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Office de la Propriété Intellectuelle du Canada

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Canadian Intellectual Property Office

CA 3096779 A1 2019/10/17

(21) 3 096 779

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2019/04/11
(87) Date publication PCT/PCT Publication Date: 2019/10/17
(85) Entrée phase nationale/National Entry: 2020/10/09
(86) N° demande PCT/PCT Application No.: IB 2019/000423
(87) N° publication PCT/PCT Publication No.: 2019/197903
(30) Priorités/Priorities: 2018/04/12 (EP18382248.5); 2018/05/14 (EP18382326.9); 2018/05/25 (EP18382360.8); 2019/02/22 (EP19382132.9)

(51) Cl.Int./Int.Cl. *A61K 39/395* (2006.01), *A61P 35/00* (2006.01), *C07K 16/24* (2006.01), *C07K 16/28* (2006.01)

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(54) Titre : COMBINAISON D'INHIBITEURS DE LIF ET D'INHIBITEURS DE L'AXE PD-1 POUR UNE UTILISATION DANS LE TRAITEMENT DU CANCER

(54) Title: COMBINATION OF LIF INHIBITORS AND PD-1 AXIS INHIBITORS FOR USE IN TREATING CANCER

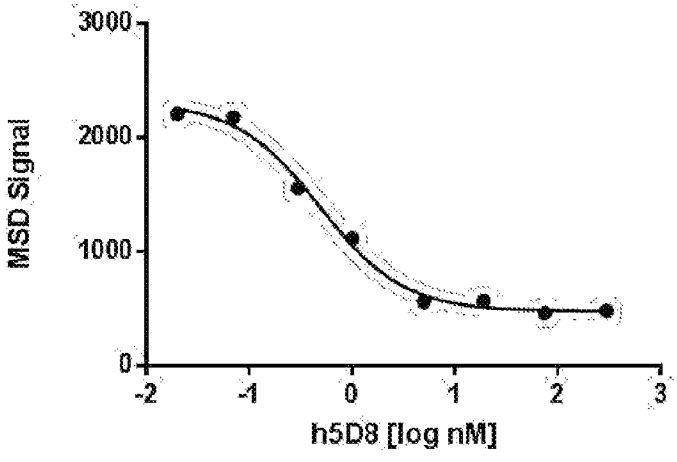


**Fig. 3A**

(57) Abrégé/Abstract:
Described herein are methods of treating cancer using combinations of Leukemia Inhibitory Factor (LIF)-binding polypeptides and PD-1 axis inhibitors.

(21) 3 096 779

(13) A1

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 October 2019 (17.10.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/197903 A8

(51) International Patent Classification:
*C07K 16/24* (2006.01) *C07K 16/28* (2006.01)

(21) International Application Number:
PCT/IB2019/000423

(22) International Filing Date:
11 April 2019 (11.04.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

| | | |
|---|---|---|
| 18382248.5 | 12 April 2018 (12.04.2018) | EP |
| 18382326.9 | 14 May 2018 (14.05.2018) | EP |
| 18382360.8 | 25 May 2018 (25.05.2018) | EP |
| 19382132.9 | 22 February 2019 (22.02.2019) | EP |

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

**Declarations under Rule 4.17:**

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

**Published:**

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

(54) Title: COMBINATION OF LIF INHIBITORS AND PD-1 AXIS INHIBITORS FOR USE IN TREATING CANCER

(57) Abstract: Described herein are methods of treating cancer using combinations of Leukemia Inhibitory Factor (LIF)-binding polypeptides and PD-1 axis inhibitors.

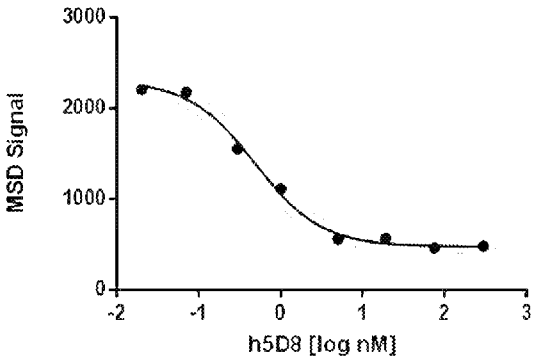



Fig. 3A

WO 2019/197903 A8

[Continued on next page]

WO 2019/197903 A8

**(48) Date of publication of this corrected version:**
20 February 2020 (20.02.2020)

**(15) Information about Correction:**
see Notice of 20 February 2020 (20.02.2020)

# COMBINATION OF LIF INHIBITORS AND PD-1 AXIS INHIBITORS FOR USE IN TREATING CANCER

## CROSS-REFERENCE

**[0001]** This application claims the benefit of priority to EP18382248.5 filed on April 12, 2018; EP18382326.9 filed on May 14, 2018; EP18382360.8 May 25, 2018; EP19382132.9 filed on February 22, 2019, each of which is incorporated by reference herein in its entirety.

## BACKGROUND

**[0002]** Leukemia inhibitory factor (LIF) is an Interleukin 6 (IL-6)-type cytokine that is involved in a variety of biological activities including the inhibition of cell differentiation. Human LIF is a polypeptide of 202 amino acids that exerts biological effects via binding to the cell surface LIF receptor (LIFR or CD118) which heterodimerizes with gp130. This leads to activation of pro-growth signaling pathways such as the mitogen activated protein kinase (MAPK) and the Janus activated kinase (JAK/STAT) pathway. High expression levels and high serum levels of LIF have been demonstrated to be associated with a poor prognosis for many types of cancer.

**[0003]** Programmed cell death protein 1, also known as PD-1 and CD279, is a cell surface receptor, expressed by activated T and B cells, that plays an important role in down-regulating the immune system and promoting self-tolerance by suppressing T cell inflammatory activity. PD-1 has been shown to bind to two different ligands, PDL-1 (CD274) and PDL-2 (CD273). Signaling through this PD-1 axis is an important mechanism for tumor growth and metastasis by allowing escape from immune surveillance. Recently, many different types of tumors have been shown to express PDL-1 and PDL-2, promoting escape from immune surveillance leading to increased tumor growth and metastasis.

## SUMMARY

**[0004]** Described herein are methods for treating or preventing a cancer, tumors, or other neoplasms in an individual. The methods and compositions of matter comprise combinations of LIF binding polypeptides and PD-1axis inhibitors. These methods may utilize anti-LIF antibodies that antagonize or block LIF activity, and polypeptides that inhibit binding activity of or signaling by PD-1, PDL-1, and PDL-2. In certain embodiments, PD-1 axis inhibitors bind and inhibit interactions between PD-1 and PDL-1 or PDL-2. In particular, these combinations exhibit a surprising synergy when compared to either anti-LIF antibodies or PD-1 axis inhibitors alone.

**[0005]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-

binding antibody, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the LIF-binding antibody is deimmunized. In certain embodiments, the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft

tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

**[0006]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 1; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 4; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 6; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 9; and (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 11. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the LIF-binding antibody is deimmunized. In certain embodiments, the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the

amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

**[0007]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 7; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the LIF-binding

antibody is deimmunized. In certain embodiments, the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

**[0008]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 2; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 7; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In

certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the LIF-binding antibody is deimmunized. In certain embodiments, the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

**[0009]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding polypeptide, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual. In certain embodiments, the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding polypeptide is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding polypeptide is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding polypeptide is administered to

the individual. In certain embodiments, the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the antibody that specifically binds to LIF comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin

heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and (b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or PD-1, PDL-1, or PDL-2 binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDl-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, or soft

tissue cancer. In certain embodiments, the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma. In certain embodiments, the cancer is refractory to treatment with a therapeutic amount of a LIF-binding polypeptide or an inhibitor of PD-1, PDL-1, or PDL-2 signaling administered as a monotherapy.

**[0010]** In another aspect, described herein, is the use of an antibody that specifically binds Leukemia Inhibitory Factor (LIF), in combination with a PD-1 binding antibody, for treating a cancer in an individual, wherein the LIF binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

**[0011]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of: (a) of a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling. In certain embodiments, the method comprises administering an effective amount of the LIF-binding polypeptide to the individual with cancer. In certain embodiments, the method comprises administering an effective amount of the inhibitor of PD-1 to the individual with cancer. In certain embodiments, the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the antibody that specifically binds to LIF comprises at least one framework region derived from a human antibody framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain

variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48 In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and: an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or a PD-1, PDL-1, or PDL-2 binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a

PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, or soft tissue cancer. In certain embodiments, the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma. In certain embodiments, the cancer is refractory to treatment with a therapeutic amount of an inhibitor of a LIF-binding polypeptide. In certain embodiments, the cancer is refractory to treatment with a therapeutic amount of an inhibitor of an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the Leukemia Inhibitory Factor (LIF) binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered separately. In certain embodiments, the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered at the same time. In certain embodiments, the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered in a single composition.

**[0012]** In another aspect, described herein, is a method of treating an individual with a cancer, the method comprising: administering to the individual with cancer an effective amount of a Leukemia Inhibitory Factor (LIF)-binding polypeptide, wherein the individual has been administered a therapeutic amount of an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling. In certain embodiments, the method inhibits growth or metastasis of the cancer. In certain embodiments, the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the LIF-binding polypeptide comprises at least one framework region derived from a human immunoglobulin framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL

sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and (b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or a PD-1, PDL-1, or PDL-2 binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, or Spartalizumab, or a PD-1binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-

tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, or soft tissue cancer. In certain embodiments, the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma. In certain embodiments, the cancer is refractory to treatment with a therapeutic amount of an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

**[0013]** In another aspect, described herein, is a method of treating an individual with a cancer, the method comprising: administering to the individual with cancer; an effective amount of an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling, wherein the individual has been administered a therapeutic amount of a Leukemia Inhibitory Factor (LIF) binding polypeptide. In certain embodiments, the method inhibits growth or metastasis of the cancer. In certain embodiments, the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the LIF-binding polypeptide comprises at least one framework region derived from a human immunoglobulin framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain

complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and (b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or of PD-1, PDL-1, or PDL-2 binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-

dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, or soft tissue cancer. In certain embodiments, the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma. In certain embodiments, the cancer is refractory to treatment with a therapeutic amount of an inhibitor of a LIF-binding polypeptide.

**[0014]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of: (a) an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and (b) of a PD-1 binding antibody.

**[0015]** In another aspect, described herein, is a kit comprising: (a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling. In certain embodiments, the LIF-binding polypeptide comprises a

fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the LIF-binding polypeptide comprises at least one framework region derived from a human immunoglobulin framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%,

95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and (b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or antigen binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, or Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the kit further comprises a pharmaceutically acceptable excipient, carrier, or diluent.

**[0016]** In another aspect, described herein, is a composition comprising: (a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling. In certain embodiments, the LIF-binding polypeptide

comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide comprises an antibody that specifically binds to LIF. In certain embodiments, the LIF-binding polypeptide comprises at least one framework region derived from a human immunoglobulin framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and (b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the antibody that specifically binds to LIF comprises: (a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%,

95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and (b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar. In certain embodiments, the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, or Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof. In certain embodiments, the composition further comprises a pharmaceutically acceptable excipient, carrier, or diluent.

**[0017]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of:

(a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 or PDL-1 binding antibody. In certain embodiments, the method comprises administering an effective amount of the antibody that specifically binds LIF to the individual with cancer. In certain embodiments, the method comprises administering an effective amount of the PD-1 or PDL-1 binding antibody to the individual with cancer. In certain embodiments, the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately. In certain embodiments, the cancer is glioblastoma multiforme (GBM), NSCLC (non-small cell lung carcinoma), ovarian cancer, colorectal cancer, thyroid cancer, or pancreatic cancer.

**[0018]** In another aspect, described herein, is a method of decreasing pro-tumoral tumor-associated macrophages (TAMs) in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 or PDL-1 binding antibody. In certain embodiments, the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered

separately. In certain embodiments, the TAM exhibits cell surface expression of any 1, 2, or 3 molecules selected from the list consisting of CD11b, CD206, and CD163.

**[0019]** In another aspect, described herein, is a method of generating immunological memory in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 or PDL-1 binding antibody. In certain embodiments, the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately. In certain embodiments, immunological memory is mediated by CD8+ T cells. In certain embodiments, immunological memory is mediated by CD4+ T cells.

**[0020]** In another aspect, described herein, is a method of increasing the amount of T lymphocytes in a tumor comprising administering to an individual afflicted with the tumor an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 or PDL-1 binding antibody. In certain embodiments, the

antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately. In certain embodiments, the T lymphocytes comprise CD8+ T cells. In certain embodiments, the T lymphocytes comprise CD4+ T cells.

**[0021]** In another aspect, described herein, is a use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1, PDL-1, or PDL-2 signaling for treating a cancer in an individual, wherein the LIF-binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, wherein LIF-binding antibody is humanized. In certain embodiments, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, wherein the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, wherein the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the cancer has previously been treated with a LIF antibody. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

**[0022]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an

immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and (b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 1; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 4; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 6; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 9; and (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 11. In certain embodiments, the LIF-binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 7; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is

administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, wherein the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has previously been treated with a checkpoint inhibitor. In certain embodiments, the cancer has previously been treated with a LIF antibody. In certain embodiments, wherein the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-

dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

**[0023]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and (ii) an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46; and (b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46 In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations. In certain embodiments, the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation. In certain embodiments, the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual. In certain embodiments, the LIF-binding antibody is humanized. In certain embodiments, the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, soft tissue cancer, or any combination thereof. In certain embodiments, the cancer comprises non-small cell lung cancer. In certain embodiments, the cancer comprises pancreatic ductal adenocarcinoma. In certain embodiments, the cancer has

previously been treated with a checkpoint inhibitor. In certain embodiments, the cancer has previously been treated with a LIF antibody. In certain embodiments, the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1. In certain embodiments, the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof. In certain embodiments, the antibody specifically binds PDL-1 or PDL-2. In certain embodiments, the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2. In certain embodiments, the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof. In certain embodiments, the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2. In certain embodiments, the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]** **Fig. 1** depicts a western blot showing inhibition of LIF-induced STAT3 phosphorylation of different anti-LIF humanized antibodies.

**[0025]** **Fig. 2A** and **2B** depicts a western blot showing inhibition of LIF-induced STAT3 phosphorylation by humanized and parental 5D8 antibodies.

**[0026]** **Fig. 3A** shows an $IC_{50}$ for LIF inhibition in U-251 cells using the h5D8 antibody.

**[0027]** **Fig. 3B** shows representative $IC_{50}$ dose response curves of r5D8 and h5D8 inhibition of

pSTAT3 under endogenous LIF stimulation conditions. Shown are the representative curves (n=1 h5D8, n=2 r5D8).

**[0028]** **Fig. 4** depicts a western blot showing inhibition of LIF-induced STAT3 phosphorylation of different monoclonal antibodies described in this disclosure.

**[0029]** **Fig. 5** depicts immunohistochemistry staining and quantification of LIF expression in glioblastoma multiforme (GBM), NSCLC (non-small cell lung carcinoma), ovarian cancer, colorectal cancer, and pancreatic tumors from human patients. Bars represent mean +/- SEM.

**[0030]** **Fig. 6A** is a graph showing an experiment conducted in a mouse model of non-small cell lung cancer using the humanized 5D8 antibody.

**[0031]** **Fig. 6B** is a graph showing an experiment conducted in a mouse model of non-small cell lung cancer using the r5D8 antibody.

**[0032]** **Fig. 7A** shows the effect of r5D8 on inhibition of U251 cells in an orthotopic mouse model of GBM. Quantification shown at day 26.

**[0033]** **Fig. 7B** shows data from mice inoculated with luciferase expressing human U251 GBM cells and then treated with 100, 200, or 300 μg of h5D8 or vehicle twice a week. Tumor size was determined by bioluminescence (Xenogen IVIS Spectrum) on day 7. The graph shows individual tumor measurements with horizontal bars indicating mean ± SEM. Statistical significance was calculated using the unpaired non-parametric Mann-Whitney U-test.

**[0034]** **Fig. 8A** shows the effect of r5D8 on inhibition of growth of ovarian cancer cells in an syngeneic mouse model.

**[0035]** **Fig. 8B** shows the individual measurements of tumors at day 25.

**[0036]** **Fig. 8C** illustrates that h5D8 shows a significant reduction in tumor growth when administered at 200 μg/mouse twice weekly ($p<0.05$). Symbols are mean + SEM, statistical significance compared with vehicle (with unpaired non-parametric Mann-Whitney U-test).

**[0037]** **Fig. 9A** shows the effect of r5D8 on inhibition of growth of colorectal cancer cells in a syngeneic mouse model.

**[0038]** **Fig. 9B** shows the individual measurements of tumors at day 17.

**[0039]** **Fig. 10A** shows reduction of macrophage infiltration to tumor sites in an orthotopic mouse model of GBM with a representative image and quantitation of CCL22+ cells.

**[0040]** **Fig. 10B** shows reduction of macrophage infiltration in a human organotypic tissue slice culture model. Shown are a representative image (left) and quantitation (right).

**[0041]** **Fig. 10C** shows reduction of macrophage infiltration to tumor sites in a syngeneic mouse model of ovarian cancer with a representative image and quantitation of CCL22+ cells.

**[0042]** **Fig. 10D** shows reduction of macrophage infiltration to tumor sites in a syngeneic mouse model of colorectal cancer with a representative image and quantitation of CCL22+ cells.

**[0043]** **Fig. 10E** shows the inflammatory phenotype of tumor associated macrophages (TAMs) harvested from tumors treated with h5D8 (15mg/kg, 2QW) on day 25 (endpoint). TAMs in treated tumors were polarized towards the M1 pro-inflammatory phenotype. Statistical significance was determined by an unpaired t-test.

**[0044]** **Fig. 10F** shows gene expression data of monocytes cultured with the conditioned media of LIF-knockdown cells.

**[0045]** **Fig. 11A** shows increases in non-myeloid effector cells in a syngeneic mouse model of ovarian cancer after treatment with r5D8.

**[0046]** **Fig. 11B** shows increases in non-myeloid effector cells in a syngeneic mouse model of colorectal cancer after treatment with r5D8.

**[0047]** **Fig. 11C** shows decreases in percentage of CD4+ $T_{REG}$ cells in a mouse model of NSCLC cancer after treatment with r5D8.

**[0048]** **Fig. 12** shows data from mice bearing CT26 tumors treated twice weekly with PBS (control) or r5D8 administered intraperitoneally in the presence or absence of anti-CD4 and anti-CD8 depleting antibodies. The graph shows individual tumor measurements at d13 expressed as mean tumor volume + SEM. Statistical differences between groups were determined by unpaired non-parametric Mann-Whitney U-test. R5D8 inhibited the growth of CT26 tumors (*$p<0.05$). The tumor growth inhibition by r5D8 was significantly reduced in the presence of anti-CD4 and anti-CD8 depleting antibodies (****$p<0.0001$).

**[0049]** **Fig. 13A** illustrates an overview of the co-crystal structure of h5D8 Fab in complex with LIF. The gp130 interacting site is mapped on the surface of LIF (dark shaded).

**[0050]** **Fig. 13B** illustrates detailed interactions between LIF and h5D8, showing residues forming salt bridges and h5D8 residues with buried surface areas greater than 100 $Å^2$.

**[0051]** **Fig. 14A** illustrates superposition of the five h5D8 Fab crystal structures and indicates a high degree of similarity despite being crystallized in different chemical conditions.

**[0052]** **Fig. 14B** illustrates an extensive network of Van der Waals interactions mediated by unpaired Cys100. This residue is well-ordered, partakes in shaping the conformations of HCDR1 and HCDR3 and is not involved in undesired disulfide scrambling. Distances between residues are shown as dashed lines and labeled.

**[0053]** **Fig. 15A** illustrates binding of h5D8 C100 mutants to human LIF by ELISA.

**[0054]** **Fig. 15B** illustrates binding of h5D8 C100 mutants to mouse LIF by ELISA.

**[0055]** **Fig. 16A** illustrates that h5D8 does not block binding between LIF and LIFR by Octet. Sequential binding of h5D8 to LIF followed by LIFR.

**[0056]** **Fig. 16B** and **16C** illustrate ELISA analysis of LIF/mAb complexes binding to immobilized LIFR or gp130. Signals of species-specific peroxidase conjugated anti-IgG

antibodies (anti-human for (-) and h5D8, anti-rat for r5D8 and B09) detecting the antibody portion of mAb/LIF complexes binding immobilized LIFR (**Fig. 16B**) or gp130 (**Fig. 16C**) coated plates.

**[0057]** **Fig. 17A** and **17B** illustrate mRNA expression of LIF (**Fig. 16A**) or LIFR (**Fig. 16B**) in 72 different human tissues.

**[0058]** **Fig. 18A-D** show data from mice with CT26 tumors treated with h5D8 and anti-PD-1 show significantly slower growth compared to tumors treated with anti-PD-1. Similar results were obtained across three independent CT26 efficacy experiments. **18A** shows a time course of tumor growth, and **18B** shows individual data points on day 24. Statistical significance determined by Mann-Whitney test. **18C** shows Kaplan-Meier survival plots for anti-PD1 (RMP1-14) and h5D8/anti-PD1 treated mice bearing CT26 or MC38 (anti-PD1 started on day 10) tumors. Bottom, Kaplan-Meier survival plots for control (IgG) and h5D8 monotherapy treated mice bearing CT26 or MC38 tumors. **18D** tumor volume in long-term tumor free CT26 survivors after tumor re-implantation.

**[0059]** **Fig. 19A-D** show flow cytometry analysis detecting the abundance of functional CD8 T cells in h5D8/anti-PD-1 treated tumors. **19A** shows CD8 T cell function defined based on their capacity to produce IFNγ in response to tumor associated peptide (GP70). **19B** shows a representative FACs data plot. Significance determined by unpaired t-test. **19C** shows, on the left, frequency of CD8+ TIL of total CD45+ immune infiltrate in CT26 tumors following therapy (*n*=7/group); on the right, frequency of IFN-γ+ CD8+ TIL following ex vivo stimulation with peptide corresponding to the H2-$L^d$-restricted gp70 (a.a.423-431; AH1) epitope from MuLV expressed by CT26 tumors (*n*=7/group). **19D** shows, on the left, frequency of CD8+ TIL of total CD45+ immune infiltrate in MC38 tumors following therapy (n=6-7/group). Right, frequency of IFN-γ+ CD8+ TIL following ex vivo stimulation with peptide corresponding to the H2-$K^b$-restricted p15e (a.a. 604-611) epitope from the MuLV expressed by MC38 tumors (n=6-7/group).

**[0060]** **Fig. 20A-P** show LIF blockade decreases tumor growth and regulates immune cell infiltration in GBM and ovarian cancer models that express high levels of LIF. **20A** shows distribution of LIF mRNA expression (log2 RSEM) across 28 distinct solid tumors. The black line represents the estimated cut-off between low expression/background noise. The bottom panel shows correlation values (Pearson $R^2$ values) between LIF expression and the relative abundance of TAMs and Tregs based on ssGSEA of the gene signatures of the immune cell types. Correlation values are only shown if the correlation is significant (adjusted P-value < 0.1). **20B** shows linear regression plots of LIF expression and relative abundance (ssGSEA rescaled from 0 to 1 for visualization purposes) of TAMs and Tregs in GBM, prostate adenocarcinoma

(PRAD), thyroid carcinoma (THCA) and ovarian carcinoma (OV) cohorts. Shade represents the confidence intervals of the regression estimate. **20C, 20H,** and **20K** show tumor growth of GL261N (**20C**), RCAS (**20H**), and ID8 (**20K**) models measured as total flux (p/s) or abdominal volume ($mm^3$), respectively. Scheme representing the experimental procedure is shown. Anti-LIF (r5D8) or isotype control (IgG) treatment started on the day of surgery (GL261N and RCAS) or 14 days post-inoculation (dpi) (ID8). **20D** and **20L** show representative p-STAT3, Ki67, CC3, and CD8 IHC percentages of staining for GL261N (**20D**), and ID8 (**20L**) tumors. **20E-20F, 20I-20J,** and **20M-20N** show percentages of $CD11b^+$ $F4/80^+$ $CD163^+$ $CD206^+$ $MHCII^{low}$ TAMs (**20E, 20M**), or $CD11b^+$ $Ly6G^-Ly6C^-$ $CD163^+$ $CD206^+$ $MHCII^{low}$ (**20I**), and $CD8^+$ T cells ($CD3^+$ $CD8^+$) of GL261N (**20F**), RCAS (**20J**) and ID8 (**20N**) tumors analyzed by flow cytometry. **20G** and **20P** show overall survival of GL261N (**20G**), and ID8 (**20P**) models treated with anti-LIF (r5D8) or IgG. Time course of abdominal volume of ID8 mice treated with anti-LIF (r5D8) or IgG (**20O**). Data are mean ± SEM. Statistical analyses by Mann-Whitney T test and Log-rank test. *P < 0.05; **P < 0.01; ***P < 0.001; ****P < 0.0001.

**[0061]** **Fig. 21A-G** show that LIF regulates CXCL9, CCL2, CD206, and CD163 in TAMs. **21A** shows differential expression analysis of isolated $CD11b^+$ cells from anti-LIF (r5D8) treated ID8 mice vs. control. Volcano plot representing the genes significantly (Q-value < 0.1) overexpressed and significantly underexpressed. A heatmap representing the expression values of the indicated genes, each column represents a sample and each row a gene. The last column represents the log2 fold change (log2 FC) of gene expression. **21B** shows mRNA expression for the indicated genes in isolated $CD11b^+$ cells from anti-LIF (r5D8) treated or untreated ID8 and GL261N tumors. **21C** shows percentage and mean fluorescent intensity (MFI) of $CCL2^+$ and $CXCL9^+$ in TAMs ($CD11b^+$ $Ly6G^-$ $Ly6C^-$) from anti-LIF (r5D8) treated or untreated GL261N tumors. **21D** shows percentage of double positive cells relative to the TAM marker positive cells. CXCL9 quantification is relative to the total number of cells. **21E** shows quantification of IHC of the indicated markers from 20 GBM tumors. Correlations between LIF staining (y-axis) and CCL2, CD206, CD163, and CXCL9 staining (x-axis) with the R-squared coefficients ($R^2$) were calculated. **21F** shows tumor growth of GL261N in $CXCL9^{-/-}$ and $CCL2^{-/-}$ mice or mice treated with the indicated antibodies is shown as total flux (p/s). **21G** shows fold increase (FI) of tumor infiltrating $CD8^+$ T cells in the indicated treatments. Data are mean ± SEM. Statistical analyses by Mann-Whitney T test. *P < 0.05; **P < 0.01; ***P < 0.001; ****P < 0.0001.

**[0062]** **Fig. 22A-H** shows LIF represses CXCL9 through epigenetic silencing and induces CCL2 through the activation of STAT3. **22A** and **22B** show qRT-PCR analysis of the indicated genes in BMDMs. BMDMs were pre-incubated with 20 ng/ml LIF for 72 h and then stimulated with 5 ng/ml IFNγ or 10 µg/ml IL4 during 6 h (**22A**) or with 0.1, 0.5, 1 and 5 ng/ml IFN'y for 24

h (**22B**). **22C** shows CXCL9 ELISA from BMDMs pre-incubated with 20 ng/ml LIF and then stimulated with 0.1 ng/ml IFNγ for 24 h. **22D** shows CXCL9 ELISA from human $CD11b^+$ sorted cells (77% $CD11b^+$ $CD14^+$, *see* **Fig. 29A**) from human GBM cultured with 20 ng/ml LIF for 72 h and then with 0.1 ng/ml IFNγ for 24 h. **22E** shows ChIP of Tri-methyl-histone H3 (H3K27me3), EZH2, and acetyl-histone4 (H4ac) was performed in BMDMs treated with 20 ng/ml LIF for 72 h. Scheme shows the analyzed *CXCL9* promoter region. **22F** shows CCL2 ELISA and *CCL2* mRNA levels in BMDMs treated with 20 ng/ml LIF for 6 and 24 h. **22G** shows p-STAT3 ChIP in BMDMs stimulated with 20 ng/ml LIF for 15 min. Schematic representation of STAT Binding Site (SBS) on *CCL2* promoter is depicted. Data are mean ± SD and statistical analyses by Student's *t*-test. **22H** shows percentage of double positive cells relative to $Iba1^+$ cells and percentage of $CXCL9^+$ cells in GBM organotypic slices (patients 1, 2, 3) incubated with 10 µg/ml anti-LIF (r5D8) for 3 days relative to the total number of cells. Data are mean of all patients ± SEM. Statistical analyses by Mann-Whitney T test. *P < 0.05, **P<0.01; ***P < 0.001; ****P < 0.0001.

**[0063]** **Fig. 23A-I** show that LIF blockade induces $CD8^+$ T cell tumor infiltration in human GBM and its combination with anti-PD1 promotes tumor regression. **23A** shows schematic representation of the experimental procedures performed with GBM patient derived xenografts and human organotypic models. **23B** shows *CXCL9* and *CCL2* mRNA expression levels in organotypic specimens treated with anti-LIF (r5D8) for 72 h and then cultured with PBMCs for 24 h (patient 4, 5, 6). **23C** shows FI of $CD8^+$ T infiltrating cells detected by flow cytometry in organotypic tissues treated with anti-LIF (r5D8) for 72 h and then cultured with PBMCs for 48 h (patient 4, 5, 6). **23D** shows FI of $CD8^+$ T infiltrating cells detected by flow cytometry in GBM organotypic tissues treated with anti-LIF (r5D8) and/or anti-CXCL9 for 72 h and then cultured with PBMCs for 48 h. **23E** shows $CD8^+$ T infiltrating cells into subcutaneously engrafted GBM specimens in NSG mice. Bar graph represents the ratio of $CD8^+$ T cells detected by flow cytometry in the tissue vs. $CD8^+$ T cells detected in the blood of the same animal. Four patients (7, 8, 9, 10) with their corresponding PBMCs were. **23F** shows survival of GL261N mice treated with anti-LIF (r5D8), anti-PD1, or the combination. Overall survival determined by Kaplan-Meier curves is shown. **23G** shows tumor growth of the treated GL261N model represented as a fold change of tumor size between 13 and 6 dpi. **23H** shows a scheme representing the experimental procedure of $3x10^5$ GL261N cells inoculated in 6 mice with complete regression by the anti-LIF (r5D8), anti-PD1 combination treatment. 10 naive mice were inoculated $3x10^5$ GL261N cells in parallel. **23I** shows schematic representation of the effect of LIF $CD8^+$ T cell tumor infiltration. Statistical analyses by Mann-Whitney T test or Log-rank test. *P < 0.05; **P < 0.01; ***P < 0.001.

**[0064]** **Fig. 24A-D** shows LIF expression in tumors. In **24A** LIF IHC was performed in tissue microarrays from human GBM and the degree of staining was quantified using the H-score method. **24B** shows LIF ELISA of the supernatant from 15 patient neurosphere cultures. **24C** and **24D** show qRT-PCR analyses of the indicated genes in $CD45^+$ and $CD45^-$ cells isolated from human GBM tumors (**24C**) and GL261N tumors (**24D**).

**[0065]** **Fig. 25A-J** shows LIF blockade in mouse models inhibits tumor growth. **25A** shows results of qRT-PCR and ELISA of LIF performed on GL261, GL261N, and GL261N CRISPR/LIF cells. **25B** shows tumor growth as total flux (p/s) at 12 dpi in mice inoculated with GL261N and GL261N CRISPR/LIF. **25C** and **25D** show ID8 cells were infected with the pLKO.1 or two independent pLKO.1-shLIF lentivirus. LIF expression was determined by qRT-PCR and ELISA (**25C**). **25D** shows results of ID8 cells inoculated in the peritoneum of mice. Treatment scheme is shown. Abdominal volume ($mm^3$) was measured at 40 dpi. **25E** shows GL261 tumor growth in mice treated with anti-LIF (r5D8) or control IgG at 12 dpi. **25F** shows results of GL261N cells inoculated in C57BL/6 mice and two immunodeficient models, NOD SCID and $RAG1^{-/-}$. Treatment scheme is shown. Tumor growth was measured at 12 dpi. **25G-25J** shows percentages of NK cells ($CD335^+$), and Tregs ($CD3^+CD4^+FoxP3^+$) gated on the $CD4^+$ T cell population in GL261N (**25G-25H**) and ID8 (**25I-25J**) tumors were determined by flow cytometry. Data are presented as mean ± SEM. Statistical analysis by Mann-Whitney T test. $*P < 0.05$; $**P < 0.01$;$***P < 0.001$; $****P < 0.0001$.

**[0066]** **Fig. 26A-H** shows the characterization of immune cell infiltrates upon treatment with anti-LIF (r5D8). **26A** shows percentage and MFI of GZMA in the $CD8^+$ T cell population of GL261N tumors. **26B** and **26C** show percentage of $PD1^+$ $CD8^+$ T cells in tumors of GL261N (**26B**) and ID8 (**26C**) models. **26D** shows percentage of infiltrating TAMs ($CD11b^+$ $Ly6G^-$ $Ly6C^-$ $CD49d^+$) in GL261N and RCAS tumors in response to treatment with anti-LIF (r5D8). Flow cytometry gating strategy is shown. **26E** shows dendritic cell population (DC) ($CD11b^+$ $CD11c^+$ $MHCII^+$) and antigen presentation, determined by MHCII expression, in GL261N tumors. **26F** shows ELISA of IL-12 and IL-10 in GL261N tumors. **26G** shows results of GL261N tumor-bearing mice treated with anti-LIF (r5D8) at 8 dpi. Tumor volume was measured as total flux (p/s) at 13 dpi. **26H** shows percentage of $CD8^+$ T cells ($CD3^+$ $CD8^+$) in tumors was determined by flow cytometry. Data are presented as mean ± SEM. Statistical analysis by Mann-Whitney T test. $*P < 0.05$; $**P < 0.01$.

**[0067]** **Fig. 27A** shows percentage of CCR2, CXCR3, and LIFR expression on TAMs ($CD11b^+$ $Ly6G^-$ $Ly6C^-$) and $CD8^+$ T cell ($CD3^+$ $CD8^+$) populations as determined by flow cytometry. Data are presented as mean ± SEM. Statistical analysis by Mann-Whitney T test. $*P < 0.05$. **27B** shows qRT-PCR analyses of the indicated genes in $CD11b^+$ $Ly6G^-$ $Ly6C^-$ and $CD11b^-$ $Ly6G^-$

Ly6C$^-$ cells sorted from GL261N tumors.

**[0068]** **Fig. 28** shows the correlation between LIF and CD163, CD206, and CCL2 expression in GBM and ovarian cancer. Regression plots between LIF and CD163, CD206, CCL2 expression (in log2 RSEM) in GBM and ovarian cancer (OV) TCGA tumor cohorts.

**[0069]** **Fig. 29A** and **29B** show regulation of CXCL9 by LIF in murine and human macrophages. **Fig. 29A** shows CD11b$^+$ CD14$^+$ cells in the culture was determined by flow cytometry. Data are presented as mean ± SD. Statistical analyses by Student' s *t*-test. **P < 0.01; ***P < 0.001. **Fig. 29B** shows BMDMs were pre-incubated with LIF (20 ng/ml) for 18 h and then stimulated with 1 μg/ml LPS for 6 h.

**[0070]** **Fig. 30** shows the anti-tumor response to anti-LIF (r5D8) and anti-PD1 combinatory treatments in GL261N, RCAS and ID8 models. **Fig. 30** shows GL261N, RCAS, and ID8 tumor-bearing mice were treated with anti-LIF(r5D8) and/or anti-PD1 (treatment scheme is shown). Tumor growth was measured as total flux (p/s) (GL261N and RCAS) or as abdominal volume ($mm^3$) (ID8). Statistical analyses by Mann-Whitney T test. *P < 0.05; **P < 0.01.

## DETAILED DESCRIPTION

**[0071]** Unless otherwise defined, all technical terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. As used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. Any reference to "or" herein is intended to encompass "and/or" unless otherwise stated.

**[0072]** In one aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding polypeptide, in combination with an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling, for treating a cancer in an individual.

**[0073]** In another aspect, described herein, is the use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with a PD-1 binding antibody, for treating a cancer in an individual, wherein the LIF binding antibody comprises: (a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid

sequence set forth in any one of SEQ ID NOs: 11 or 12; and (f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

**[0074]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of: (a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling.

**[0075]** In another aspect, described herein, is a method of treating an individual with a cancer, the method comprising: administering to the individual with cancer an effective amount of a Leukemia Inhibitory Factor (LIF)-binding polypeptide, wherein the individual has been administered a therapeutic amount of an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD-273) signaling.

**[0076]** In another aspect, described herein, is a method of treating an individual with a cancer, the method comprising: administering to the individual with cancer; an effective amount of an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling, wherein the individual has been administered a therapeutic amount of a Leukemia Inhibitory Factor (LIF) binding polypeptide.

**[0077]** In another aspect, described herein, is a method of decreasing pro-tumoral tumor-associated macrophages (TAMs) in a tumor of an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF); and (b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

**[0078]** In another aspect, described herein, is a method of generating immunological memory in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF); and (b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

**[0079]** In another aspect, described herein, is a method of increasing the amount of T lymphocytes in a tumor of an individual comprising administering to the individual afflicted with the tumor an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF); and (b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

**[0080]** In another aspect, described herein, is a method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of: (a) a Leukemia Inhibitory Factor (LIF) binding antibody comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set

forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and (b) a PD-1 binding antibody.

**[0081]** In another aspect, described herein, is a kit comprising: (a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling.

**[0082]** In another aspect, described herein, is a composition comprising: (a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and (b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling.

**[0083]** In another aspect, described herein, is a method of decreasing pro-tumoral tumor-associated macrophages (TAMs) in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 axis inhibitor.

**[0084]** In another aspect, described herein, is a method of generating immunological memory in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining

region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 axis inhibitor.

**[0085]** In another aspect, described herein, is a method of increasing the amount of T lymphocytes in a tumor comprising administering to an individual afflicted with the tumor an effective amount of a combination of: (a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: (i) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3; (ii) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5; (iii) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8; (iv) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10; (v) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and (vi) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and a PD-1 axis inhibitor.

**[0086]** As used herein the terms "individual," "subject," and "patient" are used interchangeably and include humans diagnosed with or suspected of being afflicted with a tumor, a cancer, or other neoplasm. An individual can also encompass mammals such as a mouse, rat, dog, cat, pig, sheep, cow, horse, goat, llama, alpaca, or yak.

**[0087]** As used herein the term "about" refers to an amount that is near the stated amount by 10%.

**[0088]** As used herein the term "treat" or "treating" refers to interventions to a physiological or disease state of an individual designed or intended to ameliorate at least one sign or symptom associated with said physiological or disease state. Described herein treat or treating with respect

to cancer refers to interventions intended to induce a complete response, a partial response, a delay progression of the cancer or tumor being treated, a decrease in tumor size or tumor burden, or a delay in growth of tumor or tumor burden. Treating also refers to interventions intended to reduce metastases or malignancy of a cancer or a tumor. The skilled artisan will recognize that given a heterogeneous population of individuals afflicted with a disease, not all individuals will respond equally, or at all, to a given treatment. Nevertheless, these individuals are considered treated. Unsuccessful treatments generally result in progression of disease, and a necessity for additional treatment with a different therapeutic. In certain aspects the antibodies and methods described herein can be used to maintain remission of a cancer or prevent reoccurrence of the same cancer or a different cancer related to the treated cancer.

**[0089]** As used herein the term "combination" or "combination treatment" can refer either to concurrent administration of the articles to be combined or sequential administration of the articles to be combined. As described herein, when the combination refers to sequential administration of the articles, the articles can be administered in any temporal order.

**[0090]** The terms "cancer" and "tumor" relate to the physiological condition in mammals characterized by deregulated cell growth. Cancer is a class of diseases in which a group of cells display uncontrolled growth or unwanted growth. Cancer cells can also spread to other locations, which can lead to the formation of metastases. Spreading of cancer cells in the body can, for example, occur via lymph or blood. Uncontrolled growth, intrusion, and metastasis formation are also termed malignant properties of cancers. These malignant properties differentiate cancers from benign tumors, which typically do not invade or metastasize.

**[0091]** As used herein the term an "effective amount" refers to the amount of a therapeutic that causes a biological effect when administered to a mammal. Biological effects include, but are not limited to, inhibition or blockade a receptor ligand interaction (e.g., LIF-LIFR, PD-1-PDL1/PDL-2, inhibition of a signaling pathway (e.g., STAT3 phosphorylation), reduced tumor growth, reduced tumor metastasis, or prolonged survival of an animal bearing a tumor. A "therapeutic amount" is the concertation of a drug calculated to exert a therapeutic effect. A therapeutic amount encompasses the range of dosages capable of inducing a therapeutic response in a population of individuals. The mammal can be a human individual. The human individual can be afflicted with or suspected or being afflicted with a tumor.

**[0092]** As used herein "checkpoint inhibitor" refers a drug that inhibits a biological molecule ("checkpoint molecule") produced by an organism that negatively regulates the anti-tumor/cancer activity of T cells in the organism. Checkpoint molecules include without limitation PD-1, PDL-1, PDL-2, CTLA4, TIM-3, LAG-3, VISTA, SIGLEC7, PVR, TIGIT, IDO, KIR, A2AR, B7-H3, B7H4, and NOX2.

**[0093]** As used herein, unless otherwise indicated, the term "antibody" includes antigen binding fragments of antibodies, i.e. antibody fragments that retain the ability to bind specifically to the antigen bound by the full-length antibody, e.g. fragments that retain one or more CDR regions. Examples of antibody fragments include, but are not limited to, Fab, Fab', F(ab')2, and Fv fragments; diabodies; linear antibodies; heavy chain antibodies, single-chain antibody molecules, e.g. single-chain variable region fragments (scFv), nanobodies and multispecific antibodies formed from antibody fragments with separate specificities, such as a bispecific antibody. In certain embodiments, the antibodies are humanized in such a way as to reduce an individual's immune response to the antibody. For example, the antibodies may be chimeric, e.g. non-human variable region with human constant region, or CDR grafted, e.g. non-human CDR regions with human constant region and variable region framework sequences. In certain embodiments, antibodies are deimmunized after humanization. Deimmunization involves removing or mutating one or more T-cell epitopes in the constant region of the antibody. In certain embodiments, the antibodies described herein are monoclonal. As used herein a "recombinant antibody" is an antibody that comprises an amino acid sequence derived from two different species or, or two different sources, and includes synthetic molecules, for example, an antibody that comprises a non-human CDR and a human framework or constant region. In certain embodiments, recombinant antibodies of the present invention are produced from a recombinant DNA molecule or synthesized.

**[0094]** Percent (%) sequence identity with respect to a reference polypeptide or antibody sequence is the percentage of amino acid residues in a candidate sequence that are identical with the amino acid residues in the reference polypeptide or antibody sequence, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Alignment for purposes of determining percent amino acid sequence identity can be achieved in various ways that are known for instance, using publicly available computer software such as BLAST, BLAST-2, ALIGN, or Megalign (DNASTAR) software. Appropriate parameters for aligning sequences are able to be determined, including algorithms needed to achieve maximal alignment over the full length of the sequences being compared. For purposes herein, however, % amino acid sequence identity values are generated using the sequence comparison computer program ALIGN-2. The ALIGN-2 sequence comparison computer program was authored by Genentech, Inc., and the source code has been filed with user documentation in the U.S. Copyright Office, Washington D.C., 20559, where it is registered under U.S. Copyright Registration No. TXU510087. The ALIGN-2 program is publicly available from Genentech, Inc., South San Francisco, Calif., or may be compiled from the source code. The ALIGN-2 program should be

compiled for use on a UNIX operating system, including digital UNIX V4.0D. All sequence comparison parameters are set by the ALIGN-2 program and do not vary.

**[0095]** In situations where ALIGN-2 is employed for amino acid sequence comparisons, the % amino acid sequence identity of a given amino acid sequence A to, with, or against a given amino acid sequence B (which can alternatively be phrased as a given amino acid sequence A that has or comprises a certain % amino acid sequence identity to, with, or against a given amino acid sequence B) is calculated as follows: 100 times the fraction X/Y, where X is the number of amino acid residues scored as identical matches by the sequence alignment program ALIGN-2 in that program's alignment of A and B, and where Y is the total number of amino acid residues in B. It will be appreciated that where the length of amino acid sequence A is not equal to the length of amino acid sequence B, the % amino acid sequence identity of A to B will not equal the % amino acid sequence identity of B to A. Unless specifically stated otherwise, all % amino acid sequence identity values used herein are obtained as described in the immediately preceding paragraph using the ALIGN-2 computer program.

**[0096]** The term "epitope" includes any determinant capable of being bound by an antigen binding protein, such as an antibody. An epitope is a region of an antigen that is bound by an antigen binding protein that targets that antigen, and when the antigen is a protein, includes specific amino acids that directly contact the antigen binding protein. Most often, epitopes reside on proteins, but in some instances can reside on other kinds of molecules, such as saccharides or lipids. Epitope determinants can include chemically active surface groupings of molecules such as amino acids, sugar side chains, phosphoryl or sulfonyl groups, and can have specific three dimensional structural characteristics, and/or specific charge characteristics. Generally, antibodies specific for a particular target antigen will preferentially recognize an epitope on the target antigen in a complex mixture of proteins and/or macromolecules.

**[0097]** As used herein, the term "TAMs" or "tumor-associated macrophages" includes macrophage or monocyte derived immune cells present in high numbers in the microenvironment of solid tumors. TAMs include, but are not limited to, cells expressing $CD11b^{+}$, $Ly6G^{-}$, $Ly6C^{-}$, $CD206^{+}$, $CD163^{+}$, $MHCII^{low}$, $CD49d^{+}$, or any combination thereof.

**Structural attributes of the antibodies described herein**

**[0098]** A complementarity determining region ("CDR") is a part of an immunoglobulin (antibody) variable region that is primarily responsible for the antigen binding specificity of the antibody. CDR regions are highly variable from one antibody to the next even when the antibody specifically binds the same target or epitope. A heavy chain variable region comprises three CDR regions, abbreviated VH-CDR1, VH-CDR2, and VH-CDR3; and a light chain variable region comprises three CDR regions, abbreviated VL-CDR1, VL-CDR2, and VL-

CDR3. These CDR regions are ordered consecutively in the variable region with the CDR1 being the most N-terminal and the CDR3 being the most C-terminal. Interspersed between the CDRs are framework regions which contribute to the structure and display much less variability than the CDR regions. A heavy chain variable region comprises four framework regions, abbreviated VH-FR1, VH-FR2, VH-FR3, and VH-FR4; and a light chain variable region comprises four framework regions, abbreviated VL-FR1, VL-FR2, VL-FR3, and VL-FR4. Complete full-sized bivalent antibodies comprising two heavy and light chains will comprise: 12 CDRs, with three unique heavy chain CDRs and three unique light chain CDRs; 16 FR regions, with four unique heavy chain FR regions and four unique light chain FR regions. In certain embodiments, the antibodies described herein minimally comprise three heavy chain CDRs. In certain embodiments, the antibodies described herein minimally comprise three light chain CDRs. In certain embodiments, the antibodies described herein minimally comprise three heavy chain CDRs and three light chain CDRs. The precise amino acid sequence boundaries of a given CDR or FR can be readily determined using any of a number of well-known schemes, including those described by Kabat et al. (1991), "Sequences of Proteins of Immunological Interest," 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD ("Kabat" numbering scheme); Al-Lazikani et al., (1997) *JMB* 273,927-948 ("Chothia" numbering scheme); MacCallum et al., J. *Mol. Biol.* 262:732-745 (1996), "Antibody-antigen interactions: Contact analysis and binding site topography," ("Contact" numbering scheme); Lefranc MP et al.,"IMGT unique numbering for immunoglobulin and T cell receptor variable domains and Ig superfamily V-like domains," Dev Comp *Immunol*, 2003 Jan;27(1):55-77 ("IMGT" numbering scheme); and Honegger A and Plückthun A, "Yet another numbering scheme for immunoglobulin variable domains: an automatic modeling and analysis tool," *J Mol Biol*, 2001 Jun 8;309(3):657-70, ("Aho" numbering scheme). CDRs are identified herein from variable sequences provided using different numbering systems, herein with the Kabat, the IMGT, the Chothia numbering system, or any combination of the three. The boundaries of a given CDR or FR may vary depending on the scheme used for identification. For example, the Kabat scheme is based on structural alignments, while the Chothia scheme is based on structural information. Numbering for both the Kabat and Chothia schemes is based upon the most common antibody region sequence lengths, with insertions accommodated by insertion letters, for example, "30a," and deletions appearing in some antibodies. The two schemes place certain insertions and deletions ("indels") at different positions, resulting in differential numbering. The Contact scheme is based on analysis of complex crystal structures and is similar in many respects to the Chothia numbering scheme. In certan embodiments, the CDRs of the current disclosures are determined by the KAbat method, IMGT method, Chothia method, or any combination thereof.

**[0099]** The term "variable region" or "variable domain" refers to the domain of an antibody heavy or light chain that is involved in binding the antibody to antigen. The variable domains of the heavy chain and light chain (VH and VL, respectively) of a native antibody generally have similar structures, with each domain comprising four conserved framework regions (FRs) and three CDRs (*See e.g.*, Kindt et al. Kuby *Immunology, 6th ed.*, W.H. Freeman and Co., page 91(2007)). A single VH or VL domain may be sufficient to confer antigen-binding specificity. Furthermore, antibodies that bind a particular antigen may be isolated using a VH or VL domain from an antibody that binds the antigen to screen a library of complementary VL or VH domains, respectively (*See e.g.*, Portolano et al., *J. Immunol.* 150:880-887 (1993); Clarkson et al., Nature 352:624-628 (1991)). In certain embodiments, the antibodies described herein are humanized. In certain embodiments, the antibodies described herein are chimeric. In certain embodiments, the antibodies described herein comprise variable regions of rat origin. In certain embodiments, the antibodies described herein comprise CDRs of rat origin. In certain embodiments, the antibodies described herein comprise variable regions of mouse origin. In certain embodiments, the antibodies described herein comprise CDRs of mouse origin.

**[00100]** Alterations (*e.g.,* substitutions) may be made in CDRs, *e.g.,* to improve antibody affinity. Such alterations may be made in CDR encoding codons with a high mutation rate during somatic maturation (*See e.g.*, Chowdhury, *Methods Mol. Biol.* 207:179-196 (2008)), and the resulting variant can be tested for binding affinity. Affinity maturation (e.g., using error-prone PCR, chain shuffling, randomization of CDRs, or oligonucleotide-directed mutagenesis) can be used to improve antibody affinity (*See e.g.*, Hoogenboom et al. in *Methods in Molecular Biology* 178:1-37 (2001)). CDR residues involved in antigen binding may be specifically identified, e.g., using alanine scanning mutagenesis or modeling (*See e.g.*, Cunningham and Wells *Science*, 244:1081-1085 (1989)). CDR-H3 and CDR-L3 in particular are often targeted. Alternatively, or additionally, a crystal structure of an antigen-antibody complex is analyzed to identify contact points between the antibody and antigen. Such contact residues and neighboring residues may be targeted or eliminated as candidates for substitution. Variants may be screened to determine whether they contain the desired properties.

