ANTI-PRLR ANTIBODIES AND USES THEREOF

FIELD OF THE INVENTION

[0001] The present invention relates to antibodies, and antigen-binding fragments thereof, which specifically bind prolactin receptor (PRLR), as well as antibody-drug conjugates comprising such antibodies, and methods of use thereof.

BACKGROUND

[0002] Prolactin is a polypeptide growth hormone that exerts its activity by interacting with the prolactin receptor (PRLR). PRLR is a single transmembrane receptor belonging to the class 1 cytokine receptor superfamily. The binding of prolactin to PRLR leads to receptor dimerization and intracellular signaling. Signaling through PRLR is associated with various processes such as mammary gland development, lactation, reproduction and immunomodulation. Moreover, high levels of PRLR expression have been detected in breast, prostate and other tumor types.

[0003] Blockade of PRLR signaling has been suggested as a means for treating breast and prostate cancer. (*See, e.g.,* Damiano and Wasserman, Apr. 2013, Clin. Cancer Res. 19(7):1644-1650). Anti-PRLR antibodies are mentioned, *e.g.*, in US Patent Nos. 7,867,493 and 7,422,899. Nonetheless, there is a need in the art for novel PRLR antagonists, such as anti-PRLR antibodies, for the treatment of cancer and other disorders associated with PRLR expression and/or signaling.

BRIEF SUMMARY

[0004] The present disclosure provides antibodies and antigen-binding fragments thereof that bind human prolactin receptor (PRLR). The antibodies disclosed herein are useful, *inter alia*, for targeting tumor cells that express PRLR. The anti-PRLR antibodies disclosed herein, and antigen-binding portions thereof, may be used alone in unmodified form, or may be included as part of an antibody-drug conjugate or a bispecific antibody. The present invention refers to subject matter as defined in the attached set of claims.

[0005] The antibodies disclosed herein can be full-length (for example, an IgG1 or IgG4 antibody) or may comprise only an antigen-binding portion (for example, a Fab, $F(ab')_2$ or scFv fragment), and may be modified to affect functionality, e.g., to eliminate residual effector functions (Reddy et al., 2000, J. Immunol. 164:1925-1933).

[0006] Exemplary anti-PRLR antibodies are listed in Tables 1 and 2 herein. Table 1 sets forth the amino acid sequence identifiers of the heavy chain variable regions (HCVRs), light chain variable regions (LCVRs), heavy chain complementarity determining regions (HCDR1, HCDR2 and HCDR3), and light chain complementarity determining regions (LCDR1, LCDR2 and LCDR3) of the exemplary anti-PRLR antibodies. Table 2 sets forth the nucleic acid sequence identifiers of the HCVRs, LCVRs, HCDR1, HCDR2 HCDR3, LCDR1, LCDR2 and LCDR3 of the exemplary anti-PRLR antibodies.

[0007] Disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising an HCVR comprising an amino acid sequence selected from any of the HCVR amino acid sequences listed in Table 1, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0008] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising an LCVR comprising an amino acid sequence selected from any of the LCVR amino acid sequences listed in Table 1, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0009] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising an HCVR and an LCVR amino acid sequence pair (HCVR/LCVR) comprising any of the HCVR amino acid sequences listed in Table 1 paired with any of the LCVR amino acid sequences listed in Table 1. According to certain examples, disclosed herein are antibodies, or antigen-binding fragments thereof, comprising an HCVR/LCVR amino acid sequence pair contained within any of the exemplary anti-PRLR antibodies listed in Table 1. In certain embodiments, the HCVR/LCVR amino acid sequence pair is selected from the group consisting of: 18/26; 66/74; 274/282; 290/298; and 370/378.

[0010] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a heavy chain CDR1 (HCDR1) comprising an amino acid sequence selected from any of the HCDR1 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0011] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a heavy chain CDR2 (HCDR2) comprising an amino acid sequence selected from any of the HCDR2 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0012] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a heavy chain CDR3 (HCDR3) comprising an amino acid sequence selected from any of the HCDR3 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0013] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a light chain CDR1 (LCDR1) comprising an amino acid sequence selected from any of the LCDR1 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0014] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a light chain CDR2 (LCDR2) comprising an amino acid sequence selected from any of the LCDR2 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0015] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a light chain CDR3 (LCDR3) comprising an amino acid sequence selected from any of the LCDR3 amino acid sequences listed in Table 1 or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity.

[0016] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising an HCDR3 and an LCDR3 amino acid sequence pair (HCDR3/LCDR3) comprising any of the HCDR3 amino acid sequences listed in Table 1 paired with any of the LCDR3 amino acid sequences listed in Table 1. According to certain examples, described herein are antibodies, or antigen-binding fragments thereof, comprising an HCDR3/LCDR3 amino acid sequence pair contained within any of the exemplary anti-PRLR antibodies listed in Table 1. In certain examples, the HCDR3/LCDR3 amino acid sequence pair is selected from the group consisting of: 24/32; 72/80; 280/288; 296/304; and 376/384.

[0017] Also disclosed herein are antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising a set of six CDRs (*i.e.*, HCDR1-HCDR2-HCDR3-LCDR1-LCDR2-LCDR3) contained within any of the exemplary anti-PRLR antibodies listed in Table 1. In certain examples, the HCDR1-HCDR2-HCDR3-LCDR1-LCDR2-LCDR3 amino acid sequences set is selected from the group consisting of: 20-22-24-28-30-32; 68-70-72-76-78-80; 276-278-280-284-286-288; 292-294-296-300-302-304; and 372-374-376-380-382-384.

[0018] In a related example, disclosed herein are antibodies, or antigen-binding fragments thereof that specifically bind PRLR, comprising a set of six CDRs (*i.e.*, HCDR1-HCDR2-HCDR3-LCDR1-LCDR2-LCDR3) contained within an HCVR/LCVR amino acid sequence pair as defined by any of the exemplary anti-PRLR antibodies listed in Table 1. For example, the present disclosure includes antibodies or antigen-binding fragments thereof that specifically bind PRLR, comprising the HCDR1-HCDR2-HCDR3-LCDR1-LCDR2-LCDR3 amino acid sequences set contained within an HCVR/LCVR amino acid sequence pair selected from the group consisting of: 18/26; 66/74; 274/282; 290/298; and 370/378. Methods and techniques for identifying CDRs within HCVR and LCVR amino acid sequences are well known in the art and can be used to identify CDRs within the specified HCVR and/or LCVR amino acid sequences disclosed herein. Exemplary conventions that can be used to identify the boundaries of CDRs include, *e.g.*, the Kabat definition, the Chothia definition, and the AbM definition. In general terms, the Kabat definition is based on sequence variability, the Chothia

definition is based on the location of the structural loop regions, and the AbM definition is a compromise between the Kabat and Chothia approaches. *See*, *e.g.*, Kabat, "Sequences of Proteins of Immunological Interest," National Institutes of Health, Bethesda, Md. (1991); Al-Lazikani *et al.*, *J. Mol. Biol. 273*:927-948 (1997); and Martin *et al.*, *Proc. Natl. Acad. Sci. USA 86*:9268-9272 (1989). Public databases are also available for identifying CDR sequences within an antibody.

[0019] Also disclosed herein are nucleic acid molecules encoding anti-PRLR antibodies or portions thereof. For example, disclosed herein are nucleic acid molecules encoding any of the HCVR amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the HCVR nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0020] Also disclosed herein are nucleic acid molecules encoding any of the LCVR amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the LCVR nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0021] Also disclosed herein are nucleic acid molecules encoding any of the HCDR1 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the HCDR1 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0022] Also disclosed herein are ucleic acid molecules encoding any of the HCDR2 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the HCDR2 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0023] Also disclosed herein are nucleic acid molecules encoding any of the HCDR3 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the HCDR3 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0024] Also disclosed herein are nucleic acid molecules encoding any of the LCDR1 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the LCDR1 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0025] Also disclosed herein are nucleic acid molecules encoding any of the LCDR2 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the LCDR2 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0026] Also disclosed herein are nucleic acid molecules encoding any of the LCDR3 amino acid sequences listed in Table 1; in certain examples the nucleic acid molecule comprises a polynucleotide sequence selected from any of the LCDR3 nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto.

[0027] Also disclosed herein are nucleic acid molecules encoding an HCVR, wherein the HCVR comprises a set of three CDRs (*i.e.*, HCDR1-HCDR2-HCDR3), wherein the HCDR1-HCDR2-HCDR3 amino acid sequence set is as defined by any of the exemplary anti-PRLR antibodies listed in Table 1.

[0028] Also disclosed herein are nucleic acid molecules encoding an LCVR, wherein the LCVR comprises a set of three CDRs (*i.e.*, LCDR1-LCDR2-LCDR3), wherein the LCDR1-LCDR2-LCDR3 amino acid sequence set is as defined by any of the exemplary anti-PRLR antibodies listed in Table 1.

[0029] Also disclosed herein are nucleic acid molecules encoding both an HCVR and an LCVR, wherein the HCVR comprises an amino acid sequence of any of the HCVR amino acid sequences listed in Table 1, and wherein the LCVR comprises an amino acid sequence of any of the LCVR amino acid sequences listed in Table 1. In certain examples, the nucleic acid molecule comprises a polynucleotide sequence selected from any of the HCVR nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto, and a polynucleotide sequence selected from any of the LCVR nucleic acid sequences listed in Table 2, or a substantially similar sequence thereof having at least 90%, at least 95%, at least 98% or at least 99% sequence identity thereto. In certain examples, the nucleic acid molecule encodes an HCVR and LCVR, wherein the HCVR and LCVR are both derived from the same anti-PRLR antibody listed in Table 1.

[0030] Also disclosed herein are recombinant expression vectors capable of expressing a polypeptide comprising a heavy or light chain variable region of an anti-PRLR antibody. For example, the present disclosure includes recombinant expression vectors comprising any of the nucleic acid molecules mentioned above, *i.e.*, nucleic acid molecules encoding any of the HCVR, LCVR, and/or CDR sequences as set forth in Table 1. Also included within the scope of the present disclosure are host cells into which such vectors have been introduced, as well as methods of producing the antibodies or portions thereof by culturing the host cells under conditions permitting production of the antibodies or antibody fragments,

and recovering the antibodies and antibody fragments so produced.

[0031] The present disclosure includes anti-PRLR antibodies having a modified glycosylation pattern. In some examples, modification to remove undesirable glycosylation sites may be useful, or an antibody lacking a fucose moiety present on the oligosaccharide chain, for example, to increase antibody dependent cellular cytotoxicity (ADCC) function (see Shield et al. (2002) JBC 277:26733). In other applications, modification of galactosylation can be made in order to modify complement dependent cytotoxicity (CDC).

[0032] In another example, disclosed herein is a pharmaceutical composition comprising a recombinant human antibody or fragment thereof which specifically binds PRLR and a pharmaceutically acceptable carrier. In a related example, the disclosure features a composition which is a combination of an anti-PRLR antibody and a second therapeutic agent. In one example, the second therapeutic agent is any agent that is advantageously combined with an anti-PRLR antibody. Disclosed herein are also antibody-drug conjugates (ADCs) comprising an anti-PRLR antibody conjugated to a cytotoxic agent. Exemplary combination therapies, co-formulations, and ADCs involving the anti-PRLR antibodies of the present disclosure are disclosed elsewhere herein. In one example, also disclosed herein is an isolated antibody or antigen-binding fragment that binds to cell surface-expressed human prolactin receptor (PRLR) and blocks prolactin-mediated signaling in cells expressing human PRLR, wherein the antibody or antigen-binding fragment thereof blocks prolactin-mediated signaling in cells expressing human PRLR with an IC_{50} of less than about 1.3 nM. In another example, also disclosed herein is an antibody-drug conjugate (ADC) comprising an antibody or antigen-binding fragment thereof that specifically binds cell-surface expressed human prolactin receptor (PRLR), wherein the antibody or fragment is conjugated to a cytotoxic agent, wherein the ADC inhibits the growth of cells expressing PRLR, and wherein the antibody or antigen-binding fragment thereof blocks prolactin-mediated signaling in cells expressing human PRLR with an IC_{50} of less than about 1.3 nM. In yet another example, also disclosed herein is an isolated antibody or antigen-binding fragment thereof that binds to cell surface-expressed prolactin receptor (PRLR) and blocks prolactin-mediated signaling in cells expressing PRLR, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain complementarity determining region (HCDR)-1 comprising SEQ ID NO:292; an HCDR2 comprising SEQ ID NO:294; an HCDR3 comprising SEQ ID NO:296; a light chain complementarity determining region (LCDR)-1 comprising SEQ ID NO:300; an LCDR2 comprising SEQ ID NO:302; and an LCDR3 comprising SEQ ID NO:304.

[0033] In yet another example, disclosed herein are therapeutic methods for killing tumor cells or for inhibiting or attenuating tumor cell growth using an anti-PRLR antibody or antigen-binding portion of an antibody of the disclosure. The therapeutic methods according to this example comprise administering a therapeutically effective amount of a pharmaceutical composition comprising an antibody or antigen-binding fragment of an antibody of the disclosure to a subject in need thereof. The disorder treated is any disease or condition which is improved, ameliorated, inhibited or prevented by targeting PRLR

and/or by inhibiting prolactin-mediated cell signaling through PRLR. In one aspect, the present invention refers to use of the antibody-drug conjugate (ADC) as disclosed herein in the manufacture of a medicament for killing cells that express low levels of cell-surface expressed PRLR.

[0033a] According to an aspect there is provided an isolated antibody or antigen-binding fragment that binds to cell surface-expressed human prolactin receptor (PRLR) and blocks prolactin-mediated signaling in cells expressing human PRLR, wherein the antibody or antigen-binding fragment blocks prolactin-mediated signaling in cells expressing human PRLR with an IC50 of less than about 1.3 nM, wherein:

(i) the antibody or antigen-binding fragment comprises complementarity determining regions (CDRs) having the sequences of SEQ ID NO: 292, SEQ ID NO: 294, SEQ ID NO: 296, SEQ ID NO: 300, SEQ ID NO: 302, and SEQ ID NO: 304;

(ii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 4, SEQ ID NO: 6, SEQ ID NO: 8, SEQ ID NO: 12, SEQ ID NO: 14, and SEQ ID NO: 16;

(iii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 20, SEQ ID NO: 22, SEQ ID NO: 24, SEQ ID NO: 28, SEQ ID NO: 30, and SEQ ID NO: 32;

(iv) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 52, SEQ ID NO: 54, SEQ ID NO: 56, SEQ ID NO: 60, SEQ ID NO: 62, and SEQ ID NO: 64;

(v) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 100, SEQ ID NO: 102, SEQ ID NO: 104, SEQ ID NO: 108, SEQ ID NO: 110, and SEQ ID NO: 112;

(vi) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 116, SEQ ID NO: 118, SEQ ID NO: 120, SEQ ID NO: 124, SEQ ID NO: 126, and SEQ ID NO: 128;

(vii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 132, SEQ ID NO: 134, SEQ ID NO: 136, SEQ ID NO: 140, SEQ ID NO: 142, and SEQ ID NO: 144;

(viii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 196, SEQ ID NO: 198, SEQ ID NO: 200, SEQ ID NO: 204, SEQ ID NO: 206, and SEQ ID NO: 208;

(ix) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 212, SEQ ID NO: 214, SEQ ID NO: 216, SEQ ID NO: 220, SEQ ID NO: 222, and SEQ ID NO: 224;

(x) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 228, SEQ ID NO: 230, SEQ ID NO: 232, SEQ ID NO: 236, SEQ ID NO: 238, and SEQ ID NO: 240;

(xi) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 260, SEQ ID NO: 262, SEQ ID NO: 264, SEQ ID NO: 268, SEQ ID NO: 270, and SEQ ID NO: 272;

(xii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 276, SEQ ID NO: 278, SEQ ID NO: 280, SEQ ID NO: 284, SEQ ID NO: 286, and SEQ ID

NO: 288;

(xiii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 356, SEQ ID NO: 358, SEQ ID NO: 360, SEQ ID NO: 364, SEQ ID NO: 366, and SEQ ID NO: 368; or

(xiv) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 372, SEQ ID NO: 374, SEQ ID NO: 376, SEQ ID NO: 380, SEQ ID NO: 382, and SEQ ID NO: 384.

[0033b] According to another aspect there is provided an antibody-drug conjugate (ADC) comprising an antibody or antigen-binding fragment thereof described herein conjugated to a cytotoxic agent.

[0033c] According to another aspect there is provided an antibody-drug conjugate (ADC) comprising an antibody or antigen-binding fragment thereof conjugated to DM1 via an N-succinimidyl 4-(N-maleimidomethyl)cyclohexane-1-carboxylate (SMCC) linker, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain complementarity determining region (HCDR) 1 comprising SEQ ID NO:292; an HCDR2 comprising SEQ ID NO:294; an HCDR3 comprising SEQ ID NO:296; a light chain complementarity determining region (LCDR)-1 comprising SEQ ID NO:300; an LCDR2 comprising SEQ ID NO:302; and an LCDR3 comprising SEQ ID NO:304.

[0033d] According to another aspect there is provided use of the antibody-drug conjugate (ADC) described herein in the manufacture of a medicament for killing tumor cells that express PRLR.

[0033e] According to another aspect there is provided use of the antibody-drug conjugate (ADC) described herein in the manufacture of a medicament for inhibiting or attenuating tumor growth.

[0033f] According to another aspect there is provided a pharmaceutical composition comprising the isolated antibody or antigen-binding fragment described herein and a pharmaceutically acceptable excipient.

[0033g] According to another aspect there is provided a pharmaceutical composition comprising the ADC described herein and a pharmaceutically acceptable excipient.

[0033h] According to another aspect there is provided use of the isolated antibody or antigen-binding fragment described herein in the manufacture of a medicament for inhibiting or attenuating tumor growth.

[0034] Other embodiments will become apparent from a review of the ensuing detailed description.

DETAILED DESCRIPTION

[0035] Before the present invention is described, it is to be understood that this invention is not limited to particular methods and experimental conditions described, as such methods and conditions may 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, since the scope of the present invention will be limited only by the appended claims.

[0036] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention

belongs. As used herein, the term "about," when used in reference to a particular recited numerical value, means that the value may vary from the recited value by no more than 1%. For example, as used herein, the expression "about 100" includes 99 and 101 and all values in between (*e.g.*, 99.1, 99.2, 99.3, 99.4, etc.).

[0037] Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are now described.

Definitions

[0038] The expression prolactin receptor, "PRLR," and the like, as used herein, refers to the human prolactin receptor, comprising the amino acid sequence as set forth in SEQ ID NO:404. The expression "PRLR" includes both monomeric and multimeric PRLR molecules. As used herein, the expression "monomeric human PRLR" means a PRLR protein or portion thereof that does not contain or possess any multimerizing domains and that exists under normal conditions as a single PRLR molecule without a direct physical connection to another PRLR molecule. An exemplary monomeric PRLR molecule is the molecule referred to herein as "hPRLR.mmh" comprising the amino acid sequence of SEQ ID NO:401 (*see, e.g.*, Example 3, herein). As used herein, the expression "dimeric human PRLR" means a construct comprising two PRLR molecules connected to one another through a linker, covalent bond, non-covalent bond, or through a multimerizing domain such as an antibody Fc domain. An exemplary dimeric PRLR molecule is the molecule referred to herein as "hPRLR.mFc" comprising the amino acid sequence of SEQ ID NO:402 (*see, e.g.*, Example 3, herein).

[0039] All references to proteins, polypeptides and protein fragments herein are intended to refer to the human version of the respective protein, polypeptide or protein fragment unless explicitly specified as being from a non-human species. Thus, the expression "PRLR" means human PRLR unless specified as being from a non-human species, *e.g.*, "mouse PRLR," "monkey PRLR," etc.

[0040] As used herein, the expression "cell surface-expressed PRLR" means one or more PRLR protein(s), or the extracellular domain thereof, that is/are expressed on the surface of a cell *in vitro* or *in vivo*, such that at least a portion of a PRLR protein is exposed to the extracellular side of the cell membrane and is accessible to an antigen-binding portion of an antibody. A "cell surface-expressed PRLR" can comprise or consist of a PRLR protein expressed on the surface of a cell which normally expresses PRLR protein. Alternatively, "cell surface-expressed PRLR" can comprise or consist of PRLR protein expressed on the surface of a cell that normally does not express human PRLR on its surface but has been artificially engineered to express PRLR on its surface.

[0041] As used herein, the expression "anti-PRLR antibody" includes both monovalent antibodies with a single specificity, as well as bispecific antibodies comprising a first arm that binds PRLR and a second arm that binds a second (target) antigen, wherein the anti-PRLR arm comprises any of the HCVR/LCVR or CDR sequences as set forth in Table 1 herein. The expression "anti-PRLR antibody" also includes antibody-drug conjugates (ADCs) comprising an anti-PRLR antibody or antigen-binding portion thereof conjugated to a drug or toxin (*i.e.,* cytotoxic agent). The expression "anti-PRLR antibody" also includes antibody-radionuclide

conjugates (ARCs) comprising an anti-PRLR antibody or antigen-binding portion thereof conjugated to a radionuclide.

[0042] The term "antibody", as used herein, means any antigen-binding molecule or molecular complex comprising at least one complementarity determining region (CDR) that specifically binds to or interacts with a particular antigen (*e.g.*, PRLR). The term "antibody" includes immunoglobulin molecules comprising four polypeptide chains, two heavy (H) chains and two light (L) chains inter-connected by disulfide bonds, as well as multimers thereof (*e.g.*, IgM). Each heavy chain comprises a heavy chain variable region (abbreviated herein as HCVR or V_H) and a heavy chain constant region. The heavy chain constant region comprises three domains, C_H1, C_H2 and C_H3. Each light chain comprises a light chain variable region (abbreviated herein as LCVR or V_L) and a light chain constant region. The light chain constant region comprises one domain (C_L1). The V_H and V_L regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDRs), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. In different embodiments of the invention, the FRs of the anti-PRLR antibody (or antigen-binding portion thereof) may be identical to the human germline sequences, or may be naturally or artificially modified. An amino acid consensus sequence may be defined based on a side-by-side analysis of two or more CDRs.

[0043] The term "antibody", as used herein, also includes antigen-binding fragments of full antibody molecules. The terms "antigen-binding portion" of an antibody, "antigen-binding fragment" of an antibody, and the like, as used herein, include any naturally occurring, enzymatically obtainable, synthetic, or genetically engineered polypeptide or glycoprotein that specifically binds an antigen to form a complex. Antigen-binding fragments of an antibody may be derived, *e.g.*, from full antibody molecules using any suitable standard techniques such as proteolytic digestion or recombinant genetic engineering techniques involving the manipulation and expression of DNA encoding antibody variable and optionally constant domains. Such DNA is known and/or is readily available from, *e.g.*, commercial sources, DNA libraries (including, *e.g.*, phage-antibody libraries), or can be synthesized. The DNA may be sequenced and manipulated chemically or by using molecular biology techniques, for example, to arrange one or more variable and/or constant domains into a suitable configuration, or to introduce codons, create cysteine residues, modify, add or delete amino acids, etc.

