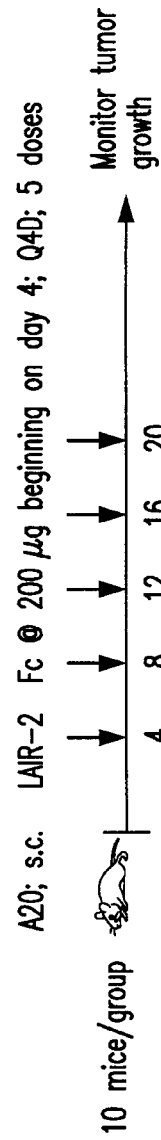


FIG. 17A

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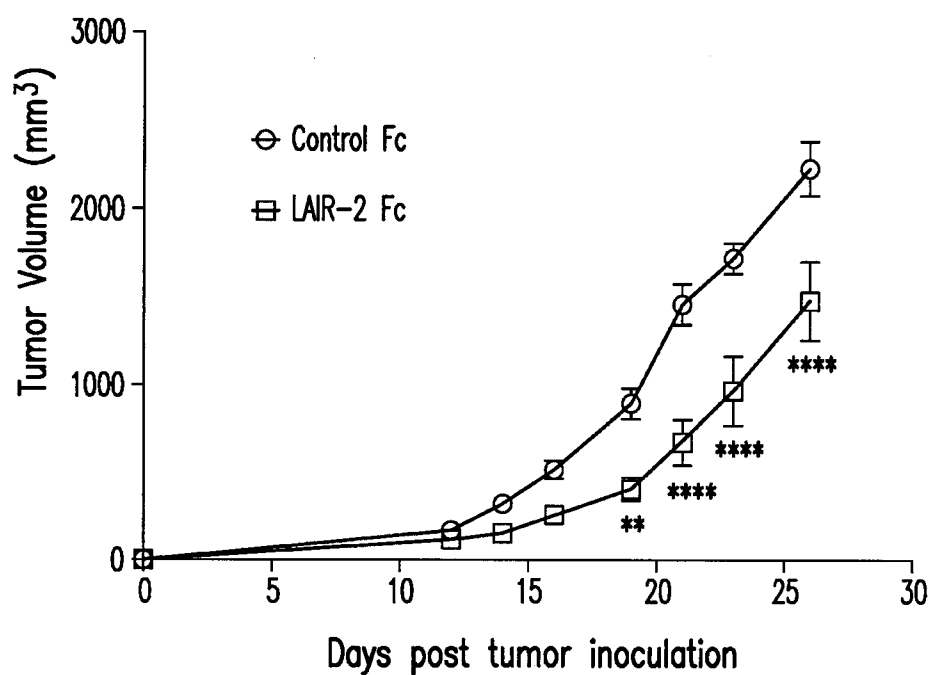