**[00101]** In certain embodiments, the antibodies described herein comprise a constant region in addition to a variable region. The heavy chain constant region ($C_H$) comprises four domains abbreviated $C_H1$, $C_H2$, $C_H3$, and $C_H4$, located at the C-terminal end of the full heavy chain polypeptide, C-terminal to the variable region. The light chain constant region ($C_L$) is much smaller than the $C_H$ and is located at the C-terminal end of the full light chain polypeptide, C-terminal to the variable region. The constant region is highly conserved and comprises different isotypes that are associated with slightly different functions and properties. In certain

embodiments, the constant region is dispensable for antibody binding to a target antigen. In certain embodiments, the constant regions of the antibody, both heavy and light chains are dispensable for antibody binding. In certain embodiments, the antibodies described herein lack one or more of a light chain constant region, heavy chain constant region, or both. Most monoclonal antibodies are of an IgG isotype; which is further divided into four subclasses $IgG_1$, $IgG_2$, $IgG_3$, and $IgG_4$. In certain embodiments, the antibodies described herein comprise any IgG subclass. In certain embodiments, the IgG subclass comprises $IgG_1$. In certain embodiments, the IgG subclass comprises $IgG_2$. In certain embodiments, the IgG subclass comprises $IgG_3$. In certain embodiments, the IgG subclass comprises $IgG_4$.

**[00102]** Antibodies comprise a fragment crystallizable region (Fc region) that is responsible for binding to complement and Fc receptors. The Fc region comprises the $C_H2$, $C_H3$, and $C_H4$ regions of the antibody molecule. The Fc region of an antibody is responsible for activating complement and antibody dependent cell cytotoxicity (ADCC). The Fc region also contributes to an antibody's serum half-life. In certain embodiments, the Fc region of the antibodies described herein comprise one ore more amino acid substitutions that promote complement mediated cell lysis. In certain embodiments, the Fc region of antibodies described herein comprises one or more amino acid substitutions that promote ADCC. In certain embodiments, the Fc region of antibodies described herein comprises one or more amino acid substitutions that reduce complement mediated cell lysis. In certain embodiments, the Fc region of antibodies described herein comprises one or more amino acid substitutions that increase binding of the antibody to an Fc receptor. In certain embodiments, the Fc receptor comprises FcγRI (CD64), FcγRIIA (CD32), FcγRIIIA (CD16a), FcγRIIIB (CD16b), or any combination thereof. In certain embodiments, the Fc region of the antibodies described herein comprise one or more amino acid substitutions that increase the serum half-life of the antibody. In certain embodiments, the one or more amino acid substitutions that increase the serum half-life of the antibody increase affinity of the antibody to the neonatal Fc receptor (FcRn).

**[00103]** In some embodiments, the antibodies of this disclosure are variants that possesses some but not all effector functions, which make it a desirable candidate for applications in which the half-life of the antibody in vivo is important yet certain effector functions (such as complement and ADCC) are unnecessary or deleterious. In vitro and/or in vivo cytotoxicity assays can be conducted to confirm the reduction/depletion of CDC and/or ADCC activities. For example, Fc receptor (FcR) binding assays can be conducted to ensure that the antibody lacks FcγR binding (hence likely lacking ADCC activity), but retains FcRn binding ability. Non-limiting examples of in vitro assays to assess ADCC activity of a molecule of interest are described in U.S. Pat. No. 5,500,362 and 5,821,337. Alternatively, non-radioactive assays methods may be employed (e.g.,

ACTI™ and CytoTox 96® non-radioactive cytotoxicity assays). Useful effector cells for such assays include peripheral blood mononuclear cells (PBMC), monocytes, macrophages, and Natural Killer (NK) cells.

**[00104]** Antibodies can have increased half-lives and improved binding to the neonatal Fc receptor (FcRn) (*See e.g.*, US 2005/0014934). Such antibodies can comprise an Fc region with one or more substitutions therein which improve binding of the Fc region to FcRn, and include those with substitutions at one or more of Fc region residues: 238, 256, 265, 272, 286, 303, 305, 307, 311, 312, 317, 340, 356, 360, 362, 376, 378, 380, 382, 413, 424, or 434 according to the EU numbering system (See e.g., U.S. Pat. No. 7,371,826). Other examples of Fc region variants are also contemplated (*See e.g.*, Duncan & Winter, Nature 322:738-40 (1988); U.S. Pat. Nos. 5,648,260 and 5,624,821; and WO94/29351).

**[00105]** Antibodies useful in the clinic are often "humanized" to reduce immunogenicity in human individuals. Humanized antibodies improve safety and efficacy of monoclonal antibody therapy. One common method of humanization is to produce a monoclonal antibody in any suitable animal (e.g., mouse, rat, hamster) and replace the constant region with a human constant region, antibodies engineered in this way are termed "chimeric". Another common method is "CDR grafting" which replaces the non-human V-FRs with human V-FRs. In the CDR grafting method all residues except for the CDR region are of human origin. In certain embodiments, the antibodies described herein are humanized. In certain embodiments, the antibodies described herein are chimeric. In certain embodiments, the antibodies described herein are CDR grafted.

**[00106]** Humanization generally reduces or has little effect on the overall affinity of the antibody. Described herein are antibodies that unexpectedly possess greater affinity for their target after humanization. In certain embodiments, humanization increases the affinity for the antibody by 10%. In certain embodiments, humanization increases the affinity for the antibody by 25%. In certain embodiments, humanization increases the affinity for the antibody by 35%. In certain embodiments, humanization increases the affinity for the antibody by 50%. In certain embodiments, humanization increases the affinity for the antibody by 60%. In certain embodiments, humanization increases the affinity for the antibody by 75%. In certain embodiments, humanization increases the affinity for the antibody by 100%. Affinity is suitably measured using surface plasmon resonance (SPR). In certain embodiments, affinity is measured using glycosylated human LIF. In certain embodiments, the glycosylated human LIF is immobilized to the surface of the SPR chip. In certain embodiments, the antibody binds with a $K_D$ of less than about 300 nanomolar, 200 nanomolar, 150 nanomolar, 125 nanomolar 100 nanomolar, 90 nanomolar, 80 nanomolar, 70 nanomolar, 60 nanomolar, 50 nanomolar, 40 nanomolar, or less.

**[00107]** The compositions and methods described herein comprise combinations of LIF-binding polypeptides with PD-1axis inhibitors. In certain embodiments, the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region. In certain embodiments, the LIF-binding polypeptide is an antibody that specifically binds to LIF. In certain embodiments, the LIF-binding antibody comprises at least one framework region derived from a human immunoglobulin framework region. In certain embodiments, the antibody that specifically binds to LIF is humanized. In certain embodiments, the antibody that specifically binds to LIF is deimmunized. In certain embodiments, the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains. In certain embodiments, the antibody that specifically binds to LIF is an IgG antibody. In certain embodiments, the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody. In certain embodiments, the LIF binding antibody is the h5D8 antibody described herein (SEQ ID NO: 42 and SEQ ID NO: 46), or a heavy chain cysteine mutant (SEQ ID NO: 66) or an antibody that possesses the CDRs of h5D8 or its cysteine mutant form.

**[00108]** In certain embodiments, described herein, the antibody utilized or administered in combination with an inhibitor of PD-1 is the h5D8 antibody. The h5d8 antibody specifically binds LIF comprises a VH-CDR1 set forth in any one of SEQ ID NOs: 1-3, a VH-CDR2 set forth in any one of SEQ ID NOs: 4 or 5, and a VH-CDR3 set forth in any one of SEQ ID NOs: 6 to 8. In certain embodiments, described herein, h5D8 specifically binds LIF and comprises a VL-CDR1 set forth in any one of SEQ ID NOs: 9 or 10, a VL-CDR2 set forth in SEQ ID NOs: 11 or 12, and a VL-CDR3 set forth in SEQ ID NO: 13. In certain embodiments, described herein, h5D8 specifically binds LIF and comprises a VH-CDR1 set forth in any one of SEQ ID NOs: 1-3, a VH-CDR2 set forth in any one of SEQ ID NOs: 4 or 5, and a VH-CDR3 set forth in any one of SEQ ID NOs: 6-8, a VL-CDR1 set forth in any one of SEQ ID NOs: 9 or 10, a VL-CDR2 set forth in SEQ ID NOs: 11 or 12, and a VL-CDR3 set forth in SEQ ID NO: 13.

**[00109]** In certain embodiments, the antibody that specifically binds LIF comprises one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more

human heavy chain framework regions comprise a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence at least about 80%, about 90%, or about 95% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a

VL-FR4 amino acid sequence at least 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody that specifically binds LIF comprises one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more human heavy chain framework regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody

specifically binds human LIF.

**[00110]** The r5D8 antibody described herein was generated from rats immunized with DNA encoding human LIF. r5D8 was cloned and sequenced and comprises CDRs (using the combination of the Kabat and IMGT CDR numbering methods) with the following amino acid sequences: a VH-CDR1 corresponding to SEQ ID NO: 1 (GFTFSHAWMH), a VH-CDR2 corresponding to SEQ ID NO: 4 (QIKAKSDDYATYYAESVKG), a VH-CDR3 corresponding to SEQ ID NO: 6 (TCWEWDLDF), a VL-CDR1 corresponding to SEQ ID NO: 9 (RSSQSLLDSDGHTYLN), a VL-CDR2 corresponding to SEQ ID NO: 11 (SVSNLES), and a VL-CDR3 corresponding to SEQ ID NO: 13 (MQATHAPPYT). This antibody has been humanized by CDR grafting and the humanized version is referred to as h5D8.

**[00111]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VH-CDR1at least 80% or 90% identical to that set forth in SEQ ID NO: 1 (GFTFSHAWMH), a VH-CDR2 at least 80%, 90%, or 95% identical to that set forth in SEQ ID NO: 4 (QIKAKSDDYATYYAESVKG), and a VH-CDR3 at least 80% or 90% identical to that set forth in SEQ ID NO: 6 (TCWEWDLDF). In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VL-CDR1 at least 80% or 90% identical to that set forth in SEQ ID NO: 9 (RSSQSLLDSDGHTYLN), a VL-CDR2 at least 80% identical to that set forth in SEQ ID NO: 11 (SVSNLES), and a VL-CDR3 at least 80% or 90% identical to that set forth in SEQ ID NO: 13 (MQATHAPPYT). In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VH-CDR1 set forth in SEQ ID NO: 1 (GFTFSHAWMH), a VH-CDR2 set forth in SEQ ID NO: 4 (QIKAKSDDYATYYAESVKG), a VH-CDR3 set forth in SEQ ID NO: 6 (TCWEWDLDF), a VL-CDR1 set forth in SEQ ID NO: 9 (RSSQSLLDSDGHTYLN), a VL-CDR2 set forth in SEQ ID NO: 11 (SVSNLES), and a VL-CDR3 set forth in SEQ ID NO: 13 (MQATHAPPYT). Certain conservative amino acid substitutions are envisioned in the amino acid sequences of the CDRs of this disclosure. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 by 1, 2, 3, or 4 amino acids. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 by 1, 2, 3, or 4 amino acids and does not affect the binding affinity by greater than 10%, 20%, or 30%. In certain embodiments, antibodies that specifically bind LIF comprise one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence at least 90%

identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more human heavy chain framework regions comprises a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% % identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise all of a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence at least 90% identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about

80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody specifically binds human LIF. In certain embodiments, the antibody that specifically binds LIF comprises one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more human heavy chain framework regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino

acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody specifically binds human LIF.

**[00112]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VH-CDR1 amino acid sequence at least 80% or 90% identical to that set forth in SEQ ID NO: 1 (GFTFSHAWMH), a VH-CDR2 amino acid sequence at least 80%, 90%, or 95% identical to that set forth in SEQ ID NO: 4 (QIKAKSDDYATYYAESVKG), and a VH-CDR3 amino acid sequence at least 80% or 90% identical to that set forth in SEQ ID NO: 8 (TSWEWDLDF). In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VL-CDR1 amino acid sequence at least 80% or 90% identical to that set forth in SEQ ID NO: 9 (RSSQSLLDSDGHTYLN), a VL-CDR2 amino acid sequence at least 80% identical to that set forth in SEQ ID NO: 11 (SVSNLES), and a VL-CDR3 amino acid sequence at least 80% or 90% identical to that set forth in SEQ ID NO: 13 (MQATHAPPYT). In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a VH-CDR1 amino acid sequence set forth in SEQ ID NO: 1 (GFTFSHAWMH), a VH-CDR2 amino acid sequence set forth in SEQ ID NO: 4 (QIKAKSDDYATYYAESVKG), a VH-CDR3 amino acid sequence set forth in SEQ ID NO: 8 (TSWEWDLDF), a VL-CDR1 amino acid sequence set forth in SEQ ID NO: 9 (RSSQSLLDSDGHTYLN), a VL-CDR2 amino acid sequence set forth in SEQ ID NO: 11 (SVSNLES), and a VL-CDR3 amino acid sequence set forth in SEQ ID NO: 13 (MQATHAPPYT). Certain conservative amino acid substitutions are envisioned in the amino acid sequences of the CDRs of this disclosure. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 by 1, 2, 3, or 4 amino acids. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 by 1, 2, 3, or 4 amino acids and does not affect the binding affinity by greater than 10%, 20%, or 30%. In certain embodiments, antibodies that specifically bind LIF comprise one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence at least 90% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more human heavy chain

framework regions comprises a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence at least 90% identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise all of a VH-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence at least 90% identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or

99% identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody specifically binds human LIF. In certain embodiments, the antibody that specifically binds LIF comprises one or more human heavy chain framework regions comprising: a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 14-17, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 18 or 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 20-22, or a VH-FR4 region amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 23-25. In certain embodiments, the one or more human heavy chain framework regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, and a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24. In certain embodiments, the antibody that specifically binds LIF comprises one or more human light chain framework regions comprising: a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 26-29, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 30-33, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 34-37, or a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in any one of SEQ ID NOs: 38-40. In certain embodiments, the one or more human light chain framework regions comprise a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the one or more human heavy chain framework regions and the one or more human light chain regions comprise a VH-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 15, a VH-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 19, a VH-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 20, a VH-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 24, a VL-FR1 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 27, a VL-FR2 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 31, a VL-FR3 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 35, and a VL-FR4 amino acid sequence identical to the amino acid sequence set forth in SEQ ID NO: 38. In certain embodiments, the antibody

specifically binds human LIF.

**[00113]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, and 44. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, and 44. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized light chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized light chain variable region comprising an amino acid sequence set forth in any one of SEQ ID NOs: 45-48. In certain embodiments, the antibody specifically binds human LIF.

**[00114]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO:42; and a humanized light chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence set forth in SEQ ID NO: 42; and a humanized light chain variable region comprising an amino acid sequence set forth in SEQ ID NO: 46.

**[00115]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 66; and a humanized light chain variable region comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region comprising an amino acid sequence set forth in SEQ ID NO: 66; and a humanized light chain variable region comprising an amino acid sequence set forth in SEQ ID NO: 46.

**[00116]** In certain embodiments, described herein, is an antibody that specifically binds LIF

comprising a humanized heavy chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60; and a humanized light chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence set forth in any one of SEQ ID NOs: 57-60; and a humanized light chain comprising an amino acid sequence set forth in any one of SEQ ID NOs: 61-64.

**[00117]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 58; and a humanized light chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 62. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence set forth in SEQ ID NO: 58; and a humanized light chain comprising an amino acid sequence set forth in SEQ ID NO: 62. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO:67; and a humanized light chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 62. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence set forth in SEQ ID NO: 67; and a humanized light chain comprising an amino acid sequence set forth in SEQ ID NO: 62.

**[00118]** In a certain embodiments, described herein, is a recombinant antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: a heavy chain complementarity determining region 1 (VH-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 3; a heavy chain complementarity determining region 2 (VH-CDR2) comprising an amino acid sequence set forth in SEQ ID NO: 4; a heavy chain complementarity determining region 3 (VH-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 7; a light chain complementarity determining region 1 (VL-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 9; and a light chain complementarity determining region 2 (VL-CDR2) comprising an amino acid

sequence set forth in SEQ ID NO: 11; and a light chain complementarity determining region 3 (VL-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 13.

**[00119]** In a certain embodiments, described herein, is a recombinant antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: a heavy chain complementarity determining region 1 (VH-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 2; a heavy chain complementarity determining region 2 (VH-CDR2) comprising an amino acid sequence set forth in SEQ ID NO: 5; a heavy chain complementarity determining region 3 (VH-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 6; a light chain complementarity determining region 1 (VL-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 10; and a light chain complementarity determining region 2 (VL-CDR2) comprising an amino acid sequence set forth in SEQ ID NO: 12; and a light chain complementarity determining region 3 (VL-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 13. Certain conservative amino acid substitutions are envisioned in the amino acid sequences of the CDRs of this disclosure. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 2, 5, 6, 10, 12, and 13 by 1, 2, 3, or 4 amino acids. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 2, 5, 6, 10, 12, and 13 by 1, 2, 3, or 4 amino acids and does not affect the binding affinity by greater than 10%, 20%, or 30%.

**[00120]** In a certain embodiments, described herein, is a recombinant antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising: a heavy chain complementarity determining region 1 (VH-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 3; a heavy chain complementarity determining region 2 (VH-CDR2) comprising an amino acid sequence set forth in SEQ ID NO: 4; a heavy chain complementarity determining region 3 (VH-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 7; a light chain complementarity determining region 1 (VL-CDR1) comprising an amino acid sequence set forth in SEQ ID NO: 9; and a light chain complementarity determining region 2 (VL-CDR2) comprising an amino acid sequence set forth in SEQ ID NO: 11; and a light chain complementarity determining region 3 (VL-CDR3) comprising an amino acid sequence set forth in SEQ ID NO: 13. Certain conservative amino acid substitutions are envisioned in the amino acid sequences of the CDRs of this disclosure. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 3, 4, 7, 9, 11, and 13 by 1, 2, 3, or 4 amino acids. In certain embodiments, the antibody comprises CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 3, 4, 7, 9, 11, and 13 by 1, 2, 3, or 4 amino acids and does not affect the binding affinity by greater than 10%, 20%, or 30%.

**[00121]** In certain embodiments, described herein, is an antibody that specifically binds LIF

comprising a humanized heavy chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 49-52; and a humanized light chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 53-56. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence set forth in any one of SEQ ID NOs: 49-52; and a humanized light chain comprising an amino acid sequence set forth in any one of SEQ ID NOs: 53-56.

**[00122]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 50; and a humanized light chain comprising an amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in of SEQ ID NO: 54. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain comprising an amino acid sequence set forth in SEQ ID NO: 50; and a humanized light chain comprising an amino acid sequence set forth in any one of SEQ ID NO: 54.

**Epitopes bound by therapeutically useful LIF antibodies**

**[00123]** Described herein is a unique epitope of human LIF that when bound inhibits LIF biological activity (e.g., STAT3 phosphorylation) and inhibits tumor growth *in vivo*. The epitope described herein consists of two discontinuous stretches of amino acids (from residue 13 to residue 32 and from residue 120 to 138 of human LIF), that are present in two distinct topological domains (alpha helixes A and C) of the human LIF protein. This binding is a combination of weak (Van der Waals attraction), medium (hydrogen binding), and strong (salt bridge) interactions. In certain embodiments, a contact residue is a residue on LIF that forms a hydrogen bond with a residue on an anti-LIF antibody. In certain embodiments, a contact residue is a residue on LIF that forms a salt bridge with a residue on an anti-LIF antibody. In certain embodiments, a contact residue is a residue on LIF that results in a Van der Waals attraction with and is within at least 5, 4, or 3 angstroms of a residue on an anti-LIF antibody.

**[00124]** In certain embodiments, the methods and compositions comprising a LIF binding antibody and a PD-1 axis inhibitor, described herein include an isolated antibody that binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or

H138 of SEQ ID NO: 68. In certain embodiments, described herein is an isolated antibody that binds all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein is an isolated antibody that binds all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that participate with the antibody in strong interactions. In a certain embodiment, the antibody interacts with helix A and C of LIF. In a certain embodiment, the antibody blocks LIF interaction with gp130.

**[00125]** In certain embodiments, described herein is an antibody comprising CDRs with an amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 that binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein is an antibody comprising CDRs with an amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 that binds to all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that participate with the antibody in strong interactions.

**[00126]** In certain embodiments, described herein is an antibody comprising CDRs with an amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 that binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein is an antibody comprising CDRs with an amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 that binds to all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that participate with the antibody in strong interactions.

**[00127]** In certain embodiments, described herein is an antibody comprising CDRs that differ

from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 by 1, 2, 3, 4, or 5 amino acids and binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein is an antibody comprising CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 6, 9, 11, and 13 by 1, 2, 3, 4, or 5 amino acids and binds to all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that participate with the antibody in strong interactions.

**[00128]** In certain embodiments, described herein is an antibody comprising CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 by 1, 2, 3, 4, or 5 amino acids and binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein is an antibody comprising CDRs that differ from the amino acid sequence set forth in any one of SEQ ID NOs: 1, 4, 8, 9, 11, and 13 by 1, 2, 3, 4, or 5 amino acids and bind to all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong interactions.

**[00129]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO:42; and a humanized light chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46 and binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein, is an antibody that specifically

binds LIF comprising a humanized heavy chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO:42; and a humanized light chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46 and binds all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong interactions.

**[00130]** In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 66; and a humanized light chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46 and binds any one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, described herein, is an antibody that specifically binds LIF comprising a humanized heavy chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 66; and a humanized light chain variable region amino acid sequence at least about 80%, about 90%, about 95%, about 97%, about 98%, or about 99% identical to the amino acid sequence set forth in SEQ ID NO: 46 and binds all of the following residues: A13, I14, R15, H16, P17, C18, H19, N20, Q25, Q29, Q32, D120, R123, S127, N128, L130, C131, C134, S135, or H138 of SEQ ID NO: 68. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong or medium interactions. In certain embodiments, the antibody only binds residues that that participate with the antibody in strong interactions.

**[00131]** In certain embodiments, the antibodies disclosed herein inhibit LIF signaling in cells. In certain embodiments, the $IC_{50}$ for biological inhibition of the antibody under serum starved conditions in U-251 cells is less than or equal to about 100, 75, 50, 40, 30, 20, 10, 5, or 1 nanomolar. In certain embodiments, the $IC_{50}$ for biological inhibition of the antibody under serum starved conditions in U-251 cells is less than or equal to about 900, 800, 700, 600, 500,

400, 300, 200, or 100 nanomolar.

**[00132]** In certain embodiments, the antibodies disclosed herein, are useful for treating tumors and cancers that express LIF. In certain embodiments, an individual treated with the antibodies of this disclosure has been selected for treatment as having a LIF positive tumor/cancer. In certain embodiments, the tumor is LIF positive or produces elevated levels of LIF. In certain embodiments, LIF positivity is determined in comparison to a reference value or a set of pathological criteria. In certain embodiments, a LIF positive tumor expresses greater than 2-fold, 3- fold, 5-fold, 10-fold, 100-fold or more LIF than a non-transformed cell from which the tumor is derived. In certain embodiments, the tumor has acquired ectopic expression of LIF. A LIF positive tumor can be determined histologically using, for example, immunohistochemistry with an anti-LIF antibody; by commonly used molecular biology methods such as, for example, mRNA quantitation by real-time PCR or RNA-seq; or protein quantitation, for example, by western blot, flow cytometry, ELISA, or a homogenous protein quantitation assays (e.g., AlphaLISA®). In certain embodiments, the antibodies can be used to treat patients diagnosed with cancer. In certain embodiments, the cancer comprises one or more cancer stem cells or is one or more cancer stem cells.

**[00133]** In certain embodiments, the antibodies disclosed herein, are useful for treating tumors in cancers that express the LIF receptor (CD118). A LIF receptor positive tumor can be determined by histopathology or flow cytometry, and, in certain embodiments, comprises a cell that binds a LIF receptor antibody greater than 2x, 3x, 4x, 5x, 10x or more than an isotype control. In certain embodiments, the tumor has acquired ectopic expression of the LIF receptor. In a certain embodiment, the cancer is a cancer stem cell. In a certain embodiment, a LIF positive tumor or cancer can be determined by immunohistochemistry using anti-LIF an anti-LIF antibody. In a certain embodiment, a LIF positive tumor is determined by IHC analysis with a LIF Level in the top 10%, 20%, 30%, 40%, or top 50% of tumors.

**[00134]** The antibodies described herein influence numerous outcomes. In a certain embodiment, the antibodies described herein can reduce the presence of M2 macrophages in tumors by at least 10%, 20%, 30%, 40%, 50%, 60 %, 70%, 80%, 90% or more in a tumor model compared to a control antibody (e.g., isotype control). M2 macrophages can be identified by staining for CCL22 and CD206 in IHC sections or by flow cytometry of tumor infiltrating immune or myeloid cells. In a certain embodiment, the antibodies described herein can reduce the binding of LIF to gp130 tumors by at least 10%, 20%, 30%, 40%, 50%, 60 %, 70%, 80%, 90% or more when compared to a control antibody (e.g., isotype control). In a certain embodiment, the antibodies described herein can reduce LIF signaling by at least 10%, 20%, 30%, 40%, 50%, 60 %, 70%, 80%, 90% or more in a LIF responsive cell line compared to a control antibody (e.g.,

isotype control). LIF signaling can be measured by, for example, western blot for phosphorylated STAT3 (a downstream target of LIF signaling). The antibodies here are also highly specific for LIF compared to other IL-6 family member cytokines. In certain embodiments, the antibodies bind human LIF with an affinity about 10x, about 50x, or about 100x greater than that of any other IL-6 family member cytokine. In certain embodiments, the LIF antibodies do not bind to other IL-6 family member cytokines that are produced in a mammalian system. In certain embodiments, the antibodies do not bind to Oncostatin M that has been produced in a mammalian system.

**[00135]** In certain embodiments, the LIF-binding polypeptides and antibodies can be administered by any route suitable for the administration of antibody-containing pharmaceutical compositions, such as, for example, subcutaneous, intraperitoneal, intravenous, intramuscular, intratumoral, or intracerebral, etc. In certain embodiments, the antibodies are administered intravenously. In certain embodiments, the antibodies are administered on a suitable dosage schedule, for example, weekly, twice weekly, monthly, twice monthly, etc. In certain embodiments, the antibodies are administered once every three weeks. The antibodies can be administered in any therapeutically effective amount. In certain embodiments, the therapeutically acceptable amount is between about 0.1 mg/kg and about 50 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 1 mg/kg and about 40 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 5 mg/kg and about 30 mg/kg. A LIF-binding polypeptide or antibody can be administered i.v. over a time period of at least about 60 minutes; however, this period can vary somewhat based upon conditions relevant to each individual administration.

**PD-1 axis inhibitors**

**[00136]** The PD-1 axis is the signaling pathway through which PD-1 exerts an inhibitory effect on T-cell responses and includes the PD-1 interaction with PDL-1 or PDL-2. The LIF-binding polypeptides and antibodies described herein can be combined with a PD-1 axis inhibitor and deployed in a method to treat a tumor, cancer or other neoplasm. In certain embodiments, the LIF-binding polypeptides and antibodies described herein can be combined with a PD-1 axis inhibitor in a pharmaceutical composition useful for treating a cancer, tumor, or other neoplasm. The h5D8 antibody described herein can be combined with a PD-1 axis inhibitor and deployed in a method to treat a tumor, cancer or other neoplasm. In certain embodiments, the h5D8 antibody described herein can be combined with a PD-1 axis inhibitor in a pharmaceutical composition useful for treating a cancer, tumor, or other neoplasm.

**[00137]** The PD-1 axis inhibitor utilized in the compositions and methods herein can inhibit signaling through PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273). The inhibitor can be an

antibody or antibody fragment, a soluble ligand-Fc fusion construct, or a small molecule inhibitor. In certain embodiments, the PD-1 axis inhibitor comprises an antibody or PD-1 binding fragment thereof. In certain embodiments, the antibody or antigen binding fragment that specifically binds PD-1 (CD279) comprises Pembrolizumab, Nivolumab, AMP-514, Spartalizumab, Tislelizumab (BGB-A317), Pidilizumab, or a PD-1 (CD279) binding fragment thereof. In certain embodiments, the PD-1 Axis inhibitor is a PD-L2 Fc fusion protein (e.g., AMP-224). In certain embodiments, the PD-1 axis inhibitor comprises an antibody or PDL-1 binding fragment that specifically binds PDL-1 (CD274). In certain embodiments, the antibody or antigen binding fragment that specifically binds to PDL-1 (CD274) comprises Durvalumab (MEDI 4376), Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 (CD274) binding fragment thereof. In certain embodiments, the PD-1 axis inhibitor comprises an antibody or PDL-2 binding fragment thereof that specifically binds PDL-2 (CD273).

**[00138]** In certain embodiments, the PD-1 axis inhibitor comprises on or more a small molecule inhibitor such as N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

**[00139]** In certain embodiments, the PD-1 axis inhibitors can be administered by any route suitable for the administration of a small molecule polypeptide or antibody-containing pharmaceutical composition, such as, for example, subcutaneous, intraperitoneal, intravenous, intramuscular, intratumoral, intracerebral, or oral. In certain embodiments, PD-1 axis inhibiting antibodies are administered intravenously. In certain embodiments, the PD-1 axis inhibiting antibodies are administered on a suitable dosage schedule, for example, weekly, twice weekly, monthly, twice monthly, once every two weeks, once every three weeks, or once every four weeks. The antibodies can be administered in any therapeutically effective amount. In certain

embodiments, the therapeutically acceptable amount is between about 0.1 mg/kg and about 50 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 1 mg/kg and about 40 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 5 mg/kg and about 30 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 5 mg/kg and about 20 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 5 mg/kg and about 15 mg/kg. In certain embodiments, the therapeutically acceptable amount is about 5 mg/kg, 6 mg/kg, 7 mg/kg, 8 mg/kg, 9 mg/kg, 10 mg/kg, 11 mg/kg, 12 mg/kg, 13 mg/kg, 14 mg/kg, 15 mg/kg, 16 mg/kg, 17 mg/kg, 18 mg/kg, 19 mg/kg, or 20 mg/kg. In one example, Durvalumab can be administered at a dosage of about 10 mg/kg once every two weeks.

**[00140]** In certain embodiments, administration to an individual of the PD-1 axis inhibitors can be at a flat dosage level of between about 100 milligrams and about 1000 milligrams. In certain embodiments, administration to an individual of the PD-1 axis inhibitors can be at flat dosage level of between about 200 milligrams and about 800 milligrams, between about 200 milligrams and about 600 milligrams, between about 200 milligrams and about 500 milligrams, between about 300 milligrams and about 500 milligrams. In certain embodiments, administration to an individual of the PD-1 axis inhibitors can be at a flat dosage level of about 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950 or 1000 milligrams. In certain embodiments, administration to an individual of the PD-1 axis inhibitors can be at level suitable for monotherapy. For example, Nivolumab can be administered at a dosage of about 240 milligrams every two weeks or about 480 milligrams every four weeks. In another example Pembrolizumab can be administered at about 200 milligrams once every three weeks.

**Dosages of h5D8**

**[00141]** In certain embodiments, the h5D8 antibody can be administered by any route suitable for the administration of antibody-containing pharmaceutical compositions, such as, for example, subcutaneous, intraperitoneal, intravenous, intramuscular, intratumoral, or intracerebral, etc. In certain embodiments, the h5D8 is administered intravenously. In certain embodiments, h5D8 is administered on a suitable dosage schedule, for example, weekly, twice weekly, monthly, twice monthly, etc. In certain embodiments, h5D8 is administered once every three weeks. H5D8 can be administered in any therapeutically effective amount. In certain embodiments, the therapeutically acceptable amount is between about 0.1 mg/kg and about 50 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 1 mg/kg and about 40 mg/kg. In certain embodiments, the therapeutically acceptable amount is between about 5 mg/kg and about 30 mg/kg. The h5D8 antibody can be administered at a flat dose regardless of the weight or mass of the individual to whom the h5D8 antibody is administered. The h5D8

antibody can be administered at a flat dose regardless of the weight or mass of the individual to whom the h5D8 antibody is administered, provided that the individual has a mass of at least about 37.5 kilograms. A flat dose of h5D8 can be administered from about 75 milligrams to about 2000 milligrams. A flat dose of h5D8 can be administered from about 225 milligrams to about 2000 milligrams, from about 750 milligrams to about 2000 milligrams, from about 1125 milligrams to about 2000 milligrams, or from about 1500 milligrams to about 2000 milligrams. A flat dose of h5D8 can be administered at about 75 milligrams. A flat dose of h5D8 can be administered at about 225 milligrams. A flat dose of h5D8 can be administered at about 750 milligrams. A flat dose of h5D8 can be administered at about 1125 milligrams. A flat dose of h5D8 can be administered at about 1500 milligrams. A flat dose of h5D8 can be administered at about 2000 milligrams.

**[00142]** Other dosages of h5D8 are contemplated. A flat dose of h5D8 can be administered at about 50, 100, 150, 175, 200, 250, 300, 325, 350, 375, 400, 425, 450, 475, 500, 525, 550, 575, 600, 625, 650, 675, 700, 725, 775, 800, 825, 850, 875, 900, 925, 950, 975, 1000, 1025, 1050, 1075, 1100, 1150, 1175, 1200, 1225, 1250, 1275, 1300, 1325, 1350, 1375, 1400, 1425, 1450, 1475, 1525, 1550, 1575, 1600, 1625, 1650, 1675, 1700, 1725, 1750, 1775, 1800, 1825, 1850, 1875, 1900, 1925, 1950, 1975, 2025, 2050, 2075, or 2100 milligrams. Any of these doses can be administered once a week, once every two weeks, once every three weeks, or once every four weeks.

**[00143]** A flat dose of h5D8 can be administered from about 75 milligrams to about 2000 milligrams once a week. A flat dose of h5D8 can be administered from about 75 milligrams to about 1500 milligrams once a week. A flat dose of h5D8 can be administered from about 225 milligrams to about 1500 milligrams, from about 750 milligrams to about 1500 milligrams, from about 1125 milligrams to about 1500 milligrams once a week. A flat dose of h5D8 can be administered at about 75 milligrams once a week. A flat dose of h5D8 can be administered at about 225 milligrams once a week. A flat dose of h5D8 can be administered at about 750 milligrams once a week. A flat dose of h5D8 can be administered at about 1125 milligrams once a week. A flat dose of h5D8 can be administered at about 1500 milligrams once a week. A flat dose of h5D8 can be administered at about 2000 milligrams once a week.

**[00144]** A flat dose of h5D8 can be administered from about 75 milligrams to about 2000 milligrams once every two weeks. A flat dose of h5D8 can be administered from about 75 milligrams to about 1500 milligrams once every two weeks. A flat dose of h5D8 can be administered from about 225 milligrams to about 1500 milligrams, from about 750 milligrams to about 1500 milligrams, from about 1125 milligrams to about 1500 milligrams once every two weeks. A flat dose of h5D8 can be administered at about 75 milligrams once every two weeks. A

flat dose of h5D8 can be administered at about 225 milligrams once every two weeks. A flat dose of h5D8 can be administered at about 750 milligrams once every two weeks. A flat dose of h5D8 can be administered at about 1125 milligrams once every two weeks. A flat dose of h5D8 can be administered at about 1500 milligrams once every two weeks. A flat dose of h5D8 can be administered at about 2000 milligrams once every two weeks.

**[00145]** A flat dose of h5D8 can be administered from about 75 milligrams to about 2000 milligrams once every three weeks. A flat dose of h5D8 can be administered from about 75 milligrams to about 1500 milligrams once every three weeks. A flat dose of h5D8 can be administered from about 225 milligrams to about 1500 milligrams, from about 750 milligrams to about 1500 milligrams, from about 1125 milligrams to about 1500 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 75 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 225 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 750 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 1125 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 1500 milligrams once every three weeks. A flat dose of h5D8 can be administered at about 2000 milligrams once every three weeks.

**[00146]** A flat dose of h5D8 can be administered from about 75 milligrams to about 2000 milligrams once every four weeks. A flat dose of h5D8 can be administered from about 75 milligrams to about 1500 milligrams once every four weeks. A flat dose of h5D8 can be administered from about 225 milligrams to about 1500 milligrams, from about 750 milligrams to about 1500 milligrams, from about 1125 milligrams to about 1500 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 75 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 225 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 750 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 1125 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 1500 milligrams once every four weeks. A flat dose of h5D8 can be administered at about 2000 milligrams once every four weeks.

**[00147]** The h5D8 antibody can be administered at a dose based on the bodyweight or mass of the individual to whom the h5D8 antibody is administered. A body weight adjusted dose of h5D8 can be administered from about 1 mg/kg to about 25 mg/kg. A body weight adjusted dose of h5D8 can be administered from about 3 mg/kg to about 25 mg/kg, from about 10 mg/kg to about 25 mg/kg, from about 15 mg/kg to about 25 mg/kg, or from about 20 mg/kg to about 25 mg/kg. A body weight adjusted dose of h5D8 can be administered at about 1 mg/kg. A body weight adjusted dose of h5D8 can be administered at about 3 mg/kg. A body weight adjusted dose of h5D8 can be administered at about 10 mg/kg. A body weight adjusted dose of h5D8 can

be administered at about 15 mg/kg. A body weight adjusted dose of h5D8 can be administered at about 20 mg/kg. A body weight adjusted dose of h5D8 can be administered at about 25 mg/kg.

**[00148]** A body weight adjusted dose of h5D8 can be administered from about 1 mg/kg to about 25 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered from about 3 mg/kg to about 25 mg/kg, from about 10 mg/kg to about 20 mg/kg, from about 15 mg/kg to about 25 mg/kg, or from about 20 mg/kg to about 25 mg/kg once every one, two, three, or four weeks.

**[00149]** Other bodyweight adjusted doses of h5D8 are contemplated. A body weight adjusted dose of h5D8 can be administered at about 2 mg/kg, 4 mg/kg, 5 mg/kg, 6 mg/kg, 7 mg/kg, 8 mg/kg, 9 mg/kg, 11 mg/kg, 12 mg/kg, 13 mg/kg, 14 mg/kg, 16 mg/kg, 17 mg/kg, 18 mg/kg, 19 mg/kg, 21 mg/kg, 22 mg/kg, 23 mg/kg, 24 mg/kg, 26 mg/kg, 27 mg/kg, 28 mg/kg, 29 mg/kg, or 30 mg/kg. Any of these doses can be administered once a week, once every two weeks, once every three weeks, or once every four weeks.

**[00150]** A body weight adjusted dose of h5D8 can be administered at about 1 mg/kg once a week. A body weight adjusted dose of h5D8 can be administered at about 3 mg/kg once a week. A body weight adjusted dose of h5D8 can be administered at about 10 mg/kg once a week. A body weight adjusted dose of h5D8 can be administered at about 15 mg/kg once a week. A body weight adjusted dose of h5D8 can be administered at about 20 mg/kg once a week. A body weight adjusted dose of h5D8 can be administered at about 25 mg/kg once a week.

**[00151]** A body weight adjusted dose of h5D8 can be administered at about 1 mg/kg once every two weeks. A body weight adjusted dose of h5D8 can be administered at about 3 mg/kg once every two weeks. A body weight adjusted dose of h5D8 can be administered at about 10 mg/kg once every two weeks. A body weight adjusted dose of h5D8 can be administered at about 15 mg/kg once every two weeks. A body weight adjusted dose of h5D8 can be administered at about 20 mg/kg once every two weeks. A body weight adjusted dose of h5D8 can be administered at about 25 mg/kg once every two weeks.

**[00152]** A body weight adjusted dose of h5D8 can be administered at about 1 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered at about 3 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered at about 10 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered at about 15 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered at about 20 mg/kg once every three weeks. A body weight adjusted dose of h5D8 can be administered at about 25 mg/kg once every three weeks.

**[00153]** A body weight adjusted dose of h5D8 can be administered at about 1 mg/kg once every four weeks. A body weight adjusted dose of h5D8 can be administered at about 3 mg/kg once

every four weeks. A body weight adjusted dose of h5D8 can be administered at about 10 mg/kg once every four weeks. A body weight adjusted dose of h5D8 can be administered at about 15 mg/kg once every four weeks. A body weight adjusted dose of h5D8 can be administered at about 20 mg/kg once every four weeks. A body weight adjusted dose of h5D8 can be administered at about 25 mg/kg once every four weeks.

**[00154]** Any of the doses detailed herein can be administered i.v. over a time period of at least about 60 minutes; however, this period can vary somewhat based upon conditions relevant to each individual administration.

**Dosage Schedules of Combination Therapies**

**[00155]** A combination treatment comprising a LIF-binding polypeptide and a PD-1 axis inhibitor can be administered in a variety of ways. The LIF-binding polypeptide and the PD-1 axis inhibitor can be administered at the same time on the same schedule, or at different times and on different schedules. When administered at the same time the administration can be by way of separate formulations or a single formulation comprising both the LIF-binding polypeptide and the PD-1 axis inhibitor. Modes of administration can be mixed, for example a LIF-binding polypeptide can be administered intravenously while a PD-1 axis inhibitor can be administered orally or by parenteral injection. In certain embodiments, a LIF-binding polypeptide is administered intravenously, parenterally, subcutaneously, intratumorally, or orally. In certain embodiments, a PD-1 axis inhibitor is administered intravenously, parenterally, subcutaneously, intratumorally, or orally.

**[00156]** When a combination treatment is administered to an individual on the same schedule the LIF-binding polypeptide and the PD-1 axis inhibitor can be administered once every week, once every two weeks, once every three weeks, or once every four weeks. The LIF-binding polypeptide and the PD-1 axis inhibitor can be administered separately or as a single formulation. H5D8 and a PD-1 axis inhibitor can be administered separately or as a single formulation.

**[00157]** When a combination treatment is administered to an individual on a different schedule the LIF-binding polypeptide and the PD-1 axis inhibitor can be alternated. In certain embodiments, a PD-1 axis inhibitor can be administered to an individual one or more times before administration of a LIF-biding polypeptide. A LIF-binding polypeptide can be administered within 1 day, 2 days, 3 days, 4 days, 5 days, or 6 days of administration of a PD-1 axis inhibitor. A LIF-binding polypeptide can be administered within 1 week, 2 weeks, 3 weeks, or 4 weeks of administration of a PD-1 axis inhibitor. The h5D8 antibody can be administered within 1 day, 2 days, 3 days, 4 days, 5 days, or 6 days of administration of a PD-1 axis inhibitor. The h5D8 antibody can be administered within 1 week, 2 weeks, 3 weeks, or 4 weeks of

administration of a PD-1 axis inhibitor.

**[00158]** A LIF-biding polypeptide can be administered to an individual one or more times before administration of a PD-1 axis inhibitor. In certain embodiments, a PD-1 axis inhibitor can be administered within 1 day, 2 days, 3 days, 4 days, 5 days, or 6 days of administration of a LIF-binding polypeptide. In certain embodiments, a PD-1 axis inhibitor can be administered within 1 week, 2 weeks, 3 weeks, or 4 weeks of administration of a LIF-binding polypeptide. In certain embodiments, a PD-1 axis inhibitor can be administered within 1 day, 2 days, 3 days, 4 days, 5 days, or 6 days of administration of the h5D8 antibody. In certain embodiments, a PD-1 axis inhibitor can be administered within 1 week, 2 weeks, 3 weeks, or 4 weeks of administration of the h5D8 antibody.

**[00159]** In certain embodiments, a LIF binding polypeptide can be administered to an individual once every week and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a LIF binding polypeptide can be administered to an individual once every two weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a LIF binding polypeptide can be administered to an individual once every three weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a LIF binding polypeptide can be administered to an individual once every four weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a PD1-axis inhibitor can be administered to an individual once every week and a LIF-binding polypeptide can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a PD1-axis inhibitor e can be administered to an individual once every two weeks and a LIF-binding polypeptide can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a PD1-axis inhibitor can be administered to an individual once every three weeks and a LIF-binding polypeptide can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, a PD1-axis inhibitor can be administered to an individual once every four weeks and a LIF-binding polypeptide can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, h5D8 can be administered to an individual one or more times before administration of a PD-1 axis inhibitor. In certain embodiments, h5D8 can be administered to an individual once every week and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, h5D8 can be administered to an

individual once every two weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, h5D8 can be administered to an individual once every three weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks. In certain embodiments, h5D8 can be administered to an individual once every four weeks and a PD1-axis inhibitor can be administered to an individual every week, every two weeks, every three weeks or every four weeks.

**[00160]** A combination treatment according to the current disclosure may comprise combinations wherein one or both of the activate ingredients (e.g., a LIF-binding polypeptide and an inhibitor of PD-1) is not effective by itself, but is effective when administered as a part of a combination treatment. In certain embodiments, an inhibitor of PD-1 is administered at a level not effective for monotherapy, but effective in combination with a LIF-binding polypeptide. In certain embodiments, an inhibitor of PD-1 is administered at a level not effective for monotherapy, but effective in combination with the h5D8 antibody. In certain embodiments, a LIF-binding polypeptide is administered at a level not effective for monotherapy, but effective in combination with an inhibitor of PD-1. In certain embodiments, h5D8 is administered at a level not effective for monotherapy, but effective in combination with an inhibitor of PD-1. In certain embodiments, both a LIF-binding polypeptide, and an inhibitor of PD-1 is administered at a level not effective for monotherapy, but is effective in combination. In certain embodiments, both h5D8, and an inhibitor of PD-1 is administered at a level not effective for monotherapy, but is effective in combination.

**Therapeutic indications**

**[00161]** In certain embodiments, disclosed herein, are methods and compositions useful for the treatment of a cancer or tumor. In certain embodiments, the cancer comprises breast, heart, lung, small intestine, colon, spleen, kidney, bladder, head, neck, ovarian, prostate, brain, pancreatic, skin, bone, bone marrow, blood, thymus, uterine, testicular, and liver tumors. In certain embodiments, tumors which can be treated with the antibodies of the invention comprise adenoma, adenocarcinoma, angiosarcoma, astrocytoma, epithelial carcinoma, germinoma, glioblastoma, glioma, hemangioendothelioma, hemangiosarcoma, hematoma, hepatoblastoma, leukemia, lymphoma, medulloblastoma, melanoma, neuroblastoma, osteosarcoma, retinoblastoma, rhabdomyosarcoma, sarcoma and/or teratoma. In certain embodiments, the tumor/cancer is selected from the group of acral lentiginous melanoma, actinic keratosis, adenocarcinoma, adenoid cystic carcinoma, adenomas, adenosarcoma, adenosquamous carcinoma, astrocytic tumors, Bartholin gland carcinoma, basal cell carcinoma, bronchial gland carcinoma, capillary carcinoid, carcinoma, carcinosarcoma, cholangiocarcinoma,

chondrosarcoma, cystadenoma, endodermal sinus tumor, endometrial hyperplasia, endometrial stromal sarcoma, endometrioid adenocarcinoma, ependymal sarcoma, Swing's sarcoma, focal nodular hyperplasia, gastronoma, germ line tumors, glioblastoma, glucagonoma, hemangioblastoma, hemangioendothelioma, hemangioma, hepatic adenoma, hepatic adenomatosis, hepatocellular carcinoma, insulinite, intraepithelial neoplasia, intraepithelial squamous cell neoplasia, invasive squamous cell carcinoma, large cell carcinoma, liposarcoma, lung carcinoma, lymphoblastic leukemia, lymphocytic leukemia, leiomyosarcoma, melanoma, malignant melanoma, malignant mesothelial tumor, nerve sheath tumor, medulloblastoma, medulloepithelioma, mesothelioma, mucoepidermoid carcinoma, myeloid leukemia, neuroblastoma, neuroepithelial adenocarcinoma, nodular melanoma, osteosarcoma, ovarian carcinoma, papillary serous adenocarcinoma, pituitary tumors, plasmacytoma, pseudosarcoma, prostate carcinoma, pulmonary blastoma, renal cell carcinoma, retinoblastoma, rhabdomyosarcoma, sarcoma, serous carcinoma, squamous cell carcinoma, small cell carcinoma, soft tissue carcinoma, somatostatin secreting tumor, squamous carcinoma, squamous cell carcinoma, undifferentiated carcinoma, uveal melanoma, verrucous carcinoma, vagina/vulva carcinoma, VIPpoma, and Wilm's tumor. In certain embodiments, the tumor/cancer to be treated with one or more antibodies of the invention comprise brain cancer, head and neck cancer, colorectal carcinoma, acute myeloid leukemia, pre-B-cell acute lymphoblastic leukemia, bladder cancer, astrocytoma, preferably grade II, III or IV astrocytoma, glioblastoma, glioblastoma multiforme, small cell cancer, and non-small cell cancer, preferably non-small cell lung cancer, lung adenocarcinoma, metastatic melanoma, androgen-independent metastatic prostate cancer, androgen-dependent metastatic prostate cancer, prostate adenocarcinoma, and breast cancer, preferably breast ductal cancer, and/or breast carcinoma. In certain embodiments, the cancer treated with the antibodies of this disclosure comprises glioblastoma. In certain embodiments, the cancer treated with one or more antibodies of this disclosure comprises pancreatic cancer. In certain embodiments, the cancer treated with one or more antibodies of this disclosure comprises ovarian cancer. In certain embodiments, the cancer treated with one or more antibodies of this disclosure comprises lung cancer. In certain embodiments, the cancer treated with one or more antibodies of this disclosure comprises prostate cancer. In certain embodiments, the cancer treated with one or more antibodies of this disclosure comprises colon cancer. In certain embodiments, the cancer treated comprises glioblastoma, pancreatic cancer, ovarian cancer, colon cancer, prostate cancer, or lung cancer. In a certain embodiment, the cancer is refractory to other treatment. In a certain embodiment, the cancer treated is relapsed. In a certain embodiment, the cancer is a relapsed/refractory glioblastoma, pancreatic cancer, ovarian cancer, colon cancer, prostate cancer, or lung cancer. In certain embodiments, the cancer comprises an advanced solid

tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, or soft tissue cancer. In certain embodiments, the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma. In certain embodiments, the cancer comprises an advanced solid tumor. In certain embodiments, the individual is refractory to previous treatment with a LIF binding antibody as a monotherapy. In certain embodiments, the individual is refractory to previous treatment with a PD-1 axis inhibitor as a monotherapy.

**Pharmaceutically acceptable excipients, carriers, and diluents**

**[00162]** In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are a component of a pharmaceutical composition. In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are a component of the same pharmaceutical composition. In certain embodiments, the pharmaceutical composition comprises a physiologically appropriate salt concentration (e.g., NaCl). In certain embodiments, the pharmaceutical composition comprises between about 0.6% and 1.2% NaCl. In certain embodiments, the pharmaceutical composition comprises between about 0.7% and 1.1% NaCl. In certain embodiments, the pharmaceutical composition comprises between about 0.8% and 1.0% NaCl. In certain embodiments, the pharmaceutical composition comprises between about 5% dextrose. In certain embodiments, the pharmaceutical composition further comprises one or more of: buffers, for example, acetate, citrate, histidine, succinate, phosphate, bicarbonate and hydroxymethylaminomethane (Tris); surfactants, for example, polysorbate 80 (Tween 80), polysorbate 20 (Tween 20), polysorbate and poloxamer 188; polyol/disaccharide/polysaccharides, for example, glucose, dextrose, mannose, mannitol, sorbitol, sucrose, trehalose, and dextran 40; amino acids, for example, histidine, glycine or arginine; antioxidants, for example, ascorbic acid, methionine; and chelating agents, for example, EDTA or EGTA.