[0044] Non-limiting examples of antigen-binding fragments include: (i) Fab fragments; (ii) F(ab')2 fragments; (iii) Fd fragments; (iv) Fv fragments; (v) single-chain Fv (scFv) molecules; (vi) dAb fragments; and (vii) minimal recognition units consisting of the amino acid residues that mimic the hypervariable region of an antibody (*e.g.*, an isolated complementarity determining region (CDR) such as a CDR3 peptide), or a constrained FR3-CDR3-FR4 peptide. Other engineered molecules, such as domain-specific antibodies, single domain antibodies, domain-

deleted antibodies, chimeric antibodies, CDR-grafted antibodies, diabodies, triabodies, tetrabodies, minibodies, nanobodies (*e.g.* monovalent nanobodies, bivalent nanobodies, etc.), small modular immunopharmaceuticals (SMIPs), and shark variable IgNAR domains, are also encompassed within the expression "antigen-binding fragment," as used herein.

[0045] An antigen-binding fragment of an antibody will typically comprise at least one variable domain. The variable domain may be of any size or amino acid composition and will generally comprise at least one CDR which is adjacent to or in frame with one or more framework sequences. In antigen-binding fragments having a V_H domain associated with a V_L domain, the V_H and V_L domains may be situated relative to one another in any suitable arrangement. For example, the variable region may be dimeric and contain V_H-V_H, V_H-V_L or V_L-V_L dimers. Alternatively, the antigen-binding fragment of an antibody may contain a monomeric V_H or V_L domain.

[0046] In certain embodiments, an antigen-binding fragment of an antibody may contain at least one variable domain covalently linked to at least one constant domain. Non-limiting, exemplary configurations of variable and constant domains that may be found within an antigen-binding fragment of an antibody of the present invention include: (i) V_H-C_H1; (ii) V_H-C_H2; (iii) V_H-C_H3; (iv) V_H-C_H1-C_H2; (v) V_H-C_H1-C_H2-C_H3; (vi) V_H-C_H2-C_H3; (vii) V_H-C_L; (viii) V_L-C_H1; (ix) V_L-C_H2; (x) V_L-C_H3; (xi) V_L-C_H1-C_H2; (xii) V_L-C_H1-C_H2-C_H3; (xiii) V_L-C_H2-C_H3; and (xiv) V_L-C_L. In any configuration of variable and constant domains, including any of the exemplary configurations listed above, the variable and constant domains may be either directly linked to one another or may be linked by a full or partial hinge or linker region. A hinge region may consist of at least 2 (*e.g.*, 5, 10, 15, 20, 40, 60 or more) amino acids which result in a flexible or semi-flexible linkage between adjacent variable and/or constant domains in a single polypeptide molecule. Moreover, an antigen-binding fragment of an antibody of the present invention may comprise a homo-dimer or hetero-dimer (or other multimer) of any of the variable and constant domain configurations listed above in non-covalent association with one another and/or with one or more monomeric V_H or V_L domain (*e.g.*, by disulfide bond(s)).

[0047] As with full antibody molecules, antigen-binding fragments may be monospecific or multispecific (*e.g.*, bispecific). A multispecific antigen-binding fragment of an antibody will typically comprise at least two different variable domains, wherein each variable domain is capable of specifically binding to a separate antigen or to a different epitope on the same antigen. Any multispecific antibody format, including the exemplary bispecific antibody formats disclosed herein, may be adapted for use in the context of an antigen-binding fragment of an antibody of the present invention using routine techniques available in the art.

[0048] The antibodies of the present invention may function through complement-dependent cytotoxicity (CDC) or antibody-dependent cell-mediated cytotoxicity (ADCC). "Complement-dependent cytotoxicity" (CDC) refers to lysis of antigen-expressing cells by an antibody of the invention in the presence of complement. "Antibody-dependent cell-mediated cytotoxicity"

(ADCC) refers to a cell-mediated reaction in which nonspecific cytotoxic cells that express Fc receptors (FcRs) (*e.g.*, Natural Killer (NK) cells, neutrophils, and macrophages) recognize bound antibody on a target cell and thereby lead to lysis of the target cell. CDC and ADCC can be measured using assays that are well known and available in the art. (*See*, *e.g.*, U.S. Patent Nos 5,500,362 and 5,821,337, and Clynes *et al.* (1998) Proc. Natl. Acad. Sci. (USA) *95*:652-656). The constant region of an antibody is important in the ability of an antibody to fix complement and mediate cell-dependent cytotoxicity. Thus, the isotype of an antibody may be selected on the basis of whether it is desirable for the antibody to mediate cytotoxicity.

[0049] In certain embodiments of the invention, the anti-PRLR antibodies of the invention are human antibodies. The term "human antibody", as used herein, is intended to include antibodies having variable and constant regions derived from human germline immunoglobulin sequences. The human antibodies of the invention may include amino acid residues not encoded by human germline immunoglobulin sequences (e.g., mutations introduced by random or site-specific mutagenesis *in vitro* or by somatic mutation *in vivo*), for example in the CDRs and in particular CDR3. However, the term "human antibody", as used herein, is not intended to include antibodies in which CDR sequences derived from the germline of another mammalian species, such as a mouse, have been grafted onto human framework sequences.

[0050] The antibodies of the invention may, in some embodiments, be recombinant human antibodies. The term "recombinant human antibody", as used herein, is intended to include all human antibodies that are prepared, expressed, created or isolated by recombinant means, such as antibodies expressed using a recombinant expression vector transfected into a host cell (described further below), antibodies isolated from a recombinant, combinatorial human antibody library (described further below), antibodies isolated from an animal (e.g., a mouse) that is transgenic for human immunoglobulin genes (see e.g., Taylor et al. (1992) Nucl. Acids Res. 20:6287-6295) or antibodies prepared, expressed, created or isolated by any other means that involves splicing of human immunoglobulin gene sequences to other DNA sequences. Such recombinant human antibodies have variable and constant regions derived from human germline immunoglobulin sequences. In certain embodiments, however, such recombinant human antibodies are subjected to *in vitro* mutagenesis (or, when an animal transgenic for human Ig sequences is used, *in vivo* somatic mutagenesis) and thus the amino acid sequences of the V_H and V_L regions of the recombinant antibodies are sequences that, while derived from and related to human germline V_H and V_L sequences, may not naturally exist within the human antibody germline repertoire *in vivo*.

[0051] Human antibodies can exist in two forms that are associated with hinge heterogeneity. In one form, an immunoglobulin molecule comprises a stable four chain construct of approximately 150-160 kDa in which the dimers are held together by an interchain heavy chain disulfide bond. In a second form, the dimers are not linked via inter-chain disulfide bonds and a molecule of about 75-80 kDa is formed composed of a covalently coupled light and heavy chain

(half-antibody). These forms have been extremely difficult to separate, even after affinity purification.

[0052] The frequency of appearance of the second form in various intact IgG isotypes is due to, but not limited to, structural differences associated with the hinge region isotype of the antibody. A single amino acid substitution in the hinge region of the human IgG4 hinge can significantly reduce the appearance of the second form (Angal et al. (1993) Molecular Immunology 30:105) to levels typically observed using a human IgG1 hinge. The instant invention encompasses antibodies having one or more mutations in the hinge, C_H2 or C_H3 region which may be desirable, for example, in production, to improve the yield of the desired antibody form.

[0053] The antibodies of the invention may be isolated antibodies. An "isolated antibody," as used herein, means an antibody that has been identified and separated and/or recovered from at least one component of its natural environment. For example, an antibody that has been separated or removed from at least one component of an organism, or from a tissue or cell in which the antibody naturally exists or is naturally produced, is an "isolated antibody" for purposes of the present invention. An isolated antibody also includes an antibody *in situ* within a recombinant cell. Isolated antibodies are antibodies that have been subjected to at least one purification or isolation step. According to certain embodiments, an isolated antibody may be substantially free of other cellular material and/or chemicals.

[0054] The anti-PRLR antibodies disclosed herein may comprise one or more amino acid substitutions, insertions and/or deletions in the framework and/or CDR regions of the heavy and light chain variable domains as compared to the corresponding germline sequences from which the antibodies were derived. Such mutations can be readily ascertained by comparing the amino acid sequences disclosed herein to germline sequences available from, for example, public antibody sequence databases. The present invention includes antibodies, and antigen-binding fragments thereof, which are derived from any of the amino acid sequences disclosed herein, wherein one or more amino acids within one or more framework and/or CDR regions are mutated to the corresponding residue(s) of the germline sequence from which the antibody was derived, or to the corresponding residue(s) of another human germline sequence, or to a conservative amino acid substitution of the corresponding germline residue(s) (such sequence changes are referred to herein collectively as "germline mutations"). A person of ordinary skill in the art, starting with the heavy and light chain variable region sequences disclosed herein, can easily produce numerous antibodies and antigen-binding fragments which comprise one or more individual germline mutations or combinations thereof. In certain embodiments, all of the framework and/or CDR residues within the V_H and/or V_L domains are mutated back to the residues found in the original germline sequence from which the antibody was derived. In other embodiments, only certain residues are mutated back to the original germline sequence, *e.g.*, only the mutated residues found within the first 8 amino acids of FR1 or within the last 8 amino

acids of FR4, or only the mutated residues found within CDR1, CDR2 or CDR3. In other embodiments, one or more of the framework and/or CDR residue(s) are mutated to the corresponding residue(s) of a different germline sequence (*i.e.*, a germline sequence that is different from the germline sequence from which the antibody was originally derived). Furthermore, the antibodies of the present invention may contain any combination of two or more germline mutations within the framework and/or CDR regions, *e.g.*, wherein certain individual residues are mutated to the corresponding residue of a particular germline sequence while certain other residues that differ from the original germline sequence are maintained or are mutated to the corresponding residue of a different germline sequence. Once obtained, antibodies and antigen-binding fragments that contain one or more germline mutations can be easily tested for one or more desired property such as, improved binding specificity, increased binding affinity, improved or enhanced antagonistic or agonistic biological properties (as the case may be), reduced immunogenicity, etc. Antibodies and antigen-binding fragments obtained in this general manner are encompassed within the present invention.

[0055] The present invention also includes anti-PRLR antibodies comprising variants of any of the HCVR, LCVR, and/or CDR amino acid sequences disclosed herein having one or more conservative substitutions. For example, the present invention includes anti-PRLR antibodies having HCVR, LCVR, and/or CDR amino acid sequences with, *e.g.*, 10 or fewer, 8 or fewer, 6 or fewer, 4 or fewer, etc. conservative amino acid substitutions relative to any of the HCVR, LCVR, and/or CDR amino acid sequences set forth in Table 1 herein.

[0056] The term "epitope" refers to an antigenic determinant that interacts with a specific antigen binding site in the variable region of an antibody molecule known as a paratope. A single antigen may have more than one epitope. Thus, different antibodies may bind to different areas on an antigen and may have different biological effects. Epitopes may be either conformational or linear. A conformational epitope is produced by spatially juxtaposed amino acids from different segments of the linear polypeptide chain. A linear epitope is one produced by adjacent amino acid residues in a polypeptide chain. In certain circumstance, an epitope may include moieties of saccharides, phosphoryl groups, or sulfonyl groups on the antigen.

[0057] The term "substantial identity" or "substantially identical," when referring to a nucleic acid or fragment thereof, indicates that, when optimally aligned with appropriate nucleotide insertions or deletions with another nucleic acid (or its complementary strand), there is nucleotide sequence identity in at least about 95%, and more preferably at least about 96%, 97%, 98% or 99% of the nucleotide bases, as measured by any well-known algorithm of sequence identity, such as FASTA, BLAST or Gap, as discussed below. A nucleic acid molecule having substantial identity to a reference nucleic acid molecule may, in certain instances, encode a polypeptide having the same or substantially similar amino acid sequence as the polypeptide encoded by the reference nucleic acid molecule.

[0058] As applied to polypeptides, the term "substantial similarity" or "substantially similar"

means that two peptide sequences, when optimally aligned, such as by the programs GAP or BESTFIT using default gap weights, share at least 95% sequence identity, even more preferably at least 98% or 99% sequence identity. Preferably, residue positions which are not identical differ by conservative amino acid substitutions. A "conservative amino acid substitution" is one in which an amino acid residue is substituted by another amino acid residue having a side chain (R group) with similar chemical properties (e.g., charge or hydrophobicity). In general, a conservative amino acid substitution will not substantially change the functional properties of a protein. In cases where two or more amino acid sequences differ from each other by conservative substitutions, the percent sequence identity or degree of similarity may be adjusted upwards to correct for the conservative nature of the substitution. Means for making this adjustment are well-known to those of skill in the art. *See, e.g.*, Pearson (1994) Methods Mol. Biol. 24: 307-331. Examples of groups of amino acids that have side chains with similar chemical properties include (1) aliphatic side chains: glycine, alanine, valine, leucine and isoleucine; (2) aliphatic-hydroxyl side chains: serine and threonine; (3) amide-containing side chains: asparagine and glutamine; (4) aromatic side chains: phenylalanine, tyrosine, and tryptophan; (5) basic side chains: lysine, arginine, and histidine; (6) acidic side chains: aspartate and glutamate, and (7) sulfur-containing side chains are cysteine and methionine. Preferred conservative amino acids substitution groups are: valine-leucine-isoleucine, phenylalanine-tyrosine, lysine-arginine, alanine-valine, glutamate-aspartate, and asparagine-glutamine. Alternatively, a conservative replacement is any change having a positive value in the PAM250 log-likelihood matrix disclosed in Gonnet *et al.* (1992) Science 256: 1443-1445. A "moderately conservative" replacement is any change having a nonnegative value in the PAM250 log-likelihood matrix.

[0059] Sequence similarity for polypeptides, which is also referred to as sequence identity, is typically measured using sequence analysis software. Protein analysis software matches similar sequences using measures of similarity assigned to various substitutions, deletions and other modifications, including conservative amino acid substitutions. For instance, GCG software contains programs such as Gap and Bestfit which can be used with default parameters to determine sequence homology or sequence identity between closely related polypeptides, such as homologous polypeptides from different species of organisms or between a wild type protein and a mutein thereof. *See, e.g.*, GCG Version 6.1. Polypeptide sequences also can be compared using FASTA using default or recommended parameters, a program in GCG Version 6.1. FASTA (e.g., FASTA2 and FASTA3) provides alignments and percent sequence identity of the regions of the best overlap between the query and search sequences (Pearson (2000) supra). Another preferred algorithm when comparing a sequence of the invention to a database containing a large number of sequences from different organisms is the computer program BLAST, especially BLASTP or TBLASTN, using default parameters. *See, e.g.*, Altschul *et al.* (1990) J. Mol. Biol. 215:403-410 and Altschul *et al.* (1997) Nucleic Acids Res. 25:3389-402.

pH-Dependent Binding

[0060] The present invention includes anti-PRLR antibodies with pH-dependent binding characteristics. For example, an anti-PRLR antibody of the present invention may exhibit reduced binding to PRLR at acidic pH as compared to neutral pH. Alternatively, anti-PRLR antibodies of the invention may exhibit enhanced binding to PRLR at acidic pH as compared to neutral pH. The expression "acidic pH" includes pH values less than about 6.2, *e.g.*, about 6.0, 5.95, 5,9, 5.85, 5.8, 5.75, 5.7, 5.65, 5.6, 5.55, 5.5, 5.45, 5.4, 5.35, 5.3, 5.25, 5.2, 5.15, 5.1, 5.05, 5.0, or less. As used herein, the expression "neutral pH" means a pH of about 7.0 to about 7.4. The expression "neutral pH" includes pH values of about 7.0, 7.05, 7.1, 7.15, 7.2, 7.25, 7.3, 7.35, and 7.4.

[0061] In certain instances, "reduced binding to PRLR at acidic pH as compared to neutral pH" is expressed in terms of a ratio of the K_D value of the antibody binding to PRLR at acidic pH to the K_D value of the antibody binding to PRLR at neutral pH (or vice versa). For example, an antibody or antigen-binding fragment thereof may be regarded as exhibiting "reduced binding to PRLR at acidic pH as compared to neutral pH" for purposes of the present invention if the antibody or antigen-binding fragment thereof exhibits an acidic/neutral K_D ratio of about 3.0 or greater. In certain exemplary embodiments, the acidic/neutral K_D ratio for an antibody or antigen-binding fragment of the present invention can be about 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 20.0. 25.0, 30.0, 40.0, 50.0, 60.0, 70.0, 100.0 or greater.

[0062] Antibodies with pH-dependent binding characteristics may be obtained, *e.g.*, by screening a population of antibodies for reduced (or enhanced) binding to a particular antigen at acidic pH as compared to neutral pH. Additionally, modifications of the antigen-binding domain at the amino acid level may yield antibodies with pH-dependent characteristics. For example, by substituting one or more amino acids of an antigen-binding domain (*e.g.*, within a CDR) with a histidine residue, an antibody with reduced antigen-binding at acidic pH relative to neutral pH may be obtained.

Anti-PRLR Antibodies Comprising Fc Variants

[0063] According to certain embodiments of the present invention, anti-PRLR antibodies are provided comprising an Fc domain comprising one or more mutations which enhance or diminish antibody binding to the FcRn receptor, *e.g.*, at acidic pH as compared to neutral pH. For example, the present invention includes anti-PRLR antibodies comprising a mutation in the C_H2 or a C_H3 region of the Fc domain, wherein the mutation(s) increases the affinity of the Fc domain to FcRn in an acidic environment (*e.g.,* in an endosome where pH ranges from about 5.5 to about 6.0). Such mutations may result in an increase in serum half-life of the antibody when administered to an animal. Non-limiting examples of such Fc modifications include, *e.g.*, a modification at position 250 (e.g., E or Q); 250 and 428 (e.g., L or F); 252 (e.g., L/Y/F/W or T), 254 (e.g., S or T), and 256 (e.g., S/R/Q/E/D or T); or a modification at position 428 and/or 433

(e.g., H/L/R/S/P/Q or K) and/or 434 (*e.g.,* H/F or Y); or a modification at position 250 and/or 428; or a modification at position 307 or 308 (*e.g.,* 308F, V308F), and 434. In one embodiment, the modification comprises a 428L (*e.g.,* M428L) and 434S (*e.g.,* N434S) modification; a 428L, 259I (*e.g.,* V259I), and 308F (*e.g.,* V308F) modification; a 433K (*e.g.,* H433K) and a 434 (*e.g.,* 434Y) modification; a 252, 254, and 256 (*e.g.,* 252Y, 254T, and 256E) modification; a 250Q and 428L modification (*e.g.,* T250Q and M428L); and a 307 and/or 308 modification (*e.g.,* 308F or 308P).

[0064] For example, the present invention includes anti-PRLR antibodies comprising an Fc domain comprising one or more pairs or groups of mutations selected from the group consisting of: 250Q and 248L (*e.g.*, T250Q and M248L); 252Y, 254T and 256E (*e.g.*, M252Y, S254T and T256E); 428L and 434S (*e.g.*, M428L and N434S); and 433K and 434F (*e.g.*, H433K and N434F). All possible combinations of the foregoing Fc domain mutations, and other mutations within the antibody variable domains disclosed herein, are contemplated within the scope of the present invention.

Biological Characteristics of the Antibodies

[0065] The present invention includes antibodies and antigen-binding fragments thereof that bind monomeric human PRLR with high affinity. For example, the present invention includes anti-PRLR antibodies that bind monomeric human PRLR (*e.g.*, hPRLR.mmh) with a K_D of less than about 4.0 nM as measured by surface plasmon resonance at 25°C or 37°C, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay. According to certain embodiments, anti-PRLR antibodies are provided that bind monomeric human PRLR at 37°C with a K_D of less than about 4 nM, less than about 3 nM, less than about 2 nM, less than about 1 nM, less than about 900 pM, less than about 800 pM, less than about 700 pM, less than about 600 pM, less than about 500 pM, less than about 400 pM, or less than about 300 pM, as measured by surface plasmon resonance, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay.

[0066] The present invention also includes antibodies and antigen-binding fragments thereof that bind monomeric human PRLR (*e.g.*, hPRLR.mmh) with a dissociative half-life (t½) of greater than about 5 minutes as measured by surface plasmon resonance at 25°C or 37°C, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay. According to certain embodiments, anti-PRLR antibodies are provided that bind monomeric human PRLR at 37°C with a t½ of greater than about 5 minutes, greater than about 6 minutes, greater than about 8 minutes, greater than about 10 minutes, greater than about 12 minutes, greater than about 14 minutes, greater than about 16 minutes, greater than about 18 minutes, greater than about 20 minutes, greater than about 30 minutes, greater than about 40 minutes, or longer, as measured by surface plasmon resonance, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay.

[0067] The present invention also includes antibodies and antigen-binding fragments thereof that bind dimeric human PRLR (*e.g.*, hPRLR.mFc) with high affinity. For example, the present

invention includes anti-PRLR antibodies that bind dimeric human PRLR with a K_D of less than about 250 pM as measured by surface plasmon resonance at 25°C or 37°C, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay. According to certain embodiments, anti-PRLR antibodies are provided that bind dimeric human PRLR at 37°C with a K_D of less than about 250 pM, less than about 200 pM, less than about 180 pM, less than about 160 pM, less than about 140 pM, less than about 120 pM, less than about 100 pM, less than about 80 pM, less than about 70 pM, or less than about 60 pM, as measured by surface plasmon resonance, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay.

[0068] The present invention also includes antibodies and antigen-binding fragments thereof that bind dimeric human PRLR (*e.g.*, hPRLR.mFc) with a dissociative half-life (t½) of greater than about 55 minutes as measured by surface plasmon resonance at 25°C or 37°C, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay. According to certain embodiments, anti-PRLR antibodies are provided that bind dimeric human PRLR at 37°C with a t½ of greater than about 55 minutes, greater than about 60 minutes, greater than about 65 minutes, greater than about 70 minutes, greater than about 75 minutes, greater than about 80 minutes, greater than about 85 minutes, greater than about 90 minutes, greater than about 95 minutes, greater than about 100 minutes, greater than about 120 minutes, greater than about 140 minutes, greater than about 160 minutes, or longer, as measured by surface plasmon resonance, *e.g.*, using an assay format as defined in Example 3 herein, or a substantially similar assay.

[0069] The present invention also includes antibodies and antigen-binding fragments thereof that bind PRLR and block prolactin-mediated signaling in cells expressing human PRLR. For example, the present invention includes anti-PRLR antibodies that block prolactin-mediated signaling in cells that express human PRLR, with an IC_{50} of less than about 1.3 nM as measured using a prolactin signaling blocking assay, *e.g.*, using an assay format as defined in Example 5 herein, or a substantially similar assay. According to certain embodiments, anti-PRLR antibodies are provided that block prolactin-mediated signaling in cells expressing human PRLR, with an IC_{50} of less than about 1.3 nM, less than about 1.2 nM, less than about 1.0 nM, less than about 900 pM, less than about 800 pM, less than about 600 pM, less than about 400 pM, less than about 200 pM, less than about 100 pM, less than about 80 pM, less than about 60 pM, less than about 40 pM, less than about 20 pM as measured using a prolactin signaling blocking assay, *e.g.*, using an assay format as defined in Example 5 herein, or a substantially similar assay.