FIG. 17B

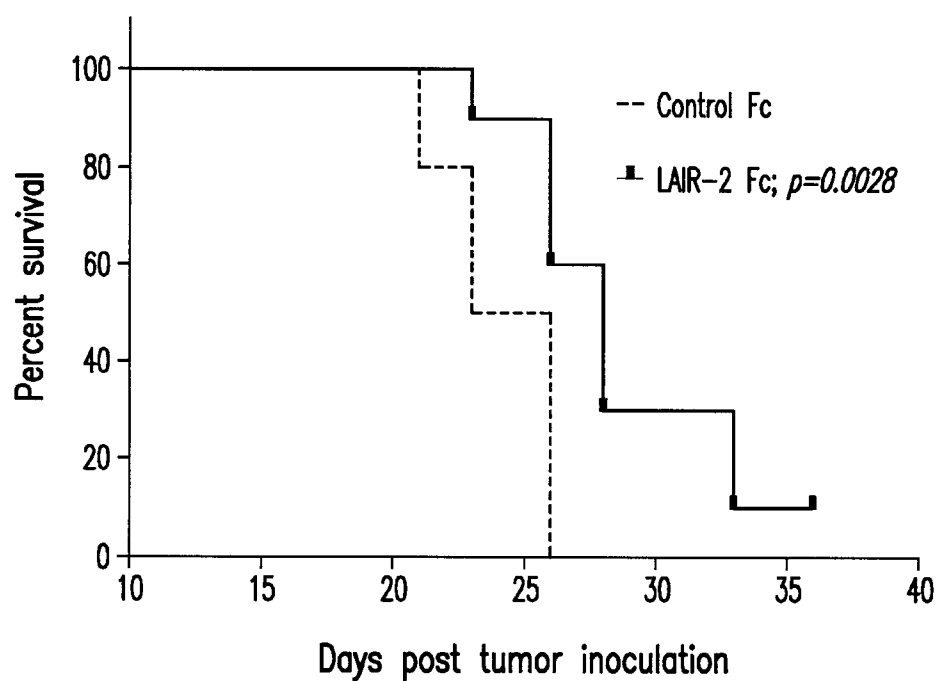


FIG. 17C

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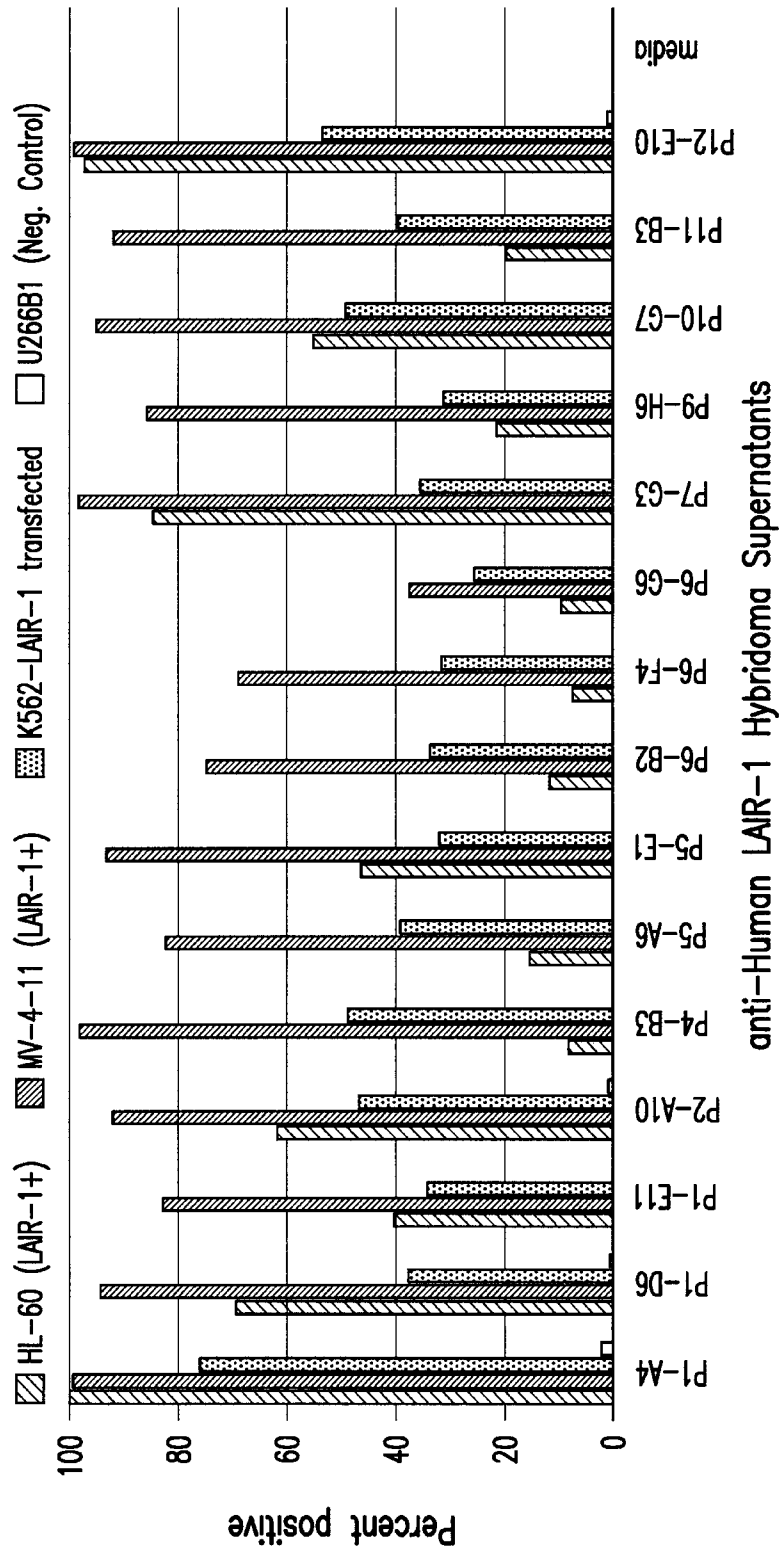


