# COMBINATION THERAPY COMPRISING OX40 BINDING AGONISTS AND PD-1 AXIS BINDING ANTAGONISTS

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims the priority benefit of U.S. Provisional Application Serial Nos. 61/917,264, filed December 17, 2013, and 62/080,991, filed November 17, 2014, each of which is incorporated herein by reference in its entirety.

## SUBMISSION OF SEQUENCE LISTING ON ASCII TEXT FILE

**[0002]** The content of the following submission on ASCII text file is incorporated herein by reference in its entirety: a computer readable form (CRF) of the Sequence Listing (file name: 146392030640SeqList.txt, date recorded: December 16, 2014, size: 72 KB).

## FIELD OF THE INVENTION

**[0003]** This invention relates to methods of treating cancers by administering a PD-1 axis binding antagonist and an OX40 binding agonist.

## BACKGROUND OF THE INVENTION

**[0004]** The provision of two distinct signals to T-cells is a widely accepted model for lymphocyte activation of resting T lymphocytes by antigen-presenting cells (APCs). Lafferty et al, Aust. J. Exp. Biol. Med. Sci 53: 27-42 (1975). This model further provides for the discrimination of self from non-self and immune tolerance. Bretscher et al, Science 169: 1042-1049 (1970); Bretscher, P.A., Proc. Nat. Acad. Sci. USA 96: 185-190 (1999); Jenkins et al, J. Exp. Med. 165: 302-319 (1987). The primary signal, or antigen specific signal, is transduced through the T- cell receptor (TCR) following recognition of foreign antigen peptide presented in the context of the major histocompatibility-complex (MHC). The second or co-stimulatory signal is delivered to T-cells by co-stimulatory molecules expressed on antigen-presenting cells (APCs), inducing T-cells to promote clonal expansion, cytokine secretion and effector function. Lenschow et al., Ann. Rev. Immunol. 14:233 (1996). In the absence of co-stimulation, T-cells can become refractory to antigen stimulation, do not mount an effective immune response, and further may result in exhaustion or tolerance to foreign antigens.

**[0005]** In the two-signal model T-cells receive both positive and negative secondary co-stimulatory signals. The regulation of such positive and negative signals is critical to maximize the host's protective immune responses, while maintaining immune tolerance and preventing autoimmunity. Negative secondary signals seem necessary for induction of T-cell tolerance, while positive signals promote T-cell activation. While the simple two-signal model still provides a valid explanation for

naive lymphocytes, a host's immune response is a dynamic process, and co- stimulatory signals can also be provided to antigen-exposed T-cells. The mechanism of co-stimulation is of therapeutic interest because the manipulation of co-stimulatory signals has shown to provide a means to either enhance or terminate cell-based immune response. Recently, it has been discovered that T cell dysfunction or anergy occurs concurrently with an induced and sustained expression of the inhibitory receptor, programmed death 1 polypeptide (PD-1). As a result, therapeutic targeting of PD-1 and other molecules which signal through interactions with PD-1, such as programmed death ligand 1 (PD-Ll) and programmed death ligand 2 (PD-L2) are an area of intense interest.

**[0006]** PD-L1 is overexpressed in many cancers and is often associated with poor prognosis (Okazaki T et al., Intern. Immun. 2007 19(7):813) (Thompson RH et al., Cancer Res 2006, 66(7):3381). Interestingly, the majority of tumor infiltrating T lymphocytes predominantly express PD-1, in contrast to T lymphocytes in normal tissues and peripheral blood T lymphocytes indicating that up-regulation of PD-1 on tumor-reactive T cells can contribute to impaired antitumor immune responses (Blood 2009 114(8):1537). This may be due to exploitation of PD-L1 signaling mediated by PD-L1 expressing tumor cells interacting with PD-1 expressing T cells to result in attenuation of T cell activation and evasion of immune surveillance (Sharpe et al., Nat Rev 2002) (Keir ME et al., 2008 Annu. Rev. Immunol. 26:677). Therefore, inhibition of the PD-L1/PD-1 interaction may enhance CD8+ T cell-mediated killing of tumors.

**[0007]** Therapeutic targeting PD-1 and other molecules which signal through interactions with PD-1, such as programmed death ligand 1 (PD-L1) and programmed death ligand 2 (PD-L2) are an area of intense interest. The inhibition of PD-L1 signaling has been proposed as a means to enhance T cell immunity for the treatment of cancer (e.g., tumor immunity) and infection, including both acute and chronic (e.g., persistent) infection. An optimal therapeutic treatment may combine blockade of PD-1 receptor/ligand interaction with an agent that directly inhibits tumor growth. There remains a need for an optimal therapy for treating, stabilizing, preventing, and/or delaying development of various cancers.

**[0008]** The mechanism of co-stimulation is of therapeutic interest because the manipulation of co-stimulatory signals has shown to provide a means to either enhance or terminate cell-based immune response. OX40 (also known as CD34, TNFRSF4, or ACT35 antigen), a member of the tumor necrosis factor receptor superfamily, can provide co-stimulatory signals to CD4+ and CD8+ T cells, leading to enhanced cell proliferation, survival, effector function, and migration. OX40 signaling also enhances memory T cell development and function. OX40 is not constitutively expressed on naïve T cells, but is induced after engagement of the T cell receptor (TCR). The ligand for OX40, OX40L, is predominantly expressed on antigen presenting cells. OX40 is highly expressed by activated CD4+ T cells, activated CD8+ T cells, memory T cells, and regulatory T (Treg) cells.

**[0009]** Combining OX40 signaling with other signaling pathways that are deregulated in tumor cells may further enhance treatment efficacy. Thus, there remains a need for such an optimal therapy for treating or delaying development of various cancers, immune related diseases, and T cell dysfunctional disorders.

**[0010]** All references cited herein, including patent applications, patent publications, and UniProtKB/Swiss-Prot Accession numbers are herein incorporated by reference in their entirety, as if each individual reference were specifically and individually indicated to be incorporated by reference.

## SUMMARY OF THE INVENTION

**[0011]** In one aspect, provided herein is a method for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody).

**[0012]** In another aspect, provided herein is a method of enhancing immune function in an individual having cancer comprising administering an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody).

**[0013]** In further aspects, provided herein are methods of treating infection (e.g., with a bacteria or virus or other pathogen). In some embodiments, the infection is with virus and/or bacteria. In some embodiments, the infection is with a pathogen. In some embodiments, the infection is an acute infection. In some embodiments, the infection is a chronic infection.

**[0014]** In another aspect, provided herein is use of a human PD-1 axis binding antagonist in the manufacture of a medicament for treating or delaying progression of cancer in an individual (or, in some embodiments, treating infection), wherein the medicament comprises the human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and wherein the treatment comprises administration of the medicament in combination with a composition comprising an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier.

**[0015]** In another aspect, provided herein is use of an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) in the manufacture of a medicament for treating or delaying progression of cancer in an individual (or, in some embodiments, treating infection), wherein the medicament comprises the OX40 binding agonist and an optional pharmaceutically acceptable carrier, and wherein the treatment comprises administration of the medicament in combination with a composition comprising a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier.

**[0016]** In another aspect, provided herein is a composition comprising a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier for use in treating or delaying progression of cancer (or, in some embodiments, treating infection) in an individual, wherein the

treatment comprises administration of said composition in combination with a second composition, wherein the second composition comprises an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier.

**[0017]** In another aspect, provided herein is a composition comprising an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier for use in treating or delaying progression of cancer in an individual (or in some embodiments, treating infection), wherein the treatment comprises administration of said composition in combination with a second composition, wherein the second composition comprises a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier.

**[0018]** In another aspect, provided herein is a kit comprising a medicament comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and a package insert comprising instructions for administration of the medicament in combination with a composition comprising an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier for treating or delaying progression of cancer (or, in some embodiments, treating infection) in an individual.

**[0019]** In another aspect, provided herein is a kit comprising a first medicament comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and a second medicament comprising an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier. In some embodiments, the kit further comprises a package insert comprising instructions for administration of the first medicament and the second medicament for treating or delaying progression of cancer (or in some embodiments, treating infection) in an individual.

**[0020]** In another aspect, provided herein is a kit comprising a medicament comprising an OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) and an optional pharmaceutically acceptable carrier, and a package insert comprising instructions for administration of the medicament in combination with a composition comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier for treating or delaying progression of cancer (or, in some embodiments, treating infection) in an individual.

**[0021]** In some embodiments, the cancer is breast cancer, lung cancer, ovarian cancer, gastric cancer, bladder cancer, pancreatic cancer, endometrial cancer, colon cancer, kidney cancer, esophageal cancer, prostate cancer, colorectal cancer, glioblastoma, neuroblastoma, or hepatocellular carcinoma.

**[0022]** In some embodiments, the individual has cancer or has been diagnosed with cancer.

**[0023]** In some embodiments, cancer cells (in a sample of the cancer from the individual) do not express PD-L1. In some embodiments, the PD-L1 biomarker is absent from the sample when it comprises 0% of the sample. In some embodiments, the PD-L1 biomarker expression is determined by protein expression (e.g., by immunohistochemistry (IHC) method).

**[0024]** In some embodiments, cancer cells (from a sample of the cancer from the individual) express PD-L1. In some embodiments, the PD-L1 biomarker is present in the sample when it comprises more than 0% of the sample. In some embodiments, the PD-L1 biomarker is detected in the sample by protein expression. In some embodiments, the protein expression is determined by immunohistochemistry (IHC). In some embodiments, the PD-L1 biomarker is detected using an anti-PD-L1 antibody. In some embodiments, the PD-L1 biomarker is detected as a weak staining intensity by IHC, a moderate staining intensity by IHC, or a strong staining intensity by IHC. In some embodiments, the PD-L1 biomarker is detected using an anti-PD-L1 antibody, and wherein the PD-L1 biomarker is detected as a moderate staining intensity by IHC, or a strong staining intensity by IHC.

**[0025]** In some embodiments, the individual has cancer that is resistant to a PD-1 axis binding antagonist. In some embodiments, the individual is refractory to a PD-1 axis binding antagonist. In some embodiments, the patient did not have an effective response to a PD-1 axis binding antagonist.

**[0026]** In some embodiments, the individual has cancer with high T cell infiltrate (e.g., as determined using a diagnostic test). In some embodiments, the individual has cancer with low or essentially undetectable T cell infiltrate (e.g., as determined using a diagnostic test).

**[0027]** In some embodiments of the methods, uses, compositions, and kits described above and herein, the treatment or administration of the human PD-1 axis binding antagonist and the OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) results in a sustained response in the individual after cessation of the treatment.

**[0028]** In some embodiments, combination treatment with OX40 binding agonist (e.g., anti-human OX40 agonist antibody) and PD-1 axis binding antagonists (e.g., anti- PD-1 or anti-PDL1 antibody) are synergistic, whereby an efficacious dose of a OX40 binding agent (e.g., anti-human OX40 agonist antibody) in the combination is reduced relative to efficacious dose of the OX40 binding agent (e.g., anti-human OX40 agonist antibody) as a single agent.

**[0029]** In some embodiments, the OX40 binding agonist is administered before the PD-1 axis binding antagonist, simultaneous with the PD-1 axis binding antagonist, or after the PD-1 axis binding antagonist. In some embodiments, the PD-1 axis binding antagonist and the OX40 binding agonist are in the same composition.

**[0030]** In some embodiments, the PD-1 axis binding antagonist and the OX40 binding agonist are in separate compositions. In some embodiments, the PD-1 axis binding antagonist is selected from the group consisting of a PD-1 binding antagonist, a PDL1 binding antagonist and a PDL2 binding antagonist. In some embodiments, the PD-1 axis binding antagonist is a PD-1 binding antagonist. In some embodiments, the PD-1 binding antagonist inhibits the binding of PD-1 to its ligand binding partners. In some embodiments, the PD-1 binding antagonist inhibits the binding of PD-1 to PDL1. In some embodiments, the PD-1 binding antagonist inhibits the binding of PD-1 to PDL2. In some embodiments, PD-1 binding antagonist inhibits the binding of PD-1 to both PDL1 and PDL2. In some

embodiments, the PD-1 binding antagonist is an antibody. In some embodiments, the PD-1 binding antagonist is nivolumab. In some embodiments, the PD-1 binding antagonist is pembrolizumab. In some embodiments, the PD-1 binding antagonist is CT-011. In some embodiments, the PD-1 binding antagonist is AMP-224. In some embodiments, the PD-1 axis binding antagonist is a PDL1 binding antagonist. In some embodiments, the PDL1 binding antagonist inhibits the binding of PDL1 to PD-1. In some embodiments, PDL1 binding antagonist inhibits the binding of PDL1 to B7-1. In some embodiments, PDL1 binding antagonist inhibits the binding of PDL1 to both PD-1 and B7-1. In some embodiments, PDL1 binding antagonist is an anti-PDL1 antibody. In some embodiments, the anti-PDL1 antibody is a monoclonal antibody. In some embodiments, the anti-PDL1 antibody is an antibody fragment selected from the group consisting of Fab, Fab'-SH, Fv, scFv, and (Fab')2 fragments. In some embodiments, the anti-PDL1 antibody is a humanized antibody or a human antibody. In some embodiments, the PDL1 binding antagonist is selected from the group consisting of: YW243.55.S70, MPDL3280A, MDX-1105, and MEDI4736. In some embodiments, the antibody comprises a heavy chain comprising HVR-H1 sequence of GFTFSDSWIH (SEQ ID NO:1), HVR-H2 sequence of AWISPYGGSTYYADSVKG (SEQ ID NO:2), and HVR-H3 sequence of RHWPGGFDY (SEQ ID NO:3); and a light chain comprising HVR-L1 sequence of RASQDVSTAVA (SEQ ID NO:4), HVR-L2 sequence of SASFLYS (SEQ ID NO:5), and HVR-L3 sequence of QQYLYHPAT (SEQ ID NO:6). In some embodiments, antibody comprises a heavy chain variable region comprising the amino acid sequence of EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYA DSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSS (SEQ ID NO:7) or EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWI SPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQG TLVTVSSASTK (SEQ ID NO:8) and a light chain variable region comprising the amino acid sequence of DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO:9). In some embodiments, the PD-1 axis binding antagonist is a PDL2 binding antagonist. In some embodiments, the PDL2 binding antagonist is an antibody. In some embodiments, the PDL2 binding antagonist is an immunoadhesin. In some embodiments, the PD-1 axis binding antagonist is an antibody (e.g., anti-PD1 antibody, anti-PDL1 antibody, or anti-PDL2 antibody) comprising one or more aglycosylation site mutation (e.g., a substitution). In some embodiments, the substitution mutation includes one or more substitutions at amino acid position N297, L234, L235, and D265 (EU numbering). In some embodiments, the substitution mutation is selected from the group consisting of N297G, N297A, L234A, L235A, and D265A (EU numbering). In some embodiments, the antibody is a human IgG1.

**[0031]** In some embodiments, the OX40 binding agonist is selected from the group consisting of an OX40 agonist antibody, an OX40L agonist fragment, an OX40 oligomeric receptor, and an OX40 immunoadhesin. In some embodiments, the OX40 agonist antibody binds human OX40. In some embodiments, the OX40 agonist antibody is any one of the anti-human OX40 agonist antibodies disclosed herein (e.g., in paragraphs 198-226). In some embodiments, the OX40 agonist antibody is MEDI6469, MEDI0562, or MEDI6383. In some embodiments, the OX40 agonist antibody is a full-length IgG1 antibody. In some embodiments, the OX40 binding agonist is a trimeric OX40L-Fc protein. In some embodiments, the OX40 binding agonist is a trimeric OX40L fusion proteins described in U.S. Pat. No. 7,959,925. In some embodiments, the OX40 binding agonist comprises one or more extracellular domains of OX40L. In some embodiments that can be combined with any other embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is not MEDI6383. In some embodiments that can be combined with any other embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is not MEDI0562. In some embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is a human and/or humanized antibody. In some embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is a depleting anti-human OX40 antibody (e.g., depletes cells that express human OX40). In some embodiments, the human OX40 expressing cells are CD4+ effector T cells. In some embodiments, the human OX40 expressing cells are Treg cells. In some embodiments, depleting is by ADCC and/or phagocytosis. In some embodiments, the antibody mediates ADCC by binding FcγR expressed by a human effector cell and activating the human effector cell function. In some embodiments, the antibody mediates phagocytosis by binding FcγR expressed by a human effector cell and activating the human effector cell function. In some embodiments, the human effector cell is selected from macrophages, natural killer (NK) cells, monocytes, and neutrophils. In some embodiments, the human effector cell is a macrophage. In some embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) has a functional Fc region. In some embodiments, the effector function of a functional Fc region is ADCC. In some embodiments, the effector function of a functional Fc region is phagocytosis. In some embodiments, the effector function of a functional Fc region is ADCC and phagocytosis. In some embodiments, the Fc region is human IgG1. In some embodiments, the Fc region is human IgG4.

**[0032]** In some embodiments of the methods, uses, compositions, and kits described above and herein, the PD-1 axis binding antagonist and/or the OX40 binding agonist (e.g., an anti- human OX40 agonist antibody) is administered intravenously, intramuscularly, subcutaneously, topically, orally, transdermally, intraperitoneally, intraorbitally, by implantation, by inhalation, intrathecally, intraventricularly, or intranasally. In some embodiments of the methods, uses, compositions, and kits described above and herein, the treatment further comprises administering a chemotherapeutic agent for treating or delaying progression of cancer in an individual. In some embodiments, the individual has been treated with a chemotherapeutic agent before the combination treatment with the PD-1 axis

binding antagonist and the OX40 binding agonist. In some embodiments, the individual treated with the combination of the PD-1 axis binding antagonist and/or the OX40 binding agonist is refractory to a chemotherapeutic agent treatment. Some embodiments of the methods, uses, compositions, and kits described throughout the application, further comprise administering a chemotherapeutic agent for treating or delaying progression of cancer.

**[0033]** In some embodiments of the methods, uses, compositions and kits described above and herein, CD8 T cells in the individual have enhanced priming, activation, proliferation and/or cytolytic activity relative to prior to the administration of the combination. In some embodiments, the number of CD8 T cells is elevated relative to prior to administration of the combination. In some embodiments, the CD8 T cell is an antigen-specific CD8 T cell. In some embodiments, Treg function is suppressed relative to prior to the administration of the combination. In some embodiments, T cell exhaustion is decreased relative to prior to the administration of the combination. In some embodiments, number of Treg cells is decreased relative to prior to the administration of the combination. In some embodiments, plasma interferon gamma is increased relative to prior to the administration of the combination. In some embodiments, number of memory T effector cells is increased relative to prior to the administration of the combination. In some embodiments, memory T effector cell activation and/or proliferation is increased relative to prior to the administration of the combination. In some embodiments, memory T effector cells are detected in peripheral blood. In some embodiments, detection of memory T effector cells is by detection of CXCR3.

**[0034]** Provided herein are methods for monitoring pharmacodynamic activity of an OX40 agonist treatment by measuring the expression level of one or more marker genes, protein(s) (e.g., a cytokine, e.g., gamma interferon) and/or cellular composition (e.g., percentage of Treg and/or absolute number of Treg; e.g., number of CD8+ effector T cells) in a sample (e.g., peripheral blood) comprising leukocytes obtained from the subject, where the subject has been treated with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody), and where the one or more marker genes are selected from a T cell marker gene, or a memory T cell marker gene (e.g., a marker of T effector memory cells); and determining the treatment as demonstrating pharmacodynamic activity based on the expression level of the one or more marker genes, protein(s) and/or cellular composition in the sample obtained from the subject, as compared with a reference, where an increased expression level of the one or more marker genes as compared with the reference indicates pharmacodynamic activity to the OX40 agonist treatment. Expression level of a marker gene, protein and/or cellular composition may be measured by one or more methods as described herein. In some embodiments, provided herein are methods for monitoring pharmacodynamic activity of an OX40 agonist treatment and a PD-1 axis binding antagonist combination treatment, comprising measuring the level of proliferating CD8+ T cells (e.g., percentage of Ki67+/total CD8+ T cells) in a sample (e.g., a peripheral blood sample) from an individual, wherein an increased level of

proliferating CD8+ T cells in the sample as compared to a reference (e.g., a level prior to combination treatment) indicates phamacodynamic activity to the combination treatment. In some embodiments, provided herein are methods for monitoring pharmacodynamic activity of an OX40 agonist treatment and a PD-1 axis binding antagonist combination treatment, comprising measuring the level of activated CD8+ T cells (e.g., percentage of CXCR3 +/total CD8+ T cells) in a sample (e.g., a peripheral blood sample) from an individual, wherein an increased level of activated CD8+ T cells in the sample as compared to a reference (e.g., a level prior to combination treatment) indicates pharmacodynamic activity to the combination treatment.

**[0035]** Provided herein are methods for monitoring responsiveness of a subject to an OX40 agonist treatment by measuring the expression level of one or more marker genes, protein(s) (e.g., a cytokine, e.g., gamma interferon) and/or cellular composition (e.g., percentage of Treg and/or absolute number of Treg; e.g., number of CD8+ effector T cells in peripheral blood samples) in a sample (e.g., peripheral blood) comprising leukocytes obtained from the subject, where the subject has been treated with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody), and where the one or more marker genes are selected from a T cell marker gene, or a memory T cell marker gene (e.g., a marker of T effector memory cells); and classifying the subject as responsive or non-responsive to the treatment based on the expression level of the one or more marker genes, protein(s) and/or cellular composition in the sample obtained from the subject, as compared with a reference, where an increased expression level of the one or more marker genes as compared with the reference indicates responsiveness or lack of reponsiveness to the OX40 agonist treatment. Expression level of a marker gene, protein and/or cellular composition may be measured by one or more methods as described herein. In some embodiments, provided herein are methods for monitoring responsiveness of an OX40 agonist treatment and a PD-1 axis binding antagonist combination treatment, comprising measuring the level of proliferating CD8+ T cells (e.g., percentage of Ki67+/total CD8+ T cells) in a sample (e.g., a peripheral blood sample) from an individual, wherein an increased level of proliferating CD8+ T cells in the sample as compared to a reference (e.g., a level prior to combination treatment) indicates responsiveness to the combination treatment. In some embodiments, provided herein are methods for monitoring responsiveness of an OX40 agonist treatment and a PD-1 axis binding antagonist combination treatment, comprising measuring the level of activated CD8+ T cells (e.g., percentage of CXCR3 +/total CD8+ T cells) in a sample (e.g., a peripheral blood sample) from an individual, wherein an increased level of activated CD8+ T cells in the sample as compared to a reference (e.g., a level prior to combination treatment) indicates responsiveness to the combination treatment.

**[0036]** It is to be understood that one, some, or all of the properties of the various embodiments described herein may be combined to form other embodiments of the present invention. These and

other aspects of the invention will become apparent to one of skill in the art. These and other embodiments of the invention are further described by the detailed description that follows.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

**[0037]** FIG. 1: Tumor infiltrating CD8+T cells express high levels of PD-1 inhibitory receptors in the CT26 colorectal syngeneic tumor model (control treated mice). Approximately half of PD-1 expressing CD8+ TILs also express OX40. Representative flow cytometry dot plots from one of 5 mice, day 2 after start of treatment with control antibody.

**[0038]** FIGS. 2A and B: (FIG. 2A) Treatment with anti-OX40 agonist antibody alone and anti-OX40 agonist antibody in combination with anti-PDL1 antagonist antibody significantly reduced proportion of intratumoral Foxp3+ Tregulatory cells (relative to total number of CD45+ cells). (FIG. 2B) Treatment with anti-OX40 agonist antibody alone and anti-OX40 agonist antibody in combination with anti-PDL1 antagonist antibody significantly reduced absolute number of intratumoral Foxp3+ T regulatory cells in the CT26 colorectal tumor model. For both (FIG. 2A) and (FIG. 2B): data are from day 9 after start of treatment, each symbol represents an individual mouse. Mice were dosed with control antibody or anti-PDL1 antibody at 10mg/kg IV for first dose on day 1, followed by 5mg/kg IP BIW (twice a week). Anti-OX40 agonist antibody was dosed at 0.1mg/kg IV for the first dose on day 1, followed by 0.1mg/kg IP TIW (three times a week).

**[0039]** FIGS. 3A and B: Treatment with anti-OX40 agonist antibody augmented PDL1 expression on (FIG. 3A) intratumoral myeloid (CD11b+ Gr-1low/intermediate) cells and on (FIG. 3B) tumor cells in the CT26 colorectal syngeneic tumor model. Data are from day 9 after start of treatment. Each dot/square represents one individual mouse. PDL1 expression measured by geometric mean fluorescence intensity (geo MFI) by flow cytometry. $^{**}p<0.01$, $^{*}p<0.05$, as calculated by unpaired t-test. Dosing in this experiment was 10mg/kg IV first dose on day 1, followed by 5mg/kg IP BIW for control antibody. Anti-OX40 agonist antibody was dosed at 0.1mg/kg IV for first dose on day 1, followed by 0.1mg/kg IP TIW.

**[0040]** FIGS. 4A, 4B: Treatment with anti-OX40 agonist antibody and anti-PDL1 antagonist antibody demonstrated synergistic combination efficacy in the MC38 colorectal cancer syngeneic tumor model in C57BL/6 mice. (FIG. 4A) Average tumor volume (mm3) measurements over time (days) by treatment group, n=10/group. (FIG. 4B) Individual tumor volume measurements over time by treatment group. Black lines indicate average of the group. Blue dashed line indicates average of control group. Gray lines are individual animals. Red lines indicate individual animals dropped from study due to ulcerated tumor or excessive tumor size. Control antibody, anti-PDL1 antibody, or anti-OX40 agonist antibody were dosed at 10mg/kg IV for first dose on day 1, followed by 10mg/kg IP TIW for 3 weeks.

**[0041]** FIGS. 5A, 5B: Treatment with anti-OX40 agonist antibody and anti-PDL1 antagonist antibody demonstrated synergistic combination efficacy in the CT26 colorectal syngeneic tumor model in Balb/c mice. (FIG. 5A) Average tumor volume (mm3) measurements over time (days) by treatment group, n=10/group. (FIG. 5B) Individual tumor volume measurements over time by treatment group. Control antibody or anti-PDL1 was dosed at 10mg/kg IV for the first dose on day 1, followed by 5mg/kg IP TIW for 3 weeks. Anti-OX40 agonist antibody was administered as a single dose at 1mg/kg IV on day 1. Black lines indicate average of the group. Blue dashed line indicates average of control group. Gray lines are individual animals. Red lines indicate individual animals dropped from study due to ulcerated tumor or excessive tumor size.

**[0042]** FIGS. 6A, 6B: Anti-OX40 agonist antibody single agent treatment shows dose responsiveness in the CT26 colorectal cancer syngeneic tumor model in Balb/c mice. (FIG. 6A) Average tumor volume (mm3) measurements over time (days) by treatment group, n=10/group. (FIG. 6B) Individual tumor volume measurements over time by treatment group. Black lines indicate average of the group. Blue dashed line indicates average of control group. Gray lines are individual animals. Red lines indicate individual animals dropped from study due to ulcerated tumor or excessive tumor size. Control antibody was dosed at 1mg/kg IV for first dose on day 1, followed by 1mg/kg IP TIW for 3 weeks. Anti-OX40 agonist antibody was dosed at 0.01mg/kg, 0.1mg/kg, or 1mg/kg IV for the first dose on day 1, followed by TIW IP for 3 weeks.

**[0043]** FIGS. 7A, 7B: Combination treatment with a sub-maximal dose of anti-OX40 agonist antibody plus anti-PDL1 antagonist antibody demonstrated synergistic combination efficacy in the CT26 colorectal cancer syngeneic tumor model in Balb/c mice. (FIG. 7A) Average tumor volume (mm3) measurements over time (days) by treatment group, n=10/group. (FIG. 7B) Individual tumor volume measurements over time by treatment group. Black lines indicate average of the group. Blue dashed line indicates average of control group. Gray lines are individual animals. Red lines indicate individual animals dropped from study due to ulcerated tumor or excessive tumor size. Control antibody or anti-PDL1 was dosed at 10mg/kg IV for the first dose on day 1, followed by 10mg/kg IP TIW for 3 weeks. Anti-OX40 agonist antibody was given 0.1mg/kg with the first dose IV on day 1 and subsequent dosing at 0.1mg/kg IP TIW for 3 weeks.

**[0044]** FIGS. 8A, 8B: In a separate experiment, anti-OX40 agonist antibody dosed at a sub-maximal efficacious dose of a single 0.1mg/kg IV injection plus anti-PDL1 demonstrated synergistic combination efficacy in the CT26 colorectal syngeneic tumor model in Balb/c mice. (FIG. 8A) Average tumor volume (mm3) measurements over time (days) by treatment group, n=10/group. (FIG. 8B) Individual tumor volume measurements over time by treatment group. Black lines indicate average of the group. Blue dashed line indicates average of control group. Gray lines are individual animals. Red lines indicate individual animals dropped from study due to ulcerated tumor or excessive tumor size. Control antibody or anti-PDL1 was dosed at 10mg/kg IV for the first dose on

day 1, followed by 5mg/kg IP TIW for 3 weeks. Anti-OX40 antibody was given 0.1mg/kg with the first or single dose IV on day 1 and subsequent dosing at 0.1mg/kg IP TIW for 3 weeks.

**[0045]** FIGS. 9A, B, C & D: Effects of combination treatment with OX40 agonist antibody and PDL1 antagonist (anti-PDL1 antagonist antibody) on levels of proliferating T cells, Treg cells, plasma interferon-gamma, and activated T cells in peripheral blood. Analysis of peripheral blood taken from combination treated CT26 mice revealed an increase in effector cell proliferation and inflammatory T cell markers. Level of proliferation of CD8+ Tcells (FIG. 9A), Treg cells (FIG. 9B), plasma interferon gamma levels (FIG. 9C) and activated T cells (FIG. 9D) were examined. (FIG. 9A) Level of proliferating CD8+ Tcells (expressed as percentage of ki67+/total CD8+ T cells) was significantly increased in animals treated with the combination of OX40 agonist antibody and PD-L1 antagonist verses treatment with OX40 agonist antibody or PDL1 antagonist antibody alone. (FIG. 9B) Decreased peripheral blood Tregs were observed with treatment with OX40 agonist antibody single agent and treatment with the combination of OX40 agonist antibody and PDL1 antagonist. (FIG. 9C) Increased plasma gamma interferon (IFNg) was observed with treatment with the combination of OX40 agonist and PDL1 antagonist. (FIG. 9D) Level of activated T cells (specifically, activated memory Teff cells) was significantly increased in animals treated with the combination of OX40 agonist antibody and PD-L1 antagonist verses treatment with OX40 agonist or PDL1 antagonist alone.

**[0046]** FIG. 10 shows association of OX40 expression with PDL1 diagnostic status in cancer samples from human patients with urothelial bladder cancer (UBC) and non-small cell lung cancer (NSCLC). Tissue samples were from patients participating in phase 1 clinical trials with anti-PD-L1 antibody, MPDL3280A. PD-L1 biomarker status of tumor infiltrating immune cells (IC) was determined using IHC as disclosed herein. OX40 expression level was determined using rtPCR analysis (Fluidigm). Triangle means that the patient had a partial or complete clinical response; circle means the patient showed stable disease, square means the patient had progressive disease.

**[0047]** FIGS. 11A, B, C, D, E, & F: show exemplary IHC analysis of control cell samples. (FIG. 11A) Negative control IHC staining of parental HEK-293 cells; (FIG. 11B) IHC staining of HEK-293 cells transfected with recombinant human PD-L1 with weak staining intensity; (FIG. 11C) IHC staining of HEK-293 cells transfected with recombinant human PD-L1 with moderate staining intensity; (FIG. 11D) IHC staining of HEK-293 cells transfected with recombinant human PD-L1 with strong staining intensity; (FIG. 11E) Positive tissue control IHC staining of placental tissue sample; (FIG. 11F) Positive tissue control IHC staining of tonsil tissue sample. All IHC staining were performed using a proprietary anti-PD-L1 antibody.

**[0048]** FIGS. 12A, B & C: show exemplary PD-L1 positive IHC staining of tumor samples from (FIG. 12A) Triple-Negative Breast Cancer; (FIG. 12B) Malignant Melanoma; (FIG. 12C) NSCLC, adenocarcinoma.

DETAILED DESCRIPTION

**[0049]** The inventors of this application demonstrated that the combination of an anti-human OX40 agonist antibody with anti-PD-L1 immune therapy resulted in synergistic inhibition of tumor growth, and increased response rates.

**[0050]** In one aspect, provided herein are methods, compositions and uses for treating or delaying progression of cancer in an individual comprising administering an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist.

**[0051]** In another aspect, provided herein are methods, compositions and uses for enhancing immune function in an individual having cancer comprising administering an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist.

**[0052]** In another aspect, provided herein are methods, compositions and uses for treating infection (e.g., with a bacteria or virus or other pathogen) in an individual having cancer comprising administering an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist.

## I. Definitions

**[0053]** Before describing the invention in detail, it is to be understood that this invention is not limited to particular compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

**[0054]** As used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to "a molecule" optionally includes a combination of two or more such molecules, and the like.

**[0055]** The term "about" as used herein refers to the usual error range for the respective value readily known to the skilled person in this technical field. Reference to "about" a value or parameter herein includes (and describes) embodiments that are directed to that value or parameter per se.

**[0056]** It is understood that aspects and embodiments of the invention described herein include "comprising," "consisting," and "consisting essentially of" aspects and embodiments.

**[0057]** The term "OX40," as used herein, refers to any native OX40 from any vertebrate source, including mammals such as primates (e.g., humans) and rodents (e.g., mice and rats), unless otherwise indicated. The term encompasses "full-length," unprocessed OX40 as well as any form of OX40 that results from processing in the cell. The term also encompasses naturally occurring variants of OX40, for example, splice variants or allelic variants. The amino acid sequence of an exemplary human OX40 lacking the signal peptide is shown in SEQ ID NO:60 (LHCVGDTYPSNDRCCHECRPGNGMVSRCSRSQNTVCRPCGPGFYNDVVSSKPCKPCTWCN

LRSGSERKQLCTATQDTVCRCRAGTQPLDSYKPGVDCAPCPPGHFSPGDNQACKPWTNCTL AGKHTLQPASNSSDAICEDRDPPATQPQETQGPPARPITVQPTEAWPRTSQGPSTRPVEVPGG RAVAAILGLGLVLGLLGPLAILLALYLLRRDQRLPPDAHKPPGGGSFRTPIQEEQADAHSTLA KI).

**[0058]** "OX40 activation" refers to activation of the OX40 receptor. Generally, OX40 activation results in signal transduction.

**[0059]** The terms "anti-OX40 antibody" and "an antibody that binds to OX40" refer to an antibody that is capable of binding OX40 with sufficient affinity such that the antibody is useful as a diagnostic and/or therapeutic agent in targeting OX40. In one embodiment, the extent of binding of an anti-OX40 antibody to an unrelated, non-OX40 protein is less than about 10% of the binding of the antibody to OX40 as measured, e.g., by a radioimmunoassay (RIA). In certain embodiments, an antibody that binds to OX40 has a dissociation constant (Kd) of $\leq$ 1μM, $\leq$ 100 nM, $\leq$ 10 nM, $\leq$ 1 nM, $\leq$ 0.1 nM, $\leq$ 0.01 nM, or $\leq$ 0.001 nM (e.g., $10^{-8}$ M or less, e.g. from $10^{-8}$ M to $10^{-13}$ M, e.g., from $10^{-9}$ M to $10^{-13}$ M). In certain embodiments, an anti-OX40 antibody binds to an epitope of OX40 that is conserved among OX40 from different species.

**[0060]** The term "PD-1 axis binding antagonist" refers to a molecule that inhibits the interaction of a PD-1 axis binding partner with either one or more of its binding partner, so as to remove T-cell dysfunction resulting from signaling on the PD-1 signaling axis – with a result being to restore or enhance T-cell function (*e.g.*, proliferation, cytokine production, target cell killing). As used herein, a PD-1 axis binding antagonist includes a PD-1 binding antagonist, a PD-L1 binding antagonist and a PD-L2 binding antagonist.

**[0061]** The term "PD-1 binding antagonist" refers to a molecule that decreases, blocks, inhibits, abrogates or interferes with signal transduction resulting from the interaction of PD-1 with one or more of its binding partners, such as PD-L1, PD-L2. In some embodiments, the PD-1 binding antagonist is a molecule that inhibits the binding of PD-1 to one or more of its binding partners. In a specific aspect, the PD-1 binding antagonist inhibits the binding of PD-1 to PD-L1 and/or PD-L2. For example, PD-1 binding antagonists include anti-PD-1 antibodies, antigen binding fragments thereof, immunoadhesins, fusion proteins, oligopeptides and other molecules that decrease, block, inhibit, abrogate or interfere with signal transduction resulting from the interaction of PD-1 with PD-L1 and/or PD-L2. In one embodiment, a PD-1 binding antagonist reduces the negative co-stimulatory signal mediated by or through cell surface proteins expressed on T lymphocytes mediated signaling through PD-1 so as render a dysfunctional T-cell less dysfunctional (*e.g.*, enhancing effector responses to antigen recognition). In some embodiments, the PD-1 binding antagonist is an anti-PD-1 antibody. In a specific aspect, a PD-1 binding antagonist is MDX-1106 (nivolumab) described herein. In another specific aspect, a PD-1 binding antagonist is MK-3475 (pembrolizumab) described herein.

In another specific aspect, a PD-1 binding antagonist is CT-011 (pidilizumab) described herein. In another specific aspect, a PD-1 binding antagonist is AMP-224 described herein.

**[0062]** The term "PD-L1 binding antagonist" refers to a molecule that decreases, blocks, inhibits, abrogates or interferes with signal transduction resulting from the interaction of PD-L1 with either one or more of its binding partners, such as PD-1, B7-1. In some embodiments, a PD-L1 binding antagonist is a molecule that inhibits the binding of PD-L1 to its binding partners. In a specific aspect, the PD-L1 binding antagonist inhibits binding of PD-L1 to PD-1 and/or B7-1. In some embodiments, the PD-L1 binding antagonists include anti-PD-L1 antibodies, antigen binding fragments thereof, immunoadhesins, fusion proteins, oligopeptides and other molecules that decrease, block, inhibit, abrogate or interfere with signal transduction resulting from the interaction of PD-L1 with one or more of its binding partners, such as PD-1, B7-1. In one embodiment, a PD-L1 binding antagonist reduces the negative co-stimulatory signal mediated by or through cell surface proteins expressed on T lymphocytes mediated signaling through PD-L1 so as to render a dysfunctional T-cell less dysfunctional (*e.g.*, enhancing effector responses to antigen recognition). In some embodiments, a PD-L1 binding antagonist is an anti-PD-L1 antibody. In a specific aspect, an anti-PD-L1 antibody is YW243.55.S70 described herein. In another specific aspect, an anti-PD-L1 antibody is MDX-1105 described herein. In still another specific aspect, an anti-PD-L1 antibody is MPDL3280A described herein. In still another specific aspect, an anti-PD-L1 antibody is MEDI4736 described herein.

**[0063]** The term "PD-L2 binding antagonist" refers to a molecule that decreases, blocks, inhibits, abrogates or interferes with signal transduction resulting from the interaction of PD-L2 with either one or more of its binding partners, such as PD-1. In some embodiments, a PD-L2 binding antagonist is a molecule that inhibits the binding of PD-L2 to one or more of its binding partners. In a specific aspect, the PD-L2 binding antagonist inhibits binding of PD-L2 to PD-1. In some embodiments, the PD-L2 antagonists include anti-PD-L2 antibodies, antigen binding fragments thereof, immunoadhesins, fusion proteins, oligopeptides and other molecules that decrease, block, inhibit, abrogate or interfere with signal transduction resulting from the interaction of PD-L2 with either one or more of its binding partners, such as PD-1. In one embodiment, a PD-L2 binding antagonist reduces the negative co-stimulatory signal mediated by or through cell surface proteins expressed on T lymphocytes mediated signaling through PD-L2 so as render a dysfunctional T-cell less dysfunctional (*e.g.*, enhancing effector responses to antigen recognition). In some embodiments, a PD-L2 binding antagonist is an immunoadhesin.

**[0064]** The term "dysfunction" in the context of immune dysfunction, refers to a state of reduced immune responsiveness to antigenic stimulation. The term includes the common elements of both exhaustion and/or anergy in which antigen recognition may occur, but the ensuing immune response is ineffective to control infection or tumor growth.

**[0065]** The term "dysfunctional", as used herein, also includes refractory or unresponsive to antigen recognition, specifically, impaired capacity to translate antigen recognition into down-stream T-cell effector functions, such as proliferation, cytokine production (e.g., IL-2) and/or target cell killing.

**[0066]** The term "anergy" refers to the state of unresponsiveness to antigen stimulation resulting from incomplete or insufficient signals delivered through the T-cell receptor (*e.g.* increase in intracellular $Ca^{+2}$ in the absence of ras-activation). T cell anergy can also result upon stimulation with antigen in the absence of co-stimulation, resulting in the cell becoming refractory to subsequent activation by the antigen even in the context of costimulation. The unresponsive state can often be overriden by the presence of Interleukin-2. Anergic T-cells do not undergo clonal expansion and/or acquire effector functions.

**[0067]** The term "exhaustion" refers to T cell exhaustion as a state of T cell dysfunction that arises from sustained TCR signaling that occurs during many chronic infections and cancer. It is distinguished from anergy in that it arises not through incomplete or deficient signaling, but from sustained signaling. It is defined by poor effector function, sustained expression of inhibitory receptors and a transcriptional state distinct from that of functional effector or memory T cells. Exhaustion prevents optimal control of infection and tumors. Exhaustion can result from both extrinsic negative regulatory pathways (e.g., immunoregulatory cytokines) as well as cell intrinsic negative regulatory (costimulatory) pathways (PD-1, B7-H3, B7-H4, etc.).

**[0068]** "Enhancing T-cell function" means to induce, cause or stimulate a T-cell to have a sustained or amplified biological function, or renew or reactivate exhausted or inactive T-cells. Examples of enhancing T-cell function include: increased secretion of gamma-interferon from CD8+ T-cells, increased proliferation, increased antigen responsiveness (e.g., viral, pathogen, or tumor clearance) relative to such levels before the intervention. In one embodiment, the level of enhancement is as least 50%, alternatively 60%, 70%, 80%, 90%, 100%, 120%, 150%, 200%. The manner of measuring this enhancement is known to one of ordinary skill in the art.

**[0069]** A "T cell dysfunctional disorder" is a disorder or condition of T-cells characterized by decreased responsiveness to antigenic stimulation. In a particular embodiment, a T-cell dysfunctional disorder is a disorder that is specifically associated with inappropriate increased signaling through PD-1. In another embodiment, a T-cell dysfunctional disorder is one in which T-cells are anergic or have decreased ability to secrete cytokines, proliferate, or execute cytolytic activity. In a specific aspect, the decreased responsiveness results in ineffective control of a pathogen or tumor expressing an immunogen. Examples of T cell dysfunctional disorders characterized by T-cell dysfunction include unresolved acute infection, chronic infection and tumor immunity.

**[0070]** "Tumor immunity" refers to the process in which tumors evade immune recognition and clearance. Thus, as a therapeutic concept, tumor immunity is "treated" when such evasion is

attenuated, and the tumors are recognized and attacked by the immune system. Examples of tumor recognition include tumor binding, tumor shrinkage and tumor clearance.

**[0071]** "Immunogenicity" refers to the ability of a particular substance to provoke an immune response. Tumors are immunogenic and enhancing tumor immunogenicity aids in the clearance of the tumor cells by the immune response. Examples of enhancing tumor immunogenicity include treatment with a PD-1 axis binding antagonist and an OX40 binding agonist.

**[0072]** "Sustained response" refers to the sustained effect on reducing tumor growth after cessation of a treatment. For example, the tumor size may remain to be the same or smaller as compared to the size at the *beginning* of the administration phase. In some embodiments, the sustained response has a duration at least the same as the treatment duration, at least 1.5X, 2.0X, 2.5X, or 3.0X length of the treatment duration.

**[0073]** The term "pharmaceutical formulation" refers to a preparation which is in such form as to permit the biological activity of the active ingredient to be effective, and which contains no additional components which are unacceptably toxic to a subject to which the formulation would be administered. Such formulations are sterile. "Pharmaceutically acceptable" excipients (vehicles, additives) are those which can reasonably be administered to a subject mammal to provide an effective dose of the active ingredient employed.

**[0074]** As used herein, the term "treatment" refers to clinical intervention designed to alter the natural course of the individual or cell being treated during the course of clinical pathology. Desirable effects of treatment include decreasing the rate of disease progression, ameliorating or palliating the disease state, and remission or improved prognosis. For example, an individual is successfully "treated" if one or more symptoms associated with cancer are mitigated or eliminated, including, but are not limited to, reducing the proliferation of (or destroying) cancerous cells, decreasing symptoms resulting from the disease, increasing the quality of life of those suffering from the disease, decreasing the dose of other medications required to treat the disease, and/or prolonging survival of individuals.