[0070] The present invention also includes antibodies and antigen-binding fragments thereof that bind PRLR but do not block prolactin-mediated signaling in cells expressing human PRLR. As used herein, an antibody or antigen-binding fragment thereof "does not block" prolactin-mediated signaling if, when tested in a prolactin signaling blocking assay such as the assay

defined in Example 5 herein or a substantially similar assay, the antibody exhibits no or only negligible blocking activity. According to certain embodiments, an antibody or antigen-binding fragment "does not block" prolactin-mediated signaling if the antibody exhibits an IC_{50} value of greater than about 10 nM, or greater than about 100 nM when tested in a prolactin signaling blocking assay such as the assay defined in Example 5 herein or a substantially similar assay.

[0071] The antibodies of the present invention may possess one or more of the aforementioned biological characteristics, or any combination thereof. The foregoing list of biological characteristics of the antibodies of the invention is not intended to be exhaustive. Other biological characteristics of the antibodies of the present invention will be evident to a person of ordinary skill in the art from a review of the present disclosure including the working Examples herein.

Antibody-Drug Conjugates (ADCs)

[0072] The present invention provides antibody-drug conjugates (ADCs) comprising an anti-PRLR antibody or antigen-binding fragment thereof conjugated to a therapeutic moiety such as a cytotoxic agent, a chemotherapeutic drug, or a radioisotope.

[0073] Cytotoxic agents include any agent that is detrimental to the growth, viability or propagation of cells. Examples of suitable cytotoxic agents and chemotherapeutic agents that can be conjugated to anti-PRLR antibodies in accordance with this aspect of the invention include, *e.g.*, 1-(2chloroethyl)-1,2-dimethanesulfonyl hydrazide, 1,8-dihydroxy-bicyclo[7.3.1]trideca-4,9-diene-2,6-diyne-13-one, 1-dehydrotestosterone, 5-fluorouracil, 6-mercaptopurine, 6-thioguanine, 9-amino camptothecin, actinomycin D, amanitins, aminopterin, anguidine, anthracycline, anthramycin (AMC), auristatins, bleomycin, busulfan, butyric acid, calicheamicins, camptothecin, carminomycins, carmustine, cemadotins, cisplatin, colchicin, combretastatins, cyclophosphamide, cytarabine, cytochalasin B, dactinomycin, daunorubicin, decarbazine, diacetoxypentyldoxorubicin, dibromomannitol, dihydroxy anthracin dione, disorazoles, dolastatin (*e.g.*, dolastatin 10), doxorubicin, duocarmycin, echinomycins, eleutherobins, emetine, epothilones, esperamicin, estramustines, ethidium bromide, etoposide, fluorouracils, geldanamycins, gramicidin D, glucocorticoids, irinotecans, kinesin spindle protein (KSP) inhibitors, leptomycins, leurosines, lidocaine, lomustine (CCNU), maytansinoids, mechlorethamine, melphalan, mercatopurines, methopterins, methotrexate, mithramycin, mitomycin, mitoxantrone, N8-acetyl spermidine, podophyllotoxins, procaine, propranolol, pteridines, puromycin, pyrrolobenzodiazepines (PBDs), rhizoxins, streptozotocin, tallysomycins, taxol, tenoposide, tetracaine, thioepa chlorambucil, tomaymycins, topotecans, tubulysin, vinblastine, vincristine, vindesine, vinorelbines, and derivatives of any of the foregoing. According to certain embodiments, the cytotoxic agent that is conjugated to an anti-PRLR antibody is a maytansinoid such as DM1 or DM4, a tomaymycin derivative, or a dolastatin derivative. According to certain embodiments, the cytotoxic agent that is conjugated to an anti-PRLR antibody is an auristatin such as MMAE, MMAF, or derivatives thereof. Other cytotoxic

agents known in the art are contemplated within the scope of the present invention, including, *e.g.*, protein toxins such ricin, *C. difficile* toxin, pseudomonas exotoxin, ricin, diphtheria toxin, botulinum toxin, bryodin, saporin, pokeweed toxins (*i.e.*, phytolaccatoxin and phytolaccigenin), and others such as those set forth in Sapra *et al.*, *Pharmacol. & Therapeutics*, 2013, 138:452-469.

[0074] The present invention also includes antibody-radionuclide conjugates (ARCs) comprising anti-PRLR antibodies conjugated to one or more radionuclides. Exemplary radionuclides that can be used in the context of this aspect of the invention include, but are not limited to, *e.g.*, ^{225}Ac, ^{212}Bi, ^{213}Bi, ^{131}I, ^{186}Re, ^{227}Th, ^{222}Rn, ^{223}Ra, ^{224}Ra, and ^{90}Y.

[0075] In certain embodiments of the present invention, ADCs are provided comprising an anti-PRLR conjugated to a cytotoxic agent (*e.g.*, any of the cytotoxic agents disclosed above) via a linker molecule. Any linker molecule or linker technology known in the art can be used to create or construct an ADC of the present invention. In certain embodiments, the linker is a cleavable linker. According to other embodiments, the linker is a non-cleavable linker. Exemplary linkers that can be used in the context of the present invention include, linkers that comprise or consist of *e.g.*, MC (6-maleimidocaproyl), MP (maleimidopropanoyl), val-cit (valine-citrulline), val-ala (valine-alanine), dipeptide site in protease-cleavable linker, ala-phe (alanine-phenylalanine), dipeptide site in protease-cleavable linker, PAB (p-aminobenzyloxycarbonyl), SPP (N-Succinimidyl 4-(2-pyridylthio) pentanoate), SMCC (N-Succinimidyl 4-(N-maleimidomethyl)cyclohexane-1 carboxylate), SIAB (N-Succinimidyl (4-iodo-acetyl)aminobenzoate), and variants and combinations thereof. Additional examples of linkers that can be used in the context of the present invention are disclosed, *e.g.*, in US 7,754,681 and in Ducry, Bioconjugate Chem., 2010, *21*:5-13, and the references cited therein.

[0076] The present invention comprises ADCs in which a linker connects an anti-PRLR antibody or antigen-binding molecule to a drug or cytotoxin through an attachment at a particular amino acid within the antibody or antigen-binding molecule. Exemplary amino acid attachments that can be used in the context of this aspect of the invention include, *e.g.*, lysine (*see*, e.g., US 5,208,020; US 2010/0129314; Hollander *et al.*, *Bioconjugate Chem.*, 2008, 19:358-361; WO 2005/089808; US 5,714,586; US 2013/0101546; and US 2012/0585592), cysteine (*see*, e.g., US 2007/0258987; WO 2013/055993; WO 2013/055990; WO 2013/053873; WO 2013/053872; WO 2011/130598; US 2013/0101546; and US 7,750,116), selenocysteine (*see*, e.g., WO 2008/122039; and Hofer *et al.*, *Proc. Natl. Acad. Sci., USA, 2008, 105*:12451-12456), formyl glycine (*see*, e.g., Carrico *et al.*, *Nat. Chem. Biol.*, 2007, 3:321-322; Agarwal *et al.*, *Proc. Natl. Acad. Sci., USA, 2013, 110*:46-51, and Rabuka *et al.*, *Nat. Protocols*, 2012, *10*:1052-1067), non-natural amino acids (*see*, *e.g.*, WO 2013/068874, and WO 2012/166559), and acidic amino acids (*see*, *e.g.*, WO 2012/05982). Linkers can also be conjugated to an antigen-binding protein via attachment to carbohydrates (*see*, *e.g.*, US 2008/0305497, WO 2014/065661, and Ryan *et al.*, *Food & Agriculture Immunol.*, 2001, *13*:127-130) and disulfide

linkers (*see, e.g.*, WO 2013/085925, WO 2010/010324, WO 2011/018611, and Shaunak *et al.*, *Nat. Chem. Biol.*, 2006, 2:312-313).

[0077] According to certain embodiments, the present invention provides ADCs, wherein an anti-PRLR antibody as described herein is conjugated to a linker-drug composition as set forth in International Patent Application No. PCT/US14/29757, filed on March 14, 2014 (*e.g.*, compound "7," also referred to herein as "M0026").

[0078] Any method known in the art for conjugating a chemical moiety to a peptide, polypeptide or other macromolecule can be used in the context of the present invention to make an anti-PRLR ADC as described herein. An exemplary method for antibody-drug conjugation via a linker is set forth in Example 6 herein. Variations on this exemplary method will be appreciated by persons of ordinary skill in the art and are contemplated within the scope of the present invention.

Targeting ADCs to Cells Expressing Low Levels of PRLR

[0079] It was surprisingly discovered by the present inventors that ADCs comprising an anti-PRLR antibody conjugated to a cytotoxic agent are able to specifically target and kill cells that express relatively low levels of cell surface PRLR. For example, in Example 7 herein, it is shown that an ADC comprising anti-PRLR antibody H1H6953N conjugated to DM1 was able to inhibit the growth of T47D cells (expressing PRLR at only 12X above background) with an IC_{50} of 1.3 nM and showed 78% killing. By contrast, ADCs against other tumor-associated antigens such as ErbB2 typically require much higher expression levels of the target antigen on cells for comparable killing potencies. For example, cell killing in the sub-nanomolar IC_{50} range was obtained with an anti-ErbB2-DM1 ADC only with cells that express ErbB2 at levels of greater than about 200X to about 400X above background (*see, e.g.*, Tables 14-17 herein). The ability to kill tumor cells that express relatively low levels of tumor-associated antigen such as PRLR means that the anti-PRLR ADCs of the present invention can provide significant therapeutic benefits with a lower dose and/or less frequent dosing than is required for ADCs that target other tumor antigens such as ErbB2.

[0080] Accordingly, the present invention provides antibody-drug conjugates (ADCs) comprising an antibody or antigen-binding fragment thereof that specifically binds human PRLR conjugated to a cytotoxic agent, wherein the ADCs effectively kill cells (*e.g.*, tumor cells) that express low levels of PRLR. In related embodiments, the present invention includes methods for effectively killing cells that express low levels of PRLR. The methods according to this aspect of the invention comprise contacting the cells with an antibody-drug conjugate (ADC) comprising an anti-PRLR antibody conjugated to a cytotoxic agent. "Contacting the cells" can be carried out *in vitro*, or *in vivo*, *e.g.*, by administering an anti-PRLR ADC to a subject in need thereof, wherein the administration causes the ADC to come into contact with cells expressing PRLR.

[0081] According to certain contexts envisioned within the scope of the present invention, a

"low level of PRLR" means an expression level of less than about 30-fold above background. According to certain embodiments, anti-PRLR ADCs are provided which effectively kill cells that express PRLR at an expression level of less than about 30-fold, 25-fold, 20-fold, 18-fold, 16-fold, 14-fold, 12-fold, 10-fold, 8-fold, or less, above background. As used herein, the term "background" means the (non-specific) signal produced when cells are treated with an isotype control antibody (*i.e.*, not specific for PRLR).

[0082] In certain other contexts, a "low level of PRLR" can be expressed in terms of the number of PRLR molecules per cell. For example, as used herein, a cell that expresses a "low level" of PRLR expresses less than about 1 million copies of PRLR per cell. In specific embodiments, a "low level" of PRLR means less than about 900,000 copies, less than about 800,000 copies, less than about 700,000 copies, less than about 600,000 copies, less than about 500,000 copies, less than about 400,000 copies, less than about 300,000 copies, less than about 200,000 copies, less than about 100,000 copies, less than about 90,000 copies, less than about 80,000 copies, less than about 70,000 copies, less than about 60,000 copies, less than about 50,000 copies, less than about 40,000 copies, less than about 30,000 copies, less than about 20,000 copies, or less than about 10,000 copies of PRLR per cell.

[0083] As used herein, "effective killing" means that the ADC exhibits an IC_{50} of less than about 20 nM, or less than about 1 nM (*e.g.*, less than about 0.9 nM, less than about 0.8 nM, less than about 0.7 nM, less than about 0.6 nM, less than about 0.5 nM, less than about 0.4 nM, or less than about 0.3 nM) in a tumor cell killing assay, such as the assay defined in Example 7 herein, or a substantially similar assay. According to this aspect of the invention, the anti-PRLR antibody component of the ADC can be any anti-PRLR antibody including anti-PRLR antibodies comprising any of the CDR or HCVR/LCVR amino acid sequences as set forth in Table 1 herein. Additionally, the cytotoxic agent component of the ADC can be any cytotoxic agent, such as DM1, or any other cytotoxic agent mentioned herein.

[0084] ADCs of the present invention are able to inhibit tumor growth and/or reduce tumor size in PRLR+ tumor-bearing animals. For example, as shown in Example 8 herein, anti-PRLR-DM1 ADCs were shown to reduce tumors to undetectable levels in mice bearing PRLR+ breast cancer xenografts. Thus, the present invention includes anti-PRLR antibodies and ADCs comprising such antibodies, wherein the antibodies or ADCs, when administered to a PRLR+ tumor-bearing animal (*e.g.*, at a frequency of about once a week, and a dose of about 1 to 15 mg/kg), inhibit tumor growth and/or reduce tumor size (*e.g.*, tumor growth inhibition of 100% or greater) by Day 52 post-administration or sooner.

Class I Cytokine Receptor Targeting

[0085] PRLR belongs to the class I cytokine receptor family. As explained above and demonstrated in the working examples herein, it was unexpectedly discovered that antibody-drug conjugates (ADCs) comprising anti-PRLR antibodies can effectively target and kill cells that express low levels of PRLR (*see* Example 7 herein). Furthermore, it was shown that ADCs

against other class I cytokine receptors (IL-4R and IL-6R) also are able to potently kill cell lines expressing relatively low levels of target antigen (*see* Example 9 herein). This property is in contrast to ADCs against other cell surface-expressed proteins, such as ErbB2, wherein effective cell killing requires high target expression. Moreover, it was also surprisingly discovered that anti-PRLR antibodies are internalized substantially faster than anti-Her2 antibodies on tumor cells (*e.g.*, T47D tumor cells), and that this property is correlated with faster internalization and degradation of cell surface PRLR compared to cell surface Her2.

[0086] In view of the results set forth herein, the present inventors conceived that the ability to target and kill cells that express low levels of cell surface antigen may be a common property shared by ADCs directed against class I cytokine receptors in general, and in particular class I cytokine receptors that are rapidly internalized. Thus, the present invention includes methods for targeting class I cytokine receptors (*e.g.*, rapidly internalizing class I cytokine receptors), and methods for killing cells that express class I cytokine receptors such as cells that express low levels of class I cytokine receptors.

[0087] The methods according to this aspect of the invention comprise contacting a cell that expresses a class I cytokine receptor with an ADC comprising an antibody or antigen-binding fragment thereof that specifically binds the class I cytokine receptor. According to certain embodiments, the cell to be targeted expresses low levels (as that expression is defined elsewhere herein) of a class I cytokine receptor and/or a class I cytokine receptor that is rapidly internalized and degraded (*e.g.*, internalized faster than a reference cell surface molecule such as Her2). Also included within the present invention are ADCs comprising an antibody or antigen-binding fragment thereof that specifically binds a class I cytokine receptor, conjugated to a cytotoxic agent. Any of the cytotoxic agents, linkers, and/or ADC-related technologies described elsewhere herein can be used in the context of this aspect of the invention.

[0088] As used herein a "class I cytokine receptor" (also sometimes referred to as a "type I cytokine receptor") means a transmembrane receptor expressed on the surface of cells that recognizes and responds to cytokines with four alpha-helical strands. As explained below, class I cytokine receptors can be heterodimeric or homodimeric. As used herein, the term "class I cytokine receptor" includes both heterodimeric and homodimeric receptors.

[0089] Heterodimeric class I cytokine receptors consist of a cytokine-specific chain and a "common chain." Accordingly, such heterodimeric class I cytokine receptors can be classified based on the type of common chain used by the receptor for signaling. Exemplary categories of heterodimeric class I cytokine receptors include: (i) common gamma chain-containing heterodimeric receptors such as IL-2R, IL-4R, IL-7R, IL-9R, IL-13R and IL-15R; (ii) common beta chain-containing heterodimeric receptors such as GM-CSF receptor, IL-3R and IL-5R; and (iii) gp130-containing heterodimeric receptors such as IL-6R, IL-11R, CNTF receptor, leukemia inhibitory factor (LIF) receptor, oncostatin M (OSM) receptor, and IL-12 receptor.

[0090] Homodimeric class I cytokine receptors include growth hormone (GH) receptor,

erythropoietin (EPO) receptor, G-CSF receptor, leptin receptor, and PRLR.

[0091] In certain embodiments of this aspect of the invention, the ADC comprises an antibody or antigen-binding fragment thereof that specifically binds a heterodimeric class I cytokine receptor. According to other embodiments of this aspect of the invention, the ADC comprises an antibody or antigen-binding fragment thereof that specifically binds a homodimeric class I cytokine receptor.

[0092] The present invention includes methods for killing a cell that expresses low levels of a heterodimeric class I cytokine receptor. The methods according to this aspect of the invention comprise contacting a cell that expresses a low level of a heterodimeric class I cytokine receptor with an ADC comprising an antibody or antigen-binding fragment thereof that specifically binds the heterodimeric class I cytokine receptor.

[0093] Alternatively, the present invention includes methods for killing a cell that expresses low levels of a homodimeric class I cytokine receptor. The methods according to this aspect of the invention comprise contacting a cell that expresses a low level of a homodimeric class I cytokine receptor with an ADC comprising an antibody or antigen-binding fragment thereof that specifically binds the homodimeric class I cytokine receptor.

Epitope Mapping and Related Technologies

[0094] The epitope to which the antibodies of the present invention bind may consist of a single contiguous sequence of 3 or more (*e.g.*, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 or more) amino acids of a PRLR protein. Alternatively, the epitope may consist of a plurality of non-contiguous amino acids (or amino acid sequences) of PRLR. In some embodiments, the epitope is located on or near the prolactin-binding domain of PRLR. In other embodiments, the epitope is located outside of the prolactin-binding domain of PRLR, *e.g.*, at a location on the surface of PRLR at which an antibody, when bound to such an epitope, does not interfere with prolactin binding to PRLR.

[0095] Various techniques known to persons of ordinary skill in the art can be used to determine whether an antibody "interacts with one or more amino acids" within a polypeptide or protein. Exemplary techniques include, *e.g.*, routine cross-blocking assay such as that described Antibodies, Harlow and Lane (Cold Spring Harbor Press, Cold Spring Harb., NY), alanine scanning mutational analysis, peptide blots analysis (Reineke, 2004, Methods Mol Biol 248:443-463), and peptide cleavage analysis. In addition, methods such as epitope excision, epitope extraction and chemical modification of antigens can be employed (Tomer, 2000, Protein Science 9:487-496). Another method that can be used to identify the amino acids within a polypeptide with which an antibody interacts is hydrogen/deuterium exchange detected by mass spectrometry. In general terms, the hydrogen/deuterium exchange method involves deuterium-labeling the protein of interest, followed by binding the antibody to the deuterium-labeled protein. Next, the protein/antibody complex is transferred to water to allow hydrogen-deuterium exchange to occur at all residues except for the residues protected by the antibody

(which remain deuterium-labeled). After dissociation of the antibody, the target protein is subjected to protease cleavage and mass spectrometry analysis, thereby revealing the deuterium-labeled residues which correspond to the specific amino acids with which the antibody interacts. *See, e.g.*, Ehring (1999) *Analytical Biochemistry* 267(2):252-259; Engen and Smith (2001) *Anal. Chem. 73*:256A-265A.

[0096] The present invention further includes anti-PRLR antibodies that bind to the same epitope as any of the specific exemplary antibodies described herein (*e.g.* antibodies comprising any of the amino acid sequences as set forth in Table 1 herein). Likewise, the present invention also includes anti-PRLR antibodies that compete for binding to PRLR with any of the specific exemplary antibodies described herein (*e.g.* antibodies comprising any of the amino acid sequences as set forth in Table 1 herein).

[0097] One can easily determine whether an antibody binds to the same epitope as, or competes for binding with, a reference anti-PRLR antibody by using routine methods known in the art and exemplified herein. For example, to determine if a test antibody binds to the same epitope as a reference anti-PRLR antibody of the invention, the reference antibody is allowed to bind to a PRLR protein. Next, the ability of a test antibody to bind to the PRLR molecule is assessed. If the test antibody is able to bind to PRLR following saturation binding with the reference anti-PRLR antibody, it can be concluded that the test antibody binds to a different epitope than the reference anti-PRLR antibody. On the other hand, if the test antibody is not able to bind to the PRLR molecule following saturation binding with the reference anti-PRLR antibody, then the test antibody may bind to the same epitope as the epitope bound by the reference anti-PRLR antibody of the invention. Additional routine experimentation (*e.g.*, peptide mutation and binding analyses) can then be carried out to confirm whether the observed lack of binding of the test antibody is in fact due to binding to the same epitope as the reference antibody or if steric blocking (or another phenomenon) is responsible for the lack of observed binding. Experiments of this sort can be performed using ELISA, RIA, Biacore, flow cytometry or any other quantitative or qualitative antibody-binding assay available in the art. In accordance with certain embodiments of the present invention, two antibodies bind to the same (or overlapping) epitope if, *e.g.*, a 1-, 5-, 10-, 20- or 100-fold excess of one antibody inhibits binding of the other by at least 50% but preferably 75%, 90% or even 99% as measured in a competitive binding assay (see, e.g., Junghans et al., Cancer Res. 1990:50:1495-1502). Alternatively, two antibodies are deemed to bind to the same epitope if essentially all amino acid mutations in the antigen that reduce or eliminate binding of one antibody reduce or eliminate binding of the other. Two antibodies are deemed to have "overlapping epitopes" if only a subset of the amino acid mutations that reduce or eliminate binding of one antibody reduce or eliminate binding of the other.

[0098] To determine if an antibody competes for binding (or cross-competes for binding) with a reference anti-PRLR antibody, the above-described binding methodology is performed in two

orientations: In a first orientation, the reference antibody is allowed to bind to a PRLR protein under saturating conditions followed by assessment of binding of the test antibody to the PRLR molecule. In a second orientation, the test antibody is allowed to bind to a PRLR molecule under saturating conditions followed by assessment of binding of the reference antibody to the PRLR molecule. If, in both orientations, only the first (saturating) antibody is capable of binding to the PRLR molecule, then it is concluded that the test antibody and the reference antibody compete for binding to PRLR. As will be appreciated by a person of ordinary skill in the art, an antibody that competes for binding with a reference antibody may not necessarily bind to the same epitope as the reference antibody, but may sterically block binding of the reference antibody by binding an overlapping or adjacent epitope.

Preparation of Human Antibodies

[0099] The anti-PRLR antibodies of the present invention can be fully human antibodies. Methods for generating monoclonal antibodies, including fully human monoclonal antibodies are known in the art. Any such known methods can be used in the context of the present invention to make human antibodies that specifically bind to human PRLR.

[0100] Using VELOCIMMUNE™ technology, for example, or any other similar known method for generating fully human monoclonal antibodies, high affinity chimeric antibodies to PRLR are initially isolated having a human variable region and a mouse constant region. As in the experimental section below, the antibodies are characterized and selected for desirable characteristics, including affinity, ligand blocking activity, selectivity, epitope, etc. If necessary, mouse constant regions are replaced with a desired human constant region, for example wild-type or modified IgG1 or IgG4, to generate a fully human anti-PRLR antibody. While the constant region selected may vary according to specific use, high affinity antigen-binding and target specificity characteristics reside in the variable region. In certain instances, fully human anti-PRLR antibodies are isolated directly from antigen-positive B cells.