FIG. 18

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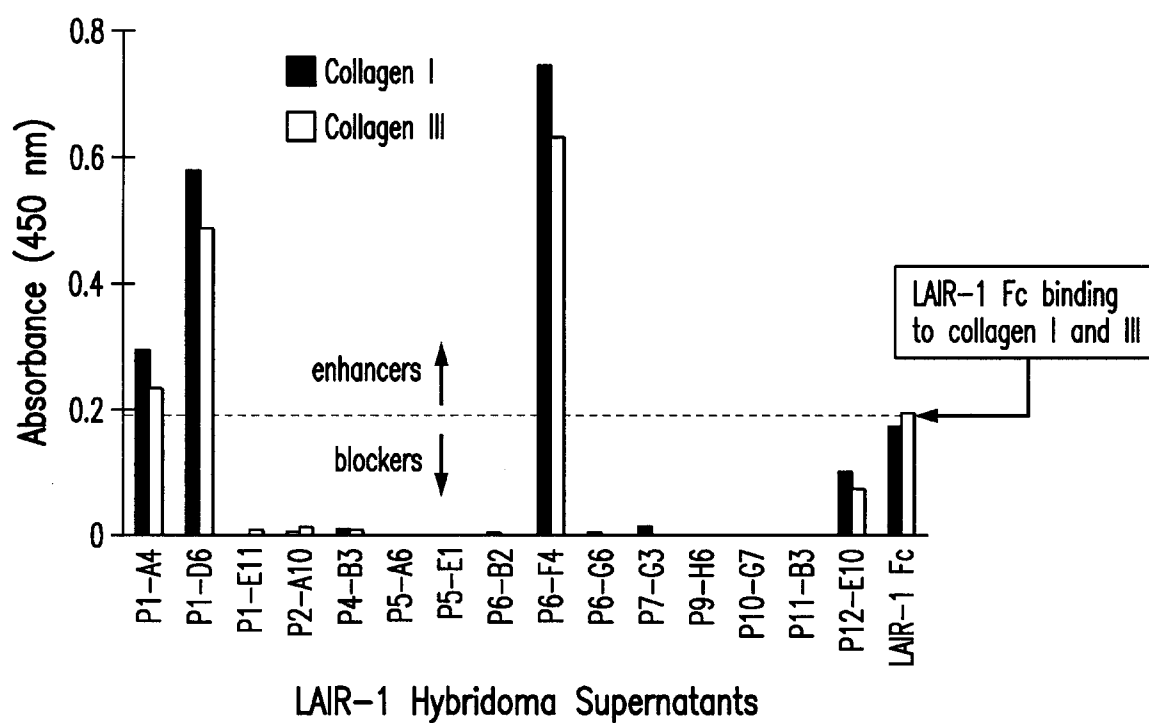