**[00163]** In certain embodiments, the PD-1 axis inhibitors, the LIF-binding polypeptides, or both the PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are administered suspended in a sterile solution. In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides are administered from the same solution. In certain embodiments, the solution comprises a physiologically appropriate salt concentration (e.g., NaCl). In certain embodiments, the solution comprises between about 0.6% and 1.2% NaCl. In certain embodiments, the solution comprises between about 0.7% and 1.1% NaCl. In certain embodiments, the solution comprises between about 0.8% and 1.0% NaCl. In certain embodiments, a highly concentrated stock solution of antibody may be diluted in about 0.9%

NaCl. In certain embodiments, the solution comprises about 0.9% NaCl. In certain embodiments, the solution further comprises one or more of: buffers, for example, acetate, citrate, histidine, succinate, phosphate, bicarbonate and hydroxymethylaminomethane (Tris); surfactants, for example, polysorbate 80 (Tween 80), polysorbate 20 (Tween 20), polysorbate and poloxamer 188; polyol/disaccharide/polysaccharides, for example, glucose, dextrose, mannose, mannitol, sorbitol, sucrose, trehalose, and dextran 40 and combinations thereof; amino acids, for example, histidine, glycine or arginine; antioxidants, for example, ascorbic acid, methionine, and combinations thereof; and chelating agents, for example, EDTA or EGTA. In certain embodiments, PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are shipped/stored lyophilized and reconstituted before administration. In certain embodiments, lyophilized antibody formulations comprise a bulking agent such as, mannitol, sorbitol, sucrose, trehalose, and dextran 40, and combinations thereof. In a certain embodiment, anti-LIF antibodies of this disclosure can be shipped and stored as a concentrated stock solution to be diluted at the treatment site of use. In certain embodiments, the stock solution comprises about 25mM histidine, about 6% sucrose, about 0.01% polysorbate, and about 20mg/mL of anti-LIF antibody. In certain embodiments, the pH of the solution is about 6.0. In certain embodiments, the form administered to an individual is an aqueous solution comprising about 25mM histidine, about 6% sucrose, about 0.01% polysorbate 80, and about 20mg/mL of h5D8 antibody. In certain embodiments, the pH of the solution is about 6.0.

**[00164]** In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are administered suspended in a sterile solution. In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides are administered from the same solution. In certain embodiments, the PD-1 axis inhibitors and the LIF-binding polypeptides are administered from separate solutions. In certain embodiments, the solution comprises a physiologically appropriate salt concentration (e.g., NaCl). In certain embodiments, the solution comprises between about 0.6% and 1.2% NaCl. In certain embodiments, the solution comprises between about 0.7% and 1.1% NaCl. In certain embodiments, the solution comprises between about 0.8% and 1.0% NaCl. In certain embodiments, a highly concentrated stock solution of antibody may be diluted in about 0.9% NaCl. In certain embodiments, the solution comprises about 0.9% NaCl. In certain embodiments, the solution further comprises one or more of: buffers, for example, acetate, citrate, histidine, succinate, phosphate, bicarbonate and hydroxymethylaminomethane (Tris); surfactants, for example, polysorbate 80 (Tween 80), polysorbate 20 (Tween 20), polysorbate and poloxamer 188; polyol/disaccharide/polysaccharides, for example, glucose, dextrose, mannose, mannitol, sorbitol, sucrose, trehalose, and dextran 40, and combinations thereof; amino acids, for example,

histidine, glycine or arginine; antioxidants, for example, ascorbic acid, methionine; and chelating agents, for example, EDTA or EGTA. In certain embodiments, PD-1 axis inhibitors and the LIF-binding polypeptides of the current disclosure are shipped/stored lyophilized and reconstituted before administration. In certain embodiments, lyophilized antibody formulations comprise a bulking agent such as, mannitol, sorbitol, sucrose, trehalose, and dextran 40, and combinations thereof. In a certain embodiment, anti-LIF antibodies of this disclosure can be shipped and stored as a concentrated stock solution to be diluted at the treatment site of use. In certain embodiments, the stock solution comprises about 25mM histidine, about 6% sucrose, about 0.01% polysorbate, and about 20mg/mL of anti-LIF antibody. In certain embodiments, the pH of the solution is about 6.0. In certain embodiments, the form administered to an individual is an aqueous solution comprising about 25mM histidine, about 6% sucrose, about 0.01% polysorbate 80, and about 20mg/mL of h5D8 antibody. In certain embodiments, the pH of the solution is about 6.0.

**[00165]** Also described herein are kits for carrying out the combination therapies described herein. In certain embodiments, a kit comprises a LIF-binding polypeptide and a PD-1 axis inhibitor. In certain embodiments, a kit comprises h5D8 and a PD-1 axis inhibitor. Either or both components can be contained in a vial of glass or other suitable material in either a lyophilized or a liquid form.

**[00166]** The h5D8 antibody, described herein, can be included in a kit comprising a vial filled with a sterile solution comprising the h5D8 antibody at a concentration of about 20 mg/mL, about 25mM histidine, about 6% sucrose, and about 0.01% polysorbate 80. The vial can be a single-use glass vial. The single-use glass vial can be filled with about 10 milliliters of 5D8 antibody at a concentration of about 20 mg/mL h5D8 antibody, about 25mM histidine, about 6% sucrose, and about 0.01% polysorbate 80. In certain embodiments, the pH of the solution is about 6.0. The h5D8 antibody, described herein, can be included in a kit comprising a vial filled with a lyophilized composition comprising the h5D8 antibody that when reconstituted in an appropriate amount of sterile diluent yields a concentration of about 20 mg/mL h5D8 antibody, about 25mM histidine, about 6% sucrose, and about 0.01% polysorbate 80. The vial can be a single-use glass vial.

**[00167]** The antibodies described herein can be administered or prepared or diluted for administration in different ways depending upon the dosage level that is ultimately to be delivered to the patient. This can be done to optimize for example the pharmaceutical properties of the patient dosage for example to reduce particulate matter. H5D8 can be prepared at a concentration of about 8 mg/mL regardless of ultimate dose delivered to the patient. In certain embodiments, the h5D8 can be prepared at a level of no more than about 10, 9, 8, 7, 6, 5 or 4

mg/mL. In certain embodiments, the h5D8 can be prepared at a level of greater than about 1, 2, 3, 4, 5, 6, or 7 mg/mL.

## EXAMPLES

**[00168]** The following illustrative examples are representative of embodiments of the compositions and methods described herein and are not meant to be limiting in any way.

*Example 1-Generation of rat antibodies specific for LIF*

**[00169]** A cDNA encoding amino acids 23-202 of human LIF was cloned into expression plasmids (Aldevron GmbH, Freiburg, Germany). Groups of laboratory rats (Wistar) were immunized by intradermal application of DNA-coated gold-particles using a hand-held device for particle-bombardment ("gene gun"). Cell surface expression on transiently transfected HEK cells was confirmed with anti-tag antibodies recognizing a tag added to the N-terminus of the LIF protein. Serum samples were collected after a series of immunizations and tested in flow cytometry on HEK cells transiently transfected with the aforementioned expression plasmids. Antibody-producing cells were isolated and fused with mouse myeloma cells (Ag8) according to standard procedures. Hybridomas producing antibodies specific for LIF were identified by screening in a flow cytometry assay as described above. Cell pellets of positive hybridoma cells were prepared using an RNA protection agent (RNAlater, cat. #AM7020 by ThermoFisher Scientific) and further processed for sequencing of the variable domains of the antibodies.

*Example 2-Generation of mouse antibodies specific for LIF*

**[00170]** A cDNA encoding amino acids 23-202 of human LIF was cloned into expression plasmids (Aldevron GmbH, Freiburg, Germany). Groups of laboratory mice (NMRI) were immunized by intradermal application of DNA-coated gold-particles using a hand-held device for particle-bombardment ("gene gun"). Cell surface expression on transiently transfected HEK cells was confirmed with anti-tag antibodies recognizing a tag added to the N-terminus of the LIF protein. Serum samples were collected after a series of immunizations and tested in flow cytometry on HEK cells transiently transfected with the aforementioned expression plasmids. Antibody-producing cells were isolated and fused with mouse myeloma cells (Ag8) according to standard procedures. Hybridomas producing antibodies specific for LIF were identified by screening in a flow cytometry assay as described above. Cell pellets of positive hybridoma cells were prepared using an RNA protection agent (RNAlater, cat. #AM7020 by ThermoFisher Scientific) and further processed for sequencing of the variable domains of the antibodies.

*Example 3-Humanization of rat antibodies specific for LIF*

**[00171]** One clone from the rat immunization (5D8) was chosen for subsequent humanization. Humanization was conducted using standard CDR grafting methods. The heavy chain and light chain regions were cloned from the 5D8 hybridoma using standard molecular cloning techniques

and sequenced by the Sanger method. A BLAST search was then conducted against human heavy chain and light chain variable sequences and 4 sequences from each were chosen as acceptor frameworks for humanization. These acceptor frameworks were deimmunized to remove T cell response epitopes. The heavy chain and light chain CDR1, CDR2 and CDR3 of 5D8 were cloned into the 4 different heavy chain acceptor frameworks (H1 to H4), and 4 different light chain frameworks (L1 to L4). Then all 16 different antibodies were tested for: expression in CHO-S cells (Selexis); inhibition of LIF-induced STAT3 phosphorylation; and binding affinity by Surface Plasmon Resonance (SPR). These experiments are summarized in **Table 1**.

**Table 1. Summary of 5D8 humanization**

| Heavy chain light chain combination | Inhibition of LIF-induced pSTAT3 from **Fig. 1** | Affinity by SPR $K_{D1}$ (pM) | Expression (ug/mL) |
|---|---|---|---|
| H0L0 | +++ | 133±46 | 393 |
| H1L1 | - | N/A | 627 |
| H1L2 | +++ | 55±23 | 260 |
| H1L3 | +++ | 54±31 | 70 |
| H1L4 | - | N/A | 560 |
| H2L1 | - | N/A | 369 |
| H2L2 | +++ | 52±22 | 392 |
| H2L3 | ++ | 136±19 | 185 |
| H2L4 | - | N/A | 78 |
| H3L1 | N/A | N/A | No expression |
| H3L2 | N/A | N/A | No expression |
| H3L3 | N/A | N/A | No expression |
| H3L4 | N/A | N/A | No expression |
| H4L1 | - | N/A | 259 |
| H4L2 | ++ | 913±308 | 308 |
| H4L3 | + | | 252 |
| H4L4 | - | N/A | 186 |

| |
|---|
| N/A= Not attempted; H0L0=chimeric antibody with full rat heavy and light chain variable regions |

**[00172]** The expression performance of the transfected cells was compared in Erlenmeyer flasks (seeding $3x10^5$ cells/mL, 200 mL culture volume) within fed-batch cultivation after 10 days of cell culture. At this point cells were harvested and the secreted antibody purified using a Protein A column and then quantitated. All humanized antibodies expressed except those using the H3 heavy chain (SEQ ID NO: 43). The H2 and L2 variable regions performed well compared to other variable regions (SEQ ID NO: 42 and SEQ ID NO: 46).

**[00173]** Inhibition of LIF-induced STAT3 phosphorylation at tyrosine 705 was determined by western blot. U251 glioma cells were plated in 6-well plates at a density of 100.000 cells/well. Cells were cultured in complete medium for 24 hours before any treatment and after that, cells were serum starved for 8 hours. After that, cells with the indicated antibodies over night at a concentration of 10 µg/ml. After treatment, proteins were obtained in radio-immunoprecipitation assay (RIPA) lysis buffer containing phosphatase and protease inhibitors, quantified (BCA-protein assay, Thermo Fisher Scientific) and used in western blot. For western blot, membranes were blocked for 1 hour in 5% non-fat dried milk - TBST and incubated with the primary antibody overnight (p-STAT3, catalog #9145, Cell Signaling or STAT3, catalog #9132, Cell Signaling) or 30 minutes (β-actin-peroxidase, catalog #A3854, Sigma-Aldrich). Membranes were then washed with TBST, incubated with secondary and washed again. Proteins were detected by chemiluminescence (SuperSignal Substrate, catalog #34076, Thermo Fisher Scientific). These results are shown in **Fig. 1**. The darker the pSTAT3 band the less inhibition is present. Inhibition was high in lanes labeled 5D8 (non-humanized rat), A(H0L0), C (H1L2), D (H1L3), and G (H2L2); inhibition was moderate in H (H2L3), O (H4L2), and P (H4L3); inhibition was absent in B (H1L1), E (H1L4), F (H2L1), I (H2L4), N (H4L1), and Q (H4L4).

**[00174]** Antibodies that exhibited inhibition of LIF-induced STAT3 phosphorylation were then analyzed by SPR to determine binding affinity. Briefly, binding of the A(H0L0), C (H1L2), D (H1L3), and G (H2L2), H (H2L3) and O (H4L2) humanized antibodies to amine coupled hLIF was observed using a Biacore™ 2002 Instrument. Kinetic constants and affinities were determined by mathematical sensorgram fitting (Langmuir interaction model [A + B = AB]) of all sensorgrams generated on all sensor chip surfaces at six ligand concentrations. The best fitted curves (minimal Chi2) of each concentration were used for calculation of kinetic constants and affinities. *See* **Table 1.**

**[00175]** Since the experimental setup used bivalent antibodies as analytes, best fitted sensorgrams, were also analyzed on basis of a bivalent analyte fitting model [A+B = AB; AB+B

= AB2] in order to obtain a more detailed insight into the target binding mechanism of the humanized antibodies. Kinetic sensorgram analysis using a bivalent fitting model [A+B = AB; AB+B = AB2] confirmed the relative affinity ranking of the mAb samples.

**[00176]** The humanized 5D8 comprising H2 and L2 was selected for more in-depth analysis due to its high binding affinity and high yield from batch culture.

*Example 4-Humanization of clone 5D8 improves binding to LIF*

**[00177]** The H2L2 clone (h5D8) was selected for further analysis and compared binding by SPR to the parental rat 5D8 (r5D8) and a mouse clone 1B2. The 1B2 antibody is a previously disclosed mouse anti-LIF antibody previously deposited at the Deutsche Sammlung von Mikroorganismen and Zellkulturen GmbH (DSM ACC3054) and was included for comparison purposes. Recombinant human LIF, purified from *E.coli* and HEK-293 cells, respectively, were used as ligands. The LIF from human or *E. coli* sources was covalently coupled to the surface of Biacore optical sensor chips using amine coupling chemistry, and binding affinities were calculated from the kinetic constants.

Materials and methods

**[00178]** Human LIF from E.coli was obtained from Millipore, reference LIF 1010; human LIF from HEK-293 cells was obtained from ACRO Biosystems, reference LIF-H521b. LIF was coupled to the sensor chips using the Biacore Amine Coupling Kit (BR-1000-50; GE-Healthcare, Uppsala). Samples were run on a Biacore™ 2002 Instrument using CM5 optical sensor chips (BR-1000-12; GE-Healthcare, Uppsala). Biacore HBS-EP buffer was used during the machine runs (BR-1001-88; GE-Healthcare, Uppsala). Kinetic analysis of binding sensorgrams was performed using BIAevaluation 4.1 software. Kinetic constants and affinities were determined by mathematical sensorgram fitting (Langmuir interaction model [A + B = AB]) of all sensorgrams generated on all sensor chip surfaces at increasing analyte concentrations. Sensorgrams were also analyzed on the basis of a bivalent analyte sensorgram fitting model [A+B = AB; AB+B = $AB_2$], including component analysis, in order to generate an estimate on the bivalent contribution to the determined Langmuir antibody – target affinities (e.g., avidity contribution). The best fitted curves (minimal $Chi^2$) of each concentration were used for calculation of kinetic constants and affinities. Summaries of these affinity experiments are shown in **Table 2** (human LIF made in *E.coli*) and **Table 3** (human LIF made in HEK 293 cells).

| **Table 2. Improved binding of 5D8 after humanization** | $K_D$ [pM] | |
|---|---|---|
| hLIF (*E. coli*) | Langmuir 1:1 sensorgram fitting | Bivalent analyte fitting |
| Mouse 1B2 | 400±210 | 1500±200 |

| | | |
|---|---|---|
| r5D8 (Rat) | 130±30 | 780±130 |
| h5D8 (humanized) | 26±14 | 82±25 |

| **Table 3. Improved binding of 5D8 after humanization** | $K_D$ [pM] | |
|---|---|---|
| hLIF (HEK 293) | Langmuir 1:1 sensorgram fitting | Bivalent analyte fitting |
| Mouse 1B2 | 320±150 | 3900±900 |
| r5D8 (rat) | 135±100 | 410±360 |
| h5D8 (humanized) | 13±6 | 63±30 |

**[00179]** The Langmuir 1:1 sensorgram fitting model from this set of experiments indicates that the humanized 5D8 (h5D8) antibody bound with ~10 - 25 times higher affinity to human LIF than mouse 1B2 and r5D8.

**[00180]** Next, the h5D8 antibody was tested against LIF of multiple species by SPR. h5D8 SPR binding kinetics were performed for recombinant LIF analytes derived from different species and expression systems: human LIF (E.coli, HEK293 cells); mouse LIF (E.coli, CHO cells); rat LIF (E.coli); cynomolgus monkey LIF (yeast, HEK293 cells).

Materials and Methods

**[00181]** The h5D8 antibody was immobilized to the sensor chip surface by non-covalent, Fc specific capturing. Recombinant, Ig(Fc) specific *S. aureus* Protein A/G was used as capturing agent, allowing sterically uniform and flexible presentation of the anti-LIF antibody to the LIF analytes. Sources of the LIF analytes are as follows: Human LIF (from *E.coli*; Millipore reference LIF 1050); Human LIF (from HEK cells ACRO Biosystems LIF-H521); Mouse LIF (*E. coli*; Millipore Cat. No NF-LIF2010); Mouse LIF (from CHO cells; Reprokine Catalog # RCP09056); Monkey LIF (yeast Kingfisher Biotech Catalog # RP1074Y); Monkey LIF produced in HEK-293 cell. Overall h5D8 exhibited binding to LIF from several species. A summary of this affinity experiment is shown in **Table 4.**

| **Table 4. Broad species reactivity of humanized 5D8** | Langmuir 1:1 sensorgram fitting | | |
|---|---|---|---|
| Analyte | mean $K_a$ (1/Ms)[$10^5$] | mean $K_d$ (1/S) [$10^{-5}$] | mean $K_D$ [pM] |
| Human LIF (*E.coli*) | 8.5 ± 0.7 | 7.2 ± 0.7 | 86 ± 9 |

| | | | |
|---|---|---|---|
| Human LIF (HEK-293) | 5.5 ± 0.02 | 3.1 ± 0.7 | 56 ± 13 |
| Mouse LIF (*E.coli*) | 21.4 ± 3.7 | 5.7 ± 1.0 | 27 ± 6 |
| Mouse LIF(CHO cells) | 6.5 ± 0.7 | 1.1 ± 0.3 | 17 ± 4 |
| Cyno Monkey LIF (yeast) | 6.3 ± 0.8 | 5.4± 0.7 | 89 ± 10 |
| Cyno Monkey LIF (HEK-293) | 2.4 ± 0.2 | 3.3± 0.3 | 134 ± 6 |

*Example 5-Humanized clone 5D8 inhibits LIF-induced phosphorylation of STAT3 in vitro*

**[00182]** To determine the biological activity of h5D8, the humanized and parental versions were tested in a cell culture model of LIF activation. **Fig. 2A** shows that the humanized clone exhibited increased inhibition of STAT3 phosphorylation (Tyr 705) when a glioma cell line was incubated with human LIF. **Fig. 2B** shows an experiment with the same set up of **Fig. 2A** repeated with different dilutions of the h5D8 antibody.

Materials and Methods

**[00183]** U251 glioma cells were plated in 6-well plates at a density of 150,000 cells/well. Cells were cultured in complete medium for 24 hours before any treatment. After that, cells were treated over night or not (control cells) with r5D8 anti-LIF antibody or h5D8 anti-LIF antibody at a concentration of 10 µg/ml.

**[00184]** After treatment, proteins were obtained in radio-immunoprecipitation assay (RIPA) lysis buffer containing phosphatase and protease inhibitors, quantified (BCA-protein assay, Thermo Fisher Scientific) and used in western blot. For western blot, membranes were blocked for 1 hour in 5% non-fatty milk - TBST and incubated with the primary antibody overnight (p-STAT3, catalog #9145, Cell Signaling or STAT3, catalog #9132, Cell Signaling) or 30 minutes (β-actin-peroxidase, catalog #A3854, Sigma-Aldrich). Membranes were then washed with TBST, incubated with secondary antibody if necessary, and washed again. Proteins were detected by chemiluminescence (SuperSignal Substrate, catalog #34076, Thermo Fisher Scientific).

*Example 6-$IC_{50}$ value of h5D8 antibody treatment on endogenous levels of LIF in U-251 cells.*

**[00185]** It was also determined that an $IC_{50}$ of as low as 490 picomolar (**Fig. 3A**) for biological inhibition for h5D8 under serum starved conditions in U-251 cells. *See* representative results **Fig. 3A** and **3B** and **Table 5**.

| Table 5. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cell Line Tissue** | **Cell Line Name** | **Treatment** | **$IC_{50}$ (nM)** | | | | **$IC_{90}$ (nM)** | **JAK inhibition (%)** |
| Endogenous LIF Condition | | | n=1 | n=2 | Mean | SD | Mean | Mean |
| GBM | U251 | h5D8 | 0.78 | 0.54 | 0.66 | 0.12 | 4.1 | 84% |
| | | r5D8 | 1.6 | 1.5 | 1.4 | 0.15 | 8.5 | 86% |
| | | | 1.2 | 1.4 | | | | |

Materials and Methods

**[00186]** The U-251 cells were seeded at 600,000 cells per 6cm plate (per condition). Cells were treated with h5D8 in corresponding concentration (titration) overnight at 37°C, under serum starvation (0.1% FBS). As a positive control for pSTAT3, recombinant LIF (R&D #7734-LF/CF) was used to stimulate the cells at 1.79 nM for 10min at 37°C. As a negative control of pSTAT3, the JAK I inhibitor (Calbiochem #420099) was used at 1uM for 30min at 37°C. Cells were then harvested on ice for lysates following the Meso Scale Discovery Multi-Spot Assay System Total STAT3 (Cat# K150SND-2 ) and Phospho-STAT3 (Tyr705) (Cat# K150SVD-2) kits' protocol, to measure protein levels detectable by the MSD Meso Sector S600.

*Example 7-Additonal antibodies that specifically bind to human LIF*

**[00187]** Other rat antibody clones (10G7 and 6B5) that specifically bind human LIF were identified and a summary of their binding characteristics are shown below in **Table 6,** clone 1B2 served as a comparison.

Materials and Methods

**[00188]** Kinetic real time binding analysis was performed for anti-LIF mAbs 1B2, 10G7 and 6B5, immobilized on the surface of CM5 optical sensor chips, applying recombinant LIF target proteins [human LIF (*E.coli*); Millipore Cat. No. LIF 1010 and human LIF (HEK293 cells); ACRO Biosystems Cat. No. LIF-H521b] as analytes.

**[00189]** Kinetic constants and affinities were obtained by mathematical sensorgram fitting using a Langmuir 1:1 binding model applying global (simultaneous fitting of sensorgram sets) as well as single curve fitting algorithms. Plausibility of global fits was assessed by $k_{obs}$ analysis.

| **Table 6. Affinity measurements of additional anti-LIF antibodies** | | Langmuir 1:1 sensorgram fitting | | |
|---|---|---|---|---|
| Analyte | clone | mean $K_a$ (1/Ms) | mean $K_d$ (1/S) | mean $K_D$ [nM] |
| Human LIF (*E.coli*) | 1B2 | 1.1 ± 0.4E5 | 1.1 ± 0.3E-3 | 9.7 ± 1.4 |
| Human LIF (HEK-293) | 1B2 | 2.0 ± 0.04E6 | 1.4 ± 0.2E-3 | 0.7 ± 0.03 |
| Human LIF (*E.coli*) | 10G7 | 7.9 ± 5.8E4 | 6.0 ± 2.3E-4 | 12.6 ± 9.5 |
| Human LIF (HEK-293) | 10G7 | 3.6 ± 1.75E5 | 3.1 ± 0.5E-4 | 1.1 ± 0.6 |
| Human LIF (*E.coli*) | 6B5 | N/A | N/A | N/A |
| Human LIF (HEK-293) | 6B5 | 3.6 ± 1.7E5 | 3.1± 0.5E-4 | 62 ± 6 |

*Example 8-Additional anti LIF antibodies inhibit LIF-induced phosphorylation of STAT3in vitro*

**[00190]** Additional clones were tested for their ability to inhibit LIF-induced phosphorylation of STAT3 in cell culture. As shown in **Fig. 4** clones 10G7 and the previously detailed r5D8 exhibited high inhibition of LIF-induced STAT3 phosphorylation, compared to the 1B2 clone. Anti-LIF polyclonal anti-sera (pos.) was included as a positive control While 6B5 exhibited no inhibition, this may be explained by a possible lack of 6B5 binding to non-glycosylated LIF which was used in this experiment.

Materials and Methods

**[00191]** Patient derived glioma cells were plated in 6-well plates at a density of 150,000 cells/well. Cells were cultured in GBM medium that consisted of Neurobasal medium (Life Technologies) supplemented with B27 (Life Technologies), penicillin/streptomycin and growth factors (20 ng/ml EGF and 20 ng/ml FGF-2 [PeproTech]) for 24 hours before any treatment. The

following day, cells were treated or not with recombinant LIF produced in E. coli or a mix of recombinant LIF plus the indicated antibodies for 15 minutes (final concentration of 10 μg/ml for the antibodies and 20 ng/ml of recombinant LIF). After treatment, proteins were obtained in radio-immunoprecipitation assay (RIPA) lysis buffer containing phosphatase and protease inhibitors, quantified (BCA-protein assay, Thermo Fisher Scientific) and used in western blot. For western blot, membranes were blocked for 1 hour in 5% non-fatty milk - TBST and incubated with the primary antibody overnight (p-STAT3, catalog #9145, Cell Signaling) or 30 minutes (β-actin-peroxidase, catalog #A3854, Sigma-Aldrich). Membranes were then washed with TBST, incubated with secondary antibody if necessary, and washed again. Proteins were detected by chemiluminescence (SuperSignal Substrate, catalog #34076, Thermo Fisher Scientific).

*Example 9- LIF is highly overexpressed across multiple tumor types*

**[00192]** Immunohistochemistry was conducted on multiple human tumor types to determine the degree of LIF expression. As shown in **Fig. 5** LIF is highly expressed in glioblastoma multiforme (GBM), non-small cell lung cancer (NSCLC), ovarian cancer, colorectal cancer (CRC), and pancreatic cancer.

*Example 10-Humanized clone h5D8 inhibits tumor growth in a mouse model of non-small cell lung carcinoma*

**[00193]** To determine the ability of the humanized 5D8 clone to inhibit a LIF positive cancer *in vivo* this antibody was tested in a mouse model of non-small cell lung carcinoma (NSCLC). **Fig. 6A** shows reduced tumor growth in mice treated with this antibody compared to a vehicle negative control. **Fig. 6B** shows data generated using the r5D8 version.

Materials and Methods

**[00194]** The murine non-small cell lung cancer (NSCLC) cell line KLN205 with high LIF levels was stably infected with lentivirus expressing the firefly luciferase gene for in vivo bioluminescence monitoring. To develop the mouse model, $5x10^5$ KLN205 non-small cell lung cancer (NSCLC) cells were orthotopically implanted into the left lung of 8-week-old immunocompetent syngeneic DBA/2 mice by intercostal puncture. Mice were treated with a control vehicle or with 15 mg/kg or 30 mg/kg of the h5D8 antibody intraperitoneally twice a week and tumor growth was monitored by bioluminescence. For the bioluminescence imaging, mice received an intraperitoneal injection of 0.2 mL of 15 mg/mL D-luciferin under 1–2% inhaled isoflurane anesthesia. The bioluminescence signals were monitored using the IVIS system 2000 series (Xenogen Corp., Alameda, CA, USA) consisting of a highly sensitive cooled CCD camera. Living Image software (Xenogen Corp.) was used to grid the imaging data and integrate the total bioluminescence signals in each boxed region. Data were analyzed using the

total photon flux emission (photons/second) in the regions of interest (ROI). The results demonstrate that treatment with the h5D8 antibody promote tumor regression. Data are presented as mean ± SEM.

*Example 11- h5D8 inhibits tumor growth in a mouse model of glioblastoma multiforme*

**[00195]** In an orthotopic GBM tumor model using a luciferase expressing human cell line U251, r5D8 significantly reduced tumor volumes in mice administered 300 µg r5D8 and h5D8 by intraperitoneal (IP) injection twice a week. Results of this study are shown in **Fig. 7A** (quantitation at day 26 post treatment). This experiment was also conducted using humanized h5D8 mice treated with 200 µg or 300µg showed a statistically significant reduction in tumor after 7 days of treatment.

Materials and Methods

**[00196]** U251 cells stably expressing luciferase were harvested, washed in PBS, centrifuged at 400g for 5min, resuspended in PBS and counted with an automated cell counter (Countess, Invitrogen). Cells were kept on ice to maintain optimal viability. Mice were anaesthetized with intraperitoneal administration of Ketamine (Ketolar50®) / Xylacine (Rompún®) (75 mg/kg and 10 mg/kg respectively). Each mouse was carefully placed in the stereotactic device and immobilized. Hair from the head was removed with depilatory cream, and the head skin was cut with a scalpel to expose the skull. A small incision was carefully made with a drill in the coordinates 1.8 mm lateral and 1mm anterior to the Lambda. 5 µL of cells were inoculated using a Hamilton 30G syringe into the right corpus striatum, at 2.5 mm of depth. Head incision was closed with Hystoacryl tissue adhesive (Braun) and mice were injected with subcutaneous analgesic Meloxicam (Metacam®) (1 mg/kg). The final cell number implanted into each mouse was $3x10^5$.

**[00197]** Mice were treated twice a week with h5D8 administered intraperitoneally. Treatment was initiated on day 0, immediately after tumor cell inoculation. Mice received a total of 2 doses of h5D8 or vehicle control.

**[00198]** Body weight and tumor volume: Body weight was measured 2 times/week and tumor growth was quantified by bioluminescence on day 7 (Xenogen IVIS Spectrum). To quantify bioluminescence activity in vivo, mice were anaesthetized using isofluorane, and injected intraperitoneally with luciferin substrate (PerkinElmer) (167 µg/kg).

**[00199]** Tumor size as determined by bioluminescence (Xenogen IVIS Spectrum) was evaluated at day 7. The individual tumor measurements and mean ± SEM for each treatment group were calculated. Statistical significance was determined by the unpaired non-parametric Mann-Whitney U-test.

*Example 12- h5D8 inhibits tumor growth in a mouse model of ovarian cancer*

**[00200]** The efficacy of r5D8 was evaluated in two other syngeneic tumor models. In the ovarian orthotopic tumor model ID8, IP administration of 300 µg r5D8 twice weekly significantly inhibited tumor growth as measured by abdominal volume (**Fig. 8A** and **8B**). Results in **Fig. 8C** show that h5D8 also reduced tumor volume at a dose of 200 µg and above.

Materials and Methods

**[00201]** ID8 cells were cultured in Dulbecco's Modified Eagle Medium (DMEM) (Gibco, Invitrogen), supplemented with 10% Fetal Bovine Serum (FBS) (Gibco, Invitrogen), 40 U/mL Penicillin and 40 µg/mL Streptomycin (PenStrep) (Gibco, Invitrogen) and 0.25 µg/mL Plasmocin (Invivogen).

**[00202]** The ID8 cells were harvested, washed in PBS, centrifuged at 400 g for 5min and resuspended in PBS. Cells were kept on ice to maintain optimal viability and 200 µL of the cell suspension was injected intraperitoneally with a 27G needle. The final cell number implanted into mice was $5x10^6$.

**[00203]** Mice were treated twice weekly with h5D8 administered i.p. at different doses as indicated. Body weights were measured 2 times/week and tumor progression was monitored by measuring abdominal girth using a caliper (Fisher Scientific).

*Example 13- r5D8 inhibits tumor growth in a mouse model of colorectal cancer*

**[00204]** In mice with subcutaneous colon CT26 tumors, r5D8 (administered 300 µg IP twice weekly) significantly inhibited tumor growth (**Fig. 9A** and **9B**).

Materials and Methods

**[00205]** CT26 cells were cultured in Roswell Park Memorial Institute medium (RPMI [Gibco, Invitrogen]), supplemented with 10% Fetal Bovine Serum (FBS), 40 U/mL penicillin and 40 µg/mL streptomycin (PenStrep) and 0.25 µg/mL Plasmocin.

**[00206]** CT26 cells ($8 \times 10^5$)were trypsinized, rinsed with PBS, centrifuged at 400 g for 5 minutes and resuspended in 100 µL PBS. Cells were kept on ice to avoid cell death. The CT26 cells were administered to mice via subcutaneous injection using a 27G needle.

**[00207]** 300 µg r5D8, or vehicle control, was administered to the mice via intraperitoneal injection (IP) twice weekly from day 3 post CT26 cell implant.

**[00208]** Body weight and tumor volumes were measured three times per week. Tumor volume was measured using a caliper (Fisher Scientific).

*Example 14- r5D8 reduces inflammatory infiltration in tumor models*

**[00209]** In the U251 GBM orthotopic model, expression of CCL22, a marker of M2 polarized macrophages, was significantly decreased in tumors treated with r5D8 as shown in **Fig. 10A**. This finding was also confirmed in a physiologically relevant organotypic tissue slice culture model using r5D8 in which three patient samples showed a significant decrease in CCL22 and

CD206 (MRC1) expression (also a marker of M2 macrophages) after treatment as shown in **Fig. 10B** (compare upper, control, to lower, treated, for both MRC1 and CCL22**)**. Furthermore, r5D8 also decreased $CCL22^{+}M2$ macrophages in syngeneic ID8 (**Fig. 10C**) and CT26 (**Fig. 10D**) tumors in immunocompetent mice. H5D8 treatment also programmed macrophages towards an immune-stimulatory phenotype in the syngeneic CT26 tumor model (**Fig. 10E** ). h5D8 treatment increased macrophages with an M1 phenotype as indicated by an increased CD206 negative/MHCII positive fraction, and decreased macrophages with an M2 phenotype as indicated by a decreased CD206 positive/MHCII negative fraction. **Fig. 10F** shows gene expression data from monocytes cultured in the conditioned media of U251 cells with LIF knock down. MRC1, CCL2, CCL1, and CTSK (denoted with triangles) all showed significant reductions in expression.

*Example 15- r5D8 increases non-myeloid effector cells*

**[00210]** To investigate additional immune mechanisms, the effect of r5D8 on T cells and other non-myeloid immune effector cells within the tumor microenvironment were evaluated. In the ovarian orthotopic ID8 syngeneic model, r5D8 treatment resulted in an increase in intratumoral NK cells and an increase in total and activated $CD4^{+}$and $CD8^{+}$T cells as shown in **Fig. 11A**. Similarly, in the colon syngeneic CT26 tumor model, r5D8 increased intratumoral NK cells, increased CD4+and CD8+T cells and trended to decrease $CD4^{+}CD25^{+}FoxP3^{+}$T-reg cells as shown in **Fig. 11B**. A trend for a decrease in $CD4^{+}CD25^{+}FoxP3^{+}$T-reg cells was also observed in the syngeneic orthotopic KLN205 tumor model following r5D8treatment as shown in **Fig. 11C**. Consistent with a requirement for T cells to mediate efficacy, depletion of $CD4^{+}$and $CD8^{+}$T cells in the CT26 model inhibited the anti-tumor efficacy of r5D8 as shown in **Fig. 12**.

Materials and Methods for T cell depletion

**[00211]** CT26 cells were cultured in RPMI culture medium (Gibco, Invitrogen), supplemented with 10% Fetal Bovine Serum (FBS [Gibco, Invitrogen]), 40 U/mL penicillin and 40 µg/mL streptomycin (PenStrep [Gibco, Invitrogen]) and 0.25 µg/mL Plasmocin (Invivogen). CT26 cells ($5 \times 10^{5}$) were collected, rinsed with PBS, centrifuged at 400 g for 5 minutes and resuspended in 100 µL PBS. Cells were kept on ice to avoid cell death. The CT26 cells were administered in both flanks to mice via subcutaneous injection using a 27G syringe. Mice were treated twice weekly with r5D8 administered intraperitoneally as indicated in the study design. Vehicle control (PBS), rat r5D8, and/or anti-CD4 and anti-CD8 was administered to the mice via intraperitoneal injection (IP) twice weekly as stated in the study design. All antibody treatments were administered concomitantly.

*Example 16-Crystal structure of h5D8 in complex with human LIF*

**[00212]** The crystal structure of h5D8 was solved to a resolution of 3.1 angstroms in order to

determine the epitope on LIF that h5D8 was bound to and to determine residues of h5D8 that participate in binding. The co-crystal structure revealed that the N-terminal loop of LIF is centrally positioned between the light and heavy chain variable regions of h5D8 (**Fig. 13A**). In addition, h5D8 interacts with residues on helix A and C of LIF, thereby forming a discontinuous and conformational epitope. Binding is driven by several salt-bridges, H-bonds and Van der Waals interactions (**Table 7**, **Fig. 13B**). The h5D8 epitope of LIF spans the region of interaction with gp130. *See* Boulanger, M.J., Bankovich, A.J., Kortemme, T., Baker, D. & Garcia, K.C. Convergent mechanisms for recognition of divergent cytokines by the shared signaling receptor gp130. *Molecular cell* 12, 577-589 (2003). The results are summarized below in **Table 7** and depicted in **Fig. 13**.

| **Table 7. Summary of X-Ray crystal structure for h5D8 in complex with human LIF** | | |
|---|---|---|
| LIF Residue (epitope) | Interaction type | h5D8 Residue (paratope, Kabat numbering) |
| **Ala13** | VDW | L-Tyr49, L-Asn53 |
| **Ile14-O** | HB | L-Ser50-OG |
| **Ile** | VDW | L-His30, L-Tyr32, L-Tyr49, L-Ser50 |
| | | H-Trp97 |
| **Arg15-NE** | SB | L-Glu55-OE1, L-Glu55-OE2 |
| **Arg15-NH1** | SB | L-Glu55-OE1, L-Glu55-OE2 |
| **Arg15-NH2** | SB | L-Glu55-OE1, L-Glu55-OE2 |
| **Arg15-O** | HB | L-Asn34-ND2 |
| **Arg15** | VDW | L-Asn34, L-Leu46, L-Tyr49, L-Glu55, L-Ser56 |
| | | H-Glu96, H-Trp97, H-Asp98, H-Leu99, H-Asp101 |
| **His16-NE2** | SB | H-Asp101-OD2 |
| **His16** | VDW | L-Tyr32, L-Asn34, L-Met89 |
| | | H-Trp95, H-Glu96, H-Trp97, H-Asp101 |
| **Pro17** | VDW | L-Tyr32, L-Ala91 |
| | | H-Trp97 |
| **Cys18** | VDW | L-Tyr32 |
| | | H-Trp33, H-Trp97 |
| **His19-NE2** | SB | H-Glu96-OE1, H-Glu96-OE2 |
| **His19** | VDW | H-His31, H-Trp33, H-Glu96 |
| **Asn20-OD1** | HB | H-Lys52-NZ |
| **Asn20-ND2** | HB | H-Asp53-OD1 |
| **Asn20** | VDW | H-Trp33, H-Lys52, H-Asp53 |
| **Gln25-NE2** | HB | H-Asp53-OD2 |
| **Gln25** | VDW | H-His31, H-Ser52C, H-Asp53 |

| | | |
|---|---|---|
| **Gln29** | VDW | H-His31 |
| **Gln32** | VDW | H-Lys52B |
| **Asp120-OD2** | HB | H-Ser30-OG |
| **Asp120** | VDW | H-Thr28, H-Ser30 |
| **Arg123-NE** | HB | H-Thr28-OG |
| **Arg123** | VDW | H-Thr28 |
| **Gly124** | VDW | H-His31 |
| **Leu125** | VDW | H-His31 |
| **Ser127-OG** | HB | H-Asp98-OD2 |
| **Ser127-O** | HB | H-Trp97-NE1 |
| **Ser127** | VDW | H-His31, H-Trp97, H-Asp98 |
| **Asn128-OD1** | HB | H-His31-NE2 |
| **Asn128** | VDW | H-His31 |
| **Leu130** | VDW | H-Trp97 |
| **Cys131** | VDW | H-Trp97 |
| **Cys134** | VDW | H-Trp97 |
| **Ser135-O** | HB | L-His30-NE2 |
| **Ser135** | VDW | L-His30 |
| **His138** | VDW | L-His30 |
| **VDW**, Van der Waals low energy binding; **HB**, hydrogen bond (medium energy binding); **SB**, salt bridge (high energy binding) | | |

Materials and Methods

**[00213]** LIF was transiently expressed in HEK 293S (Gnt $I^{-/-}$) cells and purified using Ni-NTA affinity chromatography, followed by gel-filtration chromatography in 20 mM Tris pH 8.0 and 150 mM NaCl. The recombinant h5D8 Fab was transiently expressed in HEK 293F cells and purified using KappaSelect affinity chromatography, followed by cation exchange chromatography. Purified h5D8 Fab and LIF were mixed at a 1:2.5 molar ratio and incubated at room temperature for 30 min prior to deglycosylation using EndoH. Gel-filtration chromatography was subsequently used to purify the complex. The complex was concentrated to 20 mg/mL and set up for crystallization trials using sparse matrix screens. Crystals formed at 4°C in a condition containing 19% (v/v) isopropanol, 19% (w/v) PEG 4000, 5% (v/v) glycerol, 0.095 M sodium citrate pH 5.6. The crystal diffracted to a resolution of 3.1 Å at the 08ID-1 beamline at the Canadian Light Source (CLS). Data were collected, processed and scaled using XDS as per Kabsch et al. Xds. *Acta crystallographica. Section D, Biological crystallography* 66, 125-132 (2010). Structures were determined by molecular replacement using Phaser as per McCoy et al. Phaser crystallographic software. *J Appl Crystallogr* 40, 658-674 (2007). Several iterations of model building and refinement were performed using Coot and phenix.refine until the structures converged to an acceptable $R_{work}$ and $R_{free}$. *See* Emsley et al. Features and

development of Coot. *Acta crystallographica. Section D, Biological crystallography* 66, 486-501 (2010); and Adams, et al. PHENIX: a comprehensive Python-based system for macromolecular structure solution. *Acta crystallographica. Section D, Biological crystallography* 66, 213-221 (2010) respectively. The figures were generated in PyMOL (The PyMOL Molecular Graphics System, Version 2.0 Schrödinger, LLC).

*Example 17- h5D8 has high specificity for LIF*

**[00214]** Binding of h5D8 to other LIF family members was tested to determine the binding specificity. Using Octet96 analysis h5D8 binding to human LIF is approximately 100-fold greater than binding to LIFs highest homology IL-6 family member Oncostatin M (OSM) when both proteins are produced in *E. coli*. When both proteins are produced in a mammalian system h5D8 exhibits no binding to OSM. Data are summarized in **Table 8**.

**Table 8: Summary of h5D8 Affinity Measurements for Cytokines as Measured by Octet**

| | KD [M] | kon [1/Ms] | kdis [1/s] |
|---|---|---|---|
| **h5D8 + huLIF (E. coli)** | 4.3E-10 +/- 2.0E-11 | 3.1E+05 +/- 3.1E+03 | 1.3E-04 +/- 5.8E-06 |
| **h5D8 + huLIF (mammalian)** | 1.3E-09 +/- 7.2E-11 | 1.2E+05 +/- 1.3E+03 | 1.5E-04 +/- 8.5E-06 |
| **h5D8 + huOSM (E. coli)** | 3.6E-08 +/- 1.4E-09 | 8.5E+04 +/- 3.1E+03 | 3.1E-03 +/- 4.1E-05 |
| **h5D8 + huOSM (mammalian)** | ND | ND | ND |
| **h5D8 + huIL-6 (E. coli)** | ND | ND | ND |
| ND = no binding | | | |

Materials and Methods

**[00215]** Octet Binding Experiments: Reagents were used and prepared as per manufacturer's provided manual. A Basic Kinetics Experiment was performed using Octet Data Acquisition software ver. 9.0.0.26 as follows: Setup of sensors/program: i) Equilibration (60 seconds); ii) Loading (15 seconds); iii) Baseline (60 seconds); iv) Association (180 seconds); and v) Dissociation (600 seconds)

**[00216]** Octet Affinity of h5D8 for cytokines: A Basic Kinetics Experiment was performed using Octet Data Acquisition software ver. 9.0.0.26 as follows: Amine Reactive 2ndGeneration Biosensors (AR2G) were hydrated for a minimum of 15 minutes in water. Amine conjugation of h5D8 to the biosensors was performed according to ForteBio Technical Note 26 (please see References) using the Amine Coupling Second Generation Kit. Dip steps were as performed at

30°C, 1000rpm as follows: i) 60 seconds Equilibration in water; ii) 300 seconds Activation in 20mM ECD, 10mM sulfo-NHS in water; iii) 600 second Immobilization of 10 µg/ml h5D8 in 10mM Sodium Acetate, pH 6.0; iv) 300 seconds Quench in 1M Ethanolamine, pH 8.5; v) 120 seconds Baseline in water. Kinetics experiments were then performed with the following Dip and Read steps at 30°C, 1000rpm: vi) 60 seconds Baseline in 1X kinetics buffer; vii) 180 seconds Association of appropriate serial dilutions of a cytokine in 1X kinetics buffer; viii) 300 seconds Dissociation in 1X kinetics buffer; ix) Three Regeneration/Neutralization cycles alternating between 10mM glycine pH 2.0 and 1X kinetics buffer respectively (5 seconds in each for 3 cycles). Following regeneration, the biosensors were reused for subsequent binding analyses.

**[00217]** Human recombinant LIF produced from mammalian cells was from ACROBiosystems (LIF-H521b); human recombinant OSM produced in mammalian cells was from R & D (8475-OM/CF); and human recombinant OSM produced in *E. coli* cells was from R & D (295-OM-050/CF).

*Example 18- Crystal structure of h5D8 fab*

**[00218]** Five crystal structures of the h5D8 Fab under a wide spectrum of chemical conditions were determined. The high resolutions of these structures indicate that the conformations of CDR residues are associated with minor flexibility, and are highly similar in different chemical environments. A unique feature of this antibody is the presence of a non-canonical cysteine in position 100 of the variable heavy region. Structure analysis shows that the cysteine is unpaired and largely inaccessible to the solvent.

**[00219]** H5D8 Fab was obtained by papain digestion of its IgG, followed by purification using standard affinity, ion exchange and size chromatography techniques. Crystals were obtained using vapor diffusion methods and allowed to determine five crystal structures ranging between 1.65 Å to 2.0 Å in resolution. All structures were solved in the same crystallographic space group and with similar unit cell dimensions (P212121, a~53.8 Å, b~66.5 Å, c~143.3 Å), despite crystallization conditions ranging across five different pH levels: 5.6, 6.0, 6.5, 7.5 and 8.5. As such, these crystal structures allow for comparison of the three-dimensional disposition of h5D8 Fab unimpeded by crystal packing artefacts and across a wide spectrum of chemical conditions.

**[00220]** Electron density was observed for all complementarity determining region (CDR) residues, which were subsequently modeled. Noticeably, LCDR1 and HCDR2 adopted elongated conformations that together with shallow LCDR3 and HCDR3 regions formed a binding groove at the center of the paratope (**Fig. 14A**). The five structures were highly similar across all residues, with all-atoms root mean square deviations ranging between 0.197 Å and 0.327 Å (**Fig. 14A**). These results indicated that the conformations of CDR residues were

maintained in various chemical environments, including pH levels ranging between 5.6 and 8.5 and ionic strengths ranging between 150 mM and 1 M. Analysis of the electrostatic surface of the h5D8 paratope revealed that positively and negatively charged regions equally contributed to hydrophilic properties, with no prevalent hydrophobic patches. h5D8 has the uncommon feature of a non-canonical cysteine at the base of HCDR3 (Cys100). In all five structures, this free cysteine is ordered and does not form any disulfide scrambles. Additionally, it is not modified by the addition of Cys (cysteinylation) or glutathione (glutathiolation) and makes Van der Waals interactions (3.5-4.3 Å distances) with main chain and side chain atoms of Leu4, Phe27, Trp33, Met34, Glu102 and Leu105 of the heavy chain (**Fig. 14B**). Finally, Cys100 is a predominantly buried structural residue that appears to be involved in mediating the conformations of CDR1 and HCDR3. It is thus unlikely to have reactivity with other cysteines, as observed by a homogeneous disposition of this region in our five crystal structures.

Materials and Methods

**[00221]** H5D8-1 IgG was obtained from Catalent Biologics and was formulated in 25 mM histidine, 6% sucrose, 0.01% polysorbate 80, at pH 6.0. The formulated IgG was extensively buffer-exchanged into PBS using a 10K MWCO concentrator (Millipore) prior to digestion with 1:100 microgram papain (Sigma) for 1 hour at 37°C in PBS, 1.25 mM EDTA, 10 mM cysteine. The papain-digested IgG was flown through a Protein A column (GE Healthcare) using an AKTA Start chromatography system (GE Healthcare). The Protein A flow-through, which contained the h5D8 Fab was recovered and buffer-exchanged into 20 mM sodium acetate, pH 5.6 using a 10K MWCO concentrator (Millipore). The resulting sample was loaded onto a Mono S cation exchange column (GE Healthcare) using an AKTA Pure chromatography system (GE Healthcare). Elution with a gradient of 1 M potassium chloride resulted in a predominant h5D8 Fab peak that was recovered, concentrated and purified to size homogeneity using a Superdex 200 Increase gel filtration column (GE Healthcare) in 20 mM Tris-HCl, 150 mM sodium chloride, at pH 8.0. The high purity of the h5D8 Fab was confirmed by SDS-PAGE under reducing and non-reducing conditions.

**[00222]** Purified h5D8 Fab was concentrated to 25 mg/mL using a 10K MWCO concentrator (Millipore). An Oryx 4 dispenser (Douglas Instruments) was used to set up vapor diffusion crystallization experiments with sparse matrix 96-conditions commercial screens JCSG TOP96 (Rigaku Reagents) and MCSG-1 (Anatrace) at 20°C. Crystals were obtained and harvested after four days in the following five crystallization conditions: 1) 0.085 M sodium citrate, 25.5% (w/v) PEG 4000, 0.17 M ammonium acetate, 15% (v/v) glycerol, pH 5.6; 2) 0.1 M MES, 20% (w/v) PEG 6000, 1 M lithium chloride, pH 6.0; 3) 0.1 M MES, 20% (w/v) PEG 4000, 0.6 M sodium chloride, pH 6.5; 4) 0.085 M sodium HEPES, 17% (w/v) PEG 4000, 8.5% (v/v) 2-propanol,

15% (v/v) glycerol, pH 7.5; and 5) 0.08 M Tris, 24% (w/v) PEG 4000, 0.16 M magnesium chloride, 20% (v/v) glycerol, pH 8.5. Prior to flash-freezing in liquid nitrogen, mother liquors containing the crystals were supplemented with 5-15% (v/v) glycerol or 10% (v/v) ethylene glycol, as required. Crystals were subjected to X-ray synchrotron radiation at the Advanced Photon Source, beamline 23-ID-D (Chicago, IL) and diffraction patterns were recorded on a Pilatus3 6M detector. Data were processed using XDS and structures were determined by molecular replacement using Phaser. Refinement was carried out in PHENIX with iterative model building in Coot. Figures were generated in PyMOL. All software was accessed through SBGrid.

*Example 19- Mutations at Cysteine 100 of h5D8 preserve binding*

**[00223]** Analysis of h5D8 revealed a free cysteine residue at position 100 (C100) in the variable region of the heavy chain. H5D8 variants were generated by substituting C100 with each naturally occurring amino acid in order to characterize binding to and affinity for human and mouse LIF. Binding was characterized using ELISA and Octet assay. Results are summarized in **Table 9.** ELISA EC50 curves are shown in **Fig. 15** (**Fig.15A** human LIF and **Fig. 15B** Mouse LIF).