Bioequivalents

[0101] The anti-PRLR antibodies and antibody fragments of the present invention encompass proteins having amino acid sequences that vary from those of the described antibodies but that retain the ability to bind human PRLR. Such variant antibodies and antibody fragments comprise one or more additions, deletions, or substitutions of amino acids when compared to parent sequence, but exhibit biological activity that is essentially equivalent to that of the described antibodies. Likewise, the anti-PRLR antibody-encoding DNA sequences of the present invention encompass sequences that comprise one or more additions, deletions, or substitutions of nucleotides when compared to the disclosed sequence, but that encode an anti-PRLR antibody or antibody fragment that is essentially bioequivalent to an anti-PRLR antibody or antibody fragment of the invention. Examples of such variant amino acid and DNA sequences are discussed above.

[0102] Two antigen-binding proteins, or antibodies, are considered bioequivalent if, for example, they are pharmaceutical equivalents or pharmaceutical alternatives whose rate and extent of absorption do not show a significant difference when administered at the same molar dose under similar experimental conditions, either single does or multiple dose. Some antibodies will be considered equivalents or pharmaceutical alternatives if they are equivalent in the extent of their absorption but not in their rate of absorption and yet may be considered bioequivalent because such differences in the rate of absorption are intentional and are reflected in the labeling, are not essential to the attainment of effective body drug concentrations on, *e.g.*, chronic use, and are considered medically insignificant for the particular drug product studied.

[0103] In one embodiment, two antigen-binding proteins are bioequivalent if there are no clinically meaningful differences in their safety, purity, and potency.

[0104] In one embodiment, two antigen-binding proteins are bioequivalent if a patient can be switched one or more times between the reference product and the biological product without an expected increase in the risk of adverse effects, including a clinically significant change in immunogenicity, or diminished effectiveness, as compared to continued therapy without such switching.

[0105] In one embodiment, two antigen-binding proteins are bioequivalent if they both act by a common mechanism or mechanisms of action for the condition or conditions of use, to the extent that such mechanisms are known.

[0106] Bioequivalence may be demonstrated by in vivo and in vitro methods. Bioequivalence measures include, e.g., (a) an in vivo test in humans or other mammals, in which the concentration of the antibody or its metabolites is measured in blood, plasma, serum, or other biological fluid as a function of time; (b) an in vitro test that has been correlated with and is reasonably predictive of human in vivo bioavailability data; (c) an in vivo test in humans or other mammals in which the appropriate acute pharmacological effect of the antibody (or its target) is measured as a function of time; and (d) in a well-controlled clinical trial that establishes safety, efficacy, or bioavailability or bioequivalence of an antibody.

[0107] Bioequivalent variants of anti-PRLR antibodies of the invention may be constructed by, for example, making various substitutions of residues or sequences or deleting terminal or internal residues or sequences not needed for biological activity. For example, cysteine residues not essential for biological activity can be deleted or replaced with other amino acids to prevent formation of unnecessary or incorrect intramolecular disulfide bridges upon renaturation. In other contexts, bioequivalent antibodies may include anti-PRLR antibody variants comprising amino acid changes which modify the glycosylation characteristics of the antibodies, *e.g.*, mutations which eliminate or remove glycosylation.

Species Selectivity and Species Cross-Reactivity

[0108] The present invention, according to certain embodiments, provides anti-PRLR

antibodies that bind to human PRLR but not to PRLR from other species. The present invention also includes anti-PRLR antibodies that bind to human PRLR and to PRLR from one or more non-human species. For example, the anti-PRLR antibodies of the invention may bind to human PRLR and may bind or not bind, as the case may be, to one or more of mouse, rat, guinea pig, hamster, gerbil, pig, cat, dog, rabbit, goat, sheep, cow, horse, camel, cynomologous, marmoset, rhesus or chimpanzee PRLR. According to certain exemplary embodiments of the present invention, anti-PRLR antibodies are provided which specifically bind human PRLR and cynomolgus monkey (*e.g.*, *Macaca fascicularis*) PRLR. Other anti-PRLR antibodies of the invention bind human PRLR but do not bind, or bind only weakly, to cynomolgus monkey PRLR.

Multispecific Antibodies

[0109] The antibodies of the present invention may be monospecific or multispecific (*e.g.*, bispecific). Multispecific antibodies may be specific for different epitopes of one target polypeptide or may contain antigen-binding domains specific for more than one target polypeptide. See, e.g., Tutt et al., 1991, J. Immunol. 147:60-69; Kufer *et al.*, 2004, Trends Biotechnol. 22:238-244. The anti-PRLR antibodies of the present invention can be linked to or co-expressed with another functional molecule, e.g., another peptide or protein. For example, an antibody or fragment thereof can be functionally linked (e.g., by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other molecular entities, such as another antibody or antibody fragment to produce a bi-specific or a multispecific antibody with a second binding specificity.

[0110] The present invention includes bispecific antibodies wherein one arm of an immunoglobulin binds human PRLR, and the other arm of the immunoglobulin is specific for a second antigen. The PRLR-binding arm can comprise any of the HCVR/LCVR or CDR amino acid sequences as set forth in Table 1 herein. In certain embodiments, the PRLR-binding arm binds human PRLR and blocks prolactin binding to PRLR. In other embodiments, the PRLR-binding arm binds human PRLR but does not block prolactin binding to PRLR.

[0111] An exemplary bispecific antibody format that can be used in the context of the present invention involves the use of a first immunoglobulin (Ig) C_H3 domain and a second Ig C_H3 domain, wherein the first and second Ig C_H3 domains differ from one another by at least one amino acid, and wherein at least one amino acid difference reduces binding of the bispecific antibody to Protein A as compared to a bi-specific antibody lacking the amino acid difference. In one embodiment, the first Ig C_H3 domain binds Protein A and the second Ig C_H3 domain contains a mutation that reduces or abolishes Protein A binding such as an H95R modification (by IMGT exon numbering; H435R by EU numbering). The second C_H3 may further comprise a Y96F modification (by IMGT; Y436F by EU). Further modifications that may be found within the second C_H3 include: D16E, L18M, N44S, K52N, V57M, and V82I (by IMGT; D356E, L358M, N384S, K392N, V397M, and V422I by EU) in the case of IgG1 antibodies; N44S, K52N, and V82I (IMGT; N384S, K392N, and V422I by EU) in the case of IgG2 antibodies; and Q15R,

N44S, K52N, V57M, R69K, E79Q, and V82I (by IMGT; Q355R, N384S, K392N, V397M, R409K, E419Q, and V422I by EU) in the case of IgG4 antibodies. Variations on the bispecific antibody format described above are contemplated within the scope of the present invention.

[0112] Other exemplary bispecific formats that can be used in the context of the present invention include, without limitation, *e.g.*, scFv-based or diabody bispecific formats, IgG-scFv fusions, dual variable domain (DVD)-Ig, Quadroma, knobs-into-holes, common light chain (*e.g.*, common light chain with knobs-into-holes, etc.), CrossMab, CrossFab, (SEED)body, leucine zipper, Duobody, IgG1/IgG2, dual acting Fab (DAF)-IgG, and Mab^2 bispecific formats (*see, e.g.*, Klein *et al.* 2012, mAbs 4:6, 1-11, and references cited therein, for a review of the foregoing formats). Bispecific antibodies can also be constructed using peptide/nucleic acid conjugation, *e.g.*, wherein unnatural amino acids with orthogonal chemical reactivity are used to generate site-specific antibody-oligonucleotide conjugates which then self-assemble into multimeric complexes with defined composition, valency and geometry. (*See, e.g.*, Kazane *et al.*, *J. Am. Chem. Soc.* [*Epub*: *Dec. 4, 2012*]).

Therapeutic Formulation and Administration

[0113] The invention provides pharmaceutical compositions comprising the anti-PRLR antibodies or antigen-binding fragments thereof of the present invention. The pharmaceutical compositions of the invention are formulated with suitable carriers, excipients, and other agents that provide improved transfer, delivery, tolerance, and the like. A multitude of appropriate formulations can be found in the formulary known to all pharmaceutical chemists: Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, PA. These formulations include, for example, powders, pastes, ointments, jellies, waxes, oils, lipids, lipid (cationic or anionic) containing vesicles (such as LIPOFECTIN™, Life Technologies, Carlsbad, CA), DNA conjugates, anhydrous absorption pastes, oil-in-water and water-in-oil emulsions, emulsions carbowax (polyethylene glycols of various molecular weights), semi-solid gels, and semi-solid mixtures containing carbowax. See also Powell et al. "Compendium of excipients for parenteral formulations" PDA (1998) J Pharm Sci Technol 52:238-311.

[0114] The dose of antibody administered to a patient may vary depending upon the age and the size of the patient, target disease, conditions, route of administration, and the like. The preferred dose is typically calculated according to body weight or body surface area. In an adult patient, it may be advantageous to intravenously administer the antibody of the present invention normally at a single dose of about 0.01 to about 20 mg/kg body weight, more preferably about 0.02 to about 7, about 0.03 to about 5, or about 0.05 to about 3 mg/kg body weight. Depending on the severity of the condition, the frequency and the duration of the treatment can be adjusted. Effective dosages and schedules for administering anti-PRLR antibodies may be determined empirically; for example, patient progress can be monitored by periodic assessment, and the dose adjusted accordingly. Moreover, interspecies scaling of dosages can be performed using well-known methods in the art (*e.g.*, Mordenti *et al.*, 1991,

Pharmaceut. Res. 8:1351).

[0115] Various delivery systems are known and can be used to administer the pharmaceutical composition of the invention, *e.g.*, encapsulation in liposomes, microparticles, microcapsules, recombinant cells capable of expressing the mutant viruses, receptor mediated endocytosis (see, e.g., Wu et al., 1987, J. Biol. Chem. 262:4429-4432). Methods of introduction include, but are not limited to, intradermal, intramuscular, intraperitoneal, intravenous, subcutaneous, intranasal, epidural, and oral routes. The composition may be administered by any convenient route, for example by infusion or bolus injection, by absorption through epithelial or mucocutaneous linings (e.g., oral mucosa, rectal and intestinal mucosa, etc.) and may be administered together with other biologically active agents. Administration can be systemic or local.

[0116] A pharmaceutical composition of the present invention can be delivered subcutaneously or intravenously with a standard needle and syringe. In addition, with respect to subcutaneous delivery, a pen delivery device readily has applications in delivering a pharmaceutical composition of the present invention. Such a pen delivery device can be reusable or disposable. A reusable pen delivery device generally utilizes a replaceable cartridge that contains a pharmaceutical composition. Once all of the pharmaceutical composition within the cartridge has been administered and the cartridge is empty, the empty cartridge can readily be discarded and replaced with a new cartridge that contains the pharmaceutical composition. The pen delivery device can then be reused. In a disposable pen delivery device, there is no replaceable cartridge. Rather, the disposable pen delivery device comes prefilled with the pharmaceutical composition held in a reservoir within the device. Once the reservoir is emptied of the pharmaceutical composition, the entire device is discarded.

[0117] Numerous reusable pen and autoinjector delivery devices have applications in the subcutaneous delivery of a pharmaceutical composition of the present invention. Examples include, but are not limited to AUTOPEN™ (Owen Mumford, Inc., Woodstock, UK), DISETRONIC™ pen (Disetronic Medical Systems, Bergdorf, Switzerland), HUMALOG MIX 75/25™ pen, HUMALOG™ pen, HUMALIN 70/30™ pen (Eli Lilly and Co., Indianapolis, IN), NOVOPEN™ I, II and III (Novo Nordisk, Copenhagen, Denmark), NOVOPEN JUNIOR™ (Novo Nordisk, Copenhagen, Denmark), BD™ pen (Becton Dickinson, Franklin Lakes, NJ), OPTIPEN™, OPTIPEN PRO™, OPTIPEN STARLET™, and OPTICLIK™ (sanofi-aventis, Frankfurt, Germany), to name only a few. Examples of disposable pen delivery devices having applications in subcutaneous delivery of a pharmaceutical composition of the present invention include, but are not limited to the SOLOSTAR™ pen (sanofi-aventis), the FLEXPEN™ (Novo Nordisk), and the KWIKPEN™ (Eli Lilly), the SURECLICK™ Autoinjector (Amgen, Thousand Oaks, CA), the PENLET™ (Haselmeier, Stuttgart, Germany), the EPIPEN (Dey, L.P.), and the HUMIRA™ Pen (Abbott Labs, Abbott Park IL), to name only a few.

[0118] In certain situations, the pharmaceutical composition can be delivered in a controlled

release system. In one embodiment, a pump may be used (see Langer, supra; Sefton, 1987, CRC Crit. Ref. Biomed. Eng. 14:201). In another embodiment, polymeric materials can be used; see, Medical Applications of Controlled Release, Langer and Wise (eds.), 1974, CRC Pres., Boca Raton, Florida. In yet another embodiment, a controlled release system can be placed in proximity of the composition's target, thus requiring only a fraction of the systemic dose (see, *e.g.*, Goodson, 1984, in Medical Applications of Controlled Release, supra, vol. 2, pp. 115-138). Other controlled release systems are discussed in the review by Langer, 1990, Science 249:1527-1533.

[0119] The injectable preparations may include dosage forms for intravenous, subcutaneous, intracutaneous and intramuscular injections, drip infusions, etc. These injectable preparations may be prepared by methods publicly known. For example, the injectable preparations may be prepared, *e.g.*, by dissolving, suspending or emulsifying the antibody or its salt described above in a sterile aqueous medium or an oily medium conventionally used for injections. As the aqueous medium for injections, there are, for example, physiological saline, an isotonic solution containing glucose and other auxiliary agents, etc., which may be used in combination with an appropriate solubilizing agent such as an alcohol (e.g., ethanol), a polyalcohol (e.g., propylene glycol, polyethylene glycol), a nonionic surfactant [e.g., polysorbate 80, HCO-50 (polyoxyethylene (50 mol) adduct of hydrogenated castor oil)], etc. As the oily medium, there are employed, e.g., sesame oil, soybean oil, etc., which may be used in combination with a solubilizing agent such as benzyl benzoate, benzyl alcohol, etc. The injection thus prepared is preferably filled in an appropriate ampoule.

[0120] Advantageously, the pharmaceutical compositions for oral or parenteral use described above are prepared into dosage forms in a unit dose suited to fit a dose of the active ingredients. Such dosage forms in a unit dose include, for example, tablets, pills, capsules, injections (ampoules), suppositories, etc. The amount of the aforesaid antibody contained is generally about 5 to about 500 mg per dosage form in a unit dose; especially in the form of injection, it is preferred that the aforesaid antibody is contained in about 5 to about 100 mg and in about 10 to about 250 mg for the other dosage forms.

Therapeutic Uses of the Antibodies

[0121] The present invention includes methods comprising administering to a subject in need thereof a therapeutic composition comprising an anti-PRLR antibody or an antibody-drug conjugate comprising an anti-PRLR antibody (*e.g.*, an anti-PRLR antibody or ADC comprising any of the HCVR/LCVR or CDR sequences as set forth in Table 1 herein). The therapeutic composition can comprise any of the anti-PRLR antibodies, antigen-binding fragments thereof, or ADCs disclosed herein, and a pharmaceutically acceptable carrier or diluent.

[0122] The antibodies and ADCs of the invention are useful, *inter alia*, for the treatment, prevention and/or amelioration of any disease or disorder associated with or mediated by PRLR expression or activity, or treatable by blocking the interaction between PRLR and prolactin or

otherwise inhibiting PRLR activity and/or signaling, and/or promoting receptor internalization and/or decreasing cell surface receptor number. For example, the antibodies and ADCs of the present invention are useful for the treatment of tumors that express PRLR and/or that respond to prolactin-mediated signaling, *e.g.*, breast tumors. The antibodies and antigen-binding fragments of the present invention may also be used to treat primary and/or metastatic tumors arising in the brain and meninges, oropharynx, lung and bronchial tree, gastrointestinal tract, male and female reproductive tract, muscle, bone, skin and appendages, connective tissue, spleen, immune system, blood forming cells and bone marrow, liver and urinary tract, and special sensory organs such as the eye. In certain embodiments, the antibodies and ADCs of the invention are used to treat one or more of the following cancers: renal cell carcinoma, pancreatic carcinoma, head and neck cancer, prostate cancer, malignant gliomas, osteosarcoma, colorectal cancer, gastric cancer (*e.g.*, gastric cancer with MET amplification), malignant mesothelioma, multiple myeloma, ovarian cancer, small cell lung cancer, non-small cell lung cancer, synovial sarcoma, thyroid cancer, breast cancer, or melanoma.

[0123] The anti-PRLR antibodies of the present invention are also useful for the treatment or prevention of one or more diseases or disorders selected from the group consisting of endometriosis, adenomyosis, non-hormonal female fertility contraception, benign breast disease and mastalgia, lactation inhibition, benign prostate hyperplasia, fibroids, hyper- and normoprolactinemic hair loss, and as part of hormone therapy to inhibit mammary epithelial cell proliferation.

[0124] In the context of the methods of treatment described herein, the anti-PRLR antibody may be administered as a monotherapy (*i.e.*, as the only therapeutic agent) or in combination with one or more additional therapeutic agents (examples of which are described elsewhere herein).

[0125] The present invention includes methods for identifying patients who are treatable with an antibody or ADC of the present invention by assaying for high levels of PRLR expression in one or more tissues of the patient such as a tumor tissue. In a related embodiment, the present invention includes methods for treating cancers characterized by high level expression of PRLR. For example, the present invention includes methods of treatment comprising administering an anti-PRLR antibody of the invention, or ADC thereof (*e.g.*, any of the anti-PRLR ADCs described elsewhere herein), to a subject with a tumor, wherein the tumor has been identified as expressing high levels of PRLR. In certain embodiments, the tumor is identified as expressing high levels of PRLR by immunohistochemistry of a biopsy sample or other imaging techniques such as, *e.g.*, immuno-PET imaging, etc.

Combination Therapies and Formulations

[0126] The present invention includes compositions and therapeutic formulations comprising any of the anti-PRLR antibodies described herein in combination with one or more additional therapeutically active components, and methods of treatment comprising administering such

combinations to subjects in need thereof.

[0127] The anti-PRLR antibodies of the present invention may be co-formulated with and/or administered in combination with one or more additional therapeutically active component(s) selected from the group consisting of: an EGFR antagonist (*e.g.*, an anti-EGFR antibody [*e.g.*, cetuximab or panitumumab] or small molecule inhibitor of EGFR [*e.g.*, gefitinib or erlotinib]), an antagonist of another EGFR family member such as Her2/ErbB2, ErbB3 or ErbB4 (*e.g.*, anti-ErbB2 [*e.g.*, trastuzumab or T-DM1 {KADCYLA®}], anti-ErbB3 or anti-ErbB4 antibody or small molecule inhibitor of ErbB2, ErbB3 or ErbB4 activity), an antagonist of EGFRvIII (*e.g.*, an antibody that specifically binds EGFRvIII), a cMET anagonist (*e.g.*, an anti-cMET antibody), an IGF1R antagonist (*e.g.*, an anti-IGF1R antibody), a B-raf inhibitor (*e.g.*, vemurafenib, sorafenib, GDC-0879, PLX-4720), a PDGFR-α inhibitor (*e.g.*, an anti-PDGFR-α antibody), a PDGFR-β inhibitor (*e.g.*, an anti-PDGFR-β antibody or small molecule kinase inhibitor such as, *e.g.*, imatinib mesylate or sunitinib malate), a PDGF ligand inhibitor (*e.g.*, anti-PDGF-A, -B, -C, or -D antibody, aptamer, siRNA, etc.), a VEGF antagonist (*e.g.*, a VEGF-Trap such as aflibercept, *see*, *e.g.*, US 7,087,411 (also referred to herein as a "VEGF-inhibiting fusion protein"), anti-VEGF antibody (*e.g.*, bevacizumab), a small molecule kinase inhibitor of VEGF receptor (*e.g.*, sunitinib, sorafenib or pazopanib)), a DLL4 antagonist (*e.g.*, an anti-DLL4 antibody disclosed in US 2009/0142354 such as REGN421), an Ang2 antagonist (*e.g.*, an anti-Ang2 antibody disclosed in US 2011/0027286 such as H1H685P), a FOLH1 antagonist (*e.g.*, an anti-FOLH1 antibody), a STEAP1 or STEAP2 antagonist (*e.g.*, an anti-STEAP1 antibody or an anti-STEAP2 antibody), a TMPRSS2 antagonist (*e.g.*, an anti-TMPRSS2 antibody), a MSLN antagonist (*e.g.*, an anti-MSLN antibody), a CA9 antagonist (*e.g.*, an anti-CA9 antibody), a uroplakin antagonist (*e.g.*, an anti-uroplakin [*e.g.*, anti-UPK3A] antibody), a MUC16 antagonist (*e.g.*, an anti-MUC16 antibody), a Tn antigen antagonist (*e.g.*, an anti-Tn antibody), a CLEC12A antagonist (*e.g.*, an anti- CLEC12A antibody), a TNFRSF17 antagonist (*e.g.*, an anti-TNFRSF17 antibody), a LGR5 antagonist (*e.g.*, an anti-LGR5 antibody), a monovalent CD20 antagonist (*e.g.*, a monovalent anti-CD20 antibody such as rituximab), etc. Other agents that may be beneficially administered in combination with antibodies of the invention include, *e.g.*, tamoxifen, aromatase inhibitors, and cytokine inhibitors, including small-molecule cytokine inhibitors and antibodies that bind to cytokines such as IL-1, IL-2, IL-3, IL-4, IL-5, IL-6, IL-8, IL-9, IL-11, IL-12, IL-13, IL-17, IL-18, or to their respective receptors.