FIG. 19

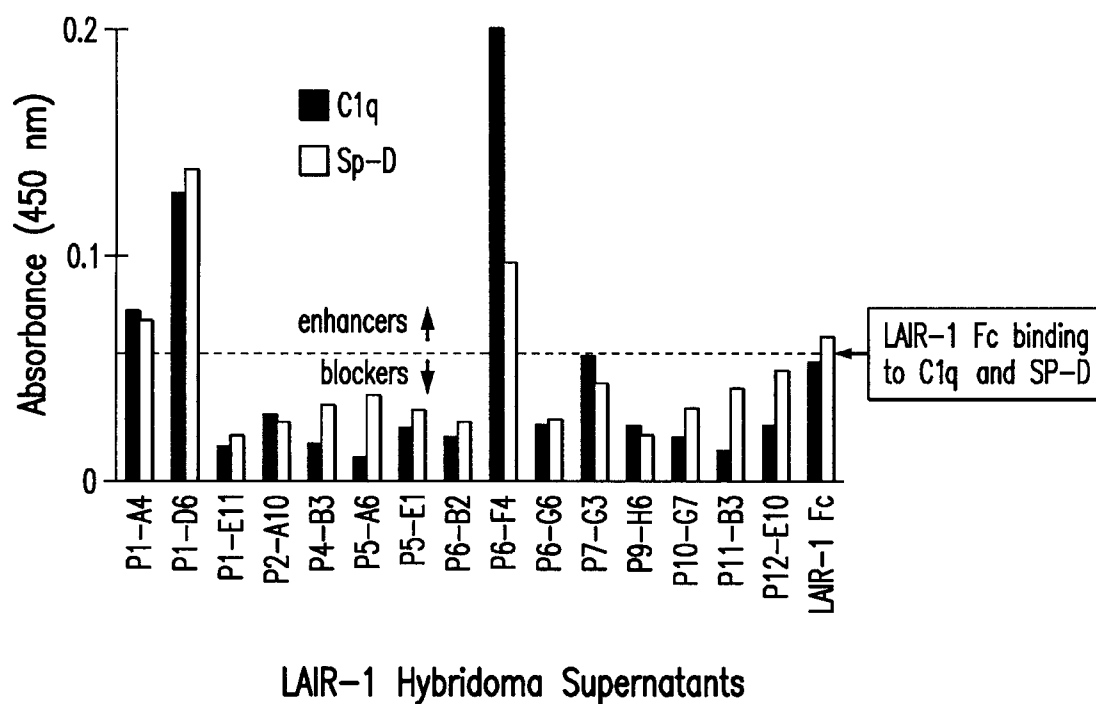


FIG. 20

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2nd mAb

	4B3	5E1	6B2	11B3	NK1A255	6F4	1E11	7G3	1A4	10G7	9H6	5A6	DX26	6G6
4B3	0.0217	0.0123	0.0256	0.043	0.0305	0.3528	-0.0098	-0.0025	-0.0005	-0.0068	0.0005	0.4912	0.6297	0.687
5E1	0.0219	0.0188	0.0658	0.0731	0.2314	0.1526	-0.0114	-0.0063	0.0095	0.0395	0.036	0.2325	0.674	0.7905
6B2	0.0064	0.0218	0.0087	0.0198	0.0121	0.0119	-0.006	-0.0047	-0.0013	-0.0003	0.0111	0.4523	0.0124	0.6653
11B3	0.0052	0.0101	0.0067	0.0169	0.0087	0.0071	-0.0063	-0.0045	-0.0055	0.0027	0.0068	0.4274	-0.001	0.618
NK1A255	0.0051	0.1018	0.0094	0.0231	0.0137	0.0153	-0.0066	0.0001	-0.0004	0.0061	0.0128	0.4367	0.0124	0.665
6F4	0.3312	0.3987	0.0105	0.0246	0.0131	0.0102	0.0375	0.0294	-0.0243	-0.0136	-0.0057	0.4378	-0.0008	0.6923
1E11	0.2729	0.2577	0.3583	0.4162	0.3416	0.3677	0.033	0.0316	0.0194	0.0655	0.1322	0.4807	0.6615	0.696
7G3	0.3035	0.2813	0.3911	0.4393	0.3802	0.3853	0.0403	0.0402	0.0376	0.0819	0.1501	0.5044	0.691	0.7623
1A4	0.5416	0.5306	0.6659	0.7656	0.6292	0.4269	0.0905	0.0813	0.0353	0.0939	0.175	0.5333	0.6867	0.8121
10G7	0.31	0.4089	0.3273	0.3971	0.3218	0.2802	0.0329	0.041	0.0246	0.0792	0.1396	0.5255	0.3399	0.772
9H6	0.1366	0.2045	0.0622	0.0831	0.072	0.0828	0.0123	0.0215	0.0176	0.0301	0.0501	0.5033	0.1383	0.7774
5A6	0.4351	0.1455	0.5596	0.6474	0.4861	0.3122	0.0263	0.0249	-0.0543	0.0029	0.0798	0.0063	0.5941	0.0278
DX26	0.386	0.4638	0.0018	0.0184	-0.0006	-0.0201	0.0773	0.0675	-0.01	-0.0128	-0.0051	0.45	0.0178	0.7021
6G6	0.3936	0.4498	0.5605	0.6443	0.5099	0.3467	0.0188	0.0285	0.0058	0.0634	0.1378	-0.0068	0.5876	0.0167