**[0075]** As used herein, "delaying progression of a disease" means to defer, hinder, slow, retard, stabilize, and/or postpone development of the disease (such as cancer). This delay can be of varying lengths of time, depending on the history of the disease and/or individual being treated. As is evident to one skilled in the art, a sufficient or significant delay can, in effect, encompass prevention, in that the individual does not develop the disease. For example, a late stage cancer, such as development of metastasis, may be delayed.

**[0076]** An "effective amount" is at least the minimum amount required to effect a measurable improvement or prevention of a particular disorder. An effective amount herein may vary according to factors such as the disease state, age, sex, and weight of the patient, and the ability of the antibody to elicit a desired response in the individual. An effective amount is also one in which any toxic or detrimental effects of the treatment are outweighed by the therapeutically beneficial effects. For

prophylactic use, beneficial or desired results include results such as eliminating or reducing the risk, lessening the severity, or delaying the onset of the disease, including biochemical, histological and/or behavioral symptoms of the disease, its complications and intermediate pathological phenotypes presenting during development of the disease. For therapeutic use, beneficial or desired results include clinical results such as decreasing one or more symptoms resulting from the disease, increasing the quality of life of those suffering from the disease, decreasing the dose of other medications required to treat the disease, enhancing effect of another medication such as via targeting, delaying the progression of the disease, and/or prolonging survival. In the case of cancer or tumor, an effective amount of the drug may have the effect in reducing the number of cancer cells; reducing the tumor size; inhibiting (*i.e.*, slow to some extent or desirably stop) cancer cell infiltration into peripheral organs; inhibit (*i.e.*, slow to some extent and desirably stop) tumor metastasis; inhibiting to some extent tumor growth; and/or relieving to some extent one or more of the symptoms associated with the disorder. An effective amount can be administered in one or more administrations. For purposes of this invention, an effective amount of drug, compound, or pharmaceutical composition is an amount sufficient to accomplish prophylactic or therapeutic treatment either directly or indirectly. As is understood in the clinical context, an effective amount of a drug, compound, or pharmaceutical composition may or may not be achieved in conjunction with another drug, compound, or pharmaceutical composition. Thus, an "effective amount" may be considered in the context of administering one or more therapeutic agents, and a single agent may be considered to be given in an effective amount if, in conjunction with one or more other agents, a desirable result may be or is achieved.

**[0077]** As used herein, "in conjunction with" refers to administration of one treatment modality in addition to another treatment modality. As such, "in conjunction with" refers to administration of one treatment modality before, during, or after administration of the other treatment modality to the individual.

**[0078]** A "disorder" is any condition that would benefit from treatment including, but not limited to, chronic and acute disorders or diseases including those pathological conditions which predispose the mammal to the disorder in question.

**[0079]** The terms "cell proliferative disorder" and "proliferative disorder" refer to disorders that are associated with some degree of abnormal cell proliferation. In one embodiment, the cell proliferative disorder is cancer. In one embodiment, the cell proliferative disorder is a tumor.

**[0080]** "Tumor," as used herein, refers to all neoplastic cell growth and proliferation, whether malignant or benign, and all pre-cancerous and cancerous cells and tissues. The terms "cancer", "cancerous", "cell proliferative disorder", "proliferative disorder" and "tumor" are not mutually exclusive as referred to herein.

**[0081]** The terms "cancer" and "cancerous" refer to or describe the physiological condition in mammals that is typically characterized by unregulated cell growth. Examples of cancer include but are not limited to, carcinoma, lymphoma, blastoma, sarcoma, and leukemia or lymphoid malignancies. More particular examples of such cancers include, but not limited to, squamous cell cancer (*e.g.*, epithelial squamous cell cancer), lung cancer including small-cell lung cancer, non-small cell lung cancer, adenocarcinoma of the lung and squamous carcinoma of the lung, cancer of the peritoneum, hepatocellular cancer, gastric or stomach cancer including gastrointestinal cancer and gastrointestinal stromal cancer, pancreatic cancer, glioblastoma, cervical cancer, ovarian cancer, liver cancer, bladder cancer, cancer of the urinary tract, hepatoma, breast cancer, colon cancer, rectal cancer, colorectal cancer, endometrial or uterine carcinoma, salivary gland carcinoma, kidney or renal cancer, prostate cancer, vulval cancer, thyroid cancer, hepatic carcinoma, anal carcinoma, penile carcinoma, melanoma, superficial spreading melanoma, lentigo maligna melanoma, acral lentiginous melanomas, nodular melanomas, multiple myeloma and B-cell lymphoma (including low grade/follicular non-Hodgkin's lymphoma (NHL); small lymphocytic (SL) NHL; intermediate grade/follicular NHL; intermediate grade diffuse NHL; high grade immunoblastic NHL; high grade lymphoblastic NHL; high grade small non-cleaved cell NHL; bulky disease NHL; mantle cell lymphoma; AIDS-related lymphoma; and Waldenstrom's Macroglobulinemia); chronic lymphocytic leukemia (CLL); acute lymphoblastic leukemia (ALL); hairy cell leukemia; chronic myeloblastic leukemia; and post-transplant lymphoproliferative disorder (PTLD), as well as abnormal vascular proliferation associated with phakomatoses, edema (such as that associated with brain tumors), Meigs' syndrome, brain, as well as head and neck cancer, and associated metastases. In certain embodiments, cancers that are amenable to treatment by the antibodies of the invention include breast cancer, colorectal cancer, rectal cancer, non-small cell lung cancer, glioblastoma, non-Hodgkins lymphoma (NHL), renal cell cancer, prostate cancer, liver cancer, pancreatic cancer, soft-tissue sarcoma, kaposi's sarcoma, carcinoid carcinoma, head and neck cancer, ovarian cancer, mesothelioma, and multiple myeloma. In some embodiments, the cancer is selected from: small cell lung cancer, glioblastoma, neuroblastomas, melanoma, breast carcinoma, gastric cancer, colorectal cancer (CRC), and hepatocellular carcinoma. Yet, in some embodiments, the cancer is selected from: non-small cell lung cancer, colorectal cancer, glioblastoma and breast carcinoma, including metastatic forms of those cancers.

**[0082]** The term "cytotoxic agent" as used herein refers to any agent that is detrimental to cells (e.g., causes cell death, inhibits proliferation, or otherwise hinders a cellular function). Cytotoxic agents include, but are not limited to, radioactive isotopes (*e.g.*, $At^{211}$, $I^{131}$, $I^{125}$, $Y^{90}$, $Re^{186}$, $Re^{188}$, $Sm^{153}$, $Bi^{212}$, $P^{32}$, $Pb^{212}$ and radioactive isotopes of Lu); chemotherapeutic agents; growth inhibitory agents; enzymes and fragments thereof such as nucleolytic enzymes; and toxins such as small molecule toxins or enzymatically active toxins of bacterial, fungal, plant or animal origin, including fragments and/or

variants thereof. Exemplary cytotoxic agents can be selected from anti-microtubule agents, platinum coordination complexes, alkylating agents, antibiotic agents, topoisomerase II inhibitors, antimetabolites, topoisomerase I inhibitors, hormones and hormonal analogues, signal transduction pathway inhibitors, non-receptor tyrosine kinase angiogenesis inhibitors, immunotherapeutic agents, proapoptotic agents, inhibitors of LDH-A, inhibitors of fatty acid biosynthesis, cell cycle signalling inhibitors, HDAC inhibitors, proteasome inhibitors, and inhibitors of cancer metabolism. In one embodiment the cytotoxic agent is a taxane. In one embodiment the taxane is paclitaxel or docetaxel. In one embodiment the cytotoxic agent is a platinum agent. In one embodiment the cytotoxic agent is an antagonist of EGFR. In one embodiment the antagonist of EGFR is N-(3-ethynylphenyl)-6,7-bis(2-methoxyethoxy)quinazolin-4-amine (*e.g.*, erlotinib). In one embodiment the cytotoxic agent is a RAF inhibitor. In one embodiment, the RAF inhibitor is a BRAF and/or CRAF inhibitor. In one embodiment the RAF inhibitor is vemurafenib. In one embodiment the cytotoxic agent is a PI3K inhibitor.

**[0083]** "Chemotherapeutic agent" includes compounds useful in the treatment of cancer. Examples of chemotherapeutic agents include erlotinib (TARCEVA®, Genentech/OSI Pharm.), bortezomib (VELCADE®, Millennium Pharm.), disulfiram, epigallocatechin gallate , salinosporamide A, carfilzomib, 17-AAG (geldanamycin), radicicol, lactate dehydrogenase A (LDH-A), fulvestrant (FASLODEX®, AstraZeneca), sunitib (SUTENT®, Pfizer/Sugen), letrozole (FEMARA®, Novartis), imatinib mesylate (GLEEVEC®, Novartis), finasunate (VATALANIB®, Novartis), oxaliplatin (ELOXATIN®, Sanofi), 5-FU (5-fluorouracil), leucovorin, Rapamycin (Sirolimus, RAPAMUNE®, Wyeth), Lapatinib (TYKERB®, GSK572016, Glaxo Smith Kline), Lonafamib (SCH 66336), sorafenib (NEXAVAR®, Bayer Labs), gefitinib (IRESSA®, AstraZeneca), AG1478, alkylating agents such as thiotepa and CYTOXAN® cyclosphosphamide; alkyl sulfonates such as busulfan, improsulfan and piposulfan; aziridines such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines including altretamine, triethylenemelamine, triethylenephosphoramide, triethylenethiophosphoramide and trimethylomelamine; acetogenins (especially bullatacin and bullatacinone); a camptothecin (including topotecan and irinotecan); bryostatin; callystatin; CC-1065 (including its adozelesin, carzelesin and bizelesin synthetic analogs); cryptophycins (particularly cryptophycin 1 and cryptophycin 8); adrenocorticosteroids (including prednisone and prednisolone); cyproterone acetate; 5α-reductases including finasteride and dutasteride); vorinostat, romidepsin, panobinostat, valproic acid, mocetinostat dolastatin; aldesleukin, talc duocarmycin (including the synthetic analogs, KW-2189 and CB1-TM1); eleutherobin; pancratistatin; a sarcodictyin; spongistatin; nitrogen mustards such as chlorambucil, chlomaphazine, chlorophosphamide, estramustine, ifosfamide, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, uracil mustard; nitrosoureas such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, and ranimnustine; antibiotics such as

the enediyne antibiotics (*e.g.*, calicheamicin, especially calicheamicin γ1I and calicheamicin ω1I (*Angew Chem. Intl. Ed. Engl.* **1994** 33:183-186); dynemicin, including dynemicin A; bisphosphonates, such as clodronate; an esperamicin; as well as neocarzinostatin chromophore and related chromoprotein enediyne antibiotic chromophores), aclacinomysins, actinomycin, authramycin, azaserine, bleomycins, cactinomycin, carabicin, caminomycin, carzinophilin, chromomycinis, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, ADRIAMYCIN® (doxorubicin), morpholino-doxorubicin, cyanomorpholino-doxorubicin, 2-pyrrolino-doxorubicin and deoxydoxorubicin), epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins such as mitomycin C, mycophenolic acid, nogalamycin, olivomycins, peplomycin, porfiromycin, puromycin, quelamycin, rodorubicin, streptonigrin, streptozocin, tubercidin, ubenimex, zinostatin, zorubicin; anti-metabolites such as methotrexate and 5-fluorouracil (5-FU); folic acid analogs such as denopterin, methotrexate, pteropterin, trimetrexate; purine analogs such as fludarabine, 6-mercaptopurine, thiamiprine, thioguanine; pyrimidine analogs such as ancitabine, azacitidine, 6-azauridine, carmofur, cytarabine, dideoxyuridine, doxifluridine, enocitabine, floxuridine; androgens such as calusterone, dromostanolone propionate, epitiostanol, mepitiostane, testolactone; anti-adrenals such as aminoglutethimide, mitotane, trilostane; folic acid replenisher such as frolinic acid; aceglatone; aldophosphamide glycoside; aminolevulinic acid; eniluracil; amsacrine; bestrabucil; bisantrene; edatraxate; defofamine; demecolcine; diaziquone; elfomithine; elliptinium acetate; an epothilone; etoglucid; gallium nitrate; hydroxyurea; lentinan; lonidainine; maytansinoids such as maytansine and ansamitocins; mitoguazone; mitoxantrone; mopidamnol; nitraerine; pentostatin; phenamet; pirarubicin; losoxantrone; podophyllinic acid; 2-ethylhydrazide; procarbazine; PSK® polysaccharide complex (JHS Natural Products, Eugene, Oreg.); razoxane; rhizoxin; sizofuran; spirogermanium; tenuazonic acid; triaziquone; 2,2',2"-trichlorotriethylamine; trichothecenes (especially T-2 toxin, verracurin A, roridin A and anguidine); urethan; vindesine; dacarbazine; mannomustine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); cyclophosphamide; thiotepa; taxoids, *e.g.*, TAXOL (paclitaxel; Bristol-Myers Squibb Oncology, Princeton, N.J.), ABRAXANE® (Cremophor-free), albumin-engineered nanoparticle formulations of paclitaxel (American Pharmaceutical Partners, Schaumberg, Ill.), and TAXOTERE® (docetaxel, doxetaxel; Sanofi-Aventis); chloranmbucil; GEMZAR® (gemcitabine); 6-thioguanine; mercaptopurine; methotrexate; platinum analogs such as cisplatin and carboplatin; vinblastine; etoposide (VP-16); ifosfamide; mitoxantrone; vincristine; NAVELBINE® (vinorelbine); novantrone; teniposide; edatrexate; daunomycin; aminopterin; capecitabine (XELODA®); ibandronate; CPT-11; topoisomerase inhibitor RFS 2000; difluoromethylornithine (DMFO); retinoids such as retinoic acid; and pharmaceutically acceptable salts, acids and derivatives of any of the above.

**[0084]** Chemotherapeutic agent also includes (i) anti-hormonal agents that act to regulate or inhibit hormone action on tumors such as anti-estrogens and selective estrogen receptor modulators

(SERMs), including, for example, tamoxifen (including NOLVADEX®; tamoxifen citrate), raloxifene, droloxifene, iodoxyfene , 4-hydroxytamoxifen, trioxifene, keoxifene, LY117018, onapristone, and FARESTON® (toremifine citrate); (ii) aromatase inhibitors that inhibit the enzyme aromatase, which regulates estrogen production in the adrenal glands, such as, for example, 4(5)-imidazoles, aminoglutethimide, MEGASE® (megestrol acetate), AROMASIN® (exemestane; Pfizer), formestanie, fadrozole, RIVISOR® (vorozole), FEMARA® (letrozole; Novartis), and ARIMIDEX® (anastrozole; AstraZeneca); (iii) anti-androgens such as flutamide, nilutamide, bicalutamide, leuprolide and goserelin; buserelin, tripterelin, medroxyprogesterone acetate, diethylstilbestrol, premarin, fluoxymesterone, all transretionic acid, fenretinide, as well as troxacitabine (a 1,3-dioxolane nucleoside cytosine analog); (iv) protein kinase inhibitors; (v) lipid kinase inhibitors; (vi) antisense oligonucleotides, particularly those which inhibit expression of genes in signaling pathways implicated in aberrant cell proliferation, such as, for example, PKC-alpha, Ralf and H-Ras; (vii) ribozymes such as VEGF expression inhibitors (*e.g.*, ANGIOZYME®) and HER2 expression inhibitors; (viii) vaccines such as gene therapy vaccines, for example, ALLOVECTIN®, LEUVECTIN®, and VAXID®; PROLEUKIN®, rIL-2; a topoisomerase 1 inhibitor such as LURTOTECAN®; ABARELIX® rmRH; and (ix) pharmaceutically acceptable salts, acids and derivatives of any of the above.

**[0085]** Chemotherapeutic agent also includes antibodies such as alemtuzumab (Campath), bevacizumab (AVASTIN®, Genentech); cetuximab (ERBITUX®, Imclone); panitumumab (VECTIBIX®, Amgen), rituximab (RITUXAN®, Genentech/Biogen Idec), pertuzumab (OMNITARG®, 2C4, Genentech), trastuzumab (HERCEPTIN®, Genentech), tositumomab (Bexxar, Corixia), and the antibody drug conjugate, gemtuzumab ozogamicin (MYLOTARG®, Wyeth). Additional humanized monoclonal antibodies with therapeutic potential as agents in combination with the compounds of the invention include: apolizumab, aselizumab, atlizumab, bapineuzumab, bivatuzumab mertansine, cantuzumab mertansine, cedelizumab, certolizumab pegol, cidfusituzumab, cidtuzumab, daclizumab, eculizumab, efalizumab, epratuzumab, erlizumab, felvizumab, fontolizumab, gemtuzumab ozogamicin, inotuzumab ozogamicin, ipilimumab, labetuzumab, lintuzumab, matuzumab, mepolizumab, motavizumab, motovizumab, natalizumab, nimotuzumab, nolovizumab, numavizumab, ocrelizumab, omalizumab, palivizumab, pascolizumab, pecfusituzumab, pectuzumab, pexelizumab, ralivizumab, ranibizumab, reslivizumab, reslizumab, resyvizumab, rovelizumab, ruplizumab, sibrotuzumab, siplizumab, sontuzumab, tacatuzumab tetraxetan, tadocizumab, talizumab, tefibazumab, tocilizumab, toralizumab, tucotuzumab celmoleukin, tucusituzumab, umavizumab, urtoxazumab, ustekinumab, visilizumab, and the anti–interleukin-12 (ABT-874/J695, Wyeth Research and Abbott Laboratories) which is a recombinant exclusively human-sequence, full-length $IgG_1 \lambda$ antibody genetically modified to recognize interleukin-12 p40 protein.

**[0086]** Chemotherapeutic agent also includes "EGFR inhibitors," which refers to compounds that bind to or otherwise interact directly with EGFR and prevent or reduce its signaling activity, and is alternatively referred to as an "EGFR antagonist." Examples of such agents include antibodies and small molecules that bind to EGFR. Examples of antibodies which bind to EGFR include MAb 579 (ATCC CRL HB 8506), MAb 455 (ATCC CRL HB8507), MAb 225 (ATCC CRL 8508), MAb 528 (ATCC CRL 8509) (see, US Patent No. 4,943, 533, Mendelsohn *et al.*) and variants thereof, such as chimerized 225 (C225 or Cetuximab; ERBUTIX®) and reshaped human 225 (H225) *(see*, WO 96/40210, Imclone Systems Inc.); IMC-11F8, a fully human, EGFR-targeted antibody (Imclone); antibodies that bind type II mutant EGFR (US Patent No. 5,212,290); humanized and chimeric antibodies that bind EGFR as described in US Patent No. 5,891,996; and human antibodies that bind EGFR, such as ABX-EGF or Panitumumab (*see* WO98/50433, Abgenix/Amgen); EMD 55900 (Stragliotto *et al. Eur. J. Cancer* 32A:636-640 (1996)); EMD7200 (matuzumab) a humanized EGFR antibody directed against EGFR that competes with both EGF and TGF-alpha for EGFR binding (EMD/Merck); human EGFR antibody, HuMax-EGFR (GenMab); fully human antibodies known as E1.1, E2.4, E2.5, E6.2, E6.4, E2.11, E6. 3 and E7.6. 3 and described in US 6,235,883; MDX-447 (Medarex Inc); and mAb 806 or humanized mAb 806 (Johns *et al., J. Biol. Chem.* 279(29):30375-30384 (2004)). The anti-EGFR antibody may be conjugated with a cytotoxic agent, thus generating an immunoconjugate (see, *e.g.*, EP659439A2, Merck Patent GmbH). EGFR antagonists include small molecules such as compounds described in US Patent Nos: 5,616,582, 5,457,105, 5,475,001, 5,654,307, 5,679,683, 6,084,095, 6,265,410, 6,455,534, 6,521,620, 6,596,726, 6,713,484, 5,770,599, 6,140,332, 5,866,572, 6,399,602, 6,344,459, 6,602,863, 6,391,874, 6,344,455, 5,760,041, 6,002,008, and 5,747,498, as well as the following PCT publications: WO98/14451, WO98/50038, WO99/09016, and WO99/24037. Particular small molecule EGFR antagonists include OSI-774 (CP-358774, erlotinib, TARCEVA® Genentech/OSI Pharmaceuticals); PD 183805 (CI 1033, 2-propenamide, N-[4-[(3-chloro-4-fluorophenyl)amino]-7-[3-(4-morpholinyl)propoxy]-6-quinazolinyl]-, dihydrochloride, Pfizer Inc.); ZD1839, gefitinib (IRESSA®) 4-(3'-Chloro-4'-fluoroanilino)-7-methoxy-6-(3-morpholinopropoxy)quinazoline, AstraZeneca); ZM 105180 ((6-amino-4-(3-methylphenyl-amino)-quinazoline, Zeneca); BIBX-1382 (N8-(3-chloro-4-fluoro-phenyl)-N2-(1-methyl-piperidin-4-yl)-pyrimido[5,4-d]pyrimidine-2,8-diamine, Boehringer Ingelheim); PKI-166 ((R)-4-[4-[(1-phenylethyl)amino]-1H-pyrrolo[2,3-d]pyrimidin-6-yl]-phenol); (R)-6-(4-hydroxyphenyl)-4-[(1-phenylethyl)amino]-7H-pyrrolo[2,3-d]pyrimidine); CL-387785 (N-[4-[(3-bromophenyl)amino]-6-quinazolinyl]-2-butynamide); EKB-569 (N-[4-[(3-chloro-4-fluorophenyl)amino]-3-cyano-7-ethoxy-6-quinolinyl]-4-(dimethylamino)-2-butenamide) (Wyeth); AG1478 (Pfizer); AG1571 (SU 5271; Pfizer); dual EGFR/HER2 tyrosine kinase inhibitors such as lapatinib (TYKERB®, GSK572016 or N-[3-chloro-4-[(3 fluorophenyl)methoxy]phenyl]-6[5[[[2methylsulfonyl)ethyl]amino]methyl]-2-furanyl]-4-quinazolinamine).

**[0087]** Chemotherapeutic agents also include "tyrosine kinase inhibitors" including the EGFR-targeted drugs noted in the preceding paragraph; small molecule HER2 tyrosine kinase inhibitor such as TAK165 available from Takeda; CP-724,714, an oral selective inhibitor of the ErbB2 receptor tyrosine kinase (Pfizer and OSI); dual-HER inhibitors such as EKB-569 (available from Wyeth) which preferentially binds EGFR but inhibits both HER2 and EGFR-overexpressing cells; lapatinib (GSK572016; available from Glaxo-SmithKline), an oral HER2 and EGFR tyrosine kinase inhibitor; PKI-166 (available from Novartis); pan-HER inhibitors such as canertinib (CI-1033; Pharmacia); Raf-1 inhibitors such as antisense agent ISIS-5132 available from ISIS Pharmaceuticals which inhibit Raf-1 signaling; non-HER targeted TK inhibitors such as imatinib mesylate (GLEEVEC®, available from Glaxo SmithKline); multi-targeted tyrosine kinase inhibitors such as sunitinib (SUTENT®, available from Pfizer); VEGF receptor tyrosine kinase inhibitors such as vatalanib (PTK787/ZK222584, available from Novartis/Schering AG); MAPK extracellular regulated kinase I inhibitor CI-1040 (available from Pharmacia); quinazolines, such as PD 153035,4-(3-chloroanilino) quinazoline; pyridopyrimidines; pyrimidopyrimidines; pyrrolopyrimidines, such as CGP 59326, CGP 60261 and CGP 62706; pyrazolopyrimidines, 4-(phenylamino)-7H-pyrrolo[2,3-d] pyrimidines; curcumin (diferuloyl methane, 4,5-bis (4-fluoroanilino)phthalimide); tyrphostines containing nitrothiophene moieties; PD-0183805 (Warner-Lamber); antisense molecules *(e.g.* those that bind to HER-encoding nucleic acid); quinoxalines (US Patent No. 5,804,396); tryphostins (US Patent No. 5,804,396); ZD6474 (Astra Zeneca); PTK-787 (Novartis/Schering AG); pan-HER inhibitors such as CI-1033 (Pfizer); Affinitac (ISIS 3521; Isis/Lilly); imatinib mesylate (GLEEVEC®); PKI 166 (Novartis); GW2016 (Glaxo SmithKline); CI-1033 (Pfizer); EKB-569 (Wyeth); Semaxinib (Pfizer); ZD6474 (AstraZeneca); PTK-787 (Novartis/Schering AG); INC-1C11 (Imclone), rapamycin (sirolimus, RAPAMUNE®); or as described in any of the following patent publications: US Patent No. 5,804,396; WO 1999/09016 (American Cyanamid); WO 1998/43960 (American Cyanamid); WO 1997/38983 (Warner Lambert); WO 1999/06378 (Warner Lambert); WO 1999/06396 (Warner Lambert); WO 1996/30347 (Pfizer, Inc); WO 1996/33978 (Zeneca); WO 1996/3397 (Zeneca) and WO 1996/33980 (Zeneca).

**[0088]** Chemotherapeutic agents also include dexamethasone, interferons, colchicine, metoprine, cyclosporine, amphotericin, metronidazole, alemtuzumab, alitretinoin, allopurinol, amifostine, arsenic trioxide, asparaginase, BCG live, bevacuzimab, bexarotene, cladribine, clofarabine, darbepoetin alfa, denileukin, dexrazoxane, epoetin alfa, elotinib, filgrastim, histrelin acetate, ibritumomab, interferon alfa-2a, interferon alfa-2b, lenalidomide, levamisole, mesna, methoxsalen, nandrolone, nelarabine, nofetumomab, oprelvekin, palifermin, pamidronate, pegademase, pegaspargase, pegfilgrastim, pemetrexed disodium, plicamycin, porfimer sodium, quinacrine, rasburicase, sargramostim, temozolomide, VM-26, 6-TG, toremifene, tretinoin, ATRA, valrubicin, zoledronate, and zoledronic acid, and pharmaceutically acceptable salts thereof.

**[0089]** Chemotherapeutic agents also include hydrocortisone, hydrocortisone acetate, cortisone acetate, tixocortol pivalate, triamcinolone acetonide, triamcinolone alcohol, mometasone, amcinonide, budesonide, desonide, fluocinonide, fluocinolone acetonide, betamethasone, betamethasone sodium phosphate, dexamethasone, dexamethasone sodium phosphate, fluocortolone, hydrocortisone-17-butyrate, hydrocortisone-17-valerate, aclometasone dipropionate, betamethasone valerate, betamethasone dipropionate, prednicarbate, clobetasone-17-butyrate, clobetasol-17-propionate, fluocortolone caproate, fluocortolone pivalate and fluprednidene acetate; immune selective anti-inflammatory peptides (ImSAIDs) such as phenylalanine-glutamine-glycine (FEG) and its D-isomeric form (feG) (IMULAN BioTherapeutics, LLC); anti-rheumatic drugs such as azathioprine, ciclosporin (cyclosporine A), D-penicillamine, gold salts, hydroxychloroquine, leflunomideminocycline, sulfasalazine, tumor necrosis factor alpha (TNFα) blockers such as etanercept (Enbrel), infliximab (Remicade), adalimumab (Humira), certolizumab pegol (Cimzia), golimumab (Simponi), Interleukin 1 (IL-1) blockers such as anakinra (Kineret), T cell costimulation blockers such as abatacept (Orencia), Interleukin 6 (IL-6) blockers such as tocilizumab (ACTEMERA®); Interleukin 13 (IL-13) blockers such as lebrikizumab; Interferon alpha (IFN) blockers such as Rontalizumab; Beta 7 integrin blockers such as rhuMAb Beta7; IgE pathway blockers such as Anti-M1 prime; Secreted homotrimeric LTa3 and membrane bound heterotrimer LTa1/β2 blockers such as Anti-lymphotoxin alpha (LTa); radioactive isotopes (*e.g.*, $At^{211}$, $I^{131}$, $I^{125}$, $Y^{90}$, $Re^{186}$, $Re^{188}$, $Sm^{153}$, $Bi^{212}$, $P^{32}$, $Pb^{212}$ and radioactive isotopes of Lu); miscellaneous investigational agents such as thioplatin, PS-341, phenylbutyrate, ET-18- $OCH_3$, or farnesyl transferase inhibitors (L-739749, L-744832); polyphenols such as quercetin, resveratrol, piceatannol, epigallocatechine gallate, theaflavins, flavanols, procyanidins, betulinic acid and derivatives thereof; autophagy inhibitors such as chloroquine; delta-9-tetrahydrocannabinol (dronabinol, MARINOL®); beta-lapachone; lapachol; colchicines; betulinic acid; acetylcamptothecin, scopolectin, and 9-aminocamptothecin); podophyllotoxin; tegafur (UFTORAL®); bexarotene (TARGRETIN®); bisphosphonates such as clodronate (for example, BONEFOS® or OSTAC®), etidronate (DIDROCAL®), NE-58095, zoledronic acid/zoledronate (ZOMETA®), alendronate (FOSAMAX®), pamidronate (AREDIA®), tiludronate (SKELID®), or risedronate (ACTONEL®); and epidermal growth factor receptor (EGF-R); vaccines such as THERATOPE® vaccine; perifosine, COX-2 inhibitor (*e.g.* celecoxib or etoricoxib), proteosome inhibitor (*e.g.* PS341); CCI-779; tipifarnib (R11577); orafenib, ABT510; Bcl-2 inhibitor such as oblimersen sodium (GENASENSE®); pixantrone; farnesyltransferase inhibitors such as lonafarnib (SCH 6636, SARASAR™); and pharmaceutically acceptable salts, acids or derivatives of any of the above; as well as combinations of two or more of the above such as CHOP, an abbreviation for a combined therapy of cyclophosphamide, doxorubicin, vincristine, and prednisolone; and FOLFOX, an abbreviation for a treatment regimen with oxaliplatin (ELOXATIN™) combined with 5-FU and leucovorin.

**[0090]** Chemotherapeutic agents also include non-steroidal anti-inflammatory drugswith analgesic, antipyretic and anti-inflammatory effects. NSAIDs include non-selective inhibitors of the enzyme cyclooxygenase. Specific examples of NSAIDs include aspirin, propionic acid derivatives such as ibuprofen, fenoprofen, ketoprofen, flurbiprofen, oxaprozin and naproxen, acetic acid derivatives such as indomethacin, sulindac, etodolac, diclofenac, enolic acid derivatives such as piroxicam, meloxicam, tenoxicam, droxicam, lornoxicam and isoxicam, fenamic acid derivatives such as mefenamic acid, meclofenamic acid, flufenamic acid, tolfenamic acid, and COX-2 inhibitors such as celecoxib, etoricoxib, lumiracoxib, parecoxib, rofecoxib, rofecoxib, and valdecoxib. NSAIDs can be indicated for the symptomatic relief of conditions such as rheumatoid arthritis, osteoarthritis, inflammatory arthropathies, ankylosing spondylitis, psoriatic arthritis, Reiter's syndrome, acute gout, dysmenorrhoea, metastatic bone pain, headache and migraine, postoperative pain, mild-to-moderate pain due to inflammation and tissue injury, pyrexia, ileus, and renal colic.

**[0091]** A "growth inhibitory agent" when used herein refers to a compound or composition which inhibits growth of a cell either in vitro or in vivo. In one embodiment, growth inhibitory agent is growth inhibitory antibody that prevents or reduces proliferation of a cell expressing an antigen to which the antibody binds. In another embodiment, the growth inhibitory agent may be one which significantly reduces the percentage of cells in S phase. Examples of growth inhibitory agents include agents that block cell cycle progression (at a place other than S phase), such as agents that induce G1 arrest and M-phase arrest. Classical M-phase blockers include the vincas (vincristine and vinblastine), taxanes, and topoisomerase II inhibitors such as doxorubicin, epirubicin, daunorubicin, etoposide, and bleomycin. Those agents that arrest G1 also spill over into S-phase arrest, for example, DNA alkylating agents such as tamoxifen, prednisone, dacarbazine, mechlorethamine, cisplatin, methotrexate, 5-fluorouracil, and ara-C. Further information can be found in Mendelsohn and Israel, eds., The Molecular Basis of Cancer, Chapter 1, entitled "Cell cycle regulation, oncogenes, and antineoplastic drugs" by Murakami et al. (W.B. Saunders, Philadelphia, 1995), e.g., p. 13. The taxanes (paclitaxel and docetaxel) are anticancer drugs both derived from the yew tree. Docetaxel (TAXOTERE®, Rhone-Poulenc Rorer), derived from the European yew, is a semisynthetic analogue of paclitaxel (TAXOL®, Bristol-Myers Squibb). Paclitaxel and docetaxel promote the assembly of microtubules from tubulin dimers and stabilize microtubules by preventing depolymerization, which results in the inhibition of mitosis in cells.

**[0092]** By "radiation therapy" is meant the use of directed gamma rays or beta rays to induce sufficient damage to a cell so as to limit its ability to function normally or to destroy the cell altogether. It will be appreciated that there will be many ways known in the art to determine the dosage and duration of treatment. Typical treatments are given as a one-time administration and typical dosages range from 10 to 200 units (Grays) per day.

**[0093]** A "subject" or an "individual" for purposes of treatment refers to any animal classified as a mammal, including humans, domestic and farm animals, and zoo, sports, or pet animals, such as dogs, horses, cats, cows, etc. Preferably, the mammal is human.

**[0094]** The term "antibody" herein is used in the broadest sense and specifically covers monoclonal antibodies (including full length monoclonal antibodies), polyclonal antibodies, multispecific antibodies (*e.g.*, bispecific antibodies), and antibody fragments so long as they exhibit the desired biological activity.

**[0095]** An "isolated" antibody is one which has been identified and separated and/or recovered from a component of its natural environment. Contaminant components of its natural environment are materials which would interfere with research, diagnostic or therapeutic uses for the antibody, and may include enzymes, hormones, and other proteinaceous or nonproteinaceous solutes. In some embodiments, an antibody is purified (1) to greater than 95% by weight of antibody as determined by, for example, the Lowry method, and in some embodiments, to greater than 99% by weight; (2) to a degree sufficient to obtain at least 15 residues of N-terminal or internal amino acid sequence by use of, for example, a spinning cup sequenator, or (3) to homogeneity by SDS-PAGE under reducing or nonreducing conditions using, for example, Coomassie blue or silver stain. Isolated antibody includes the antibody *in situ* within recombinant cells since at least one component of the antibody's natural environment will not be present. Ordinarily, however, isolated antibody will be prepared by at least one purification step.

**[0096]** "Native antibodies" are usually heterotetrameric glycoproteins of about 150,000 daltons, composed of two identical light (L) chains and two identical heavy (H) chains. Each light chain is linked to a heavy chain by one covalent disulfide bond, while the number of disulfide linkages varies among the heavy chains of different immunoglobulin isotypes. Each heavy and light chain also has regularly spaced intrachain disulfide bridges. Each heavy chain has at one end a variable domain ($V_H$) followed by a number of constant domains. Each light chain has a variable domain at one end ($V_L$) and a constant domain at its other end; the constant domain of the light chain is aligned with the first constant domain of the heavy chain, and the light chain variable domain is aligned with the variable domain of the heavy chain. Particular amino acid residues are believed to form an interface between the light chain and heavy chain variable domains.

**[0097]** The term "constant domain" refers to the portion of an immunoglobulin molecule having a more conserved amino acid sequence relative to the other portion of the immunoglobulin, the variable domain, which contains the antigen binding site. The constant domain contains the $C_H1$, $C_H2$ and $C_H3$ domains (collectively, CH) of the heavy chain and the CHL (or CL) domain of the light chain.

**[0098]** The "variable region" or "variable domain" of an antibody refers to the amino-terminal domains of the heavy or light chain of the antibody. The variable domain of the heavy chain may be

referred to as "$V_H$." The variable domain of the light chain may be referred to as "$V_L$." These domains are generally the most variable parts of an antibody and contain the antigen-binding sites.

**[0099]** The term "variable" refers to the fact that certain portions of the variable domains differ extensively in sequence among antibodies and are used in the binding and specificity of each particular antibody for its particular antigen. However, the variability is not evenly distributed throughout the variable domains of antibodies. It is concentrated in three segments called hypervariable regions (HVRs) both in the light-chain and the heavy-chain variable domains. The more highly conserved portions of variable domains are called the framework regions (FR). The variable domains of native heavy and light chains each comprise four FR regions, largely adopting a beta-sheet configuration, connected by three HVRs, which form loops connecting, and in some cases forming part of, the beta-sheet structure. The HVRs in each chain are held together in close proximity by the FR regions and, with the HVRs from the other chain, contribute to the formation of the antigen-binding site of antibodies (see Kabat et al., *Sequences of Proteins of Immunological Interest*, Fifth Edition, National Institute of Health, Bethesda, Md. (1991)). The constant domains are not involved directly in the binding of an antibody to an antigen, but exhibit various effector functions, such as participation of the antibody in antibody-dependent cellular toxicity.

**[0100]** The "light chains" of antibodies (immunoglobulins) from any mammalian species can be assigned to one of two clearly distinct types, called kappa ("κ") and lambda ("λ"), based on the amino acid sequences of their constant domains.

**[0101]** The term IgG "isotype" or "subclass" as used herein is meant any of the subclasses of immunoglobulins defined by the chemical and antigenic characteristics of their constant regions.

**[0102]** Depending on the amino acid sequences of the constant domains of their heavy chains, antibodies (immunoglobulins) can be assigned to different classes. There are five major classes of immunoglobulins: IgA, IgD, IgE, IgG, and IgM, and several of these may be further divided into subclasses (isotypes), e.g., $IgG_1$, $IgG_2$, $IgG_3$, $IgG_4$, $IgA_1$, and $IgA_2$. The heavy chain constant domains that correspond to the different classes of immunoglobulins are called α, γ, ε, γ, and μ, respectively. The subunit structures and three-dimensional configurations of different classes of immunoglobulins are well known and described generally in, for example, Abbas et al. *Cellular and Mol. Immunology*, 4th ed. (W.B. Saunders, Co., 2000). An antibody may be part of a larger fusion molecule, formed by covalent or non-covalent association of the antibody with one or more other proteins or peptides.

**[0103]** The terms "full length antibody," "intact antibody" and "whole antibody" are used herein interchangeably to refer to an antibody in its substantially intact form, not antibody fragments as defined below. The terms particularly refer to an antibody with heavy chains that contain an Fc region.

**[0104]** A "naked antibody" for the purposes herein is an antibody that is not conjugated to a cytotoxic moiety or radiolabel.

**[0105]** "Antibody fragments" comprise a portion of an intact antibody, preferably comprising the antigen binding region thereof. In some embodiments, the antibody fragment described herein is an antigen-binding fragment. Examples of antibody fragments include Fab, Fab', $F(ab')_2$, and Fv fragments; diabodies; linear antibodies; single-chain antibody molecules; and multispecific antibodies formed from antibody fragments.

**[0106]** Papain digestion of antibodies produces two identical antigen-binding fragments, called "Fab" fragments, each with a single antigen-binding site, and a residual "Fc" fragment, whose name reflects its ability to crystallize readily. Pepsin treatment yields an $F(ab')_2$ fragment that has two antigen-combining sites and is still capable of cross-linking antigen.

**[0107]** "Fv" is the minimum antibody fragment which contains a complete antigen-binding site. In one embodiment, a two-chain Fv species consists of a dimer of one heavy- and one light-chain variable domain in tight, non-covalent association. In a single-chain Fv (scFv) species, one heavy- and one light-chain variable domain can be covalently linked by a flexible peptide linker such that the light and heavy chains can associate in a "dimeric" structure analogous to that in a two-chain Fv species. It is in this configuration that the three HVRs of each variable domain interact to define an antigen-binding site on the surface of the VH-VL dimer. Collectively, the six HVRs confer antigen-binding specificity to the antibody. However, even a single variable domain (or half of an Fv comprising only three HVRs specific for an antigen) has the ability to recognize and bind antigen, although at a lower affinity than the entire binding site.

**[0108]** The Fab fragment contains the heavy- and light-chain variable domains and also contains the constant domain of the light chain and the first constant domain (CH1) of the heavy chain. Fab' fragments differ from Fab fragments by the addition of a few residues at the carboxy terminus of the heavy chain CH1 domain including one or more cysteines from the antibody hinge region. Fab'-SH is the designation herein for Fab' in which the cysteine residue(s) of the constant domains bear a free thiol group. $F(ab')_2$ antibody fragments originally were produced as pairs of Fab' fragments which have hinge cysteines between them. Other chemical couplings of antibody fragments are also known.

**[0109]** "Single-chain Fv" or "scFv" antibody fragments comprise the VH and VL domains of antibody, wherein these domains are present in a single polypeptide chain. Generally, the scFv polypeptide further comprises a polypeptide linker between the VH and VL domains which enables the scFv to form the desired structure for antigen binding. For a review of scFv, see, *e.g.*, Pluckthün, in *The Pharmacology of Monoclonal Antibodies*, vol. 113, Rosenburg and Moore eds., (Springer-Verlag, New York, 1994), pp. 269-315.

**[0110]** The term "diabodies" refers to antibody fragments with two antigen-binding sites, which fragments comprise a heavy-chain variable domain (VH) connected to a light-chain variable domain (VL) in the same polypeptide chain (VH-VL). By using a linker that is too short to allow pairing between the two domains on the same chain, the domains are forced to pair with the complementary

domains of another chain and create two antigen-binding sites. Diabodies may be bivalent or bispecific. Diabodies are described more fully in, for example, EP 404,097; WO 1993/01161; Hudson et al., *Nat. Med.* 9:129-134 (2003); and Hollinger et al., *Proc. Natl. Acad. Sci. USA* 90: 6444-6448 (1993). Triabodies and tetrabodies are also described in Hudson et al., *Nat. Med.* 9:129-134 (2003).

**[0111]** The term "monoclonal antibody" as used herein refers to an antibody obtained from a population of substantially homogeneous antibodies, e.g., the individual antibodies comprising the population are identical except for possible mutations, e.g., naturally occurring mutations, that may be present in minor amounts. Thus, the modifier "monoclonal" indicates the character of the antibody as not being a mixture of discrete antibodies. In certain embodiments, such a monoclonal antibody typically includes an antibody comprising a polypeptide sequence that binds a target, wherein the target-binding polypeptide sequence was obtained by a process that includes the selection of a single target binding polypeptide sequence from a plurality of polypeptide sequences. For example, the selection process can be the selection of a unique clone from a plurality of clones, such as a pool of hybridoma clones, phage clones, or recombinant DNA clones. It should be understood that a selected target binding sequence can be further altered, for example, to improve affinity for the target, to humanize the target binding sequence, to improve its production in cell culture, to reduce its immunogenicity *in vivo*, to create a multispecific antibody, etc., and that an antibody comprising the altered target binding sequence is also a monoclonal antibody of this invention. In contrast to polyclonal antibody preparations, which typically include different antibodies directed against different determinants (epitopes), each monoclonal antibody of a monoclonal antibody preparation is directed against a single determinant on an antigen. In addition to their specificity, monoclonal antibody preparations are advantageous in that they are typically uncontaminated by other immunoglobulins.

**[0112]** The modifier "monoclonal" indicates the character of the antibody as being obtained from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. For example, the monoclonal antibodies to be used in accordance with the invention may be made by a variety of techniques, including, for example, the hybridoma method (e.g., Kohler and Milstein, *Nature*, 256:495-97 (1975); Hongo *et al.*, *Hybridoma*, 14 (3): 253-260 (1995), Harlow *et al.*, *Antibodies: A Laboratory Manual*, (Cold Spring Harbor Laboratory Press, 2nd ed. 1988); Hammerling *et al.*, in: *Monoclonal Antibodies and T-Cell Hybridomas* 563-681 (Elsevier, N.Y., 1981)), recombinant DNA methods (see, e.g., U.S. Pat. No. 4,816,567), phage-display technologies (see, e.g., Clackson *et al.*, *Nature*, 352: 624-628 (1991); Marks *et al.*, *J. Mol. Biol.* 222: 581-597 (1992); Sidhu *et al.*, *J. Mol. Biol.* 338(2): 299-310 (2004); Lee *et al.*, *J. Mol. Biol.* 340(5): 1073-1093 (2004); Fellouse, *Proc. Natl. Acad. Sci. USA* 101(34): 12467-12472 (2004); and Lee *et al.*, *J. Immunol. Methods* 284(1-2): 119-132 (2004), and technologies for producing human or human-like antibodies in animals that have parts or all of the human

immunoglobulin loci or genes encoding human immunoglobulin sequences (see, e.g., WO 1998/24893; WO 1996/34096; WO 1996/33735; WO 1991/10741; Jakobovits *et al.*, *Proc. Natl. Acad. Sci. USA* 90: 2551 (1993); Jakobovits *et al.*, *Nature* 362: 255-258 (1993); Bruggemann *et al.*, *Year in Immunol.* 7:33 (1993); U.S. Pat. Nos. 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; and 5,661,016; Marks *et al.*, *Bio/Technology* 10: 779-783 (1992); Lonberg et al., *Nature* 368: 856-859 (1994); Morrison, *Nature* 368: 812-813 (1994); Fishwild *et al.*, *Nature Biotechnol.* 14: 845-851 (1996); Neuberger, *Nature Biotechnol.* 14: 826 (1996); and Lonberg and Huszar, *Intern. Rev. Immunol.* 13: 65-93 (1995).