**Table 9. Summary of affinities determined by Octet assay and EC50 determined by ELISA**

| Mutation | Affinity/ $k_D$ (M) | | Binding EC50 (nM) | |
|---|---|---|---|---|
| | human LIF | mouse LIF | human LIF | mouse LIF |
| C100 | <1.0E-12 ± 2.252E-11 | 9.946E-11 ± 8.272E-12 | 0.09878 | 0.1605 |
| C100S | 8.311E-10 ± 5.886E-11 | 2.793E-09 ± 5.925E-11 | n.d. | n.d. |
| C100Q | 3.87E-09 ± 1.55E-10 | 2.84E-09 ± 4.85E-11 | 10.18 | 26.33 |
| C100N | 5.59E-09 ± 1.01E-10 | 6.68E-09 ± 9.8E-11 | 13.18 | 45.87 |
| C100E | 2.67E-09 ± 4.64E-11 | 4.1E-09 ± 7.56E-11 | 7.179 | 25.3 |
| C100D | 2.02E-09 ± 8.08E-11 | 6.49E-09 ± 7.16E-11 | 11.89 | 22.88 |
| C100T | 4.36E-10 ± 2.1E-11 | 1.02E-09 ± 1.77E-11 | 5.575 | 8.753 |
| C100G | 2.49E-09 ± 4.2E-11 | 3.33E-09 ± 5.42E-11 | 21.94 | 40.17 |
| C100P | 2.74E-10 ± 2.97E-10 | <1.0E-12 ± 7.64E-10 | 34.44 | 101.9 |
| C100A | <1.0E-12 ± 2.713E-11 | <1.0E-12 ± 1.512E-11 | 0.6705 | 0.9532 |
| C100V | <1.0E-12 ± 1.805E-11 | <1.0E-12 ± 8.086E-12 | 0.2785 | 0.3647 |
| C100L | <1.0E-12 ± 1.963E-11 | 1.998E-10 ± 1.055E-11 | 0.454 | 0.547 |
| C100I | <1.0E-12 ± 1.424E-11 | 3.361E-11 ± 7.545E-12 | 0.299 | 0.3916 |
| C100M | 1.155E-09 ± 3.400E-11 | 2.676E-09 ± 2.449E-11 | 0.7852 | 1.563 |
| C100F | 4.376E-09 ± 1.127E-10 | 1.147E-08 ± 9.099E-11 | 8.932 | 21.53 |
| C100Y | 1.444E-08 ± 1.159E-09 | 2.514E-08 ± 2.047E-09 | n.d. | n.d. |
| C100W | 2.508E-08 ± 7.036E-09 | 4.819E-08 ± 4.388E-09 | n.d. | n.d. |
| C100H | 1.304E-10 ± 1.416E-10 | 4.284E-09 ± 1.231E-10 | 8.254 | n.d. |
| C100K | 7.477E-08 ± 1.581E-09 | 6.053E-08 ± 2.589E-09 | n.d. | n.d. |
| C100R | 1.455E-07 ± 6.964E-09 | 5.142E-08 ± 3.247E-09 | n.d. | n.d. |

Materials and Methods

ELISA: Binding of h5D8 C100 variants to human and mouse LIF was determined by ELISA. Recombinant human or mouse LIF protein was coated on Maxisorp 384-well plates at 1 ug/mL overnight at 4°C. Plates were blocked with 1x blocking buffer for 2 hours at room temperature. Titrations of each h5D8 C100 variants were added and allowed to bind for 1 hour at room temperature. Plates were washed three times with PBS+0.05% Tween-20. HRP-conjugated anti-human IgG was added and allowed to bind for 30 min at room temperature. Plates were washed three times with PBS+0.05% Tween-20 and developed using 1x TMB substrate. The reaction was stopped with 1M HCl and absorbance at 450 nm was measured. Generation of figures and non-linear regression analysis was performed using Graphpad Prism.

**[00224]** Octet RED96: The affinity of h5D8 C100 variants to human and mouse LIF was determined by BLI using the Octet RED96 system. h5D8 C100 variants were loaded onto Anti-Human Fc biosensors at 7.5 ug/mL following a 30 second baseline in 1x kinetics buffer. Titrations of human or mouse LIF protein were associated to the loaded biosensors for 90 seconds and allowed to dissociate in 1x kinetics buffer for 300 seconds. KDs were calculated by the data analysis software using a 1:1 global fit model.

*Example 20- h5D8 blocks binding of LIF to gp130 in vitro*

**[00225]** To determine whether h5D8 prevented LIF from binding to LIFR, a molecular binding assay using the Octet RED 96 platform was performed. H5D8 was loaded onto AHC biosensors by anti-human Fc capture. Then, the biosensors were dipped in LIF and, as expected, association was observed (**Fig. 16A**, middle third). Subsequently, the biosensors were dipped in different concentrations of LIFR. A dose-dependent association was observed (**Fig. 16A,** right third). The control experiment demonstrated that this association was LIF-specific (not shown), and not due to a non-specific interaction of LIFR with h5D8 or with the biosensors.

**[00226]** To further characterize the binding of h5D8 and LIF, a series of ELISA binding experiments was conducted. H5D8 and LIF were pre-incubated and were then introduced to plates coated with either recombinant human LIFR (hLIFR) or gp130. The lack of binding between the h5D8/LIF complex and the coated substrate would indicate that h5D8 in some way disrupted the binding of LIF to the receptor. Additionally, control antibodies that either did not bind LIF (isotype control, indicated by (-)) or that bind LIF at known binding sites (B09 does not compete with either gp130 or LIFR for LIF binding; r5D8 is the rat parental version of h5D8) were also used. The ELISA results demonstrated that the h5D8/LIF complex was able to bind hLIFR (as was r5D8/LIF complex), indicating that these antibodies did not prevent the LIF/LIFR association (**Fig. 16A**). In contrast, the h5D8/LIF complex (and a r5D8/LIF complex) was not able to bind recombinant human gp130 (**Fig. 16B**). This indicated that the gp130

binding site of LIF was affected when LIF was bound to h5D8.

*Example 21- LIF and LIFR expression in human tissues*

**[00227]** Quantitative real-time PCR was performed on many different types of human tissue in order to determine expression levels of LIF and LIFR. The mean expression levels shown in **Fig. 17A** and **17B** are given as copies per 100ng of total RNA. Most tissues expressed at least 100 copies per 100ng of total RNA. LIF mRNA expression was highest in human adipose tissue (mesenteric-ileum [1]), blood-vessel tissue (choroid-plexus [6] and mesenteric [8]) and umbilical cord [68] tissue; and lowest in brain tissue (cortex [20] and substantia-nigra [28]). LIFR mRNA expression was highest in human adipose tissue (mesenteric-ileum [1]), blood vessel tissue (pulmonary [9]), brain tissue [11-28] and thyroid [66] tissue; and was lowest in PBMCs [31]. LIF and LIFR mRNA expression levels in cynomolgus tissues were similar to those observed in human tissues, wherein LIF expression was high in adipose tissue and LIFR expression was high in adipose tissue and low in PBMCs (data not shown).

**[00228]** The tissue numbering for **Fig. 17A** and **Fig. 17B** is: 1 – adipose (mesenteric-ileum); 2 - adrenal gland; 3 - bladder; 4 - bladder (trigone); 5 - blood-vessel (cerebral: middle-cerebral-artery); 6 – blood vessel (choroid-plexus); 7 – blood vessel (coronary artery); 8 – blood vessel (mesenteric (colon)); 9 – blood vessel (pulmonary); 10 – blood vessel (renal); 11 – brain (amygdala); 12 - brain (caudate); 13 - brain (cerebellum); 14 brain – (cortex: cingulate-anterior); 15 - brain (cortex: cingulate-posterior); 16 - brain (cortex: frontal-lateral); 17 - brain (cortex: frontal-medial); 18 - brain (cortex: occipital); 19 - brain (cortex: parietal); 20 – brain (cortex: temporal); 21 - brain (dorsal-raphe-nucleus); 22 - brain (hippocampus); 23 - brain (hypothalamus: anterior); 24 - brain (hypothalamus: posterior); 25 - brain (locus coeruleus); 26 - brain (medulla oblongata); 27 – brain (nucleus accumbens); 28 - brain (substantia nigra); 29 - breast; 30 - caecum; 31- peripheral blood mononuclear cell (PBMCs); 32 - colon; 33 – dorsal root ganlia (DRG); 34 - duodenum; 35 – fallopian tube; 36 - gallbladder; 37 – heart (left atrium); 38 - heart (left ventricle); 39 - ileum; 40 - jejunum; 41 – kidney (cortex); 42 - kidney (medulla); 43 - kidney (pelvis); 44 - liver (parenchyma); 45 - liver (bronchus: primary); 46 - liver (bronchus: tertiary); 47 - lung (parenchyma); 48 – lymph gland (tonsil); 49 - muscle (skeletal); 50 - esophagus; 51 - ovary; 52 - pancreas; 53 - pineal gland; 54 – pituitary gland; 55 - placenta; 56 - prostate; 57 - rectum; 58 - skin (foreskin); 69 – spinal cord; 60 - spleen (parenchyma); 61 - stomach (antrum); 62 - stomach (body); 63 - stomach (fundus); 64 - stomach (pyloric canal); 65 - testis; 66 – thyroid gland; 67 - trachea; 68 – umbilical cord; 69 - ureter; 70 – uterus (cervix); 71 - uterus (myometrium); and 72 – vas deferens.

*Example 22-h5D8 and anti-PD-1 antibody inhibit tumor growth in a mouse model of colorectal cancer*

**[00229]** The efficacy of h5D8 was evaluated in combination with a PD-1 inhibitor in the syngeneic CT26 and MC38 models. Mice treated with a combination of PD-1 inhibitor and h5D8 exhibited decreased CT26 tumor growth when compared to mice treated with PD-1 inhibitor or h5D8 alone, as shown in **Figs. 18A** and **18B**. Whereas durable survival benefit with h5D8 monotherapy was not observed (**Fig. 18C**) and only rarely observed with anti-PD1 therapy (**Fig. 18C**), h5D8 and anti-PD1 combination resulted in long-term survival benefit in approximately 40% and 30% of treated CT26 and MC38 tumor bearing mice, respectively (**Fig. 18C**). Importantly, long-term tumor free CT26 survivors were resistant to tumor re-implantation, consistent with acquisition of long-lasting adaptive immunity (**Fig. 18D**).

**[00230]** To investigate additional immune mechanisms by which the h5D8 and PD-1 inhibitor combination had an impact on tumor growth, the effects of the combination on the functionality of infiltrating CD8 T-cells were evaluated, as shown in **Figs. 19A** and **19B**. With monotherapy h5D8 treatment, either no effect or a nominal increase in CD8 TIL was observed in CT26 and MC38 tumors, respectively. Although as monotherapy anti-PD1 had little effect on CD8 TIL, combination with h5D8 yielded significant increases in CD8 TIL in both CT26 and MC38 tumors, suggesting that the increased efficacy observed with the combination was potentially driven by increased CD8 TIL (**Figs. 19C** and **19D**).

**[00231]** Relative to the control and monotherapy treatment groups, tumors harvested from mice treated with the h5D8 and anti-PD1 combination showed not only increased CD8 TIL, but also increased cytolytic, proliferative, and antigen-experienced subsets identified by GZMB, Ki67, and CD44, respectively. The combination treated tumors also showed increased CD8/Treg, M1/M2, and CD8/CD11b ratios demonstrating potent modulation of the tumor micro-environment (TME) favoring anti-tumor immunity. These data support that LIF drives suppression of the TME, at least in part, by suppressive polarization of macrophages, which subsequently blunt host anti-tumor immunity. Inhibition of LIF with h5D8 reverses this effect, and in combination with T-cell promoting therapies, such as anti-PD1 therapy, drives strong anti-tumor immunity to enable durable survival benefit in mouse models of cancer.

**[00232]** To examine if CD8 TIL were functionally different on a per cell basis in tumors harvested from mice treated with either anti-PD1 monotherapy or the h5D8 and anti-PD1 combination, the capacity of the CD8 TIL to produce IFNγ in response to tumor specific antigens was examined. CD8 TIL isolated from anti-PD1 or h5D8 and anti-PD1 combination treated CT26 tumors showed no difference in function when stimulated ex vivo with AH1 peptide (gp70; 423-431a.a.), which comprises the immunodominant rejection antigen of CT26 (**Fig. 19C**). Similarly, CD8 TIL isolated from anti-PD1 or h5D8 and anti-PD1 combination treated MC38 tumors also showed no difference in function when stimulated ex vivo with

immunodominant tumor antigen peptides (p15e; 604-611a.a.), suggesting that the increase in combination efficacy is driven by overall increases in CD8 TIL frequency rather than increased CD8 TIL functionality on a per cell basis.

Materials and Methods

**[00233]** h5D8 and the PD-1 inhibitor, antibody clone RMP1-14 (BioXCell), were administered twice weekly at 15mg/kg and 10mg/kg doses respectively, and tumor volume was monitored through caliper-based measurements.

*Example 23-Correlations between LIF, TAMs and Tregs*

**[00234]** The effect of LIF on the cancer immune system was determined by measuring the relative abundance of tumor-associated macrophages (TAMs) and regulatory T cells (Tregs) across 28 types of solid tumors from the cancer genome atlas (TCGA). A significant correlation between LIF and TAMs and Tregs was observed across several tumor types (**Fig. 20A** and **20B**). Glioblastoma (GBM), prostate adenocarcinoma, thyroid cancer and ovarian cancer were the 4 tumor types exhibiting the highest correlations between LIF, TAMs and Tregs, while showing a high LIF expression across samples (**Fig. 20A** and **20B**). A wide range of LIF expression was observed in GBM tumors being expressed by tumor cells and the immune cell infiltrates (**Fig. 24**).

**[00235]** A significantly positive correlation between LIF and CCL2, CD163, and CD206 was seen in both the analysis of TCGA datasets of human GBM and ovarian cancer (OV) (**Fig. 28**). No correlation was observed between LIF and CXCL9 (data not shown) but relatively low levels of CXCL9 mRNA were observed across tumors. These results were validated at the protein level, by analyzing a cohort of 20 GBM patients and performing LIF, CXCL9, CCL2, CD163, and CD206 IHC of the tumors. A strong positive correlation between LIF and CCL2, CD163, and CD206 was observed (**Fig. 21E**). CXCL9 was expressed in isolated clusters of cells explaining the low levels of CXCL9 mRNA present in tumors. Notably, CXCL9 showed an inversed correlation with LIF in human GBM (**Fig. 21E**).

**[00236]** The examples described herein further illustrate that LIF assumes a crucial role in the exclusion of $CD8^+$ T cells, while promoting the presence of pro-tumoral TAMs. A blockade of LIF in tumors expressing high levels of LIF was observed to decrease CD206, CD163 and CCL2 and induced CXCL9 expression in TAMs. The blockade of LIF released the epigenetic silencing of CXCL9 triggering $CD8^+$ T cell tumor infiltration. The combination of LIF neutralizing antibodies with the inhibition of the PD1 immune checkpoint promoted tumor regression and an increase in overall survival.

Materials and Methods

**[00237]** RNA-seq data for 9,403 patients suffering from 28 distinct solid tumors was

downloaded from The Cancer Genome Atlas (TCGA), Firebrowse server (firebrowse.org, version 2016_01_28). The expression data (RSEM) was log2 transformed for all downstream analyses. Next, the gene signatures of the four immune populations of interest were obtained: TAMs, Tregs, $CD4^+$ T cells and $CD8^+$ T cells. The correlation between LIF expression and the gene signatures of the four immune populations and the correlation between LIF and a set of genes of interest were then computed.

*Example 24-Repressing LIF Function in GL261N, RCAS and ID8 models*

**[00238]** The potential immune-modulating role of LIF in cancer was studied in immunocompetent mouse models of GBM and ovarian cancer (tumor types where LIF strongly correlates with TAMs and Tregs). The GBM cell line, GL261N (a derivative of the GL261 cell line), the *GFAP-tv-a* RCAS-PDGFA, shp53, shNF1 (RCAS) transgenic model, and the ovarian cancer cell line, ID8, that generated tumors in the brain (GL261N and RCAS) and peritoneum (ID8) of mice were identified as expressing high levels of LIF (**Fig. 25**).

**[00239]** LIF function in the GL261N, RCAS, and ID8 models was repressed using neutralizing antibodies. A decrease in tumor growth and an increase in survival was observed in these models (**Fig. 20C, 20G, 20H, 20K, 20P**). The blockade of LIF in the GL261 tumor model, a tumor that did not express LIF, did not inhibit tumor growth (**Fig. 25E**). Neutralizing antibodies against LIF induced a marked decrease in p-STAT3 levels showing that in these animal models (selected based on high LIF expression) LIF was the main cytokine inducing the JAK-STAT3 pathway (**Fig. 20D** and **20L**). Moreover, while a significant decrease in Ki67 positive cells was not observed, an increase in cleaved caspase 3 (CC3) was observed, indicating that the blockade of LIF induced tumor cell death (**Fig. 20D** and **20L**).

Materials and Methods

**[00240]** All animal experiments were approved by and performed according to the guidelines of the Institutional Animal Care Committee of the Vall d'Hebron Research Institute in agreement with the European Union and national directives. Female C57BL/6 and NOD SCID were purchased from Janvier. For brain tumor models, $3x10^5$ GL261N, GL261, or RCAS cells, all of them with luciferase expression, were stereotactically inoculated into the corpus striatum of the right brain hemisphere (1 mm anterior and 1.8 mm lateral to the lambda; 2.5 mm intraparenchymal) of 8-week-old C57BL/6 mice. For ovary tumor model, $5x10^6$ ID8 ovarian cancer cells were intraperitoneally injected into 8-week-old C57BL/6 mice. A dose of 300 µg (ID8) or 600 µg (GL261N, GL261, and RCAS) of anti-LIF or a control IgG was administered intraperitoneally twice a week. Additionally, a dose of 200 µg of rat anti-mouse PD1 blocking antibody (anti-PD1, BioXCell), anti-mouse/human/rat CCL2 antibody (MCP-1, BioXcell) or 3 µg of anti-mouse CXCL9 antibody (R&D) was administered intraperitoneally twice a week.

Tumor progression was monitored by body weight and by abdominal girth (ID8), or bioluminescence measurements using the Xenogen IVIS® Spectrum (GL261N, GL261, and RCAS). Mice were euthanized when they exhibited clinical signs of disease or distress (i.e. cachexia, anorexia or increased respiratory rates) or when tumors began to interfere with normal body functions.

*Example-25 Anti-LIF treatment of GL261N tumors*

**[00241]** The role of the immune system in the response to anti-LIF treatment was evaluated using immunodeficient animals. Treatment with anti-LIF of GL261N tumors in $RAG^{-/-}$ or NOD SCID mice (both strains of mice lacking an adaptive immune response) did not show a significant impact on tumor growth (**Fig. 25F**). The results indicated that the anti-tumor response to the blockade of LIF was mainly mediated by the adaptive immune response.

Materials and Methods

**[00242]** Methods of Example 24 were used with exception to the fact that the mice used were $RAG^{-/-}$, $CCL2^{-/-}$, and $CXCL9^{-/-}$ from Jackson Laboratories and NOD SCID gamma (NSG) from Charles River.

*Example 26-Anti-LIF treatment decreases the number of pro-tumoral TAMs and increases $CD8^+$ T cell tumor infiltration*

**[00243]** The molecular mechanisms involved in the immune response to anti-LIF treatment were further investigated by observing a decrease in the number of pro-tumoral TAMs ($CD11b^+$ $Ly6G^-$ $Ly6C^-$ $CD206^+$ $CD163^+$ $MHCII^{low}$) (**Fig. 20E, 20I, 20M**) and, importantly, a concomitant increase in tumor infiltration of $CD8^+$ T cells upon treatment with anti-LIF (**Fig. 20D, 20F, 20J, 20L, 20N**). Tregs and NK cell numbers were decreased and increased, respectively, upon treatment with anti-LIF (**Fig. 25G-25J**). Infiltrating $CD8^+$ T cells expressed GZMA suggesting that they were mediating the cytotoxic effect (**Fig. 26A**). Moreover a compartment of $CD8^+$ T cells expressed PD1 (**Fig. 26B, 26C**). TAMs derived from recruited monocytes ($CD11b^+$ $Ly6G^-$ $Ly6C^-$ $CD49d^+$)[12] were decreased in response to anti-LIF (**Fig. 26D**) and no major effect was observed on the dendritic cell population ($CD11b^+$, $CD11c^+$, $MHCII^+$) (**Fig. 26E**) nor on the levels of IL-10 or IL-12 in the tissue (**Fig. 26F**).

Materials and Methods

**[00244]** Mice were euthanized and tumors were isolated. GL261N and RCAS tumors were enzymatically digested with Brain Tumor Dissociation kit and myelin was removed with Myelin Removal Beads II (all from Miltenyi Biotec). ID8 tumors were processed with Mouse Tumor Dissociation kit (Miltenyi Biotec) and ascitic liquids were collected. Human GBM specimens of the organotypic model and the patient derived xenografts were enzymatically digested with Human Tumor Dissociation kit (Miltenyi Biotec).

**[00245]** From GL261N cell suspension, $CD11b^+$ cells isolation was performed using anti-Ly6C-APC and anti-APC microbeads and anti Ly6G microbeads to deplete $Ly6G^+$ and $Ly6C^+$ populations and then with CD11b magnetic beads. $CD45^+$ cells isolation was performed with anti-mouse CD45 magnetic beads. From ID8 cell suspension, $CD11b^+$ cells were isolated using anti-CD11b magnetic beads. Finally, from organotypic slices, $CD45^+$ cells isolation was performed using anti-human CD45 magnetic beads. All the isolation procedures were performed using the MultiMACS Cell24 Separator Plus following manufacturer instructions and magnetic beads were purchased from Miltenyi Biotec.

**[00246]** The murine antibodies against CD3, CD4, CD335, CD163, MHC class II, CXCR3 (eBioscience), CD45, CD8, F4/80, CD11b, CD11c, CD206, CD49d (BD Bioscience), LIFR (Novus Biologicals) Ly6G, Ly6C, CCR2 and PD1 (Biolegend) were used for flow cytometry. Intracellular staining of FoxP3, Granzyme A (GZMA), CXCL9 (eBioscience) and CCL2 (Biolegend) were performed using a specific staining set (eBioscience). For flow human studies, antibodies against CD11b, CD14 (BD Bioscience), CD45, CD3, CXCR3 (Biolegend) and CD8 (BD Pharmigen) were used. In some occasions samples were previously incubated with LIVE/DEAD fixable yellow dead stain kit (Thermo Fisher Scientific) to determine viability. As a positive control of human GBM organotypic and patient derived xenografts, $10^6$ PBMCs (named as "spike PBMCs") was added into the control samples in order to establish the leukocyte populations.

**[00247]** Samples were acquired on a BD LSRFortessaTM cell analyzer or Navios (Beckman Coulter) and data were analyzed with Flow Jo software.

*Example 27-CD8+ T cell infiltration is not the result of the anti-tumor response to the blockade of LIF*

**[00248]** Whether LIF-mediated regulation of the tumor immune-infiltrates was the cause or the consequence of the anti-tumor response was assessed by performing an acute-treatment experiment where mice were treated with anti-LIF for 4 days after the tumor was established. The 4 day-treatment did not affect tumor growth (**Fig. 26G**) but was enough to engage $CD8^+$ T cell tumor infiltration (**Fig. 26H**). This shows that $CD8^+$ T cell infiltration was not the result of the anti-tumor response to the blockade of LIF.

*Example 28-Gene response validation*

**[00249]** The genes related to an oncogenic phenotype that were downregulated were determined by isolating $CD11b^+$ cells from the ID8 mouse model, treating the cells with anti-LIF antibodies, and performing a transcriptomic analysis. The genes identified were CCL2, CCL3, CCL7, PF4, CTSK, CD206, and CD163. And, interestingly, CXCL9 was upregulated (**Fig. 21A**). The aforementioned gene responses were validated by qRT-PCR in the ID8 and GL261N models

(**Fig. 21B**).

**[00250]** CXCL9 and CCL2 stood out as chemokines critical for $CD8^+$ T cell tumor infiltration, and the recruitment of TAMs and Tregs, respectively. CXCL9 and CCL2 regulation by the neutralization of LIF in TAMs ($CD11b^+$ $Ly6G^-$ $Ly6C^-$) was confirmed (**Fig. 21C**). Immunostaining and isolation of TAMs showed that CXCL9, CCL2, CD206, and CD163 were mainly expressed in TAMs (**Fig. 21D**) and treatment with anti-LIF regulated their expression (**Fig. 21C, 21D**). CXCR3 (CXCL9 receptor), CCR2 (CCL2 receptor) and LIFR were expressed in TAMs and $CD8^+$ T cells (**Fig. 27A**). qRT-PCR analyses quantified the presence of CD11b and CXCL9 mRNA in $CD11b^+$ $Ly6G^-$ $Ly6C^-$ and $CD11b^-$ $Ly6G^-$ $Ly6C^-$ cells sorted from GL261N tumors. (**Fig. 27B**)

Materials and Methods

**[00251]** Cells were lysed for mRNA extraction (RNeasy Mini or Micro Kit, Qiagen), retrotranscription (iScript Reverse Supermix from BioRad for mRNA), and qRT- PCR was performed using Taqman probes from Applied Biosystems, according to manufacturer's recommendations. For paraffin-embedded sections, RNA was obtained by using High Pure FFPET RNA isolation kit (Roche) and following manufacturer instructions. Reactions were carried out in a CFX384 TouchTM Real-Time PCR Detection System (Bio-Rad) and results were expressed as fold change calculated by the Ct method relative to the control sample. Murine or human *ACTB* or *GAPDH* were used as internal normalization controls.

**[00252]** RNA was assayed on the Affymetrix microarray platform with the Mouse Gene 2.1 ST. Next, it was normalized based on a Robust-Microarray Average (RMA). Genes differentially expressed in anti-LIF treated mice were identified through a Bayesian linear regression, considering paired samples, using limma Bioconductor package.

*Example 29 Anti-LIF response in CXCL9 knockout mice and CCL2 knockout mice*

**[00253]** CXCL9 and CCL2 knockout ($CXCL9^{-/-}$, $CCL2^{-/-}$) mouse models were used to test for the relevance of the regulation of CXCL9 and CCL2 in LIF oncogenic function. Tumors in these mouse models were treated with blocking antibodies against CXCL9 and CCL2. Interestingly, the anti-tumor response to the inhibition of LIF was blunted in the $CXCL9^{-/-}$ mice but not in the $CCL2^{-/-}$ mice (**Fig. 21F**). Similarly, the CXCL9 neutralizing antibody but not the CCL2 antibody impaired the anti-cancer response to anti-LIF (**Fig. 21F**). These results indicate that the main mediator of the anti-LIF response was CXCL9. As expected, the blockade of CXCL9 decreased $CD8^+$ T cell tumor infiltration in response to anti-LIF (**Fig. 21G**).

Materials and Methods

**[00254]** Slides were deparaffinized and hydrated. Antigen retrieval was performed using pH 6 or pH 9 Citrate Antigen Retrieval Solution (DAKO), 10 min 10% peroxidase ($H_2O_2$) and blocking

solution (2% BSA) for 1 h at room temperature. As a detection system, EnVision FLEX + (DAKO) was used according to the manufacturer's instructions, followed by counterstaining with hematoxilin, dehydration and mounting (DPX). The quantification of LIF, CCL2, CD163, CD206, and CXCL9 staining in GBM tumors from patients was expressed as H score (3 × percentage of strong staining + 2 × percentage of moderate staining + percentage of weak staining), giving a range of 0 to 300. Quantification of p-STAT3, Ki67, CC3, and CD8 was performed with ImageJ, counting the total number of cells of three different fields per mouse, five mice per group, and calculating the percentage of positive cells. Data in graphs are presented as mean ± SEM.

**[00255]** Immunohistochemical antibodies: human LIF (Atlas; 1:200), murine LIF (AbCam; 1:200), murine p-STAT3 (Cell Signaling; 1:50), murine Ki67 (AbCam; 1:200), murine Cleaved-Caspase3 (CC3) (Cell Signaling; 1:500), murine CD8 (Bioss; 1:200), human/murine CCL2 (Novus Biologicals, 1:200), human CXCL9 (Thermo Fischer Scientific; 1:100), and human CD163 (Leica Novacastra; 1:200).

**[00256]** Nuclei were counterstained with DAPI and images were captured using a laser scanning confocal NIKON Eclipse Ti microscope. Quantification of immunofluorescence were performed with ImageJ, counting all or up to 100 cells positive for CD11b, Iba1, or CD3 of 2-3 different fields of each mouse, 3-5 mice/group, and calculating the percentage of those cells positive for CCL2, CD206, and CD163 inside the Iba1 (for GL261N model) or CD68/CD11b (for ID8 model) positive population. For CXCL9, it was calculated the percentage of cells surrounded by the signal of this cytokine inside the total population of cells. For organotypic slices, 3-4 fields of each patient (n = 3) were quantified. For organotypic tissue immunofluorescence, five different Z-stack images per condition were processed with Fiji-Image J software. For $CD8^+$ T cells, percentage of $CD8^+$ T cells was calculated among the total population. Data in graphs are represented as mean ± SEM.

**[00257]** Immunofluorescence antibodies: human/murine CCL2 (Novus Biologicals, 1:200), human/murine CD11b (AbCam; 1:2000), human/murine Iba1 (Wako; 1:1000), murine CD68 (AbCam; 1:200), human/murine CD206 (Abcam; 1:500), murine CD163 (Abcam; 1:200), CXCL9 (murine Novus Biologicals 1:200; human Thermo Fischer Scientific; 1:200), and human CD8 (DAKO; 1:200).

*Example 30-Effect of LIF on primary cultures of mouse bone marrow derived macrophages (BMDMs)*

**[00258]** The effect of LIF on primary cultures of mouse BMDMs was studied to explore the molecular mechanisms involved in the regulation of CXCL9 and CCL2 by LIF in macrophages. LIF regulated the expression of several M1-like and M2-like markers induced by IFNγ or IL4 in

BMDMs (**Fig. 22A**). CXCL9 expression was not detected except when BMDMs were treated with IFNγ. Recombinant LIF repressed the induction of CXCL9 by IFNγ both at the mRNA and protein levels (**Fig. 22B** and **22C**). CXCL9 was also regulated by IFNγ and LIF in patient-derived TAMs ($CD11b^+$ $CD14^+$) obtained from fresh human GBM tumors (**Fig. 22D** and **29A**). These results were further validated upon observing that recombinant LIF repressed the induction of CXCL9 by LPS both at the mRNA and protein levels. (**Fig. 29B**). Thus, LIF acted as a repressor of CXCL9 induction. CXCL9 promoter binding of p-STAT3 upon treatment with LIF was not observed (data not shown). In line with this, LIF treatment was found to increase the levels of H3 lysine 27 trimethylated (H3K27me3), decrease the levels of acetylated H4 (H4ac), and increase EZH2 binding to the CXCL9 promoter region, showing that LIF was regulating CXCL9 expression through epigenetic silencing (**Fig. 22E**).

Materials and Methods

**[00259]** Bone marrow-derived macrophages (BMDMs) were obtained from six to 10-week-old C57BL/6 mice. Briefly, bone marrow precursors were cultured in DMEM (Life Technologies), supplemented with 20% heat inactivated FBS and 30% L-cell conditioned medium (cm) as a source of macrophage-colony stimulating factor. Differentiated macrophages were obtained after 6 days culture. L-cell cm was obtained from L929 cells grown in DMEM supplemented with 10% heat-inactivated FBS (Life Technologies). Human macrophages were isolated from human GBM specimens. Briefly, tumor tissue was enzymatically digested with Tumor Dissociation kit and $CD11b^+$ cells were isolated using CD11b magnetic beads and the MultiMACS Cell24 separator Plus (all from Miltenyi Biotec). $CD11b^+$ cells obtained were cultured in RPMI medium supplemented with 10% heat-inactivated FBS (Life Technologies). Recombinant LIF, IFNγ, LPS, and IL4 were purchased from Millipore, R&D Systems, Sigma and Creative BioMart, respectively.

**[00260]** Immunoprecipitation of chromatin was performed according to the Upstate (Millipore) standard protocol. Briefly, $1.2x10^7$ BMDMs were fixed using 1% formaldehyde for 10 min at 37° C, harvested, and sonicated to generate chromatin fragments of 200– 500 bp. Then 20 j.tg of sheared chromatin was immunoprecipitated overnight with 2 j.tg of anti-p-STAT3 (Tyr705) antibody, anti-Tri-Methyl-Histone H3 (Lys27) (Cell Signaling), anti-acetyl-H4 (Millipore) or anti-EZH2 (Millipore). Immunocomplexes were recovered using 20 j.tl of protein G magnetic beads, washed, and eluted. Cross-linking was reversed at 65 °C 4 h and immunoprecipitated DNA was recovered using the PCR purification kit from Qiagen. Genomic regions of interest were identified by real-time quantitative PCR (qPCR) using SYBR Green Master Mix (Invitrogen).

*Example 3- LIF regulation of immune cell tumor infiltration in patients*

**[00261]** To confirm that LIF regulates immune cell tumor infiltration through the repression of CXCL9 in tumors from actual cancer patients, organotypic tissue cultures were generated from GBM specimens freshly obtained from patients. These organotypic models allow for the short-term culture of slices of tumors that maintain the tissue architecture and stroma (including immune cells) of the tumor of the patient. Organotypic tissue cultures from 3 patients whose tumor cells expressed high levels of LIF (**Fig. 22H**). In all 3 cultures a large infiltration of TAMs was present as detected by the Iba1 marker and most of the TAMs expressed CCL2, CD163 and CD206. Interestingly, a 3-day treatment of the organotypic culture with a neutralizing antibody against LIF promoted a decrease in CCL2, CD163 and CD206 and an increase in CXCL9 expression (**Fig. 22H**).

Materials and Methods

**[00262]** Human GBM specimens were obtained from the Vall d'Hebron University Hospital and Clinic Hospital. The clinical protocol was approved by the Vall d'Hebron Institutional Review Board and Clinic Hospital (CEIC), with informed consent obtained from all subjects.

**[00263]** GBM neurospheres were generated as described as follows. Briefly, tumor samples were processed within 30 min after surgical resection. Minced pieces of human GBM samples were digested with 200 U/ml collagenase I (Sigma) and 500 U/ml DNase I (Sigma) in PBS for 1 h at 37°C with constant vigorous agitation. The single-cell suspension was filtered through a 70 µm cell strainer (BD Falcon) and washed with PBS. Finally, cells were resuspended and subsequently cultured in GBM medium that consisted of Neurobasal medium supplemented with B27, penicillin/streptomycin (all from Life Technologies) and growth factors (20 ng/ml EGF and 20 ng/ml FGF-2 (PeproTech).

**[00264]** GBM organotypic slice cultures were generated as follows. After resection, surgical specimens were cut with a scalpel into rectangular blocks of 5-10 mm length and 1-2 mm width and individually transferred into 0.4 µm membrane culture inserts (Millipore) within 6-well plates. Before placing the inserts into 6-well plates, 1.2 ml of Neurobasal medium (Life Technologies) supplemented with B27 (Life Technologies), penicillin/streptomycin (Life Technologies) and growth factors (20 ng/ml EGF and 20 ng/ml FGF-2) (PeproTech) were placed into each well. The cultures were kept at 37°C with constant humidity, 95% air and 5% $CO^2$. After one day, slices were treated with a rat anti- LIF blocking antibodyor with its corresponding normal IgG (10 µg/ml) for 3 days. For the blocking CXCL9 studies, a neutralizing mouse monoclonal antibody against human CXCL9 (R&D Systems) was added to the culture at 1.5 µg/ml. In some occasions, 0.1 ng/ml of human rIFNγ (R&D Systems) was added for 24 h. In parallel, peripheral blood mononuclear cells (PBMCs) were obtained from the whole blood of the same patient by centrifuge density separation using Lymphosep (Biowest).

PBMCs were cryopreserved in RPMI medium supplemented with 10% inactivated FBS and 10% DMSO until use. For immune cell infiltration assays, control or anti-LIF slices were embedded into Matrigel (Corning) with subsequent addition of $1x10^6$ PBMCs into 24-well plate in complete RPMI medium. In addition, supernatants were collected and organotypic slices were recovered from Matrigel and further processed for IF and flow cytometry. In some conditions, PBMCs were resuspended with PBS at a concentration of $10^6$ cells/ml and incubated for 20 min with 5 µM Cell Trace CFSE (Invitrogen). After the incubation, cells were washed with RPMI and added to the sections embedded into Matrigel. After 24 h, fluorescent PBMCs invasion into Matrigel was evaluated under microscope by counting migrating cells in five different areas per each condition.

*Example 32-Treatment with anti-LIF increased CXCL9 and decreased CCL2 expression in tumors expressing high levels of LIF*

**[00265]** LIF's impact on the immune cell tumor infiltration was assessed. After anti-LIF treatment, organotypic slices from 3 patients with tumors expressing high levels of LIF were incubated with peripheral blood mononuclear cells (PBMCs) from the same patient (**Fig. 23A**). Treatment with anti-LIF increased CXCL9 and decreased CCL2 expression (**Fig. 23B**), and induced immune cell infiltration into the Matrigel surrounding the tumor specimen (**Fig. 23B**). Notably, $CD8^+$ T cells were recruited to the tumor tissue upon LIF blockade (**Fig. 23B, 23C**) and this effect was dependent on CXCL9 since the neutralization of CXCL9 prevented $CD8^+$ T cell infiltration (**Fig. 23D**).

**[00266]** Similar results were confirmed in the context of an *in vivo* model. Tumor fragments from 4 patients, whose tumors expressed high LIF levels, were inoculated in NSG mice and these mice were treated with the LIF neutralizing antibody for 5 days. Next, each patient's PBMCs were inoculated in the mice. Interestingly, mice treated with anti-LIF showed an increase in $CD8^+$ T cell tumor infiltration and most of the infiltrating $CD8^+$ T cells expressed the CXCL9 receptor, CXCR3 (**Fig. 23E**).

*Example 33-Increase in anti-tumor response by PD1 blockade*

**[00267]** Mouse models bearing overt tumors were treated with anti-LIF and anti-PD1 antibodies and the combination of the blockade of LIF and PD1 was observed to further decreased tumor growth when compared to each individual treatment in GL261N, RCAS and ID8 tumors (**Fig. 30**). Moreover and importantly, the combined treatment with anti-LIF and anti-PD1 increased overall survival and induced tumor regression (**Fig. 23F** and **23G**).

**[00268]** The mice exhibiting complete tumor regression were collected and reinoculated $3x10^5$ tumor cells. No tumor appeared in these mice while tumors rapidly grew in naive mice inoculated in parallel with the same number of cells (**Fig. 23H**). The result of this rechallenge

experiment indicated that the combined treatment with anti-LIF and anti-PD1 generated immunological memory.

**Embodiments of the claimed invention**

**[00269]** Described herein are specific embodiments of the invention described herein.

1. Use of a Leukemia Inhibitory Factor (LIF)-binding polypeptide, in combination with an inhibitor of PD-1, PDL-1, or PDL-2 signaling for treating a cancer in an individual.

2. The use of embodiment 1, wherein the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations.

3. The use of embodiment 1, wherein the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation.

4. The use of embodiment 1 or 2, wherein the LIF-binding polypeptide is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual.

5. The use of embodiment 1 or 2, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding polypeptide is administered to the individual.

6. The use of embodiment 1 or 2, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding polypeptide is administered to the individual.

7. The use of any one of embodiments 1 to 6, wherein the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region.

8. The use of any one of embodiments 1 to 7, wherein the LIF-binding polypeptide comprises an antibody that specifically binds to LIF.

9. The use of embodiment 8, wherein the antibody that specifically binds to LIF comprises at least one framework region derived from a human antibody framework region.

10. The use of embodiment 8, wherein the antibody that specifically binds to LIF is humanized.

11. The use of embodiment 8, wherein the antibody that specifically binds to LIF is deimmunized.

12. The use of embodiment 8, wherein the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains.

13. The use of embodiment 8, wherein the antibody that specifically binds to LIF is an IgG antibody.

14. The use of embodiment 8, wherein the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody.

15. The use of any one of embodiments 8 to 14, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;

b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;

c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;

d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;

e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and

f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

16. The use of any one of embodiment 8 to 15, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and

b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48.

17. The use of embodiment 16, wherein the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in SEQ ID NO: 46.

18. The use of embodiment 17, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46.

19. The use of any one of embodiments 8 to 15, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and

b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64.

20. The use of any one of embodiments8 to 19, wherein the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar.

21. The use of any one of embodiments 8 to 19, wherein the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar.

22. The use of any one of embodiments8 to 21, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or PD-1, PDL-1, or PDL-2 binding fragment thereof.

23. The use of embodiment 22, wherein the antibody specifically binds PD-1.

24. The use of embodiment 22, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

25. The use of embodiment 22, wherein the antibody specifically binds PDL-1 or PDL-2.

26. The use of embodiment 25, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

27. The use of any one of embodiments 8 to 16, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

28. The use of embodiment 27, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

29. The use of any one of embodiments 1 to 28, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

30. The use of embodiment 29, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-

1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

31. The use of any one of embodiments 1 to 30, wherein the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, a soft tissue cancer, or any combination thereof.

32. The use of embodiment 31, wherein the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic ductal adenocarcinoma.

33. The use of any one of embodiments 1 to 32, wherein the cancer is refractory to treatment with a therapeutic amount of a LIF-binding polypeptide or an inhibitor of PD-1, PDL-1, or PDL-2 signaling administered as a monotherapy.

34. A method of treating an individual with a cancer, comprising administering to the individual with the cancer an effective amount of a combination of:

a) a Leukemia Inhibitory Factor (LIF) binding polypeptide; and

b) an inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling.

35. The method of embodiment 34, wherein the LIF binding polypeptide and the inhibitor of PD-1 (CD279), PDL-1 (CD274), or PDL-2 (CD273) signaling are administered separately.

36. The method of embodiment 34, comprising administering an effective amount of the LIF-binding polypeptide to the individual with cancer.

37. The method of embodiment 34, comprising administering an effective amount of the inhibitor of PD-1 to the individual with cancer.

38. The method of any one of embodiments 34 to 37, wherein the LIF-binding polypeptide comprises a fragment of an immunoglobulin variable region, or an immunoglobulin heavy chain constant region.

39. The method of any one of embodiments 34 to 37, wherein the LIF-binding polypeptide comprises an antibody that specifically binds to LIF.

40. The method of embodiment 39, wherein the antibody that specifically binds to LIF comprises at least one framework region derived from a human antibody framework region.

41. The method of embodiment 39, wherein the antibody that specifically binds to LIF is humanized.

42. The method of embodiment 39, wherein the antibody that specifically binds to LIF is deimmunized.

43. The method of embodiment 39, wherein the antibody that specifically binds to LIF comprises two immunoglobulin heavy chains and two immunoglobulin light chains.

44. The method of embodiment 39, wherein the antibody that specifically binds to LIF is an IgG antibody.

45. The method of embodiment 39, wherein the antibody that specifically binds to LIF is a Fab, $F(ab)_2$, single-domain antibody, a single chain variable fragment (scFv), or a nanobody.

46. The method of any one of embodiments 39 to 45, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;

b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;

c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;

d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;

e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and

f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

47. The method of any one of embodiments 39 to 46, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain variable region (VH) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 41, 42, 44, or 66; and

b) an immunoglobulin light chain variable region (VL) sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 45-48.

48. The method of embodiment 47, wherein the VH sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is at least about 80%, 90%, 95%, 97%, 98%, 99%, or 100% identical to the amino acid sequence set forth in SEQ ID NO: 46.

49. The method of embodiment 48, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46.

50. The method of any one of embodiments 39 to 46, wherein the antibody that specifically binds to LIF comprises:

a) an immunoglobulin heavy chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 57-60 or 67; and

b) an immunoglobulin light chain sequence with the amino acid sequence at least about 80%, 90%, 95%, 97%, 98%, or 99% identical to the amino acid sequence set forth in any one of SEQ ID NOs: 61-64.

51. The method of any one of embodiments 39 to 50, wherein the antibody that specifically binds to LIF binds with a $K_D$ of less than about 200 picomolar.

52. The method of any one of embodiments 39 to 50, wherein the antibody that specifically binds to LIF binds with a $K_D$ of less than about 100 picomolar.

53. The method of any one of embodiments 34 to 52, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an antibody or a PD-1, PDL-1, or PDL-2 binding fragment thereof.

54. The method of embodiment 53, wherein the antibody specifically binds PD-1.

55. The method of embodiment 54, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

56. The method of embodiment 53, wherein the antibody specifically binds PDL-1 or PDL-2.

57. The method of embodiment 56, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

58. The method of any one of embodiments 34 to 52, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

59. The method of embodiment 58, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

60. The method of any one of embodiments 34 to 52, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

61. The method of embodiment 60, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises one or more of: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202);

(2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

62. The method of any one of embodiments 34 to 61, wherein the cancer comprises an advanced solid tumor, glioblastoma, stomach cancer, skin cancer, prostate cancer, pancreatic cancer, breast cancer, testicular cancer, thyroid cancer, head and neck cancer, liver cancer, kidney cancer, esophageal cancer, ovarian cancer, colon cancer, lung cancer, lymphoma, a soft tissue cancer, or combinations thereof.

63. The method of embodiment 62, wherein the cancer comprises non-small cell lung cancer, epithelial ovarian carcinoma, or pancreatic adenocarcinoma.

64. The method of any one of embodiments 34 to 63, wherein the cancer is refractory to treatment with a therapeutic amount of an inhibitor of a LIF-binding polypeptide.

65. The method of any one of embodiments 34 to 63, wherein the cancer is refractory to treatment with a therapeutic amount of an inhibitor of an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

66. The method of any one of embodiments 34 to 65, wherein the Leukemia Inhibitory Factor (LIF) binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered separately.

67. The method of any one of embodiment 34 to 65, wherein the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered at the same time.

68. The method of any one of embodiments 34 to 65, wherein the LIF-binding polypeptide and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered in a single composition.

69. Use of an antibody that specifically binds Leukemia Inhibitory Factor (LIF), in combination with a PD-1 or PDL-1 binding antibody, for treating a cancer in an individual, wherein the LIF binding antibody comprises:

a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;
b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;
c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;
d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;
e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and
f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

70. A method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:
    i. an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;
    ii. an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;
    iii. an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;
    iv. an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;
    v. an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and
    vi. an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and
b) a PD-1 or PDL-1 binding antibody.

71. The method of embodiment 70, comprising administering an effective amount of the antibody that specifically binds LIF to the individual with cancer.

72. The method of embodiment 70, comprising administering an effective amount of the PD-1 or PDL-1 binding antibody to the individual with cancer.

73. The method of any one of embodiments 70 to 72, wherein the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately.

74. The method of any one of embodiments 70 to 73, wherein the cancer is glioblastoma multiforme (GBM), NSCLC (non-small cell lung carcinoma), ovarian cancer, colorectal cancer, thyroid cancer, pancreatic cancer, or combinations thereof.

75. A method of decreasing pro-tumoral tumor-associated macrophages (TAMs) in a tumor of an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:
   i. an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;
   ii. an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;
   iii. an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;
   iv. an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;
   v. an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and
   vi. an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and

b) a PD-1 or PDL-1 binding antibody.

76. The method of embodiment 75, comprising administering an effective amount of the antibody that specifically binds LIF to the individual with cancer.

77. The method of embodiment 75, comprising administering an effective amount of the PD-1 or PDL-1 binding antibody to the individual with cancer.

78. The method of any one of embodiments 75 to 77, wherein the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately.

79. The method of any one of embodiments 75 to 78, wherein the TAM exhibits cell surface expression of any 1, 2, or 3 molecules selected from the list consisting of CD11b, CD206, and CD163.

80. The method of any one of embodiments 75 to 78, wherein the tumor comprises a lung tumor, a brain tumor, a pancreatic tumor, a breast tumor, a kidney tumor, a colorectal tumor, an ovarian tumor, or a combination thereof.

81. A method of generating immunological memory in an individual with cancer comprising administering to the individual with cancer an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:

i. an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;

ii. an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;

iii. an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;

iv. an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;

v. an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and

vi. an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and

b) a PD-1 or PDL-1 binding antibody.

82. The method of embodiment 81, comprising administering an effective amount of the antibody that specifically binds LIF to the individual with cancer.

83. The method of embodiment 81, comprising administering an effective amount of the PD-1 or PDL-1 binding antibody to the individual with cancer.

84. The method of any one of embodiments 81 to 83, wherein the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately.

85. The method of any one of embodiments 81 to 84, wherein immunological memory is mediated by CD8+ T cells.

86. The method of any one of embodiments 81 to 84, wherein immunological memory is mediated by CD4+ T cells.

87. A method of increasing the amount of T lymphocytes in a tumor of an induvial comprising administering to the individual afflicted with the tumor an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:

i. an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;

ii. an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;

iii. an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;

iv. an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;

v. an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and

vi. an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and

b) a PD-1 or PDL-1 binding antibody.

88. The method of embodiment 87, comprising administering an effective amount of the antibody that specifically binds LIF to the individual with cancer.

89. The method of embodiment 87, comprising administering an effective amount of the PD-1 or PDL-1 binding antibody to the individual with cancer.

90. The method of embodiment 87, wherein the antibody that specifically binds LIF and the PD-1 or PDL-1 binding antibody are administered separately.

91. The method of any one of embodiments 87 to 90, wherein the T lymphocytes comprise CD8+ T cells.

92. The method of any one of embodiments 87 to 90, wherein the T lymphocytes comprise CD4+ T cells.

93. The method of any one of embodiments 87 to 90, wherein the tumor comprises a lung tumor, a brain tumor, a pancreatic tumor, a breast tumor, a kidney tumor, a colorectal tumor, an ovarian tumor, or a combination thereof.

**[00270]** While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention.

**[00271]** All publications, patent applications, issued patents, and other documents referred to in this specification are herein incorporated by reference as if each individual publication, patent application, issued patent, or other document was specifically and individually indicated to be incorporated by reference in its entirety. Definitions that are contained in text incorporated by reference are excluded to the extent that they contradict definitions in this disclosure.