1st mAb

FIG. 21

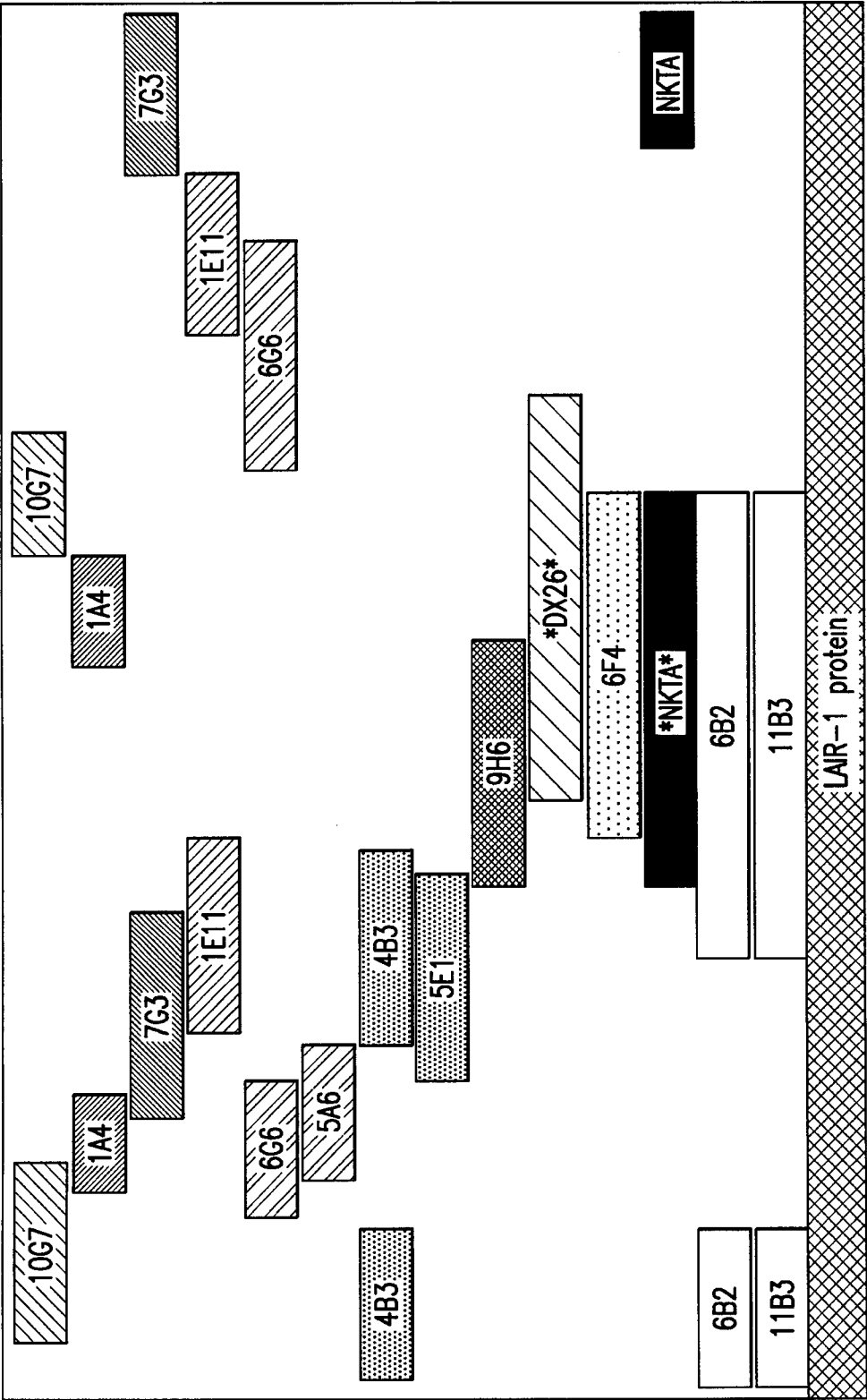


FIG. 22

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Rank	LAIR-1 chimeras	Kd(nM)	Kdis (1/s)	Kon
1	1E11	1.37	0.00124	6.5E-04
2	7G3	1.63	0.000111	7.8E-04
3	11B3	1.98	0.0017	8.4E-05
4	5E1	3.92	0.00189	4.8E-05
5	6G6	4.7	0.00322	8.5E-05
6	6B2	6.53	0.00354	5.1E-05