**[0113]** The monoclonal antibodies herein specifically include "chimeric" antibodies in which a portion of the heavy and/or light chain is identical with or homologous to corresponding sequences in antibodies derived from a particular species or belonging to a particular antibody class or subclass, while the remainder of the chain(s) is identical with or homologous to corresponding sequences in antibodies derived from another species or belonging to another antibody class or subclass, as well as fragments of such antibodies, so long as they exhibit the desired biological activity (see, *e.g.*, U.S. Pat. No. 4,816,567; and Morrison *et al.*, *Proc. Natl. Acad. Sci. USA* 81:6851-6855 (1984)). Chimeric antibodies include PRIMATTZED® antibodies wherein the antigen-binding region of the antibody is derived from an antibody produced by, e.g., immunizing macaque monkeys with the antigen of interest.

**[0114]** "Humanized" forms of non-human (e.g., murine) antibodies are chimeric antibodies that contain minimal sequence derived from non-human immunoglobulin. In one embodiment, a humanized antibody is a human immunoglobulin (recipient antibody) in which residues from a HVR of the recipient are replaced by residues from a HVR of a non-human species (donor antibody) such as mouse, rat, rabbit, or nonhuman primate having the desired specificity, affinity, and/or capacity. In some instances, FR residues of the human immunoglobulin are replaced by corresponding non-human residues. Furthermore, humanized antibodies may comprise residues that are not found in the recipient antibody or in the donor antibody. These modifications may be made to further refine antibody performance. In general, a humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the hypervariable loops correspond to those of a non-human immunoglobulin, and all or substantially all of the FRs are those of a human immunoglobulin sequence. The humanized antibody optionally will also comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. For further details, see, *e.g.*, Jones *et al.*, *Nature* 321:522-525 (1986); Riechmann *et al.*, *Nature* 332:323-329 (1988); and Presta, *Curr. Op. Struct. Biol.* 2:593-596 (1992). See also, *e.g.*, Vaswani and Hamilton, *Ann. Allergy, Asthma & Immunol.* 1:105-115 (1998); Harris, *Biochem. Soc. Transactions* 23:1035-1038 (1995); Hurle and Gross, *Curr. Op. Biotech.* 5:428-433 (1994); and U.S. Pat. Nos. 6,982,321 and 7,087,409.

**[0115]** A "human antibody" is one which possesses an amino acid sequence which corresponds to that of an antibody produced by a human and/or has been made using any of the techniques for making human antibodies as disclosed herein. This definition of a human antibody specifically excludes a humanized antibody comprising non-human antigen-binding residues. Human antibodies can be produced using various techniques known in the art, including phage-display libraries. Hoogenboom and Winter, *J. Mol. Biol.*, 227:381 (1991); Marks *et al.*, *J. Mol. Biol.*, 222:581 (1991). Also available for the preparation of human monoclonal antibodies are methods described in Cole *et al.*, *Monoclonal Antibodies and Cancer Therapy*, Alan R. Liss, p. 77 (1985); Boerner *et al.*, *J. Immunol.*, 147(1):86-95 (1991). See also van Dijk and van de Winkel, *Curr. Opin. Pharmacol.*, 5: 368-74 (2001). Human antibodies can be prepared by administering the antigen to a transgenic animal that has been modified to produce such antibodies in response to antigenic challenge, but whose endogenous loci have been disabled, *e.g.*, immunized xenomice (see, *e.g.*, U.S. Pat. Nos. 6,075,181 and 6,150,584 regarding XENOMOUSE™ technology). See also, for example, Li *et al.*, *Proc. Natl. Acad. Sci. USA*, 103:3557-3562 (2006) regarding human antibodies generated via a human B-cell hybridoma technology.

**[0116]** A "species-dependent antibody" is one which has a stronger binding affinity for an antigen from a first mammalian species than it has for a homologue of that antigen from a second mammalian species. Normally, the species-dependent antibody "binds specifically" to a human antigen (e.g., has a binding affinity (Kd) value of no more than about $1x10^{-7}$ M, preferably no more than about $1x10^{-8}$ M and preferably no more than about $1x10^{-9}$ M) but has a binding affinity for a homologue of the antigen from a second nonhuman mammalian species which is at least about 50 fold, or at least about 500 fold, or at least about 1000 fold, weaker than its binding affinity for the human antigen. The species-dependent antibody can be any of the various types of antibodies as defined above, but preferably is a humanized or human antibody.

**[0117]** The term "hypervariable region," "HVR," or "HV," when used herein refers to the regions of an antibody variable domain which are hypervariable in sequence and/or form structurally defined loops. Generally, antibodies comprise six HVRs; three in the VH (H1, H2, H3), and three in the VL (L1, L2, L3). In native antibodies, H3 and L3 display the most diversity of the six HVRs, and H3 in particular is believed to play a unique role in conferring fine specificity to antibodies. See, *e.g.*, Xu et al., *Immunity* 13:37-45 (2000); Johnson and Wu, in *Methods in Molecular Biology* 248:1-25 (Lo, ed., Human Press, Totowa, N.J., 2003). Indeed, naturally occurring camelid antibodies consisting of a heavy chain only are functional and stable in the absence of light chain. See, *e.g.*, Hamers-Casterman et al., *Nature* 363:446-448 (1993); Sheriff et al., *Nature Struct. Biol.* 3:733-736 (1996).

**[0118]** A number of HVR delineations are in use and are encompassed herein. The Kabat Complementarity Determining Regions (CDRs) are based on sequence variability and are the most commonly used (Kabat *et al.*, *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health

Service, National Institutes of Health, Bethesda, Md. (1991)). Chothia refers instead to the location of the structural loops (Chothia and Lesk *J. Mol. Biol.* 196:901-917 (1987)). The AbM HVRs represent a compromise between the Kabat HVRs and Chothia structural loops, and are used by Oxford Molecular's AbM antibody modeling software. The "contact" HVRs are based on an analysis of the available complex crystal structures. The residues from each of these HVRs are noted below.

| Loop | Kabat | AbM | Chothia | Contact |
|---|---|---|---|---|
| L1 | L24-L34 | L24-L34 | L26-L32 | L30-L36 |
| L2 | L50-L56 | L50-L56 | L50-L52 | L46-L55 |
| L3 | L89-L97 | L89-L97 | L91-L96 | L89-L96 |
| H1 | H31-H35B | H26-H35B | H26-H32 | H30-H35B (Kabat Numbering) |
| H1 | H31-H35 | H26-H35 | H26-H32 | H30-H35 (Chothia Numbering) |
| H2 | H50-H65 | H50-H58 | H53-H55 | H47-H58 |
| H3 | H95-H102 | H95-H102 | H96-H101 | H93-H101 |

**[0119]** HVRs may comprise "extended HVRs" as follows: 24-36 or 24-34 (L1), 46-56 or 50-56 (L2) and 89-97 or 89-96 (L3) in the VL and 26-35 (H1), 50-65 or 49-65 (H2) and 93-102, 94-102, or 95-102 (H3) in the VH. The variable domain residues are numbered according to Kabat et al., *supra*, for each of these definitions.

**[0120]** "Framework" or "FR" residues are those variable domain residues other than the HVR residues as herein defined.

**[0121]** The term "variable domain residue numbering as in Kabat" or "amino acid position numbering as in Kabat," and variations thereof, refers to the numbering system used for heavy chain variable domains or light chain variable domains of the compilation of antibodies in Kabat et al., *supra*. Using this numbering system, the actual linear amino acid sequence may contain fewer or additional amino acids corresponding to a shortening of, or insertion into, a FR or HVR of the variable domain. For example, a heavy chain variable domain may include a single amino acid insert (residue 52a according to Kabat) after residue 52 of H2 and inserted residues (e.g. residues 82a, 82b, and 82c, etc. according to Kabat) after heavy chain FR residue 82. The Kabat numbering of residues may be determined for a given antibody by alignment at regions of homology of the sequence of the antibody with a "standard" Kabat numbered sequence.

**[0122]** The Kabat numbering system is generally used when referring to a residue in the variable domain (approximately residues 1-107 of the light chain and residues 1-113 of the heavy chain) (e.g., Kabat *et al.*, Sequences *of Immunological Interest*. 5th Ed. Public Health Service, National Institutes of Health, Bethesda, Md. (1991)). The "EU numbering system" or "EU index" is generally used when referring to a residue in an immunoglobulin heavy chain constant region (e.g., the EU index reported

in Kabat *et al.*, *supra*). The "EU index as in Kabat" refers to the residue numbering of the human IgG1 EU antibody.

**[0123]** The expression "linear antibodies" refers to the antibodies described in Zapata et al. (1995 *Protein Eng*, 8(10):1057-1062). Briefly, these antibodies comprise a pair of tandem Fd segments (VH-CH1-VH-CH1) which, together with complementary light chain polypeptides, form a pair of antigen binding regions. Linear antibodies can be bispecific or monospecific.

**[0124]** As use herein, the term "binds", "specifically binds to" or is "specific for" refers to measurable and reproducible interactions such as binding between a target and an antibody, which is determinative of the presence of the target in the presence of a heterogeneous population of molecules including biological molecules. For example, an antibody that binds to or specifically binds to a target (which can be an epitope) is an antibody that binds this target with greater affinity, avidity, more readily, and/or with greater duration than it binds to other targets. In one embodiment, the extent of binding of an antibody to an unrelated target is less than about 10% of the binding of the antibody to the target as measured, *e.g.,* by a radioimmunoassay (RIA). In certain embodiments, an antibody that specifically binds to a target has a dissociation constant (Kd) of $\leq$ 1μM, $\leq$ 100 nM, $\leq$ 10 nM, $\leq$ 1 nM, or $\leq$ 0.1 nM. In certain embodiments, an antibody specifically binds to an epitope on a protein that is conserved among the protein from different species. In another embodiment, specific binding can include, but does not require exclusive binding.

**[0125]** The term "detection" includes any means of detecting, including direct and indirect detection.

**[0126]** The term "biomarker" as used herein refers to an indicator, *e.g.*, predictive, diagnostic, and/or prognostic, which can be detected in a sample. The biomarker may serve as an indicator of a particular subtype of a disease or disorder (*e.g.*, cancer) characterized by certain, molecular, pathological, histological, and/or clinical features. In some embodiments, a biomarker is a gene. Biomarkers include, but are not limited to, polynucleotides (*e.g.*, DNA, and/or RNA), polynucleotide copy number alterations (*e.g.*, DNA copy numbers), polypeptides, polypeptide and polynucleotide modifications (*e.g.* posttranslational modifications), carbohydrates, and/or glycolipid-based molecular markers.

**[0127]** The terms "biomarker signature," "signature," "biomarker expression signature," or "expression signature" are used interchangeably herein and refer to one or a combination of biomarkers whose expression is an indicator, *e.g.*, predictive, diagnostic, and/or prognostic. The biomarker signature may serve as an indicator of a particular subtype of a disease or disorder (*e.g.*, cancer) characterized by certain molecular, pathological, histological, and/or clinical features. In some embodiments, the biomarker signature is a "gene signature." The term "gene signature" is used interchangeably with "gene expression signature" and refers to one or a combination of polynucleotides whose expression is an indicator, *e.g.*, predictive, diagnostic, and/or prognostic. In some embodiments, the biomarker signature is a "protein signature." The term "protein signature" is

used interchangeably with "protein expression signature" and refers to one or a combination of polypeptides whose expression is an indicator, *e.g.*, predictive, diagnostic, and/or prognostic.

**[0128]** The "amount" or "level" of a biomarker associated with an increased clinical benefit to an individual is a detectable level in a biological sample. These can be measured by methods known to one skilled in the art and also disclosed herein. The expression level or amount of biomarker assessed can be used to determine the response to the treatment.

**[0129]** The terms "level of expression" or "expression level" in general are used interchangeably and generally refer to the amount of a biomarker in a biological sample. "Expression" generally refers to the process by which information (*e.g.*, gene-encoded and/or epigenetic) is converted into the structures present and operating in the cell. Therefore, as used herein, "expression" may refer to transcription into a polynucleotide, translation into a polypeptide, or even polynucleotide and/or polypeptide modifications (*e.g.*, posttranslational modification of a polypeptide). Fragments of the transcribed polynucleotide, the translated polypeptide, or polynucleotide and/or polypeptide modifications (*e.g.*, posttranslational modification of a polypeptide) shall also be regarded as expressed whether they originate from a transcript generated by alternative splicing or a degraded transcript, or from a post-translational processing of the polypeptide, *e.g.*, by proteolysis. "Expressed genes" include those that are transcribed into a polynucleotide as mRNA and then translated into a polypeptide, and also those that are transcribed into RNA but not translated into a polypeptide (for example, transfer and ribosomal RNAs).

**[0130]** "Elevated expression," "elevated expression levels," or "elevated levels" refers to an increased expression or increased levels of a biomarker in an individual relative to a control, such as an individual or individuals who are not suffering from the disease or disorder (*e.g.*, cancer) or an internal control (*e.g.*, housekeeping biomarker).

**[0131]** "Reduced expression," "reduced expression levels," or "reduced levels" refers to a decrease expression or decreased levels of a biomarker in an individual relative to a control, such as an individual or individuals who are not suffering from the disease or disorder (*e.g.*, cancer) or an internal control (*e.g.*, housekeeping biomarker). In some embodiments, reduced expression is little or no expression.

**[0132]** The term "housekeeping biomarker" refers to a biomarker or group of biomarkers (*e.g.*, polynucleotides and/or polypeptides) which are typically similarly present in all cell types. In some embodiments, the housekeeping biomarker is a "housekeeping gene." A "housekeeping gene" refers herein to a gene or group of genes which encode proteins whose activities are essential for the maintenance of cell function and which are typically similarly present in all cell types.

**[0133]** "Amplification," as used herein generally refers to the process of producing multiple copies of a desired sequence. "Multiple copies" mean at least two copies. A "copy" does not necessarily mean perfect sequence complementarity or identity to the template sequence. For example, copies can

include nucleotide analogs such as deoxyinosine, intentional sequence alterations (such as sequence alterations introduced through a primer comprising a sequence that is hybridizable, but not complementary, to the template), and/or sequence errors that occur during amplification.

**[0134]** The term "multiplex-PCR" refers to a single PCR reaction carried out on nucleic acid obtained from a single source (*e.g.*, an individual) using more than one primer set for the purpose of amplifying two or more DNA sequences in a single reaction.

**[0135]** "Stringency" of hybridization reactions is readily determinable by one of ordinary skill in the art, and generally is an empirical calculation dependent upon probe length, washing temperature, and salt concentration. In general, longer probes require higher temperatures for proper annealing, while shorter probes need lower temperatures. Hybridization generally depends on the ability of denatured DNA to reanneal when complementary strands are present in an environment below their melting temperature. The higher the degree of desired homology between the probe and hybridizable sequence, the higher the relative temperature which can be used. As a result, it follows that higher relative temperatures would tend to make the reaction conditions more stringent, while lower temperatures less so. For additional details and explanation of stringency of hybridization reactions, *see* Ausubel et al., Current Protocols in Molecular Biology, Wiley Interscience Publishers, (1995).

**[0136]** "Stringent conditions" or "high stringency conditions", as defined herein, can be identified by those that: (1) employ low ionic strength and high temperature for washing, for example 0.015 M sodium chloride/0.0015 M sodium citrate/0.1% sodium dodecyl sulfate at 50°C; (2) employ during hybridization a denaturing agent, such as formamide, for example, 50% (v/v) formamide with 0.1% bovine serum albumin/0.1% Ficoll/0.1% polyvinylpyrrolidone/50mM sodium phosphate buffer at pH 6.5 with 750 mM sodium chloride, 75 mM sodium citrate at 42°C; or (3) overnight hybridization in a solution that employs 50% formamide, 5 x SSC (0.75 M NaCl, 0.075 M sodium citrate), 50 mM sodium phosphate (pH 6.8), 0.1% sodium pyrophosphate, 5 x Denhardt's solution, sonicated salmon sperm DNA (50 µg/ml), 0.1% SDS, and 10% dextran sulfate at 42°C, with a 10 minute wash at 42°C in 0.2 x SSC (sodium chloride/sodium citrate) followed by a 10 minute high-stringency wash consisting of 0.1 x SSC containing EDTA at 55°C.

**[0137]** "Moderately stringent conditions" can be identified as described by Sambrook et al., Molecular Cloning: A Laboratory Manual, New York: Cold Spring Harbor Press, 1989, and include the use of washing solution and hybridization conditions (*e.g.*, temperature, ionic strength and %SDS) less stringent that those described above. An example of moderately stringent conditions is overnight incubation at 37°C in a solution comprising: 20% formamide, 5 x SSC (150 mM NaCl, 15 mM trisodium citrate), 50 mM sodium phosphate (pH 7.6), 5 x Denhardt's solution, 10% dextran sulfate, and 20 mg/ml denatured sheared salmon sperm DNA, followed by washing the filters in 1 x SSC at about 37-50°C. The skilled artisan will recognize how to adjust the temperature, ionic strength, etc. as necessary to accommodate factors such as probe length and the like.

**[0138]** The technique of "polymerase chain reaction" or "PCR" as used herein generally refers to a procedure wherein minute amounts of a specific piece of nucleic acid, RNA and/or DNA, are amplified as described in U.S. Pat. No. 4,683,195 issued 28 July 1987. Generally, sequence information from the ends of the region of interest or beyond needs to be available, such that oligonucleotide primers can be designed; these primers will be identical or similar in sequence to opposite strands of the template to be amplified. The 5' terminal nucleotides of the two primers may coincide with the ends of the amplified material. PCR can be used to amplify specific RNA sequences, specific DNA sequences from total genomic DNA, and cDNA transcribed from total cellular RNA, bacteriophage or plasmid sequences, etc. See generally Mullis *et al., Cold Spring Harbor Symp. Quant. Biol.*, 51: 263 (1987); Erlich, ed., PCR Technology, (Stockton Press, NY, 1989). As used herein, PCR is considered to be one, but not the only, example of a nucleic acid polymerase reaction method for amplifying a nucleic acid test sample, comprising the use of a known nucleic acid (DNA or RNA) as a primer and utilizes a nucleic acid polymerase to amplify or generate a specific piece of nucleic acid or to amplify or generate a specific piece of nucleic acid which is complementary to a particular nucleic acid.

**[0139]** "Quantitative real time polymerase chain reaction" or "qRT-PCR" refers to a form of PCR wherein the amount of PCR product is measured at each step in a PCR reaction. This technique has been described in various publications including Cronin *et al., Am. J. Pathol.* 164(1):35-42 (2004); and Ma *et al., Cancer Cell* 5:607-616 (2004).

**[0140]** The term "microarray" refers to an ordered arrangement of hybridizable array elements, preferably polynucleotide probes, on a substrate.

**[0141]** The term "polynucleotide," when used in singular or plural, generally refers to any polyribonucleotide or polydeoxyribonucleotide, which may be unmodified RNA or DNA or modified RNA or DNA. Thus, for instance, polynucleotides as defined herein include, without limitation, single- and double-stranded DNA, DNA including single- and double-stranded regions, single- and double-stranded RNA, and RNA including single- and double-stranded regions, hybrid molecules comprising DNA and RNA that may be single-stranded or, more typically, double-stranded or include single- and double-stranded regions. In addition, the term "polynucleotide" as used herein refers to triple- stranded regions comprising RNA or DNA or both RNA and DNA. The strands in such regions may be from the same molecule or from different molecules. The regions may include all of one or more of the molecules, but more typically involve only a region of some of the molecules. One of the molecules of a triple-helical region often is an oligonucleotide. The term "polynucleotide" specifically includes cDNAs. The term includes DNAs (including cDNAs) and RNAs that contain one or more modified bases. Thus, DNAs or RNAs with backbones modified for stability or for other reasons are "polynucleotides" as that term is intended herein. Moreover, DNAs or RNAs comprising unusual bases, such as inosine, or modified bases, such as tritiated bases, are included within the term

"polynucleotides" as defined herein. In general, the term "polynucleotide" embraces all chemically, enzymatically and/or metabolically modified forms of unmodified polynucleotides, as well as the chemical forms of DNA and RNA characteristic of viruses and cells, including simple and complex cells.

**[0142]** The term "oligonucleotide" refers to a relatively short polynucleotide, including, without limitation, single-stranded deoxyribonucleotides, single- or double-stranded ribonucleotides, RNA:DNA hybrids and double- stranded DNAs. Oligonucleotides, such as single- stranded DNA probe oligonucleotides, are often synthesized by chemical methods, for example using automated oligonucleotide synthesizers that are commercially available. However, oligonucleotides can be made by a variety of other methods, including in vitro recombinant DNA-mediated techniques and by expression of DNAs in cells and organisms.

**[0143]** The term "diagnosis" is used herein to refer to the identification or classification of a molecular or pathological state, disease or condition (*e.g.*, cancer). For example, "diagnosis" may refer to identification of a particular type of cancer. "Diagnosis" may also refer to the classification of a particular subtype of cancer, *e.g.*, by histopathological criteria, or by molecular features (*e.g.*, a subtype characterized by expression of one or a combination of biomarkers (*e.g.*, particular genes or proteins encoded by said genes)).

**[0144]** The term "aiding diagnosis" is used herein to refer to methods that assist in making a clinical determination regarding the presence, or nature, of a particular type of symptom or condition of a disease or disorder (*e.g.*, cancer). For example, a method of aiding diagnosis of a disease or condition (*e.g.*, cancer) can comprise measuring certain biomarkers in a biological sample from an individual.

**[0145]** The term "sample," as used herein, refers to a composition that is obtained or derived from a subject and/or individual of interest that contains a cellular and/or other molecular entity that is to be characterized and/or identified, for example based on physical, biochemical, chemical and/or physiological characteristics. For example, the phrase "disease sample" and variations thereof refers to any sample obtained from a subject of interest that would be expected or is known to contain the cellular and/or molecular entity that is to be characterized. Samples include, but are not limited to, primary or cultured cells or cell lines, cell supernatants, cell lysates, platelets, serum, plasma, vitreous fluid, lymph fluid, synovial fluid, follicular fluid, seminal fluid, amniotic fluid, milk, whole blood, blood-derived cells, urine, cerebro-spinal fluid, saliva, sputum, tears, perspiration, mucus, tumor lysates, and tissue culture medium, tissue extracts such as homogenized tissue, tumor tissue, cellular extracts, and combinations thereof.

**[0146]** By "tissue sample" or "cell sample" is meant a collection of similar cells obtained from a tissue of a subject or individual. The source of the tissue or cell sample may be solid tissue as from a fresh, frozen and/or preserved organ, tissue sample, biopsy, and/or aspirate; blood or any blood constituents such as plasma; bodily fluids such as cerebral spinal fluid, amniotic fluid, peritoneal

fluid, or interstitial fluid; cells from any time in gestation or development of the subject. The tissue sample may also be primary or cultured cells or cell lines. Optionally, the tissue or cell sample is obtained from a disease tissue/organ. The tissue sample may contain compounds which are not naturally intermixed with the tissue in nature such as preservatives, anticoagulants, buffers, fixatives, nutrients, antibiotics, or the like.

**[0147]** A "reference sample", "reference cell", "reference tissue", "control sample", "control cell", or "control tissue", as used herein, refers to a sample, cell, tissue, standard, or level that is used for comparison purposes. In one embodiment, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is obtained from a healthy and/or non-diseased part of the body (*e.g.*, tissue or cells) of the same subject or individual. For example, healthy and/or non-diseased cells or tissue adjacent to the diseased cells or tissue (*e.g.*, cells or tissue adjacent to a tumor). In another embodiment, a reference sample is obtained from an untreated tissue and/or cell of the body of the same subject or individual. In yet another embodiment, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is obtained from a healthy and/or non-diseased part of the body (*e.g.*, tissues or cells) of an individual who is not the subject or individual. In even another embodiment, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is obtained from an untreated tissue and/or cell of the body of an individual who is not the subject or individual.

**[0148]** For the purposes herein a "section" of a tissue sample is meant a single part or piece of a tissue sample, *e.g.* a thin slice of tissue or cells cut from a tissue sample. It is understood that multiple sections of tissue samples may be taken and subjected to analysis, provided that it is understood that the same section of tissue sample may be analyzed at both morphological and molecular levels, or analyzed with respect to both polypeptides and polynucleotides.

**[0149]** By "correlate" or "correlating" is meant comparing, in any way, the performance and/or results of a first analysis or protocol with the performance and/or results of a second analysis or protocol. For example, one may use the results of a first analysis or protocol in carrying out a second protocols and/or one may use the results of a first analysis or protocol to determine whether a second analysis or protocol should be performed. With respect to the embodiment of polypeptide analysis or protocol, one may use the results of the polypeptide expression analysis or protocol to determine whether a specific therapeutic regimen should be performed. With respect to the embodiment of polynucleotide analysis or protocol, one may use the results of the polynucleotide expression analysis or protocol to determine whether a specific therapeutic regimen should be performed.

**[0150]** The word "label" when used herein refers to a detectable compound or composition. The label is typically conjugated or fused directly or indirectly to a reagent, such as a polynucleotide probe or an antibody, and facilitates detection of the reagent to which it is conjugated or fused. The label may itself be detectable (*e.g.*, radioisotope labels or fluorescent labels) or, in the case of an enzymatic

label, may catalyze chemical alteration of a substrate compound or composition which results in a detectable product.

**[0151]** An "effective response" of a patient or a patient's "responsiveness" to treatment with a medicament and similar wording refers to the clinical or therapeutic benefit imparted to a patient at risk for, or suffering from, a disease or disorder, such as cancer. In one embodiment, such benefit includes any one or more of: extending survival (including overall survival and progression free survival); resulting in an objective response (including a complete response or a partial response); or improving signs or symptoms of cancer.

**[0152]** A patient who "does not have an effective response" to treatment refers to a patient who does not have any one of extending survival (including overall survival and progression free survival); resulting in an objective response (including a complete response or a partial response); or improving signs or symptoms of cancer.

**[0153]** "Antibody-dependent cell-mediated cytotoxicity" or "ADCC" refers to a form of cytotoxicity in which secreted immunoglobulin bound onto Fc receptors (FcRs) present on certain cytotoxic cells (e.g. NK cells, neutrophils, and macrophages) enable these cytotoxic effector cells to bind specifically to an antigen-bearing target cell and subsequently kill the target cell with cytotoxins. The primary cells for mediating ADCC, NK cells, express FcγRIII only, whereas monocytes express FcγRI, FcγRII, and FcγRIII. FcR expression on hematopoietic cells is summarized in Table 3 on page 464 of Ravetch and Kinet, Annu. Rev. Immunol 9:457-92 (1991). To assess ADCC activity of a molecule of interest, an in vitro ADCC assay, such as that described in US Patent No. 5,500,362 or 5,821,337 or U.S. Patent No. 6,737,056 (Presta), may be performed. Useful effector cells for such assays include PBMC and NK cells. Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed in vivo, e.g., in an animal model such as that disclosed in Clynes et al. PNAS (USA) 95:652-656 (1998). An exemplary assay for assessing ADCC activity is provided in the examples herein.

**[0154]** "Complement dependent cytotoxicity" or "CDC" refers to the lysis of a target cell in the presence of complement. Activation of the classical complement pathway is initiated by the binding of the first component of the complement system (C1q) to antibodies (of the appropriate subclass), which are bound to their cognate antigen. To assess complement activation, a CDC assay, e.g., as described in Gazzano-Santoro et al., J. Immunol. Methods 202:163 (1996), may be performed. Polypeptide variants with altered Fc region amino acid sequences (polypeptides with a variant Fc region) and increased or decreased C1q binding capability are described, e.g., in US Patent No. 6,194,551 B1 and WO 1999/51642. See also, e.g., Idusogie et al. J. Immunol. 164: 4178-4184 (2000).

**[0155]** A "depleting anti-OX40 antibody," is an anti-OX40 antibody that kills or depletes OX40-expressing cells. Depletion of OX40 expressing cells can be achieved by various mechanisms, such as antibody-dependent cell-mediated cytotoxicity and/or phagocytosis. Depletion of OX40-expressing

cells may be assayed in vitro, and exemplary methods for in vitro ADCC and phagocytosis assays are provided herein. In some embodiments, the OX40-expressing cell is a human CD4+ effector T cell. In some embodiments, the OX40-expressing cell is a transgenic BT474 cell that expresses human OX40.

**[0156]** "Effector functions" refer to those biological activities attributable to the Fc region of an antibody, which vary with the antibody isotype. Examples of antibody effector functions include: C1q binding and complement dependent cytotoxicity (CDC); Fc receptor binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (e.g. B cell receptor); and B cell activation.

**[0157]** "Fc receptor" or "FcR" describes a receptor that binds to the Fc region of an antibody. In some embodiments, an FcR is a native human FcR. In some embodiments, an FcR is one which binds an IgG antibody (a gamma receptor) and includes receptors of the FcγRI, FcγRII, and FcγRIII subclasses, including allelic variants and alternatively spliced forms of those receptors. FcγRII receptors include FcγRIIA (an "activating receptor") and FcγRIIB (an "inhibiting receptor"), which have similar amino acid sequences that differ primarily in the cytoplasmic domains thereof. Activating receptor FcγRIIA contains an immunoreceptor tyrosine-based activation motif (ITAM) in its cytoplasmic domain. Inhibiting receptor FcγRIIB contains an immunoreceptor tyrosine-based inhibition motif (ITIM) in its cytoplasmic domain. (see, e.g., Daëron, Annu. Rev. Immunol. 15:203-234 (1997)). FcRs are reviewed, for example, in Ravetch and Kinet, Annu. Rev. Immunol 9:457-92 (1991); Capel et al., Immunomethods 4:25-34 (1994); and de Haas et al., J. Lab. Clin. Med. 126:330-41 (1995). Other FcRs, including those to be identified in the future, are encompassed by the term "FcR" herein. The term "Fc receptor" or "FcR" also includes the neonatal receptor, FcRn, which is responsible for the transfer of maternal IgGs to the fetus (Guyer et al., J. Immunol. 117:587 (1976) and Kim et al., J. Immunol. 24:249 (1994)) and regulation of homeostasis of immunoglobulins. Methods of measuring binding to FcRn are known (see, e.g., Ghetie and Ward., Immunol. Today 18(12):592-598 (1997); Ghetie et al., Nature Biotechnology, 15(7):637-640 (1997); Hinton et al., J. Biol. Chem. 279(8):6213-6216 (2004); WO 2004/92219 (Hinton et al.). Binding to human FcRn in vivo and serum half life of human FcRn high affinity binding polypeptides can be assayed, e.g., in transgenic mice or transfected human cell lines expressing human FcRn, or in primates to which the polypeptides with a variant Fc region are administered. WO 2000/42072 (Presta) describes antibody variants with improved or diminished binding to FcRs. See also, e.g., Shields et al. J. Biol. Chem. 9(2):6591-6604 (2001).

**[0158]** A "functional Fc region" possesses an "effector function" of a native sequence Fc region. Exemplary "effector functions" include C1q binding; CDC; Fc receptor binding; ADCC; phagocytosis; down regulation of cell surface receptors (e.g. B cell receptor; BCR), etc. Such effector functions generally require the Fc region to be combined with a binding domain (e.g., an antibody

variable domain) and can be assessed using various assays as disclosed, for example, in definitions herein.

**[0159]** "Human effector cells" refer to leukocytes that express one or more FcRs and perform effector functions. In certain embodiments, the cells express at least FcγRIII and perform ADCC effector function(s). Examples of human leukocytes which mediate ADCC include peripheral blood mononuclear cells (PBMC), natural killer (NK) cells, monocytes, cytotoxic T cells, and neutrophils. The effector cells may be isolated from a native source, e.g., from blood.

**[0160]** A cancer or biological sample which "has human effector cells" is one which, in a diagnostic test, has human effector cells present in the sample (e.g., infiltrating human effector cells).

**[0161]** A cancer or biological sample which "has FcR-expressing cells" is one which, in a diagnostic test, has FcR-expressing present in the sample (e.g., infiltrating FcR-expressing cells). In some embodiments, FcR is FcγR. In some embodiments, FcR is an activating FcγR.

## II. PD-1 Axis Binding Antagonists

**[0162]** Provided herein is a method for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist. Also provided herein is a method of enhancing immune function in an individual having cancer comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist.

**[0163]** For example, a PD-1 axis binding antagonist includes a PD-1 binding antagonist, a PDL1 binding antagonist and a PDL2 binding antagonist. Alternative names for "PD-1" include CD279 and SLEB2. Alternative names for "PDL1" include B7-H1, B7-4, CD274, and B7-H. Alternative names for "PDL2" include B7-DC, Btdc, and CD273. In some embodiments, PD-1, PDL1, and PDL2 are human PD-1, PDL1 and PDL2.

**[0164]** In some embodiments, the PD-1 binding antagonist is a molecule that inhibits the binding of PD-1 to its ligand binding partners. In a specific aspect the PD-1 ligand binding partners are PDL1 and/or PDL2. In another embodiment, a PDL1 binding antagonist is a molecule that inhibits the binding of PDL1 to its binding partners. In a specific aspect, PDL1 binding partners are PD-1 and/or B7-1. In another embodiment, the PDL2 binding antagonist is a molecule that inhibits the binding of PDL2 to its binding partners. In a specific aspect, a PDL2 binding partner is PD-1. The antagonist may be an antibody, an antigen binding fragment thereof, an immunoadhesin, a fusion protein, or oligopeptide.

**[0165]** In some embodiments, the PD-1 binding antagonist is an anti-PD-1 antibody (e.g., a human antibody, a humanized antibody, or a chimeric antibody). In some embodiments, the anti-PD-1 antibody is selected from the group consisting of nivolumab, pembrolizumab, and CT-011. In some embodiments, the PD-1 binding antagonist is an immunoadhesin (e.g., an immunoadhesin comprising

an extracellular or PD-1 binding portion of PDL1 or PDL2 fused to a constant region (e.g., an Fc region of an immunoglobulin sequence). In some embodiments, the PD-1 binding antagonist is AMP-224. Nivolumab, also known as MDX-1106-04, MDX-1106, ONO-4538, BMS-936558, and OPDIVO®, is an anti-PD-1 antibody described in WO2006/121168. Pembrolizumab, also known as MK-3475, Merck 3475, lambrolizumab, KEYTRUDA®, and SCH-900475, is an anti-PD-1 antibody described in WO2009/114335. CT-011, also known as hBAT or hBAT-1, is an anti-PD-1 antibody described in WO2009/101611. AMP-224, also known as B7-DCIg, is a PDL2-Fc fusion soluble receptor described in WO2010/027827 and WO2011/066342.

**[0166]** In some embodiments, the anti-PD-1 antibody is nivolumab (CAS Registry Number: 946414-94-4). In a still further embodiment, provided is an isolated anti-PD-1 antibody comprising a heavy chain variable region comprising the heavy chain variable region amino acid sequence from SEQ ID NO:10 and/or a light chain variable region comprising the light chain variable region amino acid sequence from SEQ ID NO:11. In a still further embodiment, provided is an isolated anti-PD-1 antibody comprising a heavy chain and/or a light chain sequence, wherein:

(a) the heavy chain sequence has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the heavy chain sequence:

QVQLVESGGGVVQPGRSLRLDCKASGITFSNSGMHWVRQAPGKGLEWVAVIWY
DGSKRYYADSVKGRFTISRDNSKNTLFLQMNSLRAEDTAVYYCATNDDYWGQGTLVTVSS
ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY
SLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPKP
KDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTV
LHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVK
GFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEAL
HNHYTQKSLSLSLGK (SEQ ID NO:10), or

(b) the light chain sequences has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the light chain sequence:

EIVLTQSPATLSLSPGERATLSCRASQSVSSYLAWYQQKPGQAPRLLIYDASNRAT
GIPARFSGSGSGTDFTLTISSLEPEDFAVYYCQQSSNWPRTFGQGTKVEIKRTVAAPSVFIFPPS
DEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSK
ADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:11).

**[0167]** In some embodiments, the anti-PD-1 antibody is pembrolizumab (CAS Registry Number: 1374853-91-4). In a still further embodiment, provided is an isolated anti-PD-1 antibody comprising a heavy chain variable region comprising the heavy chain variable region amino acid sequence from SEQ ID NO:12 and/or a light chain variable region comprising the light chain variable region amino

acid sequence from SEQ ID NO:13. In a still further embodiment, provided is an isolated anti-PD-1 antibody comprising a heavy chain and/or a light chain sequence, wherein:

(a) the heavy chain sequence has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the heavy chain sequence:
QVQLVQSGVE VKKPGASVKV SCKASGYTFT NYYMYWVRQA PGQGLEWMGG
INPSNGGTNF NEKFKNRVTL TTDSSTTTAY MELKSLQFDD
TAVYYCARRDYRFDMGFDYW GQGTTVTVSS ASTKGPSVFP LAPCSRSTSE
STAALGCLVKDYFPEPVTVS WNSGALTSGV HTFPAVLQSS GLYSLSSVVT
VPSSSLGTKTYTCNVDHKPS NTKVDKRVES KYGPPCPPCP APEFLGGPSV
FLFPPKPKDTLMISRTPEVT CVVVDVSQED PEVQFNWYVD GVEVHNAKTK
PREEQFNSTYRVVSVLTVLH QDWLNGKEYK CKVSNKGLPS SIEKTISKAK
GQPREPQVYTLPPSQEEMTK NQVSLTCLVK GFYPSDIAVE WESNGQPENN
YKTTPPVLDSDGSFFLYSRL TVDKSRWQEG NVFSCSVMHE ALHNHYTQKS LSLSLGK
(SEQ ID NO:12), or

(b) the light chain sequences has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the light chain sequence:
EIVLTQSPAT LSLSPGERATLSCRASKGVSTSGYSYLHWYQQKPGQAPRL LIYLASYLES
GVPARFSGSG SGTDFTLTISSLEPEDFAVYYCQHSRDLPLTFGGGTKVEI KRTVAAPSVF
IFPPSDEQLK SGTASVVCLL NNFYPREAKVQWKVDNALQS GNSQESVTEQ
DSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVT KSFNRGEC (SEQ ID NO:13).

**[0168]** In some embodiments, the PDL1 binding antagonist is anti-PDL1 antibody. In some embodiments, the anti-PDL1 binding antagonist is selected from the group consisting of YW243.55.S70, MPDL3280A, MDX-1105, and MEDI4736. MDX-1105, also known as BMS-936559, is an anti-PDL1 antibody described in WO2007/005874. Antibody YW243.55.S70 (heavy and light chain variable region sequences shown in SEQ ID Nos. 20 and 21, respectively) is an anti-PDL1 described in WO 2010/077634 A1. MEDI4736 is an anti-PDL1 antibody described in WO2011/066389 and US2013/034559.

**[0169]** Examples of anti-PDL1 antibodies useful for the methods of this invention, and methods for making thereof are described in PCT patent application WO 2010/077634 A1 and US Patent No. 8,217,149, which are incorporated herein by reference.

**[0170]** In some embodiments, the PD-1 axis binding antagonist is an anti-PDL1 antibody. In some embodiments, the anti-PDL1 antibody is capable of inhibiting binding between PDL1 and PD-1 and/or between PDL1 and B7-1. In some embodiments, the anti-PDL1 antibody is a monoclonal antibody. In some embodiments, the anti-PDL1 antibody is an antibody fragment selected from the

group consisting of Fab, Fab'-SH, Fv, scFv, and $(Fab')_2$ fragments. In some embodiments, the anti-PDL1 antibody is a humanized antibody. In some embodiments, the anti-PDL1 antibody is a human antibody.

**[0171]** The anti-PDL1 antibodies useful in this invention, including compositions containing such antibodies, such as those described in WO 2010/077634 A1, may be used in combination with an OX40 binding agonist to treat cancer. In some embodiments, the anti-PDL1 antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO:7 or 8 and a light chain variable region comprising the amino acid sequence of SEQ ID NO:9.

**[0172]** In one embodiment, the anti-PDL1 antibody contains a heavy chain variable region polypeptide comprising an HVR-H1, HVR-H2 and HVR-H3 sequence, wherein:

(a) the HVR-H1 sequence is $GFTFSX_1SWIH$ (SEQ ID NO:14);

(b) the HVR-H2 sequence is $AWIX_2PYGGSX_3YYADSVKG$ (SEQ ID NO:15);

(c) the HVR-H3 sequence is RHWPGGFDY (SEQ ID NO:3);

further wherein: $X_1$ is D or G; $X_2$ is S or L; $X_3$ is T or S.

**[0173]** In one specific aspect, $X_1$ is D; $X_2$ is S and $X_3$ is T. In another aspect, the polypeptide further comprises variable region heavy chain framework sequences juxtaposed between the HVRs according to the formula: (HC-FR1)-(HVR-H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4). In yet another aspect, the framework sequences are derived from human consensus framework sequences. In a further aspect, the framework sequences are VH subgroup III consensus framework. In a still further aspect, at least one of the framework sequences is the following:

HC-FR1 is EVQLVESGGGLVQPGGSLRLSCAAS (SEQ ID NO:16)

HC-FR2 is WVRQAPGKGLEWV (SEQ ID NO:17)

HC-FR3 is RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR (SEQ ID NO:18)

HC-FR4 is WGQGTLVTVSA (SEQ ID NO:19).

**[0174]** In a still further aspect, the heavy chain polypeptide is further combined with a variable region light chain comprising an HVR-L1, HVR-L2 and HVR-L3, wherein:

(a) the HVR-L1 sequence is $RASQX_4X_5X_6TX_7X_8A$ (SEQ ID NO:20);

(b) the HVR-L2 sequence is $SASX_9LX_{10}S$, (SEQ ID NO:21);

(c) the HVR-L3 sequence is $QQX_{11}X_{12}X_{13}X_{14}PX_{15}T$ (SEQ ID NO:22);

further wherein: $X_4$ is D or V; $X_5$ is V or I; $X_6$ is S or N; $X_7$ is A or F; $X_8$ is V or L; $X_9$ is F or T; $X_{10}$ is Y or A; $X_{11}$ is Y, G, F, or S; $X_{12}$ is L, Y, F or W; $X_{13}$ is Y, N, A, T, G, F or I; $X_{14}$ is H, V, P, T or I; $X_{15}$ is A, W, R, P or T.

**[0175]** In a still further aspect, $X_4$ is D; $X_5$ is V; $X_6$ is S; $X_7$ is A; $X_8$ is V; $X_9$ is F; $X_{10}$ is Y; $X_{11}$ is Y; $X_{12}$ is L; $X_{13}$ is Y; $X_{14}$ is H; $X_{15}$ is A. In a still further aspect, the light chain further comprises variable

region light chain framework sequences juxtaposed between the HVRs according to the formula: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In a still further aspect, the framework sequences are derived from human consensus framework sequences. In a still further aspect, the framework sequences are VL kappa I consensus framework. In a still further aspect, at least one of the framework sequence is the following:

LC-FR1 is DIQMTQSPSSLSASVGDRVTITC (SEQ ID NO:23)

LC-FR2 is WYQQKPGKAPKLLIY (SEQ ID NO:24)

LC-FR3 is GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC (SEQ ID NO:25)

LC-FR4 is FGQGTKVEIKR (SEQ ID NO:26).

**[0176]** In another embodiment, provided is an isolated anti-PDL1 antibody or antigen binding fragment comprising a heavy chain and a light chain variable region sequence, wherein:

the heavy chain comprises and HVR-H1, HVR-H2 and HVR-H3, wherein further:

(i) the HVR-H1 sequence is GFTFSX$_1$SWIH; (SEQ ID NO:14)

(ii) the HVR-H2 sequence is AWIX$_2$PYGGSX$_3$YYADSVKG (SEQ ID NO:15)

(iii) the HVR-H3 sequence is RHWPGGFDY, and (SEQ ID NO:3)

the light chain comprises and HVR-L1, HVR-L2 and HVR-L3, wherein further:

(i) the HVR-L1 sequence is RASQX$_4$X$_5$X$_6$TX$_7$X$_8$A (SEQ ID NO:20)

(ii) the HVR-L2 sequence is SASX$_9$LX$_{10}$S; and (SEQ ID NO:21)

(iii) the HVR-L3 sequence is QQX$_{11}$X$_{12}$X$_{13}$X$_{14}$PX$_{15}$T; (SEQ ID NO:22)

**[0177]** Further wherein: X$_1$ is D or G; X$_2$ is S or L; X$_3$ is T or S; X$_4$ is D or V; X$_5$ is V or I; X$_6$ is S or N; X$_7$ is A or F; X$_8$ is V or L; X$_9$ is F or T; X$_{10}$ is Y or A; X$_{11}$ is Y, G, F, or S; X$_{12}$ is L, Y, F or W; X$_{13}$ is Y, N, A, T, G, F or I; X$_{14}$ is H, V, P, T or I; X$_{15}$ is A, W, R, P or T.

**[0178]** In a specific aspect, X$_1$ is D; X$_2$ is S and X$_3$ is T. In another aspect, X$_4$ is D; X$_5$ is V; X$_6$ is S; X$_7$ is A; X$_8$ is V; X$_9$ is F; X$_{10}$ is Y; X$_{11}$ is Y; X$_{12}$ is L; X$_{13}$ is Y; X$_{14}$ is H; X$_{15}$ is A. In yet another aspect, X$_1$ is D; X$_2$ is S and X$_3$ is T, X$_4$ is D; X$_5$ is V; X$_6$ is S; X$_7$ is A; X$_8$ is V; X$_9$ is F; X$_{10}$ is Y; X$_{11}$ is Y; X$_{12}$ is L; X$_{13}$ is Y; X$_{14}$ is H and X$_{15}$ is A.