[0128] The present invention includes compositions and therapeutic formulations comprising any of the anti-PRLR antibodies described herein in combination with one or more chemotherapeutic agents. Examples of chemotherapeutic agents include alkylating agents such as thiotepa and cyclosphosphamide (Cytoxan™); alkyl sulfonates such as busulfan, improsulfan and piposulfan; aziridines such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines including altretamine, triethylenemelamine, trietylenephosphoramide, triethylenethiophosphaoramide and trimethylolomelamine; nitrogen

mustards such as chlorambucil, chlornaphazine, cholophosphamide, estramustine, ifosfamide, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, uracil mustard; nitrosureas such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, ranimustine; antibiotics such as aclacinomysins, actinomycin, authramycin, azaserine, bleomycins, cactinomycin, calicheamicin, carabicin, carminomycin, carzinophilin, chromomycins, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, doxorubicin, epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins, mycophenolic acid, nogalamycin, olivomycins, peplomycin, potfiromycin, puromycin, quelamycin, rodorubicin, streptonigrin, streptozocin, tubercidin, ubenimex, zinostatin, zorubicin; anti-metabolites such as methotrexate and 5-fluorouracil (5-FU); folic acid analogues 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; amsacrine; bestrabucil; bisantrene; edatraxate; defofamine; demecolcine; diaziquone; elfornithine; elliptinium acetate; etoglucid; gallium nitrate; hydroxyurea; lentinan; lonidamine; mitoguazone; mitoxantrone; mopidamol; nitracrine; pentostatin; phenamet; pirarubicin; podophyllinic acid; 2-ethylhydrazide; procarbazine; PSK™; razoxane; sizofiran; spirogermanium; tenuazonic acid; triaziquone; 2,2',2''-trichlorotriethylamine; urethan; vindesine; dacarbazine; mannomustine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); cyclophosphamide; thiotepa; taxanes, e.g. paclitaxel (Taxol™, Bristol-Myers Squibb Oncology, Princeton, N.J.) and docetaxel (Taxotere™; Aventis Antony, France); chlorambucil; gemcitabine; 6-thioguanine; mercaptopurine; methotrexate; platinum analogs such as cisplatin and carboplatin; vinblastine; platinum; etoposide (VP-16); ifosfamide; mitomycin C; mitoxantrone; vincristine; vinorelbine; navelbine; novantrone; teniposide; daunomycin; aminopterin; xeloda; ibandronate; CPT-11; topoisomerase inhibitor RFS 2000; difluoromethylornithine (DMFO); retinoic acid; esperamicins; capecitabine; and pharmaceutically acceptable salts, acids or derivatives of any of the above. Also included in this definition are anti-hormonal agents that act to regulate or inhibit hormone action on tumors such as anti-estrogens including for example tamoxifen, raloxifene, aromatase inhibiting 4(5)-imidazoles, 4-hydroxytamoxifen, trioxifene, keoxifene, LY 117018, onapristone, and toremifene (Fareston); and anti-androgens such as flutamide, nilutamide, bicalutamide, leuprolide, and goserelin; and pharmaceutically acceptable salts, acids or derivatives of any of the above.

[0129] The anti-PRLR antibodies of the invention may also be administered and/or co-formulated in combination with antivirals, antibiotics, analgesics, corticosteroids, steroids, oxygen, antioxidants, COX inhibitors, cardioprotectants, metal chelators, IFN-gamma, and/or

NSAIDs.

[0130] The additional therapeutically active component(s), *e.g.*, any of the agents listed above or derivatives thereof, may be administered just prior to, concurrent with, or shortly after the administration of an anti-PRLR antibody of the present invention; (for purposes of the present disclosure, such administration regimens are considered the administration of an anti-PRLR antibody "in combination with" an additional therapeutically active component). The present invention includes pharmaceutical compositions in which an anti-PRLR antibody of the present invention is co-formulated with one or more of the additional therapeutically active component(s) as described elsewhere herein.

Administration Regimens

[0131] According to certain embodiments of the present invention, multiple doses of an anti-PRLR antibody (or a pharmaceutical composition comprising a combination of an anti-PRLR antibody and any of the additional therapeutically active agents mentioned herein) may be administered to a subject over a defined time course. The methods according to this aspect of the invention comprise sequentially administering to a subject multiple doses of an anti-PRLR antibody of the invention. As used herein, "sequentially administering" means that each dose of anti-PRLR antibody is administered to the subject at a different point in time, *e.g.*, on different days separated by a predetermined interval (*e.g.*, hours, days, weeks or months). The present invention includes methods which comprise sequentially administering to the patient a single initial dose of an anti-PRLR antibody, followed by one or more secondary doses of the anti-PRLR antibody, and optionally followed by one or more tertiary doses of the anti-PRLR antibody.

[0132] The terms "initial dose," "secondary doses," and "tertiary doses," refer to the temporal sequence of administration of the anti-PRLR antibody of the invention. Thus, the "initial dose" is the dose which is administered at the beginning of the treatment regimen (also referred to as the "baseline dose"); the "secondary doses" are the doses which are administered after the initial dose; and the "tertiary doses" are the doses which are administered after the secondary doses. The initial, secondary, and tertiary doses may all contain the same amount of anti-PRLR antibody, but generally may differ from one another in terms of frequency of administration. In certain embodiments, however, the amount of anti-PRLR antibody contained in the initial, secondary and/or tertiary doses varies from one another (*e.g.*, adjusted up or down as appropriate) during the course of treatment. In certain embodiments, two or more (*e.g.*, 2, 3, 4, or 5) doses are administered at the beginning of the treatment regimen as "loading doses" followed by subsequent doses that are administered on a less frequent basis (*e.g.*, "maintenance doses").

[0133] In certain exemplary embodiments of the present invention, each secondary and/or tertiary dose is administered 1 to 26 (*e.g.*, 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 5½, 6, 6½, 7, 7½, 8, 8½, 9, 9½, 10, 10½, 11, 11½, 12, 12½, 13, 13½, 14, 14½, 15, 15½, 16, 16½, 17, 17½, 18, 18½,

19, 19½, 20, 20½, 21, 21½, 22, 22½, 23, 23½, 24, 24½, 25, 25½, 26, 26½, or more) weeks after the immediately preceding dose. The phrase "the immediately preceding dose," as used herein, means, in a sequence of multiple administrations, the dose of anti-PRLR antibody which is administered to a patient prior to the administration of the very next dose in the sequence with no intervening doses.

[0134] The methods according to this aspect of the invention may comprise administering to a patient any number of secondary and/or tertiary doses of an anti-PRLR antibody. For example, in certain embodiments, only a single secondary dose is administered to the patient. In other embodiments, two or more (*e.g.*, 2, 3, 4, 5, 6, 7, 8, or more) secondary doses are administered to the patient. Likewise, in certain embodiments, only a single tertiary dose is administered to the patient. In other embodiments, two or more (*e.g.*, 2, 3, 4, 5, 6, 7, 8, or more) tertiary doses are administered to the patient. The administration regimen may be carried out indefinitely over the lifetime of a particular subject, or until such treatment is no longer therapeutically needed or advantageous.

[0135] In embodiments involving multiple secondary doses, each secondary dose may be administered at the same frequency as the other secondary doses. For example, each secondary dose may be administered to the patient 1 to 2 weeks or 1 to 2 months after the immediately preceding dose. Similarly, in embodiments involving multiple tertiary doses, each tertiary dose may be administered at the same frequency as the other tertiary doses. For example, each tertiary dose may be administered to the patient 2 to 12 weeks after the immediately preceding dose. In certain embodiments of the invention, the frequency at which the secondary and/or tertiary doses are administered to a patient can vary over the course of the treatment regimen. The frequency of administration may also be adjusted during the course of treatment by a physician depending on the needs of the individual patient following clinical examination.

[0136] The present invention includes administration regimens in which 2 to 6 loading doses are administered to a patient at a first frequency (*e.g.*, once a week, once every two weeks, once every three weeks, once a month, once every two months, etc.), followed by administration of two or more maintenance doses to the patient on a less frequent basis. For example, according to this aspect of the invention, if the loading doses are administered at a frequency of once a month, then the maintenance doses may be administered to the patient once every six weeks, once every two months, once every three months, etc.

Diagnostic Uses of the Antibodies

[0137] The anti-PRLR antibodies of the present invention may also be used to detect and/or measure PRLR, or PRLR-expressing cells in a sample, *e.g.*, for diagnostic purposes. For example, an anti-PRLR antibody, or fragment thereof, may be used to diagnose a condition or disease characterized by aberrant expression (*e.g.*, over-expression, under-expression, lack of expression, etc.) of PRLR. Exemplary diagnostic assays for PRLR may comprise, *e.g.*,

contacting a sample, obtained from a patient, with an anti-PRLR antibody of the invention, wherein the anti-PRLR antibody is labeled with a detectable label or reporter molecule. Alternatively, an unlabeled anti-PRLR antibody can be used in diagnostic applications in combination with a secondary antibody which is itself detectably labeled. The detectable label or reporter molecule can be a radioisotope, such as ^{3}H, ^{14}C, ^{32}P, ^{35}S, or ^{125}I; a fluorescent or chemiluminescent moiety such as fluorescein, or rhodamine; or an enzyme such as alkaline phosphatase, beta-galactosidase, horseradish peroxidase, or luciferase. Specific exemplary assays that can be used to detect or measure PRLR in a sample include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), immuno-PET (*e.g.*, ^{89}Zr, ^{64}Cu, etc.), and fluorescence-activated cell sorting (FACS).

[0138] Samples that can be used in PRLR diagnostic assays according to the present invention include any tissue or fluid sample obtainable from a patient which contains detectable quantities of PRLR protein, or fragments thereof, under normal or pathological conditions. Generally, levels of PRLR in a particular sample obtained from a healthy patient (*e.g.*, a patient not afflicted with a disease or condition associated with abnormal PRLR levels or activity) will be measured to initially establish a baseline, or standard, level of PRLR. This baseline level of PRLR can then be compared against the levels of PRLR measured in samples obtained from individuals suspected of having a PRLR related disease or condition.

EXAMPLES

[0139] The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to make and use the methods and compositions of the invention, and are not intended to limit the scope of what the inventors regard as their invention. Efforts have been made to ensure accuracy with respect to numbers used (e.g., amounts, temperature, etc.) but some experimental errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, molecular weight is average molecular weight, temperature is in degrees Centigrade, and pressure is at or near atmospheric.

Example 1. Generation of Anti-PRLR Antibodies

[0140] Anti-PRLR antibodies were obtained by immunizing a VELOCIMMUNE® mouse (*i.e.*, an engineered mouse comprising DNA encoding human immunoglobulin heavy and kappa light chain variable regions) with an immunogen comprising a soluble dimeric ecto domain of human PRLR. The antibody immune response was monitored by a PRLR-specific immunoassay. When a desired immune response was achieved splenocytes were harvested and fused with mouse myeloma cells to preserve their viability and form hybridoma cell lines. The hybridoma cell lines were screened and selected to identify cell lines that produce PRLR-specific antibodies. Using this technique several anti-PRLR chimeric antibodies (*i.e.*, antibodies possessing human variable domains and mouse constant domains) were obtained. In addition,

several fully human anti-PRLR antibodies were isolated directly from antigen-positive B cells without fusion to myeloma cells, as described in US 2007/0280945A1.

[0141] Certain biological properties of the exemplary anti-PRLR antibodies generated in accordance with the methods of this Example are described in detail in the Examples set forth below.

Example 2. Heavy and Light Chain Variable Region Amino Acid and Nucleic Acid Sequences

[0142] Table 1 sets forth the amino acid sequence identifiers of the heavy and light chain variable regions and CDRs of selected anti-PRLR antibodies of the invention. The corresponding nucleic acid sequence identifiers are set forth in Table 2.

Table 1: Amino Acid Sequence Identifiers

	SEQ ID NOs:							
Antibody Designation	**HCVR**	**HCDR1**	**HCDR2**	**HCDR3**	**LCVR**	**LCDR1**	**LCDR2**	**LCDR3**
H1H6762P	2	4	6	8	10	12	14	16
H1H6765P	18	20	22	24	26	28	30	32
H1H6774P	34	36	38	40	42	44	46	48
H1H6781P	50	52	54	56	58	60	62	64
H1H6782P	66	68	70	72	74	76	78	80
H1H6783P	82	84	86	88	90	92	94	96
H1H6785P	98	100	102	104	106	108	110	112
H1H6790P	114	116	118	120	122	124	126	128
H1H6792P	130	132	134	136	138	140	142	144
H1H6793P	146	148	150	152	154	156	158	160
H1H6795P	162	164	166	168	170	172	174	176
H1H6797P	178	180	182	184	186	188	190	192
H1H6800P	194	196	198	200	202	204	206	208
H1H6801P	210	212	214	216	218	220	222	224
H1H6803P	226	228	230	232	234	236	238	240
H1H6804P	242	244	246	248	250	252	254	256
H1H6807P	258	260	262	264	266	268	270	272
H1M6953N	274	276	278	280	282	284	286	288
H2M6958N2	290	292	294	296	298	300	302	304
H2M6959N2	306	308	310	312	314	316	318	320
H2M6960N	322	324	326	328	330	332	334	336
H2M6966N	338	340	342	344	346	348	350	352
H2M6967N	354	356	358	360	362	364	366	368
H2M6975N	370	372	374	376	378	380	382	384
H2M6976N	386	388	390	392	394	396	398	400

Table 2: Nucleic Acid Sequence Identifiers

	SEQ ID NOs:							
Antibody Designation	**HCVR**	**HCDR1**	**HCDR2**	**HCDR3**	**LCVR**	**LCDR1**	**LCDR2**	**LCDR3**
H1H6762P	1	3	5	7	9	11	13	15
H1H6765P	17	19	21	23	25	27	29	31
H1H6774P	33	35	37	39	41	43	45	47
H1H6781P	49	51	53	55	57	59	61	63
H1H6782P	65	67	69	71	73	75	77	79
H1H6783P	81	83	85	87	89	91	93	95
H1H6785P	97	99	101	103	105	107	109	111
H1H6790P	113	115	117	119	121	123	125	127
H1H6792P	129	131	133	135	137	139	141	143
H1H6793P	145	147	149	151	153	155	157	159
H1H6795P	161	163	165	167	169	171	173	175
H1H6797P	177	179	181	183	185	187	189	191
H1H6800P	193	195	197	199	201	203	205	207
H1H6801P	209	211	213	215	217	219	221	223
H1H6803P	225	227	229	231	233	235	237	239
H1H6804P	241	243	245	247	249	251	253	255
H1H6807P	257	259	261	263	265	267	269	271
H1M6953N	273	275	277	279	281	283	285	287
H2M6958N2	289	291	293	295	297	299	301	303
H2M6959N2	305	307	309	311	313	315	317	319
H2M6960N	321	323	325	327	329	331	333	335
H2M6966N	337	339	341	343	345	347	349	351
H2M6967N	353	355	357	359	361	363	365	367
H2M6975N	369	371	373	375	377	379	381	383
H2M6976N	385	387	389	391	393	395	397	399

[0143] Antibodies are typically referred to herein according to the following nomenclature: Fc prefix (*e.g.* "H1H," "H1M," "H2M," etc.), followed by a numerical identifier (*e.g.* "6762," "6953," "6958," etc.), followed by a "P" or "N" suffix, as shown in Tables 1 and 2. Thus, according to this nomenclature, an antibody may be referred to herein as, *e.g.*, "H1H6762P," "H1M6953N," "H2M6958N," etc. The H1H, H1M and H2M prefixes on the antibody designations used herein indicate the particular Fc region isotype of the antibody. For example, an "H1H" antibody has a human IgG1 Fc, an "H1M" antibody has a mouse IgG1 Fc, and an "H2M" antibody has a mouse IgG2 Fc, (all variable regions are fully human as denoted by the first 'H' in the antibody designation). As will be appreciated by a person of ordinary skill in the art, an antibody having a particular Fc isotype can be converted to an antibody with a different Fc isotype (*e.g.*, an antibody with a mouse IgG1 Fc can be converted to an antibody with a human IgG4, etc.), but in

any event, the variable domains (including the CDRs) – which are indicated by the numerical identifiers shown in Tables 1 and 2 – will remain the same, and the binding properties are expected to be identical or substantially similar regardless of the nature of the Fc domain.

Control Constructs Used in the Following Examples

[0144] Control constructs were included in the following experiments for comparative purposes: Control I: a human anti-PRLR antibody with heavy and light chain variable domains having the amino acid sequences of the corresponding domains of "he.06.642-2," as set forth in WO2008/02295A2; and Control II: a human anti-ErbB2 antibody with heavy and light chain variable domains having the amino acid sequences of the corresponding domains of "4D5v8" as set forth in: Carter et al., 1992, Proc. Natl. Acad. Sci. USA, 89:4285-4289.

Example 3. Surface Plasmon Resonance Derived Binding Affinities and Kinetic Constants of Human Monoclonal Anti-PRLR Antibodies

[0145] Binding affinities and kinetic constants of human monoclonal anti-PRLR antibodies were determined by surface plasmon resonance at 25°C and 37°C. Antibodies, expressed as human IgG1 Fc (*i.e.*, "H1H" designations), were captured onto an anti-human Fc sensor surface (mAb-capture format), and soluble monomeric (hPRLR.mmh; SEQ ID NO:401, or *macaca fascicularis* (mf) PRLR.mmh; SEQ ID NO:403) or dimeric (hPRLR.mFc ; SEQ ID NO:402) PRLR protein was injected over the sensor surface. Measurements were conducted on a T200 Biacore instrument. Kinetic association (k_a) and dissociation (k_d) rate constants were determined by processing and fitting the data to a 1:1 binding model using Scrubber 2.0 curve fitting software. Binding dissociation equilibrium constants (K_D) and dissociative half-lives ($t_{1/2}$) were calculated from the kinetic rate constants as: K_D (M) = k_d / k_a; and $t_{1/2}$ (min) = (ln2/(60*k_d). Results are summarized in Tables 3 and 4.

Table 3: Biacore Binding Affinities of Human Fc mAbs at 25°C

Binding at 25°C / Antibody-Capture Format					
Antibody	**Analyte**	**ka (Ms^{-1})**	**kd (s^{-1})**	**K_D (Molar)**	**T½ (min)**
H1H6953N	hPRLR.mmh	7.92E+05	2.12E-04	2.68E-10	54.5
	hPRLR.mFc	7.11E+05	4.77E-05	6.70E-11	242.2
	mfPRLR.mmh	7.27E+05	3.19E-04	4.38E-10	36.3
H1H6958N2	hPRLR.mmh	2.33E+05	2.72E-04	1.17E-09	42.5
	hPRLR.mFc	4.22E+05	3.66E-05	8.67E-11	315.8
	mfPRLR.mmh	1.95E+05	2.80E-04	1.44E-09	41.3
H1H6959N2	hPRLR.mmh	1.79E+05	3.60E-02	2.02E-07	0.3
	hPRLR.mFc	3.59E+05	5.18E-04	1.45E-09	22.3
	mfPRLR.mmh	1.29E+05	1.67E-02	1.29E-07	0.7
H1H6960N	hPRLR.mmh	1.08E+05	7.29E-04	6.74E-09	15.8
	hPRLR.mFc	2.52E+05	3.56E-05	1.41E-10	324.4
	mfPRLR.mmh	9.40E+04	5.83E-04	6.20E-09	19.8
H1H6966N	hPRLR.mmh	8.52E+05	2.57E-04	3.02E-10	44.9

	hPRLR.mFc	9.31E+05	4.08E-05	4.39E-11	282.9
	mfPRLR.mmh	7.82E+05	3.25E-04	4.16E-10	35.6
H1H6967N	hPRLR.mmh	2.46E+05	3.32E-04	1.35E-09	34.8
	hPRLR.mFc	4.07E+05	4.45E-05	1.10E-10	259.3
	mfPRLR.mmh	1.90E+05	5.85E-04	3.08E-09	19.7
H1H6975N	hPRLR.mmh	1.50E+05	7.35E-05	4.90E-10	157.1
	hPRLR.mFc	2.87E+05	1.97E-05	6.84E-11	587.8
	mfPRLR.mmh	1.15E+05	1.31E-04	1.14E-09	88.2
H1H6976N	hPRLR.mmh	5.44E+05	8.64E-04	1.59E-09	13.4
	hPRLR.mFc	1.12E+06	1.01E-04	9.06E-11	114.4
	mfPRLR.mmh	4.66E+05	8.14E-04	1.75E-09	14.2
H1H6762P	hPRLR.mmh	6.92E+05	1.79E-04	2.59E-10	64
	hPRLR.mFc	6.51E+05	6.45E-05	9.92E-11	179
	mfPRLR.mmh	4.08E+05	2.08E-04	5.11E-10	55
H1H6765P	hPRLR.mmh	9.07E+05	1.13E-04	1.24E-10	102
	hPRLR.mFc	8.69E+05	3.41E-05	3.92E-11	339
	mfPRLR.mmh	5.27E+05	1.34E-04	2.54E-10	86
H1H6774P	hPRLR.mmh	7.15E+05	8.18E-04	1.14E-09	14
	hPRLR.mFc	7.98E+05	8.94E-05	1.12E-10	129
	mfPRLR.mmh	4.95E+05	8.75E-04	1.77E-09	13
H1H6781P	hPRLR.mmh	2.08E+05	1.27E-04	6.10E-10	91
	hPRLR.mFc	2.57E+05	6.05E-05	2.36E-10	191
	mfPRLR.mmh	1.43E+05	1.41E-04	9.86E-10	82
H1H6782P	hPRLR.mmh	3.60E+05	2.47E-04	6.85E-10	47
	hPRLR.mFc	3.17E+05	7.13E-05	2.25E-10	162
	mfPRLR.mmh	2.66E+05	2.79E-04	1.05E-09	41
H1H6783P	hPRLR.mmh	2.88E+05	4.13E-04	1.43E-09	28
	hPRLR.mFc	2.64E+05	8.77E-05	3.32E-10	132
	mfPRLR.mmh	1.89E+05	3.41E-04	1.81E-09	34
H1H6785P	hPRLR.mmh	3.01E+05	1.71E-04	5.67E-10	68
	hPRLR.mFc	2.63E+05	6.07E-05	2.31E-10	190
	mfPRLR.mmh	2.27E+05	1.67E-04	7.38E-10	69
H1H6790P	hPRLR.mmh	5.65E+05	7.99E-04	1.41E-09	14
	hPRLR.mFc	5.42E+05	1.04E-04	1.92E-10	111
	mfPRLR.mmh	3.89E+05	7.93E-04	2.04E-09	15
H1H6792P	hPRLR.mmh	3.24E+05	7.94E-04	2.45E-09	15
	hPRLR.mFc	3.03E+05	9.48E-05	3.13E-10	122
	mfPRLR.mmh	2.36E+05	9.83E-04	4.17E-09	12
H1H6793P	hPRLR.mmh	2.35E+05	3.32E-04	1.41E-09	35
	hPRLR.mFc	2.29E+05	7.57E-05	3.31E-10	153
	mfPRLR.mmh	1.77E+05	3.93E-04	2.22E-09	29
H1H6795P	hPRLR.mmh	1.17E+06	1.77E-03	1.52E-09	7
	hPRLR.mFc	1.54E+06	8.41E-05	5.45E-11	137
	mfPRLR.mmh	8.44E+05	1.97E-03	2.33E-09	6
H1H6797P	hPRLR.mmh	1.13E+06	1.96E-03	1.73E-09	6
	hPRLR.mFc	9.82E+05	1.19E-04	1.22E-10	97
	mfPRLR.mmh	6.70E+05	2.09E-03	3.12E-09	6
H1H6800P	hPRLR.mmh	4.21E+05	4.09E-04	9.72E-10	28
	hPRLR.mFc	4.73E+05	8.69E-05	1.84E-10	133
	mfPRLR.mmh	3.03E+05	3.80E-04	1.25E-09	30
H1H6801P	hPRLR.mmh	8.46E+05	7.56E-04	8.94E-10	15
	hPRLR.mFc	6.75E+05	1.09E-04	1.61E-10	106
	mfPRLR.mmh	6.57E+05	1.23E-03	1.88E-09	9