SEQUENCES

| SEQ ID NO | Sequence |
|---|---|
| 1 | GFTFSHAWMH |
| 2 | GFTFSHAW |
| 3 | HAWMH |
| 4 | QIKAKSDDYATYYAESVKG |
| 5 | IKAKSDDYAT |
| 6 | TCWEWDLDF |
| 7 | WEWDLDF |
| 8 | TSWEWDLDF |
| 9 | RSSQSLLDSDGHTYLN |
| 10 | QSLLDSDGHTY |
| 11 | SVSNLES |
| 12 | SVS |
| 13 | MQATHAPPYT |
| 14 | EVQLVESGGGLVKPGGSLKLSCAAS |
| 15 | QVQLQESGGGLVKPGGSLRLSCAAS |
| 16 | EVQLVESGGGVVQPGRSLRLSCAAS |

| | |
|---|---|
| 17 | EVQLMESGGGLVKPGGSLRLSCATS |
| 18 | WVRQAPGKGLEWVA |
| 19 | WVRQAPGKGLEWVG |
| 20 | RFTISRDDSKNTLYLQMNSLKTEDTAVYYC |
| 21 | RFSISRDNAKNSLYLQMNSLRVEDTVVYYC |
| 22 | RFTISRDDSKSTLFLQMNNLKTEDTAVYYC |
| 23 | WGQGTLVTVSS |
| 24 | WGQGTMVTVSS |
| 25 | WGQGTTVTVSS |
| 26 | DVVMTQSPLSLPVTLGQPASISC |
| 27 | DIVMTQTPLSSPVTLGQPASISC |
| 28 | DIVMTQTPLSLSVTPGQPASISC |
| 29 | DVVMTQSPLSQPVTLGQPASISC |
| 30 | WFQQRPGQSPRRLIY |
| 31 | WLQQRPGQPPRLLIY |
| 32 | WLLQKPGQPPQLLIY |
| 33 | WLQQRPGQSPRRLIY |
| 34 | GVPDRFSGSGSGTDFTLKISRVEAEDVGLYYC |
| 35 | GVPDRFSGSGAGTDFTLKISRVEAEDVGVYYC |
| 36 | GVPNRFSGSGSGTDFTLKISRVEAEDVGLYYC |
| 37 | GVPDRFNGSGSGTDFTLSISRVEAEDVGVYYC |
| 38 | FGQGTKLEIK |
| 39 | FGGGTKVEIK |
| 40 | FGQGTKVEIK |
| 41 | EVQLVESGGGLVKPGGSLKLSCAASGFTFSHAWMHWVRQAPGKGLEWVAQIKAKSDDYATYYAESVK GRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTLVTVSS |
| 42 | QVQLQESGGGLVKPGGSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTMVTVSS |
| 43 | EVQLVESGGGVVQPGRSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVAQIKAKSDDYATYYAESVK GRFSISRDNAKNSLYLQMNSLRVEDTVVYYCTCWEWDLDFWGQGTTVTVSS |
| 44 | EVQLMESGGGLVKPGGSLRLSCATSGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKSTLFLQMNNLKTEDTAVYYCTCWEWDLDFWGQGTLVTVSS |
| 45 | DVVMTQSPLSLPVTLGQPASISCRSSQSLLDSDGHTYLNWFQQRPGQSPRRLIYSVSNLESGVPDRFSGS GSG TDFTLKISRVEAEDVGLYYCMQATHAPPYTFGQGTKLEIK |
| 46 | DIVMTQTPLSSPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQPPRLLIYSVSNLESGVPDRFSGS GAGTDFTLKISRVEAEDVGVYYCMQATHAPPYTFGQGTKLEIK |
| 47 | DIVMTQTPLSLSVTPGQPASISCRSSQSLLDSDGHTYLNWLLQKPGQPPQLLIYSVSNLESGVPNRFSGSG SGTDFTLKISRVEAEDVGLYYCMQATHAPPYTFGGGTKVEIK |
| 48 | DVVMTQSPLSQPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQSPRRLIYSVSNLESGVPDRFNG SGSGTDFTLSISRVEAEDVGVYYCMQATHAPPYTFGQGTKVEIK |
| 49 | MGWTLVFLFLLSVTAGVHSEVQLVESGGGLVKPGGSLKLSCAASGFTFSHAWMHWVRQAPGKGLEW VAQIKAKSDDYATYYAESVKGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTLVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV VTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKV SNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 50 | MGWTLVFLFLLSVTAGVHSQVQLQESGGGLVKPGGSLRLSCAASGFTFSHAWMHWVRQAPGKGLEW VGQIKAKSDDYATYYAESVKGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTMV TVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSS VVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISR |

| | |
|---|---|
| | TPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCK VSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 51 | MGWTLVFLFLLSVTAGVHSEVQLVESGGGVVQPGRSLRLSCAASGFTFSHAWMHWVRQAPGKGLEW VAQIKAKSDDYATYYAESVKGRFSISRDNAKNSLYLQMNSLRVEDTVVYYCTCWEWDLDFWGQGTTVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV VTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKV SNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 52 | MGWTLVFLFLLSVTAGVHSEVQLMESGGGLVKPGGSLRLSCATSGFTFSHAWMHWVRQAPGKGLEW VGQIKAKSDDYATYYAESVKGRFTISRDDSKSTLFLQMNNLKTEDTAVYYCTCWEWDLDFWGQGTLVT VSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSV VTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKV SNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTT PPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 53 | MVSSAQFLGLLLLCFQGTRCDVVMTQSPLSLPVTLGQPASISCRSSQSLLDSDGHTYLNWFQQRPGQSP RRLIYSVSNLESGVPDRFSGSGSGTDFTLKISRVEAEDVGLYYCMQATHAPPYTFGQGTKLEIKRTVAAPS VFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKA DYEKHKVYACEVTHQGLSSPVTKSFNRGEC |
| 54 | MVSSAQFLGLLLLCFQGTRCDIVMTQTPLSSPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQPP RLLIYSVSNLESGVPDRFSGSGAGTDFTLKISRVEAEDVGVYYCMQATHAPPYTFGQGTKLEIKRTVAAPS VFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKA DYEKHKVYACEVTHQGLSSPVTKSFNRGEC |
| 55 | MVSSAQFLGLLLLCFQGTRCDIVMTQTPLSLSVTPGQPASISCRSSQSLLDSDGHTYLNWLLQKPGQPPQ LLIYSVSNLESGVPNRFSGSGSGTDFTLKISRVEAEDVGLYYCMQATHAPPYTFGGGTKVEIKRTVAAPSV FIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKAD YEKHKVYACEVTHQGLSSPVTKSFNRGEC |
| 56 | MVSSAQFLGLLLLCFQGTRCDVVMTQSPLSQPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQSP RRLIYSVSNLESGVPDRFSGSGSGTDFTLSISRVEAEDVGVYYCMQATHAPPYTFGQGTKVEIKRTVAAPS VFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKA DYEKHKVYACEVTHQGLSSPVTKSFNRGEC |
| 57 | EVQLVESGGGLVKPGGSLKLSCAASGFTFSHAWMHWVRQAPGKGLEWVAQIKAKSDDYATYYAESVK GRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTLVTVSSASTKGPSVFPLAPSSKST SGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHK PSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPRE PQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 58 | QVQLQESGGGLVKPGGSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTCWEWDLDFWGQGTMVTVSSASTKGPSVFPLAPSSK STSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNH KPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP REPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 59 | EVQLVESGGGVVQPGRSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVAQIKAKSDDYATYYAESVK GRFSISRDNAKNSLYLQMNSLRVEDTVVYYCTCWEWDLDFWGQGTTVTVSSASTKGPSVFPLAPSSKST SGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHK PSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPRE PQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR |

| | |
|---|---|
| | WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 60 | EVQLMESGGGLVKPGGSLRLSCATSGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKSTLFLQMNNLKTEDTAVYYCTCWEWDLDFWGQGTLVTVSSASTKGPSVFPLAPSSKS TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNH KPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP REPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK SRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 61 | DVVMTQSPLSLPVTLGQPASISCRSSQSLLDSDGHTYLNWFQQRPGQSPRRLIYSVSNLESGVPDRFSGS GSGTDFTLKISRVEAEDVGLYYCMQATHAPPYTFGQGTKLEIKRTVAAPSVFIFPPSDEQLKSGTASVVCL LNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSP VTKSFNRGEC |
| 62 | DIVMTQTPLSSPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQPPRLLIYSVSNLESGVPDRFSGS GAGTDFTLKISRVEAEDVGVYYCMQATHAPPYTFGQGTKLEIKRTVAAPSVFIFPPSDEQLKSGTASVVCL LNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSP VTKSFNRGEC |
| 63 | DIVMTQTPLSLSVTPGQPASISCRSSQSLLDSDGHTYLNWLLQKPGQPPQLLIYSVSNLESGVPNRFSGSG SGTDFTLKISRVEAEDVGLYYCMQATHAPPYTFGGGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLL NNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPV TKSFNRGEC |
| 64 | DVVMTQSPLSQPVTLGQPASISCRSSQSLLDSDGHTYLNWLQQRPGQSPRRLIYSVSNLESGVPDRFSGS GSGTDFTLSISRVEAEDVGVYYCMQATHAPPYTFGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCL LNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSP VTKSFNRGEC |
| 65 | Blank |
| 66 | QVQLQESGGGLVKPGGSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTSWEWDLDFWGQGTMVTVSS |
| 67 | QVQLQESGGGLVKPGGSLRLSCAASGFTFSHAWMHWVRQAPGKGLEWVGQIKAKSDDYATYYAESV KGRFTISRDDSKNTLYLQMNSLKTEDTAVYYCTSWEWDLDFWGQGTMVTVSSASTKGPSVFPLAPSSK STSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNH KPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK |
| 68 | SPLPITPVNATCAIRHPCHNNLMNQIRSQLAQLNGSANALFILYYTAQGEPFPNNLDKLCGPNVTDFPPF HANGTEKAKLVELYRIVVYLGTSLGNITRDQKILNPSALSLHSKLNATADILRGLLSNVLCRLCSKYHVGHV DVTYGPDTSGKDVFQKKKLGCQLLGKYKQIIAVLAQAF |

## CLAIMS

**WHAT IS CLAIMED IS**:

1. Use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1, PDL-1, or PDL-2 signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises:
   a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;
   b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;
   c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;
   d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;
   e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and
   f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.
2. The use according to claim 1, wherein the LIF-binding antibody comprises:
   a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 1;
   b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 4;
   c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 6;
   d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 9;
   e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 11; and
   f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.
3. The use according to claim 1, wherein the LIF-binding antibody comprises:
   a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 3;

b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 5;

c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 7;

d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 10;

e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 12; and

f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

4. The use of any one of claims 1 to 3, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations.

5. The use of any one of claims 1 to 3, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation.

6. The use of any one of claims 1 to 4, wherein the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual.

7. The use of any one of claims 1 to 4, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual.

8. The use of any one of claims 1 to 4, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual.

9. The use of any one of claims 1 to 8, wherein the LIF-binding antibody is humanized.

10. The use of any one of claims 1 to 9, wherein the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46.

11. The use of claim 10, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46.

12. The use of any one of claims 1 to 11, wherein the cancer comprises an advanced solid tumor, a glioblastoma, a stomach cancer, a skin cancer, a prostate cancer, a pancreatic cancer, a pancreatic ductal adenocarcinoma, a breast cancer, a testicular cancer, a thyroid cancer, a head

and neck cancer, a liver cancer, a kidney cancer, a esophageal cancer, a ovarian cancer, a colon cancer, a lung cancer, a non-small cell lung cancer, a lymphoma, a soft tissue cancer, or any combination thereof.

13. The use of claim 12, wherein the cancer comprises non-small cell lung cancer.

14. The use of claim 12, wherein the cancer comprises pancreatic ductal adenocarcinoma.

15. The use of any one of claims 1 to 14, wherein the cancer has previously been unsuccessfully treated with a checkpoint inhibitor.

16. The use of any one of claims 1 to 15, wherein the cancer has previously been unsuccessfully treated with a LIF-binding antibody.

17. The use of claim 15 or 16, wherein the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

18. The use of any one of claims 1 to 17, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

19. Use of a Leukemia Inhibitory Factor (LIF)-binding antibody, in combination with an inhibitor of PD-1, PDL-1, or PDL-2 signaling, for treating a cancer in an individual, wherein the LIF-binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46.

20. The use of claim 19, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations.

21. The use of claim 19, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation.

22. The use of claim 19 or 20, wherein the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual.

23. The use of claims 19 or 20, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual.

24. The use of any one of claims 19 to 21, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual.

25. The use of any one of claims 19 to 24, wherein the LIF-binding antibody is humanized.

26. The use of any one of claims 19 to 25, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46.

27. The use of any one of claims 19 to 26, wherein the cancer comprises an advanced solid tumor, a glioblastoma, a stomach cancer, a skin cancer, a prostate cancer, a pancreatic cancer, pancreatic ductal adenocarcinoma, a breast cancer, a testicular cancer, a thyroid cancer, a head and neck cancer, a liver cancer, a kidney cancer, a esophageal cancer, a ovarian cancer, a colon cancer, a lung cancer, a non-small cell lung cancer, a lymphoma, a soft tissue cancer, or any combination thereof.

28. The use of claim 27, wherein the cancer comprises non-small cell lung cancer.

29. The use of claim 27, wherein the cancer comprises pancreatic ductal adenocarcinoma.

30. The use of any one of claims 19 to 29, wherein the cancer has previously been unsuccessfully treated with a checkpoint inhibitor.

31. The use of any one of claims 19 to 30, wherein the cancer has previously been unsuccessfully treated with a LIF-binding antibody.

32. The use of claim 30 or 31, wherein the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

33. The use of any one of claims 19 to 32, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

34. A method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:

i. an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 1-3;

ii. an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 4 or 5;

iii. an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 6-8;

iv. an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 9 or 10;

v. an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in any one of SEQ ID NOs: 11 or 12; and

vi. an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13; and

b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

35. The method of claim 34, wherein the LIF-binding antibody comprises:

a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 1;

b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 4;

c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 6;

d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 9;

e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 11; and

f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

36. The method of claim 34, wherein the LIF-binding antibody comprises:

a) an immunoglobulin heavy chain complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 3;

b) an immunoglobulin heavy chain complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 5;

c) an immunoglobulin heavy chain complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 7;

d) an immunoglobulin light chain complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence set forth in SEQ ID NO: 10;

e) an immunoglobulin light chain complementarity determining region 2 (VL-CDR2) comprising the amino acid sequence set forth in SEQ ID NO: 12; and

f) an immunoglobulin light chain complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence set forth in SEQ ID NO: 13.

37. The method of any one of claims 34 to 36, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations.

38. The method of any one of claims 34 to 36, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation.

39. The method of any one of claims 34 to 37, wherein the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual.

40. The method of any one of claims 34 to 37, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual.

41. The method of any one of claims 34 to 37, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual.

42. The method of any one of claims 34 to 41, wherein the LIF-binding antibody is humanized.

43. The method of any one of claims 34 to 42, wherein the LIF binding antibody comprises an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46.

44. The method of claim 43, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46.

45. The method of any one of claims 34 to 44, wherein the cancer comprises an advanced solid tumor, a glioblastoma, a stomach cancer, a skin cancer, a prostate cancer, a pancreatic cancer, a pancreatic ductal adenocarcinoma, a breast cancer, a testicular cancer, a thyroid cancer, a head and neck cancer, a liver cancer, a kidney cancer, a esophageal cancer, a ovarian cancer, a colon cancer, a lung cancer, a non-small cell lung cancer, a lymphoma, a soft tissue cancer, or any combination thereof.

46. The method of claim 45, wherein the cancer comprises non-small cell lung cancer.

47. The method of claim 45, wherein the cancer comprises pancreatic ductal adenocarcinoma.

48. The method of any one of claims 34 to 45, wherein the cancer has previously unsuccessfully been treated with a checkpoint inhibitor.

49. The method of any one of claims 34 to 45, wherein the cancer has previously unsuccessfully been treated with a LIF-binding antibody.

50. The method of claim 48 or 49, wherein the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

51. The method of any one of claims 34 to 50, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

52. The method of claim 51, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

53. The method of claim 51, wherein the antibody specifically binds PDL-1 or PDL-2.

54. The method of claim 53, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

55. The method of any one of claims 34 to 50, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

56. The method of claim 55, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

57. The method of any one of claims 34 to 50, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

58. The method of claim 57, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises on or more of: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

59. A method of treating an individual with a cancer comprising administering to the individual with cancer an effective amount of a combination of:

a) of an antibody that specifically binds Leukemia Inhibitory Factor (LIF) comprising:

i. an immunoglobulin heavy chain variable region (VH) comprising an amino acid sequence at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 42; and

ii. an immunoglobulin light chain variable region (VL) at least about 90% identical to the amino acid sequence set forth in SEQ ID NO: 46; and

b) an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

60. The method of claim 59, wherein the VH sequence is identical to the amino acid sequence set forth in SEQ ID NO: 42; and the VL sequence is identical to the amino acid sequence set forth in SEQ ID NO: 46

61. The method of claims 59 or 60, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in separate formulations.

62. The method of claim 59 or 60, wherein the LIF-binding antibody and the inhibitor of PD-1, PDL-1, or PDL-2 signaling are administered to the individual in the same formulation.

63. The method of any one of claims 59 to 61, wherein the LIF-binding antibody is administered to the individual before the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual.

64. The method of any one of claims 59 to 61, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual before the LIF-binding antibody is administered to the individual.

65. The method of any one of claims 59 to 61, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is administered to the individual at the same time as the LIF-binding antibody is administered to the individual.

66. The method of any one of claims 59 to 65, wherein the LIF-binding antibody is humanized.

67. The method of any one of claims 59 to 66, wherein the cancer comprises an advanced solid tumor, a glioblastoma, a stomach cancer, a skin cancer, a prostate cancer, a pancreatic cancer, a pancreatic ductal adenocarcinoma, a breast cancer, a testicular cancer, a thyroid cancer, a head and neck cancer, a liver cancer, a kidney cancer, a esophageal cancer, a ovarian cancer, a colon cancer, a lung cancer, a non-small cell lung cancer, a lymphoma, a soft tissue cancer, or any combination thereof.

68. The method of claim 67, wherein the cancer comprises non-small cell lung cancer.

69. The method of claim 67, wherein the cancer comprises pancreatic ductal adenocarcinoma.

70. The method of any one of claims 59 to 69, wherein the cancer has previously been unsuccessfully treated with a checkpoint inhibitor.

71. The method of any one of claims 59 to 69, wherein the cancer has previously been unsuccessfully treated with a LIF-binding antibody.

72. The method of claim 70 or 71, wherein the checkpoint inhibitor is an inhibitor of PD-1, PDL-1, or PDL-2 signaling.

73. The method of any one of claims 59 to 72, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling is an antibody or fragment thereof that binds to PD-1.

74. The method of claim 73, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

75. The method of claim 73, wherein the antibody specifically binds PDL-1 or PDL-2.

76. The method of claim 75, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

77. The method of any one of claims 59 to 72, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

78. The method of claim 77, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

79. The method of any one of claims 59 to 72, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

80. The method of claim 79, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises one or more of: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

81. The use of claim 18, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

82. The use of claim 18, wherein the antibody specifically binds PDL-1 or PDL-2.

83. The use of claim 82, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

84. The use of any one of claims 1 to 17, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

85. The use of claim 84, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

86. The use of any one of claims 1 to 17, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

87. The use of claim 86, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises one or more of: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

88. The use of claim 33, wherein the antibody comprises Pembrolizumab, Nivolumab, AMP-514, Tislelizumab, Spartalizumab, or a PD-1 binding fragment thereof.

89. The use of claim 33, wherein the antibody specifically binds PDL-1 or PDL-2.

90. The use of claim 89, wherein the antibody comprises Durvalumab, Atezolizumab, Avelumab, BMS-936559, or FAZ053, or a PDL-1 or PDL-2 binding fragment thereof.

91. The use of any one of claims 19 to 32, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises an Fc-Fusion protein that binds PD-1, PDL-1, or PDL-2.

92. The use of claim 91, wherein the Fc-Fusion protein comprises AMP-224 or a PD-1 binding fragment thereof.

93. The use of any one of claims 19 to 32, wherein the inhibitor of PD-1, PDL-1, or PDL-2 signaling comprises a small molecule inhibitor of PD-1, PDL-1, or PDL-2.

94. The use of claim 93, wherein the small molecule inhibitor of signaling through PD-1, PDL-1, or PDL-2 comprises one or more of: N-{2-[({2-methoxy-6-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]pyridin-3-yl}methyl)amino]ethyl}acetamide (BMS 202); (2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)-5-methylbenzyl)-D-serine hydrochloride; (2R,4R)-1-(5-chloro-2-((3-cyanobenzyl)oxy)-4-((3-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-2-methylbenzyl)oxy)benzyl)-4-hydroxypyrrolidine-2-carboxylic acid; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenylindole; 3-(4,6-dichloro-1,3,5-triazin-2-yl)-1-phenyl-1h-indole; L-α-Glutamine, N2,N6-bis(L-seryl-L-asparaginyl-L-threonyl-L-seryl-L-α-glutamyl-L-seryl-L-phenylalanyl)-L-lysyl-L-phenylalanyl-L-arginyl-L-valyl-L-threonyl-L-glutaminyl-L-leucyl-L-alanyl-L-prolyl-L-lysyl-L-alanyl-L-glutaminyl-L-isoleucyl-L-lysyl; (2S)-1-[[2,6-dimethoxy-4-[(2-methyl[1,1'-biphenyl]-3-yl)methoxy]phenyl]methyl]-2-piperidinecarboxylic acid; Glycinamide, N-(2-mercaptoacetyl)-L-phenylalanyl-N-methyl-L-alanyl-L-asparaginyl-L-prolyl-L-histidyl-L-leucyl-N-methylglycyl-L-tryptophyl-L-seryl-L-tryptophyl-N-methyl-L-norleucyl-N-methyl-L-norleucyl-L-arginyl-L-cysteinyl-, cyclic (1→14)-thioether; or a derivative or analog thereof.

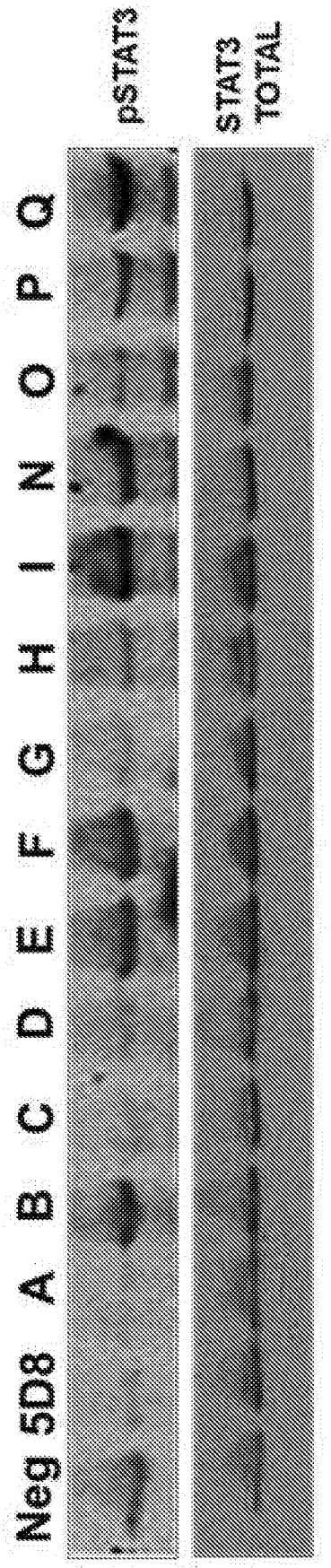
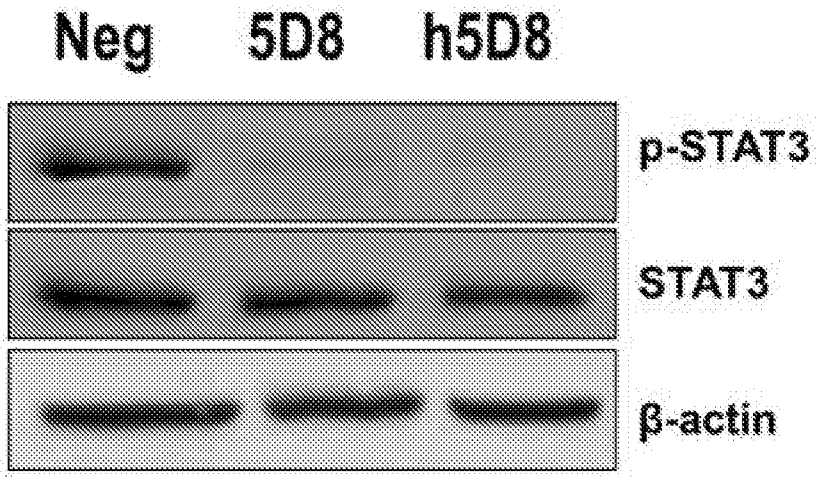



Fig. 1


Neg
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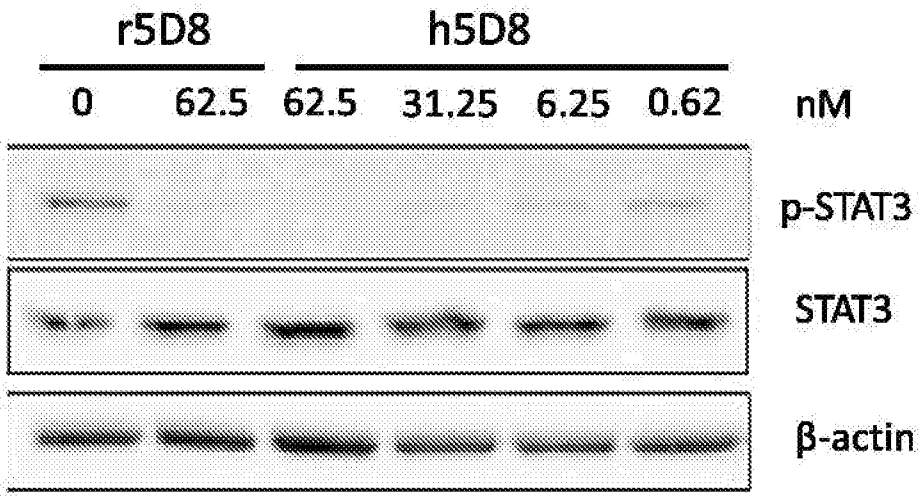
h5D8
p-STAT3
STAT3
β-actin

Fig. 2A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62.5
31.25
6.25
0.62
nM
p-STAT3
STAT3
β-actin

Fig. 2B

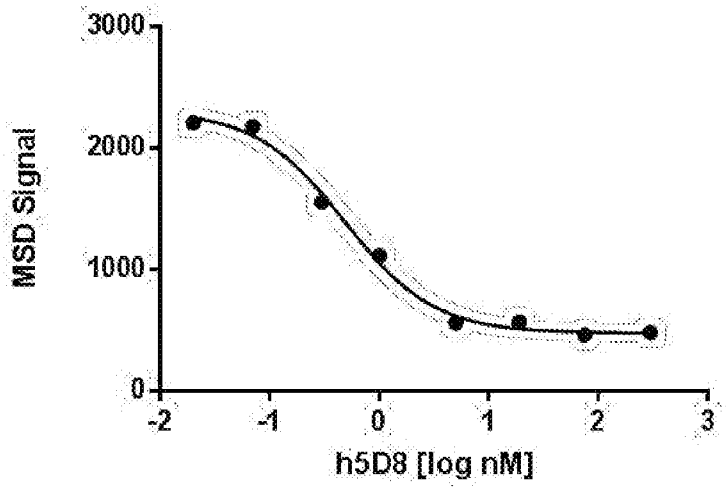

MSD Signal
3000
2000
1000
0
-2
-1
0
1
2
3
h5D8 [log nM]

Fig. 3A

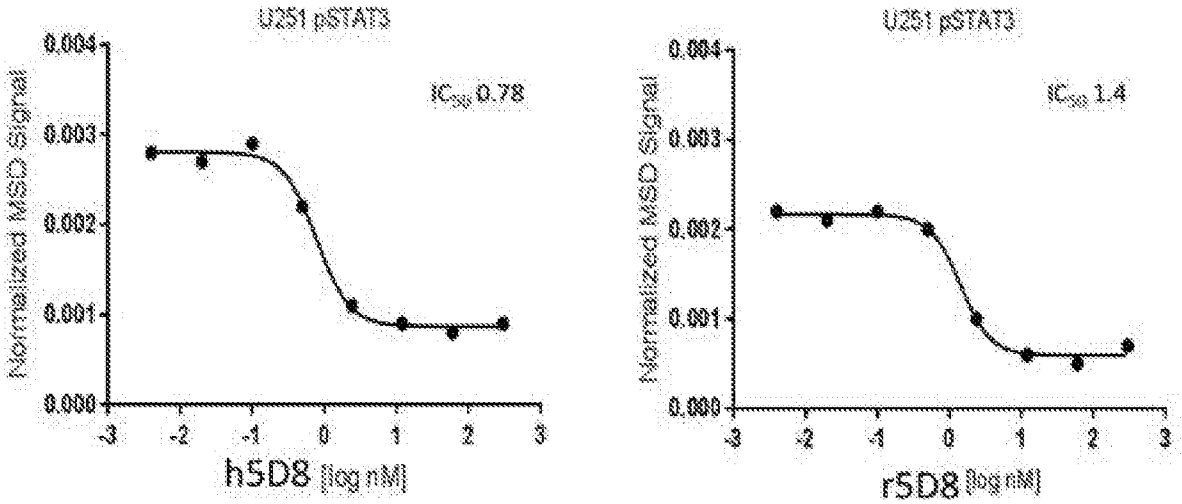

U251 pSTAT3
Normalized MSD Signal
0.004
0.003
0.002
0.001
0.000
IC50 0.78
-3
-2
-1
0
1
2
3
h5D8 [log nM]
U251 pSTAT3
Normalized MSD Signal
0.004
0.003
0.002
0.001
0.000
IC50 1.4
-3
-2
-1
0
1
2
3
r5D8 [log nM]

Fig. 3B

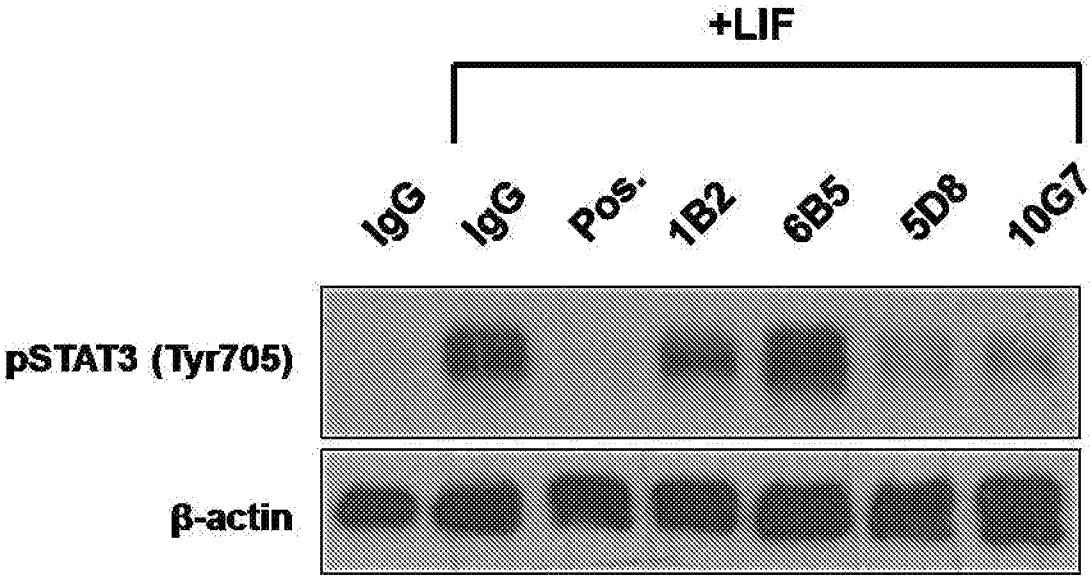



Fig. 4

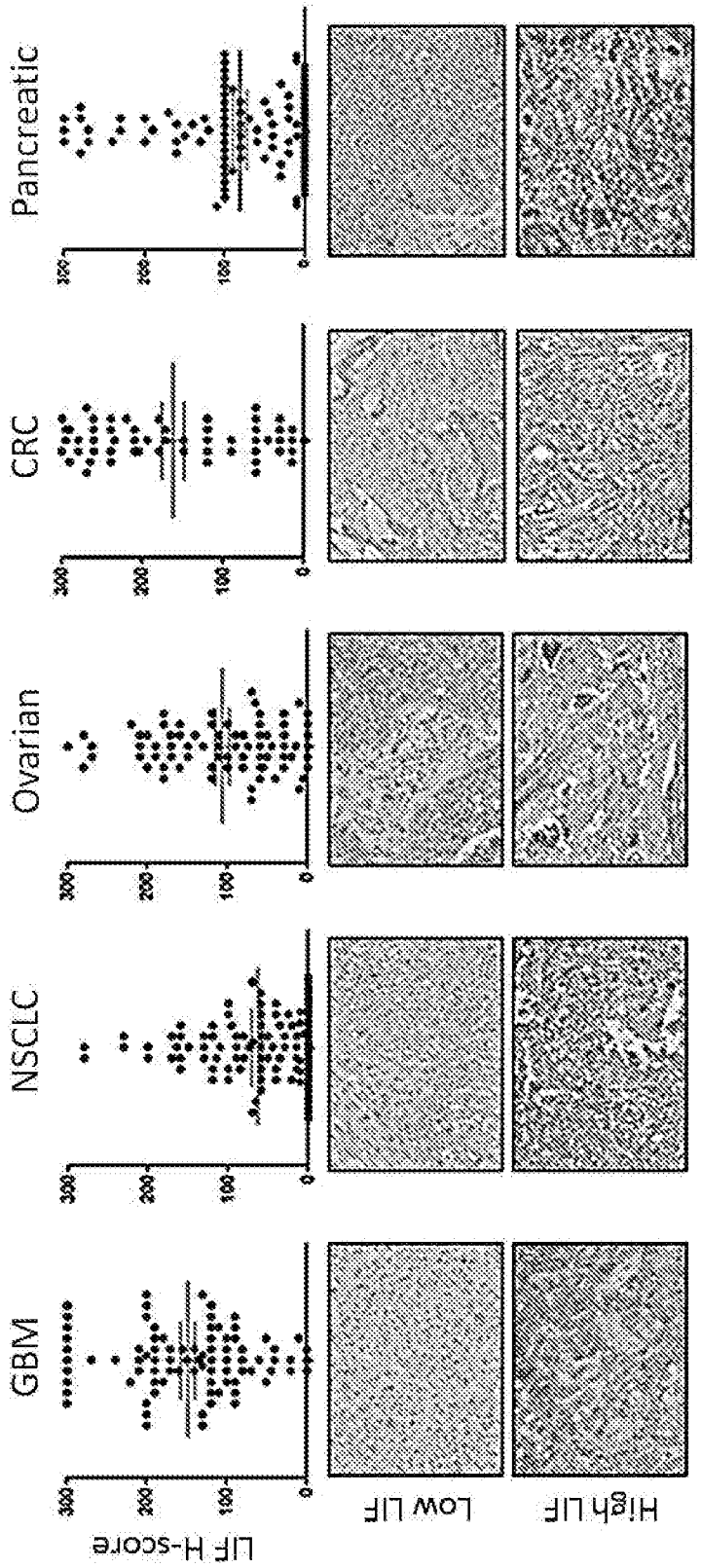

GBM
NSCLC
Ovarian
CRC
Pancreatic
LIF H-score
300
200
100
0
Low LIF
High LIF

Fig. 5

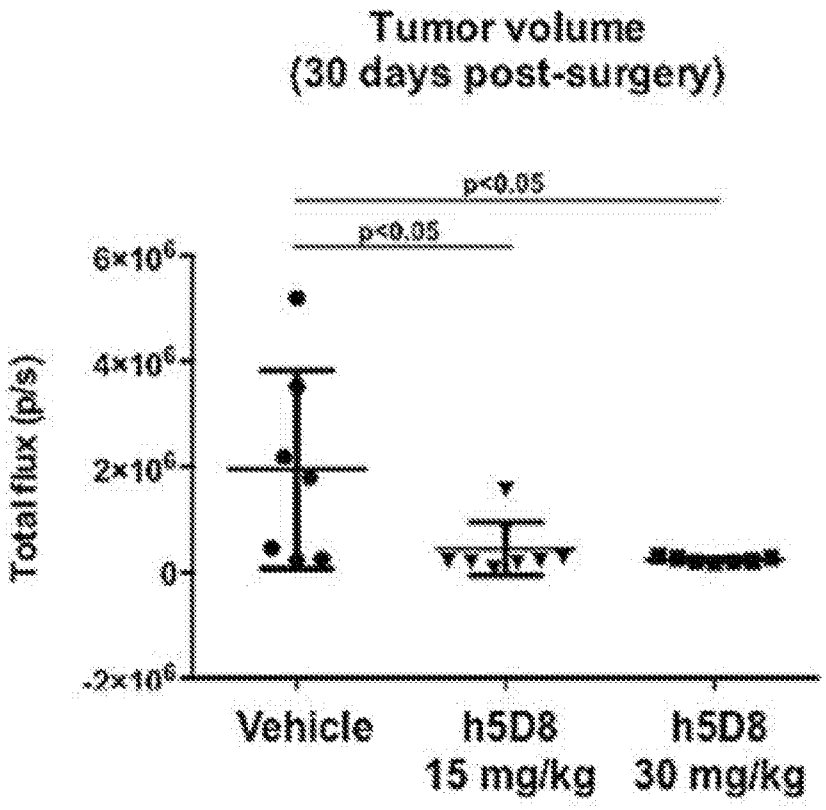

Tumor volume
(30 days post-surgery)
p<0.05
p<0.05
Total flux (p/s)
6×10^6
4×10^6
2×10^6
0
-2×10^6
Vehicle
h5D8
15 mg/kg
h5D8
30 mg/kg

Fig. 6A

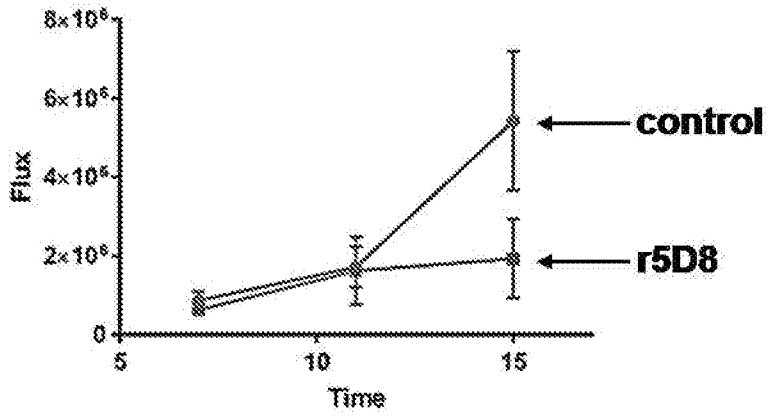

8×10^6
6×10^6
4×10^6
2×10^6
0
Flux
5
10
15
Time
control
r5D8

Fig. 6B

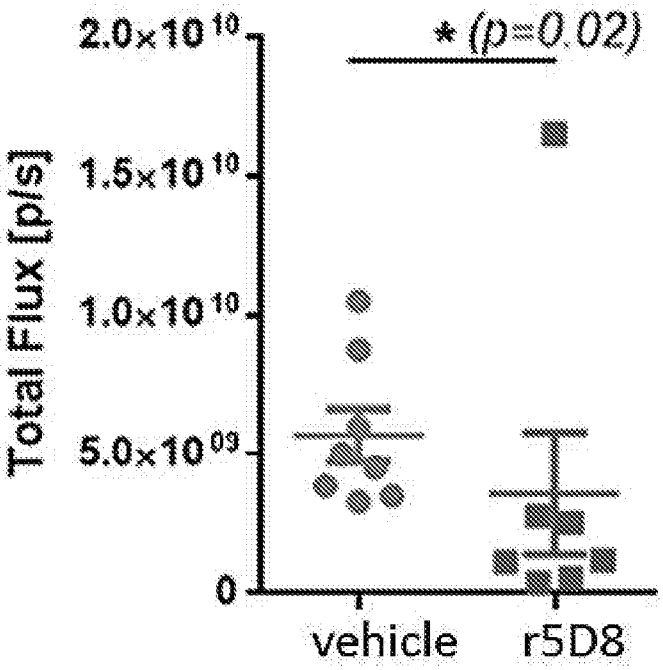

2.0×10 10
1.5×10 10
1.0×10 10
5.0×10 09
0
Total Flux [p/s]
* (p=0.02)
vehicle
r5D8

Fig. 7A

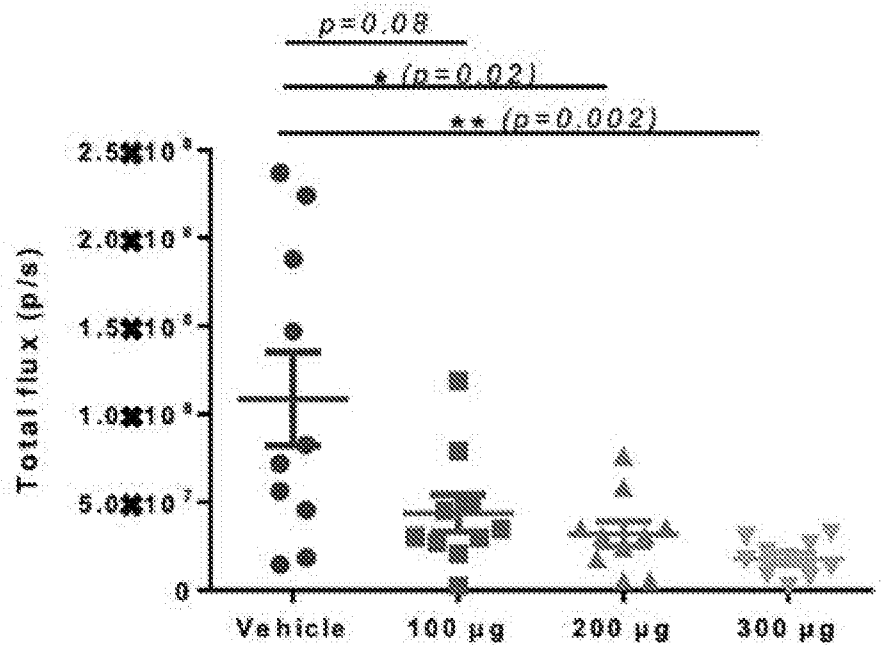

p=0.08
* (p=0.02)
** (p=0.002)
Total flux (p/s)
0
Vehicle
100 µg
200 µg
300 µg

Fig. 7B

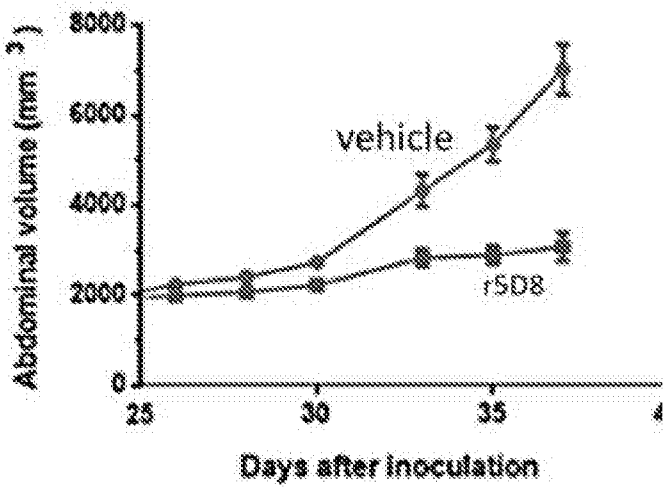



Fig. 8A

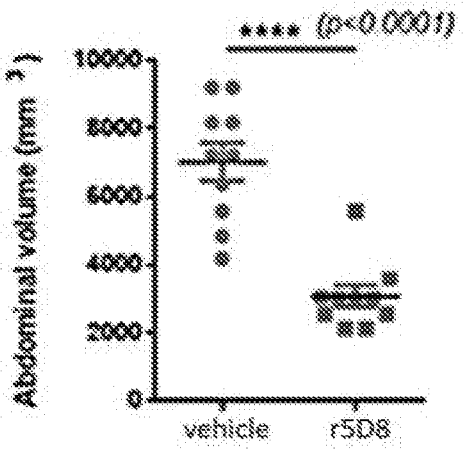



Fig. 8B

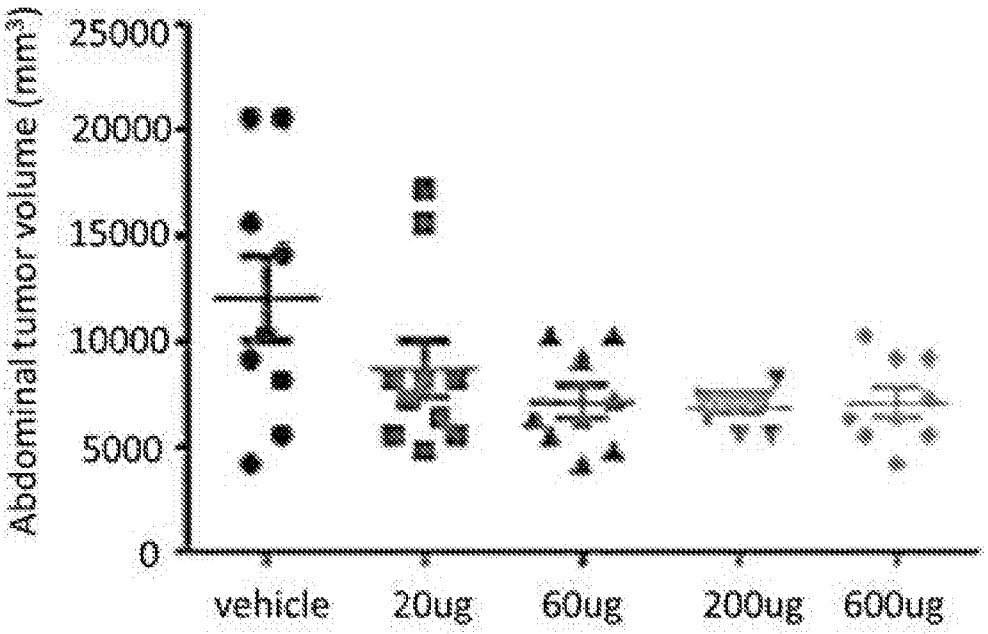



Fig. 8C

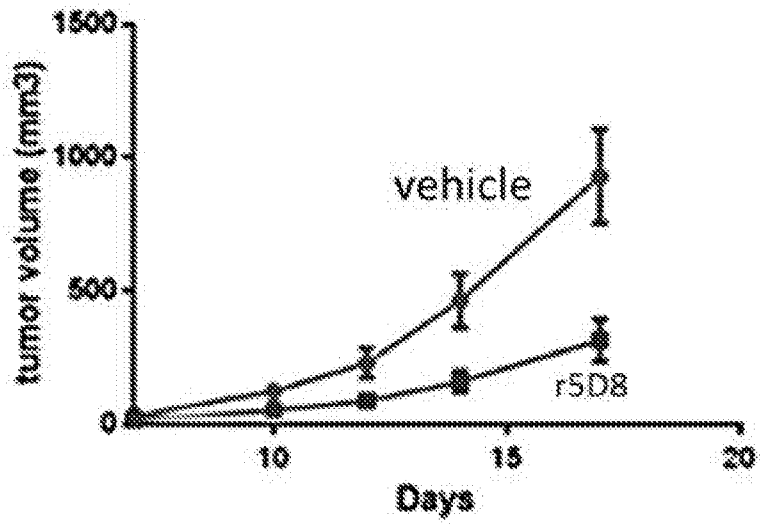

1500
1000
500
0
tumor volume (mm3)
vehicle
r5D8
10
15
20
Days

Fig. 9A

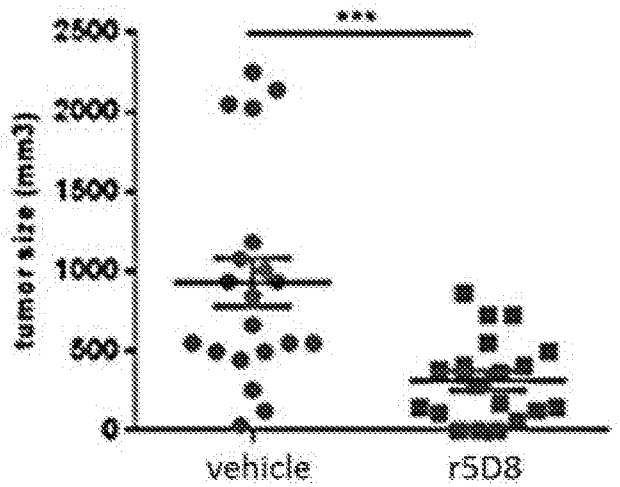

***
2500
2000
1500
1000
500
0
tumor size (mm3)
vehicle
r5D8

Fig. 9B

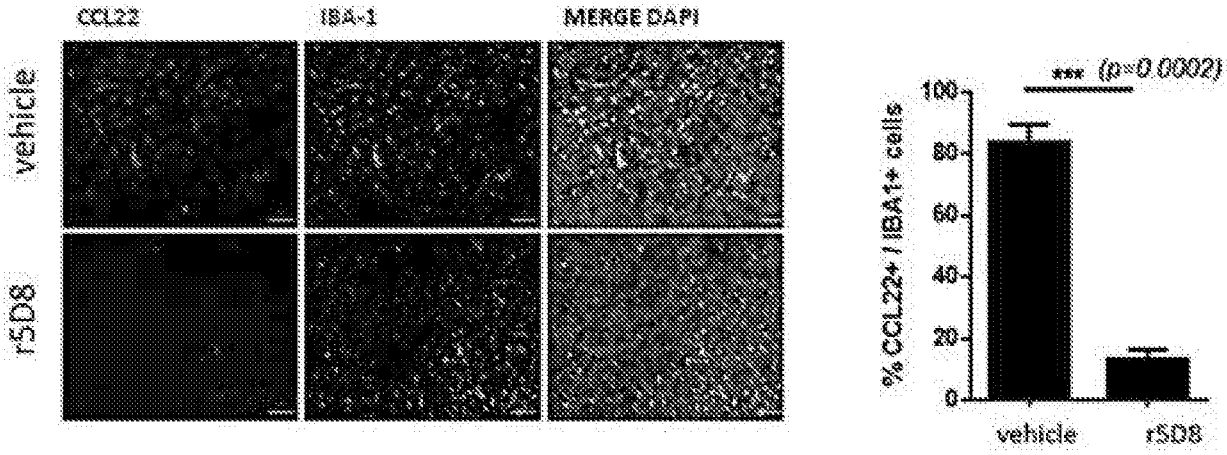

CCL22
IBA-1
MERGE DAPI
vehicle
rSD8
*** (p=0.0002)
% CCL22+ / IBA1+ cells
100
80
60
40
20
0
vehicle
rSD8