**[0179]** In a further aspect, the heavy chain variable region comprises one or more framework sequences juxtaposed between the HVRs as: (HC-FR1)-(HVR-H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4), and the light chain variable regions comprises one or more framework sequences juxtaposed between the HVRs as: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In a still further aspect, the framework sequences are derived from human consensus framework sequences. In a still further aspect, the heavy chain framework sequences are derived from a Kabat subgroup I, II, or III sequence. In a still further aspect, the heavy chain framework sequence is a VH subgroup III consensus framework. In a still further aspect, one or more of the heavy chain framework sequences is the following:

HC-FR1 EVQLVESGGGLVQPGGSLRLSCAAS (SEQ ID NO:16)

| | | |
|---|---|---|
| HC-FR2 | WVRQAPGKGLEWV | (SEQ ID NO:17) |
| HC-FR3 | RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR | (SEQ ID NO:18) |
| HC-FR4 | WGQGTLVTVSA | (SEQ ID NO:19). |

**[0180]** In a still further aspect, the light chain framework sequences are derived from a Kabat kappa I, II, II or IV subgroup sequence. In a still further aspect, the light chain framework sequences are VL kappa I consensus framework. In a still further aspect, one or more of the light chain framework sequences is the following:

| | | |
|---|---|---|
| LC-FR1 | DIQMTQSPSSLSASVGDRVTITC | (SEQ ID NO:23) |
| LC-FR2 | WYQQKPGKAPKLLIY | (SEQ ID NO:24) |
| LC-FR3 | GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC | (SEQ ID NO:25) |
| LC-FR4 | FGQGTKVEIKR | (SEQ ID NO:26). |

**[0181]** In a still further specific aspect, the antibody further comprises a human or murine constant region. In a still further aspect, the human constant region is selected from the group consisting of IgG1, IgG2, IgG2, IgG3, IgG4. In a still further specific aspect, the human constant region is IgG1. In a still further aspect, the murine constant region is selected from the group consisting of IgG1, IgG2A, IgG2B, IgG3. In a still further aspect, the murine constant region if IgG2A. In a still further specific aspect, the antibody has reduced or minimal effector function. In a still further specific aspect the minimal effector function results from an "effector-less Fc mutation" or aglycosylation. In still a further embodiment, the effector-less Fc mutation is an N297A or D265A/N297A substitution in the constant region.

**[0182]** In yet another embodiment, provided is an anti-PDL1 antibody comprising a heavy chain and a light chain variable region sequence, wherein:

(a) the heavy chain further comprises and HVR-H1, HVR-H2 and an HVR-H3 sequence having at least 85% sequence identity to GFTFSDSWIH (SEQ ID NO:1), AWISPYGGSTYYADSVKG (SEQ ID NO:2) and RHWPGGFDY (SEQ ID NO:3), respectively, or

(b) the light chain further comprises an HVR-L1, HVR-L2 and an HVR-L3 sequence having at least 85% sequence identity to RASQDVSTAVA (SEQ ID NO:4), SASFLYS (SEQ ID NO:5) and QQYLYHPAT (SEQ ID NO:6), respectively.

**[0183]** In a specific aspect, the sequence identity is 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100%. In another aspect, the heavy chain variable region comprises one or more framework sequences juxtaposed between the HVRs as: (HC-FR1)-(HVR-H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4), and the light chain variable regions comprises one or more framework sequences juxtaposed between the HVRs as: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In yet another aspect, the framework sequences are derived from human consensus framework sequences. In a still further aspect, the heavy chain framework sequences are derived from a Kabat subgroup I, II, or III sequence. In a still

further aspect, the heavy chain framework sequence is a VH subgroup III consensus framework. In a still further aspect, one or more of the heavy chain framework sequences is the following:

| | | |
|---|---|---|
| HC-FR1 | EVQLVESGGGLVQPGGSLRLSCAAS | (SEQ ID NO:16) |
| HC-FR2 | WVRQAPGKGLEWV | (SEQ ID NO: 17) |
| HC-FR3 | RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR | (SEQ ID NO:18) |
| HC-FR4 | WGQGTLVTVSA | (SEQ ID NO:19). |

**[0184]** In a still further aspect, the light chain framework sequences are derived from a Kabat kappa I, II, II or IV subgroup sequence. In a still further aspect, the light chain framework sequences are VL kappa I consensus framework. In a still further aspect, one or more of the light chain framework sequences is the following:

| | | |
|---|---|---|
| LC-FR1 | DIQMTQSPSSLSASVGDRVTITC | (SEQ ID NO:23) |
| LC-FR2 | WYQQKPGKAPKLLIY | (SEQ ID NO:24) |
| LC-FR3 | GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC | (SEQ ID NO:25) |
| LC-FR4 | FGQGTKVEIKR | (SEQ ID NO:26). |

**[0185]** In a still further specific aspect, the antibody further comprises a human or murine constant region. In a still further aspect, the human constant region is selected from the group consisting of IgG1, IgG2, IgG2, IgG3, IgG4. In a still further specific aspect, the human constant region is IgG1. In a still further aspect, the murine constant region is selected from the group consisting of IgG1, IgG2A, IgG2B, IgG3. In a still further aspect, the murine constant region if IgG2A. In a still further specific aspect, the antibody has reduced or minimal effector function. In a still further specific aspect the minimal effector function results from an "effector-less Fc mutation" or aglycosylation. In still a further embodiment, the effector-less Fc mutation is an N297A or D265A/N297A substitution in the constant region.

**[0186]** In a still further embodiment, provided is an isolated anti-PDL1 antibody comprising a heavy chain and a light chain variable region sequence, wherein:

(a) the heavy chain sequence has at least 85% sequence identity to the heavy chain sequence: EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWIS PYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGT LVTVSA (SEQ ID NO:28), or

(b) the light chain sequence has at least 85% sequence identity to the light chain sequence: DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO: 9).

**[0187]** In a specific aspect, the sequence identity is 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100%. In another aspect, the heavy chain variable region comprises one or more framework sequences juxtaposed between the HVRs as: (HC-FR1)-(HVR-

H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4), and the light chain variable regions comprises one or more framework sequences juxtaposed between the HVRs as: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In yet another aspect, the framework sequences are derived from human consensus framework sequences. In a further aspect, the heavy chain framework sequences are derived from a Kabat subgroup I, II, or III sequence. In a still further aspect, the heavy chain framework sequence is a VH subgroup III consensus framework. In a still further aspect, one or more of the heavy chain framework sequences is the following:

| | | |
|---|---|---|
| HC-FR1 | EVQLVESGGGLVQPGGSLRLSCAAS | (SEQ ID NO:16) |
| HC-FR2 | WVRQAPGKGLEWV | (SEQ ID NO:17) |
| HC-FR3 | RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR | (SEQ ID NO:18) |
| HC-FR4 | WGQGTLVTVSA | (SEQ ID NO:19). |

**[0188]** In a still further aspect, the light chain framework sequences are derived from a Kabat kappa I, II, II or IV subgroup sequence. In a still further aspect, the light chain framework sequences are VL kappa I consensus framework. In a still further aspect, one or more of the light chain framework sequences is the following:

| | | |
|---|---|---|
| LC-FR1 | DIQMTQSPSSLSASVGDRVTITC | (SEQ ID NO:23) |
| LC-FR2 | WYQQKPGKAPKLLIY | (SEQ ID NO:24) |
| LC-FR3 | GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC | (SEQ ID NO:25) |
| LC-FR4 | FGQGTKVEIKR | (SEQ ID NO:26). |

**[0189]** In a still further specific aspect, the antibody further comprises a human or murine constant region. In a still further aspect, the human constant region is selected from the group consisting of IgG1, IgG2, IgG2, IgG3, IgG4. In a still further specific aspect, the human constant region is IgG1. In a still further aspect, the murine constant region is selected from the group consisting of IgG1, IgG2A, IgG2B, IgG3. In a still further aspect, the murine constant region if IgG2A. In a still further specific aspect, the antibody has reduced or minimal effector function. In a still further specific aspect, the minimal effector function results from production in prokaryotic cells. In a still further specific aspect the minimal effector function results from an "effector-less Fc mutation" or aglycosylation. In still a further embodiment, the effector-less Fc mutation is an N297A or D265A/N297A substitution in the constant region.

**[0190]** In another further embodiment, provided is an isolated anti-PDL1 antibody comprising a heavy chain and a light chain variable region sequence, wherein:

(a) the heavy chain sequence has at least 85% sequence identity to the heavy chain sequence:EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSS (SEQ ID NO:7), or

(b) the light chain sequence has at least 85% sequence identity to the light chain sequence: DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO: 9).

**[0191]** In a still further embodiment, provided is an isolated anti-PDL1 antibody comprising a heavy chain and a light chain variable region sequence, wherein:

(a) the heavy chain sequence has at least 85% sequence identity to the heavy chain sequence: EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWI SPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQG TLVTVSSASTK (SEQ ID NO:8), or

(b) the light chain sequences has at least 85% sequence identity to the light chain sequence: DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIYSASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO: 9).

**[0192]** In a specific aspect, the sequence identity is 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100%. In another aspect, the heavy chain variable region comprises one or more framework sequences juxtaposed between the HVRs as: (HC-FR1)-(HVR-H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4), and the light chain variable regions comprises one or more framework sequences juxtaposed between the HVRs as: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In yet another aspect, the framework sequences are derived from human consensus framework sequences. In a further aspect, the heavy chain framework sequences are derived from a Kabat subgroup I, II, or III sequence. In a still further aspect, the heavy chain framework sequence is a VH subgroup III consensus framework. In a still further aspect, one or more of the heavy chain framework sequences is the following:

| | | |
|---|---|---|
| HC-FR1 | EVQLVESGGGLVQPGGSLRLSCAAS | (SEQ ID NO:16) |
| HC-FR2 | WVRQAPGKGLEWV | (SEQ ID NO:17) |
| HC-FR3 | RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR | (SEQ ID NO:18) |
| HC-FR4 | WGQGTLVTVSS | (SEQ ID NO:27). |

**[0193]** In a still further aspect, the light chain framework sequences are derived from a Kabat kappa I, II, II or IV subgroup sequence. In a still further aspect, the light chain framework sequences are VL kappa I consensus framework. In a still further aspect, one or more of the light chain framework sequences is the following:

| | | |
|---|---|---|
| LC-FR1 | DIQMTQSPSSLSASVGDRVTITC | (SEQ ID NO:23) |
| LC-FR2 | WYQQKPGKAPKLLIY | (SEQ ID NO:24) |
| LC-FR3 | GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC | (SEQ ID NO:25) |
| LC-FR4 | FGQGTKVEIKR | (SEQ ID NO:26). |

**[0194]** In a still further specific aspect, the antibody further comprises a human or murine constant region. In a still further aspect, the human constant region is selected from the group consisting of IgG1, IgG2, IgG2, IgG3, IgG4. In a still further specific aspect, the human constant region is IgG1. In a still further aspect, the murine constant region is selected from the group consisting of IgG1, IgG2A, IgG2B, IgG3. In a still further aspect, the murine constant region if IgG2A. In a still further specific aspect, the antibody has reduced or minimal effector function. In a still further specific aspect, the minimal effector function results from production in prokaryotic cells. In a still further specific aspect the minimal effector function results from an "effector-less Fc mutation" or aglycosylation. In still a further embodiment, the effector-less Fc mutation is an N297A or D265A/N297A substitution in the constant region.

**[0195]** In yet another embodiment, the anti-PDL1 antibody is MPDL3280A (CAS Registry Number: 1422185-06-5). In a still further embodiment, provided is an isolated anti-PDL1 antibody comprising a heavy chain variable region comprising the heavy chain variable region amino acid sequence from EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYA DSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSS (SEQ ID NO:7) or EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWI SPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQG TLVTVSSASTK (SEQ ID NO:8) and a light chain variable region comprising the amino acid sequence of DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO:9). In a still further embodiment, provided is an isolated anti-PDL1 antibody comprising a heavy chain and/or a light chain sequence, wherein:

(a) the heavy chain sequence has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the heavy chain sequence:
EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYA DSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSSAST KGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLS SVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP KDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYASTYRVVSVLTV LHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVK GFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEAL HNHYTQKSLSLSPG (SEQ ID NO:29), and/or

(b) the light chain sequences has at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or 100% sequence identity to the light chain sequence:

DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIYSASFLYSGVPSRFS GSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKRTVAAPSVFIFPPSDEQLKS GTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEK HKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:30).

**[0196]** In a still further embodiment, the invention provides for compositions comprising any of the above described anti-PDL1 antibodies in combination with at least one pharmaceutically-acceptable carrier.

**[0197]** In a still further embodiment, provided is an isolated nucleic acid encoding a light chain or a heavy chain variable region sequence of an anti-PDL1 antibody, wherein:

(a) the heavy chain further comprises and HVR-H1, HVR-H2 and an HVR-H3 sequence having at least 85% sequence identity to GFTFSDSWIH (SEQ ID NO:1), AWISPYGGSTYYADSVKG (SEQ ID NO:2) and RHWPGGFDY (SEQ ID NO:3), respectively, and

(b) the light chain further comprises an HVR-L1, HVR-L2 and an HVR-L3 sequence having at least 85% sequence identity to RASQDVSTAVA (SEQ ID NO:4), SASFLYS (SEQ ID NO:5) and QQYLYHPAT (SEQ ID NO:6), respectively.

**[0198]** In a specific aspect, the sequence identity is 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100%. In aspect, the heavy chain variable region comprises one or more framework sequences juxtaposed between the HVRs as: (HC-FR1)-(HVR-H1)-(HC-FR2)-(HVR-H2)-(HC-FR3)-(HVR-H3)-(HC-FR4), and the light chain variable regions comprises one or more framework sequences juxtaposed between the HVRs as: (LC-FR1)-(HVR-L1)-(LC-FR2)-(HVR-L2)-(LC-FR3)-(HVR-L3)-(LC-FR4). In yet another aspect, the framework sequences are derived from human consensus framework sequences. In a further aspect, the heavy chain framework sequences are derived from a Kabat subgroup I, II, or III sequence. In a still further aspect, the heavy chain framework sequence is a VH subgroup III consensus framework. In a still further aspect, one or more of the heavy chain framework sequences is the following:

| | | |
|---|---|---|
| HC-FR1 | EVQLVESGGGLVQPGGSLRLSCAAS | (SEQ ID NO:16) |
| HC-FR2 | WVRQAPGKGLEWV | (SEQ ID NO:17) |
| HC-FR3 | RFTISADTSKNTAYLQMNSLRAEDTAVYYCAR | (SEQ ID NO:18) |
| HC-FR4 | WGQGTLVTVSA | (SEQ ID NO:19). |

**[0199]** In a still further aspect, the light chain framework sequences are derived from a Kabat kappa I, II, II or IV subgroup sequence. In a still further aspect, the light chain framework sequences are VL kappa I consensus framework. In a still further aspect, one or more of the light chain framework sequences is the following:

| | | |
|---|---|---|
| LC-FR1 | DIQMTQSPSSLSASVGDRVTITC | (SEQ ID NO:23) |
| LC-FR2 | WYQQKPGKAPKLLIY | (SEQ ID NO:24) |
| LC-FR3 | GVPSRFSGSGSGTDFTLTISSLQPEDFATYYC | (SEQ ID NO:25) |

LC-FR4 FGQGTKVEIKR (SEQ ID NO:26).

**[0200]** In a still further specific aspect, the antibody described herein (such as an anti-PD-1 antibody, an anti-PDL1 antibody, or an anti-PDL2 antibody) further comprises a human or murine constant region. In a still further aspect, the human constant region is selected from the group consisting of IgG1, IgG2, IgG2, IgG3, IgG4. In a still further specific aspect, the human constant region is IgG1. In a still further aspect, the murine constant region is selected from the group consisting of IgG1, IgG2A, IgG2B, IgG3. In a still further aspect, the murine constant region if IgG2A. In a still further specific aspect, the antibody has reduced or minimal effector function. In a still further specific aspect, the minimal effector function results from production in prokaryotic cells. In a still further specific aspect the minimal effector function results from an "effector-less Fc mutation" or aglycosylation. In still a further aspect, the effector-less Fc mutation is an N297A or D265A/N297A substitution in the constant region.

**[0201]** In a still further aspect, provided herein are nucleic acids encoding any of the antibodies described herein. In some embodiments, the nucleic acid further comprises a vector suitable for expression of the nucleic acid encoding any of the previously described anti-PDL1, anti-PD-1, or anti-PDL2 antibodies. In a still further specific aspect, the vector further comprises a host cell suitable for expression of the nucleic acid. In a still further specific aspect, the host cell is a eukaryotic cell or a prokaryotic cell. In a still further specific aspect, the eukaryotic cell is a mammalian cell, such as Chinese Hamster Ovary (CHO).

**[0202]** The antibody or antigen binding fragment thereof, may be made using methods known in the art, for example, by a process comprising culturing a host cell containing nucleic acid encoding any of the previously described anti-PDL1, anti-PD-1, or anti-PDL2 antibodies or antigen-binding fragment in a form suitable for expression, under conditions suitable to produce such antibody or fragment, and recovering the antibody or fragment.

**[0203]** In some embodiments, the isolated anti-PDL1 antibody is aglycosylated. Glycosylation of antibodies is typically either N-linked or O-linked. N-linked refers to the attachment of the carbohydrate moiety to the side chain of an asparagine residue. The tripeptide sequences asparagine-X-serine and asparagine-X-threonine, where X is any amino acid except proline, are the recognition sequences for enzymatic attachment of the carbohydrate moiety to the asparagine side chain. Thus, the presence of either of these tripeptide sequences in a polypeptide creates a potential glycosylation site. O-linked glycosylation refers to the attachment of one of the sugars N-aceylgalactosamine, galactose, or xylose to a hydroxyamino acid, most commonly serine or threonine, although 5-hydroxyproline or 5-hydroxylysine may also be used. Removal of glycosylation sites form an antibody is conveniently accomplished by altering the amino acid sequence such that one of the above-described tripeptide sequences (for N-linked glycosylation sites) is removed. The alteration

may be made by substitution of an asparagine, serine or threonine residue within the glycosylation site another amino acid residue (e.g., glycine, alanine or a conservative substitution).

**[0204]** In any of the embodiments herein, the isolated anti-PDL1 antibody can bind to a human PDL1, for example a human PDL1 as shown in UniProtKB/Swiss-Prot Accession No.Q9NZQ7.1, or a variant thereof.

**[0205]** In a still further embodiment, the invention provides for a composition comprising an anti-PDL1, an anti-PD-1, or an anti-PDL2 antibody or antigen binding fragment thereof as provided herein and at least one pharmaceutically acceptable carrier. In some embodiments, the anti-PDL1, anti-PD-1, or anti-PDL2 antibody or antigen binding fragment thereof administered to the individual is a composition comprising one or more pharmaceutically acceptable carrier. Any of the pharmaceutically acceptable carriers described herein or known in the art may be used.

**[0206]** In some embodiments, the anti-PDL1 antibody described herein is in a formulation comprising the antibody at an amount of about 60 mg/mL, histidine acetate in a concentration of about 20 mM, sucrose in a concentration of about 120 mM, and polysorbate (e.g., polysorbate 20) in a concentration of 0.04% (w/v), and the formulation has a pH of about 5.8. In some embodiments, the anti-PDL1 antibody described herein is in a formulation comprising the antibody in an amount of about 125 mg/mL, histidine acetate in a concentration of about 20 mM, sucrose is in a concentration of about 240 mM, and polysorbate (e.g., polysorbate 20) in a concentration of 0.02% (w/v), and the formulation has a pH of about 5.5.

## III. OX40 binding agonists

**[0207]** Provided herein is a method for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist. Also provided herein is a method of enhancing immune function in an individual having cancer comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist.

**[0208]** An OX40 binding agonist includes, for example, an OX40 agonist antibody (e.g., an anti-human OX40 agonist antibody), an OX40L agonist fragment, an OX40 oligomeric receptor, and an OX40 immunoadhesin.

**[0209]** In some embodiments, the OX40 agonist antibody increases CD4+ effector T cell proliferation and/or increases cytokine production by the CD4+ effector T cell as compared to proliferation and/or cytokine production prior to treatment with the OX40 agonist antibody. In some embodiments, the cytokine is IFN-γ.

**[0210]** In some embodiments, the OX40 agonist antibody increases memory T cell proliferation and/or increasing cytokine production by the memory cell. In some embodiments, the cytokine is IFN-γ.

**[0211]** In some embodiments, the OX40 agonist antibody inhibits Treg suppression of effector T cell function. In some embodiments, effector T cell function is effector T cell proliferation and/or cytokine production. In some embodiments, the effector T cell is a CD4+ effector T cell.

**[0212]** In some embodiments, the OX40 agonist antibody increases OX40 signal transduction in a target cell that expresses OX40. In some embodiments, OX40 signal transduction is detected by monitoring NFkB downstream signaling.

**[0213]** In some embodiments, the anti-human OX40 agonist antibody is a depleting anti-human OX40 antibody (e.g., depletes cells that express human OX40). In some embodiments, the human OX40 expressing cells are CD4+ effector T cells. In some embodiments, the human OX40 expressing cells are Treg cells. In some embodiments, depleting is by ADCC and/or phagocytosis. In some embodiments, the antibody mediates ADCC by binding FcγR expressed by a human effector cell and activating the human effector cell function. In some embodiments, the antibody mediates phagocytosis by binding FcγR expressed by a human effector cell and activating the human effector cell function. Exemplary human effector cells include, e.g., macrophage, natural killer (NK) cells, monocytes, neutrophils. In some embodiments, the human effector cell is macrophage.

**[0214]** In some embodiments, the anti-human OX40 agonist antibody has a functional Fc region. In some embodiments, effector function of a functional Fc region is ADCC. In some embodiments, effector function of a functional Fc region is phagocytosis. In some embodiments, effector function of a functional Fc region is ADCC and phagocytosis. In some embodiments, the Fc region is human IgG1. In some embodiments, the Fc region is human IgG4.

**[0215]** In some embodiments, the anti-human OX40 agonist antibody is a human or humanized antibody. In some embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is not MEDI6383. In some embodiments, the OX40 binding agonist (e.g., an OX40 agonist antibody) is not MEDI0562.

**[0216]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in U.S. Patent No. 7,550,140, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain comprising the sequence of

EVQLVESGGGLVQPGGSLRLSCAASGFTFSNYTMNWVRQAPGKGLEWVSAISGSGGSTYYA
DSVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCAKDRYSQVHYALDYWGQGTLVTVSS
ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY
SLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGGPSVFLFP
PKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSV
LTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTC
LVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVM
HEALHNHYTQKSLSLSPGK (SEQ ID NO:31) and/or a light chain comprising the sequence of

DIVMTQSPDSLPVTPGEPASISCRSSQSLLHSNGYNYLDWYLQKAGQSPQLLIYLGSNRASGV PDRFSGSGSGTDFTLKISRVEAEDVGVYYCQQYYNHPTTFGQGTKLEIKRTVAAPSVFIFPPSD EQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKA DYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:32). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody 008 as described in U.S. Patent No. 7,550,140. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody 008 as described in U.S. Patent No. 7,550,140.

**[0217]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in U.S. Patent No. 7,550,140. In some embodiments, the anti-human OX40 agonist antibody comprises the sequence of DIQMTQSPDSLPVTPGEPASISCRSSQSLLHSNGYNYLDWYLQKAGQSPQLLIYLGSNRASGV PDRFSGSGSGTDFTLKISRVEAEDVGVYYCQQYYNHPTTFGQGTKLEIKRTVAAPSVFIFPPSD EQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKA DYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:33). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody SC02008 as described in U.S. Patent No. 7,550,140. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody SC02008 as described in U.S. Patent No. 7,550,140.

**[0218]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in U.S. Patent No. 7,550,140. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain comprising the sequence of EVQLVESGGGLVHPGGSLRLSCAGSGFTFSSYAMHWVRQAPGKGLEWVSAIGTGGGTYYA DSVMGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCARYDNVMGLYWFDYWGQGTLVTVS SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL YSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGGPSVFLF PPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVS VLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSV MHEALHNHYTQKSLSLSPGK (SEQ ID NO:34) and/or a light chain comprising the sequence of EIVLTQSPATLSLSPGERATLSCRASQSVSSYLAWYQQKPGQAPRLLIYDASNRATGIPARFSG SGSGTDFTLTISSLEPEDFAVYYCQQRSNWPPAFGGGTKVEIKRTVAAPSVFIFPPSDEQLKSG TASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKH KVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:35). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody 023 as described in U.S. Patent No. 7,550,140. In some embodiments, the antibody comprises a

heavy chain variable region sequence and/or a light chain variable region sequence of antibody 023 as described in U.S. Patent No. 7,550,140.

**[0219]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in U.S. Patent No. 7,960,515, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of EVQLVESGGGLVQPGGSLRLSCAASGFTFSSYSMNWVRQAPGKGLEWVSYISSSSSTIDYAD SVKGRFTISRDNAKNSLYLQMNSLRDEDTAVYYCARESGWYLFDYWGQGTLVTVSS (SEQ ID NO:36) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQGISSWLAWYQQKPEKAPKSLIYAASSLQSGVPSRFSG SGSGTDFTLTISSLQPEDFATYYCQQYNSYPPTFGGGTKVEIK (SEQ ID NO:37). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody 11D4 as described in U.S. Patent No. 7,960,515. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody 11D4 as described in U.S. Patent No. 7,960,515.

**[0220]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in U.S. Patent No. 7,960,515. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of EVQLVESGGGLVQPGRSLRLSCAASGFTFDDYAMHWVRQAPGKGLEWVSGISWNSGSIGYA DSVKGRFTISRDNAKNSLYLQMNSLRAEDTALYYCAKDQSTADYYFYYGMDVWGQGTTVT VSS (SEQ ID NO:38) and/or a light chain variable region comprising the sequence of EIVVTQSPATLSLSPGERATLSCRASQSVSSYLAWYQQKPGQAPRLLIYDASNRATGIPARFSG SGSGTDFTLTISSLEPEDFAVYYCQQRSNWPTFGQGTKVEIK (SEQ ID NO:39). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody 18D8 as described in U.S. Patent No. 7,960,515. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody 18D8 as described in U.S. Patent No. 7,960,515.

**[0221]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2012/027328, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGSELKKPGASVKVSCKASGYTFTDYSMHWVRQAPGQGLKWMGWINTETGEPTY ADDFKGRFVFSLDTSVSTAYLQISSLKAEDTAVYYCANPYYDYVSYYAMDYWGQGTTVTVS S (SEQ ID NO:40) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVSTAVAWYQQKPGKAPKLLIYSASYLYTGVPSRFS GSGSGTDFTFTISSLQPEDIATYYCQQHYSTPRTFGQGTKLEIK (SEQ ID NO:41). In some

embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody hu106-222 as described in WO 2012/027328. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody hu106-222 as described in WO 2012/027328.

**[0222]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2012/027328. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of EVQLVESGGGLVQPGGSLRLSCAASEYEFPSHDMSWVRQAPGKGLELVAAINSDGGSTYYP DTMERRFTISRDNAKNSLYLQMNSLRAEDTAVYYCARHYDDYYAWFAYWGQGTMVTVSS (SEQ ID NO:42) and/or a light chain variable region comprising the sequence of EIVLTQSPATLSLSPGERATLSCRASKSVSTSGYSYMHWYQQKPGQAPRLLIYLASNLESGVP ARFSGSGSGTDFTLTISSLEPEDFAVYYCQHSRELPLTFGGGTKVEIK (SEQ ID NO:43). In some embodiments, the antibody comprises at least one, two, three, four, five or six hypervariable region (HVR) sequences of antibody Hu119-122 as described in WO 2012/027328. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody Hu119-122 as described in WO 2012/027328.

**[0223]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2013/028231, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain comprising the sequence of MYLGLNYVFIVFLLNGVQSEVKLEESGGGLVQPGGSMKLSCAASGFTFSDAWMDWVRQSPE KGLEWVAEIRSKANNHATYYAESVNGRFTISRDDSKSSVYLQMNSLRAEDTGIYYCTWGEV FYFDYWGQGTTLTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYITCNVNHKPSNTKVDKKVEPKSCDKTHT CPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNA KTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQV YTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO:44) and/or a light chain comprising the sequence of MRPSIQFLGLLLFWLHGAQCDIQMTQSPSSLSASLGGKVTITCKSSQDINKYIAWYQHKPGKG PRLLIHYTSTLQPGIPSRFSGSGSGRDYSFSISNLEPEDIATYYCLQYDNLLTFGAGTKLELKRT VAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDS TYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO:45). In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of MYLGLNYVFIVFLLNGVQSEVKLEESGGGLVQPGGSMKLSCAASGFTFSDAWMDWVRQSPE

KGLEWVAEIRSKANNHATYYAESVNGRFTISRDDSKSSVYLQMNSLRAEDTGIYYCTWGEV FYFDYWGQGTTLTVSS (SEQ ID NO:61) and/or a light chain variable region comprising the sequence of MRPSIQFLGLLLFWLHGAQCDIQMTQSPSSLSASLGGKVTITCKSSQDINKYIAWYQHKPGKG PRLLIHYTSTLQPGIPSRFSGSGSGRDYSFSISNLEPEDIATYYCLQYDNLLTFGAGTKLELK (SEQ ID NO:62). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody Mab CH 119-43-1 as described in WO 2013/028231. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody Mab CH 119-43-1 as described in WO 2013/028231.

**[0224]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2013/038191, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of EVQLQQSGPELVKPGASVKMSCKASGYTFTSYVMHWVKQKPGQGLEWIGYINPYNDGTKY NEKFKGKATLTSDKSSSTAYMELSSLTSEDSAVYYCANYYGSSLSMDYWGQGTSVTVSS (SEQ ID NO:46) and/or a light chain variable region comprising the sequence of DIQMTQTTSSLSASLGDRVTISCRASQDISNYLNWYQQKPDGTVKLLIYYTSRLHSGVPSRFS GSGSGTDYSLTISNLEQEDIATYFCQQGNTLPWTFGGGTKLEIKR (SEQ ID NO:47). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2013/038191. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2013/038191.

**[0225]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2013/038191. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of EVQLQQSGPELVKPGASVKISCKTSGYTFKDYTMHWVKQSHGKSLEWIGGIYPNNGGSTYN QNFKDKATLTVDKSSSTAYMEFRSLTSEDSAVYYCARMGYHGPHLDFDVWGAGTTVTVSP (SEQ ID NO:48) and/or a light chain variable region comprising the sequence of DIVMTQSHKFMSTSLGDRVSITCKASQDVGAAVAWYQQKPGQSPKLLIYWASTRHTGVPDR FTGGGSGTDFTLTISNVQSEDLTDYFCQQYINYPLTFGGGTKLEIKR (SEQ ID NO:49). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2013/038191. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2013/038191.

**[0226]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1, which is incorporated herein by reference in its entirety. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWMGYINPYNDGTK YNEKFKGRVTITSDTSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:50) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAPKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYYCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:51). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0227]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWMGYINPYNDGTK YNEKFKGRVTITSDTSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:50) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAVKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYFCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:52). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0228]** In some embodiments the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWIGYINPYNDGTKY NEKFKGRATITSDTSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:53) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAPKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYYCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:51). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some

embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0229]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWIGYINPYNDGTKY NEKFKGRATITSDTSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:53) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAVKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYFCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:52). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0230]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWIGYINPYNDGTKY NEKFKGRATLTSDKSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:54) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAPKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYYCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:51). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0231]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGASVKVSCKASGYTFTSYVMHWVRQAPGQRLEWIGYINPYNDGTKY NEKFKGRATLTSDKSASTAYMELSSLRSEDTAVYYCANYYGSSLSMDYWGQGTLVTVSS (SEQ ID NO:54) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCRASQDISNYLNWYQQKPGKAVKLLIYYTSRLHSGVPSRFS GSGSGTDYTLTISSLQPEDFATYFCQQGNTLPWTFGQGTKVEIKR (SEQ ID NO:52). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 20E5 as described in WO 2014/148895A1. In some

embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 20E5 as described in WO 2014/148895A1.

**[0232]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWMGGIYPNNGGST YNQNFKDRVTITADKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTV SS (SEQ ID NO:55) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPSRF SGSGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:56). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0233]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWMGGIYPNNGGST YNQNFKDRVTITADKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTV SS (SEQ ID NO:55) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPDR FSGGGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:57). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0234]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWIGGIYPNNGGSTY NQNFKDRVTLTADKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTVS S (SEQ ID NO:58) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPSRF SGSGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:56). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some

embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0235]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWIGGIYPNNGGSTY NQNFKDRVTLTADKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTVS S (SEQ ID NO:58) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPDR FSGGGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:57). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0236]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWIGGIYPNNGGSTY NQNFKDRATLTVDKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTVS S (SEQ ID NO:59) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPSRF SGSGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:56). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0237]** In some embodiments, the OX40 agonist antibody is an anti-human OX40 agonist antibody described in WO 2014/148895A1. In some embodiments, the anti-human OX40 agonist antibody comprises a heavy chain variable region comprising the sequence of QVQLVQSGAEVKKPGSSVKVSCKASGYTFKDYTMHWVRQAPGQGLEWIGGIYPNNGGSTY NQNFKDRATLTVDKSTSTAYMELSSLRSEDTAVYYCARMGYHGPHLDFDVWGQGTTVTVS S (SEQ ID NO:59) and/or a light chain variable region comprising the sequence of DIQMTQSPSSLSASVGDRVTITCKASQDVGAAVAWYQQKPGKAPKLLIYWASTRHTGVPDR FSGGGSGTDFTLTISSLQPEDFATYYCQQYINYPLTFGGGTKVEIKR (SEQ ID NO:57). In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody clone 12H3 as described in WO 2014/148895A1. In some

embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody clone 12H3 as described in WO 2014/148895A1.

**[0238]** In some embodiments, the agonist anti-human OX40 antibody is L106 BD (Pharmingen Product # 340420). In some embodiments, the antibody comprises at least one, two, three, four, five or six hypervariable region (HVR) sequences of antibody L106 (BD Pharmingen Product # 340420). In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody L106 (BD Pharmingen Product # 340420).

**[0239]** In some embodiments, the agonist anti-human OX40 antibody is ACT35 (Santa Cruz Biotechnology, Catalog # 20073). In some embodiments, the antibody comprises at least one, two, three, four, five or six hypervariable region (HVR) sequences of antibody ACT35 (Santa Cruz Biotechnology, Catalog # 20073). In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody ACT35 (Santa Cruz Biotechnology, Catalog # 20073).

**[0240]** In some embodiments, the OX40 agonist antibody is MEDI6469. In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody MEDI6469. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody MEDI6469.

**[0241]** In some embodiments, the OX40 agonist antibody is MEDI0562. In some embodiments, the antibody comprises at least one, two, three, four, five, or six hypervariable region (HVR) sequences of antibody MEDI0562. In some embodiments, the antibody comprises a heavy chain variable region sequence and/or a light chain variable region sequence of antibody MEDI0562.

**[0242]** In some embodiments, the OX40 agonist antibody is an agonist antibody that binds to the same epitope as any one of the OX40 agonist antibodies set forth above.

**[0243]** In some embodiments, the anti-human OX40 agonist antibody has a functional Fc region. In some embodiments, the Fc region is human IgG1. In some embodiments, the Fc region is human IgG4. In some embodiments, the anti-human OX40 agonist antibody is engineered to increase effector function (e.g., compared to effector function in a wild-type IgG1). In some embodiments, the antibody has increased binding to a Fcγ receptor. In some embodiments, the antibody lacks fucose attached (directly or indirectly) to the Fc region. For example, the amount of fucose in such antibody may be from 1% to 80%, from 1% to 65%, from 5% to 65% or from 20% to 40%. In some embodiments, the Fc region comprises bisected oligosaccharides, e.g., in which a biantennary oligosaccharide attached to the Fc region of the antibody is bisected by GlcNAc. In some embodiments, the antibody comprises an Fc region with one or more amino acid substitutions which improve ADCC, e.g., substitutions at positions 298, 333, and/or 334 of the Fc region (EU numbering of residues).

**[0244]** OX40 agonists useful for the methods described herein are in no way intended to be limited to antibodies. Non-antibody OX40 agonists are contemplated and well known in the art.

**[0245]** As described above, OX40L (also known as CD134L) serves as a ligand for OX40. As such, agonists that present part or all of OX40L may serve as OX40 agonists. In some embodiments, an OX40 agonist may include one or more extracellular domains of OX40L. Examples of extracellular domains of OX40L may include OX40-binding domains. In some embodiments, an OX40 agonist may be a soluble form of OX40L that includes one or more extracellular domains of OX40L but lacks other, insoluble domains of the protein, e.g., transmembrane domains. In some embodiments, an OX40 agonist is a soluble protein that includes one or more extracellular domains of OX40L able to bind OX40L. In some embodiments, an OX40 agonist may be linked to another protein domain, e.g., to increase its effectiveness, half-life, or other desired characteristics. In some embodiments, an OX40 agonist may include one or more extracellular domains of OX40L linked to an immunoglobulin Fc domain.

**[0246]** In some embodiments, an OX40 agonist may be any one of the OX40 agonists described in U.S. Patent No. 7,696,175.

**[0247]** In some embodiments, an OX40 agonist may be an oligomeric or multimeric molecule. For example, an OX40 agonist may contain one or more domains (e.g., a leucine zipper domain) that allows proteins to oligomerize. In some embodiments, an OX40 agonist may include one or more extracellular domains of OX40L linked to one or more leucine zipper domains.

**[0248]** In some embodiments, an OX40 agonist may be any one of the OX40 agonists described in European Patent No. EP0672141 B1.

**[0249]** In some embodiments, an OX40 agonist may be a trimeric OX40L fusion protein. For example, an OX40 agonist may include one or more extracellular domains of OX40L linked to an immunoglobulin Fc domain and a trimerization domain (including without limitation an isoleucine zipper domain).

**[0250]** In some embodiments, an OX40 agonist may be any one of the OX40 agonists described in International Publication No. WO2006/121810, such as an OX40 immunoadhesin. In some embodiments, the OX40 immunoadhesin may be a trimeric OX40-Fc protein. In some embodiments, the OX40 agonist is MEDI6383.

## IV. Antibody Preparation

**[0251]** The antibody described herein is prepared using techniques available in the art for generating antibodies, exemplary methods of which are described in more detail in the following sections.

**[0252]** The antibody is directed against an antigen of interest (*i.e.*, PD-L1 (such as a human PD-L1), OX40 (such as a human OX40)). Preferably, the antigen is a biologically important polypeptide and administration of the antibody to a mammal suffering from a disorder can result in a therapeutic benefit in that mammal.

**[0253]** In certain embodiments, an antibody provided herein has a dissociation constant (Kd) of ≤ 1μM, ≤ 150 nM, ≤ 100 nM, ≤ 50 nM, ≤ 10 nM, ≤ 1 nM, ≤ 0.1 nM, ≤ 0.01 nM, or ≤ 0.001 nM (e.g. $10^{-8}$ M or less, e.g. from $10^{-8}$ M to $10^{-13}$ M, *e.g.,* from $10^{-9}$ M to $10^{-13}$ M).

**[0254]** In one embodiment, Kd is measured by a radiolabeled antigen binding assay (RIA) performed with the Fab version of an antibody of interest and its antigen as described by the following assay. Solution binding affinity of Fabs for antigen is measured by equilibrating Fab with a minimal concentration of ($^{125}$I)-labeled antigen in the presence of a titration series of unlabeled antigen, then capturing bound antigen with an anti-Fab antibody-coated plate (see, *e.g.,* Chen et al., *J. Mol. Biol.* 293:865-881(1999)). To establish conditions for the assay, MICROTITER® multi-well plates (Thermo Scientific) are coated overnight with 5 μg/ml of a capturing anti-Fab antibody (Cappel Labs) in 50 mM sodium carbonate (pH 9.6), and subsequently blocked with 2% (w/v) bovine serum albumin in PBS for two to five hours at room temperature (approximately 23°C). In a non-adsorbent plate (Nunc #269620), 100 pM or 26 pM [$^{125}$I]-antigen are mixed with serial dilutions of a Fab of interest. The Fab of interest is then incubated overnight; however, the incubation may continue for a longer period (*e.g.,* about 65 hours) to ensure that equilibrium is reached. Thereafter, the mixtures are transferred to the capture plate for incubation at room temperature (*e.g.,* for one hour). The solution is then removed and the plate washed eight times with 0.1% polysorbate 20 (TWEEN-20®) in PBS. When the plates have dried, 150 μl/well of scintillant (MICROSCINT-20™; Packard) is added, and the plates are counted on a TOPCOUNT™ gamma counter (Packard) for ten minutes. Concentrations of each Fab that give less than or equal to 20% of maximal binding are chosen for use in competitive binding assays.

**[0255]** According to another embodiment, Kd is measured using surface plasmon resonance assays using a BIACORE®-2000 or a BIACORE®-3000 (BIAcore, Inc., Piscataway, NJ) at 25°C with immobilized antigen CM5 chips at ~10 response units (RU). Briefly, carboxymethylated dextran biosensor chips (CM5, BIACORE, Inc.) are activated with *N*-ethyl-*N'*- (3-dimethylaminopropyl)-carbodiimide hydrochloride (EDC) and *N*-hydroxysuccinimide (NHS) according to the supplier's instructions. Antigen is diluted with 10 mM sodium acetate, pH 4.8, to 5 μg/ml (~0.2 μM) before injection at a flow rate of 5 μl/minute to achieve approximately 10 response units (RU) of coupled protein. Following the injection of antigen, 1 M ethanolamine is injected to block unreacted groups. For kinetics measurements, two-fold serial dilutions of Fab (0.78 nM to 500 nM) are injected in PBS with 0.05% polysorbate 20 (TWEEN-20™) surfactant (PBST) at 25°C at a flow rate of approximately 25 μl/min. Association rates ($k_{on}$) and dissociation rates ($k_{off}$) are calculated using a simple one-to-one Langmuir binding model (BIACORE® Evaluation Software version 3.2) by simultaneously fitting the association and dissociation sensorgrams. The equilibrium dissociation constant (Kd) is calculated as the ratio $k_{off}/k_{on}$. See, *e.g.,* Chen et al., *J. Mol. Biol.* 293:865-881 (1999). If the on-rate exceeds 106 M-1 s-1 by the surface plasmon resonance assay above, then the on-rate can be

determined by using a fluorescent quenching technique that measures the increase or decrease in fluorescence emission intensity (excitation = 295 nm; emission = 340 nm, 16 nm band-pass) at 25oC of a 20 nM anti-antigen antibody (Fab form) in PBS, pH 7.2, in the presence of increasing concentrations of antigen as measured in a spectrometer, such as a stop-flow equipped spectrophometer (Aviv Instruments) or a 8000-series SLM-AMINCO ™ spectrophotometer (ThermoSpectronic) with a stirred cuvette.

(i) Antigen Preparation

**[0256]** Soluble antigens or fragments thereof, optionally conjugated to other molecules, can be used as immunogens for generating antibodies. For transmembrane molecules, such as receptors, fragments of these (e.g. the extracellular domain of a receptor) can be used as the immunogen. Alternatively, cells expressing the transmembrane molecule can be used as the immunogen. Such cells can be derived from a natural source (e.g. cancer cell lines) or may be cells which have been transformed by recombinant techniques to express the transmembrane molecule. Other antigens and forms thereof useful for preparing antibodies will be apparent to those in the art.

(ii) Certain Antibody-Based Methods

**[0257]** Polyclonal antibodies are preferably raised in animals by multiple subcutaneous (sc) or intraperitoneal (ip) injections of the relevant antigen and an adjuvant. It may be useful to conjugate the relevant antigen to a protein that is immunogenic in the species to be immunized, e.g., keyhole limpet hemocyanin, serum albumin, bovine thyroglobulin, or soybean trypsin inhibitor using a bifunctional or derivatizing agent, for example, maleimidobenzoyl sulfosuccinimide ester (conjugation through cysteine residues), N-hydroxysuccinimide (through lysine residues), glutaraldehyde, succinic anhydride, $SOCl_2$, or $R^1N=C=NR$, where R and $R^1$ are different alkyl groups.

**[0258]** Animals are immunized against the antigen, immunogenic conjugates, or derivatives by combining, e.g., 100 µg or 5 µg of the protein or conjugate (for rabbits or mice, respectively) with 3 volumes of Freund's complete adjuvant and injecting the solution intradermally at multiple sites. One month later the animals are boosted with 1/5 to 1/10 the original amount of peptide or conjugate in Freund's complete adjuvant by subcutaneous injection at multiple sites. Seven to 14 days later the animals are bled and the serum is assayed for antibody titer. Animals are boosted until the titer plateaus. Preferably, the animal is boosted with the conjugate of the same antigen, but conjugated to a different protein and/or through a different cross-linking reagent. Conjugates also can be made in recombinant cell culture as protein fusions. Also, aggregating agents such as alum are suitably used to enhance the immune response.