H1H6803P	hPRLR.mmh	8.24E+04	1.37E-04	1.67E-09	84
	hPRLR.mFc	1.04E+05	6.29E-05	6.07E-10	184
	mfPRLR.mmh	6.21E+04	2.09E-04	3.37E-09	55
H1H6804P	hPRLR.mmh	4.53E+05	6.34E-04	1.40E-09	18
	hPRLR.mFc	4.51E+05	8.69E-05	1.93E-10	133
	mfPRLR.mmh	3.31E+05	6.57E-04	1.99E-09	18
H1H6807P	hPRLR.mmh	7.61E+05	1.44E-04	1.89E-10	80
	hPRLR.mFc	6.80E+05	5.46E-05	8.03E-11	212
	mfPRLR.mmh	4.37E+05	1.51E-04	3.46E-10	76
Control I	hPRLR.mmh	5.11E+05	7.44E-04	1.46E-09	15.5
	hPRLR.mFc	4.72E+05	7.53E-05	1.59E-10	153.5
	mfPRLR.mmh	2.38E+05	6.14E-03	2.59E-08	1.9

NB= No binding observed under conditions used

Table 4: Biacore Binding Affinities of Human Fc mAbs at 37ºC

Binding at 37ºC / Antibody-Capture Format					
Antibody	**Analyte**	**ka (Ms^{-1})**	**kd (s^{-1})**	**K_D (Molar)**	**T½ (min)**
H1H6953N	hPRLR.mmh	1.10E+06	1.22E-03	1.11E-09	9.4
	hPRLR.mFc	1.47E+06	1.70E-04	1.16E-10	68.0
	mfPRLR.mmh	9.47E+05	2.56E-03	2.71E-09	4.5
H1H6958N2	hPRLR.mmh	4.13E+05	1.31E-03	3.16E-09	8.8
	hPRLR.mFc	8.29E+05	1.39E-04	1.67E-10	83.3
	mfPRLR.mmh	3.28E+05	1.34E-03	4.08E-09	8.6
H1H6959N2	hPRLR.mmh	4.06E+04	2.77E-02	6.81E-07	0.4
	hPRLR.mFc	5.09E+05	2.30E-03	4.51E-09	5.0
	mfPRLR.mmh	4.46E+04	1.65E-02	3.70E-07	0.7
H1H6960N	hPRLR.mmh	1.22E+05	1.98E-03	1.62E-08	5.8
	hPRLR.mFc	2.94E+05	1.47E-04	5.00E-10	78.7
	mfPRLR.mmh	8.64E+04	1.28E-03	1.49E-08	9.0
H1H6966N	hPRLR.mmh	1.58E+06	9.60E-04	6.07E-10	12.0
	hPRLR.mFc	1.88E+06	1.27E-04	6.72E-11	91.3
	mfPRLR.mmh	1.22E+06	1.20E-03	9.82E-10	9.6
H1H6967N	hPRLR.mmh	4.24E+05	9.33E-04	2.20E-09	12.4
	hPRLR.mFc	9.07E+05	9.73E-05	1.07E-10	118.8
	mfPRLR.mmh	3.56E+05	1.62E-03	4.54E-09	7.1
H1H6975N	hPRLR.mmh	2.11E+05	2.73E-04	1.29E-09	42.3
	hPRLR.mFc	3.86E+05	7.09E-05	1.84E-10	163.0
	mfPRLR.mmh	1.40E+05	3.17E-04	2.27E-09	36.4
H1H6976N	hPRLR.mmh	7.77E+05	3.14E-03	4.04E-09	3.7
	hPRLR.mFc	1.37E+06	1.40E-04	1.02E-10	82.6
	mfPRLR.mmh	6.03E+05	3.16E-03	5.24E-09	3.7
H1H6762P	hPRLR.mmh	9.48E+05	4.55E-04	4.80E-10	25
	hPRLR.mFc	8.01E+05	1.03E-04	1.28E-10	112
	mfPRLR.mmh	6.79E+05	5.58E-04	8.23E-10	21
H1H6765P	hPRLR.mmh	1.25E+06	3.66E-04	2.92E-10	32
	hPRLR.mFc	8.01E+05	1.03E-04	1.28E-10	112
	mfPRLR.mmh	1.06E+06	5.37E-05	5.04E-11	215
H1H6774P	hPRLR.mmh	1.07E+06	3.17E-03	2.95E-09	4
	hPRLR.mFc	1.41E+06	1.94E-04	1.38E-10	60
	mfPRLR.mmh	7.23E+05	3.61E-03	5.00E-09	3
H1H6781P	hPRLR.mmh	3.39E+05	3.09E-04	9.10E-10	37

	hPRLR.mFc	4.36E+05	9.84E-05	2.26E-10	117
	mfPRLR.mmh	2.47E+05	2.67E-04	1.08E-09	43
H1H6782P	hPRLR.mmh	5.57E+05	7.16E-04	1.28E-09	16
	hPRLR.mFc	5.98E+05	1.30E-04	2.17E-10	89
	mfPRLR.mmh	3.85E+05	7.67E-04	1.99E-09	15
H1H6783P	hPRLR.mmh	4.11E+05	1.61E-03	3.91E-09	7
	hPRLR.mFc	4.91E+05	1.38E-04	2.82E-10	83
	mfPRLR.mmh	2.73E+05	1.30E-03	4.74E-09	9
H1H6785P	hPRLR.mmh	4.26E+05	4.84E-04	1.14E-09	24
	hPRLR.mFc	4.56E+05	1.17E-04	2.56E-10	99
	mfPRLR.mmh	2.97E+05	4.50E-04	1.52E-09	26
H1H6790P	hPRLR.mmh	9.40E+05	3.29E-03	3.50E-09	4
	hPRLR.mFc	6.46E+05	1.98E-04	3.06E-10	58
	mfPRLR.mmh	6.15E+05	3.21E-03	5.22E-09	4
H1H6792P	hPRLR.mmh	4.35E+05	2.29E-03	5.27E-09	5
	hPRLR.mFc	4.99E+05	1.76E-04	3.52E-10	66
	mfPRLR.mmh	3.05E+05	2.86E-03	9.37E-09	4
H1H6793P	hPRLR.mmh	3.39E+05	1.02E-03	3.02E-09	11
	hPRLR.mFc	4.10E+05	1.42E-04	3.47E-10	81
	mfPRLR.mmh	2.33E+05	1.07E-03	4.59E-09	11
H1H6795P	hPRLR.mmh	1.36E+06	5.20E-03	3.81E-09	2
	hPRLR.mFc	1.94E+06	7.77E-05	4.02E-11	149
	mfPRLR.mmh	9.73E+05	5.99E-03	6.16E-09	2
H1H6797P	hPRLR.mmh	1.29E+06	8.22E-03	6.37E-09	1
	hPRLR.mFc	1.80E+06	1.25E-04	6.91E-11	93
	mfPRLR.mmh	9.14E+05	9.06E-03	9.90E-09	1
H1H6800P	hPRLR.mmh	8.08E+05	1.19E-03	1.47E-09	10
	hPRLR.mFc	6.44E+05	1.47E-04	2.29E-10	79
	mfPRLR.mmh	4.39E+05	1.09E-03	2.48E-09	11
H1H6801P	hPRLR.mmh	9.51E+05	4.41E-03	4.63E-09	3
	hPRLR.mFc	7.93E+05	2.21E-04	2.79E-10	52
	mfPRLR.mmh	7.11E+05	7.71E-03	1.08E-08	1
H1H6803P	hPRLR.mmh	1.29E+05	3.64E-04	2.83E-09	32
	hPRLR.mFc	1.34E+05	6.20E-05	4.61E-10	186
	mfPRLR.mmh	8.73E+04	6.36E-04	7.28E-09	18
H1H6804P	hPRLR.mmh	6.07E+05	3.85E-03	6.34E-09	3
	hPRLR.mFc	5.54E+05	2.05E-04	3.69E-10	56
	mfPRLR.mmh	4.55E+05	4.26E-03	9.35E-09	3
H1H6807P	hPRLR.mmh	1.08E+06	3.36E-04	3.10E-10	34
	hPRLR.mFc	1.22E+06	1.10E-04	9.00E-11	105
	mfPRLR.mmh	8.02E+05	3.59E-04	4.48E-10	32
Control I	hPRLR.mmh	5.99E+05	2.42E-03	4.04E-09	4.8
	hPRLR.mFc	8.47E+05	2.14E-04	2.53E-10	54.0
	mfPRLR.mmh	1.53E+05	1.54E-02	1.01E-07	0.8

NB= No binding observed under conditions used

[0146] As shown in Tables 3 and 4, several antibodies of the invention displayed sub-nanomolar affinities to human and monkey PRLR protein and exhibited higher affinity than the comparator anti-PRLR antibody (Control I). For example, at 37°C, many of the anti-PRLR antibodies of the invention bound to monomeric human PRLR with K_D values less than 4 nM and T½ times greater than 5 minutes; and to dimeric human PRLR with K_D values less than 250 pM and T½ times greater than 60 minutes. These binding characteristics are substantially

better than what was observed with the Control I antibody under the same experimental conditions.

Example 4A. Anti-PRLR Antibodies Bind to Endogenous and Overexpressed PRLR Cell Lines

[0147] The ability of anti-PRLR antibodies to selectively bind PRLR expressing cell lines was next determined. Human, monkey *macaca fascicularis*, and mouse PRLR constructs with an HA tag were stably introduced into HEK293 cells via Lipofectamine 2000-mediated transfection methodology. Transfectants (HEK293/hPRLR, HEK293/mfPRLR and HEK293/mPRLR) were selected for at least 2 weeks in complete growth media plus G418.

[0148] Cell surface expression of PRLR on 293/hPRLR cells was assessed via FACS analysis. Briefly, $1x10^5$ cells were incubated with 10 µg/ml of Control antibody I, or an isotype control for 30 min on ice in antibody dilution buffer. Following two washes with antibody dilution buffer, cells were incubated with 10 µg/ml of PE conjugated anti-human secondary antibodies for 30 min on ice. Following two additional washes, samples were run on a Hypercyt® cytometer and analyzed in ForeCyt™ (IntelliCyt, Albuquerque, NM). The mean fluorescence intensities (MFI) were expressed as fold change above isotype control levels (background). FACS binding confirmed that Control I selectively bound to 293/hPRLR expressing cells with MFIs that were 30 fold above background (isotype ctrl) levels and less than 2 fold binding on parental cells.

[0149] Cell surface copy number of PRLR was also quantitatively determined on T47D, MCF7 and MCF7/hPRLR-overexpressing cell lines. Briefly, $1x10^5$ cells were incubated with 100 nM of the anti-PRLR antibody H1H6953N-Alexa647 for 30 min on ice in antibody dilution buffer. Following two washes with antibody dilution buffer, samples were run on a Hypercyt® cytometer (IntelliCyt, Albuquerque, NM) and the mean fluorescence intensities (MFI) were determined in ForeCyt™ (IntelliCyt, Albuquerque, NM). The MFI for each cell line was then converted to Alexa647 molecules of equivalent soluble fluorescence (MESF) via the Quantum Alexa Fluor 647 MESF kit according to manufacturer instructions (Bangs Laboratories, Inc, Fishers, IN). The average number of fluorophores per H1H6953N-A647 protein (F/P ratio) was determined via the Simply Cellular anti-Human IgG kit according to manufacture instructions (Bangs Laboratories, Inc, Fishers, IN). The MESF values were divided by the F/P ratio to determine the PRLR cell surface copy number or H1H6953N antigen binding capacity on each cell line. Using this method, it was determined that the approximate cell surface copy number of PRLR on the various cell lines was as follows: T47D = 27,000; MCF7 = 3,000; and MCF7/hPRLR = 190,000.

[0150] Next, the anti-PRLR antibodies of the present invention were tested via FACS for selective binding to the engineered overexpressing PRLR HEK293 cell lines, as well as to non-expressing HEK293 cells and a native PRLR expressing cell line (T47D). Results are shown in Table 5.

Table 5: FACS Cell Surface Binding of Anti-PRLR Antibodies

	FACS Cell Binding (Fold Above Background)				
Antibody	**HEK293**	**HEK293/hPRLR**	**HEK293/mfPRLR**	**HEK293/ mPRLR**	**T47D**
unstained	1	1	1	1	1
Secondary only	1	1	1	1	1
Control I	1	31	13	7	30
*H1H6762P	1	36	26	2	38
*H1H6765P	2	38	27	1	40
H1H6774P	1	1	29	1	39
*H1H6781P	1	37	26	1	40
H1H6782P	3	41	32	4	43
*H1H6783P	1	37	27	1	38
*H1H6785P	1	37	26	2	40
*H1H6790P	1	37	24	1	34
*H1H6792P	1	37	28	3	37
H1H6793P	2	2	32	2	43
H1H6795P	1	1	22	1	34
H1H6797P	1	1	25	2	38
*H1H6800P	1	35	29	1	41
H1H6801P	7	47	88	56	45
*H1H6803P	1	39	28	1	39
H1H6804P	1	1	29	1	34
*H1H6807P	2	32	27	2	34
*H1H6953N	2	37	29	2	40
*H1H6958N2	1	35	30	1	37
H1H6959N2	1	6	11	2	9
*H1H6960N	1	29	23	1	33
*H1H6966N	1	29	18	1	31
*H1H6967N	1	38	28	2	41
*H1H6975N	1	38	29	1	46
H1H6976N	1	8	29	1	37
Isotype Ctrl I	1	1	1	1	NA
Isotype Ctrl II	1	1	NA	NA	1

*Denotes antibodies with specific binding on HEK293/hPRLR, HEK293/mfPRLR and T47D and less than 2-fold binding on HEK293 parental cells.

[0151] As shown in Table 5, a majority of the anti-human PRLR antibodies specifically bound to HEK293/PRLR cells at >25-fold above background levels with negligible binding to parental cells. Antibodies that bound to human PRLR were similarly shown to bind to monkey (*macaca fascicularis*) PRLR on HEK293/mfPRLR cells. Antibodies that were identified to be strong binders to HEK293/hPRLR cells were similarly shown to be robust binders to native PRLR expressing T47D cells. Cross-reactivity to rodent PRLR was not observed.

[0152] In summary, antibodies of this invention displayed strong binding to human and monkey PRLR on engineered cell lines as well as endogenously expressed PRLR.

Example 4B. Anti-PRLR Antibodies Are Internalized by PRLR-Expressing Cells in vitro

[0153] In this Example, the internalization of anti-PRLR antibodies by PRLR-expressing cells (T47D) was assessed. Briefly, 20,000 T47D cells were seeded in collagen coated 96 well

plates. The next day, cells were incubated with anti-human PRLR antibodies (10 µg/ml) for 30 min on ice followed by two PBS washes. Cells were then incubated with alexa488 conjugated anti-hFc Fab secondary antibodies for 30 minutes on ice followed by two additional PBS washes. Antibodies were allowed to internalize for 1h at 37°C in internalization buffer (PBS + 2% FBS) or remained at 4°C. Cells were fixed in 4% formaldehyde, nuclei were stained with DRAQ5 (Cell signaling), and images were acquired on the ImageXpress micro XL (Molecular Devices). Whole cell alexa488 intensity at 37°C (Binding) and the alexa488 intensity in the intracellular vesicles at 37°C (Internalization) were determined via Columbus image analysis software (PerkinElmer). The intensities are expressed as a percentage of the strongest internalizing antibody, H1H6975N, and are summarized in Table 6.

Table 6

Cell Line: T47D [mAb] 1µg/mL (0.67 nM)		
Antibody	**% Internalization relative to Control I**	**% Total Binding relative to Control I**
anti-PRLR control I	**100.0**	**100.0**
H1H6975N	214.2	225.9
H1H6800P	198.3	186.8
H1H6803P	190.5	205.5
H1H6762P	186.3	176.7
H1H6765P	186.3	191.3
H1H6793P	179.9	177.9
H1H6782P	179.3	209.9
H1H6976N	169.5	180.4
H1H6785P	169.1	168.0
H1H6958N2	169.0	161.5
H1H6967N	168.6	158.6
H1H6781P	165.1	166.2
H1H6774P	162.3	173.7
H1H6783P	160.7	165.8
H1H6792P	155.9	110.6
H1H6953N	153.9	164.2
H1H6795P	150.7	123.4
H1H6801P	148.9	155.7
H1H6807P	147.0	152.7
H1H6790P	146.9	122.8
H1H6797P	145.2	151.2
H1H6804P	138.9	149.6
H1H6966N	137.2	111.3
H1H6960N	120.0	89.7
H1H6959N2	15.3	2.0

[0154] With the exception of H1H6959N2, all tested antibodies bound T47D and nearly 100% of all bound mAbs internalized within 1h. The total internalized antibody intensity for most antibodies was greater than the anti-human PRLR control antibody (Control I).

Example 5. Anti-PRLR Antibodies Inhibit PRL-Mediated Receptor Activation in Cells Expressing Human PRLR

[0155] The ability of anti-PRLR antibodies to block prolactin (PRL)-mediated receptor activation was examined in a luciferase-based reporter assay. The endocrine hormone PRL binds to the extracellular domain of its cognate receptor PRLR, triggering rapid homodimerization and activating several downstream signaling cascades.

[0156] In this example, an engineered cell line was used to determine the ability of anti-PRLR antibodies to block ligand activation of the PRLR receptor. Briefly, HEK293/hPRLR/STAT5-Luc cell lines with stable incorporation of a human PRLR expression cassette and the STAT5-dependent luciferase reporter were generated via sequential rounds of Lipofectamine® 2000-mediated transfection (LifeTechnologies, Carlsbad, CA). Cells were selected for at least two weeks in the presence of 500 µg/mL G418 (hPRLR) and 100 µg/mL hygromycin B (STAT5-Luc). The STAT5-Luc assay utilized $2x10^5$ HEK293/hPRLR/STAT5-Luc cells seeded in complete growth medium on PDL-coated 96 well plates grown overnight at 37°C, 5% CO_2. To generate antibody inhibition curves, cells were incubated (6 hr at 37°C) with serially diluted anti-human PRLR antibodies (100 nM to 24 pM) in the presence of 5 nM constant PRL before recording signal. PRL dose response curves were generated by the addition of serially diluted PRL (100 nM to 24 pM) to cells and recording signal after a 6hr (37°C) incubation in the absence of antibodies. The ability of the antibodies to activate PRLR in the absence of ligand was also assessed.

[0157] Luciferase activity was measured with ONE-Glo™ reagent (Promega, Madison, WI). Relative light units (RLUs) were measured on a Victor luminometer (Perkin Elmer, Shelton, CT). EC_{50}/IC_{50} values were determined from a four-parameter logistic equation over an 8-point response curve using GraphPad Prism. Percent blocking and percent activation are reported for the highest antibody dose. Results are shown in Table 7.

Table 7: IC_{50} and Percent Blocking of PRL-Mediated Signaling by Anti-PRLR Antibodies

Antibody	IC_{50} of Blocking 5nM PRL [M]	Percent Blocking at 100nM Antibody
H1H6762P	2.19E-11	100
H1H6765P	3.30E-11	100
H1H6774P	NB	0
H1H6781P	2.70E-11	100
H1H6782P	NB	0
H1H6783P	ND	59

H1H6785P	3.45E-10	100
H1H6790P	2.06E-10	100
H1H6792P	5.70E-10	100
H1H6793P	ND	65
H1H6795P	NB	0
H1H6797P	NB	0
H1H6800P	3.55E-10	100
H1H6801P	1.40E-10	100
H1H6803P	6.27E-10	100
H1H6804P	7.89E-09	100
H1H6807P	6.00E-10	100
H1H6953N	1.05E-10	100
H1H6958N2	1.98E-10	100
H1H6959N2	ND	52
H1H6960N	1.58E-09	100
H1H6966N	ND	54
H1H6967N	7.68E-10	100
H1H6975N	2.41E-10	100
H1H6976N	ND	23
Control I	1.33E-09	100

NB: Not blocking; ND: Not determined due to incomplete blocking

[0158] As summarized in Table 7, a majority of the antibodies of this invention inhibited activation of the STAT5 reporter, with IC_{50} values ranging from 22 pM to 8 nM. All inhibitory antibodies blocked activation to baseline levels (100 percent blocking). Additionally, the antibodies tested in this assay did not activate STAT5 in the absence of PRL ligand.

[0159] In summary, the data of this Example show that a majority of the anti-PRLR antibodies of the invention block PRL-mediated receptor activation. Additionally, a majority of the antibodies inhibit receptor activation more potently than the anti-PRLR Control I antibody. For example, several anti-PRLR antibodies of the present invention blocked prolactin-mediated signaling with IC_{50} values of less than about 1.3 nM. On the other hand, certain anti-PRLR antibodies of the invention, despite being able to bind PRLR, did not exhibit prolactin blocking activity. Such non-blocking anti-PRLR antibodies may find uses in various therapeutic contexts where PRLR targeting is desired without interfering with normal prolactin-mediated signaling.

Example 6. Preparation and Characterization of Anti-PRLR Antibody Drug Conjugates

[0160] Selected anti-PRLR antibodies were conjugated to the maytansinoid DM1 through an SMCC linker using methods similar to those set forth in US Patent No. 5,208,020 and US Patent Application Publication No. 2010/0129314. The conjugates were purified by size exclusion chromatography and sterile filtered. All starting materials and solvents were purchased

commercially and used without purification, unless otherwise noted.

[0161] Protein and linker/payload concentrations were determined by UV spectral analysis and MALDI-TOF mass spectrometry. Size-exclusion HPLC established that all conjugates used were >95% monomeric, and RP-HPLC established that there was <0.5% unconjugated linker payload. Yields are reported in Table 8 and 9 based on protein. All conjugated antibodies were analyzed by UV for linker payload loading values according to Hamblett *et al*, 2004, Clinical Cancer Research 10(20):7063-7070, and by mass difference, native versus conjugated.

Table 8: Protein Concentrations for Anti-PRLR Unconjugated Antibodies

Compound	ε252 nm (cm^{-1} M^{-1})	ε280 nm (cm^{-1} M^{-1})
SMCC-DM1	26790	5700
Antibody (unconjugated)	**ε252 nm (cm^{-1} M^{-1})**	**ε280 nm (cm^{-1} M^{-1})**
H1H6958N2	74462	195440
H1H6959N2	77485	209420
H1H6960N	84926	214460
H1H6953N	80673	220420
H1H6975P	81120	199804
Isotype Control	84723	218360

Table 9: Antibody Linker/Payload Concentrations for Anti-PRLR-SMCC-DM1 Conjugates

Antibody Conjugate	Payload : Antibody Molar Ratio (UV)	Payload : Antibody Molar Ratio (MS)	Yield %
H1H6958N2-DM1	4.0	3.4	64
H1H6959N2-DM1	3.8	3.3	64
H1H6960N-DM1	3.6	3.0	64
H1H6953N-DM1	3.2	2.7	52
H1H6803P-DM1	ND	3.1	55
H1H6762P-DM1	ND	2.9	70
H1H6765P-DM1	ND	2.3	55
H1H6782P-DM1	ND	2.8	65
H1H6793P-DM1	ND	3.8	55
H1H6975P-DM1	3.0	3.4	60
H1H6800P-DM1	3.0	3.2	50
Isotype Control-DM1	3.3	3.3	80

ND: not determined

[0162] This Example illustrates the conjugation of anti-PRLR antibodies of the present invention with DM1 through an SMCC linker. The payload : antibody molar ratio was calculated to be from about 2.3 to about 3.8 for the conjugated antibodies of this Example. Percent yields for the antibodies of the invention ranged from around 50% to 70%.