Fig. 10A

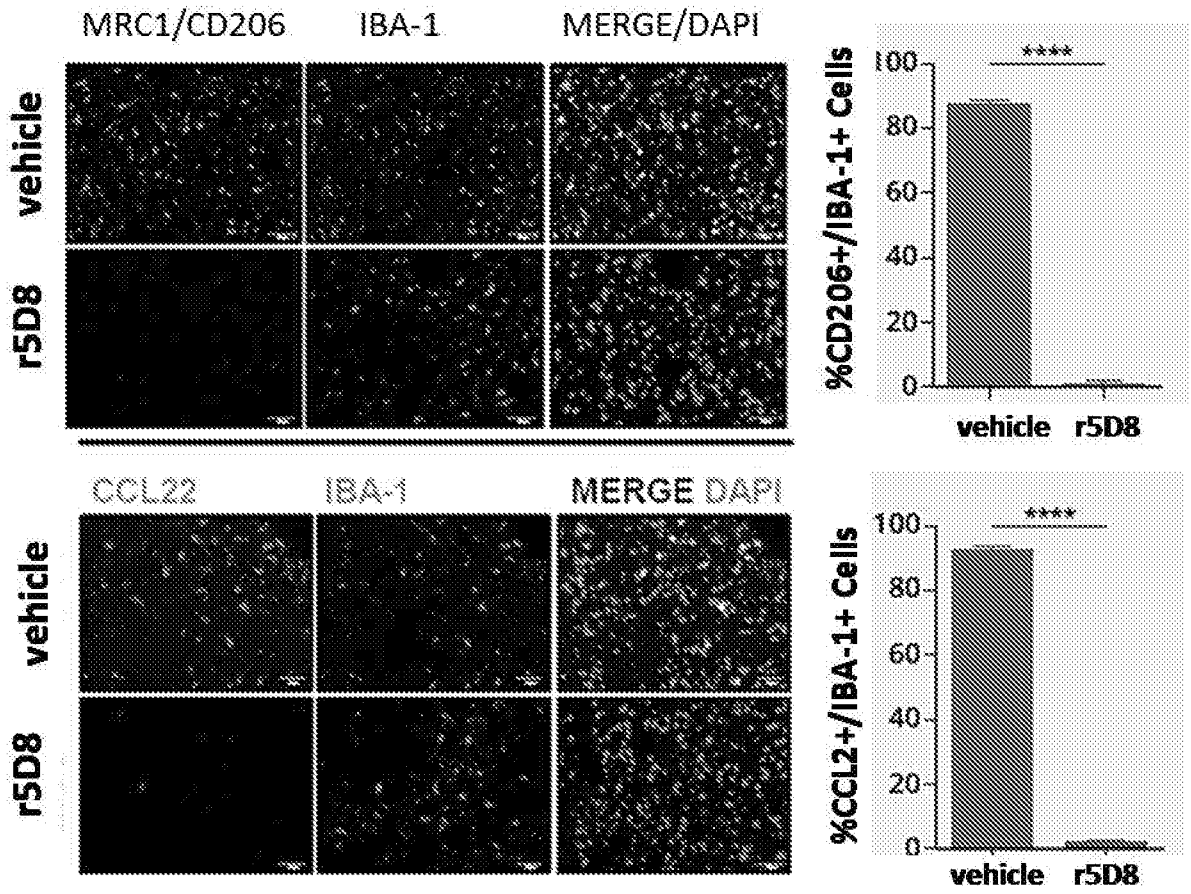

MRC1/CD206
IBA-1
MERGE/DAPI
vehicle
r5D8
%CD206+/IBA-1+ Cells
****
100
80
60
40
20
0
vehicle
r5D8
CCL22
IBA-1
MERGE DAPI
vehicle
r5D8
%CCL2+/IBA-1+ Cells
****
100
80
60
40
20
0
vehicle
r5D8

Fig. 10B

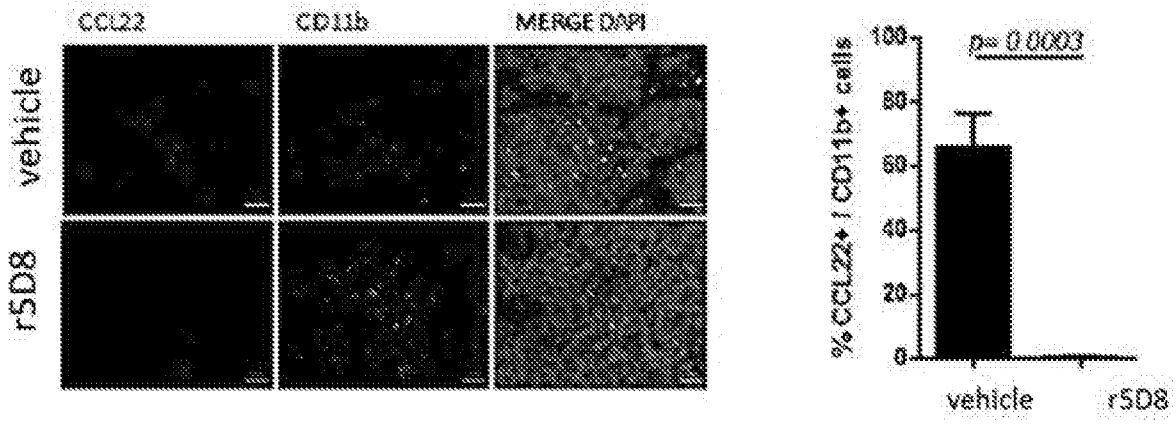



Fig. 10C

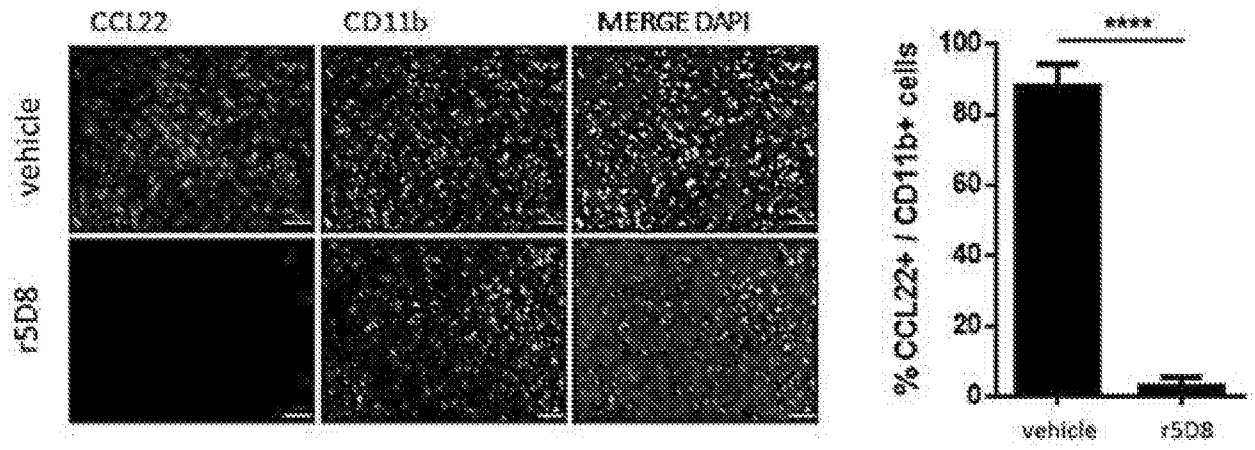



Fig. 10D

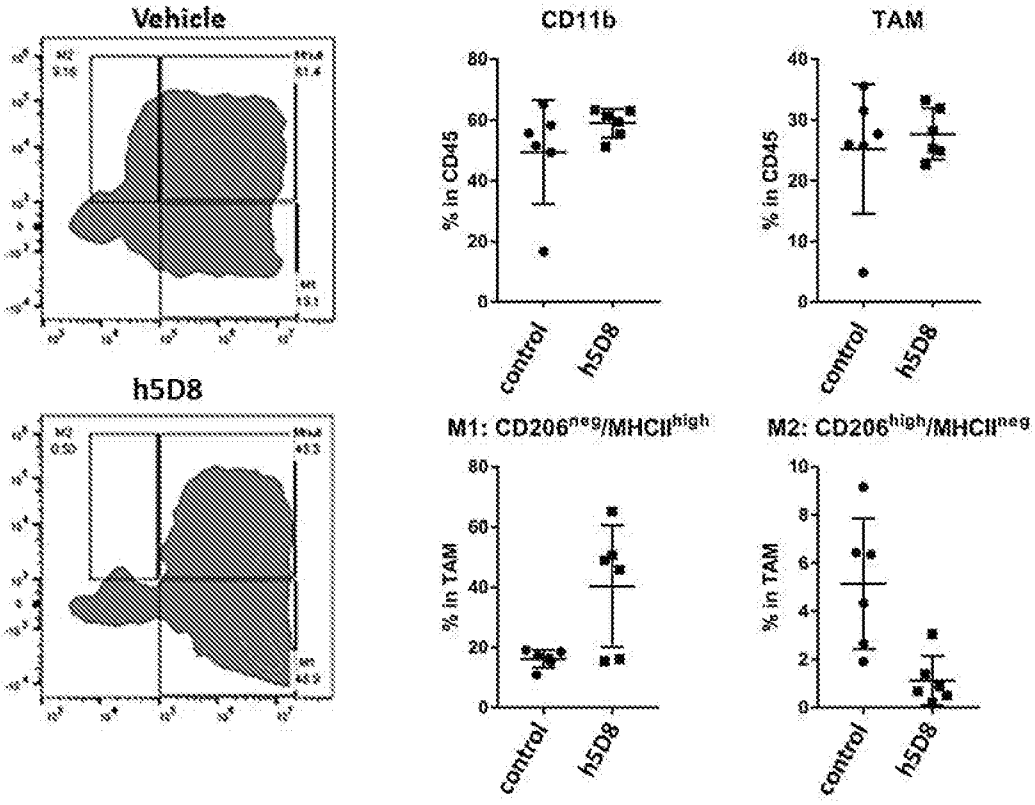

Vehicle
h5D8
CD11b
% in CD45
control
h5D8
TAM
% in CD45
control
h5D8
M1: CD206neg/MHCIIhigh
% in TAM
control
h5D8
M2: CD206high/MHCIIneg
% in TAM
control
h5D8

**Fig. 10E**

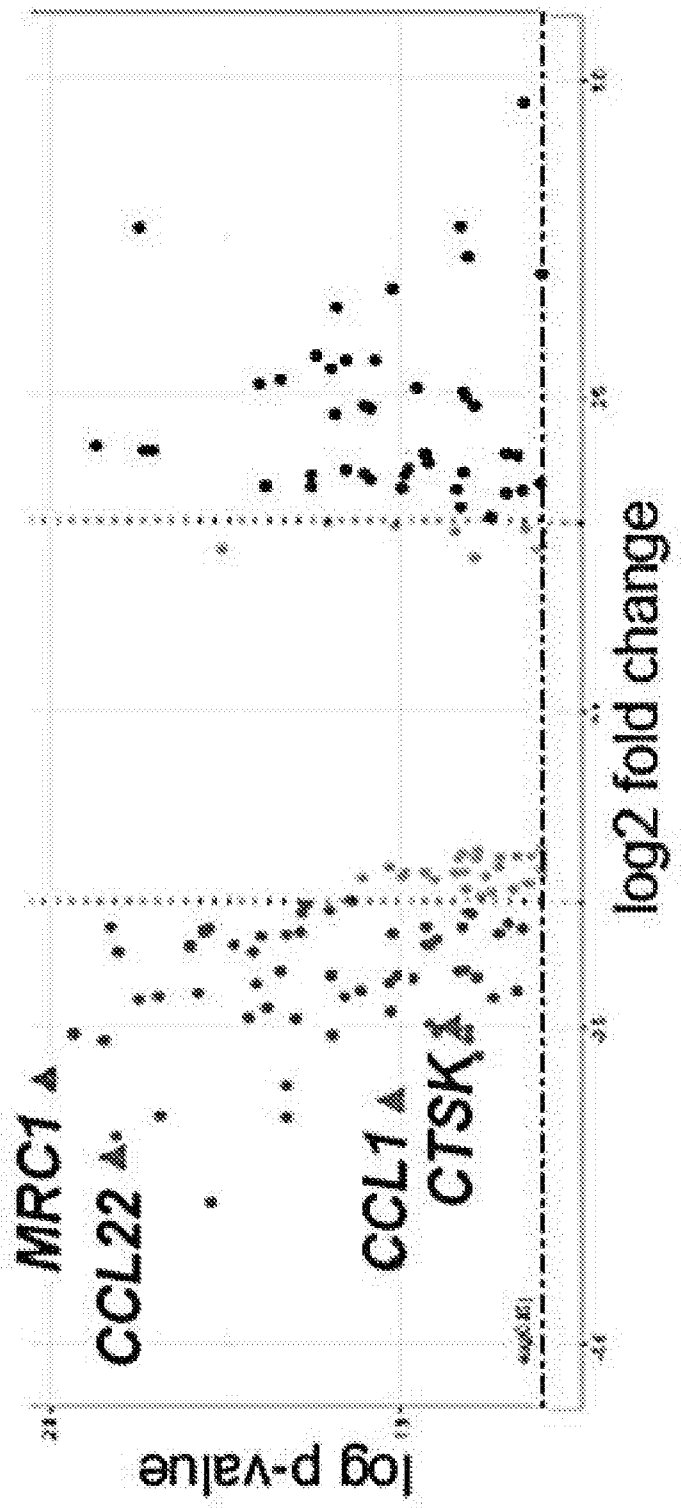



Fig. 10F

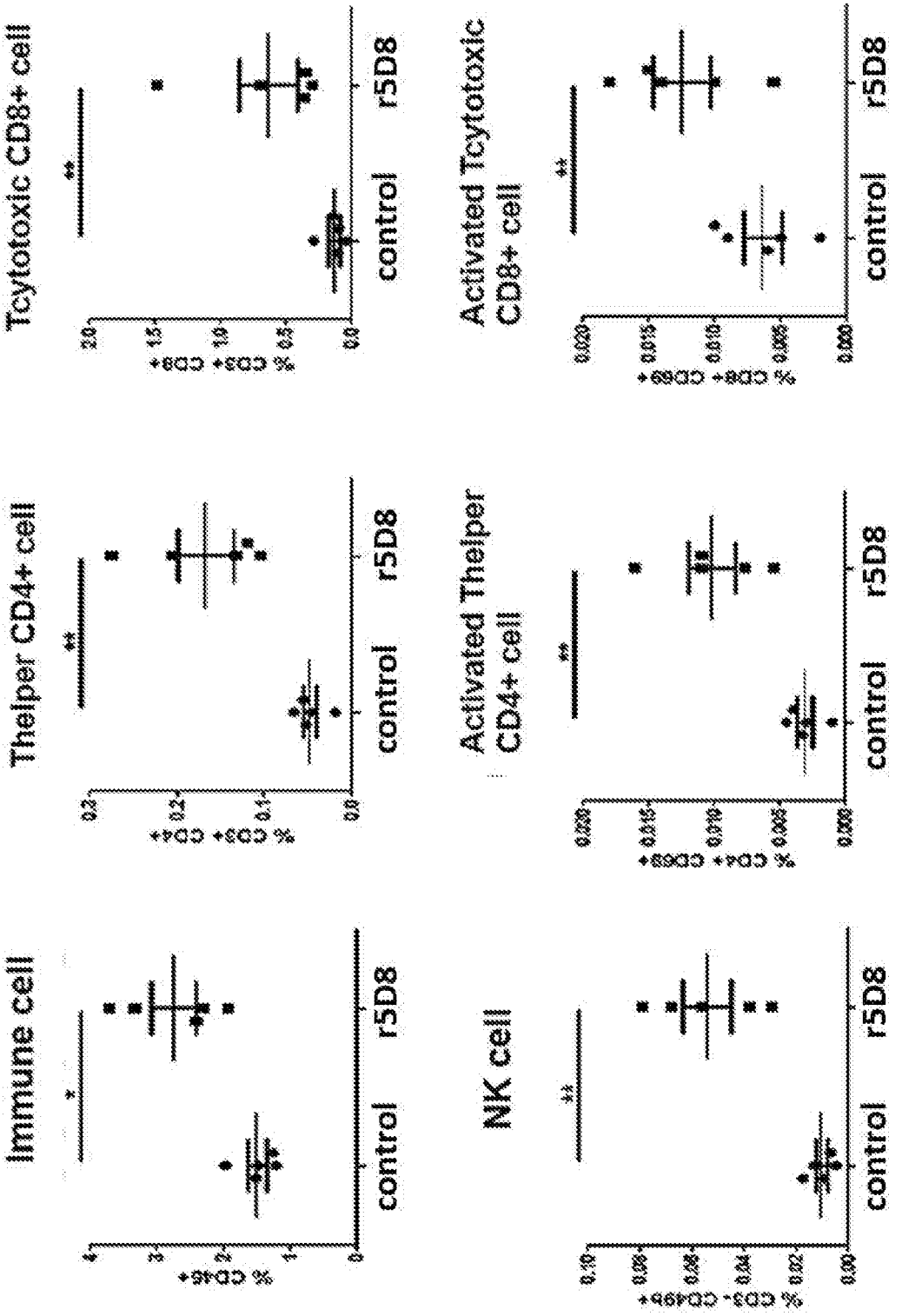

Tcytotoxic CD8+ cell
Thelper CD4+ cell
Activated Tcytotoxic CD8+ cell
Activated Thelper CD4+ cell
Immune cell
NK cell
control
r5D8

Fig. 11A

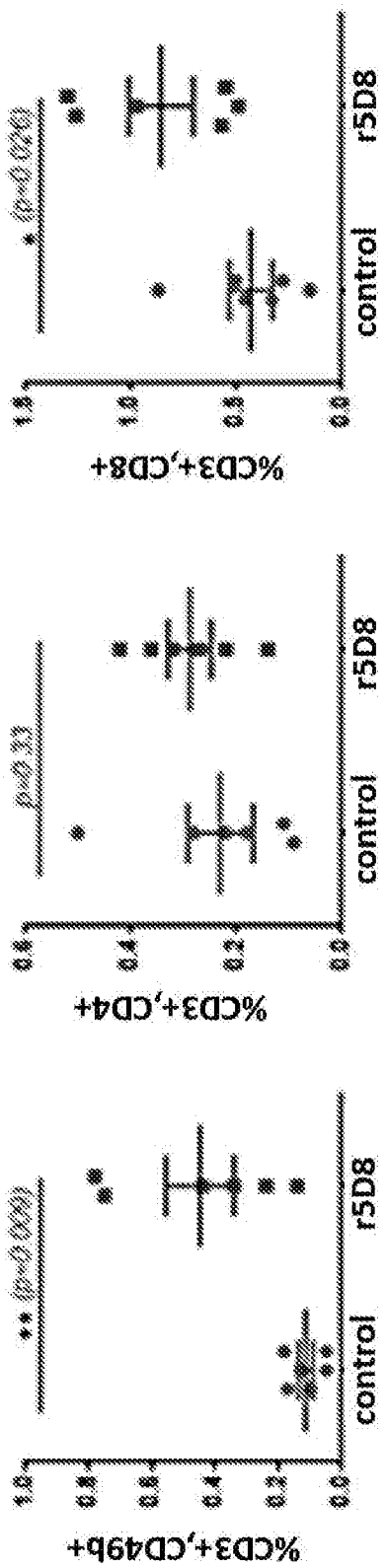

%CD3+,CD49b+
** (p=0.009)
control
r5D8
%CD3+,CD4+
p=0.33
control
r5D8
%CD3+,CD8+
* (p=0.02)
control
r5D8

Fig. 11B

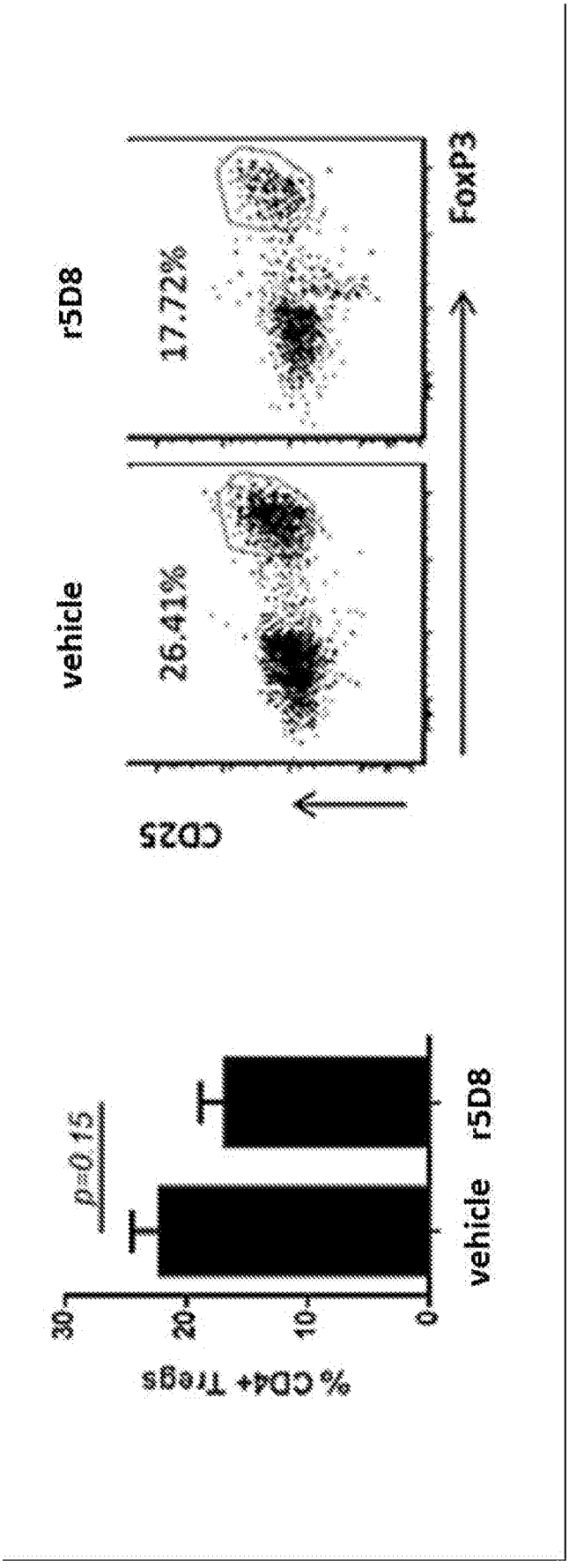

vehicle
r5D8
26.41%
17.72%
CD25
FoxP3
p=0.15
% CD4+ Tregs
30
20
10
0
vehicle
r5D8

Fig. 11C

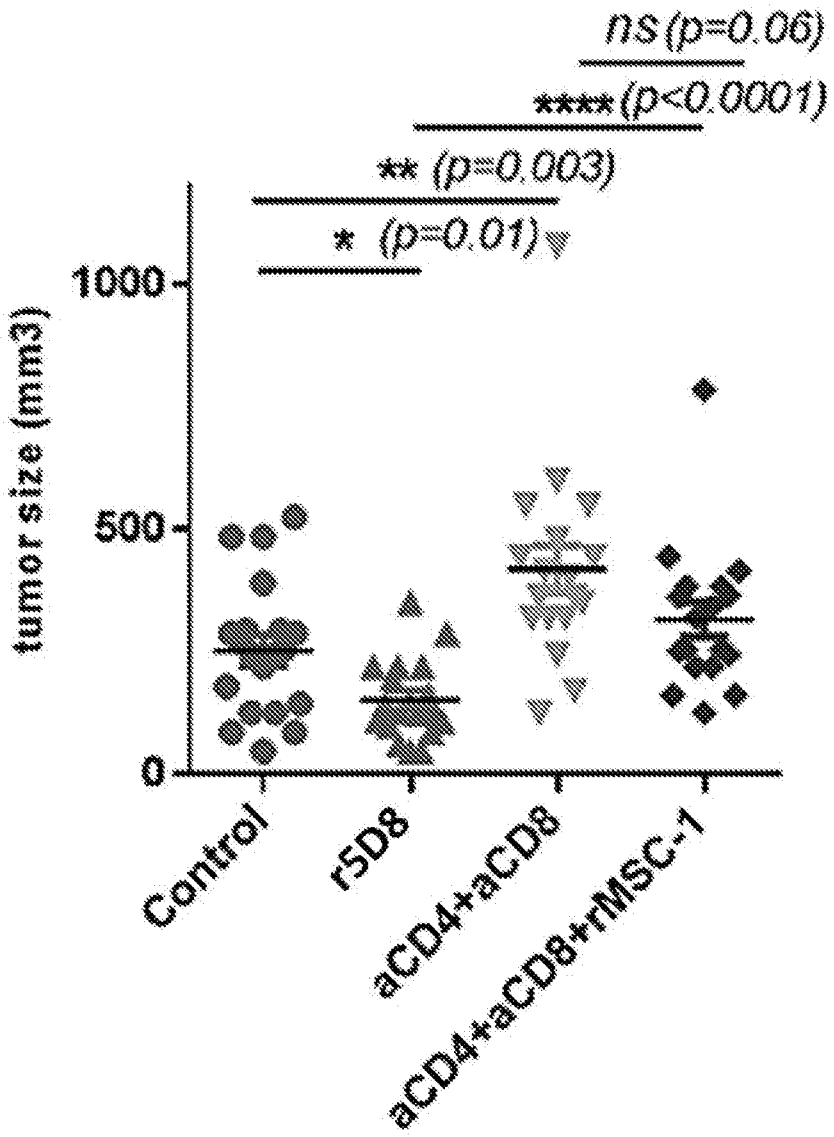

ns (p=0.06)
**** (p<0.0001)
** (p=0.003)
* (p=0.01)
tumor size (mm3)
1000
500
0
Control
r5D8
aCD4+aCD8
aCD4+aCD8+rMSC-1

Fig. 12

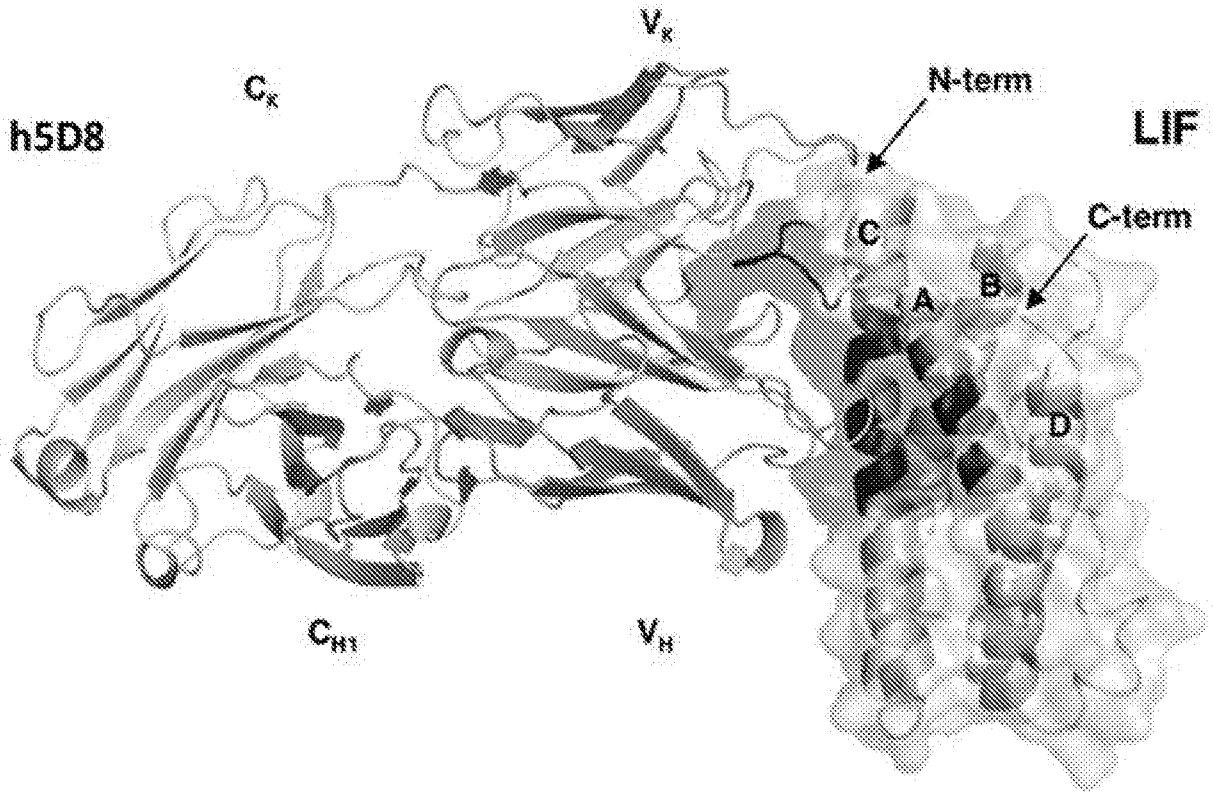



Fig. 13A

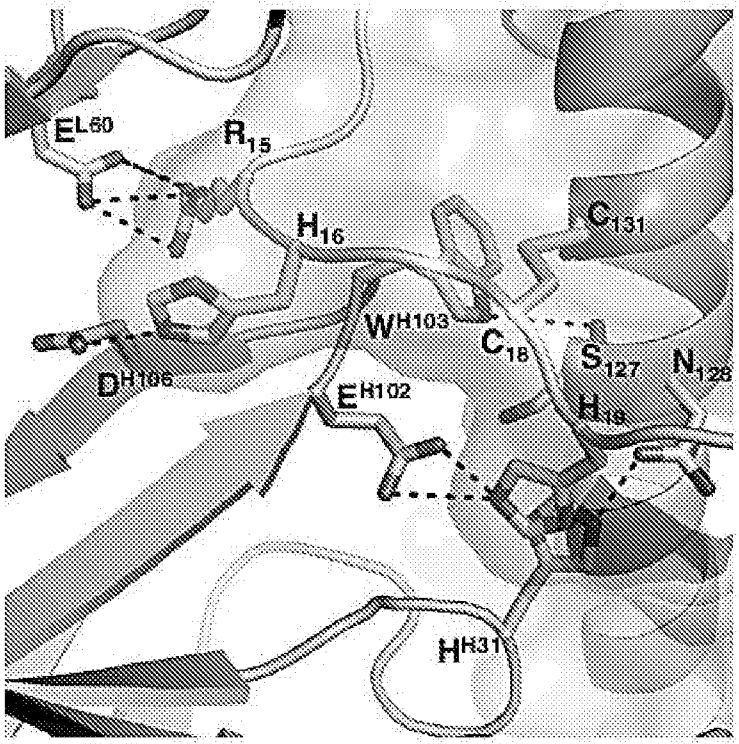



Fig. 13B

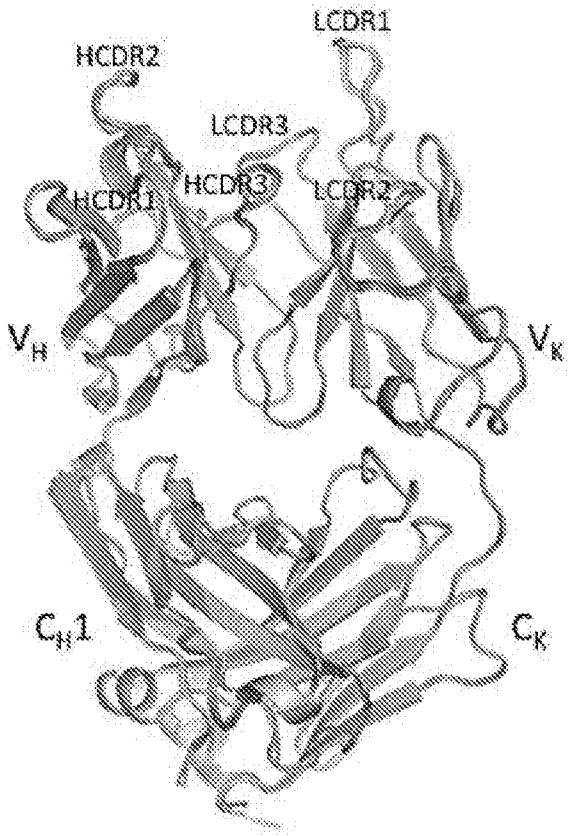



Fig. 14A

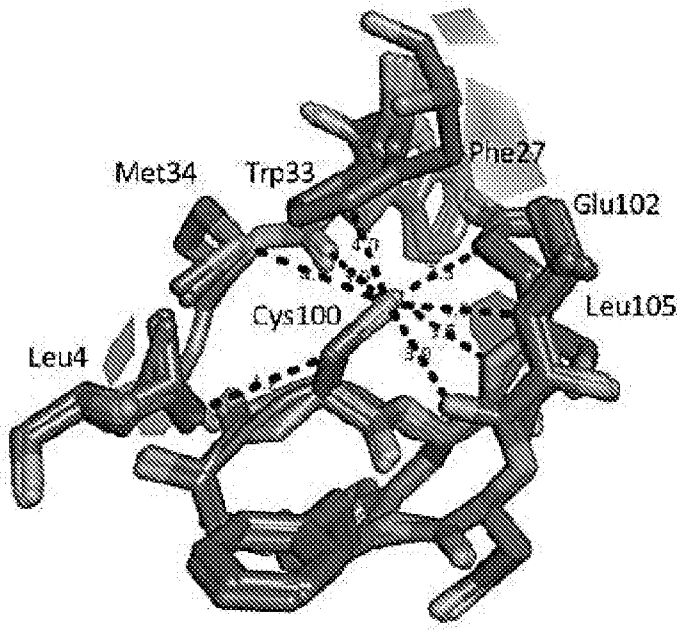



Fig. 14B

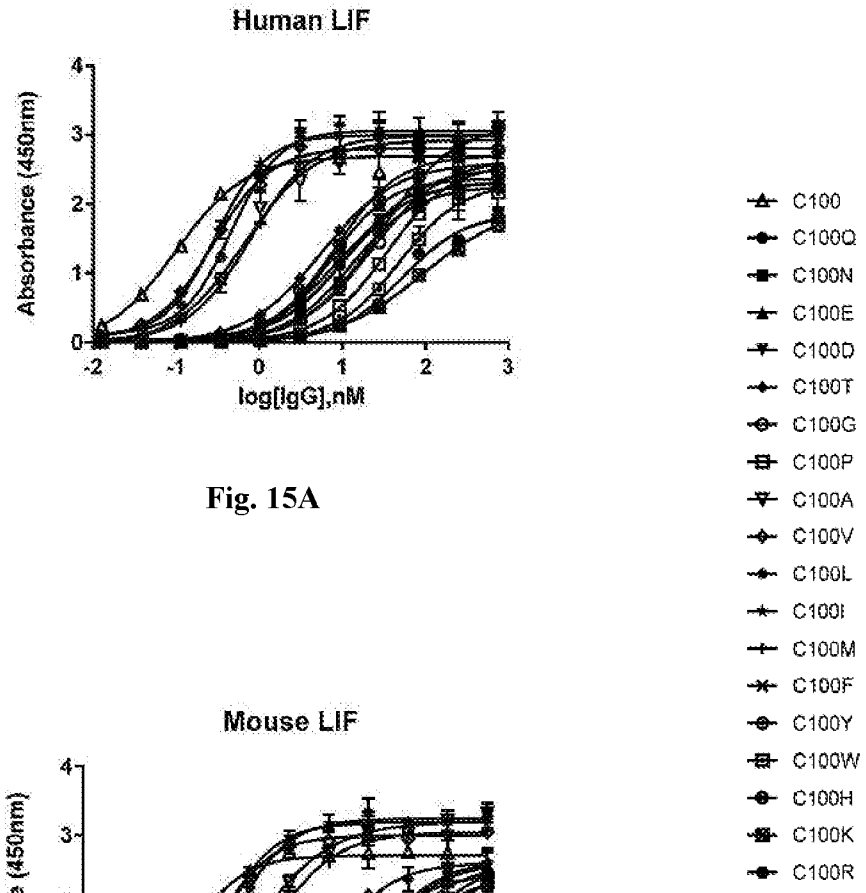



Fig. 15A

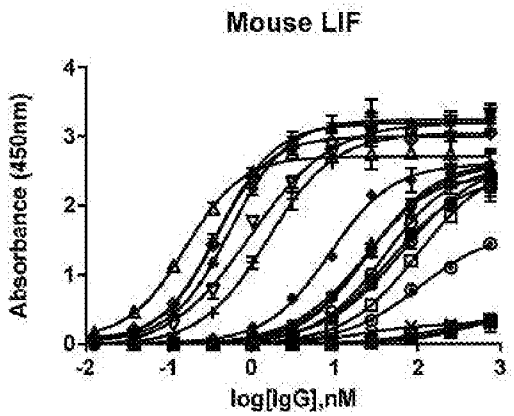



Fig. 15B

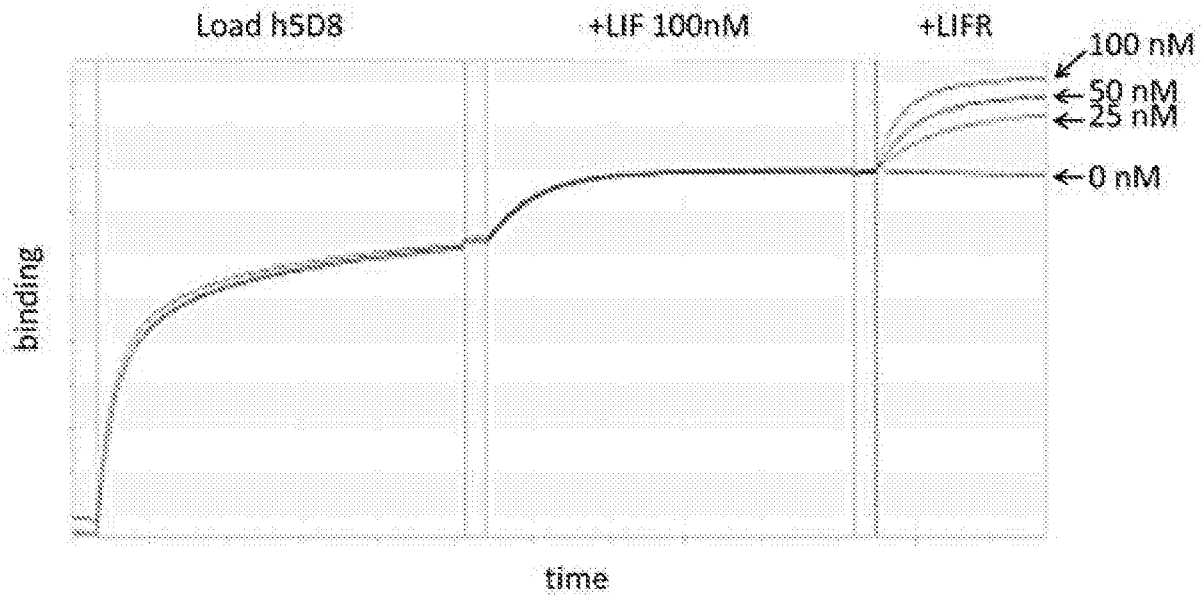



Fig. 16A

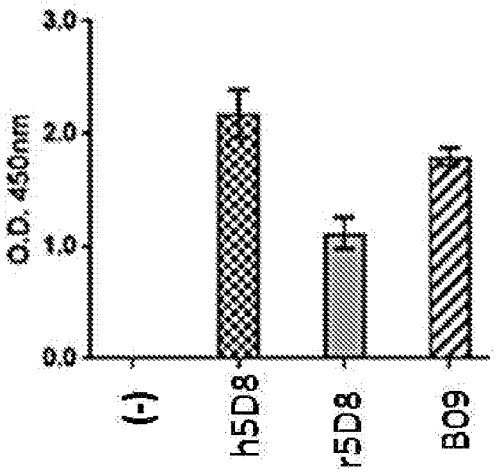



Fig. 16B

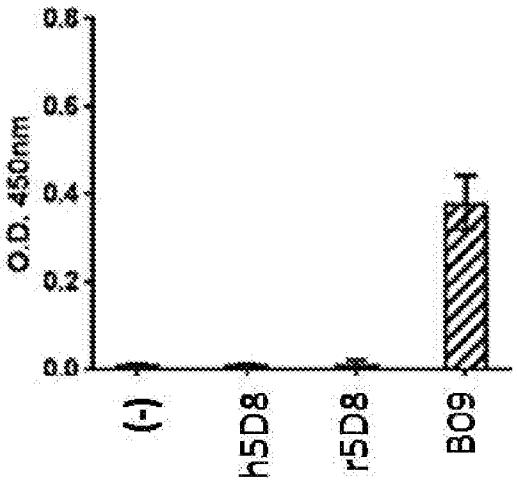



Fig. 16C

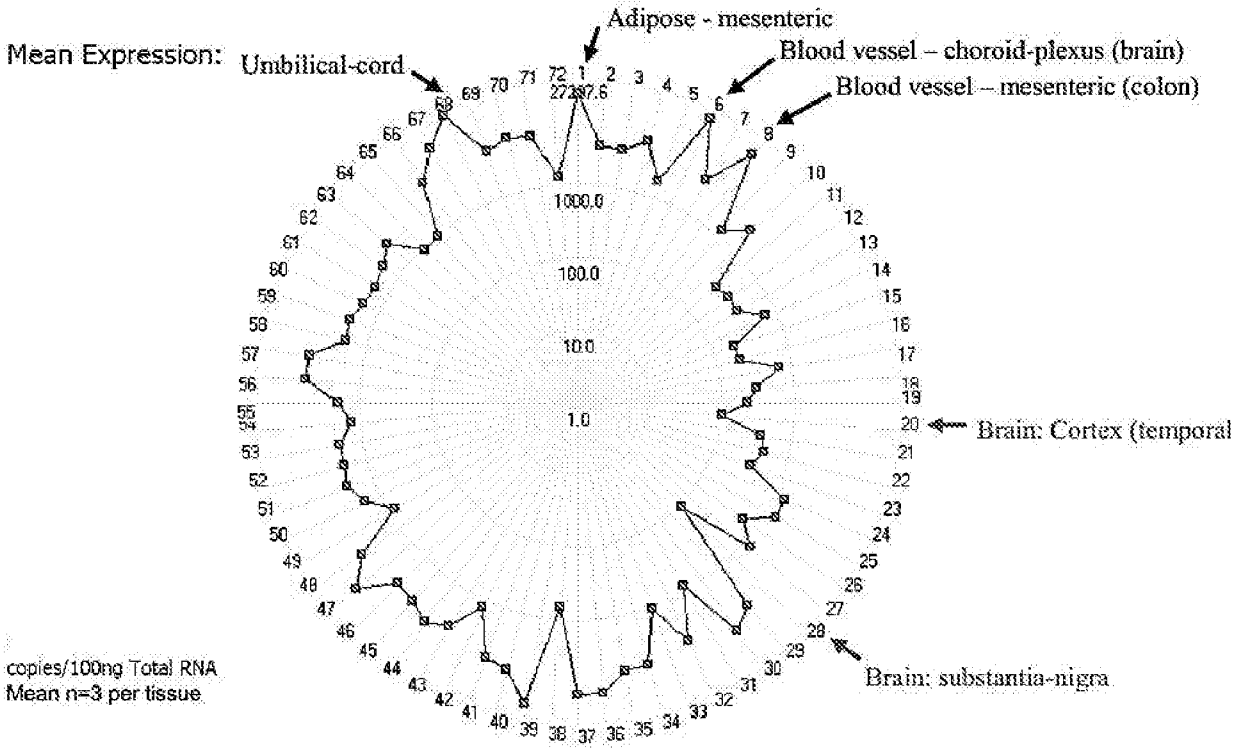

Mean Expression:
Adipose - mesenteric
Umbilical-cord
Blood vessel – choroid-plexus (brain)
Blood vessel – mesenteric (colon)
1000.0
100.0
10.0
1.0
Brain: Cortex (temporal
Brain: substantia-nigra
copies/100ng Total RNA
Mean n=3 per tissue

**Fig. 17A**

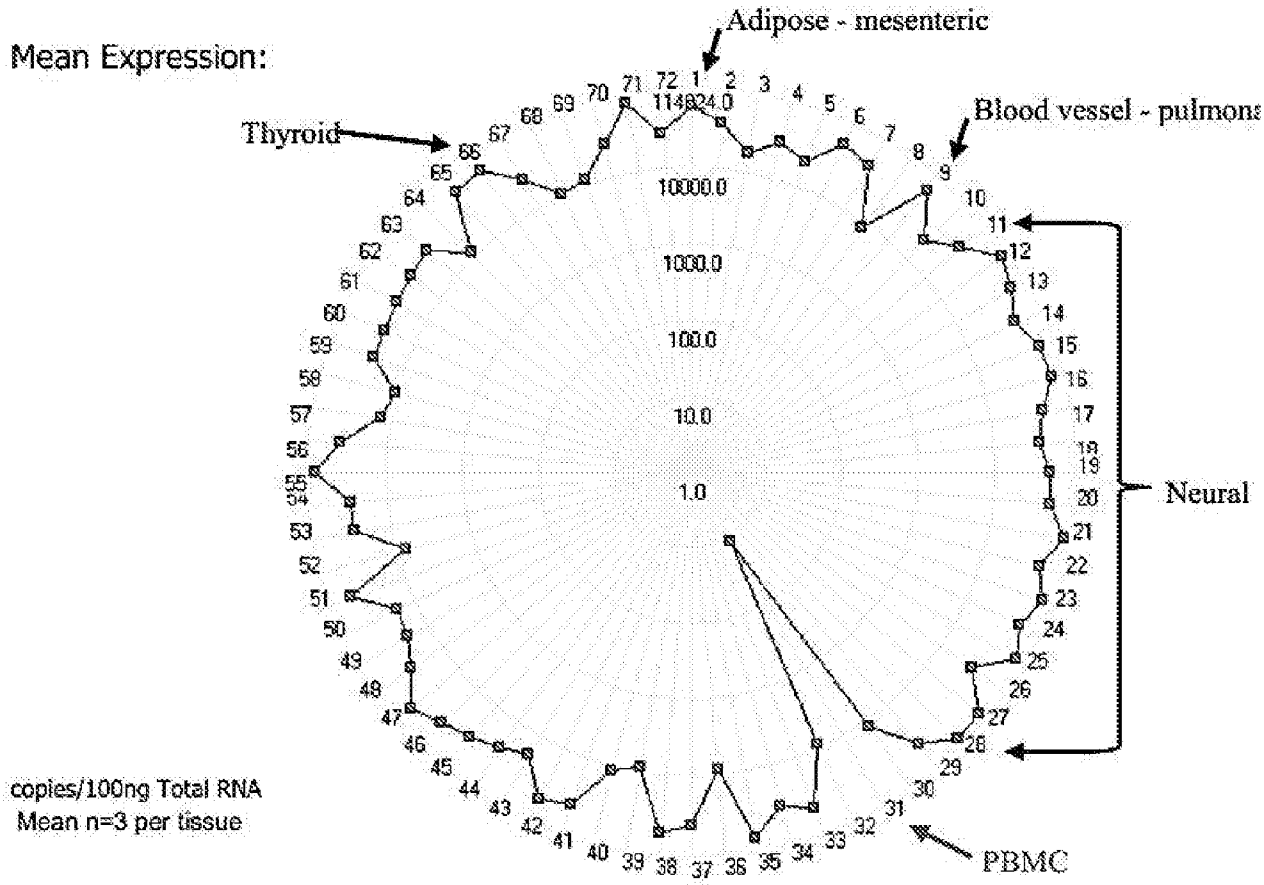

Mean Expression:
Adipose - mesenteric
Thyroid
Blood vessel - pulmons
Neural
PBMC
10000.0
1000.0
100.0
10.0
1.0
copies/100ng Total RNA
Mean n=3 per tissue