**[0259]** Monoclonal antibodies of the invention can be made using the hybridoma method first described by Kohler *et al.*, *Nature*, 256:495 (1975), and further described, e.g., in Hongo *et al.*, *Hybridoma*, 14 (3): 253-260 (1995), Harlow *et al.*, *Antibodies: A Laboratory Manual*, (Cold Spring

Harbor Laboratory Press, 2nd ed. 1988); Hammerling *et al.*, in: *Monoclonal Antibodies and T-Cell Hybridomas* 563-681 (Elsevier, N.Y., 1981), and Ni, *Xiandai Mianyixue*, 26(4):265-268 (2006) regarding human-human hybridomas. Additional methods include those described, for example, in U.S. Pat. No. 7,189,826 regarding production of monoclonal human natural IgM antibodies from hybridoma cell lines. Human hybridoma technology (Trioma technology) is described in Vollmers and Brandlein, *Histology and Histopathology*, 20(3):927-937 (2005) and Vollmers and Brandlein, *Methods and Findings in Experimental and Clinical Pharmacology*, 27(3):185-91 (2005).

**[0260]** For various other hybridoma techniques, see, *e.g.*, US 2006/258841; US 2006/183887 (fully human antibodies), US 2006/059575; US 2005/287149; US 2005/100546; US 2005/026229; and U.S. Pat. Nos. 7,078,492 and 7,153,507. An exemplary protocol for producing monoclonal antibodies using the hybridoma method is described as follows. In one embodiment, a mouse or other appropriate host animal, such as a hamster, is immunized to elicit lymphocytes that produce or are capable of producing antibodies that will specifically bind to the protein used for immunization. Antibodies are raised in animals by multiple subcutaneous (sc) or intraperitoneal (ip) injections of a polypeptide of the invention or a fragment thereof, and an adjuvant, such as monophosphoryl lipid A (MPL)/trehalose dicrynomycolate (TDM) (Ribi Immunochem. Research, Inc., Hamilton, Mont.). A polypeptide of the invention (e.g., antigen) or a fragment thereof may be prepared using methods well known in the art, such as recombinant methods, some of which are further described herein. Serum from immunized animals is assayed for anti-antigen antibodies, and booster immunizations are optionally administered. Lymphocytes from animals producing anti-antigen antibodies are isolated. Alternatively, lymphocytes may be immunized *in vitro*.

**[0261]** Lymphocytes are then fused with myeloma cells using a suitable fusing agent, such as polyethylene glycol, to form a hybridoma cell. See, *e.g.*, Goding, *Monoclonal Antibodies: Principles and Practice*, pp. 59-103 (Academic Press, 1986). Myeloma cells may be used that fuse efficiently, support stable high-level production of antibody by the selected antibody-producing cells, and are sensitive to a medium such as HAT medium. Exemplary myeloma cells include, but are not limited to, murine myeloma lines, such as those derived from MOPC-21 and MPC-11 mouse tumors available from the Salk Institute Cell Distribution Center, San Diego, Calif. USA, and SP-2 or X63-Ag8-653 cells available from the American Type Culture Collection, Rockville, Md. USA. Human myeloma and mouse-human heteromyeloma cell lines also have been described for the production of human monoclonal antibodies (Kozbor, *J. Immunol.*, 133:3001 (1984); Brodeur *et al.*, *Monoclonal Antibody Production Techniques and Applications*, pp. 51-63 (Marcel Dekker, Inc., New York, 1987)).

**[0262]** The hybridoma cells thus prepared are seeded and grown in a suitable culture medium, e.g., a medium that contains one or more substances that inhibit the growth or survival of the unfused, parental myeloma cells. For example, if the parental myeloma cells lack the enzyme hypoxanthine guanine phosphoribosyl transferase (HGPRT or HPRT), the culture medium for the hybridomas

typically will include hypoxanthine, aminopterin, and thymidine (HAT medium), which substances prevent the growth of HGPRT-deficient cells. Preferably, serum-free hybridoma cell culture methods are used to reduce use of animal-derived serum such as fetal bovine serum, as described, for example, in Even *et al.*, *Trends in Biotechnology*, 24(3), 105-108 (2006).

**[0263]** Oligopeptides as tools for improving productivity of hybridoma cell cultures are described in Franek, *Trends in Monoclonal Antibody Research*, 111-122 (2005). Specifically, standard culture media are enriched with certain amino acids (alanine, serine, asparagine, proline), or with protein hydrolyzate fractions, and apoptosis may be significantly suppressed by synthetic oligopeptides, constituted of three to six amino acid residues. The peptides are present at millimolar or higher concentrations.

**[0264]** Culture medium in which hybridoma cells are growing may be assayed for production of monoclonal antibodies that bind to an antibody of the invention. The binding specificity of monoclonal antibodies produced by hybridoma cells may be determined by immunoprecipitation or by an *in vitro* binding assay, such as radioimmunoassay (RIA) or enzyme-linked immunoadsorbent assay (ELISA). The binding affinity of the monoclonal antibody can be determined, for example, by Scatchard analysis. See, *e.g.*, Munson *et al.*, *Anal. Biochem.*, 107:220 (1980).

**[0265]** After hybridoma cells are identified that produce antibodies of the desired specificity, affinity, and/or activity, the clones may be subcloned by limiting dilution procedures and grown by standard methods. See, *e.g.*, Goding, *supra.* Suitable culture media for this purpose include, for example, D-MEM or RPMI-1640 medium. In addition, hybridoma cells may be grown *in vivo* as ascites tumors in an animal. Monoclonal antibodies secreted by the subclones are suitably separated from the culture medium, ascites fluid, or serum by conventional immunoglobulin purification procedures such as, for example, protein A-Sepharose, hydroxylapatite chromatography, gel electrophoresis, dialysis, or affinity chromatography. One procedure for isolation of proteins from hybridoma cells is described in US 2005/176122 and U.S. Pat. No. 6,919,436. The method includes using minimal salts, such as lyotropic salts, in the binding process and preferably also using small amounts of organic solvents in the elution process.

(iii) Library-Derived Antibodies

**[0266]** Antibodies of the invention may be isolated by screening combinatorial libraries for antibodies with the desired activity or activities. For example, a variety of methods are known in the art for generating phage display libraries and screening such libraries for antibodies possessing the desired binding characteristics such as the methods described in Example 3. Additional methods are reviewed, *e.g.,* in Hoogenboom et al. in *Methods in Molecular Biology* 178:1-37 (O'Brien et al., ed., Human Press, Totowa, NJ, 2001) and further described, *e.g.,* in the McCafferty et al., *Nature* 348:552-554; Clackson et al., *Nature* 352: 624-628 (1991); Marks et al., *J. Mol. Biol.* 222: 581-597 (1992); Marks and Bradbury, in *Methods in Molecular Biology* 248:161-175 (Lo, ed., Human Press, Totowa,

NJ, 2003); Sidhu et al., *J. Mol. Biol.* 338(2): 299-310 (2004); Lee et al., *J. Mol. Biol.* 340(5): 1073-1093 (2004); Fellouse, *Proc. Natl. Acad. Sci. USA* 101(34): 12467-12472 (2004); and Lee et al., *J. Immunol. Methods* 284(1-2): 119-132(2004).

**[0267]** In certain phage display methods, repertoires of VH and VL genes are separately cloned by polymerase chain reaction (PCR) and recombined randomly in phage libraries, which can then be screened for antigen-binding phage as described in Winter et al., *Ann. Rev. Immunol.*, 12: 433-455 (1994). Phage typically display antibody fragments, either as single-chain Fv (scFv) fragments or as Fab fragments. Libraries from immunized sources provide high-affinity antibodies to the immunogen without the requirement of constructing hybridomas. Alternatively, the naive repertoire can be cloned (*e.g.,* from human) to provide a single source of antibodies to a wide range of non-self and also self-antigens without any immunization as described by Griffiths et al., *EMBO J,* 12: 725-734 (1993). Finally, naive libraries can also be made synthetically by cloning unrearranged V-gene segments from stem cells, and using PCR primers containing random sequence to encode the highly variable CDR3 regions and to accomplish rearrangement *in vitro*, as described by Hoogenboom and Winter, *J. Mol. Biol.*, 227: 381-388 (1992). Patent publications describing human antibody phage libraries include, for example: US Patent No. 5,750,373, and US Patent Publication Nos. 2005/0079574, 2005/0119455, 2005/0266000, 2007/0117126, 2007/0160598, 2007/0237764, 2007/0292936, and 2009/0002360.

**[0268]** Antibodies or antibody fragments isolated from human antibody libraries are considered human antibodies or human antibody fragments herein.

(iv) Chimeric, Humanized and Human Antibodies

**[0269]** In certain embodiments, an antibody provided herein is a chimeric antibody. Certain chimeric antibodies are described, *e.g.,* in U.S. Patent No. 4,816,567; and Morrison et al., *Proc. Natl. Acad. Sci. USA*, 81:6851-6855 (1984)). In one example, a chimeric antibody comprises a non-human variable region (*e.g.,* a variable region derived from a mouse, rat, hamster, rabbit, or non-human primate, such as a monkey) and a human constant region. In a further example, a chimeric antibody is a "class switched" antibody in which the class or subclass has been changed from that of the parent antibody. Chimeric antibodies include antigen-binding fragments thereof.

**[0270]** In certain embodiments, a chimeric antibody is a humanized antibody. Typically, a non-human antibody is humanized to reduce immunogenicity to humans, while retaining the specificity and affinity of the parental non-human antibody. Generally, a humanized antibody comprises one or more variable domains in which HVRs, *e.g.,* CDRs, (or portions thereof) are derived from a non-human antibody, and FRs (or portions thereof) are derived from human antibody sequences. A humanized antibody optionally will also comprise at least a portion of a human constant region. In some embodiments, some FR residues in a humanized antibody are substituted with corresponding residues from a non-human antibody (*e.g.,* the antibody from which the HVR residues are derived), *e.g.,* to restore or improve antibody specificity or affinity.

**[0271]** Humanized antibodies and methods of making them are reviewed, *e.g.,* in Almagro and Fransson, *Front. Biosci.* 13:1619-1633 (2008), and are further described, *e.g.,* in Riechmann et al., *Nature* 332:323-329 (1988); Queen et al., *Proc. Nat'l Acad. Sci. USA* 86:10029-10033 (1989); US Patent Nos. 5, 821,337, 7,527,791, 6,982,321, and 7,087,409; Kashmiri *et al.*, *Methods* 36:25-34 (2005) (describing SDR (a-CDR) grafting); Padlan, *Mol. Immunol.* 28:489-498 (1991) (describing "resurfacing"); Dall'Acqua et al., *Methods* 36:43-60 (2005) (describing "FR shuffling"); and Osbourn et al., *Methods* 36:61-68 (2005) and Klimka et al., *Br. J. Cancer*, 83:252-260 (2000) (describing the "guided selection" approach to FR shuffling).

**[0272]** Human framework regions that may be used for humanization include but are not limited to: framework regions selected using the "best-fit" method (see, *e.g.,* Sims et al. *J. Immunol.* 151:2296 (1993)); framework regions derived from the consensus sequence of human antibodies of a particular subgroup of light or heavy chain variable regions (see, *e.g.,* Carter et al. *Proc. Natl. Acad. Sci. USA*, 89:4285 (1992); and Presta et al. *J. Immunol.*, 151:2623 (1993)); human mature (somatically mutated) framework regions or human germline framework regions (see, *e.g.,* Almagro and Fransson, *Front. Biosci.* 13:1619-1633 (2008)); and framework regions derived from screening FR libraries (see, *e.g.,* Baca et al., *J. Biol. Chem.* 272:10678-10684 (1997) and Rosok et al., *J. Biol. Chem.* 271:22611-22618 (1996)).

**[0273]** In certain embodiments, an antibody provided herein is a human antibody. Human antibodies can be produced using various techniques known in the art. Human antibodies are described generally in van Dijk and van de Winkel, *Curr. Opin. Pharmacol.* 5: 368-74 (2001) and Lonberg, *Curr. Opin. Immunol.* 20:450-459 (2008).

**[0274]** Human antibodies may be prepared by administering an immunogen to a transgenic animal that has been modified to produce intact human antibodies or intact antibodies with human variable regions in response to antigenic challenge. Such animals typically contain all or a portion of the human immunoglobulin loci, which replace the endogenous immunoglobulin loci, or which are present extrachromosomally or integrated randomly into the animal's chromosomes. In such transgenic mice, the endogenous immunoglobulin loci have generally been inactivated. For review of methods for obtaining human antibodies from transgenic animals, see Lonberg, *Nat. Biotech.* 23:1117-1125 (2005). See also, *e.g.,* U.S. Patent Nos. 6,075,181 and 6,150,584 describing XENOMOUSE™ technology; U.S. Patent No. 5,770,429 describing HUMAB® technology; U.S. Patent No. 7,041,870 describing K-M MOUSE® technology, and U.S. Patent Application Publication No. US 2007/0061900, describing VELOCIMOUSE® technology). Human variable regions from intact antibodies generated by such animals may be further modified, *e.g.,* by combining with a different human constant region.

**[0275]** Human antibodies can also be made by hybridoma-based methods. Human myeloma and mouse-human heteromyeloma cell lines for the production of human monoclonal antibodies have

been described. (See, *e.g.,* Kozbor *J. Immunol.*, 133: 3001 (1984); Brodeur et al., *Monoclonal Antibody Production Techniques and Applications*, pp. 51-63 (Marcel Dekker, Inc., New York, 1987); and Boerner et al., *J. Immunol.*, 147: 86 (1991).) Human antibodies generated via human B-cell hybridoma technology are also described in Li et al., *Proc. Natl. Acad. Sci. USA*, 103:3557-3562 (2006). Additional methods include those described, for example, in U.S. Patent No. 7,189,826 (describing production of monoclonal human IgM antibodies from hybridoma cell lines) and Ni, *Xiandai Mianyixue*, 26(4):265-268 (2006) (describing human-human hybridomas). Human hybridoma technology (Trioma technology) is also described in Vollmers and Brandlein, *Histology and Histopathology*, 20(3):927-937 (2005) and Vollmers and Brandlein, *Methods and Findings in Experimental and Clinical Pharmacology*, 27(3):185-91 (2005).

**[0276]** Human antibodies may also be generated by isolating Fv clone variable domain sequences selected from human-derived phage display libraries. Such variable domain sequences may then be combined with a desired human constant domain. Techniques for selecting human antibodies from antibody libraries are described below.

(v) Antibody Fragments

**[0277]** Antibody fragments may be generated by traditional means, such as enzymatic digestion, or by recombinant techniques. In certain circumstances there are advantages of using antibody fragments, rather than whole antibodies. The smaller size of the fragments allows for rapid clearance, and may lead to improved access to solid tumors. For a review of certain antibody fragments, see Hudson et al. (2003) *Nat. Med.* 9:129-134.

**[0278]** Various techniques have been developed for the production of antibody fragments. Traditionally, these fragments were derived via proteolytic digestion of intact antibodies (see, e.g., Morimoto et al., *Journal of Biochemical and Biophysical Methods* 24:107-117 (1992); and Brennan et al., *Science*, 229:81 (1985)). However, these fragments can now be produced directly by recombinant host cells. Fab, Fv and ScFv antibody fragments can all be expressed in and secreted from E. coli, thus allowing the facile production of large amounts of these fragments. Antibody fragments can be isolated from the antibody phage libraries discussed above. Alternatively, Fab'-SH fragments can be directly recovered from E. coli and chemically coupled to form $F(ab')_2$ fragments (Carter et al., *Bio/Technology* 10:163-167 (1992)). According to another approach, $F(ab')_2$ fragments can be isolated directly from recombinant host cell culture. Fab and $F(ab')_2$ fragment with increased *in vivo* half-life comprising salvage receptor binding epitope residues are described in U.S. Pat. No. 5,869,046. Other techniques for the production of antibody fragments will be apparent to the skilled practitioner. In certain embodiments, an antibody is a single chain Fv fragment (scFv). See WO 93/16185; U.S. Pat. Nos. 5,571,894; and 5,587,458. Fv and scFv are the only species with intact combining sites that are devoid of constant regions; thus, they may be suitable for reduced nonspecific binding during in vivo use. scFv fusion proteins may be constructed to yield fusion of an effector

protein at either the amino or the carboxy terminus of an scFv. See *Antibody Engineering*, ed. Borrebaeck, *supra*. The antibody fragment may also be a "linear antibody", e.g., as described in U.S. Pat. No. 5,641,870, for example. Such linear antibodies may be monospecific or bispecific.

(vi) Multispecific Antibodies

**[0279]** Multispecific antibodies have binding specificities for at least two different epitopes, where the epitopes are usually from different antigens. While such molecules normally will only bind two different epitopes (i.e. bispecific antibodies, BsAbs), antibodies with additional specificities such as trispecific antibodies are encompassed by this expression when used herein. Bispecific antibodies can be prepared as full length antibodies or antibody fragments (e.g. $F(ab')_2$ bispecific antibodies). In one aspect, provided are bispecific antibodies that bind OX40 and PD-1. In one aspect, provided are bispecific antibodies that bind OX40 and PD-L1.

**[0280]** Methods for making bispecific antibodies are known in the art. Traditional production of full length bispecific antibodies is based on the coexpression of two immunoglobulin heavy chain-light chain pairs, where the two chains have different specificities (Millstein et al., *Nature*, 305:537-539 (1983)). Because of the random assortment of immunoglobulin heavy and light chains, these hybridomas (quadromas) produce a potential mixture of 10 different antibody molecules, of which only one has the correct bispecific structure. Purification of the correct molecule, which is usually done by affinity chromatography steps, is rather cumbersome, and the product yields are low. Similar procedures are disclosed in WO 93/08829, and in Traunecker et al., *EMBO J.*, 10:3655-3659 (1991).

**[0281]** One approach known in the art for making bispecific antibodies is the "knobs-into-holes" or "protuberance-into-cavity" approach (see, *e.g.,* US Pat. No. 5,731,168). In this approach, two immunoglobulin polypeptides (*e.g.,* heavy chain polypeptides) each comprise an interface. An interface of one immunoglobulin polypeptide interacts with a corresponding interface on the other immunoglobulin polypeptide, thereby allowing the two immunoglobulin polypeptides to associate. These interfaces may be engineered such that a "knob" or "protuberance" (these terms may be used interchangeably herein) located in the interface of one immunoglobulin polypeptide corresponds with a "hole" or "cavity" (these terms may be used interchangeably herein) located in the interface of the other immunoglobulin polypeptide. In some embodiments, the hole is of identical or similar size to the knob and suitably positioned such that when the two interfaces interact, the knob of one interface is positionable in the corresponding hole of the other interface. Without wishing to be bound to theory, this is thought to stabilize the heteromultimer and favor formation of the heteromultimer over other species, for example homomultimers. In some embodiments, this approach may be used to promote the heteromultimerization of two different immunoglobulin polypeptides, creating a bispecific antibody comprising two immunoglobulin polypeptides with binding specificities for different epitopes.

**[0282]** In some embodiments, a knob may be constructed by replacing a small amino acid side chain with a larger side chain. In some embodiments, a hole may be constructed by replacing a large amino acid side chain with a smaller side chain. Knobs or holes may exist in the original interface, or they may be introduced synthetically. For example, knobs or holes may be introduced synthetically by altering the nucleic acid sequence encoding the interface to replace at least one "original" amino acid residue with at least one "import" amino acid residue. Methods for altering nucleic acid sequences may include standard molecular biology techniques well known in the art. The side chain volumes of various amino acid residues are shown in the following table. In some embodiments, original residues have a small side chain volume (*e.g.,* alanine, asparagine, aspartic acid, glycine, serine, threonine, or valine), and import residues for forming a knob are naturally occurring amino acids and may include arginine, phenylalanine, tyrosine, and tryptophan. In some embodiments, original residues have a large side chain volume (*e.g.,* arginine, phenylalanine, tyrosine, and tryptophan), and import residues for forming a hole are naturally occurring amino acids and may include alanine, serine, threonine, and valine.

**Table 1.** Properties of amino acid residues

| Amino acid | One-letter abbreviation | Mass[a] (daltons) | Volume[b] (Å$^3$) | Accessible surface area[c] (Å$^2$) |
|---|---|---|---|---|
| Alanine (Ala) | A | 71.08 | 88.6 | 115 |
| Arginine (Arg) | R | 156.20 | 173.4 | 225 |
| Asparagine (Asn) | N | 114.11 | 117.7 | 160 |
| Aspartic Acid (Asp) | D | 115.09 | 111.1 | 150 |
| Cysteine (Cys) | C | 103.14 | 108.5 | 135 |
| Glutamine (Gln) | Q | 128.14 | 143.9 | 180 |
| Glutamic Acid (Glu) | E | 129.12 | 138.4 | 190 |
| Glycine (Gly) | G | 57.06 | 60.1 | 75 |
| Histidine (His) | H | 137.15 | 153.2 | 195 |
| Isoleucine (Ile) | I | 113.17 | 166.7 | 175 |
| Leucine (Leu) | L | 113.17 | 166.7 | 170 |
| Lysine (Lys) | K | 128.18 | 168.6 | 200 |
| Methionine (Met) | M | 131.21 | 162.9 | 185 |
| Phenylalanine (Phe) | F | 147.18 | 189.9 | 210 |
| Proline (Pro) | P | 97.12 | 122.7 | 145 |
| Serine (Ser) | S | 87.08 | 89.0 | 115 |
| Threonine (Thr) | T | 101.11 | 116.1 | 140 |
| Tryptophan (Trp) | W | 186.21 | 227.8 | 255 |
| Tyrosine (Tyr) | Y | 163.18 | 193.6 | 230 |

| Amino acid | One-letter abbreviation | Mass[a] (daltons) | Volume[b] (Å$^3$) | Accessible surface area[c] (Å$^2$) |
|---|---|---|---|---|
| Valine (Val) | V | 99.14 | 140.0 | 155 |

[a]Molecular weight of amino acid minus that of water. Values from Handbook of Chemistry and Physics, 43rd ed. Cleveland, Chemical Rubber Publishing Co., 1961.

[b]Values from A.A. Zamyatnin, Prog. Biophys. Mol. Biol. 24:107-123, 1972.

[c]Values from C. Chothia, J. Mol. Biol. 105:1-14, 1975. The accessible surface area is defined in Figures 6-20 of this reference.

**[0283]** In some embodiments, original residues for forming a knob or hole are identified based on the three-dimensional structure of the heteromultimer. Techniques known in the art for obtaining a three-dimensional structure may include X-ray crystallography and NMR. In some embodiments, the interface is the CH3 domain of an immunoglobulin constant domain. In these embodiments, the CH3/CH3 interface of human $IgG_1$ involves sixteen residues on each domain located on four anti-parallel β-strands. Without wishing to be bound to theory, mutated residues are preferably located on the two central anti-parallel β-strands to minimize the risk that knobs can be accommodated by the surrounding solvent, rather than the compensatory holes in the partner CH3 domain. In some embodiments, the mutations forming corresponding knobs and holes in two immunoglobulin polypeptides correspond to one or more pairs provided in the following table.

**Table 2.** Exemplary sets of corresponding knob-and hole-forming mutations

| **CH3 of first immunoglobulin** | **CH3 of second immunoglobulin** |
|---|---|
| T366Y | Y407T |
| T366W | Y407A |
| F405A | T394W |
| Y407T | T366Y |
| T366Y:F405A | T394W:Y407T |
| T366W:F405W | T394S:Y407A |
| F405W:Y407A | T366W:T394S |

| | |
|---|---|
| F405W | T394S |

Mutations are denoted by the original residue, followed by the position using the Kabat numbering system, and then the import residue (all residues are given in single-letter amino acid code). Multiple mutations are separated by a colon.

**[0284]** In some embodiments, an immunoglobulin polypeptide comprises a CH3 domain comprising one or more amino acid substitutions listed in Table 2 above. In some embodiments, a bispecific antibody comprises a first immunoglobulin polypeptide comprising a CH3 domain comprising one or more amino acid substitutions listed in the left column of Table 2, and a second immunoglobulin polypeptide comprising a CH3 domain comprising one or more corresponding amino acid substitutions listed in the right column of Table 2.

**[0285]** Following mutation of the DNA as discussed above, polynucleotides encoding modified immunoglobulin polypeptides with one or more corresponding knob- or hole-forming mutations may be expressed and purified using standard recombinant techniques and cell systems known in the art. See, e.g., U.S. Pat. Nos. 5,731,168; 5,807,706; 5,821,333; 7,642,228; 7,695,936; 8,216,805; U.S. Pub. No. 2013/0089553; and Spiess et al., Nature Biotechnology 31: 753-758, 2013. Modified immunoglobulin polypeptides may be produced using prokaryotic host cells, such as *E. coli*, or eukaryotic host cells, such as CHO cells. Corresponding knob- and hole-bearing immunoglobulin polypeptides may be expressed in host cells in co-culture and purified together as a heteromultimer, or they may be expressed in single cultures, separately purified, and assembled *in vitro*. In some embodiments, two strains of bacterial host cells (one expressing an immunoglobulin polypeptide with a knob, and the other expressing an immunoglobulin polypeptide with a hole) are co-cultured using standard bacterial culturing techniques known in the art. In some embodiments, the two strains may be mixed in a specific ratio, *e.g.,* so as to achieve equal expression levels in culture. In some embodiments, the two strains may be mixed in a 50:50, 60:40, or 70:30 ratio. After polypeptide expression, the cells may be lysed together, and protein may be extracted. Standard techniques known in the art that allow for measuring the abundance of homo-multimeric vs. hetero-multimeric species may include size exclusion chromatography. In some embodiments, each modified immunoglobulin polypeptide is expressed separately using standard recombinant techniques, and they may be assembled together *in vitro*. Assembly may be achieved, for example, by purifying each modified immunoglobulin polypeptide, mixing and incubating them together in equal mass, reducing disulfides (*e.g.,* by treating with dithiothreitol), concentrating, and reoxidizing the polypeptides. Formed bispecific antibodies may be purified using standard techniques including cation-exchange chromatography and measured using standard techniques including size exclusion chromatography. For a more detailed description of these methods, see Speiss et al., *Nat Biotechnol* 31:753-8, 2013. In

some embodiments, modified immunoglobulin polypeptides may be expressed separately in CHO cells and assembled *in vitro* using the methods described above.

**[0286]** According to a different approach, antibody variable domains with the desired binding specificities (antibody-antigen combining sites) are fused to immunoglobulin constant domain sequences. The fusion preferably is with an immunoglobulin heavy chain constant domain, comprising at least part of the hinge, CH2, and CH3 regions. It is typical to have the first heavy-chain constant region (CH1) containing the site necessary for light chain binding, present in at least one of the fusions. DNAs encoding the immunoglobulin heavy chain fusions and, if desired, the immunoglobulin light chain, are inserted into separate expression vectors, and are co-transfected into a suitable host organism. This provides for great flexibility in adjusting the mutual proportions of the three polypeptide fragments in embodiments when unequal ratios of the three polypeptide chains used in the construction provide the optimum yields. It is, however, possible to insert the coding sequences for two or all three polypeptide chains in one expression vector when the expression of at least two polypeptide chains in equal ratios results in high yields or when the ratios are of no particular significance.

**[0287]** In one embodiment of this approach, the bispecific antibodies are composed of a hybrid immunoglobulin heavy chain with a first binding specificity in one arm, and a hybrid immunoglobulin heavy chain-light chain pair (providing a second binding specificity) in the other arm. It was found that this asymmetric structure facilitates the separation of the desired bispecific compound from unwanted immunoglobulin chain combinations, as the presence of an immunoglobulin light chain in only one half of the bispecific molecule provides for a facile way of separation. This approach is disclosed in WO 94/04690. For further details of generating bispecific antibodies see, for example, Suresh et al., *Methods in Enzymology*, 121:210 (1986).

**[0288]** According to another approach described in WO96/27011, the interface between a pair of antibody molecules can be engineered to maximize the percentage of heterodimers which are recovered from recombinant cell culture. One interface comprises at least a part of the $C_H3$ domain of an antibody constant domain. In this method, one or more small amino acid side chains from the interface of the first antibody molecule are replaced with larger side chains (e.g. tyrosine or tryptophan). Compensatory "cavities" of identical or similar size to the large side chain(s) are created on the interface of the second antibody molecule by replacing large amino acid side chains with smaller ones (e.g. alanine or threonine). This provides a mechanism for increasing the yield of the heterodimer over other unwanted end-products such as homodimers.

**[0289]** Bispecific antibodies include cross-linked or "heteroconjugate" antibodies. For example, one of the antibodies in the heteroconjugate can be coupled to avidin, the other to biotin. Such antibodies have, for example, been proposed to target immune system cells to unwanted cells (U.S. Pat. No. 4,676,980), and for treatment of HIV infection (WO 91/00360, WO 92/200373, and EP 03089).

Heteroconjugate antibodies may be made using any convenient cross-linking methods. Suitable cross-linking agents are well known in the art, and are disclosed in U.S. Pat. No. 4,676,980, along with a number of cross-linking techniques.

**[0290]** Techniques for generating bispecific antibodies from antibody fragments have also been described in the literature. For example, bispecific antibodies can be prepared using chemical linkage. Brennan et al., *Science*, 229: 81 (1985) describe a procedure wherein intact antibodies are proteolytically cleaved to generate $F(ab')_2$ fragments. These fragments are reduced in the presence of the dithiol complexing agent sodium arsenite to stabilize vicinal dithiols and prevent intermolecular disulfide formation. The Fab' fragments generated are then converted to thionitrobenzoate (TNB) derivatives. One of the Fab'-TNB derivatives is then reconverted to the Fab'-thiol by reduction with mercaptoethylamine and is mixed with an equimolar amount of the other Fab'-TNB derivative to form the bispecific antibody. The bispecific antibodies produced can be used as agents for the selective immobilization of enzymes.

**[0291]** Recent progress has facilitated the direct recovery of Fab'-SH fragments from E. coli, which can be chemically coupled to form bispecific antibodies. Shalaby et al., *J. Exp. Med.*, 175: 217-225 (1992) describe the production of a fully humanized bispecific antibody $F(ab')_2$ molecule. Each Fab' fragment was separately secreted from E. coli and subjected to directed chemical coupling in vitro to form the bispecific antibody.

**[0292]** Various techniques for making and isolating bispecific antibody fragments directly from recombinant cell culture have also been described. For example, bispecific antibodies have been produced using leucine zippers. Kostelny et al., *J. Immunol.*, 148(5):1547-1553 (1992). The leucine zipper peptides from the Fos and Jun proteins were linked to the Fab' portions of two different antibodies by gene fusion. The antibody homodimers were reduced at the hinge region to form monomers and then re-oxidized to form the antibody heterodimers. This method can also be utilized for the production of antibody homodimers. The "diabody" technology described by Hollinger et al., *Proc. Natl. Acad. Sci. USA*, 90:6444-6448 (1993) has provided an alternative mechanism for making bispecific antibody fragments. The fragments comprise a heavy-chain variable domain ($V_H$) connected to a light-chain variable domain ($V_L$) by a linker which is too short to allow pairing between the two domains on the same chain. Accordingly, the $V_H$ and $V_L$ domains of one fragment are forced to pair with the complementary $V_L$ and $V_H$ domains of another fragment, thereby forming two antigen-binding sites. Another strategy for making bispecific antibody fragments by the use of single-chain Fv (sFv) dimers has also been reported. *See* Gruber et al, *J. Immunol*, 152:5368 (1994).

**[0293]** Antibodies with more than two valencies are contemplated. For example, trispecific antibodies can be prepared. *Tuft et al. J. Immunol.* 147: 60 (1991).

(vii) Single-Domain Antibodies

**[0294]** In some embodiments, an antibody of the invention is a single-domain antibody. A single-domain antibody is a single polypeptide chain comprising all or a portion of the heavy chain variable domain or all or a portion of the light chain variable domain of an antibody. In certain embodiments, a single-domain antibody is a human single-domain antibody (Domantis, Inc., Waltham, Mass.; *see*, *e.g.*, U.S. Pat. No. 6,248,516 B1). In one embodiment, a single-domain antibody consists of all or a portion of the heavy chain variable domain of an antibody.

(viii) Antibody Variants

**[0295]** In some embodiments, amino acid sequence modification(s) of the antibodies described herein are contemplated. For example, it may be desirable to improve the binding affinity and/or other biological properties of the antibody. Amino acid sequence variants of the antibody may be prepared by introducing appropriate changes into the nucleotide sequence encoding the antibody, or by peptide synthesis. Such modifications include, for example, deletions from, and/or insertions into and/or substitutions of, residues within the amino acid sequences of the antibody. Any combination of deletion, insertion, and substitution can be made to arrive at the final construct, provided that the final construct possesses the desired characteristics. The amino acid alterations may be introduced in the subject antibody amino acid sequence at the time that sequence is made.

(ix) Substitution, Insertion, and Deletion Variants

**[0296]** In certain embodiments, antibody variants having one or more amino acid substitutions are provided. Sites of interest for substitutional mutagenesis include the HVRs and FRs. Conservative substitutions are shown in Table 1 under the heading of "conservative substitutions." More substantial changes are provided in Table 1 under the heading of "exemplary substitutions," and as further described below in reference to amino acid side chain classes. Amino acid substitutions may be introduced into an antibody of interest and the products screened for a desired activity, *e.g.*, retained/improved antigen binding, decreased immunogenicity, or improved ADCC or CDC.

**Table 3.** Exemplary Substitutions.

| Original Residue | Exemplary Substitutions | Preferred Substitutions |
|---|---|---|
| Ala (A) | Val; Leu; Ile | Val |
| Arg (R) | Lys; Gln; Asn | Lys |
| Asn (N) | Gln; His; Asp, Lys; Arg | Gln |
| Asp (D) | Glu; Asn | Glu |
| Cys (C) | Ser; Ala | Ser |
| Gln (Q) | Asn; Glu | Asn |
| Glu (E) | Asp; Gln | Asp |
| Gly (G) | Ala | Ala |

| Original Residue | Exemplary Substitutions | Preferred Substitutions |
|---|---|---|
| His (H) | Asn; Gln; Lys; Arg | Arg |
| Ile (I) | Leu; Val; Met; Ala; Phe; Norleucine | Leu |
| Leu (L) | Norleucine; Ile; Val; Met; Ala; Phe | Ile |
| Lys (K) | Arg; Gln; Asn | Arg |
| Met (M) | Leu; Phe; Ile | Leu |
| Phe (F) | Trp; Leu; Val; Ile; Ala; Tyr | Tyr |
| Pro (P) | Ala | Ala |
| Ser (S) | Thr | Thr |
| Thr (T) | Val; Ser | Ser |
| Trp (W) | Tyr; Phe | Tyr |
| Tyr (Y) | Trp; Phe; Thr; Ser | Phe |
| Val (V) | Ile; Leu; Met; Phe; Ala; Norleucine | Leu |

**[0297]** Amino acids may be grouped according to common side-chain properties:

- **a.** hydrophobic: Norleucine, Met, Ala, Val, Leu, Ile;
- **b.** neutral hydrophilic: Cys, Ser, Thr, Asn, Gln;
- **c.** acidic: Asp, Glu;
- **d.** basic: His, Lys, Arg;
- **e.** residues that influence chain orientation: Gly, Pro;
- **f.** aromatic: Trp, Tyr, Phe.

**[0298]** Non-conservative substitutions will entail exchanging a member of one of these classes for another class.

**[0299]** One type of substitutional variant involves substituting one or more hypervariable region residues of a parent antibody (*e.g.* a humanized or human antibody). Generally, the resulting variant(s) selected for further study will have modifications (*e.g.,* improvements) in certain biological properties (*e.g.,* increased affinity, reduced immunogenicity) relative to the parent antibody and/or will have substantially retained certain biological properties of the parent antibody. An exemplary substitutional variant is an affinity matured antibody, which may be conveniently generated, *e.g.,* using phage display-based affinity maturation techniques such as those described herein. Briefly, one or more HVR residues are mutated and the variant antibodies displayed on phage and screened for a particular biological activity (e.g. binding affinity).

**[0300]** Alterations (*e.g.,* substitutions) may be made in HVRs, *e.g.,* to improve antibody affinity. Such alterations may be made in HVR "hotspots," *i.e.,* residues encoded by codons that undergo mutation at high frequency during the somatic maturation process (see, *e.g.,* Chowdhury, *Methods Mol. Biol.* 207:179-196 (2008)), and/or SDRs (a-CDRs), with the resulting variant VH or VL being

tested for binding affinity. Affinity maturation by constructing and reselecting from secondary libraries has been described, *e.g.,* in Hoogenboom et al. in *Methods in Molecular Biology* 178:1-37 (O'Brien et al., ed., Human Press, Totowa, NJ, (2001).) In some embodiments of affinity maturation, diversity is introduced into the variable genes chosen for maturation by any of a variety of methods (*e.g.,* error-prone PCR, chain shuffling, or oligonucleotide-directed mutagenesis). A secondary library is then created. The library is then screened to identify any antibody variants with the desired affinity. Another method to introduce diversity involves HVR-directed approaches, in which several HVR residues (*e.g.,* 4-6 residues at a time) are randomized. HVR residues involved in antigen binding may be specifically identified, *e.g.,* using alanine scanning mutagenesis or modeling. CDR-H3 and CDR-L3 in particular are often targeted.

**[0301]** In certain embodiments, substitutions, insertions, or deletions may occur within one or more HVRs so long as such alterations do not substantially reduce the ability of the antibody to bind antigen. For example, conservative alterations (*e.g.,* conservative substitutions as provided herein) that do not substantially reduce binding affinity may be made in HVRs. Such alterations may be outside of HVR "hotspots" or SDRs. In certain embodiments of the variant VH and VL sequences provided above, each HVR either is unaltered, or contains no more than one, two or three amino acid substitutions.

**[0302]** A useful method for identification of residues or regions of an antibody that may be targeted for mutagenesis is called "alanine scanning mutagenesis" as described by Cunningham and Wells (1989) *Science*, 244:1081-1085. In this method, a residue or group of target residues (*e.g.,* charged residues such as arg, asp, his, lys, and glu) are identified and replaced by a neutral or negatively charged amino acid (*e.g.,* alanine or polyalanine) to determine whether the interaction of the antibody with antigen is affected. Further substitutions may be introduced at the amino acid locations demonstrating functional sensitivity to the initial substitutions. Alternatively, or additionally, a crystal structure of an antigen-antibody complex 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.

**[0303]** Amino acid sequence insertions include amino- and/or carboxyl-terminal fusions ranging in length from one residue to polypeptides containing a hundred or more residues, as well as intrasequence insertions of single or multiple amino acid residues. Examples of terminal insertions include an antibody with an N-terminal methionyl residue. Other insertional variants of the antibody molecule include the fusion to the N- or C-terminus of the antibody to an enzyme (*e.g.,* for ADEPT) or a polypeptide which increases the serum half-life of the antibody.

(x) Glycosylation variants

**[0304]** In certain embodiments, an antibody provided herein is altered to increase or decrease the extent to which the antibody is glycosylated. Addition or deletion of glycosylation sites to an

antibody may be conveniently accomplished by altering the amino acid sequence such that one or more glycosylation sites is created or removed.

**[0305]** Where the antibody comprises an Fc region, the carbohydrate attached thereto may be altered. Native antibodies produced by mammalian cells typically comprise a branched, biantennary oligosaccharide that is generally attached by an N-linkage to Asn297 of the CH2 domain of the Fc region. See, *e.g.,* Wright et al. *TIBTECH* 15:26-32 (1997). The oligosaccharide may include various carbohydrates, *e.g.,* mannose, N-acetyl glucosamine (GlcNAc), galactose, and sialic acid, as well as a fucose attached to a GlcNAc in the "stem" of the biantennary oligosaccharide structure. In some embodiments, modifications of the oligosaccharide in an antibody of the invention may be made in order to create antibody variants with certain improved properties.

**[0306]** In one embodiment, antibody variants are provided comprising an Fc region wherein a carbohydrate structure attached to the Fc region has reduced fucose or lacks fucose, which may improve ADCC function. Specifically, antibodies are contemplated herein that have reduced fusose relative to the amount of fucose on the same antibody produced in a wild-type CHO cell. That is, they are characterized by having a lower amount of fucose than they would otherwise have if produced by native CHO cells (*e.g.,* a CHO cell that produce a native glycosylation pattern, such as, a CHO cell containing a native FUT8 gene). In certain embodiments, the antibody is one wherein less than about 50%, 40%, 30%, 20%, 10%, or 5% of the N-linked glycans thereon comprise fucose. For example, the amount of fucose in such an antibody may be from 1% to 80%, from 1% to 65%, from 5% to 65% or from 20% to 40%. In certain embodiments, the antibody is one wherein none of the N-linked glycans thereon comprise fucose, *i.e.,* wherein the antibody is completely without fucose, or has no fucose or is afucosylated. The amount of fucose is determined by calculating the average amount of fucose within the sugar chain at Asn297, relative to the sum of all glycostructures attached to Asn 297 (e. g. complex, hybrid and high mannose structures) as measured by MALDI-TOF mass spectrometry, as described in WO 2008/077546, for example. Asn297 refers to the asparagine residue located at about position 297 in the Fc region (Eu numbering of Fc region residues); however, Asn297 may also be located about ± 3 amino acids upstream or downstream of position 297, *i.e.,* between positions 294 and 300, due to minor sequence variations in antibodies. Such fucosylation variants may have improved ADCC function. See, *e.g.,* US Patent Publication Nos. US 2003/0157108 (Presta, L.); US 2004/0093621 (Kyowa Hakko Kogyo Co., Ltd). Examples of publications related to "defucosylated" or "fucose-deficient" antibody variants include: US 2003/0157108; WO 2000/61739; WO 2001/29246; US 2003/0115614; US 2002/0164328; US 2004/0093621; US 2004/0132140; US 2004/0110704; US 2004/0110282; US 2004/0109865; WO 2003/085119; WO 2003/084570; WO 2005/035586; WO 2005/035778; WO2005/053742; WO2002/031140; Okazaki et al. *J. Mol. Biol.* 336:1239-1249 (2004); Yamane-Ohnuki et al. *Biotech. Bioeng.* 87: 614 (2004). Examples of cell lines capable of producing defucosylated antibodies include Lec13 CHO cells deficient in protein

fucosylation (Ripka et al. *Arch. Biochem. Biophys.* 249:533-545 (1986); US Pat Appl No US 2003/0157108 A1, Presta, L; and WO 2004/056312 A1, Adams *et al.*, especially at Example 11), and knockout cell lines, such as alpha-1,6-fucosyltransferase gene, *FUT8,* knockout CHO cells (see, *e.g.,* Yamane-Ohnuki et al. *Biotech. Bioeng.* 87: 614 (2004); Kanda, Y. et al., *Biotechnol. Bioeng.*, 94(4):680-688 (2006); and WO2003/085107).

**[0307]** Antibody variants are further provided with bisected oligosaccharides, *e.g.,* in which a biantennary oligosaccharide attached to the Fc region of the antibody is bisected by GlcNAc. Such antibody variants may have reduced fucosylation and/or improved ADCC function. Examples of such antibody variants are described, *e.g.,* in WO 2003/011878 (Jean-Mairet et al.); US Patent No. 6,602,684 (Umana et al.); US 2005/0123546 (Umana *et al.*), and Ferrara et al., Biotechnology and Bioengineering, 93(5): 851-861 (2006). Antibody variants with at least one galactose residue in the oligosaccharide attached to the Fc region are also provided. Such antibody variants may have improved CDC function. Such antibody variants are described, *e.g.,* in WO 1997/30087 (Patel et al.); WO 1998/58964 (Raju, S.); and WO 1999/22764 (Raju, S.).

**[0308]** In certain embodiments, the antibody variants comprising an Fc region described herein are capable of binding to an FcγRIII. In certain embodiments, the antibody variants comprising an Fc region described herein have ADCC activity in the presence of human effector cells or have increased ADCC activity in the presence of human effector cells compared to the otherwise same antibody comprising a human wild-type IgG1Fc region.

(xi) Fc region variants

**[0309]** In certain embodiments, one or more amino acid modifications may be introduced into the Fc region of an antibody provided herein, thereby generating an Fc region variant. The Fc region variant may comprise a human Fc region sequence (*e.g.,* a human IgG1, IgG2, IgG3 or IgG4 Fc region) comprising an amino acid modification (*e.g.* a substitution) at one or more amino acid positions.