Example 7. Anti-PRLR Antibody-Drug Conjugates Effectively Kill Cells with Low-to-Moderate PRLR Expression Levels as well as Cells with High PRLR Expression Levels

[0163] To determine the relative cell-killing potency of anti-PRLR ADCs of the invention compared to a similar anti-ErbB2 ADC, cell-killing assays were run on multiple cells lines expressing either PRLR, ErbB2 or a combination of both receptors.

[0164] PRLR-overexpressing cells, including HEK293, PC3, MCF7 and NCI-N87, were generated to assess the ability of anti-PRLR conjugated antibodies to reduce cell viability. For comparative purposes, PC3 and T47D cells with overexpressed ErbB2 were also generated, as well as an MCF7 cell line over-expressing both hPRLR and hErbB2. Briefly, Lipofectamine® 2000-mediated transfection methodology was utilized to generate HEK293 cells expressing human PRLR (HEK293/hPRLR) or human ErbB2 (HEK293/hErbB2). Lipofectamine LTX with Plus Reagent was used to generate PC3 cells expressing human PRLR (PC3/hPRLR) or human ErbB2 (PC3/hErbB2). Lentiviral-mediated transduction was utilized to generate MCF7 cells expressing human PRLR (MCF7/hPRLR), NCI-N87 cells expressing human PRLR (NCI-N87/hPRLR), T47D cells over-expressing human ErbB2 (T47D/hErbB2), and MCF7 cells expressing both human PRLR and human ErbB2 (MCF7/hPRLR/hErbB2). All lines were selected for at least two weeks in complete growth media plus appropriate selection reagents. Stably expressing populations were enriched for PRLR expression via FACS using the anti PRLR antibody Control I.

[0165] Cell surface expression of PRLR and ErbB2 was analyzed via FACS using either the Control I anti-PRLR antibody or Control II anti-HER2 antibody, respectively. Additionally, endogenous PRLR cell surface expression on the T47D#11 cell line, a variant of the T47D line selected for more aggressive in vivo tumor growth, was also determined. Approximately $1x10^6$ cells were incubated with 10 µg/ml of anti-PRLR Control Antibody (Control I), an anti-ErbB2 control antibody (Control II), or an isotype control for 30 min on ice in antibody dilution buffer. Following two washes with antibody dilution buffer, cells were incubated with 10 µg/ml of PE conjugated anti-human secondary antibodies for 30 min on ice. Following two additional washes, samples were run on the Accuri C6 (BD) cytometer and analyzed with FlowJo software (Tree Star, Inc., Ashland, OR). Relative expression level results are shown in Table 10.

Table 10: Human PRLR Cell Surface Expression (Engineered & Endogenous Lines)

Cell Line	FACS Binding (MFI FOLD ABOVE ISOTYPE CONTROL)				
	Unstained	Secondary alone	Isotype Ctrl	Anti-PRLR (Control I)	Anti-ErbB2 (Control II)
293	1X	1X	1X	1X	28X
293/hErbB2	1X	1X	1X	1X	215X

293/hPRLR	1X	1X	1X	18X	18X
PC3	1X	1X	1X	1X	41X
PC3/hErbB2	1X	1X	1X	1X	238X
PC3/hPRLR	1X	1X	1X	13X	31X
T47D	1X	1X	1X	12X	87X
T47D#11	1X	1X	1X	10X	ND
T47D/hErbB2	1X	1X	1X	12X	437X
SK-BR-3	1X	1X	1X	1X	600X
MCF7	1X	1X	1X	3X	42X
MCF7/hPRLR	1X	1X	1X	55X	36X
MCF7/hPRLR/hErbB2	1X	1X	1X	55X	349X
NCI-N87	1X	1X	1X	1X	1,400X
NCI-N87/hPRLR	1X	1X	1X	6X	1,400X

[0166] In general, exogenous PRLR surface expression ranged from 6-fold to 55-fold over background, with most engineered cells exhibiting 12-fold to 18-fold PRLR expression over background. Endogenous PRLR expression was 3-fold over background in MCF7 cells but was not detected in parental HEK293, PC3 and NCI-N87 lines. Endogenous PRLR expression was 12-fold over background in the T47D cell line and 10-fold over background in the T47D#11 variant cell line. ErbB2 expression was detected in all PRLR-expressing cell lines, and ranged from 18-fold to 1400-fold above background.

[0167] Next, the ability of anti-PRLR-DM1 antibody-drug conjugates (*i.e.*, anti-PRLR antibodies conjugated to DM1 via a non-cleavable linker [SMCC]) to reduce cell viability was determined using in vitro cell based assays. Cells were seeded in PDL-coated 96 well plates at 1500 to 10000 cells per well in complete growth media and allowed to grow overnight. For cell viability curves, ADCs or free DM1 (as the methyl disulfide derivative DM1-SMe) were added to the cells at final concentrations ranging from 500 nM to 5 pM and incubated for 3 days. The 293, PC3 and T47D cells were incubated with CCK8 (Dojindo, Rockville, MD) for the final 1-3 hours and the absorbance at 450nm (OD_{450}) was determined on a Flexstation3 (Molecular Devices, Sunnyvale, CA). MCF7 cells were treated with Hoechst 33342 nuclear stain while being fixed with 4% formaldehyde. Images were acquired on the ImageXpress micro XL (Molecular Devices, Sunnyvale, CA) and nuclear counts were determined via Columbus image analysis software (Perkin Elmer, Shelton, CT). Background OD_{450} values (PC3, 293, and T47D) or nuclear counts (MCF7) from digitonin (40 nM) treated cells was subtracted from all wells and viability was expressed as a percentage of the untreated controls. IC_{50} values were determined from a four-parameter logistic equation over a 10-point response curve (GraphPad Prism). IC_{50} values and percent cell killing are shown in Tables 11 and 12.

Table 11: Cell Kill Potency of Anti-PRLR-DM1 Antibody-Drug Conjugates

Antibody-Drug Conjugate	293		293/PRLR		PC3		PC3/PRLR	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	0.27	98	0.36	97	0.47	91	0.59	80
H1H6953N-DM1	100	88	0.28	95	110	78	0.86	67
H1H6958N2-DM1	75	98	0.10	95	150	83	0.43	83
H1H6959N2-DM1	75	100	4.82	95	150	79	11.6	82
H1H6960N-DM1	75	100	0.38	95	150	80	1.13	82
H1H6975N-DM1	100	87	ND	ND	200	71	2.70	68
H1H6762P-DM1	100	89	ND	ND	250	78	0.98	66
H1H6765P-DM1	100	86	ND	ND	200	70	0.57	70
H1H6782P-DM1	100	86	ND	ND	300	67	0.92	64
H1H6793P-DM1	100	84	ND	ND	200	72	3.65	65
H1H6800P-DM1	150	85	ND	ND	150	72	1.37	68
H1H6803P-DM1	300	7	ND	ND	150	72	2.32	70
Control I-DM1	100	92	0.28	95	>100	79	7.28	80
Isotype ctrl-DM1	100	60	100	93	125	78	110	63

IC_{50} values are in nM; ND: not determined

Table 12: Cell Kill Potency of Anti-PRLR-DM1 Antibody-Drug Conjugates (continued)

Antibody-Drug Conjugate	T47D		MCF7		MCF7/PRLR	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	0.45	86	1.17	83	1.47	88
H1H6953N-DM1	1.64	79	100	55	0.29	76
H1H6958N2-DM1	1.34	71	100	77	0.19	77
H1H6959N2-DM1	48.90	71	100	82	0.47	80
H1H6960N-DM1	5.10	71	100	77	0.29	78
H1H6975N-DM1	6.90	80	150	73	0.49	87
H1H6762P-DM1	12.60	80	110	64	0.46	83
H1H6765P-DM1	1.63	78	150	68	0.18	84
H1H6782P-DM1	4.19	74	120	57	0.65	85
H1H6793P-DM1	11.10	53	125	67	0.54	87
H1H6800P-DM1	3.20	79	150	65	0.40	85
H1H6803P-DM1	8.61	77	150	60	0.44	84
Control I-DM1	24.50	65	100	46	0.59	75
Isotype ctrl-DM1	150	61	120	66	100	84

IC_{50} values are in nM

[0168] As summarized in Tables 11 and 12, several anti-PRLR-DM1 antibody-drug conjugates potently reduced cell viability in multiple cell backgrounds, with IC_{50} values as low as 100 pM. An exemplary anti-PRLR conjugated antibody, H1H6958N2-DM1, reduced the cell viability of

HEK293, PC3 and MCF7-PRLR expressing cells with sub-nM IC_{50}s ranging from 100 pM to 460 pM, and killed endogenously expressing T47D cells with an IC_{50} of 1.3 nM. The similarly conjugated anti-PRLR Control I antibody (Control I-DM1) was several fold less potent than H1H6958N2-DM1 across all cell lines. Non-binding isotype controls and unconjugated antibodies had no impact on cell viability.

[0169] Additionally, the impact of the PRLR ligand, PRL, on PRLR-SMCC-DM1 cell kill in T47D cells was assessed. T47D cells were incubated simultaneously with PRL (15 nM) and either a non-blocking anti PRLR antibody (H1H6782P) or a receptor blocking antibody (H1H6958N2). Results are summarized in Table 13.

Table 13: Cell Kill Potency of Anti-PRLR-DM1 Antibody-Drug Conjugates in the Presence of PRLR Ligand (PRL)

	HEK293		T47D	
Treatment	**IC_{50} (nM)**	**% Kill**	**IC_{50} (nM)**	**% Kill**
Me-SS-May Free DM1	0.6	94	0.30	100
Isotype Control-SMCC-DM1	100	78	300	94
Isotype Control-SMCC-DM1 +15nM PRL	170	82	97	89
H1H6958N2-SMCC-DM1	90	88	1.0	100
H1H6958N2-SMCC-DM1 +15nM PRL	110	86	3.0	100
H1H6782P-SMCC-DM1	90	83	1.0	98
H1H6782P-SMCC-DM1 + 15nM PRL	70	78	2.0	97

[0170] As shown in Table 13, the presence of PRL had only a modest impact on PRLR ADC-mediated cell kill with an observed 2-3 fold reduction in the cell kill potency of the tested mAbs.

[0171] The potency of anti-PRLR conjugated antibodies compared with a similarly conjugated antibody to the co-expressed ErbB2 cell surface target was also assessed. Both PRLR and ErbB2 are expressed in a majority of breast cancers, and anti-ErbB2 antibodies conjugated to DM1 have shown clinical efficacy in targeting ErbB2 (+) breast cancer (Hurvitz et al; 2013). An ErbB2 Control Antibody (Control II) conjugated to DM1 (Control II-DM1) was tested in *in vitro* viability assays in the cell lines generated above. Cell kill potency of conjugated anti-PRLR antibodies compared to the anti-ErbB2 conjugated antibody is summarized in Tables 14-17.

Table 14: Cell Kill Potency of Anti-PRLR-DM1 and Anti-ErbB2-DM1 Antibody-Drug Conjugates

Antibody-Drug Conjugate	293		293/ErbB2		293/PRLR	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	0.5	95	0.26	100	0.82	95
H1H6953N-DM1 (Anti PRLR-DM1)	100	92	120	98	0.43	93
Control II-DM1 (Anti ErbB2-DM1)	100	89	2.0	98	100	88
Isotype Control-DM1	150	86	110	98	150	86
PRLR expression	1X		1X		18X	
ErbB2 expression	28X		215X		18X	

IC_{50} values are in nM

Table 15: Cell Kill Potency of Anti-PRLR-DM1 and Anti-ErbB2-DM1 Antibody-Drug Conjugates (continued)

Antibody-Drug Conjugate	PC3		PC3/ErbB2		PC3/PRLR	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	0.44	88	0.42	85	0.24	82
H1H6953N-DM1 (Anti PRLR-DM1)	100	80	80	73	0.68	76
Control II-DM1 (Anti ErbB2-DM1)	90	80	1.1	80	100	62
Isotype Control-DM1	85	82	90	71	100	62
PRLR expression	1X		1X		13X	
ErbB2 expression	41X		238X		31X	

IC_{50} values are in nM

Table 16: Cell Kill Potency of Anti-PRLR-DM1 and Anti-ErbB2-DM1 Antibody-Drug Conjugates (continued)

Antibody-Drug Conjugate	T47D		T47D/ErbB2		SK-BR-3		MCF7	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	0.21	80	0.18	71	0.39	74	0.54	78
H1H6953N-DM1 (Anti PRLR-DM1)	1.3	78	2.4	80	100	77	82	74
Control II-DM1 (Anti ErbB2-DM1)	100	59	1.18	81	0.48	81	80	68
Isotype Control-DM1	100	62	120	75	110	76	100	65
PRLR expression	12X		12X		1X		3X	
ErbB2 expression	87X		437X		600X		42X	

IC_{50} values are in nM

Table 17: Cell Kill Potency of Anti-PRLR-DM1 and Anti-ErbB2-DM1 Antibody-Drug Conjugates (continued)

Antibody-Drug Conjugate	MCF7/PRLR		MCF/PRLR +ErbB2		NCI-N87		NCI-N87/PRLR	
	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill	IC_{50}	% Kill
DM1 (free drug)	1.85	79	0.82	77	0.84	95	1.45	98
H1H6953N-DM1 (Anti PRLR-DM1)	0.33	76	0.33	77	90	83	2.9	94
Control II-DM1 (Anti ErbB2-DM1)	100	56	0.63	76	0.22	95	0.66	94
Isotype Control-DM1	150	61	100	70	90	85	85	88
PRLR expression	55X		55X		1X		6X	
ErbB2 expression	36X		349X		1400X		1400X	

IC_{50} values are in nM

[0172] Anti-PRLR-DM1 antibodies effectively killed cells even with relatively low levels of PRLR expression. For example, H1H6953N-DM1 (anti-PRLR-DM1) inhibited the growth of T47D cells (expressing PRLR at only 12X above background) with an IC_{50} of 1.3 nM and showed 78% killing. This same antibody also inhibited the growth of 293/hPRLR cells (expressing PRLR at 18X above background) with and IC_{50} of 0.43 nM and showed 93% killing. Equivalent killing with the anti-ErbB2-DM1 antibody ("control II") was observed only in cells that express the target antigen at levels greater than about 200X to about 400X above background (*see e.g.*, PC3/hErbB2, expressing ErbB2 at 238X above background and T47D/hErbB2, expressing ErbB2 at 437X above background). Therefore, these data suggest that anti-PRLR antibody-drug conjugates can effectively target and kill tumor cells with relatively low levels of PRLR expression, while anti-ErbB2 antibody drug conjugates are effective only against tumors with very high ErbB2 expression levels.

[0173] Finally, the potency of anti-PRLR antibodies conjugated to DM1 via the non-cleavable linker SMCC was compared to the cell killing potency of anti-PRLR antibodies conjugated to MMAE via the cleavable linker: mc-vc-PAB (available from Concortis, San Diego, CA). Cells used in this experiment were PC3, PC3/hPRLR, MCF7/ATCC and MCF7/PRLR. Results are shown in Table 18.

Table 18: Anti-PRLR ADC Cell Kill Potency

	PC3		PC3/hPRLR		MCF7/ATCC		MCF7/PRLR	
	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill
Free DM1	0.5	90	1.0	70	3.0	80	1.9	86
Free MMAE	1.4	90	1.0	77	2.4	83	1.5	95

Isotype Control I-SMCC-DM1	95	79	100	79	100	71	100	76
Isotype Control I-mc-VC-PAB-MMAE	200	33	145	55	143	23	143	21
H1H6953N-SMCC-DM1	90	81	0.4	83	80	70	0.1	80
H1H6953N-mc-VC-PAB-MMAE	130	49	0.2	80	150	42	0.1	85
H1H6958N2-SMCC-DM1	110	81	0.5	79	90	72	0.2	83
H1H6958N2-mc-VC-PAB-MMAE	100	39	0.5	82	150	53	0.2	88
H1H6765P-SMCC-DM1	80	80	0.3	83	90	71	0.1	81
H1H6765P-mc-VC-PAB-MMAE	150	29	0.40	85	150	38	0.2	86

[0174] As shown in Table 18, nearly equivalent cell killing in PC3/hPRLR and MCF7/hPRLR cell lines was observed for both the non-cleavable DM1 ADCs (H1H6953-SMCC-DM1, H1H6958N2-SMCC-DM1, and H1H6765-SMCC-DM1) and for the cleavable MMAE ADCs (H1H6953-mc-vc-PAB-MMAE, H1H6958N2-mc-VC-PAB-MMAE, and H1H6765-mc-VC-PAB-MMAE).

[0175] Additional toxins (DM4, MeNHC3-May, and MMD) conjugated to anti-PRLR antibodies were also tested in T47D and MCF7/hPRLR cell lines, and results are summarized in Tables 19 (293 and T47D cell killing) and 20 (MCF7/ATCC and MCF7/PRLR cell killing). (ND = not detected).

Table 19: Anti-PRLR Antibody Drug Conjugates – Cell Killing Properties (293 and T47D Cell Lines)

			Cell Line			
			293		T47D	
Antibody	**Linker**	**Drug**	**IC_{50} nM**	**% Kill**	**IC_{50} nM**	**% Kill**
Free		DM1 (Me-SS-May)	1.2	95	1.5	100
		MMAE	0.9	100	1	100
		DM4	0.6	100	0.5	100
		MMD	0.9	100	2	100
		MeNHC3-May	60	90	90	100
Isotype Control I	**SMCC**	DM1	150	80	140	50
	mc-VC-PAB	MMAE	300	30	300	20
		MMD	300	70	140	70
		MeNHC3-May	300	30	300	30
	SPDB	DM4	50	90	30	100
H1H6953N	**SMCC**	DM1	100	90	1.5	100
	mc-VC-PAB	MMAE	ND	ND	1.0	80

		MMD	110	70	1.0	90
		MeNHC3-May	300	20	1.0	90
H1H6958N2	**SMCC**	DM1	100	90	2	100
	mc-VC-PAB	MMAE	ND	ND	1	90
	SPDB	DM4	ND	ND	1	100
H1H6975P	**SMCC**	DM1	80	90	2	100
	mc-VC-PAB	MMD	110	80	3	90
H1H6782P	**SMCC**	DM1	120	80	3	100
	mc-VC-PAB	MMD	230	70	2	90
	mc-VC-PAB	MeNHC3-May	60	90	2	90
H1H6765P	**SMCC**	DM1	85	100	1	90
	mc-VC-PAB	MMAE	ND	ND	1	90

Table 20: Anti-PRLR Antibody Drug Conjugates – Cell Killing Properties (MCF7/ATCC and MCF7/PRLR Cell Lines)

			Cell Line			
			MCF7/ATCC		**MCF7/PRLR**	
Antibody	**Linker**	**Drug**	**IC_{50} nM**	**% Kill**	**IC_{50} nM**	**% Kill**
Free		DM1 (Me-SS-May)	1.3	80	0.8	80
		MMAE	2.4	80	1.5	95
		DM4	1.3	90	2	90
		MMD	2	90	0.4	90
		MeNHC3-May	100	70	50	80
Isotype Control I	**SMCC**	DM1	300	60	150	70
	mc-VC-PAB	MMAE	140	20	140	20
		MMD	300	40	70	75
		MeNHC3-May	300	30	200	55
	SPDB	DM4	70	80	80	90
H1H6953N	**SMCC**	DM1	90	70	0.3	80
	mc-VC-PAB	MMAE	150	40	0.1	85
		MMD	300	50	0.2	90
		MeNHC3-May	150	60	0.2	80
H1H6958N2	**SMCC**	DM1	70	70	0.2	80
	mc-VC-PAB	MMAE	150	50	0.2	90
	SPDB	DM4	25	80	0.8	90
H1H6975P	**SMCC**	DM1	200	70	0.2	80
	mc-VC-PAB	MMD	150	50	0.2	90
H1H6782P	**SMCC**	DM1	250	70	0.3	80
	mc-VC-PAB	MMD	200	50	0.3	90
	mc-VC-PAB	MeNHC3-May	250	50	0.2	80
H1H6765P	**SMCC**	DM1	150	70	0.3	90
	mc-VC-PAB	MMAE	150	40	0.2	90

[0176] All tested anti PRLR ADCs, regardless of the toxin and linker utilized, specifically killed the tested cells. T47D cell viability IC_{50}s ranged from 0.6 nM to 3.4nM and MCF7/hPRLR cell viability IC50s ranged from 0.2 nM to 0.8 nM.

Example 8. Anti-PRLR Antibody-Drug Conjugates Effectively Inhibit Tumor Growth in vivo

[0177] To determine the *in vivo* efficacy of the anti-PRLR-DM1 antibody-drug conjugates, studies were performed in immunocompromised mice bearing PRLR+ breast cancer xenografts.

[0178] Briefly, 20 x 10^6 MCF7/PRLR cells (ATCC HTB-22 transfected with full length hPRLR as previously described) were implanted subcutaneously into the left mammary fat pad of female NCr nude mice. In other studies, 10 x 10^6 PC3/PRLR (ATCC CRL-1435 transfected with full length hPRLR as previously described) were implanted subcutaneously into the left flank of male SCID mice. Additionally, 10 x 10^6 parental T47D (ATCC HTB-133) or 7.5 x 10^{10} T47D#11 cells (ATCC HTB-133 serially passaged in vivo as described below) were subcutaneously implanted into the left flank of female CB17 SCID mice. All mice were obtained from Taconic (Hudson, NY). Each bolus of cells was supplemented with a 90-day estrogen release pellet (1.7 mg/pellet; Innovative Research America, Sarasota FL). Once tumors had reached an average volume of 250mm^3, mice were randomized into groups of seven and dosed with anti-PRLR antibody-drug conjugates of the invention or control reagents. Control reagents included PBS vehicle, free methyl-disulfide DM1 (DM1-SMe) and isotype Control 1-DM1.

[0179] In multi-dose studies, mice were dosed once a week for a total of three weeks with tumor volumes and body weights being monitored twice weekly throughout the study. Test ADCs were dosed at 5 and/or 15 mg/kg in the multi-dose studies. In single-dose studies, mice received a single dose of test ADC, and tumor volumes and body weights were monitored twice weekly throughout the study. Test ADCs were dosed at 1, 2.5, 5, and 15 mg/kg in the single-dose studies. Average tumor size as well as tumor growth inhibition relative to the vehicle treated group were calculated for each group. Tumors were measured with calipers twice a week until the average size of the vehicle group reached 1000mm^3. Tumor size was calculated using the formula (length x $width^2$)/2. Tumor growth inhibition was calculated according to the following formula: $(1-((T_{final}-T_{initial})/(C_{final}-C_{initial})))*100$, where T (treated group) and C (control group) represent the mean tumor mass on the day the vehicle group reached 1000mm^3. Animals were observed to Day 52. Results are summarized in Tables 21-25 (multi-dose) and Table 26 (single dose). (NT = not tested in the particular experiment shown).