**Fig. 17B**

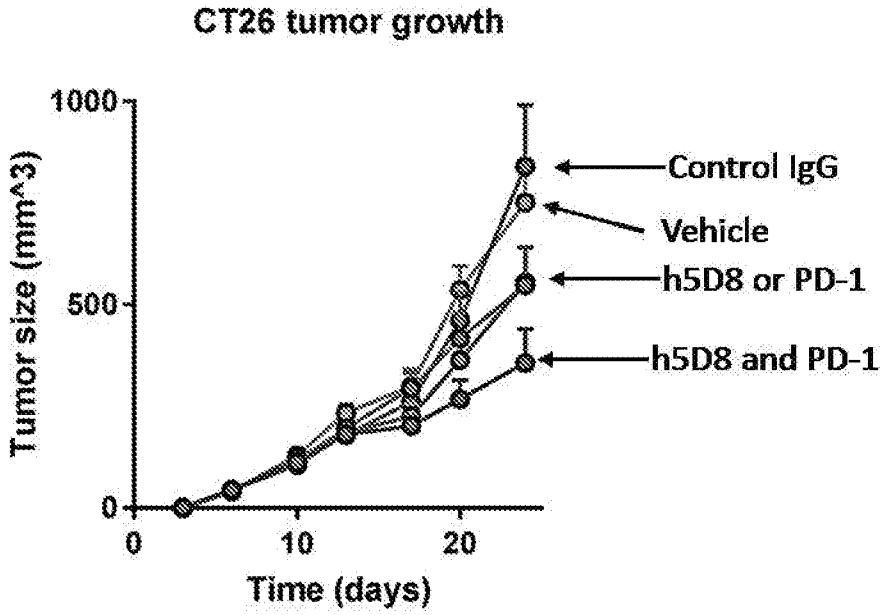



Fig. 18A

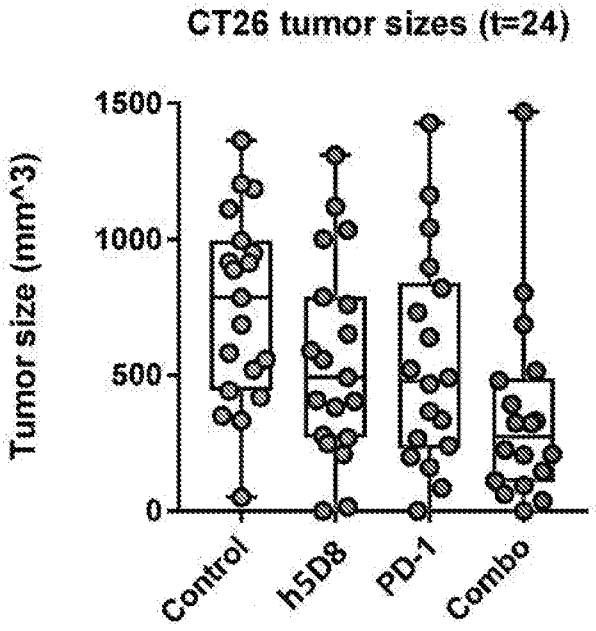



Fig. 18B

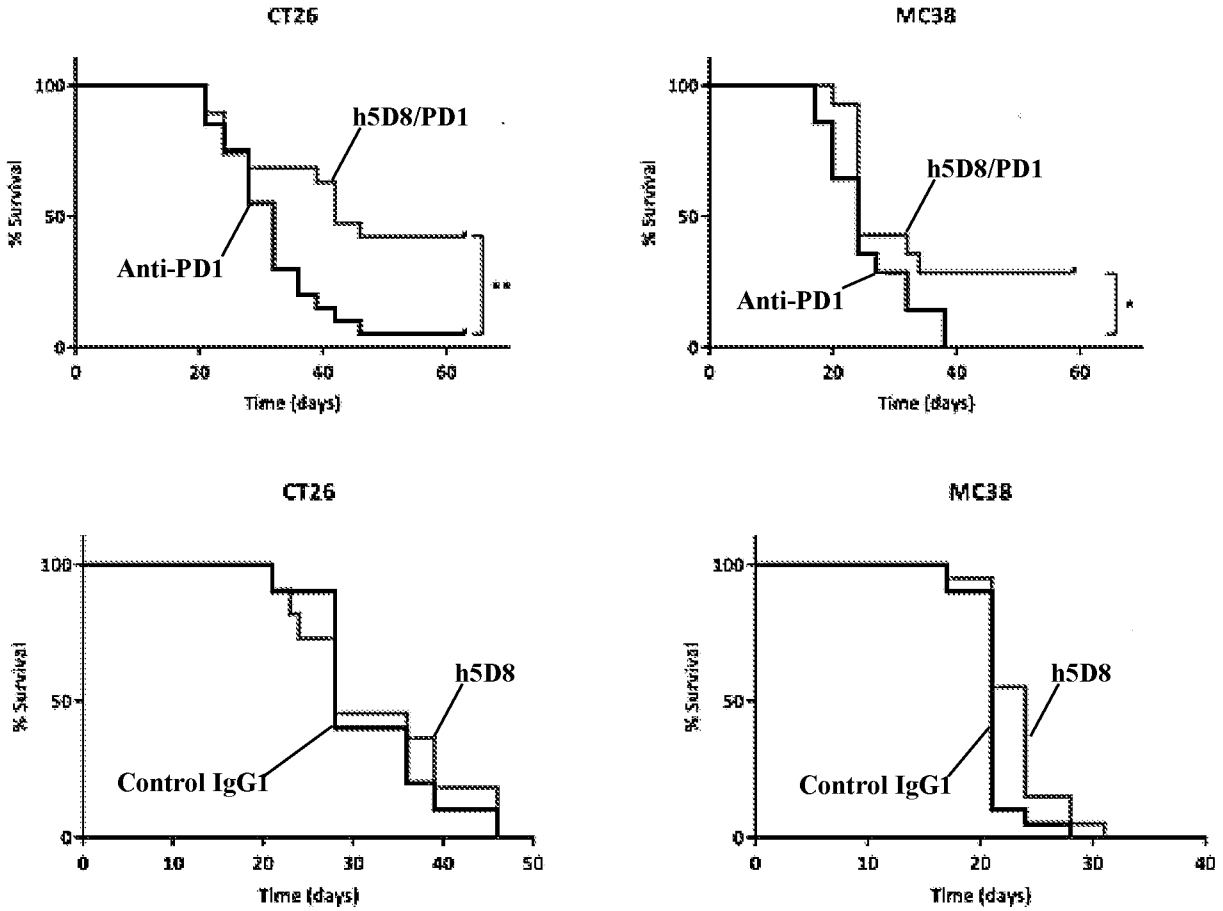



Fig. 18C

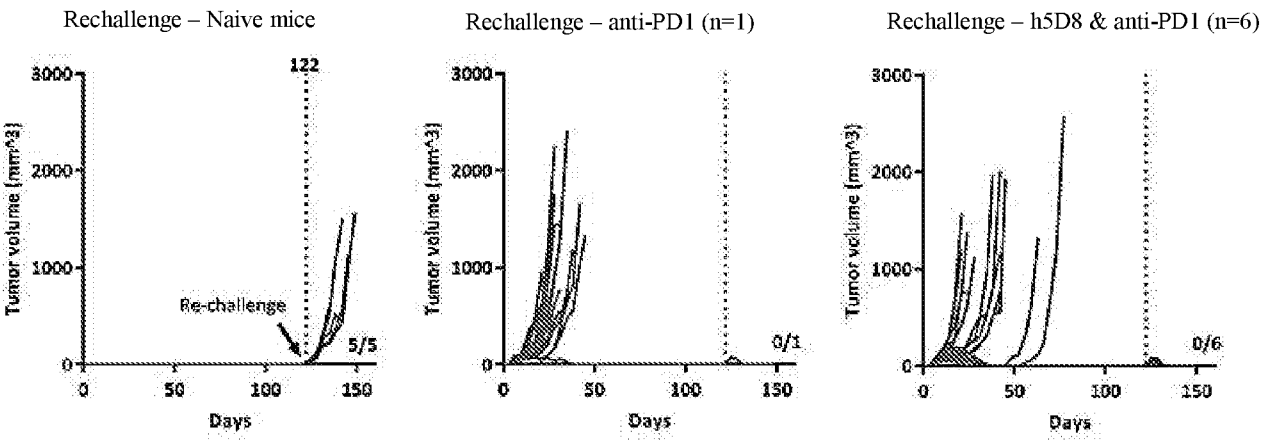



Fig. 18D

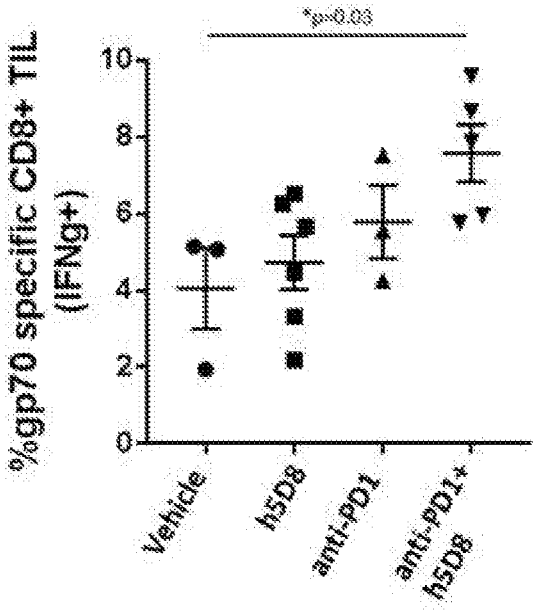



Fig. 19A

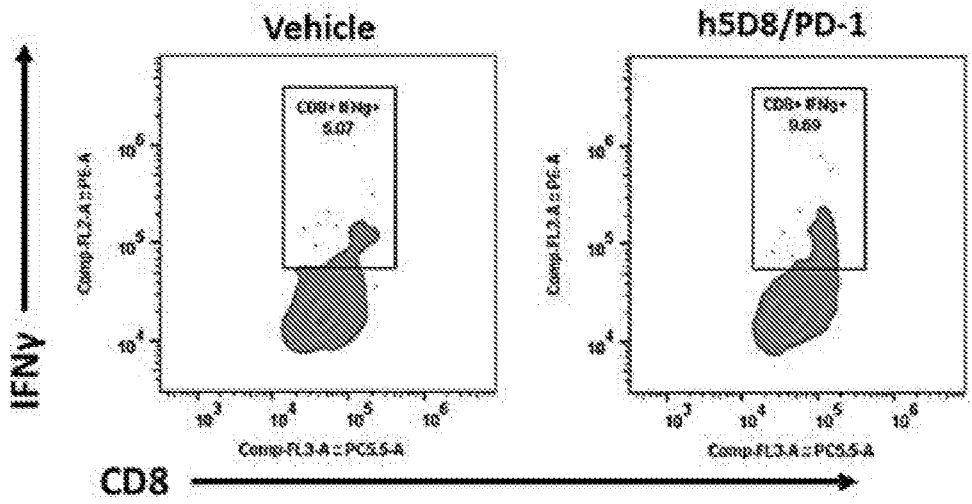



Fig. 19B

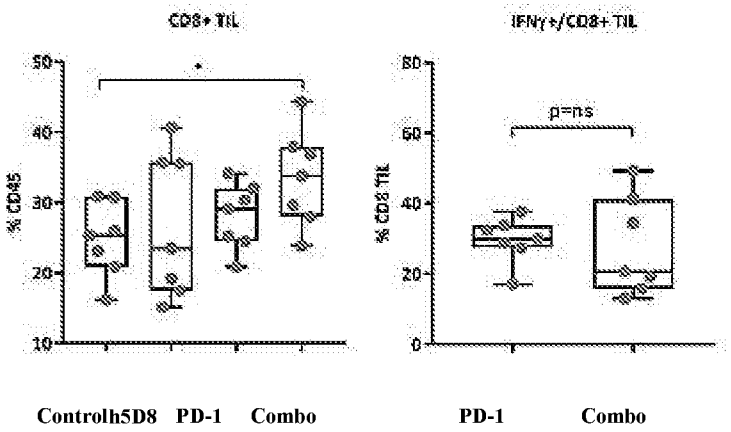



Fig. 19C

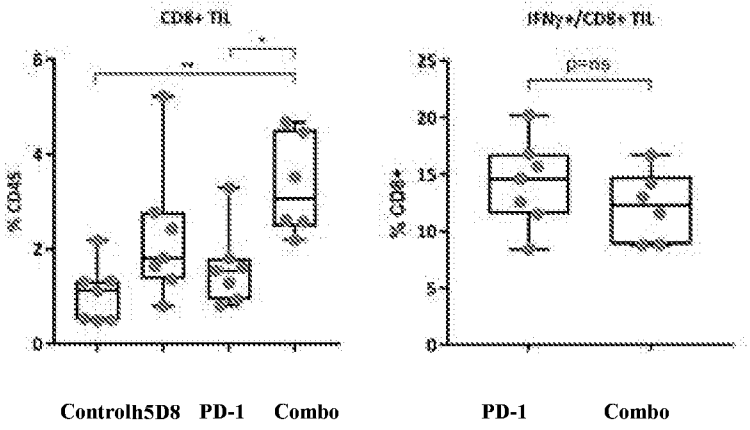



Fig. 19D

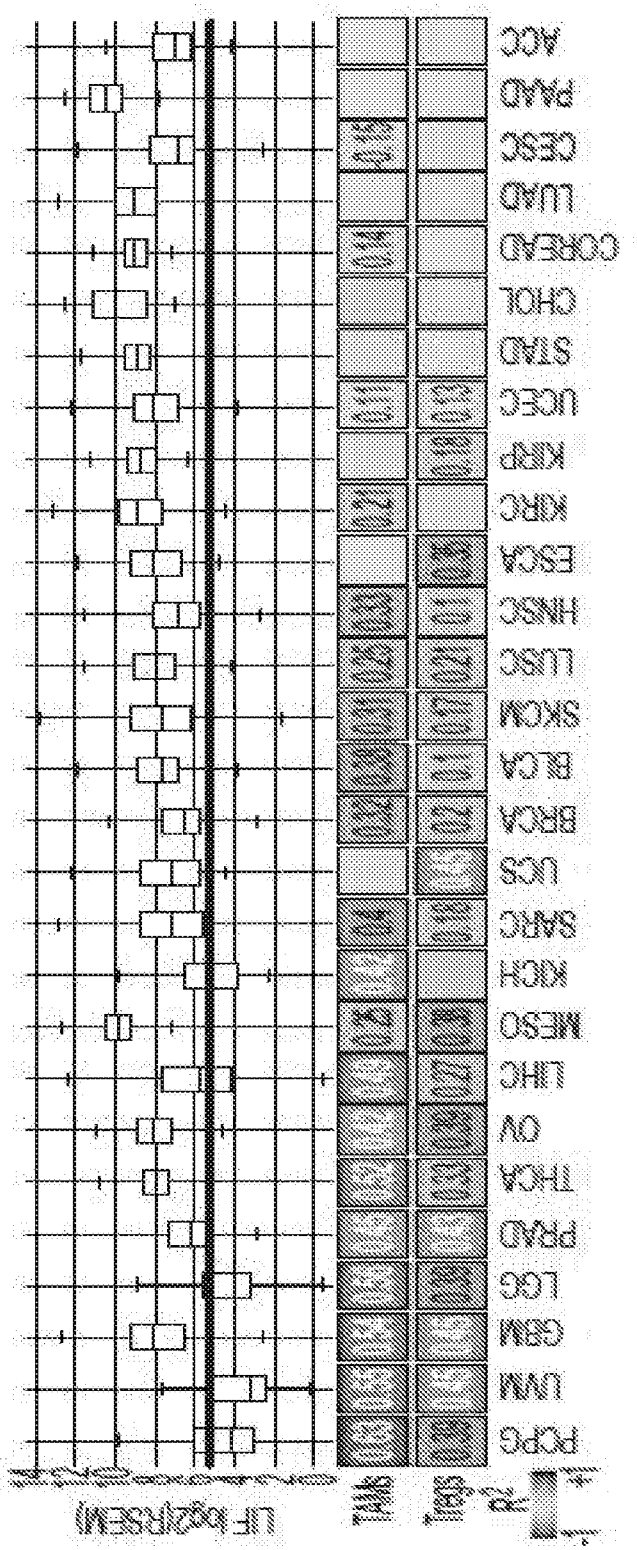

ACC
PAAD
CESC
LUAD
COREAD
CHOL
STAD
UCEC
KIRP
KIRC
ESCA
HNSC
LUSC
SKCM
BLCA
BRCA
UCS
SARC
KICH
MESO
LIHC
OV
THCA
PRAD
LGG
GBM
UVM
PCPG

Fig. 20A

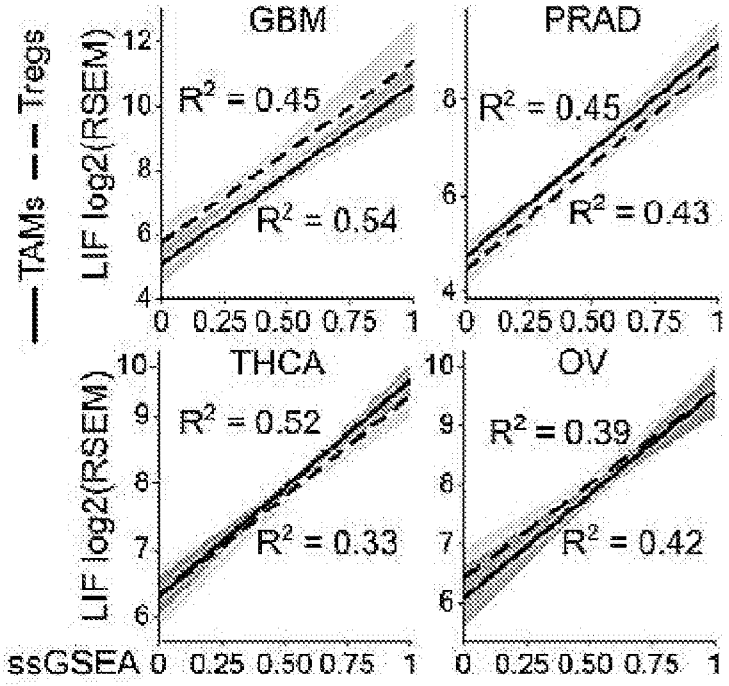



**Fig. 20B**

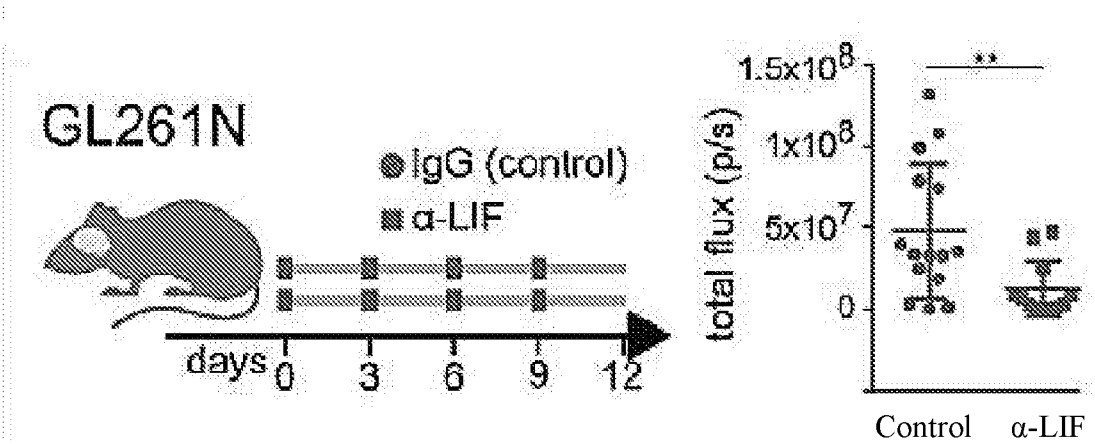



**Fig. 20C**

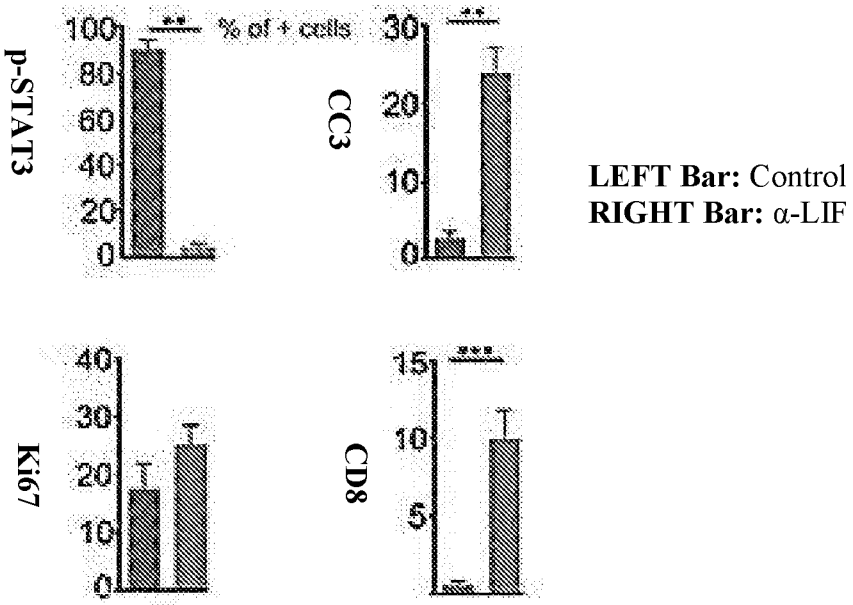



Fig. 20D

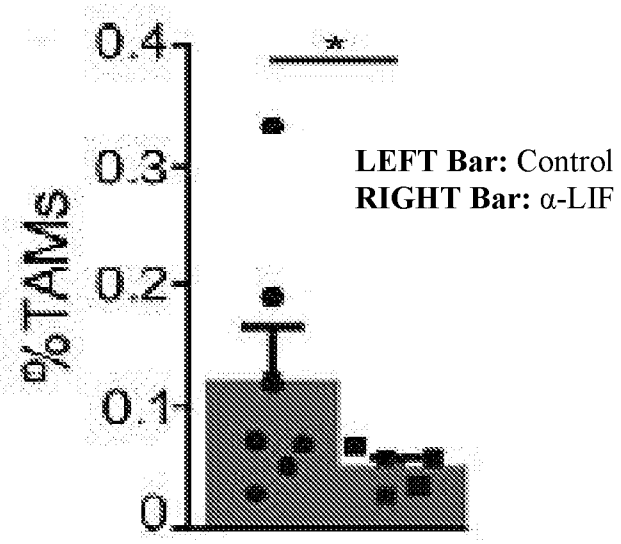



Fig. 20E

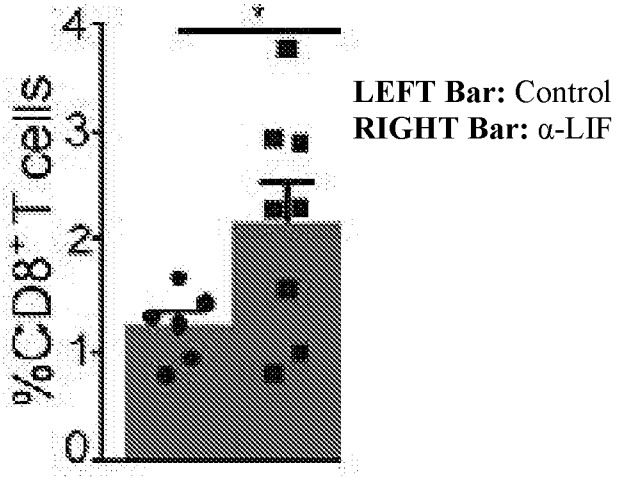



Fig. 20F

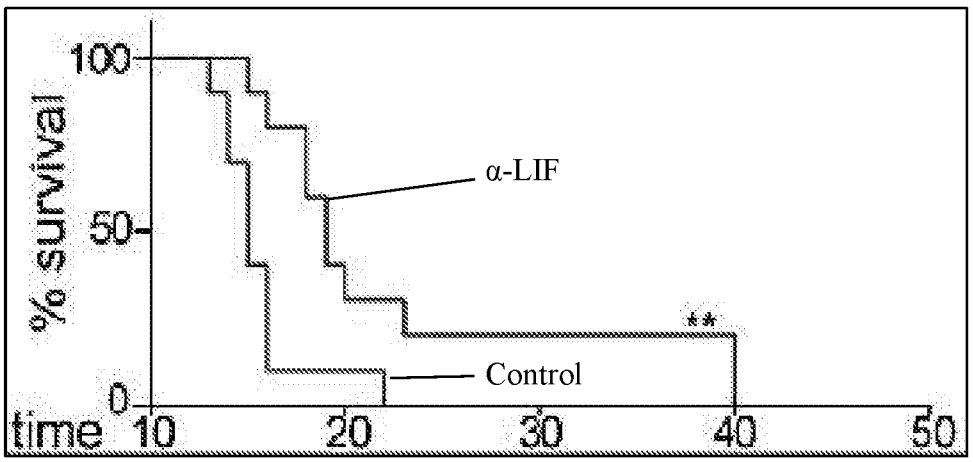



Fig. 20G

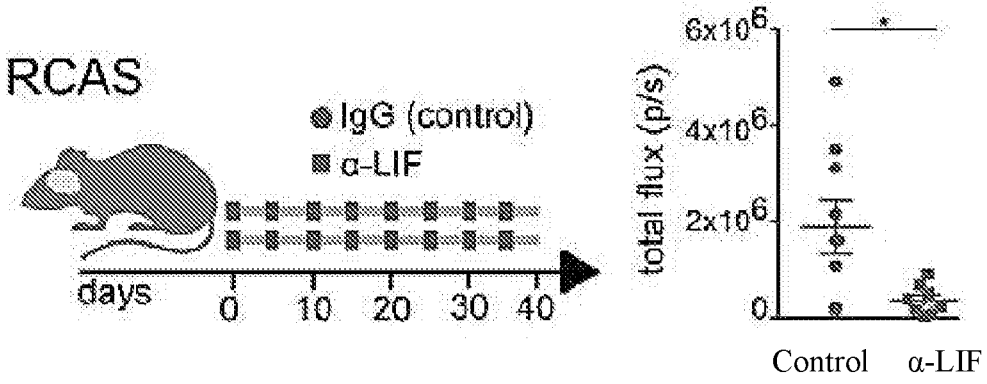



**Fig. 20H**

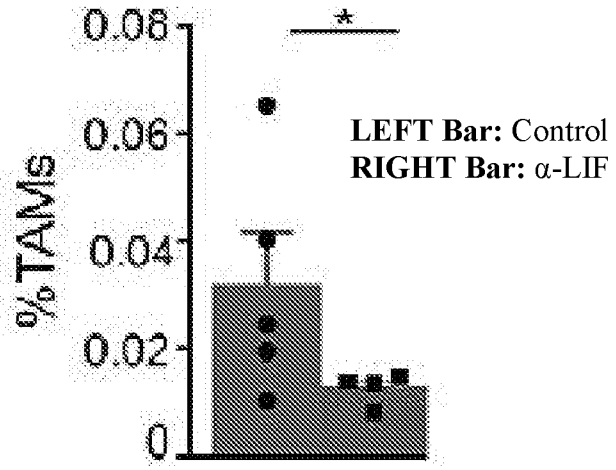



**Fig. 20I**

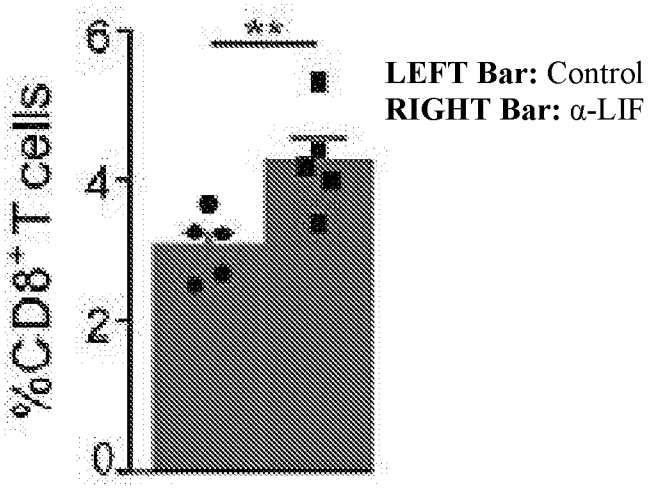



Fig. 20J

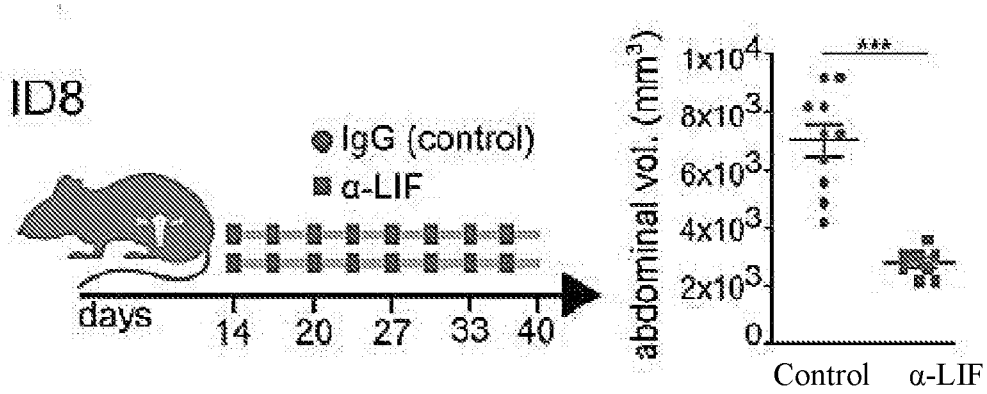



Fig. 20K

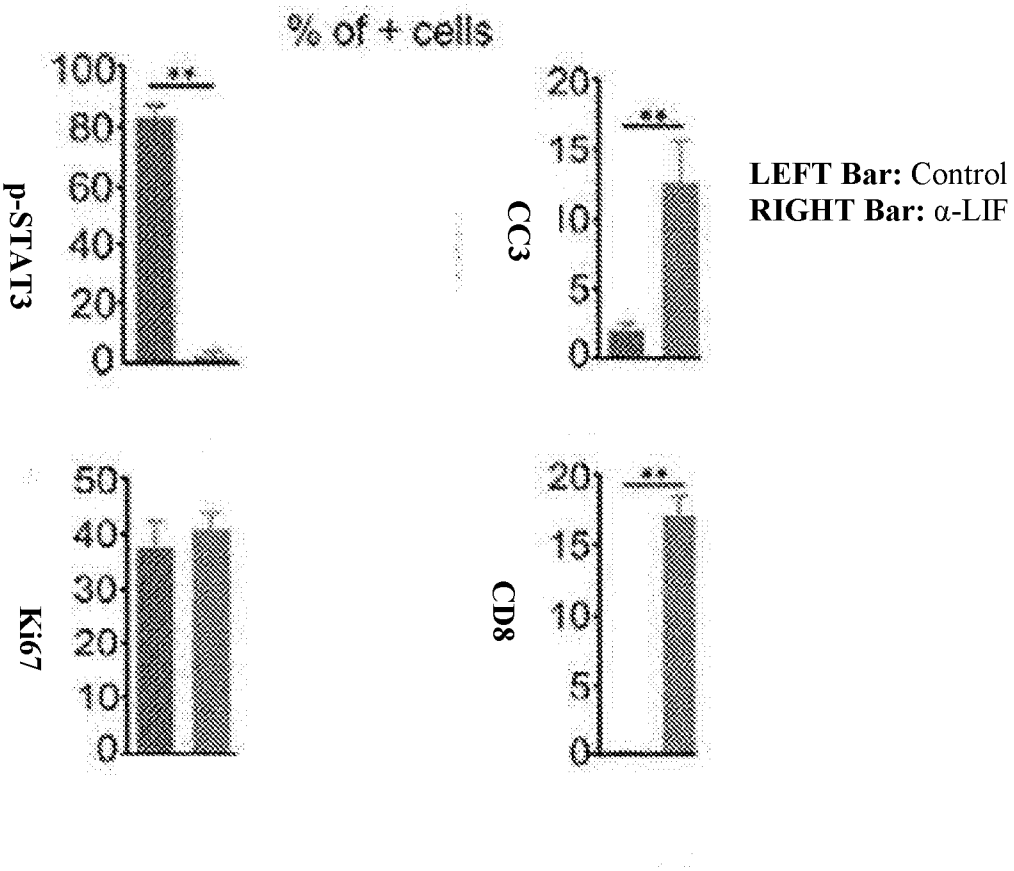



Fig. 20L

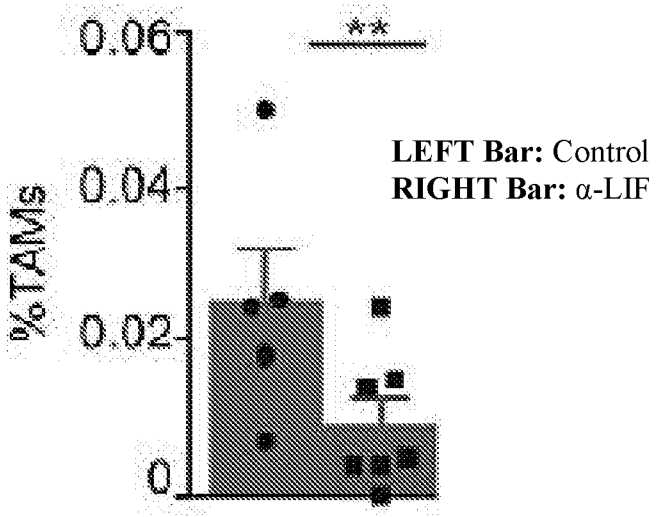



Fig. 20M

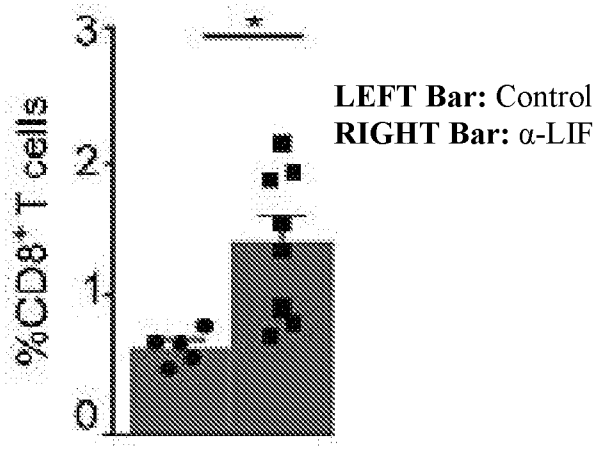



Fig. 20N

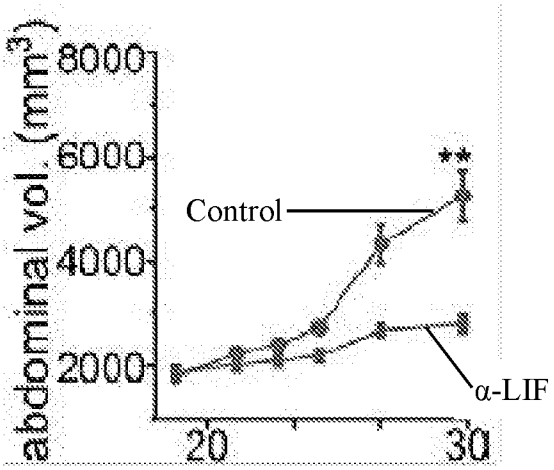



Fig. 20O

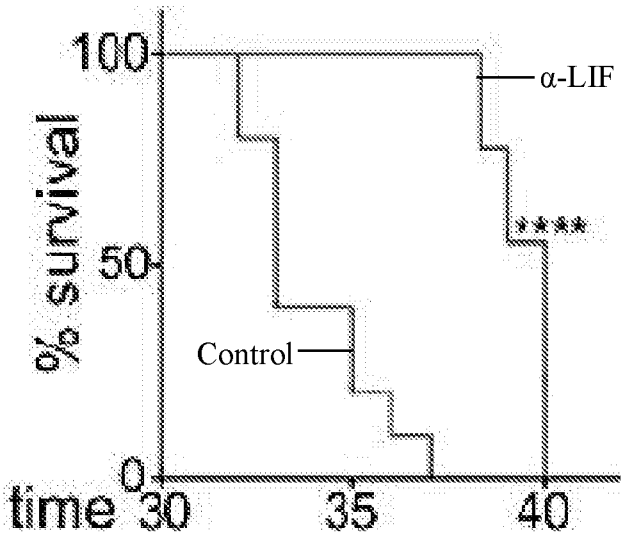



**Fig. 20P**

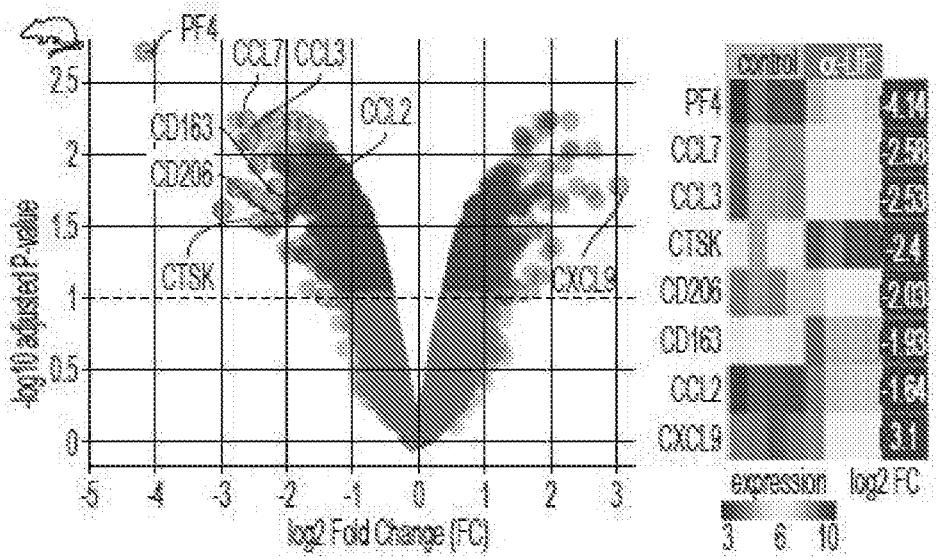



Fig. 21A

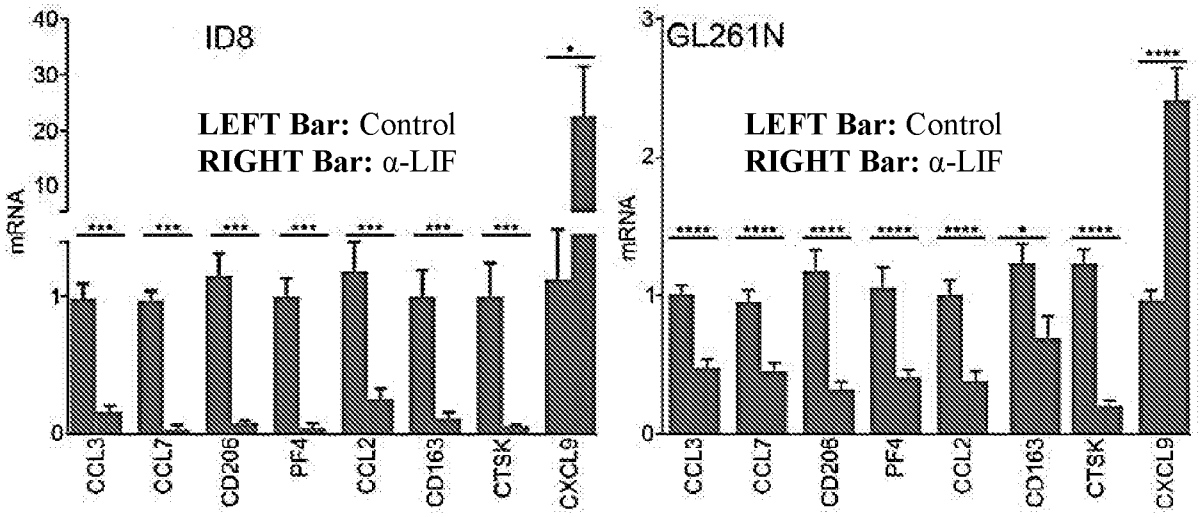



Fig. 21B

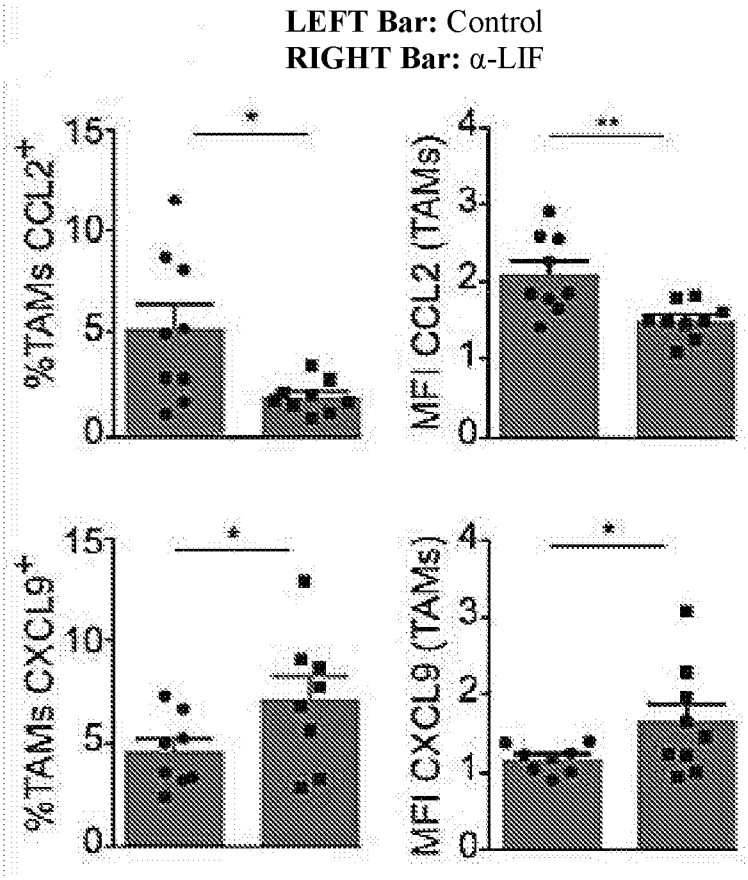

LEFT Bar: Control
RIGHT Bar: α-LIF
%TAMs CCL2+
MFI CCL2 (TAMs)
%TAMs CXCL9+
MFI CXCL9 (TAMs)
*
**
*
*
15
10
5
0
4
3
2
1
0

Fig. 21C

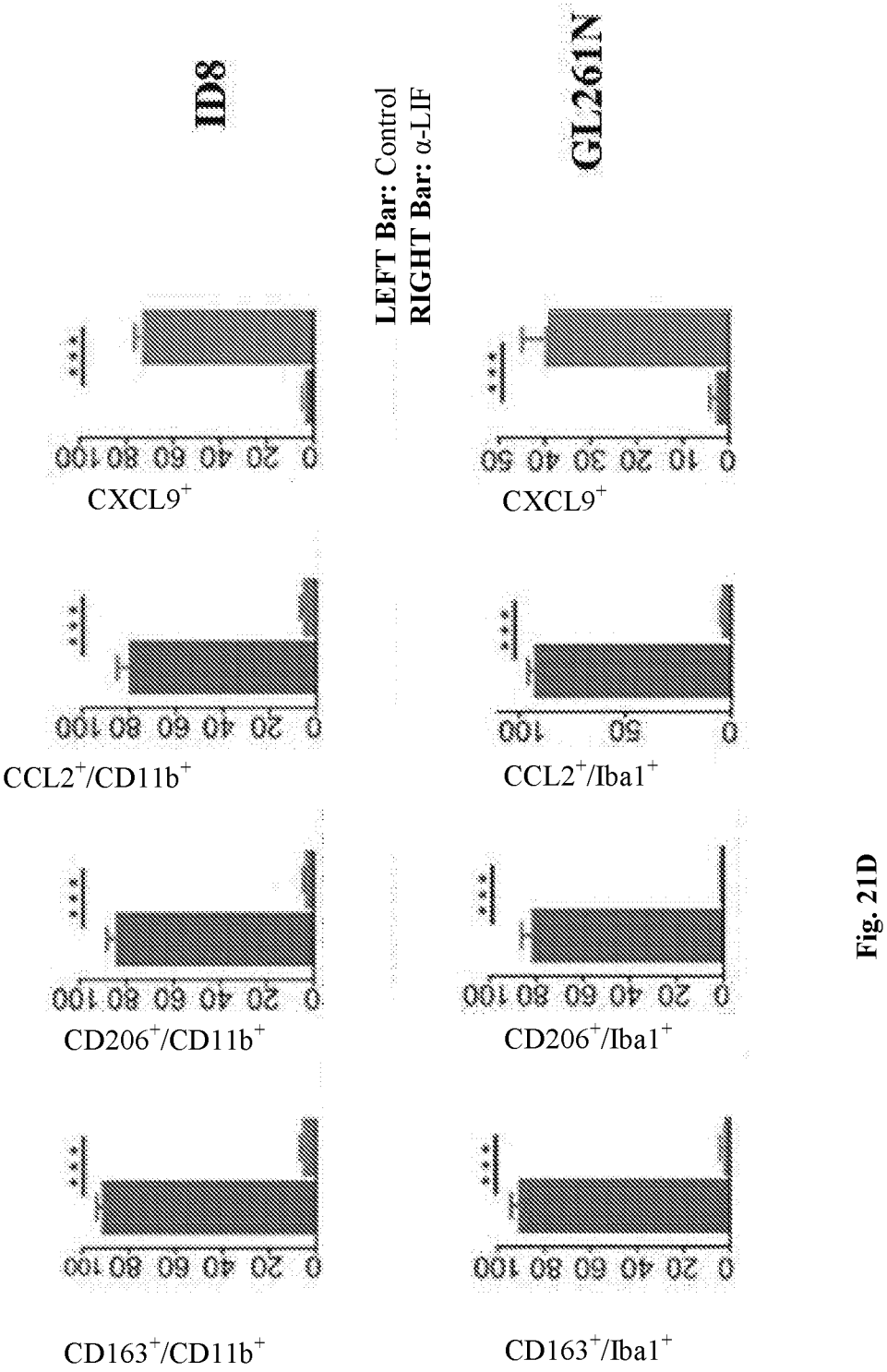

ID8
GL261N
LEFT Bar: Control
RIGHT Bar: α-LIF
CXCL9+
CXCL9+
CCL2+/CD11b+
CCL2+/Iba1+
CD206+/CD11b+
CD206+/Iba1+
CD163+/CD11b+
CD163+/Iba1+