**[0310]** In certain embodiments, the invention contemplates an antibody variant 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. The primary cells for mediating ADCC, NK cells, express Fc(RIII only, whereas monocytes express Fc(RI, Fc(RII and Fc(RIII. FcR expression on hematopoietic cells is summarized in Table 3 on page 464 of Ravetch and Kinet, *Annu. Rev. Immunol.* 9:457-492 (1991). Non-limiting examples of *in vitro* assays to assess ADCC activity of a molecule of interest is described in U.S. Patent No. 5,500,362 (see, e.g. Hellstrom, I. et al. *Proc. Nat'l Acad. Sci. USA* 83:7059-7063 (1986)) and Hellstrom, I et al., *Proc. Nat'l Acad. Sci. USA* 82:1499-1502 (1985);

5,821,337 (see Bruggemann, M. et al., *J. Exp. Med.* 166:1351-1361 (1987)). Alternatively, non-radioactive assays methods may be employed (see, for example, ACTI™ non-radioactive cytotoxicity assay for flow cytometry (CellTechnology, Inc. Mountain View, CA; and CytoTox 96® non-radioactive cytotoxicity assay (Promega, Madison, WI). Useful effector cells for such assays include peripheral blood mononuclear cells (PBMC) and Natural Killer (NK) cells. Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed *in vivo*, *e.g.,* in an animal model such as that disclosed in Clynes et al. *Proc. Nat'l Acad. Sci. USA* 95:652-656 (1998). C1q binding assays may also be carried out to confirm that the antibody is unable to bind C1q and hence lacks CDC activity. See, *e.g.,* C1q and C3c binding ELISA in WO 2006/029879 and WO 2005/100402. To assess complement activation, a CDC assay may be performed (see, for example, Gazzano-Santoro *et al.*, *J. Immunol. Methods* 202:163 (1996); Cragg, M.S. et al., *Blood* 101:1045-1052 (2003); and Cragg, M.S. and M.J. Glennie, *Blood* 103:2738-2743 (2004)). FcRn binding and *in vivo* clearance/half life determinations can also be performed using methods known in the art (see, *e.g.,* Petkova, S.B. et al., *Int'l. Immunol.* 18(12):1759-1769 (2006)).

**[0311]** Antibodies with reduced effector function include those with substitution of one or more of Fc region residues 238, 265, 269, 270, 297, 327 and 329 (U.S. Patent No. 6,737,056). Such Fc mutants include Fc mutants with substitutions at two or more of amino acid positions 265, 269, 270, 297 and 327, including the so-called "DANA" Fc mutant with substitution of residues 265 and 297 to alanine (US Patent No. 7,332,581).

**[0312]** Certain antibody variants with improved or diminished binding to FcRs are described. (See, *e.g.,* U.S. Patent No. 6,737,056; WO 2004/056312, and Shields et al., *J. Biol. Chem.* 9(2): 6591-6604 (2001).)

**[0313]** In certain embodiments, an antibody variant comprises an Fc region with one or more amino acid substitutions which improve ADCC, *e.g.,* substitutions at positions 298, 333, and/or 334 of the Fc region (EU numbering of residues). In an exemplary embodiment, the antibody comprising the following amino acid substitutions in its Fc region: S298A, E333A, and K334A.

**[0314]** In some embodiments, alterations are made in the Fc region that result in altered (*i.e.,* either improved or diminished) C1q binding and/or Complement Dependent Cytotoxicity (CDC), *e.g.,* as described in US Patent No. 6,194,551, WO 99/51642, and Idusogie et al. *J. Immunol.* 164: 4178-4184 (2000).

**[0315]** Antibodies with increased half lives and improved binding to the neonatal Fc receptor (FcRn), which is responsible for the transfer of maternal IgGs to the fetus (Guyer et al., *J. Immunol.* 117:587 (1976) and Kim et al., *J. Immunol.* 24:249 (1994)), are described in US2005/0014934A1 (Hinton et al.)). Those antibodies comprise an Fc region with one or more substitutions therein which improve binding of the Fc region to FcRn. Such Fc variants 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, *e.g.,* substitution of Fc region residue 434 (US Patent No. 7,371,826). See also Duncan & Winter, *Nature* 322:738-40 (1988); U.S. Patent No. 5,648,260; U.S. Patent No. 5,624,821; and WO 94/29351 concerning other examples of Fc region variants.

(xii) Antibody Derivatives

**[0316]** The antibodies of the invention can be further modified to contain additional nonproteinaceous moieties that are known in the art and readily available. In certain embodiments, the moieties suitable for derivatization of the antibody are water soluble polymers. Non-limiting examples of water soluble polymers include, but are not limited to, polyethylene glycol (PEG), copolymers of ethylene glycol/propylene glycol, carboxymethylcellulose, dextran, polyvinyl alcohol, polyvinyl pyrrolidone, poly-1,3-dioxolane, poly-1,3,6-trioxane, ethylene/maleic anhydride copolymer, polyaminoacids (either homopolymers or random copolymers), and dextran or poly(n-vinyl pyrrolidone)polyethylene glycol, propropylene glycol homopolymers, prolypropylene oxide/ethylene oxide co-polymers, polyoxyethylated polyols (e.g., glycerol), polyvinyl alcohol, and mixtures thereof. Polyethylene glycol propionaldehyde may have advantages in manufacturing due to its stability in water. The polymer may be of any molecular weight, and may be branched or unbranched. The number of polymers attached to the antibody may vary, and if more than one polymer are attached, they can be the same or different molecules. In general, the number and/or type of polymers used for derivatization can be determined based on considerations including, but not limited to, the particular properties or functions of the antibody to be improved, whether the antibody derivative will be used in a therapy under defined conditions, etc.

(xiii) Vectors, Host Cells, and Recombinant Methods

**[0317]** Antibodies may also be produced using recombinant methods. For recombinant production of an anti-antigen antibody, nucleic acid encoding the antibody is isolated and inserted into a replicable vector for further cloning (amplification of the DNA) or for expression. DNA encoding the antibody may be readily isolated and sequenced using conventional procedures (*e.g.*, by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of the antibody). Many vectors are available. The vector components generally include, but are not limited to, one or more of the following: a signal sequence, an origin of replication, one or more marker genes, an enhancer element, a promoter, and a transcription termination sequence.

(a) Signal Sequence Component

**[0318]** An antibody of the invention may be produced recombinantly not only directly, but also as a fusion polypeptide with a heterologous polypeptide, which is preferably a signal sequence or other polypeptide having a specific cleavage site at the N-terminus of the mature protein or polypeptide. The heterologous signal sequence selected preferably is one that is recognized and processed (*e.g.*, cleaved by a signal peptidase) by the host cell. For prokaryotic host cells that do not recognize and

process a native antibody signal sequence, the signal sequence is substituted by a prokaryotic signal sequence selected, for example, from the group of the alkaline phosphatase, penicillinase, lpp, or heat-stable enterotoxin II leaders. For yeast secretion the native signal sequence may be substituted by, *e.g.*, the yeast invertase leader, a factor leader (including *Saccharomyces* and *Kluyveromyces* α-factor leaders), or acid phosphatase leader, the *C. albicans* glucoamylase leader, or the signal described in WO 90/13646. In mammalian cell expression, mammalian signal sequences as well as viral secretory leaders, for example, the herpes simplex gD signal, are available.

(b) Origin of Replication

**[0319]** Both expression and cloning vectors contain a nucleic acid sequence that enables the vector to replicate in one or more selected host cells. Generally, in cloning vectors this sequence is one that enables the vector to replicate independently of the host chromosomal DNA, and includes origins of replication or autonomously replicating sequences. Such sequences are well known for a variety of bacteria, yeast, and viruses. The origin of replication from the plasmid pBR322 is suitable for most Gram-negative bacteria, the 2μ, plasmid origin is suitable for yeast, and various viral origins (SV40, polyoma, adenovirus, VSV or BPV) are useful for cloning vectors in mammalian cells. Generally, the origin of replication component is not needed for mammalian expression vectors (the SV40 origin may typically be used only because it contains the early promoter.

(c) Selection Gene Component

**[0320]** Expression and cloning vectors may contain a selection gene, also termed a selectable marker. Typical selection genes encode proteins that (a) confer resistance to antibiotics or other toxins, *e.g.*, ampicillin, neomycin, methotrexate, or tetracycline, (b) complement auxotrophic deficiencies, or (c) supply critical nutrients not available from complex media, *e.g.*, the gene encoding D-alanine racemase for *Bacilli*.

**[0321]** One example of a selection scheme utilizes a drug to arrest growth of a host cell. Those cells that are successfully transformed with a heterologous gene produce a protein conferring drug resistance and thus survive the selection regimen. Examples of such dominant selection use the drugs neomycin, mycophenolic acid and hygromycin.

**[0322]** Another example of suitable selectable markers for mammalian cells are those that enable the identification of cells competent to take up antibody-encoding nucleic acid, such as DHFR, glutamine synthetase (GS), thymidine kinase, metallothionein-I and -II, preferably primate metallothionein genes, adenosine deaminase, ornithine decarboxylase, *etc.*

**[0323]** For example, cells transformed with the DHFR gene are identified by culturing the transformants in a culture medium containing methotrexate (Mtx), a competitive antagonist of DHFR. Under these conditions, the DHFR gene is amplified along with any other co-transformed nucleic

acid. A Chinese hamster ovary (CHO) cell line deficient in endogenous DHFR activity (e.g., ATCC CRL-9096) may be used.

**[0324]** Alternatively, cells transformed with the GS gene are identified by culturing the transformants in a culture medium containing L-methionine sulfoximine (Msx), an inhibitor of GS. Under these conditions, the GS gene is amplified along with any other co-transformed nucleic acid. The GS selection/amplification system may be used in combination with the DHFR selection/amplification system described above.

**[0325]** Alternatively, host cells (particularly wild-type hosts that contain endogenous DHFR) transformed or co-transformed with DNA sequences encoding an antibody of interest, wild-type DHFR gene, and another selectable marker such as aminoglycoside 3'-phosphotransferase (APH) can be selected by cell growth in medium containing a selection agent for the selectable marker such as an aminoglycosidic antibiotic, *e.g.*, kanamycin, neomycin, or G418. See U.S. Pat. No. 4,965,199.

**[0326]** A suitable selection gene for use in yeast is the *trp*1 gene present in the yeast plasmid YRp7 (Stinchcomb *et al.*, *Nature*, 282:39 (1979)). The *trp*1 gene provides a selection marker for a mutant strain of yeast lacking the ability to grow in tryptophan, for example, ATCC No. 44076 or PEP4-1. Jones, *Genetics*, 85:12 (1977). The presence of the *trp*1 lesion in the yeast host cell genome then provides an effective environment for detecting transformation by growth in the absence of tryptophan. Similarly, *Leu*2-deficient yeast strains (ATCC 20,622 or 38,626) are complemented by known plasmids bearing the *Leu*2 gene.

**[0327]** In addition, vectors derived from the 1.6 μm circular plasmid pKD1 can be used for transformation of *Kluyveromyces* yeasts. Alternatively, an expression system for large-scale production of recombinant calf chymosin was reported for *K. lactis*. Van den Berg, *Bio/Technology*, 8:135 (1990). Stable multi-copy expression vectors for secretion of mature recombinant human serum albumin by industrial strains of *Kluyveromyces* have also been disclosed. Fleer *et al.*, *Bio/Technology*, 9:968-975 (1991).

(d) Promoter Component

**[0328]** Expression and cloning vectors generally contain a promoter that is recognized by the host organism and is operably linked to nucleic acid encoding an antibody. Promoters suitable for use with prokaryotic hosts include the *pho*A promoter, β-lactamase and lactose promoter systems, alkaline phosphatase promoter, a tryptophan (trp) promoter system, and hybrid promoters such as the tac promoter. However, other known bacterial promoters are suitable. Promoters for use in bacterial systems also will contain a Shine-Dalgarno (S.D.) sequence operably linked to the DNA encoding an antibody.

**[0329]** Promoter sequences are known for eukaryotes. Virtually all eukaryotic genes have an AT-rich region located approximately 25 to 30 bases upstream from the site where transcription is initiated. Another sequence found 70 to 80 bases upstream from the start of transcription of many genes is a

CNCAAT region where N may be any nucleotide. At the 3' end of most eukaryotic genes is an AATAAA sequence that may be the signal for addition of the poly A tail to the 3' end of the coding sequence. All of these sequences are suitably inserted into eukaryotic expression vectors.

**[0330]** Examples of suitable promoter sequences for use with yeast hosts include the promoters for 3-phosphoglycerate kinase or other glycolytic enzymes, such as enolase, glyceraldehyde-3-phosphate dehydrogenase, hexokinase, pyruvate decarboxylase, phosphofructokinase, glucose-6-phosphate isomerase, 3-phosphoglycerate mutase, pyruvate kinase, triosephosphate isomerase, phosphoglucose isomerase, and glucokinase.

**[0331]** Other yeast promoters, which are inducible promoters having the additional advantage of transcription controlled by growth conditions, are the promoter regions for alcohol dehydrogenase 2, isocytochrome C, acid phosphatase, degradative enzymes associated with nitrogen metabolism, metallothionein, glyceraldehyde-3-phosphate dehydrogenase, and enzymes responsible for maltose and galactose utilization. Suitable vectors and promoters for use in yeast expression are further described in EP 73,657. Yeast enhancers also are advantageously used with yeast promoters.

**[0332]** Antibody transcription from vectors in mammalian host cells can be controlled, for example, by promoters obtained from the genomes of viruses such as polyoma virus, fowlpox virus, adenovirus (such as Adenovirus 2), bovine papilloma virus, avian sarcoma virus, cytomegalovirus, a retrovirus, hepatitis-B virus, Simian Virus 40 (SV40), or from heterologous mammalian promoters, e.g., the actin promoter or an immunoglobulin promoter, from heat-shock promoters, provided such promoters are compatible with the host cell systems.

**[0333]** The early and late promoters of the SV40 virus are conveniently obtained as an SV40 restriction fragment that also contains the SV40 viral origin of replication. The immediate early promoter of the human cytomegalovirus is conveniently obtained as a HindIII E restriction fragment. A system for expressing DNA in mammalian hosts using the bovine papilloma virus as a vector is disclosed in U.S. Pat. No. 4,419,446. A modification of this system is described in U.S. Pat. No. 4,601,978. See also Reyes *et al.*, *Nature* 297:598-601 (1982) on expression of human β-interferon cDNA in mouse cells under the control of a thymidine kinase promoter from herpes simplex virus. Alternatively, the Rous Sarcoma Virus long terminal repeat can be used as the promoter.

(e) Enhancer Element Component

**[0334]** Transcription of a DNA encoding an antibody of this invention by higher eukaryotes is often increased by inserting an enhancer sequence into the vector. Many enhancer sequences are now known from mammalian genes (globin, elastase, albumin, α-fetoprotein, and insulin). Typically, however, one will use an enhancer from a eukaryotic cell virus. Examples include the SV40 enhancer on the late side of the replication origin (bp 100-270), the cytomegalovirus early promoter enhancer, the polyoma enhancer on the late side of the replication origin, and adenovirus enhancers. See also Yaniv, *Nature* 297:17-18 (1982) on enhancing elements for activation of eukaryotic promoters. The

enhancer may be spliced into the vector at a position 5' or 3' to the antibody-encoding sequence, but is preferably located at a site 5' from the promoter.

(f) Transcription Termination Component

**[0335]** Expression vectors used in eukaryotic host cells (yeast, fungi, insect, plant, animal, human, or nucleated cells from other multicellular organisms) will also contain sequences necessary for the termination of transcription and for stabilizing the mRNA. Such sequences are commonly available from the 5' and, occasionally 3', untranslated regions of eukaryotic or viral DNAs or cDNAs. These regions contain nucleotide segments transcribed as polyadenylated fragments in the untranslated portion of the mRNA encoding antibody. One useful transcription termination component is the bovine growth hormone polyadenylation region. See WO94/11026 and the expression vector disclosed therein.

(g) Selection and Transformation of Host Cells

**[0336]** Suitable host cells for cloning or expressing the DNA in the vectors herein are the prokaryote, yeast, or higher eukaryote cells described above. Suitable prokaryotes for this purpose include eubacteria, such as Gram-negative or Gram-positive organisms, for example, Enterobacteriaceae such as *Escherichia*, *e.g.*, *E. coli*, *Enterobacter*, *Erwinia*, *Klebsiella*, *Proteus*, *Salmonella*, *e.g.*, *Salmonella typhimurium*, *Serratia*, *e.g.*, *Serratia marcescans*, and *Shigella*, as well as *Bacilli* such as *B. subtilis* and *B. licheniformis* (*e.g.*, *B. licheniformis* 41P disclosed in DD 266,710 published 12 Apr. 1989), *Pseudomonas* such as *P. aeruginosa*, and *Streptomyces*. One preferred *E. coli* cloning host is *E. coli* 294 (ATCC 31,446), although other strains such as *E. coli* B, *E. coli* X1776 (ATCC 31,537), and *E. coli* W3110 (ATCC 27,325) are suitable. These examples are illustrative rather than limiting.

**[0337]** Full length antibody, antibody fusion proteins, and antibody fragments can be produced in bacteria, in particular when glycosylation and Fc effector function are not needed, such as when the therapeutic antibody is conjugated to a cytotoxic agent (e.g., a toxin) that by itself shows effectiveness in tumor cell destruction. Full length antibodies have greater half-life in circulation. Production in E. coli is faster and more cost efficient. For expression of antibody fragments and polypeptides in bacteria, see, e.g., U.S. Pat. No. 5,648,237 (Carter et. al.), U.S. Pat. No. 5,789,199 (Joly et al.), U.S. Pat. No. 5,840,523 (Simmons et al.), which describes translation initiation region (TIR) and signal sequences for optimizing expression and secretion. *See also* Charlton, *Methods in Molecular Biology*, *Vol.* 248 (B. K. C. Lo, ed., Humana Press, Totowa, N.J., 2003), pp. 245-254, describing expression of antibody fragments in *E. coli*. After expression, the antibody may be isolated from the E. coli cell paste in a soluble fraction and can be purified through, e.g., a protein A or G column depending on the isotype. Final purification can be carried out similar to the process for purifying antibody expressed e.g., in CHO cells.

**[0338]** In addition to prokaryotes, eukaryotic microbes such as filamentous fungi or yeast are suitable cloning or expression hosts for antibody-encoding vectors. *Saccharomyces cerevisiae*, or common baker's yeast, is the most commonly used among lower eukaryotic host microorganisms. However, a number of other genera, species, and strains are commonly available and useful herein, such as *Schizosaccharomyces pombe*; *Kluyveromyces* hosts such as, *e.g.*, *K. lactis*, *K. fragilis* (ATCC 12,424), *K. bulgaricus* (ATCC 16,045), *K. wickeramii* (ATCC 24,178), *K. waltii* (ATCC 56,500), *K. drosophilarum* (ATCC 36,906), *K. thermotolerans*, and *K. marxianus*; *yarrowia* (EP 402,226); *Pichia pastoris* (EP 183,070); *Candida*; *Trichoderma reesia* (EP 244,234); *Neurospora crassa*; *Schwanniomyces* such as *Schwanniomyces occidentalis*; and filamentous fungi such as, *e.g.*, *Neurospora*, *Penicillium*, *Tolypocladium*, and *Aspergillus* hosts such as *A. nidulans* and *A. niger*. For a review discussing the use of yeasts and filamentous fungi for the production of therapeutic proteins, see, e.g., Gerngross, *Nat. Biotech.* 22:1409-1414 (2004).

**[0339]** Certain fungi and yeast strains may be selected in which glycosylation pathways have been "humanized," resulting in the production of an antibody with a partially or fully human glycosylation pattern. *See*, *e.g.*, Li et al., *Nat. Biotech.* 24:210-215 (2006) (describing humanization of the glycosylation pathway in *Pichia pastoris*); and Gerngross et al., *supra*.

**[0340]** Suitable host cells for the expression of glycosylated antibody are also derived from multicellular organisms (invertebrates and vertebrates). Examples of invertebrate cells include plant and insect cells. Numerous baculoviral strains and variants and corresponding permissive insect host cells from hosts such as *Spodoptera frugiperda* (caterpillar), *Aedes aegypti* (mosquito), *Aedes albopictus* (mosquito), *Drosophila melanogaster* (fruitfly), and *Bombyx mori* have been identified. A variety of viral strains for transfection are publicly available, *e.g.*, the L-1 variant of *Autographa californica* NPV and the Bm-5 strain of *Bombyx mori* NPV, and such viruses may be used as the virus herein according to the invention, particularly for transfection of *Spodoptera frugiperda* cells.

**[0341]** Plant cell cultures of cotton, corn, potato, soybean, petunia, tomato, duckweed (*Leninaceae*), alfalfa (*M. truncatula*), and tobacco can also be utilized as hosts. *See*, *e.g.*, U.S. Pat. Nos. 5,959,177, 6,040,498, 6,420,548, 7,125,978, and 6,417,429 (describing PLANTIBODIES™ technology for producing antibodies in transgenic plants).

**[0342]** Vertebrate cells may be used as hosts, and propagation of vertebrate cells in culture (tissue culture) has become a routine procedure. Examples of useful mammalian host cell lines are monkey kidney CV1 line transformed by SV40 (COS-7, ATCC CRL 1651); human embryonic kidney line (293 or 293 cells subcloned for growth in suspension culture, Graham *et al.*, *J. Gen Virol.* 36:59 (1977)); baby hamster kidney cells (BHK, ATCC CCL 10); mouse sertoli cells (TM4, Mather, *Biol. Reprod.* 23:243-251 (1980)); monkey kidney cells (CV1 ATCC CCL 70); African green monkey kidney cells (VERO-76, ATCC CRL-1587); human cervical carcinoma cells (HELA, ATCC CCL 2); canine kidney cells (MDCK, ATCC CCL 34); buffalo rat liver cells (BRL 3A, ATCC CRL 1442);

human lung cells (W138, ATCC CCL 75); human liver cells (Hep G2, HB 8065); mouse mammary tumor (MMT 060562, ATCC CCL51); TRI cells (Mather *et al.*, *Annals N.Y. Acad. Sci.* 383:44-68 (1982)); MRC 5 cells; FS4 cells; and a human hepatoma line (Hep G2). Other useful mammalian host cell lines include Chinese hamster ovary (CHO) cells, including $DHFR^-$ CHO cells (Urlaub *et al.*, *Proc. Natl. Acad. Sci. USA* 77:4216 (1980)); and myeloma cell lines such as NS0 and Sp2/0. For a review of certain mammalian host cell lines suitable for antibody production, see, e.g., Yazaki and Wu, *Methods in Molecular Biology*, Vol. 248 (B. K. C. Lo, ed., Humana Press, Totowa, N.J., 2003), pp. 255-268.

**[0343]** Host cells are transformed with the above-described expression or cloning vectors for antibody production and cultured in conventional nutrient media modified as appropriate for inducing promoters, selecting transformants, or amplifying the genes encoding the desired sequences.

(h) Culturing the Host Cells

**[0344]** The host cells used to produce an antibody of this invention may be cultured in a variety of media. Commercially available media such as Ham's F10 (Sigma), Minimal Essential Medium ((MEM), (Sigma), RPMI-1640 (Sigma), and Dulbecco's Modified Eagle's Medium ((DMEM), Sigma) are suitable for culturing the host cells. In addition, any of the media described in Ham *et al.*, *Meth. Enz.* 58:44 (1979), Barnes *et al.*, *Anal. Biochem.* 102:255 (1980), U.S. Pat. Nos. 4,767,704; 4,657,866; 4,927,762; 4,560,655; or 5,122,469; WO 90/03430; WO 87/00195; or U.S. Pat. Re. 30,985 may be used as culture media for the host cells. Any of these media may be supplemented as necessary with hormones and/or other growth factors (such as insulin, transferrin, or epidermal growth factor), salts (such as sodium chloride, calcium, magnesium, and phosphate), buffers (such as HEPES), nucleotides (such as adenosine and thymidine), antibiotics (such as GENTAMYCIN™ drug), trace elements (defined as inorganic compounds usually present at final concentrations in the micromolar range), and glucose or an equivalent energy source. Any other necessary supplements may also be included at appropriate concentrations that would be known to those skilled in the art. The culture conditions, such as temperature, pH, and the like, are those previously used with the host cell selected for expression, and will be apparent to the ordinarily skilled artisan.

(xiv) Purification of Antibody

**[0345]** When using recombinant techniques, the antibody can be produced intracellularly, in the periplasmic space, or directly secreted into the medium. If the antibody is produced intracellularly, as a first step, the particulate debris, either host cells or lysed fragments, are removed, for example, by centrifugation or ultrafiltration. Carter *et al.*, *Bio/Technology* 10:163-167 (1992) describe a procedure for isolating antibodies which are secreted to the periplasmic space of *E. coli*. Briefly, cell paste is thawed in the presence of sodium acetate (pH 3.5), EDTA, and phenylmethylsulfonylfluoride (PMSF) over about 30 min. Cell debris can be removed by centrifugation. Where the antibody is secreted into

the medium, supernatants from such expression systems are generally first concentrated using a commercially available protein concentration filter, for example, an Amicon or Millipore Pellicon ultrafiltration unit. A protease inhibitor such as PMSF may be included in any of the foregoing steps to inhibit proteolysis and antibiotics may be included to prevent the growth of adventitious contaminants.

**[0346]** The antibody composition prepared from the cells can be purified using, for example, hydroxylapatite chromatography, hydrophobic interaction chromatography, gel electrophoresis, dialysis, and affinity chromatography, with affinity chromatography being among one of the typically preferred purification steps. The suitability of protein A as an affinity ligand depends on the species and isotype of any immunoglobulin Fc domain that is present in the antibody. Protein A can be used to purify antibodies that are based on human γ1, γ2, or γ4 heavy chains (Lindmark *et al.*, *J. Immunol. Meth.* 62:1-13 (1983)). Protein G is recommended for all mouse isotypes and for human γ3 (Guss *et al.*, *EMBO J.* 5:15671575 (1986)). The matrix to which the affinity ligand is attached is most often agarose, but other matrices are available. Mechanically stable matrices such as controlled pore glass or poly(styrenedivinyl)benzene allow for faster flow rates and shorter processing times than can be achieved with agarose. Where the antibody comprises a $C_H3$ domain, the Bakerbond ABX™ resin (J. T. Baker, Phillipsburg, N.J.) is useful for purification. Other techniques for protein purification such as fractionation on an ion-exchange column, ethanol precipitation, Reverse Phase HPLC, chromatography on silica, chromatography on heparin SEPHAROSE™ chromatography on an anion or cation exchange resin (such as a polyaspartic acid column), chromatofocusing, SDS-PAGE, and ammonium sulfate precipitation are also available depending on the antibody to be recovered.

**[0347]** In general, various methodologies for preparing antibodies for use in research, testing, and clinical are well-established in the art, consistent with the above-described methodologies and/or as deemed appropriate by one skilled in the art for a particular antibody of interest.

C. Selecting Biologically Active Antibodies

**[0348]** Antibodies produced as described above may be subjected to one or more "biological activity" assays to select an antibody with beneficial properties from a therapeutic perspective or selecting formulations and conditions that retain biological activity of the antibody. The antibody may be tested for its ability to bind the antigen against which it was raised. For example, methods known in the art (such as ELISA, Western Blot, etc.) may be used.

**[0349]** For example, for an anti-PDL1 antibody, the antigen binding properties of the antibody can be evaluated in an assay that detects the ability to bind to PDL1. In some embodiments, the binding of the antibody may be determined by saturation binding; ELISA; and/or competition assays (e.g. RIA's), for example. Also, the antibody may be subjected to other biological activity assays, e.g., in order to evaluate its effectiveness as a therapeutic. Such assays are known in the art and depend on the target antigen and intended use for the antibody. For example, the biological effects of PD-L1

blockade by the antibody can be assessed in CD8+T cells, a lymphocytic choriomeningitis virus (LCMV) mouse model and/or a syngeneic tumor model e.g., as described in US Patent 8,217,149.

**[0350]** To screen for antibodies which bind to a particular epitope on the antigen of interest (e.g., those which block binding of the anti-PDL1 antibody of the example to PD-L1), a routine cross-blocking assay such as that described in *Antibodies, A Laboratory Manual*, Cold Spring Harbor Laboratory, Ed Harlow and David Lane (1988), can be performed. Alternatively, epitope mapping, e.g. as described in Champe et al., *J. Biol. Chem.* 270:1388-1394 (1995), can be performed to determine whether the antibody binds an epitope of interest.

**[0351]** In one aspect, assays are provided for identifying anti-OX40 antibodies thereof having biological activity. Biological activity may include, e.g., binding OX40 (e.g., binding human and/or cynomolgus OX40), increasing OX40-mediated signal transduction (e.g., increasing NFkB-mediated transcription), depleting cells that express human OX40 (e.g., T cells), enhancing T effector cell function (e.g., CD4+ effector T cell, CD8+ effector T cell), e.g., by increasing effector T cell proliferation and/or increasing cytokine production (e.g., gamma interferon) by effector T cells, enhancing memory T cell function (e.g., CD4+ memory T cell), e.g., by increasing memory T cell proliferation and/or increasing cytokine production by memory T cells (e.g., gamma interferon), inhibiting regulatory T cell function (e.g., by decreasing Treg suppression of effector T cell function (e.g., CD4+ effector T cell function, CD8+ effector T cell function). Antibodies having such biological activity in vivo and/or in vitro are also provided.

**[0352]** In certain embodiments, an antibody of the invention is tested for such biological activity.

**[0353]** T cell costimulation may be assayed using methods known in the art and exemplary methods are disclosed herein. For example, T cells (e.g., memory or effector T cells) may be obtained from peripheral white blood cells (e.g., isolated from human whole blood using Ficoll gradient centrifugation). Memory T cells (e.g., CD4+ memory T cells) or effector T cells (e.g. CD4+ Teff cells) may be isolated from PBMC using methods known in the art. For example, the Miltenyi CD4+ memory T cell isolation kit or Miltenyi naïve CD4+ T cell isolation kit may be used. Isolated T cells are cultured in the presence of antigen presenting cells (e.g., irradiated L cells that express CD32 and CD80), and activated by addition of anti-CD3 antibody in the presence or absence of OX40 agonist antibody. Effect of agonist OX40 antibody of T cell proliferation may be measured using methods well known in the art. For example, the CellTiter Glo kit (Promega) may be used, and results read on a Multilabel Reader (Perkin Elmer). Effect of agonist OX40 antibody on T cell function may also be determined by analysis of cytokines produced by the T cell. In one embodiment, production of interferon gamma by CD4+ T cells is determined, e.g., by measurement of interferon gamma in cell culture supernatant. Methods for measuring interferon gamma are well-known in the art.

**[0354]** Treg cell function may be assayed using methods known in the art and exemplary methods are disclosed herein. In one example, the ability of Treg to suppress effector T cell proliferation is

assayed. T cells are isolated from human whole blood using methods known in the art (e.g., isolating memory T cells or naïve T cells). Purified CD4+ naïve T cells are labeled (e.g., with CFSE) and purified Treg cells are labeled with a different reagent. Irradiated antigen presenting cells (e.g., L cells expressing CD32 and CD80) are co-cultured with the labeled purified naïve CD4+ T cells and purified Tregs. The co-cultures are activated using anti-CD3 antibody and tested in the presence or absence of agonist OX40 antibody. Following a suitable time (e.g., 6 days of coculture), level of CD4+ naïve T cell proliferation is tracked by dye dilution in reduced label staining (e.g., reduced CFSE label staining) using FACS analysis.

**[0355]** OX40 signaling may be assayed using methods well known in the art and exemplary methods are disclosed herein. In one embodiment, transgenic cells are generated that express human OX40 and a reporter gene comprising the NFkB promoter fused to a reporter gene (e.g., beta luciferase). Addition of OX40 agonist antibody to the cells results in increased NFkB transcription, which is detected using an assay for the reporter gene.

**[0356]** Phagocytosis may be assayed, e.g., by using monocyte-derived macrophages, or U937 cells (a human histiocytic lymphoma cells line with the morphology and characteristics of mature macrophages). OX40 expressing cells are added to the monocyte-derived macrophages or U937 cells in the presence or absence of anti-OX40 agonist antibody. Following culturing of the cells for a suitable period of time, the percentage of phagocytosis is determined by examining percentage of cells that double stain for markers of 1) the macrophage or U937 cell and 2) the OX40 expressing cell, and dividing this by the total number of cells that show markers of the OX40 expressing cell (e.g., GFP). Analysis may be done by flow cytometry. In another embodiment, analysis may be done by fluorescent microscopy analysis.

**[0357]** ADCC may be assayed, e.g., using methods well known in the art. Exemplary methods are described in the definition section and an exemplary assay is disclosed in the Examples. In some embodiments, level of OX40 is characterized on an OX40 expressing cell that is used for testing in an ADCC assay. The cell may be stained with a detectably labeled anti-OX40 antibody (e.g., PE labeled), then level of fluorescence determined using flow cytometry, and results presented as median fluorescence intensity (MFI). In another embodiment, ADCC may be analyzed by CellTiter Glo assay kit and cell viability/cytotoxicity may be determined by chemioluminescence.

**[0358]** The binding affinities of various antibodies to FcγRIA, FcγRIIA, FcγRIIB, and two allotypes of FcγRIIIA (F158 and V158) may be measured in ELISA-based ligand-binding assays using the respective recombinant Fcγ receptors. Purified human Fcγ receptors are expressed as fusion proteins containing the extracellular domain of the receptor γ chain linked to a Gly/6xHis/glutathione S-transferase (GST) polypeptide tag at the C-terminus. The binding affinities of antibodies to those human Fcγ receptors are assayed as follows. For the low-affinity receptors, i.e. FcγRIIA (CD32A), FcγRIIB (CD32B), and the two allotypes of FcγRIIIA (CD16), F-158 and V-158, antibodies may be

tested as multimers by cross-linking with a F(ab')2 fragment of goat anti-human kappa chain (ICN Biomedical; Irvine, CA) at an approximate molar ratio of 1:3 antibody:cross-linking $F(ab')_2$. Plates are coated with an anti-GST antibody (Genentech) and blocked with bovine serum albumin (BSA). After washing with phosphate-buffered saline (PBS) containing 0.05% Tween-20 with an ELx405™ plate washer (Biotek Instruments; Winooski, VT), Fcγ receptors are added to the plate at 25 ng/well and incubated at room temperature for 1 hour. After the plates are washed, serial dilutions of test antibodies are added as multimeric complexes and the plates were incubated at room temperature for 2 hours. Following plate washing to remove unbound antibodies, the antibodies bound to the Fcγ receptor are detected with horseradish peroxidase (HRP)–conjugated $F(ab')_2$ fragment of goat anti-human $F(ab')_2$ (Jackson ImmunoResearch Laboratories; West Grove, PA) followed by the addition of substrate, tetramethylbenzidine (TMB) (Kirkegaard & Perry Laboratories; Gaithersburg, MD). The plates are incubated at room temperature for 5–20 minutes, depending on the Fcγ receptors tested, to allow color development. The reaction is terminated with 1 M $H_3PO_4$ and absorbance at 450 nm was measured with a microplate reader (SpectraMax®190, Molecular Devices; Sunnyvale, CA). Dose-response binding curves are generated by plotting the mean absorbance values from the duplicates of antibody dilutions against the concentrations of the antibody. Values for the effective concentration of the antibody at which 50% of the maximum response from binding to the Fcγ receptor is detected ($EC_{50}$) were determined after fitting the binding curve with a four-parameter equation using SoftMax Pro (Molecular Devices).

**[0359]** Cells for use in any of the above in vitro assays include cells or cell lines that naturally express OX40 or that have been engineered to express OX40. Such cells include activated T cells, Treg cells and activated memory T cells that naturally express OX40. Such cells also include cell lines that express OX40 and cell lines that do not normally express OX40 but have been transfected with nucleic acid encoding OX40. Exemplary cell lines provided herein for use in any of the above in vitro assays include transgenic BT474 cells (a human breast cancer cell line) that express human OX40

**[0360]** It is understood that any of the above assays may be carried out using an immunoconjugate of the invention in place of or in addition to an anti-OX40 antibody.

**[0361]** It is understood that any of the above assays may be carried out using anti-OX40 antibody and an additional therapeutic agent (e.g., a PD-1 axis binding agent (e.g., an anti-PD-1 or anti-PD-L1 antibody).

D. Pharmaceutical Compositions and Formulations

**[0362]** Also provided herein are pharmaceutical compositions and formulations comprising a PD-1 axis binding antagonist and/or an antibody described herein (such as an anti-PD-L1 antibody, or an anti-human OX40 agonist antibody, and a pharmaceutically acceptable carrier.

**[0363]** Pharmaceutical compositions and formulations as described herein can be prepared by mixing the active ingredients (such as an antibody or a polypeptide) having the desired degree of purity with

one or more optional pharmaceutically acceptable carriers (*Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980)), in the form of lyophilized formulations or aqueous solutions. Pharmaceutically acceptable carriers are generally nontoxic to recipients at the dosages and concentrations employed, and include, but are not limited to: buffers such as phosphate, citrate, and other organic acids; antioxidants including ascorbic acid and methionine; preservatives (such as octadecyldimethylbenzyl ammonium chloride; hexamethonium chloride; benzalkonium chloride; benzethonium chloride; phenol, butyl or benzyl alcohol; alkyl parabens such as methyl or propyl paraben; catechol; resorcinol; cyclohexanol; 3-pentanol; and m-cresol); low molecular weight (less than about 10 residues) polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine, glutamine, asparagine, histidine, arginine, or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrins; chelating agents such as EDTA; sugars such as sucrose, mannitol, trehalose or sorbitol; salt-forming counter-ions such as sodium; metal complexes (*e.g.* Zn-protein complexes); and/or non-ionic surfactants such as polyethylene glycol (PEG). Exemplary pharmaceutically acceptable carriers herein further include insterstitial drug dispersion agents such as soluble neutral-active hyaluronidase glycoproteins (sHASEGP), for example, human soluble PH-20 hyaluronidase glycoproteins, such as rHuPH20 (HYLENEX®, Baxter International, Inc.). Certain exemplary sHASEGPs and methods of use, including rHuPH20, are described in US Patent Publication Nos. 2005/0260186 and 2006/0104968. In one aspect, a sHASEGP is combined with one or more additional glycosaminoglycanases such as chondroitinases.

**[0364]** Exemplary lyophilized antibody formulations are described in US Patent No. 6,267,958. Aqueous antibody formulations include those described in US Patent No. 6,171,586 and WO2006/044908, the latter formulations including a histidine-acetate buffer.

**[0365]** The composition and formulation herein may also contain more than one active ingredients as necessary for the particular indication being treated, preferably those with complementary activities that do not adversely affect each other. Such active ingredients are suitably present in combination in amounts that are effective for the purpose intended.

**[0366]** Active ingredients may be entrapped in microcapsules prepared, for example, by coacervation techniques or by interfacial polymerization, for example, hydroxymethylcellulose or gelatin-microcapsules and poly-(methylmethacylate) microcapsules, respectively, in colloidal drug delivery systems (for example, liposomes, albumin microspheres, microemulsions, nano-particles and nanocapsules) or in macroemulsions. Such techniques are disclosed in *Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980).

**[0367]** Sustained-release preparations may be prepared. Suitable examples of sustained-release preparations include semipermeable matrices of solid hydrophobic polymers containing the antibody, which matrices are in the form of shaped articles, *e.g.* films, or microcapsules. The formulations to

be used for *in vivo* administration are generally sterile. Sterility may be readily accomplished, *e.g.,* by filtration through sterile filtration membranes.

## IV. Methods of Treatment

**[0368]** Provided herein are methods for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody). In some embodiments, the treatment results in a sustained response in the individual after cessation of the treatment. The methods described herein may find use in treating conditions where enhanced immunogenicity is desired such as increasing tumor immunogenicity for the treatment of cancer. Also provided herein are methods of enhancing immune function in an individual having cancer comprising administering to the individual an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody) . In further aspects, provided herein are methods of treating infection (e.g., with a bacteria or virus or other pathogen) . In some embodiments, the infection is with virus and/or bacteria. In some embodiments, the infection is with a pathogen. In some embodiments, the infection is an acute infection. In some embodiments, the infection is a chronic infection.

**[0369]** Any of the PD-1 axis binding antagonists and the OX40 binding agonists known in the art or described herein may be used in the methods.

**[0370]** In some embodiments, the individual is a human.

**[0371]** In some embodiments, the individual has been treated with a OX40 binding agonist therapy before the combination treatment with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody).

**[0372]** In some embodiments, the individual has cancer that is resistant (has been demonstrated to be resistant) to one or more PD-1 axis antagonists. In some embodiments, resistance to PD-1 axis antagonist includes recurrence of cancer or refractory cancer. Recurrence may refer to the reappearance of cancer, in the original site or a new site, after treatment. In some embodiments, resistance to PD-1 axis antagonist includes progression of the cancer during treatment with the PD-1 axis antagonist. In some embodiments, resistance to PD-1 axis antagonist includes cancer that does not response to treatment. The cancer may be resistant at the beginning of treatment or it may become resistant during treatment. In some embodiments, the cancer is at early stage or at late stage.

**[0373]** In another aspect, the individual has cancer that expresses (has been shown to express e.g., in a diagnostic test) PD-L1 biomarker. In some embodiments, the patient's cancer expresses low PD-L1 biomarker. In some embodiments, the patient's cancer expresses high PD-L1 biomarker. In some embodiments of any of the methods, assays and/or kits, the PD-L1 biomarker is absent from the sample when it comprises 0% of the sample.

**[0374]** In some embodiments of any of the methods, assays and/or kits, the PD-L1 biomarker is present in the sample when it comprises more than 0% of the sample. In some embodiments, the PD-L1 biomarker is present in at least 1% of the sample. In some embodiments, the PD-L1 biomarker is present in at least 5% of the sample. In some embodiments, the PD-L1 biomarker is present in at least 10% of the sample.

**[0375]** In some embodiments of any of the methods, assays and/or kits, the PD-L1 biomarker is detected in the sample using a method selected from the group consisting of FACS, Western blot, ELISA, immunoprecipitation, immunohistochemistry, immunofluorescence, radioimmunoassay, dot blotting, immunodetection methods, HPLC, surface plasmon resonance, optical spectroscopy, mass spectrometery, HPLC, qPCR, RT-qPCR, multiplex qPCR or RT-qPCR, RNA-seq, microarray analysis, SAGE, MassARRAY technique, and FISH, and combinations thereof.

**[0376]** In some embodiments of any of the methods, assays and/or kits, the PD-L1 biomarker is detected in the sample by protein expression. In some embodiments, protein expression is determined by immunohistochemistry (IHC). In some embodiments, the PD-L1 biomarker is detected using an anti-PD-L1 antibody. In some embodiments, the PD-L1 biomarker is detected as a weak staining intensity by IHC. In some embodiments, the PD-L1 biomarker is detected as a moderate staining intensity by IHC. In some embodiments, the PD-L1 biomarker is detected as a strong staining intensity by IHC. In some embodiments, the PD-L1 biomarker is detected on tumor cells, tumor infiltrating immune cells, stromal cells and any combinations thereof. In some embodiments, the staining is membrane staining, cytoplasmic staining or combinations thereof.

**[0377]** In some embodiments of any of the methods, assays and/or kits, the absence of the PD-L1 biomarker is detected as absent or no staining in the sample. In some embodiments of any of the methods, assays and/or kits, the presence of the PD-L1 biomarker is detected as any staining in the sample.

**[0378]** In some embodiments, the combination therapy of the invention comprises administration of a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody). The PD-1 axis binding antagonist and the OX40 binding agonist may be administered in any suitable manner known in the art. For example, The PD-1 axis binding antagonist and the OX40 binding agonist may be administered sequentially (at different times) or concurrently (at the same time). In some embodiments, the PD-1 axis binding antagonist is in a separate composition as the OX40 binding agonist. In some embodiments, the PD-1 axis binding antagonist is in the same composition as the OX40 binding agonist.

**[0379]** The PD-1 axis binding antagonist and the OX40 binding agonist (e.g., anti-human OX40 agonist antibody) may be administered by the same route of administration or by different routes of administration. In some embodiments, the PD-1 axis binding antagonist is administered intravenously, intramuscularly, subcutaneously, topically, orally, transdermally, intraperitoneally,

intraorbitally, by implantation, by inhalation, intrathecally, intraventricularly, or intranasally. In some embodiments, the OX40 binding agonist is administered intravenously, intramuscularly, subcutaneously, topically, orally, transdermally, intraperitoneally, intraorbitally, by implantation, by inhalation, intrathecally, intraventricularly, or intranasally. An effective amount of the PD-1 axis binding antagonist and the OX40 binding agonist may be administered for prevention or treatment of disease. The appropriate dosage of the PD-1 axis binding antagonist and/or the OX40 binding agonist (e.g., anti-human OX40 agonist antibody) may be determined based on the type of disease to be treated, the type of the PD-1 axis binding antagonist and the OX40 binding agonist, the severity and course of the disease, the clinical condition of the individual, the individual's clinical history and response to the treatment, and the discretion of the attending physician. In some embodiments, combination treatment with OX40 binding agonist (e.g., anti-human OX40 agonist antibody) and PD-1 axis binding antagonists (e.g., anti- PD-1 or anti-PDL1 antibody) are synergistic, whereby an efficacious dose of a OX40 binding agent (e.g., anti-human OX40 agonist antibody) in the combination is reduced relative to efficacious dose of the OX40 binding agent (e.g., anti-human OX40 agonist antibody) as a single agent.

**[0380]** As a general proposition, the therapeutically effective amount of the antibody administered to human will be in the range of about 0.01 to about 50 mg/kg of patient body weight whether by one or more administrations. In some embodiments, the antibody used is about 0.01 to about 45 mg/kg, about 0.01 to about 40 mg/kg, about 0.01 to about 35 mg/kg, about 0.01 to about 30 mg/kg, about 0.01 to about 25 mg/kg, about 0.01 to about 20 mg/kg, about 0.01 to about 15 mg/kg, about 0.01 to about 10 mg/kg, about 0.01 to about 5 mg/kg, or about 0.01 to about 1 mg/kg administered daily, for example. In some embodiments, the antibody is administered at 15 mg/kg. However, other dosage regimens may be useful. In one embodiment, an anti-PDL1 antibody described herein is administered to a human at a dose of about 100 mg, about 200 mg, about 300 mg, about 400 mg, about 500 mg, about 600 mg, about 700 mg, about 800 mg, about 900 mg, about 1000 mg, about 1100 mg, about 1200 mg, about 1300 mg or about 1400 mg on day 1 of 21-day cycles. The dose may be administered as a single dose or as multiple doses (e.g., 2 or 3 doses), such as infusions. The dose of the antibody administered in a combination treatment may be reduced as compared to a single treatment. The progress of this therapy is easily monitored by conventional techniques.