Table 21: Tumor Size and Tumor Growth Inhibition Following Multi-Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – MCF7/PRLR tumors (TRIAL #1) [NCr Nude mice – data collected at Day 52]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	1068 ± 384	-
Free DM1	0.2	625 ± 141	57
Isotype control Ab-DM1	5	NT	NT
	15	300 ± 141	96
H1H6958N2	15	483 ± 46	74
H1H6958N2-DM1	5	51 ± 33	128
	15	0 ± 0	133
H1H6953N	15	421 ± 23	79
H1H6953N-DM1	5	107 ± 45	120
	15	0 ± 0	133
H1H6975N	15	659 ± 144	51
H1H6975N-DM1	5	125 ± 46	118
	15	0 ± 0	135
H1H6782P	15	NT	NT
H1H6782P-DM1	5		
	15		
H1H6765P	15	NT	NT
H1H6765P-DM1	5		
	15		

Table 22: Tumor Size and Tumor Growth Inhibition Following Multi-Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – MCF7/PRLR tumors (TRIAL #2) [NCr Nude mice – data collected at Day 63]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	870 ± 211	-
Free DM1	0.2	1080 ± 451	-33
Isotype control Ab-DM1	5	1106 ± 371	-39

	15	712 ± 214	24
H1H6958N2	15	766 ± 128	17
H1H6958N2-DM1	5	117 ± 10	116
	15	0 ± 0	137
H1H6953N	15	NT	NT
H1H6953N-DM1	5		
	15		
H1H6975N	15	NT	NT
H1H6975N-DM1	5		
	15		
H1H6782P	15	300 ± 83	88
H1H6782P-DM1	5	74 ± 34	123
	15	0 ± 0	137
H1H6765P	15	737 ± 182	19
H1H6765P-DM1	5	90 ± 56	122
	15	0 ± 0	136

Table 23: Tumor Size and Tumor Growth Inhibition Following Multi-Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – PC3/PRLR tumors (TRIAL #1) [SCID mice – data collected at Day 63]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	1311 ± 257	-
Free DM1	0.2	1361 ± 120	-5
Isotype control Ab-DM1	5	1379 ± 128	-7
	15	1091 ± 93	19
H1H6958N2	15	1507 ± 106	-19
H1H6958N2-DM1	5	1247 ± 171	5
	15	808 ±83	46
H1H6953N	15	1306 ± 127	0
H1H6953N-DM1	5	1058 ± 138	23
	15	892 ± 53	39

H1H6975N	15	1185 ± 97	12
H1H6975N-DM1	5	973 ± 169	31
	15	895 ± 63	38
H1H6782P	15	NT	NT
H1H6782P-DM1	5		
	15		
H1H6765P	15	NT	NT
H1H6765P-DM1	5		
	15		

Table 24: Tumor Size and Tumor Growth Inhibition Following Multi-Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – PC3/PRLR tumors (TRIAL #2) [SCID mice – data collected at Day 55]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	1222 ± 99	0
Free DM1	0.2	1147 ± 59	7
Isotype control Ab-DM1	5	1052 ± 101	16
	15	1049 ± 127	16
H1H6958N2	15	917 ± 253	28
H1H6958N2-DM1	5	566 ± 63	61
	15	230 ± 22	94
H1H6953N	15	NT	NT
H1H6953N-DM1	5		
	15		
H1H6975N	15	NT	NT
H1H6975N-DM1	5		
	15		
H1H6782P	15	1154 ± 212	6
H1H6782P-DM1	5	490 ± 63	69
	15	321 ± 33	85

H1H6765P	15	1208 ± 72	1
H1H6765P-DM1	5	489 ± 70	70
	15	181 ± 42	98

Table 25: Tumor Size and Tumor Growth Inhibition Following Multi-Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – T47D#11 tumors [SCID mice – data collected at Day 66]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	1234 ± 88	0
Free DM1	0.2	1433 ± 23	-19
Isotype control Ab-DM1	5	1340 ± 176	-9
	15	1678 ± 67	-42
H1H6958N2	15	1259 ± 122	-3
H1H6958N2-DM1	5	168 ± 19	102
	15	44 ± 5	112
H1H6953N	15	NT	NT
H1H6953N-DM1	5		
	15		
H1H6975N	15	NT	NT
H1H6975N-DM1	5		
	15		
H1H6782P	15	1537 ± 111	-29
H1H6782P-DM1	5	293 ± 20	90
	15	124 ± 36	106
H1H6765P	15	1278 ± 164	-3
H1H6765P-DM1	5	183 ± 28	100
	15	69 ± 12	111

Table 26: Tumor Size and Tumor Growth Inhibition Following Single Dose Administration of Anti-PRLR Antibody-Drug Conjugates and Controls – MCF7/PRLR tumors [data collected at Day 55]

Treatment Group	Dose (mg/kg)	Final Tumor size mm^3 (mean ± SEM)	Average Tumor Growth Inhibition (%)
Vehicle	--	710 ± 249	0
Isotype Control Ab-DM1	15	514 ± 86	38
H1H6958N2	15	703 ± 160	1
H1H6958N2-1	1	274 ± 142	86
H1H6958N2-1	2.5	172 ± 53	109
H1H6958N2-1	5	107 ± 26	120
H1H6958N2-1	15	33 ± 23	136

DISCUSSION

[0180] In this example, five exemplary anti-PRLR antibodies conjugated to DM1 were initially assessed for the ability to reduce MCF7/PRLR and PC3/PRLR tumor volume in multi-dose studies. In the first multi-dose trial (Table 21), H1H6958N2-DM1, H1H6953N-DM1 and H1H6975N-DM1 antibodies potently inhibited MCF7/PRLR tumor growth at both 5 and 15 mg/kg doses. At the highest dose, all three DM1 conjugated antibodies reduced tumors to undetectable levels, with a percent reduction in tumor volume of about 133-135%. This finding was replicated in a second multi-dose trial (Table 22) when H1H6958N2-DM1 was tested alongside two additional exemplary anti-PRLR antibodies conjugated to DM1: H1H6782P and H1H6765P. In this second trial, tumor growth was also reduced to undetectable levels at the highest dose of 15 mg/kg, with percent reduction in tumor volume of 136-137%. Although treatment with unconjugated anti-PRLR antibodies resulted in moderate reduction of tumor volume (17-79%) compared to the vehicle group, the greatest inhibition in tumor size was observed in cohorts treated with antibody-drug conjugates.

[0181] Next, the anti-tumor efficacy of these same exemplary anti-PRLR-DM1 antibodies was assessed in multi-dose studies in mice bearing PRLR positive PC3/PRLR xenografts. (Tables 23 and 24). Mice were treated after tumors had grown for 21 days. H1H6958N2-DM1, H1H6953N-DM1 and H1H6975N-DM1 all demonstrated inhibition of tumor growth, especially at the highest dose of 15 mg/kg. (Table 23). Anti-tumor effect was similarly observed in a second trial, when H1H6958N2-DM1 was tested alongside H1H6765P-DM1 and H1H6782P-DM1 after 15 days of tumor growth. At the highest dose administered, tumor inhibition across trials ranged from 38-98%. (Table 24). In comparison, an Isotype-control conjugated to DM1 produced only 16% tumor inhibition with final tumor volumes not significantly different to vehicle controls.

[0182] A further assessment of the anti-PRLR ADCs repeatedly dosed at 5 and 15mg/kg was

performed in mice bearing T47D#11 xenografts endogenously expressing PRLR. (Table 25). As in other tumor models, dosing was initiated when tumor size averaged 200 mm^3. Results obtained in this tumor model were consistent with earlier results and clearly demonstrated the anti-tumor activity of the anti-PRLR antibodies conjugated to DM1. For example, H1H6958N2-DM1, H1H6765P-DM1 and H1H6782P-DM1 ADCs potently inhibited tumor growth at both the 5 and 15 mg/kg dose. At 5 mg/kg anti-PRLR-DM1 conjugated antibodies exhibited 89-100% tumor inhibition whereas at 15 mg/kg DM1-conjugated antibodies resulted in 106-112 % tumor growth inhibition. Importantly, unconjugated anti-PRLR antibodies were not observed to have any anti-tumor efficacy in this endogenous tumor model, indicating the role of the DM1 conjugate in producing anti-tumor efficacy. Again, efficacy of anti-PRLR ADC was very specific as control ADC failed to have any effect on tumor growth.

[0183] In a final example, anti-PRLR DM1-conjugated antibody H1H6958N2 was assessed in MCF7/PRLR xenografted mice in a single-dose study. (Table 26). As in multiple-dose studies, established tumors were allowed to grow to approximately 200 mm^3 before a single dose was administered. Here, H1H6958N2-DM1 was given at 1, 2.5, 5 and 15 mg/kg. As summarized in Table 26, a dose dependent anti-tumor effect was seen across the wide range used in this study. Anti-tumor effect was observed at all doses, with 1 mg/kg causing a significant decrease in tumor volume relative to vehicle control tumors. Further, although 15 mg/kg of Isotype Control I-DM1 had some anti-tumor effect (~38% tumor growth inhibition), doses of anti-PRLR-DM1 at 2.5 mg/kg and higher significantly reduced tumor volume (> 100% tumor growth inhibition at all doses above 1 mg/kg tested). Single doses of 5 and 15 mg/kg demonstrated anti-tumor efficacy comparable to that observed following repeat dosing at the same level, illustrating the potency of the anti-PRLR ADCs.

[0184] In summary, this example illustrates that conjugated anti-PRLR antibodies of the invention are potent inhibitors of tumor growth and are able to reduce tumor size to undetectable levels in the various tumor models tested.

Example 9. Antibody-Drug Conjugates Against Class-I Cytokine Receptors Effectively Kill Cell Lines Expressing Low Levels of Target Antigen

[0185] As discussed elsewhere herein, antibody-drug conjugates against PRLR effectively kill PRLR-expressing cell lines, even those that express relatively low levels of target antigen. As previously noted, PRLR belongs to the class I cytokine receptor family, which includes IL-4R and IL-6R. Similar to PRLR, IL-4R and IL-6R are single-pass transmembrane receptors; IL-4R mediates IL-4 and IL-13 signaling, while IL-6R mediates IL-6 signaling via a co-complex with the gp130 receptor. In further support of the general concept that ADCs directed against class I cytokine receptors may be used to effectively kill cells, including cells that express low-levels of target antigen, the cell-killing ability of ADCs directed against IL-4R and IL-6R was evaluated.

[0186] Cell surface antigen levels on cells that endogenously or recombinantly express IL-4R or IL-6R were first established using FACS. Briefly, approximately 1 million KG-1 ($IL\text{-}4R^+$),

HEK293/IL-4R and Ramos (IL-6R$^+$) cells were incubated with exemplary anti-IL-4R (H4H083P2, *see* US Pat. No. 7,608,693) and anti-IL-6R (VV6A9-5, *see* US Pat. No. 7,582,298) antibodies for 30 min on ice. After washing, a PE-conjugated anti-human secondary antibody (10 µg/ml) was added for 30 min followed by a second washing step and subsequent analysis on an Accuri C6 cytometer using FlowJo software (Tree Star, Inc., Ashland, OR). Relative IL-4R and IL-6R cell surface expression levels were calculated as the mean fluorescence intensity (MFI) above isotype control levels. Expression levels are summarized in Table 27.

Table 27: Relative IL-4R and IL-6R Cell Surface Expression on IL-4R and IL-6R Endogenously or Recombinantly Expressing Cell Lines

	Cell Line Expression Level; Fold Over Background			
Receptor Expression	HEK293	HEK293/ IL4R	KG-1	Ramos
IL-4R	2	50	1	4
IL-6R	1	1	7	1

[0187] As shown in Table 27, HEK293 and Ramos cells endogenously expressed IL-4R at levels 2-fold and 4-fold over background, respectively, while the engineered HEK293/IL-4R cell line expressed IL-4R at levels 50-fold above background. IL-4R expression was undetectable over background on KG-1 cells. IL-6R expression was detected at 7-fold above background levels in KG-1 cells, and not on HEK293 or Ramos cell lines.

[0188] Next, exemplary anti-IL-4R (H4H083P2) and anti-IL-6R (VV6A9-5) antibodies were conjugated to the cytotoxic drug DM1 and their potency in cytotoxicity assays was evaluated. Briefly, HEK293/IL-4R, Ramos or KG-1 cell lines, as well as HEK293 parental cells were seeded in PDL-coated 96-well plates at 1500 to 10,000 cells per well. ADCs or free DM1 (as the methyl disulfide derivative DM1-SMe) were added to the cells at final concentrations ranging from 300 nM to 15 pM and incubated for 3 days. Cells were incubated with CCK8 (Dojindo, Rockville, MD) for the final 1-3 hours and the absorbance at 450nm (OD_{450}) was determined on a Flexstation3 (Molecular Devices, Sunnyvale, CA). Background OD_{450} values from digitonin (40 nM) treated cells were subtracted from all wells and viability was expressed as a percentage of the untreated controls. IC_{50} values were determined from a four-parameter logistic equation over a 10-point response curve (GraphPad Prism). Results are presented in Table 28.

Table 28: Cell killing Properties of Anti-IL4R and Anti-IL6R Antibody Drug Conjugates on IL4R and IL-6R-Expressing Cell Lines

Antibody-Drug Conjugate	HEK293		HEK293/ hIL4R		KG-1		Ramos	
	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill	IC_{50} (nM)	% Kill
DM1 (Free Drug)	0.27	100	0.33	98	1.26	89	0.34	100

Isotype control-DM1	70	89	110	91	100	74	60	91
Anti-IL-4R-DM1	80	91	0.22	95	90	83	18	91
Anti-IL-6R-DM1	100	88	70	92	38	77	70	94
Receptor Expression Levels: Fold over Isotype Ctrl								
IL-4R	2		50		1		4	
IL-6R	1		1		7		1	

[0189] As shown in Table 28, anti-IL-4R-DM1 antibody-drug conjugates reduced Ramos cell viability with an IC_{50} value of 18 nM despite an IL-4R surface expression of only 4-fold above background levels. IL-4R-DM1 ADCs reduced high IL-4R-expressing HEK293/IL-4R viability with an IC_{50} of 0.22 nM. Anti-IL-6R-DM1 antibody-drug conjugates had a modest but reproducible impact on the viability of KG-1 cells (expressing IL-6R at a level of 7-fold above background) with an IC_{50} value of 38 nM compared to an IC_{50} value of 100 nM by an equivalently conjugated isotype control ADC.

[0190] In summary, this Example demonstrates that anti-IL-4R and anti-IL-6R antibody drug conjugates exhibited potent and reproducible cytotoxicity even on cell lines expressing modest receptor levels. This result is similar to what was observed with anti-PRLR ADCs where potent cell killing was obtained even on cells expressing low levels of PRLR (*see*, *e.g.*, Example 7 herein). Thus, this Example provides further support for the inventive concept that anti-class I cytokine receptor ADCs in general may be effective therapeutic agents against cell lines and tumors that express class I cytokine receptors even at low levels.

[0191] The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the invention in addition to those described herein will become apparent to those skilled in the art from the foregoing description and the accompanying figures. Such modifications are intended to fall within the scope of the appended claims.

What is claimed is

1. An isolated antibody or antigen-binding fragment that binds to cell surface-expressed human prolactin receptor (PRLR) and blocks prolactin-mediated signaling in cells expressing human PRLR, wherein the antibody or antigen-binding fragment blocks prolactin-mediated signaling in cells expressing human PRLR with an IC_{50} of less than about 1.3 nM, wherein:

(i) the antibody or antigen-binding fragment comprises complementarity determining regions (CDRs) having the sequences of SEQ ID NO: 292, SEQ ID NO: 294, SEQ ID NO: 296, SEQ ID NO: 300, SEQ ID NO: 302, and SEQ ID NO: 304;

(ii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 4, SEQ ID NO: 6, SEQ ID NO: 8, SEQ ID NO: 12, SEQ ID NO: 14, and SEQ ID NO: 16;

(iii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 20, SEQ ID NO: 22, SEQ ID NO: 24, SEQ ID NO: 28, SEQ ID NO: 30, and SEQ ID NO: 32;

(iv) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 52, SEQ ID NO: 54, SEQ ID NO: 56, SEQ ID NO: 60, SEQ ID NO: 62, and SEQ ID NO: 64;

(v) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 100, SEQ ID NO: 102, SEQ ID NO: 104, SEQ ID NO: 108, SEQ ID NO: 110, and SEQ ID NO: 112;

(vi) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 116, SEQ ID NO: 118, SEQ ID NO: 120, SEQ ID NO: 124, SEQ ID NO: 126, and SEQ ID NO: 128;

(vii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 132, SEQ ID NO: 134, SEQ ID NO: 136, SEQ ID NO: 140, SEQ ID NO: 142, and SEQ ID NO: 144;

(viii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 196, SEQ ID NO: 198, SEQ ID NO: 200, SEQ ID NO: 204, SEQ ID NO: 206, and SEQ ID NO: 208;

(ix) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 212, SEQ ID NO: 214, SEQ ID NO: 216, SEQ ID NO: 220, SEQ ID NO: 222, and SEQ ID NO: 224;

(x) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 228, SEQ ID NO: 230, SEQ ID NO: 232, SEQ ID NO: 236, SEQ ID NO: 238, and SEQ ID NO: 240;

(xi) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 260, SEQ ID NO: 262, SEQ ID NO: 264, SEQ ID NO: 268, SEQ ID NO: 270, and SEQ ID NO: 272;

(xii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 276, SEQ ID NO: 278, SEQ ID NO: 280, SEQ ID NO: 284, SEQ ID NO: 286, and SEQ ID NO: 288;

(xiii) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 356, SEQ ID NO: 358, SEQ ID NO: 360, SEQ ID NO: 364, SEQ ID NO: 366, and SEQ ID NO: 368; or

(xiv) the antibody or antigen-binding fragment comprises CDRs having the sequences of SEQ ID NO: 372, SEQ ID NO: 374, SEQ ID NO: 376, SEQ ID NO: 380, SEQ ID NO: 382, and SEQ ID NO: 384.

2. The isolated antibody or antigen-binding fragment of claim 1 that blocks prolactin-mediated signaling in cells expressing human PRLR with an IC_{50} of less than about 400 pM.

3. The antibody or antigen-binding fragment of claim 1 or claim 2, wherein:

(i) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 290 and an LCVR having the sequence of SEQ ID NO: 298;

(ii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 2 and an LCVR having the sequence of SEQ ID NO: 10;

(iii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 18 and an LCVR having the sequence of SEQ ID NO: 26;

(iv) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 50 and an LCVR having the sequence of SEQ ID NO: 58;

(v) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 98 and an LCVR having the sequence of SEQ ID NO: 106;

(vi) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 114 and an LCVR having the sequence of SEQ ID NO: 122;

(vii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 130 and an LCVR having the sequence of SEQ ID NO: 138;

(viii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 194 and an LCVR having the sequence of SEQ ID NO: 202;

(ix) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 210 and an LCVR having the sequence of SEQ ID NO: 218;

(x) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 226 and an LCVR having the sequence of SEQ ID NO: 234;

(xi) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 258 and an LCVR having the sequence of SEQ ID NO: 266;

(xii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 274 and an LCVR having the sequence of SEQ ID NO: 282;

(xiii) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 354 and an LCVR having the sequence of SEQ ID NO: 362; or

(xiv) the antibody or antigen-binding fragment comprises an HCVR having the sequence of SEQ ID NO: 370 and an LCVR having the sequence of SEQ ID NO: 378.

4. An antibody-drug conjugate (ADC) comprising an antibody or antigen-binding fragment thereof of any one of claims 1 to 3 conjugated to a cytotoxic agent.

5. The ADC of claim 4, wherein the cytotoxic agent is a maytansinoid.

6. The ADC of claim 5, wherein the maytansinoid is DM1 or DM4.

7. The ADC of claim 5 or claim 6, wherein the maytansinoid is connected to the antibody via a cleavable linker.

8. The ADC of claim 5 or claim 6, wherein the maytansinoid is connected to the antibody via a non-cleavable linker.

9. The ADC of any one of claims 4 to 8, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain complementarity determining region (HCDR)-1 comprising SEQ ID NO:292; an HCDR2 comprising SEQ ID NO:294; an HCDR3 comprising SEQ ID NO:296; a light chain complementarity determining region (LCDR)-1 comprising SEQ ID NO:300; an LCDR2 comprising SEQ ID NO:302; and an LCDR3 comprising SEQ ID NO:304.

10. The ADC of claim 9, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain variable region (HCVR) comprising SEQ ID NO:290 and a light chain variable region (LCVR) comprising SEQ ID NO:298.

11. The ADC of claim 5, wherein the maytansinoid is connected to the antibody via an N-succinimidyl 4-(N-maleimidomethyl)cyclohexane-1-carboxylate (SMCC) linker.

12. An antibody-drug conjugate (ADC) comprising an antibody or antigen-binding fragment thereof conjugated to DM1 via an N-succinimidyl 4-(N-maleimidomethyl)cyclohexane-1-carboxylate (SMCC) linker, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain complementarity determining region (HCDR)-1 comprising SEQ ID NO:292; an HCDR2 comprising SEQ ID NO:294; an HCDR3 comprising SEQ ID NO:296; a light chain complementarity determining region (LCDR)-1 comprising SEQ ID NO:300; an LCDR2 comprising SEQ ID NO:302; and an LCDR3 comprising SEQ ID NO:304.

13. The ADC of claim 12, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain variable region (HCVR) comprising SEQ ID NO:290 and a light chain variable region (LCVR) comprising SEQ ID NO:298.

14. Use of the antibody-drug conjugate (ADC) of any one of claims 4 to 12 in the manufacture of a medicament for killing tumor cells that express PRLR.

15. The use of claim 14, wherein the tumor cells express less than 1 million copies of PRLR per cell.

16. The use of claim 14, wherein the tumor cells express between 3,000 and 500,000 copies of PRLR per cell.

17. The use of any one of claims 14 to 16, wherein the tumor cells are breast tumor cells.

18. Use of the antibody-drug conjugate (ADC) of any one of claim 4 to 12 in the manufacture of a medicament for inhibiting or attenuating tumor growth.

19. The use of claim 18, wherein the tumor is selected from the group consisting of a renal tumor, a pancreatic tumor, a head and neck tumor, a breast tumor, a prostate tumor, a colon tumor, a gastric tumor, and ovarian tumor, a lung tumor, and a skin tumor.

20. The use of claim 19, wherein the tumor is a breast tumor.

21. A pharmaceutical composition comprising the isolated antibody or antigen-binding fragment of any one of claims 1 to 3 and a pharmaceutically acceptable excipient.

22. A pharmaceutical composition comprising the ADC of any one of claims 4 to 12 and a pharmaceutically acceptable excipient.

23. Use of the isolated antibody or antigen-binding fragment of any one of claims 1 to 3 in the manufacture of a medicament for inhibiting or attenuating tumor growth.

24. The use of claim 23, wherein the tumor is selected from the group consisting of a renal tumor, a pancreatic tumor, a head and neck tumor, a breast tumor, a prostate tumor, a colon tumor, a gastric tumor, and ovarian tumor, a lung tumor, and a skin tumor.

25. The use of claim 24, wherein the tumor is a breast tumor.