7	9H6	11.6	0.0104	8.4E-05
8	6F4	12.77	0.0115	9.1E-05
9	10G7	14.9	0.0154	9.0E-05
10	12E10V1	20.2	0.0127	6.3E-05
11	5A6	23.3	0.0302	1.3E-06
12	4B3	32.3	0.02	6.3E-05
13	12E10V2	No binding		

FIG. 23

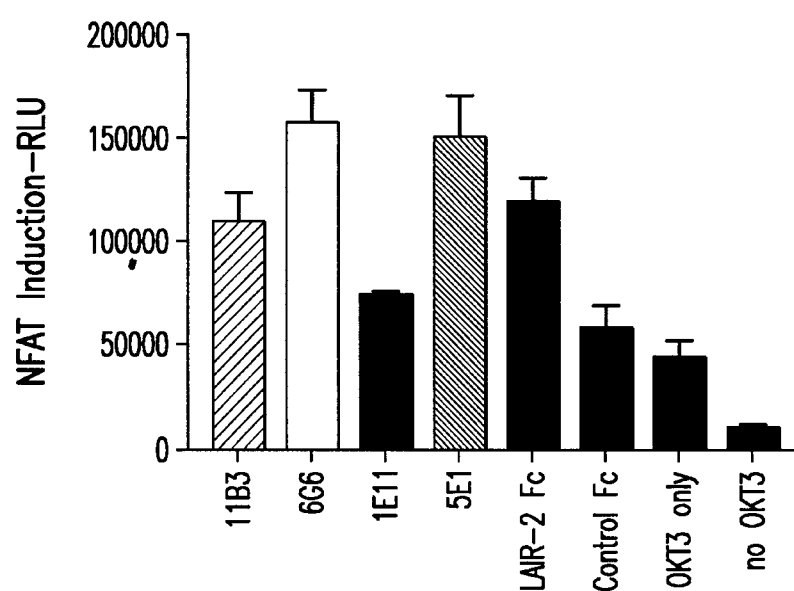


FIG. 24A

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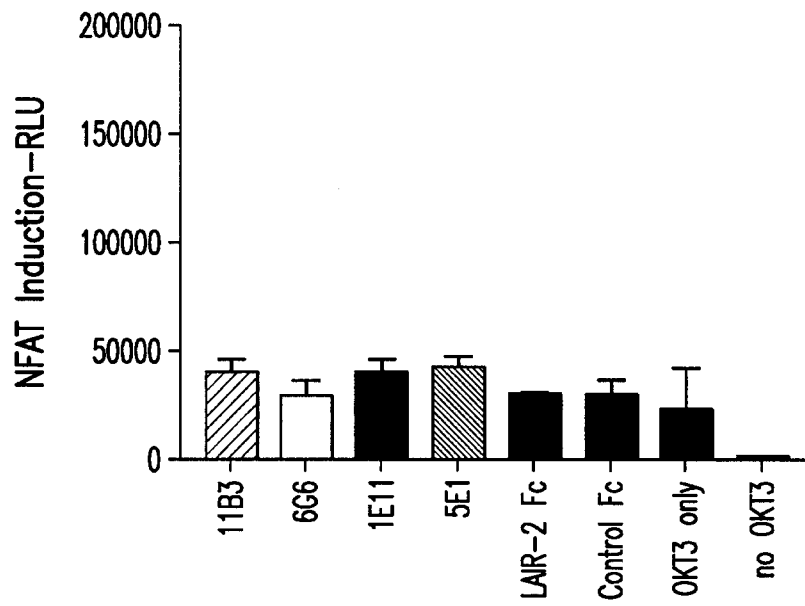