Fig. 21D

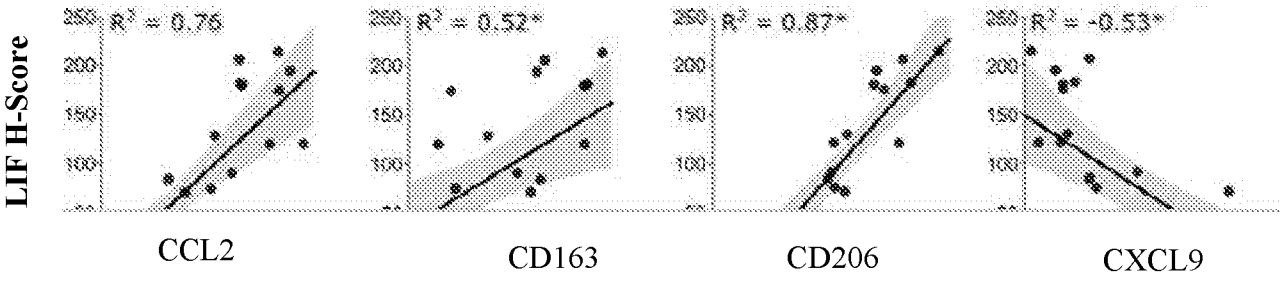



**Fig. 21E**

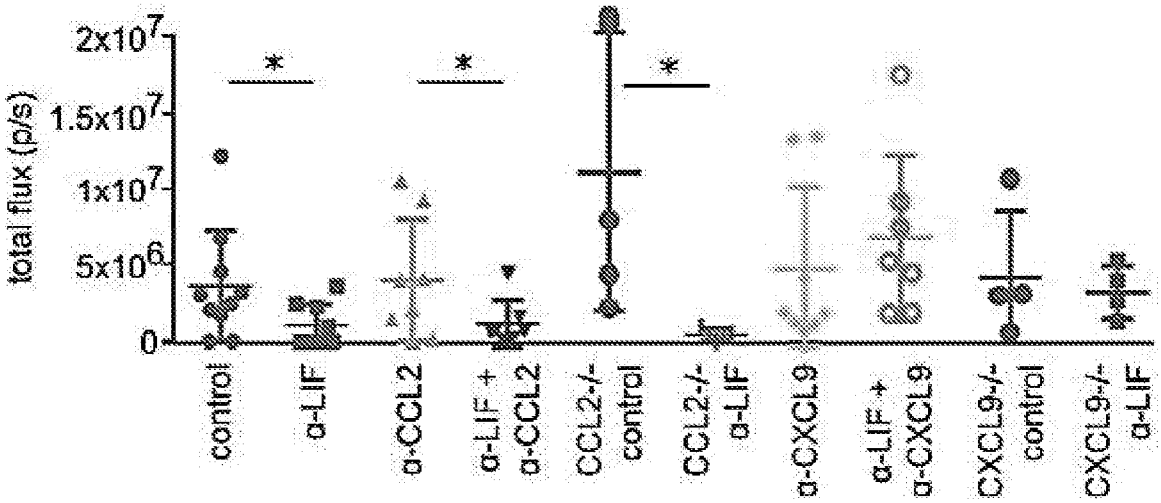



**Fig. 21F**

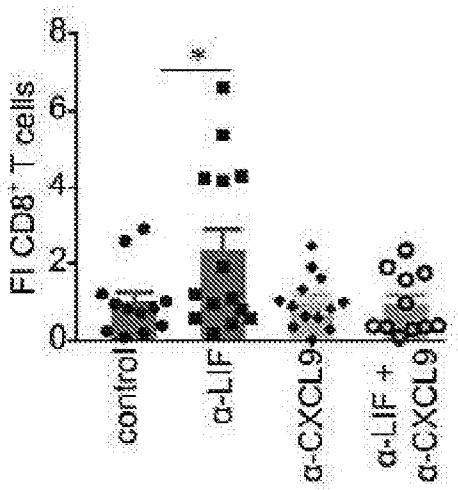



Fig. 21G

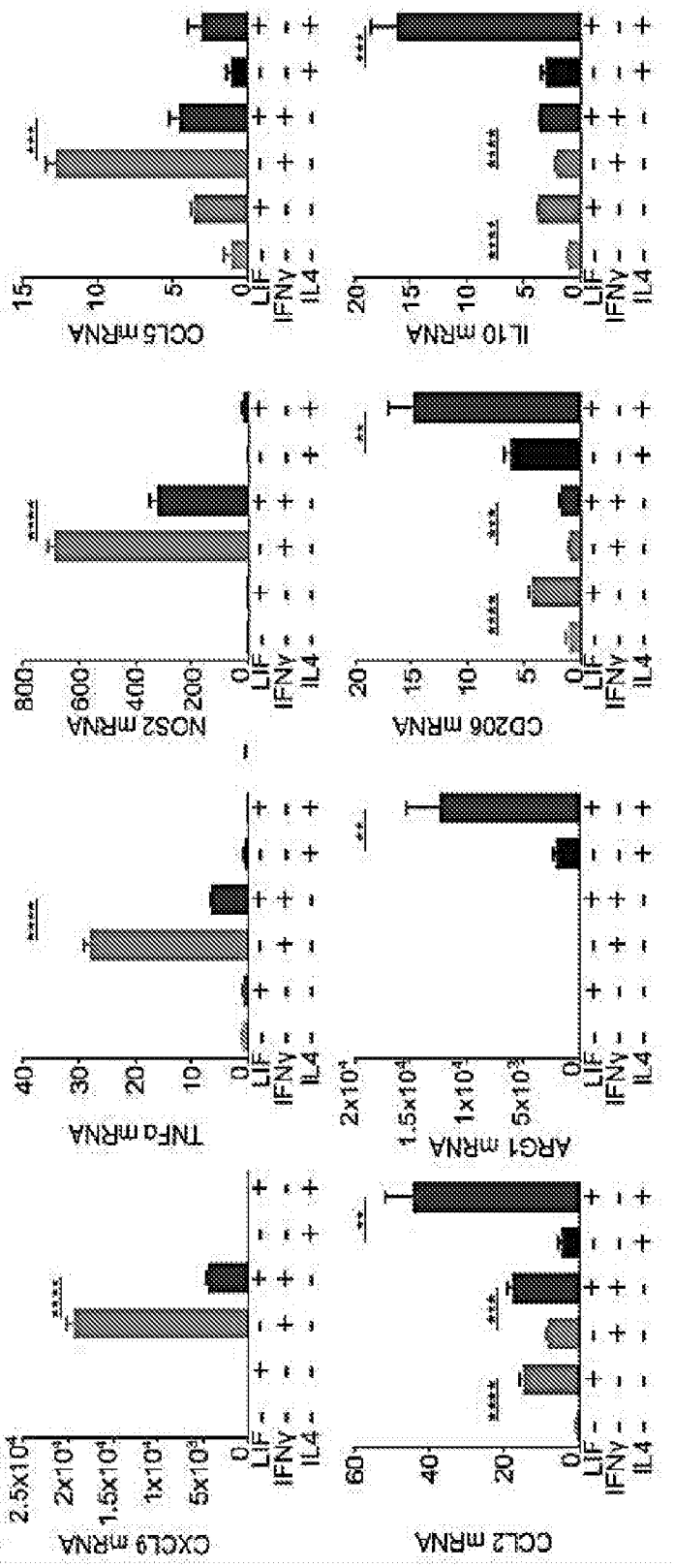

CXCL9 mRNA
CCL2 mRNA
TNFα mRNA
ARG1 mRNA
NOS2 mRNA
CD206 mRNA
CCL5 mRNA
IL10 mRNA
LIF
IFNγ
IL4

Fig. 22A

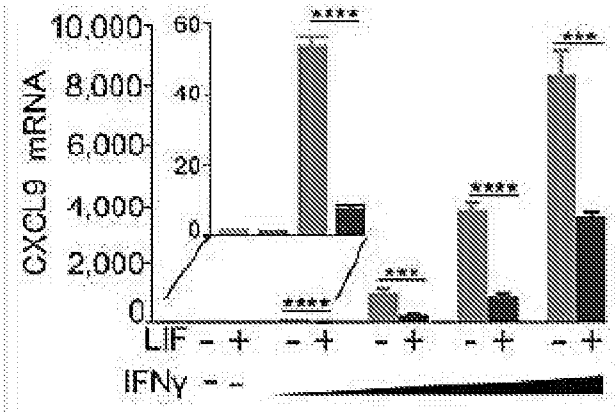



Fig. 22B

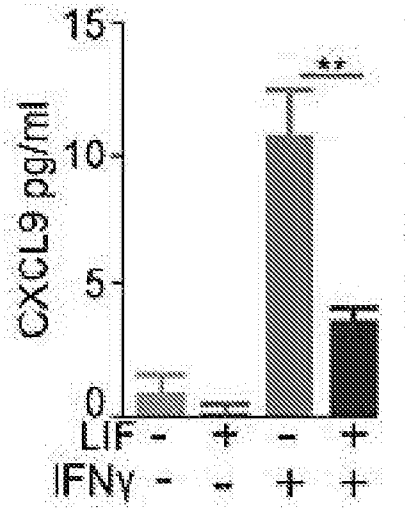



Fig. 22C

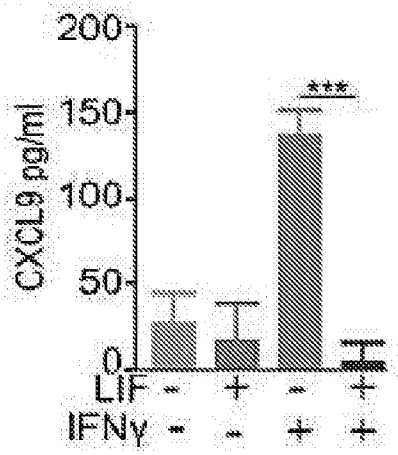



**Fig. 22D**

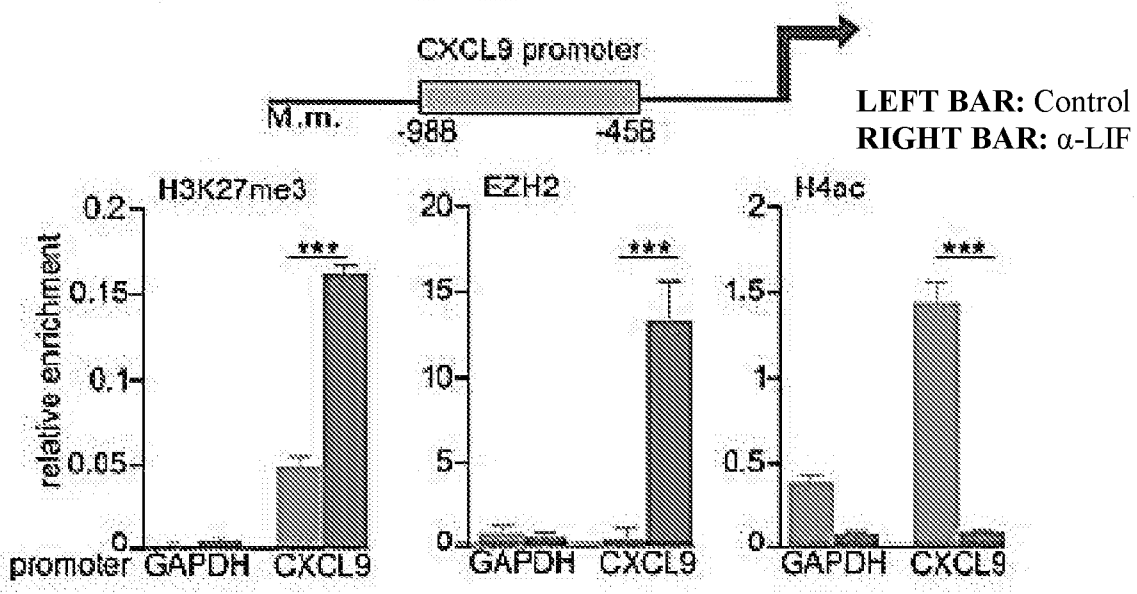



**Fig. 22E**

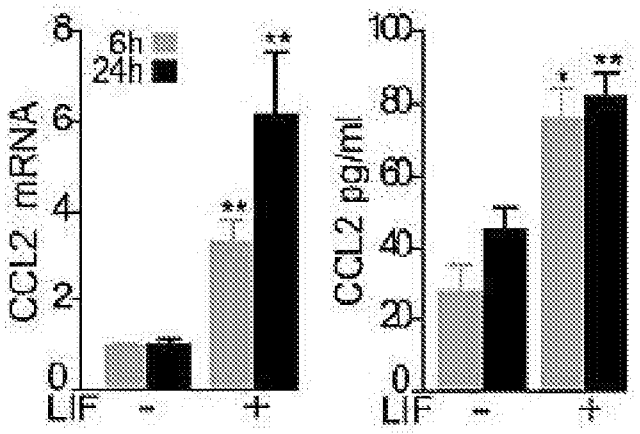



Fig. 22F

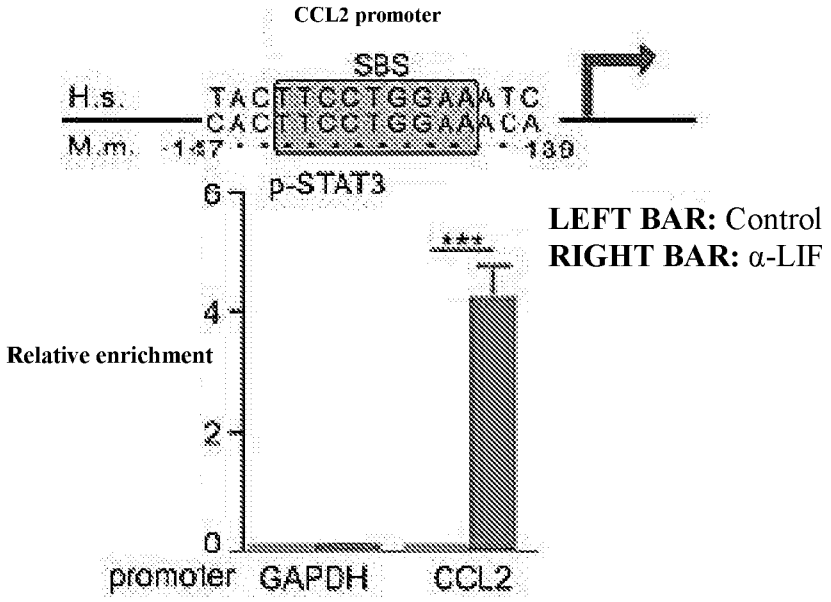



Fig. 22G

**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

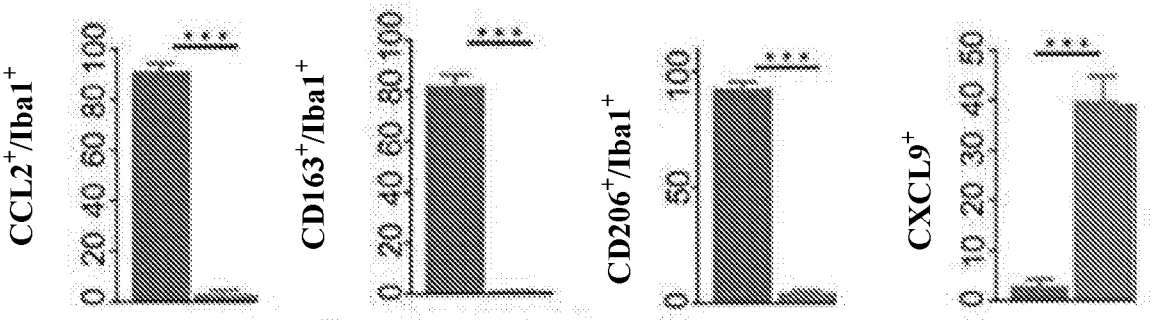



**Fig. 22H**

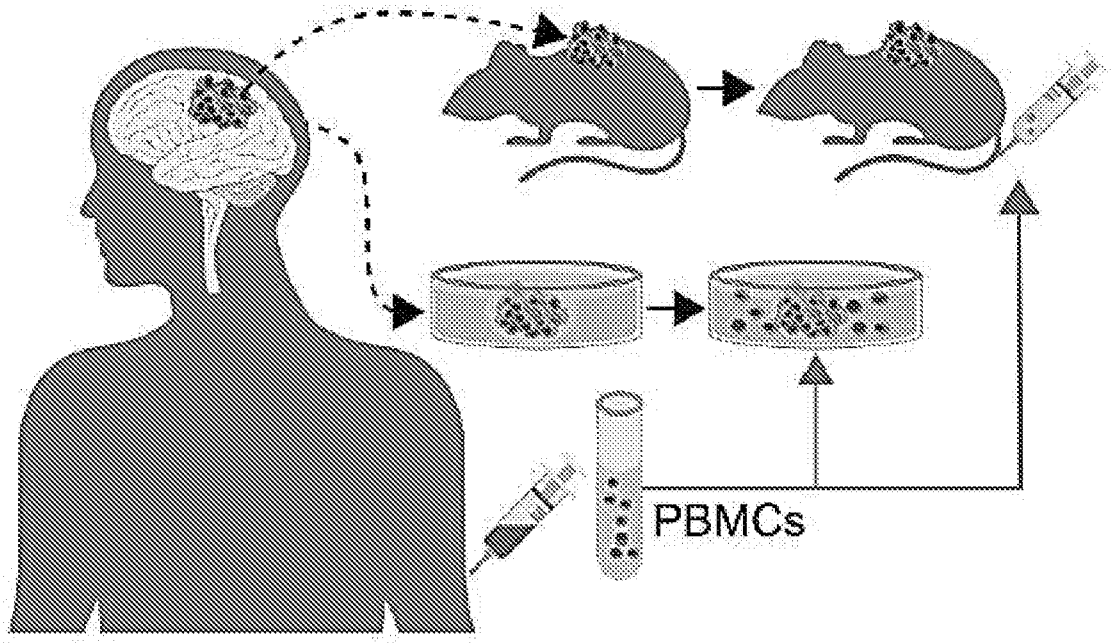



Fig. 23A

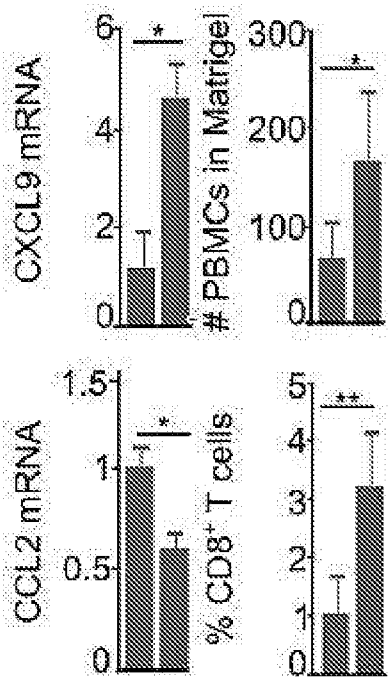
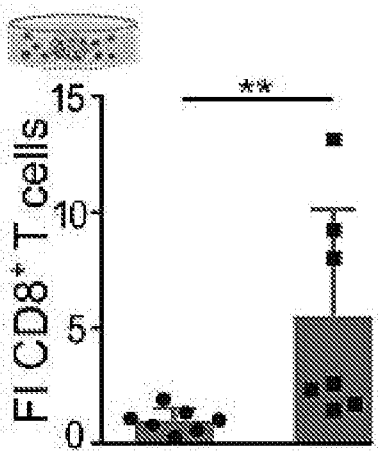
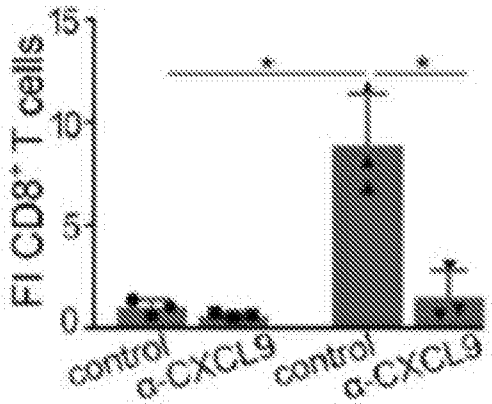

CXCL9 mRNA
# PBMCs in Matrigel
CCL2 mRNA
% CD8+ T cells
LEFT BAR: Control
RIGHT BAR: α-LIF

**Fig. 23B**




**LEFT BAR:** Control
**RIGHT BAR:** α-LIF

**Fig. 23C**




**LEFT BAR:** Control
**RIGHT BAR:** α-LIF

**Fig. 23D**

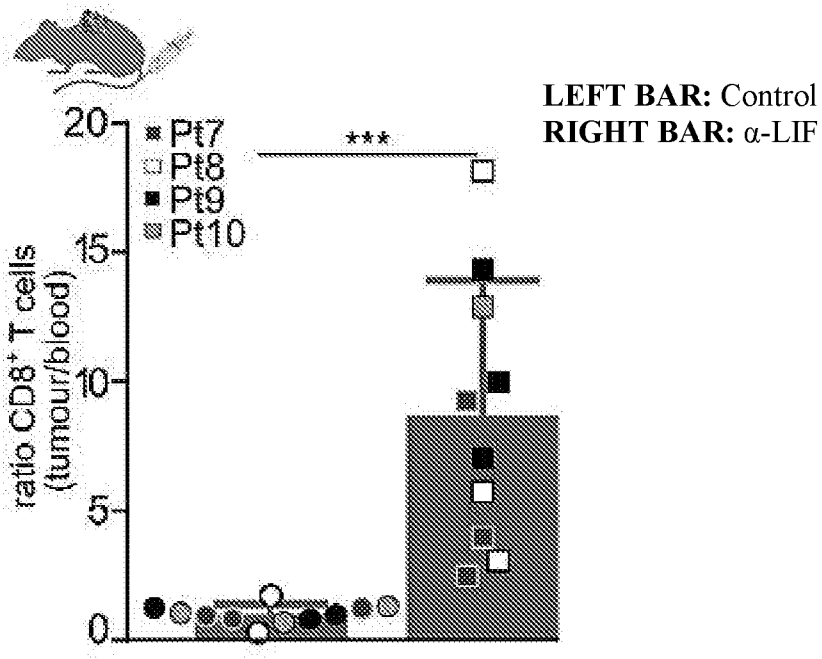

LEFT BAR: Control
RIGHT BAR: α-LIF
20
15
10
5
0
ratio CD8+ T cells (tumour/blood)
Pt7
Pt8
Pt9
Pt10
***

**Fig. 23E**

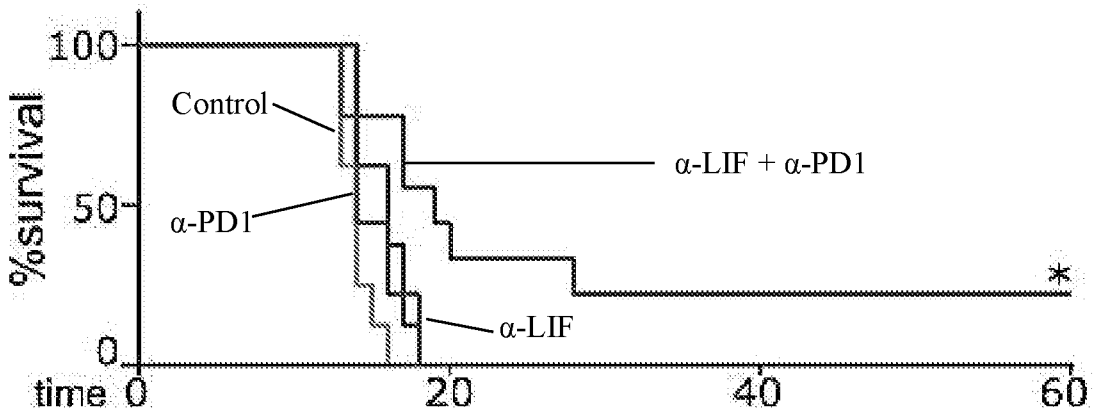



**Fig. 23F**

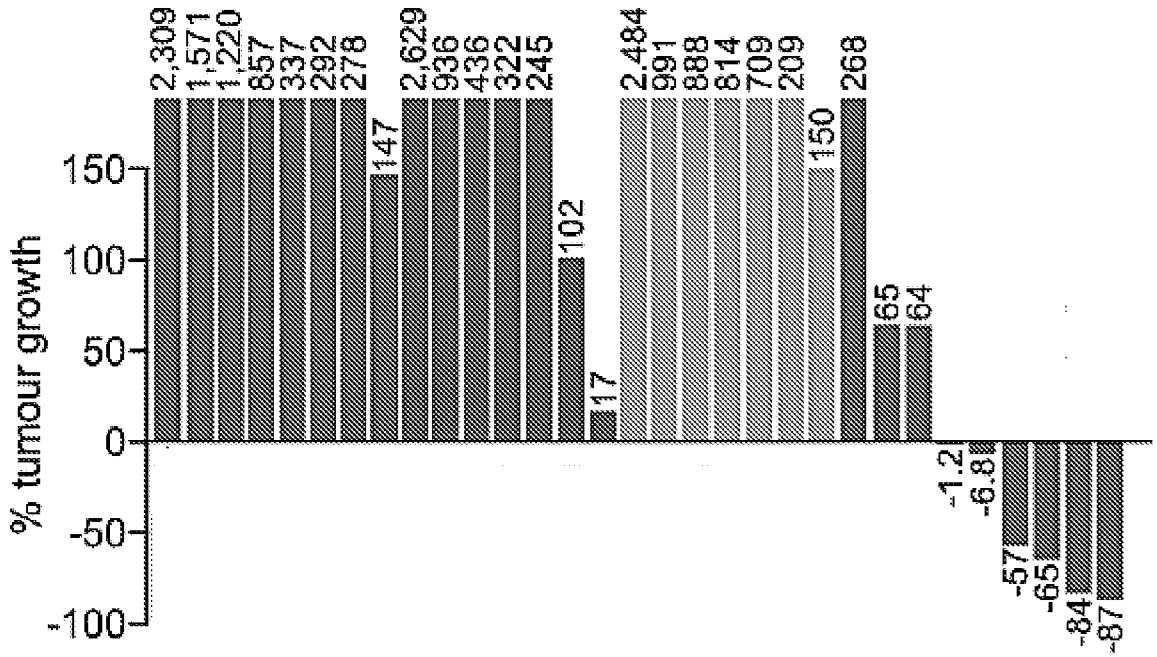



Fig. 23G

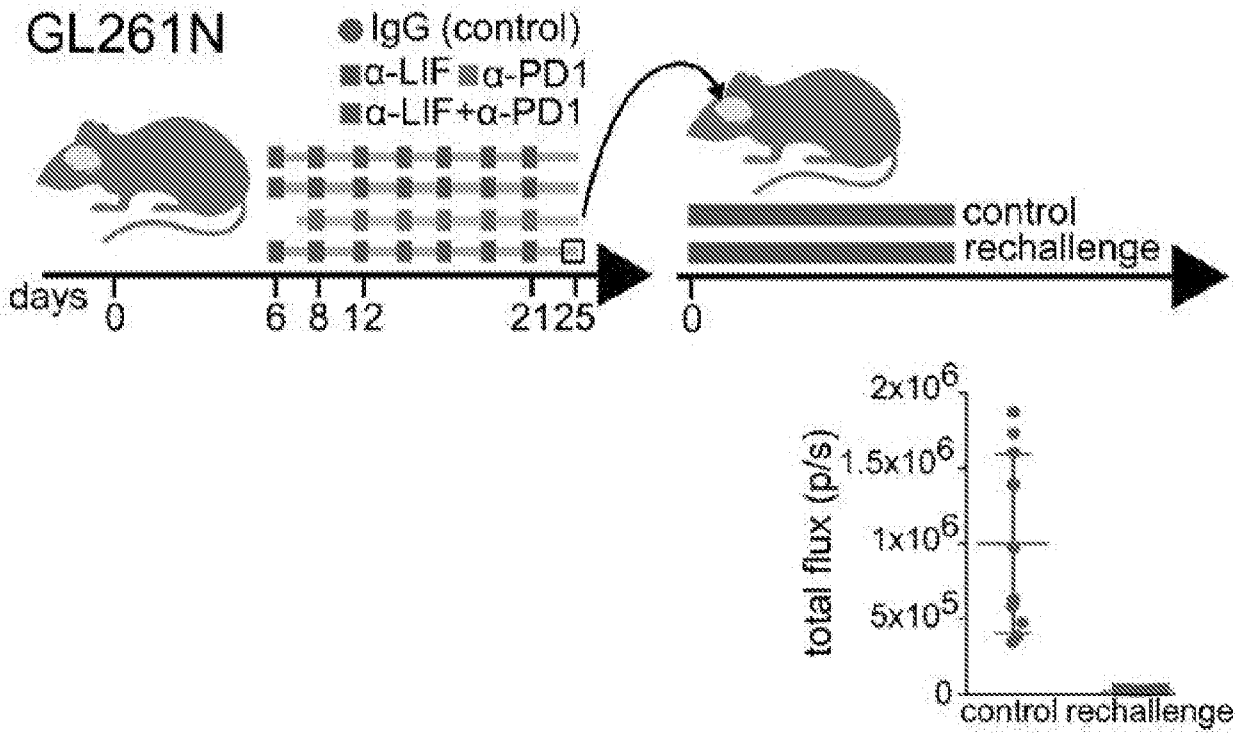



Fig. 23H

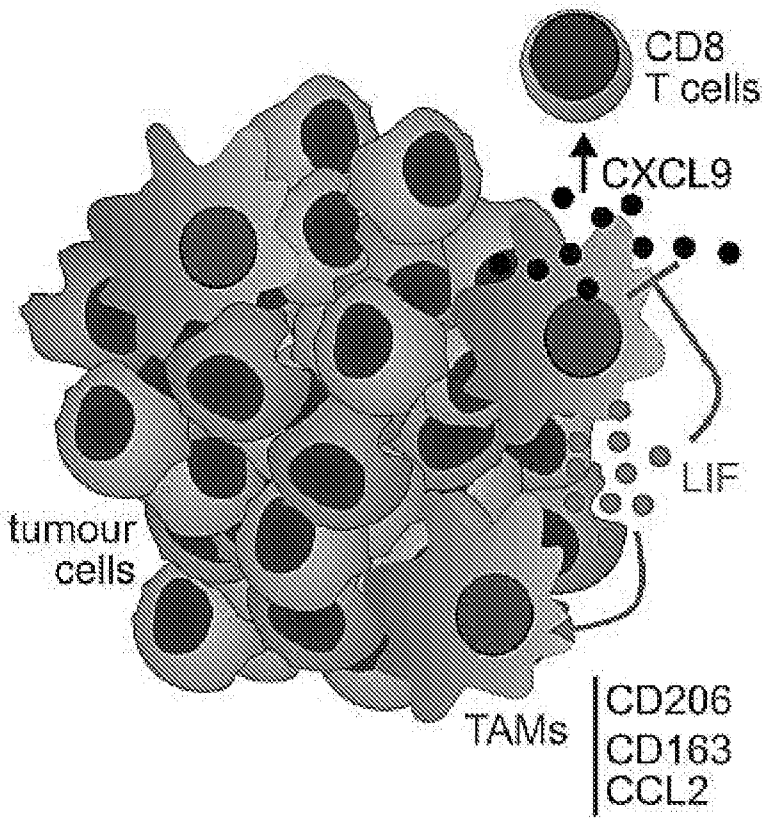



**Fig. 23I**

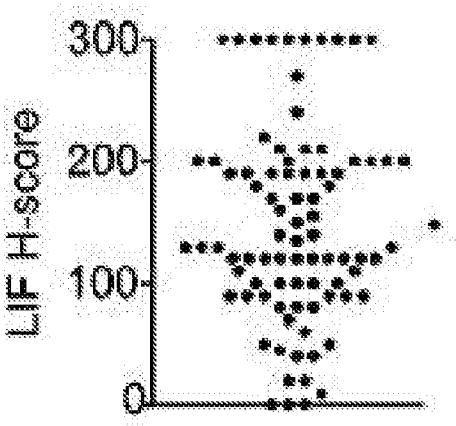



Fig. 24A

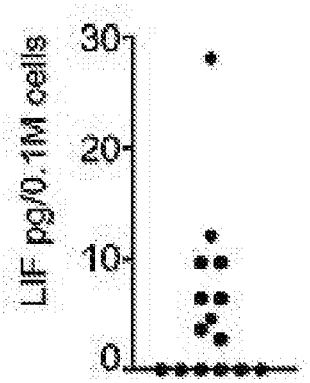



Fig. 24B

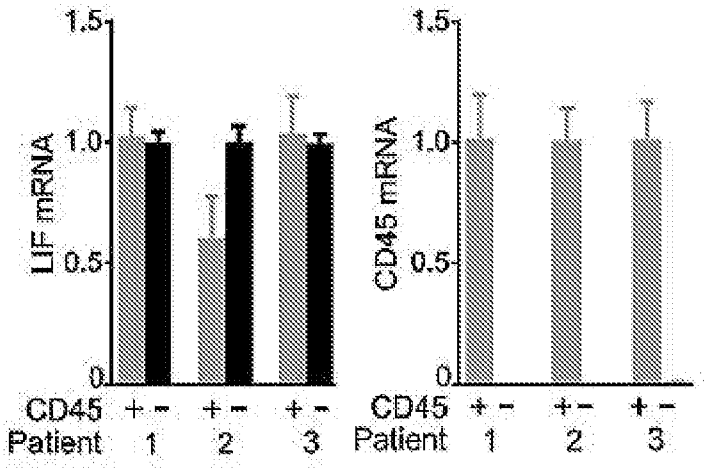



Fig. 24C

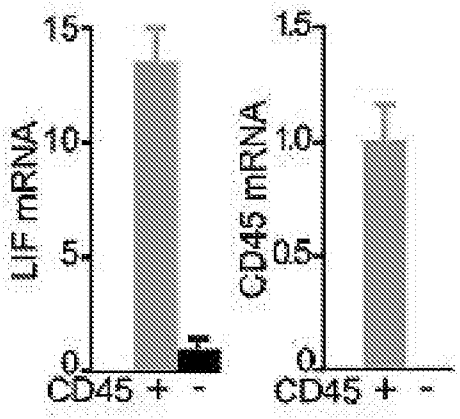



Fig. 24D

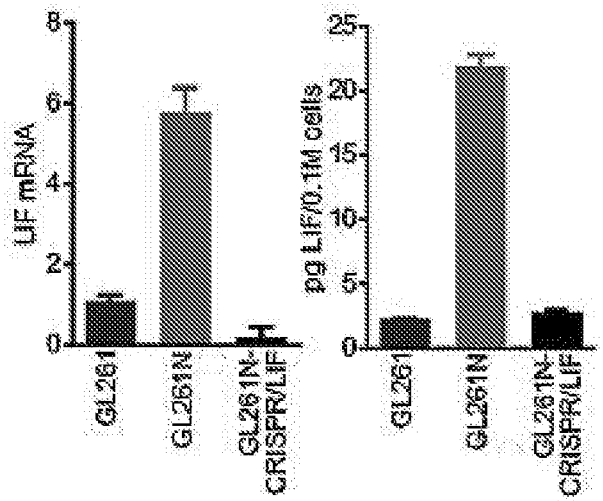



Fig. 25A

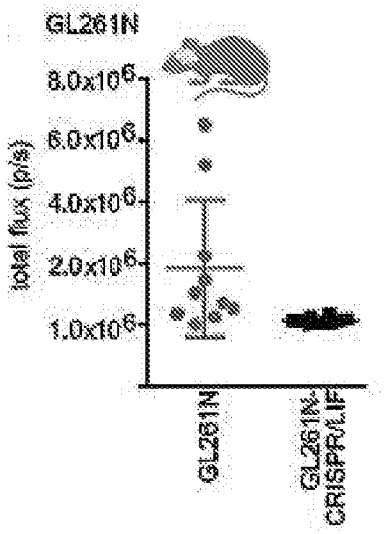



Fig. 25B

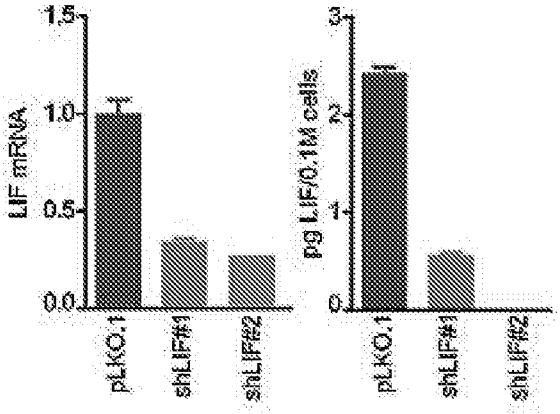



Fig. 25C

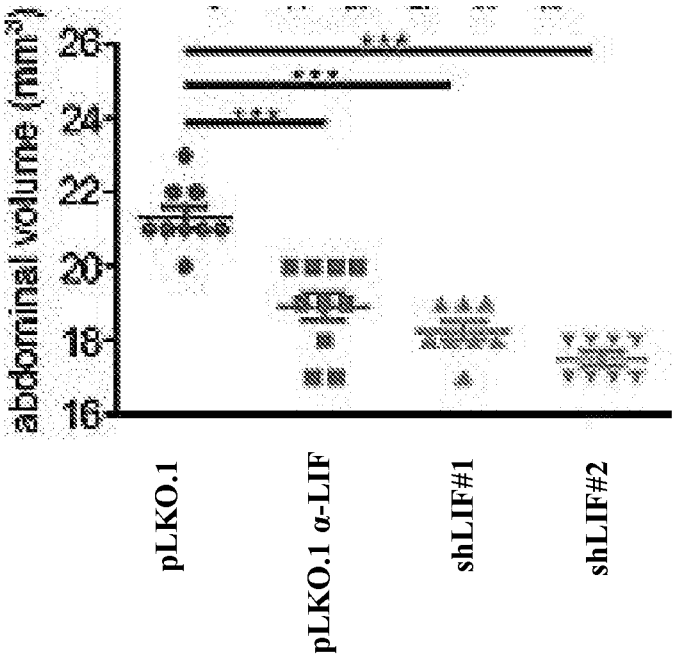



Fig. 25D

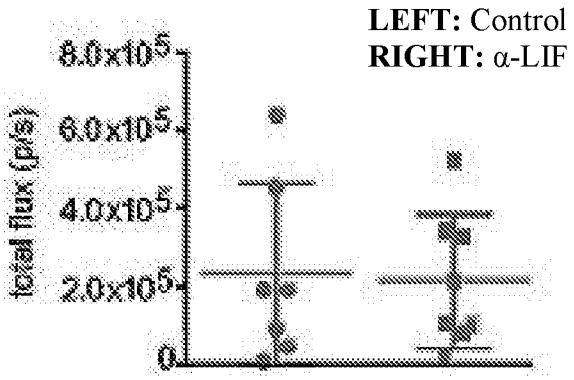



Fig. 25E

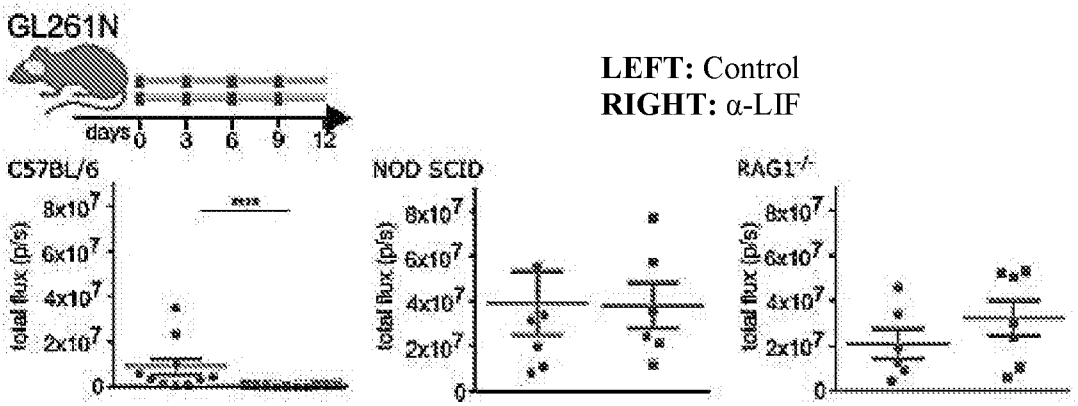



Fig. 25F

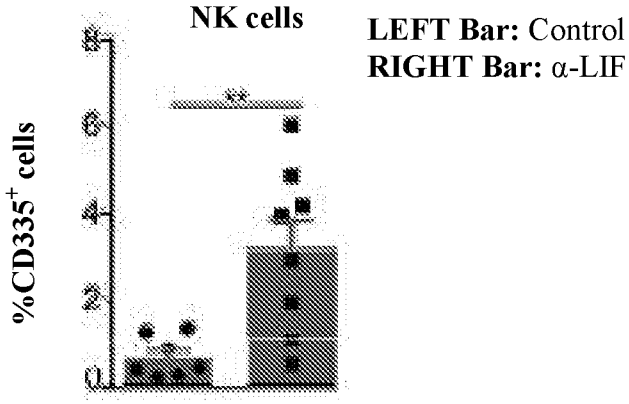



Fig. 25G

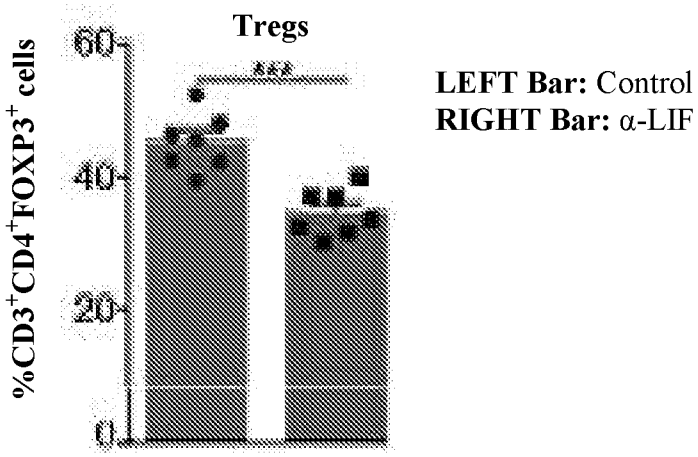
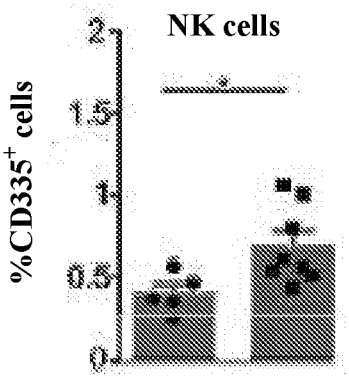
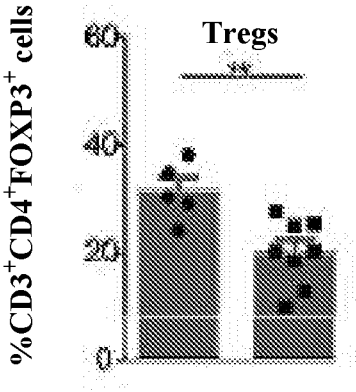



Fig. 25H



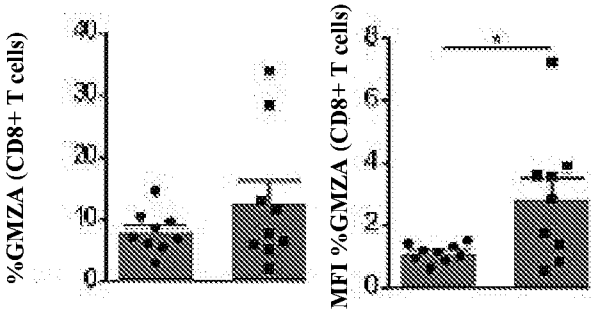

**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

**Fig. 25I**




**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

**Fig. 25J**




**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

**Fig. 26A**

**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

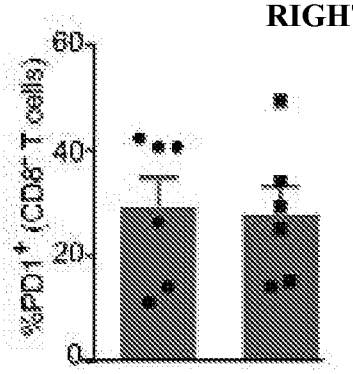
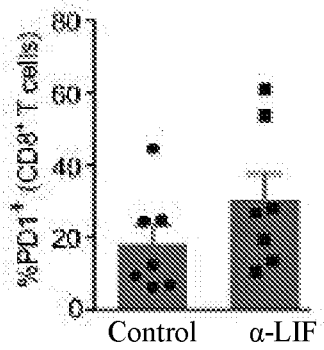
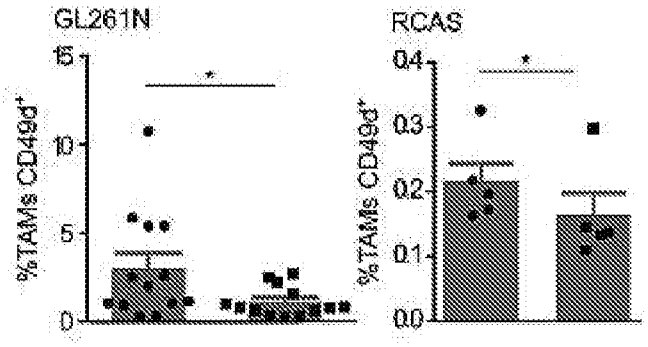



**Fig. 26B**




**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

**Fig. 26C**




**LEFT Bar:** Control
**RIGHT Bar:** α-LIF

**Fig. 26D**

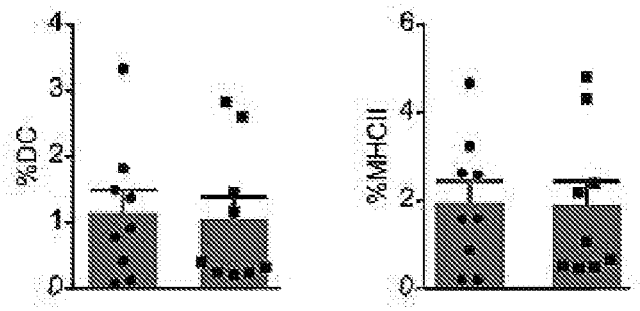



Fig. 26E

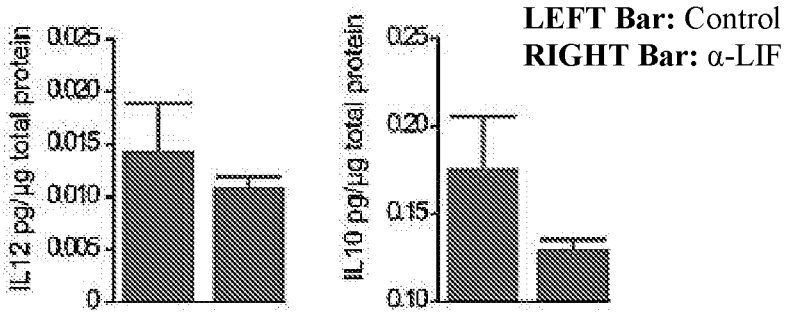



Fig. 26F

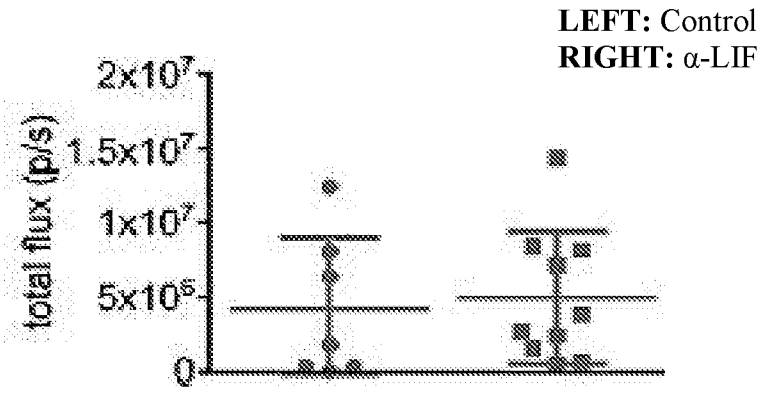



Fig. 26G

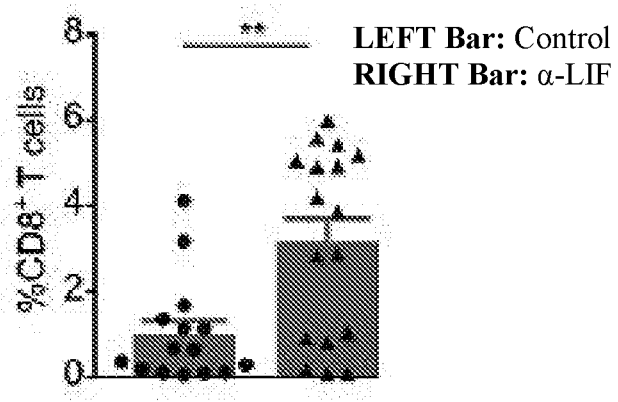



Fig. 26H

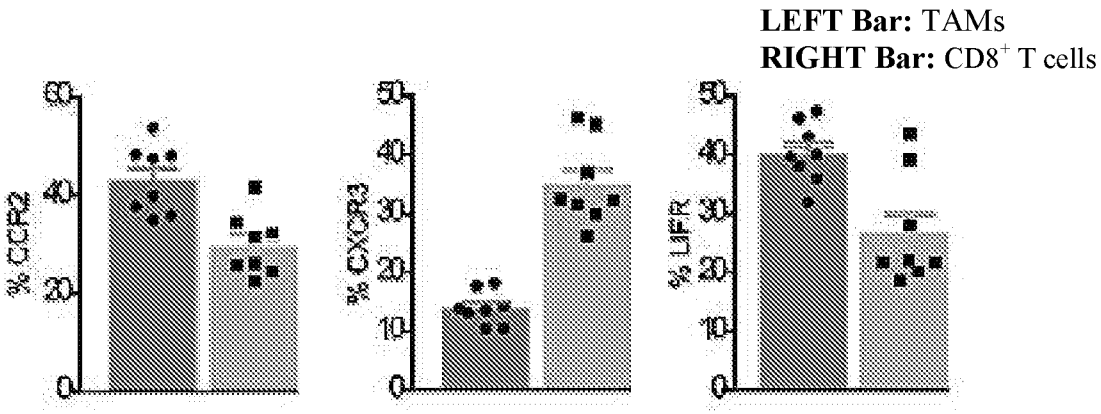



Fig. 27A

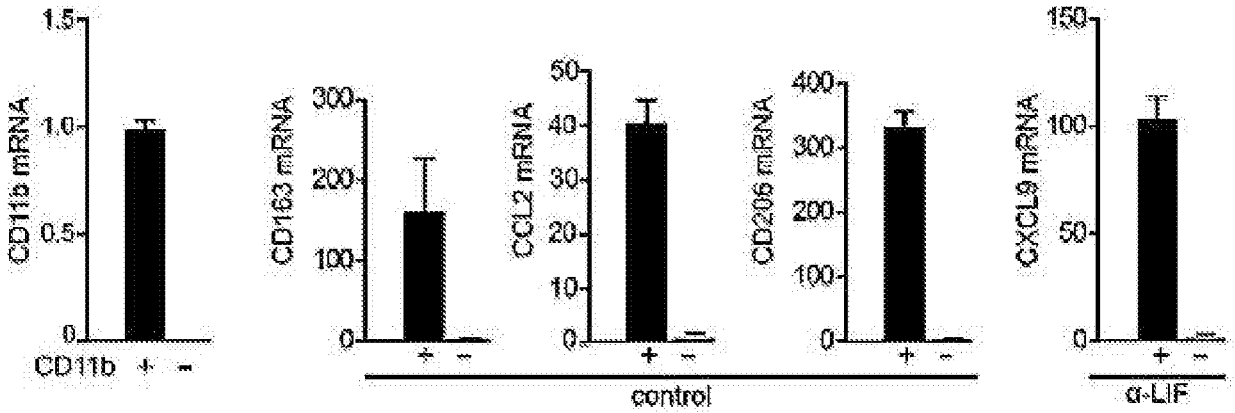



Fig. 27B

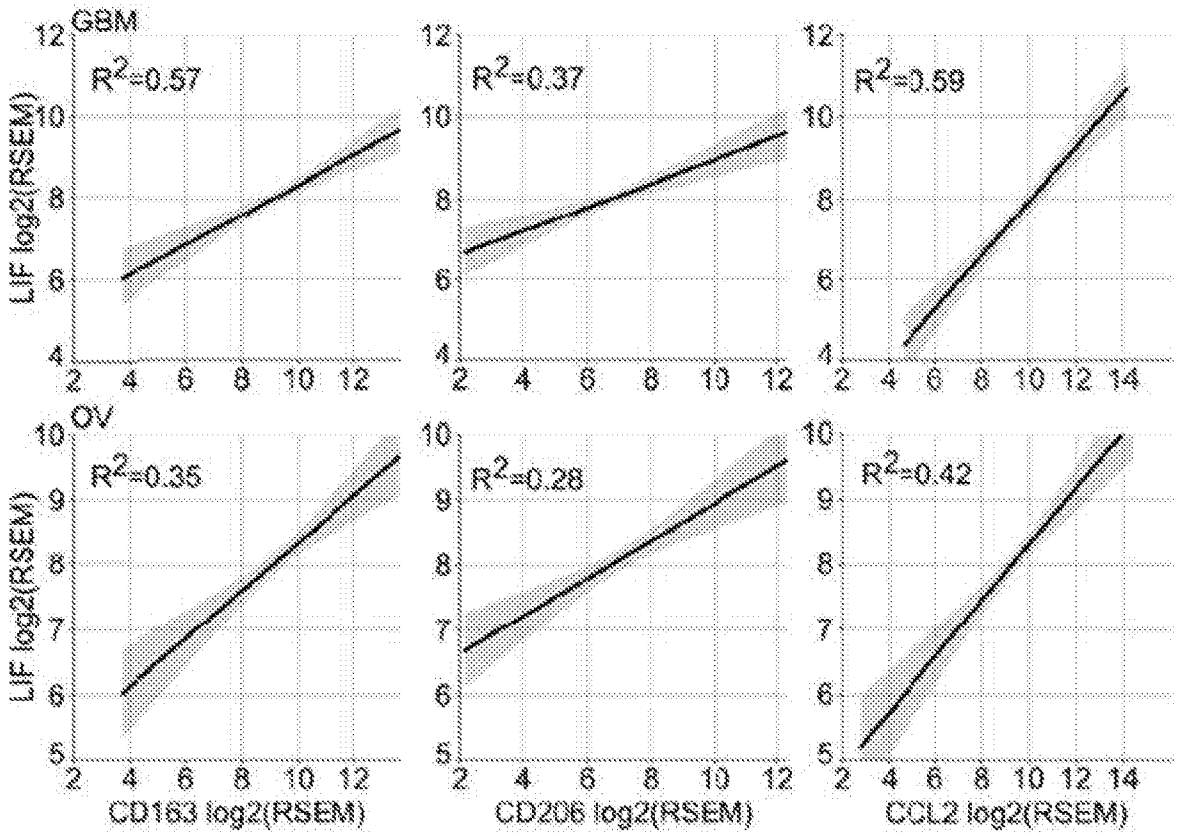

GBM
R2=0.57
R2=0.37
R2=0.59
OV
R2=0.35
R2=0.28
R2=0.42
LIF log2(RSEM)
LIF log2(RSEM)
CD163 log2(RSEM)
CD206 log2(RSEM)
CCL2 log2(RSEM)

**Fig. 28**

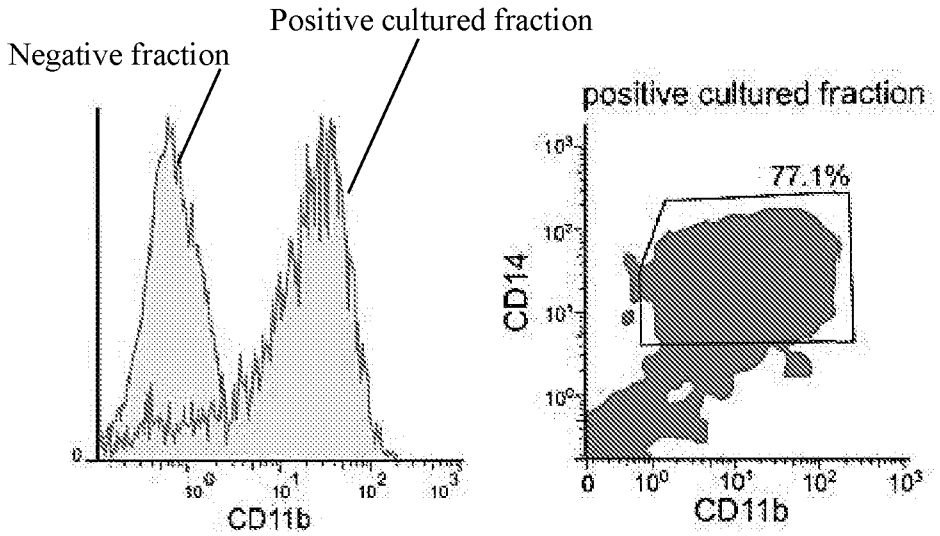



Fig. 29A

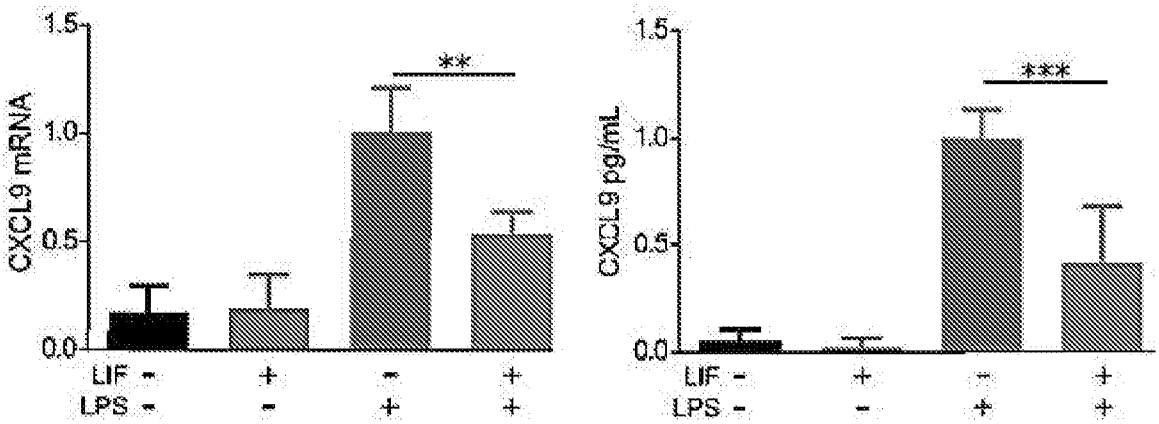



Fig. 29B

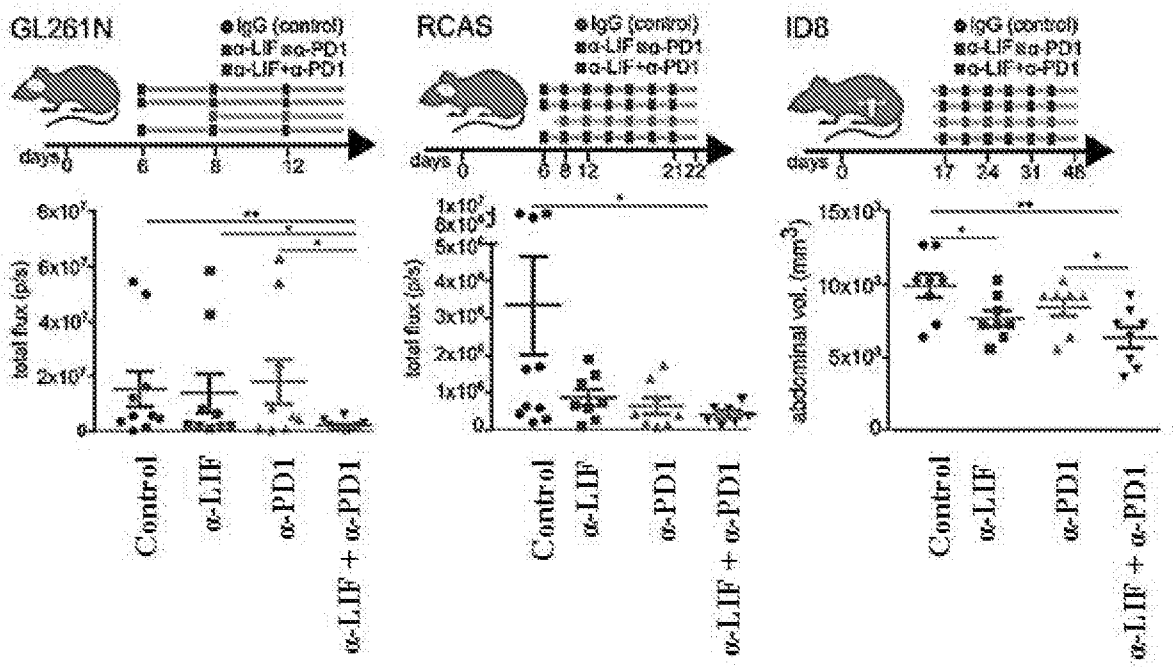

GL261N
RCAS
ID8
IgG (control)
α-LIF
α-PD1
α-LIF+α-PD1
days
total flux (p/s)
abdominal vol. (mm³)
Control
α-LIF
α-PD1
α-LIF + α-PD1

**Fig. 30**