**[0381]** In some embodiments, the methods may further comprise an additional therapy. The additional therapy may be radiation therapy, surgery (*e.g.*, lumpectomy and a mastectomy), chemotherapy, gene therapy, DNA therapy, viral therapy, RNA therapy, immunotherapy, bone marrow transplantation, nanotherapy, monoclonal antibody therapy, or a combination of the foregoing. The additional therapy may be in the form of adjuvant or neoadjuvant therapy. In some embodiments, the additional therapy is the administration of small molecule enzymatic inhibitor or anti-metastatic agent. In some embodiments, the additional therapy is the administration of side-

effect limiting agents (*e.g.,* agents intended to lessen the occurrence and/or severity of side effects of treatment, such as anti-nausea agents, etc.). In some embodiments, the additional therapy is radiation therapy. In some embodiments, the additional therapy is surgery. In some embodiments, the additional therapy is a combination of radiation therapy and surgery. In some embodiments, the additional therapy is gamma irradiation. In some embodiments, the additional therapy is therapy targeting PI3K/AKT/mTOR pathway, HSP90 inhibitor, tubulin inhibitor, apoptosis inhibitor, and/or chemopreventative agent. In some embodiments, the additional therapy is CTLA-4 (also known as CD152), *e.g.,* a blocking antibody, ipilimumab (also known as MDX-010, MDX-101, or Yervoy®), tremelimumab (also known as ticilimumab or CP-675,206), an antagonist directed against B7-H3 (also known as CD276), *e.g.,* a blocking antibody, MGA271, an antagonist directed against a TGF beta, *e.g.,* metelimumab (also known as CAT-192), fresolimumab (also known as GC1008), or LY2157299, a treatment comprising adoptive transfer of a T cell (*e.g.,* a cytotoxic T cell or CTL) expressing a chimeric antigen receptor (CAR), a treatment comprising adoptive transfer of a T cell comprising a dominant-negative TGF beta receptor, *e.g,* a dominant-negative TGF beta type II receptor, a treatment comprising a HERCREEM protocol (see, e.g., ClinicalTrials.gov Identifier NCT00889954), an agonist directed against CD137 (also known as TNFRSF9, 4-1BB, or ILA), *e.g.,* an activating antibody, urelumab (also known as BMS-663513), an agonist directed against CD40, *e.g.,* an activating antibody, CP-870893, an agonist directed against OX40 (also known as CD134), *e.g.,* an activating antibody, administered in conjunction with a different anti-OX40 antibody (e.g., AgonOX)., an agonist directed against CD27, *e.g.,* an activating antibody, CDX-1127, indoleamine-2,3-dioxygenase (IDO), 1-methyl-D-tryptophan (also known as 1-D-MT), an antibody-drug conjugate (in some embodiments, comprising mertansine or monomethyl auristatin E (MMAE)), an anti-NaPi2b antibody-MMAE conjugate (also known as DNIB0600A or RG7599), trastuzumab emtansine (also known as T-DM1, ado-trastuzumab emtansine, or KADCYLA®, Genentech), DMUC5754A, an antibody-drug conjugate targeting the endothelin B receptor (EDNBR), *e.g.,* an antibody directed against EDNBR conjugated with MMAE, an angiogenesis inhibitor , an antibody directed against a VEGF, *e.g.,* VEGF-A, bevacizumab (also known as AVASTIN®, Genentech), an antibody directed against angiopoietin 2 (also known as Ang2), MEDI3617, an antineoplastic agent, an agent targeting CSF-1R (also known as M-CSFR or CD115), anti-CSF-1R (also known as IMC-CS4), an interferon, for example interferon alpha or interferon gamma, Roferon-A, GM-CSF (also known as recombinant human granulocyte macrophage colony stimulating factor, rhu GM-CSF, sargramostim, or Leukine®), IL-2 (also known as aldesleukin or Proleukin®), IL-12, an antibody targeting CD20 (in some embodiments, the antibody targeting CD20 is obinutuzumab (also known as GA101 or Gazyva®) or rituximab), an antibody targeting GITR (in some embodiments, the antibody targeting GITR is TRX518), in conjunction with a cancer vaccine (in some embodiments, the cancer vaccine is a peptide cancer vaccine, which in some embodiments is a personalized peptide vaccine; in

some embodiments the peptide cancer vaccine is a multivalent long peptide, a multi-peptide, a peptide cocktail, a hybrid peptide, or a peptide-pulsed dendritic cell vaccine (see, e.g., Yamada et al., Cancer Sci, 104:14-21, 2013)), in conjunction with an adjuvant, a TLR agonist, *e.g.,* Poly-ICLC (also known as Hiltonol®), LPS, MPL, or CpG ODN, tumor necrosis factor (TNF) alpha, IL-1, HMGB1, an IL-10 antagonist, an IL-4 antagonist, an IL-13 antagonist, an HVEM antagonist, an ICOS agonist, *e.g.,* by administration of ICOS-L, or an agonistic antibody directed against ICOS, a treatment targeting CX3CL1, a treatment targeting CXCL10, a treatment targeting CCL5, an LFA-1 or ICAM1 agonist, a Selectin agonist, a targeted therapy, an inhibitor of B-Raf, vemurafenib (also known as Zelboraf®, dabrafenib (also known as Tafinlar®), erlotinib (also known as Tarceva®), an inhibitor of a MEK, such as MEK1 (also known as MAP2K1) or MEK2 (also known as MAP2K2). cobimetinib (also known as GDC-0973 or XL-518), trametinib (also known as Mekinist®), an inhibitor of K-Ras, an inhibitor of c-Met, onartuzumab (also known as MetMAb), an inhibitor of Alk, AF802 (also known as CH5424802 or alectinib), an inhibitor of a phosphatidylinositol 3-kinase (PI3K), BKM120, idelalisib (also known as GS-1101 or CAL-101), perifosine (also known as KRX-0401), an Akt, MK2206, GSK690693, GDC-0941, an inhibitor of mTOR, sirolimus (also known as rapamycin), temsirolimus (also known as CCI-779 or Torisel®), everolimus (also known as RAD001), ridaforolimus (also known as AP-23573, MK-8669, or deforolimus), OSI-027, AZD8055, INK128, a dual PI3K/mTOR inhibitor, XL765, GDC-0980, BEZ235 (also known as NVP-BEZ235), BGT226, GSK2126458, PF-04691502, PF-05212384 (also known as PKI-587). The additional therapy may be one or more of the chemotherapeutic agents described herein.

**[0382]** The efficacy of any of the methods described herein (e.g., combination treatments including administering an effective amount of a combination of a PD-1 axis binding antagonist and an OX40 binding agonist) may be tested in various models known in the art, such as clinical or pre-clinical models. Suitable pre-clinical models are exemplified herein and further may include without limitation ID8 ovarian cancer, GEM models, B16 melanoma, RENCA renal cell cancer, CT26 colorectal cancer, MC38 colorectal cancer, and Cloudman melanoma models of cancer.

**[0383]** The efficacy of any of the methods described herein (e.g., combination treatments including administering an effective amount of a combination of a PD-1 axis binding antagonist and an OX40 binding agonist) may be tested in a GEM model that develops tumors, including without limitation GEM models of non-small-cell lung cancer, pancreatic ductal adenocarcinoma, or melanoma. For example, a mouse expressing $Kras^{G12D}$ in a $p53^{null}$ background after adenoviral recombinase treatment as described in Jackson, E.L., *et al.* (2001) *Genes Dev.* 15(24):3243-8 (description of $Kras^{G12D}$) and Lee, C.L., *et al.* (2012) *Dis. Model Mech.* 5(3):397-402 (FRT-mediated $p53^{null}$ allele) may be used as a pre-clinical model for non-small-cell lung cancer. As another example, a mouse expressing $Kras^{G12D}$ in a $p16/p19^{null}$ background as described in Jackson, E.L., *et al.* (2001) *Genes Dev.* 15(24):3243-8 (description of $Kras^{G12D}$) and Aguirre, A.J., *et al.* (2003) *Genes Dev.* 17(24):3112-26

($p16/p19^{null}$ allele) may be used as a pre-clinical model for pancreatic ductal adenocarcinoma (PDAC). As a further example, a mouse with melanocytes expressing $Braf^{V600E}$ in a melanocyte-specific $PTEN^{null}$ background after inducible (e.g., 4-OHT treatment) recombinase treatment as described in Dankort, D., *et al.* (2007) *Genes Dev.* 21(4):379-84 (description of $Braf^{V600E}$) and Trotman, L.C., *et al.* (2003) *PLoS Biol.* 1(3):E59 ($PTEN^{null}$ allele) may be used as a pre-clinical model for melanoma. For any of these exemplary models, after developing tumors, mice are randomly recruited into treatment groups receiving combination anti-PDL1 and OX40 binding agonist (e.g., anti-human OX40 agonist antibody) treatment or control treatment. Tumor size (e.g., tumor volume) is measured during the course of treatment, and overall survival rate is also monitored.

**[0384]** In another aspect, provided herein are methods for enhancing immune function in an individual having cancer comprising administering an effective amount of a combination of a PD-1 axis binding antagonist and an OX40 binding agonist.

**[0385]** In some embodiments of the methods of the present disclosure, the cancer (in some embodiments, a sample of the patient's cancer as examined using a diagnostic test) has elevated levels of T cell infiltration. As used herein, T cell infiltration of a cancer may refer to the presence of T cells, such as tumor-infiltrating lymphocytes (TILs), within or otherwise associated with the cancer tissue. It is known in the art that T cell infiltration may be associated with improved clinical outcome in certain cancers (see, *e.g.,* Zhang *et al.*, N. Engl. J. Med. 348(3):203-213 (2003)).

**[0386]** However, T cell exhaustion is also a major immunological feature of cancer, with many tumor-infiltrating lymphocytes (TILs) expressing high levels of inhibitory co-receptors and lacking the capacity to produce effector cytokines (Wherry, E.J. Nature immunology 12: 492-499 (2011); Rabinovich, G.A., *et al.,* Annual review of immunology 25:267-296 (2007)). In some embodiments of the methods of the present disclosure, the individual has a T cell dysfunctional disorder. In some embodiments of the methods of the present disclosure, the T cell dysfunctional disorder is characterized by T cell anergy or decreased ability to secrete cytokines, proliferate or execute cytolytic activity. In some embodiments of the methods of the present disclosure, the T cell dysfunctional disorder is characterized by T cell exhaustion. In some embodiments of the methods of the present disclosure, the T cells are CD4+ and CD8+ T cells. Without being bound by theory, OX40 binding agonist treatment may increase T cell (e.g., CD4+ T cell, CD8+ T cell, memory T cell) priming, activation and/or proliferation relative to prior to the administration of the combination. In some embodiments, the T cells are CD4+ and/or CD8+ T cells.

**[0387]** In some embodiments of the methods of the present disclosure, the cancer (in some embodiments, a sample of the patient's cancer is examined using a diagnostic test) has low levels of T cell infiltration. In some embodiments, the cancer (in some embodiments, a sample of the patient's cancer is examined using a diagnostic test) has no detectable T cell infiltrate. In some embodiments, the cancer is a non-immunogenic cancer (e.g., non-immunogenic colorectal cancer and/or ovarian

cancer). Without being bound by theory, OX40 binding agonist treatment may increase T cell (e.g., CD4+ T cell, CD8+ T cell, memory T cell) priming, activation and/or proliferation relative to prior to the administration of the combination.

**[0388]** In some embodiments of the methods of the present disclosure, activated CD4 and/or CD8 T cells in the individual are characterized by $\gamma$-IFN$^+$ producing CD4 and/or CD8 T cells and/or enhanced cytolytic activity relative to prior to the administration of the combination. $\gamma$-IFN$^+$ may be measured by any means known in the art, including, *e.g.,* intracellular cytokine staining (ICS) involving cell fixation, permeabilization, and staining with an antibody against $\gamma$-IFN. Cytolytic activity may be measured by any means known in the art, *e.g.,* using a cell killing assay with mixed effector and target cells.

**[0389]** In some embodiments, CD8+ T cells are characterized, e.g., by presence of CD8b expression (e.g., by rtPCR using e.g., Fluidigm) (Cd8b is also known as T-cell surface glycoprotein CD8 beta chain; CD8 antigen, alpha polypeptide p37; Accession No. is NM_172213). In some embodiments, CD8+ T cells are from peripheral blood. In some embodiments, CD8+ T cells are from tumor.

**[0390]** In some embodiments, Treg cells are characterized, e.g., by presence of Fox3p expression (e.g., by rtPCR e.g., using Fluidigm) (Foxp3 is also known as forkhead box protein P3; scurfin; FOXP3delta7; immunodeficiency, polyendocrinopathy, enteropathy, X-linked; the accession no. is NM_014009). In some embodiments, Treg are from peripheral blood. In some embodiments, Treg cells are from tumor.

**[0391]** In some embodiments, inflammatory T cells are characterized, e.g., by presence of Tbet and/or CXCR3 expression (e.g., by rtPCR using, e.g., Fluidigm). In some embodiments, inflammatory T cells are from peripheral blood. In some embodiments, inflammatory T cells are from tumor.

**[0392]** In some embodiments of the methods of the present disclosure, CD4 and/or CD8 T cells exhibit increased release of cytokines selected from the group consisting of IFN- $\gamma$, TNF-$\alpha$ and interleukins. Cytokine release may be measured by any means known in the art, *e.g.,* using Western blot, ELISA, or immunohistochemical assays to detect the presence of released cytokines in a sample containing CD4 and/or CD8 T cells.

**[0393]** In some embodiments of the methods of the present disclosure, the CD4 and/or CD8 T cells are effector memory T cells. In some embodiments of the methods of the present disclosure, the CD4 and/or CD8 effector memory T cells are characterized by having the expression of CD44$^{high}$ CD62L$^{low}$. Expression of CD44$^{high}$ CD62L$^{low}$ may be detected by any means known in the art, *e.g.,* by preparing single cell suspensions of tissue (*e.g.,* a cancer tissue) and performing surface staining and flow cytometry using commercial antibodies against CD44 and CD62L. In some embodiments of the methods of the present disclosure, the CD4 and/or CD8 effector memory T cells are characterized by having expression of CXCR3 (also known as C-X-C chemokine receptor type 3; Mig receptor; IP10

receptor; G protein-coupled receptor 9; interferon-inducible protein 10 receptor; Accession No. NM_001504). In some embodiments, the CD4 and/or CD8 effector memory T cells are from peripheral blood. In some embodiments, the CD4 and/or CD8 effector memory T cells are from tumor.

**[0394]** In some embodiments of the methods of the present disclosure, the administration of an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist to an individual is characterized by increased inflammatory markers (e.g., CXCR3) on CD8 T cells relative to prior to the administration of the human PD-1 axis binding antagonist and the OX40 binding agonist. CXCR3/CD8 T cells may be measured by any means known the art and methods described in the Examples. In some embodiments, CXCR3/CD8 T cells are from peripheral blood. In some embodiments, CXCR3/CD8 T cells are from tumor.

**[0395]** In some embodiments of the methods of the invention, Treg function is suppressed relative to prior to the administration of the combination. In some embodiments, T cell exhaustion is decreased relative to prior to the administration of the combination.

**[0396]** In some embodiments, number of Treg is decreased relative to prior to the administration of the combination. In some embodiments, plasma interferon gamma is increased relative to prior to the administration of the combination. Treg number may be assessed, e.g., by determining percentage of CD4+Fox3p+ CD45+ cells (e.g., by FACS analysis). In some embodiments, absolute number of Treg, e.g., in a sample, is determined. In some embodiments, Treg are from peripheral blood. In some embodiments, Treg are from tumor.

**[0397]** In some embodiments, T cell priming, activation and/or proliferation is increased relative to prior to the administration of the combination. In some embodiments, the T cells are CD4+ and/or CD8+ T cells. In some embodiments, T cell proliferation is detected by determining percentage of Ki67+ CD8+ T cells (e.g., by FACS analysis). In some embodiments, T cell proliferation is detected by determining percentage of Ki67+ CD4+ T cells (e.g., by FACS analysis). In some embodiments, the T cells are from peripheral blood. In some embodiments, the T cells are from tumor.

**[0398]** Any of the PD-1 axis binding antagonists and the OX40 binding agonists known in the art or described herein may be used in the methods of the present disclosure.

## VI. Methods of detection and diagnosis

**[0399]** In some embodiments, the sample is obtained prior to treatment with a PD-1 axis binding antagonist (in some embodiments, prior to treatment with OX40 binding agonist, e.g., anti-human OX40 agonist antibody, e.g., treatment in combination with PD-1 axis binding antagonist). In some embodiments, the tissue sample is formalin fixed and paraffin embedded, archival, fresh or frozen

**[0400]** In some embodiments, the sample is whole blood. In some embodiments, the whole blood comprises immune cells, circulating tumor cells and any combinations thereof.

**[0401]** Presence and/or expression levels/amount of a biomarker (*e.g.,* PD-L1) can be determined qualitatively and/or quantitatively based on any suitable criterion known in the art, including but not limited to DNA, mRNA, cDNA, proteins, protein fragments and/or gene copy number. In certain embodiments, presence and/or expression levels/amount of a biomarker in a first sample is increased or elevated as compared to presence/absence and/or expression levels/amount in a second sample. In certain embodiments, presence/absence and/or expression levels/amount of a biomarker in a first sample is decreased or reduced as compared to presence and/or expression levels/amount in a second sample. In certain embodiments, the second sample is a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue. Additional disclosures for determining presence/absence and/or expression levels/amount of a gene are described herein.

**[0402]** In some embodiments of any of the methods, elevated expression refers to an overall increase of about any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98%, 99% or greater, in the level of biomarker (*e.g.,* protein or nucleic acid (*e.g.,* gene or mRNA)), detected by standard art known methods such as those described herein, as compared to a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue. In certain embodiments, the elevated expression refers to the increase in expression level/amount of a biomarker in the sample wherein the increase is at least about any of 1.5X, 1.75X, 2X, 3X, 4X, 5X, 6X, 7X, 8X, 9X, 10X, 25X, 50X, 75X, or 100X the expression level/amount of the respective biomarker in a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue. In some embodiments, elevated expression refers to an overall increase of greater than about 1.5 fold, about 1.75 fold, about 2 fold, about 2.25 fold, about 2.5 fold, about 2.75 fold, about 3.0 fold, or about 3.25 fold as compared to a reference sample, reference cell, reference tissue, control sample, control cell, control tissue, or internal control (*e.g.,* housekeeping gene).

**[0403]** In some embodiments of any of the methods, reduced expression refers to an overall reduction of about any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98%, 99% or greater, in the level of biomarker (*e.g.,* protein or nucleic acid (*e.g.,* gene or mRNA)), detected by standard art known methods such as those described herein, as compared to a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue. In certain embodiments, reduced expression refers to the decrease in expression level/amount of a biomarker in the sample wherein the decrease is at least about any of 0.9X, 0.8X, 0.7X, 0.6X, 0.5X, 0.4X, 0.3X, 0.2X, 0.1X, 0.05X, or 0.01X the expression level/amount of the respective biomarker in a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue.

**[0404]** Presence and/or expression level/amount of various biomarkers in a sample can be analyzed by a number of methodologies, many of which are known in the art and understood by the skilled artisan, including, but not limited to, immunohistochemistry ("IHC"), Western blot analysis, immunoprecipitation, molecular binding assays, ELISA, ELIFA, fluorescence activated cell sorting

("FACS"), MassARRAY, proteomics, quantitative blood based assays (as for example Serum ELISA), biochemical enzymatic activity assays, in situ hybridization, Southern analysis, Northern analysis, whole genome sequencing, polymerase chain reaction ("PCR") including quantitative real time PCR ("qRT-PCR") and other amplification type detection methods, such as, for example, branched DNA, SISBA, TMA and the like), RNA-Seq, FISH, microarray analysis, gene expression profiling, and/or serial analysis of gene expression ("SAGE"), as well as any one of the wide variety of assays that can be performed by protein, gene, and/or tissue array analysis. Typical protocols for evaluating the status of genes and gene products are found, for example in Ausubel *et al.,* eds., 1995, Current Protocols In Molecular Biology, Units 2 (Northern Blotting), 4 (Southern Blotting), 15 (Immunoblotting) and 18 (PCR Analysis). Multiplexed immunoassays such as those available from Rules Based Medicine or Meso Scale Discovery ("MSD") may also be used.

**[0405]** In some embodiments, presence and/or expression level/amount of a biomarker is determined using a method comprising: (a) performing gene expression profiling, PCR (such as rtPCR or qRT-PCR), RNA-seq, microarray analysis, SAGE, MassARRAY technique, or FISH on a sample (such as a subject cancer sample); and b) determining presence and/or expression level/amount of a biomarker in the sample. In some embodiments, the microarray method comprises the use of a microarray chip having one or more nucleic acid molecules that can hybridize under stringent conditions to a nucleic acid molecule encoding a gene mentioned above or having one or more polypeptides (such as peptides or antibodies) that can bind to one or more of the proteins encoded by the genes mentioned above. In one embodiment, the PCR method is qRT-PCR. In one embodiment, the PCR method is multiplex-PCR. In some embodiments, gene expression is measured by microarray. In some embodiments, gene expression is measured by qRT-PCR. In some embodiments, expression is measured by multiplex-PCR.

**[0406]** Methods for the evaluation of mRNAs in cells are well known and include, for example, hybridization assays using complementary DNA probes (such as in situ hybridization using labeled riboprobes specific for the one or more genes, Northern blot and related techniques) and various nucleic acid amplification assays (such as RT-PCR using complementary primers specific for one or more of the genes, and other amplification type detection methods, such as, for example, branched DNA, SISBA, TMA and the like).

**[0407]** Samples from mammals can be conveniently assayed for mRNAs using Northern, dot blot or PCR analysis. In addition, such methods can include one or more steps that allow one to determine the levels of target mRNA in a biological sample (*e.g.,* by simultaneously examining the levels a comparative control mRNA sequence of a "housekeeping" gene such as an actin family member). Optionally, the sequence of the amplified target cDNA can be determined.

**[0408]** Optional methods include protocols which examine or detect mRNAs, such as target mRNAs, in a tissue or cell sample by microarray technologies. Using nucleic acid microarrays, test and control

mRNA samples from test and control tissue samples are reverse transcribed and labeled to generate cDNA probes. The probes are then hybridized to an array of nucleic acids immobilized on a solid support. The array is configured such that the sequence and position of each member of the array is known. For example, a selection of genes whose expression correlates with increased or reduced clinical benefit of anti-angiogenic therapy may be arrayed on a solid support. Hybridization of a labeled probe with a particular array member indicates that the sample from which the probe was derived expresses that gene.

**[0409]** According to some embodiments, presence and/or expression level/amount is measured by observing protein expression levels of an aforementioned gene. In certain embodiments, the method comprises contacting the biological sample with antibodies to a biomarker (*e.g.,* anti-PD-L1 antibodies) described herein under conditions permissive for binding of the biomarker, and detecting whether a complex is formed between the antibodies and biomarker. Such method may be an in vitro or in vivo method. In one embodiment, an antibody is used to select subjects eligible for therapy with PD-L1 axis binding antagonist *e.g.,* a biomarker for selection of individuals.

**[0410]** In certain embodiments, the presence and/or expression level/amount of biomarker proteins in a sample is examined using IHC and staining protocols. IHC staining of tissue sections has been shown to be a reliable method of determining or detecting presence of proteins in a sample. In some embodiments of any of the methods, assays and/or kits, the PD-L1 biomarker is PD-L1. In some embodiments, PD-L1 is detected by immunohistochemistry. In some embodiments, elevated expression of a PD-L1 biomarker in a sample from an individual is elevated protein expression and, in further embodiments, is determined using IHC. In one embodiment, expression level of biomarker is determined using a method comprising: (a) performing IHC analysis of a sample (such as a subject cancer sample) with an antibody; and b) determining expression level of a biomarker in the sample. In some embodiments, IHC staining intensity is determined relative to a reference. In some embodiments, the reference is a reference value. In some embodiments, the reference is a reference sample (*e.g.*, control cell line staining sample or tissue sample from non-cancerous patient).

**[0411]** IHC may be performed in combination with additional techniques such as morphological staining and/or fluorescence in-situ hybridization. Two general methods of IHC are available; direct and indirect assays. According to the first assay, binding of antibody to the target antigen is determined directly. This direct assay uses a labeled reagent, such as a fluorescent tag or an enzyme-labeled primary antibody, which can be visualized without further antibody interaction. In a typical indirect assay, unconjugated primary antibody binds to the antigen and then a labeled secondary antibody binds to the primary antibody. Where the secondary antibody is conjugated to an enzymatic label, a chromogenic or fluorogenic substrate is added to provide visualization of the antigen. Signal amplification occurs because several secondary antibodies may react with different epitopes on the primary antibody.

**[0412]** The primary and/or secondary antibody used for IHC typically will be labeled with a detectable moiety. Numerous labels are available which can be generally grouped into the following categories: (a) Radioisotopes, such as $^{35}S$, $^{14}C$, $^{125}I$, $^{3}H$, and $^{131}I$; (b) colloidal gold particles; (c) fluorescent labels including, but are not limited to, rare earth chelates (europium chelates), Texas Red, rhodamine, fluorescein, dansyl, Lissamine, umbelliferone, phycocrytherin, phycocyanin, or commercially available fluorophores such SPECTRUM ORANGE7 and SPECTRUM GREEN7 and/or derivatives of any one or more of the above; (d) various enzyme-substrate labels are available and U.S. Patent No. 4,275,149 provides a review of some of these. Examples of enzymatic labels include luciferases (*e.g.,* firefly luciferase and bacterial luciferase; U.S. Patent No. 4,737,456), luciferin, 2,3-dihydrophthalazinediones, malate dehydrogenase, urease, peroxidase such as horseradish peroxidase (HRPO), alkaline phosphatase, β-galactosidase, glucoamylase, lysozyme, saccharide oxidases (*e.g.,* glucose oxidase, galactose oxidase, and glucose-6-phosphate dehydrogenase), heterocyclic oxidases (such as uricase and xanthine oxidase), lactoperoxidase, microperoxidase, and the like.

**[0413]** Examples of enzyme-substrate combinations include, for example, horseradish peroxidase (HRPO) with hydrogen peroxidase as a substrate; alkaline phosphatase (AP) with para-Nitrophenyl phosphate as chromogenic substrate; and β-D-galactosidase (β-D-Gal) with a chromogenic substrate (*e.g.,* p-nitrophenyl-β-D-galactosidase) or fluorogenic substrate (*e.g.,* 4-methylumbelliferyl-β-D-galactosidase). For a general review of these, *see* U.S. Patent Nos. 4,275,149 and 4,318,980.

**[0414]** In some embodiments of any of the methods, PD-L1 is detected by immunohistochemistry using an anti- PD-L1 diagnostic antibody (*i.e.*, primary antibody). In some embodiments, the PD-L1 diagnostic antibody specifically binds human PD-L1. In some embodiments, the PD-L1 diagnostic antibody is a nonhuman antibody. In some embodiments, the PD-L1 diagnostic antibody is a rat, mouse, or rabbit antibody. In some embodiments, the PD-L1 diagnostic antibody is a monoclonal antibody. In some embodiments, the PD-L1 diagnostic antibody is directly labeled.

**[0415]** Specimens thus prepared may be mounted and coverslipped. Slide evaluation is then determined, *e.g.,* using a microscope, and staining intensity criteria, routinely used in the art, may be employed. In one embodiment, it is understood that when cells and/or tissue from a tumor is examined using IHC, staining is generally determined or assessed in tumor cell and/or tissue (as opposed to stromal or surrounding tissue that may be present in the sample). In some embodiments, it is understood that when cells and/or tissue from a tumor is examined using IHC, staining includes determining or assessing in tumor infiltrating immune cells, including intratumoral or peritumoral immune cells. In some embodiments, the presence of a PD-L1 biomarker is detected by IHC in >0% of the sample, in at least 1% of the sample, in at least 5% of the sample, or in at least 10% of the sample, as described in Table 4 below. In some embodiments, the presence of a PD-L1 biomarker is detected by IHC in <5% of cells. In some embodiments, the presence of a PD-L1 biomarker is

detected by IHC in <1% of cells. In some embodiments, the presence of a PD-L1 biomarker is detected by IHC in 0% of cells.

**[0416]** In some embodiments of any of the methods, assays, and/or kits, the presence of a PD-L1 biomarker is detected by IHC with PD-L1 staining of any intensity. In some embodiments, the PD-L1 biomarker is detected by IHC as a weak staining intensity. In some embodiments, the PD-L1 biomarker is detected by IHC as a moderate staining intensity. In some embodiments, the PD-L1 biomarker is detected by IHC as a strong staining intensity.

**[0417]** In some embodiments, the PD-L1 biomarker is detected by IHC in tumor cells, tumor infiltrating immune cells and combinations thereof.

**[0418]** Anti-PD-L1 antibodies suitable for use in IHC are well known in the art. One of ordinary skill understands that additional suitable anti-PD-L1 antibodies may be identified and characterized by comparing with anti-PD-L1 antibodies using the IHC protocol disclosed herein, for example.

**[0419]** Positive tissue controls are exemplified using placenta and tonsil tissues (strong PD-L1 staining intensity); HEK-293 cells transfected with recombinant human PD-L1 (varying degrees of PD-L1 staining intensity from weak, moderate and strong intensity). The following may be referred to for exemplary PD-L1 IHC criteria.

**Table 4.**

| PD-L1 Status | Staining criteria |
|---|---|
| Negative | 0% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| Positive | >0% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥1% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥5% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥10% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |

**[0420]** In some embodiments, PDL1 status is diagnosed according to the guidelines provided in Table 4 above.

**[0421]** In some embodiments, the criteria for PD-L1 IHC diagnostic assessment is provided as follows:

**Table 5**

| PD-L1 Diagnostic Assessment | IHC Scores |
|---|---|
| Absence of any discernible PD-L1 staining<br>OR<br>Presence of discernible PD-L1 staining of any intensity in tumor-infiltrating immune cells covering < 1% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 0 |
| Presence of discernible PD-L1 staining of any intensity in tumor-infiltrating immune cells covering between ≥ 1 % to < 5% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 1 |
| Presence of discernible PD-L1 staining of any intensity in tumor infiltrating immune cells covering between ≥ 5 % to < 10% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 2 |
| Presence of discernible PD-L1 staining of any intensity in tumor infiltrating immune cells covering ≥ 10% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 3 |

**[0422]** In some embodiments, PDL1 status is diagnosed according to the guidelines provided in Table 5 above. In some embodiments, a sample with a score of IHC 0 and/or IHC 1 may be considered PDL1 biomarker negative. In some embodiments, a sample with a score of IHC 2 and/or IHC 3 may be considered PDL1 biomarker positive. In some embodiments, a sample is diagnosed as IHC 0, IHC 0 and/or 1, IHC 1, IHC 1 and/or 2, IHC 2, IHC 2 and/or 3, or IHC 3.

**[0423]** In some embodiments, PDL1 expression is evaluated on a tumor or tumor sample. As used herein, a tumor or tumor sample may encompass part or all of the tumor area occupied by tumor cells. In some embodiments, a tumor or tumor sample may further encompass tumor area occupied by tumor associated intratumoral cells and/or tumor associated stroma (*e.g.,* contiguous peri-tumoral desmoplastic stroma). Tumor associated intratumoral cells and/or tumor associated stroma may include areas of immune infiltrates (*e.g.,* tumor infiltrating immune cells as described herein) immediately adjacent to and/or contiguous with the main tumor mass. In some embodiments, PDL1 expression is evaluated on tumor cells. In some embodiments, PDL1 expression is evaluated on immune cells within the tumor area as described above, such as tumor infiltrating immune cells.

**[0424]** In alternative methods, the sample may be contacted with an antibody specific for said biomarker under conditions sufficient for an antibody-biomarker complex to form, and then detecting said complex. The presence of the biomarker may be detected in a number of ways, such as by Western blotting and ELISA procedures for assaying a wide variety of tissues and samples, including

plasma or serum. A wide range of immunoassay techniques using such an assay format are available, *see, e.g.,* U.S. Pat. Nos. 4,016,043, 4,424,279 and 4,018,653. These include both single-site and two-site or "sandwich" assays of the non-competitive types, as well as in the traditional competitive binding assays. These assays also include direct binding of a labeled antibody to a target biomarker.

**[0425]** Presence and/or expression level/amount of a selected biomarker in a tissue or cell sample may also be examined by way of functional or activity-based assays. For instance, if the biomarker is an enzyme, one may conduct assays known in the art to determine or detect the presence of the given enzymatic activity in the tissue or cell sample.

**[0426]** In certain embodiments, the samples are normalized for both differences in the amount of the biomarker assayed and variability in the quality of the samples used, and variability between assay runs. Such normalization may be accomplished by detecting and incorporating the expression of certain normalizing biomarkers, including well known housekeeping genes. Alternatively, normalization can be based on the mean or median signal of all of the assayed genes or a large subset thereof (global normalization approach). On a gene-by-gene basis, measured normalized amount of a subject tumor mRNA or protein is compared to the amount found in a reference set. Normalized expression levels for each mRNA or protein per tested tumor per subject can be expressed as a percentage of the expression level measured in the reference set. The presence and/or expression level/amount measured in a particular subject sample to be analyzed will fall at some percentile within this range, which can be determined by methods well known in the art.

**[0427]** In one embodiment, the sample is a clinical sample. In another embodiment, the sample is used in a diagnostic assay. In some embodiments, the sample is obtained from a primary or metastatic tumor. Tissue biopsy is often used to obtain a representative piece of tumor tissue. Alternatively, tumor cells can be obtained indirectly in the form of tissues or fluids that are known or thought to contain the tumor cells of interest. For instance, samples of lung cancer lesions may be obtained by resection, bronchoscopy, fine needle aspiration, bronchial brushings, or from sputum, pleural fluid or blood. Genes or gene products can be detected from cancer or tumor tissue or from other body samples such as urine, sputum, serum or plasma. The same techniques discussed above for detection of target genes or gene products in cancerous samples can be applied to other body samples. Cancer cells may be sloughed off from cancer lesions and appear in such body samples. By screening such body samples, a simple early diagnosis can be achieved for these cancers. In addition, the progress of therapy can be monitored more easily by testing such body samples for target genes or gene products.

**[0428]** In certain embodiments, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is a single sample or combined multiple samples from the same subject or individual that are obtained at one or more different time points than when the test sample is obtained. For example, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is obtained at an earlier time point from the same subject or individual than

when the test sample is obtained. Such reference sample, reference cell, reference tissue, control sample, control cell, or control tissue may be useful if the reference sample is obtained during initial diagnosis of cancer and the test sample is later obtained when the cancer becomes metastatic.

**[0429]** In certain embodiments, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is a combined multiple samples from one or more healthy individuals who are not the subject or individual. In certain embodiments, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is a combined multiple samples from one or more individuals with a disease or disorder (*e.g.,* cancer) who are not the subject or individual. In certain embodiments, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is pooled RNA samples from normal tissues or pooled plasma or serum samples from one or more individuals who are not the subject or individual. In certain embodiments, a reference sample, reference cell, reference tissue, control sample, control cell, or control tissue is pooled RNA samples from tumor tissues or pooled plasma or serum samples from one or more individuals with a disease or disorder (*e.g.,* cancer) who are not the subject or individual.

**[0430]** In some embodiments, the sample is a tissue sample from the individual. In some embodiments, the tissue sample is a tumor tissue sample (*e.g.*, biopsy tissue). In some embodiments, the tissue sample is lung tissue. In some embodiments, the tissue sample is renal tissue. In some embodiments, the tissue sample is skin tissue. In some embodiments, the tissue sample is pancreatic tissue. In some embodiments, the tissue sample is gastric tissue. In some embodiments, the tissue sample is bladder tissue. In some embodiments, the tissue sample is esophageal tissue. In some embodiments, the tissue sample is mesothelial tissue. In some embodiments, the tissue sample is breast tissue. In some embodiments, the tissue sample is thyroid tissue. In some embodiments, the tissue sample is colorectal tissue. In some embodiments, the tissue sample is head and neck tissue. In some embodiments, the tissue sample is osteosarcoma tissue. In some embodiments, the tissue sample is prostate tissue. In some embodiments, the tissue sample is ovarian tissue, HCC (liver), blood cells, lymph nodes, and/or bone/bone marrow tissue. In some embodiments, the tissue sample is colon tissue. In some embodiments, the tissue sample is endometrial tissue. In some embodiments, the tissue sample is brain tissue (*e.g.,* glioblastoma, neuroblastoma, and so forth).

**[0431]** In some embodiments, a tumor tissue sample (the term "tumor sample" is used interchangeably herein) may encompass part or all of the tumor area occupied by tumor cells. In some embodiments, a tumor or tumor sample may further encompass tumor area occupied by tumor associated intratumoral cells and/or tumor associated stroma (*e.g.,* contiguous peri-tumoral desmoplastic stroma). Tumor associated intratumoral cells and/or tumor associated stroma may include areas of immune infiltrates (*e.g.,* tumor infiltrating immune cells as described herein) immediately adjacent to and/or contiguous with the main tumor mass.

**[0432]** In some embodiments of any of the methods, the disease or disorder is a tumor. In some embodiments, the tumor is a malignant cancerous tumor (*i.e.,* cancer). In some embodiments, the tumor and/or cancer is a solid tumor or a non-solid or soft tissue tumor. Examples of soft tissue tumors include leukemia (*e.g.*, chronic myelogenous leukemia, acute myelogenous leukemia, adult acute lymphoblastic leukemia, acute myelogenous leukemia, mature B-cell acute lymphoblastic leukemia, chronic lymphocytic leukemia, polymphocytic leukemia, or hairy cell leukemia) or lymphoma (*e.g.*, non-Hodgkin's lymphoma, cutaneous T-cell lymphoma, or Hodgkin's disease). A solid tumor includes any cancer of body tissues other than blood, bone marrow, or the lymphatic system. Solid tumors can be further divided into those of epithelial cell origin and those of non-epithelial cell origin. Examples of epithelial cell solid tumors include tumors of the gastrointestinal tract, colon, colorectal (*e.g.*, basaloid colorectal carcinoma), breast, prostate, lung, kidney, liver, pancreas, ovary (*e.g.*, endometrioid ovarian carcinoma), head and neck, oral cavity, stomach, duodenum, small intestine, large intestine, anus, gall bladder, labium, nasopharynx, skin, uterus, male genital organ, urinary organs (*e.g.*, urothelium carcinoma, dysplastic urothelium carcinoma, transitional cell carcinoma), bladder, and skin. Solid tumors of non-epithelial origin include sarcomas, brain tumors, and bone tumors. In some embodiments, the cancer isnon-small cell lung cancer (NSCLC). In some embodiments, the cancer is second-line or third-line locally advanced or metastatic non-small cell lung cancer. In some embodiments, the cancer is adenocarcinoma. In some embodiments, the cancer is squamous cell carcinoma. In some embodiments, the cancer is non-small cell lung cancer (NSCLC), glioblastoma, neuroblastoma, melanoma, breast carcinoma (e.g. triple-negative breast cancer), gastric cancer, colorectal cancer (CRC), or hepatocellular carcinoma. In some embodiments, the cancer is a primary tumor. In some embodiments, the cancer is a metastatic tumor at a second site derived from any of the above types of cancer.

**[0433]** In some embodiments of any of the methods, the cancer displays human effector cells (e.g., is infiltrated by human effector cells). Methods for detecting human effector cells are well known in the art, including, e.g., by IHC. In some embodiments, the cancer display high levels of human effector cells. In some embodiments, human effector cells are one or more of NK cells, macrophages, monocytes. In some embodiments, the cancer is any cancer described herein. In some embodiments, the cancer is non-small cell lung cancer (NSCLC), glioblastoma, neuroblastoma, melanoma, breast carcinoma (e.g. triple-negative breast cancer), gastric cancer, colorectal cancer (CRC), or hepatocellular carcinoma.

**[0434]** In some embodiments of any of the methods, the cancer displays cells expressing FcR (e.g., is infiltrated by cells expressing FcR). Methods for detecting FcR are well known in the art, including, e.g., by IHC. In some embodiments, the cancer display high levels of cells expressing FcR. In some embodiments, FcR is FcγR. In some embodiments, FcR is activating FcγR. In some embodiments, the cancer is non-small cell lung cancer (NSCLC), glioblastoma, neuroblastoma, melanoma, breast

carcinoma (e.g. triple-negative breast cancer), gastric cancer, colorectal cancer (CRC), or hepatocellular carcinoma.

**[0435]** In some embodiments, the PD-L1 biomarker is detected in the sample using a method selected from the group consisting of FACS, Western blot, ELISA, immunoprecipitation, immunohistochemistry, immunofluorescence, radioimmunoassay, dot blotting, immunodetection methods, HPLC, surface plasmon resonance, optical spectroscopy, mass spectrometery, HPLC, qPCR, RT-qPCR, multiplex qPCR or RT-qPCR, RNA-seq, microarray analysis, SAGE, MassARRAY technique, and FISH, and combinations thereof. In some embodiments, the PD-L1 biomarker is detected using FACS analysis. In some embodiments, the PD-L1 biomarker is PD-L1. In some embodiments, the PD-L1 expression is detected in blood samples. In some embodiments, the PD-L1 expression is detected on circulating immune cells in blood samples. In some embodiments, the circulating immune cell is a CD3+/CD8+ T cell. In some embodiments, prior to analysis, the immune cells are isolated from the blood samples. Any suitable method to isolate/enrich such population of cells may be used including, but not limited to, cell sorting. In some embodiments, the PD-L1 expression is elevated in samples from individuals that respond to treatment with an inhibitor of the PD-L1/PD-1 axis pathway, such as an anti-PD-L1 antibody. In some embodiments, the PD-L1 expression is elevated on the circulating immune cells, such as the CD3+/CD8+ T cells, in blood samples.

**[0436]** Provided herein are methods for monitoring pharmacodynamic activity of an OX40 agonist treatment by measuring the expression level of one or more marker genes, protein(s) (e.g., a cytokine, e.g., gamma interferon) and/or cellular composition (e.g., percentage of Treg and/or absolute number of Treg; e.g., number of CD8+ effector T cells) in a sample comprising leukocytes obtained from the subject, where the subject has been treated with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody), and where the one or more marker genes are selected from a T cell marker gene, or a memory T cell marker gene (e.g., a marker of T effector memory cells); and determining the treatment as demonstrating pharmacodynamic activity based on the expression level of the one or more marker genes, protein(s) and/or cellular composition in the sample obtained from the subject, as compared with a reference, where an increased expression level of the one or more marker genes as compared with the reference indicates pharmacodynamic activity to the OX40 agonist treatment. Expression level of a marker gene, protein and/or cellular composition may be measured by one or more methods as described herein.

**[0437]** As used herein, "pharmacodynamic (PD) activity" may refer to an effect of a treatment (e.g., an OX40 agonist in combination with a PD-1 axis antagonist treatment) to the subject. An example of a PD activity may include modulation of the expression level of one or more genes. Without wishing to be bound to theory, it is thought that monitoring PD activity, such as by measuring expression of a gene marker, may be advantageous during a clinical trial examining an OX40 agonist and PD-1 axis

antagonist. Monitoring PD activity may be used, for example, to monitor response to treatment, toxicity, and the like.

**[0438]** In some embodiments, the expression level of one or more marker genes, proteins and/or cellular composition may be compared to a reference which may include a sample from a subject not receiving a treatment (e.g., an OX40 agonist treatment in combination with a PD-1 axis binding antagonist). In some embodiments, a reference may include a sample from the same subject before receiving a treatment (e.g., an OX40 agonist treatment in combination with a PD-1 axis binding antagonist). In some embodiments, a reference may include a reference value from one or more samples of other subjects receiving a treatment (e.g., an OX40 agonist treatment in combination with a PD-1 axis antagonist). For example, a population of patients may be treated, and a mean, average, or median value for expression level of one or more genes may be generated from the population as a whole. A set of samples obtained from cancers having a shared characteristic (e.g., the same cancer type and/or stage, or exposure to a common treatment such as an OX40 agonist in combination with a PD-1 axis binding antagonist) may be studied from a population, such as with a clinical outcome study. This set may be used to derive a reference, e.g., a reference number, to which a subject's sample may be compared. Any of the references described herein may be used as a reference for monitoring PD activity.