FIG. 24B

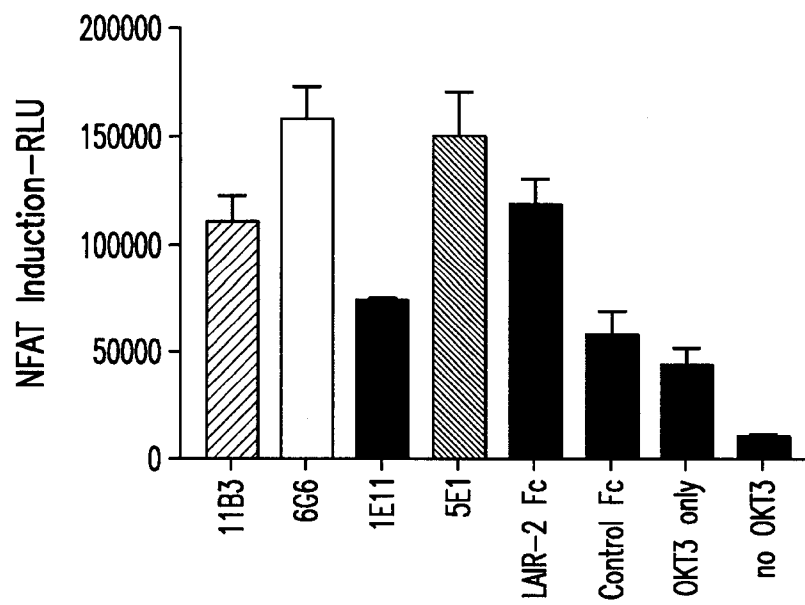


FIG. 25A

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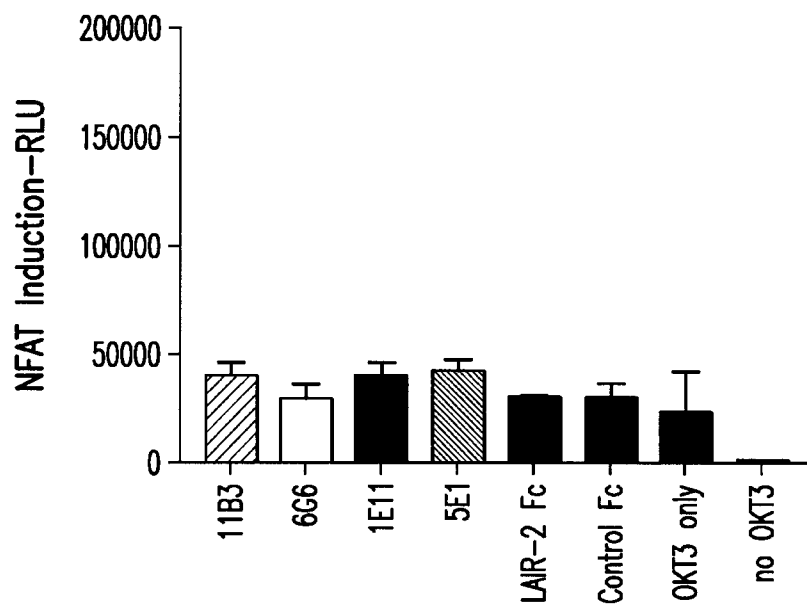


FIG. 25B