**[0439]** Provided herein are methods for monitoring responsiveness of a subject to an OX40 agonist treatment by measuring the expression level of one or more marker genes, protein(s) (e.g., a cytokine, e.g., gamma interferon) and/or cellular composition (e.g., percentage of Treg and/or absolute number of Treg; e.g., number of CD8+ effector T cells in peripheral blood samples) in a sample comprising leukocytes obtained from the subject, where the subject has been treated with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody), and where the one or more marker genes are selected from a T cell marker gene, or a memory T cell marker gene (e.g., a marker of T effector memory cells); and classifying the subject as responsive or non-responsive to the treatment based on the expression level of the one or more marker genes, protein(s) and/or cellular composition in the sample obtained from the subject, as compared with a reference, where an increased expression level of the one or more marker genes as compared with the reference indicates responsiveness or lack of reponsiveness to the OX40 agonist treatment. Expression level of a marker gene, protein and/or cellular composition may be measured by one or more methods as described herein.

**[0440]** In some embodiments, a reference for monitoring responsiveness may include a sample from a subject not receiving a treatment (e.g., an OX40 agonist treatment in combination with PD-1 axis binding antagonist). In some embodiments, a reference for monitoring responsiveness may include a sample from the same subject before receiving a treatment (e.g., an OX40 agonist treatment in combination with PD-1 axis binding antagonist). In some embodiments, a reference for monitoring

responsiveness may include a reference value from one or more samples of other patients receiving a treatment (e.g., an OX40 agonist treatment in combination with PD-1 axis binding antagonist). For example, a population of patients may be treated, and a mean, average, or median value for expression level of one or more genes may be generated from the population as a whole. A set of samples obtained from cancers having a shared characteristic (e.g., the same cancer type and/or stage, or exposure to a common treatment such as an OX40 agonist) may be studied from a population, such as with a clinical outcome study. This set may be used to derive a reference, e.g., a reference number, to which a subject's sample may be compared. Any of the references described herein may be used as a reference for monitoring PD activity.

**[0441]** Certain aspects of the present disclosure relate to measurement of the expression level of one or more genes or one or more proteins in a sample. In some embodiments, a sample may include leukocytes. In some embodiments, the sample may be a peripheral blood sample (e.g., from a patient having a tumor). In some embodiments, the sample is a tumor sample. A tumor sample may include cancer cells, lymphocytes, leukocytes, stroma, blood vessels, connective tissue, basal lamina, and any other cell type in association with the tumor. In some embodiments, the sample is a tumor tissue sample containing tumor-infiltrating leukocytes. In some embodiments, the sample may be processed to separate or isolate one or more cell types (e.g., leukocytes). In some embodiments, the sample may be used without separating or isolating cell types.

**[0442]** A tumor sample may be obtained from a subject by any method known in the art, including without limitation a biopsy, endoscopy, or surgical procedure. In some embodiments, a tumor sample may be prepared by methods such as freezing, fixation (e.g., by using formalin or a similar fixative), and/or embedding in paraffin wax. In some embodiments, a tumor sample may be sectioned. In some embodiments, a fresh tumor sample (i.e., one that has not been prepared by the methods described above) may be used. In some embodiments, a tumor sample may be prepared by incubation in a solution to preserve mRNA and/or protein integrity.

**[0443]** In some embodiments, the sample may be a peripheral blood sample. A peripheral blood sample may include white blood cells, PBMCs, and the like. Any technique known in the art for isolating leukocytes from a peripheral blood sample may be used. For example, a blood sample may be drawn, red blood cells may be lysed, and a white blood cell pellet may be isolated and used for the sample. In another example, density gradient separation may be used to separate leukocytes (e.g., PBMCs) from red blood cells. In some embodiments, a fresh peripheral blood sample (i.e., one that has not been prepared by the methods described above) may be used. In some embodiments, a peripheral blood sample may be prepared by incubation in a solution to preserve mRNA and/or protein integrity.

**[0444]** In some embodiments, responsiveness to treatment may refer to any one or more of: extending survival (including overall survival and progression free survival); resulting in an objective

response (including a complete response or a partial response); or improving signs or symptoms of cancer. In some embodiments, responsiveness may refer to improvement of one or more factors according to the published set of RECIST guidelines for determining the status of a tumor in a cancer patient, *i.e.,* responding, stabilizing, or progressing. For a more detailed discussion of these guidelines, see Eisenhauer et al., *Eur J Cancer* 2009;45: 228−47; Topalian et al., *N Engl J Med* 2012;366:2443−54; Wolchok et al., *Clin Can Res* 2009;15:7412−20; and Therasse, P., *et al. J. Natl. Cancer Inst.* 92:205-16 (2000). A responsive subject may refer to a subject whose cancer(s) show improvement, e.g., according to one or more factors based on RECIST criteria. A non-responsive subject may refer to a subject whose cancer(s) do not show improvement, e.g., according to one or more factors based on RECIST criteria.

**[0445]** Conventional response criteria may not be adequate to characterize the anti-tumor activity of immunotherapeutic agents, which can produce delayed responses that may be preceded by initial apparent radiological progression, including the appearance of new lesions. Therefore, modified response criteria have been developed that account for the possible appearance of new lesions and allow radiological progression to be confirmed at a subsequent assessment. Accordingly, in some embodiments, responsiveness may refer to improvement of one of more factors according to immune-related response criteria2 (irRC). See, e.g., Wolchok et al., Clin Can Res 2009;15:7412 – 20. In some embodiments, new lesions are added into the defined tumor burden and followed, e.g., for radiological progression at a subsequent assessment. In some embodiments, presence of non-target lesions are included in assessment of complete response and not included in assessment of radiological progression. In some embodiments, radiological progression may be determined only on the basis of measurable disease and/or may be confirmed by a consecutive assessment $\geq$ 4 weeks from the date first documented.

**[0446]** In some embodiments, responsiveness may include immune activation. In some embodiments, responsiveness may include treatment efficacy. In some embodiments, responsiveness may include immune activation and treatment efficacy.

## VI. Articles of Manufacture or Kits

**[0447]** In another embodiment of the invention, an article of manufacture or a kit is provided comprising a PD-1 axis binding antagonist and/or an OX40 binding agonist (e.g., anti-human OX40 agonist antibody). In some embodiments, the article of manufacture or kit further comprises package insert comprising instructions for suing the PD-1 axis binding antagonist in conjunction with an OX40 binding agonist to treat or delay progression of cancer in an individual or to enhance immune function of an individual having cancer. Any of the PD-1 axis binding antagonist and/or an OX40 binding agonists described herein may be included in the article of manufacture or kits.

**[0448]** In some embodiments, the PD-1 axis binding antagonist and the OX40 binding agonist (e.g., anti-human OX40 agonist antibody) are in the same container or separate containers. Suitable containers include, for example, bottles, vials, bags and syringes. The container may be formed from a variety of materials such as glass, plastic (such as polyvinyl chloride or polyolefin), or metal alloy (such as stainless steel or hastelloy). In some embodiments, the container holds the formulation and the label on, or associated with, the container may indicate directions for use. The article of manufacture or kit may further include other materials desirable from a commercial and user standpoint, including other buffers, diluents, filters, needles, syringes, and package inserts with instructions for use. In some embodiments, the article of manufacture further includes one or more of another agent (e.g., a chemotherapeutic agent, and anti-neoplastic agent). Suitable containers for the one or more agent include, for example, bottles, vials, bags and syringes.

**[0449]** The specification is considered to be sufficient to enable one skilled in the art to practice the invention. Various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description and fall within the scope of the appended claims. All publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.

## EXAMPLES

**[0450]** The invention will be more fully understood by reference to the following examples. They should not, however, be construed as limiting the scope of the invention. It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims.

***Materials and methods***

**[0451]** ***In vivo* tumor models:** CT26 and MC38 colorectal cell lines were maintained at Genentech. For CT26 studies, 8-10 week old female Balb/c mice (Charles River Laboratories; Hollister, CA) were inoculated subcutaneously in the right unilateral flank with 0.1 million CT26 cells. For MC38 studies, 8-10 week old female C57BL/6 mice (Charles River Laboratories) were inoculated subcutaneously in the right unilateral flank with 0.1 million MC38 cells. When tumors achieved a mean tumor volume of approximately 150mm3, mice were recruited and randomized into treatment groups and antibody treatment started the following day 1. All animal studies were conducted according to guidelines and regulations stated in the Animals Welfare Act and The Guide for the Care and Use of Laboratory Animals and IACUC Guidelines. Treatment groups were as follows: 1) Control antibody, 10 mg/kg IV first dose, followed by 5mg/kg IP, BIWx2, n=5; 2) Murine anti-mouse OX40 agonist monoclonal antibody (a chimeric antibody with rat anti-mouse OX40 variable regions derived from an OX86 antibody and mouse IgG2a Fc. As such, this murine antibody is

capable of effector function, including without limitation ADCC), 0.1 mg/kg IV first dose, followed by IP, TIWx2, n=5; 3) Murine anti-PD-L1, 10 mg/kg IV first dose, followed by 5 mg/kg IP, TIWx2, n=5; and 4) Murine anti-mouse OX40 monoclonal antibody, 0.1 mg/kg IV first dose, followed by IP, TIWx2 and murine anti-PD-L1, 10 mg/kg IV first dose, followed by 5 mg/kg IP TIWx2, n=5. Mice were sacrificed and peripheral blood was harvested on day 9 post first dose.

**[0452] Antibodies:** All treatment antibodies were generated at Genentech. Control antibody was anti-gp120 mouse IgG1, clone 10E7.1D2. The anti-OX40 antibody was clone OX-86 mouse-IgG2a (generated by cloning rat anti-mouse OX40 agonist antibody OX-86 onto a murine IgG2a backbone) and anti-PDL1 was clone 6E11.1.9 mouse IgG1. Dosing schedules were as indicated on the figure legends with first or single doses administered intraveneously (IV) and subsequent doses given intraperitoneally (IP). Antibodies were diluted in either PBS or 20mM histidine acetate, 240 mM sucrose, 0.02 % polysorbate 20, pH 5.5. TIW indicates administration 3 times a week, BIW indicates administration twice a week.

**[0453] Tumor processing and flow cytometry:** Tumors were harvested and minced with a razor blade prior to digesting in RPMI-1640 media with 5% fetal bovine serum plus Collagenase D (Roche; Indianapolis, IN) at 0.25mg/ml and DNAse I (Roche) at 0.1 mg/ml for 15 minutes at 37C on a rocking platform in C-tubes (Miltenyi Biotec; San Diego, CA). After incubation, tumors were processed on a gentleMACS (Miltenyi Biotec), filtered and washed to generate single cell suspensions. Cells were counted on a Vi-Cell counter (Beckman Coulter; Brea, CA).

**[0454]** Peripheral blood was evaluated for activation and proliferation of T cells by flow cytometry. 50 uL blood was stained with commercial antibodies against CD45, CD3, CD4, CD8, CXCR3, (all BD Biosciences) and Ki67 (eBiosciences) per manufacturers' instructions. Cells were first stained with Live/Dead Near-Infared viability dye (Life Technologies; Grand Island, NY) in PBS for 30 minutes on ice, then washed. Cells were then Fc receptor blocked with purified anti-CD16/-CD32 (BD Biosciences; San Jose, CA) prior to subsequent surface staining for 30 minutes on ice in PBS + 0.5% BSA + 2mM EDTA buffer. For assessing PD-1, and OX40 expression of T cells, cells were stained as follows: PD1-FITC, CD3-PerCp.Cy5.5, CD4-PE-Cy7, CD8 Pacific Blue, CD45 v500, (BD Biosciences); OX40 Alexa Fluor 647 (Genentech, clone 1H1). To assess PDL1 expression of various cell types, staining was as follows: CD11b-FITC, Gr-1 PE-Cy7, CD8 Alexa 700, CD45 v500, CD4-PerCp.Cy5.5 (BD Biosciences); PDL1-biotin (Genentech, clone 6F8.2.5) followed by streptavidin-PE (BD Bioscience). To assess Foxp3+ T regulatory cell populations, cells were first surface stained with: CD45-PE-Cy7, CD4 PerCp-Cy5.5 (BD Biosciences), and then fixed overnight at 4C in 1x foxp3 fix/permeabilization buffer (eBioscience; San Diego, CA). Cells were then permeabilized in 1x foxp3 permeabilization buffer (eBioscience) and stained with Foxp3-FITC (eBioscience). Stained cells were acquired using FACS Diva software on a Fortessa or FACS Canto II (BD Biosciences), followed by analysis on FlowJo software.

**[0455] Tumor dissection and Fluidigm expression analysis:** RNA was extracted from FFPE derived archival tumors for UBC or NSCLC as described (Powles, T., *et al.* (2014) *Nature* 515:558-62; Herbst, R.S., *et al* (2014) *Nature* 515:563-7). Briefly, tumor FFPE sections were macro-dissected to enrich for neoplastic tissue, and tissue was lysed using tumor lysis buffer and Proteinase K to allow for complete digestion and release of nucleic acids. RNA was isolated using the High Pure FFPE RNA Micro Kit (Roche Applied Sciences, Indianapolis, IN) according to the manufacturer's protocol.

**[0456]** Gene-expression analysis was performed using the BioMark HD real-time PCR Platform (Fluidigm) as described previously (Shames, D.S., *et al.* (2013) *PLoS ONE* 8:e56765). All Taq- man assays in the expression panel were FAM-MGB and ordered through Life Technologies either made-to-order or custom-designed, including four reference genes: SP2, GUSB, TMEM55B and VPS33B. A geometric median of the $C_t$ values for the four reference genes (SP2, GUSB, TMEM55B and VPS33B) was calculated for each sample, and expression levels were determined using the delta $C_t$ ($DC_t$) method as follows: $C_t$ (target Gene) 2 GeoMedian $C_t$ (reference genes). Median mRNA expression levels (as measured by immunochip (iChip)) across patients on study were used as cutoffs to derive high- versus low-expression categorization. P values were determined by t test.

**[0457] PD-L1 Immunohistochemistry (IHC)**: Formalin-fixed paraffin-embedded (FFPE) sections of a tumor sample or cancer cell line were analyzed.

**[0458]** Formalin-fixed, paraffin-embedded tissue sections were deparaffinized prior to antigen retrieval, blocking and incubation with primary anti-PD-L1 antibodies. Following incubation with secondary antibody and enzymatic color development, sections were counterstained and dehydrated in series of alcohols and xylenes before coverslipping.

**[0459]** The following protocol was used for IHC. Formalin-fixed, paraffin- embedded (FFPE) tissue sections of 4-mm thickness were stained for PD-L1 with an anti-human PD-L1 rabbit monoclonal antibody on an automated staining platform using a concentration of 4.3 mg/ml, with signal visualization by diaminobenzidine; sections were counter-stained with haematoxylin. PD-L1 expression was evaluated on tumor-infiltrating immune cells using the following scoring scheme:

| PD-L1 Diagnostic Assessment | IHC Scores |
|---|---|
| Absence of any discernible PD-L1 staining<br>OR<br>Presence of discernible PD-L1 staining of any intensity in tumor-infiltrating immune cells covering < 1% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 0 |
| Presence of discernible PD-L1 staining of any intensity in tumor-infiltrating immune cells covering between ≥ 1 % to < 5% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 1 |
| Presence of discernible PD-L1 staining of any intensity in tumor infiltrating immune cells covering between ≥ 5 % to < 10% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 2 |
| Presence of discernible PD-L1 staining of any intensity in tumor infiltrating immune cells covering ≥ 10% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma | IHC 3 |

**[0460]** The Ventana Benchmark XT or Benchmark Ultra system was used to perform PD-L1 IHC staining using the following reagents and materials:

Primary antibody: anti- PD-L1 Rabbit Monoclonal Primary Antibody

Specimen Type: Formalin-fixed paraffin embedded (FFPE) section of tissue samples and control cell pellets of varying staining intensities

Procedure Species: Human Instrument: BenchMark XT or Benchmark Ultra

Epitope Recovery Conditions: Cell Conditioning, standard 1 (CC1, Ventana, cat # 950-124)

Primary Antibody Conditions: 1/100, 6.5 µg/ml /16 minutes at 36°C

Diluent: Antibody dilution buffer (Tris-buffered saline containing carrier protein and Brig-35)

Negative control: Naive Rabbit IgG at 6.5 µg/ml (Cell Signaling) or diluent alone

Detection: Optiview or Ultraview Universal DAB Detection kit (Ventana), and amplification kit (if applicable) were used according to manufacturer's instructions (Ventana).

Counterstain: Ventana Hematoxylin II (cat # 790-2208)/ with Bluing reagent (Cat # 760-2037) (4 minutes and 4 minutes, respectively)

**[0461]** The Benchmark Protocol was as follows:

1. paraffin ( Selected )
2. Deparaffinization ( Selected )
3. Cell Conditioning ( Selected )

4. Conditioner #1 ( Selected )

5. Standard CC1( Selected )

6. Ab Incubation Temperatures ( Selected )

7. 36C Ab Inc. ( Selected )

8. Titration ( Selected )

9. Auto-dispense ( Primary Antibody ), and Incubate for ( 16 minutes)

10. Countstain (Selected )

11. Apply One Drop of (Hematoxylin II ) ( Countstain ), Apply Coverslip, and Incubate for (4 minutes)

12. Post Counterstain (Selected )

13. Apply One Drop of ( BLUING REAGENT ) ( Post Countstain ), Apply Coverslip, and Incubate for ( 4 minutes)

14. Wash slides in soap water to remove oil

15. Rinse slides with water

16. Dehydrate slides through 95% Ethanol, 100% Ethanol to xylene (Leica autostainer program #9)

17. Cover slip.

***Results***

**[0462]** OX40 is known to be a co-stimulatory molecule expressed on activated CD4 T cells (Teff) and T regulatory (Treg) cells. OX40 is not constitutively expressed on naïve T cells, but is induced after engagement of the T cell receptor (TCR). Ligation of OX40 in the presence of TCR stimulation is known to enhance T effector cell function via dual mechanism of potentiating activation of Teff cells and inhibiting Treg cells. Anti-OX40 treatment was found to reduce Treg activity in an in vitro Treg suppression assay. These results demonstrate that OX40 agonist treatment is able to modulate several critical T cell functions.

**[0463]** The inhibition of PD-L1 signaling has been proposed as a means to enhance T cell immunity for the treatment of cancer (e.g., tumor immunity) and infection, including both acute and chronic (e.g., persistent) infection.

**[0464]** We examined whether intratumoral T cells expressed PD-1 and OX40. As shown in FIG. 1, intratumoral CD8+ T cells expressed inhibitory receptors such as PD-1, but a large proportion of these cells also expressed OX40. This result suggests that OX40 stimulation of Teffector cells might counteract the effect of PD-1 and other inhibitory receptors expressed on T cells.

**[0465]** Treatment with anti-OX40 agonist antibodies (single agent) significantly reduced the proportion of intratumoral Foxp3+ regulatory T cells relative to total number of CD45+ cells (CD45 defines all hematopoietic cells, such as leukocytes; FIG. 2A), as well as significantly reducing the absolute number of intratumoral Foxp3+ Treg (FIG. 2B). In addition, treatment with a combination of

anti-OX40 agonist antibody and anti-PDL1 antagonist antibody significantly reduced the proportion of intratumoral Foxp3+ regulatory T cells relative to total number of CD45+ cells (FIG. 2A) as well as absolute number of intratumoral Foxp3+ Treg (FIG. 2B). These results demonstrated that OX40 agonist-mediated reduction of intratumoral Foxp3+ Treg is maintained when OX40 agonist is administered in combination with anti-PDL1 antagonist.

**[0466]** We examined the effect of OX40 agonist treatment on PD-L1 expression. Treatment with anti-OX40 agonist significantly increased PD-L1 expression in tumor cells and intratumoral myeloid cells, suggesting that PD-L1 can limit anti-OX40 efficacy in a negative feedback manner (FIGS. 3A&B). Without being bound by theory, these results suggest that treatment with OX40 agonist may enhance treatment with a PD-1 axis inhibitor, since treatment with OX40 agonist increased PD-L1 expression. Clinical data associates increased PDL1 expression as enriching for response to PD1 axis antagonists (e.g., anti-PD-L1 antagonist antibodies).

**[0467]** Treatment with anti-OX40 agonist antibody and anti-PDL1 antagonist antibody demonstrated synergistic combination efficacy in the CT26 and MC38 colorectal cancer syngeneic tumor models (FIGS. 4A&B, 5A&B). Analysis of individual tumor volume measurements (from individual mice in each experiment; FIGS. 4B, 5B) revealed that combination treated animals showed significant tumor-size reduction at higher frequency as compared to animals treated with either agent (OX40 agonist, PDL1 antagonist) alone. Put another way, the frequency of animals with partial and compete response is significantly higher in combination treated animals as compared to animals treated with either agent alone.

**[0468]** Analysis of peripheral blood taken from combination treated CT26 mice revealed an increase in effector cell proliferation and inflammatory T cell markers (FIGS. 9A, B, C, &D). Level of proliferation of CD8+ Tcells (FIG. 9A), Treg cells (FIG. 9B), plasma interferon gamma levels (FIG. 9C) and activated T cells (FIG. 9D) were examined. Increase in proliferation (Ki67), plasma interferon gamma, and inflammatory markers (Tbet, CXCR3) in the combination arm (relative to either single agent arm) revealed synergism of aPDL1 (checkpoint blockade) and aOX40 (co-stimulation) activities.

**[0469]** Specifically, level of proliferating CD8+ T cells (expressed as percentage of ki67+/total CD8+ T cells) was significantly increased in animals treated with the combination of OX40 agonist and PD-L1 antagonist verses treatment with OX40 agonist or PDL1 antagonist alone (FIG. 9A). Level of proliferating CD8+ T cells in combination-treated animals was greater than the additive effect of single-agent treated populations, demonstrating that a synergistic effect of OX40 agonist treatment in combination with PD-1 axis inhibition could be detected by analysis of peripheral blood markers and cells.

**[0470]** In addition, decreased peripheral blood Tregs were observed with treatment with OX40 agonist single agent, and decrease in peripheral blood Tregs was maintained in the combination (of

OX40 agonist and PDL1 antagonist) therapy arm (FIG. 9B). Increased plasma gamma interferon was observed with the combination of OX40 agonist and PDL1 antagonist (FIG. 9C).

**[0471]** Chemokine receptor CXCR3 is a Gαi protein-coupled receptor in the CXC chemokine receptor family. There are two variants of CXCR3: CXCR3-A binds to the CXC chemokines CXCL9 (MIG), CXCL10 (IP-10), and CXCL11 (I-TAC), whereas CXCR3-B can also bind to CXCL4 in addition to CXCL9, CXCL10, and CXCL11 (Clark-Lewis, I., *et al.* (2003) *J. Biol. Chem.* 278(1):289-95). CXCR3 is expressed primarily on activated T lymphocytes and NK cells, and some epithelial cells. CXCR3 and CCR5 are preferentially expressed on Th1 cells and upregulated on effector memory CD8 T cells (Groom, J.R. and Luster, A.D. (2011) *Exp. Cell Res.*317(5):620-31). CXCR3 is able to regulate leukocyte trafficking. Binding of chemokines to CXCR3 induces various cellular responses, most notably integrin activation, cytoskeletal changes and chemotactic migration of inflammatory cells (Groom, J.R. and Luster, A.D. (2011) *Exp. Cell Res.*317(5):620-31).

**[0472]** Level of activated T cells (specifically, activated memory Teff cells, determined using the CXCR3 marker) was significantly increased in animals treated with the combination of OX40 agonist and PD-L1 antagonist versus treatment with OX40 agonist or PDL1 antagonist alone (FIG. 9D). Level of T memory effector cells (CXCR3+) in combination-treated animals was greater than the additive effect of single-agent treated populations, demonstrating that a synergistic effect of OX40 agonist treatment in combination with PD-1 axis inhibition could be detected by analysis of peripheral blood markers and cells. Increase in proliferation (Ki67) and inflammatory markers (CXCR3) on CD8 T cells in the combination treatment arm may suggest enhancement of cytotoxicity via synergism of anti-PDL1 (checkpoint blockade) and anti-OX40 (co-stimulation) activities.

**[0473]** In addition, combination treatment effects were detected by increase in effector and inflammatory T cell markers (e.g., by rtPCR (Fluidigm) analyzed in combination treated tumor samples verses sample treated with either agent alone. For example, markers for Treg (Fox3p), CD8+ Teffs (CD8b), and activated T cells (e.g., Tbet, CXCR3, e.g., interferon gamma response-associated genes) may be analyzed.

**[0474]** Experiments were conducted to examine the dose-response effect of OX40 agonist antibody treatment in the CT26 colorectal cancer syngeneic tumor models. Anti-OX40 agonist antibody single agent treatment shows dose responsiveness (FIG. 6A, B). A 0.1 mg/ml dose showed sub-maximal efficacy, and was selected for further combination treatment experiments.

**[0475]** FIGS. 7A and B show the results of treatment with sub-therapeutic doses of anti-OX40 agonist antibody in combination with anti-PDL1 antagonist antibody, as compared to treatment with either agent alone. Synergistic combination efficacy was observed, suggesting that the OX40 agonist antibody maximum efficacious dose may be lower when treated in combination with a PD-1 axis antagonist.

**[0476]** FIGS. 8A and B show the results of treatment with a single dose of a sub-therapeutic level of anti-OX40 agonist antibody in combination with an anti-PDL1 antagonist antibody, as compared to treatment with either agent alone. Synergistic combination efficacy was observed, suggesting that the OX40 agonist antibody maximum efficacious dose may be lower when OX40 agonist antibody is provided in combination with a PD-1 axis antagonist.

**[0477]** FIG. 10 shows association of OX40 expression with PDL1 diagnostic status in cancer samples from human patients with urothelial bladder cancer (UBC) and non-small cell lung cancer (NSCLC). Tissue samples were from patients participating in phase 1 clinical trials with anti-PD-L1 antibody, MPDL3280A. PD-L1 biomarker status of tumor infiltrating immune cells (IC) was determined using IHC as disclosed herein. OX40 expression level was determined using rtPCR analysis (Fluidigm). In UBC, OX40 expression was observed in patients with PDL1 IHC status of 0 or 1. Level of OX40 expression correlated with PDL1 IHC status, with increased PDL1 expression correlating with increased OX40 expression. In NSCLC, expression of OX40 was observed in patients with low or no PDL1 expression by IHC (as well as in samples with PDL1 IHC status of 2 and 3). These results suggest (a) potential for improved responses with combination treatment with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody) in patients having PDL1 IHC 0 and/or 1 status; (b) potential for improved responses with combination treatment with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody) in patients who do not respond to prior PD-1 axis binding antagonist treatment; and (c) potential for improved responses with combination treatment with a PD-1 axis binding antagonist and an OX40 binding agonist (e.g., anti-human OX40 agonist antibody) in patients having PDL1 IHC 2 and/or 3 status.

**[0478]** The results of a clinical study evaulating the anti-PD-L1 antibody MPDL3280A for use in the treatment of cancer suggested that PD-L1 expression was associated with clinical response to MPDL3280A. It was found that the association of tumor infiltrating immune cell PDL1 expression with treatment response appeared stronger than that with tumor cell PDL1 expression. Tumor infiltrating immune cells may be more sensitive to IFNg expression and may act preferentially to suppress pre-existing T cell responses before therapy (Herbst, R.S., *et al* (2014) *Nature* 515:563-7). Without wishing to be bound to theory, it is thought that OX40 agonist treatment may increase IFNg expression, leading to enhanced PDL1 expression in tumor infiltrating immune cells and concomitant increased responsiveness to PD-1 axis binding antagonist treatment. Combination treatment including an OX40 binding agonist and a PD-1 axis binding antagonist may therefore be useful in the treatment of patients with a lower PDL1 biomarker status.

**[0479] Scoring PD-L1 Expression by IHC:** The presence or absence of PD-L1 expression in tumor specimens was evaluated using anti-PD-L1-specific antibody that can detect PD-L1 in human formalin-fixed, paraffin-embedded (FFPE) tissues by IHC. To measure and quantify relative

expression of PD-L1 in tumor samples, a PD-L1 IHC scoring system was developed to measure PD-L1 specific signal in tumor cells and tumor infiltrating immune cells. Immune cells are defined as cells with lymphoid and/or macrophage/histiocyte morphology.

**[0480]** Tumor cell staining is expressed as the percent of all tumor cells showing membranous staining of any intensity. Infiltrating immune cell staining is defined as the percent of the total tumor area occupied by immune cells that show staining of any intensity. The total tumor area encompasses the malignant cells as well as tumor-associated stroma, including areas of immune infiltrates immediately adjacent to and contiguous with the main tumor mass. In addition, infiltrating immune cell staining is defined as the percent of all tumor infiltrating immune cells.

**[0481]** There was a wide dynamic range of PD-L1 staining intensities in tumor tissues. Irrespective of subcellular localization, the signal was also classified as strong, moderate, weak, or negative staining.

**[0482]** As shown in FIG. 11, negative signal intensity was characterized by an absence of any detectable signal, as illustrated using HEK-293 cells (FIG. 11A). In contrast, positive signal intensity was characterized by a golden to dark brown membrane staining, as illustrated using HEK-293 cells transfected with recombinant human PD-L1 (see FIGS. 11B-D). Finally, positive signal intensity was also illustrated by staining of placental trophoblasts (FIG. 11E) and strong staining in the area of tonsilar crypts (FIG. 11F) and often in membranous pattern that is characterized by a golden to dark brown staining. In tumor tissues, PD-L1 negative samples were qualified as having no detectable signal or only weak cytoplasmic background staining when evaluated using a 20× objective. In contrast, PD-L1 positive samples demonstrated primarily membranous staining in tumor cells and/or infiltrating immune cells. PD-L1 staining was observed with variable intensity from weak with fine, light-brown membranes to strong with dark-brown thick membranes easily recognized at low magnification.

**[0483]** Three representative PD-L1 positive tumor samples are shown in FIG. 12. For Triple-Negative Breast Cancer, it was observed that most tumor cells were strongly positive for PD-L1 showing a combination of membranous and cytoplasmic staining (100x magnification) (FIG. 12A). For Malignant Melanoma, a cluster of immune cells was observed, some of them with membranous staining for PD-L1, and rare tumor cells (arrows) with membranous staining for PD-L1 (400x magnification) (FIG. 12B). For NSCLC, adenocarcinoma, a cluster of immune cells with strong staining for PD-L1 was observed, with several tumor cells (arrows) having membranous and/or cytoplasmic staining for PD-L1 (400x magnification) (FIG. 12C).

**[0484]** The staining in positive cases tended to be focal with respect to spatial distribution and intensity. The percentages of tumor or immune cells showing staining of any intensity were visually estimated and used to determine PD-L1 status. An isotype negative control was used to evaluate the presence of background in test samples.

**[0485]** Staining required one serial tissue section for H&E, a second serial tissue section for anti-PD-L1, and a third serial tissue section for the isotype negative control. The PD-L1-transfected HEK-293 cell line control or tonsil slides were used as run controls and a reference for assay specificity.

**[0486]** PDL-1 Status Criteria

| PD-L1 Status | Staining criteria |
|---|---|
| Negative | 0% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| Positive | >0% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥1% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥5% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |
| | ≥10% membrane staining or cytoplasmic staining or combinations of both at ANY staining intensity |

**[0487]** The table shown above describes one embodiment of using PDL1 staining criteria to determine PDL1 status. In another embodiment, a sample with an IHC score of IHC 0 and/or 1 may be considered PDL1 negative, while a sample with an IHC score of IHC 2 and/or 3 may be considered PDL1 positive. In some embodiments, PDL1 expression (*e.g.*, PDL1 staining) on the tumor itself is evaluated.

**[0488]** In some cases, the PD-L1 positive status may comprise the presence of discernible PD-L1 staining of any intensity in either tumor cells or tumor infiltrating immune cells in up to 50% of tumor area occupied by tumor cells, associated intratumoral, and contiguous peri-tumoral desmoplastic stroma. Thus, PD-L1 positive staining includes as high as 50% of tumor cells or tumor infiltrating immune cells showing staining of any intensity.

**[0489]** Evaluable slides stained with anti-PD-L1 were evaluated as described above. Negative staining intensity was characterized by an absence of any detectable signal or a signal that was characterized as pale gray to blue (rather than brown or tan) and absence of membrane enhancement. The case was negative if there were no (e.g., absent) membrane staining.

**[0490]** Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, the descriptions and examples should not be construed as limiting the scope of the invention. The disclosures of all patent and scientific literature cited herein are expressly incorporated in their entirety by reference.

# CLAIMS

WHAT IS CLAIMED IS:

1. A method for treating or delaying progression of cancer in an individual comprising administering to the individual an effective amount of a human PD-1 axis binding antagonist and an OX40 binding agonist.

2. The method of claim 1, wherein the PD-1 axis binding antagonist is selected from the group consisting of a PD-1 binding antagonist, a PDL1 binding antagonist and a PDL2 binding antagonist.

3. The method of claim 2, wherein the PD-1 axis binding antagonist is a PD-1 binding antagonist.

4. The method of claim 3, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to its ligand binding partners.

5. The method of claim 3, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to PDL1.

6. The method of claim 3, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to PDL2.

7. The method of claim 3, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to both PDL1 and PDL2.

8. The method of any one of claims 3-7, wherein the PD-1 binding antagonist is an antibody.

9. The method of claim 3, wherein the PD-1 binding antagonist is nivolumab.

10. The method of claim 3, wherein the PD-1 binding antagonist is pembrolizumab.

11. The method of claim 3, wherein the PD-1 binding antagonist is CT-011.

12. The method of claim 3, wherein the PD-1 binding antagonist is AMP-224.

13. The method of claim 2, wherein the PD-1 axis binding antagonist is a PDL1 binding antagonist.

14. The method of claim 13, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to PD-1.

15. The method of claim 13, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to B7-1.

16. The method of claim 13, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to both PD-1 and B7-1.

17. The method of any one of claims 13-16, wherein the PDL1 binding antagonist is an anti-PDL1 antibody.

18. The method of claim 17, wherein the anti-PDL1 antibody is a monoclonal antibody.

19. The method of claim 17, wherein the anti-PDL1 antibody is an antibody fragment selected from the group consisting of Fab, Fab'-SH, Fv, scFv, and $(Fab')_2$ fragments.

20. The method of claim 17, wherein the anti-PDL1 antibody is a humanized antibody or a human antibody.

21. The method of claim 13, wherein the PDL1 binding antagonist is selected from the group consisting of: YW243.55.S70, MPDL3280A, MDX-1105, and MEDI4736.

22. The method of claim 17, wherein the antibody comprises a heavy chain comprising HVR-H1 sequence of GFTFSDSWIH (SEQ ID NO:1), HVR-H2 sequence of AWISPYGGSTYYADSVKG (SEQ ID NO:2), and HVR-H3 sequence of RHWPGGFDY (SEQ ID NO:3); and a light chain comprising HVR-L1 sequence of RASQDVSTAVA (SEQ ID NO:4), HVR-L2 sequence of SASFLYS (SEQ ID NO:5), and HVR-L3 sequence of QQYLYHPAT (SEQ ID NO:6).

23. The method of claim 17, wherein the antibody comprises a heavy chain variable region comprising the amino acid sequence of EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYA DSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSS (SEQ ID NO:7) or EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWI SPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQG TLVTVSSASTK (SEQ ID NO:8) and a light chain variable region comprising the amino acid sequence of DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASF LYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO:9).

24. The method of claim 2, wherein the PD-1 axis binding antagonist is a PDL2 binding antagonist.

25. The method of claim 24, wherein the PDL2 binding antagonist is an antibody.

26. The method of claim 24, wherein the PDL2 binding antagonist is an immunoadhesin.

27. The method of any one of claims 8, 17-23, and 25, wherein the antibody is a human IgG1 having Asn to Ala substitution at position 297 according to EU numbering.

28. The method of any one of claims 1-27, wherein the OX40 binding agonist is selected from the group consisting of an OX40 agonist antibody, an OX40L agonist fragment, an OX40 oligomeric receptor, and an OX40 immunoadhesin.

29. The method of any one of claims 1-28, wherein the OX40 binding agonist is an OX40 agonist antibody that binds human OX40.

30. The method of claim 29, wherein the OX40 agonist antibody is MEDI6469, MEDI0562, or MEDI6383.

31. The method of claim 29, wherein the OX40 agonist antibody is a full-length human IgG1 antibody.

32. The method of any one of claims 1-28, wherein the OX40 binding agonist is a trimeric OX40L-Fc protein.

33. The method of any one of claims 1-28, wherein the OX40 binding agonist is an OX40L agonist fragment comprising one or more extracellular domains of OX40L.

34. The method of any one of claims 1-33, wherein the cancer is breast cancer, lung cancer, ovarian cancer, gastric cancer, bladder cancer, pancreatic cancer, endometrial cancer, colon cancer, kidney cancer, esophageal cancer, prostate cancer, colorectal cancer, glioblastoma, neuroblastoma, or hepatocellular carcinoma.

35. The method of any one of claims 1-34, wherein the individual has cancer or has been diagnosed with cancer.

36. The method of any one of claims 1-35, wherein the treatment results in a sustained response in the individual after cessation of the treatment.

37. The method of any one of claims 1-36, wherein the OX40 binding agonist is administered before the PD-1 axis binding antagonist, simultaneous with the PD-1 axis binding antagonist, or after the PD-1 axis binding antagonist.

38. The method of any one of claims 1-37, wherein the individual is a human.

39. A method of enhancing immune function in an individual having cancer comprising administering an effective amount of a PD-1 axis binding antagonist and an OX40 binding agonist.

40. The method of claim 39, wherein CD8 T cells in the individual have enhanced priming, activation, proliferation and/or cytolytic activity relative to prior to the administration of the PD-1 axis binding antagonist and the OX40 binding agonist.

41. The method of claim 39, wherein the number of CD8 T cells is elevated relative to prior to administration of the combination.

42. The method of claim 41, wherein the CD8 T cell is an antigen-specific CD8 T cell.

43. The method of claim 39, wherein Treg function is suppressed relative to prior to the administration of the combination.

44. The method of claim 39, wherein T cell exhaustion is decreased relative to prior to the administration of the combination.

45. The method of any one of claims 39-44, wherein the PD-1 axis binding antagonist is selected from the group consisting of a PD-1 binding antagonist, a PDL1 binding antagonist and a PDL2 binding antagonist.

46. The method of claim 45, wherein the PD-1 axis binding antagonist is a PD-1 binding antagonist.

47. The method of claim 46, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to its ligand binding partners.

48. The method of claim 46, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to PDL1.

49. The method of claim 46, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to PDL2.

50. The method of claim 46, wherein the PD-1 binding antagonist inhibits the binding of PD-1 to both PDL1 and PDL2.

51. The method of any one of claims 46-50, wherein the PD-1 binding antagonist is an antibody.

52. The method of claim 46, wherein the PD-1 binding antagonist is nivolumab.

53. The method of claim 46, wherein the PD-1 binding antagonist is pembrolizumab.

54. The method of claim 46, wherein the PD-1 binding antagonist is CT-011.

55. The method of claim 46, wherein the PD-1 binding antagonist is AMP-224.

56. The method of claim 45, wherein the PD-1 axis binding antagonist is a PDL1 binding antagonist.

57. The method of claim 56, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to PD-1.

58. The method of claim 56, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to B7-1.

59. The method of claim 56, wherein the PDL1 binding antagonist inhibits the binding of PDL1 to both PD-1 and B7-1.

60. The method of any one of claims 56-59, wherein the PDL1 binding antagonist is an anti-PDL1 antibody.

61. The method of claim 60, wherein the anti-PDL1 antibody is a monoclonal antibody.

62. The method of claim 60, wherein the anti-PDL1 antibody is an antibody fragment selected from the group consisting of Fab, Fab'-SH, Fv, scFv, and $(Fab')_2$ fragments.

63. The method of claim 60, wherein the anti-PDL1 antibody is a humanized antibody or a human antibody.

64. The method of claim 56, wherein the PDL1 binding antagonist is selected from the group consisting of: YW243.55.S70, MPDL3280A, MDX-1105, and MEDI4736.

65. The method of claim 60, wherein the anti-PDL1 antibody comprises a heavy chain comprising HVR-H1 sequence of GFTFSDSWIH (SEQ ID NO:1), HVR-H2 sequence of AWISPYGGSTYYADSVKG (SEQ ID NO:2), and HVR-H3 sequence of RHWPGGFDY (SEQ ID NO:3); and a light chain comprising HVR-L1 sequence of RASQDVSTAVA (SEQ ID NO:4), HVR-L2 sequence of SASFLYS (SEQ ID NO:5), and HVR-L3 sequence of QQYLYHPAT (SEQ ID NO:6).

66. The method of claim 60, wherein the anti-PDL1 antibody comprises a heavy chain variable region comprising the amino acid sequence of EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSS (SEQ ID NO:7) or EVQLVESGGGLVQPGGSLRLSCAASGFTFSDSWIHWVRQAPGKGLEWVAWISPYGGSTYYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYCARRHWPGGFDYWGQGTLVTVSSASTK (SEQ ID NO:8) and a light chain variable region comprising the amino acid sequence of DIQMTQSPSSLSASVGDRVTITCRASQDVSTAVAWYQQKPGKAPKLLIY SASFLYSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQYLYHPATFGQGTKVEIKR (SEQ ID NO:9).

67. The method of claim any one of claims 51, 60-63, 65 and 66, wherein the antibody is a human IgG1 having Asn to Ala substitution at position 297 according to EU numbering.

68. The method of claim 45, wherein the PD-1 axis binding antagonist is a PDL2 binding antagonist.

69. The method of claim 68, wherein the PDL2 binding antagonist is an antibody.

70. The method of claim 68, wherein the PDL2 binding antagonist is an immunoadhesin.

71. The method of any one of claims 39-70, wherein the OX40 binding agonist is selected from the group consisting of an OX40 agonist antibody, an OX40L agonist fragment, an OX40 oligomeric receptor, and an OX40 immunoadhesin.

72. The method of claim 71, wherein the OX40 binding agonist is an OX40 agonist antibody that binds human OX40.

73. The method of claim 72, wherein the OX40 agonist antibody is MEDI6469, MEDI0562, or MEDI6383.

74. The method of claim 72, wherein the OX40 agonist antibody is a full-length IgG1 antibody.

75. The method of any one of claims 39-70, wherein the OX40 binding agonist is a trimeric OX40L-Fc protein.

76. The method of any one of claims 39-70, wherein the OX40 binding agonist is an OX40L agonist fragment comprising one or more extracellular domains of OX40L.

77. The method of any one of claims 39-76, wherein the cancer is breast cancer, lung cancer, ovarian cancer, gastric cancer, bladder cancer, pancreatic cancer, endometrial cancer, colon cancer, kidney cancer, esophageal cancer, prostate cancer, colorectal cancer, glioblastoma, neuroblastoma, or hepatocellular carcinoma.

78. The method of any one of claims 39-77, wherein the individual has been diagnosed with cancer.

79. The method of any one of claims 39-78, wherein the treatment results in a sustained response in the individual after cessation of the treatment.

80. The method of any one of claims 39-79, wherein the OX40 binding agonist is administered before the PD-1 axis binding antagonist, simultaneous with the PD-1 axis binding antagonist, or after the PD-1 axis binding antagonist.

81. The method of any one of claims 39-80, wherein the individual is a human.

82. The method of any one of claims 1-81, wherein the PD-1 axis binding antagonist and/or the OX40 binding agonist are administered intravenously, intramuscularly, subcutaneously, topically, orally, transdermally, intraperitoneally, intraorbitally, by implantation, by inhalation, intrathecally, intraventricularly, or intranasally.

83. The method of any one of claims 1-82, further comprising administering a chemotherapeutic agent for treating or delaying progression of cancer.

84. Use of a human PD-1 axis binding antagonist in the manufacture of a medicament for treating or delaying progression of cancer in an individual, wherein the medicament comprises the human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and wherein the treatment comprises administration of the medicament in combination with a composition comprising an OX40 binding agonist and an optional pharmaceutically acceptable carrier.

85. Use of an OX40 binding agonist in the manufacture of a medicament for treating or delaying progression of cancer in an individual, wherein the medicament comprises the OX40 binding agonist and an optional pharmaceutically acceptable carrier, and wherein the treatment comprises

administration of the medicament in combination with a composition comprising a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier.

86. A composition comprising a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier for use in treating or delaying progression of cancer in an individual, wherein the treatment comprises administration of said composition in combination with a second composition, wherein the second composition comprises OX40 binding agonist and an optional pharmaceutically acceptable carrier.

87. A composition comprising an OX40 binding agonist and an optional pharmaceutically acceptable carrier for use in treating or delaying progression of cancer in an individual, wherein the treatment comprises administration of said composition in combination with a second composition, wherein the second composition comprises a human PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier.

88. A kit comprising a medicament comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and a package insert comprising instructions for administration of the medicament in combination with a composition comprising an OX40 binding agonist and an optional pharmaceutically acceptable carrier for treating or delaying progression of cancer in an individual.

89. A kit comprising a first medicament comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier, and a second medicament comprising an OX40 binding agonist and an optional pharmaceutically acceptable carrier.

90. The kit of claim 89, wherein the kit further comprises a package insert comprising instructions for administration of the first medicament and the second medicament for treating or delaying progression of cancer in an individual.

91. A kit comprising a medicament comprising an OX40 binding agonist and an optional pharmaceutically acceptable carrier, and a package insert comprising instructions for administration of the medicament in combination with a composition comprising a PD-1 axis binding antagonist and an optional pharmaceutically acceptable carrier for treating or delaying progression of cancer in an individual.